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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2026-27/188 Date: 02.07.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/308 dated 08.08.2025

In supersession to the above referred Circular, the structure and syllabus of Semester III and IV of the **Master of Science in Remote Sensing and Geographical Information System** Programme, approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

The Syllabus of Semester I and II approved earlier by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is also attached.

The Dean & Vice-Dean (Academic) of the School of Earth, Ocean and Atmospheric Sciences are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.07.02 11:30:38 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
2. The Vice-Dean (Academic), School of Earth, Ocean and Atmospheric Sciences, Goa University.

Copy to:

1. Chairperson, BoS in Remote Sensing & GIS, Goa University.
2. Programme Director, M.Sc. Remote Sensing and Geographical Information System, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME
Established in the academic year 2019, the School of Earth, Ocean, and Atmospheric Sciences (SEOAS) was conceptualized to promote a comprehensive, systems-based approach to understanding the Earth. Moving beyond the compartmentalized study of the lithosphere, atmosphere, hydrosphere, and cryosphere, SEOAS fosters an integrative perspective central to Earth System Science. Recognising the Earth as a dynamic and interconnected system, the school seeks to equip emerging scientists, ranging from oceanographers and atmospheric researchers to Earth scientists and GIS specialists, with the tools and knowledge necessary to address urgent global challenges such as climate change, environmental degradation, and sustainability. A cornerstone of this systems-based education is Remote Sensing and Geographic Information Systems (GIS). These technologies are pivotal for conducting multi-scale geospatial analyses spanning local, regional, and global dimensions and for decoding the complex interactions that define the Earth system. Accordingly, the Remote Sensing and GIS curriculum at SEOAS has been strategically developed to integrate foundational scientific theory with practical, solution-oriented applications. The curriculum merges the core principles of the natural sciences with advanced geospatial technologies to produce meaningful, policy-relevant insights. Remote sensing entails the acquisition of digital data through sensors, which is then processed and visualized to monitor and analyze environmental phenomena. When coupled with GIS, remotely sensed data can be synthesized with in-situ information, enabling powerful spatial analyses and evidence-based decision-making. Together, Remote Sensing and GIS form the analytical backbone of modern Earth observation and modelling efforts. The curriculum is designed to cultivate both technical competence and conceptual depth. A strong foundation in mathematics and linear algebra is emphasized to prepare students for higher-level spatial data analysis. Proficiency in programming languages is also an integral part of the training, ensuring that students are capable of implementing sophisticated remote sensing algorithms and workflows. Furthermore, the programme offers hands-on experience with industry-standard software packages, including ENVI, ERDAS Imagine, ORFEO Toolbox, SNAP, QGIS, and GRASS GIS, thus preparing students for research, policy, and professional careers in the geospatial domain. Crucially, the programme promotes domain awareness, i.e., the ability to contextualize geospatial tools within specific environmental and thematic frameworks. This multidisciplinary and application-driven approach enables students to become skilled remote sensing professionals capable of tackling complex environmental challenges with scientific rigour, technological expertise, and societal relevance.

OBJECTIVES OF THE PROGRAMME
The Remote Sensing and GIS programme at SEOAS aims to equip students with a holistic understanding of Earth system processes through geospatial technologies. It integrates theoretical knowledge with hands-on training in remote sensing, GIS, spatial analysis, and programming to address real-world environmental challenges. Emphasising both scientific rigour and technical proficiency, the programme prepares students for research and professional careers in academia, industry, and public policy, while promoting ethical and sustainable use of geospatial data.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Develop systems-based understanding of Earth processes
PSO 2.	Enable spatial data generation, integration and interpretation
PSO 3.	Foster research and innovation in environmental problem-solving
PSO 4.	Prepare students for multidisciplinary career pathways
PSO 5.	Promote ethical and sustainable geospatial practices

PROGRAMME STRUCTURE
M.Sc. in Remote Sensing and Geographical Information System
Effective from Academic Year 2025-26

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	RSG-5000	Remote Sensing Techniques and Applications	2T	400
2	RSG-5001	Remote Sensing Techniques and Applications Practical	2P	400
3	RSG-5002	Principles and Applications of GIS	2T	400
4	RSG-5003	Principles and Applications of GIS Practical	2P	400
5	RSG-5004	Satellite Meteorology and Atmospheric Sensing	2T	400
6	RSG-5005	Satellite Meteorology and Atmospheric Sensing Practical	2P	400
7	RSG-5006	Satellite Oceanography	2T	400
8	RSG-5007	Satellite Oceanography Practical	2P	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	RSG-5201	Optical, Infrared and Microwave Remote Sensing	4T	400
2	RSG-5202	Remote Sensing and GIS in Coastal Geomorphology	2T	400
3	RSG-5203	Remote Sensing and GIS in Coastal Geomorphology Practical	2P	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-5008**	Digital Image Processing	2T	500
2	**RSG-5009**	Digital Image Processing Practical	2P	500
3	**RSG-5010**	Geospatial Analysis and Modelling	2T	500
4	**RSG-5011**	Geospatial Analysis and Modelling Practical	2P	500
5	**RSG-5012**	Aerosol Remote Sensing and Atmospheric Dynamics	2T	500
6	**RSG-5013**	Aerosol Remote Sensing and Atmospheric Dynamics Practical	2P	500
7	**RSG-5014**	Ocean Optical Modelling	2T	500
8	**RSG-5015**	Ocean Optical Modelling Practical	2P	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-5204**	Remote Sensing and Climate	2T	400
2	**RSG-5205**	Remote Sensing and Climate Practical	2P	400
3	**RSG-5206**	Geospatial Applications for Water Resource Management	2T	400
4	**RSG-5207**	Geospatial Applications for Water Resource Management Practical	2P	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

SEMESTER III				
Research Specific Elective (RSE) Courses (12 credits) *In fulfilment of the requirements of the RSE credits, each student shall be required to enrol in the corresponding practical courses of RSG-6000, RSG-6002, RSG-6004, and RSG-6006, i.e., RSG-6001, RSG-6003, RSG-6005, and RSG-6007, respectively. The successful completion of these courses shall collectively account for twelve (12) credits, which shall be applied towards the total credit requirement prescribed under RSE.				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-6000**	Optical Characterisation of Inland and Coastal Waters	2T	500
2	**RSG-6001**	Optical Characterisation of Inland and Coastal Waters Practical	2P	500
3	**RSG-6002**	Microwave Remote Sensing Applications	2T	500
4	**RSG-6003**	Microwave Remote Sensing Applications Practical	2P	500
7	**RSG-6004**	Geospatial Application in Urban and Rural Development	2T	500
8	**RSG-6005**	Geospatial Application in Urban and Rural Development Practical	2P	500
9	**RSG-6006**	Advanced Topics in Ocean Data Assimilation	2T	500
10	**RSG-6007**	Advanced Topics in Ocean Data Assimilation Practical	2P	500
11	**RSG-6008**	Cultural Landscapes and Geospatial Heritage in India	2T	500
12	**RSG-6009**	Research Methodology	4T	500
Total Credits for RSE Courses in Semester III			**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-6401**	Python for Geosciences	2T+2P	500
2	**RSG-6402**	GNSS and Map Projections	2T+2P	500
3	**RSG-6403**	Geospatial Analysis for Weather Applications	2T+2P	500
4	**RSG-6404**	Lifelong Learning: Large Marine Ecosystems	2T+2P	500
Total Credits for DSVE Courses in Semester III			**8**	
Total Credits in Semester III			**20**	

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-6501**	Discipline-Specific Dissertation	40	500

SEMESTER IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	RSG-6201	Remote Sensing and GIS for Coastal Zone Management and Sustainability	4T	500
2	RSG-6202	Aerosol and Regional Weather	4T	500
3	RSG-6203	Remote Sensing for Open Ocean Processes	4T	500
4	RSG-6204	Operational Oceanography	4T	500
5	RSG-6205	WebGIS	4T	500
6	RSG-6206	Climate Change and Society	4T	500
7	RSG-6207	Disaster Risk Reduction and Climate Resilience	4T	500
8	RSG-6208	Photogrammetry and Drone Applications	4T	500
		Total Credits for GE Courses in Semester IV	**20**	

Discipline Specific Dissertation (DSD)/ Internship (20 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**RSG-6502**	Discipline-Specific Dissertation	20	500
		Total Credits in Semester IV	**20**	

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Remote Sensing Techniques and Applications
Course Code	RSG-5000
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course provides a foundational understanding of remote sensing principles, technologies, and applications, with a focus on data acquisition, sensor types, and practical uses in environmental and resource management.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Define the basic concepts and components of remote sensing.	PSO 1
	CO 2. Understand the principles of EMR and its interaction with Earth and the atmosphere	PSO 1

	CO 3. Identify types of remote sensing platforms, sensors, and resolutions.		PSO 1, PSO 2	
	CO 4. Explain remote sensing data acquisition, applications, and associated technologies		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Remote Sensing: Definition, Scope, and Historical Evolution; Principles of Remote Sensing and Electromagnetic Radiation; Components of Remote Sensing including active and passive remote sensing; Transmission of Electromagnetic Radiation and its Interaction with Earth's Surface; Propagation of Reflected/Emitted Energy through Atmosphere.	**15**	CO 1, CO 2	K1, K2
Module 2:	Types of Remote Sensing Platforms; Types of Sensors and bands; Concepts of pixel, swath, Spatial, Spectral, Temporal, and Radiometric Resolution; Data Acquisition in Remote Sensing; Applications of Remote Sensing; Advantages and Limitations of Remote Sensing; In-situ and Remote Sensor Technologies and UAV Applications.	**15**	CO 3, CO 4	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing.* New York: The Guilford Press. 2. Chuvieco, E. (2016). *Fundamentals of Satellite Remote Sensing.* Boca Raton, Florida: CRC Press. 3. Jensen, J. R. (2015). *Remote Sensing of the Environment: An Earth Resource Perspective. Boston, Massachusetts: Pearson.* 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2014). *Remote Sensing and Image Interpretation.* Hoboken, New Jersey: Wiley. 5. Mobley, C. D. (1994). *Light and Water: Radiative Transfer in Natural Waters. San Diego, California: Academic Press.* 6. Richards, J. A. (2022). *Remote Sensing Digital Image Analysis.* Cham, Switzerland: Springer.			
References/ Readings:	1. Mulla, D. J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosystems Engineering, 114*(4), 358–371. https://doi.org/10.1016/j.biosystemseng.2012.08.009 2. Pinter Jr., P. J., Hatfield, J. L., Schepers, J. S., Barnes, E. M., Moran, M. S., Daughtry, C. S. T., & Upchurch, D. R. (2003). Remote sensing for crop management. *Photogrammetric Engineering & Remote Sensing, 69*(6), 647–664.			

	https://doi.org/10.14358/PERS.69.6.647 3. Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*, *61*(4), 301–325. https://doi.org/10.1016/S0305-9006(03)00066-7 4. Schowengerdt, R. A. (2007). Remote sensing: Models and methods for image processing. *Remote Sensing of Environment*, 110(3), 300–306. https://doi.org/10.1016/j.rse.2007.03.003 5. Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. *Remote Sensing of Environment*, *117*, 34–49. https://doi.org/10.1016/j.rse.2011.02.030
Web Resources:	1. ISRO's Remote Sensing Handbooks (https://www.isro.gov.in/Miscellaneous.html). 2. IOCCG Reports on Ocean Colour Remote Sensing (https://ioccg.org/what-we-do/ioccg-publications/ioccg-reports/). 3. NASA and ESA Satellite Data Portals (https://www.earthdata.nasa.gov/) 4. VEDAS (Visualisation of Earth observation Data and Archival System) https://vedas.sac.gov.in 5. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in

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Title of the Course	Remote Sensing Techniques and Applications Practical
Course Code	RSG-5001
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This course provides practical experience in remote sensing, focusing on image processing, data correction, and spectral analysis for real-world applications in environmental monitoring and resource management.			
Course Outcomes:	Students will be able to,	**Mapped to PSO**		
	CO 1. Understand satellite data and its sources for remote sensing analysis	PSO 1		
	CO 2. Evaluate and integrate remote sensing data for analysis and interpretation.	PSO 1		
	CO 3. Apply conversion techniques for DN values to spectral radiance and reflectance, and analyse spectral signatures	PSO 1, PSO 2		
	CO 4. Analyse and correct satellite data and evaluate spectral ratios and indices	PSO 3		
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Familiarity with remote sensors; Data sources, metadata and portals; Layer Stacking of Multispectral Imagery; Creating a subset of an image; Band Combination and Colour Composites.	**30**	CO 1, CO 2	K2, K3
Module 2:	Conversion of DN values to spectral Radiance & Reflectance; Corrections of Satellite Data, Radiometric Corrections; Atmospheric Correction; Geometric Correction; Analysis of Spectral Reflectance: spectral signature curve, Spectral Ratios & Indices.	**30**	CO 3, CO 4	K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practicals			
Texts:	1. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing*. New York: The Guilford Press. 2. Chuvieco, E. (2016). *Fundamentals of Satellite Remote Sensing*. Boca Raton, Florida: CRC Press. 3. Jensen, J. R. (2015). *Remote Sensing of the Environment: An Earth Resource Perspective. Boston, Massachusetts: Pearson.* 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2014). *Remote Sensing and Image Interpretation*. Hoboken, New Jersey: Wiley. 5. Mobley, C. D. (1994). *Light and Water: Radiative Transfer in Natural Waters. San Diego, California: Academic Press*. 6. Richards, J. A. (2022). *Remote Sensing Digital Image Analysis*. Cham, Switzerland: Springer.			
References/ Readings:	1. Mulla, D. J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosystems Engineering*, *114*(4), 358–371. https://doi.org/10.1016/j.biosystemseng.2012.08.009 2. Pinter Jr., P. J., Hatfield, J. L., Schepers, J. S., Barnes, E. M., Moran, M. S., Daughtry, C. S. T., & Upchurch, D. R. (2003). Remote sensing for crop management. *Photogrammetric Engineering & Remote Sensing*, *69*(6), 647–664. https://doi.org/10.14358/PERS.69.6.647 3. Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*, *61*(4), 301–325. https://doi.org/10.1016/S0305-9006(03)00066-7 4. Schowengerdt, R. A. (2007). Remote sensing: Models and methods for image processing. *Remote Sensing of Environment*, 110(3), 300–306. https://doi.org/10.1016/j.rse.2007.03.003 5. Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends.			

	Remote Sensing of Environment, *117*, 34–49. https://doi.org/10.1016/j.rse.2011.02.030
Web Resources:	1. ISRO's Remote Sensing Handbooks (https://www.isro.gov.in/Miscellaneous.html). 2. IOCCG Reports on Ocean Colour Remote Sensing (https://ioccg.org/what-we-do/ioccg-publications/ioccg-reports/). 3. NASA and ESA Satellite Data Portals (https://www.earthdata.nasa.gov/) 4. VEDAS (Visualisation of Earth observation Data and Archival System) https://vedas.sac.gov.in 5. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in

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Title of the Course	Principles and Applications of GIS
Course Code	RSG-5002
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	This course aims to provide students with a foundational understanding of GIS, covering its components, data structures, software frameworks, and real-world applications.			
Course Outcomes:	Students will be able to,		**Mapped to PSO**	
	CO 1. Explain the fundamentals, components, and applications of GIS		PSO 1	
	CO 2. Compare spatial data types, models, and GIS software frameworks		PSO 1	
	CO 3. Understand spatial data errors and geodatabase concepts		PSO 1, PSO 2	
	CO 4. Apply mapping principles and spatial data management techniques		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	Introduction to GIS: Definitions, Components, History and Evolution, Need and Scope; Interdisciplinary Relations; Application Areas; Current Issues; Trends and Future; GIS software packages: proprietary & open source; Introduction to GIS software framework; Data types: spatial data, non-spatial data; data structures and data models (Raster & Vector); ESRI Shapefile, GDB and higher data storage formats.	**15**	CO1, CO2	K1, K2
Module 2:	Types and sources of errors in vector data; Topology; Introduction to Geodatabase and Types of Geodatabases; Georeferencing: Introduction to map projections and geometric transformations; Conversion of existing data (Rasterise / Vectorise); Elements & Principles of Map Layout; Types of Maps (Based on Scale, Purpose and Applications); Submarine groundwater discharge (SGD).	**15**	CO3, CO4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Anbazhagan, S., Subramanian, S.K. & Yang, X., editors (2011). *Geoinformatics in Applied Geomorphology*. Boca Raton, Florida: CRC Press. 2. Awange, J. & Kiema, J.B. (2013) Environmental Geoinformatics. In Environmental Science and Engineering. Heidelberg, Germany: Springer. 3. Karimi, H.A., editor (2014). *Big Data: Techniques and Technologies in Geoinformatics*. Boca Raton, Florida: CRC Press. 4. Li, J. (2007). *Geomatics Solutions for Disaster Management* (edited by S. Zlatanova & A. G. Fabbri). Heidelberg, Germany: Springer (p. 444). 5. Longley, P. & Batty, M. (2003). *Advanced Spatial Analysis: The CASA Book of GIS*. Redlands, California: ESRI Press. 6. Sinha, A.K., editor (2006). *Geoinformatics: Data to Knowledge*, Vol. 397. Boulder, Colorado: Geological Society of America. 7. Skidmore, A., editor (2017). *Environmental Modelling with GIS and Remote Sensing*. Boca Raton, Florida: CRC Press.			
References/ Readings:	1. Burrough, P. A. (1986). Principles of geographical information systems for land resources assessment. *International Journal of Geographical Information Systems, 1*(1), 7–15. https://doi.org/10.1080/02693798708927887 2. Goodchild, M. F. (2009). Geographic information systems and science: Today and tomorrow. *Annals of GIS, 15*(1),			

	3–9. https://doi.org/10.1080/19475680903250715 3. Guo, D., & Mennis, J. (2009). Spatial data mining and geographic knowledge discovery—An introduction. *Computers, Environment and Urban Systems, 33*(6), 403–408. https://doi.org/10.1016/j.compenvurbsys.2009.11.001 4. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). GIS and science: On the influence of geography and geographic information science. *Geographical Analysis, 37*(1), 1–8. https://doi.org/10.1111/j.1538-4632.2005.00697.x 5. Wright, D. J., Goodchild, M. F., & Proctor, J. D. (1997). Demystifying the persistent ambiguity of GIS as "tool" versus "science". *Annals of the Association of American Geographers, 87*(2), 346–362. https://doi.org/10.1111/0004-5608.872057
Web Resources:	1. Esri GIS Dictionary & Education Resources (https://www.esri.com/en-us/what-is-gis) 2. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 3. National Geographic – Geographic Information Systems (GIS) National Geographic Society. (n.d.). *Geographic Information Systems (GIS)* https://education.nationalgeographic.org/resource/geographic-information-system-gis 4. OpenStreetMap – Learn OSM Beginner's Guide LearnOSM. (n.d.). *Beginner's Guide to OpenStreetMap (OSM)* https://learnosm.org/en/beginner/ 5. QGIS Documentation – Introduction to GIS Concepts https://docs.qgis.org/latest/en/docs/gentle_gis_introduction/

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Title of the Course	Principles and Applications of GIS Practical
Course Code	RSG-5003
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to provide hands-on experience with GIS and data analysis, focusing on tasks like data visualisation, georeferencing, and vector data creation. Students will gain practical skills in error identification, topology building, and data conversion between raster and vector formats	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Apply geospatial tools for data handling and visualization	PSO 1
	CO 2. Identify and correct spatial data errors	PSO 1
	CO 3. Apply data conversion and mapping techniques in digital cartography	PSO 1, PSO 2
	CO 4. Create and interpret different types of maps for spatial representation	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Data Visualisation; Map projections and Georeferencing: Transformation methods; Map to image rectification; Image to image registration; Vector data Creation; Working with Attributes; Error identification & Correction; Topology Building.	**30**	CO 1, CO 2	K1, K2, K3
Module 2:	Conversion of existing data (Rasterize/Vectorize). Digital Cartography: Layout Generation; Using Multiple Data Frames; Creation of Different Types of Maps: Topographic Maps, Physical Maps, Thematic maps, Isopleth Maps, Flow Maps.	**30**	CO 3, CO 4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Anbazhagan, S., Subramanian, S.K. & Yang, X., editors (2011). *Geoinformatics in Applied Geomorphology*. Boca Raton, Florida: CRC Press. 2. Awange, J. & Kiema, J.B. (2013) *Environmental Geoinformatics. In Environmental Science and Engineering*. Heidelberg, Germany: Springer. 3. Karimi, H.A., editor (2014). *Big Data: Techniques and Technologies in Geoinformatics*. Boca Raton, Florida: CRC Press. 4. Li, J. (2007). *Geomatics Solutions for Disaster Management* (edited by S. Zlatanova & A. G. Fabbri). Heidelberg, Germany: Springer 5. Longley, P. & Batty, M. (2003). *Advanced Spatial Analysis: The CASA Book of GIS*. Redlands, California: ESRI Press. 6. Sinha, A.K., editor (2006). *Geoinformatics: Data to Knowledge*, Vol. 397. Boulder, Colorado: Geological Society of America. 7. Skidmore, A., editor (2017). *Environmental Modelling with GIS and Remote Sensing*. Boca Raton, Florida: CRC Press.			
References/ Readings:	1. Burrough, P. A. (1986). Principles of geographical information systems for land resources assessment. *International Journal of Geographical Information Systems*, *1*(1), 7–15. https://doi.org/10.1080/02693798708927887			

	2. Goodchild, M. F. (2009). Geographic information systems and science: Today and tomorrow. *Annals of GIS, 15*(1), 3–9. https://doi.org/10.1080/19475680903250715 3. Guo, D., & Mennis, J. (2009). Spatial data mining and geographic knowledge discovery—An introduction. *Computers, Environment and Urban Systems, 33*(6), 403–408. https://doi.org/10.1016/j.compenvurbsys.2009.11.001 4. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). GIS and science: On the influence of geography and geographic information science. *Geographical Analysis, 37*(1), 1–8. https://doi.org/10.1111/j.1538-4632.2005.00697.x 5. Wright, D. J., Goodchild, M. F., & Proctor, J. D. (1997). Demystifying the persistent ambiguity of GIS as "tool" versus "science". *Annals of the Association of American Geographers, 87*(2), 346–362. https://doi.org/10.1111/0004-5608.872057
Web Resources:	1. Esri GIS Dictionary & Education Resources (https://www.esri.com/en-us/what-is-gis) 2. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 3. National Geographic – Geographic Information Systems (GIS) National Geographic Society. (n.d.). *Geographic Information Systems (GIS)* https://education.nationalgeographic.org/resource/geographic-information-system-gis 4. OpenStreetMap – Learn OSM Beginner's Guide LearnOSM. (n.d.). *Beginner's Guide to OpenStreetMap (OSM)* https://learnosm.org/en/beginner/ 5. QGIS Documentation – Introduction to GIS Concepts https://docs.qgis.org/latest/en/docs/gentle_gis_introduction/

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Title of the Course	Satellite Meteorology and Atmospheric Sensing
Course Code	RSG-5004
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the fundamental principles of satellite-based atmospheric sensing and radiative transfer, with a focus on retrieving atmospheric parameters from satellite and ground-based instruments. It includes hands-on training in processing satellite datasets for weather, aerosol, and trace gas analysis, and demonstrates their application in environmental monitoring.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand satellite-based data processing techniques to retrieve atmospheric parameters such as aerosols, ozone, and temperature profiles.	PSO 1, PSO 2
	CO 2. Understand spatial and temporal patterns in atmospheric data.	PSO 2
	CO 3. Demonstrate understanding of geospatial tools and their application in processing and visualizing atmospheric datasets.	PSO 3

	CO 4. Apply satellite data access and pre-processing techniques to retrieve atmospheric constituents.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Fundamentals of Satellite Meteorology and Atmospheric Sensing; Structure and composition of the atmosphere; Electromagnetic radiation interaction with the atmosphere (absorption, scattering, emission); Radiative transfer principles and sensor characteristics; Overview of meteorological satellites and sensors (e.g., MODIS, AIRS, TROPOMI, OMI, GOSAT, Imager and Sounder INSAT series); Ground-based networks: LIDAR, AERONET; Retrieval of aerosol optical depth, ozone, and vertical profiles.	**15**	CO1	K1, K2
Module 2:	Applications of satellite meteorology, e.g., air quality monitoring, dust storms, and crop burning; Role of remote sensing in weather forecasting and early warning systems; Climate variability and atmospheric dynamics from satellite observations; Case studies: Indian Summer Monsoon, urban pollution events, aerosol transport.	**15**	CO2	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Ackerman, S. A., & Knox, J. A. (2021). Meteorology: Understanding the atmosphere (5^{th} ed Burlington, Massachusetts: Jones & Bartlett Learning. 2. Campbell, J. B., & Wynne, R. H. (2023). Introduction to remote sensing (6^{th} ed.). New York, New York: The Guilford Press. 3. Elachi, C., & van Zyl, J. J. (2021). Introduction to the physics and techniques of remote sensing (4^{th} ed.). Hoboken, New Jersey: Wiley. 4. Rees, W. G. (2022). Physical principles of remote sensing (4^{th} ed.). Cambridge, United Kingdom: Cambridge University Press. 5. Robinson, P., & Henderson-Sellers, A. (2020). Contemporary climatology (3^{rd} ed.). Abingdon, United Kingdom: Routledge.			
References/ Readings:	1. Holben, B. N., Eck, T. F., Slutsker, I., Tanré, D., Buis, J. P., Setzer, A., ... & Smirnov, A. (1998). AERONET-A federated instrument network and data archive for aerosol characterization. Remote Sensing of Environment, 66(1),			

	1–16. https://doi.org/10.1016/S0034-4257(98)00031-5 2. Joiner, J., Veihelmann, B., Loyola, D., Worden, H. M., Kim, J., Boesch, H., ... & Röckmann, T. (2021). TROPOMI on Sentinel-5 Precursor: first year in operation (AMT/ACP inter-journal SI). 3. King, M. D., Menzel, W. P., Kaufman, Y. J., Tanré, D., Gao, B. C., Platnick, S., ... & Nakajima, T. (2003). Cloud and aerosol properties, precipitable water, and profiles of temperature and water vapor from MODIS. IEEE Transactions on Geoscience and Remote Sensing, 41(2), 442–458. https://doi.org/10.1109/TGRS.2002.808226. 4. Levelt, P. F., van den Oord, G. H., Dobber, M. R., Mälkki, A., Visser, H., de Vries, J., ... & Veefkind, J. P. (2006). The Ozone Monitoring Instrument. IEEE Transactions on Geoscience and Remote Sensing, 44(5), 1093–1101. https://doi.org/10.1109/TGRS.2006.872333 5. Remer, L. A., Kaufman, Y. J., Tanré, D., Mattoo, S., Chu, D. A., Martins, J. V., ... & Holben, B. N. (2005). The MODIS aerosol algorithm, products, and validation. Journal of the Atmospheric Sciences, 62(4), 947–973. https://doi.org/10.1175/JAS3385.1
Web Resources:	1. European Space Agency (ESA). (n.d.). Copernicus Open Access Hub. https://scihub.copernicus.eu/ 2. NASA Earthdata. (n.d.). Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 3. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol Robotic Network. https://aeronet.gsfc.nasa.gov/ 4. World Meteorological Organization (WMO). (2014). Guide to satellite applications in meteorology and climatology (WMO-No. 1198). https://library.wmo.int/index.php?lvl=notice_display&id=15659

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Title of the Course	Satellite Meteorology and Atmospheric Sensing Practical
Course Code	RSG-5005
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the fundamental principles of satellite-based atmospheric sensing and radiative transfer, with a focus on retrieving atmospheric parameters from satellite and ground-based instruments. It includes hands-on training in processing satellite datasets for weather, aerosol, and trace gas analysis, and demonstrates their application in environmental monitoring.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand satellite-based data processing techniques to retrieve atmospheric parameters such as aerosols, ozone, and temperature profiles.	PSO 1, PSO 2
	CO 2. Understand spatial and temporal patterns in atmospheric data.	PSO 2
	CO 3. Demonstrate understanding of geospatial tools and their application in processing and visualizing atmospheric datasets.	PSO 3

	CO 4. Apply satellite data access and pre-processing techniques to retrieve atmospheric constituents.	PSO 3		
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Satellite data access, e.g., NASA Giovanni, Copernicus, MODIS/AIRS portals; Data Visualisation and interpretation using standard remote sensing and GIS tools; Retrieval and plotting of AOD, NO_2, and ozone; Profiles of temperature, subsequent estimations of standard meteorological parameters, humidity, Temperature and humidity profiling from AIRS and radiosonde datasets.	**30**	CO 3	K1, K2
Module 2:	Air quality trend analysis using multi-year remote sensing data; Regional event analyses of dust transport, smog and airborne pollutants; Integration of LIDAR and AERONET data in ground validation; Final-project: Analysis of a selected atmospheric event with report and presentation.	**30**	CO 4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Ackerman, S. A., & Knox, J. A. (2021). Meteorology: Understanding the atmosphere (5^{th} ed Burlington, Massachusetts: Jones & Bartlett Learning. 2. Campbell, J. B., & Wynne, R. H. (2023). Introduction to remote sensing (6^{th} ed.). New York, New York: The Guilford Press. 3. Elachi, C., & van Zyl, J. J. (2021). Introduction to the physics and techniques of remote sensing (4^{th} ed.). Hoboken, New Jersey: Wiley. 4. Rees, W. G. (2022). Physical principles of remote sensing (4^{th} ed.). Cambridge, United Kingdom: Cambridge University Press. 5. Robinson, P., & Henderson-Sellers, A. (2020). Contemporary climatology (3^{rd} ed.). Abingdon, United Kingdom: Routledge.			
References/ Readings:	1. Holben, B. N., Eck, T. F., Slutsker, I., Tanré, D., Buis, J. P., Setzer, A., ... & Smirnov, A. (1998). AERONET-A federated instrument network and data archive for aerosol characterization. Remote Sensing of Environment, 66(1), 1–16. https://doi.org/10.1016/S0034-4257(98)00031-5			

	2. Joiner, J., Veihelmann, B., Loyola, D., Worden, H. M., Kim, J., Boesch, H., ... & Röckmann, T. (2021). TROPOMI on Sentinel-5 Precursor: first year in operation (AMT/ACP inter-journal SI). 3. King, M. D., Menzel, W. P., Kaufman, Y. J., Tanré, D., Gao, B. C., Platnick, S., ... & Nakajima, T. (2003). Cloud and aerosol properties, precipitable water, and profiles of temperature and water vapor from MODIS. IEEE Transactions on Geoscience and Remote Sensing, 41(2), 442–458. https://doi.org/10.1109/TGRS.2002.808226. 4. Levelt, P. F., van den Oord, G. H., Dobber, M. R., Mälkki, A., Visser, H., de Vries, J., ... & Veefkind, J. P. (2006). The Ozone Monitoring Instrument. IEEE Transactions on Geoscience and Remote Sensing, 44(5), 1093–1101. https://doi.org/10.1109/TGRS.2006.872333 5. Remer, L. A., Kaufman, Y. J., Tanré, D., Mattoo, S., Chu, D. A., Martins, J. V., ... & Holben, B. N. (2005). The MODIS aerosol algorithm, products, and validation. Journal of the Atmospheric Sciences, 62(4), 947–973. https://doi.org/10.1175/JAS3385.1
Web Resources:	1. European Space Agency (ESA). (n.d.). Copernicus Open Access Hub. https://scihub.copernicus.eu/ 2. NASA Earthdata. (n.d.). Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 3. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol Robotic Network. https://aeronet.gsfc.nasa.gov/ 4. World Meteorological Organization (WMO). (2014). Guide to satellite applications in meteorology and climatology (WMO-No. 1198). https://library.wmo.int/index.php?lvl=notice_display&id=15659

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Title of the Course	Satellite Oceanography
Course Code	RSG-5006
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the principles of oceanography and large-scale circulation, emphasizing the use of satellite remote sensing to observe physical, biological, and chemical processes in the oceans. It provides training in accessing and interpreting satellite-derived oceanographic parameters and demonstrates their integration with ocean models.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the basic concepts of ocean structure, dynamics, and the Earth's climate-ocean interactions.	PSO 1, PSO 2
	CO 2. Use satellite datasets to extract and analyse key ocean parameters such as SST, SSH, ocean colour, and salinity.	PSO 2
	CO 3. Interpret variations in oceanographic processes from satellite observations.	PSO 3
	CO 4. Apply satellite-derived oceanographic data to basic modelling workflows and case studies	PSO 3

Approved by: Standing Committee of the Academic Council on 24th & 25th June 2025

	related to climate and ecosystem variability.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Fundamentals of Oceanography & General Circulation: Introduction to Oceanography; Physical, chemical, biological, and geological oceanography; Oceanic provinces - Coastal, shelf, deep-sea, upwelling zones; Global Ocean Circulation: Wind-driven circulation; Thermohaline circulation & deep-water formation; Ocean-atmosphere interactions; Role of the ocean in climate systems; Principles of Satellite Oceanography; Satellite Platforms & Sensors.	**15**	CO 1	K1, K2
Module 2:	Satellite-Derived Ocean Variables and retrievals - Radiative transfer models, Sea Surface Temperature, Sea Surface Height and Altimetry, Ocean colour, Ocean salinity, Ocean surface winds & waves; Ocean Currents; Ocean Colour Remote Sensing; Bio-optical models & algorithm selection, and parameters, e.g., cholorophyll-a, non-algal particulates and coloured dissolved organic matter, and photosynthetically active radiation, etc.	**15**	CO 2, CO 3	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Emery, W. J., & Thomson, R. E. (2014). Data analysis methods in physical oceanography (3rd ed.). Amsterdam, Netherlands: Elsevier. 2. Lalli, C. M., & Parsons, T. R. (1997). Biological oceanography: An introduction (2nd ed.). Oxford, United Kingdom: Butterworth-Heinemann. 3. Mann, K. H., & Lazier, J.R.N. (2013). Dynamics of marine ecosystems: Biological-physical interactions in the oceans (3rd ed.). Chichester, United Kingdom: Wiley-Blackwell. 4. Mobley, C. D. (1994). Light and water: Radiative transfer in natural waters. San Diego, California: Academic Press. 5. Rees, W. G. (2022). Physical principles of remote sensing (4th ed.). Cambridge, United Kingdom: Cambridge University Press.			
References/ Readings:	1. Behrenfeld, M. J., & Falkowski, P. G. (1997). Photosynthetic rates derived from satellite-based chlorophyll concentration. Limnology and Oceanography, 42(1), 1–20. https://doi.org/10.4319/lo.1997.42.1.0001 2. Chelton, D. B., Schlax, M. G., & Samelson, R. M. (2011). Global observations of nonlinear mesoscale eddies.			

	Progress in Oceanography, 91(2), 167–216. https://doi.org/10.1016/j.pocean.2011.01.002 3. Le Traon, P. Y., Nadal, F., & Ducet, N. (1998). An improved mapping method of multisatellite altimeter data. Journal of Atmospheric and Oceanic Technology, 15(2), 522–534. https://doi.org/10.1175/1520-0426(1998)015<0522:AIMMOM>2.0.CO;2 4. McClain, C. R. (2009). A decade of satellite ocean color observations. Annual Review of Marine Science, 1, 19–42. https://doi.org/10.1146/annurev.marine.010908.163650 5. Siegel, D. A., Doney, S. C., & Yoder, J. A. (2002). The North Atlantic spring phytoplankton bloom and Sverdrup's critical depth hypothesis. Science, 296(5568), 730–733. https://doi.org/10.1126/science.1069174
Web Resources:	1. European Union Copernicus Programme. (n.d.). Marine data and services. https://marine.copernicus.eu/ 2. NASA Goddard Space Flight Center. (n.d.). MODIS, SeaWiFS, and VIIRS ocean color data archive. https://oceancolor.gsfc.nasa.gov/ 3. Space Applications Centre (ISRO). (n.d.). Satellite data for oceanographic and meteorological research in India. https://www.mosdac.gov.in/

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Title of the Course	Satellite Oceanography Practical
Course Code	RSG-5007
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the principles of oceanography and large-scale circulation, emphasizing the use of satellite remote sensing to observe physical, biological, and chemical processes in the oceans. It provides training in accessing and interpreting satellite-derived oceanographic parameters and demonstrates their integration with ocean models.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the basic concepts of ocean structure, dynamics, and the Earth's climate-ocean interactions.	PSO 1, PSO 2
	CO 2. Use satellite datasets to extract and analyse key ocean parameters such as SST, SSH, ocean colour, and salinity.	PSO 2
	CO 3. Interpret variations in oceanographic processes from satellite observations.	PSO 3
	CO 4. Apply satellite-derived oceanographic data to basic modelling workflows and case	PSO 3

	studies related to climate and ecosystem variability.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Remote Sensing Data Processing: Accessing Oceanographic Satellite Data; Bhoonidhi-NRSC, Mosdac-SAC of ISRO; INCOIS data sources; NASA Ocean Colour; Copernicus Marine, and NOAA databases; Data Processing & Visualization; extracting time series; Mapping oceanographic features from satellite data.	**30**	CO1	K1, K2
Module 2:	Algorithm Implementation: Ocean colour processing and SST anomaly detection & trend analysis; Field survey for validation of derived products of local estuaries for comparison; Giovanni, SeaDAS, and level-corrections. Final Project: Regional Analysis.	**30**	CO2, CO3	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Emery, W. J., & Thomson, R. E. (2014). Data analysis methods in physical oceanography (3rd ed.). Amsterdam, Netherlands: Elsevier. 2. Lalli, C. M., & Parsons, T. R. (1997). Biological oceanography: An introduction (2nd ed.). Oxford, United Kingdom: Butterworth-Heinemann. 3. Mann, K. H., & Lazier, J.R.N. (2013). Dynamics of marine ecosystems: Biological-physical interactions in the oceans (3rd ed.). Chichester, United Kingdom: Wiley-Blackwell. 4. Mobley, C. D. (1994). Light and water: Radiative transfer in natural waters. San Diego, California: Academic Press. 5. Rees, W. G. (2022). Physical principles of remote sensing (4th ed.). Cambridge, United Kingdom: Cambridge University Press.			
References/ Readings:	1. Behrenfeld, M. J., & Falkowski, P. G. (1997). Photosynthetic rates derived from satellite-based chlorophyll concentration. Limnology and Oceanography, 42(1), 1–20. https://doi.org/10.4319/lo.1997.42.1.0001 2. Chelton, D. B., Schlax, M. G., & Samelson, R. M. (2011). Global observations of nonlinear mesoscale eddies. Progress in Oceanography, 91(2), 167–216. https://doi.org/10.1016/j.pocean.2011.01.002 3. Le Traon, P. Y., Nadal, F., & Ducet, N. (1998). An improved mapping method of multisatellite altimeter data.			

	Journal of Atmospheric and Oceanic Technology, 15(2), 522–534. https://doi.org/10.1175/1520-0426(1998)015<0522:AIMMOM>2.0.CO;2 4. McClain, C. R. (2009). A decade of satellite ocean color observations. Annual Review of Marine Science, 1, 19–42. https://doi.org/10.1146/annurev.marine.010908.163650 5. Siegel, D. A., Doney, S. C., & Yoder, J. A. (2002). The North Atlantic spring phytoplankton bloom and Sverdrup's critical depth hypothesis. Science, 296(5568), 730–733. https://doi.org/10.1126/science.1069174
Web Resources:	1. European Union Copernicus Programme. (n.d.). Marine data and services. https://marine.copernicus.eu/ 2. NASA Goddard Space Flight Center. (n.d.). MODIS, SeaWiFS, and VIIRS ocean color data archive. https://oceancolor.gsfc.nasa.gov/ 3. Space Applications Centre (ISRO). (n.d.). Satellite data for oceanographic and meteorological research in India. https://www.mosdac.gov.in/

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Discipline Specific Elective (DSE) Courses

Title of the Course	Optical, Infrared and Microwave Remote Sensing
Course Code	RSG-5201
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course offers in-depth functioning and applications of optical, infrared, and microwave remote sensing sensors. Students will learn to interpret data from panchromatic, multispectral, hyperspectral, thermal, and microwave systems and apply multi-sensor datasets to environmental, coastal, and disaster applications through case studies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the physical principles governing electromagnetic radiation and its interaction with vegetation, soil, water, and the atmosphere.	PSO 1, PSO 2
	CO 2. Differentiate between optical, infrared, and microwave sensing techniques in terms of platforms, sensors, and spectral properties.	PSO 2

	CO 3. Apply the principles of thermal infrared and microwave sensing to real-world problems such as temperature estimation, land surface dynamics, and disaster detection.		PSO 3	
	CO 4. Integrate and analyze multi-sensor datasets (optical, IR, and microwave) for environmental, marine, and hazard mapping applications.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Fundamentals of Electromagnetic Radiation and Remote Sensing. Electromagnetic Spectrum; Energy Sources; Laws of Radiation (Planck's, Stefan-Boltzmann, Wien's law); Interaction of EM waves with Atmosphere, Vegetation, Water, and Soil. Atmospheric Scattering and Absorption Effects.	**10**	CO 1	K1, K2
Module 2:	Optical Remote Sensing. Basics of Optical Sensors: Panchromatic, Multispectral, Hyperspectral Imaging; Passive vs. Active Sensors; Optical Sensor Platforms on board Satellites; Image characteristics: Spatial, Spectral, Radiometric, and Temporal Resolution; Application of Optical Remote Sensing.	**15**	CO 2, CO 3, CO 4	K1, K2
Module 3:	Infrared Remote Sensing; Thermal Infrared Radiation and its Properties; Blackbody Radiation, Emissivity, and Temperature Estimation; Thermal Sensors and Platforms; Application of Infrared Remote Sensing; Microwave Remote Sensing; Microwave Spectrum; Active vs. Passive Microwave Remote Sensing; Radar Principles: Scattering mechanisms, Polarization, Backscatter, and Speckle; Radiometer, Scatterometer, and SAR, Altimeter sensors and missions; Applications of Microwave Remote Sensing.	**20**	CO 2, CO 3, CO 4	K1, K2
Module 4:	Data fusion: Combining Optical, Infrared, and Microwave Datasets; Remote Sensing for Disaster Management; Coastal and Marine Applications; Future trends in remote sensing include small satellites, AI/ML integration, and hyperspectral-microwave synergy.	**15**	CO 4	K1, K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Campbell, J. B., & Wynne, R. H. (2023). Introduction to remote sensing (6th ed.). New York, New York: The Guilford Press. 2. Jensen, J. R. (2007). Remote sensing of the environment: An Earth resource perspective (2nd ed.). Upper Saddle River, New Jersey: Pearson.			

	3. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote sensing and image interpretation (7th ed.). Hoboken, New Jersey: Wiley. 4. Richards, J. A., & Jia, X. (2006). Remote sensing digital image analysis (4th ed.). Berlin, Germany: Springer. 5. Schott, J. R. (2007). Remote sensing: The image chain approach (2nd ed.). New York, New York: Oxford University Press.
References/ Readings:	1. Bannari, A., Morin, D., Bonn, F., & Huete, A. R. (1995). A review of vegetation indices. Remote Sensing Reviews, 13(1–2), 95–120. https://doi.org/10.1080/02757259509532298 2. McCandless, S. W., & Jackson, C. R. (2004). Ocean radar scatterometry. Proceedings of the IEEE, 92(8), 1421–1431. https://doi.org/10.1109/JPROC.2004.831883 3. Schmugge, T., Kustas, W. P., Ritchie, J. C., Jackson, T. J., & Rango, A. (2002). Remote sensing in hydrology. Advances in Water Resources, 25(8–12), 1367–1385. https://doi.org/10.1016/S0309-1708(02)00065-9 4. Tucker, C. J. (1979). Red and photographic infrared linear combinations for monitoring vegetation. Remote Sensing of Environment, 8(2), 127–150. https://doi.org/10.1016/0034-4257(79)90013-0 5. Ulaby, F. T., Moore, R. K., & Fung, A. K. (1986). Microwave remote sensing: Active and passive. IEEE Transactions on Geoscience and Remote Sensing, 24(3), 389–393. https://doi.org/10.1109/TGRS.1986.289643
Web Resources:	1. European Union Copernicus Programme. (n.d.). Marine data and services. https://marine.copernicus.eu/ 2. NASA Goddard Space Flight Center. (n.d.). MODIS, SeaWiFS, and VIIRS ocean color data archive. https://oceancolor.gsfc.nasa.gov/ 3. Space Applications Centre (ISRO). (n.d.). Satellite data for oceanographic and meteorological research in India. https://www.mosdac.gov.in/

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Title of the Course	Remote Sensing & GIS in Coastal Geomorphology
Course Code	RSG-5202
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to impart knowledge on the use of Remote Sensing & GIS for monitoring and managing coastal environments.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand coastal geomorphology, landforms, and processes	PSO 1, PSO 2
	CO 2. Assess the role of coastal zones in environmental management and evaluate human impacts and hazards	PSO 2
	CO 3. Understand shoreline extraction and spatial modelling techniques	PSO 3
	CO 4. Analyse coastal risks and pollution through case studies	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to coastal geomorphology and classification of coasts; Overview of coastal landforms and processes (waves, tides, currents, sediment transport, sea-level changes); Importance of coastal zones in environmental management and risk assessment; Human impacts and natural hazards in coastal zones.	**15**	CO 1, CO 2	K1, K2
Module 2:	Techniques for shoreline extraction; Time-series analysis and change detection; Spatial modelling of coastal erosion; flood risk Assessment; Monitoring coastal vegetation; Coastal disaster management; Introduction to integrated coastal zone management; shoreline change analysis.	**15**	CO 3, CO 4	K1, K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Jensen, J. R. (2007). *Remote sensing of the environment: An Earth resource perspective* (2nd ed.). Upper Saddle River, New Jersey: Pearson Prentice Hall. 2. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). *Remote sensing and image interpretation* (7th ed.). Hoboken, New Jersey: John Wiley & Sons. 3. Maiti, S. (2021). *Remote sensing of coastal environments*. Cham, Switzerland: Springer. 4. Masselink, G., & Hughes, M. G. (2014). *Introduction to coastal processes and geomorphology* (2nd ed.). Abingdon, United Kingdom: Routledge. 5. Thieler, E. R., & Danforth, W. W. (1994). *Historical shoreline mapping (DSAS): Methods and applications*. Reston, Virginia: U.S. Geological Survey.			
References/ Readings:	1. Chand, P., & Acharya, P. (2010). Shoreline change and sea-level rise along the coast of Odisha, East coast of India. *Journal of Coastal Research, 26*(6), 1069–1076. https://doi.org/10.2112/JCOASTRES-D-10-00053.1 2. Hapke, C. J., Himmelstoss, E. A., Kratzmann, M. G., List, J. H., & Thieler, E. R. (2011). National assessment of shoreline change: Historical shoreline change along the New England and Mid-Atlantic coasts. *U.S. Geological Survey Open-File Report 2010–1118.* https://pubs.usgs.gov/of/2010/1118/ https://coast.noaa.gov/data/docs/digitalcoast/shoreline-mapping.pdf			

	3. Maiti, S., & Bhattacharya, A. K. (2009). Shoreline change analysis and its application to prediction: A remote sensing and statistics-based approach. *Marine Geology, 257*(1–4), 11–23. https://doi.org/10.1016/j.margeo.2008.10.006 4. NOAA Office for Coastal Management. (2020). *Shoreline mapping: Best practices and guidelines*. National Oceanic and Atmospheric Administration 5. Rajawat, A. S., Chauhan, H. B., & Ajai. (2015). Shoreline change analysis using remote sensing and GIS: A case study of the Gulf of Khambhat, India. *Arabian Journal of Geosciences*, *8*(5), 3065–3077. https://doi.org/10.1007/s12517-014-1403-x
Web Resources:	1. European Space Agency (ESA) – Coastal Zones Applications https://www.esa.int/Applications/Observing_the_Earth/Coastal_zones 2. National Centre for Coastal Research: National Assessment of Shoreline Changes https://www.nccr.gov.in/?q=technical-report 3. ISRO – Bhuvan Coastal GIS Applications https://bhuvan.nrsc.gov.in 4. NASA Earth Observatory – Coastal Monitoring https://earthobservatory.nasa.gov 5. NOAA Digital Coast https://coast.noaa.gov/digitalcoast/ 6. USGS Coastal and Marine Hazards and Resources Program https://www.usgs.gov/programs/cmhrp

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Title of the Course	Remote Sensing & GIS in Coastal Geomorphology Practical	
Course Code	RSG-5203	
Number of Credits	2	
Theory/Practical	Practical	
Level	400	
Effective from AY	2025-2026	
New Course	Yes	
Bridge Course/ Value-added Course	No	
Course for advanced learners	No	

Pre-requisites for the Course:	Nil	
Course Objectives:	This course will help in building skills in data processing, feature extraction, risk modelling, and mapping coastal environmental issues.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Process and Analyse satellite data for coastal applications	PSO 1, PSO 2
	CO 2. Analyse shoreline features and detect changes using satellite data	PSO 2
	CO 3. Apply models for coastal risk and vulnerability assessment	PSO 3
	CO 4. Analyse and map coastal features and hazards	PSO 3

Approved by: Standing Committee of the Academic Council on 24th & 25th June 2025

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Downloading and preparing satellite data for coastal applications; Using Multispectral data for detecting coastal features; digitisation and mapping of coastal landforms; Shoreline extraction using manual, semi-automatic and automatic approaches; and Digital Shoreline Assessment System analysis using time-series satellite data.	**30**	CO1, CO2	K1, K2
Module 2:	DEM-based coastal flood risk and inundation mapping; Creating and applying Coastal Vulnerability Index (CVI); Erosion risk modelling; Mapping and Detection of Oil spill; Sediment plume; and algal blooms.	**30**	CO3, CO4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Jensen, J. R. (2007). Remote sensing of the environment: An Earth resource perspective (2nd ed.). Upper Saddle River, New Jersey: Pearson Prentice Hall. 2. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote sensing and image interpretation (7th ed.). Hoboken, New Jersey: John Wiley & Sons. 3. Maiti, S. (2021). Remote sensing of coastal environments. Cham, Switzerland: Springer. 4. Masselink, G., & Hughes, M. G. (2014). Introduction to coastal processes and geomorphology (2nd ed.). Abingdon, United Kingdom: Routledge. 5. Thieler, E. R., & Danforth, W. W. (1994). Historical shoreline mapping (DSAS): Methods and applications. Reston, Virginia: U.S. Geological Survey.			
References/ Readings:	1. Chand, P., & Acharya, P. (2010). Shoreline change and sea-level rise along the coast of Odisha, East coast of India. *Journal of Coastal Research*, *26*(6), 1069–1076. https://doi.org/10.2112/JCOASTRES-D-10-00053.1 2. Hapke, C. J., Himmelstoss, E. A., Kratzmann, M. G., List, J. H., & Thieler, E. R. (2011). National assessment of shoreline change: Historical shoreline change along the New England and Mid-Atlantic coasts. *U.S. Geological Survey Open-File Report 2010–1118.* https://pubs.usgs.gov/of/2010/1118/ https://coast.noaa.gov/data/docs/digitalcoast/shoreline-mapping.pdf			

	3. Maiti, S., & Bhattacharya, A. K. (2009). Shoreline change analysis and its application to prediction: A remote sensing and statistics-based approach. *Marine Geology*, *257*(1–4), 11–23. https://doi.org/10.1016/j.margeo.2008.10.006 4. NOAA Office for Coastal Management. (2020). *Shoreline mapping: Best practices and guidelines*. National Oceanic and Atmospheric Administration 5. Rajawat, A. S., Chauhan, H. B., & Ajai. (2015). Shoreline change analysis using remote sensing and GIS: A case study of the Gulf of Khambhat, India. *Arabian Journal of Geosciences, 8*(5), 3065–3077. https://doi.org/10.1007/s12517-014-1403-x
Web Resources:	1. European Space Agency (ESA) – Coastal Zones Applications https://www.esa.int/Applications/Observing_the_Earth/Coastal_zones 2. ISRO – Bhuvan Coastal GIS Applications https://bhuvan.nrsc.gov.in 3. NASA Earth Observatory – Coastal Monitoring https://earthobservatory.nasa.gov 4. NOAA Digital Coast https://coast.noaa.gov/digitalcoast/ 5. USGS Coastal and Marine Hazards and Resources Program https://www.usgs.gov/programs/cmhrp

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SEMESTER II

Discipline Specific Core (DSC) Courses

Title of the Course	Digital Image Processing
Course Code	RSG-5008
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5000	
Course Objectives:	This course aims to provide students with a comprehensive understanding of digital image processing concepts, including image enhancement, classification, and error correction techniques in remote sensing. Students will also learn about image transformation, classification methods, and accuracy assessment for remote sensing products.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Explain concepts of digital image processing and data formats	PSO 1, PSO 2
	CO 2. Understand error correction methods and image enhancement techniques	PSO 2

	CO 3. Explore image enhancement and analysis techniques		PSO 3	
	CO 4. Analyse image classification methods and assess accuracy		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Concepts of Digital Image and Digital Image Processing; Digital Image Data Format; Image data storage and retrieval; Pre-Processing: Radiometric Errors and correction - Correcting remote sensing system detector error; remote sensing atmospheric correction; Geometric Errors and correction - Internal and external Geometric errors; Types of geometric correction; Mosaicking; Image enhancement Techniques - An overview; Image reduction and magnification.	**15**	CO1, CO2	K1, K2
Module 2:	Contrast Enhancement - Linear and non-linear, Band Rationing; Spatial filtering and Edge enhancement; Density slicing, Multi image manipulation - addition, subtraction; Principal Component Analysis; Principles of Image Classification; Image Classification process, supervised image classification, unsupervised image classification; Classification algorithms; Fuzzy classification; Microwave and thermal image processing; Fourier Transform and Wavelet analysis; Object-oriented Image Segmentation; Concept of Accuracy Assessment; Kappa Analysis.	**15**	CO3, CO4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Gonzalez, R. C., & Woods, R. E. (2018). *Digital Image Processing* (4th ed.). London, United Kingdom: Pearson. 2. Dey, N., Bhatt, C. & Ashour, A.S. (2018). *Big Data for Remote Sensing: Visualization, Analysis and Interpretation.* Cham, Switzerland: Springer. 3. Johnston, K., Ver Hoef, J.M., Krivoruchko, K. & Lucas, N. (2001). *Using ArcGIS Geostatistical Analyst*, Vol. 380. Redlands, California: ESRI Press. 4. Reddy, M.A. & Reddy, A. (2008). *Textbook of Remote Sensing and Geographical Information Systems*. Hyderabad, India: BS Publications 5. Scott, L.M. & Janikas, M.V. (2010) Spatial statistics in ArcGIS. In: *Handbook of Applied Spatial Analysis*. Heidelberg, Germany: Springer.			

	6. Wong, D.W.S. & Lee, J. (2005). *Statistical Analysis of Geographic Information with ArcView GIS and ArcGIS.* Hoboken, New Jersey: John Wiley & Sons
References/ Readings:	1. Cheng, G., Huang, Y., Li, X., Lyu, S., Xu, Z., Zhao, Q., & Xiang, S. (2023). Change detection methods for remote sensing in the last decade: A comprehensive review. https://doi.org/10.3390/rs16132355. 2. Jensen, J. R. (2005). Introductory digital image processing: A remote sensing perspective. International Journal of Remote Sensing, 26(15), 3335–3336. https://doi.org/10.1080/01431160500112183 3. Liu, C. (2023). A review of digital image processing techniques and future prospects. *International Journal of Computer Science and Information Technology*, *11*(2), 45–59. https://doi.org/10.62051/ijcsit.v4n3.22 4. Lu, D., Mausel, P., Brondízio, E., & Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing*, *25*(12), 2365–2401. https://doi.org/10.1080/0143116031000139863 5. Mather, P. M. (2004). Computer processing of remotely-sensed images: An introduction. *International Journal of Remote Sensing*, *25*(19), 3709–3711. https://doi.org/10.1080/01431160410001688891
Web Resources:	1. ITC – Remote Sensing and Digital Image Processing Course https://www.itc.nl/education/study-finder/remote-sensing-and-digital-image-processing/ 2. Natural Resources Canada – Digital Image Processing https://natural-resources.canada.ca/maps-tools-publications/satellite-elevation-air-photos/digital-image-processing 3. NASA Earthdata – Remote Sensing Overview https://www.earthdata.nasa.gov/learn/earth-observation-data-basics/remote-sensing

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Title of the Course	Digital Image Processing Practical
Course Code	RSG-5009
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5001			
Course Objectives:	This course aims to familiarise students with GIS software, focusing on remote sensing data visualisation, pre-and post-processing protocols, and various image enhancement and classification techniques. Students will also gain hands-on experience in image mosaicking and accuracy assessment.			
Course Outcomes:	Students will be able to,		**Mapped to PSO**	
	CO 1. Apply software tools for the visualisation and processing of remote sensing data		PSO 1, PSO 2	
	CO 2. Perform image enhancement and manage data formats in remote sensing		PSO 2	
	CO 3. Execute image processing techniques for enhancement and classification		PSO 3	
	CO 4. Perform an accuracy assessment and change detection in remote sensing data		PSO 3	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Visualisation of remote sensing data; pre-processing and post-processing protocols; Data formats in physical sciences; Import and export of satellite data to various formats; Image enhancement techniques – image contrast, histogram equalisation and density slicing. Image compression techniques.	**30**	CO1, CO2	K2, K3
Module 2:	Resolution merge and mosaic; Band Rationing; Filtering techniques; Principal Component Analysis; Classification supervised and unsupervised; Recoding of Pixels; Accuracy Assessment; Change detection.	**30**	CO3, CO4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practicals			
Texts:	1. Gonzalez, R. C., & Woods, R. E. (2018). *Digital Image Processing* (4^{th} ed.). London, United Kingdom: Pearson. 2. Dey, N., Bhatt, C. & Ashour, A.S. (2018). *Big Data for Remote Sensing: Visualization, Analysis and Interpretation.* Cham, Switzerland: Springer. 3. Johnston, K., Ver Hoef, J.M., Krivoruchko, K. & Lucas, N. (2001). *Using ArcGIS Geostatistical Analyst*, Vol. 380. Redlands, California: ESRI Press. 4. Reddy, M.A. & Reddy, A. (2008). *Textbook of Remote Sensing and Geographical Information Systems*. Hyderabad, India: BS Publications 5. Scott, L.M. & Janikas, M.V. (2010) Spatial statistics in ArcGIS. In: *Handbook of Applied Spatial Analysis*. Heidelberg, Germany: Springer. 6. Wong, D.W.S. & Lee, J. (2005). *Statistical Analysis of Geographic Information with ArcView GIS and ArcGIS.* Hoboken, New Jersey: John Wiley & Sons			
References/ Readings:	1. Jensen, J. R. (2005). Introductory digital image processing: A remote sensing perspective. International Journal of Remote Sensing, 26(15), 3335–3336. https://doi.org/10.1080/01431160500112183 2. Mather, P. M. (2004). Computer processing of remotely-sensed images: An introduction. *International Journal of Remote Sensing*, *25*(19), 3709–3711. https://doi.org/10.1080/01431160410001688891 3. Lu, D., Mausel, P., Brondízio, E., & Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing*, *25*(12), 2365–2401. https://doi.org/10.1080/0143116031000139863			

	4. Liu, C. (2023). A review of digital image processing techniques and future prospects. *International Journal of Computer Science and Information Technology*, *11*(2), 45–59. https://doi.org/10.62051/ijcsit.v4n3.22 5. Cheng, G., Huang, Y., Li, X., Lyu, S., Xu, Z., Zhao, Q., & Xiang, S. (2023). Change detection methods for remote sensing in the last decade: A comprehensive review. https://doi.org/10.3390/rs16132355.
Web Resources:	1. ITC – Remote Sensing and Digital Image Processing Course https://www.itc.nl/education/study-finder/remote-sensing-and-digital-image-processing/ 2. Natural Resources Canada – Digital Image Processing https://natural-resources.canada.ca/maps-tools-publications/satellite-elevation-air-photos/digital-image-processing 3. NASA Earthdata – Remote Sensing Overview https://www.earthdata.nasa.gov/learn/earth-observation-data-basics/remote-sensing

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Title of the Course	Geospatial Analysis and Modelling
Course Code	RSG-5010
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5002			
Course Objectives:	This course aims to provide students with an understanding of basic spatial analysis techniques, spatial data acquisition, and database operations, along with advanced methods such as network analysis, spatial interpolation, and surface analysis. Students will also learn about multi-criteria analysis and its applications in site suitability studies.			
Course Outcomes:	Students will be able to,		**Mapped to PSO**	
	CO 1. Explain concepts of spatial data and database management in GIS		PSO 1, PSO 2	
	CO 2. Understand techniques of spatial analysis and data querying		PSO 2	
	CO 3. Describe spatial modelling and analysis techniques in GIS		PSO 3	
	CO 4. Identify principles of network analysis, interpolation, and surface analysis		PSO 3	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Basics of Basic Spatial Analysis; Spatial Data Acquisition; Attribute data sources; Spatial and attribute data input; Data storage; RDBMS; database operations; Spatial and non-spatial data editing functions; Quality of spatial data; Measurement; Classification & Reclassification; Data Query: Attribute query, Spatial Query, Report Generation from Attribute Data; Vector Data Overlay Analysis: Clip, Merge, Buffering, Union, Erase, Identity, Intersect, Spatial Join; Grid-based Operations: local, focal, zonal and global functions.	**15**	CO1, CO2	K1, K2
Module 2:	Integration and Modelling: Logic operations, general arithmetic operations, general statistical operations, geometric operations; Network Analysis: Concept & Types of network analysis; Spatial Interpolation: Introduction, Control Points, Thiessen Polygons, IDW, Kriging, Trend surface analysis; Surface analysis: DEM, TIN, Contour, slope, aspect, Hill Shading, Viewshed Analysis and 3D modelling; Multi Criteria Analysis: Introduction, Site suitability Analysis.	**15**	CO3, CO4	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Anbazhagan, S., Subramanian, S.K. & Yang, X. (2011). *Geoinformatics in Applied Geomorphology*. Boca Raton, Florida: CRC Press. 2. Awange, J. & Kiema, J.B. (2013). *Environmental Geoinformatics. In Environmental Science and Engineering.* Heidelberg, Germany: Springer. 3. Karimi, H.A., editor (2014). *Big Data: Techniques und Technologies in Geoinformatics*. Boca Raton, Florida: CRC Press. 4. Li, J. (2007). *Geomatics Solutions for Disaster Management* (edited by S. Zlatanova & A. G. Fabbri). Heidelberg, Germany: Springer. 5. Longley, P. & Batty, M. (2003). *Enhanced Spatial Analysis: The CASA Book of GIS*. Redlands, California: ESRI Press. 6. Sinha, A.K., (2006). *Geoinformatics: Data to Knowledge*, Vol. 397. Boulder, Colorado: Geological Society of America. 7. Skidmore, A., (2017). *Environmental Modelling with GIS and Remote Sensing*. Boca Raton, Florida: CRC Press.			

References/ Readings:	1. Jiang, B., & Yao, X. (2010). Geospatial analysis and modelling of urban structure and dynamics. In B. Jiang & X. Yao (Eds.), Geospatial Analysis and Modelling of Urban Structure and Dynamics (pp. 1–16). Springer. https://doi.org/10.1007/978-90-481-8572-6_1 2. Weng, Q. (2009). Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications, and trends. ISPRS Journal of Photogrammetry and Remote Sensing, 64(4), 335–344 https://doi.org/10.1016/j.isprsjprs.2009.03.007 3. Batty, M. (2007). Editorial: Some thoughts on geospatial analysis and modelling. Computers, Environment and Urban Systems, 31(3), 185–190. https://doi.org/10.1016/j.compenvurbsys.2007.08.001 4. Iyer, R. T., & Krishnan, M. T. (2023). Citation network analysis of geostatistical and machine learning based spatial prediction. Spatial Information Research, 31, 625–636. https://doi.org/10.1007/s41324-023-00526-0 5. Fotheringham, A. S., Brunsdon, C., & Charlton, M. (2002). Geographically weighted regression: The analysis of spatially varying relationships. Wiley.
Web Resources:	1. ESRI – GIS and Spatial Analysis Training https://www.esri.com/training/ 2. Coursera – Geospatial and Environmental Analysis (UC Davis) https://www.coursera.org/learn/geospatial-analysis 3. GIS Lounge - Introduction to Spatial Analysis https://www.gislounge.com/spatial-analysis/ 4. QGIS Tutorials and Tips – Learn Geospatial Analysis with QGIS https://www.qgistutorials.com/en/ 5. Earth Data Science – Geospatial Data Science with Python https://www.earthdatascience.org/

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Title of the Course	Geospatial Analysis and Modelling Practical
Course Code	RSG-5011
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5003	
Course Objectives:	This course aims to provide students with hands-on experience in working with spatial and non-spatial data, performing spatial queries, and conducting overlay and network analysis. Students will also gain practical skills in spatial interpolation, surface analysis, 3D modelling, and site suitability analysis.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Perform data queries, geospatial measurements, and overlay analysis techniques	PSO 1, PSO 2
	CO 2. Execute network analysis and integrate spatial data	PSO 2
	CO 3. Apply spatial interpolation and surface analysis techniques	PSO 3
	CO 4. Perform site suitability analysis using spatial methods	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Working with Attributes; Linking spatial & non-spatial data; Data Query: Spatial & Non-spatial Query; Geospatial measurement; Overlay Analysis: Clip, Merge, Buffering, Union, Erase, Identity, Intersect; Network Analysis: Shortest path, Fastest path, Isochrone Maps, Matrix calculation;	**30**	CO1, CO2	K1, K2, K3
Module 2:	Spatial Interpolation: IDW, Kriging; Surface analysis: DEM and TIN Creation, Contour, slope, aspect, Hill Shading, Viewshed Analysis and 3D modelling; Site suitability Analysis.	**30**	CO3, CO4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Anbazhagan, S., Subramanian, S.K. & Yang, X. (2011). *Geoinformatics in Applied Geomorphology*. Boca Raton, Florida: CRC Press. 2. Awange, J. & Kiema, J.B. (2013). *Environmental Geoinformatics. In Environmental Science and Engineering.* Heidelberg, Germany: Springer. 3. Karimi, H.A., editor (2014). *Big Data: Techniques und Technologies in Geoinformatics*. Boca Raton, Florida: CRC Press. 4. Li, J. (2007). *Geomatics Solutions for Disaster Management* (edited by S. Zlatanova & A. G. Fabbri). Heidelberg, Germany: Springer. 5. Longley, P. & Batty, M. (2003). *Enhanced Spatial Analysis: The CASA Book of GIS*. Redlands, California: ESRI Press. 6. Sinha, A.K., (2006). *Geoinformatics: Data to Knowledge*, Vol. 397. Boulder, Colorado: Geological Society of America. 7. Skidmore, A., (2017). *Environmental Modelling with GIS and Remote Sensing*. Boca Raton, Florida: CRC Press.			
References/ Readings:	1. Jiang, B., & Yao, X. (2010). Geospatial analysis and modelling of urban structure and dynamics. In B. Jiang & X. Yao (Eds.), Geospatial Analysis and Modelling of Urban Structure and Dynamics (pp. 1–16). Springer. https://doi.org/10.1007/978-90-481-8572-6_1 2. Weng, Q. (2009). Thermal infrared remote sensing for urban climate and environmental studies: Methods,			

	applications, and trends. ISPRS Journal of Photogrammetry and Remote Sensing, 64(4), 335–344 https://doi.org/10.1016/j.isprsjprs.2009.03.007 3. Batty, M. (2007). Editorial: Some thoughts on geospatial analysis and modelling. Computers, Environment and Urban Systems, 31(3), 185–190. https://doi.org/10.1016/j.compenvurbsys.2007.08.001 4. Iyer, R. T., & Krishnan, M. T. (2023). Citation network analysis of geostatistical and machine learning based spatial prediction. Spatial Information Research, 31, 625–636. https://doi.org/10.1007/s41324-023-00526-0 5. Fotheringham, A. S., Brunsdon, C., & Charlton, M. (2002). Geographically weighted regression: The analysis of spatially varying relationships. Wiley.
Web Resources:	1. ESRI – GIS and Spatial Analysis Training https://www.esri.com/training/ 2. Coursera – Geospatial and Environmental Analysis (UC Davis) https://www.coursera.org/learn/geospatial-analysis 3. GIS Lounge – Introduction to Spatial Analysis https://www.gislounge.com/spatial-analysis/ 4. QGIS Tutorials and Tips – Learn Geospatial Analysis with QGIS https://www.qgistutorials.com/en/ 5. Earth Data Science – Geospatial Data Science with Python https://www.earthdatascience.org/

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Title of the Course	Aerosol Remote Sensing and Atmospheric Dynamics
Course Code	RSG-5012
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5004	
Course Objectives:	To provide advanced understanding of aerosol sources, optical properties, and interaction with atmospheric dynamics by enhancing skills in processing and interpreting aerosol data alongside meteorological profiles and reanalysis datasets.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the radiative and dynamic effects of aerosols in the atmosphere and their interaction with weather systems.	PSO 1, PSO 2
	CO 2. Understand the retrieval principles of satellite-based aerosol products and validation using AERONET data.	PSO 2
	CO 3. Analyse and apply satellite and reanalysis datasets to study aerosol transport and dynamics.	PSO 3

	CO 4. Analyse multi-sensor datasets for environmental, marine, and hazard mapping applications.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to atmospheric aerosols: sources, types, size distribution, lifetimes; Optical and radiative properties of aerosols: AOD, SSA, AE, asymmetry factor; Satellite-based aerosol sensing from various satellites of space agencies and data portals, and algorithms; Meteorological foundations: atmospheric layers, stability, boundary layer dynamics over land and ocean domains; Role of aerosols in radiation balance and atmospheric thermodynamic characterization.	**15**	CO 1	K1, K2
Module 2:	Coupling of aerosols with meteorological processes (mixing, wind transport, precipitation); AERONET validation: inversion products, quality levels, sky radiance; Case studies: crop burning, haze episodes, dust transport; Aerosol-climate feedbacks and climate model integration; Future trends: machine learning for aerosol type classification, hyperspectral observations	**15**	CO 2, CO 3, CO 4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Holton, J. R. (2004). An introduction to dynamic meteorology (4th ed.). Amsterdam, Netherlands: Elsevier Academic Press. 2. Levy, R. C., Remer, L. A., Mattoo, S., Vermote, E. F., & Kaufman, Y. J. (2013). The MODIS aerosol algorithm, products, and validation. In S. A. King (Ed.), Satellite remote sensing of the atmosphere: Techniques and applications (pp. 67–98). Amsterdam, Netherlands: Elsevier 3. Petty, G. W. (2006). A first course in atmospheric radiation (2nd ed.). Madison, Wisconsin: Sundog Publishing. 4. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.). Hoboken, New Jersey: Wiley. 5. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: An introductory survey (2nd ed.). Amsterdam, Netherlands: Academic Press			
References/ Readings:	1. Kaufman, Y. J., Tanré, D., & Boucher, O. (2002). A satellite view of aerosols in the climate system. Nature, 419(6903), 215–223. https://doi.org/10.1038/nature01091			

	2. Levy, R. C., Remer, L. A., et al. (2013). Global evaluation of the Collection 6 MODIS aerosol optical depth retrievals. Atmospheric Measurement Techniques, 6, 2989–3034. https://doi.org/10.5194/amt-6-2989-2013 3. Holben, B. N., et al. (1998). AERONET: A federated instrument network and data archive for aerosol characterization. Remote Sensing of Environment, 66(1), 1-16. https://doi.org/10.1016/S0034-4257(98)00031-5 4. Chin, M., et al. (2009). Atmospheric aerosol properties and climate impacts. Journal of the Atmospheric Sciences, 66(2), 713–731. https://doi.org/10.1175/2008JAS2796.1 5. Torres, O., Bhartia, P. K., Herman, J. R., Sinyuk, A., Holben, B., & Eck, T. F. (2002). A long-term record of aerosol optical depth from TOMS observations and comparison to AERONET measurements. Journal of the Atmospheric Sciences, 59(3), 398–413. https://doi.org/10.1175/1520-0469(2002)059<0398:ALTROA>2.0.CO;2
Web Resources:	1. NASA. (n.d.). MODIS, VIIRS, and TROPOMI aerosol data access. Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 2. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol monitoring and validation network. https://aeronet.gsfc.nasa.gov 3. European Centre for Medium-Range Weather Forecasts (ECMWF). (n.d.). Atmospheric data including aerosol forecasts and reanalysis. https://atmosphere.copernicus.eu 4. Space Applications Centre (ISRO). (n.d.). Satellite data for meteorology and oceanography. https://www.mosdac.gov.in 5. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in

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Title of the Course	Aerosol Remote Sensing and Atmospheric Dynamics Practical
Course Code	RSG-5013
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5005	
Course Objectives:	To provide advanced understanding of aerosol sources, optical properties, and interaction with atmospheric dynamics by enhancing skills in processing and interpreting aerosol data alongside meteorological profiles and reanalysis datasets.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the radiative and dynamic effects of aerosols in the atmosphere and their interaction with weather systems.	PSO 1, PSO 2
	CO 2. Understand the retrieval principles of satellite-based aerosol products and validation using AERONET data.	PSO 2
	CO 3. Analyse and apply satellite and reanalysis datasets to study aerosol transport and dynamics.	PSO 3

	CO 4. Analyse multi-sensor datasets for environmental, marine, and hazard mapping applications.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Accessing aerosol datasets from various data portals of the space agencies; Online and Offline Visualization of AOD and AE; Processing AERONET data and comparing it with satellite retrievals; Mapping of aerosol products; Meteorological profile analysis using ERA5 (temperature, RH, wind) and other data sets over different domains of land and ocean;	**30**	CO3, CO4	K2, K3
Module 2:	Case study 1: Aerosol plumes over India; Case study 2: CALIPSO-based vertical profiling of dust layers; Time-series analysis of AOD and AQI in urban regions; Wind and boundary layer height overlays with aerosol maps to study transport; Final project: Event-based aerosol-meteorology analysis, report and presentation;	**30**	CO3, CO4	K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Holton, J. R. (2004). An introduction to dynamic meteorology (4th ed.). Amsterdam, Netherlands: Elsevier Academic Press. 2. Levy, R. C., Remer, L. A., Mattoo, S., Vermote, E. F., & Kaufman, Y. J. (2013). The MODIS aerosol algorithm, products, and validation. In S. A. King (Ed.), Satellite remote sensing of the atmosphere: Techniques and applications (pp. 67–98). Amsterdam, Netherlands: Elsevier 3. Petty, G. W. (2006). A first course in atmospheric radiation (2nd ed.). Madison, Wisconsin: Sundog Publishing. 4. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.). Hoboken, New Jersey: Wiley. 5. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: An introductory survey (2nd ed.). Amsterdam, Netherlands: Academic Press			
References/ Readings:	1. Chin, M., et al. (2009). Atmospheric aerosol properties and climate impacts. Journal of the Atmospheric Sciences, 66(2), 713–731. https://doi.org/10.1175/2008JAS2796.1 2. Holben, B. N., et al. (1998). AERONET: A federated instrument network and data archive for aerosol			

	characterization. Remote Sensing of Environment, 66(1), 1-16. https://doi.org/10.1016/S0034-4257(98)00031-5 3. Kaufman, Y. J., Tanré, D., & Boucher, O. (2002). A satellite view of aerosols in the climate system. Nature, 419(6903), 215–223. https://doi.org/10.1038/nature01091 4. Levy, R. C., Remer, L. A., et al. (2013). Global evaluation of the Collection 6 MODIS aerosol optical depth retrievals. Atmospheric Measurement Techniques, 6, 2989–3034. https://doi.org/10.5194/amt-6-2989-2013 5. Torres, O., Bhartia, P. K., Herman, J. R., Sinyuk, A., Holben, B., & Eck, T. F. (2002). A long-term record of aerosol optical depth from TOMS observations and comparison to AERONET measurements. Journal of the Atmospheric Sciences, 59(3), 398–413. https://doi.org/10.1175/1520-0469(2002)059<0398:ALTROA>2.0.CO;2
Web Resources:	1. European Centre for Medium-Range Weather Forecasts (ECMWF). (n.d.). Atmospheric data including aerosol forecasts and reanalysis. https://atmosphere.copernicus.eu 2. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 3. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol monitoring and validation network. https://aeronet.gsfc.nasa.gov 4. NASA. (n.d.). MODIS, VIIRS, and TROPOMI aerosol data access. Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 5. Space Applications Centre (ISRO). (n.d.). Satellite data for meteorology and oceanography. https://www.mosdac.gov.in

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Title of the Course	Ocean Optical Modelling
Course Code	RSG-5014
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5006	
Course Objectives:	This course introduces the physical and biological foundations of ocean optical modelling and radiative transfer in aquatic environments, with a focus on the bio-optical properties of water constituents like phytoplankton, CDOM, and NAP. It covers theoretical approaches, including empirical, semi-analytical, and physics-based models, and demonstrates the application of inverse modelling and bio-optical algorithms for remote sensing of ocean colour and ecosystem monitoring.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand the interaction of electromagnetic radiation with seawater and optically active constituents.	PSO 1, PSO 2
	CO 2. Understand radiative transfer theory, absorption, scattering, and light attenuation processes in aquatic systems.	PSO 2

	CO 3. Apply bio-optical models to estimate primary production and light availability in different oceanic regimes.		PSO 3	
	CO 4. Interpret satellite-derived ocean colour data using bio-optical algorithms and case-based analysis.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Basics of electromagnetic radiation in aquatic media; Interaction of light with water molecules and suspended constituents; Radiative transfer equation (RTE): derivation and physical interpretation; Absorption, scattering, backscattering, and emission in seawater; Photosynthetically available radiation (PAR) and diffuse attenuation coefficient (Kd); Inherent and apparent optical properties (IOPs and AOPs); Phytoplankton ecology and its impact on ocean optics; Optical roles of coloured dissolved organic matter (CDOM) and non-algal particulates (NAP) in oceans, coastal waters and estuaries;	**15**	CO1	K1, K2
Module 2:	Underwater solar transmission, important variables; in-situ instruments and measurement of light underwater, and its physical principles; Optical modelling techniques, and overview empirical, (semi-) analytical, and physics-based models. Inverse modelling method and retrieval of optical properties; Atmospheric correction in ocean colour remote sensing; An overview of algorithms to retrieve chlorophyll-a, CDOM and NAP in open ocean, coastal and estuarine waters.	**15**	CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Babin, M., Roesler, C. S., & Cullen, J. J. (Eds.). (2008). *Real-time coastal observing systems for ecosystem dynamics and harmful algal blooms: Theory, instrumentation and modelling*. Paris, France: UNESCO; Boca Raton, Florida: CRC Press.. 2. IOCCG (International Ocean Colour Coordinating Group). (2000). *Remote sensing of ocean colour in coastal, and other optically complex waters.* (IOCCG Report No. 3). Dartmouth, Nova Scotia, Canada: IOCCG. 3. Kirk, J. T. O. (2011). *Light and photosynthesis in aquatic ecosystems* (3rd ed.). Cambridge, United Kingdom: Cambridge University Press.			

	4. Lee, Z. (2021). *Remote sensing of aquatic coastal ecosystem processes: Science and management applications*. Cham, Switzerland: Springer. 5. Mobley, C. D. (1994). *Light and water: Radiative transfer in natural waters*. San Diego, California: Academic Press.
References/ Readings:	1. Bricaud, A., Babin, M., Morel, A., & Claustre, H. (1995). Variability in the chlorophyll-specific absorption coefficients of natural phytoplankton: Analysis and parameterization. Journal of Geophysical Research, 100(C7), 13321–13332. https://doi.org/10.1029/95JC00463 2. Gordon, H. R., & Morel, A. (1983). Remote assessment of ocean color for interpretation of satellite visible imagery: A review. Springer-Verlag Lecture Notes in Coastal and Estuarine Studies, 4, 114 pp. 3. Lee, Z., Carder, K. L., & Arnone, R. A. (2002). Deriving inherent optical properties from water color: A multiband quasi-analytical algorithm for optically deep waters. Applied Optics, 41(27), 5755–5772. https://doi.org/10.1364/AO.41.005755 4. Morel, A., & Maritorena, S. (2001). Bio-optical properties of oceanic waters: A reappraisal. Journal of Geophysical Research: Oceans, 106(C4), 7163–7180. https://doi.org/10.1029/2000JC000319 5. Sathyendranath, S., & Platt, T. (1993). Remote sensing of water-column primary production. International Journal of Remote Sensing, 14(3), 593–609. https://doi.org/10.1080/01431169308904360
Web Resources:	1. European Centre for Medium-Range Weather Forecasts (ECMWF). (n.d.). Atmospheric data including aerosol forecasts and reanalysis. https://atmosphere.copernicus.eu 2. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 3. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol monitoring and validation network. https://aeronet.gsfc.nasa.gov 4. NASA. (n.d.). MODIS, VIIRS, and TROPOMI aerosol data access. Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 5. Space Applications Centre (ISRO). (n.d.). Satellite data for meteorology and oceanography. https://www.mosdac.gov.in

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Title of the Course	Ocean Optical Modelling Practical
Course Code	RSG-5015
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the physical and biological foundations of ocean optical modelling and radiative transfer in aquatic environments, with a focus on the bio-optical properties of water constituents like phytoplankton, CDOM, and NAP. It covers theoretical approaches, including empirical, semi-analytical, and physics-based models, and demonstrates the application of inverse modelling and bio-optical algorithms for remote sensing of ocean colour and ecosystem monitoring.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Apply satellite-based ocean colour data for retrieving chlorophyll, CDOM, and turbidity concentrations.	PSO 1, PSO 2
	CO 2. Implement semi-analytical and empirical models to process and validate ocean optical parameters.	PSO 2

	CO 3. Analyze temporal and spatial trends of ocean colour in different oceanic regimes.		PSO 3	
	CO 4. Analyze optical water types and variability.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Accessing and downloading satellite datasets from NASA Ocean Color Web; Visualization and processing of L2/L3 reflectance data; Calculation of remote sensing reflectance (Rrs) and derived properties (e.g., Kd, PAR); Applying OCx algorithms for chlorophyll-a concentration; Processing and comparison of CDOM and turbidity using semi-analytical algorithms; Quality control of ocean colour products using climatology and in-situ match-ups; QAA (Quasi-Analytical Algorithm) implementation for deriving IOPs (absorption, backscattering);	**30**	CO 1, CO 2	K2, K3, K4
Module 2:	Time-series analysis of ocean optical parameters in the open ocean; Case study: coastal eutrophication monitoring; Case study: Trends in optically active constituents; OCM Data Analysis; Case study: Influence of upwelling on optical signatures and primary production; Comparative analysis of empirical vs; semi-analytical algorithms; Integration of in-situ data for satellite validation; Spatial-temporal dynamics of one water quality parameter;	**30**	CO 3, CO 4	K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Babin, M., Roesler, C. S., & Cullen, J. J. (Eds.). (2008). Real-time coastal observing systems for ecosystem dynamics and harmful algal blooms: Theory, instrumentation and modelling. Paris, France: UNESCO; Boca Raton, Florida: CRC Press. 2. IOCCG (International Ocean Colour Coordinating Group). (2000). Remote sensing of ocean colour in coastal, and other optically complex waters. (IOCCG Report No. 3). Dartmouth, Nova Scotia, Canada: IOCCG. 3. Kirk, J. T. O. (2011). Light and photosynthesis in aquatic ecosystems (3rd ed.). Cambridge, United Kingdom: Cambridge University Press. 4. Lee, Z. (2021). Remote sensing of aquatic coastal ecosystem processes: Science and management applications. Cham, Switzerland: Springer.			

	5. Mobley, C. D. (1994). Light and water: Radiative transfer in natural waters. San Diego, California: Academic Press.
References/ Readings:	1. Bricaud, A., Babin, M., Morel, A., & Claustre, H. (1995). Variability in the chlorophyll-specific absorption coefficients of natural phytoplankton: Analysis and parameterization. Journal of Geophysical Research, 100(C7), 13321–13332. https://doi.org/10.1029/95JC00463 2. Gordon, H. R., & Morel, A. (1983). Remote assessment of ocean colour for interpretation of satellite visible imagery: A review. Springer-Verlag Lecture Notes in Coastal and Estuarine Studies, 4, 114 pp. 3. Lee, Z., Carder, K. L., & Arnone, R. A. (2002). Deriving inherent optical properties from water color: A multiband quasi-analytical algorithm for optically deep waters. Applied Optics, 41(27), 5755–5772. https://doi.org/10.1364/AO.41.005755 4. Morel, A., & Maritorena, S. (2001). Bio-optical properties of oceanic waters: A reappraisal. Journal of Geophysical Research: Oceans, 106(C4), 7163–7180. https://doi.org/10.1029/2000JC000319 5. Sathyendranath, S., & Platt, T. (1993). Remote sensing of water-column primary production. International Journal of Remote Sensing, 14(3), 593–609. https://doi.org/10.1080/01431169308904360
Web Resources:	1. European Centre for Medium-Range Weather Forecasts (ECMWF). (n.d.). Atmospheric data including aerosol forecasts and reanalysis. https://atmosphere.copernicus.eu 2. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 3. NASA Goddard Space Flight Center. (n.d.). AERONET: Aerosol monitoring and validation network. https://aeronet.gsfc.nasa.gov 4. NASA. (n.d.). MODIS, VIIRS, and TROPOMI aerosol data access. Earth Observing System Data and Information System (EOSDIS). https://earthdata.nasa.gov 5. Space Applications Centre (ISRO). (n.d.). Satellite data for meteorology and oceanography. https://www.mosdac.gov.in

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Discipline Specific Elective (DSE) Courses

Title of the Course	Remote Sensing and Climate
Course Code	RSG-5204
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the principles and techniques of remote sensing for climate system monitoring and modelling, focusing on satellite observation of key climate variables such as temperature, precipitation, aerosols, and greenhouse gases. It develops skills in interpreting climate datasets, detecting variability and trends, and understanding their relevance to global policy frameworks like the IPCC and SDGs.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Understand how satellite remote sensing contributes to observing the Earth's climate system.	PSO 1, PSO 2
	CO 2. Understand the retrieval of essential climate variables (ECVs) using passive and active	PSO 2

	satellite sensors.			
	CO 3. Use satellite-derived datasets to analyse ECV trends.		PSO 3	
	CO 4. Interpret climate variability and assess regional climate impacts and anomalies.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Climate Systems and Climate Change; Essential Climate Variables (ECVs) and Satellite-Based Climate Monitoring; Overview of Earth Observation Missions (NASA, ESA, ISRO, NOAA); Radiation Laws: Planck's Law, Stefan-Boltzmann Law, Wien's Law; Earth's Energy Balance and Radiative Transfer Principles; Atmospheric Remote Sensing and Climate Variability; Measurement of Greenhouse Gases (CO_2, CH_4, O_3) and Climate Forcing; Satellite-Based Observations of Atmospheric Temperature and Humidity; Aerosols and Their Role in Climate; Cloud Cover, Albedo, and Radiative Forcing	**15**	CO 1, CO 2	K1, K2
Module 2:	Satellite-Based Precipitation Measurements; Remote Sensing of Cyclones, Droughts, and Heatwaves; Sea Surface Temperature and Ocean Circulation (MODIS, Sentinel-3); Satellite Altimetry and Sea Level Rise Monitoring; Remote Sensing of Vegetation and Land Use Change; Monitoring Snow Cover, Glaciers, and Ice Sheets; Remote Sensing of Forest Carbon Storage; Carbon Cycle and Climate Feedbacks; Role of AI/ML in Climate Data Analysis; Climate Data Fusion: Optical, IR, and Microwave Integration; Satellite Data in Climate Policy and Mitigation Strategies;	**15**	CO 3, CO 4	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Goody, R. M., & Yung, Y. L. (1995). *Atmospheric radiation: Theoretical basis* (2nd ed.). New York, New York: Oxford University Press. 2. IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press. 3. Jensen, J. R. (2007). *Remote sensing of the environment: An Earth resource perspective* (2nd ed.). Upper Saddle River, New Jersey: Pearson.			

	4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). *Remote sensing and image interpretation* (7th ed.). Hoboken, New Jersey: Wiley. 5. Trewartha, G. T., & Horne, L. H. (1980). *An introduction to climate* (5th ed.). New York, New York: McGraw-Hill.
References/ Readings:	1. Hall, D. K., & Riggs, G. A. (2007). Accuracy assessment of the MODIS snow-cover products. Hydrological Processes, 21(12), 1534–1547. https://doi.org/10.1002/hyp.6715 2. Liu, Y. Y., et al. (2015). Recent reversal in loss of global terrestrial biomass. Nature Climate Change, 5(5), 470–474. https://doi.org/10.1038/nclimate2581 3. Trenberth, K. E., Fasullo, J. T., & Kiehl, J. (2009). Earth's global energy budget. Bulletin of the American Meteorological Society, 90(3), 311–324. https://doi.org/10.1175/2008BAMS2634.1 4. Wentz, F. J., & Schabel, M. (2000). Precise climate monitoring using complementary satellite data sets. Nature, 403(6768), 414–416. https://doi.org/10.1038/35000184 5. Zhang, Y., Rossow, W. B., Lacis, A. A., Oinas, V., & Mishchenko, M. I. (2004). Calculation of radiative fluxes from the surface to top of atmosphere based on ISCCP and other global data sets: Refinements of the radiative transfer model and the input data. Journal of Geophysical Research: Atmospheres, 109(D19). https://doi.org/10.1029/2003JD004457
Web Resources:	1. Copernicus Climate Data Store (CDS). (n.d.). Essential climate variables and ERA5 reanalysis datasets. https://cds.climate.copernicus.eu 2. IPCC Data Distribution Centre. (n.d.). Climate change scenarios, observations, and projections. https://www.ipcc-data.org 3. NASA Earthdata. (n.d.). Climate Data from MODIS, AIRS, CERES, and OCO-2. https://earthdata.nasa.gov

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Title of the Course	Remote Sensing and Climate Practical
Course Code	RSG-5205
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the principles and techniques of remote sensing for climate system monitoring and modelling, focusing on satellite observation of key climate variables such as temperature, precipitation, aerosols, and greenhouse gases. It develops skills in interpreting climate datasets, detecting variability and trends, and understanding their relevance to global policy frameworks like the IPCC and SDGs.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Apply remote sensing tools to acquire and visualise satellite-based climate datasets.	PSO 1, PSO 2
	CO 2. Process and interpret atmospheric datasets including greenhouse gases and aerosols.	PSO 2
	CO 3. Analyze precipitation trends, SST variations, and cyclone tracks using multi-temporal datasets.	PSO 3
	CO 4. Interpret climate change case studies, structured reports and policy briefs.	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Accessing global and regional climate data from NASA Earthdata/ESA Climate Change Initiative (CCI)/ISRO Bhuvan/Bhoonidhi portals; Working with NetCDF/HDF formats in Panoply, QGIS, or Python; Visualising trends in global temperature, rainfall, and carbon concentrations; Greenhouse gas analysis (CO_2, CH_4) using OCO-2, TROPOMI datasets; Aerosol Optical Depth (AOD) retrieval and analysis from MODIS; Atmospheric correction techniques for optical data pre-processing.	**30**	CO1, CO2	K1, K2
Module 2:	Satellite-based precipitation data processing; Cyclone detection and tracking using satellite imagery; Estimation of storm intensity, rainfall anomaly, and landfall impact; Sea Surface Temperature (SST) mapping and anomaly trend analysis; Time-series case studies: heatwaves, floods, or ENSO signals; Interpreting remote sensing findings to assess regional climate impacts; Communication in Climate Science: visuals, summaries, and policy briefs.	**30**	CO3, CO4	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Goody, R. M., & Yung, Y. L. (1995). Atmospheric radiation: Theoretical basis (2nd ed.). New York, New York: Oxford University Press. 2. IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press. 3. Jensen, J. R. (2007). Remote sensing of the environment: An Earth resource perspective (2nd ed.). Upper Saddle River, New Jersey: Pearson. 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote sensing and image interpretation (7th ed.). Hoboken, New Jersey: Wiley. 5. Trewartha, G. T., & Horne, L. H. (1980). An introduction to climate (5th ed.). New York, New York: McGraw-Hill.			
References/	1. Hall, D. K., & Riggs, G. A. (2007). Accuracy assessment of the MODIS snow-cover products. Hydrological			

Readings:	Processes, 21(12), 1534–1547. https://doi.org/10.1002/hyp.6715 2. Liu, Y. Y., et al. (2015). Recent reversal in the loss of global terrestrial biomass. Nature Climate Change, 5(5), 470–474. https://doi.org/10.1038/nclimate2581 3. Trenberth, K. E., Fasullo, J. T., & Kiehl, J. (2009). Earth's global energy budget. Bulletin of the American Meteorological Society, 90(3), 311–324. https://doi.org/10.1175/2008BAMS2634.1 4. Wentz, F. J., & Schabel, M. (2000). Precise climate monitoring using complementary satellite data sets. Nature, 403(6768), 414–416. https://doi.org/10.1038/35000184 5. Zhang, Y., Rossow, W. B., Lacis, A. A., Oinas, V., & Mishchenko, M. I. (2004). Calculation of radiative fluxes from the surface to the top of the atmosphere based on ISCCP and other global data sets: Refinements of the radiative transfer model and the input data. Journal of Geophysical Research: Atmospheres, 109(D19). https://doi.org/10.1029/2003JD004457
Web Resources:	1. Copernicus Climate Data Store (CDS). (n.d.). Essential climate variables and ERA5 reanalysis datasets. https://cds.climate.copernicus.eu 2. IPCC Data Distribution Centre. (n.d.). Climate change scenarios, observations, and projections. https://www.ipcc-data.org 3. NASA Earthdata. (n.d.). Climate Data from MODIS, AIRS, CERES, and OCO-2. https://earthdata.nasa.gov

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Title of the Course	Geospatial Application for Water Resource Management
Course Code	RSG-5206
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to provide students with an understanding of the role of remote sensing and GIS in understanding water resources and their management.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Explain key concepts of water resource management and watershed systems	PSO 1, PSO 2
	CO 2. Understand water interactions and quality parameters for watershed assessment.	PSO 2
	CO 3. Describe coastal hydrological systems and the impacts of sea-level rise and salinization	PSO 3
	CO 4. Assess the role of GIS models in watershed management and flood inundation mapping	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to Water Resource Management, Definition, importance, and challenges, Hydrological cycle and water balance, Surface water and groundwater interactions, Parameters affecting water quality, Concept of watershed, watershed delineation, Physical parameters of watershed; Submarine groundwater discharge (SGD).	**15**	CO 1, CO 2	K1, K2
Module 2:	Introduction to coastal hydrology and hydrogeology, Coastal aquifers, estuaries, and deltaic systems, impacts of sea-level rise, salinization, and tidal influences on freshwater availability, Water resource management challenges in coastal areas, GIS Models for watershed Management, Flood inundation mapping & 3D Modelling;	**15**	CO 3, CO 4	K1, K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Bhaskar, N. R., & James, D. L. (1993). *Surface Water Hydrology*. Englewood Cliffs, New Jersey: Prentice Hall.. 2. Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied Hydrology*. New York, New York: McGraw-Hill. 3. Goudie, A. (2013). *The Human Impact on the Natural Environment: Past, Present, and Future*. Chichester, United Kingdom: Wiley-Blackwell. 4. Grabs, W., & Martinec, J. (1991). *Hydrological Models for Water Resources System Design and Operation*. Paris, France: UNESCO. 5. Jensen, J. R. (2007). *Remote Sensing of the Environment: An Earth Resource Perspective*. Upper Saddle River, New Jersey: Pearson Education. 6. Linsley, R. K., Franzini, J. B., Freyberg, D. L., & Tchobanoglous, G. (1992). *Water Resources Engineering*. New York, New York: McGraw-Hill. 7. Maidment, D. R. (2002). *Arc Hydro: GIS for Water Resources*. Redlands, California: ESRI Press. 8. Raghunath, H. M. (2006). *Hydrology: Principles, Analysis and Design*. New Delhi, India: New Age International Publishers.			
References/ Readings:	1. Jeznach, L. C., & Granato, G. E. (2020). Comparison of SELDM simulated total-phosphorus concentrations with ecological impervious-area criteria. Journal of Environmental Engineering, 146(8), 04020077. https://doi.org/10.1061/(ASCE)EE.1943-7870.0001763 2. Nagahama, V. H., Sweeney, J., & Cahill, N. (2024). A scalable Bayesian spatiotemporal model for water level			

	predictions using a nearest neighbour Gaussian process approach. arXiv preprint arXiv:2412.06934. https://arxiv.org/abs/2412.06934 3. Rawat, S., Tateh, S., & Dubey, S. (2025). Geographical information system (GIS) applications for water resources management. *International Journal of Advanced Research in Science, Communication and Technology*, 7(1), 613–620. 4. Stonewall, A. J., Granato, G. E., & Glover-Cutter, K. M. (2019). Assessing potential effects of highway and urban runoff on receiving streams in total maximum daily load watersheds in Oregon using the Stochastic Empirical Loading and Dilution Model. U.S. Geological Survey Scientific Investigations Report 2019–5053. https://doi.org/10.3133/sir20195053 5. Weaver, J. C., Granato, G. E., & Fitzgerald, S. A. (2019). Assessing water quality from highway runoff at selected sites in North Carolina with the Stochastic Empirical Loading and Dilution Model (SELDM). U.S. Geological Survey Scientific Investigations Report 2019–5031. https://doi.org/10.3133/sir20195031
Web Resources:	1. HydroSHEDS – Hydrological Data and Mapping https://www.hydrosheds.org/ 2. India-WRIS (Water Resources Information System of India) https://indiawris.gov.in/ 3. International Water Management Institute (IWMI). https://www.iwmi.cgiar.org/ 4. National Water Informatics Centre (NWIC), India https://nwic.gov.in/ 5. World Bank – Water Resource Management. https://www.worldbank.org/en/topic/waterresourcesmanagement

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Title of the Course	Geospatial Application for Water Resource Management Practical
Course Code	RSG-5207
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to provide students with hands-on experience in using remote sensing and GIS techniques in water resource management.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Apply spectral indices and change detection techniques for mapping surface water bodies	PSO 1, PSO 2
	CO 2. Analyze spatial patterns of water quality parameters using GIS tools.	PSO 2
	CO 3. Analyze watershed and drainage for spatial analysis and assessment.	PSO 3
	CO 4. Simulate flood inundation and hydrologic processes using 3D and GIS-based models	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Familiarisation with software packages Panoply/SeaDAS/.SNAP/QGIS/ ERDAS/ArcGIS/Python/MATLAB; Mapping surface water bodies using Spectral Indices, Change detection of lakes, wetlands, and estuaries; Turbidity mapping; Visualization of water quality data in GIS (pH, EC, TDS, salinity)	30	CO 1, CO 2	K1, K2, K3
Module 2:	Watershed and drainage extraction using Digital Elevation Models; Morphometric Analysis (stream ordering, Stream length, Drainage density, Basin relief, Slope analysis); Flood inundation mapping and simulation & 3D Modelling, hydrologic simulation modelling;	30	CO 3, CO 4	K2, K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Bhaskar, N. R., & James, D. L. (1993). Surface Water Hydrology. Englewood Cliffs, New Jersey: Prentice Hall.. 2. Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). Applied Hydrology. New York, New York: McGraw-Hill. 3. Goudie, A. (2013). The Human Impact on the Natural Environment: Past, Present, and Future. Chichester, United Kingdom: Wiley-Blackwell. 4. Grabs, W., & Martinec, J. (1991). Hydrological Models for Water Resources System Design and Operation. Paris, France: UNESCO. 5. Jensen, J. R. (2007). Remote Sensing of the Environment: An Earth Resource Perspective. Upper Saddle River, New Jersey: Pearson Education. 6. Linsley, R. K., Franzini, J. B., Freyberg, D. L., & Tchobanoglous, G. (1992). Water Resources Engineering. New York, New York: McGraw-Hill. 7. Maidment, D. R. (2002). Arc Hydro: GIS for Water Resources. Redlands, California: ESRI Press. 8. Raghunath, H. M. (2006). Hydrology: Principles, Analysis and Design. New Delhi, India: New Age International Publishers.			
References/ Readings:	1. Jeznach, L. C., & Granato, G. E. (2020). Comparison of SELDM simulated total-phosphorus concentrations with ecological impervious-area criteria. Journal of Environmental Engineering, 146(8), 04020077.			

	https://doi.org/10.1061/(ASCE)EE.1943-7870.0001763 2. Nagahama, V. H., Sweeney, J., & Cahill, N. (2024). A scalable Bayesian spatiotemporal model for water level predictions using a nearest neighbour Gaussian process approach. arXiv preprint arXiv:2412.06934. https://arxiv.org/abs/2412.06934 3. Rawat, S., Tateh, S., & Dubey, S. (2025). Geographical information system (GIS) applications for water resources management. *International Journal of Advanced Research in Science, Communication and Technology*, 7(1), 613–620. 4. Stonewall, A. J., Granato, G. E., & Glover-Cutter, K. M. (2019). Assessing potential effects of highway and urban runoff on receiving streams in total maximum daily load watersheds in Oregon using the Stochastic Empirical Loading and Dilution Model. U.S. Geological Survey Scientific Investigations Report 2019–5053. https://doi.org/10.3133/sir20195053 5. Weaver, J. C., Granato, G. E., & Fitzgerald, S. A. (2019). Assessing water quality from highway runoff at selected sites in North Carolina with the Stochastic Empirical Loading and Dilution Model (SELDM). U.S. Geological Survey Scientific Investigations Report 2019–5031. https://doi.org/10.3133/sir20195031
Web Resources:	1. HydroSHEDS – Hydrological Data and Mapping https://www.hydrosheds.org/ 2. India-WRIS (Water Resources Information System of India) https://indiawris.gov.in/ 3. International Water Management Institute (IWMI). https://www.iwmi.cgiar.org/ 4. National Water Informatics Centre (NWIC), India https://nwic.gov.in/ 5. World Bank – Water Resource Management. https://www.worldbank.org/en/topic/waterresourcesmanagement

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Optical Characterisation of Inland and Coastal Waters
Course Code	RSG-6000
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course:	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5007/RSG-5008/RSG-5027/RSG-5028	
Course Objectives:	This course provides knowledge of aquatic optics and its application in inland and coastal water studies using remote sensing.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles of aquatic optics in natural waters.	PSO 1, PSO 2
	CO 2. Differentiate between inherent and apparent optical properties and their measurement techniques.	PSO 1, PSO 2

	CO 3. Evaluate the influence of water constituents (phytoplankton, CDOM, NAP) on aquatic optics.		PSO 1, PSO 2, PSO 3	
	CO 4. Apply optical characterisation in remote sensing for environmental monitoring of inland and coastal waters.		PSO 2, PSO 3, PSO 5	
Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Influence of dissolved organic matter, suspended sediments, phytoplankton and detritus, optical variability in lakes, reservoirs, estuaries, and coastal seas. Inherent optical properties and apparent optical properties (reflectance, diffuse attenuation, Secchi depth), measurement methods, bio-optical models linking IOPs and AOPs with water quality and constituent concentrations.	**12**	CO 1, CO 2	K1, K2
Module 2:	Empirical, Analytical, semi-empirical, semi-analytical, and ML-based bio-optical algorithms. Remote sensing algorithms for chlorophyll-a, CDOM, and total suspended matter; optical complexity in turbid Case-2 waters; retrieval challenges in estuaries and coastal zones; satellite missions for water quality monitoring (Landsat, Sentinel-2/3, MODIS, PACE); Applications in ecosystem monitoring, eutrophication assessment, primary productivity studies, and climate-related processes.	**18**	CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures, Tutorials and Assignments			
Texts:	1. IOCCG (2000). Remote Sensing of Ocean Colour in Coastal, and Other Optically-Complex, Waters (Report No. 3). IOCCG. https://doi.org/10.25607/OBP-95. 2. Kirk, J. T. O. (2010/2013 online). Light and Photosynthesis in Aquatic Ecosystems (3rd ed.). Cambridge Univ. Press. https://doi.org/10.1017/CBO9781139168212. 3. Mobley, C. D. (2022). The Oceanic Optics Book. IOCCG. https://doi.org/10.25607/OBP-1710.			
References/ Readings:	1. Brando, V. E., Dekker, A. G., Park, Y. J., & Schroeder, T. (2012). Adaptive semi-analytical inversion of ocean colour radiometry in optically complex waters. Applied Optics, 51(15), 2808–2833. https://doi.org/10.1364/AO.51.002808. 2. Gilerson, A. A., Gitelson, A. A., Zhou, J., et al. (2010). Algorithms for remote estimation of chlorophyll a in coastal and inland waters using red and near-infrared bands. Optics Express, 18(23), 24109–24125.			

	https://doi.org/10.1364/OE.18.024109. 3. Nechad, B., Ruddick, K. G., & Park, Y. (2010). Calibration and validation of a generic multisensor algorithm for mapping total suspended matter in turbid waters. Remote Sensing of Environment, 114(4), 854–866. https://doi.org/10.1016/j.rse.2009.11.022. 4. Odermatt, D., Gitelson, A., Brando, V. E., & Schaepman, M. (2012). Review of constituent retrieval in optically deep and complex waters from satellite imagery. Remote Sensing of Environment, 118, 116–126. https://doi.org/10.1016/j.rse.2011.11.013. 5. Sathyendranath, S., Brewin, R. J. W., Brockmann, C., et al. (2019). An ocean-colour time series for climate studies: OC-CCI. Sensors, 19(19), 4285. https://doi.org/10.3390/s19194285. 6. Stramski, D., Joshi, I., & Reynolds, R. A. (2022). Ocean colour algorithms to estimate particulate organic carbon (POC) for multi-mission records. Remote Sensing of Environment, 269, 112776. https://doi.org/10.1016/j.rse.2021.112776. 7. Werdell, P. J., & Bailey, S. W. (2005). An improved in-situ bio-optical data set for ocean colour algorithm development and satellite data product validation. Remote Sensing of Environment, 98(1), 122–140. https://doi.org/10.1016/j.rse.2005.07.001.
Web Resources:	1. IOCCG Reports: https://ioccg.org 2. NASA Ocean Color Web: https://oceancolor.gsfc.nasa.gov 3. Ocean Optics Web Book: http://www.oceanopticsbook.info

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Title of the Course	Optical Characterisation of Inland and Coastal Waters Practical
Course Code	RSG-6001
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5007/RSG-5008/RSG-5027/RSG-5028	
Course Objectives:	To provide hands-on training in the measurement, processing, and interpretation of optical properties of inland and coastal waters.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Perform field and laboratory measurements of inherent and apparent optical properties.	PSO 1, PSO 2
	CO 2. Analyse optical datasets and derive water quality parameters using bio-optical models.	PSO 2, PSO 3
	CO 3. Apply satellite data processing for the retrieval of optical water quality indicators.	PSO 2, PSO 3, PSO 5
	CO 4. Prepare reports integrating field, laboratory, and satellite observations.	PSO 3, PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Instrumentation for aquatic optics: profiling radiometers, Secchi disk; measurement of absorption, scattering, and attenuation; estimation of apparent optical properties such as reflectance and diffuse attenuation; Field surveys; collection of water samples for pigment, NAP and CDOM analysis; laboratory spectrophotometry for absorption spectra.	**30**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	Processing of in situ optical datasets; computation of IOPs and AOPs from raw measurements; bio-optical model application for estimating chlorophyll, CDOM, and NAP; Preparation of case studies and project-based reporting.	**30**	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. IOCCG (2000). Remote Sensing of Ocean Colour in Coastal, and Other Optically-Complex, Waters (Report No. 3). IOCCG. https://doi.org/10.25607/OBP-95. 2. Kirk, J. T. O. (2010/2013 online). Light and Photosynthesis in Aquatic Ecosystems (3rd ed.). Cambridge Univ. Press. https://doi.org/10.1017/CBO9781139168212. 3. Mobley, C. D. (2022). The Oceanic Optics Book. IOCCG. https://doi.org/10.25607/OBP-1710.			
References/ Readings:	1. Brando, V. E., Dekker, A. G., Park, Y. J., & Schroeder, T. (2012). Adaptive semi-analytical inversion of ocean colour radiometry in optically complex waters. Applied Optics, 51(15), 2808–2833. https://doi.org/10.1364/AO.51.002808. 2. Gilerson, A. A., Gitelson, A. A., Zhou, J., et al. (2010). Algorithms for remote estimation of chlorophyll a in coastal and inland waters using red and near-infrared bands. Optics Express, 18(23), 24109–24125. https://doi.org/10.1364/OE.18.024109. 3. Nechad, B., Ruddick, K. G., & Park, Y. (2010). Calibration and validation of a generic multisensor algorithm for mapping total suspended matter in turbid waters. Remote Sensing of Environment, 114(4), 854–866. https://doi.org/10.1016/j.rse.2009.11.022. 4. Odermatt, D., Gitelson, A., Brando, V. E., & Schaepman, M. (2012). Review of constituent retrieval in optically deep and complex waters from satellite imagery. Remote Sensing of Environment, 118, 116–126.			

	https://doi.org/10.1016/j.rse.2011.11.013. 5. Sathyendranath, S., Brewin, R. J. W., Brockmann, C., et al. (2019). An ocean-colour time series for climate studies: OC-CCI. Sensors, 19(19), 4285. https://doi.org/10.3390/s19194285. 6. Stramski, D., Joshi, I., & Reynolds, R. A. (2022). Ocean colour algorithms to estimate particulate organic carbon (POC) for multi-mission records. Remote Sensing of Environment, 269, 112776. https://doi.org/10.1016/j.rse.2021.112776. 7. Werdell, P. J., & Bailey, S. W. (2005). An improved in-situ bio-optical data set for ocean colour algorithm development and satellite data product validation. Remote Sensing of Environment, 98(1), 122–140. https://doi.org/10.1016/j.rse.2005.07.001.
Web Resources:	1. IOCCG Reports: https://ioccg.org 2. NASA Ocean Colour Web: https://oceancolor.gsfc.nasa.gov 3. Ocean Optics Web Book: http://www.oceanopticsbook.info

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Title of the Course	Microwave Remote Sensing Applications
Course Code	RSG-6002
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5001/RSG-5005/RSG-5007/RSG-5025	
Course Objectives:	To introduce principles and applications of microwave remote sensing for land, ocean, and atmospheric studies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the fundamentals of microwave interactions with natural targets.	PSO 1, PSO 2
	CO 2. Differentiate between active and passive microwave systems and their observational capabilities.	PSO 1, PSO 2
	CO 3. Analyse microwave data for applications in agriculture, forestry, hydrology, oceans, and atmosphere.	PSO 2, PSO 3
	CO 4. Evaluate the role of microwave remote sensing in disaster management, resource monitoring, and climate studies.	PSO 2, PSO 3, PSO 4

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Electromagnetic spectrum and microwave region; properties of microwaves; polarisation, wavelength dependence, and penetration capabilities; interaction with soil, vegetation, snow, ice, and ocean surfaces; dielectric properties of natural media; atmospheric effects on microwave propagation. Active and passive microwave systems; radar equation fundamentals; imaging radar and synthetic aperture radar (SAR); scatterometers, radiometers, altimeters, and SAR interferometry; spaceborne missions (ERS, RADARSAT, Sentinel-1, RISAT, Oceansat, SMAP, SMOS).	**15**	CO 2, CO 3	K1, K2, K3, K4
Module 2:	Calibration and validation concepts. Land applications: soil moisture, crop monitoring, forestry, snow and ice mapping; ocean applications: wind speed and direction, waves, currents, sea ice; atmospheric applications: rainfall retrieval, storm monitoring; disaster management: floods, landslides, cyclones, earthquakes; climate studies: long-term records of soil moisture, ice-sheet mass balance, sea-level rise.	**15**	CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures, Tutorials and Assignments			
Texts:	1. Moran, M. S. (1999), Principles and Applications of Imaging Radar, Manual of Remote Sensing, 3rd Edition, Volume 2, Eos Trans. AGU, 80(6), 67–67, doi:10.1029/99EO00047 2. Rees, W. G. (2006). Remote Sensing of Snow and Ice. CRC Press. https://doi.org/10.1201/9780367801069 3. Tsang, L., Kong, J. A., & Shin, R. T. (1985). Theory of microwave remote sensing. Wiley Series in Remote Sensing. New York. ISBN: 0471888605 4. Raizer, V. (2024). Advances in passive microwave remote sensing of oceans. CRC Press. https://doi.org/10.1201/9781003497110			
References/ Readings:	1. Colliander, A., et al. (2017). Validation of SMAP soil moisture products with core validation sites. Remote Sensing of Environment, 191, 215–231. https://doi.org/10.1016/j.rse.2017.01.021 2. Das, N. N., Entekhabi, D., Dunbar, R. S., Colliander, A., Chen, F., Crow, W., ... & Njoku, E. G. (2018). The SMAP mission combined active-passive soil moisture products at 9 km and 3 km spatial resolutions. Remote sensing of environment, 211, 204-217. https://doi.org/10.1016/j.rse.2018.04.011 3. Njoku, E. G. (2005). Passive microwave remote sensing of the Earth from space: A review. Proceedings of the			

	IEEE, 70(7), 728-750. https://doi.org/10.1109/PROC.1982.12380 4. Matzler, Christian & Rosenkranz, P.W. & Battaglia, A. & Wigneron, Jean-Pierre. (2006). Thermal Microwave Radiation - Applications for Remote Sensing. https://doi.org/10.1049/PBEW052E. 5. Zhang, L., Liu, M., He, W. *et al.* (2024). Ground Passive Microwave Remote Sensing of Atmospheric Profiles Using WRF Simulations and Machine Learning Techniques. J Meteorol Res **38**, 680–692. https://doi.org/10.1007/s13351-024-4004-2
Web Resources:	1. ESA Sentinel-1 Mission: https://sentinel.esa.int/web/sentinel/missions/sentinel-1 2. ISRO Radar Missions: https://www.isro.gov.in 3. NASA SMAP: https://smap.jpl.nasa.gov

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Title of the Course	Microwave Remote Sensing Applications Practical
Course Code	RSG-6003
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5002/RSG-5006/RSG-5008/RSG-5026	
Course Objectives:	To provide hands-on experience in processing, analysis, and interpretation of microwave remote sensing datasets for land, ocean, and atmospheric applications.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Process and visualise microwave remote sensing datasets from active and passive sensors.	PSO 2, PSO 3
	CO 2. Analyse radar backscatter and radiometric signals for land, ocean, and atmospheric studies.	PSO 1, PSO 2, PSO 3
	CO 3. Apply microwave datasets for case studies in agriculture, hydrology, oceanography, and disaster management.	PSO 2, PSO 3, PSO 4
	CO 4. Prepare reports integrating multi-sensor microwave observations with geospatial tools.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to data sources (Sentinel-1 SAR, RISAT, SMAP, SMOS, Oceansat scatterometer); data formats and download portals (ESA Copernicus Hub, NASA DAACs, ISRO Bhuvan); preprocessing workflows including radiometric calibration, speckle filtering, terrain correction, and geocoding; visualisation of backscatter coefficients and brightness temperatures; comparison of active *vs* passive datasets.	**30**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	Land: soil moisture retrieval, crop monitoring, forest biomass estimation; oceans: wind field extraction, wave spectra, sea ice mapping; atmosphere: rainfall retrieval, cyclone case studies; disasters: flood inundation mapping, landslide detection; integration of microwave datasets with GIS for thematic mapping; preparation of project reports highlighting real-world applications.	**30**	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Moran, M. S. (1999), Principles and Applications of Imaging Radar, Manual of Remote Sensing, 3rd Edition, Volume 2, Eos Trans. AGU, 80(6), 67–67. https://doi.org/10.1029/99EO00047 2. Rees, W. G. (2006). Remote Sensing of Snow and Ice. CRC Press. https://doi.org/10.1201/9780367801069 3. Tsang, L., Kong, J. A., & Shin, R. T. (1985). Theory of microwave remote sensing. Wiley Series in Remote Sensing. New York. ISBN: 0471888605 4. Raizer, V. (2024). Advances in passive microwave remote sensing of oceans. CRC Press. https://doi.org/10.1201/9781003497110			
References/ Readings:	1. Colliander, A., et al. (2017). Validation of SMAP soil moisture products with core validation sites. Remote Sensing of Environment, 191, 215–231. https://doi.org/10.1016/j.rse.2017.01.021 2. Das, N. N., Entekhabi, D., Dunbar, R. S., Colliander, A., Chen, F., Crow, W., ... & Njoku, E. G. (2018). The SMAP mission combined active-passive soil moisture products at 9 km and 3 km spatial resolutions. Remote sensing of environment, 211, 204-217. https://doi.org/10.1016/j.rse.2018.04.011 3. Njoku, E. G. (2005). Passive microwave remote sensing of the Earth from space: A review. Proceedings of the IEEE, 70(7), 728-750. https://doi.org/10.1109/PROC.1982.12380 4. Matzler, Christian & Rosenkranz, P.W. & Battaglia, A. & Wigneron, Jean-Pierre. (2006). Thermal Microwave			

	Radiation - Applications for Remote Sensing. https://doi.org/10.1049/PBEW052E. 5. Zhang, L., Liu, M., He, W. *et al.* (2024). Ground Passive Microwave Remote Sensing of Atmospheric Profiles Using WRF Simulations and Machine Learning Techniques. J Meteorol Res **38**, 680–692. https://doi.org/10.1007/s13351-024-4004-2
Web Resources:	1. ESA Sentinel-1 Mission: https://sentinel.esa.int/web/sentinel/missions/sentinel-1 2. ISRO Radar Missions: https://www.isro.gov.in 3. NASA SMAP: https://smap.jpl.nasa.gov

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Title of the Course	Geospatial Applications in Urban and Rural Development
Course Code	RSG-6004
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5003/RSG-5021/RSG-5023	
Course Objectives:	This course will provide knowledge on the use of geospatial technologies for planning, monitoring, and sustainable development of urban and rural landscapes.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the role of remote sensing and GIS in urban and rural development planning.	PSO 1, PSO 2
	CO 2. Analyse geospatial datasets for land use/land cover mapping, infrastructure planning, and resource management.	PSO 2, PSO 3
	CO 3. Apply spatial analysis techniques for urban growth, rural resource development, and socio-economic assessments.	PSO 2, PSO 3, PSO 4
	CO 4. Evaluate sustainable practices and policy frameworks using geospatial evidence.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Urban land use and land cover mapping; urban sprawl analysis and monitoring; infrastructure planning using GIS; transportation network analysis; smart city initiatives and geospatial databases; integration of census and socio-economic data with GIS; urban sustainability indicators. Agricultural land use mapping, precision agriculture and crop monitoring using remote sensing, and watershed and irrigation management.	**15**	CO 1, CO 2	K1, K2, K3
Module 2:	Rural infrastructure mapping (roads, health, education); resource distribution and accessibility analysis; GIS for rural livelihood planning and poverty alleviation. Linking urban and rural planning through geospatial integration; peri-urban dynamics and land transitions; case studies of Indian cities and villages; geospatial support to government programs (Smart Cities Mission, PMGSY, Digital India Land Records Modernisation, PMKSY); role of geospatial technologies in monitoring UN SDGs.	**15**	CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures, Tutorials and Assignments			
Texts:	1. Jensen, J. R., & Jensen, R. R. (2013). Introductory Geographic Information Systems. Pearson. ISBN: 032188535X, 9780321885357 2. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Systems and Science (4th ed.). Wiley. ISBN: 978-1-119-12845-8 3. Roy, P.S., Dwivedi, R.S., & Vijayan, D. (2010). Remote Sensing Applications, NRSC-ISRO. https://www.nrsc.gov.in/nrscnew/resources_ebooks.php			
References/ Readings:	1. Dewan, A. M., & Yamaguchi, Y. (2009). Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanisation. Applied Geography, 29(3), 390–401. https://doi.org/10.1016/j.apgeog.2008.12.005 2. Serbin, S. P., Ahl, D. E., & Gower, S. T. (2013). Spatial and temporal validation of the MODIS LAI and FPAR products across a boreal forest wildfire chronosequence. Remote Sensing of Environment, 133, 71-84. https://doi.org/10.1016/j.rse.2013.01.022 3. Zimmerman, R., & Faris, C. (2011). Climate change mitigation and adaptation in North American cities. Current			

	Opinion in Environmental Sustainability, 3(3), 181-187. https://doi.org/10.1016/j.cosust.2010.12.004 4. Qiao, Z., Tian, G., & Xiao, L. (2013). Diurnal and seasonal impacts of urbanisation on the urban thermal environment: A case study of Beijing using MODIS data. ISPRS Journal of Photogrammetry and Remote Sensing, 85, 93-101. https://doi.org/10.1016/j.isprsjprs.2013.08.010 5. Srivastava, P. K., Han, D., Ramirez, M. R., & Islam, T. (2012). Machine learning techniques for downscaling SMOS satellite soil moisture using MODIS land surface temperature for hydrological applications. Water Resources Management, 27(8), 3127–3144. https://doi.org/10.1007/s11269-013-0337-9
Web Resources:	1. FAO GeoNetwork: https://www.fao.org/geonetwork 2. ISRO Bhuvan Urban and Rural Datasets: https://bhuvan.nrsc.gov.in 3. UN-Habitat Urban Data: https://data.unhabitat.org

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Title of the Course	Geospatial Applications in Urban and Rural Development Practical
Course Code	RSG-6005
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5004/RSG-5022/RSG-5024	
Course Objectives:	This course will provide practical skills in applying remote sensing and GIS tools for urban and rural planning, monitoring, and sustainable development.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Generate and process geospatial datasets for urban and rural studies.	PSO 2
	CO 2. Perform spatial analysis for urban growth, infrastructure, and resource distribution.	PSO 2, PSO 3
	CO 3. Apply GIS and remote sensing workflows to case studies in urban sustainability and rural development.	PSO 2, PSO 3, PSO 4
	CO 4. Prepare geospatial outputs and reports for decision-making and policy support.	PSO 3, PSO 4, PSO 5

Approved by: Standing Committee of the Academic Council on 24th & 25th November 2025

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Downloading and preprocessing satellite images for urban analysis (Landsat, Sentinel-2, Cartosat); supervised and unsupervised classification for land use/land cover mapping; urban sprawl detection using time-series data; GIS-based analysis of road networks, utilities, and services; integration of socio-economic data with geospatial layers; mapping urban sustainability indicators.	**30**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	Geospatial mapping of agricultural land and crop monitoring; NDVI and vegetation indices for assessing crop health; watershed delineation and irrigation mapping using DEMs; analysis of accessibility to rural infrastructure (schools, health centres, markets) using GIS; case studies linking geospatial tools to government rural development programs (PMKSY, PMGSY, MGNREGA); preparation of thematic maps and project reports.	**30**	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. ESRI (2011). Getting to Know ArcGIS Desktop. ESRI Press. 2. QGIS Documentation: https://docs.qgis.org 3. Jensen, J. R., & Jensen, R. R. (2013). Introductory Geographic Information Systems. Pearson. ISBN: 032188535X, 9780321885357 4. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Systems and Science (4th ed.). Wiley. ISBN: 978-1-119-12845-8 5. Roy, P.S., Dwivedi, R.S., & Vijayan, D. (2010). Remote Sensing Applications, NRSC-ISRO. https://www.nrsc.gov.in/nrscnew/resources_ebooks.php			
References/ Readings:	1. Dewan, A. M., & Yamaguchi, Y. (2009). Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanisation. Applied Geography, 29(3), 390-401. https://doi.org/10.1016/j.apgeog.2008.12.005 2. Serbin, S. P., Ahl, D. E., & Gower, S. T. (2013). Spatial and temporal validation of the MODIS LAI and FPAR products across a boreal forest wildfire chronosequence. Remote Sensing of Environment, 133, 71-84. https://doi.org/10.1016/j.rse.2013.01.022			

	3. Zimmerman, R., & Faris, C. (2011). Climate change mitigation and adaptation in North American cities. Current Opinion in Environmental Sustainability, 3(3), 181-187. https://doi.org/10.1016/j.cosust.2010.12.004 4. Qiao, Z., Tian, G., & Xiao, L. (2013). Diurnal and seasonal impacts of urbanisation on the urban thermal environment: A case study of Beijing using MODIS data. ISPRS Journal of Photogrammetry and Remote Sensing, 85, 93-101. https://doi.org/10.1016/j.isprsjprs.2013.08.010 5. Srivastava, P. K., Han, D., Ramirez, M. R., & Islam, T. (2012). Machine learning techniques for downscaling SMOS satellite soil moisture using MODIS land surface temperature for hydrological applications. Water Resources Management, 27(8), 3127–3144. https://doi.org/10.1007/s11269-013-0337-9
Web Resources:	1. FAO Handbooks on GIS for Agriculture: https://www.fao.org/geospatial 2. ISRO Bhuvan Urban & Rural Development: https://bhuvan.nrsc.gov.in 3. OpenStreetMap for Urban & Rural Data: https://www.openstreetmap.org

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Title of the Course	Advanced Topics in Ocean Data Assimilation
Course Code	RSG-6006
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5005/RSG-5007/RSG-5025/RSG-5027	
Course Objectives:	This course will introduce advanced concepts, methods, and applications of data assimilation in ocean modelling for improved forecasting and climate studies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles of ocean data assimilation and its role in ocean state estimation.	PSO 1, PSO 2
	CO 2. Differentiate between variational, ensemble, and hybrid methods in the context of ocean modelling.	PSO 1, PSO 2
	CO 3. Apply assimilation techniques to integrate satellite and in situ ocean observations with numerical models.	PSO 2, PSO 3
	CO 4. Evaluate the role of ocean data assimilation in forecasting, reanalysis, and coupled Earth system modelling.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Overview of ocean circulation models (e.g., MOM, MITgcm, NEMO, HYCOM); need for data assimilation in oceanography; observations used in ocean assimilation: satellite (SST, SSH, ocean colour, scatterometer winds, altimetry) and in situ (Argo, moorings, gliders, ship-based CTD); role of observational errors and background error covariances; operational systems for ocean forecasting (Mercator, HYCOM, INCOIS-IMODS). Optimal interpolation for ocean state estimation; variational methods (3D-Var, 4D-Var) in ocean models; ensemble methods (EnKF, filters, hybrid schemes); assimilation of different ocean observations (SSH altimetry, SST, ocean colour, Argo profiles); challenges in assimilating biogeochemical and ecosystem variables; introduction to coupled ocean-atmosphere assimilation.	**18**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	Ocean forecasting (currents, temperature, salinity); data assimilation for cyclone track and storm surge prediction; reanalyses (GLORYS, ORAS5, ECCO, INCOIS reanalysis products); role in climate studies (ENSO prediction, Indian Ocean Dipole, monsoon variability); ocean data assimilation in support of the Blue Economy (fisheries, shipping, offshore operations).	**12**	CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Cushman-Roisin, B., & Beckers, J. M. (2011). Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects. International Geophysics, Elsevier, B.V. https://www.sciencedirect.com/bookseries/international-geophysics/vol/101 2. Lahoz, W., Khattatov, B., & Ménard, R. (Eds.). (2010). Data Assimilation: Making Sense of Observations. Springer. https://doi.org/10.1007/978-3-540-74703-1 3. Schiller, A., & Brassington, G. B. (Eds.). (2011). Operational Oceanography in the 21st Century. Springer. https://doi.org/10.1007/978-94-007-0332-2			
References/ Readings:	1. Balmaseda, M. A., Mogensen, K., & Weaver, A. T. (2013). Evaluation of the ECMWF ocean reanalysis system ORAS4. Quarterly Journal of the Royal Meteorological Society, 139(674), 1132–1161. https://doi.org/10.1002/qj.2063 2. Mirocha, J., Kosović, B., & Kirkil, G. (2014). Resolved turbulence characteristics in large-eddy simulations nested			

	within mesoscale simulations using the Weather Research and Forecasting Model. Monthly Weather Review, 142(2), 806-831. https://doi.org/10.1175/MWR-D-13-00064.1 3. Doi, T., Storto, A., Behera, S. K., Navarra, A., & Yamagata, T. (2017). Improved prediction of the Indian Ocean dipole mode by use of subsurface ocean observations. Journal of Climate, 30(19), 7953-7970. https://doi.org/10.1175/JCLI-D-16-0915.1 4. Penny, S. G., & Hamill, T. M. (2017). Coupled data assimilation for integrated earth system analysis and prediction. Bulletin of the American Meteorological Society, 98(7), ES169-ES172. https://ntrs.nasa.gov/api/citations/20170007430/downloads/20170007430.pdf 5. Stammer, D., et al. (2016). Ocean data assimilation in support of climate applications: Status and perspectives. Annual Review of Marine Science, 8, 491–518. https://doi.org/10.1146/annurev-marine-122414-034113
Web Resources:	1. INCOIS Indian Ocean Forecasting: https://incois.gov.in 2. ECCO Ocean Reanalysis: https://ecco-group.org 3. Mercator Ocean International: https://www.mercator-ocean.eu

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Title of the Course	Advanced Topics in Ocean Data Assimilation Practical
Course Code	RSG-6007
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	RSG-5006/RSG-5008/RSG-5026/RSG-5028	
Course Objectives:	This course will provide practical training in handling, processing, and assimilating ocean observational datasets into numerical models for forecasting and climate studies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Access and preprocess satellite and in situ oceanographic datasets for assimilation.	PSO 2
	CO 2. Apply data assimilation techniques to improve ocean model outputs.	PSO 2, PSO 3
	CO 3. Analyse case studies of ocean forecasting, reanalysis, and climate variability using assimilated products.	PSO 3, PSO 4
	CO 4. Prepare scientific outputs and reports demonstrating the utility of ocean data assimilation.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Downloading and handling Argo profile data (temperature, salinity); preprocessing satellite SST, SSH (altimetry), and ocean colour datasets; introduction to Copernicus Marine Environment Monitoring Service (CMEMS), NODC, and ECCO data portals; gridding, interpolation, and quality control of observational datasets; preparing observation files for assimilation experiments.	**30**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	Running simplified assimilation workflows (optimal interpolation, ensemble methods) in ocean state estimation; integration of datasets and case studies; analysis of assimilated fields for ocean circulation and thermal structure; case studies of ENSO/Indian Ocean Dipole/MJO events; evaluation of reanalysis products (ORAS5, GLORYS, ECCO, ERA5); preparation of project-based reports demonstrating applications in forecasting and climate studies.	**30**	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Cushman-Roisin, B., & Beckers, J. M. (2011). Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects. International Geophysics, Elsevier, B.V. https://www.sciencedirect.com/bookseries/international-geophysics/vol/101 2. Lahoz, W., Khattatov, B., & Ménard, R. (Eds.). (2010). *Data Assimilation: Making Sense of Observations*. Springer. https://doi.org/10.1007/978-3-540-74703-1 3. Schiller, A., & Brassington, G. B. (Eds.). (2011). Operational Oceanography in the 21st Century. Springer. https://doi.org/10.1007/978-94-007-0332-2			
References/ Readings:	1. Balmaseda, M. A., Mogensen, K., & Weaver, A. T. (2013). Evaluation of the ECMWF ocean reanalysis system ORAS4. Quarterly Journal of the Royal Meteorological Society, 139(674), 1132–1161. https://doi.org/10.1002/qj.2063 2. Mirocha, J., Kosović, B., & Kirkil, G. (2014). Resolved turbulence characteristics in large-eddy simulations nested within mesoscale simulations using the Weather Research and Forecasting Model. Monthly Weather Review, 142(2), 806-831. https://doi.org/10.1175/MWR-D-13-00064.1 3. Doi, T., Storto, A., Behera, S. K., Navarra, A., & Yamagata, T. (2017). Improved prediction of the Indian Ocean dipole mode by use of subsurface ocean observations. Journal of Climate, 30(19), 7953-7970.			

	https://doi.org/10.1175/JCLI-D-16-0915.1 4. Penny, S. G., & Hamill, T. M. (2017). Coupled data assimilation for integrated earth system analysis and prediction. Bulletin of the American Meteorological Society, 98(7), ES169-ES172. https://ntrs.nasa.gov/api/citations/20170007430/downloads/20170007430.pdf 5. Stammer, D., et al. (2016). Ocean data assimilation in support of climate applications: Status and perspectives. Annual Review of Marine Science, 8, 491–518. https://doi.org/10.1146/annurev-marine-122414-034113
Web Resources:	1. INCOIS Ocean Forecasting Services: https://incois.gov.in 2. CMEMS Data Portal: https://marine.copernicus.eu 3. ECCO Reanalysis Products: https://ecco-group.org

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Title of the Course	Cultural Landscapes and Geospatial Heritage in India
Course Code	RSG-6008
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course will help students understand India's cultural landscapes and heritage, and their interpretation through geospatial technologies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the concept of cultural landscapes and their evolution in the Indian context.	PSO 1, PSO 5
	CO 2. Analyse spatial patterns of heritage, pilgrimage, and settlement landscapes using geospatial tools.	PSO 2, PSO 3, PSO 4
	CO 3. Apply GIS and remote sensing techniques for mapping and conserving tangible and intangible heritage.	
	CO 4. Evaluate national and international frameworks for heritage management and sustainable tourism.	

Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Concept of cultural landscapes and history of remote sensing; UNESCO World Heritage Sites in India; sacred landscapes, pilgrimage circuits, temple towns, stepwells, ghats, and traditional agricultural landscapes; cultural routes such as the *Char Dham Yatra* and Buddhist Circuit corridors and hazard zonation; role of cultural geography in shaping India's identity.	**14**	CO 1, CO 2	K1, K2
Module 2:	Applications of Remote Sensing and GIS in heritage documentation; archaeological remote sensing; digital heritage mapping of monuments, forts, and temple complexes; 3D modelling using UAVs and photogrammetry; integration of cultural heritage datasets into national portals (Bhuvan, ASI heritage GIS); case studies of geospatial documentation of heritage sites in India. Integration of cultural and natural heritage for sustainable tourism: policy frameworks - UNESCO, INTACH, and India's National Heritage Mission.	**16**	CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures/Assignments			
Texts:	1. Rajani, M. B. (2021). Patterns in Past Settlements: Geospatial Analysis of Imprints of Cultural Heritage on Landscapes. Springer Verlag, Singapore. ISBN-13: 978-9811574689 2. Mitchell, N., Rössler, M., & Tricaud, P.-M. (2009). World Heritage Cultural Landscapes: A Handbook for Conservation and Management. UNESCO World Heritage Centre. https://whc.unesco.org/documents/publi_wh_papers_26_en.pdf 3. Jain, S. (2021). India: UNESCO World Heritage Sites. Hirmer-Verlag, Hirmer. ISBN-13: 978-3777435718 4. Dwivedi, S. (2016). Buddhist Heritage Sites of India: Foreword by His Holiness - The Dalai Lama. Rupa Publications India. ISBN-13: 978-8129142375 5. Shrestha, G. B., & Ray, P. K. C. (2007). Application of remote sensing and GIS in landslide hazard zonation of Joshimath-Badrinath road corridor, Garhwal Himalaya, India. *Journal of Nepal Geological Society*, *35*, 67–74. https://doi.org/10.3126/jngs.v35i0.23641			
Web Resources:	1. UNESCO World Heritage Centre: https://whc.unesco.org 2. ISRO Bhuvan Cultural Heritage Portal: https://bhuvan.nrsc.gov.in			

	3. Archaeological Survey of India (ASI): https://asi.nic.in

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Title of the Course	Research Methodology
Course Code	RSG-6009
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To train students in scientific research methods, design, and communication, with emphasis on applications in Remote Sensing and GIS.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles of research design, scientific methods, and ethics in geospatial sciences.	PSO 1, PSO 5
	CO 2. Formulate research questions, hypotheses, and methodologies specific to Remote Sensing and GIS.	PSO 2, PSO 3
	CO 3. Apply statistical, computational, and geospatial techniques for data analysis and interpretation.	PSO 2, PSO 3
	CO 4. Prepare research reports, proposals, and scientific communication outputs for	PSO 3, PSO 4, PSO 5

	multidisciplinary audiences.			
Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Philosophy and process of scientific research; epistemology and ontology in Earth system sciences; types of research (exploratory, descriptive, analytical, experimental); research ethics, plagiarism, and intellectual property rights; role of Remote Sensing and GIS in interdisciplinary research.	**10**	CO 1	K1, K2
Module 2:	Problem identification and statement; objectives and hypothesis formulation; qualitative and quantitative approaches; experimental and observational research designs; sampling methods for field surveys; integration of Remote Sensing and GIS into research workflows; designing research protocols aligned with SDGs and national missions.	**20**	CO 2	K1, K2, K3, K4
Module 3:	Data collection from primary (field, laboratory) and secondary (satellite archives, databases) sources; data cleaning and preprocessing; statistical methods (descriptive statistics, correlation, regression, hypothesis testing); spatial statistics and geostatistics (interpolation, clustering, spatial autocorrelation); use of open-source and proprietary software (R, Python, QGIS, ArcGIS, MATLAB). Structure of research reports, theses, and scientific papers; citation styles and reference management; preparation of research proposals for funding agencies; oral and poster presentation skills; communicating science to policymakers, media, and public; open science and reproducibility in geospatial research.	**30**	CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Kothari, C. R. (2013). Research Methodology: Methods and Techniques (2nd ed.). New Age International Publishers. Jaipur. 2. Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.). Sage Publications. Thousand Oaks, California. 3. Montgomery, D. C., & Runger, G. C. (2014). Applied Statistics and Probability for Engineers (6th ed.). Wiley. India.			

References/ Readings:	6. Foody, G. M. (2002). Status of land cover classification accuracy assessment. Remote Sensing of Environment, 80(1), 185–201. https://doi.org/10.1016/S0034-4257(01)00295-4 7. Pontius Jr, R. G., & Millones, M. (2011). Death to Kappa: birth of quantity disagreement and allocation disagreement for accuracy assessment. International journal of remote sensing, 32(15), 4407-4429. https://doi.org/10.1080/01431161.2011.552923 8. Zimmerman, R., & Faris, C. (2011). Climate change mitigation and adaptation in North American cities. Current Opinion in Environmental Sustainability, 3(3), 181-187. https://doi.org/10.1016/j.cosust.2010.12.004 9. Qiao, Z., Tian, G., & Xiao, L. (2013). Diurnal and seasonal impacts of urbanization on the urban thermal environment: A case study of Beijing using MODIS data. *ISPRS Journal of Photogrammetry and Remote Sensing*, *85*, 93-101. https://doi.org/10.1016/j.isprsjprs.2013.08.010 10. Srivastava, P. K., Han, D., Ramirez, M. R., & Islam, T. (2012). Machine learning techniques for downscaling SMOS satellite soil moisture using MODIS land surface temperature for hydrological application. Water Resources Management, 27(8), 3127–3144. https://doi.org/10.1007/s11269-013-0337-9
Web Resources:	1. UGC-INFLIBNET Research Tools: https://www.inflibnet.ac.in 2. NASA Earthdata: https://earthdata.nasa.gov 3. ESRI Research Methodology Resources: https://www.esri.com/en-us/what-we-do/research

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Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Python for Geosciences
Course Code	RSG-6401
Number of Credits	2T + 2P
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide students with a theoretical understanding of Python programming concepts and their applications in geosciences.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the fundamentals of Python programming, syntax, and data structures.	PSO 2
	CO 2. Describe Python libraries relevant to data analysis and geosciences (NumPy, Pandas, Matplotlib).	PSO 2
	CO 3. Analyse geospatial data handling workflows in Python.	PSO 2, PSO 3
	CO 4. Evaluate the role of Python in modern geoscientific research and problem-solving.	PSO 3, PSO 4

Approved by: Standing Committee of the Academic Council on 24th & 25th November 2025

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Python basics: syntax, data types, operators, loops, conditional statements, functions; introduction to Anaconda, Jupyter Notebook environment; overview of scientific libraries. Concepts of data handling and visualisation in Python; reading CSV, NetCDF, and shapefiles; workflows for geoscientific datasets; principles of reproducible programming of geophysical variables, integrating remote sensing long-term data sets. Trends, Climatology, Time-series analysis and assessment. Anomalies and Clustering techniques. Uncertainties and Projections.	**30**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Module 2:	Hands-on with NumPy and Pandas: array operations, data cleaning, descriptive statistics; plotting geoscientific data with Matplotlib; exercises on temperature and rainfall datasets. Geospatial workflows: handling NetCDF climate data with xarray/netCDF4; raster and vector operations with Rasterio and Geopandas; case studies on ocean colour, SST, and precipitation anomalies; project-based scripting, assessment, and presentations.	**60**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K5, K6
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures and Assignments.			
Texts:	1. Zelle, J. (2017). Python Programming: An Introduction to Computer Science. Franklin, Beedle & Associates. 2. Wes McKinney (2017). Python for Data Analysis. O'Reilly. 3. Johansson, F. (2019). Numerical Python. Apress. 4. VanderPlas, J. (2016). *Python Data Science Handbook*. O'Reilly. 5. Raschka, S. (2015). *Python Machine Learning*. Packt.			
Web Resources:	1. https://docs.python.org 2. https://geopandas.org 3. https://xarray.pydata.org			

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Title of the Course	GNSS and Map Projections
Course Code	RSG-6402
Number of Credits	2T + 2P
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide knowledge and hands-on skills in Global Navigation Satellite Systems (GNSS) and map projections for geospatial applications.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles of GNSS, satellite positioning, and reference systems.	PSO 2
	CO 2. Apply GNSS instruments and data processing techniques for positioning and navigation.	PSO 2, PSO 3
	CO 3. Analyse coordinate systems, datums, and map projections for geospatial integration.	PSO 3, PSO 4
	CO 4. Create accurate geospatial outputs by integrating GNSS data with GIS and remote sensing.	PSO 3, PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to GNSS, NAVIC; History of Navigation and Positioning; Objectives; Types of Earth's Positioning System; GPS, GALILEO and GLONASS; GPS Components: space segment, Control segment, User segment; GPS Receiver and its Types; GPS Errors; Differential Global Positioning System (DGPS); Satellite Based Augmentation System (SBAS), GAGAN. Fundamentals of coordinate systems (geographic, projected), datums (WGS84, Everest, NAD83); concepts of projections (cylindrical, conic, azimuthal) and distortions; use of GIS software for projection transformation. Selection of appropriate projection for spatial analysis and mapping, Impact of projection choice on spatial data accuracy and analysis	**30**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4
Module 2:	Procedure for GPS Survey, Handling GPS Device, GPS Survey (Mark the point, Tracking, Point and Line generation); Data Conversion: Excel to Shapefile, GPS to GPX, KML/KMZ to Shapefile. Procedure for DGPS Survey, DGPS setting of Instruments: Base and Rover; DGPS Survey: Real-Time Kinematic (RTK) Survey, Post-Processed Kinematic (PPK) Survey, DGPS Survey Data Processing.; Project & Reproject Geospatial data Reprojection and transformation techniques in GIS software.	**60**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures/Assignments			
Texts:	1. Hofmann-Wellenhof, B., Lichtenegger, H., & Collins, J. (2012). Global Positioning System: Theory and Practice. Springer. 2. Misra, P., & Enge, P. (2011). Global Positioning System: Signals, Measurements, and Performance. Ganga-Jamuna Press. 3. Snyder, J. P. (1987). Map Projections: A Working Manual. USGS Professional Paper 1395.			
References/ Readings:	1. Rizos, C. (2002). Network RTK research and implementation: A geodetic perspective. *Journal of Global Positioning Systems*, *1*(2), 144–150. 2. Soler, T., & Snay, R. A. (2004). Transforming positions and velocities between the International Terrestrial Reference Frame of 2000 and the North American Datum of 1983. *Journal of Surveying Engineering*, *130*(2), 49–55.			

Web Resources:	1. NavIC (ISRO): https://www.isro.gov.in/NavIC 2. IGS (International GNSS Service): https://www.igs.org 3. EPSG Geodetic Parameter Dataset: https://epsg.org

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Title of the Course	Geospatial Analysis for Weather Applications
Course Code	RSG-6403
Number of Credits	2T + 2P
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide theoretical understanding of geospatial methods and datasets for weather monitoring and analysis.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain fundamental weather parameters and their geospatial representation.	PSO 1, PSO 2
	CO 2. Describe remote sensing missions and ground-based networks for weather monitoring.	PSO 1, PSO 2
	CO 3. Analyse geospatial techniques for mapping extreme weather events.	PSO 2, PSO 3
	CO 4. Evaluate the role of geospatial methods in regional weather prediction and risk assessment.	PSO 3, PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to weather systems: temperature, rainfall, pressure, winds; weather data sources (IMD, NOAA, ECMWF, ISRO satellites); overview of INSAT, NOAA, Meteosat, Himawari missions; GIS for weather integration. Geospatial methods for weather: spatial interpolation of meteorological data, mapping anomalies; cyclone and flood mapping; case studies of Indian monsoon variability and extreme events.	**30**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4
Module 2:	Hands-on with IMD rainfall data, INSAT and NOAA satellite products; preprocessing datasets; GIS-based rainfall and temperature interpolation and statistical techniques; plotting synoptic-scale weather maps. Case studies: cyclone track mapping (Bay of Bengal, Arabian Sea); flood and heatwave analysis; trend analysis of rainfall variability; preparation of weather risk maps using GIS; project-based reporting.	**60**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures and Assignments			
Texts:	1. Kuligowski, R. J., et al. (Eds.). (2020). Satellite Precipitation Measurement: Volume 1-Applications. Springer. https://doi.org/10.1007/978-3-030-24568-9 2. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric Science: An Introductory Survey (2nd ed.). Academic Press. https://doi.org/10.1016/C2009-0-00034-8			
References/ Readings:	1. Hou, A. Y., et al. (2014). The Global Precipitation Measurement (GPM) mission. Bulletin of the American Meteorological Society, 95(5), 701–722. https://doi.org/10.1175/BAMS-D-13-00164.1 2. Justice, C. O., et al. (2002). An overview of MODIS Land data processing and product status. Remote Sensing of Environment, 83(1–2), 3–15. https://doi.org/10.1016/S0034-4257(02)00084-6 3. Kazemi Garajeh, M., Haji, F., Tohidfar, M. et al. Spatiotemporal monitoring of climate change impacts on water resources using an integrated approach of remote sensing and Google Earth Engine. Sci Rep 14, 5469 (2024). https://doi.org/10.1038/s41598-024-56160-9 4. Roy Bhowmik, S. K., & Durai, V. R. (2008). Real-time weather prediction using satellite data over the Indian region. Mausam, 59(1), 83–94. 5. Tian, Y., and C. D. Peters-Lidard (2007), Systematic anomalies over inland water bodies in satellite-based precipitation estimates, Geophys. Res. Lett., 34, L14403, doi:10.1029/2007GL030787.			

Web Resources:	1. IMD Weather Data: https://mausam.imd.gov.in 2. NASA Giovanni Climate Data Portal: https://giovanni.gsfc.nasa.gov 3. NOAA Climate Data Records: https://www.ncdc.noaa.gov

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Title of the Course	Lifelong Learning: Large Marine Ecosystems
Course Code	RSG-6404
Number of Credits	2T + 2P
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide conceptual understanding of the structure, functioning, and management of Large Marine Ecosystems (LMEs), and the application of remote sensing technologies.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the ecological and physical characteristics of Large Marine Ecosystems.	PSO 1
	CO 2. Describe global distribution, productivity, and biodiversity patterns in LMEs.	PSO 1, PSO 2
	CO 3. Analyse human impacts and governance frameworks of LMEs.	PSO 3, PSO 4
	CO 4. Evaluate sustainability and policy approaches for effective LME management.	PSO 3, PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Definition and classification of LMEs; global distribution; ecological features (productivity, fish stocks, pollution, ecosystem health); role of LMEs in global ocean-climate interactions with emphasis on remote sensing and geospatial technologies. Socio-economic pressures on LMEs (fisheries, pollution, climate change, shipping); Concept and functioning of Urban Seas; International governance frameworks (UNEP, IOC-UNESCO, GEF projects); Case studies on Bay of Bengal and Arabian Sea LMEs.	**30**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
Module 2:	Practical on satellite datasets (MODIS, OLCI, OC-CCI, etc.) for productivity and SST; Comparative seasonal analysis and climatology of primary productivity of LMEs; time-series analysis of marine productivity in selected LMEs. Case study projects: Bay of Bengal, Arabian Sea, and Humboldt Current LMEs, etc.; assessment of socio-economic drivers using open datasets (FAO, World Bank, UNEP); Project and final presentation.	**60**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K6
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures and Assignments			
Texts:	1. IOC-UNESCO. (2016). A Handbook on Governance and Socioeconomics of Large Marine Ecosystems. UNESCO Publishing. https://wedocs.unep.org/bitstream/handle/20.500.11822/12485/lme_gov_handbook.pdf 2. Sherman, K., & Hempel, G. (Eds.). (2009). The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas. UNEP. https://www.undp.org/sites/g/files/zskgke326/files/publications/UNDP%20Report,%20Large%20marine%20ecosystem_WEB.PDF			
References/ Readings:	1. Duda, A. M., & Sherman, K. (2002). A new imperative for improving management of Large Marine Ecosystems. Ocean & Coastal Management, 45(11–12), 797–833. https://doi.org/10.1016/S0964-5691(02)00107-2 2. Haugen, J.B., Link, J.S., Cribari, K. et al. Marine ecosystem-based management: challenges remain, yet solutions exist, and progress is occurring. npj Ocean Sustain 3, 7 (2024). https://doi.org/10.1038/s44183-024-00041-1 3. ICES. ICES Stakeholder Engagement Strategy. 1756180 Bytes https://ices-library.figshare.com/articles/report/ICES_Stakeholder_Engagement_Strategy/21815106/1 (2023) https://doi.org/10.17895/ICES.PUB.21815106.V1.			

	4. Kelley, E., & Sherman, K. (2018). Trends of the Large Marine Ecosystem assessment and management approach as reflected in the literature. Ocean & Coastal Management, 155, 104–112. https://doi.org/10.1016/j.ocecoaman.2017.12.008 5. Kirstin Holsman, Jameal Samhouri, Geoffrey Cook, Elliott Hazen, Erik Olsen, Maria Dillard, Stephen Kasperski, Sarah Gaichas, Christopher R. Kelble, Mike Fogarty, et al. An ecosystem-based approach to marine risk assessment. Ecosyst Health Sustain. 2017;3(1):e01256.DOI:10.1002/ehs2.1256
Web Resources:	1. LME Portal: https://lme.edc.uri.edu 2. IOC-UNESCO Marine Policy Resources: https://ioc.unesco.org 3. FAO Fisheries & Aquaculture: https://www.fao.org/fishery

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SEMESTER IV

Generic Elective (GE) Courses

Title of the Course	Remote Sensing and GIS for Coastal Zone Management and Sustainability
Course Code	RSG-6201
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide knowledge and analytical skills in applying remote sensing and GIS for coastal zone monitoring, management, and sustainability.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles and techniques of remote sensing and GIS in coastal zone studies.	PSO 1, PSO 2
	CO 2. Analyse coastal processes, landforms, and ecosystems using geospatial datasets.	PSO 1, PSO 2, PSO 3
	CO 3. Apply geospatial tools for integrated coastal zone management (ICZM), hazard	PSO 2, PSO 3, PSO 4

	monitoring, and policy support.			
	CO 4. Evaluate sustainability strategies for coastal environments through geospatial evidence and case studies.		PSO 3, PSO 4, PSO 5	
Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to coastal zones: geomorphology, hydrodynamics, and ecosystems; coastal processes including tides, waves, sediment transport, and shoreline change; overview of remote sensing and GIS principles for coastal applications; data sources (Landsat, Sentinel, IRS, high-resolution commercial satellites, UAVs); GIS layers for coastal mapping and monitoring.	**10**	CO 1	K1, K2
Module 2:	Mapping and monitoring of coastal landforms (beaches, dunes, estuaries, deltas, lagoons, mangroves, coral reefs); application of multispectral, hyperspectral, and LiDAR data for coastal resource assessment; habitat mapping and change detection; role of geospatial technologies in biodiversity conservation and blue carbon ecosystems.	**15**	CO 2	K1, K2, K3
Module 3:	Remote sensing for monitoring coastal hazards: erosion, storms, floods, sea-level rise, and oil spills; GIS-based vulnerability and risk assessment; ICZM frameworks, zonation maps, and coastal regulation zone (CRZ) mapping; case studies from India and global coastal regions; integration of socio-economic and ecological data.	**20**	CO 3	K1, K2, K3, K4
Module 4:	Sustainable coastal development: ecosystem services, fisheries, aquaculture, and tourism; climate change impacts on coastal zones; geospatial tools for monitoring SDGs related to coastal sustainability; participatory GIS and community-based monitoring; policy frameworks (UNEP, ICZM India, Blue Economy initiatives); case studies highlighting successful sustainable practices.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Clark, J. R. (1996). *Coastal Zone Management Handbook*. CRC Press. https://doi.org/10.1201/9781315139654 2. Ramkumar, M., James, A., & Menier, D. (Eds.). (2018). *Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues*. Elsevier. ISBN: 978012814350			

References/ Readings:	1. Kuleli, T., Guneroglu, A., Karsli, F., & Dihkan, M. (2011). Automatic detection of shoreline change on coastal Ramsar wetlands of Turkey. Ocean Engineering, 38(10), 1141-1149. https://doi.org/10.1016/j.oceaneng.2011.05.006 2. Li, R., Liu, W., Yang, L., Sun, S., Hu, W., Zhang, F., & Li, W. (2018). DeepUNet: A deep fully convolutional network for pixel-level sea-land segmentation. IEEE journal of selected topics in applied earth observations and remote sensing, 11(11), 3954-3962. https://doi.org/10.1109/JSTARS.2018.2833382 3. Toure, S., Diop, O., Kpalma, K., & Maiga, A. S. (2019). Shoreline detection using optical remote sensing: A review. *ISPRS International Journal of Geo-Information*, *8*(2), 75. https://doi.org/10.3390/ijgi8020075 4. Vos, K., Splinter, K. D., Harley, M. D., Simmons, J. A., & Turner, I. L. (2019). CoastSat: A Google Earth Engine-enabled Python toolkit to extract shorelines from publicly available satellite imagery. Environmental Modelling & Software, 122, 104528. https://doi.org/10.1016/j.envsoft.2019.104528
Web Resources:	1. ICZM Project India: https://iczmpwb.org 2. UNEP Coastal Management Resources: https://www.unep.org 3. NOAA Digital Coast: https://coast.noaa.gov/digitalcoast

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Title of the Course	Aerosol and Regional Weather
Course Code	RSG-6202
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:		
Course Objectives:	The students shall learning the role of aerosols in atmospheric processes and their impact on regional weather using observational, remote sensing, and modelling approaches.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the sources, properties, and measurement techniques of aerosols.	PSO 1, PSO 2
	CO 2. Analyse aerosol-radiation and aerosol-cloud interactions and their implications for weather.	PSO 1, PSO 2, PSO 3
	CO 3. Apply remote sensing and ground-based observations to assess aerosol distributions and variability.	PSO 2, PSO 3
	CO 4. Evaluate the role of aerosols in regional climate and weather extremes through case studies and model outputs.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Definition and classification of aerosols; natural and anthropogenic sources; physical, chemical, and optical properties; transport and removal processes; methods of aerosol measurement (ground-based: AERONET, lidars; in situ samplers).	**10**	CO 1	K1, K2
Module 2:	Aerosol-radiation interactions: scattering, absorption, direct and semi-direct effects; aerosol-cloud interactions: CCN, IN, cloud microphysics, cloud lifetime effect; influence of aerosols on monsoons, precipitation, and boundary layer dynamics.	**15**	CO 2	K1, K2, K3, K4
Module 3:	Satellite aerosol products (MODIS, MISR, VIIRS, Sentinel-5P, CALIPSO); ground-based networks (AERONET, SKYNET, MPLNET); data assimilation of aerosol properties; case studies of aerosol variability over India and surrounding regions; integration of multi-sensor data for regional assessments.	**20**	CO 3	K1, K2, K3, K4
Module 4:	Aerosols and their role in regional climate variability; impact on monsoon rainfall, fog, dust storms, and air quality; extreme weather events influenced by aerosol loading; use of regional climate models (WRF-Chem, RegCM) to study aerosol impacts; policy perspectives on air pollution and mitigation.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments.			
Texts:	1. Kulkarni, P., Baron, P. A., & Willeke, K. (Eds.). (2011). Aerosol measurement: principles, techniques, and applications. John Wiley & Sons. DOI:10.1002/9781118001684 2. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change (3rd ed.). Wiley. ISBN: 978-1-118-94740-1			
References/ Readings:	1. Bharath, J., Kumar, T. V. L., Salgueiro, V., Costa, M. J., & Mall, R. K. (2024). Aerosol characteristics in CMIP6 models' global simulations and their evaluation with the satellite measurements. International Journal of Climatology, 44(1), 217-236. https://doi.org/10.1002/joc.8324 2. Johnson, B. T., Christopher, S., Haywood, J. M., Osborne, S. R., McFarlane, S., Hsu, C., ... & Kahn, R. (2009). Measurements of aerosol properties from aircraft, satellite and ground-based remote sensing: A case-study from the Dust and Biomass-burning Experiment (DABEX). Quarterly Journal of the Royal Meteorological Society: A journal of the atmospheric sciences, applied meteorology and physical oceanography, 135(641), 922-934.			

	https://doi.org/10.1002/qj.420 3. Li, Z., Lau, W. M., Ramanathan, V., Wu, G., Ding, Y., Manoj, M. G., ... & Brasseur, G. P. (2016). Aerosol and monsoon climate interactions over Asia. Reviews of Geophysics, 54(4), 866-929. https://doi.org/10.1002/2015RG000500 4. Ramanathan, V., & Feng, Y. (2009). Air pollution, greenhouse gases and climate change: Global and regional perspectives. Atmospheric environment, 43(1), 37-50. https://doi.org/10.1016/j.atmosenv.2008.09.063 5. Srivastava, R. (2017). Trends in aerosol optical properties over South Asia. International Journal of Climatology, 37(1), 371-380. https://doi.org/10.1002/joc.4710
Web Resources:	1. NASA Earthdata Aerosol Resources: https://earthdata.nasa.gov 2. AERONET Aerosol Monitoring: https://aeronet.gsfc.nasa.gov 3. IMD Air Quality and Aerosol Studies: https://mausam.imd.gov.in

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Title of the Course	Remote Sensing for Open Ocean Processes
Course Code	RSG-6203
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide students with knowledge of open ocean processes and upskill them in applying remote sensing for their monitoring and analysis.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the physical, chemical, and biological processes governing the open ocean.	PSO 1, PSO 2
	CO 2. Analyse satellite observations of sea surface temperature, salinity, height, winds, and ocean colour.	PSO 2, PSO 3
	CO 3. Apply multi-sensor datasets to study open ocean circulation, productivity, and variability.	PSO 2, PSO 3, PSO 4
	CO 4. Evaluate the role of remote sensing in addressing open ocean challenges, including climate change and resource management.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Physical processes: ocean circulation, waves, tides, mesoscale eddies; chemical processes: carbon cycle, nutrient dynamics; biological processes: primary production, plankton distribution, fisheries linkages; role of open ocean in climate regulation. UN Ocean Decade 2020-2030: Challenges and Outcomes.	**15**	CO 1	K1, K2
Module 2:	Thermal sensors for SST (AVHRR, MODIS, VIIRS, Sentinel-3 SLSTR); microwave sensors for sea surface salinity (SMOS, Aquarius, SMAP); altimetry for sea surface height and geostrophic currents (TOPEX, Jason, Sentinel-6); Scatterometers for winds (QuikSCAT, ASCAT); ocean colour sensors for chlorophyll and productivity (SeaWiFS, OLCI, PACE).	**15**	CO 2	K1, K2, K3, K4
Module 3:	Ocean circulation studies (ENSO, Indian Ocean Dipole, monsoonal circulation); eddy detection and tracking; upwelling and productivity hotspots; fisheries applications; biogeochemical applications including carbon flux estimation; integration of remote sensing with in situ networks (Argo, moorings).	**15**	CO 3	K1, K2, K3, K4, K5
Module 4:	Role of open ocean remote sensing in global climate change research; long-term ocean climate records (SST, SSH, chlorophyll trends); sea-level rise and its implications; marine resources and sustainable development; contribution to SDGs (SDG 13 Climate Action, SDG 14 Life Below Water); case studies of ocean monitoring in the Indian Ocean and global oceans.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Robinson, I. S. (2010). Discovering the ocean from space: the unique applications of satellite oceanography. Springer Science & Business Media. https://link.springer.com/book/10.1007/978-3-540-68322-3 2. Stewart, R. H. (2008). Introduction to physical oceanography. https://earthweb.ess.washington.edu/booker/ESS514/stewart/stewart_ocean_book.pdf			
References/ Readings:	1. Behrenfeld, M. J., & Falkowski, P. G. (1997). Photosynthetic rates derived from satellite-based chlorophyll concentration. *Limnology and oceanography*, *42*(1), 1-20. https://doi.org/10.4319/lo.1997.42.1.0001 2. Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J. P., Chan, F., English, C. A., ... & Talley, L. D. (2012). Climate			

	change impacts on marine ecosystems. *Annual review of marine science*, *4*(2012), 11-37. https://doi.org/10.1146/annurev-marine-041911-111611 3. Henson, S. A., Cole, H. S., Hopkins, J., Martin, A. P., & Yool, A. (2018). Detection of climate change-driven trends in phytoplankton phenology. *Global Change Biology*, *24*(1), e101-e111. https://doi.org/10.1111/gcb.13886 4. McClain, C. R. (2009). A decade of satellite ocean color observations. *Annual Review of Marine Science*, *1*, 19–42. https://doi.org/10.1146/annurev.marine.010908.163650 5. Vignudelli, S., Akhir, M. F., Zainol, Z., & Mansor, K. N. A. A. K. (2023). Satellite altimetry and ocean circulation: from open ocean to the coast. In *Coastal Altimetry* (pp. 1-19). Elsevier. https://doi.org/10.1016/B978-0-323-91708-7.00002-X
Web Resources:	1. NASA Ocean Color: https://oceancolor.gsfc.nasa.gov 2. Copernicus Marine Service: https://marine.copernicus.eu 3. NOAA CoastWatch & Open Ocean Products: https://coastwatch.noaa.gov

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Title of the Course	Operational Oceanography
Course Code	RSG-6204
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The course shall train students with knowledge of operational oceanography, focusing on observations, modelling, data assimilation, and applications for ocean services and sustainability.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the concepts, scope, and components of operational oceanography.	PSO 1, PSO 2
	CO 2. Analyse ocean observations and forecasting systems used in operational services.	PSO 1, PSO 2, PSO 3
	CO 3. Apply modelling and data assimilation techniques for ocean forecasting and reanalysis.	PSO 2, PSO 3, PSO 4
	CO 4. Evaluate the role of operational oceanography in supporting the blue economy, disaster resilience, and climate adaptation.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Concept and evolution of operational oceanography; global frameworks (GOOS, GODAE); observing systems and requirements; national and international initiatives (NOAA, ECMWF, Mercator, INCOIS); role in marine services, fisheries, shipping, and coastal management.	**15**	CO 1	K1, K2, K3
Module 2:	In situ networks: Argo floats, moorings, tide gauges, gliders, ships of opportunity; remote sensing missions for operational services: altimetry, scatterometry, ocean colour, SST, SSS; data management systems; data quality control and integration.	**15**	CO 2	K1, K2, K3
Module 3:	Ocean circulation models (HYCOM, NEMO, MOM); data assimilation methods (OI, 3DVar, 4DVar, EnKF); coupled ocean-atmosphere models; ocean reanalyses (ORAS5, GLORYS, ECCO, INCOIS reanalysis); applications in marine forecasting and climate studies.	**15**	CO 3	K1, K2, K3, K4
Module 4:	Operational services for navigation, fisheries, offshore industry, search-and-rescue, and disaster management (cyclones, storm surges, tsunamis); contributions to SDGs and Blue Economy; climate change adaptation strategies; Indian case studies (INCOIS, NIOT); future directions in digital twins and AI for ocean services.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures/Assignments/Tutorials			
Texts:	1. Schiller, A., & Brassington, G. B. (Eds.). (2011). *Operational oceanography in the 21st century*. Springer Science & Business Media. https://link.springer.com/book/10.1007/978-94-007-0332-2 2. Alvarez Fanjul, E., Ciliberti, S. A., & Bahurel, P. (2022). Implementing Operational Ocean Monitoring and Forecasting Systems. https://www.mercator-ocean.eu/wp-content/uploads/2022/01/ETOOFS-Summary-Booklet.pdf			
References/ Readings:	1. Haine, T. W., Gelderloos, R., Jimenez-Urias, M. A., Siddiqui, A. H., Lemson, G., Medvedev, D., ... & Hill, C. N. (2021). Is computational oceanography coming of age?. Bulletin of the American Meteorological Society, 102(8), E1481-E1493. https://doi.org/10.1175/BAMS-D-20-0258.1 2. Spindler, T. (2023). Synergies in Operational Oceanography: The Intrinsic Need for Sustained Ocean Observations. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2019.00450			

	3. Solabarrieta, L., Del Campo, A., Alvarez, D., Abalia, A., Nieto, A., Epelde, I., ... & Misurale, F. (2022, October). Revamping data system and portal in the Basque Operational Oceanography. In 2022 IEEE International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters (MetroSea) (pp. 193-197). IEEE. https://doi.org/10.1109/MetroSea55331.2022.9950947 4. Fanjul, E. A., Ciliberti, S., Pearlman, J., Wilmer-Becker, K., Bahurel, P., Ardhuin, F., ... & Zufic, R. (2024). Promoting best practices in ocean forecasting through an Operational Readiness Level. Frontiers in Marine Science, 11, 1443284.
Web Resources:	1. INCOIS Ocean Services: https://incois.gov.in 2. Mercator Ocean International: https://www.mercator-ocean.eu 3. GOOS - Global Ocean Observing System: https://www.goosocean.org 4. ETOOFS Guide – Ocean Prediction: UN Decade Collaborative Centre: https://www.unoceanprediction.org/en/

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Title of the Course	WebGIS
Course Code	RSG-6205
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce concepts, technologies, and applications of WebGIS for geospatial data sharing, analysis, and decision support.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the principles and architecture of WebGIS systems.	PSO 1, PSO 2
	CO 2. Analyse web mapping standards, data formats, and interoperability protocols.	PSO 2, PSO 3
	CO 3. Apply tools and platforms for developing and deploying WebGIS applications.	PSO 2, PSO 3, PSO 4
	CO 4. Evaluate WebGIS applications for sustainable development, governance, and societal benefits.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Concepts of GIS on the web; differences between desktop GIS and WebGIS; client-server architecture; components of WebGIS (server, client, database, middleware); evolution of web mapping services; examples of global and Indian WebGIS platforms.	**15**	CO 1	K1, K2
Module 2:	Web mapping standards (OGC WMS, WFS, WCS, WMTS); spatial databases (PostGIS, Oracle Spatial); data formats (GeoJSON, KML, shapefiles, raster services); interoperability and data sharing protocols; cloud-based geospatial services.	**15**	CO 2	K1, K2, K3
Module 3:	Open-source platforms (GeoServer, MapServer, Leaflet, OpenLayers); commercial platforms (ArcGIS Online, Google Earth Engine); system design and architecture of WebGIS applications; hands-on with publishing and consuming web services; integrating APIs and interactive dashboards.	**15**	CO 3	K1, K2, K3, K4
Module 4:	WebGIS applications in urban planning, natural resource management, disaster management, climate monitoring, and citizen science; participatory GIS and crowdsourced data; government initiatives in India (Bhuvan, National Geoportal); evaluating societal and sustainability impacts of WebGIS.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture/Tutorials/Assignments			
Texts:	1. Fu, P., & Sun, J. (2010). WebGIS: Principles and Applications. ESRI Press. 2. Peng, Z. R., & Tsou, M. H. (2003). Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Networks. Wiley. 3. Steiniger, S., & Hunter, A. J. S. (2013). Free and Open-Source GIS Software for Building a Spatial Data Infrastructure.			
References/ Readings:	1. Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69(4), 211–221. 2. Haklay, M., Singleton, A. D., & Parker, C. (2008). Web Mapping 2.0: The neogeography of the GeoWeb. Geography Compass, 2(6), 2011–2039.			
Web Resources:	1. OGC Standards: https://www.ogc.org			

	2. ISRO Bhuvan Portal: https://bhuvan.nrsc.gov.in 3. ArcGIS Online: https://www.arcgis.com

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Title of the Course	Climate Change and Society
Course Code	RSG-6206
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To explore the science, impacts, and societal dimensions of climate change, focusing on adaptation, mitigation, and sustainable futures.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the scientific basis and drivers of climate change.	PSO 1, PSO 2
	CO 2. Analyse the societal impacts of climate change across regions and sectors.	PSO 1, PSO 3
	CO 3. Apply frameworks for adaptation, mitigation, and resilience in societal contexts.	PSO 3, PSO 4
	CO 4. Evaluate climate policies, agreements, and sustainable practices from local to global perspectives.	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Climate system and energy balance; greenhouse gases and radiative forcing; evidence from observations (temperature rise, precipitation shifts, cryosphere decline, sea-level rise); role of natural *vs* anthropogenic drivers; climate models, scenarios, and projections.	**15**	CO 1	K1, K2
Module 2:	Impacts on agriculture, water, health, energy, fisheries, and urban systems; regional disparities in vulnerability; climate-driven migration and displacement; extreme events (heatwaves, cyclones, floods, droughts); social equity, justice, and intergenerational implications.	**15**	CO 2	K1, K2, K3, K4
Module 3:	Adaptation approaches: ecosystem-based adaptation, climate-resilient agriculture, disaster preparedness; mitigation strategies: renewable energy, carbon markets, reforestation, circular economy; concepts of resilience and vulnerability assessment; role of innovation and technology.	**15**	CO 3	K1, K2, K3, K4
Module 4:	Global frameworks: UNFCCC, Kyoto Protocol, Paris Agreement, IPCC assessments; India's NAPCC and State Action Plans; SDGs and climate-development linkages; role of NGOs, civil society, and community-based initiatives; pathways towards climate justice and sustainable societies.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures and Assignments.			
Texts:	1. IPCC (2021). Climate Change 2021: The Physical Science Basis. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/ 2. Lackner, M., Sajjadi, B., & Chen, W. Y. (Eds.). (2022). Handbook of climate change mitigation and adaptation. Cham, Switzerland: Springer. https://doi.org/10.1038/s41558-021-01097-4			
References/ Readings:	1. Alves, F., & Schmidt, L. (2022). Editorial: Climate change and society. Frontiers in Sociology, 7, Article 991193. https://doi.org/10.3389/fsoc.2022.991193 2. Dietz, T., Shwom, R., & Whitley, C. T. (2020). Climate change and society. Annual Review of Sociology, 46, 135–158. https://doi.org/10.1146/annurev-soc-121919-054614 3. IPCC (2021). Climate Change 2021: The Physical Science Basis. Cambridge University Press.			

	https://www.ipcc.ch/report/ar6/wg1/ 4. Lackner, M., Sajjadi, B., & Chen, W. Y. (Eds.). (2022). Handbook of climate change mitigation and adaptation. Cham, Switzerland: Springer. https://doi.org/10.1038/s41558-021-01097-4 5. Memon, M. H. (2023). Climate change and adaptation: Exploring drivers of social vulnerability. Weather, Climate, and Society, 15(4), 1–12. https://doi.org/10.1175/WCAS-D-21-0113.1
Web Resources:	1. UNFCCC: https://unfccc.int 2. IPCC Data Portal: https://www.ipcc-data.org 3. India's NAPCC: https://moef.gov.in

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Title of the Course	Disaster Risk Reduction and Climate Change
Course Code	RSG-6207
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide students with knowledge and skills for understanding, analysing, and addressing disaster risks in the context of climate change, with emphasis on resilience building.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Explain the concepts, frameworks, and approaches to disaster risk reduction (DRR).	PSO 1, PSO 5
	CO 2. Analyse the linkages between climate change, extreme events, and disaster risk.	PSO 1, PSO 3
	CO 3. Apply geospatial and scientific methods for risk assessment and resilience planning.	PSO 2, PSO 3, PSO 4
	CO 4. Evaluate policies, governance mechanisms, and community-based strategies for climate resilience.	PSO 3, PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Disaster concepts: hazard, vulnerability, exposure, capacity, risk; global frameworks for DRR (Sendai Framework, Hyogo Framework); types of disasters: hydro-meteorological, geological, technological, biological; disaster risk governance and institutional frameworks in India.	**15**	CO 1	K1, K2
Module 2:	Climate change as a risk multiplier; extreme events: floods, droughts, cyclones, heatwaves, sea-level rise; regional vulnerability (urban *vs.* rural, coastal vs. inland); climate-disaster linkages in India and global case studies; assessing compound risks (multi-hazard contexts).	**15**	CO 2	K1, K2, K3, K4
Module 3:	Geospatial methods in DRR: hazard zonation, vulnerability mapping, exposure modelling; use of RS & GIS in flood, cyclone, landslide, and drought risk assessments; early warning systems (tsunami, flood forecasting); participatory risk mapping; resilience indicators and indices.	**15**	CO 3	K1, K2, K3, K4, K5
Module 4:	Building resilience through adaptation and mitigation; community-based DRR; ecosystem-based adaptation; integration of DRR with SDGs and Paris Agreement; Indian national frameworks (NDMA, NAPCC, State Action Plans); role of NGOs, local governance, and citizen participation in resilience building.	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Lectures and Assignments			
Texts:	1. Eslamian, S., Eslamian, F., & Frameworks, N. (2021). Handbook of disaster risk reduction for resilience. Cham: Springer International Publishing. https://link.springer.com/book/10.1007/978-3-030-61278-8 2. Smith, K., Fearnley, C. J., Dixon, D., Bird, D. K., & Kelman, I. (2023). Environmental hazards: assessing risk and reducing disaster. Routledge. https://doi.org/10.4324/9781351261647			
References/ Readings:	1. IPCC (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX Report). Cambridge University Press. https://doi.org/10.1017/CBO9781139177245 2. Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., ... & Trisos, C. H. (2021). A framework for complex climate change risk assessment. One Earth, 4(4), 489-501. https://doi.org/10.1016/j.oneear.2021.03.005			

	3. Newman, R., & Noy, I. (2023). The global costs of extreme weather that are attributable to climate change. Nature Communications, 14(1), 6103. https://doi.org/10.1038/s41467-023-41888-1 4. Nohrstedt, D., Mazzoleni, M., Parker, C. F., & Di Baldassarre, G. (2021). Exposure to natural hazard events unassociated with policy change for improved disaster risk reduction. Nature communications, 12(1), 193. https://doi.org/10.1038/s41467-020-20435-2
Web Resources:	1. UNDRR: https://www.undrr.org 2. NDMA India: https://ndma.gov.in 3. IPCC Special Reports: https://www.ipcc.ch

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Title of the Course	Photogrammetry and Drone Applications
Course Code	RSG-6208
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The students shall examine the science of climate change and its societal impacts, with emphasis on adaptation, mitigation, and sustainable pathways.	
Course Outcomes:	Students will be able to,	**Mapped to PSO**
	CO 1. Analyse principles of photogrammetry and apply stereoscopic techniques for spatial information extraction.	PSO 1, PSO 5
	CO 2. Evaluate advanced photogrammetric methods and apply digital techniques for geospatial applications.	PSO 1, PSO 3
	CO 3. Analyse UAV systems and design drone-based data acquisition missions	PSO 2, PSO 3, PSO 4
	CO 4. Apply UAV data processing techniques and evaluate geospatial outputs	PSO 3, PSO 4, PSO 5

Content:		No. of hours	Mapped to CO	Cognitive Level
Module 1:	Definition, scope and applications of photogrammetry; types of photogrammetry - aerial, terrestrial and satellite; aerial photography - flight planning, scale, overlap and side-lap; geometry of vertical and oblique photographs; elements of photographic interpretation - tone, texture, pattern, shape, size, shadow, site and association; stereoscopy - principles, parallax, relief displacement and height determination.	**15**	CO 1	K1, K2
Module 2:	Photogrammetric instruments - stereoscopes, stereo-plotters, analytical and digital systems; orientation of photographs: interior, exterior, relative and absolute; orthophoto generation and mosaicking; digital photogrammetry: Structure from Motion (SfM), point clouds, DEM and DSM extraction; applications in topographic mapping.	**15**	CO 2	K1, K2, K3, K4
Module 3:	Types and history of UAVs; components and system architecture of drones; payloads and sensors (RGB, multispectral, thermal, lidar); basics of aerodynamics relevant to UAV flight; mission planning - flight planning parameters, regulatory / safety guidelines; image acquisition metrics - resolution, overlap, ground sample distance (GSD)	**15**	CO 3	K1, K2, K3, K4, K5
Module 4:	Image preprocessing - radiometric, geometric corrections; photogrammetry with UAV data - orthomosaic generation, DSM/DEM, point cloud processing; data stitching and mosaicking; analysis with spectral indices and thermal data; integration with GIS; UAV applications	**15**	CO 4	K1, K2, K3, K4, K5
Pedagogy:	Use of Conventional, Online and ICT Methods. Theory/Lectures/Assignments.			
Texts:	1. American Society for Photogrammetry and Remote Sensing (ASPRS). (2025). Manual of Photogrammetry (6th ed.). Bethesda, MD: ASPRS. 2. Hess, M., & Green, S. (2021). Structure from Motion: Digital Techniques for Documenting and Preserving Cultural Heritage. Amsterdam, Netherlands: Amsterdam University Press. 3. Jiang, W., San, J., & Xiao, X. (Eds.). (2022). Techniques and Applications of UAV-Based Photogrammetric 3D Mapping. Basel, Switzerland: MDPI Books.			

	4. Kavanagh, B. F., & Mastin, J. D. (2014). Surveying: Principles and Applications (9th ed.). New York, NY: Pearson. 5. Wolf, P. R., Dewitt, B. A., & Wilkinson, B. E. (2014). Elements of Photogrammetry with Applications in GIS (4th ed.). New York, NY: McGraw-Hill Education.
References/ Readings:	1. Bhakal, S., Pandey, A., & Jain, K. (2024). Precision Agriculture: A Web-GIS Framework for Health and Stress Assessment Using Multi-Source Remote Sensing Data. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLVIII-4/2024, 59. https://doi.org/10.5194/isprs-archives-XLVIII-4-2024-59-2024 2. Singh, C. H., Mishra, V., & Jain, K. (2023). High-Resolution Mapping of Forested Hills Using Real-Time UAV Terrain Following. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, X-1/W1-2023, 665. https://doi.org/10.5194/isprs-annals-X-1-W1-2023-665-2023 3. Singh, P. S., Sharma, M., Saikhom, V., Chutia, D., Gupta, C., & Raju, P. L. N. (2018). Towards Generation of Effective 3D Surface Models from UAV Imagery Using Open Source Tools. Current Science, 114(2), 314-321. https://doi.org/10.18520/cs/v114/i02/314-321 4. Somani, P., Chitranshi, A. R., Gaur, A., & Balotiya, G. (2024). Assessment of Unmanned Aerial Vehicle (UAV) based photogrammetric survey for road alignment using direct geo-referencing technology. Indian Journal of Engineering & Materials Sciences, 31(6). https://doi.org/10.56042/ijems.v31i6.9562 5. Xing, L., Li, Y., & Yue, C. (2025). Improvement of UAV-Photogrammetric Survey Accuracy Using Point Feature Constraints of Markers. Journal of the Indian Society of Remote Sensing. https://doi.org/10.1007/s12524-025-02246-4
Web Resources:	1. International Society for Photogrammetry and Remote Sensing (ISPRS). (n.d.). Global organization promoting photogrammetry, remote sensing, and spatial information sciences. https://www.isprs.org 2. European Centre for Medium-Range Weather Forecasts (ECMWF). (n.d.). Atmospheric data, including aerosol forecasts and reanalysis. https://atmosphere.copernicus.eu 3. Indian Space Research Organisation. Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in

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