UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 17-12-2022 has approved the recommendations of the Academic Council made at its meeting dated 11-03-022 and 21-03-2022 respectively, regarding approval to Start MS & Ph.D. in Remote Sensing Program alongwith its Syllabi and Courses of Reading/Scheme of Studies at the Centre for Remote Sensing subject to the condition that there should not be overlapping in Courses and the said Programs shall be started after getting NOC from HEC and fulfillment of required faculty.

The Syllabi and Courses of Reading/Scheme of Studies for MS & Ph.D. in Remote Sensing are attached herewith, vide Annexure-A&B,

Sd/-
SHAHID JAVED
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.

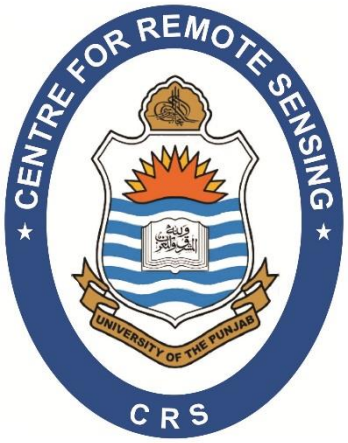
No. D/ 386 /Acad. **Dated: 11- 01 /2023.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Sciences.
2. Incharge, Centre for Remote Sensing.
3. Chairperson, DPCC
4. Director, IT for placement at website.
5. Controller of Examinations
6. A.O (Statutes)
7. Secretary to the Vice-Chancellor
8. P.S. to Registrar
9. Assistant Syllabus

Assistant Registrar (Academic)
for Registrar

Scheme of Studies and Course Outlines
for
PhD in Remote Sensing



Centre for Remote Sensing
University of the Punjab, Lahore

Program Title: PhD in Remote Sensing
Department: Centre for Remote Sensing
Faculty: Faculty of Science

1. Centre for Remote Sensing: Mission

Centre for Remote Sensing is a nexus for research, education, and training in remote sensing & its allied disciplines and their applications. The centre aims to provide a hub for scientific research, collaborations, and incubation of ideas encapsulating the use of observational data from space borne, airborne and ground-based sensors and in-situ measurements of land, water and atmosphere of the Earth and the outer space.

The mandate of the Centre for Remote Sensing comprises of but not limited to:

i. Teaching, capacity building, and research related to Remote Sensing & its allied disciplines and their applications.
ii. Sensitize scientists, policy makers, administrators, and public about the socio-economic benefits of remote sensing and its applications
iii. Provide consultancy and technical assistance
iv. Development of remote sensing applications to contribute to geospatial industry
v. Development of the structure of databases from satellite imagery on temporal basis in different areas and disciplines and making the information available to the public and private sectors
vi. Development of decision support systems/tools such as, warning systems and long-term observatories. Research activities and projects concerning major topics such as: landuse/landcover and changes, and climate change and possible associated connections and studies regarding different applied contexts.

2. Introduction

Remote sensing is an emerging and demanding field in the modern technological era from national to international level. Remote Sensing studies related to applications are inherently interdisciplinary, multifaceted, and address complexities. Degree holders may find jobs at geospatial technology organizations, mapping companies, land surveying firms, research institutes, and in related applied technologies serving both in private and public sectors, and public utilities or government departments. Remote sensing graduates may also find jobs at consulting firm and scientific laboratories, where they have the opportunity to enhance their skills in remote sensing technologies and techniques. Moreover, they may support scientists in designing and conducting analysis based on remotely sensed data, facilitating the decisions for some optimal techniques using these modern datasets and relevant equipment etc.

3. Program Introduction

The mission of the doctoral program of Centre For Remote Sensing is to develop scholars of the discipline of Remote Sensing capable of conceptualizing and conducting a program of research that advances remote sensing knowledge and contributes to promote research activities and projects at national level in particular and to international scientific community in general about the use of space technology, remote sensing and geographical information science (GISc) pertaining to land, water, and atmosphere of the Earth. The foundation of the success of this program lies in the balance and substantive match between the student and the advisory faculty. The aim of educational experience focuses on the processes of exploring and examining multidimensional approach of knowledge, opening up the new horizons and broadening the integrated knowledge base. The researcher's development is fostered through exposure to an array of philosophic and methodological aspects of remote sensing and related basic and applied disciplines through academic endeavours.

4. Program Objectives

1. To give researchers an opportunity to participate in rigorous scholarly pursuit, and to contribute to industrial and academic research.
2. To improve research based scientific thinking and to enhance professional skills for teaching, research, and scientific administrative positions in wide range of professions in national and international organizations.

3. Design a plan for a progressive scholarly growth and career development.
4. To develop research scholars that display well-honed aptitude for intellectual critique and scholarly writing.
5. Integrate remote sensing knowledge as an innovative futuristic tool within the broad social, economic, and political contexts to influence the strategic direction of policy institutions and organizations.
6. Encourage multidisciplinary knowledge and skills in the allied and emerging areas of science and engineering syncing with remote sensing.

5. Market Need / Rationale of the Program

a) *Potential Students for the program*

This programme shall provide opportunities of research and development for students having background in Space Science, GIS/Geomatics, Meteorology, Disaster Management, Environmental Sciences, Geography, Geology, Geophysics, Earth Sciences, Civil Engineers, Town Planning, City & Regional Planning, or other relevant fields.

b) *Potential Employers*

The graduates from this centre can join any public sector or private organization using remote sensing and geospatial data such as Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), National Disaster Management Authority (NDMA), Provincial Disaster Management Authority (PDMA)s, National Geospatial Services Pakistan, Pakistan Meteorological Department (PMD), National Engineering Services, Pakistan (NESPAK), National Agricultural Research Centre (NARC), Civil Aviation Authority (CAA), Water and Power Development Authority (WAPDA), Rescue-1122, International Centre for Integrated Mountain Development (ICIMOD), Oil and Gas Development Company Limited (OGDCL), Survey of Pakistan (SOP), Geological Survey of Pakistan (GSP), National Highway Authority (NHA), Punjab Information Technology Board (PITB), International research and development organizations such as Food and Agriculture Organization (FAO), World Wide Fund for Nature (WWF), World Food Program (WFP), International Water logging and Salinity Research Institute (IWASRI), National Institute of Oceanography, Forest Department, Agriculture/ Food Sector and other R&D Organizations, Revenue Department and Development Authorities, The Urban Units, Utilities Companies, Police Departments, UN Habitat, etc. and other research and development organizations after getting this degree in Remote Sensing.

c) *Academic Projections*

This is a first-degree programme, in Pakistan, exclusively launched for Remote Sensing studies. Some other combined programmes have already been launched such as “Remote Sensing and GIS” by PU, NUST-Islamabad, and GCU-Faisalabad in Pakistan. Internationally several universities and research centres including Centre for Remote Sensing (Boston University), Centre for Remote Sensing (University of Florida), Remote Sensing Research Centre (The University of Queensland) offer higher level degrees exclusively in Remote Sensing.

d) *Faculty*

Currently, one Associate Professor and 5 Assistant Professors are available for this programme with core expertise in Remote Sensing.

Name	Degree	Area of Specialization	Total
Dr. Syeda Adila Batool	PhD	Climate Change, Environmental Sciences	6
Dr. Zia ul Haq	PhD	Remote Sensing, Atmospheric Studies	
Dr. Shahid Parvez	PhD	Remote Sensing, Landuse/Landcover	
Dr. Asim Daud Rana	PhD	Remote Sensing, Landuse/Landcover	

Dr. Khalid Mahmood	PhD	Geospatial Technologies	
Dr. Salman Tariq	PhD	Remote Sensing, Land and Oceanic Studies	

e) Physical Facilities

A Remote Sensing Lab has been established, with the capacity of 40 students, as a part of National Centre of GIS and Space Applications which will be available for this programme. Other labs will be established in short period of time. Funds for a Library has been approved and it is in establishment phase.

6. Admission Eligibility Criteria

- **Years of Study completed**
  Minimum of 18 years of education with Science / Engineering background

- **Study Program/Subject**
  MPhil / MS degree in Remote Sensing, Space Science, GIS/Geomatics, Geology, Geophysics, Meteorology, Disaster Management, Environmental Sciences, Energy & Environment, Geo-Environmental Conservation & Sustainable Development, Mountain Conservation, or relevant subject as determined by the admission committee of the centre.

- **Percentage/CGPA**
  i. CGPA 3.0 (out of 4.0 in the Semester System) or First Division (in the Annual System) in M.Phil/M.S/Equivalent is required
  ii. Other disciplines graduates will have to enroll in prerequisite/ deficiency courses as proposed by the Centre and as per HEC & PU prescribed guidelines.
- **Entry Test with minimum requirement**
  40% entry test weightage

7. Duration of the Program

6 Semesters / 3 Years

8. Categorization of Courses as per HEC Recommendation and Difference

Semester	Courses	Category (Credit Hours)					
		Core Courses	Basic Courses	Major Electives	Minor Electives	Any Other	Semester Load
1	3	6		3			9
2	3	6		3			9
3	Thesis						
4	Thesis						
5	Thesis						
6	Thesis						
PU							
HEC Guidelines							
Difference (HEC &) PU	No difference						

**Core: Compulsory, Basic: Foundation, Major Electives: Professional, Minor Electives: Specialization.*
Note: The course/column heads are customizable according to nature and level of the program.

9. Scheme of Studies / Semester-wise workload

#	Course Code	Course Title	Course Type	Prerequisite	Credit Hours
Semester-I					
1	CRSC701	Advanced Remote Sensing and Digital Image Processing	Core	Nil	3 (2+1)
2	CRSC702	Remote Sensing Applications in Environment and Climate Studies	Core	CRSC701	3 (2+1)
3	CRSEL	Elective-I	Major Elective	Nil	3 (2+1)
Total Credit hours				**09**	
Semester-II					
#	**Code**	**Course Title**	**Course Type**	**Prerequisite**	**Credit Hours**
1	CRSC703	Applied Remote Sensing	Core	CRSC701	3 (2+1)
2	CRSC704	Atmospheric Remote Sensing	Core	CRSC703	3 (2+1)
3	CRSEL	Elective-II	Major Elective	Nil	3 (3+0)
Total Credit hours				**09**	
Semester-III-VI					
#	**Code**	**Course Title**		**Prerequisite**	**Credit Hours**
1	CRST	Thesis			

1. Type of course may be core (compulsory), basic (foundation), major elective (professional), minor elective (specialization) etc.

Research Thesis/ Project/ Internship
36 credit hours in 4 semesters

10. Award of Degree

Degree awarding criteria will be followed as per PU and HEC guidelines

11. NOC from Professional Councils (if applicable)

Not applicable

12. Faculty Strength

CRS is newly established centre and currently faculty available from Department of Space Science as following

Degree	Area/Specialization	Total
PhD	1. Climate Change, Environmental Sciences 2. Remote Sensing, Atmospheric Studies 3. Remote Sensing, Landuse/Landcover 4. Remote Sensing, Landuse/Landcover 5. Geospatial Technologies 6. Remote Sensing, Land and Oceanic Studies	6
Total		**6**

13. Present Student Teacher Ratio in the Department

Not applicable

14. Course Outlines separately for each course

COURSE OUTLINES

Title	**Advanced Remote Sensing and Digital Image Processing**
Code Number	CRSC701
Semester	1
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to synthesize the potential of data captured from remotely sensed images that may be used as an interdisciplinary approach to spatial decision-making and problem solving 2. Familiarise the theoretical background of electromagnetic radiation, pre-processing, and classification techniques 3. Acquire interactive practical skills that penetrate all the necessary steps of processing RS data to classify land use/ land cover from digital satellite data and aerial photographs 4. Gain hands on experience on software for satellite image processing
Suggested Readings	i. Dalezios, N. R. (2021). *Remote Sensing Applications in Environmental and Earth System Sciences*. Taylor & Francis Group. ii. Jian Guo Liu and Philippa J Mason. (2016). *Image Processing and GIS for Remote Sensing: Techniques and Applications.* Wiley Blackwell. iii. Jensen, J. R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Pearson Education, Inc. iv. Lillesand, T. M., Kiefer, R. W., Chipman, J. W. (2015). *Remote Sensing and Image Interpretation*. John Wiley & Sons, Inc. v. Lillesand, K., & R. W. (2007). *Remote Sensing and Image Interpretation, 5th Edition.* John Wiley & Sons.
Contents	**Unit-I** 1.1. Introduction and background of remote sensing and digital image processing 1.2. The Electromagnetic Spectrum 1.3. Different optical remote sensing data types 1.4. Resolutions of satellite sensors **Unit-II** 2.1. Acquisition of remotely sensed data 2.2. Introduction to Google Earth Engine (GEE) 2.3. Image enhancement techniques 2.4. Spatial filtering techniques 2.5. Accuracy Assessment 2.6. Georeferencing **Unit-III** 3.1. Land cover classification using various methods 3.2. Object based classification 3.3. Fuzzy classification 3.4. Principal component analysis **Unit-IV** 4.1. Applications of remote sensing in vegetation, snow, water, and land cover 4.2. RADAR and LiDAR remote sensing 4.3. Elevation modeling and application of DEM

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</table>

Title	**Remote Sensing Applications in Environment and Climate Studies**
Code Number	CRSC702
Semester	1
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to accurately describe the conclusions (and limitations) of literature on the causes and consequences of climate change, and should know where to go to seek more detailed information 2. Able to run simple climate models, and offer high-level explanations of the relationship between the inputs and outputs of such models 3. Enable them to describe the consequences of climate change, and different approaches to mitigating it 4. Able to do sampling and analysis of air pollutant 5. Develop an understanding of working of air pollution control devices
Suggested Readings	i. Dr. Prasad S., Thenkabail, John G., Lyon, Professor Alfredo Huete. (2019). *Remote Sensing and Global Climate Change.* CRC press. ii. Kaku, K. (2019). *Satellite Remote Sensing for Disaster Management Support: A Holistic and Staged Approach Based on Case Studies in Sentinel Asia.* International Journal of Disaster Risk Reduction, 33, 417–432. iii. Nangyal, H., & Khan, M. S. (2020). *Environmental Pollution, Biodiversity, and Sustainable Development: Issues and Remediation*. Apple Academic Press Inc. iv. Robin A. Vaughan, Arthur P. Cracknell. (2011). *Remote Sensing and Global Climate Change.* Springer. v. Valavanis, V. D. (2019). *Geographic Information Systems in Oceanography and Fisheries.* CRC Press, Taylor & Francis Group. vi. William Emery, Adriano Camps. (2019). *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications.* Elsevier.
Contents	**Unit-I** 1.1. Understanding Global Environmental Pollution 1.2. Impact of Remote Sensing on Monitoring Climate Change 1.3. Global climate change Processes **Unit-II** 2.1. Principles of remote sensing 2.2. Physical principles of remote sensing techniques 2.3. Instruments 2.4. The cryosphere 2.4.1. Snow and ice extent 2.4.2. Ice sheet mapping & monitoring **Unit-III** 3.1. Remote Sensing applications of Land cover and the biosphere 3.2. Global biomass 3.3. Terrestrial carbon dynamics 3.4. Desertification 3.5. Soil moisture 3.6. Land-atmosphere interaction

	Unit-IV 4.1. Global warming 4.2. Earth radiation budget 4.3. Global mean temperatures 4.4. Cloud cover and feedback loops 4.5. EO and the Gaia hypothesis **Unit-V** 5.1. Polar climate 5.2. Water pollution-eutrophication 5.3. Air pollution 5.3.1. Climate, Hazardous air pollutants 5.3.2. Photochemical Smog 5.3.3. Aerosols and Remote Sensing 5.3.4. Stratospheric Ozone Destruction **Unit-VI** 6.1. Oceanography 6.2. Remote sensing of ocean biology 6.3. Advance applications of environment and climate change 6.4. Health and environmental effects 6.5. Capacity building and sustainable development 6.6. Global monitoring input to sustainable use of natural resources 6.7. International development and environmental security

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Title	**Applied Remote Sensing**
Code Number	CRSC703
Semester	2
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to think and function as a prudent professional applied remote sensing 2. Generate and analyze Radar, LiDAR, UAV, Hyperspectral data images. 3. Gain the knowledge to practical situations 4. Able to respond flexibly towards restoration of problematic landcover/land use of specific areas
Suggested Readings	i. Claus Weitkamp. (2005). Lidar: Range-Resolved Optical Remote Sensing of the Atmosphere, 1st edition. Springer ii. Dimitris G. Manolakis. (2016). Hyperspectral Imaging Remote Sensing (Physics, Sensors, and Algorithms). Cambridge University Press iii. Felipe Gonzalez Toro, Antonios Tsourdos. (2018). UAV or Drones for Remote Sensing Applications: Volume 2. MDPI iv. Harold Mott. (2006). Remote Sensing with Polarimetric Radar. IEEE Press v. Prem Chandra Pandey, Prashant Srivastava, Heiko Balzter, Bimal Bhattacharya, George Petropoulos. (2020). Hyperspectral Remote Sensing. Elseiver
Contents	**Unit-I** 1.1. Microwave Remote Sensing 1.2. Antenna Propagation and Theory 1.3. Radar Measurements and Radar Scatterometers 1.4. Surface-Scattering Models for Earth Observations **Unit-II** 2.1. Advance Air-/spaceborne synthetic aperture radar (SAR) 2.2. Advance Interferometric SAR 2.3. Advance Radar Remote Sensing Applications 2.4. Radar Applications in Oceans, Urban, Forest and Defense **Unit-III** 3.1. Light Detection and Ranging (LiDAR) Systems 3.2. Advance LiDAR processing, and analysis 3.3. LiDAR Data Format and Accuracy 3.4. LiDAR Point Cloud Data Processing 3.5. LiDAR applications and Software's 3.5.1. Urban Feature Extraction 3.5.2. Vegetation Analysis **Unit-IV** 4.1. Advance UAV Systems 4.1.1. UAV flight and data collection practices 4.1.2. Advance Photogrammetric Techniques 4.2. Orthorectified imagery 4.2.1. 3D models and terrain surfaces 4.3. Advance Thermal Remote Sensing 4.3.1. Surface Flux and Energy Balance 4.3.2. Advance Thermal Infrared Techniques

	4.3.3. Land Surface Temperature Retrieval Techniques 4.3.4. Thermal Infrared Applications **Unit-V** 5.1. Advance Hyperspectral Remote Sensing 5.2. High resolution Spectro-radiometry 5.3. Advances in Field Spectroscopy 5.3.1. Advance Hyperspectral Analytical techniques 5.4. Spectral mixture modelling 5.5. Feature space modelling 5.6. Atmospheric Corrections 5.7. Advance Hyperspectral Remote Sensing Systems and Applications 5.8. Vegetation Health Analysis 5.9. Drought, Minerology and Geological Applications

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
		25	35	40	100
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Title	**Atmospheric Remote Sensing**
Code Number	CRSC704
Semester	2
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Able to synthesize the potential of remote sensing applications regarding to the environment and climate studies that may be used as an interdisciplinary approach to spatial decision-making and problem solving 2. Gain the theoretical background of how climate is changed over decades, pollution, weather phenomenon, and their impacts 3. Acquire interactive practical skills that penetrate all the necessary steps of processing RS data to classify land use/ land cover from digital satellite data and aerial photographs
Suggested Readings	i. Dmitry E. Alexander A. K. (2021). *Foundations of Atmospheric Remote Sensing.* Springer. ii. Kelkar, R. R. (2007). *Satellite Meteorology*. BS Publications. iii. Stojče Dimov Ilčev. (2018). *Global Satellite Meteorological Observation (GSMO) Theory*. Volume 1. Springer. iv. William J. Blackwell, Frederick W. C. (2009). *Neural Networks in Atmospheric Remote Sensing*. MIT. v. Yang Liu, Jun Wang, Omar T. (2017). *Remote Sensing of Atmospheric Pollution*. MDPI.
Contents	**Unit-I** 1.1. Advance Atmospheric Science concepts 1.2. Physical processes in weather systems 1.3. Physical Properties of Terrestrial Atmosphere 1.4. Gaseous Composition of Earth **Unit-II** 2.1. Temperature Profiles 2.1.1 Advance concept of Earth's Energy Balance 2.1.2 Solar Spectrum and Earth's Thermal Emission 2.2. Advance concpets of Light interaction with atmosphere 2.2.1. Polarization 2.2.2. Phase concept 2.2.3. Irradiance and radiance **Unit-III** 3.1. Radiative Transfer Models (RTM) 3.2. Advance concepts of Radiative Transfer Equations 3.3. Discrete Ordinate methods in RTM 3.4. Direct and Inverse Radiative Transfer problems 3.5. Advance Retrieval Techniques **Unit-IV** 4.1. Weather Systems 4.1.1. Winds 4.1.2. Weather masses 4.1.3. Clouds 4.1.4. Fronts in the temperate zones 4.2. Greenhouse effect 4.3. El Niño /La Nina events

	4.4. Ocean/atmosphere relationships and other tropospheric processes **Unit-V** 5.1. Satellite Meteorological Parameters and Instruments 5.2. Boundary layer characteristics 5.2.1. Turbulence - Micro, Meso and Macro scale processes 5.2.2. Advanced weather report interpretation 5.2.3. Scales of statute miles vs. kilometeres 5.2.4. Inches of mercury vs. hectopascals 5.3. Advancements in Satellite Meteorological Observations 5.4. Advanced Atmospheric Remote Sensing Concepts 5.5. Retrievals of atmospheric parameters through Remote Sensing measurements 5.6. Satellite Meteorological Systems, POES, GOES, METEOSAT, GMS etc.

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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ELECTIVE COURSES

Title	**Radar Meteorology**
Code Number	CRSEL705
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Gain the knowledge of radar meteorology, solid conceptual and mathematical foundation is founded to interpret radar measurements 2. Identify the data requirements for water resources and interpret the analysis of the same 3. Estimate the design parameters of radar image processing using elementary methods 4. Develop skills to interpret the radar datasets and images
Suggested Readings	i. Chen, P. (2017). *Atmospheric Remote Sensing and Image Interpretation of Spaceborne Synthetic Aperture Radar.* Ocean Publishing House. ii. Fabry, F. (2015). *Radar Meteorology: Principles and Practice*. Cambridge University Press. iii. Kun-Shan C. (2020). *Principles of Synthetic Aperture Radar Imaging (Signal and Image Processing of Earth Observations).* CRC Press. iv. Raghavan, S. (2013). *Radar meteorology*. Springer Science & Business Media. v. Rauber, R. M., & Nesbitt, S. W. (2018). *Radar Meteorology: A First Course*. John Wiley & Sons.
Contents	**Unit-I** 1.1. Introduction to weather radar 1.2. Historical developments 1.3. Types of weather radar measurements 1.4. Radar Components 1.5. Radar Bands 1.6. Review of Electromagnetic waves **Unit-II** 2.1. Radar equation for point and volume targets 2.2. Radar signal processing 2.3. Doppler measurements **Unit-III** 3.1. Radar observations to meteorological quantities 3.2. Dual polarization radar observations 3.3. Interpretation of storm observations 3.4. Detailed study of rainfall 3.5. QPE and hydrometeor classification with dual-polarization radars

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
		25	35	40	100

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Title	**Weather Remote Sensing**
Code Number	CRSEL706
Credit hours	3
Learning Outcomes	After completing this course, the students will 1. Acquire the understanding that how aerosols impact climate through processes of scattering and absorption of radiations 2. Able to describe types of clouds and their structure 3. Gain knowledge of geostrophic winds and cyclones in the earth atmospheric system 4. Identify the impact of human activity on the energy balance in the earth atmospheric system
Suggested Readings	i. Hewitt, C. N., & Jackson, A. V. (2020). *Atmospheric Science for Environmental Scientists.* John Wiley & Sons. ii. Hobes, P. V. (2000). *Introduction to Atmospheric Chemistry*. Cambridge University Press. iii. Ritchie, G. (2017). *Atmospheric Chemistry, From the Surface to the Stratosphere.* World Scientific Publishing. iv. Visconti, G. (2016). *Fundamentals of Physics and Chemistry of the Atmosphere.* Springer. v. William Emery, Adriano Camps. (2015). *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications.* Pearson.
Contents	**Unit-I** 1.1. Formation and behaviours of clouds 1.2. Theoretical and experimental look at cloud 1.3. The chemistry of clouds and fogs 1.4. Statistics of size distributions 1.5. Brownian motion **Unit-II** 2.1. Atmospheric aerosols 2.2. Precipitation formation and cloud physics 2.3. Atmospheric chemistry and air quality 2.4. Fronts and thunderstorms monitoring from space 2.5. Mid-latitude cyclones **Unit-III** 3.1. Photochemistry of urban, rural, and marine tropospheric air 3.2. Cloud and precipitation retrievals using satellite 3.3. Satellite and ground-based observations of atmospheric clouds and particulate matter 3.4. Weather observations from space 3.4.1. Visible satellite imagery 3.4.2. Infrared satellite imagery 3.4.3. Water vapor imagery 3.5. Air pollution and its impacts

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Title	**Advanced Spatial Databases**
Code Number	CRSEL707
Credit hours	3
Learning Outcomes	After completing this course, the students will 1. Understand mathematical and statistical concepts required for spatial database development 2. Understand different database systems, their components, processes, and their interconnections 3. Perform data exploration and visualization 4. Understand the importance and implications of quantifying uncertainty in environmental assessment and modelling 5. Build the foundation of understating of cartography, digital image, spatial and non-spatial data, and geospatial terminology
Suggested Readings	i. David W. Allen. (2019). *Focus on Geodatabases in ArcGIS Pro.* ESRI Press. ii. John R. Jensen. (2018). *Drone Aerial Photography and Videography: Data Collection and Image Interpretation.* iii. Shekhar, S. (2007). *Spatial Databases*. Pearson Education India. iv. Zurbarán, M., Kraft, T., Mather, S. V., Park, B., & Wightman, P. (2018). *Post GIS Cookbook: Store, Organize, Manipulate, and Analyze Spatial Data*. Packt Publishing.
Contents	**Unit-I** 1.1. Introduction to spatial database 1.2. Spatial data representation **Unit-II** 2.1. Creating a Geodatabase 2.2. Spatial database management techniques and method 2.3. Populating a Geodatabase 2.4. Designing the Geodatabase Schema 2.5. Developing Labels and Annotation **Unit-III** 3.1. Exploring Cartographic Techniques 3.2. Logical geographic data models for spatial databases 3.3. Query processing and optimization 3.4. Working with Topology 3.4.1. Design conceptual data models for spatial databases using ER diagram approach 3.4.2. Process and retrieve geographic data from spatial databases 3.4.3. Pyramid structure 3.4.4. Data access methods and data compressing **Unit-IV** 4.1. Introduction to modern commercial and open-source spatial databases products 4.2. Advances and trends in spatial databases: Network data model and Spatio-temporal data model 4.3. Spatial data mining and applications of spatial databases

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Title	**Air Quality Assessment and Management**
Code Number	CRSEL 708
Credit hours	3
Learning Outcomes	After completing this course, the students will 1. Gain knowledge on the types and the science of environmental pollution 2. Appreciate the effect of polluting on human health 3. Gain analytical ability to link cause and effect of pollution 4. Identify critical issues of handling pollution vis a vis human being 5. Able to develop pollution mitigation/abetment strategies
Suggested Readings	I. Borrego, C., & Schayes, G. (2013). *Air Pollution Modelling and Its Application XV*. Springer. II. Dr. Daniel A, Vallero. (2019). *Air Pollution Calculations: Quantifying Pollutant Formation, Transport, Transformation, Fate and Risks.* Elsevier. III. Islam, T., Hu, Y., Kokhanovsky, A. A., & Wang, J. (2017). *Remote Sensing of Aerosols, Clouds, and Precipitation*. Elsevier. IV. Jacobson, M. Z. (2012). *Air Pollution and Global Warming: History, Science, and Solutions*. Cambridge University Press. V. Rais Akhtar. (2018). *Climate Change and Air Pollution: The Impact on Human Health in Developed and Developing Countries.* Springer. VI. Tomasi, C., Fuzzi, S., & Kokhanovsky, A. (2017). *Atmospheric Aerosols: Life Cycles and Effects on Air Quality and Climate*. John Wiley & Sons. VII. Vadrevu, K. P., Toshimasa, O., & Justice, C. O. (2021*). Biomass Burning in South and Southeast Asia*. CRC Press.
Contents	**Unit-I** 1.1. Overview of air pollution 1.2. Sources, sinks and classification of air pollutants 1.3. Formation and emissions of air pollutants **Unit-II** 2.1. Aerosols and its types 2.2. Impacts of particulate pollution on human health, materials, and ecosystem 2.3. Impact of meteorological parameters on air quality 2.4. Satellite and ground-based classification of aerosols **Unit-III** 3.1. Rationale for Air Quality Modelling 3.2. Types of models and their uses 3.3. Monitoring strategies for Local Air Quality Management 3.3.1. Air quality models input data and techniques 3.3.2. Air quality model validation, verification, and adjustment 3.4. Automatic and passive monitoring methods 3.4.1. Field, lab, and data protocols 3.5. Air Pollution Problems and Phenomena 3.6. Atmospheric Chemistry and Deposition 3.6.1. Eulerian Models 3.6.2. Lagrangian Particle Models 3.6.3. Long-range and Global Modelling

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Title	**Climate Change Vulnerability Assessment and Adaptation**
Code Number	CRSEL709
Credit hours	3
Learning Outcomes	After completing this course, the students will 1. Able to demonstrate sound understanding of the atmosphere and climate as integral part of the physical environment 2. Enable to appreciate the interaction between earth and atmosphere system, particularly the microclimate 3. Can integrate and use meteorological knowledge in the matrices of environmental research 4. Able to describe types of clouds and their structure 5. Gain the knowledge of how geostrophic winds and cyclones are caused in the earth atmospheric system
Suggested Readings	i. Dessler, A. (2015). *Introduction to Modern Climate Change*. Cambridge University Press. ii. Malcolm Dowden. (2018). *Climate Change and Sustainable Development: Law, Policy and Practice.* Estates Gazette. iii. Neelin, J. D. (2010). *Climate Change and Climate Modelling*. Cambridge University Press. iv. Rais Akhtar, Cosimo Palagiano. (2018). *Climate Change and Air Pollution: The Impact on Human Health in Developed and Developing Countries.* Springer. v. Schmittner, A. (2017). *Introduction to Climate Science*. Open Textbook Library. vi. Tanner, T., & Horn-Phathanothai, L. (2014). *Climate Change and Development.* Routledge.
Contents	**Unit-I** 1.1. Introduction 1.2. Key concepts in climatology and meteorology 1.3. Structure and composition of atmosphere 1.4. Elements and factors of climate 1.4.1. Temperature distribution 1.4.2. Humidity and its types 1.4.3. Atmospheric Pressure and global pressure belts **Unit-II** 2.1. Atmospheric Circulation 2.1.1. Air stability and instability 2.1.2. Storms 2.1.3. Cyclones 2.1.4. Hurricanes, typhoons, and tornadoes, 2.2. Clouds and its types 2.2.1. Jet streams 2.2.2. Air masses and fronts **Unit-III** 3.1. Classification of climates 3.2. Climate variability and climate change 3.3. Ozone Layer and ozone layer depletion 3.4. Natural and anthropogenic emissions 3.5. Greenhouse gasses and global warming 3.6. El-Niño and La-Niña **Unit-IV** 4.1. Climatic regions of Pakistan and their characteristics

	4.2. Climatic data: sources, collection, analysis, and presentation 4.3. Weather satellites 4.4. Applications of Remote Sensing in Climate Change Vulnerability Assessment and Adaptation

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Title	**Remote Sensing for Marine and Coastal Management**
Code Number	CRSEL710
Credit hours	3
Learning Outcomes	After completing this course, the students will 1. Enable them to synthesize the knowledge of biogeochemical processes and scientific challenges at the interfaces of seawater, landmasses, sediment, and atmosphere 2. Develop their skills on synthesis and extension of the information provided in marine chemistry, geochemistry, physical oceanography, and biology
Suggested Readings	I. Bartlett, D. J., & Celliers, L. (2017). *Geoinformatics for Marine and Coastal Management*. CRC Press, Taylor & Francis Group. II. Mather, P.M. (2011). *Computer Processing of Remotely Sensed Images. 4th ed*. Wiley-Blackwell. III. Richards, J.A., (2009). *Remote Sensing with Imaging Radar*. Springer, Heidelberg, Germany. IV. Valavanis, V. D. (2019). *Geographic Information Systems in Oceanography and Fisheries*. CRC Press, Taylor & Francis Group. V. Woodhouse, I.H. (2006). *Introduction to Microwave Remote Sensing*. Taylor and Francis, Boca Raton, Florida.
Contents	**Unit-I** 1.1. Introduction to Coastal Zone Management 1.2. Overview of remote sensing and GIS with respect to Marine Sciences 1.3. Marine environment and climate change 1.4. Biogeochemical cycles of macro and micronutrients **Unit-II** 2.1. Physical Oceanography 2.1.1. Coupling climate 2.1.2. Ocean currents 2.1.3. Biogeochemistry 2.2. Trace elements toxicity for marine biota 2.3. Photochemical processes in seawater 2.4. Interactions between metal and organic matter 2.4.1. Sediments 2.4.2. Sediment-water interface, and their role on the oceanic cycle 2.4.3. Coastal systems and geochemical processes, 2.4.4. Climate changes and feedbacks from the marine biogeochemical cycles **Unit-III** 3.1. Ocean acidification 3.2. Carbon cycle and De-oxygenation of ocean 3.3. Suboxic and anoxic-sulfidic zones 3.4. Limiting and controlling elements for the biological production: interactions between biogeochemical cycles and marine ecosystems **Unit-IV** 4.1. Data products from MODIS, VIIRS, and Copernicus 4.2. Coastal Resource Mapping 4.3. Remote Sensing based Coastal mapping and coastal boundary identification 4.4. Geospatial Applications of Mangrove and Coral Reef Mapping 4.5. Coastal Risk Assessment 4.6. Potential Fishing Zone Mapping

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Title	**Advanced Agro-meteorology**
Code Number	CRSEL711
Credit hours	3(2+1)
Learning Outcomes	After completing this course, the students will 1. Able to address environmental and agricultural problems facing our global community 2. Gain the skills to synthesize the different processes that determine crop growth and development 3. Develop skills to identify the major climatic influences on growth and development of crops 4. Gain interactive skills to apply the different methods used for modifying microclimates of crops 5. Describe the different crop models available and their applicability to crop growth and development
Suggested Readings	i. Dr. Prasad S. Thenkabail, John G. Lyon, Professor Alfredo Huete. (2019). *Advanced Applications in Remote Sensing of Agricultural Crops and Natural Vegetation.* CRC Press. ii. Meena, R. S. (2021). *Agrometeorology*. IntechOpen. iii. Mishra, R. S., & Bahadur, R. (2016). *Agrometeorological Approach to Sustainable Agriculture*. Daya Publishing House. iv. Simone Pascucci, Stefano Pignatti, Raffaele Casa. (2020). *Hyperspectral Remote Sensing of Agriculture and Vegetation*. MDPI AG. v. Yadav, R. P. (2018). *Agricultural Meteorology*. Rajat Publications.
Contents	**Unit-I** 1.1. The nature of laminar and turbulent flow 1.2. Friction, Eddy stresses and momentum fluxes 1.3. The vertical wind structure in the surface 1.4. The Ekman layers 1.5. Turbulence and temperature profiles The Richardson number and adiabatic wind profiles **Unit-I** 2.1. Energy balance 2.2. Radiation fluxes 2.3. Surface albedo 2.4. Soil heat fluxes 2.5. Eddy fluxes 2.6. Energy balance equation for different types of surfaces 2.7. Penman method 2.8. Daily and annual temperature cycles **Unit-III** 3.1. Scope of Agro meteorology 3.2. Boundary layer climate and growth of crops 3.3. Rainfall, potential and actual Evapotranspiration, and their management 3.4. Water harvesting 3.5. Mulching and wind breakers Soil erosion and soil leaking **Unit-IV** 4.1. Relationships between climate and ecology 4.2. Remote Sensing Data for Agricultural Meteorology 4.3. Nature of the climatic data

	4.4. Remote Sensing based Computational techniques 4.5. Range of equipment for conducting field experiments 4.6. Surface weather observations 4.7. Estimation of evapotranspiration in GIS

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Assignments-Types and Number with calendar		Assignments will be given according to the choice of respective teacher but in general, four assignments should be given i.e., in the 2nd, 4th, 10th, and 12th week of a semester. * All assignments must be completed and presented on time.			
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Title	**Photogrammetry**
Code Number	CRSEL712
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Acquire the interactive skills to implement a range of photogrammetric measurement techniques. 2. Able to apply the theory of photogrammetry to a range of measurement problems. 3. Gain the skills to determine the precision that can be achieved by a variety of photogrammetry techniques 4. Demonstrate how to use various photogrammetry software 5. Able to analyse the results obtained and portray them in a cogent manner
Suggested Readings	i. Armstrong, C. (2019). *Photogrammetry*. SAE International. ii. DeWitt, B., Wolf, P., & Wilkinson, B. (2014). *Elements of Photogrammetry with Application in GIS (4th ed.)*. McGraw-Hill Education. iii. Förstner, W., & Wrobel, B. P. (2016). *Photogrammetric Computer Vision: Statistics, Geometry, Orientation, and Reconstruction*. Springer. iv. John R. Jensen. (2018). *Drone Aerial Photography and Videography: Data Collection and Image Interpretation.*
Contents	**Unit-I** 1.1. Brief history of photography and photogrammetry 1.2. Basic optics 1.3. Digital Aerial Photographs 1.4. Scanning Existing Photography **Unit-II** 2.1. Image Sources 2.2. Analogue and Digital cameras 2.3. Sensors and Scanners 2.4. Geometry of Aerial Photographs and Satellite Images 2.5. Radar Images in Photogrammetry **Unit-III** 3.1. Use of GPS in Photogrammetry 3.2. Ortho-Images 3.3. Stereophotogrammetry 3.4. Orientation and transformations Camera and lens calibrations **Unit-IV** 4.1. 3D Modelling using Photogrammetry Data 4.1.1 Aerial Triangulation Measurement (ATM) 4.1.2 Digital Surface Modelling 4.1.3 Digital Terrain Modelling 4.2. Mosaics of DTMs and Ortho images 4.3. Applications of Photogrammetry

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Title	**Remote Sensing for Disaster Management**
Code Number	CRSEL713
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Understand the different types of natural hazard, their major driving forces/factor, and the causes 2. Understand the relationship/interface between geophysical processes and human activities in causing natural hazard 3. Interpret hazards scenarios at the global as well as National level 4. Understand the mitigation approaches, their choices, and alternatives 5. Develop foundations for hazard, risk, and vulnerability assessment
Suggested Readings	i. Dr. Daniel A. Vallero. (2019). *Air Pollution Calculations: Quantifying Pollutant Formation, Transport, Transformation, Fate and Risks.* Elsevier. ii. Goss, J. (2017). *Risk Assessment*. BBC Books. iii. Ha, H., Fernando, R., & Mahajan, S. (2019). *Disaster Risk Management*. Business Expert Press. iv. Hongjie Xie, Xianwei Wang. (2018). *Applications of Remote Sensing/GIS in Water Resources and Flooding Risk Managements.* MDPI AG. v. Kaku, K. (2019). *An Introduction to Applying Satellite Remote Sensing to Disaster Management.* Cambridge Scholars Publishing. vi. Saied Pirasteh, Jonathan Li. (2017). *Global Changes and Natural Disaster Management: Geo-information Technologies*. Springer. vii. Tomaszewski, B. (2020). *Geographic Information Systems (GIS) for Disaster Management*. Routledge.
Contents	**Unit-I** 1.1. Advanced Disaster Management 1.1.1. Framework 1.1.2. Planning 1.1.3. Assessment and information management 1.1.4. Response management and the role of different stakeholders 1.1.5. Policy guidelines on vulnerable groups 1.2. Multi-hazard Early Warning and Dissemination Mechanisms 1.2.1. Response Mechanism 1.2.2. Processes **Unit-II** 2.1. Remote Sensing systems used in Disaster Management 2.2. Datasets and tools 2.3. Remote Sensing Platforms 2.4. Remote Sensing based Risk modelling and vulnerability analysis **Unit-III** 2.5. Remote Sensing based Early Warning and Damage Assessment 2.6. Decision support tools in Climate Risk Management 2.7. Geospatial intelligence for crisis management 2.8. Applications of Remote Sensing in Disaster Management **Unit-IV** 4.1. Advanced Introduction to Remote Sensing Processes in Disaster Management 4.2. Remote Sensing and Drought crisis 4.2.1. Land and water management planning 4.2.2. Crop water requirement mapping 4.3. Remote Sensing and Earthquake

	4.3.1. Hazard mapping 4.3.2. Measuring strain accumulation 4.3.3. Damage assessment **Unit-V** 5.1. Remote Sensing and Flood 5.1.1. Mapping flood-prone areas 5.1.2. Rainfall mapping 5.1.3. Flood mapping 5.2. Remote Sensing and Landslide 5.2.1. Risk modelling 5.2.2. Slope stability 5.2.3. Mapping affected areas 5.3. Remote Sensing and Fire 5.3.1. Mapping fire-prone areas 5.3.2. Fire detection 5.3.3. Damage assessment 5.4. Remote Sensing and Cyclone 5.4.1. Vulnerability analysis 5.4.2. Long-range climate modelling 5.4.3. Storm surge predictions

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
Assessment Criteria	**Marks %**	Session	Mid	Final	Total %
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Title	**Advanced Applications of AI in Remote Sensing**
Code Number	CRSEL714
Credit hours	3 (2+1)
Learning Outcomes	After completing this course, the students will 1. Gain the practical implications about the integration of Remote sensing applications with advance AI algorithms 2. Develop their skills to integrate RS data with AI 3. Think critically to address multifaceted scientific issues and environmental phenomenon; pertain independent decision for synchronizing information to formulate innovative and intellectual advances towards focused research over wider theoretical and practical domains
Suggested Readings	i. Alpaydin, E. (2016*). Machine Learning: The new AI*. MIT Press. ii. Bramer, M. (2009). *Artificial Intelligence: An International Perspective*. Springer Science & Business Media. iii. Burger, S. V. (2018). *Introduction to Machine Learning with R*. O'Reilly Media, Inc. iv. D. Jude Hemanth. (2020). *Artificial Intelligence Techniques for Satellite Image Analysis.* Springer. v. Haupt S. E., Pasini A., Marzban, C. (2009). *Artificial Intelligence Methods in the Environmental Sciences.* Springer Nature. vi. Hsieh, W. W. (2009). *Machine Learning Methods in the Environmental Sciences: Neural Networks and Kernels.* Cambridge University Press. vii. Maria Pia Del Rosso, Alessandro Sebastianelli, Silvia Liberata Ullo. (2021). *Artificial Intelligence Applied to Satellite-based Remote Sensing Data for Earth Observation.* Institution of Engineering and Technology.
Contents	**Unit-I** 1.1. Fundamentals of Artificial Intelligence (AI) 1.2. Principles of artificial intelligence 1.3. Foundations of artificial Intelligence 1.4. Machine learning and Augmented Reality **Unit-II** 2.1. Designing of intelligent systems 2.2. Stages and Processes of Artificial Intelligence in Satellite image processing 2.3. Multispectral and Hyperspectral Satellite Sensors and AI 2.4. Multisensor Data Fusion and Machine Learning for Environmental Remote Sensing 2.5. Remote Sensing Modelling using AI **Unit-III** 3.1. AI in Python programs 3.2. Applications of AI in Remote Sensing of Climate Change 3.3. Environmental Modelling Sustainable development **Unit-IV** 4.1. Fuzzy Machine Learning Algorithms for Remote Sensing 4.2. Decision Tree 4.3. Artificial Neural Networks 4.4. Image Segmentation 4.5. Image classification using Machine Learning 4.6. Deep Convolution Neural Network 4.7. Detection of Objects in Satellite imagery using Neural Network Algorithms 4.8. Satellite Image Classification Algorithms

	4.8.1. Random Forest Techniques 4.8.2. Remote Sensing Deep learning approaches

Teaching-learning strategies		Class Lecture method, which includes seminars, discussions, assignments, and projects. (Audio-visual tools are used where necessary)			
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Note: Any elective course may be revised and added/deleted by the approval of BoS/Ad Hoc Committee for Centre for Remote Sensing.

Checklist for a New Academic Program

Parameters	
1. Department Mission and Introduction	✓
2. Program Introduction	✓
3. Program Alignment with University Mission	✓
4. Program Objectives	✓
5. Market Need/ Rationale	✓
6. Admission Eligibility Criteria	✓
7. Duration of the Program	✓
8. Assessment Criteria	✓
9. Courses Categorization as per HEC Recommendation	✓
10. Curriculum Difference	✓
11. Study Scheme / Semester-wise Workload	✓
12. Award of Degree	✓
13. Faculty Strength	✓
14. NOC from Professional Councils (if applicable)	NA

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Incharge