

GEOG - GEOGRAPHICAL SCIENCES

GEOG413 Migration: Latin America and the United States (3 Credits)

Develops an understanding of the push and pull factors that have contributed to human mobility (migration) that has transformed the Americas. The class is divided in two parts: immigration and emigration from Latin American and Latin America migration to the United States. We will be interested in studying the migration shifts that have occurred in Latin America and the theories that help explain them. The themes that will be addressed are the history of migration with Latin America and to North America, the impact of this migration on both sending and receiving countries, and the various policy strategies and issues concerning migration.

Prerequisite: GEOG313; or permission of BSOS-Geography department.

Recommended: HIST250; or USLT201; or LASC234.

Credit Only Granted for: GEOG413, or GEOG498M.

Formerly: GEOG498M.

GEOG415 Land Use, Climate Change, and Sustainability (3 Credits)

The issues of climate change and land use change as two interlinked global and regional environmental issues and their implications for society and resource use are explored.

Prerequisite: GEOG306; or permission of BSOS-Geography department.

Recommended: GEOG340; or GEOG342; or GEOG331. Or GEOG201; and GEOG211.

Credit Only Granted for: GEOG415 or GEOG498D.

Formerly: GEOG498D.

GEOG416 Conceptualizing and Modeling Human-Environmental Interactions (3 Credits)

Develops skills to carry out research that integrates environmental and economic aspects of sustainability by introducing extensively used quantitative tools for analyzing human-environmental interactions in the field of ecological economics. These include, e.g., index number calculations and decomposition analysis, Environmental Kuznets Curve (EKC), environmental input-output analysis and life-cycle analysis, and multi-criteria decisions aid (MCDA). Students will need laptops to run models during class.

Prerequisite: Permission of BSOS-Geography department.

Corequisite: MATH130, MATH140, or MATH120; or MATH220.

GEOG417 Land Cover Characterization Using Multi-Spectral Remotely Sensed Data Sets (3 Credits)

Students will be introduced to the image processing steps required for characterizing land cover extent and change. Key components of land cover characterization, including image interpretation, algorithm implementation, feature space selection, thematic output definition, and scripting will be discussed and implemented.

Prerequisite: GEOG272 and GEOG306; or permission of BSOS-Geography department.

Jointly offered with: GEOG617.

Credit Only Granted for: GEOG417 or GEOG617.

GEOG418 Field and Laboratory Techniques in Environmental Science (1-3 Credits)

Lecture and laboratory learning each week. A variable credit course that introduces field and laboratory analyses in environmental science. Individual learning contract are developed with instructor.

Restriction: Permission of BSOS-Geography department.

Credit Only Granted for: GEOG418 or GEOG448.

Formerly: GEOG448.

GEOG421 Changing Geographies of China (3 Credits)

Covers physical geography, history, and economic and political systems of the world's most populous country. The major focus will be on geographical issues in China's contemporary development: agriculture, population, urbanization, resource and energy, and environment.

Prerequisite: Permission of BSOS-Geography department. Or GEOG202; and GEOG201; and (GEOG435, GEOG333, or GEOG332).

Recommended: GEOG130; or GEOG140.

Credit Only Granted for: GEOG328B or GEOG421.

Formerly: GEOG328B.

GEOG422 Changing Geographies of Sub-Saharan Africa (3 Credits)

Students will develop an understanding of the geographic contexts of Sub-Saharan Africa, including an overview of the physical, bioclimatic, historical, cultural, political, demographic, health and economic geographies of Sub-Saharan Africa. Students will fill in the map of Africa by studying the spatial distribution within each of these geographic domains. In addition to an overview of geography South of the Sahara, the Congo will be taken as a more intensive case study through additional readings, lectures and discussions.

Prerequisite: Permission of BSOS-Geography department. Or GEOG201; and GEOG202; and (GEOG335 or GEOG333).

Recommended: GEOG130 or GEOG110.

Credit Only Granted for: GEOG328C, GEOG422.

Formerly: GEOG328C.

GEOG423 Latin America (3 Credits)

A geography of Latin America and the Caribbean in the contemporary world: political and cultural regions, population and natural resource distribution, economic and social development, poverty, crime, urbanization, migration trends, and natural disasters.

Prerequisite: Permission of BSOS-Geography department. Or GEOG201 and GEOG202; and (GEOG332, GEOG435, or GEOG333).

Recommended: GEOG130 and GEOG110.

Credit Only Granted for: GEOG313 or GEOG423.

Formerly: GEOG313.

GEOG431 Culture and Natural Resource Management (3 Credits)

Basic issues concerning the natural history of humans from the perspective of the geographer. Basic components of selected behavioral and natural systems, their evolution and adaptation, and survival strategies.

Credit Only Granted for: GEOG421 or GEOG431.

Formerly: GEOG421.

GEOG432 Spatial Econometrics (3 Credits)

An introduction to modern econometric techniques in general and spatial econometrics in particular, using the popular open source statistical computer language R. A focus on using statistical computing to produce analytical reports for real-world applications, research papers, and dissertations.

Prerequisite: Permission of BSOS-Geography department.

Jointly offered with: GEOG732.

Credit Only Granted for: GEOG432 or GEOG732.

GEOG438 Seminar in Human Geography (3 Credits)

Selected topics in human geography.

Recommended: GEOG201; or GEOG211.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG440 Polar Remote Sensing (3 Credits)

The harsh environment of the vast polar regions makes them some of the most inaccessible places on Earth. With widespread environmental change already underway, satellite remote sensing provides the only means by which to obtain year-round observations of the polar climate system. The objective of this course is to provide students with an overview of polar remote sensing techniques, including the physical principles of active and passive sensors, orbits, electromagnetic radiation, atmospheric transmission, calibration and validation. We will focus on measurements of the polar oceans, sea ice, glaciers, ice sheets, snow and permafrost, and examine the response of the cryosphere to climate change.

Prerequisite: PHYS171 or PHYS161; and AOSC401 or GEOG301; or with permission of instructor.

Cross-listed with: AOSC440.

Jointly offered with: AOSC642.

Credit Only Granted for: AOSC440, GEOG440, AOSC642, or GEOG640.

GEOG441 The Coastal Ocean (3 Credits)

Introduction to coastal oceanography, focusing on the physical, biological, and geological aspects of ocean areas on the inner continental shelves. Wave, currents, and tidal dynamics of bays, open coast, estuaries, and deltas. Sedimentary environments of major coastal types. Ecology and biogeochemical relationships, including benthic and planktonic characteristics. Coastal evolution with sea level rise. Human impacts: eutrophication, modification of sedimentation. The coastal future: rising sea level, hypoxia, and increased storminess.

Prerequisite: GEOG140; or students who have taken courses with comparable content may contact the department; or permission of BSOS-Geography department.

Credit Only Granted for: GEOG441 or GEOG498C.

Formerly: GEOG498C.

GEOG442 Biogeography and Environmental Change (3 Credits)

Biogeographical topics of global significance, including a consideration of measurement techniques, and both descriptive and mechanistic modeling. Topics may include: scale in biogeography, biodiversity, carbon geography, climate and vegetation, interannual variability in the biosphere, land cover, global biospheric responses to climate change, NASA's Mission to Planet Earth and Earth Observation System. The class focuses on both natural and anthropogenic controls, impacts of biogeography on climate and ecosystem services and different methods in biogeography.

Prerequisite: GEOG301. And GEOG201 and GEOG211; or permission of BSOS-Geography department. Jointly offered with GEOG642.

Credit Only Granted for: GEOG642, GEOG442, GEOG447, or GEOG484.

Formerly: GEOG447.

GEOG458 Special Topics in Study Abroad IV (1-6 Credits)

Special topics course taken as part of an approved study abroad program.

Repeatable to: 15 credits if content differs.

GEOG461 Machine Learning for Computational Earth Observation Science (CEOS) (3 Credits)

Provides an introduction to machine learning methods and models with an emphasis on Earth observation. Topics will include supervised (decision trees, random forest, neural networks, support vector machine, Gaussian process and ensemble techniques), and unsupervised techniques (clustering/segmentation, dimension reduction, multi-dimensional data visualization). The course will highlight the state-of-the-art deep learning models; object-based versus pixel-based image classification; how to deal with missing data and non-uniform coverage of data; and large scale land cover land use mapping from heterogeneous satellite data. Practical part will include satellite image classification by applying classification models and biophysical parameters retrieval by applying regression models.

Prerequisite: GEOG371.

GEOG470 Algorithms for Geospatial Computing (3 Credits)

An introduction to fundamental geospatial objects and geometric algorithms for spatio-temporal data processing and analysis. Point data representation and analysis: spatial data models and data structures, algorithms for spatial queries, point clustering algorithms. Surface and scalar field modeling, such as terrains: raster and triangle-based models (TINs), algorithms for building and querying TINs. Algorithms for natural and urban terrain analysis: morphology computation and visibility analysis. Applications to processing and analysis of LiDAR (Light Detection And Ranging) data in the context of terrain reconstruction, urban modeling, forest management and bathymetry reconstruction for coastal data management. Road network computation and analysis: algorithms for route computation in road networks, and for road network reconstruction from GPS and satellite data.

Prerequisite: GEOG276; or a minimum grade of C- in CMSC330 and CMSC351; or permission of instructor.

Cross-listed with: CMSC401.

Jointly offered with: GEOG770.

Credit Only Granted for: CMSC498Q, CMSC401, CMSC788I, GEOG470, GEOG498I, GEOG770, or GEOG788I.

Formerly: GEOG498I.

GEOG471 Technologies for Computational Earth Observations (3 Credits)

An introduction and exploration of cutting-edge novel remote sensing datasets and their associated science uses and applications. We present several modules focused on different technologies (multispectral, lidar, radar, thermal), and for each have both hands-on lab assignments, lectures, and applications case studies. Data fusion techniques, and common analysis and processing pitfalls are presented and discussed. Hands-on computer labs allow students to explore each dataset via online tutorials. After all datasets are presented, students download their own datasets in an area of interest to them, and work toward a unique student-driven project for presentation to the class. The sky is literally the limit in this interactive course which provides a research experience opportunity for students in a supportive atmosphere.

Prerequisite: GEOG371 or permission of instructor.

GEOG472 Remote Sensing: Digital Processing and Analysis (3 Credits)

Digital image processing and analysis applied to satellite and aircraft land remote sensing data. Consideration is given to image preprocessing techniques including radiometric calibration, geometric registration as well as atmospheric correction. Analysis methods include digital image exploration, feature extraction, thematic classification, change detection, and biophysical characterization. An application-oriented course project will be completed through the self-guided computer labs.

Prerequisite: GEOG272 and GEOG306; or students who have taken courses with comparable content may contact the department.

GEOG473 Geographic Information Systems and Spatial Analysis (3 Credits)

Analytical uses of geographic information systems; data models for building geographic data bases; types of geographic data and spatial problems; practical experience using advanced software for thematic domains such as terrain analysis, land suitability modeling, demographic analysis, and transportation studies.

Prerequisite: GEOG306 and GEOG373; or students who have taken courses with comparable content may contact the department.

Credit Only Granted for: GEOG473 or GEOG482.

Formerly: GEOG482.

GEOG475 Geographic Visualization and Digital Mapping (3 Credits)

An overview of the basic concepts and techniques that underlie digital map making and the broader field of geographic visualization for intermediate GIS users. This includes the use of color, map symbolization, map layout, and also the contribution to geographic visualization from the fields of scientific visualization, information visualization, and cognition. Fundamentals of dynamic map design and web mapping will be introduced through the use of animated and interactive maps.

Prerequisite: GEOG373 and GEOG306.

GEOG476 Object-Oriented Computer Programming for GIS (3 Credits)

Expands on conceptual and practical aspects of programming for geographic applications. The main focus of this course is to provide students more advanced programming in object oriented programming languages (i.e. Python). In addition, students will develop a proficiency in applying these advanced programming principles to manipulating spatial data sources within the Geographic Information Systems (GIS).

Prerequisite: GEOG373 and GEOG376; or permission of BSOS-Geography department. And must have completed MATH220; or must have completed or be concurrently enrolled in MATH120, MATH130, or MATH140.

Restriction: Must be in Geography program; or must be in GIS minor.

GEOG498 Topical Investigations (1-3 Credits)

Independent study under individual guidance.

Prerequisite: Restricted to advanced undergraduate students; and 24 credits in GEOG courses. Or restricted to graduate students.

Repeatable to: 6 credits if content differs.

GEOG601 The Nature and Practice of Science (3 Credits)

Introduces students to the nature and practice of science in physical and human geography, including practical methods for research productivity, professional, societal and ethical obligations of scientists, the philosophy of science, and the scientific literature. Students will prepare and critically evaluate research proposals.

Restriction: Permission of BSOS-Geography department.

Credit Only Granted for: GEOG601 or GEOG788N.

Formerly: GEOG788N.

GEOG603 Masters Research Tutorial (3 Credits)

Development of Masters scholarly paper topic, critical literature review, formulation of geographical approach to research methodology. Individual meetings with faculty. Comprehensive exam before the end of the semester.

Prerequisite: GEOG600.

Restriction: Permission of BSOS-Geography department.

Credit Only Granted for: GEOG603 or GEOG610.

Formerly: GEOG610.

GEOG606 Quantitative Spatial Analysis (3 Credits)

Multivariate statistical method applications to spatial problems. Linear and non-linear correlation and regression, factor analysis, cluster analysis. Spatial statistics including: trend surfaces, sequences, point distributions. Applications orientation.

Prerequisite: GEOG305; or permission of BSOS-Geography department.

Credit Only Granted for: GEOG605 or GEOG606.

Formerly: GEOG605.

GEOG608 Comprehensive Portfolio Assessment Summary (1-3 Credits)

Evaluation of a PhD student's portfolio.

Repeatable to: 3 credits.

GEOG609 Seminar in Remote Sensing (3 Credits)

Topics in Remote Sensing: These may include agricultural, forestry, coastal environments, urban environments, and other major applications of remote sensing. Also may focus on new and existing earth observation missions dedicated to land research.

Prerequisite: GEOG480.

Repeatable to: 6 credits if content differs.

GEOG615 Land Cover and Land Use Change (3 Credits)

This class provides an examination of land cover and land use change science, addressing the causes, impacts and projection of change.

Key concepts of land use science are presented and recent research papers and case studies are reviewed. Class consists of lectures, invited presentations and individual student projects and presentations.

Prerequisite: GEOG442, GEOG472, GEOG435, or GEOG473; or permission of BSOS-Geography department.

GEOG617 Land Cover Characterization Using Multi-Spectral Remotely Sensed Data Sets (3 Credits)

Students will be introduced to the image processing steps required for characterizing land cover extent and change. Key components of land cover characterization, including image interpretation, algorithm implementation, feature space selection, thematic output definition, and scripting will be discussed and implemented.

Prerequisite: Permission of BSOS-Geography department.

Jointly offered with: GEOG417.

Credit Only Granted for: GEOG417 or GEOG617.

GEOG618 Seminar in Geomorphology (3 Credits)

Selected topics; this can include discussion of empirical and theoretical research methods applied to geomorphological problems including review of pertinent literature.

GEOG628 Seminar in Climatology (3 Credits)

Selected topics in climatology chosen to fit the individual needs of advanced students.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG630 Climate, Energy, and Policy (3 Credits)

Students will learn about climate change and energy policy from multiple perspectives including social economic, technological, scientific, and behavioural aspects and their interdependence. The course will also consider the report of the Intergovernmental Panel on Climate Change on mitigation and applied cost/benefit analysis of Climate Change.

Prerequisite: Permission of BSOS-Geography department; or enrolled in the Geographical Sciences Graduate Program(s).

Credit Only Granted for: GEOG430, GEOG630, or GEOG788E.

Formerly: GEOG788E.

Additional Information: This course will make occasional use of the popular open source statistical computer language R for practical workshops.

GEOG638 Seminar in Biogeography (3 Credits)

Topics in Biogeography: Biological aspects of Geography. These may include ecology, biodiversity, climate-vegetation interactions, impacts of global change.

Prerequisite: Must have completed 6 credits of biogeography or ecology; or students who have taken courses with comparable content may contact the department.

Repeatable to: 6 credits if content differs.

GEOG639 Seminar in Physical Geography (3 Credits)

Examination of selected themes and problems in physical geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG640 Polar Remote Sensing (3 Credits)

The harsh environment of the vast polar regions makes them some of the most inaccessible places on Earth. With widespread environmental change already underway, satellite remote sensing is the only way to obtain year-round observations of the polar climate system. The objective of this course is to provide students with an overview of polar remote sensing techniques, including the physical principles of active and passive sensors, orbits, electromagnetic radiation, atmospheric transmission, calibration and validation. We will focus on measurements of the polar oceans, sea ice, glaciers and ice sheets and examine the response of the cryosphere to climate change.

Prerequisite: PHYS171 or PHYS161; and AOSC401 or GEOG301; or with permission of instructor.

Cross-listed with: AOSC642.

Jointly offered with: AOSC440.

Credit Only Granted for: AOSC440, GEOG440, AOSC642, or GEOG640.

GEOG642 Biogeography and Environmental Change (3 Credits)

Biogeographical topics of global significance, including a consideration of measurement techniques, and both descriptive and mechanistic modeling. Topics may include: scale in biogeography, biodiversity, carbon geography, climate and vegetation, interannual variability in the biosphere, land cover, global biospheric responses to climate change, NASA's Mission to Planet Earth and Earth Observation System. The class focuses on both natural and anthropogenic controls, impacts of biogeography on climate and ecosystem services and different methods in biogeography.

Restriction: Permission of BSOS-Geography department. Jointly offered with GEOG442.

Credit Only Granted for: GEOG788C, GEOG642, or GEOG442.

Formerly: GEOG788C.

GEOG646 Programming for GIS (3 Credits)

An introduction to computer programming using Python and web programming languages. It is required for students in the MSGIS program before they enroll in more advanced programming courses (GEOG656 and GEOG657). This course teaches students the fundamentals concepts of computer science. Students will learn about the components of a computer program such as data management, conditional statements, iterative statements, and file processing. Students will develop programs and web apps for the purpose of automating tasks and assisting with data analysis.

Additional Information: This class is recommended for all MSGIS students who have no prior computer programming background as well as those who wish to have additional practice. The skills learned in this class will be useful for more advanced courses such as GEOG656 (Programming and Scripting for GIS), GEOG657 (Web Programming), and GEOG650 (Mobile GIS).

GEOG648 Seminar in Cultural Geography (3 Credits)

Examination of selected themes and problems in cultural geography.

Repeatable to: 6 credits if content differs.

GEOG650 MOBILE GIS (3 Credits)

This course covers how to create, test, and publish mobile GIS applications that work across multiple platforms (Android, iOS, and Black Berry Tablet OS) and adapt to a smartphone or tablet display.

Prerequisite: GEOG657.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

GEOG651 Spatial Statistics (3 Credits)

This course is about quantitative analysis of spatial data. It is intended to provide a broad survey of various methods of exploratory statistical data analysis most useful in environmental and social sciences. The course is a mix of theory, methods, and applications geared towards helping students: (1) develop an understanding of the important theoretical concepts in spatial data analysis; and (2) gain practical experience in application of spatial statistics to a variety of social and environmental problems using advanced statistical software.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

GEOG652 Digital Image Processing and Analysis (3 Credits)

Digital image processing and analysis applied to satellite and aircraft land remote sensing data. Consideration is given to preprocessing steps including calibration and geo registration. Analysis methods include digital image exploration, feature extraction thematic classification, change detection, and biophysical characterization. One or more application examples may be reviewed.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in the Geospatial Information Sciences (Graduate Certificate) program.

GEOG653 Spatial Analysis (3 Credits)

Methods of spatial analysis including measuring aspects of geometric features and identifying spatial patterns of geospatial objects that are represented as point, line, network, areal data, and 3-D surfaces.

Prerequisite: GEOG579; or students who have taken courses with comparable content may contact the department.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in the Geospatial Information Sciences (Graduate Certificate) program.

GEOG654 GIS and Spatial Modeling (3 Credits)

Provide foundations and understanding on various issues related to modeling and simulation in GIS context. It will address the concepts, tools, and techniques of GIS modeling, and presents modeling concepts and theory as well as provides opportunities for hands-on model design, construction, and application. The focus will be on raster-based modeling. This course is also application-orientated, particularly in these fields such as terrain modeling, LULC modeling, hydrological modeling, suitability modeling, etc.

Prerequisite: GEOG653.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

GEOG655 Spatial Database System (3 Credits)

This course is designed to help students understand, analyze, design, and implement spatial databases. While the basic concepts and theories of database will be introduced, the focus of this course will be on providing students with hands-on experiences to practice the technical skills used in spatial database design and implementation. SQL, Oracle, and ArcSDE are the key topics.

Prerequisite: GEOG653.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

GEOG656 Advanced Programming for GIS (3 Credits)

Programming and scripting for intermediate GIS users. The fundamental concepts of computer programming will be introduced within the Geoprocessing framework in ArcGIS primarily using Python. Concepts of object-oriented programming and scripting will be presented. Students will develop skills in programming techniques to explore, manipulate and model spatial data using the Geoprocessor methods.

Prerequisite: GEOG653.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

GEOG657 Web Programming (3 Credits)

Intermediate course designed to teach students the techniques for Web development, particularly creating dynamic and data-driven Web applications. Introduces a high-level, object-oriented programming language such as VB.Net and the designing, coding, debugging, testing, and documenting for the development of Web-based applications. Other popular Web development tools such as DHTML, CSS and PHP are also covered.

Prerequisite: GEOG653.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Geospatial Information Sciences program.

Credit Only Granted for: GEOG657 or GEOG788R.

Formerly: GEOG788R.

GEOG658 Seminar in Historical Geography (3 Credits)

An examination of themes and problems in historical geography with reference to selected areas.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG660 Advanced Remote Sensing Using Lidar (3 Credits)

Lidar, also known as laser scanning, is an active remote sensing tool that can produce high-resolution point clouds. Lidar is being applied to problems such as terrain modeling, biomass estimation, change detection, feature extraction, and measuring tree canopy. Topics covered are fundamentals of lidar, current developments in lidar technology, and different applications where lidar is being used. Students will get hands-on learning about lidar data management, processing, and analysis.

Prerequisite: GEOG652.

Recommended: GEOG656 and GEOG654.

Credit Only Granted for: GEOG660 or GEOG788G.

Formerly: GEOG788G.

GEOG661 Fundamentals of Geospatial Intelligence (3 Credits)

Geospatial Intelligence (GEOINT) is the collection, analysis, visualization and dissemination of geospatial information to support decision-making. This course introduces the fundamental knowledge required to become a successful GEOINT practitioner, including the history of the GEOINT discipline, the intelligence applications of remote sensing and Geographic Information Systems (GIS) technologies, and how GEOINT products are used to support national security and humanitarian missions. Upon completion of this course you will understand the roles that technology, policy, doctrine, government, and industry play in shaping the Geospatial Intelligence discipline, and develop the technical knowledge and domain expertise to create basic GEOINT products that provide context for decision makers.

GEOG662 Advances in GIS and Remote Sensing (3 Credits)

Focuses on state-of-the-art advances in geographic information science and remote sensing as they support geospatial intelligence. Focus on synergies between GIS and remote sensing in informatics, computer science, and spatial engineering, and their application to problem domains in human systems, physical systems, and cyberspace. Advances in GIS presents recent advances regarding fundamental issues of geo-spatial information science (space and time, spatial analysis, uncertainty modeling and geo-visualization), and new scientific and technological research initiatives for geo-spatial information science (such as spatial data mining, mobile data modeling, and location-based services). Advances in remote sensing will provide opportunity to understand and work with latest developments in the Remote Sensing datasets. The curriculum covers wide range of remote sensing data interpretation and their processing techniques.

Restriction: Students taking the course must be familiar with data structures, basic GIS and RS concepts, and demonstrate basic understanding of using GIS and RS software. And must be enrolled in Geographical Sciences MPS or graduate certificate program; or permission of BSOS-Geography department.

GEOG663 Big Data Analytics (3 Credits)

Provides a comprehensive introduction to big data analytics, emphasizing statistical and machine learning techniques for analyzing large datasets. While rooted in geography and spatial sciences, the course is broadly applicable across socio-behavioral sciences. Students will gain hands-on experience with industry-standard tools and frameworks for data exploration, modeling, and visualization. Topics covered include foundational data analytics methods using R, clustering techniques, regression analysis, text analysis, and deep learning with Keras and TensorFlow. The course also explores geospatial machine learning in ArcGIS, big data processing with Hadoop and Spark, and working with distributed computing frameworks such as MapReduce, Pig, Hive, and NoSQL databases.

Recommended: Students taking the course must be familiar with data structures, basic GIS and RS concepts, and demonstrate basic understanding of using GIS and RS software.

Restriction: Permission of BSOS-Geography department; or must be enrolled in Geographical Sciences MPS or graduate certificate program.

GEOG664 GEOINT Systems and Platforms (3 Credits)

There are numerous systems and platforms that support the collection, visualization and dissemination of Geospatial Intelligence (GEOINT). Platforms such as satellites and aircraft carry sensors systems that can detect both physical and man-made objects on the earth. Ground-based processing systems are used to analyze and visualize sensor data, and also to create and disseminate GEOINT products that guide decision-making. In this course you will learn how to develop and implement source-to-screen GEOINT workflows, and will understand how to use a system of systems approach to describe the programmatic and technical strengths and weaknesses of many different GEOINT systems and platforms.

GEOG665 Algorithms for Geospatial Intelligence Analysis (3 Credits)

Exposes students to fundamental algorithms in geospatial intelligence and their application in methodological and substantive domains, and their implementation in computer programs and software systems. Current topics include spatial and space-time analysis, cartographic transformations, data compression and reduction, MapReduce and distributed data access, genetic algorithms, clustering and indexing algorithms, filtering algorithms, geometry and tessellation algorithms, routing algorithms, localization algorithms, and complexity and scaling. Implementation of algorithms will be explored through pseudo-code and a variety of scripting, data access, and programming languages.

Recommended: Students taking the course must be familiar with data structures, basic GIS and RS concepts, and demonstrate basic understanding of using GIS and RS software.

Restriction: Permission of BSOS-Geography department; or must be enrolled in Geographical Sciences MPS or graduate certificate program.

GEOG666 Drones for Data Collection (3 Credits)

Topics covered in this class include: how to prepare students to obtain their FAA Remote Pilot License, understand how to pick drone systems for a data need, and utilize Pix4D to process drone imagery. Before talking about data students will learn about drone and aviation specific laws that will affect them while carrying out operations. Once legal limitations of drone flights have been covered the course will shift toward learning how to select a drone system based on specifications of the equipment and needs of the project and flying. Students will then move on to data processing utilizing Pix4D, Python, and Bash to clean data and automate processing.

Prerequisite: GEOG646 or GEOG656.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in Graduate Certificate: Professional Studies-Geospatial Information Sciences.

Credit Only Granted for: GEOG688E or GEOG666.

Formerly: GEOG688E.

GEOG668 Seminar in Economic Geography (3 Credits)

Examination of themes and problems in the field of economic geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG670 Open Source GIS (3 Credits)

An exploration of techniques for using Free and Open Source Software for GIS (FOSS4g) from conception to final presentation of results. Advanced concepts and techniques including enterprise GIS, spatial SQL, parallel processing, and displaying the results of GIS analysis over the Internet will also be covered.

Credit Only Granted for: GEOG670 or GEOG788A.

Formerly: GEOG788A.

Additional Information: Students do not need any experience using open source GIS, but students are expected to be comfortable using a desktop GIS such as ArcGIS.

GEOG672 Biophysics of Optical Remote Sensing (3 Credits)

Biophysical principles, phenomena and processes underlying multispectral remote sensing in the optical portion of the EM spectrum. Includes computer-based exercises that explore the biophysical basis of land patterns and dynamics observed in remote sensing data.

Prerequisite: GEOG472; or students who have taken courses with comparable content may contact the department; or permission of BSOS-Geography department.

GEOG677 Web GIS (3 Credits)

This course is designed to: (1) introduce the concepts and theories that are related to an increasingly important technology b (2) introduce various technologies or techniques for creating, analyzing, and disseminating GIS data and services via the Web. Students will be required to practice almost all of the Web GIS tools including client side mapping frameworks like the ArcGIS API for JavaScript, Mapbox, Leaflet, Google Map API, OpenLayers; server side systems including ArcGIS Enterprise (Server/Portal/DataStore), GeoServer; data formats for the web WMS, WFS, Feature Services, MapServices. Students will also be exposed to the experience of working with the Cloud environment such as AWS EC2 and Azure.

Recommended: GEOG676.

Restriction: Permission of BSOS-Geography department.

GEOG679 Seminar in Urban Geography (3 Credits)

Post-industrial urbanization; urban planning and management; metropolitan systems; internal structure of the city; use of techniques in urban locational research; transportation and land use.

Repeatable to: 6 credits if content differs.

GEOG680 GEOINT Networks (3 Credits)

Networks are an important part of the Geospatial Intelligence (GEOINT) cycle, from the sensor networks that are used to collect raw geospatial information to the telecommunication networks that are used to disseminate finished GEOINT products. Transportation networks, computer networks, social networks, and many other man-made and natural features can also be characterized by a link-node network topology, and can be studied using network science methods. Upon completion of this course you will be able characterize and classify real-world GEOINT networks and their components, understand network dynamics including routing, scalability, and robustness, and be able to apply engineering methods for network design and network analysis.

GEOG681 Introduction to Computational Social Science (3 Credits)

Introduction to Computational Social Science serves as an introduction to the basis for computational social science (CSS) across diverse disciplines and topics at the intersection of the socio-behavioral sciences, physical sciences, and computing sciences. We will explore the foundations for CSS in different subject domains, as the methods used to build representations of social science entities, phenomena, and processes in computational media. We will also critique applied computational social science as it relates to topics that cut across the socio-behavioral sciences, or that specialize within particular socio-behavioral science domains.

Credit Only Granted for: GEOG681 or GEOG788W.

Formerly: GEOG788W.

GEOG682 Open Source Intelligence (3 Credits)

Open Source Intelligence (OSINT) is information that is publicly available that is collected and analyzed to support decision-making. The collection and analysis of OSINT is often considered to be the first step in developing an all-source intelligence product, where OSINT is fused with Geospatial Intelligence (GEOINT), Signals Intelligence (SIGINT), and Measurement and Signature Intelligence (MASINT), and Human Intelligence (HUMINT). In this course you will learn about the sources, ethics, and methods that are associated with OSINT, and will also develop knowledge and skills related to open-source geospatial technologies and organizations such as the Open Geospatial Consortium (OGC).

GEOG683 Hazards and Emergency Management (3 Credits)

Timely and accurate Geospatial Intelligence (GEOINT) is essential for protecting people from hazardous events such as floods, wildfires, tsunamis, hurricanes, industrial accidents, and terrorist attacks. GEOINT plays a critical role in all four stages of emergency management: preparedness, mitigation, response, and recovery. The use of remote sensing and Geographic Information Systems (GIS) before, during, and after Hurricane Katrina and the 9/11 terror attacks are two of the case studies that are discussed during this course. You will develop a deeper understanding of the emergency management successes and failures that occurred during these historic and deadly events, and learn the technical skills to develop and disseminate GEOINT products that support decision-making at all four stages of emergency management.

GEOG685 Machine Learning and Data Mining (3 Credits)

Introduces statistical and spatial analysis over machine learning in mining data sets (and tackling big data problems), primarily in geography and spatial sciences, but with broader appeal throughout the socio-behavioral sciences. Students will be introduced to a range of methods that can be applied to the exploration, modeling, and visualization of big quantitative data. This course explores data cleaning, statistical analysis, and data-mining for geospatial and non-geospatial data in structured and unstructured form, with an emphasis on large silos of data across diverse sources and assumptions. Topics will include open sourcing, metadata schemes, data standards and models, data-access, data-mining, clustering methods, classifiers, data reduction, machine learning, filtering schemes, real-time and streaming data, archiving and preservation, and handling uncertainty.

Prerequisite: GEOG665 or equivalent.

GEOG686 Mobile GIS and Geocomputing (3 Credits)

An introduction to mobile GIS, to the programming concepts underlying mobile GIS development, and to the design and implementation of a mobile GIS application. Covers how to develop, test, and publish mobile GIS native apps working across two mobile platforms: Android and iOS. Leverages the capabilities of JavaScript, Swift, Google maps, ArcGIS Server and runtime SDK to developing and publishing mobile GIS apps.

Prerequisite: Permission of BSOS-Geography department; or must be enrolled in Geographical Sciences MPS or graduate certificate program.

Recommended: Students taking the course must be familiar with data structures, basic GIS concepts, and demonstrate basic understanding of object-oriented programming under GIS environment.

Credit Only Granted for: GEOG477, GEOG498V, GEOG788V or GEOG777.

Additional Information: Tablets that run android and iOS will be loaned to registered students at no cost.

GEOG687 Applied GEOINT- Regional Geostrategic Issues (3 Credits)

Applies a geospatial intelligence (GEOINT) lens when examining the political, military, economic and cultural effects of geography in historical and contemporary terms: specific emphasis is placed on the role of geography in the formulation of regional, e.g., Africa, military/political policy in land power, sea power, and air power. Comprehensive geopolitical theories will be incorporated with geospatial technologies as analytical tools in this course.

GEOG688 Selected Topics in GIS (1-3 Credits)

Readings and discussion on selected topics in the field of Geographic Information Science (GIS).

Repeatable to: 15 credits if content differs.

GEOG693 Independent Study in GEOINT (3 Credits)

In order to broaden the scope of the knowledge for our students in the ever-changing technologies in Geospatial Intelligence, the independent study course gives students an opportunity to explore a topic of interest under the close supervision of a faculty with expertise in the field. The course may include directed readings, applied work, assisting the faculty member with a research project, carrying out an independent research project, or other activities deemed appropriate by the supervising faculty member and the program.

Restriction: Permission of the Geospatial Intelligence program.

GEOG694 Computerized Map Projections and Transformations (3 Credits)

Computer generated projections; techniques for transforming one coordinate system to another; software for producing different map projections; mathematical and perceptual problems in producing and using projections.

Prerequisite: GEOG694; or students who have taken courses with comparable content may contact the department; or permission of BSOS-Geography department.

GEOG697 Capstone Project (3 Credits)

An independent research project that demonstrates competence in geospatial intelligence technologies. This project can originate from an internship, from relevant work at a current or past employer, or can be developed in conjunction with a department faculty. The student will prepare a project report and presentation which shall contain an executive summary, background information including a literature review and establishment of requirements, a detailed technical description of the project data and methods, a discussion of results obtained, and final conclusions and recommendations. The final project submission will include all data, computer code and/or workflow documentation required to replicate the project results. In completing this project, students develop a concrete example of how GEOINT technologies can be applied to solve real-world problems, and begin developing a portfolio that can be presented to potential employers.

Prerequisite: 24 credits in GEOG courses.

Restriction: Students taking the course must be familiar with data structures, basic GIS and RS concepts, and demonstrate basic understanding of using GIS and RS software. And must be enrolled in Geographical Sciences MPS or graduate certificate program; or permission of BSOS-Geography department.

GEOG698 Selected Topics in Geography (1-3 Credits)

Readings and discussion on selected topics in the field of geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 12 credits if content differs.

GEOG699 Seminar in Computer Cartography (3 Credits)

Selected topics in computer-assisted cartography: algorithms for linear generalization, containing three-dimensional mapping and continuous-time mapping.

Prerequisite: GEOG373; or students who have taken courses with comparable content may contact the department; or permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG718 Seminar in Integrative Studies (3 Credits)

Selected topics integrating various areas of study within the field of geography and/or related disciplines.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG732 Spatial Econometrics (3 Credits)

An introduction to modern econometric techniques in general and spatial econometrics in particular, using the popular open source statistical computer language R. A focus on using statistical computing to produce analytical reports for real-world applications, research papers, and dissertations.

Prerequisite: Permission of BSOS-Geography department.

Jointly offered with: GEOG432.

Credit Only Granted for: GEOG432 or GEOG732.

GEOG738 Seminar in Human Geography (3 Credits)

Selected topics in human geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG748 Seminar in Physical Geography (3 Credits)

Selected topics in physical geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG749 Seminar in Biogeography (3 Credits)

Selected topics in biogeography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG761 Machine Learning for Computational Earth Observation Science (CEOS) (3 Credits)

Provides an introduction to machine learning methods and models with an emphasis on Earth observation. Topics will include supervised (decision trees, random forest, neural networks, support vector machine, Gaussian process and ensemble techniques), and unsupervised techniques (clustering/segmentation, dimension reduction, multi-dimensional data visualization). The course will highlight the state-of-the-art deep learning models; object-based versus pixel-based image classification; how to deal with missing data and non-uniform coverage of data; and large scale land cover land use mapping from heterogeneous satellite data. Practical part will include satellite image classification by applying classification models and biophysical parameters retrieval by applying regression models.

Jointly offered with: GEOG461.

Credit Only Granted for: GEOG461, GEOG688M or GEOG761.

Formerly: GEOG688M.

GEOG770 Algorithms for Geospatial Computing (3 Credits)

Geometric primitives and algorithms for discrete and continuous spatial data processing. Point data representation and analysis: spatial data structures, neighbor finding and range queries, clustering algorithms. Terrain modeling: grids and TINs, algorithms and data structures for building and querying TINs, gridding and interpolation. Terrain analysis: segmentation through watershed computation, algorithms for visibility computation. Applications to LiDAR data processing and analysis for forest management, urban modeling, and coastal data mapping.

Prerequisite: GEOG276 or permission of instructor.

Jointly offered with: GEOG470.

Credit Only Granted for: CMSC498Q, CMSC401, CMSC788I, GEOG470, GEOG498I, GEOG770, or GEOG788I.

Formerly: GEOG788I.

GEOG778 Seminar in Remote Sensing (3 Credits)

Selected topics in remote sensing.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG779 Seminar in Geographic Information Science (3 Credits)

Selected topics in geographic information science.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 6 credits if content differs.

GEOG788 Selected Topics in Geography (1-3 Credits)

Readings and discussion on selected topics in the field of geography.

Restriction: Permission of BSOS-Geography department.

Repeatable to: 12 credits if content differs.

GEOG789 Independent Readings (1-8 Credits)

Independent reading as arranged between a graduate faculty member and graduate student.

Repeatable to: 8 credits if content differs.

GEOG790 Internship in Geography (3 Credits)

Field experience in the student's specialty in a Federal, state, or local agency or private business. Research paper required.

GEOG795 Professional Practices Seminar (1 Credit)

Development and preparation of a resume, selecting and helping reference writers, conducting successful interviews, negotiating an employment package, giving professional presentations, proposal preparation, writing reports, codes of ethics and responsibilities. Presentations from practitioners in GIS field. Basic project management skills and strategies in preparation for professional project.

Restriction: Must be in Geospatial Information Sciences (Master's) program.

GEOG796 GIS Project Management (3 Credits)

Project management methodology is covered, emphasizing implementing and integrating GIS into broader projects. Topics include project initiation, planning, scope, scheduling, budgeting and risk management.

Prerequisite: GEOG653, GEOG652, and GEOG606.

Restriction: Must be in Geospatial Information Sciences (Master's) program; or must be in the Geospatial Information Sciences (Graduate Certificate) program.

Credit Only Granted for: GEOG796 or INFM706.

Formerly: INFM706.

GEOG797 Professional Project (3 Credits)

Data and materials can originate from an internship (internal or external) or from relevant work experience with current employer. Under direction of faculty advisor, students will prepare a project report containing explanation of the requirements for the work, technical account of the activities undertaken, including literature review, description of methods and approaches taken, a critical discussion of results, along with conclusions and recommendations developed from the project. Final project will consist of a full-fledged GIS application that is up and running and can be tested, providing potential employers with a portfolio demonstrating student's ability to manage and develop a GIS application in real world situations.

Restriction: Must be in Geospatial Information Sciences (Master's) program.

GEOG798 Selected Topics in Geography: Seminar Series (1 Credit)

Readings and discussions on selected topics in the field of geography.

Repeatable to: 6 credits if content differs.

GEOG799 Master's Thesis Research (1-6 Credits)**GEOG898 Pre-Candidacy Research (1-8 Credits)****GEOG899 Doctoral Dissertation Research (1-8 Credits)**