

GeoS4S Module Climate Change and Adaptation

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Abstract

The earth is experiencing a profound climate change which influences the land surface processes. The application of geospatial techniques helps people to obtain skills for measuring spatiotemporal patterns of climate change and evaluating its impacts on the ecosystem and human life. This teaching module focuses on the basic concepts of climate change and adaptation and employs case studies and interactive exercises to measure the elements of climate change and their spatial distribution. Its high-level goal is to use modelling tools to generate climate change scenarios. The current paper summarizes the learning objectives, lesson content, learning activities and evaluation scheme for this module.

Key Words: Climate Change, Adaptation Strategies, Energy Balance, Air Moisture, Geospatial Technique, Spatial Interpolation, Downscaling Technique

1. Introduction

Climate means the weather characteristics in terms of long term and wide area. Climate change has been shown by direct and indirect evidence. Climate change varies with the time spans and locations, and is reflected by many meteorological parameters. Studies on climate change focus on the variations of meteorological parameters, which relates to the geospatial characteristics. The geospatial techniques will help deal with the spatial distribution and changing trends of meteorological parameters, and also offer the tools for studying the relationship of the parameters and modeling the dynamics of climate system. GIS as an important tool has been widely used for climate change studies.

1.1 Module Description

The earth is experiencing a profound climate change which influences the land surface processes. The climate change requires to get a more thorough understanding of the scientific basis of both natural and anthropogenic causes. This module focuses on the basic concepts of climate change and adaptation. The causes and impacts of climate change will be introduced in the module on the basis of the principles of energy balance and moisture circulation. Through readings, lectures, discussions and laboratory exercises, students are able to use modelling tools to generate climate change scenarios. The application of geospatial techniques helps students to obtain skills for measuring spatiotemporal patterns of climate change and evaluating their impacts on the ecosystem and human life. Both the mitigation measures and the potential strategies for adaption and mitigation for global warming also will be proposed and discussed in the module. A key objective will be to provide students with a knowledge base and skills to critically evaluate information concerning climate change and related issues. Geo-related laboratory exercises include: (1) Functions of GIS in climate change studies; (2) GIS-assisted spatial interpolation and presentation of climatic data; (3) Climate models and modelling climate changes.

1.2 Learning Outcomes

- Gain knowledge about climate system and climate change, and use GIS-assisted to identify the evidences of climate change with direct and indirect observation;
- Familiarize measurement of the elements of climate change and enable to explain what are causes driving climate change;
- Identify and apply geospatial techniques for evaluating climate change and its impacts;
- Enable to use climate generator and/or downscaling technique to generate climate change scenarios and apply generated data to assess climate change in a given region;
- Assess potential impacts of future climate change and propose the potential strategies for adaptation and mitigation for global warming

2. Module Structure

2.1 Module Overview

This module consists of 14 lessons with slides and accompanying notes in total which amounts to a minimum of 150 hours of effort required for studying the core material. Most of the lessons equal to about 4 to 5 hours, excluding reading material, lab exercises and assignments. Plus 1 final report, the module is intended to provide credit equivalent to 6 ECTS. The module materials are designed to be used flexibly, in either a traditional classroom setting or for on-line study.

2.2 Summary of Lesson Content

This section briefly presents the content and goals of each lesson.

- *Lesson 1: Introduction to climate change* - This lesson shows the knowledge about the phenomenon of weather and climate, and explains the concept of climate change. It also describes the approaches to climate change studies using Geo-techniques. There is a required reading assignment “Climate Change is a Geographic Problem” in this lesson.
- *Lesson 2: Earth's climate system* - This lesson describes the concept and components of Earth's climate system, the radiative forcing of Earth's climate system, as well as biogeochemical cycles and its links to the climate system. There are quizzes on the components of the climate system, feedbacks among components of the climate system and radiative forcing types of Earth's climate system in this lesson.
- *Lesson 3: Application of GIS in climate change studies* - This lesson describe some information about GIS. Via a case study, it shows how to create and present climatic dataset using GIS software.
- *Lesson 4: Evidence and impact of climate change* - This lesson identifies the main evidences of climate change, analyzes the trend of climate change and recognizes the consequences of climate change. There are quizzes on global warming, evidence to support the climate change and plant productivity under climate change in this lesson.
- *Lesson 5: Energy balance and temperature* - This lesson explains the concepts of radiation, the energy balance on the earth, and how latitude, elevation, ocean, land use and land cover affect regional distribution of temperature. There is a reading assignment with a report to show how human activities influence climate variations.
- *Lesson 6: Causes of climate change* - This lesson explains the causes of climate change, greenhouse effects and how human activities have contributed to climate change. There are quizzes on the sources of energy for the Earth, main natural factors influencing the energy budget of the Earth, greenhouse gases and global cooling in this lesson.
- *Lesson 7: Air moisture and precipitation* - This lesson explains the process of air cooling, air humidity and environmental lapse rate and the factors influencing the distribution of precipitation.
- *Lesson 8: Spatial interpolation of Climate Parameters* - This lesson presents different methods for spatial interpolation, performs GIS-assisted spatial interpolation of climate data via a case study and discusses the characteristics of different interpolation methods.
- *Lesson 9: Climate extremes* - This lesson explains the concept and types of climate extremes and shows the method to assess climate extremes. There is a reading assignment with a report to show the impacts of climate extremes on human systems based on the required reading assignment “Changes in Impacts of Climate Extremes” in this lesson.
- *Lesson 10: Land-Air interactions and feedback Mechanisms* - This lesson explains the feedback concept and main cases of land-atmosphere interactions. There are quizzes on main feedbacks to control the precipitation and the temperature change and main consequences from deforestation in Amazon in this lesson.
- *Lesson 11: Climate models and modelling climate changes* - In this lesson, students learn the concept and types of climate models, how to assess the performance of climate models and downscaling techniques.
- *Lesson 12: Climate models and modelling climate changes (Lab-tutorial)* - In this exercise, students learn to downscale the climatic factors with a statistical method via a case study.
- *Lesson 13: Future climate change and projected impacts* - This lesson presents how to generate future scenarios, the trend of future climate change and potential impacts of future climate change. There is a required reading assignment “A guide to Representative Concentration Pathways” in this lesson.

underground, key water management challenges and main points, and framework of IBM smart water management.

- *Lesson 13: Case study 3: GeoKSCloud: The Geographical Knowledge Service Cloud* - An example of urban public security management system - GeoKSCloud: The Geographical Knowledge Service Cloud is described in this lesson. In this lesson, students can understand the aim, three layers architecture, five functions, and three key technologies of GeoKSCloud.
- *Lesson 14: Practice* - This lesson requires students to use what they have learned to realize the urban intelligent planning and management/Other intelligent systems to deepen their understanding and cognition of Smart City.
- *Lesson 15: Visiting the local Urban Administration Departments* - This lesson aims to let the students understand the operation of Smart city through visiting the local Urban Administration Departments. This way enables students to truly understand how scientific research serves social practice.

3. Hands-on Sessions

The module provides several interactive and hands-on activities to supplement the lecture content, deepen students' understanding, and develop their practical skills. Many of these activities are part of the module evaluation scheme.

- Spatial data analysis technologies by using ArcGIS (Lesson 3)
- The application of free cloud computation platform (Lesson 6)
- Finding check-in hot spot areas for both native and non-native people in Beijing City (Lesson 7)
- A system architecture and service model of smart city (Lesson 9)
- Draw the future map of smart city (Lesson 10 - Lesson 13)

This module does not assume any prior knowledge of specific software, although some of the activities will be easier if students have some exposure to GIS related software.

4. Teaching and Learning System

The module is divided into six sub-modules, which use rather different learning methods.

Sub-module 1: (lessons 1-2) introduces concepts, components, and technologies of Digital City and Smart City. Aside from studying the overview provided by lecture notes, students will read several short papers understanding the background and practice of Smart City.

Sub-module 2: (lessons 3) focuses on geo-data acquisition, integration, visualization and mining. Students will complete an exercise about spatial data analysis technologies by using ArcGIS.

Sub-module 3: (lessons 4-7) considers computer-related technology, such as ICT, IoT, Cloud Computing, and big data. Students will accomplish two related exercises. They will also complete a hands-on assignment, one focusing on spatio-temporal data warehouse and data mining technologies.

Sub-module 4: (lessons 8-9) introduces the technologies related system optimization, coordination, architecture, and pattern. Students will complete an exercise and a hands-on assignment.

Sub-module 5: (lessons 10) presents latest progress and trends of Smart City. Students will be required to prepare an exercise on drawing the future map of smart city.

Sub-module 6: (lessons 11-15) presents several case studies and practice of Smart City. Students will complete an exercise. They will also need to accomplish a hands-on assignment, which requires students to use knowledge and methodology to find solutions to urban intelligent information systems.

5. Evaluation System

Performance evaluation for this module includes three components: class participation (10%), two reports (assignment 1: 15%, assignment 2: 25%), and a term paper (50%). The details are as follows:

specific knowledge of climate change. Some exercise in this module can be done not only by GIS software but also by some programming languages. For the students who can use a programming language, it is a good idea to do the exercise with program, particularly when the climate data is large. The intention of this module is to train students with basic scientific literacy. After learning this module, it is hoped that each student can resolve a problem in a logical way.

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Bibliography

- Adger, W. N., Arnell, N. W. and Tompkins, E. L., 2005, Successful Adaptation to Climate Change Across Scales. *Global Environmental Change*, 15(2), 77-86.
- Dangermond, J. and Artz. M., 2010, Climate Change is a Geographic Problem - The Geographic Approach to Climate Change. ESRI, 32.
- Intergovernmental Panel on Climate Change, 2001, The Climate System: an Overview, *Climate Change 2001: The Scientific Basis*.
- Intergovernmental Panel on Climate Change, 2007. Has Climate Variability, or have Climate Extremes, Changed? Retrieved on 13 April 2007.
- Trzaska, S. and Schnarr, E., 2014, A Review of Downscaling Methods for Climate Change Projections. United States Agency for International Development by Tetra Tech ARD, 1-42.