Course Title: Environmental Challenges and Sustainable Development in China

Instructor: Prof. Mei Zheng
Schedule: July 13-25, 2020
Course Credit: 2 credits

Course Description

Objective:
With fast economic development, environmental challenge is one of the most important issues that China is facing now. This course is intended for undergraduate students to examine key issues and topics that are related to environmental pollution in China and discuss sustainable pathways. The course is organized around the central question – the most pressing environmental challenges in China and sustainability. It includes the introduction of basic structure of earth system, the current status and causes of major environmental pollution in China, and the policies and control plans for pollution abatement. This course will present how China improves its air quality greatly in recent years, including sources, formation mechanisms, health impacts, and policies that lead to effective reduction of $PM_{2.5}$ concentration or haze in Beijing.

Pre-requisites /Target audience
Students wishing to enroll in this course are expected to be interested in environmental issues and sustainability of future earth. Students majoring in science and engineering are welcome to enroll.

Proceeding of the Course
This course will be given primarily by lectures. Participation and discussions are important in this course. Students should complete the required readings and are expected to actively engaged in class discussion. Attendance is mandatory and three absence without legitimate reasons will lead to failure in the course. At the end of the course, each student is expected to give a presentation about environmental pollution. The student will select a topic after discussing with the course instructor.

Evaluation Details
The evaluation will be based on the following three parts:
Attendance: 15%
Participation: 25%
Final Presentation: 60%

Text Books and Reading Materials
Required and recommended readings will be provided to the students through email or hardcopy. No book purchase is required.

Class Schedule

(Subject to adjustment)

Session 1: Introduction to the Earth system
Description of the session:
- Introduction of course schedule and student self-introduction
- Introduction to the Earth system

Questions:
- What is changing in our planetary system due to human activities?
- What are the major tools to monitor changes in the Earth system?
- What are the major structures of the Earth system?

Session 2: Introduction to Atmosphere
Description of the session:
- Introduction of the basic structure of atmosphere
- Introduction of wind patterns of atmosphere
- Greenhouse gas and global CO_2 monitoring

Questions:
- What are the vertical profiles of temperature and chemical species in atmosphere?
- How to measure CO_2 concentration in atmosphere (past and present)?

Readings:
Book : "Atmospheric Science: An Introductory Survey" by John Wallace and Peter Hobbs

Session 3: Introduction to Ocean
Description of the session:
- Introduction of major processes in ocean
- Introduction of ocean circulation patterns
- Nutrients and gases in ocean

Questions:
- What is the driving force for ocean circulation?
- How do anthropogenic activities impact ocean properties and processes?

Readings:
Book: "Oceanography: An Invitation to Marine Science" by Tom Garrison

Session 4: Major environmental challenges in China
Description of the session:
- Economic growth and the environment
- Major environmental issues in China, including air, water, and soil.
- Recommendations and outlook

Questions:
- What are the major environmental issues that China is facing now?
- How did China recognize and solve environmental pollution problems?
- What kinds of effort have been done to resolve these problems?
- How China and the world affect each other?

Readings:
1) Jianguo Liu and Jared Diamond, China's environment in a globalizing world. Nature, 2005.
2) David Parrish and Tong Zhu, Clean air for megacities. Science, 2009.
3) Mehran Idris Khan and Yen-Chiang Chang, Environmental challenges and current practices in China – A thorough analysis. Sustainability, 2018.

Session 5: History of air pollution in China
Description of the session:
- Key air pollution issues since 1970s in China
- Main pollutant types
- Emission sources and emission trends
- Key policies for reducing pollution
- Major air pollution intervention

Questions:
- What are the key air pollution problems in each decade?
- What are the major pollutants, their sources, and trends?
- What are the major policies and are they effective?
- What are the major approaches for environmental management in China?

Readings:
1) Chak K. Chan, and Xiaohong Yao, Air pollution in mega cities in China. Atmospheric Environment, 2008.
2) Aunan K, Hansen MH, Wang S. Introduction: air pollution in China. China Quarterly, 2018.
3) The World Bank, China: Air, Land and Water, World Bank, Washington DC, 2001.

Session 6: Haze in China – Characteristics
Description of the session:

- Key pollutants of haze in China
-   Major sources of haze
-   Spatial and seasonal variations of haze

Questions:
- What are the major emission sources contributing to the haze?
- What are the spatial distributions of haze?
- How is haze formed and developed?
- How is haze in China different from air pollution problems in other countries?

Readings:
1) Tong Zhu, Air Pollution in China: Scientific challenges and policy implications. National Science Review, 2017.
2) Idir Bouarar, Xuemei Wang, and Guy P. Brasseur (eds), Air pollution in Eastern Asia: an integrated perspective. Springer, 2017.
3) Rohde, R. A., and Muller, R. A., Air pollution in China: mapping concentrations and sources. PLoS ONE, 2015.

Session 7: Haze in China: formation mechanisms
Description of the session:
- Major emission sources and emission inventory in China
- Chemical and physical processes for haze formation
- Methods to understand formation mechanisms
- Major primary and secondary pollutants in haze

Questions:
- How many types of haze in China?
- What are the key processes that result in haze?
- How does each process interact with each other?

Readings:
1) Ru-jin Huang, Yanlin Zhang, et al. High secondary aerosol contribution to particulate pollution during haze events in China. Nature, 2014.
2) Yingtao Jia, Kenneth A. Rahn, Kebin He, Tianxue Wen, and Yuesi Wang, A novel technique for quantifying the regional component of urban aerosol solely from its sawtooth cycles. Journal of Geophysical Research, 2008.
3) Jun Liu, Denise L. Mauzerall, Air pollutant emissions from Chinese households: A major and underappreciated ambient pollution source. Proceedings of the National Academy of Sciences of the United States of America, 2016.
4) Jiandong Wang, Shuxiao Wang et al., Impact of aerosol-meteorology interactions on fine particle pollution during China's severe haze episode in January 2013. Environmental Research Letters, 2014.

Session 8: Haze in China: health impacts
Description of the session:
- Major pollutants that have health impacts and their sources
- Indicators for health impacts
- Interventions and health benefits
- Indoor air pollution and health impacts due to coal combustion

Questions:
- What are the key chemical species that have the most adverse health impacts?
- What are the major sources that contribute to the health impacts in China?
- How is indoor air pollution different from outdoor air pollution?
- What are the major issues due to indoor residential coal combustion?

Readings:
1) Haidong Kan, Environmental health in China: challenges and opportunities. Environmental Health Perspectives, 2009.
2) Renjie Chen, Peng Yin et al., Fine particulate air pollution and daily mortality: a nationwide analysis in 272 Chinese cities. American Journal of Respiratory and Critical Care Medicine, 2017.
3) Frank Kelly and Tong Zhu, Transport solutions for cleaner air. Science, 2016.
4) C. Liu, R. Chen, F. Sera, A. M. Vicedo-Cabrera et al., Ambient particulate air pollution and daily mortality in 652 cities. The New England Journal of Medicine, 2019.

Session 9: Measuring and modeling
Description of the session:
- Methods to measure air pollutants
- Satellite and remote sensing and sensor network in China
- Online and fast measurements of air pollutants and identification of sources
- Modelling air pollution
- Regional transport of air pollutants

Questions:
- How does China identify the major sources of haze?
- How to determine local and regional contribution?
- How to locate source regions of haze?

Readings:
1) Aaron van Donkelaar, Randall V. Martin, Michael Brauer et al., Global estimates of ambient fine particulate matter concentrations form satellite-based aerosol optical depth: development and application. Environmental Health Perspectives, 2010.

2) Xing Chang, Shuxiao Wang et al., Contributions of inter-city and regional transport to PM2.5 concentrations in the Beijing-Tianjin-Hebei region and its implications on regional joint air pollution control. Science of the Total Environment, 2019.
3) Yue Liu, Mei Zheng et al., High-time-resolution source apportionment of PM2.5 in Beijing with multiple models. Atmospheric Chemistry and Physics, 2019.

Session 10: Policies and actions for reducing air pollution
Description of the session:
- Air quality improvement and progress in China (Beijing as an example)
- Major policies in China for air pollution prevention
- Effectiveness of measures
- Quantitative estimate of contribution from emission reduction

Questions:
- How quick is the improvement of air quality in China?
- What policies are most effective and how to identify?
- How to determine the contributions from emission reduction and meteorology?
- What are lessons learned from experience of other countries?
- What are the future challenges of future improvement?

Readings:
1) The United Nations Environment Programme, A review of air pollution control in Beijing: 1998-2013, UNEP Report, 2016.
2) Yingying Zeng, Yuanfei Cao, Xue Qiao, Barnabas C. Seyler, and Ya Tang, Air Pollution Reduction in China: recent success but great challenge for the future. Science of the Total Environment, 2019.
3) Mingxu Liu, Xin Huang, Yu Song et al., Ammonia emission control in China would mitigate haze pollution and nitrogen deposition, but worsen acid rain. Proceedings of the National Academy of Sciences of the United States of America, 2019.
4) Bo Zhang, Dan Tong, Qiang Zhang et al., Trends in China's anthropogenic emissions since 2020 as a consequence of clean air actions. Atmospheric Chemistry and Physics, 2018.

Session 11: Water pollution in China
Description of the session:
- Current status of water pollution – fresh water
- Major issues for water pollution – coastal and ocean water
- The water pollution action plans in China
- Health impacts of water pollution

Questions:
- What are the major pollutants and sources of water pollution in China?

- What are the future challenges of water pollution?

Readings:
1) Dongmei Han, Matthew J. Currell, and Guoliang Cao, Deep challenges for China's war on water pollution. Environmental Pollution, 2016.
2) Wen-qing Lu, Shao-hua Xie et al., Water pollution and health impact in China: a mini review. Open Environmental Science, 2008.
3) Kai Zhang, Huahong Shi et al., Microplastic pollution in China's inland water systems: a review of findings, methods, characteristics, effects, and management. Science of the Total Environment, 2018.

Session 12: Emerging ocean science in China
Description of the session:
- Recent progress and development of ocean science in China
- Major research programs and areas of ocean science
- Interactions between atmosphere and ocean

Questions:
- What progress China has made in ocean science in recent years?
- What are the new findings from major marine programs?
- How does atmospheric deposition impact ocean productivity?

Readings:
1) Richard Stone, China makes waves with ambitious ocean research plan. Science, 2012.
2) Kathleen McLaughlin, Cannonball! China's megasplash in ocean research. Science, 2016.

Session 13: Major global environment challenges and sustainability development
Description of the session:
- Global environmental changes
- The changing earth surface: Land and water
- The changing atmosphere: global warming, photochemical smog, and stratospheric ozone depletion

Questions:
- What are the major anthropogenic activities that are changing the Earth?
- What are the major impacts of human activities?
- Will the proposed geoengineering approaches for reducing global warming effective?

Readings:

Fred T. Mackenzie, Our changing plant: An introduction to earth system science and global environmental change, Pearson Education, Inc. (4th Edition). Chapters 10, 11, 12, and 14.

Session 14: Group discussion with experts - I
Description of the session:
The first session will be discussions with students and invited experts in the areas of studying measurements, modeling, chemistry, and physics of air pollution in China. The discussion will focus on topics related to haze formation mechanisms, measurement tools, major pollutants and sources, chemical and physical processes etc.

Session 15: Group discussion with experts – II
Description of the session:
The second session will be discussions with students and invited experts in the areas of studying environmental policy, economics, health impacts, and air quality management of air pollution in China. The discussion will focus on major policies in China, the effectiveness of different measures, health benefits due to air quality improvement etc.

Session 16: Student final presentation
Description of the session:
Each student will select a topic related to environmental pollution and give a 15-min presentation. The topic will be finalized after discussing with the instructor.