**Atmospheric Chemistry 16:375:540 Fall 2021**
Instructor: Mary Whelan, mary.whelan@rutgers.edu, Office ENV 354
OH: Wednesday 11a-12p

**Course Goals**
Use models to understand transport and transformation of components of the atmosphere
Identify and explain atmospheric processes, Earth surface processes, and interactions with outer space that change the composition of the atmosphere
Interpret atmospheric concentration data effectively and understand if more info is needed
Appreciate the complexity of atmospheric chemical processes and how they affect life on Earth
Provide and effectively receive feedback on scientific writing

**Course Assignments:**

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| Pre and Post Assessments | 4% |
| 6 Problem Sets: due Wednesdays, handed out Monday the previous week | 48% |
| Project: due Wednesdays, 3 drafts, 1 peer evaluation, 2 presentations | 48% |

**Reference texts** are available electronically as Course Reserves or on the Canvas site. *Modeling Atmospheric Chemistry* by Brasseur and Jacob (2017), *Biogeochemistry* by Schlesinger (2020), *Atmospheric Chemistry and Physics* by Seinfeld & Pandis (2016), and *Atmospheric Chemistry* by Daniel Jacob (1999/2021)

**Schedule and Goals**

| Week | Topics/*Assessments*/*Reading* | Goals |
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| 0-1 | Atmospheric composition<br>*Jacob Ch 1 (2021)*<br>*Pre-course Assessment* | Recall the composition of the atmosphere<br>Appreciate the trace nature of trace gases<br>Contrast mixing ratios, number density, and column concentration<br>Connect Henry's Law with phase changes and changes in atmospheric conditions |
| 2 | Atmospheric Structure<br>*Jacob Ch 2 (2021)* | Understand how pressure is measured, the concept of partial pressure contrasted with mixing ratio<br>Calculate the barometric law, the number of moles in the atmosphere<br>Describe where "weather" occurs in the atmosphere<br>Compare conditions in the troposphere with the stratosphere |
| 3 | Simple Models<br>*Jacob Ch 3 (2021)*<br>*Problem Set #1 due* | Apply single and double box models to solve for lifetime<br>Calculate changes in concentration from an initial condition to a steady state<br>Link what we know about states of matter with wet/dry deposition<br>Investigate the balance of noble gases in the atmosphere |
| 4 | Atmospheric Transport<br>*Brasseur Ch 3*<br>*Problem Set #2 due* | Investigate the Coriolis force, jet streams<br>Calculate lapse rates to determine atmospheric stability<br>Connect the typical vertical and horizontal mixing times with atmospheric observations of chemical species |
| 5 | Light<br>*Feracci et al (2018) and Li et al (2018)*<br>*Project Topic Due, short presentations* | Review black body radiation and light wavelengths<br>Contrast the "visible" and "invisible" parts of the atmosphere<br>Explicitly link atmospheric composition to greenhouse effect<br>Discuss seasons, uneven distribution of sunlight<br>Introduce the role of OH, identify important light reactions |

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| 6 | Nitrogen and Oxygen<br>*Lyons et al (2014)*<br>*Problem Set #3 due* | Recall the role of plate tectonics and the evolution of life in the evolution of Earth's mostly nitrogen atmosphere<br>Critique what we know about the history of the atmosphere and the rise of oxygen Explore the relative importance of photosynthesis and rock weathering to the oxygen cycle |
| 7 | Carbon and Water<br>*Walker et al (2020) Box 1 and 2*<br>*Project Draft #1* | Sketch out the carbon cycle fast and slow components<br>Interpret the Mauna Loa record, carbon and oxygen isotope data, and the "flying carpet"<br>Critique current evidence for carbon fertilization<br>Incorporate what we know about water vapor/cloud feedbacks into what we know about photosynthesis<br>Recall the role of isotopic signatures in chemical processes |
| 8 | Global Warming Potential and Lifetime<br>*Shine et al (2005)* | Investigate the methane cycle<br>Appraise the different impacts of gases on the radiative balance of the atmosphere taking into account lifetime<br>Compare different government climate change strategies in light of different base times for global warming potential |
| 9 | Aerosols, bioaerosols, biomass burning<br>*Seinfeld Ch 8*<br>*Problem Set #4 due* | Define aerosol, life cycle, composition, and structure<br>Identify reactions that happen with the aid of aerosols<br>Weigh the direct and indirect effects of aerosols on radiative balance<br>Investigate the variation of aerosol loading and El Niño events |
| 10 | Chemical Kinetics and Precipitation<br>*Jacob Ch 9 (1999)*<br>*Project Draft #2* | Categorize the various chemical processes that occur in the atmosphere and what variables control their rates<br>Examine precipitation data to hypothesize what reactions affect rainfall composition<br>Appreciate the historical problem of acid rain and response<br>Formulate equations for the reaction rates for gas-phase and mixed phase reactions<br>Classify key radical-assisted reactions |
| 11 | Halogens and reactions in the stratosphere<br>*Jacob Ch 10 (1999)*<br>*Problem Set #5 due* | Appreciate the discovery of the ozone hole and the international response<br>Investigate the Chapman reactions, catalytic loss cycles<br>Examine data from the WMO report to assess the current state of the ozone hole<br>Contrast the role of aerosols in the stratosphere to those in the troposphere |
| 12 (Mon only) | Review and Synthesis<br>*Student peer review due* | |
| 13 | Oxidation in the Atmosphere<br>*McNorton et al (2016)*<br>*Problem Set #6 due* | Review what we know about the OH radical<br>Relate the concentration of OH to lifetime of methane and carbon monoxide<br>Contrast the role of NOx in the troposphere vs stratosphere<br>Examine data related to the long term transport of NOx |
| 14 | Remote sensing the atmosphere<br>*A-Train, ISS, CubeSat*<br>*Post-course assessment*<br>*Final Project AGU-style talks* | Review available atmospheric composition satellite products<br>Interpret data and modeled interpretations for global and regional sources/sinks of trace gases<br>Discuss the disconnect between a map of averaged data versus raw satellite data |
| 15 | Final Project Due<br>*No class meeting*<br>*Final Project Manuscript Due* | Turn in the final draft of your project via Canvas by **5pm** on Monday, December 13 |