Earth System Science ESCI 795/895; NR 797/897; EOS 895
Syllabus for Fall 2004

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Lectures: James 116 W/F 8:40 –10:00am
Lab: Tischler Computer Lab, James 20 Friday 1:00-3:00 pm
Environmental Sciences Lecture Series: Th 3:30-5:00pm, James 303

Student Learning Objectives:

1. Describe key **components, interactions, and concepts** that characterize the modern earth system (knowledge, comprehension)
2. Analyze the causes of change in the Earth System over varied temporal and spatial scales (analysis)
3. Build simple models of key Earth System interactions; apply this knowledge to key scientific questions in Earth System Science (application)
4. Read, discuss, and evaluate Earth System Science papers in the primary literature (synthesis, evaluation)
5. Relate knowledge of Earth System Science to the human condition (application)
6. Develop peer-to-peer learning/teaching skills and effectiveness at working in groups (skills)
7. Evaluate the role of uncertainty for Earth System Science research and decision making (evaluation)

Reading for Lecture

1. Background Reading: Kump LR, Kasting JF, Crane RG (2004) The Earth System, 2nd edition, Pearson Education Inc., Upper Saddle River, New Jersey, ISBN0131420593.

2. Primary Literature including articles both for background (to enhance textbook reading) and for advanced concepts have been compiled into an electronic course packet posted on the blackboard site. There will be 2-5 readings from the electronic course packet each week.

Laboratory Reading:

Laboratory readings and exercises will be posted on Blackboard. Background reading (material from Harte, J. (1988) Consider a Spherical Cow. A Course in Environmental Problem Solving, and Harte, J. (2001). Consider a Cylindrical Cow: more adventures in environmental problem solving) will also be posted on the blackboard site.

NOTE: Course lectures, information, readings, and student presentations will be posted online at: http://blackboard.unh.edu

Course Prerequisites: Calculus I and permission of instructor

For undergraduate students, our goal is to attract juniors and seniors from CEPS and COLSA who have already taken a progression of courses in their field of study. Our main criteria for selecting students will be evidence of this progression in a science based major. We also expect to attract incoming M.Sc and Ph. D. students with a Earth Science background/plan-of-study.

COURSE CONTENT

NOTE: Each class will include a segment providing background information and a segment on advanced concepts (AC) of particular relevance to the Earth System. Students will be expected to have read both the background material and advanced concepts articles so that they can participate in class exercises and discussions in a meaningful way. This class participation will provide one means of student assessment.

In addition to the lectures, students are required to attend the five Environmental Science Lectures by NASA Goddard scientists. Four of the five lectures will be on Thursday from 3:30 to 5:00 pm in James 303. One lecture (Michael King on Tuesday Sept 28) will be from 12:40 to 2:00 pm in the MUB Theater II.

PART 1: Earth System Science (ESS) Concepts, Components, and Cycles

L1 Course structure, class objectives, motivation for class, intro to concept mapping
L2 Earth System Components
Initial exercise in developing concept map of the Earth System
AC: Spatial and temporal scales of analysis
L3 Earth System Concepts: Interactions and Processes
AC: Why is ESS important for humanity?
L4 Solar Luminosity and the Role of the Sun in the Earth System
AC: solar and orbital variability
L5 Earth's Energy Balance and the Greenhouse Effect
AC: Why is the Earth's temperature just right?
L6 Earth's Energy Balance and the Greenhouse Effect (con'd)
AC: Uncertainty: Climate Feedbacks
L7 Atmosphere (temperature, pressure, circulation)
AC: Semi-permanent high and low pressure cells
L8 Hydrosphere I: The Water Cycle, evaporation and precipitation
AC: Human influence on the global water cycle
L9 Hydrosphere II: Ocean Structure and circulation
AC: NADW and thresholds; non-linear feedbacks

9/28 **Environmental Sciences Lecture:** Michael King (NASA Goddard)

12:30 – 2:00 PM, MUB Theater II

L10 Coupled Ocean-Atmosphere circulation systems (ENSO, NAO and Monsoons)
AC: teleconnections and climate forecasting

9/30 **Environmental Sciences Lecture:** David Adameck (NASA Goddard)

L11 Cryosphere: Snow and Ice
AC: short-term temporal variability of sea ice and mountain glaciers
L12 Lithosphere: Plate Tectonics, Paleogeography, and Volcanoes
AC: Pinatubo cooling; Tibetan Plateau and global cooling

10/7 **Environmental Sciences Lecture:** Robert Bindschadler (NASA Goddard)

L13: Biochemistry: Carbon Cycle
AC: Approaches and uncertainty in modern carbon budgets
L14 Biochemistry: N,S,P Cycles
AC: Linkages among biogeochemical cycles
L15 Biophysics: Land Cover Influence on Climate
AC: Biophysics and climate simulations
L16 Biosphere and Biodiversity
AC: Role and value of major ecosystem services

10/21 **Environmental Sciences Lecture:** Compton Tucker (NASA Goddard)

L17 Review and 2nd exercise in developing concept map of the Earth System

10/28 EXAM 1

10/28 **Environmental Sciences Lecture:** R. Calahan (NASA Goddard)

PART II: ESS Interactions and Feedbacks – Case Studies

L18 Rise of Atmospheric Oxygen
L19 Snowball Earth
L20 K-T Boundary Extinction Event
L21 Rapid Climate Change Events over last glacial cycle
L22 NO CLASS: VETRANS DAY
L23 Holocene Climate Change and Civilization
L24 Last 100 years of climate change
L25 Threshold response: Ozone Hole
11/25 NO CLASS: THANKSGIVING
L26 Recent Land Use, Fossil Fuel Burning and the Carbon Cycle
L27 Recent Biosphere Feedbacks
L28 Scenarios of Climate Change in the Future

L29 Review and 3rd exercise in developing concept map of the Earth System
12/16 Final Exam (during final exam period)

LABORATORIES – BUILDING COMPUTER MODELS

•Models will be developed using Stella™ Software.
•Lab work will be graded and discussed each week to measure student progression.
•Labs will utilize and apply information covered lecture & reading materials.

Part I: Introduction to Modeling:

This part of the course will consist of student interviews, and an introduction to the structure and use of models as tools for scientific analyses/investigation. Topics addressed will include: order of magnitude estimation, box models, units, lifetimes, equlibria, timescales to reach equlibria, differential equations, integration, feedbacks, stability, and an introduction to Stella computer modeling software. As we expect to have students with varied backgrounds taking this course, we will pay special attention to students who require additional assistance (both via pairing students with strong numerical skills with those whose numerical skills are not as strong and focused help from the TA and the Professors).

Week 1: Student Interviews
Week 2: Earth System Science Critical Thinking 1
Week 3: Earth System Science Critical Thinking 2 & Introduction to Stella

Part II: Modeling Earth System Dynamics:

Week 4: Earth System Dynamics I: Energy Balance
Week 5: Earth System Dynamics II: Variable Forcing
Week 6: Earth System Dynamics III: Potential Biospheric Feedbacks
Week 7: Earth System Dynamics IV: GHG Dynamics
Week 8: Synthesis

Part III: Student Case Studies Using Computer Models

Student teams will identify and address important cases studies in Earth System Science using computer models, and present results in the form of oral, PowerPoint, and poster presentations. The major goals of this section of the lab are threefold: (1) the development and application of quantitative skills for addressing key problems in Earth System Science, (2) an increased understanding of important case studies in Earth System Science using models, and (3) the development and application of professional skills for presenting scientific information. Student teams will provide weekly presentations on progress and issues.

Week 9: Identification of case study and student teams
Week 10: Presentations and theoretical background for model development
Week 11: Presentations and Model Development
Week 12: Progress Reports and Continued Model Development

Week 13: Progress Reports and Continued Model Development
Week 14/15: Presentation of student projects

Student Project Topics (Examples):

- 40 million year cooling
- Snowball Earth
- Biodiversity
- Rapid Climate Change Events
- Quaternary Glaciations and the Carbon Cycle
- Paleocene/Eocene

GRADING

Exams (2) 20% each	40%
Weekly class exercises:	10%
Labs:	30%
Research Paper/Presentation:	20%

Weekly class exercises include short oral summaries of required readings, short in class exercises, discussions, and debates. The laboratories will be graded based on material handed in for grading as well as oral updates of research and the final oral/poster presentations.

Graduate students will be expected to produce additional material and efforts in several areas on which they will be graded accordingly. This includes leading discussions and exercises during lectures, an additional essay question on the two exams, an additional critical thinking problem in each of the first seven laboratory exercises, and providing leadership to the student teams working on the laboratory case studies.