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Using CCMC Space Weather Modeling Resources in a Capstone Undergraduate Course

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AOSS 477: Space Weather Modeling

- U-M offers a senior-level course in space weather modeling
  - Taken by all Space Weather concentration students in our ESSE BSE degree program
  - Also taken by a fraction of the space physics PhD students
  - Also taken by a few M-Eng in Space Engineering students
- This year: 12 enrolled in the course
  - Seems reasonable given the student populations
  - No baseline: this is only our second time offering it as a real course

History of 477

- Aaron Ridley and I "taught" it 4 years ago
  - Taught as a directed study
  - Met for only 1 hour each week, very little instruction
  - 5 different modeling projects, all written reports
  - No coverage of what's in the codes
  - Students loved it but wanted more in-class time
- Moldwin taught it 2 years ago, as AOSS 477
  - First offering as a "real" classroom course
  - No PPT files to pass on to me...all journal article reviews
  - Second half: no class at all, just individual meetings
  - Students loved it but still wanted more in-class time

What is it about?

- ***Using*** state-of-the-art space weather models
  - Not really a programming course
  - We have a different one for that
- Synthesis, capstone course for the undergraduates
  - Applying knowledge learned in previous courses
  - They have taken several others up to this point:
  - AOSS 323: Earth System Analysis
  - AOSS 370: Solar-Terrestrial Relations
  - AOSS 410: Earth System Modeling
  - AOSS 450: Geophysical Electromagnetics
  - AOSS 462 Atmospheric and Space Instrumentation
  - PHYS 405: Electricity and Magnetism
  - NERS 471: Plasma Physics

Sidenote on AOSS 370

- This course is a lot like Knipp's ASEN 5335 @ CU
  - First-time-exposure to space physics
  - Emphasize the conceptual level first, then equations
  - Highly data oriented with a mixture of theory
    - No modeling, just some model-result graphics
  - Difference: for junior-level undergrads, not MS and PhD students
- Culminating final project: space weather event analysis
  - Give them a day and let them decipher it
- Haven't used CCMC for this class, but iSWA/SWE is perfect for it

AOSS 477 is a report-based course

- Students learn about the guts of numerical models used for space physics
  - Lots of details on equations being solved and numerical methods used to convert equations to code
  - Examples across the entire spectrum of space physics
- Students use some of the models and conduct their own space weather numerical investigation
  - Several projects on using codes and writing/presenting reports based on their numerical experiments
  - Data used as model input and for model result comparison

Even more on what they learn

- But also, they will:
  - Hone your technical report writing skills
  - Improve your public presentation skills
  - Read/discuss a few journal articles and decide what is good/bad about them
- What's up with this last one...journal articles?
  - Final report is essentially a journal article on numerical modeling of a space physics phenomenon/region
    - Literature search, model description, sensitivity study, data-model comparison, interpretation of their findings, and summary
  - I teach this by having them critique other modeling papers

Winter 2012 Class Schedule

- Weeks 1 - 5: The CCMC, paper critiques
  - Paper critique #1: Due Friday, January 13
  - Paper critique #2: Due W/F, February 1 and 3
- Weeks 6 – 11: The details of modeling
  - Modeling project #1: Due February 22 and 24
  - Modeling project #2: Due March 21 and 23
- Weeks 12 - 14: Large-scale modeling
  - Modeling project #3: Due April 9 - 16
- Final exam: no final exam for this course
- Grading: later reports worth more than early ones

To Computer Lab or Not?

- I struggled with this question
  - Decided on no computer lab sessions for the course
  - I hope that this works out for me...we'll see!
- I'll use some online resource during class
  - Students are free to bring laptops to class
- This is not a programming class
  - Not entirely true: there will be programming for modeling study #2
  - Also: students need to make their own plots

A book for a modeling course?

- Suggested textbooks to have:
  - Cravens: Physics of Solar System Plasmas, Cambridge, 1997.
    - Used in AOSS 370 (taken by all undergraduates in the class)
  - Gombosi: Physics of Space Environment, Cambridge, 1998.
    - Used in AOSS 574 (taken by all graduate students in the class)
- Neither is required, either is recommended
  - I list supplemental readings from these books as I present different types of space weather models
  - Hopefully the students will use these to augment in-class material as needed

CCMC Usage in this Course

- Not so much yet
  - We're still in the "learning how to conduct a study" stage
  - Students are still doing critiques of modeling papers
  - Lots of in-class discussions on good v bad modeling
    - Talking about the techniques of conducting a thorough study
    - Talking about the method of clearly writing up a study
    - Talking about the best practices for presenting a scientific study
- So far: "Intro to the CCMC" class sessions
  - Show and tell of how to navigate the CCMC website

Coming Up: February and March

- Details of CCMC models
  - Going "under the hood" with a model
    - One model per class session
  - Several aspects to this:
    - What region/phenomenon is being modeled by a code?
    - What equations are being solved by the code?
    - What numerical approach was used in the code?
    - What typical grids are used in the code?
    - What inputs does the code require?
    - What outputs does the code produce?
    - What are the ranges of I/O validity for the code?
    - What other codes are similar in region, equation, or numerics?
- Will use CCMC extensively for this, plus papers

Modeling Study #1

- Students will use CCMC to explore a region of space
  - Data only as input, just model results
  - Pick one model and get to know it
  - Read papers on the model to understand what others have done with it
  - Explore the range of input parameters
    - See what this does to the output
    - Could just use archival run results, but also instant/RoR jobs
  - Write a report and give a presentation on your findings
- Students can choose what code to use for this
  - But, they have to change for modeling studies #2 and #3

Modeling Study #2

- Write your own numerical model
  - Any formulaic "model" is acceptable
    - I will go over a bunch in class before assigning this project
  - Dst, CPCP, magnetopause, RB e- fluxes, etc.
  - Must write the code from scratch yourself
  - Must use a month of data to drive the model
  - Must use other data for output comparison
    - Dst predictor: data is obvious
    - Magnetopause predictor: GOES/LANL crossings
  - Write a report and give a presentation on your findings
- No direct CCMC involvement here

Modeling Study #3

- The biggy: putting it all together
  - Conduct a study that leads to a journal-style report
  - Data as input and output comparisons
  - Lots of literature review and interpretative discussion
  - Bigger report and longer presentation
- CCMC will be heavily used by some
  - Undergrads: almost certainly using a CCMC model
  - M-Eng students: definitely using a CCMC code
  - PhD students: maybe using their research project code
    - But maybe not, especially for non-numerical-oriented students

Summary: Please help!

- I am here to learn
  - Taught this class 4 years ago as a directed study
  - Moldwin taught it 2 years ago, also in ind. study mode
  - A "new" course for me, and I am teaching it a new way
- I am very receptive to suggestions
  - Any experiences you have had with this proposed course structure are welcome
- I am willing to share
  - Not yet, because I don't have very much developed