Air Force Institute of Technology / CCMC Educational Activities

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Asst Professor of Atmospheric Physics

Educating the World's Best Air Force

AFIT Programs

- Resident Graduate Education
  - –Graduate School of Engineering and Management
    - Physics
    - Electrical & Computer Engineering
    - Aeronautics & Astronautics
    - Systems & Engineering Management
    - Mathematics & Statistics
    - Operational Sciences

- Resident Graduate Education
  - –Graduate School of Engineering and Management

- Professional Continuing Education

AFIT Programs

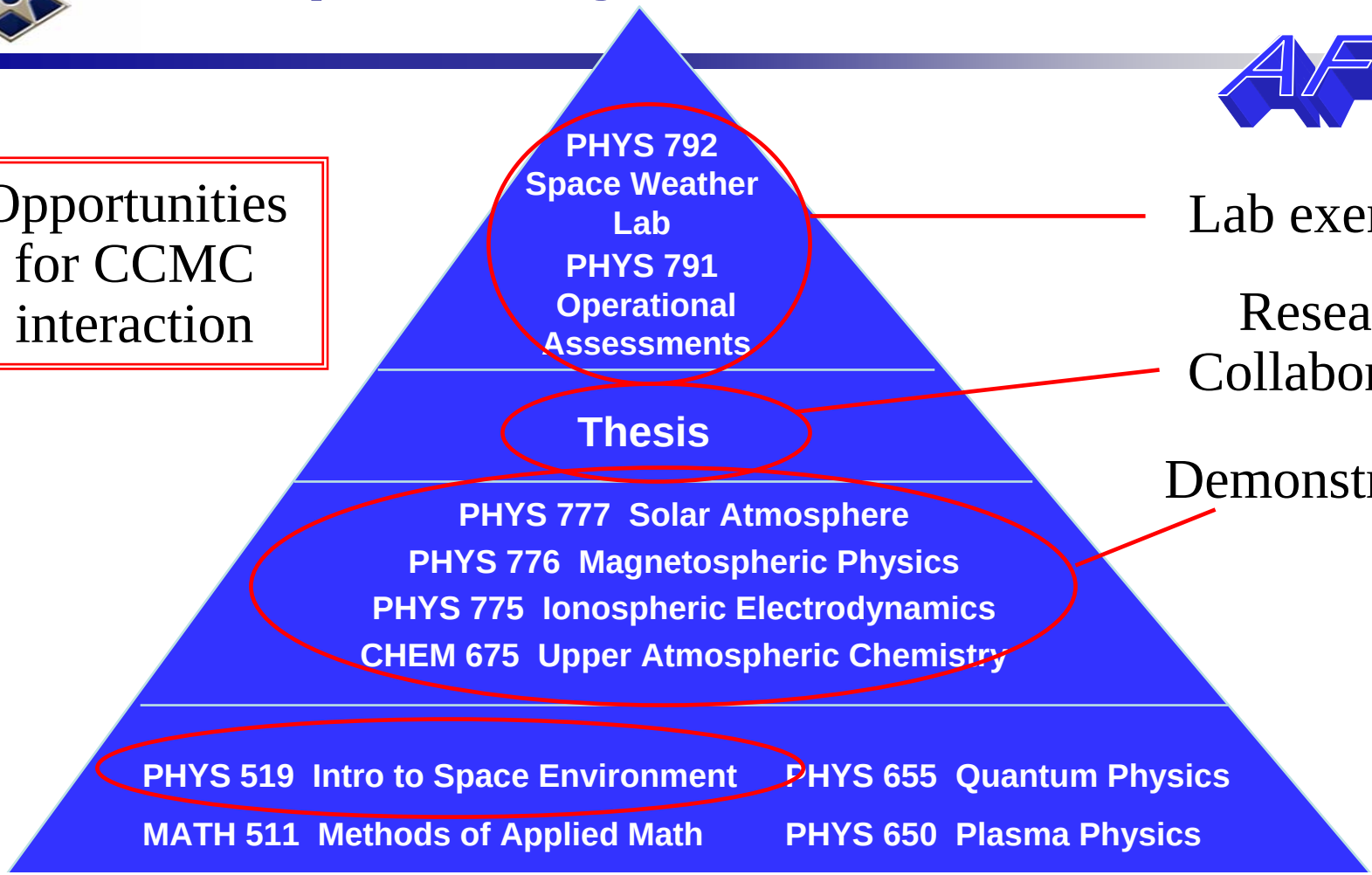
- Resident Graduate Education
  - –Graduate School of Engineering and Management
- Professional Continuing Education
  - –Civil Engineer and Services School
  - –School of Systems and Logistics
- Civilian Institution Programs
  - –Graduate and Continuing Education
  - –Health Care Education

Space Physics Curriculum

- Primary mission to educate future space wx officers
  - Breadth of coverage
  - Ops focus to courses & research
  - Faculty field experience
- Also serve cross-over students and civilians

Space Physics Curriculum

Opportunities for CCMC interaction



Lab exercises

Research Collaboration

Demonstrations

- Space physics tracks also available to other programs (e.g. aero, astro, and electrical engineering)

Overview

- Three areas of “interaction”
  - Research
  - Laboratory exercises
  - Classroom demonstrations
- Research
  - Best fit within current paradigm
- Laboratory exercises
  - Lessons learned
- Demos vs. eye-candy
  - Most room for improvement

AFIT Research

- Small program; leverage external resources
- Most research performed in collaboration with AFRL
- Traditional research areas
  - Validate computer models (e.g. PRISM, MSM)
  - Exploitation of new data sources (e.g. CEASE, SCINDA)
  - New modeling/forecasting techniques for
    - HF communication
    - Spacecraft hazards
    - Scintillation effects

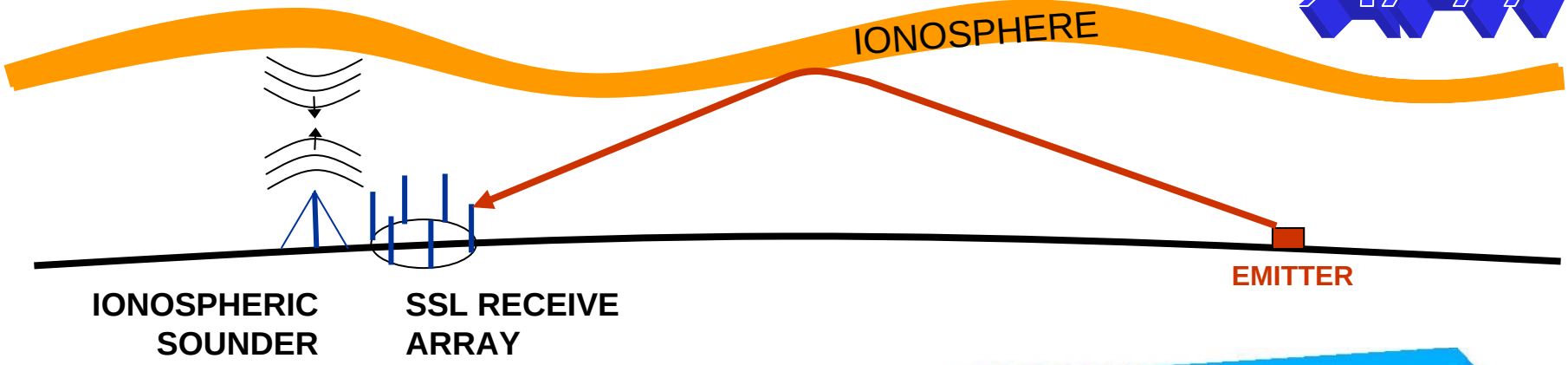
Recent Thesis Topics

- “Ionospheric response to solar x-ray flares”
- “GPS scintillation climatology measured by the SCINDA network”
- “Assessment of HF ray-tracing through assimilative ionospheric models”
- “Anisotropy in the South Atlantic Anomaly”
- “Characterization of the solar wind using DMSP ion drift data”
- “Flight-level radiation hazards due to solar energetic protons”
- “A correlation of GEO and LEO energetic electron events using data from the CEASE instrument”
- “Derivation of the Dst index from the SSM magnetometer on DMSP”
- “Estimating equatorial, F-region vertical E×B drift velocities from ground-based magnetometers”

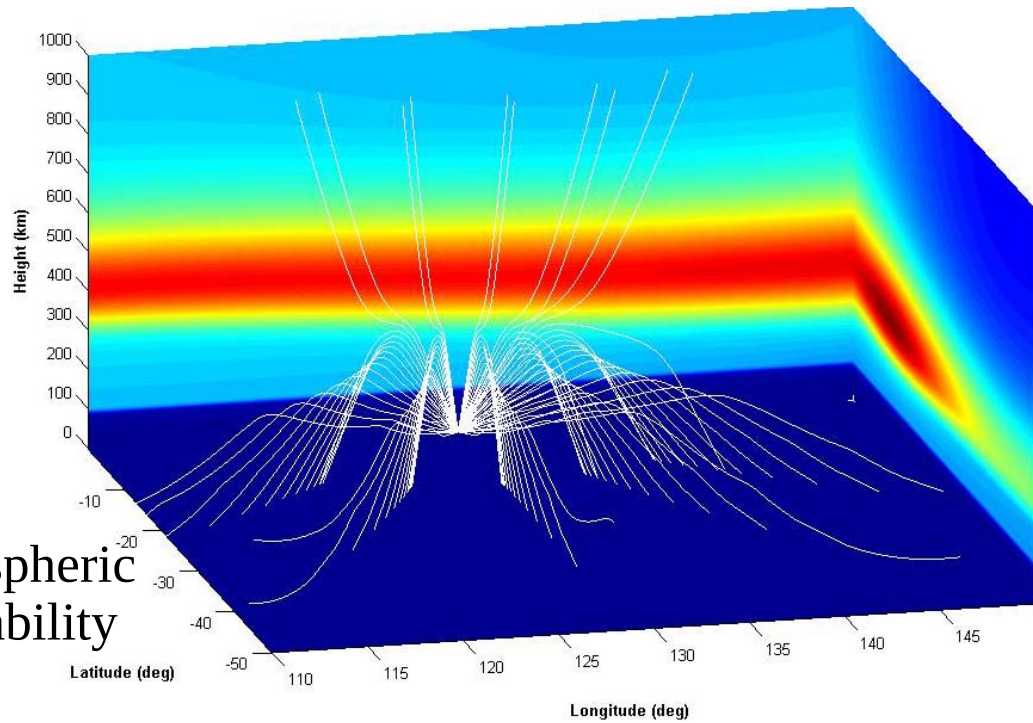
CCMC Collaboration

- Performance metrics for models of interest to DoD
  - e.g. GAIM, WSA, radiation belt
  - Compare empirical, assimilative, physical models
  - Fits comfortably within current CCMC paradigm
- Leverage CCMC infrastructure for research
  - The promise of CCMC
  - Reality: resources vs flexibility
  - Access to numerical output critical
  - Examples: ray-tracing using GAIM; ionospheric response to solar flares

HF Geo-location Example

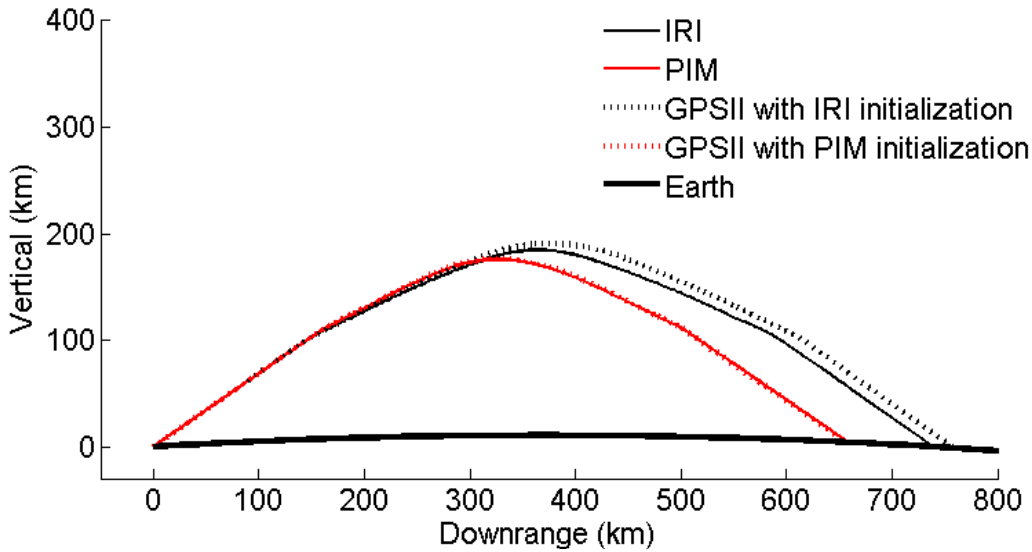


- Joshua Werner, M.S. 2007
- Improve geo-location of HF emitters
  - Requires accurate 3-D ionospheric specification
  - Current approach employs “active” ionospheric measurements versus “passive”
- Technique: combine assimilative ionospheric models with ray-tracing code; test capability vs ground-truth



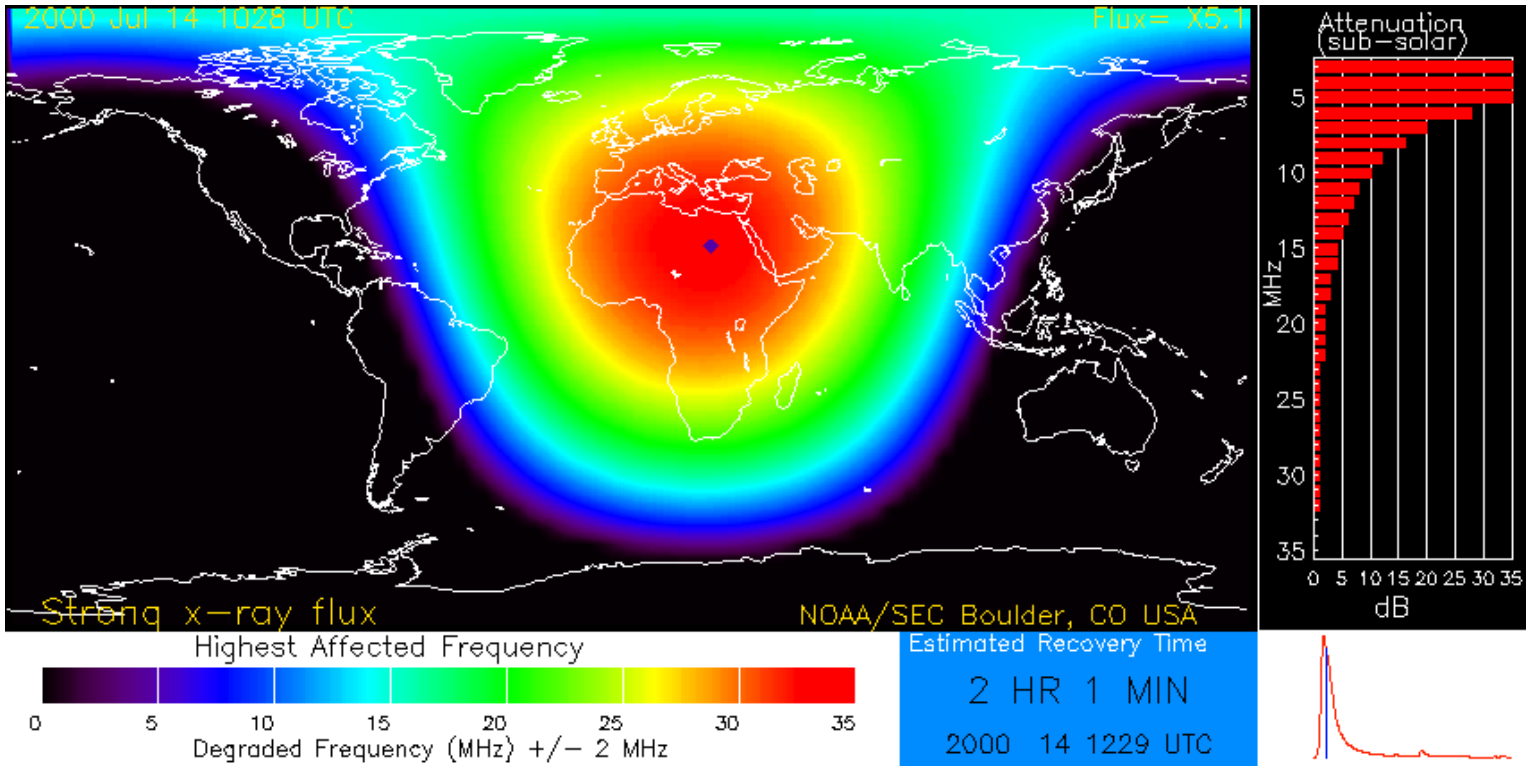
HF Geo-location Example

- Do assimilative ionospheric models improve HF ray-tracing capabilities?
- Initial work used GPS Ionospheric Inversion (GPSII) model [*Fridman et al.*, 2006]
- Extend study to include GAIM
  - Ideal use of CCMC capabilities
- Issues:
  - Resolution: ran GPSII at 0.5°, CCMC GAIM nominally 5°×15°
  - Ability to select data sources



Propagation of a 7 MHz signal transmitted from Dayton, OH toward Norfolk, VA at local noon on 9 Jan 06

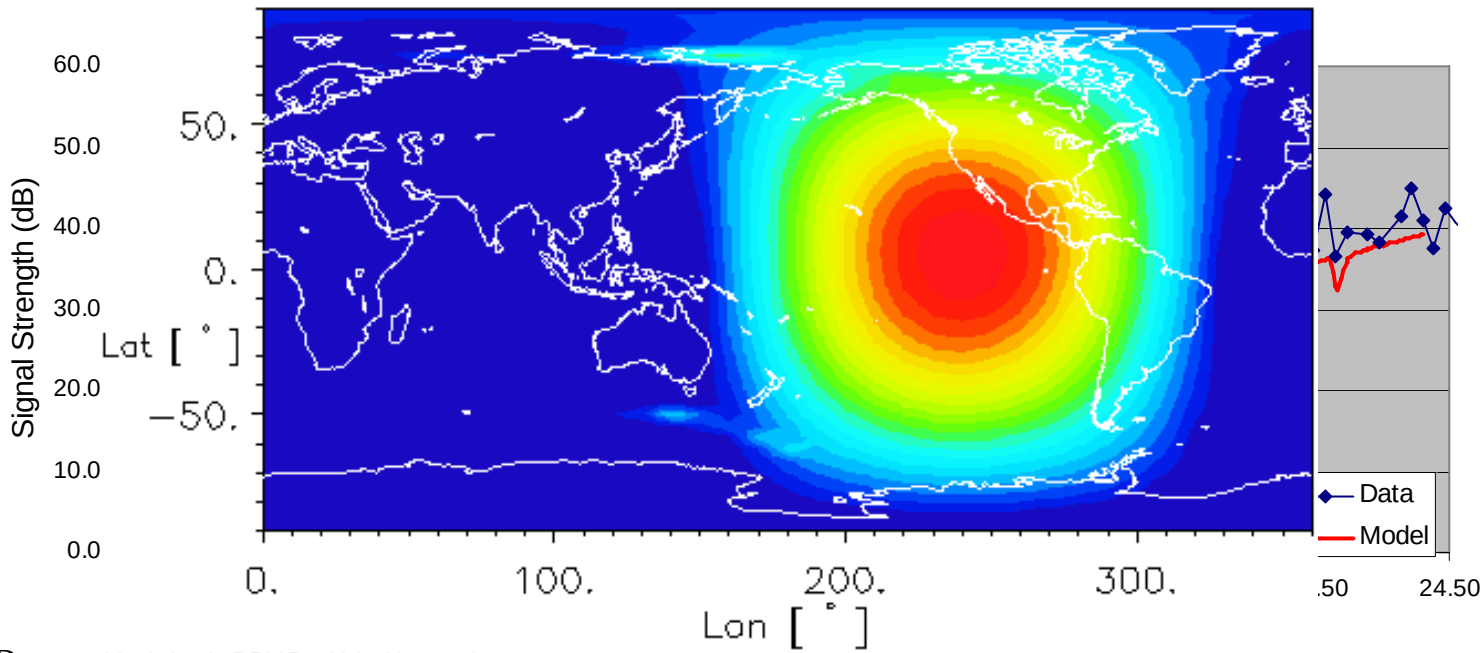
HF Radio Absorption Example



- Evelyn Schumer, Ph.D. student
- Validate and improve current models of HF radio absorption during solar flares
- Technique: Generate empirical model from HF signal database; cross-validate with physical D-region models; improve understanding of D-region processes

HF Radio Absorption Example

- ABBYNormal computes absorption due to single pass through ionosphere
  - CCMC: Global maps by request, single location on demand
- Not suited for comparison to data (multi-pass)
  - Couple ABBYNormal ionosphere with ray-tracing code



Data co[illegible]Model at CCMC: AbbyNormal

Research Summary

- Collaboration with CCMC when it makes sense
  - Leverage infrastructure to overcome computational requirements, data inputs, model idiosyncrasies
  - Ideal for GAIM, WSA, magnetosphere codes
  - Validation and verification easiest within current framework
- Downside is a lack of flexibility
  - Grid resolution, input variables
  - Altering model physics
  - e.g. ABBYNormal, SAMI2

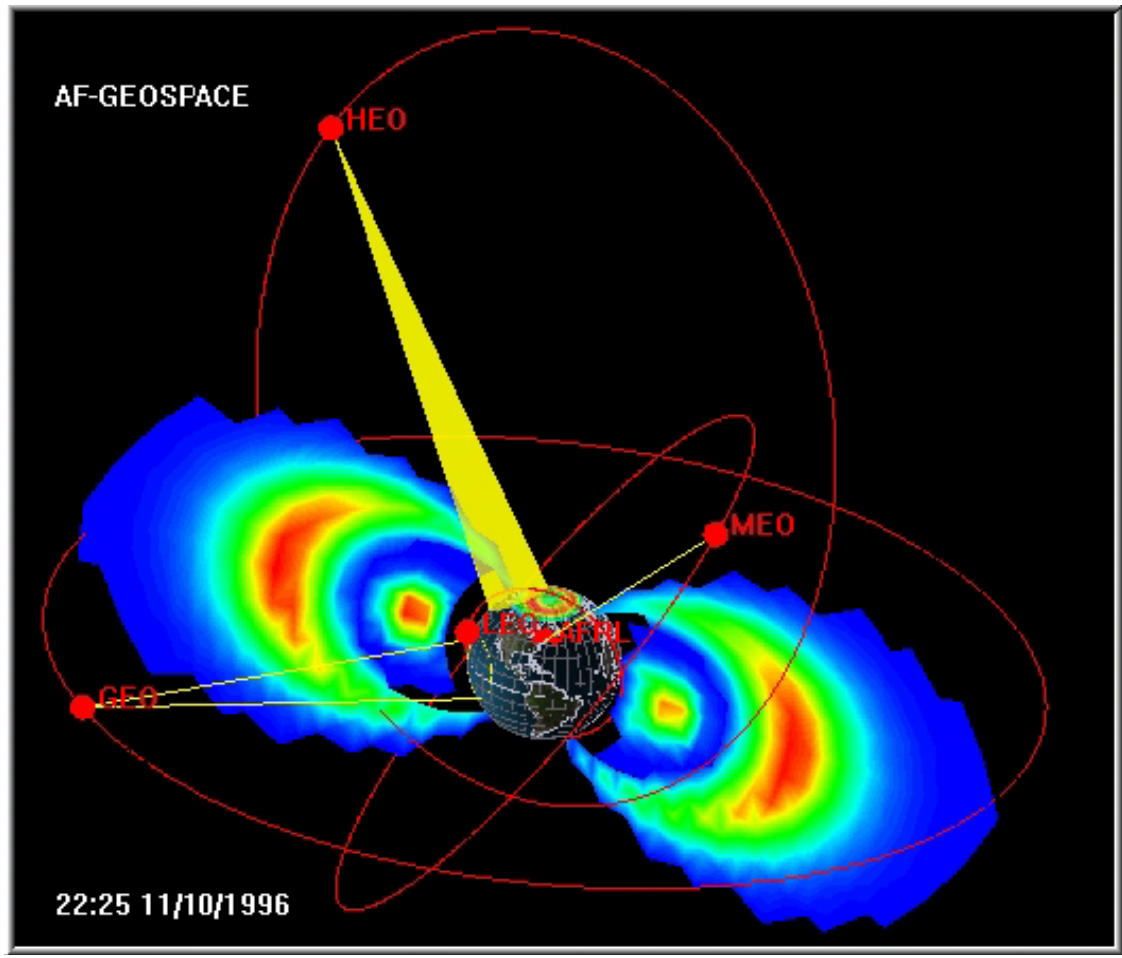
Laboratory Exercises

- Space Weather Lab course
  - Goal: Familiarize students with available space weather models
- Method
  - Lecture: describe model, provide context/background
  - Guided tour: step-by-step instructions to familiarize student with required inputs, plotting output, interpretation
  - Open-ended exercises
  - Student write-up
- Currently taught using both AF-GEOSpace and CCMC models
  - Each has strengths and weaknesses

Laboratory Exercises

AF-GEOSpace v2.1

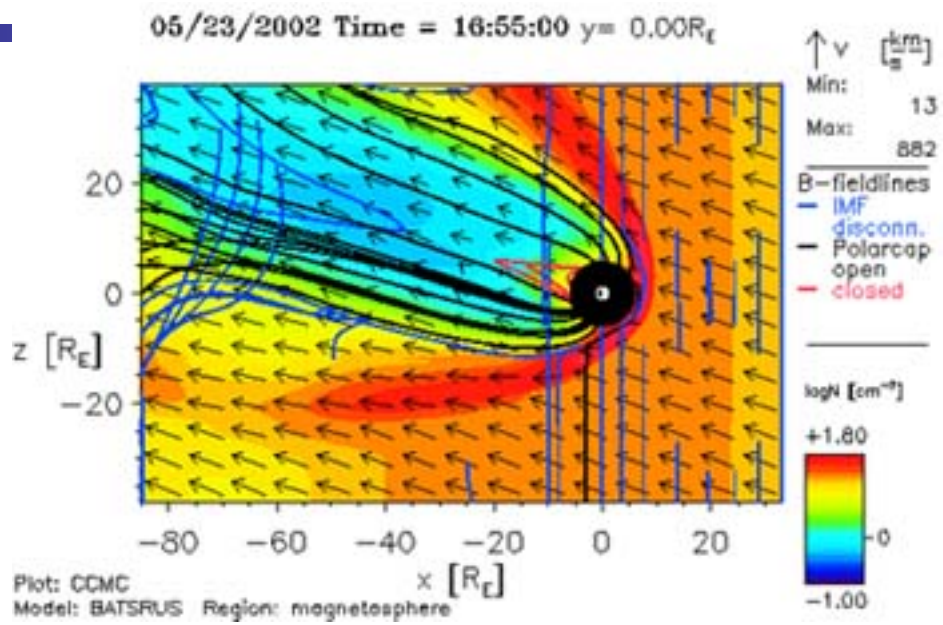
- Windows based GUI interface to numerous space weather models
- Stand-alone application
- Strengths
  - Simple standard plotting routines; 1-, 2-, 3-D
  - Easy to overlay output from multiple models
  - Excellent documentation
- Weaknesses
  - Nearly all empirical models
  - *Simple* plotting routines
  - Difficult to access numerical output

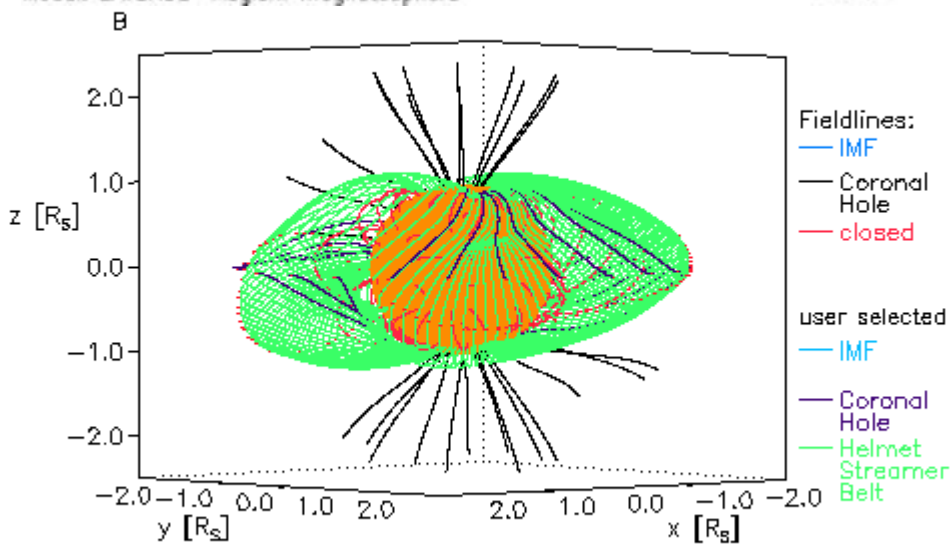


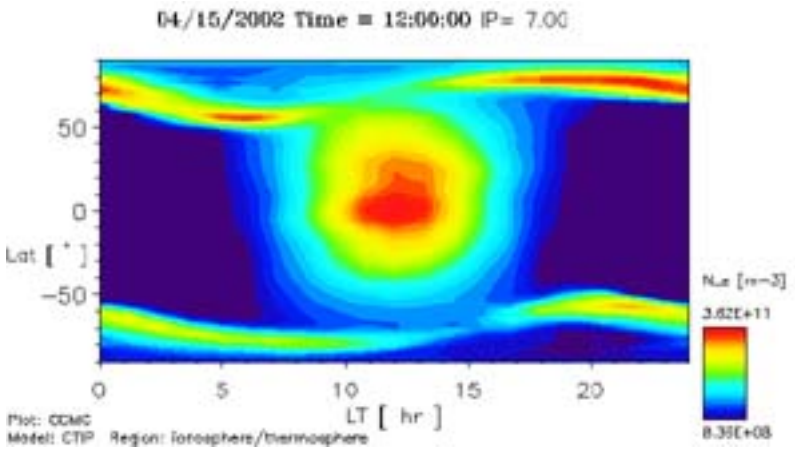
Laboratory Exercises

CCMC

- Internet based GUI interface
- Strengths
  - Most advanced models
  - Common interface for input/plotting
- Weaknesses
  - Uneven documentation
  - *Simple* plotting routines
  - Difficult to access numerical output





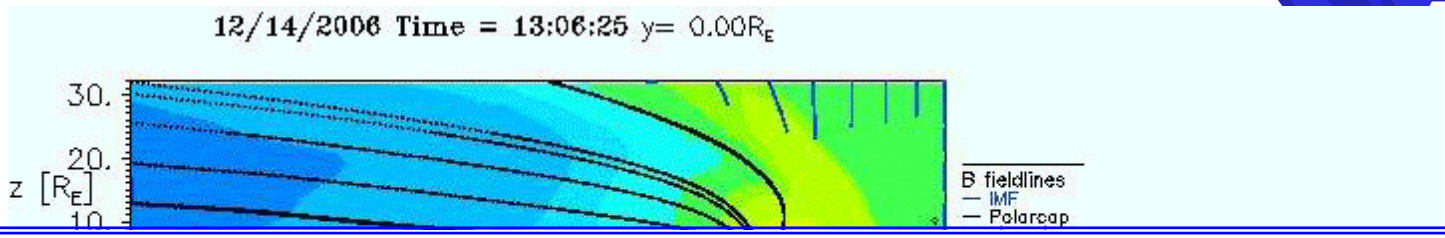


Model at CCMC: PFSS

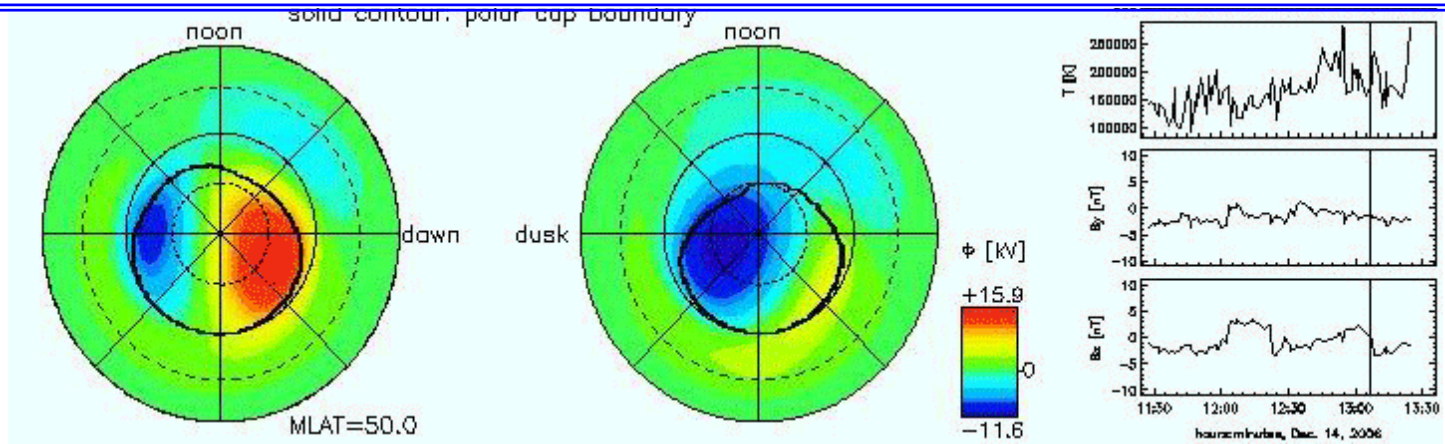
Laboratory Summary

- CCMC provides excellent resource for lab course
  - Greatest strength is diversity and quality of models
- But…students find it daunting
- Lessons learned (i.e. requested improvements)
  - Improve/standardize documentation
  - Ability to overlay/compare model output
  - More advanced visualization features
  - Better extraction of numerical output

Demos vs. “eye-candy”

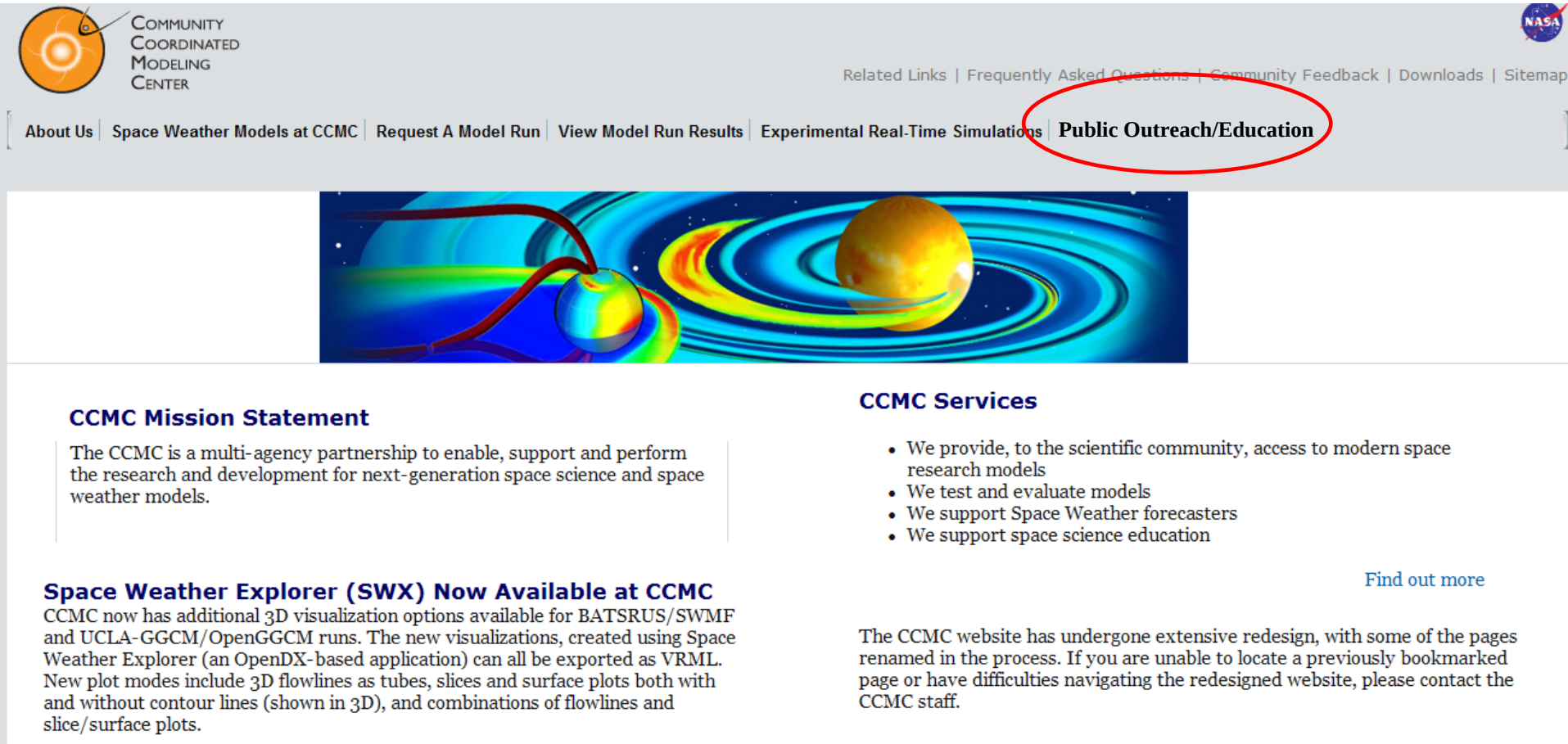


- Without explanation, the best model output is just “eye-candy”
- Should be a CCMC strength
- Few movies available, small figures
- Intimidating to all but experts – missed opportunity



Public Outreach/Education

- CCMC needs Public Outreach/Education link
  - All models create *highlights* page with movie or figures
  - Require detailed description geared to educators/public



Summary

- Many opportunities for research interaction
- Laboratory projects have been successful
- Work remains in packaging product for wider use

“the CCMC will strive to make all output beneficial to educational institutions, and amenable to broad distribution to the general public”

“Graphics and visualization techniques will be exploited for displaying CCMC output in appealing formats that can be used in classrooms or for public dissemination”

CCMC CONOPS