

CCMC in University Education in Embry-Riddle Aeronautical University

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Embry-Riddle Aeronautical University,

Fast Facts <http://www.erau.edu/about/fast-facts.html>

- Embry-Riddle Aeronautical University is the world's oldest (founded in 1925), largest, and most prestigious university specializing in aviation and aerospace. It is the only accredited, aviation-oriented university in the world.
- In DB campus 28 Undergraduate programs, 15 Master's program and 2 Ph.D programs (started in Fall 2010).
- Two residential campuses, Daytona Beach campus (4496 UGS students, 593 GS), Prescott Campus (1654 UGS, 51 GS); Worldwide Campus (20,076 UGS, 7215 GS).
- Total annual enrollment (34,000 students)
- The annual operating budget of Embry-Riddle is approximately \$275 million.



Nicole Stott proudly displayed an Embry-Riddle banner while living and working on the International Space Station for three months.

Space Physics Related Programs in Physical Sciences Department

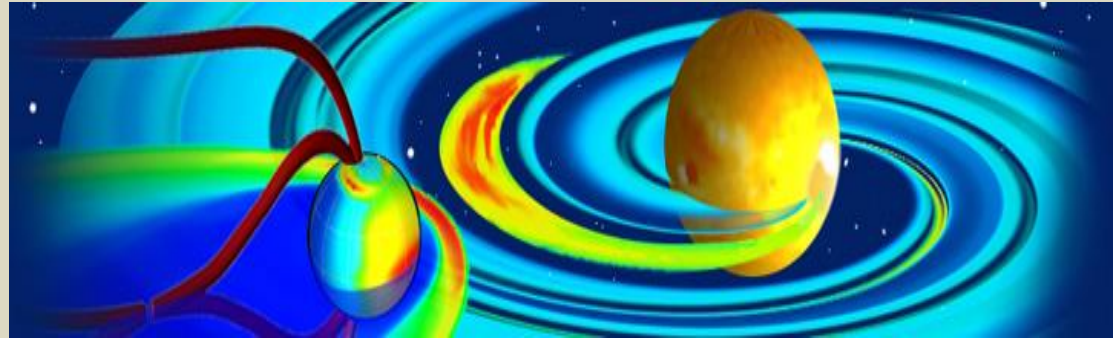
- [B.S in Engineering Physics](#)
- [B.S in Space Physics](#)
- [M.S in Engineering Physics](#)
- [Ph.D in Engineering physics \(since 2010\)](#)



ERAU Courses offered at Physical Sciences department where CCMC models could be used or have been used

B.S courses:

- EP 410 Space Physics
- EP 420 Planetary Science
- EP 495 Plasma Physics



M.S courses:

- EP 509 Advanced Space Physics

Ph.D courses (program started in 2010 so these elective course have not been offered yet):

- EP 704 Upper Atmospheric Physics
- EP 711 Computational Atmospheric Dynamics
- EP 710 Space Plasma Physics

EP 509-Advanced Space Physics (4 month course meeting 3 hrs/week)

PART I (Plasma Physics)

- Quick review of basic plasma physics:
Single Particle dynamics and derivation various drift speeds
- Kinetic Theory and particle distribution Function
- How spacecraft measure distribution Function: Relationship between Differential particle flux and distribution function
- Derivation of fluid plasma equations: 2- fluid plasma and MHD
- Derivation of generalized Ohm's law and scaling of the terms in gen. Ohm's law
- Properties of MHD equations
- MHD equilibrium
- MHD waves, discontinuities
- Magnetic reconnection

PART II (Applications to Space Environment)

- Sun & Solar wind, Bow Shock, Magnetosheath, magnetopause, magnetosphere, cusp, tail, inner magnetosphere, MI_coupling & aurora, SW interaction with other solar system bodies
- **Numerical Simulations: Local and Global simulations and applications**
- Data analysis techniques and applications to Cluster data

40% Homework + Quizzes

20 % Project

5 % Professionalism + class participation

15% Mid-term Exam

20% Two-hour final exam

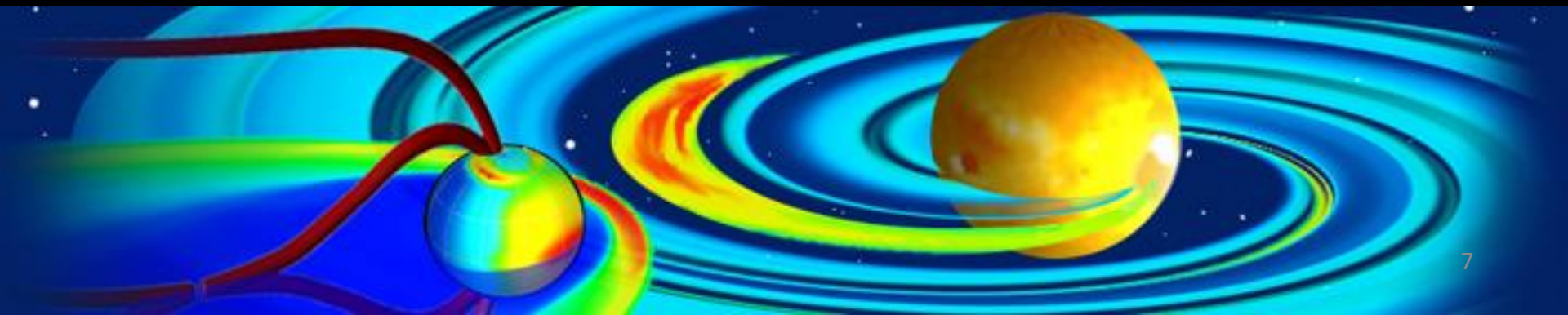
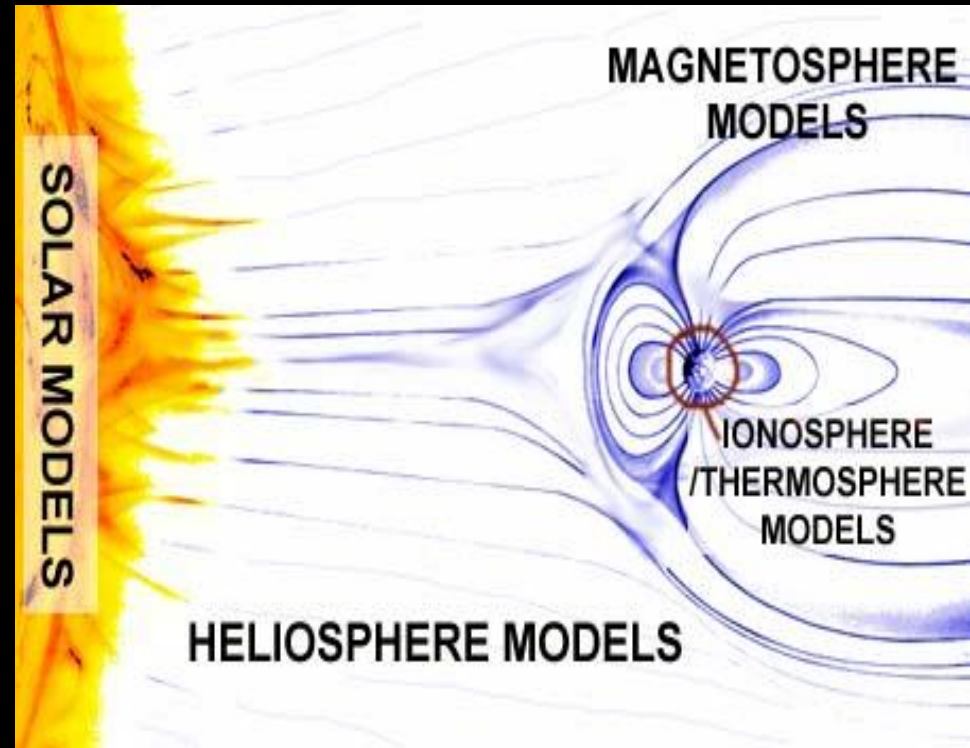
Numerical Simulations: Local and Global simulations and applications

- Motivation for numerical simulations
- Well posed problems
- Characterization of PDEs
- Discretization (finite volume, finite element, spectral methods, finite differences method)
- Finite differences approximation of derivatives
- Examples of discretization of 2-D fluid equations using finite differences Leap-frog scheme
- Appropriate time step for simulations (Courant condition)
- Introduction to Local and Global simulations
- Applications of simulations to dayside reconnection, cusp reconnection, tail reconnection, Kelvin-Helmholtz Instability

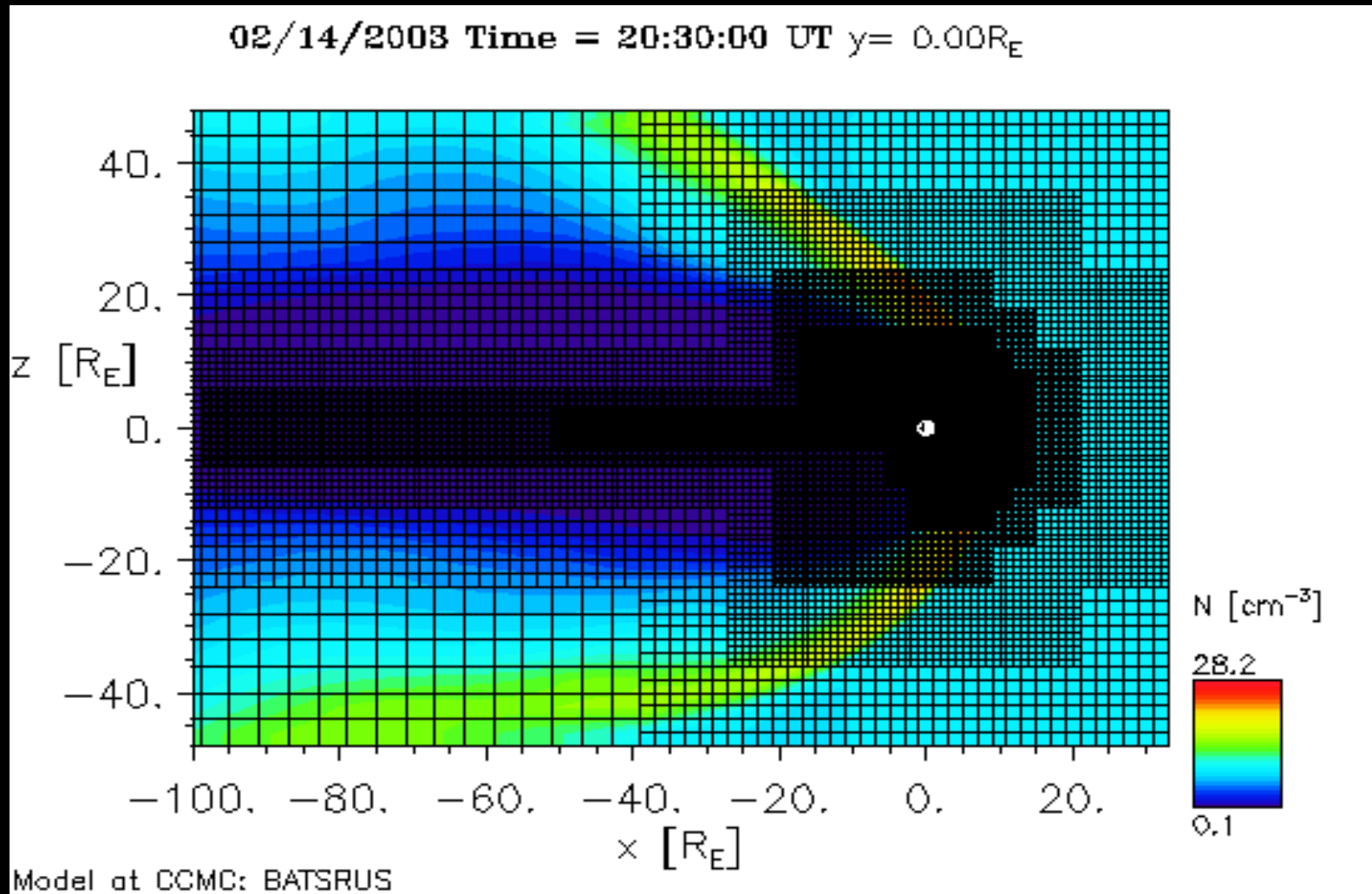
Global Simulations

<http://ccmc.gsfc.nasa.gov/>

- CCMC provides to the scientific community, access to modern space research models
- test and evaluate models
- support Space Weather forecasters
- support space science education



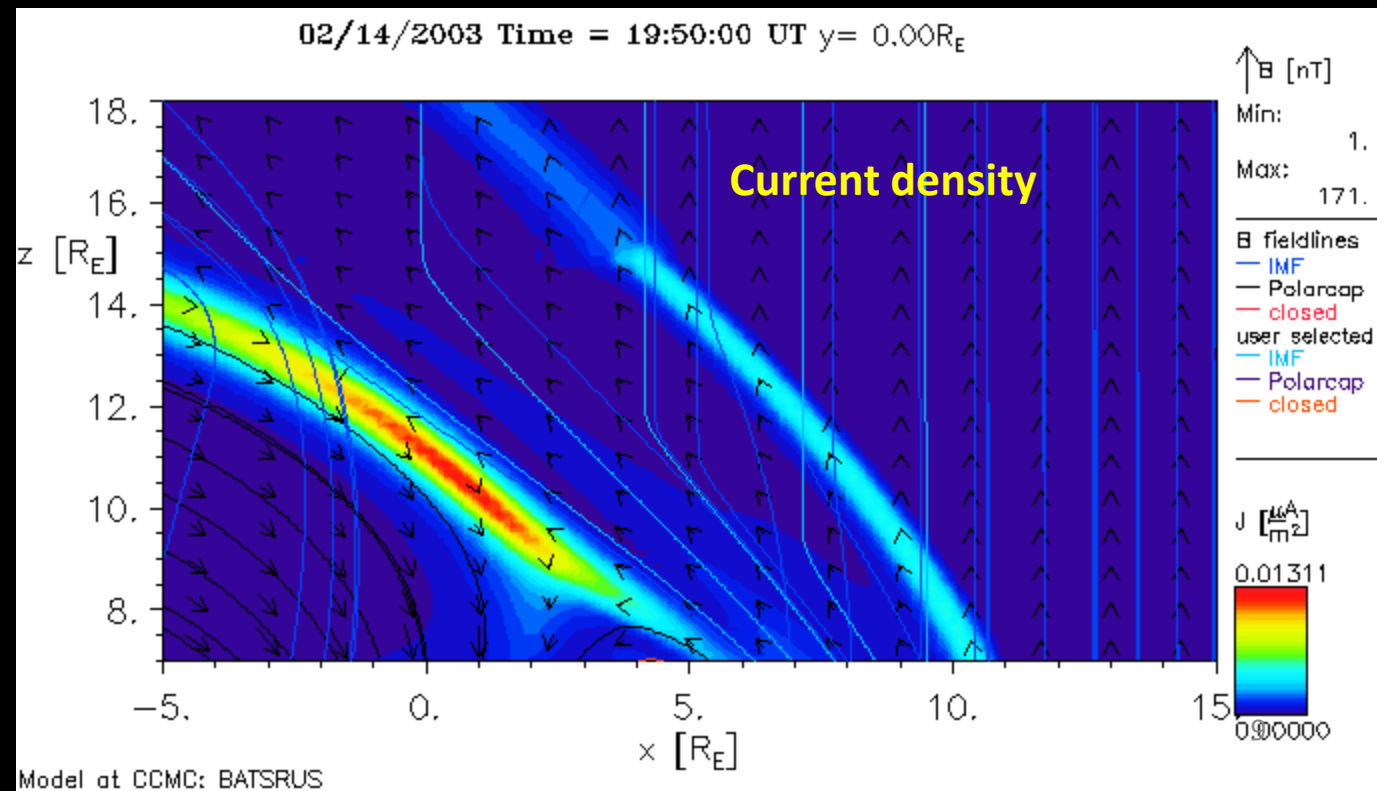
BATSRUS run for event when IMF changes from northward to southward diamagnetic cavity event



Let's go now to NASA website and use their software to visualize Global Code Run-results

<http://ccmc.gsfc.nasa.gov>

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Student projects

- Applications of simulations to student projects on dayside reconnection, cusp reconnection, tail reconnection, Kelvin-Helmholtz Instability
- For example Luz Martinez applied CCMC for her EP509 project on high-latitude cusp reconnection (run number 042111_1)
- Students have also utilized old existing runs in their projects
- I request students to write project report in [GRL format](#).
- I have found 3 master's student from EP509 class: Thomas W Moore and Emily Hyatt are currently utilizing CCMC for their M.S thesis work.

CCMC use in M.S-thesis work

Thomas W Moore (ERAU EP M.S student) is doing his M.S thesis work on *“Signatures of Plasma heating events at LLBL associated with Kelvin-Helmholtz Instability and Kinetic Alfven waves”*.

- We are using CCMC to get **The Large Scale Structure of the Magnetosheath** at the vicinity of Cluster spacecraft, compare with the data and use these both to determine the best initial conditions for our local simulations of KHI.
- We also plan to do *high-resolution runs* of our list of events and see whether KHI can be resolved.

Emily Hyatt (ERAU EP M.S student) studies the ionospheric mapping of all old (published literature) and new KHI events (found by Thomas W Moore) and studies optical, radar and ground magnetometer data for these events

- We are running local and global numerical MHD simulations
- Will study ionosphere also in Global simulations
- Map field lines also with NASA CCMC MHD model

Outreach: Annual “Women of Aviation”-event in Daytona Beach, students in my EP509 class joined me in teaching local middle school girls about space weather



Discussion

- CCMC is a great tool for space physics education
- It is great for visualization and highlighting the properties of different plasma and B-field regions in space
- Great tool to assist interpret spacecraft data (useful for M.S students and Ph.D students research)
- It is great for demonstrating physical principles.
- Students have enjoyed the EP509 class, especially they have liked the projects and the capability to visualize plasma physics principles with help of simulations.
- I have found very motivated students in EP509 class who want to do their M.S degree and pursue a Ph.D.

Possible Future Possibilities

- Utilize ERAU's unique specialization in engineering, aviation and space physics.
- Possible Interdisciplinary projects in ERAU between space physics and air traffic control students: Space weather impact on GPS accuracy.
- Utilize QEP "Ignite" –program funding for undergraduate research projects (5 million dollars) .

