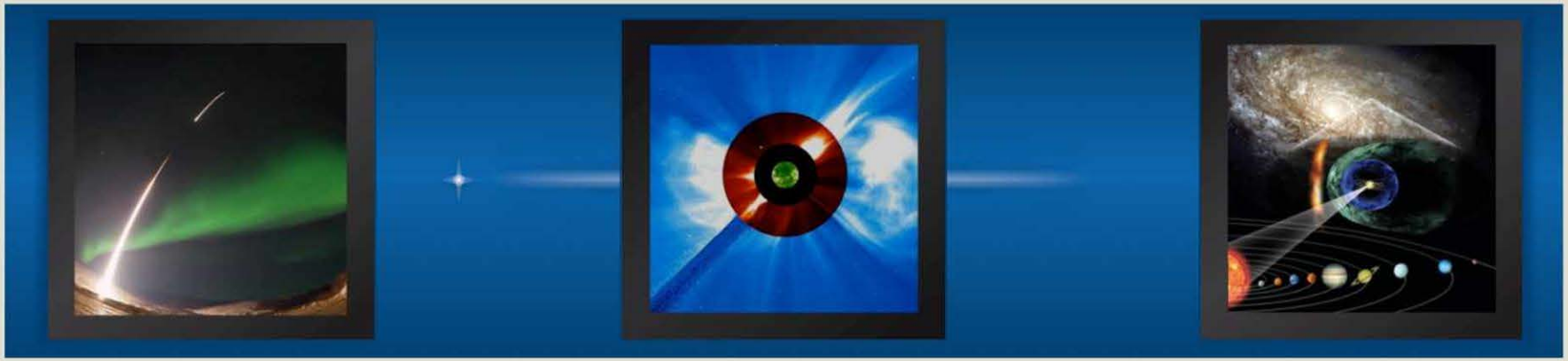
Heliophysics Subcommittee Report for the NAC Science Committee

Jill Dahlburg & Neil Murphy
NASA Heliophysics Subcommittee (HPS)

28 July 2015



Heliophysics Subcommittee (HPS) Membership

HPS Membership -

- Vassilis Angelopoulos (University of California, Los Angeles)
- Spiro Antiochos (NASA Goddard Space Flight Center)
- Jill P. Dahlburg (Naval Research Laboratory)
- Bart W. De Pontieu (Lockheed Martin Space Systems Corporation)
- Mihir I. Desai (Southwest Research Institute)
- Heather A. Elliott (Southwest Research Institute)
- Maura Hagan (National Center for Atmospheric Research)
- Michael W. Liemohn (University of Michigan)
- Ralph L. McNutt, Jr. (The Johns Hopkins University)
- Neil Murphy (Jet Propulsion Laboratory)
- James M. Russell III (Hampton University)
- Roger W. Smith (University of Alaska Fairbanks)
- W. Kent Tobiska (Space Environment Technologies)

AGENDA -

- HPD Division Overview
- HPD Flight Program Status

} **Steven Clarke's Presentation**

- HPD CubeSats
- Senior Review Results
- Science Presentation
- R&A Program Update / H-TIDeS
- Airborne Observations Opportunities
- MMS Update / GI Funding
- THOR – ESA M4 Mission
- Interstellar Probe
- Other Discussion Topics
- Topics Deferred for Future Discussion
- Heliophysics Science Highlights

The HPD was recommended by NASA as achieving noteworthy progress in the 2015 SOAR (Strategic Objective Annual Review) assessment, one of four noteworthy progress ratings across the Agency.

The HPS offers its sincerest congratulations for this outstanding achievement.

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HPS July 2015 CubeSat Observation

Six HPD CubeSats are being developed -

- ELFIN (Electron Losses and Fields Investigation)
- CeRES (Compact Radiation Belt Explorer)
- CuSPP (CubeSat mission to study Solar Particles over the Earth's Poles)
- TBEx (Tandem Beacon-Explorer)
- SORTIE (Scintillation Observations and Response of The Ionosphere to Electrodynamics)
- MinXSS (Miniature X-ray Solar Spectrometer CubeSat)

The HPS noted that it will be important for the broadly interesting and valuable datasets from these experiments to be accessible to the community as a whole.

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HPS July 2015 Senior Review Comment

All fifteen HPD extended missions in the Heliophysics System Observatory are being extended, including the returning missions ACE, AIM, CINDI, Hinode, IBEX, RHESSI, STEREO, TIMED, THEMIS, TWINS, Voyager, and Wind, and the IRIS, SDO, and Van Allen Probe missions that are entering their extended phases of operation. These missions, taken together, form a flexible and dynamic distributed system that provides forefront science and also operationally capable space weather data.

The HPS was very pleased with the decision to continue all of the reviewed HPD missions.

HPS July 2015 Discussion About Risk

The Senior Review discussion led HPS to discuss flight projects risks and future potential costs of risk intolerance.

The HPS reflected that there is a general perception in the science community that flight projects are over-reviewed, and consequently that **it would be helpful to evaluate statistics on the number of formal reviews for as many flight projects (by project) as possible over the period of current and previous Decadal Surveys and to compare these data with the final development cost of the projects.**

The motivation would be to determine if reviews are occurring at too high a cost-to-benefit ratio.

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- HPD Division Overview
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- Senior Review Results
- Science Presentation; Bob Leamon
- R&A Program Update / H-TIDeS
- Airborne Observations Opportunities; Dave Pierce
- MMS Update / GI Funding
- THOR – ESA M4 Mission; Stuart Bale
- Interstellar Probe; Ralph McNutt
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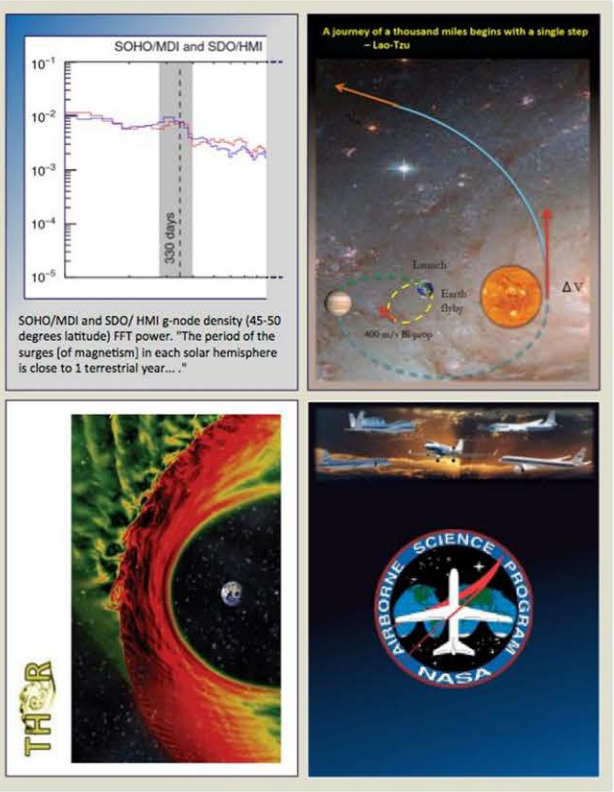
HPS Meeting Science Talks, July 2015

Bob Leamon

described an intriguing possibility of using measurements of solar Rossby waves to better understand solar variability. [S.W. McIntosh, R.J. Leamon *et al.*, 'The solar magnetic activity band interaction and instabilities that shape quasi-periodic variability,' Nature Communications, April 2015 (DOI: 10.1038/ncomms7491)].



Ralph McNutt

contributed a truly inspiring Interstellar Probe briefing about the new frontier in deep space exploration: the interstellar medium itself.

Stuart Bale

provided a presentation about THOR (Turbulence Heating ObserveR), which has been selected by ESA for a Phase-0 mission study.

Dave Pierce

spoke about NASA's airborne observation opportunities and the talk stimulated much thought among the Subcommittee members about HPS use of this capability. The HPS committed to help disseminate information to the user community about these versatile observational platforms.

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- Senior Review Results
- Science Presentation
- R&A (Research & Analysis) Program Update / H-TIDeS; Arik Posner, Jeff Morrill
- Airborne Observations Opportunities
- MMS Update / GI Funding; Bill Patterson
- THOR – ESA M4 Mission
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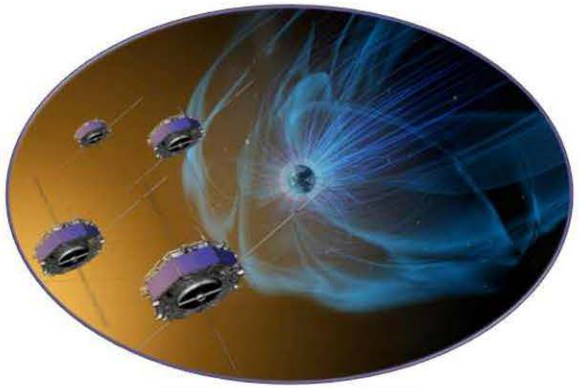

HPS July 2015 R&A Proposal and Review Discussion

NASA updates were provided about

H-TIDeS (Heliophysics Technology & Instrument Development for Science) *and*
H-GI and H-SR (Heliophysics Guest Investigator, and Supporting Research),
and also specific discussion about Magnetic Multiscale Mission [MMS] H-GI funding.

H-GI ROSES language has been modified for 2015 -- adopted from Astrophysics -- to clarify differences between H-SR and H-GI, which hopefully will help to disambiguate the calls.

Potential next steps for MMS/H-GI:

For ROSES 2016, a fully open H-GI call, which will allow proposal pressure to determine relative funding for MMS related research; and,

For ROSES 2017, a special GI call for either MMS or coordinated observations between MMS and other HPD missions, as warranted, based on ROSES 2016 response.

For H-TIDeS 2014:

- NASA received 98 Step-1 Proposals, and 84 Step-2 Proposals were reviewed;
- The first-year total request was $44.32M, with $6.6M funding available for FY2015;
- NASA selected 13 proposals: a 15% selection rate and oversubscription ratio of 6.7.

HPS July 2015 R&A Proposal and Review Discussion, *cont.*

In response, the HPS observed:

Even though R&A funding is critical to HPD success, the lack of adequate funding and resulting proposal pressure can potentially strain the review process.

The HPS accordingly suggested that HPD consider instituting a simple, short 'exit' survey for both proposers and panel reviewers for Step-1 and Step-2 proposals, which would help to evaluate the overall quality of the review process as seen by the community.

HPS July 2015 Recommendation for SC Consideration

Recommendation for SC Consideration: HPD should either increase the size of the grants to bring them more in line with their values of 30 years ago and/or reduce the number of pages from 15 to 10 or less for the Scientific/Technical/Management Section for R&A proposals.

Major Reasons for the Proposing the Recommendation: For more than three decades, the basic size and scope of the H-SR & H-GI grants have remained the same: 15 page proposals for ~$125K/year for a duration of three years. The cumulative inflation index over the past 30 years is approximately a factor of 3.4; consequently at today's salary rates and grant funding level, a full time early career scientist currently needs more than two full grants to support his/her funding. This situation has led to the community and HPD spending an increasing amount of effort on writing and reviewing proposals for a decreasing amount of effective support. Larger awards and/or reduced page limits will ease the burden on the proposers and also allow each panelist to review more proposals. This could also result in smaller review panels and provide additional cost savings.

Consequences of Failing to Follow the Proposed Recommendation: The proposal writing/reviewing process will continue to increase the burden on the community and the Discipline scientists.

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- Other Discussion Topics
    - Opportunity to utilize fueled payload adapter fittings [PAFs]
- Topics Deferred for Future Discussion
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HPS July 2015 Recommendation for SC Consideration

Recommendation for SC Consideration: NASA should explicitly offer the use of fueled payload adapter fittings [PAFs] as part of their launch services, or alternatively enable use of such capabilities by the proposers outside the cost cap as long as the total cost for the new PAF capability is less than the official cost of the dedicated launch option for any given Announcement of Opportunity.

Major Reasons for Proposing the Recommendation: The use of fueled PAFs[1,2] in place of traditional Explorer launch options is currently not a standard launch option. Such an option could enable a wider range of low-cost Explorer missions, for example full missions that are within the Mission of Opportunity cost cap. Currently the savings from alternate launch capabilities are firewalled from the proposing team's use towards their launch costs as secondaries, significantly reducing the budget available for the mission. There is a perception of risk associated with fueled PAFs, as they are not an approved NASA launch service (per NPD 8610.7d attachment A). Allowing fueled PAFs to be considered part of the proposer's flight system will provide sufficient oversight to retire any actual risk.

[1]*SHERPA modified ESPA ring on Falcons: http://www.spaceflightindustries.com/sherpa/*
[2]*LCROSS ESPA ring on EELVs: https://en.wikipedia.org/EELV_Secondary_Payload_Adapter*

Consequences of No Action: A wide range of orbits at reduced costs to NASA would be unavailable if fueled PAFs are not utilized for new science.

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  - HPD staffing needs;
  - Changing cost-to-benefit ratio of flight project reviews?

    The HPS hopes to examine this topic more closely, with the help of the HPD.
- Heliophysics Science Highlights

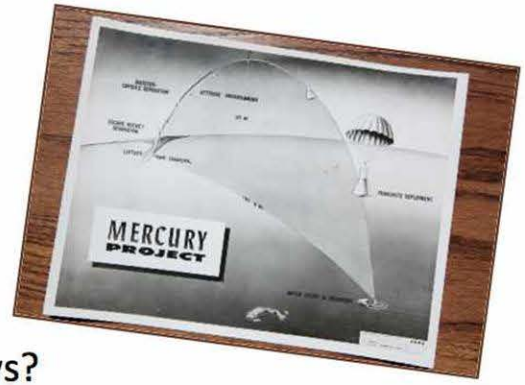

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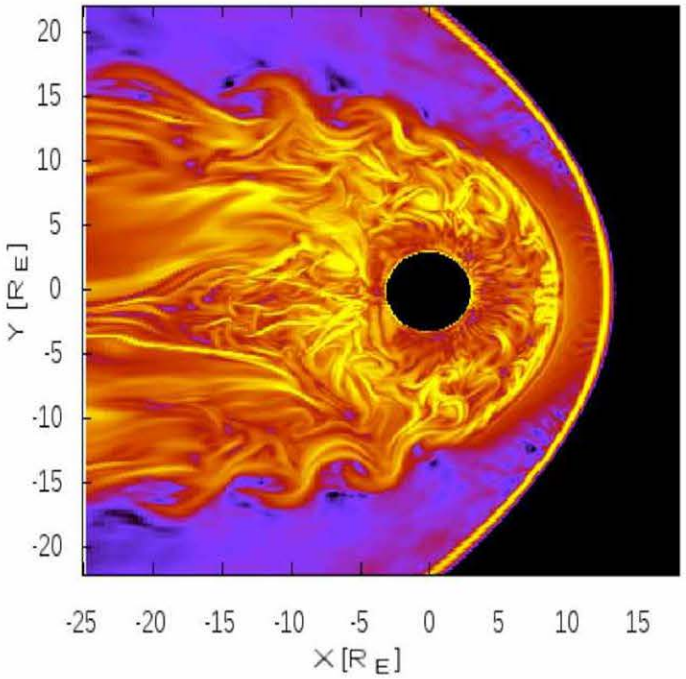
Chart-20: **- THEMIS (**Time History of Events and Macroscale Interactions during Substorms**): discovery**

Charts -21 & 22: **- *Hinode*/EIS (**Extreme-ultraviolet Imaging Spectrometer**): discovery, & simulation validation with space data**

Charts -23 & 24: **- WACCM (**Whole Atmosphere Community Climate Model**): discovery, & simulation validation with space data**

The wavy magnetopause



ABOVE: This magnetosphere simulation shows, in color code, the electrical current density in the equatorial plane. The wavy region, when Earth's magnetic field interacts with the streaming solar wind, is the magnetopause. BELOW: Example of similar waves in the atmosphere.

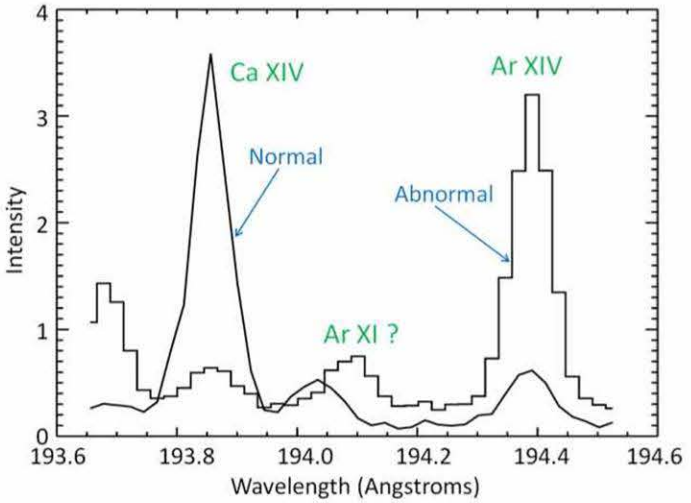
- Using >1000 hours of THEMIS magnetopause observations, Kavoshi & Raeder find that Kelvin-Helmholtz (KH) waves -- produced by solar wind flow shear at Earth's magnetopause -- are quite common (see simulation, top left).
- These waves are similar to wind-over-water waves or wind-shear waves in atmospheric clouds (see example bottom, left).
- These waves occur 19% of the time at the magnetopause, much more often than previously thought. KH waves are also found when they are least expected, during slow solar wind (~270 km/s).
- Such high KH occurrence frequency has implications for plasma entry into the magnetosphere, and for excitation of ultra-low low frequency waves inside Earth's magnetosphere which can, in turn, energize the radiation belts.

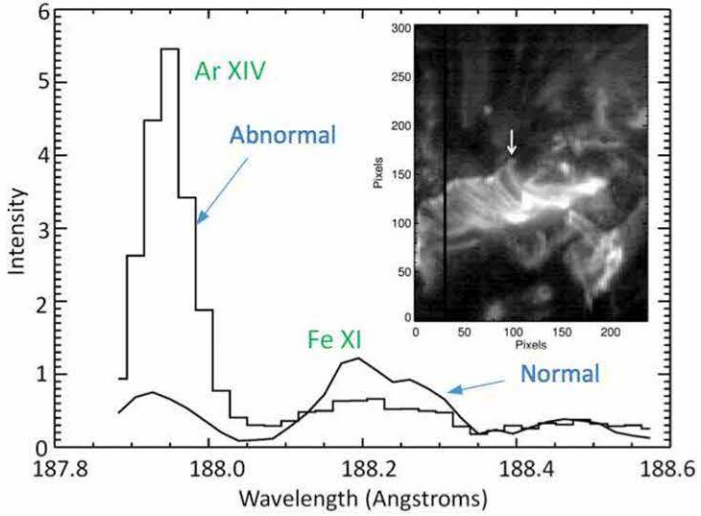
Kavosi & Raeder, *Nature Communications*, 2015.
http://www.unh.edu/news/releases/2015/05/ds11breakingwaves.cfm

Monster Inverse FIP Effect Observed in the Sun!

THE INVERSE FIRST IONIZATION POTENTIAL (FIP) EFFECT IS A PROCESS WHICH RESULTS IN DIFFERENT ELEMENT ABUNDANCES IN THE SOLAR CORONA THAN IN THE PHOTOSPHERE.

- The inverse FIP effect has never been observed before in the Sun.
- The inverse FIP effect has just been observed in our star by the Extreme-ultraviolet Imaging Spectrometer (EIS) on *Hinode.**
- **Argon XIV** is enhanced by a factor of about 30 over its normal coronal abundance, in the example illustrated here.
- This inverse FIP enhancement is <u>seven times larger</u> than the photospheric abundance!
- Other enhancements in other regions are a factor of two or three greater than photospheric.
- The enhancements are seen close to sunspots. The precise association is not known.
- The solar coronal electron density is ~4 x 10^{10} up to about 10^{12} cm^{-3}.



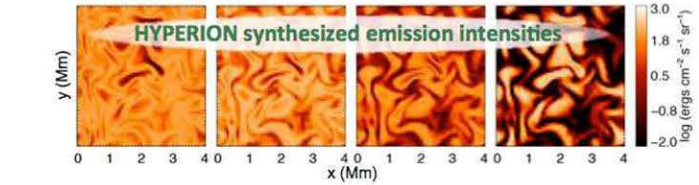


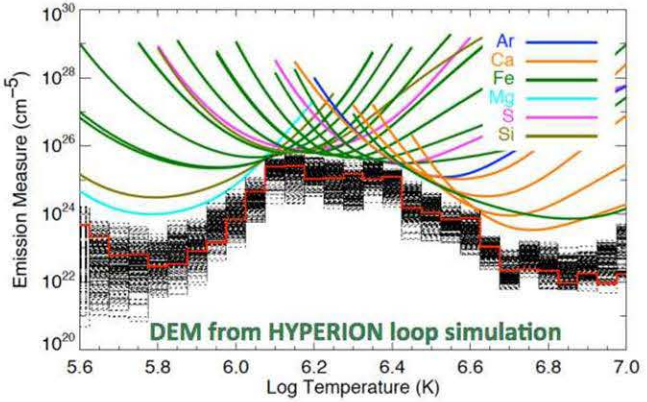
** G.A. Doschek, H.P. Warren, U. Feldman, "Anomalous Relative Ar/Ca Coronal Abundances Observed by the Hinode/EIS Imaging Spectrometer Near Sunspots," Ap.J.Lett 808:L7 20 July 2015; doi: 10.1088/2041-8205/808/1/L7*

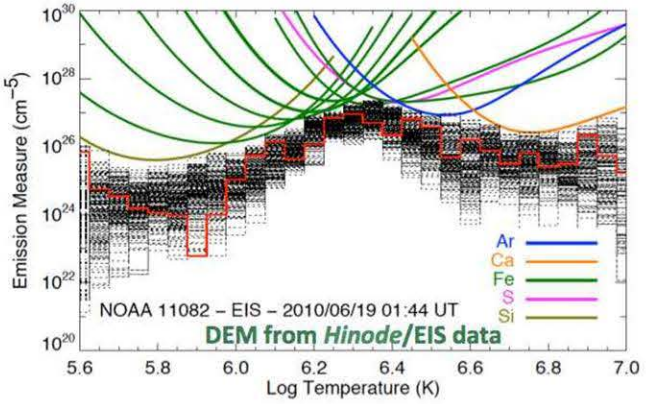
HYPERION coronal loop simulations agree with *Hinode*/EIS data

THE QUESTION OF WHY THE SUN IS HOTTER ON THE OUTSIDE THAN ON THE INSIDE – WHY THE SOLAR CORONA IS SO HOT COMPARED TO THE PHOTOSPHERE – IS ONE OF THE MOST EXCITING ASTRONOMY PUZZLES OF THE CENTURY.

- Numerically accurate magnetohydrodynamic simulations of typical coronal loops agree with *Hinode*/EIS solar data, when the (HYPERION code) computations include all of these physics effects: full 3D; compressibility; radiation transport; thermal conduction; and advection of the loop footpoints by random photospheric-mimicking motions.
- The HYPERION simulated loops, which are 50,000 km in length and have axial magnetic field intensities of 0.01-0.04 Tesla, exhibit turbulent coronal heating that is strongly intermittent in space and time, with only small portions of the multi-strand, multi-thermal loops heated at any given instant.
- HYPERION emission line intensities are synthesized from the numerical loop number densities and temperatures, and are used to compute differential emission measure [DEM] distributions. The numerical loop intensities and corresponding DEMs agree very well with *Hinode*/EIS DEM distributions for similar loops(right).



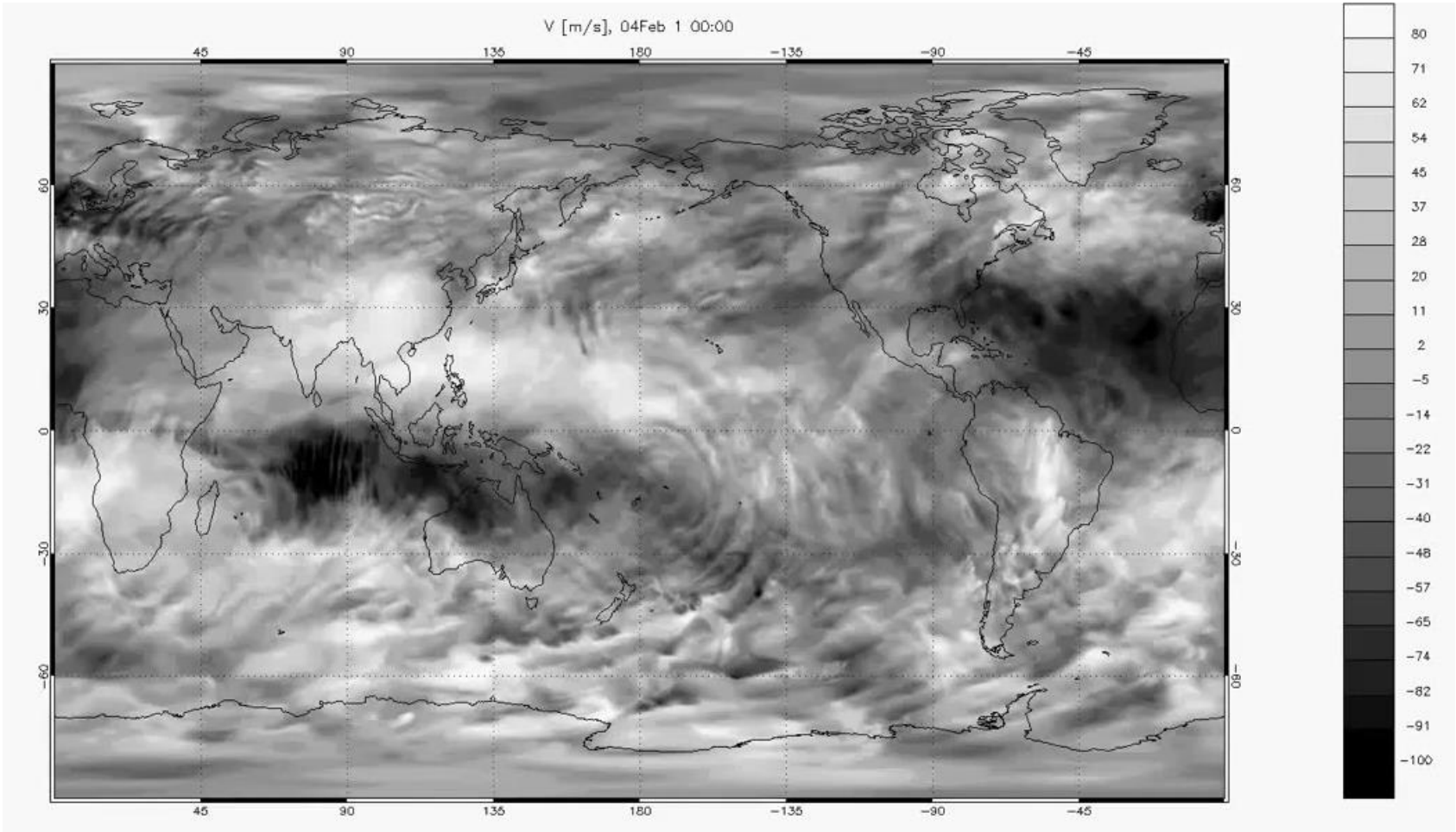




R.B. Dahlburg, G. Einaudi. B.D. Taylor, I. Ugarte-Urra, H.P. Warren, A.F. Rappazzo, M. Velli, "Observational Signatures of Coronal Loop Heating and Cooling Driven by Footpoint Shuffling," Ap.J. submitted, June 2015.

Gravity Waves in the Mesopause Region

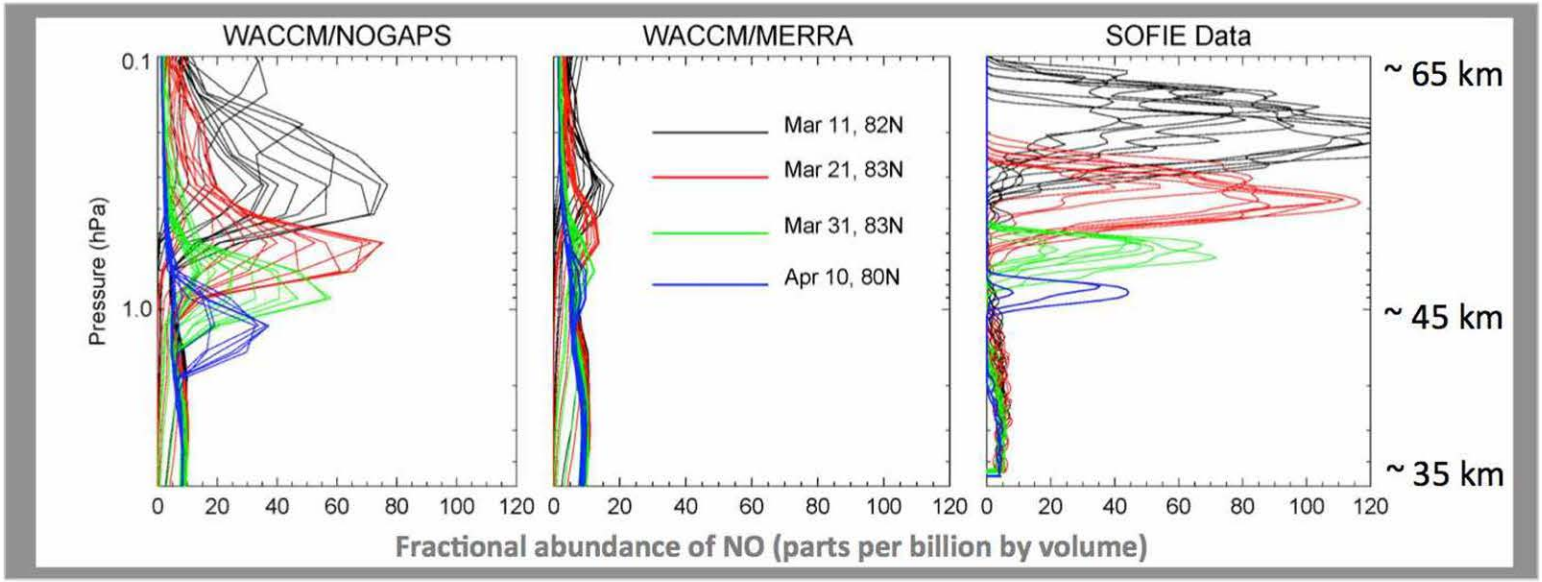
Whole **A**tmosphere **C**ommunity **C**limate **M**odel Meridional Winds at 95 km during February



- Unprecedented mesoscale-resolving whole atmosphere general circulation model
- WACCM at ~0.25° horizontal resolution and 0.1 scale height vertical resolution
- Reveals increasing dominance of explicitly resolved gravity waves at high altitudes
- Note planetary-scale extent of a concentric GW excited by a tropical cyclone

[*after Liu et al.,* 2014]

AIM nitric oxide (NO) data shows connection between space weather and the middle atmosphere; validates whole atmosphere models



- NO produced in the aurora borealis illustrates effects of space weather on the thermosphere. Under cover of polar night, NO can sometimes get pulled down deep into the middle atmosphere.
- Whole atmosphere models (NCAR/WACCM) either use lower/middle atmosphere-only weather (MERRA) or weather up to the edge of space (NRL-NOGAPS).
- **Best agreement with the AIM/SOFIE data is achieved with WACCM constrained by NOGAPS.***

Validates models of atmospheric coupling.

*(POCs: Dr. David Siskind & Dr. Fabrizio Sassi, Naval Research Laboratory)

SOFIE: Solar Occulation for Ice Experiment; AIM: Aeronomy of Ice in the Mesosphere
WACCM: Whole Atmosphere Community Climate Model
MERRA: Modern Era Retrospective Reanalysis for Research and Applications, the NASA/GSFC stratosphere-only model
NOGAPS: Navy Operational Global Atmospheric Predictions System. A research prototype version of this ex-operational system was extended up to 90 km


When you have a good idea: never give up!