AGU ADVANCING EARTH AND SPACE SCIENCES

Perspectives of Earth and Space Scientists

NEWS ARTICLE
10.1029/2025CN000296

Correspondence to:
A. W. Breneman,
aaron.w.breneman@nasa.gov

Citation:
Breneman, A. W., Halford, A. J., Sinnhuber, M., Carter, B., Bukowski, A., Cantwell, K., et al. (2025). Breaking down the wall that historically separates the atmosphere, ionosphere, and magnetosphere (AIM) communities: AGU Chapman conference on AIM coupling. *Perspectives of Earth and Space Scientists*, *6*, e2025CN000296. https://doi.org/10.1029/2025CN000296

Received 9 JUL 2025
Accepted 11 SEP 2025
Corrected 9 OCT 2025

This article was corrected on 9 OCT 2025. See the end of the full text for details.

Breaking Down the Wall That Historically Separates the Atmosphere, Ionosphere, and Magnetosphere (AIM) Communities: AGU Chapman Conference on AIM Coupling

A. W. Breneman[1], A. J. Halford[1], M. Sinnhuber[2], B. Carter[3], A. Bukowski[4], K. Cantwell[5], V. E. Ledvina[6], S. D. Walton[7], and J. Pettit[1]

[1]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [2]Karlsruhe Institute of Technology, Karlsruhe, Germany, [3]Royal Melbourne Institute of Technology, Melbourne, VIC, Australia, [4]University of Michigan, Ann Arbor, MI, USA, [5]Dartmouth College, Hanover, NH, USA, [6]University of Alaska Fairbanks Geophysical Institute, Fairbanks, AL, USA, [7]University of California, Berkeley, Berkeley, CA, USA

Abstract This meeting report summarizes outcomes from the AGU Chapman Conference on *Particle Precipitation: Drivers, Properties, and Impacts on Atmosphere, Ionosphere, Magnetosphere (AIM) Coupling*, held 14–21 February 2025, in Melbourne, Australia. This conference brought together scientists from around the world to identify pressing AIM open science questions and next steps for solidifying cross-community collaborations. Efforts have resulted in the upcoming Town Hall session *Building Bridges Between the Atmosphere, Ionosphere, Magnetosphere (AIM) Communities* at the 2025 AGU meeting in New Orleans, USA. This Town Hall aims to establish a recurring meeting to address the scientific and societal challenges of AIM coupling.

Plain Language Summary This report briefly summarizes outcomes from a February 2025 scientific meeting in Melbourne, Australia that brought together scientists from around the world to discuss ways to increase collaborations amongst the atmosphere, ionosphere, and magnetosphere (AIM) communities. These collaborations are critical for addressing frontier science questions relevant to our understanding and prediction of space weather and its impacts on our technological society. A follow-up Town Hall session at the 2025 AGU meeting will explore how to build stronger connections across these scientific fields.

1. Article

Energetic particle precipitation (EPP) is one of the fundamental drivers of *space weather* in the coupled atmosphere-ionosphere-magnetosphere (AIM) system. These electrons and ions from the Sun and terrestrial magnetosphere and ionosphere range in energy from hundreds of eV to GeV and precipitate into the atmosphere in response to enhanced topside (solar and magnetosphere) driving. They deposit their energy at a wide range of altitudes guided by the Earth's magnetic field, enhancing ionization and changing current density, neutral temperature and density, composition, and winds. During times of prolonged geomagnetic activity or solar energetic particle events, the resulting changes can adversely affect anthropogenic systems, for example, by disruption of communication and power systems, and by increased variability in satellite drag hastening orbital decay. In addition to its effects on space weather, EPP has been recognized as an important component of climate via its ability to indirectly destroy ozone, modifying the local radiative balance in the middle atmosphere with implications for dynamics down to tropospheric weather systems.

Despite the recognized importance of EPP as a driver of space weather and regional climate variability, the ways in which the coupled AIM system interacts are highly complex and remain poorly understood and constrained. This is, in part, due to the lack of data within this region of space that is too high for balloons to float and too low for satellites to orbit. Remote sensing from space is possible, and has provided vital information about AIM coupling, but ongoing satellite missions are now well past their expected lifetime, with few new missions in the pipeline. The lack of data inhibits the ability for space weather models to be validated and make reliable forecasts. To compound this situation, different aspects of the coupled system are studied by the different communities with a historic lack of overlap caused by regional separation, siloed funding mechanisms, and distinct physical processes. Properly studying AIM dynamics—a societal level priority—requires a *global systems science* (holistic) approach to data collection, analysis, and modeling.

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An AGU Chapman conference in Melbourne, Australia in February 2025, hosted by RMIT University, brought together over 70 researchers to bridge knowledge and communication gaps separating the different communities. Discussions focused on identifying the most pressing open science questions, the data products each community can provide and that each requires, and next steps for solidifying cross-collaborations.

Highlighted open science questions included:

How do the drivers of topside (magnetospheric) energetic electron precipitation determine its spatial, temporal, and energy-dependent variability, and how does this affect local and global chemistry changes in the middle and upper atmosphere?

How are the impacts of magnetospheric forcing modulated by neutral dynamics in the middle and upper atmosphere?

One illustrative example compares two mechanisms by which energetic electrons create NOx, leading to stratospheric ozone loss:

Indirect effect: <100 keV electrons precipitate above 90 km, producing NOx that is transported downward across the mesopause.

Direct effect: >100 keV electrons penetrate to lower altitudes, producing NOx directly below the mesopause.

Properly addressing this type of interdisciplinary question requires the development of close working relationships amongst experimentalists and modelers across the AIM communities.

To this goal, a notable meeting outcome was the organization of a Town Hall session at the upcoming 2025 AGU meeting entitled *Building Bridges Between the Atmosphere*, *Ionosphere*, *Magnetosphere (AIM) Communities*. The intent of this Town Hall session is to solicit input toward developing a recognizable community identity and the establishment of a recurring meeting addressing scientific issues fundamental to AIM coupling. This effort was led by some of the early-career scientists and students whose attendance at the Chapman conference was enabled through targeted travel grants. Their enthusiasm reflects a promising future for a more unified AIM research community.

Acknowledgments
AWB and AJH were funded by the Space Precipitation Impacts HISFM 2021, and AJH was funded in part by the AIMFHAR HISFM 2025. VL was supported by NASA Award 80NSSC25K7546, and KC was supported by NASA SMD Heliophysics Division award number 80NSSC24K0241. AB was supported by NASA grants 80NSSC23M0192 and 80NSSC20K1581.

Data Availability Statement

Data were not used, nor created for this research.

Erratum

Since original publication of this article the following has been added to the Acknowledgments: "AB was supported by NASA grants 80NSSC23M0192 and 80NSSC20K1581." This may be considered the authoritative version of record.