

CEDAR/GEM 2018

Creating Convergence:

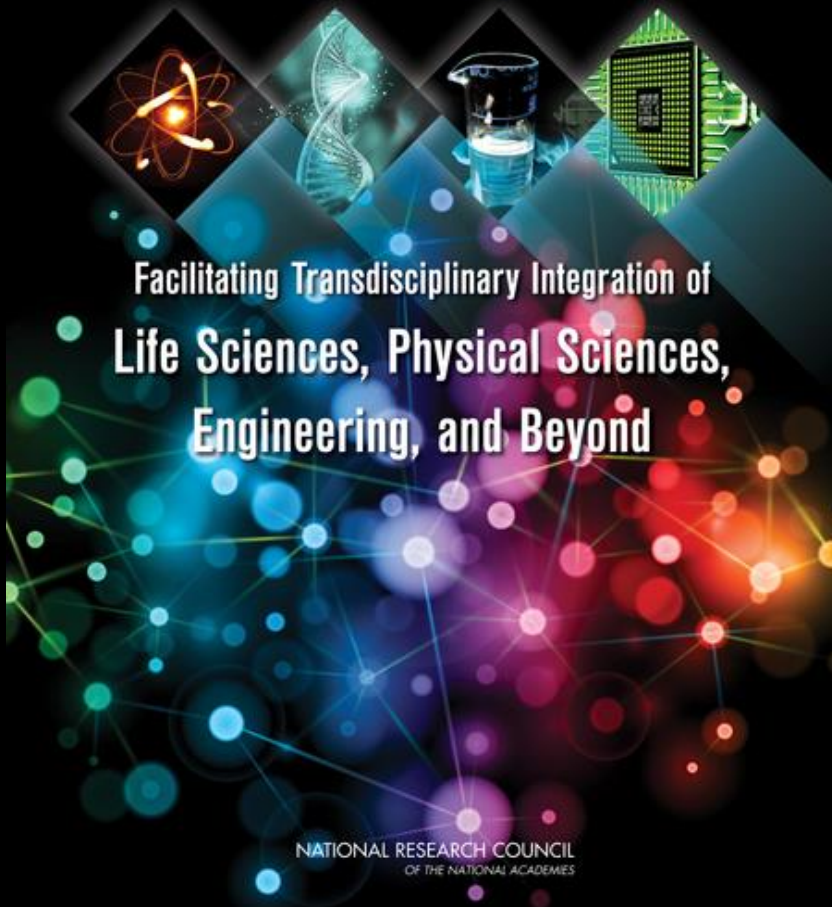
[Merging the Physical World with the Data World]



Jeffrey P. Thayer

Aerospace Engineering Sciences Department, University of Colorado

Convergence



This PDF is available at
<http://nap.edu/18722>

- ❖ Convergence Research at the National Science Foundation (NSF) one of 10 Big Ideas for Future NSF Investments.
- ❖ Convergence research entails integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation.



Convergence Accelerators FY19

- ❖ Convergence Accelerators targeting two of these Big Ideas: Harnessing the Data Revolution and the Future of Work at the Human-Technology Frontier.



Convergence

- ❖ Convergence Research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.

The Universality of Plasma-Neutral Interactions

- ❖ Planetary Space-Atmosphere Interaction Regions
- ❖ Stellar Chromospheres
- ❖ Dusty Plasmas
- ❖ Interplanetary Space Weather (Planetary Habitability)
- ❖ Interstellar Space Weather (Exoplanets)

Convergence

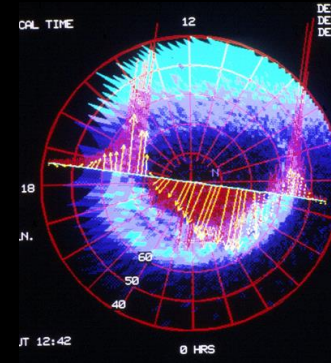
- ❖ Deep integration across disciplines. As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities and languages become increasingly intermingled or integrated. New frameworks, paradigms or even disciplines can form sustained interactions across multiple communities.

SAIR Plasma-Neutral Interactions

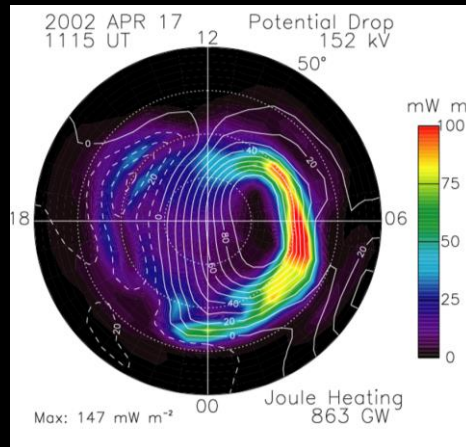
Plasma-Neutral Chemistry



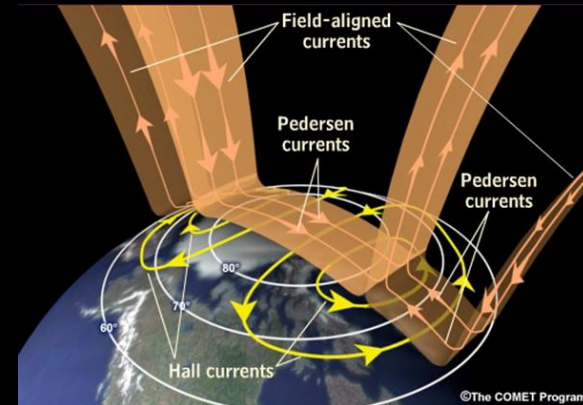
Plasma-Neutral Drag Forces



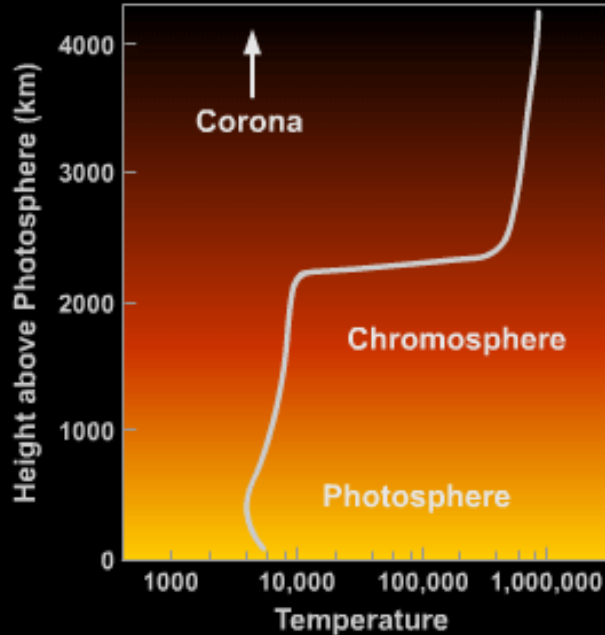
Plasma-Neutral Frictional Heating



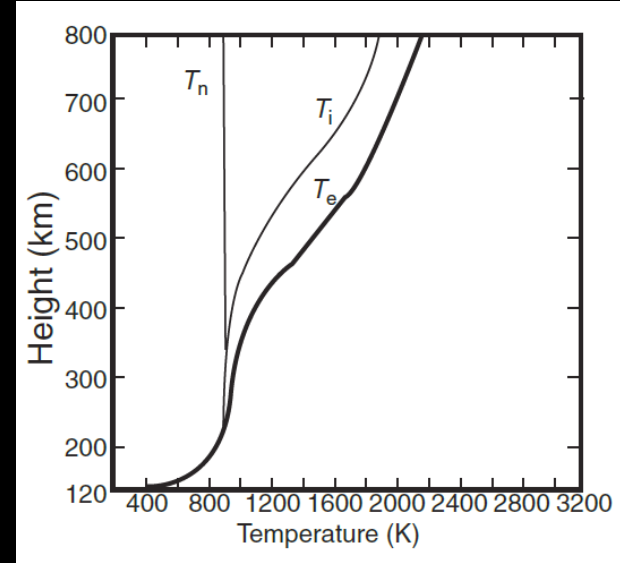
Plasma-Neutral Electrodynamics



Chromosphere / Ionosphere Comparison



Solar Chromosphere



Earth's Ionosphere/Thermosphere

Leake, J. E.; DeVore, C. R.; Thayer, J. P.; Burns, A. G.; Crowley, G.; Gilbert, H. R.; Huba, J. D.; Krall, J.; Linton, M. G.; Lukin, V. S.; Wang, W. (2014), Ionized Plasma and Neutral Gas Coupling in the Sun's Chromosphere and Earth's Ionosphere/Thermosphere, Space Science Reviews, Volume 184, Issue 1-4, pp. 107-172, doi: 10.1007/s11214-014-0103-1

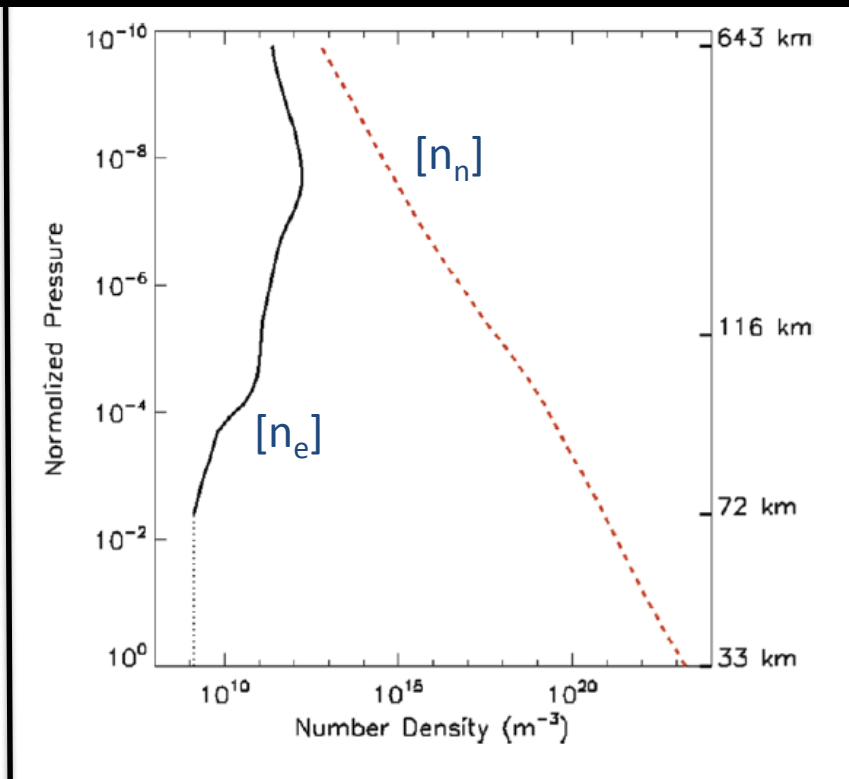
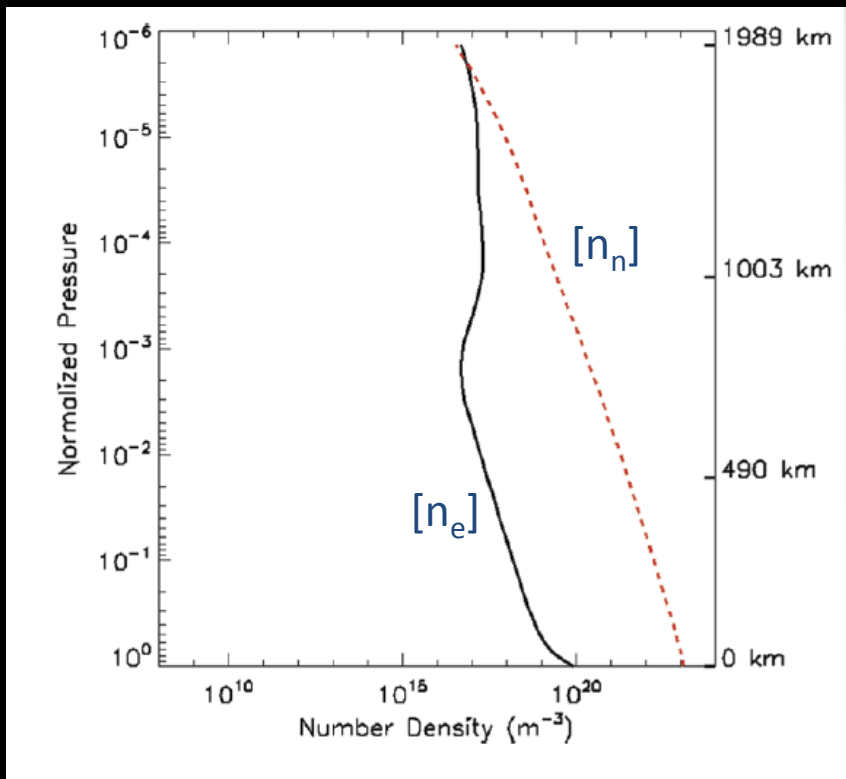
Convergence

- ❖ From its inception, the convergence paradigm intentionally brings together intellectually-diverse researchers to develop effective ways of communicating across disciplines by adopting common frameworks and a new scientific language, which may, in turn, afford solving the problem that engendered the collaboration, developing novel ways of framing research questions, and opening new research vistas

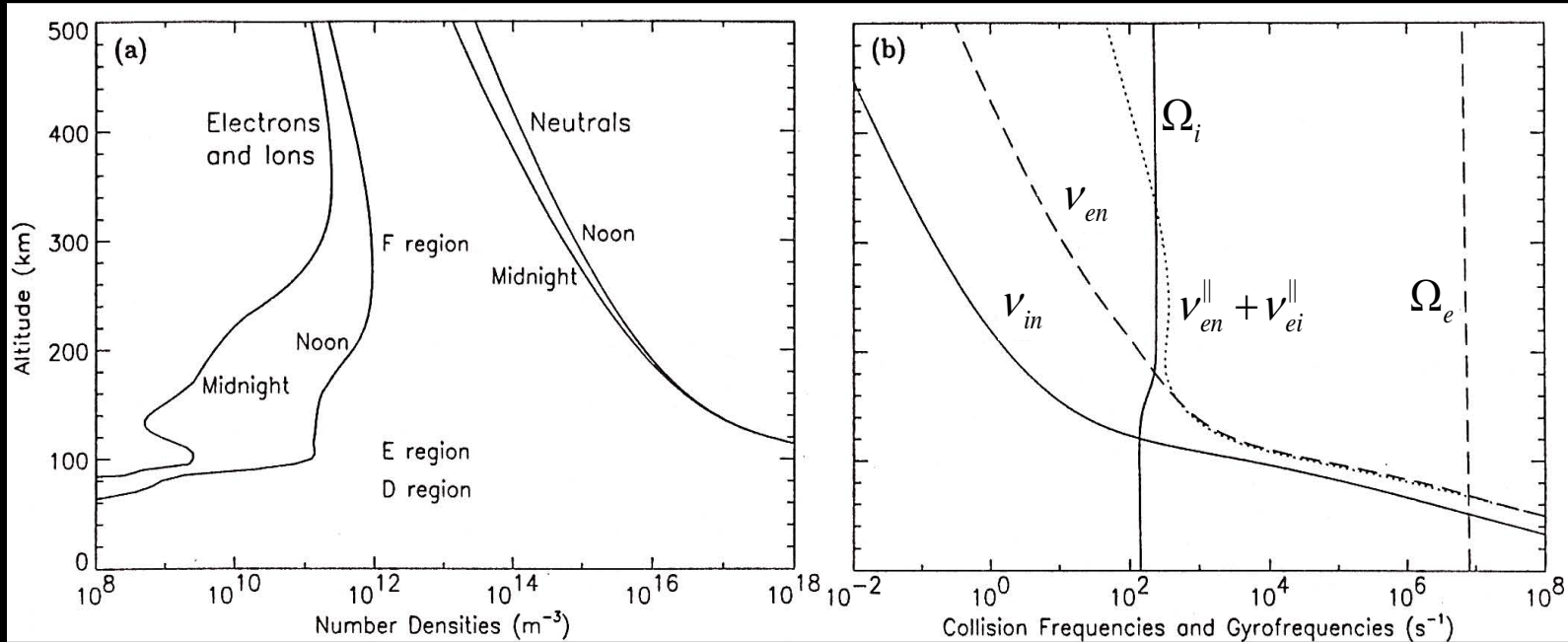
Weakly Ionized Gas

Solar Chromosphere

Earth's Ionosphere / Thermosphere



I/T: Plasma-Neutral Interactions



$$k = \frac{\Omega}{\nu}, \text{ mobility}$$

$$\Omega = \frac{qB}{m}, \text{ gyrofrequency}$$

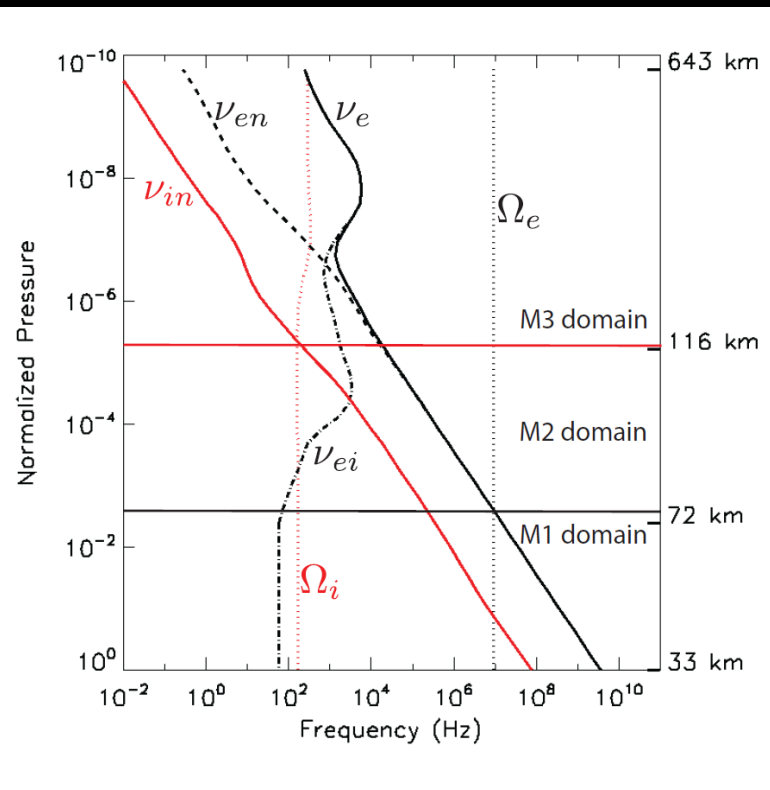
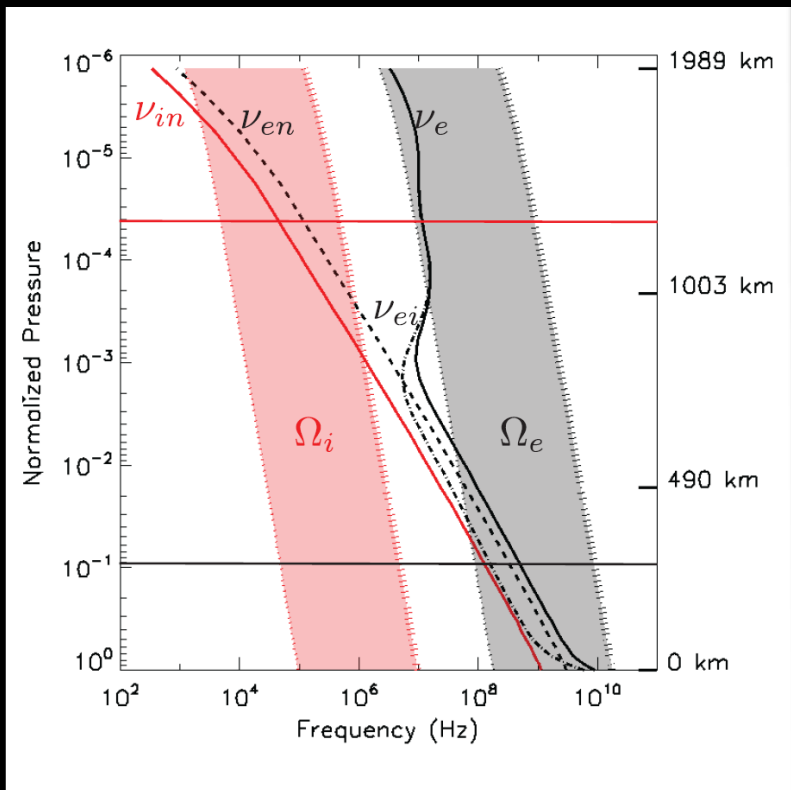
ν_{en} , electron-neutral collision frequency

ν_{in} , ion-neutral collision frequency

Plasma – Neutral Interactions

Solar Chromosphere

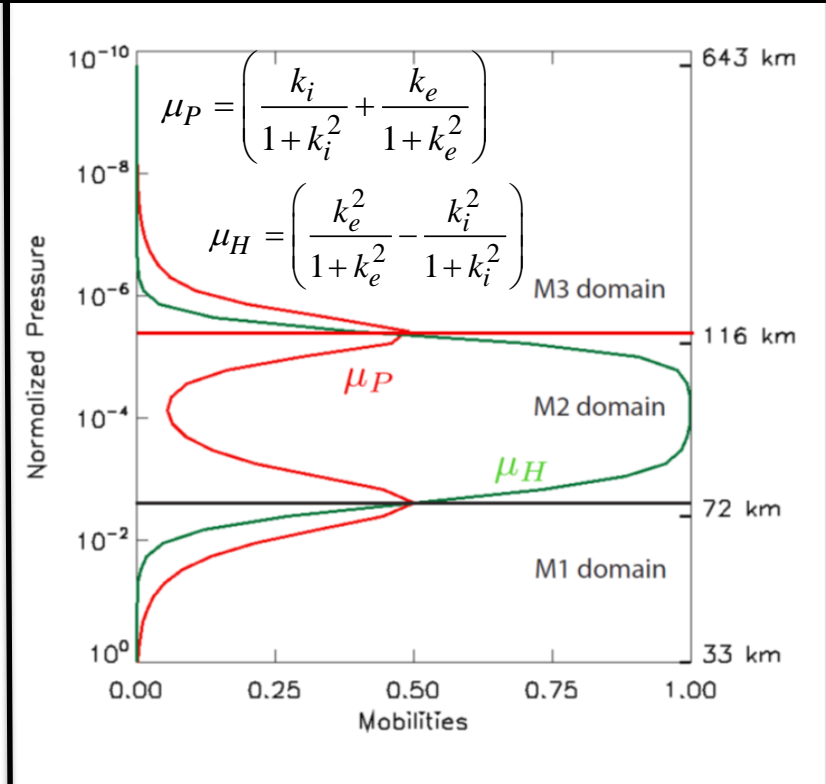
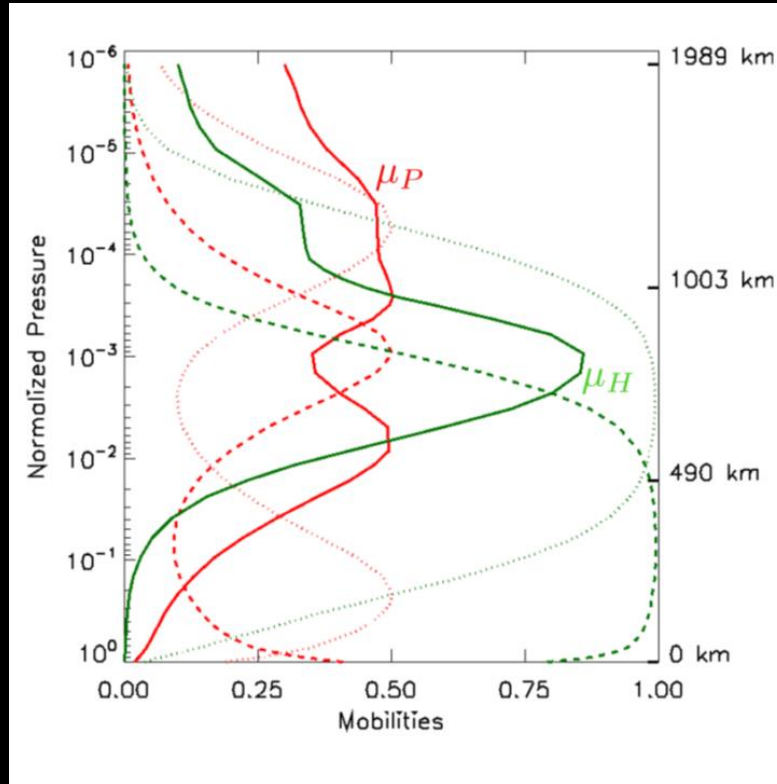
Earth's Ionosphere / Thermosphere



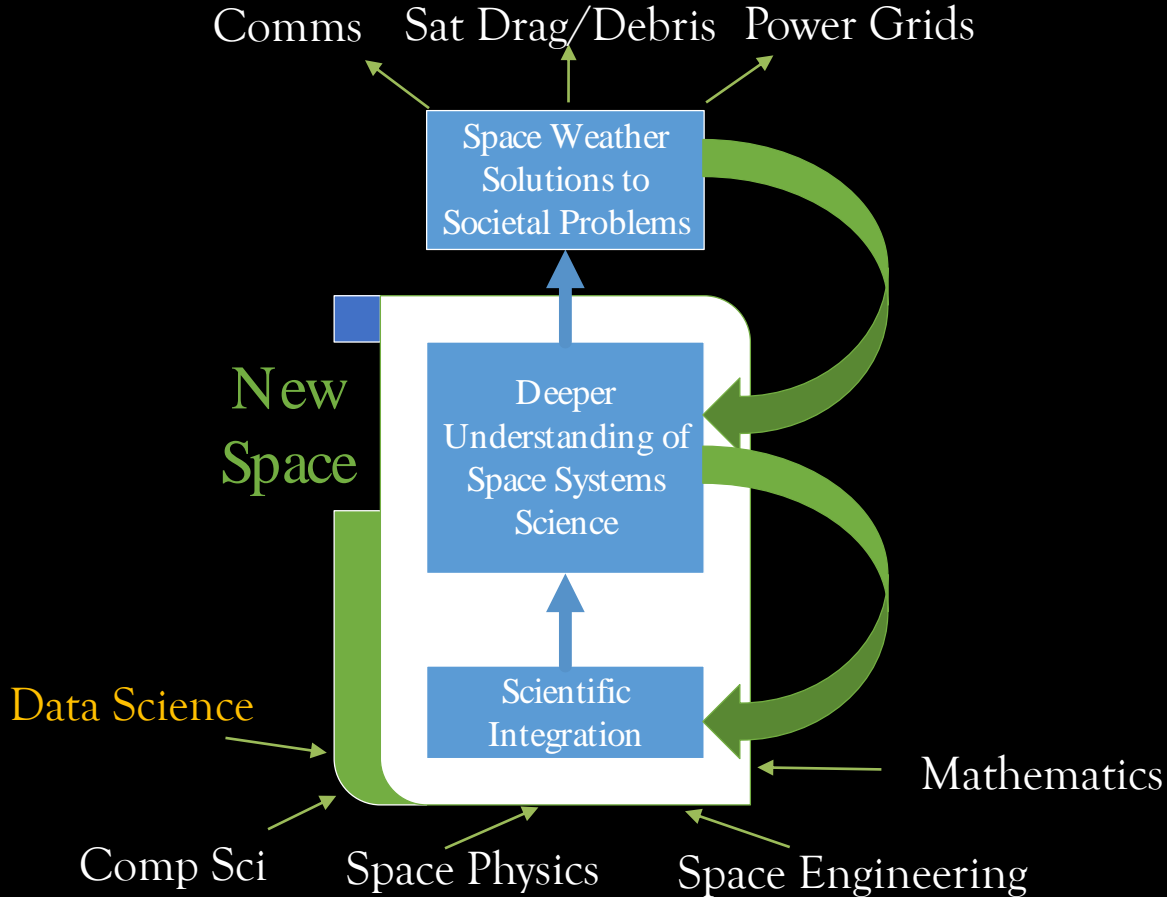
Charge Mobilities

Solar Chromosphere

Earth's Ionosphere / Thermosphere

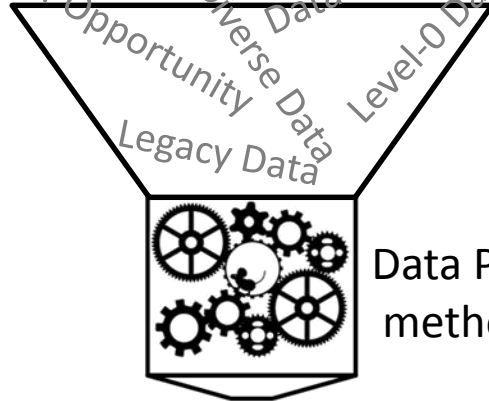


Creating Convergence: Research Ecosystem



Creating Convergence with Data Science

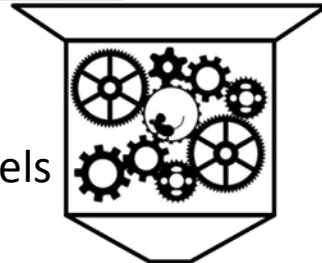
Data of Opportunity
Diverse Data
Data Uncertainty
Legacy Data
Level-0 Data



Data Processing
methods

F_{11} F_{12} F_{33}

Data Ingestion |
Assimilation |
Physics-Based models



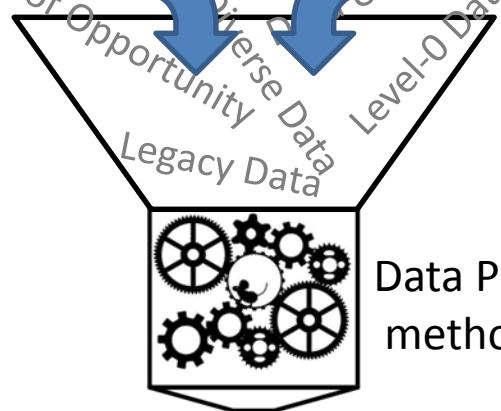
System Visualization |
Interpretation |
Advancement



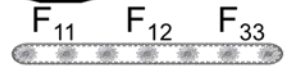
Diversity of Opportunity
Diverse Data
Level-0 Data
Legacy Data
Uncertainty

Global Aeronomy:

- Distributed array of small sensors
- Satellite Systems



Data Processing methods



Data Ingestion |
Assimilation |
Physics-Based models



System Visualization |
Interpretation |
Advancement



Precision Aeronomy:

- Large-Scale Facilities
- Dedicated Instrumentation

