Between Earth and Space

Ensemble Modeling & Data Assimilation of the Space-Atmosphere Interaction Region (SAIR)

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& SAIR project collaborators

Image Courtesy: NASA

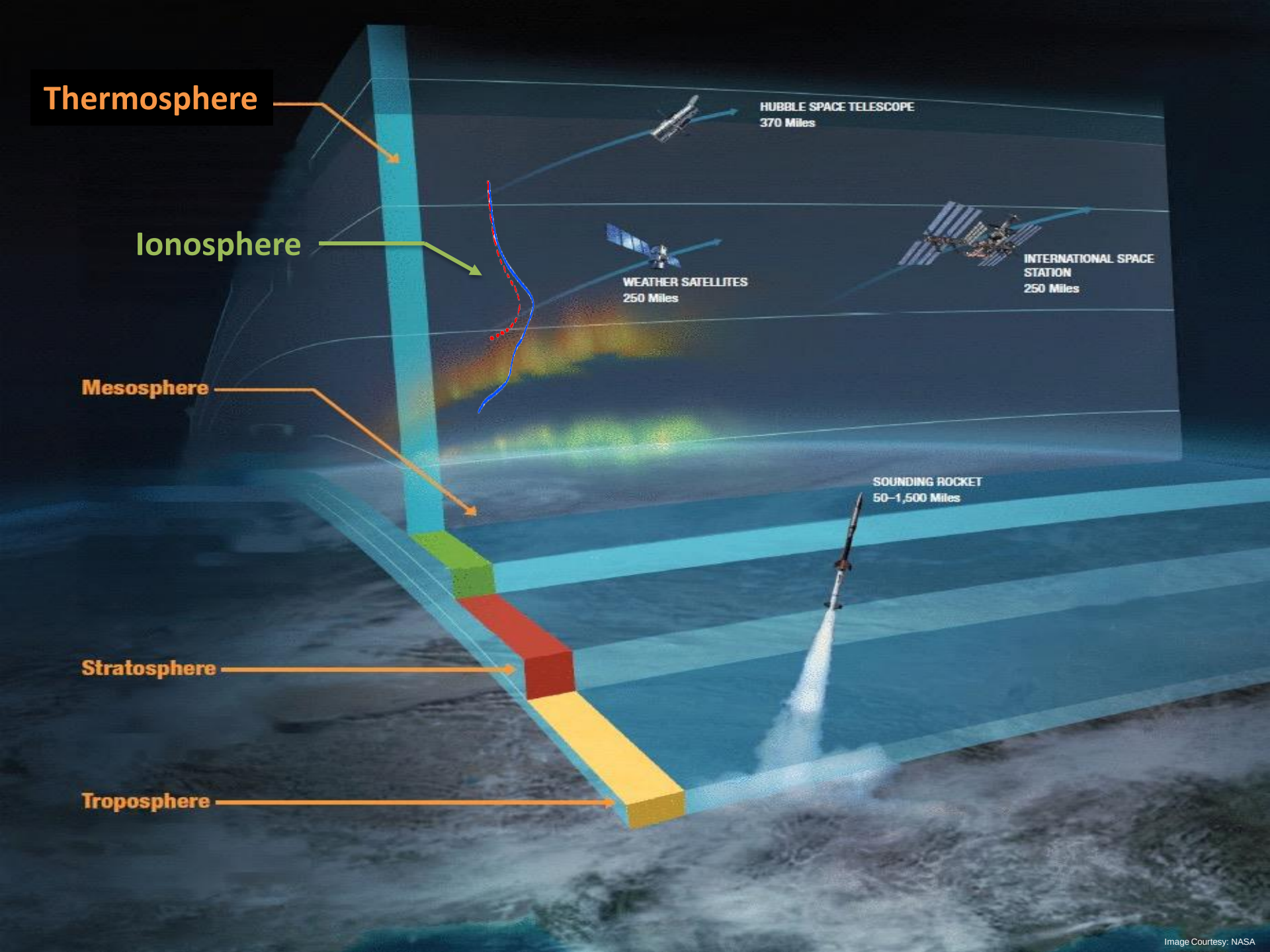
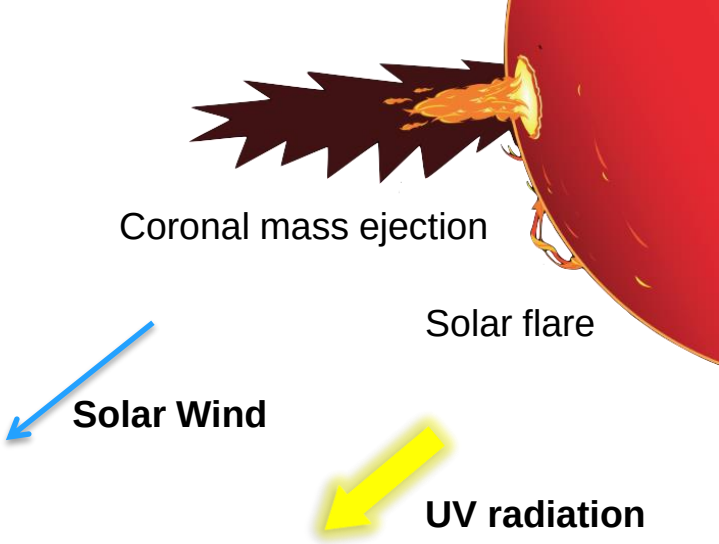


Image Courtesy: NASA

Earth-to-space weather



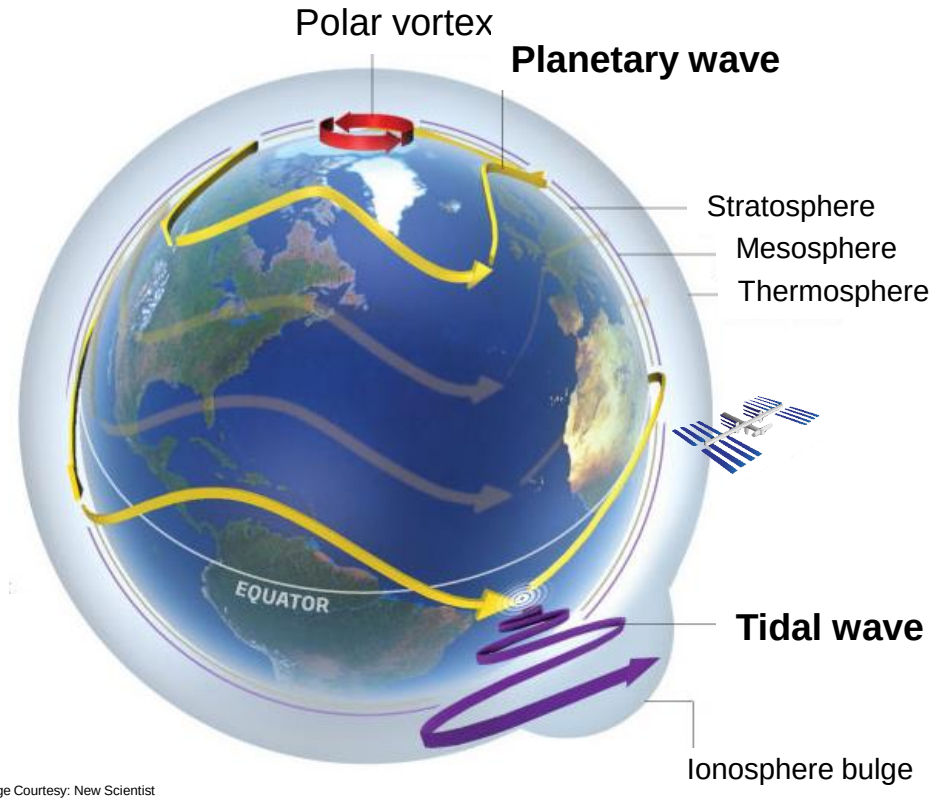


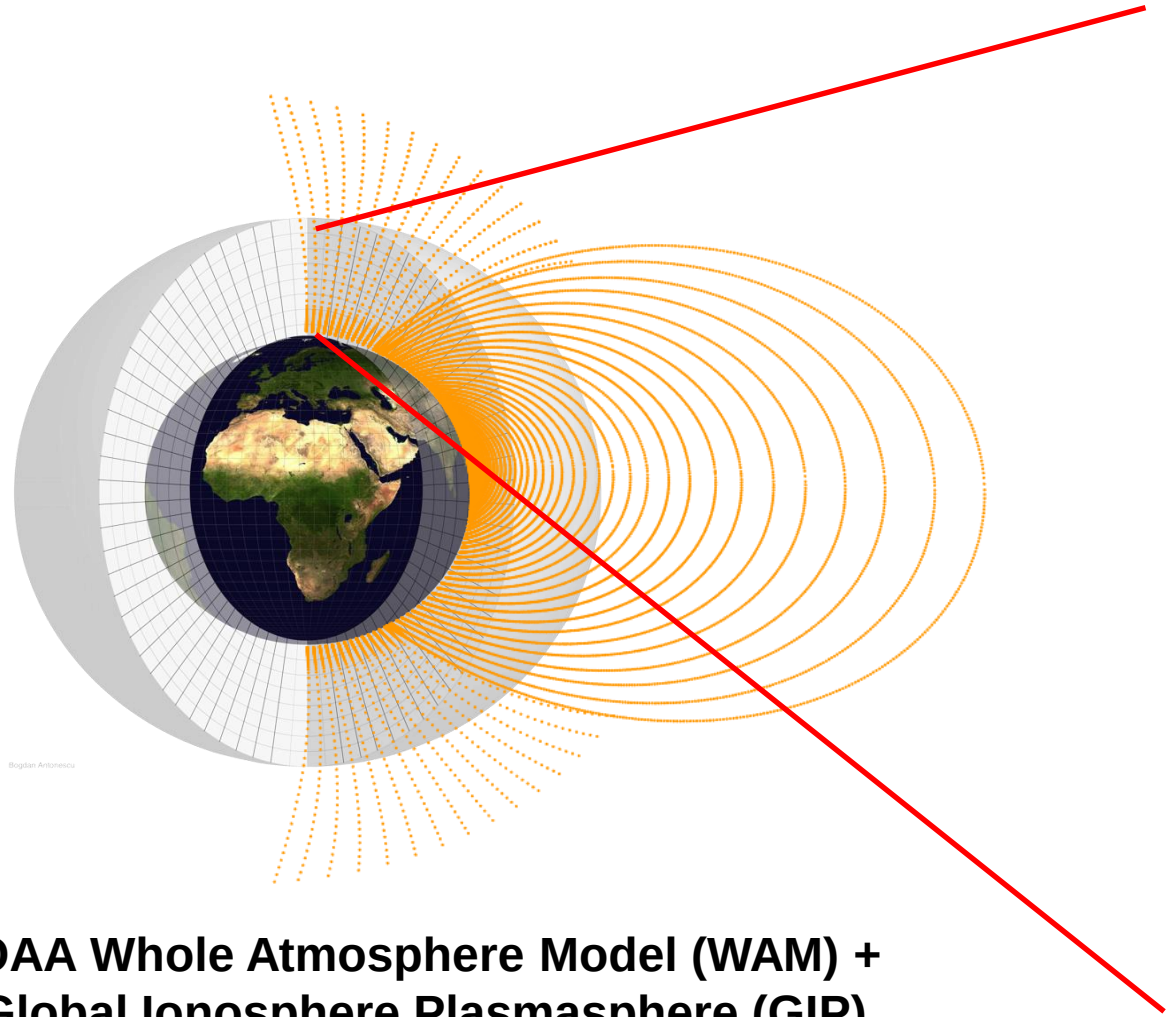
Image Courtesy: New Scientist

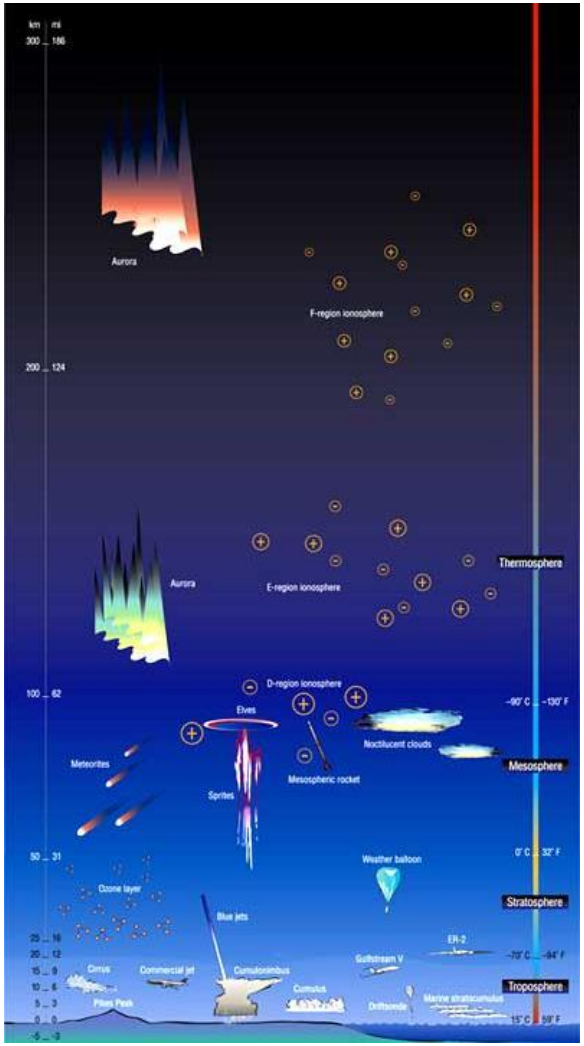
Observations

real, but sparse

Forecast Model

comprehensive, but theoretical



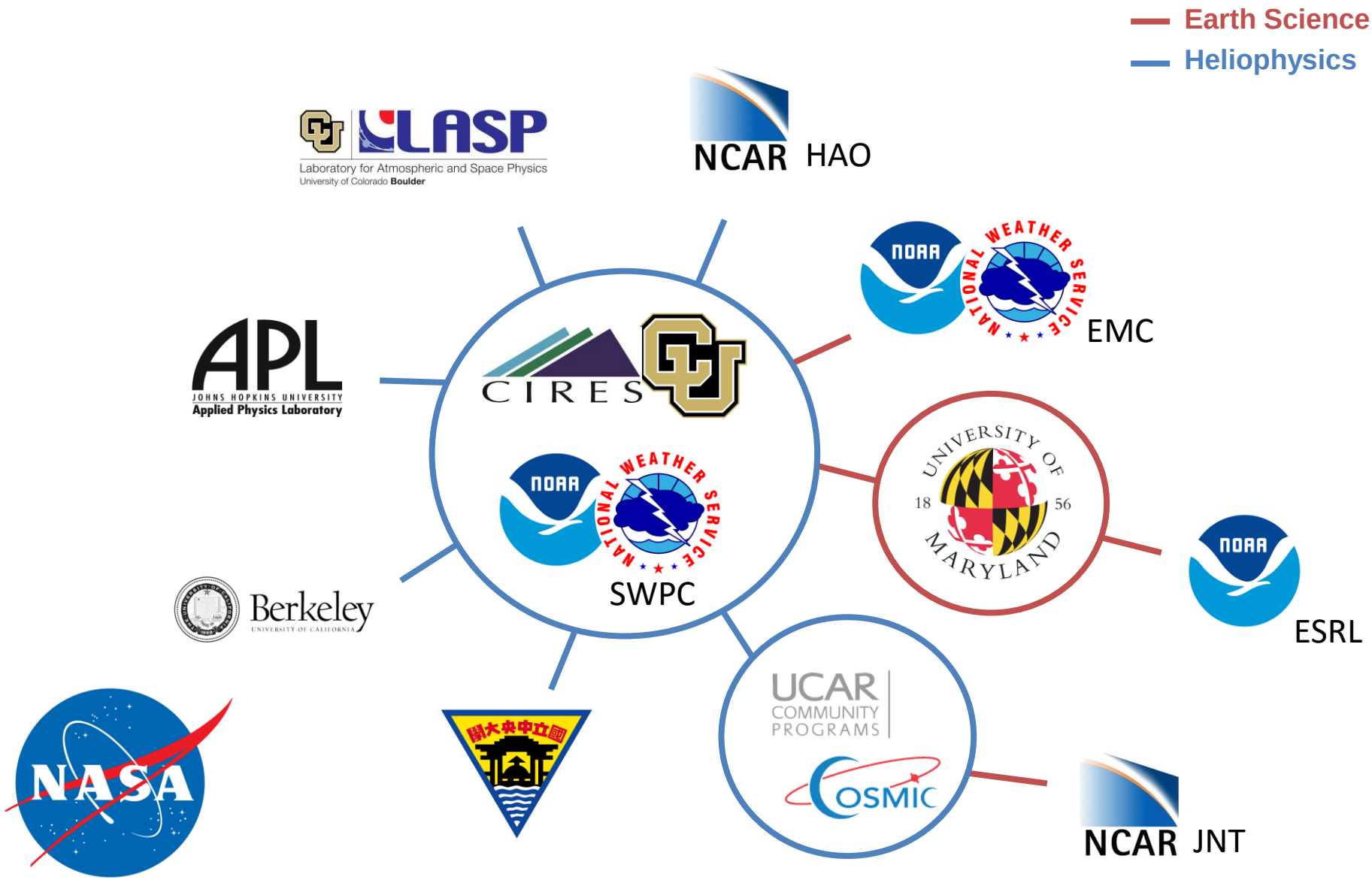


NOAA Whole Atmosphere Model (WAM) +
+ Global Ionosphere Plasmasphere (GIP)
[e.g., Akmaev et al., 2008; Fuller-Rowell et al., 2011; Fang et al., 2013]

Image Courtesy: UCAR & GFDL

Uncertainty?

Heliophysics Grand Challenges Research Project 2014-2017

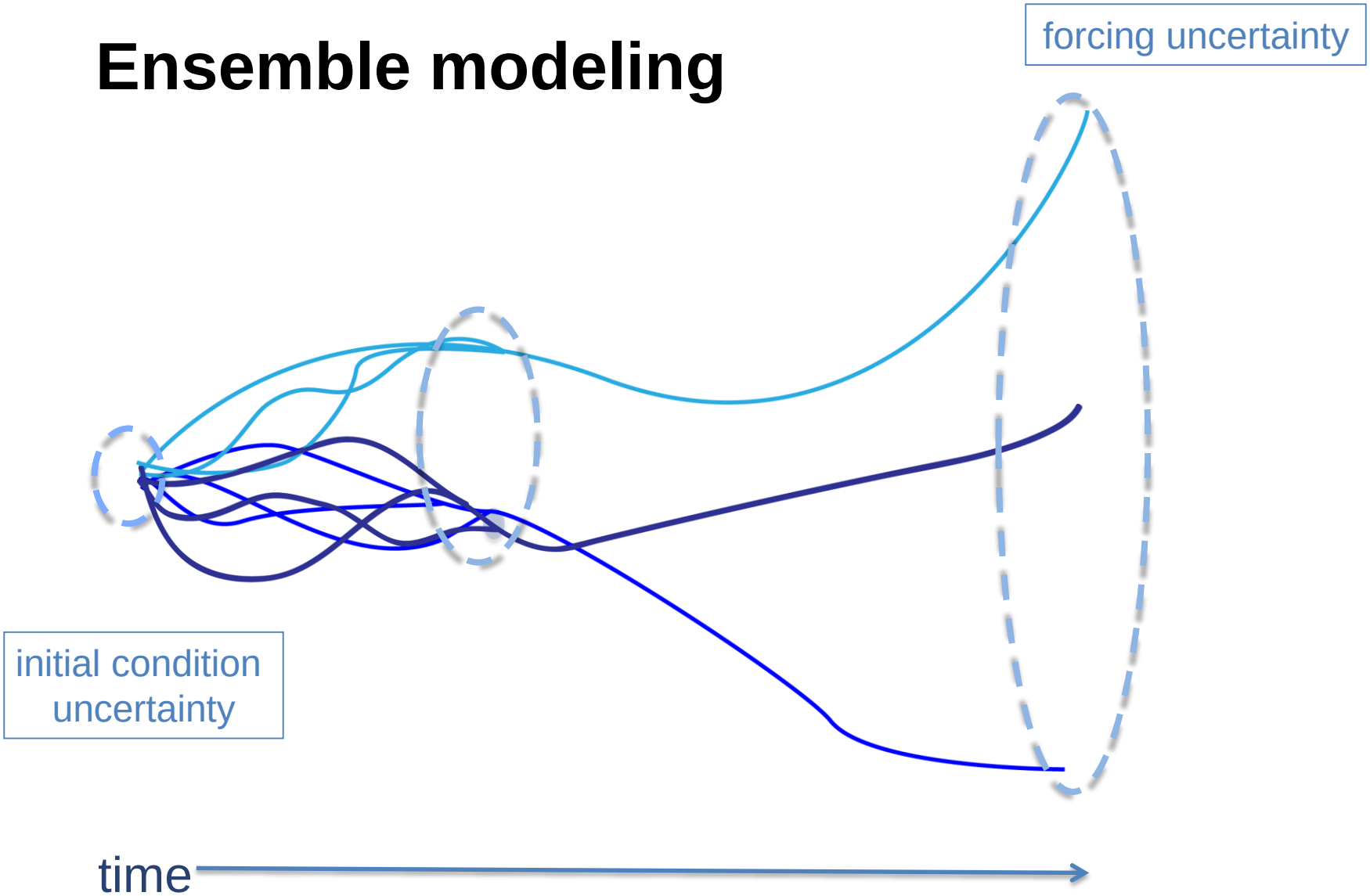


Observations + Forecast Model

= Data Assimilation

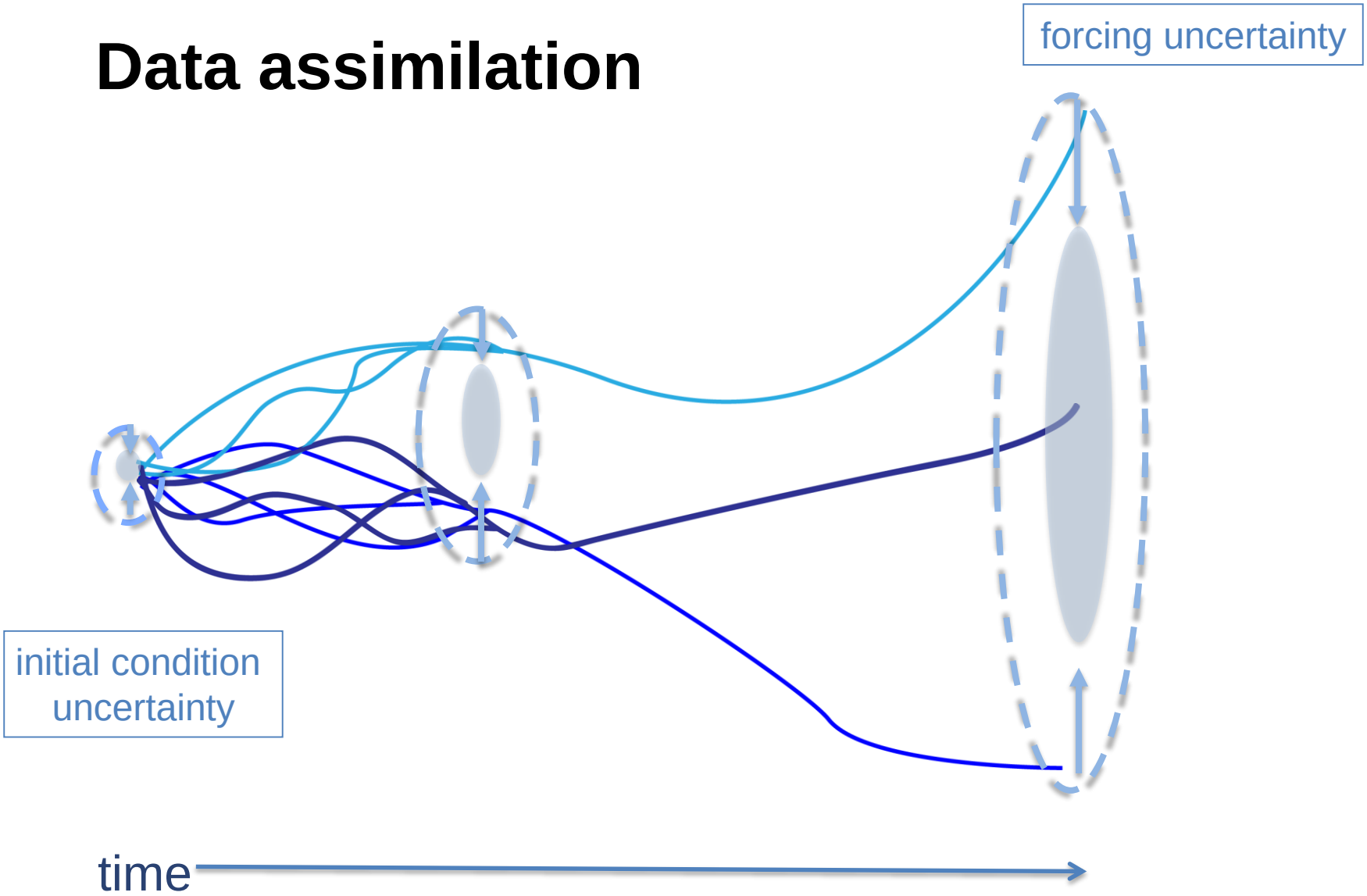
How do we “shrink” uncertainty?

Ensemble modeling

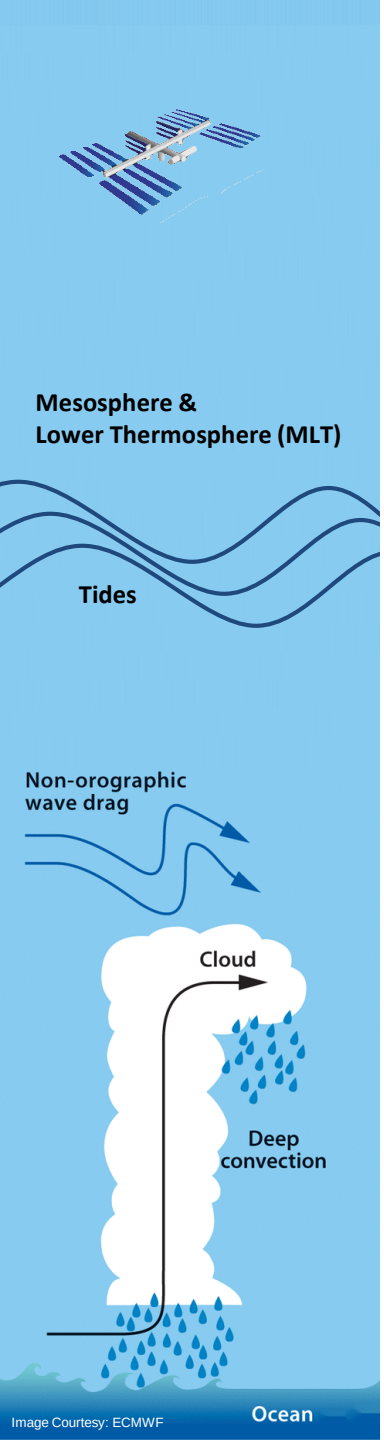


How do we “shrink” uncertainty?

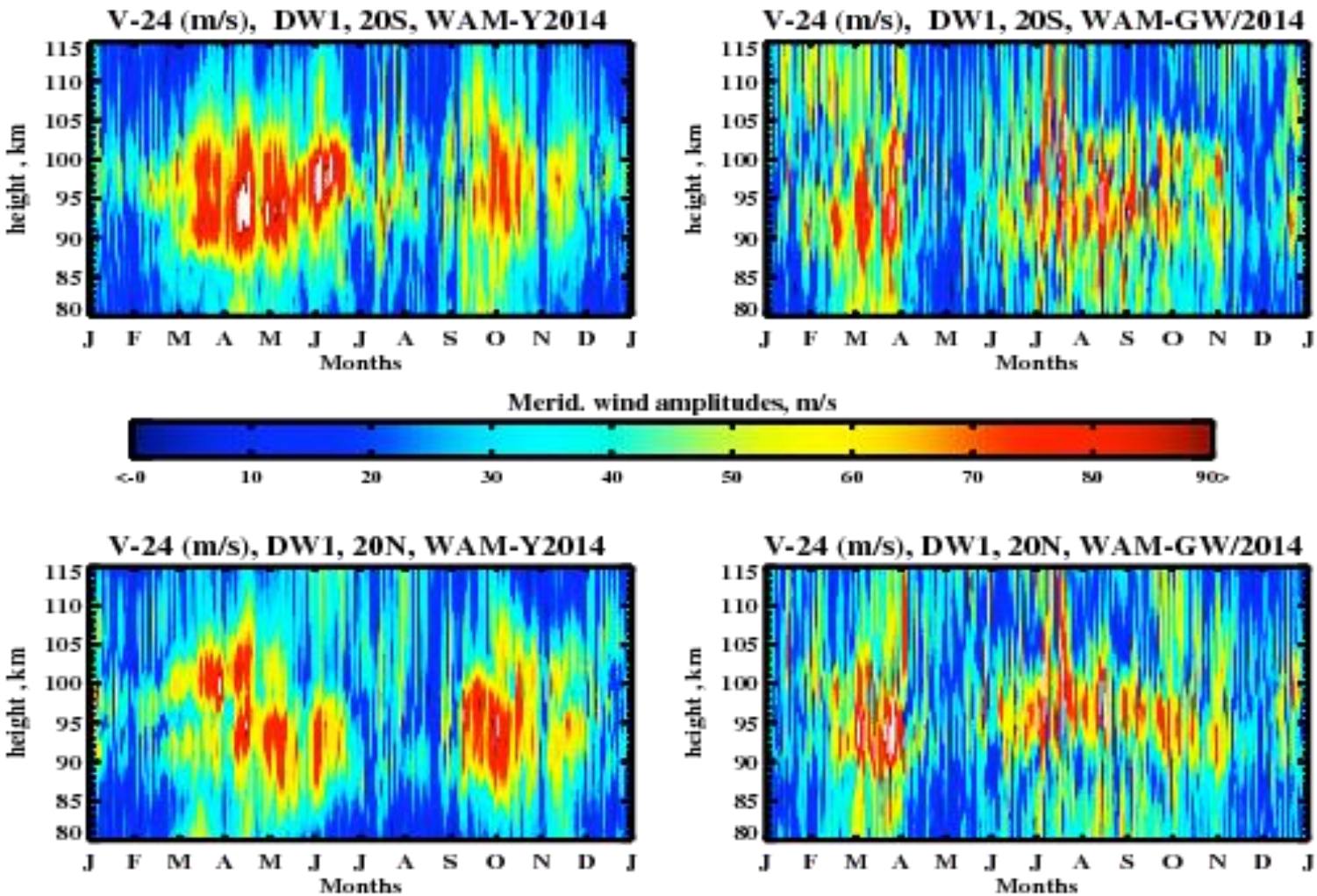
Data assimilation



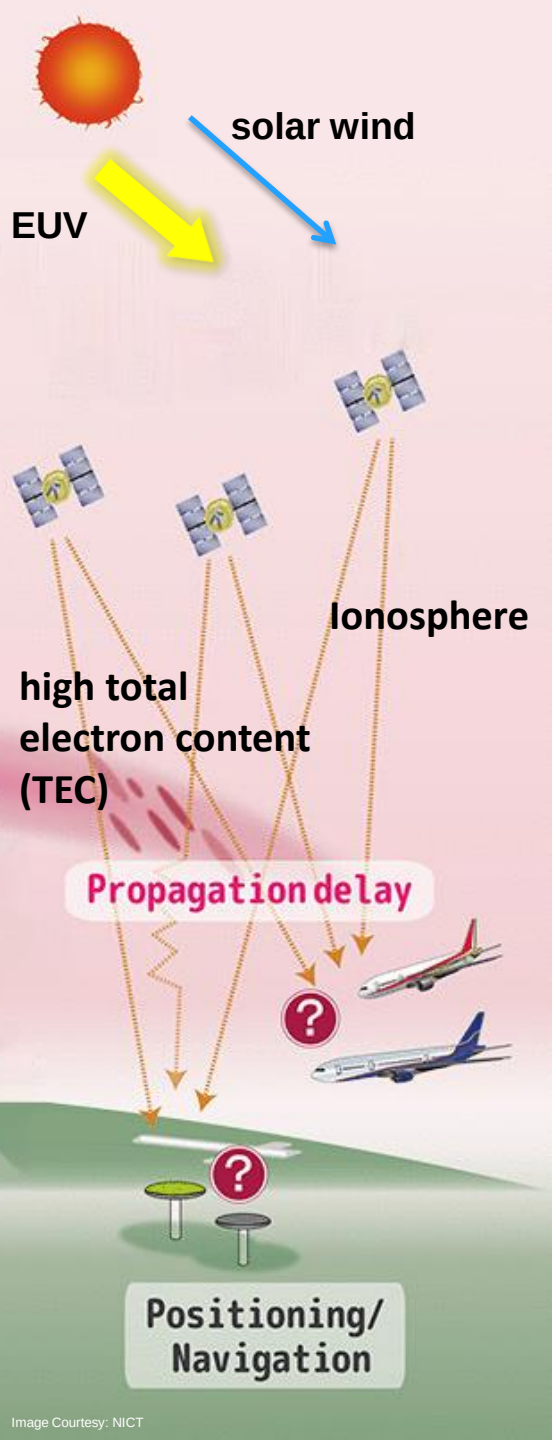
Impact of non-orographic gravity waves on day-to-day MLT tidal variability over one year



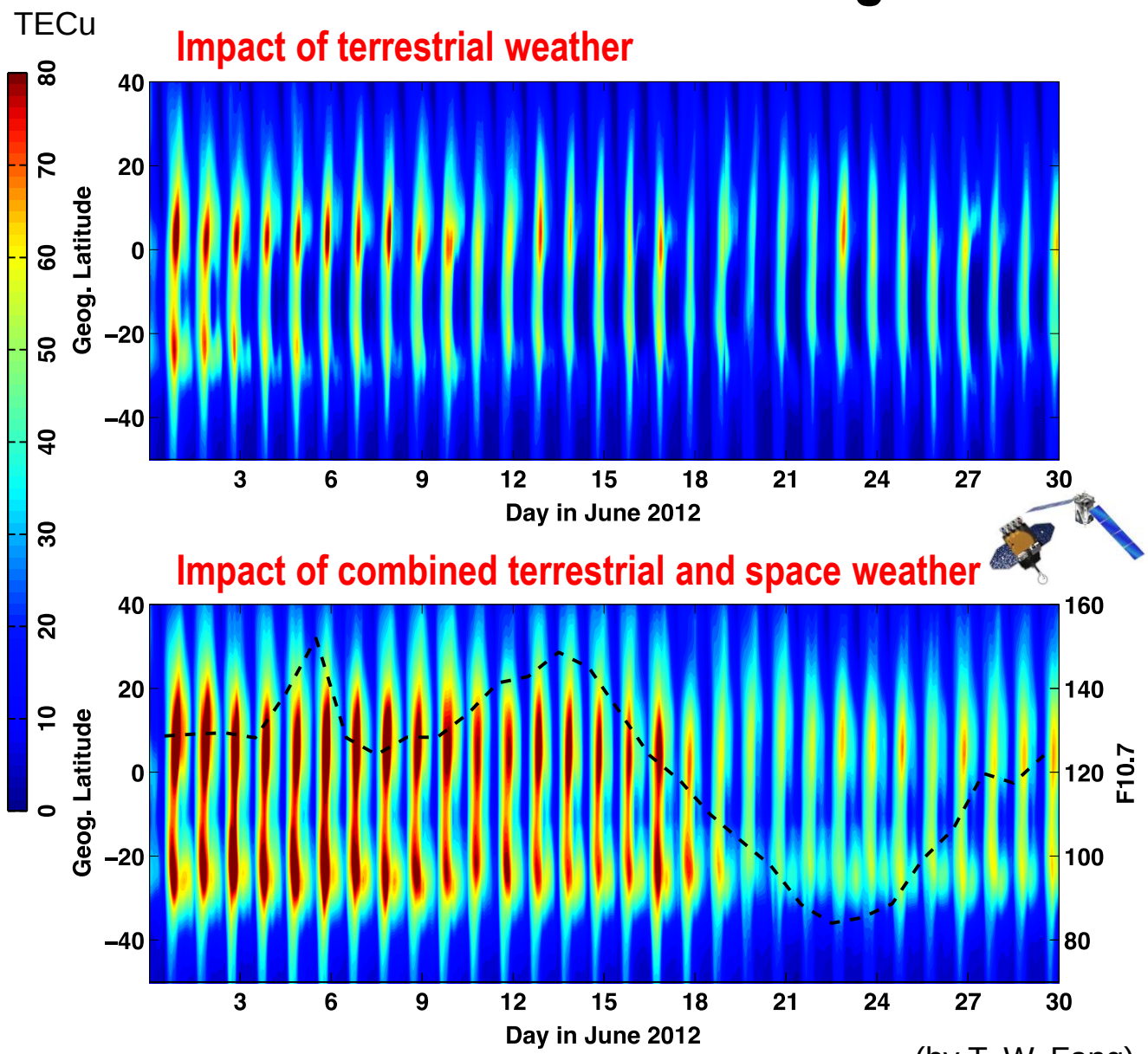
More variability



(by V. Yudin)



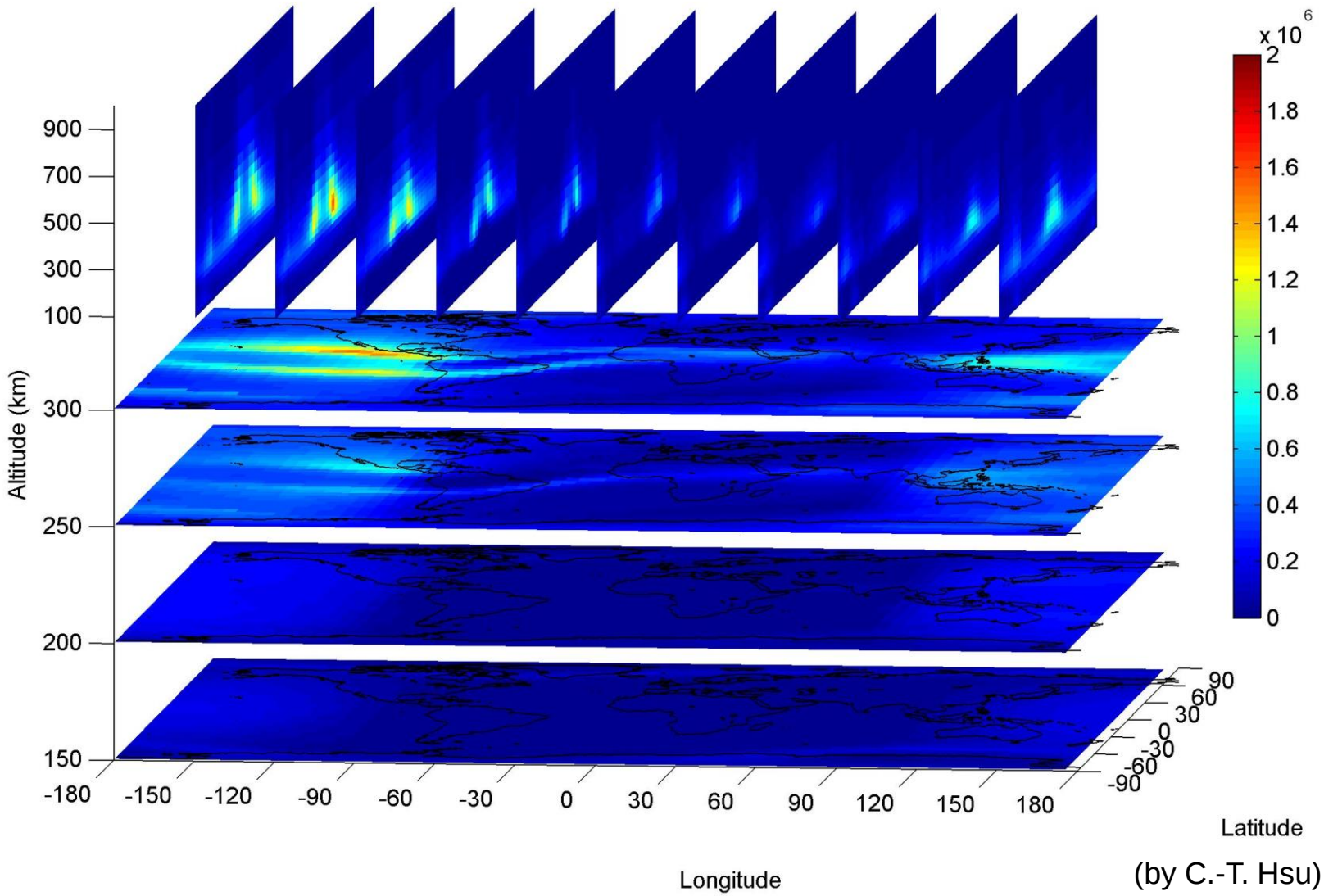
Ionospheric weather over one month at Peru's Jicamarca longitude



(by T.-W. Fang)

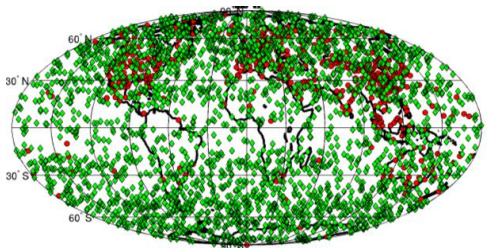
Ionosphere prediction before data assimilation

Sep 19, 2010



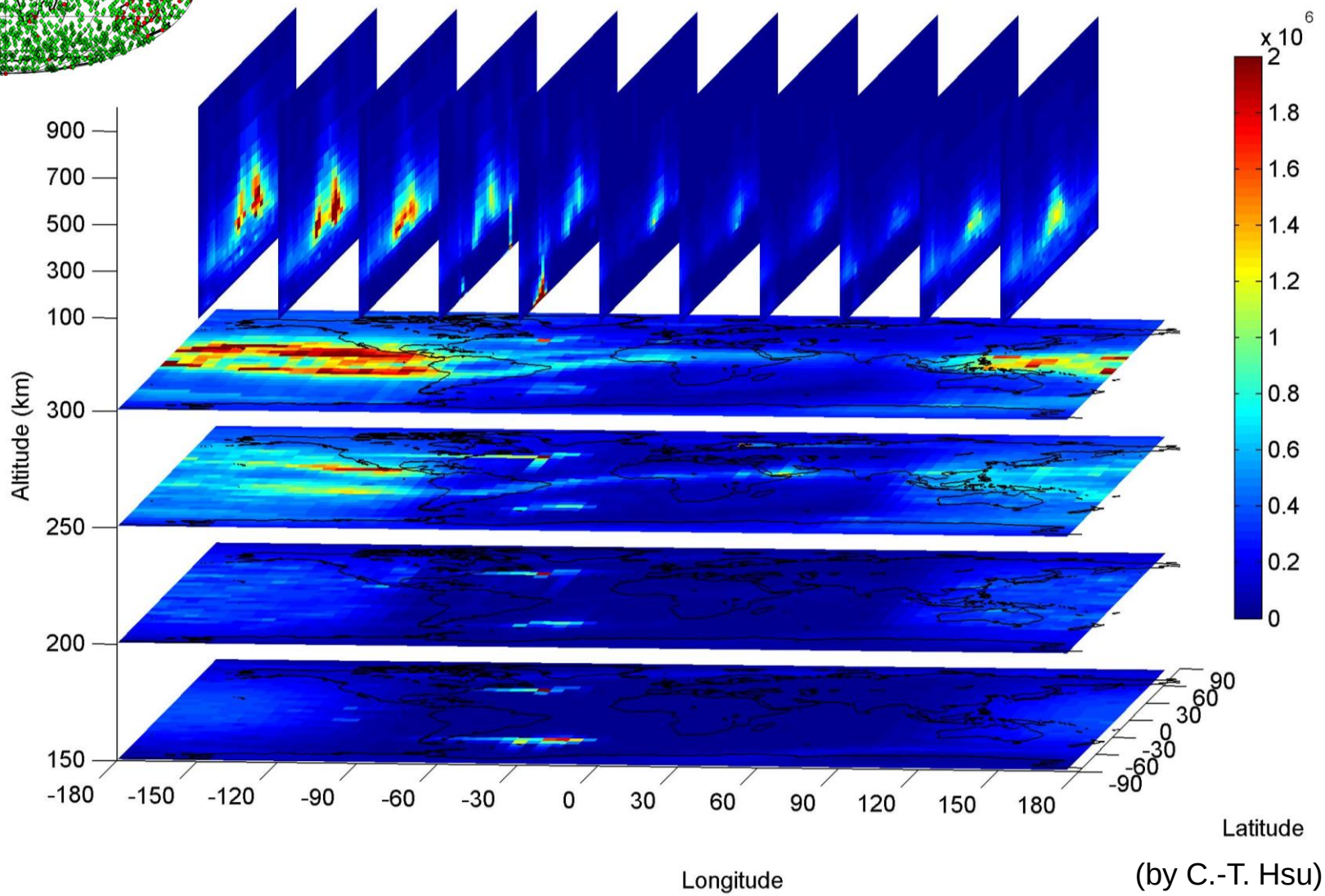
(by C.-T. Hsu)

Ionosphere prediction after data assimilation



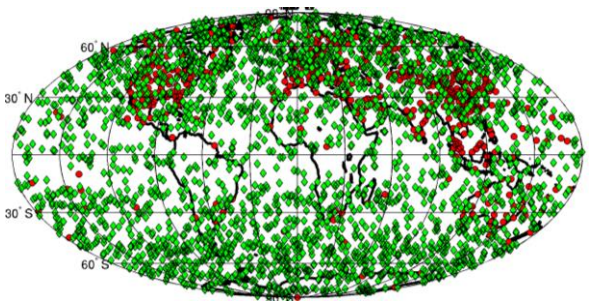
86,000 sTEC data from 55 COSMIC RO events

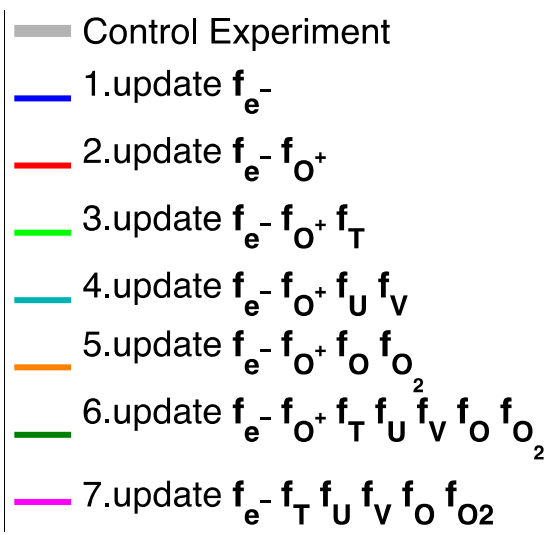
Sep 19, 2010



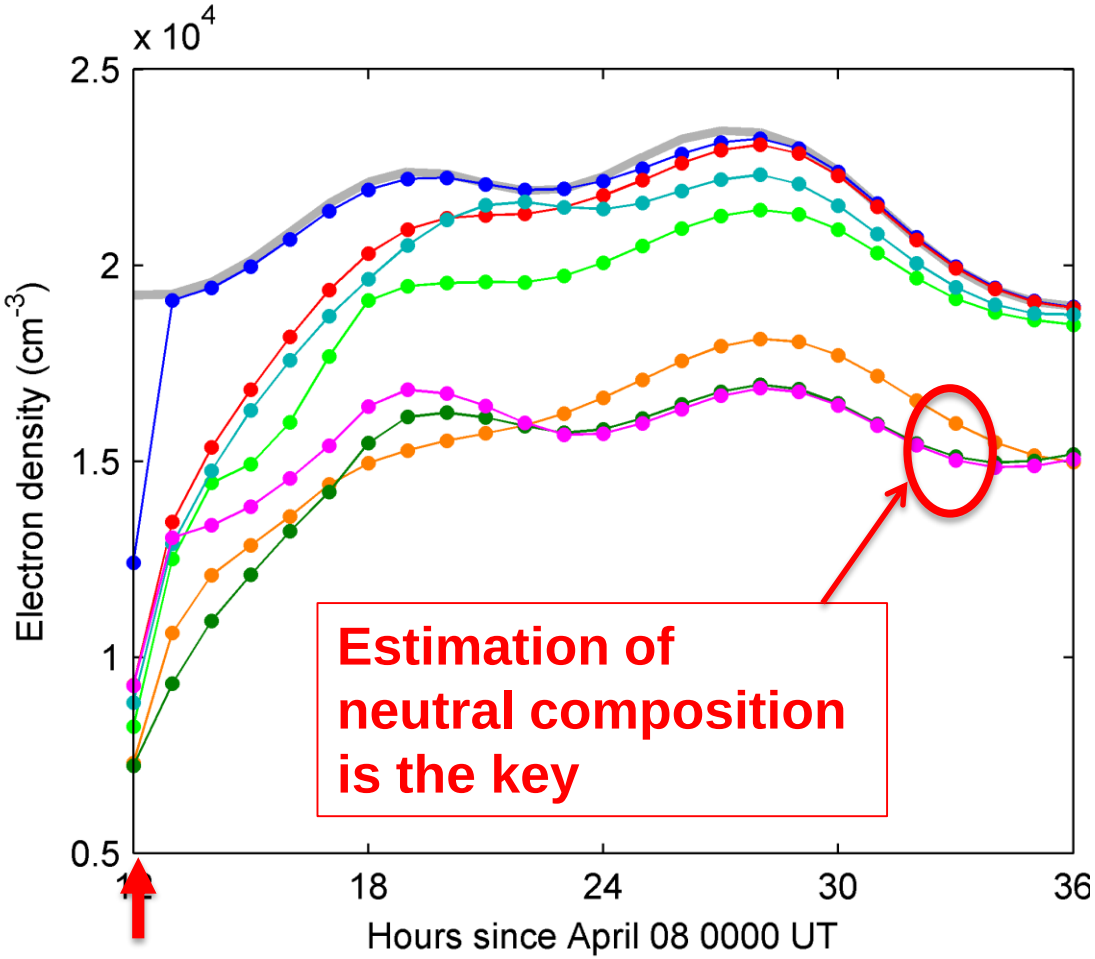
(by C.-T. Hsu)

Predictability of the ionosphere can be extended by assimilation of COSMIC RO data





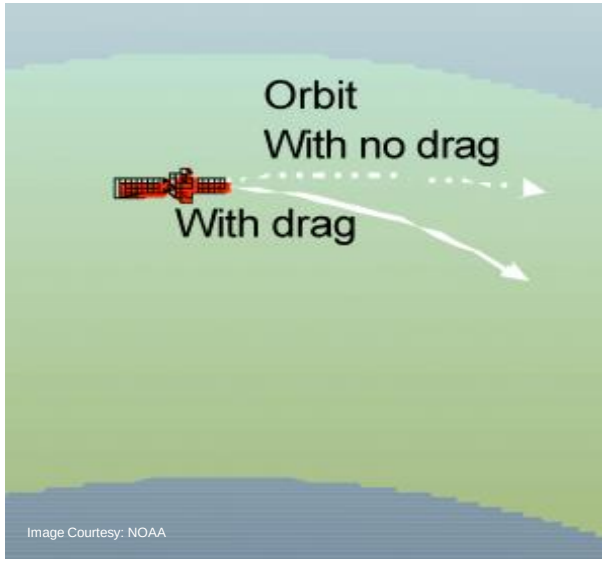
Ensemble forecast error over 24 hours

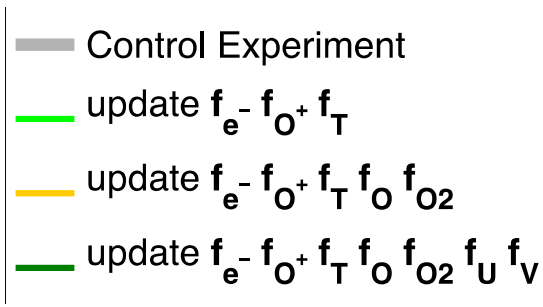


initialization

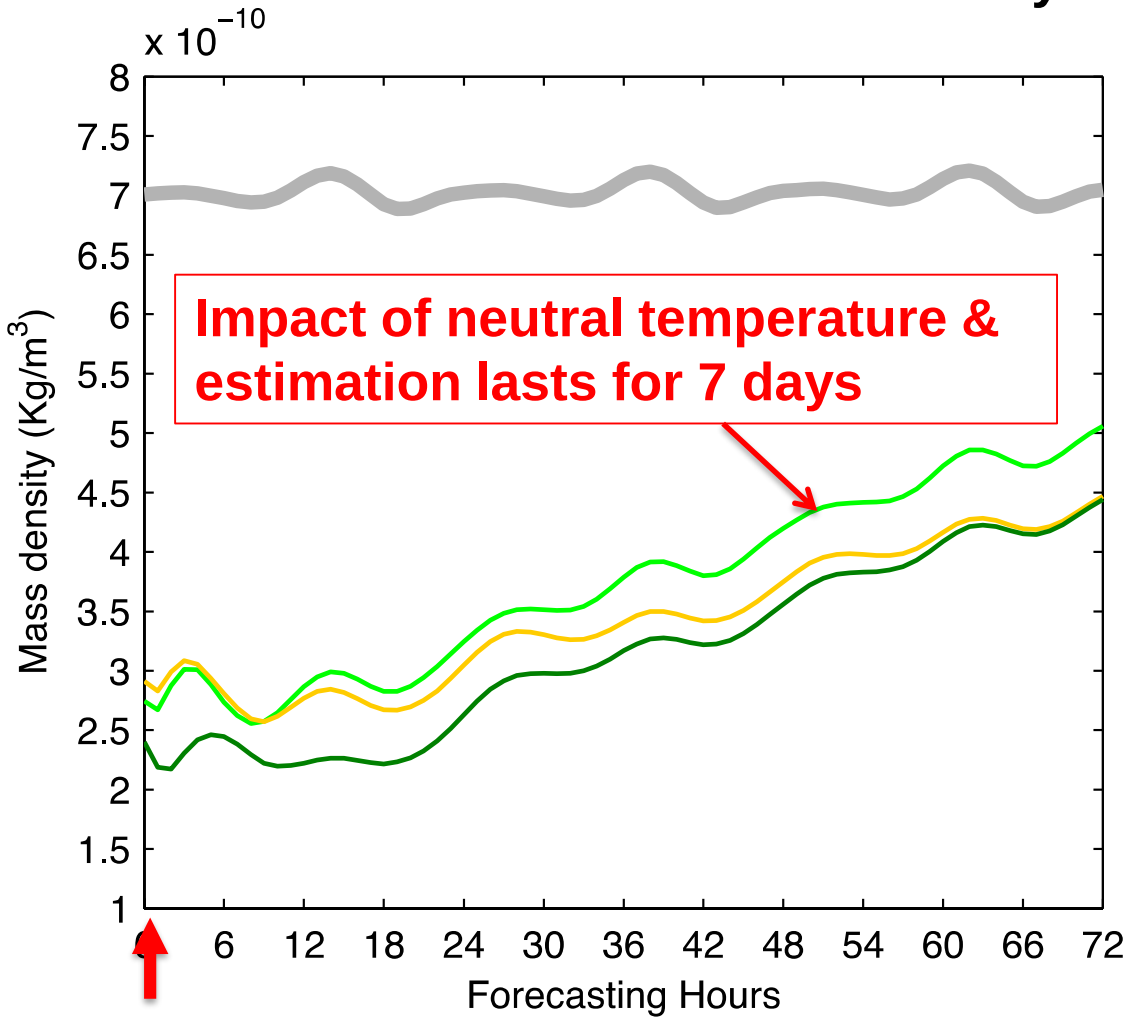
[Hsu et al., 2015]

Predictability of the neutral mass density can be extended by assimilation of COSMIC RO data





Ensemble forecast error over 3 days

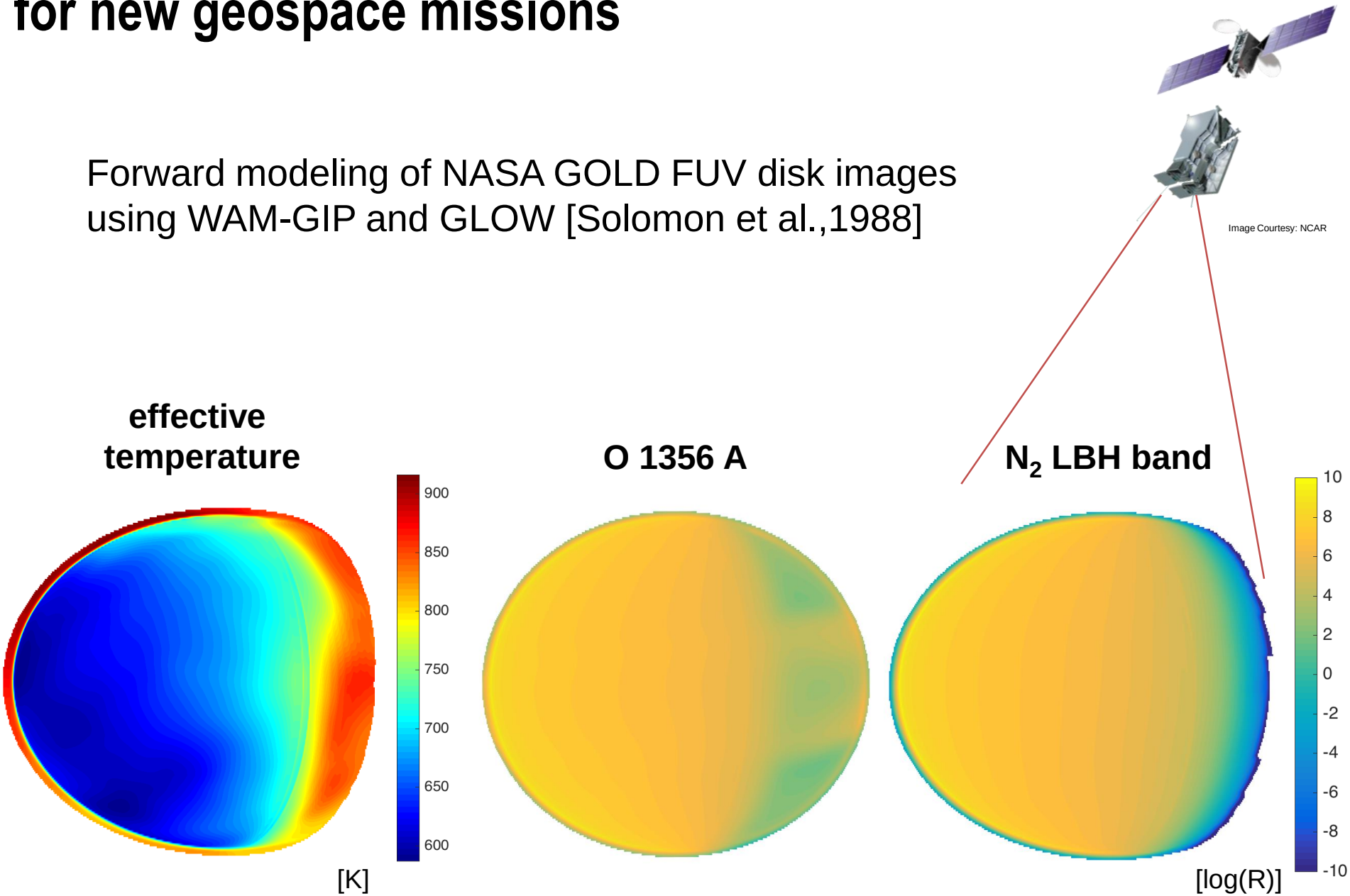


initialization

[Matsuo and Hsu., 2016]

Developing observing system simulation experiments for new geospace missions

Forward modeling of NASA GOLD FUV disk images using WAM-GIP and GLOW [Solomon et al.,1988]



Main Points

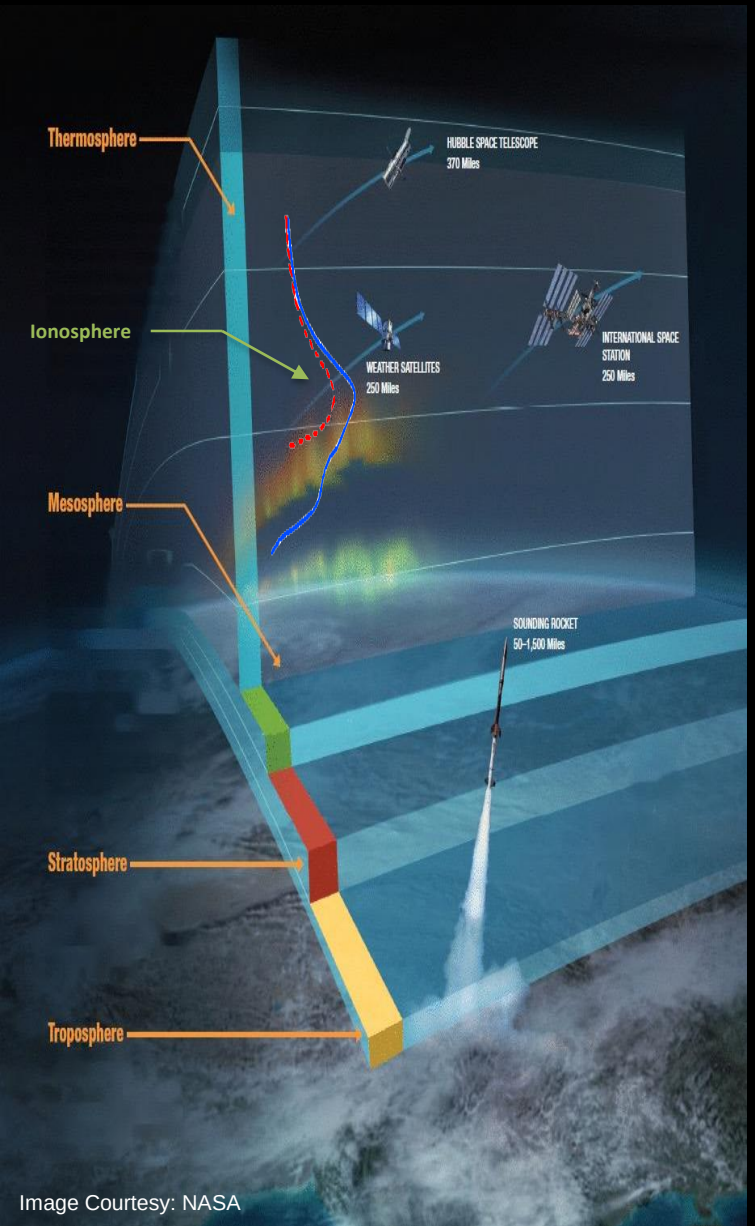
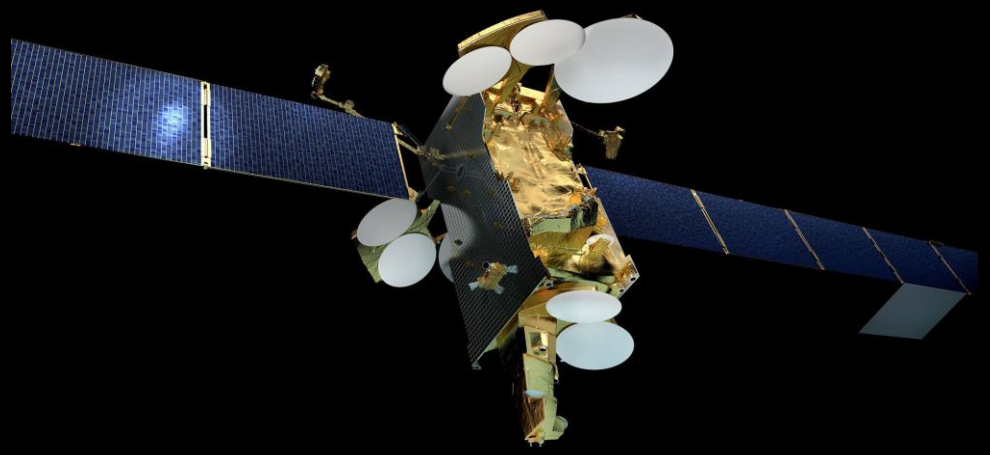


Image Courtesy: NASA

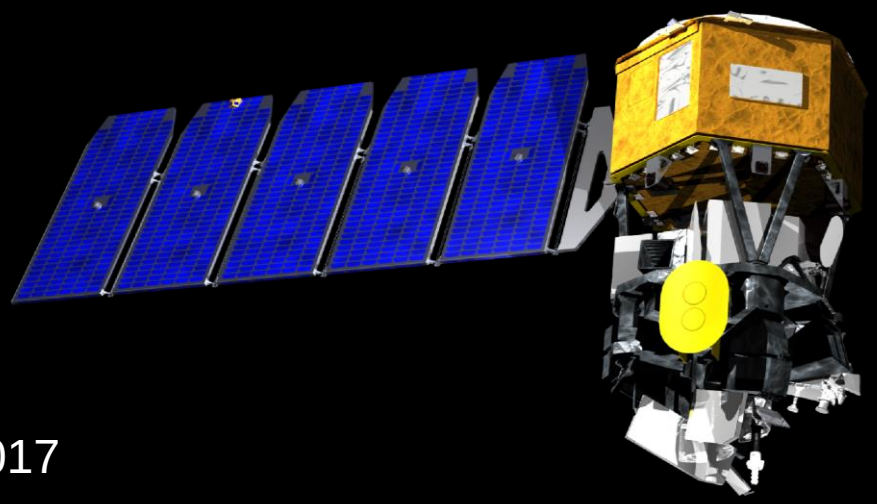
- Both terrestrial and space weather contribute to the upper atmosphere variability.
- Ensemble modeling is a key to quantifying the uncertanty of the model prediction.
- Data assimilation can provide more accurate predictions of important changes in the upper atmosphere.
- More research will help us to understand the predictability of the upper atmosphere and how to reducing uncertainty.

New Missions

COSMIC II – March 2017



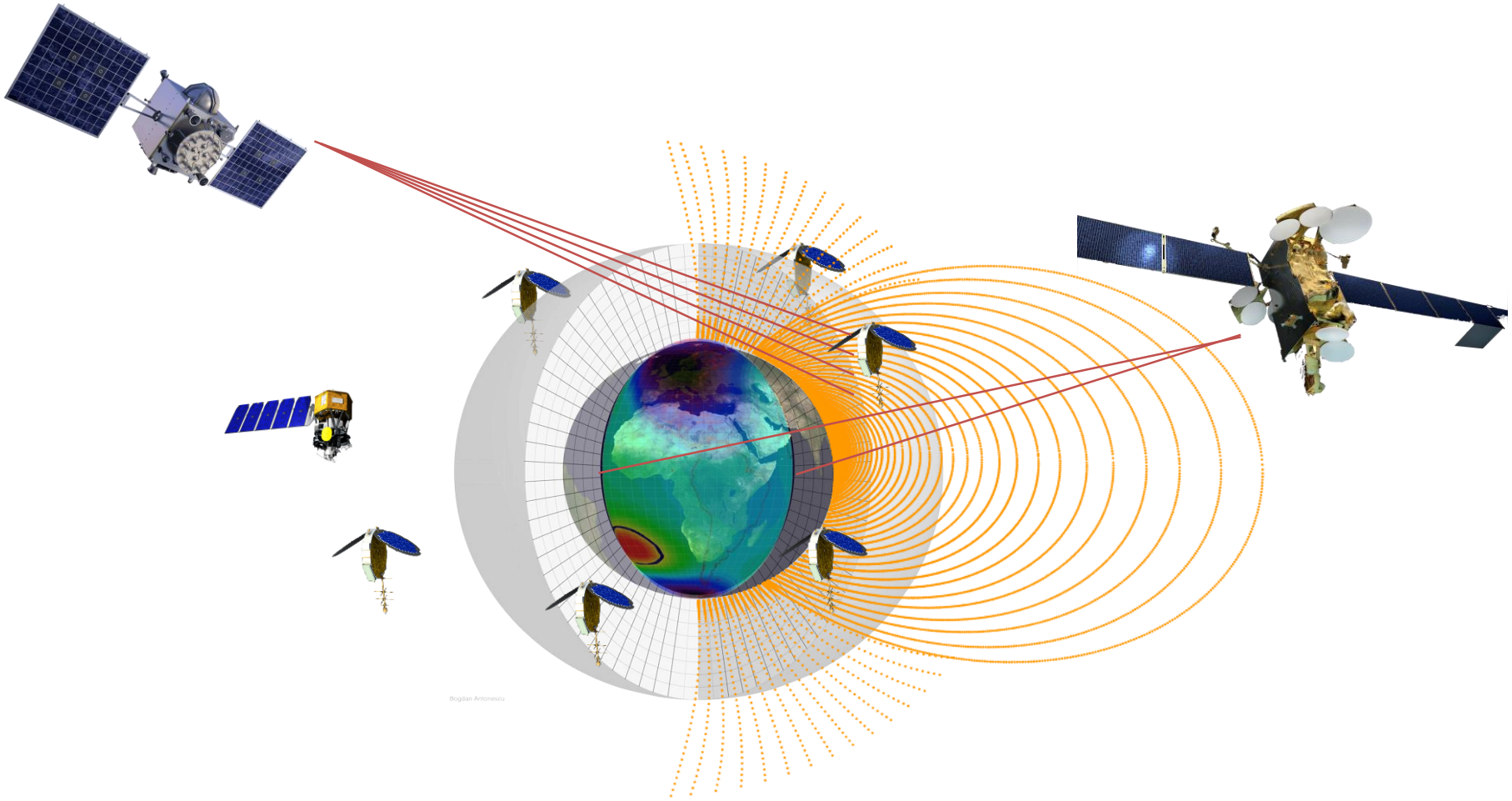
GOLD – September 2017 (April 2018)



ICON – June 2017

Image Courtesy: NASA, SES, & www.cgtrader.com

Unprecedented Opportunity



Ionosphere (90-5000 km): COSMIC-II will provide ***~0.3 M*** *per 0.5-1 hour* (12K profiles/day)

Thermosphere (110-500 km): GOLD will provide ***~10K emission*** data *per 0.5-1 hour*

Troposphere and Stratosphere (0-50 km): ***~ 40 M*** *per 6 hours*

THE NEW FUTURE OF SPACE
COMMERCIAL SPACE TRANSPORTAION