Thermospheric weather in FPI data and first-principles models

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- What are the characteristics of thermospheric wind variability?
- How well are our models doing?

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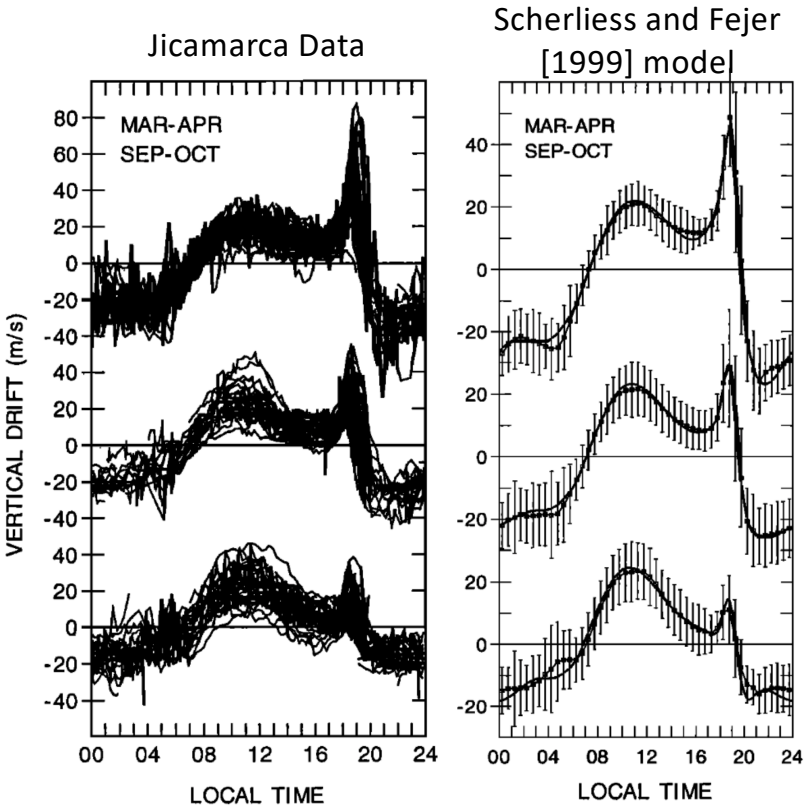
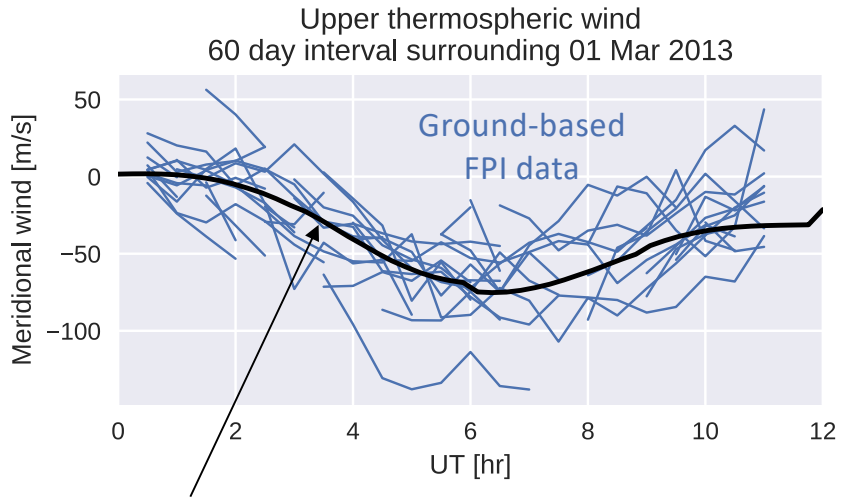
“Climate is what you expect; weather is what you get”

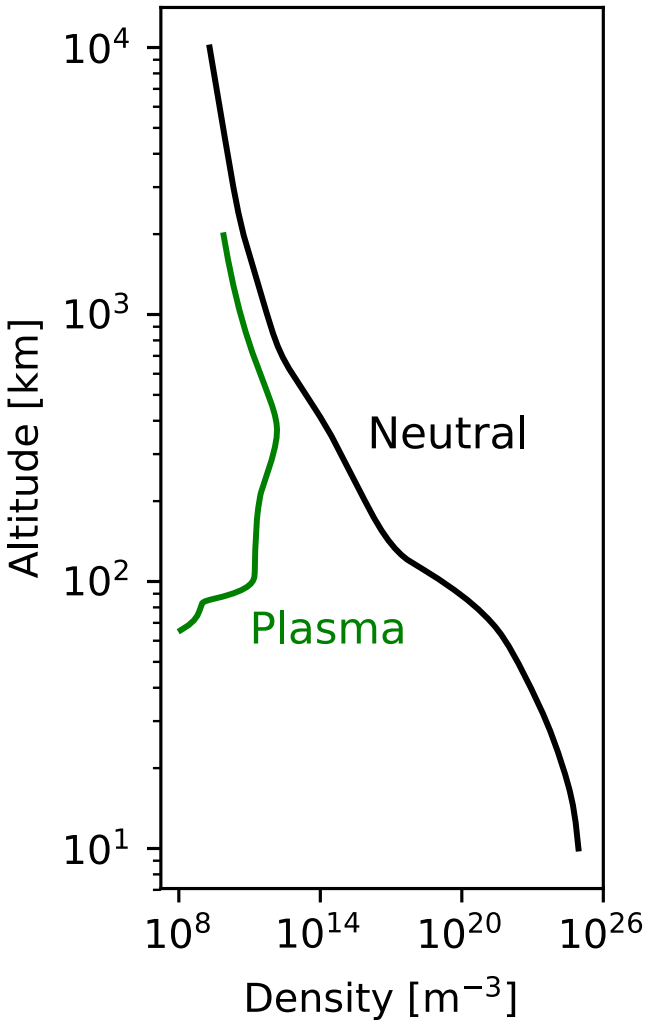
- Andrew John Herbertson





- Significant progress has been made modeling the climate (e.g., MSIS, IRI, HWM, CTMT)
- Predictions of day-to-day variability remain out of reach
- The first step is statistically characterizing this variability
  - Spatially
  - Temporally

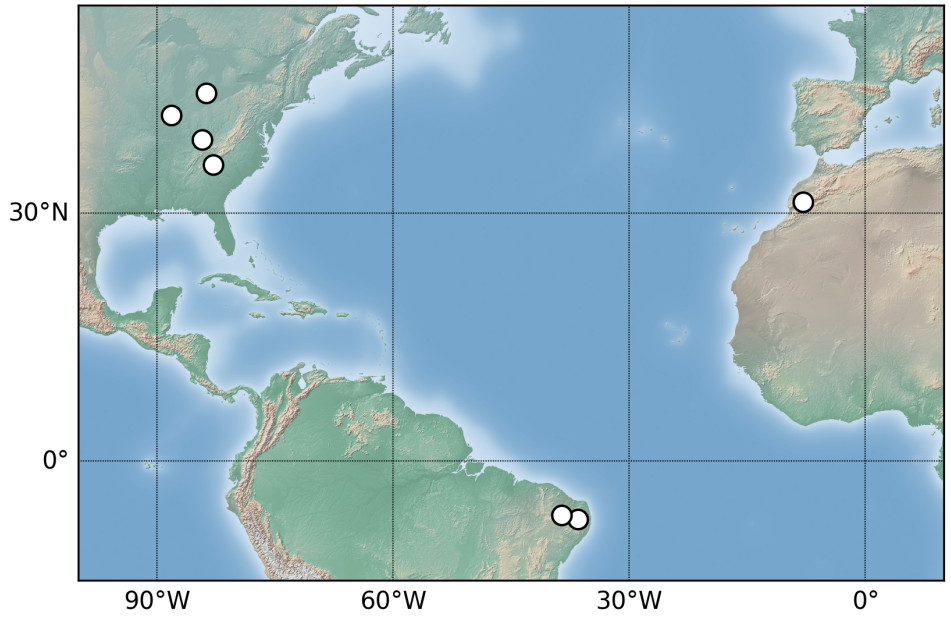
Thermospheric Weather

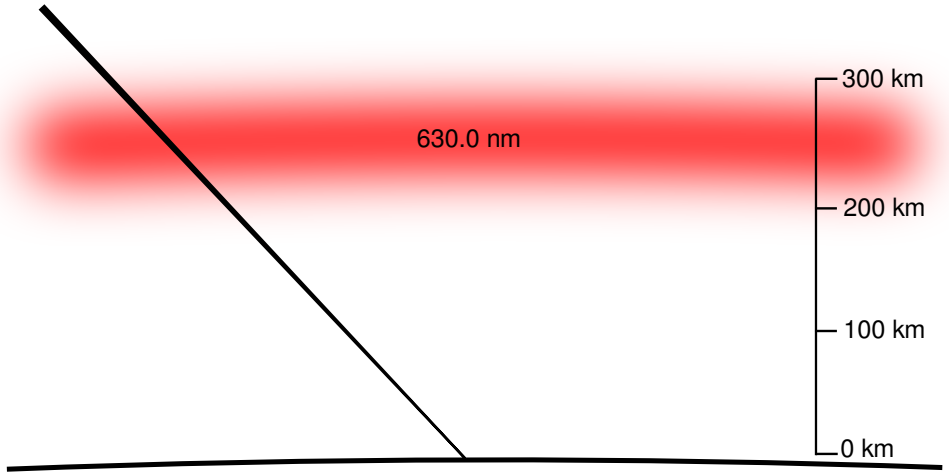


- Plasma variability is largely driven by neutral variability
- Focus on **upper thermosphere (~250 km)** variability
  - Density variability → satellite drag
  - Composition variability → plasma production/loss
  - **Wind variability** → electrodynamics and momentum forcing
- Move beyond case studies towards a systematic approach

Fabry-Perot interferometer (FPI) network

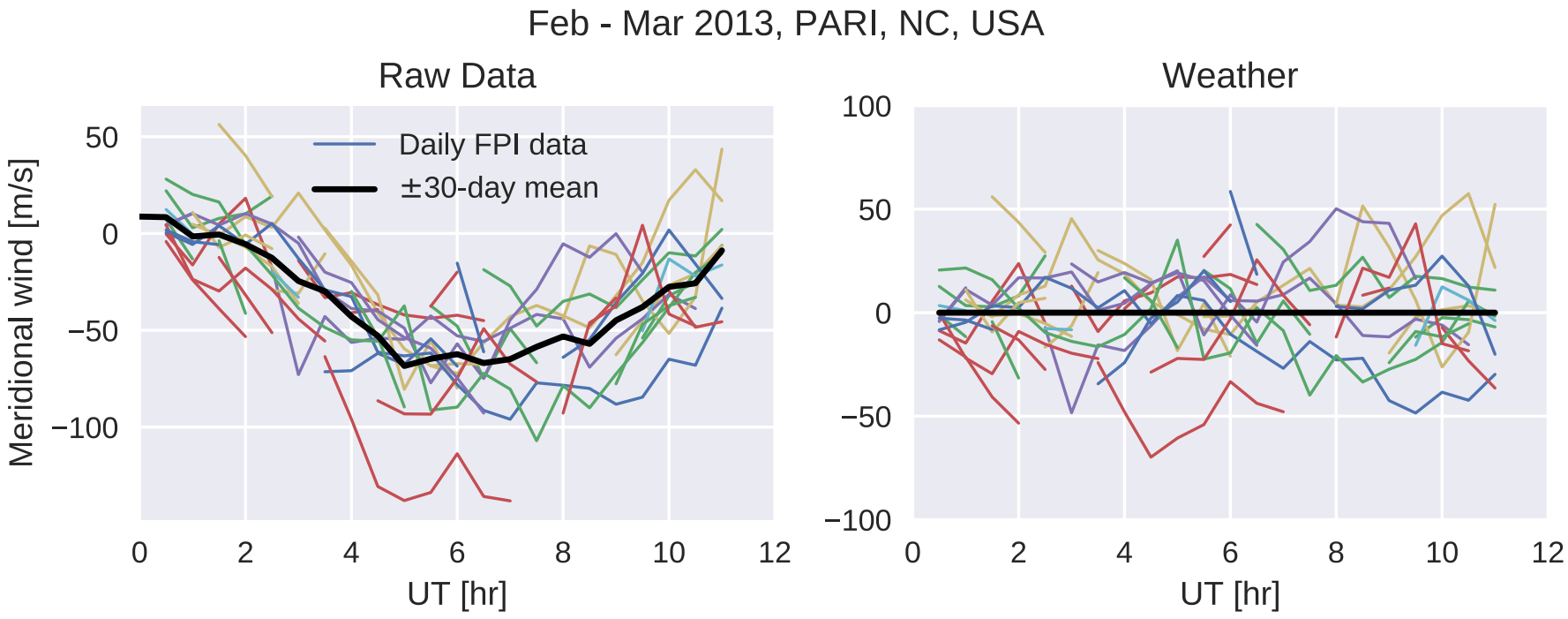
7 Ground-based sites
Neutral wind
250 km altitude
30 min bins
Nighttime and clear skies





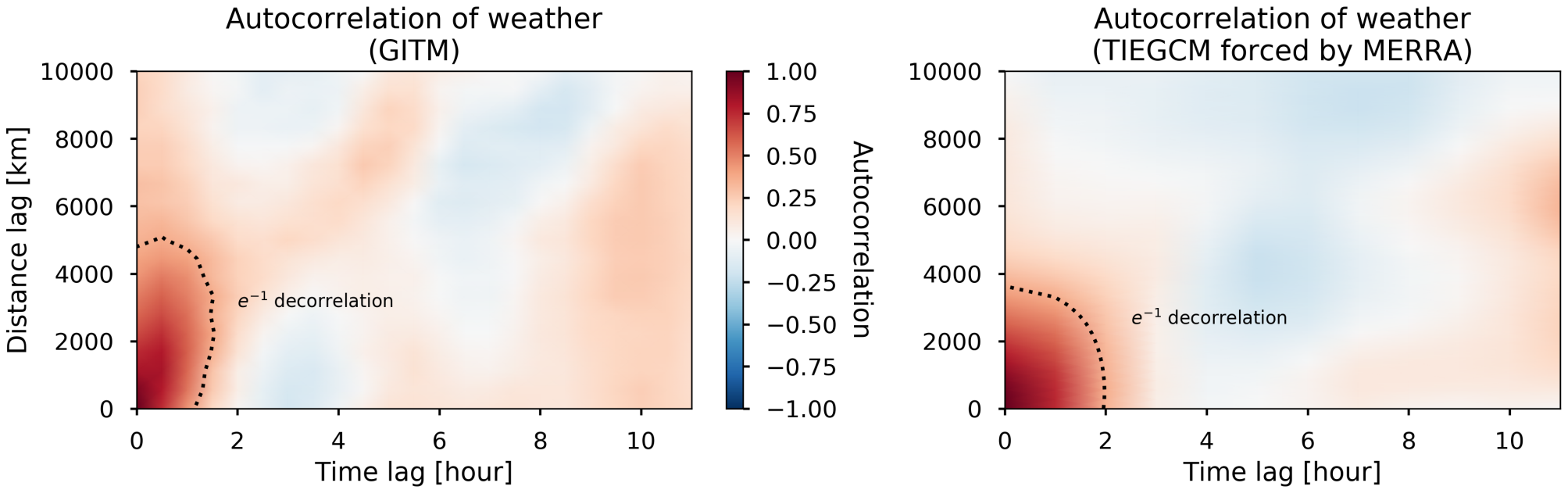
FPI data

- Analyze one year of data for **Kp ≤ 3**
- Removal of 60-day "climate" creates a wide-sense stationary random process suitable for statistical interpretation
    - And for connecting with Kalman-filter-type assimilative models

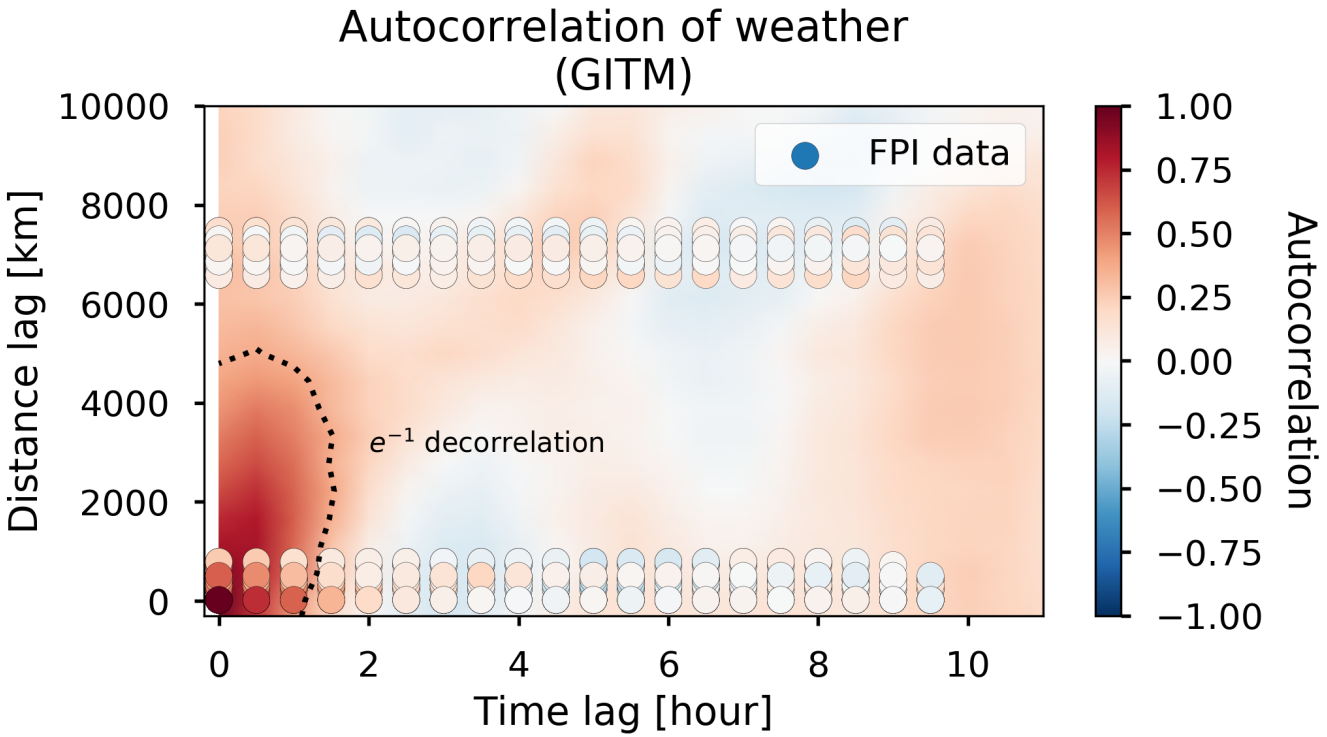


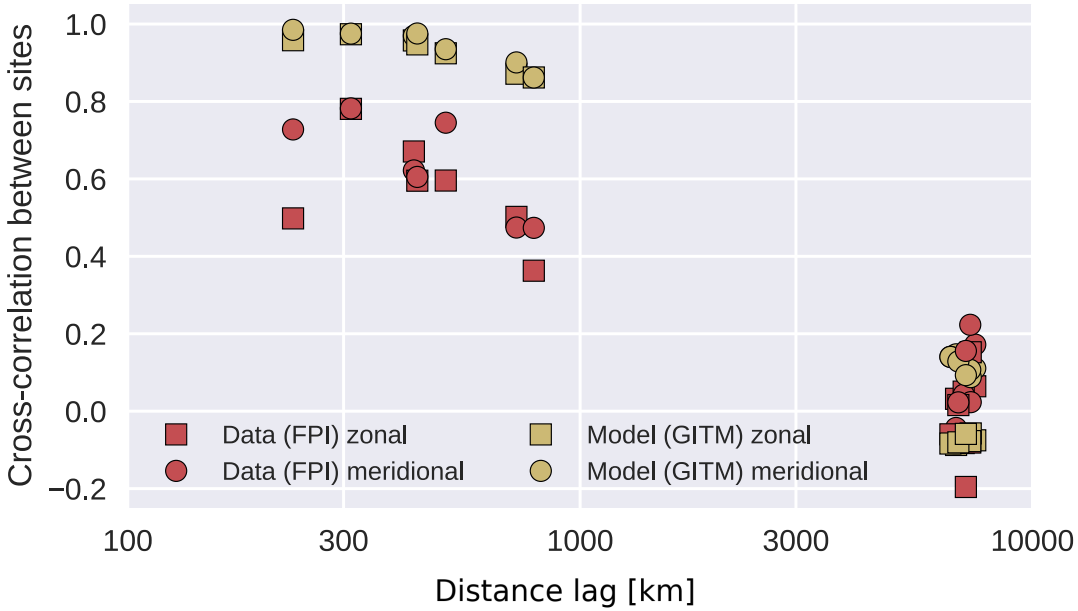
Global Ionosphere Thermosphere Model (GITM)

Year	2013
Lower Boundary	~97.5 km, MSIS/HWM14
High Latitude Forcing	*Weimer* [2005]; *Fuller-Rowell and Evans* [1987]

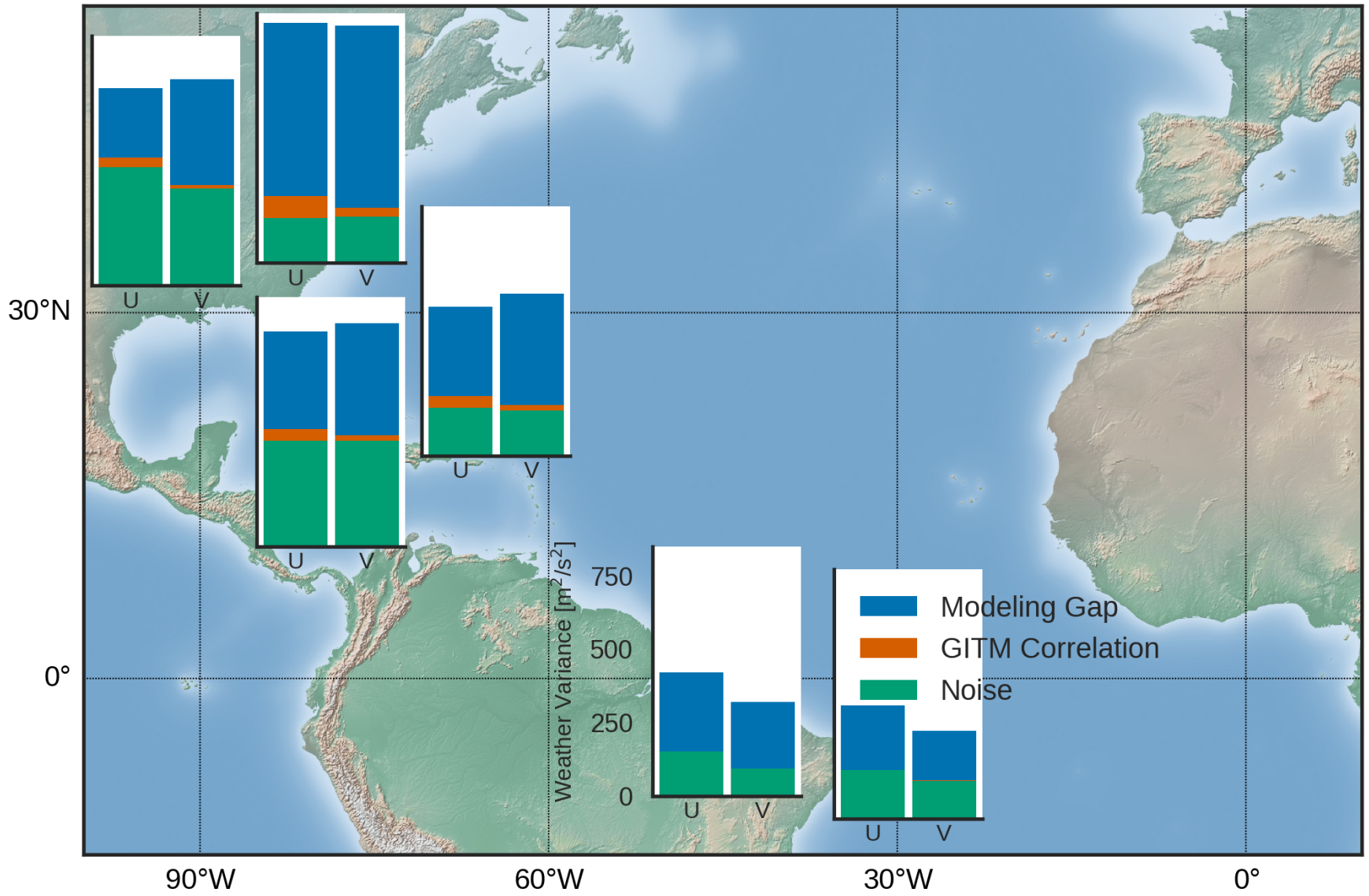


courtesy Astrid Maute





- Data contain more spatial structure than the model
- Temporal decorrelation matches well
- **Spatial decorrelation is too small to be explained by tidal variability**



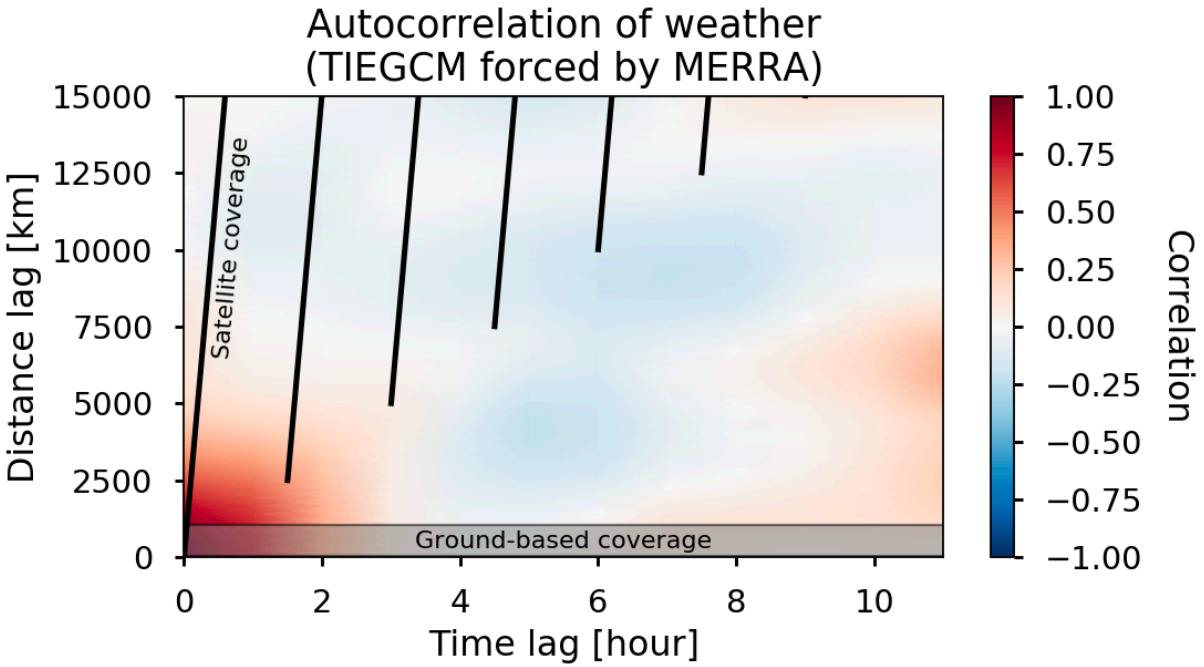
GITM captures 0-13% of measured weather variance
(correlation < 0.36)

Conclusion

Decorrelation time is well modeled by GITM → **2 hours**

Decorrelation distance is much shorter than GITM predicts → **1000 km** (data) **5000 km** (model) → **Suggests upper thermospheric weather *not* dominated by tidal variability**

Progress will be enabled by larger networks of ground-based instruments combined with satellite data



See *Harding et al.* [2019] for more

https://doi.org/10.1029/2018JA026032