

# The Research and Operational Value of the Midwave Infrared Sounding of Temperature and Humidity in a Constellation for Winds (MISTiC Winds) Mission Concept

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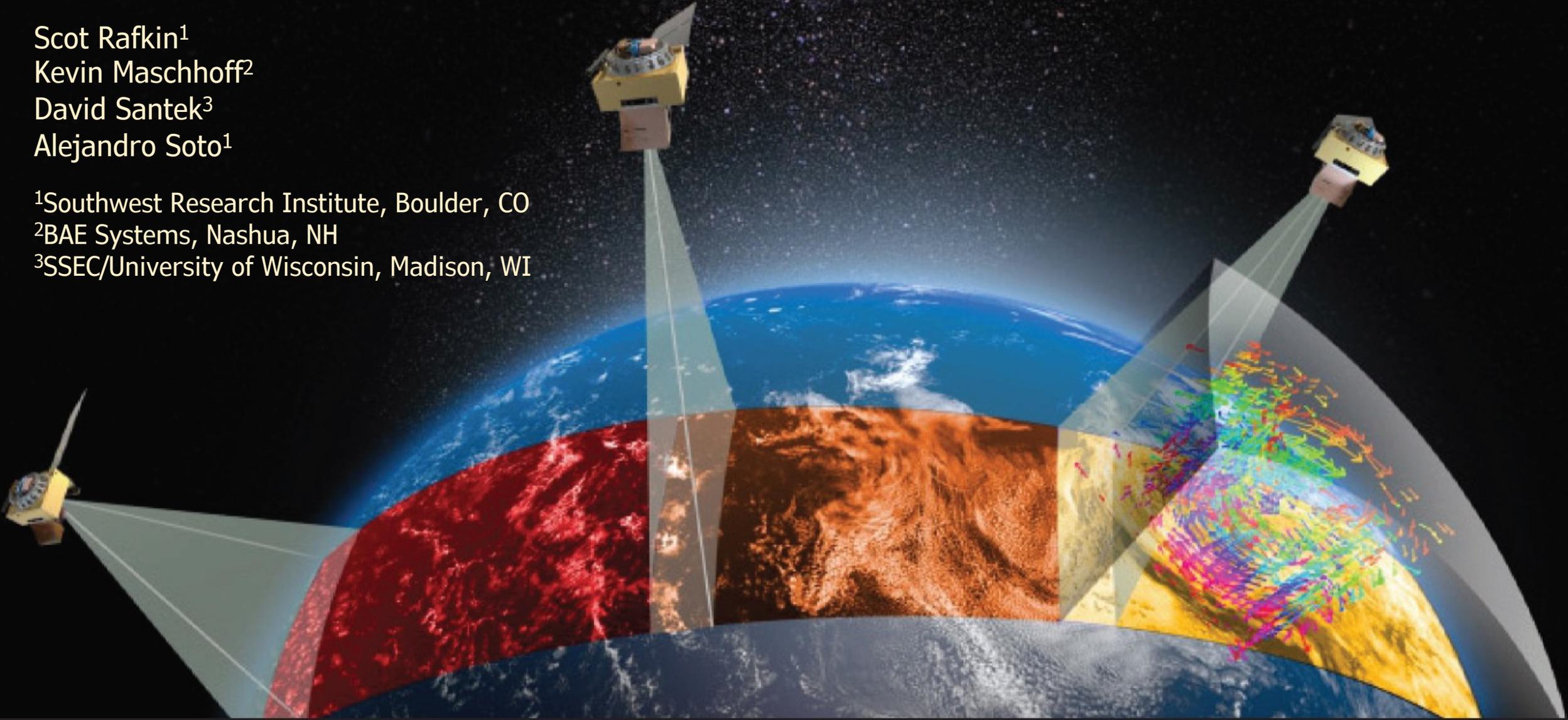
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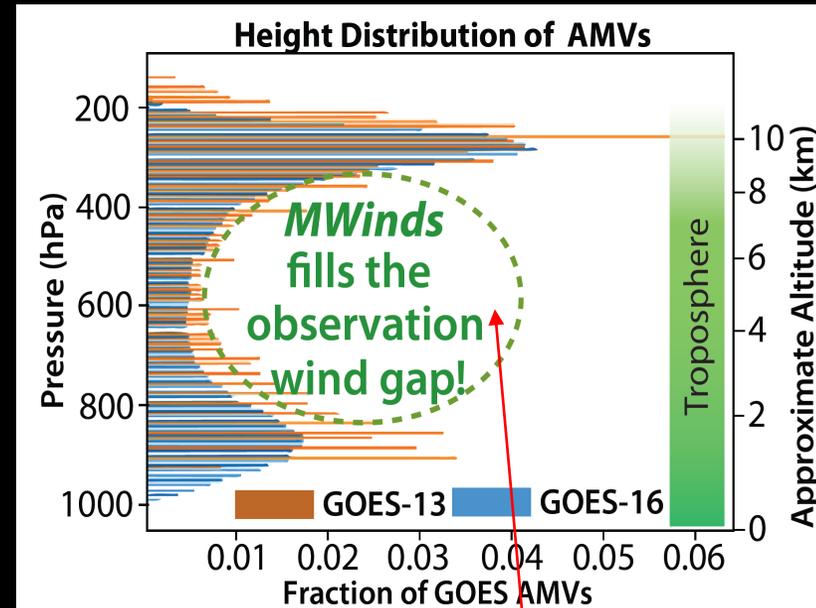


# Wind is a Fundamental Property of the Atmosphere

- Difficult to comprehensively measure wind.
- Winds are identified in the Earth Science Decadal Survey as a high priority targeted observable.



The MISTiC Winds (MWinds) mission concept responds to the Decadal Survey Targeted Observable and fills the tropospheric wind observation gap by obtaining comprehensive, global atmospheric motion vectors (AMVs).



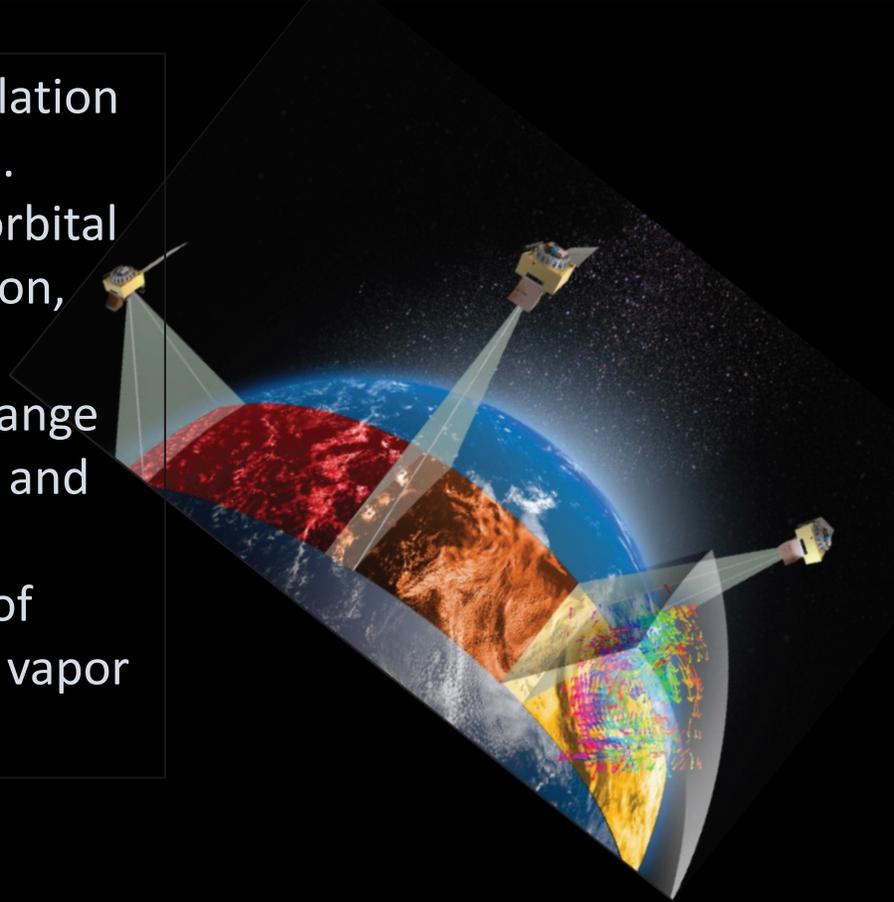
A dynamically important region

- The MISTiC instrument is a miniaturized, mid-IR hyperspectral imaging sounder.
- Heritage from AIRS.
- Greatly reduced resource requirements.
- AMVs are obtained by flying MISTiC instruments in a small satellite constellation.

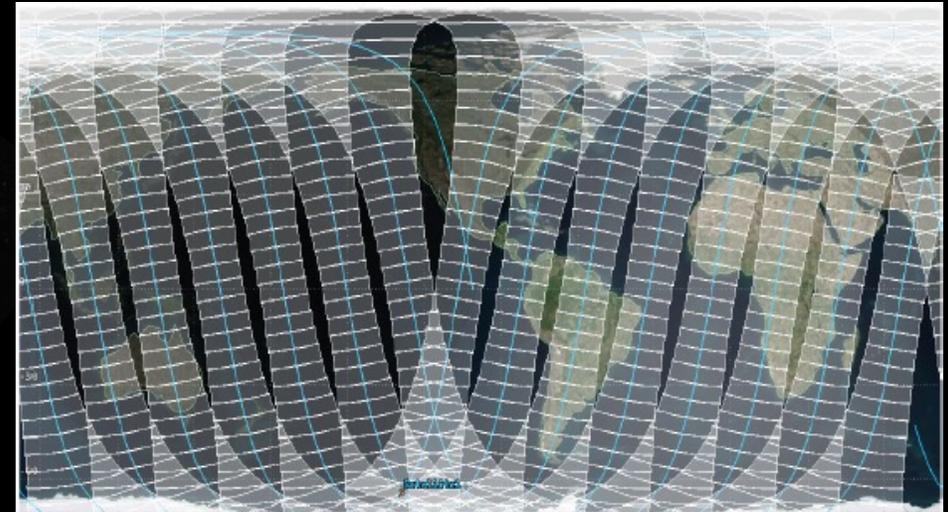
(Maschhoff *et al.*, 2019, *Remote Sensing*)

# MISTiC Winds Mission Concept: Designed for AMVs

- A small satellite constellation of  $\geq 1$  near-polar orbits.
- Three MISTiCs in each orbital plane,  $\sim 15$  min separation, same ground track.
- AMVs from the time-change of water vapor features and clouds.
- Simultaneous retrieval of temperature and water vapor profiles.



Each orbital plan provides near global coverage with a 12 hour revisit cadence.



Up to 70% of AMV error is from inaccurate height assignment (Velden and Bedka, 2009, *J. Appl. Met. Clim.*).

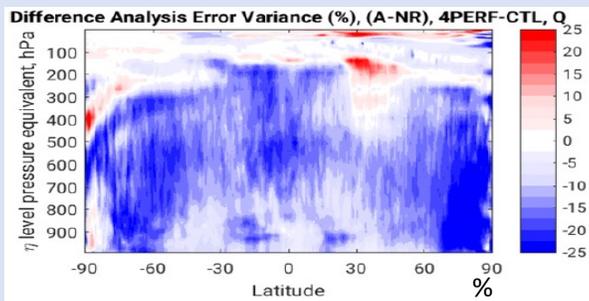
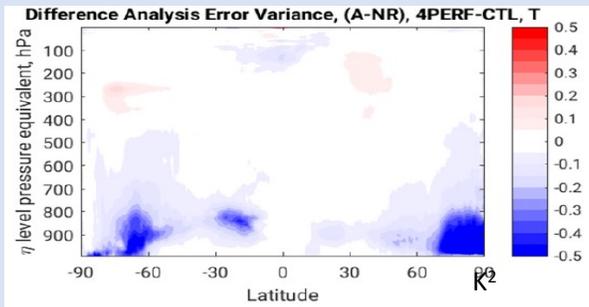
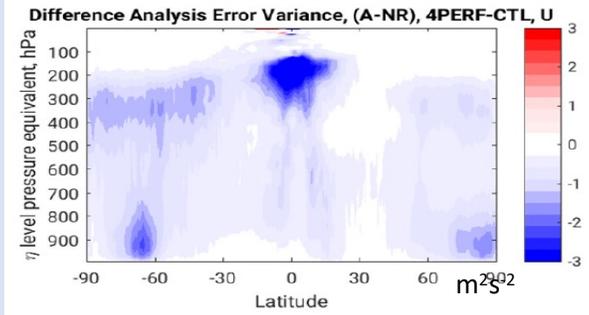
**Height assignment error is tied directly to spectral performance.**

**MISTiC Winds minimizes both feature tracking error and height assignment error.**

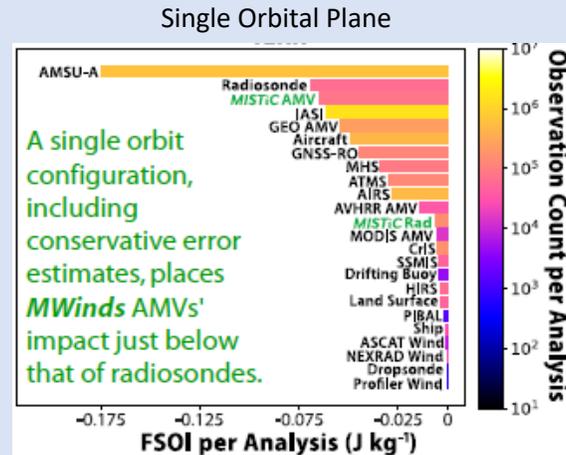
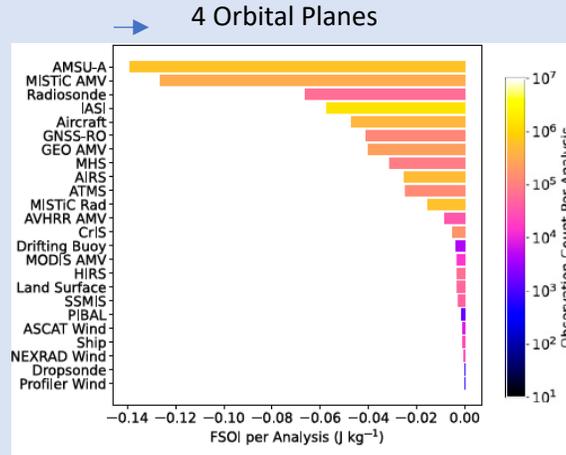
# Major *Global* Improvements from Assimilation of Simulated MISTiC AMVs and Radiance

(McCarty et al., 2021, J. Atmos. Ocean Tech.)

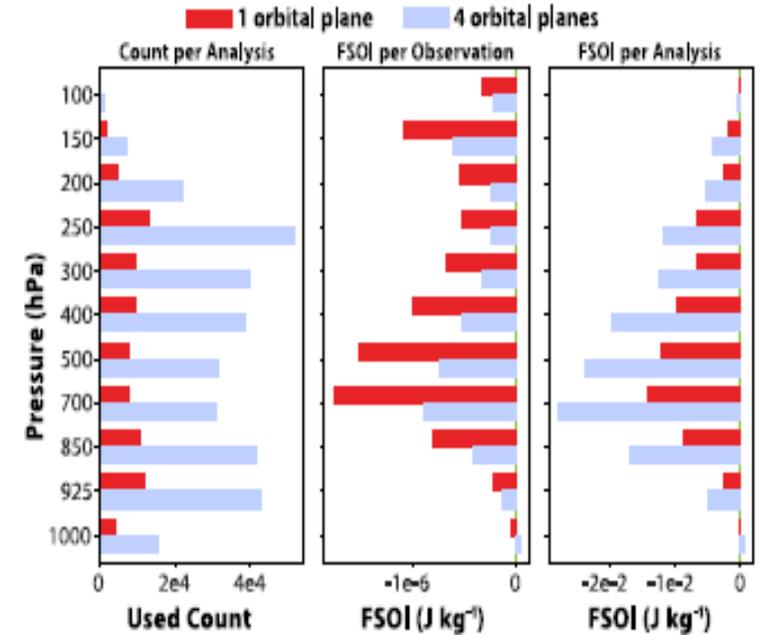
## 4 Orbital Planes



## Forecast Sensitivity to Observation Impact



## Forecast Sensitivity-Observation Impact Metrics



Adapted from McCarty et al, 2021

# High Impact Weather Events

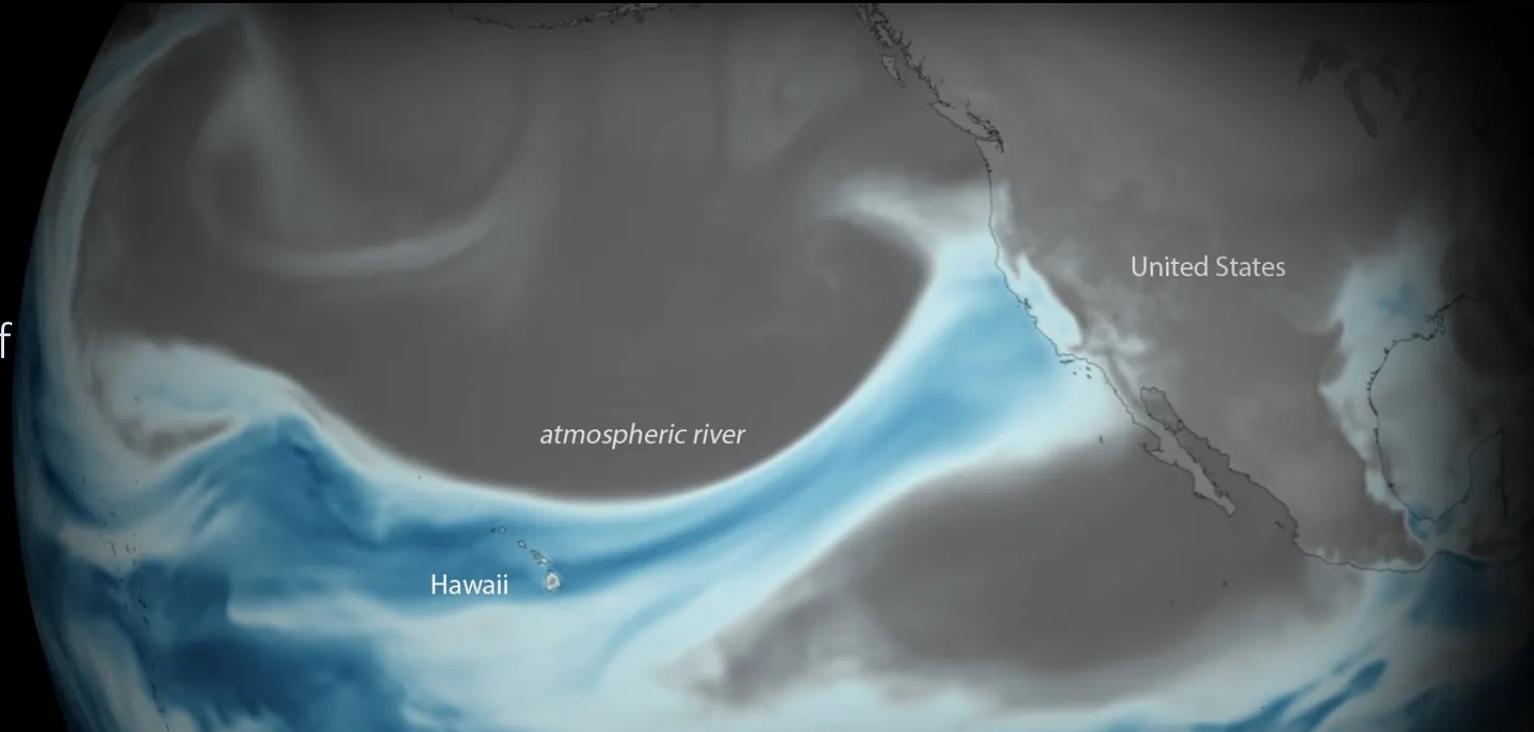
What about the value and impact of MISTiC Winds for individual, high impact weather events? E.g., Atmospheric Rivers (ARs).

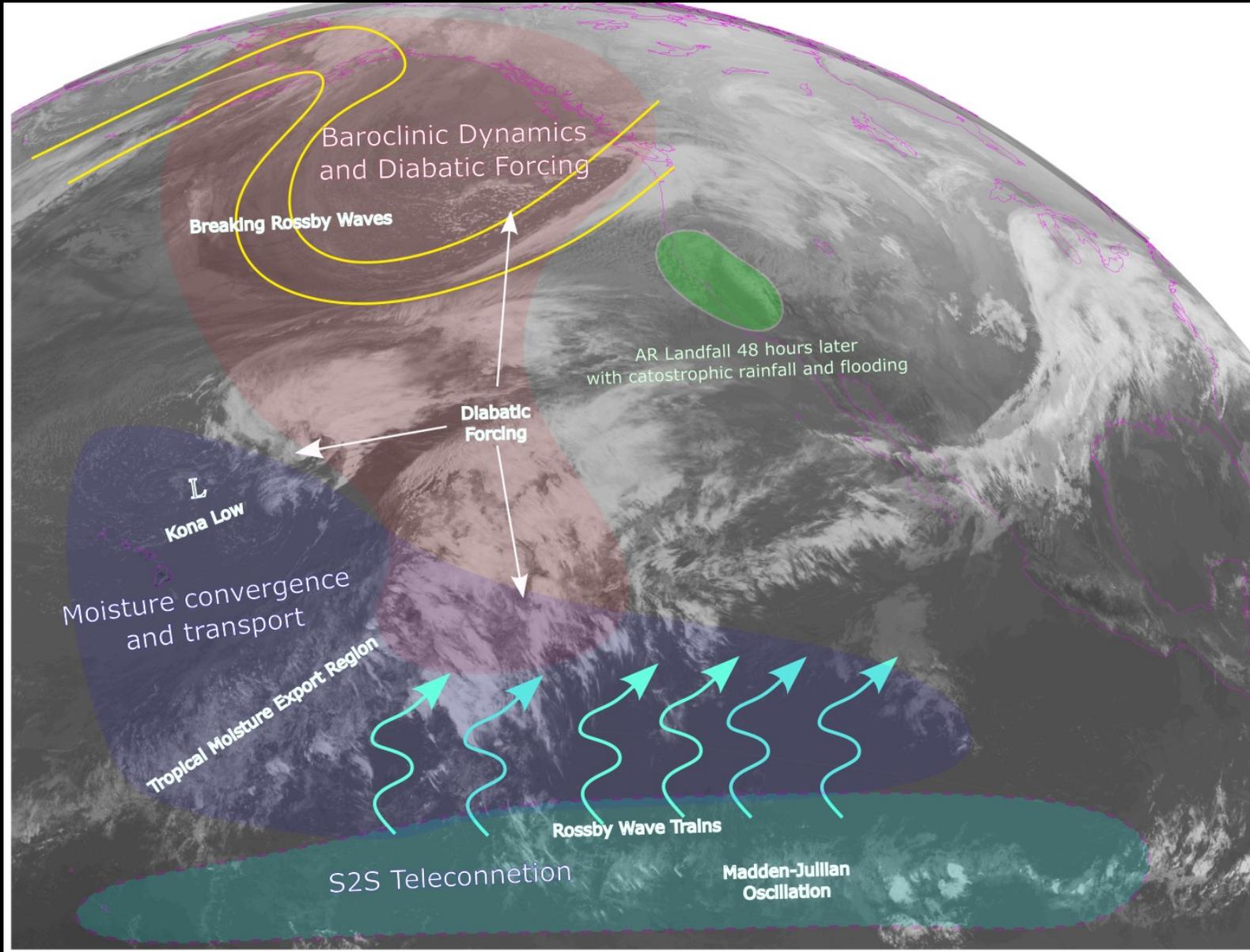
What are the underlying dynamical processes that drive these systems?

What determines the evolution and strength of the systems?

How much forecast benefit is there from hyperspectral AMVs and radiance?

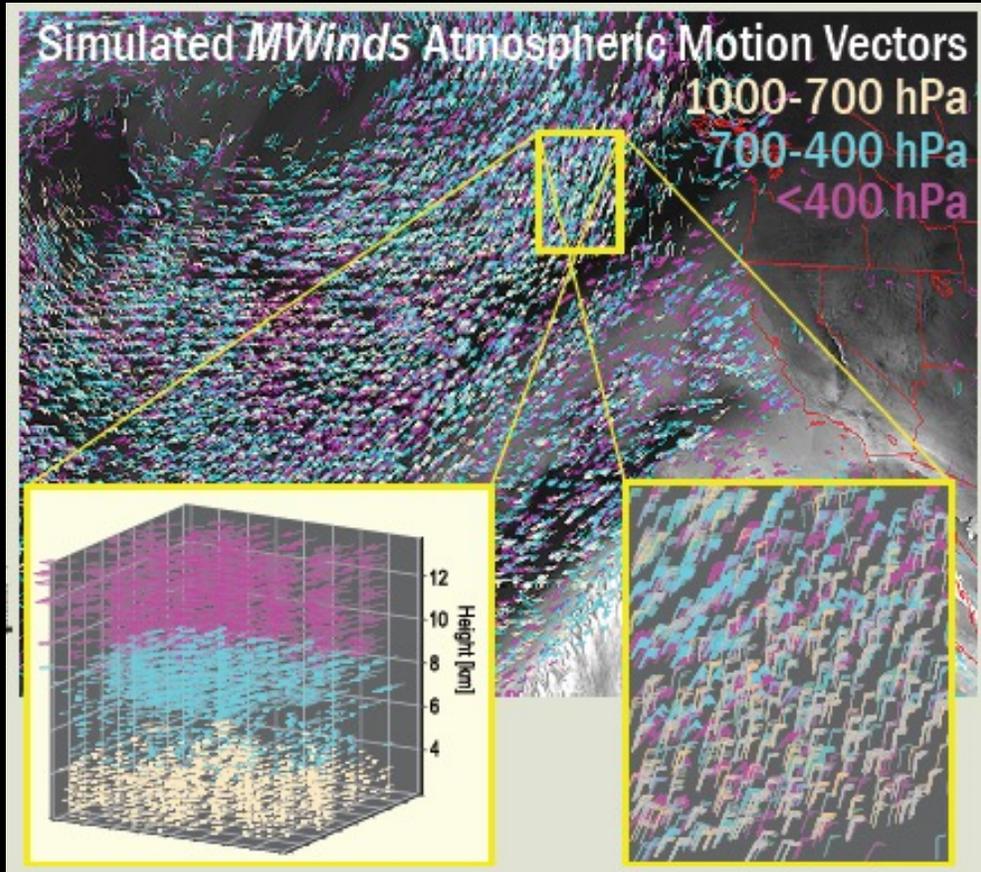
Answering all these questions requires observations of the large-scale, pre-cursor AR environment, not just the AR itself





# Precursor Dynamics and Processes in the AR Environment

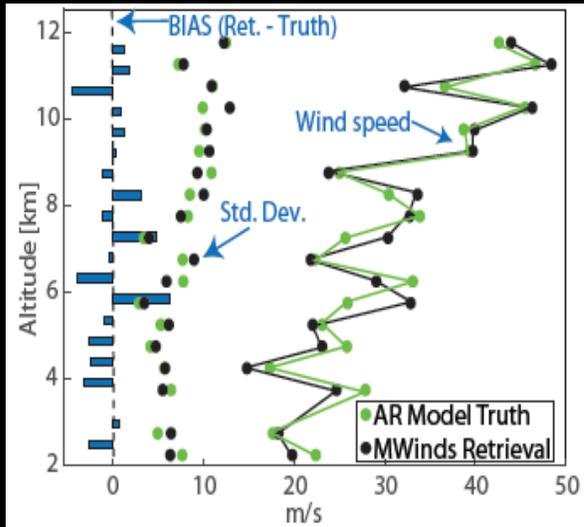
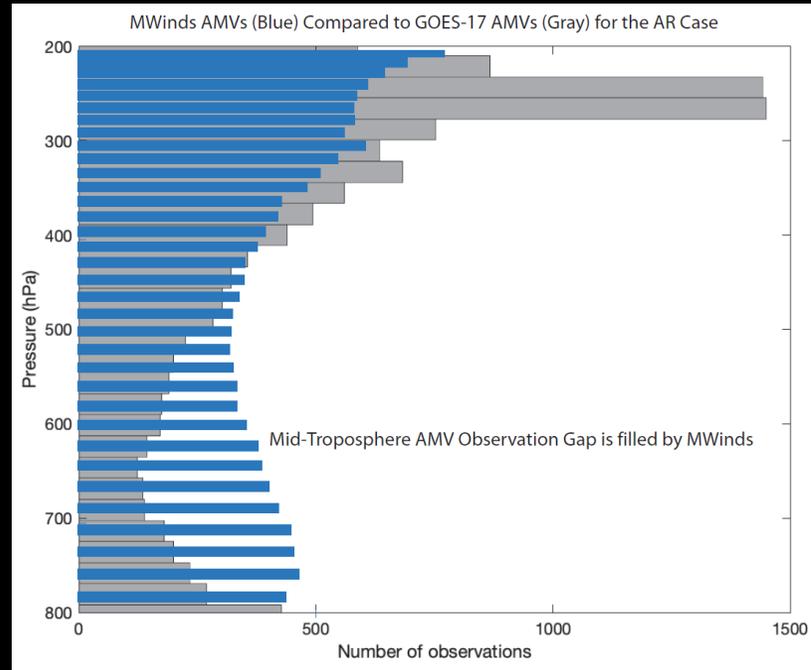
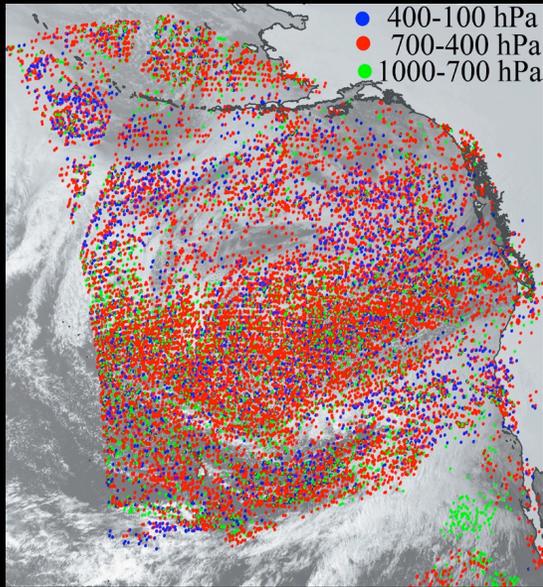
# Synthetic MISTiC AMV Retrievals and Radiance for 2019 'Valentine's Day' Atmospheric River Event



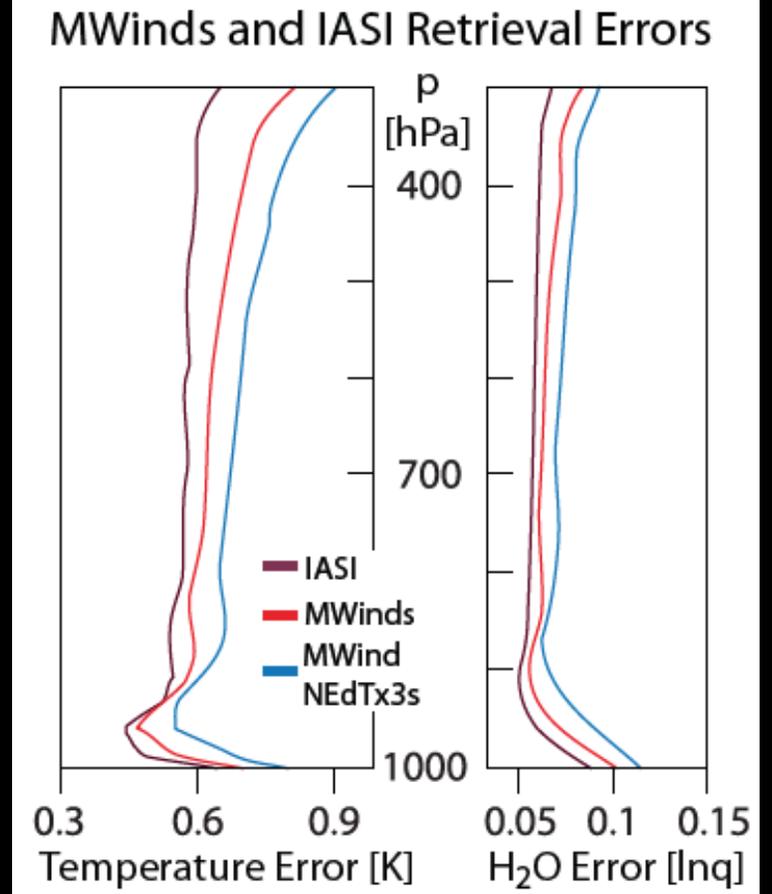
## Numerical Experiment Methodology

- Forward model radiance based on model temperature and moisture using MISTiC spectral performance and errors.
- Retrieve water vapor and temperature.
- Calculate AMVs by feature tracking water vapor.
- Exclude AMVs below clouds.
- Compare retrieved results with original model data to evaluate ability of MISTiC Winds to capture thermodynamic and kinematic fields.

# MISTiC Winds in Atmospheric River Scenario



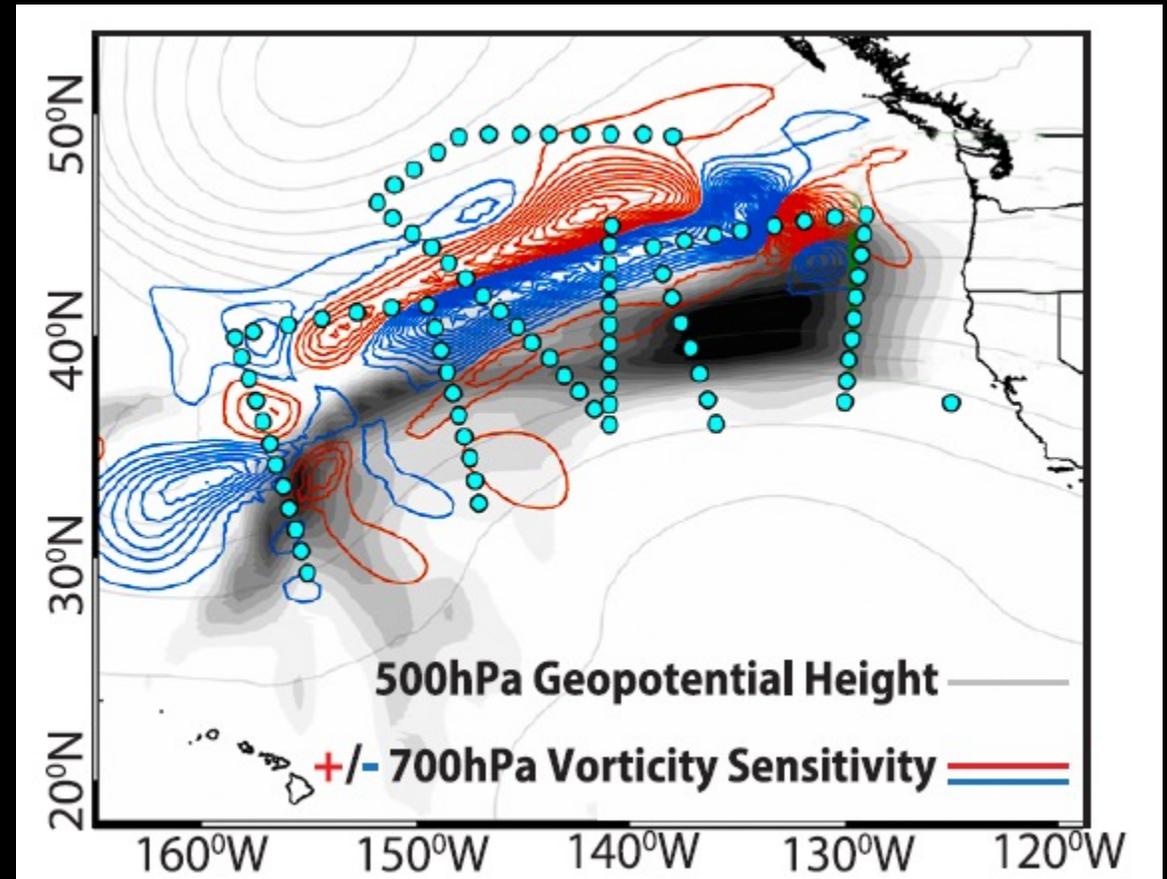
- AMV yield is more than doubled in the lower to mid-troposphere compared to GOES.
- MISTiC AMVs capture the vertical structure of the strong wind shear.
- The spatial variation of the winds is also reproduced.



T and q errors comparable to IASI but in a fraction of the resource envelope.

# But What About Winds in the Cloudy AR?

- Forecast sensitivity is often outside the AR core.
- The cloudy, high IVT AR core is largely a response to complex large-scale dynamical forcing in the clear/partly-cloudy AR environment.
- AR core structure is often obtained by reconnaissance.
- Need to focus wind and thermodynamic observations where it matters most and where observations are lacking.



Adapted from Ralph et al, 2020, *BAMS*.

# Summary

- MISTiC Winds could provide transformational information and forecast improvement both globally and for individual high-impact weather systems.
- MISTiC Winds responds to Decadal Survey Targeted Observable #4 – Tropospheric Winds, and would substantially close the existing observation gap.
- Additional value is provided by simultaneous wind, temperature, and moisture retrievals.
- Combining contemporaneous and collocated kinematic and thermodynamic information yields new and improved analysis capabilities:
  - Total wind  $\neq$  thermally-balanced circulation.
  - E.g., potential vorticity analysis, vapor transport, baroclinic instability.