

Transformational Science with the WindMapper Mission Concept

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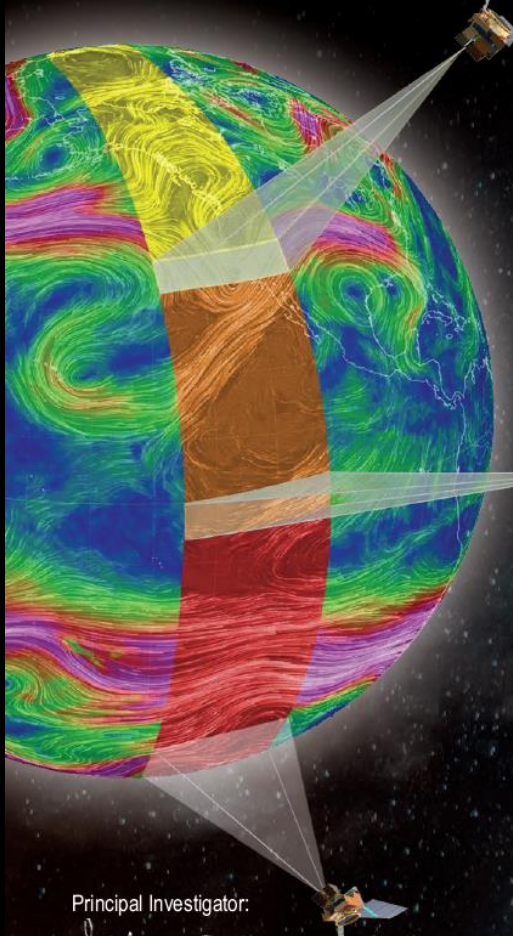
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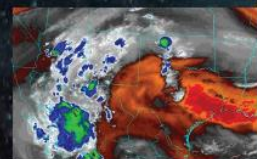

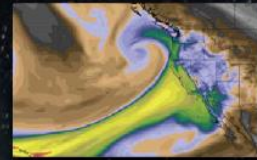
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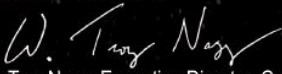
Revealing the mechanisms responsible for societally impactful atmospheric rivers and monsoon storm systems.



Closing the tropospheric observation wind gap with accurate, globally comprehensive, vertically-resolved winds.

Principal Investigator:

Dr. Scot Rafkin, Program Director

Authorizing Official:

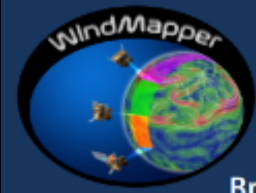

Tory Nagy, Executive Director, Contracts.



BAE SYSTEMS

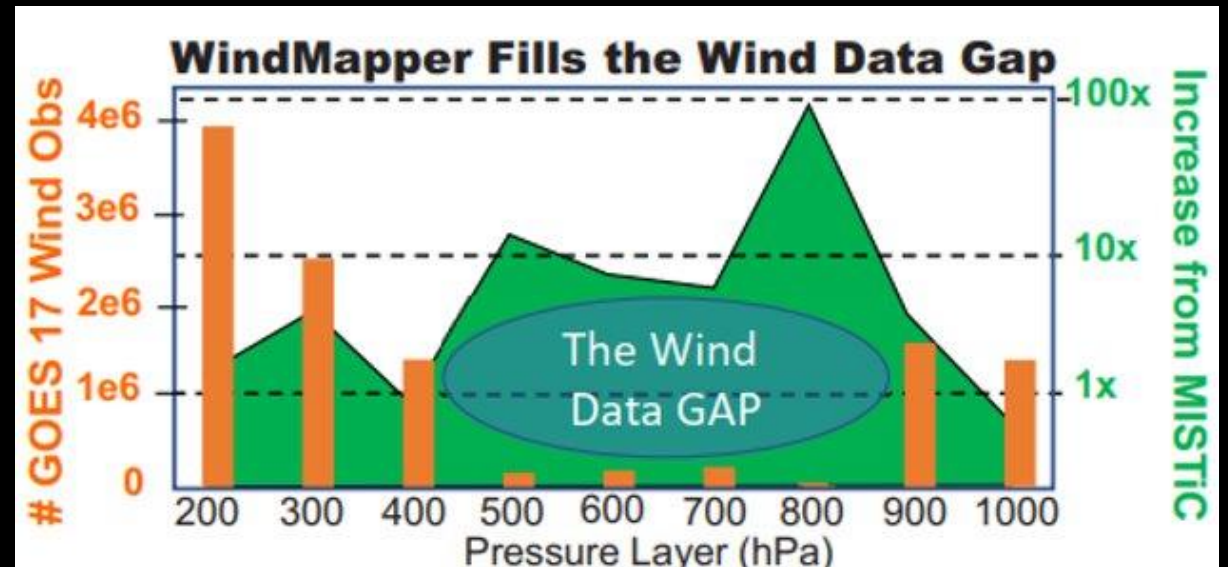


Proposing Institution: Southwest Research Institute



- Wind is a fundamental property of the atmosphere.
- Difficult to comprehensively measure wind.
- Earth Science Decadal Survey identified tropospheric winds as a high priority targeted observable.
- A targeted observable for the new NASA Earth System Explorers Program.

- WindMapper responds to the Decadal Survey and fills the tropospheric wind observation gap with comprehensive, global atmospheric motion vectors (AMVs) with accurate height assignment.
- Up to 70% of AMV error is from inaccurate height assignment. (Velden and Bedka, 2009, *J. Appl. Met. Clim.*)
- **WindMapper: $<2.3 \text{ ms}^{-1}$ rmse over 100 hPa layer at $<1.7 \text{ km}$ ground sampling distance.**



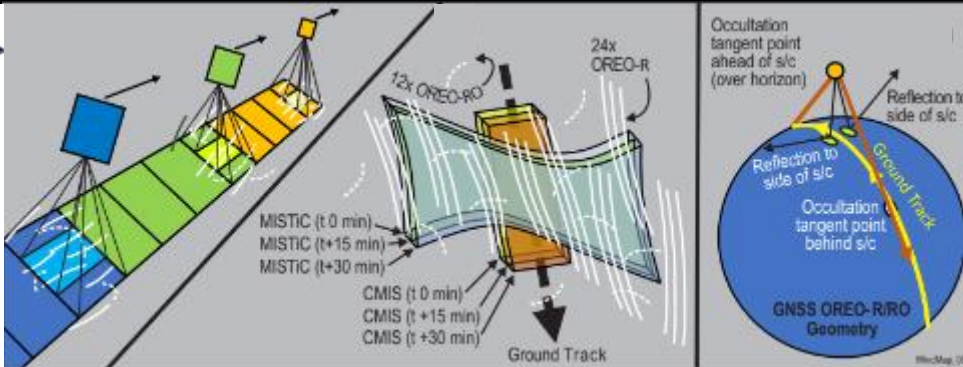
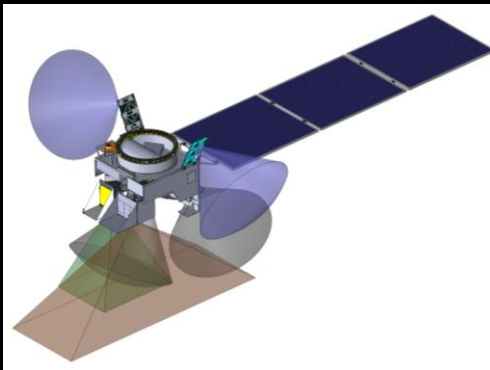
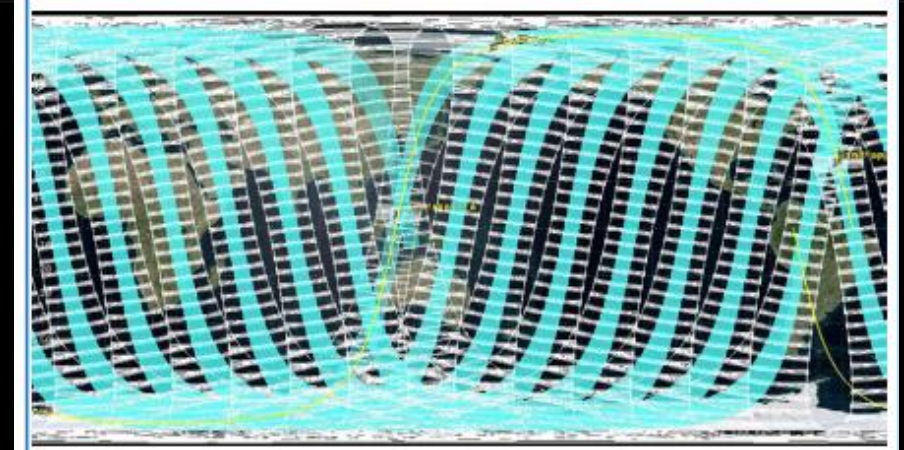
Data and analysis courtesy of Nikki Privé, NASA GSFC



Observation Concept

- A small, three-satellite constellation in near-polar orbit.
- ~15 min observatory separation with same ground track.
- Hyperspectral AMVs from the time-change of water vapor features and clouds (MISTiC Winds).
- Stereo AMVs and cloud top velocity from imaging of clouds (CMIS).
- Ocean surface wind speed (OREO GNSS-R)
- Simultaneous retrieval of temperature and water vapor profiles (MISTiC Winds and OREO GNSS RO).
- Land surface water coverage and soil moisture (OREO GNSS-R)

Near global coverage with <12-hour revisit cadence.

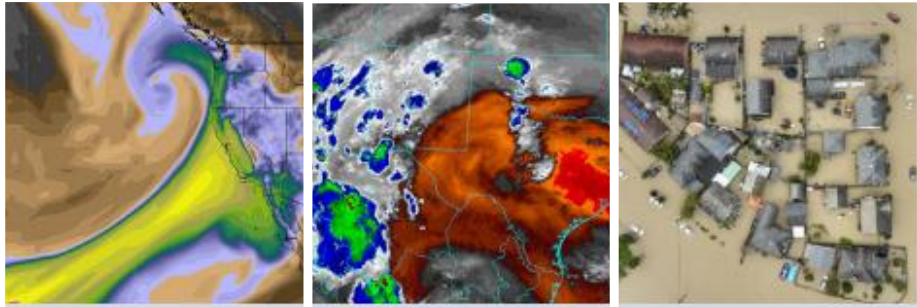


- All observations are over time scales \ll decorrelation time scales (Powell et al., 2023, BAMS)
- Effectively contemporaneous and colocated.
- Enables key diagnostic studies (e.g., PV) without dynamical balance assumptions.

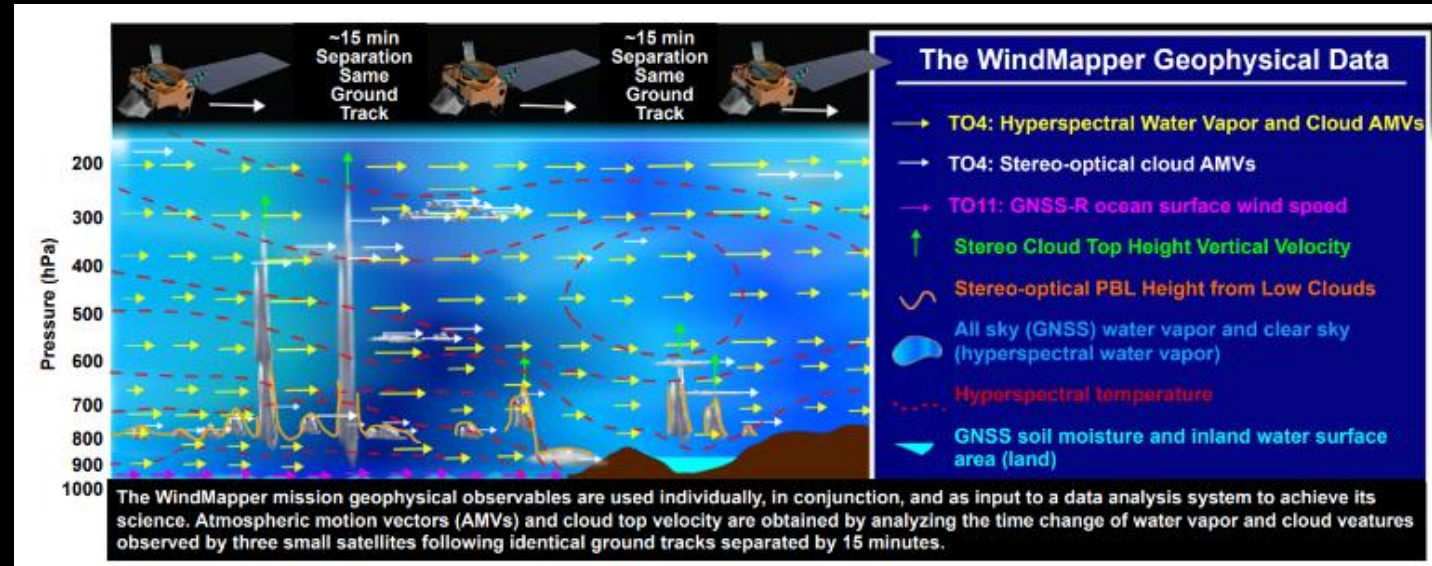


Mission Goal: Reveal the precursor mechanisms responsible for extreme moisture transport weather events and improve their representation in models of Earth's changing climate system.

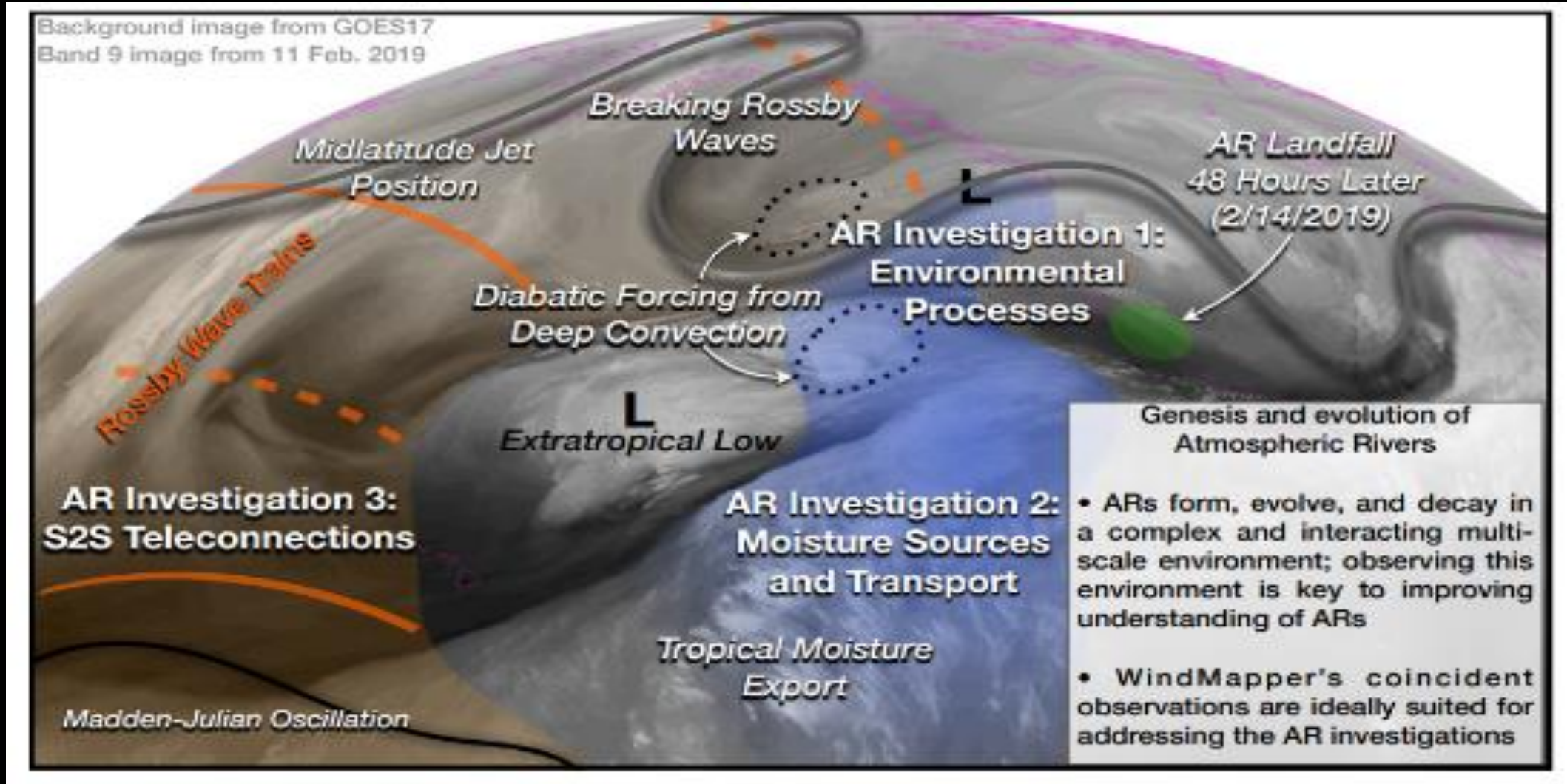
Science Objective. Identify and quantify the relative importance of the mechanisms responsible for the genesis and evolution of atmospheric rivers and monsoon disturbances.



Application Objective. Fill the mid-tropospheric observation gap in vertically-resolved wind and quantify the improvement in atmospheric analyses and Earth System models to such observations.

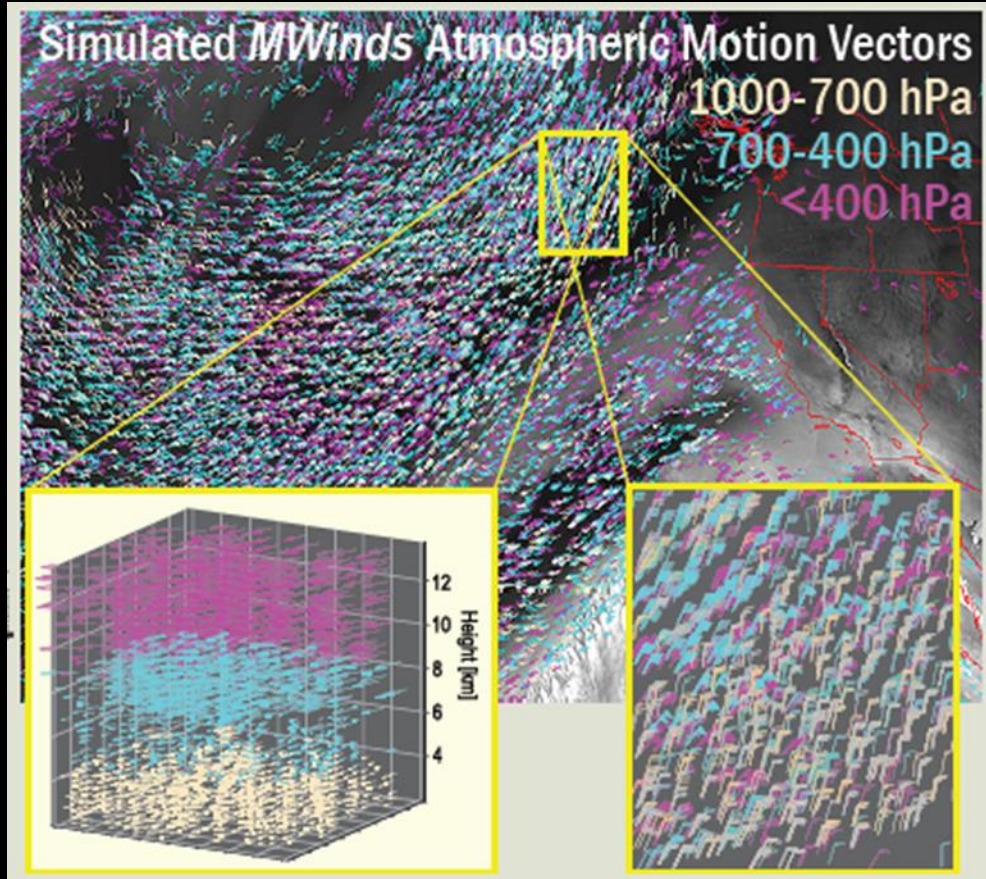


WindMapper addresses fundamental unknowns about the formation and development of atmospheric rivers and monsoon disturbances within their large-scale context by simultaneously observing and quantifying the dynamics and thermodynamics of the atmospheric environment that produces them.





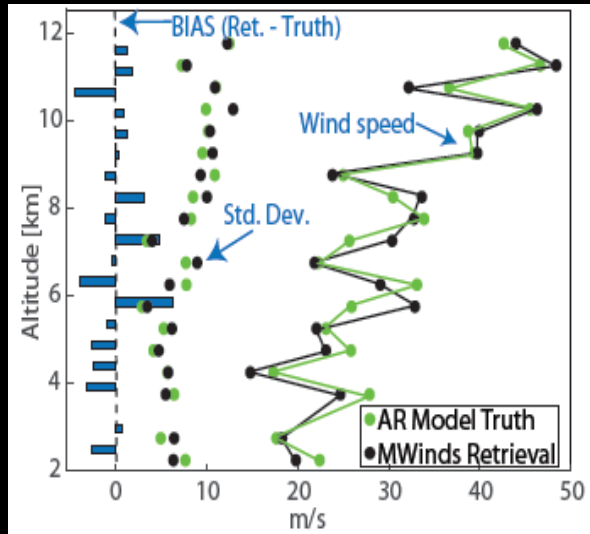
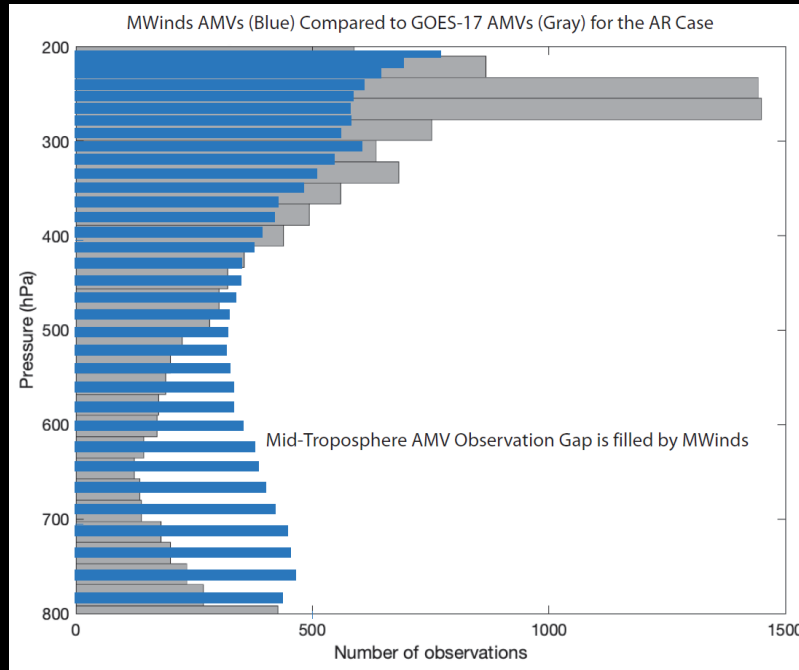
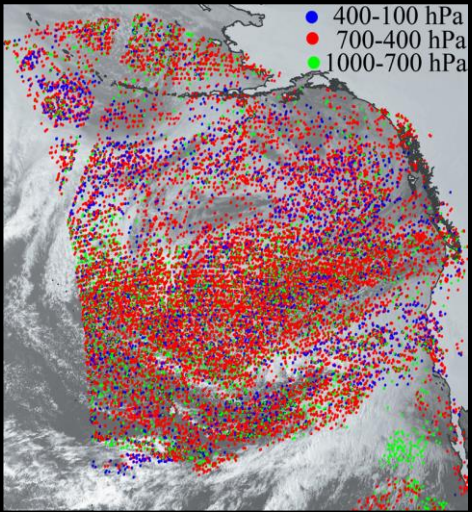
2019 'Valentine's Day' Atmospheric River Event



WRF simulation and data courtesy of NCAR

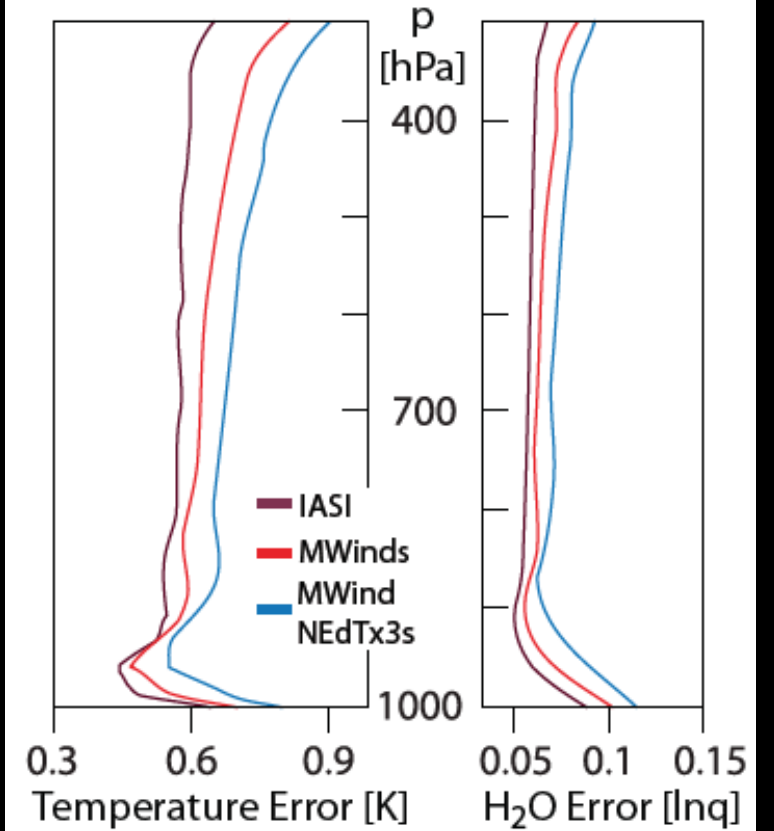
Numerical Experiment Methodology

- Forward model radiance based on model temperature and moisture using only 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.**



- AMV number 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.

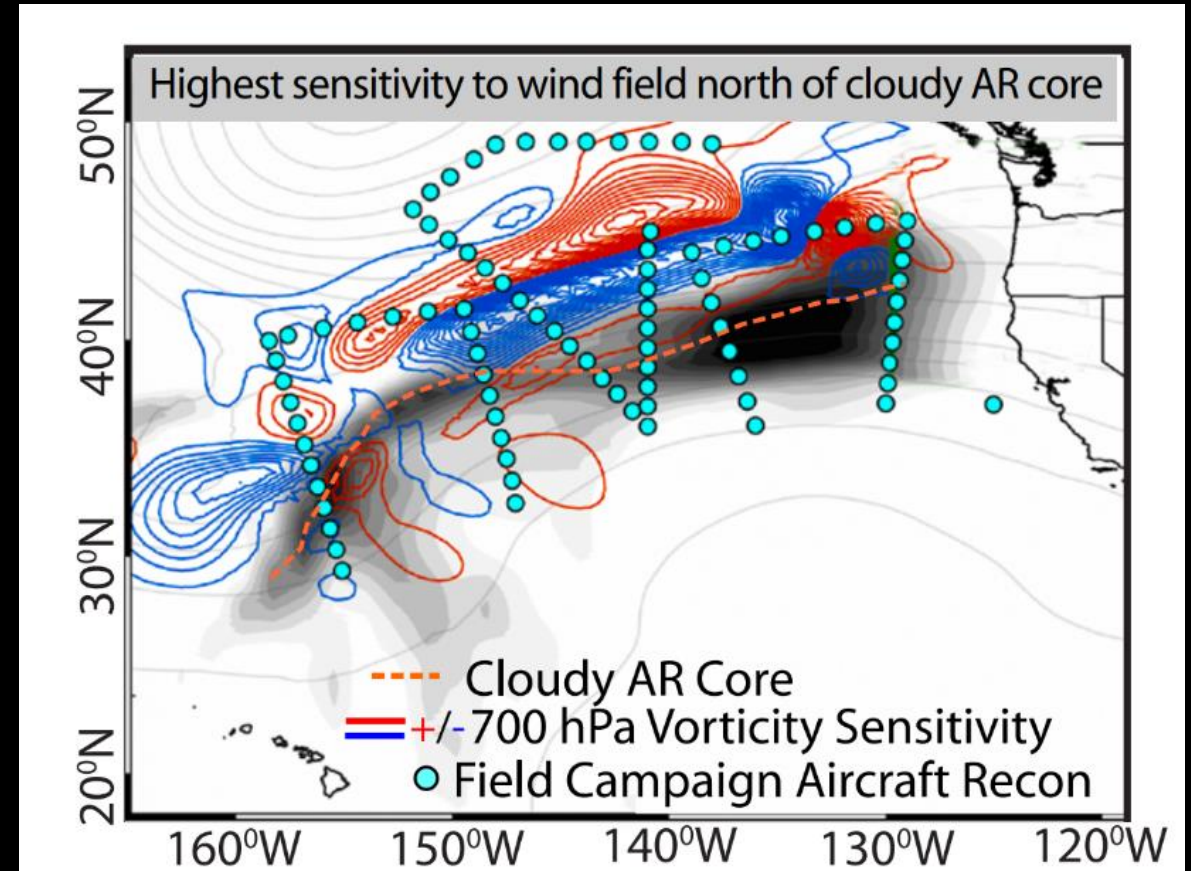
MWinds and IASI Retrieval Errors



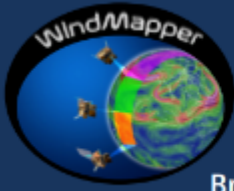
T and q errors comparable to IASI but in a fraction of the resource envelope.



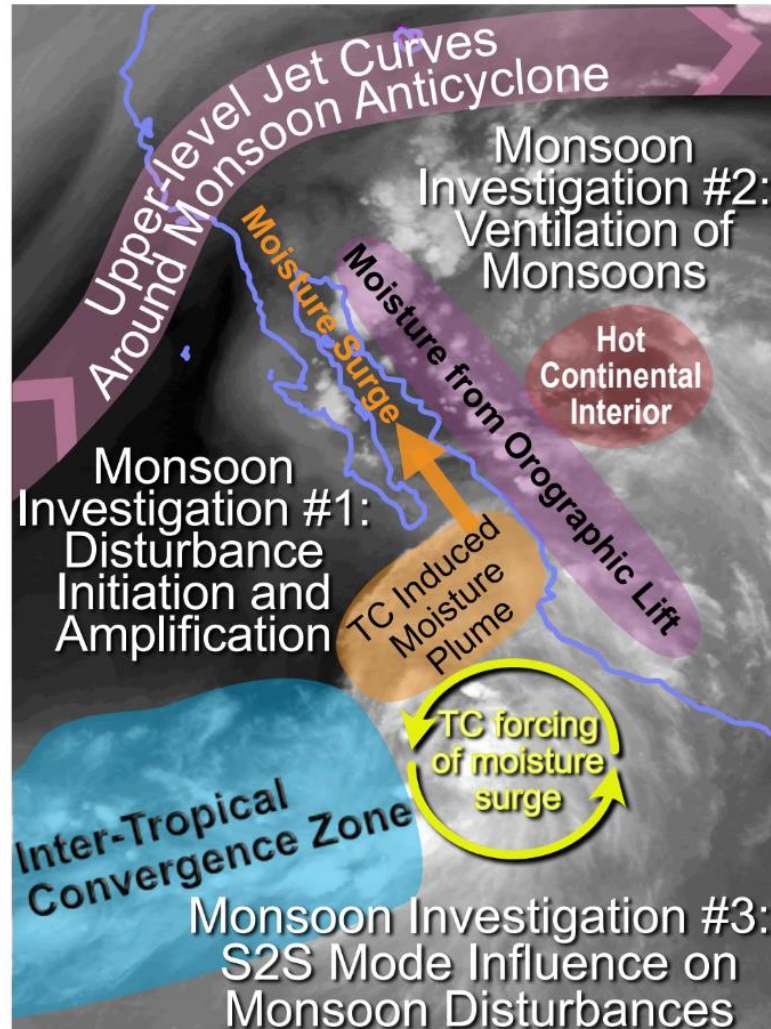
- A mix of clear, partly cloudy, and cloudy air is optimal.
- Forecast sensitivity is often outside the AR core.
- AR core is often a *response* to complex large-scale dynamics and processes outside the core.
- AR core structure is often obtained by reconnaissance.
- Need to focus wind and thermodynamic observations where it matters most and where observations are lacking.



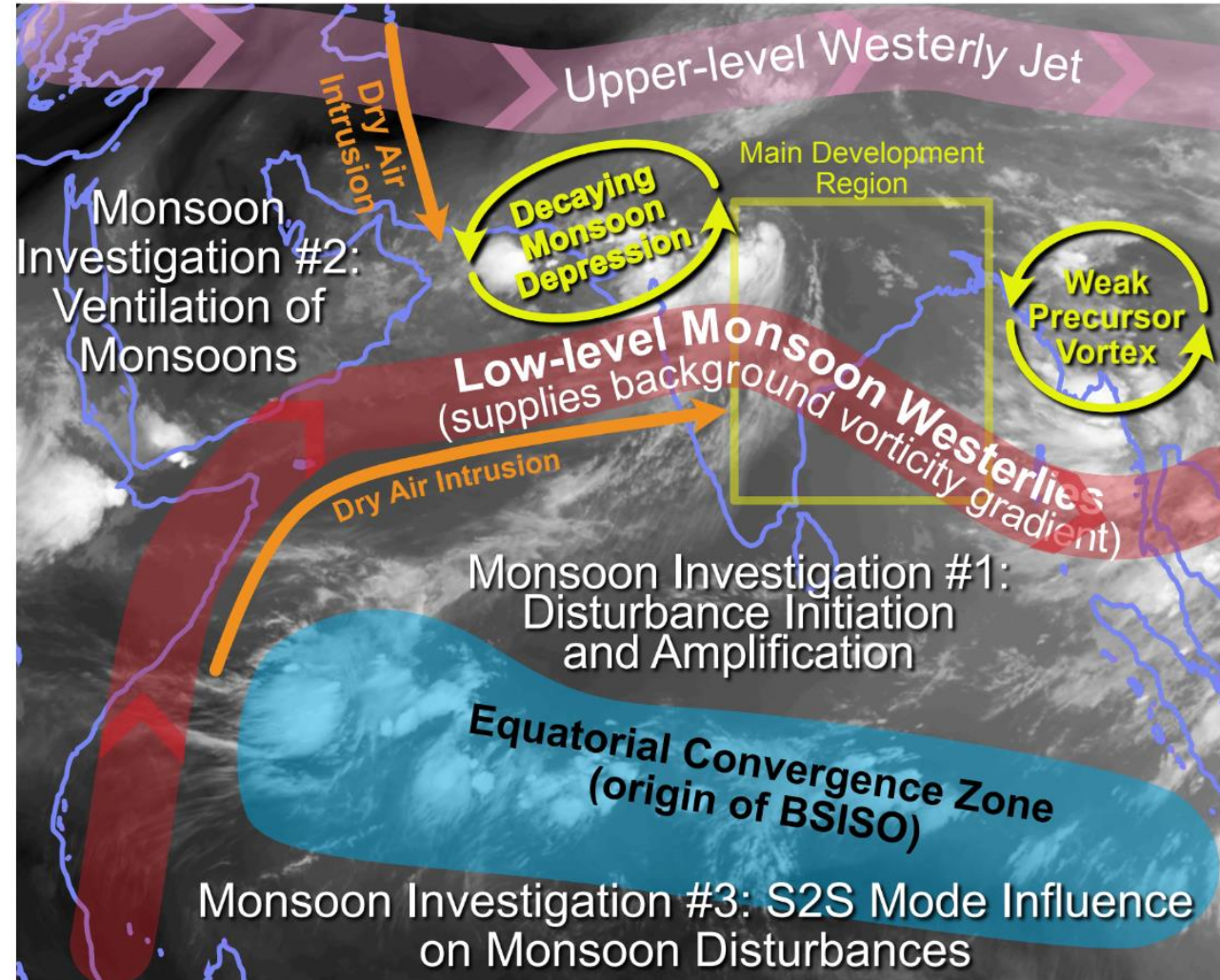
Adapted from Ralph et al, 2020, *BAMS*.



North America Monsoon



Southeast Asia Monsoon





WindMapper Summary

Breakthrough Wind Observations Revealing the Mechanisms Driving Atmospheric Rivers and Monsoon Disturbances

- A mission concept proposed to the NASA Earth System Explorer Program.
- Responds to Decadal Survey Targeted Observables (Tropospheric Winds and Ocean Surface Winds) and fills the existing observation gap.
- Additional value is provided by simultaneous wind, temperature, and moisture retrievals.
- Provides transformational science focused on atmospheric rivers and monsoon disturbances and enables breakthrough improvements in NWP.
- Combining kinematic and thermodynamic information yields new and improved analysis capabilities.
- An exceptional and diverse international team.

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