National Aeronautics and Space Administration

FY25 Strategic University Research Partnership (SURP)

Maximize spatial and vertical information in joint sounder and imager observations using ensemble machine-learning approach for Planetary Boundary Layer (PBL) and Extreme Events

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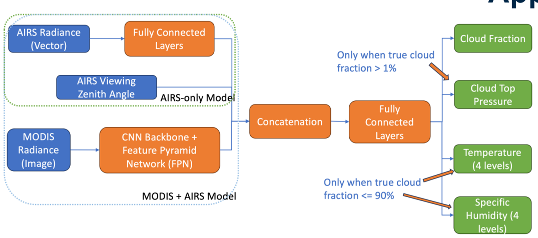
Background

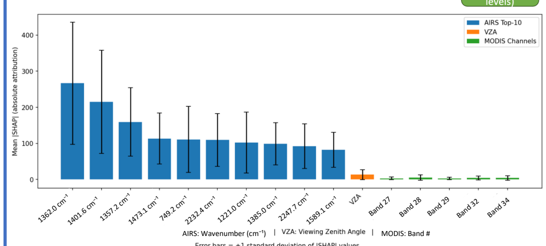
- IR sounding in the presence of clouds has been an issue for decades, especially for T/q profiles underneath the clouds.
- The synergy between hyperspectral soundings (high spectral resolution) and imaging spectrometer (high spatial resolution): a MODIS pixel within an AIRS footprint can see through clouds.

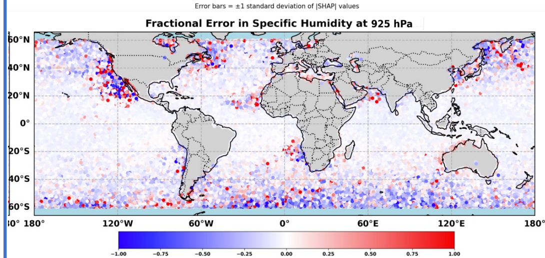
Objectives

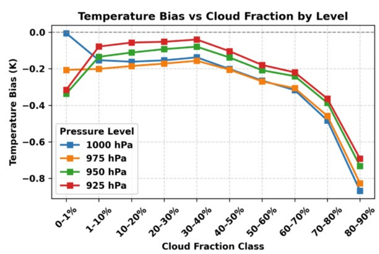
- Vertical correlations in the T and q profiles: how to make best use of such intrinsic a priori constraints?
- Question to address: ***Can we build a deep-learning model to get cloud information and T/q profiles below clouds?***

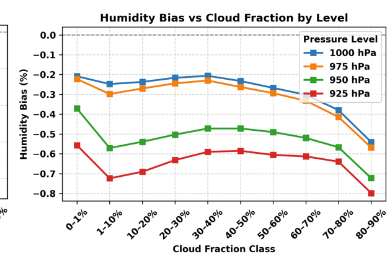
Approach and Results

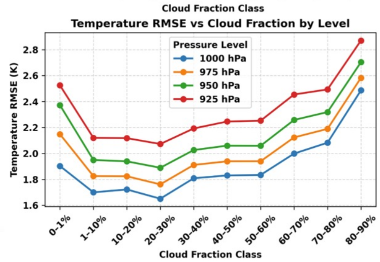


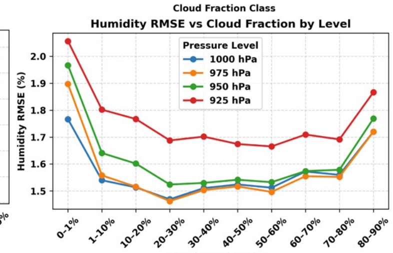












- AIRS channels (~300–600 hPa) contribute most substantially to the overall PBL retrieval performance.
- Combining spatial and spectral information with a suitable deep-learning framework yields robust PBL T/q retrievals in the presence of clouds up to 90% cloud amount, as well as robust estimations of cloud fraction and CTP.
- Most challenging cases are seen over marine stratus regions and coastal regions (especially beyond 40°N/S).

Significance/Benefits to JPL and NASA

- PBL is one of the next Decadal Survey focus with a potential space-borne component of hyperspectral IR and MW sounding. An algorithm digesting multiple observations must be developed to elevate the PBL measurement into a concrete mission concept. However, as constrained by fundamental physics of radiative transfer, no space-borne single instrument can probe the PBL with desired accuracies or both vertical resolution and horizontal coverage.
- We show a deep-learning model framework that can effectively ingest spatial and spectral information to make PBL thermodynamic profile retrievals below cloud robust up to a 90% cloud fraction. Proposed Y2 and Y3 efforts have a special focus on the PBL thermodynamic conditions during extreme events also provides capability of delivering actionable science and innovative tools to the community using NASA's Earth science observations.

References: Wang X., Iwabuchi H., and Yamashita T., Remote Sens. Environ., 275: 113026, 2022.

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