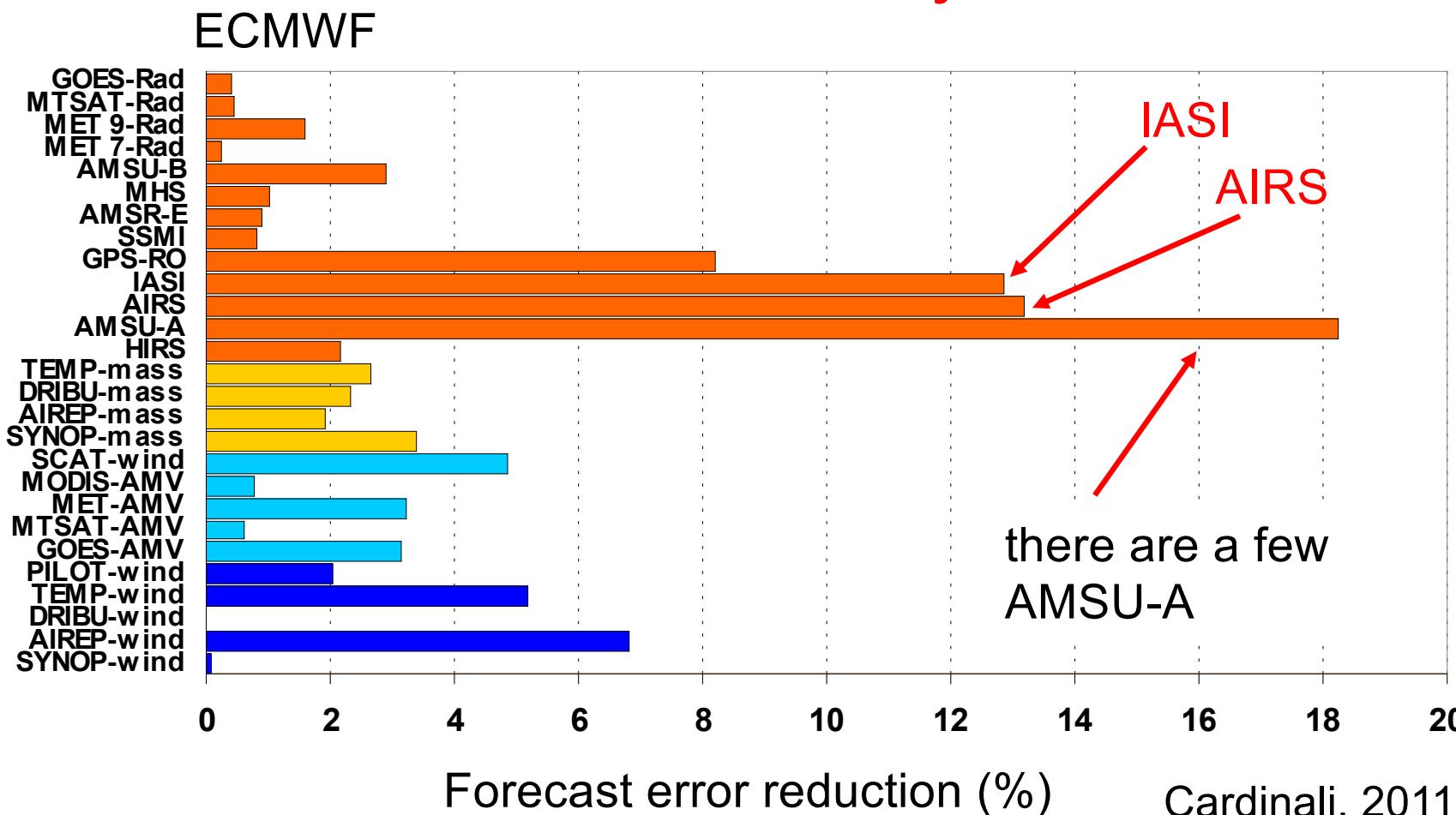




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AIRS, Weather Prediction and Re-Analysis



AIRS has been absolutely critical:

- For improving forecasts over last 20 years
- For improving re-analysis products (ERA, MERRA)

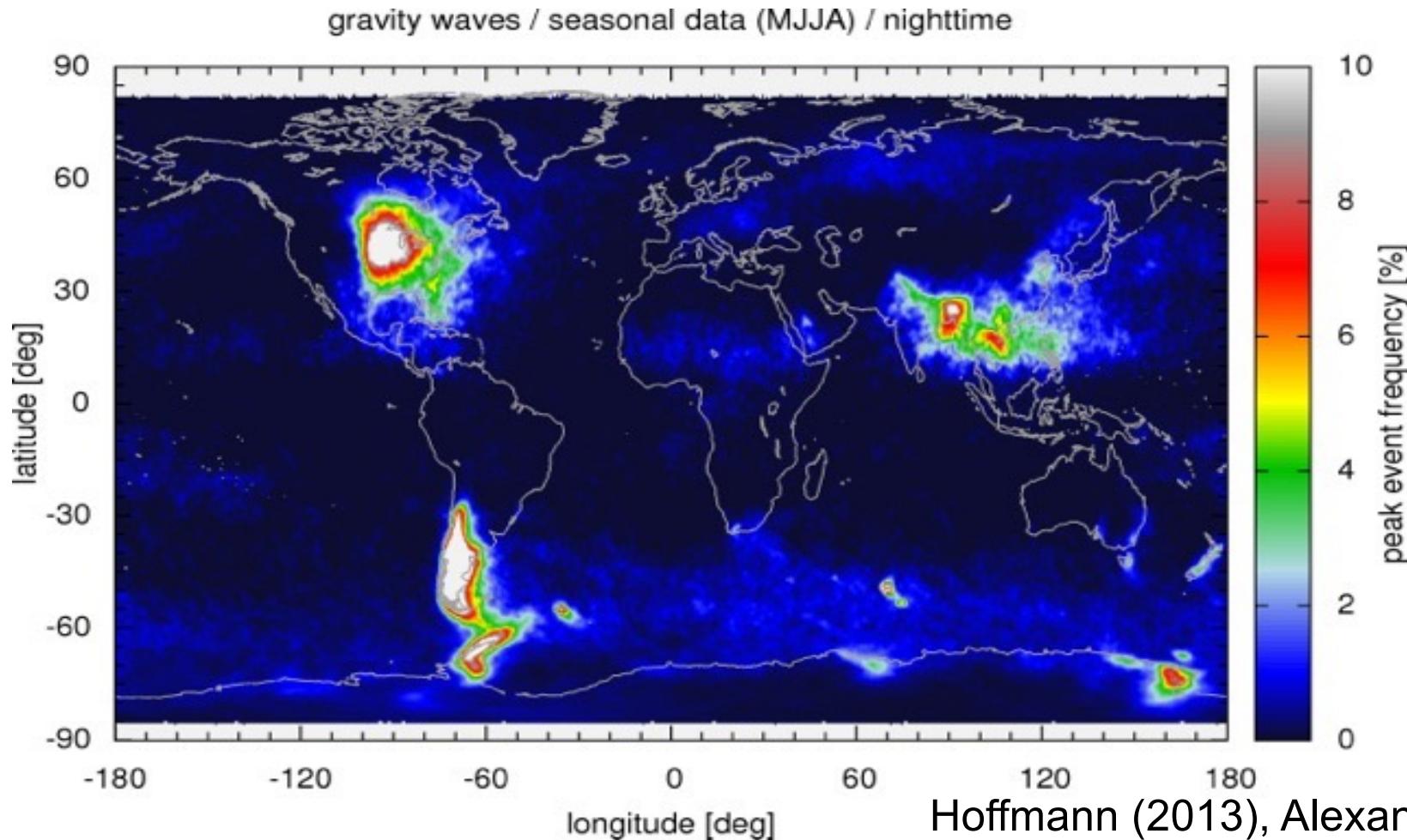
Cardinali, 2011 +
several more studies



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AIRS and Atmospheric Gravity Waves: A Discovery Story



Hoffmann (2013), Alexander and
co-authors – several publications

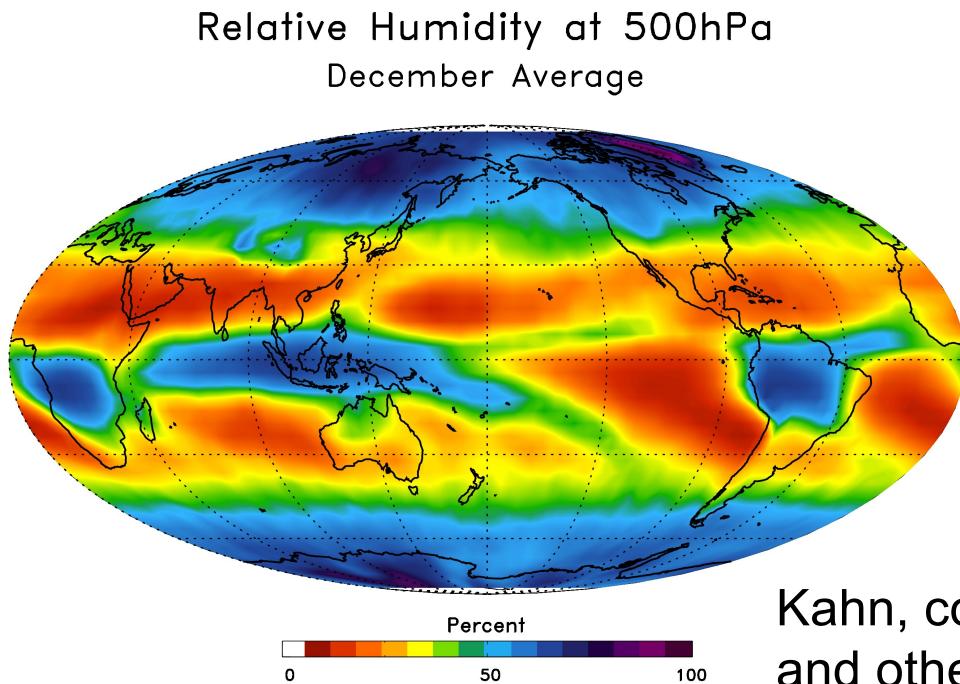
- Key gravity wave source regions identified by AIRS
- AIRS has helped discover a new key Asian monsoon region



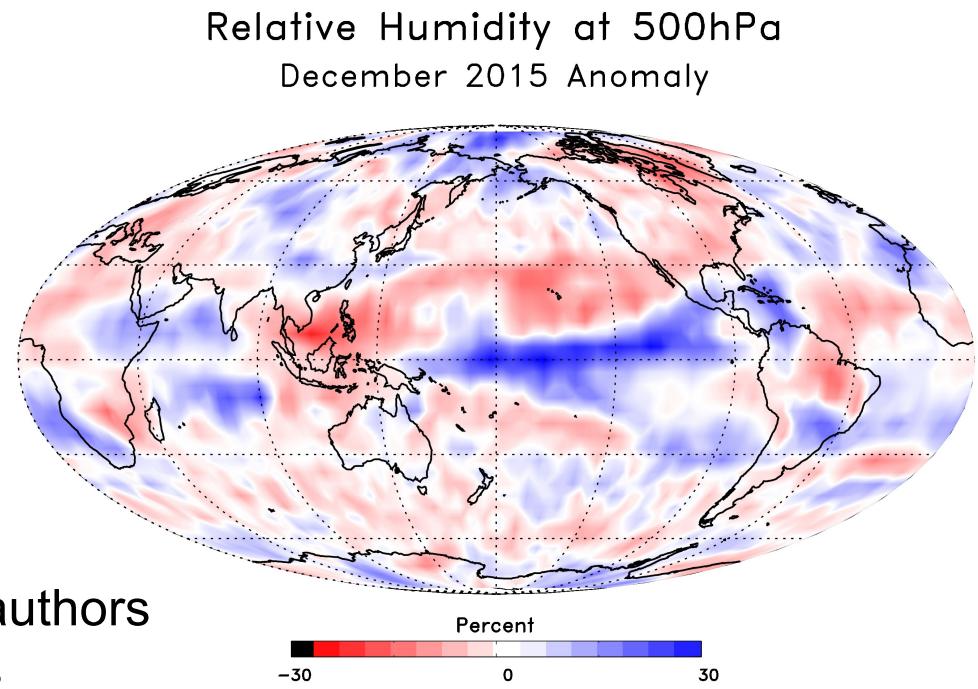
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Ocean-Atmosphere Variability: ENSO

AIRS probes into the vertical structure of the atmosphere: e.g.
Significant ENSO changes in mid-tropospheric relative humidity



Kahn, co-authors
and others



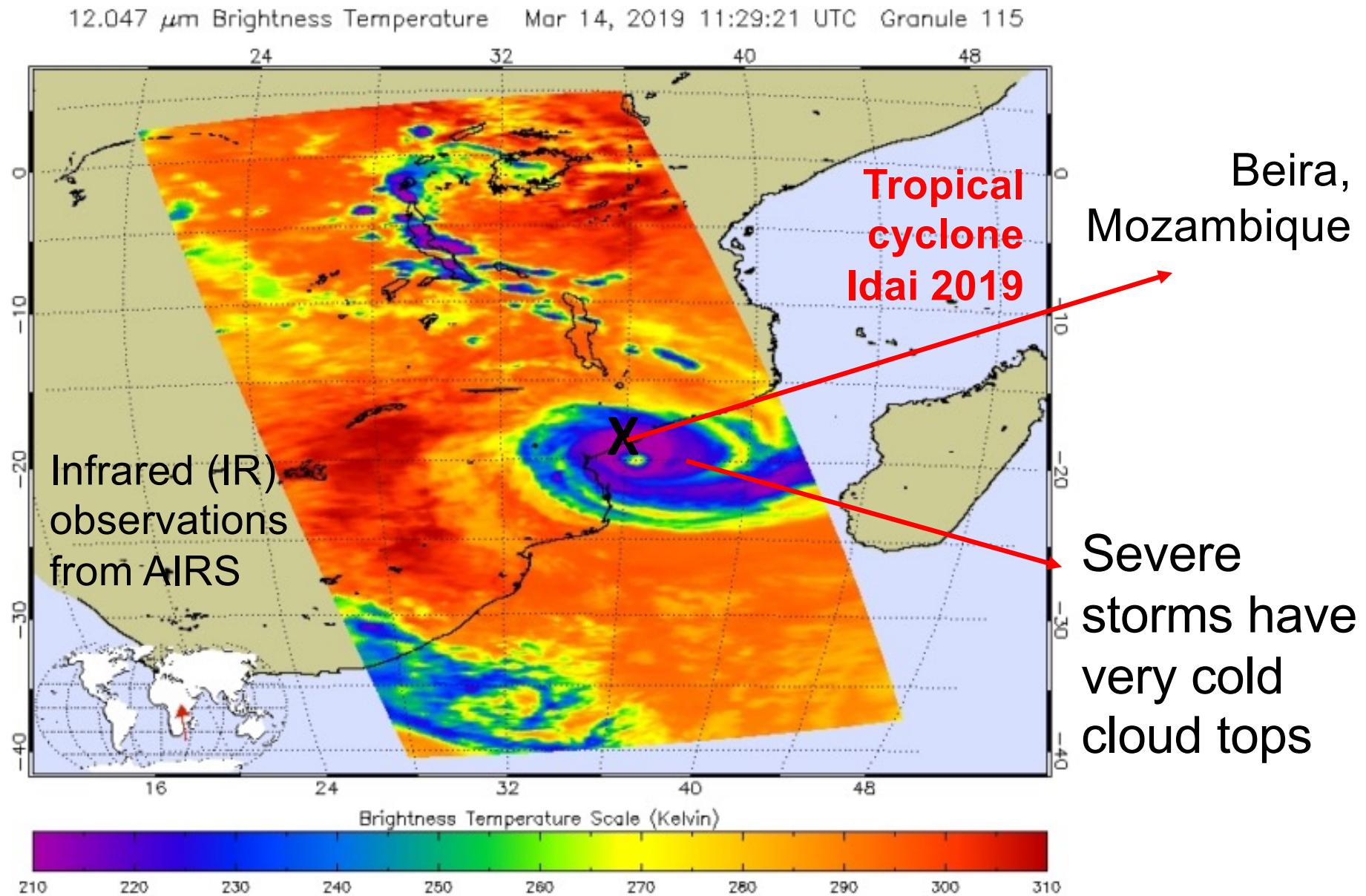
Long records allow to study several ENSO events and to better
understand the impacts of - and what controls - ENSO



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Severe Weather from Space: How Severe Storms Change with Climate

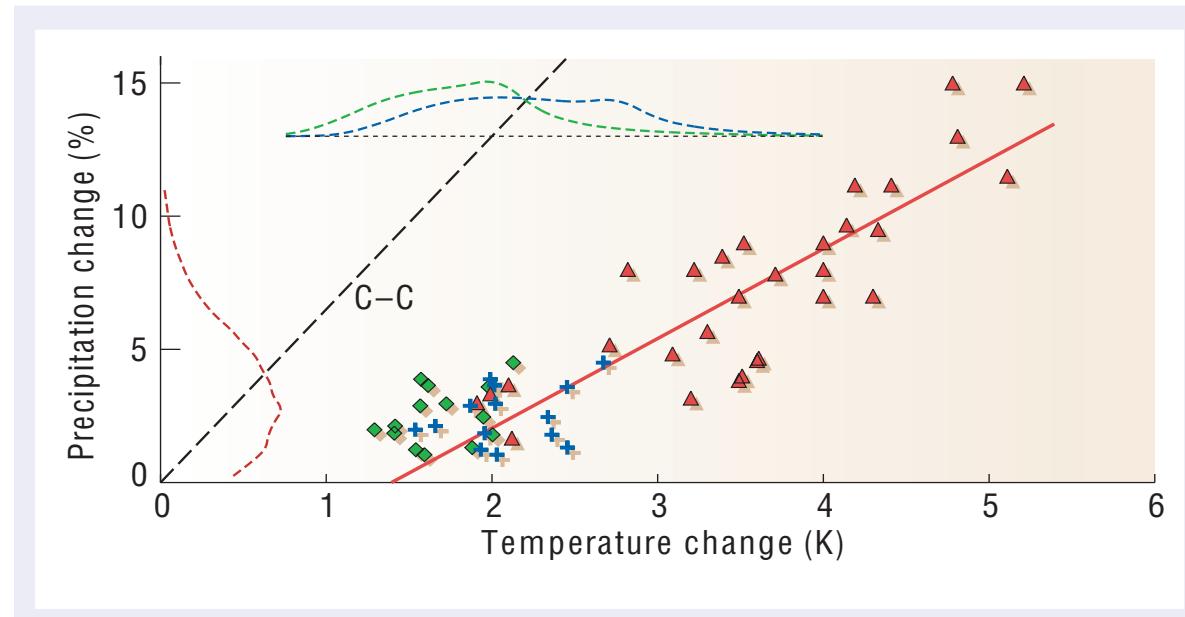




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Severe Weather and Climate

How do severe storms/precipitation change with climate?



Allen & Ingram,
Nature 2002

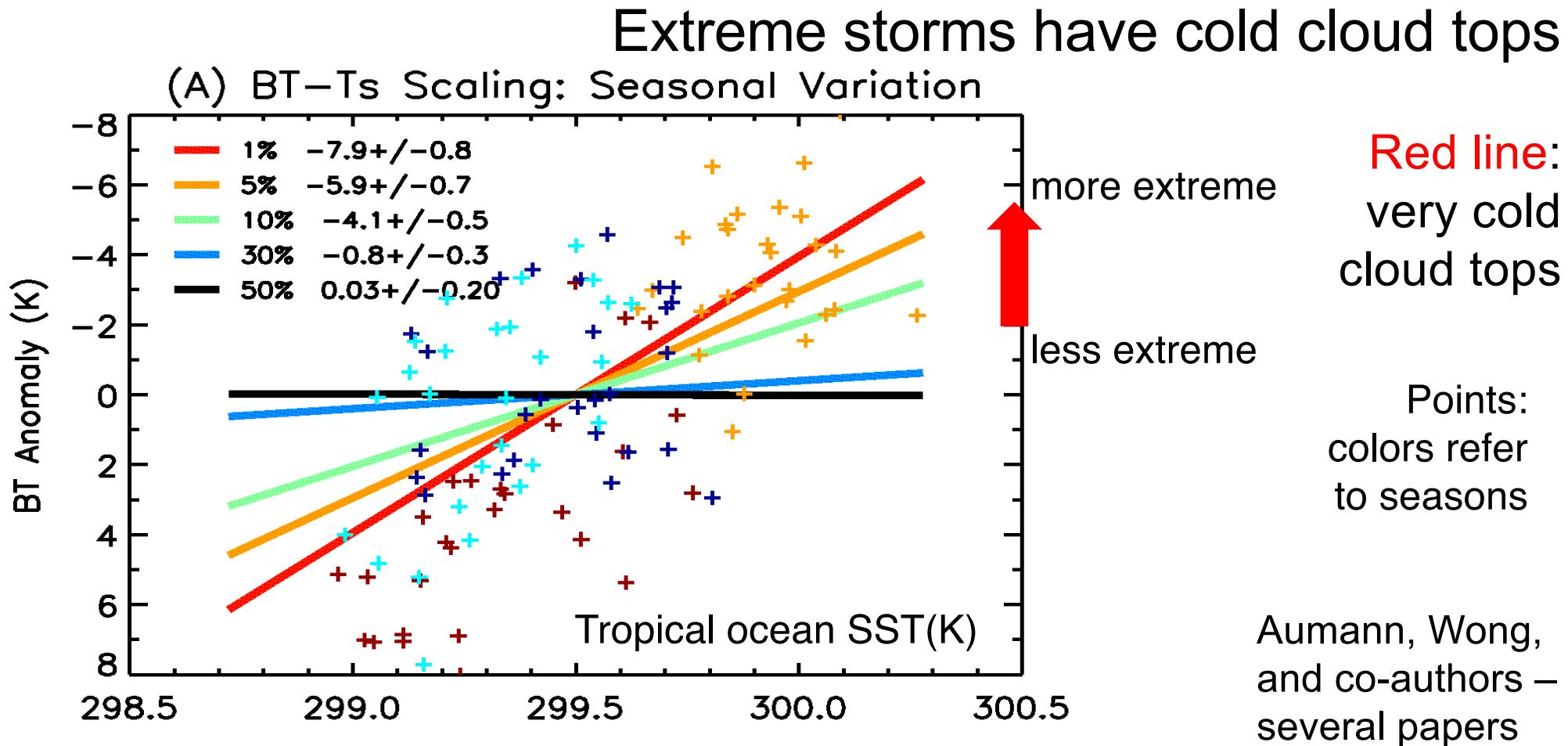
- Water vapor changes follow Clausius-Clapeyron ($\sim 7\%/\text{K}$)
[atmospheric RH \sim constant]
- Global mean precipitation much less than C-C ($\sim 2-3 \%\text{/K}$)
- Will extreme precipitation change much faster?



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AIRS radiances and Severe Weather



- Very cold cloud temperatures decrease fast with warmer ocean
- More severe storms increase faster with ocean temperatures
- Could imply significant future increase in severe storms



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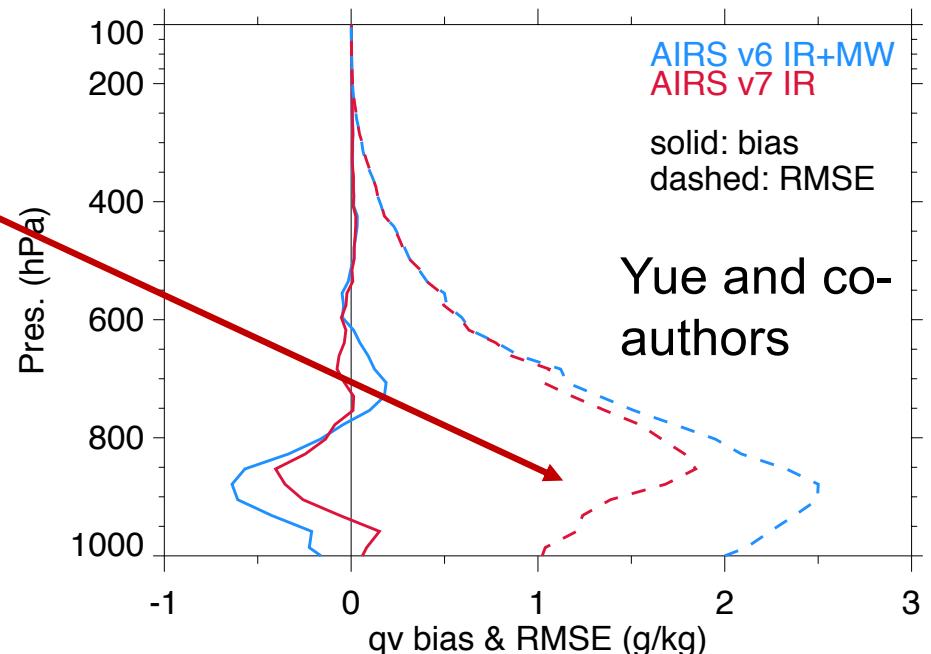
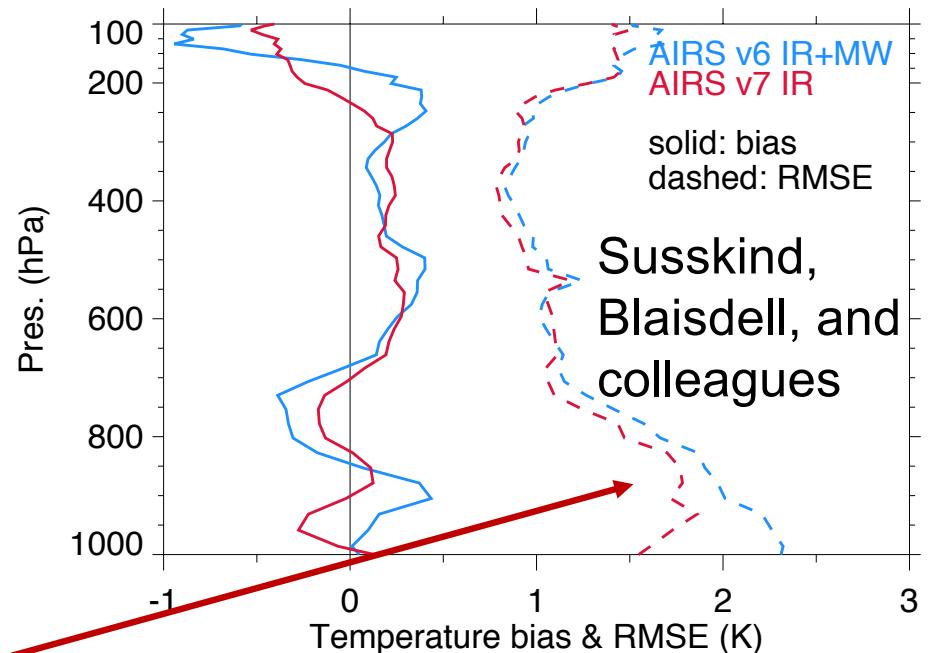
AIRS Version 7

AIRS version 7 L2 and L3 is publicly available at DAAC for full mission (since July 2020)

Evaluation against 500 sondes over subtropical Pacific (MAGIC campaign)

AIRS v7 improves temperature and water vapor retrievals in lower atmosphere (PBL)

AIRS single-footprint retrievals are being evaluated





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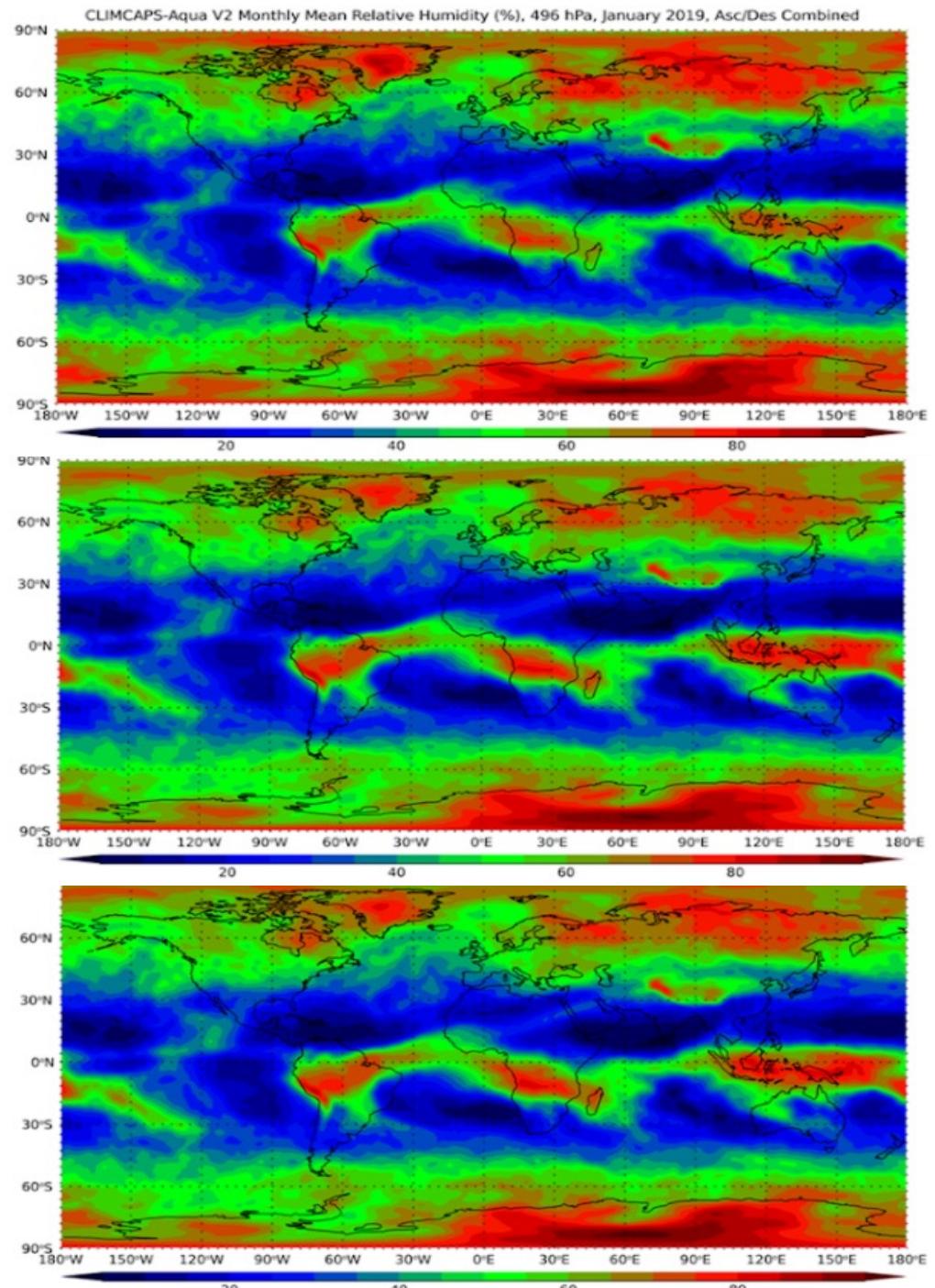
Unified Sounder Retrieval Algorithm

CLIMCAPS Aqua/AIRS has been
publicly released June 2021

CLIMCAPS uses radiances from all
sounders on Aqua, SNPP, and JPSS-
1/NOAA-20

Vertical profiles of temperature, water
vapor, trace gases, cloud and surface
properties

**Figure: Relative humidity (Jan. 2019) at
500 hPa from Aqua (IR-only), SNPP
and NOAA-20 satellites, from
CLIMCAPS (Smith and Barnet, 2020)**





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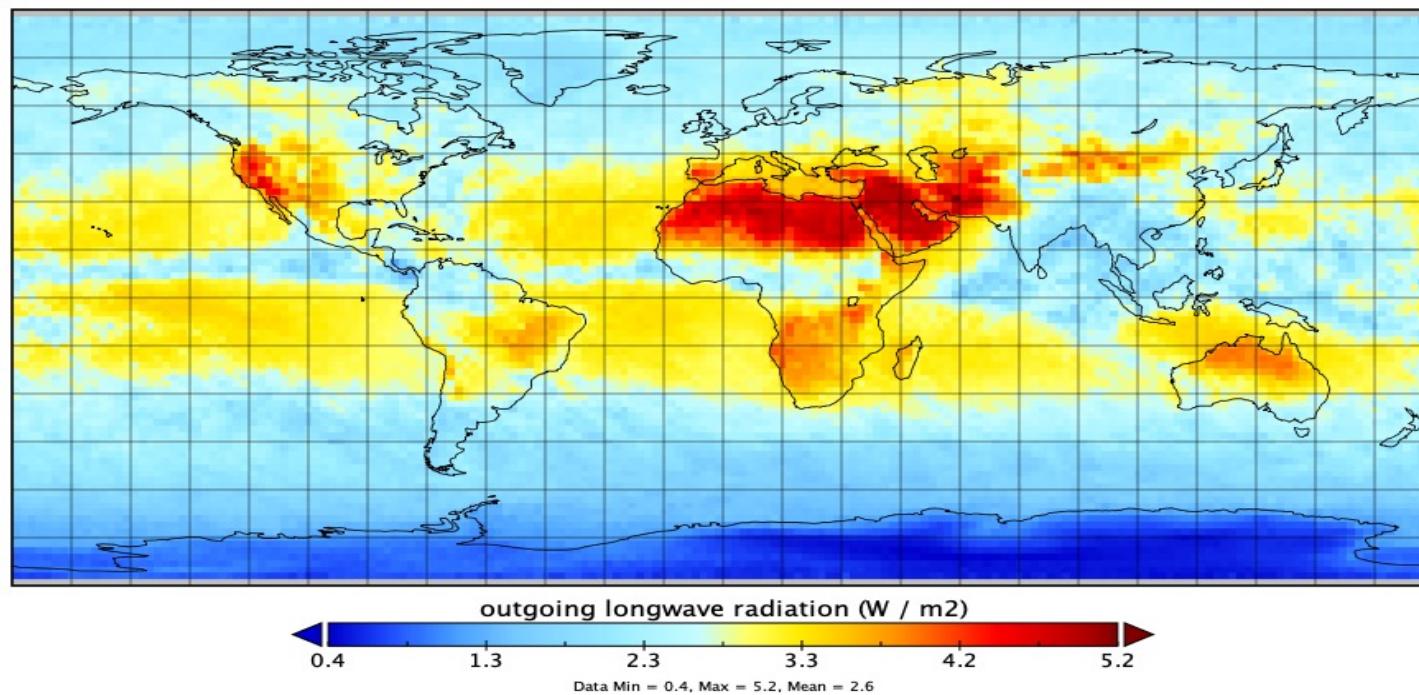
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AIRS Spectral OLR

New L3 monthly spectral outgoing longwave radiation (OLR) product (developed by Xianglei Huang et al, 2008, 2010, 2014):

- Spectrally resolved OLR, spatially gridded in $2^\circ \times 2^\circ$ grid cells
- Spectral flux at 10 cm^{-1} resolution
- Compared against CERES and re-analyses
- Contains information on trends in narrow bands
- Data record: 2002 – present

2004–07 Daytime 905 cm^{-1} outgoing longwave radiation

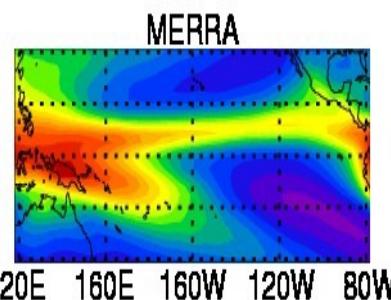
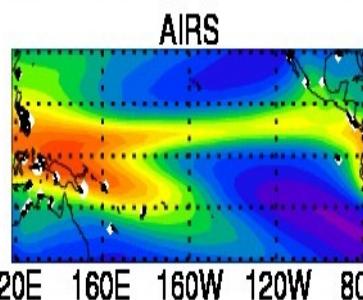
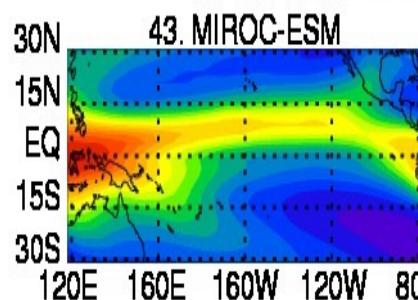
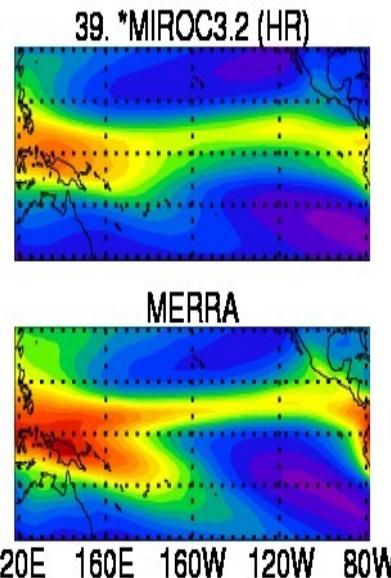
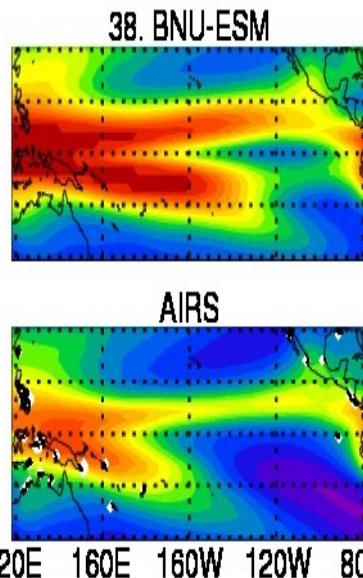
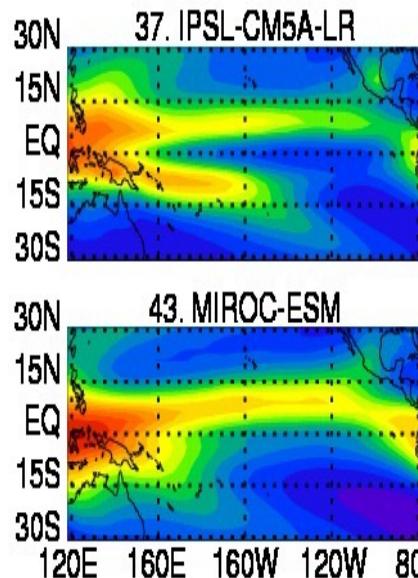
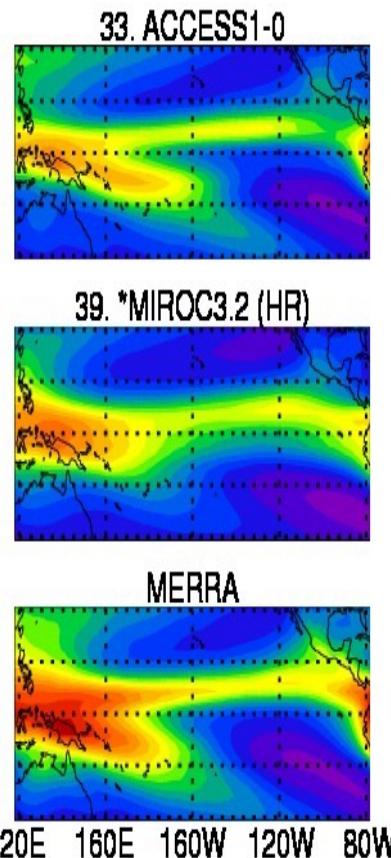
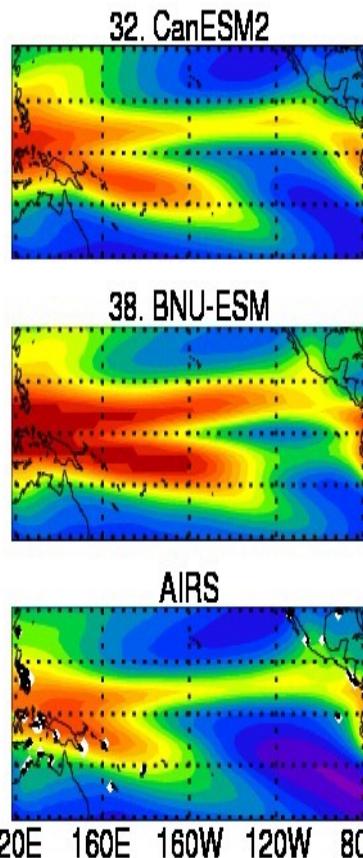
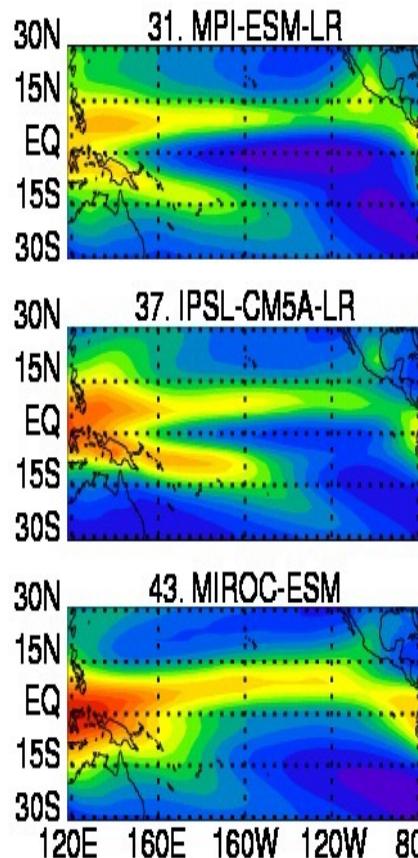




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AIRS and Climate Model Validation



500 hPa humidity from AIRS and CMIP climate models

AIRS data was used extensively to evaluate climate models from the latest Climate Model Intercomparison Project (CMIP6)

These models are the foundation for the most recent IPCC Assessment Report (AR6)

AIRS data and papers were cited numerous times in the latest IPCC



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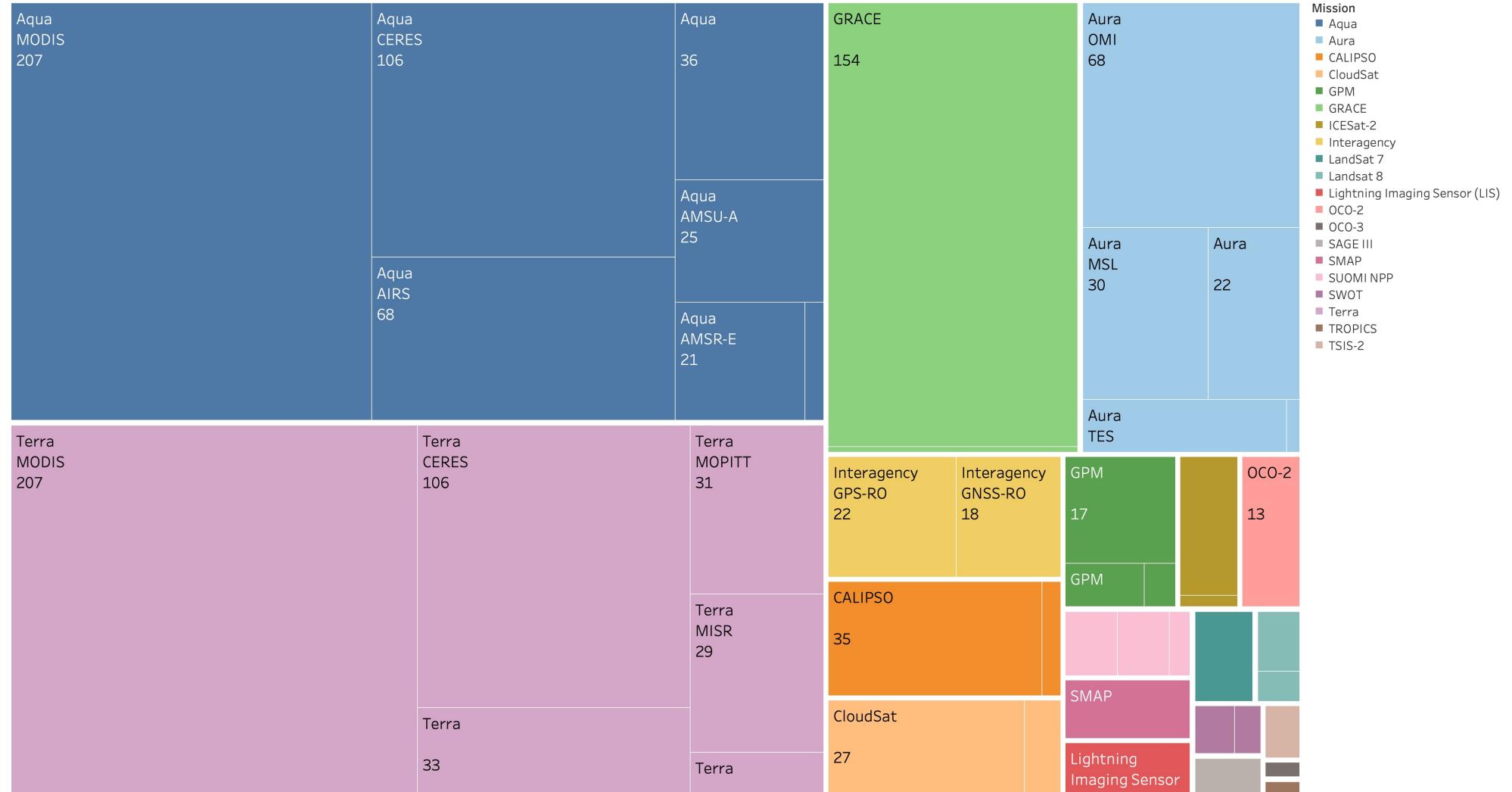
AIRS and IPCC

NASA Earth Observations

Mission and Instrument Counts From IPCC Report* Body and Reference Abstracts

Total Count: 1393

*IPCC 6th Assessment Report, Working Group I



Mission, Instrument and count of Mission. Color shows details about Mission. Size shows count of Mission. The marks are labeled by Mission, Instrument and count of Mission.

Courtesy of Hyon and colleagues

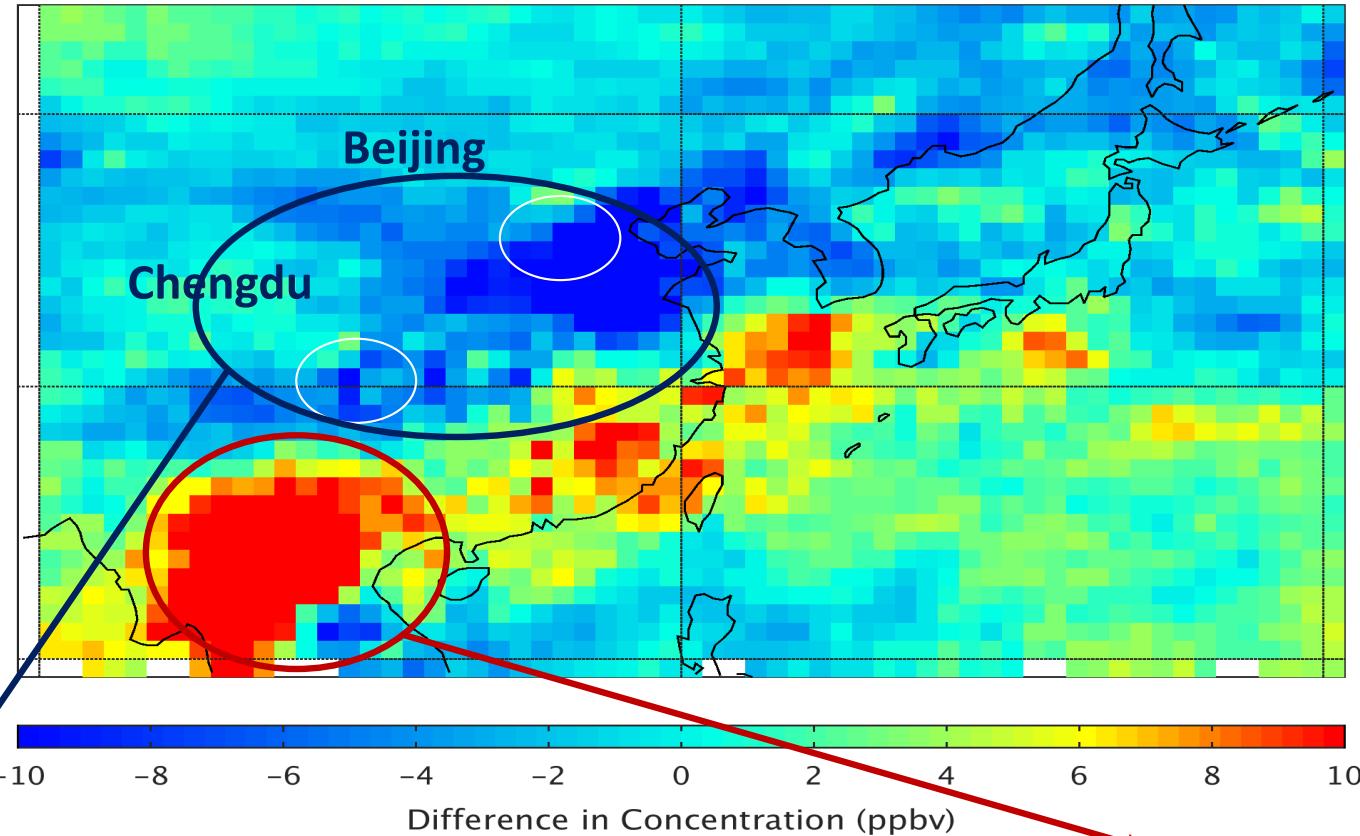


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AIRS CO and COVID-19: East Asia in Feb 2020

AIRS CO anomalies February 2020
Feb 2020 Daytime CO @ 500mb Anomaly [2003–2019]

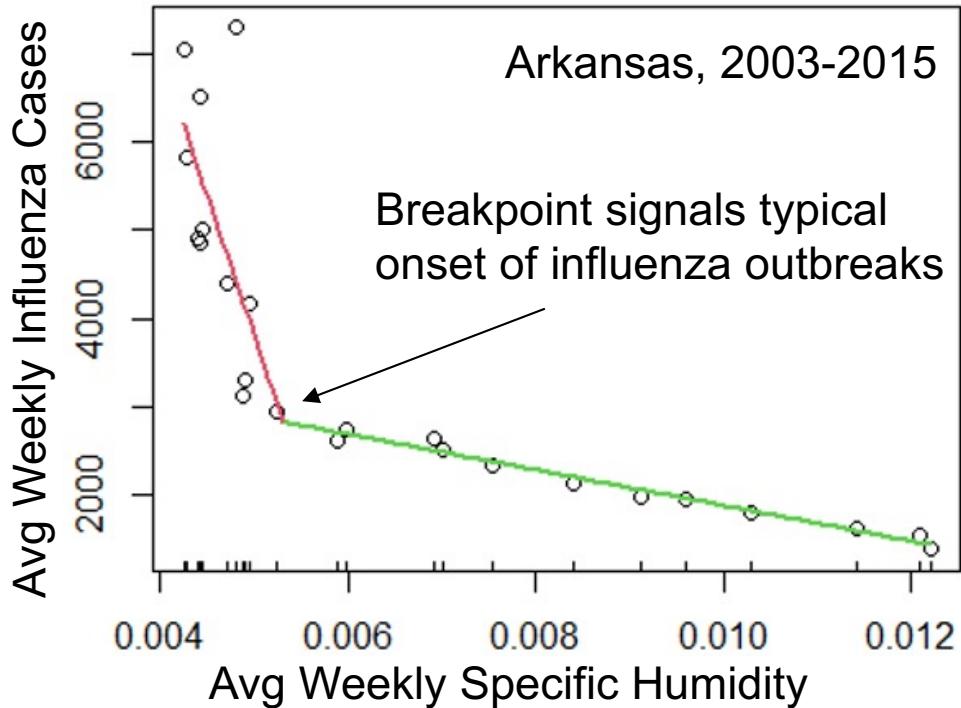


AIRS CO anomalies show impact of fires and COVID-19 lockdown

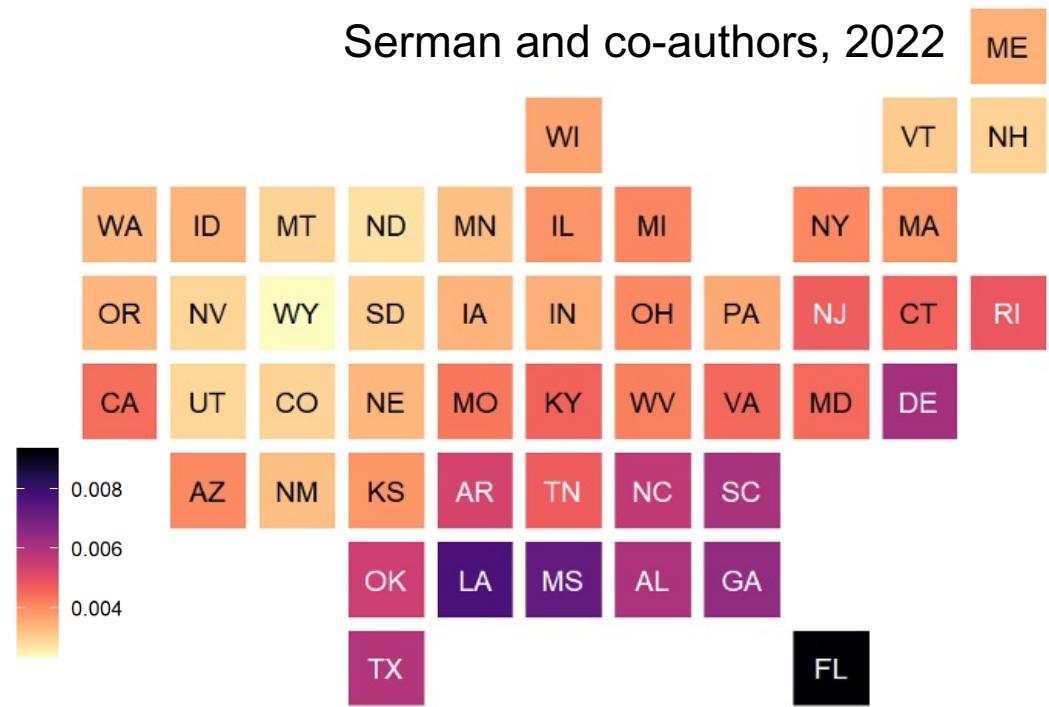


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AIRS, Humidity and Influenza



Serman and co-authors, 2022



State breakpoint estimates across US

Key points:

- Each state has an average weekly humidity breakpoint that signals influenza onset
- Linear relation between state humidity breakpoints and state annual average humidity



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L1 Stability and Continuity

Long (20 years) and remarkably stable record of AIRS hyperspectral radiances/brightness temperatures

AIRS record is long and stable enough to address key climate questions

Strow and DeSouza-Machado (Atmos Meas Tech, 2020):

- present a novel generic methodology to study L1 stability
- establish stability of AIRS blackbody and 100's of channels to $\sim 0 \pm 0.02$ K/decade using independent standards (e.g., CO₂, SST)

Continuity - Combining AIRS, CrIS, and IASI:
Climate Hyperspectral InfraRed Product (CHIRP)

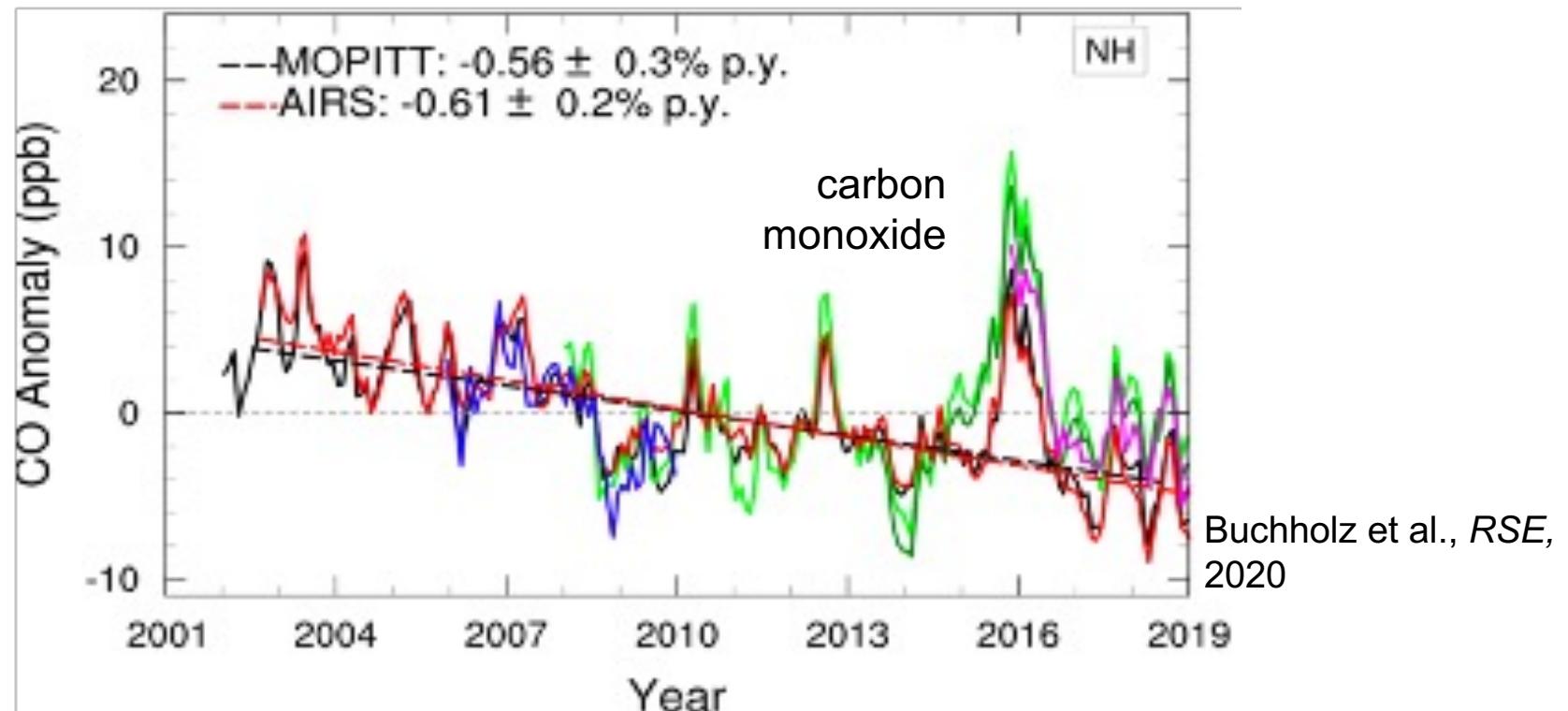
Consistent climate-level radiance time series spanning AIRS + CrIS



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Twenty Years of Climate Monitoring

With twenty years of accurate and stable observations, AIRS can monitor how the 21st Century climate is changing in a unique way



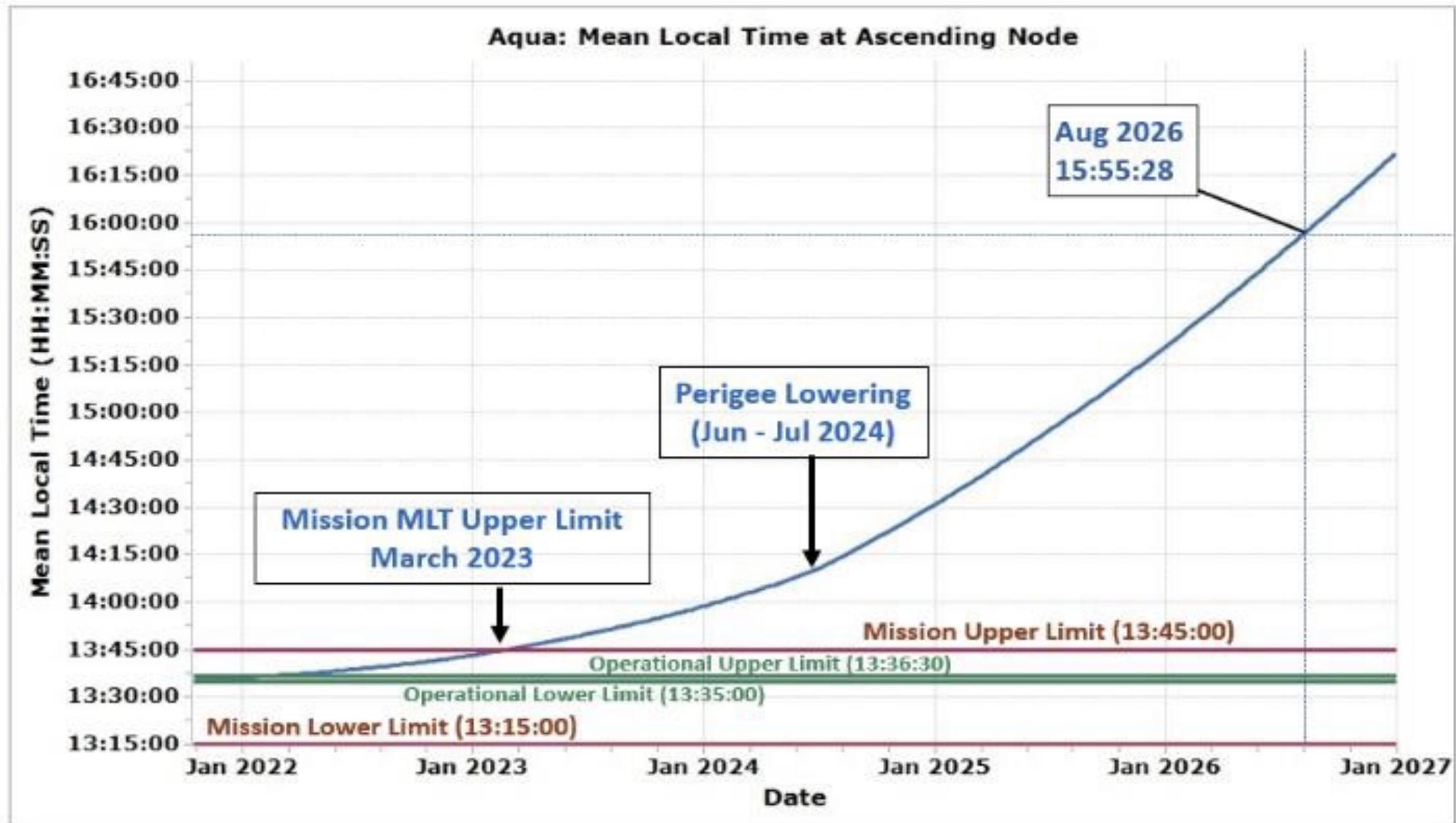
Monitoring carbon monoxide (CO) from space is critical to study the impact of fossil fuel burning and wildfires on atmospheric composition

AIRS is healthy and can continue to monitor climate change for several years



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Aqua: Mean Local Time



By late 2026 Aqua may not have enough power to operate



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Summary

- AIRS is 1st hyperspectral IR sounder and was launched in 2002
- Provides global daily observations of key atmospheric properties
- Climate monitoring of key properties (e.g., T, q, CO₂, CO, OLR, clouds)
- Critical to address key climate questions: e.g. How clouds and extreme weather change with climate; How Arctic responds to climate change.

Historical legacy of AIRS: Long (20 years) and remarkably stable record of AIRS hyperspectral radiances

Climate science requires ability to measure trends of order 0.1 K/decade

AIRS instrument trends/drifts are < 0.1 K/decade



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Future

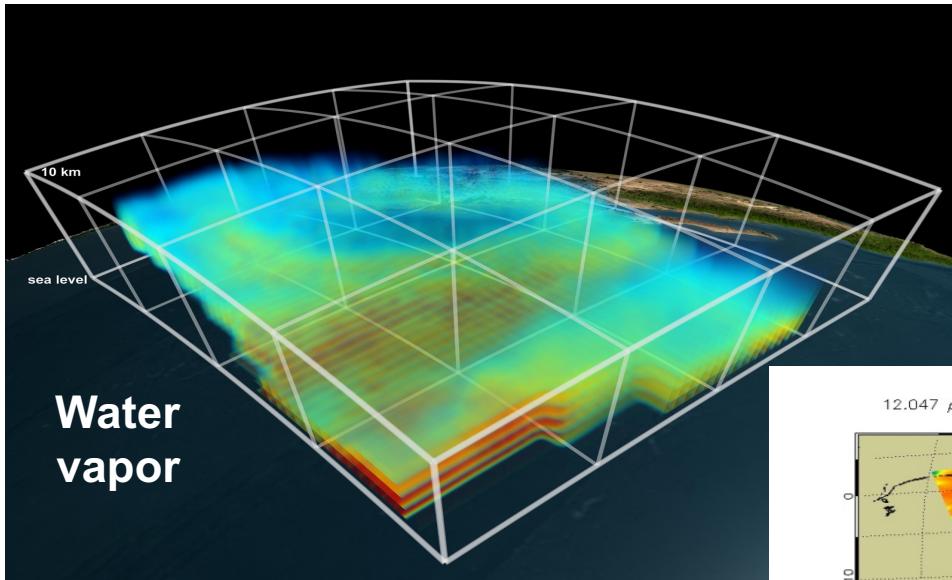
- Remarkably accurate and stable AIRS 20-year record is unique for climate monitoring: forcings, feedbacks, extremes
- Budget pressure on Aqua (EOS)
- Great excitement to use/assimilate AIRS at different times of day ➤ significant potential impact on weather forecasts
- AIRS/CrIS/(IASI) continuity: CHIRP, CLIMCAPS, others
- PBL: Decadal Survey Incubation Targeted Observable
- But nothing can replace a few more years of AIRS
- The best is yet to come



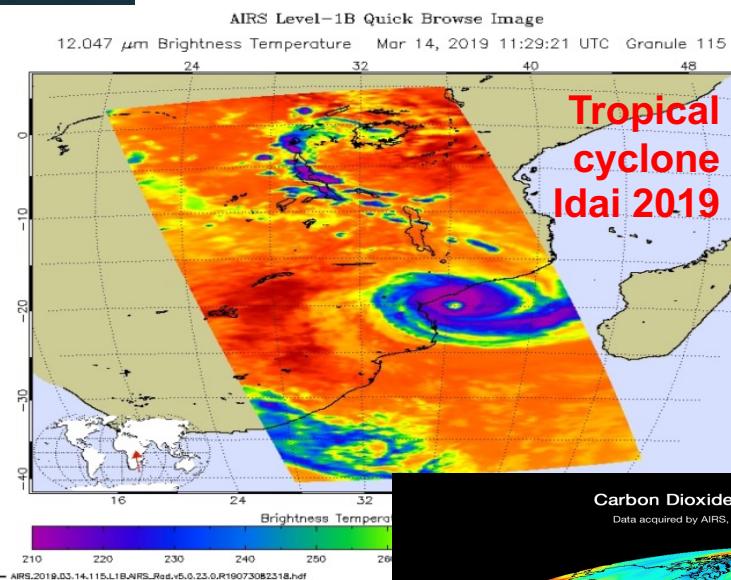
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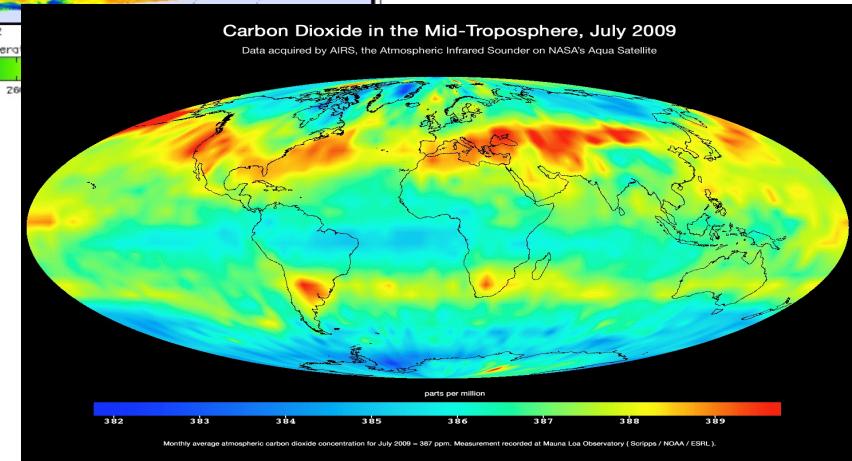
Atmospheric Infrared Sounder AIRS/AMSU/HSB



First measurements of the three-dimensional structure of temperature and water vapor from a global perspective



AIRS radically improved global weather forecasts



First maps of the global meandering of carbon dioxide