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A COMBINED ATMOSPHERIC WATER DATA SET FOR HYDROLOGY STUDIES

Eric J. Fetzer, M. Garay, Annmarie Eldering, William G. Read, Fredrick W. Irion, Bjorn H. Lambrigtsen, and Duane E. Waliser

Jet Propulsion Laboratory, California Institute of Technology

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Eric.J.Fetzer@jpl.nasa.gov

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Today's Topics

- **Our proposed work.**
- **Its relevance.**
- **Our approach.**
- **Some results to date.**

***Warning*: This talk is AIRS-centric because we have most experience with AIRS.**

Eric.J.Fetzer@jpl.nasa.gov

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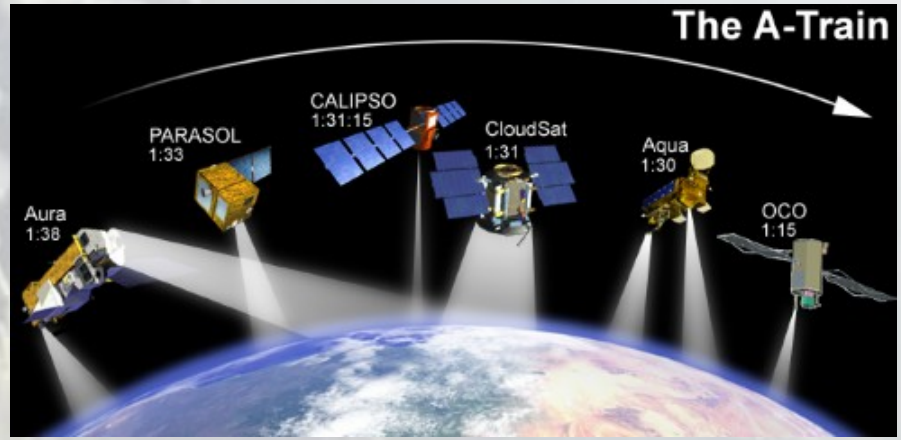
An A-Train Bestiary

- ***The A-Train*: formation-flying NASA satellites.**
- ***Several instruments measure atmospheric water substance*:**
  - ***Aqua:***
    - **AIRS** (Atmospheric Infrared Sounder)
    - **AMSR-E** (Advances Scanning Microwave Radiometer for EOS)
    - **MODIS** (Moderate Resolution Imaging Spectroradiometer)
  - ***Aura:***
    - **EOS MLS** (Microwave Limb Sounder)
  - ***CloudSat/Calypso***
    - CloudSat radar
    - Calypso lidar
  - ***Others:***
    - **CERES, TES, AMSU-B**.



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Our Proposed Work

- ***A combined atmospheric water data set from the A-Train*.**
  - ***Includes:***
    - ***Temperature*** from AIRS.
    - ***Water vapor*** from AIRS, MLS, AMSR-E and MODIS.
    - ***Cloud top properties*** from AIRS, MODIS and CloudSat/Calypso.
    - ***Cloud liquid quantities*** from AMSR-E, MODIS and CloudSat.
    - ***Cloud ice quantities*** from MLS, CloudSat and AMSU-B on NOAA 16.
- **Features:**
  - ***Preserves instantaneous relationships between quantities along the orbit track.***
  - ***One-stop shopping for a variety of A-Train quantities.***
  - ***Place on a common, nested grid.***
  - ***Five-year time frame.***

Eric.J.Fetzer@jpl.nasa.gov

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Goals

- **This work is supported the NASA Energy and Water-cycle Study (NEWS) program.**
- **We serve the modelling and analysis communities through directed research and collaboration.**
- **Paraphasing NEWS goals:**
  - ***The ultimate goal of NEWS is a breakthrough improvement in the nation's energy and water cycle prediction capability.***
  - ***Prediction systems...to quantify the hydrologic consequences of climate change and produce useful seasonal and longer-range hydrologic predictions...based on observed initial values and changing boundary conditions.***

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Good News / Bad News

- **Good News:**
  - ***The A-Train instruments provide nearly instantaneous, redundant observations.***
  - ***Instrument teams have broad knowledge.***

- **~~Bad News~~ Challenges:**
  - ***Many observations are difficult to validate.***
  - ***A-Train instruments are not co-registered.***
  - ***Some data sets are very large and complex.***
  - ***Retrieval rrors are often poorly characterized.***
  - ***Scientific potential of individual data sets not fully realized.***

Eric.J.Fetzer@jpl.nasa.gov

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Addressing the Challenges

- ***Through collaborations*:**
  - ***With instrument teams.***
  - ***With scientist using A-Train data sets.***
    - Process studies are critical to understanding the data.

- ***Through NEWS-directed analyses*. Intercompare similar quantities (where possible) to help constrain uncertainties. Completed and ongoing analyses:**
  - ***Total water vapor from AIRS and AMSR-E.***
  - ***Total water vapor from AIRS and MODIS.***
  - ***Cloud top properties from AIRS and MODIS.***
  - ***Upper tropospheric quantities from AIRS and MLS.***

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One Example: AIRS - AMSR-E Total Precipitable Water Vapor

- **From two instruments on Aqua**
  - ***Differing sensitivity to clouds***
    - *AIRS retrieval effective up to ~80% IR cloud fraction*
    - *AMSR-E 'sees' through non-precipitating clouds*
- **Two objectives:**
  1. ***Biases as a function of AIRS retrieved cloud amount***
  2. ***Global biases in climatologies. Important implications for AIRS height-resolved water vapor.***

- **Results currently in press:** **Fetzer et al. 2006: Biases in total precipitable water vapor climatologies from AIRS and AMSR-E, Accepted, *J. Geophys. Res.***

Eric.J.Fetzer@jpl.nasa.gov

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AIRS and AMSR-E total water vapor

Good agreement for *matched* observations

Consistency implies both systems work well.

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

(<AIRS> - <AMSR-E>) / <AMSR-E>; < > == Time Mean

with HSB

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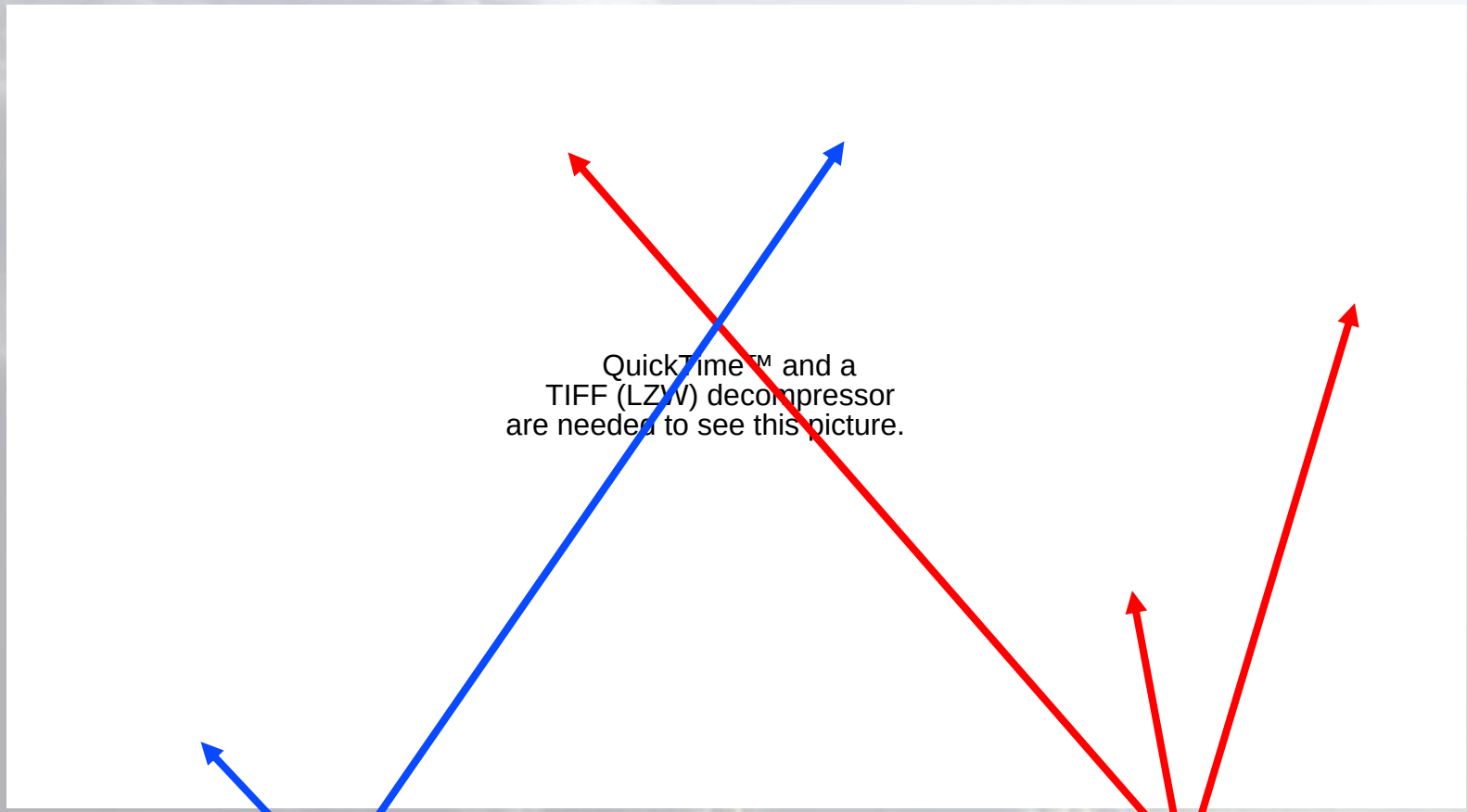
Full AIRS & AMSR-E climatologies

AIRS can be drier OR wetter

because of cloud-induced sampling effects



AIRS climatology is *drier* than AMSR-E at high latitudes

AIRS climatology is *wetter* than AMSR-E in stratus

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AIRS - AMSR-E Comparison: Summary and Conclusions

- **Biases in their climatologies for two reasons:**
  1. **Slight *moist* bias in AIRS due to loss of HSB**
  2. ***Cloud effects can lead to wet or dry sampling biases in AIRS***
     - **AIRS dry in mid- and high-latitude storms by 20-30%.**
     - **AIRS wet in stratus regions by 15% (subtropics) to 60% (cold air outbreaks).**
     - **AIRS unbiased throughout tropics and non-stratus subtropics**

- ***The CrIMSS system on NPOESS will have similar sampling issues.***

Eric.J.Fetzer@jpl.nasa.gov

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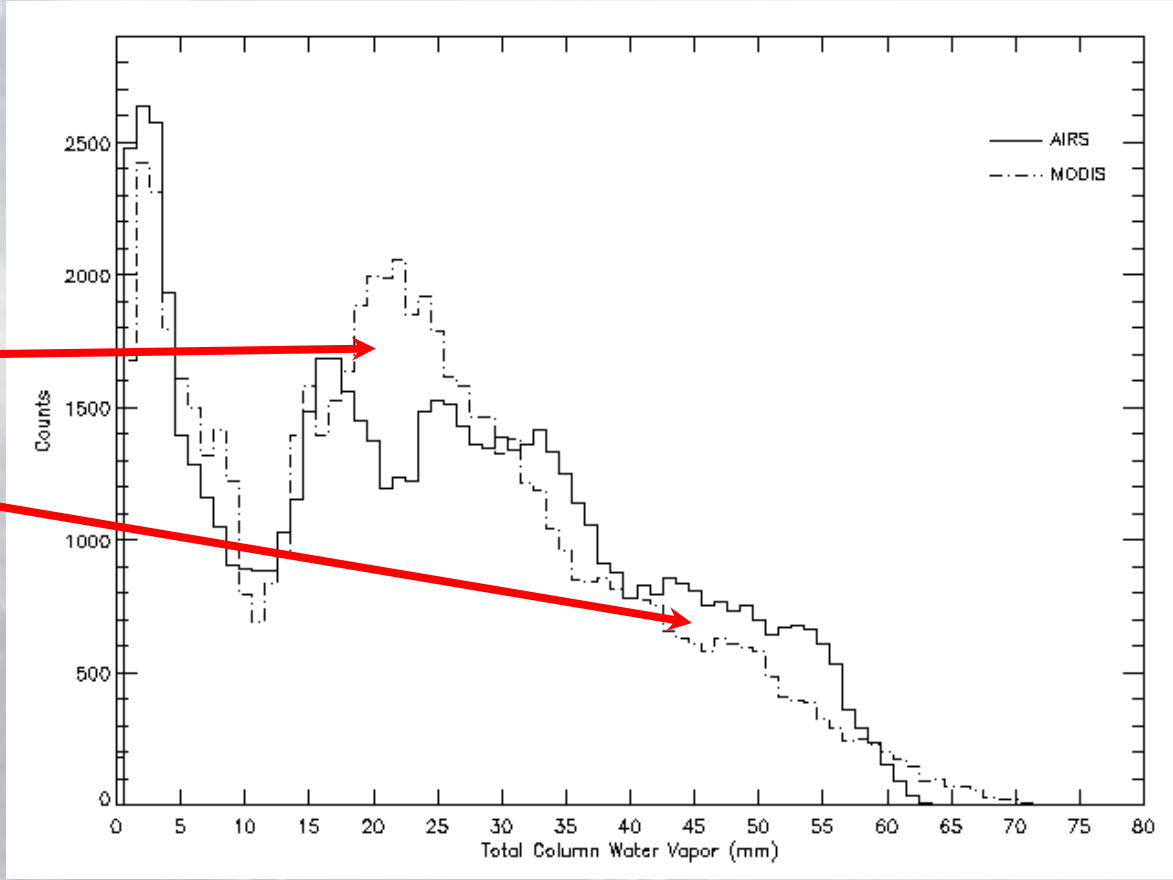
AIRS and MODIS total water vapor Global comparison, one day

Note: **We do *not* see similar discrepancies in the AIRS-AMSR-E comparison**



FROM: **M. Garay et al. Preliminary comparison of precipitable water vapor measurements from AIRS and MODIS on the Aqua satellite, in preparation.**

Eric.J.Fetzer@jpl.nasa.gov

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Other Intercomparison Studies

- ***Brian Kahn: AIRS and MODIS Cloud Top Properties***

- ***Bill Read and Eric Fetzer: AIRS and MLS upper tropospheric properties.***

Eric.J.Fetzer@jpl.nasa.gov

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Comparing AIRS and MLS upper tropospheric water vapor

- **Preliminary results:**
  - ***See** Froidevaux, L, N. et al., 2006: Early validation analyses of atmospheric profiles from EOS MLS on the Aura satellite. Accepted, IEEE Transactions Geosciences and Remote Sensing.*
    - 316 hPa: AIRS 25% drier,
    - 215 hPa: AIRS 3% wetter
    - 147 hPa: AIRS 12% wetter

Eric.J.Fetzer@jpl.nasa.gov

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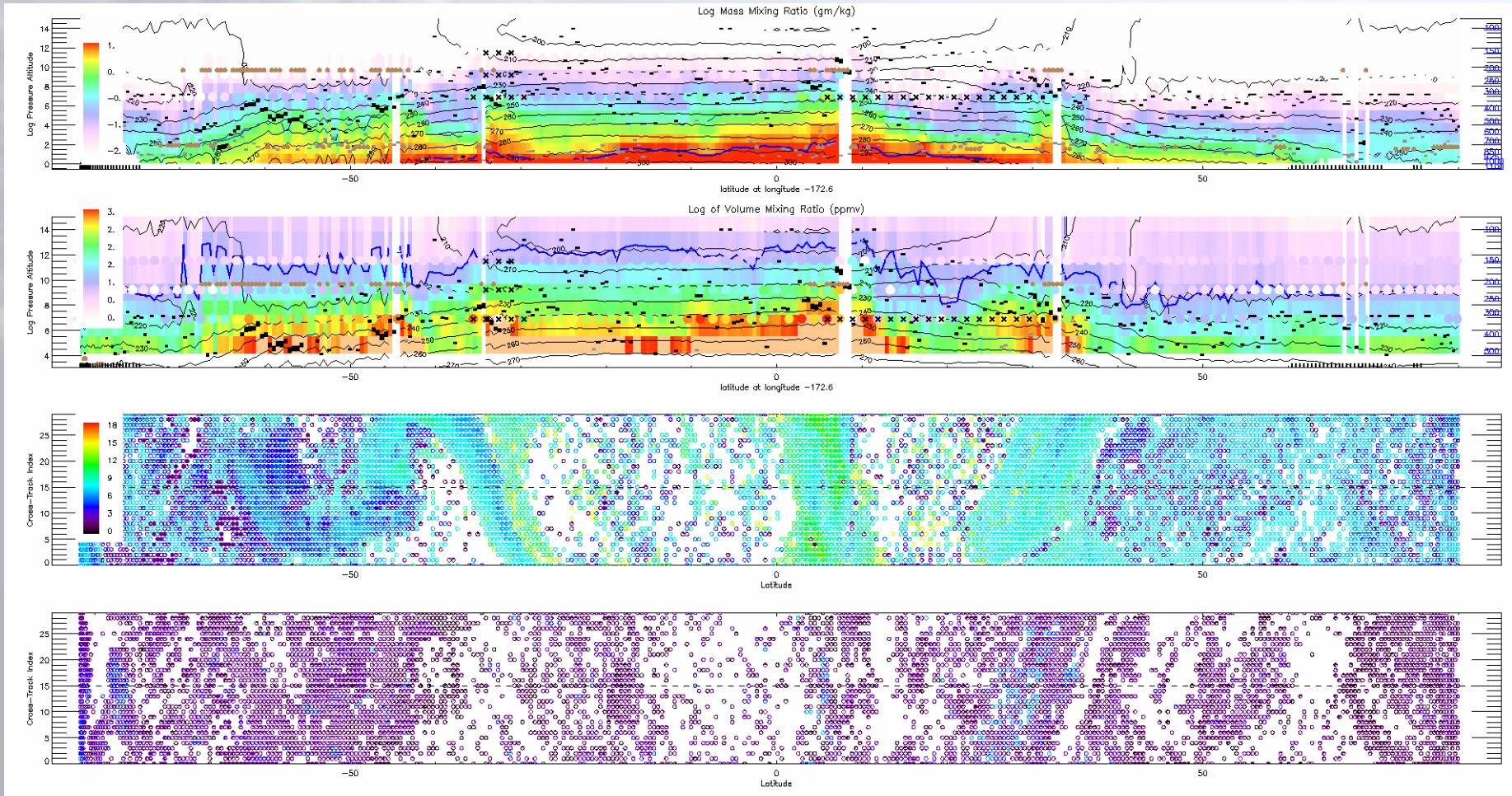
Digging Deeper:
Plot AIRS and MLS variables over half orbits



Top: AIRS and MLS water vapor, clouds, temperature, quality flags for a half orbit
Bottom: AIRS cloud top height and fraction.

Eric.J.Fetzer@jpl.nasa.gov

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Pasadena, California

Posing some *preliminary* hypotheses about AIRS and MLS upper trop. water vapor

- ***Both AIRS and MLS are susceptible to cloud effects***
  - ***Different geometries and radiative transfer***
    - Limb *versus* nadir sounding
    - Ice scatter of microwaves for MLS; ice/liquid attenuation in IR for AIRS.
  - ***But:***
    - The data sets *probably* contain some complementary information.
    - Analyses more complicated than AIRS-AMSR-E total water vapor.

  - ***Important implications for combined cloud and humidity climatologies.***

Eric.J.Fetzer@jpl.nasa.gov

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Some Other Preliminary Conclusions

- **AIRS appears insensitive to water vapor at 300 hPa over winter poles, at 150 hPa in tropics.**

  ⇒ ***Use MLS only in some regions.***

- **AIRS may be better able to sound through moderately thick ice clouds.**

  ⇒ ***Use AIRS only in some regions.***

Eric.J.Fetzer@jpl.nasa.gov

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California Institute of Technology
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Scientific Analyses

- ***Process***

Eric.J.Fetzer@jpl.nasa.gov

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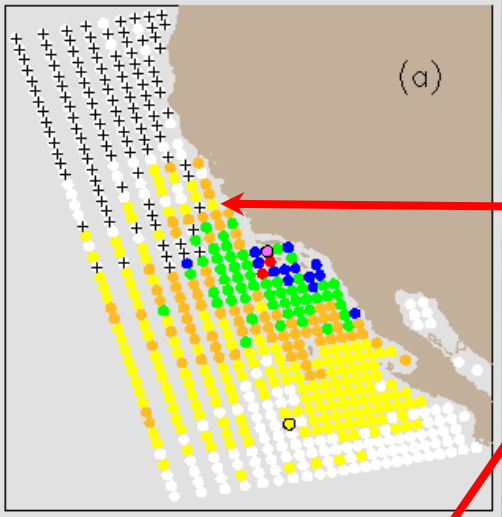
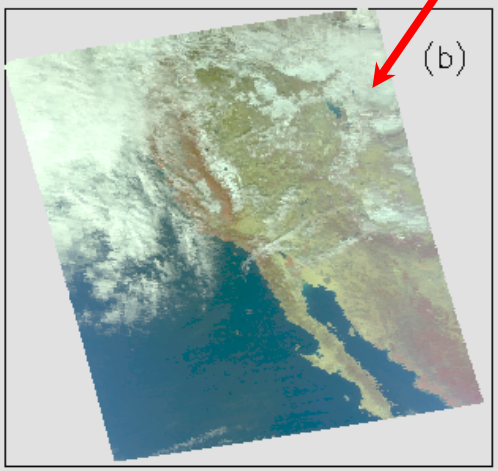
AIRS Detection of Near-Surface Temperature Inversions

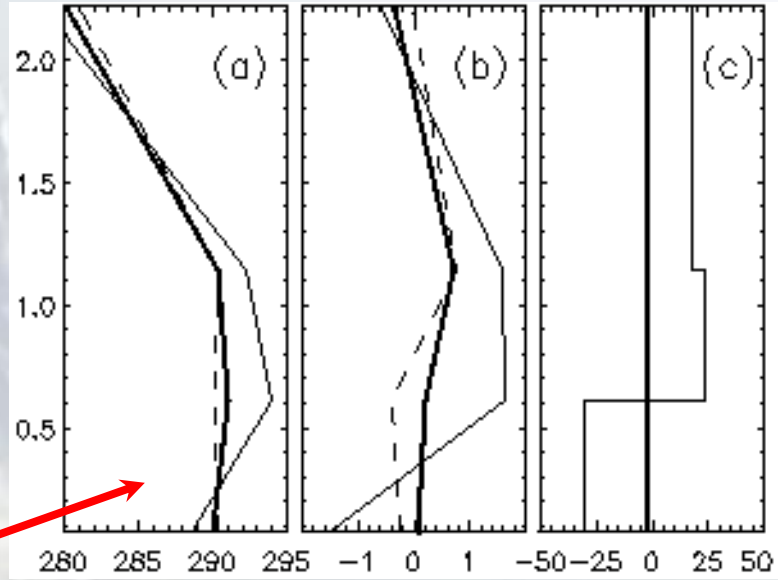




Inversion locations- even under clouds

The Vis/NIR image

Mean T and q vs. ECMWF



See:

E. Fetzer, J. Teixeira, E. Olsen, and E. Fishbein, 2004, Satellite remote sounding of atmospheric boundary layer temperature inversions over the subtropical eastern Pacific, *Geophys. Res. Lett.*, vol. 31, L17102, doi:10.1029/2004GL020174.

Eric.J.Fetzer@jpl.nasa.gov

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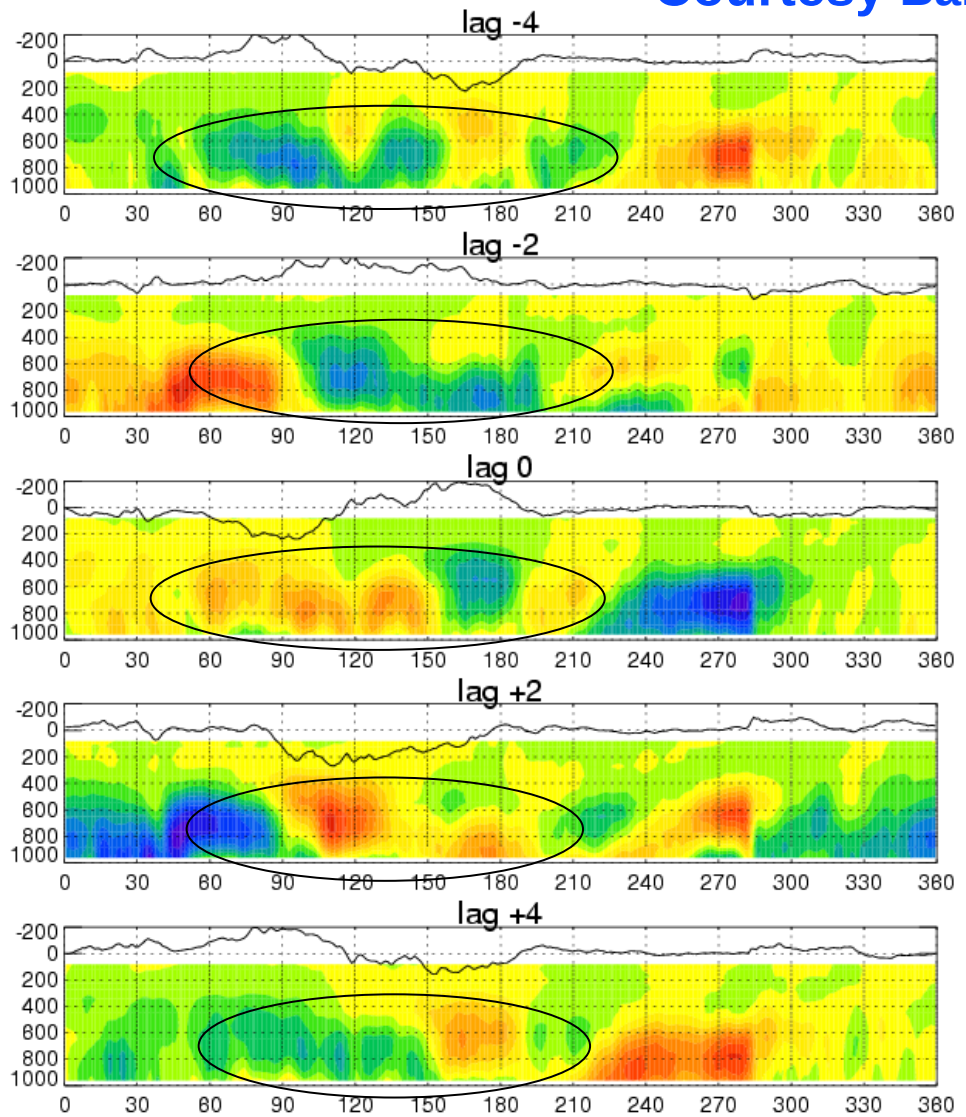
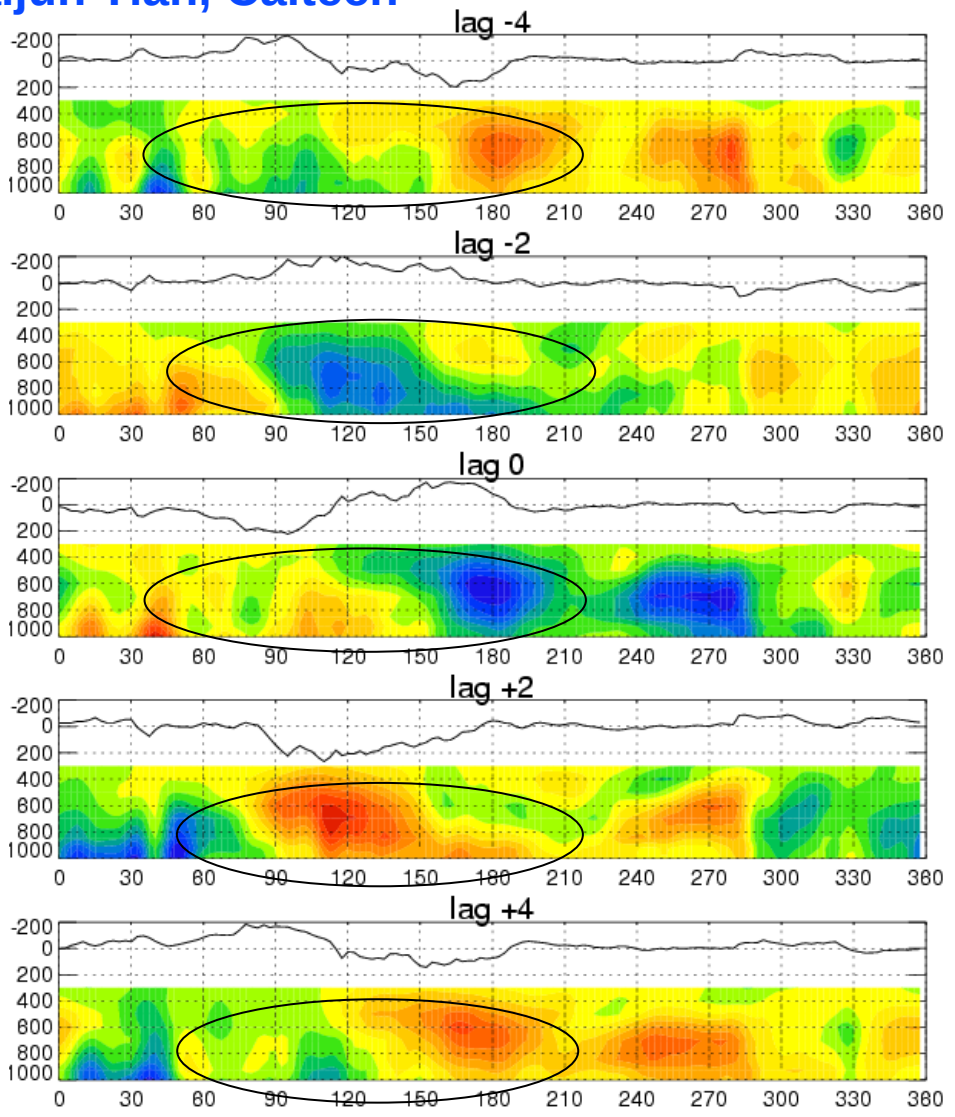
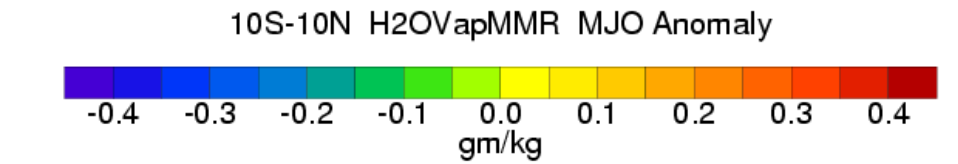
Madden-Julian Oscillation

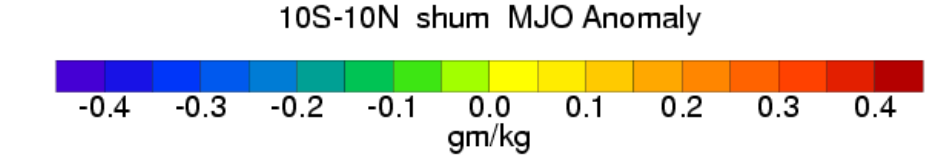
Courtesy Baijun Tian, Caltech

AIRS L3 **NCEP**









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Summary

The AIRS temperature and water products are useful for scientific analyses. See:

Fetzer, E. J., et al., Satellite remote sounding of atmospheric boundary layer temperature inversions over the subtropical eastern Pacific, *Geophys. Res. Lett.*, vol. 31, L17102, doi:10.1029/2004GL020174, 2004.

Gettelman, A., et al., 2004, Validation of satellite data in the upper troposphere and lower stratosphere with in-situ aircraft instruments. *Geophys. Res. Lett.*, vol. 31, L22107, doi:10.1029/2004GL020730.

Tian, B., et al., MJO climatologies in AIRS and NCEP. Manuscript in review, JAS.

Two additional manuscripts by Gettelman et al. on AIRS relative humidity.

Eric.J.Fetzer@jpl.nasa.gov