SSM/T2 and MOZAIC: Bringing Together Satellite and Aircraft Long-Term UTH Measurements

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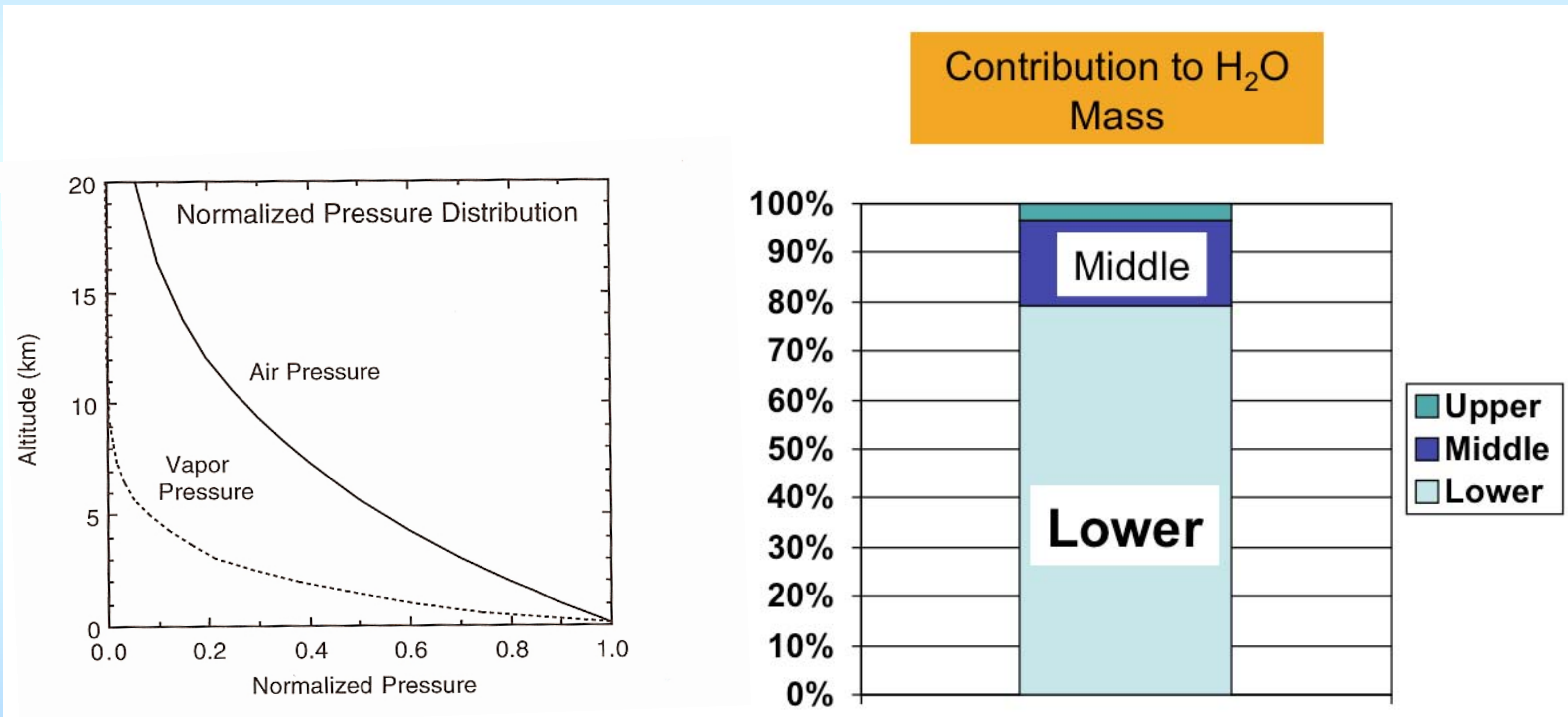
Background

Upper-tropospheric humidity (UTH)



Upper: 500-200 hPa; Middle: 700-500 hPa; Lower: 1000-700 hPa

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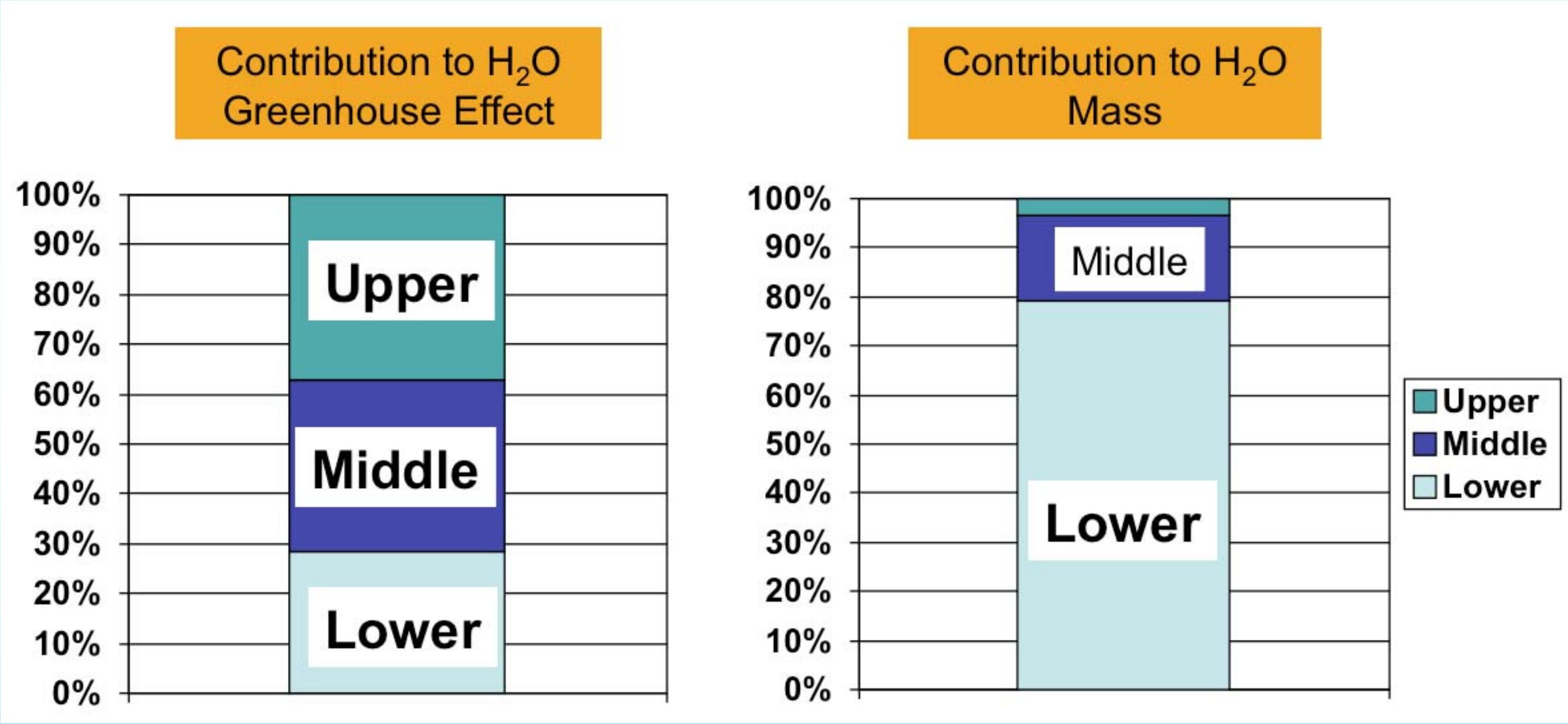


Upper: 500-200 hPa; Middle: 700-500 hPa; Lower: 1000-700 hPa

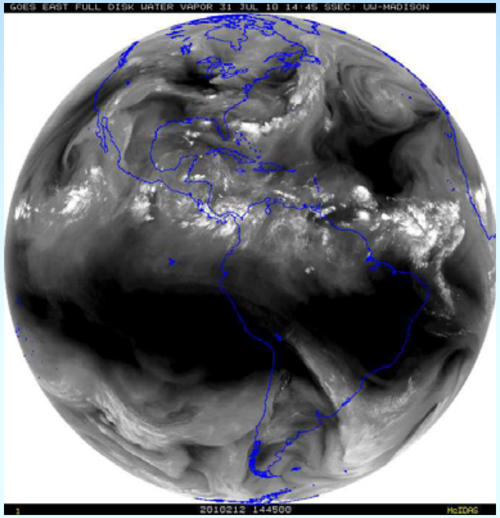
Outline

- Project goal & approach
- Initial results (June 2010-Feb 2011)
- Issues
- Next step
- Asking community for feedbacks

Goal: "…bring together all the UTH-related radiance data from multiple satellites and process them to establish a long-term, global, inter-calibrated radiance record from which UTH can be retrieved and UTH research can be conducted."

UTH-related radiances

- Water vapor imagery (6.5 μm)

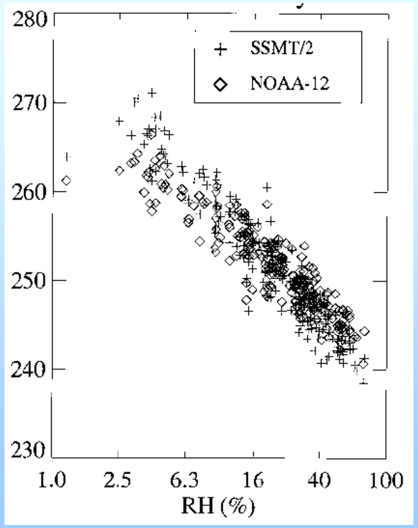


Soden & Bretherton (1993) was the first to provide an easy-to-understand interpretation of the satellite water vapor radiance, popularizing the use the UTH radiances in a broader community (e.g., GCM community).

$$a + bTB = \ln(< RH >)$$

- HIRS has a similar water vapor channel (ch12)

- Also, SSM/T2, AMSU-B, MHS have the 183-GHz channel that has similar sensitivity to UTH



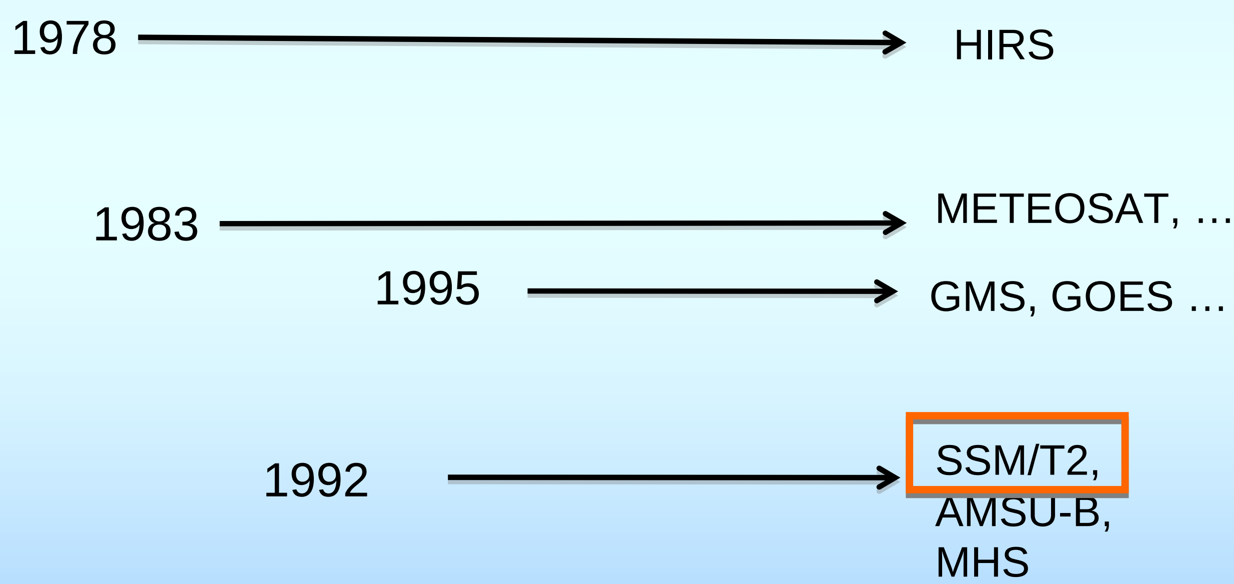
Berg et al. 1999

Overview

Goal: "…bring together all the UTH-related radiance data from multiple satellites and process them to establish a long-term, global, inter-calibrated radiance record from which UTH can be retrieved and UTH research can be conducted."

Source Data

- (6.7 μm) HIRS ch12 on LEOs
- (6.3-6.5 μm): water vapor channel on GEOs
- (~183 GHz): SSM/T2, SSMIS, AMSU-B, and MHS



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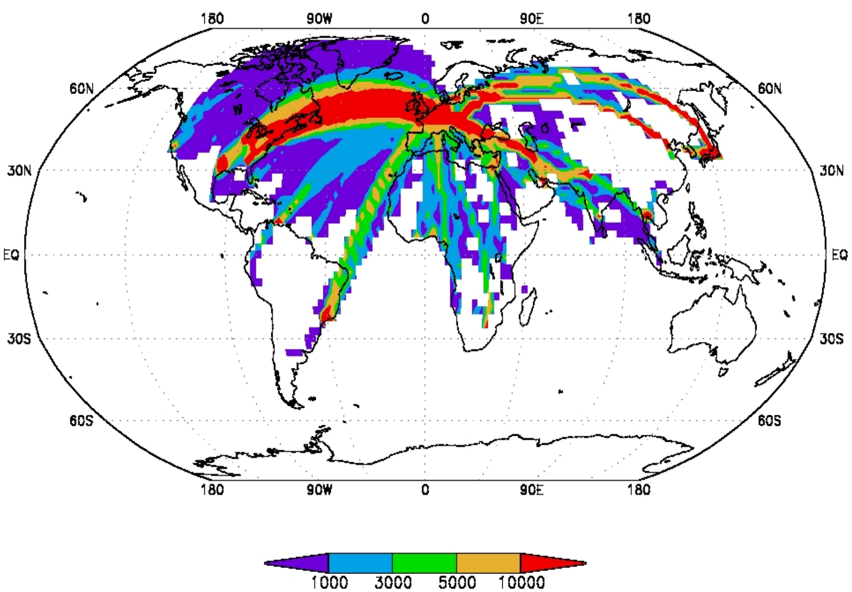
MOZAIC Project:

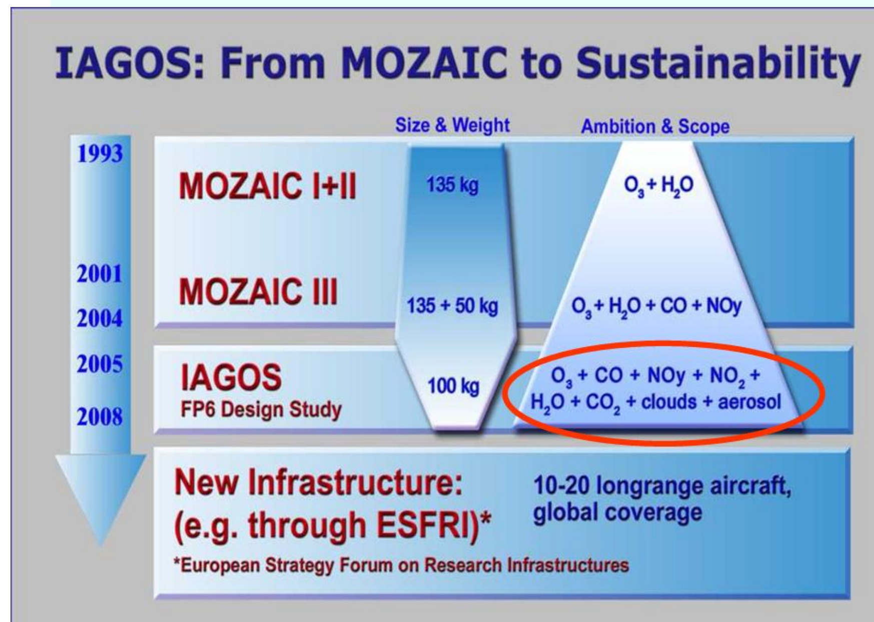
Founded by the EU in 1993;

Operational since 08/94 with ~ 2500 flights/yr (this number is increasing)

RH ~ 5% accuracy

Measurement of Ozone and Water Vapour by Airbus In-Service Aircraft (MOZAIC)





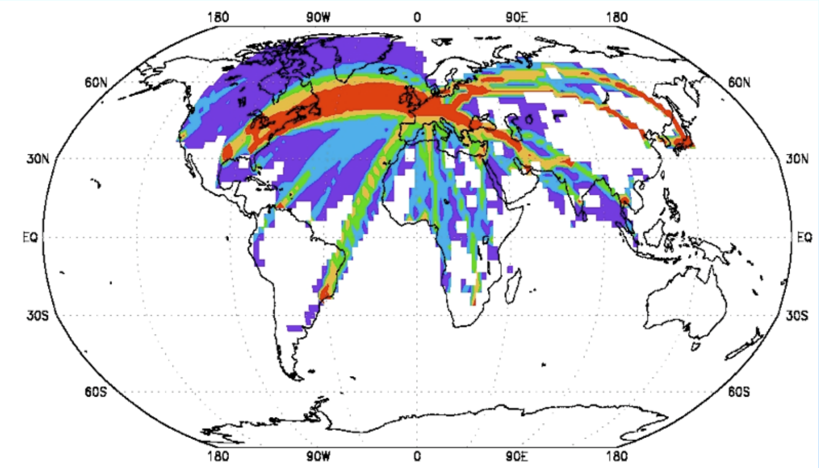
Proposed Approaches

1. Use MOZAIC measurements as an independent and accurate calibration anchor to inter-calibrate UTH-related radiances, starting from MW and extending to IR.

2. Compare this new calibration method with existing approaches (**e.g., SNO**)

$$a + bTB = \ln(< RH >)$$

The RH-TB relation is the basis for the calibration.



Proposed Approaches (cont'd)

3. Label each IR/MW UTH radiance with cloud information from ISCCP *(cloud-cleared radiances are used for calibration, but for the final product, we will retain all radiances that are labeled with cloud information).*

Wu et al. (1993) & Bates et al. (1996) showed that cloud clearing is the dominant source of uncertainties in IR UTH radiances.

Cloud contamination is less of a problem for MW UTH radiance (e.g., Berg et al. 1999 and Luo 2003). Hence, collocating the IR and MW UTH radiances has synergistic value.

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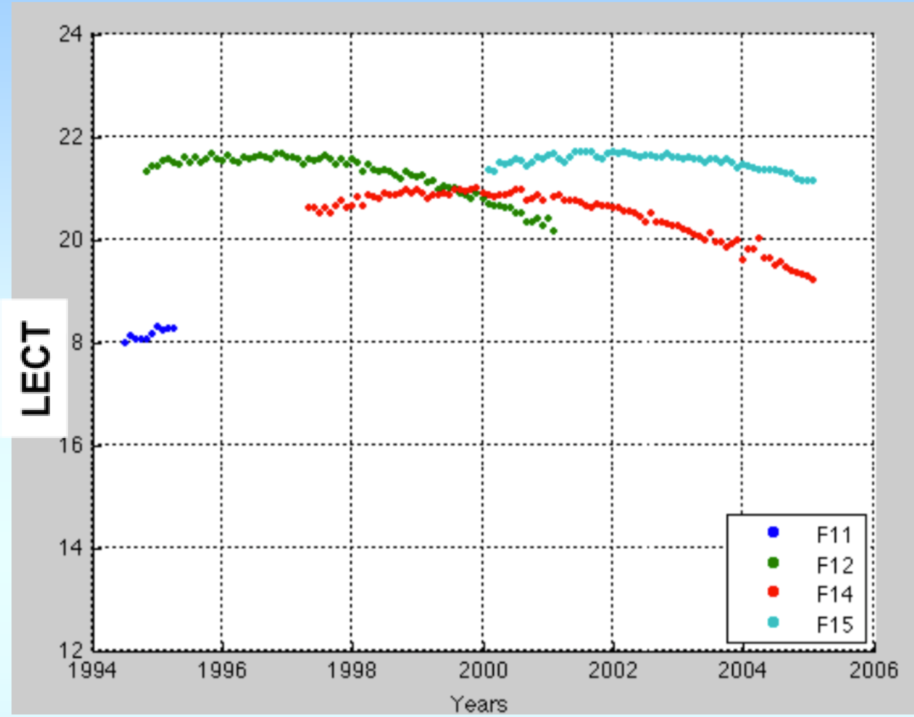
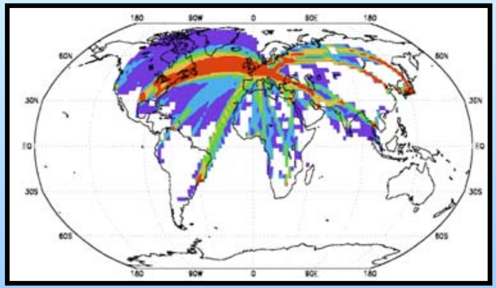
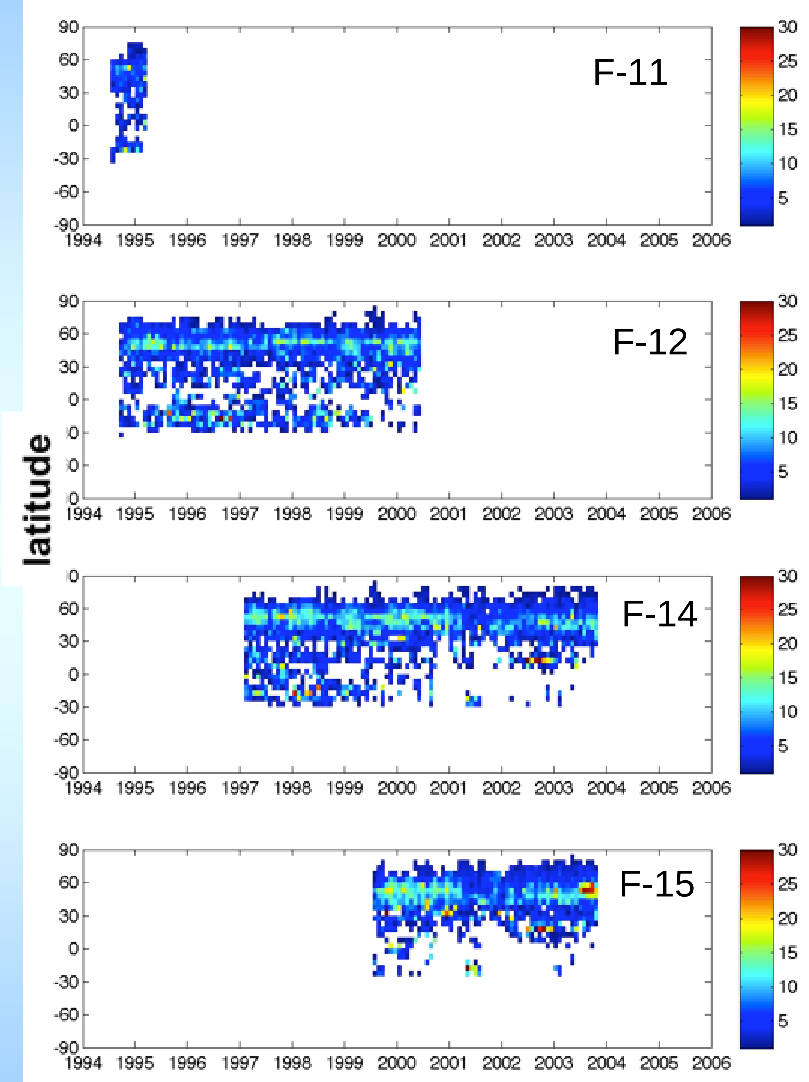
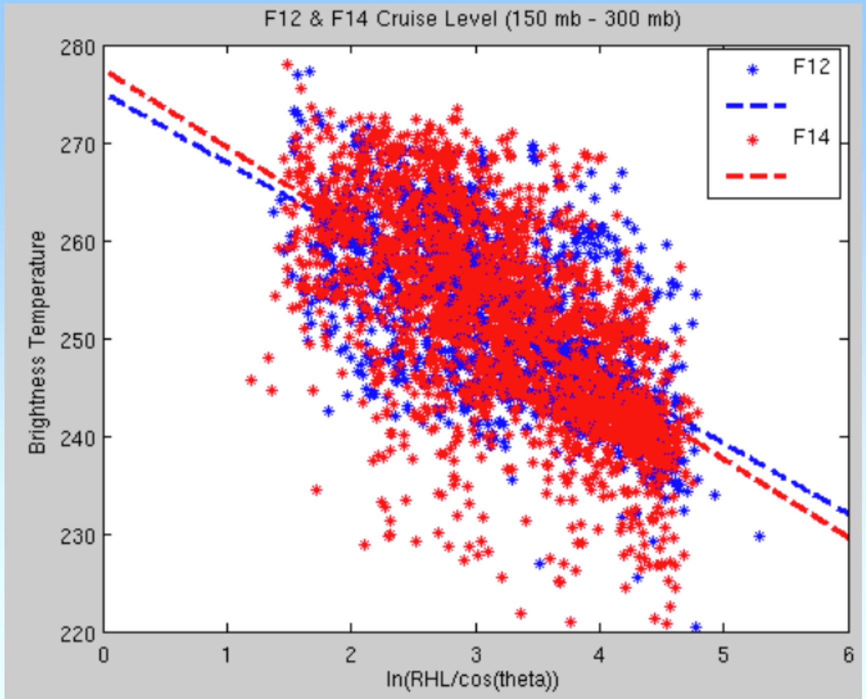
SSM/T2 data obtained from NCDC

Match with MOZAIC under flights





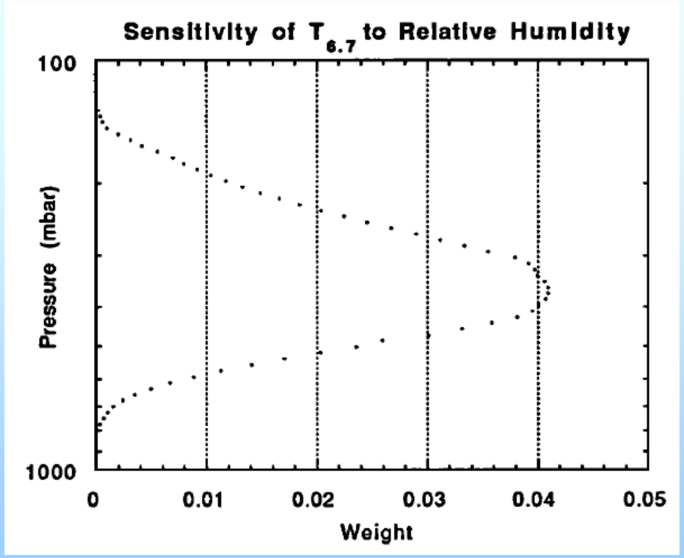




$$a + bTB = \ln\left(\frac{<RH>}{\cos\theta}\right)$$

We matched MOZAIC cruise level (200-300 hPa) data with SSM/T2 183±1 GHz brightness temperature (50 km and 30 min).

The relationship is too noisy to be much useful for calibration purposes.

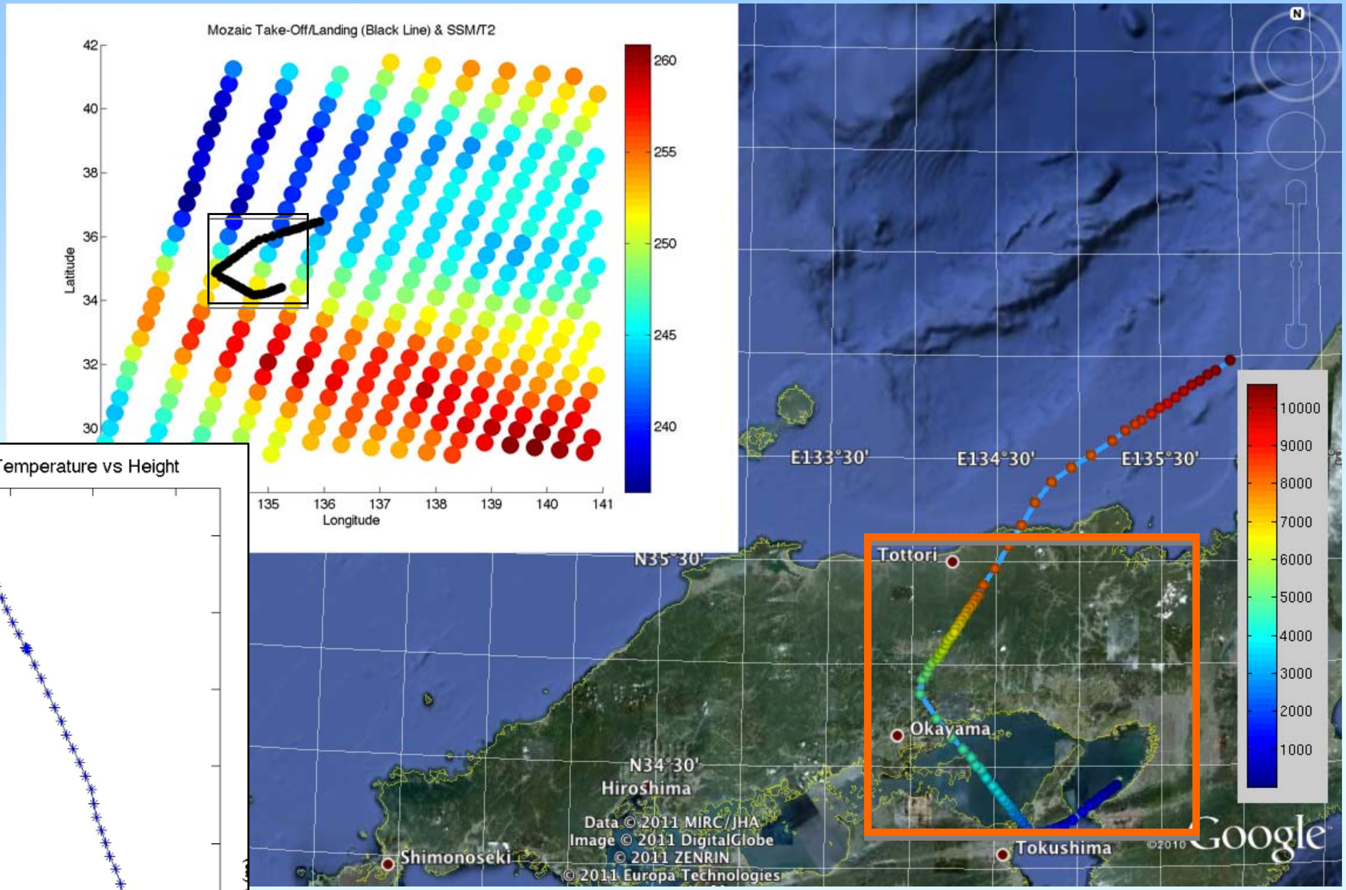


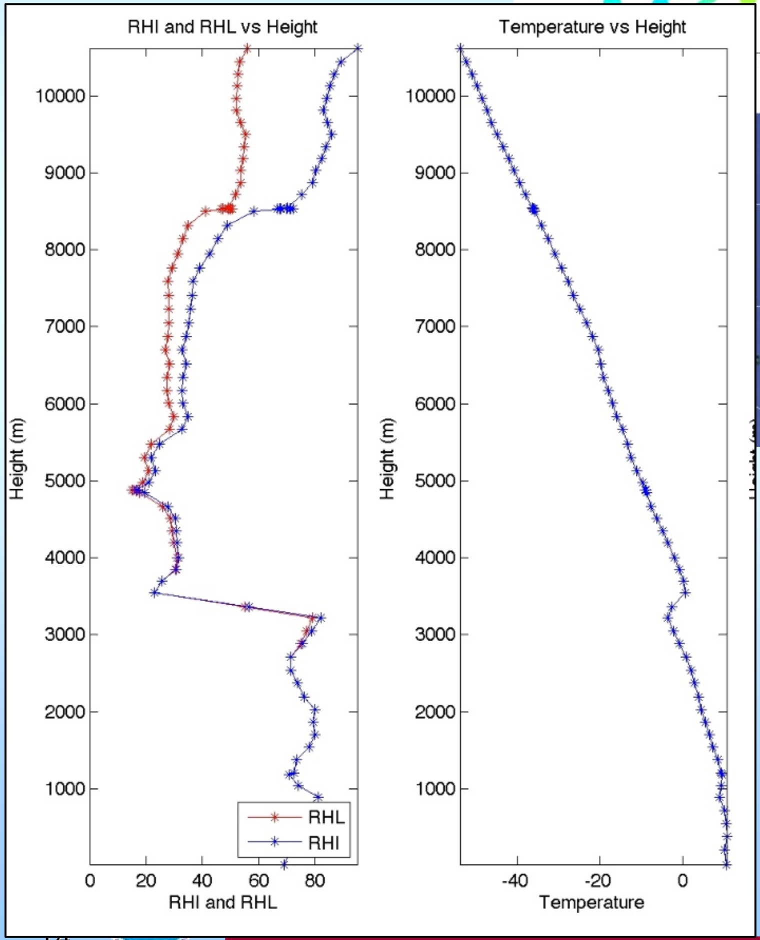
If you check the original paper by Soden et al. (1994),

1)<RH> refers to a weighted average (humidity Jacobian) of the RH over a thick layer (200-500 hPa)

1)This layer is not a fixed layer but floats up and down depending on RH and, to a lesser extent, T profiles.

“Profiling” ability of MOZAIC.

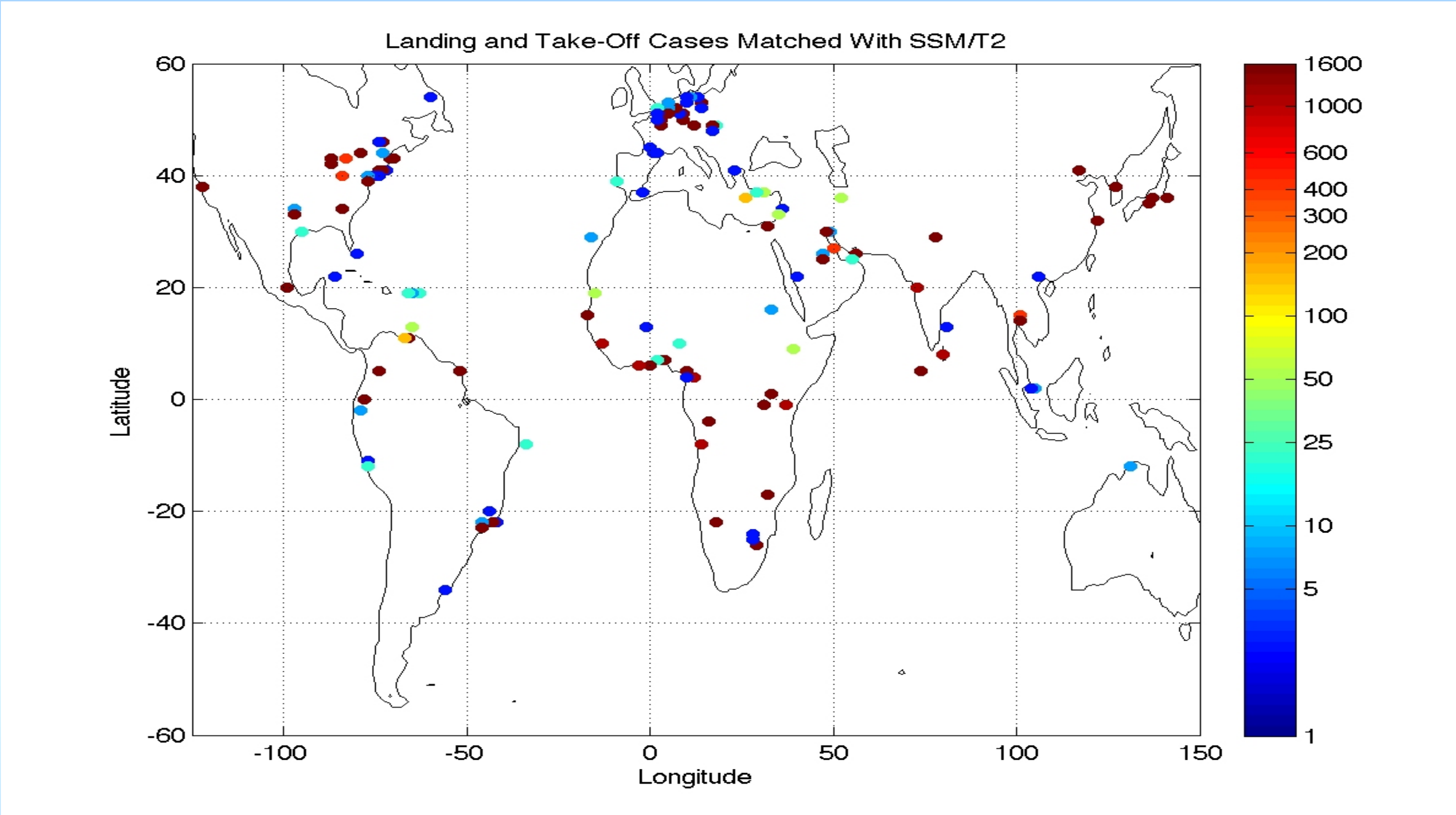


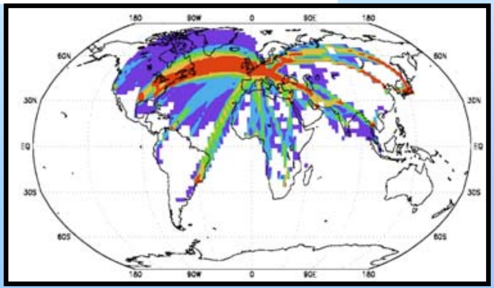


~ 150 km

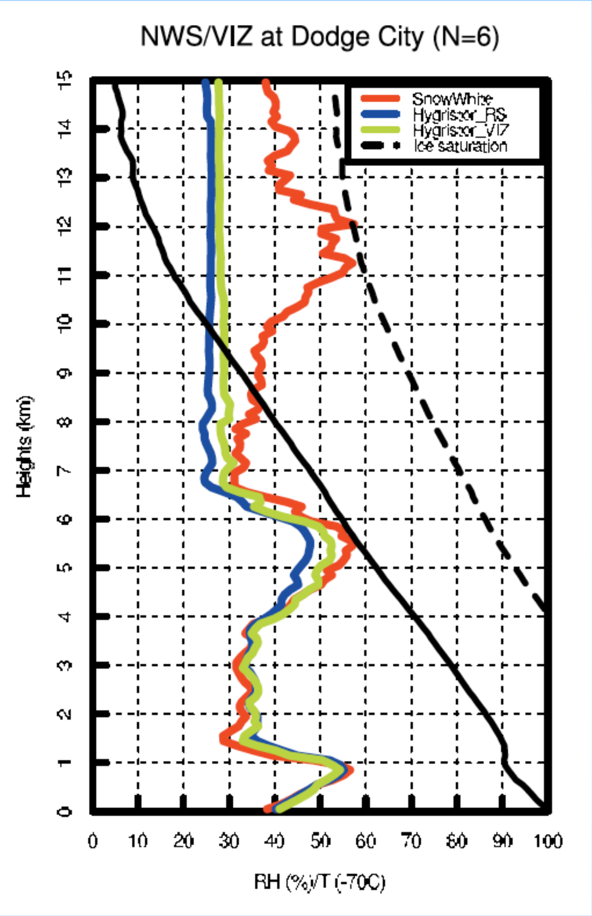
Another problem revealed: spatial inhomogeneity of satellite TBs over the area covered by the aircraft ascent/descent

Number of MOZAIC ascent/descent matched with SSM/T2





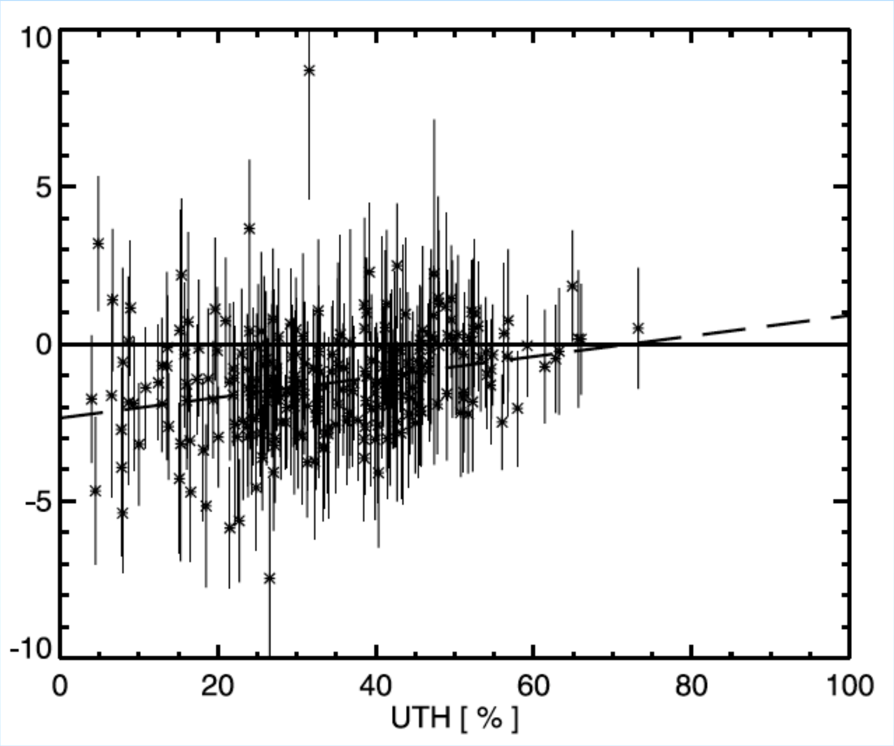
Operational radiosondes are not a good choice for evaluating UTH radiances



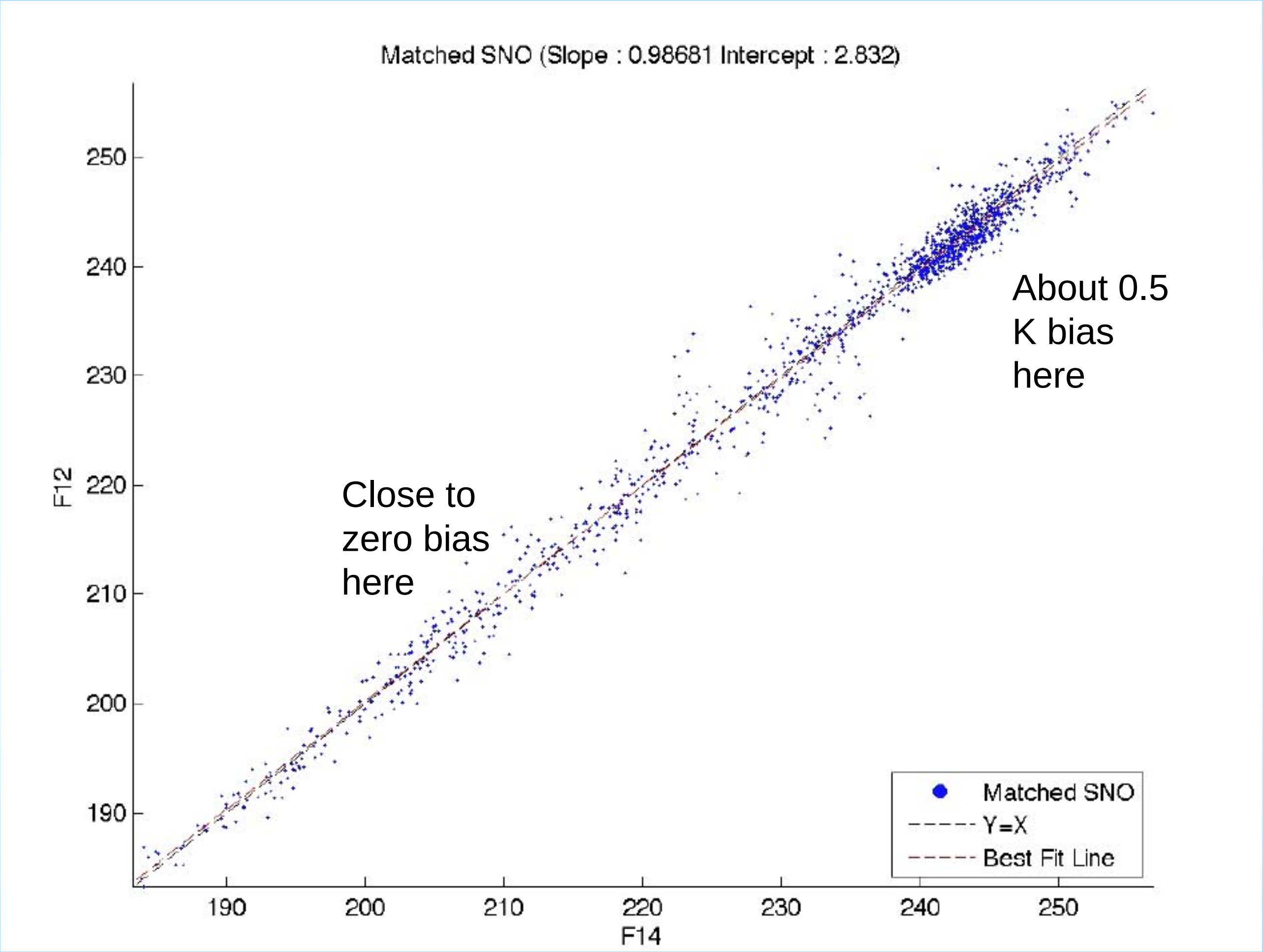
Comparison with chilled mirror dew point hygrometer (red)

Wang et al. 2003

Observed minus calculated Tb (183±1 GHz) based on collocated operational radiosondes and AMSU-B data (Buehler et al. 2004)



Simultaneous Nadir Overpass (SNO): 5 sec & 50 km



Caveat: out of 4 years of overlap between F12 and F14, we only found 4 days that contain the SNO: June 8-11 1999.

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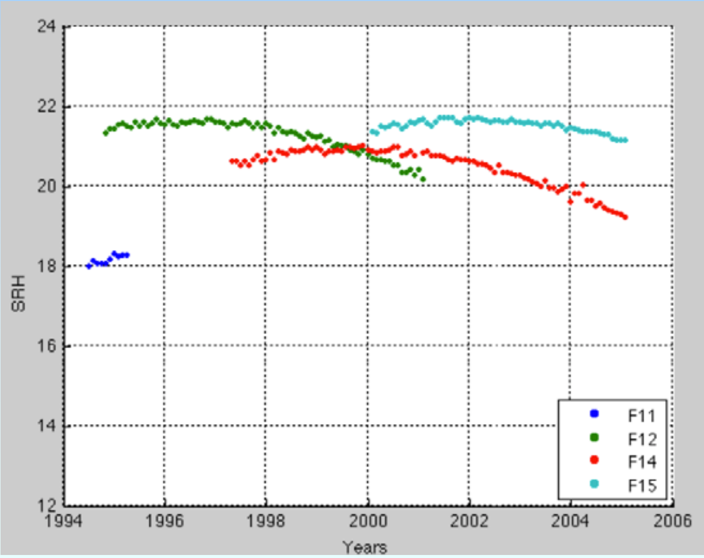
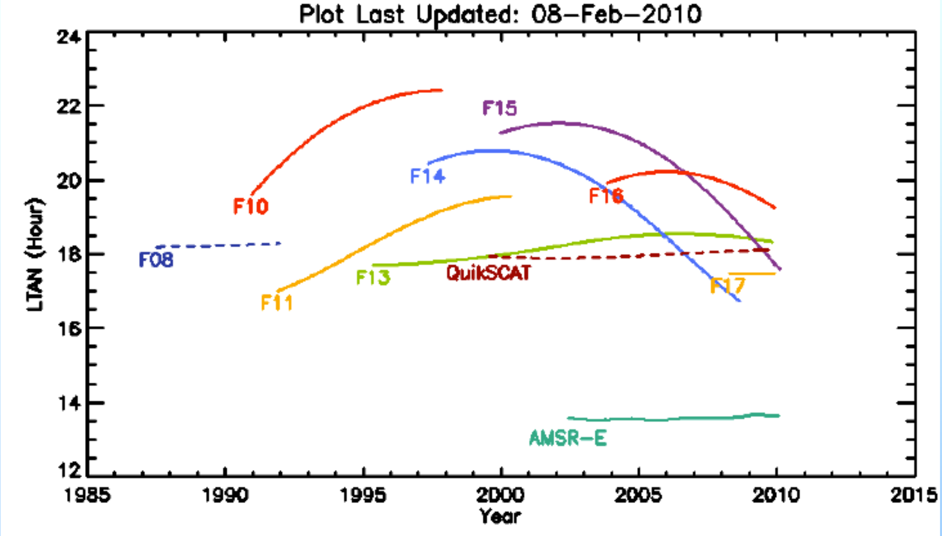
Issue 1: SSM/T2 data incomplete



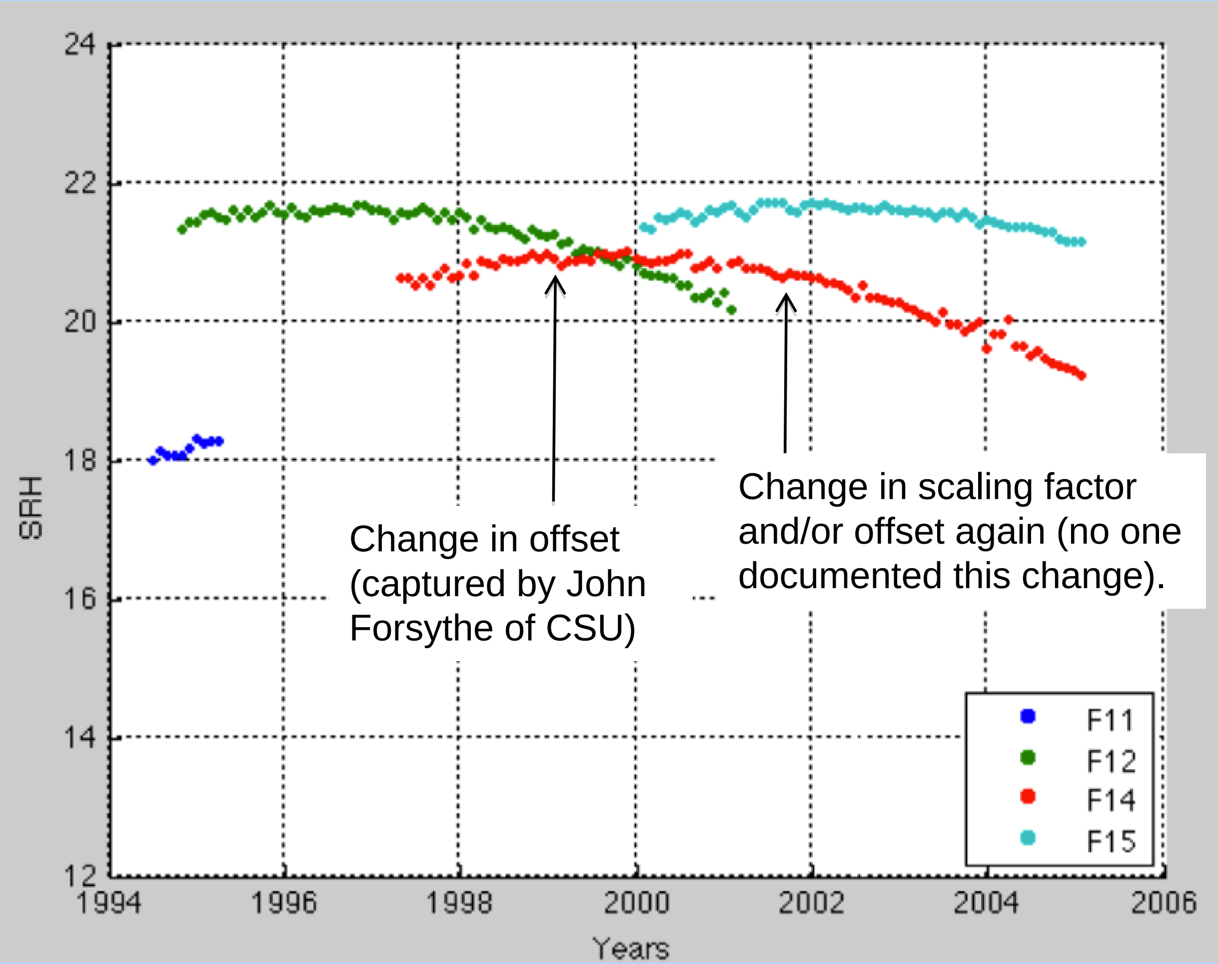
This is what we've obtained from NCDC



This is what we should have from these DMSP satellites

Courtesy: RSS

Issue 2: undocumented change in scaling factor and/or offset



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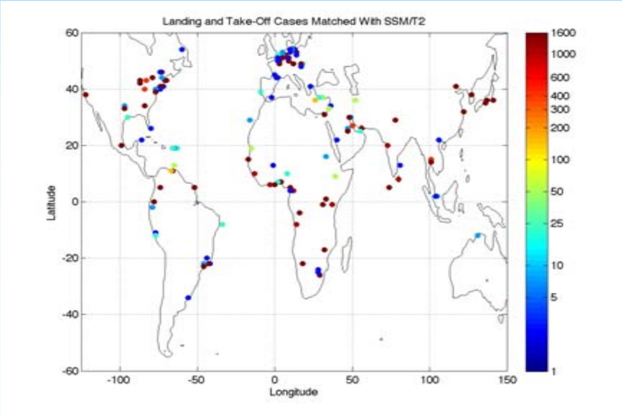
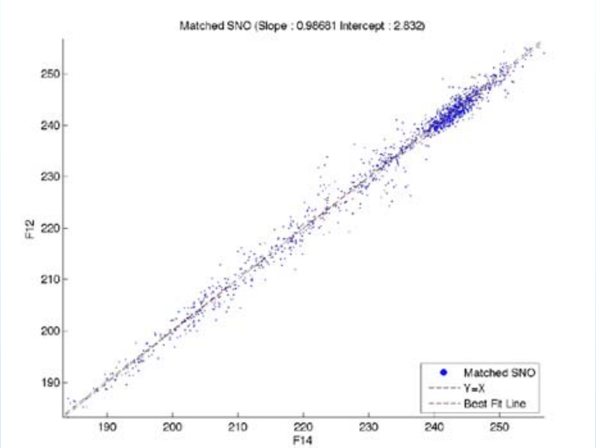
1. Find out the changes in scaling factors/offsets and restore the SSM/T2 data (currently SSM/T2 are useful only for 1994-2001)



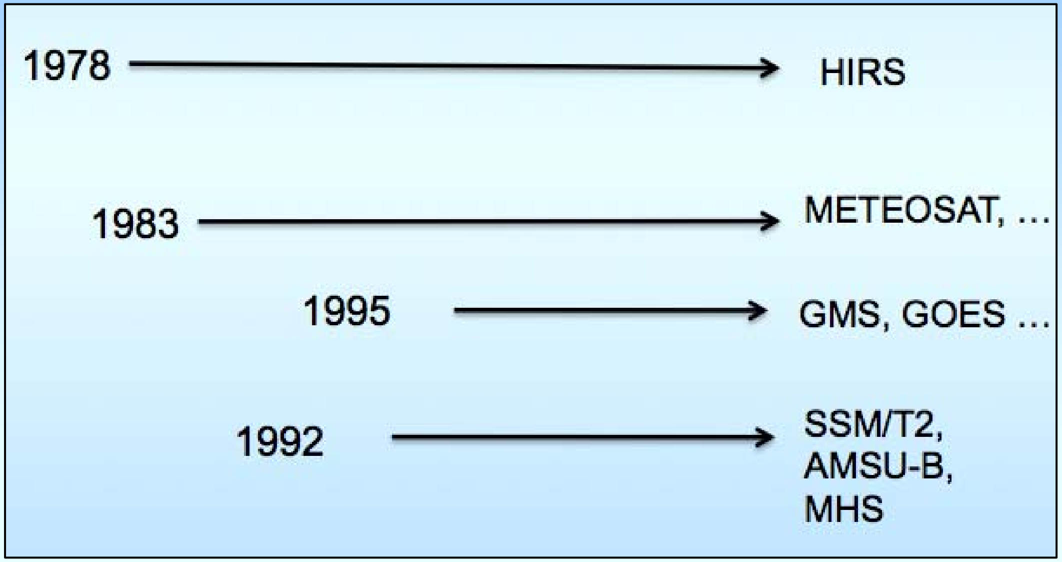
2. Run a RTM through the T/RH/O_3 profiles collected from MOZAIC ascent/descent and compare the calculated TBs with the observed ones.

Do the same thing for 183±3, 183±7 GHz channels



3. Further explore the SNO method. Check if different calibration methods agree with each other.

4. Run the same analysis through AMSU-B and MHS



5. Bring together microwave and IR UTH radiances and explore their differences in sensitivity to cloud contamination (new ISCCP data provide 10-km & 3 hr cloud information).

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