Global Cloud Property Continuity from MODIS to Suomi-NPP Sensors

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Three topics:

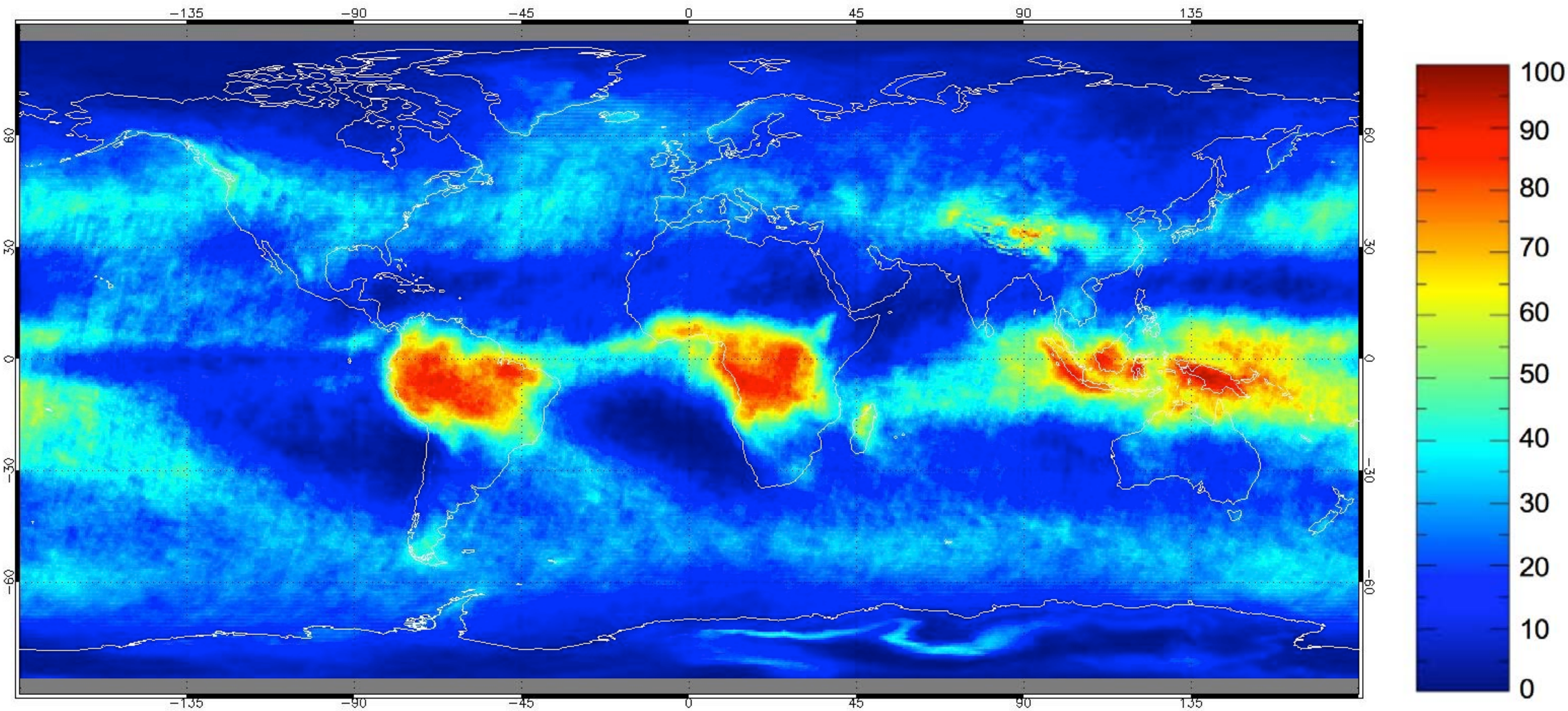
MODIS-HIRS monthly mean analysis for month of March over record

Construction of 13.3-µm channel based on VIIRS-CrIS data fusion

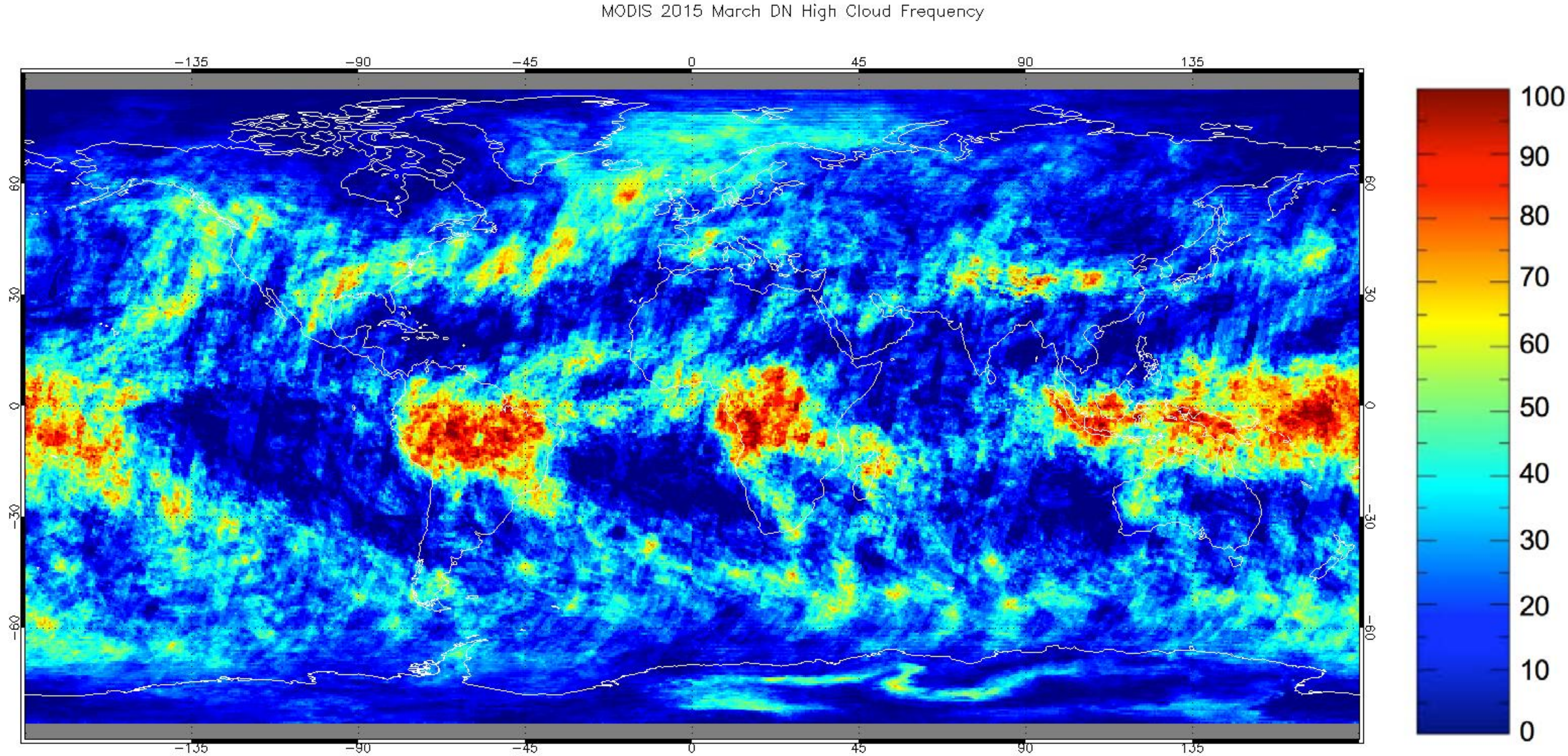
Issues for Atmosphere Team Breakout

Joint MODIS-Suomi NPP Science Team Meeting
May 2015

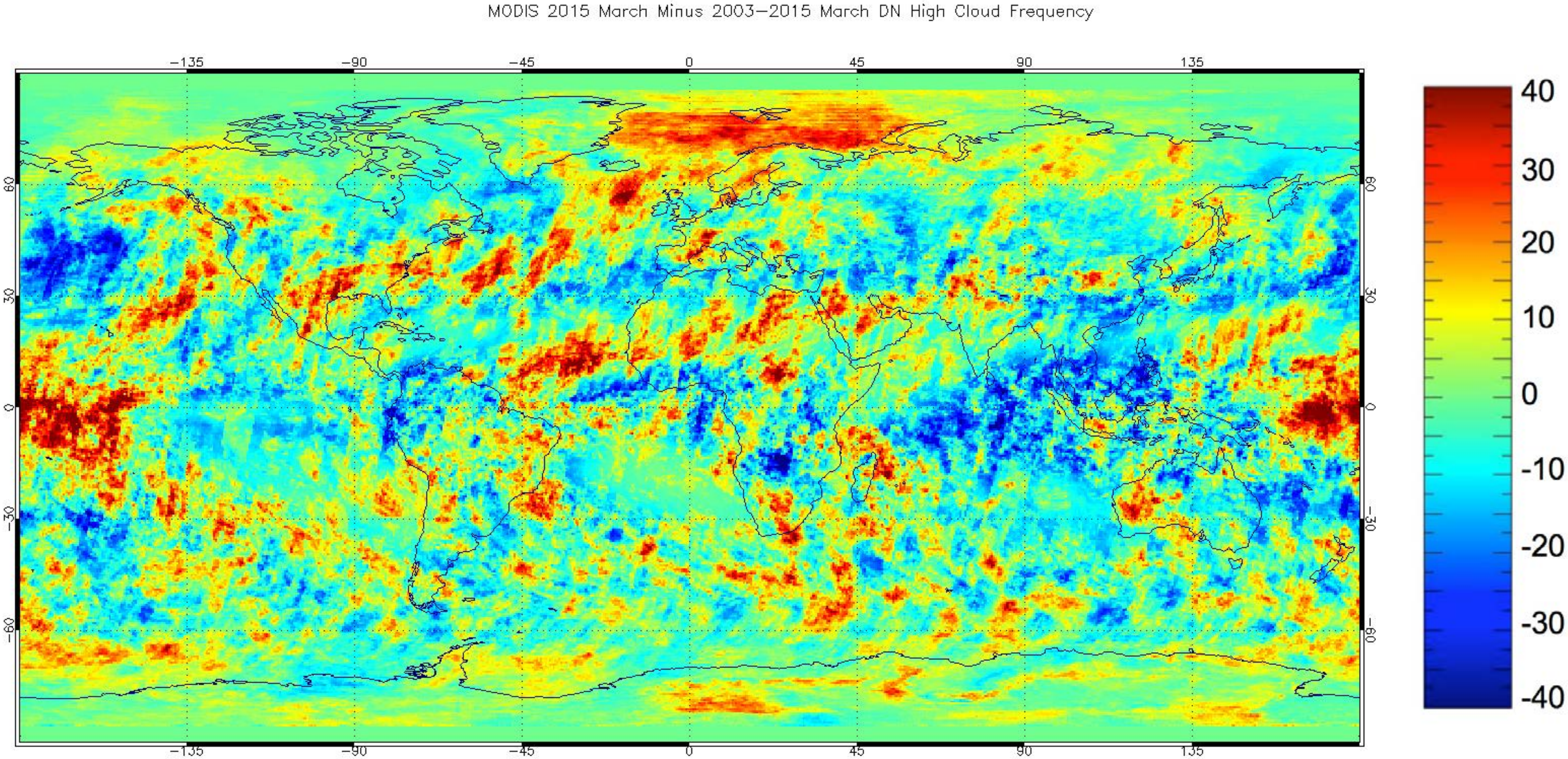
MODIS-Aqua: Nighttime Monthly Mean of High Cloud Frequencies for March from 2003-2015



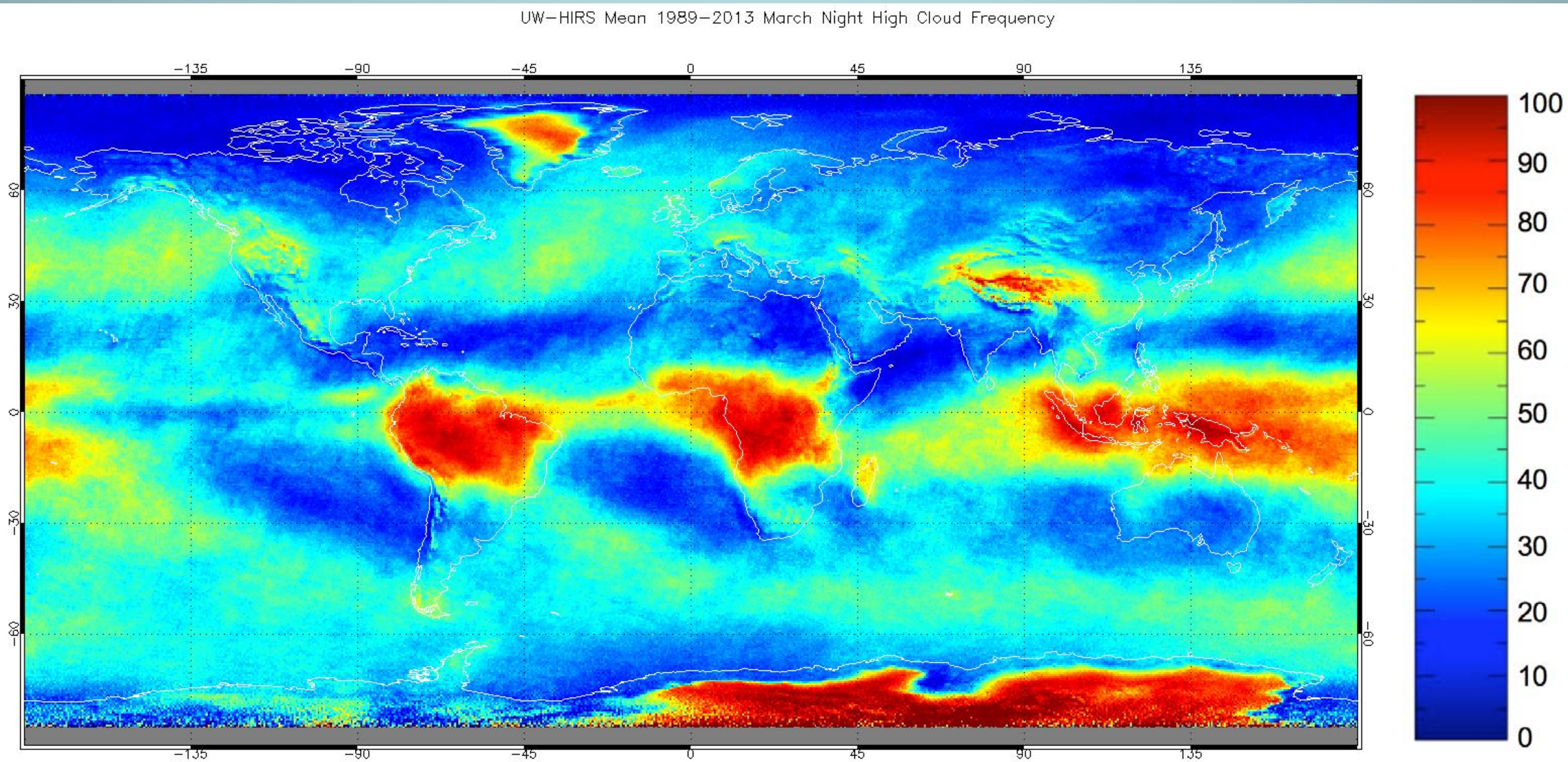
MODIS-Aqua: High Cloud Frequencies for March 2015



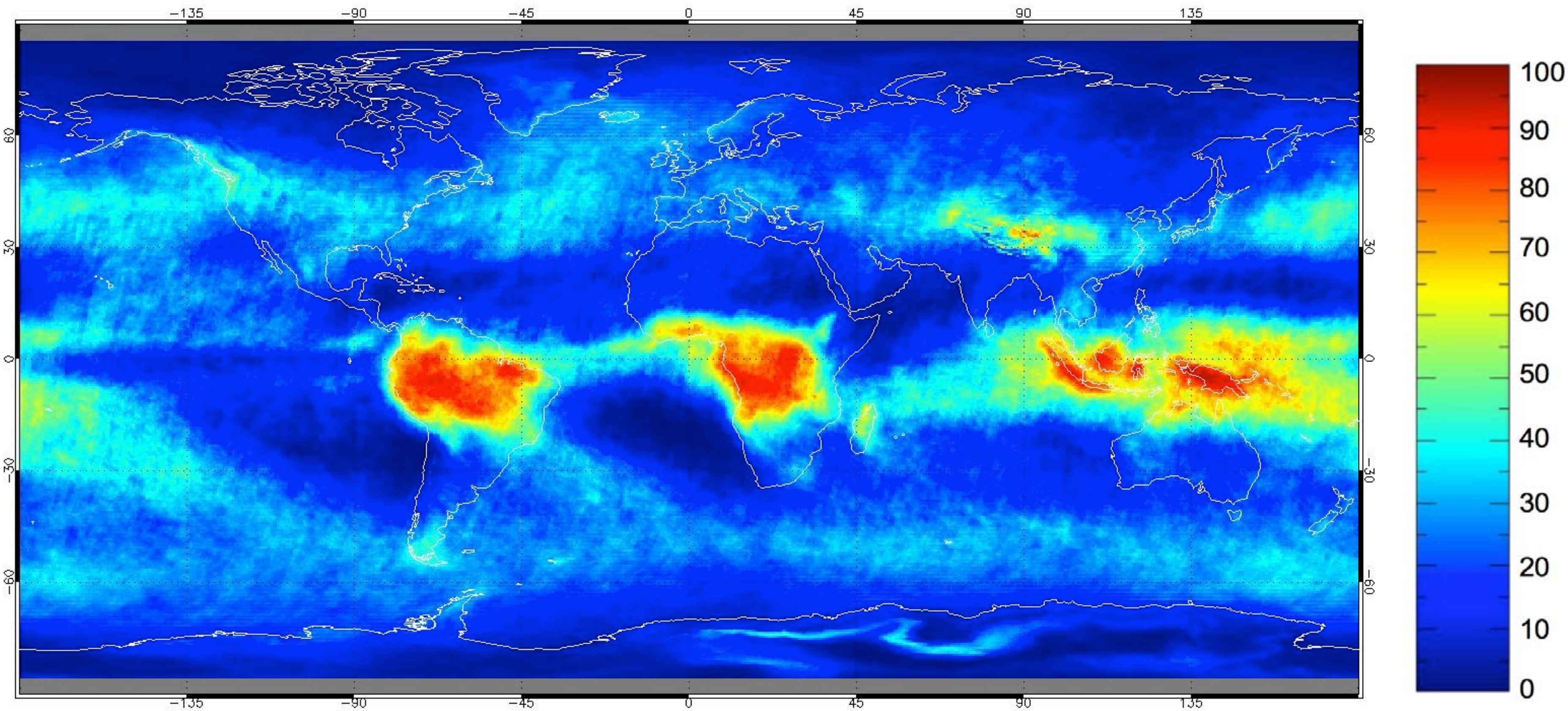
Percentage difference of (March 2015 – Monthly Mean) High Clouds from MODIS Aqua



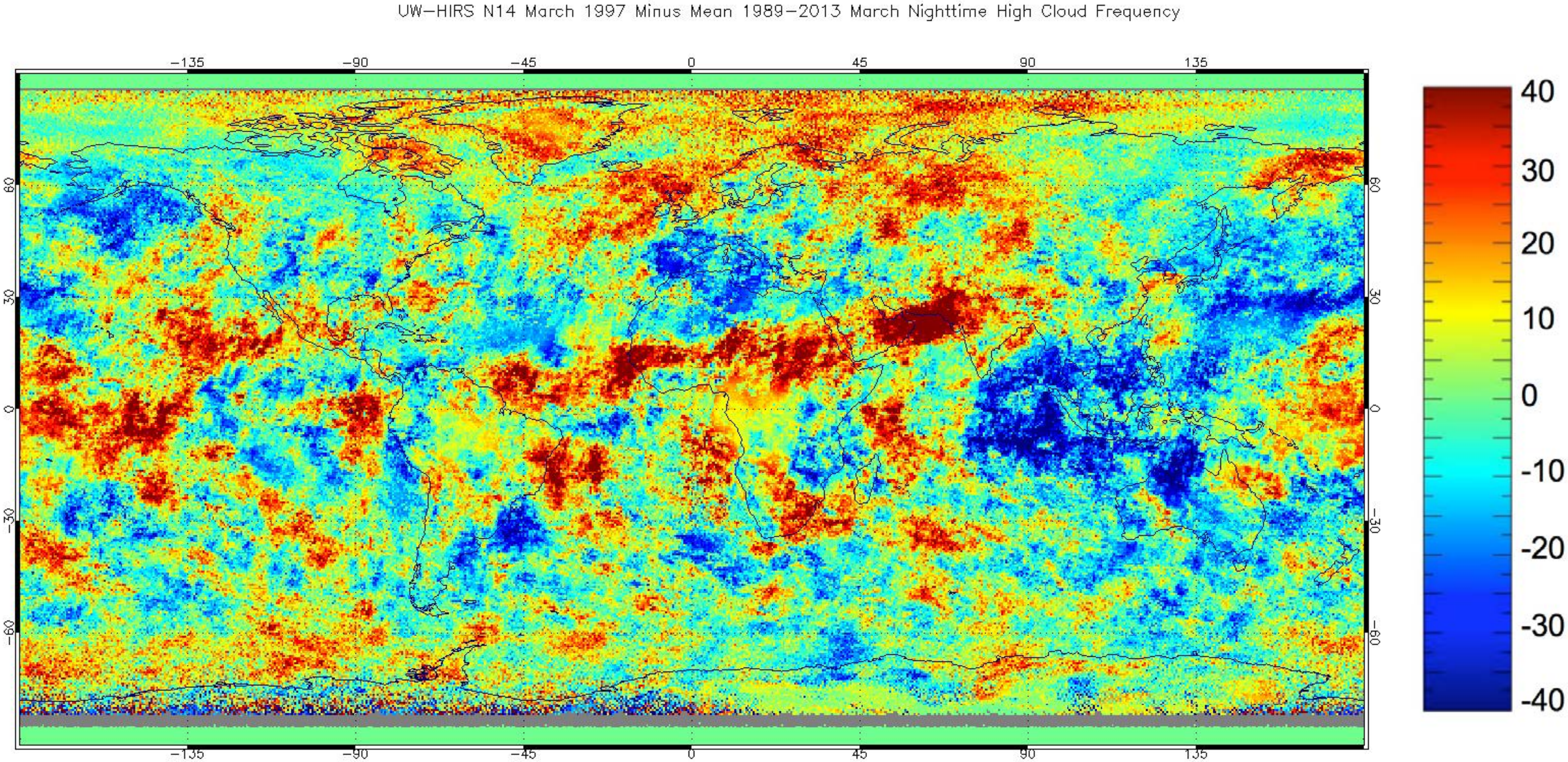
HIRS Nighttime Monthly Mean of High Cloud Frequencies for March from 1989–2013



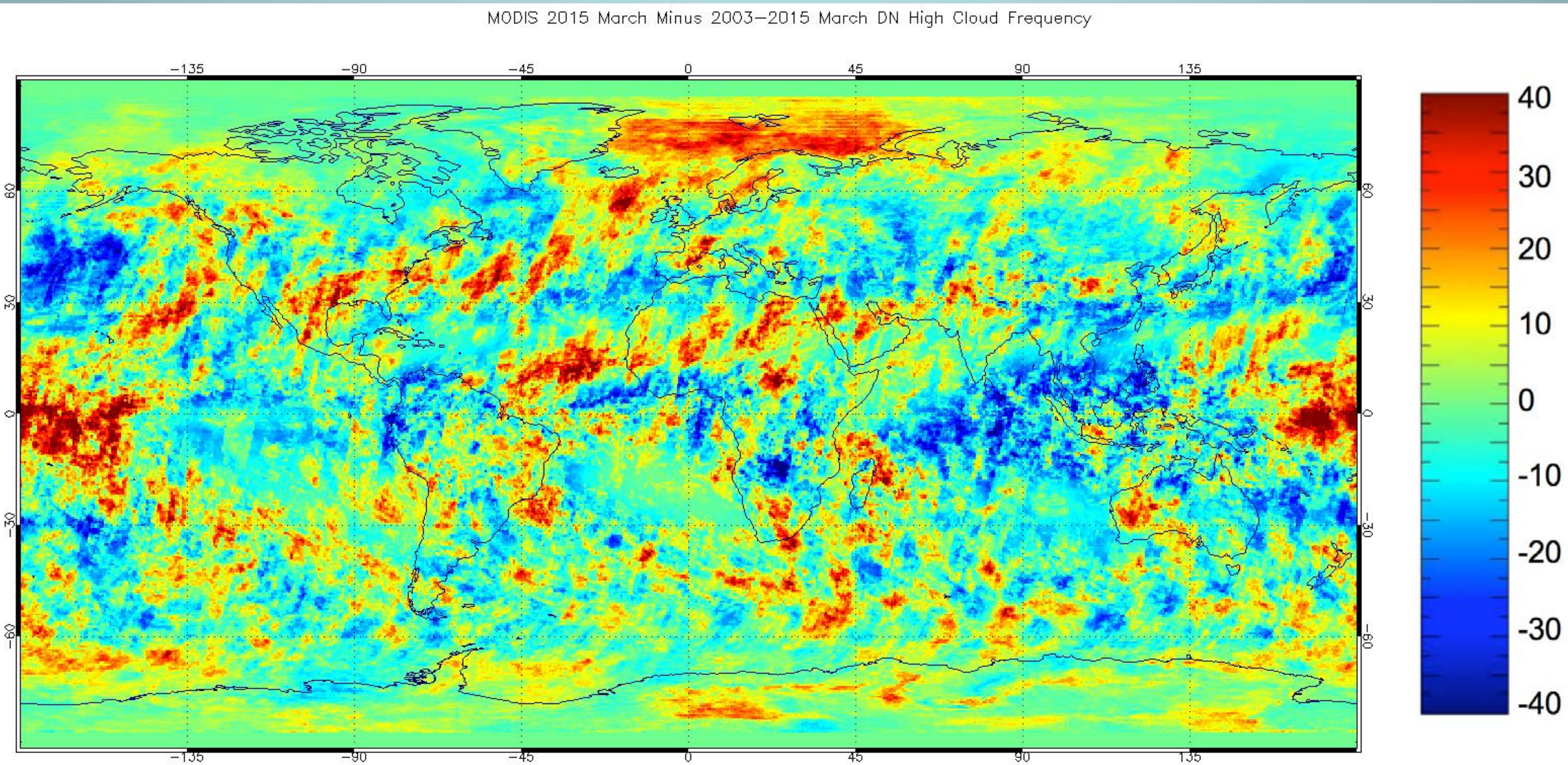
MODIS-Aqua: Nighttime Monthly Mean of High Cloud Frequencies for March from 2003-2015



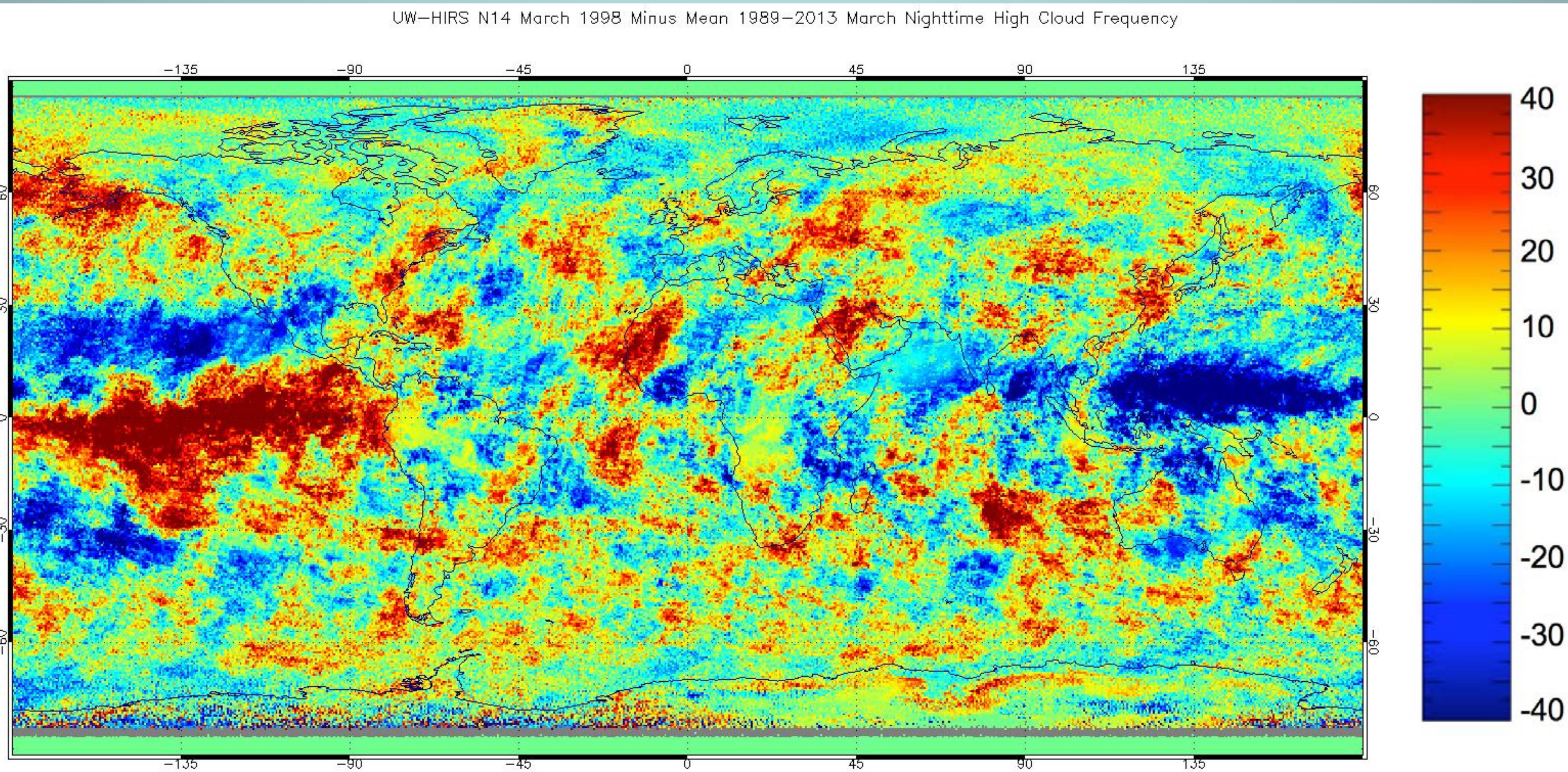
Percentage difference of (March 1997 – Monthly Mean) High Clouds from HIRS



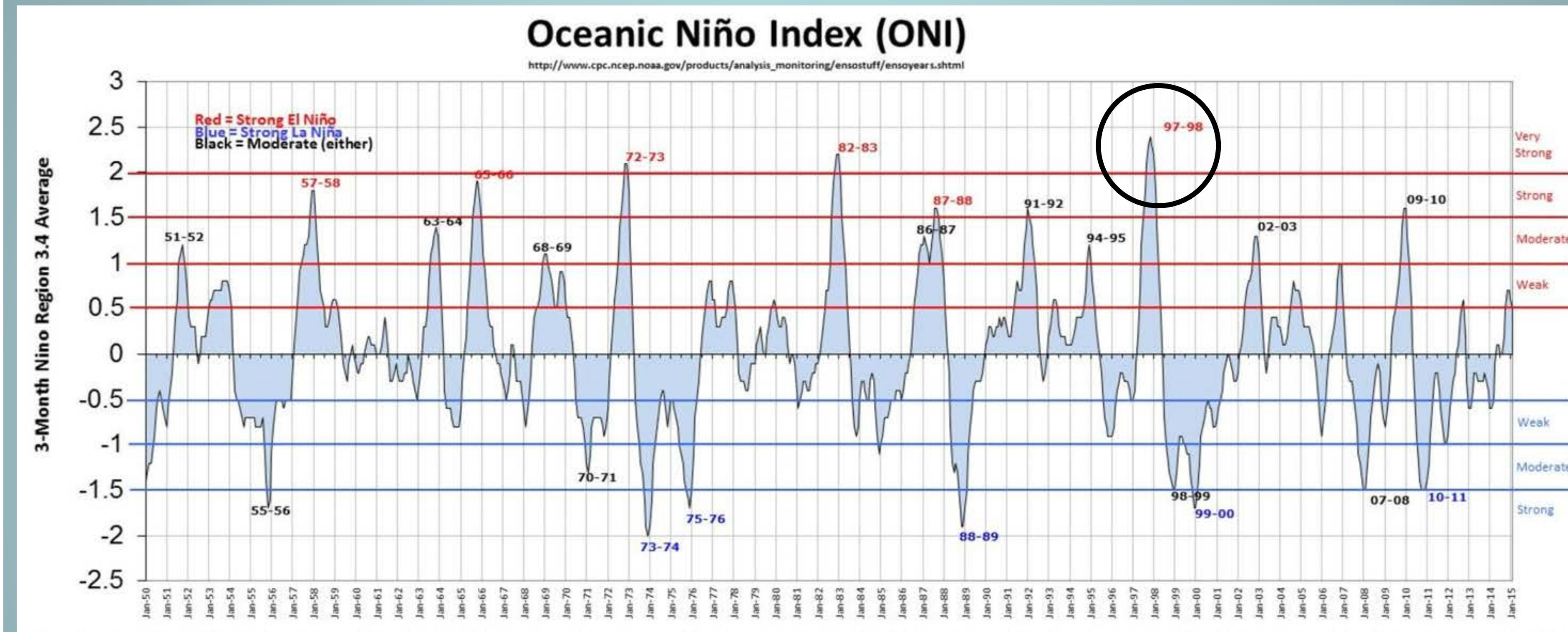
Percentage difference of (March 2015 – Monthly Mean) High Clouds from Aqua MODIS



Note what happened in following year: 1998
HIRS High Cloud Frequency



El Nino-La Nina Years and Intensities



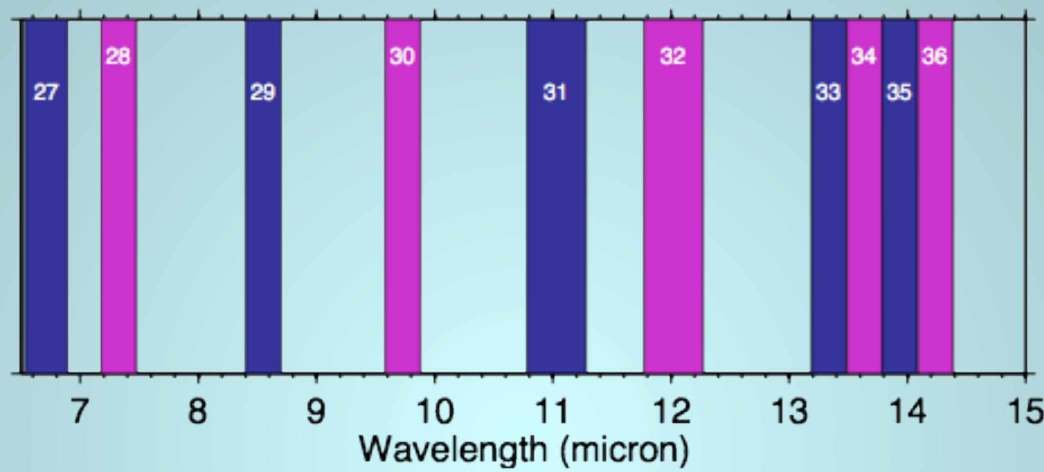
1950 1960 1970 1980 1990 2000 2010

Shakespeare: What's past is prologue…?

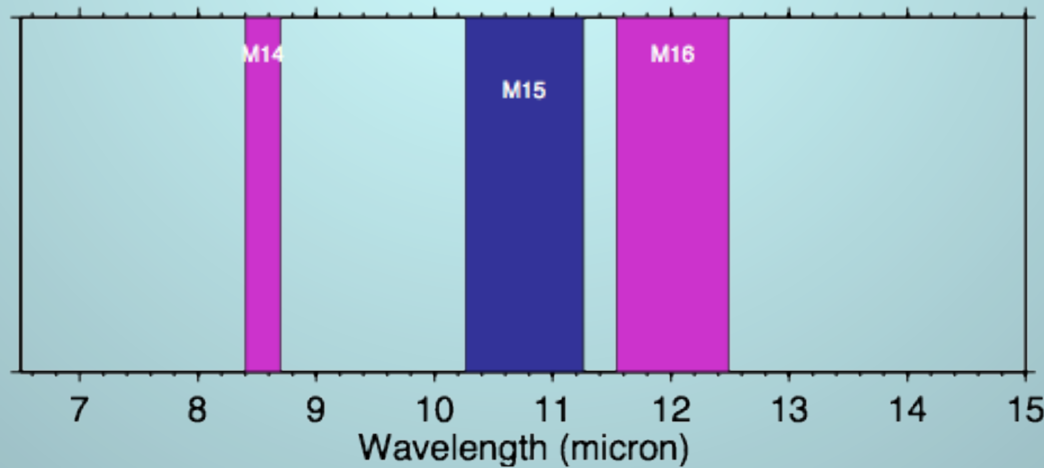
http://ggweather.com/enso/oni.htm

VIIRS and MODIS IR spectral bands

MODIS



VIIRS: M bands



Different Approaches to Linking Imager and Sounder

Approach 1: Perform analysis for sounder FOV as first step

- Use CTP from sounder as first guess for imager-based optimal estimation

Approach 2: Data fusion statistical approach to construct 13.3 μm at imager resolution

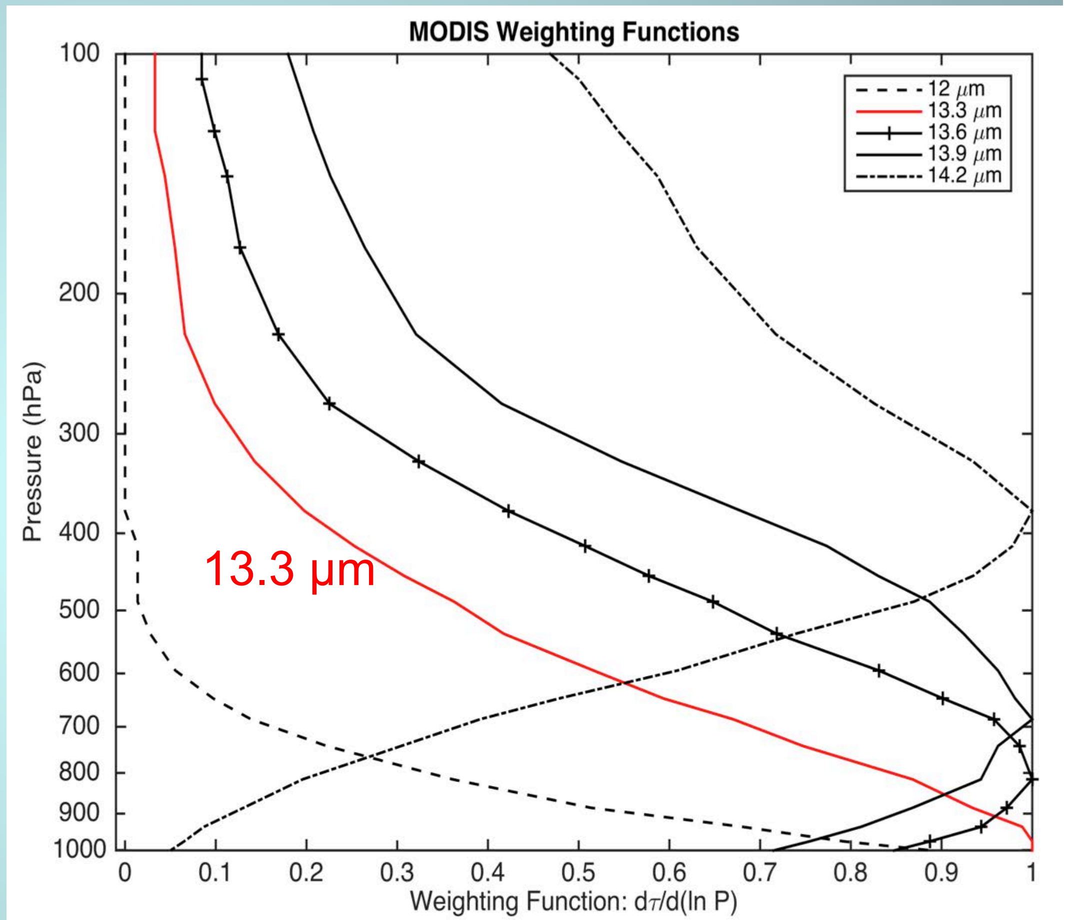
- Use combination of IR window and 13.3-μm channels in optimal estimation

Potential application to other polar-orbiting platforms

Sensor		Swath Width (km)
AVHRR	NOAA	2800
HIRS		2200
MODIS	Aqua	2330
AIRS		1650
VIIRS	S-NPP	3040
CrIS		2200
AVHRR	Metop-A/B	2800
HIRS/IASI		2200

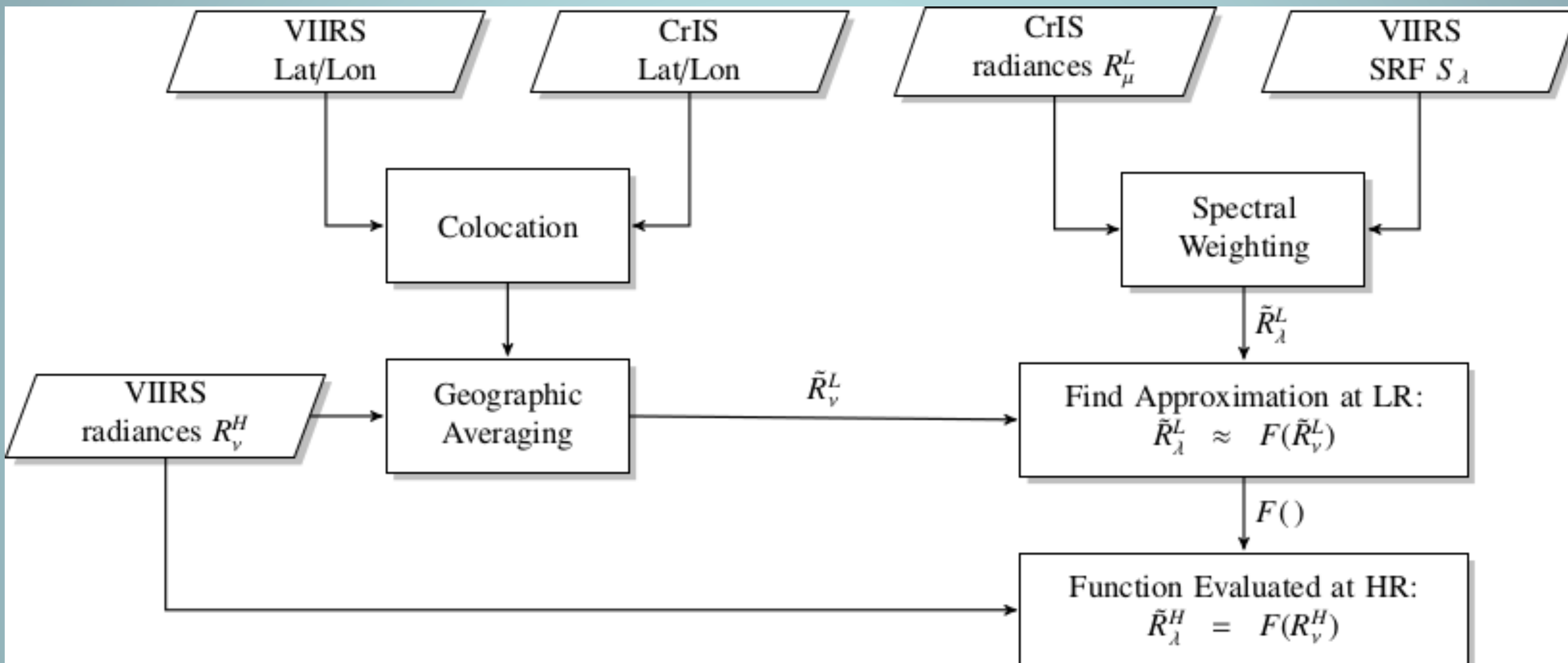
Decadal heritage with 15-µm CO_2 channel data

- Continuity: HIRS record dating back to 1978
- Infer CTP for optically thin ice clouds (Menzel et al. 2008)
- Detection and analysis of multilayered clouds (cirrus over water cloud; Baum et al. 1995)
- For cloud phase, separating low from high clouds (Baum et al. 2012)
- For optimal estimation, use of even a single 15-µm channel greatly limits the solution space for optically thin cirrus (Heidinger et al. 2010)



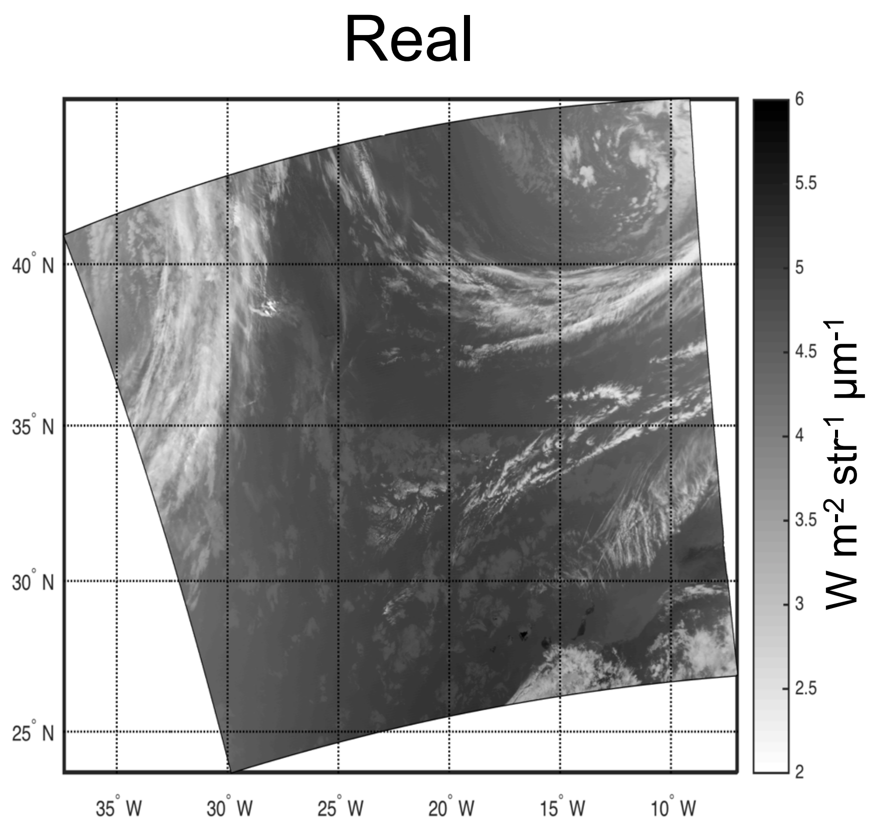
Baum et al. 1995: Satellite remote sensing of multiple cloud layers. *J. Atmos. Sci.*, 52, 4210-4230.
Baum et al. 2012: MODIS cloud top property refinements for Collection 6. *J. Appl. Meteor. Clim.*, 51, 1145-1163.
Heidinger et al. 2010: Using CALIPSO to explore the sensitivity to cirrus height in the infrared observations from NPOESS/VIIRS and GOES-R/ABI. *J. Geophys. Res.*, **115**, D00I15, doi:10.1029/2009JD012379.
Menzel et al. 2008: MODIS global cloud-top pressure and amount estimation: algorithm description and results. *J. Appl. Meteor. Clim.*, 47, 1175-1198.

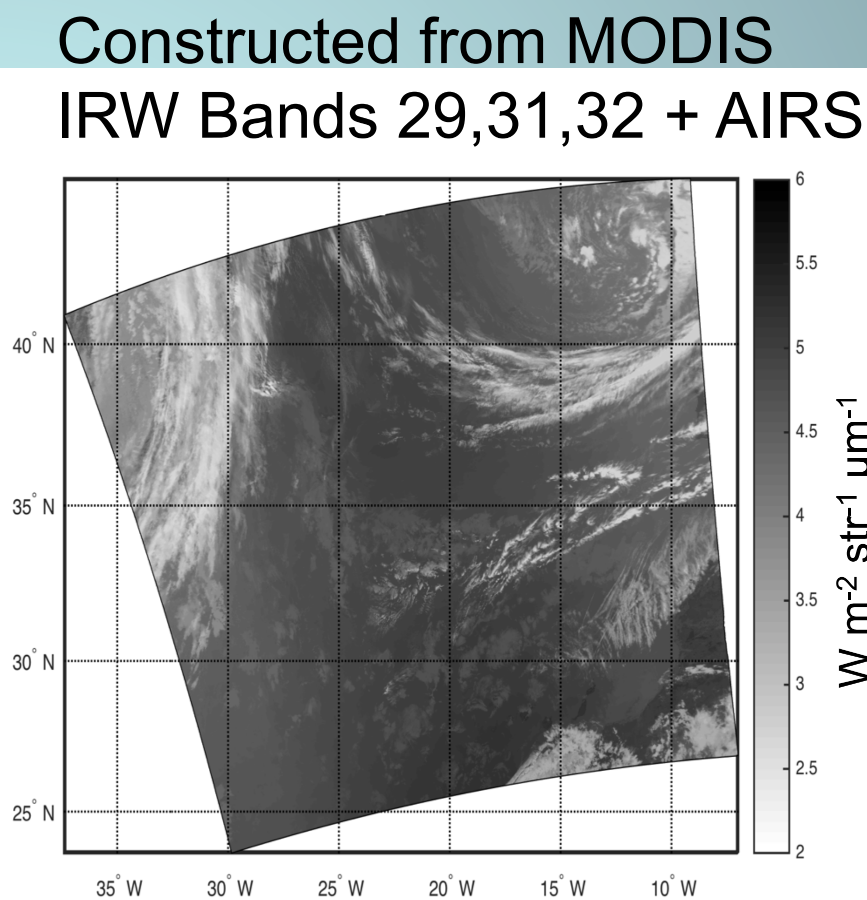
Statistical Reconstruction



Cross et al., 2013: Statistical estimation of a 13.3-μm Visible Infrared Imaging Radiometer Suite channel using multisensor data fusion. *J. Appl. Remote Sens*. **7** (1), 073473, doi: 10.1117/1.JRS.7.073473.

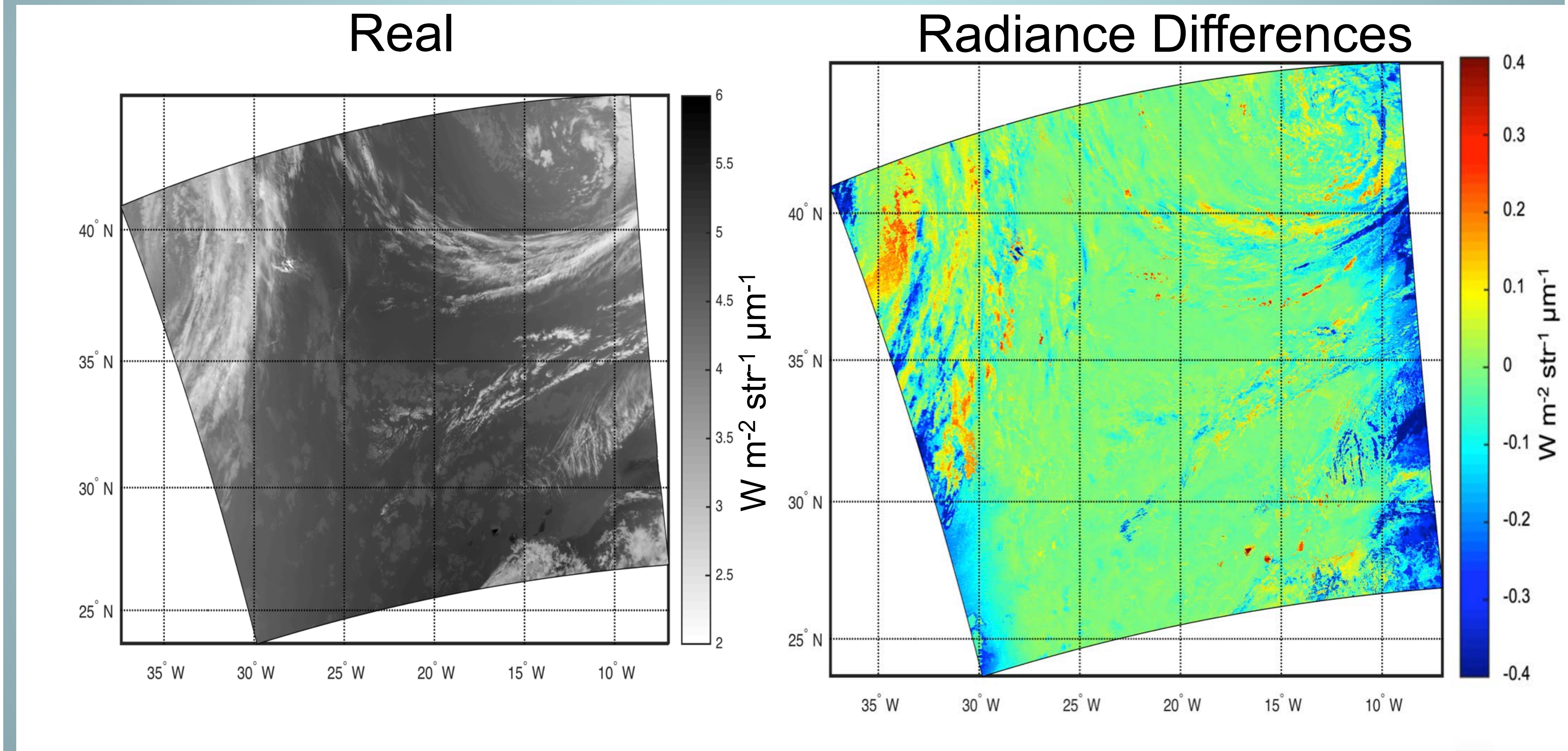
Statistical construction of a high spatial resolution 13.3-μm MODIS channel from AIRS



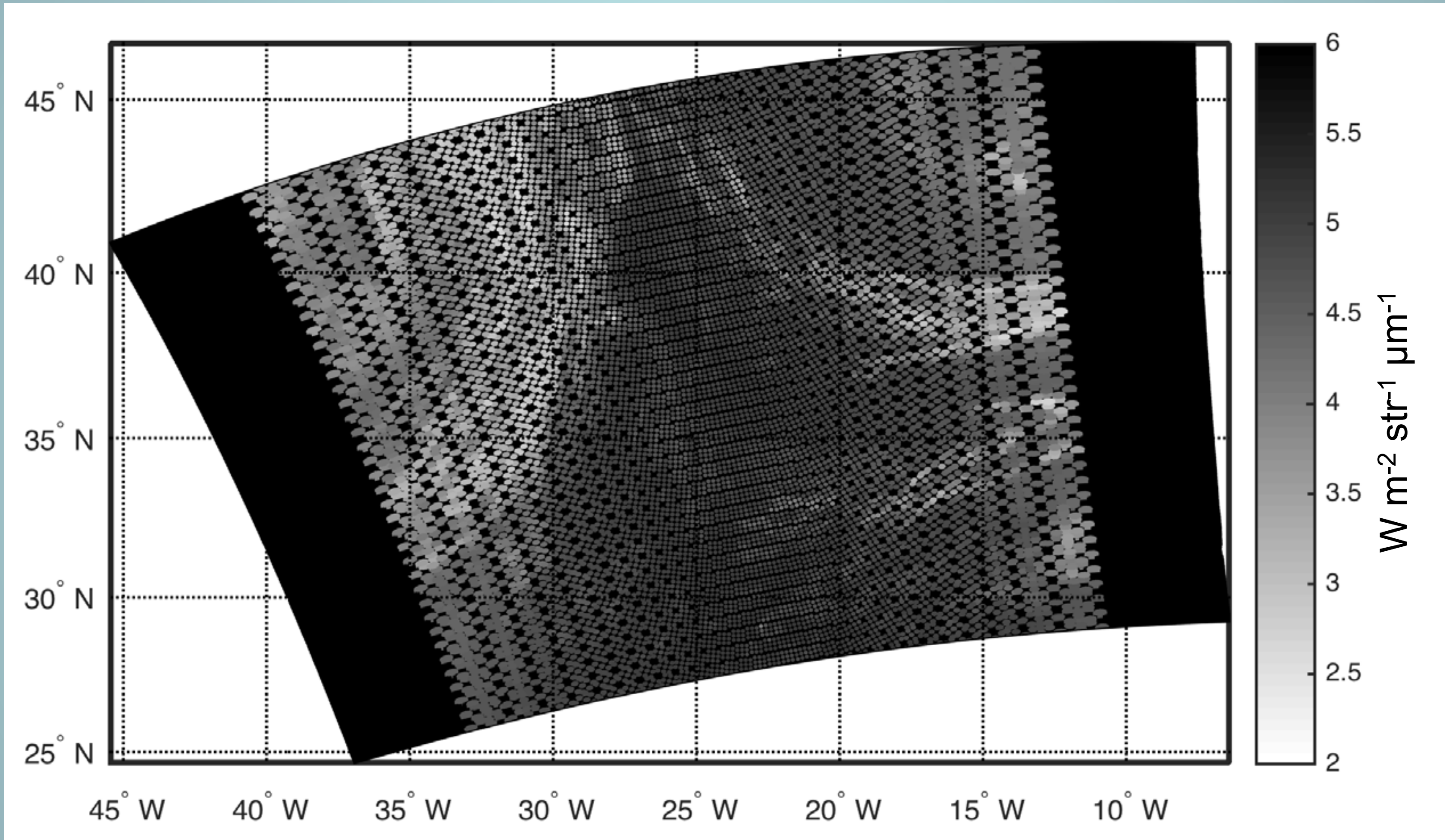


Scene over eastern Atlantic Ocean on April 17, 2015 at 1435 UTC

Radiance Differences Between Real and Constructed 13.3-μm channel

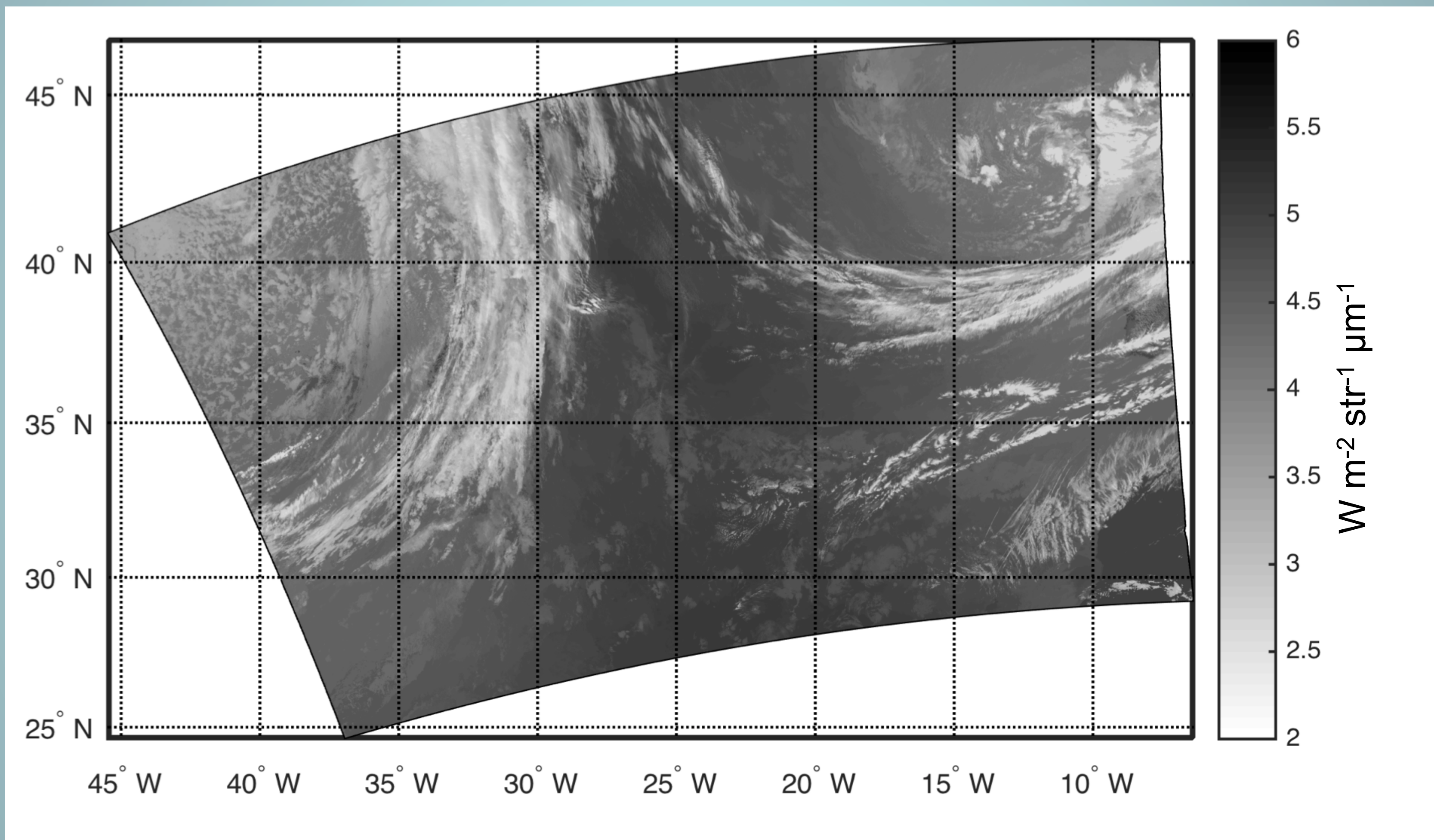


CrIS FOVs Superimposed on VIIRS Swath

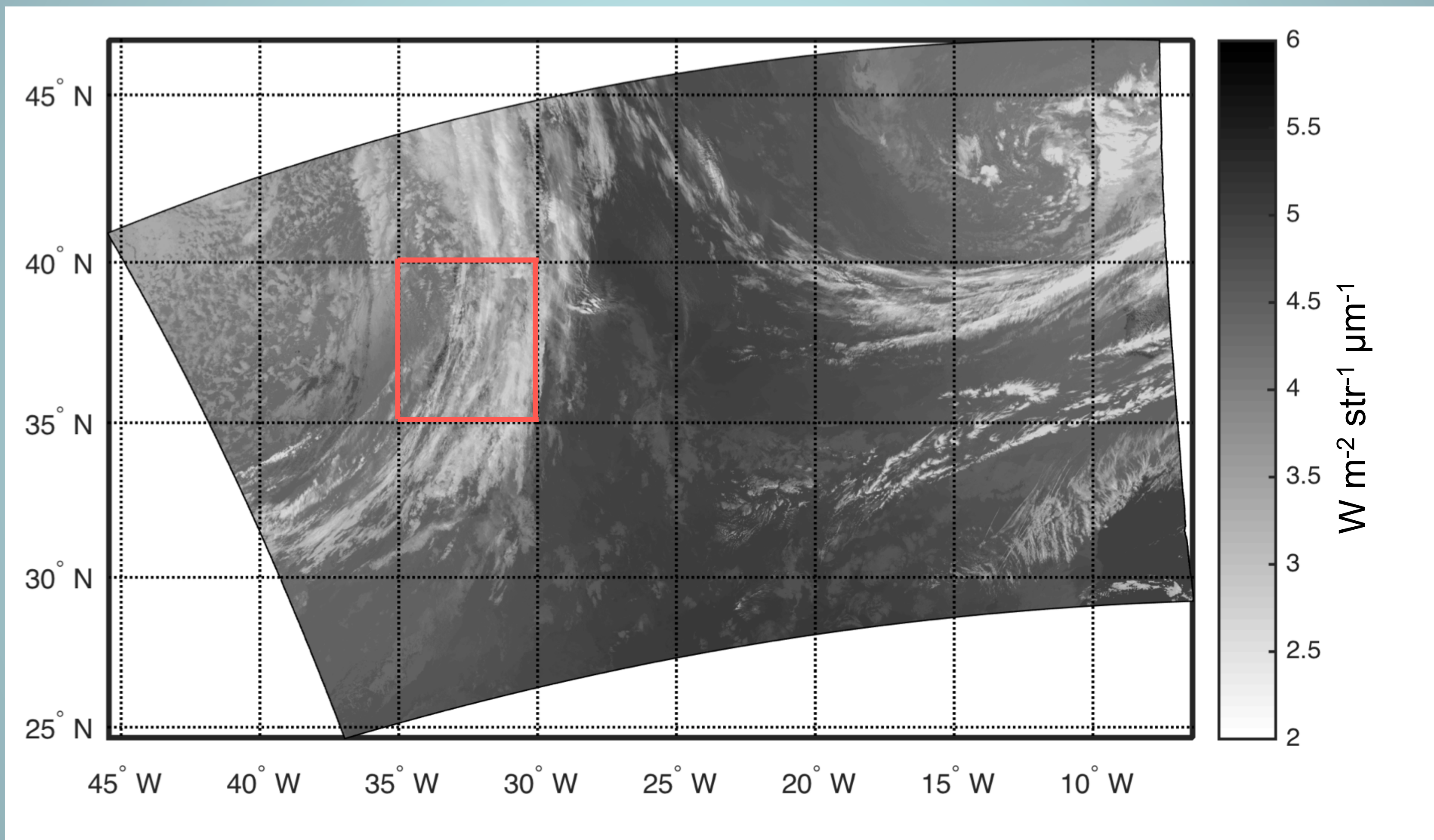


Scene over eastern Atlantic Ocean on April 17, 2015 at 1440 UTC

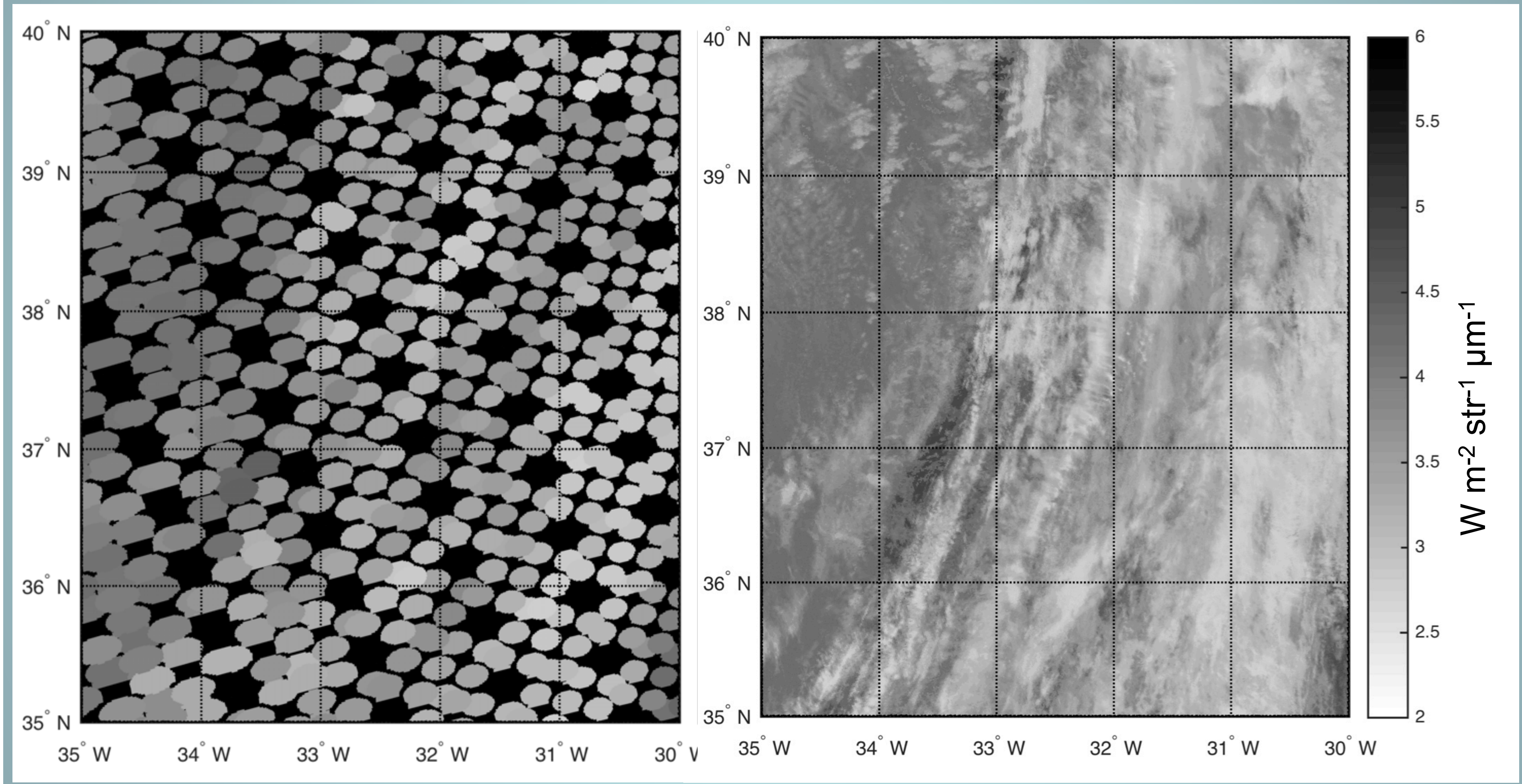
VIIRS Constructed 13.3-μm Channel



Now focus on 5°x5° region



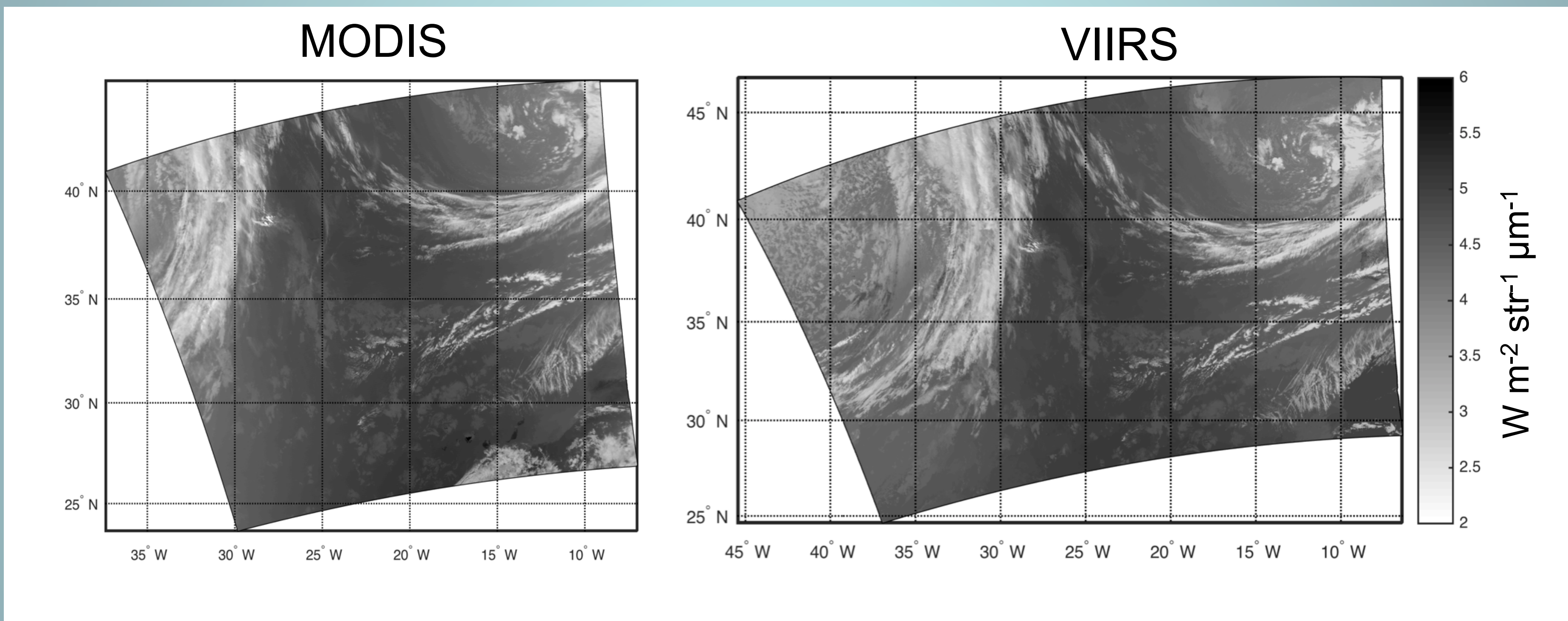
CrIS Resolution vs. Constructed 13.3-μm Channel



What would we rather use for retrievals?

Comparison of MODIS to VIIRS 13.3-μm Radiances

April 17, 2015



1435 UTC

1440 UTC

About the statistical construction approach

Not rocket science, it's computer science

Pros:

- No striping, noise, or other artifacts
- Response function same as for MODIS-Aqua
- Hyperspectral IR data are well calibrated
- Do not have to account for gaps between sounder FOVs

Cons:

- Radiance differences increase outside of sounder swath
- Requires aligning imager and sounder granules

Radiance differences are about 1-2% of the total (~1˚K/typical scene)

Note: this approach works only for the 13.3-μm channel – it can not be used to construct any of the IR water vapor channels or a different 15-μm CO_2 channel

Atmosphere Team Breakout Session

What is meant by "continuity"?

Availability of MVCM and potentially a VIIRS simulator for team

Data format(s)

Calibration/Validation

Level-3: Data filtering, aggregating, and gridding

ATBD preparation and review

Topical groups are being formed to facilitate some of these goals as part of the 1st International Cloud Working Group (ICWG-1)

The 1st International Cloud Working Group

Will be held in Lille, France in May 2016

http://www.icare.univ-lille1.fr/crew

Anticipated Topical Groups

- Use of Combined Sensors for Cloud Retrievals
- Cloud Modeling
- Cloud Height for Wind Applications
- Cloud Retrievals over Snow and Ice Surfaces
- Severe Weather Applications
- Validation Sources
- Assessment of Level-2 Passive Imager Cloud Parameter Retrievals
- Assessment of Retrieval Uncertainties
- Filtering/Aggregation Methods for Climate Applications
- Assessment of Cloud Parameter Data Records for Climate Studies

In summary

Our approach fuses data from two sensors (imager + sounder) to build a high spatial resolution 13.3-μm band.

This 13.3-μm band is used subsequently for CTH and IR phase, mitigating some of the impact caused by lack of IR sounding bands on VIIRS.

This approach may also prove useful for historical and future platforms.

Cloud product continuity assumes the ability to demonstrate that there is consistency over space and time in products from different sensors and teams…even between different versions by the same team. The issue is choosing a straightforward way to compare the same parameter in different data products.

The ICWG-1 will provide a platform for the community to decide how to filter and aggregate each parameter to promote product comparisons.