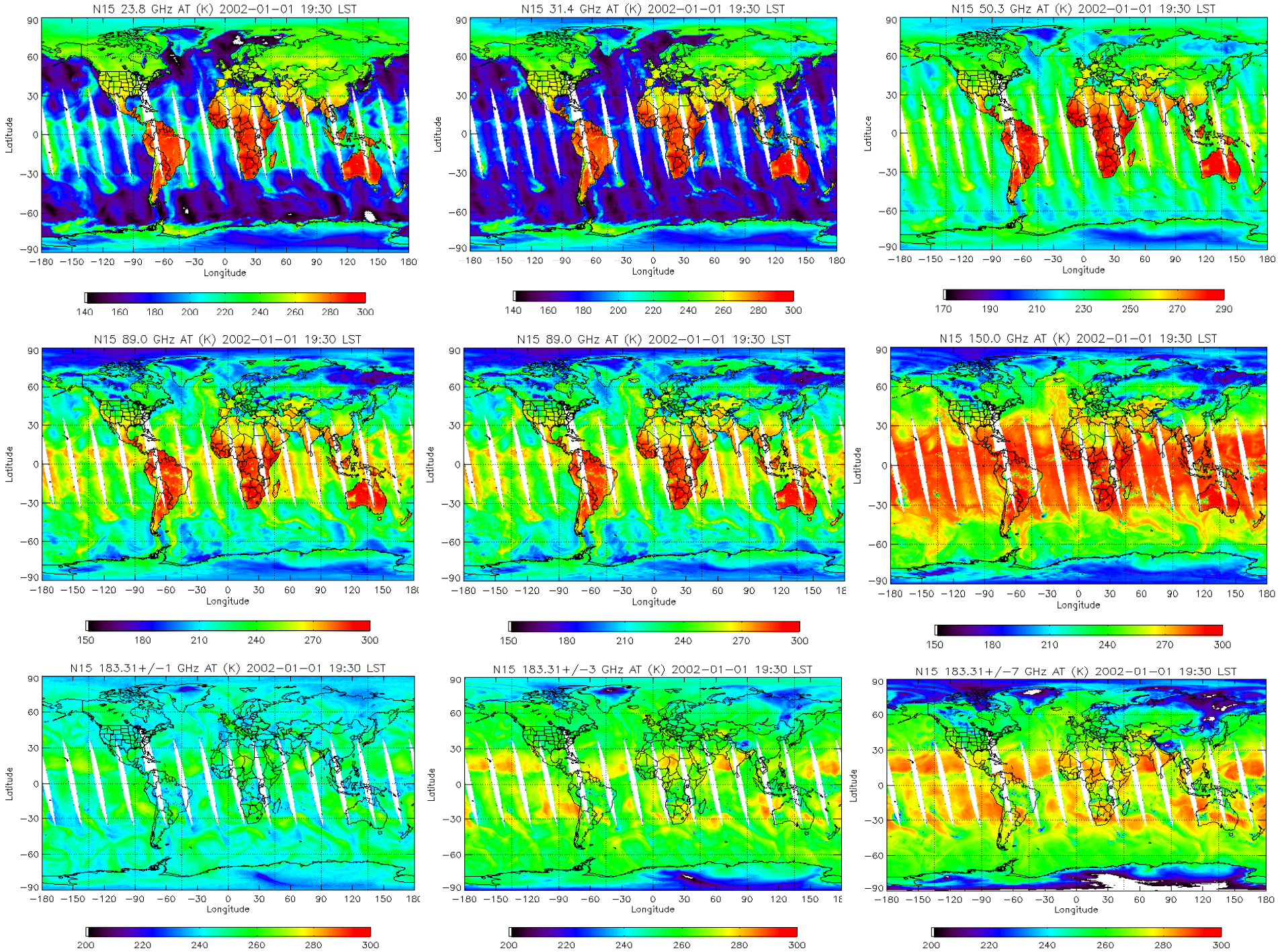
Project Overview – The Development of AMSU FCDR's and TCDR's for Hydrological Applications

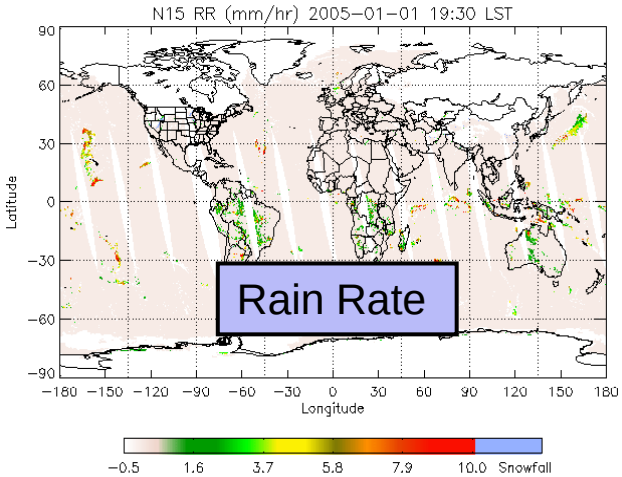
Huan Meng[1], Ralph Ferraro[1], Chabitha Devaraj[2], Isaac Moradi[2], Wenze Yang[2]

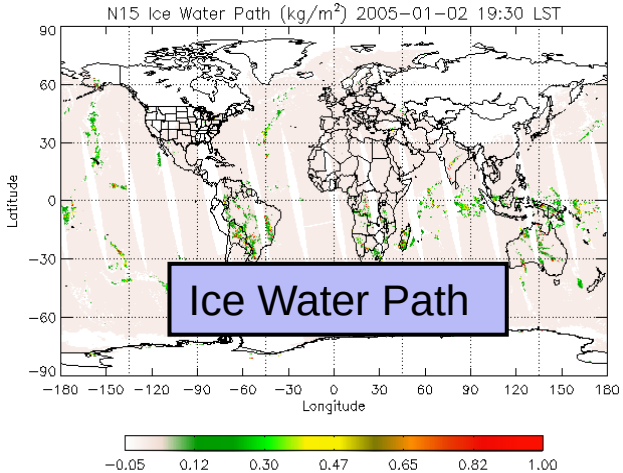
[1]Satellite Climate Studies Branch, NOAA/NESDIS/STAR/CoRP/
[2]NOAA Corporate Institute for Climate and Satellites
Huan.Meng@noaa.gov

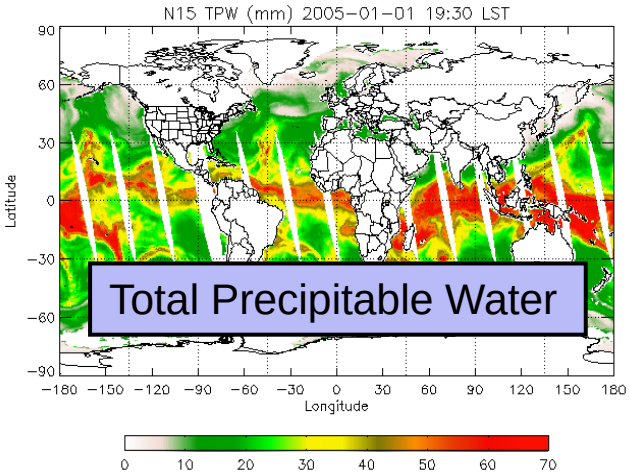
Overview (1/3)

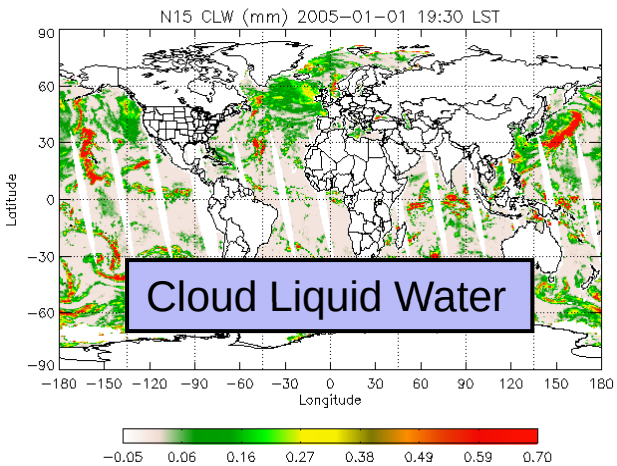
- **Generals**
  - A NCDC/CDR Program project, funding period: May 1, 2010 – April 30, 2013
  - Team: Ralph Ferraro, Huan Meng (Co-PI's) from NOAA/NESDIS/STAR; Wenze Yang, Chabitha Devaraj, Isaac Moradi from CICS/UMD
- **Goals**
  - Develop Advance Microwave Sounding Unit-A and -B (AMSU-A/-B), and Microwave Humidity Sounder (MHS) FCDR's for window and water vapor channels
    - AMSU-A: 23.8, 31.4, 50.3, 89.0 GHz, *i.e.* channel 1-3 and 15. Complementary to C. Zou's FCDR's on AMSU-A channels 4-14.
    - AMSU-B/MHS: 89, 150/157; 183.3±1, 183.3±3, 183.3±7/190.3 GHz, *i.e.* all channels
  - Develop TCDR's for hydrological products: Rain Rate, TPW, CLW, IWP, Snow Cover, SWE, SIC

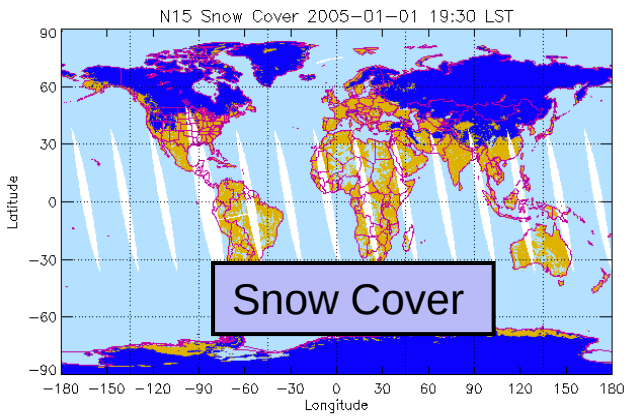

N15 23.8 GHz AT (K) 2002-01-01 19:30 LST
N15 31.4 GHz AT (K) 2002-01-01 19:30 LST
N15 50.3 GHz AT (K) 2002-01-01 19:30 LST
N15 89.0 GHz AT (K) 2002-01-01 19:30 LST
N15 89.0 GHz AT (K) 2002-01-01 19:30 LST
N15 150.0 GHz AT (K) 2002-01-01 19:30 LST
N15 183.31+/-1 GHz AT (K) 2002-01-01 19:30 LST
N15 183.31+/-3 GHz AT (K) 2002-01-01 19:30 LST
N15 183.31+/-7 GHz AT (K) 2002-01-01 19:30 LST
Latitude
Longitude



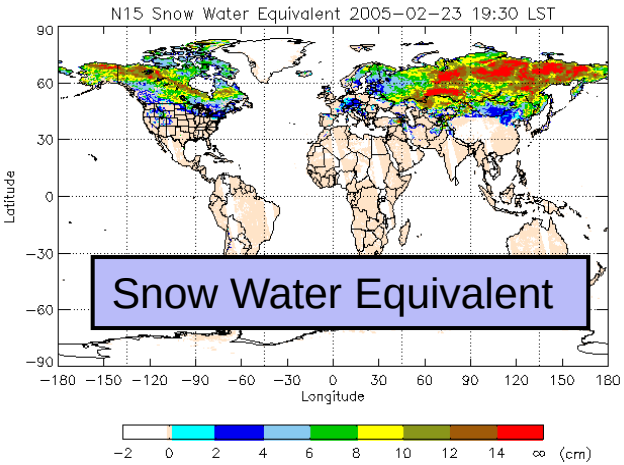


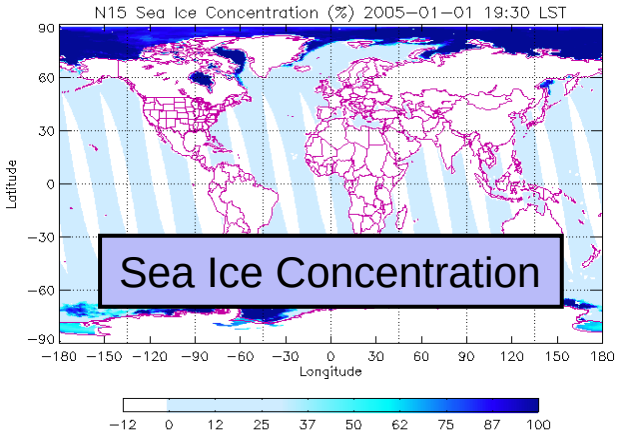






Blue is snow, yellow is land without snow, light blue is undetermined (rain, desert, water, etc.





Overview (2/3)

- **AMSU hydrological products**

Products	Main Channels Used in MSPPS*
Rain Rate	AMSU-A 23.8 and 31.4 GHz; AMSU-B/MHS 89, 150/157, 183.3±1, ±3, ±7/190.3 GHz
Ice Water Path	AMSU-A 23.8 and 31.4 GHz; AMSU-B/MHS 89 and 150/157 GHz
Total Precipitable Water	AMSU-A 23.8 and 31.4 GHz
Cloud Liquid Water	AMSU-A 23.8 and 31.4 GHz
Snow Cover	AMSU-A 23.8, 31.4 GHz and 89 GHz; AMSU-B/MHS 89 GHz
Snow Water Equivalent	AMSU-A 23.8 and 31.4 GHz; AMSU-B/MHS 89 GHz
Sea Ice	AMSU-A 23.8, 31.4, and 50.3 GHz

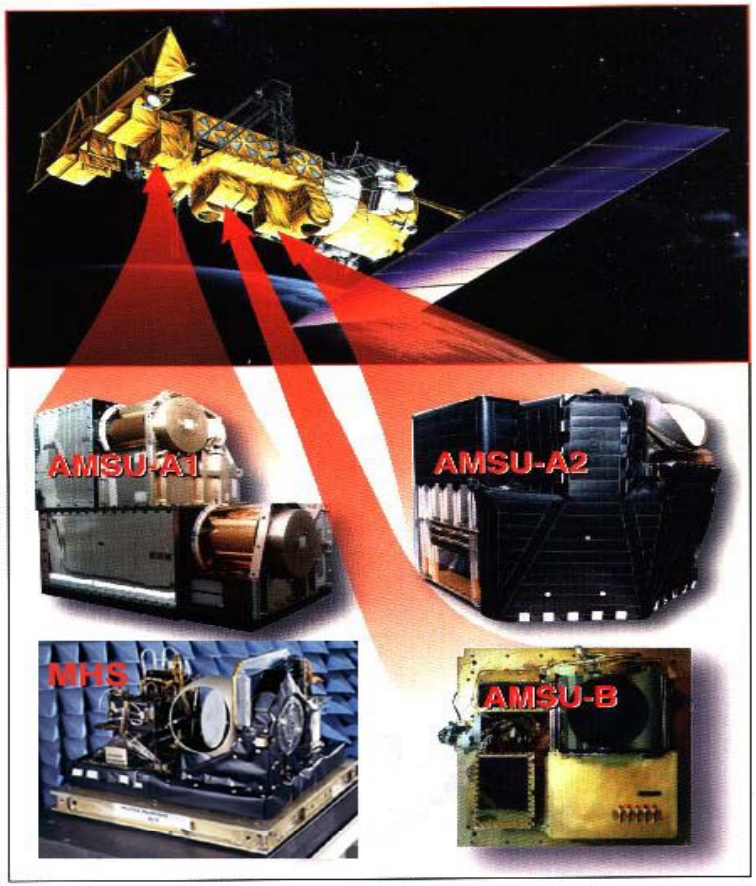
* In MIRS, all AMSU-A, -B/MHS channels are used in product retrievals

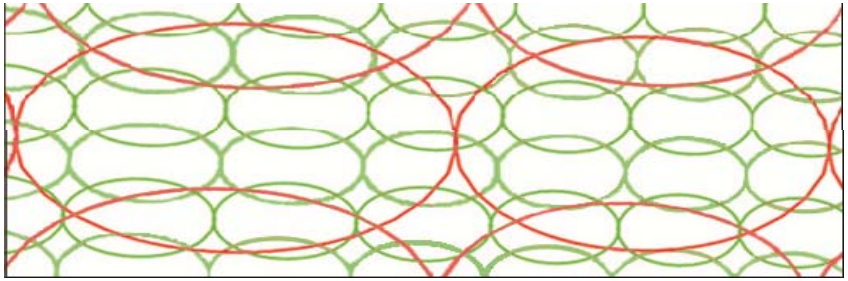
Overview (3/3)

- **Source Data**
  - NOAA-15,16,17,18,19 & MetOp-A L1B data
  - Aqua AMSU-A L1B data
- **Deliverables**
  - FCDR's from 2000 – 2010 for all satellites (perhaps to 1998 for NOAA-15)
  - TCDR's; same time periods
- **Current/Expected Users**
  - National: government (NASA, NOAA, NRL); science community
  - International: IPCC; GEWEX (GPCP); CEOS; GCOS; IPWG
  - Other – General climate community

Sensors – AMSU-A/-B, MHS

- Aboard polar orbiting satellites
- Cross track scan
- “Mixed” polarizations
- AMSU-A (A1-1, A1-2, and A2): 30 FOVs with footprint (km) of 48 x 48 – 80 x 150
- AMSU-B/MHS: 90 FOVs with footprint (km)16 x 16 – 26 x 52
- 1 AMSU-A FOV corresponds to 3x3 AMSU-B/MHS FOV’s



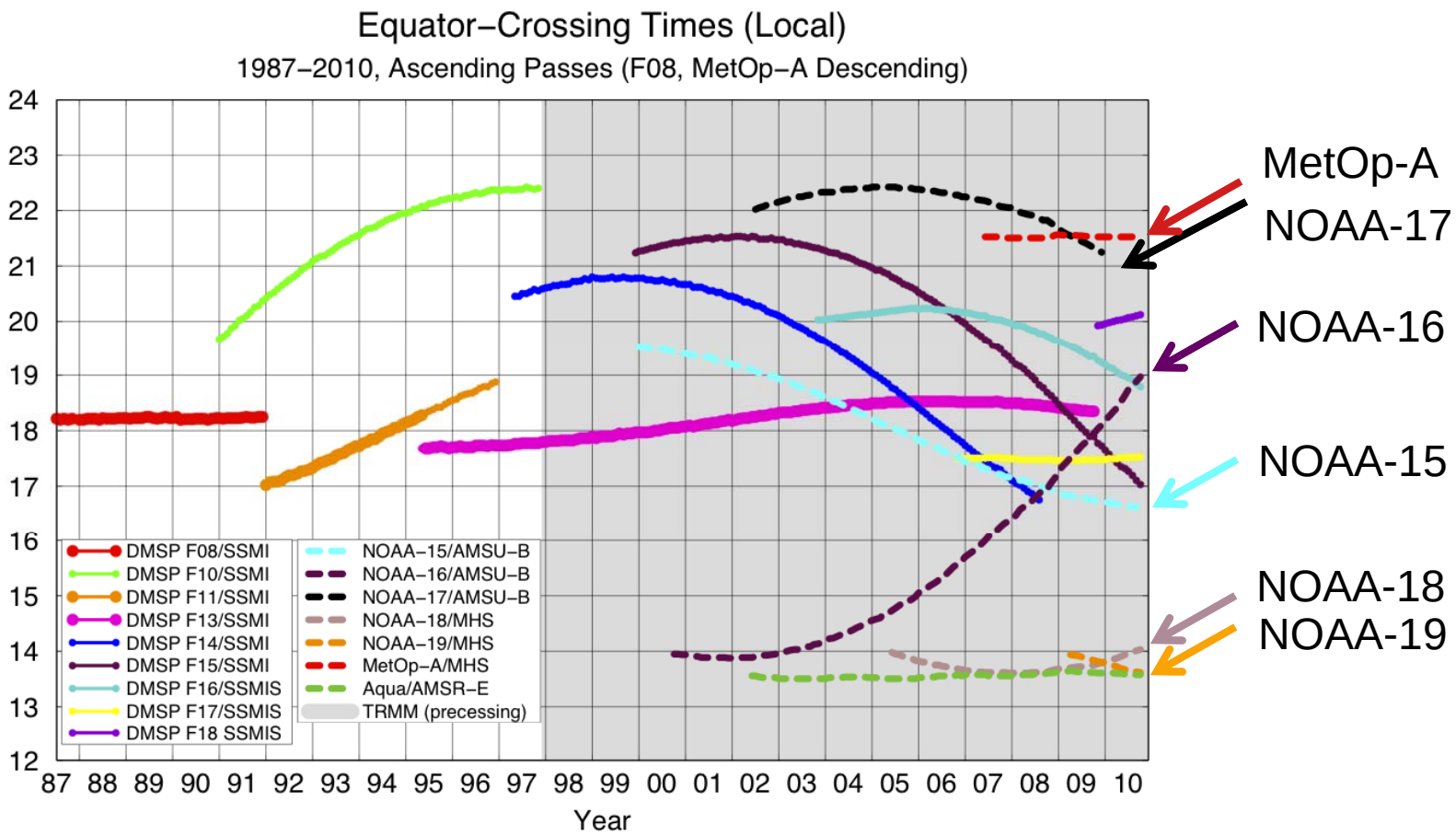


Satellites

- **POES satellites: NOAA-15 to NOAA-19, and MetOp-A**

Satellite	Launch Date	Length (year)	Instruments	Note
NOAA-15	May 13, 1998	11 (13)	AMSU-A & -B	❖RFI ❖Large geolocation error since March 2010 ❖Degradation and loss (Sept 2010) of water vapor channels
NOAA-16	Sept 21, 2000	10	AMSU-A & -B	Degradation of water vapor channels
NOAA-17	Jun 24, 2002	8	AMSU-A & -B	❖AMSU-A ch3 and 15 only have 1-year record ❖Loss of water vapor channels since Dec 2009 ❖Minor RFI
NOAA-18	May 20, 2005	5	AMSU-A & MHS	
MetOp-A	Oct 19, 2006	4	AMSU-A & MHS	
NOAA-19	Feb 6, 2009	2	AMSU-A & MHS	

Importance of AMSU Products



Thickest lines denote GPCP calibrator.

Image by Eric Nelkin (SSAI), 20 October 2010, NASA/Goddard Space Flight Center, Greenbelt, MD.

Team Responsibilities

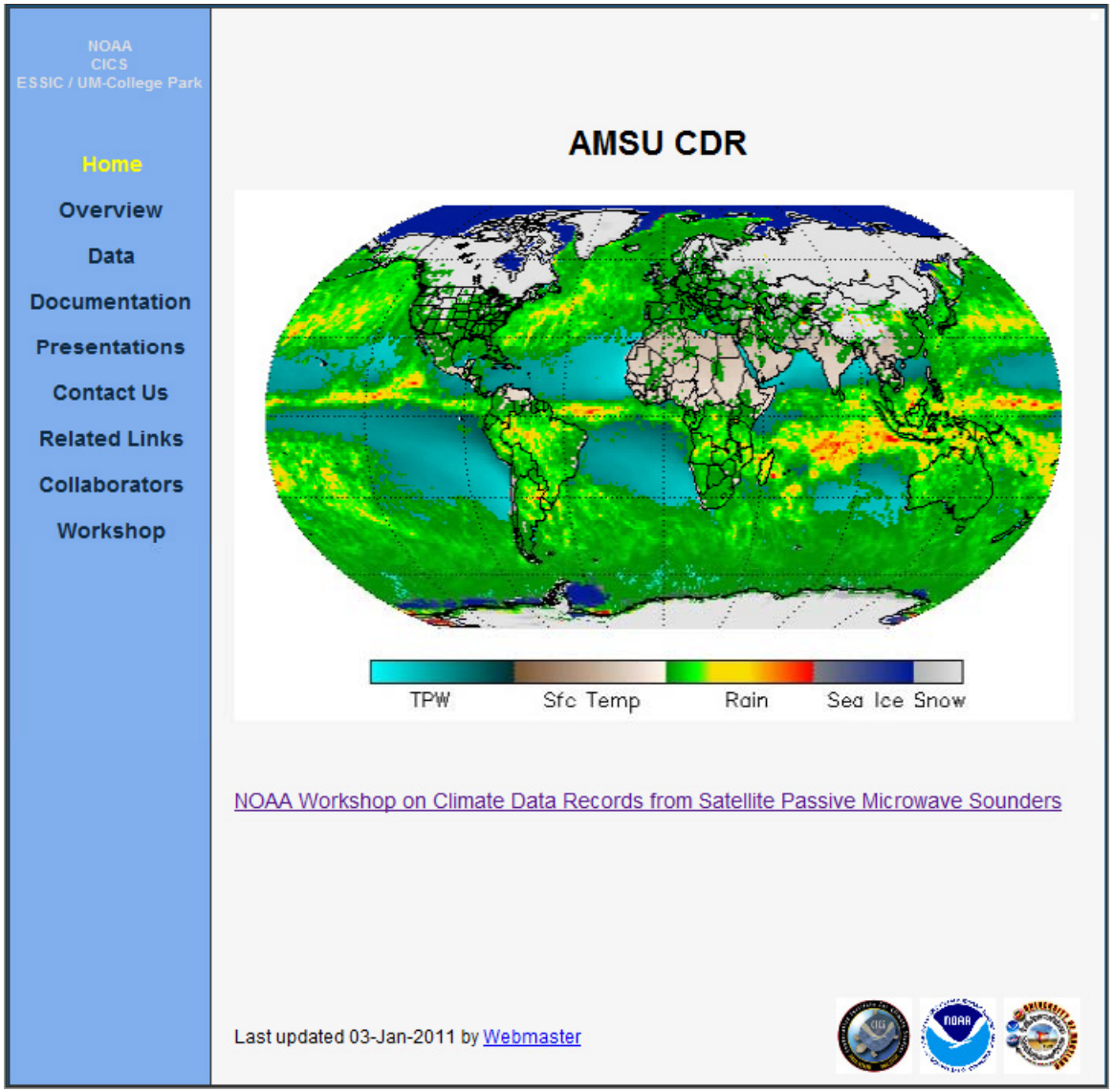
- **R. Ferraro**: Project management
- **H. Meng**: Technical lead
- **C. Devaraj** (Nov 2010): AMSU-B/MHS channel-1 and -2 (window channels), web master
- **I. Moradi** (Jan 2011): Geolocation correction, AMSU-B/MHS channel-3 to -5 (water vapor channels)
- **W. Yang** (Apr 2010): AMSU-A channel-1 to -3 and -15 (window channels)

Progress (1/2)

- **Data collection**
  - AMSU L1B data (1998 – 2010)
  - AMSU L2 data (2000 – 2010)
  - ERA-Interim (1998 – 2008)
  - PATMOS-x cloud data (1998 - 2009)
- **Metadata**
  - NOAA/NESDIS/STAR MSPPS project log
  - NOAA/NESDIS/OSDPD operational log
- **Geolocation error correction**
- **AMSU-A scan bias characterization**
- **AMSU-A sensor drift identification**
- **MHS scan bias characterization**

Progress (2/2)

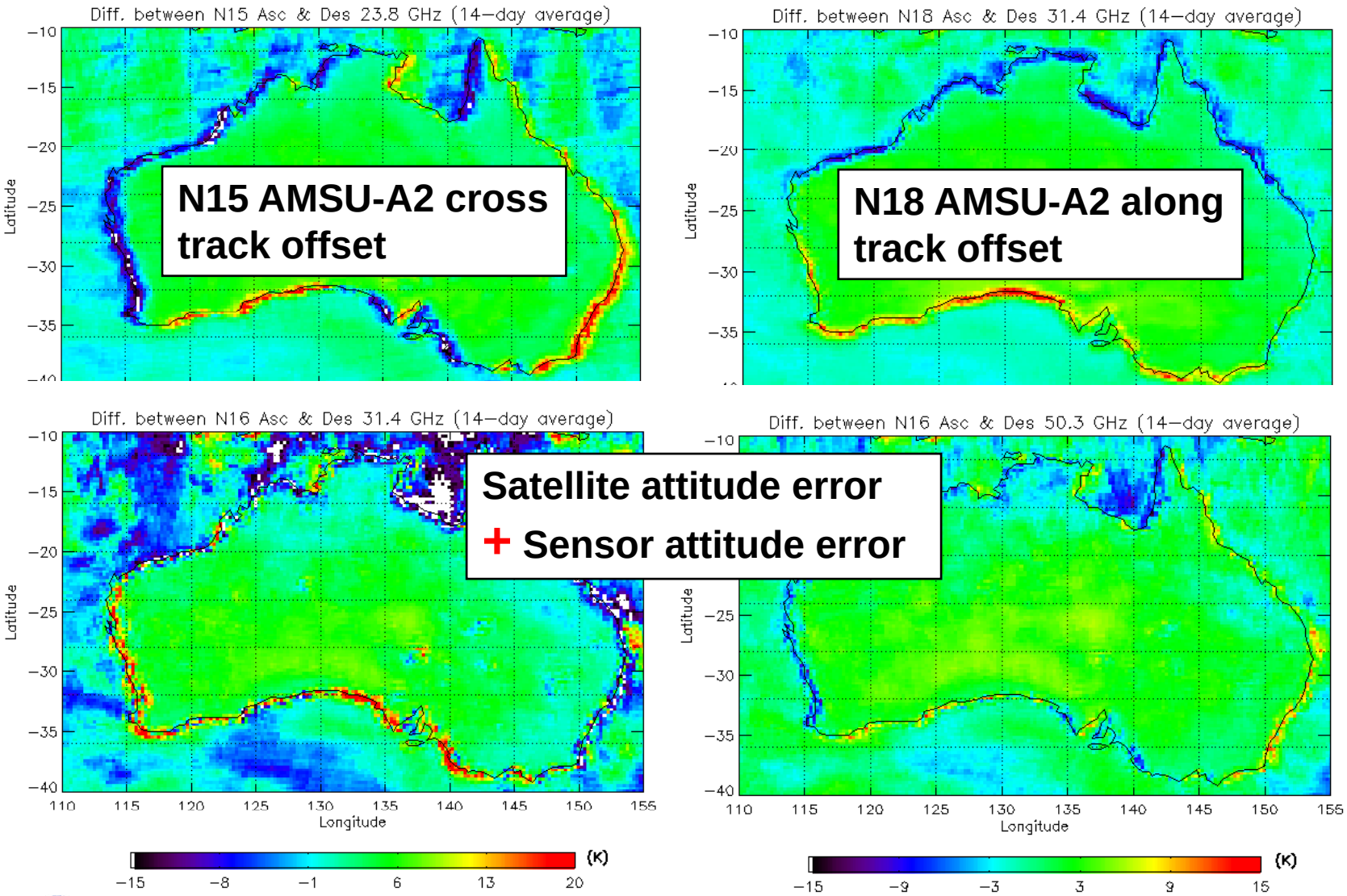
- **Project Website:** http://cics.umd.edu/AMSU-CDR/home.html



AMSU/MHS Bias Sources

Bias Source	Effect
Satellite and sensor attitude errors Satellite clock drift	Geolocation error, scan bias, LZA bias
Antenna pattern correction bias (asymmetry, sidelobe spacecraft interference etc.)	Scan bias
Polarization twist	Scan bias
Reflector misalignment	Scan bias
Orbital decay	LZA bias
Sensor RFI	Scan bias, measurement bias
Warm target contamination + sensor nonlinear calibration error	Measurement bias
Pre-launch calibration offset	Measurement bias
Sensor and satellite degradations	Measurement bias

Geolocation Error (1/2)

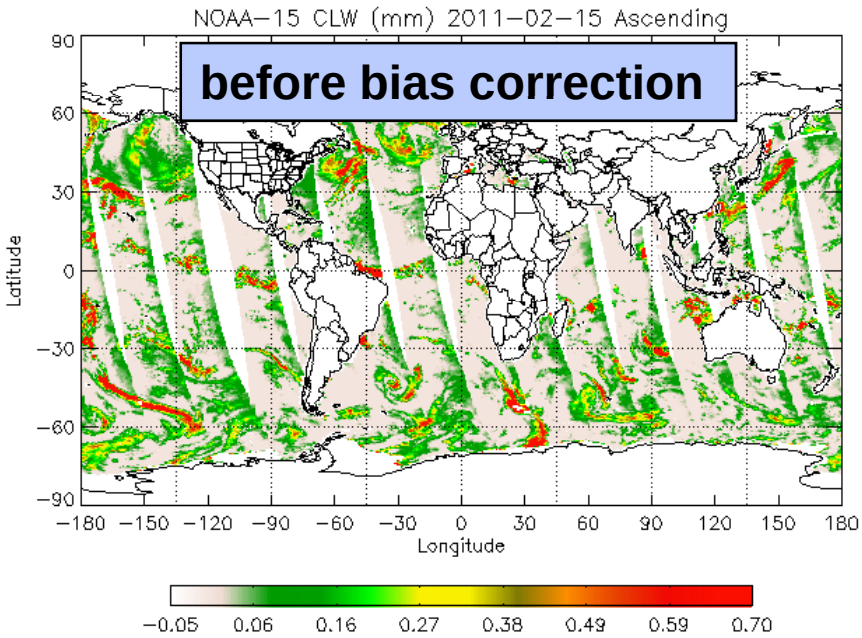


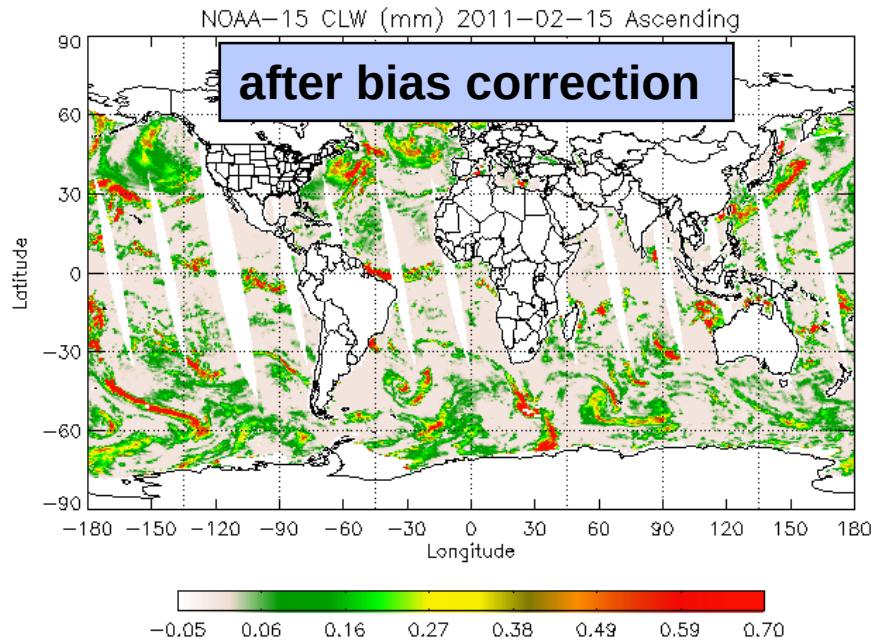
Geolocation Error (2/2)

- **Correction of geolocation error**
  - Combine satellite and sensor attitude errors into three variables: pitch, yaw, and roll
  - Kigawa & Weinreb method to determine geolocation with given attitude variables
  - Evaluate the difference between ascending and descending antenna temperatures along Australia coastline

AMSU-A Scan Bias

- **CLW bias** (CLW uses AMSU-A channel 1 and 2)

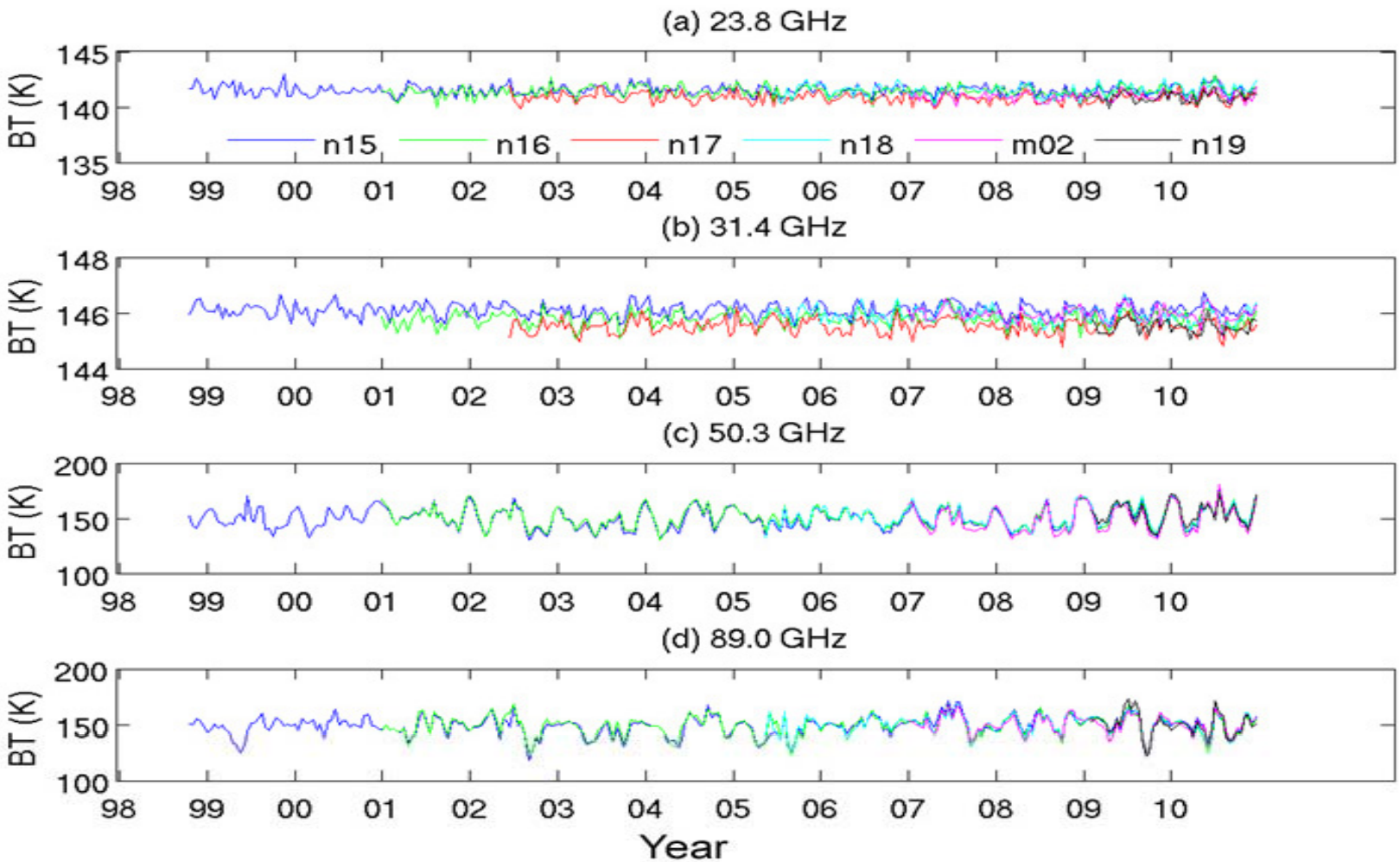




- **Scan bias characterization**
  - CRTM simulation
  - Over ocean
  - Stratification by environmental conditions

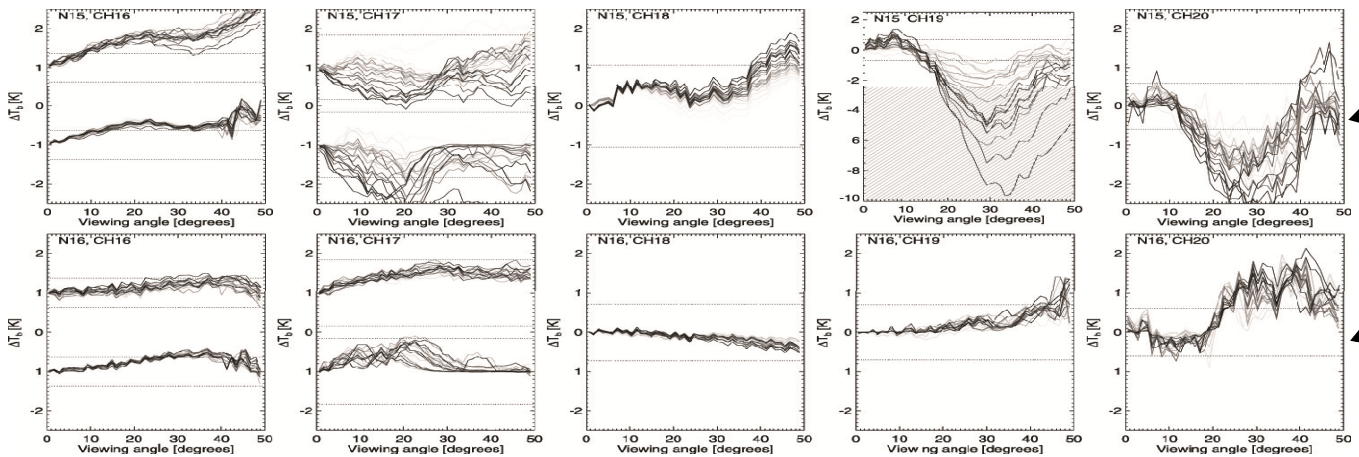
AMSU-A Sensor Drift

- **Single satellite Tb drift**
  - ❖ Vicarious cold reference



AMSU-B/MHS Scan Bias

- **AMSU-B asymmetry (Buehler *et al.*, 2005)**



NOAA-15 (RFI effect)

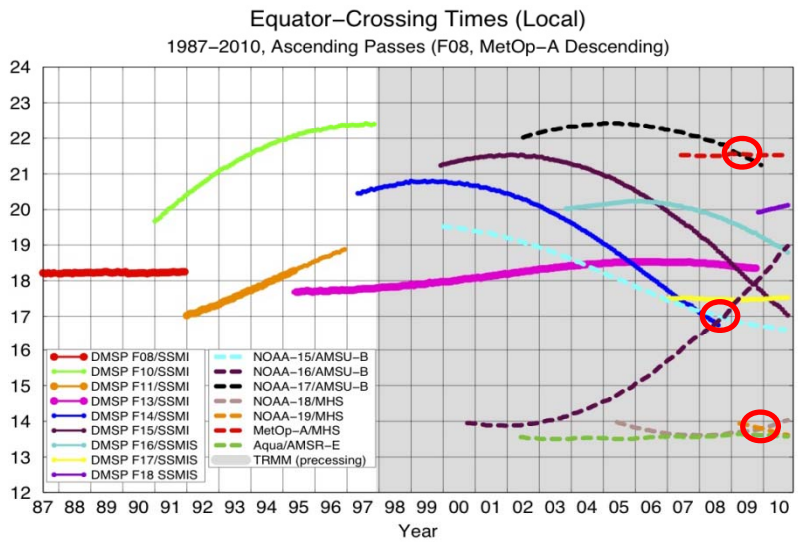
NOAA-16

  - NOAA-15 asymmetry in AMSU-B channel 4 and 5 is large before RFI correction
  - Asymmetry in AMSU-B water vapor channels is generally small

- **MHS scan bias**
  - Small scan biases in NOAA-18 water vapor channels
  - Relatively large scan biases in NOAA-18 window channels

Inter-Satellite Calibration (1/2)

- **SNO**
  - Challenging in polar regions for AMSU-A due to surface radiometric inhomogeneity. A lesser problem for AMSU-B/MHS.
  - Overlapping satellites pairs:
    - NOAA-15 and -16 (Aug 08)
    - NOAA-17 and MetOp-A (Apr, May 09)
    - NOAA-18 and -19 (Sept 09) (Aqua AMSU-A)



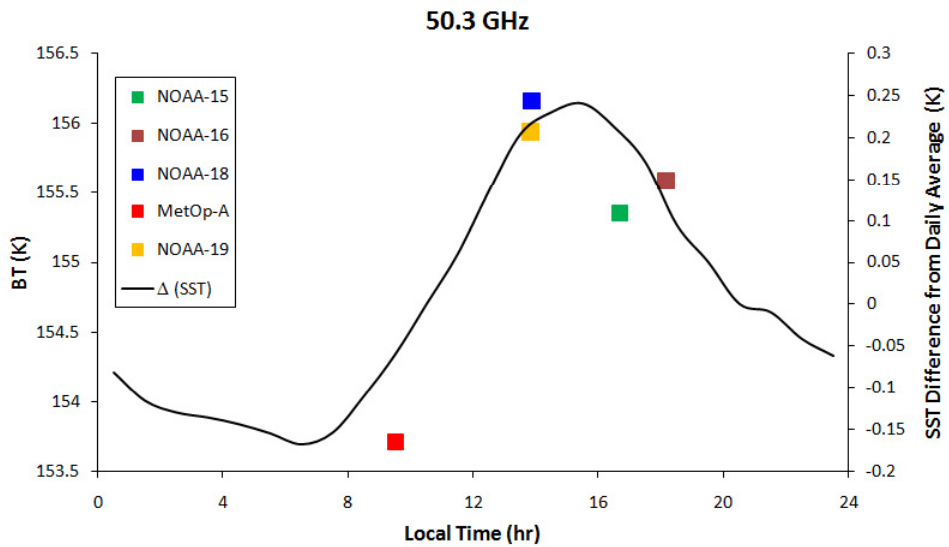
Thickest lines denote GPCP calibrator.

Image by Eric Nelkin (SSAI), 20 October 2010, NASA/Goddard Space Flight Center, Greenbelt, MD.

  - Inter-calibration with all satellites: polar regions with improved SNO collocation technique (Iacovazzi & Cao, 2008)?

Inter-Satellite Calibration (2/2)

- **Vicarious Calibration**
  - Diurnal cycle is present



- **Double Difference**
  - Requirements less stringent than SNO – for all satellites inter-calibration?

Next Steps

- **Single satellite calibration**
  - Geolocation error correction
  - LZA bias correction
  - Scan bias correction
- **Inter-satellite calibration**
  - Systematic measurement error correction
- **TCDR products**
  - Consistency of hydrological products (diurnal effects)