



CDR DEVELOPMENT PROJECT

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

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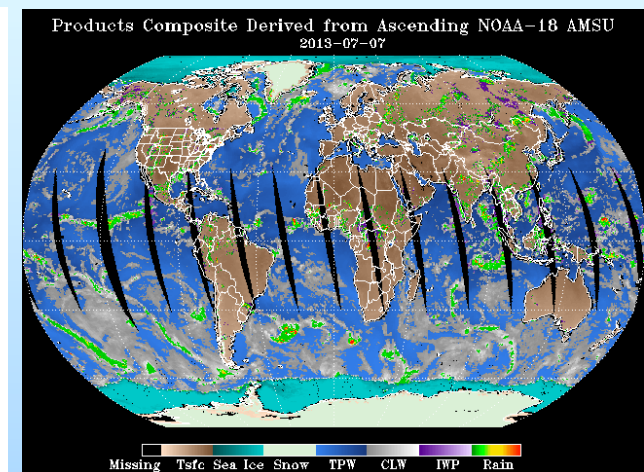
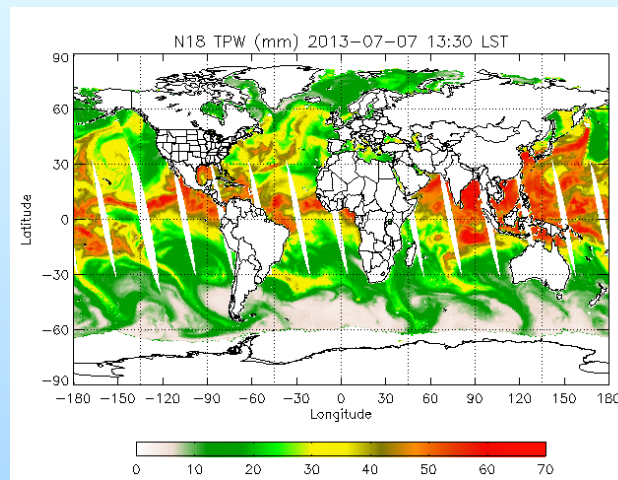
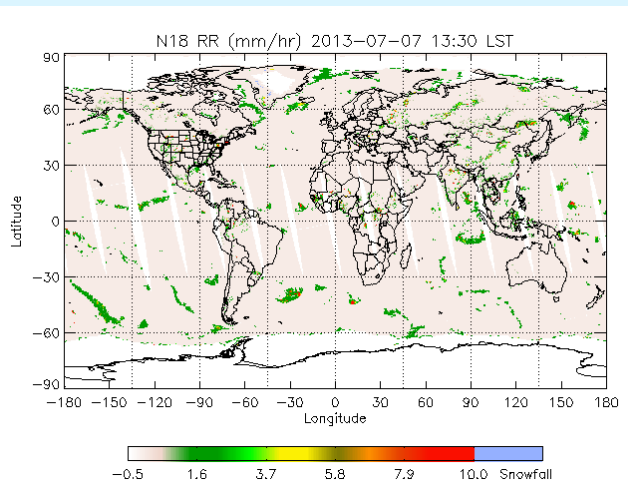
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Outline

- Project Description
- Production and QA Approach
- Applications
- Schedule & Issues

Project Description (1/2)

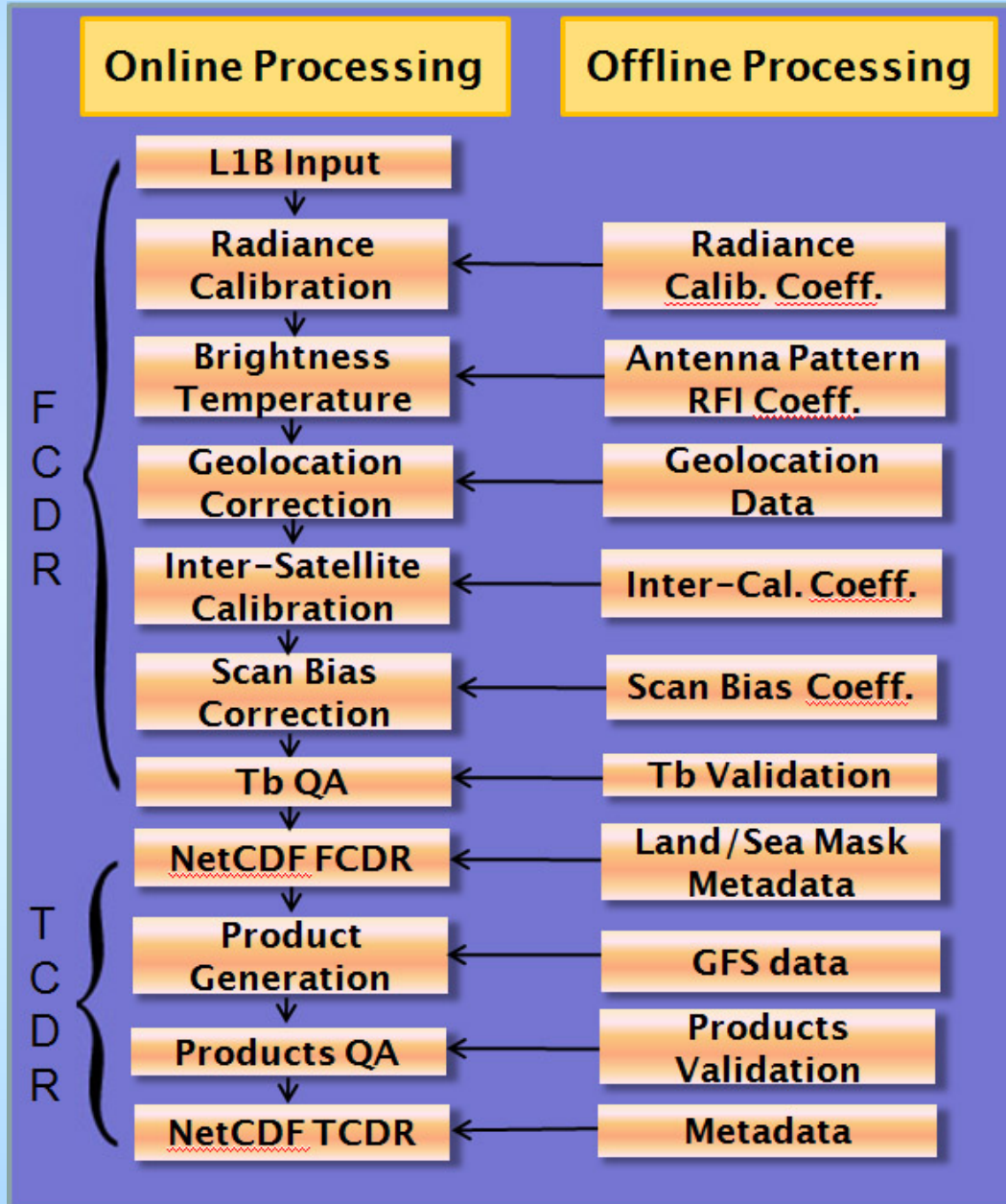
- Develop AMSU-A/-B and MHS FCDR's for “window” and “water vapor” channels
 - AMSU-A: 23.8, 31.4, 50.3, 89.0 GHz
 - AMSU-B/MHS: 89, 150/157; 183 ± 1 , 183 ± 3 , $183\pm7/190$ GHz
- Develop TCDR's for hydrological products (12 products)
 - Rain rate (and snowfall detection), total precipitable water, cloud liquid water, ice water path, sea ice concentration, snow cover, snow water equivalent, land surface temperature, land surface emissivity 23, 31 and 50 GHz.
- Satellites: NOAA-15,16,17,18,19 & MetOp-A
- Time period: Years 2000-2010 (depending on launch date)



Project Description (2/2)

CDR(s)	Period of Record & Temporal Resolution	Spatial Resolution & Projection	Update Frequency	Data file distinction criteria	Inputs	Uncertainty Estimates	Collateral Products
AMSU-A window channels Tb's	2000-2010, 2 measure./day/satellite	48 km at nadir; no projection	Yearly	Orbit	L1B, ancillary data	Not available yet	Geolocation corrected data
AMSU-B all channels Tb's	2000-2010, 2 measure./day/satellite	16 km at nadir; no projection	Yearly	Orbit	L1B, ancillary data	Not available yet	Geolocation corrected data
MHS all channels Tb's	2005-2010, 2 measure./day/satellite	16 km at nadir; no projection	Yearly	Orbit	L1B, ancillary data	Not available yet	Geolocation corrected data
AMSU-A products (TPW, CLW, Ts, ϵ)	2000-2010, 2 measure./day/satellite	48 km at nadir; no projection	Yearly	Orbit	AMSU-A FCDR Tb's, ancillary data	Not available yet	None
AMSU-B products (all others)	2000-2010, 2 measure./day/satellite	16 km at nadir; no projection	Yearly	Orbit	AMSU-A & -B FCDR Tb's, ancillary data	Not available yet	None
MHS products (all others)	2005-2010, 2 measure./day/satellite	16 km at nadir; no projection	Yearly	Orbit	AMSU-A & MHA FCDR Tb's, ancillary data	Not available yet	None

Production Approach



- AMSU-A and AMSU-B / MHS CDRs take different approaches in scan bias correction and inter-satellite calibration
- Processing requires:
 - C time and NetCDF toolkits
 - FORTRAN CRTM libraries
 - HDF4 libraries
 - HDF-EOS2 libraries

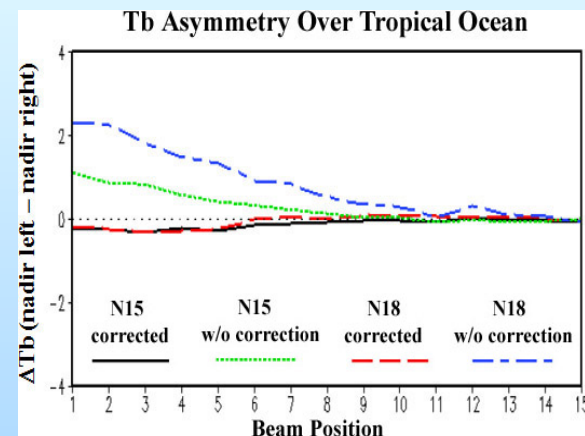
Validation & Quality Assurance

■ Validation

- Statistics derived from comparing FCDR with model outputs (CRTM + ERA-Interim)
- Asymmetry index as a measure of accuracy for scan bias correction
- Statistical analysis of the FCDR and TCDR time series

■ Quality Assurance

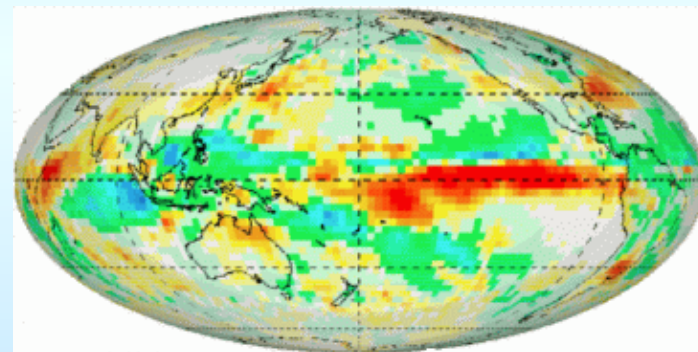
- Visual inspection will be conducted routinely
- Examining scan bias with pair-wise Tb differences
- Analyzing monthly and daily averages of brightness temperatures over the targeted regions and the globe
- Analyzing time series to verify long-term consistency and continuity



Uses & Applications (1/3)

■ Applications and Uses

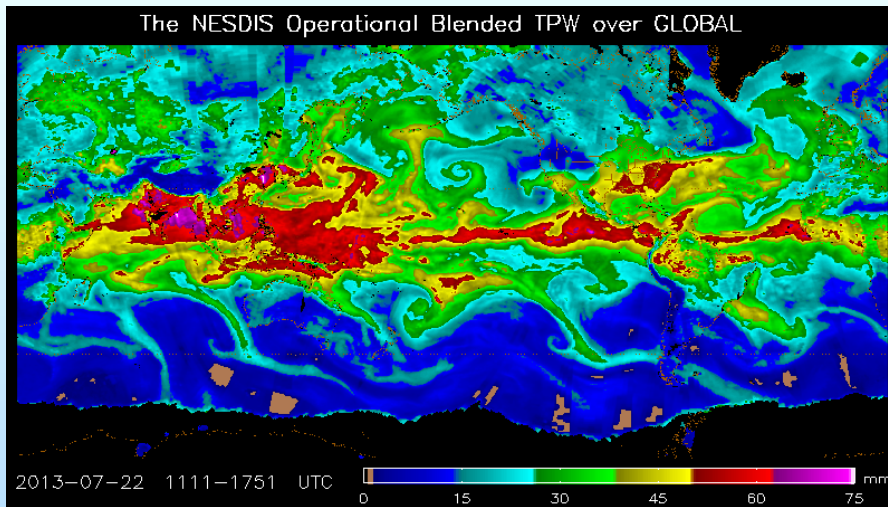
- AMSU CDR's are geared for use with other similar data sets
 - Because time series is only 11 years in length at present, the stand alone TCDR's do not offer information of long term trends
 - The CDR's are best suited when they are combined with similar CDR's from other sensors (e.g., SSM/I, AMSR-E, TMI)
- Primary “scientific” user would be “blended” product developers and organizations, e.g., for precipitation and other hydrological products:
 - WCRP/GEWEX/GPCP
 - NASA/TRMM and GPM programs
 - NOAA/CMORPH precipitation product
- Users of the blended products include:
 - Climate community
 - Government, research, planning/mitigation
 - Insurance industry
 - Areas of vulnerability for hazards such as floods (and in areas where conventional data does not exist)
 - Commodity Market
 - Agricultural monitoring and changes and potential crop losses
 - Water Resource Managers
 - Seasonal to interannual changes



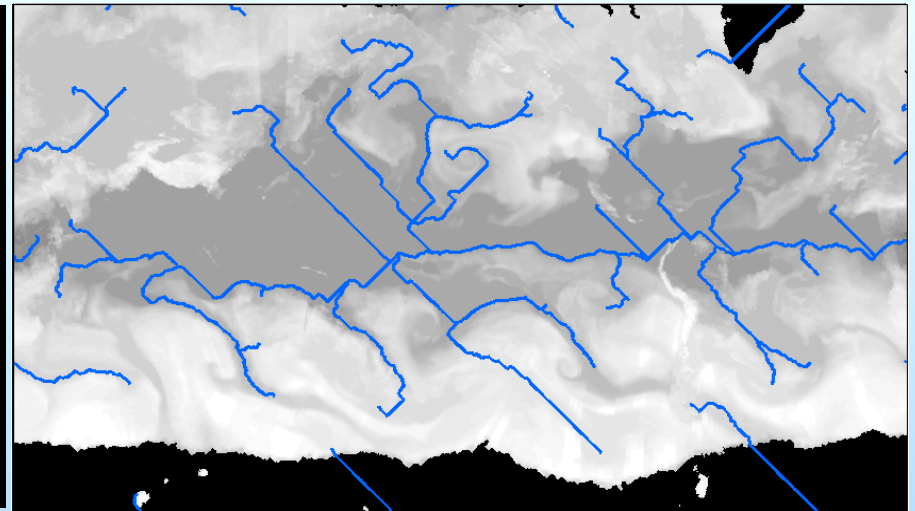
Uses & Applications (2/3)

- Atmospheric Rivers (AR) – potential to develop climatology from this data set and fuse together with SSM/I CDR
 - AMSU-A window channels are used to retrieve TPW (total precipitable water).
 - AR's connected to prolonged flooding events, e.g., “The Pineapple Connection” in the U.S.
 - AR's have broad impact on agriculture, health, tourism, water resources, etc.
 - Are the AR's changing over time?

Blended TPW from July 22, 2013



Automated AR Detection from July 22, 2013



Uses & Applications (3/3)

■ Key Scientific Findings

- AMSU-A/AMSU-B/MHS can have significant geolocation errors
 - Problem can be more severe in a particular satellite or time period
 - NOAA-15 AMSU-A2 was the most problematic
- AMSU-A/AMSU-B/MHS can have significant cross scan biases
 - NOAA-15 AMSU-A and MetOp-A MHS were the most severe
- Several AMSU-B sensors show degradation over time
 - NOAA-16 AMSU-B channel 5 has the largest degradation
- Multiple calibration methods are required to generate CDR's for AMSU/all channels (e.g., SNO, vicarious calibration, etc.)
 - Bias is often scene temperature and/or polarization dependent
 - Warm target contamination caused by orbital drift is one of the most important error sources for inter-satellite calibration

Schedule & Issues (1/2)

■ Accomplishments and project status

- Published two papers (scan bias and geolocation correction)
- Completed AMSU-A window channels warm-target contamination correction
- Inter-calibrated AMSU/MHS water vapor channels
- Inter-calibrated Windows Channels from AMSU-B/MHS
- Developed beta CDR for NOAA-15 and NOAA-18 AMSU-A window channels, which includes geolocation correction, inter-calibration, and scan bias correction
- Developed beta CDR for MHS NOAA-18 Water Vapor Channels, which includes geolocation correction and inter-calibration
- Regular participation at CALCON and GPM X-CAL group to share our findings and gain insight from others
- Further Inter-satellite calibration for AMSU-A window channels is ongoing
- Beta CDR data sets are being analyzed for the effectiveness of the correction methods

■ Milestones to finish development & testing

- August 2013: AMSU-A & AMSU-B/MHS Beta data available to public on CICS server
- September 2013: Complete AMSU-A inter-satellite calibration
- October 2013: Complete AMSU-B/MHS scan bias correction
- November 2013: Release next beta version of AMSU-A & AMSU-B/MHS TCDR's
- December 2013: Ready to deliver to NCDC/Initial Operational Capability (IOC)

Schedule & Issues (2/2)

- **State any risks or concerns**
 - We are currently in no-cost extension status
 - AMSU-B and MHS data can not be easily inter-calibrated – there are some small differences between the two sensors such as polarization difference, or frequency difference that prevent inter-calibrating these instruments
 - Outside dependencies
 - PATMOS-x data (missing 2006/2007 data for some satellites, no 2010 data yet)
 - SGP4, third party navigation package for geolocation correction
- **How can the CDR Program better assist you?**
 - Help to build connections between ‘real-world’ users and CDR developers
 - We focus mainly on the scientific issues to generate the best CDR

Acknowledgements

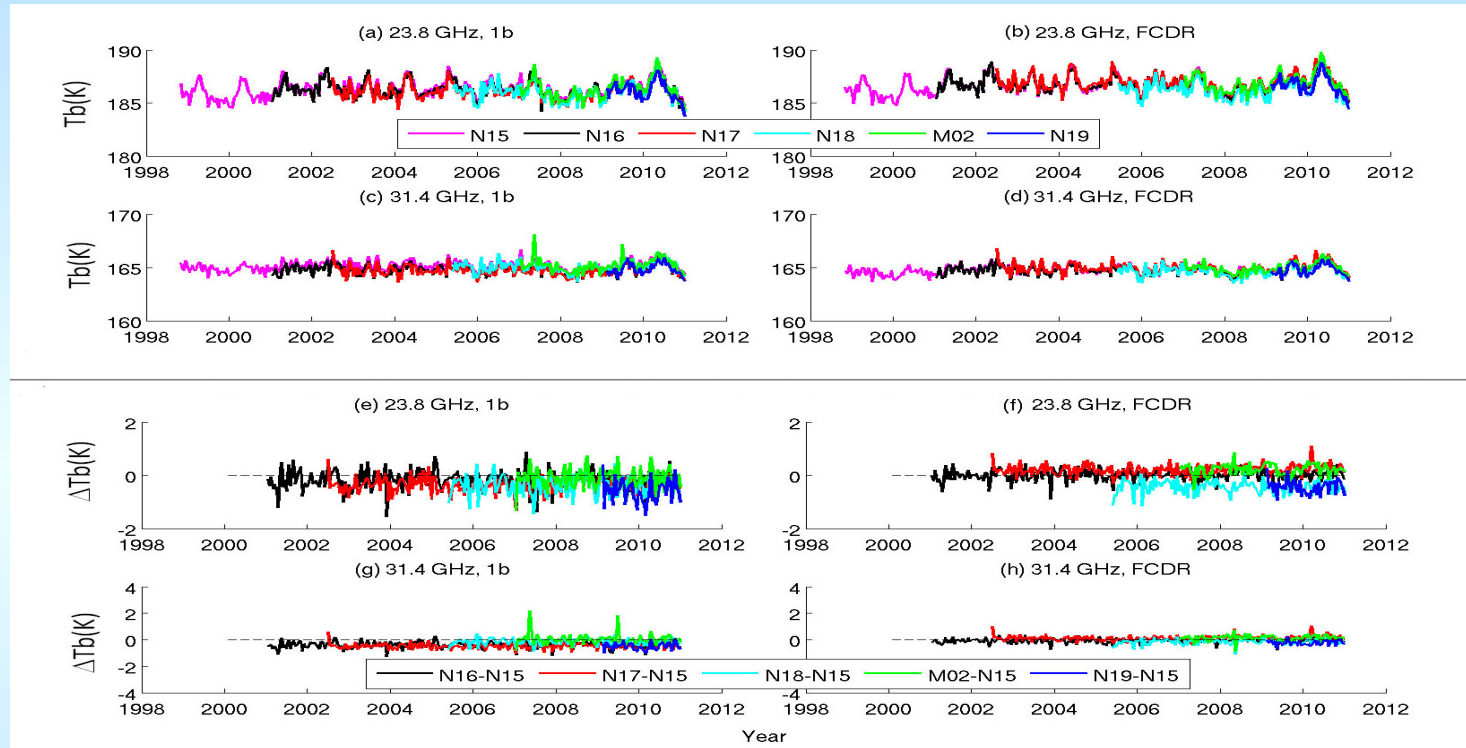
Cheng-Zhi Zou, Tsan Mo, Andy Heidinger, Matt Sapiiano, Stephen Bilanow, Ben Ho, Jonny Luo, Hai-Tien Lee, Wesley Berg, Brian Nelson, Hilawe Semunegus, Mark Liu, Yong Han, Fuzhong Weng, Jim Shiue, William Blackwell, Darren McKague, Peter Bauer, Viju John

Project Papers:

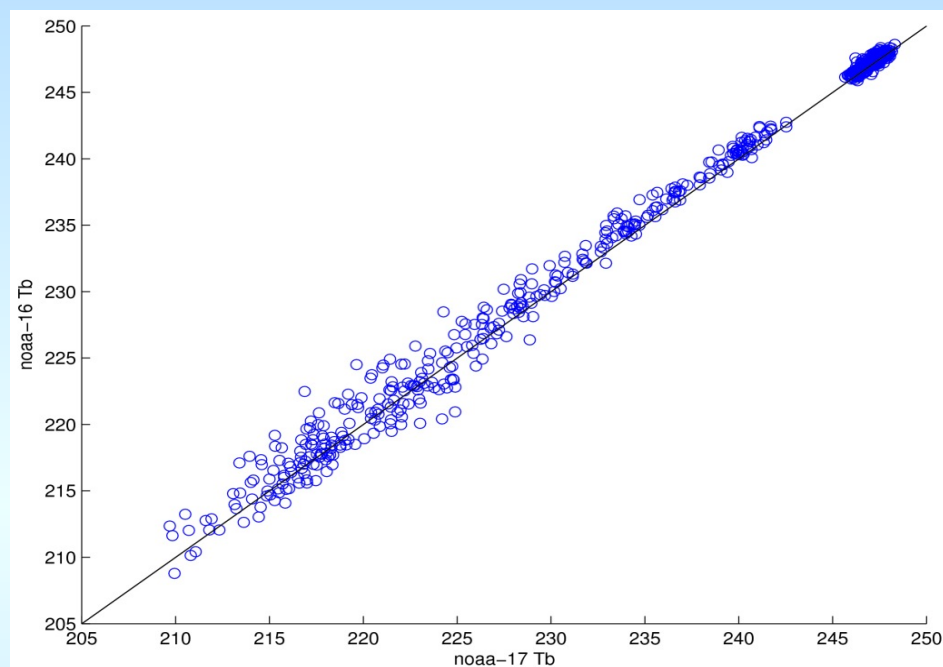
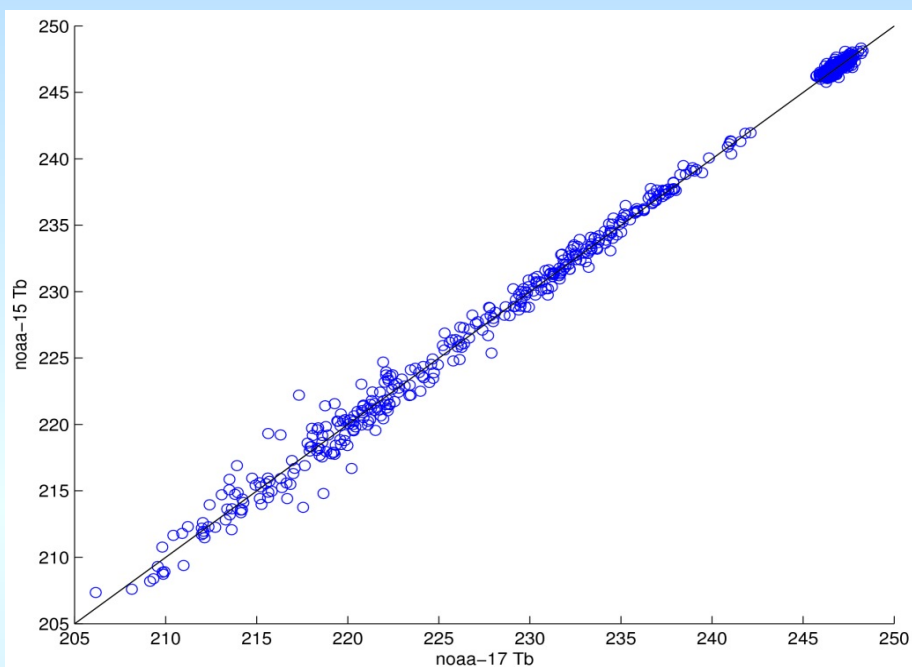
- Yang, W., H. Meng, R.R. Ferraro, I. Moradi, C. Devaraj, 2013: Cross-Scan Asymmetry of AMSU-A Window Channels: Characterization, Correction and Verification, *IEEE Transactions on Geoscience and Remote Sensing*, 51(3). DOI: 10.1109/TGRS.2012.2211884.
- Moradi, I., H. Meng, R.R. Ferraro, S. Bilanow, 2013: Correcting geolocation errors for microwave instruments aboard NOAA satellites, *IEEE Transactions on Geoscience and Remote Sensing*, 51, 3625-3637. DOI: 10.1109/TGRS.2012.2225840.

Backups

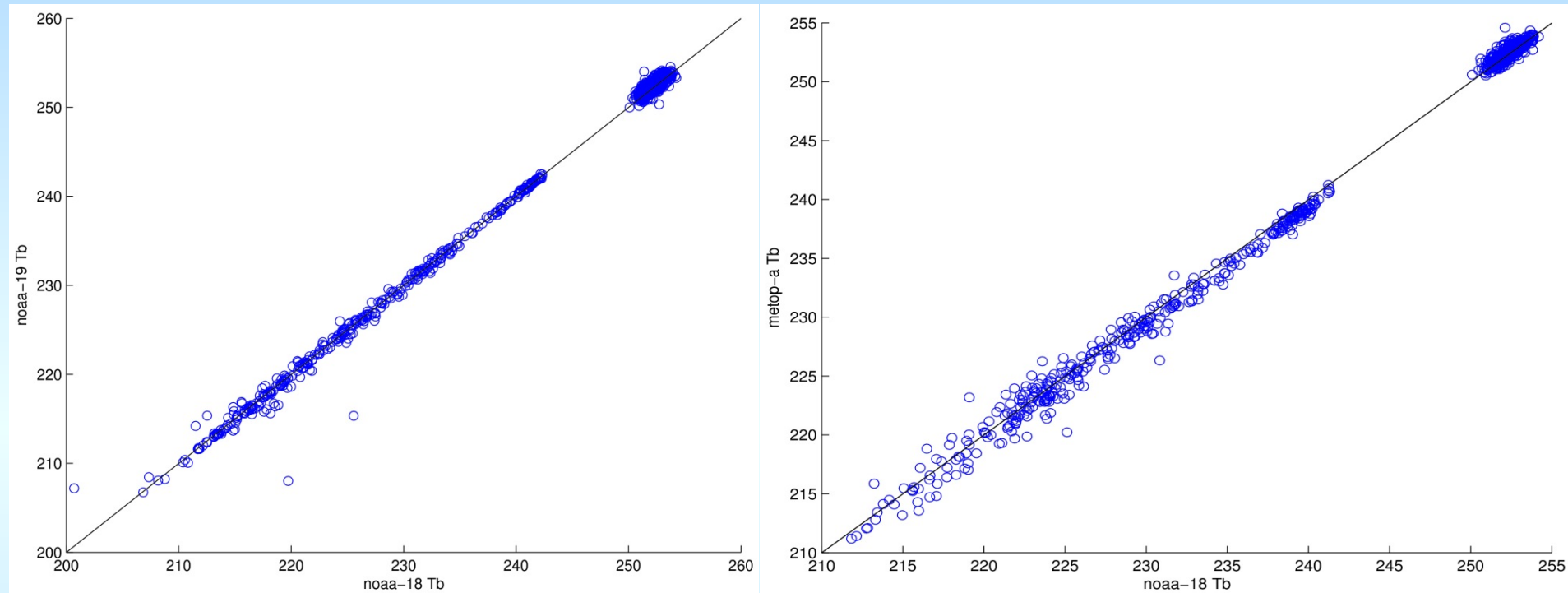
AMSU-A Inter-Calibration Warm Target Contamination Correction



ΔT_b STD by Satellite Pair	23.4 GHz		31.4 GHz	
	Before Correction	After Correction	Before Correction	After Correction
N16-N15	0.374	0.218	0.263	0.195
N17-N15	0.285	0.202	0.217	0.205
N18-N15	0.386	0.239	0.259	0.197
M02-N15	0.370	0.219	0.384	0.210
N19-N15	0.424	0.262	0.276	0.187



Averages of brightness temperatures over tropical region (warm end) and Antarctica (cold end) for NOAA-15 and NOAA-16 AMSU-B Channel 3 versus NOAA-17 AMSU-B Channel 3.



Averages of brightness temperatures over tropical region (warm end) and Antarctica (cold end) for NOAA-19 and MetOp-A MHS Channel 3 versus NOAA-18 MHS Channel 3.

User Application Statements

■ From Jeff McCollum, FM Global Insurance:

- “We’ve recently started flood mapping outside the U.S. where flood maps aren’t readily available. We’ve started where stream gage and rain gauge data are available, so that we can get by without satellite data (although they can be helpful for hydrologic model calibration). But as we expand into other locations with limited ground-based data, remote sensing and reanalyses/land surface models may be our main data source. We need climate data records that are as long as possible so we can estimate magnitudes for extreme events, e.g. 100-yr rainfall. Then we can use hydrologic modeling to estimate x-yr discharges used for flood mapping. Since the reanalyses/land surface model data outputs are usually longer but less accurate than satellite precip, we can also use satellite precip to somehow make the longer but less accurate model precip data more useful.”

■ From Alan Basist, WeatherPredict Consulting:

- “Weather Predict Consulting consistently uses the microwave satellite data provided by NESDIS to run operational products for Renaissance Reinsurance. These services are essential to the planning and monitoring activities, in order to assess risk profiles for return period of natural disasters, as well as their associated loss profiles. This helps us to assign the appropriate level of premium, and/or determine if an offer from a reinsurance program is properly priced. The data allows us to also assess hazards (such as flood, drought, and crop yields) as they develop. We use these data to determine the probability of various level of loss, which allows us to calculate the loss/cost ratio as an event unfolds. This is beneficial to monitoring our potential payout, and maintaining a up-to-date calculation of the cost of an impending event. Any additional data we could use from the AMSU instrument would be an useful contribution to the expanding utility of the services and products provided by NESDIS.”