Reprocessing HIRS Cloud and Moisture Measurements

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Project Description

Estimating cloud and TPW trends for the past 30 years from HIRS radiances sensitive to atmospheric CO_2 and H_2O that have been

(a) recalibrated using SNOs with reference to Metop HIRS and

(b) reprocessed using improved MODIS heritage algorithms.

Project Description

CDR(s) (Validated Outputs)	Period of Record	Spatial Resolution; Projection information	Time Step	Data format	Inputs	Uncertainty Estimates (in percent or error)	Collateral Products (unofficial and/or unvalidated)
Cld Top Pressure (CTP) TPW	1979 - present	20 km equal angle projection	One day	netcdf	HIRS 2/3/4 Chs 4-7: CO2, 8, 10: IRW 11-12: H2O PATMOS-X Cld Msk NCEP Reanalysis	CTP - 50 hPa TPW - 3 mm	

Production Approach

- Radiances
  - Recalibrated using SNOs with reference to Metop HIRS
- Cloud Top Pressure
  - Find clouds using PATMOS-X GAC cloud mask
  - Use MODIS heritage CO2 Slicing algorithm to find high and mid-level clouds;
  - Rely on IRW to describe low-level clouds
  - Use constant lapse rate (varying with latitude) to find marine stratus heights
  - Validate against CALIOP
- Total Precipitable Water
  - Apply MODIS TPW (plus high, mid, and low PW) adapted to HIRS spectral channels in clear skies
  - Include new UW IR surface emissivity maps
  - Compare with MODIS and GDAS; validate against ground based microwave and AIRS Q(p)

Production Approach

Standardizing set-up of ancillary data for all sensor processing is in progress

- Developing python based system to read static/dynamic maps (surface emissivity/albedo, surface elevation, ecosystem type, land/water, etc.),
- Use CRTM or PFAAST to perform clear sky RT calculations for HIRS channels (that require meteorological profiles)

Set up will be separated from the production algorithm

Quality Assurance Approach

- Comparing each month against long term monthly trend
  - Re-thinking Level 3 gridding (Smith et al paper)
- Comparing against CALIOP for selected months in all seasons both poles
- Comparing against GEWEX cloud data sets
- Peer review process

Publications

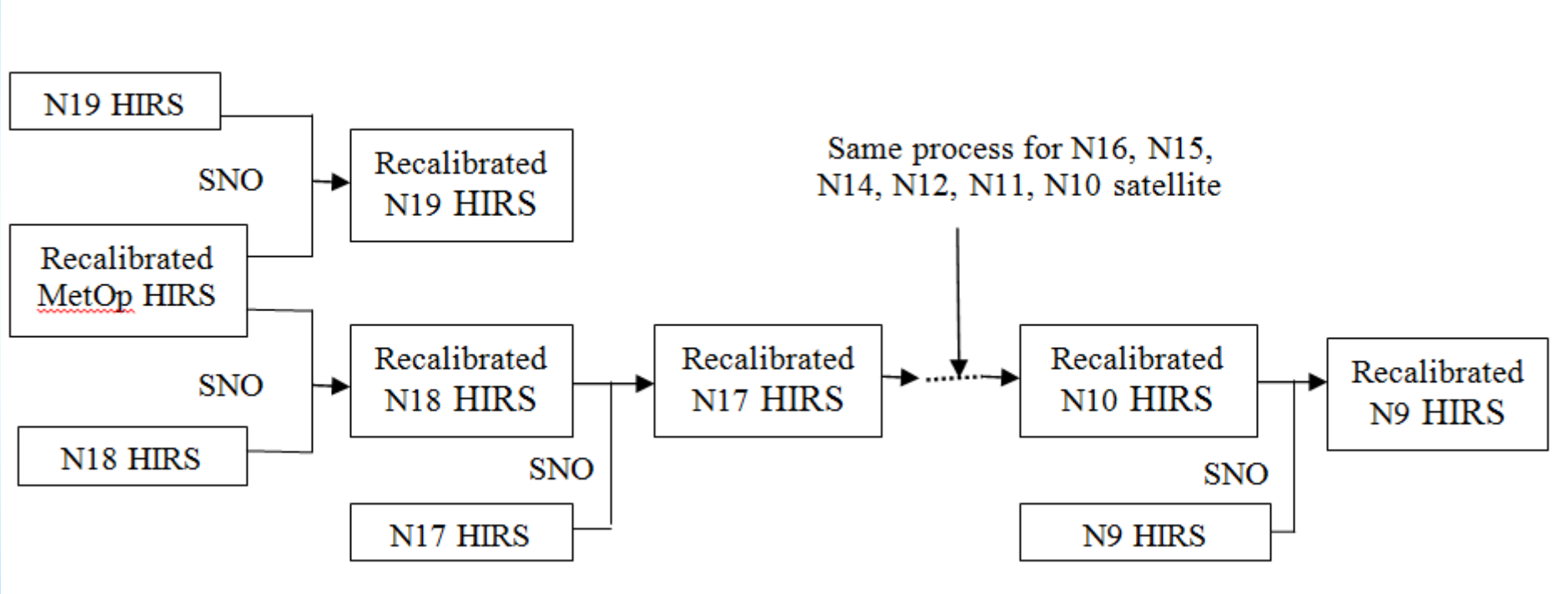
(1) Baum, B. A., W. P. Menzel, R. A. Frey, D. C. Tobin, R. E. Holz, S. A. Ackerman, A. K. Heidinger, and P. Yang, 2012: MODIS Cloud Top Property Refinements for Collection 6, Jour. Appl. Meteor. Clim., 51, No. 6, 1145-1163

(2) Smith, N., W. P. Menzel, E. Weisz, A. Heidinger, and B. A. Baum: A uniform space-time grid for comparison of global satellite cloud products: Characterization and sensitivity studies. J. Appl. Meteor. Clim., In press.

(3) Chen, R., C. Cao, and W. P. Menzel, 2012: Inter-satellite Calibration of NOAA HIRS CO2 Channels to Ensure the Long-term Time Series Consistency for Climate Studies. Under revision for J. Geophys. Res.-Atmos.

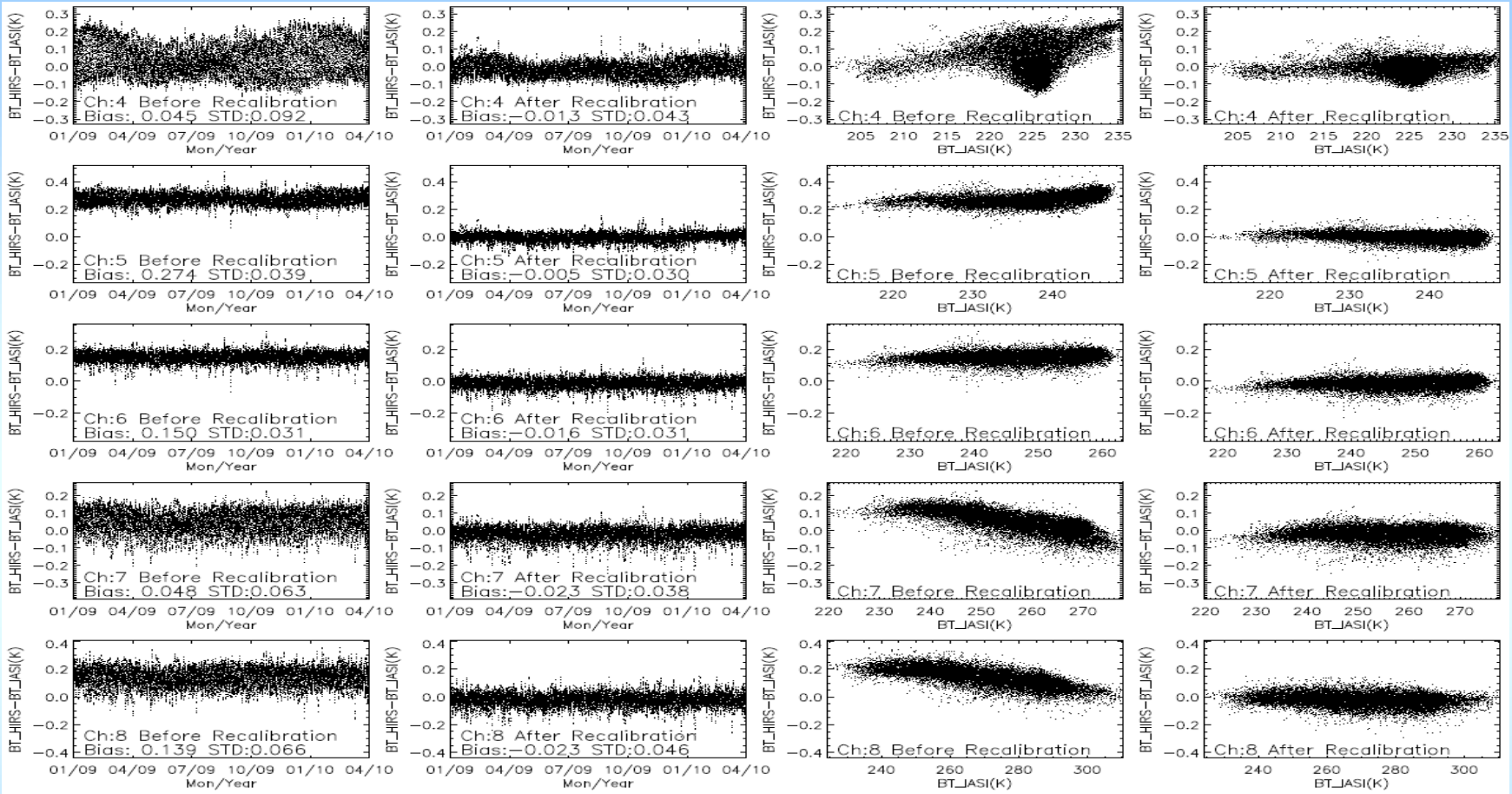
(4) Kolat, U., W. P. Menzel, E. Olson, and R. Frey, 2012: Very High Cloud Detection in More than Two Decades of HIRS Data. Submitted to J. Geophys. Res.-Atmos.

Inter-satellite calibration process for HIRS on NOAA satellites



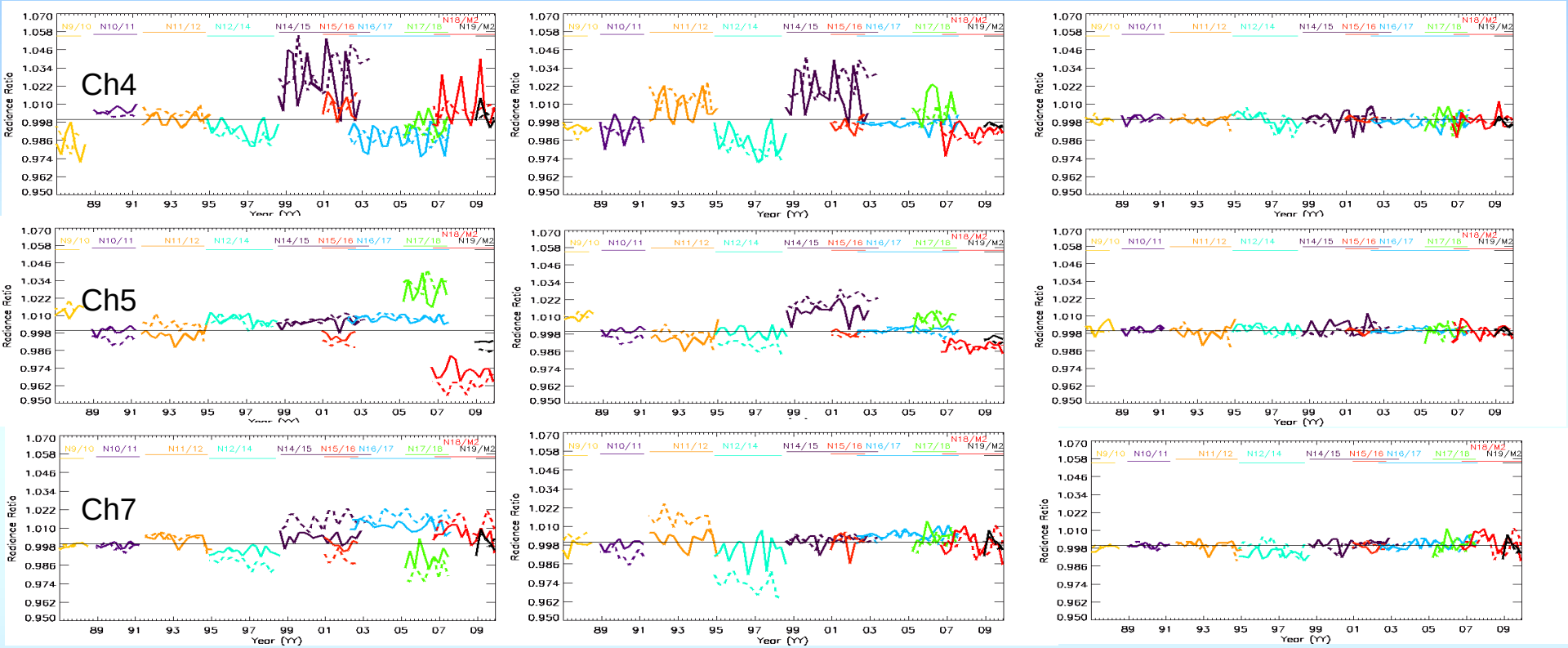
Use Metop HIRS recalibrated via IASI as calibration reference for all NOAA HIRS via SNOs

MetOp HIRS Recalibration Using IASI



- Correction of blackbody bias (0.14 K), SRF shifts (-0.13, 0.09, -0.15 cm-1 , for Ch 4, 5, and 7), and correction of calibration non-linearity term.
- Validated with 16 months sampled MetOp data (the fifth orbit of each day)
- Both mean bias and bias variation are significantly reduced (less than 0.1K)
- Both T-dependent and non-T-dependent biases are significantly reduced

Process of HIRS Inter-satellite Calibration

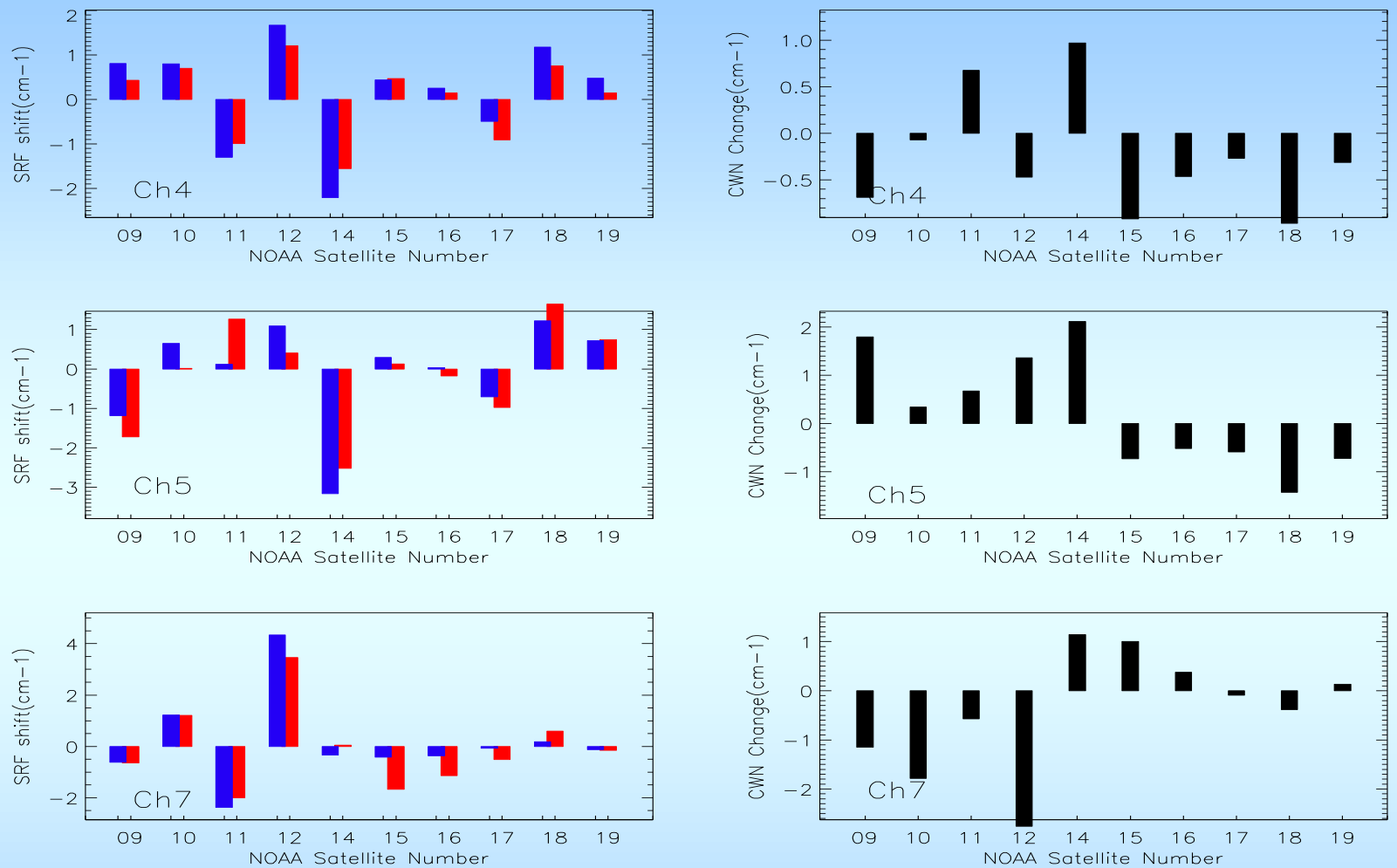


Original After known SRF differences After SRF shifts

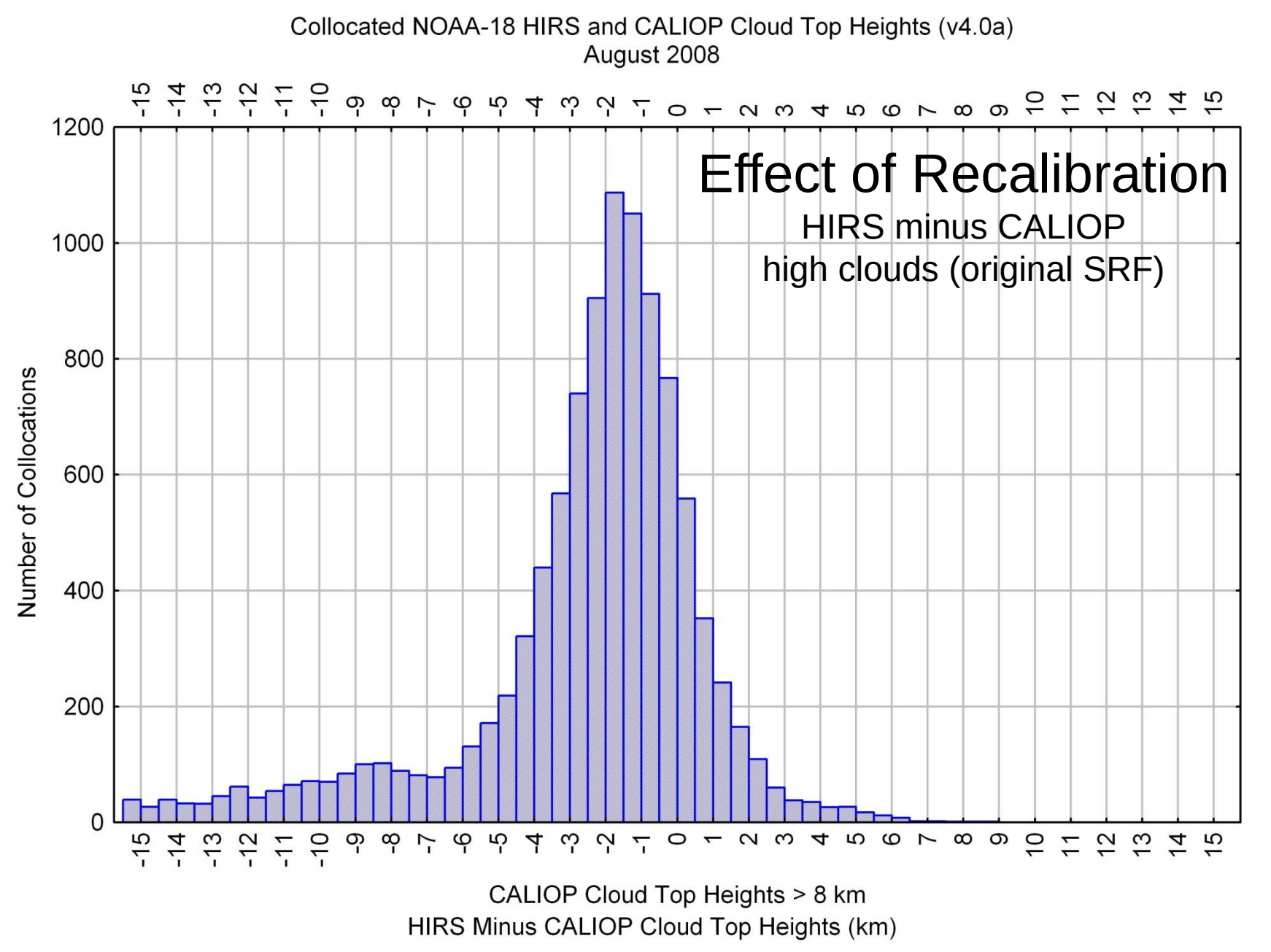
- IASI-simulated HIRS data are used to develop linear models to estimate impacts of SRF differences and shifts on inter-satellite radiance biases
- After accounting for effect of pre-launch SRF differences, inter-satellite biases are recalculated
- Optimized SRF shifts (which can be as large as 2.5 cm-1) minimize RMS of biases to less than 1%.

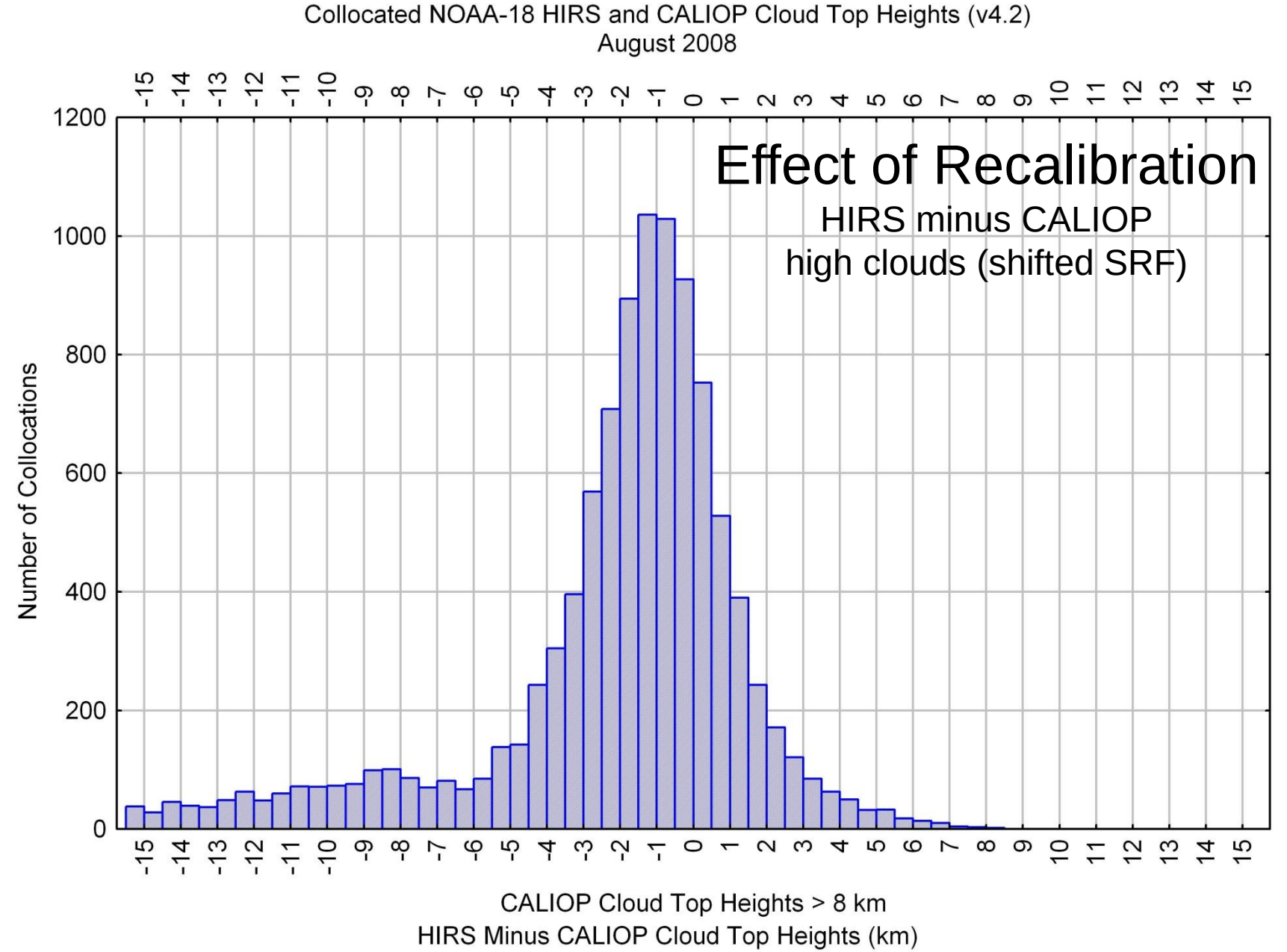
10

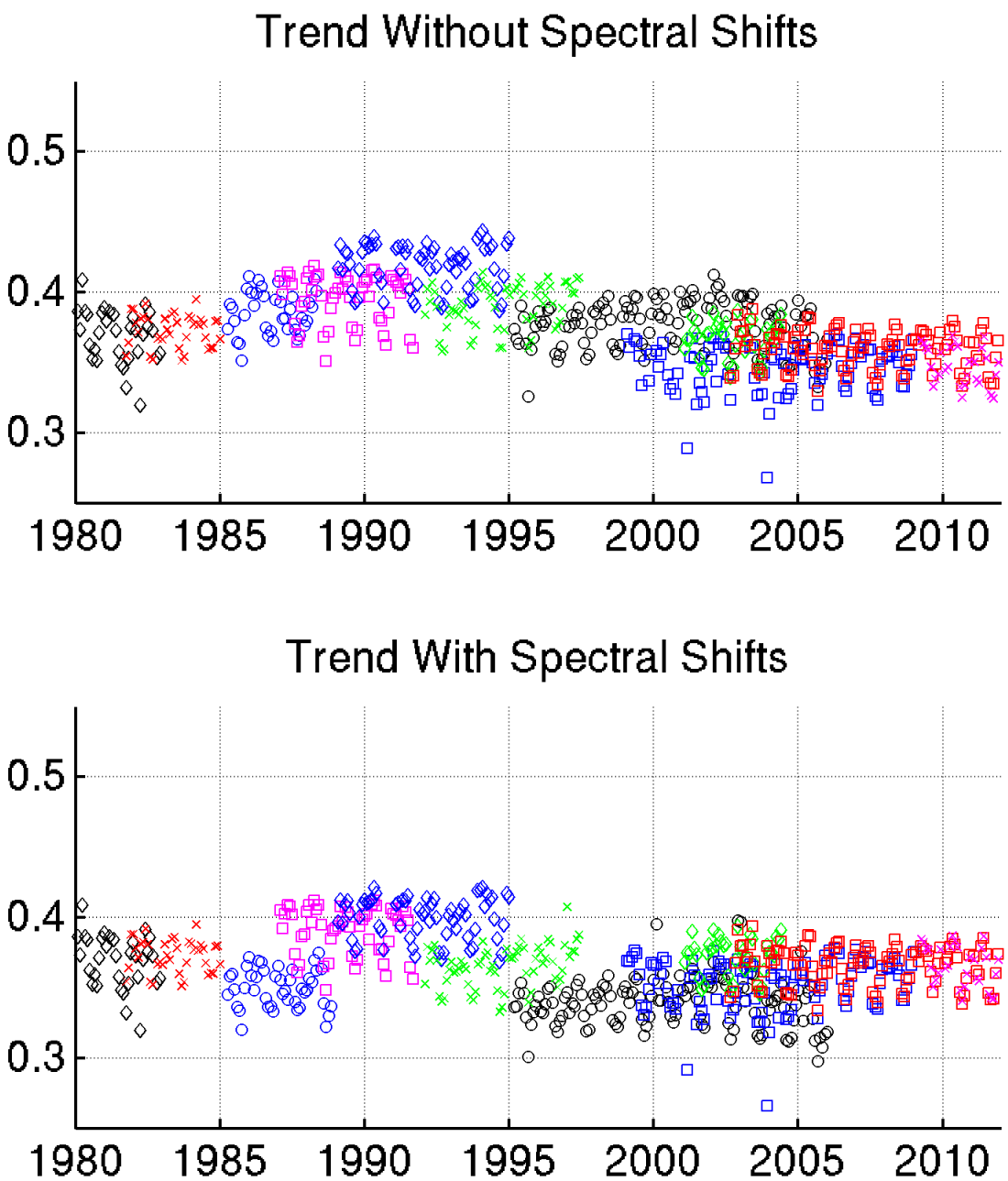
Recomputation of HIRS SRF Shifts



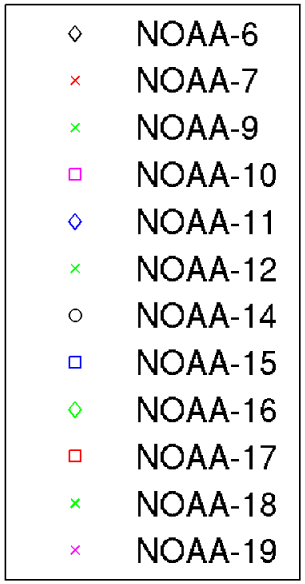
- (left) Inter-satellite SRF shifts minimizing sensor to sensor radiance bias in SNOs for north (blue) and south (red) poles.
- (right) Accumulated SRF shift after referencing each HIRS to Metop HIRS that was recalibrated wrt IASI


Collocated NOAA-18 HIRS and CALIOP Cloud Top Heights (v4.0a)
August 2008
Effect of Recalibration
HIRS minus CALIOP
high clouds (original SRF)
Number of Collocations
0
200
400
600
800
1000
1200
-15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
CALIOP Cloud Top Heights > 8 km
HIRS Minus CALIOP Cloud Top Heights (km)

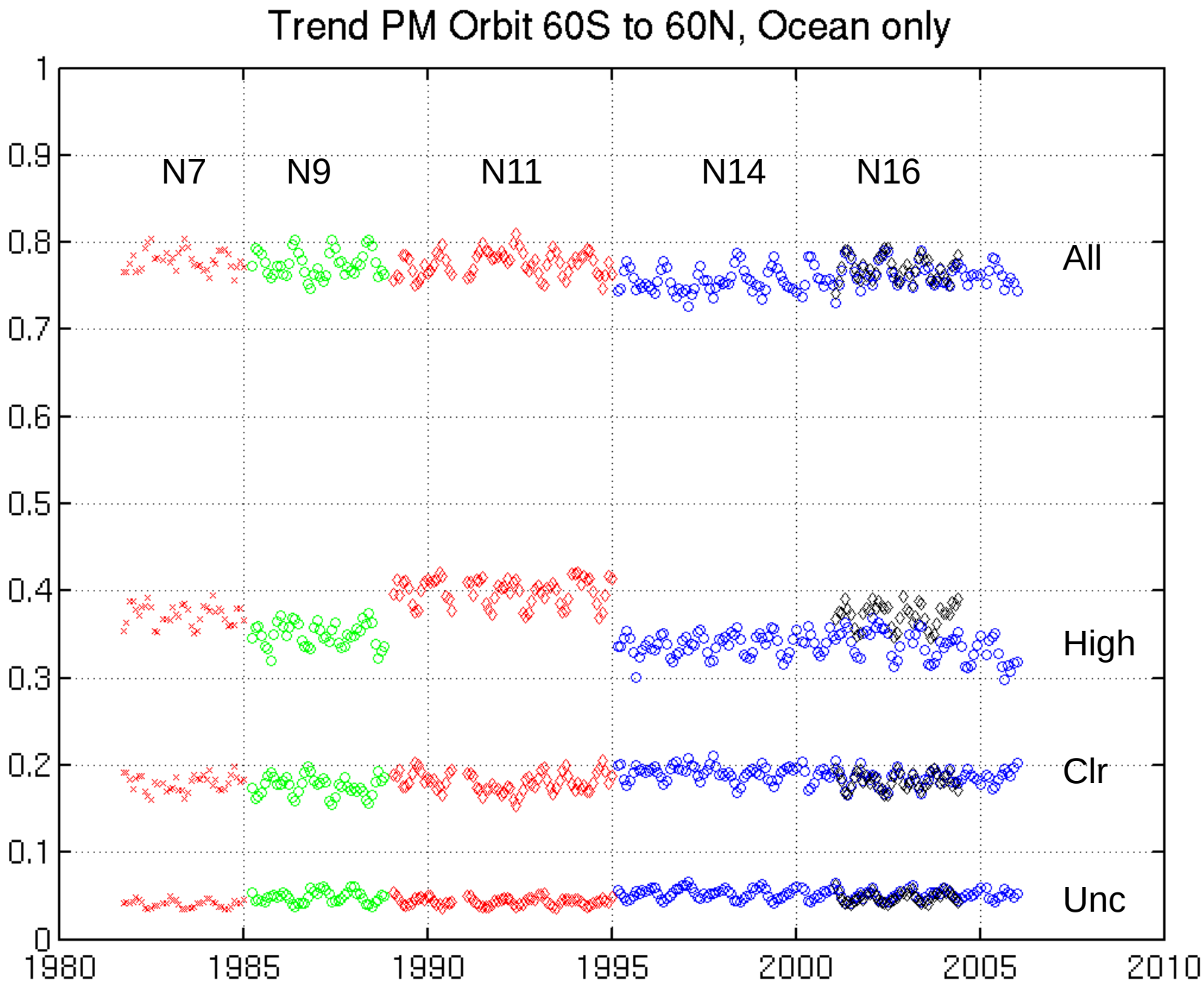

Collocated NOAA-18 HIRS and CALIOP Cloud Top Heights (v4.2)
August 2008
Effect of Recalibration
HIRS minus CALIOP
high clouds (shifted SRF)
Number of Collocations
0
200
400
600
800
1000
1200
-15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
CALIOP Cloud Top Heights > 8 km
HIRS Minus CALIOP Cloud Top Heights (km)

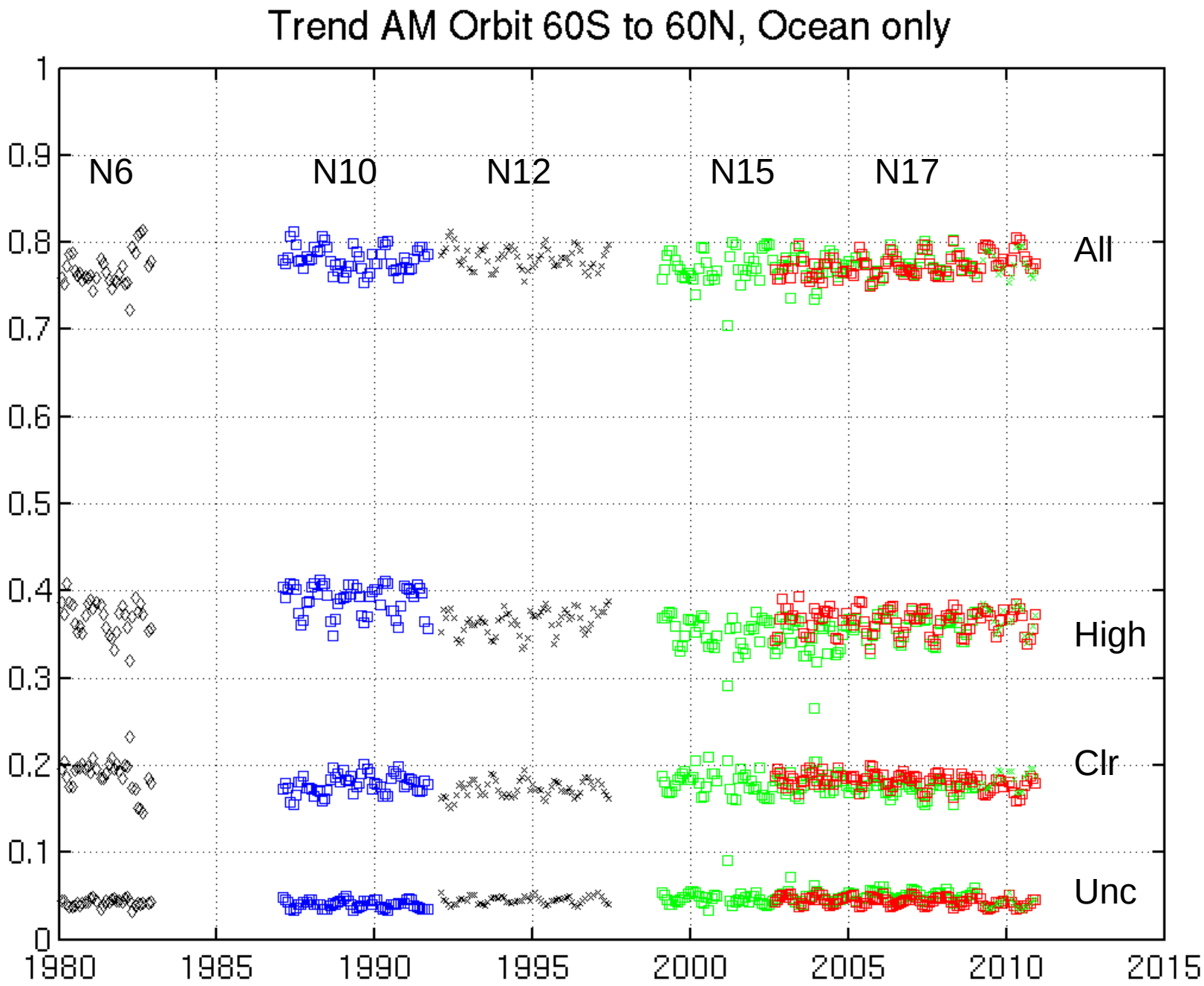


High Clouds 60S to 60N



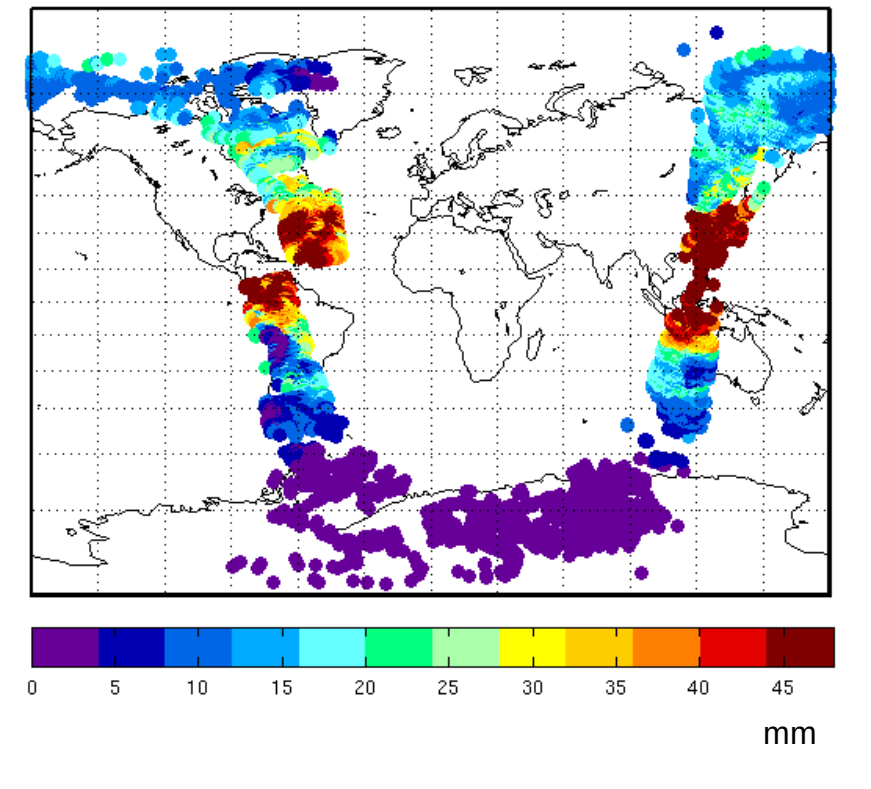
Without PATMOS-x cloud mask


Trend PM Orbit 60S to 60N, Ocean only
N7
N9
N11
N14
N16
All
High
Clr
Unc
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1985
1990
1995
2000
2005
2010

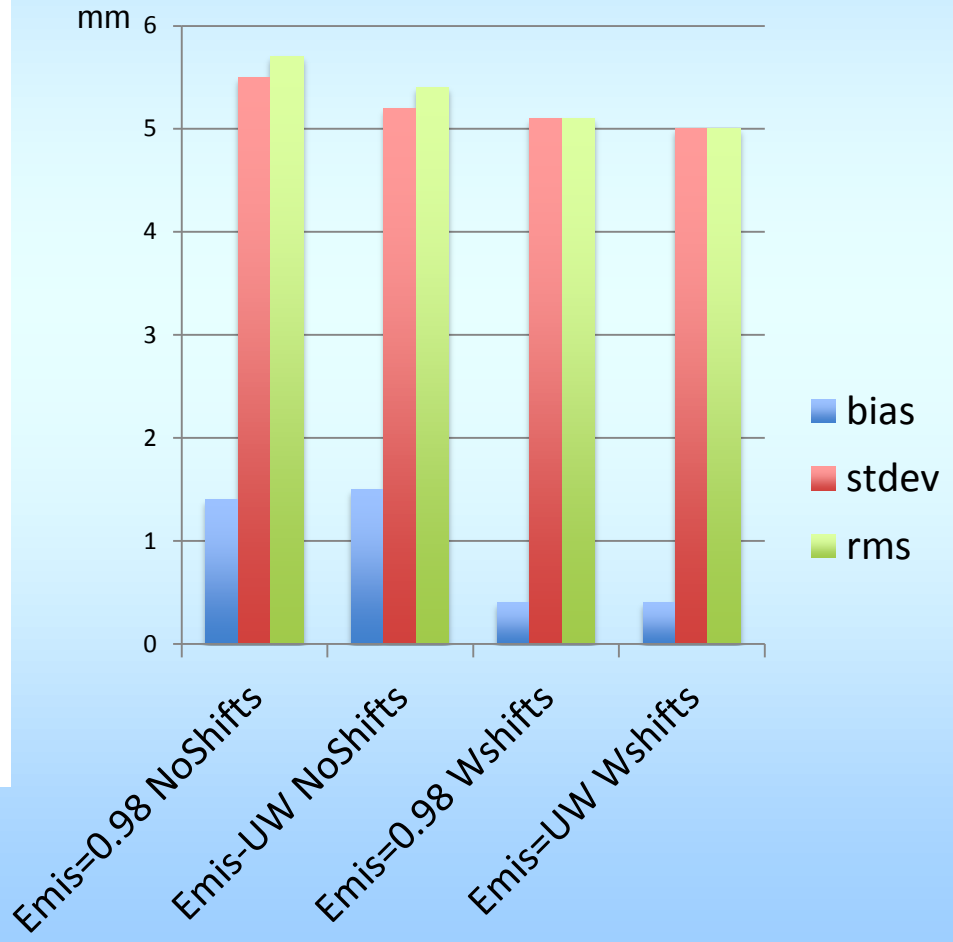

Trend AM Orbit 60S to 60N, Ocean only
N6
N10
N12
N15
N17
All
High
Clr
Unc
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1980
1985
1990
1995
2000
2005
2010
2015

One orbit of N18/HIRS4 TPW

August 13 2008
orbit S1642.E1827

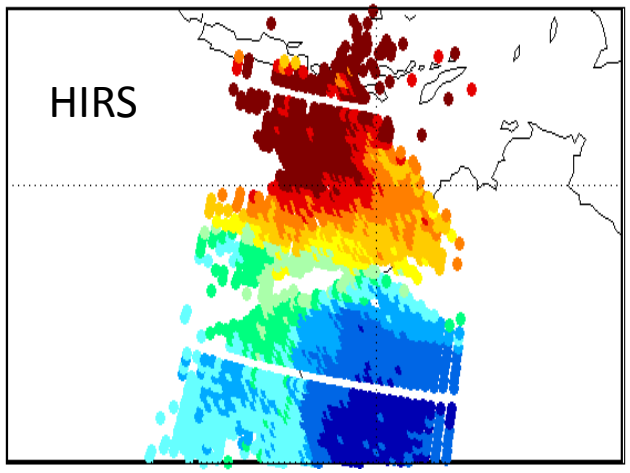


Comparison with GDAS

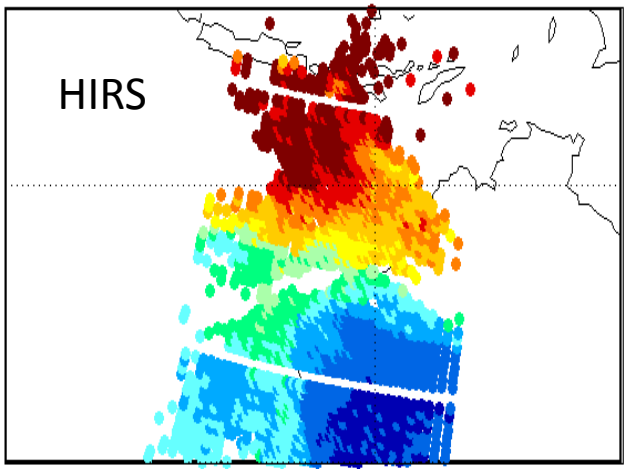


NOAA18/HIRS TPW compared to GDAS and Aqua/MODIS/TPW

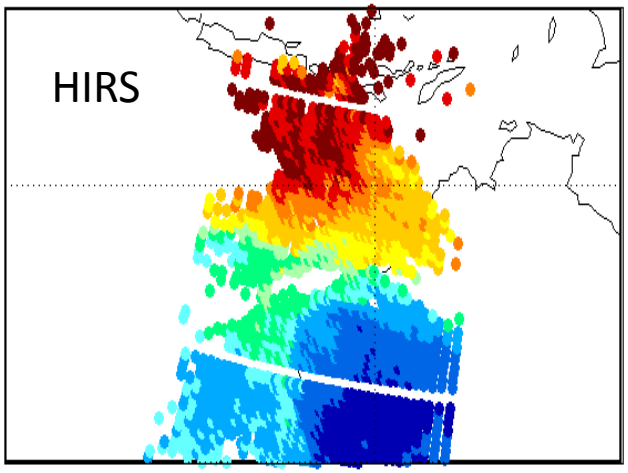
Emis=0.98 : wo Shifts

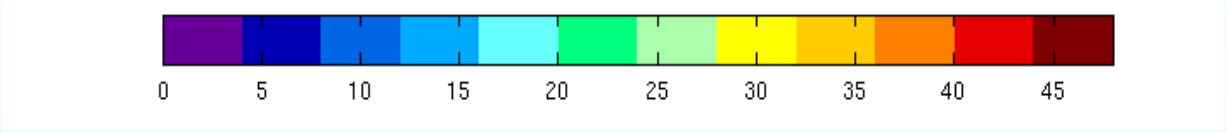


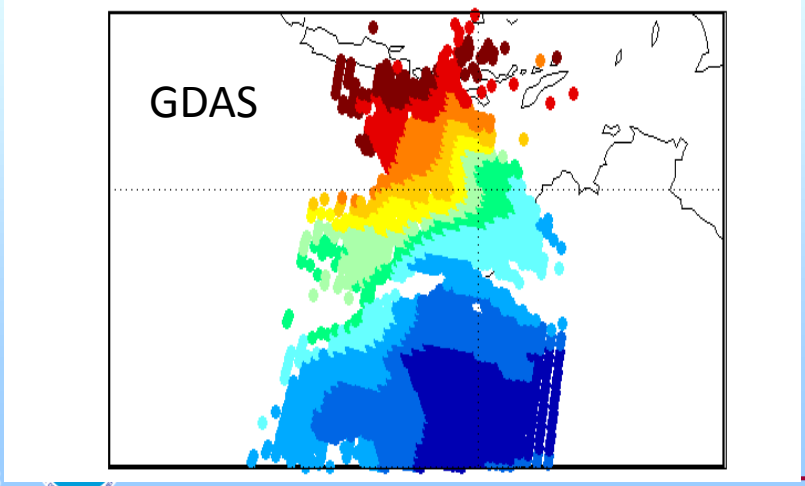
Emis=UWemis : wo Shifts



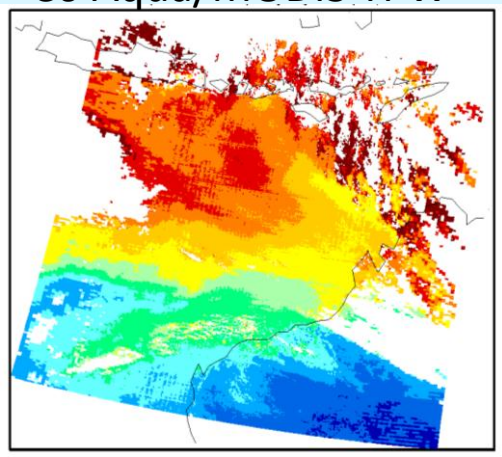
Emis=Uwemis : with Shifts







C6 Aqua/MODIS TPW



08.13.2008
17:35 UTC

Applications

*** HIRS contributes to International Cloud Climatology Effort**

- One of only two data sets that has resolved sensor to sensor calibration issues to produce internally consistent and stable cloud products (HIRS & PATMOS-x) from 1980 to present using state-of-the-art sensor to sensor calibrations
- Provides context for evaluation of cloud climatologies from national and international groups (e.g. GEWEX)

*** HIRS used to support NWP ReAnalysis Effort**

- Worked with ECMWF to introduce realistic high clouds in reanalysis by introduction of CO2 slicing

*** HIRS supports Air Force Line of Sight Estimation**

- Working to enhance performance of ballistic missile and missile-interceptor testing at Kwajalein Missile Range.

*** HIRS supports NWS ASOS Long Term Data Record**

- Supplements automated records limited to 10000 ft with high cloud determinations

Applications

*** HIRS used to investigate Regional Precipitation Trends**

- Exploring link between regional changes in cloud and precipitation (working with Curtin University to understand northward rainband movement in Western Australia which has introduced extreme drought over agricultural regions)

*** HIRS used to investigate Effects of Industrial Pollution**

- Exploring connection between air quality and non-precipitating high cloud trends in eastern China (collaborating with Chinese National Meteorological Satellite Center) and in eastern European countries (in contact with scientists at St Petersburg University)

Schedule & Issues

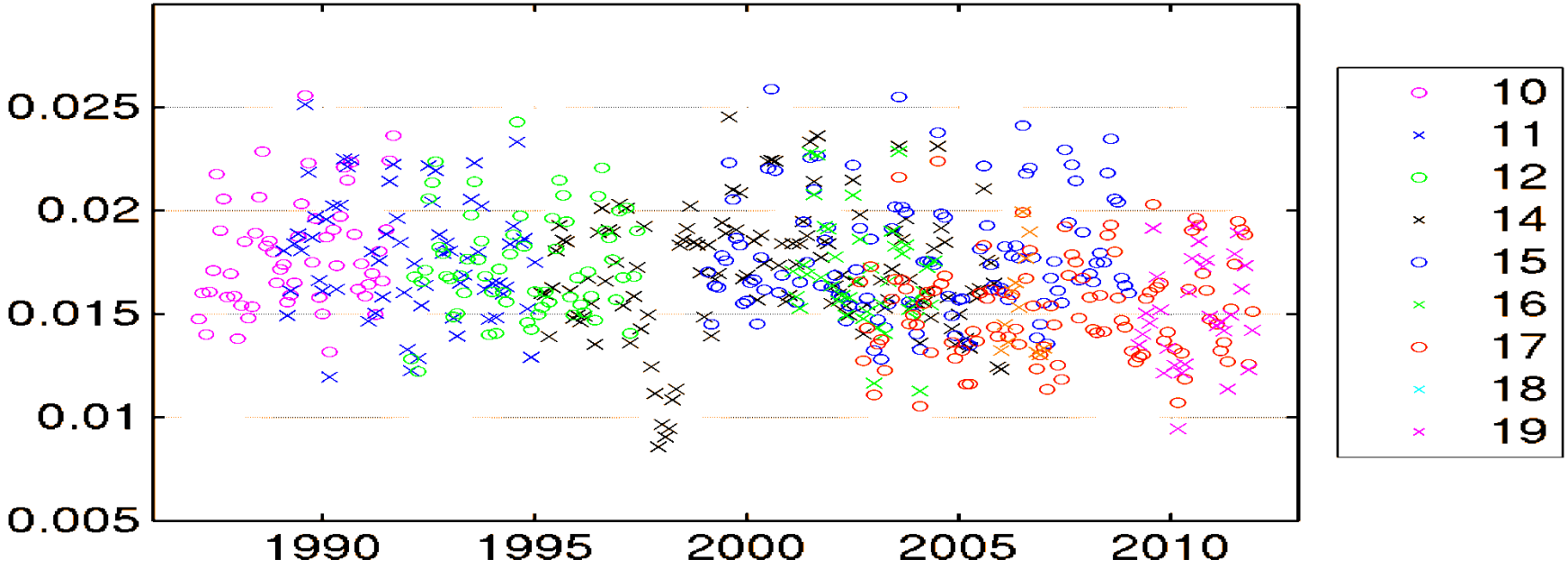
- Project status and plans for next phase

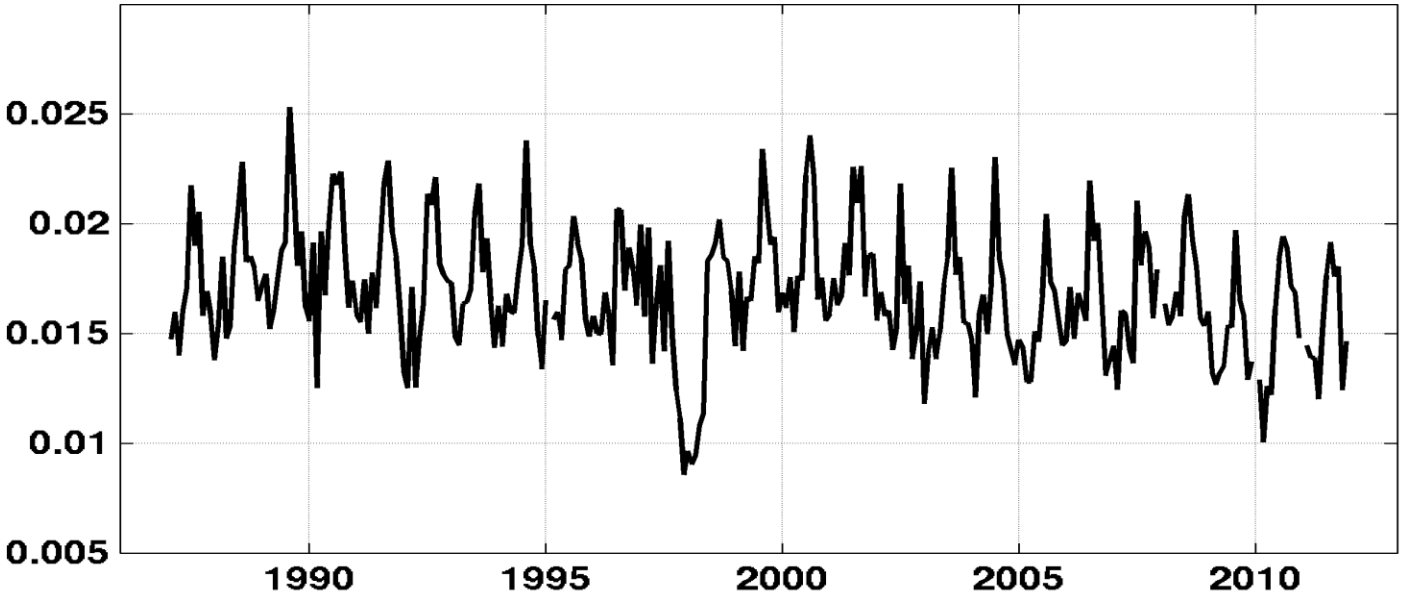
4Q11	- Recalibrated HIRS
	- Hosted Cloud Retrieval Evaluation Workshop
1Q12	- Tested PATMOS plus HIRS merging for 1month
2Q12	- Compared HIRS clouds with new SRFs against CALIOP
3Q12	- Processed TPW with new SRFs and ε_{sfc} for month
4Q12	- Establish benchmark data sets for CTP and TPW
1Q13	- Study trends and publish results
2Q13	- Prepare s/w for NCDC

- Risks or concerns
  - Requesting no cost extension
  - CRTM s/w updates
  - transition from research-grade to more flexible software may take more resources

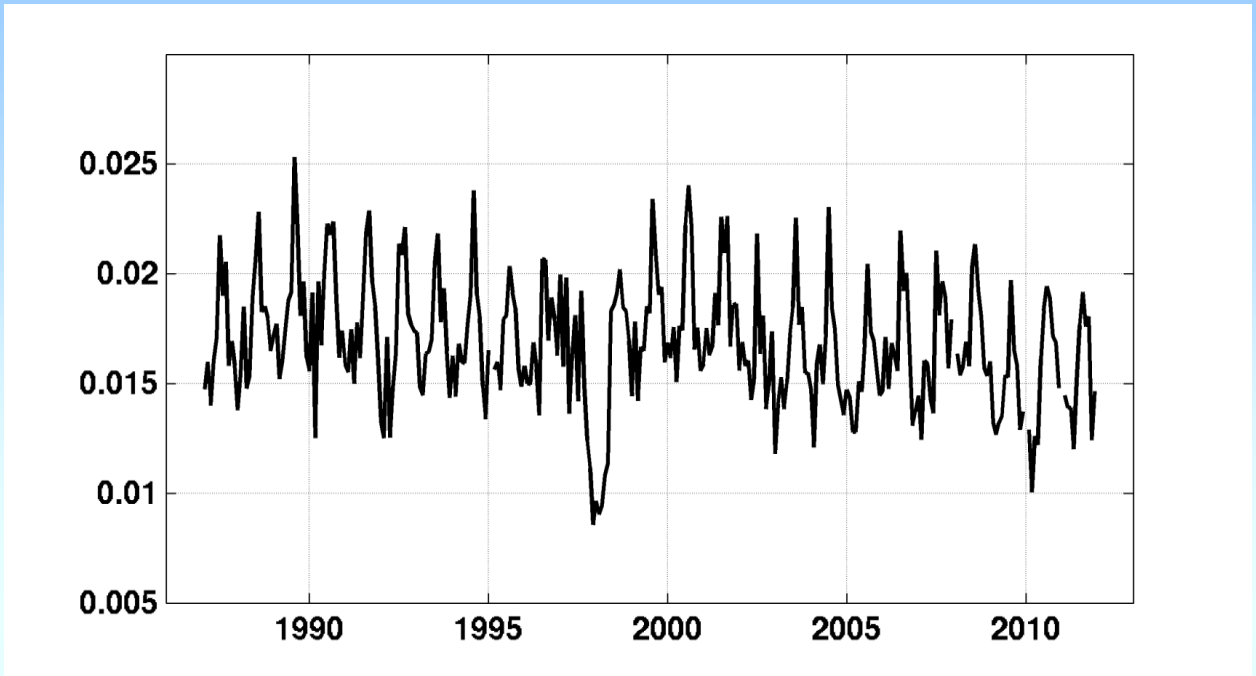
Backup

UT/LS Cloud Detection from NOAA-10 to -19

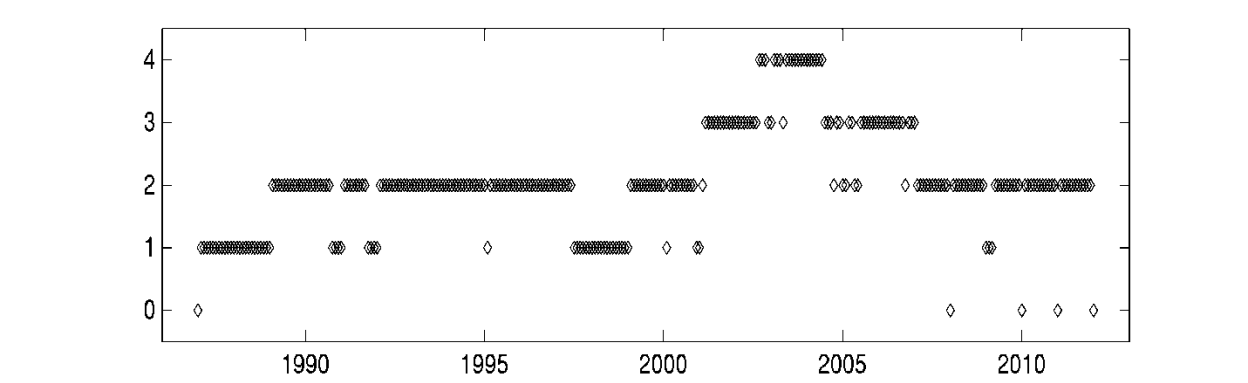




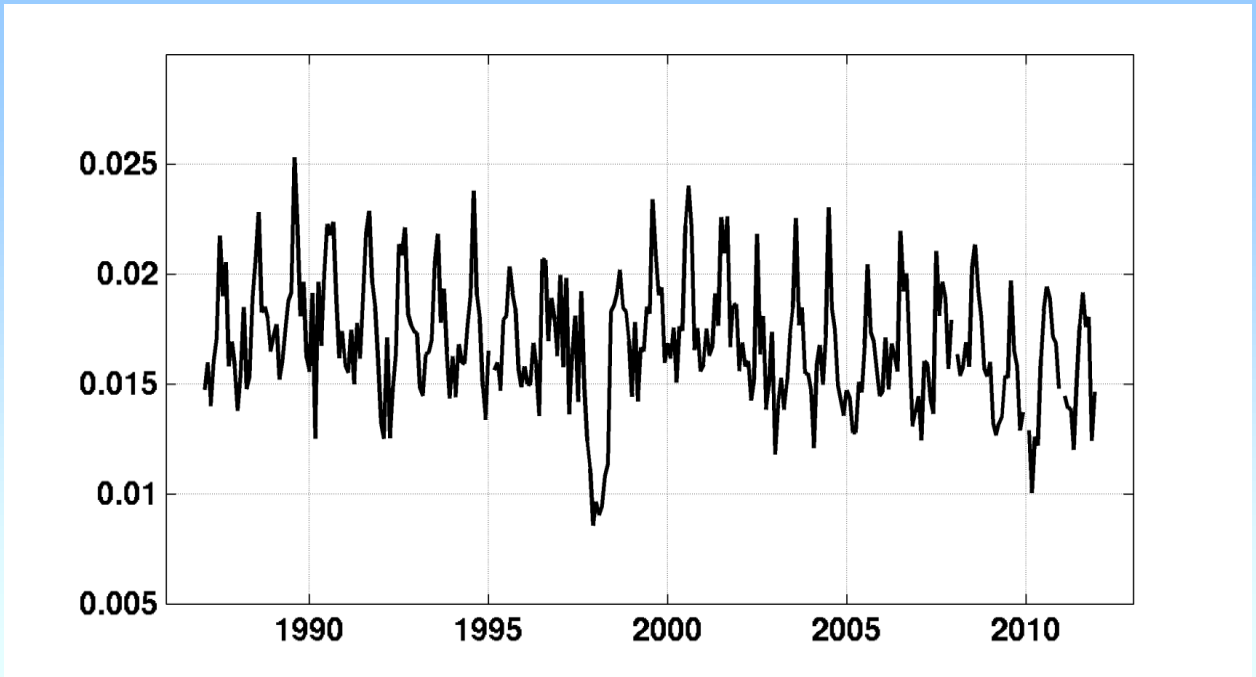
Fraction of Obs in ITCZ with BT13.9 > BT13.3



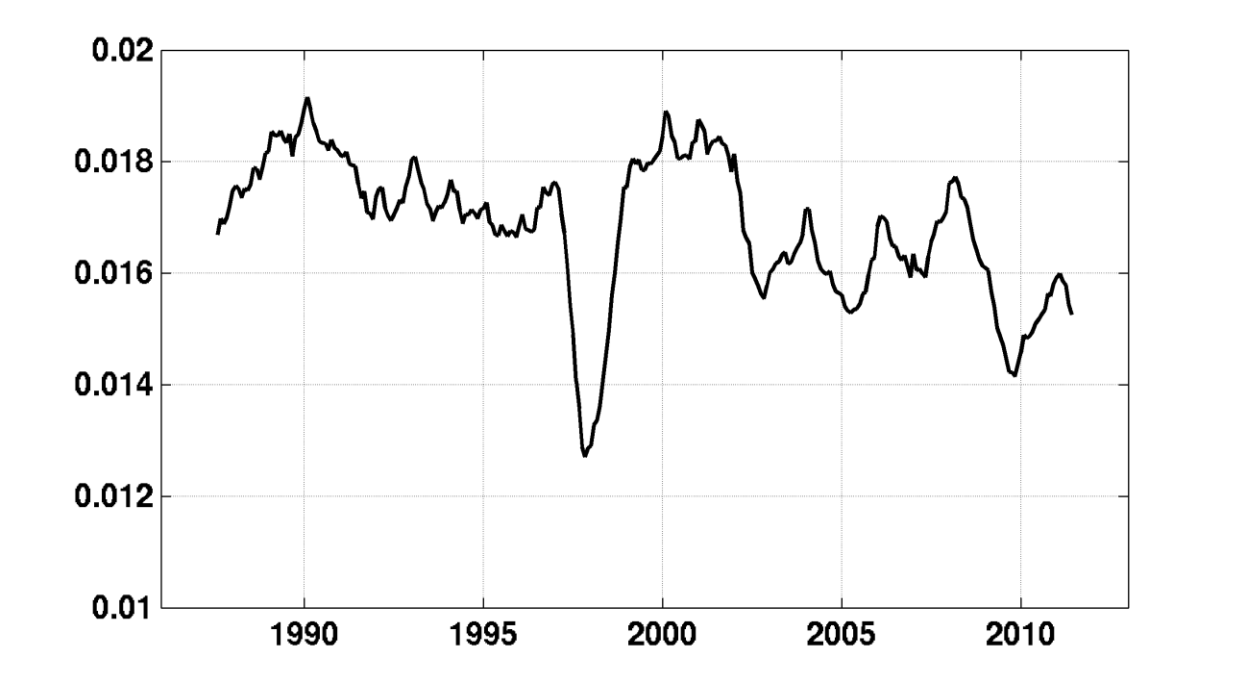
Monthly Mean



 # Sats Used



Monthly Mean



13 month smoother applied