



Reprocessing HIRS Cloud and Moisture Measurements

**W. Paul Menzel, Erik Olson, Richard Frey,
Eva Borbas, Bryan Baum
UW/SSEC**

**Changyong Cao, Ruiyue Chen
NESDIS/STAR**

**608-263-4930
paulm@ssec.wisc.edu**

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Project Description

Estimate cloud and TPW trends for the past 30 years from HIRS radiances sensitive to atmospheric CO₂ and H₂O that have been:

- recalibrated using SNOs with reference to Metop HIRS,
- processed using updates in MODIS Collection 6 algorithms, and
- screened for clouds using co-located AVHRR GAC cloud mask from PATMOS-x

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: CO ₂ , 8, 10: IRW 11-12: H ₂ O PATMOS-X Cld Mask NCEP Reanalysis	CTP - 50 hPa TPW - 3 mm	

Production Approach for CTP

Radiances

- Recalibrated using SNOs with reference to Metop (CO₂ bands)

Steps for operational use of HIRS package

1. Need AVHRR GAC cloud mask and HIRS L1b
2. Obtain co-location between AVHRR and HIRS
3. Perform radiance bias
4. Compute global CTP and effective emissivity, which requires ancillary data (currently NCEP reanalysis, Version 1; switch to Climate Forecast System Reanalysis?) and RTM calculations (PFAST now; CRTM preferred); uses new methodology developed for MODIS Collection 6
5. Apply space-time gridding method to obtain global products

Production Approach for TPW

Adapts MODIS TPW regression method (provides high, mid, and low PW) to HIRS spectral channels (16) in clear sky conditions

Requires clear-sky from PATMOS-x

Regression coefficients determined from CRTM and a large training set of atmospheric profiles, but modifications for SRF shifts are slow to be adopted into CRTM

Uses UW IR global, monthly, 5-km surface emissivity maps

Validation & Quality Assurance

Compare each month to long term monthly trend

- Use Space Time Gridding Level 3 gridding (Smith et al paper)

Compare CTPs to CALIOP and GEWEX for selected months in all seasons at both poles

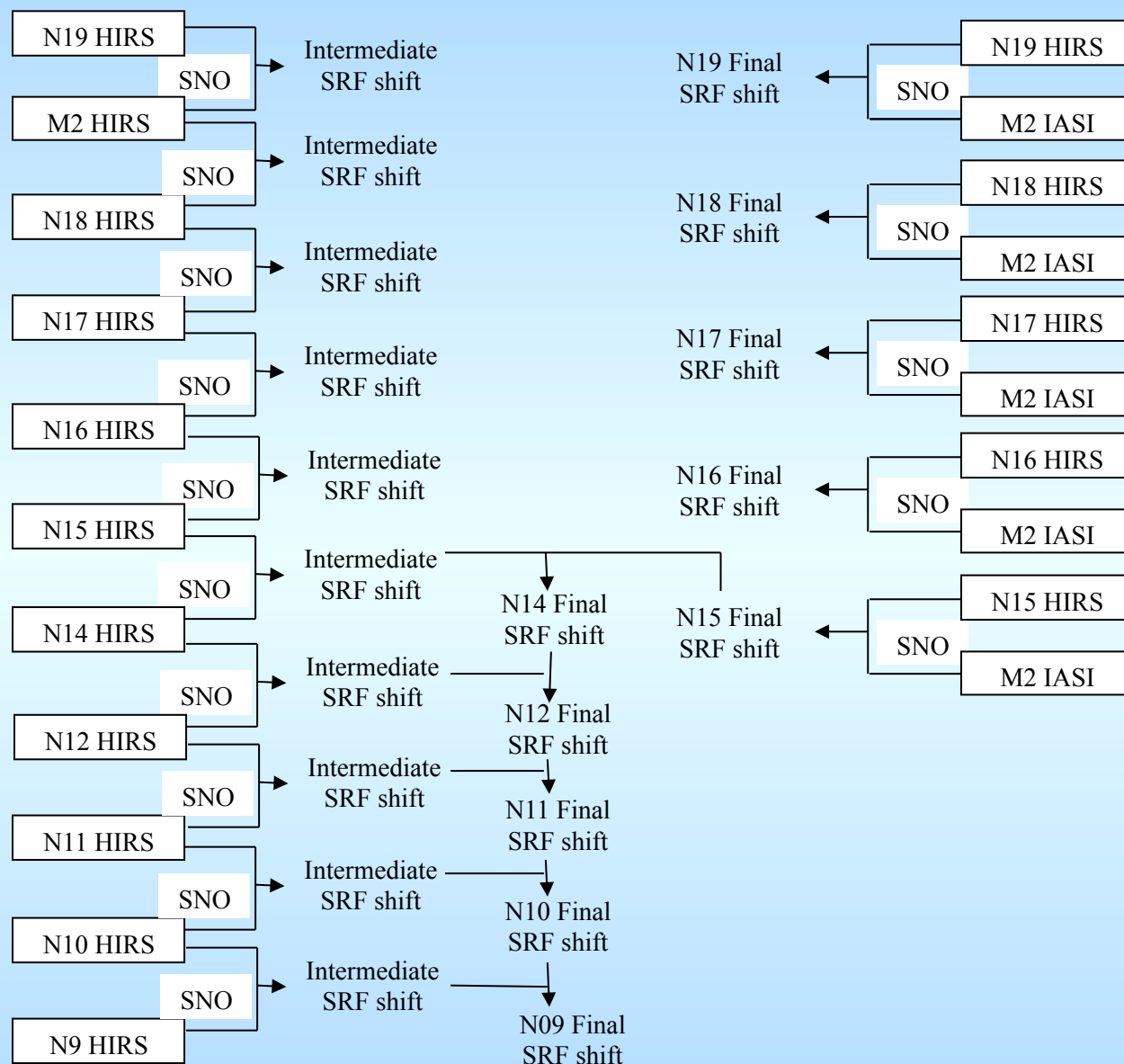
Compare HIRS TPW to MODIS, AIRS, IASI, SSM/I, NVAP, ...

Peer review process

Publications

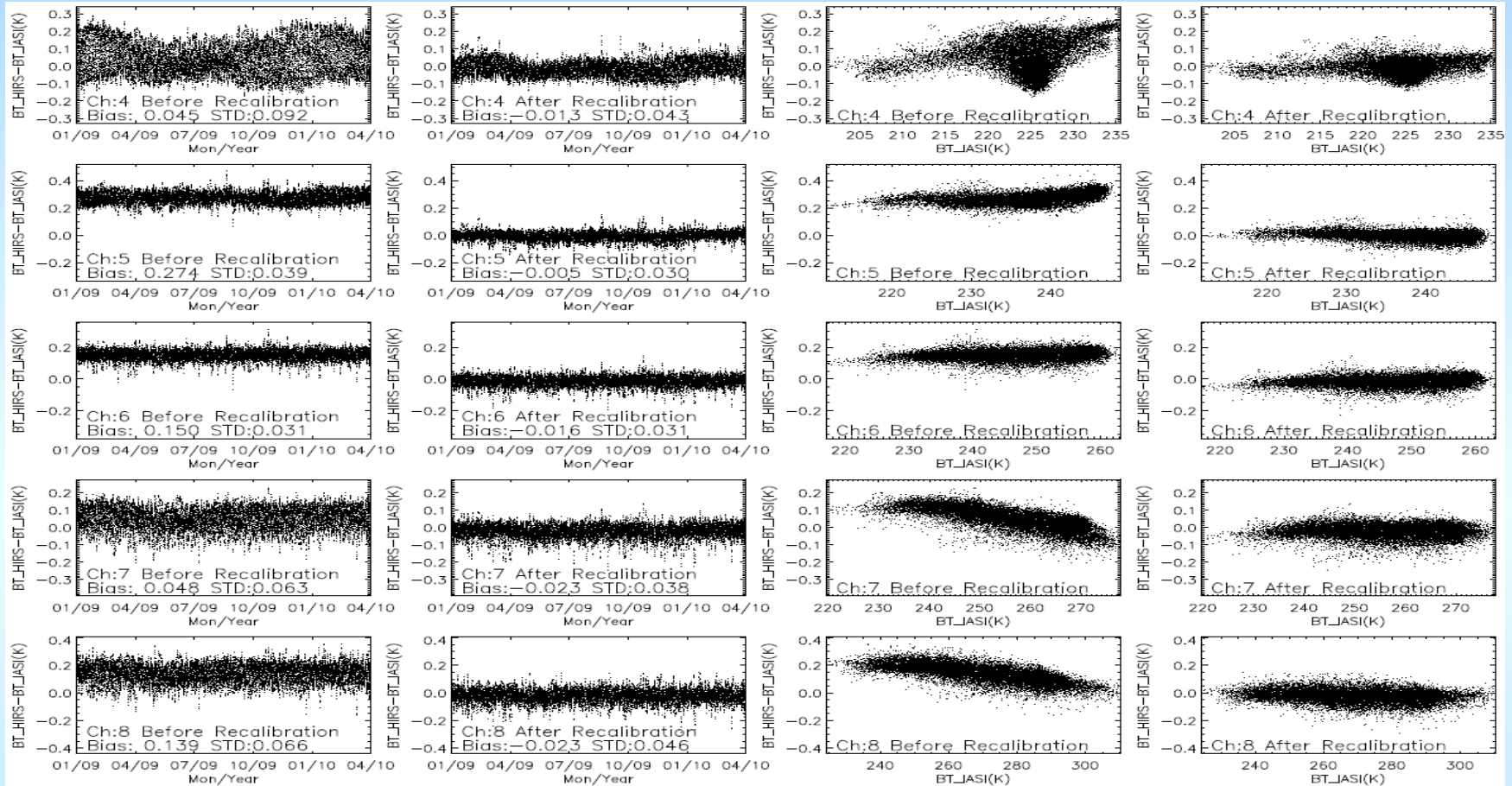
- (1) Baum, B. A., W. P. Menzel, R. A. Frey, D. C. Tobin, R. E. Holz, S. A. Ackerman, A. K. Heidinger, and P. Yang, 2012: MODIS Cloud Top Property Refinements for Collection 6, *Jour. Appl. Meteor. Clim.*, 51, No. 6, 1145-1163
- (2) Smith, N., W. P. Menzel, E. Weisz, A. Heidinger, and B. A. Baum, 2012: 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, 2013: Intersatellite calibration of NOAA HIRS CO2 channels for climate studies, *J. Geophys. Res. Atmos.*, 118, doi:10.1002/jgrd.50447.
- (4) Kolat, U., W. P. Menzel, E. Olson, and R. A. Frey, 2013: Very High Cloud Detection in More than Two Decades of HIRS Data. *Jour. Geophys. Res. Atmos.*, 118, 3278-3284. doi:10.1029/2012JD018496
- (5) Stubenrauch, C. J., W. B. Rossow, S. Kinne, S. Ackerman, G. Cesana, H. Chepfer, L. Di Girolamo, B. Getzewich, A. Guignard, A. Heidinger, B. C. Maddux, W. P. Menzel, P. Minnis, C. Pearl, S. Platnick, C. Poulsen, J. Riedi, S. Sun-Mack, A. Walther, D. Winker, S. Zeng, G. Zhao, 2013: Assessment of Global Cloud Datasets from Satellites: Project and Database initiated by the GEWEX Radiation Panel. *Bull. Amer. Meteor. Soc.*, 94, doi:10.1175/BAMS-D-12-00117.1

Inter-satellite calibration process for HIRS on NOAA satellites



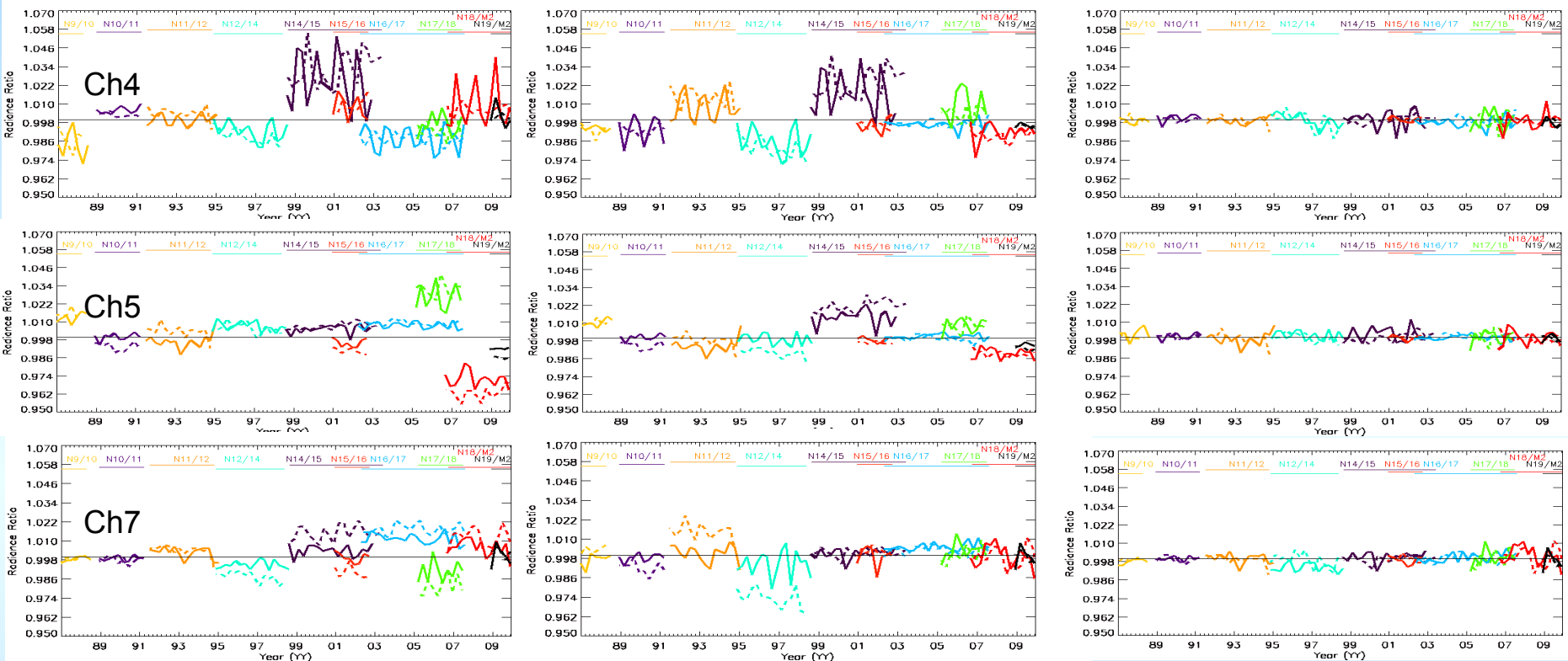
Metop HIRS, recalibrated by IASI, is calibration reference for all NOAA HIRS via SNOs

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



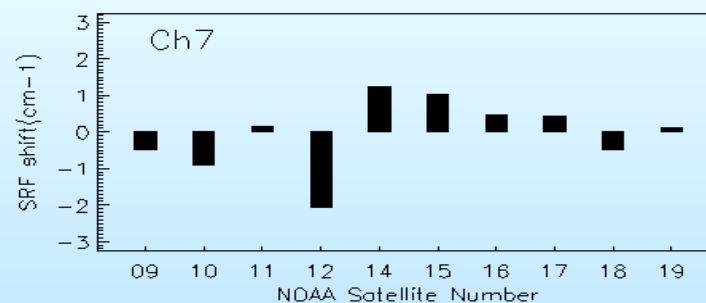
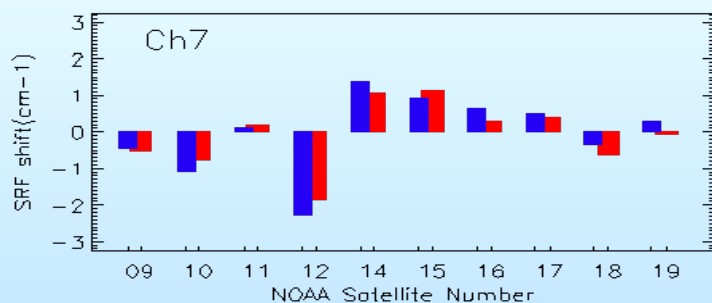
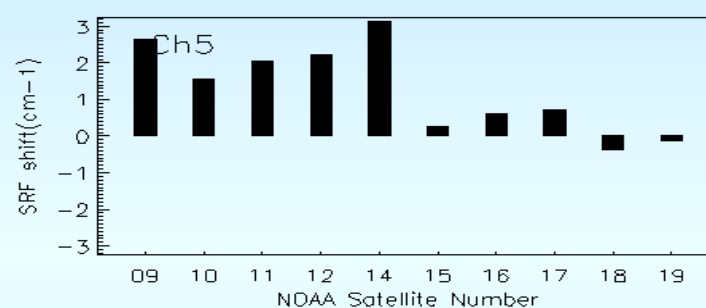
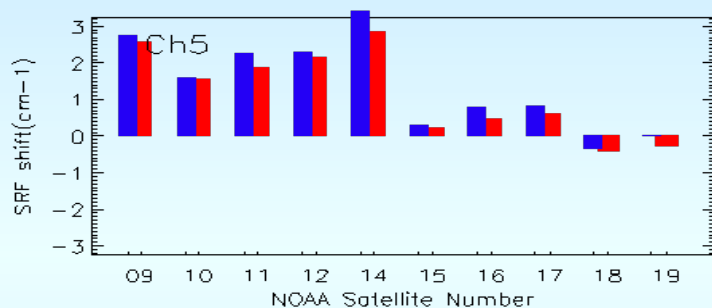
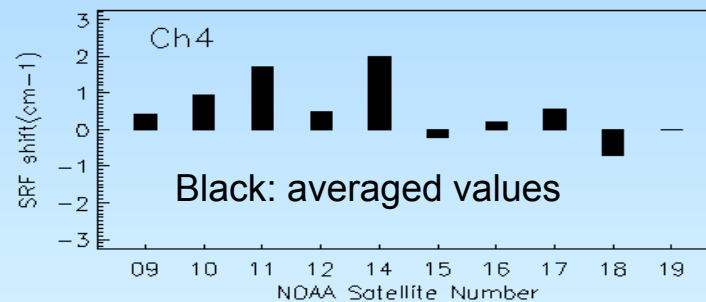
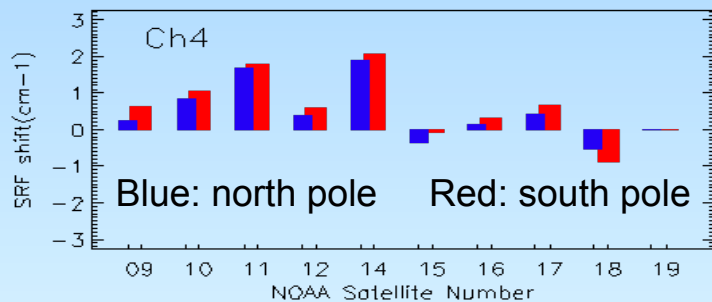
Original

After known SRF differences

After SRF shifts

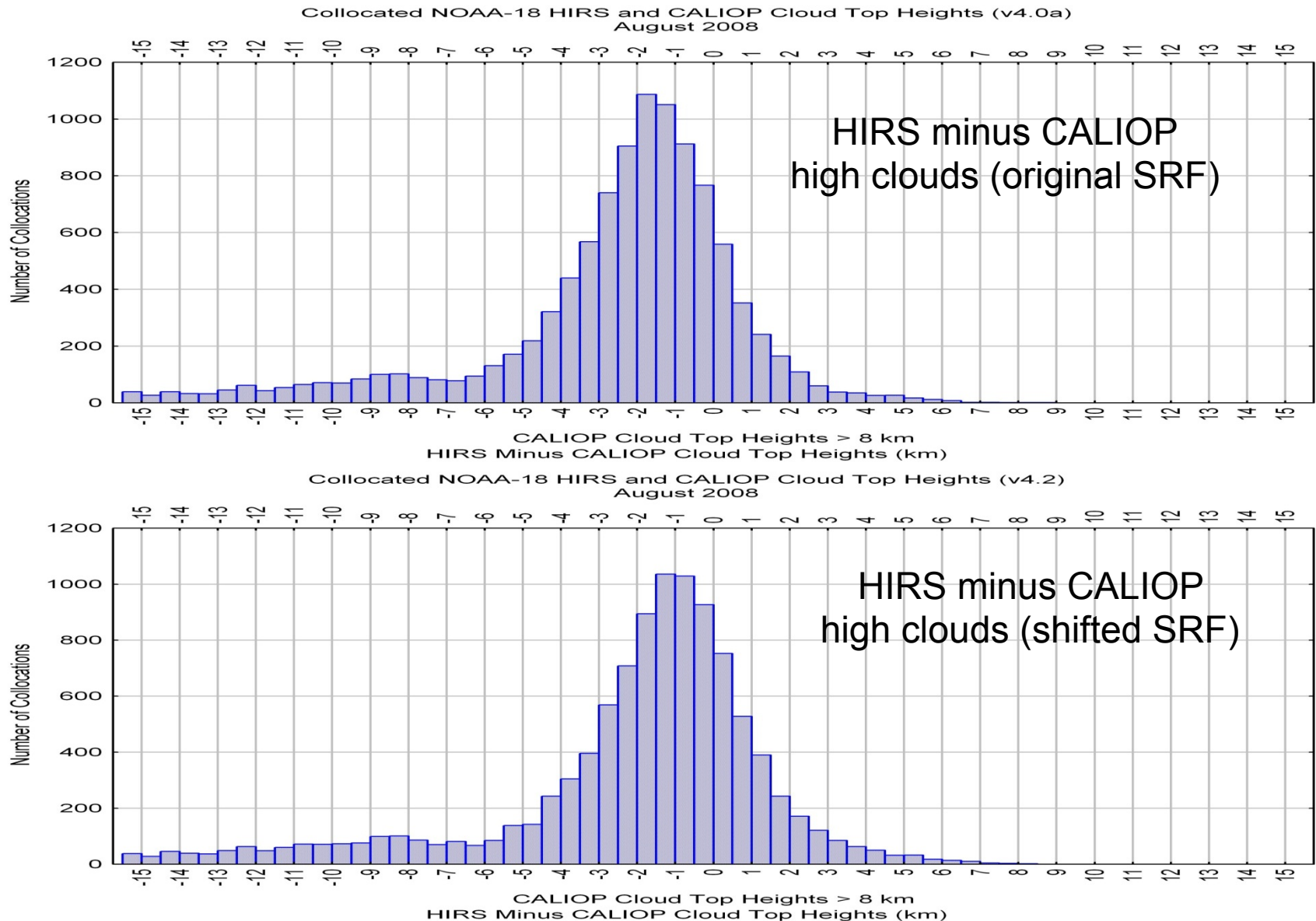
- IASI-simulated HIRS data are used to develop linear models to estimate impacts of SRF differences and shifts on inter-satellite radiance biases
- After accounting for effect of pre-launch SRF differences, inter-satellite biases are recalculated
- Optimized SRF shifts (which can be as large as 2.5 cm⁻¹)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

Recomputation of HIRS SRF Shifts

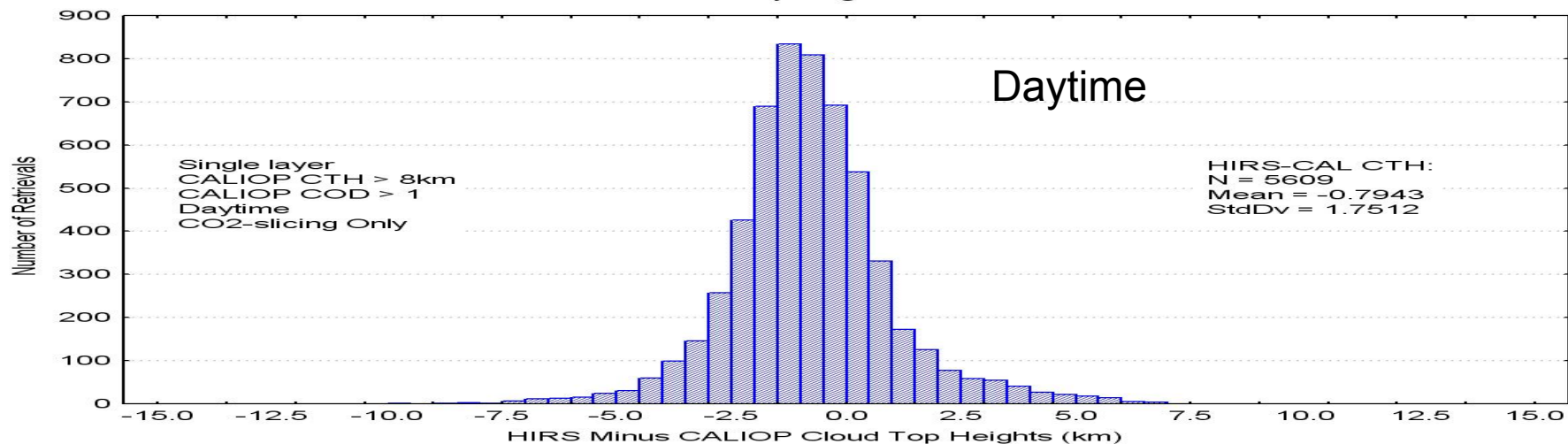


The final SRF shifts for HIRS on NOAA-9 through -19 needed to achieve agreement with the HIRS on MetOp-A using near-nadir data.

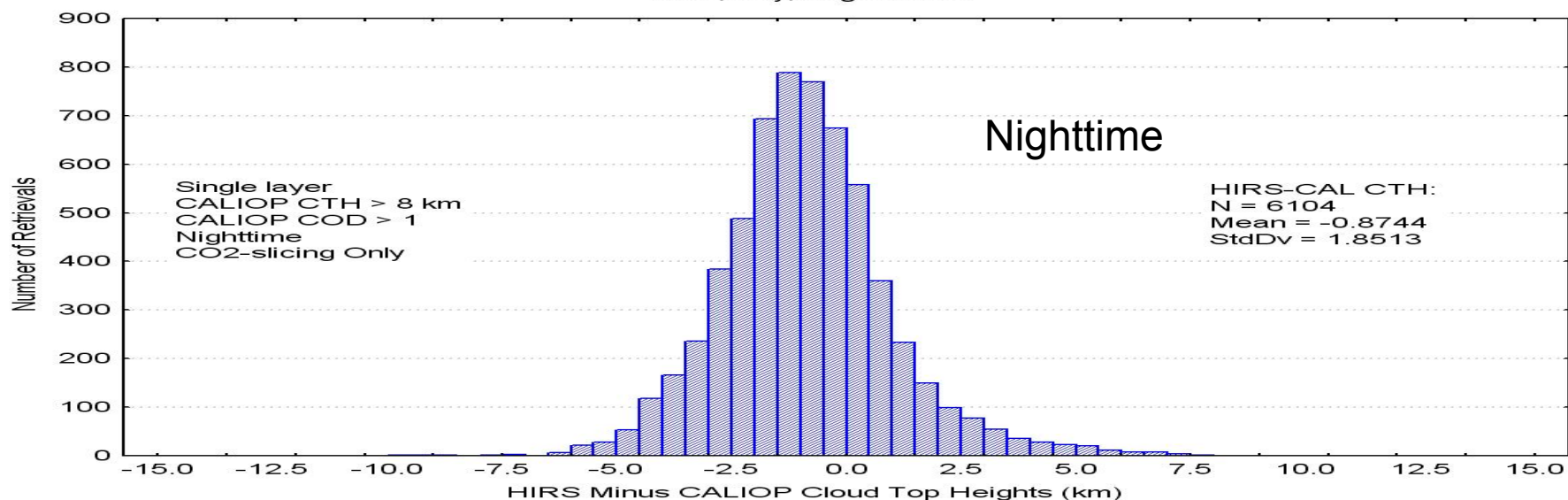
Effect of Recalibration on CTP



NOAA-18 HIRS and CALIOP Cloud Top Height Retrievals
June, July, August 2008

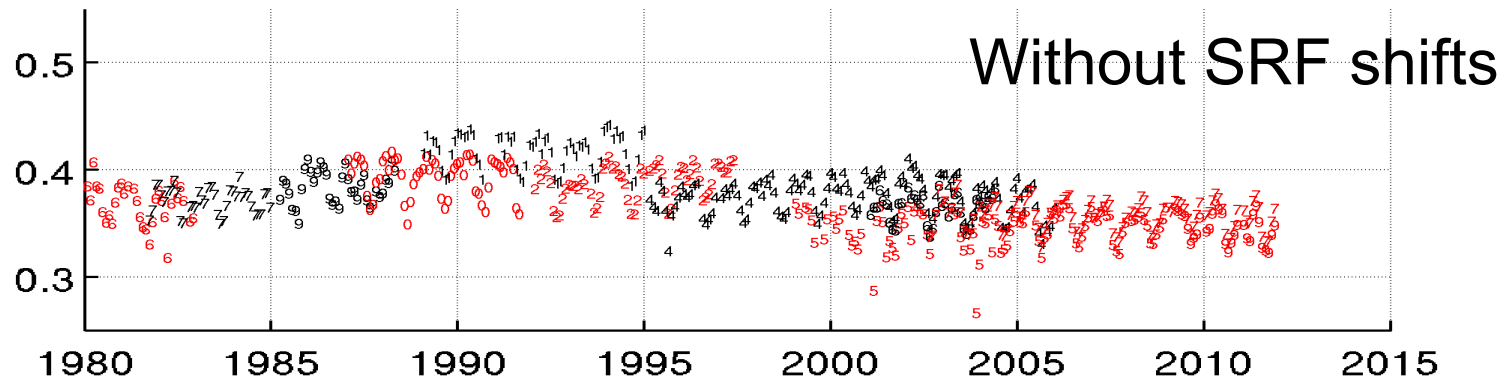


NOAA-18 HIRS and CALIOP Cloud Top Height Retrievals
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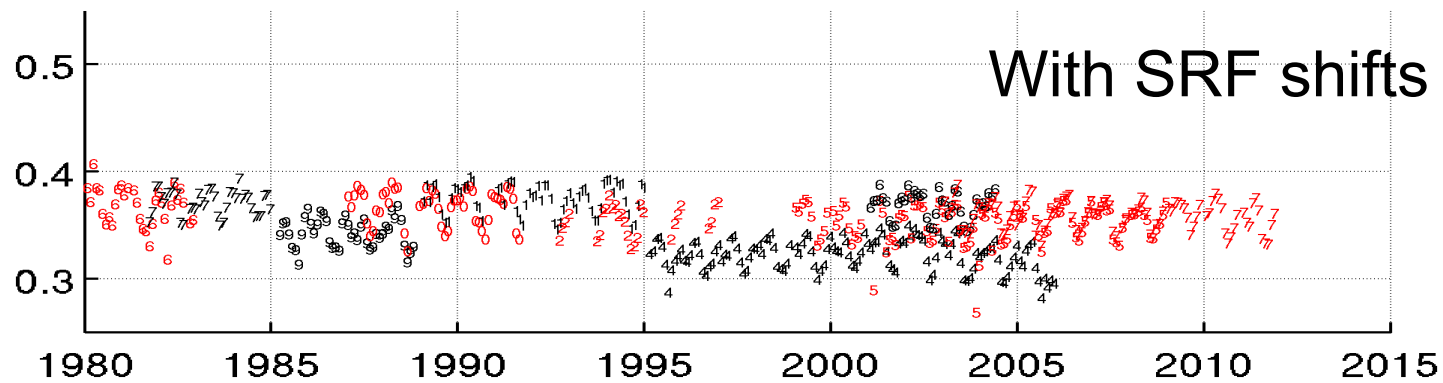


HIRS-CALIOP CTH distributions for June, July, August 2008
when CALIOP sees a cloud higher than 8 km and COT ≥ 1 .
HIRS is lower than CALIOP by 0.8 to 0.9 km on average.

60S to 60N, Ocean High Cloud Fraction



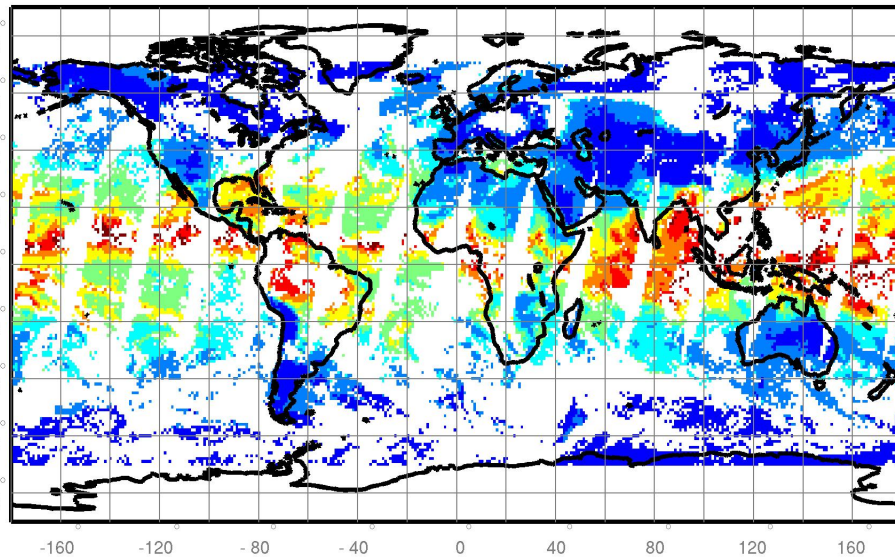
Trend With 2012r2 Spectral Shifts



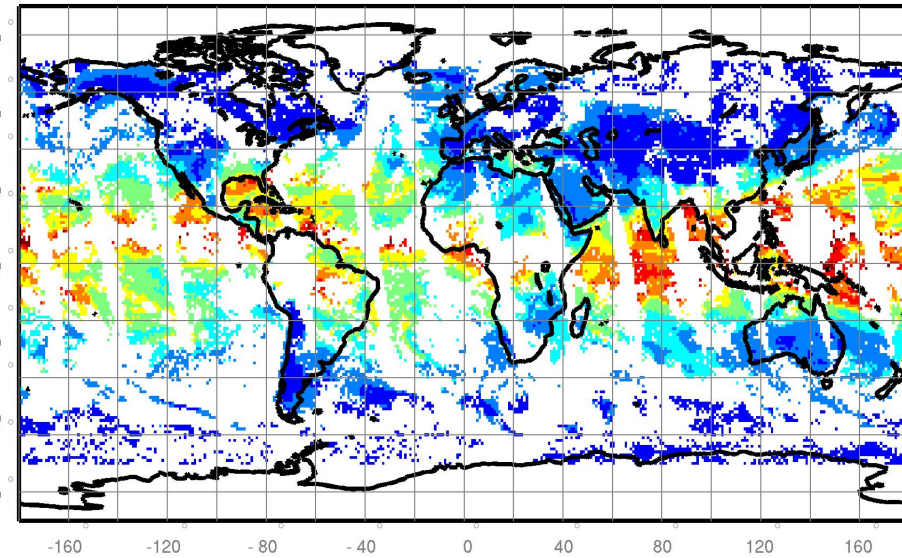
Afternoon and morning high (CTP<440 hPa) cloud over ocean trends from 1980 through 2011 given in fraction of total HIRS observations before (top) and after (bottom) the latest spectral shifts. The number indicates the NOAA satellite (e.g. 0 for NOAA-10, 1 for NOAA-11, and so on) and the color indicates the orbit (red for descending morning and black for ascending afternoon). Note this is without the PATMOS-x cloud mask.

METOPA/HIRS TPW comparison with F16/SSMI on Oct 15, 2009

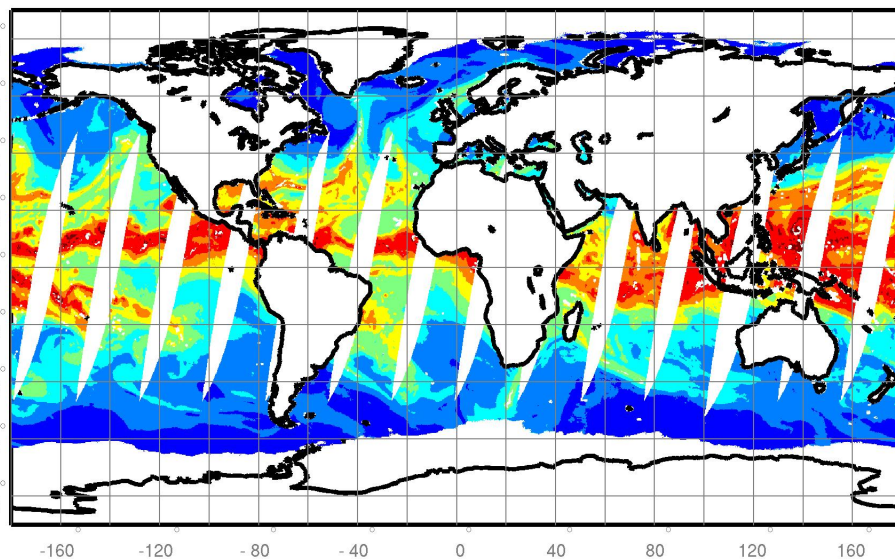
METOPA/HIRS Daytime



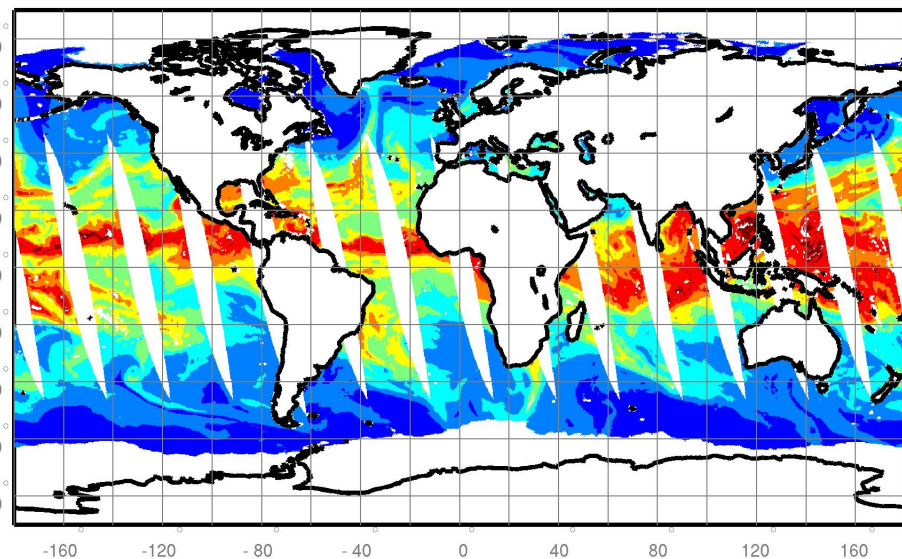
METOPA/HIRS Nighttime



F16/SSMI (V7) Daytime



F16/SSMI (V7) Nighttime



Uses & 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

Uses & 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

- 3Q12 - Processed TPW with new SRFs and ϵ_{sfc} for month
- 4Q12 - Established benchmark data sets for CTP and TPW
- 1Q13 - Transferred HIRS L1b netcdf converter
- 2Q13 - Transferred ATBD, benchmark data,
and CTP s/w to NCDC
- 3Q13 - Transfer TPW s/w and benchmark data to NCDC

Risks or concerns

- Resources dwindling – products likely limited to 10 years (note: complete record requested)
- Transition of software for ancillary data, CRTM, and Level 3 gridding will require additional resources
- Should recalibrate remaining HIRS channels (e.g., IR H₂O)
- Guidance on priorities necessary given resource limitations

CO2 HIRS spectral shifts (Dec 21, 2012) H2O HIRS Spectral shifts (Dec 13, 2012)

provided by ruiyue.chen@noaa.gov (NOAA STAR)

	Ch4(14.2)	Ch5(13.9)	Ch7(13.3)	Ch12(6.7)
hirs2n09	0.72	2.42	-0.67	1.1
hirs2n10	1.06	1.48	-1.12	3.0
hirs2n11	1.67	1.94	-0.04	4.2
hirs2n12	0.51	2.03	-2.25	4.1
hirs2n14	2.13	2.80	1.14	4.1
hirs3n15	-0.21	0.27	1.01	0.6
hirs3n16	0.22	0.62	0.47	0.8
hirs3n17	0.54	0.72	0.44	-0.3
hirs4n18	-0.71	-0.37	-0.49	3.3
hirs4n19	-0.00	-0.12	0.10	0.7
hirs4moa	-0.15	0.10	-0.15	2.2

