Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record

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Outline

- Brief Project Overview
- Approach (1-2 slides)
- Results/Accomplishments (1-3 slides)
- Validation Strategy/Results (1-2 slides)
- Algorithm/Product Maturity
- Issues/Risks & Work-Off Plans
- Schedule
- Research-to-Operations or Delivery Plan
- Resources

Overview

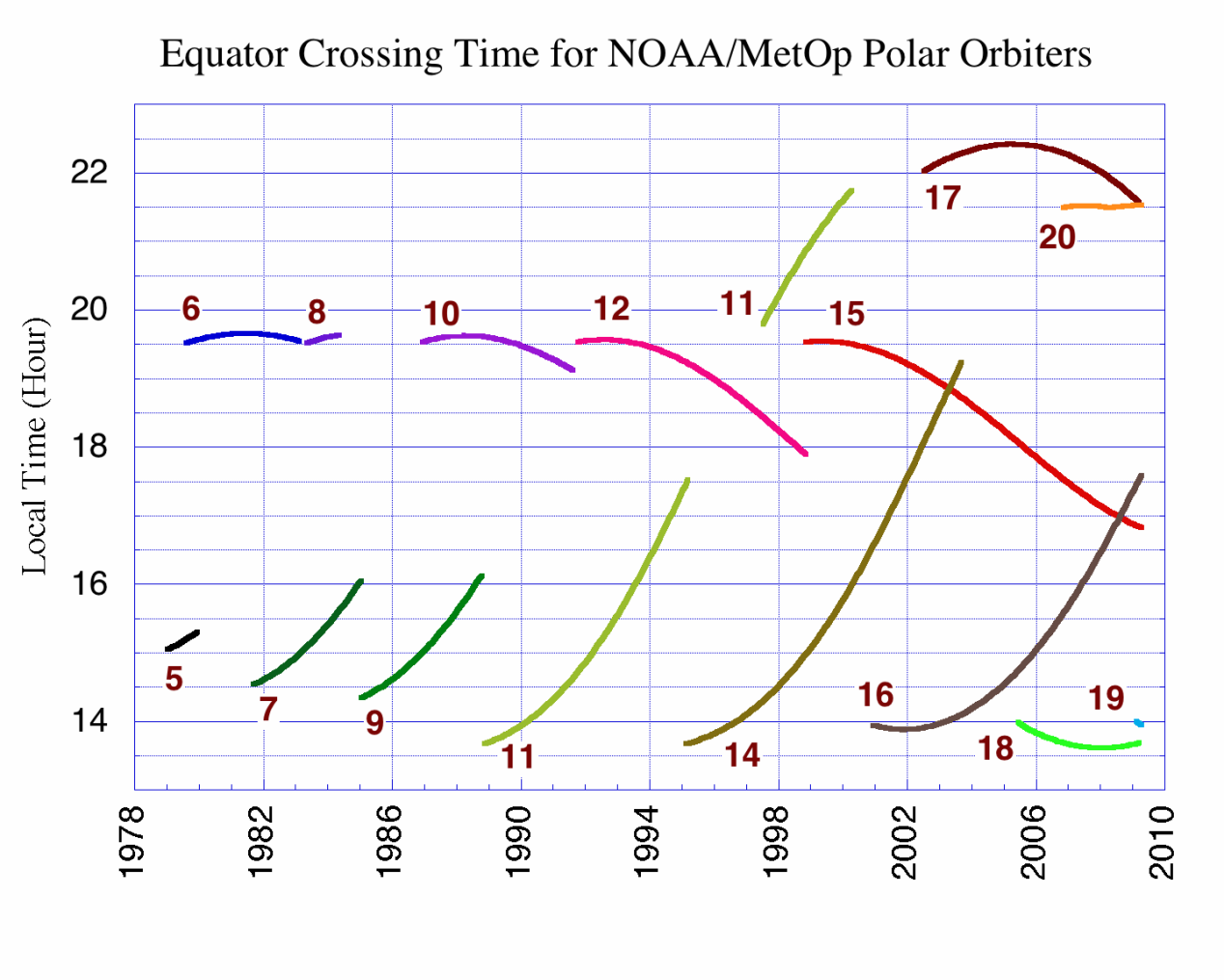
- Goals –
  - Extend and Maintain HIRS OLR CDR Time series
  - Improve OLR Algorithm
  - Define Operational OLR CDR Production System
  - Develop OLR algorithms for future sounders (sustainability)
- Source Data –
  - HIRS Level-1b data (thank NCDC/SAA/CLASS/Axel Graumann, ETL/Darren Jackson)
- Deliverables
  - HIRS OLR Time Series (1979 to present, monthly mean)
  - HIRS OLR CDR Production System
  - IASI/CrIS OLR Algorithms (preliminary)
- ECVs addressed – OLR (component of TOA ERB).
- Current/expected user communities: CPC, CDC, GEWEX (ERB, ENSO, Tropical convectivity, …)

Approach (1)

- OLR Algorithm: Ellingson et al. (1989)
- OLR CDR product: Lee et al. (2007)
  - Radiance calibration (McMillin, revised)
  - Inter-satellite calibration
  - Diurnal models (regional & monthly)
- OLR Algorithm Improvements
  - Nonlinearity
  - Hyperspectral instruments

Approach (2)

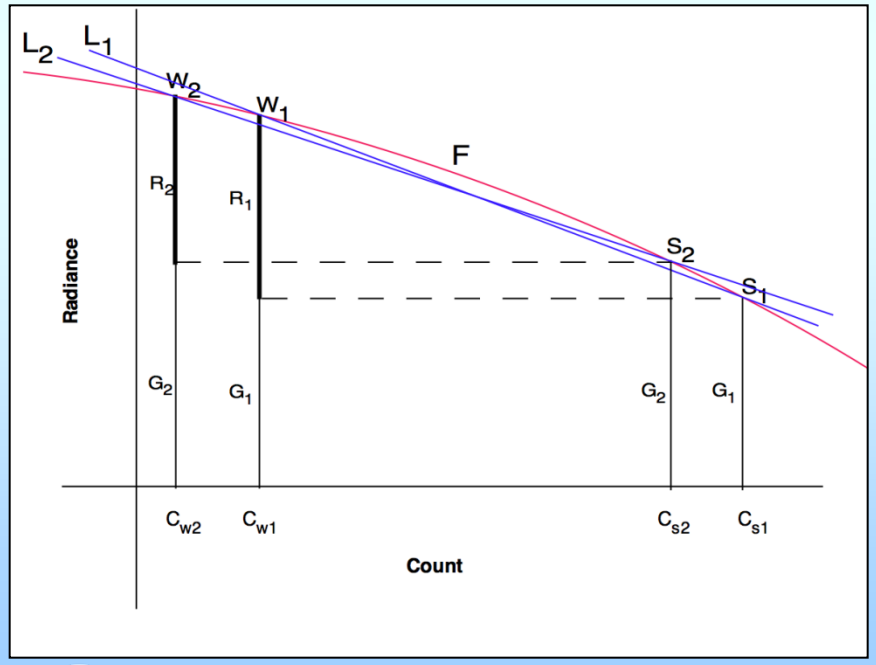
Temporal Coverage of HIRS Observations



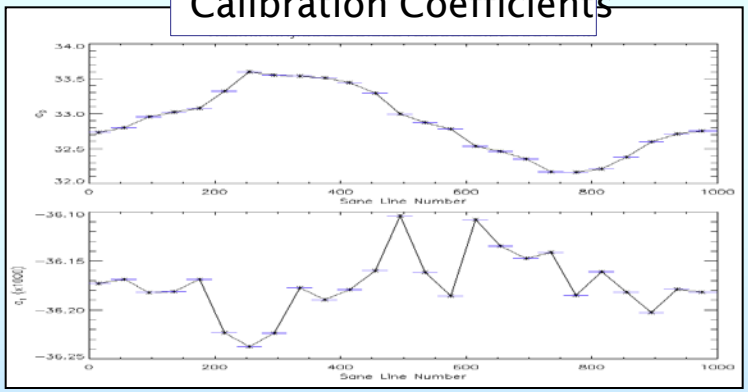
- Inter-satellite calibration is performed with observations overlapping in space and time.
- Temporal integral uncertainty is greatly reduced with the diurnal models – eliminating the orbital drift artifact.

Results/Accomplishments (1a)

- Radiance calibration
  - Overhauled McMillin method
  - Investigated calibration methods
  - Developing nonlinear calibration



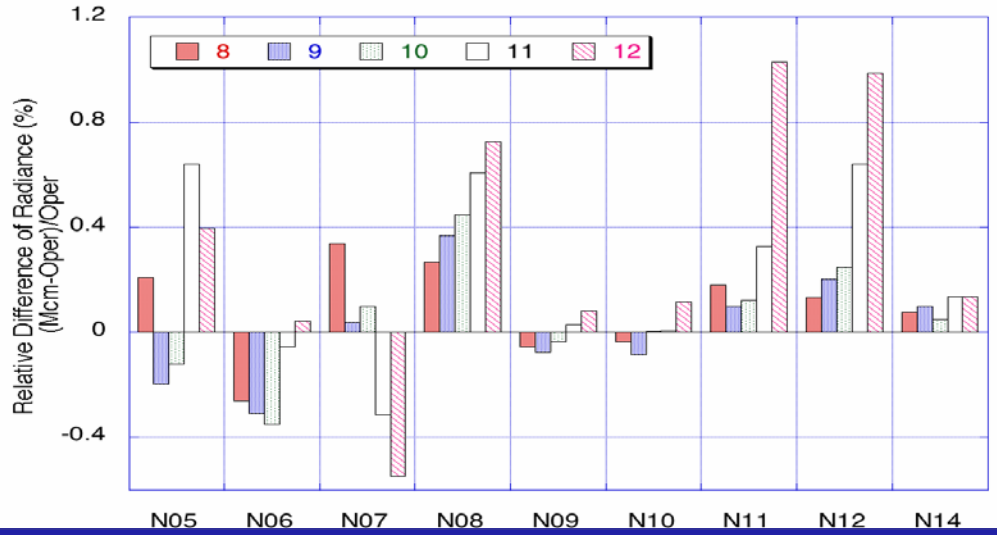
Calibration Coefficients



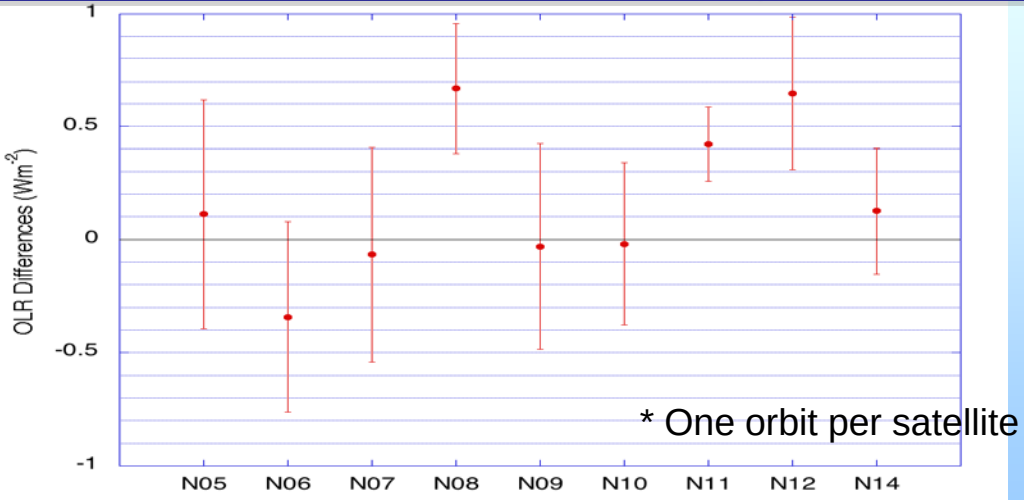
F represents the "True" calibration function
L is the linear approximation of the calibration function
W = IWT scan
S = space view scan
Cw = Internal Warm Target (IWT) view count
Cs = Space view count
G = background radiance
R = IWT radiance determined via PRT

Results/Accomplishments (1b)

Relative Differences of Radiance (McM minus Oper)/Oper



OLR Differences (McMillin minus Operational)



* One orbit per satellite

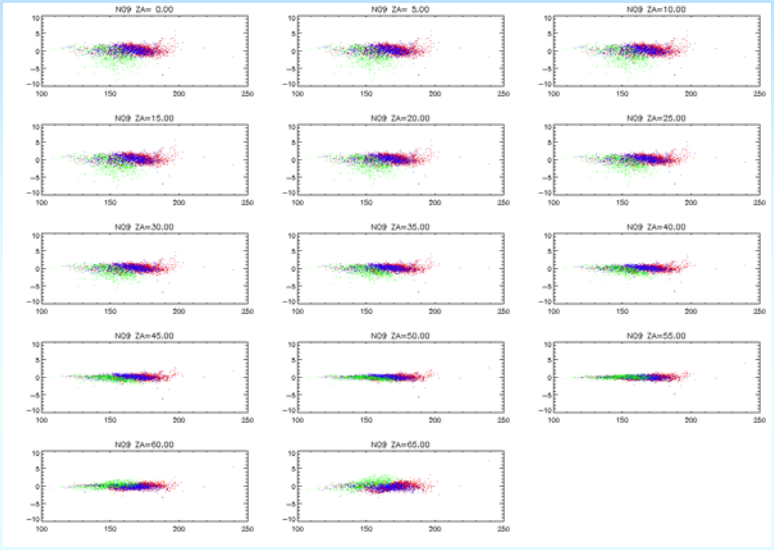
Results/Accomplishments (2)
OLR Algorithm Improvement

Multi-band OLR Models with polynomial predictors

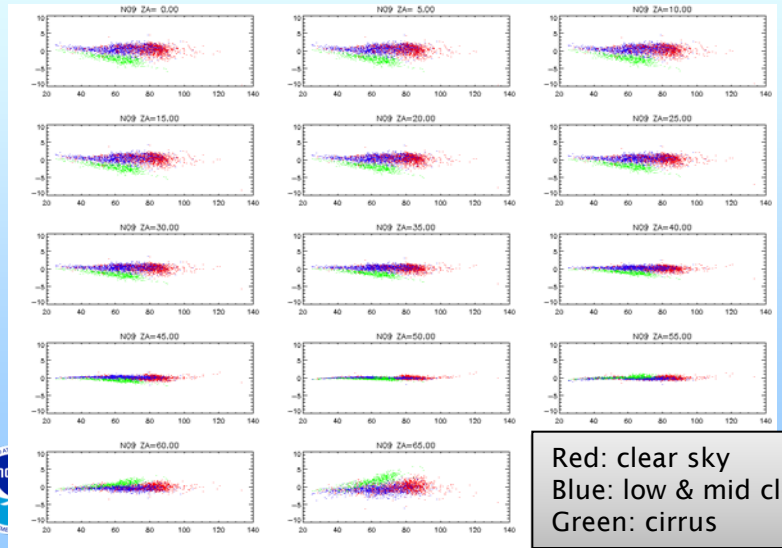
$$F_{\Delta\nu} = \sum_{j=1}^{M}\sum_{i=0}^{N} a_{ij}(\theta)\cdot\left(N_j(\theta)\right)^i$$

To eliminate Scene and Angular dependent biases

Window

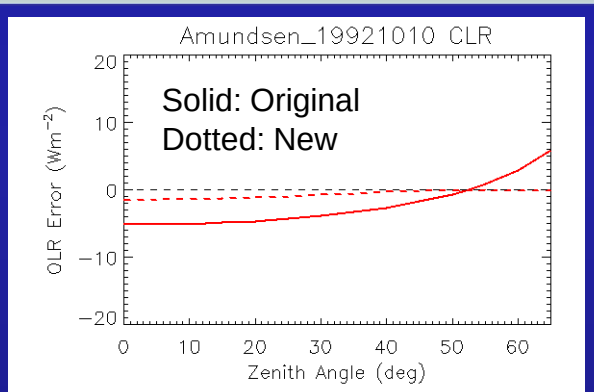


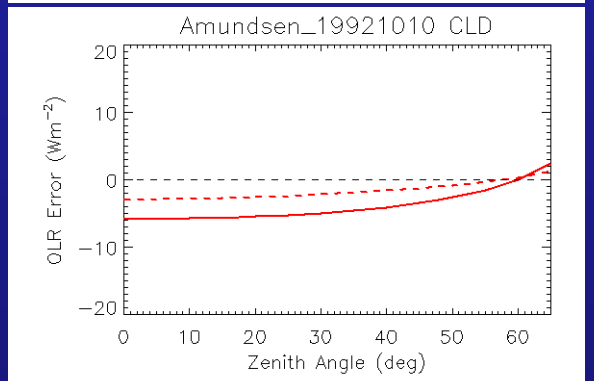
Non-Window



Red: clear sky
Blue: low & mid cloud
Green: cirrus

Test on Antarctic Profiles





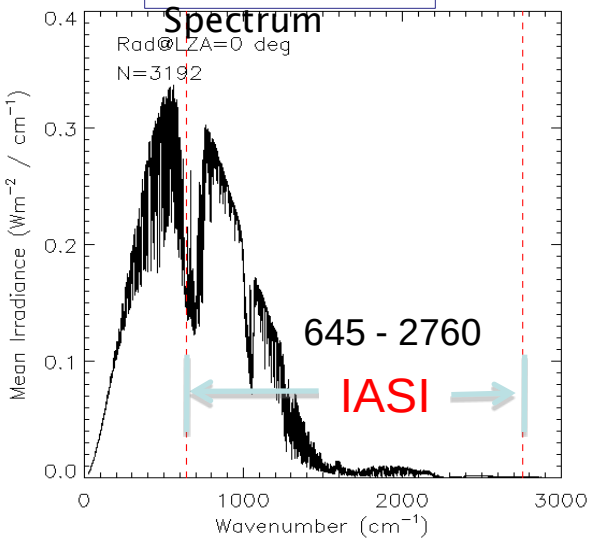
Results/Accomplishments (3)
IASI OLR Model

$$\ln(F_\nu) = \sum_{j=1}^{M}\sum_{i=0}^{N} a_{ij}(\theta)\cdot\left(\ln(I_{\nu_j}(\theta))\right)^j$$

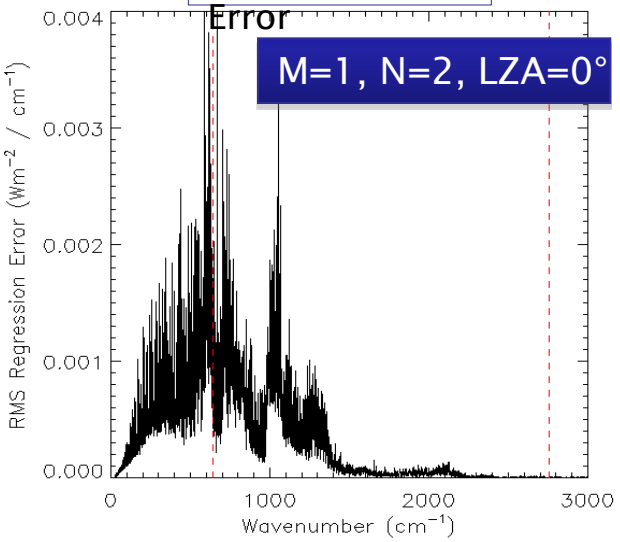
$\Delta\nu = 0.5cm^{-1}$
For apodized IASI L1C radiance

$$F_\nu = 2\pi\int_0^{\pi/2} I_\nu(\theta)\cos(\theta)\sin(\theta)d\theta$$

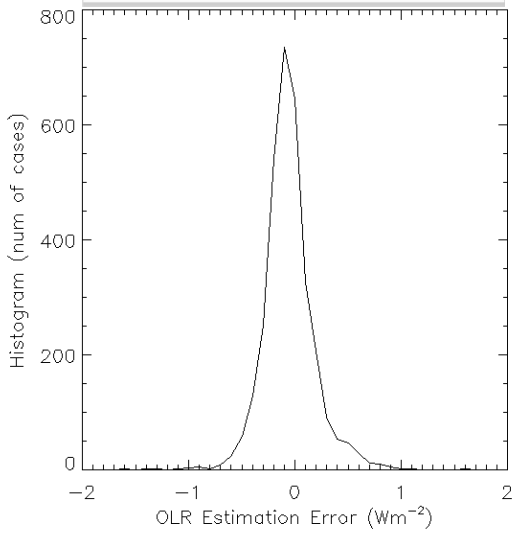
Mean Spectrum



Regression Error



N=3192
Mean = -0.01 Wm^{-2}
STD Diff = 0.24 Wm^{-2}
RMS Diff = 0.24 Wm^{-2}



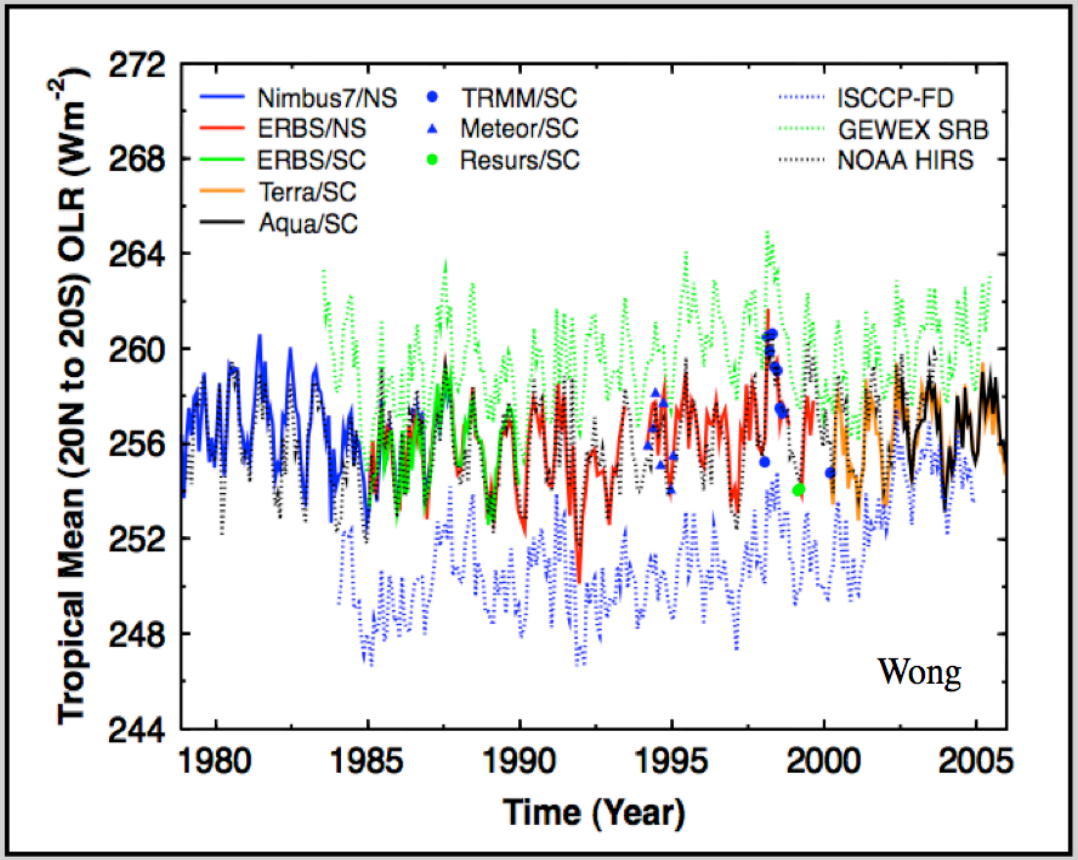
- Extremely accurate! With a **0.2 Wm^{-2}** rms regression error in OLR.
- Issues
  1. Near normal error distribution, slightly skewed.
  2. Possible negative bias error in warm (desert) scenes

Validation Strategy/Results (1)

- Inter-comparison of OLR products is the primary method for validation – caution that errors may be in the 'reference'. Cross-examination is the key.
- Applications ultimately show strengths and problems! Always prepare for re-processing when necessary.

Validation Strategy/Results (2)

Tropical OLR with Broadband Overlap Adjustment



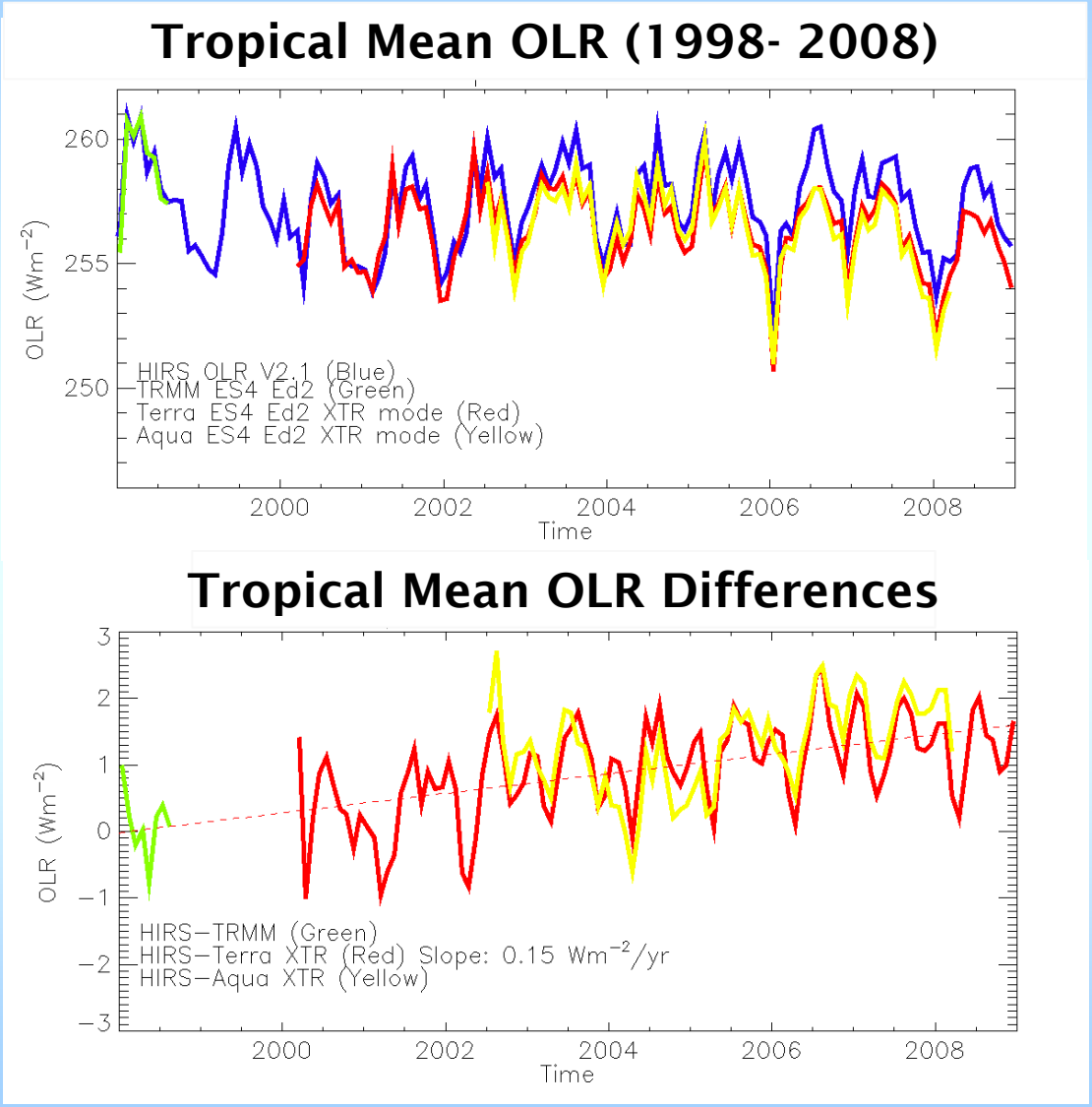
Proposed adjustment uses overlap points from TRMM/Terra/Resurs, TRMM/ERBS-NS, ERBS-NS/SC, and Nimbus7-NS/ERBS

Total change to ERBS/Nimbus nearly 5 W m^{-2}

The GEWEX RFA inter-comparisons show that the HIRS OLR agrees very well to the composite broadband OLR time series in variability and in absolute radiometry in the tropics.

HIRS OLR has a stability comparable to the ERBS non-scanner (WFOV) OLR product, within 0.3 Wm^{-2}/decade.

Validation Strategy/Results (3)



- Very good agreement between HIRS and CERES OLR product in the Tropics. STD Diff = ~0.7 Wm^{-2}
  Correl. = 0.97, 0.92, 0.92
- HIRS-CERES(Terra) has a slope of about 0.15 Wm^{-2}/yr
- Most differences can be attributed to the errors in CERES Ed.2 product (instrument degradation; ~0.15 to 0.2 Wm^{-2}/yr error unaccounted for in 2000-2005, level off afterwards)

Blue: HIRS OLR
Green: CERES TRMM
Red: CERES Terra
Yellow: CERES Aqua

Product Maturity

Maturity	Sensor Use	Algorithm stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none
2	Research Mission	Some changes expected	Research grade (extensive)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing
3	Research Missions	Minimal changes expected	Research grade (extensive); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
4	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD, Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators

Issues/Risks & Work- Off Plans

- HIRS/IASI/CrIS Radiance Measurement
  - Noisy or missing observations
    - ➢ Alternative OLR models (risking lower accuracy and inconsistency)
  - Early termination of satellites
    - ➢ degrade temporal integral confidence (use Geo)
    - ➢ no direct inter-satellite calibration (use transfer standard)
- Science support
  - Validation, Maintenance and Improvement
    - ➢ Require allocation of "operational" long term funding to sustain the product

Schedule

- 3rd year Milestones
  - Continue IASI OLR algorithm development
  - Continue HIRS OLR CDR algorithms revision
  - Inter-comparison and quality assessment
  - ATBD for Version 1 HIRS OLR CDR
  - Initialize CrIS OLR algorithm development
  - Operational production of HIRS OLR CDR
  - Operational real-time monitoring
  - Reprocessing for Version 2 HIRS OLR CDR

Research- to- Operations or Delivery Plan

- Designate NCDC for NOAA Data Center
- Parallel system running at CICS
- Transfer of production tools (Fortran/IDL). Establish point of contact (science and IT).
- Scheduling Algorithm Design Review, Critical Design Review, Unit Test Review
- Prepare ATBD

Resources

- Number of personnel: 3 (~ 0.8 FTE)
- Key equipment: 8-core Linux
- Key collaborating projects or personnel
  - Bob Ellingson, CERES Science Team, GEWEX-RFA, STAR, NCDC
- NOAA points-of-contact or collaborators, as applicable
  - TBD
- Target NOAA Data Center
  - TBD (CICS, NCDC, CPC, OSDPD)