An Alternative Inter-satellite Calibration of the UMD HIRS OLR Retrievals

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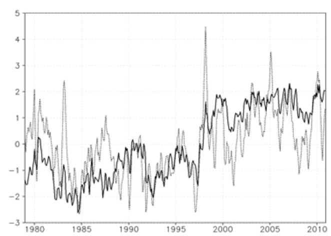
Background, Problem and Approach

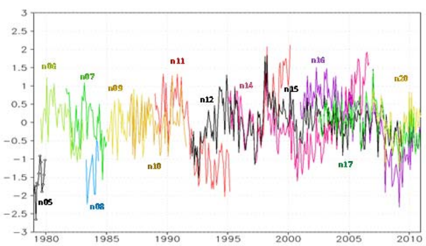
The observational record for determining Outgoing Longwave Radiation (OLR) from satellites remains largely fragmented with gaps over the past three decades among the Earth Radiation Budget Experiment (ERBE), Earth Radiation Budget Satellite (ERBS) and Clouds and the Earth's Radiant Energy System (CERES) measurements.

Multi-band OLR retrievals are thus an important supplement to the broadband measurements. The most semi-continuous set of OLR retrievals comes from the University of Maryland (UMD) algorithm that uses four HIRS (High Resolution Infrared Sounder) channels on the NOAA polar orbiting satellites to *estimate* OLR. but residual biases due principally to diurnal drift of the polar orbiter platforms remain an issue.

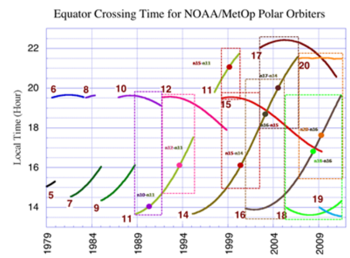
Here we show how an alternative recalibration of the UMD retrievals taking advantage of the relative diurnal drift rates between "morning" and "evening" satellite platforms removes much of the remaining uncertainty due to changes in equator crossing times.



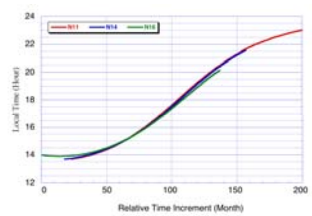
The upward trend in HIRS UMD OLR is most apparent for the entire globe with a value of nearly 4 Wm^{-2} over the thirty-two year period. Since 1979 global surface temperatures have risen on the order of 0.4 degrees C so an OLR increase of order 1.5 Wm^{-2} would be expected in the case of no radiative feedback.



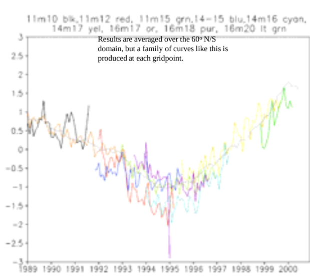
Global mean OLR anomalies (asc +desc)/2 with respect to each satellite's mean annual cycle over its lifetime (Wm^{-2})



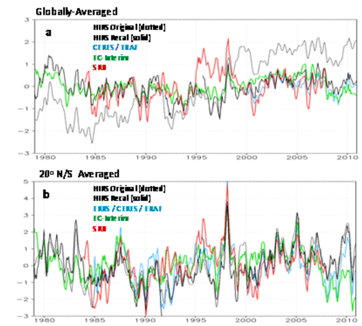
Equatorial crossing times for NOAA operational polar orbiting satellites. Dashed lines indicate temporal segments of overlap where the PM satellites (N11, n14, n16) are drifting rapidly compared to other satellites. Dots indicate the mid-points of these periods.



Similarity in relative drift rates of equatorial crossing times enable parameterization of correction

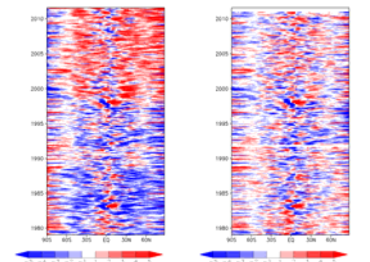


Curve segments which approximate AM-PM drift rates are independent of each other. Because the PM sensors share a similar diurnal drift rate, where the segments overlap in time they should have the same offset value. We thus (arbitrarily) adjust the curves segments using n11 as the reference.



Global and Tropical Average Anomaly Time Series. Each of the time series has a three-month running smoother applied. For the global domain the revised HIRS data now have only a small trend, 0.23 Wm^{-2} $decade^{-1}$ or 0.70 Wm^{-2} over the 32-year record and correlate well with those of the EC-Int (0.86).

Signals from individual ENSO warm and cold events are now a much more pronounced source of variability with elevated OLR accompanying the warm SST episodes in 1982/83, 1987/88, 1997/98 and 2010.

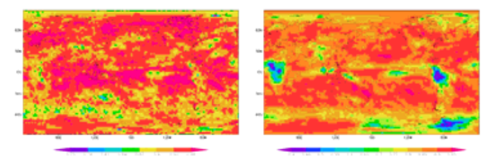


Hovmoeller plot s of OLR. In contrast to the original data set (left) the step increases in OLR for most latitudes and the opposite sign change in SH high latitudes are completely eliminated (right). ENSO events are now the most prominent variations although there are significant interannual signals at high latitudes of both hemispheres.

Revised Intercalibration Strategy

1. For each month we average the ascending and descending passes of each satellite at each gridpoint and compute de-seasonalized anomalies.
2. Identify discreet periods where these PM sensor drift rates are much larger than those of AM sensors. (E.g., from 1992 through 1994 the drift rate of n15 is very small compared to that of n11).
3. Using (i) the property that the PM sensors n11, n14 and n16 drift diurnally at a similar rate (Fig x) and (ii) the relatively constant local times for the AM satellites, develop a diurnal correction parameterized on satellite local time departure from an initial time, say 1400 LST (See Fig. x).
4. After correcting the individual PM satellites they can be inter-calibrated using their overlap periods (1998 through 1999 for n11 and n14 and 2000 through 2004 for n14 and n16).
5. This time series of monthly maps, which we refer to as "PMsat", is then used to calibrate OLR from the AM satellites (n10 onward) during the periods of excessive drift;
6. The resulting sequence termed "AMsat" is then used to interrelate the satellites n05 through n09 by virtue of the n09/n10 overlap.

Field Correlation with CERES 2000-2010



For the recalibrated HIRS (left) broad areas with CERES correlations in excess of 0.95 extend across the tropics with only isolated regions as low as 0.80. EC-Int OLR correlations are somewhat lower over oceanic regions and much lower (~ 0.4) over tropical land areas and over the W.H portion of Antarctica.

Summary

The adjusted HIRS data (using no other external information) show much better agreement with OLR from the European Center Interim Reanalysis (EC-Int), longer-term signals in the Global Energy and Water Cycle Experiment / Surface Radiation Budget (GEWEX/SRB) retrievals, and also agree well with ERBS and CERES OLR measurements. These results augur well for narrowing the uncertainties in multi-decadal estimates of this important climate variable.