Recalibration of Microwave Sounding Unit for Climate Studies Using Simultaneous Nadir Overpasses

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The measurements from Microwave Sounding Unit (MSU) onboard different NOAA polar-orbiting satellites have been extensively used for detecting atmospheric temperature trend during the last several decades. However, temperature trends derived from these measurements are under significant debate, mostly caused by calibration errors. This study recalibrates the MSU Channel 2 observations at level 0 using the post-launch simultaneous nadir overpass (SNO) matchups and then provides a well-merged new MSU 1b dataset for climate studies. The calibration algorithm consists of a dominant linear response of the MSU raw counts to the Earth-view radiance plus a smaller quadratic term. Uncertainties are represented by a constant offset and errors in the coefficient for the nonlinear quadratic term. A SNO matchup dataset for nadir pixels with criteria of simultaneity of less than 100 seconds and within a ground distance of 111 km is generated for all overlaps of NOAA satellites. The simultaneous nature of these matchups eliminates the impact of orbital drifts on the calibration. A radiance error model for the SNO pairs is developed and then used to determine the offsets and nonlinear coefficients through regressions of the SNO matchups. It is found that the SNO matchups can accurately determine the differences of the offsets as well as the nonlinear coefficients between satellite pairs, thus providing a strong constraint to link calibration coefficients of different satellites together. However, SNO matchups alone cannot determine the absolute values of the coefficients because there is a high degree of colinearity between satellite SNO observations. Absolute values of calibration coefficients are obtained through sensitivity experiments, in which the percentage of variance in the brightness temperature difference time series that can be explained by the warm target temperatures of overlapping satellites is a function of the calibration coefficient. By minimizing these percentages of variance for overlapping observations, a new set of calibration coefficients is obtained from the SNO regressions. These new coefficients are significantly different from the pre-launch calibration values, but they result in bias-free SNO matchups and near-zero contaminations by the warm target temperatures in terms of the calibrated brightness temperature.

Applying the new calibration coefficients to the Level 0 MSU observations, a well-merged MSU pentad dataset is generated for climate trend studies. To avoid errors caused by small SNO samplings between NOAA 10 and 9, observations only from and after NOAA 10 are used. In addition, only ocean averages are investigated so that diurnal cycle effect can be ignored. The global ocean-averaged intersatellite biases for the pentad dataset are between 0.05 to 0.1 K, which is an order of magnitude smaller than that obtained when using the unadjusted calibration algorithm. The ocean-only anomaly trend for the combined MSU channel 2 brightness temperature is found to be 0.198 K decade-1 during 1987-2003.

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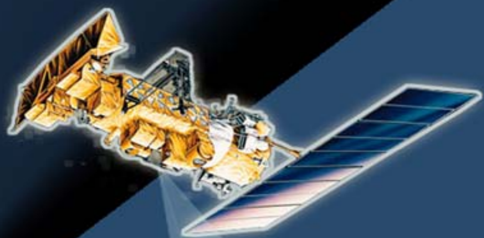

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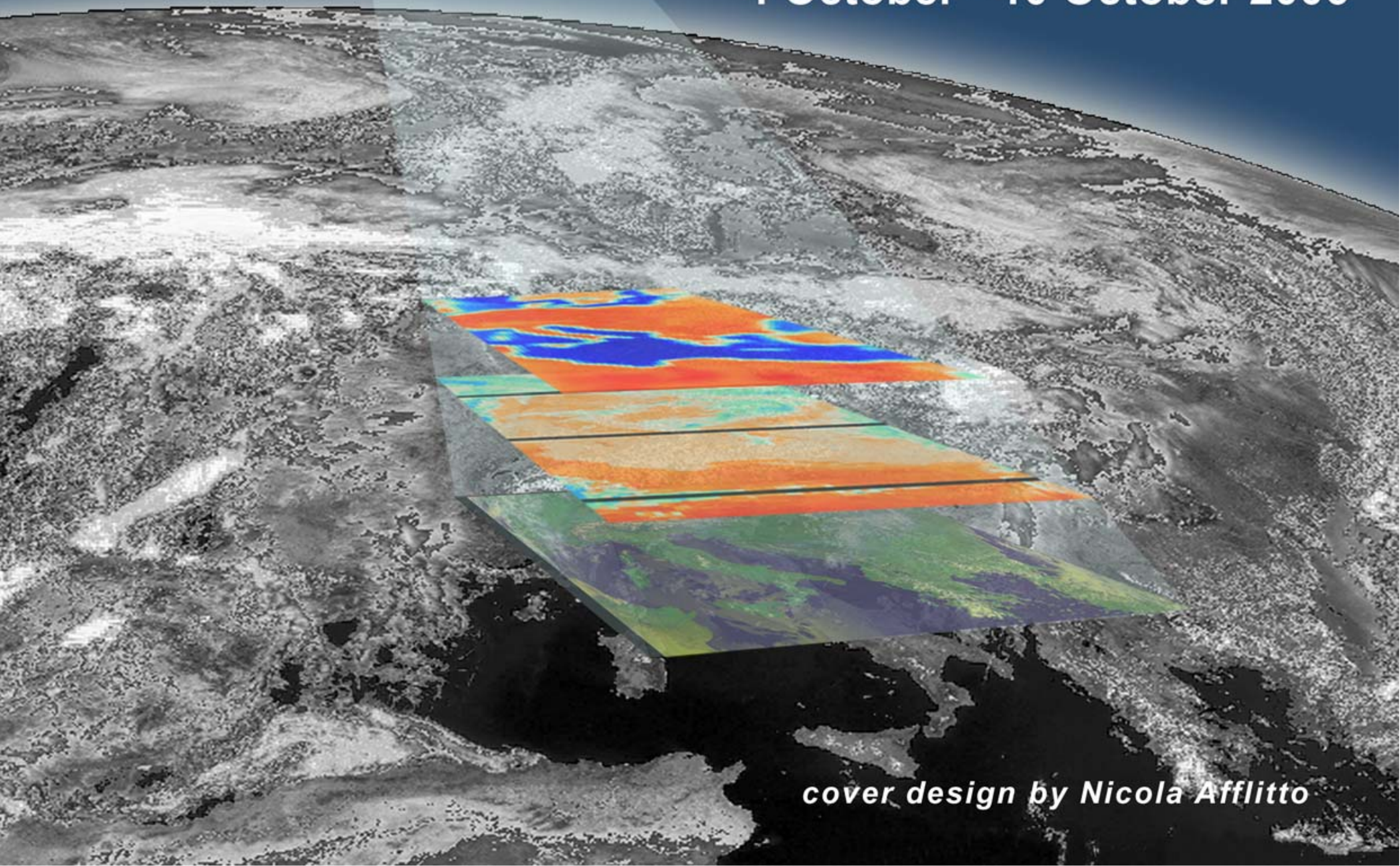

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