A New Highly Stable Multi-Decade Satellite Climate Data Set Derived from Polar Hyperspectral Infrared Sensors

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NASA's Atmospheric Infrared Sounder (AIRS) started the continuous measurement of the Earth's upwelling infrared radiation at high spectral resolution in Sept. 2002 in a 13:30 polar orbit. The AIRS record was supplemented by the CrIS sensor flying on the NASA SNPP platform, also in the 13:30 polar orbit, in 2012. In 2018 a second CrIS sensor on NOAA's JPSS-1 platform (NOAA-20) began operation, also in the 13:30 orbit. Two more CrIS sensors are presently being procured for the JPSS-2 and 3 satellites, which will extend this record from 2002 through ~2040. EUMETSAT's METOP-A/B/C provide very similar hyperspectral observations starting with the IASI sensors in the 09:30 orbit, starting in 2007, which will be continued with METOP-SG for years to come.

Inter-calibration of all of the operating sensors shows agreement generally to 0.2K or better in brightness temperature. More importantly, we have shown that the radiometric stability of the AIRS sensors is in the 0.002 K/year range or 0.02K/decade, based on measurements of CO2 and SST trends. Similar stability is expected for CrIS and IASI. Community consensus suggests that direct radiance trending, followed by conversion of these trends to geophysical quantities will yield the most accurate climate trends.

Here we introduce a new satellite hyperspectral infrared radiance product we call the "Climate Hyperspectral InfraRed Product (CHIRP)" that combines AIRS, CrIS, and IASI into a homogeneous Level 1 radiance product with a common spectral response and channel centers for all three satellites. This grid is equivalent to an interferometer with optical path differences of 0.8/0.6/0.4 cm for the long-wave/mid-wave/short-wave spectral bands. This corresponds to a virtual instrument with the same spectral resolution of the JPSS-1 CrIS sensor in the long-wave, with 25/50% degradation in spectral resolution in the mid-wave/short-wave. This choice allows accurate conversion of the long AIRS record to an equivalent interferometer record. Conversion of IASI to CHIRP is trivial. Conversion of all sensors to the CHIRP spectra grid permits simple adjustments of inter-satellite radiometric bias differences since all measurements are first converted to a common spectral grid. Multiple methods (SNOs, statistical inter-comparisons) indicate these adjustments can be made to the 0.03K level or better.

A sample application of CHIRP to climate trending will be given by showing multi-decade anomalies of temperature, humidity, and ozone profiles retrieved from CHIRP radiance anomalies, a retrieval that requires almost no a-priori information. This data set should yield definitive
measurements of water-vapor feedback and heavily contribute to our understanding of both tropospheric and stratospheric temperature trends. Initial production of CHIRP radiances that combine AIRS and CrIS are expected to begin in late 2020.