SPIE NEWS ITEM

NASA's Advancements in Space-Based Spectrometry Lead to Improvements in Weather Prediction and Understanding of Climate Processes

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AIRS (Atmospheric Infra-Red Sounder), was launched, in conjunction with AMSU-A (Advanced Microwave Sounding Unit-A) on the NASA polar orbiting research satellite EOS (Earth Observing System) Aqua satellite in May 2002 as a next generation atmospheric sounding system. Atmospheric sounders provide information primarily about the vertical distribution of atmospheric temperature and water vapor distribution. This is achieved by measuring outgoing radiation in discrete channels (spectral intervals) which are sensitive primarily to variations of these geophysical parameters. The primary objectives of AIRS/AMSU were to utilize such information in order to improve the skill of numerical weather prediction as well as to measure climate variability and trends.

AIRS is a multi-detector array grating spectrometer with 2378 channels covering the spectral range 650 cm^{-1} (15 microns) to 2660 cm^{-1} (3.6 microns) with a resolving power ($\nu/\delta\nu$) of roughly 1200 where $\delta\nu$ is the spectral channel bandpass. Atmospheric temperature profile can be determined from channel observations taken within the 15 micron (the long-wave CO_2 absorption band) and within the 4.2 micron (the short-wave CO_2 absorption band). Radiances in these (and all other) spectral intervals in the infrared are also sensitive to the presence of clouds in the instrument's field of view (FOV), which are present about 95% of the time. AIRS was designed so as to allow for the ability to produce accurate Quality Controlled atmospheric soundings under most cloud conditions. This was achieved by having 1) extremely low channel noise values in the shortwave portion of the spectrum and 2) a very flat spatial response function within a channel's FOV. IASI, the high spectral resolution IR interferometer flying on the European METOP satellite, does not contain either of these important characteristics. The AIRS instrument was also designed to be extremely stabile with regard to its spectral radiometric characteristics, which is critical with regard to the ability to measure accurate long term trends.

AIRS, at nadir viewing, has nine 13.5 km by 13.5 km FOV's that lie within a single 45 km by 45 km AMSU Field Of Regard (FOR). The AIRS Science Team retrieval algorithm generates a single sounding per FOR, using the nine AIRS fields of view to derive clear column radiances for each channel i, which represent the radiance channel i would have seen if the FOR were completely cloud free. Geophysical parameters are determined so as to be consistent with clear column radiances for a select set of channels. Following theoretical considerations, coefficients needed to determine clear column radiances for all channels are determined using only observations in the longwave CO_2 band and longwave window region, while atmospheric and surface temperatures are determined using clear column radiances only in the shortwave CO_2 band and shortwave window region. This optimal approach is practical for AIRS

because noise on the shortwave channels is very low. The operational AIRS Science Team Version 5 retrieval algorithm uses this approach and has resulted in marked improvement in the use of AIRS products for data assimilation and also in the generation of accurate climate data sets. This new methodology also allowed for the generation of error estimates of the retrieved products which are used for Quality Control and are critical for their optimal use of in weather and climate applications. A number of important results using AIRS Version 5 products are given below.

1) Assimilation of Quality Controlled AIRS Version 5 temperature profiles produced superior 5-7 day forecasts than those obtained using the NOAA operational procedure of assimilating observed AIRS radiances. Assimilation of Quality Controlled AIRS temperature soundings also has resulted in a significant improvement in the ability to predict the track of Tropical Storm Nargis,that devastated parts of Indonesia in 2006, compared to the operational procedure.

2) OLR computed from AIRS products confirms the result observed by CERES that global mean OLR has been decreasing at a rate of 0.12 $W/m^2/yr$ over the Aqua time period September 2002 through December 2009. The majority of this decrease occurs in the tropics as a result of a significant redistribution of cloud cover and water vapor in response to a very strong La Niña event starting in late 2007.

3) Twice daily global fields of CO derived from AIRS accurately depict the space and time propagation of CO coming from fires.

4) AIRS provided the first accurate global monthly mean fields of CO_2 concentration which showed both local seasonal cycles and CO_2 growth over time.

NASA has a new proposed design, employing two dimensional detector arrays, for a new Low Earth Orbiting instrument ARIES, which would have AIRS-like spectral and radiometric characteristics but would view the earth with a 1 km spatial resolution. Products derived from such an instrument would result in a further significant improvement in the ability to improve weather prediction, monitor climate parameters, and derive atmospheric water vapor and trace gas distribution.

References:

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