AIRS and Climate Science

The Atmospheric Infrared Sounder, AIRS, flying on a NASA weather and climate research satellite called Aqua, is the first spaceborne instrument designed specifically to measure the most critical global climate change indicators. AIRS' cutting edge technology allows it to **measure air temperature and the amounts of water vapor and greenhouse gases with remarkable precision and accuracy**. As a result, we are now beginning to gather data from space with the quality that will allow us to address many of the scientific questions related to Earth's climate and global change in the atmosphere.

AIRS has demonstrated exceptional accuracy and yield, providing over 300,000 temperature and water vapor profiles globally with accuracies comparable to radiosondes – even from uninhabited or totally inaccessible areas. The AIRS "satellite-sondes" enable direct observation of atmospheric events and processes related to severe weather and climate. For the first time, we are forming a precise picture of the three-dimensional global distribution of water vapor and carbon dioxide, Earth's primary greenhouse gases.

Climate Processes and Model Validation

Climate models are an important tool for predicting future climate and they are the foundation for national and international climate change assessment reports. Models require vigorous validation of the processes that govern atmospheric transport and radiation balance using state-of-the-art observations.

Previous model evaluations typically use reanalysis from forecast centers. This reanalysis data are constructed by combining forecast model simulations and past observations from different sources, and they have been limited in their accuracy.

AIRS is able to provide a highly accurate daily source of global three dimensional temperature and water vapor fields, and these data have been used in studies to evaluate the temperature and water vapor fields in the state-of-the-art climate models. Studies have shown the majority of climate models have considerable errors in the vertical and horizontal distribution of temperature and water vapor on an annual climatology. For example, in comparison to AIRS, most climate models have a tropospheric cold bias (around 2 K), especially in the extratropical upper troposphere. Most climate models also have a too-wet troposphere over the southeastern tropical Pacific in comparison to AIRS, closely related to the well-known double-Intertropical Convergence Zone (ITCZ) problem in fully coupled global climate models. The **AIRS water vapor data also help to constrain climate sensitivity and reduce its large uncertainty range in climate models.**

Cloud and Water Vapor Feedbacks

The largest uncertainties for future climate predictions using global climate models are associated with cloud and water vapor feedback processes. Until now, measurements of water vapor from the atmosphere's upper troposphere have been limited. As a result, accurate modeling of water vapor feedbacks with increasing surface temperature are a problem for global climate models. Since its launch in 2002, the **AIRS instrument has been able to provide data which has shown a positive correlation between sea surface temperature and water vapor at 250 hPa**, indicating a "positive" upper tropospheric water vapor feedback with increased surface warming. Other studies using **AIRS data have confirmed that water vapor feedback is positive with increased global warming.**

Madden-Julian Oscillation

Eastward moving intraseasonal oscillations of intense rainfall and drought are important tropical atmospheric processes over the tropical Indian and Western Pacific Oceans. Referred to as the Madden Julian Oscillation (MJO), this cycle has a period of about 45 days and is particularly active during the Northern Hemisphere winter season, November–April. The **AIRS high vertical and horizontal resolution data of temperature and water vapor have revealed a new vertical moist thermodynamic structure of the MJO** and have improved scientist's ability to validate theories governing the MJO. For example, AIRS observations show a warm/moist pre-conditioning of the lower middle troposphere prior to intense rainfall and a cold/dry pre-conditioning of the lower middle troposphere prior to drought; temporal and spatial distributions better match expectations than model predictions.

Gravity and Mountain Waves

AIRS enables observation of temperature waves including gravity waves and mountain waves. Gravity waves are oscillations in the vertical temperature profile over a horizontal distance. AIRS provides good coverage and horizontal resolution enabling observations in and above the troposphere. Each year Polar Stratospheric Clouds (PSCs) form when the temperature in the stratosphere drops below 195K. Certain types of PSCs convert reservoirs of chlorine to an activated form that destroys ozone. Scientists used AIRS data to identify a case whereby formation of PSC's were caused by of an Antarctic Peninsula mountain wave event.