ARM Research Highlights

Tropical Radiosonde Comparisons Improve Past and Present Humidity Data

The Atmospheric Radiation Measurement (ARM) Program's Tropical Western Pacific (TWP) site is an excellent environment for research focused on improving the accuracy of temperature and humidity profiles used in climate modeling. In 1999, the ARM Program organized a campaign, Nauru99, to compare data from ground-based measurement instrumentation on the Republic of Nauru against data from the surrounding ocean. One goal of this collaborative effort was to evaluate the accuracy of a correction algorithm developed to adjust for dry bias in previous radiosonde humidity soundings.

The research team used spectral radiance observations from an independently calibrated atmospheric emitted radiance interferometer to test scaling of radiosondes by microwave radiometer (MWR) data versus (1) the original sonde data, and (2) that sonde data corrected using an empirical technique supplied by Vaisala (the sonde manufacturers). Precipitable water vapor and calculated infrared radiation from the clear sky were compared.

In collaboration with the National Oceanic and Atmospheric Administration, and the Japan Marine Science and Technology Center, ARM's Nauru99 campaign provided a rare opportunity to compare original and corrected land-based radiosonde temperature and humidity measurements with those obtained at sea.

Because of the demonstrated quality of ARM's MWR instruments and data, the large scatter between measurements and calculations proved to be a result of error in the older radiosondes. Nauru99 confirmed that the Vaisala correction algorithm greatly improved radiosonde measurement accuracy, and can be applied to past and present data to reduce uncertainties in the radiosonde humidity measurements. It also demonstrated the importance of using MWR data to scale the results for even greater accu-

An Affordable, Flexible, and More Accurate Method for Computing Radiative Transfer

Cloud properties are both complex and variable, making it difficult to create accurate models. Calculating radiative transfer is a time consuming, inflexible, and often biased process. The Independent Column Approximation (ICA) model can accurately determine domain-average fluxes in variable clouds, but it is very expensive. ARM researchers have developed a new, less costly radiation transfer scheme based on the ICA. This new method incorporates a Monte Carlo integration of the ICA (McICA) and provides unbiased radiative fluxes. By separating the processes of determining cloud structure within a domain from the calculation of radiative transfer, the radiation code can become simpler and more flexible, while assumptions about cloud structure can be applied uniformly to flux and heating rate calculations. The consistent and accurate treatment of cloud structure in radiation and precipitation calculations is allowing ARM researchers to reduce the uncertainty in global climate models. Plans are to incorporate the McICA into high-profile weather and climate models within the next couple of years.

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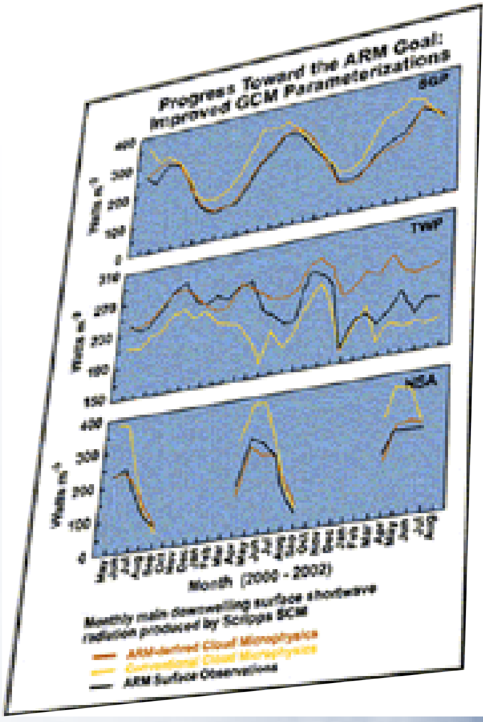
For Ice Particles, Size and Shape Do Matter



Due to the irregular shape and large range of sizes of ice crystals, predicted particle size in ice clouds is a key uncertainty in climate models. The current method of predicted particle size is based on a combination of theory and observation. Particle size affects the amount of solar radiation that is scattered back to space or reaches the Earth, and how much long-wave radiation is emitted. Therefore, the particle size in the cloud is critical in determining the effect of the cloud on the radiation budget (cloud radiative forcing).

Using interactive and non-interactive simulations of tropical clouds, ARM scientists are trying to improve the way ice clouds are treated in climate models. The interactive simulations help determine the net uncertainties associated with the different parameterization schemes, whereas the noninteractive simulations help identify which factors cause variations in predicted cloud and radiative properties.

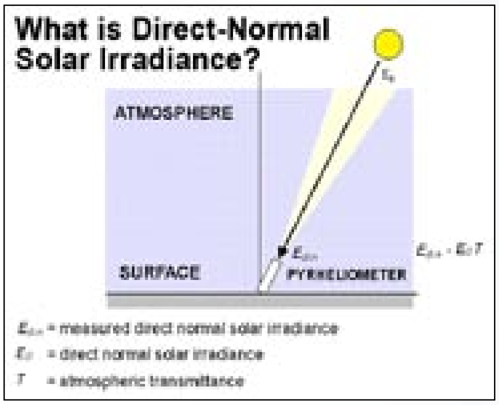
ARM Researchers implemented a range of empirical coefficients to describe the mean ice crystal size using the Scripps Institution of Oceanography single-column model. They found that where the size and shape of ice crystals are concerned, a simulation based on an average of the values of the coefficients does not give the same result as the average of a set of simulations using varying coefficients. They also concluded that, until multivariate dependences of the average cloud particle radius can be better described, parameterizations should provide a range of coefficients or ranges of possible average particle radius values. Whether the parameterization developed in this study can be used for non-tropical cloud types remains to be determined.

The Fade Factor: Modeled vs. Measured Direct-Normal Solar Irradiance

Direct-normal solar irradiance (DNSI) is the total energy in the solar spectrum at any given time on a unit area at the Earth's surface perpendicular to the direction of the sun. The value of DNSI depends only on atmospheric extinction of solar energy – whether through absorption or scattering.

During a set of clear-sky experiments performed at ARM's Southern Great Plains site in north-central Oklahoma, atmospheric composition and aerosol optical thickness (AOT) measurements were fed into a moderate resolution radiative transfer model, MODTRAN-3, to estimate DNSI. The resulting estimate was then compared with measured values obtained with normal incidence pyrheliometers and absolute cavity radiometers. For 36 independent comparisons, the agreement between measured and model-estimated values of DNSI fell within the combined uncertainties in the measurement (0.3%-0.7%) and model calculation (1.8%).

While the variation in DNSI was due mainly to variation in solar zenith angle, agreement between the measured and modeled DNSI proved to be nearly independent of airmass and water vapor path abundance. Airmass is a measure of the amount of atmosphere traversed by the direct beam of the sun. The airmass equals "1" if the sun is directly overhead, and increases as the sun angles toward the horizon.



Work by others has suggested that typical general circulation models underestimate the globally averaged solar flux absorbed in the atmosphere by 25 to 30 W m-2. The discrepancy has been attributed principally to inadequate parameterization of absorption by water vapor or other components, such as aerosols, that spectrally correlate with water vapor. If MODTRAN-3 suffered the same inadequacies in parameterization, the resulting effect on DNSI would be readily apparent as a bias that would increase with increasing airmass or water path abundance. The results of these experiments do not show this bias, indicating that all important atmospheric absorption phenomena are present in the MODTRAN-3 model.

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