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WORKSHOP ON PHYSICS OF MESOSPHERE-STRATOSPHERE-TROPOSPHERE INTERACTIONS WITH SPECIAL EMPHASIS ON MST RADAR TECHNIQUES

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PROBING THE TROPICAL ATMOSPHERE: TROPICAL CONVECTION AND PRECIPITATION

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Probing the Tropical Atmosphere: Tropical Convection and Precipitation.

Lecture Notes:
This lecture presents some recent developments in probing the tropical atmosphere for the purpose of studying tropical convection and precipitating cloud systems. We begin by showing some examples of precipitating cloud systems observed with profilers in the tropics. The Classification of the precipitation is presented next. Diurnal variability is discussed next. Contributions of profilers to precipitation measurement are presented in the context of the NASA/NASDA Tropical Rainfall Measuring Mission. Calibration of profiler measurements by disdrometer is followed by the use of the profiler for calibration of scanning radar. He lecture concludes with some remarks on the use of profilers for the retrieval of drop-size distributions.

1. Profiler Observations of Convective Systems:
UHF profilers are very sensitive to hydrometeors. Profilers provide a nearly continuous record of the temporal evolution of convective systems that pass over the profiler. An example from Kapingamarangi is used to illustrate the profiler observations. The profilers reveal the vertical structure of the convective systems with sufficient detail to diagnose and classify stratiform and convective precipitation. Continuous measurements make possible the determination of the diurnal cycle of the precipitation.

2. The Vertical Structure of precipitating cloud systems:
Profilers provide a means to visualize the vertical structure of the precipitating clouds. The reflectivity time-height cross sections reveal the presence or absence of a bright band. Bright bands are caused by melting hydrometeors that are coated with liquid. The bright band coincides with the height of rapidly increasing fall velocities in the melting region. Doppler spectral width also shows a signature at the melting level. Spectral width is increased in regions of turbulent motion and decreased in regions of reduced turbulence. Mature stratiform clouds show reduced spectral width and are relatively stationary and exhibit little vertical motion.

3. Classification of Precipitation:
Precipitation can be classified by examining the vertical structure of the convective clouds. When a melting layer signature is present stratiform precipitation is indicated and when it is absent convective precipitation is indicated: deep convection if it extends above 5 km and shallow convection if it is below that level. A mixed or transition regime is indicated by a melting layer and large spectral width above the melting level. An additional category is deep clouds without precipitation at the surface. This category is very common over the western Pacific warm pool region.

In research conducted during TOGA COARE the disdrometer classifications have been compared with profiler classifications. The vertical structure of the reflectivity, Doppler velocity and Spectral Width have been determined for profiler and disdrometer classifications using the two instruments together.

4. Diurnal Variability:

Diurnal variability is easily seen in profiler observations. Typically there is an afternoon maximum in convection over land. A peak in stratiform precipitation lags the peak in convective precipitation by several hours. Over the ocean there is a nighttime peak in precipitation.

5. Contributions of Profiler to Precipitation Measurement:

The contribution of profilers to precipitation measurement is illustrated by showing an example of the calibration of profiler reflectivities by a collocated disdrometer. This was done during TRMM Ground Validation Field campaigns. First it is shown that a Joss-Waldvogel disdrometer can be used to calibrate the lowest profiler range gates that are fully recovered. A calibrated profiler can then be used to calibrate a scanning radar as is illustrated for TEFLUN A in Texas.

6. Drop Size distributions:

Drop size distributions can be retrieved from profiler observations under certain circumstances. Several methods have been used. A single profiler can be used when both Bragg and Rayleigh components are distinguishable in the Doppler spectrum. Another approach is to use two profilers: a VHF profiler measures the air motions and a UHF profiler can be used to measure the precipitation component. Still another approach is to determine the best fit to the Doppler spectrum with drop-size distributions, vertical velocity and turbulence spectral width. These methods are currently under development at the NOAA Aeronomy Laboratory under NASA TRMM sponsorship. The drop-size distributions are important parameters for TRMM since several of the TRMM Algorithms depend on the drop-size distribution. It is a goal of the NOAA research to develop the capability to eventually use the profiler as a disdrometer to retrieve the vertical profile of drop-size distributions.