Ground-Based Radiometric Observations of Atmospheric Water for Climate Research

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Introduction

Surface-based microwave and infrared radiometers have been employed by the National Oceanic and Atmospheric Administration's Environmental Technology Laboratory (NOAA/ETL) in climate research since 1987. The ability of these systems to operate continuously and unattended for extended periods of time has provided significant new information on atmospheric water vapor and cloud liquid. These data are being employed to improve our understanding of cloud-radiation feedback mechanisms, an understanding that is fundamental to accurate prediction of global warming.

In addition to collecting data on the relation between atmospheric water substance, atmospheric transmission and cloud albedo, the radiometric observations provide groundtruth for validation and calibration of satellite measurements of water vapor and liquid water. This application is extremely important since accurate satellite monitoring of the earth is required to evaluate possible atmospheric changes that may influence global climate.

Description of the NOAA/ETL Database

Table 1 summarizes the climate research programs in which ETL has participated. Continuous observations during these programs have provided statistical descriptions of precipitable water vapor and cloud liquid, information on cloud albedo and transmission versus cloud liquid, and fractal characteristics of liquid water. The radiometric data have also complemented other remote sensors such as K-band cloud Doppler radar and Doppler lidar. In addition, radiometric observations compose a database of ground-truth for calibration and validation of satellite, e.g., Special

Table 1. Climate research programs using NOAA/ETL microwave and infrared radiometers.

Program	Time Period	Location
FIRE I[(a)]	1 to 19 July 1987	San Nicolas Island, California
FIRE II	13 Nov to 7 Dec 1991	Coffeyville, Kansas
ASTEX[(b)]	1 to 28 June 1992	Porto Santo Island, Portugal
ASTEX	6 to 28 June 1992	R/V *Malcolm Baldridge* (N. Atlantic)
Post-ASTEX Observations	10 July 1992 to 17 June 1993	Porto Santo Island, Portugal
PROBE/TOGA-COARE[(c)]	15 Jan to 28 Feb 1993	Kavieng, Papua New Guinea

(a) First International Satellite Cloud Climatology Project (ISCCP) Regional Experiment.
(b) Atlantic Stratocumulus Transition EXperiment.
(c) Pilot Radiation OBservation Experiment/Tropical Ocean Global Atmosphere-Coupled Ocean Atmosphere Response Experiment.

Sensor Microwave/Imager (SSM/I), European Research Satellite-1 (ERS-1), measurements of water vapor and cloud liquid.

An example of the continuous observations made by ground-based radiometric instruments is given in Figure 1. Precipitable water vapor and integrated cloud liquid (a) were measured by a three-channel (20.6, 31.65 and 90.0 GHz) radiometer. Infrared (IR) brightness temperature (b) was measured at a wavelength of 10.7 µm. The infrared system is employed as an indicator of the phase of the cloud water. For example, if the IR system indicates the presence of a cloud, but the microwave radiometer does not, the cloud is most likely composed of ice. Solar irradiance is shown in (c), which clearly shows the absorption of the solar radiation by the cloud liquid.

Statistical comparisons of precipitable water vapor and liquid water path observed at the locations of Table 1 are shown in Figure 2. This figure gives an indication of the extremes in water substance contained in the NOAA/ETL database. Other locations contain water amounts intermediate between the distributions in Figure 2.

Research Opportunities

Because of the large number of problems remaining in climate and global change, collaborative research studies using the NOAA/ETL database are encouraged. More information on possible joint studies can be obtained from the authors.

Acknowledgments

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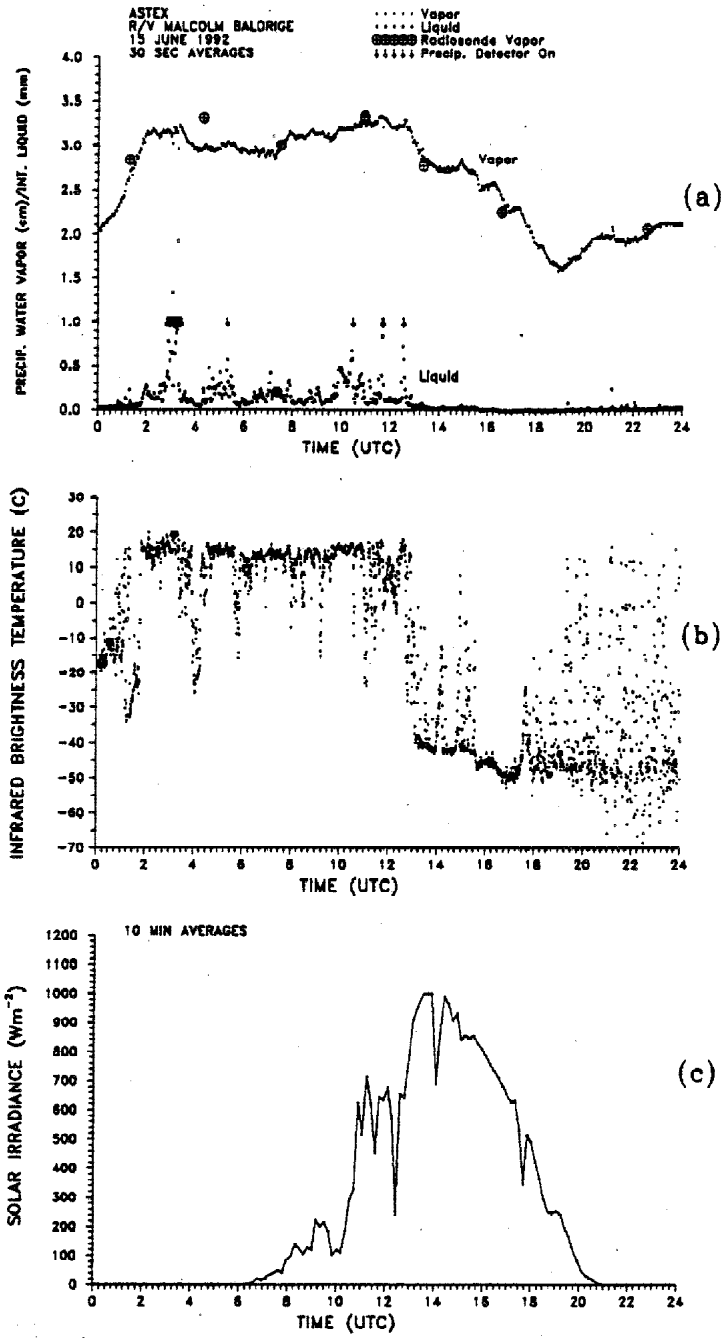

Figure 1. Typical time series (a) of precipitable water vapor and liquid water, (b) infrared brightness temperature, and (c) solar irradiance.

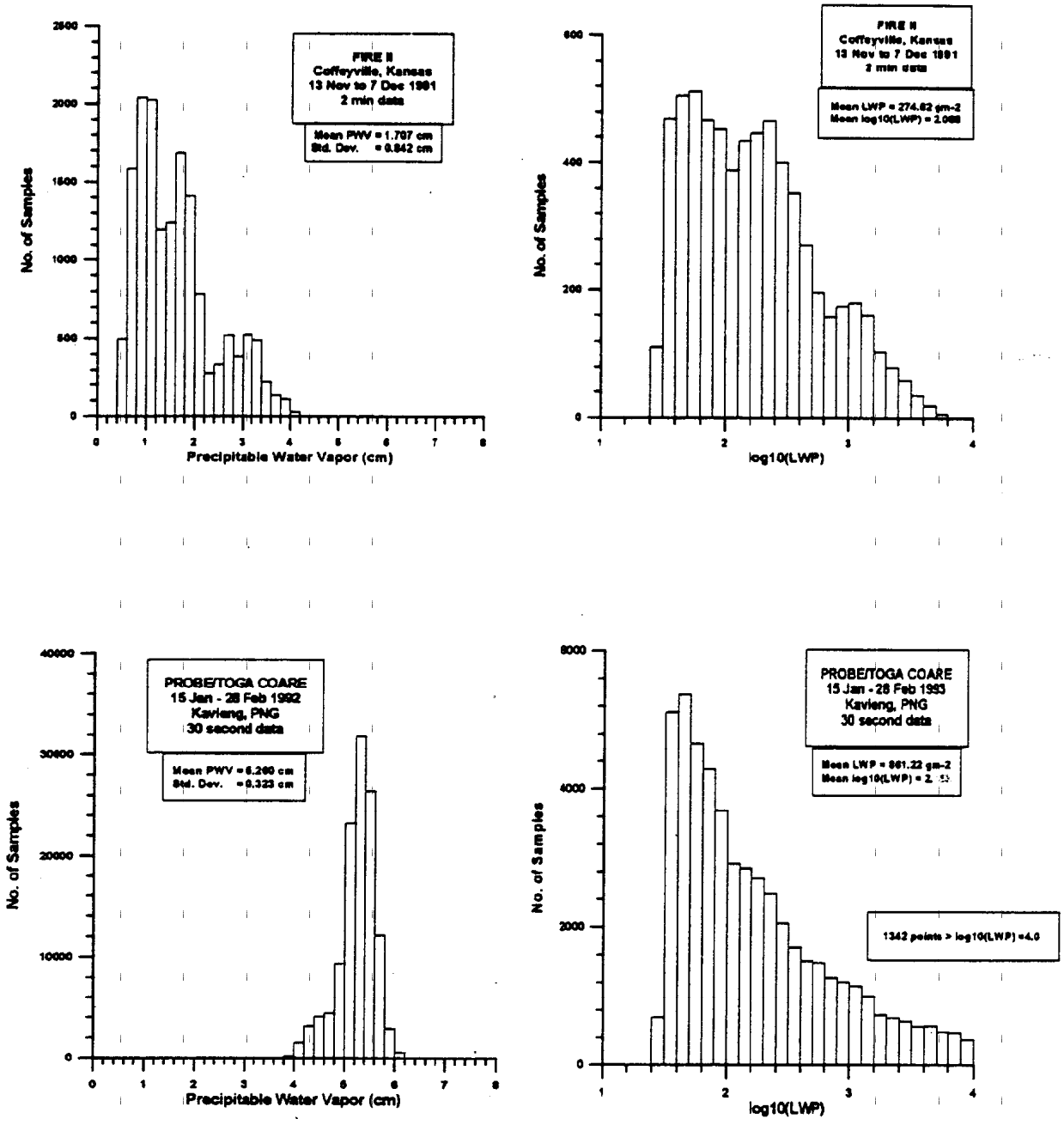

Figure 2. Histograms of precipitable water vapor and integrated cloud liquid for Coffeyville, Kansas, and Kavieng, Papua New Guinea. Note the contrast in water amounts between a relatively dry continental location and a moist tropical location.