18 APRIL 2001 : AN OPEN DISCUSSION MEETING - MEASURING MOISTURE IN THE ATMOSPHERE

Dr J Nash, Met Office - Developments in measurements of relative humidity by radiosondes - jnash@metoffice.com

The basic types of radiosonde sensors in use since 1980 will be described. Limitations on the measurements will be assessed. Test results from WMO Radiosonde comparisons held between 1984 and 1993 will be reviewed. Comparisons between recently developed commercial sensors and a chilled mirror hygrometer will be used to judge the improvement in performance offered by the most recent designs.

Dr P Anderson, British Antarctic Survey - Measuring atmospheric moisture at very low dew-point - psan@pcmail.nerc-bas.ac.uk

Measuring vertical moisture transport at low temperatures is of interest to the polar boundary layer community, as well as having application to stratospheric studies. Moisture fluxes at high latitude pose a number of measurement problems due to the low absolute humidity encountered, low operating temperatures, and paradoxically, high relative humidity which may cause hoar ice to build up on sensors. Eddy correlation techniques using optical absorption instruments require extended path lengths and window heating. Non in situ cooled mirror instruments, although very accurate, can suffer from sampling error if ice coats any snorkel tubing. In situ cooled mirrors require careful aspiration, are expensive or too heavy for profiling.

Many of these problems may be solved by a re-appraisal of the capacitive humidity device, already used in small probes and on RAWINsonde units. These devices use a porous polyimide film as a dielectric in a capacitor, which then varies in capacitance according to moisture "absorbed into the fabric" of the film. A peculiarity of such devices is that they respond to relative, not specific humidity; as such are well adapted to low temperature but near-saturation studies, such as over-snow evaporation. The RH behaviour has been explained by a model which assumes that water forms a quasi-liquid layer over the relatively large internal surface area of the porous polyimide (Anderson, 1995). Following this, Flemming (1998) has improved the accuracy of these sensors using a new temperature correction, whilst Pang et al (1996) have reduced hysteresis and significantly improved the linearity of the device using infra-red illumination of the film. After six years, the model appears robust, and could now be used to design an improved commercial sensor, one that is fast, accurate and cheap.

References:

Anderson, P.S. 1995. Mechanism for the Behavior of Hydroactive Materials used in Humidity Sensors. J. Atmos and Oceanic Tech. 12, (3). 662 - 667
Fleming, R.J., 1998: A note on temperature and relative humidity corrections for humidity sensors. J. Atmos and Ocean Tech, 15 (6) 1511-1515
Pang, SX, Grassl, H and Jager, H. 1996: An improved humidity sensor. J. Atmos and Ocean Tech, 13 (5) 1110-1115

Dr D Jones, Met Office - Estimating atmospheric moisture from the advanced microwave sounding unit-B - dcjones@metoffice.com

Humidity measurements from space are a highly desirable commodity for numerical weather prediction (NWP) centres because conventional radiosonde measurements are restricted primarily to landmasses, with very few observations over the oceans. Prior to the launch of microwave humidity sounders, spaceborne estimates of humidity made by infrared sounders were limited to cloud-free regions, which are often well removed from areas of synoptic development. In May 1998, the first of a series of humidity sounders was launched to address this problem. A component of the Advanced Microwave Sounding Unit (a combined temperature and humidity sounding instrument), AMSU-B measures thermally-emitted microwave radiation at wavelengths of the order of 2 mm. With only three humidity channels there is only a limited amount of vertical information available from AMSU-B radiances, which are also functions of the vertical temperature profile. The measurements are therefore best used in conjunction with high quality background temperature and humidity information provided by NWP models.

An overview of the process of deriving humdity information from these measurements and their impact on NWP performance will be given. Useful cloud imagery for forecasters which result as a by-product of this exercise will also be demonstrated.

Dr D Kilham, University of Bristol - Estimating atmospheric moisture content from the special sensor microwave imager - d.a.kilham@bristol.ac.uk

Of all the global climate-driving parameters, cloud liquid water content is arguably the least well understood and difficult to measure, yet climatologically one of the most important. Advances in space-borne microwave instrumentation (e.g. SSM/I, ATSR/M, TMI, AMSU-B and the future SSMIS) promise to provide global monitoring of the total vertically integrated liquid water path (LWP). However, the accuracy of this remotely sensed parameter is not known with any certainty due to the lack of independent comparison data.

The CLOREVAL project aimed to quantify the current performance of space-based LWP estimates by validating against in situ measurements – principally using aircraft cloud probes – and other airborne and surface-based microwave remote sensing instruments. The project made full use of special dedicated and other field campaign datasets to quantify coincidental LWP measurements. It applied that knowledge in the retrieval techniques that can be used to derive LWP to the required accuracy for later use in weather forecasting and climate monitoring and prediction. This project gathered data during a number of field campaigns using aircraft, ship and surface-based sensors coincident with SSM/I overpasses, together with supporting data - e.g. from other satellite sensors and NWP model analyses. These data were used to firstly quantify and validate the accuracy of SSM/I LWP estimates derived using a range of current techniques.

Passive microwave measurements of integrated water vapour (IWV) have a more successful retrieval history, mainly due to the availability of calibration data found in humidity profiles derived from radiosonde measurements. Many workers have developed methods for retrieving IWV from SSM/I, with somewhat mixed results. This talk will also highlight some of these methods.

Dr E Westwater, NOAA - Intercomparison of different techniques for measuring or estimating atmospheric moisture - Ed.R.Westwater@noaa.gov

The development of accurate radiative transfer models is important for a variety of applications in meteorology and climate. Although accurate modeling of radiative transfer in both clear and cloudy atmospheres is the ultimate goal, it is important to calculate radiance during known clear conditions as well. Here, we focus on surface-based measurements. A straightforward method to test and to improve models is to measure spectrally-resolved radiance with a well calibrated radiometer and compare with radiosonde measurements of temperature and humidity profiles. Analysis of data taken at the United States Department of Energy's Atmospheric Radiation Measurement (ARM) Program showed frequent unreasonable departures of measurements from calculations. The spectral-radiance measurements were made by the Atmospheric Emitted Radiance Interferometer (AERI) which is calibrated to better than 1%. Measurements of precipitable water vapor by ground-based microwave radiometers (MWRs) showed that batch-to-batch variations of radiosonde humidity measurements were responsible for some of the inconsistencies. Therefore, a series of Water Vapor Intensive Operating Periods (WVIOPs) were conducted at ARM facilities to address some of the issues in measuring water vapor: identifying and correcting spurious radiosonde data; calibration of MWRs; and Raman lidars and their calibration. In this lecture, data from several WVIOPs and related experiments are shown: the ARM Central Facility in September-October 2000; Barrow, Alaska, in March 1999; and the Republic of Nauru in March 1999.

Dr H Pumphrey, University of Edinburgh - Remote sensing of stratospheric water vapour - hcp@met.ed.ac.uk

It has been known for many years that the stratosphere is very dry compared to the troposphere. For this reason, measuring the humidity of the stratosphere tends to require different techniques to measuring the humidity of the troposphere. In this talk, the scientific reasons for measuring the humidity of the stratosphere will be briefly described. The morphology, sources and sinks of water vapour in the middle atmosphere, as we presently understand them, will be summarised. The various methods, remote and in-situ, that have been used to measure water vapour in the middle atmosphere will be reviewed. Results from some recent space-based missions will be presented in some more detail. The talk will conclude with a discussion of features that remain unknown and how various missions in the future will address these issues