The Measurement of Water Vapour in the Tropical and Arctic Atmosphere

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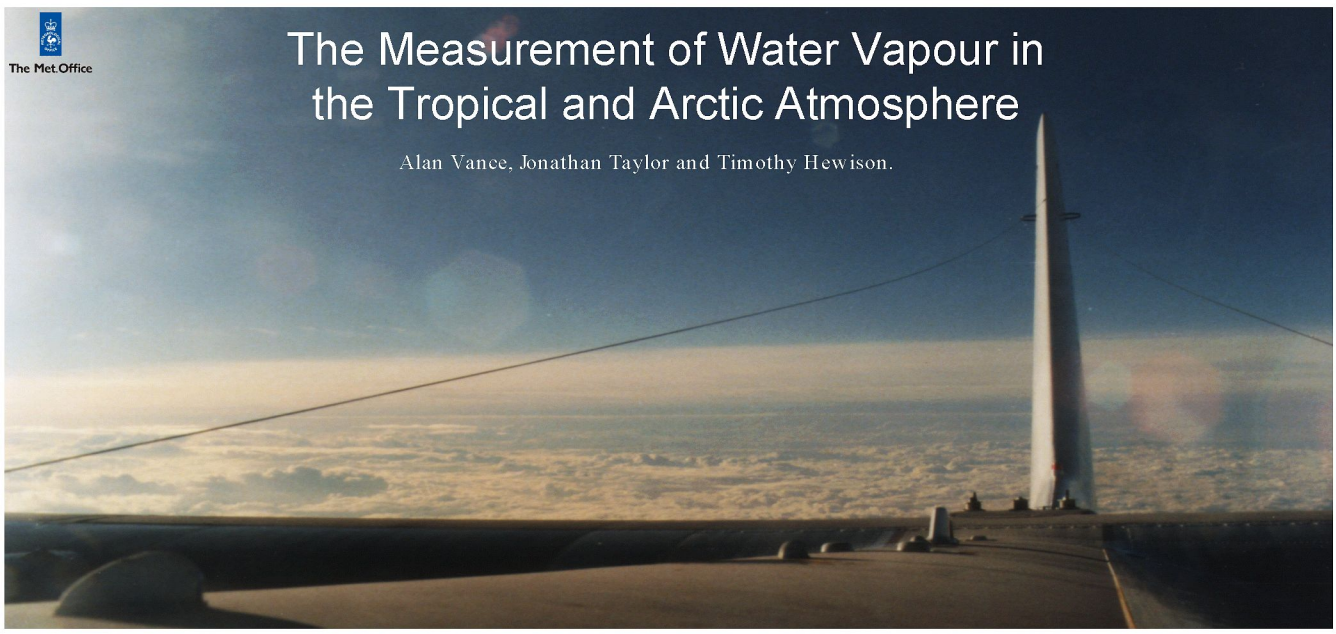

Introduction

The accurate description of the water vapour in the atmosphere is a pre-condition to the study of atmospheric spectroscopy with high resolution radiometers. This poster presents some preliminary results from the intercomparison of mass mixing ratio measurements made using various pairs of in-situ aircraft and balloon borne instruments last year.

During 1999 the UK Meteorological Office C-130 aircraft was used to study water vapour in the atmosphere in tropical, mid-latitude and arctic conditions as part of the MOTH (Measurement Of Tropospheric Humidity) measurement campaigns.

Here some of the combined results of MOTH Tropic and MOTH Arctic results are presented.

Typical C-130 Flight Patterns:

These consisted of a combination of:

- measurement of vertical profiles during climbs and descents from 15 m over the sea surface to maximum altitude altitude (8 - 9 km)
- straight and level runs at various altitudes (for infrared and microwave measurements
- launch of dropsondes at high level.

MOTH Tropic (26th April - 9th May 1999)

Aircraft:

C-130 operating out of Wideawake, Ascension Island (7° 58' S 14° 24' W) with the majority of flights being within 160 km of the island and downwind of it.

Balloons:

Launched from Wideawake airfield. Instruments used during the campaign were Viasala RS80 and RS90 'humicap' devices and the Snow White frost-point hygrometer. Some balloons carried only an RS80 or RS90 but many carried a combination of instruments.

MOTH Arctic (1st - 7th December 1999)

Aircraft:

C-130 operating out of Kalmar, Sweden (56° 41' N, 16° 17' E) with flights over the southern Baltic (55° - 59° N) (depending on weather and satellite overpasses).

Balloons:

Launched from Visby airfield (57° 59' N, 18° 36' E), Gotland. The same sensors were used as in MOTH Tropic.

Comparison with General Eastern Hygrometer

The following five plots (figures 1-5) show comparisons of the mass mixing ratios (g/ g) of water obtained from the General Eastern 1011B dew point hygrometer with the Total Water probe (UKMO-developed), both fitted to the C-130 aircraft, and the those derived from the three types of balloon-borne radiosonde, the RS90 dropsondes launched from the C-130.

In all plots:

- data points are shown in red
- mean is shown in dark blue
- 1-σ limits are shown in light blue

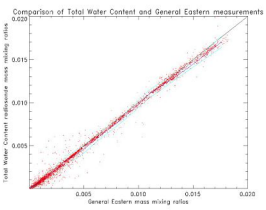

Figure 1. Total water content mass mixing ratio versus General Eastern mass mixing ratio. A slight, but not significant, dry bias is seen in the total water probe.

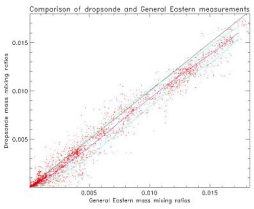

Figure 2. Dropsonde mass mixing ratio versus General Eastern mass mixing ratio. A dry bias of about 10% is seen in the dropsonde mixing ratios above 11 g/ kg.

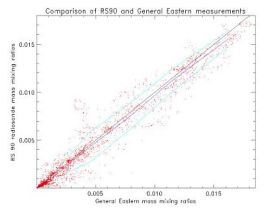

Figure3. RS90 mass mixing ratio versus General Eastern mass mixing ratio. Good agreement between these instruments is seen throughout the range of mixing ratios encountered although there is some suggestion of a dry bias in the RS90 at high mixing ratios.

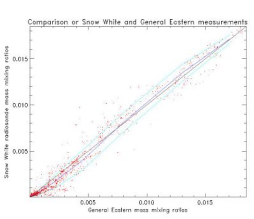

Figure 4. Snow White mass mixing ratio versus General Eastern mass mixing ratio. Good agreement between these instruments.

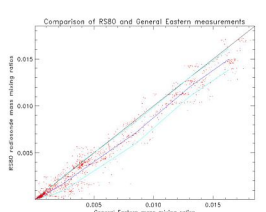

Figure 5. RS80 mass mixing ratio versus General Eastern mass mixing ratio. A slight dry bias in the RS80 becomes evident at mixing ratios above 6 g/ kg.

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Comparison with Vaisala RS80 Radiosonde

The following five plots (figures 6-10) show comparisons of the mass mixing ratios (g/ g) of water obtained from the Vaisala RS80 radiosonde with the balloon-borne RS90 and Snow White instruments flown during the MOTH campaigns, with the Total Water and General Eastern instruments on the C-130, and the RS90 dropsondes launched from the C-130.

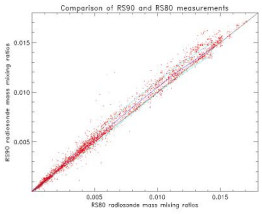

Figure 6. RS90 mass mixing ratio versus RS80 mass mixing ratio. Good agreement is seen at all mixing ratios although the RS90 has a slight wet bias.

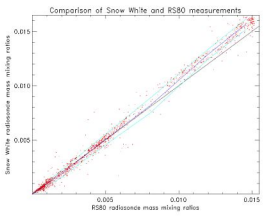

Figure 7. Snow White mass mixing ratio versus RS80 mass mixing ratio. Although good agreement is seen in dry conditions the Snow White exhibits a significant wet bias at high mixing ratios.

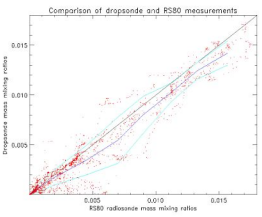

Figure 8. Dropsonde mass mixing ratio versus RS80 mass mixing ratio. A dry bias can be seen at all mixing ratios, becoming significant at high mixing ratios.

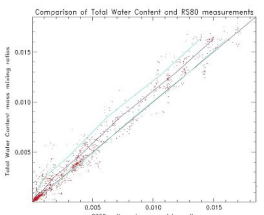

Figure 9. Total water content mass mixing ratio versus RS80 mass mixing ratio. A dry bias can be seen at all mixing ratios, possibly becoming significant at mixing ratios above 6 g/ kg.

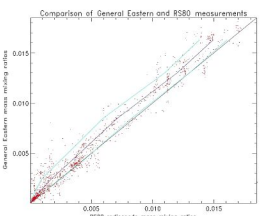

Figure 10. General Eastern mass mixing ratio versus RS80 mass mixing ratio. A wet dry bias in the General Eastern becomes evident at mixing ratios above 6 g/ kg.

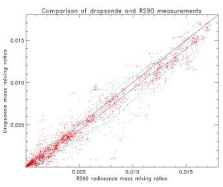

Figure 11. RS90 dropsonde mass mixing ratio versus balloon-borne RS90 mass mixing ratio. The two instruments, which have the same type of sensor element agree to within one standard deviation although a dry bias is evident in the dropsonde data.

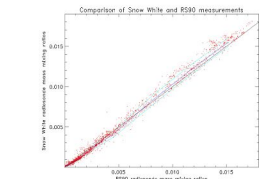

Figure 12. Snow White mass mixing ratio versus RS90 mass mixing ratio. Reasonable agreement is seen at all relevant mixing ratios a possible wet bias in the Snow White data is evident at higher mixing ratios. All Snow White sondes were flown in tandem with RS90s.

Discussion

Most of the above plots show reasonable or good agreement between most of the instruments except at high mixing ratios but in assessing these, the following three points must be borne in mind:

1) The sample sizes in these intercomparisons are small and unequal. Table 1 shows the numbers of compared profiles between the various instruments. A number of potential intercomparisons were rejected as the two profiles clearly came from different air masses, or one of the profile pair was unusable due to faulty instrumentation.

2) There were in many cases a significant geographical displacement between different profile measurements. This was especially the case during MOTH Arctic when the weather frequently prevented the C-130 from operating near the balloon launch site, and hence the probability of differences resulting from meteorology rather than instrumental factors is increased.

3) In order to facilitate use of the microwave and infrared instruments the C-130 was required to avoid flying near cloud for much of the time. Since the balloon launch site was fixed and hence unable to avoid cloud it is possible that an artificial bias may have been introduced between the aircraft and balloon-borne instruments.

	General Eastern	RS80	RS90
General Eastern	-	11	-
Total Water	32	11	-
Dropsonde	30	14	26
RS80	11	-	-
RS90	22	27	-
Snow White	12	10	17

Table 1. Numbers of profiles compared for each sensor pair.

4) All MOTH Tropic balloon soundings were made over or very close to Ascension Island and hence may have been effected by the island in ways which the aircraft and dropsonde profiles would not. Averages of the profiles derived from specific balloon and aircraft instruments suggest that the climatological humidity profile over the island may be different from that found above the surrounding ocean. Further work is required before the significance of this may be assessed.

It is hoped that further hygrometer intercomparisons and comparisons of *in-situ* and remote sensing measurements will remove some of the uncertainty that remains concerning the measurement of atmospheric water vapour.