Results from recent atmospheric soundings campaigns in northern Finland have been used here to provide comparisons with the operational level 2 data of the Infrared Atmospheric Sounding Interferometer (IASI) on board the EUMETSAT Metop-A (Meteorological Operational) satellite. The in situ sounding activities took place during 2008-2011, including the LAPBIAT Atmospheric Sounding Campaign in Sodankylä in winter/spring 2010. Balloon borne cryogenic frost point hygrometers (CFH) were flown, which provide reference class measurements for the atmospheric humidity in upper troposphere and lower stratosphere.

INTRODUCTION

In situ observations by radiosondes provide a tool to calibrate and validate satellite based measurements. Radiosondes such as RS92 are widely used for temperature and tropospheric water vapor profile observations (Calbet et al., 2011; Kivi et al., 2010). During the recent years several field measurement campaigns have been conducted at the high-latitude site Sodankylä (location: 67.368 °N, 26.633 °E, 179 m above mean sea level) to assess the accuracy of the radiosonde humidity measurements. In January- March 2010 the LAPBIAT Atmospheric Sounding Campaign provided a series of RS92 versus Cryogenic Frostpoint Hygrometer (CFH) comparison flights. The latter can be considered as a reference instrument for upper troposphere and lower stratosphere humidity measurements. Here we first present humidity profile comparisons with satellite borne measurements by IASI onboard EUMETSAT’s Metop-A satellite. Secondly we present comparisons of RS92 and CFH humidity profiles.

OBSERVATIONS

Our water vapor observations were made by research grade balloon borne instruments that combined a cryogenic frost point hygrometer CFH and an ECC type of ozonesonde. Pressure, temperature, relative humidity and GPS location were measured by RS92-SGP sondes in the same payload. The sonde launches were timed to Metop-A overpasses, thus they can be used to validate satellite products. The IASI products were processed at the EUMETSAT Central Facilities in Darmstadt and were obtained from the Eumetsat Data Centre. Figure 1 shows the locations of the sondes at 400 hPa (triangles) and nearest IASI pixel centres (circles). The launch site is marked with a black square. The legend lists the date of the sounding together with time (hh:mm:ss) and distance (km) differences between the IASI pixel centre and sonde at 400 hPa. In most cases we aimed in selecting cloud-free conditions in the middle and upper troposphere to perform our CFH sonde launches. For the IASI comparisons, 39 best matching CFH soundings were selected from the LAPBIAT and earlier campaigns covering a time period from 23 January 2008 to 15 August 2011. Collocation criteria for the selected pixels were: distance < 50 km and time difference < 2 h.
RESULTS

Comparison of IASI L2 water vapour and temperature profiles were performed for individual cases as well as for the set of 39 collocated profiles. An example of the individual comparisons is shown in Figure 2, while the results of the statistical approach are shown in Figure 3 and 4. For example, we found that at 600 hPa linear regression fits result in 0.963 and 0.904 for the squared correlation coefficients ($r^2$) of the temperature and water vapor correlations, respectively. The correlation of temperature remains high throughout the profiles, while the water vapor correlation decreases above 300 hPa at the altitude of the tropopause layer.

Figure 2: Example profiles of temperature (left) and CFH water vapor (right) soundings (blue) together with corresponding IASI L2 profiles (red) on June 30, 2011. IASI data are the closest measurement relative to the sonde location at 400 hPa.
Figure 3: Correlation of IASI L2 temperature (left) and water vapor (right) product with corresponding temperature and CFH water vapor soundings at 600 hPa. Linear regression fits (blue lines) give 0.963 and 0.904 for the squared correlation coefficients ($r^2$) of the temperature and water vapor correlations, respectively.

Figure 4: Left: squared correlation coefficient ($r^2$) at selected pressure levels from 30 to 900 hPa for temperature and water vapor, obtained as in the figure 3. Middle: temperature difference (IASI-sounding). Right: water vapor relative difference 100(IASI-CFH)/CFH. The blue line is the mean while the red line is one standard deviation of the 39 data points. The soundings were averaged to IASI pressure levels before taking the difference. Averaging kernels will be applied when they become available in the IASI L2 products.

Each CFH payload included a RS92 radiosonde. This allowed to refine the empirical corrections derived from the comparisons of the CFH and RS92 dual flights reported earlier (e.g. in Kivi et al., 2010). Daytime comparisons from May 17, 2009 until August 15, 2011 are shown in Figure 5. The radiation bias correction can be calculated by:

$$C_{\text{rad}(P)} = -1.2529 \ln(P)^2 + 36.18 \ln(P) – 187.1,$$

where $P$ is pressure in hectopascals. The corrected RH values can be derived as

$$\text{RH}_{\text{corr}} = \text{RH} / C_{\text{rad}}.$$
where RH is the uncorrected relative humidity measured by the RS92 sondes produced since June 2008. Similar bias corrections can be applied to the relative humidity profiles measured by the other models of the RS92. Recently the radiation bias removing and time-lag correction were introduced in the RS92 operational software (Vaisala, 2011). An example of software comparisons is shown in Figure 6. Data processing algorithm v3.64 is an improved version of an earlier algorithm version.

Figure 5: Relative difference between RS92 and the CFH humidity profiles during daytime flights in Sodankylä from May 17, 2009 until August 15, 2011.

Figure 6: An example of humidity algorithm comparison from April 19, 2011. Operational data processing algorithm v3.64 is an improved version of an earlier algorithm version (v.3.62) to reduce time-lag and radiation dry bias of the RS92 humidity measurements.
REFERENCES


