WATER VAPOR MEASUREMENTS OVER NORTHERN FINLAND

Rigel Kivi[1], Jukka Kujanpää[1], Osmo Aulamo[1], Xavier Calbet[2], Francois Montagner[2], Petteri Survo[3], Hannu Jauhiainen[3], Johanna Lentonen[3], Heikki Turtiainen[3], Holger Vömel[4]

(1) Finnish Meteorological Institute, (2) EUMETSAT, (3) Vaisala Oy, (4) Deutscher Wetterdienst

Abstract

Infrared Atmospheric Sounding Interferometer (IASI) on board the EUMETSAT Metop-A (Meteorological Operational) satellite has been operational since 2007. Here we report water vapor profile comparisons using IASI operational level 2 data and in situ observations by cryogenic frost point hygrometers (CFH) during years 2008-2012. The balloon borne in situ observations were made over Sodankylä, Finland. In addition to the CFH we also performed flights by a new Vaisala reference radiosonde RR01, which is currently in development phase.

INTRODUCTION

Satellite observations provide global coverage of water vapor distribution. Confidence in satellite measurements is largely based on validation by ground-based instruments (Calbet et al., 2011; Kivi et al., 2010). Here we compare the Infrared Atmospheric Sounding Interferometer (IASI) water vapor observations on board the EUMETSAT's MetOp satellite with ground based measurements at Sodankylä, Finland (67.37º N, 26.63º E). The ground based measurements include research grade cryogenic frost point hygrometer (CFH) and more recently also measurements by RR01, which is a prototype version of a new operational reference radiosonde by Vaisala. At Sodankylä we have performed a series of balloon flights using the new sensor in order to understand the performance, suitability for reference grade measurements and to improve the sensor.

OBSERVATIONS

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. Here IASI level 2 water vapor sounding products are compared with the collocated measurements by research grade hygrometers. The IASI products were processed at the EUMETSAT Central Facilities in Darmstadt and were obtained from the Eumetsat Data Centre (August et al., 2012). Figure 1 shows the locations of the sondes at 400 hPa (triangles) and nearest IASI pixel centres (circles). In most cases we aimed in selecting cloud-free conditions in the middle and upper troposphere to perform the CFH sonde launches. For the IASI comparisons, 49 best matching CFH soundings were selected based on the soundings at Sodankylä, covering a time period from 23 January 2008 to 17 August 2012. Collocation criteria for the selected pixels were: distance < 100 km and time difference < 2 h.

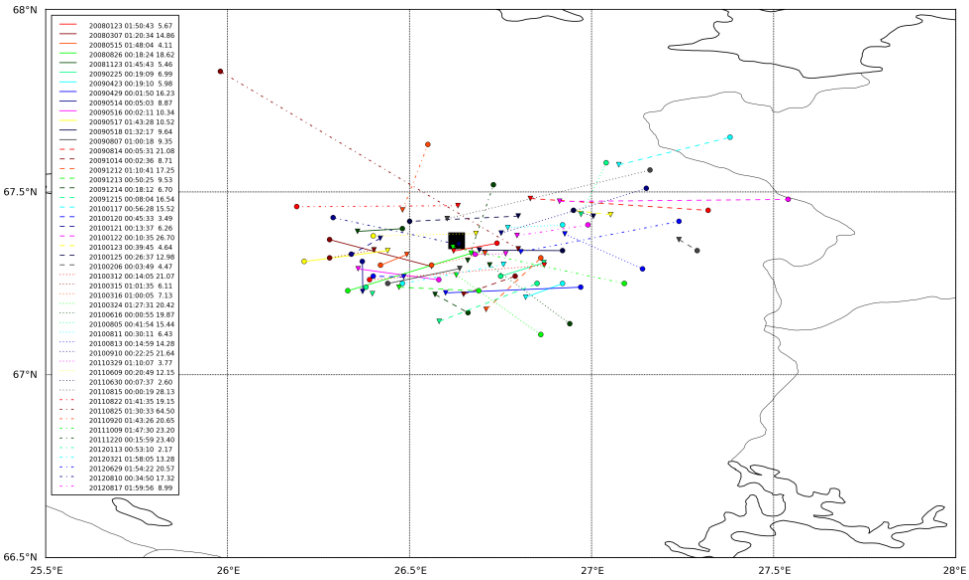

Figure 1: **Illustration of the collocations between 400 hPa locations of the sondes (stars) and the nearest IASI pixel centres (circles). The launch site is marked with a black square. The legend provides the date of the sounding together with time (hh:mm:ss) and distance (km) differences between the IASI pixel centre and sonde at 400 hPa.**

RESULTS

Comparison of IASI L2 water vapor and temperature profiles were performed for individual cases as well as for the set of 49 collocated profiles. Summary of the results is shown in Figure 2. We found that in mid-troposphere at 500 hPa linear regression fits result in 0.96 and 0.9 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.

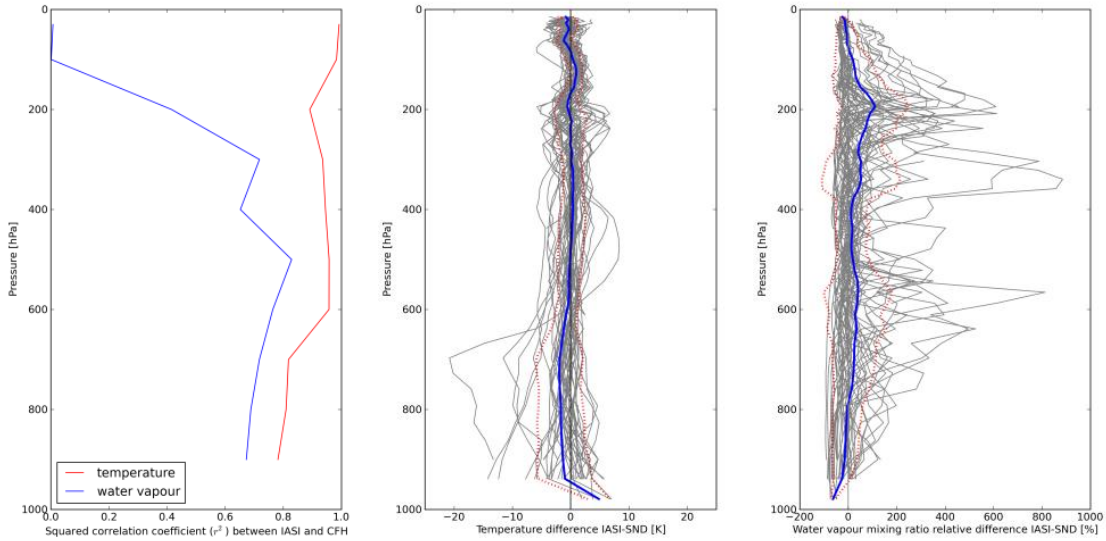

Figure 2: **Left: squared correlation coefficient (r^2) at selected pressure levels from 30 to 900 hPa for temperature and water vapor. Middle: temperature difference (IASI-sounding). Right: water vapor relative difference 100(IASI-CFH)/CFH. The blue line is the mean while the red line is one standard deviation of the 49 data points. The soundings were averaged to IASI pressure levels before taking the difference.**

We also performed a series of RR01 launches together with the CFH instrument in the same payload. RR01 is a prototype version of a new reference radiosonde by Vaisala. This instrument combines Vaisala RS92 radiosonde and an additional Drycap capacitive thin film sensor capable for humidity measurements in the lower stratosphere and upper troposphere. Frost point temperature range of the instrument is -30..-90 °C. RR01 is a light weight sensor and it is relatively easy to operate compared to the CFH. An example of measurements in Sodankylä is shown in Figure 3. During the comparison flight no significant bias was observed between frost point measured by RR01 and CFH, however some earlier versions of RR01 have shown 1-2 K positive bias in the stratosphere relative to the CFH (Lehtola et al., 2010).

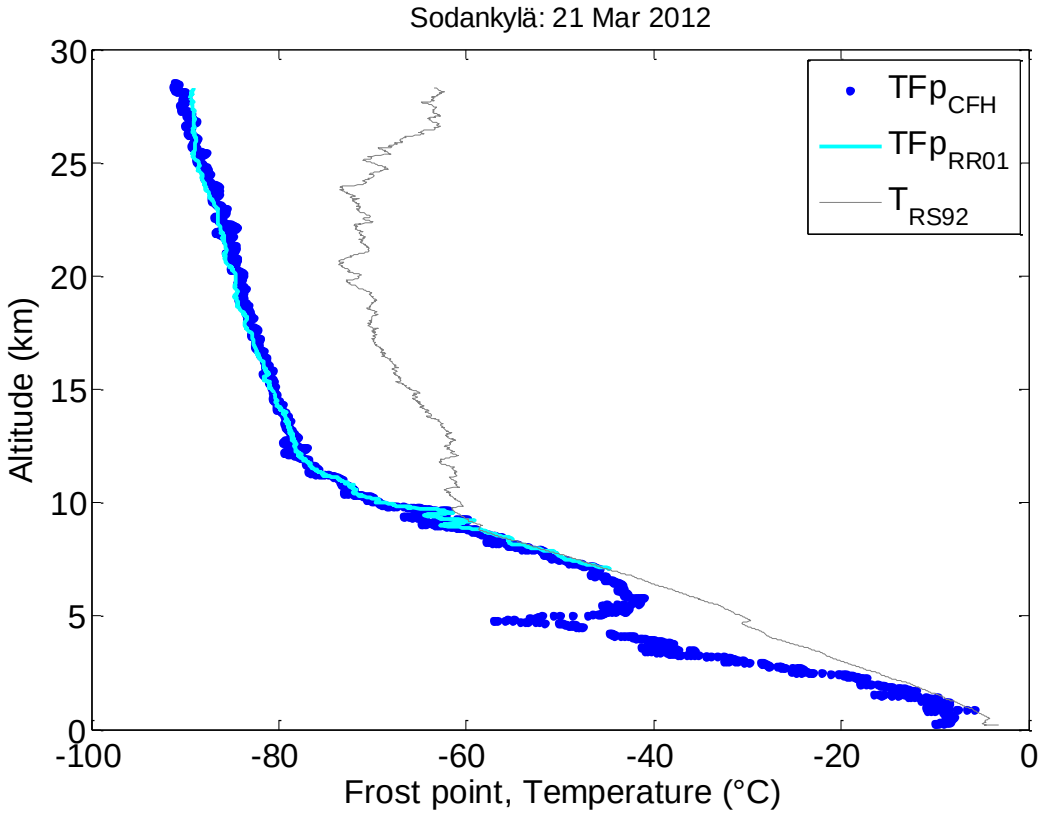

Figure 3: **Frost point measured by cryogenic frost point hygrometer CFH (dark blue dots) and prototype of reference radiosonde RR01 (light blue line) flown on March 12, 2012 over Sodankylä, Finland. Temperature measured by RS92 is also shown (grey line).**

REFERENCES

August, T., Klaes, D., Schlüssel, P., Hultberg, T., Crapeau, M., Arriaga, A., O'Carroll, A., Coppens, D., Munro, R., and Calbet, X. (2012), IASI on Metop-A: Operational Level 2 retrievals after five years in orbit, Journal of Quantitative Spectroscopy and Radiative Transfer, 113(11), July 2012, 1340-1371, doi:10.1016/j.jqsrt.2012.02.028.

Calbet, X., R. Kivi, S. Tjemkes, F. Montagner, R. Stuhlmann (2011), Matching radiative transfer models and radiosonde data from the EPS/Metop Sodankylä campaign to IASI measurements, Atmos. Meas. Tech., 4, 1177-1189, doi:10.5194/amt-4-1177-2011.

Kivi, R., J. Kujanpää, O. Aulamo, X. Calbet, F. Montagner, H. Vömel (2010), Atmospheric water vapor observations in northern Finland in support of the satellite measurements, 2010 EUMETSAT Meteorological Satellite Conference, 20-24 September 2010, Córdoba, Spain, EUMETSAT, P.57.

Lehtola, T., P. Survo, H. Turtiainen, R. Kivi (2010), Application of Vaisala Drycap® Sensor in Upper Troposphere and Lower Stratosphere Humidity Measurements, Upper-Air and Remote Sensing Observations of Water Vapor. WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2010), Helsinki, Finland, 30 August - 1 September 2010.