Validation of ground-based remote sensing temperature profiles with radio-soundings

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Abstract

Within the project CN-MET (Centrale Nucléaire et METéorologie), three microwave radiometers for temperature profiling are currently tested at the aerological station of Payerne (Switzerland). This paper describes preliminary results obtained with two of those, compared to operational radio-soundings performed at the same location.

CN-MET

CN-MET represents an operational tool, using modern measurements and simulation techniques and resources (Calpini et al, 2006). It will provide continuous information on the current three dimensional meteorological situation in the vicinity of the nuclear power plants, as well as short-range (+3 to +24 hours) forecasts of its evolution. Various types of atmosphere measurements are planned including three wind profilers for the profiling of wind speed and direction and three microwave radiometers for the temperature profiling. These data will ultimately be used as real-time information for forecasters as well as assimilation information for the CN-MET specially designed high resolution model.

Microwave radiometer measurements

Ground-based microwave radiometry for the retrieval of temperature and humidity profiles has been studied for quite some time (Westwater et al, 1965). Atmospheric water vapour profile information is derived from frequency channels covering 6 GHz of the high frequency wing of the pressure broadening, relatively weak water vapour line (22-28 GHz) while temperature profile information is derived from frequency channels covering the 51-58 GHz domain. Output of the system is an automatically generated profile of temperature and water vapor (if the option is available) every 10 minutes.

Example and comparison with radio-soundings

Three microwave radiometers installed at Payerne in 2006 (Figure 1) are currently tested versus the radio-soundings operationally launched twice a day at the same location (0 and 12 UTC). An example of a daily time series can be seen in Figure 2. One can easily detect the diurnal evolution of the planetary boundary layer with nocturnal cooling and daytime warming. This figure illustrates very well the high potential of such systems for meteorological applications as well as input for numerical weather prediction models. Validation with radio-soundings are currently underway. On Figure 2 (bottom) the good performance of the micro-wave radiometers at the radio-soundings launching times can be noted for that day, taken into account the fact that both sampling rate and vertical resolutions are different.

Results of a preliminary statistical analysis performed on 1.5 months of measurements is shown in Figure 3. Two microwave radiometers are validated versus about 90 radio-soundings grouped in two categories. The nighttime mean profile shows the regular presence of a ground-based temperature inversion layer which is well reproduced by the radiometers. The daytime mean profiles are typical for summer with surface heating producing super-adiabatic profiles near to the surface. From this analysis and as it was defined in the specifications, the overall radiometers behavior was within 1C compared to radio-soundings.

Summary

A preliminary test phase between two microwave radiometers and radio-soundings considered as reference showed an overall good behavior of these ground-based remote sensing systems in absence of rain. Even in presence of temperature inversion close to the ground, the two systems matched the temperature radio-soundings profiles within ±1C in average. There are still some improvements to be put in the systems especially regarding systematic biases. Furthermore these systems have difficulties to measure elevated temperature inversions and they are not operating correctly in presence of rain. Further analyses will focus on extending the analysis time period on other seasons as well as on adding the third system. Finally, microwave radiometer water vapor profiles will be validated.

References

Bertrand Calpini, Yves Alain Roulet, Dominique Ruffieux and Philippe Steiner. Current development of the remote sensing meteorological network and the fine grid weather forecast model for the nuclear power plants security in Switzerland. WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation(TECO-2006), Geneva, Switzerland, 4-6 December, 2006.

Westwater, E., Ground-based passive probing using the microwave spectrum of oxygen. Radio Science, 69D, 1201-1211, 1965.

Figure 1. The three microwave radiometers installed at the aerological station of Payerne, Switzerland.

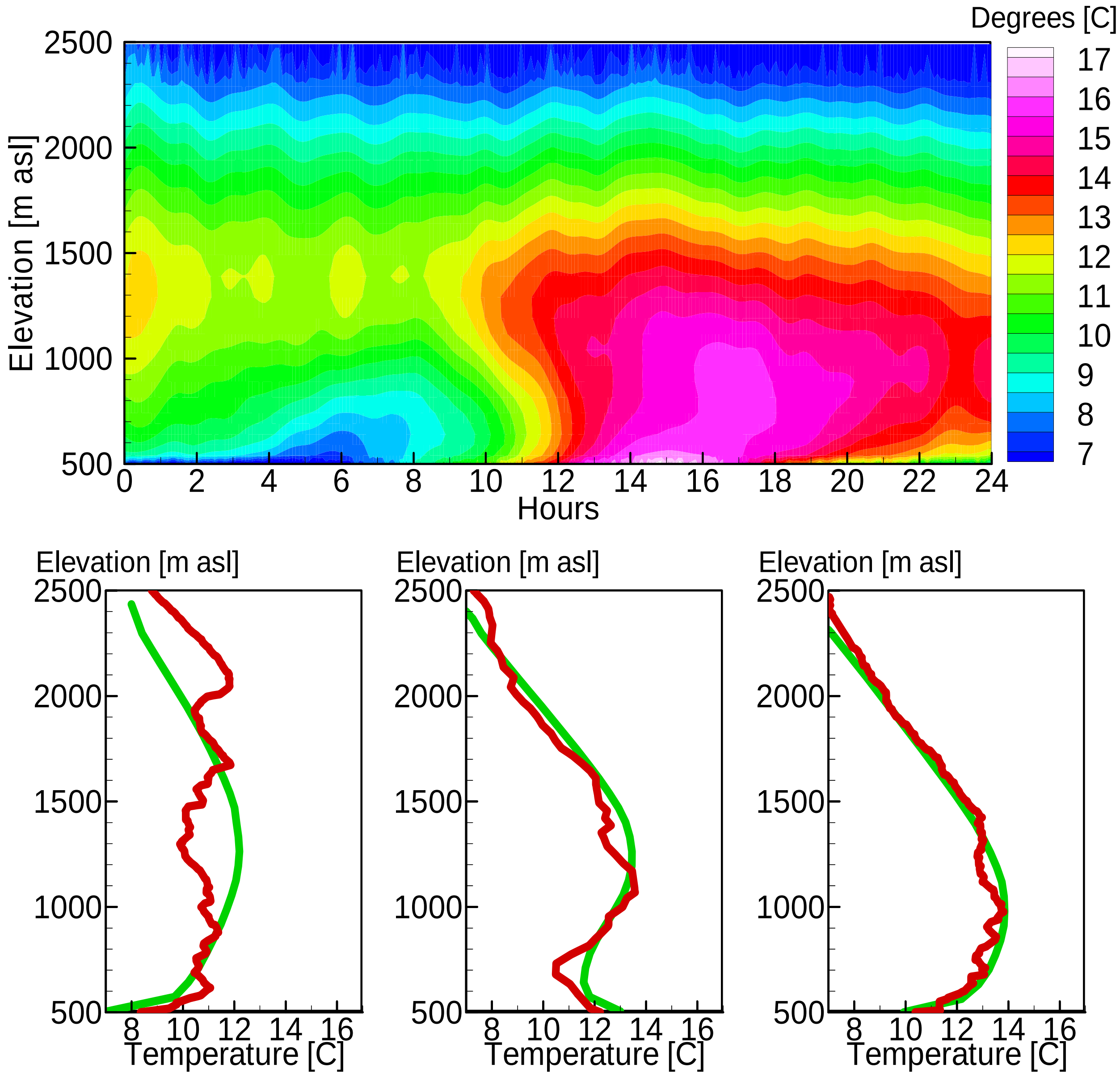

Figure 2. Micro-wave radiometer temperature profiles, 9 October, 2006. Upper picture : temperature profiles time series. Lower pictures : comparison with radio-sounding profiles at 23 UTC, 8 October (left), 12 UTC (center), and 23 UTC (right); green curve = microwave radiometer and red curve = radio-sounding.

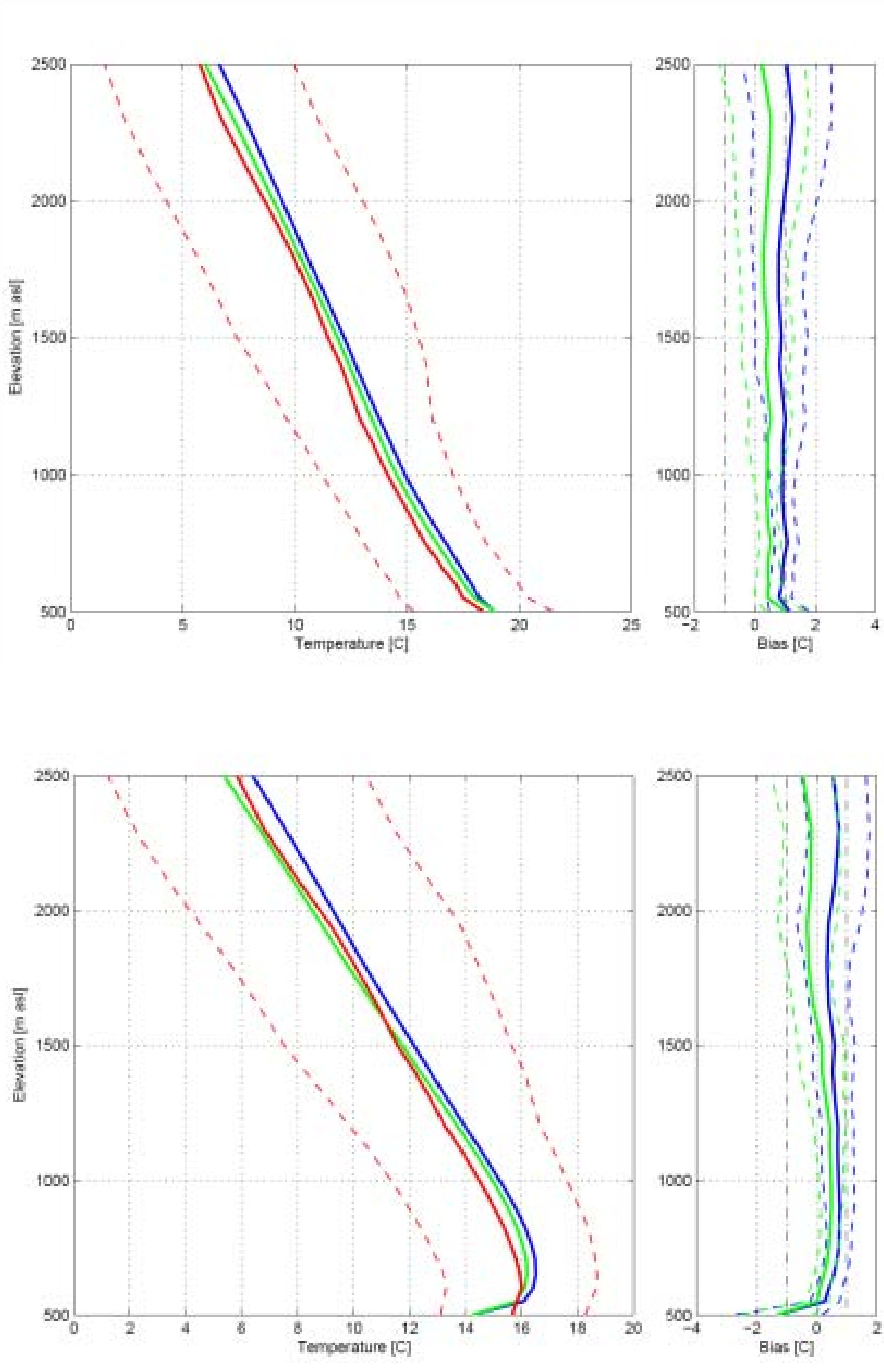

Figure 3. Two microwave radiometers versus 12 UTC (above) and 0 UTC (below) radio-soundings, 11 August, 2006 – 25 September, 2006 (only cases without rain). Left panels: mean profiles, right panels: biases. Red = radio-sounding, blue = first microwave radiometer, green = second microwave radiometer, dashed lines = standard deviations.