News from the Microwave Working Group

Zimmerwald observatory located at 46.88°N, 7.47°E and 905.5 masl. Photo: Geir Braathen

A novel ground-based microwave radiometer for middle-atmospheric wind profile measurements

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Wind information is crucial to study dynamical processes in the atmosphere. However, despite very strong horizontal winds in the middle atmosphere that can reach velocities well beyond 100 m/s, the measurement of wind between 30 and 70 km remains one of the more difficult problems in atmospheric measurement techniques. Radiosonde and aeroplane measurements are limited to the troposphere and lower stratosphere whereas the commonly used radar, lidar and airglow techniques for the upper atmosphere cannot be used below approximately 70 km altitude.

One of the only techniques to measure wind profiles throughout the entire middle atmosphere are the well known but very expensive and thus scarce rocket experiments. Since 2008 the so-called "Rayleigh/Mie/Raman" lidar located at the ALOMAR research station in Andenes [1] is also able to measure wind in this altitude region. However, due to considerable operational costs and the impossibility to measure under overcast conditions it cannot provide a continuous data series. Moreover, in the last years effort has been made to use the data from the global infrasound monitoring network to gain middle-atmospheric wind informations and first sketches of possible retrieval approaches have just been published [3].

The Institute of Applied Physics of the University of Bern contributes to the closing of the data gap in the middle-atmosphere with the development of Doppler wind radiometry by designing the microwave wind radiometer WIRA (Figure 1) in combination with the setting up of a first retrieval approach [4].

Figure 1. WIRA with its frontend and quasioptical system.

Ground-based radiometry has the advantage to allow the realisation of long and quasi continuous time series as such instruments can operate independently of daylight conditions and are only weekly affected by cloud cover. Moreover, automated and remotely controlled operation of such instruments is possible and the construction costs are signficantly lower than for active techniques. WIRA is a passive ground-based microwave radiometer observing the radiation emitted by a rotational transition of the ozone molecule at 142 GHz.

From the Doppler shift between the spectra measured from opposite azimuthal directions the horizontal wind can be deduced. The fact that these spectra are pressure broadened is used to retrieve altitude dependent information. Until now, the horizontal wind in five mostly independent altitude levels has been determined.

Current work focusses on the development of a wind prole retrieval in an optimal estimation sense in collaboration with the development team of the ARTS/QPACK radiative transfer model and inversion package [2].

Two years of data have been collected at Bern (46°57′ N, 7°26′ E) and Sodankylä (67°22′ N, 26°38′ E) what makes WIRA the first microwave instrument continuously measuring wind in the middle-atmospheric gap region over extended time periods. For both stations surprisingly good agreement between the data from WIRA and the operational analysis data from the ECMWF model have been found in short time and small scale patterns (Fig. 2) as well as in the long term statistics (Fig. 3).

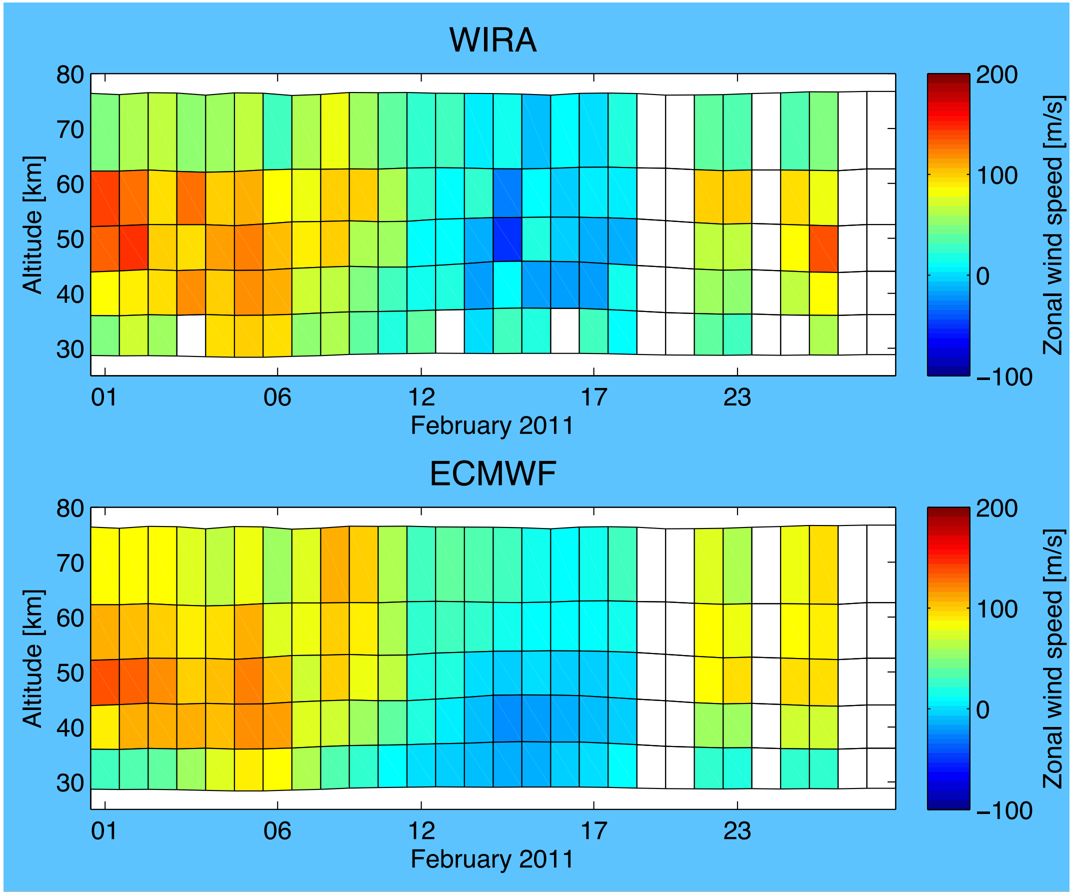

Figure 2. Example of a comparison between zonal wind from WIRA and from ECWMF.

In autumn 2012, WIRA was substantially upgraded increasing the signal to noise ratio of our wind measurements by a factor of 2.4. The instrument has now been installed at the Observatoire de Haute-Provence in the framework of the ARISE campaign where intercomparisons with a new wind lidar are planned.

References

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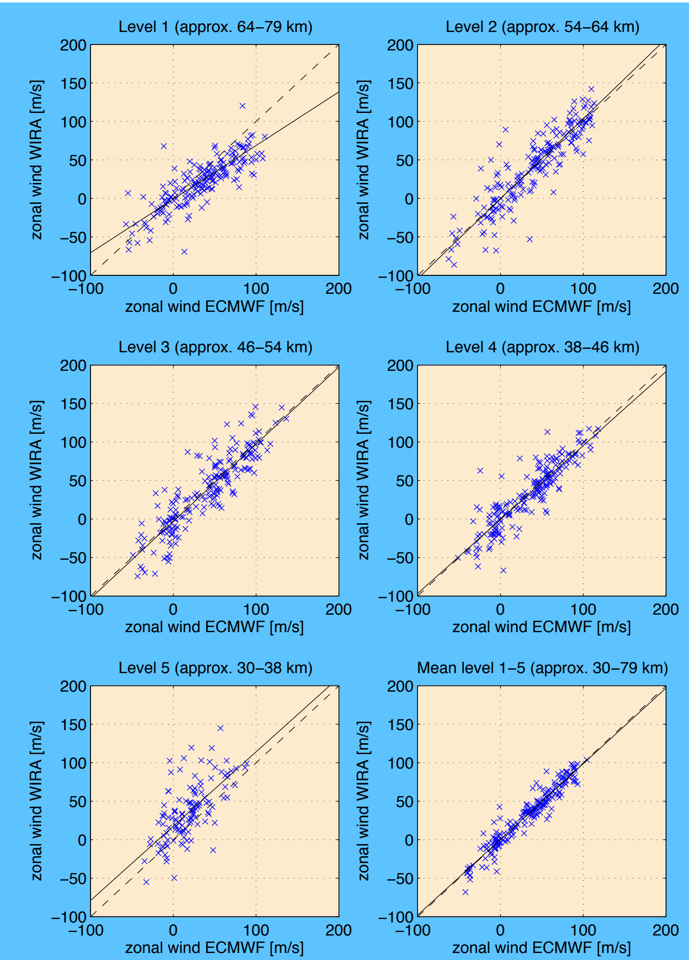

Figure 3. Scatter plots of the daily average zonal wind from WIRA and ECMWF for the Bern time series. The reason for the discrepancy on the uppermost level might be that the decrease of wind speed in the upper atmosphere is not well captured in ECMWF because of the low model top. Similar results have been found for Sodankylä.