1. MIAWARA (Middle Atmospheric Water Vapour Radiometer)
MIAWARA is a groundbased microwave-radiometer, located in Zimmerwald (CH), 46.89°N, 7.47°E, which measures the rotational transition line of water vapour at 22.235 GHz using a digital FFT-spectrometer (resolution 61 kHz, bandwidth 1 GHz). Calibration is done by a combination of balancing (instrument properties) and tipping curves (atmospheric properties).

Balancing calibration (continuously)
- Switching between line (sky at 20° elevation) and reference load
- difference spectra (line-reference)

Tipping curve calibration (each ~20 min)
- Tipping curves (sky at 20-60° elevation)
- total power spectra
- tropospheric attenuation

2. Inversion of water vapour profiles (Retrieval)
22 GHz-emission line is pressure broadened: lineshape depends on the altitude of emission.
- middle atmosphere: mainly center of the line
- troposphere: mainly wings of the line

Lineshape contributions of the 22 GHz water vapour emission line for several altitudes

Optimal estimation (OEM):
- water vapour profiles are inverted from spectra using first guess (a priori) profiles from other sources, e.g. MLS-satellite, and uncertainty estimates

Operational middle atmosphere retrieval
- spectra from balancing calibration, corrected for tropospheric attenuation
- vmr profiles for 25-80 km

Retrieval of tropospheric water vapour
- total power spectra from tipping calibration
- a-priori profile = monthly climatology from a set of campaign balloon soundings launched in Thun (~10 km from site) combined with actual surface value from Zimmerwald meteo station
- vmr profiles for 2-10 km

3. Improving the tropospheric retrieval using additional constraints
External information could be used as additional retrieval constraints, e.g. to define a fixed vmr value at a certain altitude ("fixed-point") through which the retrieved profile should pass. One attempt is to use available cloud coverage information to get a fixed-point at cloud base height:

4. Results
- The tropospheric retrieval delivers reasonable water vapour vmr-profiles up to 7 km with limited vertical resolution.
- Above 7 km, the retrieved profile is more or less a reproduction of the a-priori
- Comparisons with operational balloon soundings launched in Payerne (40 km from the site) show generally a good agreement.
- The concept with the cloud base as additional constraint could be successfully applied in simulations and real data.

5. Summary and Outlook
- MIAWARA is able to deliver water vapour vmr profiles from surface to 7 km and from 25 to 80 km.
- Additional retrieval constraints can improve the performance of the tropospheric retrieval.
- A major task will be to combine the tropospheric and middle atmospheric retrieval approach to one integrated retrieval setup and to fill the UT/LS gap with data from other sources.

Acknowledgements: This work is part of a COST-action ES0604 project, balloon sounding data was kindly provided from MeteoSwiss, Payerne, Switzerland