Microwave remote sensing of the boundary layer: Active and Passive

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Passive: High-Resolution Temperature Sounding

Precise measurements of the **boundary layer temperature profile** with high vertical resolution and a rapid update cycle can be obtained by modern microwave radiometers with a hardware specifically designed for this purpose.

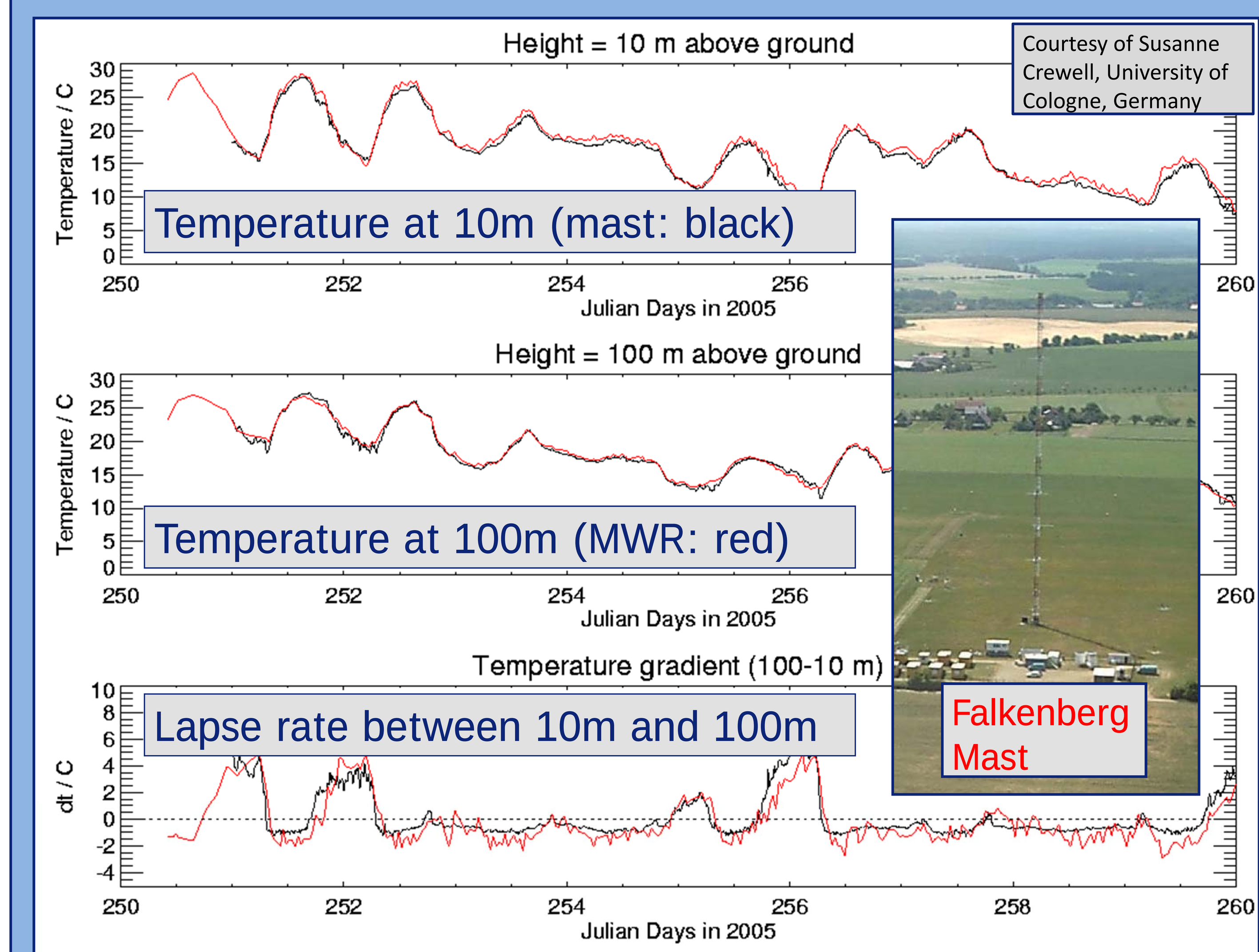
The elevation-scan method:

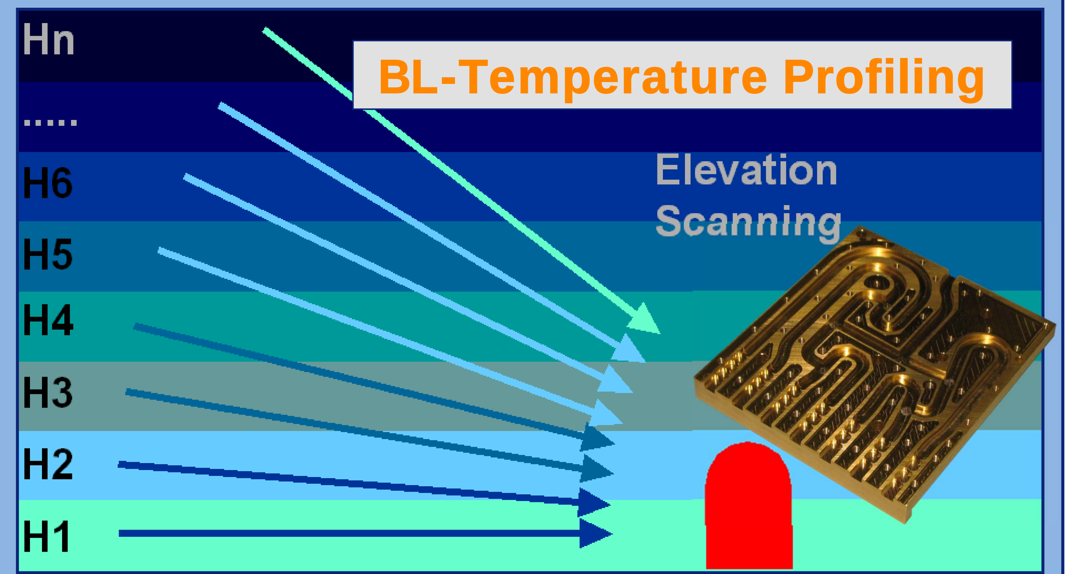
- Shifts the weighting functions of saturated channels (small penetration depth due to high opacity)
- Observes Brightness Temperature signal changes of only a few (1 to 4) Kelvin on top of the close to ambient TB readings.

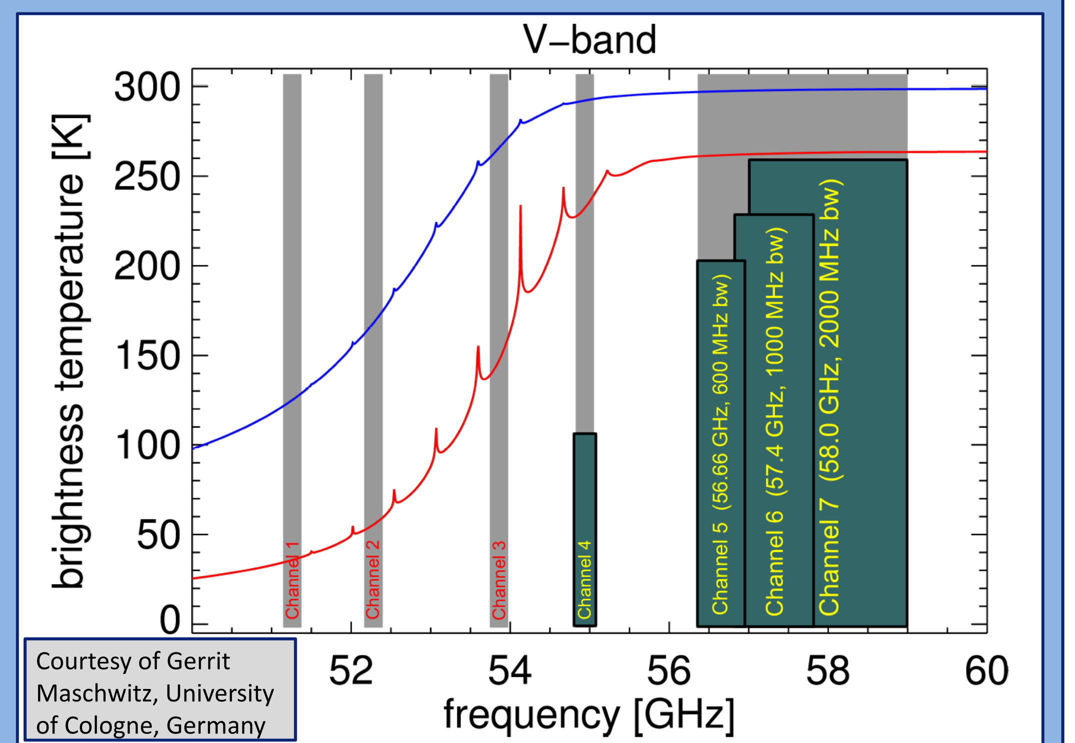
To resolve these signals with sufficient accuracy to be beneficial for the profile retrieval, the MWR needs:

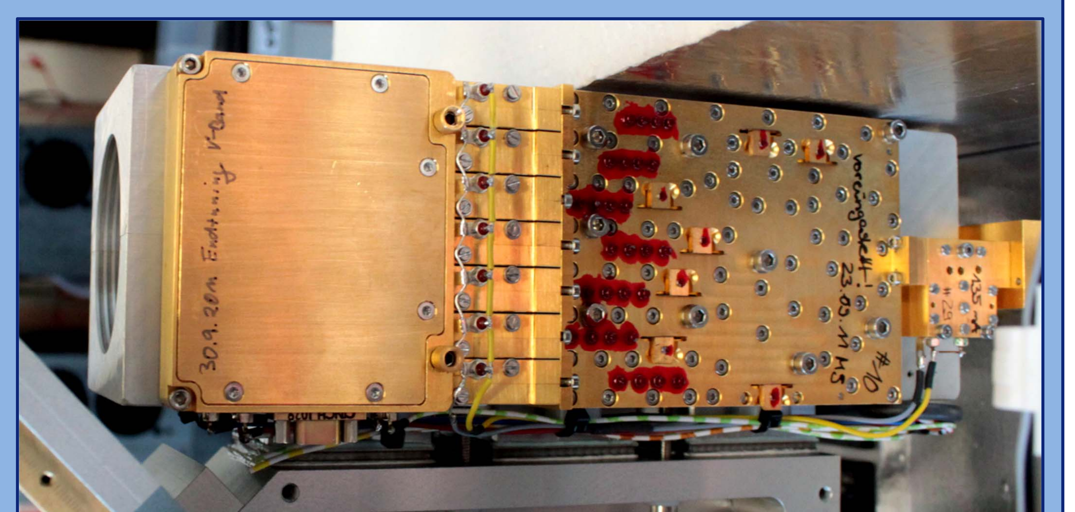
- Noise-reduction by increasing bandwidth in opaque channels × 10 and integration time × 20
- → Noise level better than 0.03 K RMS @ 20 s integration time
- Parallel data acquisition (speed, individual filters)
- → 3-min update when using 8 elevation angles / 20 s each
- High resolution beam using large-aperture optics
- → Scans down to 4.8° elevation with 1.8° beam
- Retrievals with optimised angle /frequency selection
- → Vertical resolution around 50 m at surface, 0.25 K RMS

Comparisons with 100m mast at Falkenberg: better agreement than balloons (but with 3 minute update cycle)



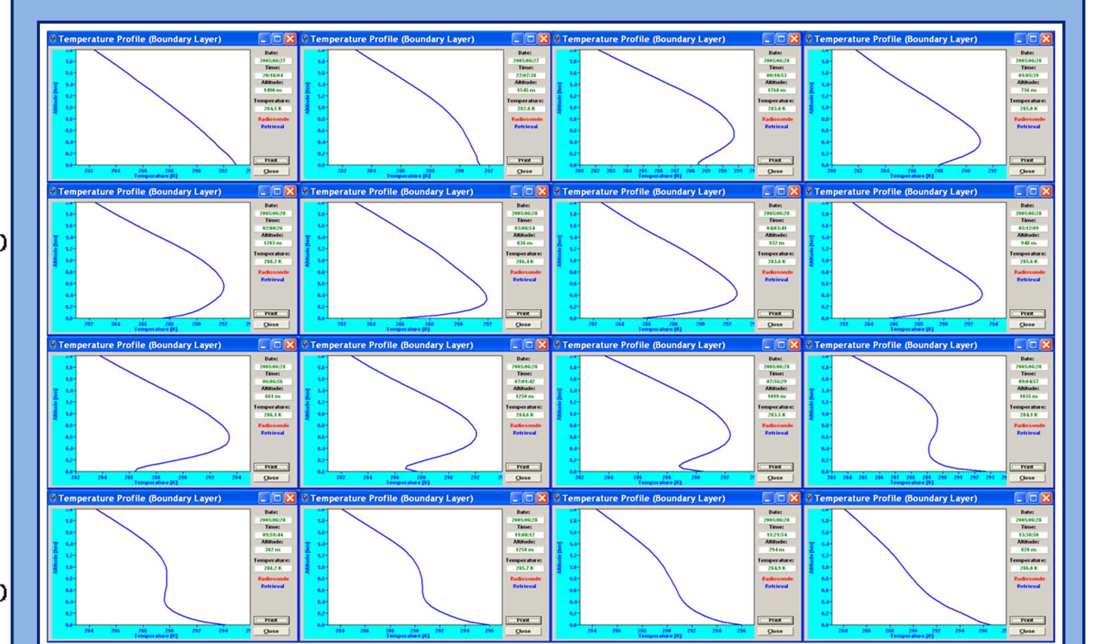






Elevation angles, airmass, and channel usage

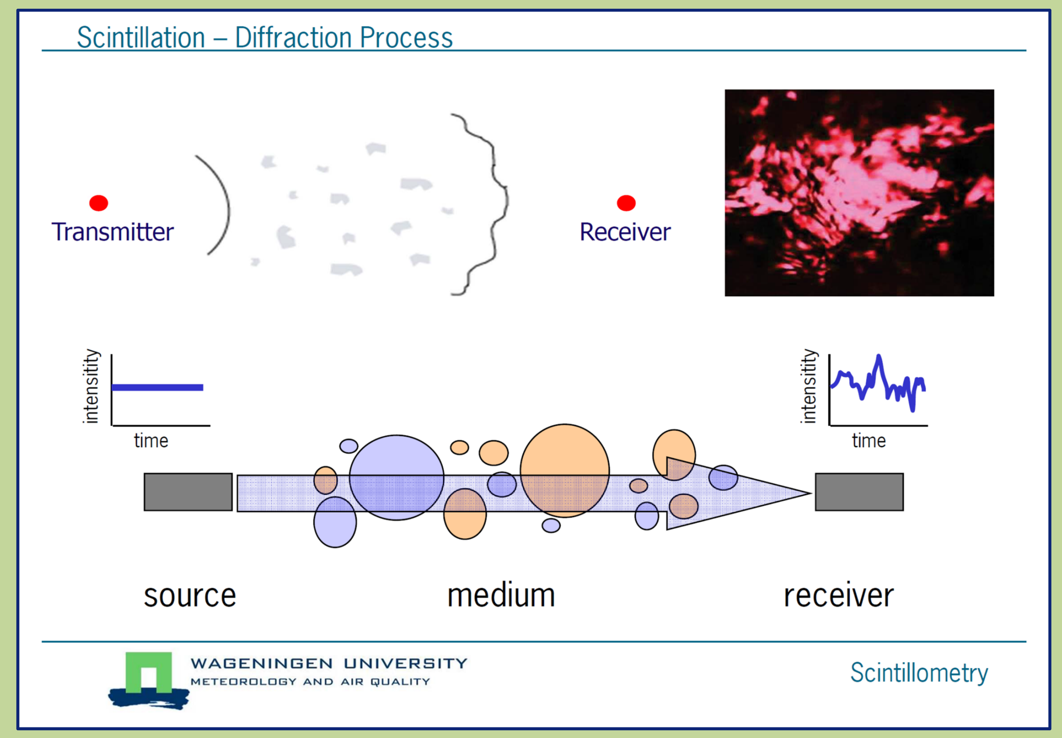
Regr.	90°	30°	19.2°	14.4°	11.4°	8.4°	6.6°	4.8°
Linear	1 – 7	4 – 7	4 – 7	6 + 7	6 + 7	7	7	7
Quad.	1 – 7	–	–	–	–	–	–	–
Airm.	1.00	2.00	3.04	4.02	5.05	6.84	8.70	11.95

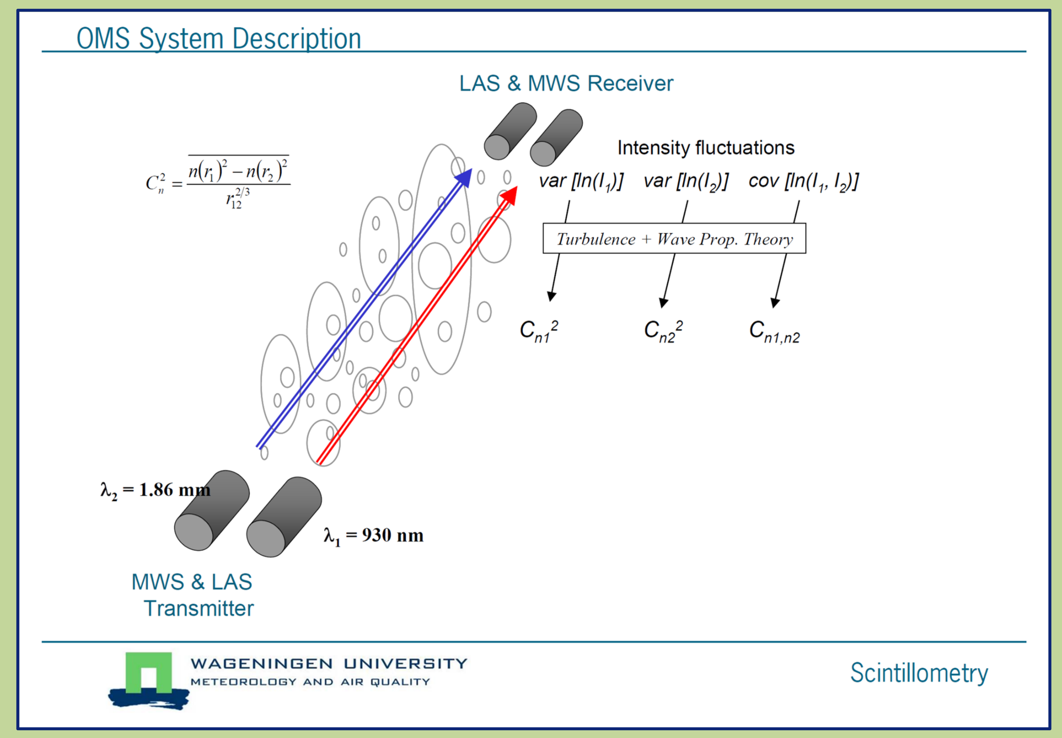


Active: Microwave Scintillometers (MWSC) for Evapotranspiration

Scintillometry observations of the boundary layer are commonly used for the estimation of the sensible heat flux (H). The scintillation principle relies on the observation of a highly stable reference signal (transmitter) by a horizontally displaced receiver. The turbulent fluxes cause time dependent variations of the refractive index, which lead to a spectrum of intensity fluctuations.

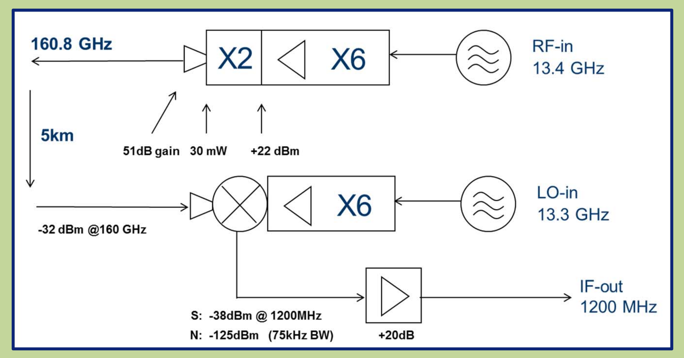
Together with the Wageningen University (and co-funded by STW, Stichting voor de Technische Wetenschappen), RPG recently has started the development of a microwave scintillometer system. When combined with an optical LAS, the evapotranspiration (L_vE) can be determined.





Key features of the MWSC-160:

- Frequency: 160.8 GHz (λ=1.86 mm) for small beam and sufficient co-spectrum with optical LAS
- 300 mm Cassegrain optics (51 dB gain)
- 40 mW transmitted power
- Amplitude stability: 2×10^{-6}
- Frequency stability: 1 kHz
- Detection b/w: 10 kHz



The prototype is currently being tested at RPG. We expect availabilty for the market at the end of 2012.

Future developments:

RPG will build and test a 94 GHz ***FMCW cloud-radar*** by 2013:

- 500 mW transmitted power, 50 dB antenna gain
- Approx. 100 dB dynamic range
- 4 to 25 m vertical resolution, Doppler capabilities
- Extendability: dual-frequency and passive microwave channels