Plenary Discussion Topics: Passive Profiling

- Long-term, continuous, unmanned observation has been proved!
  + multiple, simultaneously detecting channels in MW – high spectral resolution in IR
  + direct detection with low noise amplifiers to avoid RFI (issue in MW)
  + clouds (especially in IR) cause complications
  + scanning in azimuth & elevation growing
    → definition of scan patterns is missing

Are our retrieval algorithms good enough?
What about uncertainty estimates? Covariances?

- Are current systems able to provide unattended continuous operation?
  YES, but
  - quality control
    - fewer – but more rigourous, unattend calibrations! (esp for MW)
    - clean radome – rain/dew/icing detection

Do we need an observation monitoring system?

- What is the spatial resolution?
  - temporal: good <= 1 s
  - vertical: poor (2-10 degrees of freedom; see talk by Turner)
  - horizontal: <10 deg for water vapour & cloud variations; see talk by Crewell)

Can we identify micro to meso-α convective circulation structures within the PBL?
Plenary Discussion Topics: Passive Profiling

- What are the limitations of passive profiling?
  - vertical resolution
  - clouds in IR
  - Radio Frequency Interference (RFI) ➔ direct detection, small bandpass width
  - better network of users – standard data „life cycle“
  - consistent „reference RT“ (absorption model, beamwidth, earth curvature, refractivity..)

  **Are our radiative transfer models accurate (and consistent) enough?**

- Where will the technology be in ten years?
  - more compact, scanning and simpler to use
  - combined act/pass platform
  - multiple applications (propagation/communication, astronomy, geodesy, atmospheric sciences)
  - lower price (depends on numbers)

  **Will we be able to get the price into the range of ceilometers?**

  **Shall we aim for a similar network density?**

- For which applications are single instrument type sufficient?
  - verification & climatology of single parameters
  - diurnal PBL cycle
  - air quality and dispersion modelling
  - pre satellite studies & ground truthing
The final products should:
- rely on common retrievals
- be well documented concerning genesis (i.e. reproducible)
- have a common format
- have an error characterization
- be available through the web (possibly continuously)

…
Bias problem (V-Band)
Bias problem – Retrieval T-profile
Bias problem – Retrieval T-profile
BT observations

Microwave radiometer has to observe $T_B$ as accurate as possibly

- high sensitivity/low noise $\Delta T_B^{Br}$
- high stability $\Delta T_B^{Bs}$
  → thermal control
- high absolute accuracy $\Delta T_B^{ba}$
- calibration parameter (gain, $T_{sys}$, $\alpha$)
  → (4-point calibration, tipping curve)
- representative frequency band
  → include bandbass characteristics
Calibration issues

At 530hPa O2 channels at 51GHz and 52GHz are transparent enough to be calibrated by the tipping curve method:

- 156 elevation scans on Aug 16, 2009 down to 4 air masses are used to derive mean calibration factors (0.946/0.946, good repeatability = homogeneous conditions), opacity/air mass correlate by >0.9998

- An instrument tilt of 0.2° is balanced by averaging TB of symm. elevations

- Compared to the LN2 calibration TB_MWR is reduced by 2.1K/3.0K

- Tmr is derived from surface temperature. Its uncertainty has an effect on the calibration by <0.5K
Gas Absorption

- Line-by-line zenith TB calculations at surface for downwelling radiation
- Atmospheric input: radiosonde profiles of T, p, q
- Line parameters derived from laboratory measurements
- Absorption of H2, O2 and N, no trace gases, no scattering
- Coupling of pressure-broadened absorption lines is involved
  - High resolution spectrum at the oxygen absorption complex at 60GHz gives a model spread of up to 2K for the background and differences of more than 10K at the Zeeman peaks

Gerrit Maschwitz
Problem: Absorption model uncertainties ...

6 MONORTM simulations for 2 climatologies, only WV and O$_2$ considered, 2 overlapping pairs with similar water vapor amount

Rosenkranz '98 - MONORTM

Liebe and Layton '87 - MONORTM

Liebe '93 - MONORTM

Note y-axis scale change!
Original models

Models modified to meet obs. @ 150 GHz

by D.D. Turner
Spatial and Temporal Resolutions

(a) Radiosondes:
- Synoptic scale; twice daily. Thermodynamic vertical profiles for weather diagnostics and prediction
- Don’t resolve microscale & mesoscale features of min to hours and 1-10 km scale

(b) Satellite:
Crude vertical resolution within boundary layer

(c) Radiometer:
Continuous observations to fill temporal gaps between radiosondes
  (i) Microwave: Measurements during both cloudy and clear air
  (ii) Infrared: Biased in cloudy condition

Vertical resolution declines in proportion to height above ground level

How do the following methods improve vertical resolution?
  (i) Narrow-beam radiometer
  (ii) Including scanning measurements to vertical pointing observations
  (iii) 1-D Var method
  (iv) Tradeoff between std. error and spatial resolution
  (v) Tomography technique
Improvement in resolution by adding scanning measurements to vertical pointing observations

Vivek
Tradeoff curve: Uncertainty vs Spatial Resolution

From Conrath, B., J., 1972, JAS
Retrieval Algorithm Setup for simple IR & MWR

- MIXCRA data set of $\tau$, $r_e$, LWP
- Radiosonde profiles of T, p, q

Training

- RT-model
  - LWP
  - $TB_{IR}$, $TB_{MW}$

Multi-linear regression

Test

- RT-model
  - $TB_{IR}$, $TB_{MW}$

Retrieval algorithm

Comparison

- LWP
Ideal conditions during 2007 Black Forest AMF deployment

- 24 Oct. – 4. Nov. \(\rightarrow\) persisting low stratocumulus layer, often with LWP < 100 gm\(^{-2}\).
RT Results, TB Sensitivities

IRT#1: bandpath 10.2-11.9 microns
IRT#2: bandpath 11.1-12.8 microns

LWP [gm$^{-2}$]

TB_IRT [K]

LWP [gm$^{-2}$]

TB_IRT#2-TB_IRT#1 [K]