A Novel Microwave Radiometer for Assessment of Atmospheric Propagation Conditions for 10 and 90 GHz Frequency Bands

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ATPROP Atmospheric Propagation and Profiling System

Manufacturing

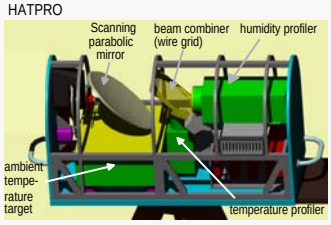
Included channels:
HATPRO - Humidity And Temperature PROfiler
- 7 frequencies between 22.4 and 31.4 GHz
- 7 frequencies between 51.2 and 59.0 GHz
- Additional frequencies: 15.3 GHz and 90 GHz
  90 GHz: Improvement of water vapour retrieval
  15 GHz: retrieving heavy cloud and light rainfall attenuation
- Two separate devices coupled by controlling software

New calibration method :
Dicke Switch + noise diode
=> Highly precise measurement without interrupting

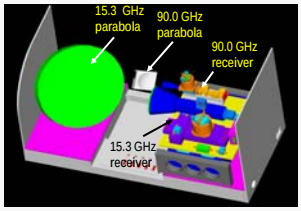
Observing Parameters:
- Temperature profiles
- Humidity profiles
- Integrated Water Vapour – IWV
- Liquid Water Path – LWP
- Spatial inhomogenities in clouds and water vapour using elevation and azimuth scans
- Propagation parameters: Excess Path Length (EPL), Attenuation Acs, A_{cl}, A_{rain} for clear sky, cloudy and rainy conditions, respectively

Design of both ATPROP modules

HATPRO

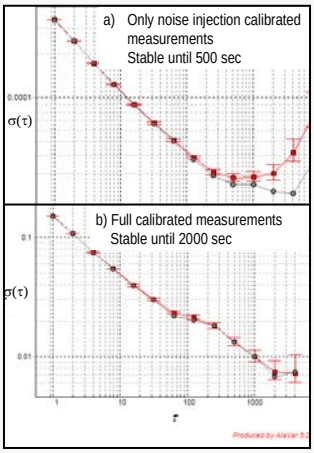


15/90 GHz Module



Radiometric stability

Allan Standard Deviation of voltage for a single channel:
23.04 GHz channel

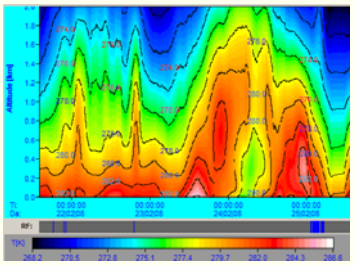


Stability of radiometer:
Using only noise switching and full calibration method

Chanel in GHz	Stability (noise swiching)	Stability (full calibration)
15.3	250 s	➢2000 s
22.24	500 s	➢2000 s
23.04	500 s	➢2000 s
23.84.	500 s	➢2000 s
25.44	300 s	➢2000 s
26.24	500 s	➢2000 s
27.84	1000 s	➢2000 s
31.40	500 s	➢2000 s
51.26	150 s	➢2000 s
52.28	250 s	➢2000 s
53.86	250 s	➢2000 s
54.94	250 s	➢2000 s
56.66	250 s	➢2000 s
57.30	200 s	➢2000 s
58.00	200 s	➢2000 s
90.00	250 s	➢2000 s

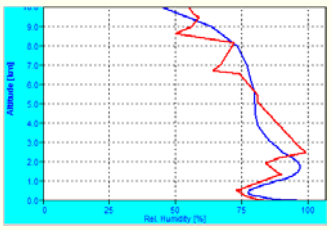
First Measurements

Time series of boundary layer temperature profiles



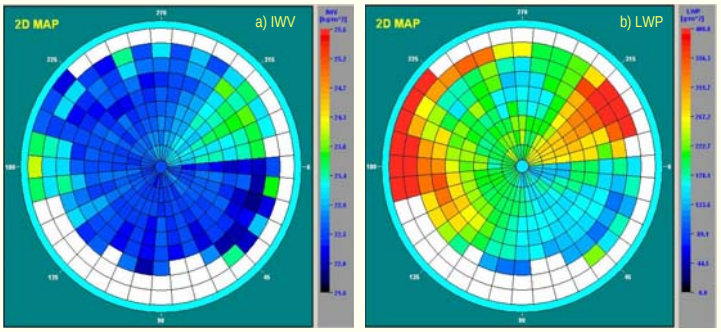
- Highly resolved temperature profiles over a range of 4 days
- e.g. detecting nightly inversion layer

Profile of relative humidity



Comparison of one ATPROP profile of relative humidity (blue) and the corresponding radio sounding of De Bilt (red) ~ 200 km northwest of ATPROPS location

Volume scans of integrated water vapour and liquid water path



Volume scan of the whole hemisphere a) integrated water vapour b) liquid water path
Elevation angle: 9° to 90°, increment 9°
Azimuth angle: 0° to 350°, increment 10°
White Pixel:
Removed obstacles

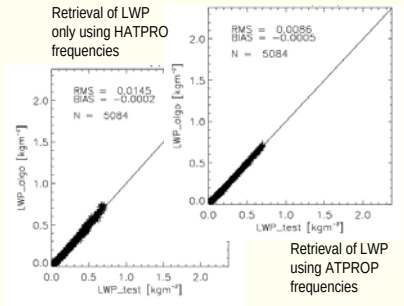
Retrieval development

Dataset: 12 years of high resolved quality checked radio soundings of De Bilt

Cloud Models:
1) Modified adiabatic cloud model (Carstens 1994)
2) Decker Model (Decker 1974)
3) Salonen Model (Mattioli 2006)

Gas absorprion models: Liebe 1993
Rosenkranz 1998

Retrieval of LWP only using HATPRO frequencies



Retrieval of LWP using ATPROP frequencies

Accuracy of LWP

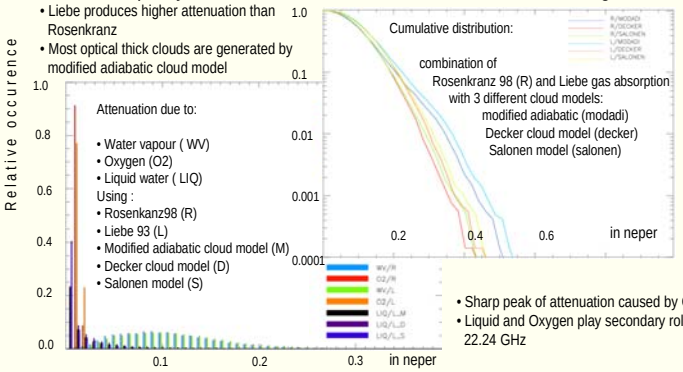
Number of frequencies	RMS(LWP)
2 frequencies (23.8, 31.4 GHz)	0.0183 kg/m²
14 HATPRO frequencies	0.0145 kg/m²
16 ATPROP frequencies	0.0086 kg/m²

Accuracy of attenuation identified at
1) ATPROP frequencies
- Relative error around 1 %
- RMS, correlation growing strongly in optically thick atmosphere

2) Other frequencies
Retrieved attenuation on different satellite communication frequencies shows nearly the same RMS, and correlation refers to the test data set.

Frequency distributions of 22.24 GHz attenuation of De Bild soundings

- Liebe produces higher attenuation than Rosenkranz
- Most optical thick clouds are generated by modified adiabatic cloud model



- Sharp peak of attenuation caused by Oxygen
- Liquid and Oxygen play secondary roles at 22.24 GHz

Acknowledgements

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References

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