Radiometer Physics GmbH

RPG-XCH-DP Dual Polarized Radiometers

APPLICATIONS

- Soil moisture measurements, ground refractive index
- LWP (Liquid Water Path) and IWV (Integrated Water Vapour) measurements
- Rain observations
- Discrimination of Cloud Liquid (LWC) and Rain Liquid (LWR)
- Accurate LWP measurements during rain events
- Cloud physics and structure
- Full sky IWV / LWP mapping, cloud coverage

FEATURES

- LWP and IWV, polarisation difference (PD) at different frequencies
- X (in RPG-XCH-DP) stands for 4 (two frequencies, typically 21.0 (18.7) and 36.5 GHz), 6 (10.7 / 21.0 (18.7) / 36.5 GHz) or 8 (6.925 / 10.7 / 21.0 (18.7) / 36.5 GHz)
- All microwave channels measured in parallel
- High temporal resolution (1 second), spatial resolution (6° HPBW)
- IWV (integrated water vapour) and LWP (integrated cloud liquid) full sky maps (350 points) within 10 minutes. Determination of cloud coverage and monitoring of abrupt changes in the 3d humidity field
- Distinguishes between cloud liquid water and rain liquid. Precise determination of total liquid water content (LWP)
- Covers all rain rate events (depending on model), light rain <2 mm/h up to 50 mm/h
- Immune to RF interference below reception bands (e.g. radio transmitters, mobile phones etc.), direct detection receiver layout
- Purely passive operation, no internal oscillators or other RF sources
- Extremely short calibration cycles (sky tipping, 2 minutes), complete internal auto-calibration systems including noise sources (noise switching, gain calibration) and Dicke switches (system noise temperature calibration)
- Internal data file backup system
- Rain protection of microwave windows
- Modular design allows for later frequency extensions (4 frequencies maximum)

INTRODUCTION

The RPG-XCH-DP is a 2/3/4 frequency, dual polarisation radiometer with direct detection receivers and complete auto-calibration frontends. The system requires no external calibration targets and performs sky tippings for absolute calibration purposes. The system is split into different frequency modules which are grouped on top of a precision elevation / azimuth positioner. Therefore the antennas can reach every point in the sky and complicated scanning schemes, including full sky LWP / IWV maps are possible.
One of the key features is the measurement of polarisation difference (PD) during rain events under e.g. 30° elevation angle. Falling droplets are flattened due to the air resistance from below and nearly form an ellipsoid with long axis along the horizontal direction. Therefore the emission of falling droplets is more pronounced in the horizontal polarisation compared to the vertical. This allows for the separation of cloud liquid (perfectly round droplets, approx. 20 µm in diameter) and rain liquid. Without taking the polarisation difference into account, a radiometer overestimates the total liquid water content during rain by assuming that the brightness temperature signal is all generated by small cloud droplets. The small cloud droplets produce a much lower sky temperature than the bigger rain droplets, even with the same amount of liquid water. Therefore the rain droplet contribution to the sky temperature is relatively large while their contribution to the total liquid is smaller.

HIGHLIGHTS

Zenith Sky Observations

When observing the sky in zenith direction, polarization splitting should be zero, even if clouds are passing the field of view. Falling rain droplets are vertically flattened, but this cannot be seen in zenith direction.

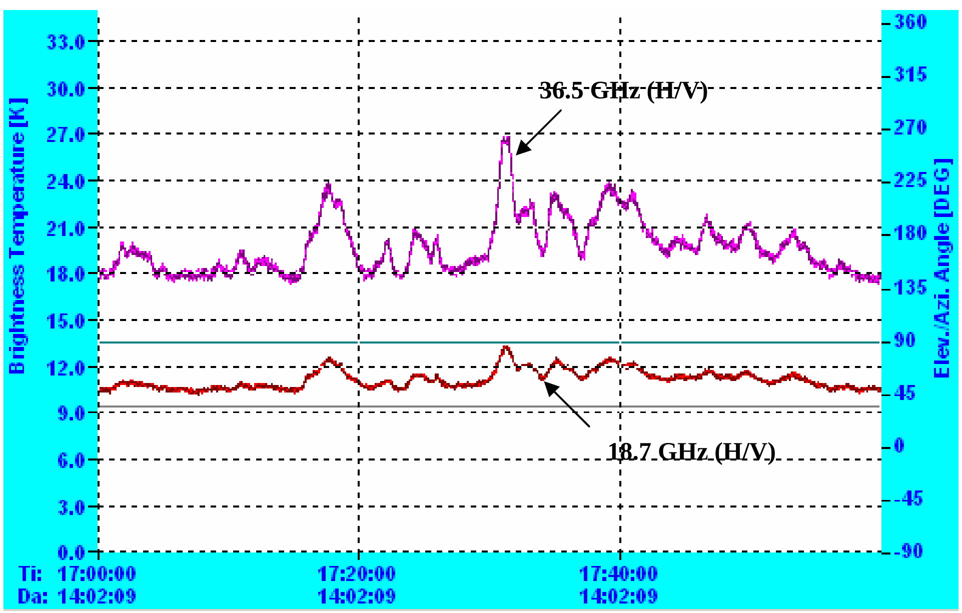


Fig.1

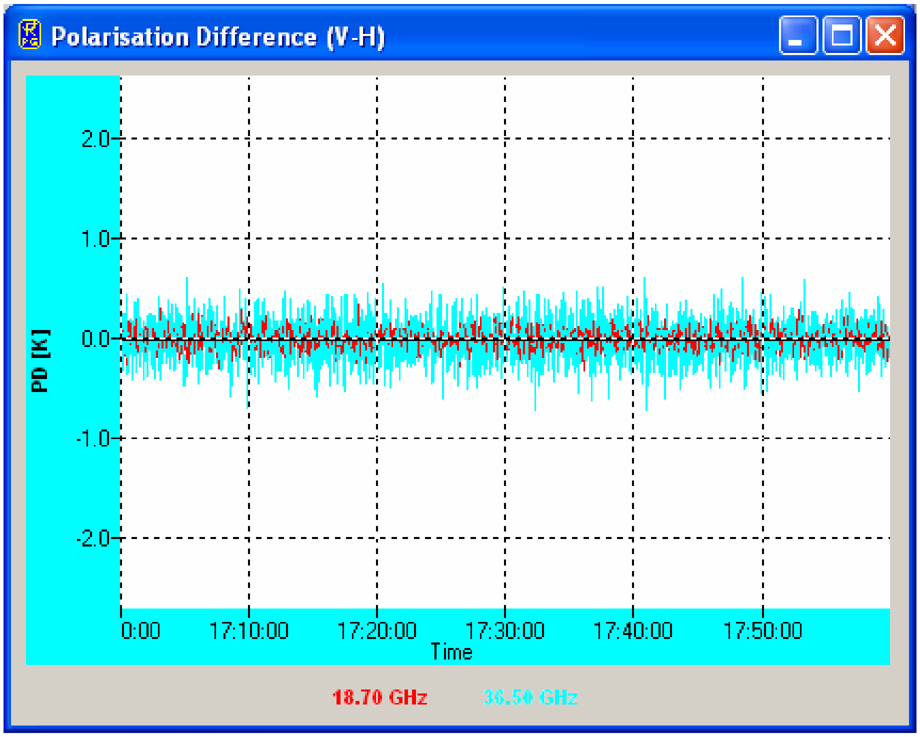
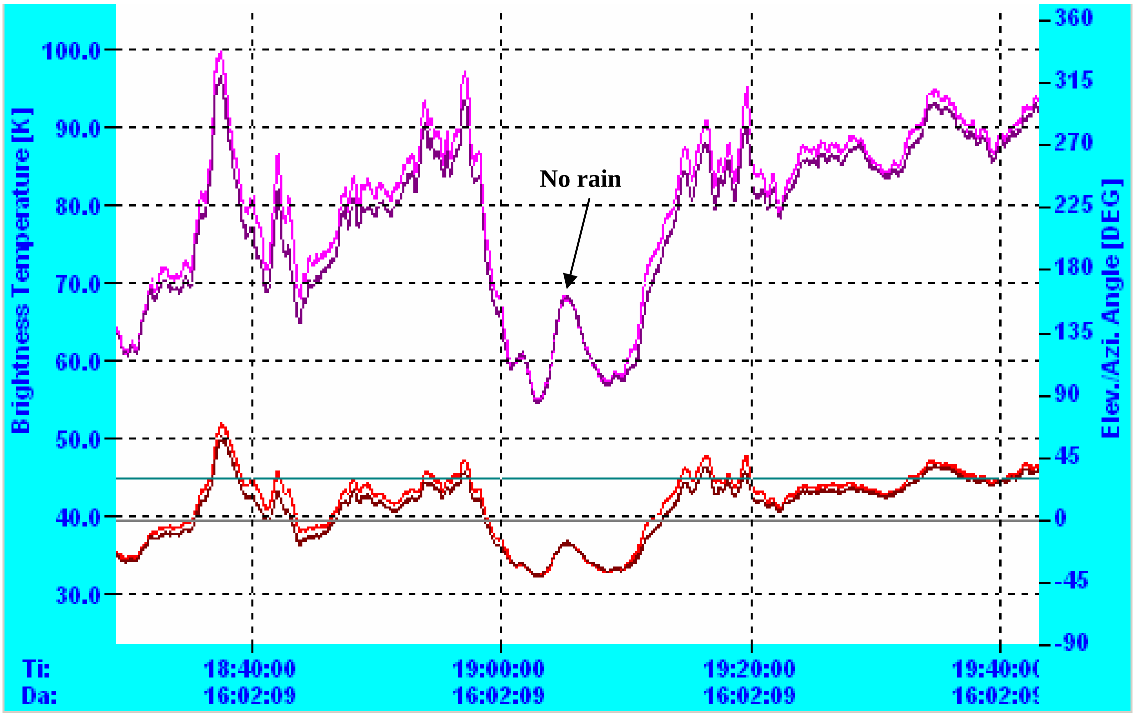


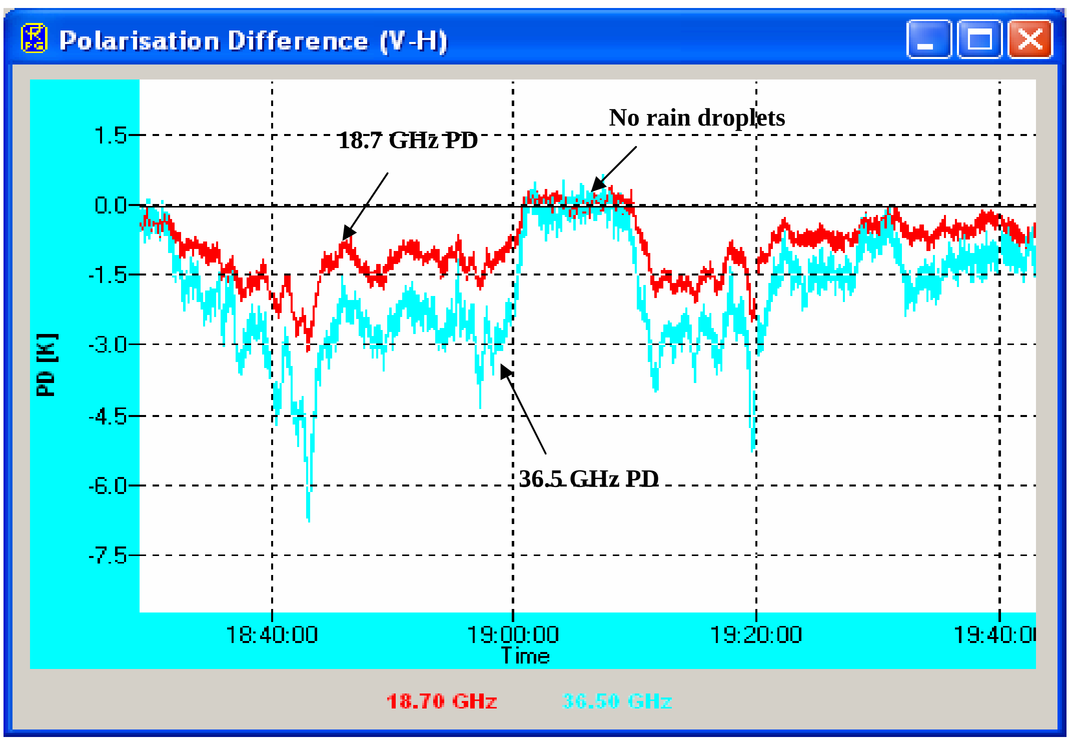
Fig.2

Polarisation effects due to falling rain droplets have to be observed under lower elevation angles (e.g. 30°). Therefore, by directing the radiometer to zenith, the polarization difference between V and H should vanish. Fig.1 shows the TBs observed for a cloudy atmosphere and Fig.2 is the polarization difference.

Observations Under Low Elevation Angles

The following measurements were performed at 30° elevation angle, observing a raining atmosphere (rain rate 5mm/h). The polarization splitting is very obvious but immediately drops down to zero, when the rain pauses.
As expected, the 36.5 GHz channels respond much more sensitively to the liquid water and the polarization difference is more exaggerated. The 36.5 GHz channels are used for light rain detection while the 18.7 GHz channels cover the strong rain events with rain rates above 20-30 mm/h when the 36.5 GHz channels are starting to saturate.
Fig.3 shows the retrieval outputs for the Tb time series above. LWR is the liquid water content of the rain droplets, LWC denotes the cloud liquid and LWP is the total liquid water amount. The three time series are consistent even though the three quantities have been derived by three independent retrieval algorithms, one for each product.


Brightness Temperature [K]
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
No rain
360
315
270
225
180
135
90
45
0
-45
-90
Elev./Azi. Angle [DEG]
Ti:
Da:
18:40:00
16:02:09
19:00:00
16:02:09
19:20:00
16:02:09


Polarisation Difference (V-H)
PD [K]
1.5
0.0
-1.5
-3.0
-4.5
-6.0
-7.5
18.7 GHz PD
No rain droplets
36.5 GHz PD
18:40:00
19:00:00
19:20:00
Time
18.70 GHz
36.50 GHz

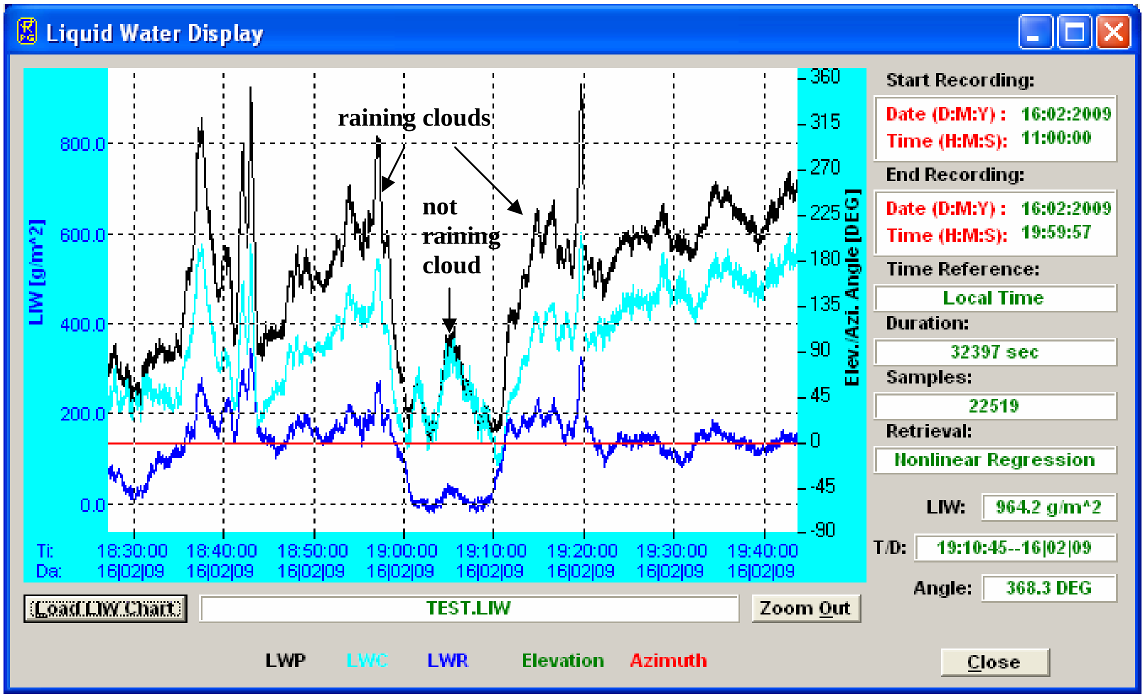

Liquid Water Display
raining clouds
not raining cloud
LIW [g/m^2]
Elev./Azi. Angle [DEG]
800.0
600.0
400.0
200.0
0.0
360
315
270
225
180
135
90
45
0
-45
-90
Ti: 18:30:00 18:40:00 18:50:00 19:00:00 19:10:00 19:20:00 19:30:00 19:40:00
Da: 16|02|09 16|02|09 16|02|09 16|02|09 16|02|09 16|02|09 16|02|09 16|02|09
Start Recording:
Date (D:M:Y) : 16:02:2009
Time (H:M:S): 11:00:00
End Recording:
Date (D:M:Y) : 16:02:2009
Time (H:M:S): 19:59:57
Time Reference:
Local Time
Duration:
32397 sec
Samples:
22519
Retrieval:
Nonlinear Regression
LIW: 964.2 g/m^2
T/D: 19:10:45--16|02|09
Angle: 368.3 DEG
Load LIW Chart
TEST.LIW
Zoom Out
LWP
LWC
LWR
Elevation
Azimuth
Close

Fig.3

DETAILED INSTRUMENT SPECIFICATIONS

Parameter	Specification
System noise temperatures	<900 K typical for all receiver (including calibration frontend
Radiometric resolution	0.2 RMS @ 1.0 sec integration time
Channel bandwidth	400 MHz
Absolute system stability	1.0 K
Radiometric range	0-350 K
Absolute calibration	with internal Dicke switch & external cold load, automatic sky tipping
Internal calibration	gain: with internal Dicke Switch + noise standard automatic abs. cal.: sky tipping calibration
Receiver and antenna thermal stabilization	Accuracy <0.05 K
Gain nonlinearity error correction	Automatic, four point method
Brightness calculation	based on exact Planck radiation law
Integration time	>=1 second for each channel
Data interface	RS-232, 115 kBaud
Data rate	9.5 kByte/sec., RS-232
Instrument control	Industrial PC, Pentium based
Housekeeping	all system parameters, history documentation
Optical resolution	HPBW: 6.1°
Sidelobe level	<-30dBc
Pointing speed	elevation: 3°/sec, azimuth: 5°/sec
Operating temperature range	-30°C to +45°C
Power consumption	<350 Watts average, 500 Watts peak
Input voltage	100-230 V AC, 50 to 60 Hz
Weight	105 kg for receiver modules, 300 kg for positioner