



## RPG-HATPRO-G4 series

Microwave radiometers for continuous atmospheric profiling

### Applications



**Tropospheric Profiling**  
of temperature, humidity and liquid water

**Water Vapour Monitoring**  
e.g. at astronomical sites

**Now-Casting**

- atmospheric stability
- severe weather

**Data Assimilation**  
input for weather and climate models

**Boundary Layer Profiling**

- high-resolution temperature profiles (better than balloons)
- 24/7 monitoring of temperature inversions
- fog detection
- air pollution applications

Absolute calibration of  
**Cloud Radars**

**Satellite Tracking**

- wet/dry delay
- humidity profiles along line of sight

## Design

**Direct Detection Filter-Bank Receivers**

**Parallel Detection at all 14 channels**

**Immune to RF Interference < 18 GHz\***

**100% Duty Cycle**

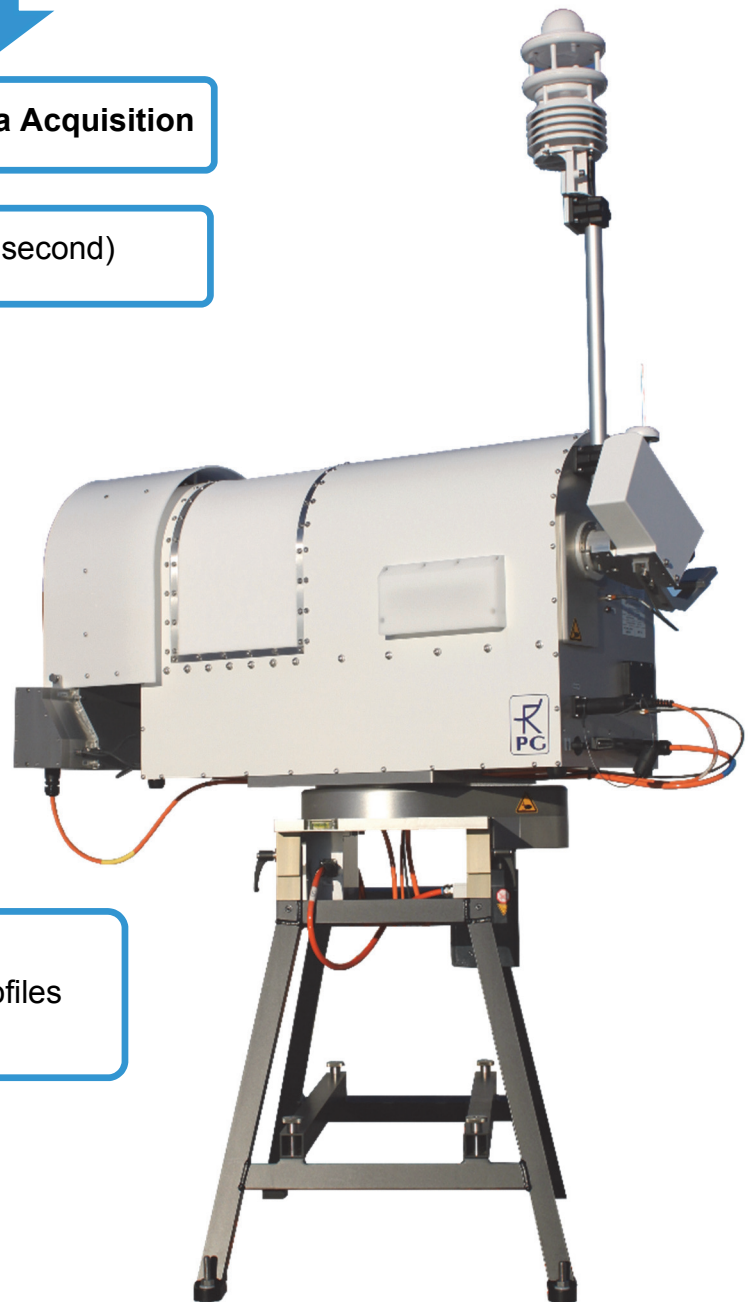
**Fast Data Acquisition**

**High Temporal Resolution (1second)**

**Narrow Beams**  
(~2° - 4° HPBW)

**High Spatial Resolution**

- boundary layer temperature profiles
- 2D sky mapping



\*e.g. radio transmitter or mobile phones

## Hardware Features



### Integrated Automatic Weather Station

Lufft® WS600-UMB to measure wind, rain rate, pressure, temperature, relative humidity

### Mitigation System for Rain / Fog / Dew

- strong blower
- radome with hydrophobic coating
- efficient heater system (1.8 kW)

**Azimuth Positioner**  
for full sky scanning\*

**Data Backup**  
on embedded  
Radiometer-PC

**IR Radiometer**  
for cloud base  
height detection\*

**Ethernet Interface**  
for network capability

**Fibre-Optical Data Cable**  
for lightning protection and  
secure data transmission

### IR Scanner

for synchronous IR and microwave observations\*

\*optional

## Software Features

### State-of-the-art Retrievals

- Neural Network (NN)
- customized

### Accurate North-Alignment

By sun-tracking\*\* using integrated GPS receiver

### Atmospheric Data Products

- profiles of temperature / humidity / liquid
- Integrated water vapour (IWV)
- integrated cloud liquid (LWP)
- atmospheric attenuation
- cloud base height\*

### Detailed Housekeeping Data

- instrument status / control
- data quality checks / flags

### Thermodynamic Diagrams and stability indices

### Free Software Updates

### Automatic Recovery after power failures

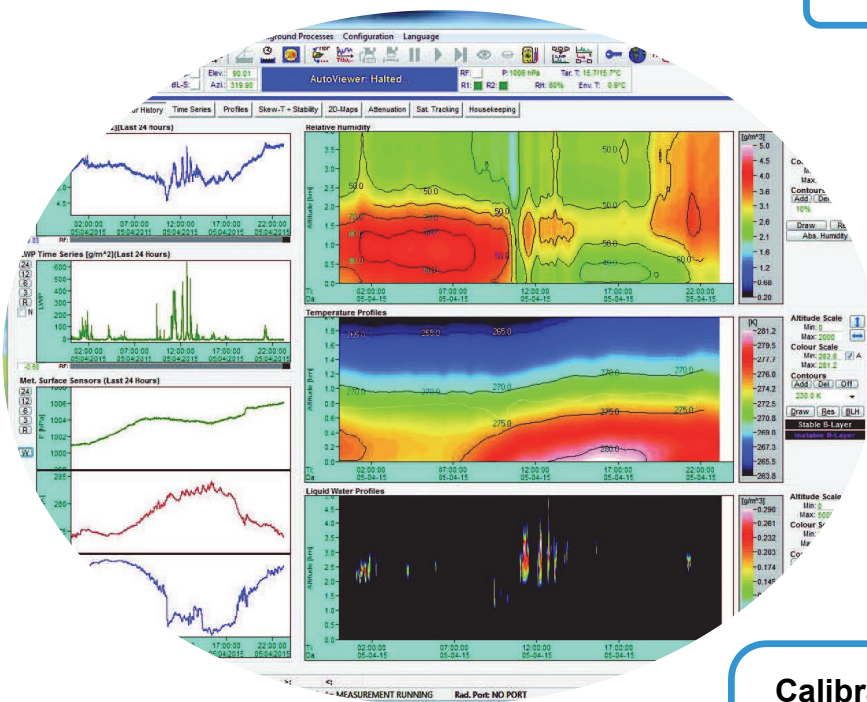
### Calibration

- short calibration cycles
- automatic sky-tipping
- automatic internal calibrations including noise sources
- manual liquid nitrogen calibration (every 6 months)

### Output Data

- Level 0 (detector voltages)
- Level 1 (brightness temperatures)
- Level 2 (retrieved products)
- automatic conversion to netCDF, ASCII, BUFR, RAOB®

\*only with IR radiometer, \*\*only with azimuth positioner



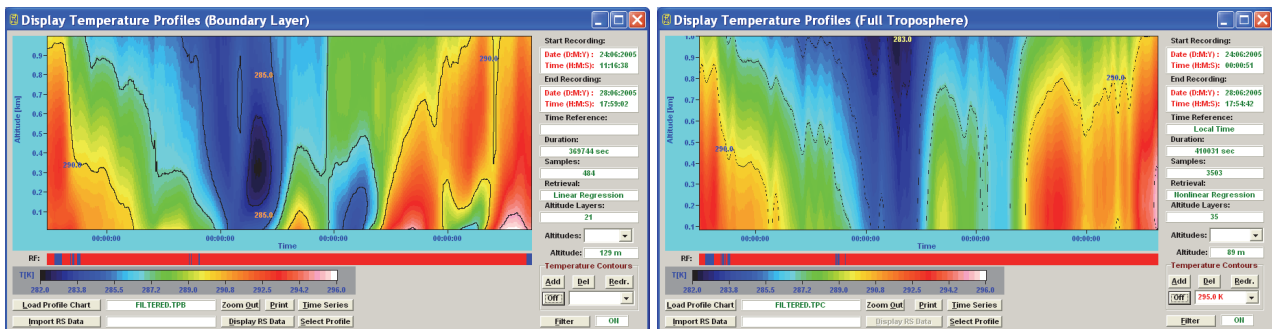




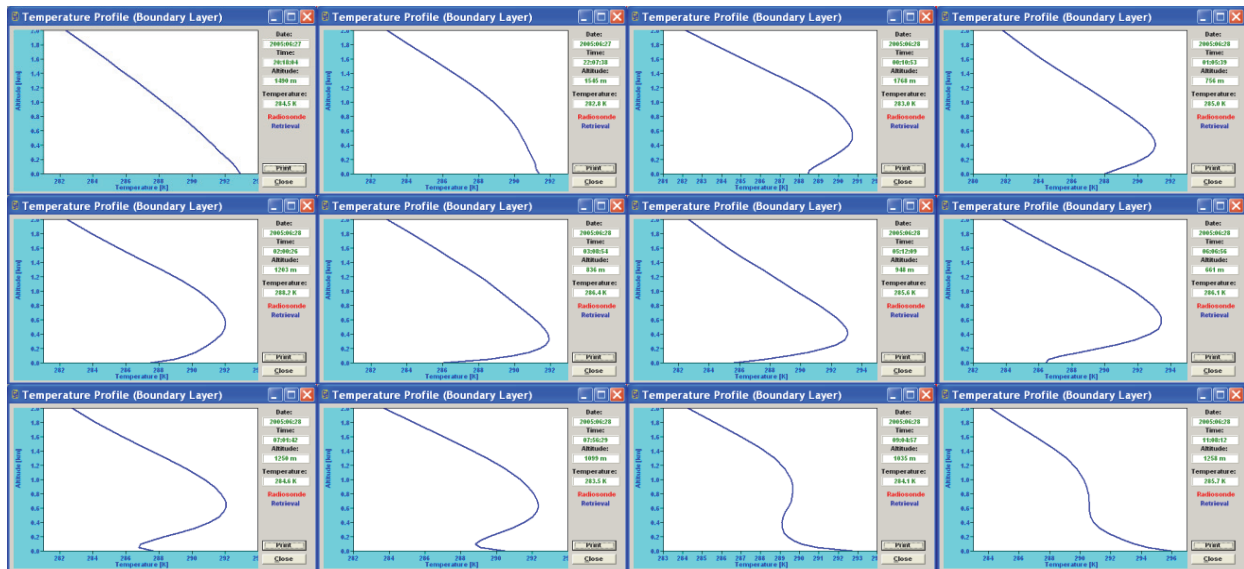
## Selected Highlights

### Boundary Layer Temperature Profiling

Temperature profiles are continuously retrieved from zenith measurements for the entire troposphere (0-10 km). Besides that, the boundary layer observation mode, which utilizes frequent elevation scanning, provides an enhanced vertical resolution within the boundary layer (0-2 km):



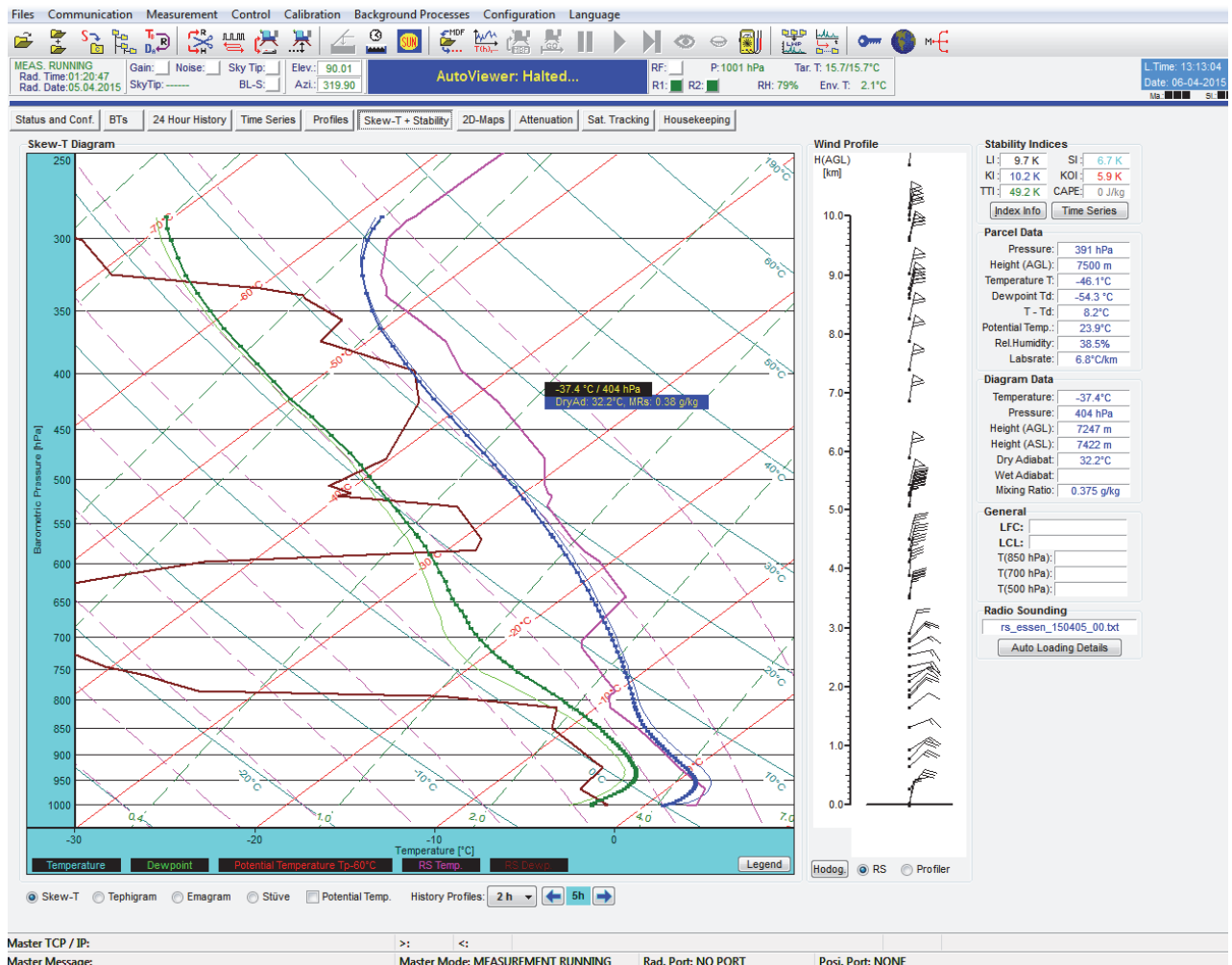
The boundary layer mode allows the monitoring of the formation and decay of temperature inversions in time:





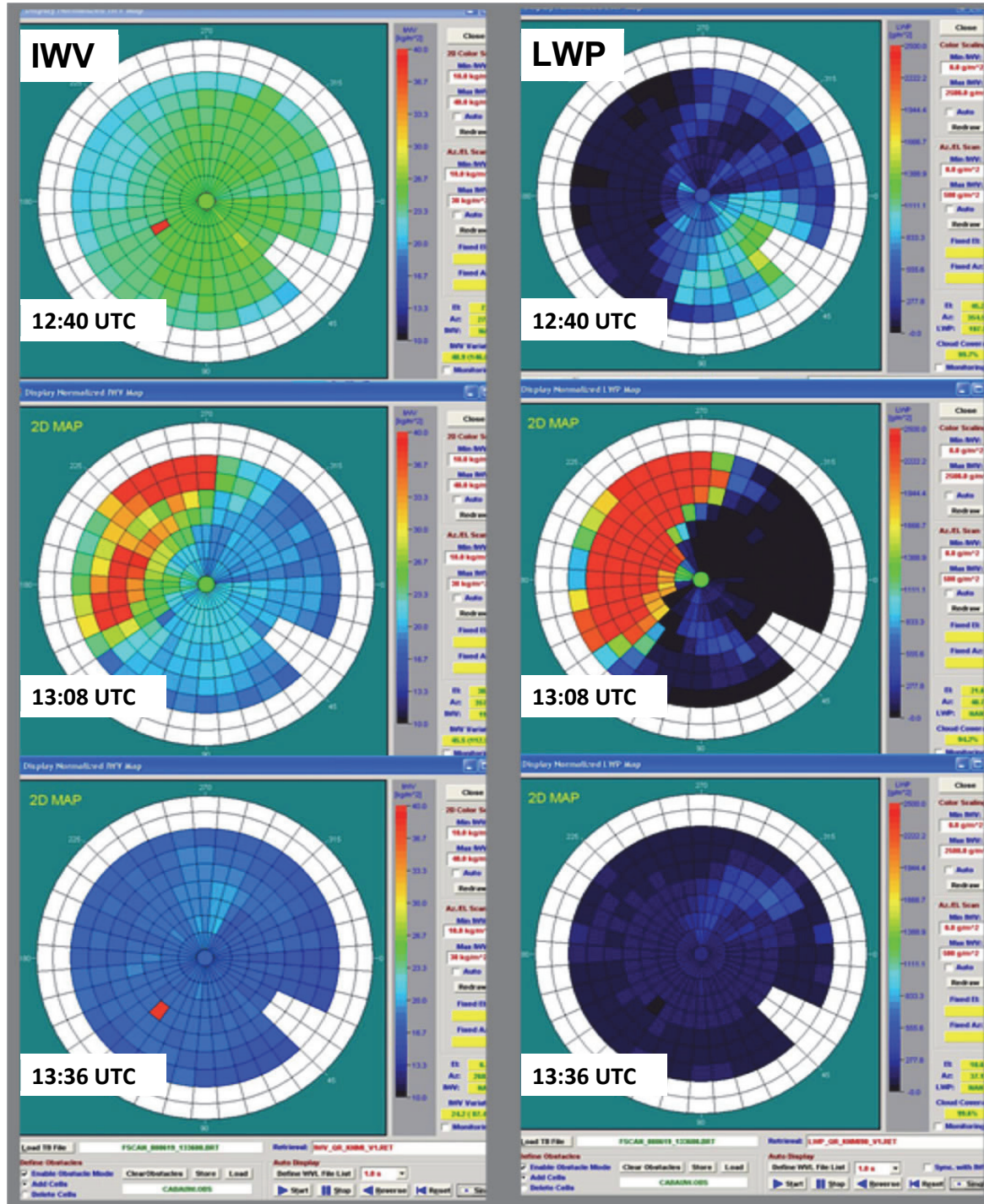
## Thermodynamic Diagrams

RPG's operating software offers a number of common thermodynamic diagrams. Apart from the most recent profiles of temperature and dew point (retrieved from humidity and temperature profiles), the history of mean hourly temperature profiles is displayed. Additionally, vertical profiles from radiosondes and wind profilers in ASCII format (e.g. RAOB®) can be uploaded and displayed. Common stability indices (Lifted Index (LI), Showalter Index (SI), K Index (KI), Total Totals Index (TTI), Convective Index (KOI), CAPE) and characteristic levels (LFC, LCL) are calculated.



## Integrated Water Vapor (IWV) and Liquid Water Path (LWP)

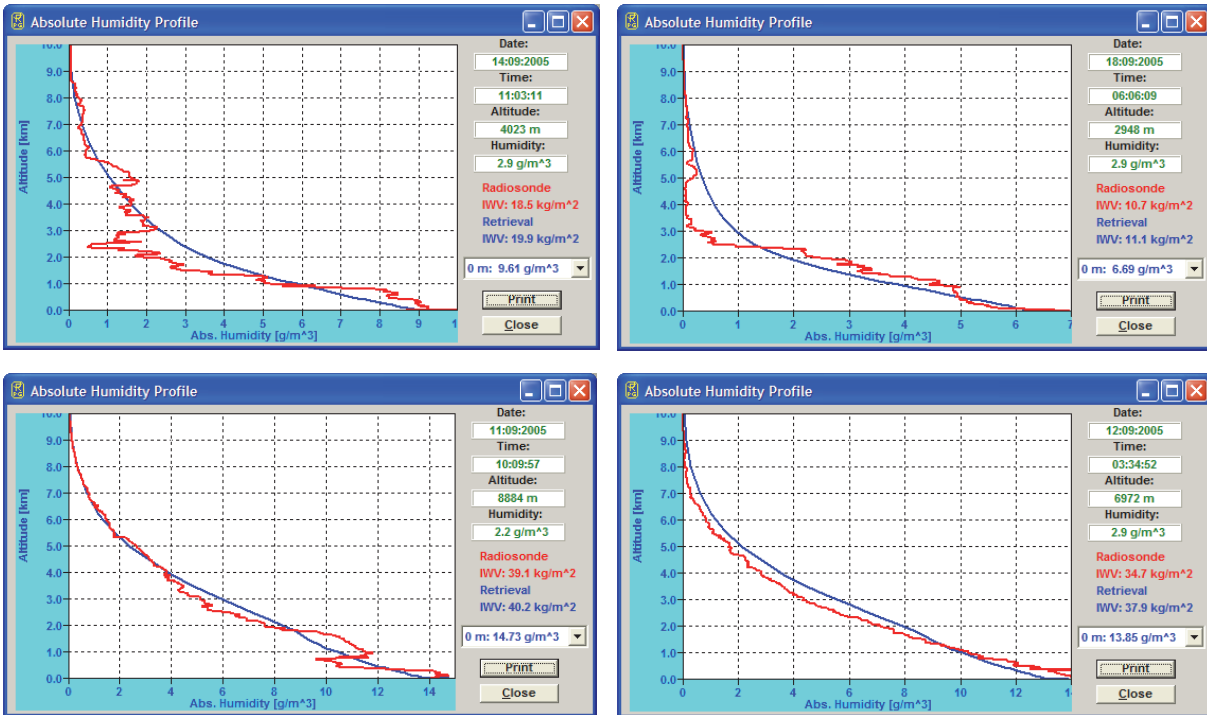
Full sky IWV and LWP maps\* below show inhomogeneous water vapour distributions and cloud coverage (provided with optional azimuth positioner).



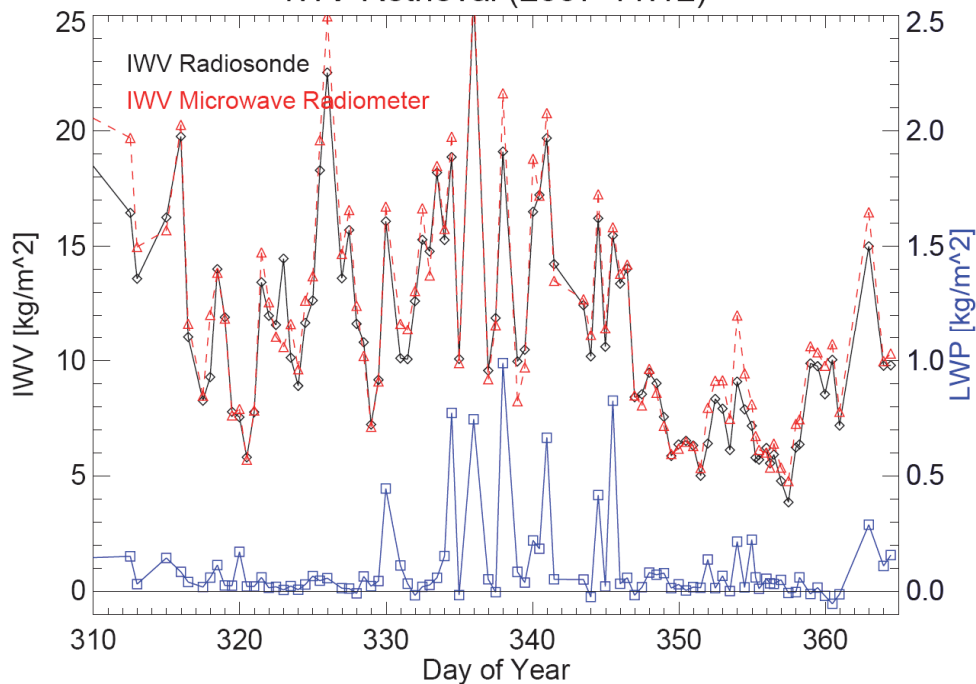
\*only with azimuth positioner

## Tropospheric Humidity Profiling

Integrated Water Vapour measurements remain accurate even with LWP of 1000 g/m<sup>2</sup>.



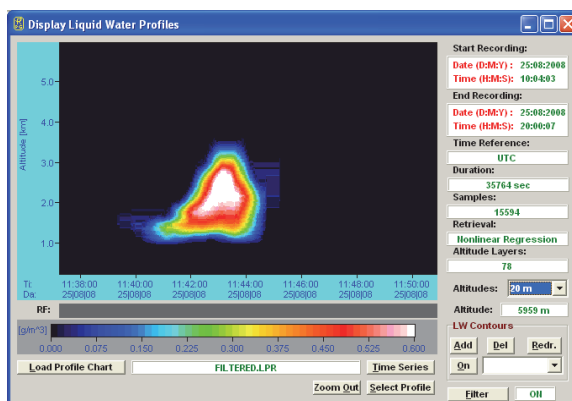
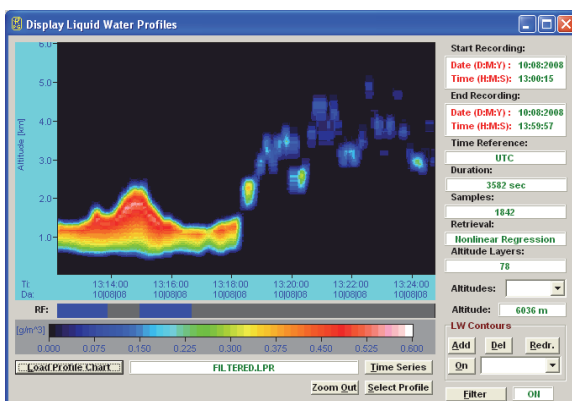
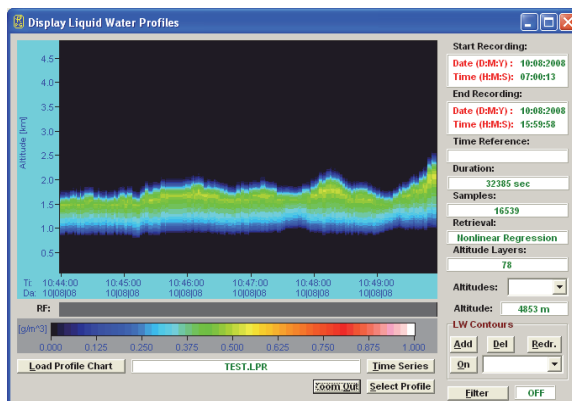
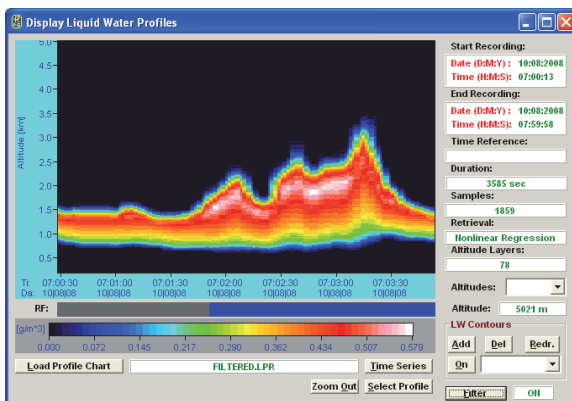
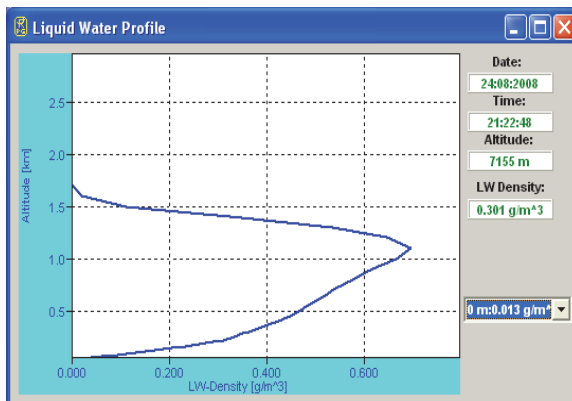
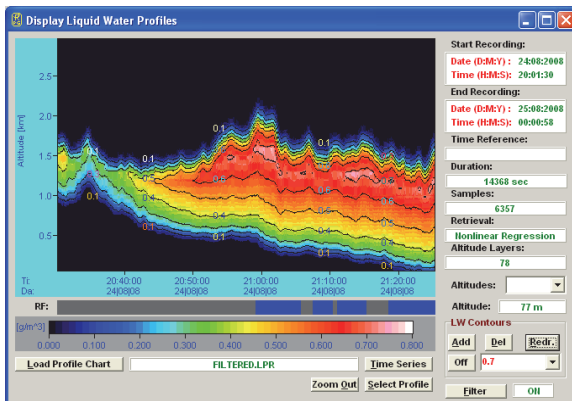
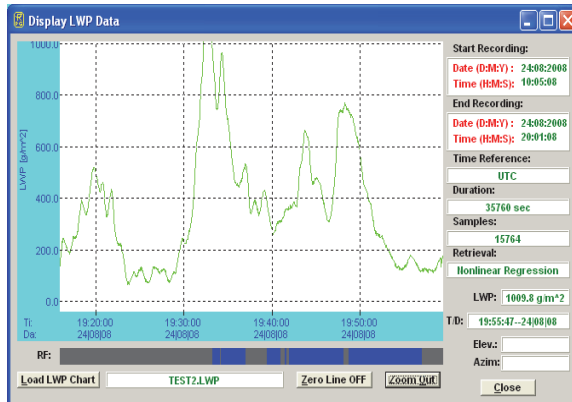
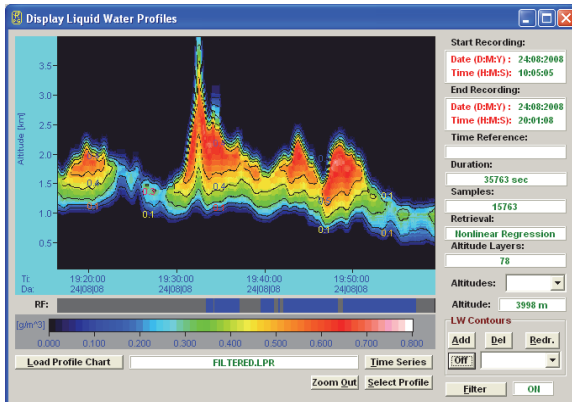
IWV Retrieval (2007-11.12)







## Liquid Water Profiling





## Profiling Radiometer Models

- **RPG-HUMPRO**
  - Humidity PROfiler
  - 7 channels: 22.24 GHz to 31.4 GHz
  - over-sampling for redundancy
  
- **RPG-TEMPRO**
  - Temperature PROfiler
  - 7 channels 51 GHz to 58 GHz
  - over-sampling for redundancy
  - customized direct detection channels for precise Boundary Layer (BL) temperature profiles in elevation scanning mode
  
- **RPG-HATPRO**
  - Humidity And Temperature PROfiler (standard profiling radiometer)
  - 7 channels: 22.24 GHz to 31.4 GHz
  - 7 channels 51 GHz to 58 GHz
  - over-sampling for redundancy
  - customized direct detection channels for precise Boundary Layer (BL) temperature profiles in elevation scanning mode
  
- **RPG-LHATPRO**
  - Low-Humidity And Temperature PROfiler
  - Designed for arctic conditions and/or high altitudes
  - Water vapour sounding at 183 GHz
  - 6 DSB channels with individual bandwidth

## Detailed Instrument Specifications

Parameter	Specification
Humidity profile performance (zenith and along track)	Vertical resolution: 200 m (range 0-2000 m) 400 m (range 2000-5000 m) 800 m (range 5000-10000 m)
	Accuracy: 0.3 g/m <sup>3</sup> maximum bias typical (abs. humidity) 0.1 g/m <sup>3</sup> RMS typical (absolute hum.) 5% RMS (rel. humidity)
Temperature profile performance (zenith and along track)	Vertical resolution: BL-Mode: 30 m (range 0-1200 m) Z-Mode: 200 m (range 1200-5000 m) 400 m (range 5000-10000 m)
	Accuracy: 0.25 K RMS (range 0-500 m) 0.50 K RMS (range 500-1200 m) 0.75 K RMS (range 1200-4000 m) 1.00 K RMS (range 4000-10000 m)



Liquid water profile performance (only with IR radiometer)	<p>Vertical resolution: 250 m (range 0-2000 m) 300 m (range 2000-5000 m) 500 m (range 5000-10000 m)</p> <p>Accuracy: cloud base height: 50 m (range 0-300 m) 100 m (range 300-1000 m) 200 m (range 1000-3000 m) 400 m (range 3000-5000 m) 600 m (range 5000-10000 m)</p> <p>density: 0.03 g/m<sup>3</sup> RMS Threshold: 50 g/m<sup>2</sup> LWP Only single layer clouds are modelled</p>
IR radiometer option	9.6-11.5 µm band, accuracy 1 K, noise: 0.2 K RMS
LWP	Accuracy: ± 20 g/m <sup>2</sup> Noise: 2 g/m <sup>2</sup> RMS
IWV	Accuracy: ± 0.2 kg/m <sup>2</sup> RMS, Noise: 0.05 kg/m <sup>2</sup> RMS
Full sky IWV and LWP maps (only with azimuth positioner)	350 points in 6 minutes rapid scanning
Satellite tracking mode (only with azimuth positioner)	Determines wet/dry delay, atmospheric attenuation and humidity profiles along line of sight for all visible GPS / Galileo satellites in a single scan (2 minutes) scanning with RINEX navigation file or direct GPS vector reading from GPS clock
Channel centre frequencies	K-Band: 22.24 GHz, 23.04 GHz, 23.84 GHz, 25.44 GHz, 26.24 GHz, 27.84 GHz, 31.4 GHz V-Band: 51.26 GHz, 52.28 GHz, 53.86 GHz, 54.94 GHz, 56.66 GHz, 57.3 GHz, 58.0 GHz
Channel bandwidth	2000 MHz @ 58.0 GHz, 1000 MHz @ 57.3 GHz, 600 MHz @ 56.66 GHz, 230 MHz @ all other
System noise temperatures	<400 K typical for 22.2 – 31.4 GHz profiler <600 K typical for 51.4 – 58.0 GHz profiler
Radiometric resolution	K-Band: 0.10 K RMS, V-Band: 0.15 K RMS (@ 1 second integration time)
Absolute brightness temperature	0.5 K
Radiometric range	0-800 K
Absolute calibration	with internal ambient & external cold load
Internal calibration	<ul style="list-style-type: none"> <li>gain: with internal noise standard</li> <li>gain + system noise: ambient temperature target + noise standard</li> <li>abs. cal. of humidity profiler: sky tipping calibration</li> </ul>
Receiver and antenna thermal stabilization	Stability better than 0.03 K over full operating temperature range



Gain nonlinearity error correction	Automatic, four point method
Brightness calculation	Based on exact Planck radiation law
Integration time	≥ 0.4 seconds for each channel, user selectable
Sampling rate for profiles	≥ 1 second (user-selectable)
Rain / fog mitigation system	Highly efficient blower system (130 Watts), hydrophobic coated microwave transparent window, 1.8 kW heater module preventing formation of dew under fog conditions
Integrated weather station	Lufft® WS600-UMB on 1-m mast mounted to radiometer: <ul style="list-style-type: none"><li>• temperature, pressure, relative humidity</li><li>• wind speed, wind direction, rain rate</li></ul>
Data interface / rate	Ethernet (TCP/IP)
Instrument control (external PC)	Windows™ System with Ethernet interface
Instrument control (internal)	Embedded PC, controls all internal calibrations, data acquisition, data file backup on 10 GB flash memory, control of azimuth positioner, communication with host, can run measurements independently from host PC
Housekeeping data	Detailed instrument status information, including health checks, quality flags, calibration history and log files
Retrieval algorithms	Neural Network algorithms
Optical resolution	HPBW (frequency dependent): 3.0° - 4.2° for water vapour, 1.8° - 2.2° for temperature profiler
Side-lobe level	< -30 dBc
Pointing range / resolution	Elevation: 0° to 180° (0.15° steps), full s/w control Azimuth (optional): 0° to 360° (0.1° steps), full s/w control
Pointing speed	45°/sec (elevation), 40°/sec (azimuth, optional)
Operating temperature range	-40°C to +45°C
Power consumption	< 120 Watts average, 350 Watts peak for warming-up (without dew blower heater), blower: 130 Watts max.
Lightning protection	Power line: circuit breakers Data line: Fibre optics cable (max. length: 1400 m)
Input voltage	90-230 V AC, 50 to 60 Hz
Weight	60 kg (without dew blower)
Dimensions	63 × 36 × 90 cm <sup>3</sup>