

### Microwave Scintillometer RPG-MWSC-160

### **RPG-MWSC-160**

Radiometer Physics GmbH (RPG) released the first commercially available microwave scintillometer RPG-MWSC-160. It is designed for combined operation with an optical Large Aperture Scintillometer (LAS) to simultaneously observe sensible and latent heat fluxes.

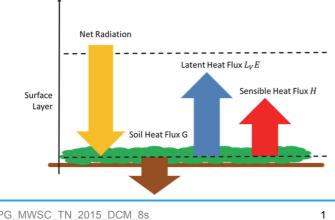


# **Applications**

Measurement of sensible heat flux H and evapotranspiration (latent heat flux  $L_V E$ ) significant for:

- Irrigation
- Water management
- Hydrology
- Forest fire warning
- Weather forecasting
- Radiation budget studies







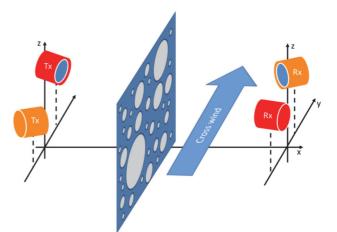
RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany 09/2015 +49 (0) 2225 99981 – 0 www.radiometer-physics.de remotesensing-sales@radiometer-physics.de

All data and specifications are subject to change without notice!  $\ensuremath{\mathbb{C}}$  Radiometer Physics GmbH 2015



## Concept

- Transmit / receive system
- Transmitter: constant signal
- Receiver: observes fluctuations
- Information Content: Turbulence modulates the refractive index of air, leading to intensity fluctuations
- Combination of microwave (RPG-MWSC-160) and infrared signal (LAS) frequencies allows simultaneous determination of sensible and latent heat fluxes.

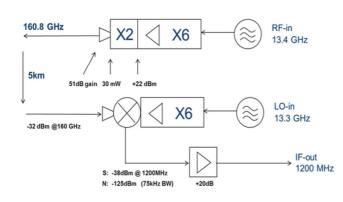


Setup of combined **MWS** and **LAS** system with crossing signal beams. The turbulence field is shifted through the beams by the mean wind across the measurement path.

## Design

The RPG-MWSC-160 prototype was developed by RPG and Wageningen University (The Netherlands) within the OMS (Optical and Microwave Scintillation) project. The RPG-MWSC-160 uses hardware developments from space projects.

- High frequency (160.8 GHz) for good co-spectrum with LAS
- Large aperture (300 mm) provides small beam width
- Tuneable power level (max. >25 mW) allows path length between 500 m and 10 km
- Low weight (~10 kg) and power consumption (~20 W)





RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany 09/2015 +49 (0) 2225 99981 – 0 www.radiometer-physics.de remotesensing-sales@radiometer-physics.de

2

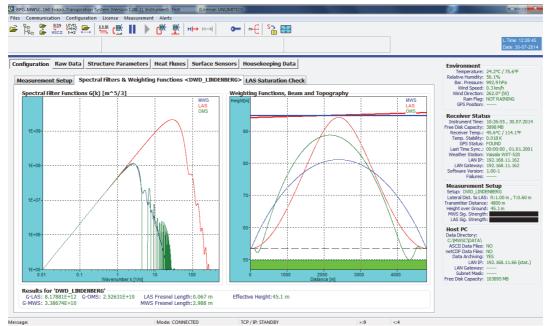


## **Operating Software**

The RPG-MWSC-160 comes with a comprehensive operating software package [2]. The software synchronously digitizes the microwave and optical raw signals. Complete data processing from raw signals to heat fluxes is performed **online**. All data products are continuously displayed on the screen and automatically stored.

RPG-MWSC-160 Evapo-Transpiration System (Version 1.00-1), Instrument: Test     (License: UNL	IMITED)	
Files Communication Configuration License Measurement Alerts		
🖻 🏗 🚼 👯 💭 🙀 🔛 🔛 🔛 👘 🕅 🕨	••••   H•-E   S 🚡 🕕	
		L.Time: 12:28:46 Date: 30-07-2014
Configuration Raw Data Structure Parameters Heat Fluxes Surface Sense	Housekeeping Data	Environment Temperature: 24.2°C / 75.6°F
Measurement Setup Spectral Filters & Weighting Functions < DWD_LINDENB	ERG> LAS Saturation Check	Relative Humidity: 55.8% Bar, Pressure: 992.9 hPa
	MWSC	Wind Speed: 0.4 km/h
z † T(ransmitters) R(eceivers) †z	Type: RPG-MWSC-160 V	Wind Direction: 19.0° (NNE) Rain Flag: NOT RAINING
ZTM (WSC)	Wavel.:1860 µm Aperture:0.30 m	GPS Position:
	Height Above Ground	Receiver Status Instrument Time: 10:28:56, 30.07.2014
	zTM: 45.00 m zRM: 45.00 m	Free Disk Capacity: 3898 MB
	LAS	Receiver Temp.: 45.6°C / 114.1°F Temp. Stability: 0.015 K
Topography 1/1v	Type: Wageningen LAS 🔹	GPS Status: FOUND Last Time Sync.: 00:00:00, 01.01.2001
Ground	Wavel.:0.940 µm Aperture:0.15 m	Weather Station: Vaisala WXT-520 LAN IP: 192.168.11.162
	Height Above Ground zTL: 44.40 m zRL: 46.00 m	LAN Gateway: 192.168.11.162
GPS / + + + + + + + + + + + + + + + + + +		Software Version: 1.00-1 Failures:
x1 x2 x3 x4 x5 x6 x7 x8 x9 x10 Topography (z = GPS Heights)	Y-Displacement yTL: 0.00 m yRL: 0.00 m	Measurement Setup
	yrc: 0.00 m yrc: 0.00 m	Setup: DWD_LINDENBERG Lateral Dist. to LAS: R:1.00 m , T:0.60 m
Orient. rel. to North (CW): 0° Surf. Roughn.: 0.3 m	Setup Handling	Transmitter Distance: 4800 m Height over Ground: 45.1 m
x1 x2 x3 x4 x5 x6 x7 x8 x9 x10	Current Setup: Browse	MWS Sig. Strength:
x [m] 0 500 1000 1500 2000 2500 3000 3500 4000 4800	DWD_LINDENBERG	LAS Sig. Strength:
z[m] 50 50 50 50 50 50 50 50 50 50 50 50	New Entry Name:	Host PC Data Directory:
Data Storage Options	Add Delete Overwrite	C:\MWSC\DATA\ ASCII Data Files: NO
Scintillometer Host PC	Aug Delete Overwrite	netODF Data Files: NO Data Archiving: YES
Variances (*.VAR) Raw Data (*.RAW) Fluxes (*.FLX)		LAN IP: 192.168.11.66 (stat.)
Variances (*.VAR) Variances (*.VAR)	Calc. Time: Cancel	LAN Gateway: Subnet Mask:
		Free Disk Capacity: 103895 MB
Marca Comparison	TCD (TD CTANDDY	4 2000

User interface for setup of a combined optical / microwave system.



Left: Spectral weighting functions [1]. Right: Path weighting functions and effective height.

 RPG\_MWSC\_TN\_2015\_DCM\_8s
 3
 09/2015

 RPG Radiometer Physics GmbH
 +49 (0) 2225 99981 – 0

 Werner-von-Siemens-Str. 4
 www.radiometer-physics.de

 53340 Meckenheim, Germany
 remotesensing-sales@radiometer-physics.de

 All data and specifications are subject to change without notice! © Radiometer Physics GmbH 2015



### Field Observations

The prototype of the RPG-MWSC-160 was successfully tested in two extended field campaigns in Sonora (Mexico) and Lindenberg (Germany). RPG-MWSC-160 was operated in combination with different optical LAS systems.

#### Sonora, Mexico

RPG-MWSC-160 was operated in combination with two different LAS systems across an irrigated sub-tropical crop field in Sonora (Mexico). The experiment characterized by short path length and low observation height over a flat and homogeneous surface. During the day Bowen ratios are usually smaller than 1, i.e. the latent heat flux is dominating.



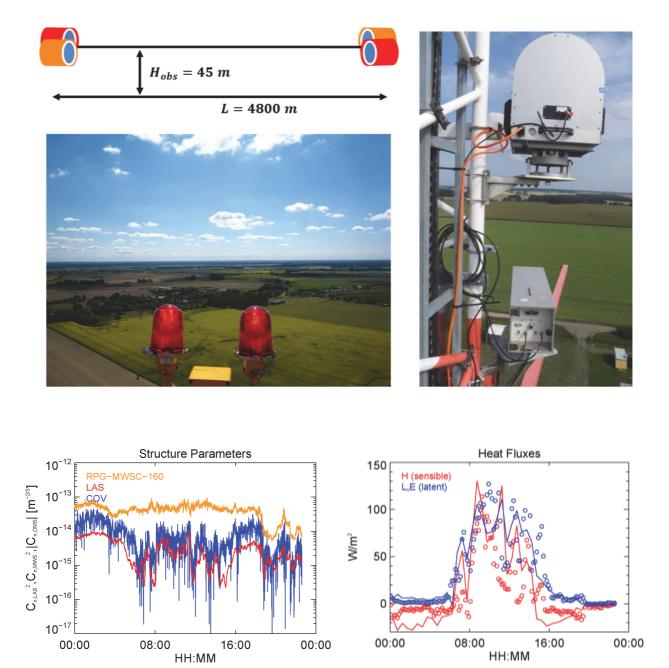
#### Lindenberg, Germany

RPG-MWSC-160 was tested in mid-latitude continental climate. It was operated in combination with two LAS systems (Wageningen University and Scintec BLS900) over a long signal path between two measurement towers with an observation height of approximately 45 m. The setup is characterized by inhomogeneous landscape with patches of woodland, lakes and crops. The combined scintillometer measurements provide heat fluxes with a Bowen ratio around 1. Measurements are in good agreement with Eddy-Covariance (EC) station data.

RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany 4



### Microwave Scintillometer RPG-MWSC-160



Measurement time series for a long path over heterogeneous landscape (September 8, 2013, Germany). Left: refractive index structure parameters for **RPG-MWSC-160**, optical **LAS**, and for the signal covariance (**COV**) of both instruments (combined optical / microwave method, Lüdi et al. [1]). Right: estimates of path integrated **sensible heat flux H** and **latent heat flux L**<sub>V</sub>E. Circles give measurements from an Eddy Covariance station (EC).

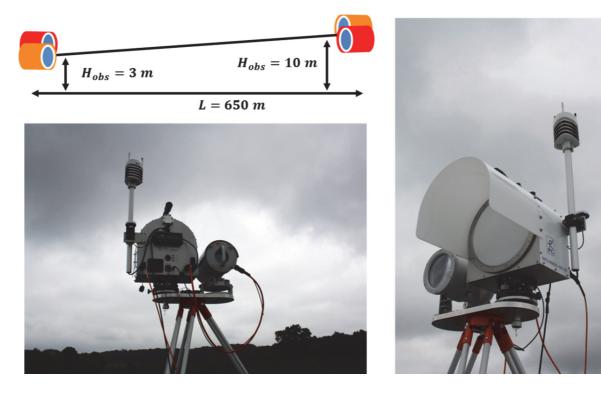
RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany

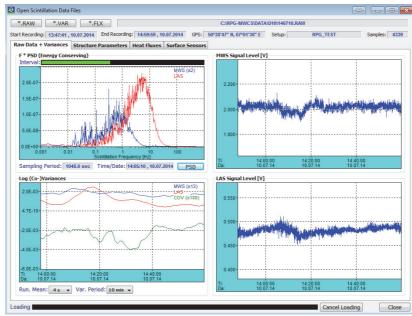


### Microwave Scintillometer RPG-MWSC-160

#### Meckenheim, Germany

In July 2014 the re-design of the RPG-MWSC-160 prototype was tested in combination with a LAS (Kipp&Zonen Mk-II) and RPG's operating software. Data processing now includes surface sensor data from the integrated external weather station (Vaisala WXT 520). A one hour time series of heat fluxes under variable cloudiness is given below. Observations were performed over a dry rapeseed field.



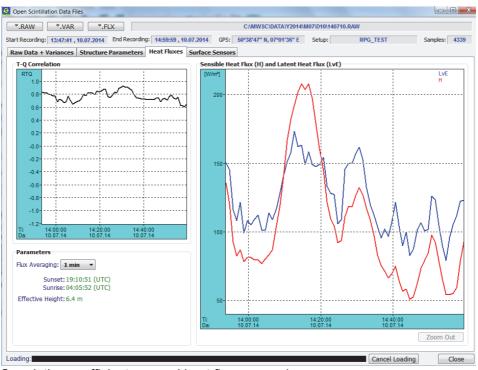


Power spectra, raw signals and variances are continuously displayed.

6

RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany 09/2015 +49 (0) 2225 99981 – 0 www.radiometer-physics.de remotesensing-sales@radiometer-physics.de



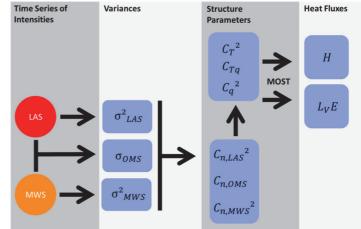


#### Correlation coefficient $R_{TO}$ and heat fluxes **H** and $L_V E$ .

### **Data Processing**

- Data Processing following Lüdi et al. [1] (see instrument manual [2] for details):
  - Calculate signal MWS and LAS variances and covariance between the signals
  - Triple of variances  $\Rightarrow$  structure parameters of refractive index ( $C_n^2$ ).
  - Read surface sensors from integrated weather station.
  - Apply Monin-Obukhov Similarity Theory (MOST)  $\Rightarrow$  heat fluxes H and  $L_V E$ .
  - Available data formats: – Signal (co)variances
  - Structure parameters
  - Correlation coefficient  $R_{TO}$

  - Heat fluxes H,  $L_V E$ .
  - Weather station data
  - Housekeeping data



RPG\_MWSC\_TN\_2015\_DCM\_8s RPG Radiometer Physics GmbH Werner-von-Siemens-Str. 4 53340 Meckenheim, Germany 09/2015 +49 (0) 2225 99981 – 0 www.radiometer-physics.de remotesensing-sales@radiometer-physics.de

7



# **Specifications**

Paramete	arameter Specification		
Frequency	quency 160.8 GHz (λ=1.86 mm)		
Radiated power ma		maximum power: >25 mW, 50 dB attenuator	
Antenna type	•	Cassegrain with 300 mm aperture	
Antenna gain 52 dB		52 dB	
Beam width		0.45° FWHM	
Detection bar	ndwidth	10 kHz	
Gain stability		> 2.0 × 10 <sup>-5</sup>	
Temperature stability <		< 0.03 K (two-stage control)	
Power supply		12 V DC	
Power consumption		max. 50 W (per unit), 20 W typical (receiver), 15 W typical (transmitter)	
	Level 0	<ul> <li>1 kHz digital raw data for RPG-MWSC-160 and LAS</li> <li>housekeeping data.</li> </ul>	
Output data	Level 1	(co)variances of the combined optical / microwave system.	
	Level 2	<ul> <li>structure parameters C<sub>n</sub><sup>2</sup></li> <li>sensible and latent heat fluxes H, L<sub>V</sub>E</li> </ul>	
Type of installation		Line of sight Tx/Rx system (transmit / receive)	
Baseline leng	gth	500 m to 10 km	

### References

[1] A. Lüdi, F. Beyrich, and C. Mätzler, "Determination of the Turbulent Temperature– Humidity Correlation from Scintillometric Measurements", *Bound.-Layer Meteorol.*, vol. 117, no. 3, pp. 525–550, Dec. 2005.

[2] RPG-MWSC-160-Instrument Manual, "Installation, Operation and Software Guide", RPG Radiometer Physics GmbH, ftp://ftp.radiometer-physics.de/pub/Radiometer/Manuals/