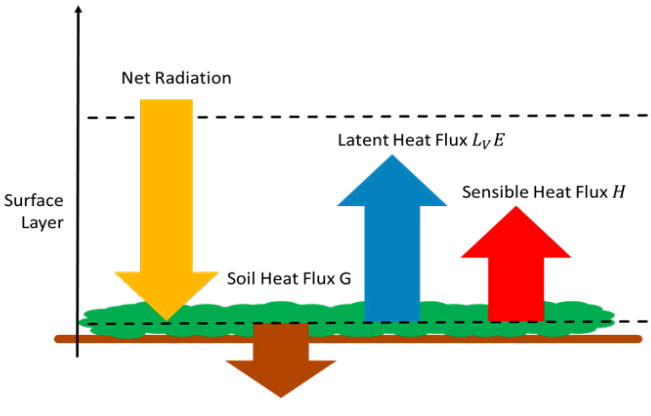
RPG-MWSC-160

Radiometer Physics GmbH (RPG) offers the only 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

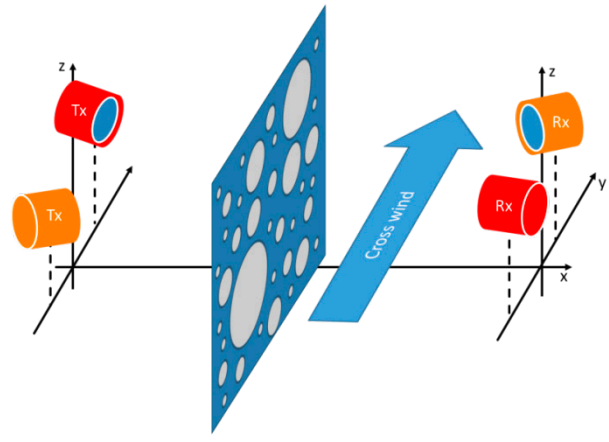
Measurement of sensible heat flux H and evapotranspiration (latent heat flux L_vE) significant for:

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



Concept

- Transmit / receive system:
  - Transmitter: continuous 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.

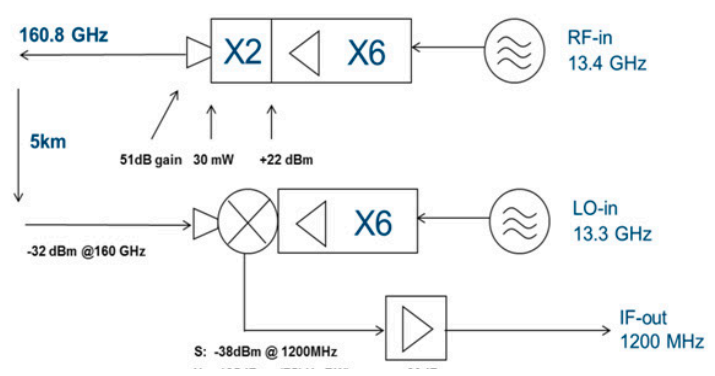


*Setup of combined **MWS** and **LAS** system with crossing signal beams. The turbulence field is shifted through the beams by the mean wind across the measurement path.*

Design

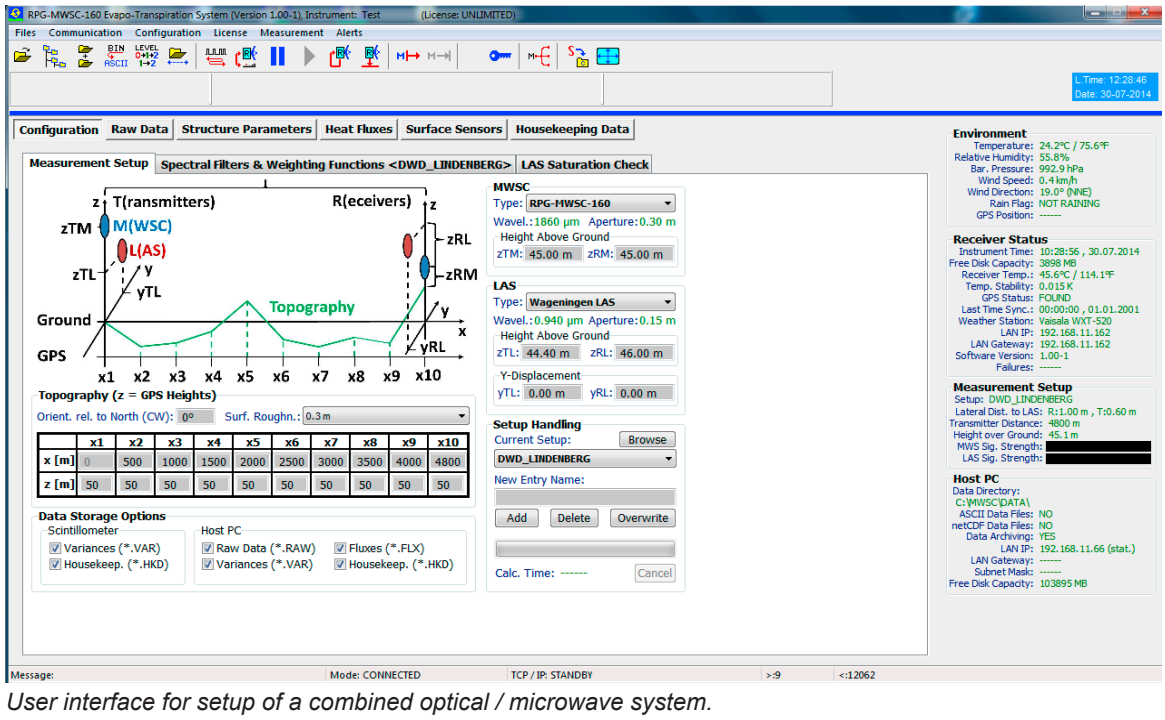
The RPG-MWSC-160 prototype was developed by RPG and Wageningen University (The Netherlands) within the OMS (Optical and Microwave Scintillation) project. The RPG-MWSC-160 uses hardware developments from space projects.

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

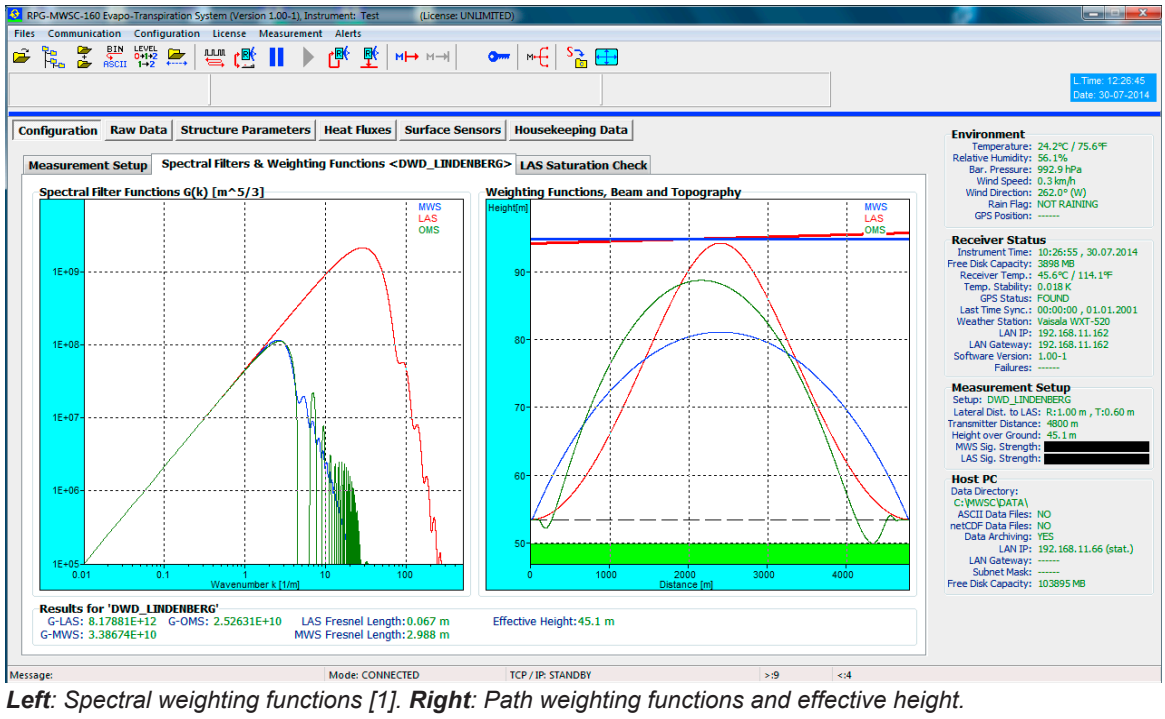


Operating Software

The RPG-MWSC-160 comes with a comprehensive operating software package *[2],* which processes the synchronously digitized microwave and optical raw signals. The complete data processing from raw signals to heat fluxes is performed in **real-time**. All data products are continuously displayed on the screen and automatically stored.



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



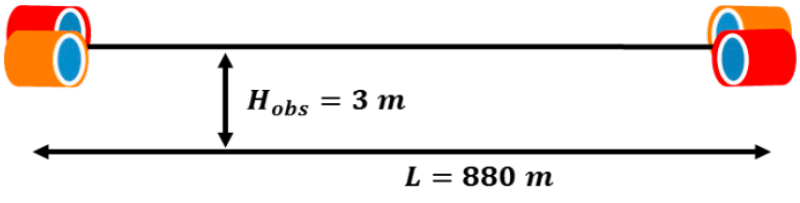
***Left**: Spectral weighting functions [1]. **Right**: Path weighting functions and effective height.*

Field Observations

The RPG-MWSC-160 was successfully operated in combination with different optical LAS systems within two comprehensive field campaigns in Sonora (Mexico) and Lindenberg (Germany).

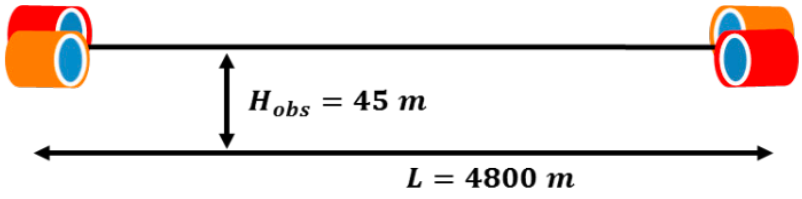
Sonora, Mexico

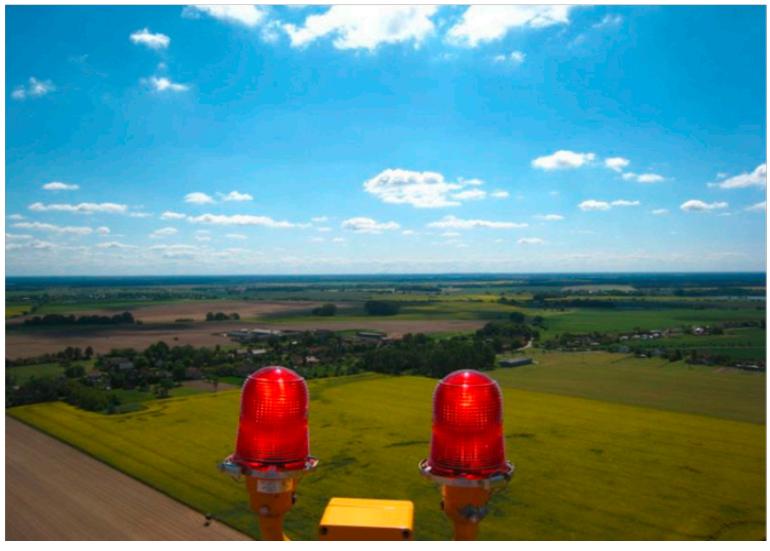
RPG-MWSC-160 was operated in combination with two different LAS systems across an irrigated sub-tropical crop field in Sonora (Mexico). The experiment was characterized by a short path length and a low observation height over a flat and homogeneous surface. During the day, Bowen ratios were usually smaller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

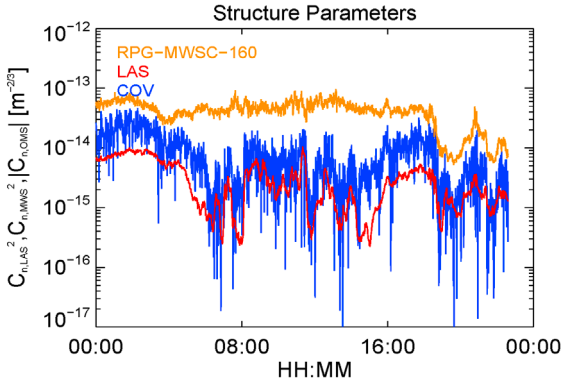


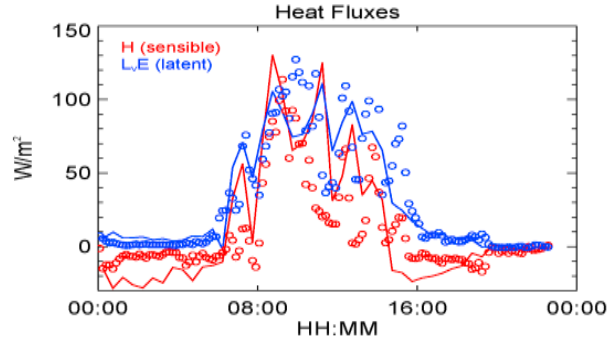
Lindenberg, Germany

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





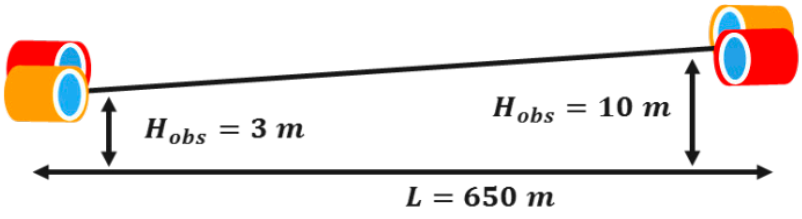


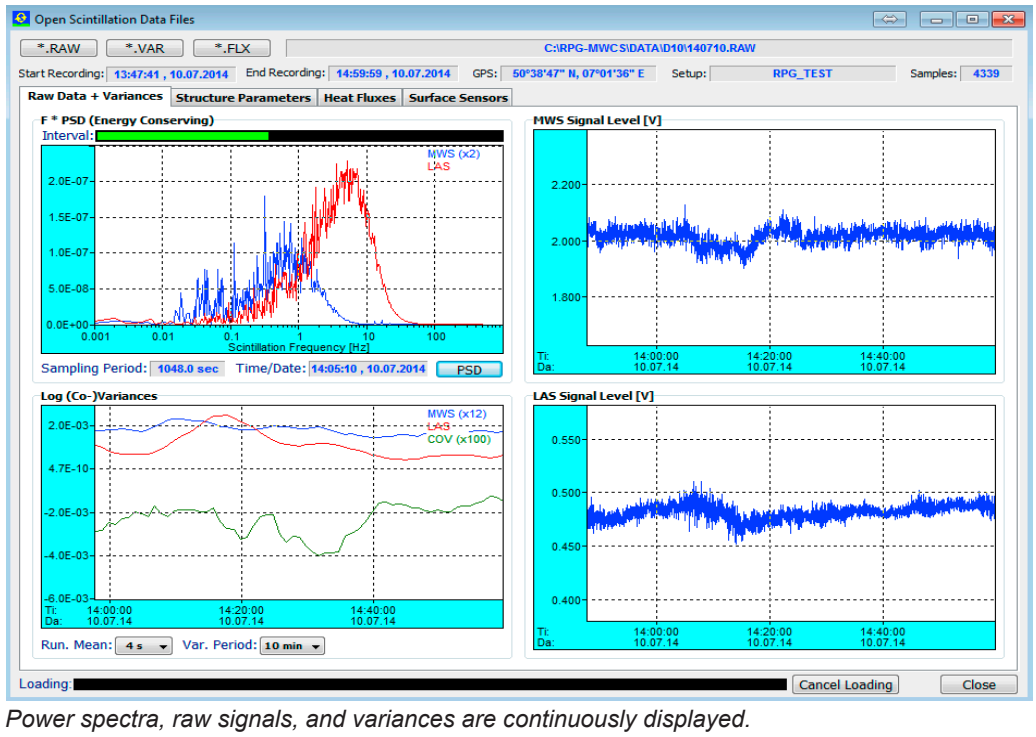


*Measurement time series for a long path over heterogeneous landscape (September 8, 2013, Germany). Left: refractive index structure parameters for **RPG-MWSC-160**, optical **LAS**, and for the signal covariance (**COV**) of both instruments (combined optical / microwave method, Lüdi et al. [1]). Right: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

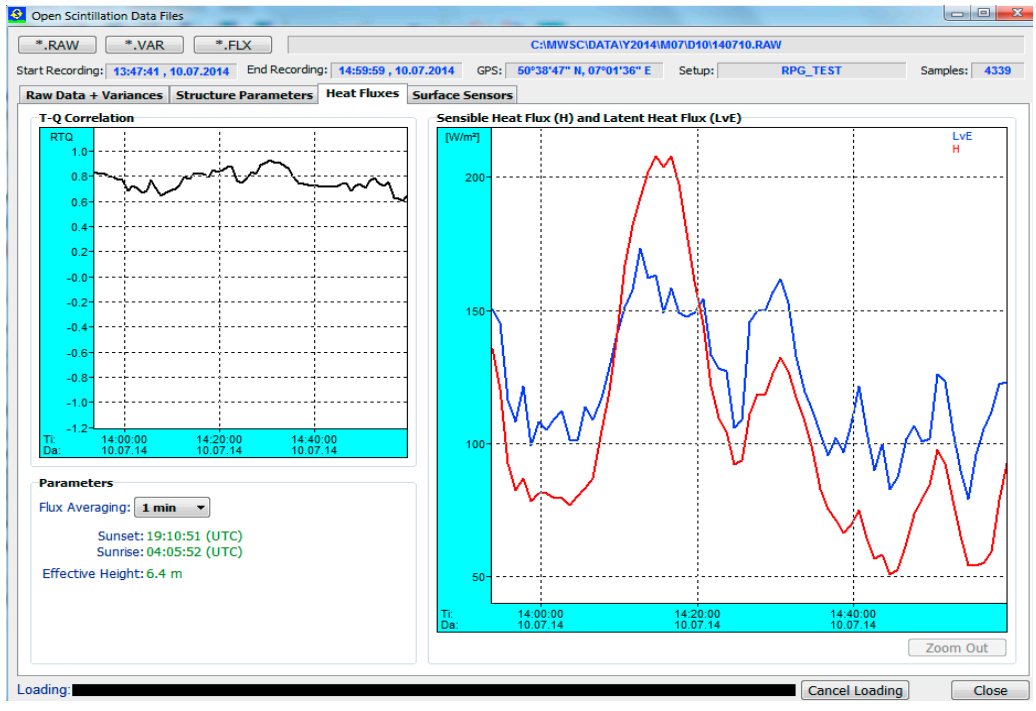
Meckenheim, Germany

In July 2014 the RPG-MWSC-160 was tested in combination with a LAS (Kipp&Zonen Mk-II) and RPG's operating software. Data processing included surface sensor data from the integrated 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.





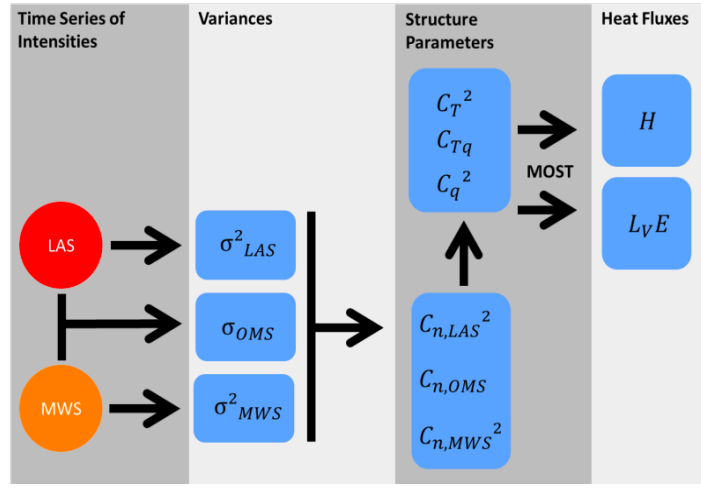
Power spectra, raw signals, and variances are continuously displayed.



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 ⇒ structure parameters of refractive index (C_n^2).
  - Read surface sensors from integrated weather station
  - Apply Monin-Obukhov Similarity Theory (MOST) ⇒ Heat fluxes H and L_vE.

- Available data formats:
  - Signal (co)variances
  - Structure parameters
  - Correlation coefficient R_{TQ}
  - **Heat fluxes** H, L_vE
  - Weather station data
  - Housekeeping data



Specifications

Parameter		Specification
Frequency		160.8 GHz (λ=1.86 mm)
Radiated power		maximum power: < 25 mW, 50 dB attenuator
Antenna type		Cassegrain with 300 mm aperture
Antenna gain		52 dB
Beam Width		0.45° FWHM
Detection bandwidth		10 kHz
Sensitivity		2.0 x 10^{-5}
Temperature stability		< 0.03 K (two-stage control)
Power supply		10.8 - 13.2 V DC
Power consumption		max. 60 W (per unit), 20 W typical (Rx), 15 W typical (Tx)
Output data	Level 0	• 1 kHz digital raw data for RPG-MWSC-160 and LAS • housekeeping data
	Level 1	(co)variances of the combined optical / microwave system.
	Level 2	• structure parameters C_n^2 • sensible and latent heat fluxes H, L_vE
Type of installation		Line of sight Tx/Rx system (transmit / receive)
Baseline length		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, “Operation & Software Guide”, RPG Radiometer Physics GmbH, http://www.radiometer-physics.de/download/PDF/Scintillometer/RPG-MWSC-160_Instrument_Manual_2018.pdf