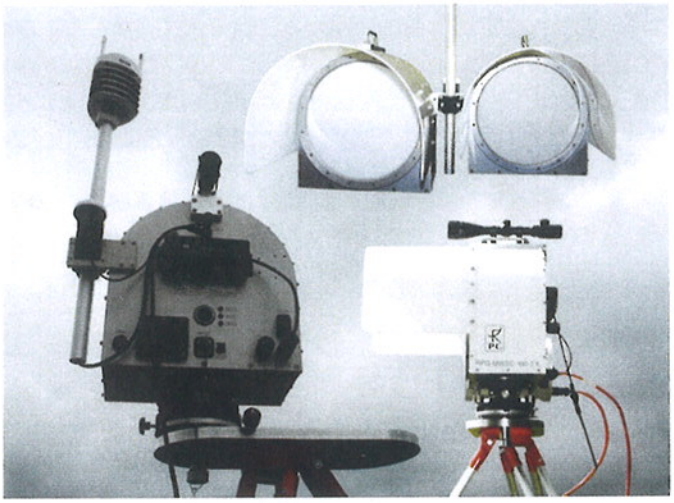
RPG-MWSC-160

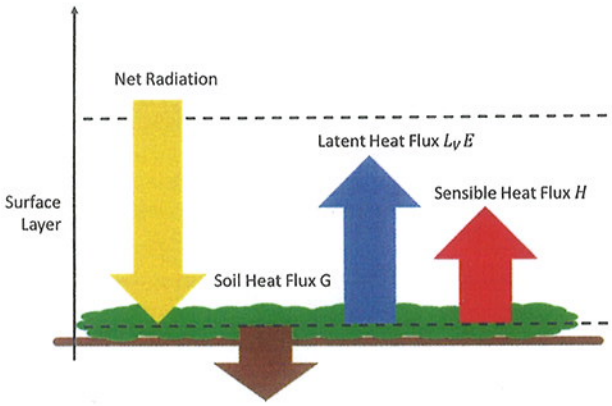
In 2014 Radiometer Physics GmbH (RPG) released the first commercially available microwave scintillometer RPG-MWSC-160. It was designed for combined operation with an optical Large Aperture Scintillometer (LAS) to observe sensible and latent heat fluxes at the same time.



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



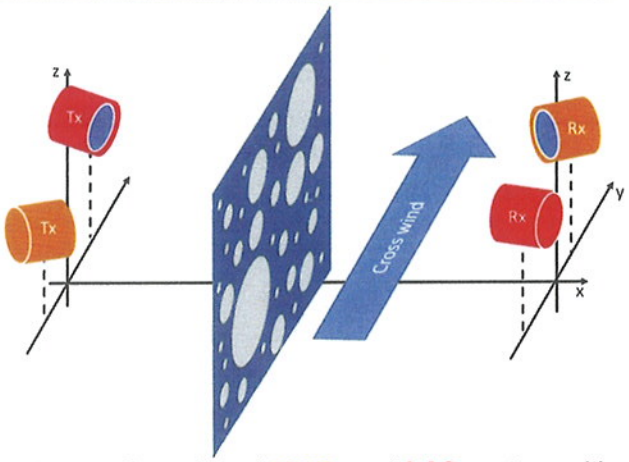
Concept

- Transmit / receive system

– Transmitter: constant signal
– Receiver: observes fluctuations

- Information Content: Turbulence modulates the refractive index of air, which leads 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

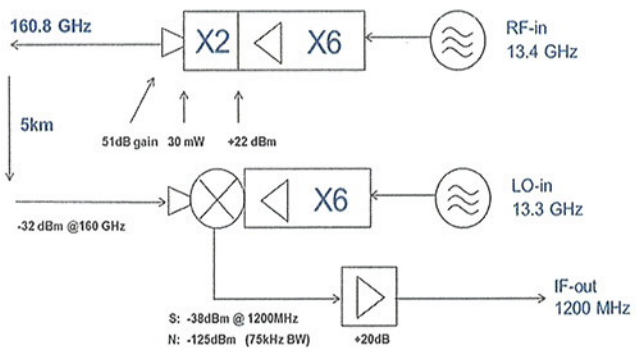
The RPG-MWSC-160 prototype was developed by RPG and Wageningen University (The Netherlands) within the OMS (Optical and Microwave Scintillation) project. The RPG-MWSC-160 uses hardware developments from space projects.

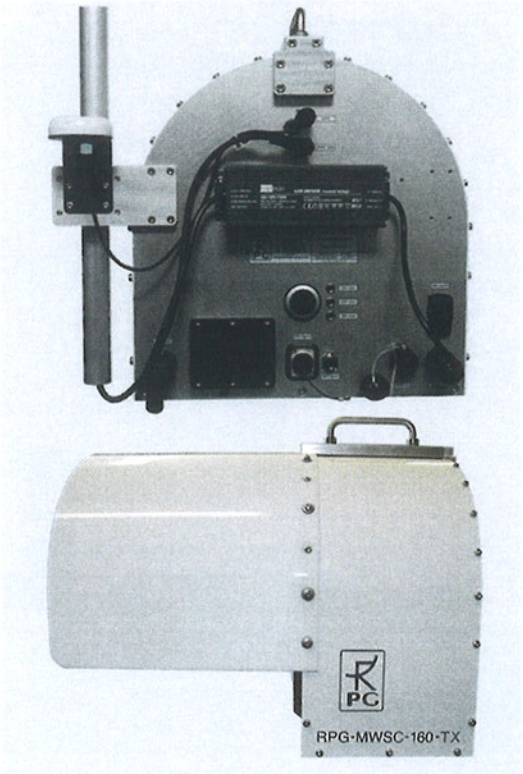
- High frequency (160.8 GHz) for good co-spectrum with LAS

- Large aperture (30 mm) provides small beam width

- Tunable power level (max. >25 mW) allows path length between 500 m and 10 km

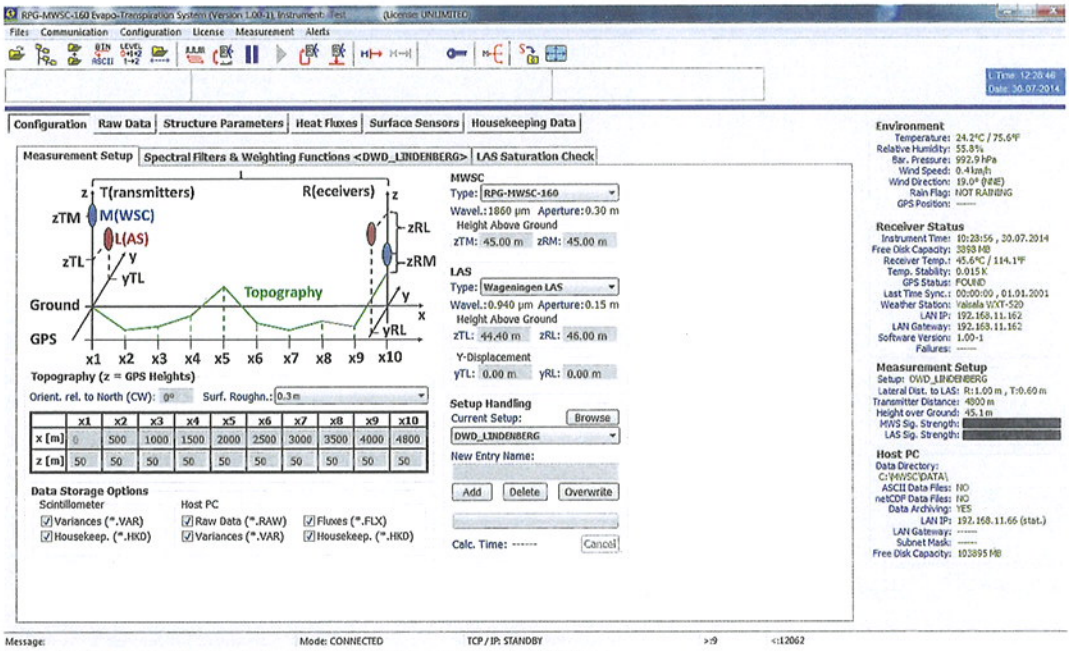
- Low weight (~10 kg) and power consumption (~20 W)



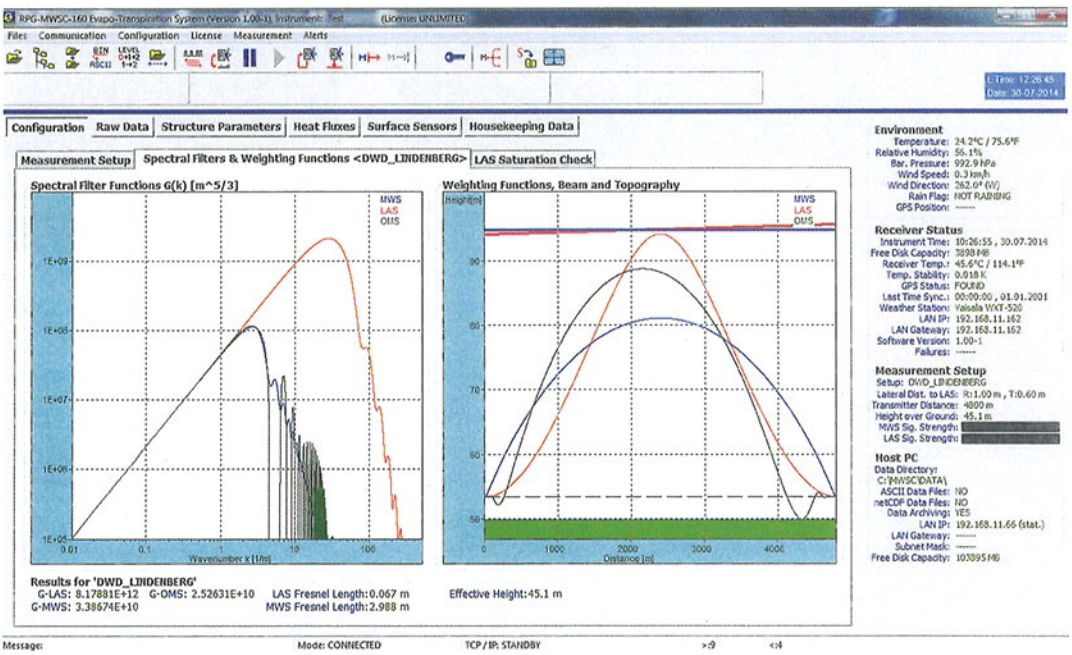


Operating Software

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.



User interface for setup of a combined OMS system.



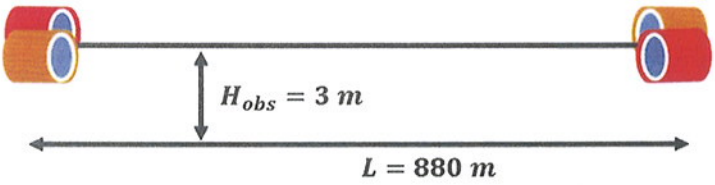
left: Spectral weighting functions [1], **right**: Path weighting functions and effective height.

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.

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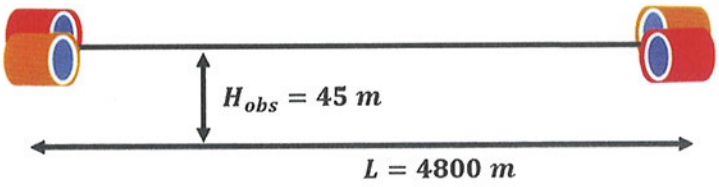

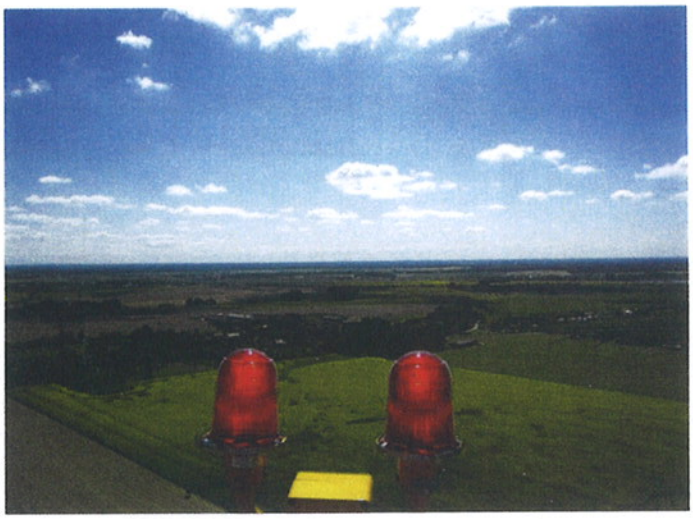

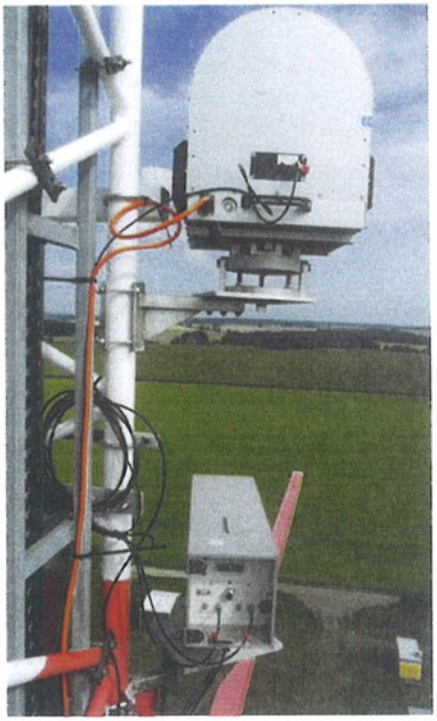

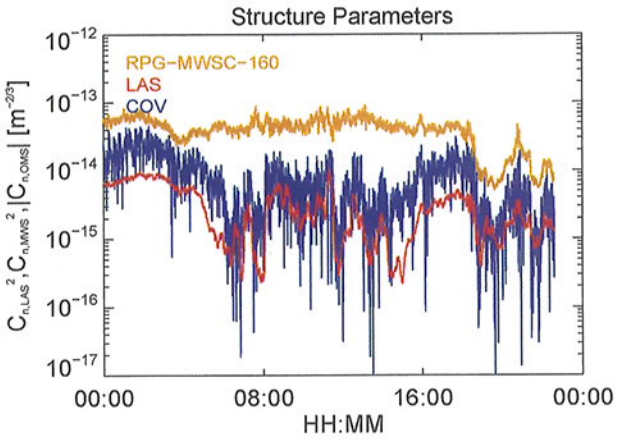

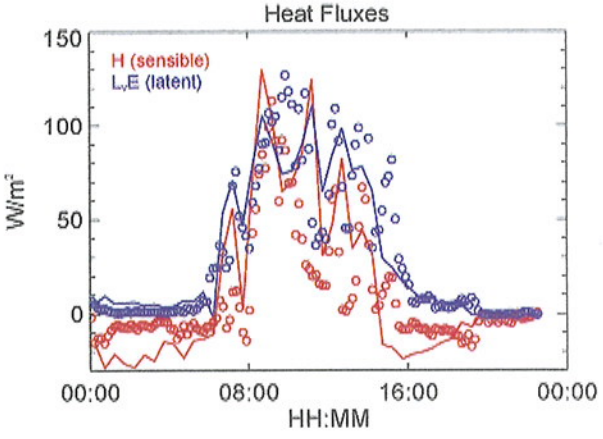

*Measurement time series for a long path over heterogeneous landscape (September 8, 2013, Germany). Left: refractive index structure parameters for **RPG-MWSC-160**, optical **LAS**, and for the signal covariance (**COV**) of both instruments (OMS method, Lüdi et al. [1]). Right: estimates of path integrated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

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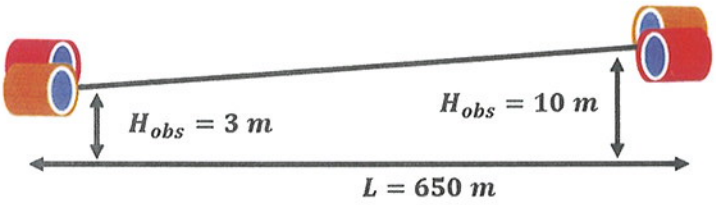
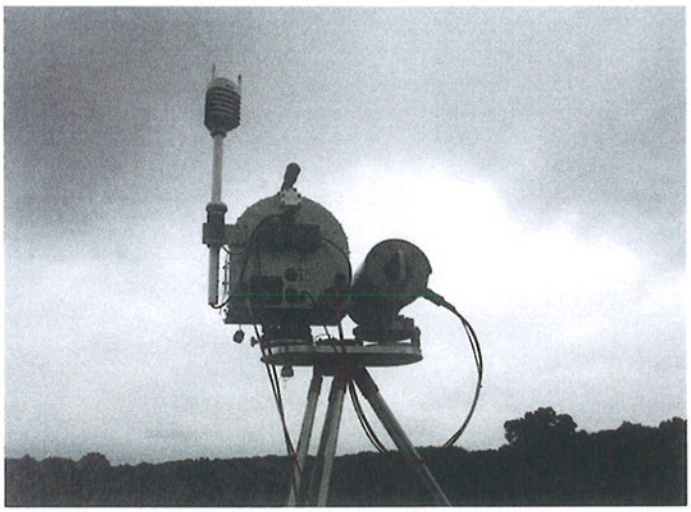
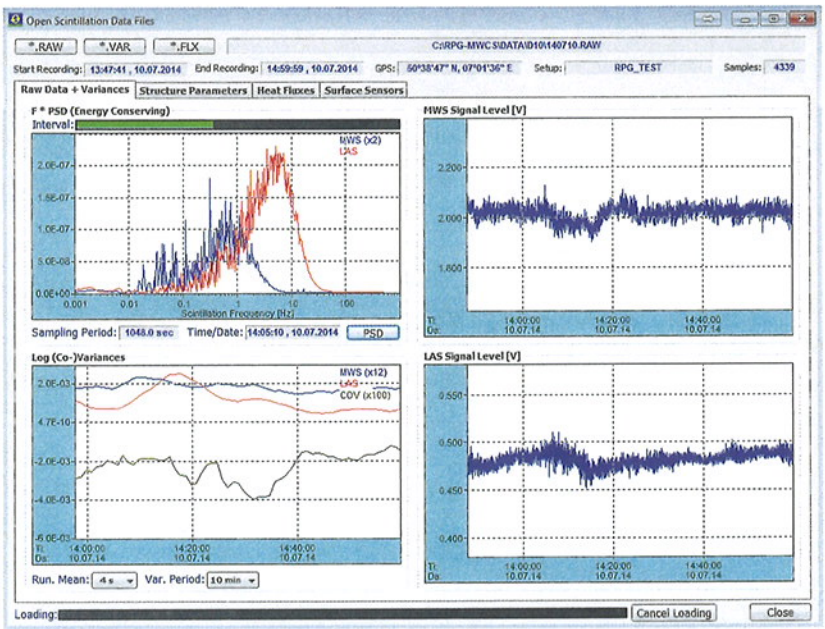
In July 2014 the re-design of the RPG-MWSC-160 prototype was tested in combination with a LAS (Kipp&Zonen Mk-II) and RPG's operating software. Data processing now includes surface sensor data from the integrated external weather station (Vaisala WXT 520). A one hour time series of heat fluxes under variable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







Power spectra, raw signals and variances are continuously displayed.

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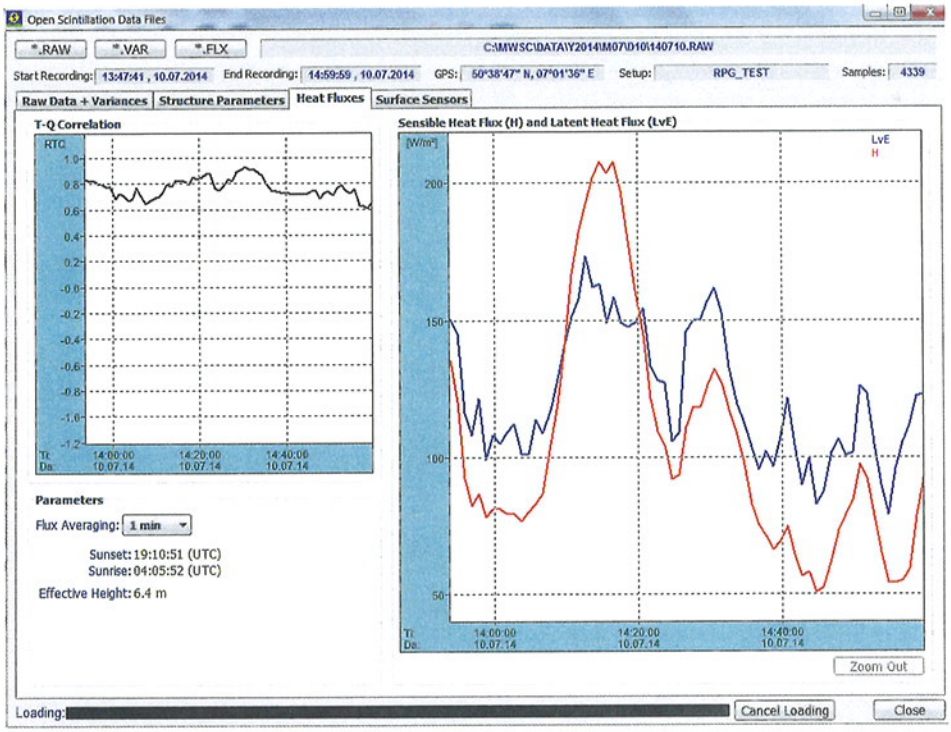
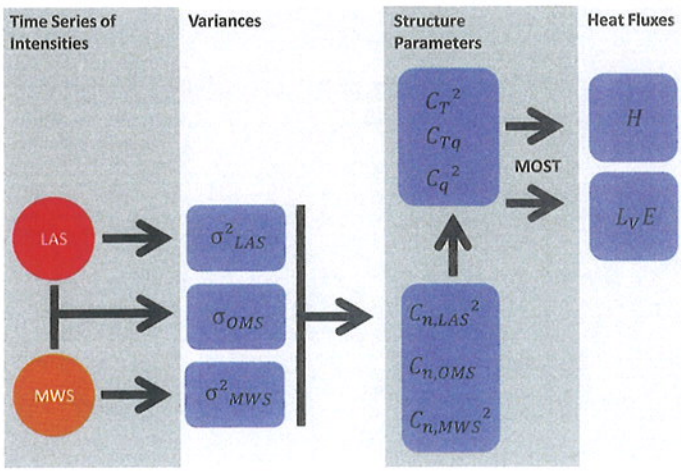


Correlation coefficient R_{TQ} and heat fluxes $\boldsymbol{H}$ and $\boldsymbol{L_V E}$.

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 ⇒ 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 $L_V E$.

- Available data formats:
  - Signal (co-)variances
  - Structure parameters
  - Correlation coefficient R_{TQ}
  - **Heat fluxes $\boldsymbol{H}$, $\boldsymbol{L_V E}$.**
  - 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
Gain stability		> 2.0×10^{-5}
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)
Output data	Level 0	• 500 Hz digital raw data for RPG-MWSC-160 and LAS • housekeeping data.
	Level 1	• (co)variances of the combined OMS system.
	Level 2	• structure parameters C_n^2 • sensible and latent heat fluxes H, $L_V E$ (with weather station)
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, "Installation, Operation and Software Guide", RPG Radiometer Physics GmbH, ftp://ftp.radiometer-physics.de/pub/Radiometer/Manuals/