Where the Tower Meets its Shadow

Micrometeorological Measurements in Gobabeb

Probing the Surface Energy Balance

Scientific Background

The knowledge of the surface energy balance is important for weather and climate models. Around one third of the Earth's land surfaces are deserts (hyper- to semi-arid). In contrast, long-term measurements of the components of the surface energy balance are rare. The main purpose of the research MCR carries out in Gobabeb is to close this gap and to contribute to the understanding of the micrometeorology/-climatology of such exceptional environments.

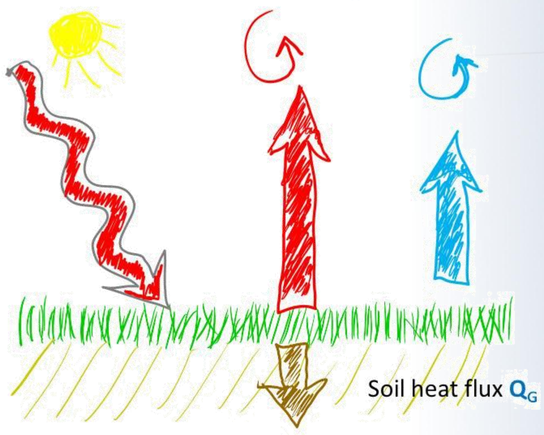
Surface Energy Balance

At the Earth's surface, the simplified energy balance equation can be written as

$$Q^* + Q_G = Q_H + Q_E$$

where Q^* is the net radiation, the remaining amount of energy from the radiation balance. The soil heat flux Q_G is the part of the energy "flowing" into (out of) the soil during day (night). Q_H the turbulent sensible heat flux directed upward during daytime (warming the air). Q_E is the turbulent latent heat flux which corresponds do the flux of water vapor (up: evaporation, down: condensation). The left hand side can be regarded as the available energy which is partitioned into the turbulent heat fluxes on the right hand side.

Net radiation Q^* Sensible heat flux Q_H Latent heat flux Q_E

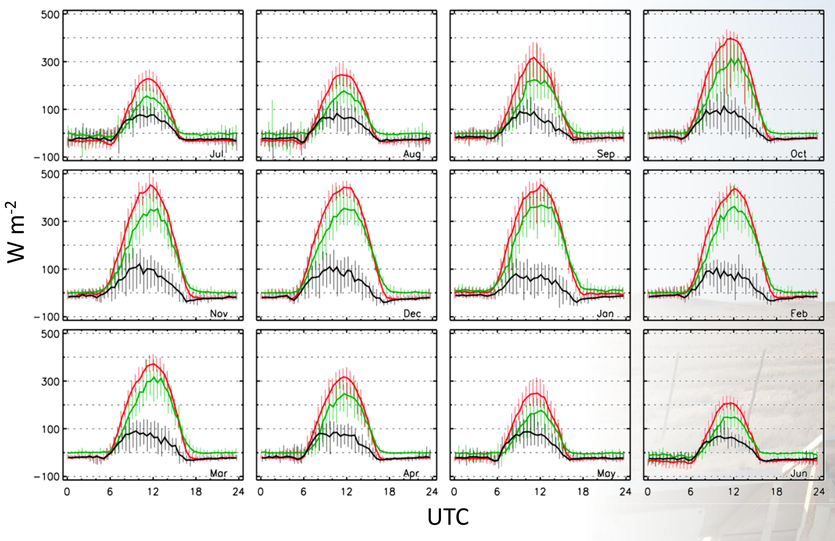


Instruments From MCR

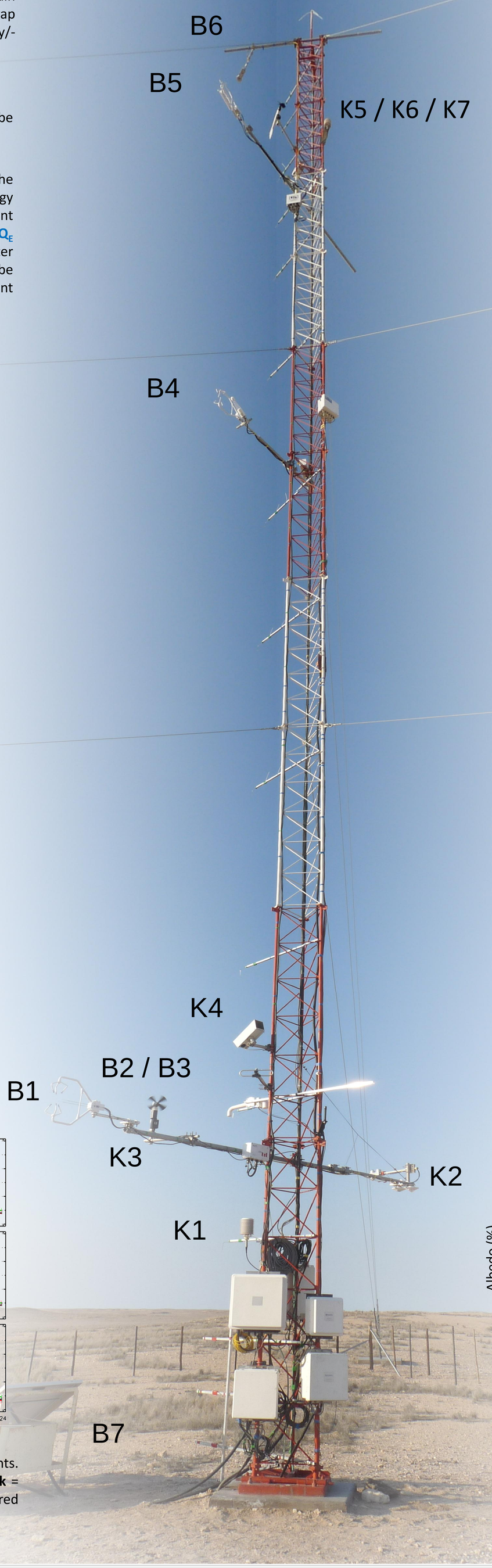
	Height (m)	Quantity	Manufacturer/Type
B1	3.3	Wind vector, acoustic temperature	Campbell sonic CSAT3
B2	3.6	Aspirated air temperature	Ventilated thermocouple
B3	18 levels	Temperature profile	Thermocouples
B4	14.5	Wind vector, temperature CO_2/H_2O concentration	Campbell sonic CSAT3 LiCOR open path gas analyzer Li7500
B5	23.5	Wind vector, temperature CO_2/H_2O concentration	Campbell EC150 Sonic CSAT3, open path gas analyzer EC100
B6	30	Radiation balance	Kipp & Zonen CNR4
B7	-0.02, -0.05, -0.1, -0.2, -0.5, -1.0	Soil temperature profile	UMTS TH3
B7	-0.04	Soil heat flux	Hukseflux HFP01SC (2) REBS HFT3 (3)
B7	-0.02	Soil temperature	Campbell T107 (3)

Measurements started 09/09. B4 from 03/11 to 11/12. B5 started 07/12 and replaces B4. B3 is temporary (07/12-11/12).

First Example



Mean monthly diurnal courses of the surface energy balance components. **Red** = available energy (Q^*+Q_G). **Green** = sensible heat flux (Q_H). **Black** = residual term. Until March 2011 latent heat flux was not measured directly and was assumed to be negligible.



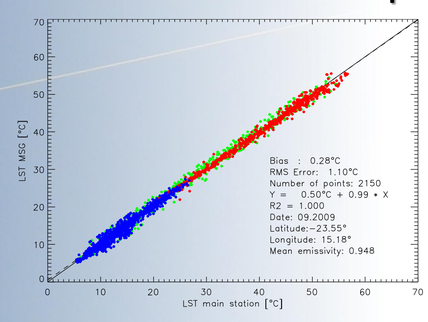
Probing Surface Temperatures

Scientific Background

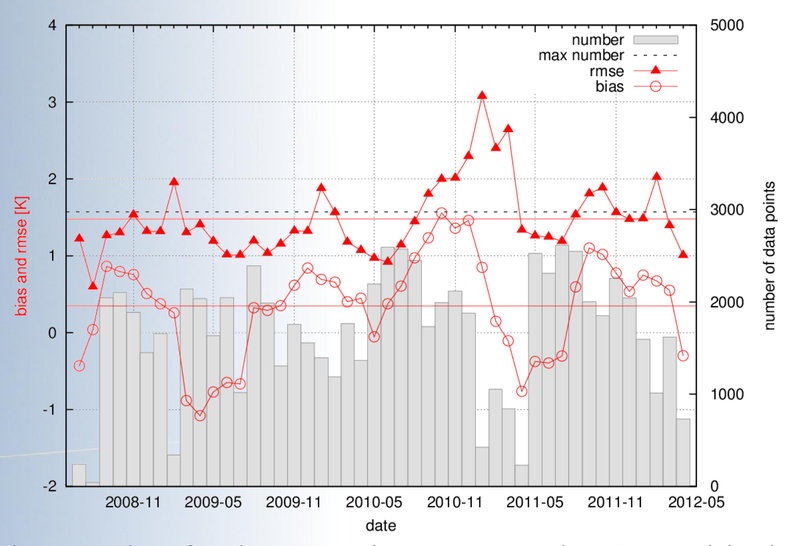
Land surface temperature (LST) is an important parameter of the surface energy budget; together with surface emissivity, it determines upward thermal radiation and is closely connected to sensible and latent heat fluxes between surface and atmosphere. Thus, a reliable and long-term estimation of LST is extremely important for a wide range of applications, including model validation, data assimilation, hydrological applications and climate monitoring.

LST is an operational satellite product of the 'Land Surface Analysis – Satellite Application Facility (LSA SAF)'. As a contribution to this project, Karlsruhe Institute of Technology (KIT) operates four long term LST validation stations: of these, Gobabeb is the only station representing the deserts within the field of view of Meteosat Second Generation (MSG). Gobabeb station LST are derived from measured up-welling and down-welling radiances and the quasi-static land surface emissivity of the gravel plains, which was determined with high accuracy during field experiments.

Land Surface Temperature from Satellite



The plot shows LST obtained for the MSG satellite vs. Gobabeb main station LST for September 2009 (2150 valid data pairs). Colors relate to morning, afternoon and night. The data were matched to within one minute: the small bias & RMSE demonstrate the excellent quality of the satellite LST product.

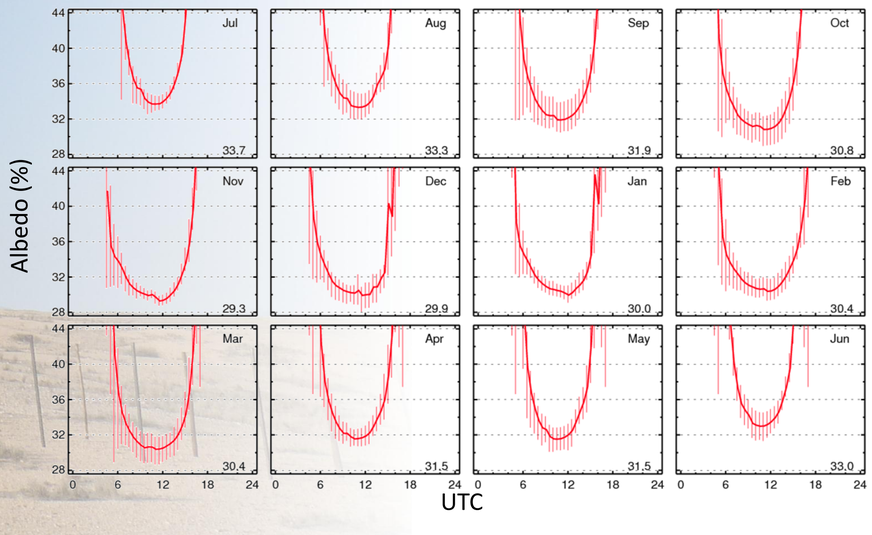


The mean bias for the entire observation period is 0.3 K while the corresponding root mean square error is 1.5 K. The bias varies by about ±1K and appears to be at least partly seasonal. The small (Oct/Nov 2010) and the big rainy season (Jan/Feb 2011) were exceptionally wet and cloudy.

Instruments Operated by KIT

	Height (m)	Quantity	Manufacturer/Type
K1/K7	1.9/25	Air temperature Relative humidity	Vaisala HMP45
K2	3.1	Radiation balance	Kipp & Zonen CNR1
K3/K6	3.2/25.3	Windspeed, W.direction	Young propeller 1503
K4	4.3	Sky temperature	Heitronics pyrometer KT15.85IIP
K5	25	Surface temperature	2 x Heitronics KT15.85IIP

Second Example



Mean monthly diurnal courses of the broadband albedo derived from the lower net radiation sensor (CNR1, KIT). Albedo means the ratio of reflected incoming solar radiation to the incoming solar radiation in percent.

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