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Measuring and modelling broadband albedo on Lewis Glacier, Mt Kenya

ORCID iD Rainer Prinz

Rainer Prinz[1], Lindsey Nicholson[2], Thomas Mölg[3], Georg Kaser[2]

(1) Department of Geography and Regional Science, University of Graz, Austria | (2) Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck, Austria | (3) Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Germany

Introduction

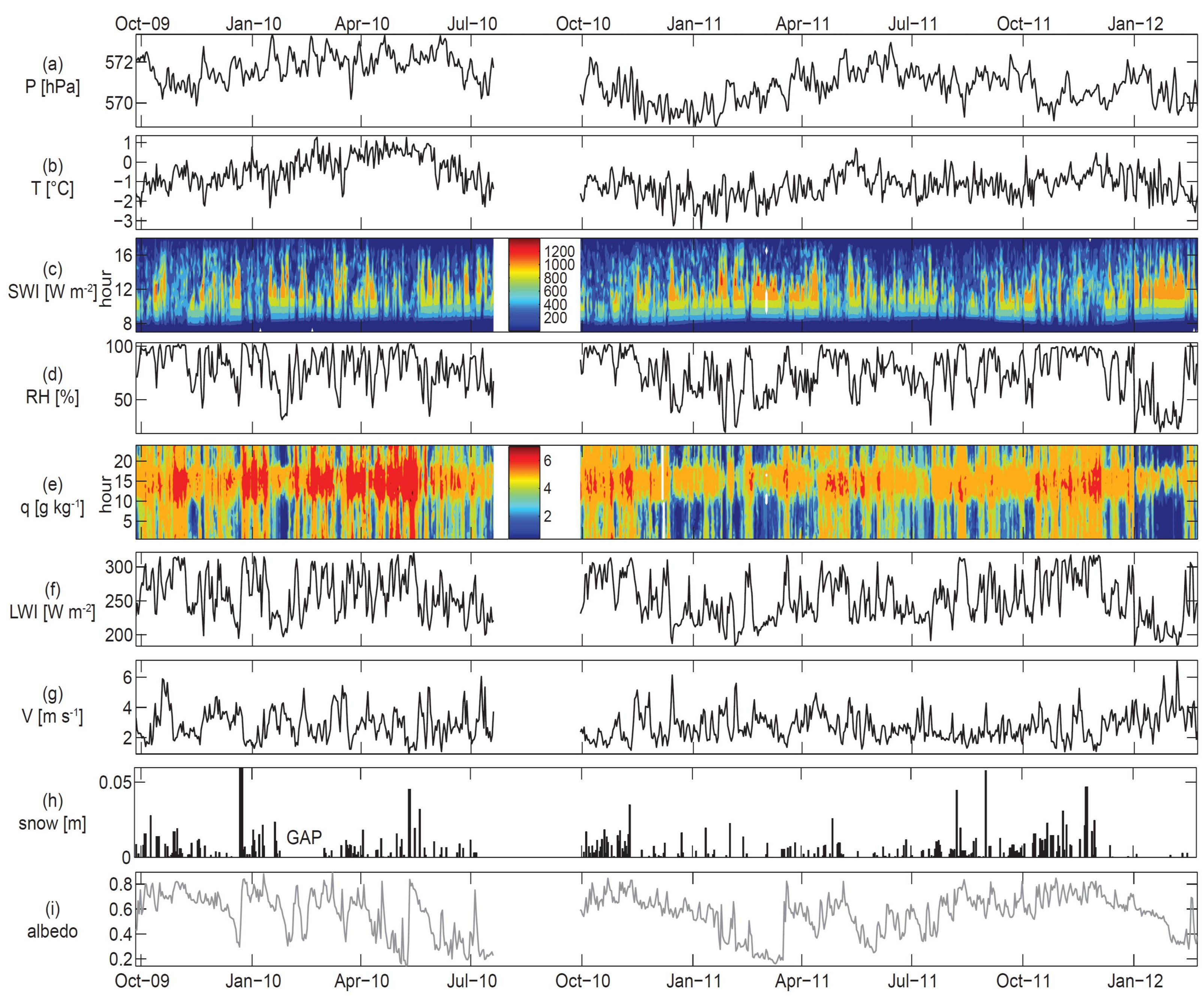
Footprint of the tropical (0.15° S) and high altitude (4830 m) climate

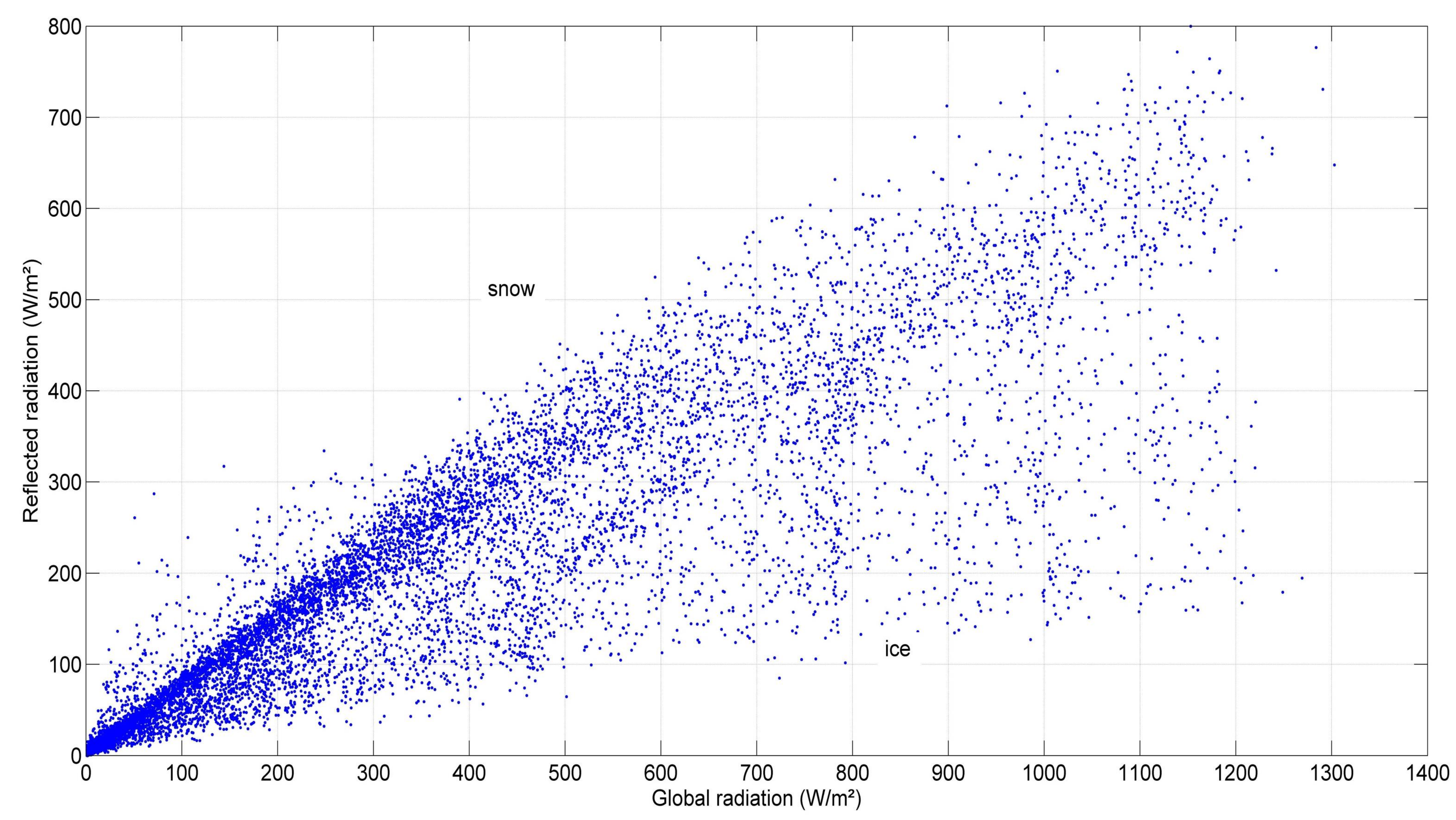
- Hygric seasons and high diurnal climate variability
- Snow fall events not confined to seasons and occurring almost daily
- High diurnal variability in energy balance: fresh snow in the afternoon, fast decay of snow albedo in the morning, melt around noon
- High sublimation rates
- Fresh snow events frequently at the limit of the measurement accuracy (1 cm)

Challenge: Calibrate albedo parameterization for distributed mass and energy balance modelling!

Measurements

In-situ observations of different climate parameters (Nicholson et al. 2013) and incoming versus reflected short-wave radiation (scatter plot) performed on Lewis Glacier between 01 Oct 2009 and 22 Feb 2012. Radiative fluxes were recorded by a Kipp&Zonen CNR4 net radiometer above the 15° inclined glacier surface.





Modelling

The parameterization of albedo employs an approach from Oerlemans and Knap (1998), where the albedo (α) is a function of the snowfall frequency, i.e. time since the last snowfall (s-i), and snow depth (d). The effects of snow ageing (t^*) and snow depth on the albedo are given by e-folding constants to compute albedo values between constant fresh snow and firn albedos and variable ice albedo, which is a linear function of the dew point temperature (*DPT*) to account for variations of the ice albedo due to sublimation (Mölg et al. 2009).

$$\alpha_{snow} = \alpha_{firn} + \left(\alpha_{frsnow} - \alpha_{firn}\right) exp\left(\frac{s-i}{t^*}\right) \quad (1)$$

$$\alpha = \alpha_{snow} + \alpha_{ice} - \alpha_{snow}\, exp\left(\frac{-d}{d^*}\right) \quad (2)$$

$$\alpha_{ice} = c_1\, DPT + c_2 \quad (3)$$

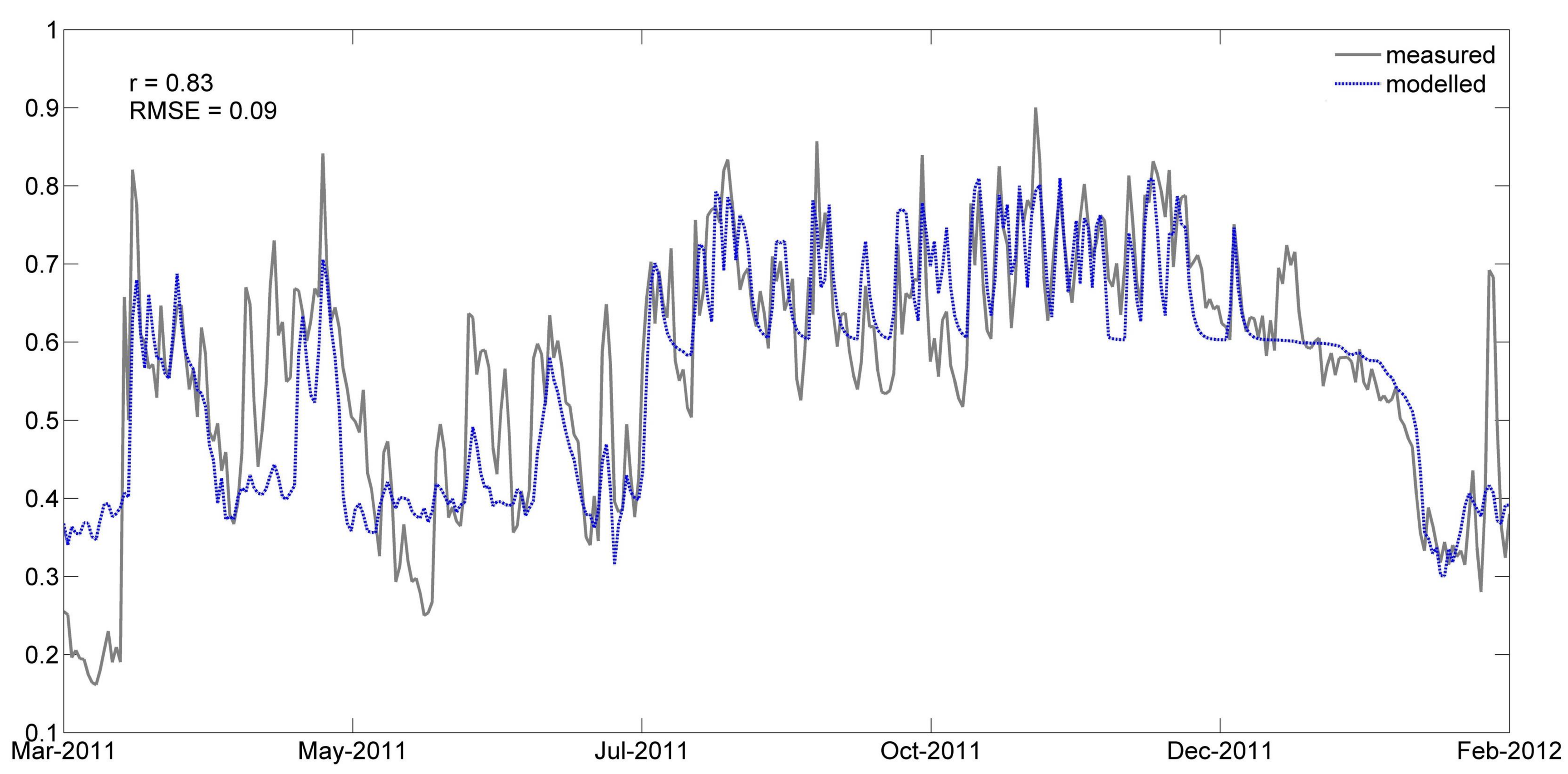
Results

Optimal values were found by a Monte Carlo simulation, including the total mass balance model parameter setup, using a subsequent cross validation confirming the best parameter setup (Prinz et al. 2016).

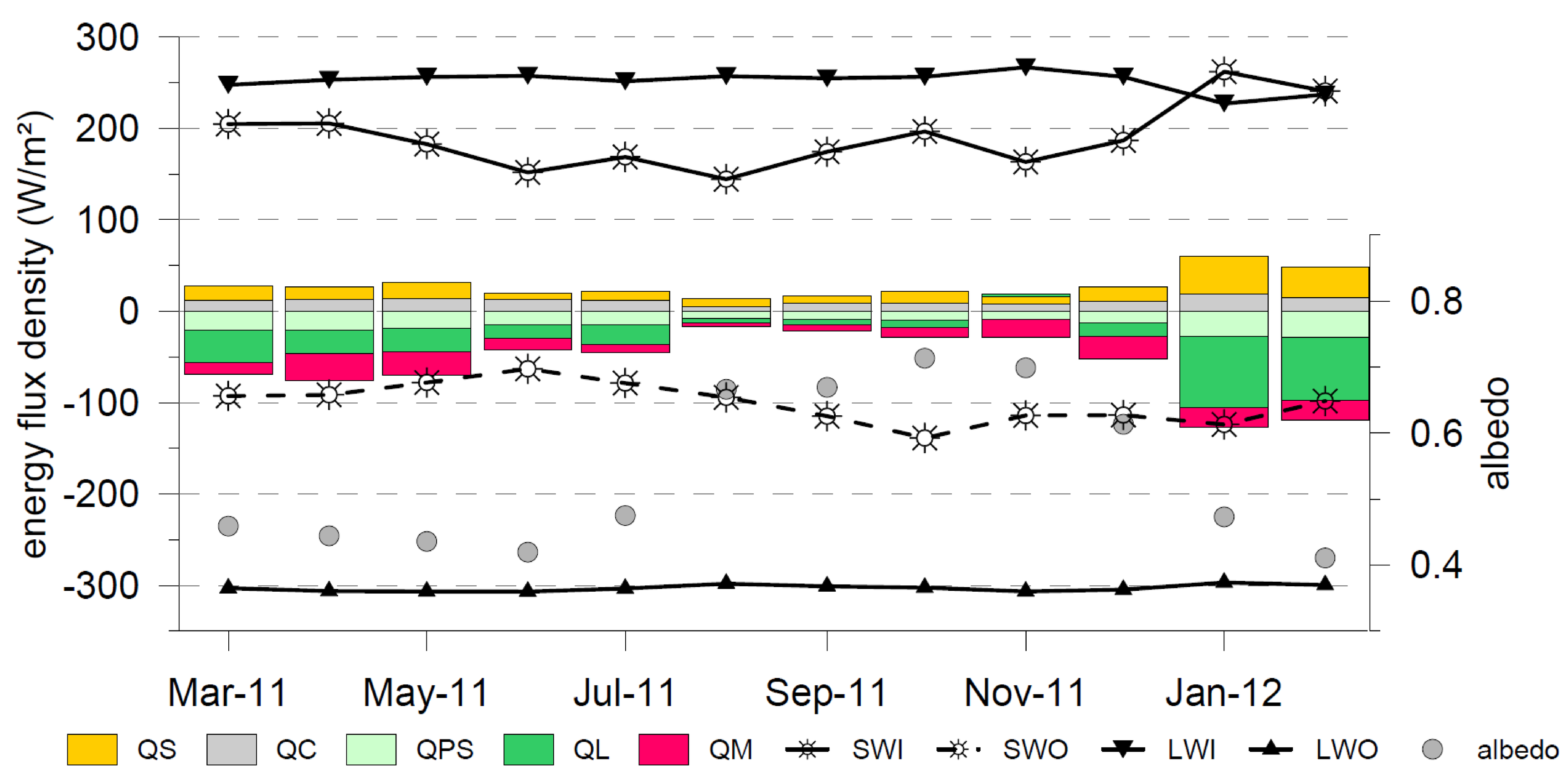
$$\alpha_{firn} = 0.60, \quad \alpha_{frsnow} = 0.81$$

$$t^* = 1.3 \text{ (days)}, \quad d^* = 4.1 \text{ (cm)}$$

$$c_1 = 0.0056\ (°C^{-1}), \quad c_2 = 0.4179$$



Measured and modelled mean daily albedo using equations and values given above.



Resulting mean monthly energy flux densities of the final, distributed model setup for the mass balance year 2011/12.

References:

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