Quasi Real-Time Verification of aLMo Radiation Budget Forecast with Payerne Measurements

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1 Surface Energy Budget Estimate and Measurement

In order to validate the weather prediction model used by MeteoSwiss (aLMo), analyses were performed with measured components of the energy budget at Payerne. The aerological station of Payerne is located in the Swiss Mittelland at 491 m asl (46.813°N, 6.943°E). The region is characterized by rollings hills surrounded to the N-NW by the Jura mountains (1000-1500 m asl) and to the S-SE by the Alps (1000-3000 m asl).

For this analysis, the parameters taken into account are the energy budget components:

– radiation budget components:

$$Q^* = (K\downarrow - K\uparrow) + (L\downarrow - L\uparrow) \tag{1}$$

– surface energy balance:

$$Q^* = Q_h + Q_e + Q_g \tag{2}$$

By merging (1) and (2), we obtain:

$$(K\downarrow - K\uparrow) + (L\downarrow - L\uparrow) = Q_h + Q_e + Q_g \tag{3}$$

Among those components, the model calculates the short-wave (K^*) and the long-wave (L^*) balance, the sensible heat (Q_h) and the latent heat (Q_e). The ground flux (Q_g) is estimated by considering the residual of Eq.(3). The different radiation fluxes going down and up are deduced from the following equations :

$$K^* = K\downarrow - K\uparrow \tag{4}$$

$$K^* = K\downarrow (1-\alpha) \tag{5}$$

$$L^* = L\downarrow - L\uparrow \tag{6}$$

$$L^* = L\downarrow - \varepsilon\sigma T_g^4 \tag{7}$$

where α is the albedo, ε is the emissivity, σ is the Stefan-Boltzmann constant and T_g is the surface ground temperature.

To judge the ability of the model to forecast these components, aLMo data are compared with the measurements of the Basic Surface Radiation Network (BSRN) station of Payerne (Switzerland) and of a sonic anemometer for the sensible heat. The value of the ground flux is obtained from (Stull, 1998):

$$\frac{\partial T}{\partial t} = -\frac{1}{C_g}\frac{\partial Q_g}{\partial z}\,. \tag{8}$$

By a reformulation of this equation, the ground flux is calculated by adding the measured flux at a depth, z, to the energy stored in the layer above the heat flux plates (Campbell, 1999).

The stored energy (S) is given by

$$S = C_g(\Delta T/\Delta t)\Delta z\,, \tag{9}$$

and the soil heat flux (Q_g) by

$$Q_g = Q_{gz} + S\,, \tag{10}$$

where Q_{gz} is the flux measured at 8 cm, C_g the soil heat capacity, 2.6 $\mathrm{Jm^{-}3K^{-}1}$ in Payerne (Mühlemann, 1996), T, the temperatures, Δt, the time interval and z, the depth.

To measure Q_g, sensors giving the flux at 8 cm below surface and the temperature at 2 cm and 6 cm below surface have been installed. The temperature was determined by averaging the 2 measured temperatures and the Δz corresponds to the depth of the soil heat flux plate. Finally, the latent heat being not measured in Payerne, its value will be equal to the residual of the equation.

2 Quasi Real-Time Comparisons and Statistics

An operational validation of the surface energy budget was set within MeteoSwiss. Every day, all forecasted and measured components of eq (3) are automatically extracted and the various time series displayed on a MeteoSwiss intranet web page. Furthermore, statistics are made available at the end of each month and of each season. The mean seasonal diurnal cycle of the differences of surface energy budget components are shown in Figure 1 (model minus measurements). One can notice an overall good estimate of the calculated parameters while both residuals (latent heat for measurements and ground flux for the model) show a significant temporal shift illustrated by a sinus shape curve of the differences. The maximal differences occurred in summer when the incoming solar intensity is the highest.

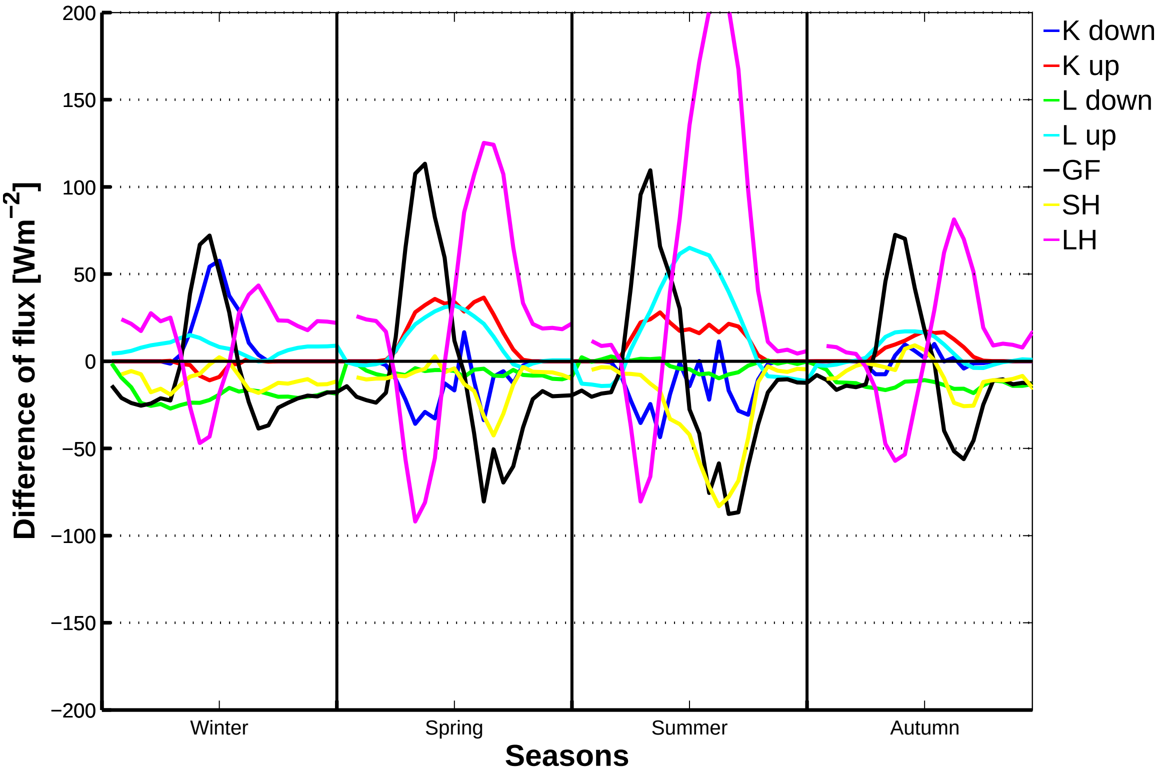

Figure 1: Differences of mean seasonal diurnal cycle of the surface energy budget between aLMo and measurements at Payerne for the year 2003.

3 Summary

A summary of conclusions taken from the analysis of a limited number of months is presented below. The quality of the $K\downarrow$ can be greatly influenced by the meteorological situation, with anticyclonic situations going together with good simulations. The $K\downarrow$ radiation is better predicted in summer than in winter because the low stratus are difficult to model. If the $K\uparrow$ is not so badly modeled in June compared to January, it has nevertheless a strong tendency to be underestimated by the model. The problem is certainly due to a too low value of the modeled albedo.

Concerning the $L\downarrow$, it seems that stable situation corresponds to a good prediction whereas an unstable situation to predictions of lower quality. In a great number of cases, the modeled $L\downarrow$ are underestimated, probably due to a wrong estimate of the clouds (their presence, their height). The difference between the modeled and measured $L\uparrow$ radiation being in general insignificant, the meteorological situations do not seem to have any influence on the quality of $L\uparrow$ simulations.

For the cases when the sensible heat is badly predicted, the model is either overestimating either underestimating. Nevertheless, in January, there are not only intensity shifts but also temporal shifts. The meteorological situation does not influence that much the value of the sensible heat. If the sensible heat for perturbed days is badly modeled in June, it can be in some cases extremely well modeled in January. That can be explained by the weak solar energy income which softens the shift of some of the components.

4 References

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