LBA-MIP driver data gap filling algorithms

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1 Forcing data

Yearly gap-filled meteorological driver data were created from LBA flux tower datasets at hourly time-steps. For off-line simulations land surface models generally require RG_d (down-welling short-wave radiation; W m^{-2}), LW_d (down-welling long-wave radiation; W m^{-2}), T_a (air temperature; K), Q_a (specific humidity; kg kg^{-1}), u (wind speed; m s^{-1}), P_s (surface pressure; Pa), P (rainfall rate; mm s^{-1}). Measurements of these quantities at the tower reference height were used, only filled by lower profile measurements where available and needed. Outliers which deviated $n\sigma$ times from the median-filtered time-series were removed (σ is the standard deviation of the original time-series and $n = 4$, except for Q_a where $n = 8$; for u where $n = 20$ and for LW_d where $n = 16$). Up to two month long successive gaps were filled by applying a 7 day running mean diurnal cycle forwards and backwards through the yearly time-series. Years with more than 2 month of consecutive missing data were not used.

The following exceptions were applied to the above procedure:

1. RG_d was not median-filtered since most of its variability occurs on diurnal time scale. Instead the potential solar radiation as a function of latitude and local solar time, scaled with the annual maximum observed RG_d, provided an upper bound for RG_d.

2. P was not median-filtered. Daily climatological precipitation derived from all the available years were used to replace days where hourly tower data was missing. Daily climatological precipitation for K67, K77 and K83 were derived from a quality filtered time-series of nearby stations (D. Fitzjarrald, personal communication). Daily precipitation

totals were evenly distributed at night between 00:00 - 04:00 during days when no hourly data were available.

3. For sites with no P_s, it was estimated by

$$P_s = P_{s_0} e^{-\frac{Mgz}{RT_a}}, \quad (1)$$

where P_{s_0} is the mean sea level pressure (101300 Pa), M is the molecular weight of air (0.029 kg mol^{-1}), g is the gravitational acceleration (9.81 m s^{-2}), z is the tower height above sea level (m) and R is the universal gas constant (8.314 J K^{-1} mol^{-1}).

4. For sites with no LW_d (most sites), it was estimated from the surface radiation balance:

$$LW_d = R_n - RG_d + RG_u + \sigma \left(\frac{T_a + T_r}{2} \right)^4, \quad (2)$$

where R_n and RG_u are non-gap-filled net radiation (Wm^{-2}) and upwelling solar radiation (Wm^{-2}), σ is the Stefan-Bolzmann constant ($5.67 \cdot 10^{-8}$ Wm^{-2}K^{-4}) and T_r is either the canopy temperature or soil surface temperature (K), depending on data availability. As a backup algorithm (either of the above variables missing, most sites, again) down-welling long-wave radiation was estimated by using the clear-sky LW_d parameterization by Idso [1981], modified by an emissivity correction factor as proposed by Gabathuler et al. [2001]:

$$LW_d = \epsilon_c \epsilon_0 \sigma T_a^4, \quad (3)$$

where:

$$\epsilon_c = 1 + 0.3(1 - K_0)^2 \text{ and} \quad (4)$$

$$\epsilon_0 = 0.7 + e_a \cdot 5.95 \cdot 10^{-5} e^{\frac{1500}{T_a}}, \quad (5)$$

where ϵ_0 is the clear sky atmospheric emissivity (-) as a function of T_a and atmospheric vapor pressure e_a (mb). ϵ_c (-) adjusts ϵ_0 for cloud cover. It depends on the clearness index K_0 (-), which ranges from 0 to 1 (full cloud cover to clear sky). K_0 can be approximated by dividing measured by potential down-welling solar radiation, but only during daytime. We replaced all nocturnal K_0 values where RG_d was below 50 W m^{-2} with linearly interpolated values. While clear sky

LW_d can be reasonably estimated the above formulation for all-sky LW_d is a rough fix in need for some data. Since cloud emissivity depends on e.g. cloud type, water content and cloud vertical extent an uncertainty of roughly 5-20 W m^{-2} is introduced to the driver dataset [Gabathuler et al., 2001] by using this algorithm. We recommend all flux tower networks to measure LW_d according to BSRN (Baseline Surface Radiation Network; McArthur [2000]) guidelines and report it as a mandatory variable.

The consistently gap-filled meteorological forcing data from the 8 LBA-MIP sites are available as ALMA compliant NetCDF files and ASCII files at the public ftp site: ftp://ezdods.ethz.ch/pub_read/stockli/lba_mip/driver/.

References

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