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A physics-based correction method for homogenizing historical subdaily time series from Switzerland

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Homogeneous long-term climatological time series provide useful information on climate back to the preindustrial era. High temporal resolution of climate data is desirable to address trends and variability in the mean climate and in climatic extremes. For Switzerland, three long (∼250 yrs) historical time series (Basel, Geneva, Gr. St. Bernhard) that were hitherto available in the form of monthly means only have recently been digitized (in cooperation with MeteoSwiss) on a subdaily scale. The digitized time series contain subdaily data (varies from 2–6 daily measurements) on temperature, precipitation/snow height, pressure and humidity, and subdaily descriptions on wind direction, wind speeds and cloud cover.

Long-term climatological records often contain inhomogeneities due to non climatic changes such as station relocations, changes in instrumentation and instrument exposure, changes in observing schedules/practices and environmental changes in the proximity of the observation site. Those disturbances can distort or hide the true climatic signal and could seriously affect the correct assessment and analysis of climate trends, variability and climatic extremes. It is therefore crucial to detect and eliminate artificial shifts and trends, to the extent possible, in the climate data prior to its application. Detailed information of the station history and instruments (metadata) can be of fundamental importance in the process of homogenization in order to support the determination of the exact time of inhomogeneities and the interpretation of statistical test results.

While similar methods can be used for the detection of inhomogeneities in subdaily or monthly mean data, quite different correction methods can be chosen. The wealth of information in a high temporal resolution in combination with multivariate data series allows more physics-based correction methods.
For instance, a detected radiation error in temperature can be corrected with an error model that incorporates - at least - radiation and ventilation terms. Naturally ventilated shields with liquid-in-glass thermometers were usually used in the early years of systematic temperature measurements. Such shields prevent the thermometer from being exposed to direct shortwave radiance. But a side effect is that they uncouple the sensor from the air temperature outside the shield and create their own microclimate within the shield. This may lead to considerable differences of internal and "real" air temperature. Such differences basically arise from solar radiance, longwave radiation exchange to and from the shield, and evaporative cooling after rainfall. Furthermore these biases exponentially increase with the decrease of ambient wind speed.

With information on shield installation geometry and environment, sunrise/sunset times, cloud cover, precipitation, days with snow cover, and wind speed, the external influences on the shield (terms) can be calculated and an error model, based on known correction values (from MeteoSwiss), can be fitted. Coefficients that presumably depend on characteristics of the internal sensor-shield system (airflow, convectivity, conductivity) can either be assed from empirical studies or treated as unknowns in the model.

This model includes all of the known physical processes affecting the radiative error for a given site of observation and sensor-shield system and is general enough to be easily applicable to other stations and observation systems.