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Estimation of large scale daily evapotranspiration using geostationary meteorological satellite observations

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Accurate estimate of daily evapotranspiration over large areas is important both for understanding hydrological processes on the earth and for water resources management. Remote sensing observations of land surface have been used to estimate evapotranspiration (ET) over large areas, when point measurements cannot provide such information efficiently because of insufficient coverage density. Conventional methods to estimate regional daily ET are based on extrapolation of instantaneous ET estimates usually from polar-orbiting satellite observations at clear sky moments and assuming clear sky conditions prevailing throughout the day. However, such methods are unable to overcome uncertainties caused by eventual cloud interference along a day course.

The new generations of geostationary meteorological satellites having frequent temporal sampling and relatively higher spatial resolution than older generations, carries the promise of solving the problem of time integration to estimate daily ET. Such observations at high temporal resolution are particularly helpful in capturing the diurnal variation of land surface temperature, the most critical land surface parameter in determining the energy partitioning between sensible heat flux and latent heat flux. However, cloud-free measurements during a day may be sparse and not simultaneous for different pixels. A time series analysis technique using Fourier transfer analysis as described in Harmonic Analyze of Time Series (HANTS) is therefore needed to fill the gaps in sparse satellite observations due to clouds contamination.

In this research, instantaneous latent heat flux in turn the evapotranspiration is calculated from an energy balance based model SEBS (Surface Energy Balance System) firstly using a set of land surface parameters provided by LandSAF products retrieved from observations of SEVIRI (Spinning Enhanced Visible and Infrared Imager) onboard Meteosat Second Generation (MSG).

Secondly, HANTS algorithm is used to reconstruct gap-filled time series of instantaneous ET along a day. In the end, daily evapotranspiration is calculated from the reconstructed gap-filled time series of instantaneous estimation of evapotranspiration.

The algorithm validation was done using data from limited number of flux tower sites of CarboEurope project in Europe by comparing the energy balance flux components estimated by SEBS with tower flux measurements. Analyses of daily variation of estimated surface heat fluxes show that the proposed method is able to generate large scale net radiation, sensible, latent, and soil heat fluxes that follow closely daily variation of the courses of these flux components as observed by ground measurements.

It was found that abnormal values in the estimated latent heat flux are observed near cloudy pixels. It indicates that pixels close to cloudy pixels may be affected by clouds but not masked in the MSG land surface temperature product.

In general, reconstruction of evapotranspiration time-series using HANTS algorithm is demonstrated to be a promising technique to overcome the interference of clouds and preserve inherent trends of evapotranspiration process over a day when applied to a large-scale. HANTS reconstruction is capable to maintain daily variation of evapotranspiration on less cloudy days by keeping good correlation with the ground measurements. However, the technique has proven to be limited to areas with cloud cover less than 60% along a day course. Comparison of the daily total ET estimated from SEBS/MSG/HANTS technique with daily ET calculated using conventional method (using one-time measurements of a day and assuming clear sky throughout a day) has shown that the former is less affected by the intensity of cloud interference along the day.