An Improved Atmospheric Correction Method with Diurnal Temperature Cycle Model for MSG-SEVIRI TIR Data under Clear Sky Condition

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Abstract : Knowledge of land surface temperature (LST) is of crucial important in energy balance studies and environment modeling. Satellite thermal infrared (TIR) imagery is the primary source for retrieving LST at the regional and global scales. Due to the combination of atmosphere and land surface of received radiance by TIR sensors, atmospheric effect correction has to be performed to remove the atmospheric transmittance and upwelling radiance. Spinning Enhanced Visible and Infrared Imager (SEVIRI) onboard Meteosat Second Generation (MSG) provides measurements every 15 minutes in 12 spectral channels covering from visible to infrared spectrum at fixed view angles with 3km pixel size at nadir, offering new and unique capabilities for LST, LSE measurements. However, due to its high temporal resolution, the atmosphere correction could not be performed with radiosonde profiles or reanalysis data since these profiles are not available at all SEVIRI TIR image acquisition times. To solve this problem, a two-part six-parameter semi-empirical diurnal temperature cycle (DTC) model has been applied to the temporal interpolation of ECMWF reanalysis data. Due to the fact that the DTC model is underdetermined with ECMWF data at four synoptic times (UTC times: 00:00, 06:00, 12:00, 18:00) in one day for each location, some approaches are adopted in this study. It is well known that the atmospheric transmittance and upwelling radiance has a relationship with water vapour content (WVC). With the aid of simulated data, the relationship could be determined under each viewing zenith angle for each SEVIRI TIR channel. Thus, the atmospheric transmittance and upwelling radiance are preliminary removed with the aid of instantaneous WVC, which is retrieved from the brightness temperature in the SEVIRI channels 5, 9 and 10, and a group of the brightness temperatures for surface leaving radiance (Tg) are acquired. Subsequently, a group of the six parameters of the DTC model is fitted with these Tg by a Levenberg-Marquardt least squares algorithm (denoted as DTC model 1). Although the retrieval error of WVC and the approximate relationships between WVC and atmospheric parameters would induce some uncertainties, this would not significantly affect the determination of the three parameters, td, ts and β (β is the angular frequency, td is the time where the Tg reaches its maximum, ts is the starting time of attenuation) in DTC model. Furthermore, due to the large fluctuation in temperature and the inaccuracy of the DTC model around sunrise, SEVIRI measurements from two hours before sunrise to two hours after sunrise are excluded. With the knowledge of td , ts, and β, a new DTC model (denoted as DTC model 2) is accurately fitted again with these Tg at UTC times: 05:57, 11:57, 17:57 and 23:57, which is atmospherically corrected with ECMWF data. And then a new group of the six parameters of the DTC model is generated and subsequently, the Tg at any given times are acquired. Finally, this method is applied to SEVIRI data in channel 9 successfully. The result shows that the proposed method could be performed reasonably without assumption and the Tg derived with the improved method is much more consistent with that from radiosonde measurements.

Keywords : atmosphere correction, diurnal temperature cycle model, land surface temperature, SEVIRI
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