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# Regional scale net radiation estimation by means of Landsat and TERRA/AQUA imagery and GIS modeling

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Net radiation (Rn) is one of the most important variables for the estimation of surface energy budget and is used for various applications including agricultural meteorology, climate monitoring and weather prediction. Moreover, net radiation is an essential input variable for potential as well as actual evapotranspiration modeling. Nowadays, radiometric measurements provided by Remote Sensing and GIS analysis are the technologies used to compute net radiation at regional scales in a feasible way.

In this study we present a regional scale estimation of the daily Rn on clear days, (Catalonia, NE of the Iberian Peninsula), using a set of 22 Landsat images (17 Landsat-5 TM and 5 Landsat-7 ETM+) and 171 TERRA/AQUA images MODIS from 2000 to 2007 period. TERRA/AQUA MODIS images have been downloaded by means of the EOS Gateway. We have selected three different types of products which contain the remote sensing data we have used to model daily Rn: daily LST product, daily calibrated reflectances product and daily atmospheric water vapour product. Landsat-5 TM images have been corrected by means of conventional techniques based on first order polynomials taking into account the effect of land surface relief using a Digital Elevation Model, obtaining an RMS less than 30 m. Radiometric correction of Landsat non-thermal bands has been done following the methodology proposed by Pons and Solé (1994), which allows to reduce the number of undesired artifacts that are due to the effects of the atmosphere or to the differential illumination which is, in turn, due to the time of the day, the location in the Earth and the relief (zones being more illuminated than others, shadows, etc). Atmospheric correction of Landsat thermal band has been carried out by means of a single-channel algorithm improvement developed by Cristóbal et al. (2009) and the land surface emissivity computed by means of the methodology proposed by Sobrino and Raissouni (2000).

Rn has been estimated through the balance among the net shortwave radiation Rn and the net longwave radiation. In addition, two types of approaches have been carried out for its determination: the estimation of the variables implied in the calculation of Rn at daily level (Rndl); and the calculation of the Rn at the time of satellite pass (Rni) and its subsequent conversion to daily Rn by means of the Rn ratio.

Net shortwave radiation has been computed by means of albedo and a solar radiation model obtained through a DEM following the methodology of Pons and Ninyerola (2008).This methodology takes into account the position of the Sun, the angles of incidence, the projected shadows and the distance from the Earth to the Sun at one hour intervals. The diffuse radiation is estimated from the direct radiaton and the exoatmospheric direct solar irradiance is estimated with the Page equation (1986) and fitted by Baldasano et al. (1994).

Net longwave radiation has been calculated through land surface temperature and emissivity, atmospheric water vapour and air temperature. Air temperature has been modeled by means of multiple regression analysis and GIS interpolation using ground meteorological stations. Finally, air emissivity has been computed using air temperature models and atmospheric water vapour following the methodology developed by Dilley and O'Brien (1998).

Finally, models have been validated through a set of 13 ground meteorological standard stations and an experimental station placed in a Mediterranean mountain area over a Pinus sylvestris stand. Obtained results show a mean RMSE of 20 W m-2 in the case of Landsat and a mean RMSE of 22 W m-2 in the case of TERRA/AQUA MODIS, being these results in agreement with other published results, but also offering better RMSE in some cases.

Keywords: Net radiation, Landsat, TERRA/AQUA MODIS, GIS modeling, regional scale.