APPLICATION OF SATELLITE-BASED METHODS FOR ESTIMATING EVAPOTRANSPIRATION IN THESSALIA PLAIN, GREECE

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1. Abstract
Estimation of evapotranspiration using both meteorological ground-based measurements and satellite-derived information has been widely studied during the last few decades and various methods have been developed for this purpose. In our application, we estimated the regional daily actual evapotranspiration during the 2001 summer season (June-August) over Thessalia plain in Pitsos river basin. It is an area of intensive agricultural activity. Satellite data were accounted for those days that were available. For the case study, two different methods were applied and compared to the conventional and well-known FAO Penman-Monteith method. Satellite data, adequately processed (radiometric calibration, sun illumination conditions correction and geometric correction), were used in conjunction with gridded data from the three nearest meteorological stations. The methods, which were properly adapted, exploit surface temperature and surface albedo assessments, obtained respectively from the infrared channels 4-5 and the visible channel 1 of NOAA-AVHRR images. The first method requires daily mean surface temperatures, so NOAA-15 satellite images were used, while for the second one the average rate of surface temperature rise during the morning is required, so a combination of NOAA-14 and NOAA-15 satellite images was used. The results of the study are quite encouraging, especially for the first method. In the future we intend to combine the satellite-derived data (Tauf, Albedo, NDVI) with detailed land-use and land-cover classification map based on high-resolution satellite data.

2. Case Study

- Study area: Pitsos River basin, Thessalia plain, Central Greece
- Data period: 2001 summer season (June-August)
- Days for which ET was estimated: 21 (7 days per month)
- The satellite data used make up a data set of images uniformly distributed in the time frame of the study.
- Satellites used: NOAA-AVHRR 14 and 15
- Receiving stations: ISARS/NOA
- Number of satellite images processed: 42 (21x2)
- Spatial resolution: 10m x 10m
- Meteorological stations available: Larissa, Trikala and Agchialos stations
- Assumption for the summer crops of the plain:
  - 50% maize - 50% cotton

3. Image Processing

- Radial calibration
- Normalization of the reflectances of bands 1 and 2 (R1, R2) and temperatures of bands 4 and 5 (T4, T5) to ERDAS
- Import of normalized reflectances of bands 1 and 2 for the sun zenith angle 90°
- Normalization of the reflectances of bands 4 and 5 (T4, T5) to ERDAS
- Geometric correction using control points and a second order polynomial
- Area of interest masking: Cloud, sea, barren soil, etc.
- Areas exclusion

4. Methodologies

4.1 FAO Penman-Monteith Method

\[ ET = \frac{0.408kK_{c}f(\alpha_{e}, \eta_{e})}{1 + (1 - 0.403\beta_{e})} \]

where:
- \( K_{c} \): crop coefficient
- \( \alpha_{e} \): slope vapor pressure curve
- \( \eta_{e} \): relative humidity
- \( \beta_{e} \): psychometric constant
- \( u_{2} \): wind speed at 2m height
- \( \Delta \): temperature difference between 8 and 10 local time
- \( \gamma \): mean daily as temperature difference

4.2 Granger Method

\[ ET = \frac{39.006R_{f} + f(\alpha_{e}, \eta_{e})}{1 + (1 - 0.403\beta_{e})} \]

where (additionally):
- \( f(\beta_{e}) = 0.62\exp(0.28\beta_{e}) \)
- \( G = 1 + (1 + 0.026\exp(0.045\beta_{e})) \)
- \( C_{w} \): wind speed at 2m height
- \( R_{f} \): ratio of actual to potential evaporation
- \( P \): atmospheric pressure

4.3 Carlson and Buffum Method

\[ ET = R_{f} - \frac{S_{t} - S_{n}}{t} \]

where (additionally):
- \( S_{t} \): total surface temperature during the morning
- \( S_{n} \): nighttime surface temperature
- \( B \): constants depending on surface roughness, wind speed, type of soil, type of vegetation
- \( t \): time (days)

5. Results

Daily actual evapotranspiration estimated by the three methods in the centre of the plain

Granger Method: This method is generally following the same trend with the FAO Penman-Monteith method, apart from the days with relative high wind speed values, where an inverse gradient is observed.
Carlson and Buffum Method: This method is obviously less stable and less reliable since it depends mainly on the temperature rise during the morning. On the other hand, it is much simpler and requires less input data.

6. Conclusions

- The FAO Penman-Monteith method is generally following the trend of FAO Penman-Monteith method and usually gives a good estimation of the evapotranspiration during the development of the crop.
- However it has a significant number of outliers.

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8. References