

ANALYSIS OF THE ENERGETIC FLOWS THROUGH THE SEBAL APPLICATION TO THE ASSESSMENT OF THE ACTUAL EVAPOTRANSPIRATION IN A NAPA VALLEY VINEYARD CALIFORNIA (USA).

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Abstract

The use of water resources is constantly growing in agriculture industry and the reduction of this resource is due by both anthropogenic and climate factors. Under this perspective it is necessary to develop monitoring systems able to forecast the consumption of water. The knowledge of the actual water demand of a crop is therefore strategic for the rational use of resources and to improve the quality of the crop production. Recent applications of remote sensing in agriculture provide a valuable contribution to release this purpose [3,4,6], besides the integration of remotely sensed data with measures retrieved by meteorological stations allows the development of models able to estimate the actual evapotranspiration (ET_{act}) for a given crop. The purpose of this work was to calculate ET_{act} in a vineyard, placed in Napa Valley (California, USA), by a energy balance model based on the analysis of remote sensed data from the Landsat 5 satellite during the 2008 wine production season (fig. 1).

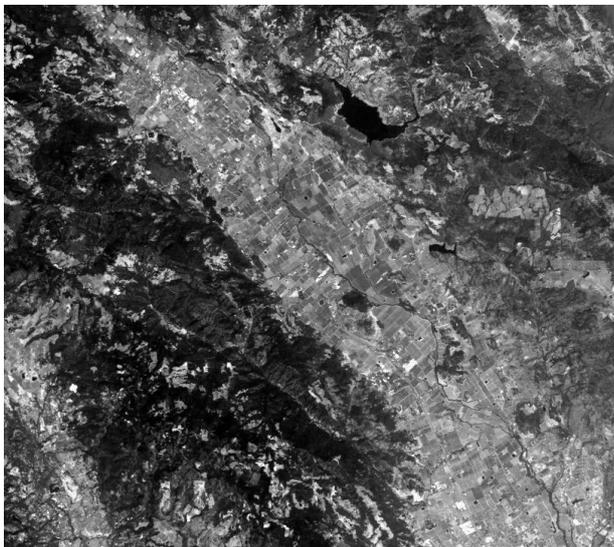


Fig. 1 Napa Valley (California, USA). TM Landsat 5 (RGB Composit)

Introduction

The study site presents an extension of about 200 ha it was selected within one of the main wineries of California located in Oakville in the middle of Napa Valley (California, USA). Napa Valley is probably the most important wine production area of North America, it presents an extension length of 50 km and a

width of 6 km, narrow between two mountain chains and placed side by side to Pacific coast of the United States. The climate in this region is very similar to a Mediterranean condition, characterized by a rainfall that is concentrated in the months November to April and a dry period between May to October. Its particular shape and position on the Pacific coast means that during the summer months it is not affected by fog which typically focuses on the coast, but at the same time it is not so far from the pacific coast so as not to benefit from the moist humid winds from the ocean. The prevailing culture in all the valley is the wine. The study area is flat maintaining itself with an average of almost 50 meters above sea level. The study site is divided into several blocks with relatively large size, each block is handled individually by the winemakers as "minimal unit of management" both in the vegetative phase of growing and later in the harvest. The pedology of the study area shows a high content of clay in relation to the sand, except in the northernmost part characterized by a higher prevalence of sand.

Methodology

During the 2008 wine production season (May - September) there are 6 TM images (Landsat 5) of the area concerned from USGS. Each image has been processed so as to obtain for each pixel the corresponding value of reflectance, each one with the own atmospheric effect correction. Spectroradiometric measures were conducted on the ground for the image calibration procedure, besides temperature and LAI measures were acquired to complete the data time series. In the analysis phase for every images have been applied different vegetation indices (NDVI, SAVI) and were evaluated the albedo, useful to run the SEBAL. It was also essential the use of a DEM of the study.

It was retrieved the meteorological data from the CIMIS net station (California Irrigation Management Information System) on the website.

The SEBAL (Surface Energy Balances Algorithms for Land) is a model that allows to estimate ET_{act} from the remainder of the energy balance through the integration of satellite with meteorological data, pixel by pixel [1,2,5,7,9]. The result is a map of the real spatial distribution of the evapotranspiration. By the energy balance equation, the latent heat flux (λET) is obtained from the sum / difference of the various components of the flows of net radiation (R_n), sensible heat (H) and

soil heat (G_0). The λET is then converted to instantaneous ET_{ist} and then in daily evapotranspiration (ET_{daily}) by the assessment of reference ET fraction (ET_rF), given by the ratio of ET_{ist} and the ET reference from the CIMIS weather station. The ET_rF is a parameter considered stable for almost all day long, remained constant during the central hours, the expected value range is between 0 to 1.

By this time the SEBAL is a model widely validated in many parts of the world [8] through comparative studies with lysimeters or with scintillometer connected to weather stations, able to assess accurately the flow of sensible heat using the emission of a laser beam.

Tab. 1 Block 7

Julian Day	125	157	173	189	205	237
Sebal ET_rF	0.11	0.24	0.17	0.15	0.16	0.16
Sebal ET_{daily}	0.81	1.43	1.25	0.90	1.02	0.81
CIMIS K_c	0.34	0.69	0.69	0.67	0.67	0.66
CIMIS ET_0	3.91	6.04	7.46	5.92	6.37	5.13
Ground LAI	0.85	2.41	2.41	2.32	2.32	2.25

Results

By the use of the SEBAL model were evaluated the ET_{daily} values for every blocks inside the vineyard. The Table 1 shows the comparison between the retrieved ET_rF and ET_{daily} with the K_c and ET_0 measured by the weather station and the LAI measured on ground during the time. K_c was evaluated as function of LAI. In every blocks of the vineyard the different values were retrieved evaluating the mean.

The figure 2 shows the ET_{daily} versus the LAI and the potential ET from the CIMIS station. Daily evapotranspiration seems grow up in the same way of the LAI during the year with the same trend but value are lower than the CIMIS ET_0 .

The figure 3 shows the trend of the ET_rF versus the K_c . The growing up of LAI in the left side of the graphic shows the vegetative increment of the canopy since May to the first half of June.

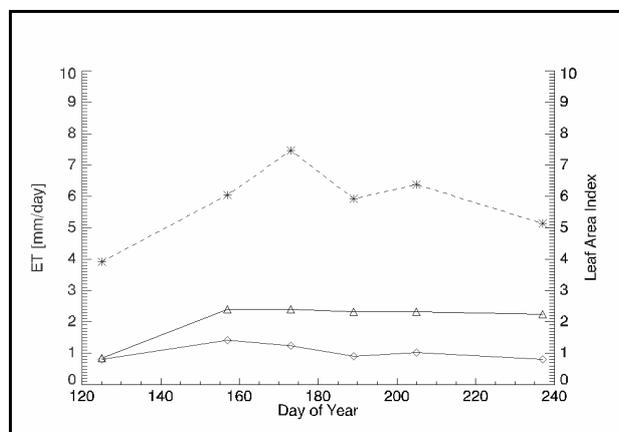


Fig. 2

ET_{Daily} \diamond — \diamond
 LAI \triangle — \triangle
 ET_0 *—*—*

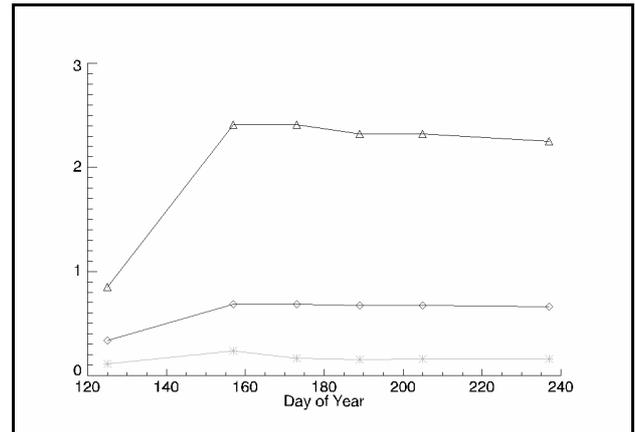


Fig. 3

ET_rF \diamond — \diamond
 LAI \triangle — \triangle
 K_c *—*—*

Conclusions

The main purpose of the present study was to test the application of the SEBAL during a whole growing season in a vineyard located in Napa Valley (California, USA) to aid the winemakers to manage water resource using data retrieved from satellite and weather station.

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Bibliography

- [1] Allen, R. G., Pereira, L. S., Raes, D., and Smith, M., (1998). *Crop evapotranspiration. Guidelines for computing crop water requirements*. Food and Agricultural Organization of the United Nations (FAO) Irrigation and Drain, Paper No. 56, Rome, Italy, 24–47.
- [2] Bastiaanssen, W.G.M., Menenti, M., Feddes, R.A., and Holstlag, A.A.M., (1998). *A remote sensing surface energy balance algorithm for land (SEBAL): 2 Validation*. *J. of Hydr.* 212-213:213-229.
- [3] Bastiaanssen, W.G.M. (2000). *SEBAL-based sensible and latent heat fluxes in the irrigated Gediz Basin, Turkey*. *J. Hydrology* 229: 87-100.
- [4] Ciruolo G., Minacapilli M. and Sciortino M. (2007). *Stima dell'evapotraspirazione effettiva mediante telerilevamento aereo iperspettrale*. *J.of Ag. Eng* 2. 49-60.
- [5] Kustas, W.P., Daughtry, C.S.T. and Van Oevelen, P.J. (1993). *Analytical treatment of the relationship between soil heat flux/net radiation ratio and vegetation indices*. *Remote Sens. Environ.*, 46, 319-330.
- [6] Monteith, J.L., and Unsworth, M. (1990). *Principles of Environmental Physics*. 2 ed. Edward Arnold, London.
- [7] Nichols, W.E. and Cuenca, R.H. (1993). *Evaluation of evaporative fraction for parameterization of the surface energy balance*. *Water Resour. Res.*, 29, 3681-3690.
- [8] Tasumi, M., Trezza R., Allen R. and Wright L. (2003). *U.S. Validation Tests on the SEBAL Model for Evapotranspiration via Satellite*. *ICID Workshop on Remote Sens. of ET for Large Regions*, 17 Sept. 2003.
- [9] Waters, R., Allen R., Tasumi, M., Trezza R., Bastiaanssen, W. (2002). *SEBAL-Advanced Training and User Manual*. 98 pp. Idaho, USA.