IV INOVAGRI INTERNATIONAL MEETING
XXVI CONIRD - CONGRESSO
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III SBS - SIMPÓSIO BRASILEIRO DE SALINIDADE

ACTUAL EVAPOTRANSPIRATION ESTIMATED BY ORBITAL SENSORS, UAV AND METEOROLOGICAL STATION FOR VINEYARDS IN THE SOUTHERN BRAZIL

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SUMMARY: The estimation of actual evapotranspiration in Serra Gaúcha region, southern Brazil, is fundamental for grapevine monitoring as well as to support the management of crop irrigation systems. Evapotranspiration can be determined as balance energy residual. Therefore, it is possible to estimate evapotranspiration by remote sensing. This work aims to compare different methods of estimate actual evapotranspiration data in vineyards, in Pinto Bandeira-RS, southern Brazil. The data were obtained by OLI and TIRS sensors from Landsat-8, images obtained by camera fixed to an unmanned aerial vehicle (UAV), and from a meteorological station installed in the experimental vineyard area. Using the QGIS software it was possible to implement the METRIC algorithm equations for the UAV and orbital images. For the meteorological data, evapotranspiration was estimated by the Penman-Monteith method, parameterized by FAO-56. This study demonstrated that images from multispectral cameras on UAV and from orbital sources (LANDSAT-8) are affordable on showing the ET variation on vineyard areas. As this is a preliminary study, future improvements needed to be tested, like other algorithms and fine adjustments to reduce the variations found.

KEYWORDS: Remote sensing, *Vitis vinifera* L., irrigation management.

ESTIMATIVA DE EVAPOTRANSPIRAÇÃO ATUAL POR SENSORES ORBITAIS, UAVS E ESTAÇÃO METEOROLÓGICA PARA VINHEDOS NO SUL DO BRASIL

RESUMO: No contexto da viticultura da Serra Gaúcha, sul do Brasil, o conhecimento dos valores de evapotranspiração atual é fundamental para o acompanhamento do desenvolvimento

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do ciclo da videira e para servir de apoio no manejo de sistemas de irrigação da cultura. A ET pode ser estimada por meio de sensoriamento remoto, através de sensores que consigam captar o montante de radiação direta ou indiretamente. O presente estudo visa comparar métodos de obtenção de dados de evapotranspiração em vinhedos, no município de Pinto Bandeira, sul do Brasil. Os dados foram obtidos pelos sensores OLI e TIRS do Landsat-8, câmera acoplada a um veículo aéreo não tripulado (UAV), e a partir de uma estação meteorológica instalada na área de estudo. Com uso do software QGIS foi possível implementar as equações do algoritmo METRIC para as imagens orbitais e do UAV. Para os dados meteorológicos, a evapotranspiração foi estimada através do método de Penman-Monteith. As imagens obtidas por UAV ou satélite foram bastante promissoras em mostrar as variações da ET no vinhedo. Como este é um estudo preliminar, faz-se necessário alguns ajustes e melhorias, como testes de outros algoritmos para reduzir as variações encontradas.

PALAVRAS-CHAVE: Sensoriamento remoto, *Vitis vinífera* L., manejo de irrigação.

INTRODUCTION

Estimating the actual evapotranspiration in Serra Gaúcha region, southern Brazil, is fundamental for grapevine monitoring as well as to support the management of crop irrigation systems. Sustainable water management enables a better use of available water resources, helping to control and develop the river basin.

Evapotranspiration, the main component of the hydrological cycle, is the amount of water that the soil-plant system loses to the atmosphere through evaporation and transpiration. It is responsible for almost the entire volume of water transferred from the continent to the atmosphere. It is also very important in the release of the latent heat flux (LE), which, according to Bastiaanssen et al. (1998), is very important for different applications in studies of hydrology, agronomy and atmospheric modeling.

There are several methods of estimating evapotranspiration (ET) with high reliability, generating measurements with precision and accuracy, according to Allen et al. (2002). However, according to the same author, they have limitations when estimating ET for large areas, and to map the the spatial variability of ET at field scales. These limitations are overcome with the use of remote sensing techniques, through radiometric data obtained from images, since they are capable to cover large areas or areas with a rather rugged relief, showing the spatial variations of ET (Boegh et al., 2002; Hafeez et al., 2002).

The evapotranspiration can be determined as energy balance residual. Therefore, it is possible to estimate evapotranspiration by remote sensing, through sensors that can capture the radiation amount or by sensor that directly or indirectly captures this radiation.

The energy balance method through radiometric data allow the obtaining the vertical flow of latent heat (LE) from orbital and unmanned aerial vehicle (UAV) images, reaching the ET values throw the difference of the soil heat flux density – G, sensible heat – H, and net radiation (Rn). This method is used by the main algorithms which use orbital images on ET estimation, as METRIC algorithm (Allen et al., 2007).

According to Allen et al. (2007), the METRIC (Mapping evapotranspiration at high resolution and with internalized calibration) algorithm was developed for determination of the ET, based on SEBAL algorithm, with some particularities related to the choice of the “hot” and “cold” pixels, the calculation of the temperature difference in that pixels, and the estimative of ET per day.

Thereby this work aims to compare different methods of estimate actual evapotranspiration data in vineyards, in Pinto Bandeira-RS, southern Brazil, specifically the METRIC algorithm applied to orbital and UAVs images, and data obtained by meteorological stations.

MATERIAL AND METHODS

The experiment was conducted at Geisse winery, in Pinto Bandeira city, Rio Grande do Sul State, located 29º09’04”S and 51º25'38”W and 740 meters above sea level (Figure 1). The climate is Cfb according to the Köppen classification with an average annual temperature of 17.6°C and annual rainfall of 1,793 mm with well distributed throughout the year (Falcade & Mandelli, 1999). The vineyard experimental area was installed in 2013 with ‘Chardonnay’ and ‘Pinot Noir’ cultivar, conducted by the 'espalier' system. Vine density was 4545 vines per hectare, with 2,2m x 1,0m spacing. Usual phenological phases dates are: budding at the end of August; flowering in October; maturation in January/February; leaf fall in April.

ET-source-data was taken from meteorological station installed in the experimental vineyard area (coordinates 29° 9'7.19"S 51°25'36.02"W). For the meteorological data, evapotranspiration was estimated by the Penman-Monteith method, parameterized by FAO-56 (Allen et al, 1998).

The orbital data were obtained by OLI and TIRS sensors from Landsat-8, downloaded from Earth Explorer/USGS online repository, of the dates 13-JAN-2017, 29-JAN-2017 and 14-

FEB-2017. The images of 29-JAN and 14-FEB where discarded due cloud coverage on the area.

The images obtained by multispectral camera fixed to an helicopter-based unmanned aerial vehicle (UAV) from AIBOTIX®, carrying onboard a Nikon CoolpixA® Camera, covering the RGB and NIR bands.

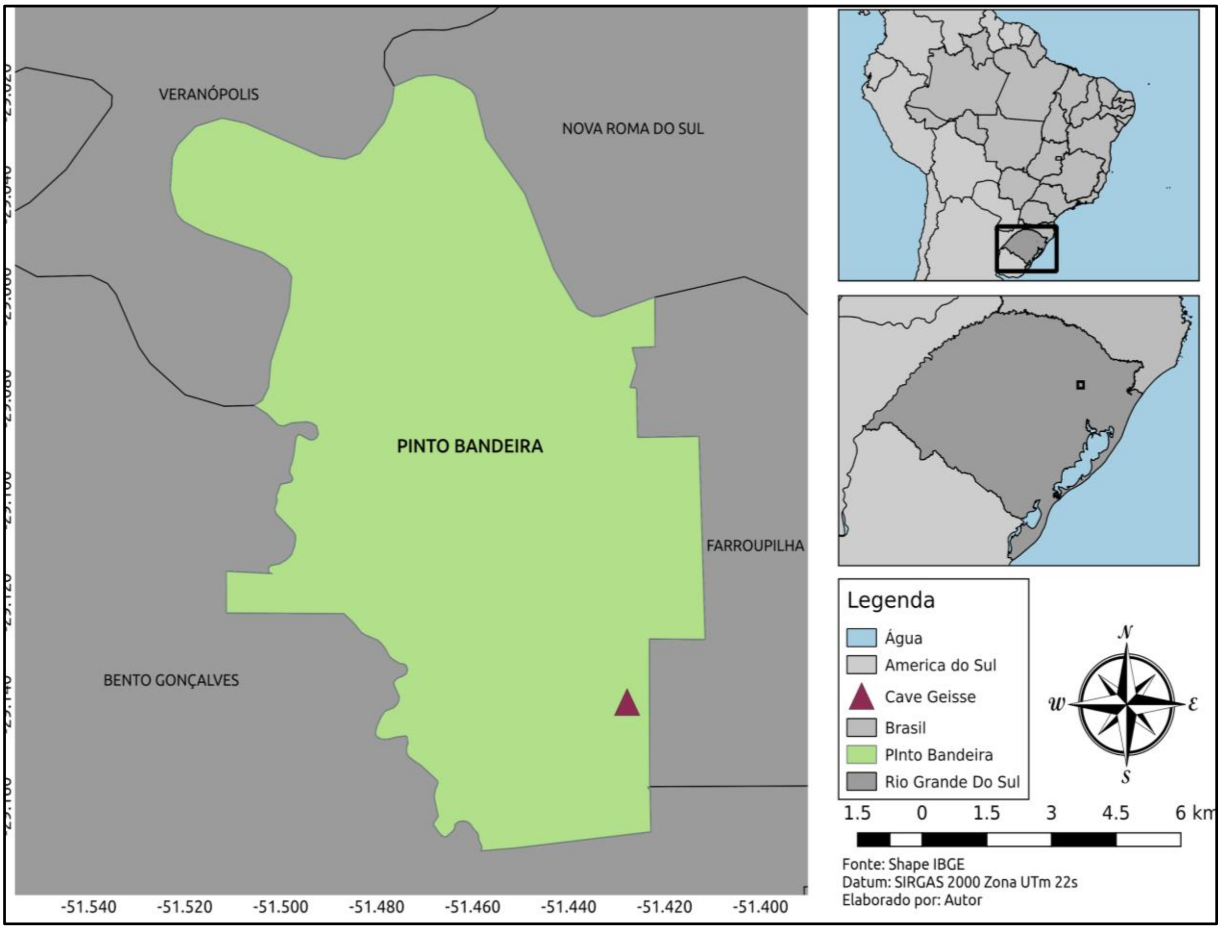

Figure1. Study location – Cave Geisse Winery – Pinto Bandeira / RS / Brazil

Using the QGIS software it was possible to implement the METRIC algorithm equations for the UAV and orbital images. First, it was applied the radiometric and atmospheric corrections using the SCP (Semi-Automatic Classification Plugin) to both images, obtaining an output image representing the spectral radiance of the surface. From this image, it were calculated the vegetation indexes, the NDVI (Normalized Difference Vegetation Index), the SAVI (Soil Adjusted Vegetation Index), and the LAI (Leaf Area Index). From this indexes and the image data, it was calculated emissivity (ε), surface temperature (T_S), and albedo (α), allowing the calculation of the surface net radiation (Rn), heat flux into the soil (G), sensible heat flux (H) and, finally, the instant latent heat flux (λET) through the equation:

$$\lambda ET = R_n - H - G \quad (1)$$

The λET was used to estimate the daily evapotranspiration dividing by the latent heat of vaporization (L=2.45 MJ m^{-2} mm^{-1}).

More details of the METRIC algorithm application can be found in Allen et al (2007) and Folhes et al (2007).

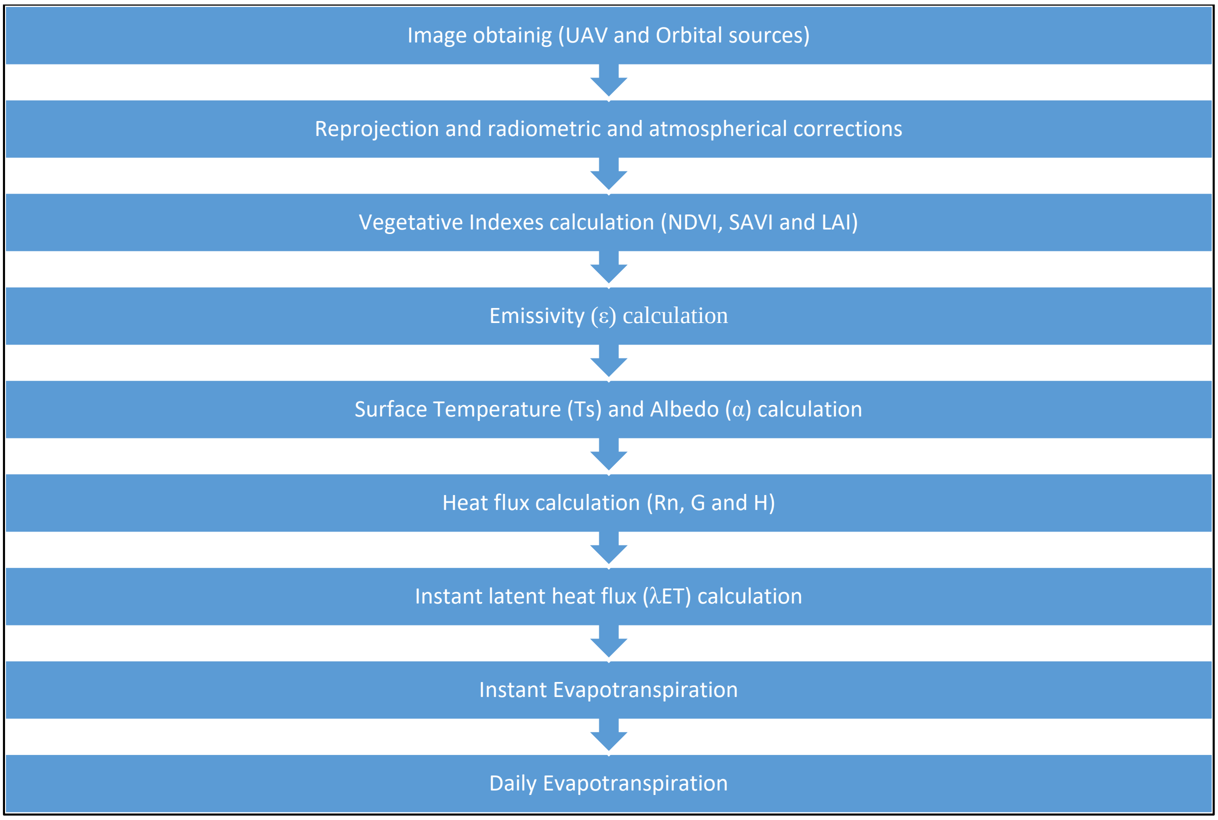

Figure 2. Methodological flow for images processing

RESULTS AND DISCUSSION

Table 1 shows the daily ET calculated by Penman-Monteith method using data from meteorological station near the experiment area for the months of January and February/2017.

Table 1. ET for the months of January and February/2017 calculated from meteorological station data by Penman-Monteith method

January				February			
Day	ET ($mm.day^{-1}$)	Day	ET ($mm.day^{-1}$)	Day	ET ($mm.day^{-1}$)	Day	ET ($mm.day^{-1}$)
01	3.78	17	3.63	01	1.49	17	2.46
02	2.88	18	4.86	02	1.63	18	2.33

03	4.64	19	5.56	03	2.27	19	1.82
04	2.91	20	5.37	04	2.56	20	2.09
05	2.37	21	4.31	05	1.38	21	1.83
06	2.70	22	5.02	06	2.22	22	1.85
07	3.17	23	4.51	07	2.39	23	1.28
08	4.06	24	5.15	08	2.01	24	1.14
09	1.83	25	3.16	09	2.33	25	1.71
10	3.02	26	1.69	10	2.06	26	2.11
11	2.91	27	3.54	11	0.66	27	2.04
12	5.66	28	5.36	12	1.56	28	1.75
13	5.83	29	3.01	13	1.33		
14	3.51	30	3.06	14	1.16		
15	5.53	31	3.24	15	1.81		
16	3.02			16	2.16		

Figure 3 shows ET estimated from orbital image using the METRIC algorithm on LandSat 8 images (OLI/TIRS sensors). On January 13th, 2017, we can compare the data from both sources, 5.83 mm d^{-1} from meteorological station (Table 1) and 6.29 mm d^{-1} from LS8 (pixels near the station point), a difference of 0.46 mm d^{-1}, or 7.9%.

Figure 3. Daily ET obtained from LandSat8 image using METRIC algorithm on 13/jan/2017 over a reference map (Google Images®)

Figure 4 shows the ET estimated from UAV image using the METRIC algorithm. On February 10th, 2017, we can compare the data from both sources, 2.06 mm d^{-1} from meteorological station and 2.17mm d^{-1} from UAV (pixels near the station point), a difference of 0.11 mm d^{-1}, or 5.3%.

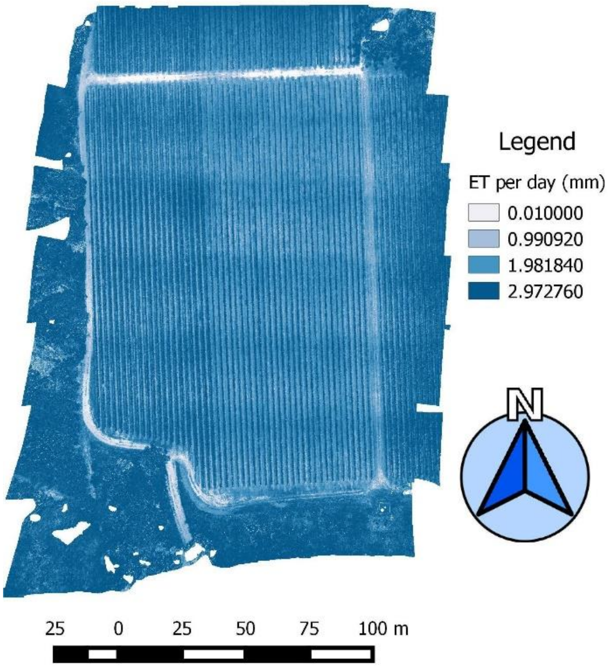

Figure 4. Daily ET obtained from UAV image using METRIC algorithm on Feb 10, 2017.

Senay et al. (2016), using LandSat for mapping water use in the Colorado River Basin (USA), found a clear advantage on using Landsat images for mapping ET, allowing to quantify water use at a field scale, with the cost of reduced temporal frequency and problems with cloud cover, that we also experimented during this short study. From three images downloaded for this cycle, only one could be used due to cloud coverage on the study site.

These issues can be overpassed on the use of UAVs, which have much better resolution (spatial and temporal), allowing better estimation of water requirements of the orchard. Ortega-Farias et al. (2016), using UAV for estimating energy balance over a drip-irrigated olive orchards, also found that multispectral and thermal cameras on UAVs can provide tools to evaluate the effects of spatial variability of energy balance components over heterogeneous orchards, such as vineyards, which present different plant densities and fractional covers.

Gago (2015) also mention the best image's resolution, provided by the reduced altitude of the flight, as the greatest advantage of the UAVs images. On other hand, their disadvantage is they need more flights to cover large areas. On this study, as the area was not big (1.6ha), it was needed two flights on an altitude of 40m to cover the whole area.

CONCLUSIONS

This study demonstrated that images from multispectral cameras on UAV and from orbital sources (LANDSAT-8) are affordable on showing the ET variation on vineyard areas. The great advantage of this methods is showing the spatial variability across the area, which is very difficult to obtaining from other sources. The UAV images showed very promising, as they have better spatial and temporal resolutions. As this is a preliminary study, future improvements needed to be tested, like other algorithms and fine adjustments to reduce the error variations found.

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