THE UNIVERSITY OF OVIEDO'S MODIS RECEPTION ANTENNA: REAL-TIME WEATHER PRODUCTS

Carmen Recondo [1,2], Juanjo Peón [1], and Juan C. Fernández-Iglesias [2]

[1] Area of Cartography, Geodesic and Photogrammetric Engineering. Department of Mining Exploitation and Prospecting
[2] Institute of Natural Resources and Spatial Planning (INDUROT)
University of Oviedo, Asturias, Spain. e-mails: mdrecondo@uniovi.es, peonjuan@uniovi.es, carlos.indurot@uniovi.es

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I. INTRODUCTION

The **surface air temperature (T_a)** and **surface relative humidity (RH)** are key variables in many environmental risk models. A **daily operational method to obtain these variables in peninsular Spain** is required for fire risk models.

These weather variables can be obtained via remote sensing using data from Moderate Resolution Imaging Spectroradiometer (MODIS).

Since 2007, **the University of Oviedo operates a MODIS data reception system**, which receives daytime and night-time MODIS data in real time from the Terra and Aqua satellites (**Figure 1**). The raw data (Level 0) received by the system are processed in real time using the freely distributed software International MODIS/AIRS Processing Package (IMAPP) to create several Level 1B and Level 2 products.

Several **empirical algorithms** have been developed **to derive weather products from the MODIS data received by our reception system**. These algorithms enable us to estimate daily mean, maximum, and minimum values of T_a, RH, and **surface water vapour pressure (e_0)**, over cloud-free land areas in peninsular Spain.

Currently, **maps of daily maximum and mean T_a at 1-km spatial resolution** are generated by a full automatic computing system and **distributed to end users through our MODIS Web Map Service (WMS)**. These maps are available daily, after the first daytime Terra overpass, between 10 and 12:30 GMT.

Figure 1. The University of Oviedo's MODIS reception antenna.

II. ALGORITHMS FOR GENERATING WEATHER PRODUCTS

Air temperature and relative humidity can not be directly obtained from remote sensing data, but they can be estimated using other related variables obtained via remote sensing, such as **land surface temperature (LST)** and **total precipitable water (W)**.

Empirical models for estimating T_a, e_0, and RH were developed using data from 331 ground-level meteorological stations and MODIS data received and processed by our direct broadcast system during the year 2010. Fifty percent of the sample was used for model calibration and the remaining fifty percent for validation.

The technique used for modelling the weather variables was the **multiple linear regression (MLR)**. Spatiotemporal variables were included in the models to improve their prediction ability. The complete list of variables used in the models is shown in **Table 1**.

Remote sensing variables (MODIS products obtained with IMAPP)	Spatiotemporal variables
Daytime Terra total precipitable water (W) Daytime Terra land surface temperature (LST_{day}) Night-time Aqua land surface temperature (LST_{night}) Daytime Terra NDVI	Height (h) Longitude (λ) Distance to the coast (d_{coast}) Curvature (c) Julian day of the year (JD)

Table 1. List of variables used in the multiple linear regression models.

A detailed description and comparison of the algorithms can be found in Recondo *et al*. (2013a, 2013b) and Peón *et al*. (2014).

The best multiple linear regression models for estimating T_a, e_0, and RH are included in **Table 2**.

Variable	Prediction model (Multiple Linear Regression)
Surface air temperature	T_a (mean) = 131 + 0.510·LST_{day} + 2.82·W + 4.5·NDVI - 0.21·λ + 0.0048·JD - 0.0012·h T_a (max) = 104 + 0.631·LST_{day} + 2.06·W + 5.5·NDVI - 0.13·λ + 0.0062·JD - 0.0014·h T_a (min) = 20 + 0.92·LST_{night} + 0.6·W - 110·c - 0.004·λ - 0.0027·JD + 0.0008·h
Surface water vapour pressure	e_0 (mean) = 3.6 + 5.49·W - 0.17·λ - 0.0024·d_{coast} + 0.0037·JD e_0 (max) = 2.9 + 5.12·W - 0.19·λ - 0.0024·d_{coast} + 0.0041·JD e_0 (min) = 3.5 + 4.26·W - 0.19·λ - 0.0061·d_{coast} + 0.0016·JD
Surface relative humidity	RH (mean) = 355 + 8.9·W - 1.03·LST_{day} - 0.019 ·d_{coast} - 0.002·λ + 0.0030·h + 6·NDVI + 0.002·JD RH (max) = 215 + 4.2·W - 0.45·LST_{day} - 0.002·d_{coast} + 0.41·λ + 0.0015·h + 9·NDVI + 0.001·JD RH (min) = 309 + 9.1·W - 0.97·LST_{day} - 0.025·d_{coast} - 0.53·λ + 0.0051·h + 0.4·NDVI - 0.008·JD

Table 2. Multiple linear regression models for estimating weather variables.

The validation of these models was successful (**Table 3**). The best estimations were obtained for T_a (errors ~2 K) and the worst for RH (errors ~10%).

	Surface air temperature			Surface water vapour pressure			Surface relative humidity		
	T_a (mean)	T_a (max)	T_a (min)	e_0 (mean)	e_0 (max)	e_0 (min)	RH (mean)	RH (max)	RH (min)
n	2979	2979	2099	2731	2573	2577	2731	2592	2577
R^2	0.92	0.92	0.91	0.83	0.80	0.67	0.39	0.12	0.46
RMSD	2.05 K	2.40 K	1.88 K	1.86 hPa	1.99 hPa	2.21 hPa	10.05%	11.83%	8.66%
Bias	0.05 K	-0.01 K	0.11 K	0.09 hPa	0.17 hPa	0.03 hPa	-0.36%	-1.42%	0.28%

Table 3. Validation of the models for estimating weather variables. n: number of observations; RMSD: root mean square error of the differences; Bias: mean of the residuals.

III. SAMPLE PRODUCTS

Figure 2 shows an **example of several weather products** generated using MODIS data received by the University of Oviedo's direct broadcast system.

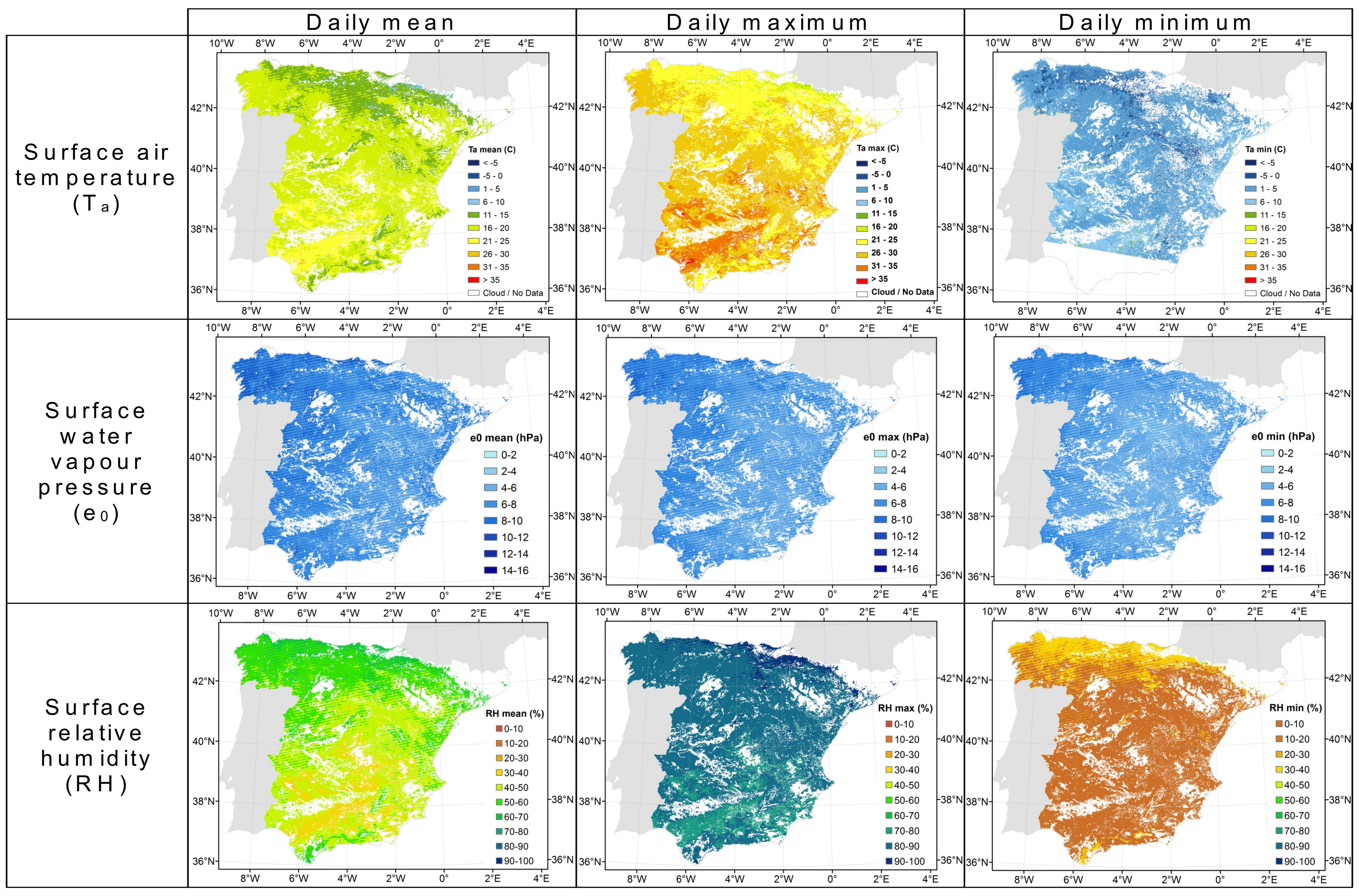

Figure 2. Maps of daily mean, maximum, and minimum T_a, e_0, and RH generated from MODIS data received on May 3, 2016. The spatial resolution of the maps is 1 km.

IV. DISTRIBUTION OF PRODUCTS TO END USERS

Maps of daily maximum and mean T_a over cloud-free land areas in peninsular Spain **are currently distributed to end users** by the INDUROT (University of Oviedo), in real time, after the first Terra overpass (10-12:30 GMT). These maps are freely available and can be consulted in the **INDUROT web viewer** (**Figure 3**) or through our **Web Map Service (WMS)** using a GIS desktop application (**Figure 4**).

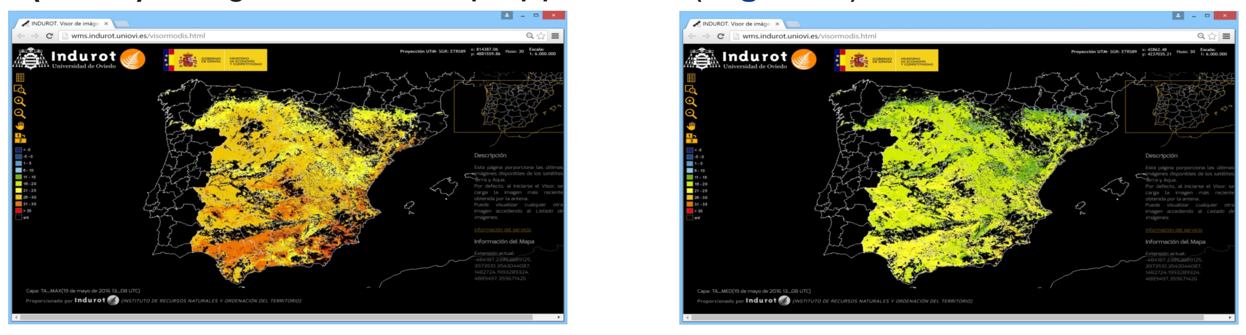

Figure 3. Sample maps of daily maximum and mean T_a (May 19, 2016) in the INDUROT web viewer.

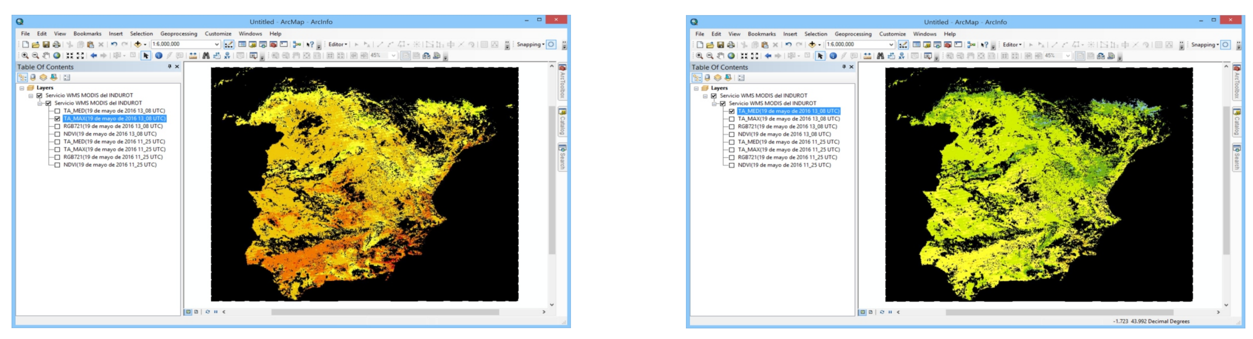

Figure 4. Sample maps of daily maximum and mean T_a (May 19, 2016) consulted through WMS on ArcGIS desktop.

Further information and **WMS URLs**, as well as daily MODIS quicklooks, can be found on the INDUROT webpage:

http://www.indurot.uniovi.es/actividad/modis

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