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Minimum summer temperatures in the southeast of the iberian peninsula through satellite thermographies

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The latitudinal position of the southeast of the Iberian Peninsula generates high average temperatures (between 25 and 30ºC) during the summer season, although, its complex orography and the important altitudinal gradient, generates important differences in the minimum temperatures, influenced especially by intense inversion temperature nocturnal (ITN) in inland valleys. The increase in new meteorological stations and the increase in the density of observation networks, together with the implementation of its own network of cold pole recording thermometers (CAP) in the provinces of Murcia, Albacete or Jaén, leads to greater knowledge of the distribution of night surface temperatures. For this, a thermal analysis is carried out in the six provinces that make up the southeast of the Iberian Peninsula (Alicante, Albacete, Murcia, Jaén, Granada and Almería).

The main objective of the research is the generation of cartography (thermographs) that reflects the distribution of night temperatures in the southeast of the Iberian Peninsula, carried out through satellite products. The aim is to analyze the thermal contrasts in the statistically warmer time of the year (hottest days of summer period from 2017 to 2020), with the support of observational data, which also serve to validate the satellite product in the study area.

Methodologically, images from the SUOMI-NPP satellite (Band I5 product of the VIIRS instrument) are used, with which surface thermographies are performed during the hottest days of summer period (July 15 to August 15) from the years 2017 to 2020. One of the objectives is analyze in detail the thermal contrasts during the early mornings of atmospheric stability, and their comparison with the surface temperatures recorded in automatic meteorological stations (EMAs) and an own datalogger network. Therefore, 147 EMAs belonging to different official bodies (AEMET, SIAR and Junta de Andalucía) are used. A total of 92 stations belong to the Sistema de Información Agroclimática para el Regadío (SIAR) del Ministerio de Agricultura, Pesca y Alimentación; 32 to the a la Red de estaciones agroclimáticas de la Consejería de Agricultura, Ganadería,

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Pesca y Desarrollo Sostenible de la Junta de Andalucía; 8 to the State Meteorological Agency (AEMET), together with 15 recording thermometers belonging to the author's own network.

The use of the own datalogger network is justified by the use of enclaves with minimum average temperatures lower than those provided by official networks, in an effort to reach populated high mountain areas and remote areas. The recorder thermometers (dataloggers) used are mostly Elitech RC-5 brand of 25000 records (with calibration certification from CNAS, China National Accreditation Service), two of them are Microlite 32K (32000 records), and finally, located in two sites with the coldest average temperatures, and under the harshest winter conditions, two 50,000-record HOBO MX25 loggers are used. In most observatories, an artisanal meteorological checkpoint composed of 11 white plates is used, in 3 of them the approved meteorological checkpoint is Davis type (7714), and finally, for the thermometers located in the places of Navalasno and Nava del Polvo they are located inside two pagoda-type meteorological checkpoints, provided by AEMET Murcia (Image 1). The recorders used have a 10 minutes' time range, with an accuracy of ± 0.3˚C and a thermal resolution of 0.1°C. Those located in Monterilla and Navalasno are calibrated by the Territorial Delegation of AEMET of Murcia, in the Territorial Meteorological Center of Guadalupe. Those responsible for the maintenance of the instruments determine a deviation of + 0.2ºC in the minimum temperatures.

The preparation of the final cartography (thermographs) for the different provinces analyzed is carried out with an average of 50 daily maps through the free license software QGIS 3.10.7. It is about 50 stable early mornings (with nocturnal thermal inversion processes), without cloud cover (0%), and complemented with the support of data analysis of minimum surface temperatures during the hottest days of summer observation periods (2017, 2018, 2019 and 2020).

The statistical validation of the VIIRS LST product (Band I5) with the minimum temperatures recorded on the surface is carried out with the Spearman correlation coefficient, the BIAS and the mean square error (RMSE).

The VIIRS LST product (Band I5) is subjected to a statistical verification with the surface temperatures recorded in the surface meteorological stations. The statistical correlations for the entire sample are relevant (Spearman's R2 of 0.87), with a confidence level of 0.99. The Bias, and the RMSE of the differences between Band I5 and the meteorological stations is -0.2 and 1.83ºC respectively for the whole study area.

In general, and with the exception of the altitudinal band higher than 1000 m, the vast majority of the study area presents a Bias and RMSE not higher than -0.51 and 1.83ºC. The highest altitudinal band (> 1000 m) has a smaller statistical sample (102) with the smaller number of meteorological stations in mountainous areas. The thermal difference between the Band I5 product and the temperatures of the meteorological stations used is -0.2ºC. In other words, satellite images very slightly underestimate the minimum temperatures recorded on the surface, especially where the nocturnal reversal processes are more intense, generally in higher altitude zones.

The statistical correlations in the rest of the altitudinal ranges are similar, between 0.80 and 0.75, with minor thermal differences (-0.5 to -0.3ºC). Between 250 and 1000 m. altitude, the statistical results show very important results. However, the observatories with altitudes below 250 m (with the warmest values) register a somewhat lower correlation (0.54), but statistically corroborated with a Bias and RMSE of 0.41 and 1.63ºC. In this altitudinal range, the temperature difference is 0.4ºC, where the values estimated by the Band I5 product underestimate the surface temperature recorded by the observatories, probably motivated by the effect of the urban heat islands (ICU), when coinciding with the most densely populated area.

The spatial distribution of the nocturnal thermal values in the different analyzed provinces is motivated by the complexity of the orography with daily thermal differences in the minimum temperatures of up to 23.4ºC between elevated inland valleys and coastal areas. During the analysis period, absolute differences were recorded between 29.8ºC in the capital Jaén, and 1.0ºC in the Nava del Polvo area (province of Jaén).

Most of the population is located around the provincial capitals, coastal and pre-coastal axes, where, in general, the minimum summer temperatures are higher. The provincial capitals of Granada, Jaén or Albacete, located in inland areas, are strongly influenced by night-time ICUs, with a significant thermal increase compared to their peri-urban area. The vast majority of meteorological stations are located here, so the sectors with the highest average values are well represented. The main difficulty lies in the observation of depopulated inland areas, sparsely inhabited mountain valleys and medium / high mountains.

In analysis carried out in the study area during the hottest days of summer observation period, notable results show in the provinces analyzed, with an absolute difference in the average temperatures of the minimum of 15.1ºC between Nava del Polvo (8.4ºC) and Los Belones (23.5ºC) separated by 182.2 km in a straight line. And it is that, in the last four hottest days of summer observation period (2016-2020) and a total of 128 days of analysis, the Metropolitan Area of Murcia, close to the city center (CMT AEMET), records 100% of tropical nights, influenced, undoubtedly, by the nocturnal ICU. Espín et al., (2018) determine notable thermal differences in the Vega Media of the Segura river (Murcia), specifically between La Contraparada and the AEMET CMT (in topographic highlight), with an altitude difference of 4 m and 4.2 km of distance. The average rate of change (lapse rate or LR) is 80.2ºC / 100 m, with absolute values of 192.9ºC / 100 m on 11/06/2013 (minimum absolute temperature of 16.0ºC in the CMT AEMET and 8,3ºC in the Contraparada).

In the same time, temperatures remain close to frost, with absolute minimum values of 1.0ºC in the Sierra de la Cabrilla (Nava del Polvo, Jaén). The most important daily difference in absolute minimum temperatures was recorded on 07/29/2018, with 23.4ºC, undoubtedly a really outstanding value. During the aforementioned day, a minimum temperature of 1.2ºC was registered in the area of Monterilla (Jaén), in Hernán Perea Plateau, under an intense ITN process. In the same area previously described (Los Belones) the minimum temperature does not drop below 24.6ºC.

In short, the intense ITN processes in high altitude valleys in the interior of the peninsular southeast, generate important thermal differences with the coastal, pre-coastal areas, and orographically rugged midlands, where the minimum summer temperatures do not usually drop in most cases of 20°C. The use of recording thermometers in these mountainous areas has been able to discover unusually low minimum temperatures in the heat of the hottest days of summer observation period in plateaus, remote uninhabited areas, or mountain valleys, with minimum temperatures close to 0ºC. Even in inhabited areas such as La Risca or Benablón (Murcia), Cañadas de Nerpio (Albacete), Cañada Grande (Almería), Guadix (Granada) or Pontones (Jaén), the minimum temperatures drop below 10ºC, so it is a significant recurrence in only 4 observation periods.