DESCRIPTION AND ADJUSTMENT OF THE BIAS PRODUCED BY THE INTRODUCTION OF AWS IN TEMPERATURE STATIONS IN SPAIN.

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We study a subset of a larger dataset provided by the Spanish Agency Estatal de Meteorología (AEMET) and the Servei Meteorològic de Catalunya (SMC). This preliminary raw dataset contains around 134,000 paired observations from 47 different stations, located all over Spain, and has been quality controlled to eliminate abnormal observations. The quality control process has been performed by flagging those pairs of values (AWS and CON) for which:
- Daily maximum temperature is larger or equal than daily minimum temperature either in the AWS or the CON series.
- Either the AWS or the CON measurement does not fall in the range comprised between -50°C and 50°C.
- Either the AWS or the CON measurement is outside the -40°C to 40°C range and the difference AWS-CON is larger than 2°C.
- Either the AWS or the CON measurement is an outlier, defined as an AWS-CON difference outside the limits defined by the 75th percentile minus 4 interquartile ranges of the dataset.
- Compute monthly means for those months with at least 15 values. Notice that this is far from the usual WMO criteria (5 missing values across the month or 3 consecutive missing values during the month), but it is considered that 15 values can provide a solid enough average for our purpose of describing the differences between AWS and CON observations.
- Retain years for which the 12 monthly means could be computed and compute annual means.

The analyzed dataset contains nearly 30,000 pairs and 102 complete years, belonging to 30 different stations.

In a second step, incomplete years have been removed from the analysis by applying the following procedure:
- Select those days for which both AWS and CON have a valid measurement both in daily maximum temperature and daily minimum temperature.
- Compute daily differences in TX for Salamanca-Matacán.

FIGURES 3 AND 4 show the monthly averages of the differences AWS-CON and the annual EEDFs for two stations: Barcelona-Fabra (3) and Salamanca-Matacán (4). In both cases, daytime values tend to be warmer in the AWS and nighttime values warmer in the CON. Barcelona-Fabra shows a change in behavior in phase with the stratospheric cooling of the AWS since July 2007, with a sharp reduction of the differences. The EEDFs for Salamanca-Matacán’s TN show a changing pattern across the distribution.

ADJUSTMENTS

TABLE 1.- 2867, TX. COMPARISON OF RAW VS DIFFERENT ADJUSTMENTS

<table>
<thead>
<tr>
<th></th>
<th>P90</th>
<th>P75</th>
<th>P50</th>
<th>P25</th>
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</tr>
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<tr>
<td>Unadjusted</td>
<td>-0.60</td>
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<td>0.00</td>
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<td>PAM Modified</td>
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<td>-0.10</td>
<td>-0.05</td>
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<td>-0.10</td>
</tr>
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</table>

NOTE: the adjustment factors and the regression models have been computed using two years of data and applied to a different section of the series for validation.

FIGURE 5 shows the monthly differences depicted in FIGURES 3 and 4, together with different adjustments applied. Namely: 1) a monthly mean adjustment: 2) a linear regression model; 3) a linear regression model stratified by months; 0) & 5) two different versions of Percentile Matching Algorithms. All the adjustments reduce the monthly averaged differences. Table 1 shows how the Percentile Matching Algorithms also reduce better the differences between different percentiles in TX for Salamanca-Matacán.

NOTE: the adjustment factors and the regression models have been computed using two years of data and applied to a different section of the series for validation.

FIGURE 1 shows annual statistics. The mean annual bias is 0.1°C in TX and -0.2°C in TN. Thus, on average, AWS are in this dataset slightly warmer during the day and slightly cooler at night. For TX, 46.4% of the observations correspond to a warmer bias and 43.9% is colder AWS. The remaining 9.7% show no difference. These values are, respectively, 40.0% 53.0% and 6.2% for TN. For both daytime and nighttime temperatures, around half of the observations show difference smaller or equal in absolute value to 0.5°C (56.7% and 49.5%), meanwhile the percentage of cases with an absolute bias smaller or equal than 0.1°C 15.3% in TX and 22.2% in TN.

FIGURE 2 shows the monthly distributions of the AWS-CON daily differences. These statistics (not shown) are quite similar to the annual. For TX, larger mean differences are found in January and February (12°C and 13°C), with the rest of the months oscillating between 0.1°C and 0.3°C. For TN, all months present negative biases between -1°C and -2°C. All the monthly distributions, represented in FIGURE 2, are leptokurtic and skewed, presenting heavy tails and large maximum modulus differences. Naturally, an in-depth inspection of the dataset reveals the differences between stations and even in different years of the same station (see next section). However, their inspection confirms a larger prevalence of the cool-AWS bias and negative differences in TN and a larger percentage of cases inside the ±0.5°C and ±0.1°C thresholds in TX.

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FIGURE 3: Station 200E (Barcelona-Fabra) UP LEFT: Annual values of the temperature differences AWS-CON. BOTTOM: ECDFs of AWS (red) and CON (blue) daily minimum temperatures.

FIGURE 4: Station 2007 Salamanca-Matacán: LEFT Annual values of the temperature differences AWS-CON in TX (red) and TN (blue); RIGHT: ECDFs of AWS (red) and CON (blue) daily minimum temperatures.

FIGURE 5: Monthly Differences AWS-CON and AWS-Adjusted. UP: Barcelona-Fabra. DOWN: Salamanca-Matacán. In each panel: pointed line is original, red is monthly adjustments, green is linear regression bias is linear regression bias by months, cyan is modified PAM; yellow is original PAM.