ON THE BIAS INTRODUCED BY THE AUTOMATIZATION OF TEMPERATURE OBSERVATION IN SPAIN

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INTRODUCTION

- The change from conventional stations to automatic weather stations is happening routinely in many station networks across the world.
- One may expect more AWS-CON substitutions in the near future.
- These changes may be a source of inhomogeneity.
- The study of parallel measurements provides insights on the size, shapes and the suitability of different correction methods.

La Granadella Station. AWS instruments and conventional station. Picture: Servei Meteorològic de Catalunya.
OBJECTIVES OF THIS TALK

• Introduce the network prepared under the Spanish Grant CGL2012-32193

• Provide general statistics on the differences between AWS-CON measurements, provided by parallel measurements.

• Apply and evaluate different versions of the Quantile Match Algorithm (Trewin 2012) and different regression models to adjust the series
EXPERIMENT DESIGN

- Dataset Compilation
- Long series selection
- Outliers detection
- Segmentation
- Quality Control
- Model and validation sections
- Application of the models
- Analysis
Data have been provided by the Agencia Estatal de Meteorología, AEMET, and the Servei Meteorològic de Catalunya, SMC.

The raw dataset contains ~ 134,000 paired observations from 47 different stations, located all over Spain.

From the raw dataset, only those stations with at least 730 paired observations in both TX and TN were initially retained, for a total amount of 118,000 paired observations from 26 sites.

Some of the rejected stations and additional stations have the potential to complete the requested number of observations.

The dataset contains a similar number of paired precipitation paired observations, not yet analyzed.
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RAW NETWORK STATISTICS

TX. Negative: 53.2 Zero: 12.8 Positive: 34 Abs. 0.5: 83

TN. Negative: 53.2 Zero: 23.4 Positive: 23.4 Abs. 0.5: 8

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RAW NETWORK STATISTICS

TX. > 50: 74.5 >80: 31.9

TN. > 50: 72.3 >80: 38.3

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EXAMPLE AWS-CON RAW SERIES

TX, clear seasonal cycle; not apparent in TN, dominated by outliers.

Avilés.
EXAMPLE AWS-CON RAW SERIES

2867

Salamanca Apt.

Dominated by outliers,
no smaller seasonal cycle in TX

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EXAMPLE AWS-CON RAW SERIES

Murcia/San Javier.

Dominated by large inhomogeneities

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EXAMPLE AWS-CON RAW SERIES

Salamanca Apt.

Dominated by outliers, no smaller seasonal cycle in TX
QUALITY CONTROL

• Ran twice: before and after segmentation

• Detected values flagged and not used for analysis
  - Errors: \( t_{\text{max}} > t_{\text{min}} \) in any sensor
  - Hard limits: \( \text{abs}(t_x) \) or \( \text{abs}(t_n) > 50 \)
  - Combined limits: \( \text{abs}(t_x) \) or \( \text{abs}(t_n) > 40 \) and the difference between sensors is larger than 2\(^\circ\)C
  - Outliers: differences not included in \( p_{75}+4IQR \) and \( p_{25}-3IQR \)
HSP DETERMINATION

- Visual, cghseg and SNHT over AR1 on difference series.
- For some stations, supporting metadata has been facilitated
- Final decision: manual
- HSP have been identified
- Only HSP with at least 730 values have been retained for analysis.

SNHT detection over Barcelona Fabra. Metadata supports the last two breaks, which are retained.
### METADATA AWS NURIA & SANT PAU

<table>
<thead>
<tr>
<th>Estación</th>
<th>Fecha</th>
<th>Tipo de Medida</th>
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QUANTILE-MATCH ADJUSTEMENTS

- Following Trewin (2012) process for parallel measurements
- Determination of monthly normals for Site 1 and Site 2
- Linear Interpolation to daily normals
  - Modification: harmonics
- Anomalies to daily normals
- Define sample of observations for each month (usually, the same month, previous and following)
- Compute percentiles over the sample (with limit in 90, 95, 99)
- Add normals to percentiles and compute differences for site 1 and site 2 (Dmj)
  - Differences are smoothed with a loess filter

\[ T_2 = T_1 + D_{m,j}, \text{ where } j \text{ is a value such that } TP_{1,m,j} \]
\[ = T_1. \]
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ADJUST. FACTORS:
RAW vs LOESS FILTERED
REGRESSION MODELS

• To contrast with the QM adjustments, different regression model-based adjustments have been computed using as predictands the temperature at the CON site, its DTR, their quadratic transformations and their interactions with harmonics up to the 3rd degree.
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QUADRATIC TERMS TX, DTR AND HARMONICS INTERACTION

QUADRATIC TERMS, TX AND DTR AS PREDICTANT

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NETWORK PROB. AWS-ADJ /AWS-CON IN [-0.5°, +0.5°]

> 1 = IMPROVEMENT.

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QM75, loess, cut

QM95, loess, cut

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Simple regression with TX-CON as predictand
ADJUSTMENT EXAMPLES

TX, DTR as predictands; quadratic terms, interaction with Harmonics.

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ADJUSTMENT EXAMPLES

1212E tn 1

Statistics

QM90
ADJUSTMENT EXAMPLES

QM90, Murcia/San Javier

Reduction in error, bias in median (negative diffs are more adjusted than positive ones)
ADJUSTMENT EXAMPLES

Very good adjustment.
CONCLUSIONS AND FURTHER WORK

- We investigate a dataset containing parallel measurements AWS-CON for Spain
- The QM adjustments described in Trewin (2012) provides good results, outperforming the applied regression models
- Some QM-Adjustments may introduce biases in the median (mean) difference.
- Detection of inhomogeneities in the difference is key for a good adjustment.
- Improve outliers detection We need to better understand why outliers are outliers
- Consider other adjustment models, including those using other variables to improve corrections
- Explore adjustments for precipitation
THANKS FOR YOUR ATTENTION