



## **Estimating daily climatological normals in a changing climate**

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Climatological normals are widely used baselines to describe and characterise a given meteorological situation. The World Meteorological Organisation (WMO) recommends to estimate climatological normals as the average of observations over a 30-yr period. This approach may lead to strongly biased normals in a changing climate.

Here we propose a new method to estimating daily climatological normals in a non-stationary climate. Our statistical framework relies on the assumption that the response to climate change is smooth over time and on a decomposition of the response inspired by the pattern scaling assumption. We therefore consider a non-linear functional statistical model. Inference is carried out using smoothing splines techniques. We discuss the selection of smoothing parameters using a variant of cross validation. The new method is compared, in a predictive sense and in a perfect model framework, to previously proposed alternatives such as the WMO standard (reset either on a decadal or annual basis), averages over shorter periods and hinge fits. Results show that our technique outperforms all alternatives considered. They confirm that previously proposed techniques are substantially biased – biases are typically as large as a few tenth to more than 1 degree by the end of the century – while our method is not.

We argue that such “climate change corrected” normals might be very useful for climate monitoring, and that weather services could consider using two different sets of normals (i.e. both stationary and non-stationary) for different purposes.