European Climatic Energy Mixes (ECEM)

Climate Change

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October 2017, Webinar

Copernicus Europe's eyes on Earth

European Commission

Outline

- ★ Climate Variables developed within WP2 of ECEM
- ★ Based on ERA-Interim Reanalysis (1979 to the present) but bias adjusted to observational data
- ★ Different 'real world' datasets and land/ocean masks
- ★ Comparisons of adjusted and unadjusted datasets

Climate variables

- ★ Assessing ERA-Interim quality by comparison to gridded observed data (over land areas) for various variables
- ★ Emphasis here on Climate Variables of greatest relevance to Renewable Energy (radiation/sunshine and wind, and precipitation influences HEP), but others (e.g. temperature, RH influences Demand) are also relevant
- ★ ERA-Interim despite probably being the best Reanalysis is not perfect. We can assess how good it is (when and where) by comparisons with gridded observational datasets. Improving on it is termed bias adjustment

Climate Variables – Relevant for Energy

- ★ Air Temperature (mean, maximum and minimum) at 2m
- ★ Precipitation
- ★ Solar Radiation
- ★ Wind Speed at 10m (also WS100m with a formula)
- ★ Relative Humidity (uses air and dewpoint temperature)

- ★ ERA5 will be available by 2019. Here WS100m will be output directly
- ★ ERA5 will have improved spatial resolution and hourly temporal resolution
- ★ ERA5 ought to be better, but as it doesn't ingest much more data than ERA-Interim, it will also likely need bias adjusting
- ★ ERA5 will also provide ensembles, which will give a measure of uncertainty

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Bias Adjustment Procedures used in ECEM

- ★ Numerous approaches in the literature (most variable independent, but some are more complex involving multivariate relationships between the variables)
- ★ Most were introduced for bias-adjusting GCMs and RCMs (i.e. projections), where biases with observations are larger than for Reanalyses

- ★ Our bias-adjustment approach (Jones et al., 2017) is distributional in nature, and equates the distributions between ERA-Interim and Observations, based on different distributions for different variables (following Tye et al., 2014)

- ★ Jones, P.D., Harpham, C., Troccoli, A., Gschwind, B., Ranchin, T., Wald, L., Goodess, C.M. and Dorling, S., 2017: Using ERA-Interim reanalysis for creating datasets of energy-relevant climate variables. *Earth System Science Data* **9**, 471-495, doi.org/10.5194/essd-9-471-2017.

- ★ Tye, M.R., Stephenson, D.B., Holland, G.J. and Katz, R.W., 2014: A Weibull approach for improving climate model projections of tropical cyclone wind-speed distributions. *J. Climate* 27, 6119-6133.

Variable Distributions

- ★ Weibull Distribution for Wind Speeds
- ★ Normal Distribution for Air Temperature
- ★ Gamma Distribution for Dewpoint Depression (needed to produce RH)
- ★ Gamma Distribution for Precipitation (Fits much better when a low threshold for daily precipitation is selected, 0.5-1.0mm). Adjusting ERA-Interim will set all low precipitation totals to zero
- ★ Solar Irradiance (directly adjusted using satellite data, as very few direct observational sites)

- ★ Wind Speed and Dewpoint Depression values from HadISD
- ★ Air Temperature and Precipitation from E-OBS
- ★ Solar Irradiance from Helioclim-v3 satellite data
- ★ Details of datasets in Jones et al (2017)

Bias Adjustment and Uncertainty

- ★ Is bias adjustment worth it? Can be assessed by the transfer functions (to Energy Indicators) within WP3 – are these improved with the adjustments?
- ★ Look at differences between unadjusted Reanalysis and the ECEM bias-adjusted version. Here we will look at differences in the long-term means from 1979 to the near present

- ★ Equating the distribution, only ensures the mean is the same for a normal distribution

- ★ Bias adjustment comes in various forms. How important is the inter-variable consistency in the energy context?
- ★ Multivariate adjustment also being assessed in ECEM (Dekens *et al*., 2017). More difficult to apply this approach to more than two variables

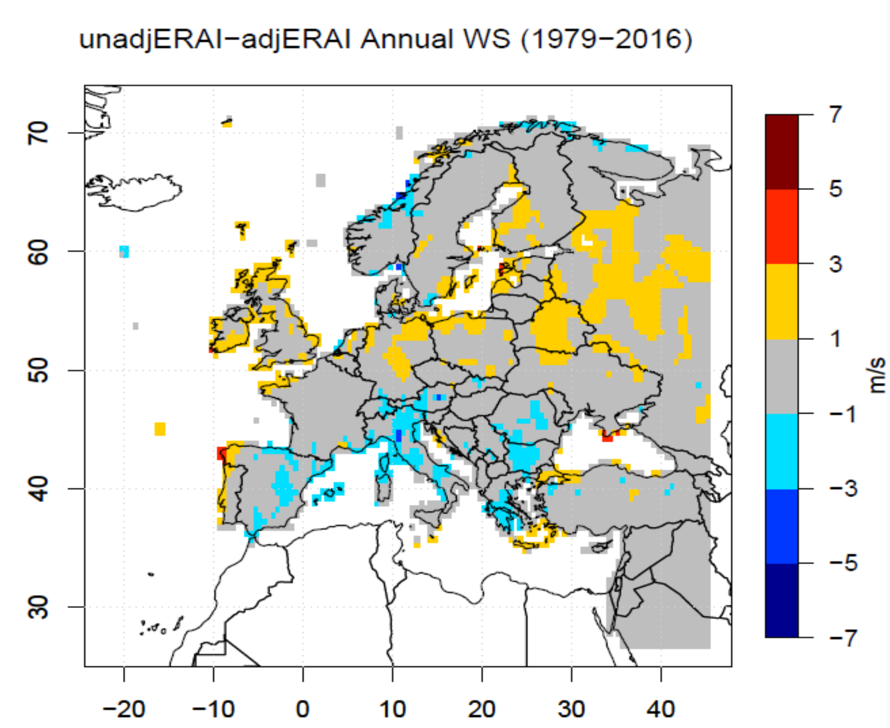
★ Dekens, L., Parey, S., Grandjacques, M., and Dacunha-Castelle, D., 2017: Multivariate distribution correction of climate model outputs: a generalisation of quantile mapping approaches, *Environmetrics*, https://doi.org/10.1002/env.2454

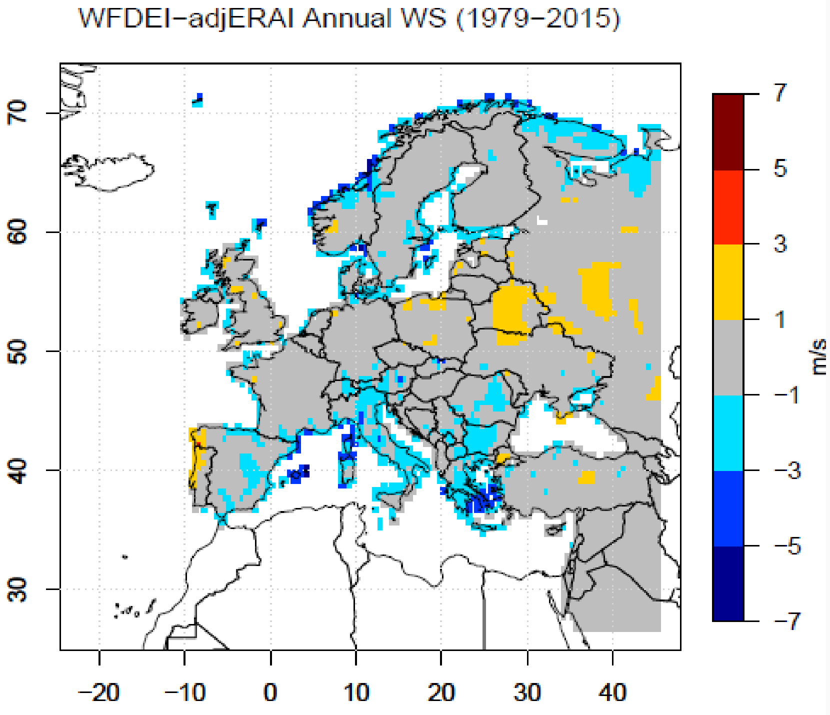
'Real World' Datasets

- ECEM has used 'real world' datasets (E-OBS, HadISD, GPCC, CRU TS 3.23, discussed in Jones et al., 2017). Here we use another 'real world' dataset (the well-used WFDEI dataset (Weedon et al., 2014)
- WFDEI is the dataset used to bias adjust the RCM data for the Climate Projection data used in the ECEM Demonstrator
- **WFDEI** is **W**atch **F**orcing **D**ata applied to **E**ra-**I**nterim
- Important to know what real-world datasets are based on and how they have been used
- WFDEI is also based on ERA-Interim (adjusted by CRU TS 3.23, for air temperature, GPCC for precipitation and not adjusted for wind speed). WFDEI is unadjusted ERA-Interim data for wind speed, but plots in the ECEM Demonstrator show this is not always the case. This is being investigated
- No surface-based dataset for solar radiation, so not discussed here

- Weedon, G. P., Balsamo, G., Bellouin, N., Gomes, S., Best, M. J., and Viterbo, P.: The WFDEI meteorological forcing data set: WATCH Forcing Data methodology applied to ERA-Interim reanalysis data, Water Resources Research, 50, 7505-7514, doi: 10.1002/2014WR015638, 2014.

Unadjusted minus adjusted (Wind Speeds)





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Why the Differences?

- ★ **Stations used may not be representative of larger regions, particularly near coasts**
- ★ WFDEI is based on unadjusted ERA-Interim, but not for some coastal regions and periods used here
- ★ **Important to check land/sea masks**
- ★ Another C3S project (C4E, who bias-adjusted the RCM data) found similar differences between station data (HadISD and ISDLite) and WFDEI (See Figure)
- ★ A gridded wind speed data is needed. This will come in the C3S project SURFOBS

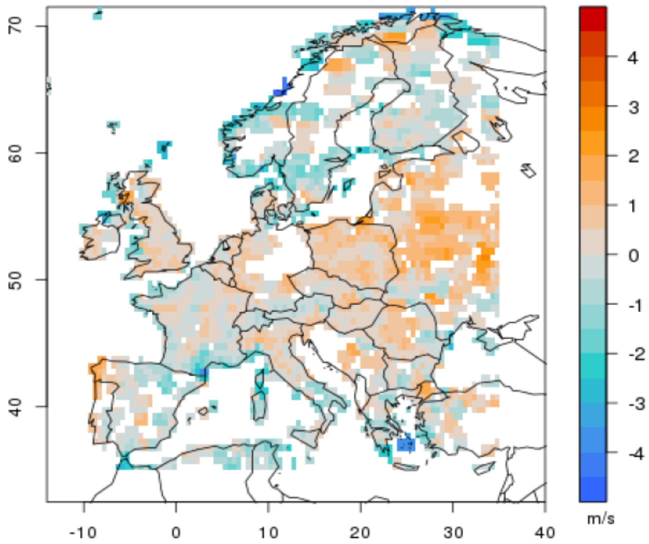

Figure 4-1: Difference between 1981-2000 averages of 10m wind speed from WFDEI data and ISDLite-based dataset built following the methodology of Tobin et al 2015. Only the grid points having ISDLite stations within 75km of the grid point center are kept in order to ensure a certain level of quality for the ISDLite-based dataset.

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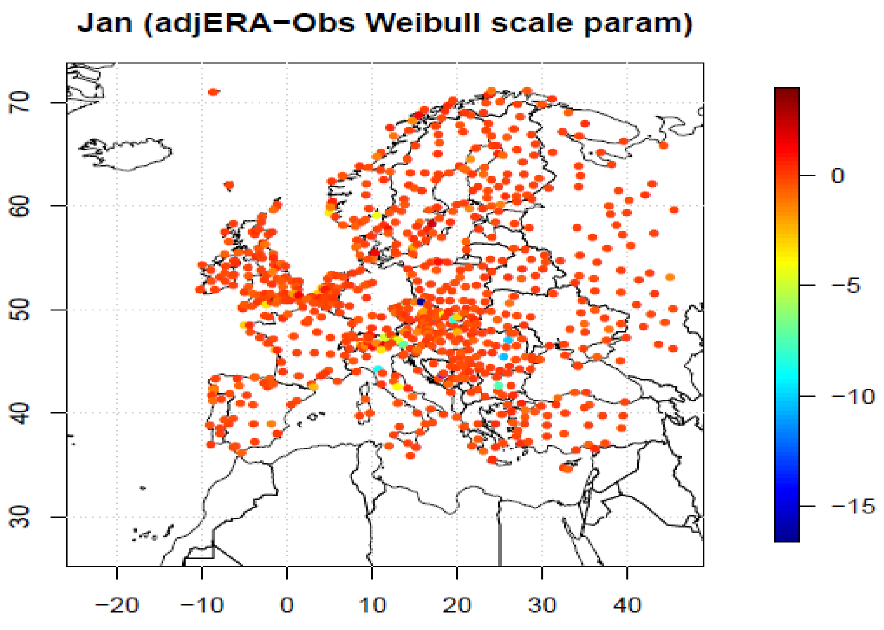
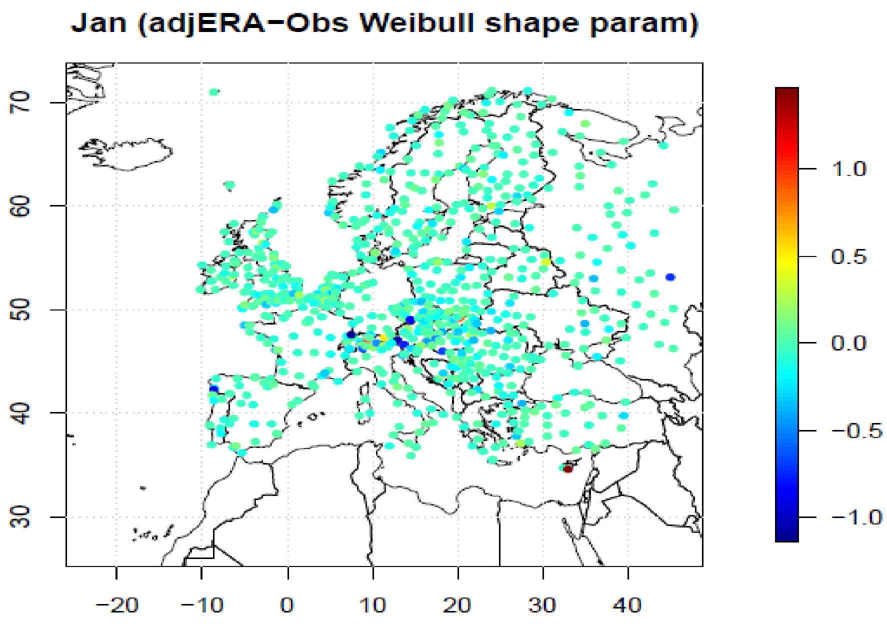
Station Distributions (Wind Speeds)





Available station data for wind speeds is quite variable

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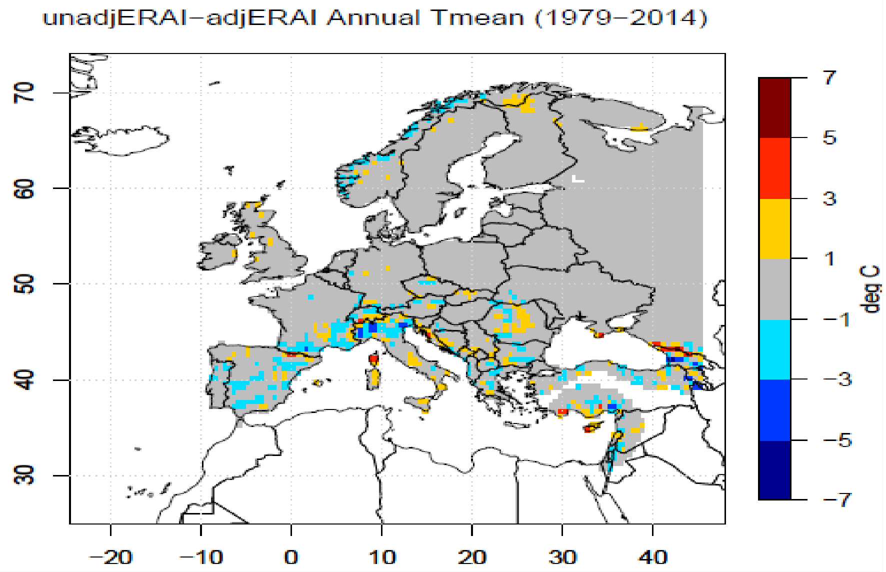
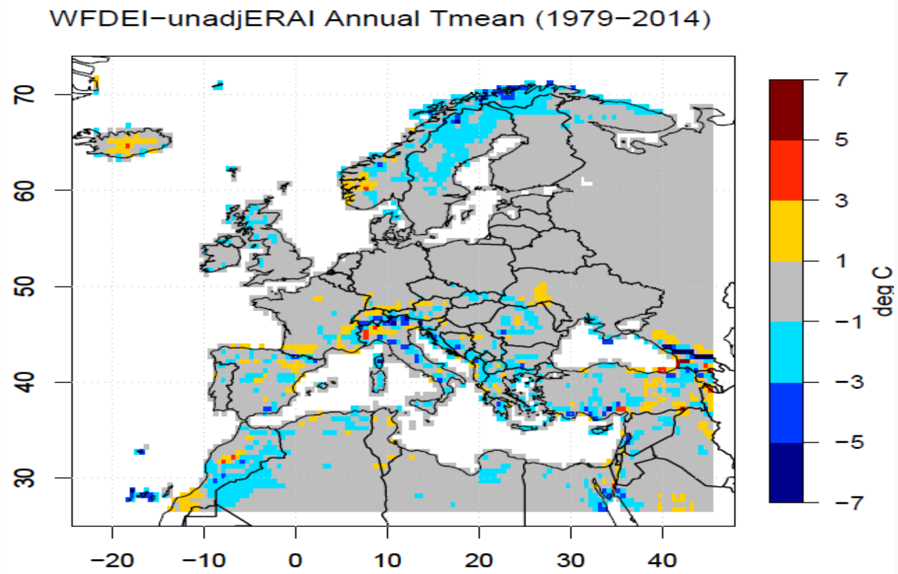
Unadjusted-ERA/WFDEI minus adjusted-ERA (Temperature)





- ★ Differences largest in mountain ranges and around some coastlines
- ★ WFDEI uses a lapse rate to estimate temperatures at higher elevations
- ★ Differences generally much smaller than for wind speed

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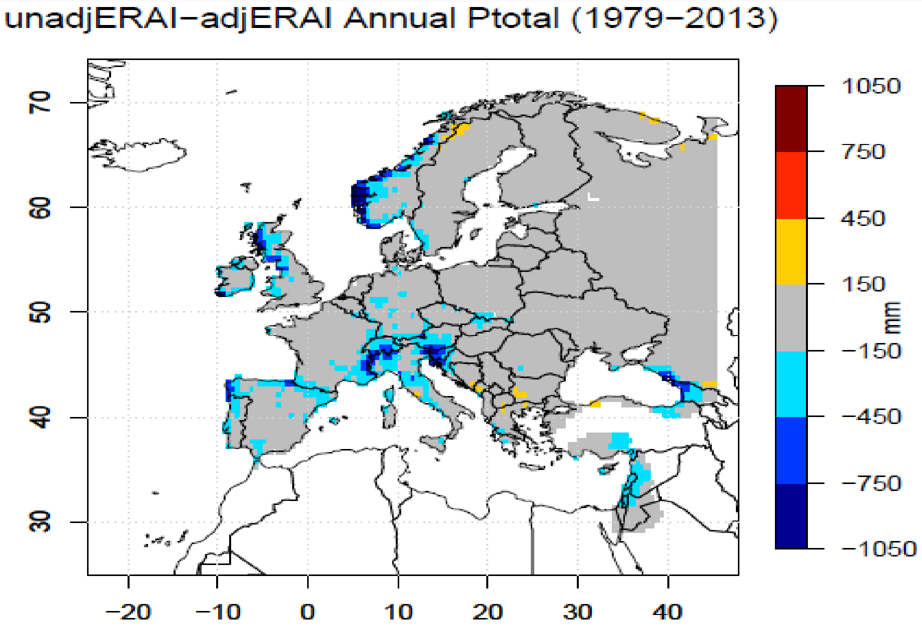
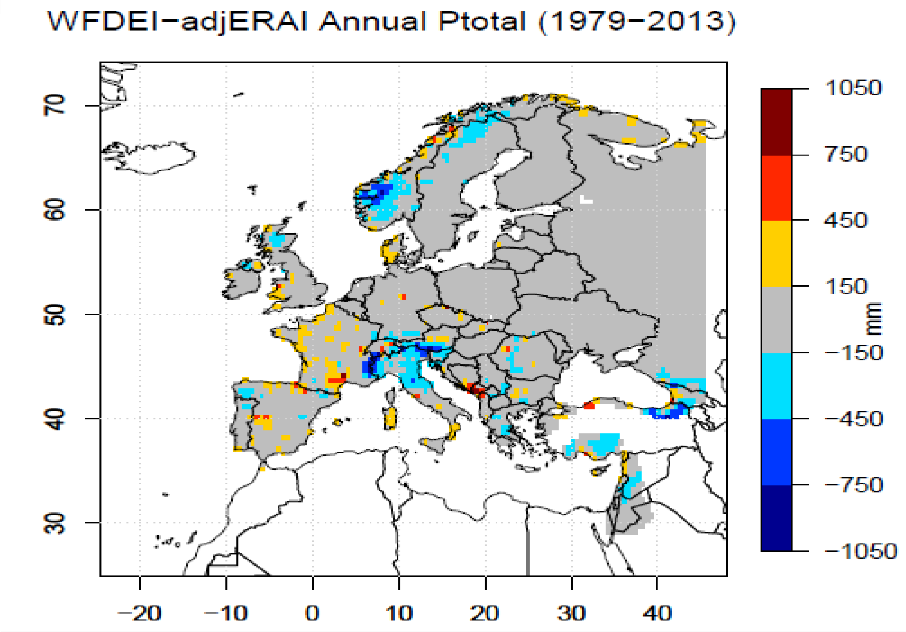
Unadjusted-ERA/WFDEI minus adjusted-ERA Precipitation





- ★ Differences tend to largest in mountain ranges and around some coastlines
- ★ The annual differences shown also mask larger differences which partly cancel from the monthly scale

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Impacts of bias-adjustments for the ECEM Demonstrator

- ★ Country and cluster averages produced for the ECEM Demonstrator
- ★ Effects of bias adjustment differ for each variable
- ★ Largest effects for wind speed, as station network in unevenly distributed, and the exact site locations can be important near coasts and in mountainous regions
- ★ Effects appear largest for countries with long coastlines and islands where wind speeds are low, but higher around coasts (e.g. Italy and Greece). Differences are proportionately smaller in windier countries of NW Europe
- ★ For temperature and precipitation, differences with WFDEI are mostly in mountainous areas and partially relate to WFDEI's method of accounting for elevation

Where are we now?

- ★ Updated in early 2017 to provide complete series for 1979-2016
- ★ Approach can be adapted for ERA-5 when fully available
- ★ Bias-adjusted data available at ftp://ecem.climate.copernicus.eu and eventually through the Climate Data Store (CDS)
- ★ Country and cluster averages produced for the ECEM Demonstrator

Possible discussion points

- ★ Data availability – large netcdf files
- ★ Quality of the observational data series. This is clearly an issue with greater uncertainty in bias adjustments for wind speed and irradiance than the many more observations for air temperature and precipitation data
- ★ Uncertainty issues (spatial scales, structural)
- ★ Uncertainties for some variables can be large locally, but this is likely due to the representativeness of the observed series
- ★ Impact of ERA-5. Only possible to assess this when the simulation is fully complete from 1979 to 2016

Climate Change

Thank you for your attention

Limitations

- ★ Uncertainty in bias adjustments is small, more so for gridded observational fields like air temperature and precipitation
- ★ Uncertainty in bias adjustments is larger for wind speed and irradiance, but part of this is due to comparing station series with gridded ERA-Interim data
- ★ Assessing uncertainty is dependent on the quality of the observational (station and gridded) datasets used. This is important to bear in mind in regions of sparse data coverage and in regions of high elevation (where stations may be at quite different elevations, so less representative of ERA-Interim grid-box averages)
- ★ Assessing uncertainty this way also only considers the bias-adjustment method used. Other bias-adjustment methods might have produced slightly different results, with the effect of this being referred to as ‘structural’ uncertainty

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