Are two years long enough?

The effect of the length of numerical model data on wind resource assessments

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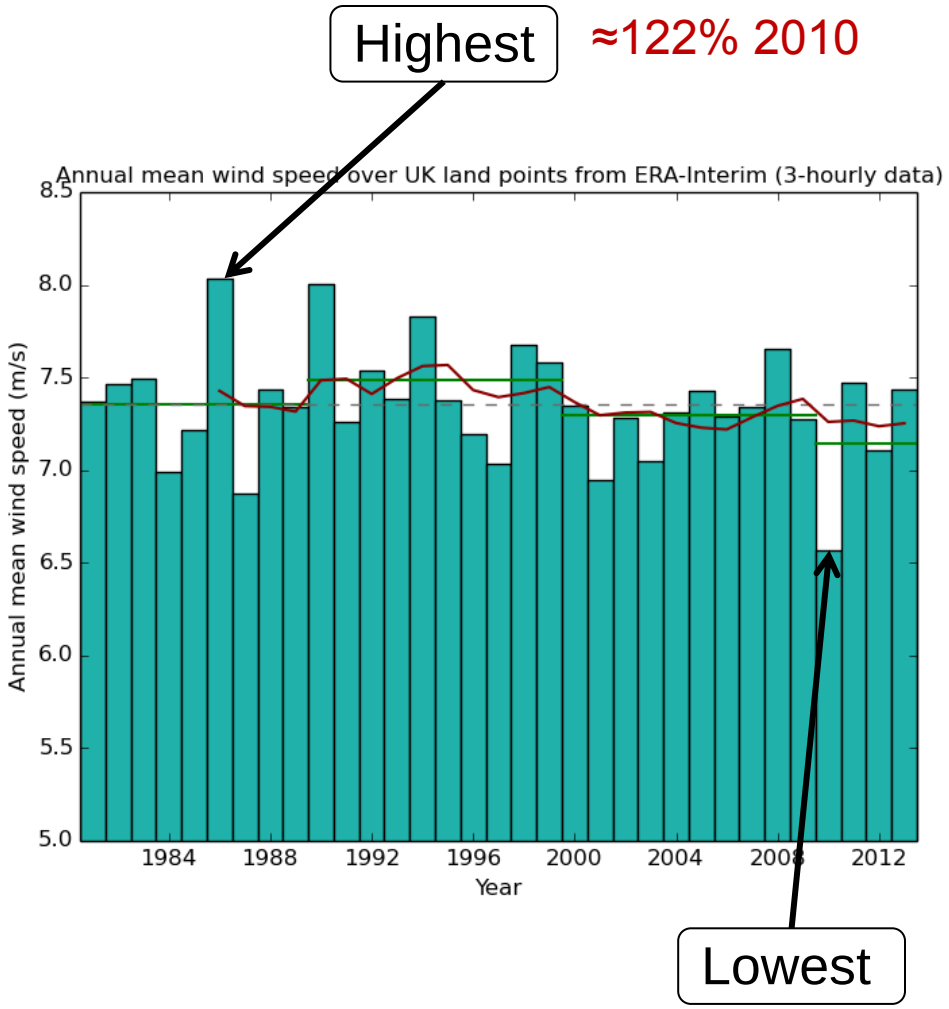
14th EMS Annual Meeting & 10th ECAC – 06-10 October 2014, Prague, Czech Republic

Introduction

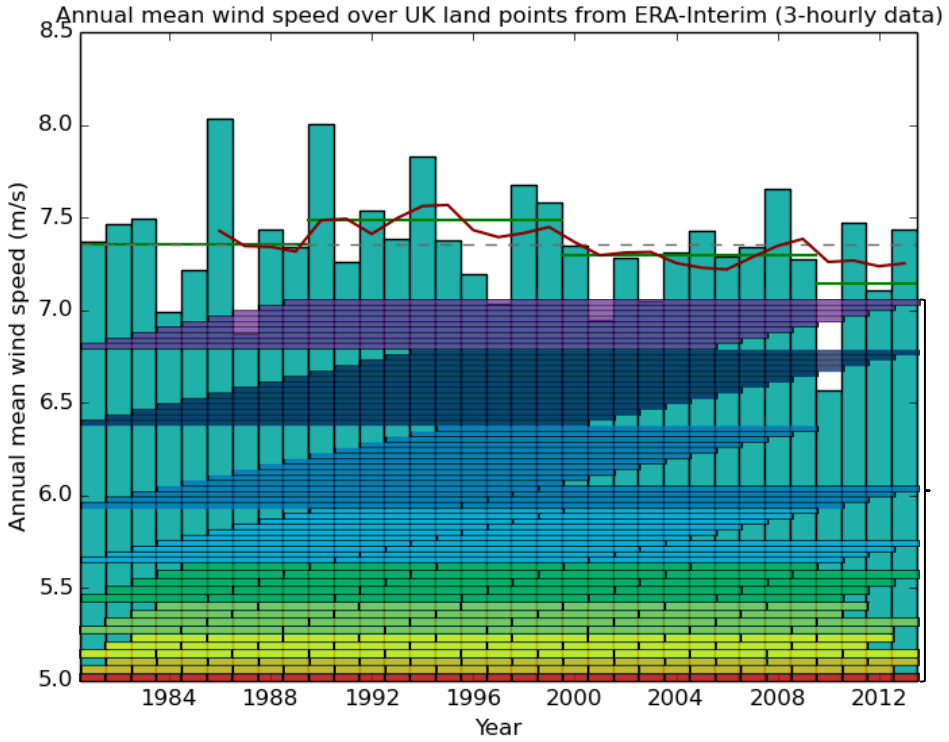
- Numerical wind resource assessments
  - Take forecast or hindcast data
  - Apply corrections and adjustments to make it site and height specific
  - Often involve use of reanalysis data or observations
  - Assess suitability of a site by looking at factors such as long term mean wind speed and variability of the winds
- Currently the Met Office uses hindcasts or archived forecasts ≥ 7 years
  - Hindcasts = large expense
  - Quantify level of uncertainty associated with using shorter periods
  - Others looked into something similar (e.g. Liléo “Long-term correction of wind measurements”, looking at sampling on 20CR)

Introduction



- Past regularly used as a proxy for the future
- Numerical resource assessments often only use a short period of high resolution data to be representative of a longer period
- Linear regression can be used to do this
- Not just long term means that are important, but the variance too
- Trying to provide the best modelled data that mimics measurements

VMM & Method

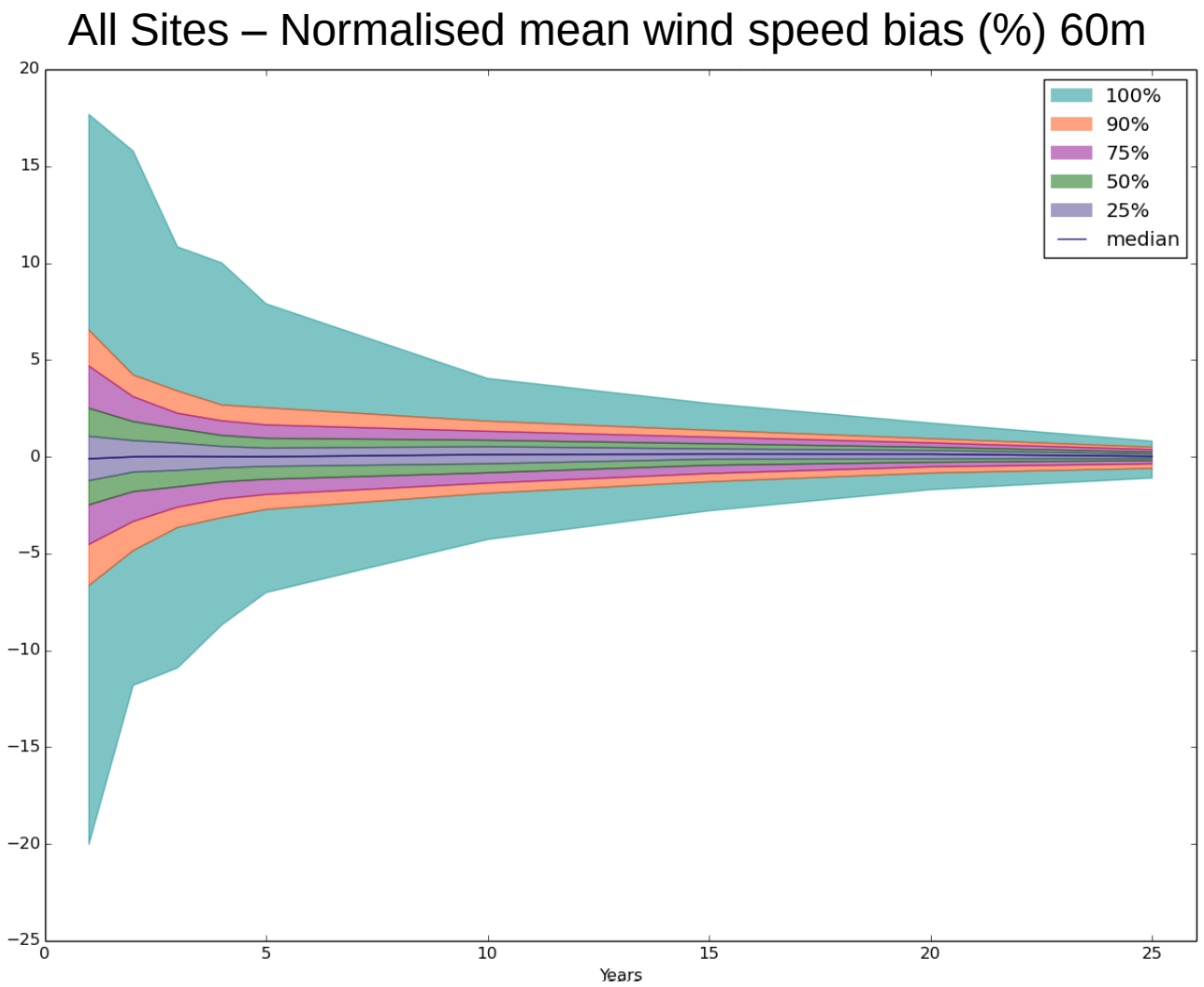


221

- Virtual Met Mast (VMM)
  - Orographic roughness adjustment
  - Local height adjustment
  - Climatological extension
- Generated corrected time series for 86 sites across Europe ranging in complexity
- **60m** (80m & 100m)
- Split into time series of consecutive years:
  - 1 , 2, 3, 4, 5, 10, 15, 20 & 25
- Results will be shown in comparison to a “truth” of the full hindcast period

Results – no climatological extension applied

- Normalised mean wind speed bias
- Across all 86 locations and 221 permutations for each



Results – no climatological extension applied

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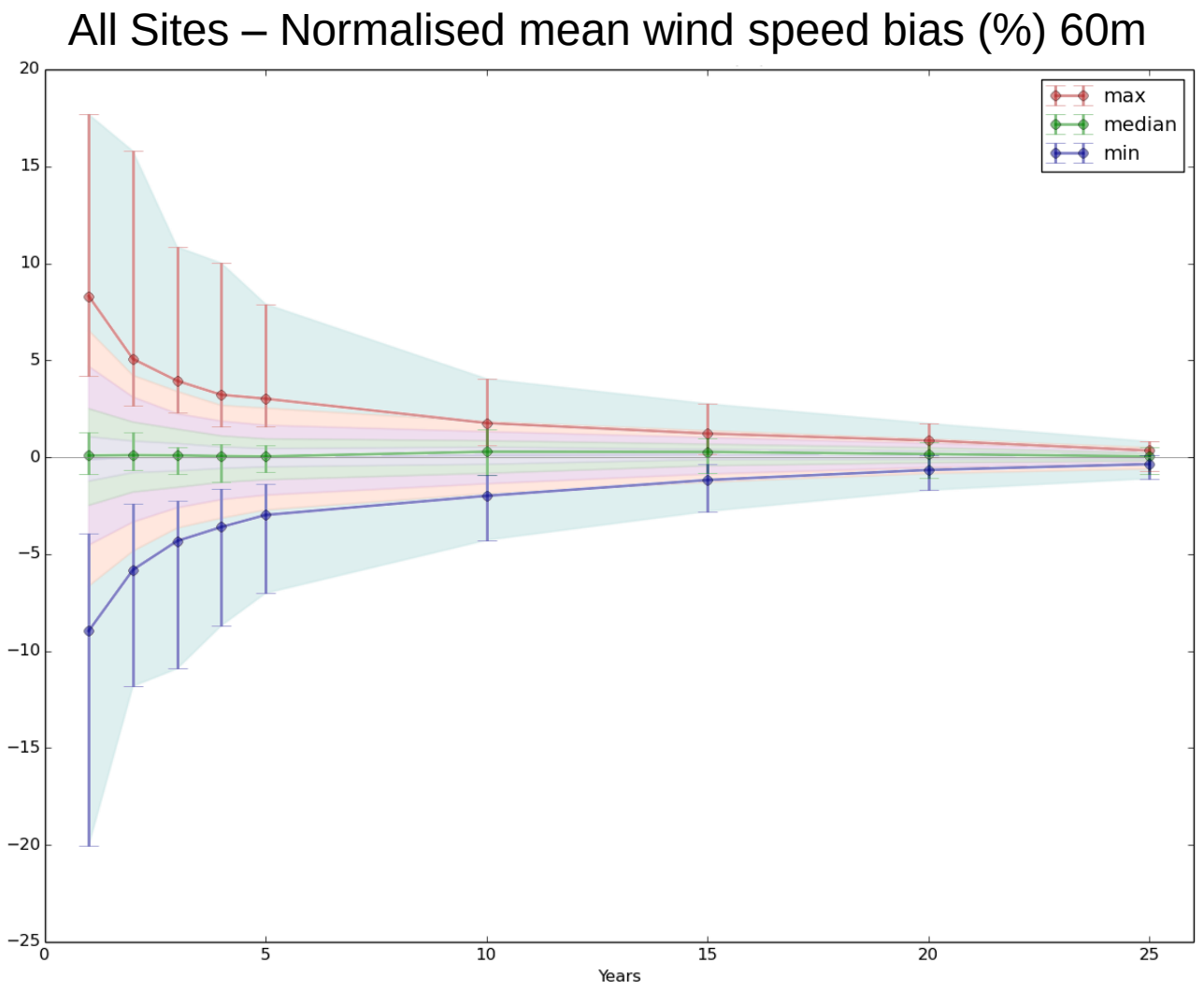
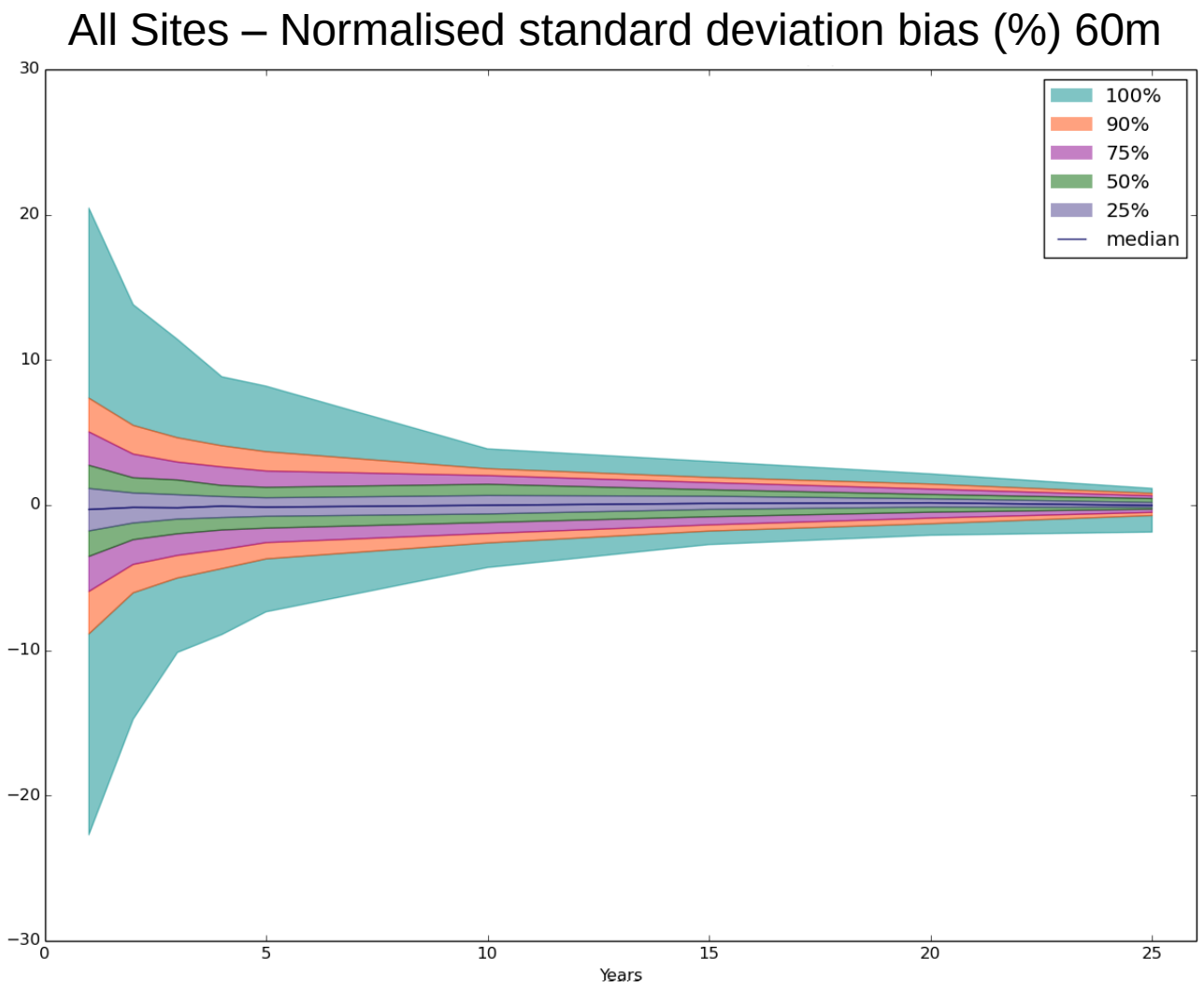
- Over plot the range in the maximum, minimum and medians for the 86 sites



Results – no climatological extension applied

- Normalised standard deviation of the hourly wind speeds bias
- Across all 86 locations and 221 permutations for each



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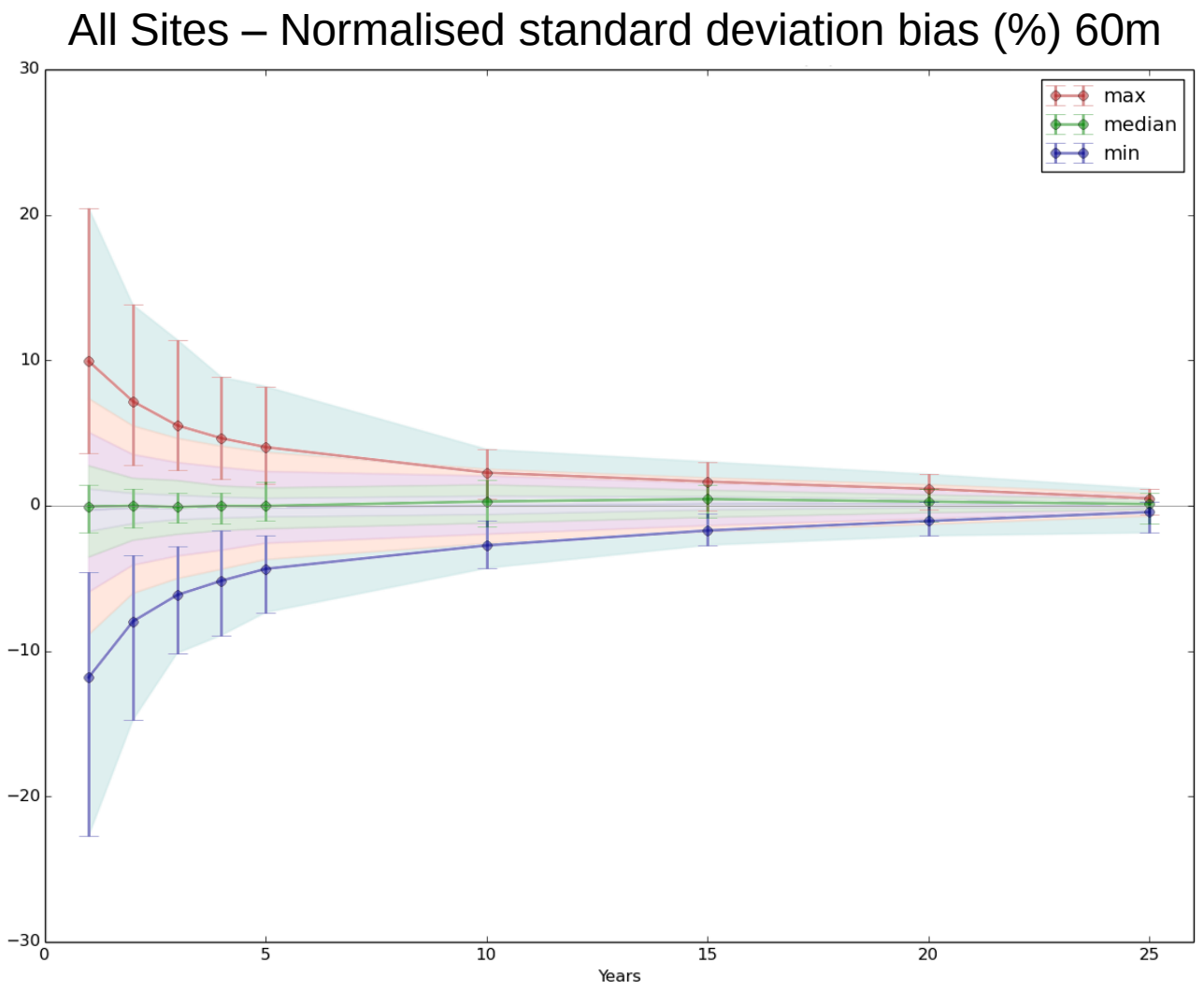
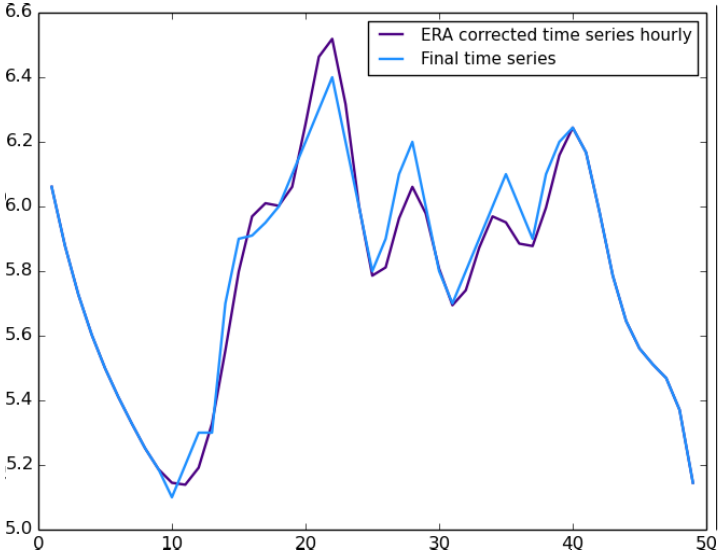


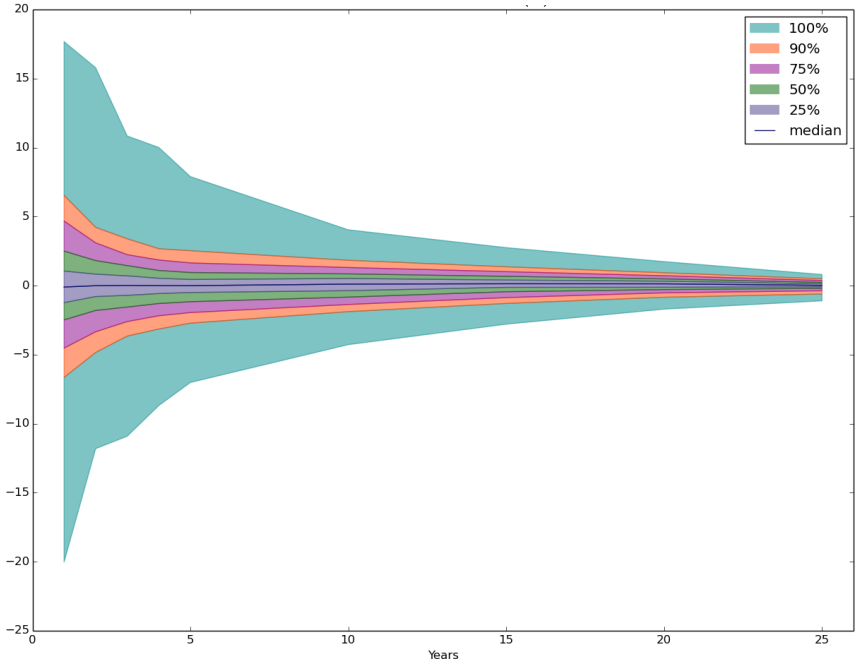
Results – linear regression extension applied

- Applied a climatological extension based on linear regression against ERA-Interim data
  - Matched pairs between the permutation time series and the 3-hourly ERA-Interim data
  - Applied a linear fit through the data
  - Rescaled the 3-hourly ERA-Interim time series
  - Used cubic spline fit to produce an hourly time series
  - Replaced the overlapping section with the original corrected time series

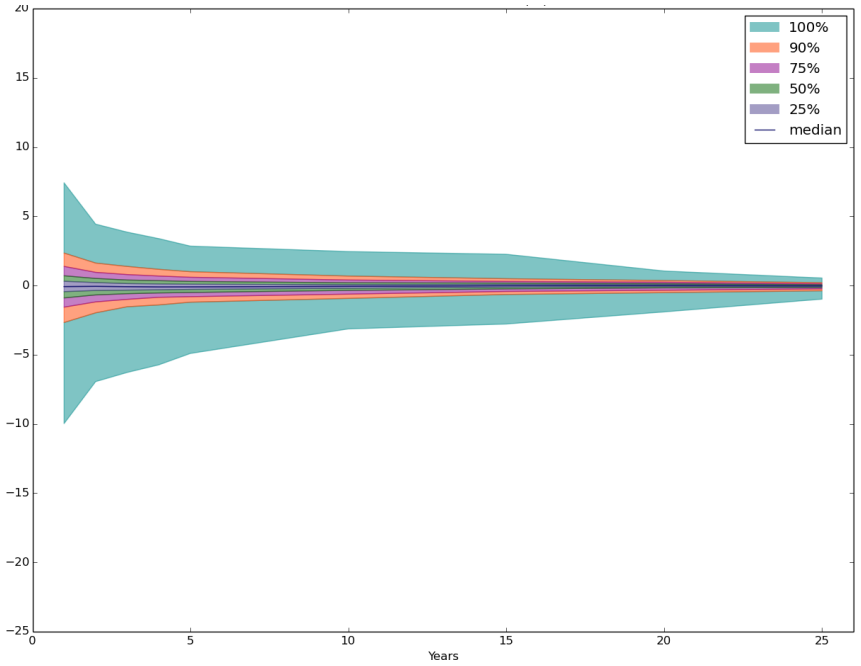


Results – linear regression extension applied

Comparison of
All Sites – Normalised mean wind speed bias (%) 60m



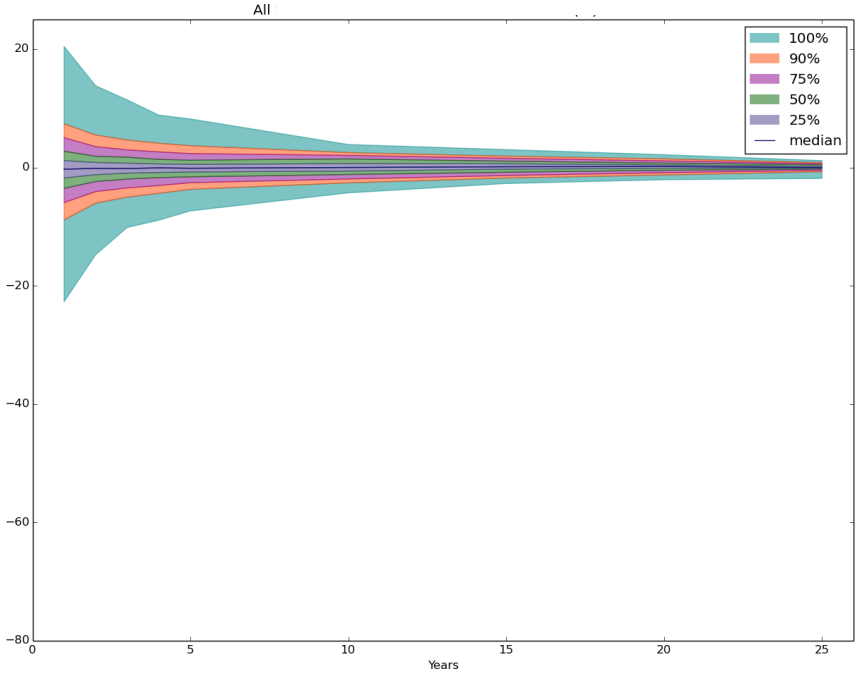
No climatological extension



Linear regression extension

Results – linear regression extension applied

Comparison of
All Sites – Normalised standard deviation bias (%) 60m



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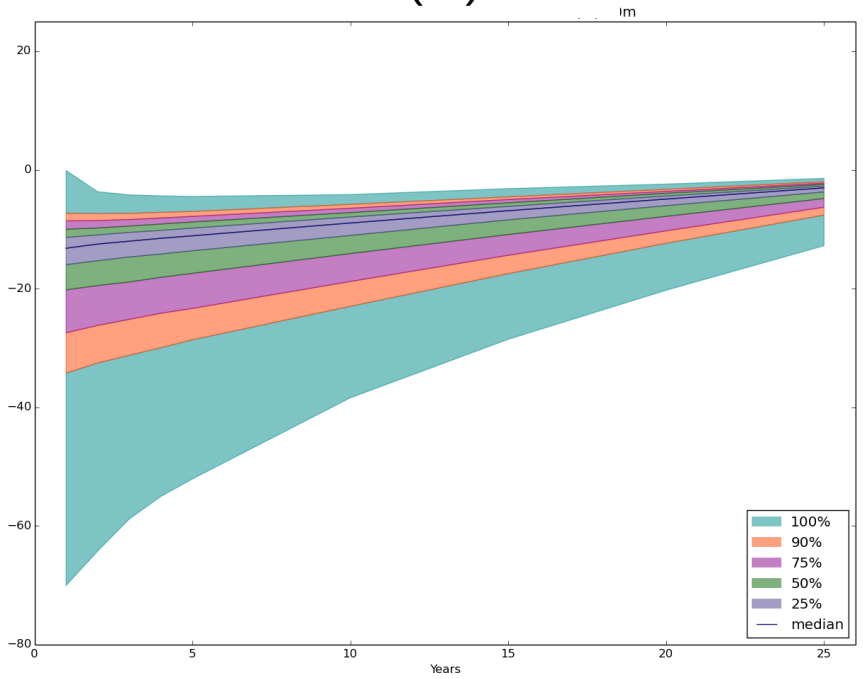


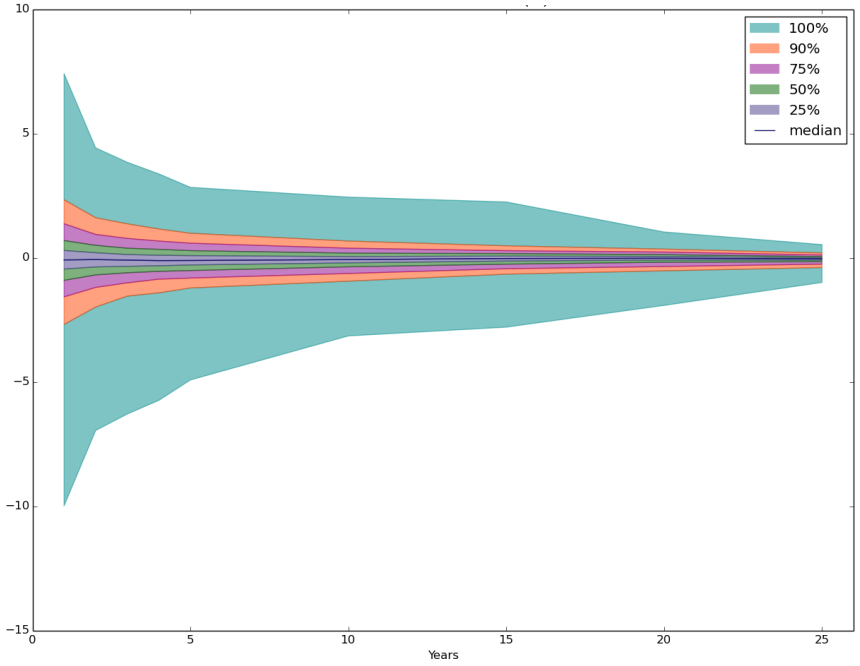
Linear regression extension

Results – matrix method extension applied

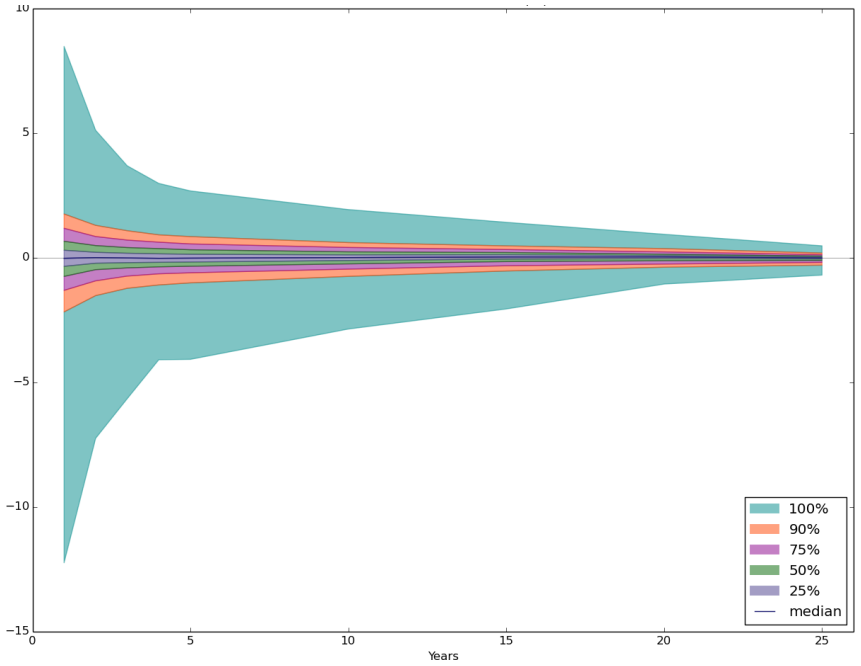
- Applied a climatological extension based on a probability matrix.
- Matched pairs between the permutation time series and the 3-hourly ERA-Interim data.
- These data were binned into a 480×480 probability matrix based on 40×1m/s wind speed bins and 12×30° wind direction bins to produce the conditional probability matrix.
- The product of this probability matrix with the distribution of the winds from the full ERA-Interim period gives a corrected distribution which is then used to calculate means, standard deviations and Weibull parameters.
- This method does not give a meteorological time series.
  - Could produce one using a random number generator or machine learning.

Results – matrix method extension applied

Comparison of
All Sites – Normalised mean wind speed bias (%) 60m



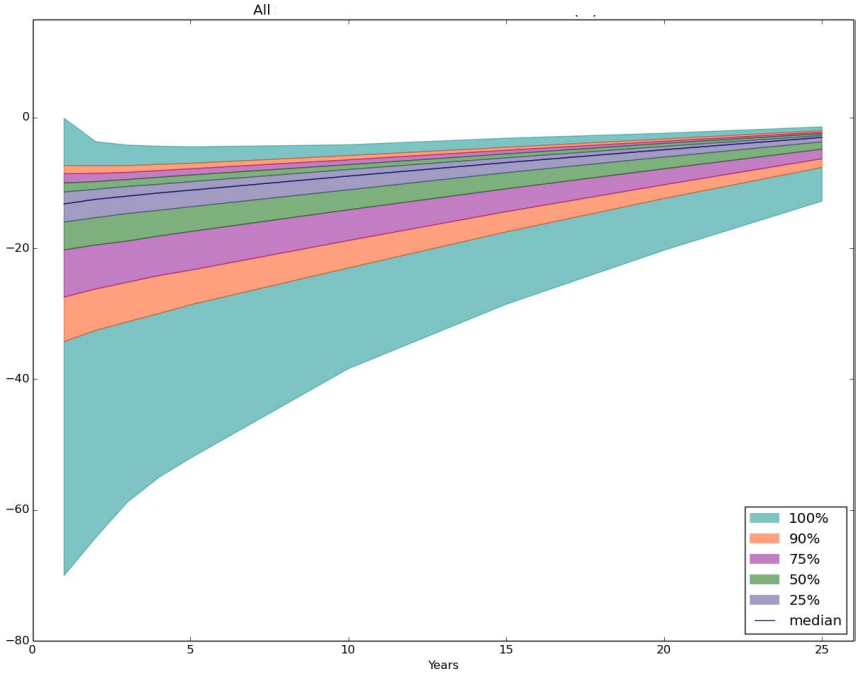
Linear regression extension



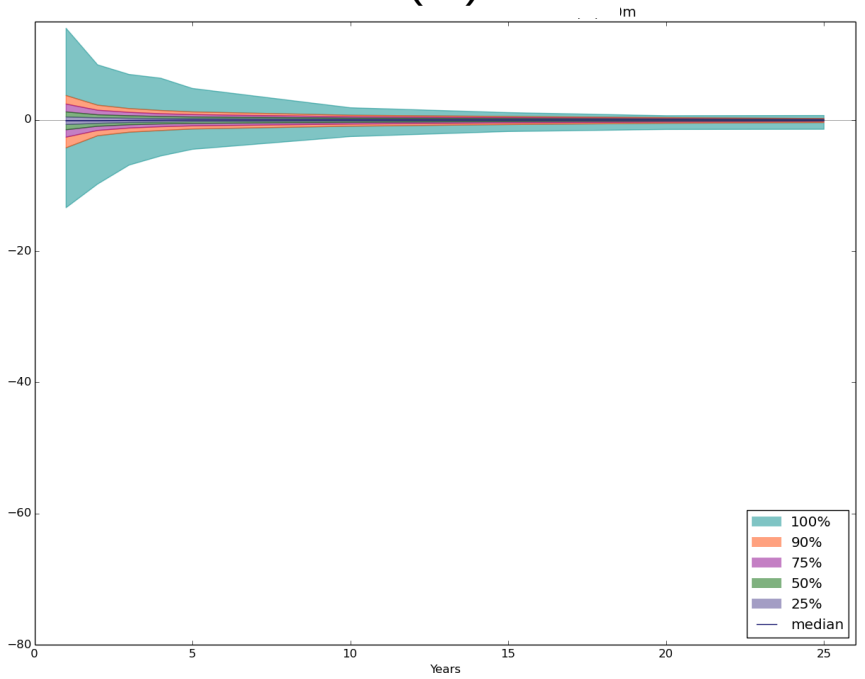
Matrix method extension

Results – matrix method extension applied

Comparison of
All Sites – Normalised standard deviation bias (%) 60m



Linear regression extension

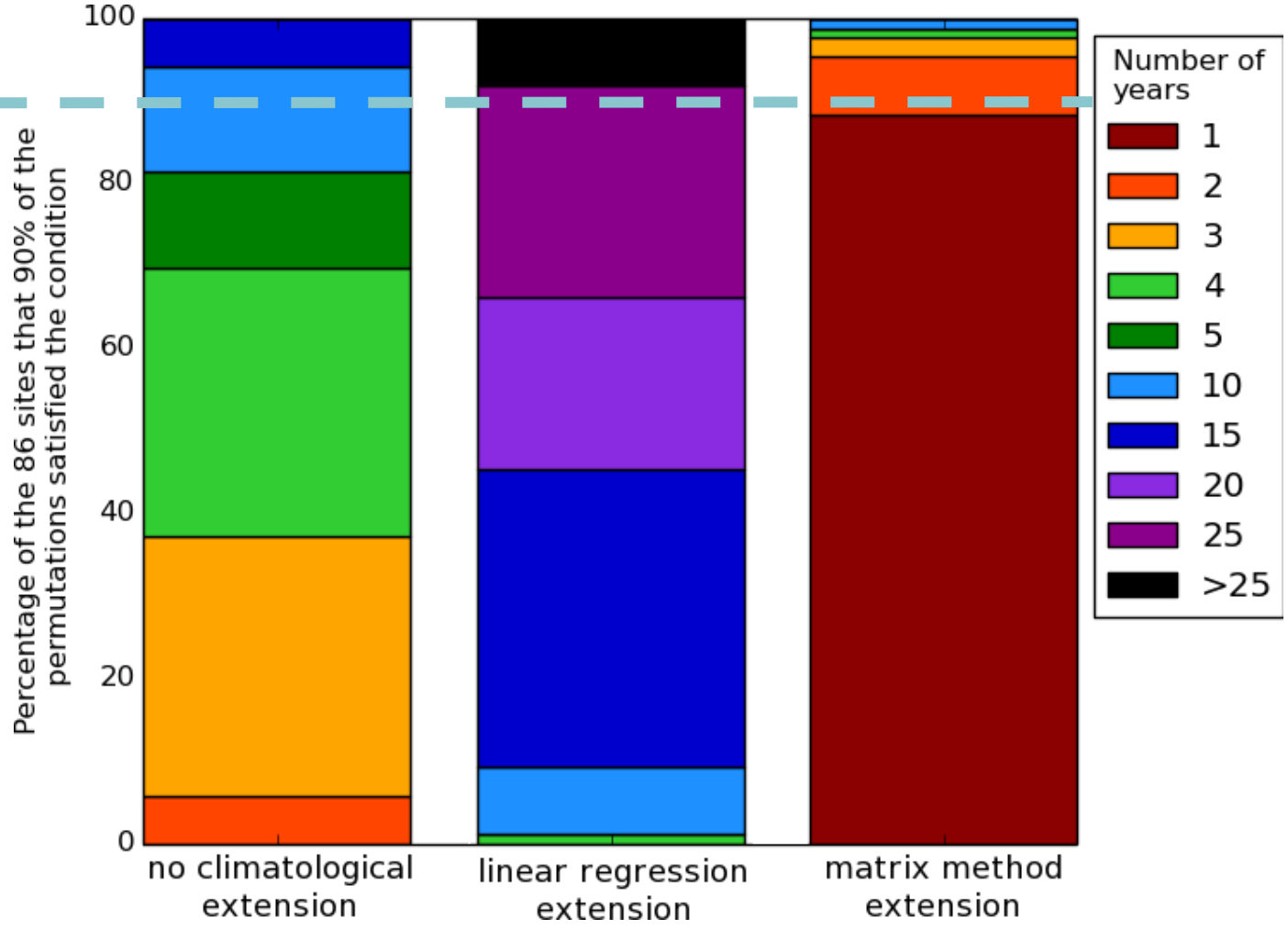


Matrix method extension

Results – uncertainty levels

Uncertainty levels: Mean ±3% Standard deviation ±7%

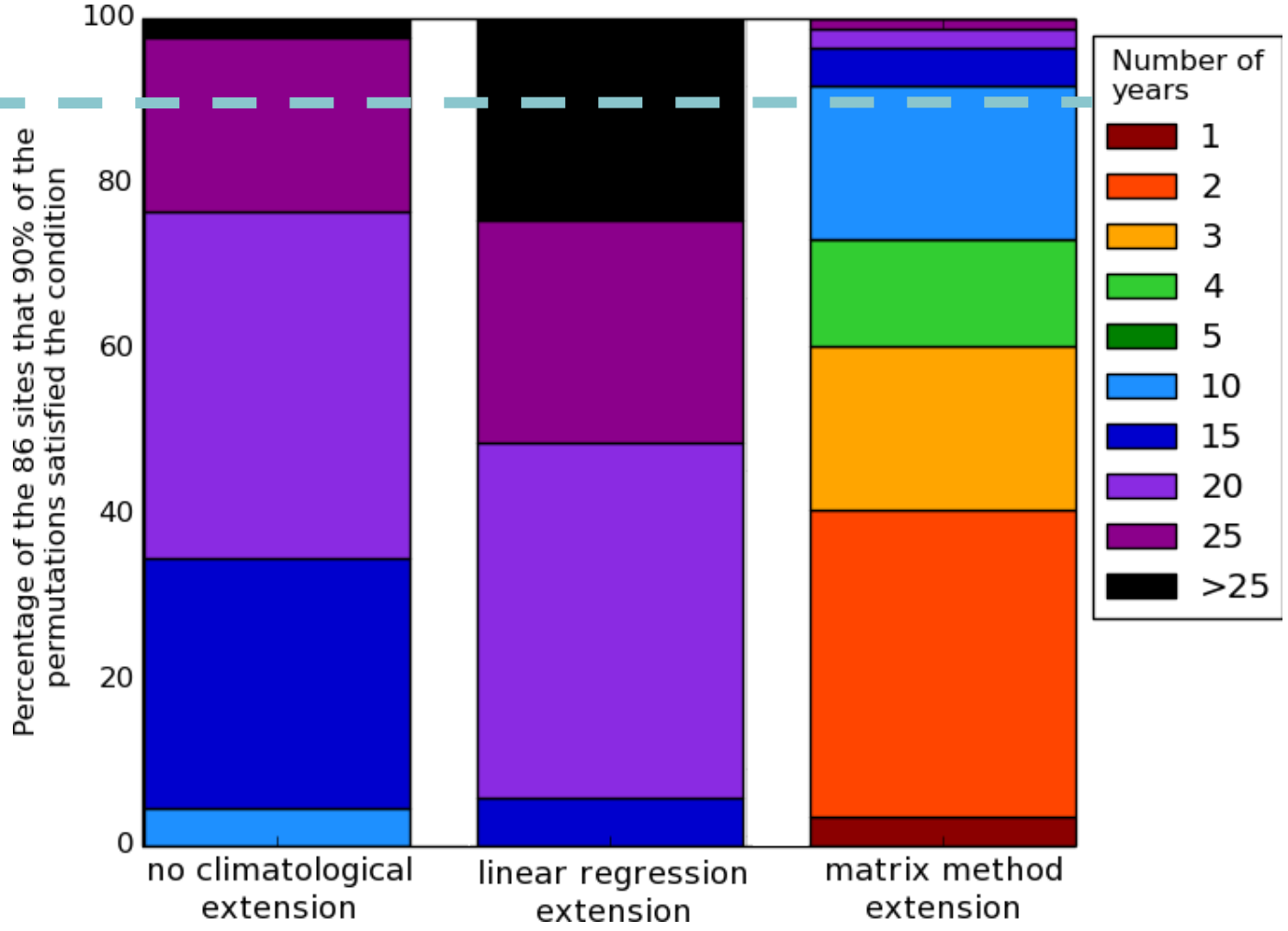
90%
~78 sites



Results – uncertainty levels

Uncertainty levels: Mean ±1% Standard deviation ±5%

90%
~78 sites



Summary

- Large spread possible in both the mean bias and the bias in standard deviations when using subset of consecutive years compared to the full period
- Spread can be reduced using an extension method
  - Care needs to be taken when using linear regression as if statistical properties of long-term data will effect corrected time series
- Matrix method rather than linear regression reduced uncertainty but lose meteorological time series
- Years downscaled will often be the years preceding the current date, so will be very dependent on how representative these years are

Q. Are two years long enough?

A. Depends on user needs but often, no.

At the 86 sites looked at the table below shows the number of years that would be required for 90% of the sites (>77) to have the given uncertainty levels for 90% of the permutations looked at.

Uncertainty level		No climatological extension						Linear regression extension						Matrix method extension					
Mean	Standard deviation	**All** 86	*HC* 21	*MC* 23	*LC* 23	*NS* 13	*OS* 6	**All** 86	*HC* 21	*MC* 23	*LC* 23	*NS* 13	*OS* 6	**All** 86	*HC* 21	*MC* 23	*LC* 23	*NS* 13	*OS* 6
±3%	±7%	**10**	*10*	*10*	*5*	*15*	*5*	**25**	*>25*	*25*	*20*	*25*	*20*	**2**	*3*	*1*	*1*	*2*	*1*
±1%	±5%	**25**	*25*	*25*	*20*	*25*	*20*	**>25**	*>25*	*>25*	*25*	*25*	*25*	**10**	*20*	*10*	*5*	*10*	*3*

Questions?