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Northeast Atlantic and western European storminess since 1880

Paul Della-Marta & Malcolm Haylock

Outline

EMULATE dataset

A stochastic gridded dataset

Storminess changes

Extreme distribution of storminess

Conclusions

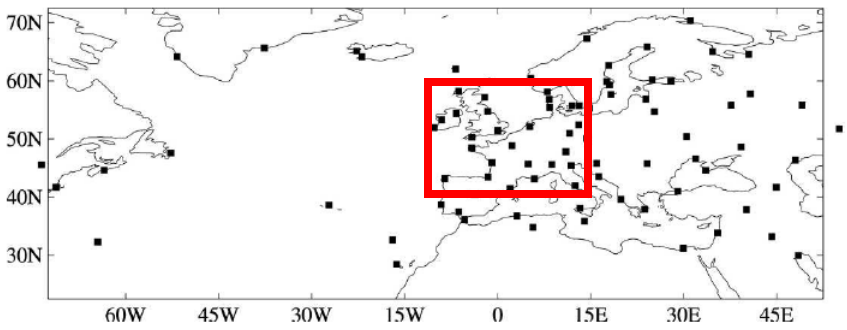
EMULATE dataset (Ansell et al 2006)

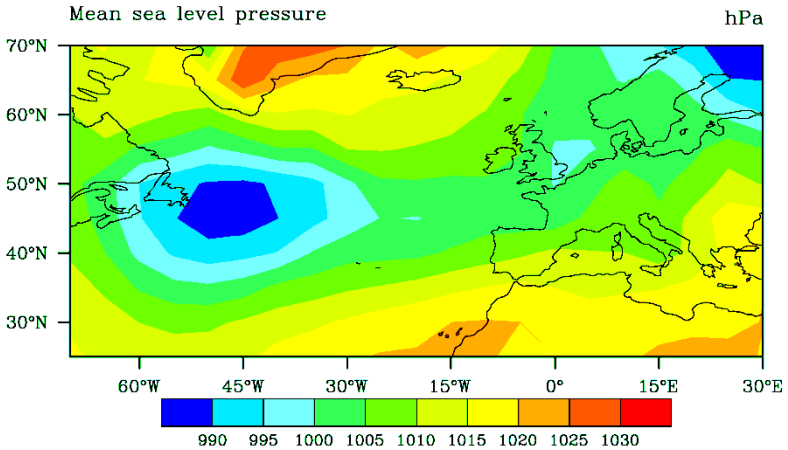
Uses up to 86 MSLP land stations, QC, homogenised

ICOADS data (gridded ship observations)

Digitised weather charts

Reduced Space Optimal Interpolation gridding





EMULATE dataset

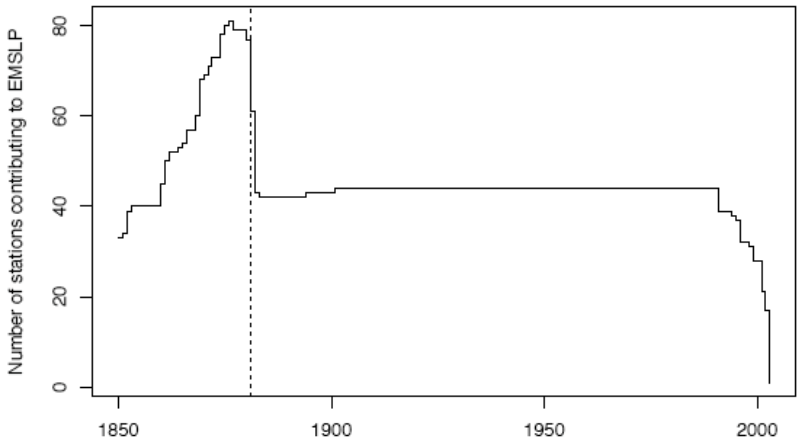
Land stations: non-stationary, constant from 1882

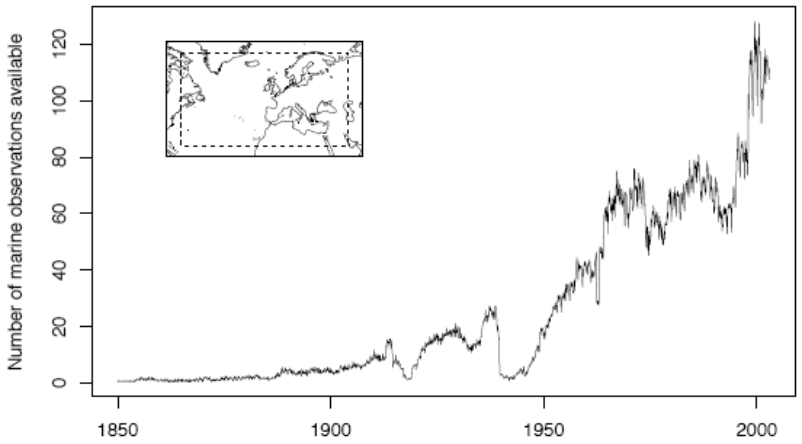
Number of ICOADS data points non-stationary

RSOI smoothes variability in data sparse regions

Inhomogeneities in cyclone tracked parameters (Bhend, 2005)

Error statistics provided do not allow spatially realistic simulations to be performed





Bhend (2005)

A stochastic gridded dataset

For a sparse network, one of the largest sources of uncertainty is interpolation to a regular grid

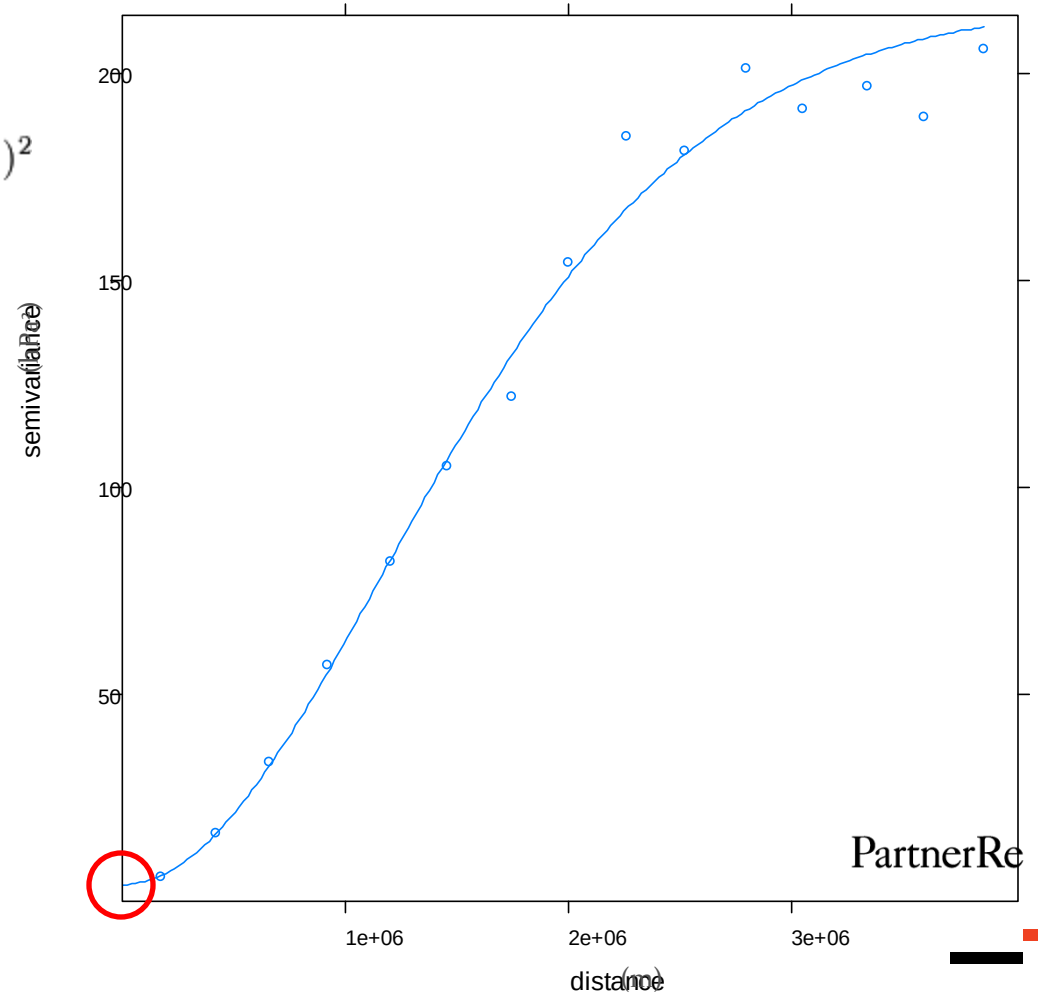
Cross-validation exercises show the most skillful interpolators are geostatistical methods (e.g. Kriging)

Geostatistical methods use the empirical spatial correlation structure to give an estimate that is

- Best – minimised MSE of residuals
- Linear – linear weight of neigbouring observations
- Unbiased – sum of weights = 1
- Estimator – the answer is given probablistically

The variogram

$$\hat{\gamma}(h) = \frac{1}{2} \cdot \frac{1}{n(h)} \sum_{i=1}^{n(h)} (z(x_i + h) - z(x_i))^2$$

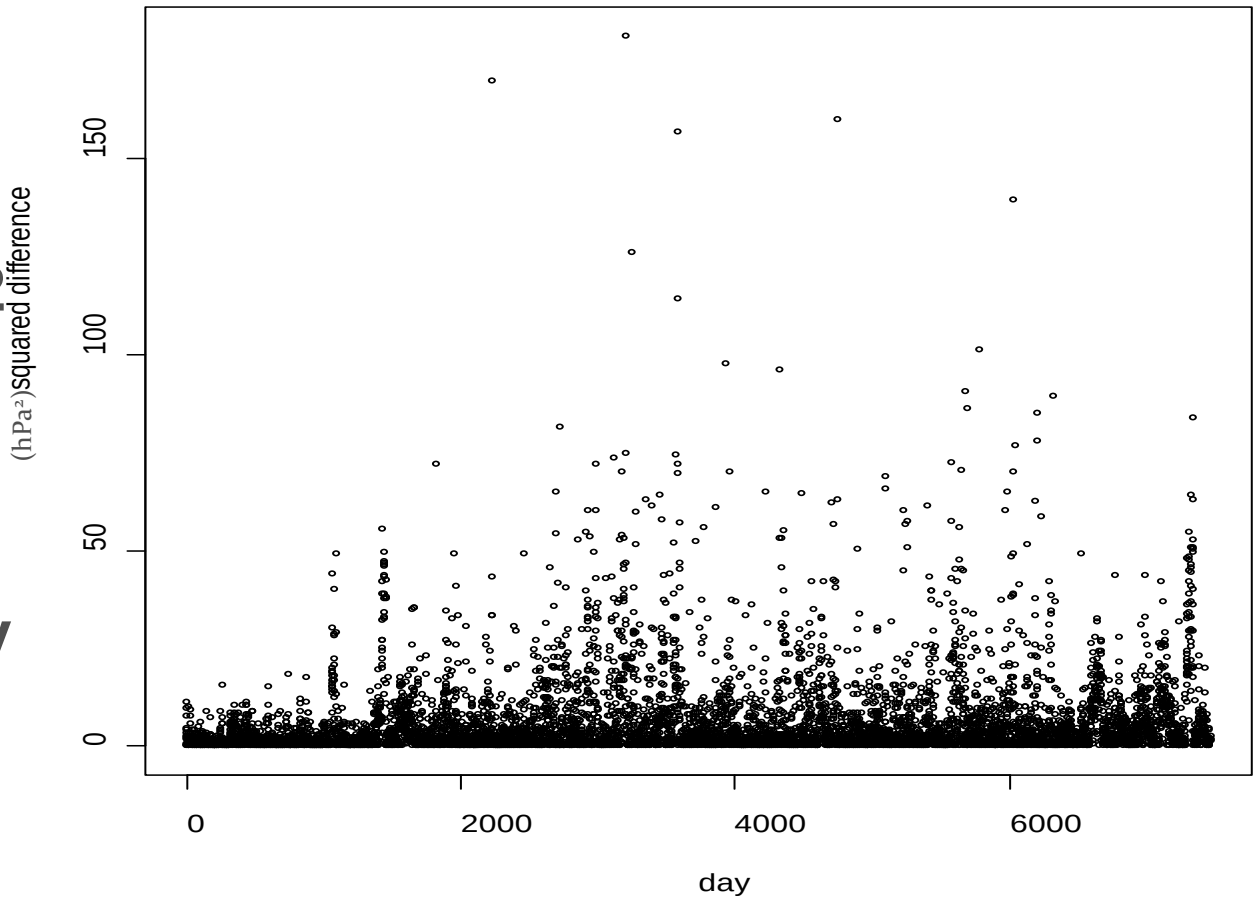


The nugget

Stockholm-Uppsala (63km)

MSE=5.9 hPa2

Gradients of 15hPa over 63kms → Homogenesity issues?



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Sequential Gaussian Simulation

Creates a set of possible realisations that honour the observations and the spatial correlation structure

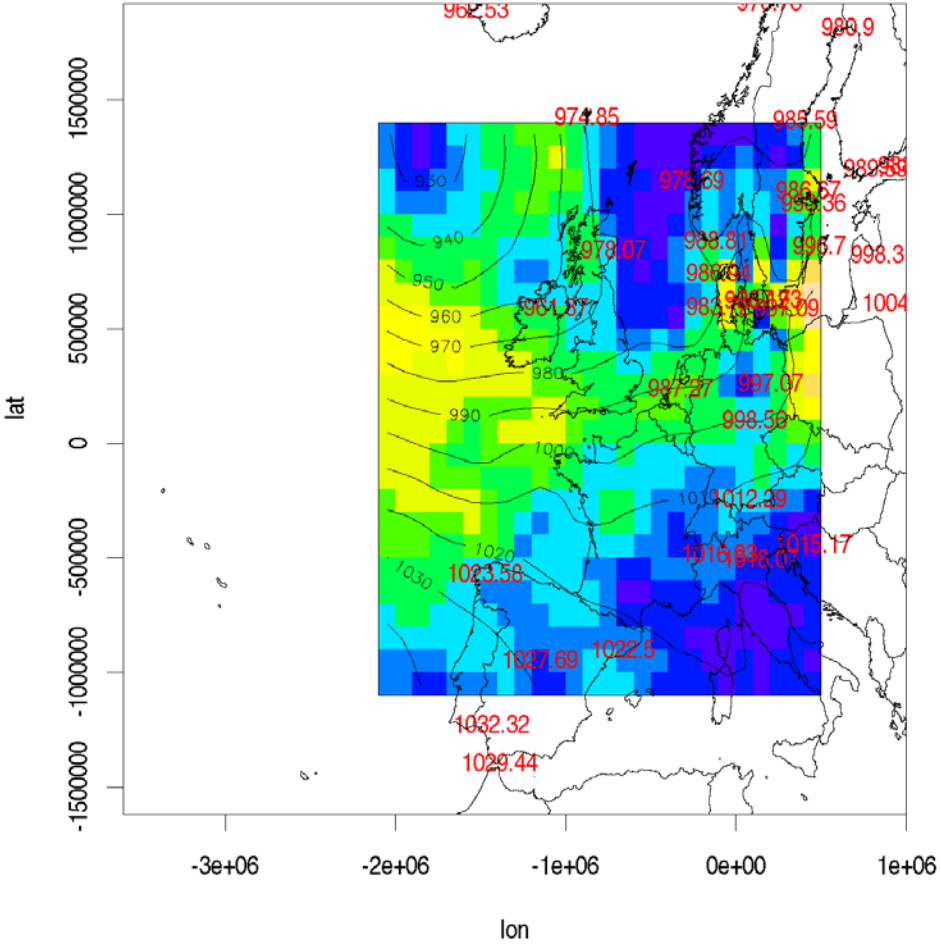
Gives individual simulations that look more realistic than the smoother best guess (mean).

Performed by a random walk through the grid space, randomly drawing a value from the probablistic interpolations

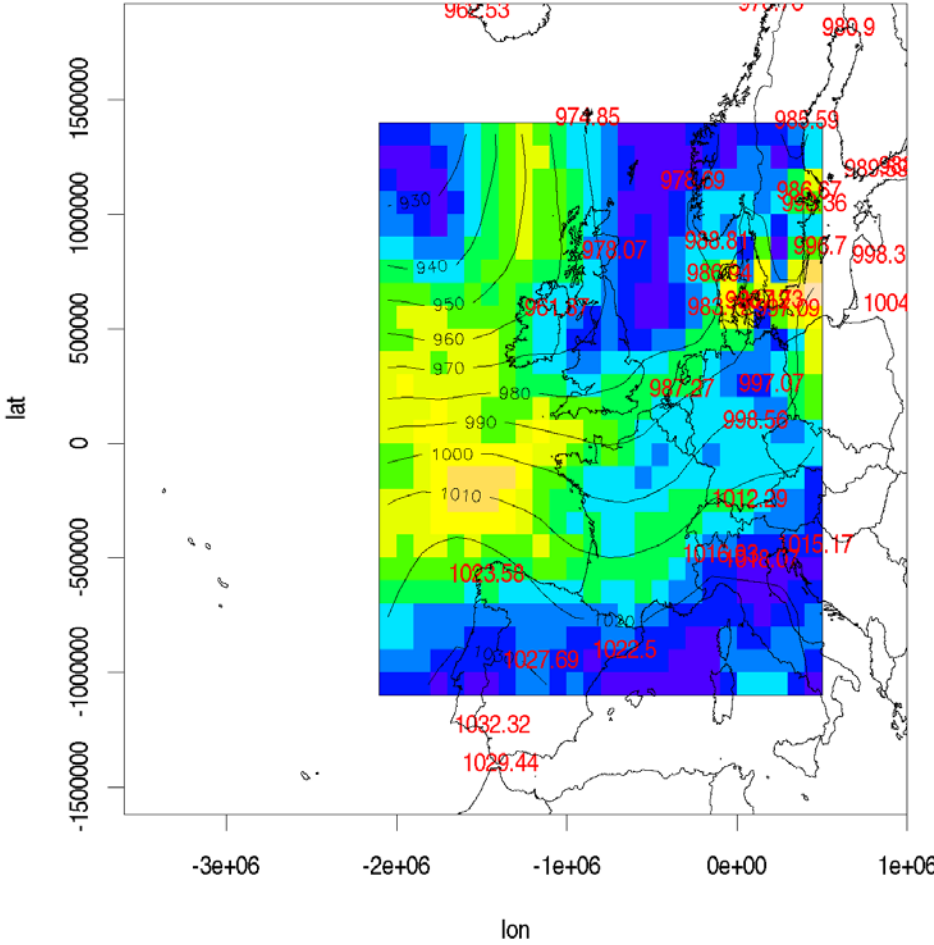
Conditions successive randomisations on both observations and previously generated grid points

Example Perturbation: Daria 1990

Simulation 1

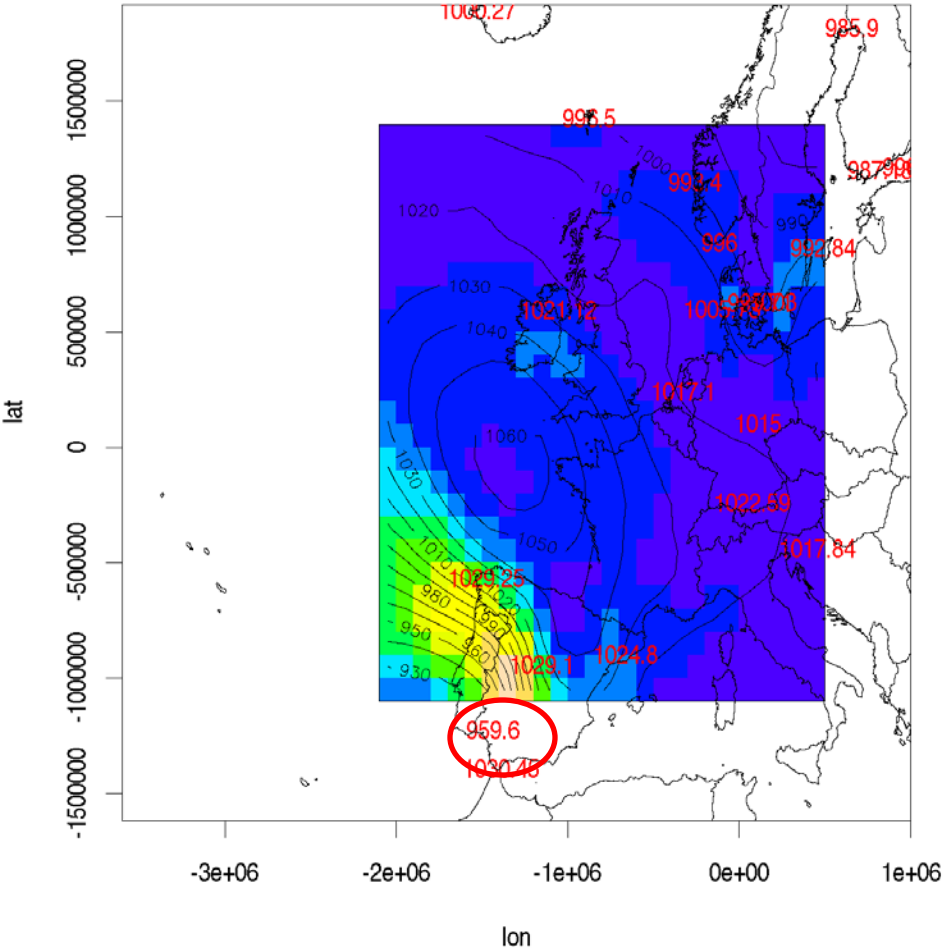


Simulation 2

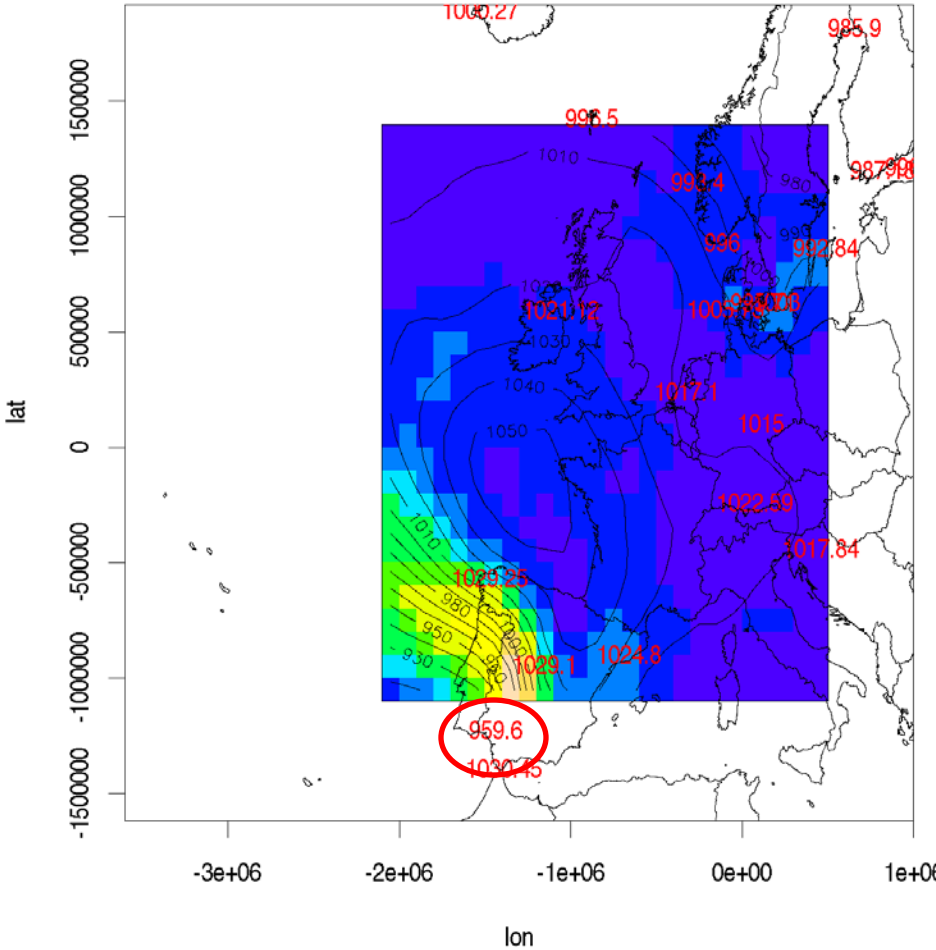


Example Perturbation: ‘Storm’ caused by inhomogeneity in the EMULATE data

Simulation 1



Simulation 2



Extreme Wind Indices

Use the sequential Gaussian simulation to generate 100 daily MSLP gridded fields from 1882-2000

Calculate geostrophic wind speed

Calculate EWI based on method in Della-Marta etal (2009)

- Mean: Magnitude based
- Q95: Magnitude based
- Sw3q90: Magnitude based
- Sfq95: Relative to local climatology
- Sfq95q99: Relative to local climatology

EWI example: October-April 1989/1990

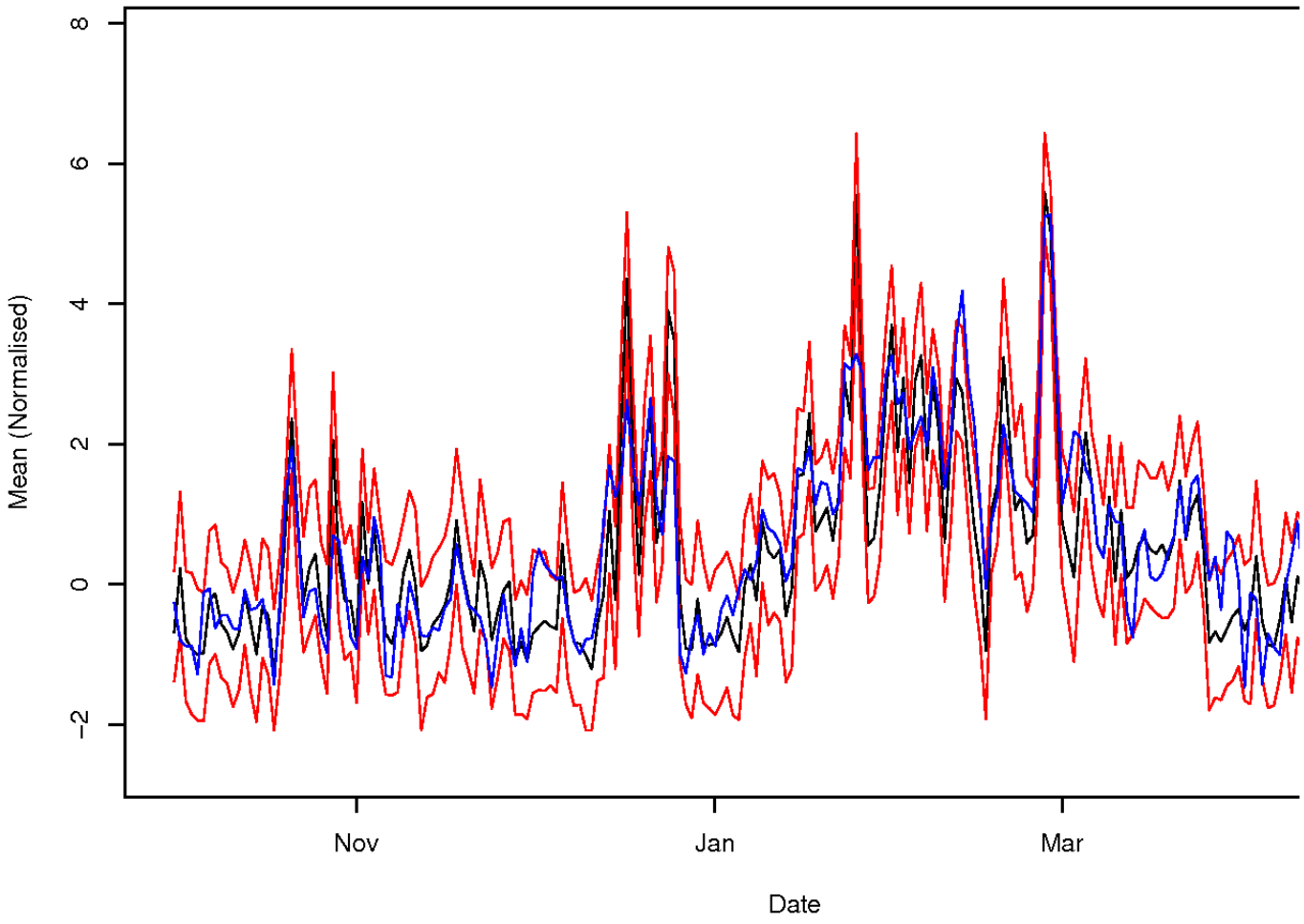
Red: 95% CI

Blue: EMULATE (original)

Black: Median of 100 simulations

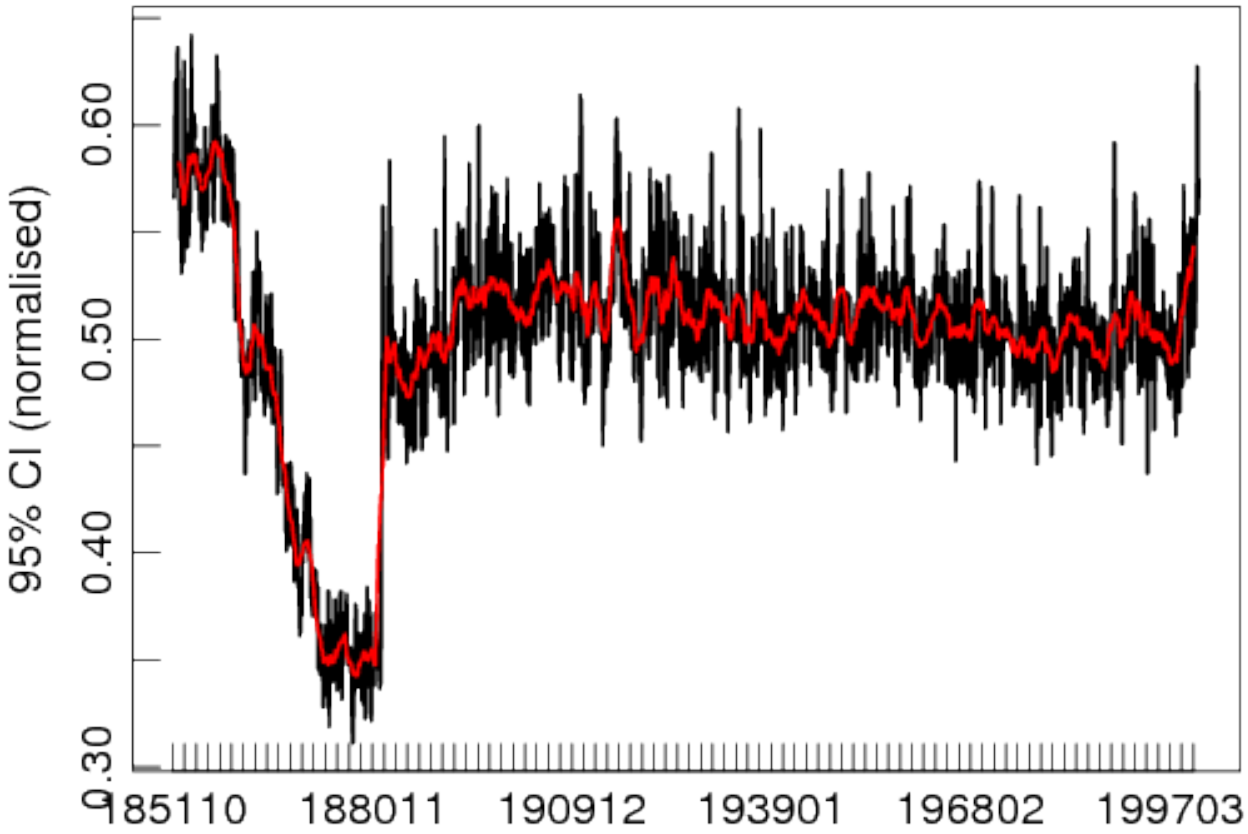
Daily variability of strongest storms captured within error

Well documented storms identified



EWI: Daily 95% Confidence Interval

- Error independent of index magnitude
- Lower error in early period
- Higher in latest period
- Some evidence of seasonality in the CI



Monthly averaged storminess

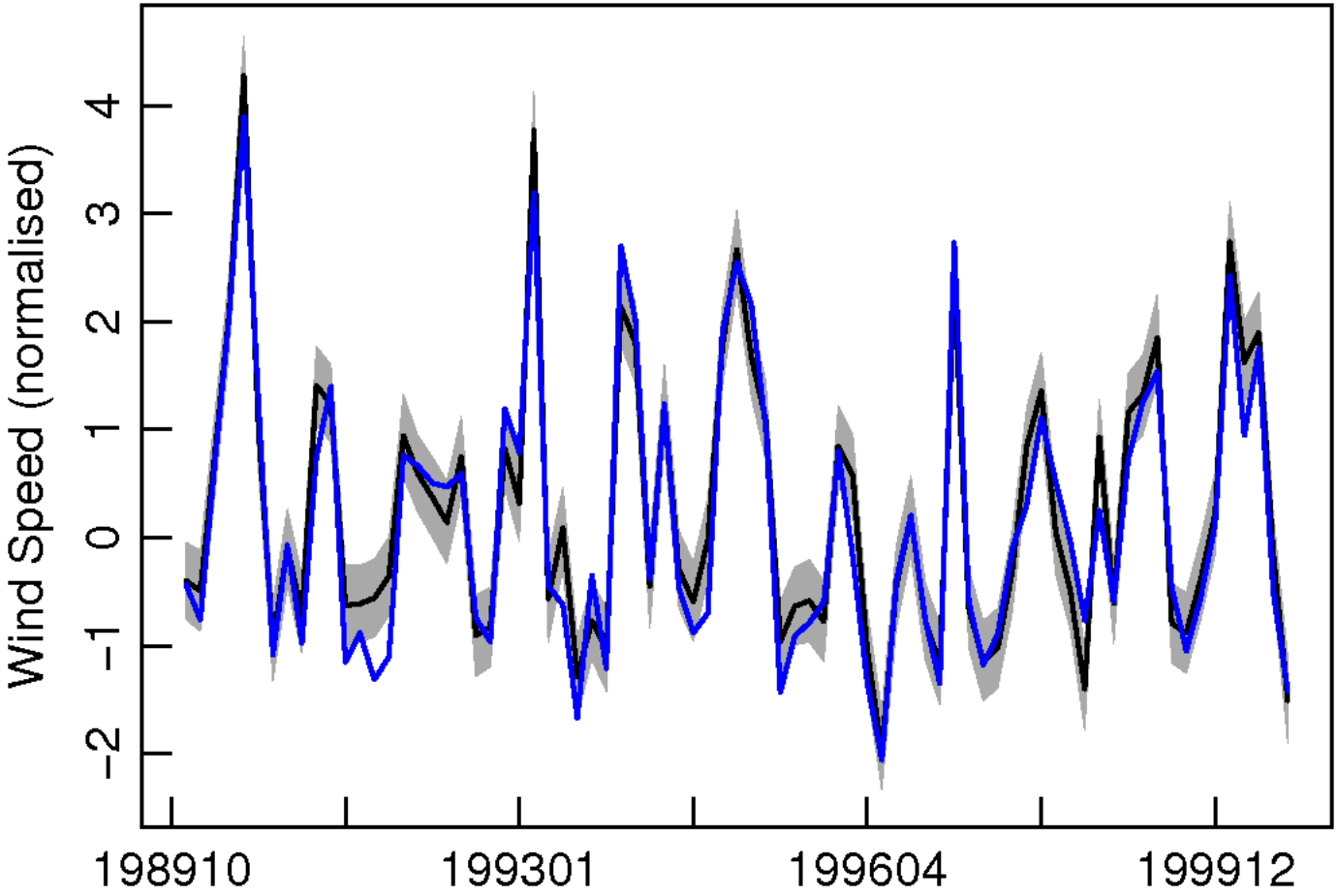
Use Law of propagation of uncertainty (independent)

Blue: EMULATE (original)

Black: Median

Grey: 95% CI

Variability well captured within CI



Storminess 1882-2000

Monthly averaged Mean October-April

Blue: OLS trend

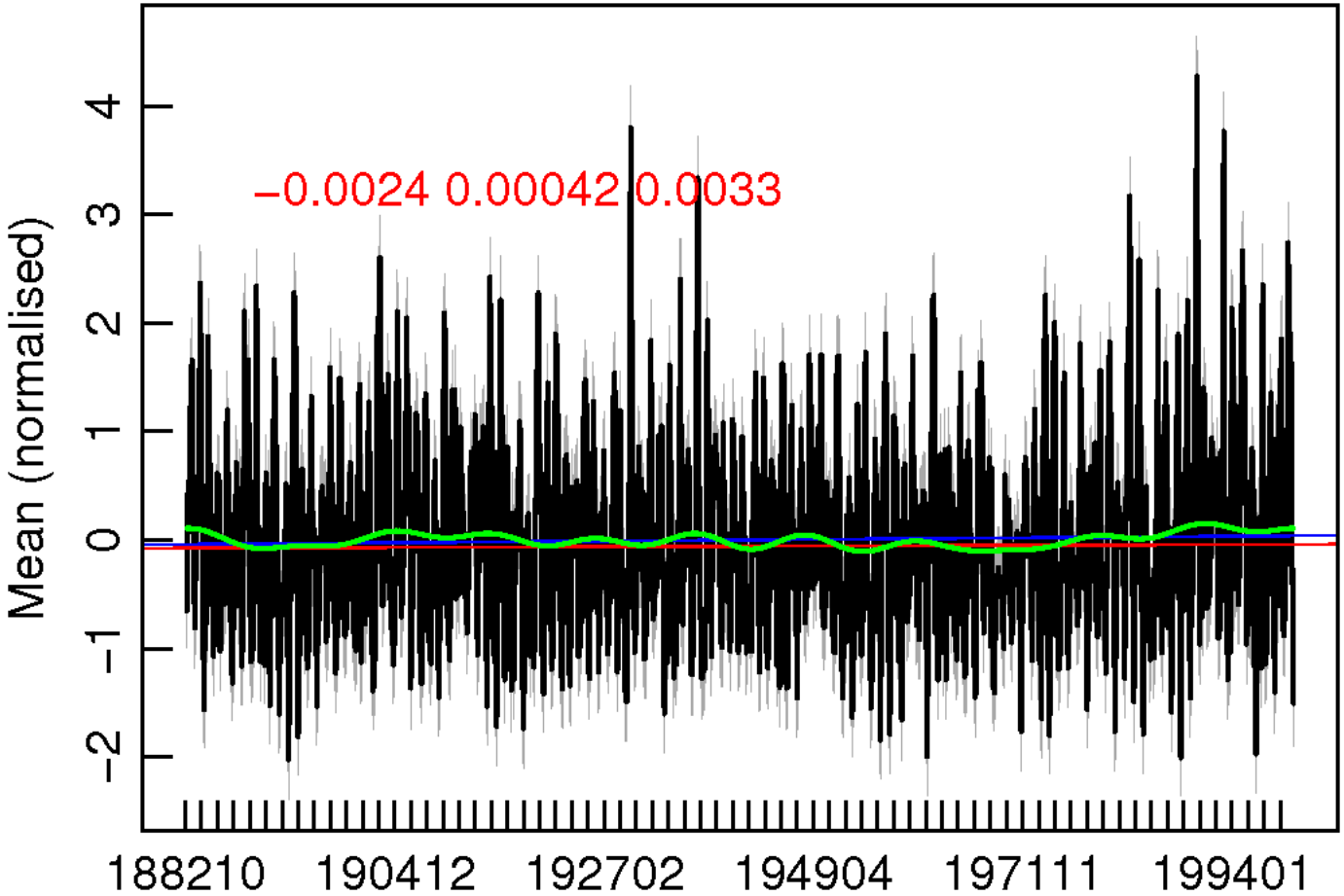
Red: Robust linear model

Green: decadal low pass filter

Black: Median

Grey: 95% CI

No trend



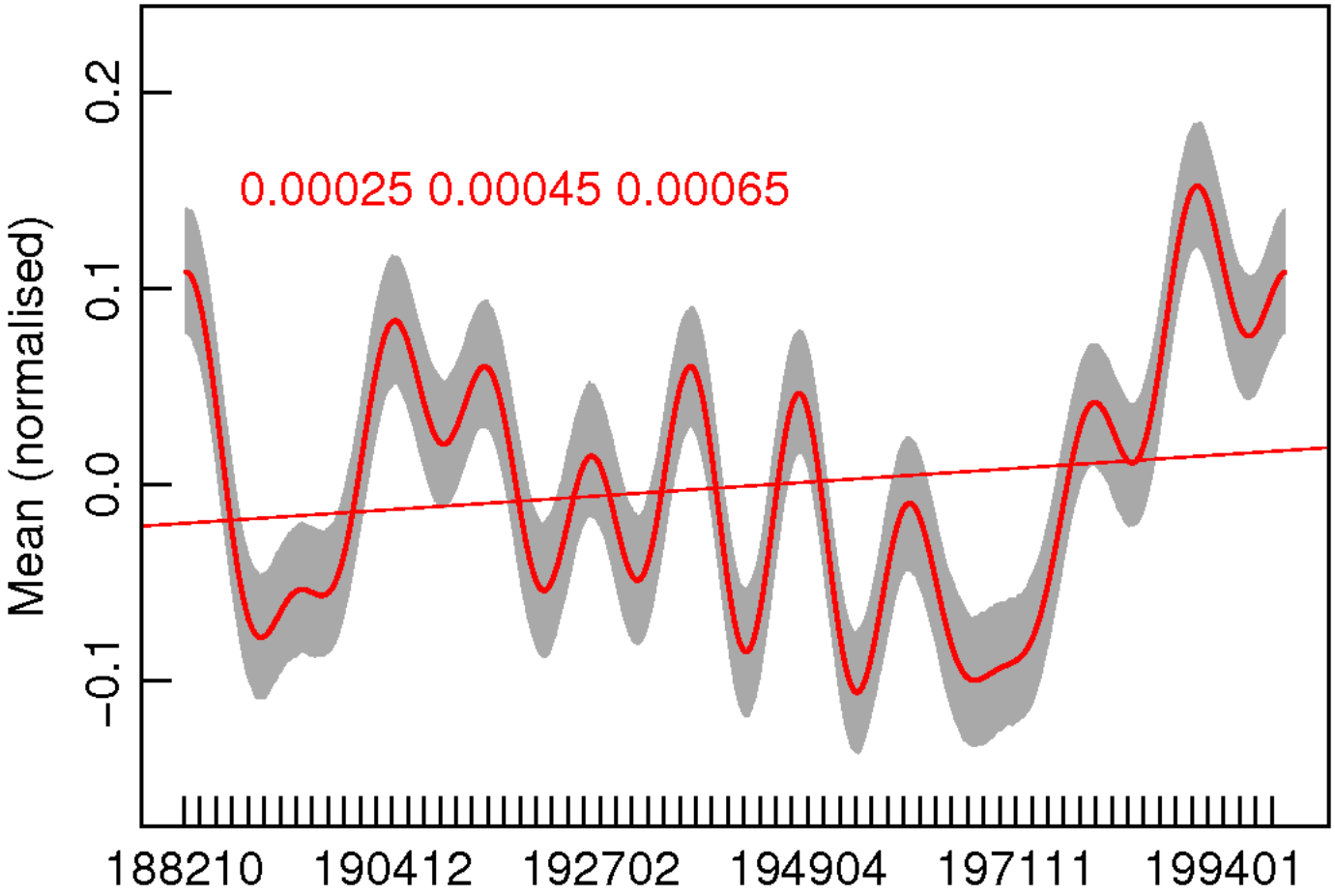
Decadal storminess 1882-2000

Decadal smoothed

Grey: 95%CI, Daily error propagated to decadal scale

Some evidence of a positive trend (not considering recent years)

Variability well captured within CI



Extreme storminess GPD climatology

Take daily EWI, identify 'storms', fit a GPD

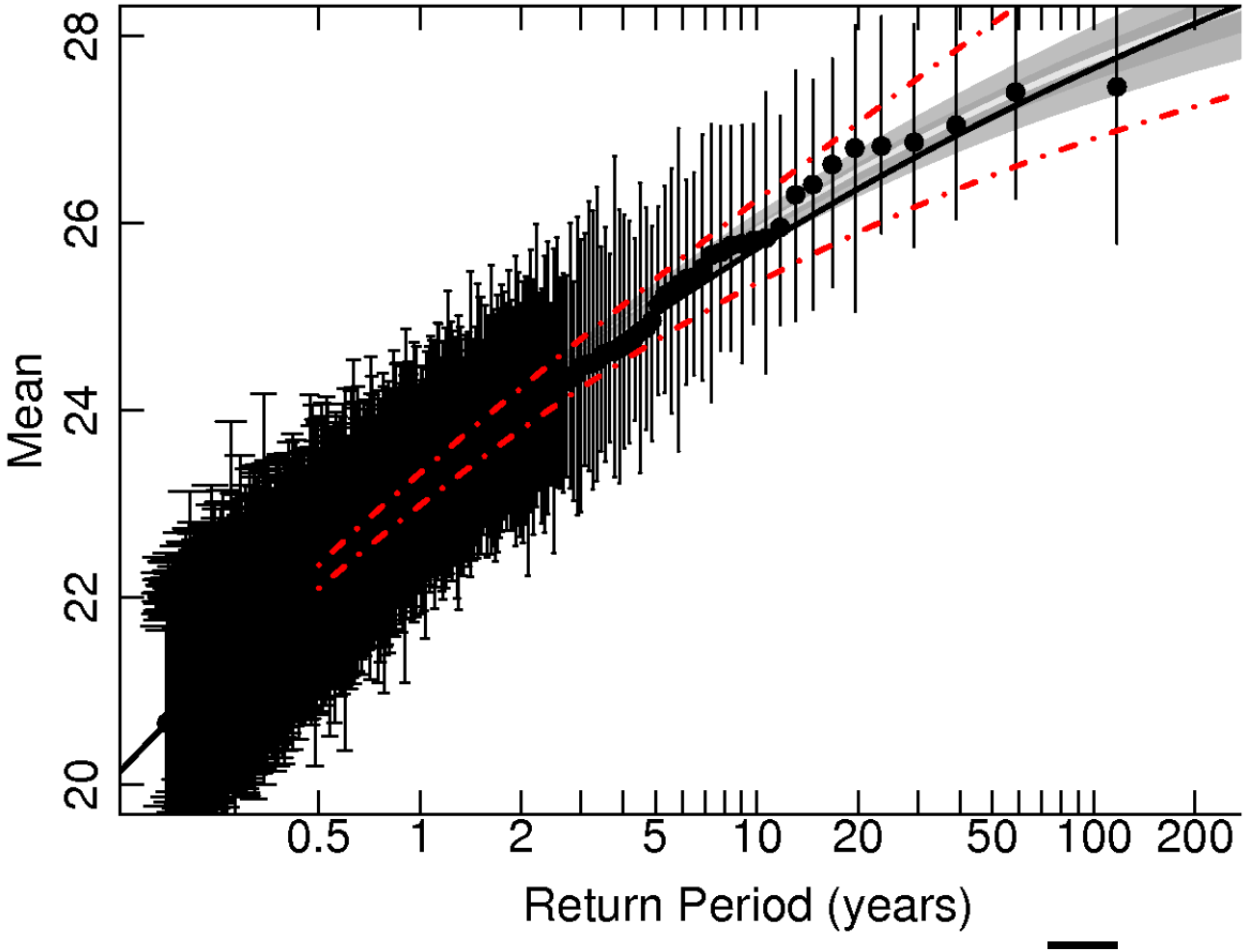
Black line and dots: best fit GPD to median Mean EWI

Red: 95% CI to the media GPD fit

Grey: range of GPD fittec to perturbed daily EWI

GPD fit robust to relative large daily error

RP of individual storms very uncertain



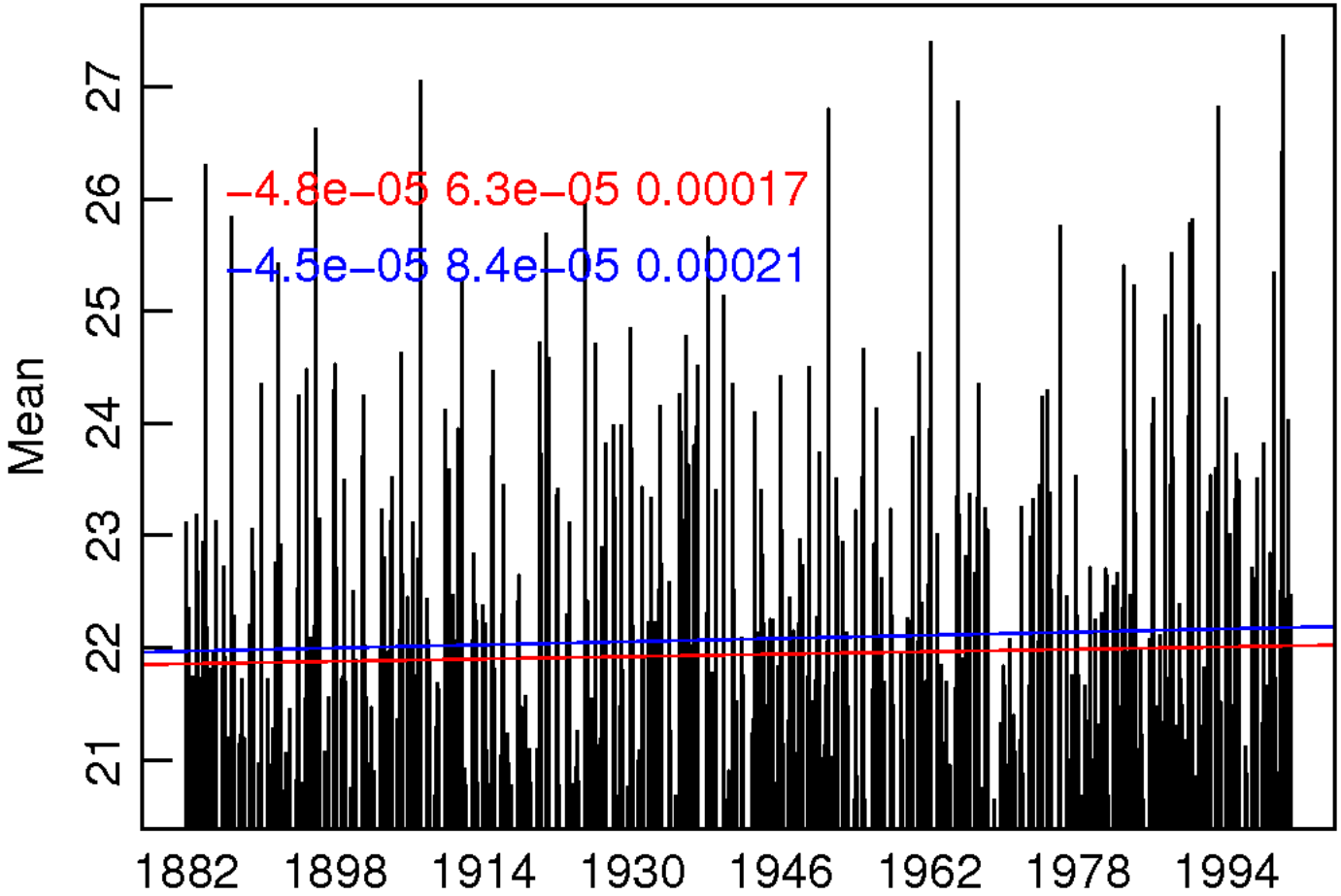
Extreme storminess 1882-2000

Consider only peaks above a high threshold (95th percentile)

Blue: OLS trend fitted to median EWI

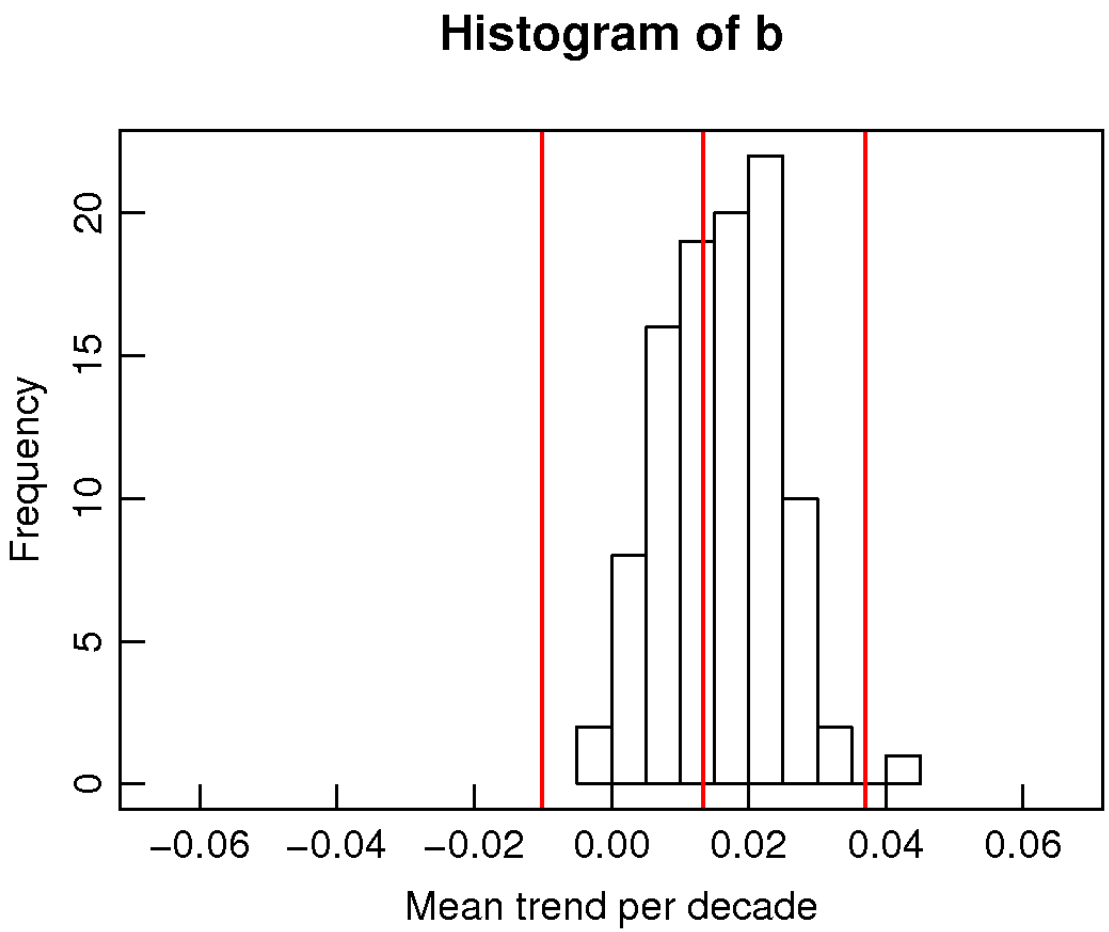
Red: Robust linear model fitted to median EWI

No trend



Median trend and simulation trend

Distribution of trends from simulation (histogram) show more evidence of a positive trend than 95% CI (red lines) derived from the median EWI



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Vector Generalised Linear Models

Analogous to Generalised Linear Models

The parameters of many different distributions can be modeled as functions of covariates

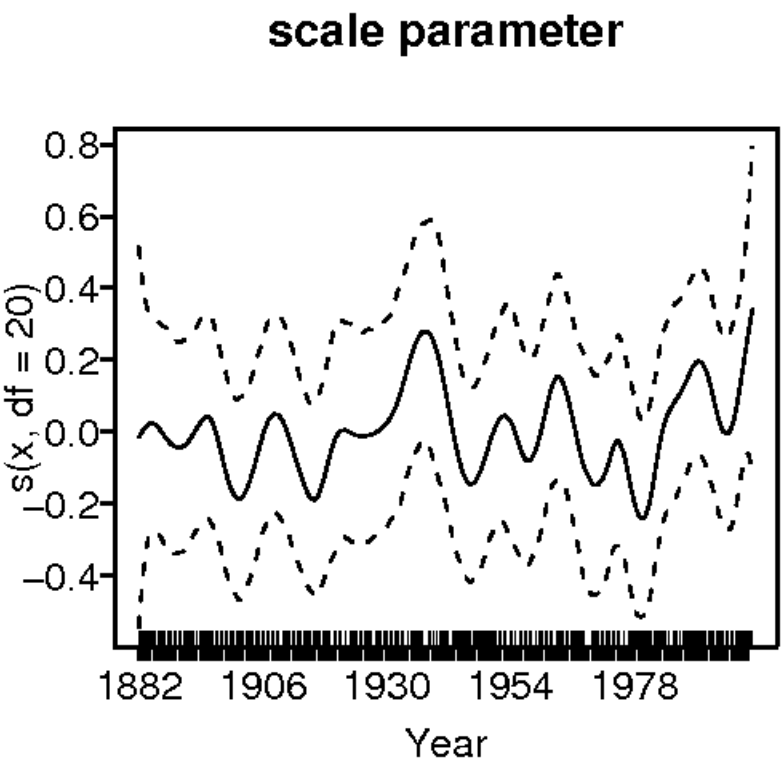
Applied to the two parameter GPD, covariate=time

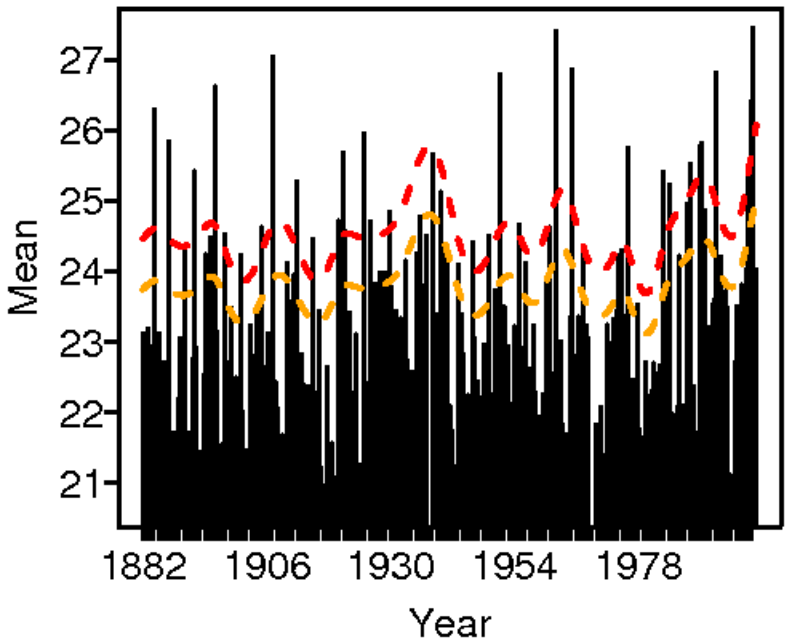
GPD scale parameter variability

Left: decadal variability in the scale parameter

- 95% CI of the fit to the scale parameter large

Right: 90th and 95th percentile of the GPD

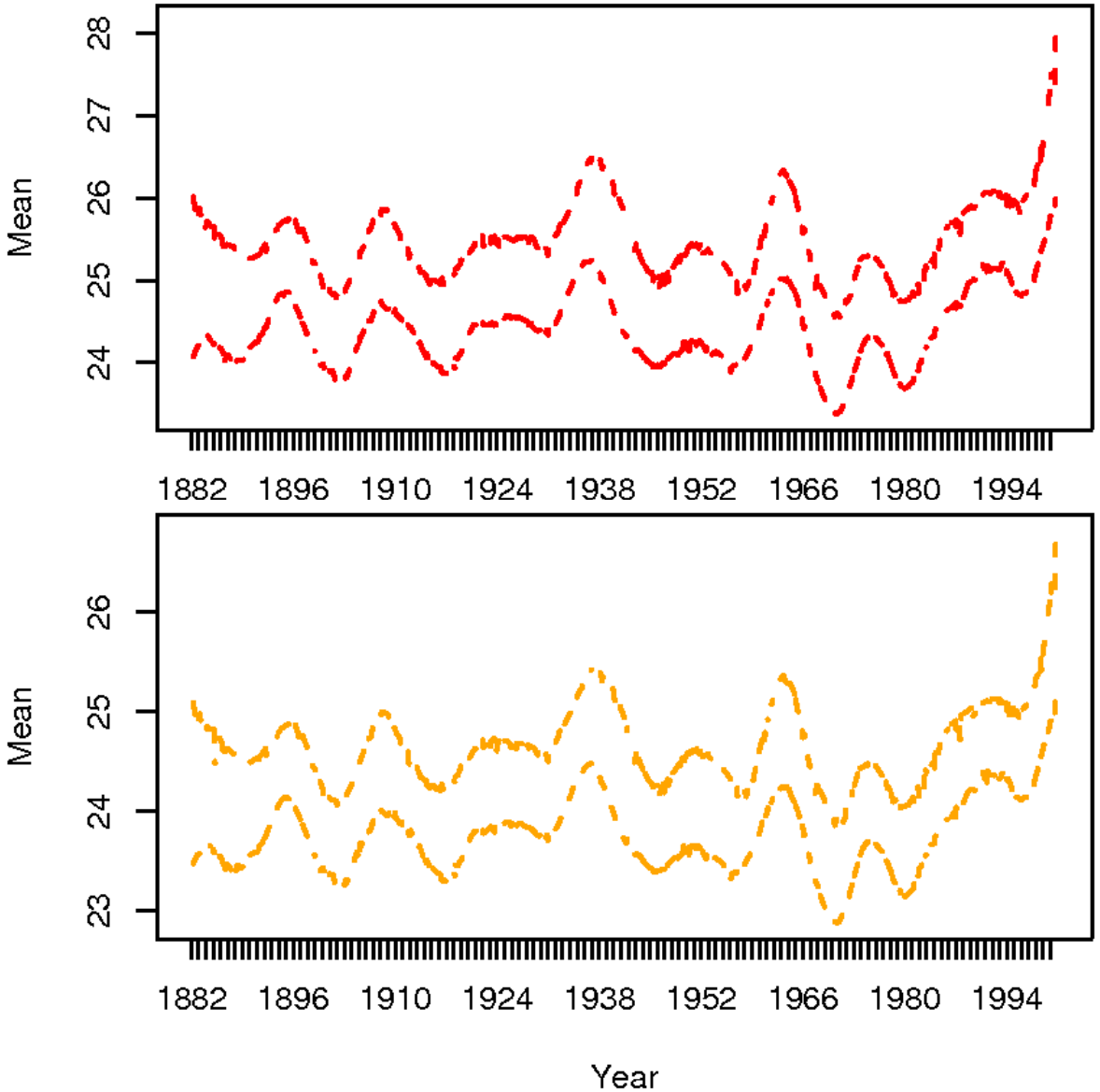




Simulation error in 95th and 90th percentiles

95% CI show that some decadal variability signal is visible in the 95th and 90th GPD percentiles

Does not consider the VGLM uncertainty



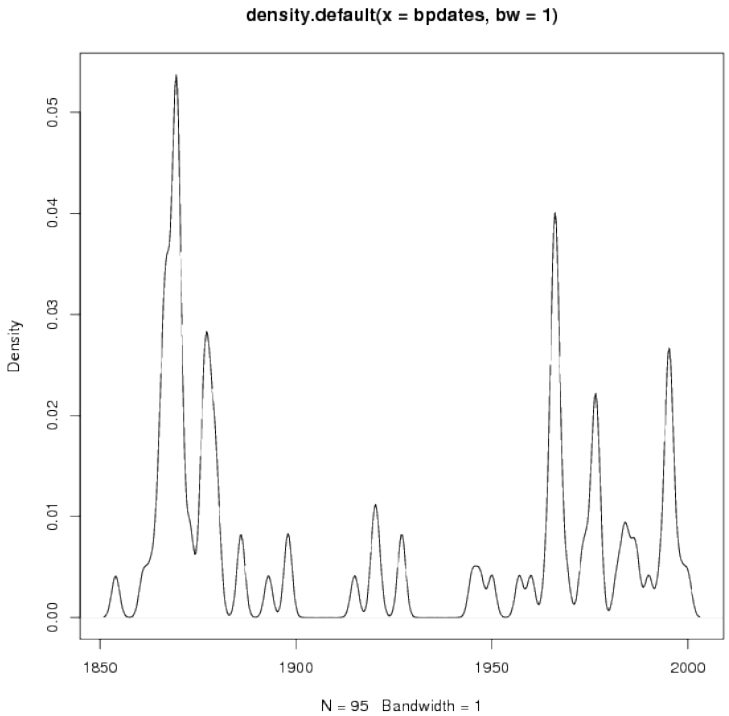
Progress and Next steps

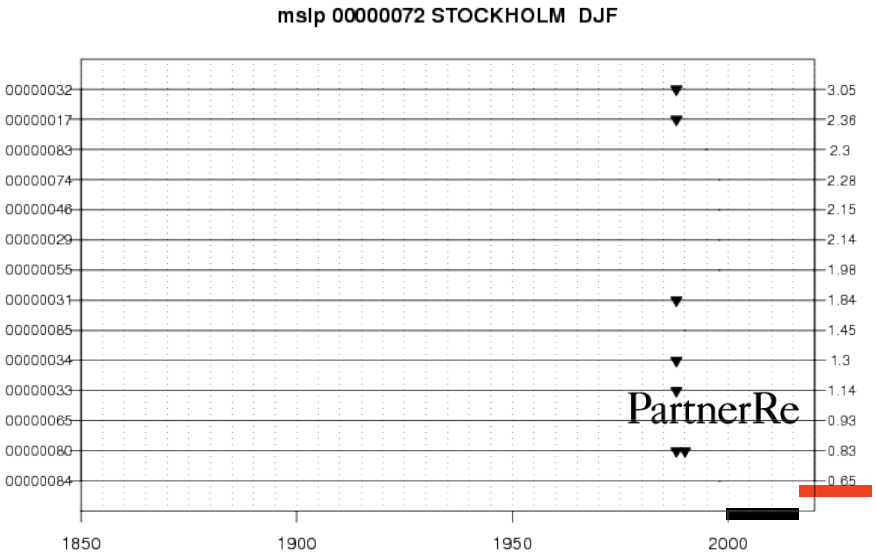
Homogenising the station records → detection and correction method of Caussinus & Mestre (2004)

Preliminary analysis shows the MSLP data to still contain inhomogeneities

Update MSLP station records – collaboration sought!

Include the ICOADS data





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Conclusions

Original EMULATE dataset has drawbacks due to RSOI method combined data availability

Simpler approach to gridding combined with simulations (preserving spatial variability) allows robust error estimates on derived statistics

Monthly and decadal storminess variability and changes well captured by the network of (sparse) land based stations.

No trend in storminess 1882-2000, however large inter-decadal variability (consistent with most previous studies)

Conclusions

Daily extreme storminess climatology robust to relatively large error on daily EWI values

Return Period estimates for individual extreme ‘storms’ are very uncertain

Some evidence of an increase in extreme storminess

VGLM models can be useful in determining covariates of extreme value distributions

Some decadal signal in the 90th and 95th percentiles of the GPD detectable within simulation noise.

References

Ansell et al (2006) JoC

Bhend, J (2004) MSc Thesis Uni Bern

Caussinus & Mestre (2004) JAStat

Della-Marta et al (2009) IJC

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