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North Sea winds and storm surges in a changing climate

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- Climate change and surges
- ESSENCE/WAQUA simulations
 - uncertainty
 - projections
- Other results



Problem

- Increasing GHG concentrations change climate
- => winds might change
- => surges might change
- => **could impact coastal safety**

- safety \Leftrightarrow rare events (NL: once in 10,000 years)
- rare events => extrapolation
- => large uncertainty, ...
- ... increased if situation non-stationary

- **uncertainty reduced by using large model ensemble**



Essence + WAQUA

Essence

- ECHAM5/MPI-OM
- 17-member ensemble
- 1950-2100, SRES A1b

WAQUA

- storm surge model
- Northwest European shelf
- 8 km x 8 km
- output every 10 minutes



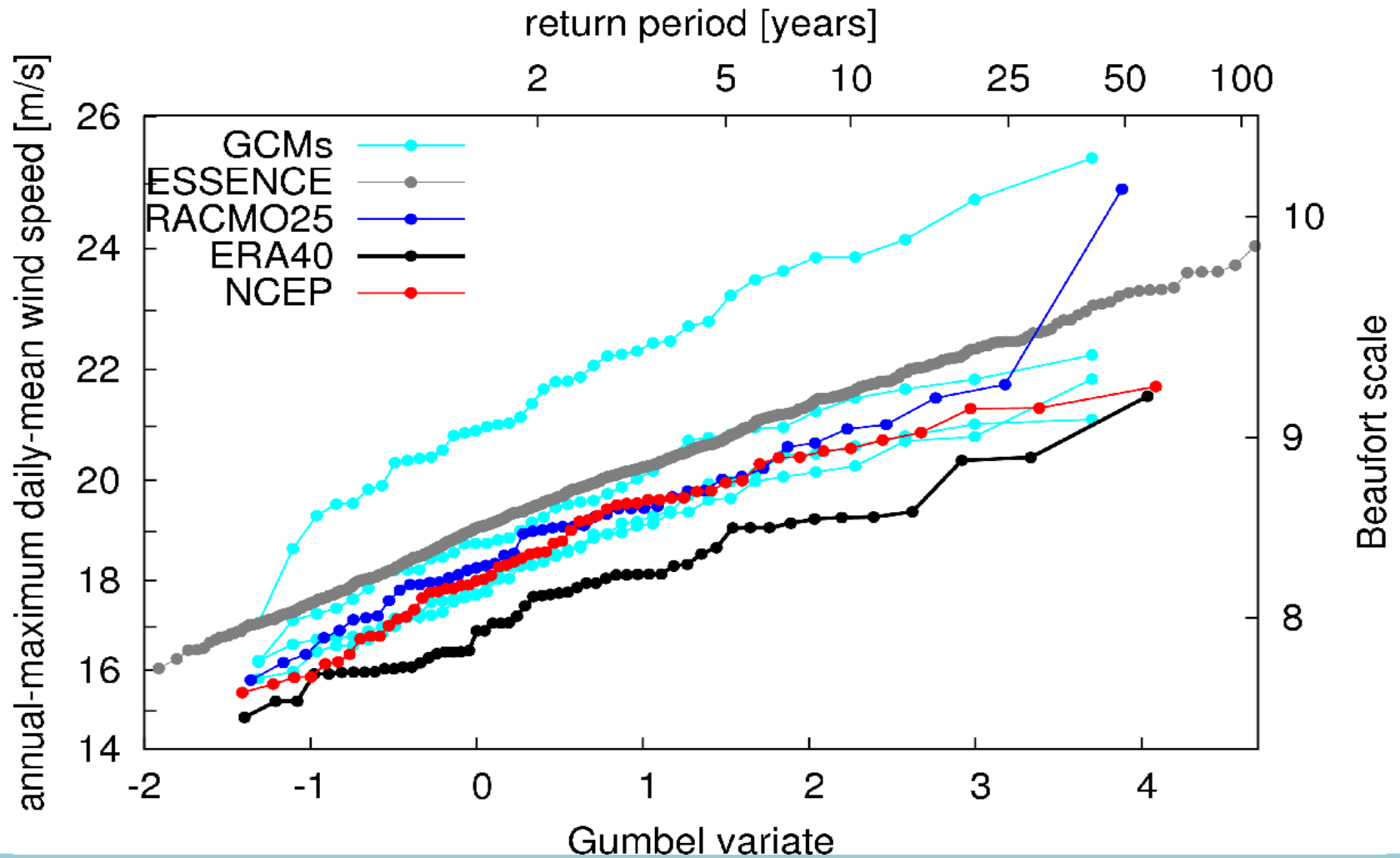
Verification

- Essence winds
- Essence extreme winds
- WAQUA and low-resolution forcing

Winds



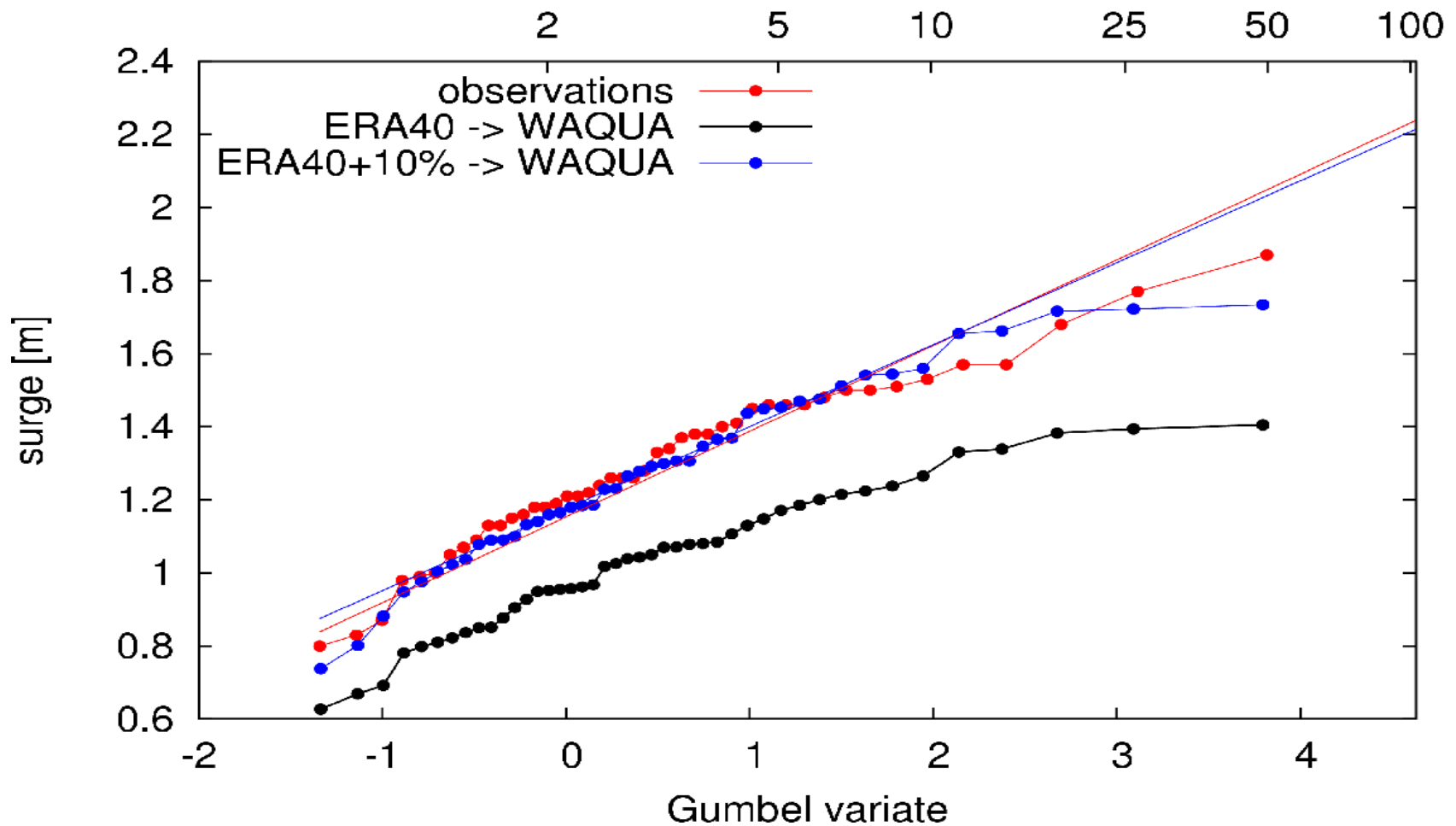
Return level plot of daily-mean wind speed at (2.5E,55N)



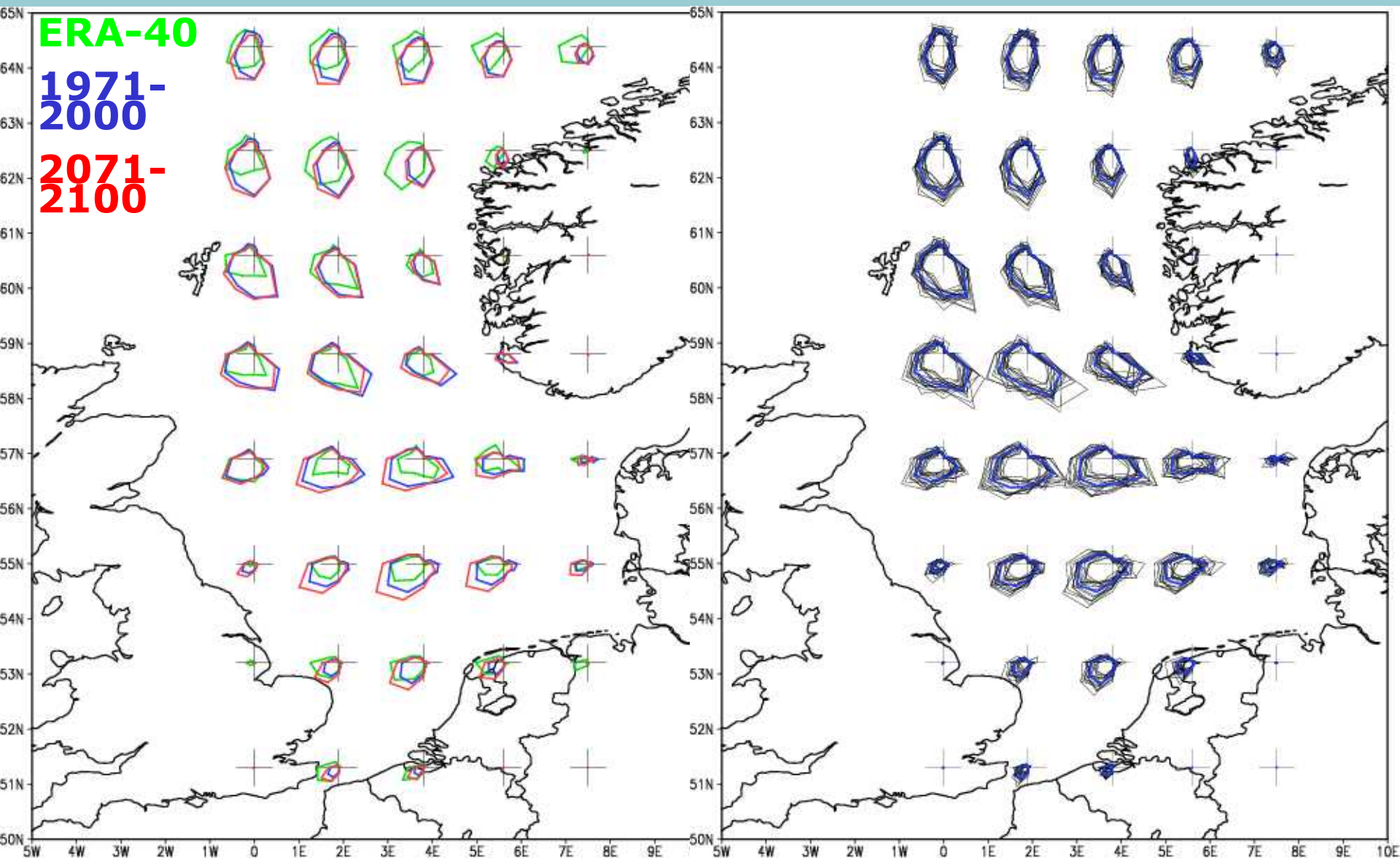
WAQUA - verification



Hoek van Holland



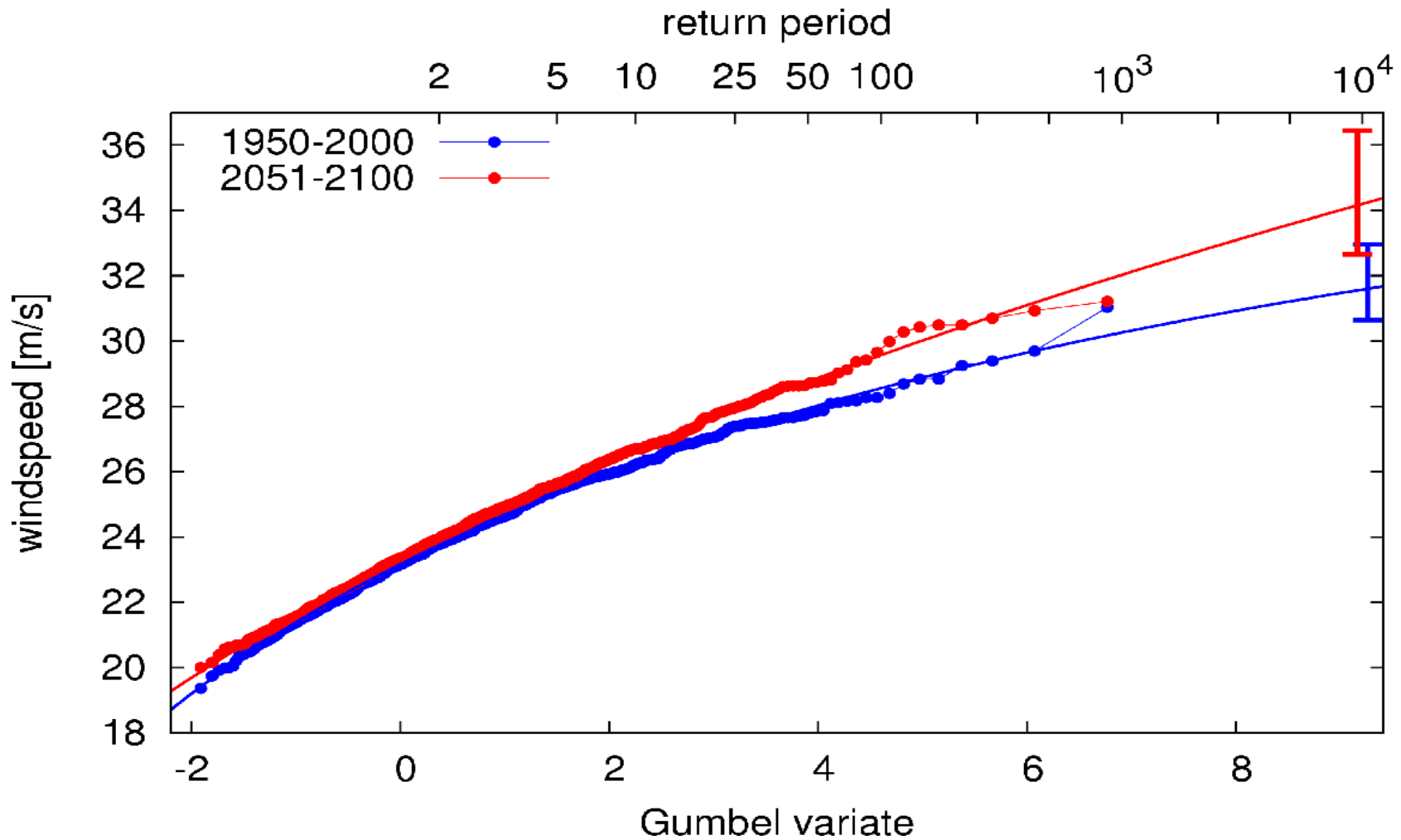
Will the wind change ?



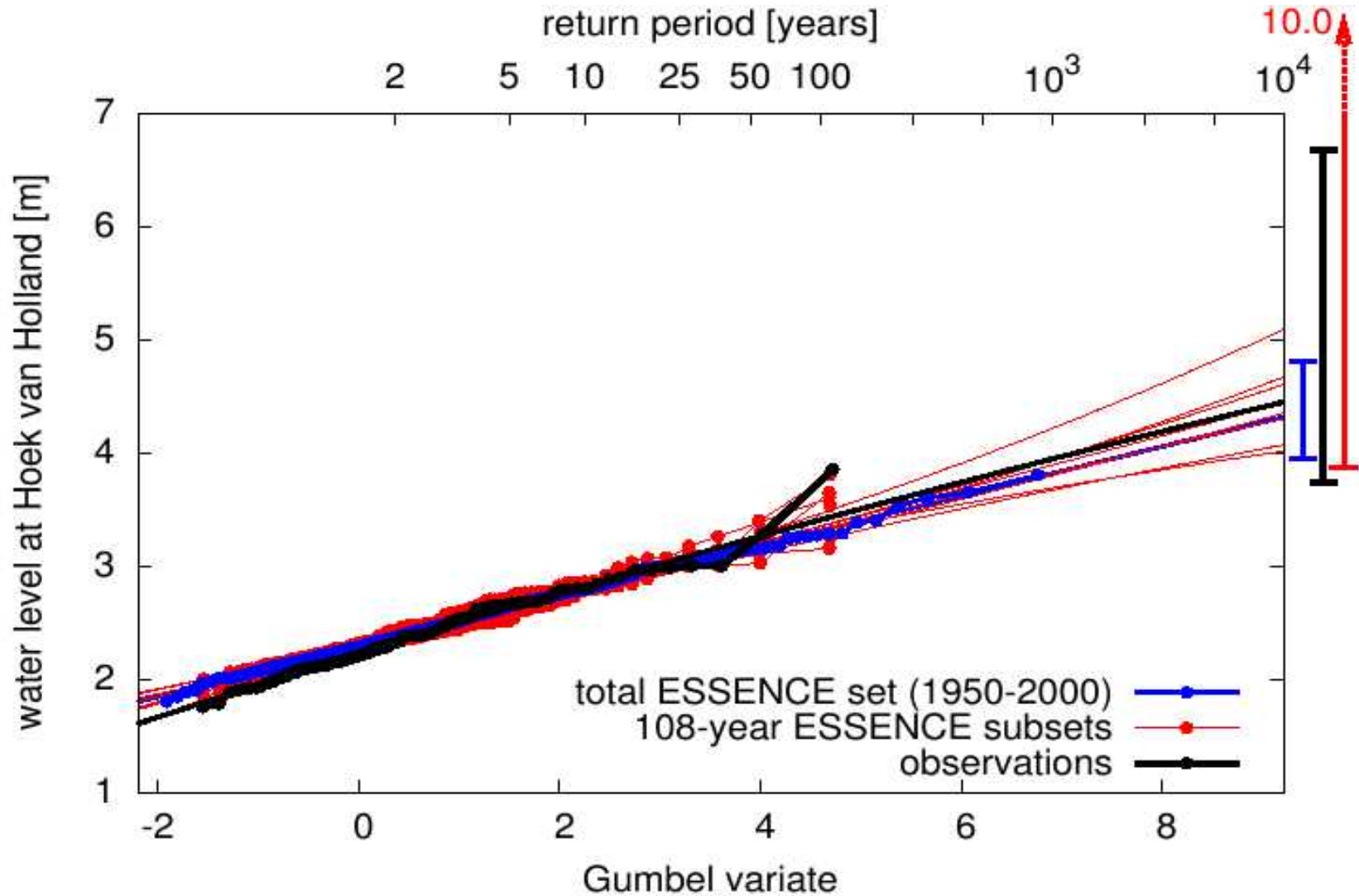
ESSENCE winds



(1.8E;55N)



Uncertainty present-day water levels



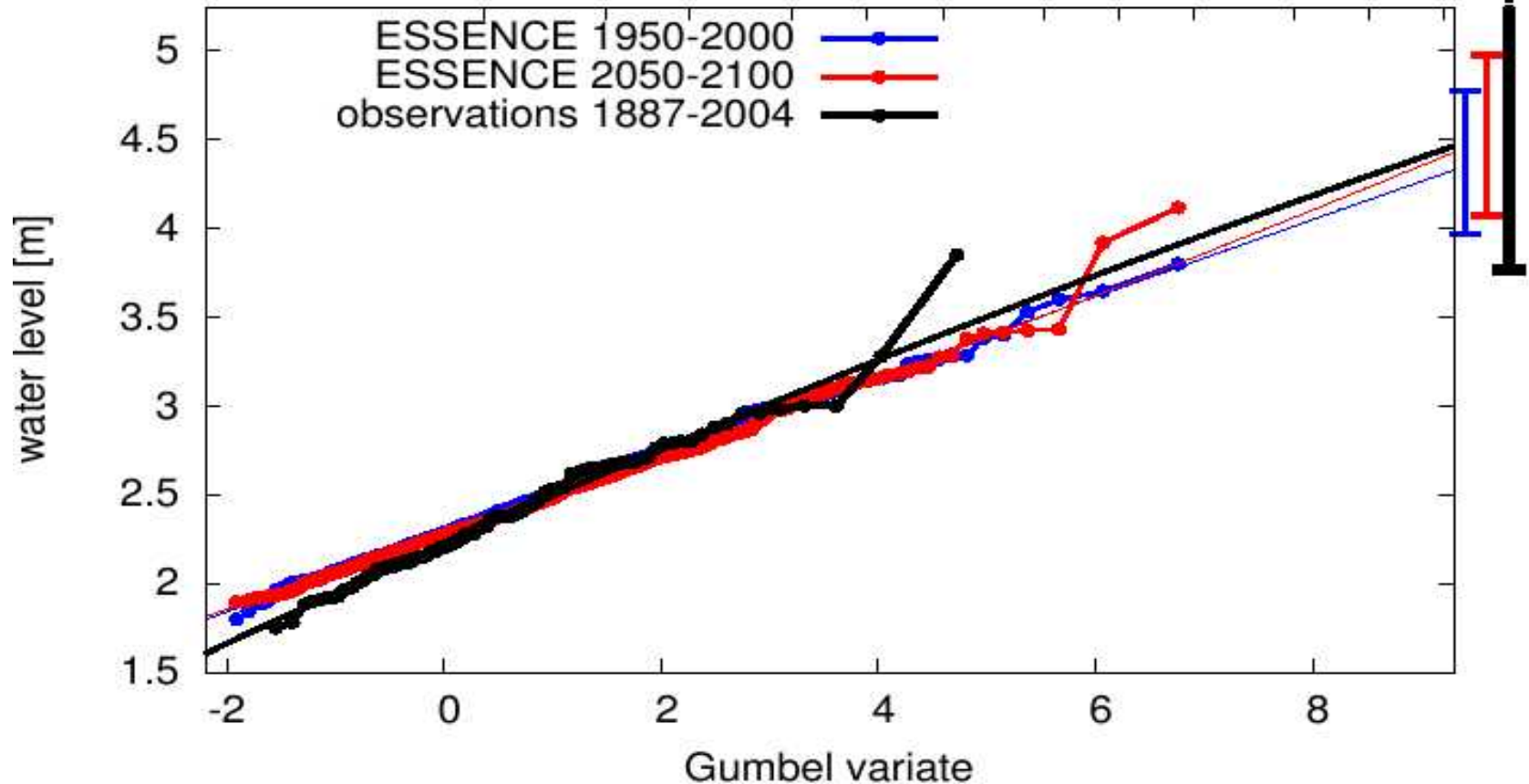
Future water levels



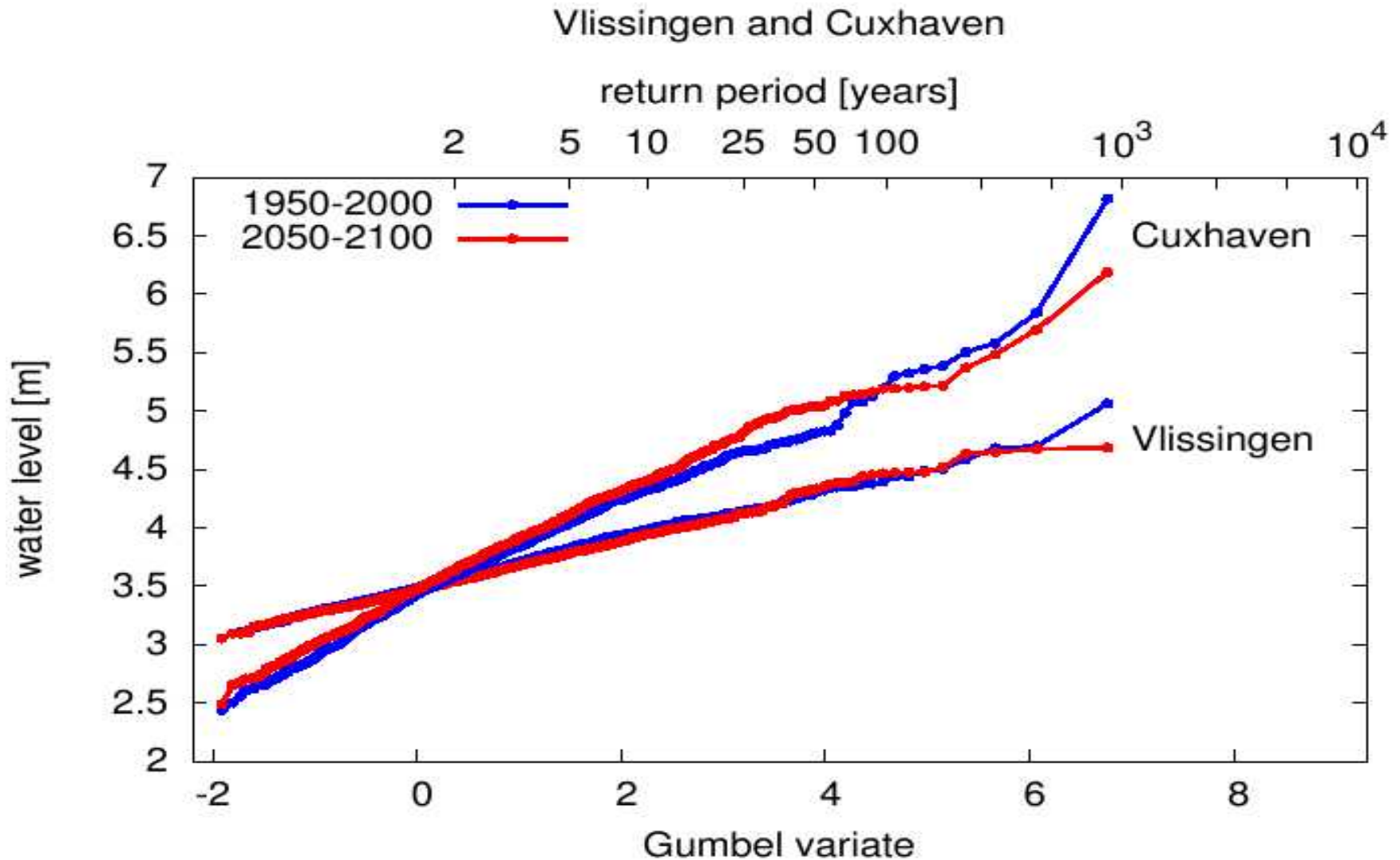
Hoek van Holland

return period

2 5 10 25 50 100 10^3 10^4



Other stations





Conclusions

- expected **winds**: more westerly, slightly higher
- natural variability > change
- expected **surge**: no change

- sea level rise => no effect on surge



Results from other studies (Dutch coast)

KNMI'06	AR4 + statistic al surge model	wind & surge	no change
Lowe et al (2008); UKCP	GCM, RCM, surge model	surge	small increase large uncertai nty
Debernard	3 GCMs	wind	slight



Uncertainties / Open Questions

- only one model
- morphology changes – natural or artificial
- sea level rise => coastline
- local wind (esp. Wadden Sea)



The End !!!



The 100-year return value - 1

temperature that on average occurs once per 100 years

obtained by fitting a GEV to annual maxima:

$$G(x) = \exp \left\{ - \left[1 + \xi \left(\frac{x - \mu}{\sigma} \right) \right]^{-1/\xi} \right\}$$

μ : location

σ : scale

ξ : shape



The 100-year return value - 2

$$G(x) = \exp \left\{ - \left[1 + \xi \left(\frac{x - \mu}{\sigma} \right) \right]^{-1/\xi} \right\}$$

defined for $1 + \xi \left(\frac{x - \mu}{\sigma} \right) > 0$

=> bounded by $x_{\max} = \mu - \sigma/\xi$ for $\xi < 0$

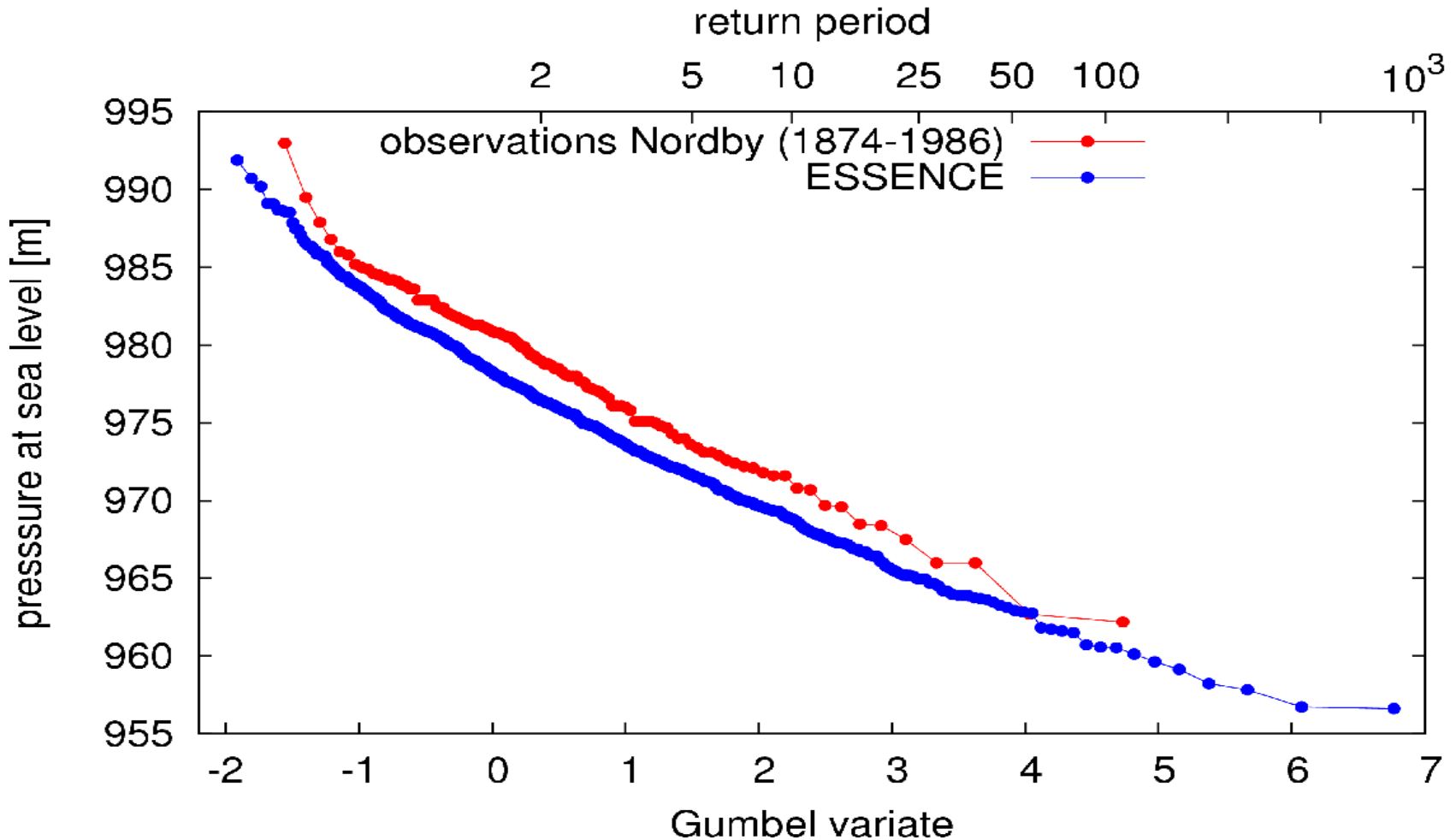
return time $T(x)$ for level x is $1 - G(x)$ percentile:

$$T(x) = \frac{1}{1 - G(x)}$$

Depth of depressions

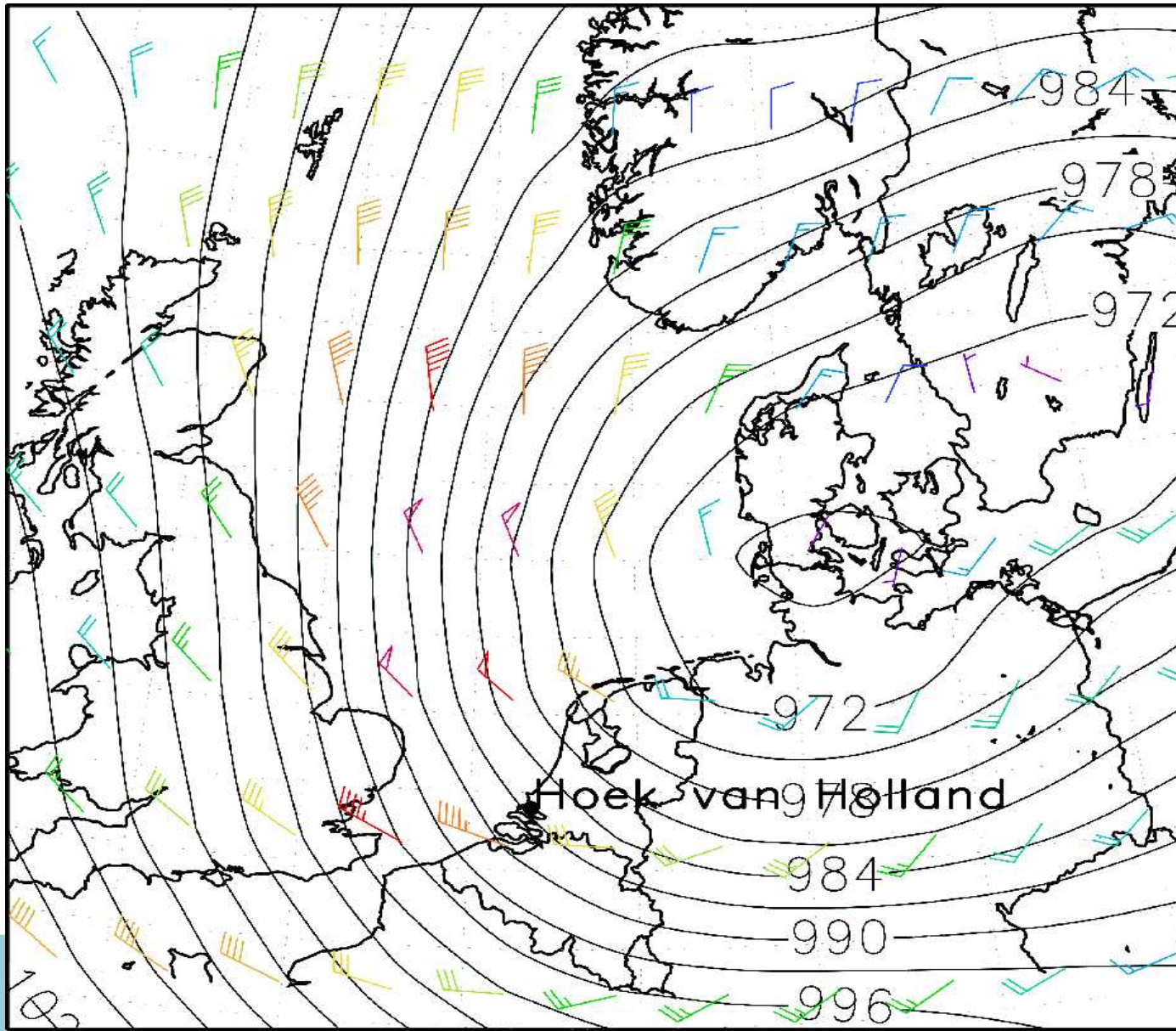


Nordby (Denmark) at (55:27N,8:24N)





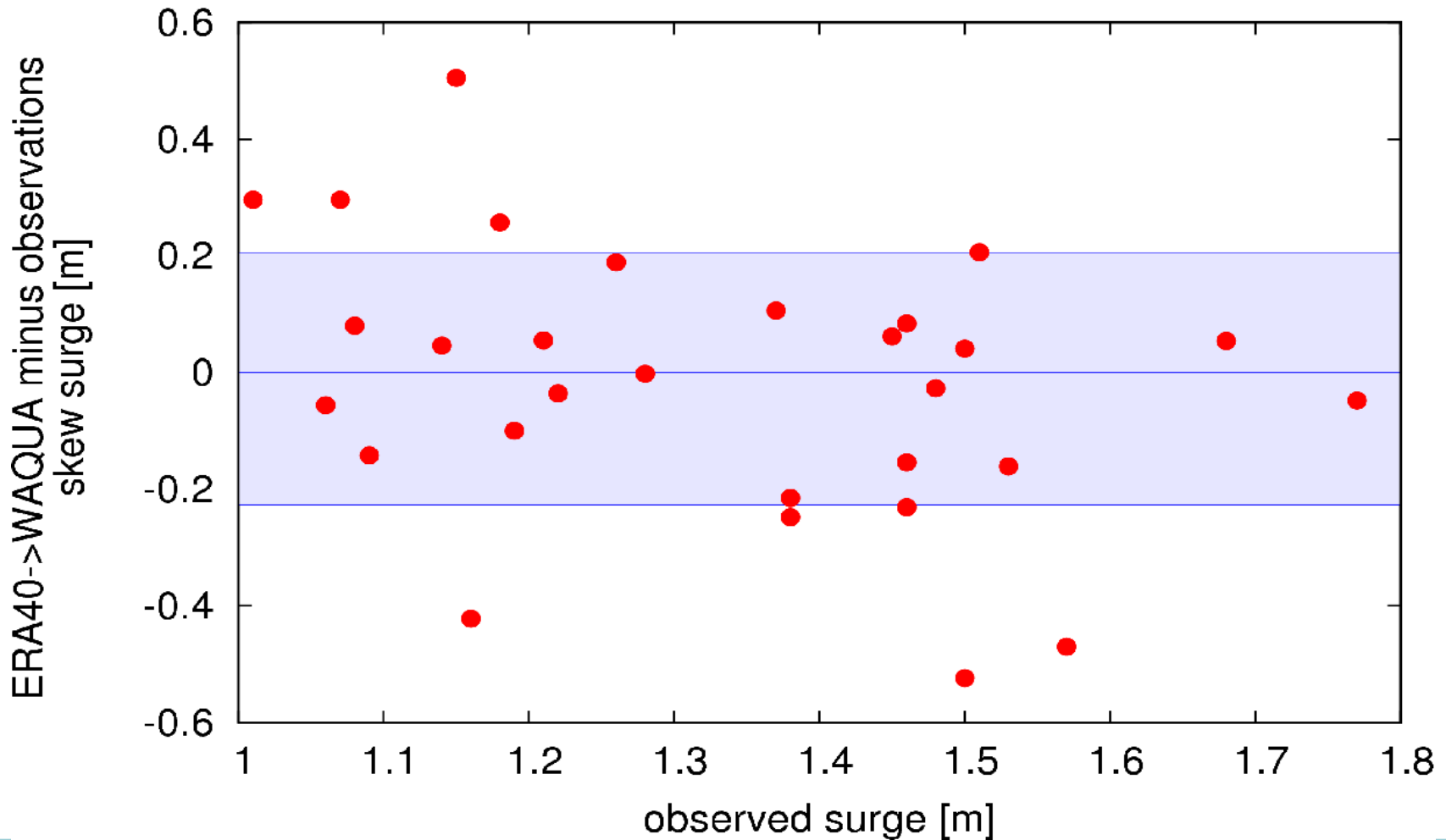
Wind at max. surge



Obs vs. modelled surges



Correlation between ERA40->WAQUA and observations
30 (of 44) similar events

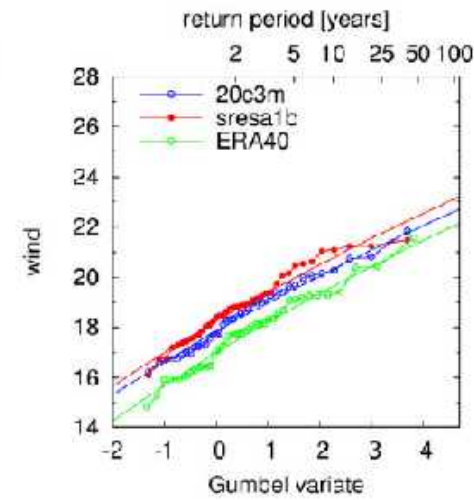
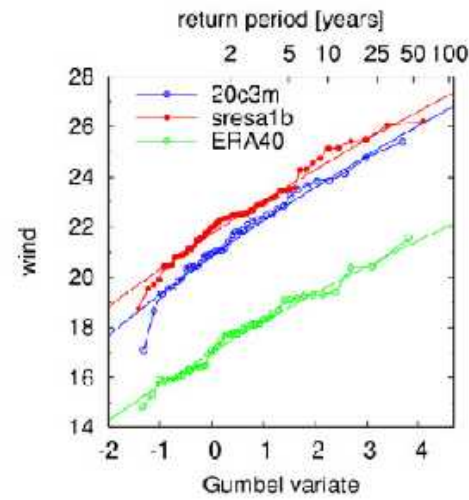
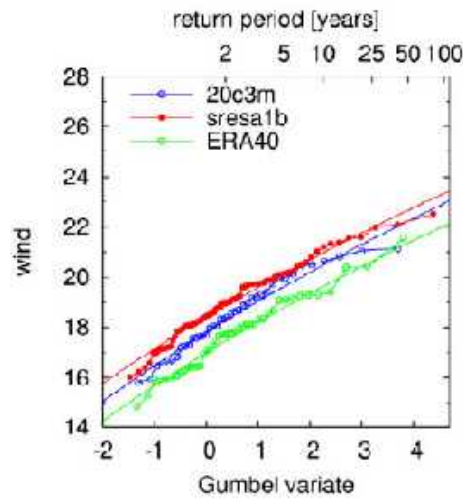
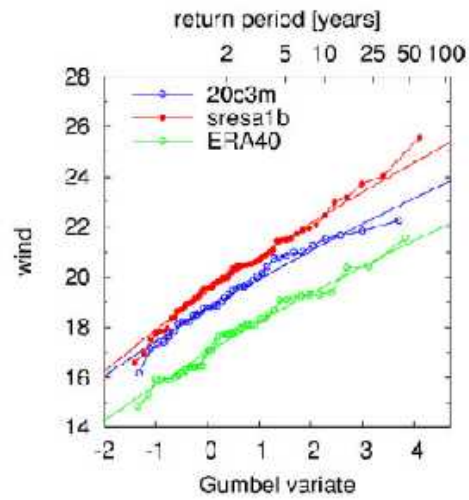


ECHAM5

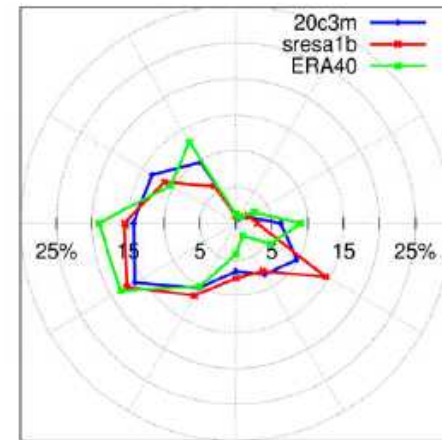
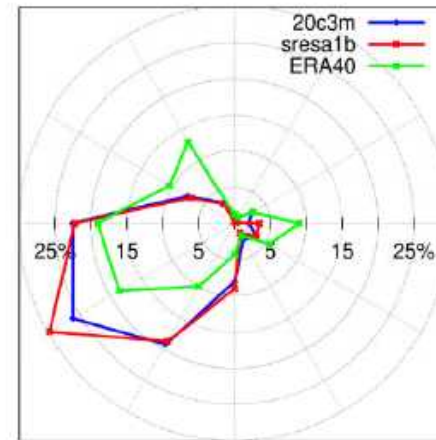
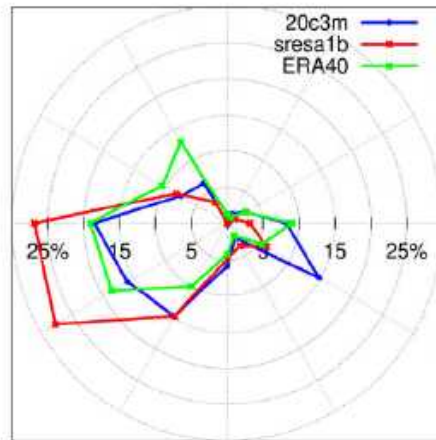
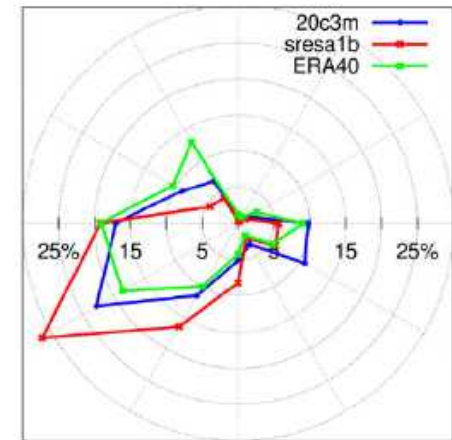
GFDL2.1

CCC63

MIROCHI



Wind





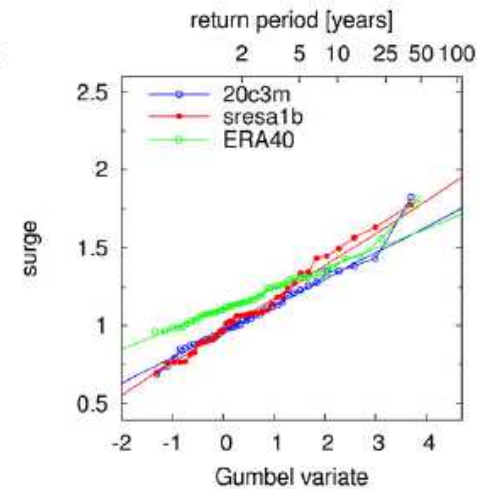
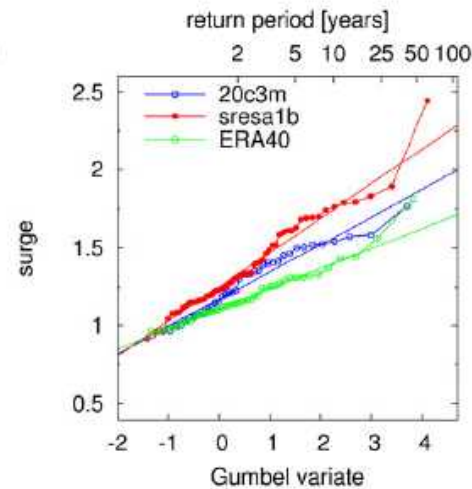
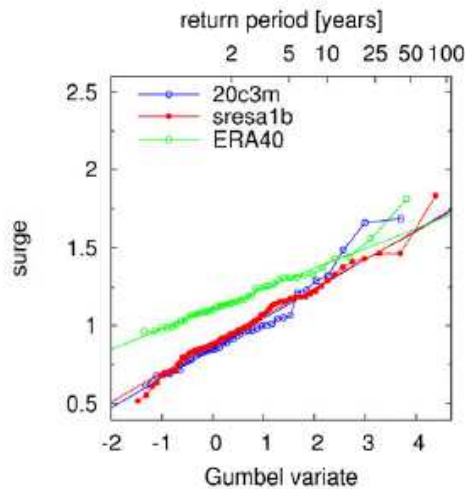
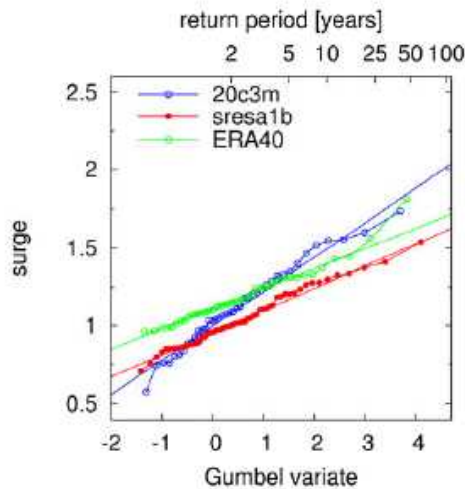
Northerly winds most important for surge heights => no large changes in surge heights expected

ECHAM5

GFDL2.1

CCC63

MIROCHI



Surge (simple model)