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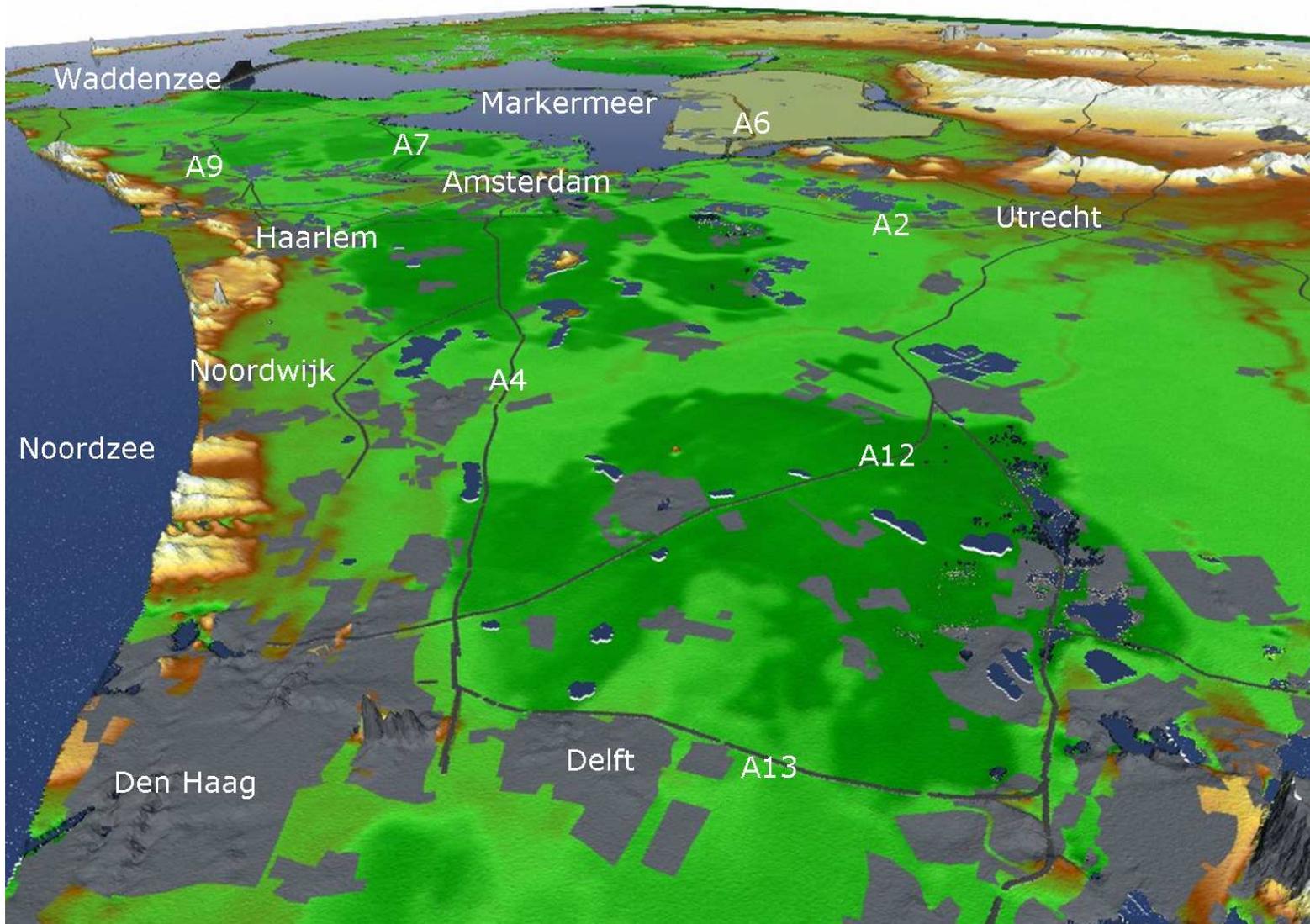
High extremes in the Low Countries

The use of extreme value theory for flooding defence in The Netherlands

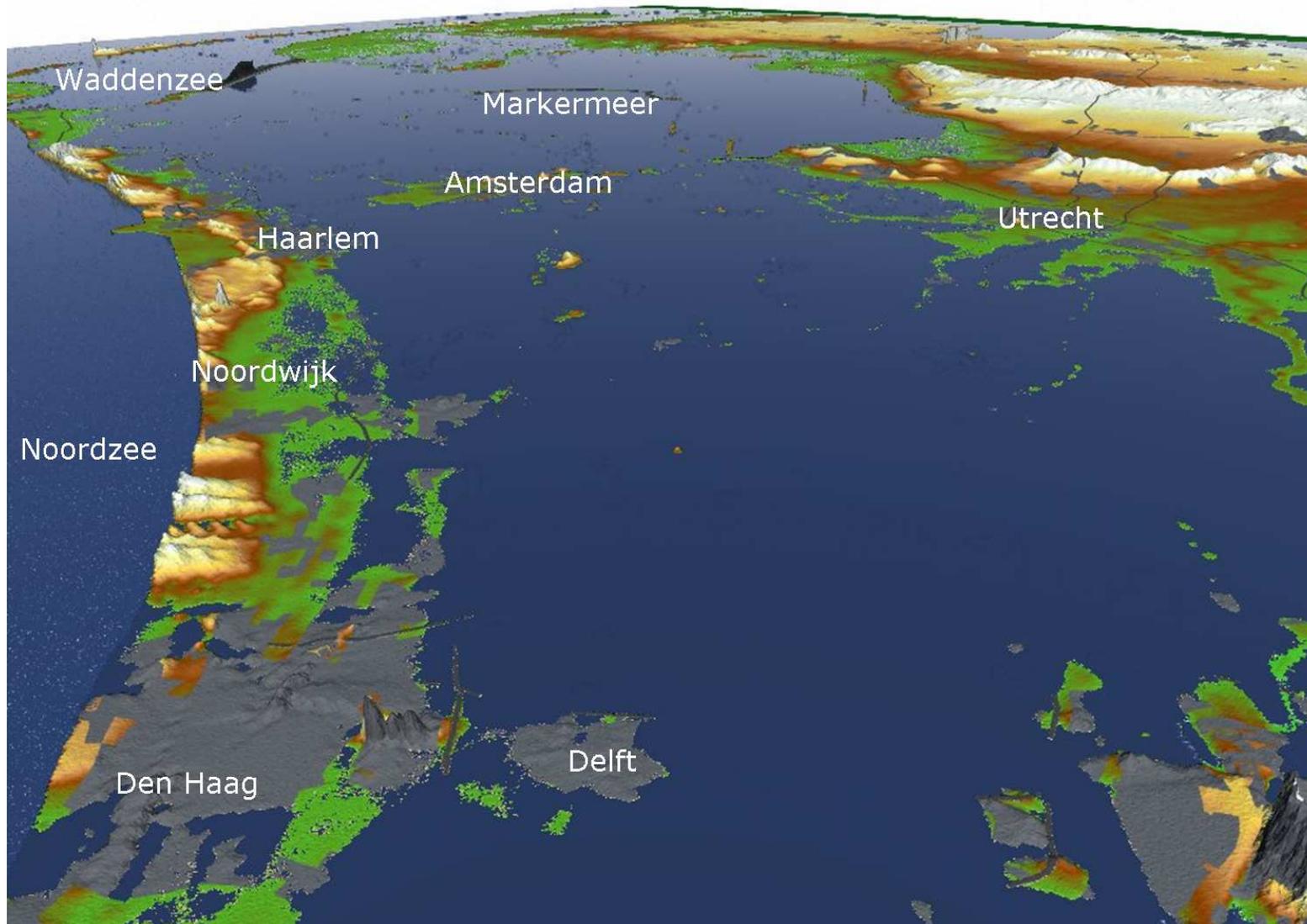
Modeling Methodologies – 11-12 july, 2006

Henk van den Brink

.... **The Low Countries with sea-dikes**



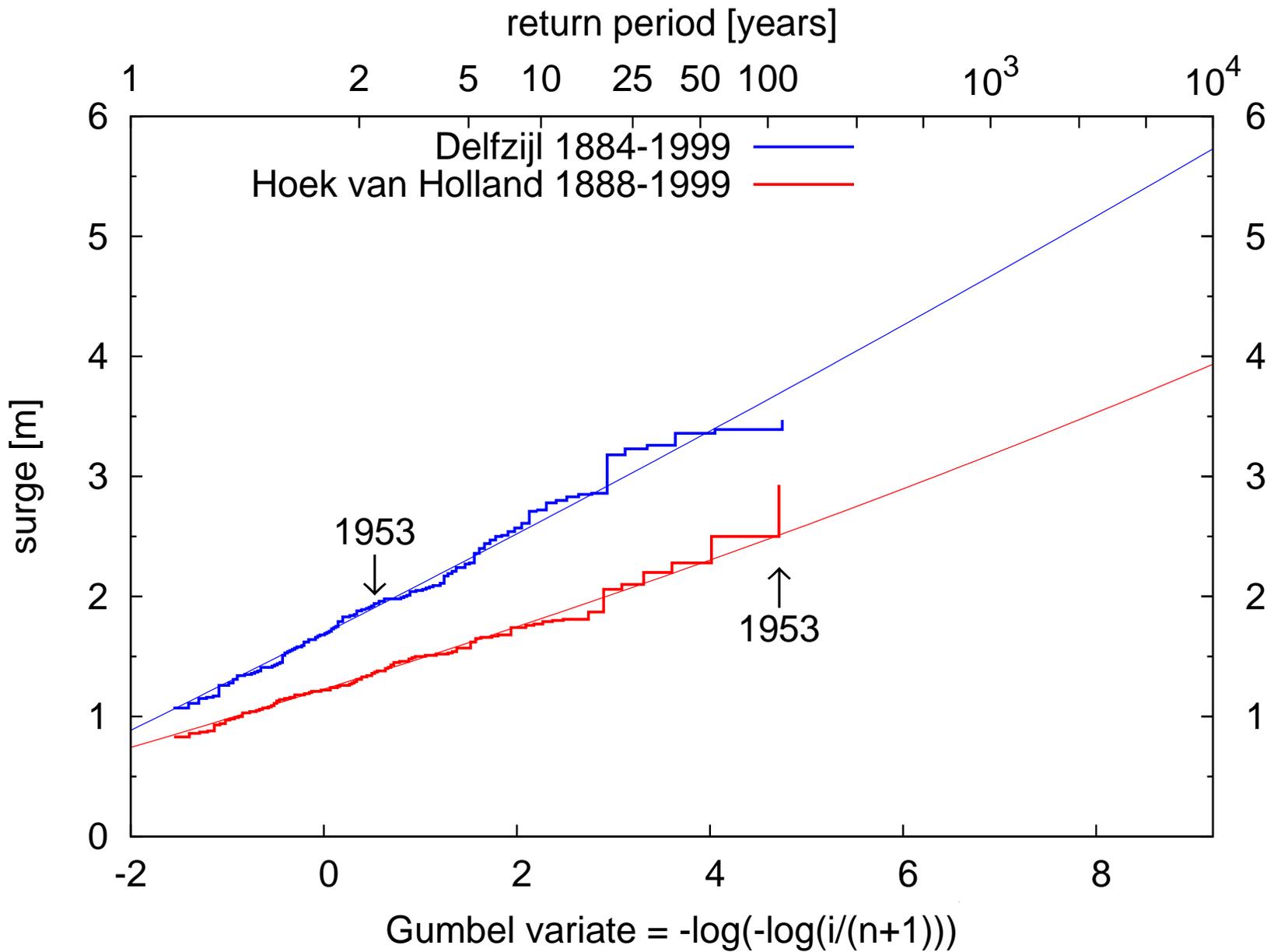
.... **The Low Countries without sea-dikes**



.... **Aims:**

- to make accurate estimates of the sea level reached once in 10.000 years ($P \leq 10^{-4} \text{ yr}^{-1}$)
- (to find out if these estimates change due to greenhouse effects)

.... **Gumbel plot of surge:**



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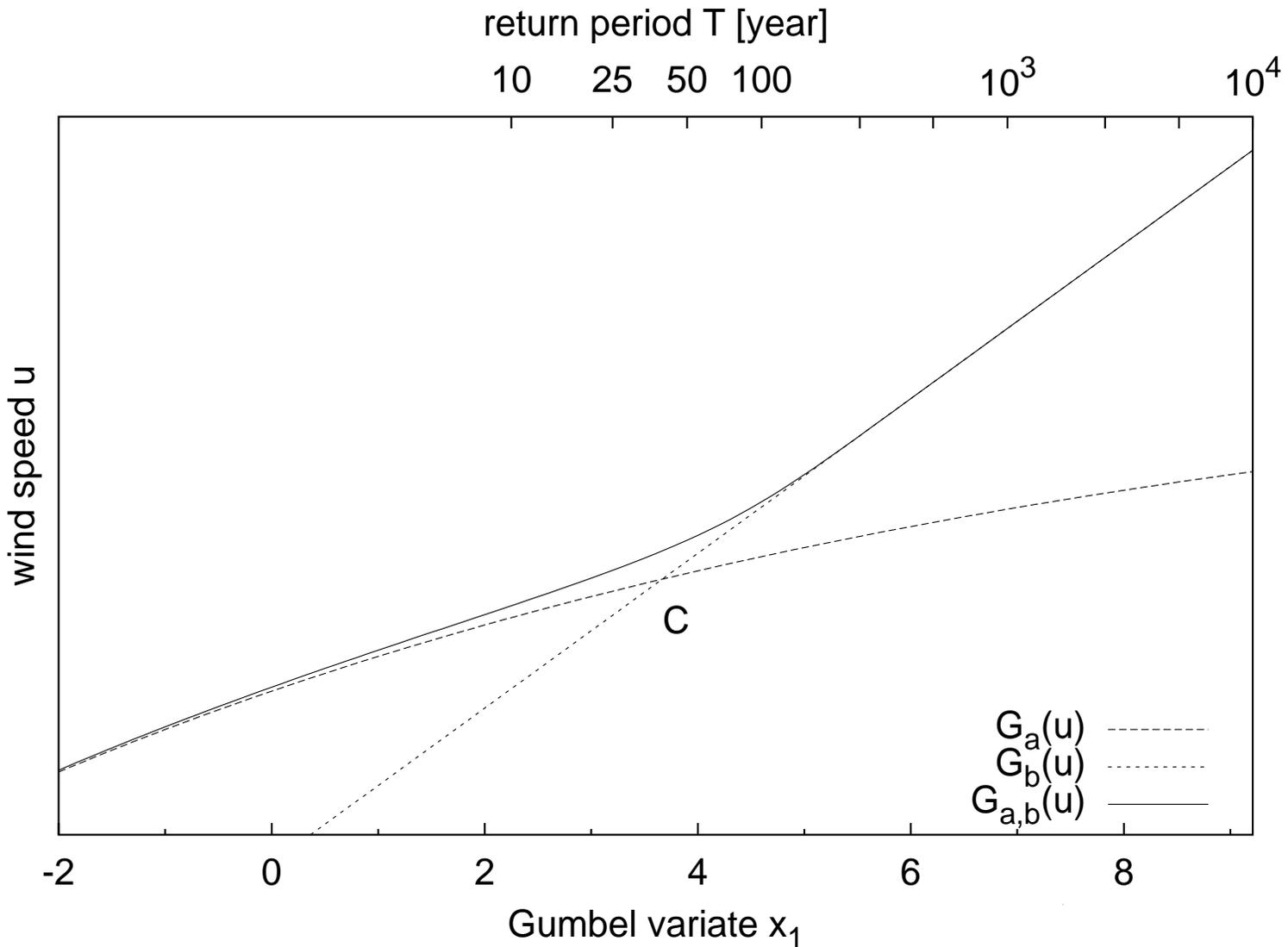
however:

- are assumptions valid?
 - convergence of annual maxima?
 - single population?

.... **Examples of 'double populations':**

- water levels
 - storm surges
 - tsunami's
 - sea level rise (i.e. not stationary)
- river discharges/height
 - precipitation
 - snow melt
 - river flooding
- wind speed
 - extratropical storm
 - hurricane
 - wind-spout/tornado

.... **Gumbel plot of mixed distribution:**

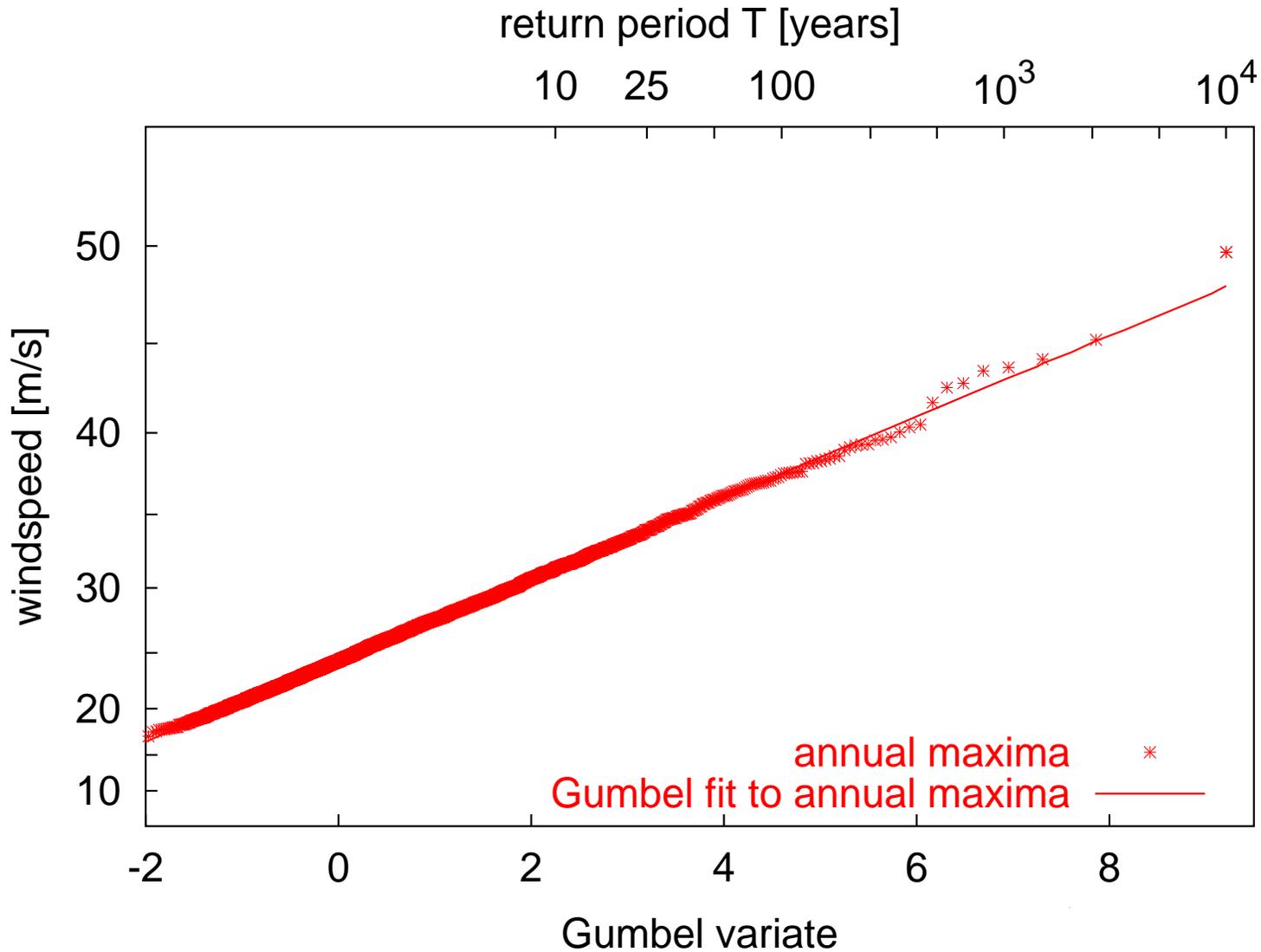


.... **How to detect mixed distributions?**

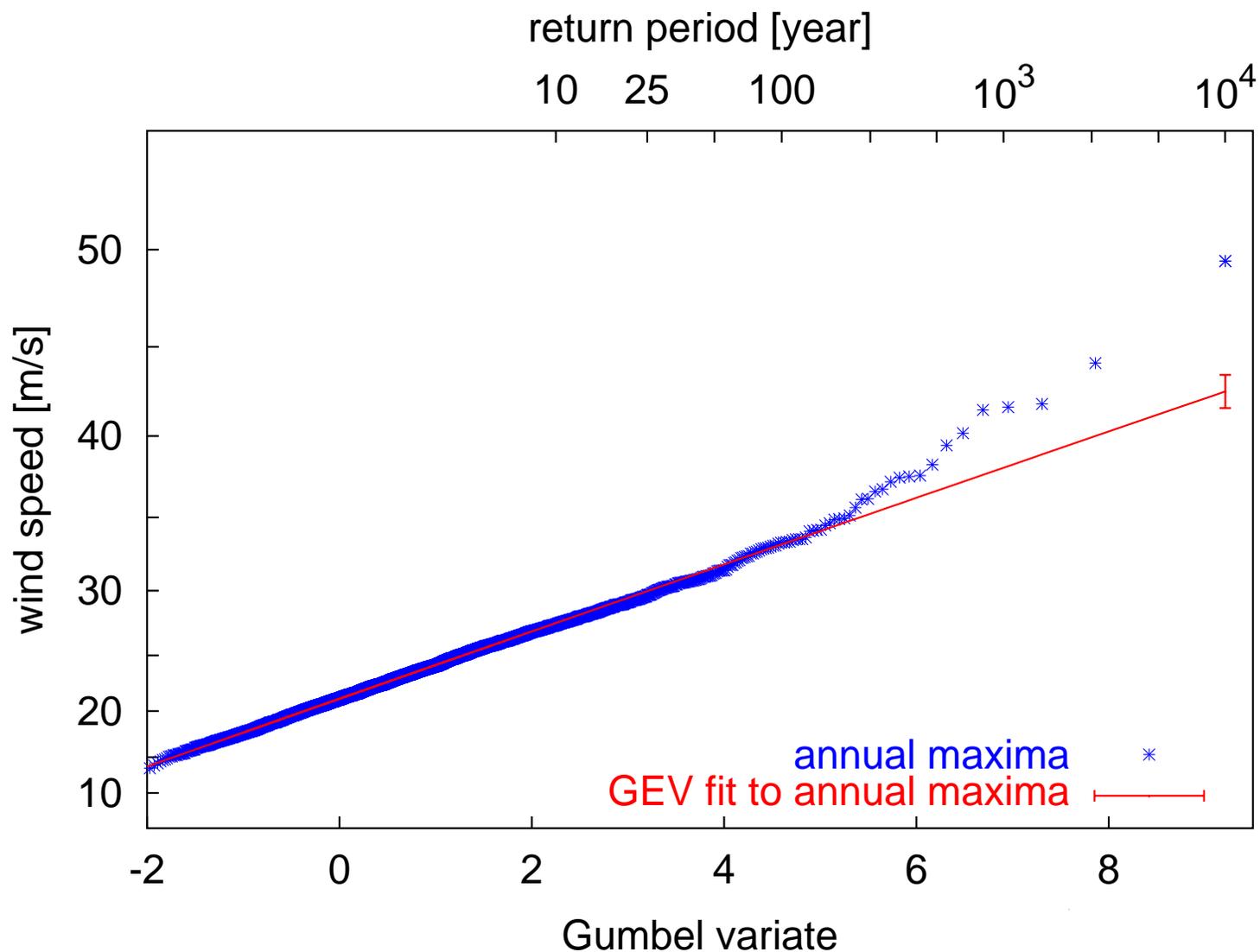
- records needed far longer than return period of point 'C'
- use 'synthetic' data \Rightarrow climate runs!

....

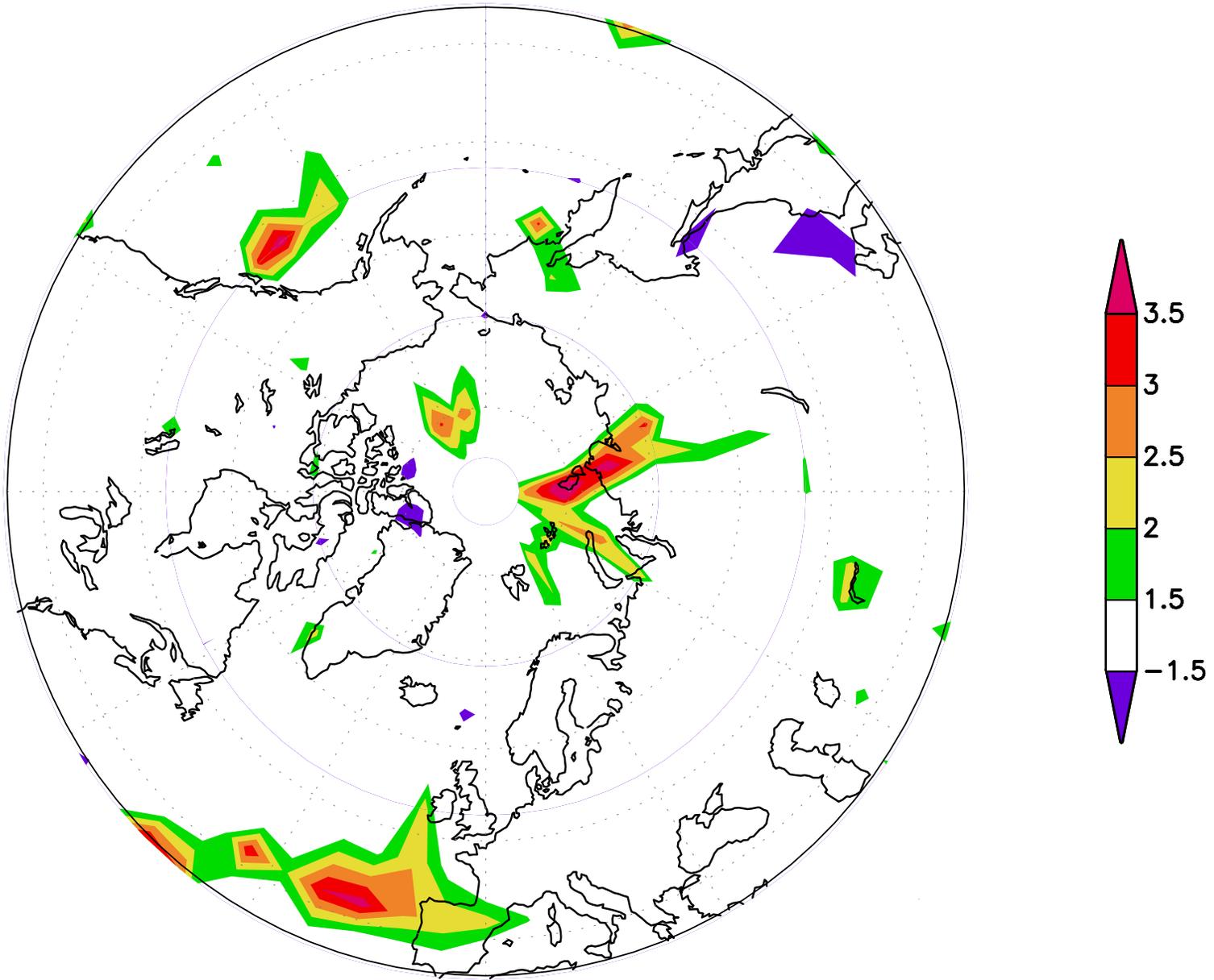
Results for KNMI-model Ecbilt-Clio



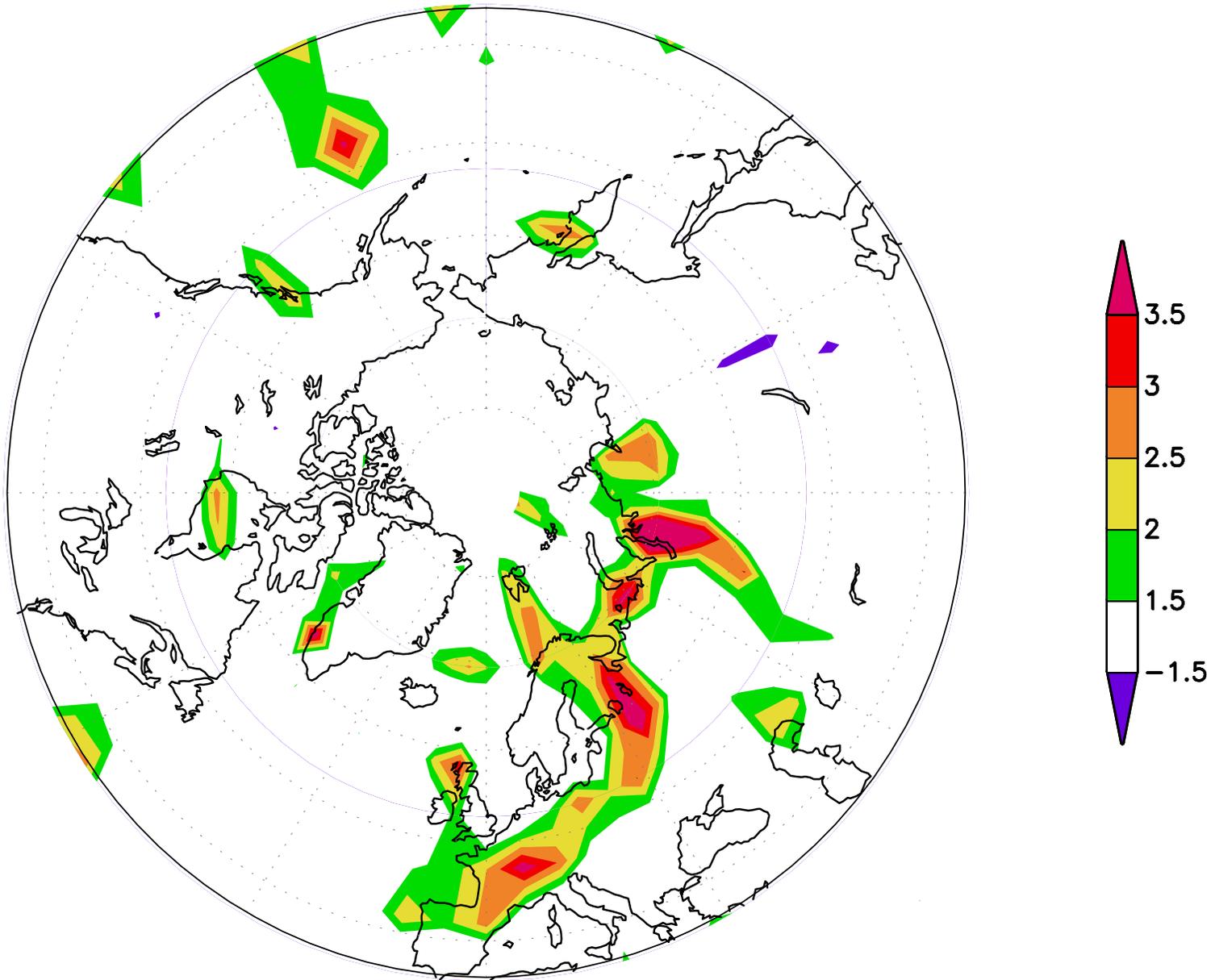
.... **For another grid point:**



.... **location of Superstorms:**



.... and in 2C02 climate:

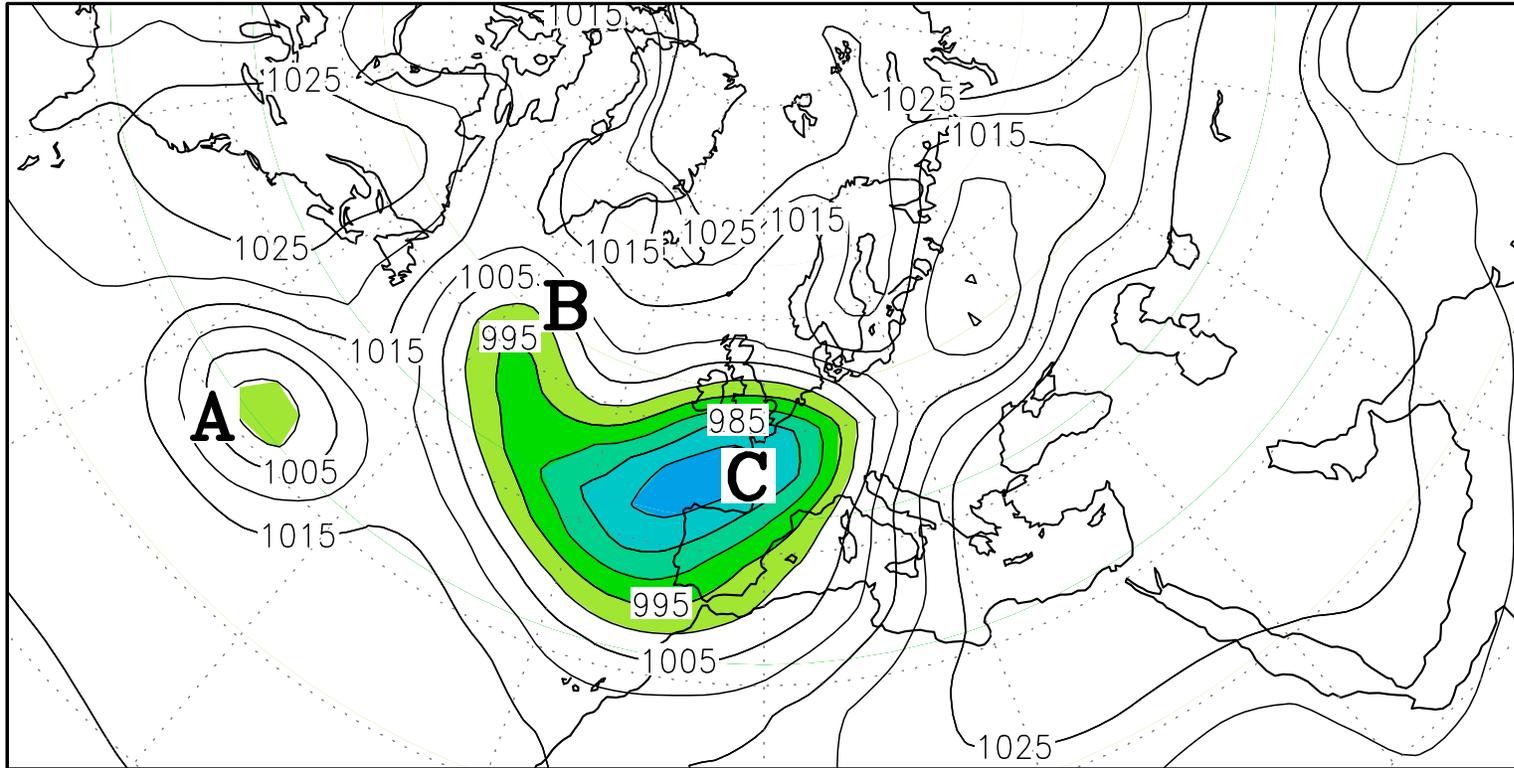


.... **Meteorological conditions for superstorms:**

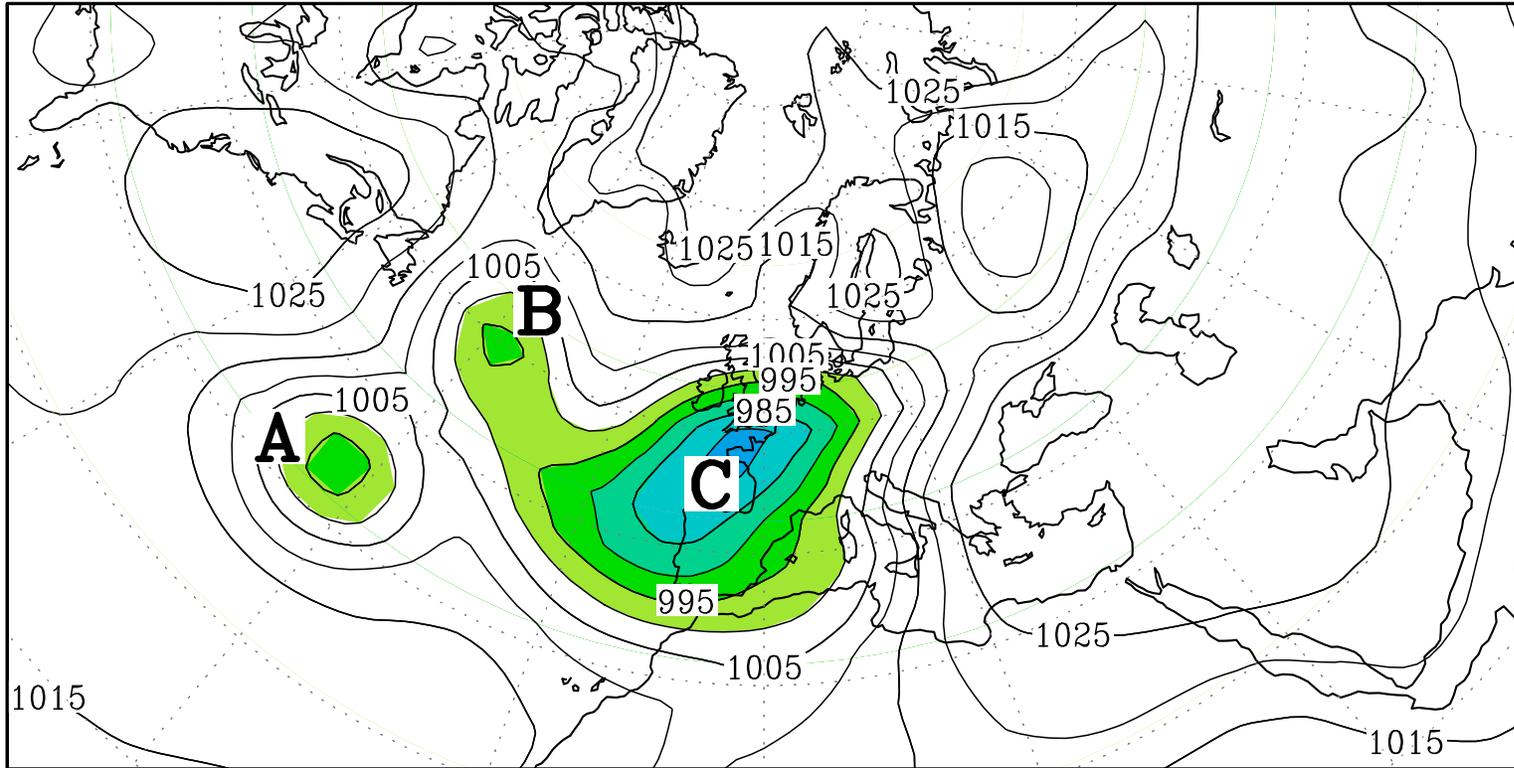
- 'Merging' of two storms
- Strong jetstream
- Extreme precipitation

NO TROPICAL CYCLONES!

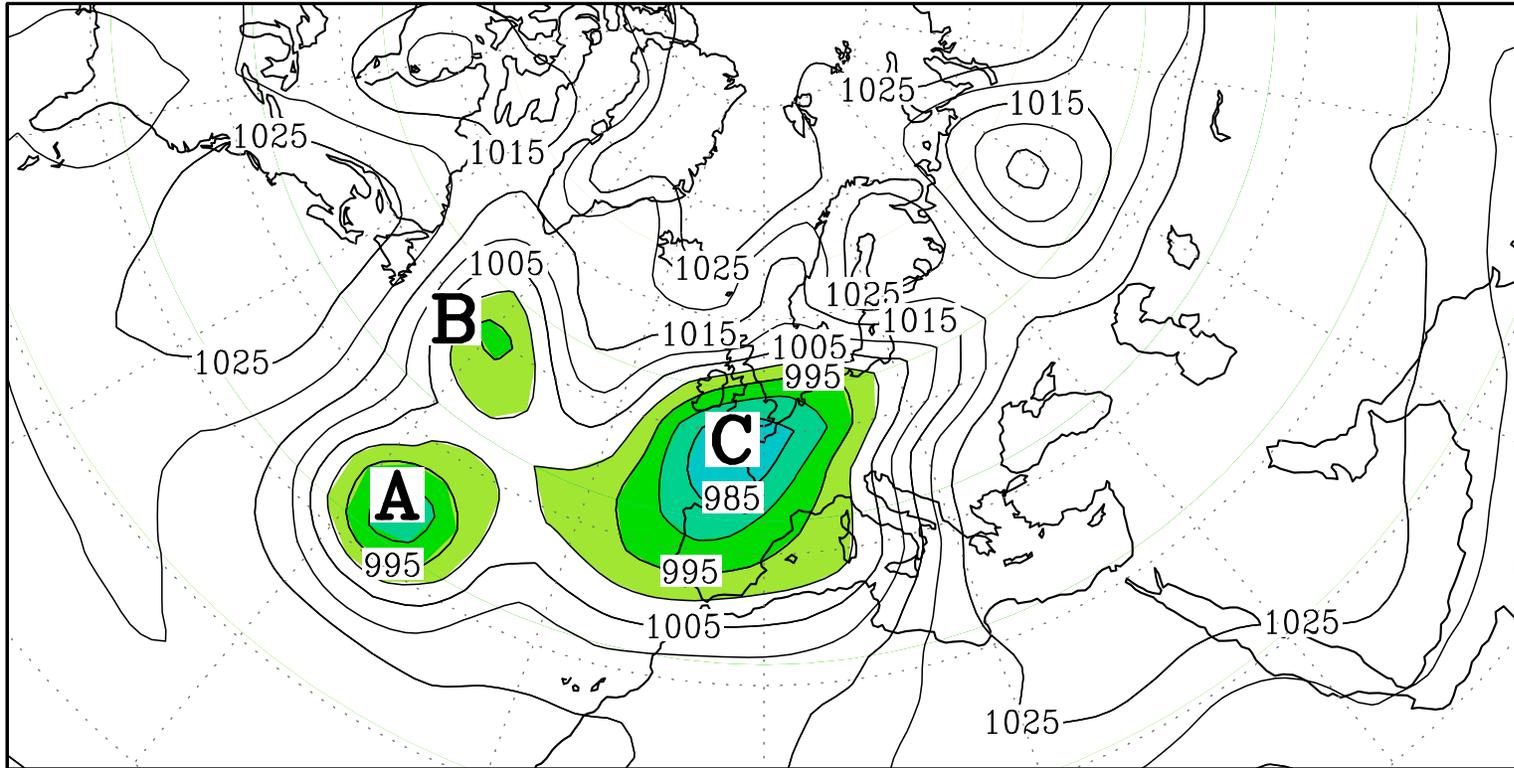
.... **pressure at sea level [mbar]**



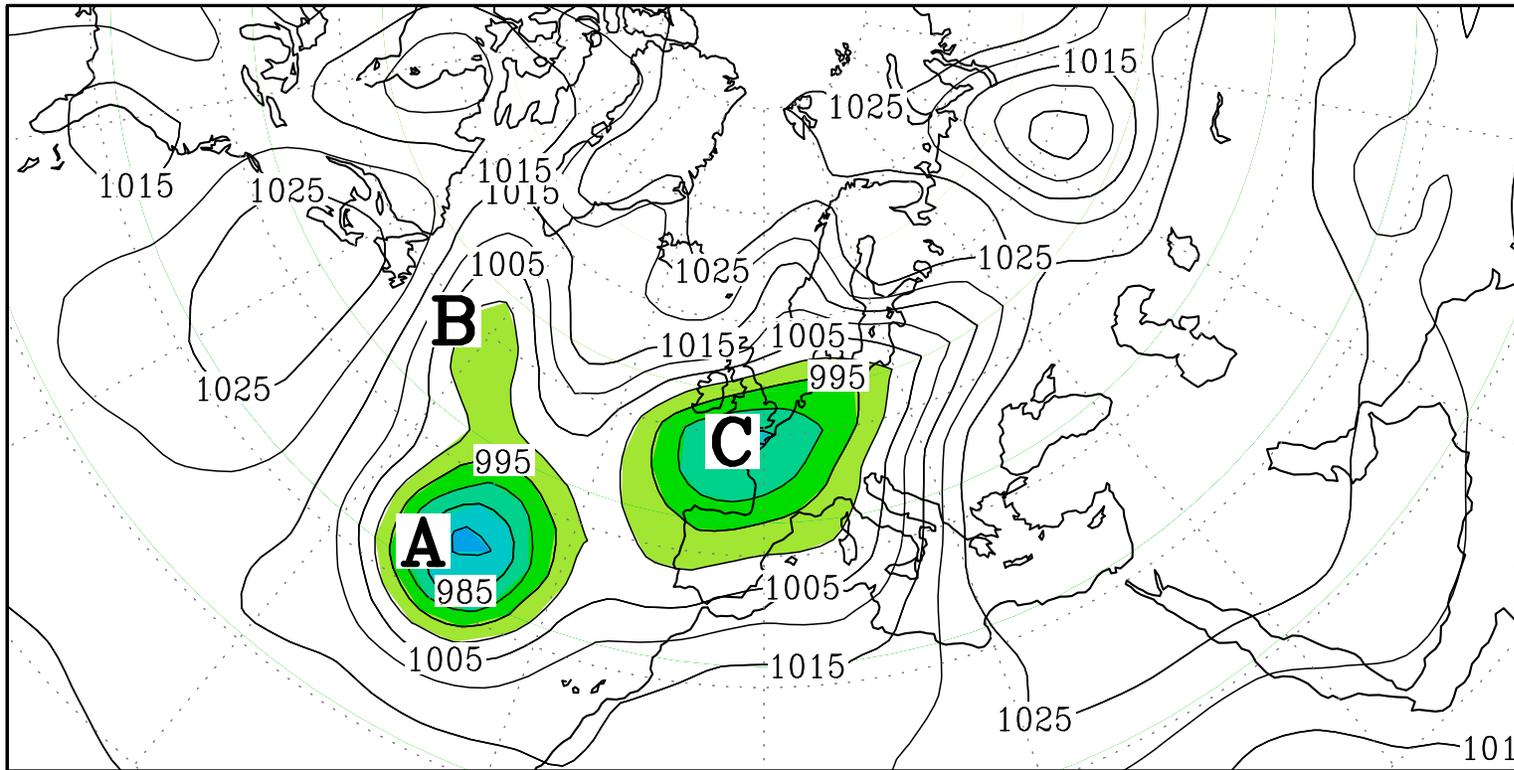
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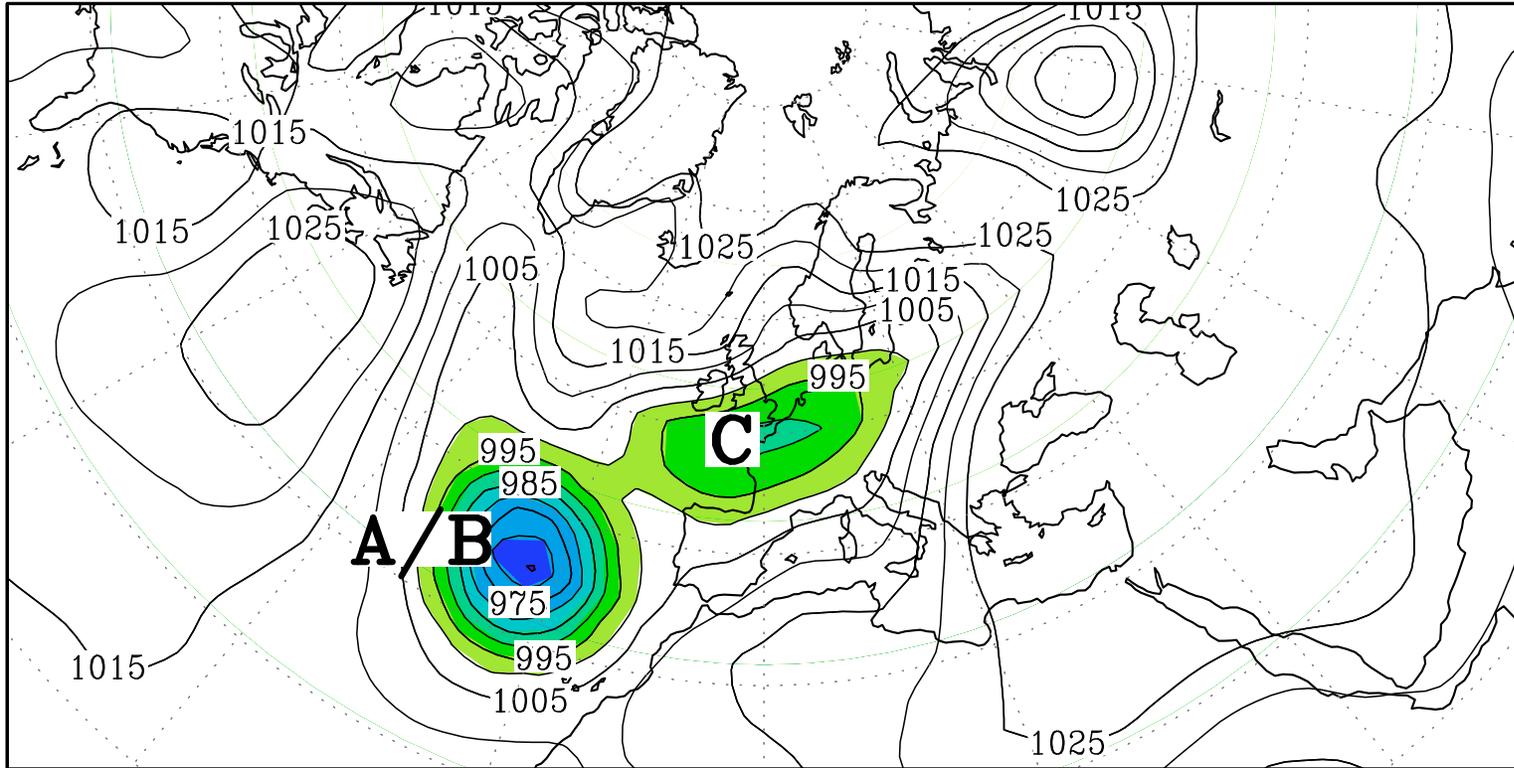
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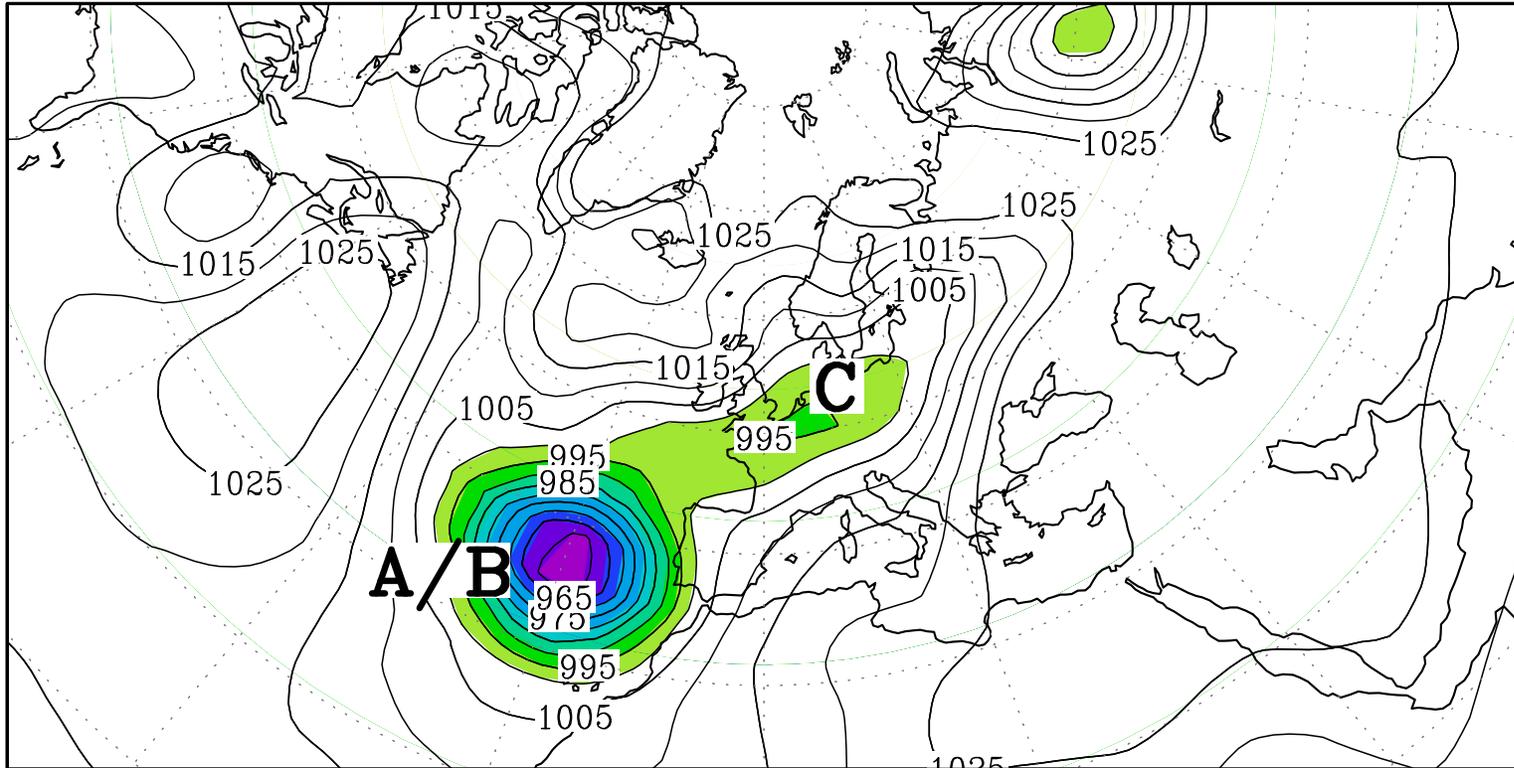
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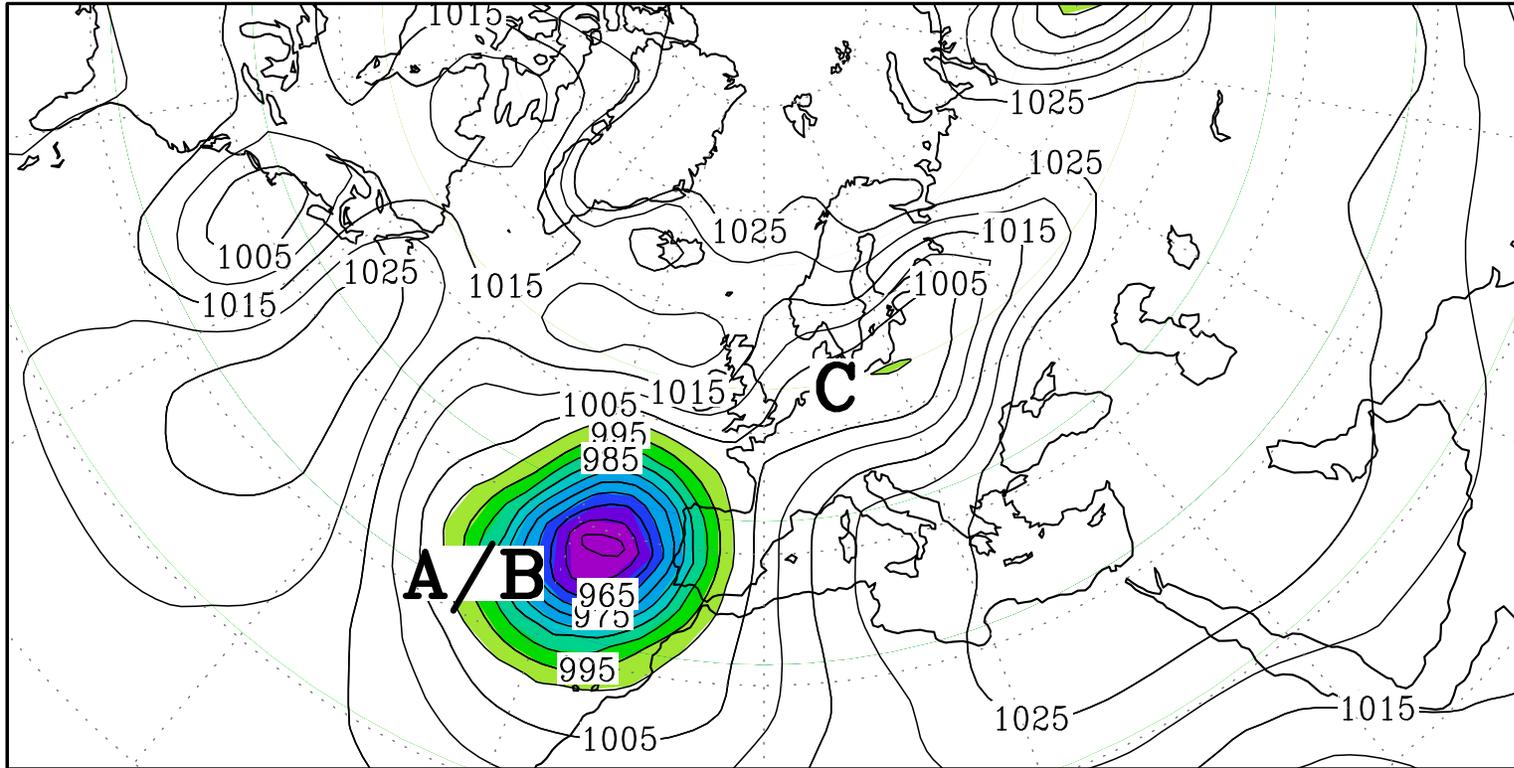
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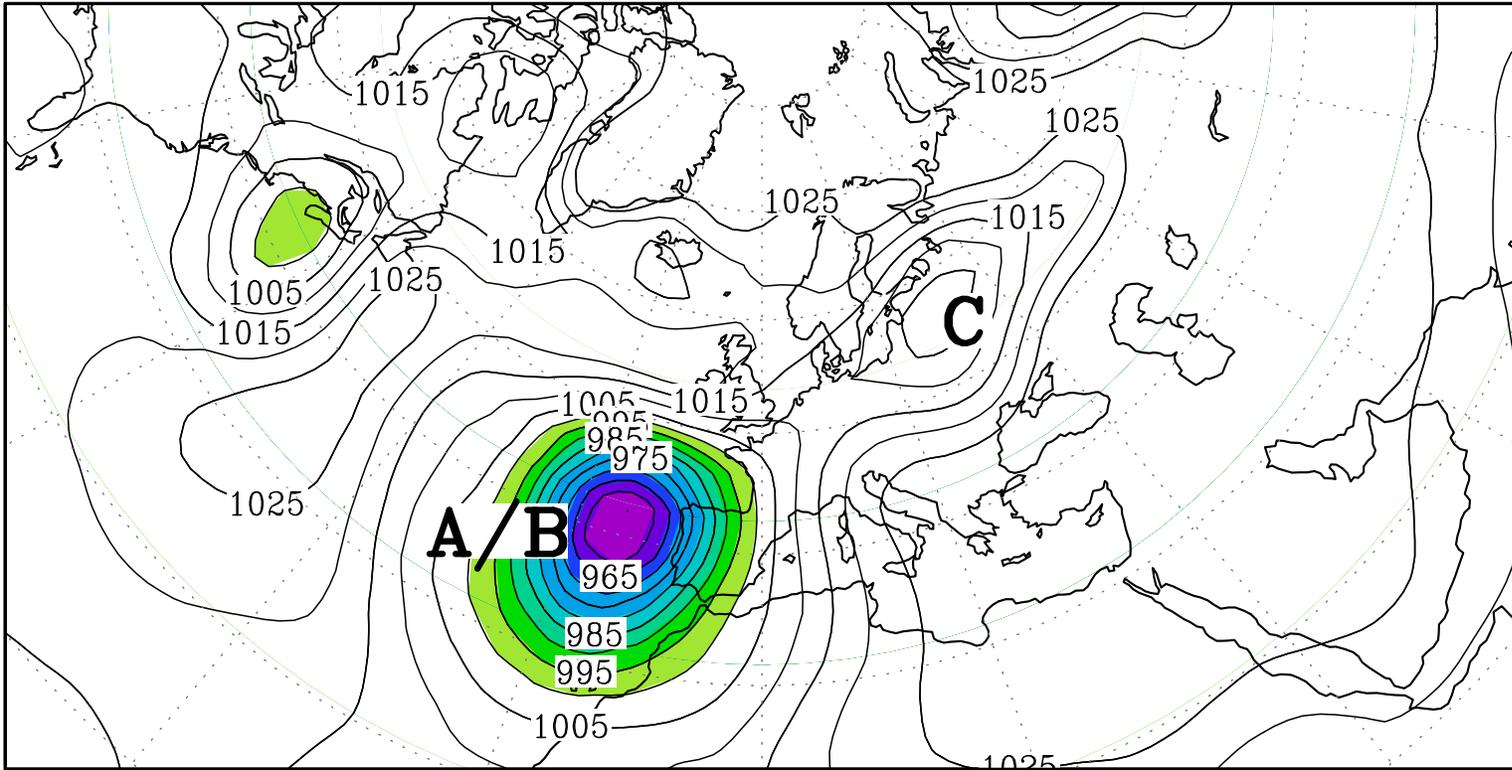
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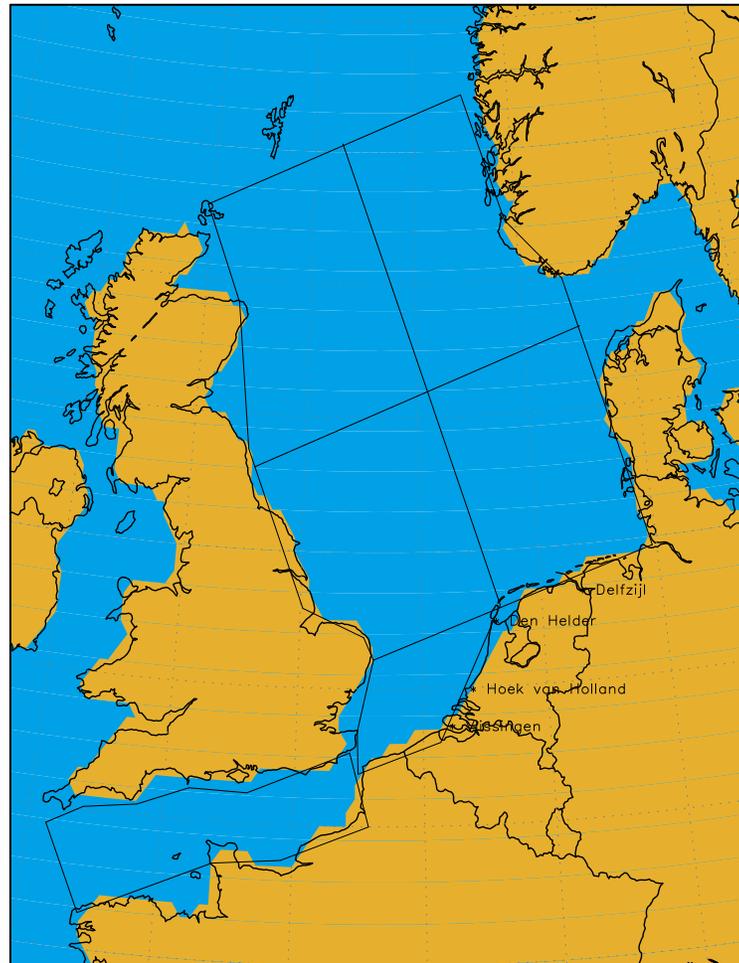


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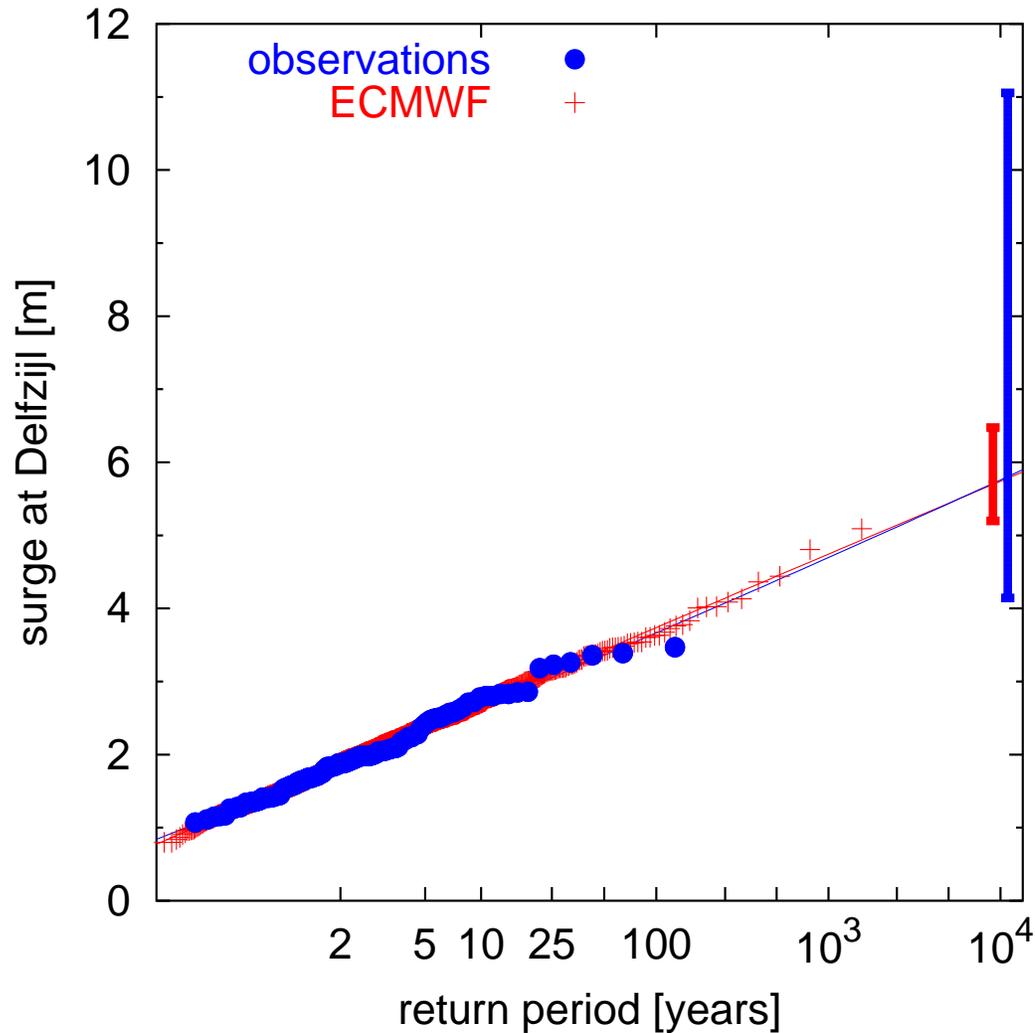


.... **Back to surges: "Timmerman" model:**

$$\text{Surge} \approx \gamma C_d u^2 \sin(\phi - \beta) + \frac{\Delta p}{\rho g}$$

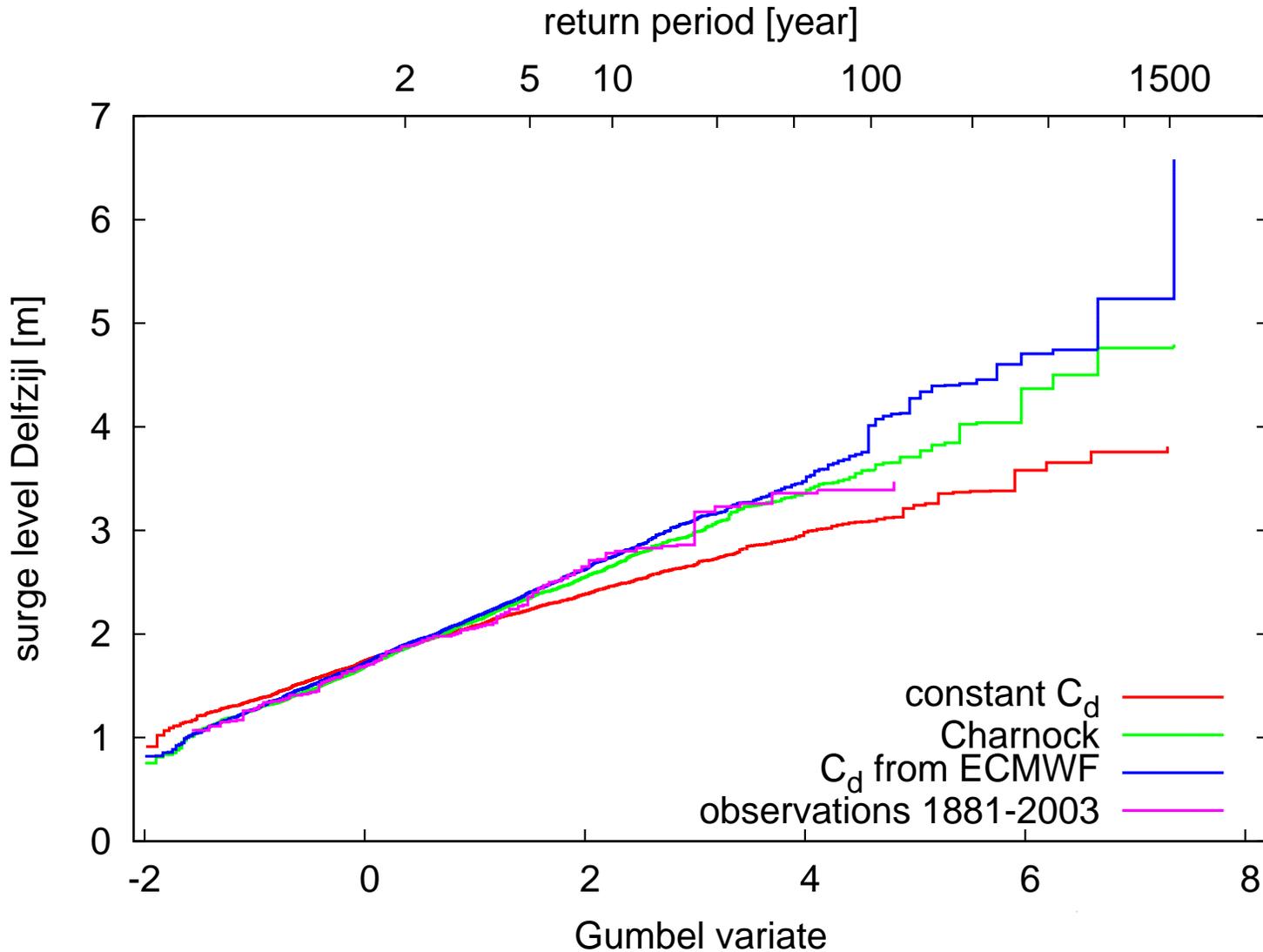


.... **1500 'years' of ECMWF seasonal forecasts:**



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Influence of drag coefficient:

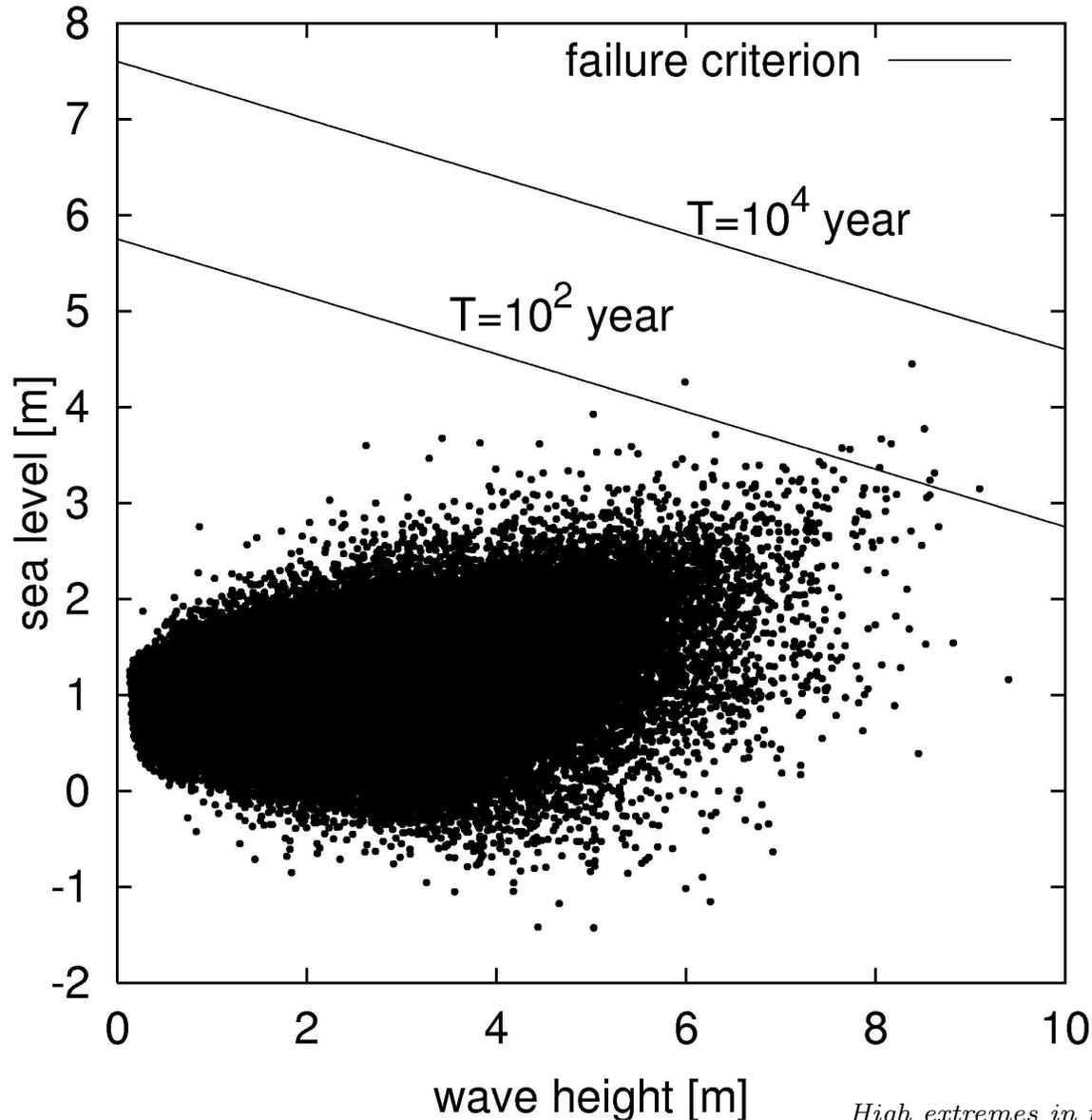


.... **Pettemer seadike:**

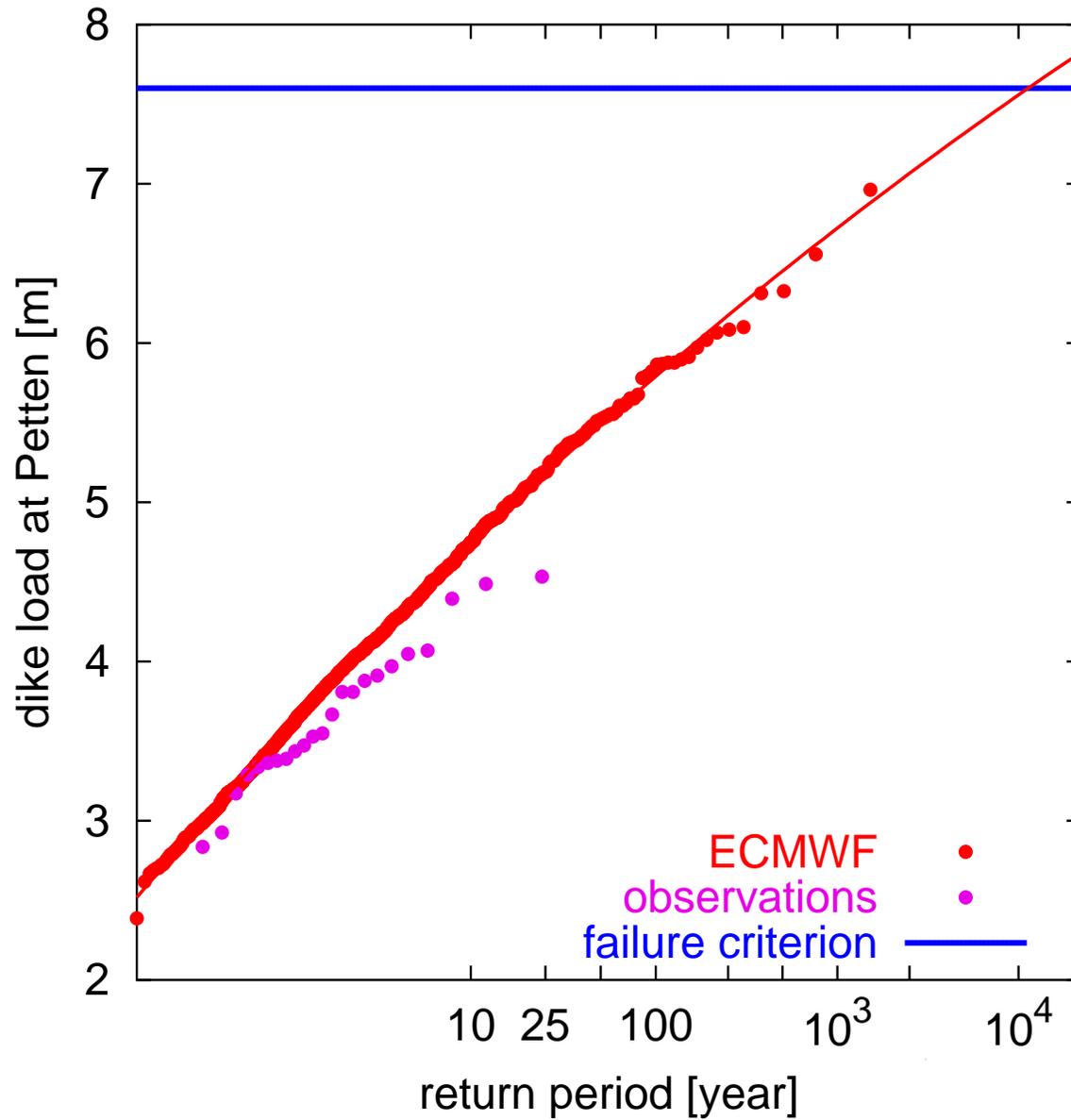


.... **Pettemer seadike:**

Dike fails if: dike load $\equiv L_P + 0.3 H > 7.6$ [m]



.... **Gumbel plot of dike load:**



.... **Summary:**

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- De Haan in 1990:
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- now:
 - Fighting the arch-enemy with mathematics....
 -and climate models!



Questions...?