Norwegian Meteorological Institute met.no

Climate variability & extremes

R.E. Benestad

'Insuring Future Climate Change', Nov. 3, 2008, Norway

The drift

GCM = Global Climate Model
ESD=Empirical-Statistical Downscaling
RCM=Regional Climate Model

- **Definitions:**
  - **Climate & Extremes**
- **Key uncertainties:**

  i) Model

  GCM - RCMs

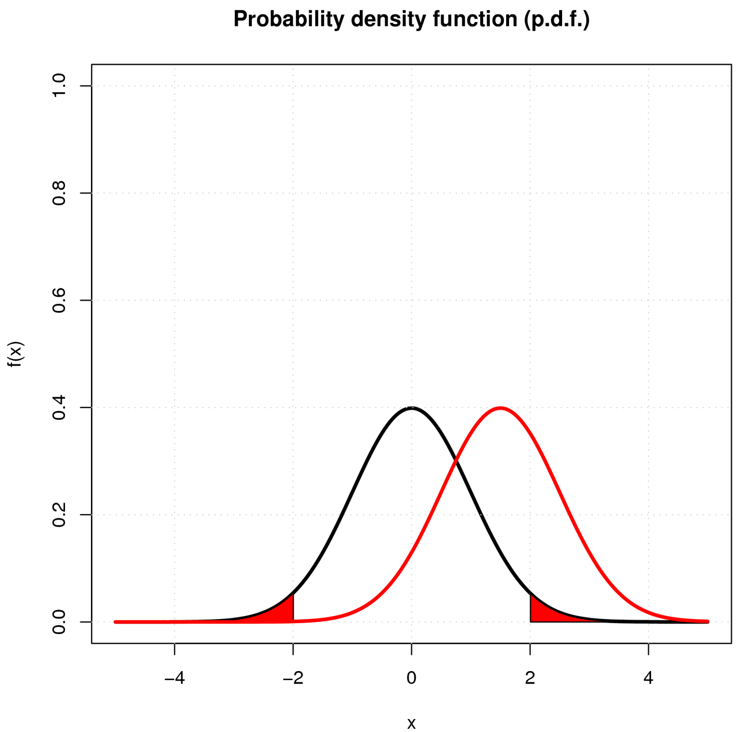
  GCM - ESD

  ii) Methodological
- **Future projections**

Definitions

- Climate = typical weather pattern
  - Expected range & frequency of variability
  - historical/empirical know how
  - Statistical representation: The *pdf*
- Extremes = rare events
  - Usually near the boundary of the variability range
  - Often low or high values
- *Climate change = pdf changes over time.*

IPCC AR4:
"**Extreme weather event** An extreme weather event is an event that is **rare at a particular place** and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season)."



Extremes

- **Types**
  - Precipitation
  - Wind/storms
  - Temperature
  - Phenomena:
    - lightning, hail, tornadoes
  - Complex

Extremes: uncertainties Data

- **Small statistical sample (rare)**
- **Spatial scale**
  - Very local events often missed
    - Density of observational network
  - Large-scale events (droughts, floods)
    - One event of the kind
- **Violent**
  - Cut-off/instrument failure
  - Washed/blown away
- **Changes in environment/Infrastructure**
  - Water management
  - Coastal habitation

U.S. Floods 1993

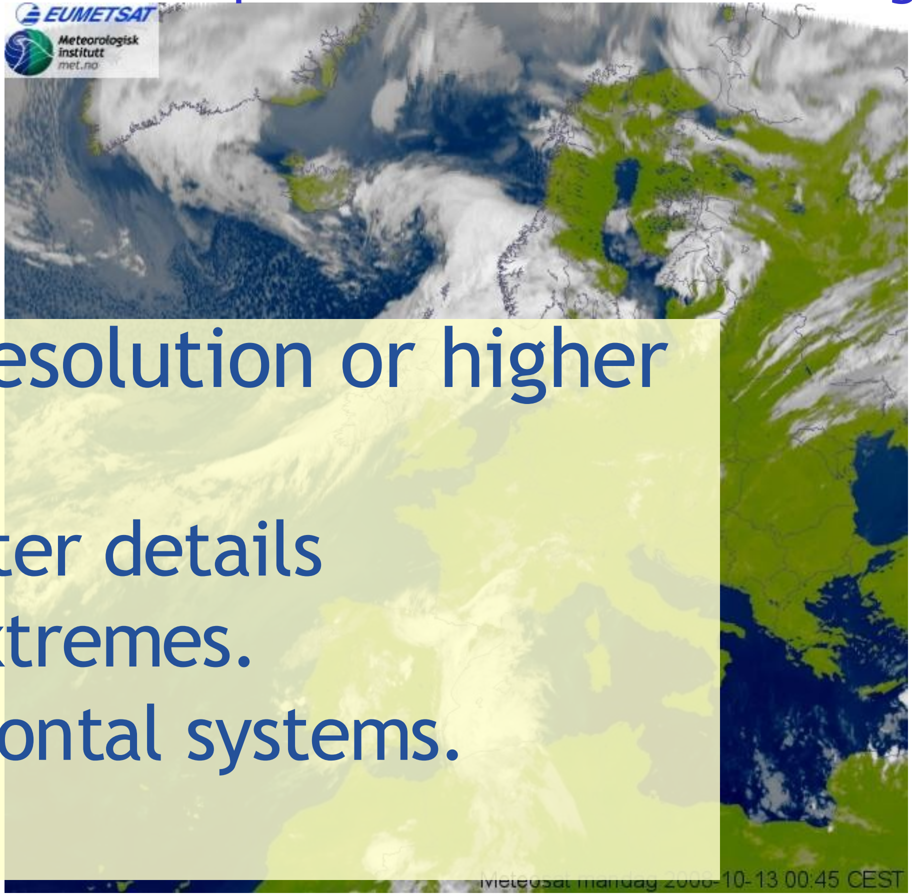
The Great Dust Bowl, 1935

Hurricane Katarina, 2005

Model limitations

- GCMs
  - distribution/transport
  - ~100-km-resolution (60ºN)
- RCMs & shortcomings
  - Spatial scale: ~ 50 km
  - Parameterisation
- ESD & shortcomings
  - Predict pdfs?

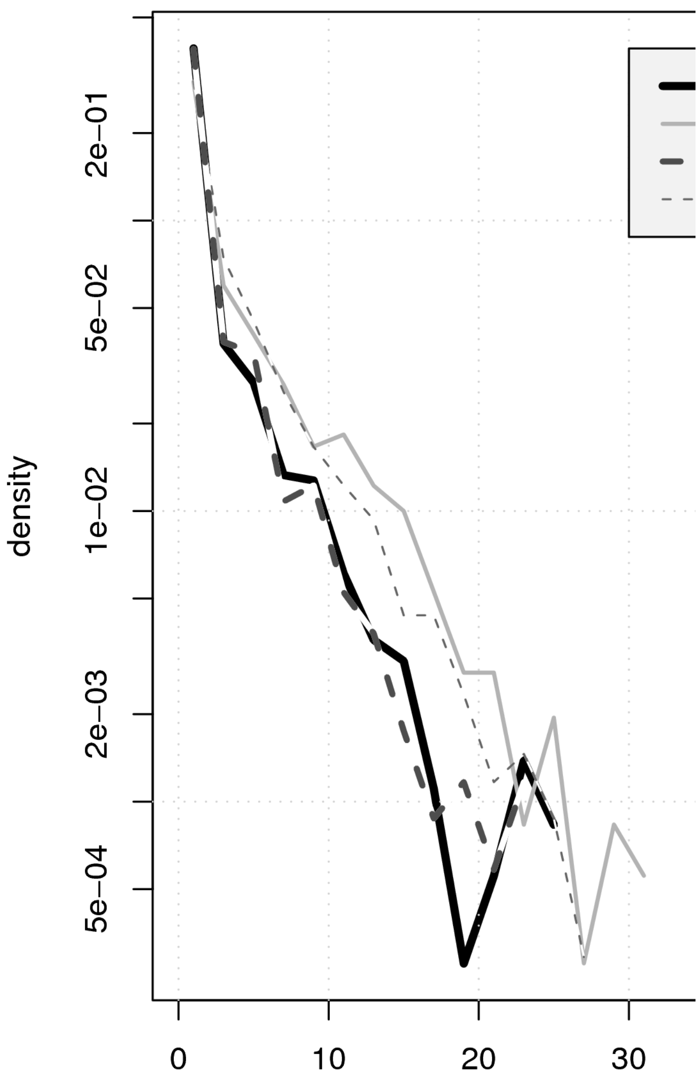
GCM = Global Climate Model
NWM=Numerical Weather Model
RCM=Regional Climate Model
ESD=Empirical-statistical downscaling

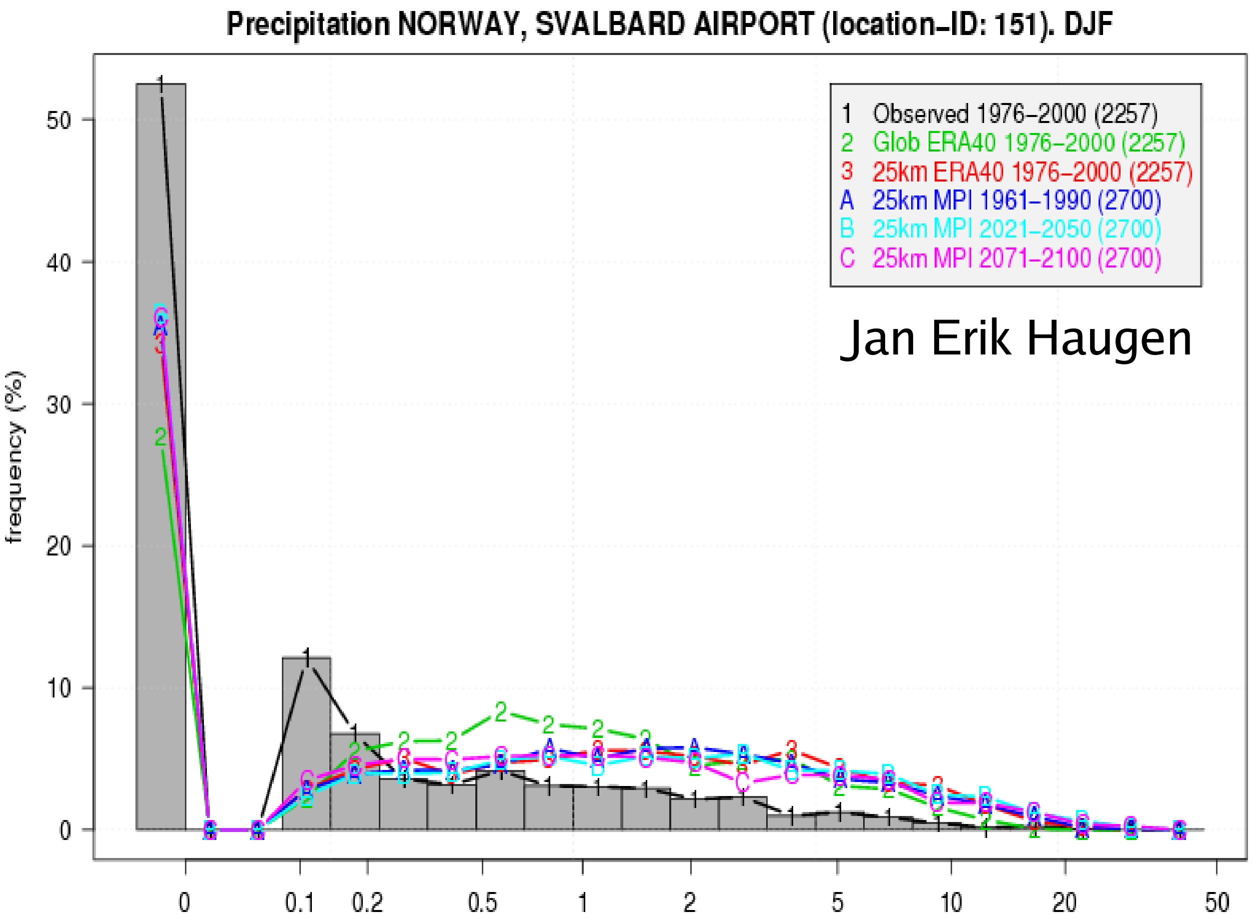


- Present NWMs: 20km resolution or higher
  - (down to 1km)
  - Higher resolution: better details
    - localized rainfall extremes.
  - Resolving storm and frontal systems.
- Models adequate?

Precipitation

OSLO – BLINDERN DJF precip &

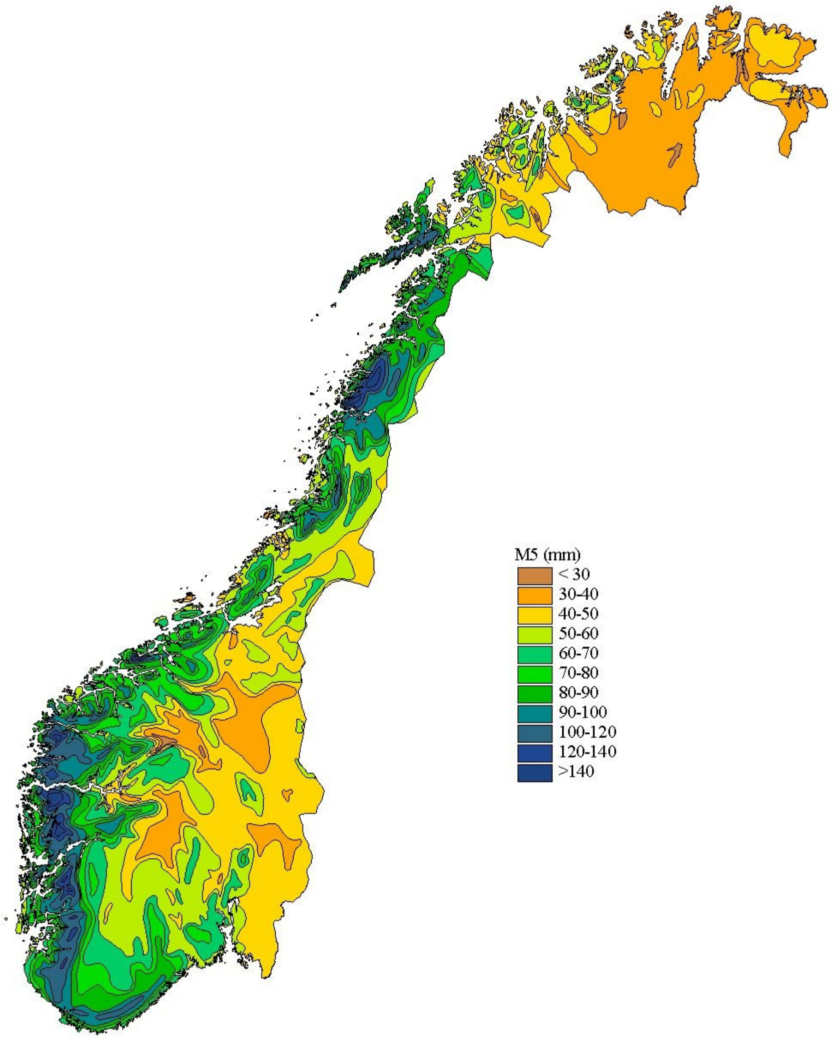


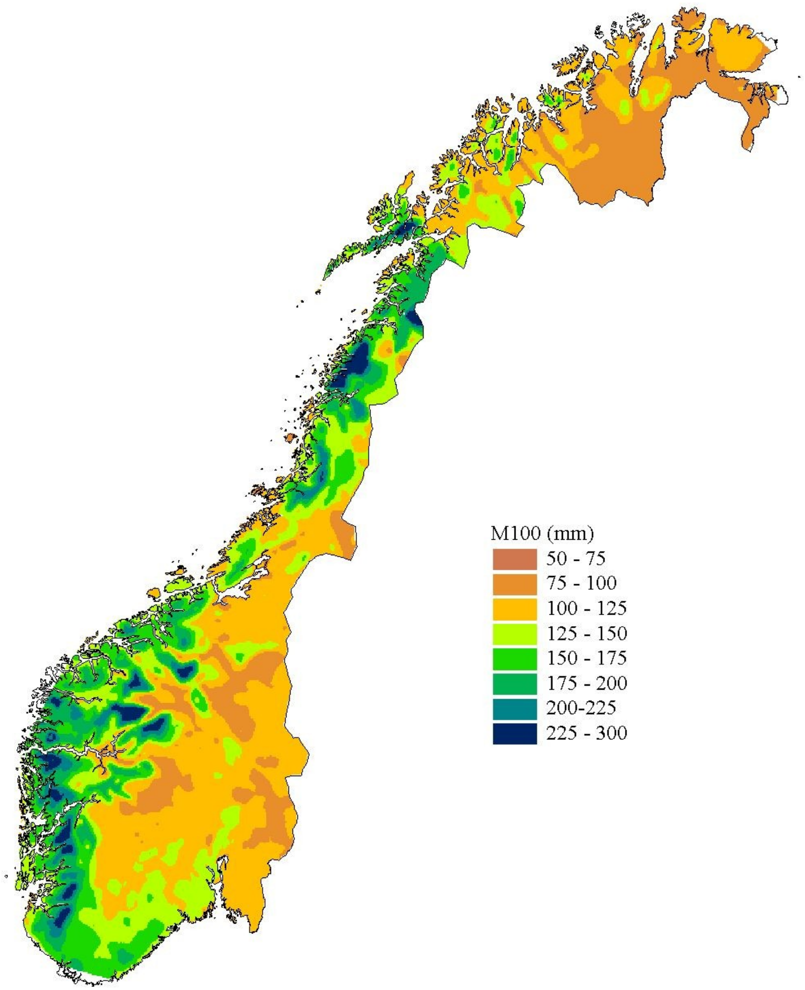


Precipitation (mm/day)

GCM=ECHAM5 (T63L32), RCM=HIRHAM (50km), period=1980−−99

Precipitation: historical patterns

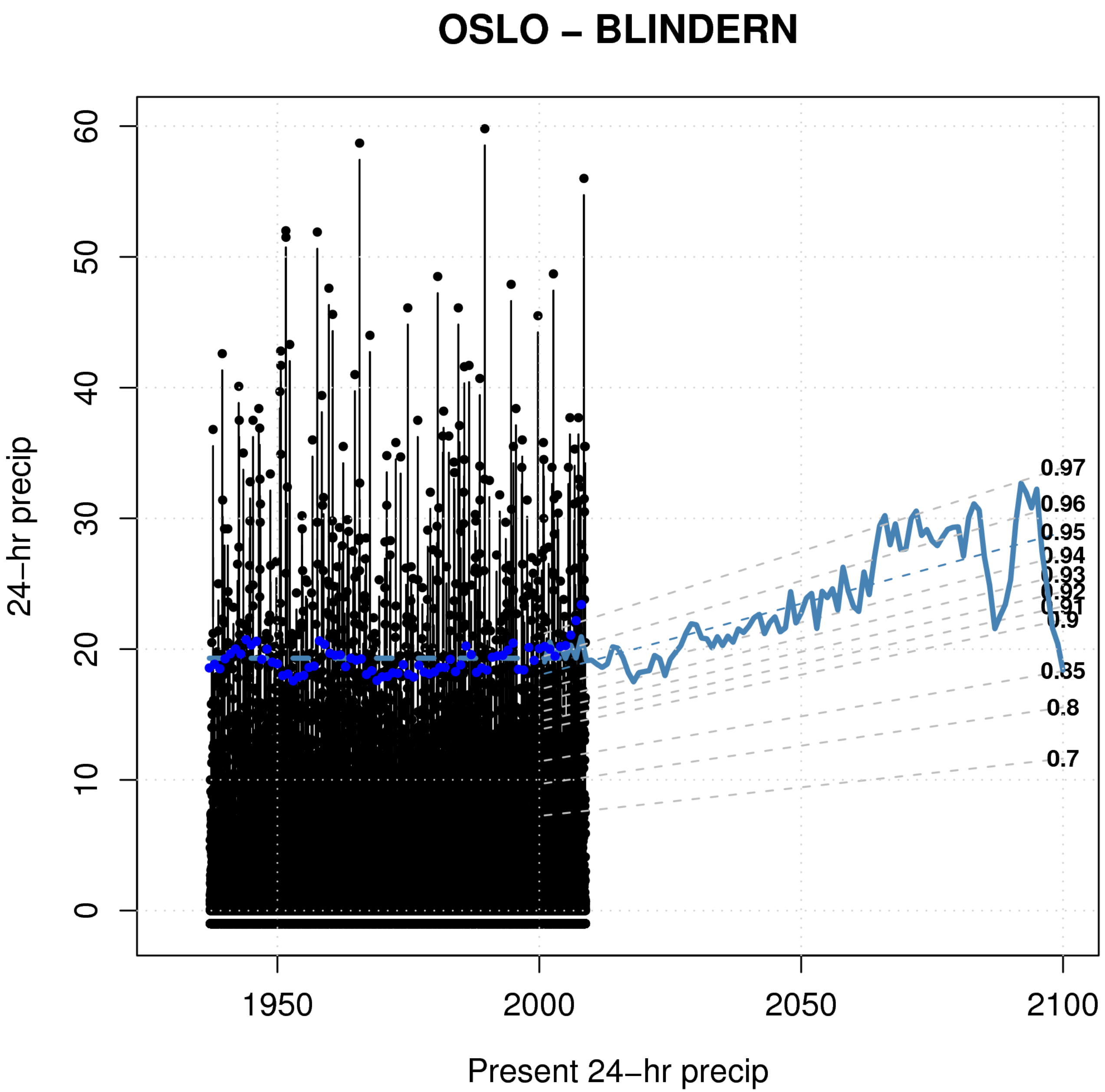


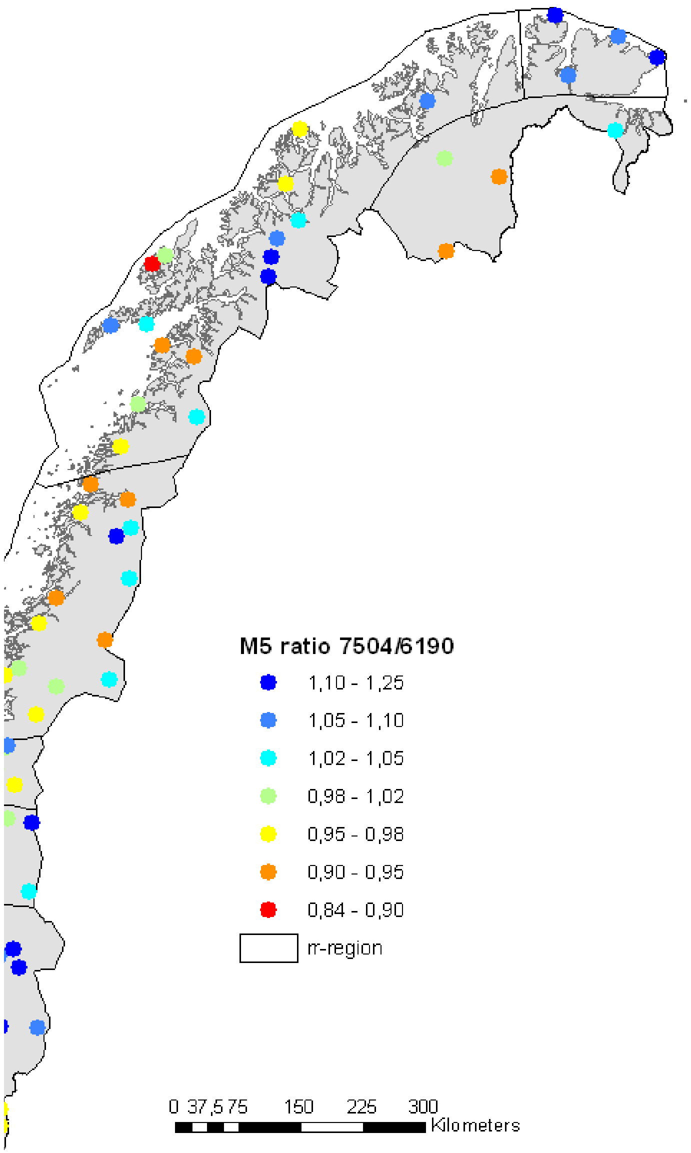


24-hour precip with return interval
of 5 yr (left) og 100 yr (right)

E.J. Førland

Precipitation





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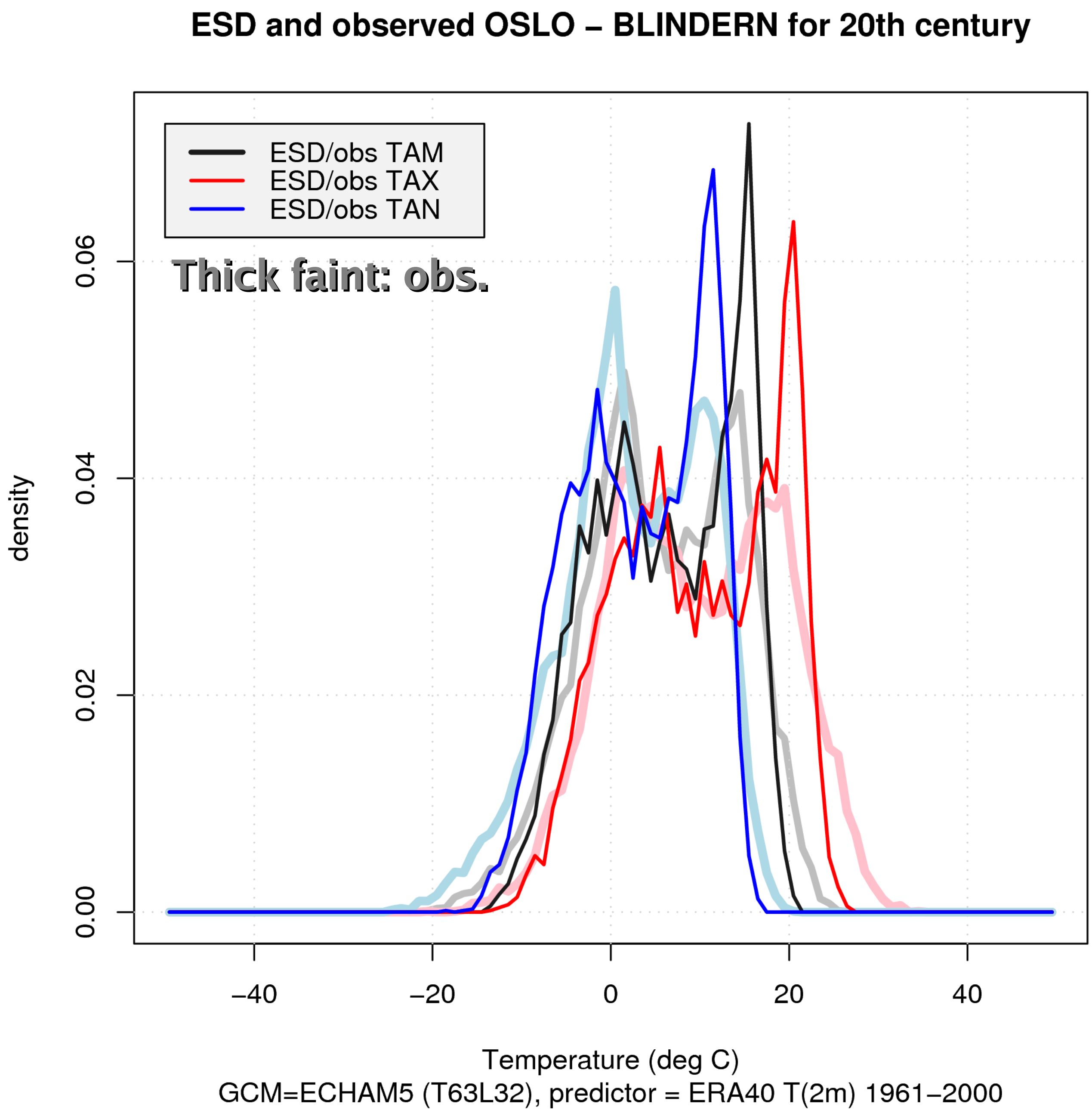
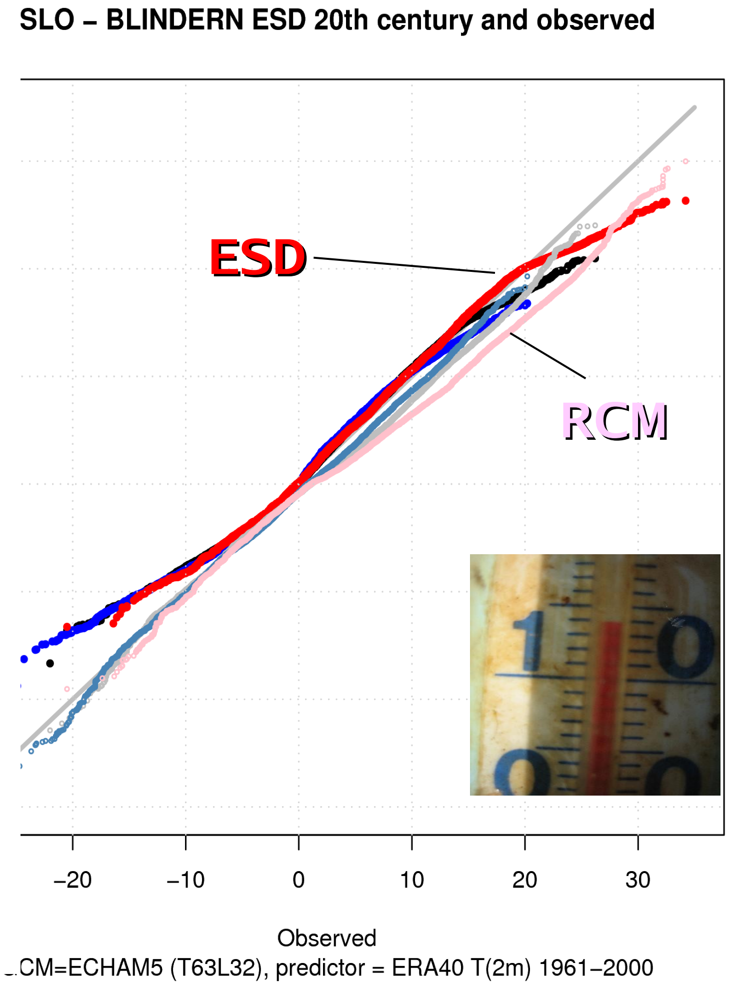
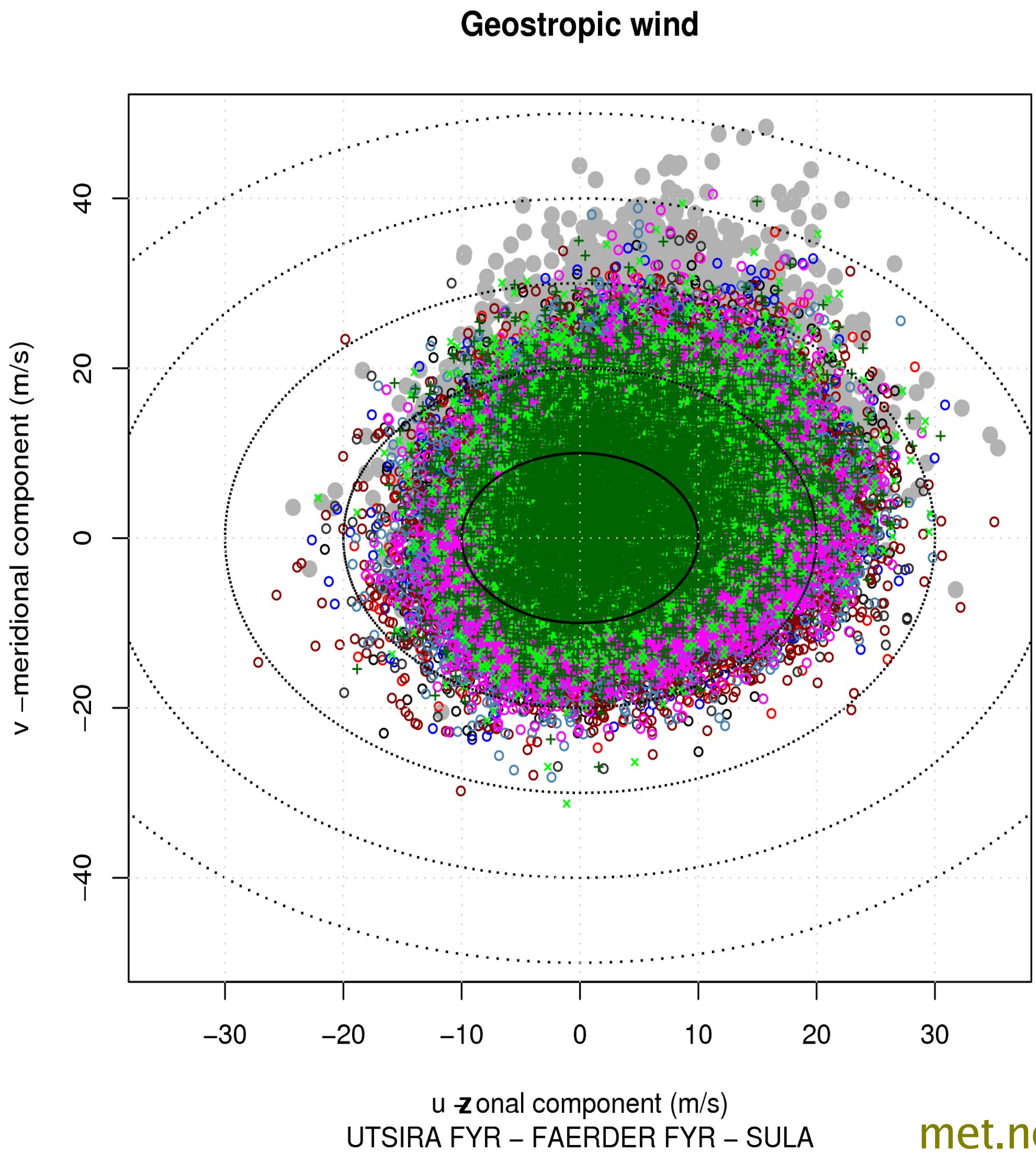
T(2m): mean, max, min

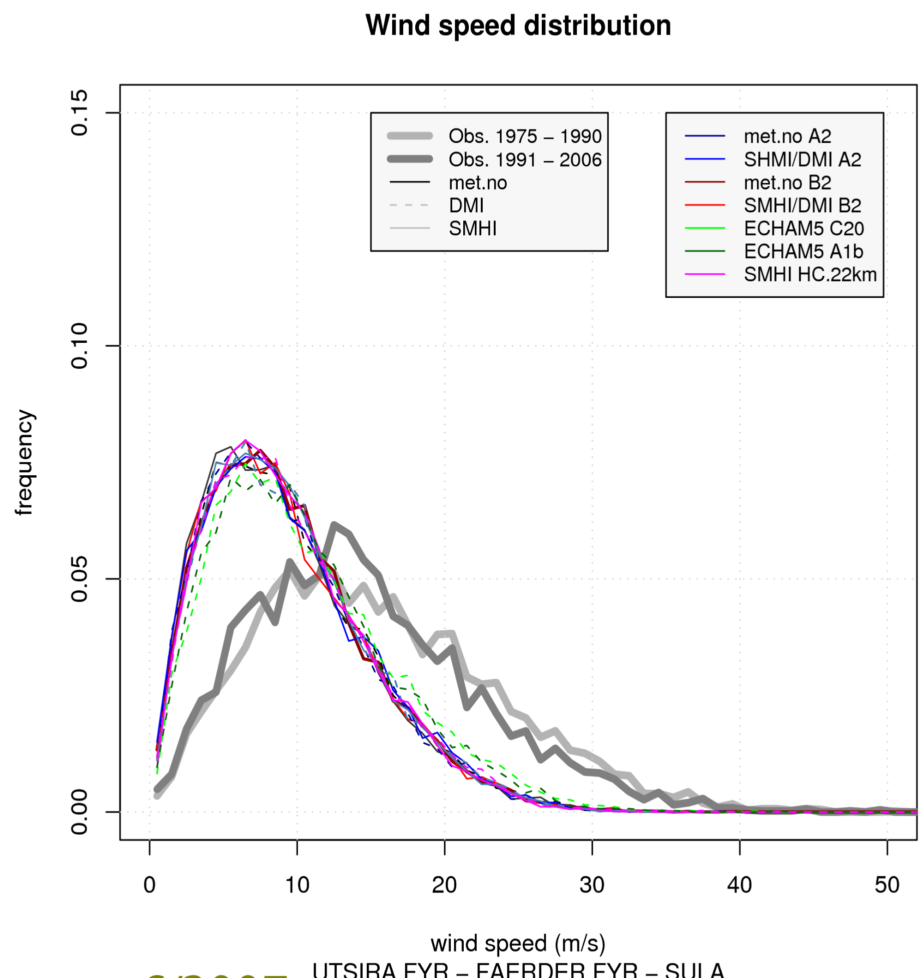
met.no report 9/2007





Wind speed





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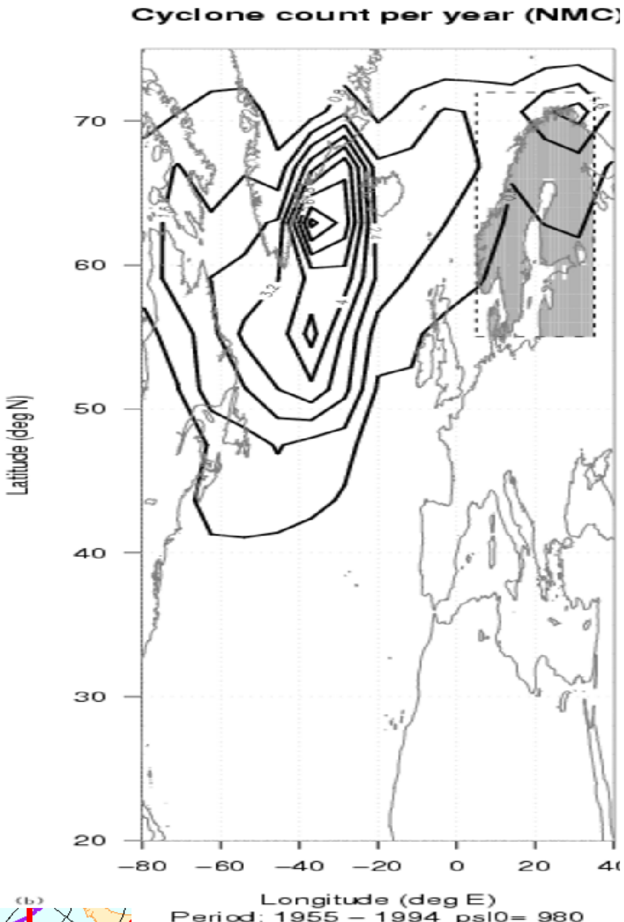

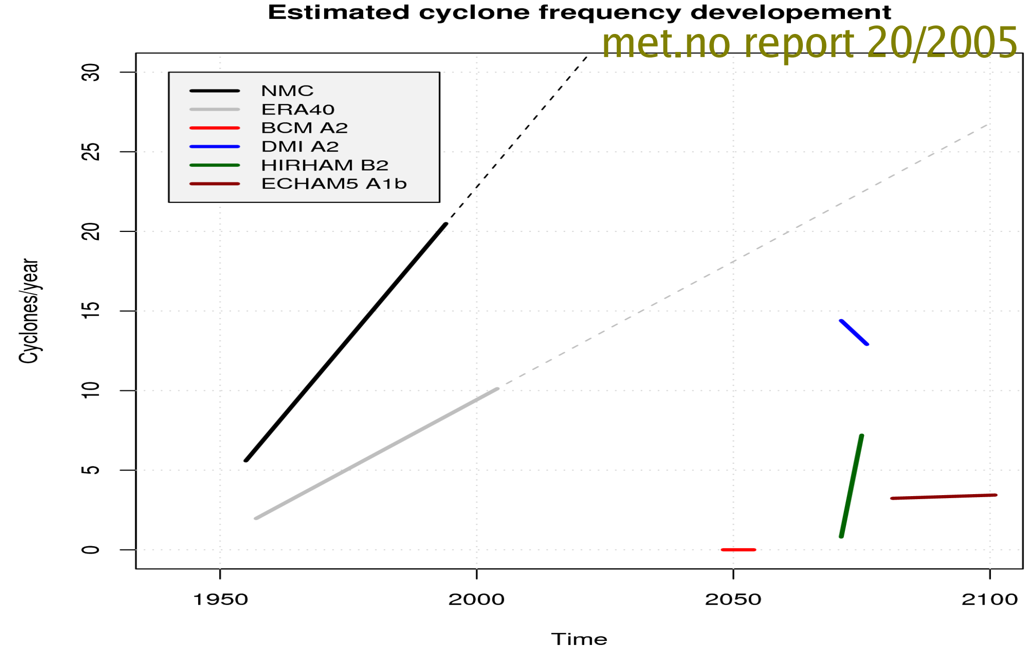

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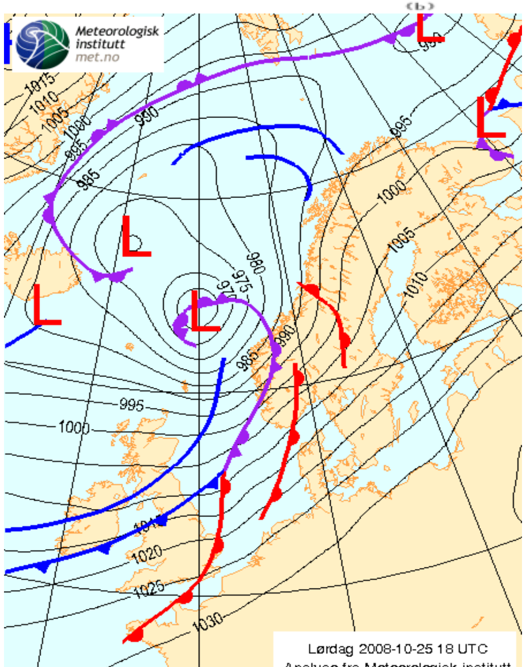
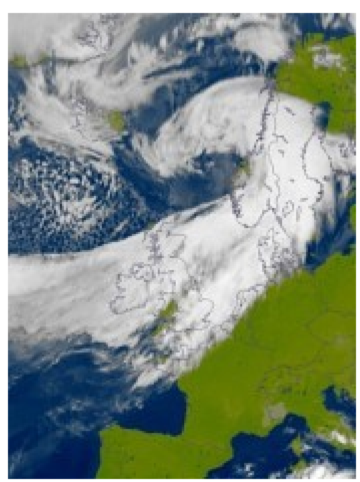
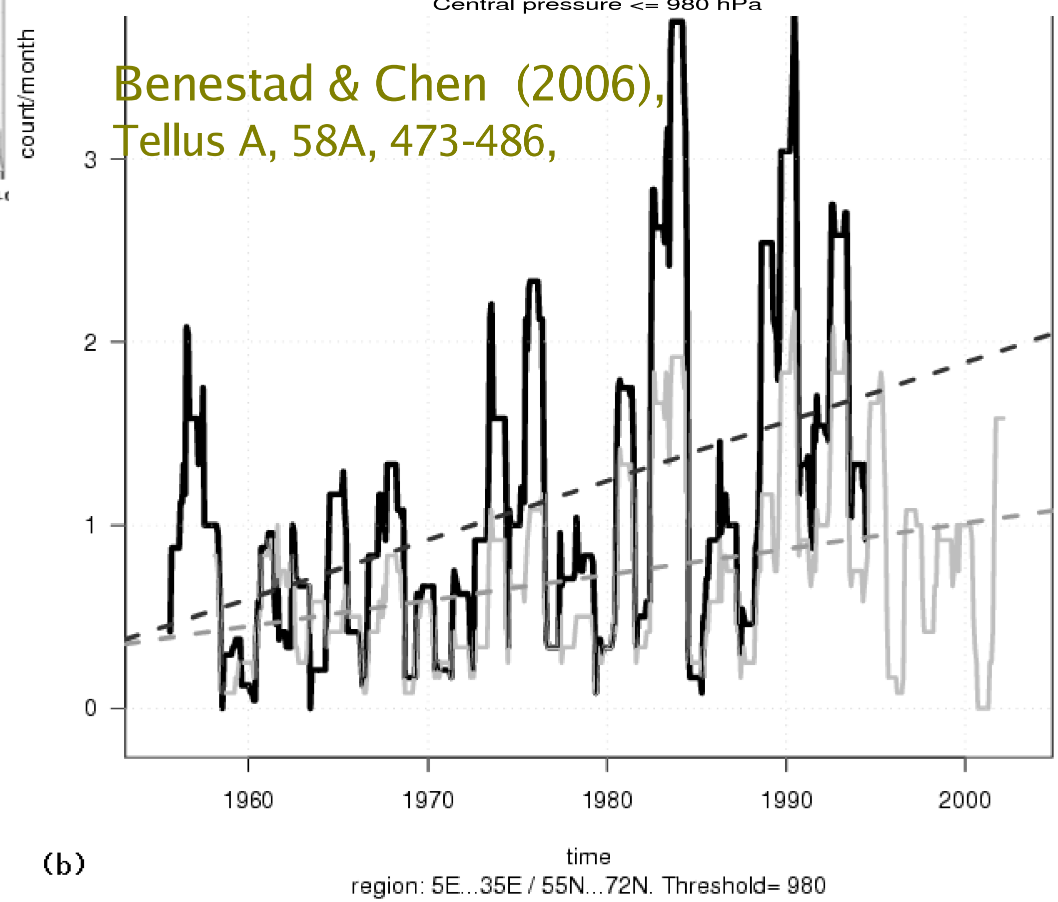


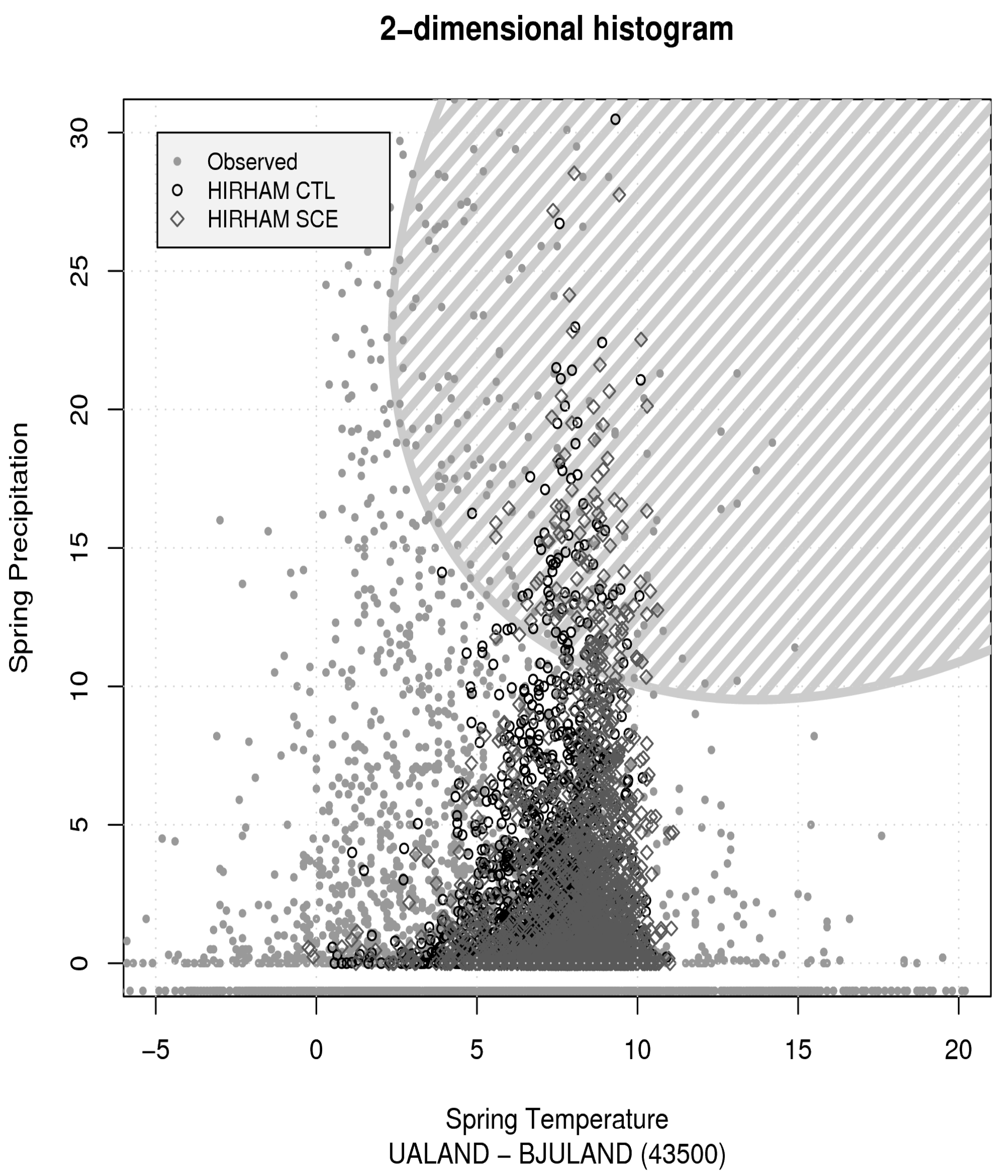


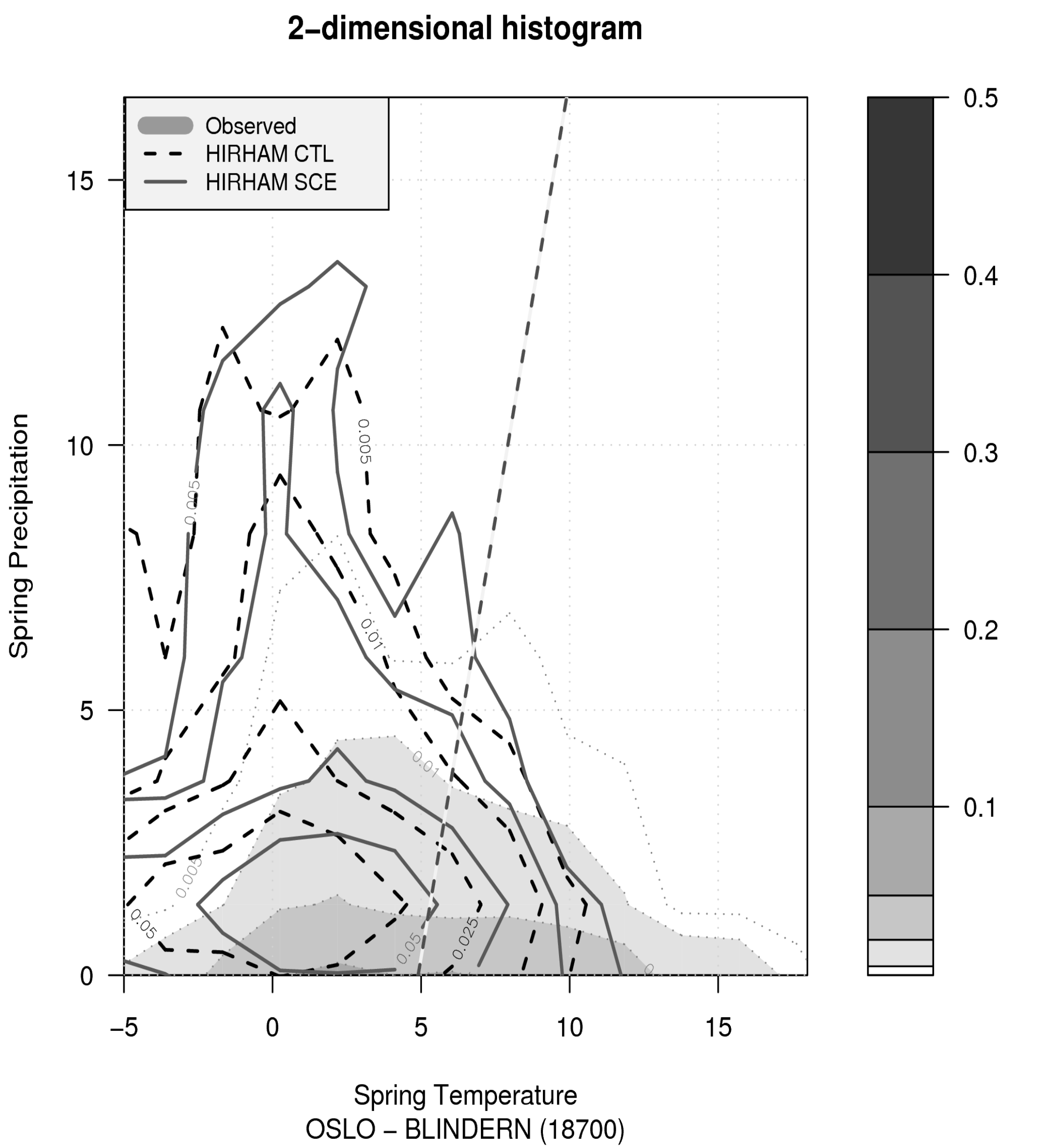


Benestad & Chen (2006),
Tellus A, 58A, 473-486,

Complex extremes

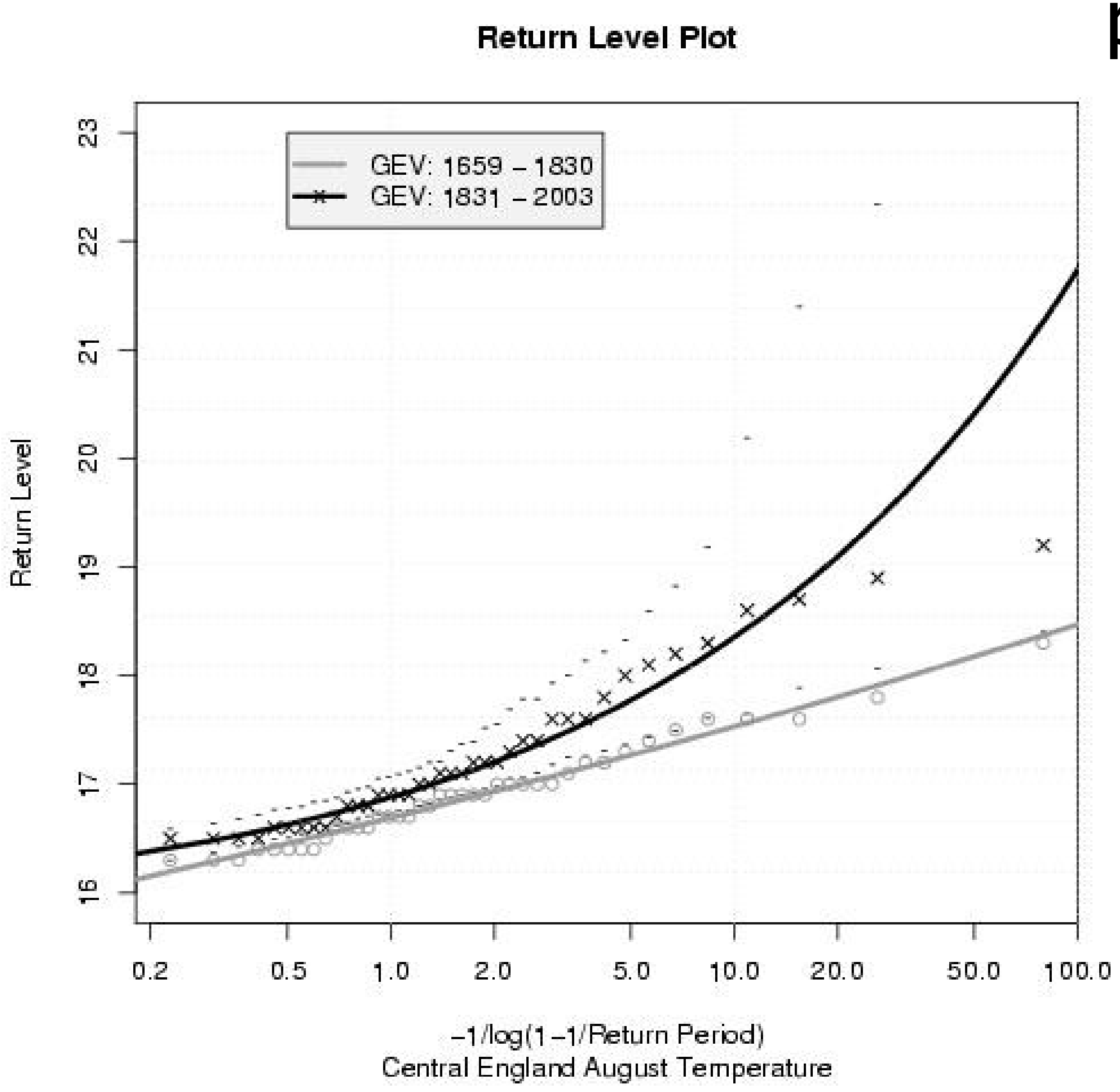
Benestad & Haugen (2007),
Clim. Change, vol 85, p. 381-406





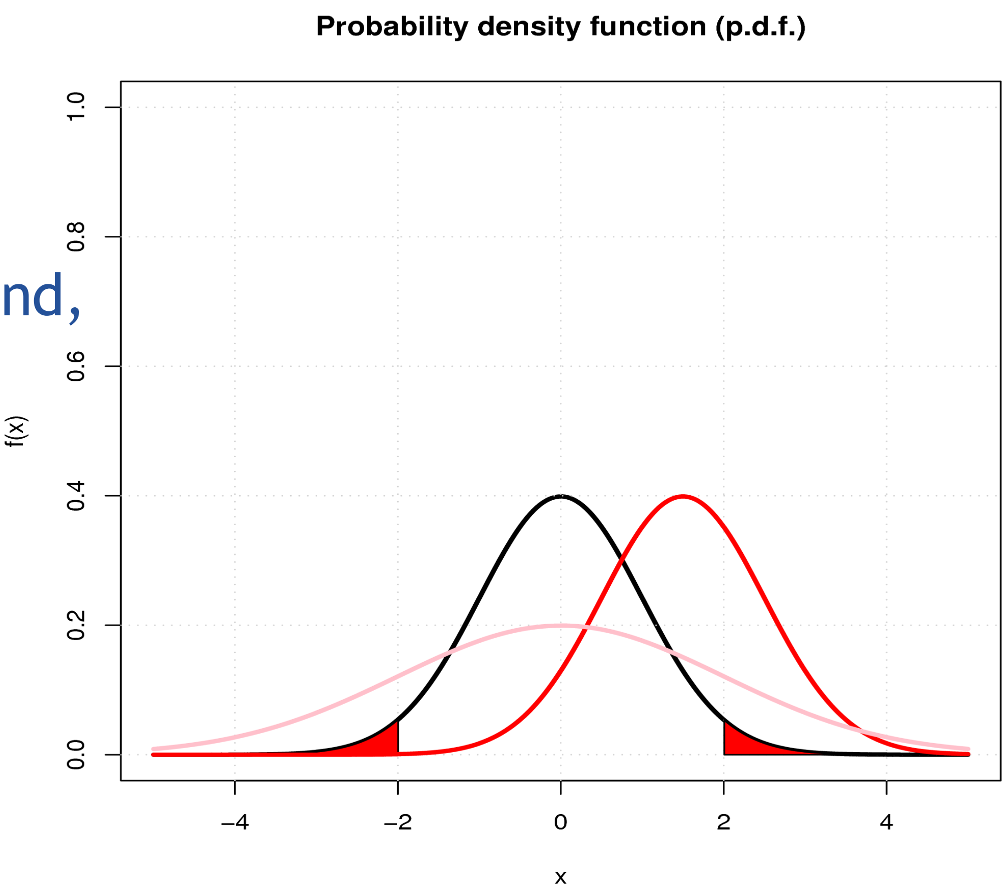
Methodological uncertainties

pdf is not stationary

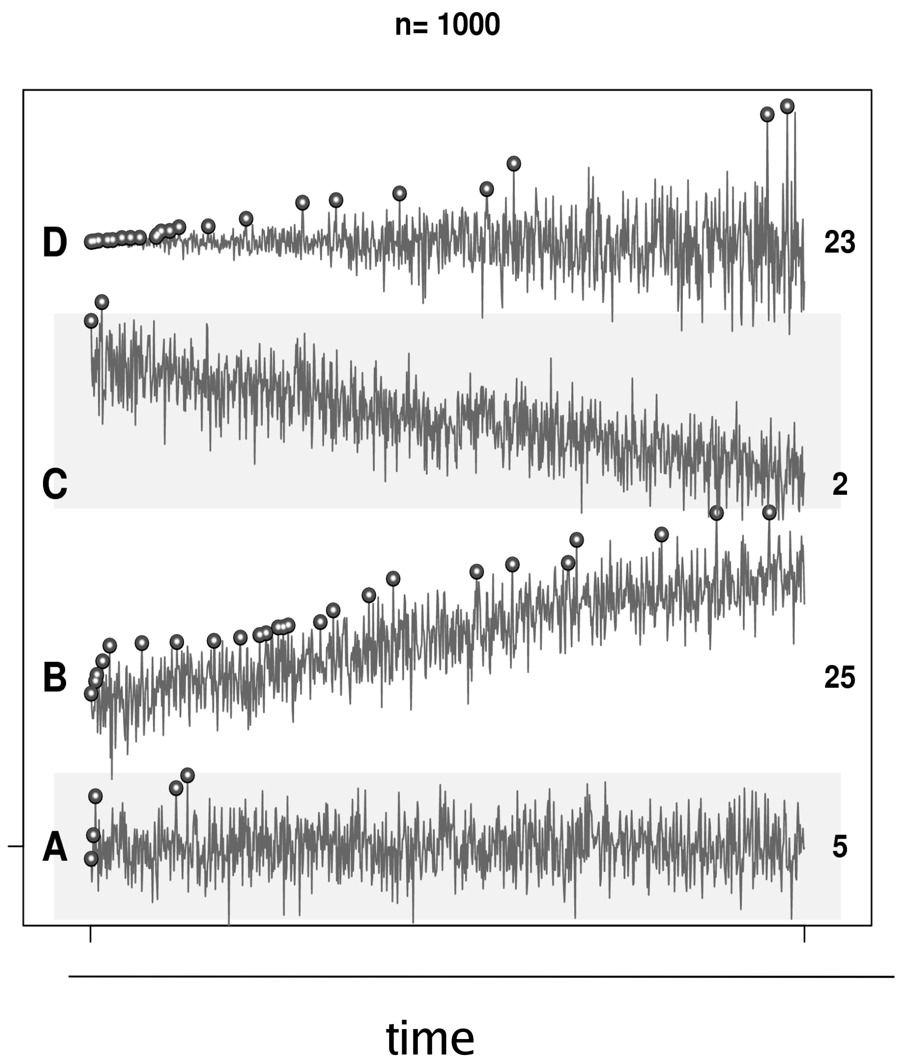


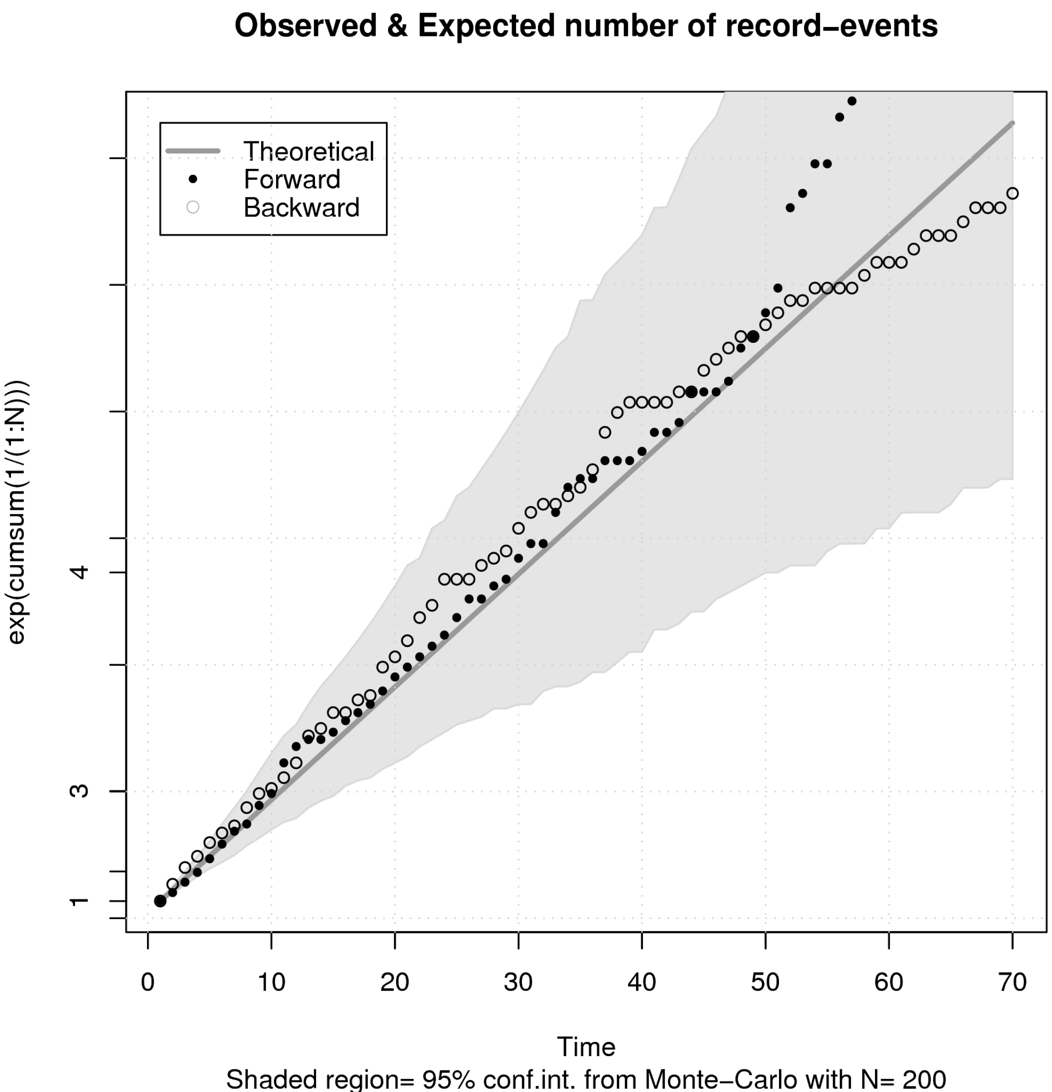
Testing extremes: pdf

- The pdf is changing
  - Climate change: definition
- New shape and location
  - Predictable?
- iid-test:
  - Changing tails of pdf
    - Return value, clipping, trend, analog

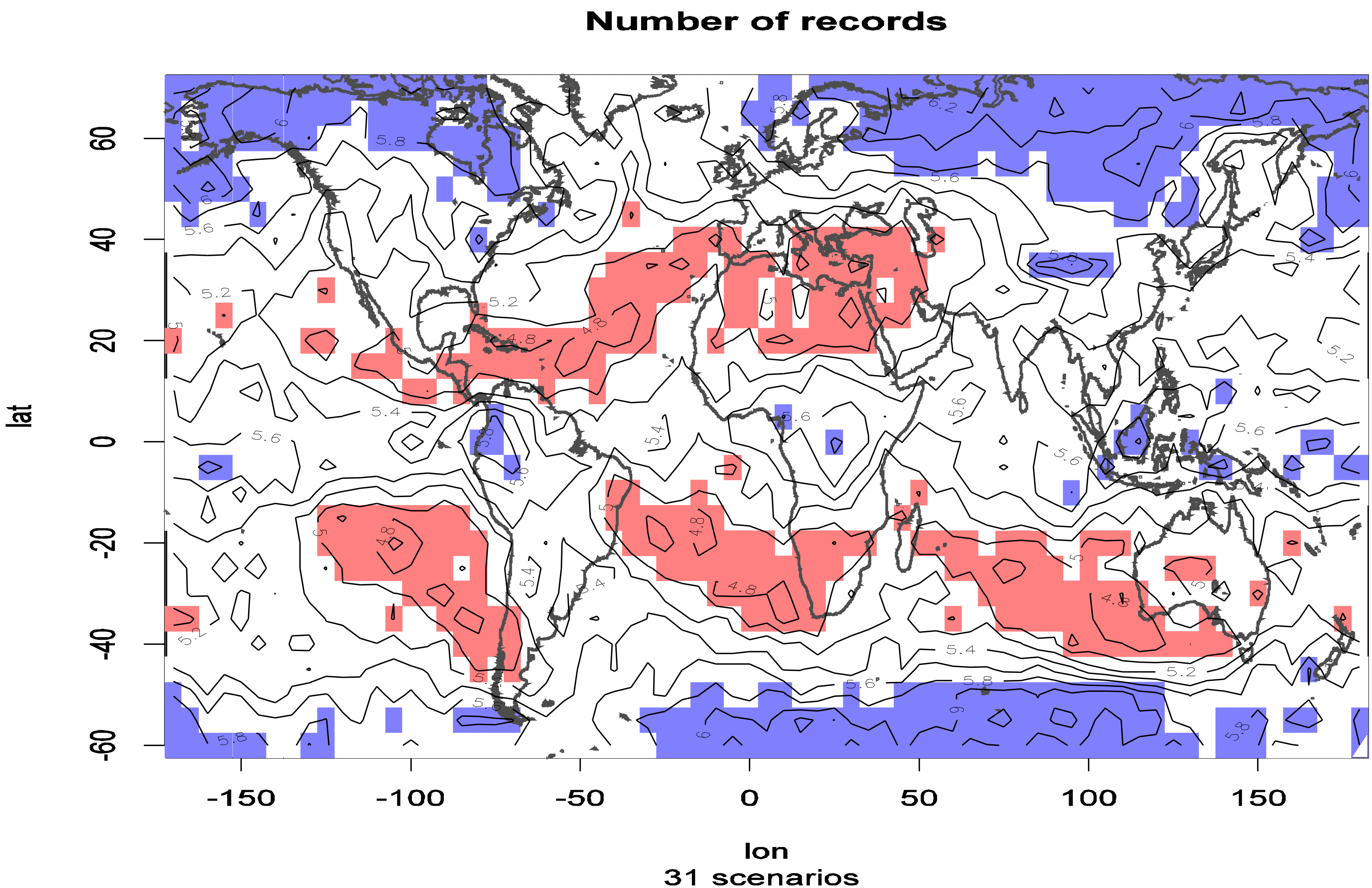


Testing extremes: pdf



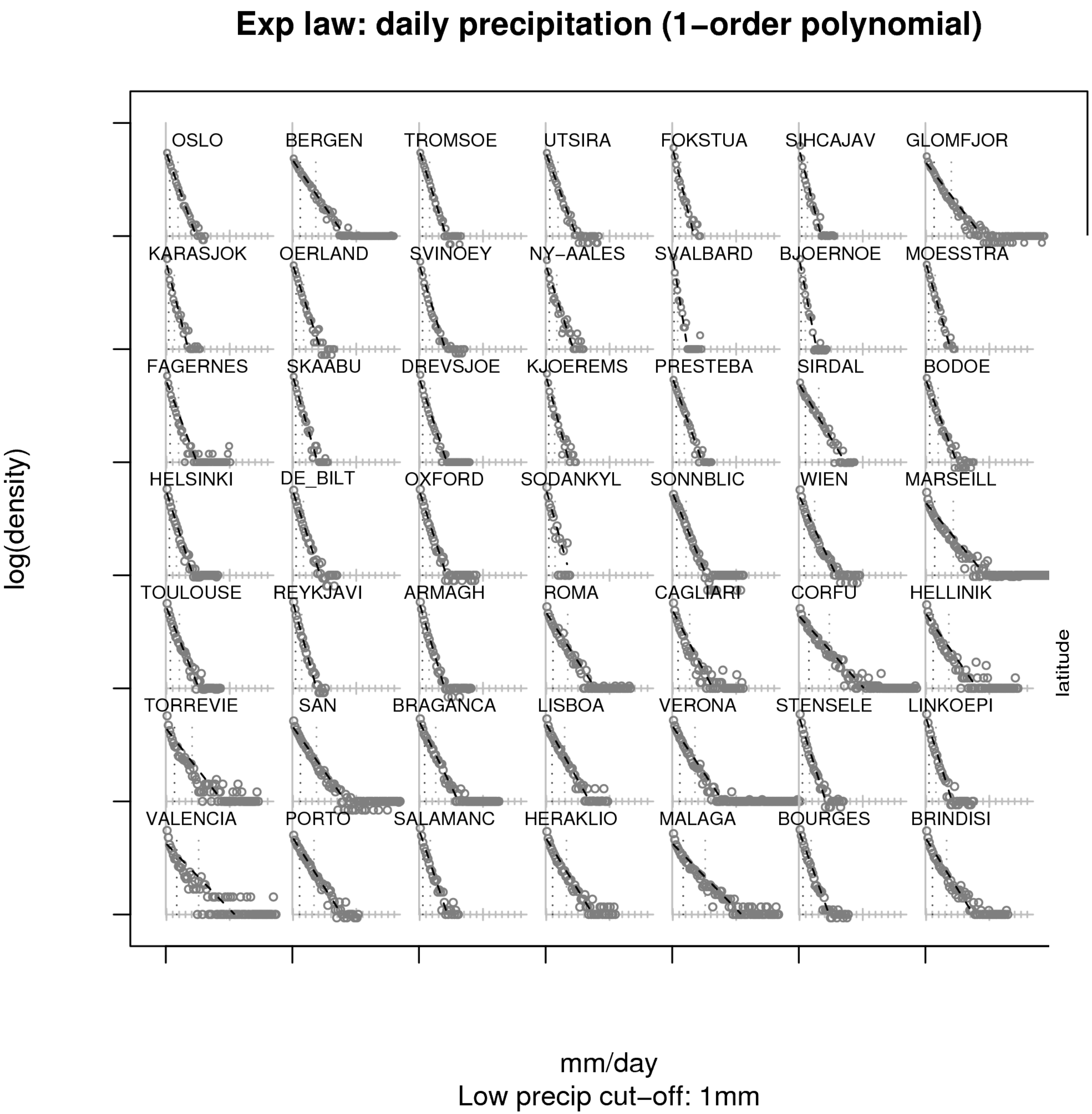


Record-event statistics

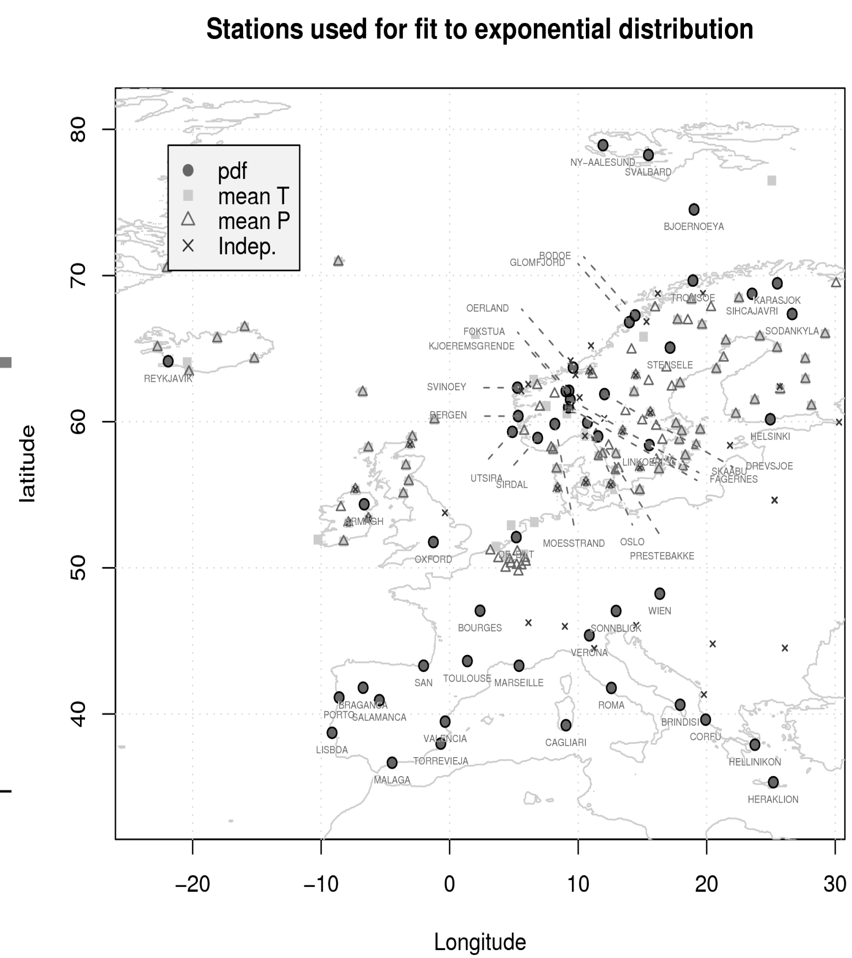


Benestad, R.E (2006) *J.Clim* Vol. **19**

Predicting pdfs



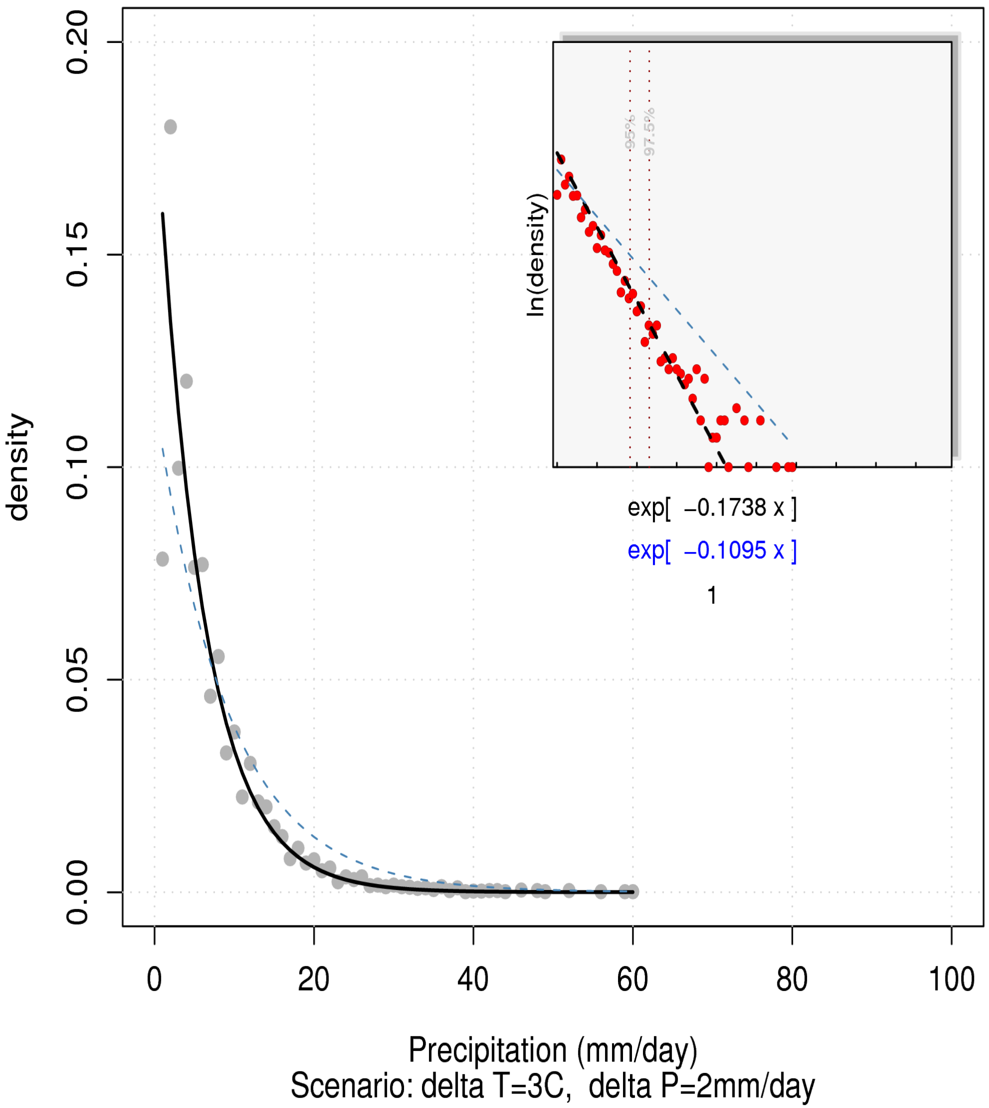
Benestad (2007),
Clim. Res. vol 34,p. 195-210



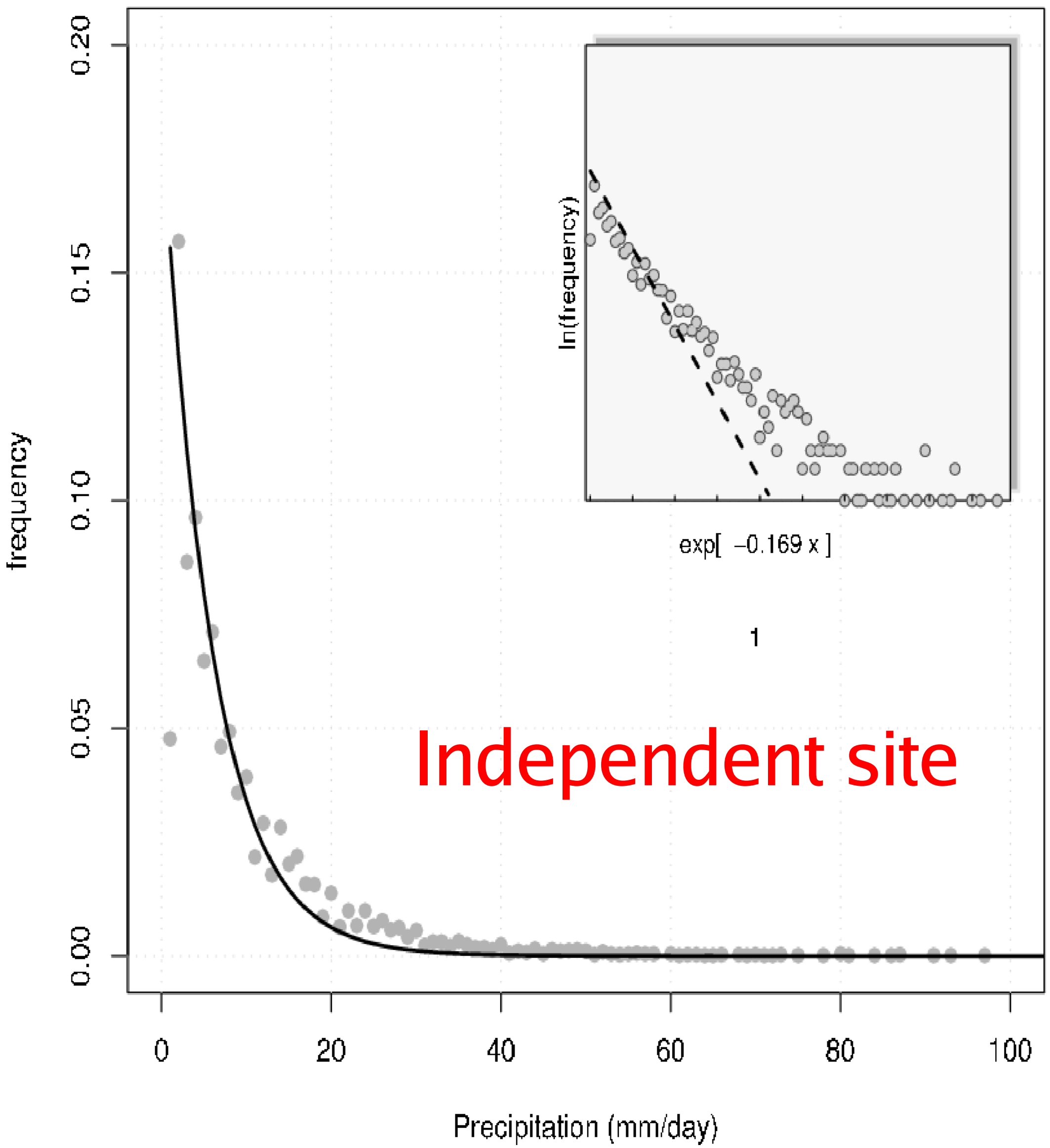
24-hr precipitation pdf

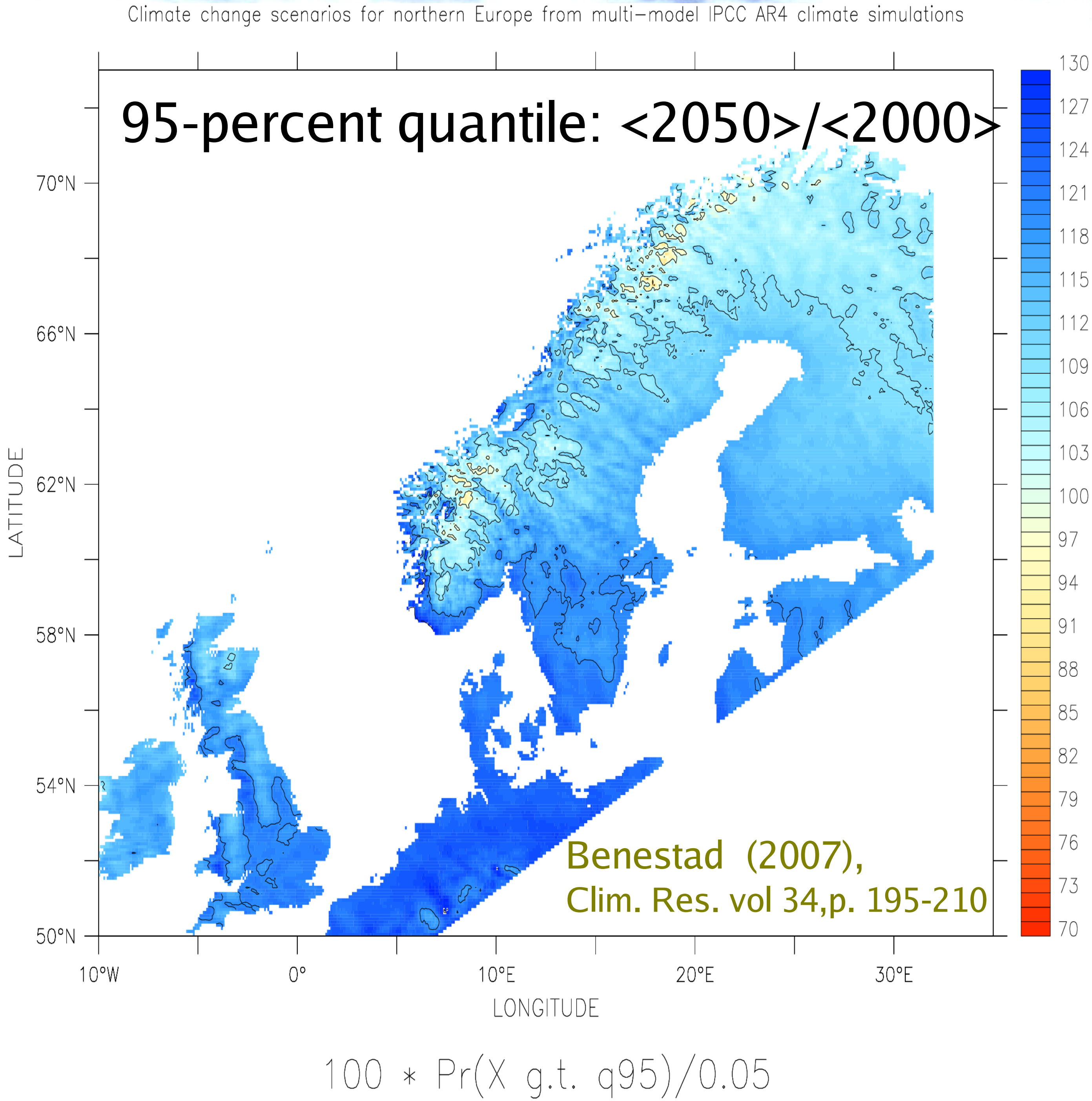
Benestad (2007),
Clim. Res. vol 34,p. 195-210

OSLO – BLINDERN



TEIGARHORN





Climate change scenarios for northern Europe from multi-model IPCC AR4 climate simulations
95-percent quantile: <2050>/<2000>
70°N
66°N
62°N
58°N
54°N
50°N
LATITUDE
10°W
0°
10°E
20°E
30°E
LONGITUDE
130
127
124
121
118
115
112
109
106
103
100
97
94
91
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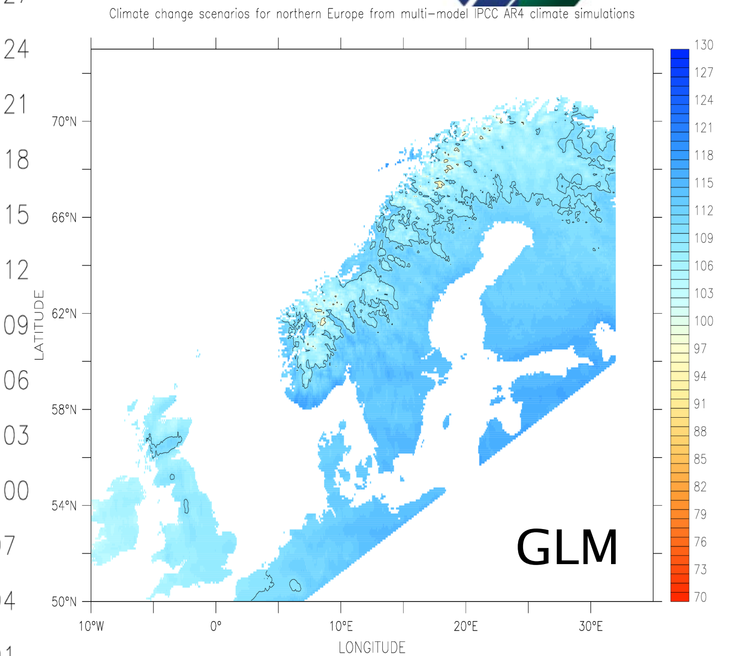
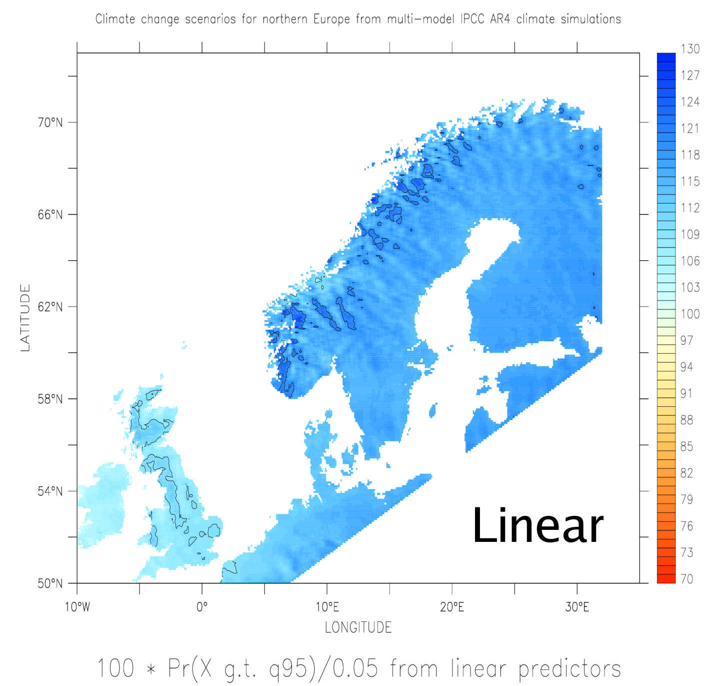
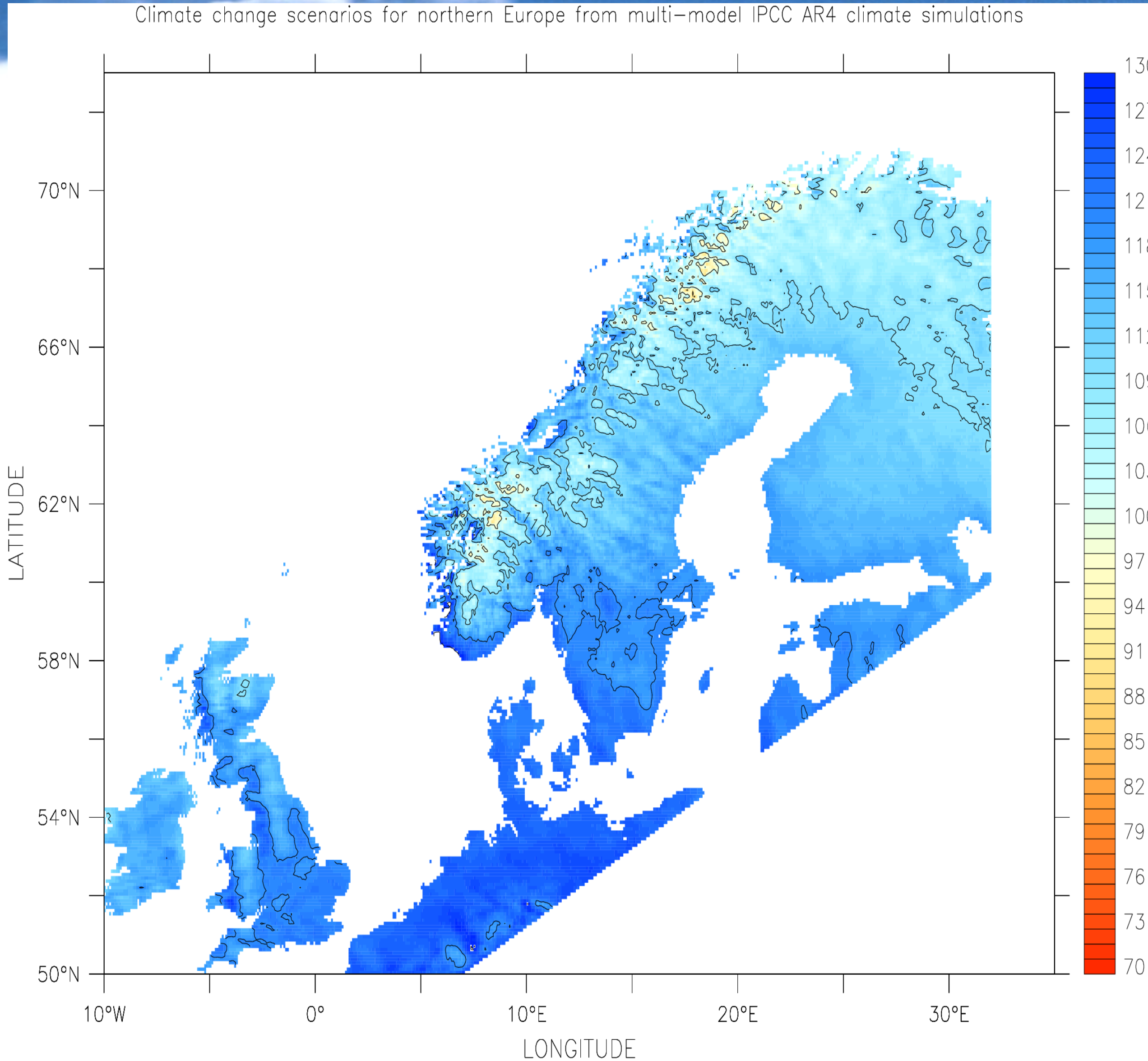
Benestad (2007),
Clim. Res. vol 34,p. 195-210
100 * Pr(X g.t. q95)/0.05



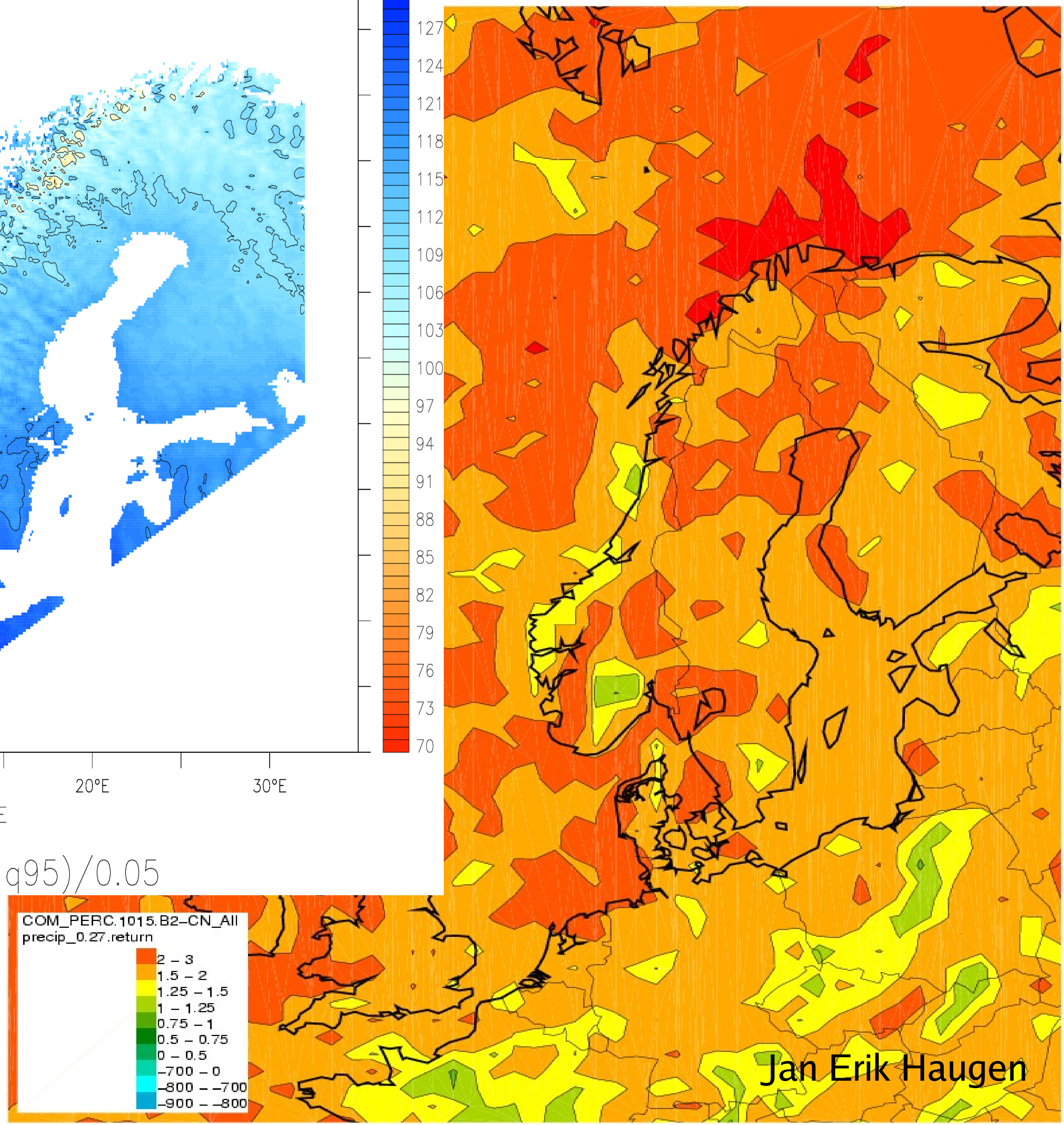
Climate change scenarios for northern Europe from multi-model IPCC AR4 climate simulations
GLM
LATITUDE
LONGITUDE



Climate change scenarios for northern Europe from multi-model IPCC AR4 climate simulations
Linear
LATITUDE
LONGITUDE
100 * Pr(X g.t. q95)/0.05 from linear predictors



100 * Pr(X g.t. q95)/0.05



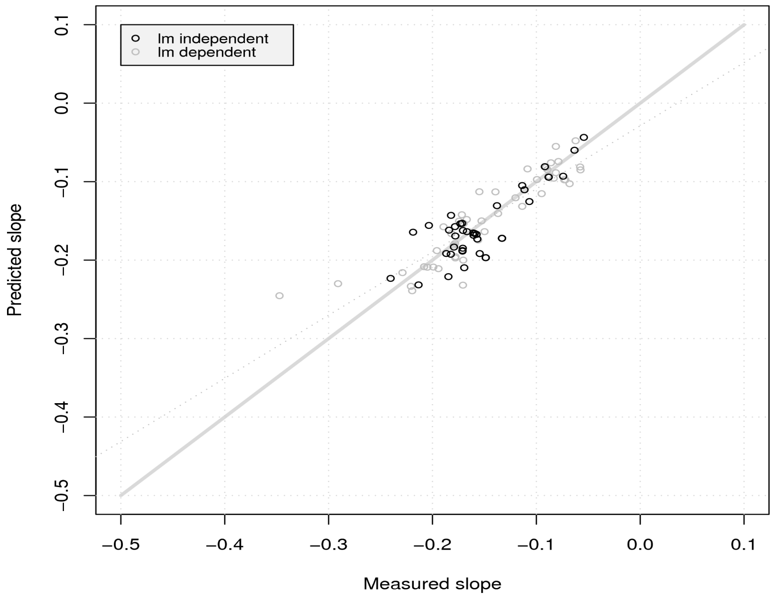
Jan Erik Haugen

Conclusions

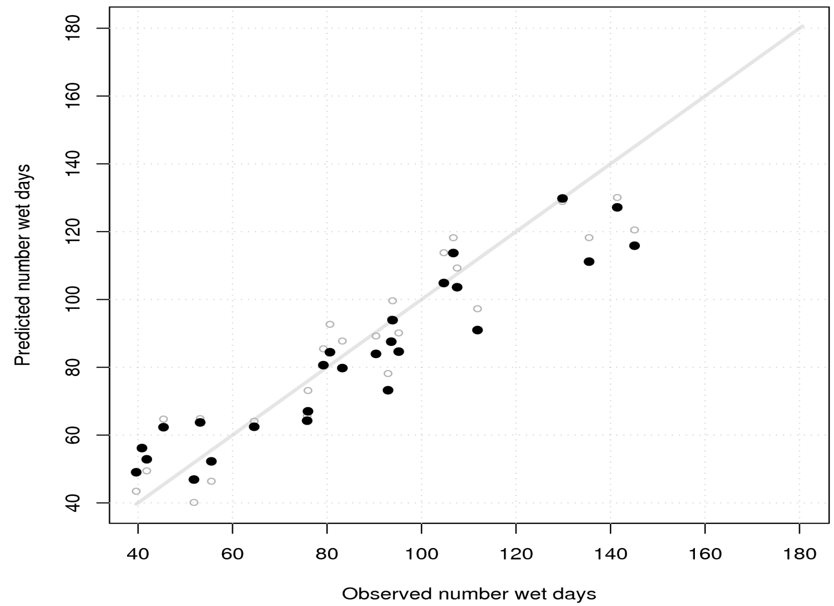
- **Extremes**
  - Sparse observations
- **RCMs**
  - Biased statistics: tails.
  - Storms/wind: Not representative.
  - Dominates in community
- **ESD**
  - Downscaling *pdf*s
  - Independent approach
- **Uncertainty**
  - GCMs and local representation
  - Bias revealed using RCM + ESD

Benestad (2007),
Clim. Res. vol 34,p. 195-210

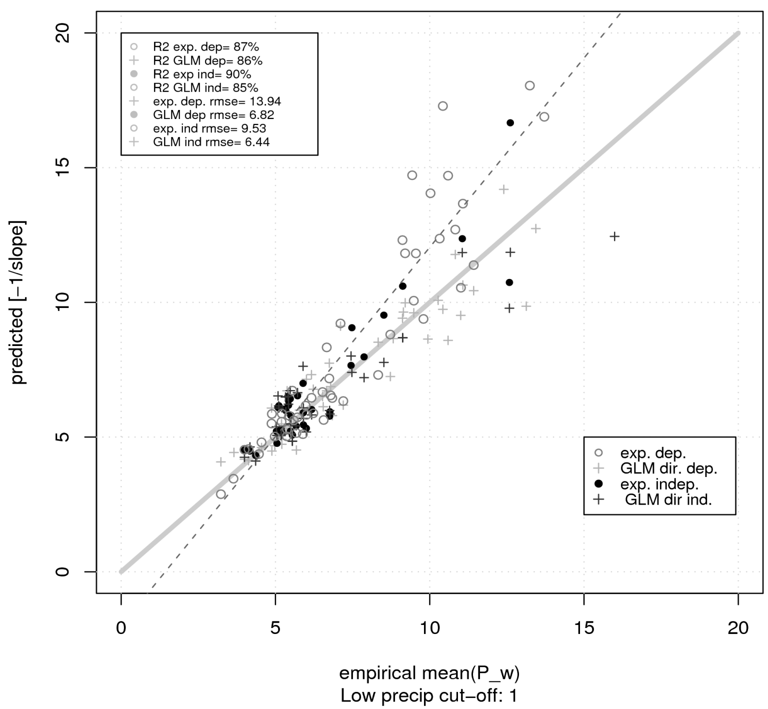
Validation of Eq. 3



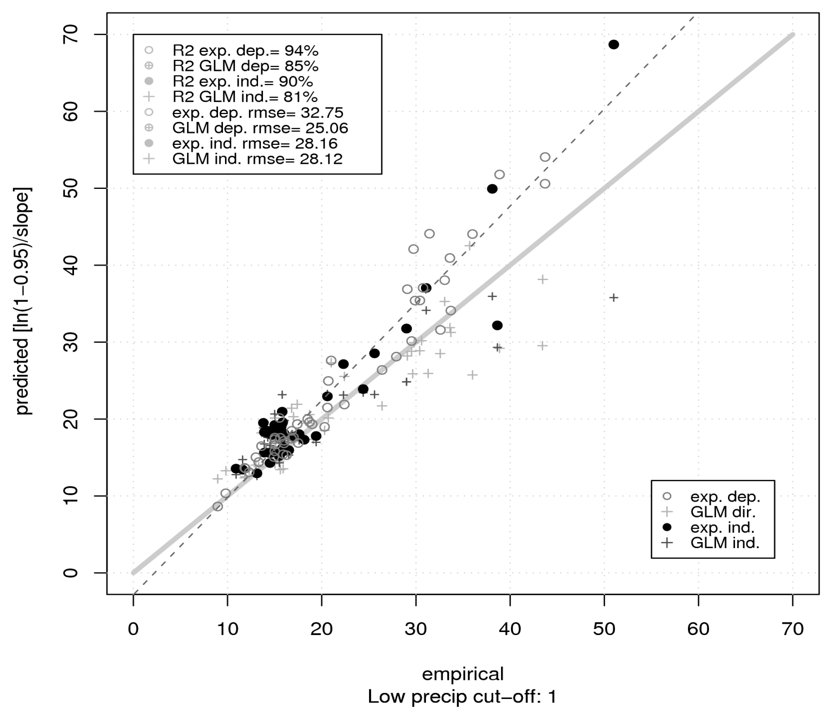
N_R



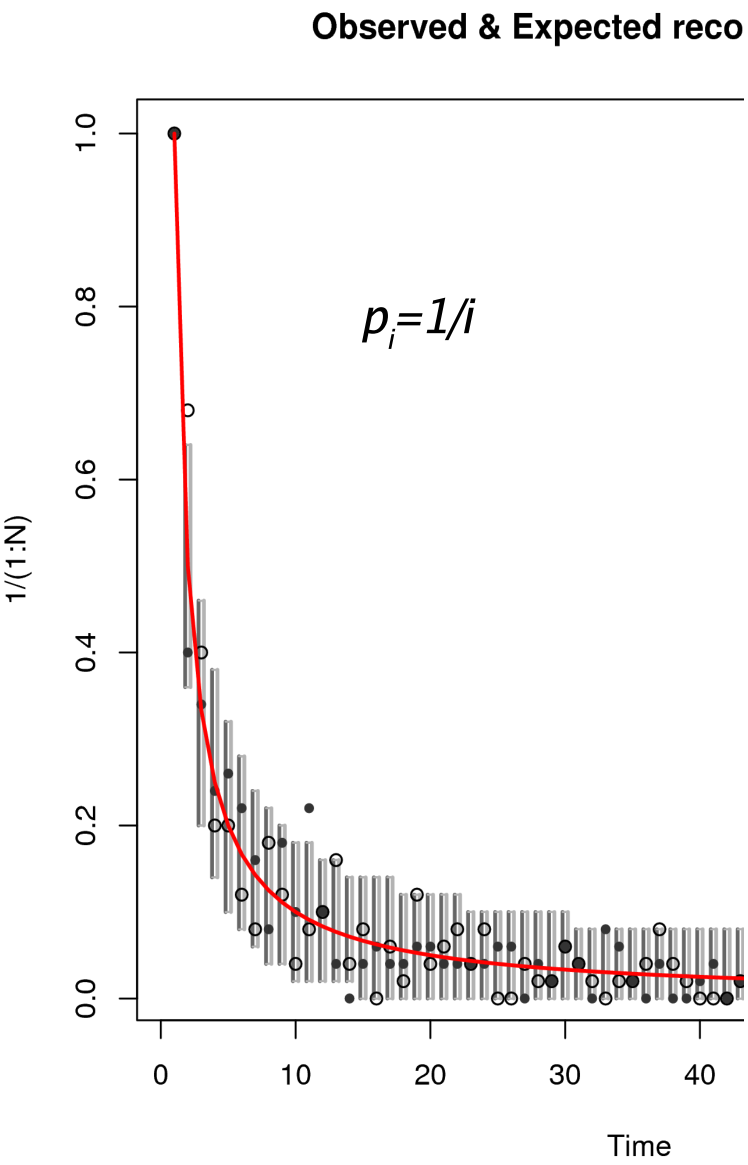
Mean: empirical v.s. theoretical

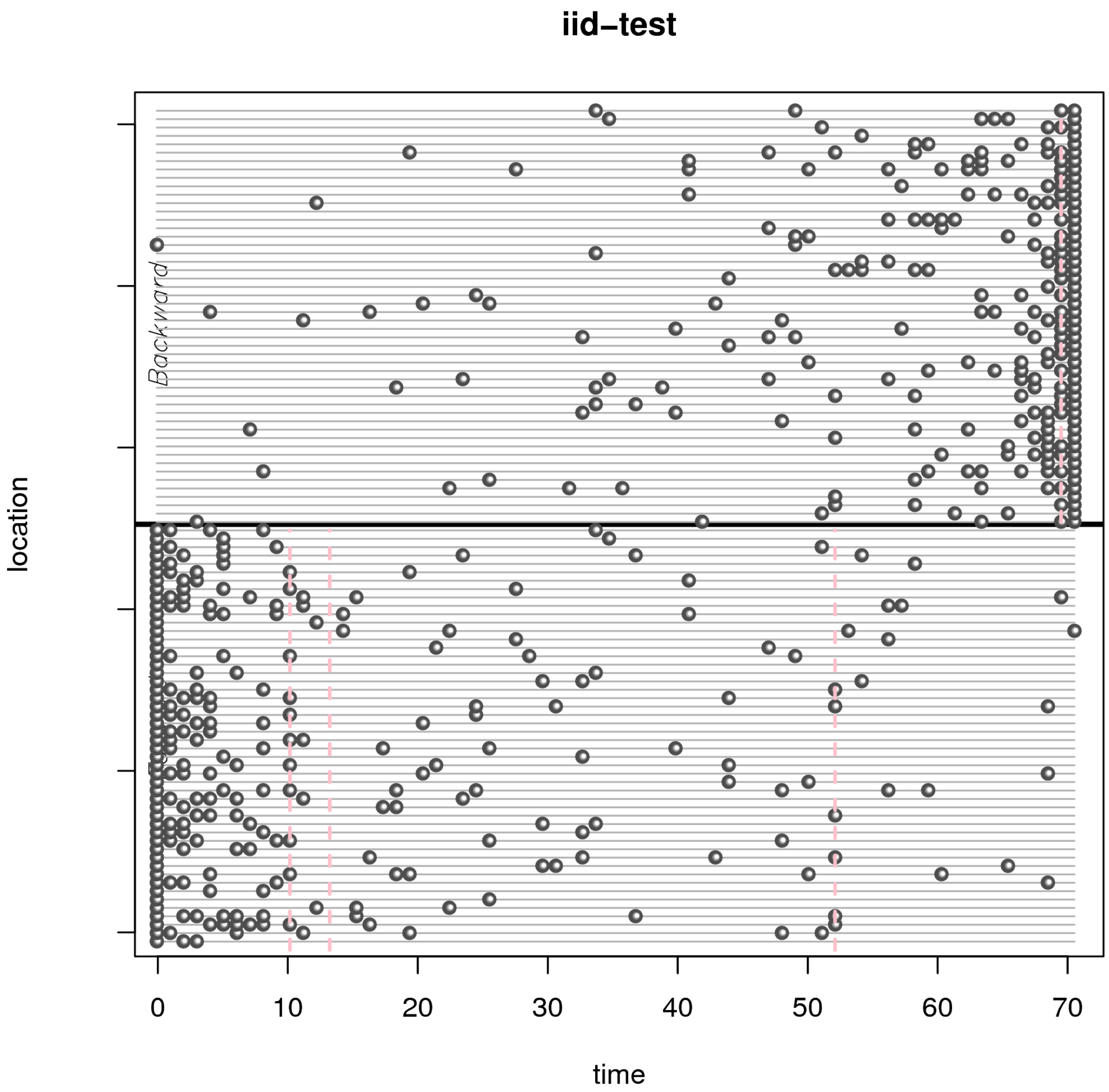


0.95 percentile: empirical v.s. theoretical



Testing extremes: pdf





T(2m): consistency & range