Changes in storm occurrence over Northern-Central Europe

with material from Christoph Matulla, the BACC report, Matthias Zahn and Frauke Feser

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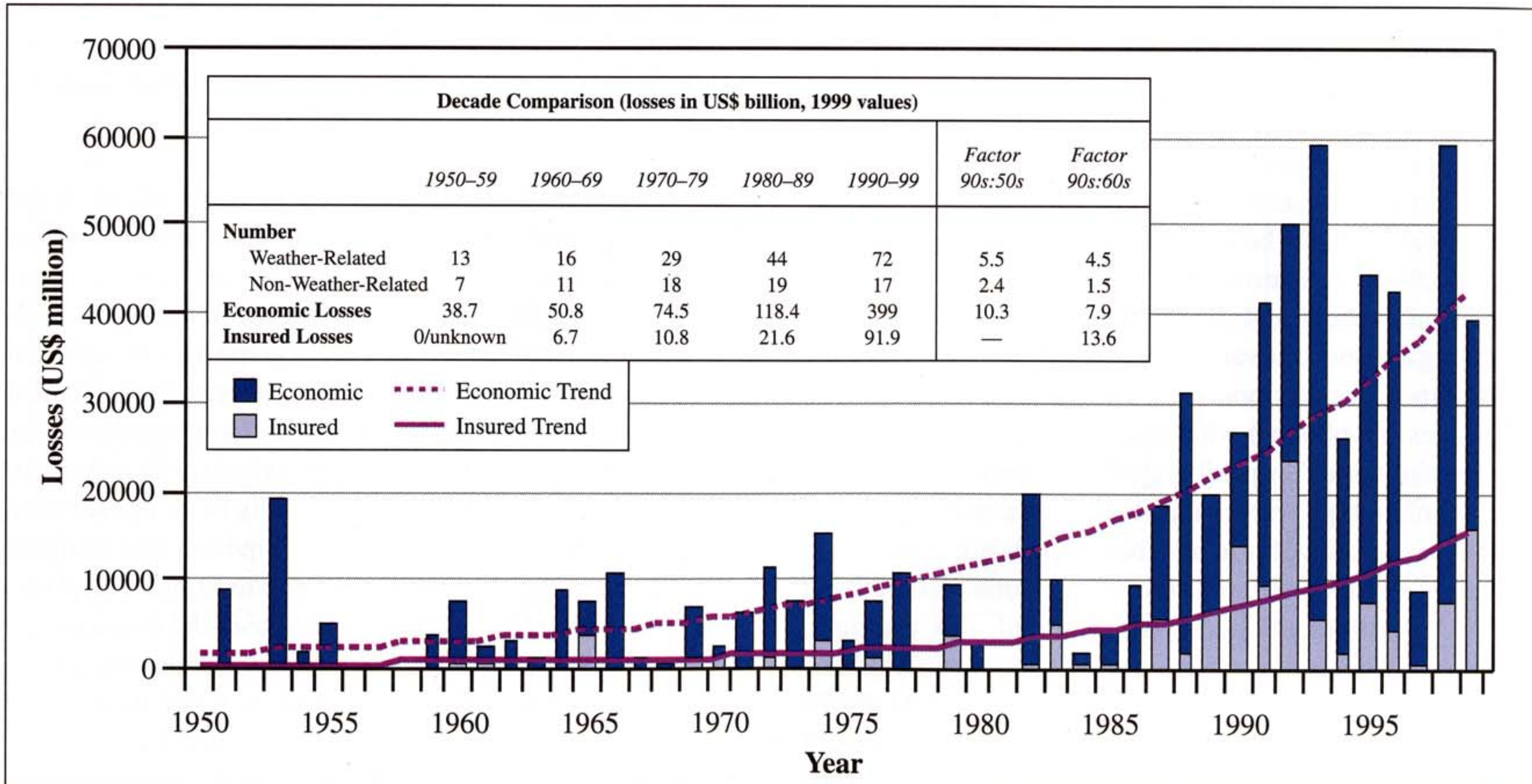
Challenge

Storminess best represented by wind statistics, possibly derived quantities such as stream function, vorticity, but wind time series are almost always

- inhomogeneous
- too short

Damages and extreme weather

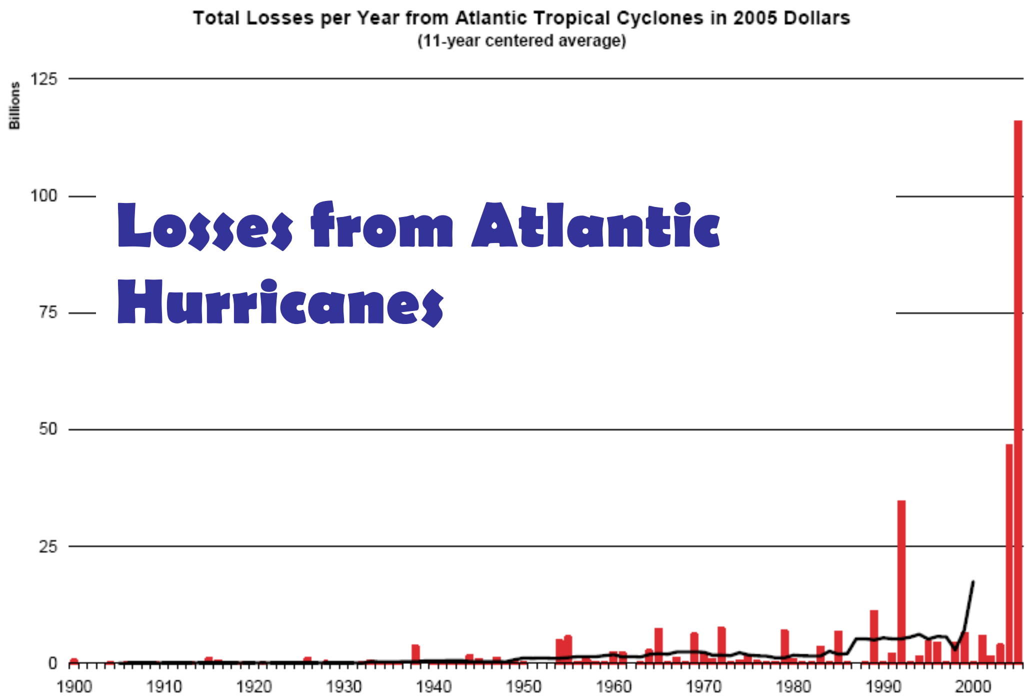


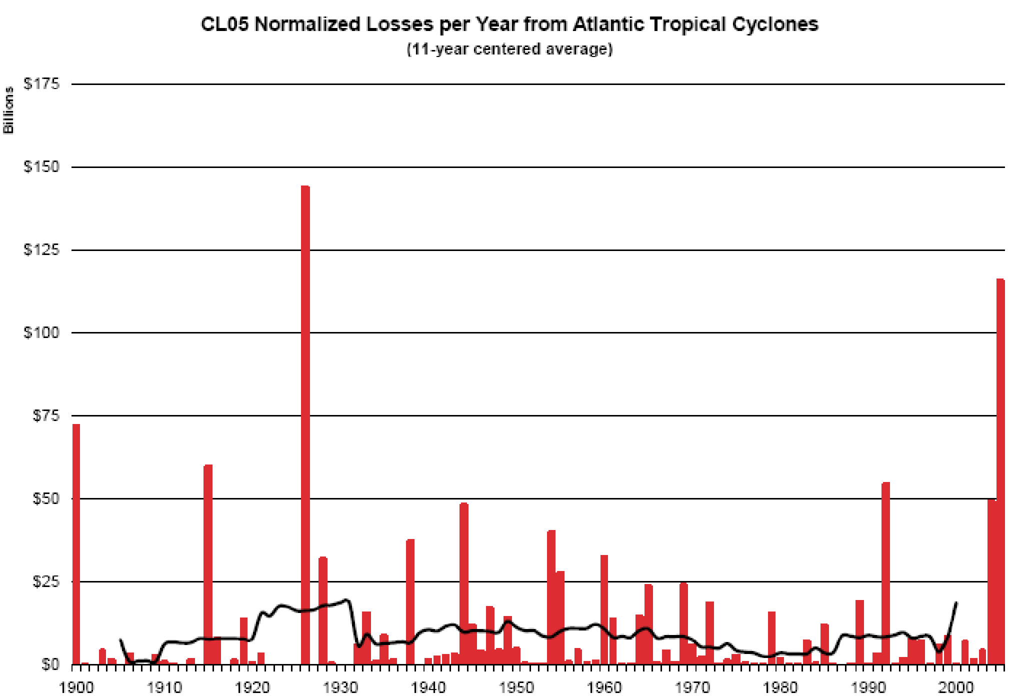
Decade Comparison (losses in US$ billion, 1999 values)							
	1950–59	*1960–69*	*1970–79*	*1980–89*	*1990–99*	*Factor 90s:50s*	*Factor 90s:60s*
Number							
Weather-Related	13	16	29	44	72	5.5	4.5
Non-Weather-Related	7	11	18	19	17	2.4	1.5
Economic Losses	38.7	50.8	74.5	118.4	399	10.3	7.9
Insured Losses	0/unknown	6.7	10.8	21.6	91.9	—	13.6

Figure TS-5: The costs of catastrophic weather events have exhibited a rapid upward trend in recent decades. Yearly economic losses from large events increased 10.3-fold from US$4 billion yr^{-1} in the 1950s to US$40 billion yr^{-1} in the 1990s (all in 1999 US$). The insured portion of these losses rose from a negligible level to US$9.2 billion annually during the same period, and the ratio of premiums to catastrophe losses fell by two-thirds. Notably, costs are larger by a factor of 2 when losses from ordinary, noncatastrophic weather-related events are included. The numbers generally include "captive" self-insurers but not the less-formal types of self-insurance.

The increase in damages related to extreme weather conditions is massive – but is it because the weather is getting worse?

Losses from Atlantic Hurricanes





Hardly

"Great Miami", 1926, Florida, Alamaba – damages of 2005 usage - in 2005 money: 139 b$

Katrina, 2005: 81 b$

Pielke, Jr., R.A., Gratz, J., Landsea, C.W., Collins, D., Saunders, M., and Musulin, R., 2008. Normalized Hurricane Damages in the United States: 1900-2005. Natural Hazards Review

Counting storms in weather maps – steady increase of NE Atlantic storms since the 1930s ….

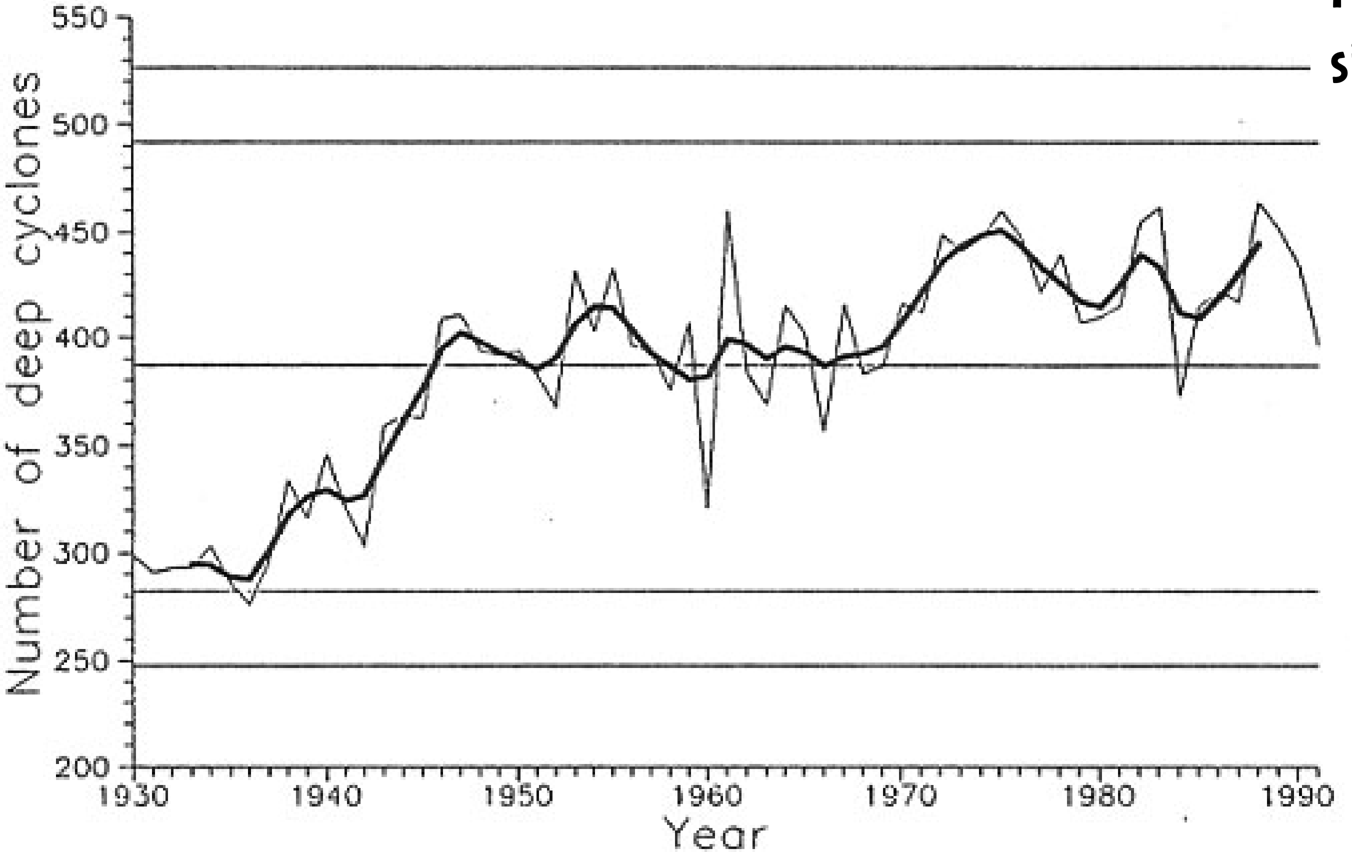
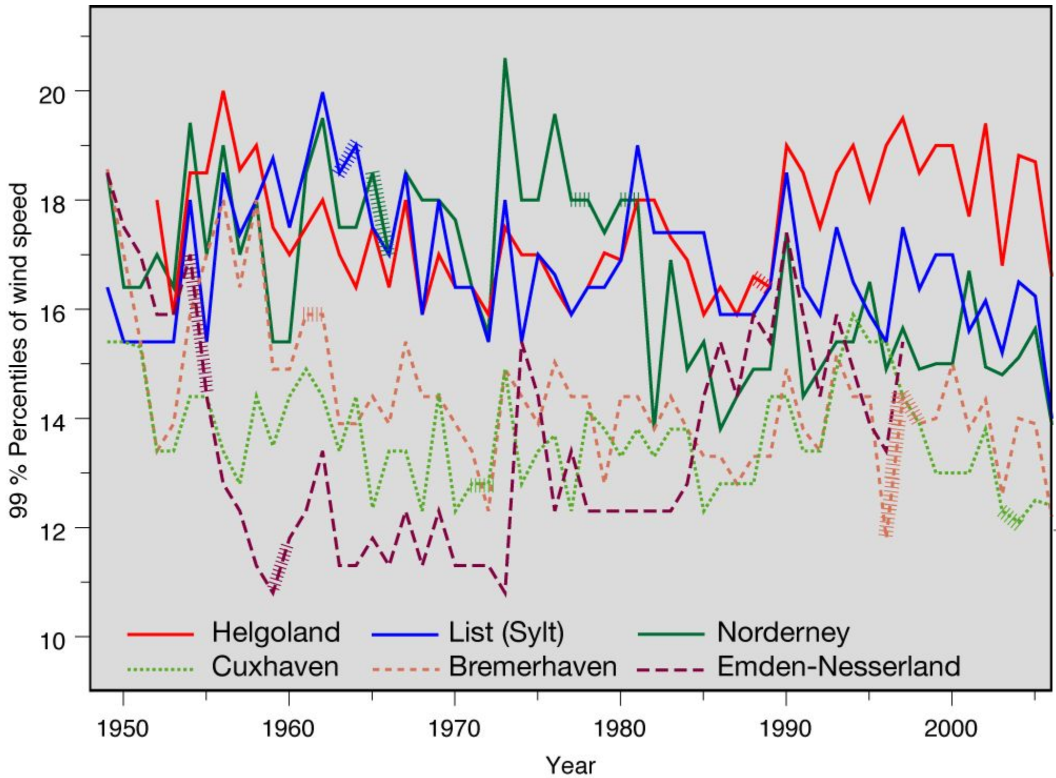


Figure 2 Absolute annual number of deep cyclones 1930–1991[1)]



Examples of inhomogeneities in wind records

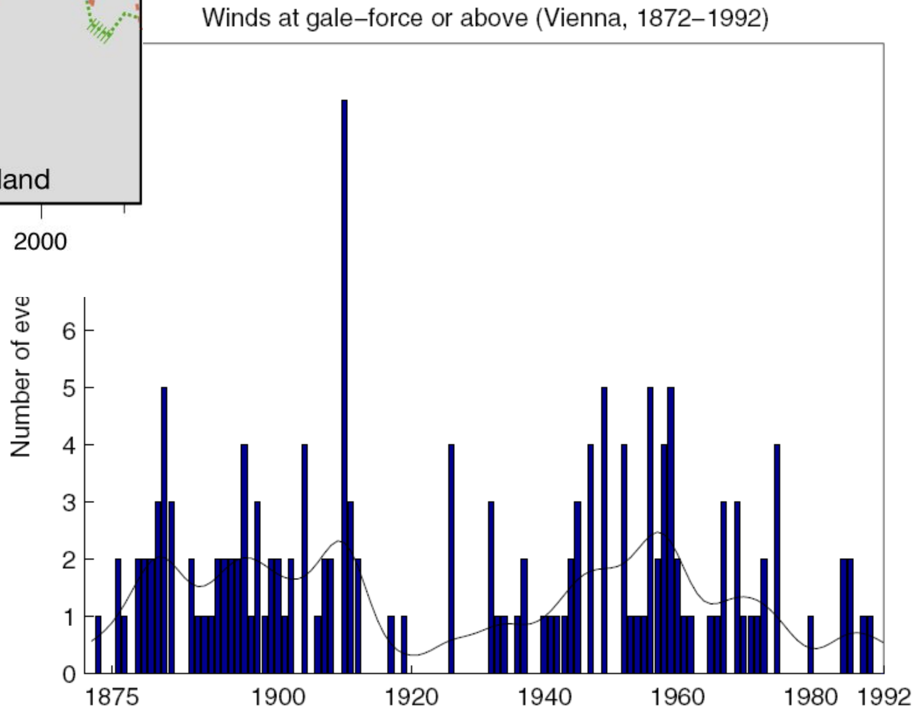
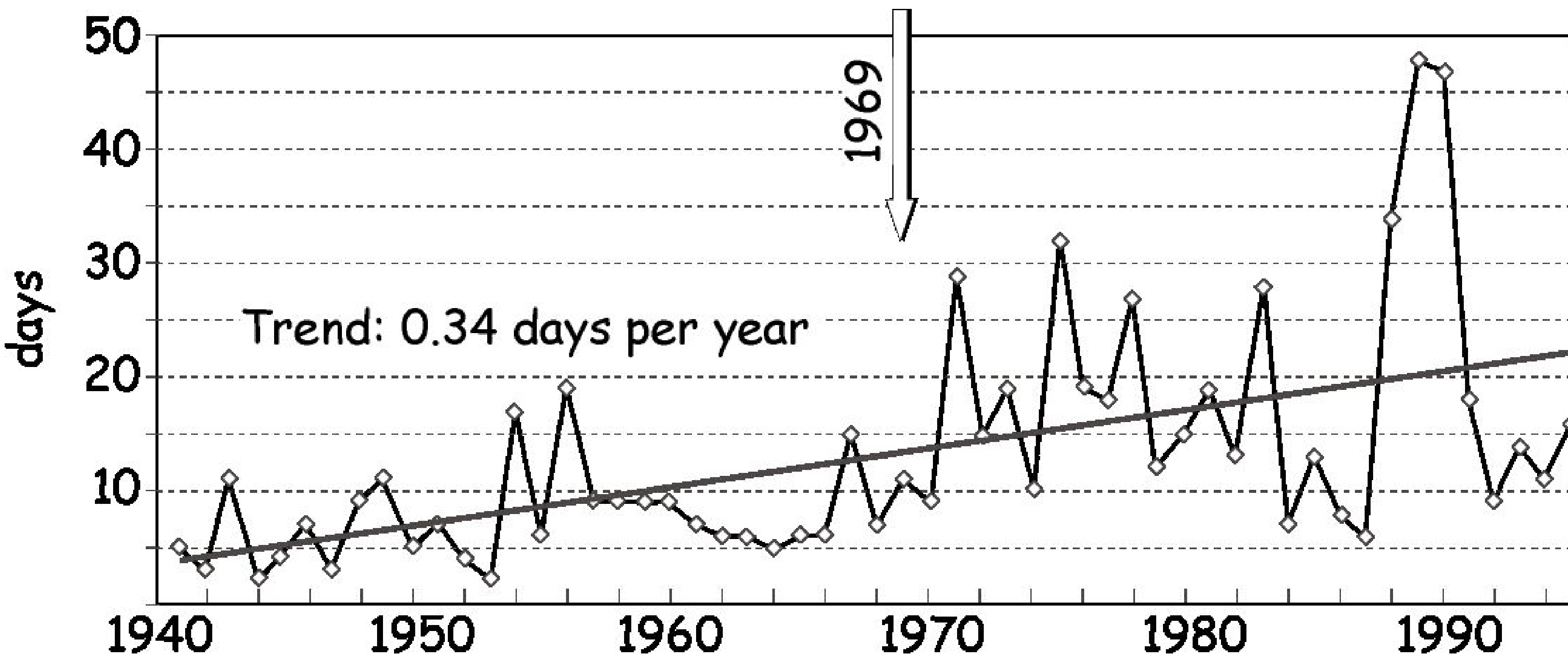
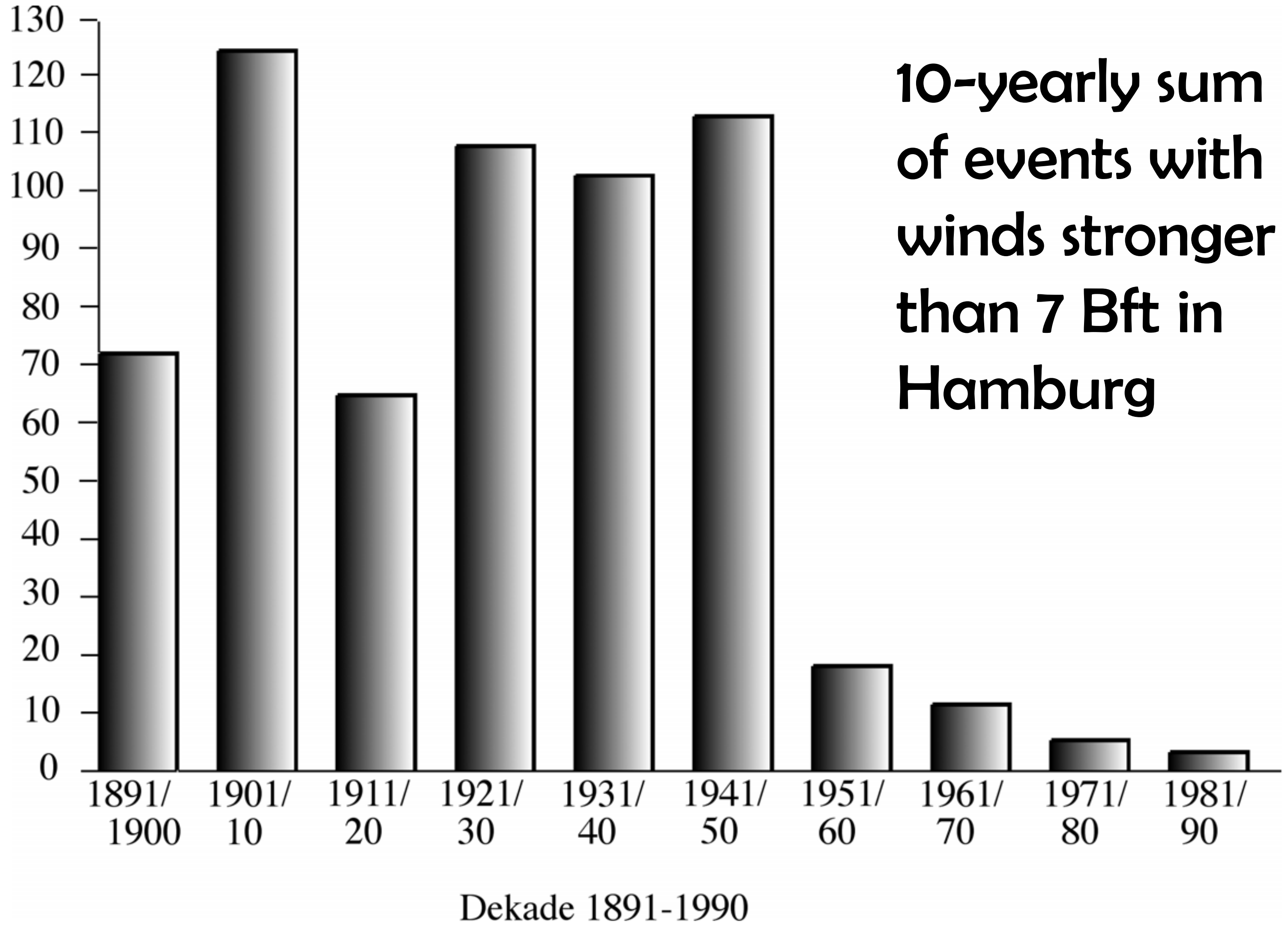


Fig. 1 Number of storm events (November–February) at or above Beaufort 8 and the Gaussian low-pass (21 years) filtered curve

Time series of frequency of stormy days in Kullaberg (south-western Sweden), number of days per year with wind speed ≥21 m/s





130
120
110
100
90
80
70
60
50
40
30
20
10
0
1891/ 1900
1901/ 10
1911/ 20
1921/ 30
1931/ 40
1941/ 50
1951/ 60
1961/ 70
1971/ 80
1981/ 90
Dekade 1891-1990
10-yearly sum of events with winds stronger than 7 Bft in Hamburg

For assessing changing storm conditions, principally **two approaches** are possible:

- Use of proxies, such as daily and sub-daily air pressure readings.
- Empirical or dynamical downscaling of large scale information.

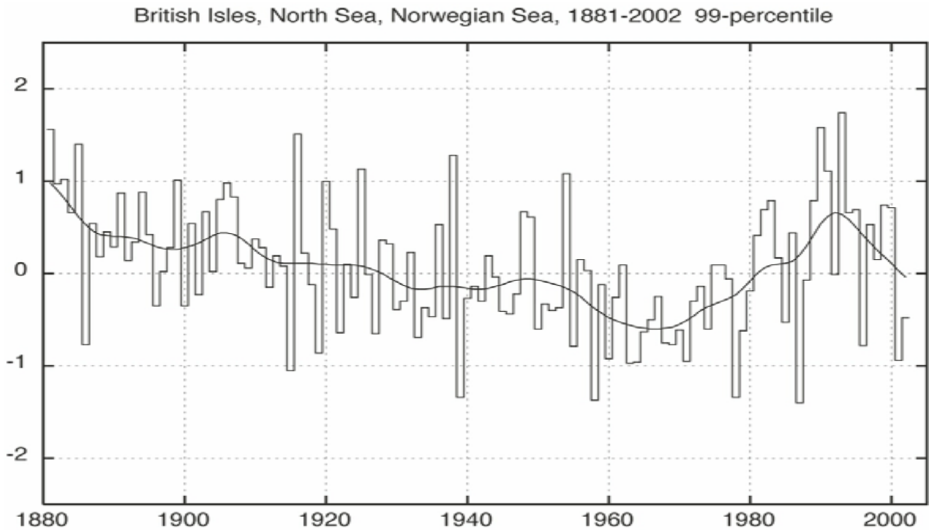
Usage of weather analyses, incl. re-analyses and proxies such as damages are not suitable.

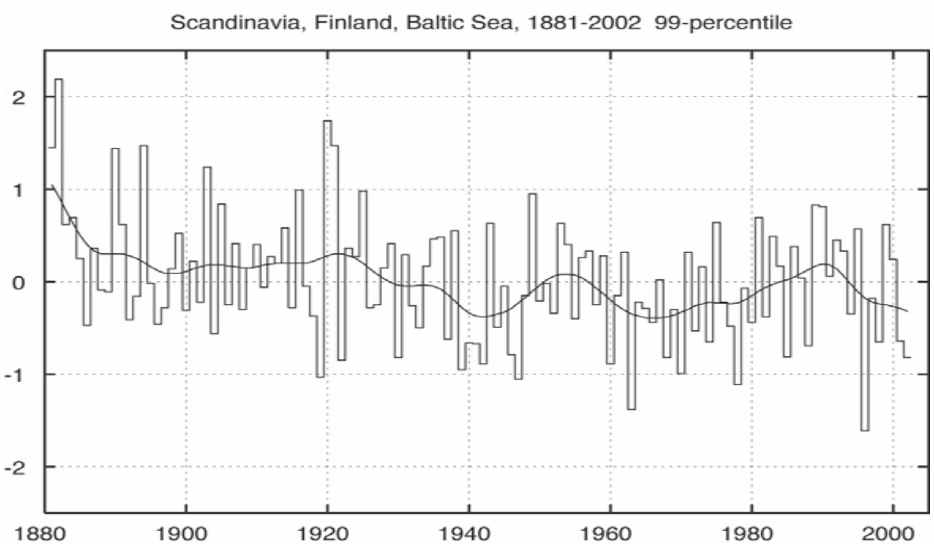
Pressure proxies

Air pressure readings are usually homogenous

- Annual/seasonal percentiles of geostrophic wind derived from triangles of pressure readings (e.g., 95 or 99%iles); such percentiles of geostrophic wind and of “real” wind are linearly related.
- Annual frequency of events with geostrophic wind equal or larger than 25 m/s
- Annual frequency of 24 hourly local pressure change of 16 hPa in a year
- Annual frequency of pressure readings less than 980 hPa in a year

Geostropic wind stats N Europe





99%iles of annual geostrophic wind speeds

for a series of station triangles in the North Sea regions and in the Baltic Sea region.

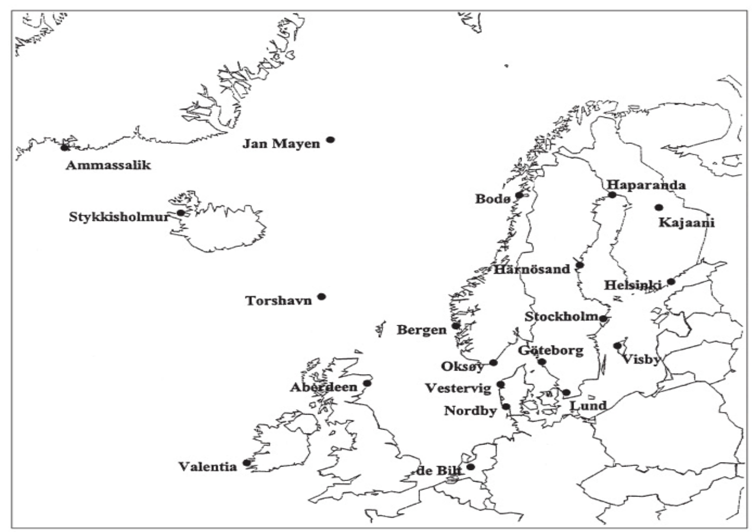
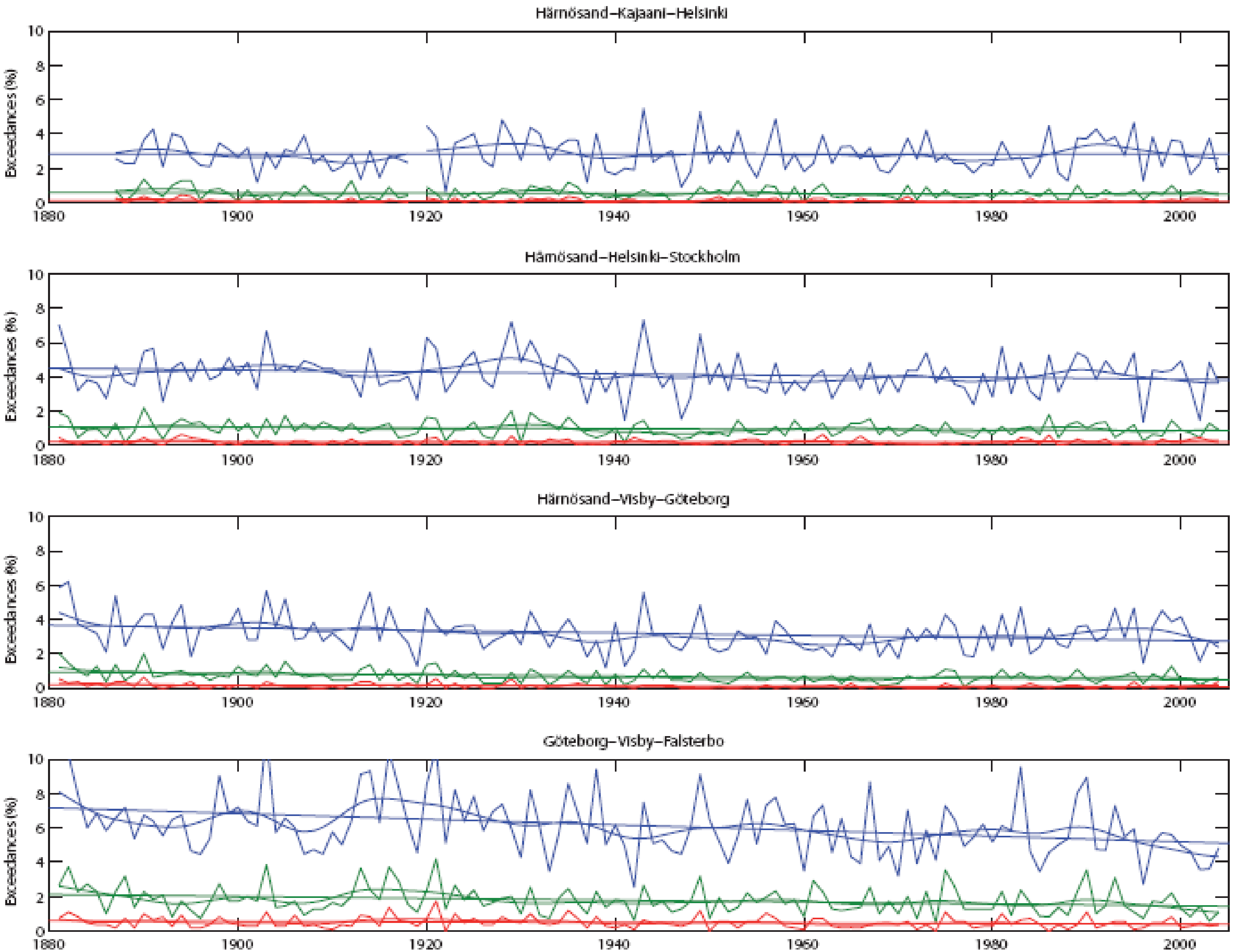


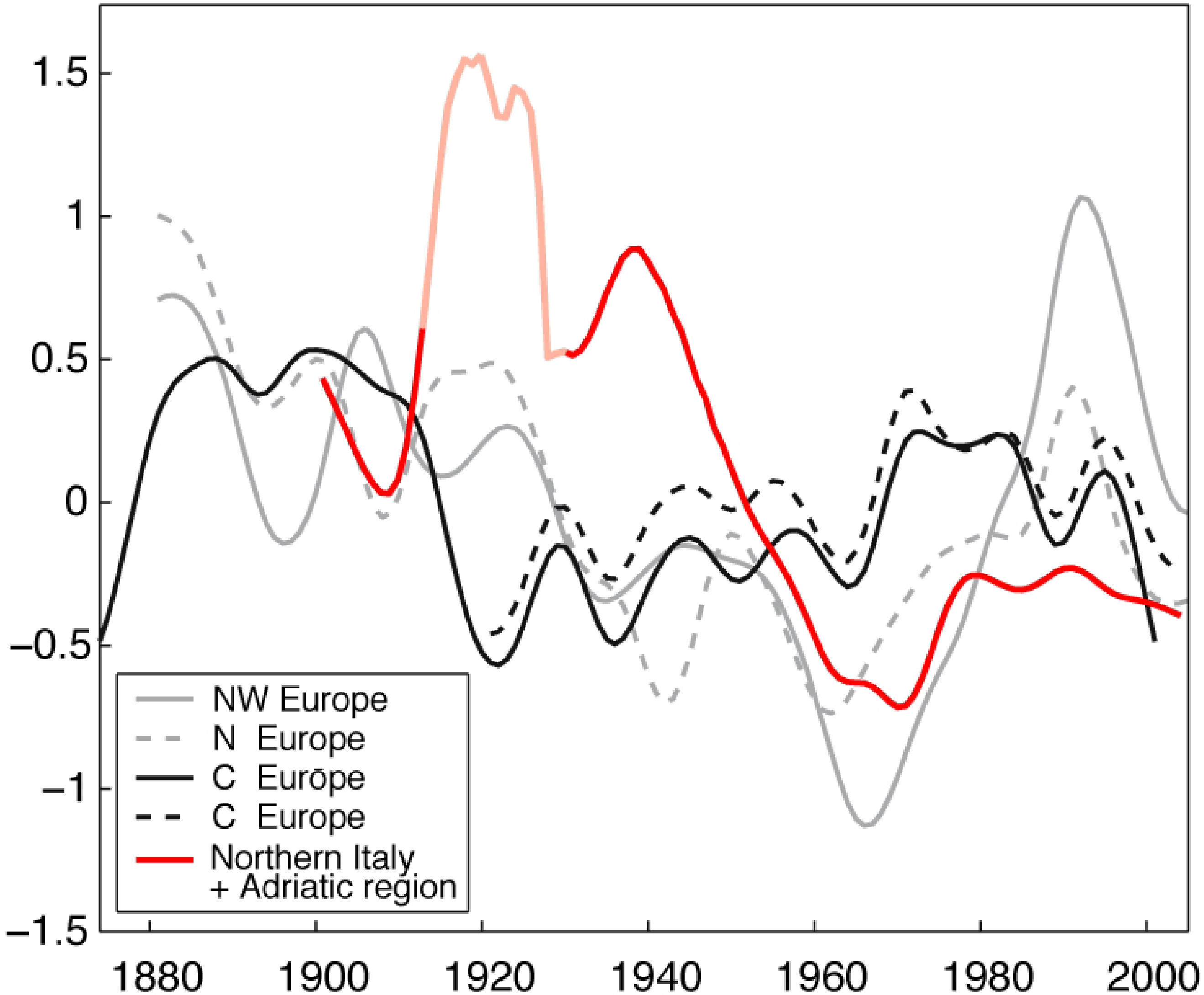
Fig. 1. Stations with long time series of 3 pressure observations per day

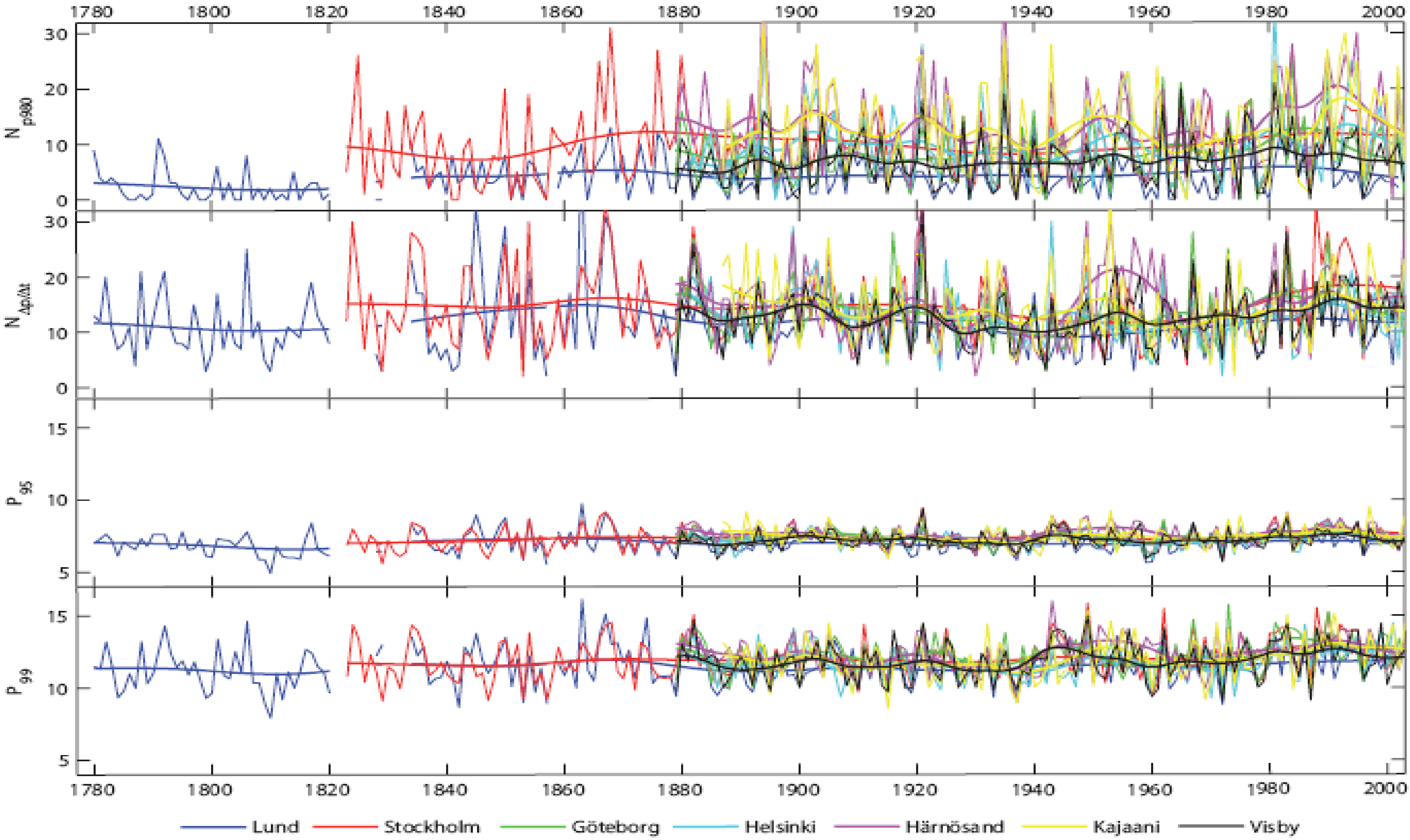
Alexandersson et al., 2002



Geostrophic wind statistics for four triangles in the Baltic Sea region; from BACC, 2008

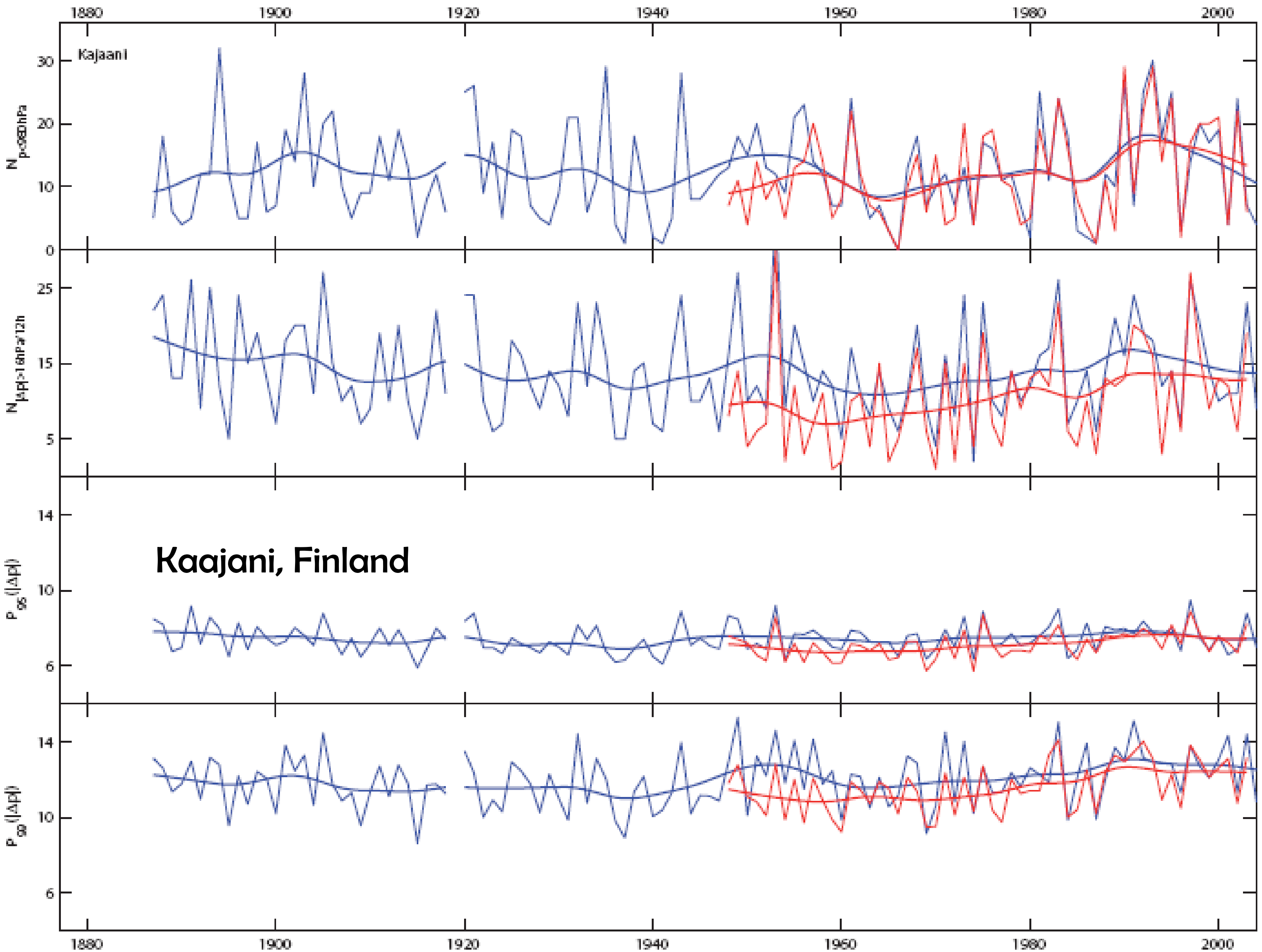
Normalized geostrophic wind percentiles in Europe (smoothed) – by Christoph Matulla, ZMAG, Vienna





Time series of pressure-based storminess indices derived from pressure readings. From top to bottom: Annual number of pressure observations below 980 hPa (N_{p980}), annual number of absolute pressure differences exceeding 16 hPa/12 h ($N_{Dp/Dt}$),
Intra-annual 95-percentile and 99-percentile of the pressure differences (P_{95} and P_{99}) in units of hPa.

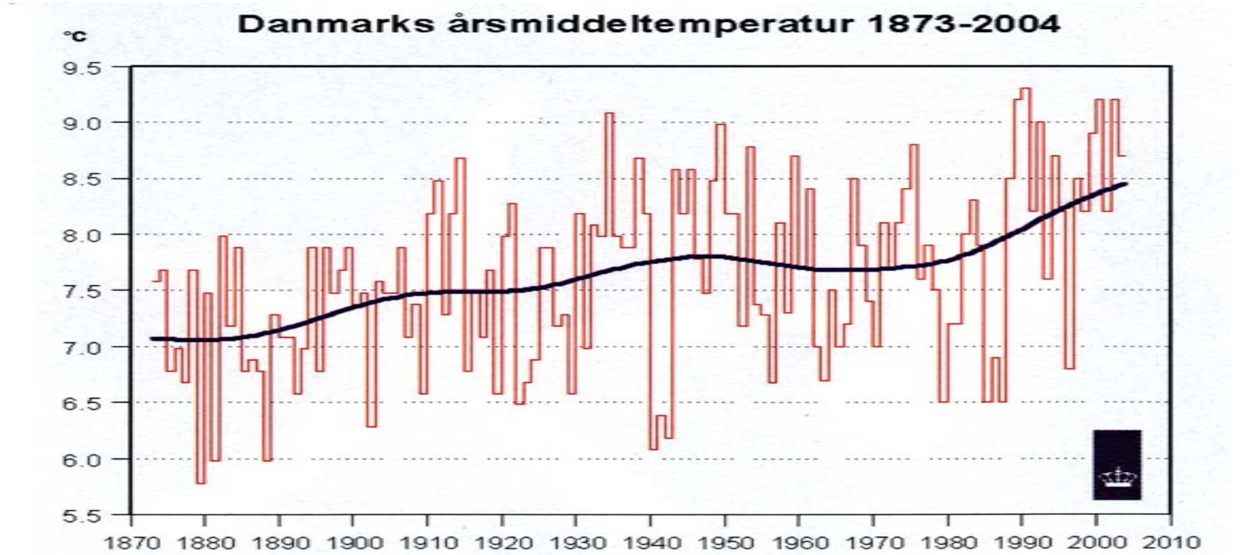
From BACC 2008.

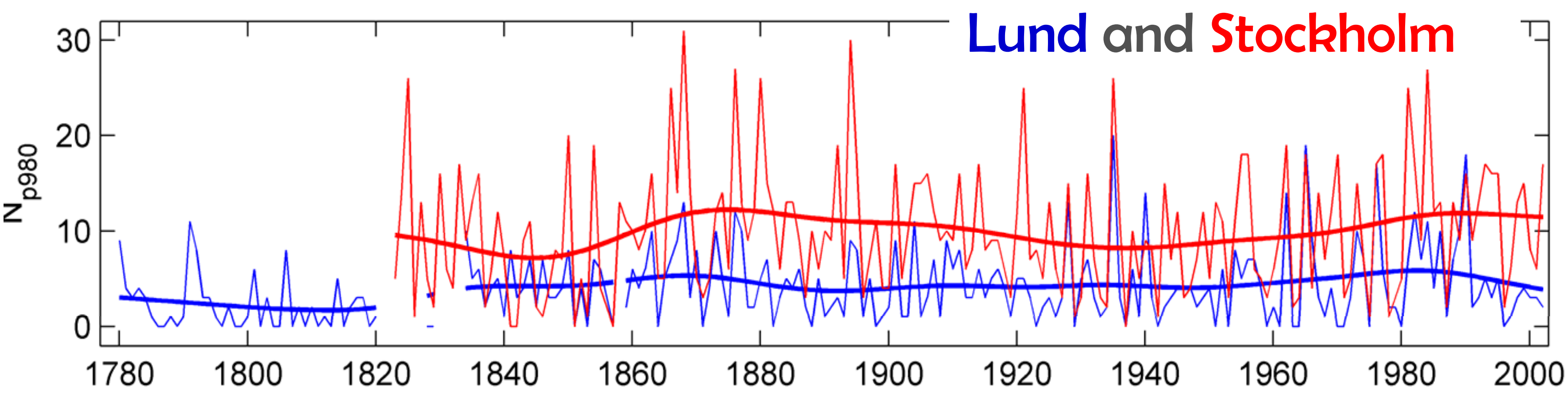


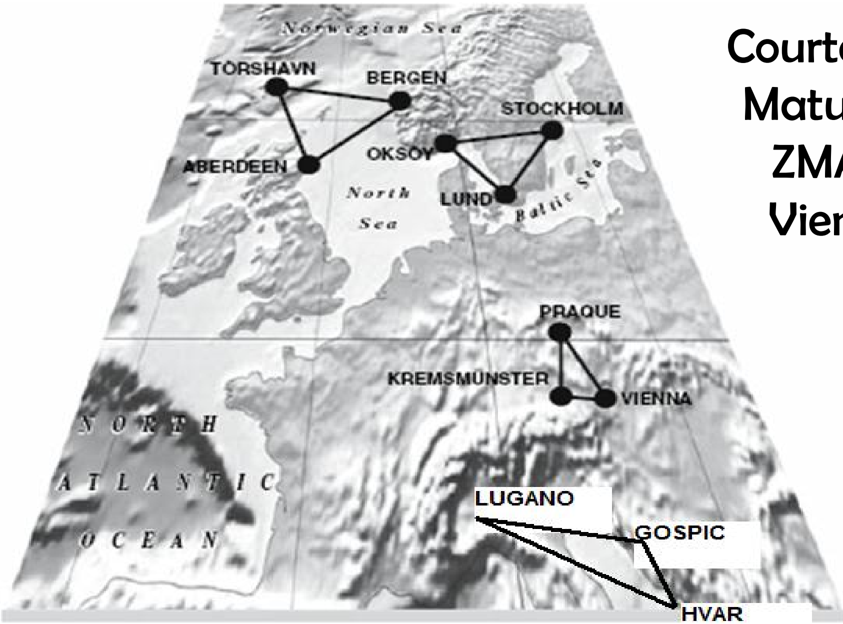
Kajaani
Kaajani, Finland
1880
1900
1920
1940
1960
1980
2000
$N_{p<980hPa}$
$N_{|\Delta p|>16hPa/12h}$
$P_{95}(|\Delta p|)$
$P_{99}(|\Delta p|)$

Regional development of storminess and temperature

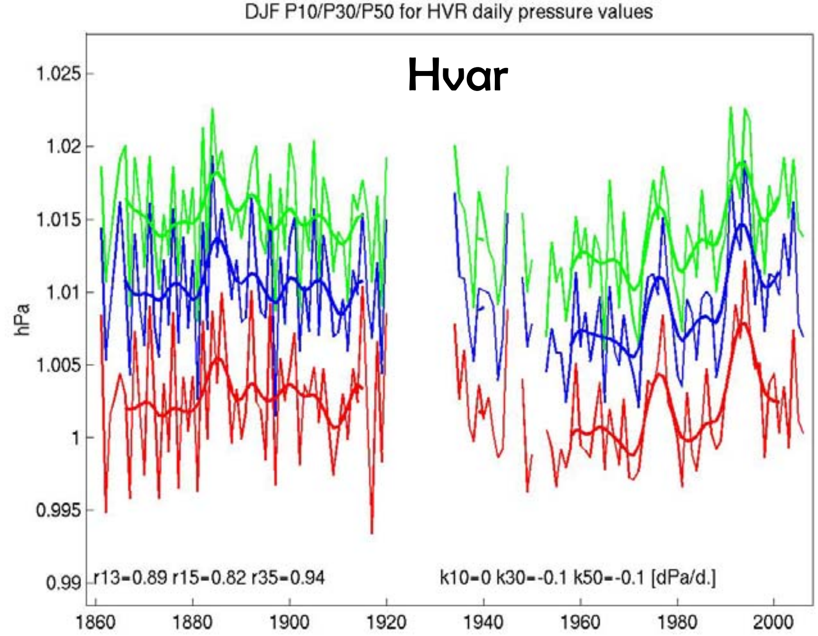
Unchanging extratropcial storm conditions is not contradicting the fact that temperature is rising,

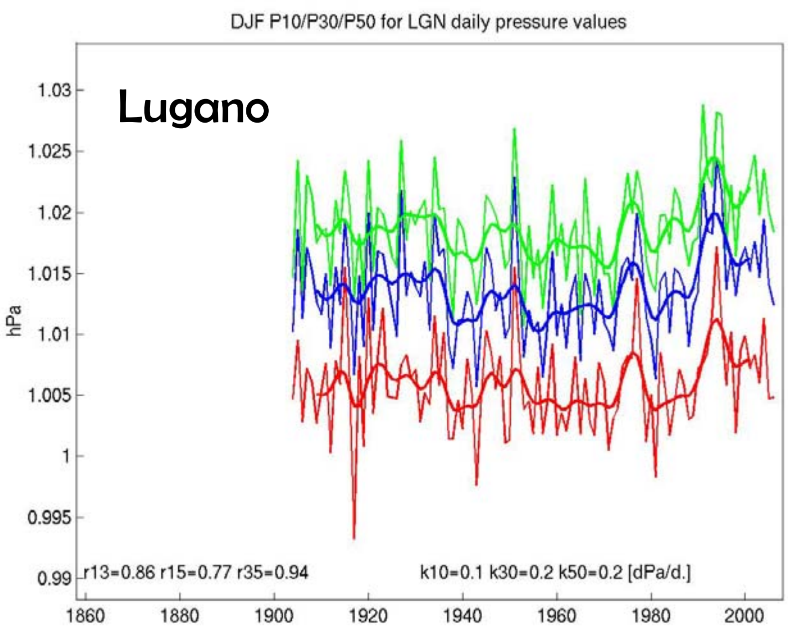


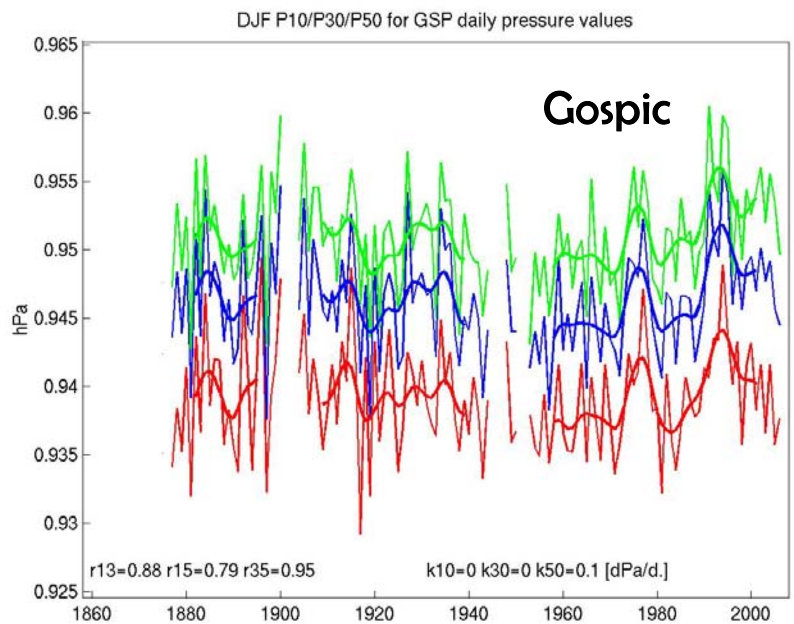


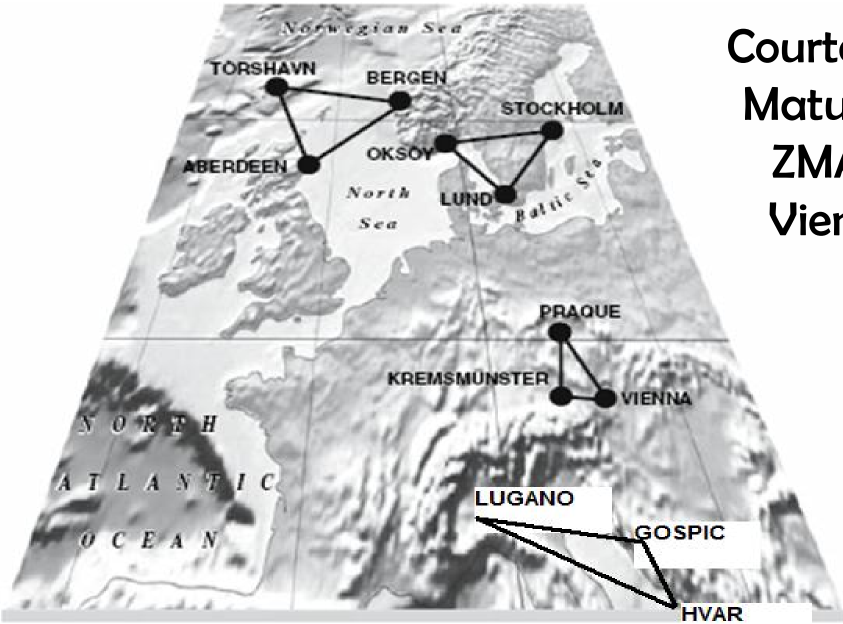


Courtesy: Matulla, ZMAG, Vienna

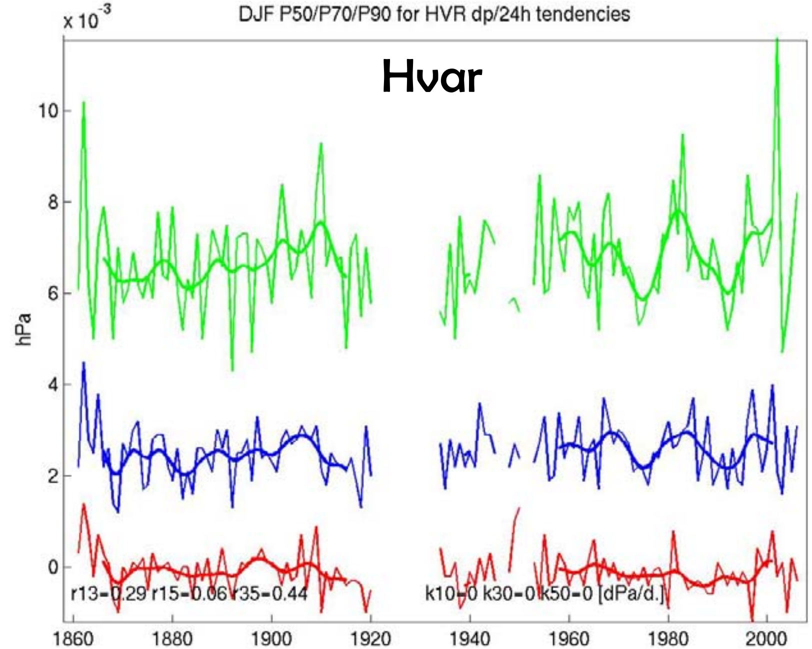


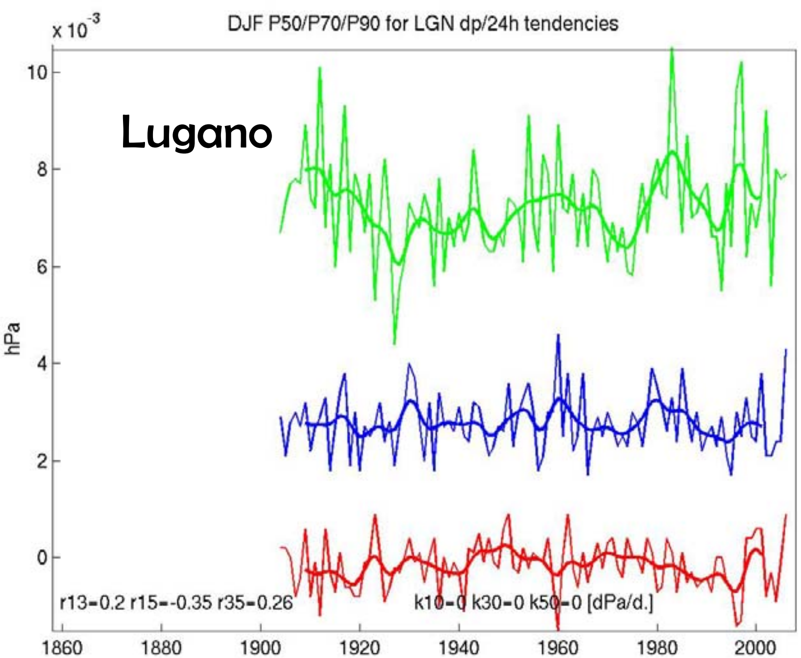


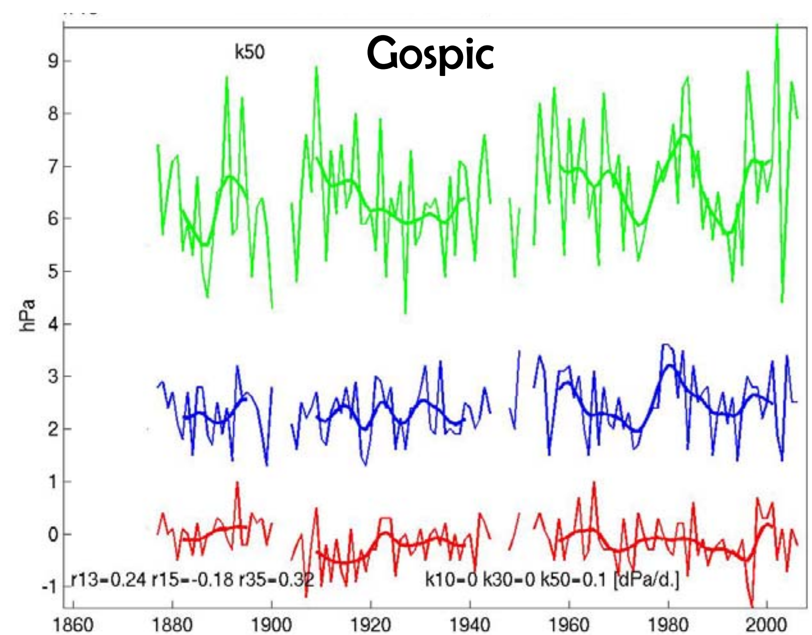




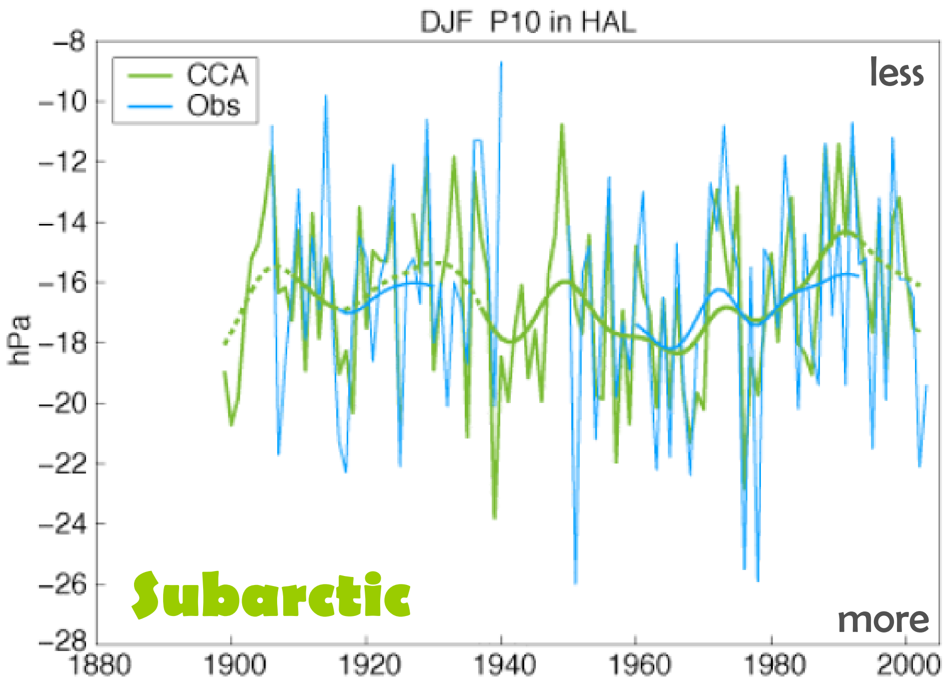
Courtesy: Matulla, ZMAG, Vienna

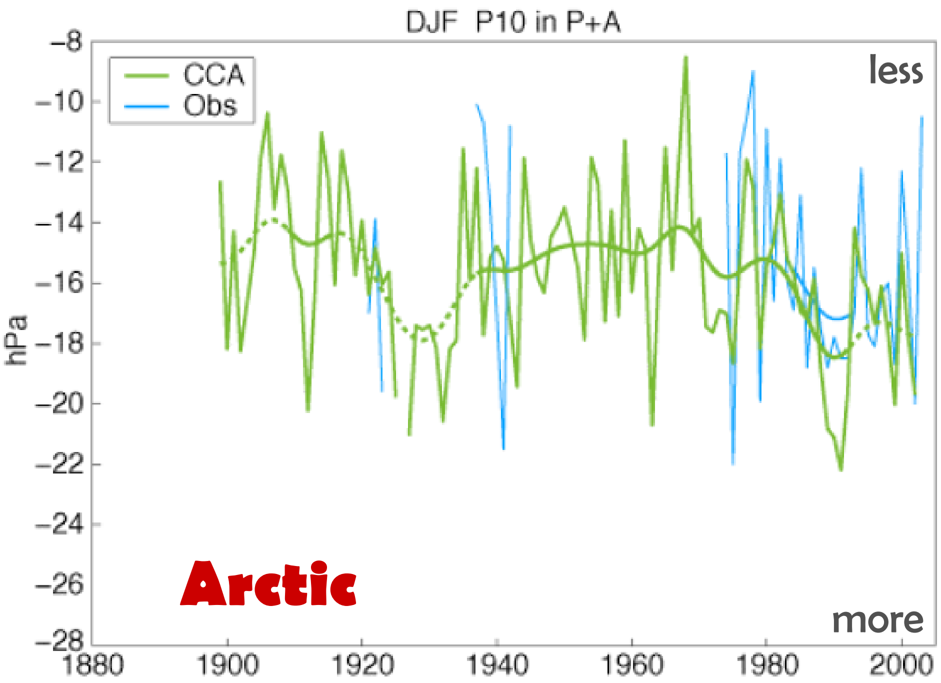






Pressure Proxies E Canada



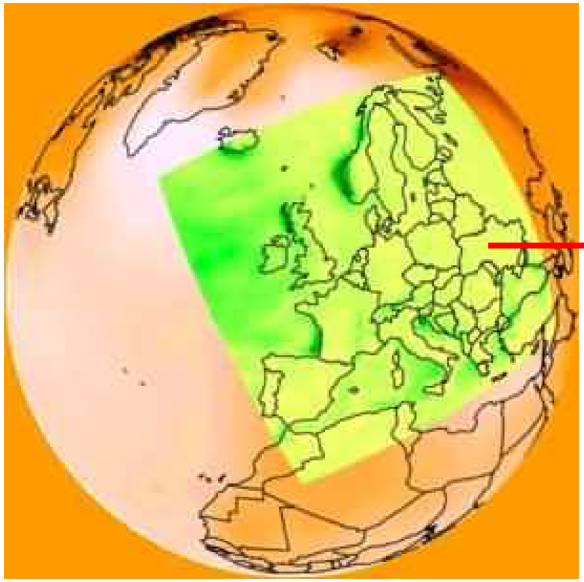


Change of intra-winter 10%-ile of pressure readings at E Canadian stations Halifax and PondInlet in the Arctic.

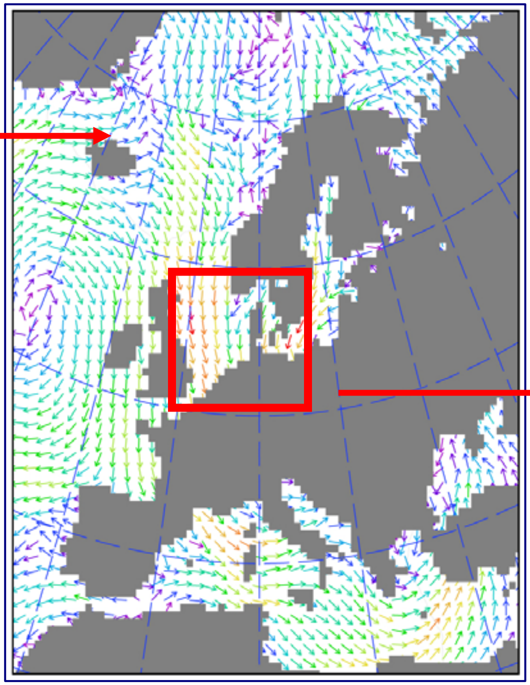
Dynamical downscaling of large scale re-analyses

Applications: past and future marine weather in N Europe

downscaling cascade for constructing variable regional and local marine weather statistics

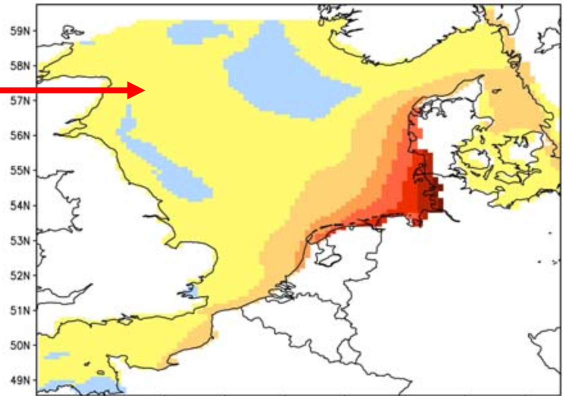


Globale development (NCEP)



Dynamical Downscaling REMO or CLM

Simulation with barotropic model of North Sea

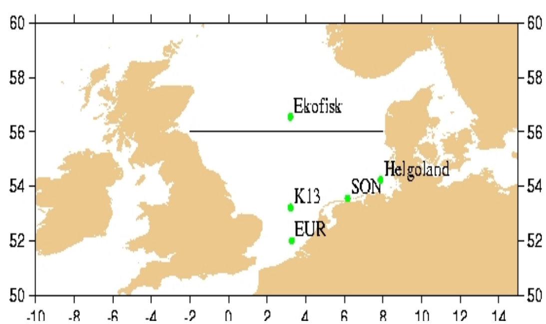


Cooperation with a variety of governmental agencies and with a number of private companies

Dynamical Downscaling: Baroclinic storms

Problem solved for synoptic systems in N Europe in CoastDat@GKSS, using RCM spectrally nudged to NCEP

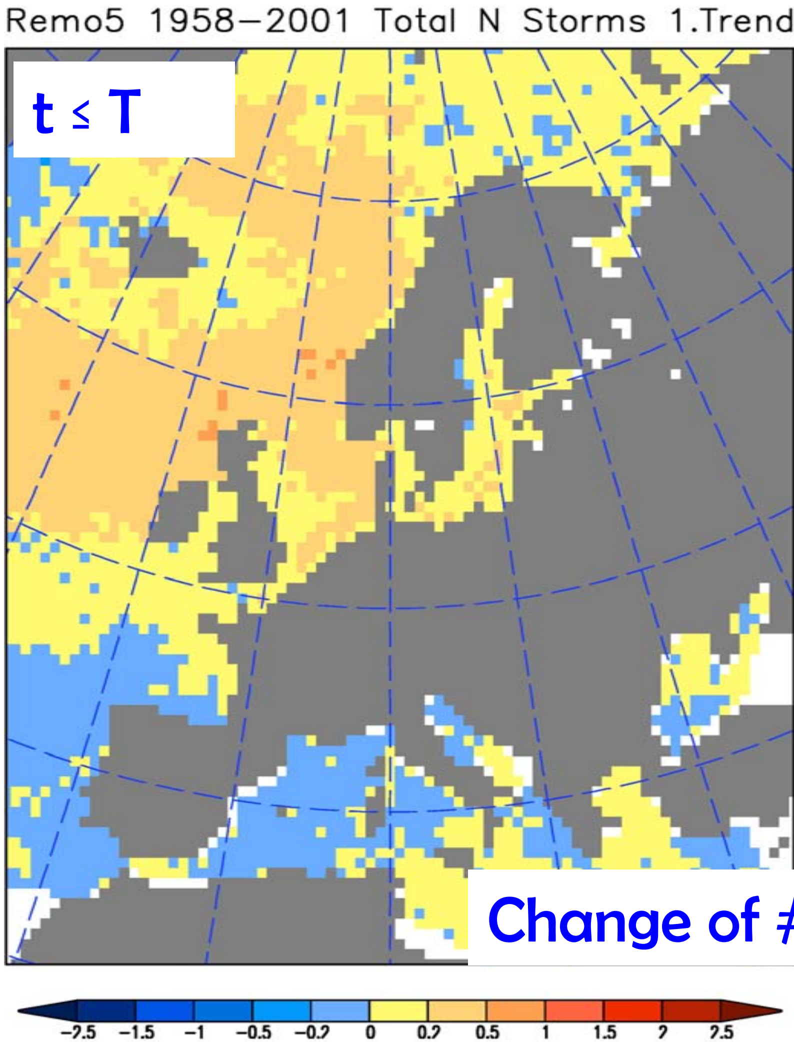
- retrospective analysis 1958-2005
- good skill with respect to statistics, but not all details are recovered.

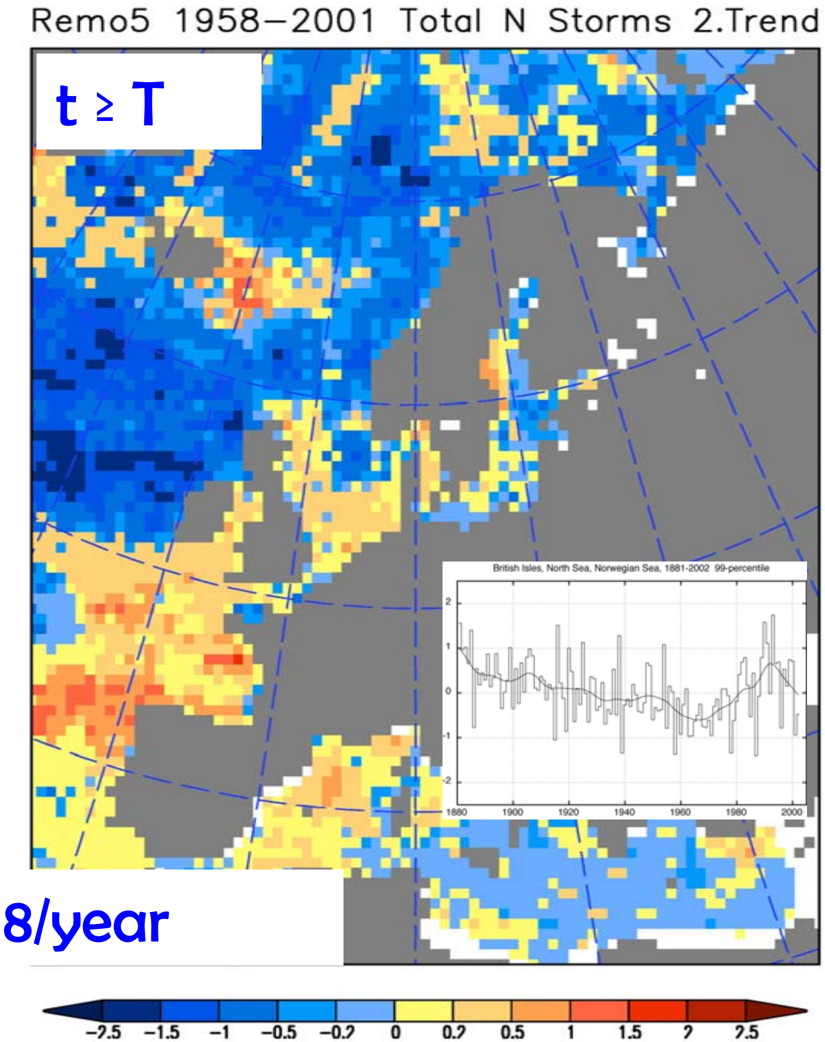


		Wind [m/s]					
		coastDat			Observed		
	Years	x_r^{90}	x_r	x_r^{90}	x_r^{90}	x_r	x_r^{90}
K13	2	24.38	25.17	25.96	24.05	25.21	26.37
	5	25.86	27.28	28.70	25.75	27.64	29.53
	25	28.44	31.33	34.22	28.09	32.77	37.45
EUR	2	22.50	23.16	23.82	23.16	24.03	24.90
	5	23.76	24.82	25.88	24.33	25.94	27.55
	25	25.67	28.00	30.33	26.43	29.75	33.07

Weisse, R., H. von Storch and F. Feser, 2005: Northeast Atlantic and North Sea storminess as simulated by a regional climate model 1958-2001 and comparison with observations. J. Climate 18, 465-479

Stormcount 1958-2001





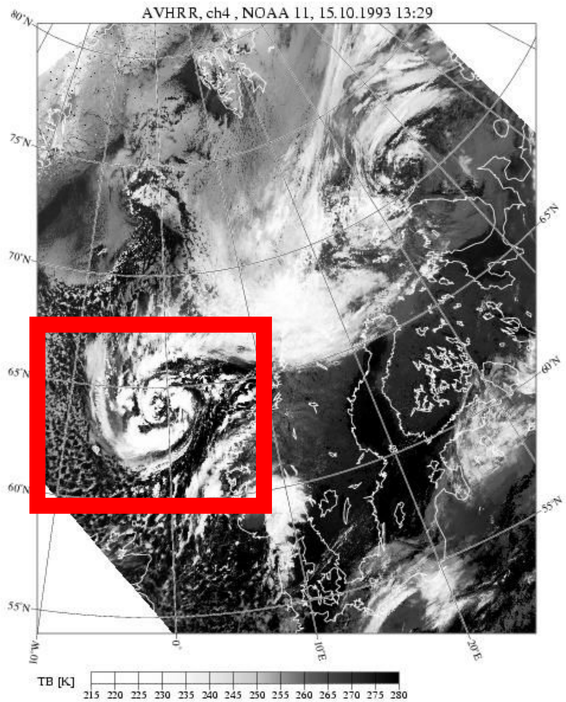
Change of # Bft 8/year

Weisse et al., J. Climate, 2005

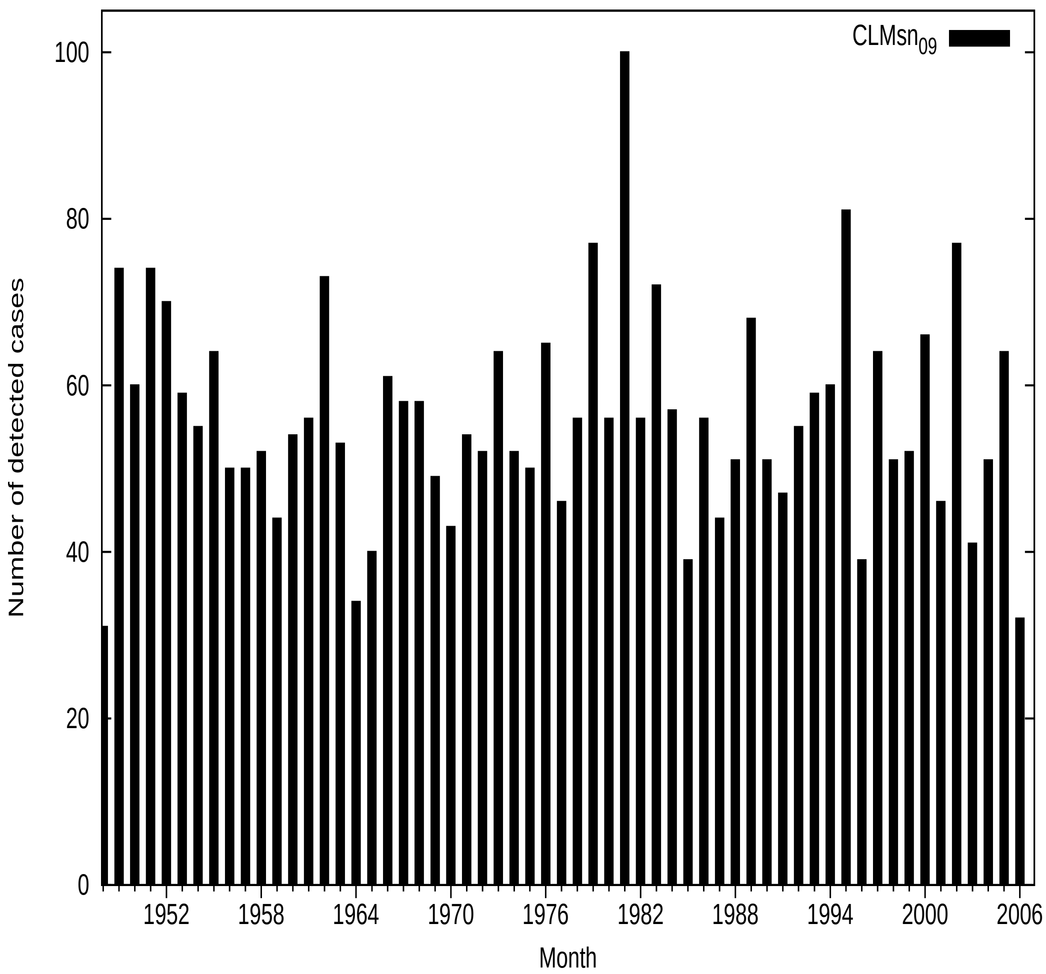
Dynamical Downscaling: Polar Lows

Joint work with Matthias Zahn

Continuous simulation with regional model CLM, 1948-2006, run and (large-scale) constrained with NCEP/NCAR re-analysis

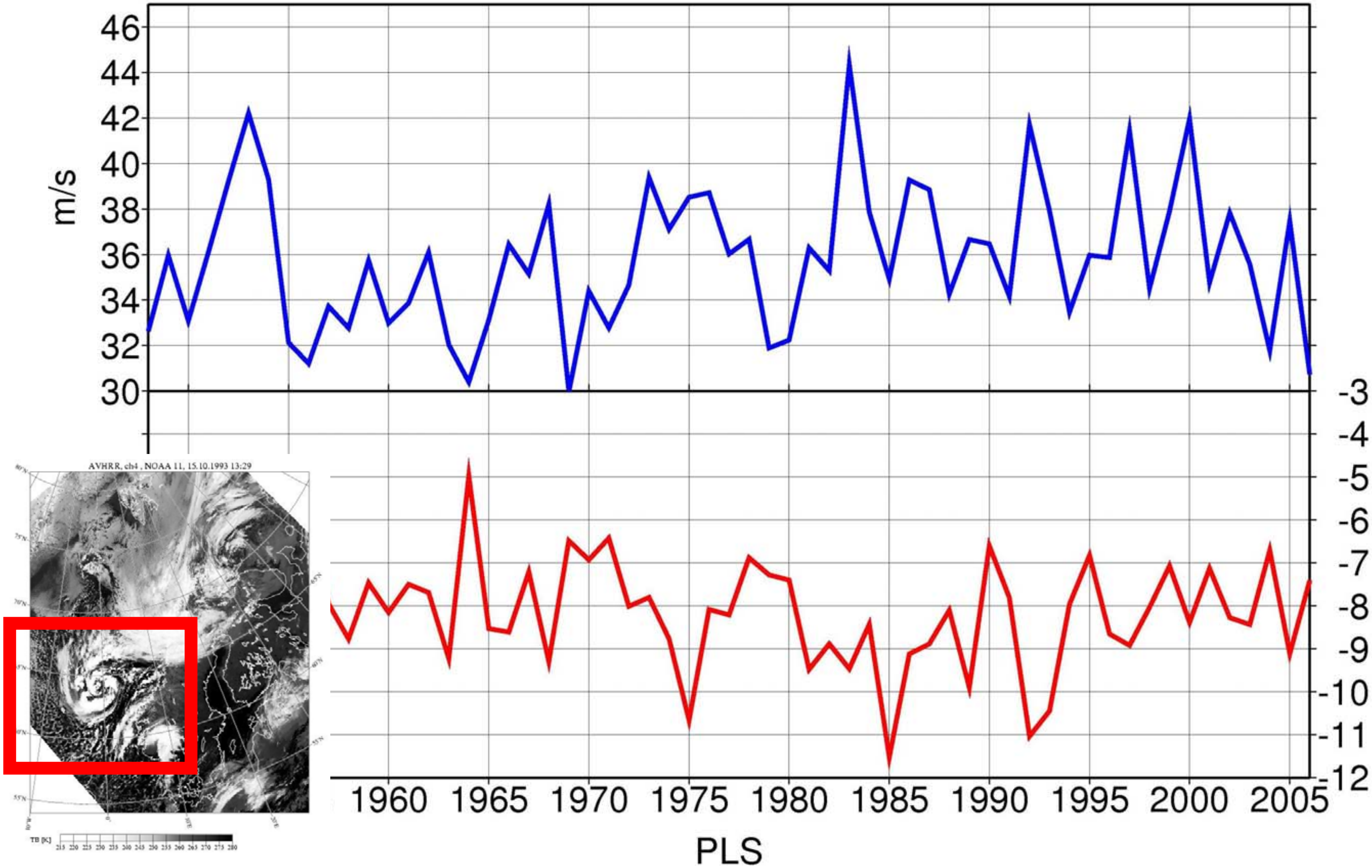


No. of PLows detected in the respective winter (Jul y-1 til Jun y), calc. period Jan 1948 - Dec. 2006

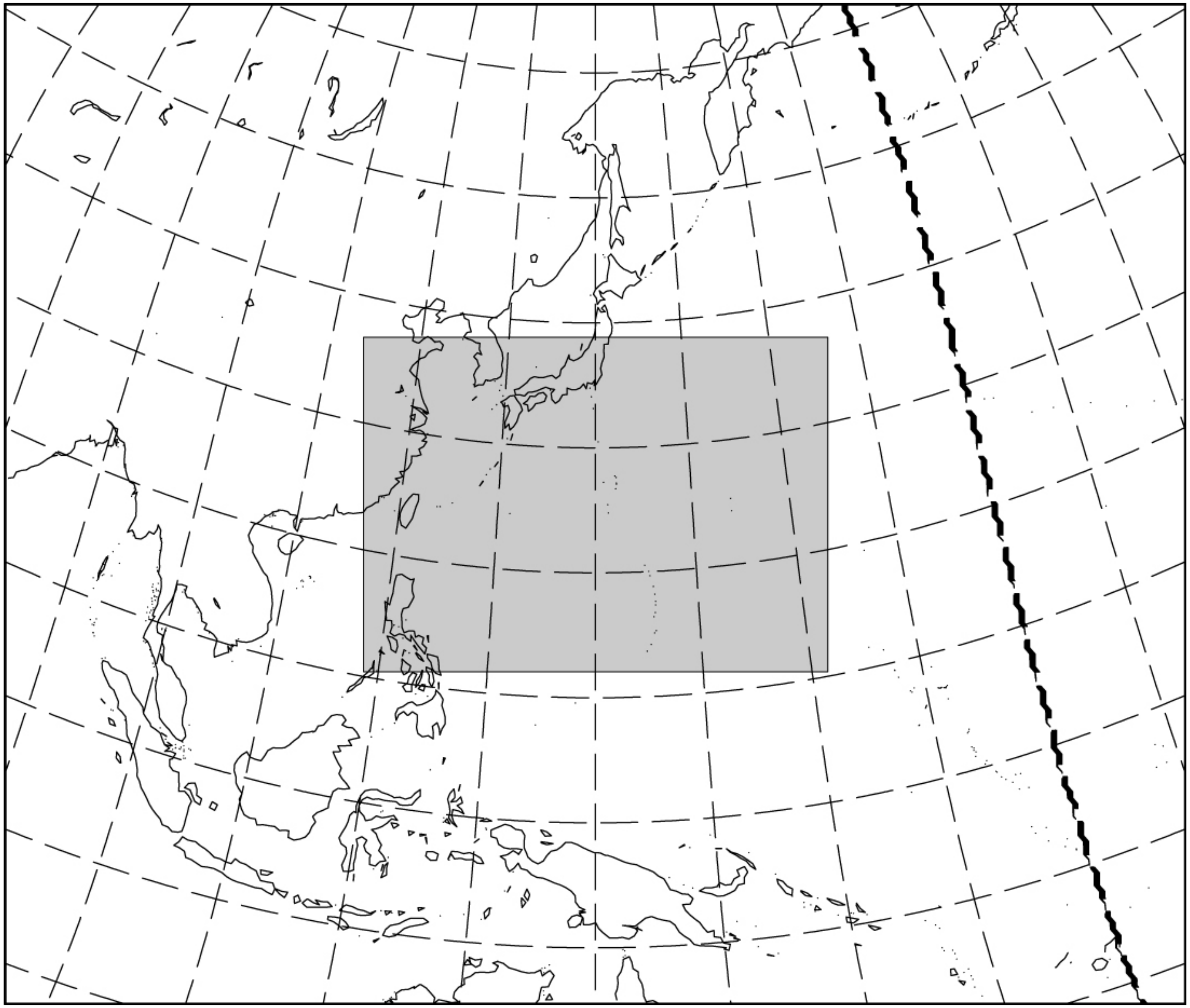


Joint work with Matthias Zahn

Max Ws and Min fmslp per PL season



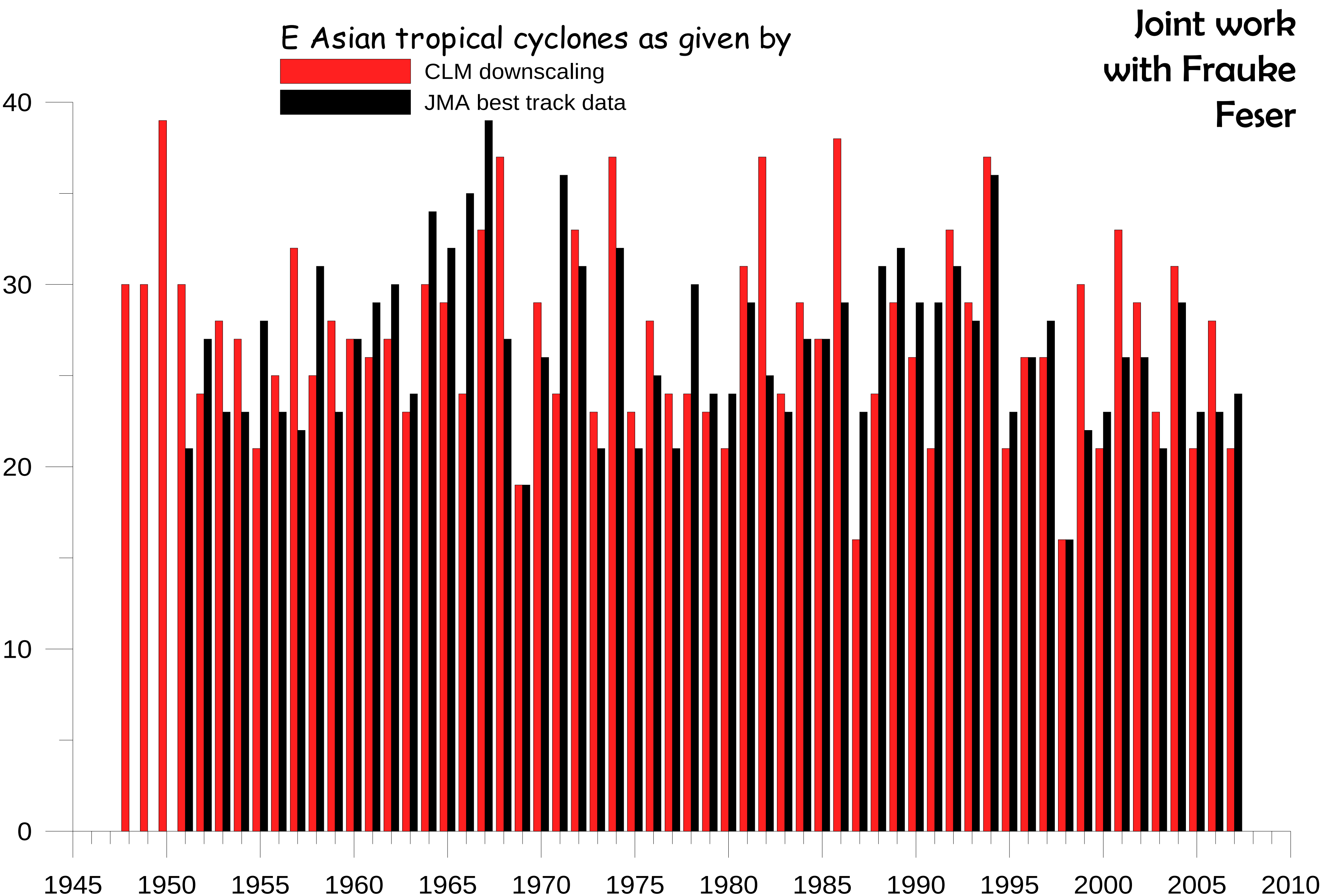
Dynamical Downscaling: E Asian Typhoons



60 year simulation with 50 km grid,

Experimental case and season simulations with embedded 18 km grid.

Joint work with Frauke Feser



Note: different criteria employed

Conclusion: Usage of proxies

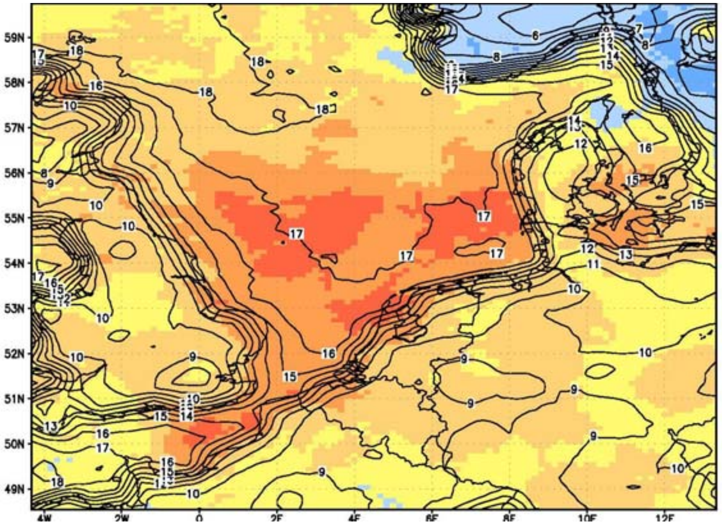
1. Monitoring extra-tropical storminess may be based on air pressure proxies.
2. This allows assessments for 100 and more years.
3. Decades long upward and downwards trends have been detected in recent years.
4. These trends are not sustained and have show recent reversals in all considered regions.
5. Recent trends are not beyond the range of natural variations, as given by the historical past, but are more of intermittent character. Regional temperatures rose significantly at the same time.

Conclusion: Usage of dynamical downscaling

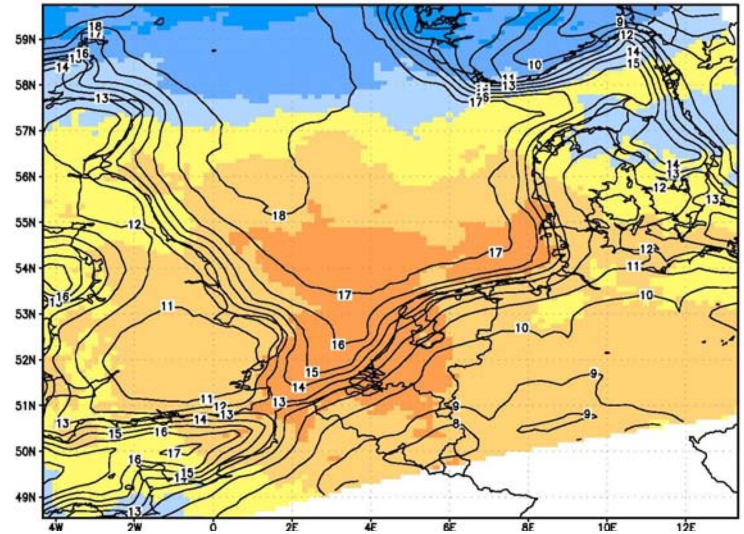
1. Dynamical downscaling for describing synoptic and mesoscale variability is doable.
2. Simulation of extra-tropical baroclinic disturbances satisfying; wind my be used for simulating wave and surge climatologies and trends.
3. Results for mid-latitude baroclinic storms consistent with result obtained through pressure proxies – no overall trend.
4. Meso-scale variability (Polar Lows and Tropical Cyclones) is also described, but the depth of the cyclones is not as deep as found in reality; also the winds are too weak.
5. Analysis of 60 year simulations point to strong year-to-year variability in polar low and E Asian TC activity, to less decade-to-decade variability and no noteworthy trend in frequency.

A2 - CTL: changes in 99 % - iles of wind speed (6 hourly, DJF): west wind sector selected (247.5 to 292.5 deg)

HIRHAM

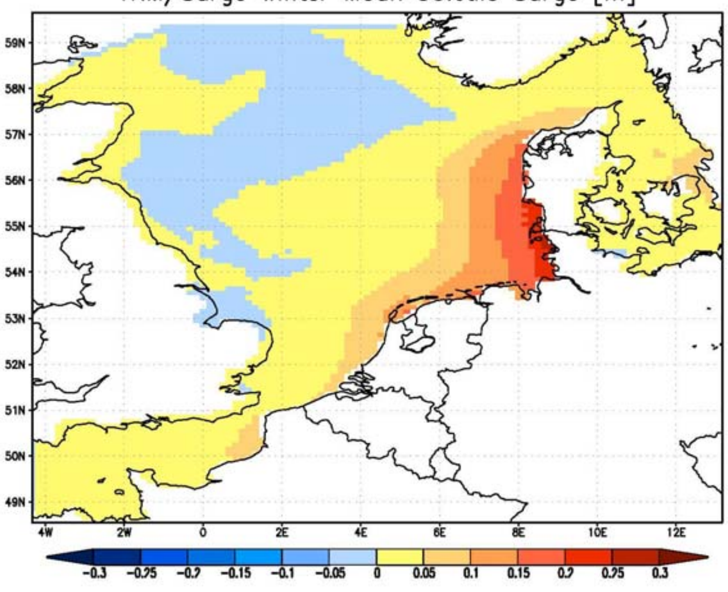


RCAO

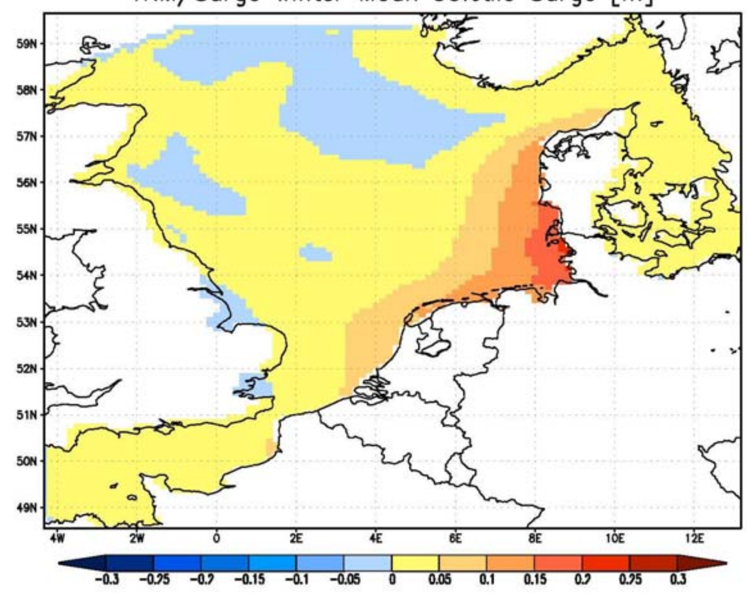


Scenarios for 2085

TRM/Surge winter Mean 99%tile Surge [m]

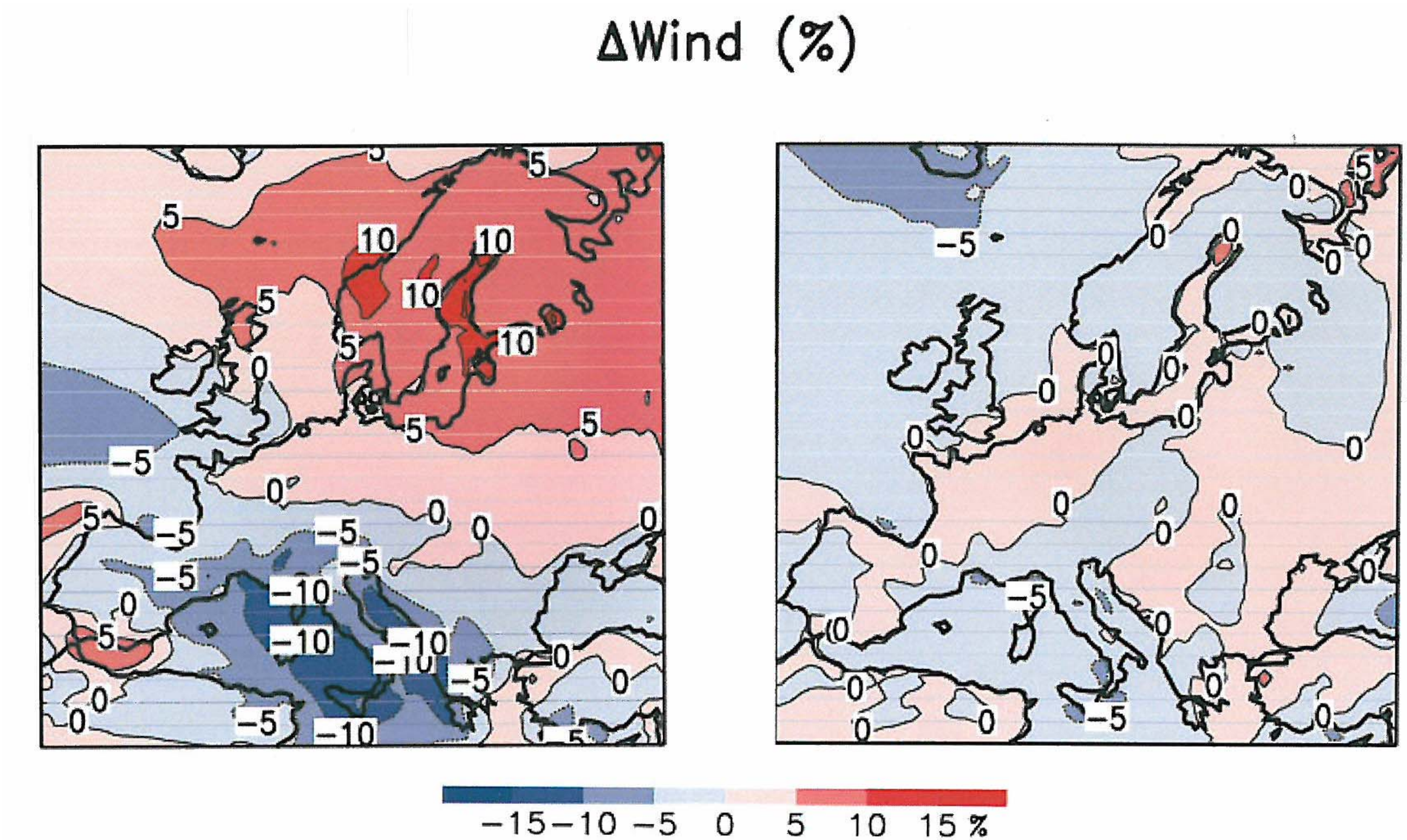


TRM/Surge winter Mean 99%tile Surge [m]



Woth, personal communication

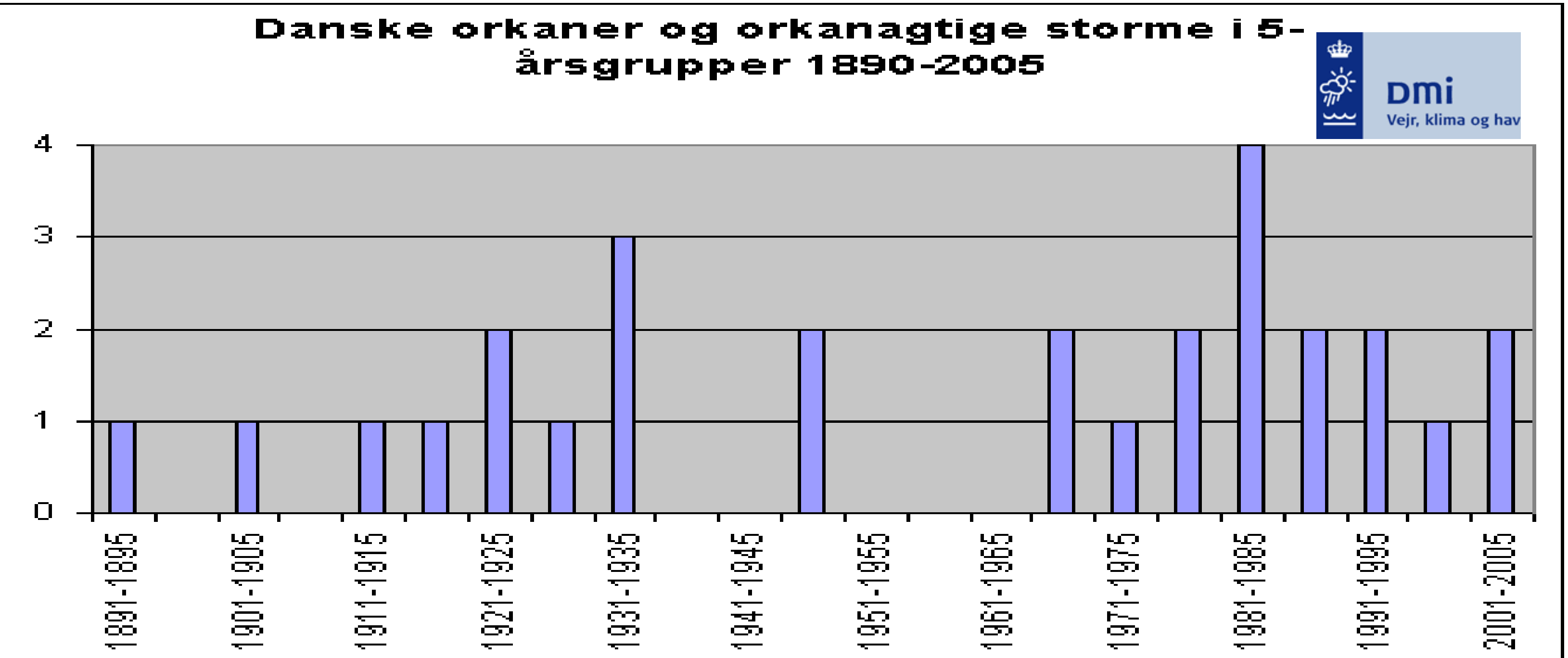
What may happen in the future?



RCAO/ECHAM4 A2 Szenario RCAO/HadAM3H

IPCC 2007

2008-03-13



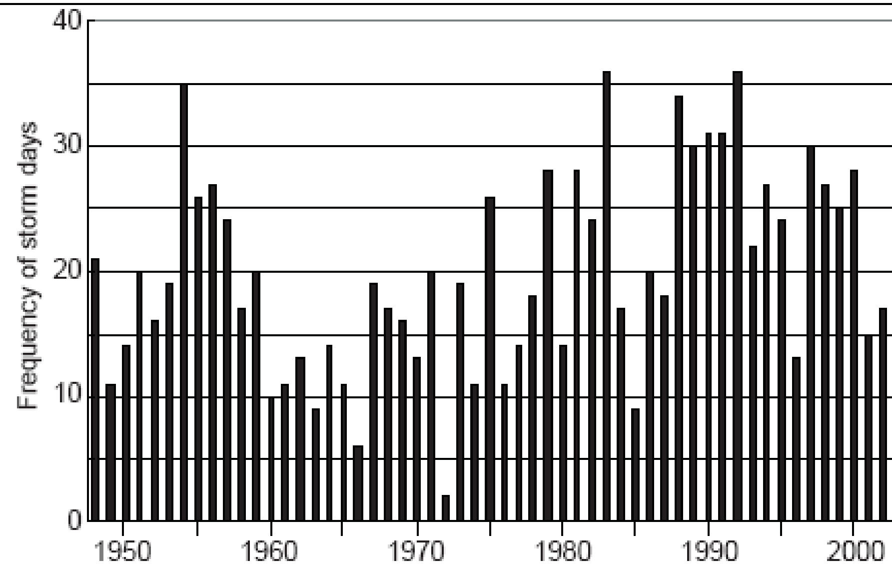


Fig. 2.29. Annual frequency of 'storm days' at Vilsandi, Saaremaa Island, Estonia, derived from homogenised wind measurements. A day was designated as a 'storm day' when mean wind speed during a single observation (10 minutes) was 15 m s^{-1} or higher (adapted from Orviku et al. 2003)