Baltic from Space Workshop, 29-31 March 2007
Helsinki Finland

Salinity Dynamics in the Baltic Sea

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Baltic Earth
Earth System Science for the Baltic Sea Region

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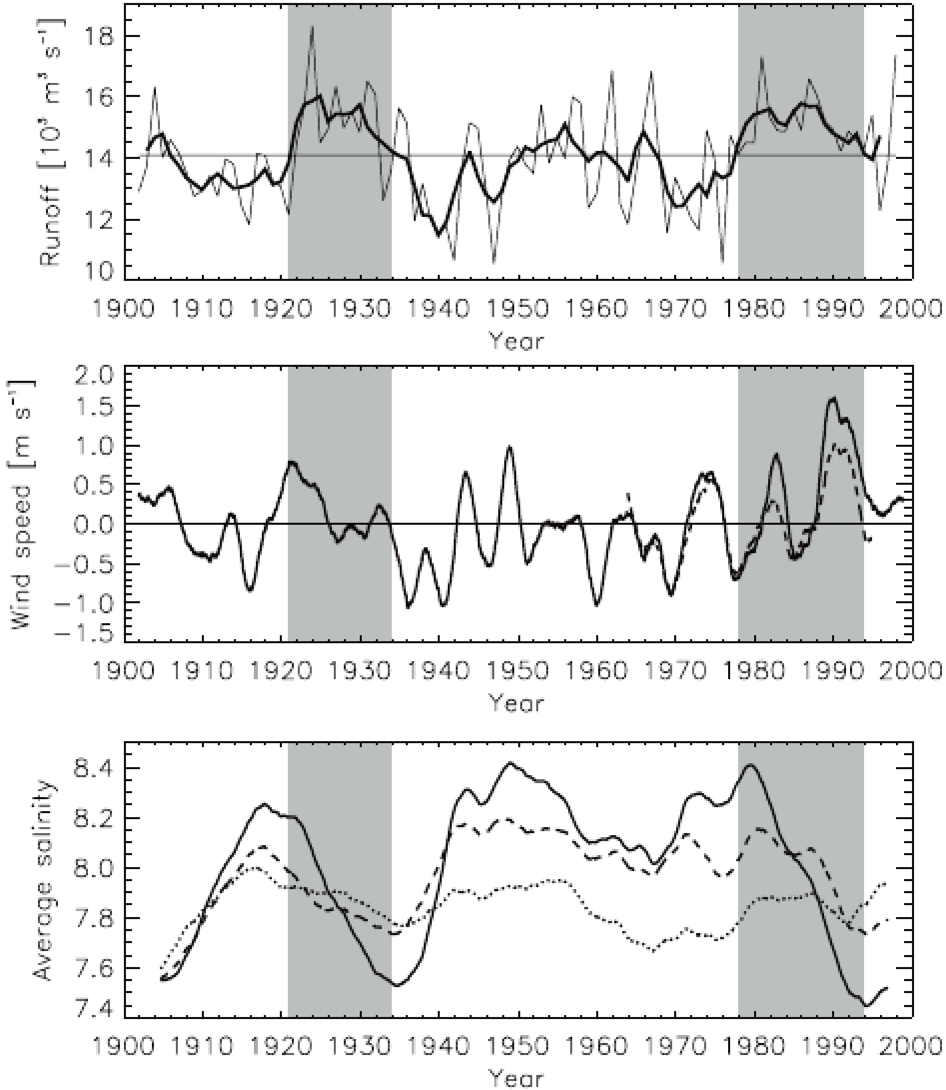
Salinity dynamics long-term changes

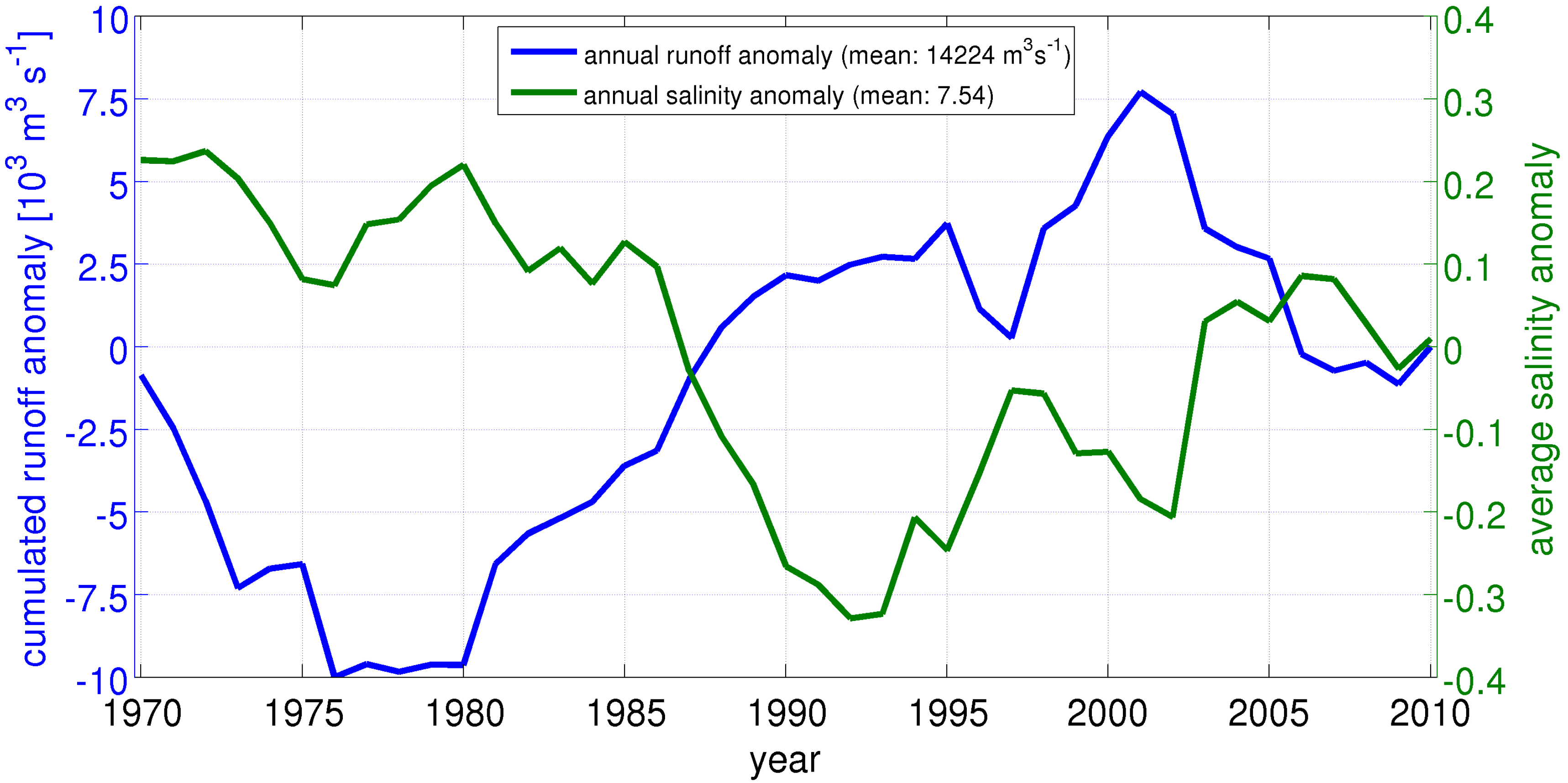


Salinity is an elementary factor Controlling the ecosystem of the Baltic Sea

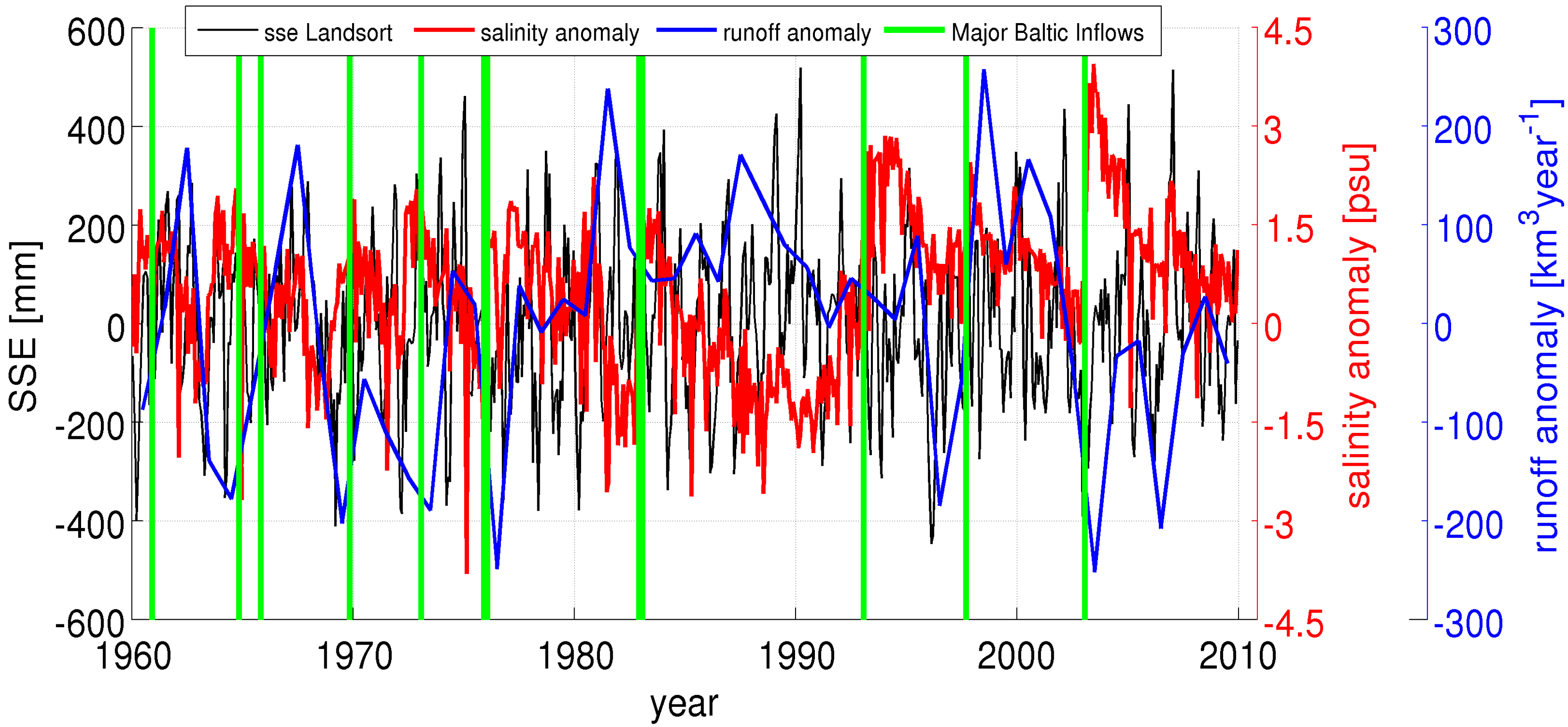
BACC 2008 (Meier & Kauker, 2003):

- no long-term trend in the mean salinity for the 20th century
- half of the decadal variability is explained by the accumulated river runoff
- the remaining decadal variability is explained by the zonal wind fluctuations

Salinity dynamics mid-term changes

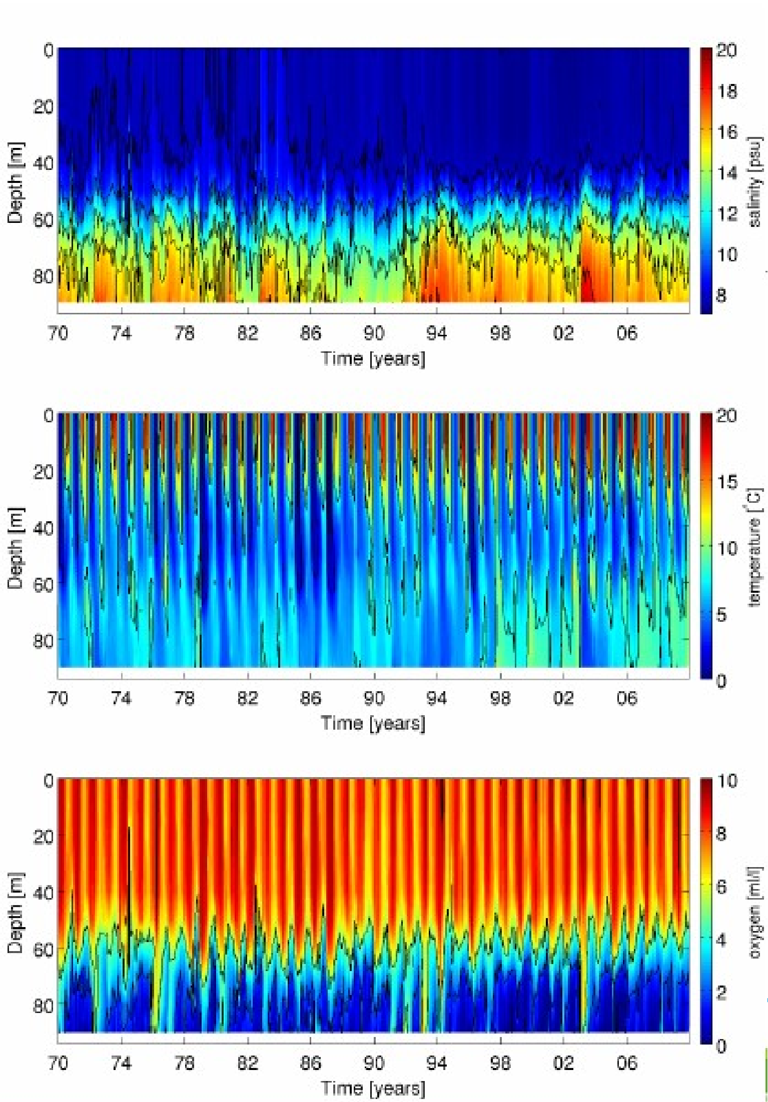


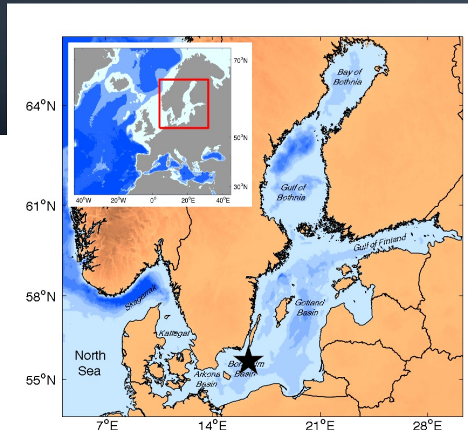
Salinity dynamics
Annual/decadal variability



SSE Landsort (black), SD 25 deep salinity (red), runoff (blue), MBI (green)

Salinity dynamics
Annual/decadal variability





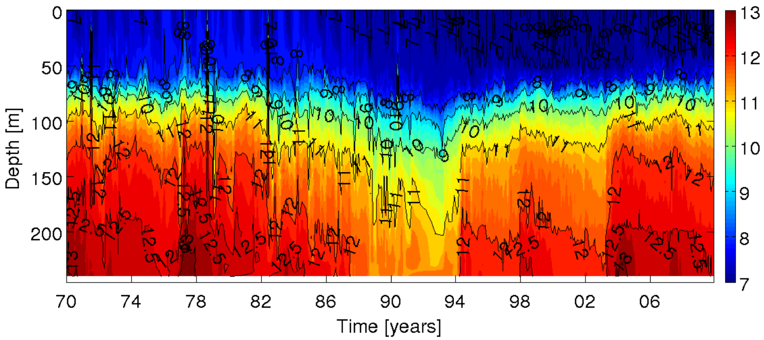
Salinity dynamics in the sub-basins of the Baltic Sea is more complex, and it impacts on the oxygen distribution in the deep basins.

Major players are:

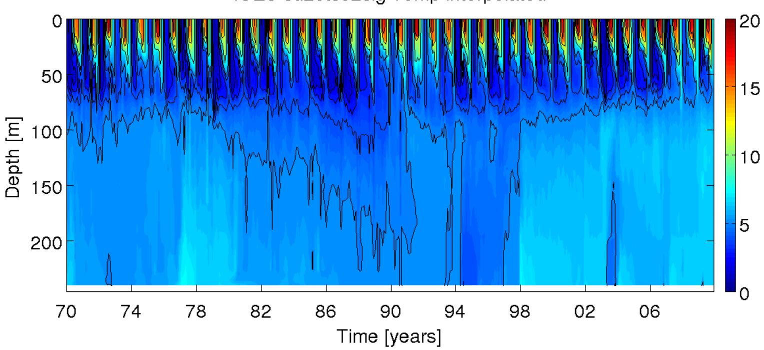
- Atmospheric circulation
- Large volume changes/Major Baltic Inflows
- Sub-basin water exchange
- Circulation and advection
- Net precipitation and runoff
- Turbulent mixing

Salinity dynamics
Annual/decadal variability

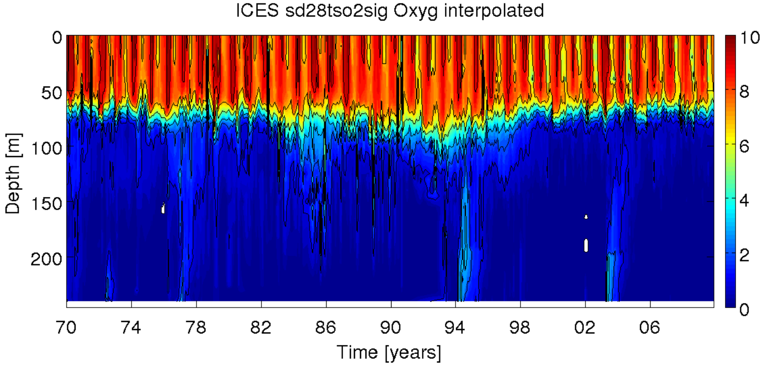
ICES sd28tso2sig Salt interpolated

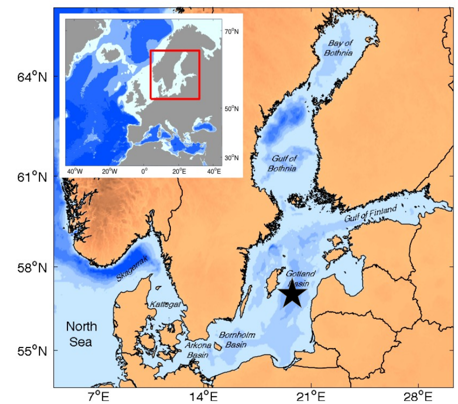


ICES sd28tso2sig Temp interpolated



ICES sd28tso2sig Oxyg interpolated





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Salinity dynamics
Trends 1979-2015

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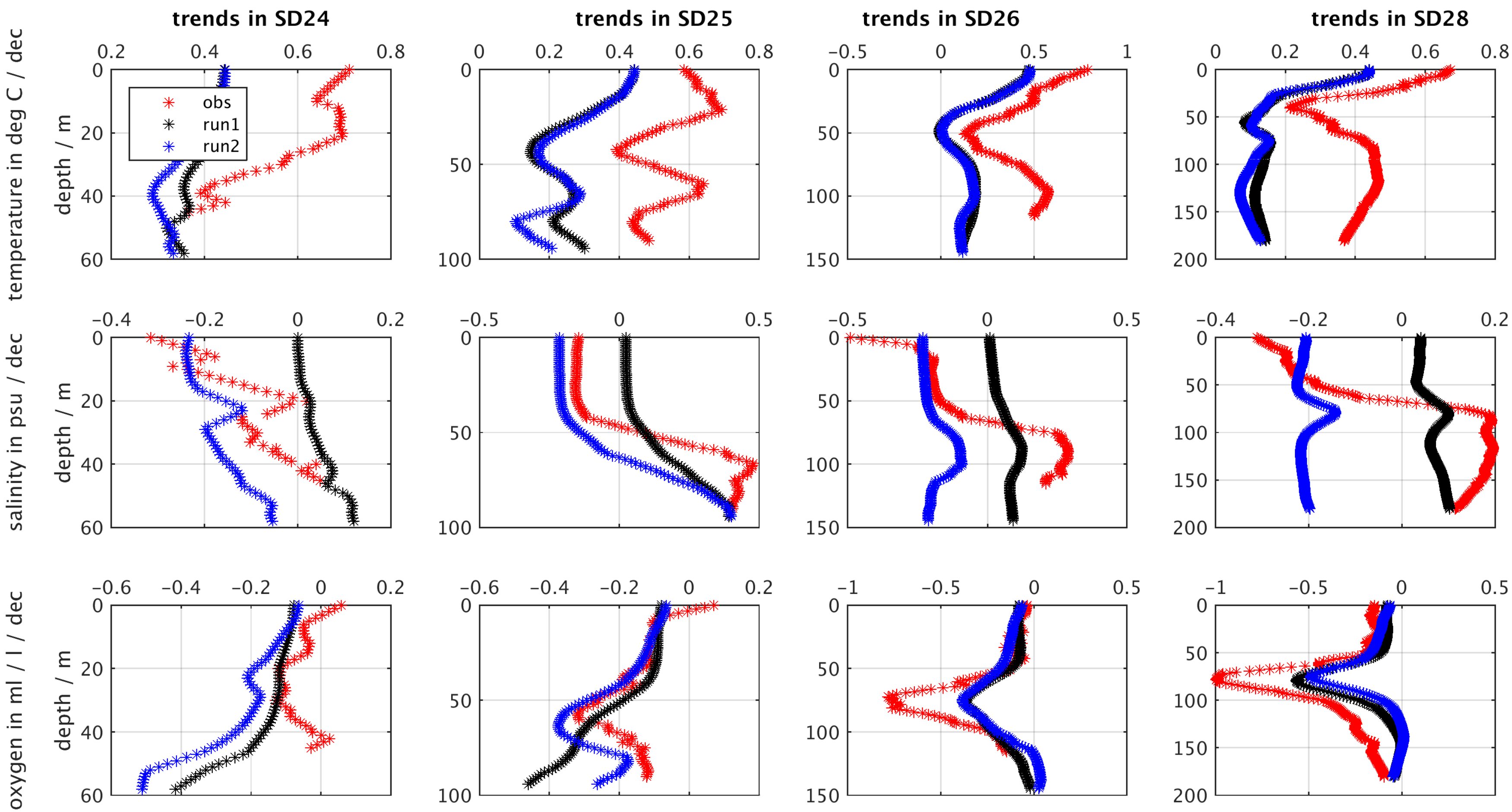

Arkona Basin | Bornholm Basin | Gdansk Basin | E-Gotland Basin

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Salinity dynamics
Trends 1979-2015

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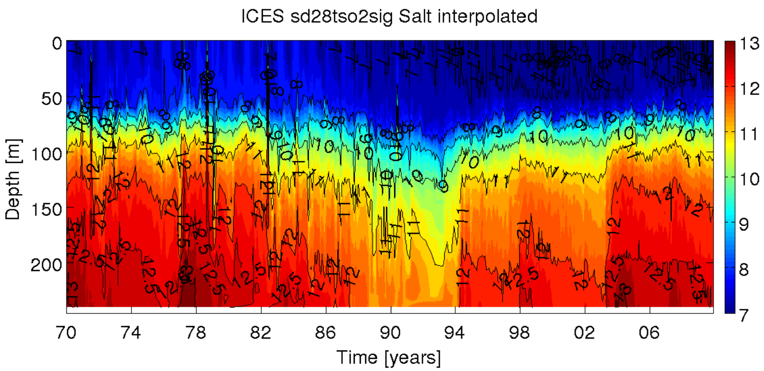
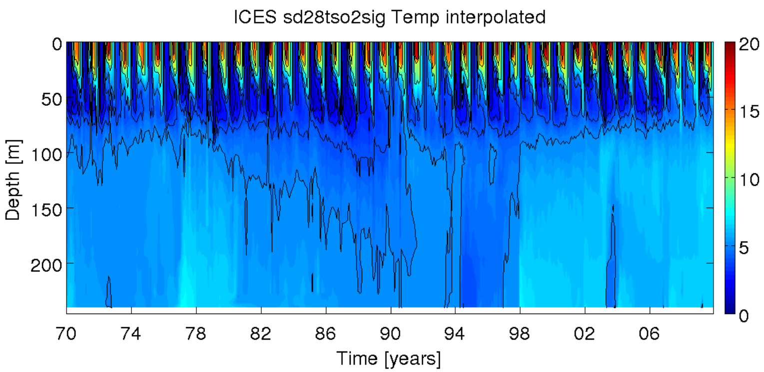
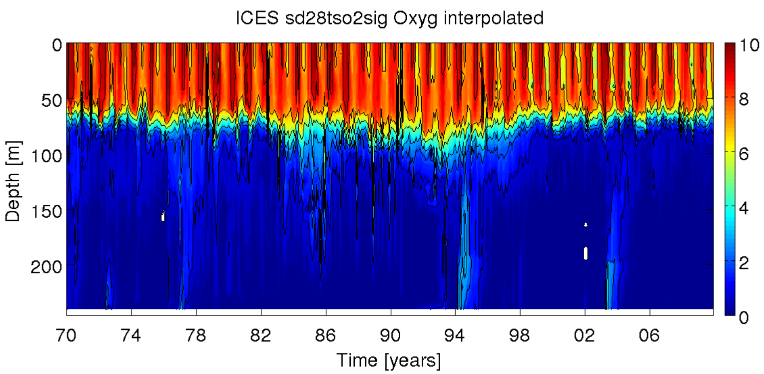
sd	air temperature [°C/dec]	precipitation [mm/year /dec]	rel. Humidity [%/dec]	temperature 1.5m [°C/dec]	salinity 1.5m [psu/dec]	oxygen 1.5m [ml/l /dec]
sd24	0.48	7.24	-0.37	0.44	-0.24	-0.07
sd25	0.45	0.38	-0.05	0.45	-0.21	-0.07
sd26	0.47	-12.87	-0.06	0.47	-0.23	-0.07
sd27	0.46	3.21	0.34	0.46	-0.20	-0.07
sd28	0.48	-4.11	0.06	0.44	-0.20	-0.07
sd29	0.55	2.72	-0.02	0.53	-0.16	-0.09
sd30	0.65	-4.47	0.22	0.45	-0.17	-0.08
sd31	0.68	22.08	0.61	0.40	-0.13	-0.07
sd32	0.60	5.98	-0.05	0.46	0.03	-0.09

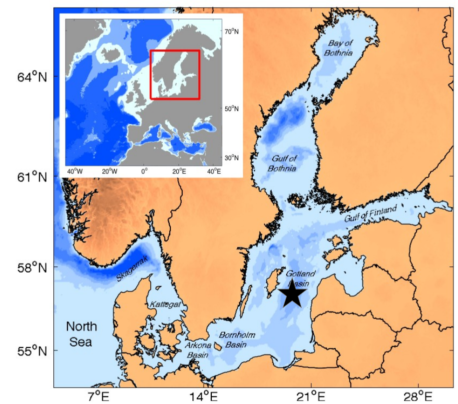
Atmospheric data ERA-Interim reanalysis 1979-2015

Salinity dynamics
Annual/decadal variability









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Large Volume Changes
Landsort SSE & Arkona MARNET Salinity

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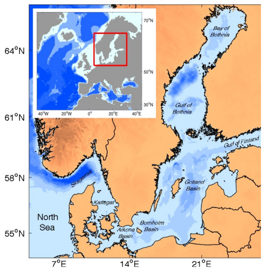
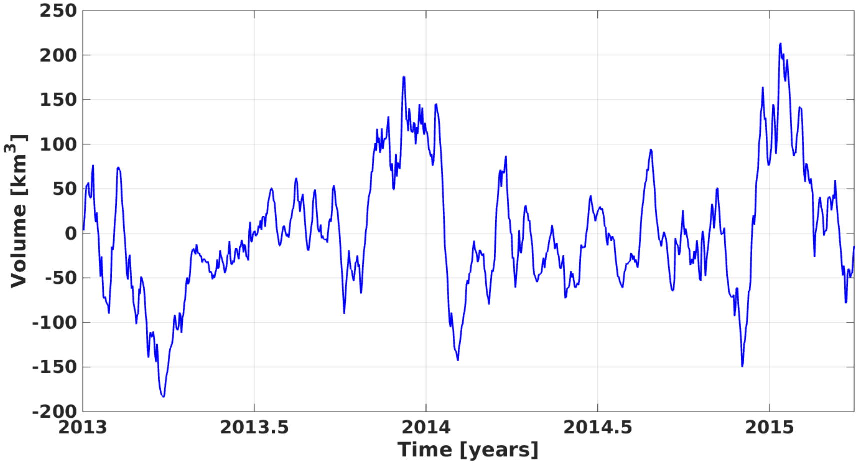
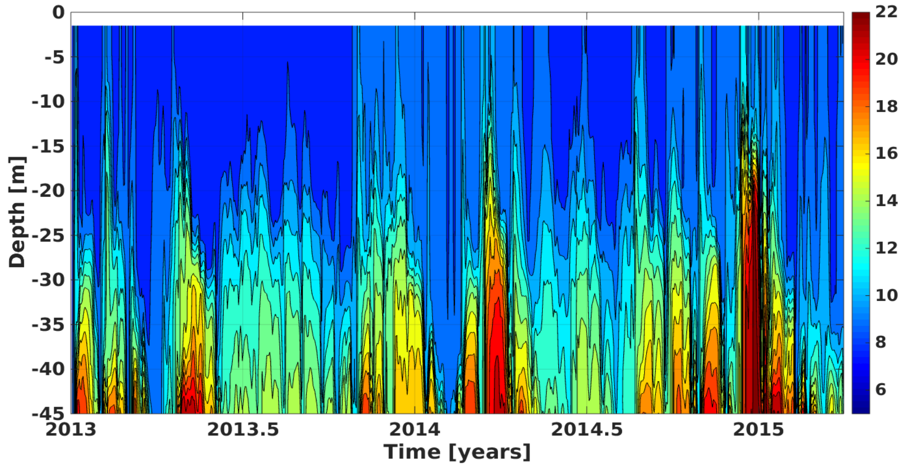




Volume change [km³]
2013-2015
caclulated from sea level data
at Landsort Norra



Salinity [PSU] at Arkona
MARNET station

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Sea level Landsort – Detection of LVCs/MBIs

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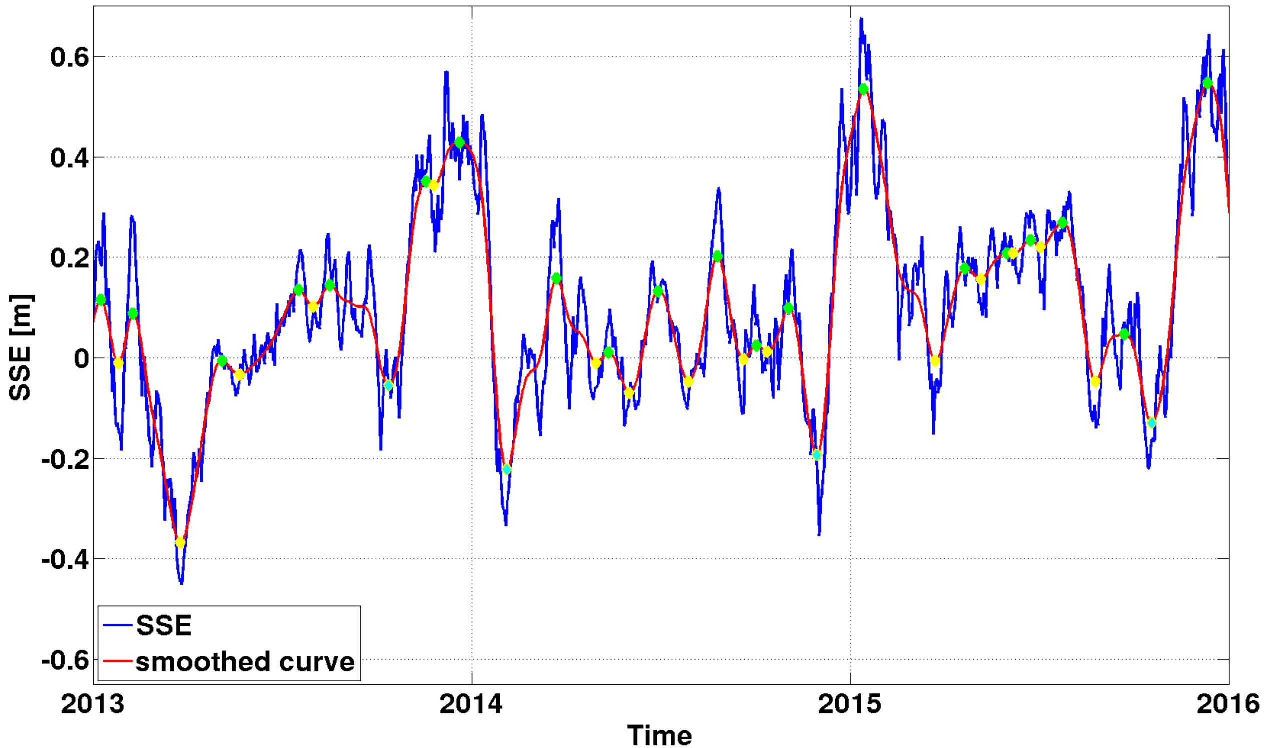
SSE 2013-2015 with tagged minima and maxima



SSE at Landsort (blue), filtered TS (red; Pasanen et al. 2013), minima (yellow), maxima (green); detected LVCs (cyan) defined as volume change of at least 60 km³, including runoff correction 1.3 km³/day

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LVCs – Large Volume Changes

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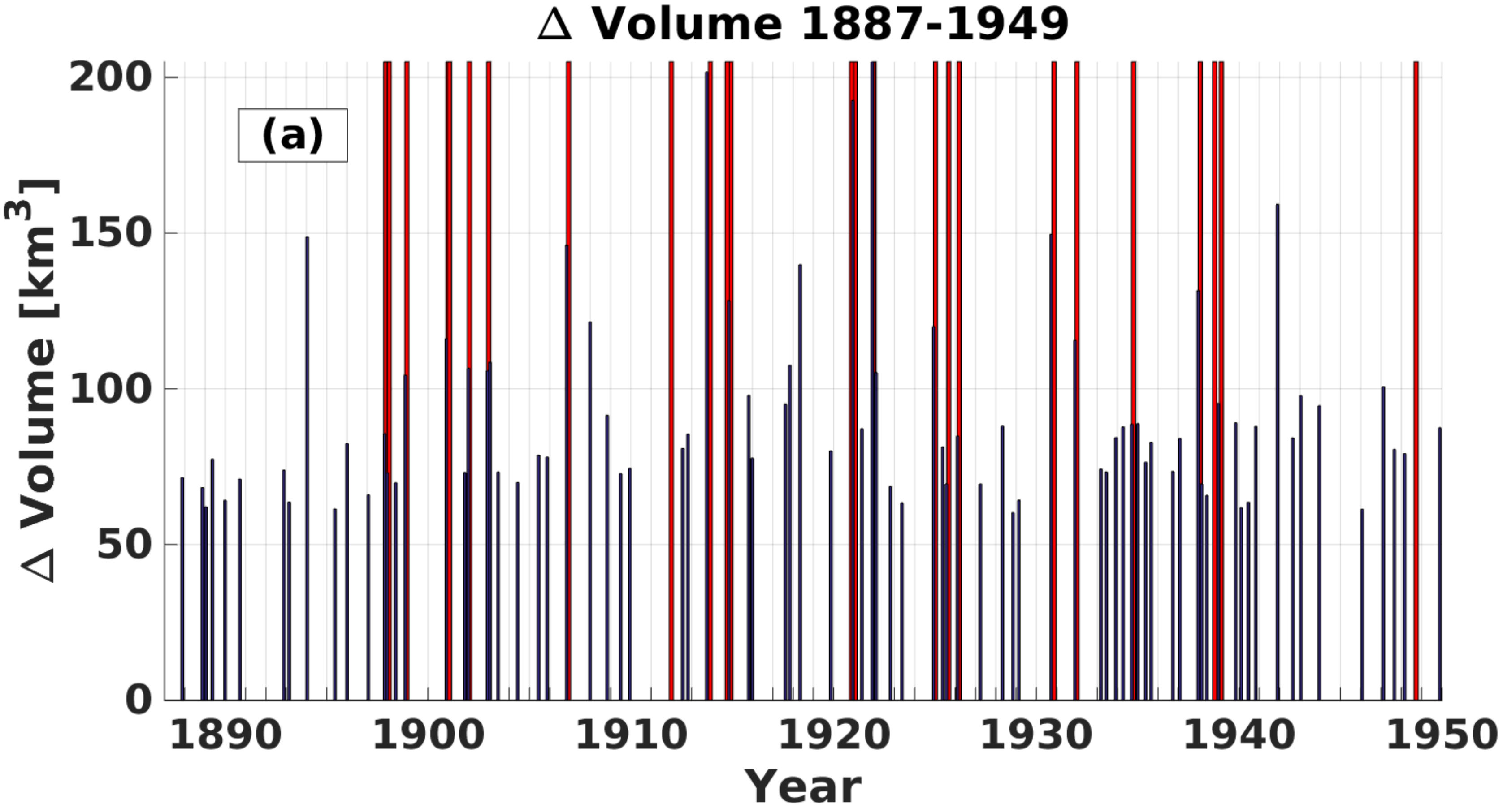

Detected LVCs (blue), observed MBIs (red), threshold 60 km³, runoff compensated

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LVCs – Large Volume Changes

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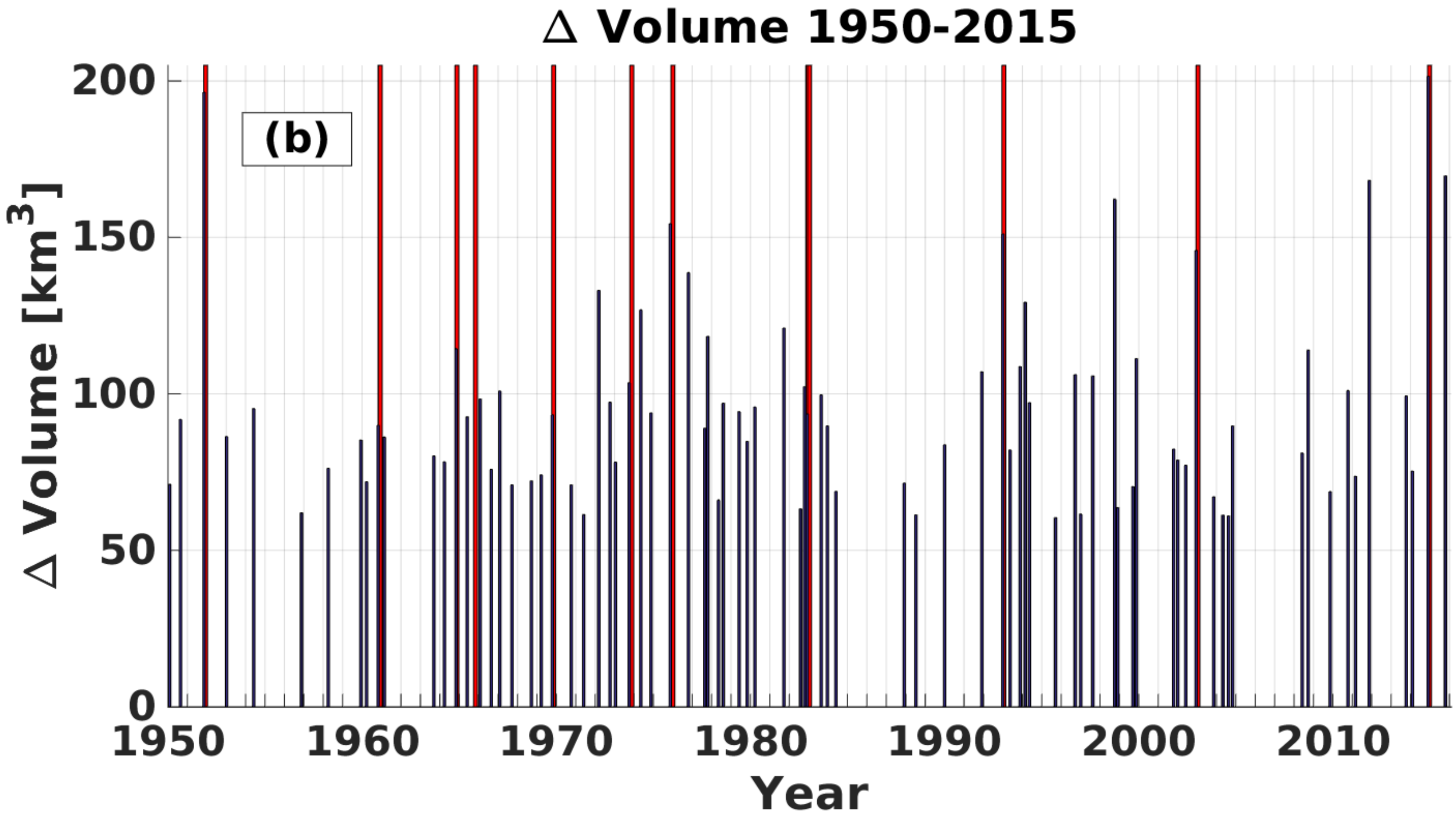

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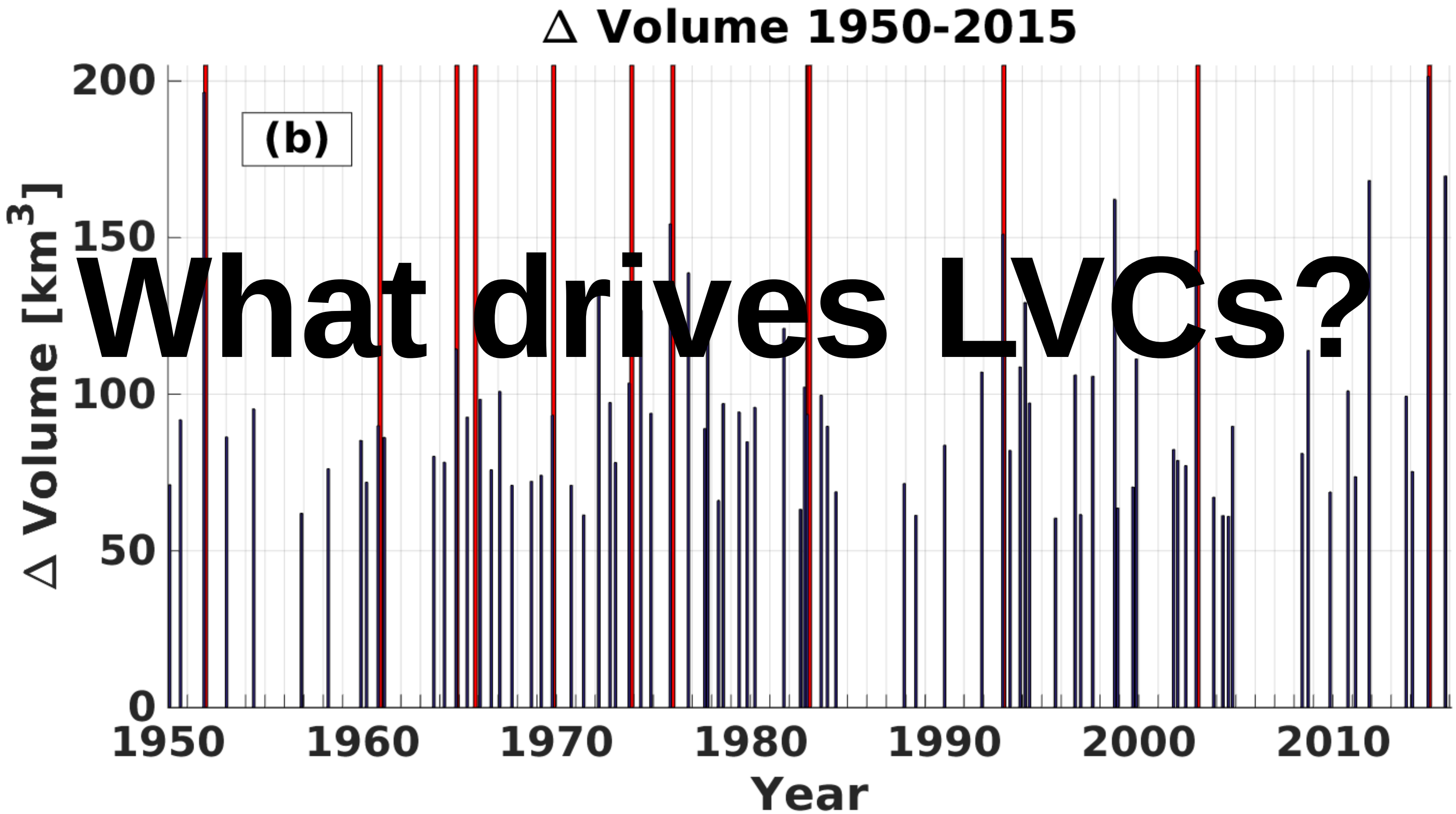
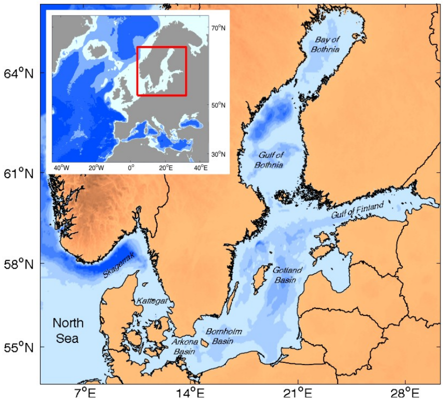
LVCs – Large Volume Changes



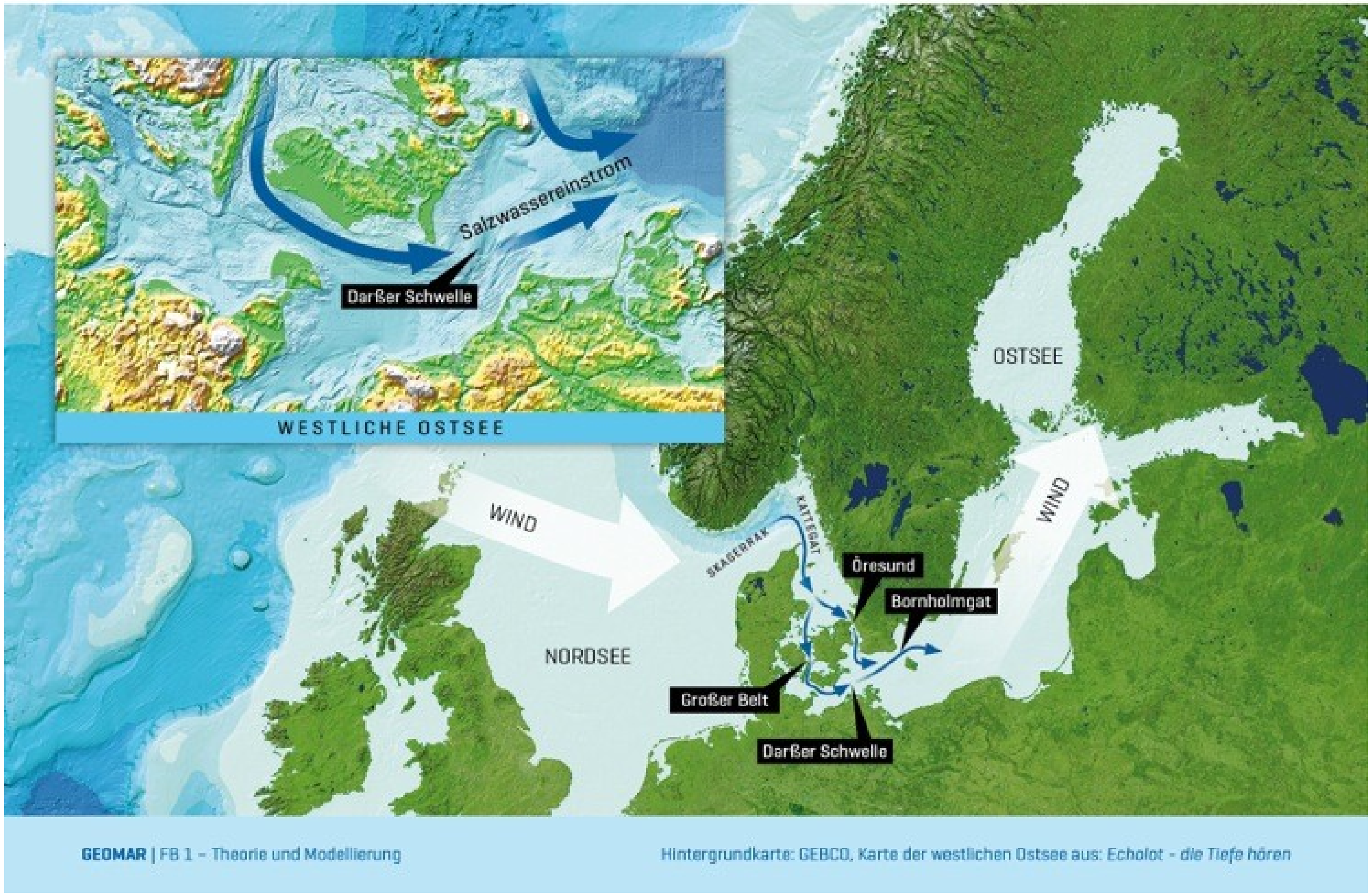
What drives LVCs?

Detected LVCs (blue), observed MBIs (red), threshold 60 km³, runoff compensated

LVCs & MBIs
Atmospheric conditions



Map of the Baltic Sea



Deep cyclones tracking

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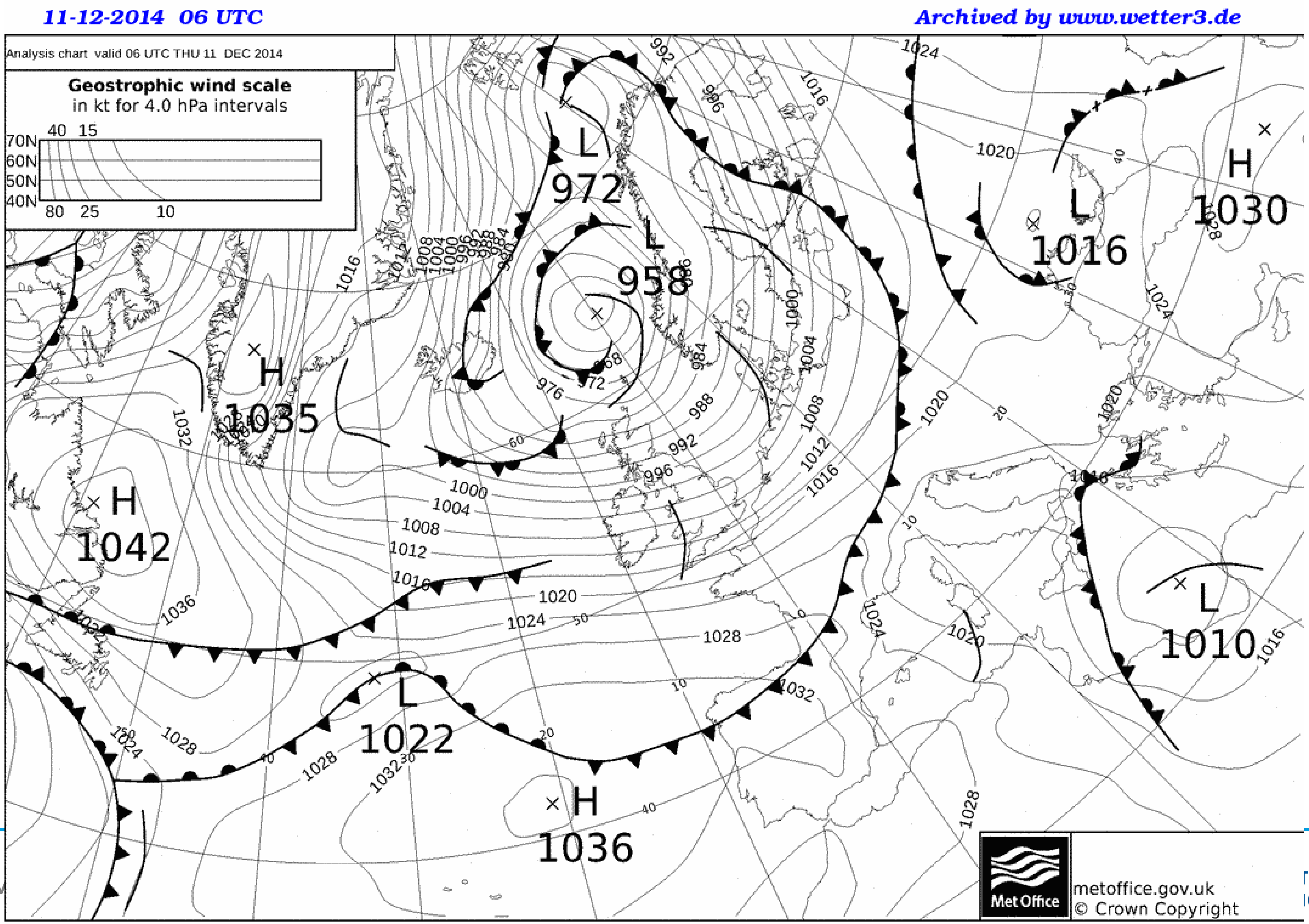

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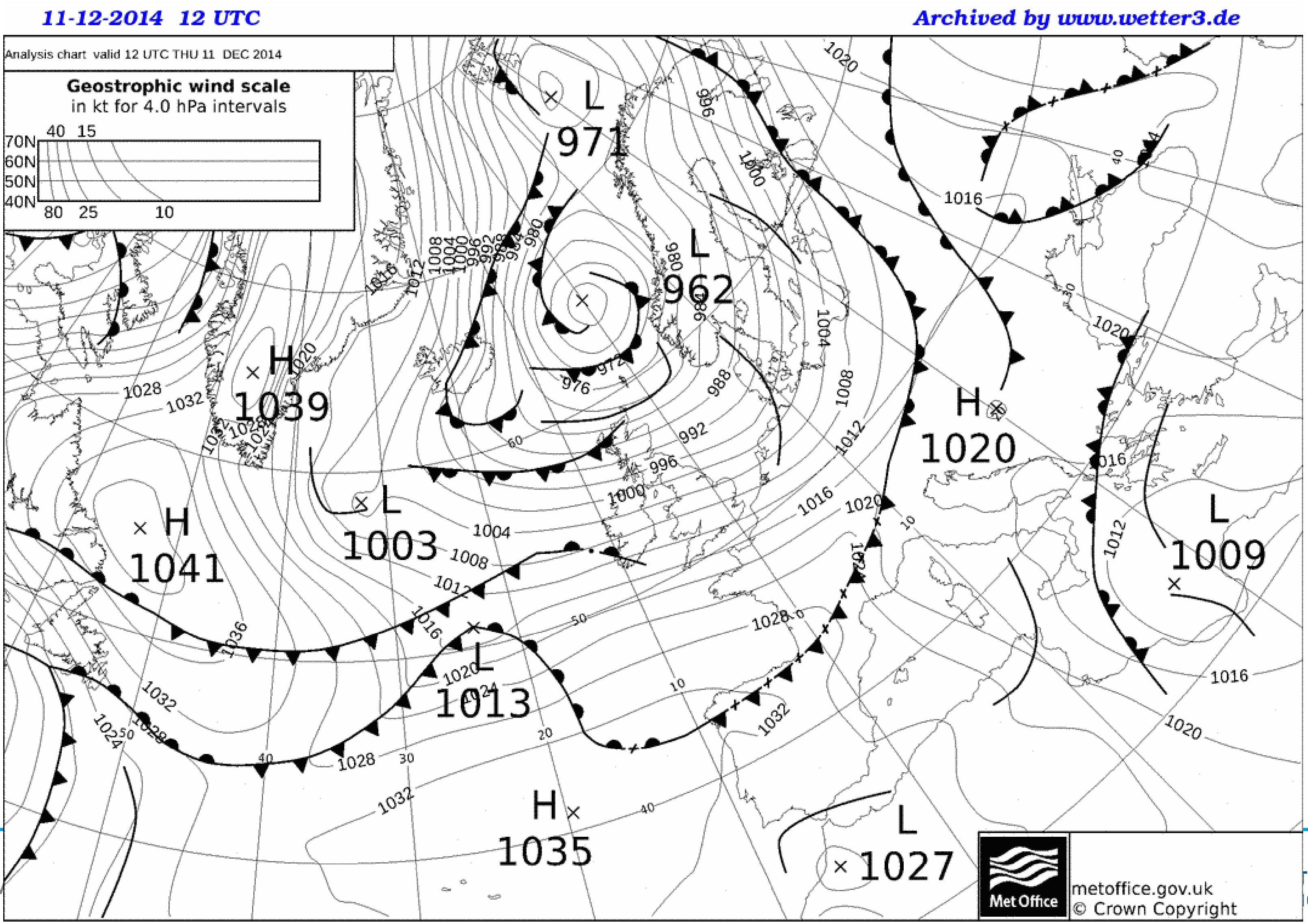
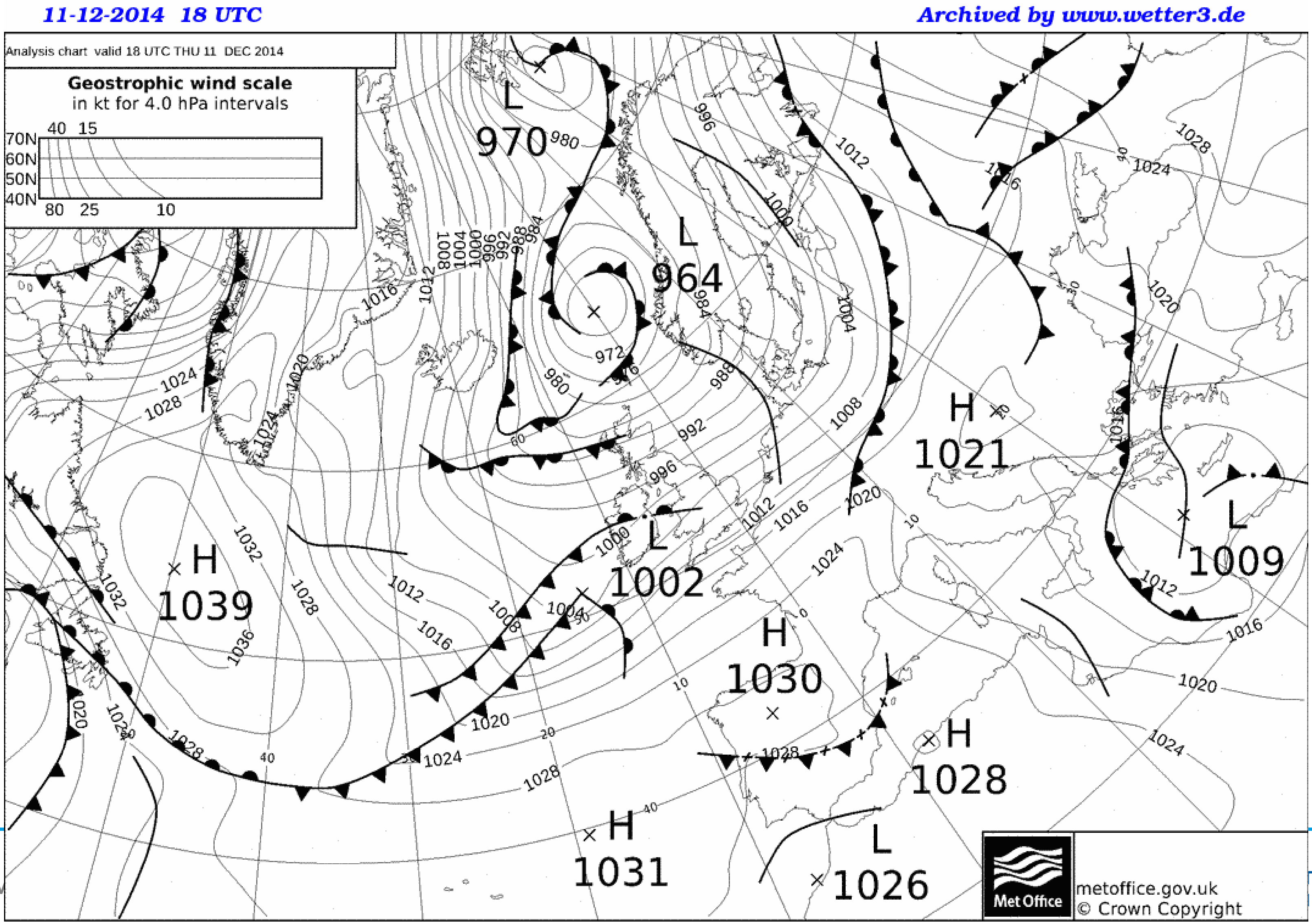


Deep cyclones tracking



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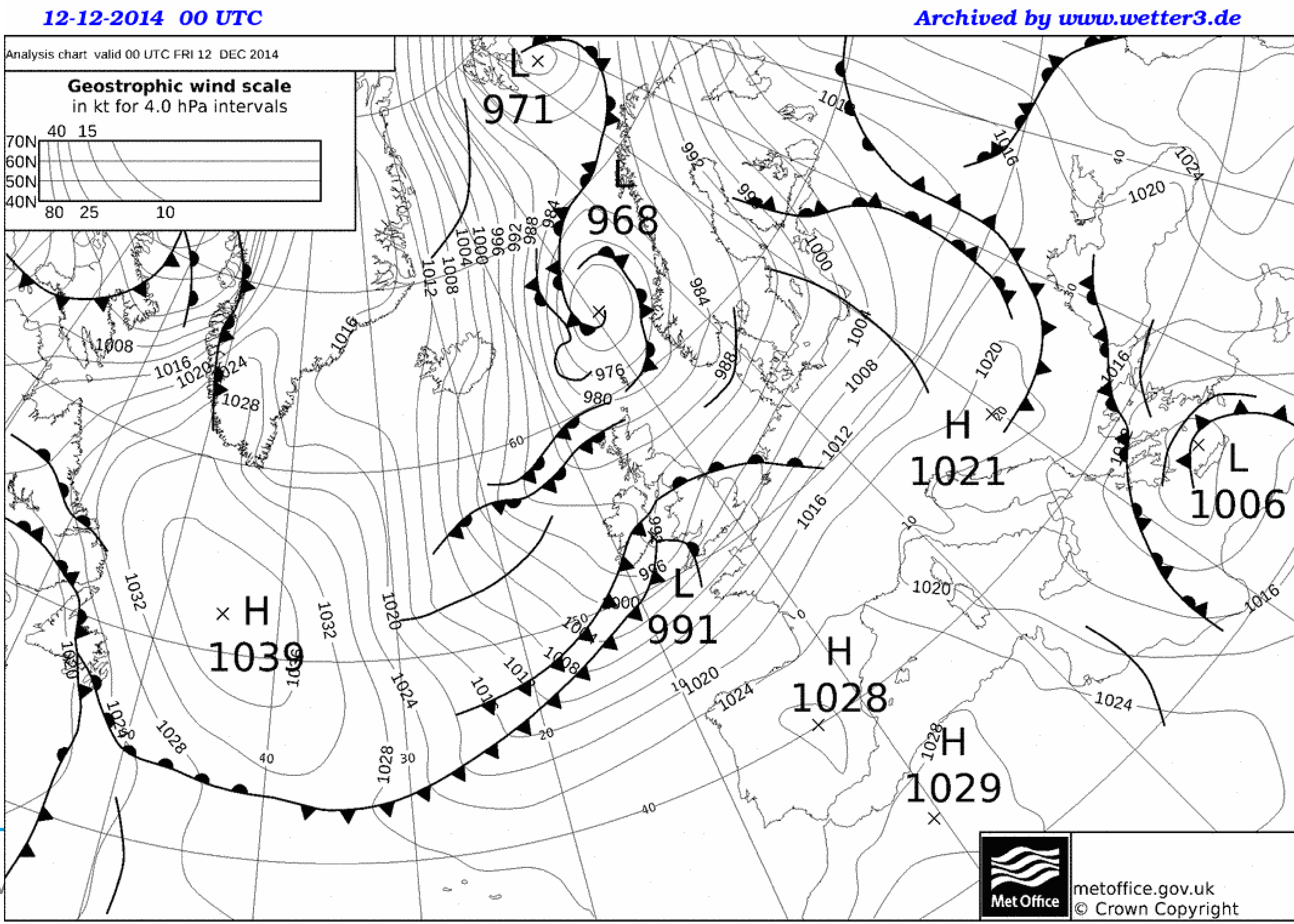

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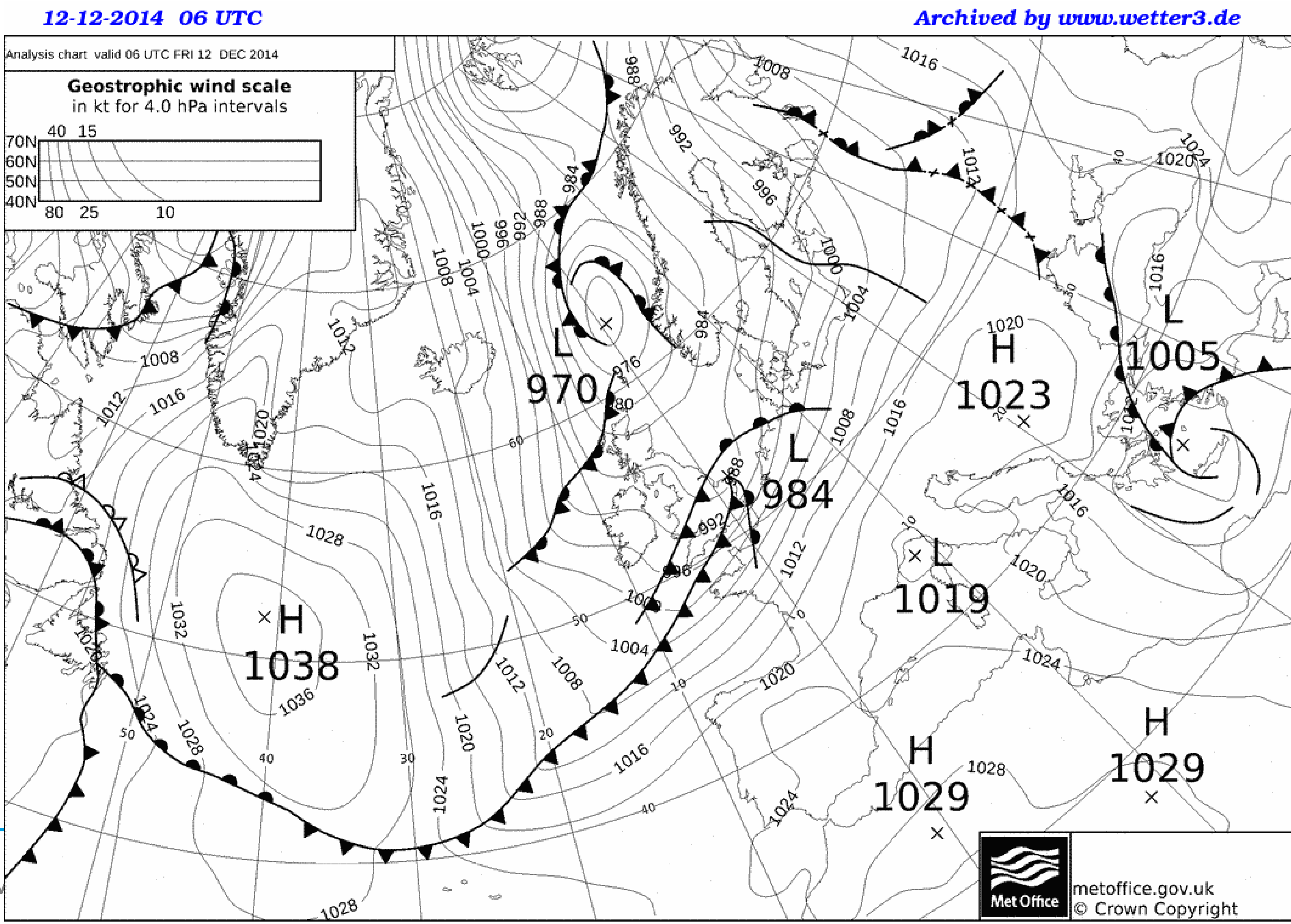

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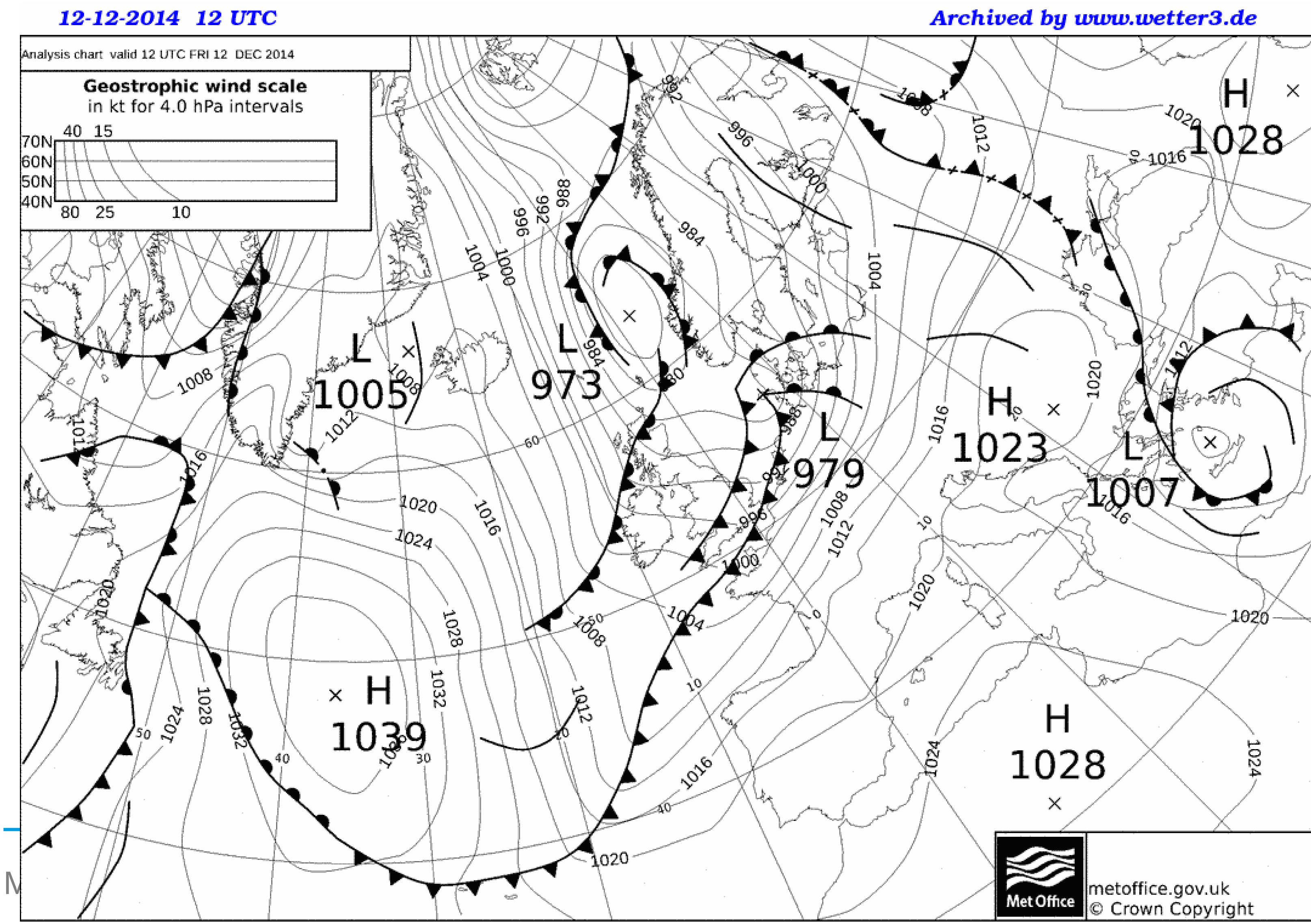

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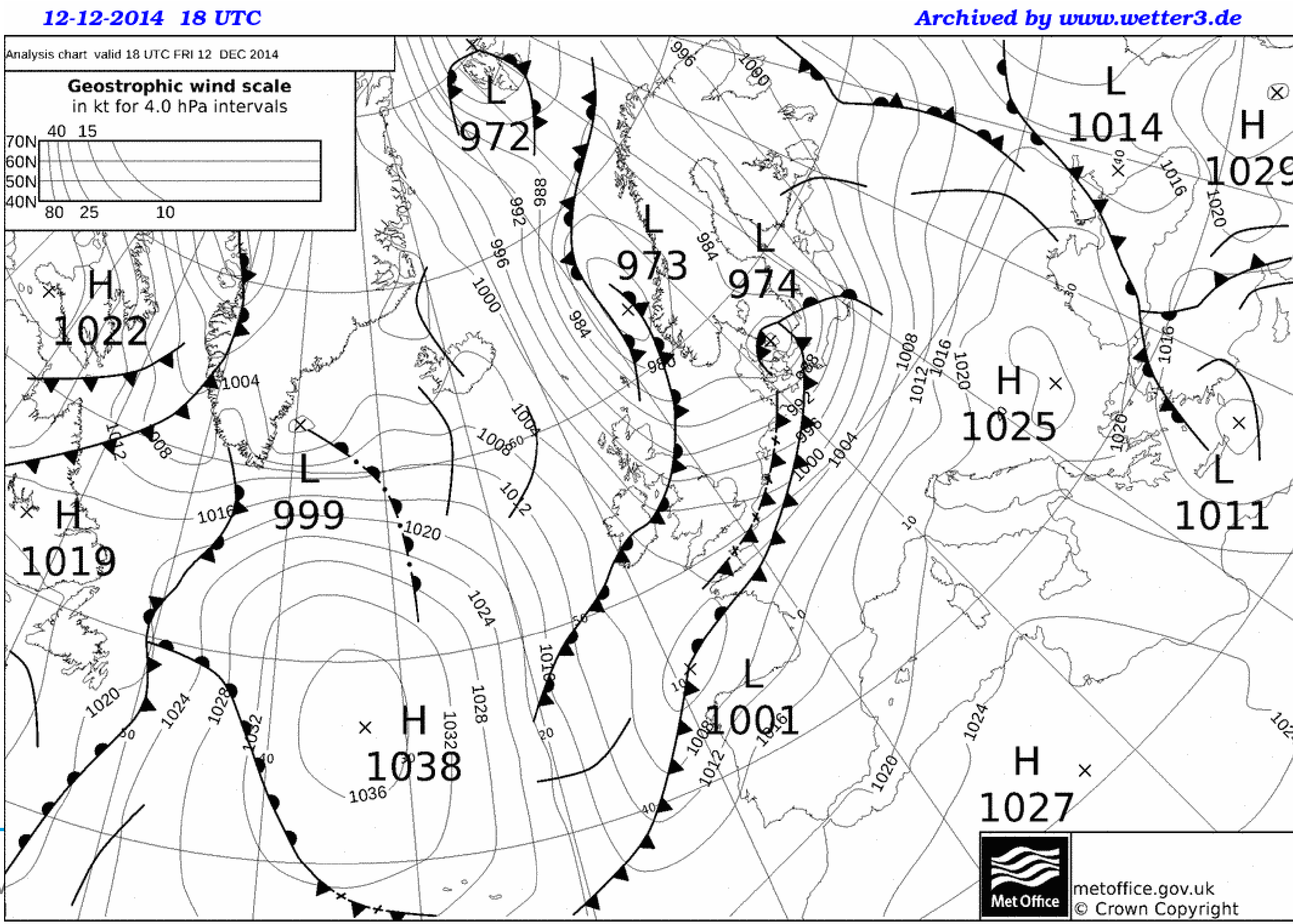
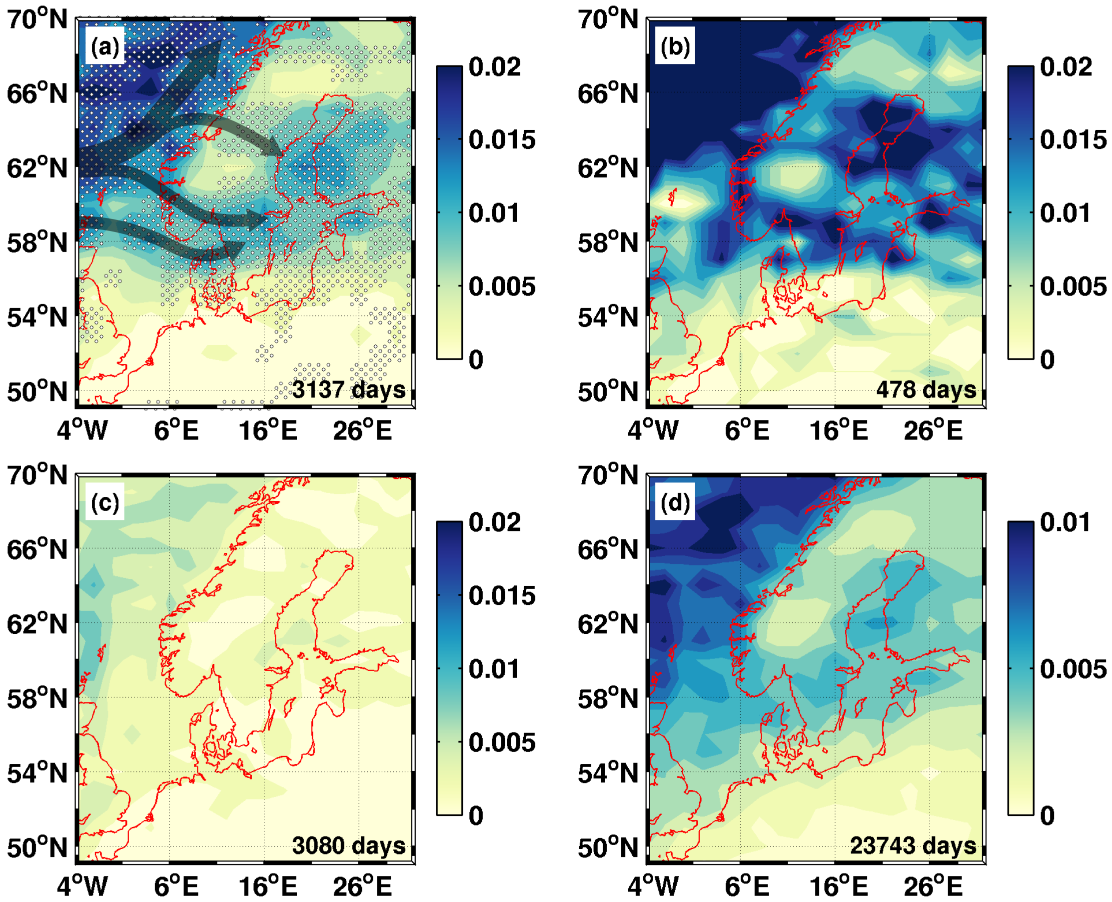
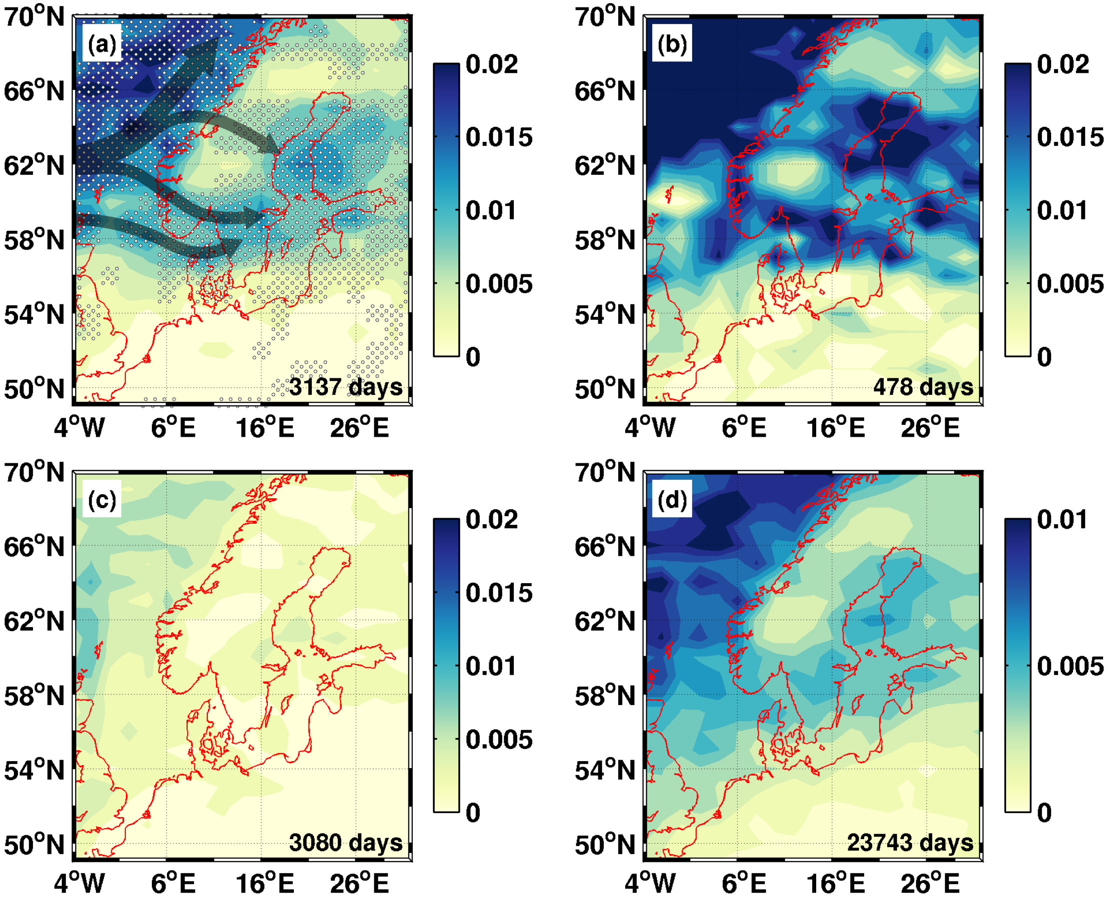


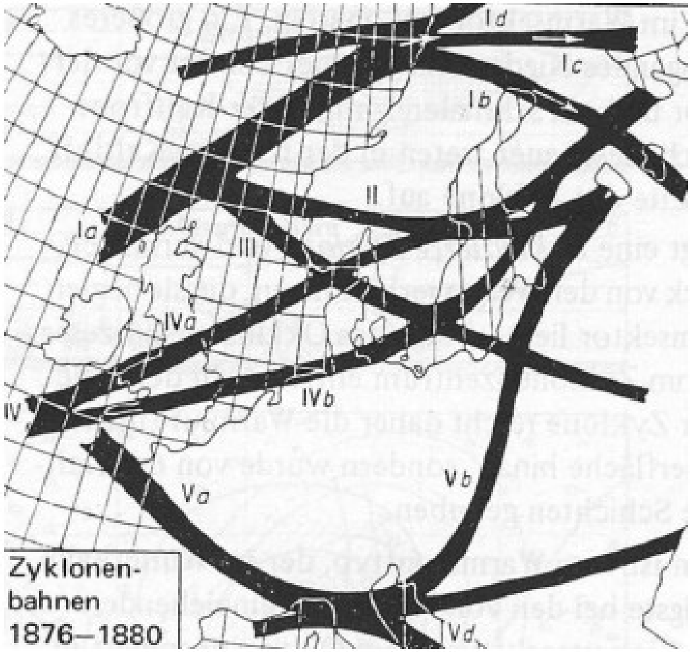
LVC – Cyclone tracking (Tilinina et al. 2013)



Relative cyclone frequency based on NCEP/NCAR SLPs and cyclone tracking, (a) LVCs period, (b) MBIs period, (c) 40 days before SSE minimum, (d) climatology.

LVC – Cyclone tracking (Tilinina et al. 2013)

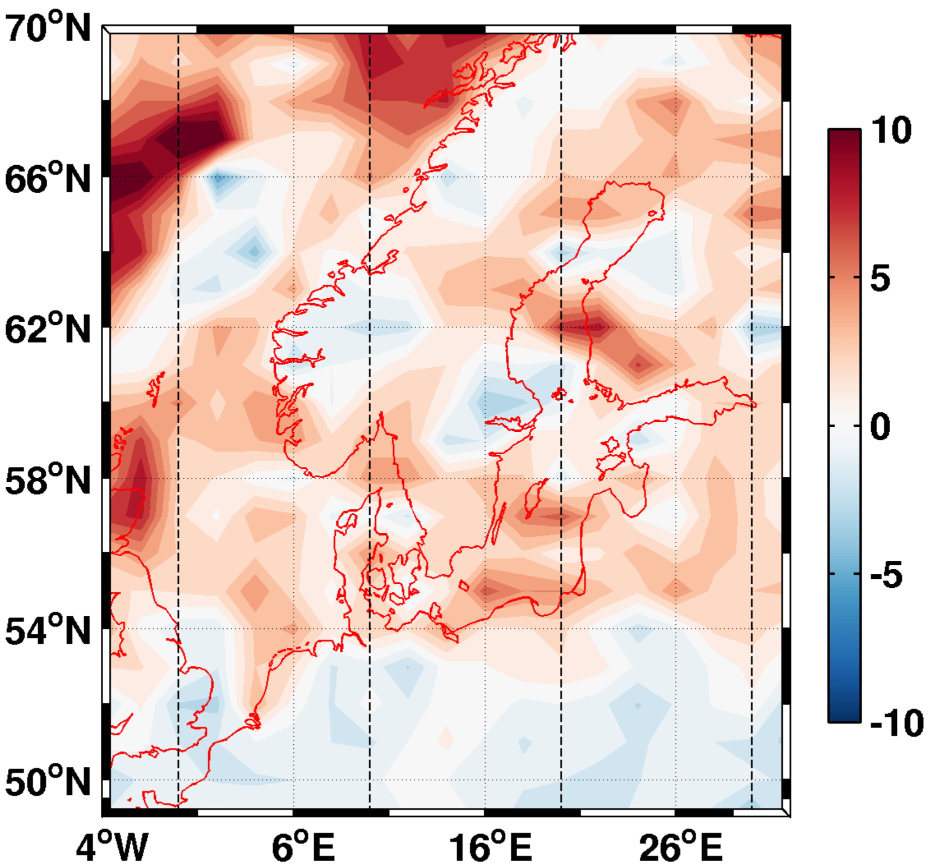


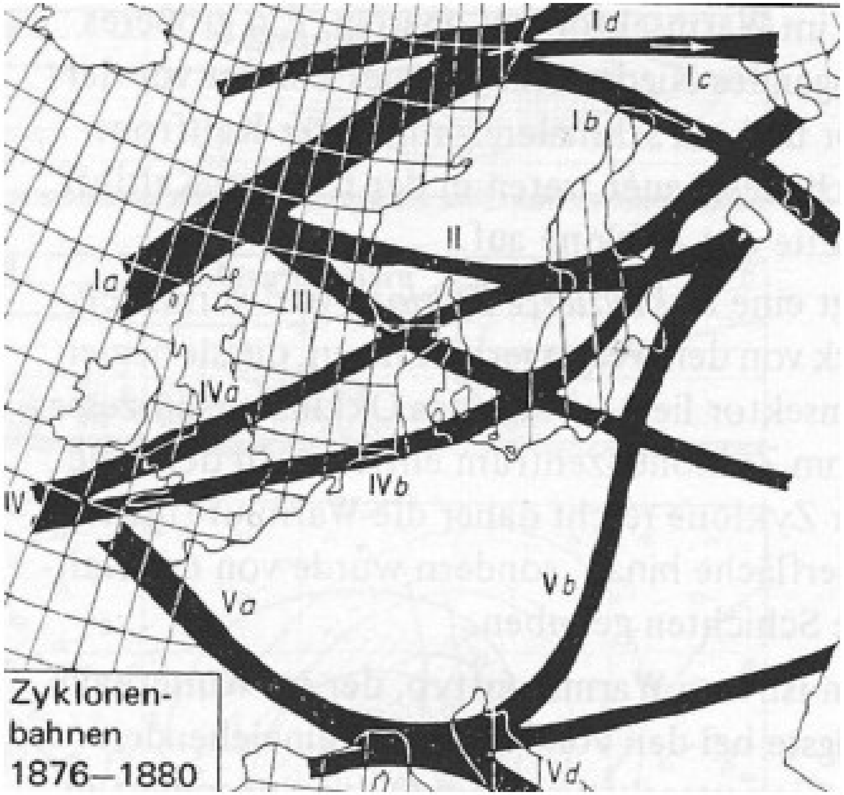


Typical cyclone tracks
van Bebber 1891
Ic, Ib, (II), III, IVa

Relative cyclone frequency based on NCEP/NCAR SLPs and cyclone tracking, (a) LVCs period, (b) MBIs period, (c) 40 days before SSE minimum, (d) climatology.

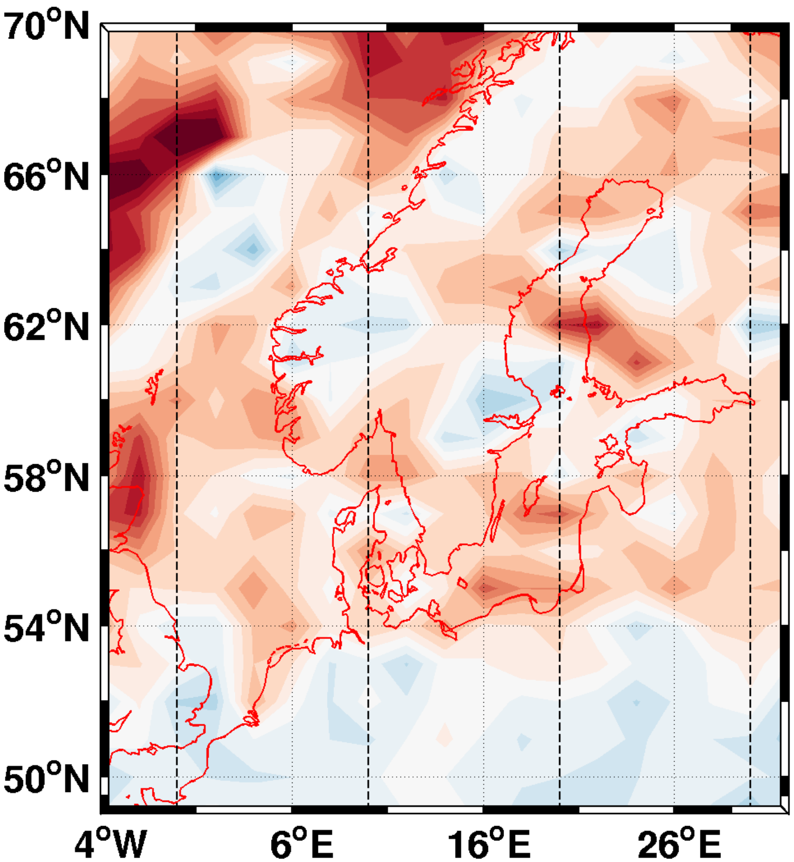
LVC – Cyclone tracking
Trend of cyclone frequencies

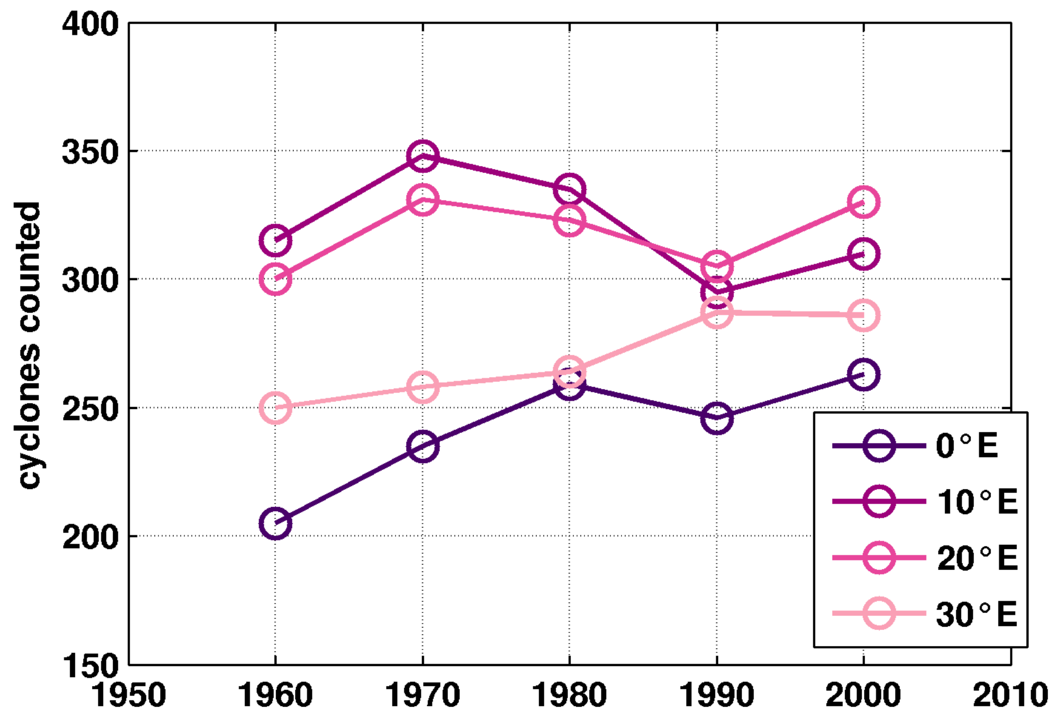




Trend of deep cyclone frequencies for the period 1950-2010; van Bebber cyclone tracks

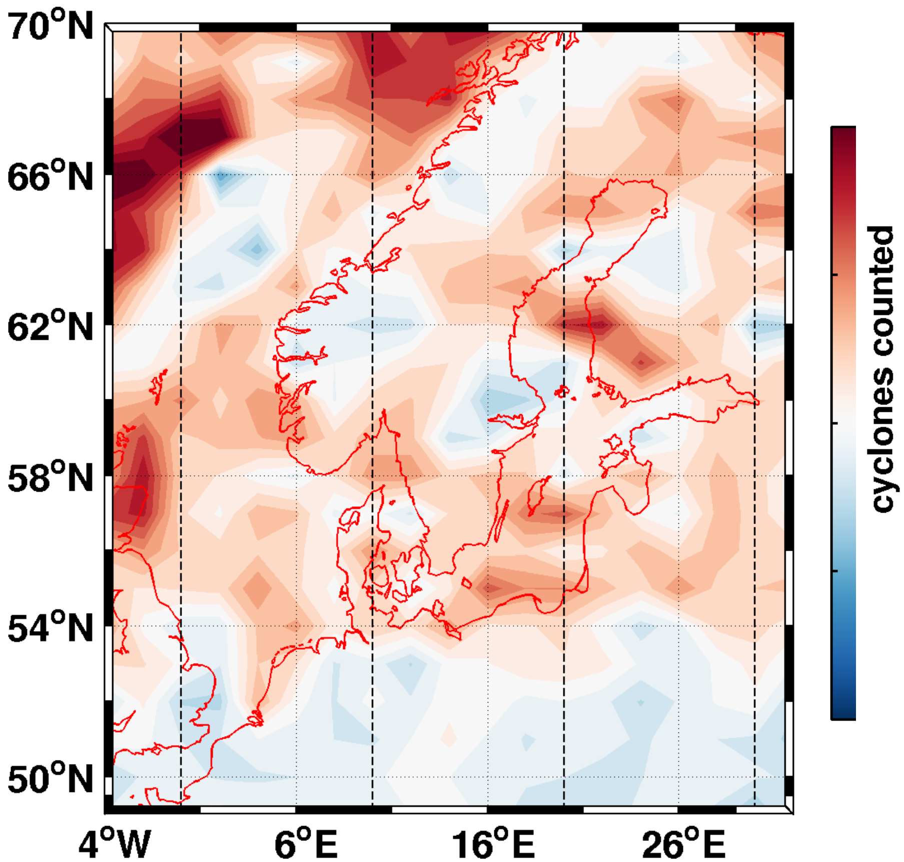
LVC – Cyclone tracking
Trends of cyclones

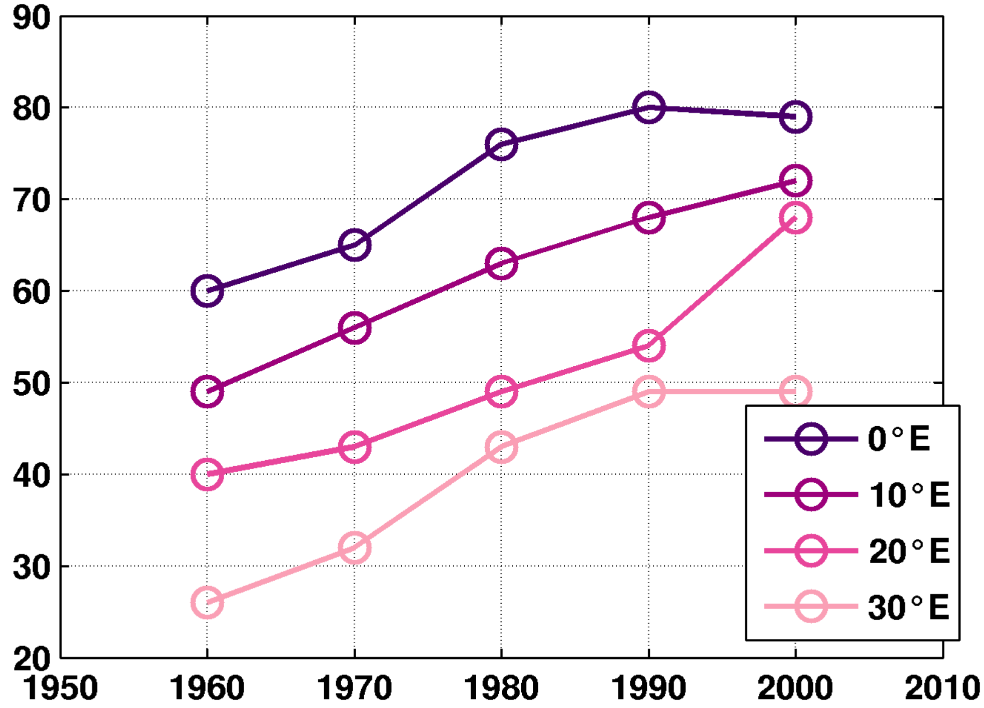




Trend of deep cyclone frequencies for period 1950-2010 & counted cyclones crossing different meridional sections from west to east based on 20 years periods 1950-1970, 1960-1980,1970-1990, 1980-2000, 1990-2000.

LVC – Cyclone tracking
Trends of cyclones





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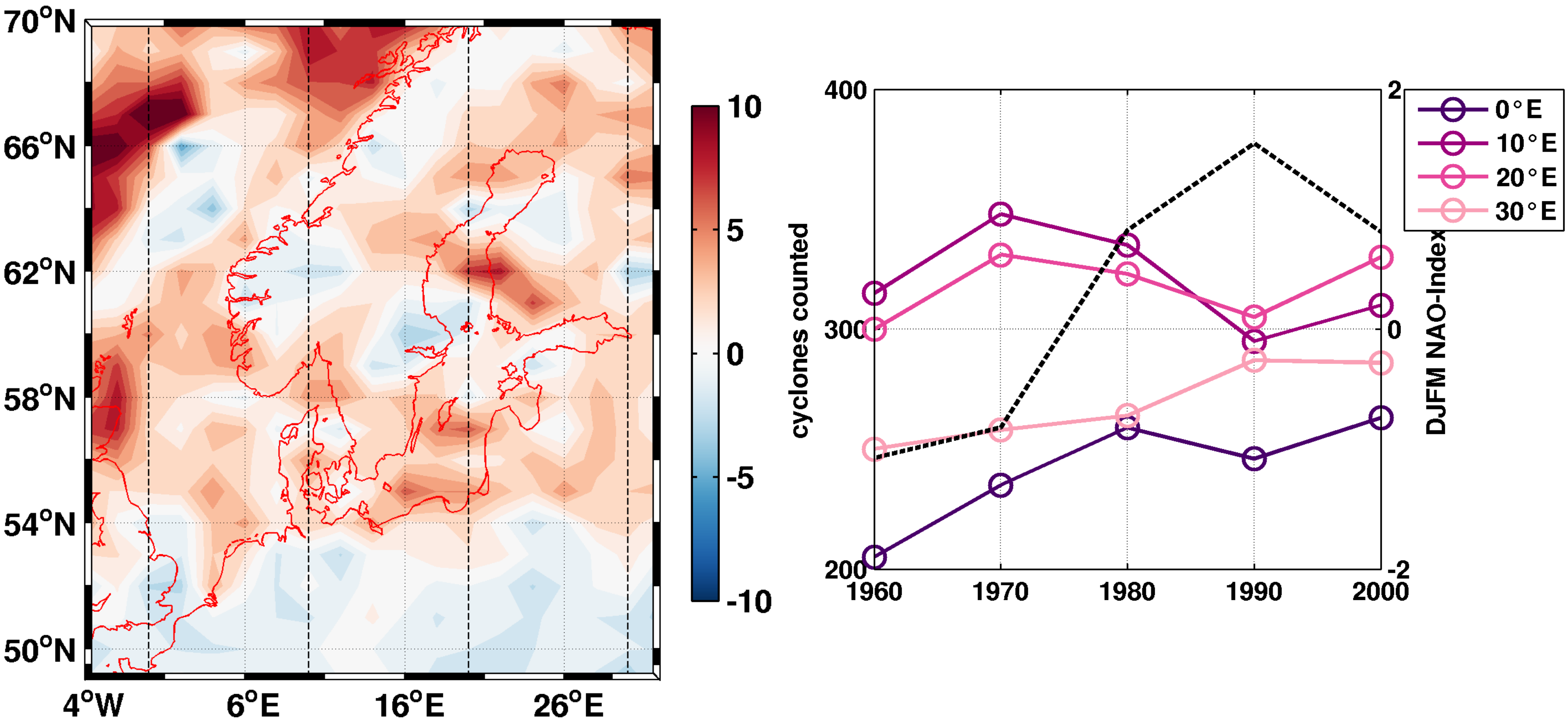
LVC – Cyclone tracking
Trends of cyclones



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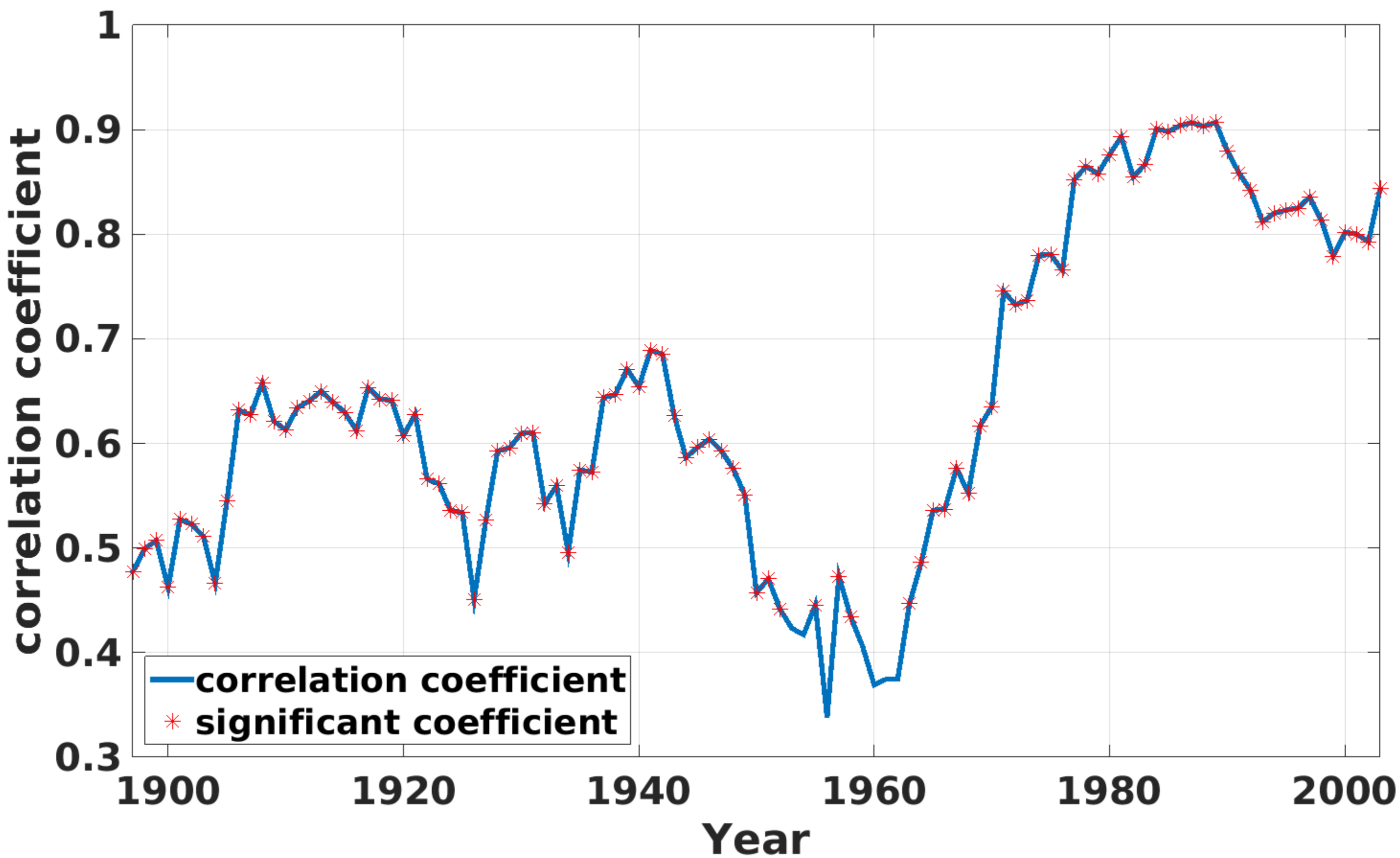
Correlation SSE and NAO (DJFM)



Running correlation (20-year window) NAO (DJFM) – Landsort SSE

Correlation SSE and NAO (DJFM)

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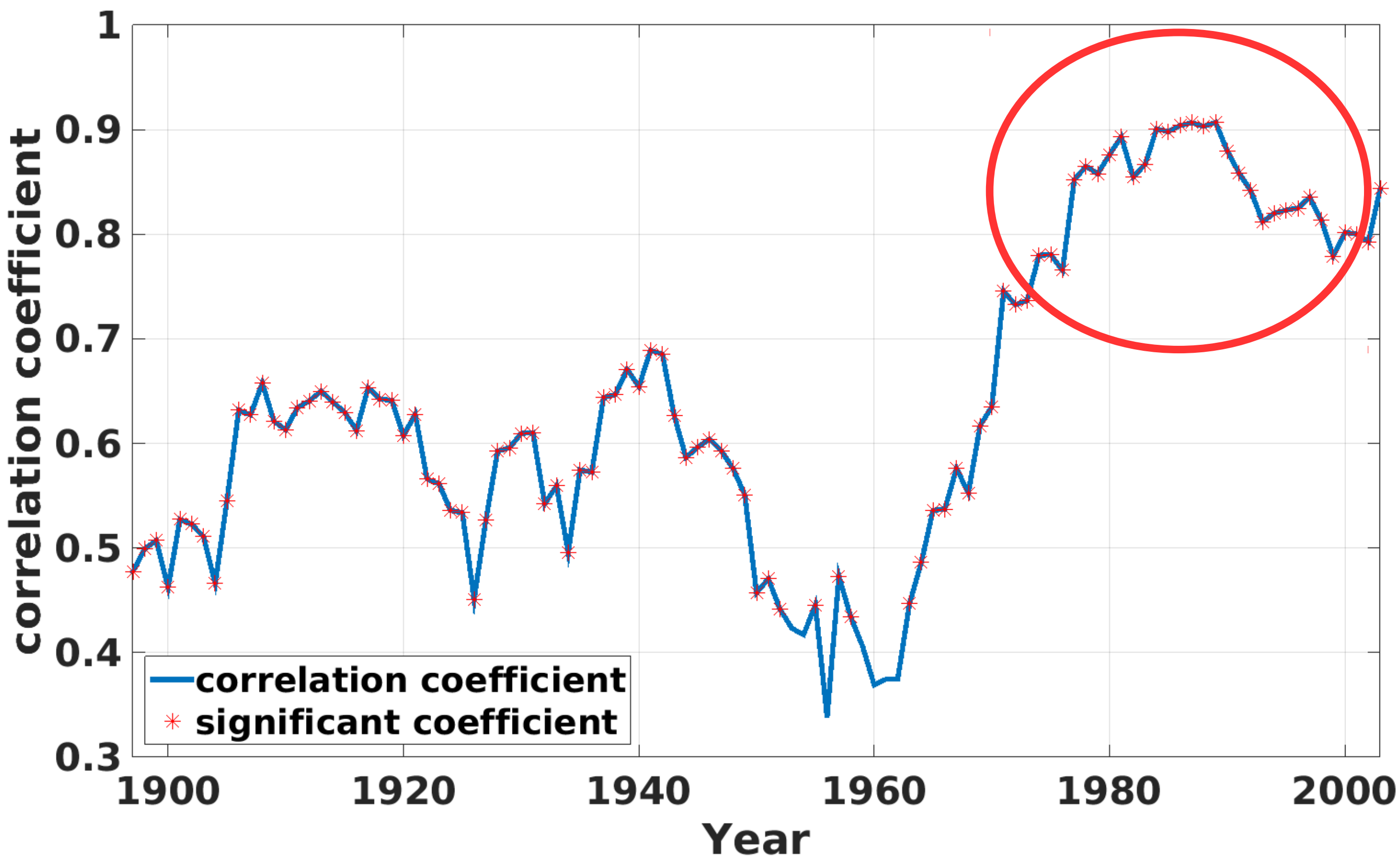
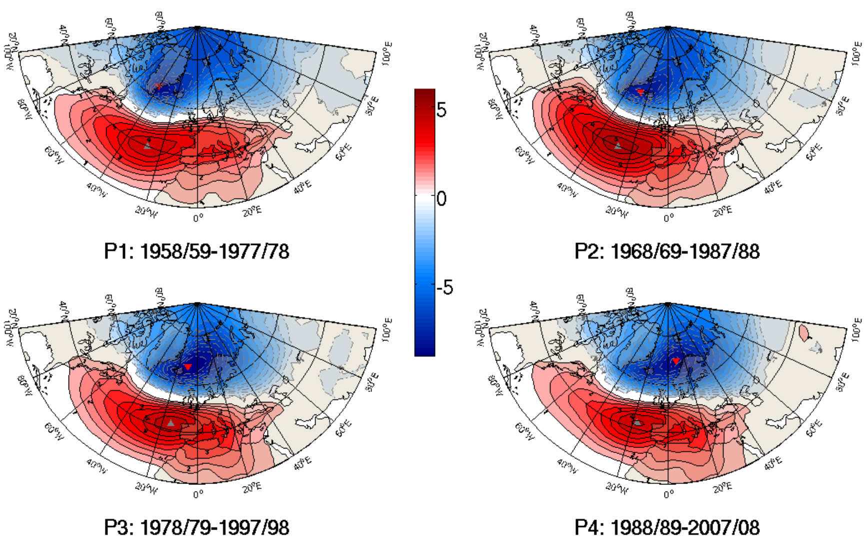
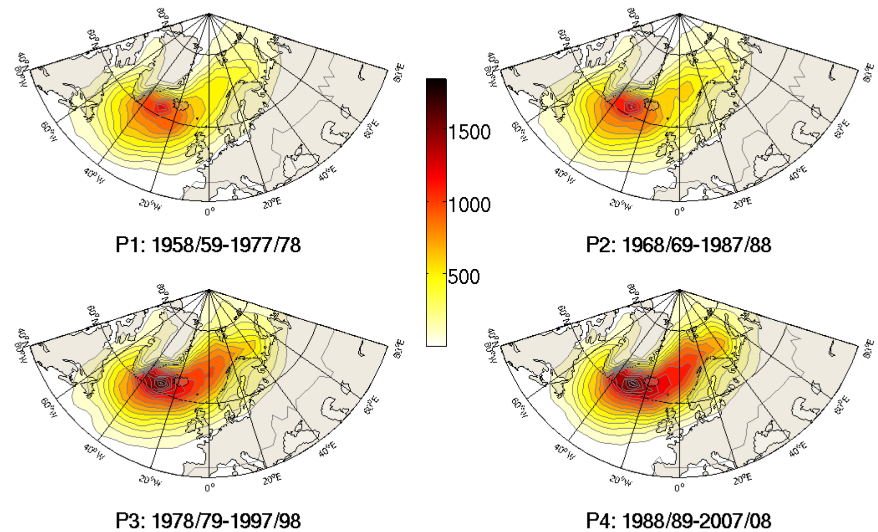


Running correlation (20-year window) NAO (DJFM) – Landsort SSE

Large Scale atmospheric variability



First EOF DJFM-averaged SLP-anomalies, NCEP-NCAR reanalysis Data 1958-2008



Total number of (DJFM) deep cyclones < 980 hPa, NCEP-NCAR reanalysis Data 1958-2008

Lehmann et al. 2011

Conclusions
Salinity dynamics

- Long-term salinity dynamics is controlled by river runoff and net precipitation and the governing east-west wind conditions

- The mid-term and short term (monthly/annual/decadal) salinity dynamics is much more complex with strong salinity variability also affecting temperature and oxygen

- Over recent decades a negative salinity trend at the surface of about 0.2 psu/decade is apparrent, 0.4-0.6 °C/decade for temperature and 0.07-0.09 ml/l/decade for oxygen.

- The temperature trend is about the same as the air temperature trend, for oxygen at the surface it is mostly the change in solubility, and for the surface salinity runoff and net precipitation. However, in deeper parts the salinity trend is reversed.

Conclusions
Salinity dynamics

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- LVCs/MBIs are related to specific atmospheric circulation types and deep cyclone pathways

- We found four main corridors of deep cyclone pathways which are associated with LVCs/MBIs and which fits very well with van Bebbers cyclone tracks

- From the atmospheric analysis it turned out that for MBIs the relative frequency (intensity) of deep cyclones along the pathways is increased compared with LVCs

- There is a varying positive correlation between the Landsort SSE and the NAO winter index
  - NAO+ : increasing zonal wind and at the same time decreasing blocking activity
  - (high pressure, easterly winds); increased vertical mixing

    ➜ This is affecting the haline stratification in the Danish Straits which strongly modifies the salt flux of inflowing water masses