Norwegian Meteorological Institute

Norwegian Climate Center

AMIP-type horizontal resolution experiments with NorESM

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Motivation:

For given a computer resource, ESMs need to balance between:

- Process complexity
  - chemistry, aerosols, cloud microphysics, vegetation, hydrology, sea-ice…
- Spatial resolution
  - vertical: cirrus clouds, wave breaking, wave reflection, stable diffusion,…
  - horisontal: transport fluxes, storm tracks, regional patterns, blocking,…
- Length of simulation periods and ensemble size
  - century-scale with multi-decadal variability
  - required signal-to-noise ratio while spanning all sources of uncertainty

Motivation:

- The choice of resolution and complexity can be inter-dependant: complex processes can be poorly described with inadequate resolution

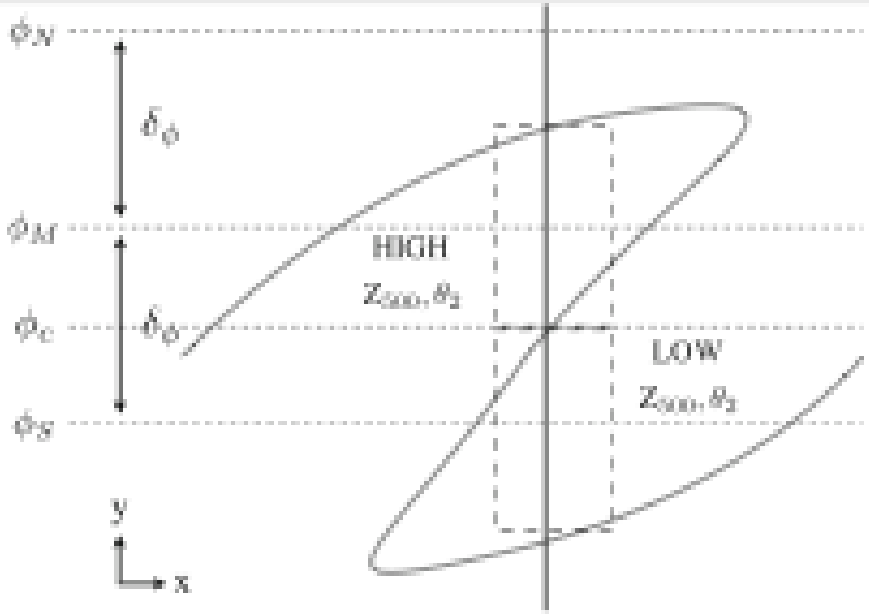
  e.g.:
  modeled climate feedbacks through vegetation changes caused by changed frequency and length of droughts and precipitation

  →this links to the models' ability to simulate
  - extratropical storm tracks,
  - blocking,
  - any regional flow patterns defining major sources and transport pathways of moisture contributing to continental precipitation ("atmospheric rivers")

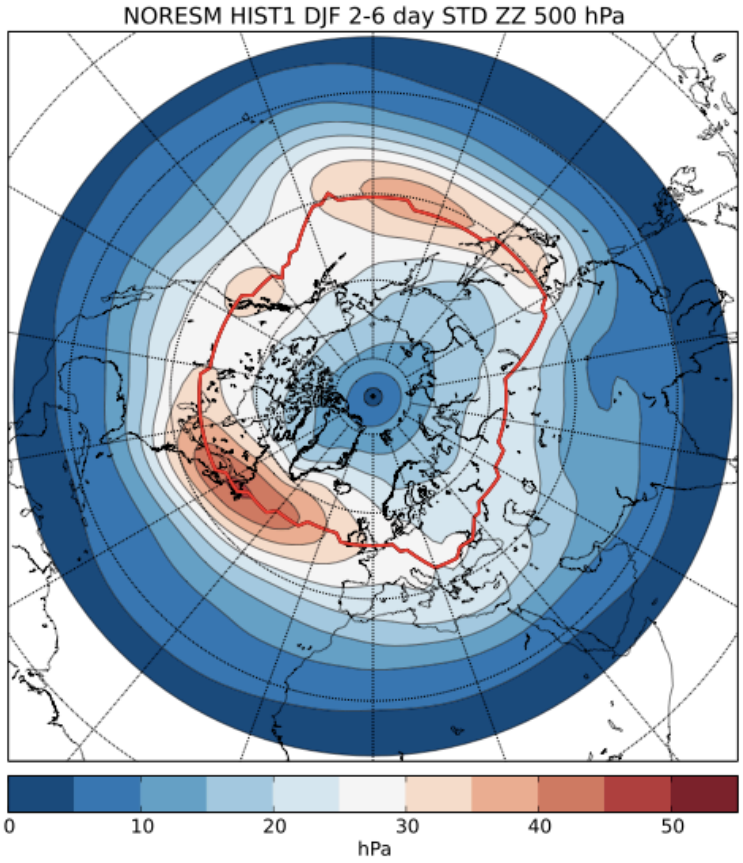
  Persistent planetary waves and blocking also define atmospheric transport pathways for the Arctic

Atmospheric blocking

TM index



Lejanäs and Økland (1983)
Tibaldi and Molteni (1990)



Searches for persistent reversals in the gradient of 500 hPa around a central latitude, defined by the seasonally mean position of the baroclinic zones. Blocked longitude > 5 days.

AMIP-type resolution tests
CAM4-Oslo and CAM5.3 (basis for CAM5-Oslo)

- CAM4-Oslo: 1.9x2.5 degrees (1979-2005) →~200km
- CAM4-Oslo: 0.9x1.25 degrees (1979-2005) →~100km
- CAM4-Oslo: 0.47x0.63 degrees (1979-1998) →~50km

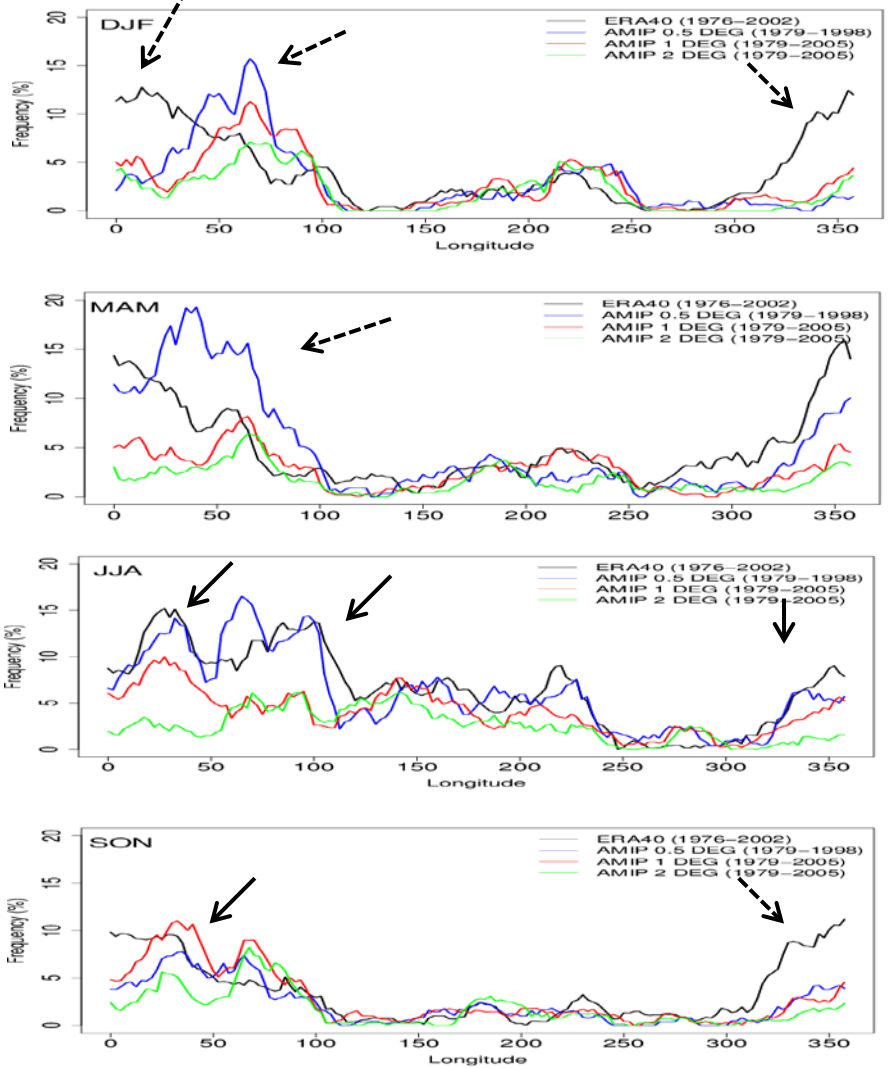
- CAM5.3: 0.9x1.25 degrees (1979-2001)

- Comparison with EC ERA40 or NCEP reanalyses:

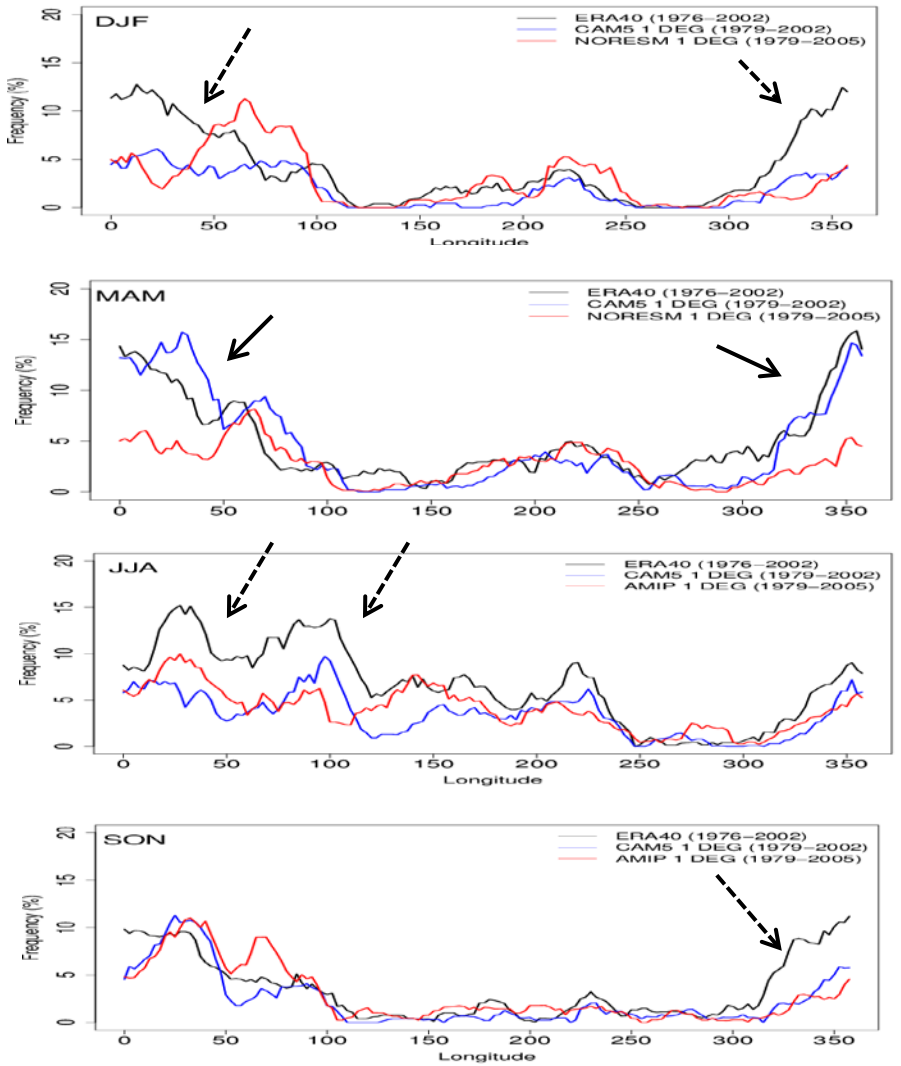
- storm bands (baroclinic wave activity zones)
- Blocking frequency
- Regional flow regime patterns from EOF1 and EOF2

NH Blocking activity, AMIP and ERA40

ERA, AMIP200, AMIP100, AMIP50



ERA, AMIP100, CAM5.3_100km



----> major errors

——> error reductions

NH Blocking activity, some conclusions

Main problem area in CAM4-Oslo (~200km):
underestimated occurrence in central Atlantic / western Eurasia

Improvements with increased horizontal resolution in CAM4-Oslo (~50km)
- summer everywhere
- autumn western Eurasia

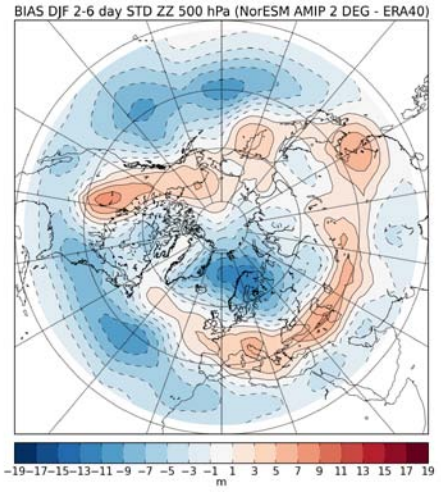
but then also with overestimated occurrence, winter and spring in Europe

Switch to CAM5.3 (~100km):
- Considerably improved occurrence in spring
- no overshooting in winter and spring
- the underestimates in summer which were removed with ~50km, return

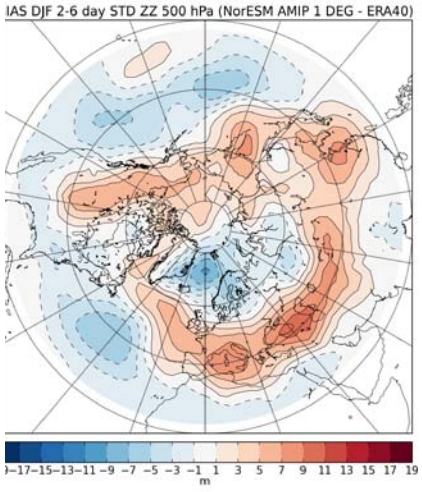
Underestimated occurrence in central Atlantic in winter and autumn persist.
→Any link to NAO?

Winter baroclinic activity. DJF, (2-6)d bandpass, standard dev. (AMIP – ERA40)

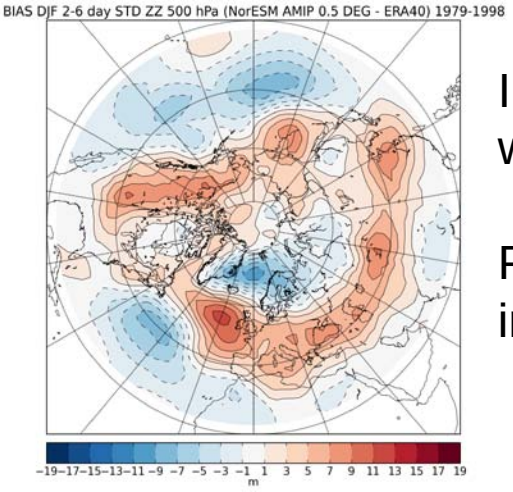
~200km CAM4-Oslo



~100km



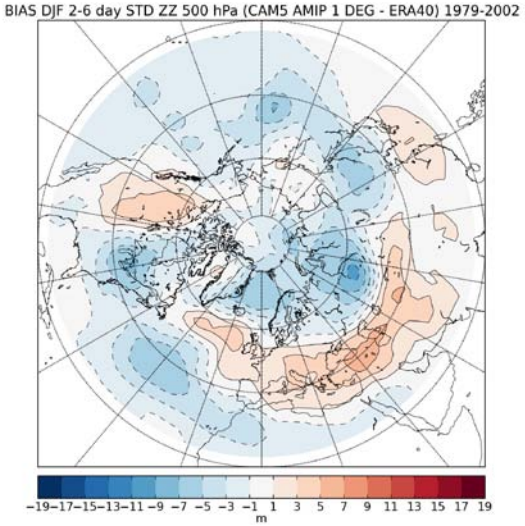
~50km



Increased activity with high resolution.

Pattern errors not influenced

~100km CAM5.3



Errors considerably reduced in Pacific-North-American sector.

Still too zonal in Atlantic-Eurasian sector

NATL Storm tracks in CMIP5

Zappa, Shaffrey L.C and Hodges K.I, 2013, Journal of Climate, 5379-5396

CMIP5-models vs. EC ERA Interim, DJF

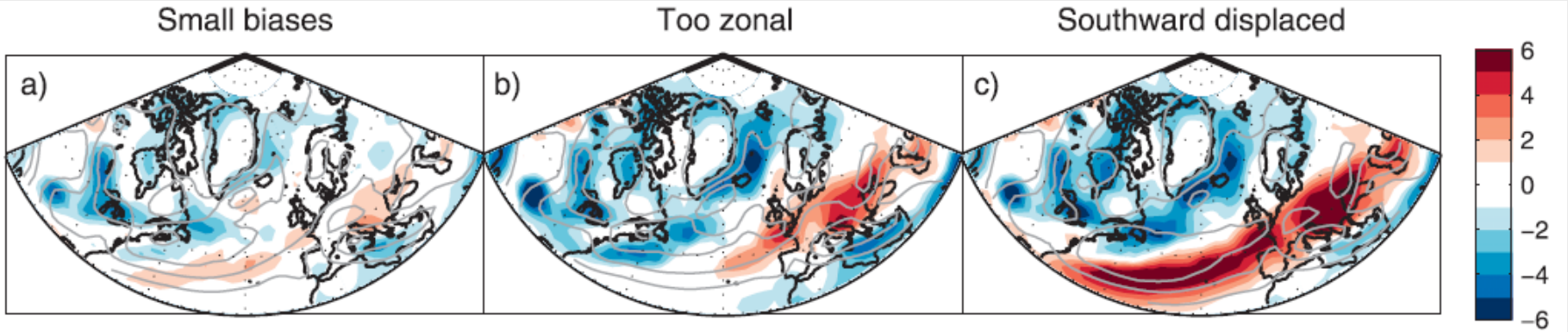


FIG. 5. Mean DJF track density [cyclones month^{-1} (5° spherical cap)$^{-1}$] bias (HIST − ERA-Interim) of the CMIP5 models (shading) separately computed for three groups of similar behavior: (a) the small-bias group, (b) the too-zonal group, and (c) the southward-displaced group. The criterion used for defining the groups is given in the text. The group mean climatology is contoured with isolines every 4 cyclones month^{-1} (5° spherical cap)$^{-1}$.

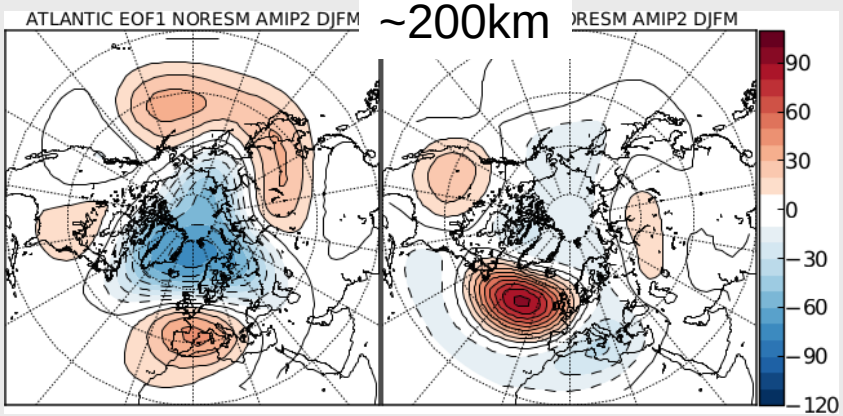
Small-bias group only models of rel. high resolution
GFDL CM3 (200 km),
HadGem2-ES (170km),
MRI-CGCM3 (120 km),
EC-Earth(120 km)

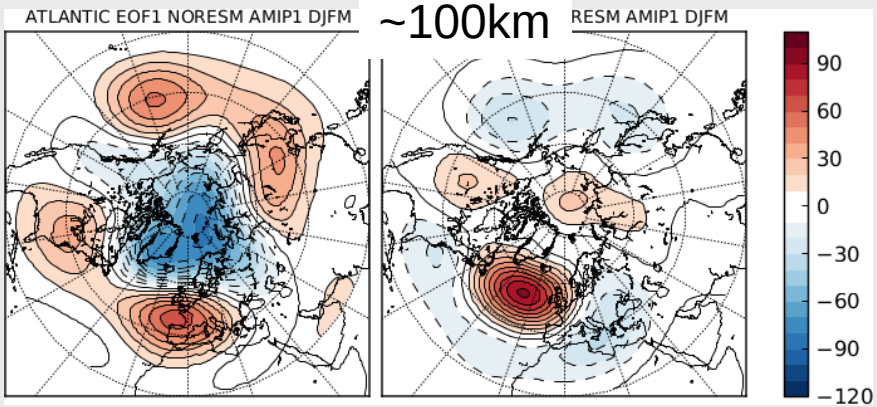
NorESM1-M in most populated category:

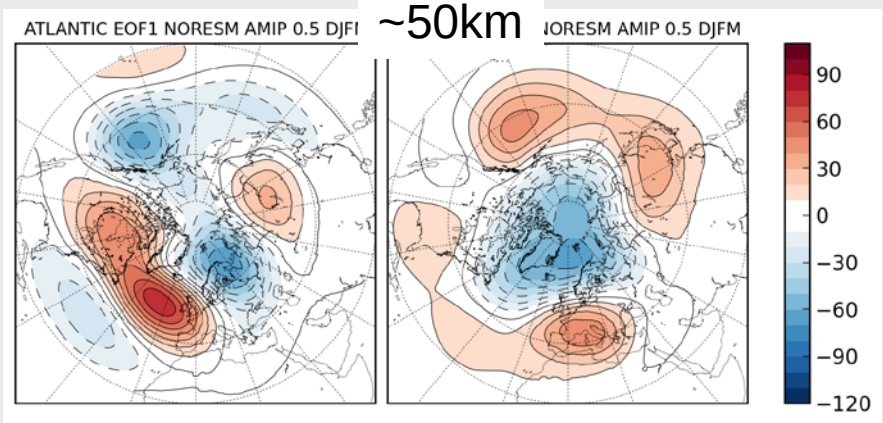
Too zonal

MIROC-ESM,
BCC-CSM1.1
FGOALS-g2
overestimate the number of North Atlantic cyclones

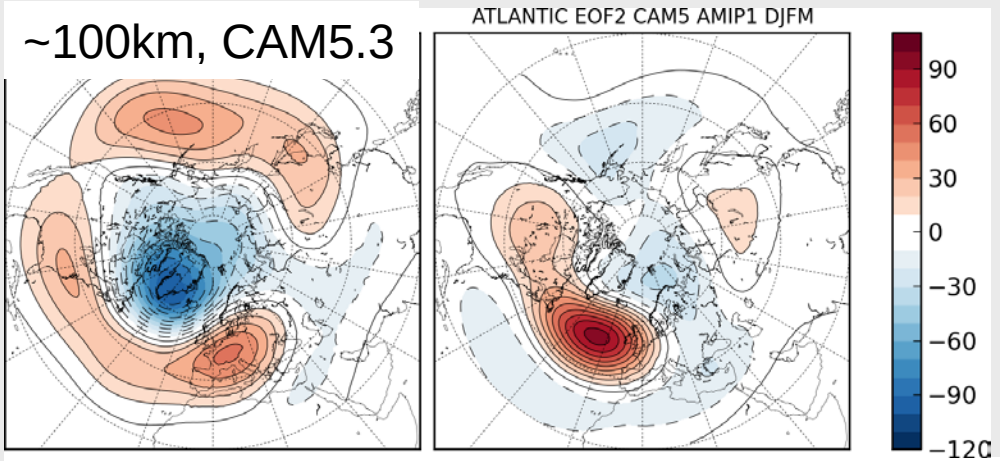
North Atlantic, DJFM EOF1 -2 major regional flow patterns

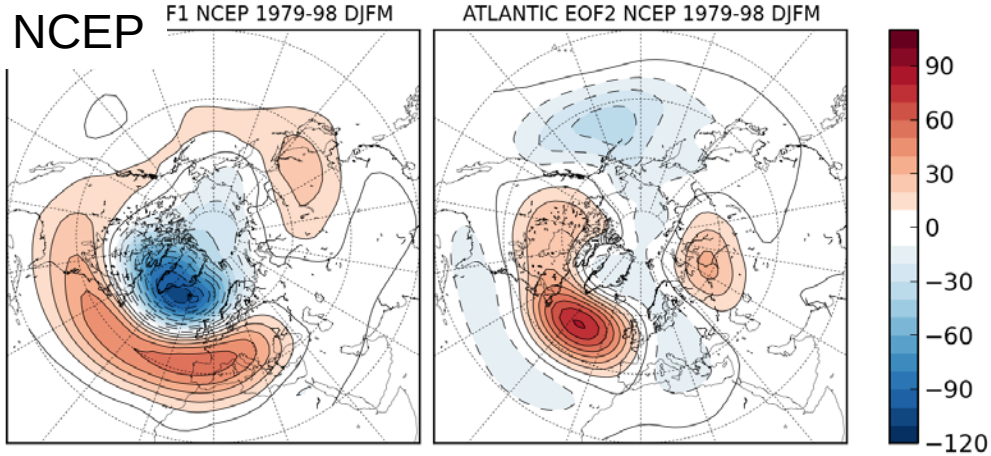






- All model versions give too high correlation between the hemispheres.
- CAM4-Oslo (~50km): patterns improved, EOFs are switched.
- CAM5.3 (~100km): Patterns considerably improved, EOF1 is less – but still is -annular.



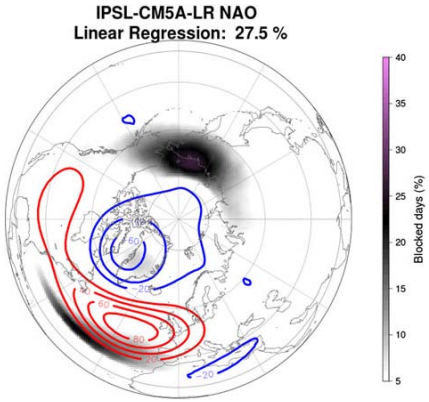


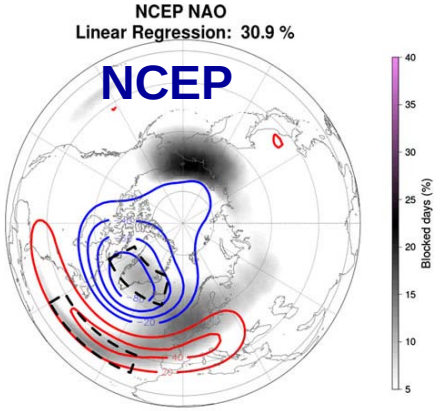
On the misinterpretation of the North Atlantic Oscillation in CMIP5 models

Clim Dyn
DOI 10.1007/s00382-013-1970-y

Paolo Davini · Chiara Cagnazzo

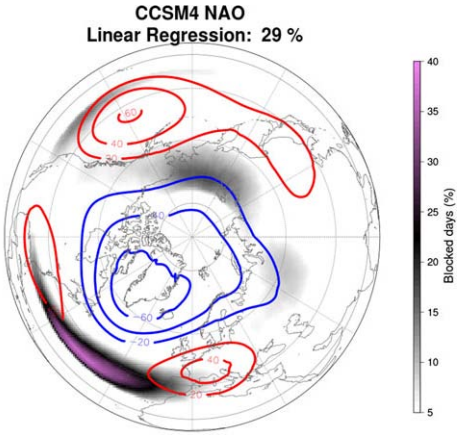
CMIP5-models separated into 3 groups based on EOF-1 and the occurrence blocking



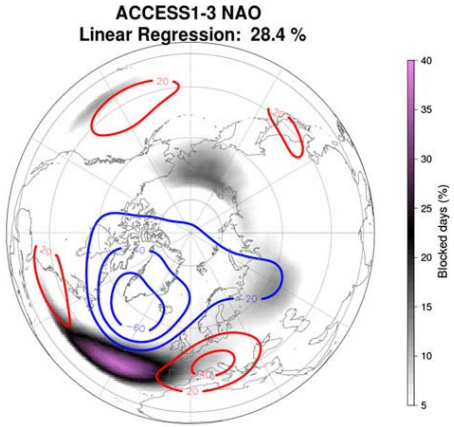


"Anticyclonic EOF1".

CCSM4 →



"**Annular EOF1**"



"Pulsating EOF1".

Poleward bias in jet stream position

→absence of Greenland Blocking

→first pattern of variability is too hemispheric (in stead of NAO).

Colours: EOF-1;
shading: blocking

NH Blocking activity, some questions

Other models (ECMWFs IFS) give much better results for ~50km (Jung et al, 2011).
Why not for CAM4-Oslo?

In particular:
the underestimated occurrence in central Atlantic in winter and autumn persist in all the experiments.

Would CAM5.3 with ~50km give better results?

Is better vertical resolution in upper troposphere and in the stratosphere needed?

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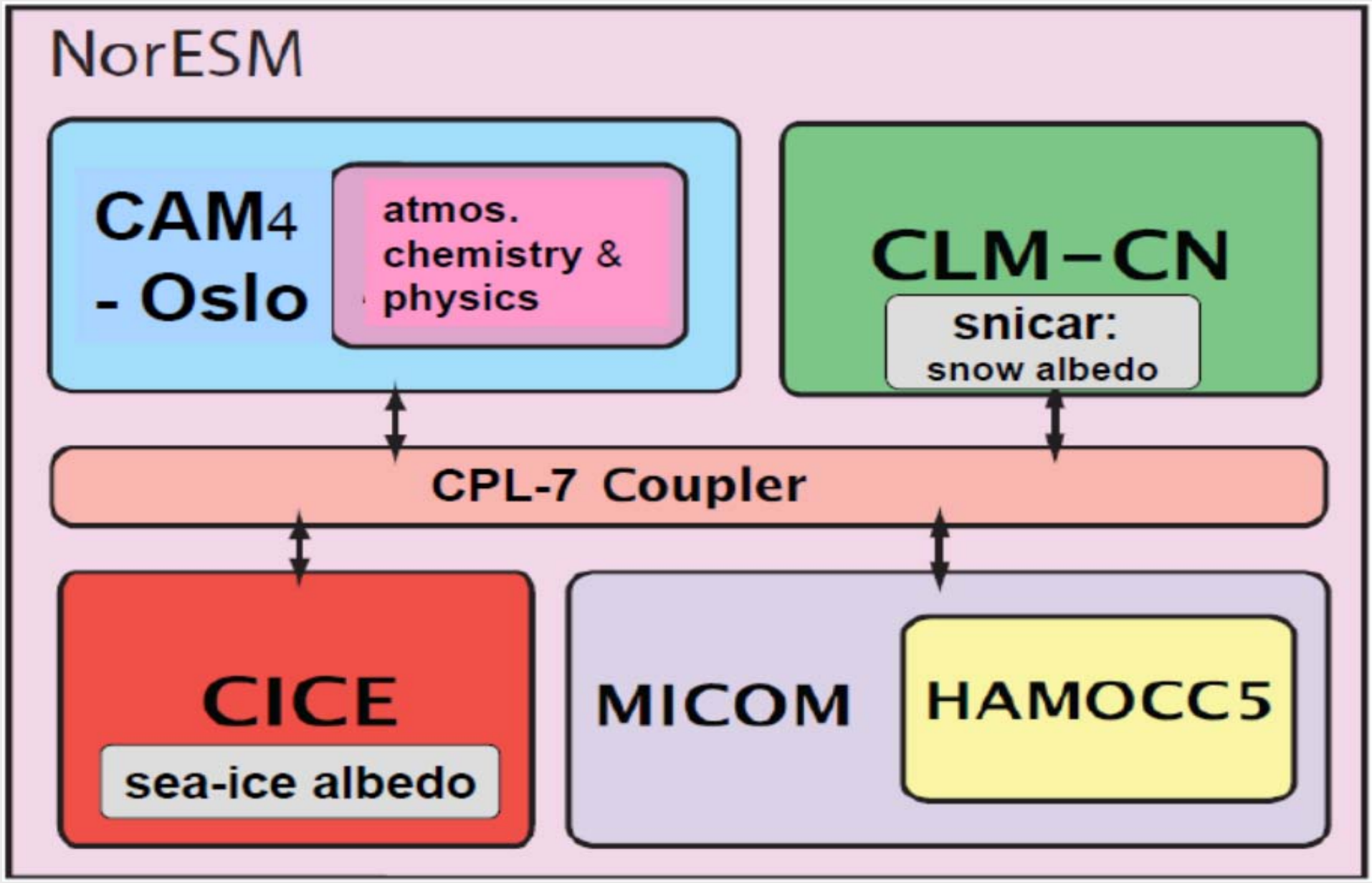
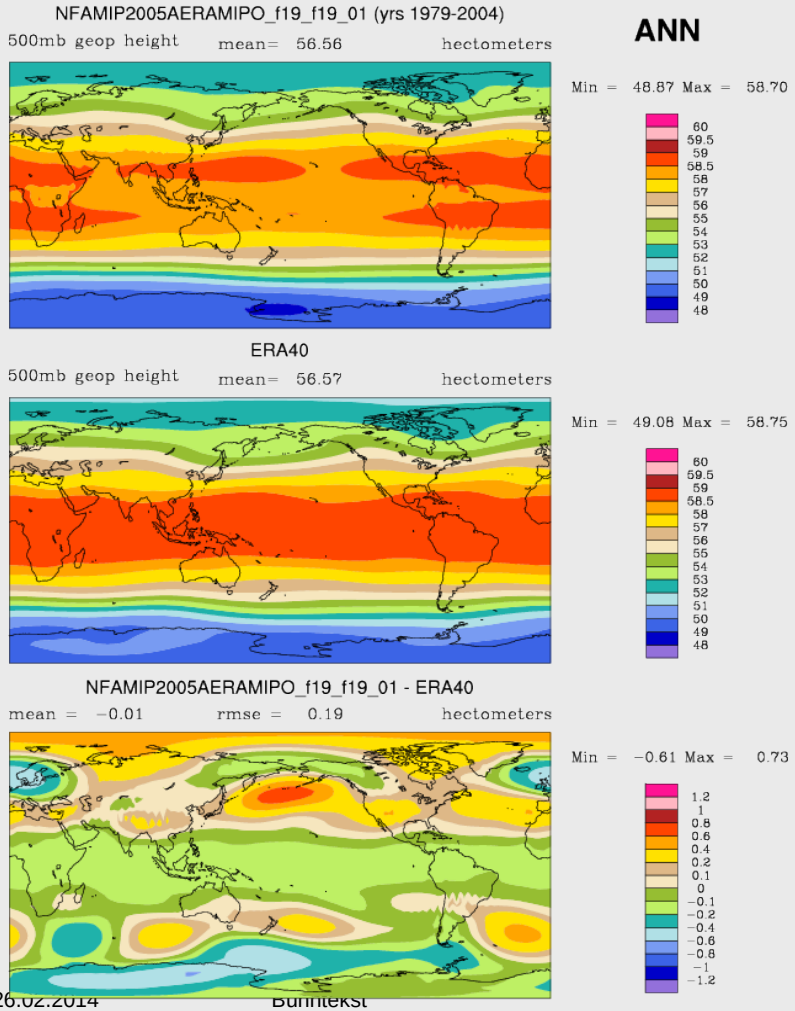
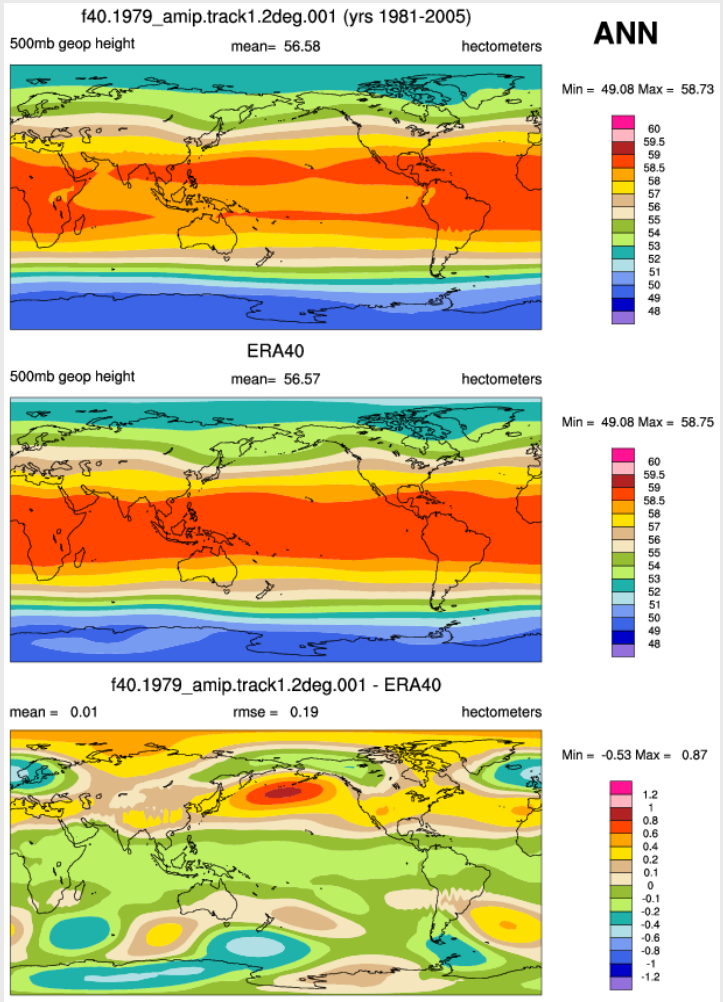

NorESM
CAM4 - Oslo
atmos. chemistry & physics
CLM-CN
snicar: snow albedo
CPL-7 Coupler
CICE
sea-ice albedo
MICOM
HAMOCC5

CAM4-Oslo circulation pattern similar to CAM4

CAM4-Oslo



CAM4 from AMWG web-page



Woollings et al, 2010, J. Climate
Greenland Blocking and NAO

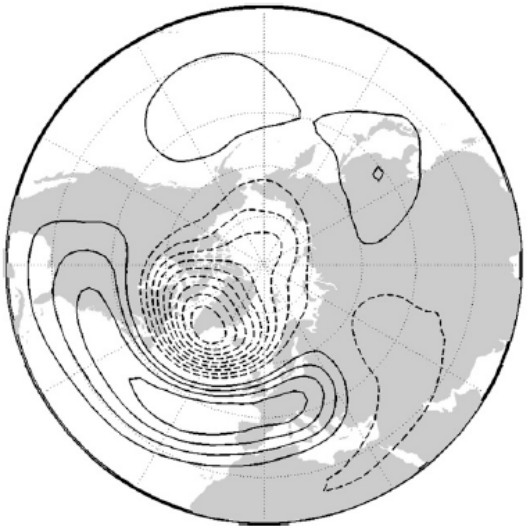


FIG. 2. The winter NAO pattern, defined as the first EOF of monthly mean Z_{500} over 20°–90°N, 90°W–90°E. The pattern is shown by regressing the monthly anomalies onto the principal component time series, with a contour interval of 10 m per standard deviation. Negative contours are dashed and the zero contour is omitted.

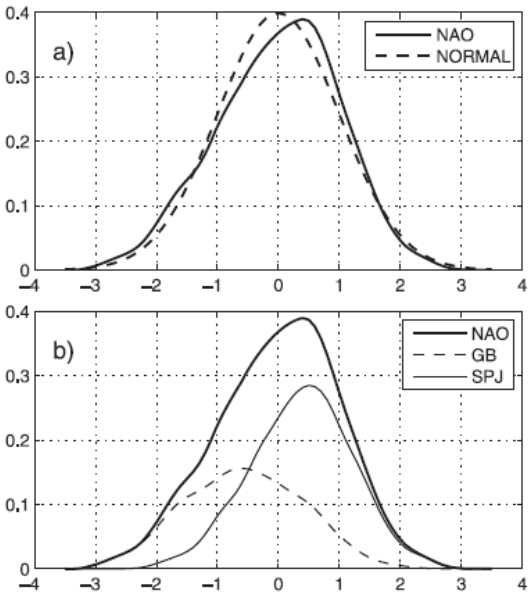


FIG. 3. (a) PDF of the daily NAO index compared to a normal distribution. (b) The same PDF split into the GBE and non-GBE days of W08.

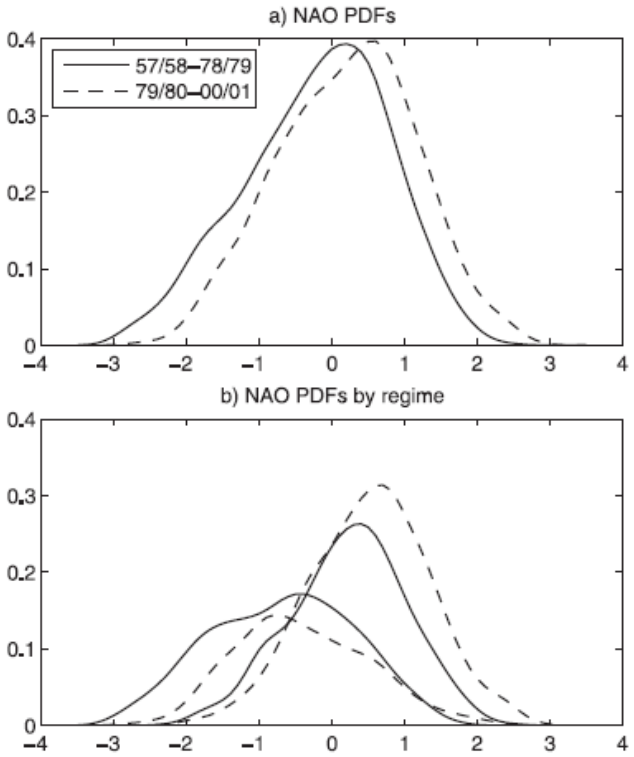
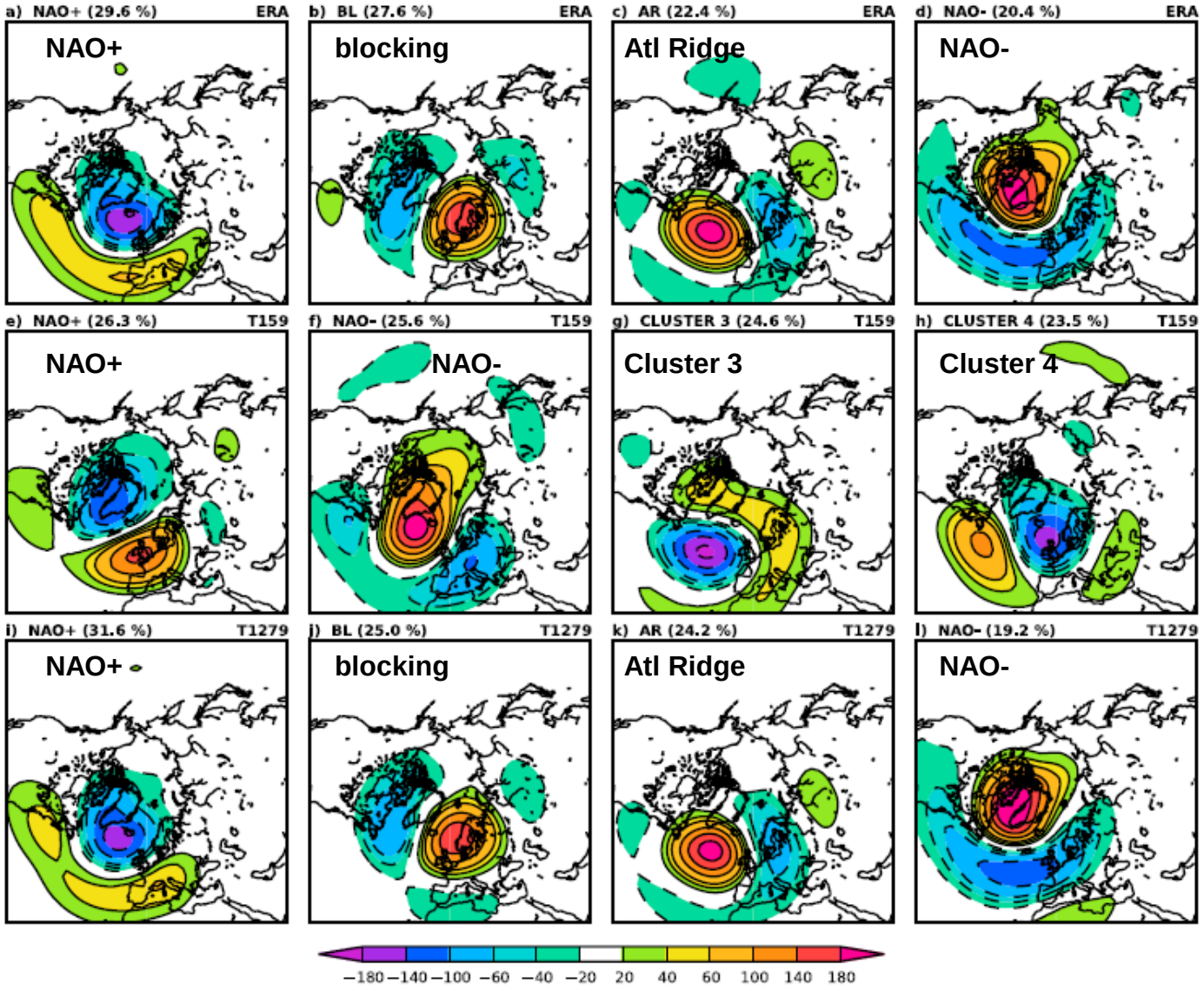


FIG. 10. (a) PDFs of the daily NAO index as in Fig. 3 for the first and second halves of ERA-40. (b) The same PDFs split into Greenland blocking and subpolar jet days for the first (solid lines) and second (dashed lines) periods.

Persistent blocking events over Greenland are Greenland blocking episodes (GBE). Arise from cyclonic wavebreaking events near the start of the Atlantic storm track. Blocking in the region 50–60N, 30–70W is clearly related to NAO.

Dawson, Palmer, Corti, (2012) GRL, 39: Resolution



EC ERA

EC IFS T159
~125km

EC IFS T1279
~16km

Figure 1. Cluster centroid maps of 500 hPa geopotential height. The maps are composites of daily geopotential height anomalies for each day the given cluster is active. Contours of negative anomalies are dashed. The climatological frequency of occurrence for each cluster is given next to the name. Clusters are presented for ERA (a) NAO+ cluster, (b) BL cluster, (c) AR cluster, and (d) NAO− cluster; T159 model configuration (e) NAO+ cluster, (f) NAO− cluster, (g) Cluster 3, and (h) Cluster 4; and the T1279 model configuration (i) NAO+ cluster, (j) BL cluster, (k) AR cluster, and (l) NAO− cluster.