The summer North Atlantic Oscillation –current understanding and future plans

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Introduction

- Basic characteristics of Summer NAO
- Summer NAO and influencing factors
- Possible Global teleconnections
- Any predictability?
- Future plans

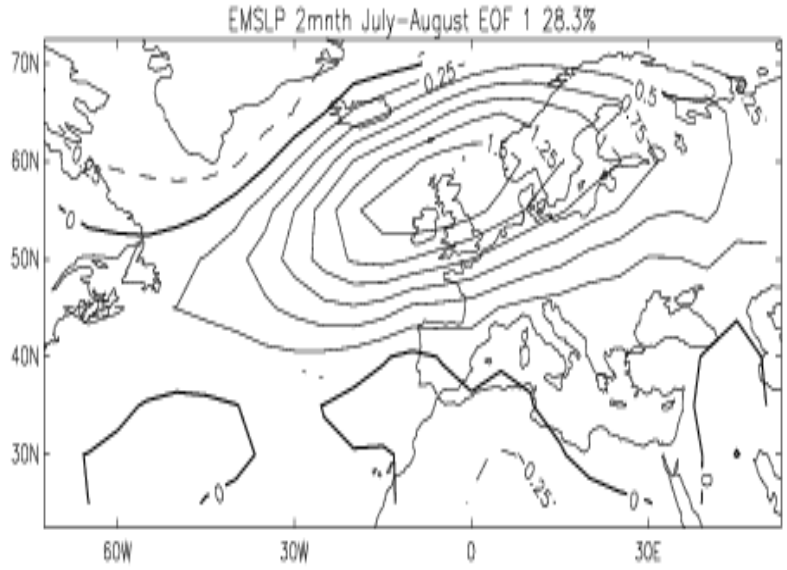
Thanks to:

- Nick Dunstone Hadley Centre for creating the Arctic sea ice model results

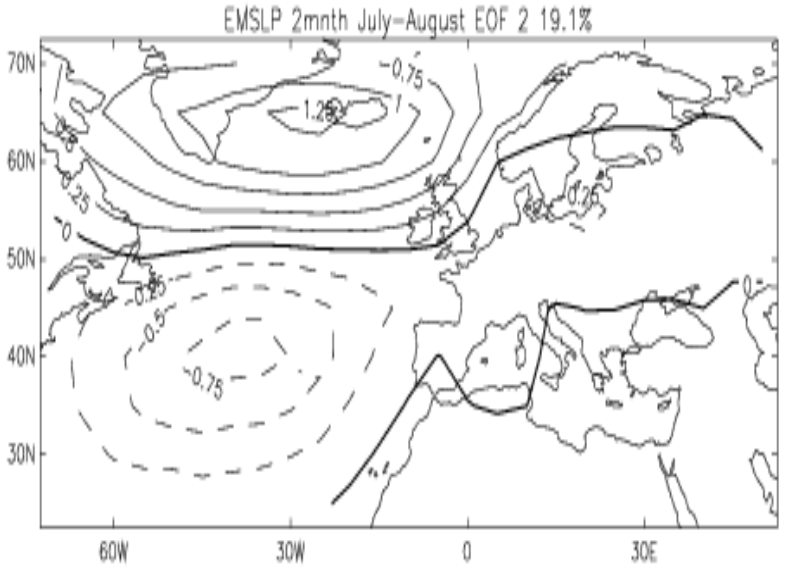
- Jo Camp Hadley Centre for tropical storm results

- Other members of Adam Scaife's team for QBO model results

First and Second EOFs of July-Aug PMSL, Daily EMSLP domain, 1881-2003



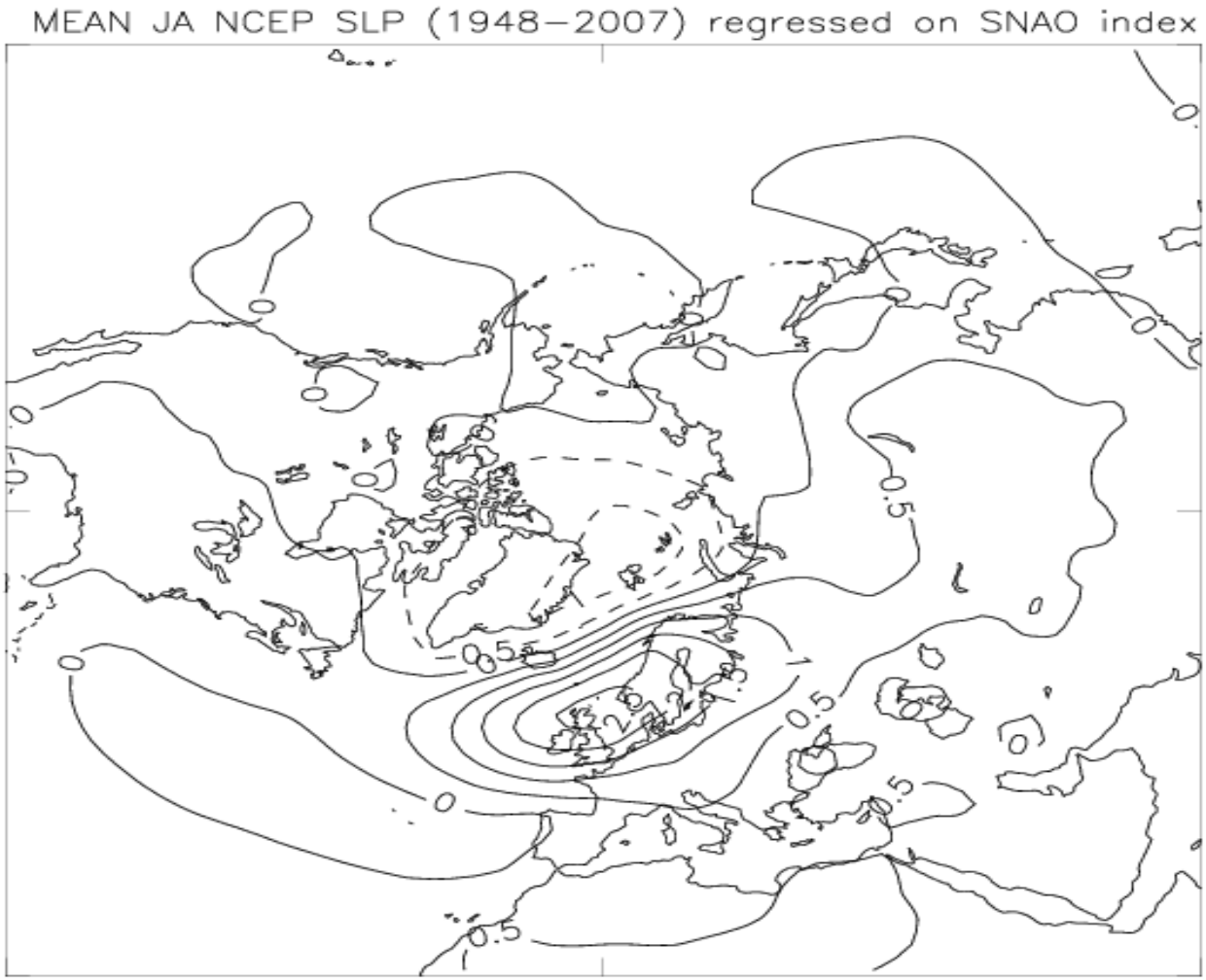
Summer NAO



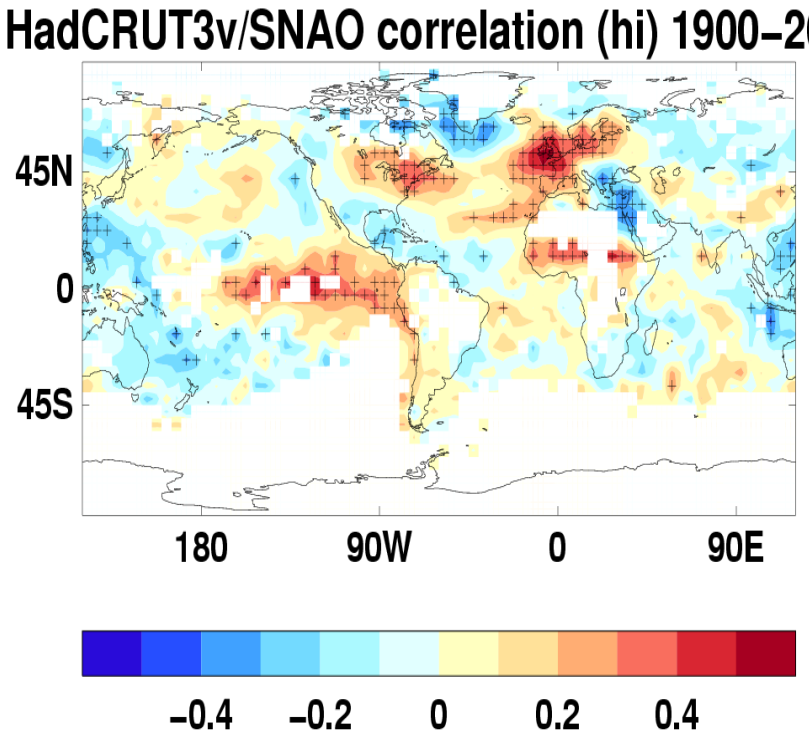
Portis "Mobile NAO"

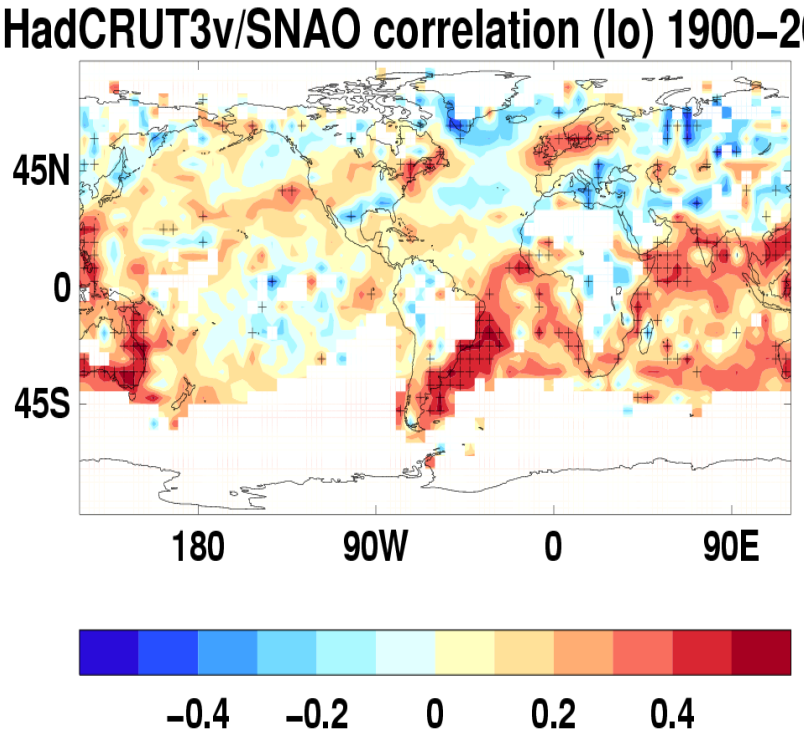
Full surface pattern of the July and August mean SNAO

28.3% of 2 month variance



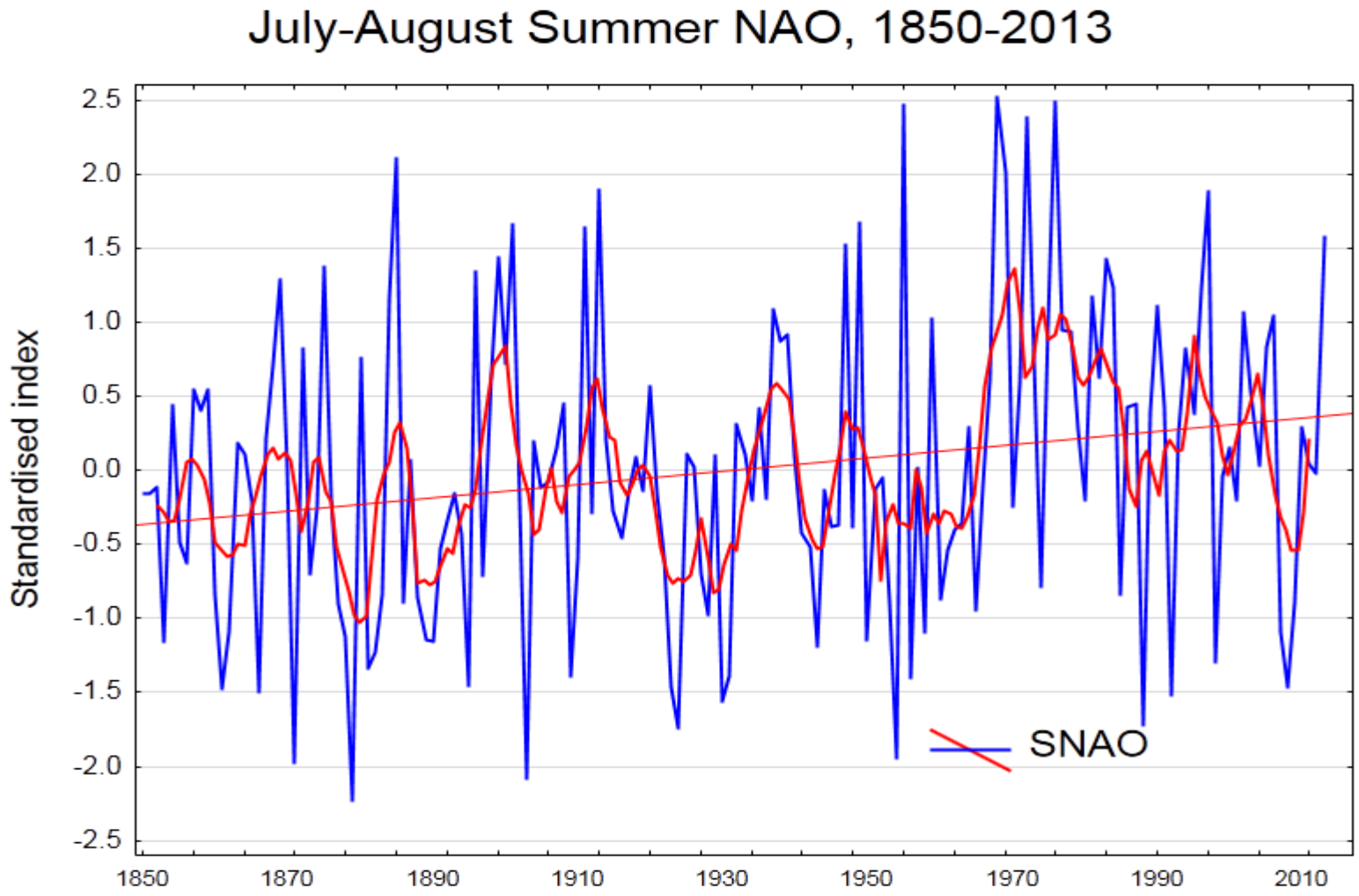
Correlation of daily SNAO with surface temperature, July and Aug





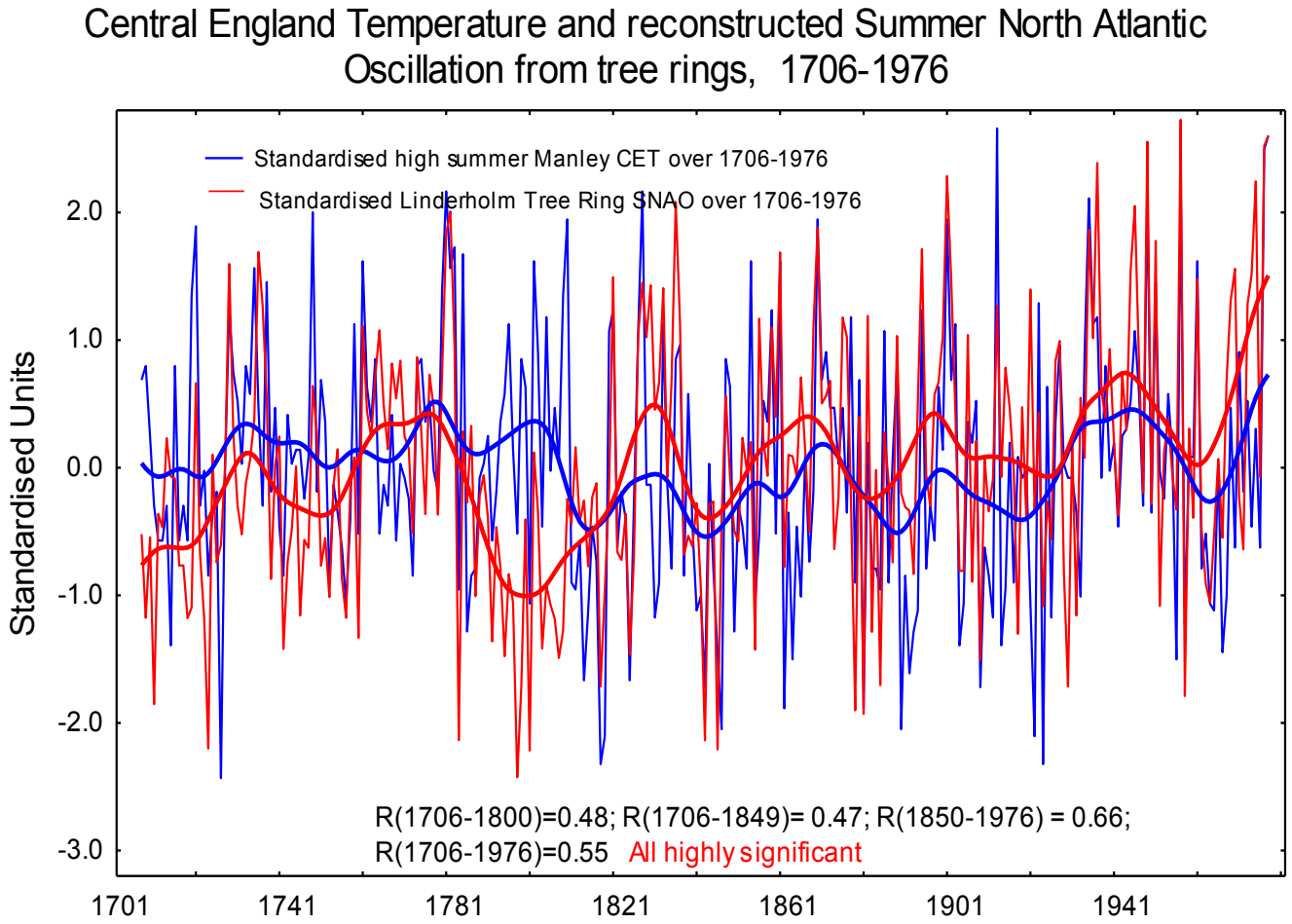
Interannual

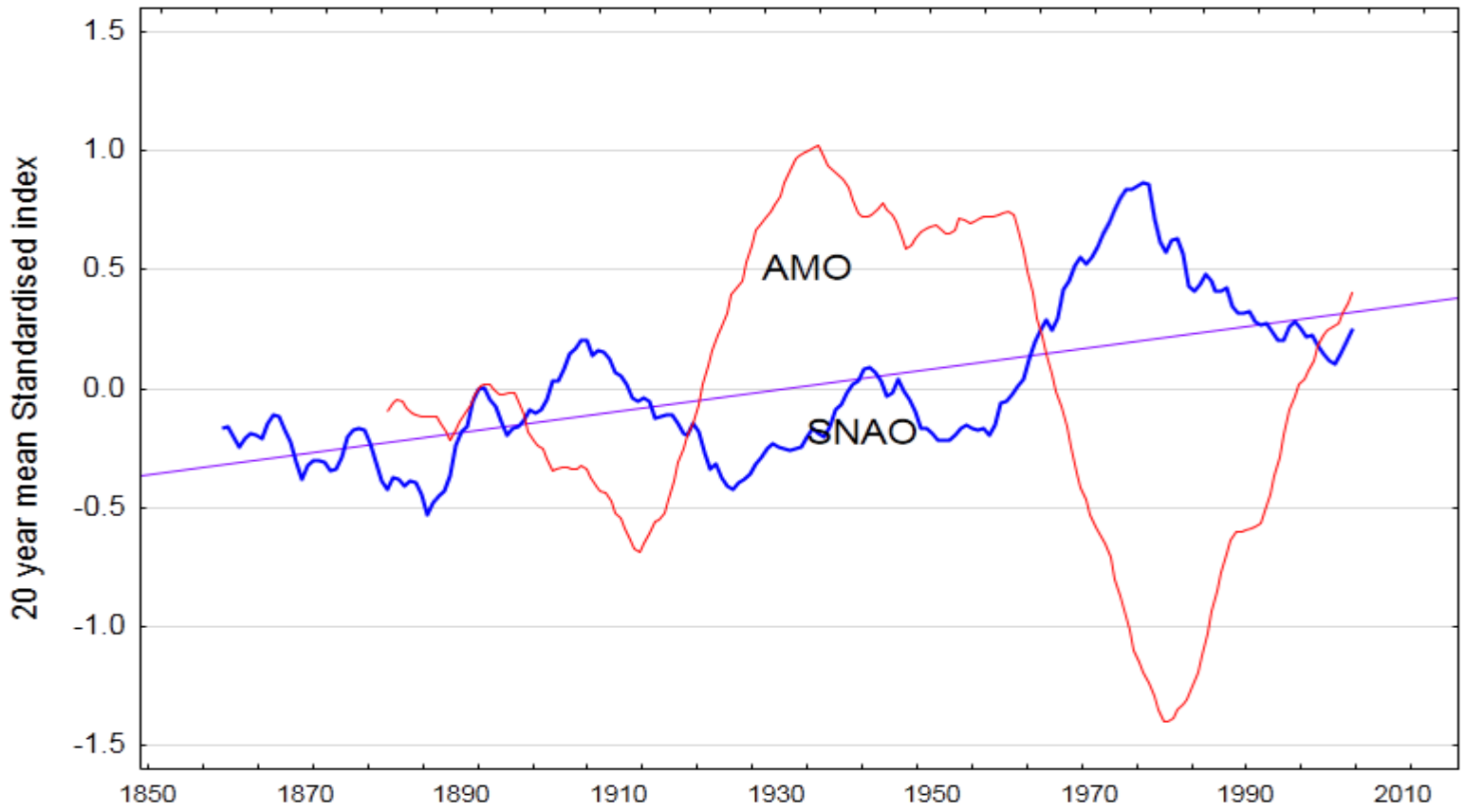
> 10 years



SNAO back to 1706

Reconstructed SNAO (red) and CET (blue)

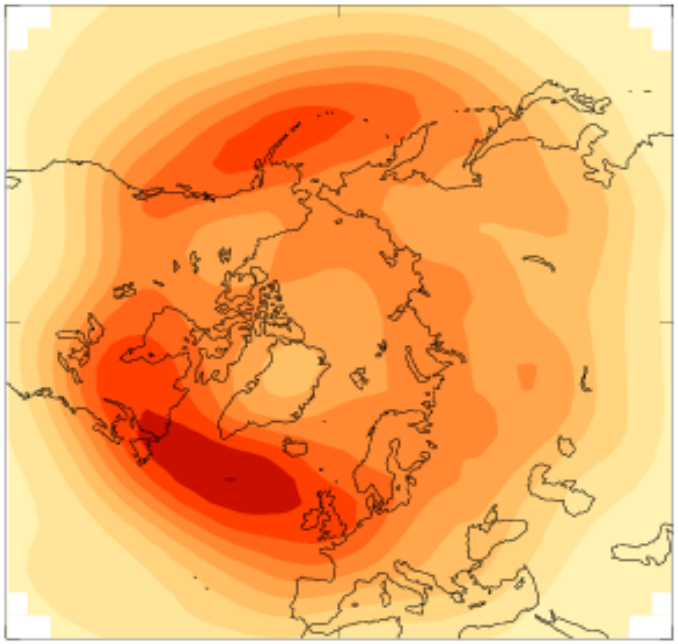




Possible long term increase of >0.5 standard deviations since 1850 superimposed on AMO/interhemispheric SST influences

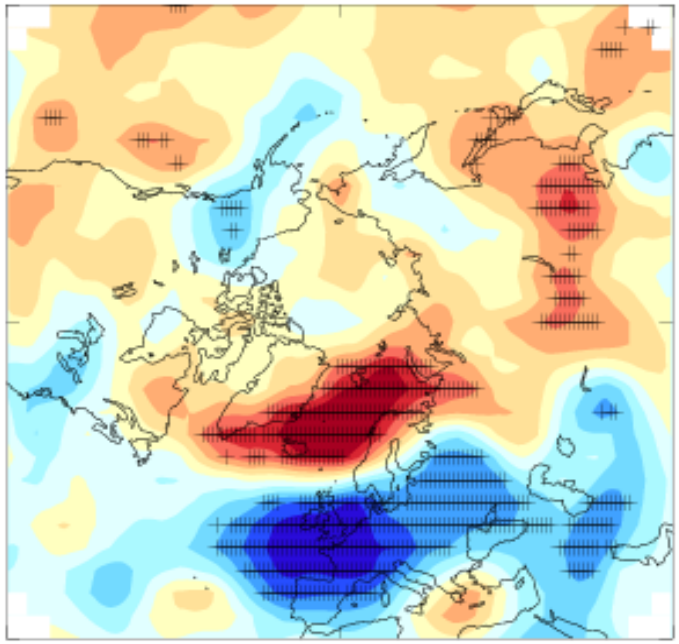
SNAO and storm tracks in July-August

Mean JA storm track



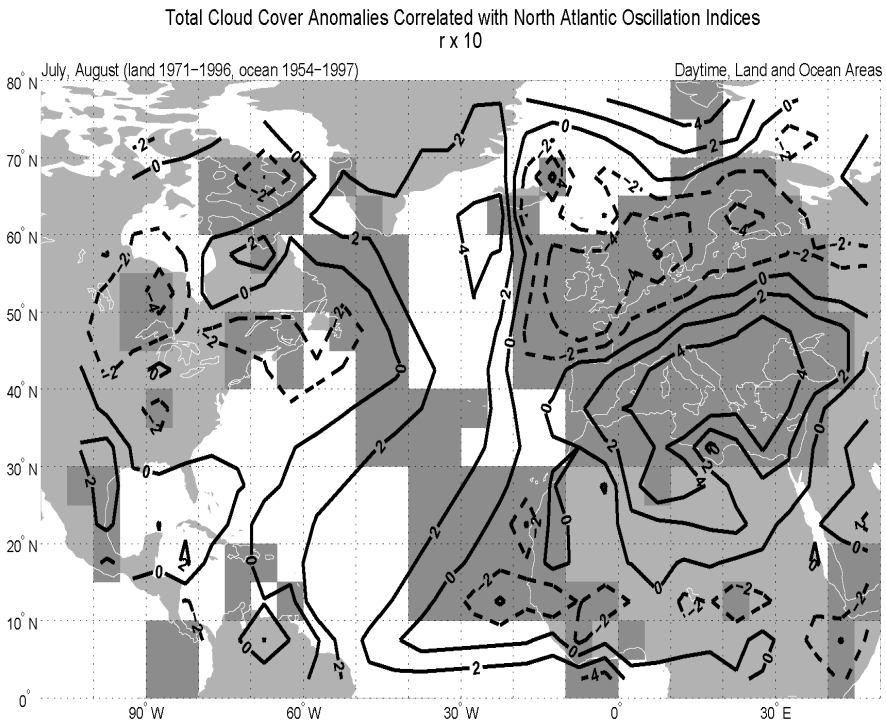
Standard deviation of 300 hPa Height on 2-8 day time scale Mean storm track

SNAO correlation

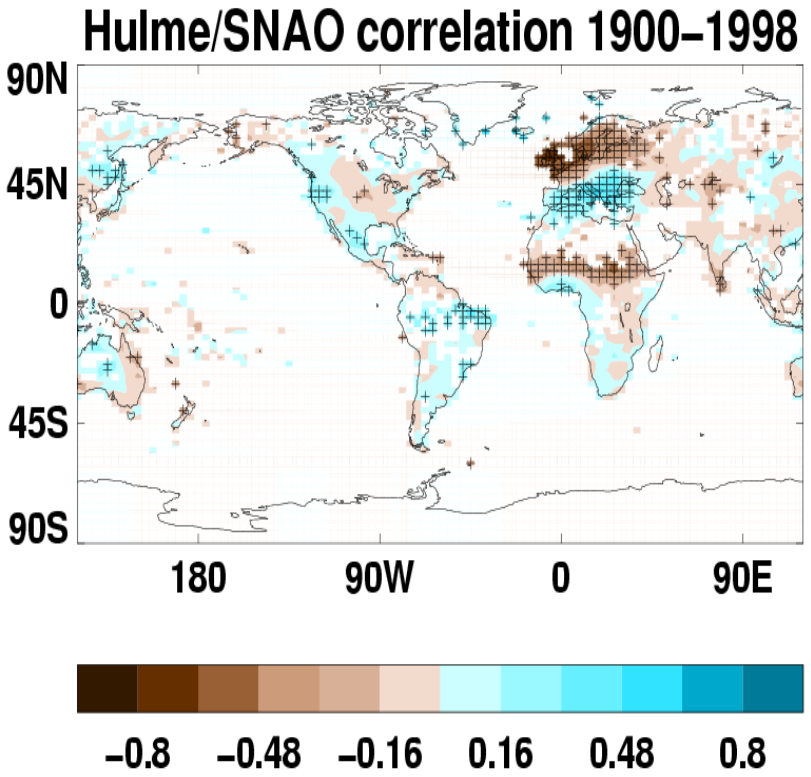


Correlation of storm track with SNAO. Storm track moves north for positive SNAO

SNAO correlation with rainfall and cloudiness, July and Aug



cloudiness



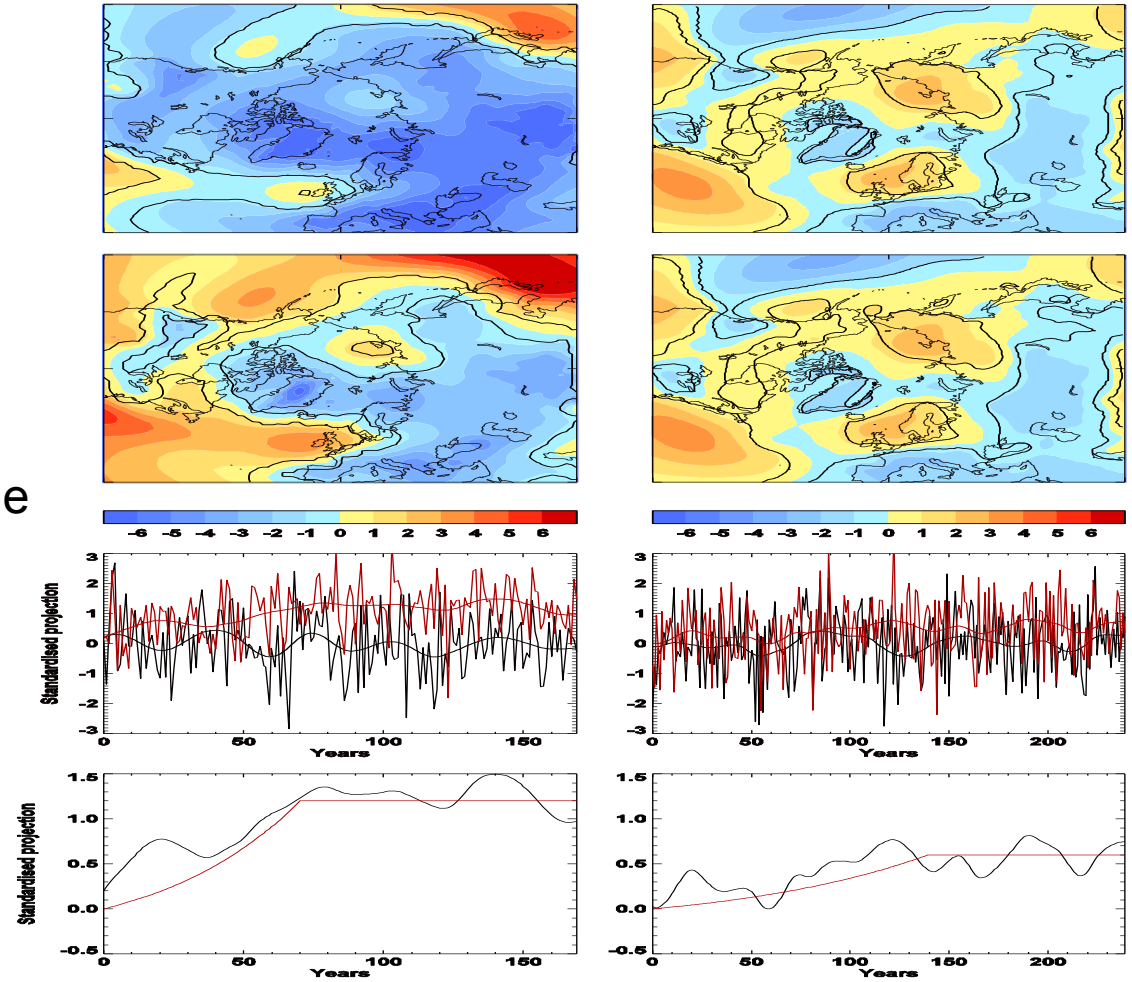
rainfall

SNAO and PMSL response to an increase to 4x pre-industrial CO2

PMSL change

PMSL change adjusted for mean domain change

SNAO 4xCO2 (red) compared to control (black)

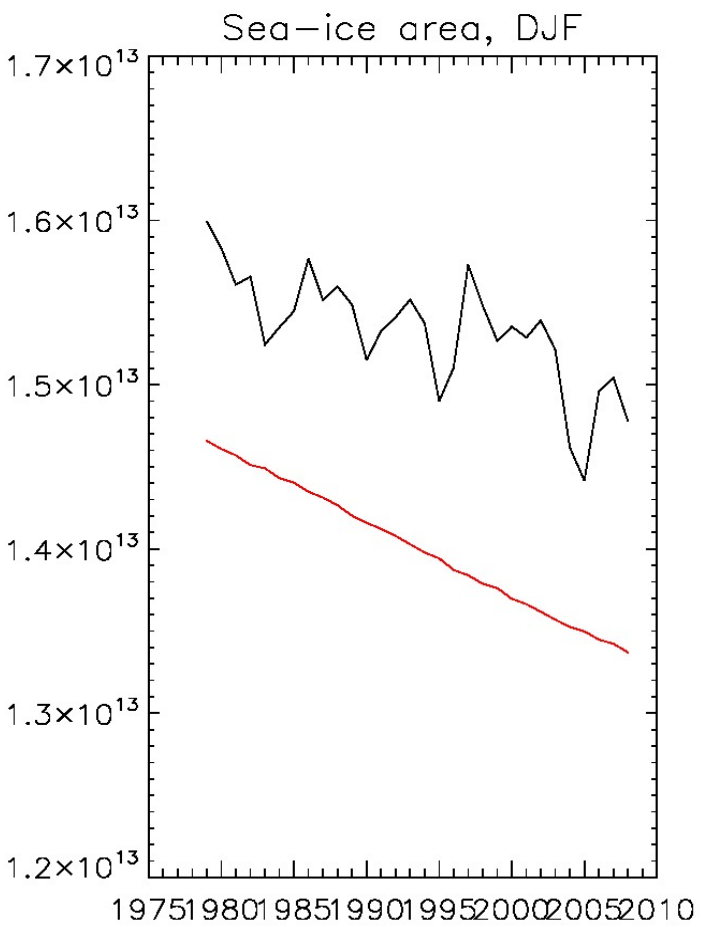


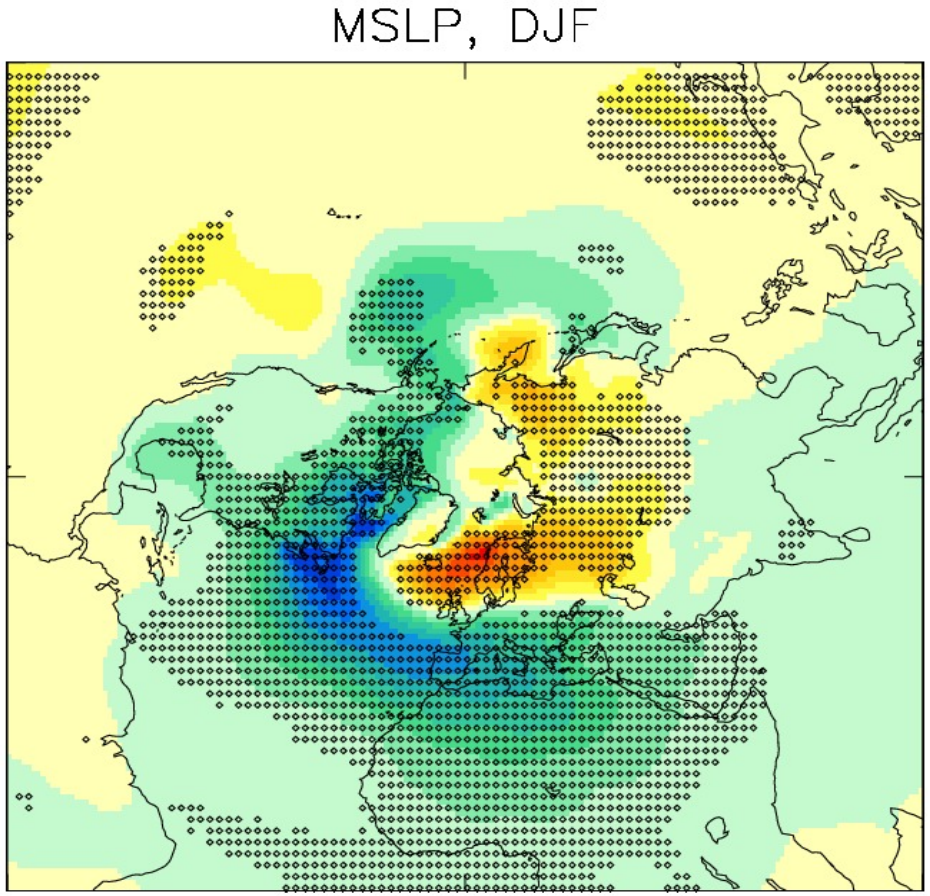
Likely non-stationarity of SNAO under greenhouse warming

Arctic Sea ice and winter and summer climate

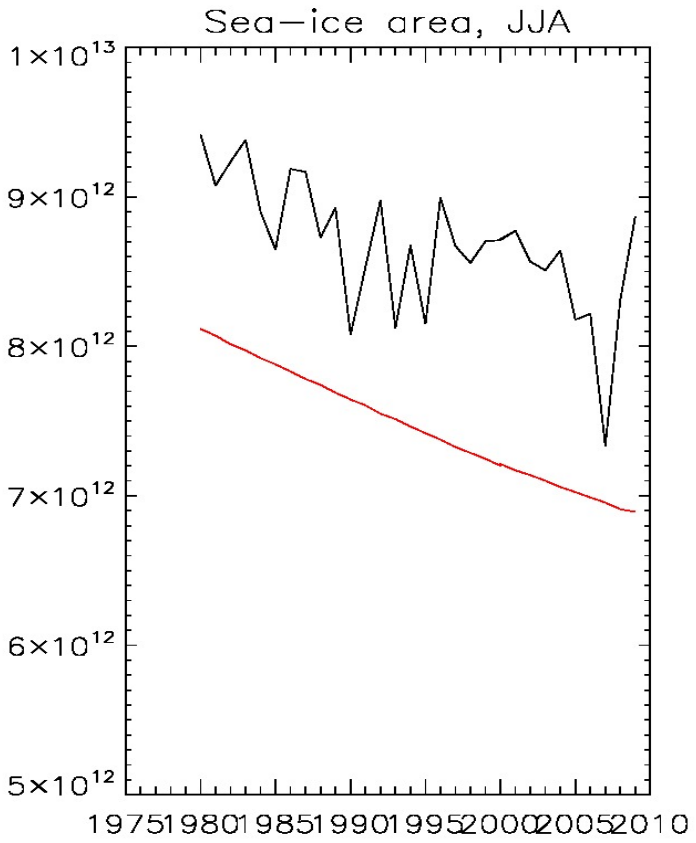
- HadGEM3 run in N96 1x1 degree ocean mode
- Run single experiment with observed sea ice extent changes 1979-2009
- Run single parallel experiment with systematically reduced sea ice extent linear trend expected 2009-39
- Both experiments nudged to same ocean conditions below 200m so almost no effects of phenomena like AMO variations
- No changes in GHG and other forcings
- Look at the impact of perturbed minus control experiment on PMSL

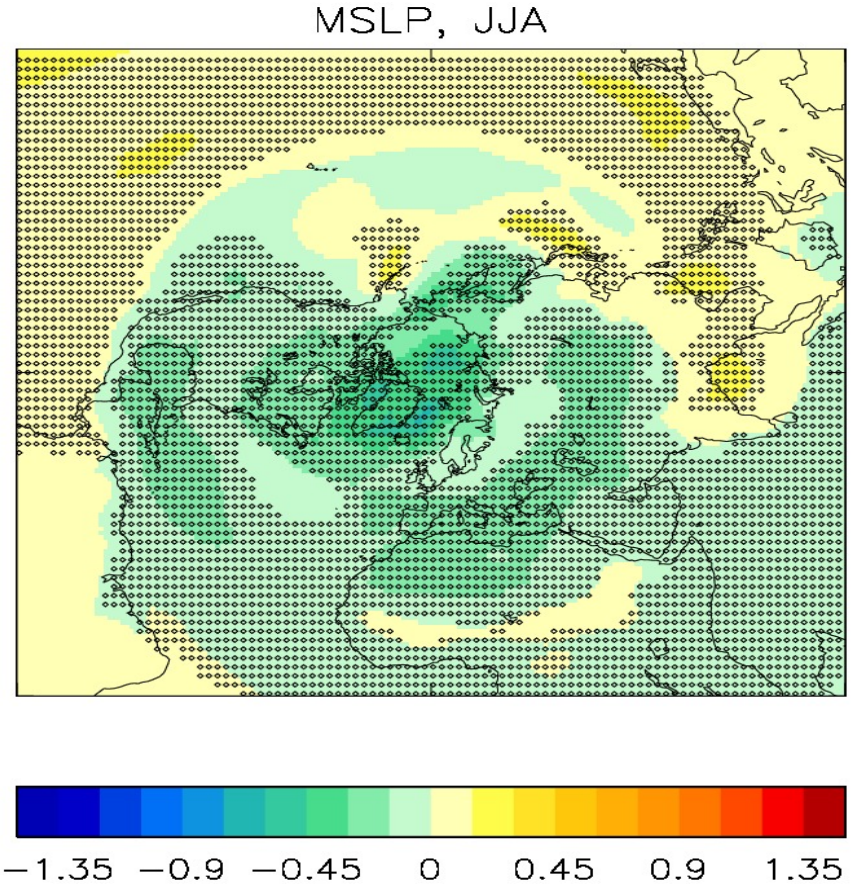
Winter HadGEM3 results





Summer HadGEM3 results

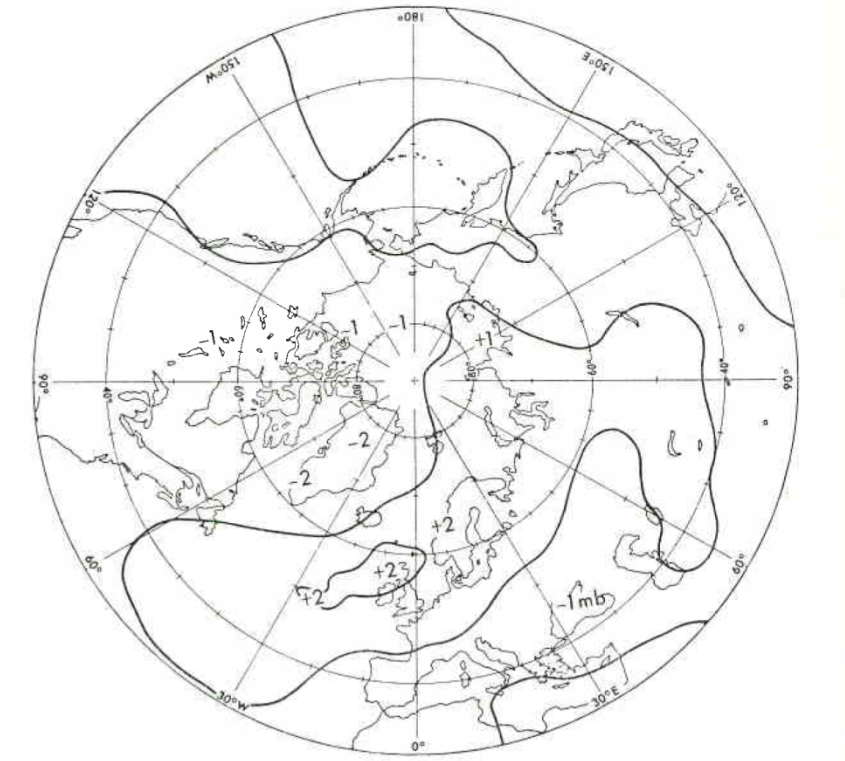




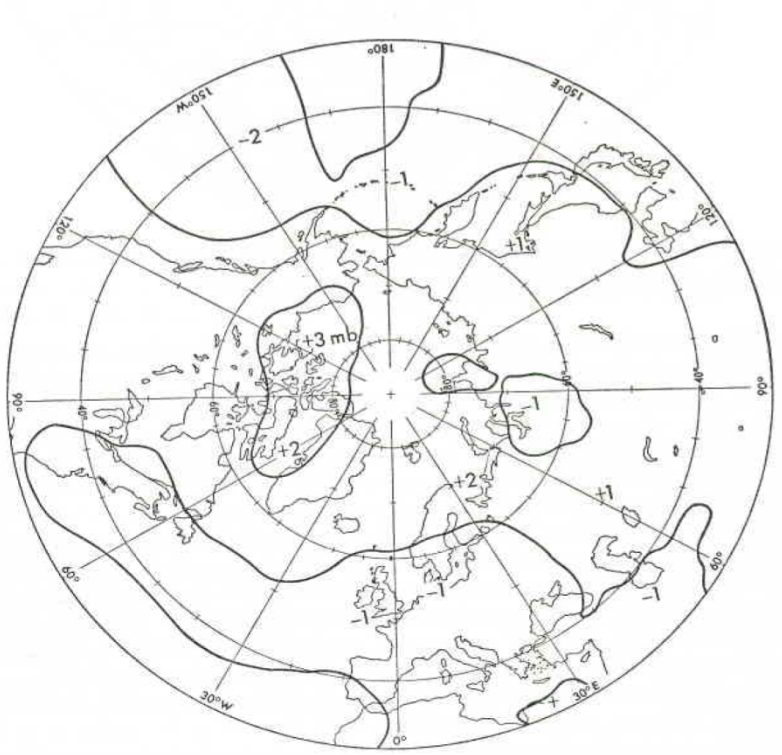
General slight fall in SLP around the Arctic and Atlantic sector with reduced sea ice. No significant fall in much of southern SNAO region.

Does the QBO influence European Summer climate?

Ebdon, 1975, Met Mag

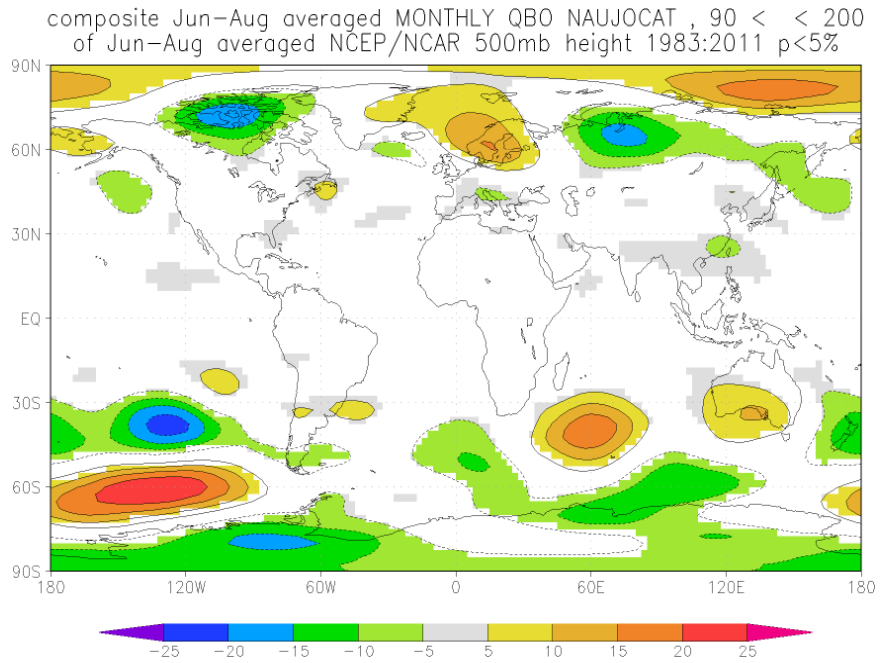


Mean PMSL anomaly
of 8 westerly 30hPa QBO
Julys, 1955-1973

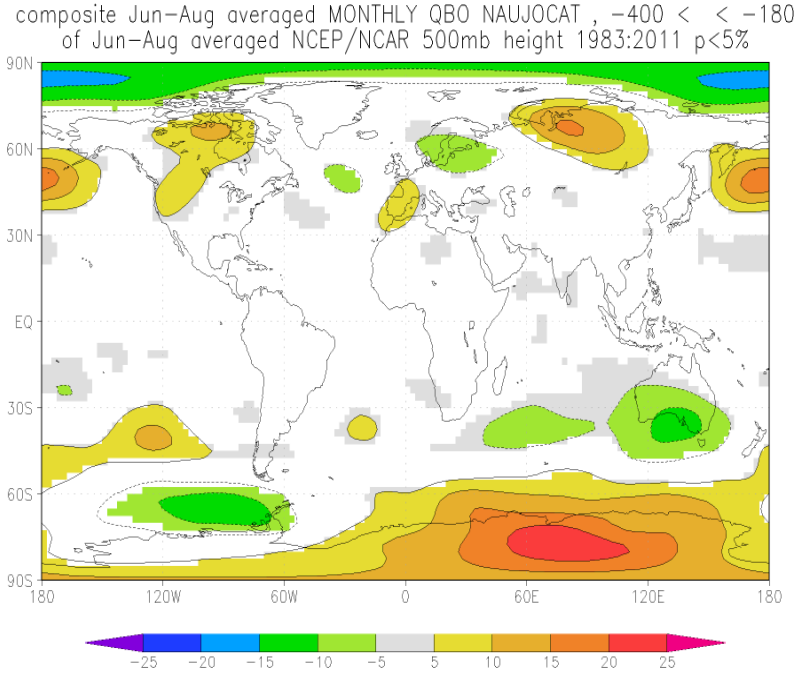


Mean PMSL anomaly
of 8 easterly 30 hPa QBO
Julys, 1954-1972

Using only more recent 500hPa data, June - August



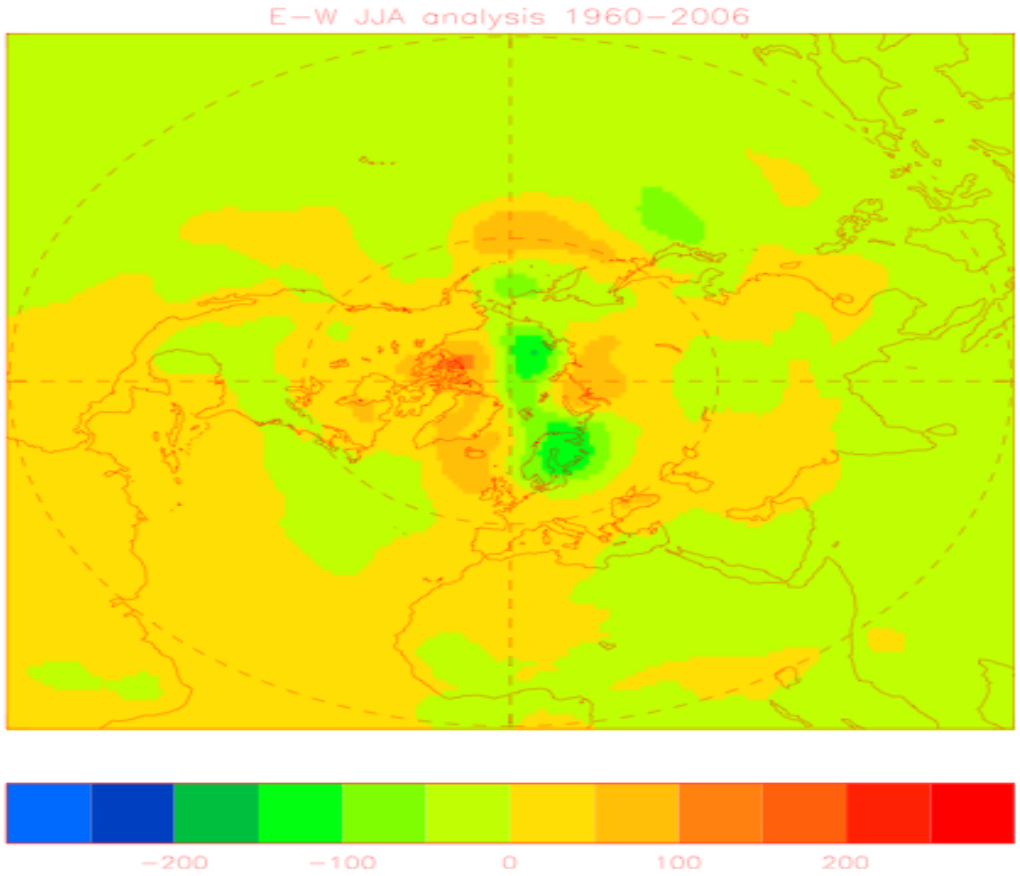
Westerly QBO



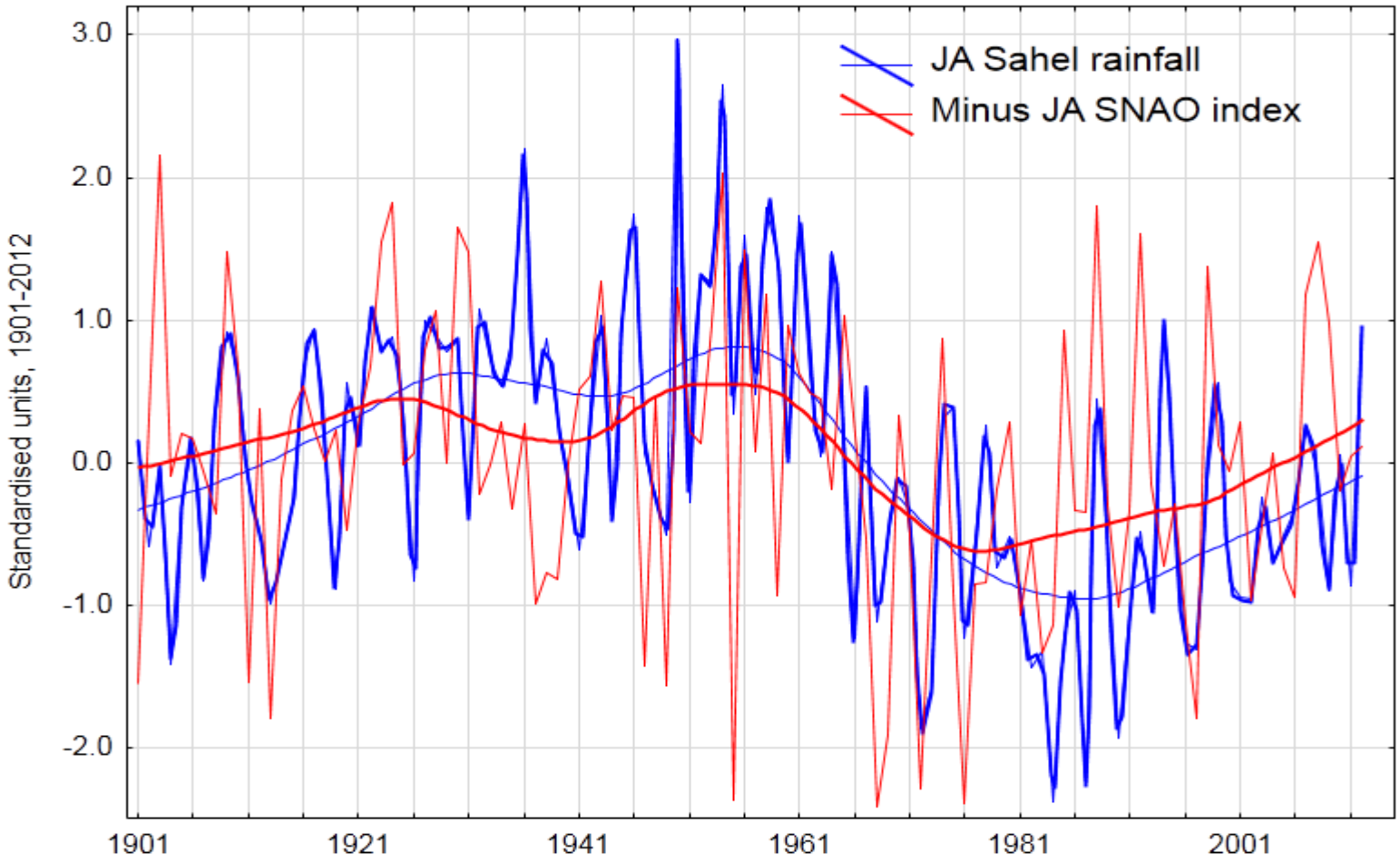
Easterly QBO

- Little significance at surface, likely field significance at 500 hPa using QBO data > +- 1 standard deviation. Small effect near UK.
- Bigger Southern Hemisphere signal – small factor for extratropical Australian winter?

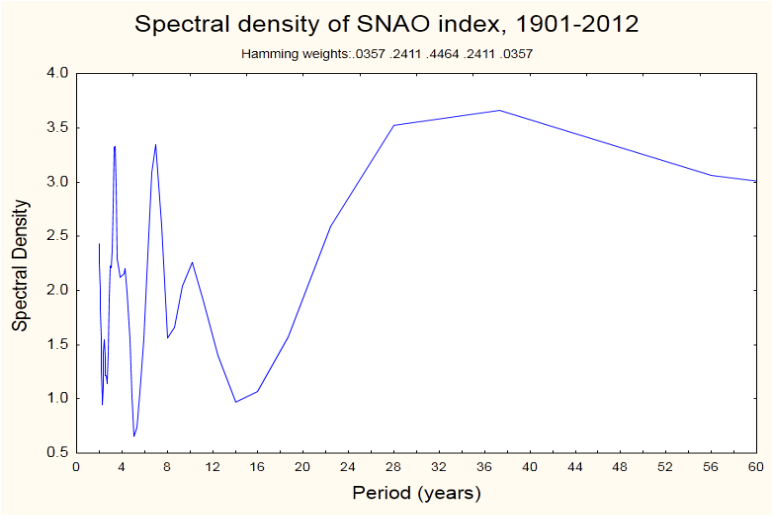
QBO HadGEM3 PMSL results, 1960-2006 using DePreSys hindcasts QBO 30hPa winds >5m/s or <-5m/s

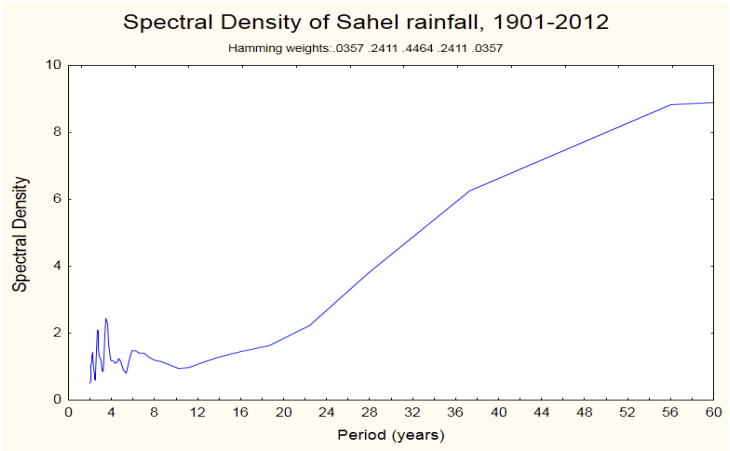


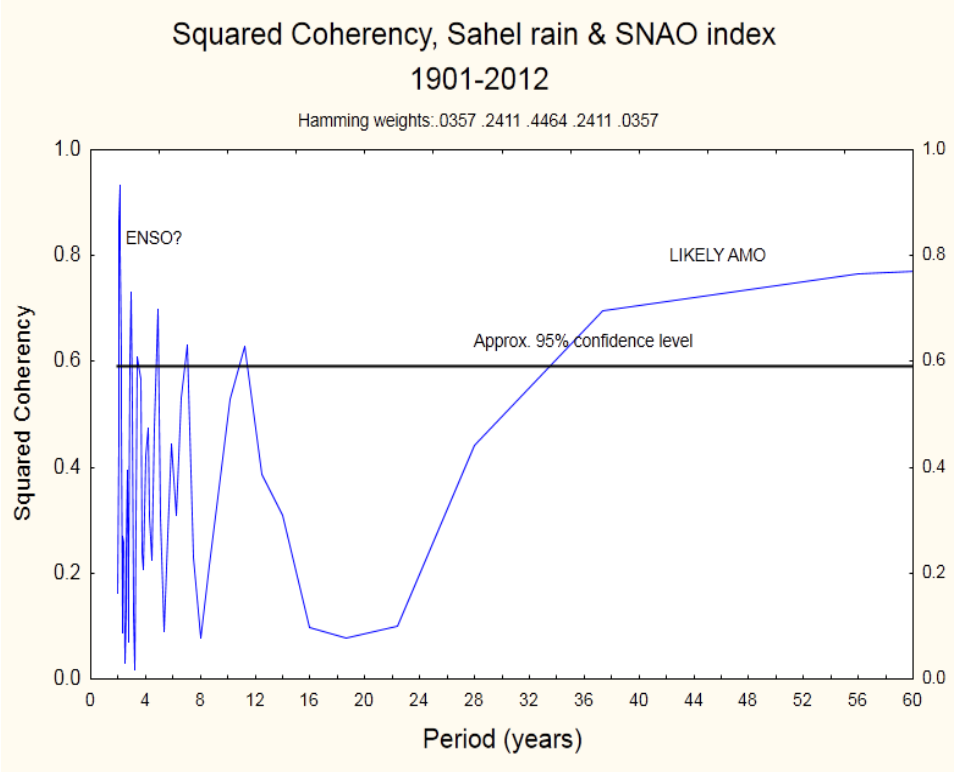
Near UK, westerly minus easterly results almost as weak as observations



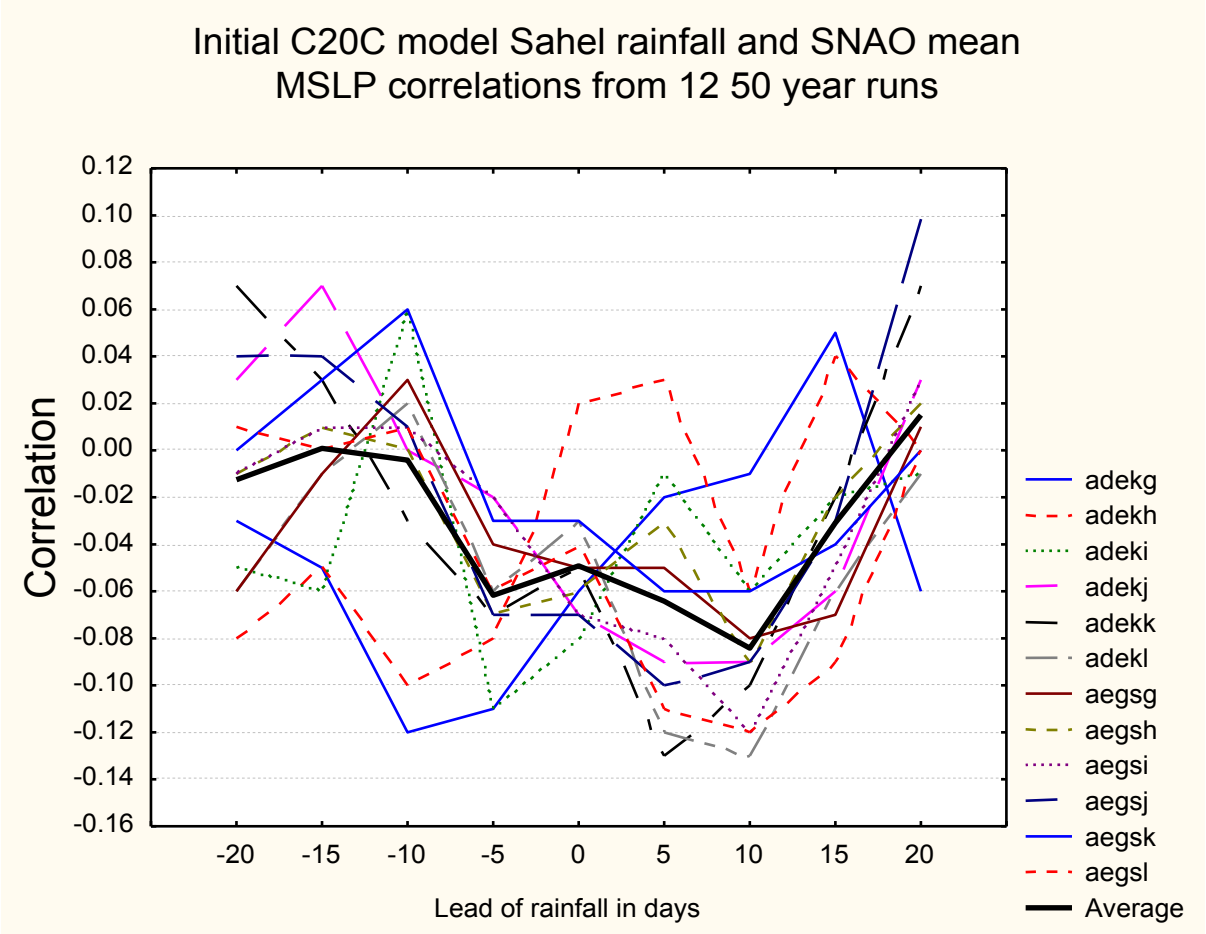
Sahel rainfall & SNAO, 1901-2012 (standardised indices)



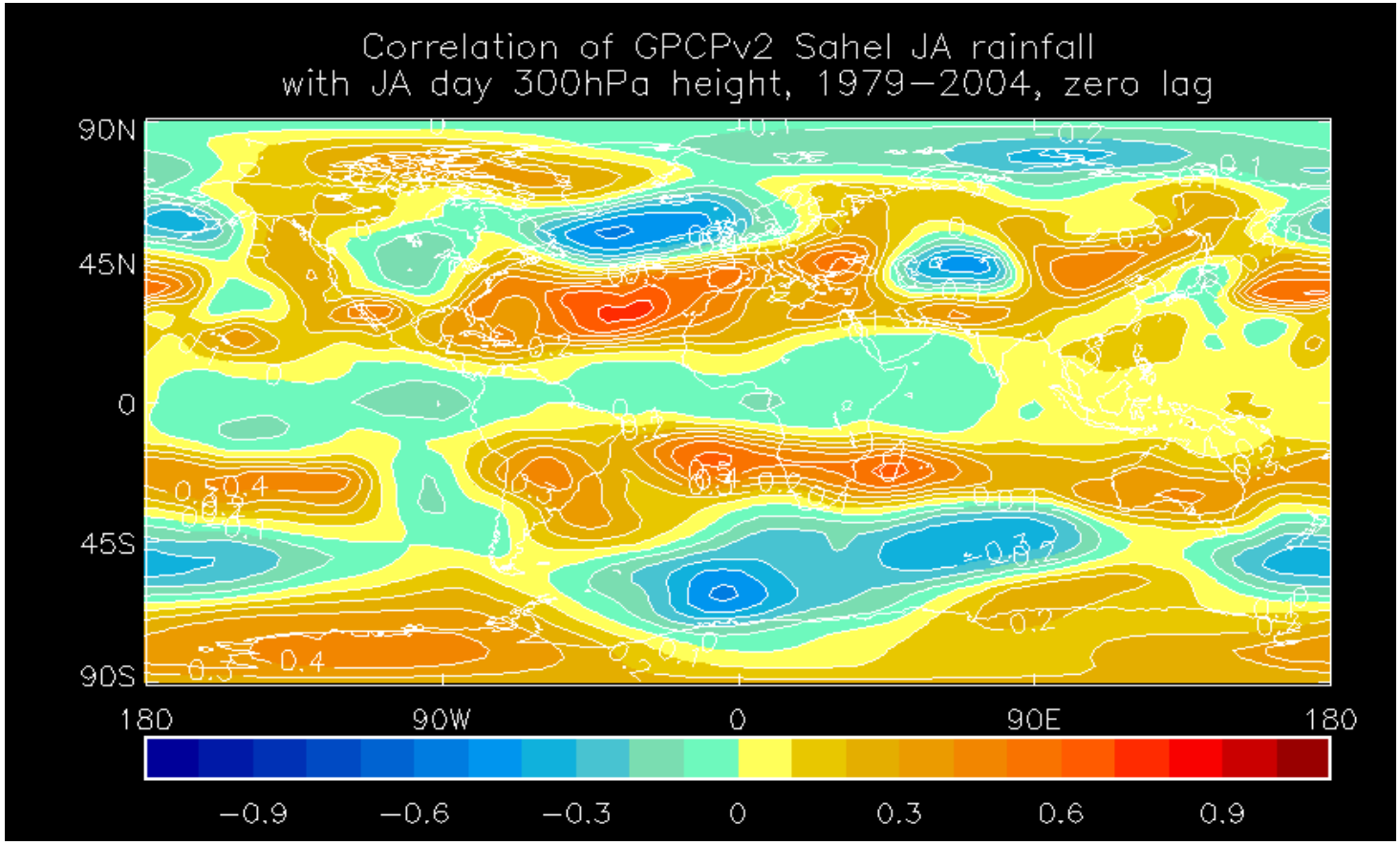




C20C experiments – HadAM3 model pressure over N W Europe and model Sahel rainfall

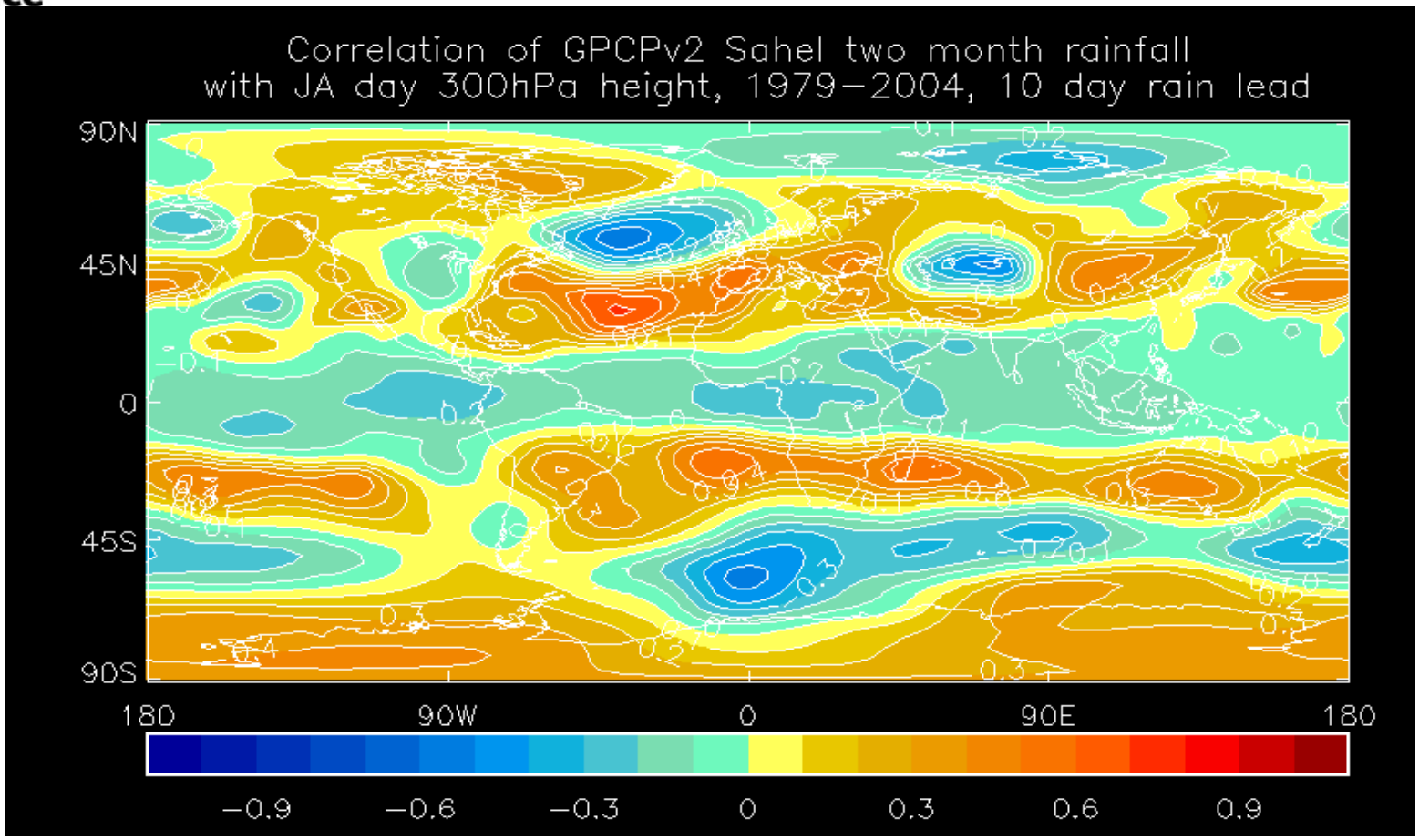


Zero lag correlation of JA Sahel rainfall and JA 300hPa height from NCEP

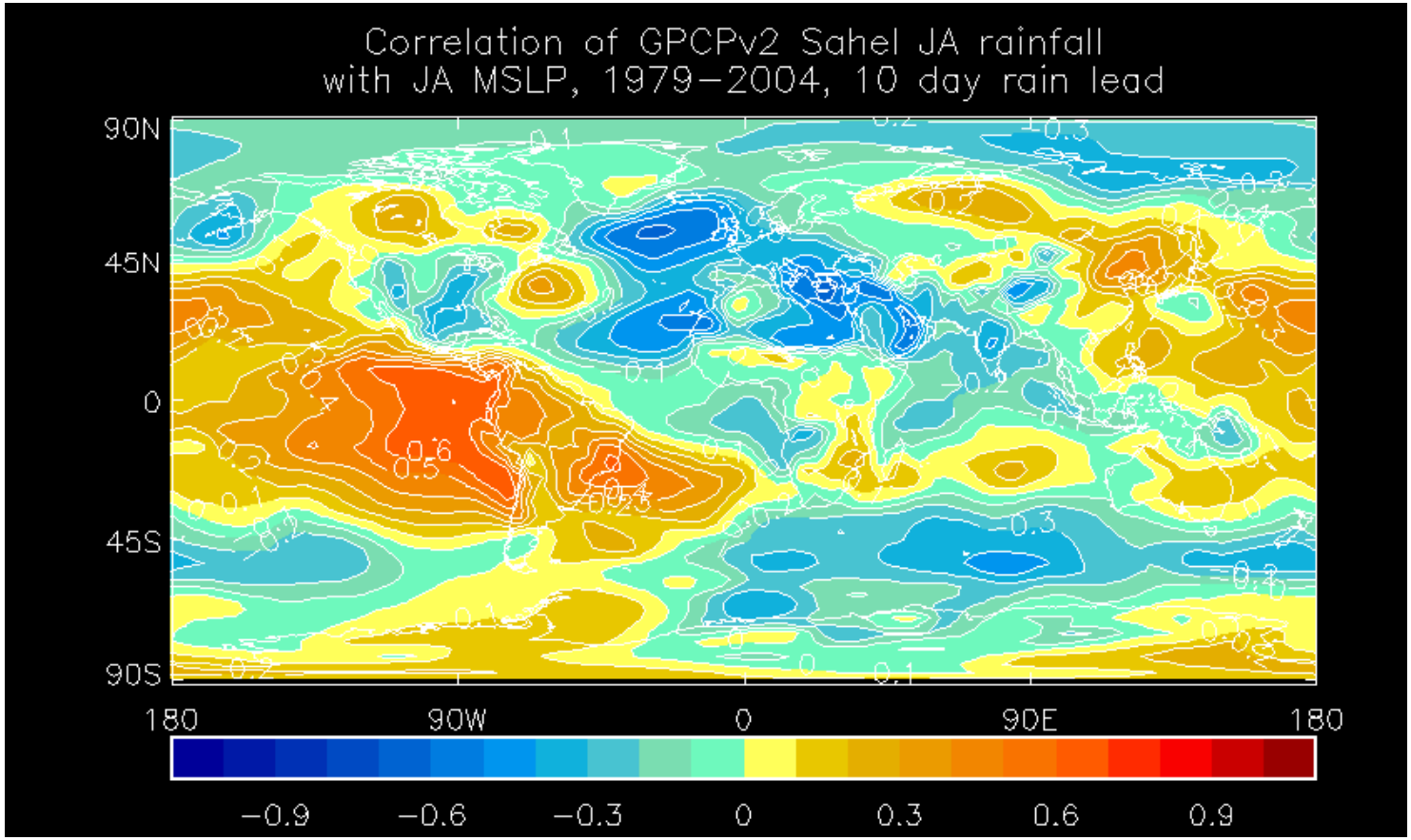


Values > c. +-0.45 in magnitude are significant

Similar but 10 day Sahel rain lead



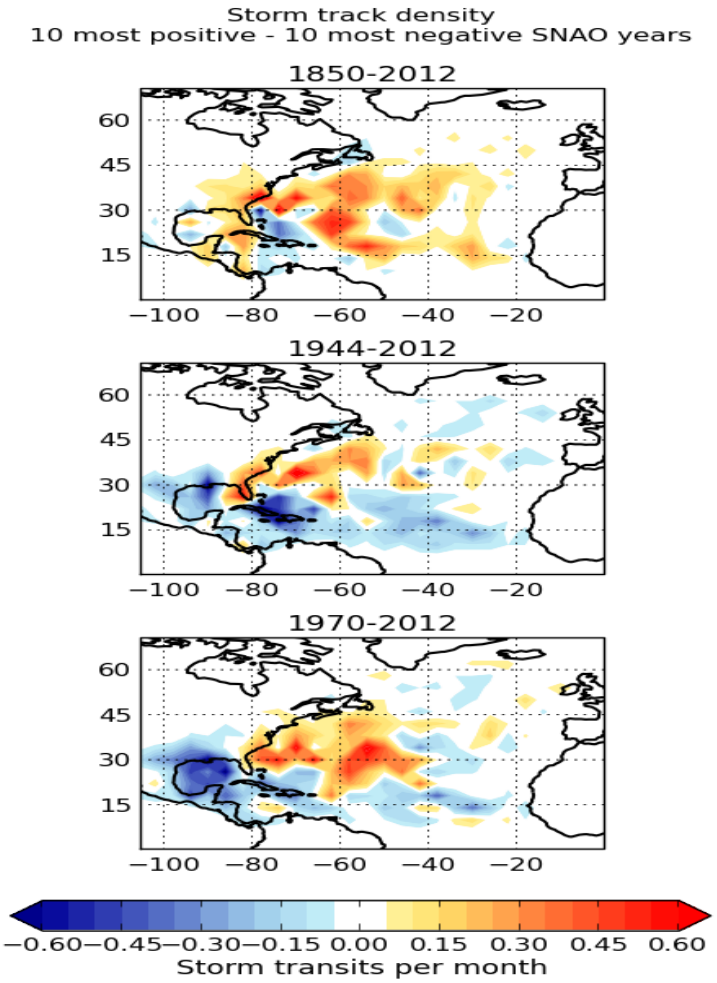
Similar but PMSL with 10 day Sahel rainfall lead



JA Sahel rainfall and SNAO

- Good indications in observations of global teleconnections of Sahel rainfall and SNAO
- Variations in the two phenomena are linked
- Weak indication on obs. and model that a 10 day rainfall lead produces a stronger response.
- But overall C20C HadAM3 model response very weak, though in the observed direction.
- Winter Southern Hemisphere and summer Northern Hemisphere subtropical jets may be involved somehow

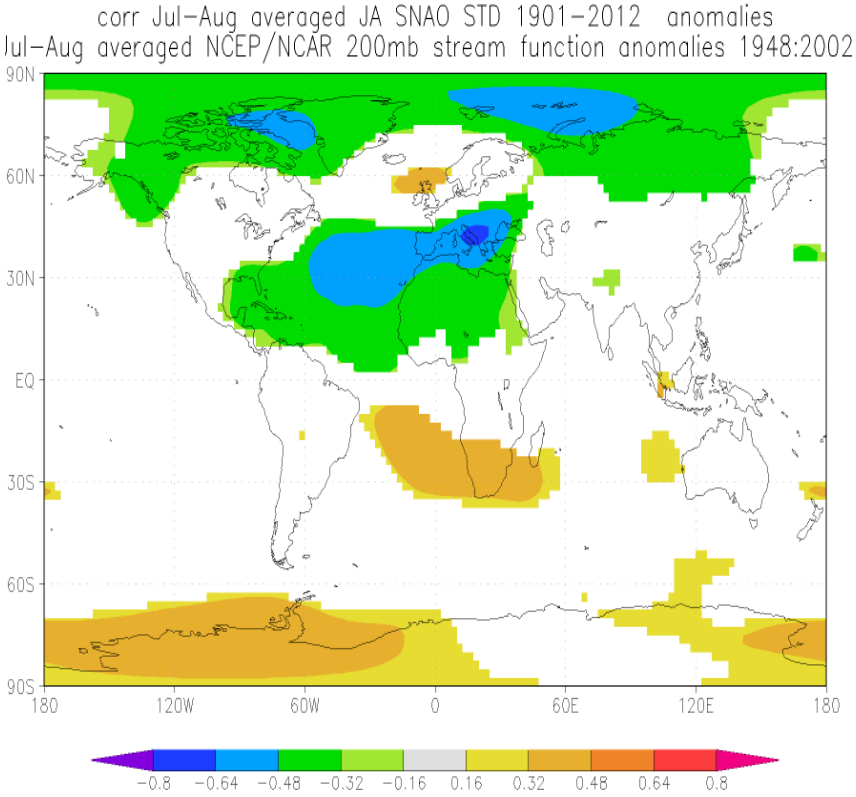
Do tropical storm frequencies relate to SNAO?



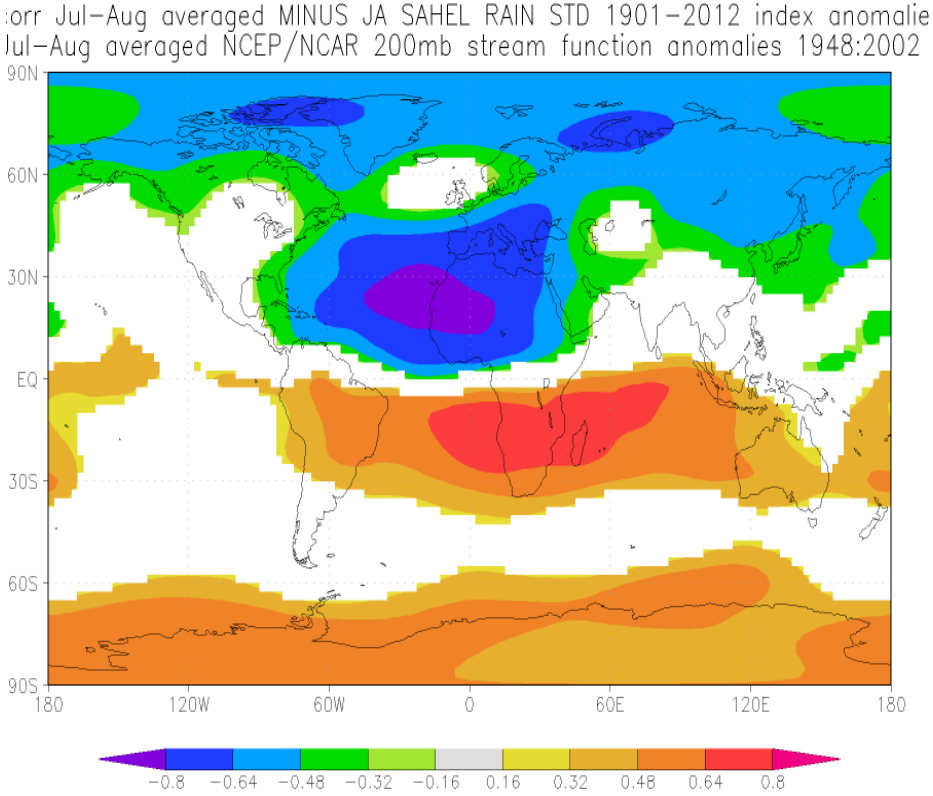
Weak tendency to more tropical storms reaching Newfoundland storm development region in most positive SNAOs

Correlation NCEP 200hPa streamfunction JA SNAO & JA Sahel rainfall,1948-2002

SNAO

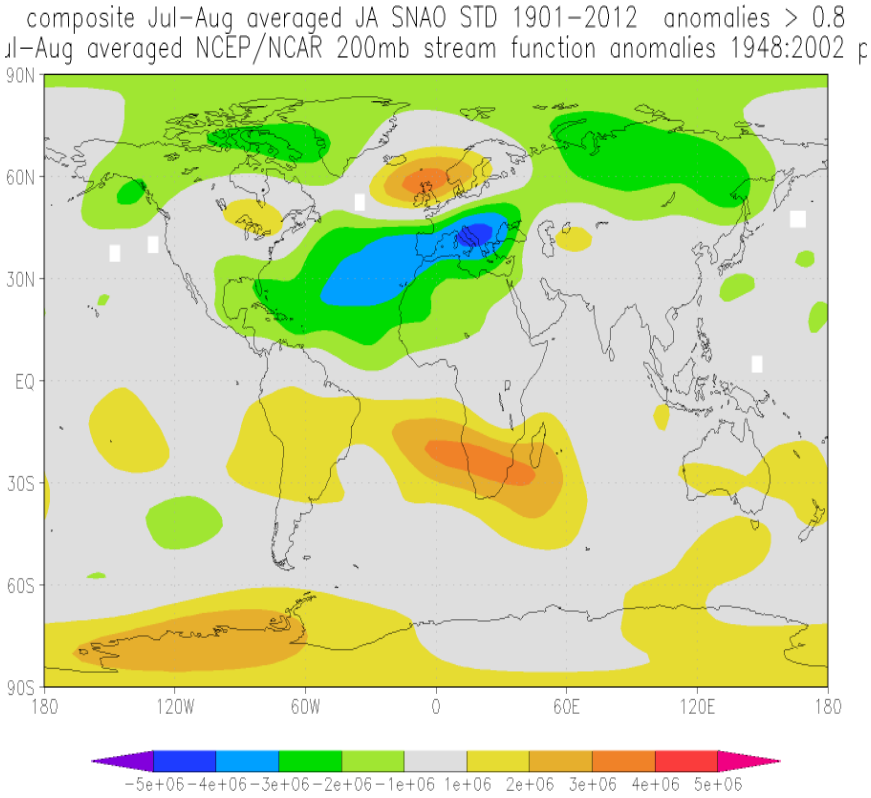


Minus SAHEL rain

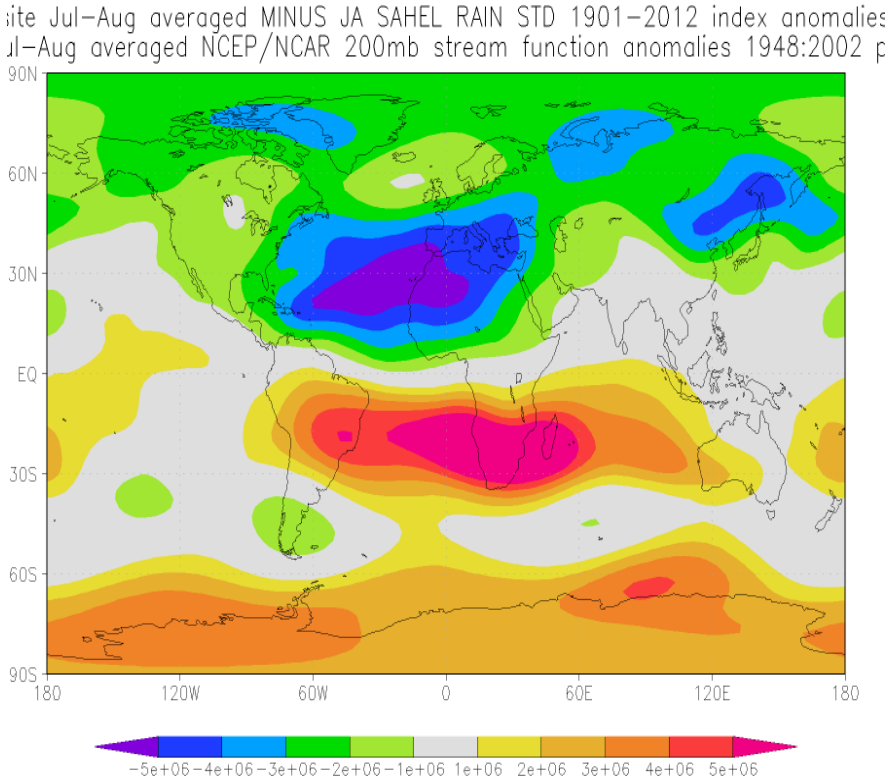


Composite NCEP 200hPa streamfunction JA SNAO & JA Sahel rainfall,1948-2002

SNAO >0.8 sd

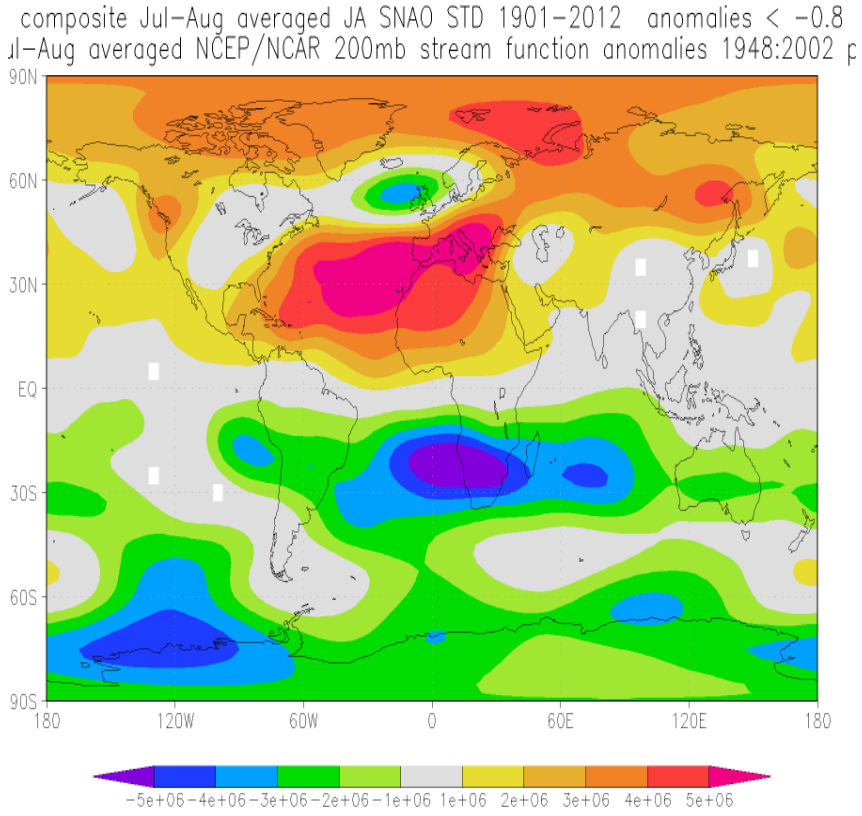


Minus SAHEL rain>0.8 sd

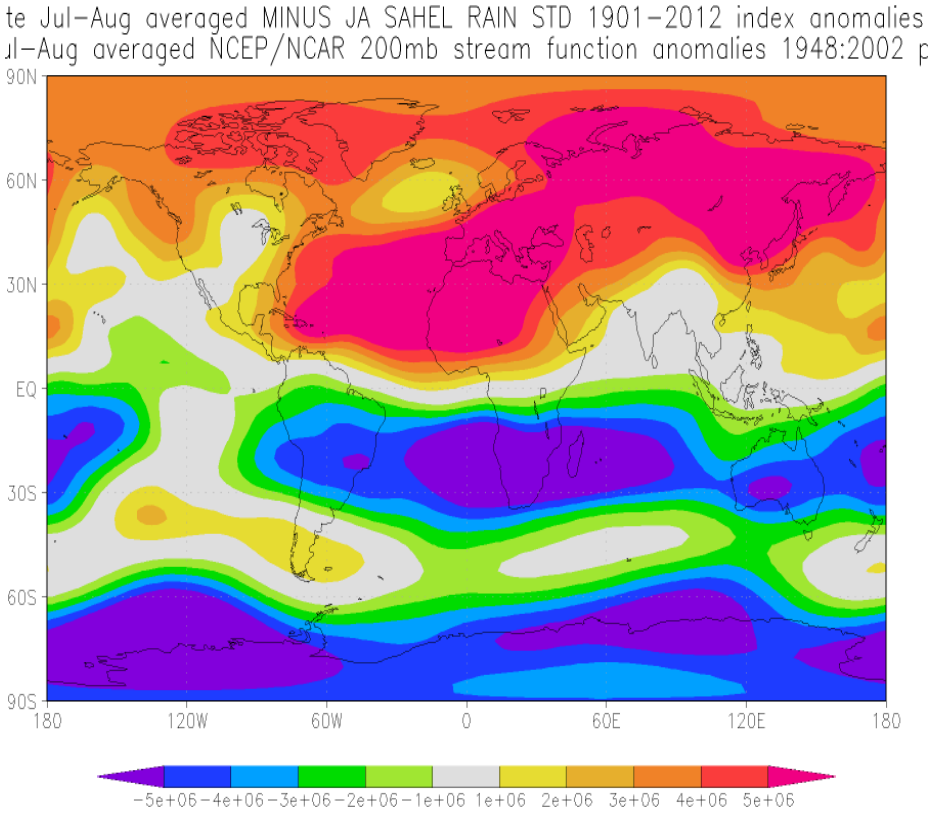


Composite NCEP 200hPa streamfunction JA SNAO & JA Sahel rainfall,1948-2002

SNAO <-0.8 sd

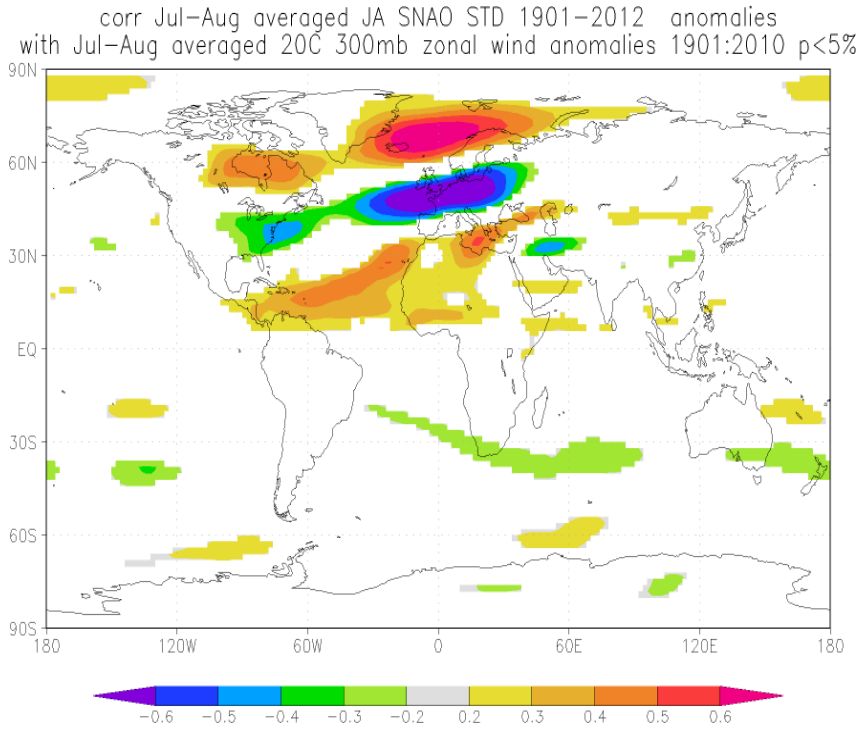


Minus SAHEL rain<-0.8 sd

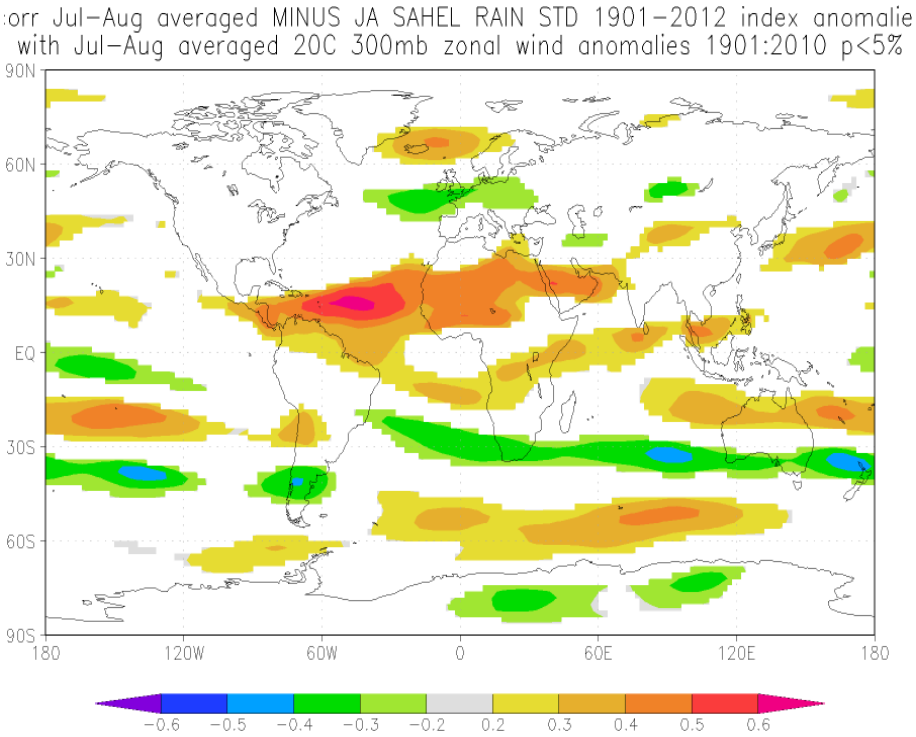


Correlation C20 reanalysis zonal winds at 300hPa JA SNAO & JA Sahel rainfall,1901-2010

SNAO



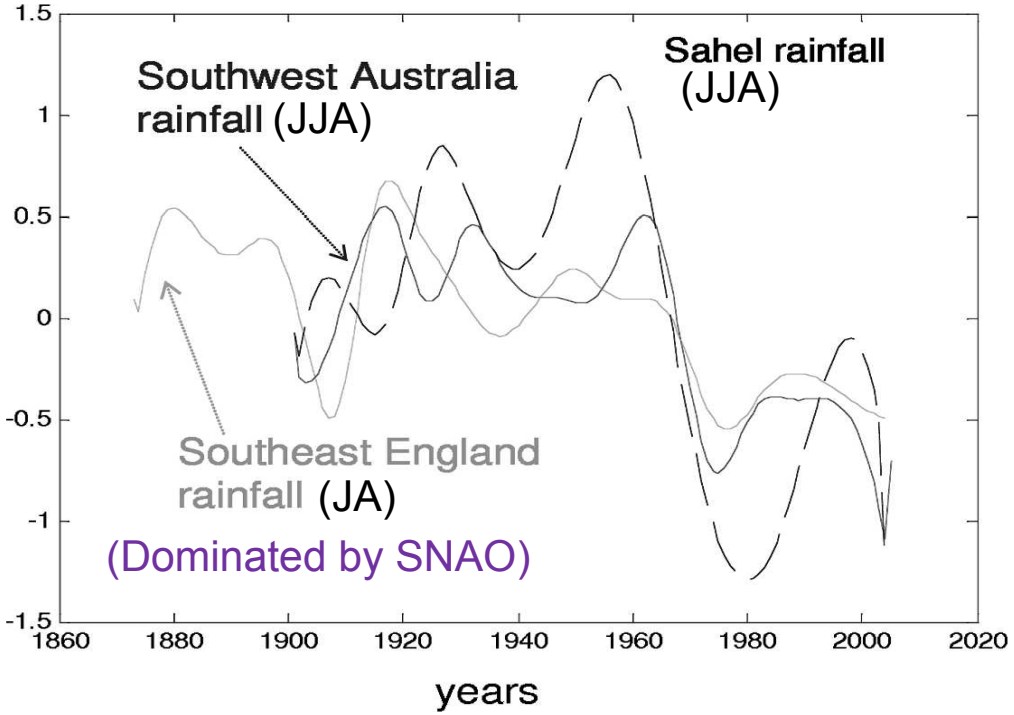
Minus SAHEL rain



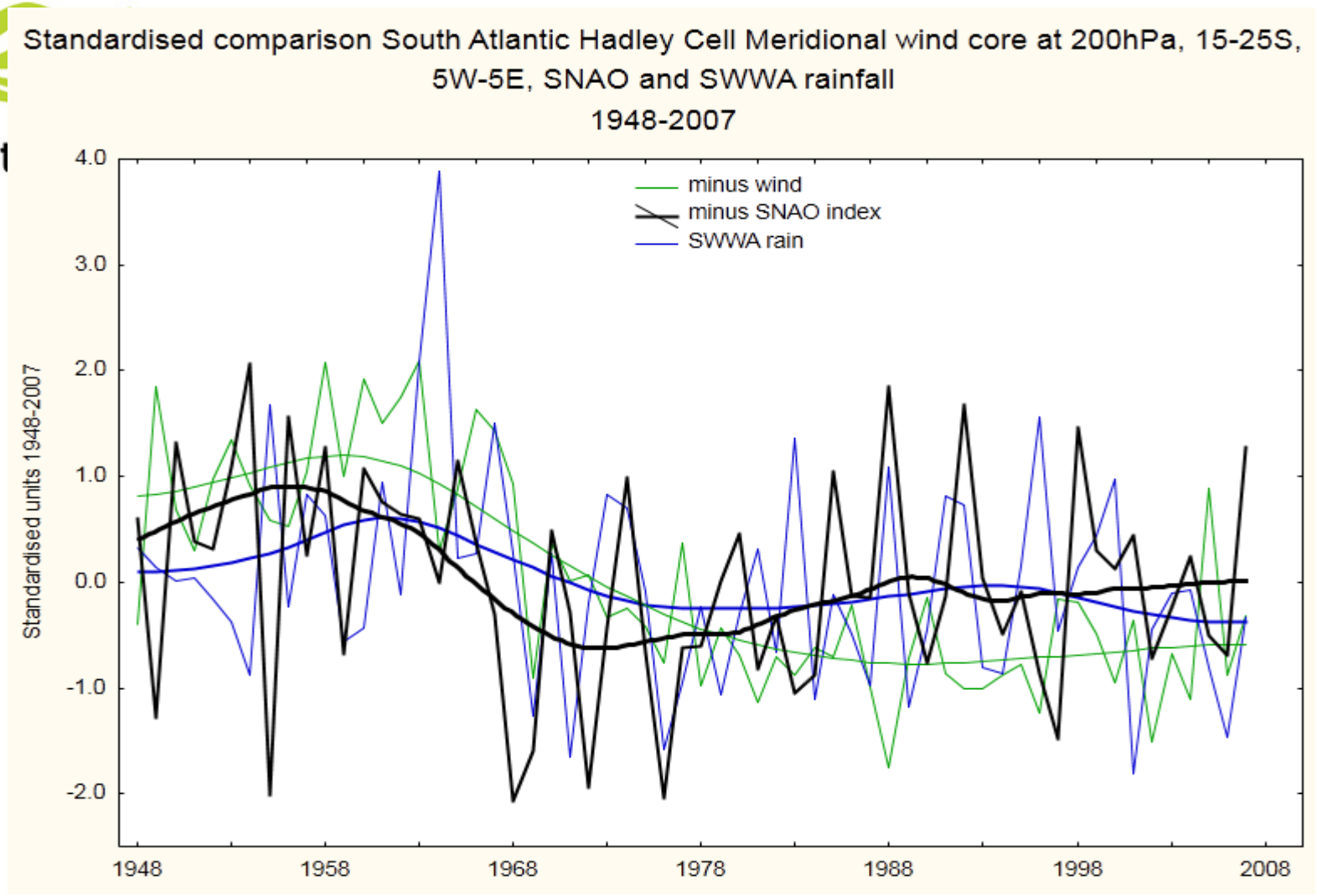
Does this further support inter-hemispheric decadal (J)JA teleconnections via the regional Hadley Circulation?

Strength/latitude of Southern winter subtropical jet stream affects SWWA winter rainfall (Baines, 2005, Aust. Met. Mag.)

Is there really such a link quasi- decadally at least?



Baines & Folland, 2007, J. Clim., Fig. 10



Possible quasi decadal link, though poor interannual correlations

Conclusions

- SNAO is the high summer equivalent of the winter NAO.
- Strongly related to storm tracks, North West European summer droughts, wet periods and heat waves. Atlantic tropical storm variations may have a weak influence.
- Possible long term tendency to increased positive (UK dry) phase under enhanced greenhouse gases.
- Well correlated with West African Monsoon. Both influenced by AMO.
- Arctic sea ice reduction influences unclear - deserve more investigation.
- Global teleconnections of both SNAO and West African monsoon – and to extra-tropical winter south west Australia?
- Next step is to investigate variations in Atlantic/African longitude Hadley Circulation in JJAS including subtropical jet streams of both Hemispheres and possible AMO/interhemispheric SST anomaly links.