

On the climate variability and the recent abrupt cooling over Subpolar North Atlantic

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and Jenny V. Mecking³

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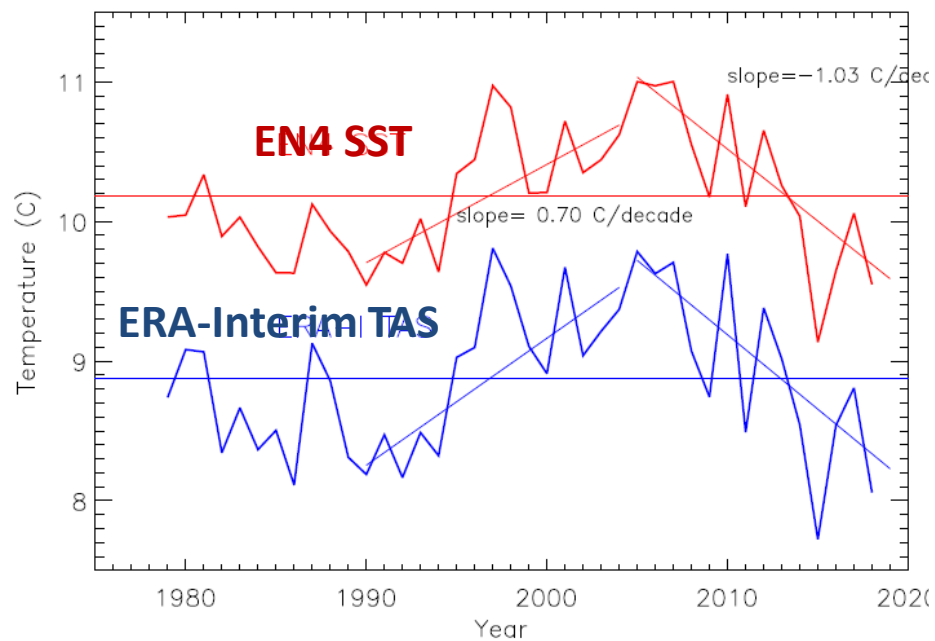
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³ University of Southampton, UK

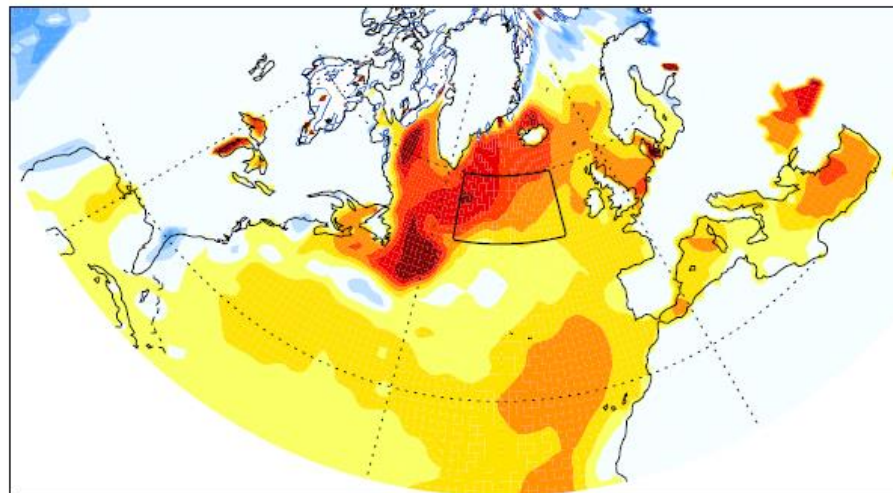
Acknowledgements: Alex Megann (NOC, Southampton), Dan Copsey (UK MetOffice), Martin Andrews (UK Met Office) for making the data of ocean analysis and model simulations available for this study.

The recent Temp. trends in North Atlantic

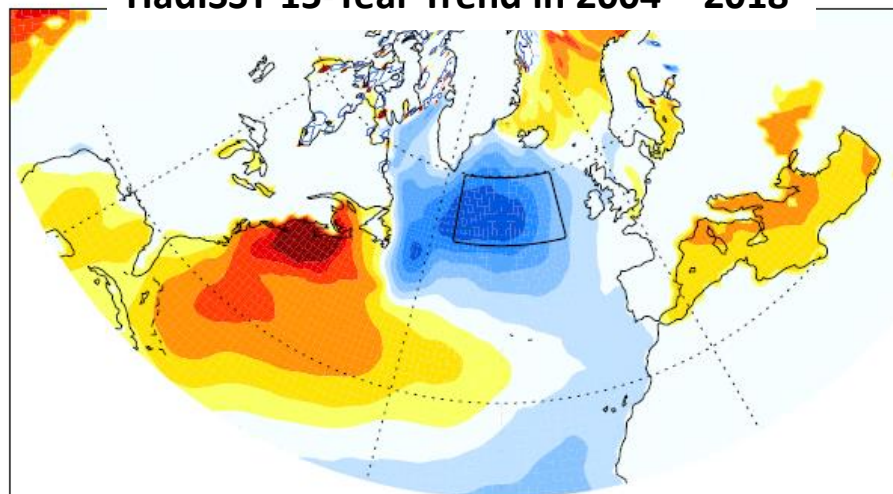
Mean Surf. Temp. over N. Atl. Subpolar



HadISST 15-Year Trend in 1990 - 2004



HadISST 15-Year Trend in 2004 - 2018



Objectives

- What are the observed characteristics of the temperature variations over the North Atlantic subpolar gyre region (SPG)?
- What drives the abrupt changes in SPG? What is the role of natural variability in relative to the anthropogenic forcing?

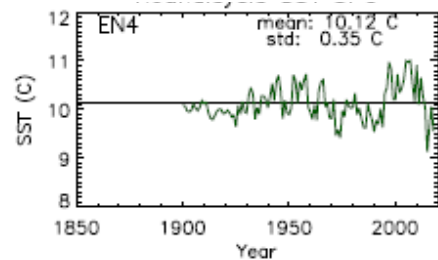
Observation and Model Data Analyzed

- Ocean observation & analysis:
 - HadISST, EN4, FOSI/NEMO&JRA55, ERA-Interim SST
- Atmospheric reanalysis:
 - ERA-Interim, NCEP, NC20thC, ERA-20C
- Model simulations
 - Long CMIP control:
 - 6 CMIP6 pre-industrial control, 500 – 1200 years
 - 1 present-day control, 298 years
 - CMIP5 historical + RCP scenarios
 - 32 models: 1850 – 2100 (250 year)
 - 8 models extended to 2300 (450 year)
 - 1 model extended to 3200 (1350 year)

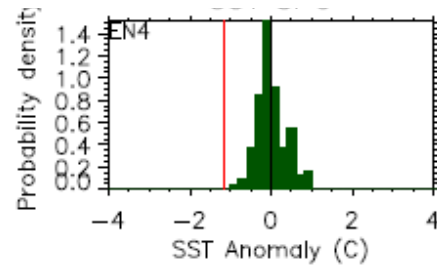
The observed variability in SPG

Area mean temperature for SPG region (40-15°W,50-60°N)

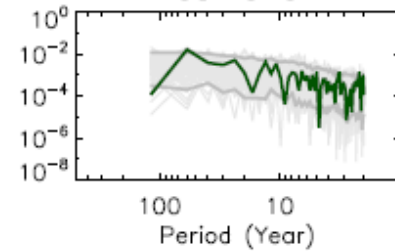
EN4 SST time series



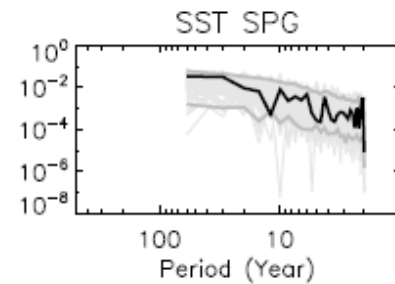
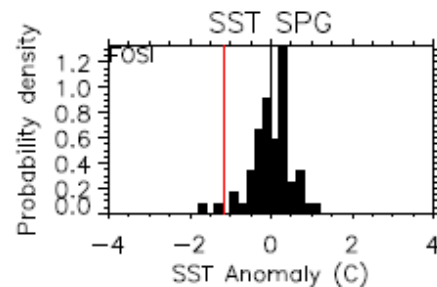
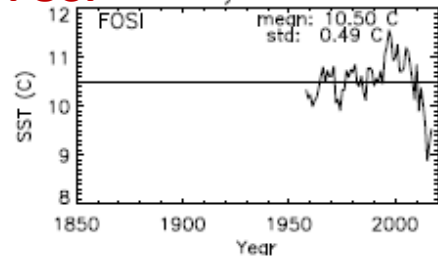
Histogram of SST anomaly



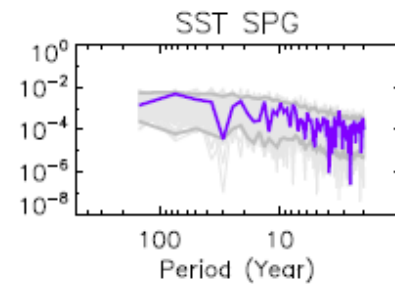
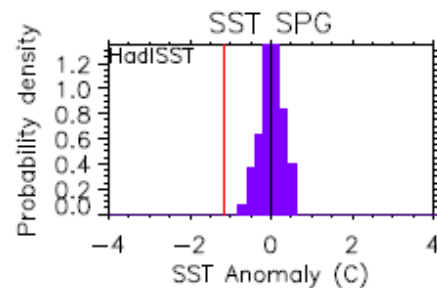
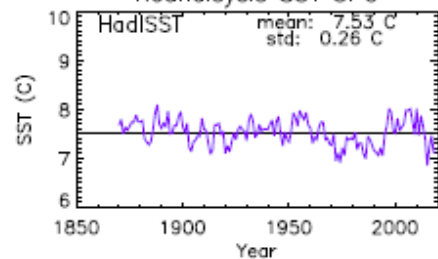
Power spectrum



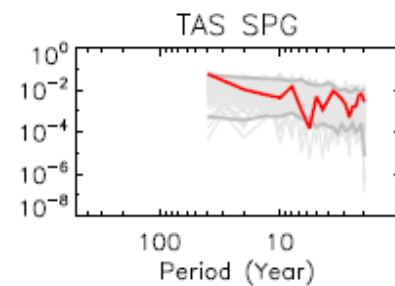
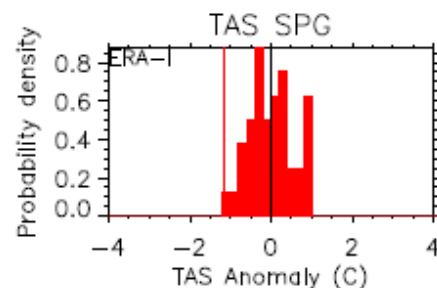
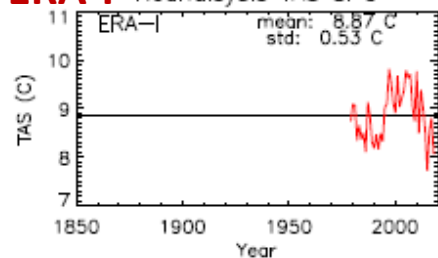
FOSI Reanalysis SST SPG



HadISST Reanalysis SST SPG



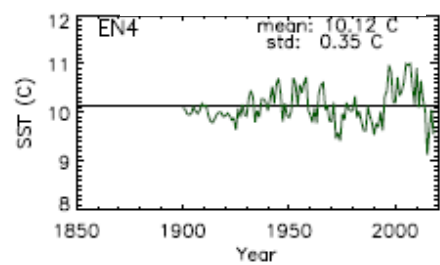
ERA-I Reanalysis TAS SPG



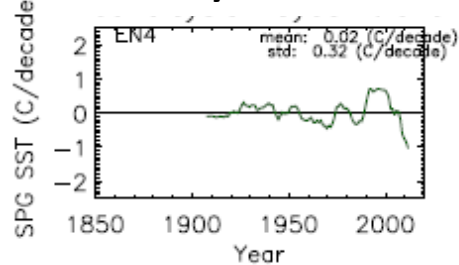
The observed decadal trend in SPG

Area mean temperature and 15-year trends for SPG region

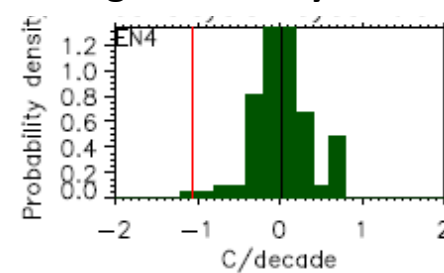
EN4 SST time series



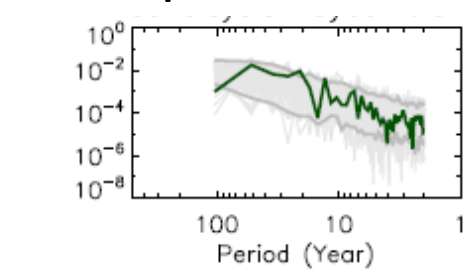
SST 15-year trend



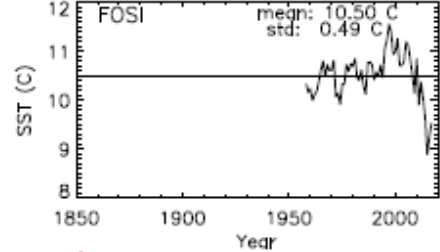
Histogram of 15-year trend



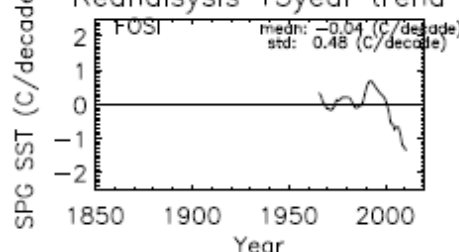
Power spectrum of trend



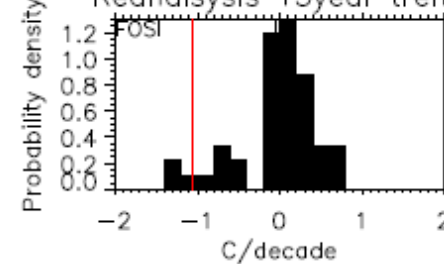
FOSI Reanalysis SST SPG



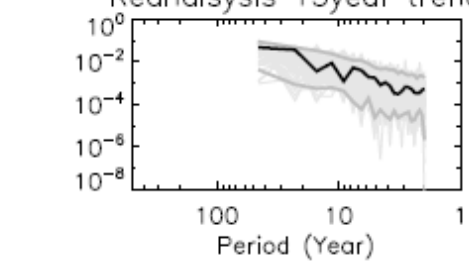
Reanalysis 15year trend



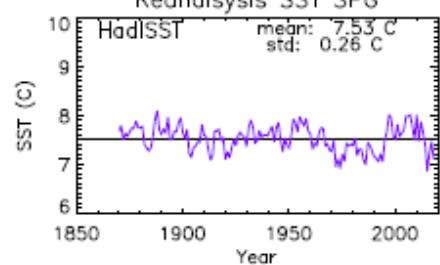
Reanalysis 15year trend



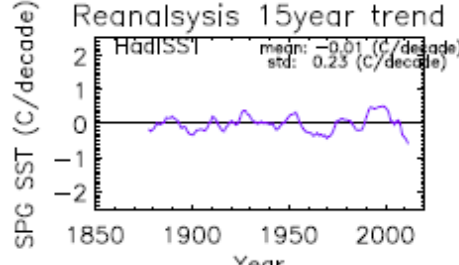
Reanalysis 15year trend



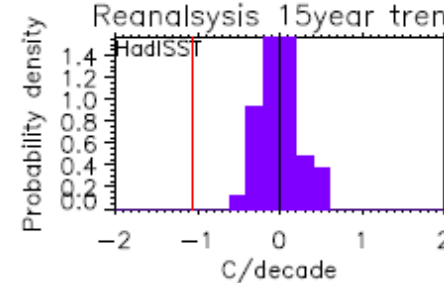
HadISST Reanalysis SST SPG



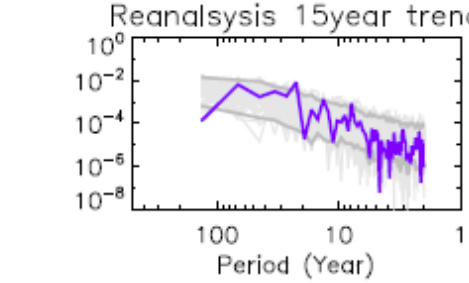
Reanalysis 15year trend



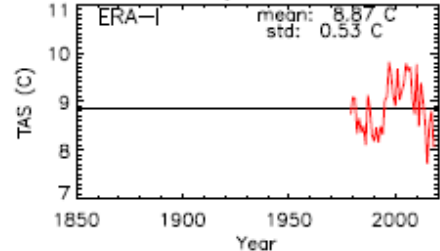
Reanalysis 15year trend



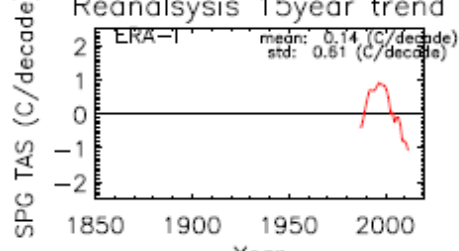
Reanalysis 15year trend



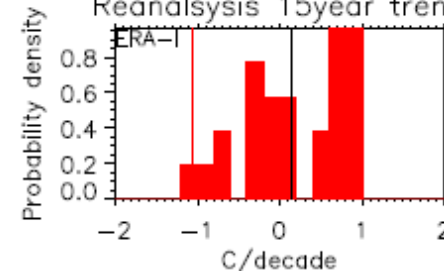
ERA-I Reanalysis TAS SPG



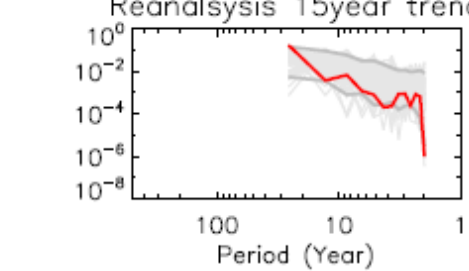
Reanalysis 15year trend



Reanalysis 15year trend



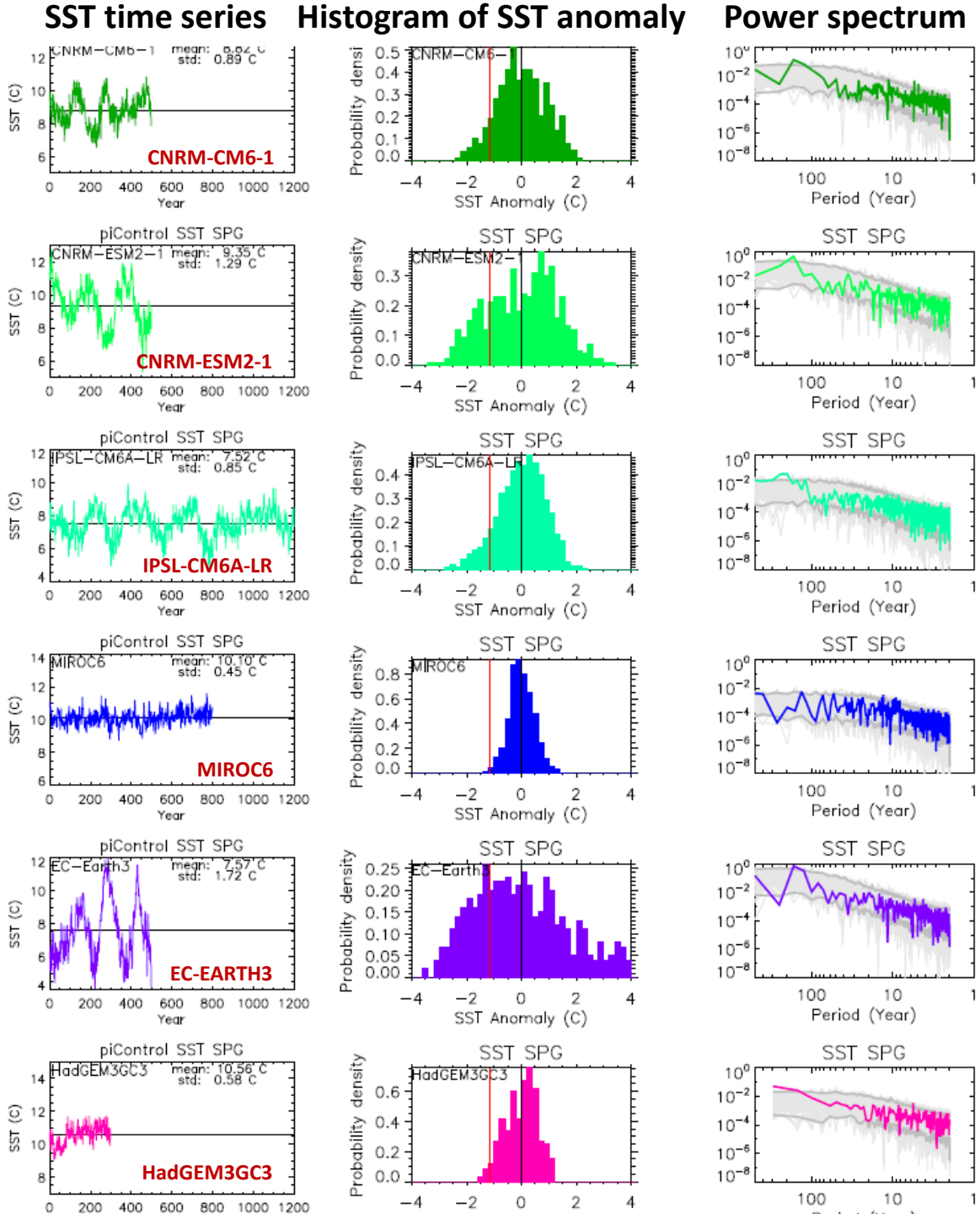
Reanalysis 15year trend



The unforced signals

Time series of SPG SST

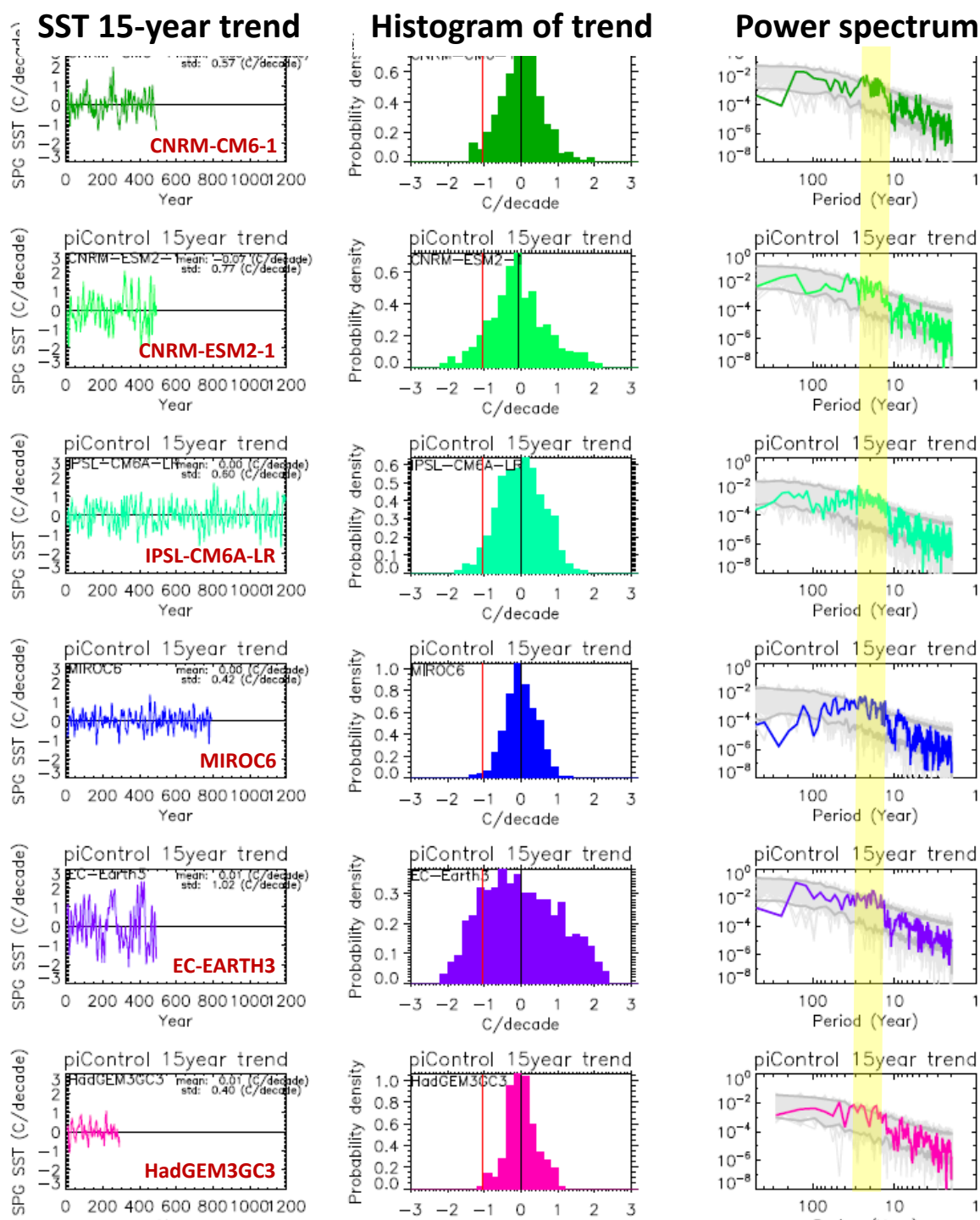
- Pre-industrial control from six CMIP6 models
- One present-day control
- Anomaly respect to all-time mean
- **Distribution rather normal**
- **No obvious standing out frequency of variability**
- **Signal of variability at very low frequency (> 100 years)**



The unforced signals

Time series of *15-year linear trend* of SPG SST

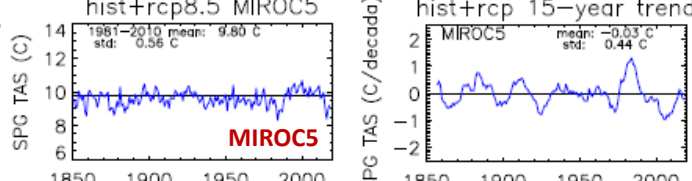
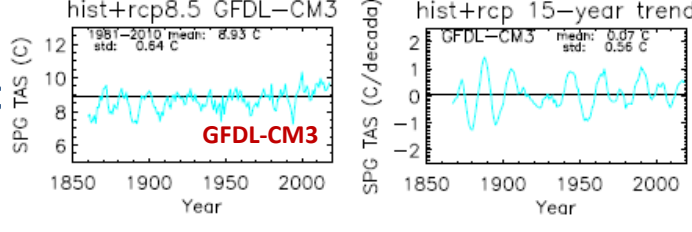
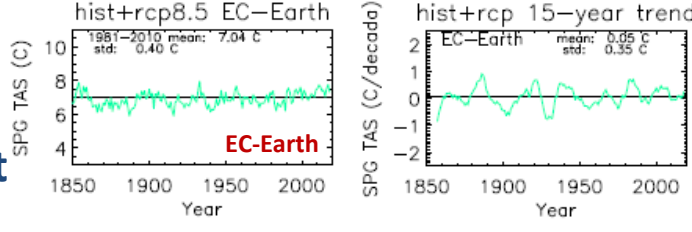
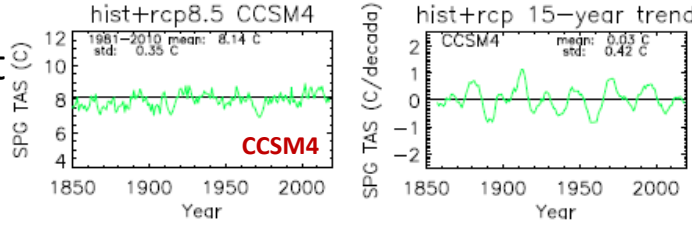
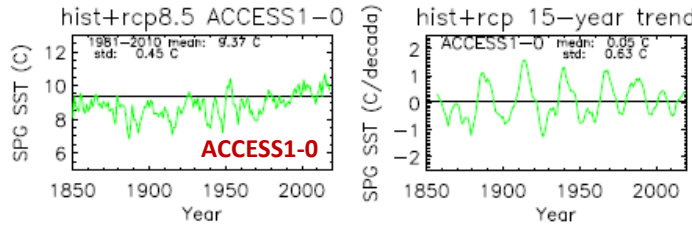
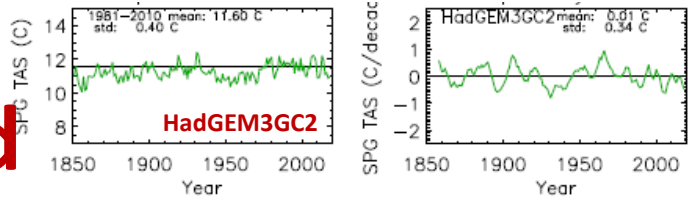
- Pre-industrial control from six CMIP6 models
- One present-day control
- **Distribution rather normal**
- **The recent observed abrupt cooling trend may occur as extreme events**
- **Some signal of variability at 20-30 years period**



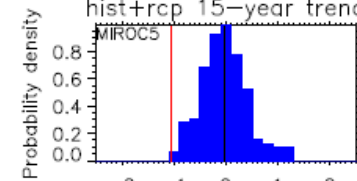
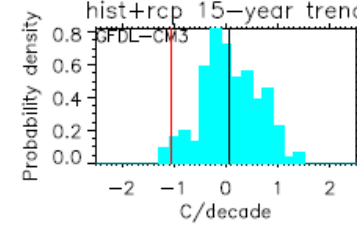
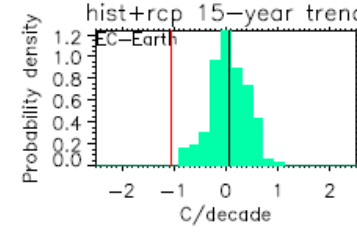
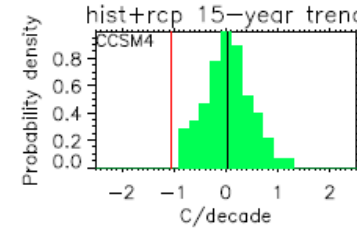
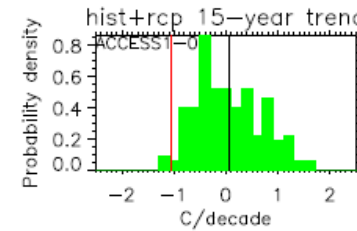
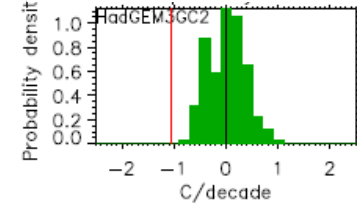
The forced signals

- Historical + RCP4.5/RCP8.5 1850-2018
- Anomaly respect to 1981-2010
- Normal distribution
- The recent observed abrupt cooling trend may occur in some model but only very rare
- Some signal of variability at 20-30 years period

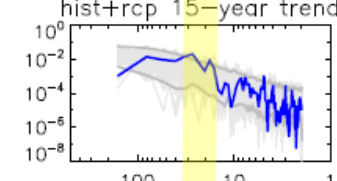
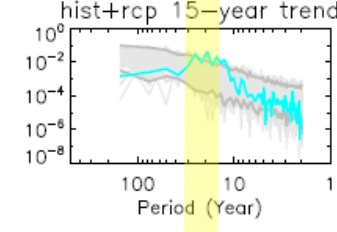
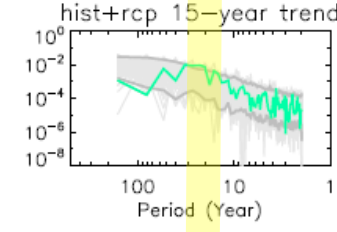
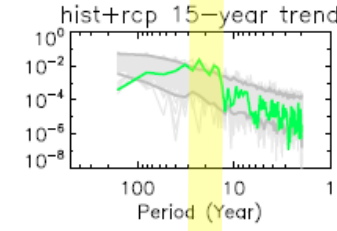
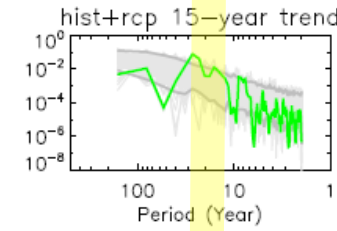
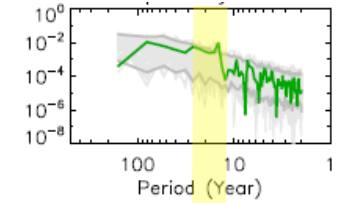
SPG SST time series SST 15-year trend



Histogram of trend



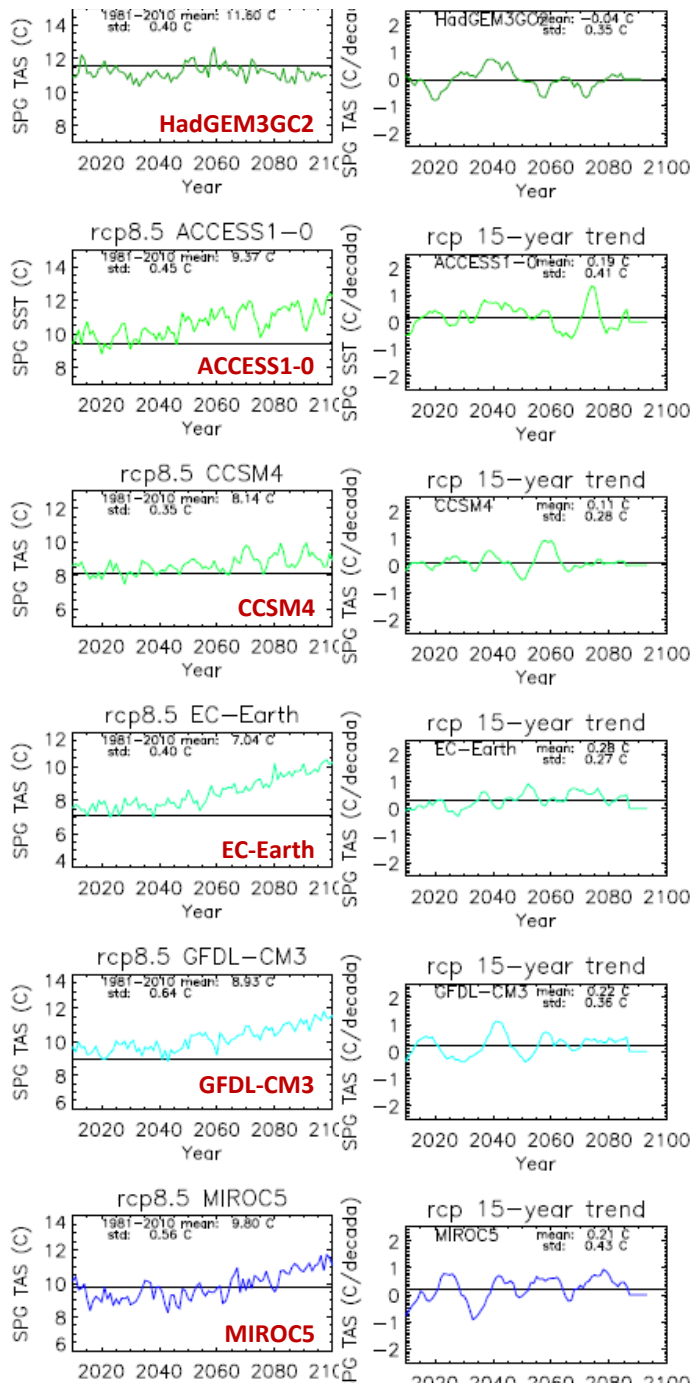
Power spectrum



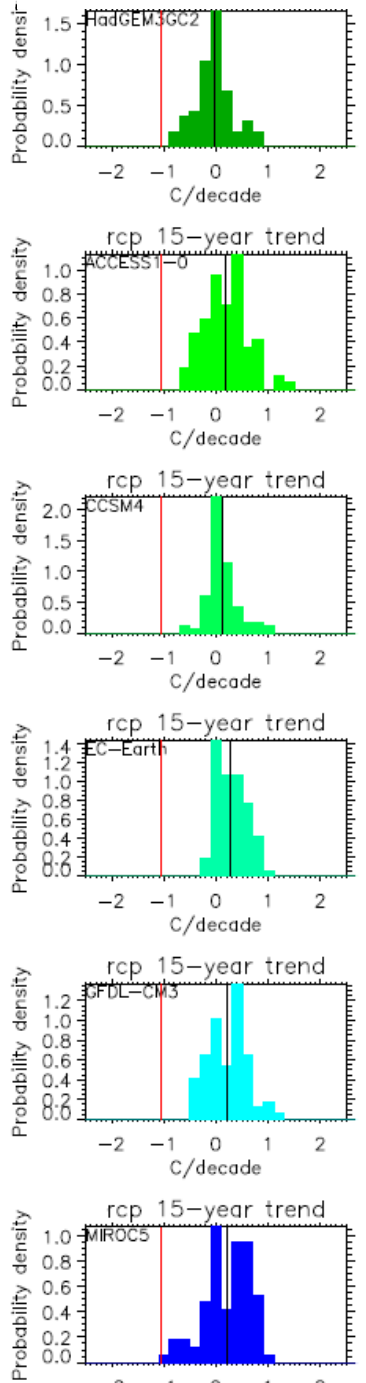
Under strong forcing

- Future period 2010-2100, RCP4.5/RCP8.5
- Anomaly respect to 1981-2010
- Distribution rather normal
- Narrowing of the distribution

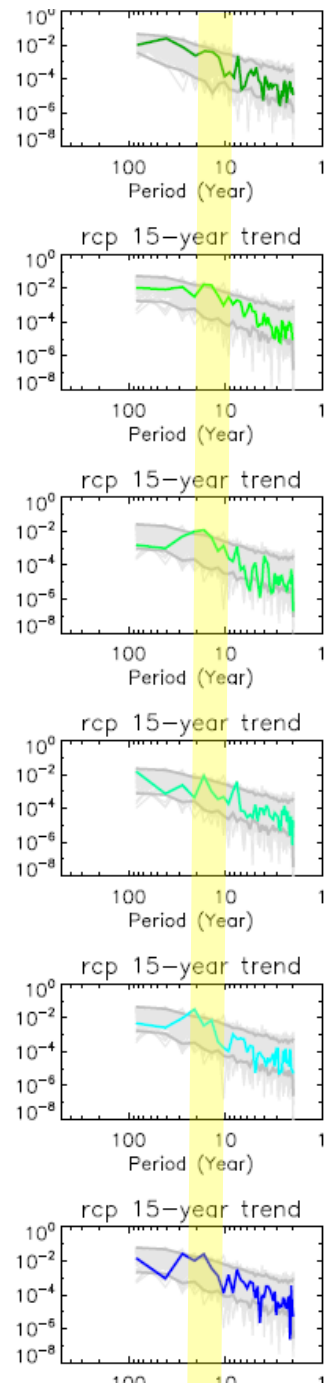
SPG SST time series SST 15-year trend



Histogram of trend



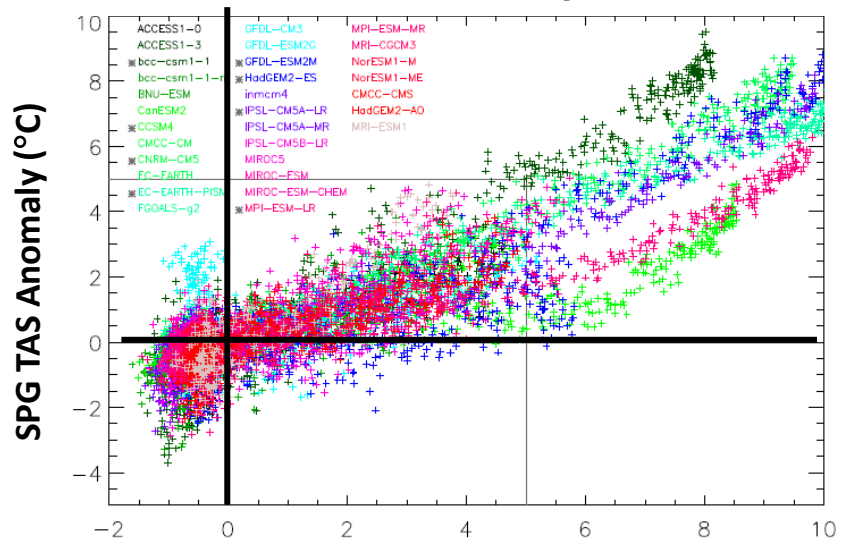
Power spectrum



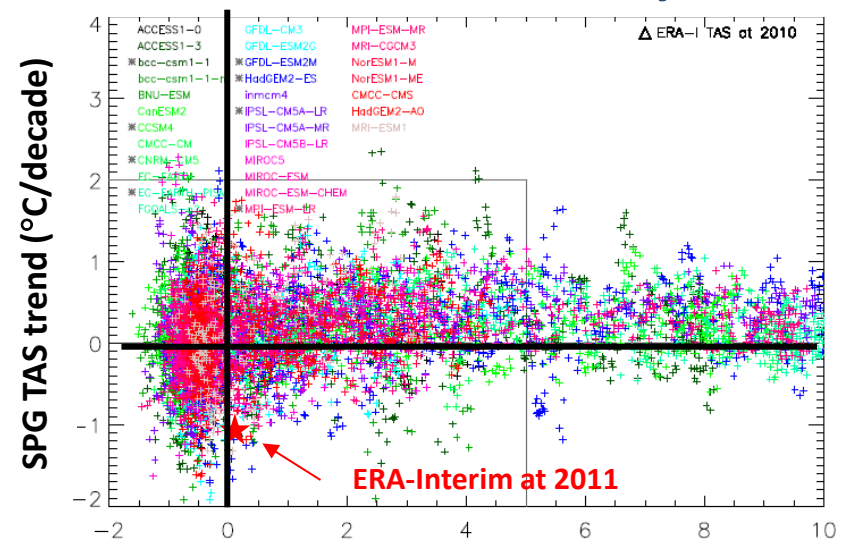
SPG temperature vs. global mean TAS

- 32 CMIP5 models
- Historical + (extended) RCP8.5

Hist.+RCP8.5 TAS anomaly wrt. 1981-2010

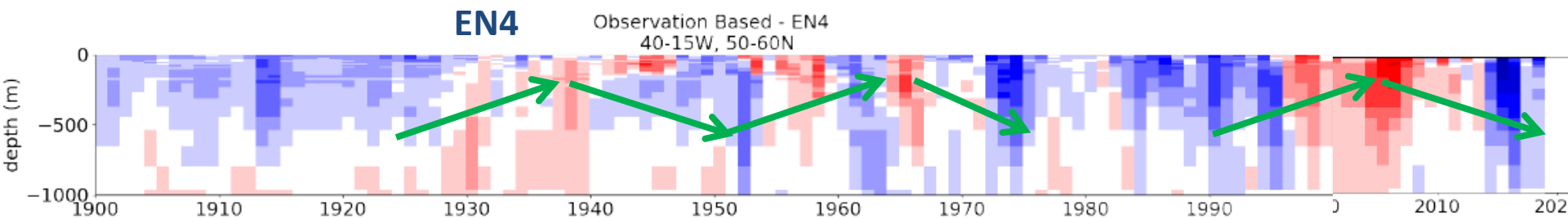


Hist.+RCP8.5 SPG TAS 15-year trend

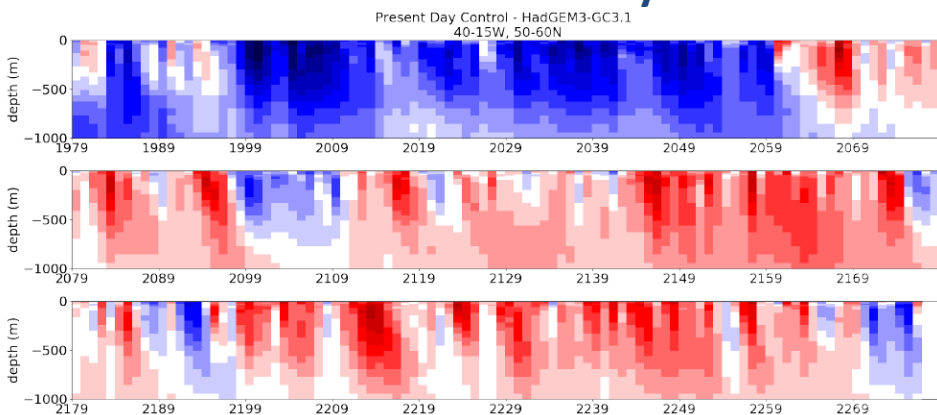


Global Mean TAS Anomaly (°C)

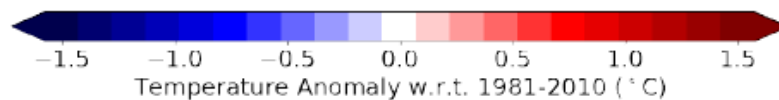
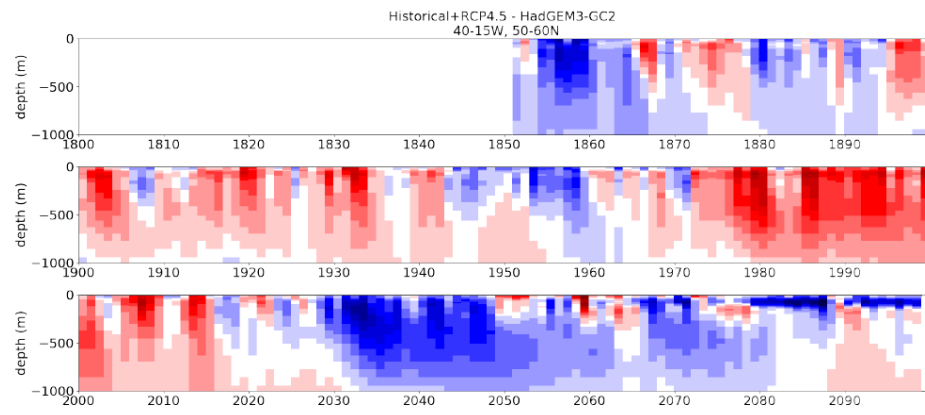
Ocean temperature Anomaly over SPG



HadGEM3GC3 Present-day Control



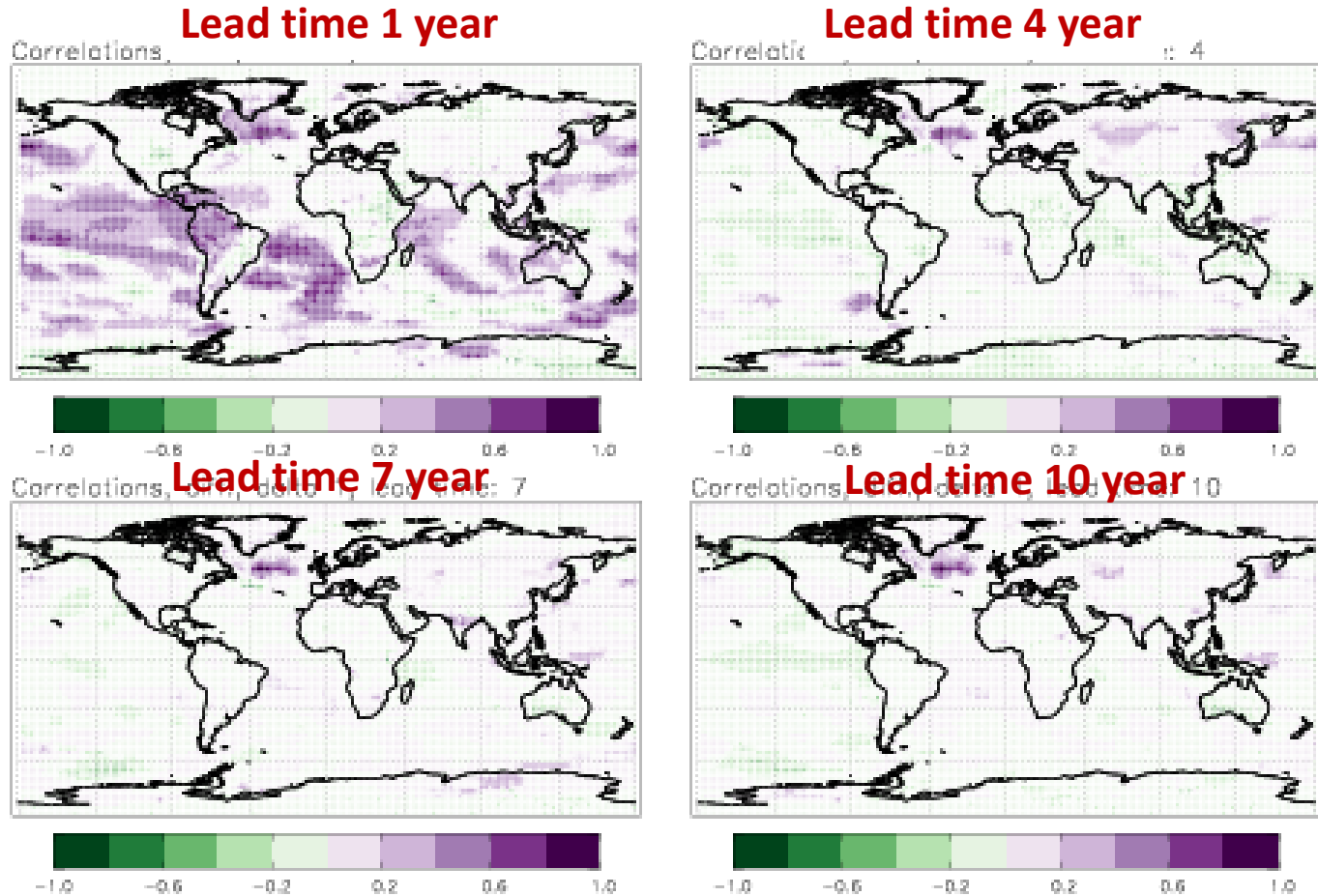
HadGEM3GC2 Historical + RCP4.5



Implication for decadal predictability

LENS TAS Correlations with Obs., Initialized EXP. – Historical EXP.

- CESM LENS (initialized DP) and historical experiments
- 40 members
- 10-years initialized DP starting every Nov. 1 for 1970-2005



POSTER by Bo Christiansen: “The Skill Of Dynamical Decadal Forecasts With Focus On The North Atlantic” at session *Predictability limits*

Summary

- The SPG is a region with large decadal variability, where warming and cooling trends of decadal timescales occur frequently and alternatively, in both *unforced* and *climate change* experiments;
- Under the RCP8.5 scenario, models project that the SPG temperature will increase along with global warming, and its 15-year tends to be less variable
- More ocean and atmospheric analyses for understanding the mechanisms and impact for decadal predictability

Thank you!



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