Mid-latitude Ocean-atmosphere interaction in the North Atlantic, and relevance to prediction

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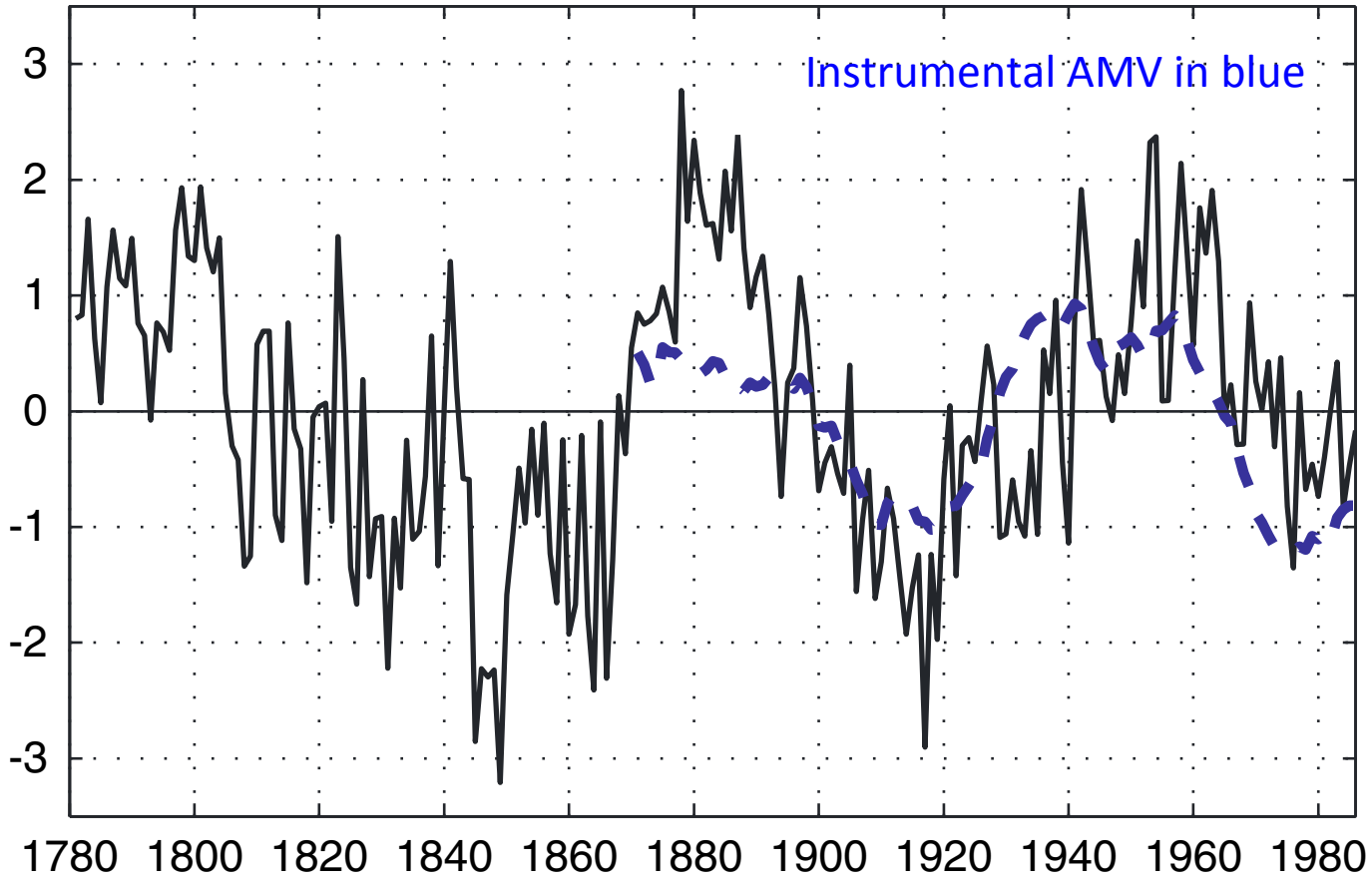
Atlantic multi-decadal variability: More marine proxy data needed to understand its true nature

Principle component analysis of five coral records from the tropical Atlantic



Svendsen et al. 2014

Some insights on the AMV from instrumental data and climate models

1. Atmospheric forcing of ocean variability

How consistent is the slab ocean – AGCM interpretation of AMV?

2. Ocean forcing of atmospheric variability?

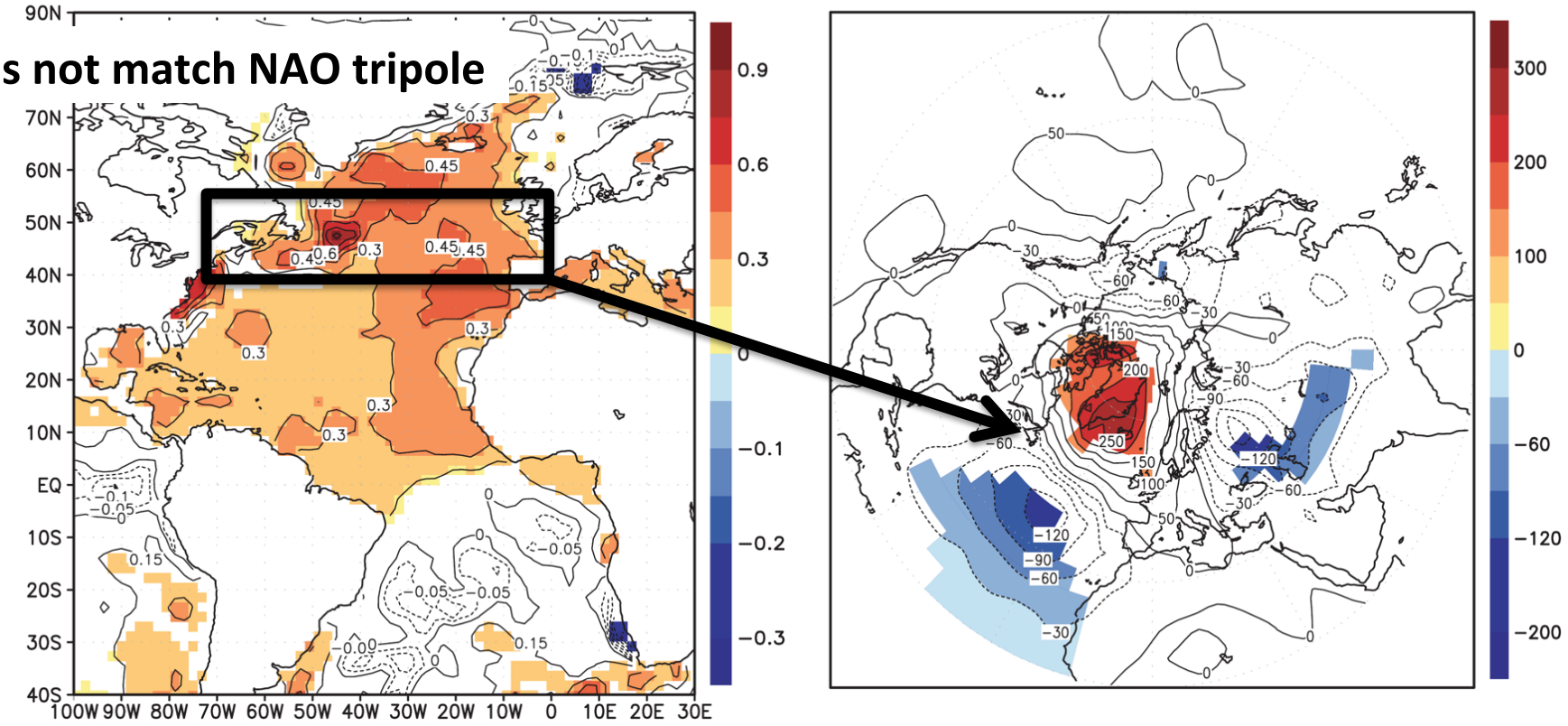
3. Implications for climate prediction

Atlantic multi-decadal variability warm phase and negative winter NAO

Composite analysis of 10yr running mean AMV-index, 1870-2009

SST (JFM, °C)

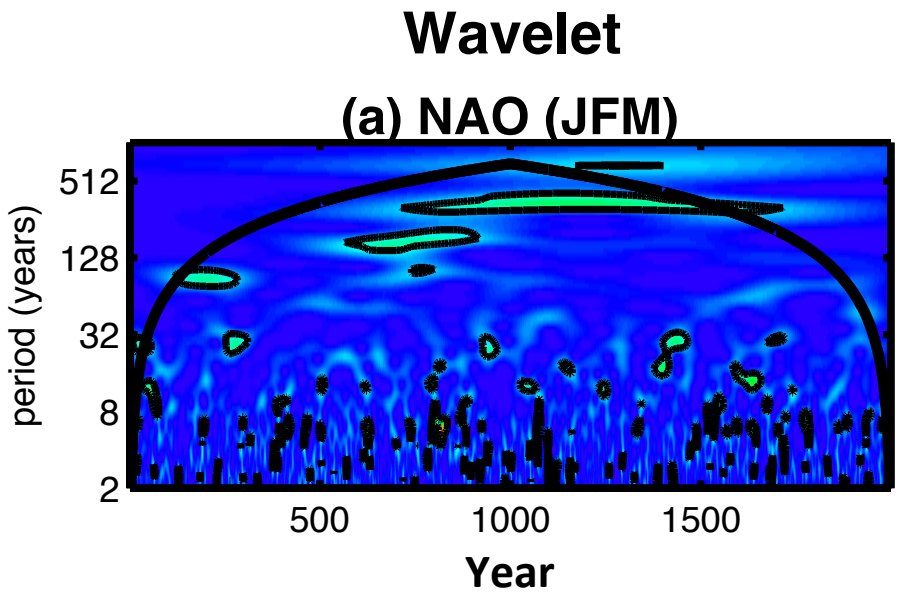
SLP (JFM, Pa)

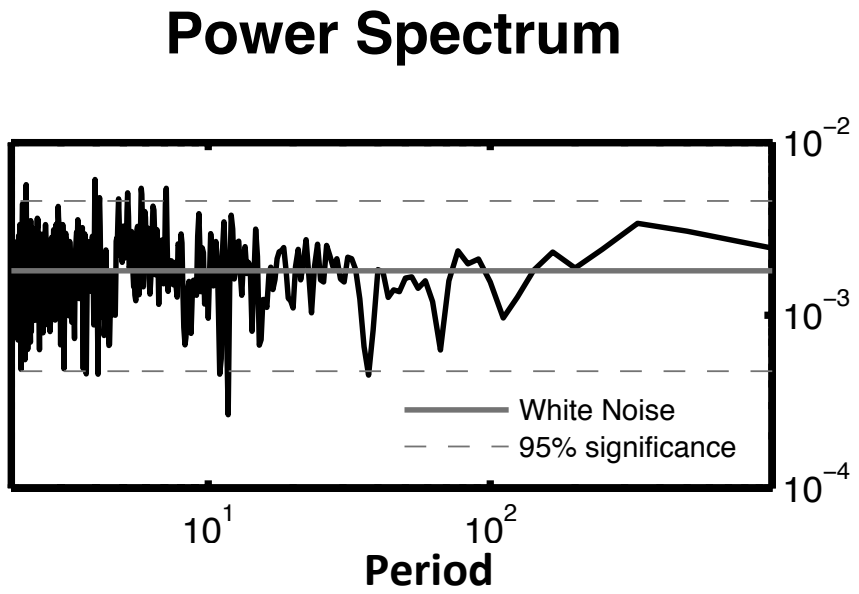


Omrani et al. (2014)

The Stochastic null hypothesis

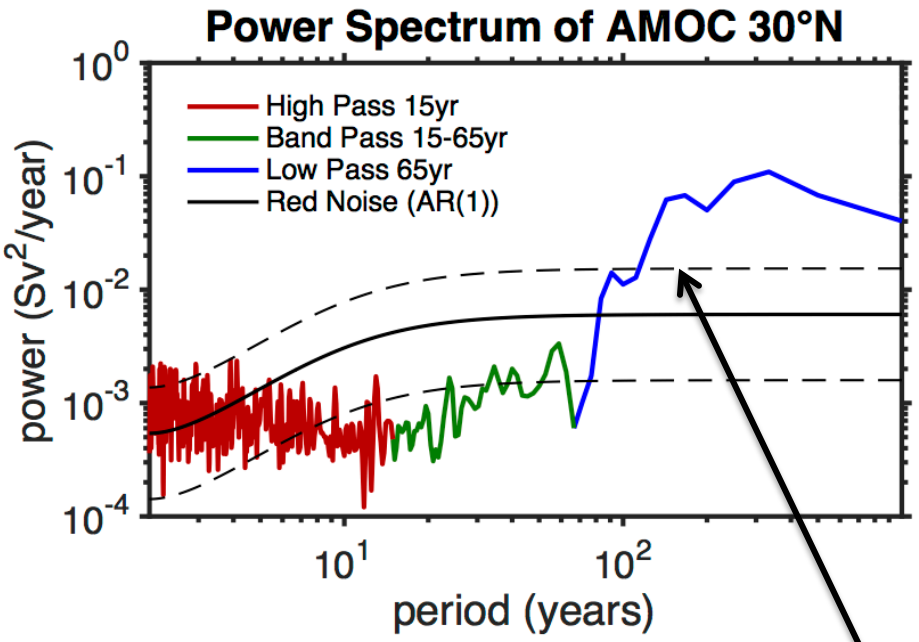
- NEMO OGCM – 0.5x0.5 deg. globally, 46 vertical levels
- Synthetic white noise NAO time series
- NAO-patterns of anomalous fluxes

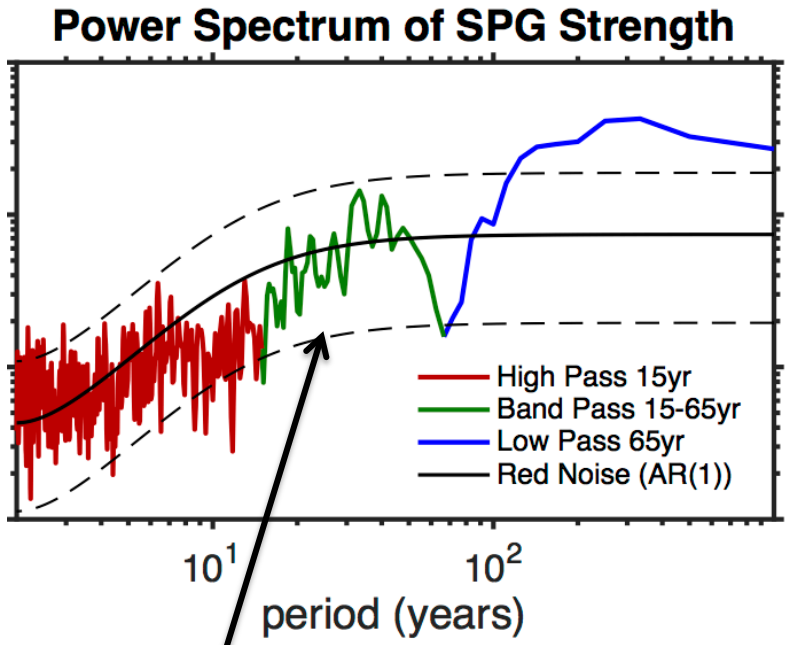


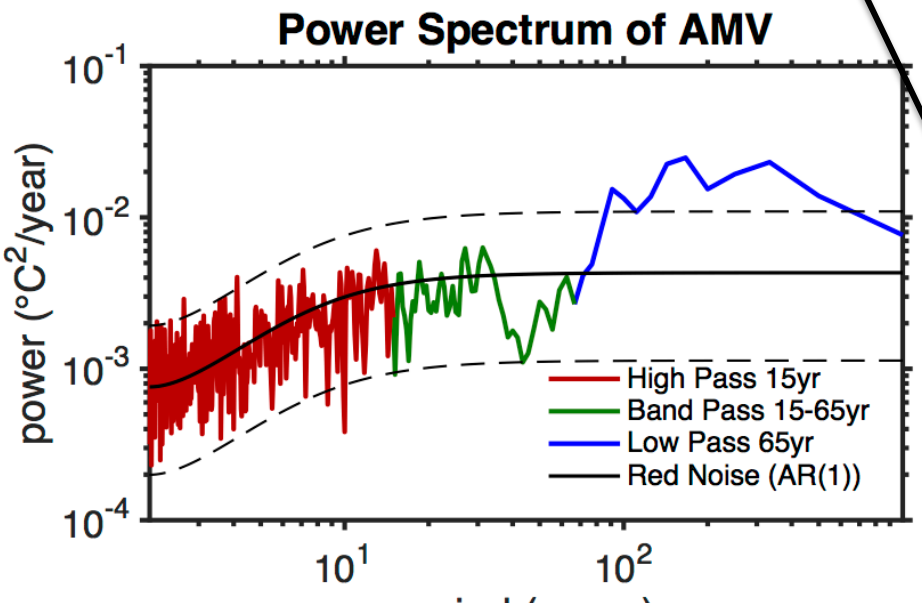


Mecking et al. 2014, 2015

Oceanic response to stochastic NAO not AR-1







Stochastic spatial resonance

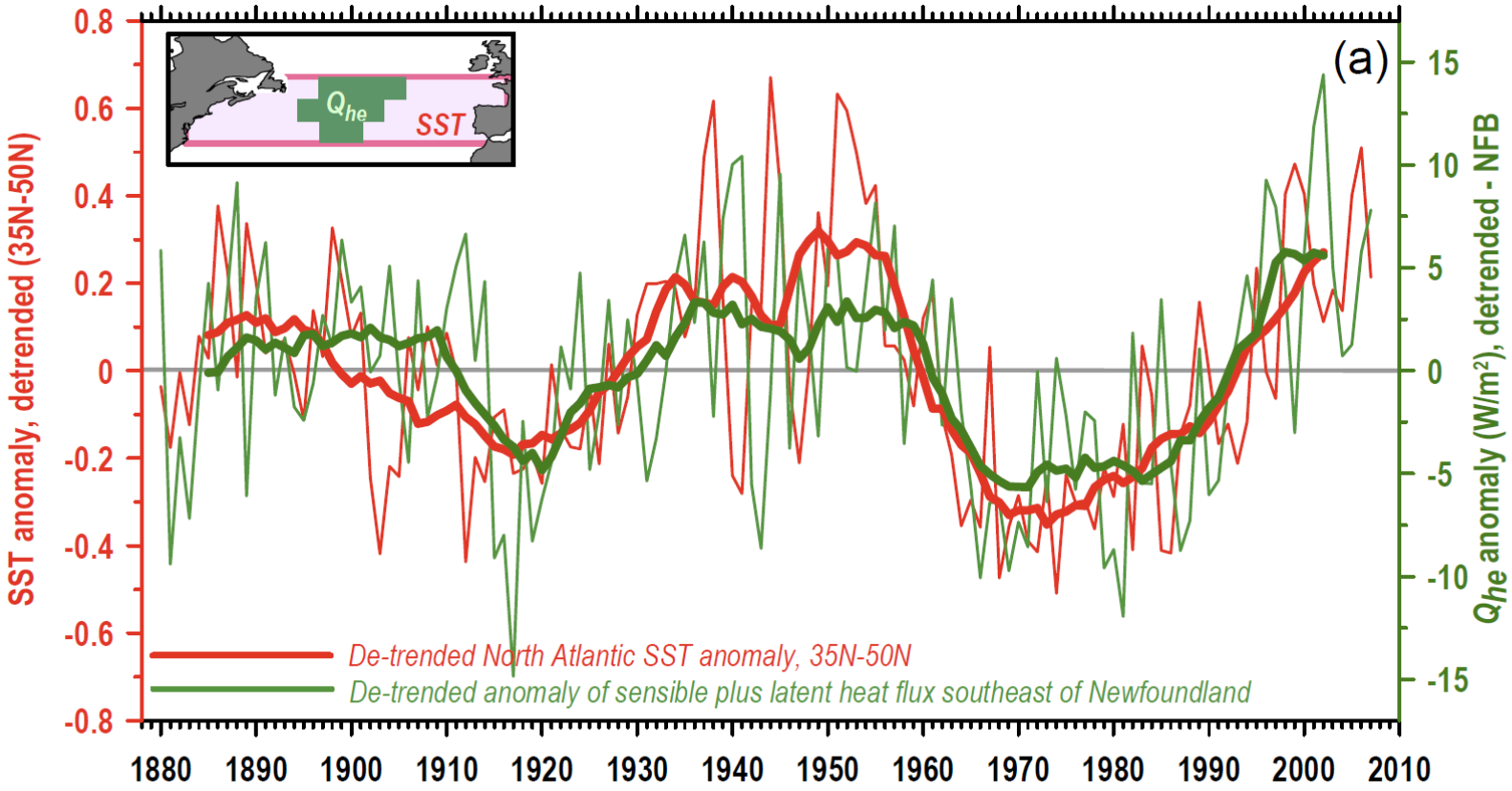
Quasi-equilibrium state

Mecking et al. 2013, 2015

Reconstructed fluxes prove Bjerknes' conjecture: on decadal timescales ocean drives mid-latitude SST and turbulent heat fluxes

Annual mean indices:

Atlantic multi-decadal variations SST and turbulent heat flux



Gulev et al. (2013)

2. Ocean forcing of atmospheric variability?

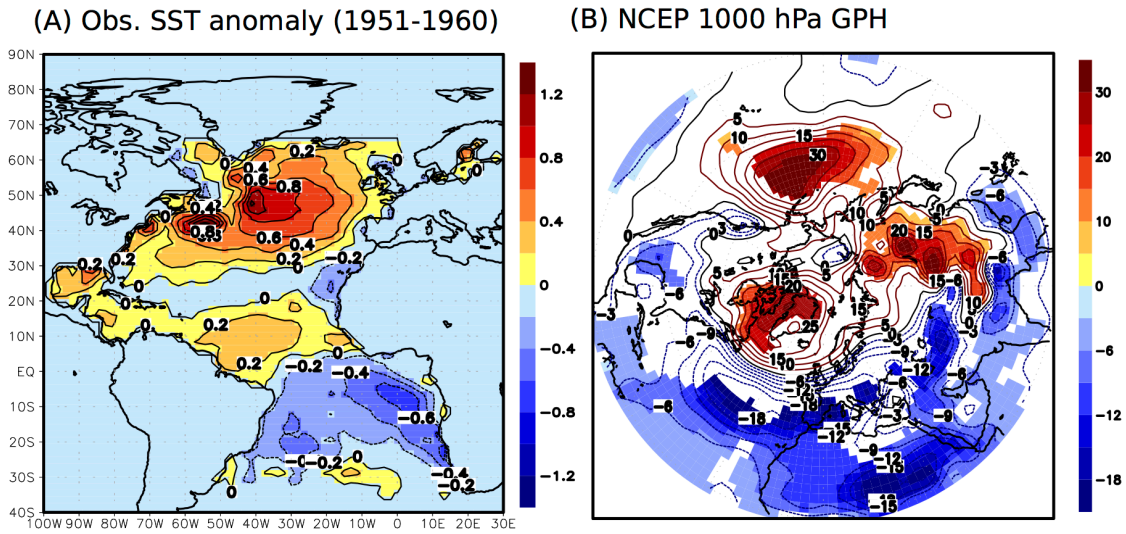
Old question being revisited by new work:

- Higher horizontal resolution, sharp SST fronts, high-frequency SST data (e.g., Minobe et al. 2008, Nakamura et al. 2004, Taguchi et al. 2012, Zhou et al. 2015)

- Role of stratosphere-troposphere interaction in the atmospheric response to large-scale SST changes.

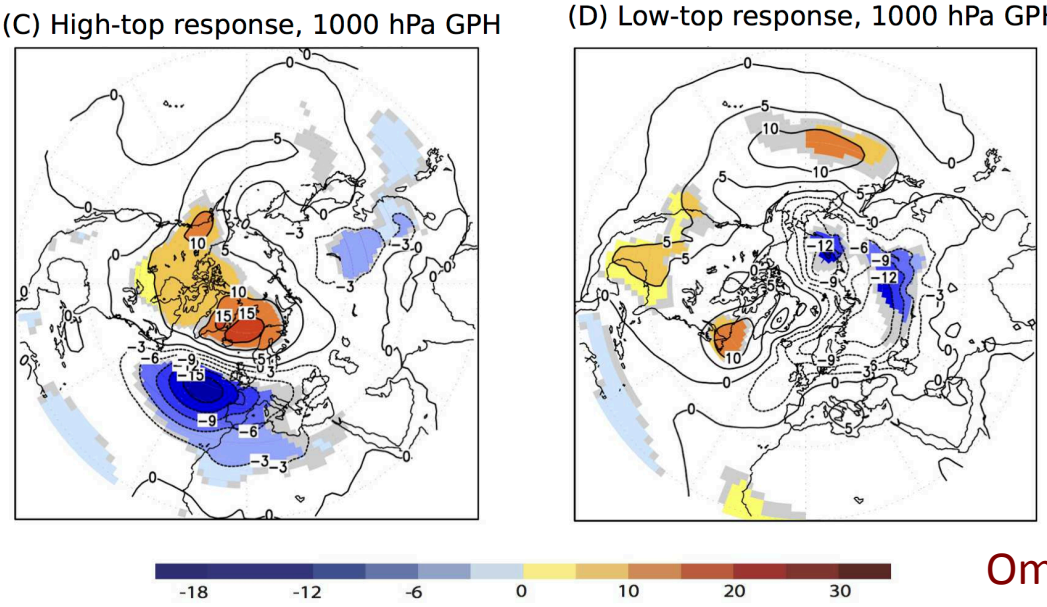
Stratospheric resolving model captures response to warm AMV conditions (1951-1960)

Observed SST anomalies



NCEP/NCAR Geopot. height anomalies

High-top simulated response (MAECHAM5)



Low-top simulated response (MAECHAM5)

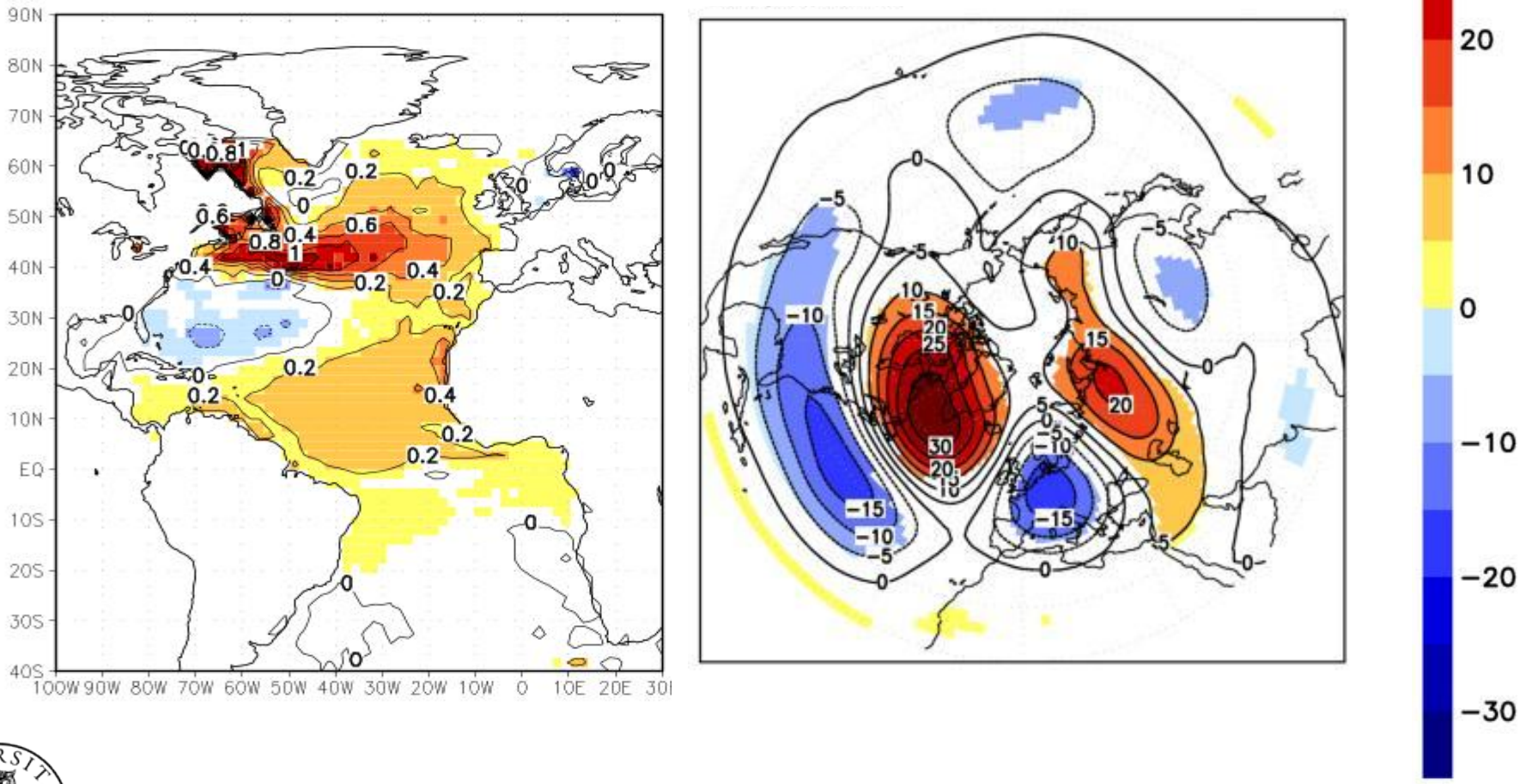
Omrani et al. 2014

ECHAM6/MPIOM stratosphere Resolving model reproduces warm phase – negative NAO relation

Winter (JFM) composite analysis of unfiltered AMV-index

SST

500 hPa GPH



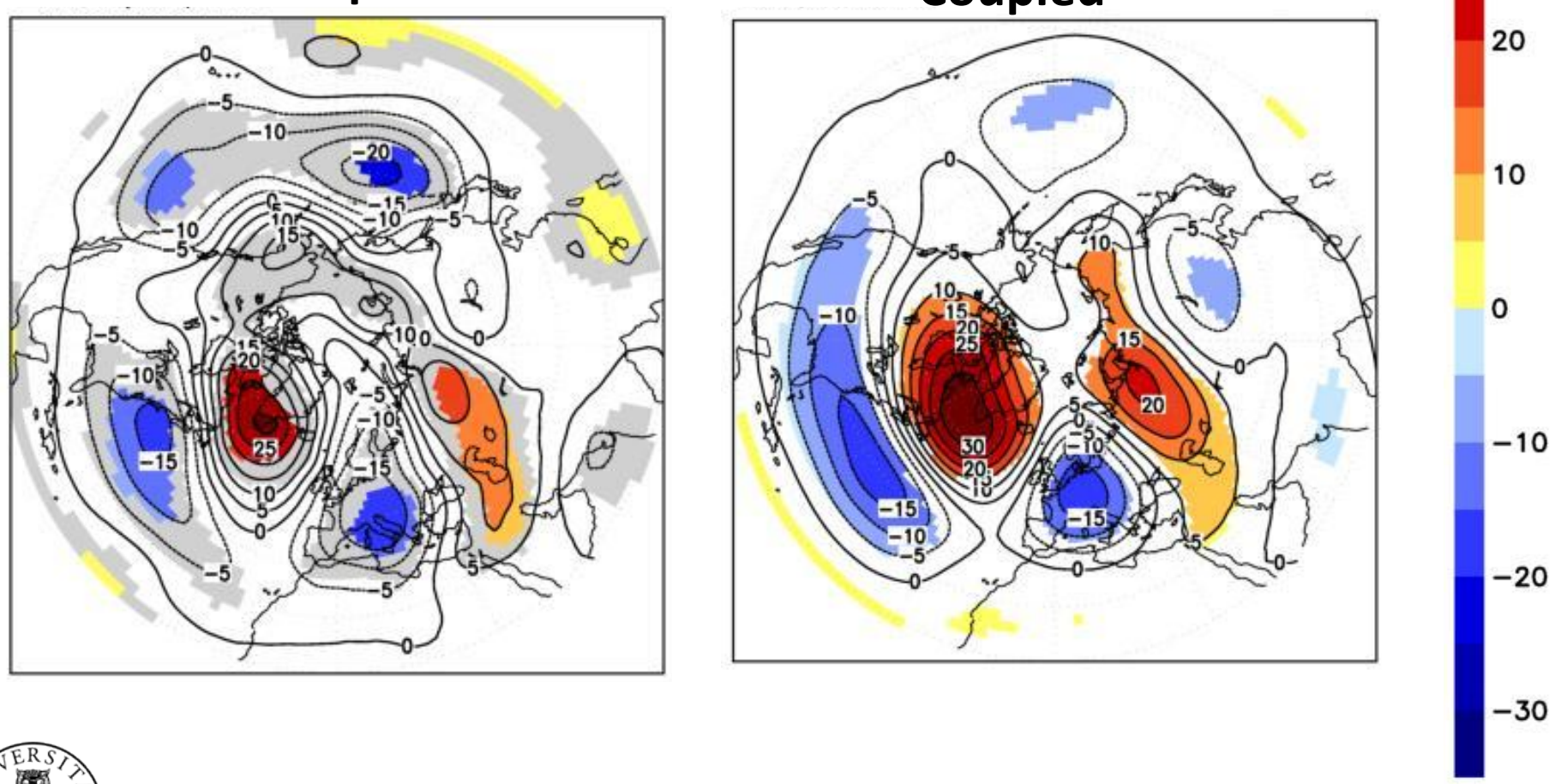
Omrani et al. 2015

Warm phase – Atmospheric pattern largely driven by North Atlantic SST

500 hPa GPH (JFM)

Uncoupled

Coupled



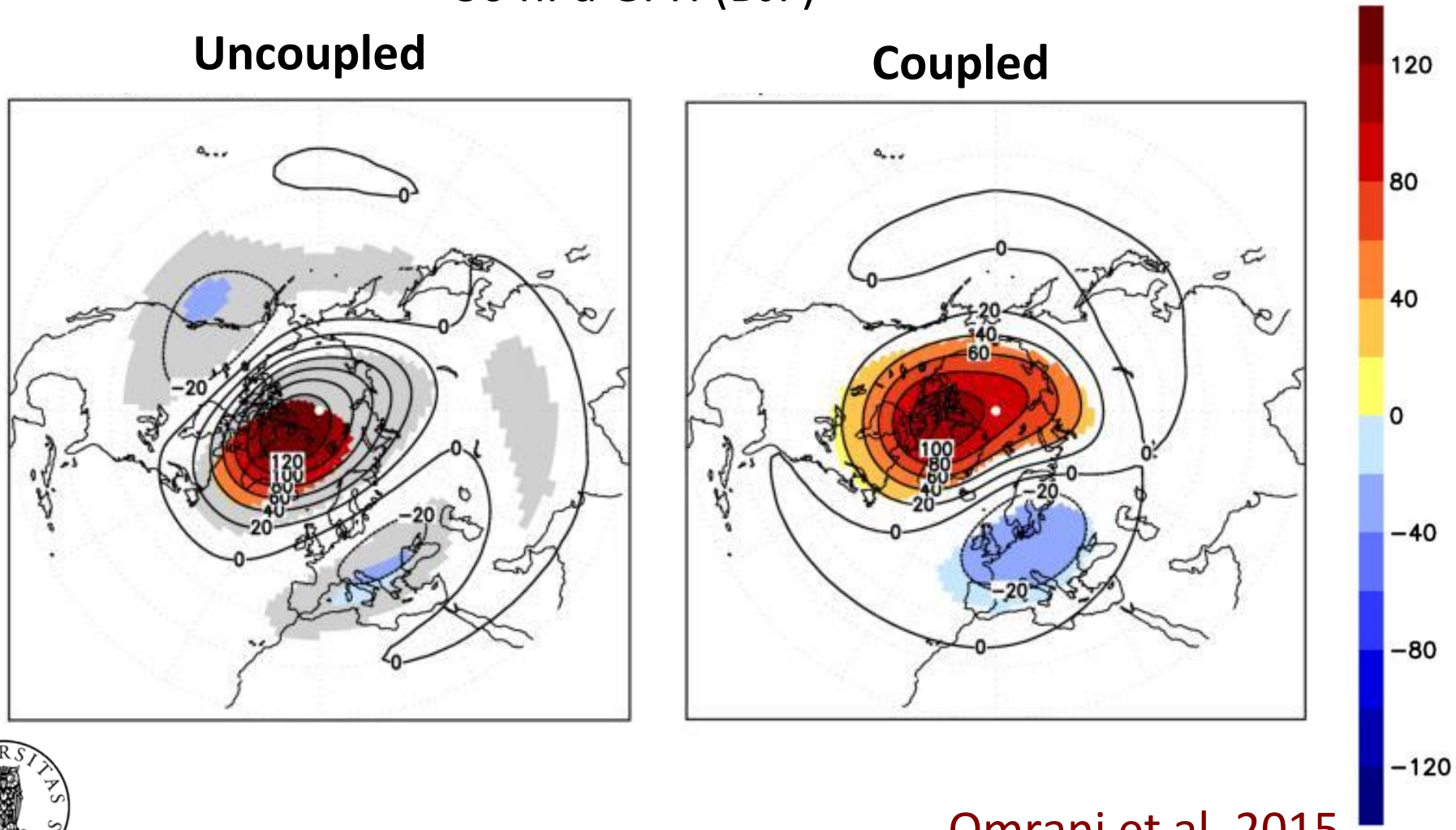
Omrani et al. 2015

Warm phase – Stratospheric polar vortex weakening largely driven by North Atlantic SST

30 hPa GPH (DJF)

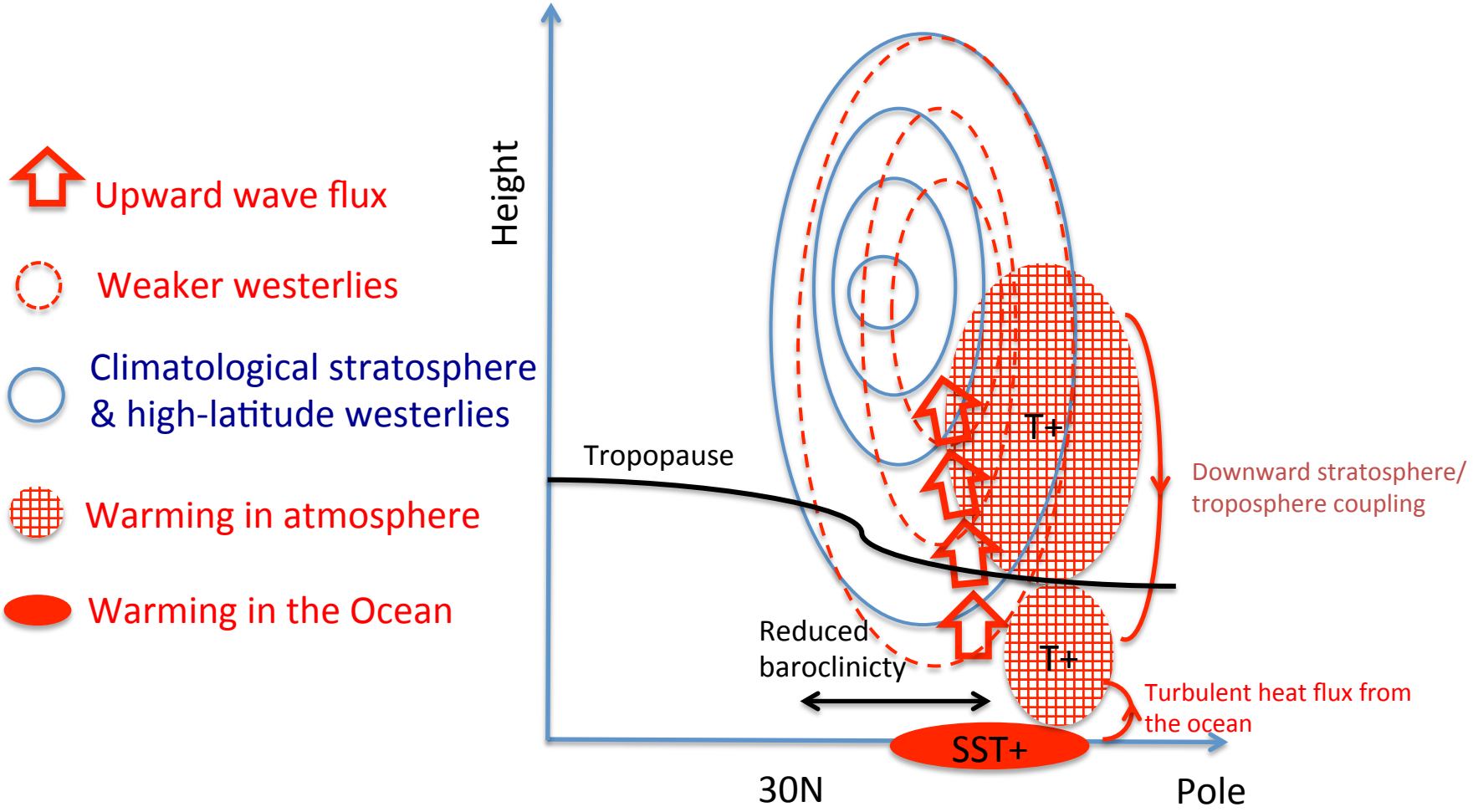
Uncoupled

Coupled



Omrani et al. 2015

Schematic of the atmospheric response to extra-tropical North Atlantic SST

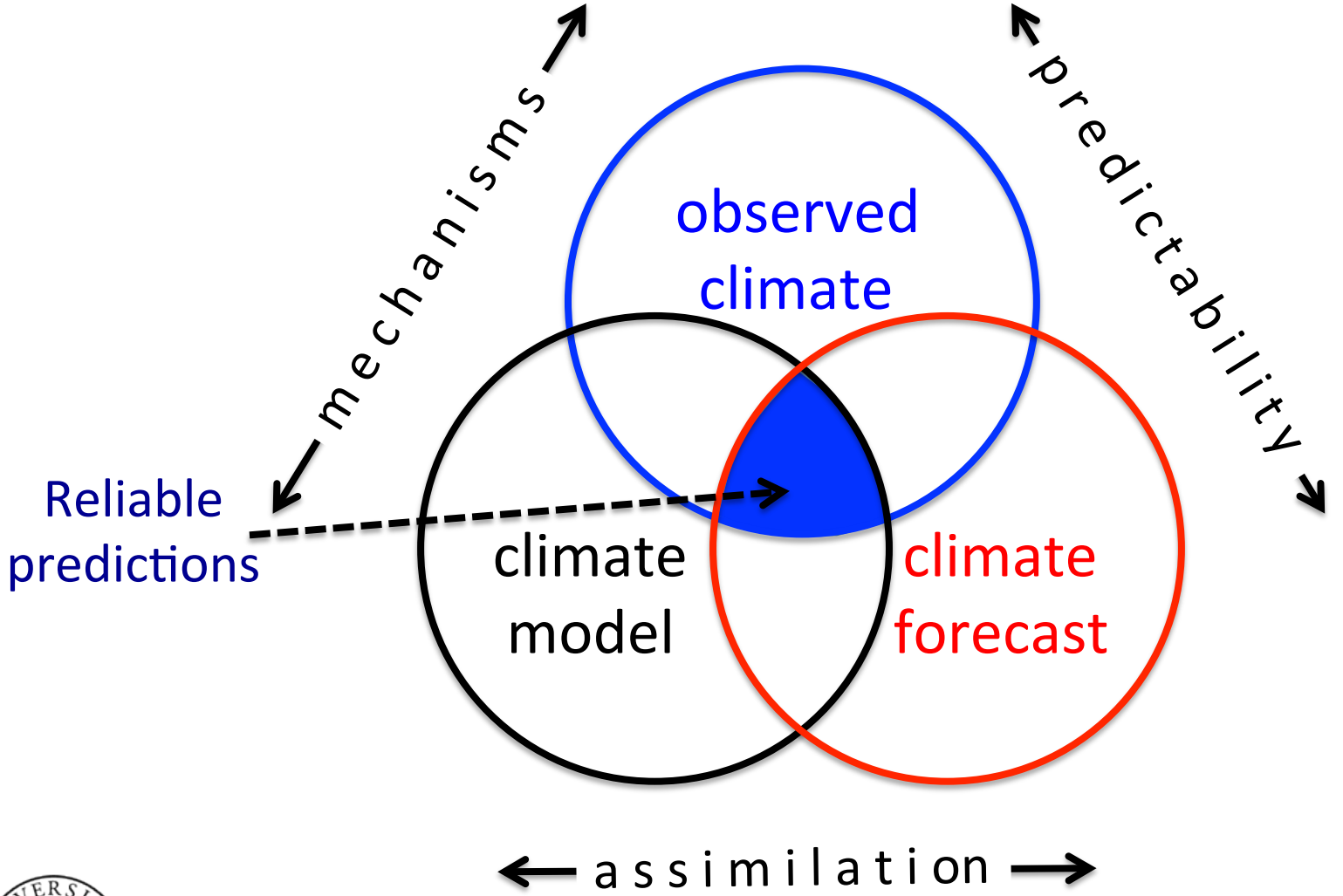


Keenlyside et al., ERL, 2014

3. Implications for climate prediction

Conceptual view of the prediction problem

The differing representations of predictable dynamics



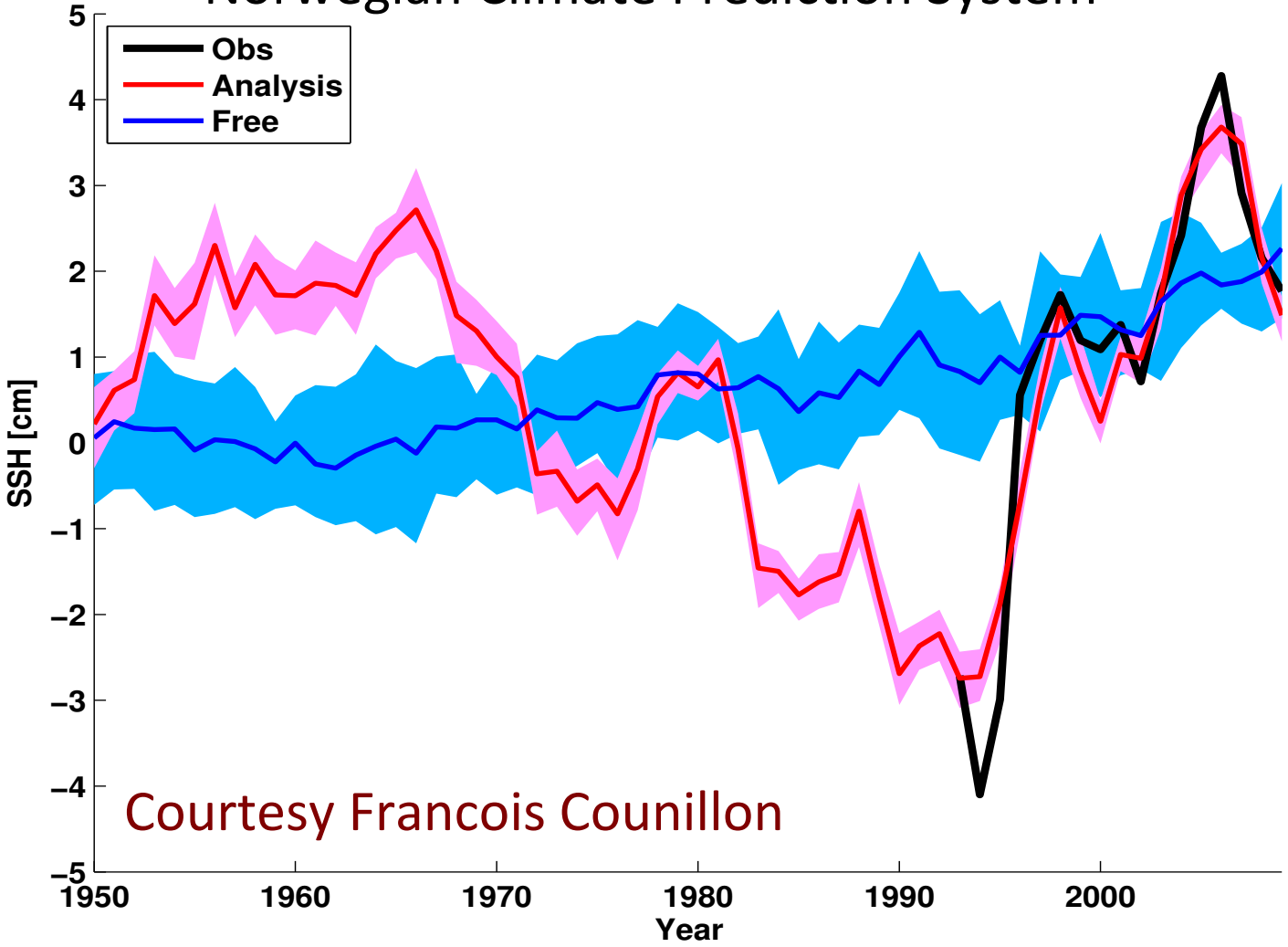
Courtesy Tor Eldevik

Sources of error and prediction skill

- Climate predictability arises from **interaction** of slowly varying components of the climate system with the atmosphere
- Misrepresentation of these interactions:
  - Errors in the mean state and variability
  - Strong forecast drift that degrades forecast skill
  - Renders models poor tools in estimating predictability
- Coupled data assimilation provides a pathway forward

Ability of an EnKF data assimilation to constrain system with limited data

Subpolar Gyre Strength from SST anomaly assimilation
Norwegian Climate Prediction System



Summary

1. The slab ocean – AGCM interpretation of AMV not consistent with current understanding
2. Observations and model indicate warm AMV drives negative NAO
   - stratosphere playing a key role
   - Cold AMV response is less well simulated
   - Supported by several studies (Omrani et al. 2014,2015; Peings and Magnusdotir 2014,2015; Gastineau et al. 2014; Frankignoul et al. 2015)