

Arctic sea ice variability & predictability

Ed Hawkins

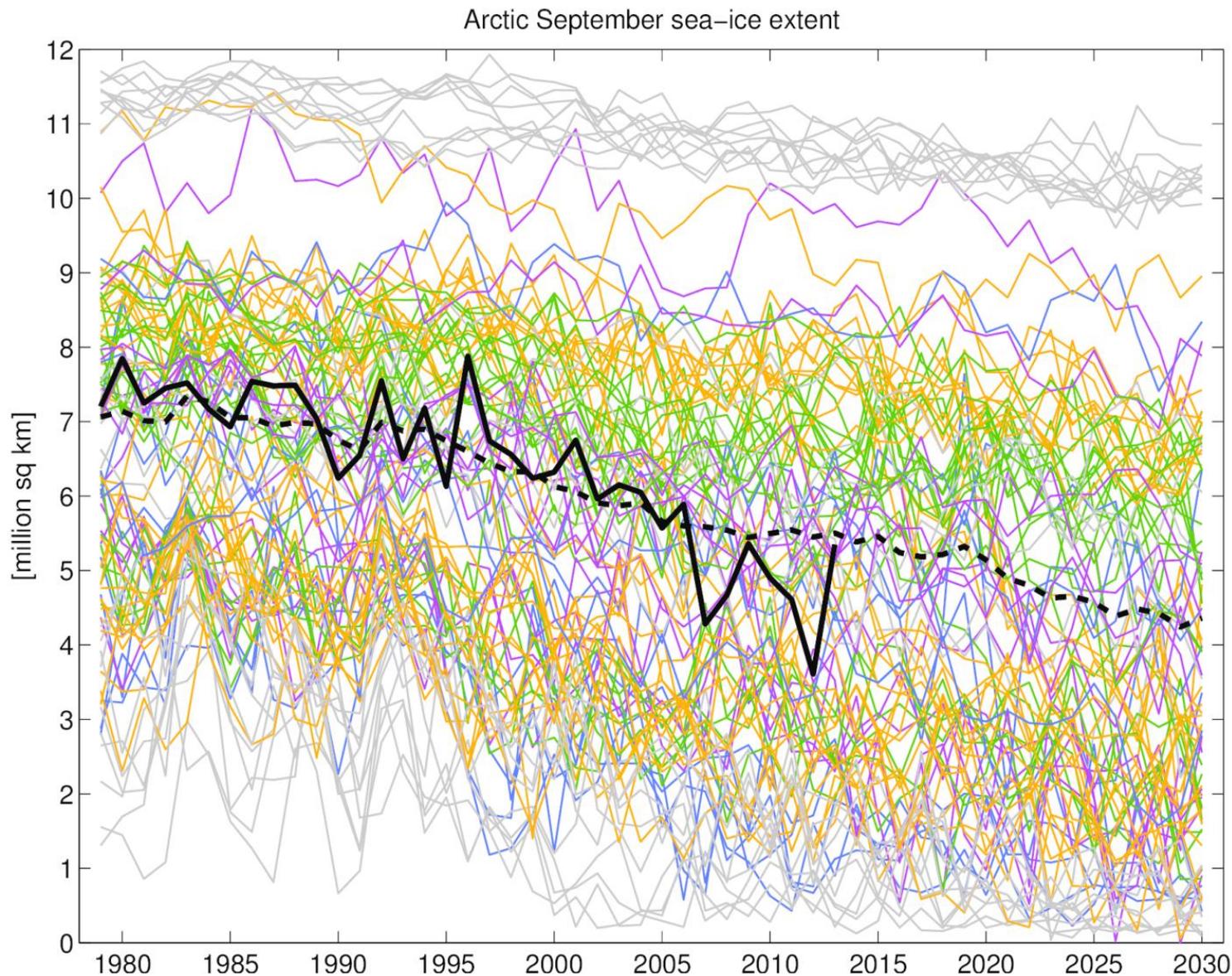
NCAS-Climate, University of Reading

Thanks to:

Jonny Day, Steffen Tietsche, Nat Melia, Keith Haines (APPOSITE project)
Neil Swart, John Fyfe, Jen Kay, Alex Jahn, Reto Knutti

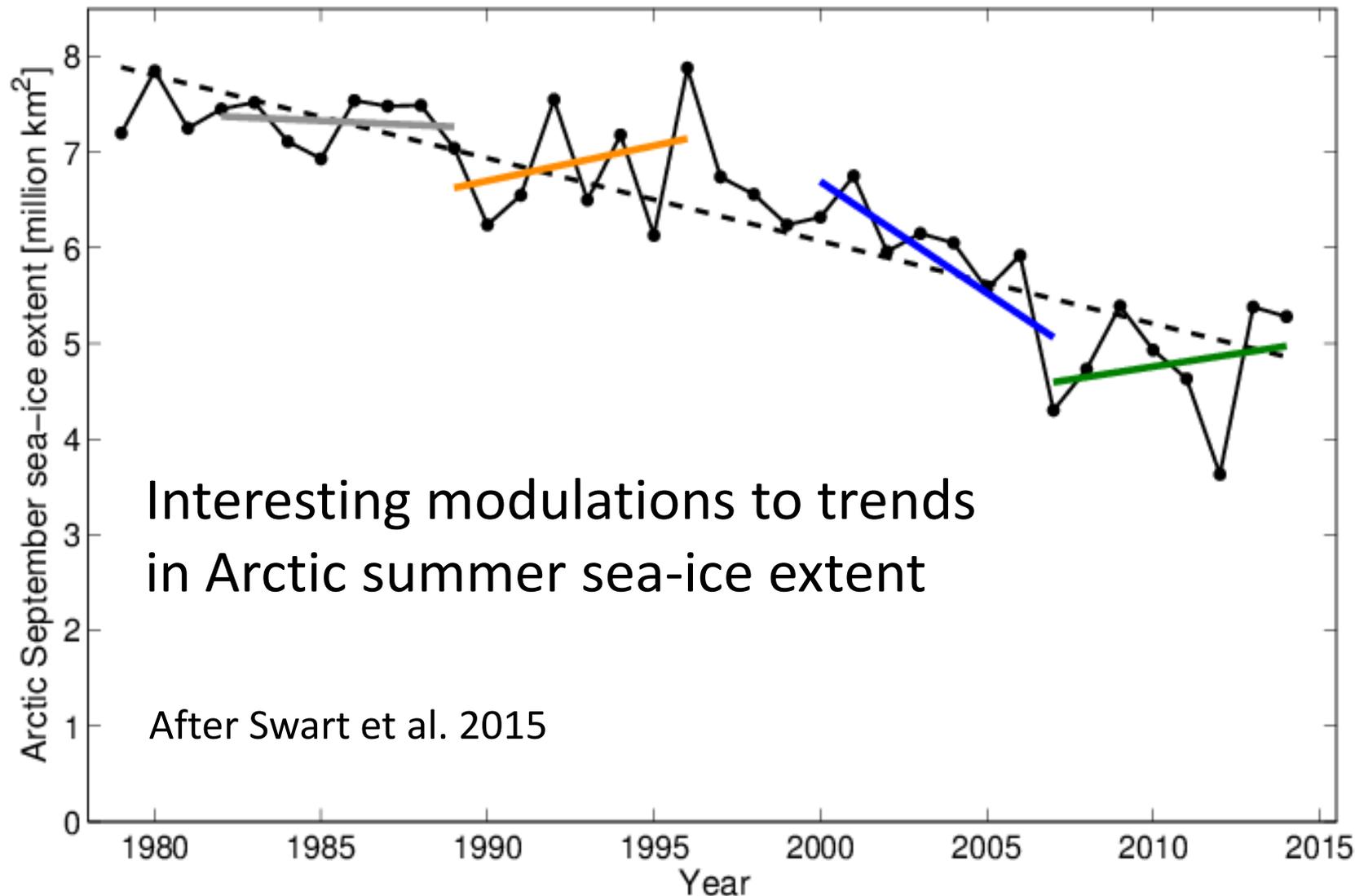


What about Arctic sea-ice?



CMIP5
projections of
September
sea ice extent

Role of trend & variability in Arctic September sea-ice extent changes



Arctic sea-ice trends

Grey: CMIP5

Cyan: CESM1

Red: Observations

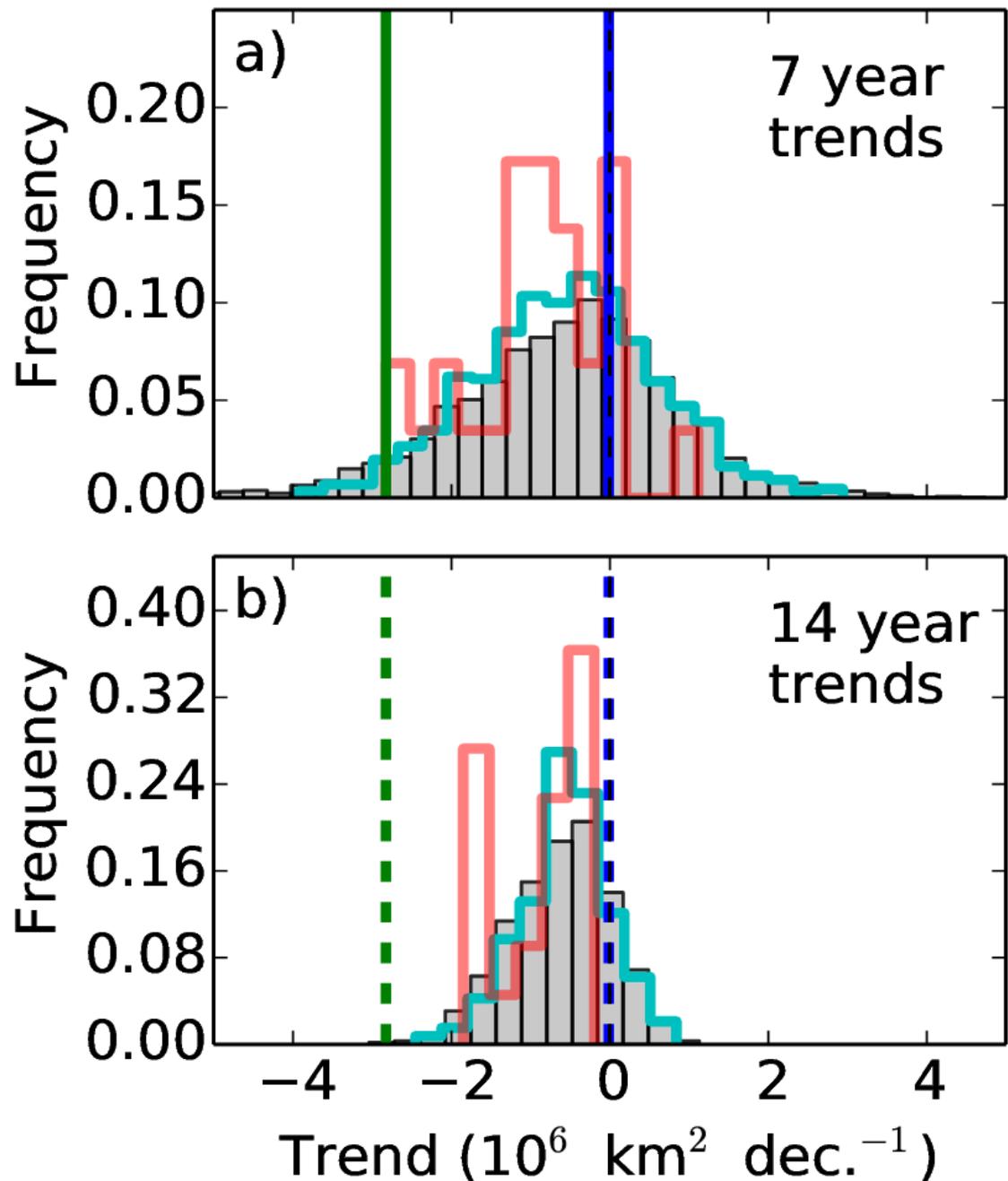
Green: 2001-2007

Blue: 2007-2013

Also see:

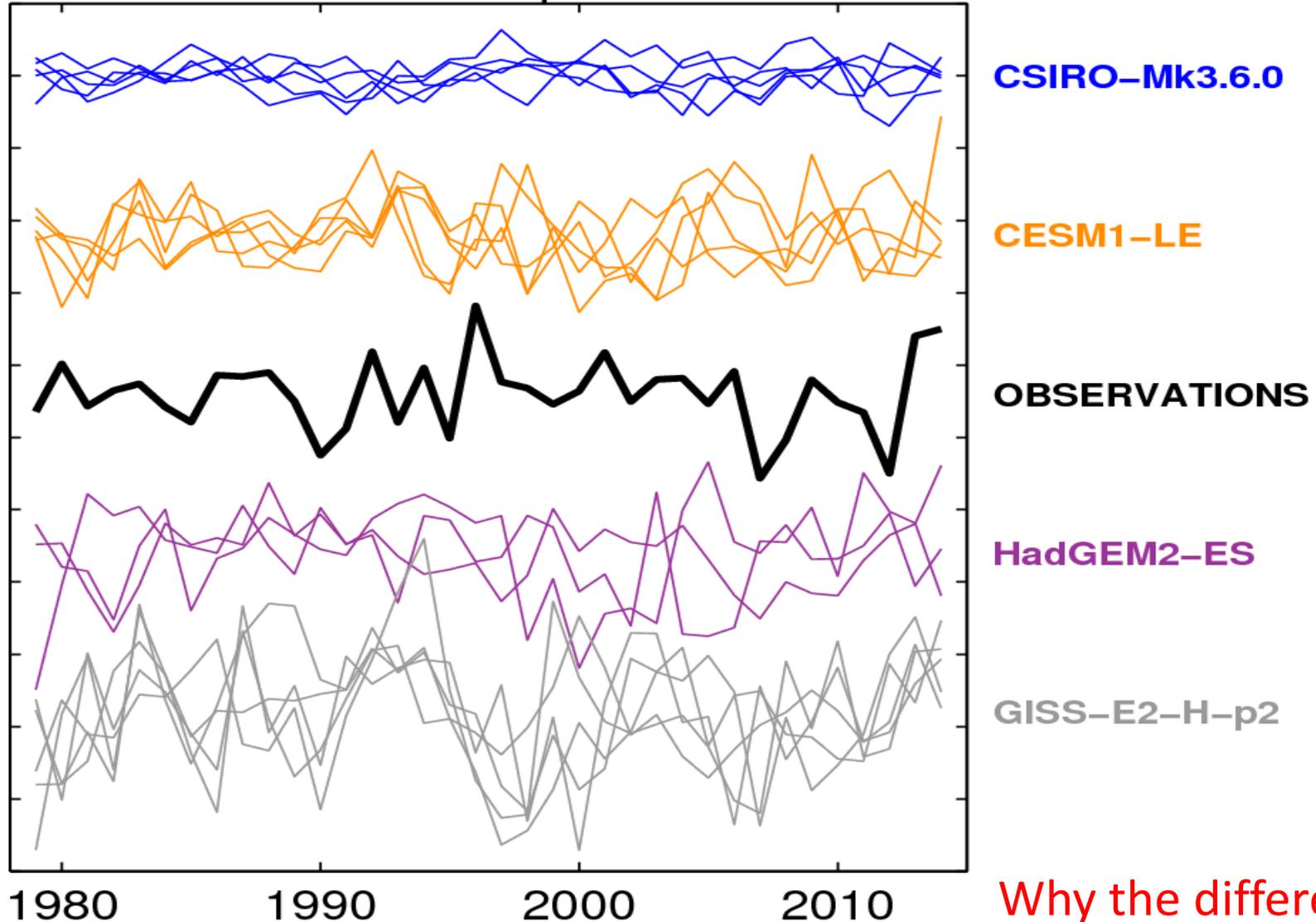
Kay et al. 2010

Day et al. 2013



Arctic sea-ice variability

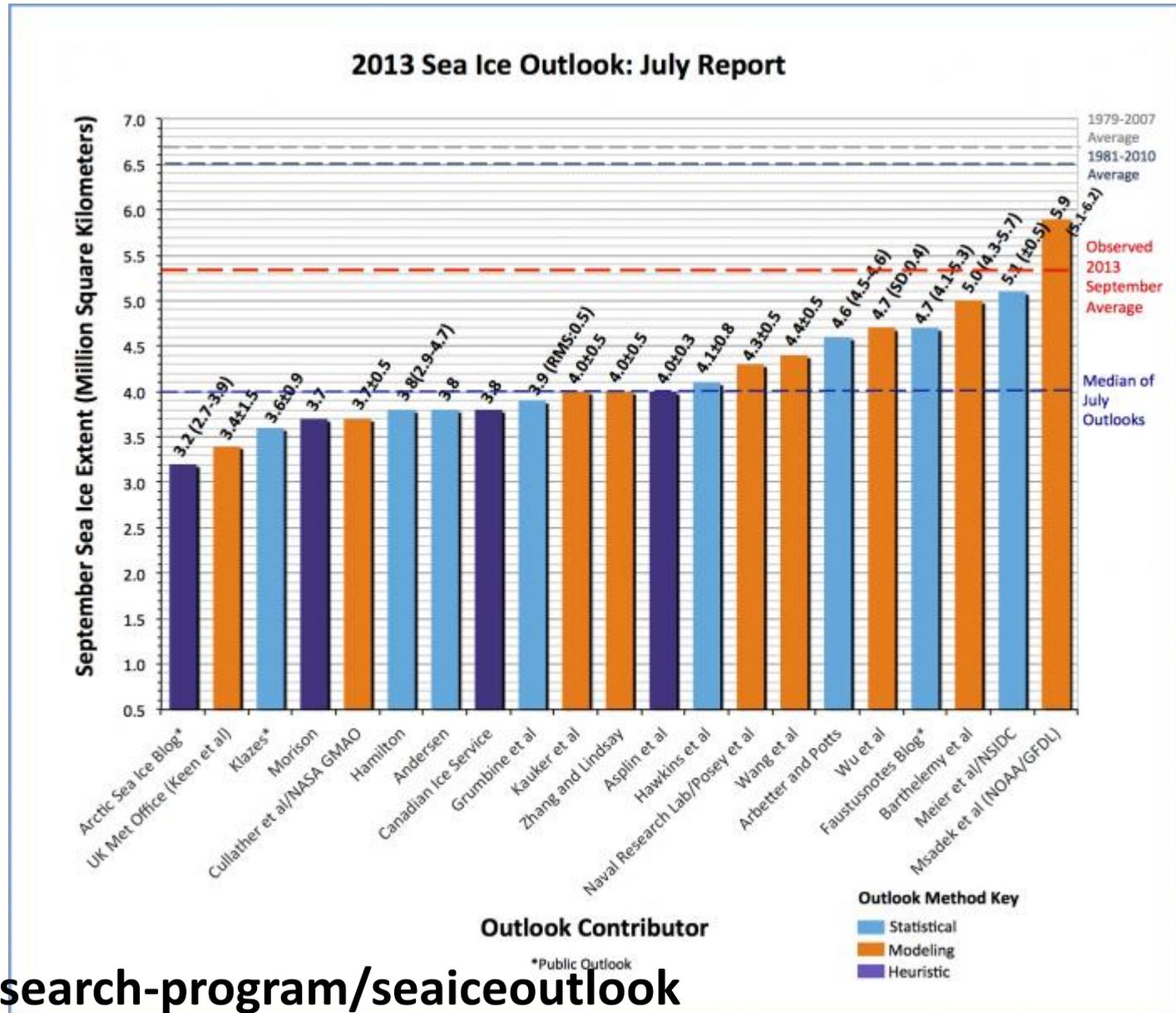
Detrended Arctic September sea-ice extent



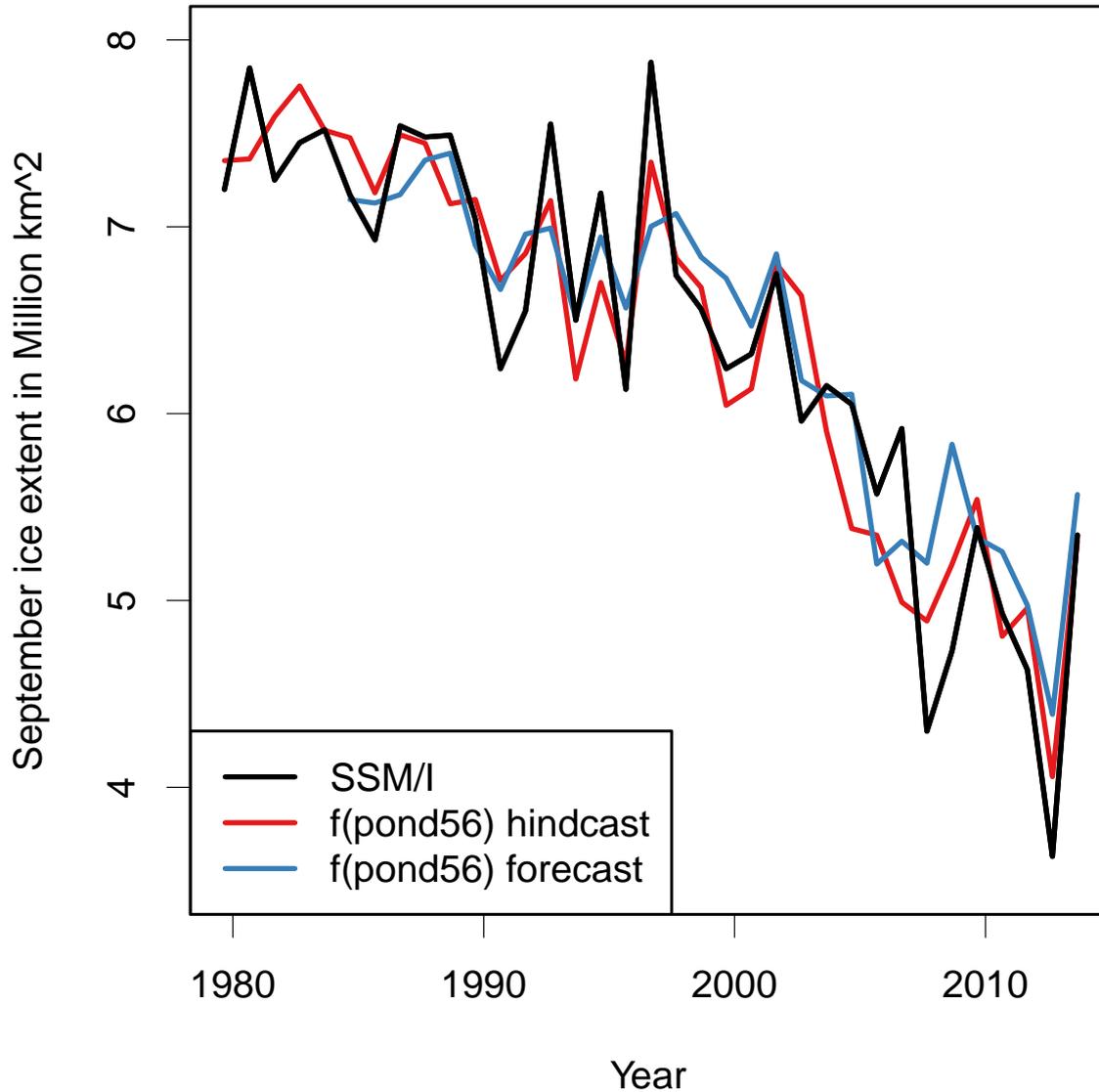
Why the differences?

Since 2008,
real-time
forecasts for
September ice
extent have
been collected
by ARCUS

See: Stroeve et
al. 2014

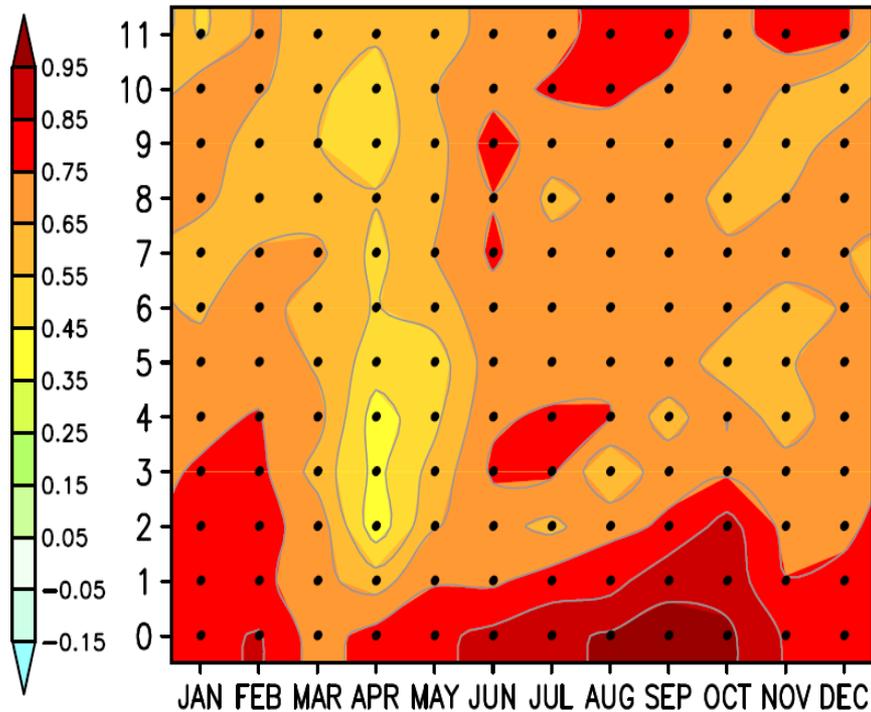


September Arctic sea ice predicted by spring melt pond fraction

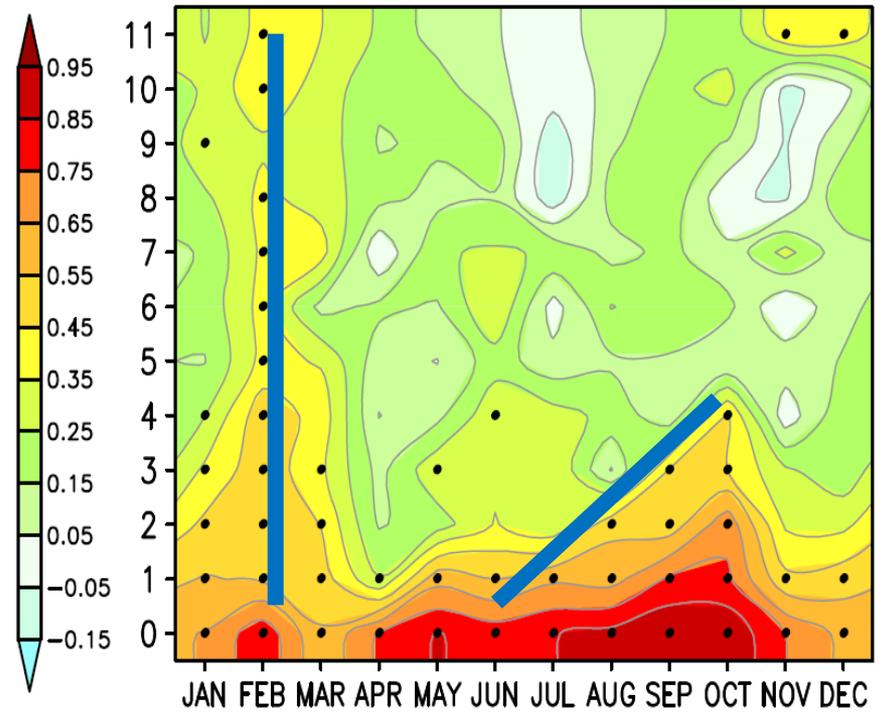


Schröder et al. 2014

Correlation skill for Arctic sea-ice extent from GCM hindcasts



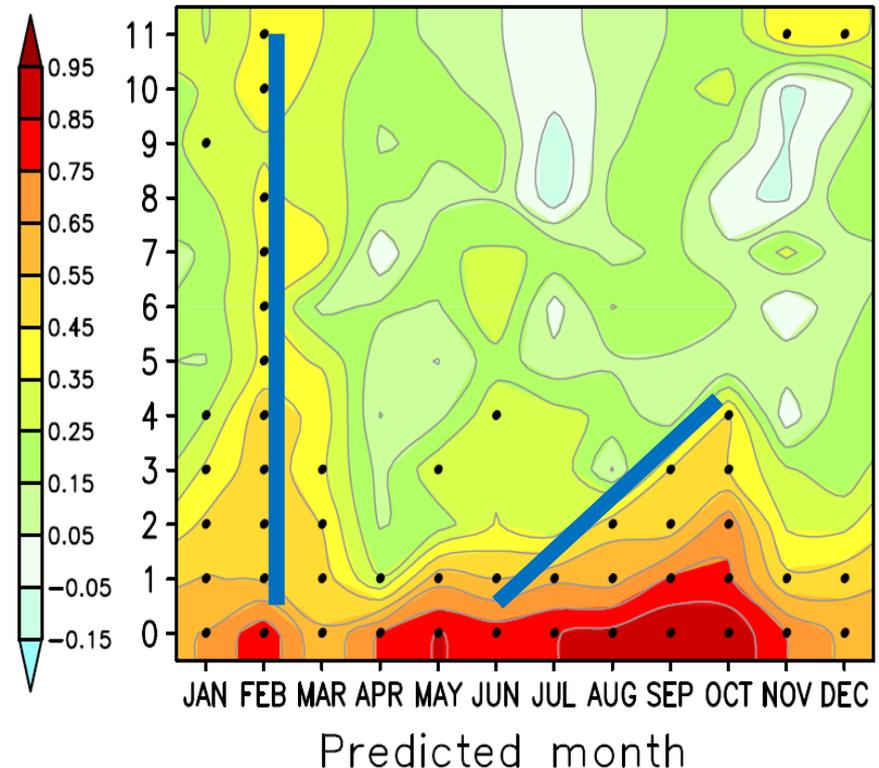
Predicted Month
Including trend



Predicted month
Without trend

Correlation skill for Arctic sea-ice extent from GCM hindcasts

- Are these features due to observation and/or model inadequacies?
- Or, have we reached the limit of predictability?
- How important is sea ice thickness?



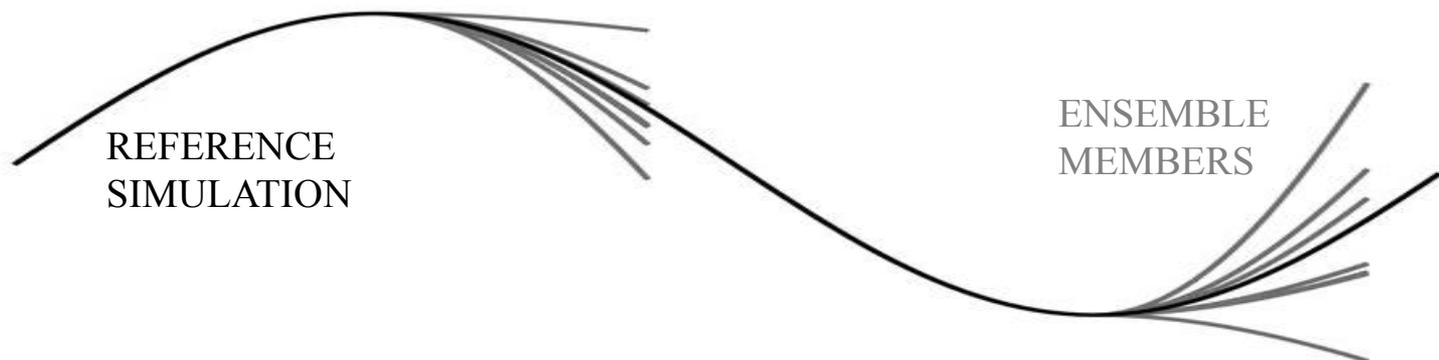
Without trend

Sigmond et al. 2013, GRL

Also see: Wang et al. 2013,
Chevallier et al. 2013,
Merryfield et al. 2013

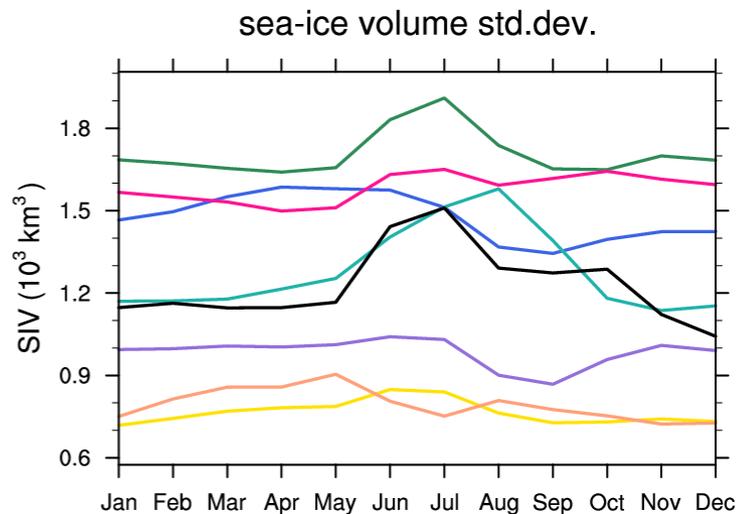
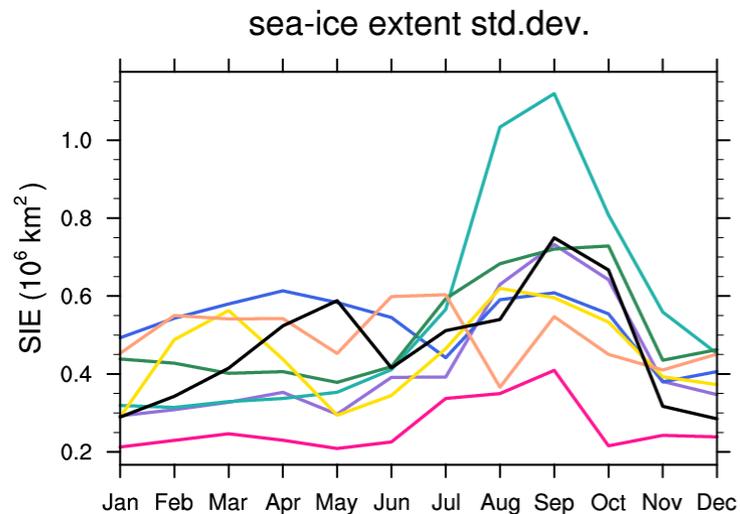
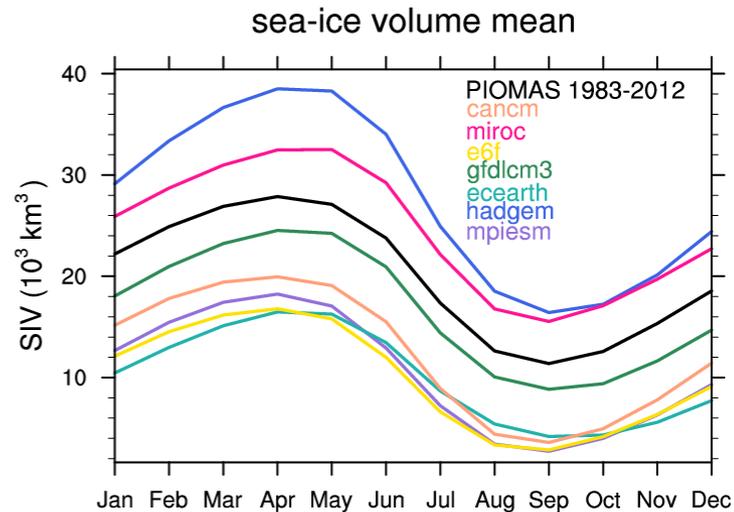
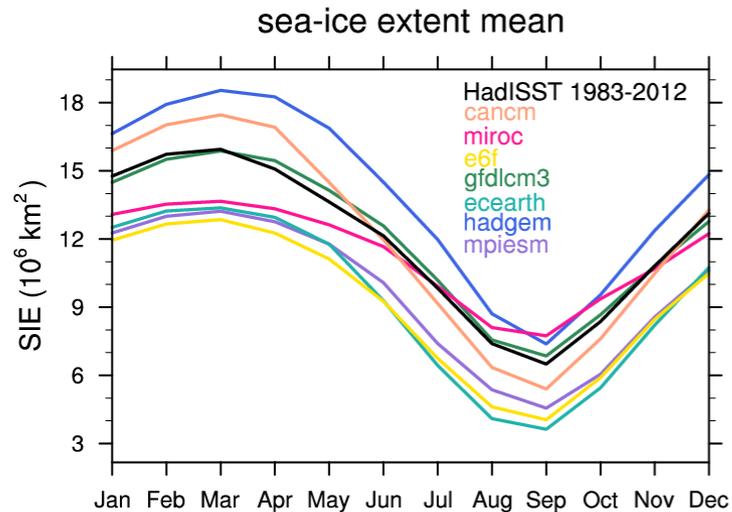
‘Perfect model’ framework:

- Examine how well a GCM can predict itself
- Predicting the real world with the same GCM is a harder problem
- The estimated ‘perfect’ skill is therefore an upper limit for the skill of that GCM to predict real world

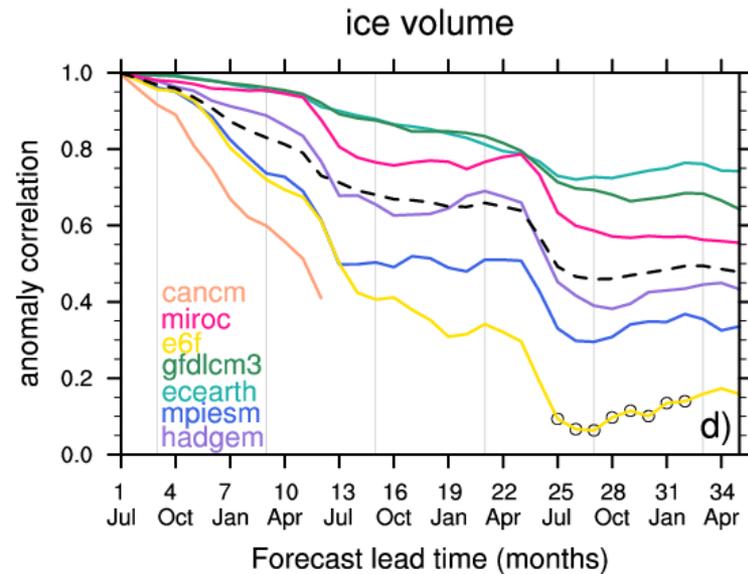
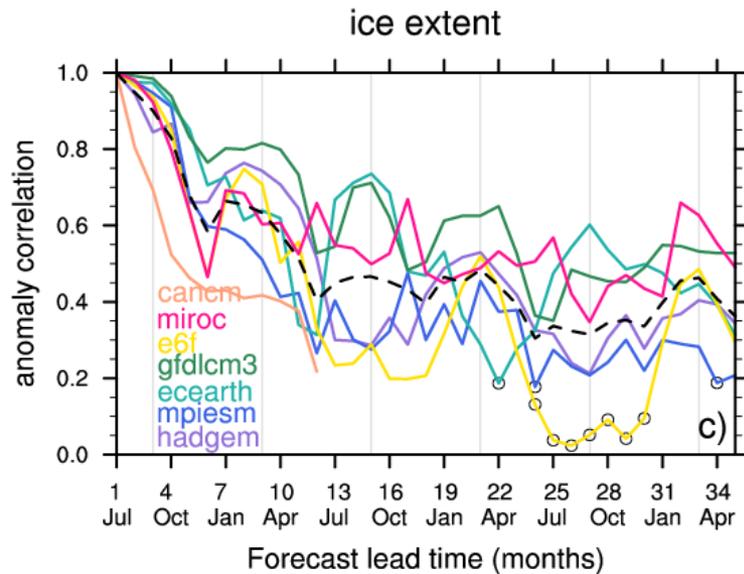
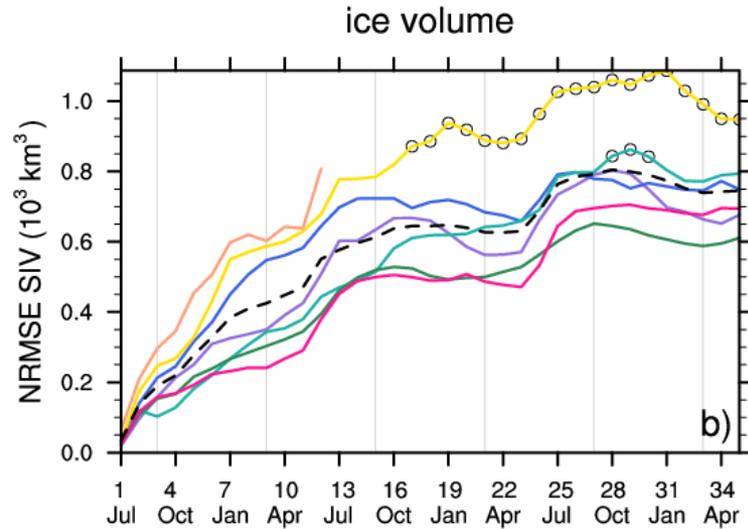
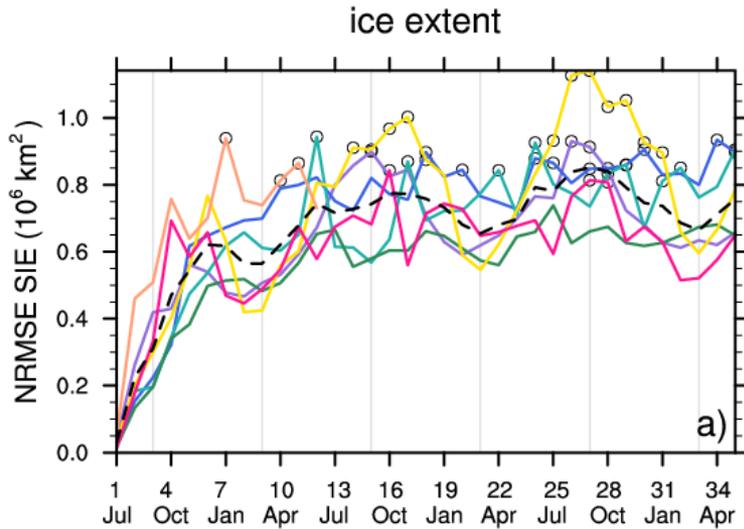


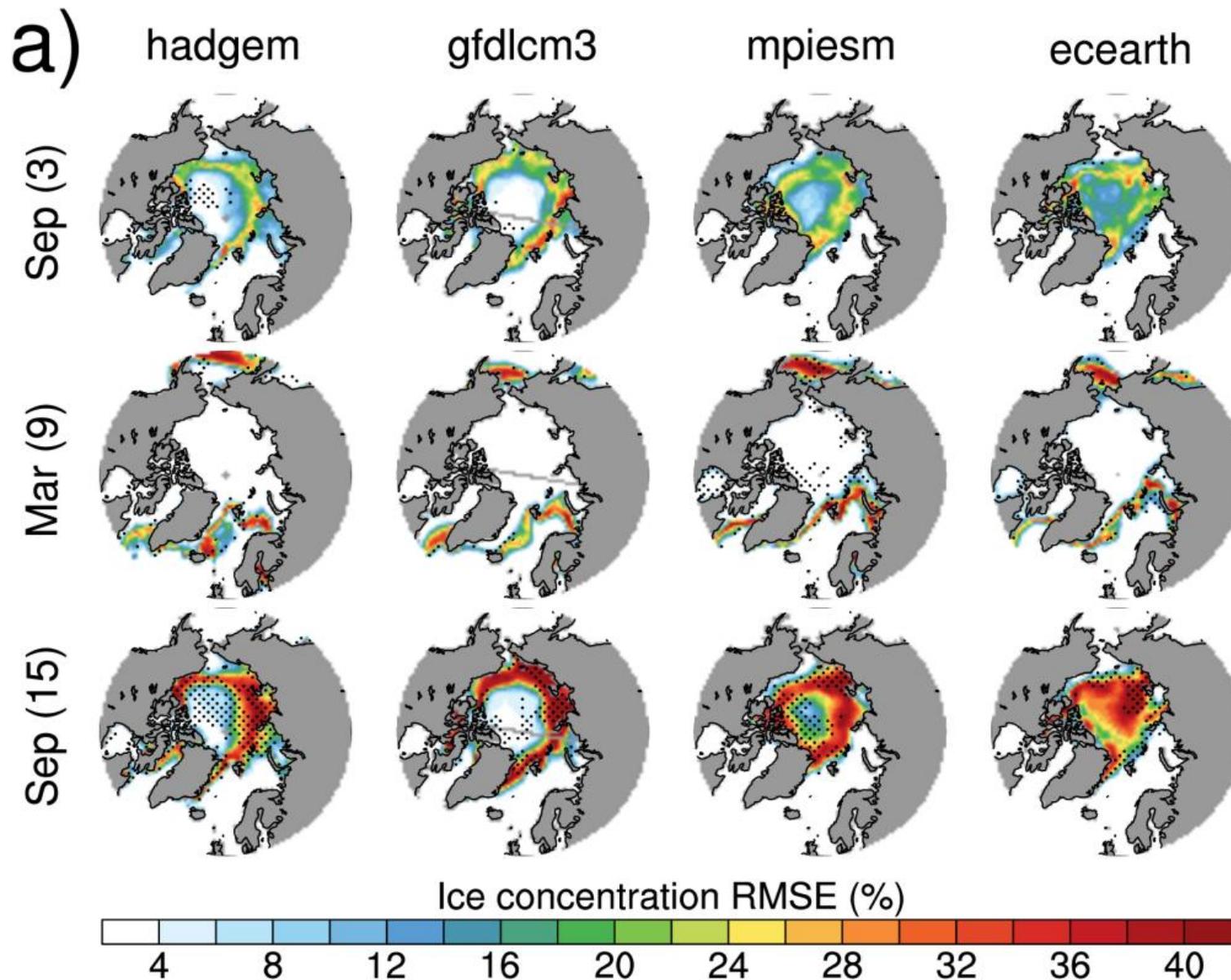
Ensemble design:

- 7 GCMs (HadGEM1, EC-EARTH2, MPI-ESM, GFDL-CM3, ECHAM6-FESOM, CanCM4 & MIROC5)
- Experiments started on 1st July in at least 8 different years from reference control simulation
- Range of initial conditions chosen to sample different states of the Arctic
- Between 8 and 16 ensemble members, generated by making tiny perturbations to atmospheric initial conditions
- Run for 3 years

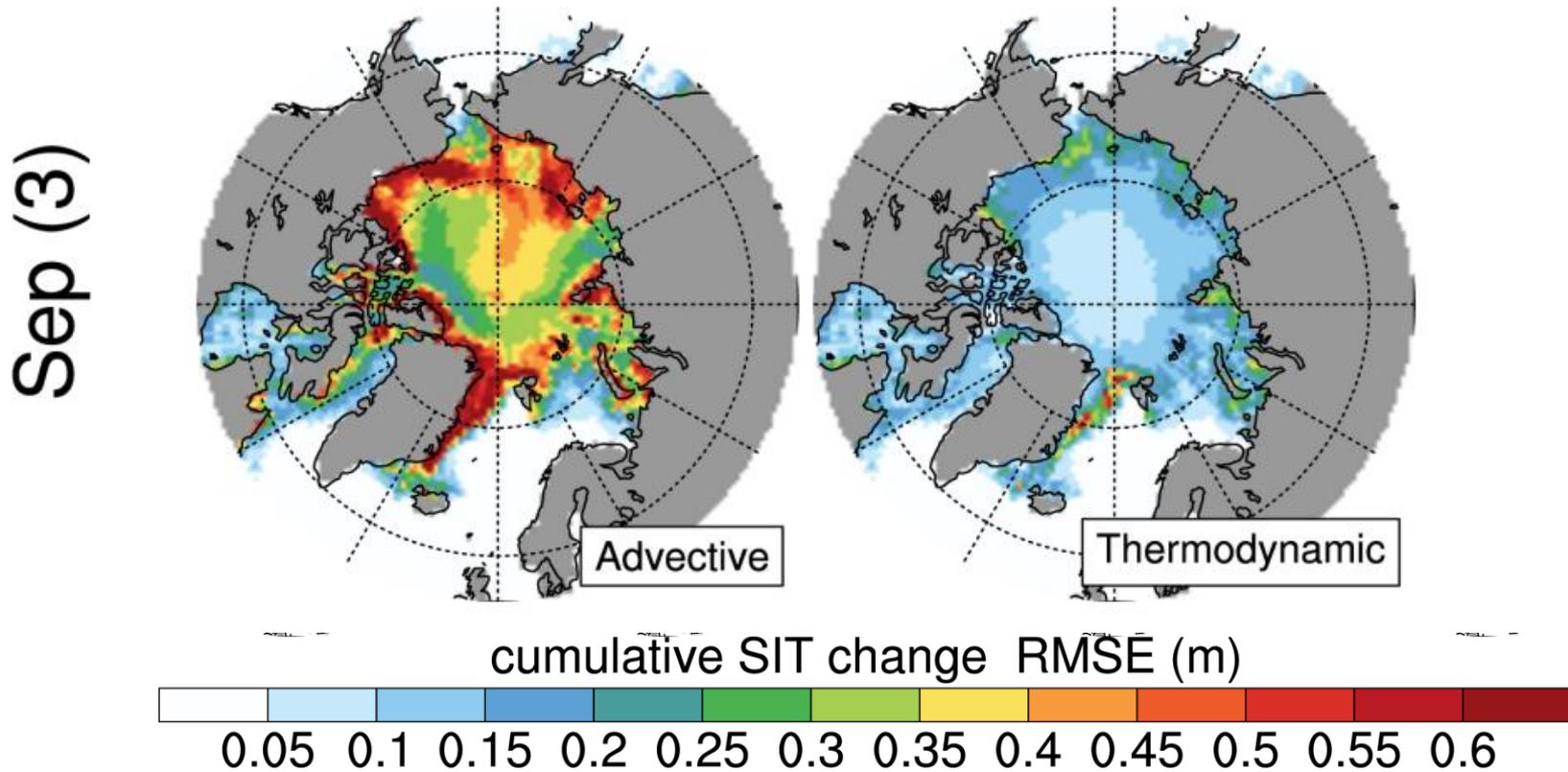


Potential predictability estimates





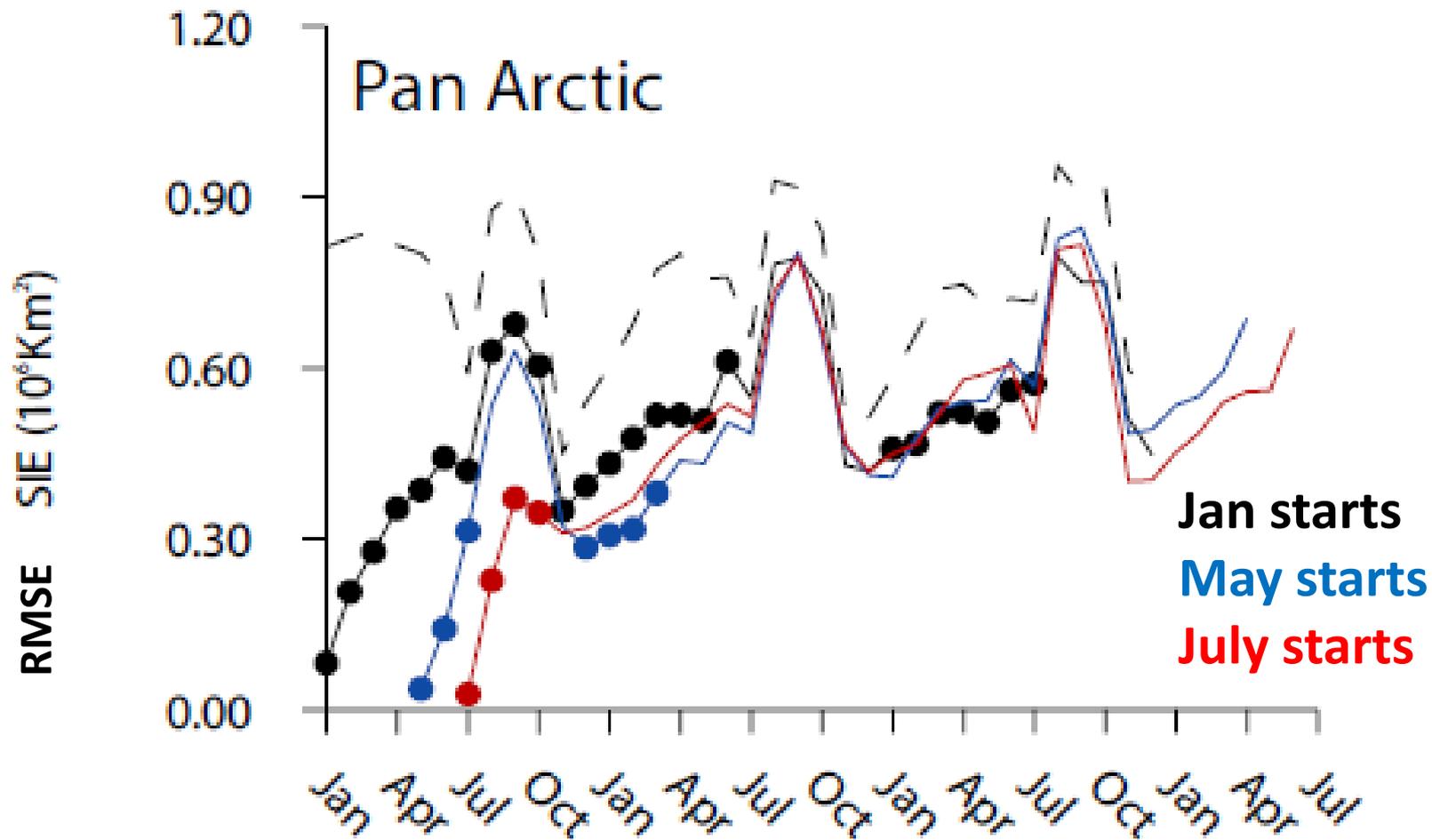
a) hadgem



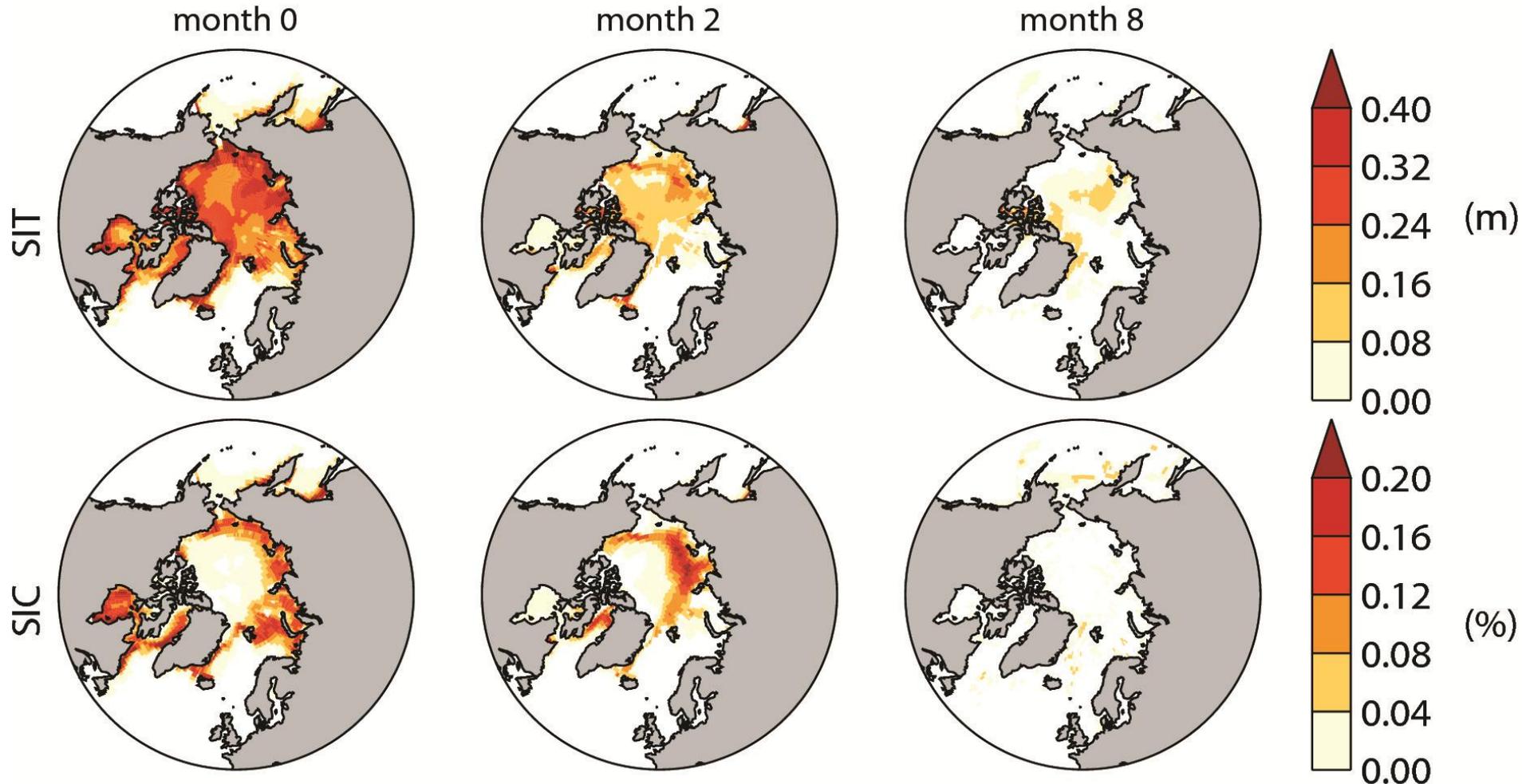
(Similar results for MPI-ESM)

Tietsche et al., GRL, 2014

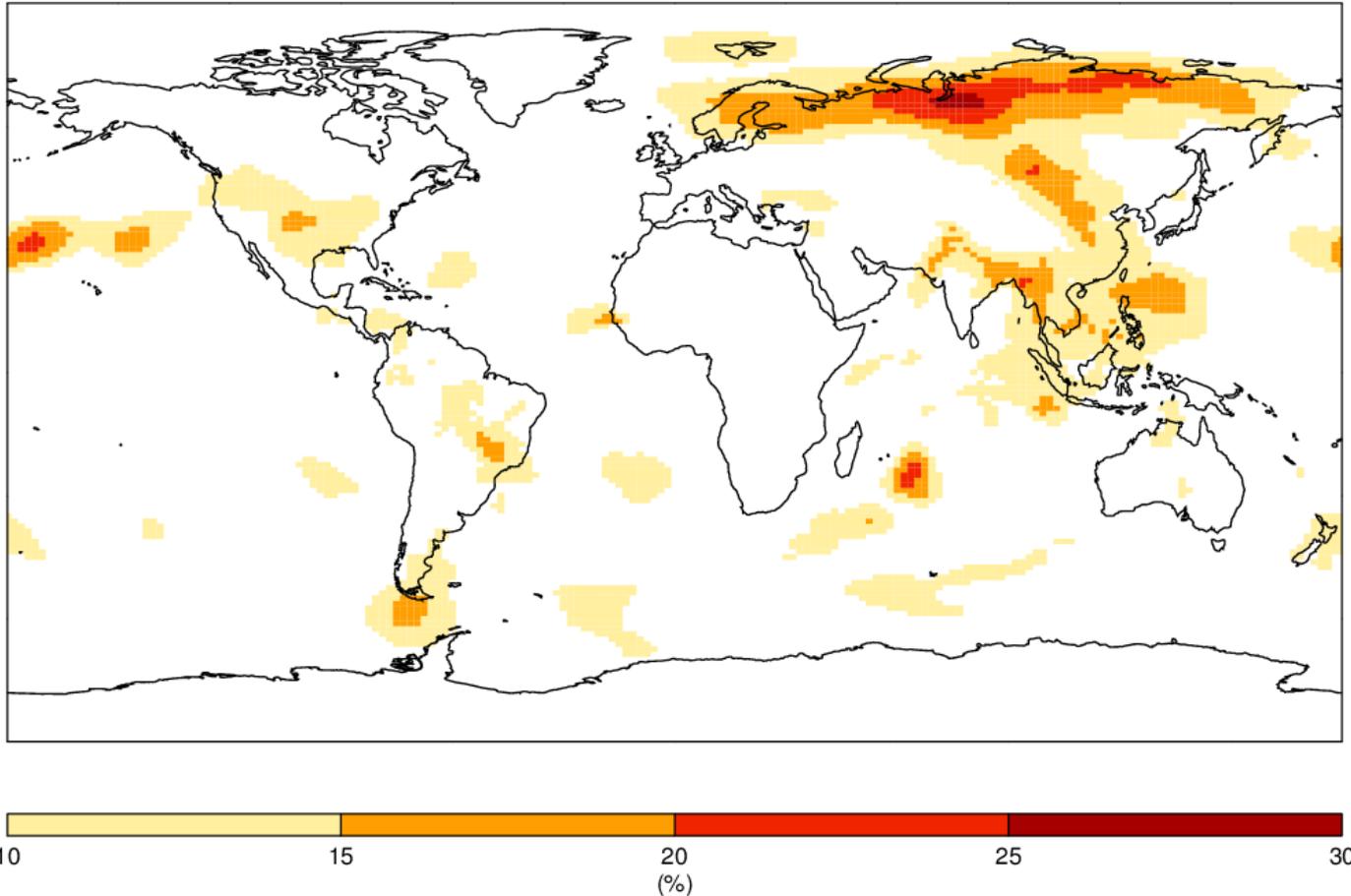
HadGEM1.2 simulations from different start months



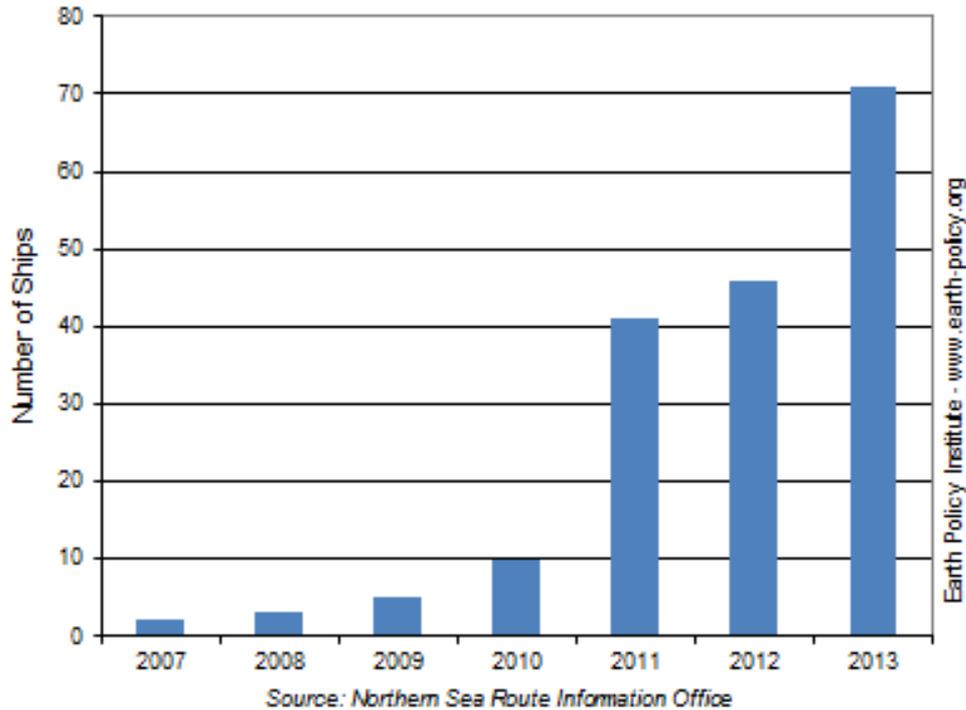
Error difference if ice thickness is replaced by climatology on 1st July:



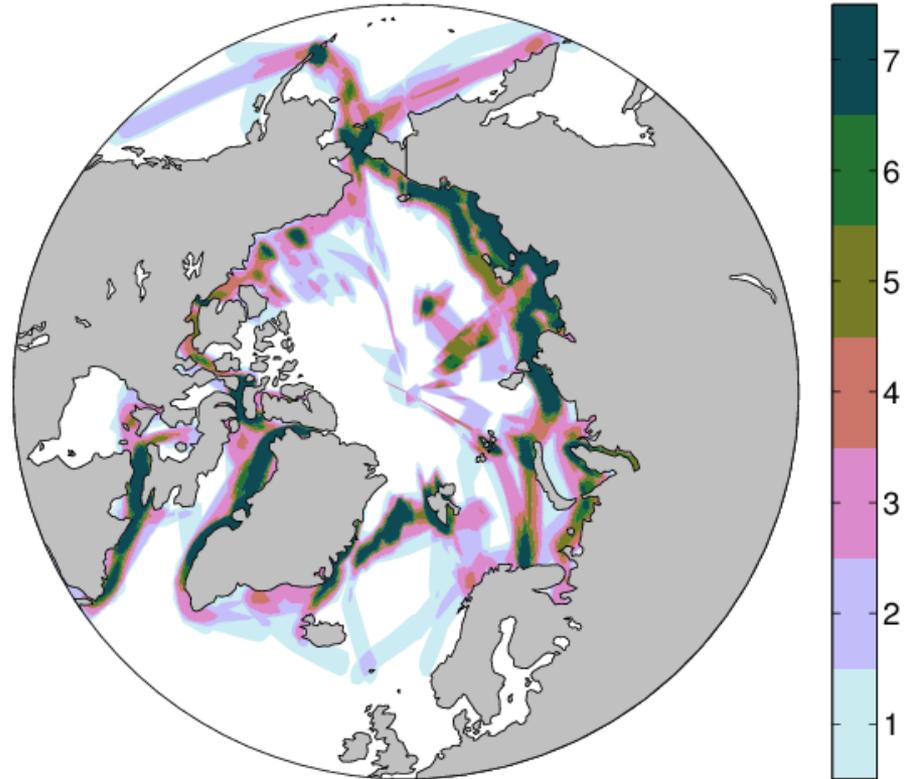
Increase in Jan MSLP error



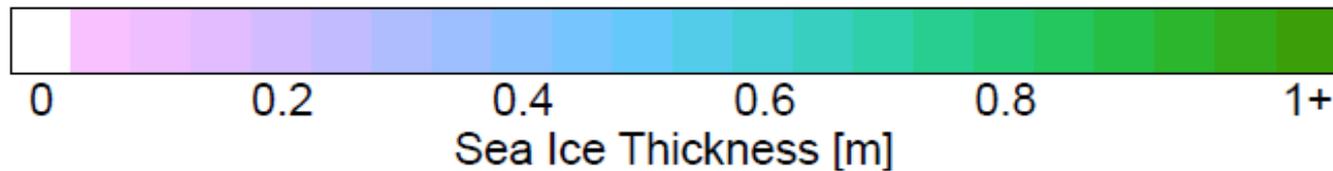
Ships Crossing Arctic Northern Sea Route, 2007-2013



Ship track density in the Arctic – August 2011

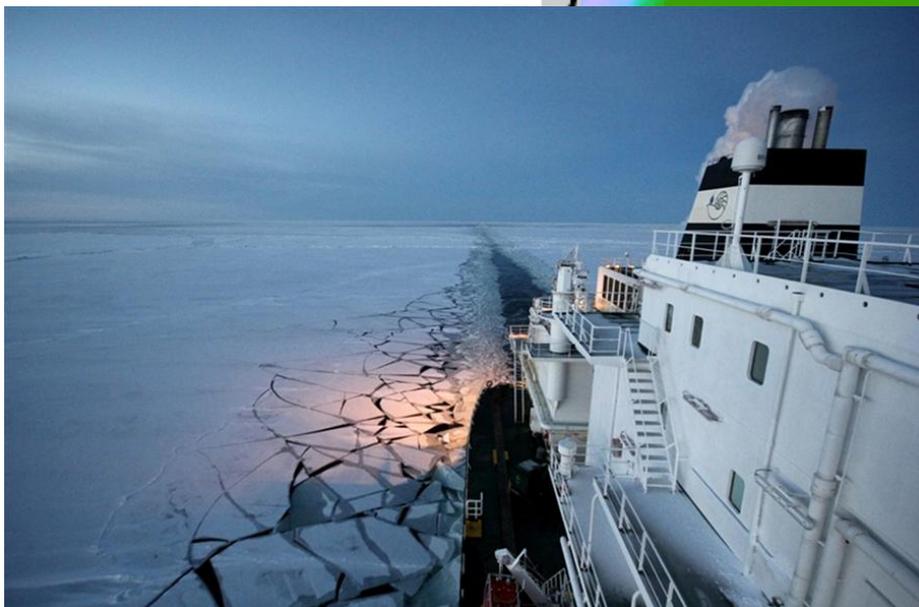
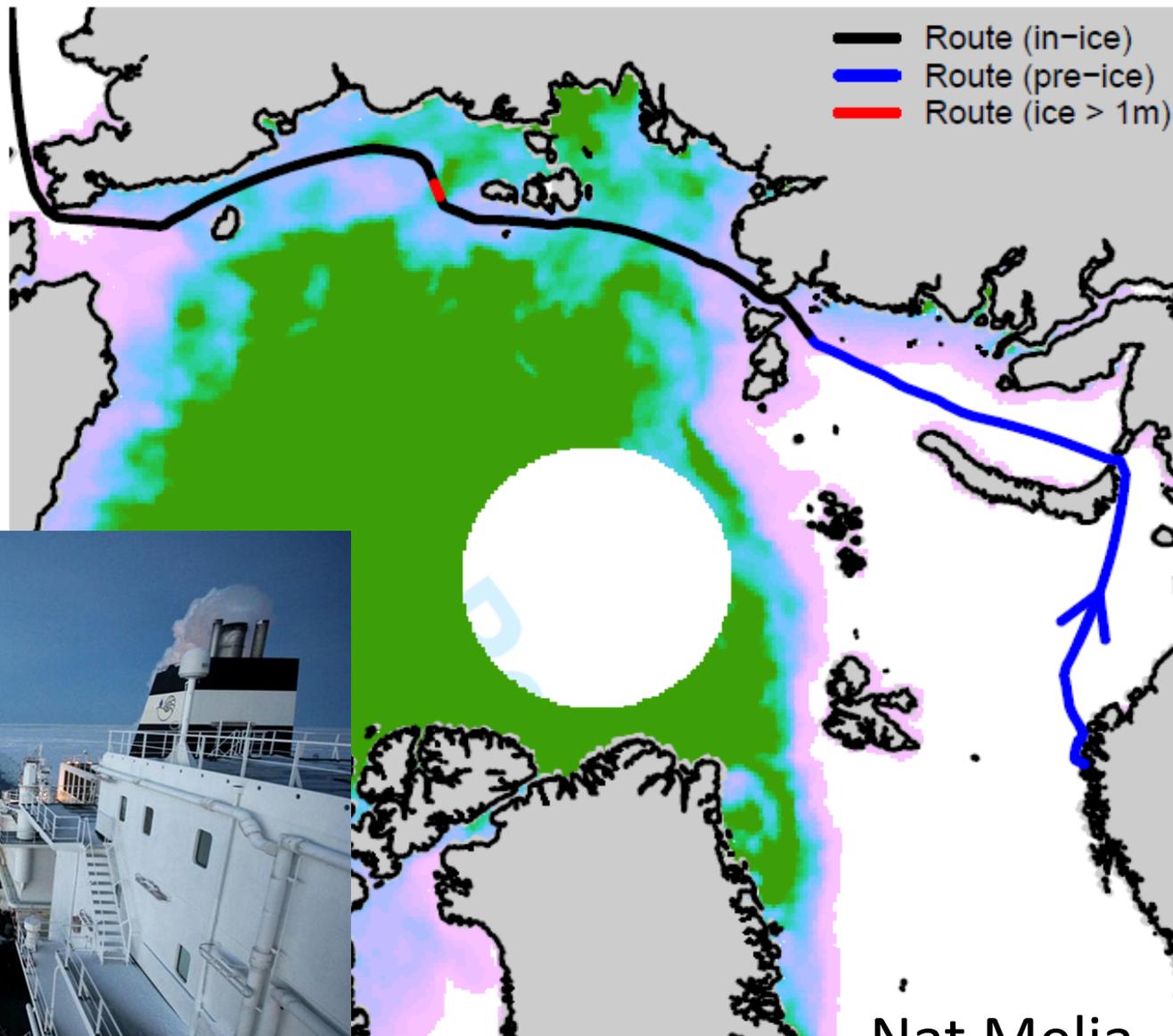


Why predict?



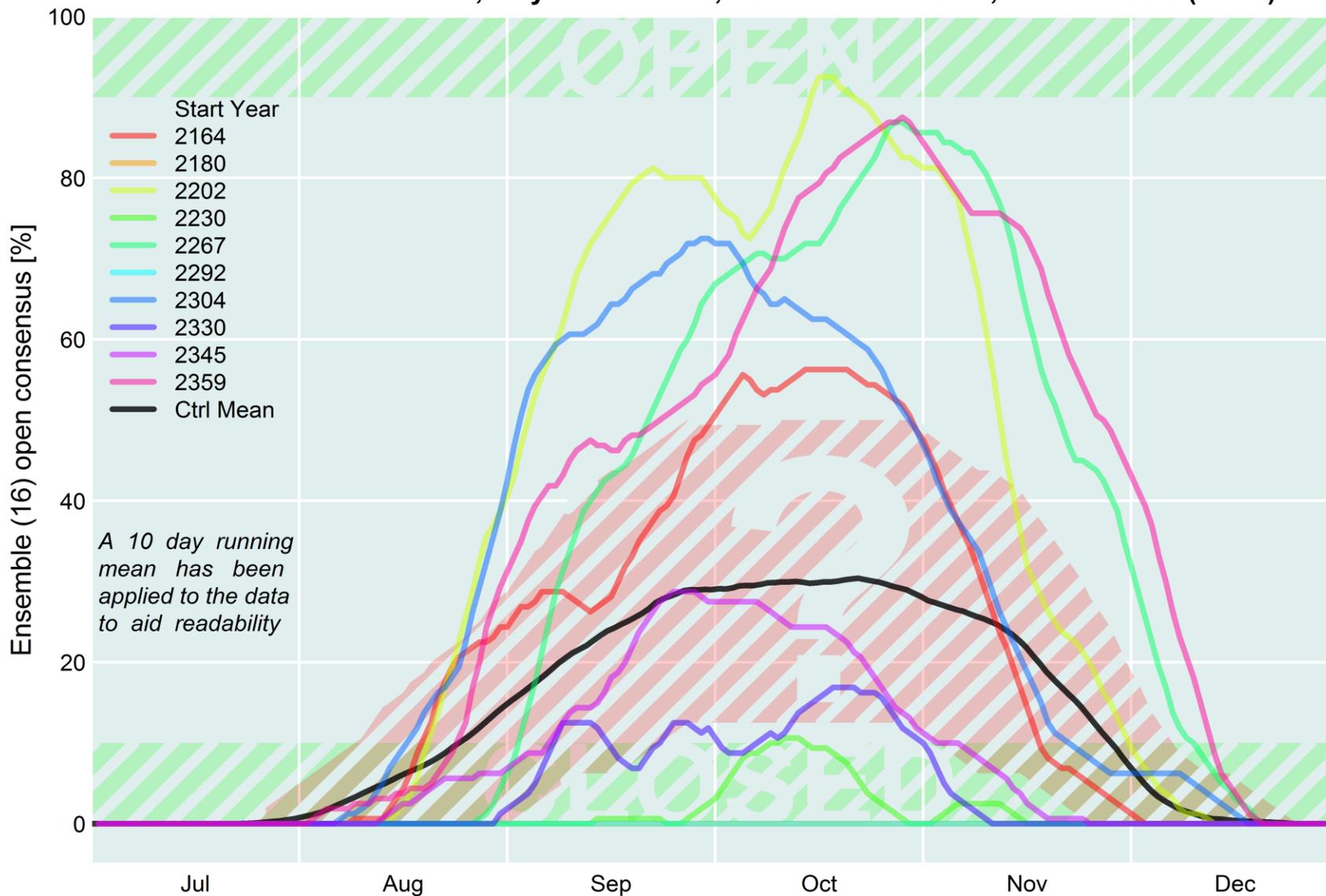
The 'Ob River' –
November 2012

The first LNG
tanker to cross
the Arctic



Potential predictability of route opening

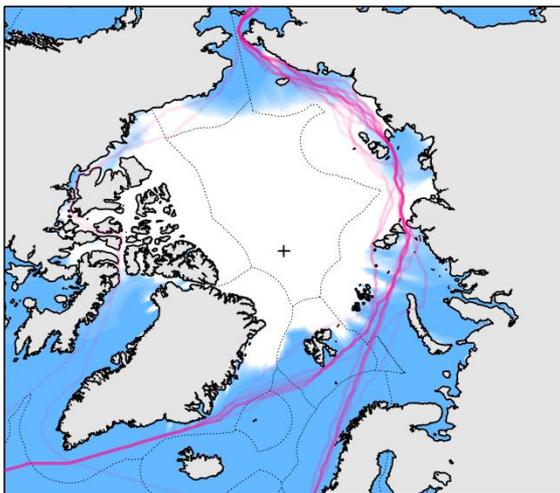
HadGEM1.2 Control Run, July Initialisation, Northern Sea Route, Polar Class 6 (1.2 m)



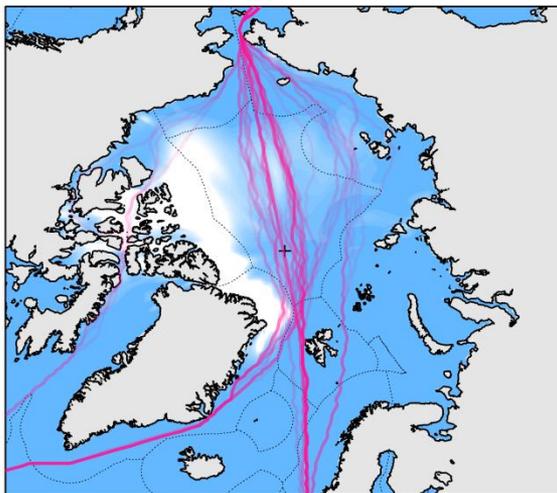
Future sea route accessibility

RCP8.5 HadGEM2 September

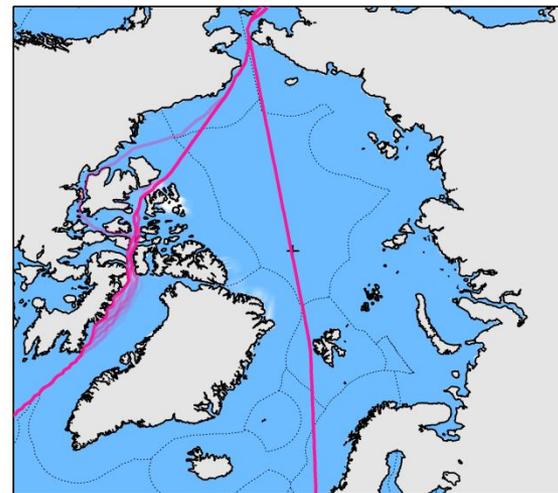
2015-30



2045-60

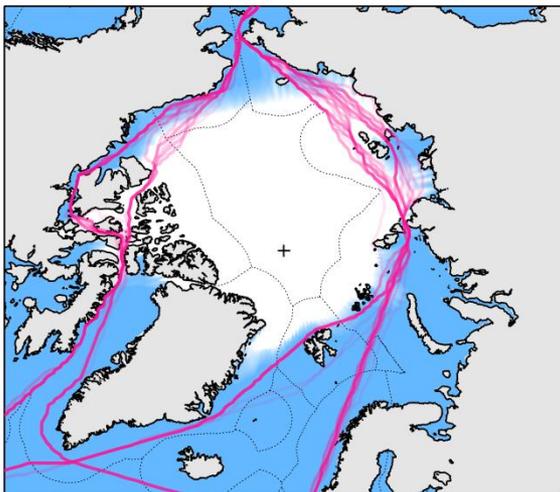


2075-90

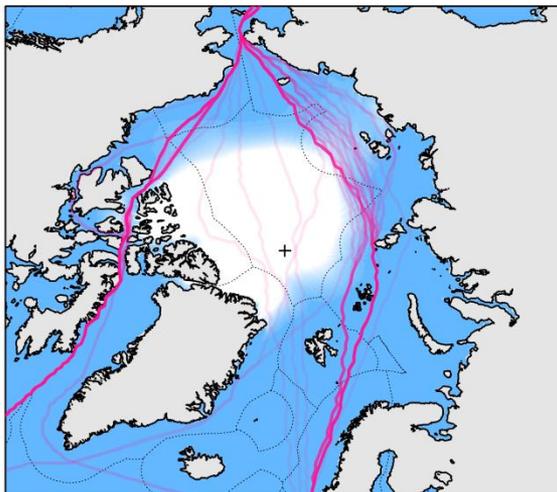


RCP8.5 MPI September

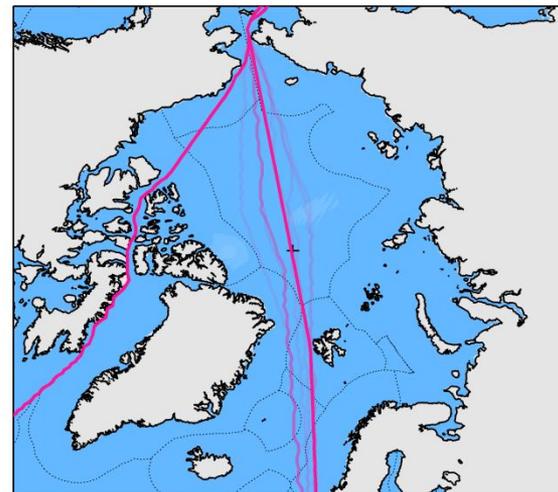
2015-30



2045-60



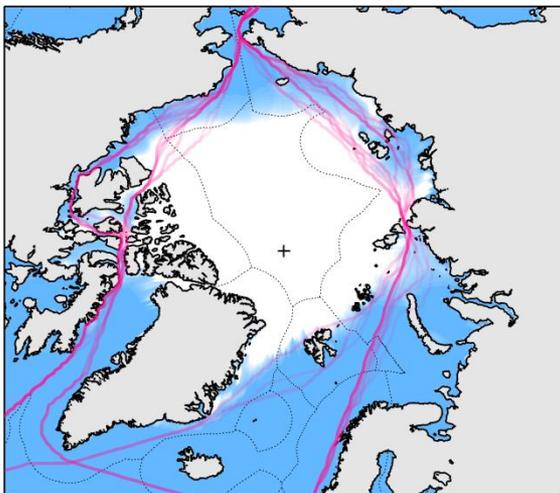
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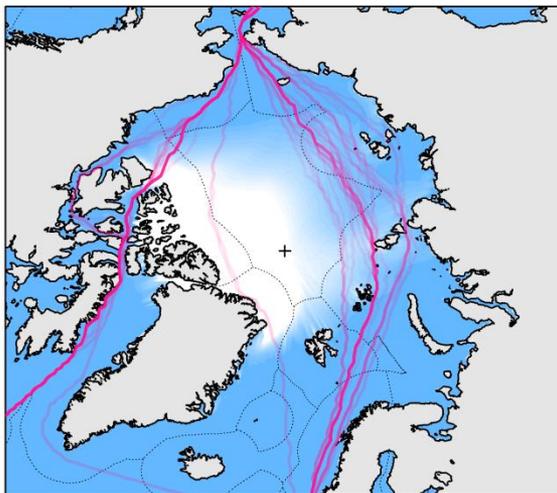
Future sea route accessibility

RCP8.5 CESM September

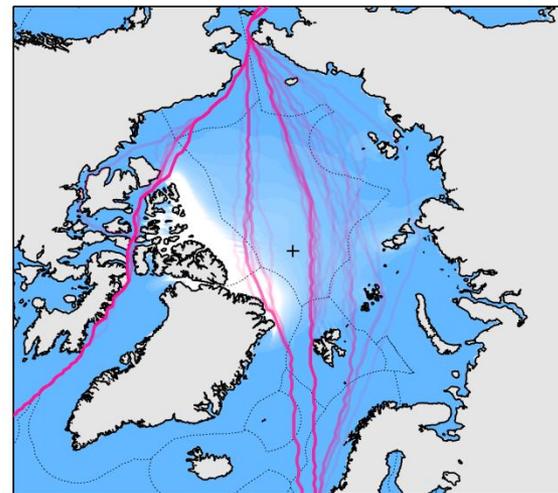
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2045-60

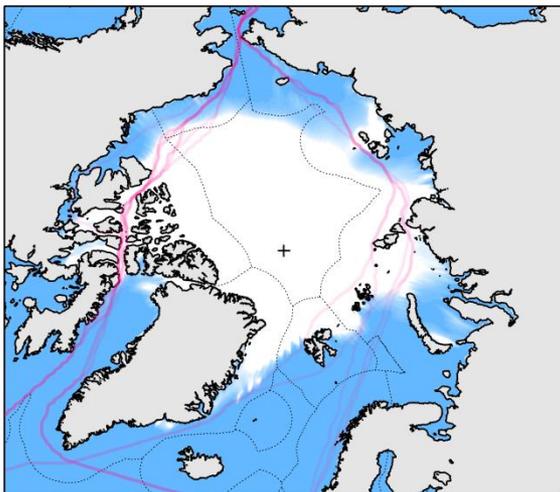


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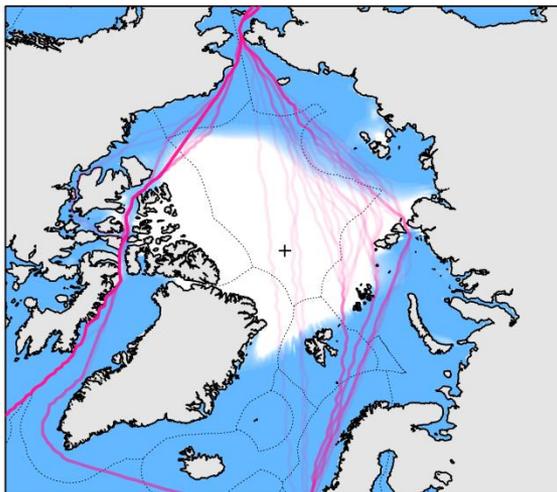


RCP8.5 MIROC5 September

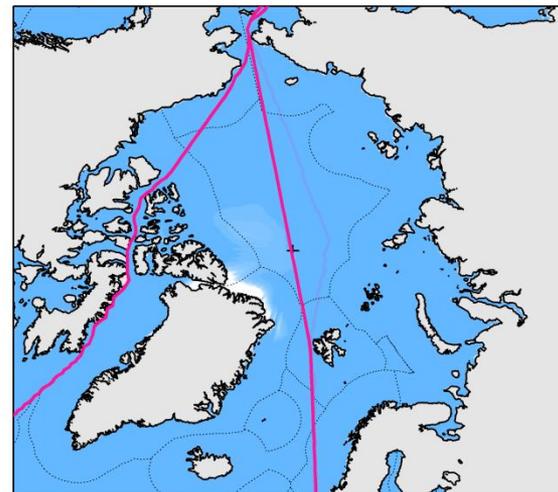
2015-30



2045-60



2075-90



- Arctic climate has variability on a range of timescales
- Interaction between long-term trend and variability is critical when considering predictions for the future
- Simulated decadal sea ice extent ‘hiatuses’ seen in GCMs, similar to recent observations
- Potential to forecast some seasonal sea ice variability
- More summer predictability for post-May start dates
- Initial sea ice thickness is important for predictions
- Potential predictability in shipping accessibility too

- Expand work to Southern Hemisphere
- More process-based predictability studies
- Data assimilation of sea ice thickness (and age?)
- Operational seasonal shipping accessibility predictions?