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Variation in the reliability of ensemble SST predictions from seasonal to decadal timescales

Chun Kit Ho, **Ed Hawkins**, Len Shaffrey, Jochen Bröcker

NCAS-Climate, University of Reading, UK

Leon Hermanson, James Murphy, Doug Smith

UK Met Office, Exeter, UK

e.hawkins@reading.ac.uk

@ed_hawkins

University of Reading

Submitted to GRL

Reliability of seasonal to decadal predictions

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- Can seasonal to decadal prediction systems support production of reliable **probabilistic** forecasts?

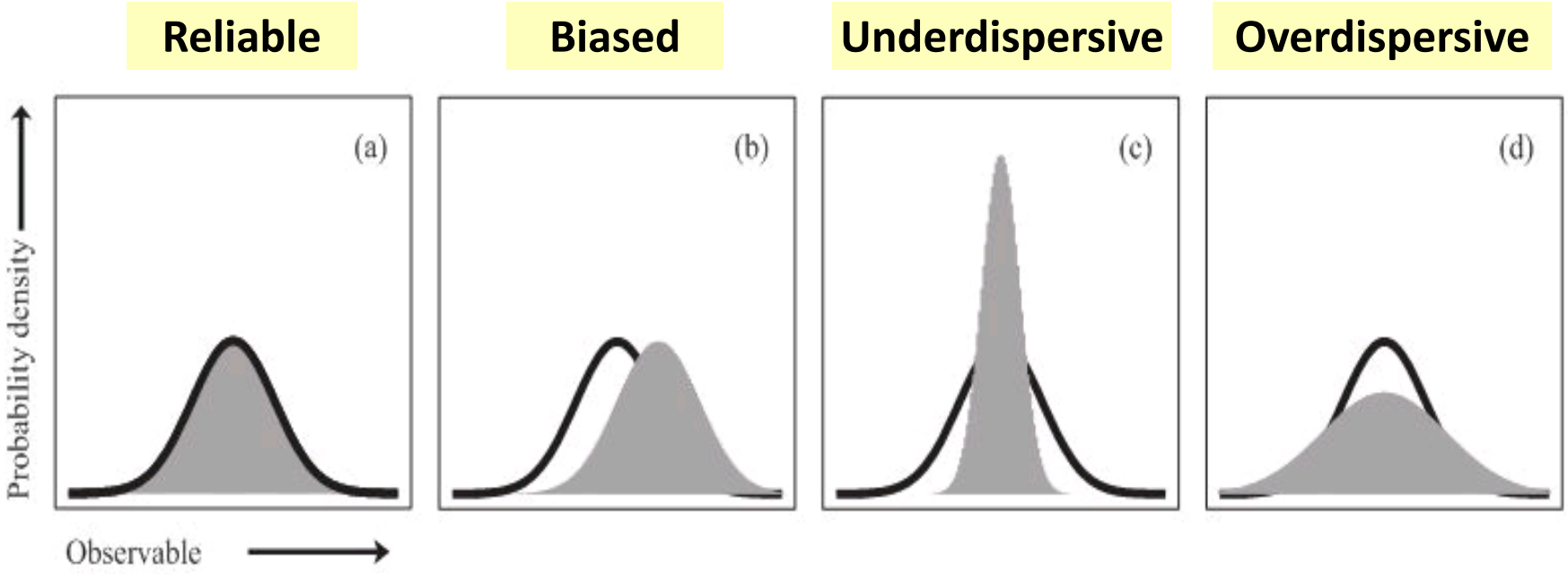

Fig. 8.1 from Weigel (2012)

Reliability and dispersion

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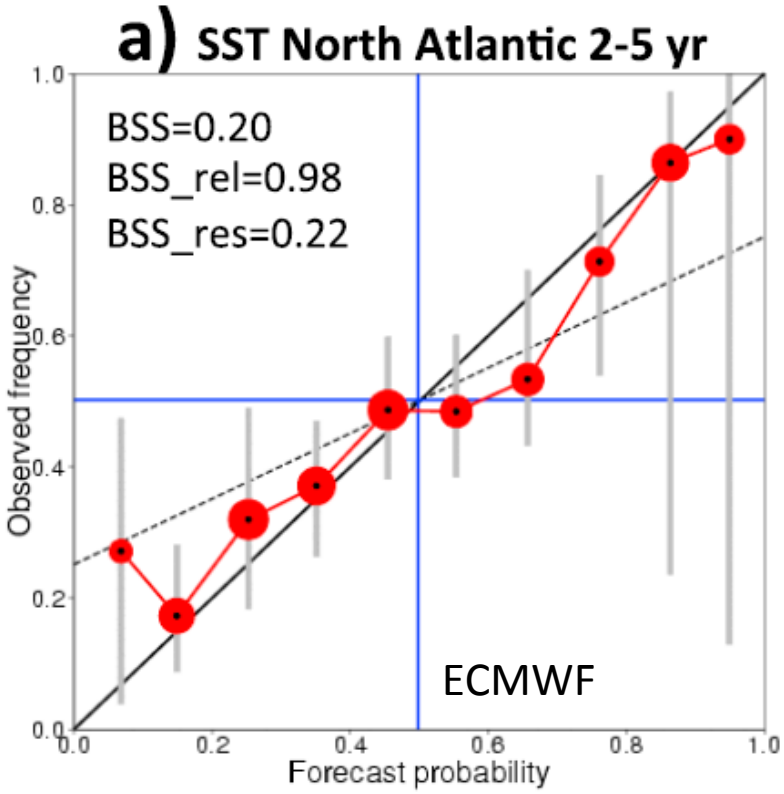
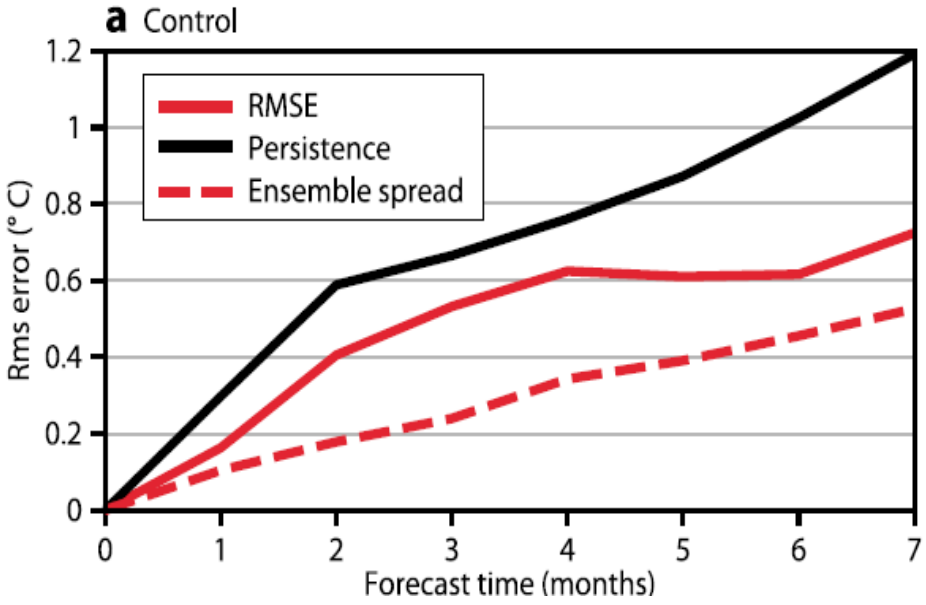


RMSE in Nino 3.4 predictions from ECMWF



Reliability: forecast probabilities should match observed relative frequency

Dispersion: ensemble spread should be the same as RMSE – necessary for reliability

Corti et al. 2012

Weisheimer et al. 2011

Parallel DePreSys ensemble experiments

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- We consider the **spread-error ratio** for different lead times:

$$\sqrt{\frac{m+1}{m}}\frac{\sigma_e(\tau)}{\mathrm{RMSE}(\tau)}$$

  - Ratio > 1: **overdispersion** (underconfident)
  - Ratio < 1: **underdispersion** (overconfident)

m = number of ensemble members

ENSEMBLE DESIGN – 3 parallel ensembles with HadCM3:

DePreSys ICE **DePreSys PPE** **NoAssim PPE**

- All have 46 hindcasts (1960-2005), 9 ensemble members
- Both DePreSys ensembles are anomaly initialised from obs.
- Initial condition ensemble (ICE) uses standard HadCM3
- Perturbed Physics Ensembles (PPE) use 9 spun-up versions of HadCM3 with perturbations to 29 atmospheric parameters
- This analysis compares hindcast SSTs with HadISST

Spread-error ratio - first season (DJF)

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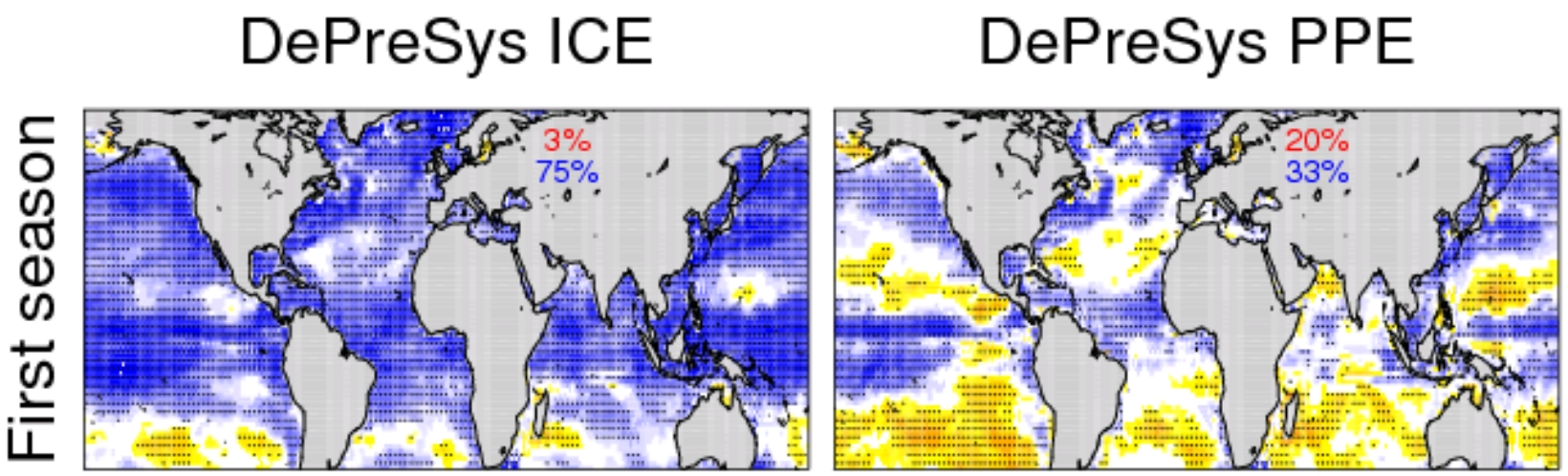
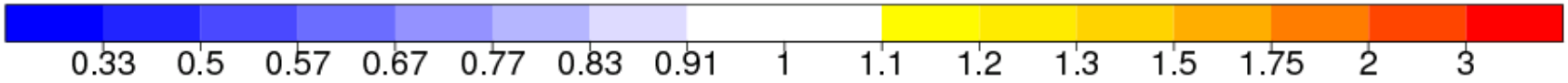


- Underdispersion consistent with many other seasonal prediction systems
- Perturbed physics ensemble has improved reliability



Spread-error ratio – first year

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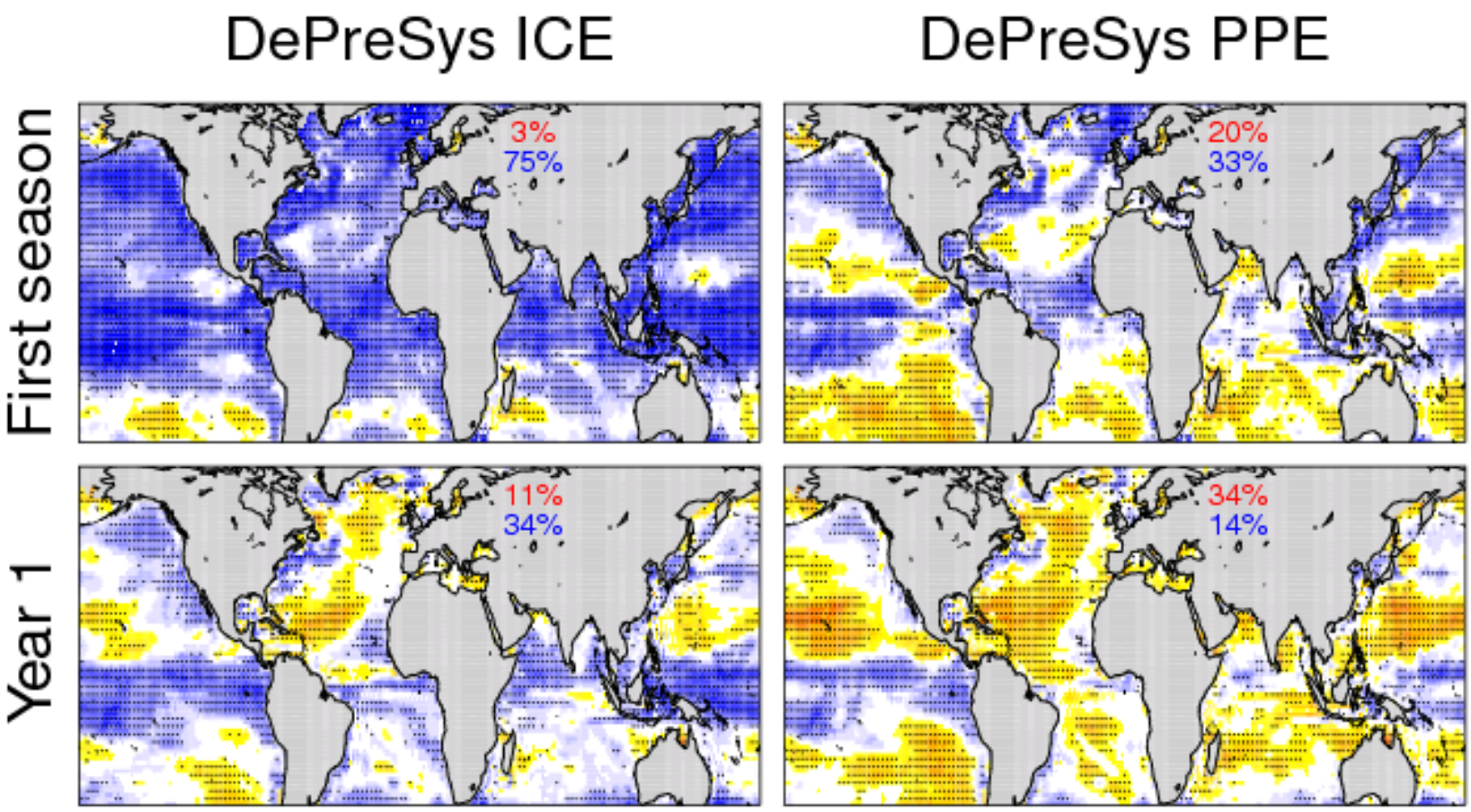
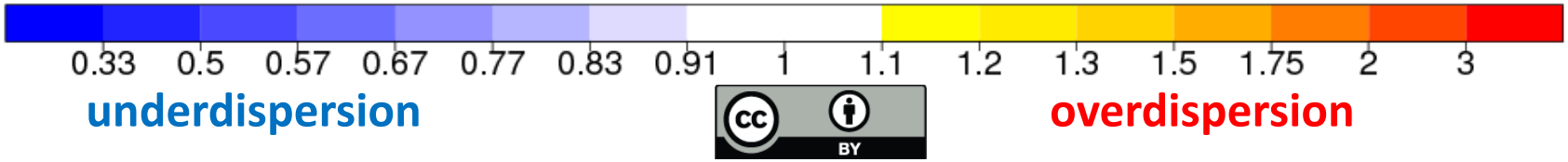


- Dispersion increases when considering year 1



Spread-error ratio – first three years

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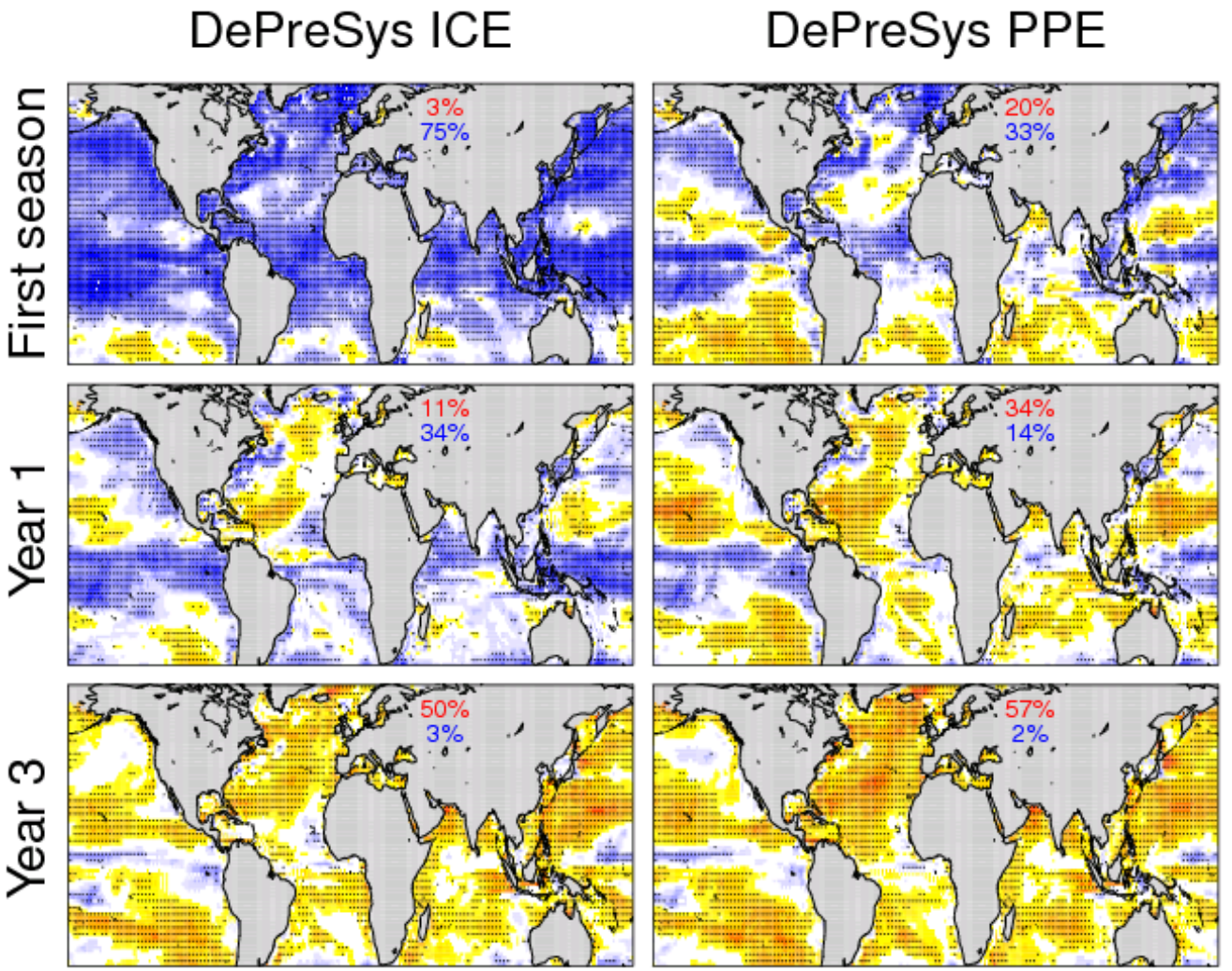

Spread-error ratio – first nine years

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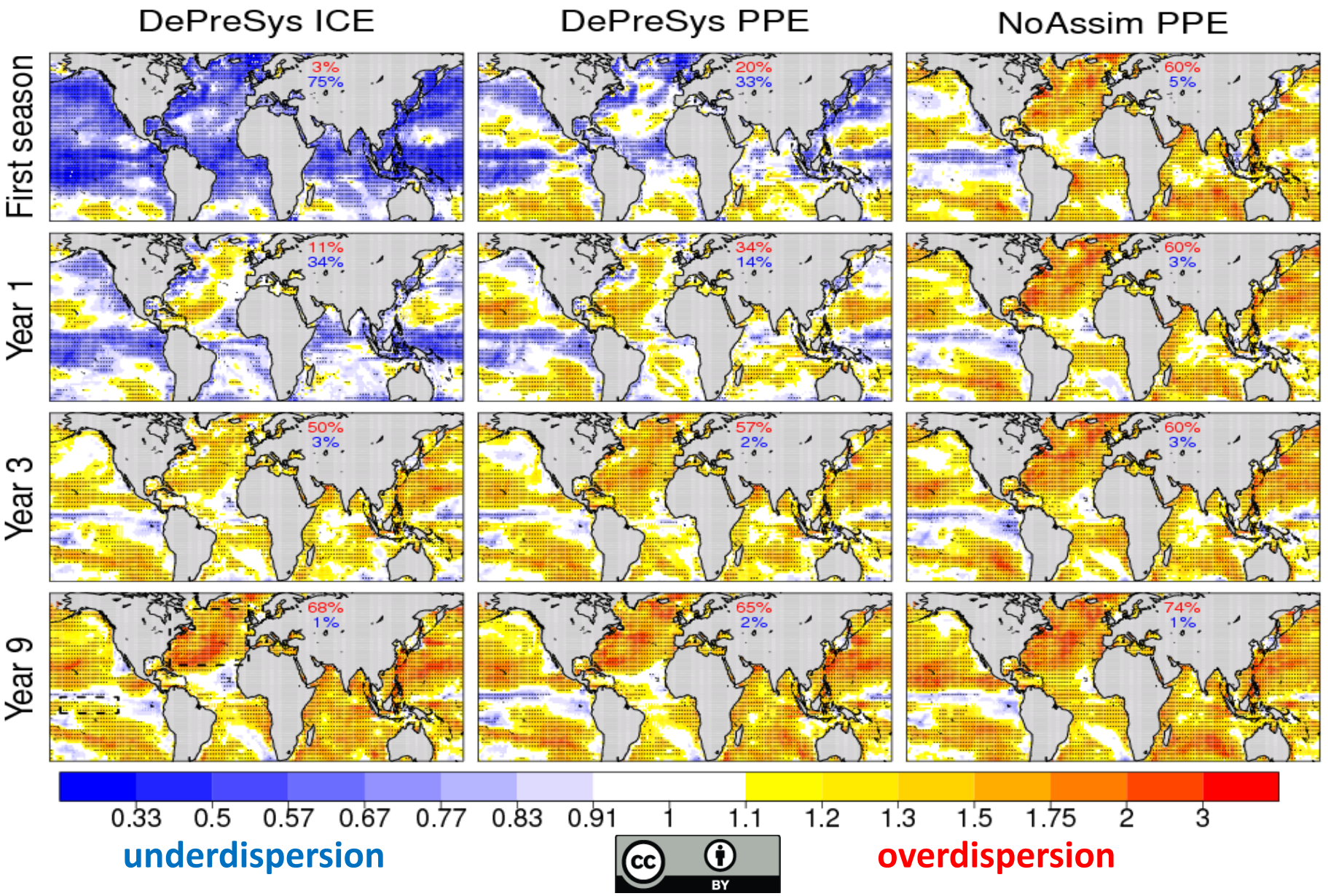

What causes the overdispersion?

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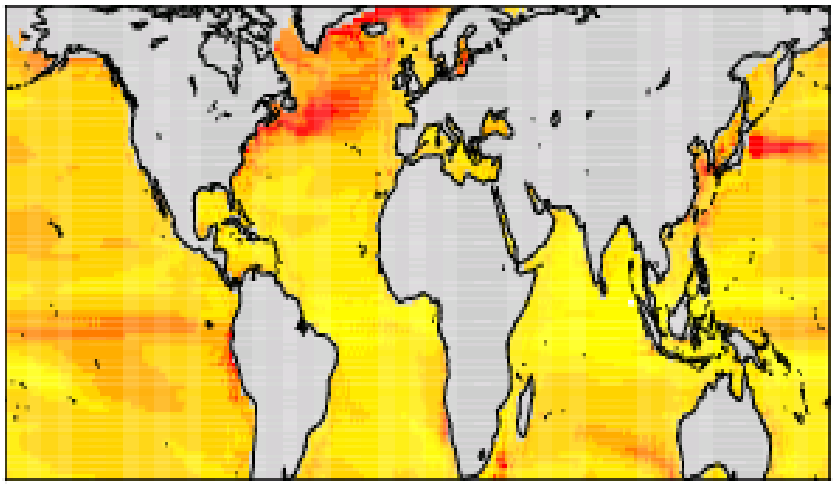
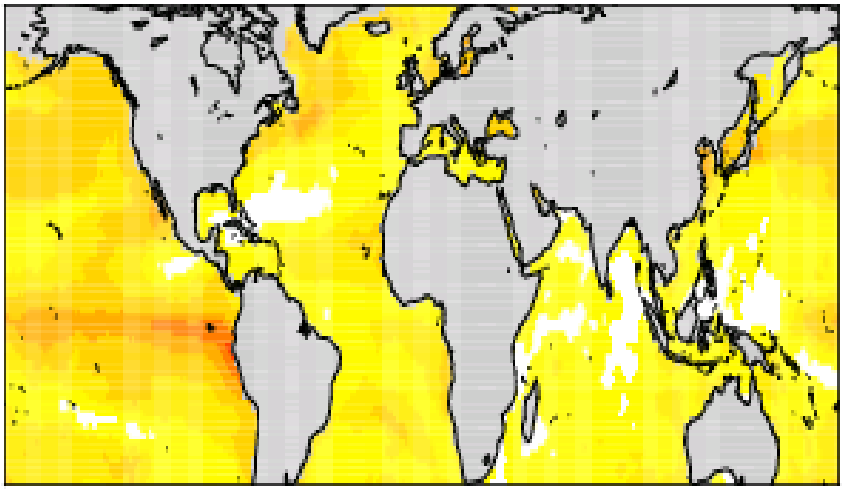
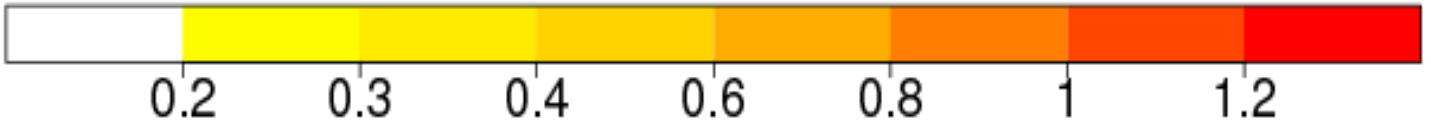
- For a reliable system, observations & ensemble forecasts need to have same climatological variance

HadCM3 control SSTs



HadISST (detrended)





Standard deviation (K)

What causes the overdispersion?

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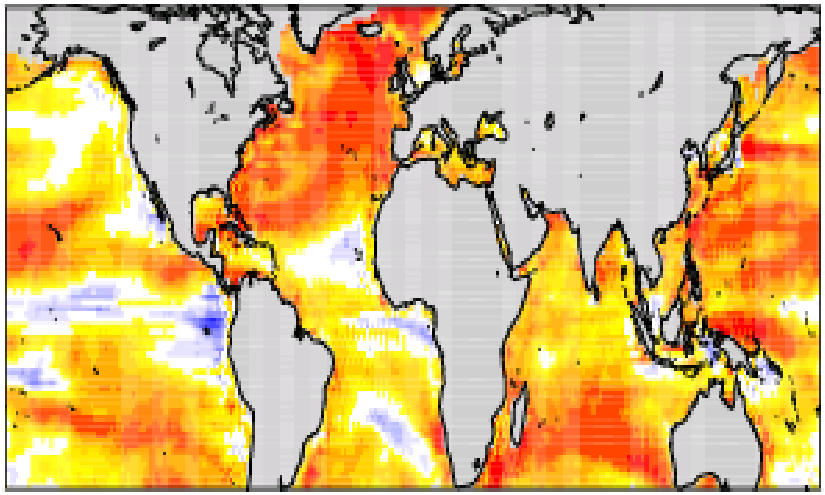
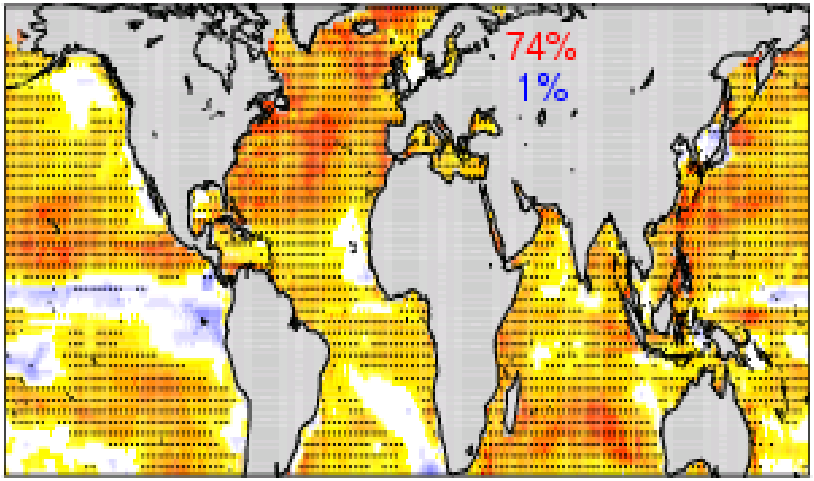
- For a reliable system, observations & ensemble forecasts need to have same climatological variance

Ratio of model to observed variability



Year 9 dispersion in NoAssim PPE



Summary

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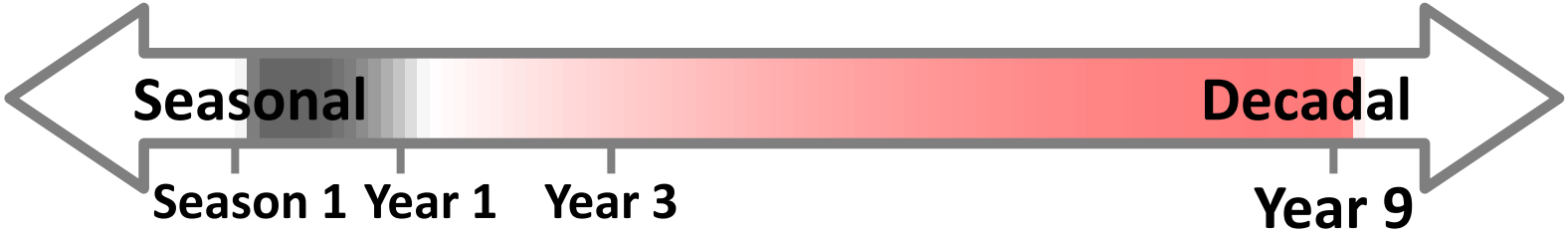
Factors affecting dispersion in DePreSys SST forecasts



Excessive **model internal variability**

Model initialisation reduces spread

Parameter perturbations produce larger spread than initial condition perturbations

Spatial variation of reliability

- North Atlantic most overdispersed
- Underdispersion in Tropical Pacific for all lead times

Implications

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- **Ensemble prediction system design**
  - Climate model variability is at least as important as any perturbation scheme
  - Simulated variability should be assessed in forecast system design
  - Both skill *and* reliability should be assessed when analysing hindcasts
  - Dispersion estimates are robust to considering fewer start dates (not shown)

"…the condition of confidence or otherwise forms a very important part of the prediction…" - Ernest Cooke, 1906