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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Berlin, 11th of May 2017

Joint uncertainty assessment of models and observations in verification of climate predictions

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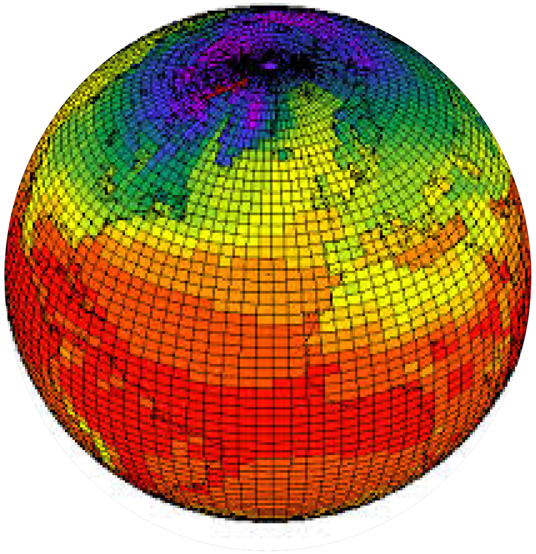
SPECS Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

esa European Space Agency

VERITAS-CCI

Traditional evaluation perspective

Model



Observations

→

Reality

A shift in the paradigm

Reality

Model A

Observation A

Observation B

A traditional verification question

Is model system B superior to model system A?

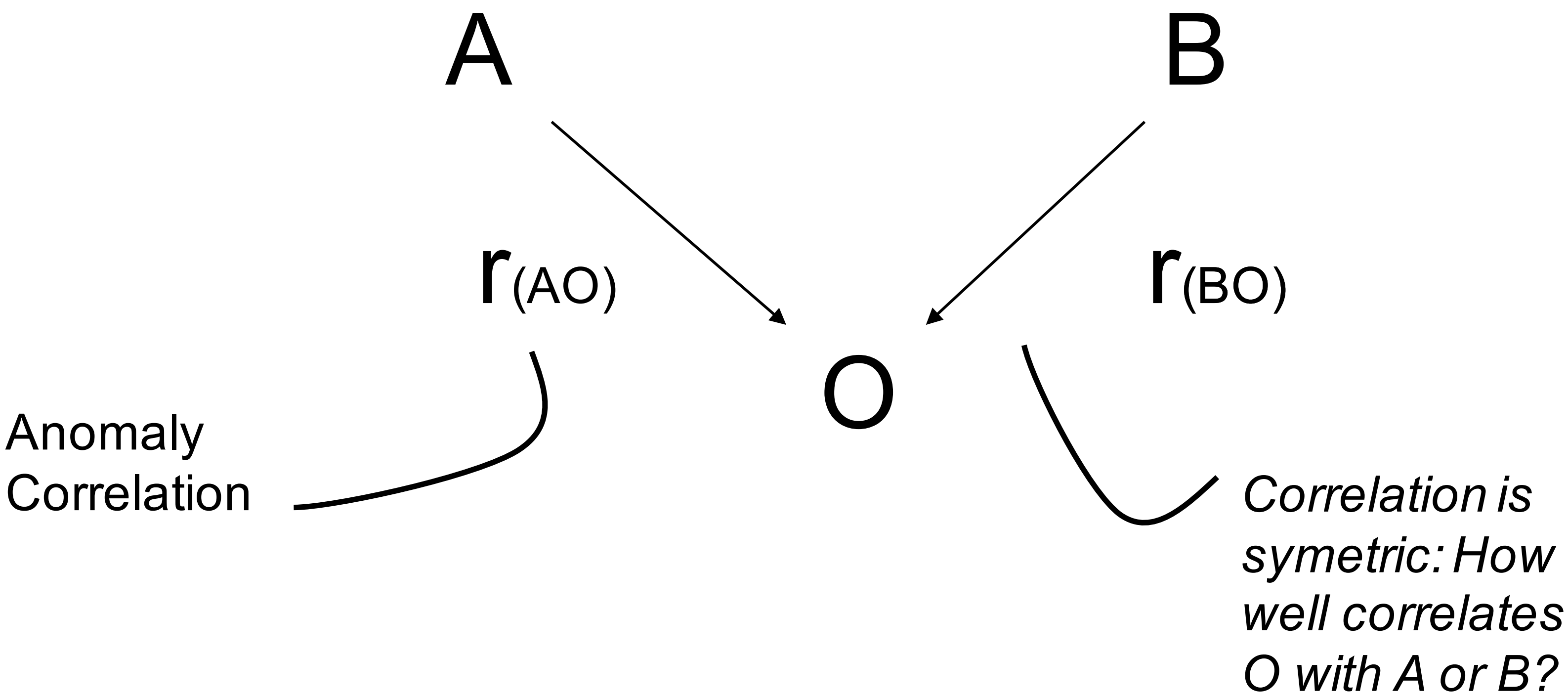
A

Low horizontal resolution

B

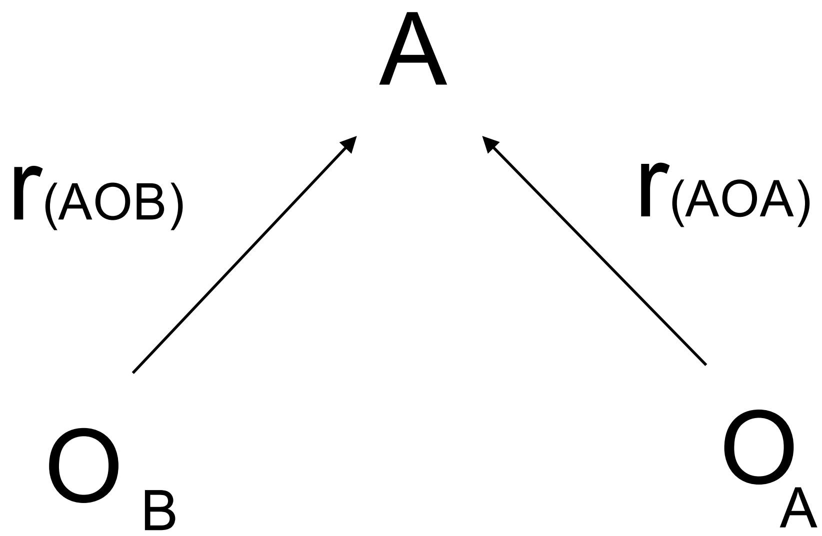
High horizontal resolution

Compare hindcast skill with an observation

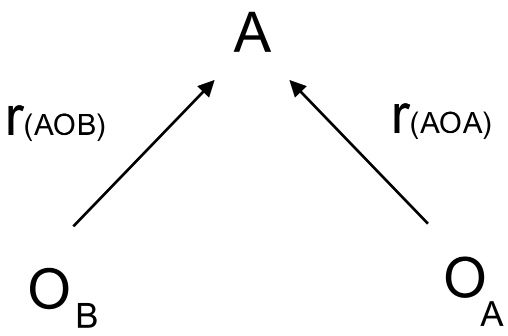


Reversing the question

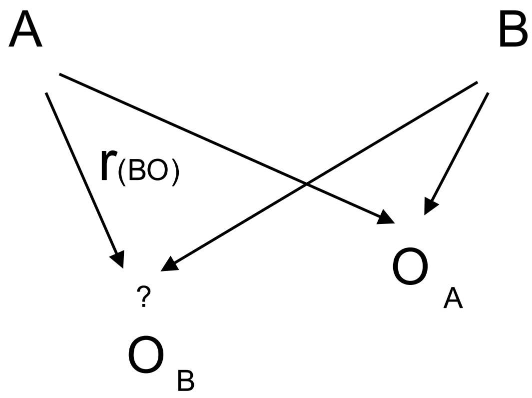
Which observation is better? A useful question?



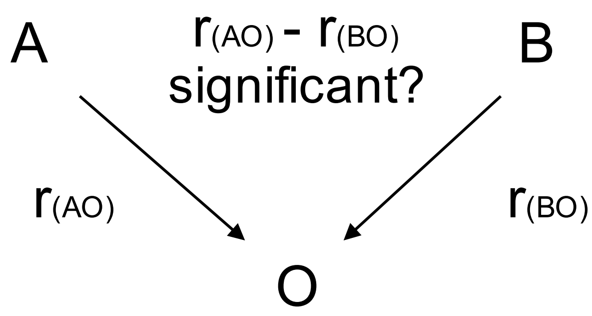
Overview this presentation



(a) Which observations has the smallest error

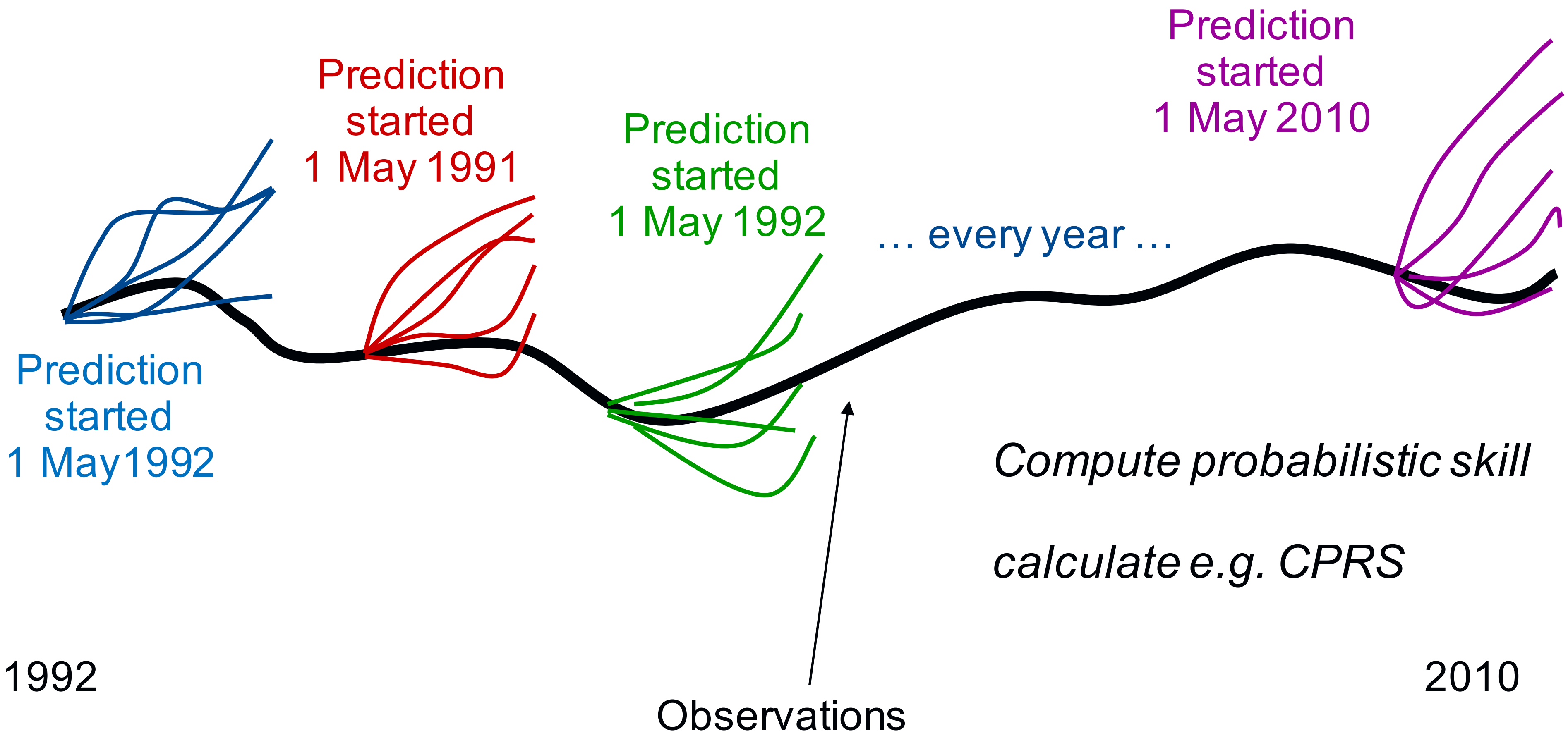


(b) How important is observational uncertainty



(c) How to detect improvements in models or observations

Seasonal forecast skill



Seasonal forecast skill

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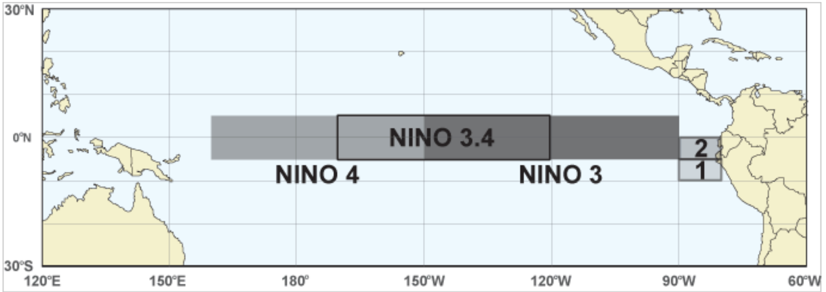
Target: Global and Niño3.4 SST



Observations: 4 Sea-surface Temperature (SST) observations: ESA-CCI, HadISST, ERSST4, ERA-Interim

Prediction started 1 May 1991

Prediction started 1 May 1992

… every year …

Prediction started 1 May 2010

Prediction started 1 May 1992

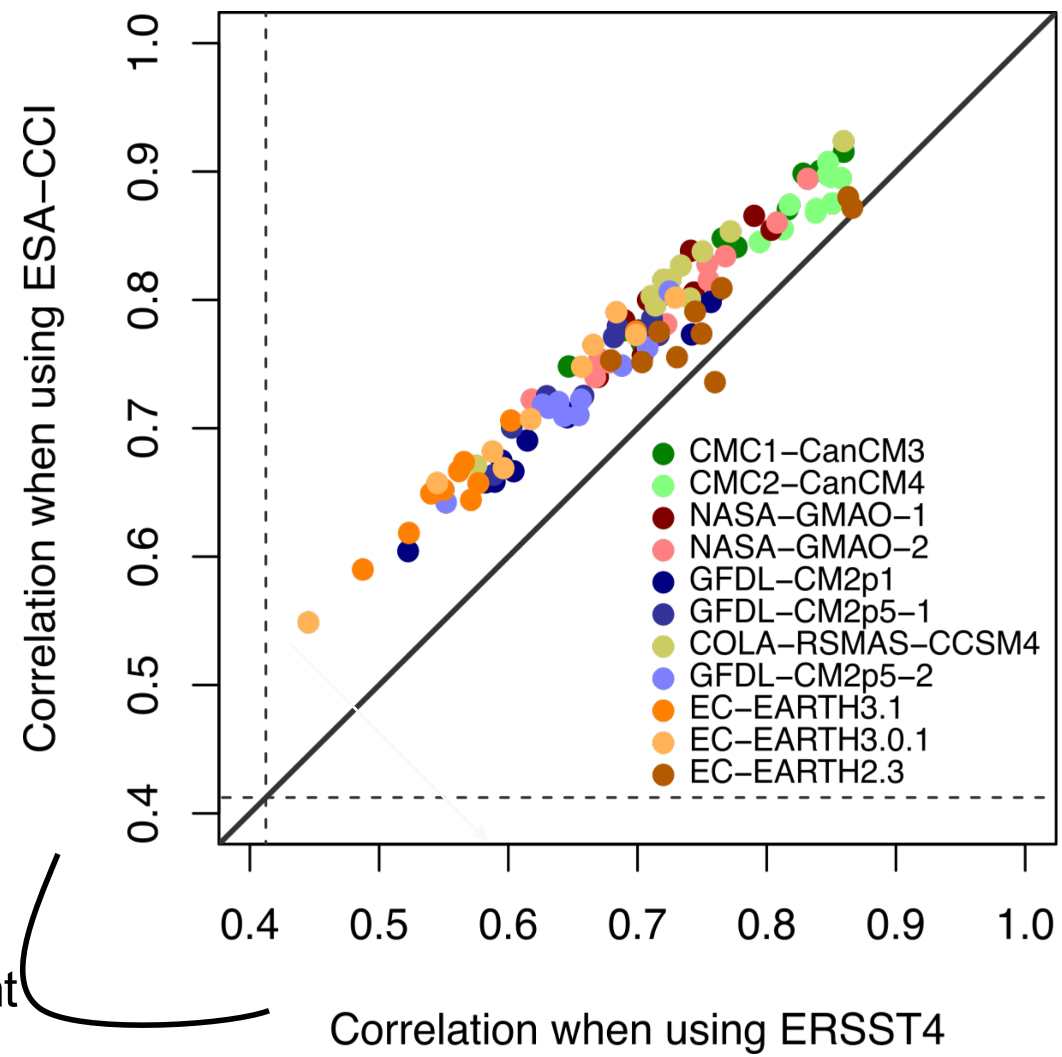
Compute ensemble-mean to distill climate signal

calculate e.g. anomaly correlation

Models: EC-Earth (3 versions), ECMWF S4, North American Multi-Model Ensemble (NMME, 7 models)
10 – member forecast each

CCI SST yields systematic higher correlation skill across many models

Independent from the models



Fully independent datasets

Massonnet et al. (2016) Science

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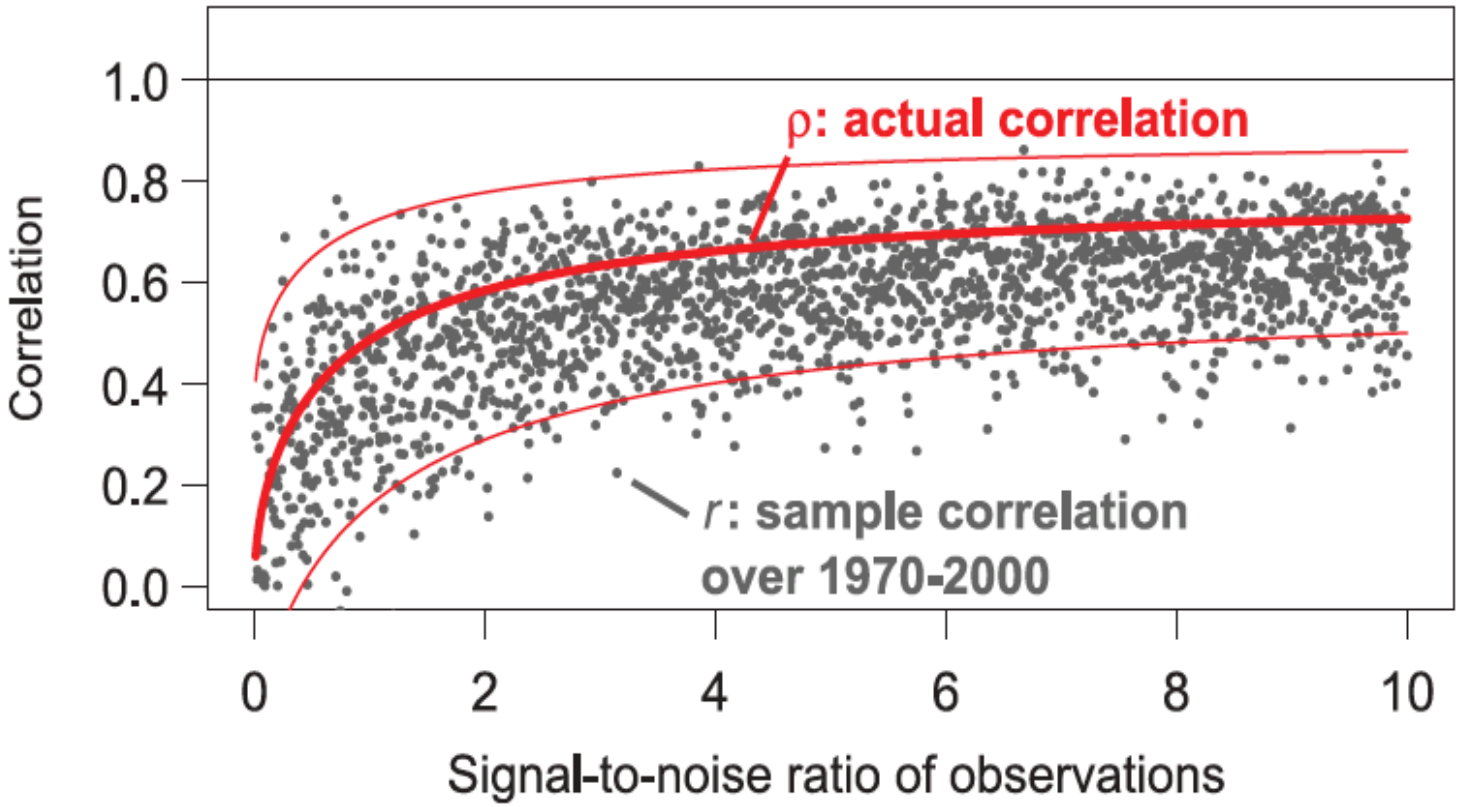
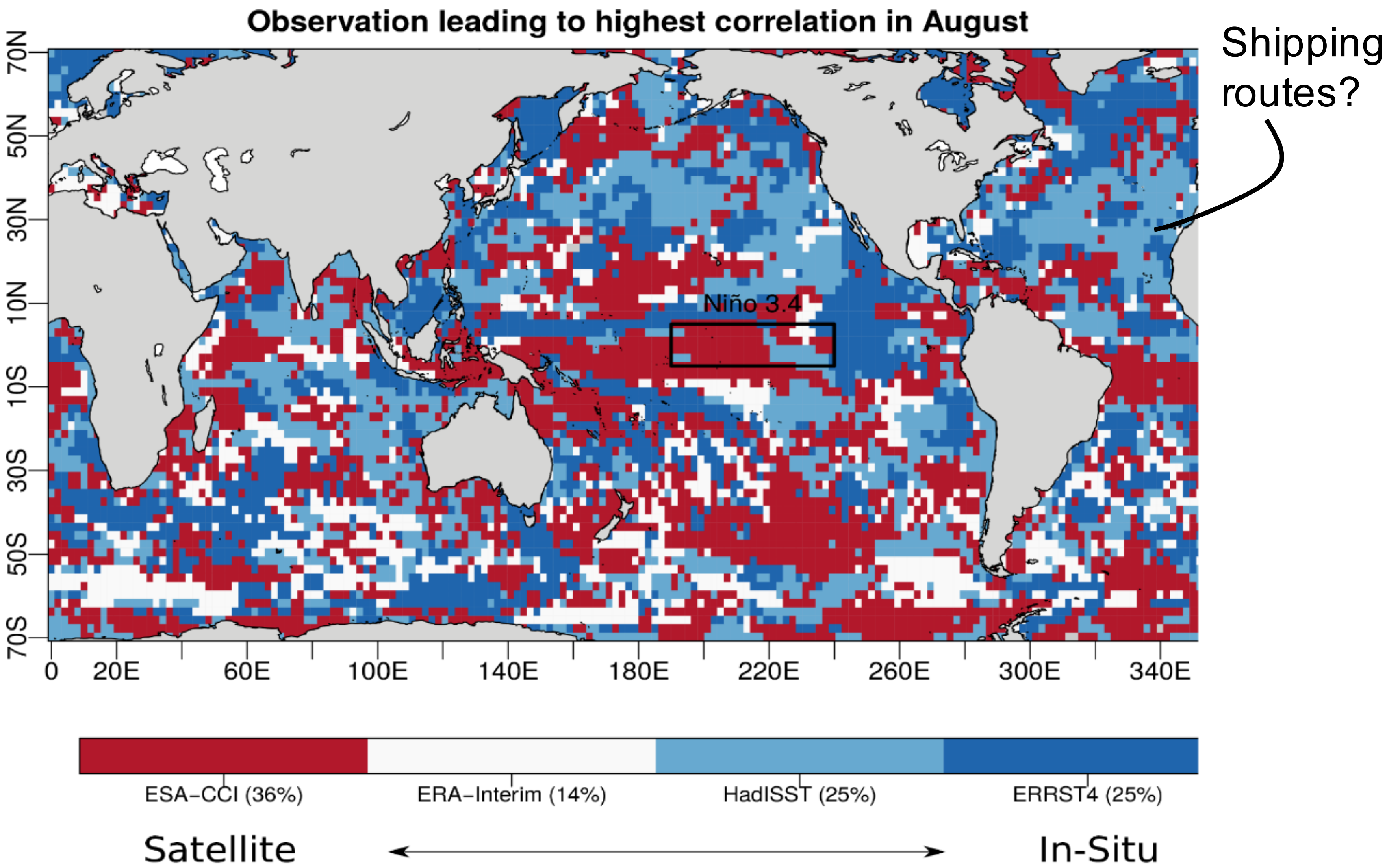
Correlation reduces with noise either co-variates: observational uncertainty reduces forecast skill



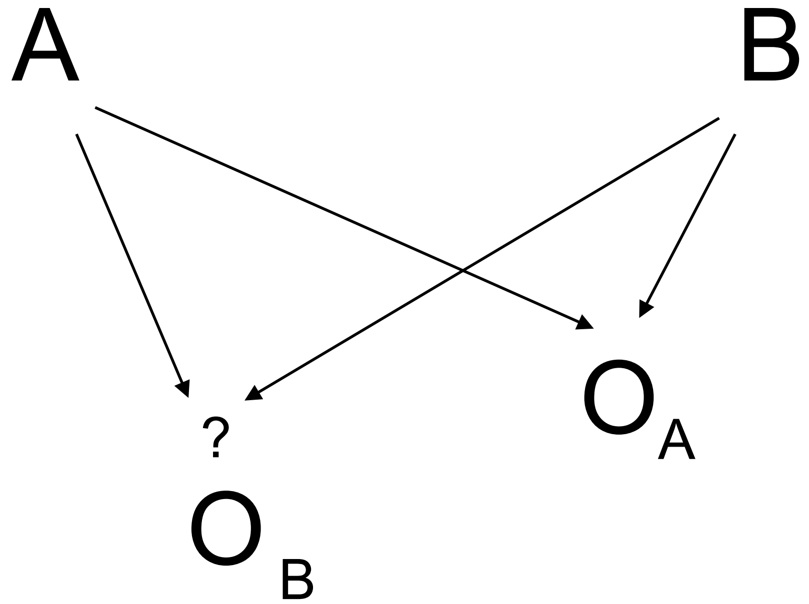
Massonnet et al. (2016) Science

Choice of observation may differ on the location, overall CCI best



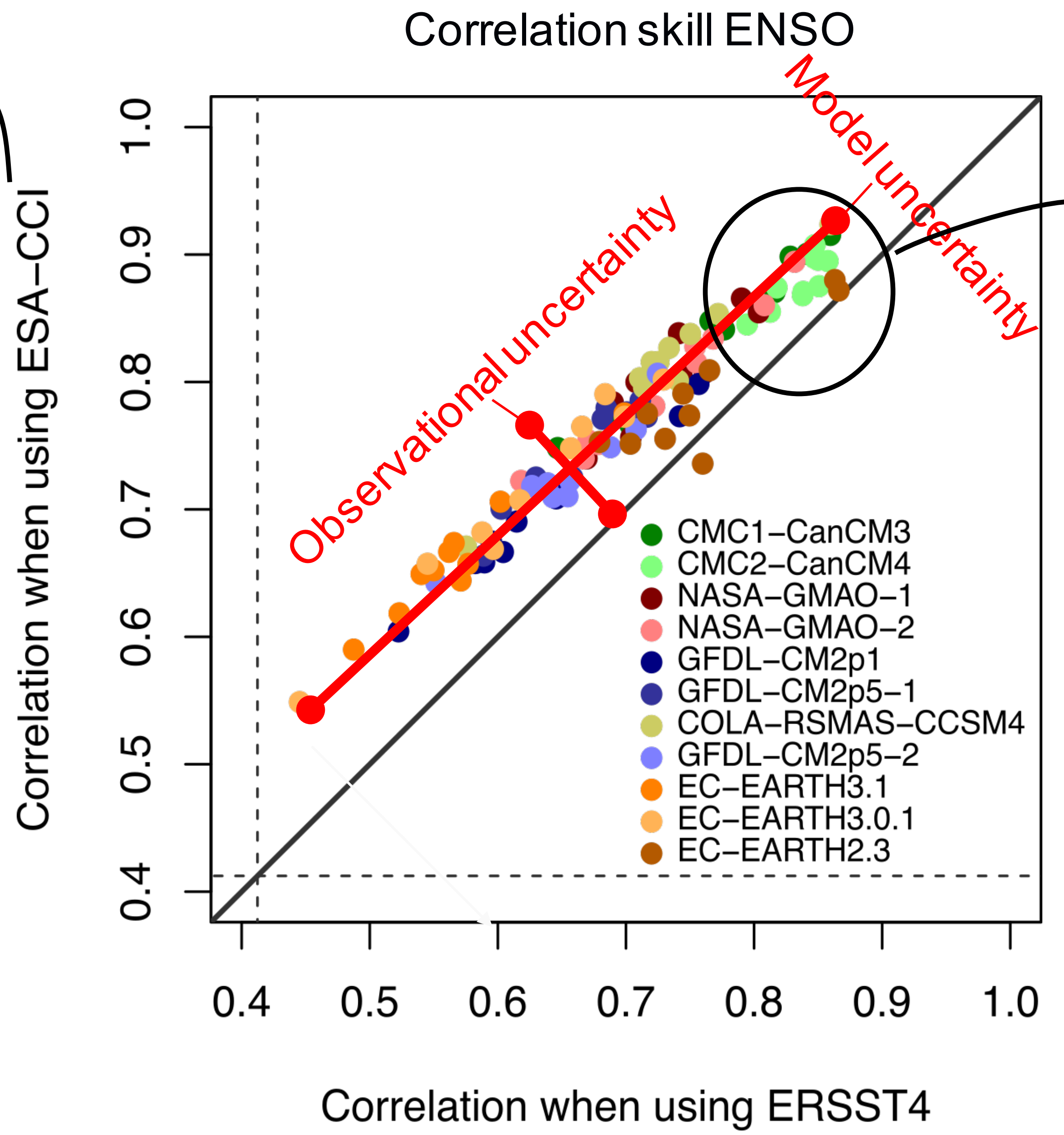
Massonnet et al. (2016) Science

How important is the observational uncertainty?



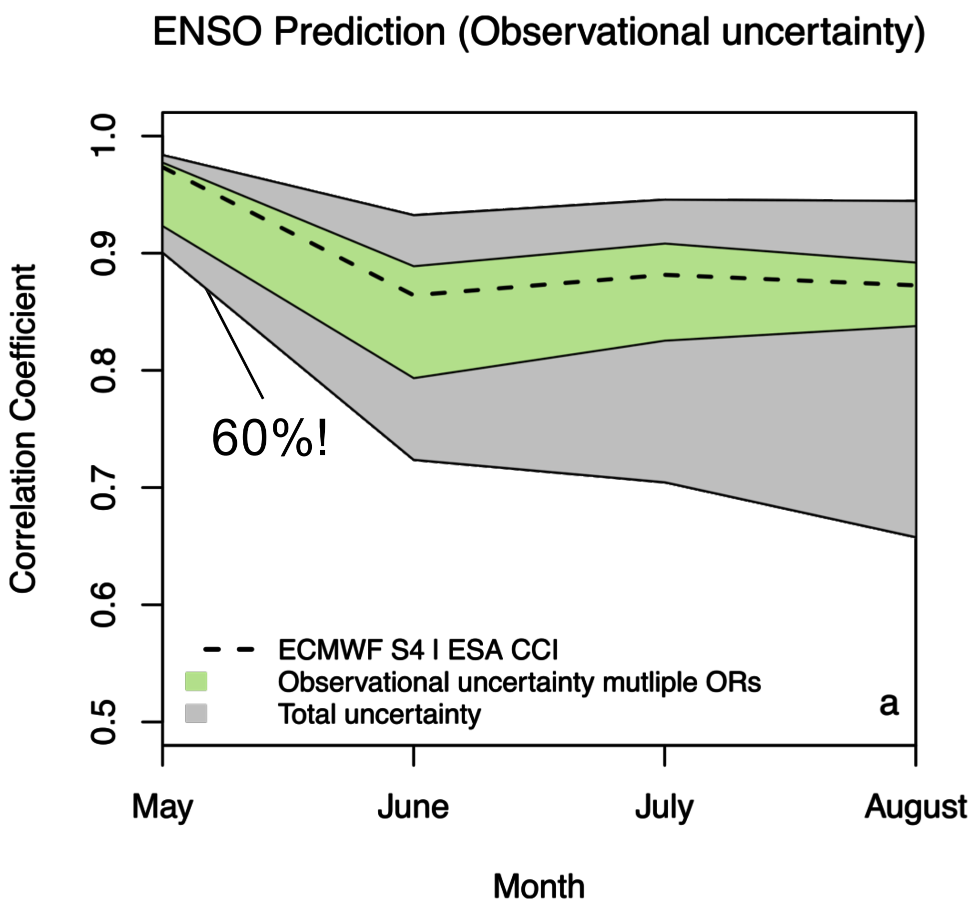
Acknowledging joint uncertainty

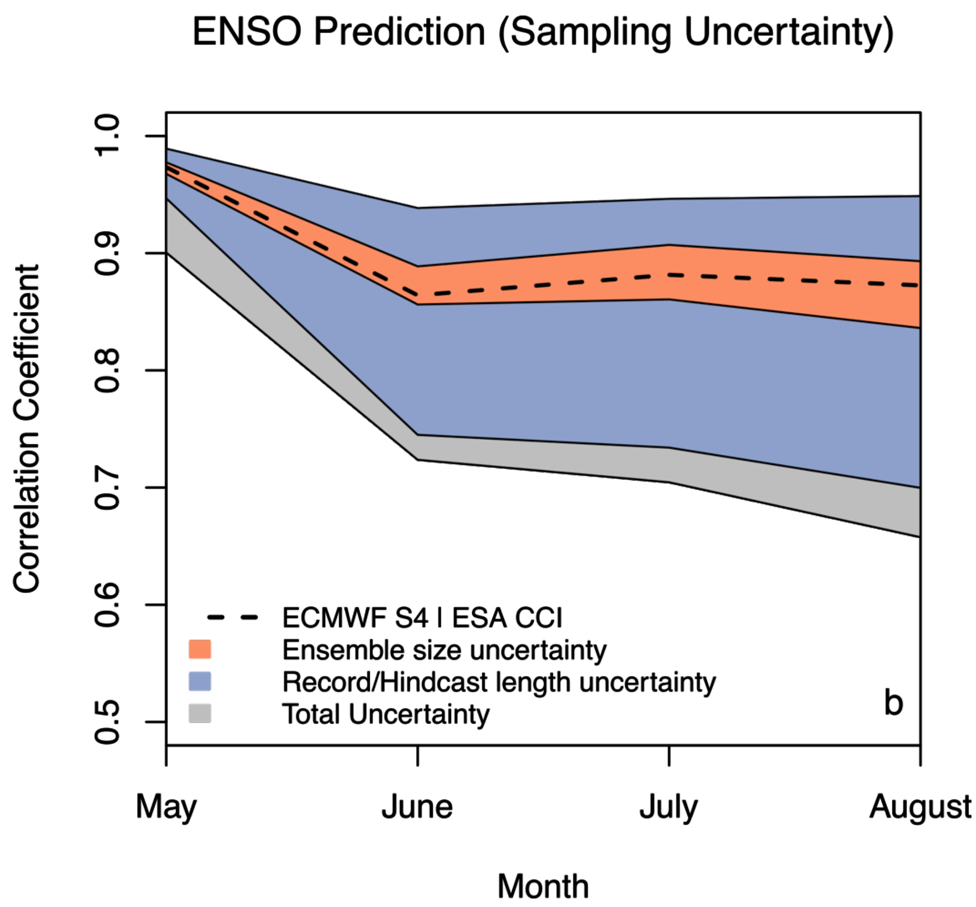
Independent from the models



How important for individual system?

Comparison to sample uncertainties: observational uncertainty is an important source of verification uncertainty for ENSO

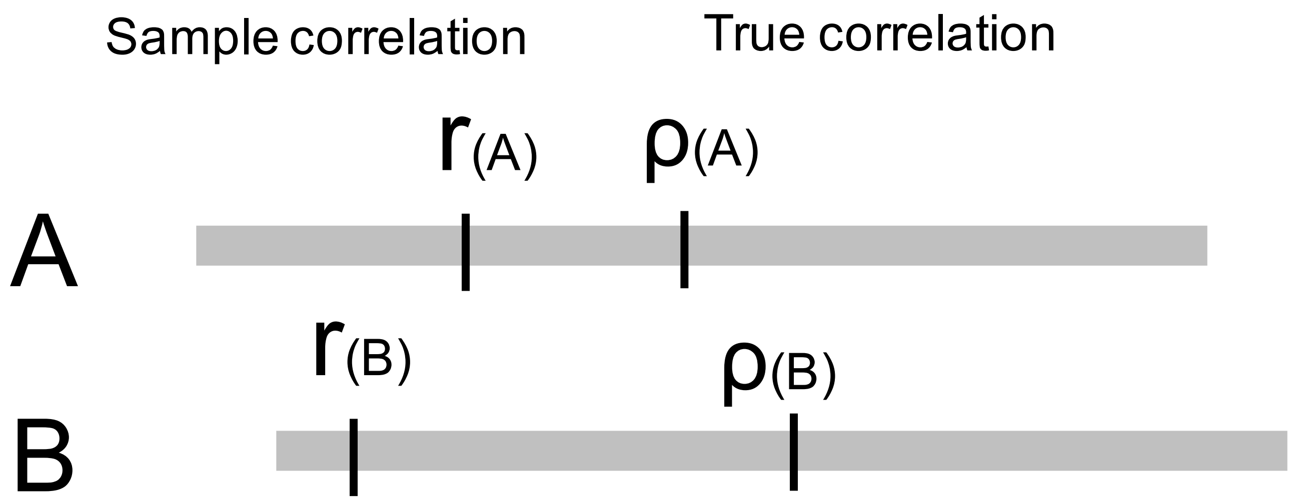




Bellprat et al. (2017) Remote Sensing of the Environment

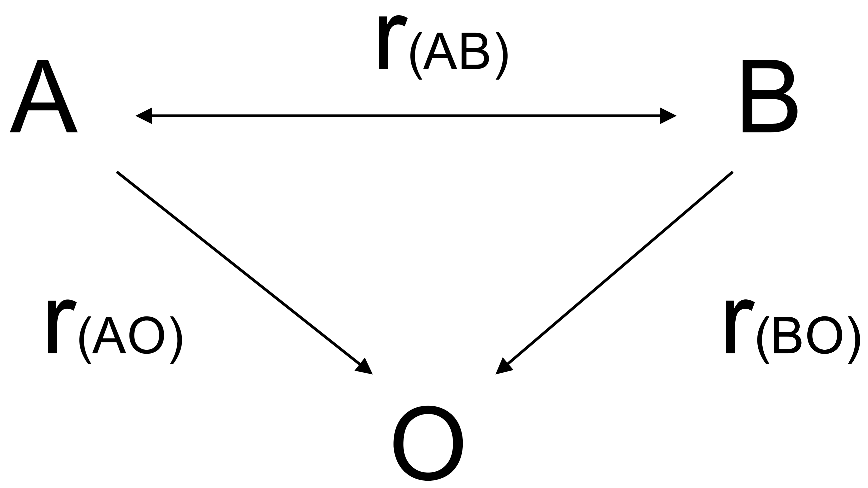
Detecting statistical differences

Are the differences in performance of models or observations significant $r_{(CCI)} > r_{(ERSST)}$?



Dependence

Models and observations are statistically dependent!



Fisher-test (common test in community) assumes independence while newer tests (Steiger, 1980, Zou, 2007) don't.

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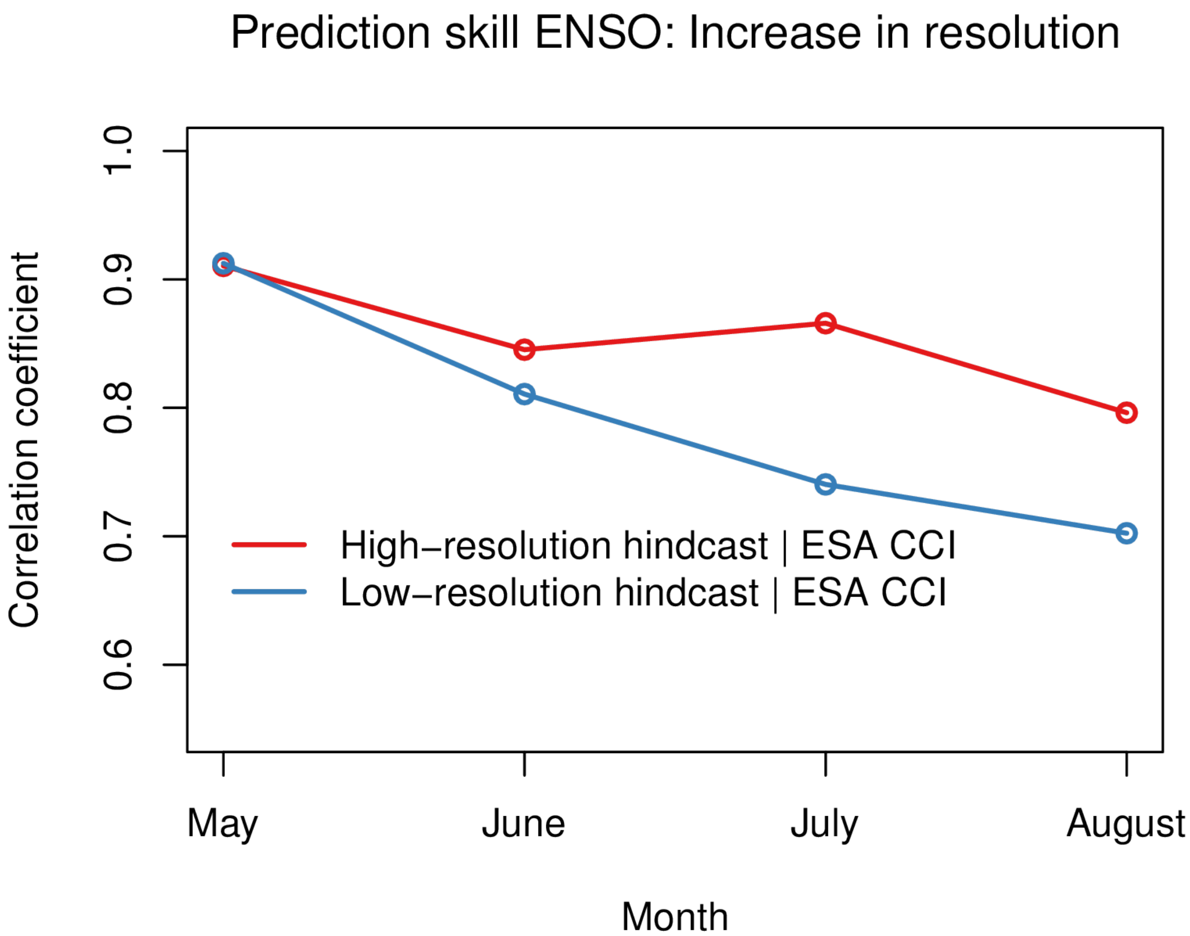
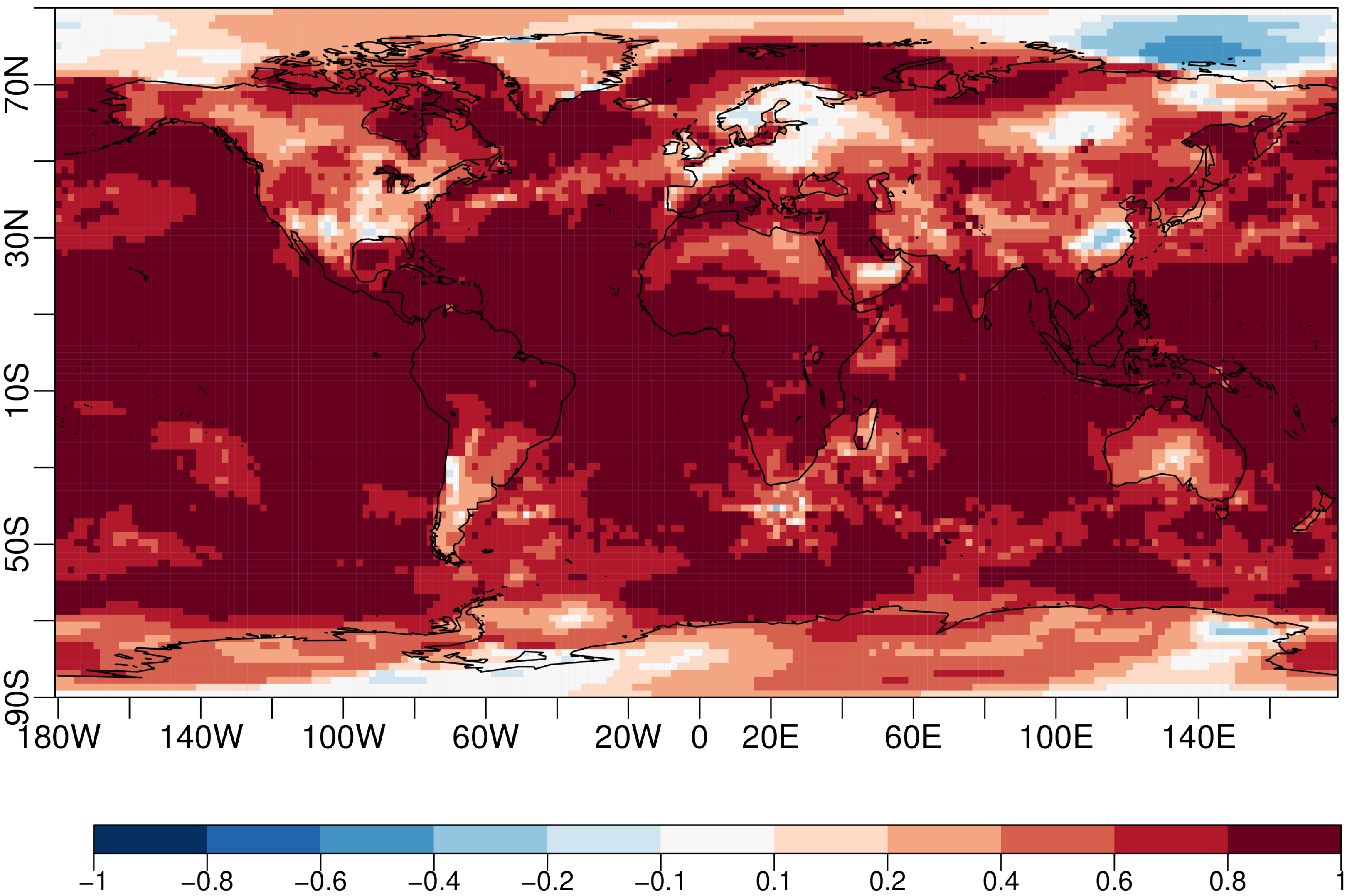
High-resolution hindcasts improves El Niño Southern Oscillation (ENSO) predictions, but change not significant at 5% (Fisher-test)



Bellprat et al. (2015) Tech. Rep. BSC 002

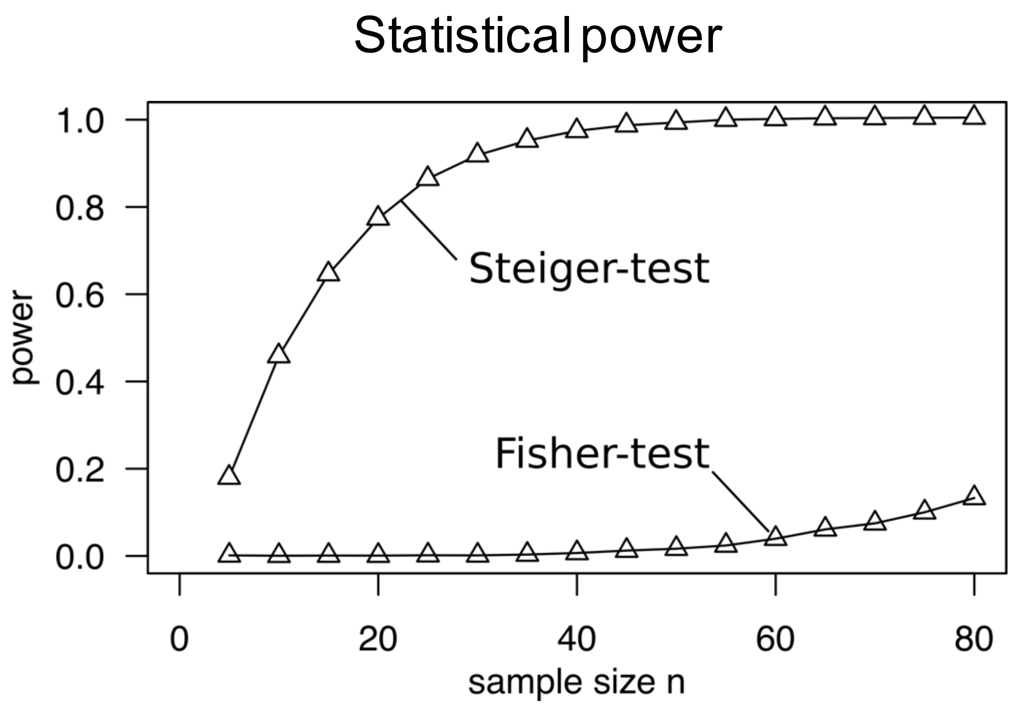
Model dependence

Correlation of Low and High-resolution hindcast



Statistical power dependent tests

Power to detect a difference between increases dramatically. Improvement now statistical significant at 1% level.



In medicinal science only studies with power > 80% are accepted, a guideline for forecasting?

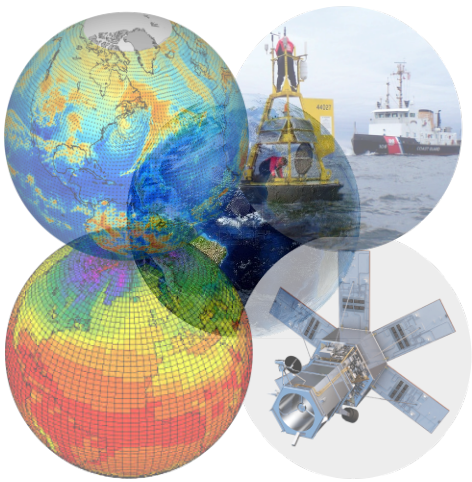
Siegert et al. (2017) Monthly Weather Review

A joint uncertainty perspective

Models and observations are both approximations of the truth and uncertainty in both sources can be important.

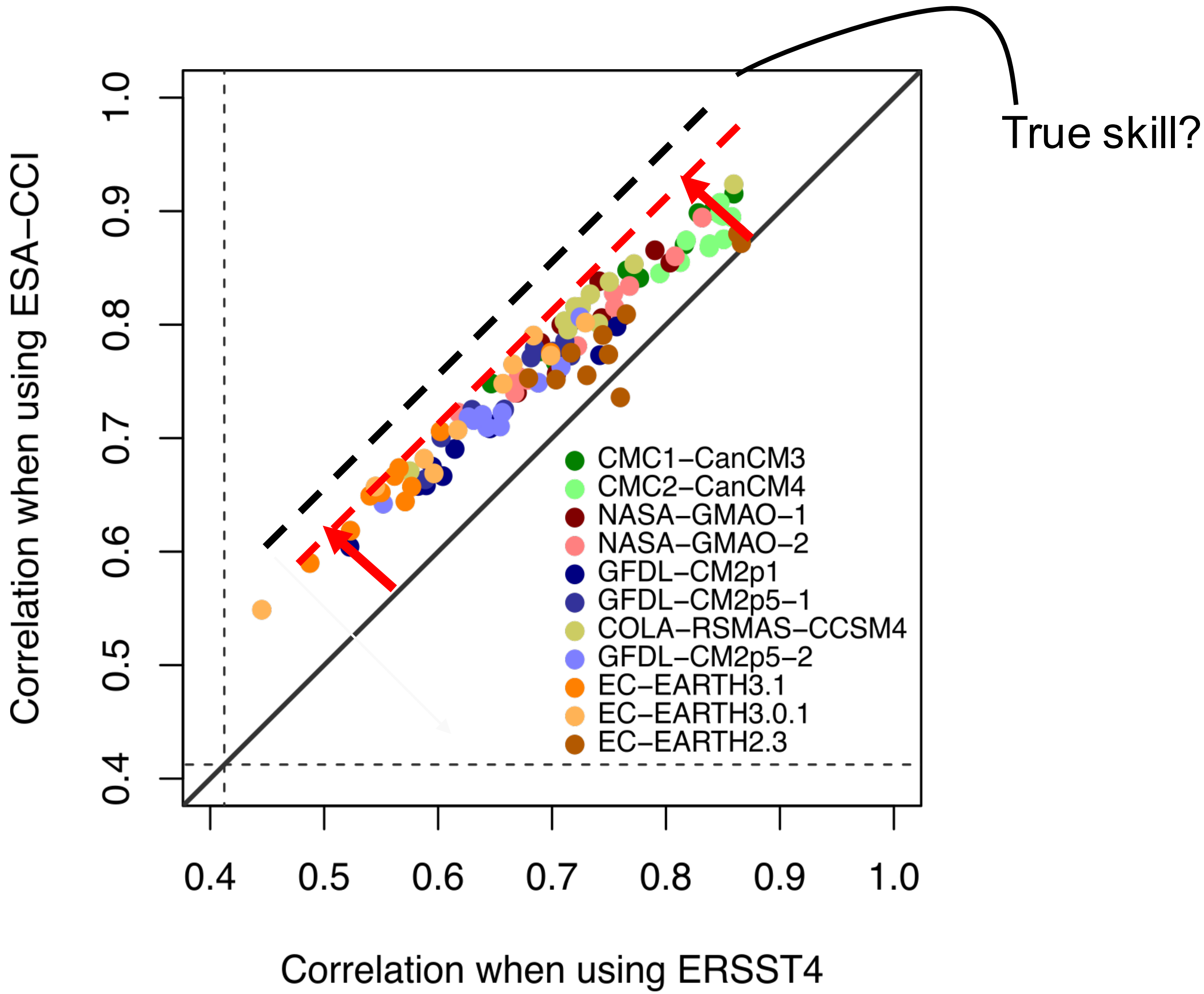
Models can be valuable in assessing observational quality and thus guide a more objective dataset selection

Testing improvements in models and observations requires the consideration of dependence between all source of information

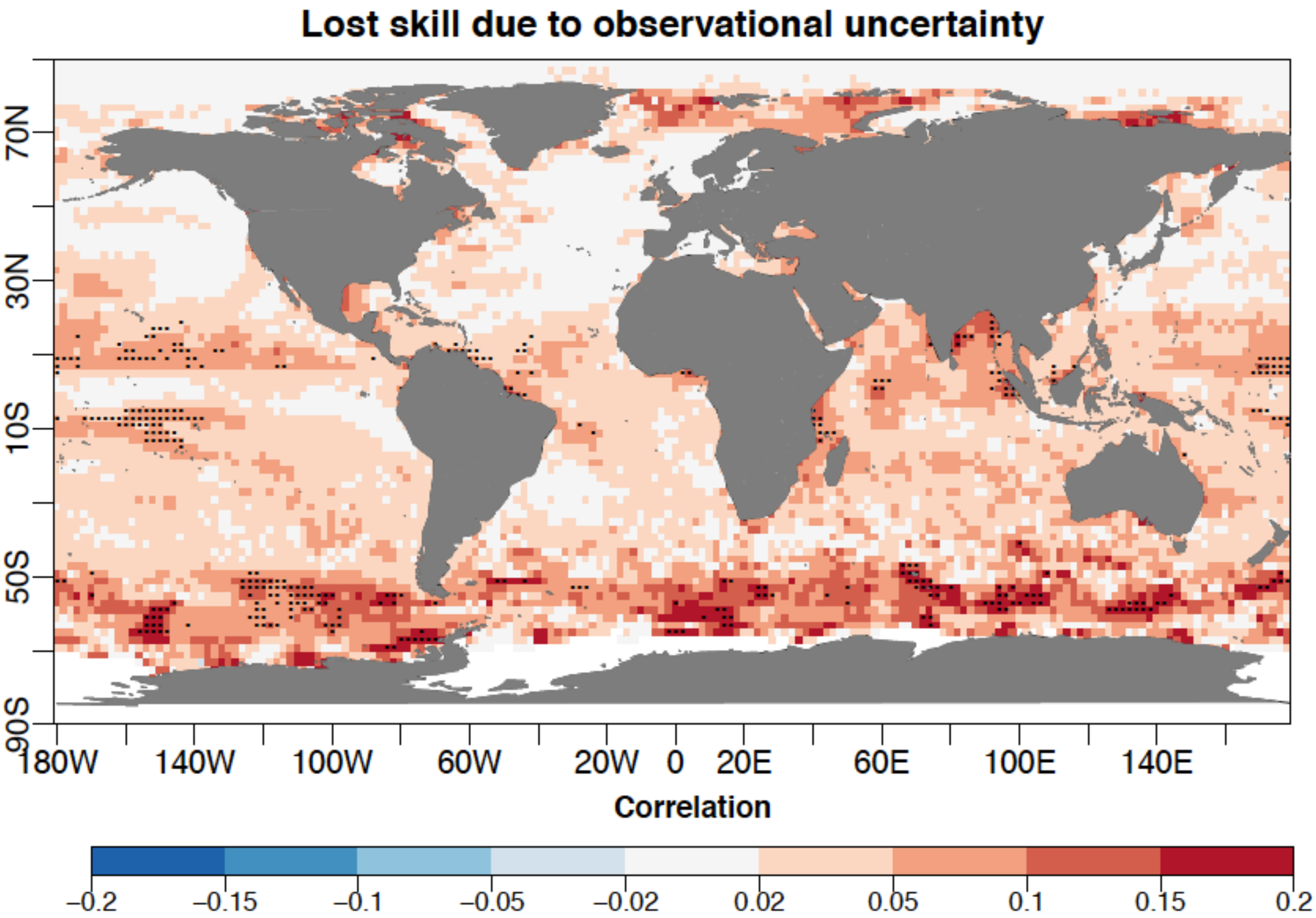


Outlook: What is the "true" skill ?

True climate predictions skill is systematically underestimated due to uncertainties in the observations

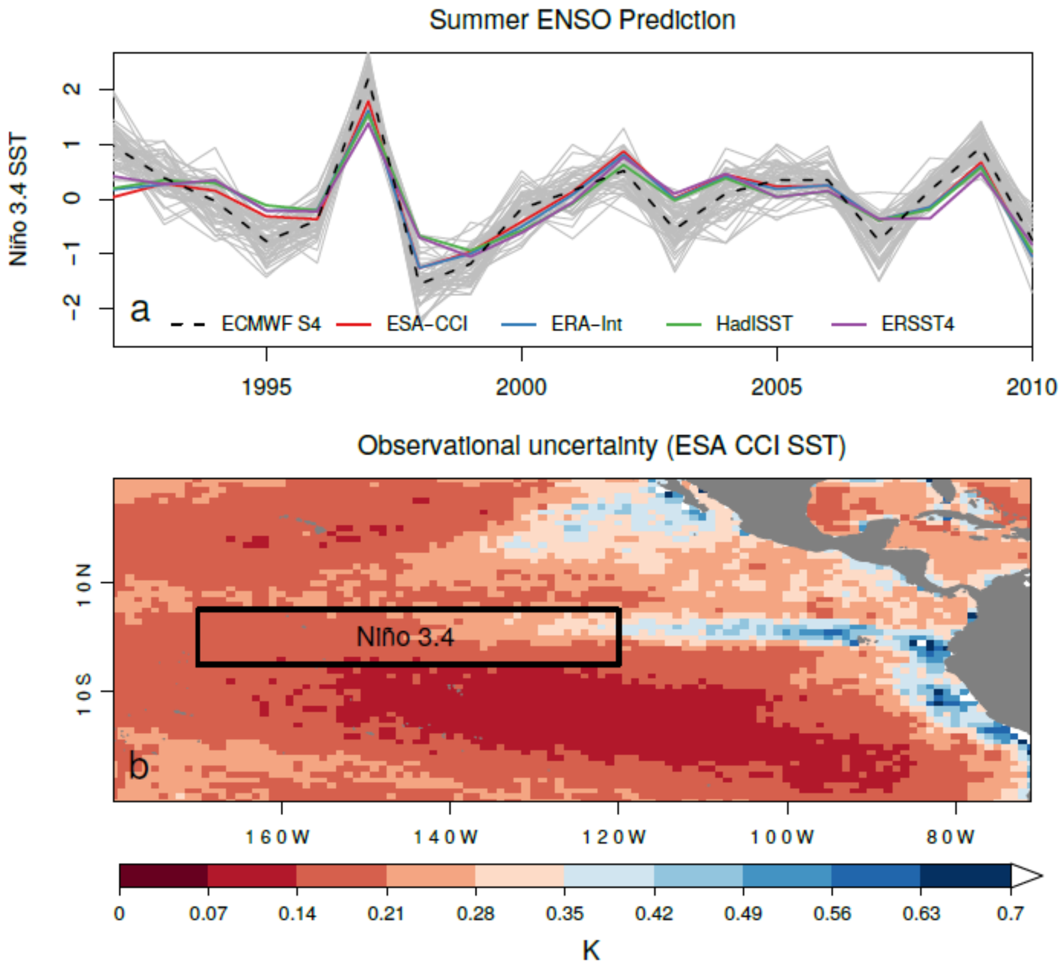


Seasonal SST forecast skill is underestimated up to 0.2 correlation



Observational uncertainty CCI

Model evaluation often requires spatial and temporal averaging, requires the consideration of error correlation scales



Monthly
Niño3.4

Uncorrelated uncertainty reduces by $1/\sqrt{N}$ but errors are not uncorrelated!

Daily, 4 km

Bellprat et al. (2017) Remote Sensing of the Environment

Outlook

Quantifying observational uncertainty is a challenge and propagation scales represented to by the models is a big gap – A stronger interaction is required with the observational data community

ESA *Climate Modelling User Group (CMUG)* is going to explore observational uncertainty in model – observation inter-comparison strongly in the future

Metrics and new statistical tests are required that can make use of the observational uncertainty data that future data sets are going to provide

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Thank you!

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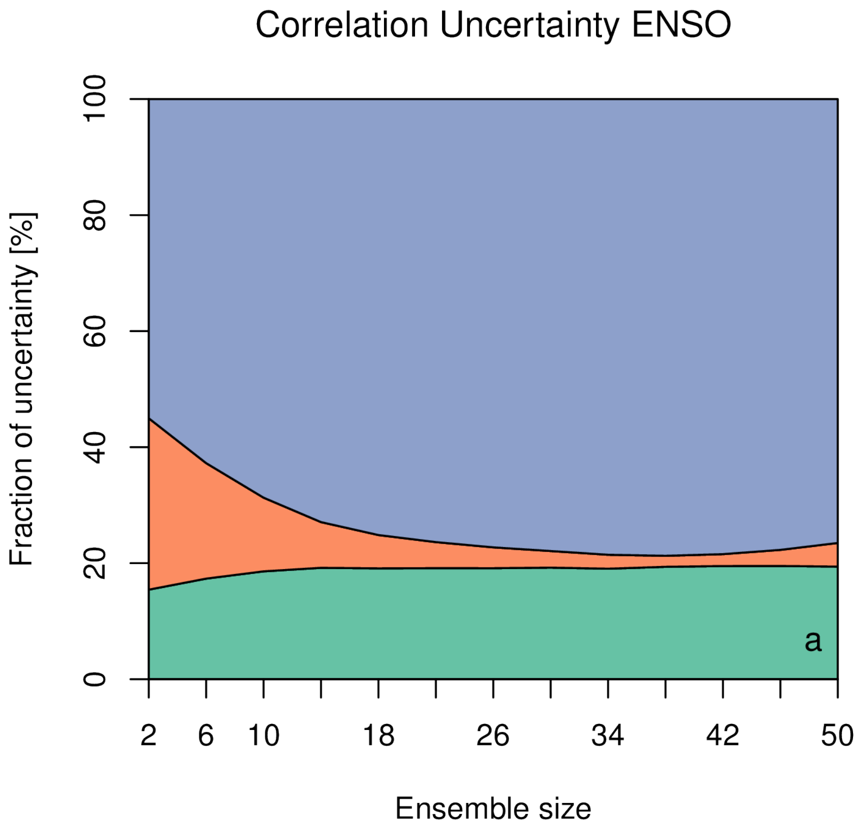
Massonnet, F., Bellprat, O., Guemas, V., Doblas-Reyes, F. J., (2016). Using climate models to estimate the quality of global observational data sets, *Science (AAAS)*

Bellprat, O., Massonnet, F., Siegert, S., Guemas, V., Doblas-Reyes, F. J. (2017). Exploring observational uncertainty in verification of climate model predictions, *Remote Sensing of the Environment (RSE)*, *in review*

Siegert, S., Bellprat, O., Menegoz, M., Stephenson, D., Doblas-Reyes, F. (2016). Detecting improvements in forecast correlation skill: Statistical testing and power analysis. *Monthly Weather Review*

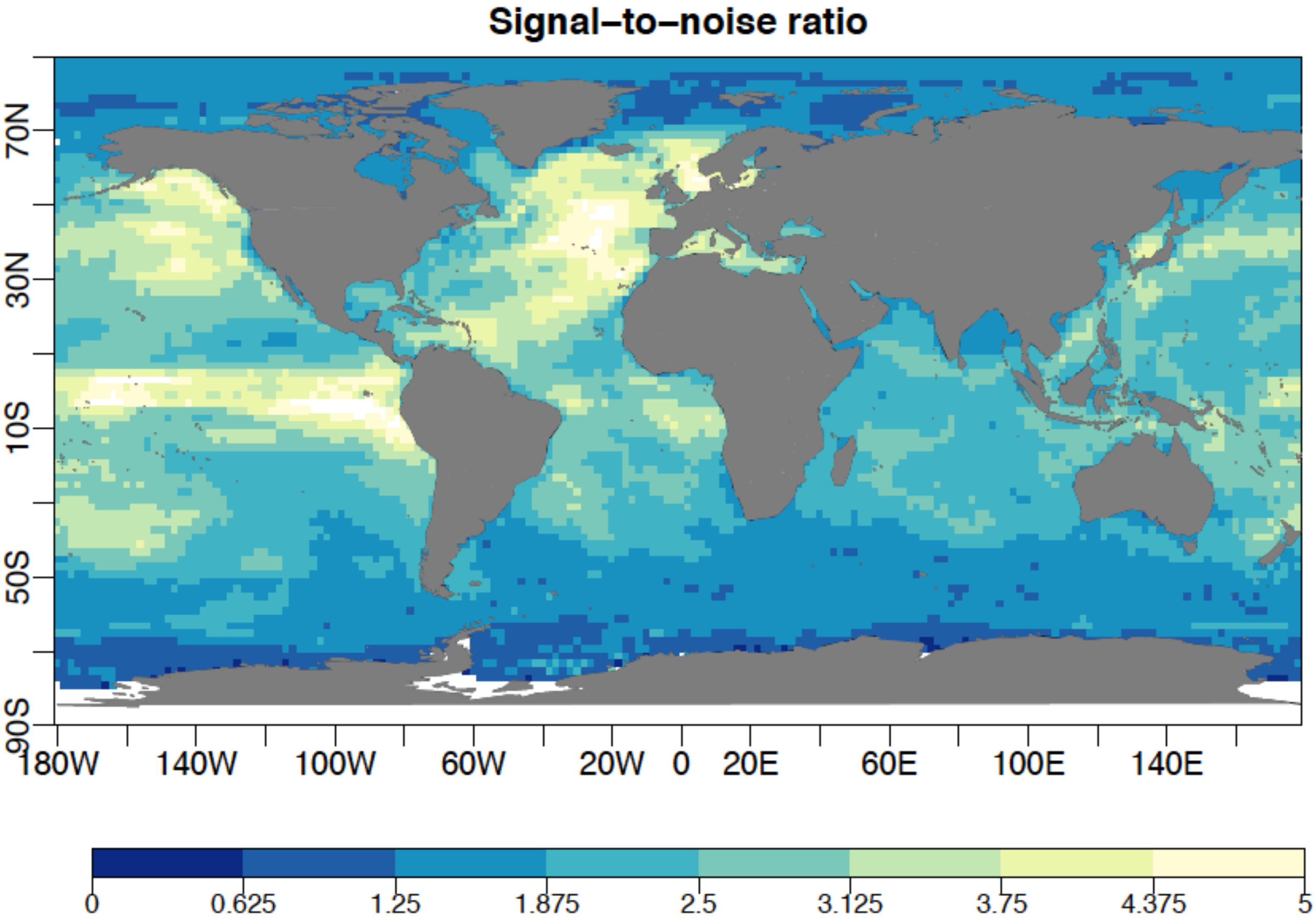
Extra Slides

Sensitivity to sample



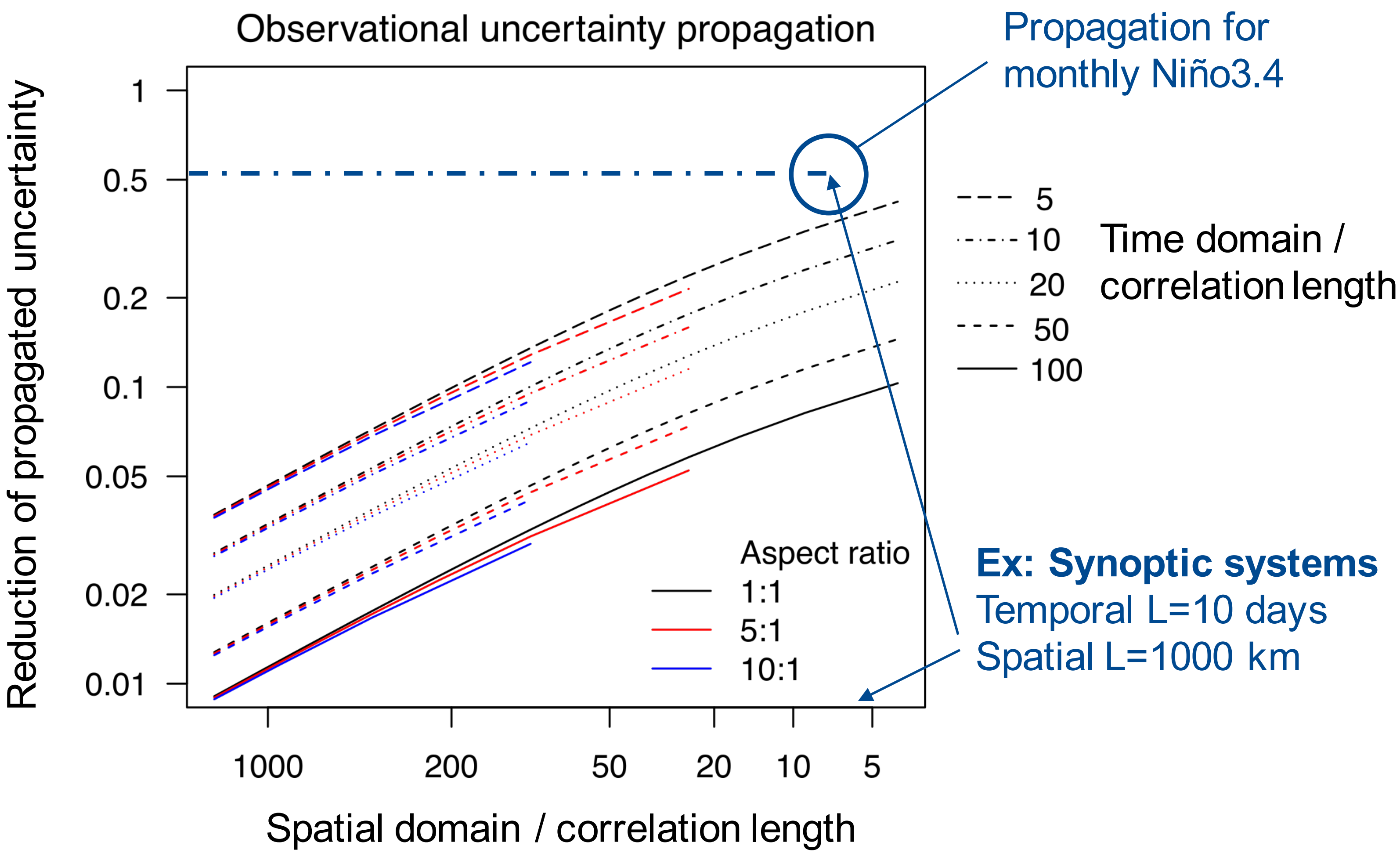
Signal-to-noise ratio SSTs

Signal (inter-annual variability) versus observational uncertainty (noise)



A "look-up" propagation figure

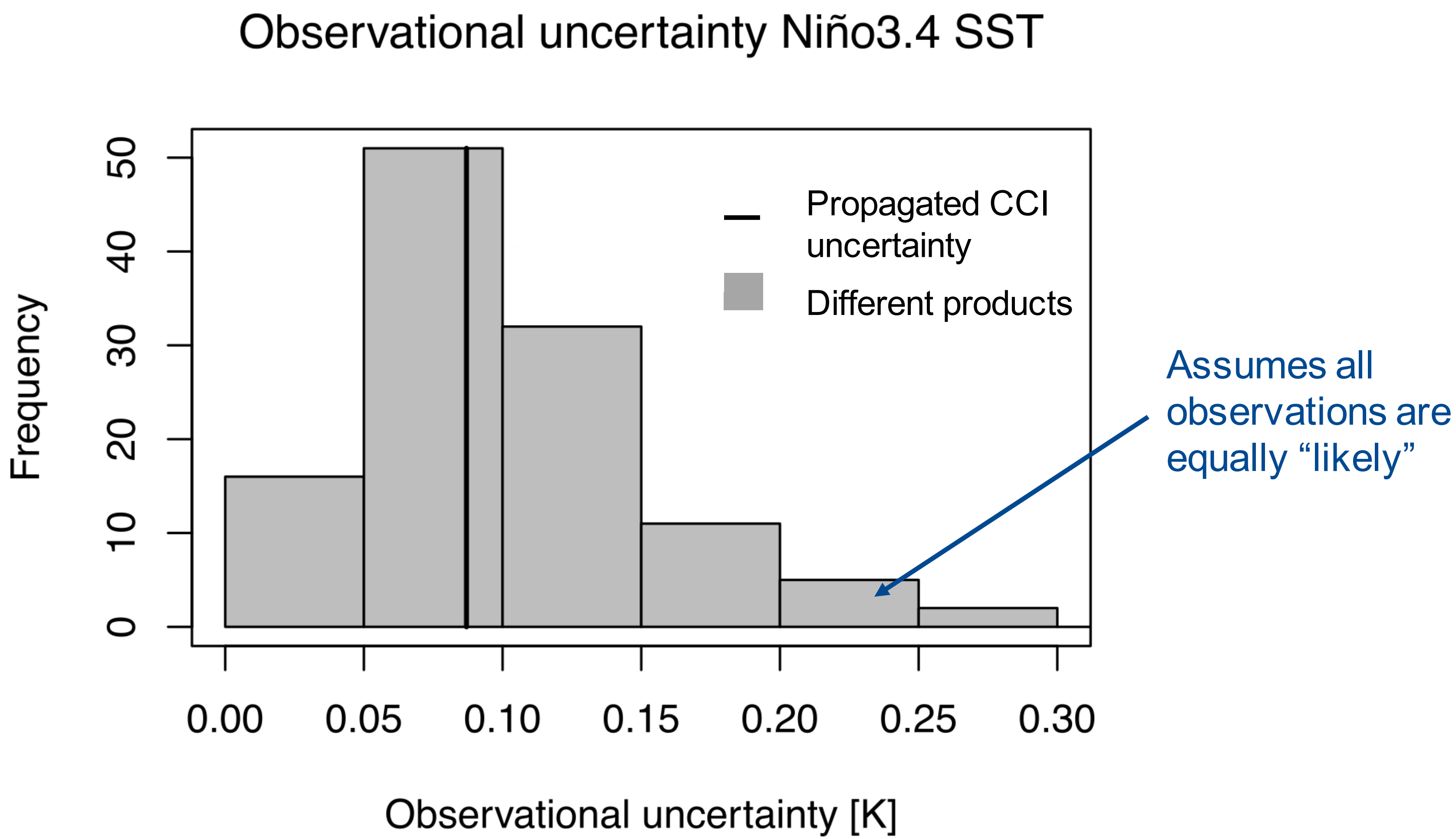
Use of error correlation scales: analytical solution that allows to look-up propagation factors



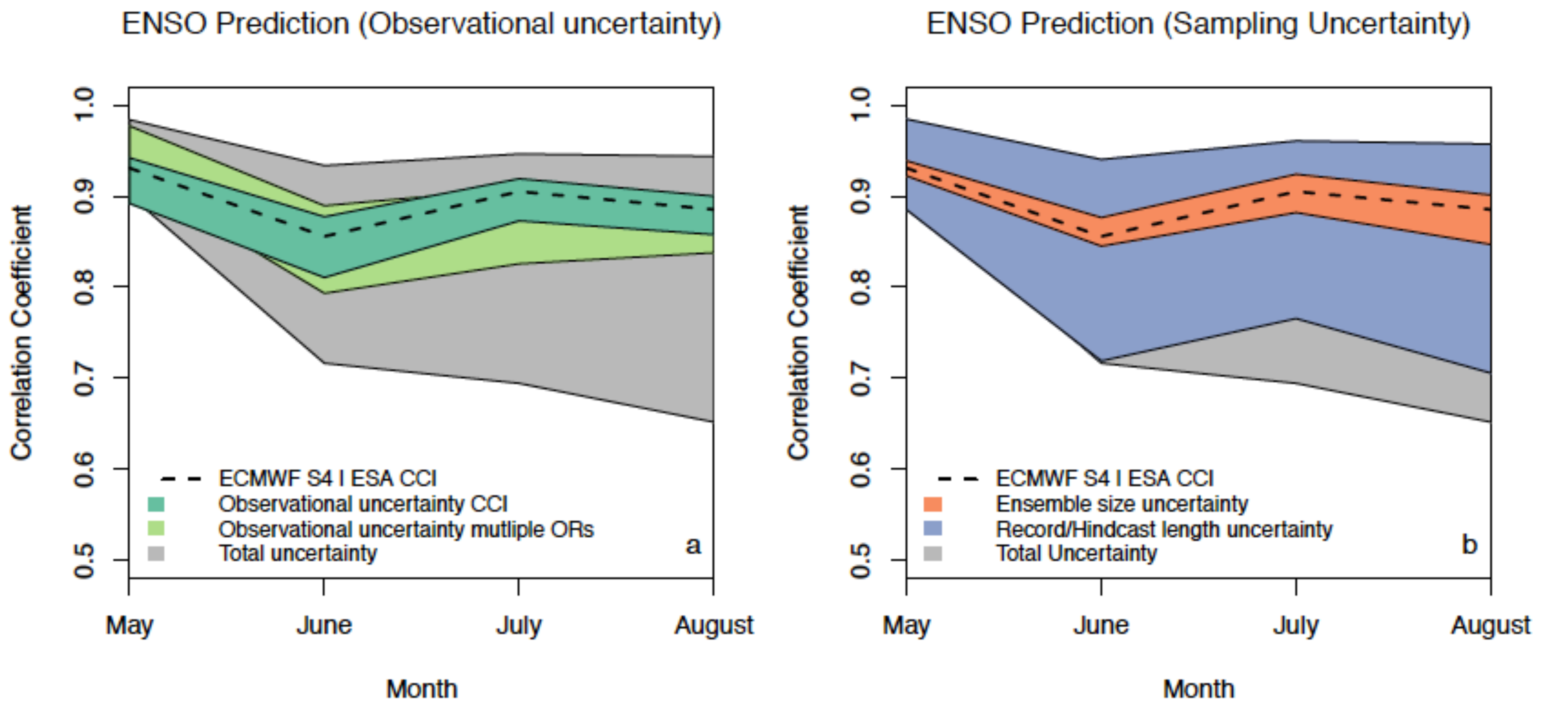
Bellprat et al. (2017) *RSE (in review)*

Comparison to multi-observations

Propagation assuming synoptic scales (1000 km, 10 days) of weather systems agrees well with deviations between existing products



ESA CCI Uncertainty estimate



Relative contributions