VERITAS-CCI

Exploring observational uncertainty in verification of climate predictions

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Introduction

Climate model predictions and observations of the Earth's climate are the two available decision-making tools to confront climate change.

Uncertainty quantification has to entail both sources of information. So far we have focused on understanding uncertainties in the models and the sample limitation when comparing models with observations.

Observations are uncertain themselves which affect the quality assessment of climate models. Climate predictions skill is therefore systematically underestimated. The relevance of observational uncertainty remains poorly ackknowledged, a gap which is here explored in the context of seasonal prediction.

Prediction and observation of the El Niño Southern Oscillation

The ECMWF seasonal forecast system 4 (S4) and four observations of global SSTs are used (SST CCI analyzed (satellite only), HadISST (satellite+ in-situ), ERSST4 (in-situ only), ERA-Interim (re-analysis))

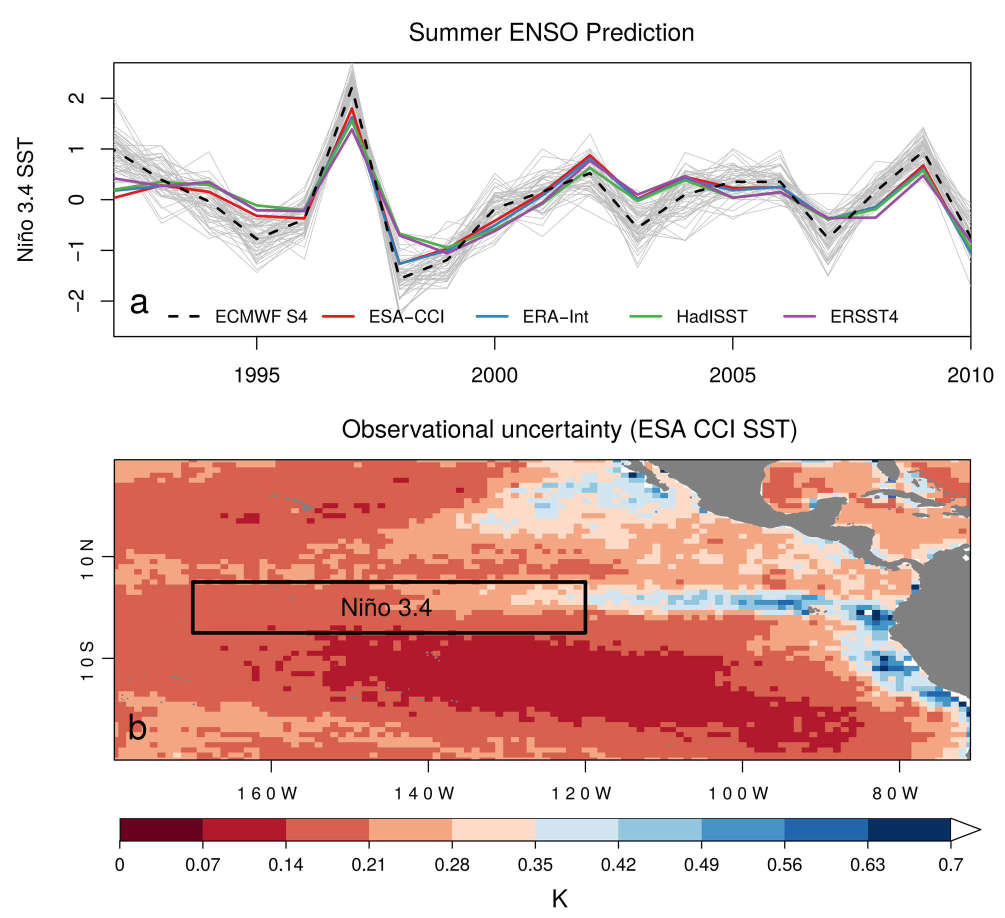


Figure 1: (a) Observed and predicted Niño3.4 conditions for the period 1992 - 2010 (SST CCI period) in summer. Dashed line shows ensemble mean of S4, grey lines all ensemble members (51). (b) Uncertainty of SST CCI at 1st June 2000. Observational uncertainty in the Niño3.4 region varies very little (0.22 ± 0.001 K)

Observational uncertainty a relevant source of uncertainty in verification

Climate prediction skill is subject of three uncertainty sources: (1) Ensemble size uncertainy (2) Sample of retro-spective predictions or record period of observations (3) Observational uncertainty.

Uncertainty (1,2) are commonly reported where (3) is assumed to be negnigible. For ENSO observational uncertainties can account for about 20 - 60 % of total verification uncertainty.

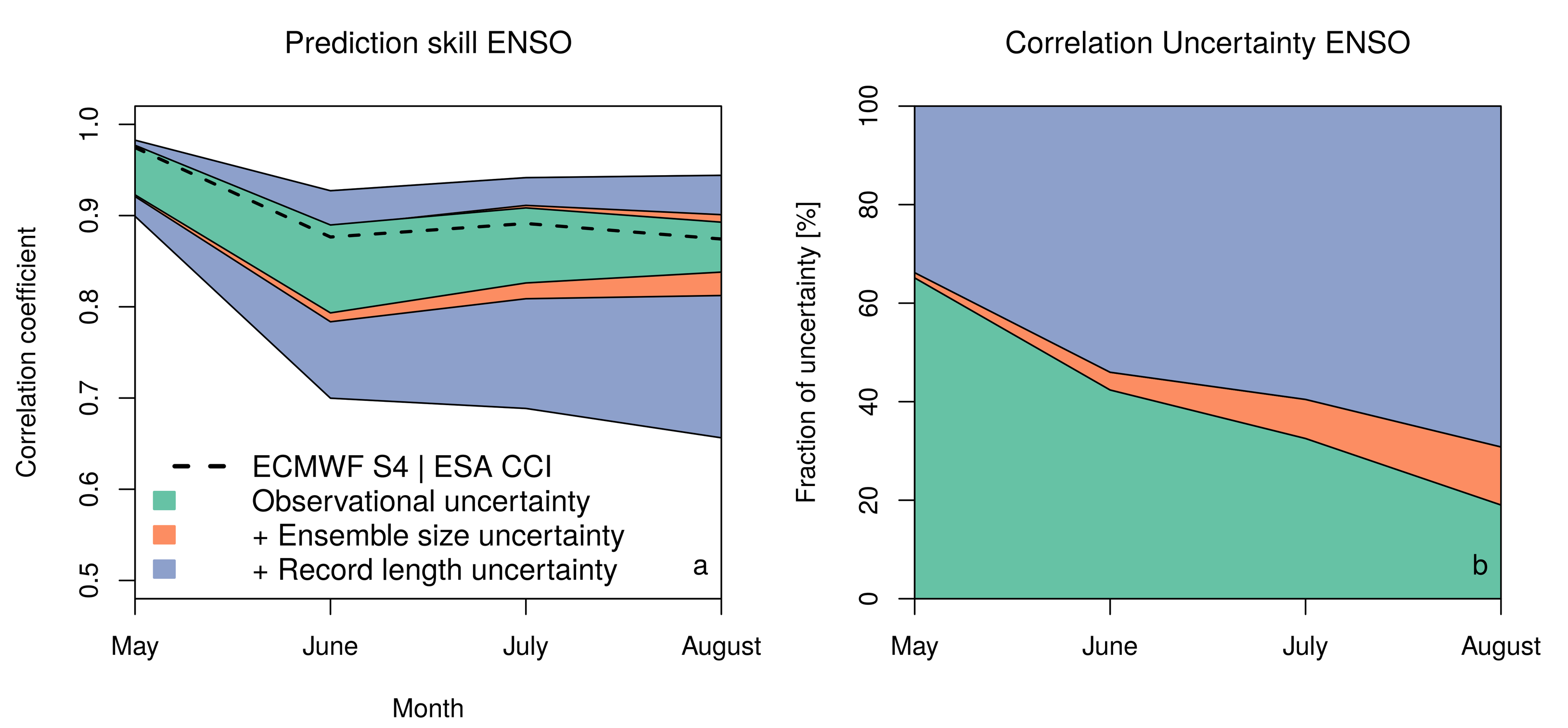
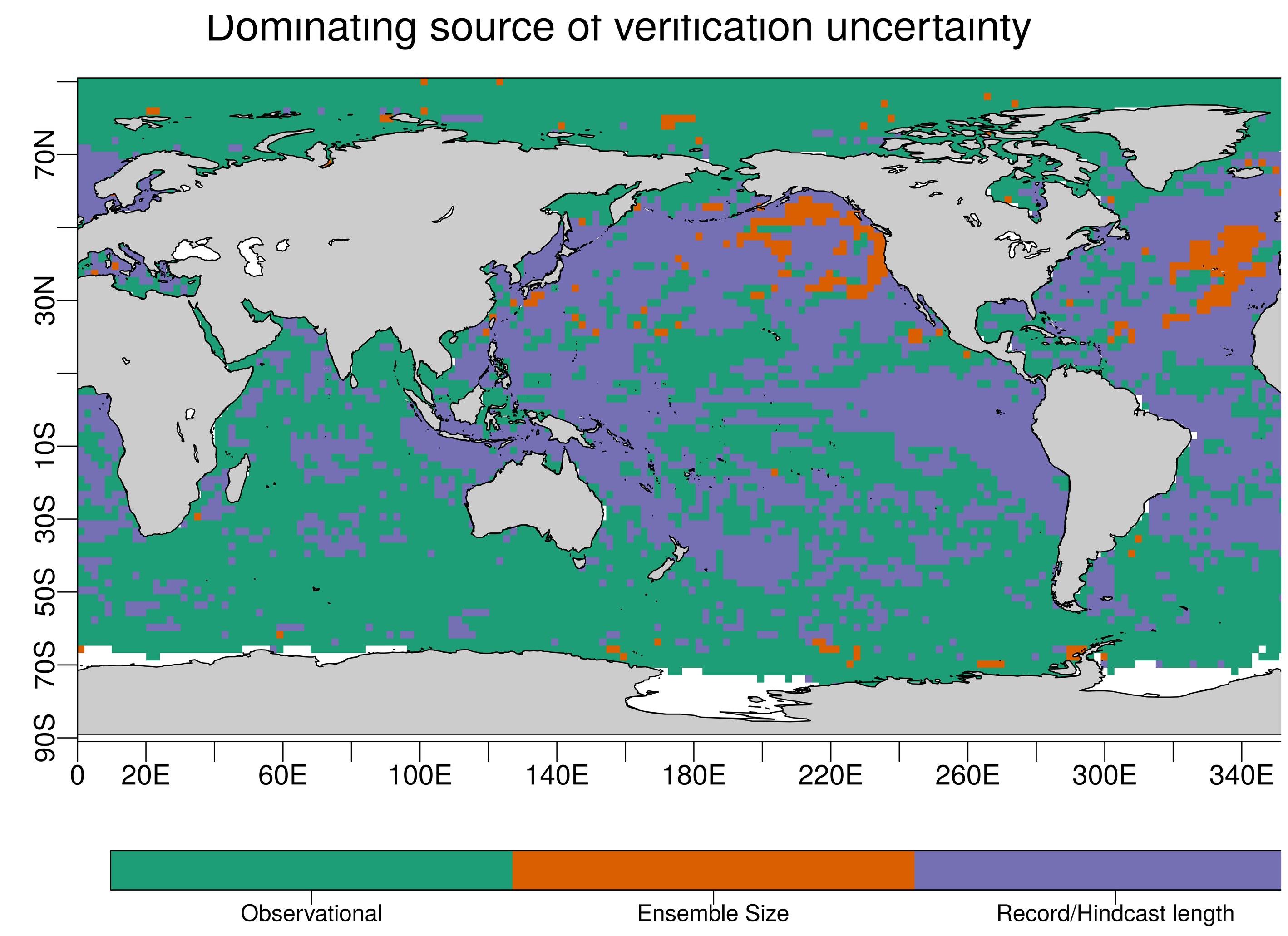


Figure 2: (a) Seasonal prediction skill (dahsed) measured as the correlation between the ensemble mean forecast and the observations (SST CCI). Predictions are initialised in May and skill decreases in the course of the season. (a-b) Areas denote uncertainty due to each source of uncertainty in absolute (a) and relative (b) terms. Uncertainty sources show the 5-95% confidence interval obtained by bootstrapping.

Observational uncertainty already a dominanting source at high-latitudes

Concept of Fig. 2 expanded to a global view. Observational uncertainty is a dominating source at high-latitudes (weak in-situ sampling). At North Pacific and Atlantic record length dominates (intense in-situ sampling). Ensemble size is a dominant source of uncertainty in regions where SST are forced by the Atmosphere.



Methods: Propagation of observational uncertainties for model verification

One of the challenges in dealing with observational uncertainty is to go from grid-point wise observational uncertainty to observational uncertainty of the space-time average, a necessity in climate model evaluation.

Uncertainty propagation is complex and computationally demanding. A useful assumption is to assume a constant observational uncertainty in the domain of interest (e.g. Niño3.4 at monthly scales). This allows to derive an analytical solution and to create a "look-up" figure applicable to any uncertainty propagation case

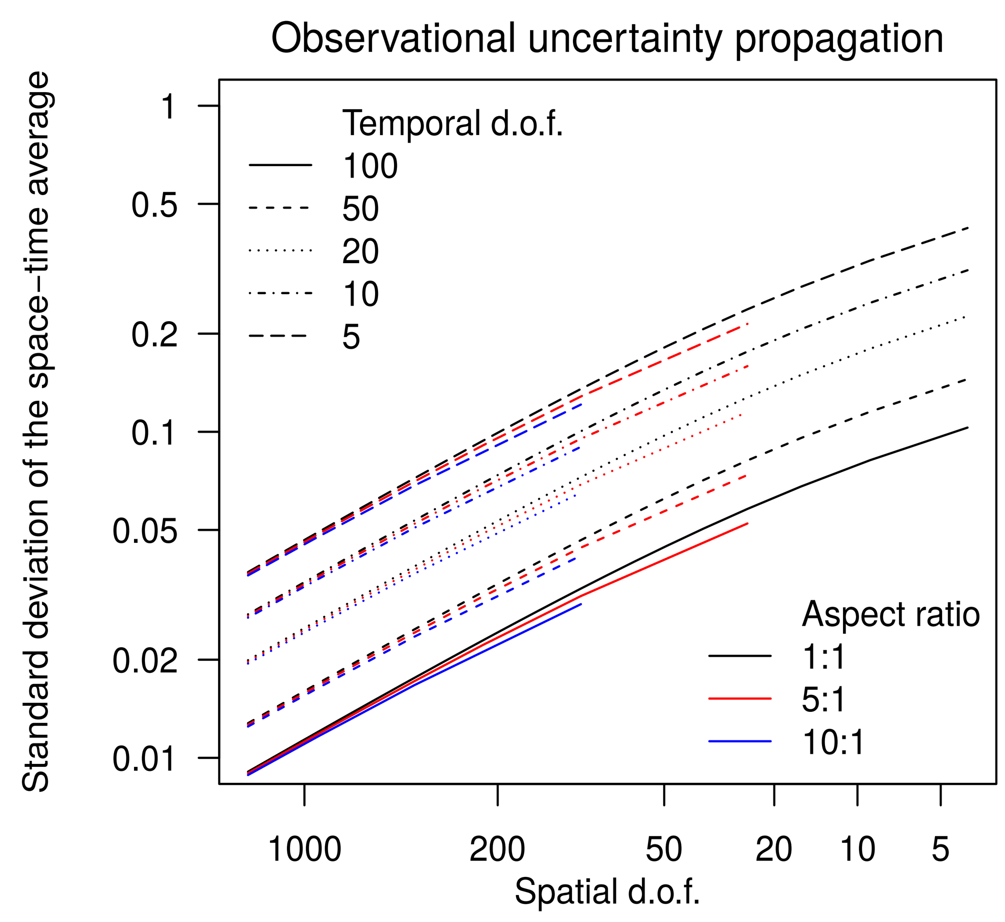


Figure 4: "Look-up" figure for uncertainty propagation for different correlation scales expressed as degrees of freedom (d.o.f) that the length scale fits into the domain of the space-time mean.

Analytical solution and comparison to uncertainty from different datasets

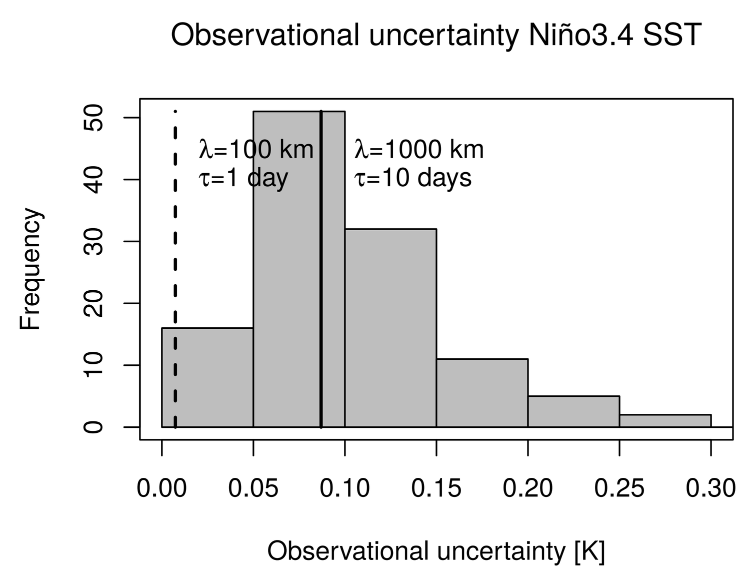


Figure 5: Propagated SST CCI uncertainty (vertical lines) for synoptic correlation scales in comparison touncertainty derived from observations.

$$\Sigma_{ijt} = \exp\left(-\frac{\Delta x\sqrt{(i'-i)^2+(j'-j)^2}}{\lambda} - \frac{\Delta t|t'-t|}{\tau}\right) \quad (1)$$

$$\overline{\sigma_x} = \Sigma \cdot \sigma_x \cdot \Sigma^{-T} \quad (2)$$

$$\overline{\sigma_x} = \sigma_x^2 \frac{(T+2S_T)(MN+2NS_M+2MS_N+4S_{MN})}{M^2N^2T^2} \quad (3)$$

$$S_M = \sum_{i=1}^{M-1}(M-i)e^{-\frac{i\Delta x}{\lambda}} \quad (4)$$

$$S_N = \sum_{j=1}^{N-1}(N-j)e^{-\frac{j\Delta x}{\lambda}} \quad (5)$$

$$S_T = \sum_{t=1}^{T-1}(T-t)e^{-\frac{t\Delta t}{\tau}} \quad (6)$$

$$S_{MN} = \sum_{i=1}^{M-1}\sum_{j=1}^{N-1}(M-i)(N-j)e^{-\frac{\sqrt{i^2+j^2}}{d\lambda}} \quad (7)$$

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