Influence of Atmospheric Errors on Weeks 2-4 California Current System Predictions

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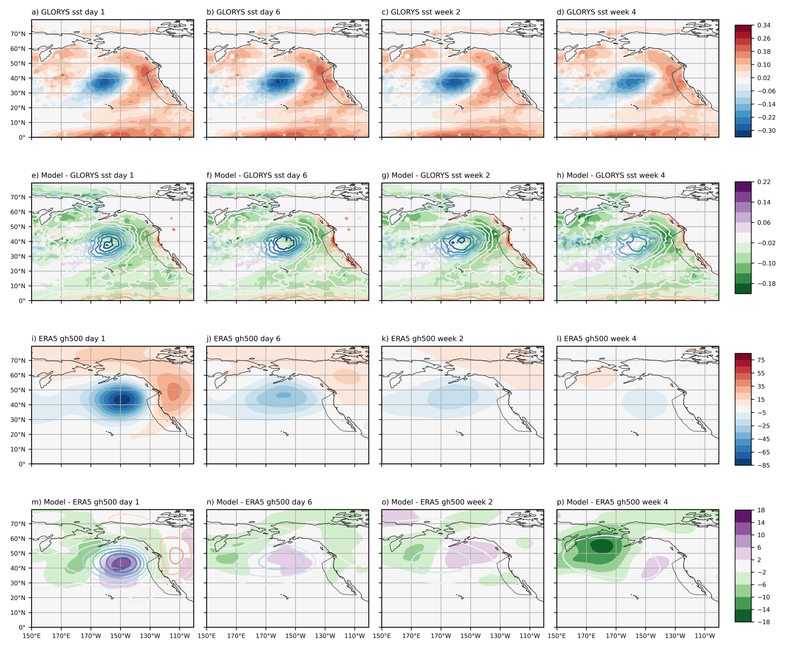
Abstract

The **California Current System (CCS)** is a highly productive marine ecosystem in the North East Pacific along the west coast of North America. Seasonal upwelling primarily during the spring and summer brings nutrient-rich cold water to the surface and has implications for marine species distribution and abundance. The region is one of the most productive fisheries in the world.

Not much known about **what influences CCS SST forecasts on subseasonal-to-seasonal (S2S) time scales**. Oceanic Kelvin waves from the tropical Pacific generate ocean teleconnections that influence CCS SSTs, SSH and bottom temperatures. Both the Madden-Julian oscillation (MJO) and ENSO have been shown to impact anomalous non-tidal residual water levels along the west coast of North America on S2S time scales.

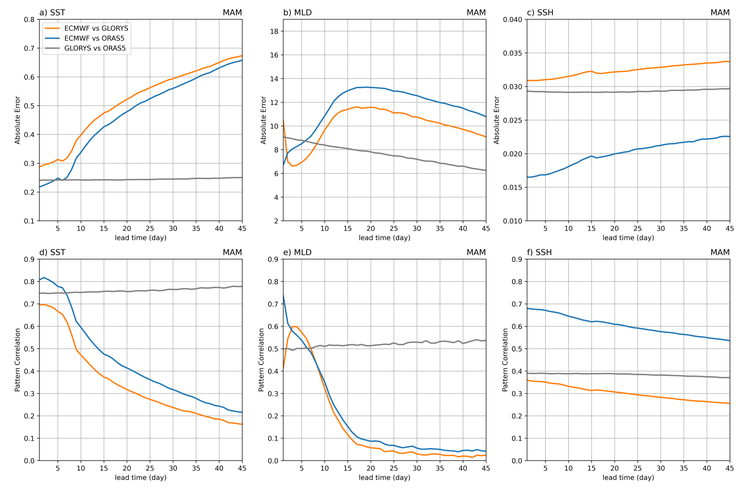
Here we use Ensemble Sensitivity Analysis (ESA) to identify regions where conditioning forecasts on more skillful atmospheric states at lead weeks 1 and 2 improves the forecasts of oceanic anomalies in the CCS at weeks 2-4.

Model errors in the CCS



Composites of SST and Z500 conditioned on negative Z500 anomalies at day 1 of the forecast in the region 20N-50N, 200E-220E. Anomaly composites for GLORYS SST for a) day 1, b) day 6, c) week 2 and d) week4 and differences between model SST and GLORYS in shading and model SST in contours for e) day 1, f) day 6, g) week 2 and h) week4. Anomaly composites for ERA5 Z500 for i) day 1, j) day 6, k) week 2 and l) week4 and differences between model Z500 and ERA5 in shading and model Z500 in contours for m) day 1, n) day 6, o) week 2 and p) week4. Contour intervals are the same for reanalysis and model anomalies.

This illustrates two types of error that can influence CCS ocean states at later leads: 1) **atmospheric model errors in amplitude at early lead times**, and 2) errors in the coupling between model atmosphere states and the ocean.



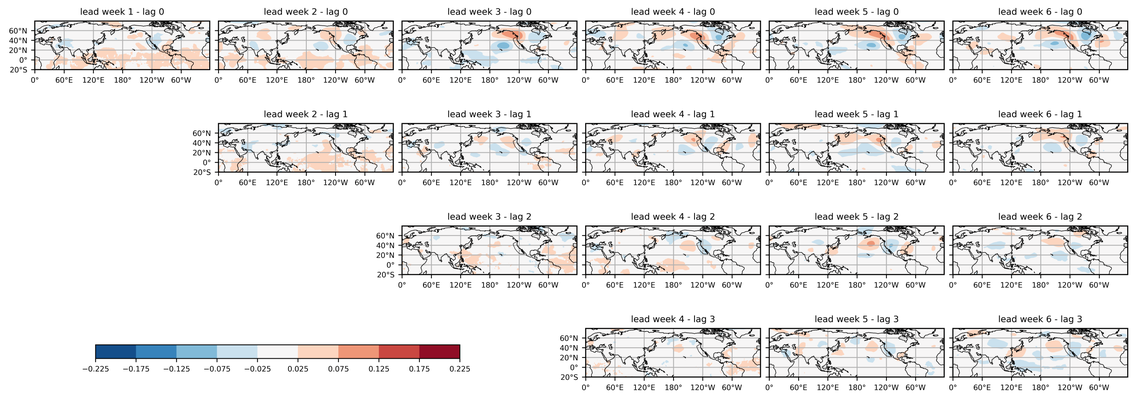
Model absolute error (top) and pattern correlation (bottom) in the CCS during MAM.

Model biases in the seasonal evolution of CCS ocean states. Error grows most rapidly between day 5-15.

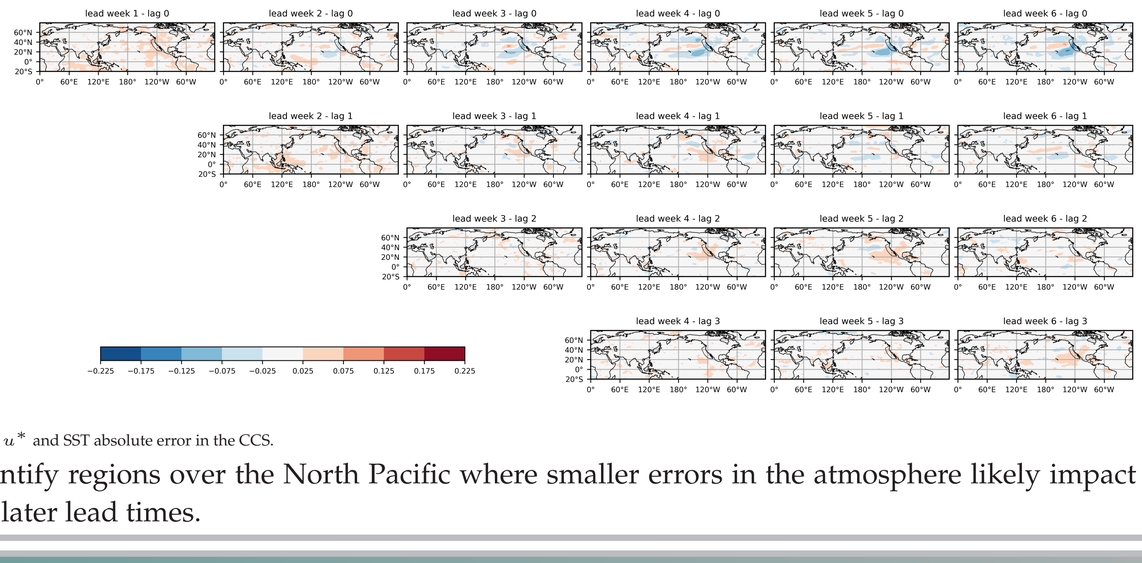
Ensemble Sensitivity Analysis

- Ensemble sensitivity provides accurate estimates of the impact of initial condition changes to a forecast metric.
- Is useful for identifying a target region for additional observations because, unlike adjoint sensitivity, the analysis-error statistics are included in the ensemble calculation.
- The equation for ESA represents linear regression where the independent variable is an analysis grid point and the dependent variable is the forecast metric.
- Examples for forecast metrics are ACC or absolute error over a region.

$$\frac{\partial J}{\partial x} = \frac{cov(J, x)}{var(x)} \tag{1}$$



Ensemble Sensitivity Analysis for Z500 and SST absolute error in the CCS.

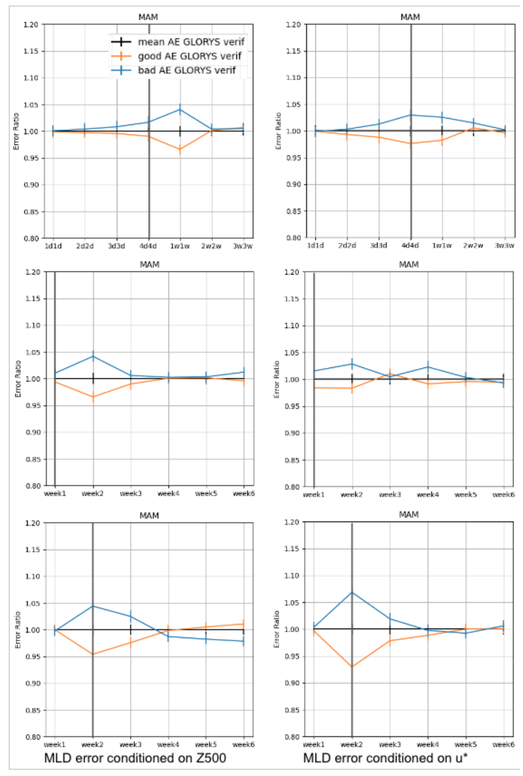


Ensemble Sensitivity Analysis for u^* and SST absolute error in the CCS.

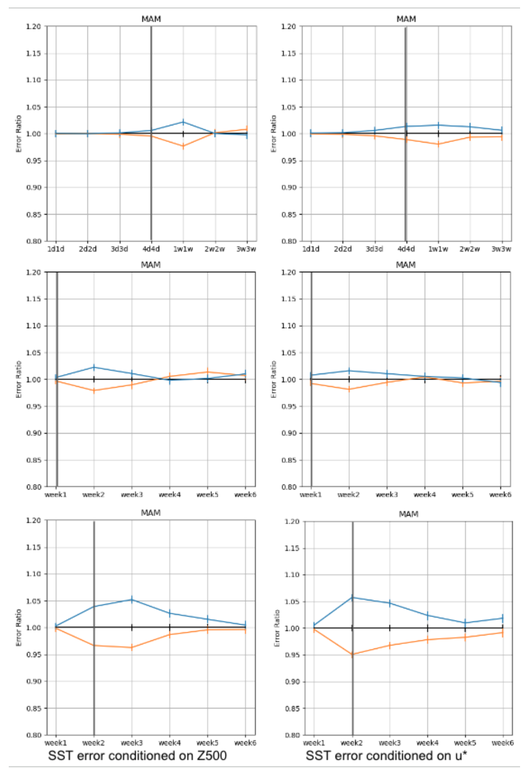
We use ESA to identify regions over the North Pacific where smaller errors in the atmosphere likely impact errors in the ocean state in the CCS at later lead times.

Error Conditioning

Do we see improvement in CCS ocean errors when conditioning on the best ensemble members in the atmosphere?



Absolute error in CCS MLD conditioned on the best and worst ensemble members for Z500 in the region 20-50N, 200-220E (left) and friction velocity u^* in the region 10-30N, 200-230E at lead times 4-7days (top), week1 (middle), and week2 (bottom).



Absolute error in CCS SST conditioned on the best and worst ensemble members for Z500 in the region 20-50N, 200-220E (left) and friction velocity u^* in the region 10-30N, 200-230E at lead times 4-7days (top), week1 (middle), and week2 (bottom).

- ESA is able to identify atmospheric regions influencing CCS ocean errors.
- Ensemble members with smaller Z500 errors tend to also have smaller errors in SST and MLD in the CCS.
- Error reduction in SST and MLD is up to 5% during the following week.
- Friction velocity (u^*) has similar impact with different timing.

Summary and Next Steps

- We use Ensemble Sensitivity Analysis (ESA) to identify regions where conditioning forecasts on more skillful atmospheric states at lead weeks 1 and 2 improves the forecasts of oceanic anomalies in the CCS at weeks 2-4.
- ESA maps resemble patterns similar to the PNA or PMM depending on the variable.
- Composites on negative Z500 anomalies in the ensemble sensitivity region show quickly reducing atmospheric signals, but longer lived signals in the ocean.

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