The spring minimum in subseasonal 2-meter temperature forecast skill over North America

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Introduction

- Subseasonal (weeks 3-8 lead time) forecasts of temperature and precipitation are highly desirable, but, at present not always skillful (de Andrade 2018; Pegion et al. 2019).
- Instead, identifying the smaller portion of forecasts that are useful, called 'forecasts of opportunity', has become a goal of subseasonal forecasting and research.
- It is well known that during winter, tropical processes such as the El Niño-Southern Oscillation (ENSO) and Madden-Julian Oscillation (MJO) can impart signals in the extratropics and can lead to periods of elevated skill (Albers and Newman 2021).
- However, forecasts of opportunity during other times of the year, in particular spring, have not been as extensively investigated.

In this study, we consider **subseasonal temperature forecast skill over North America** during late winter, spring, and early summer generated by a machine learning model called a *linear inverse model* (LIM, Penland and Sardeshmukh 1995). We also use the LIM to examine how predictable temperature patterns can be used to identify **forecasts of opportunity**, and find that in spring both the typical forecast and forecasts of opportunity are not as useful as during winter and summer (Figs. 3-4). This is consistent with a minimum in the forecast signal-to-noise ratio (Fig. 5).

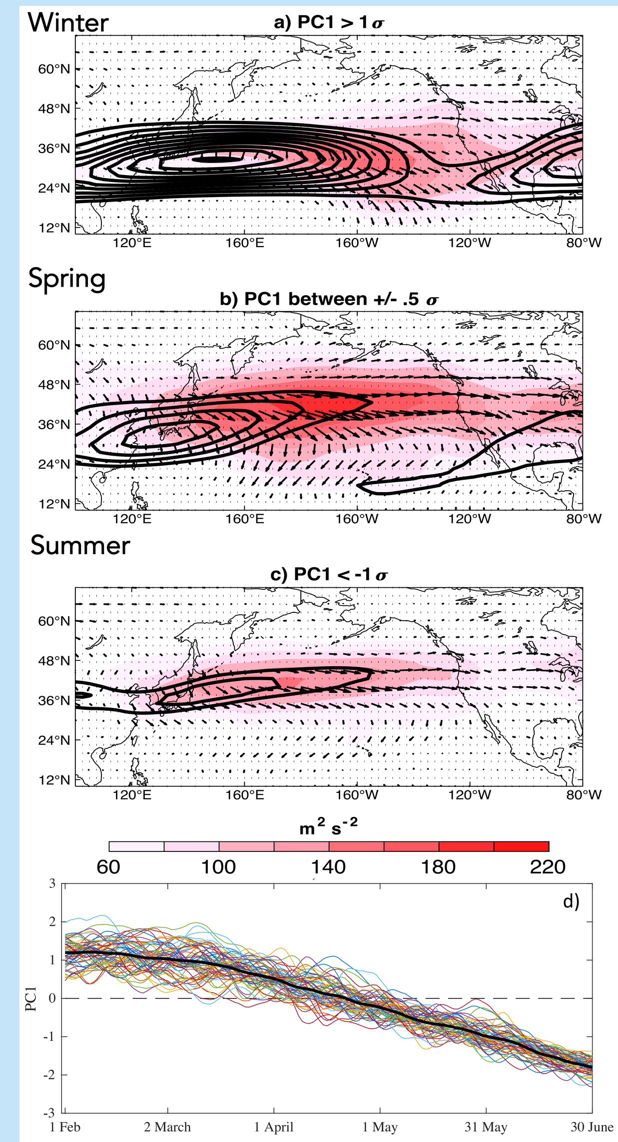


Figure 1: Composite 200-hPa zonal wind (contours) and eddy kinetic energy (fill) during a) late winter, b) spring and c) early summer. Panel d) shows how the three groups were selected, following *Breeden et al. 2021, ACP*

The Spring Transition of the North Pacific Jet

- The North Pacific jet and its variability have a strong influence on 2-meter temperatures over North America, and the nature of this influence evolves seasonally.
- There is high year-to-year variability in when the jet transitions from its winter to spring state (Fig. 1d), with consequences for the storm track, and, as we will show, subseasonal temperature prediction.
- Evaluating week 3-5 lead time jet forecasts by a leading operational subseasonal model reveals that the jet itself is less predictable as spring progresses (Fig. 2).

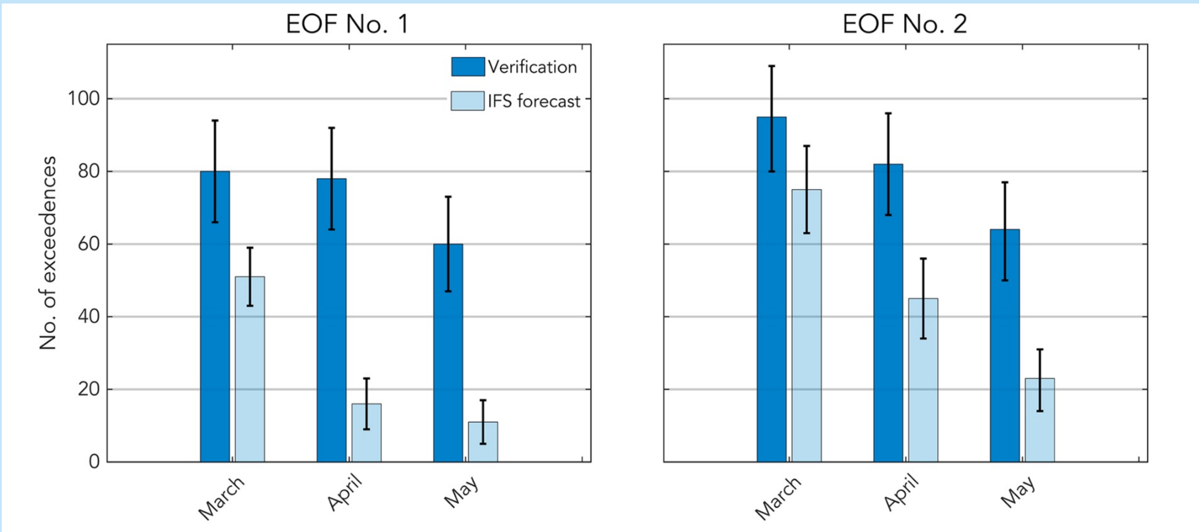


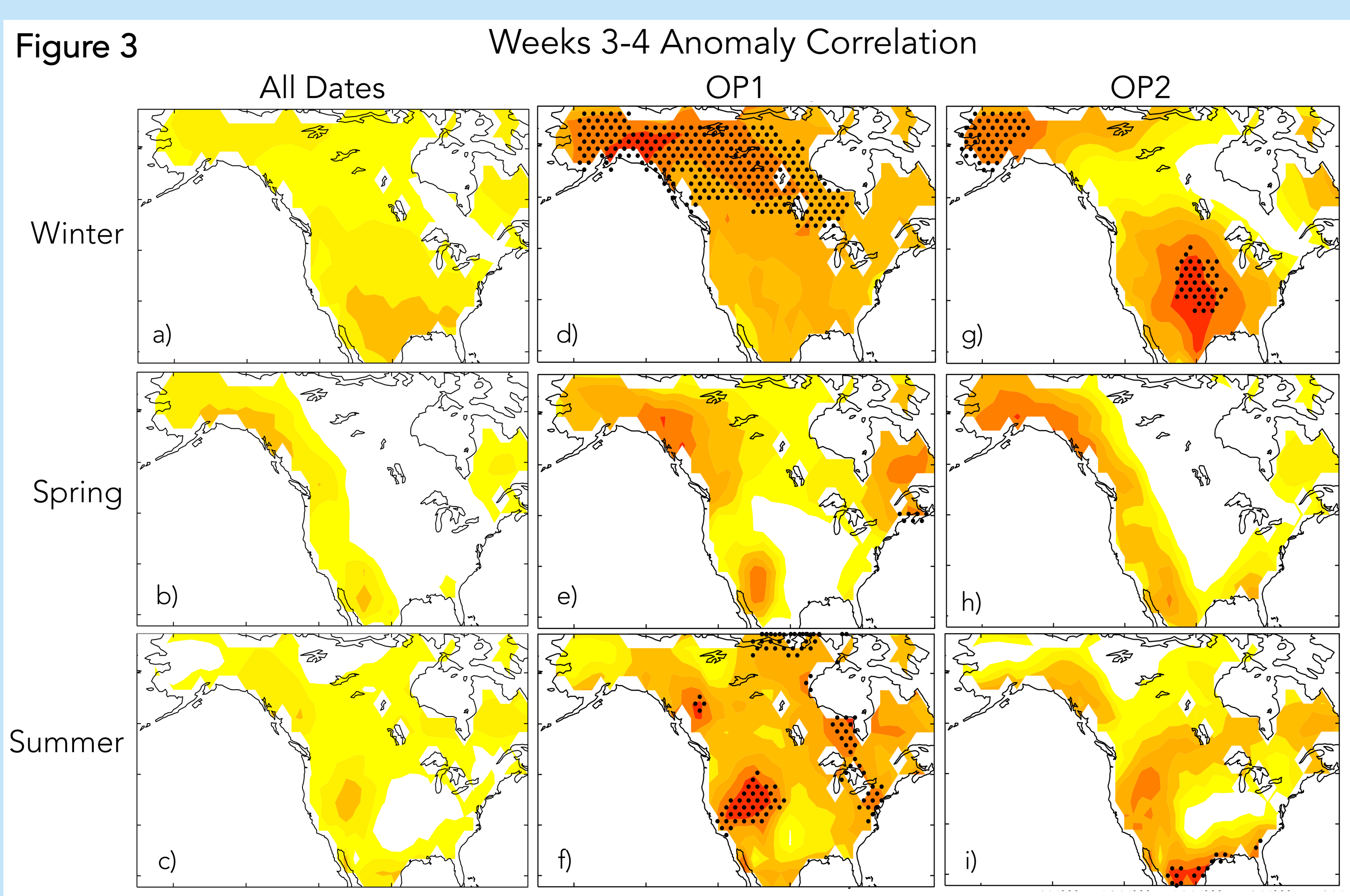
Figure 2: Number of days characterized by observed 'verification' North Pacific jet modes (EOF No. 1 and EOF No. 2) in the months March, April, and May, are shown in the dark blue bars. The number of strong week 3-5 forecast jet modes by the ECMWF IFS forecast model is shown in the light blue bars.
Taken from *Albers et al. 2021 WCD*

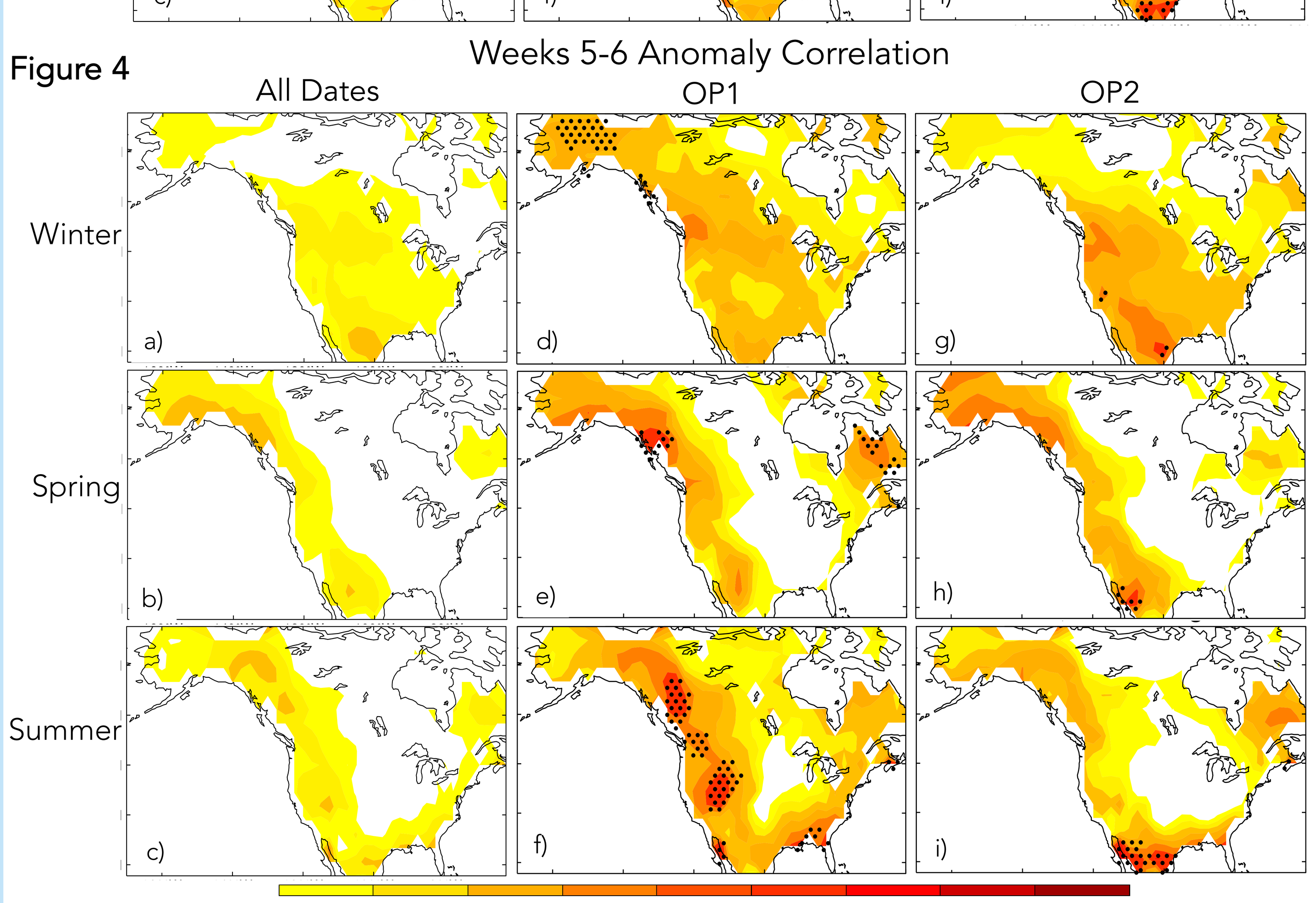
Research Questions

1. How does subseasonal North American 2-meter temperature forecast skill evolve during the spring transition?

2. Can forecasts of opportunity be identified for North American 2-meter temperature?

2-Meter Temperature Forecast Skill and Forecasts of Opportunity





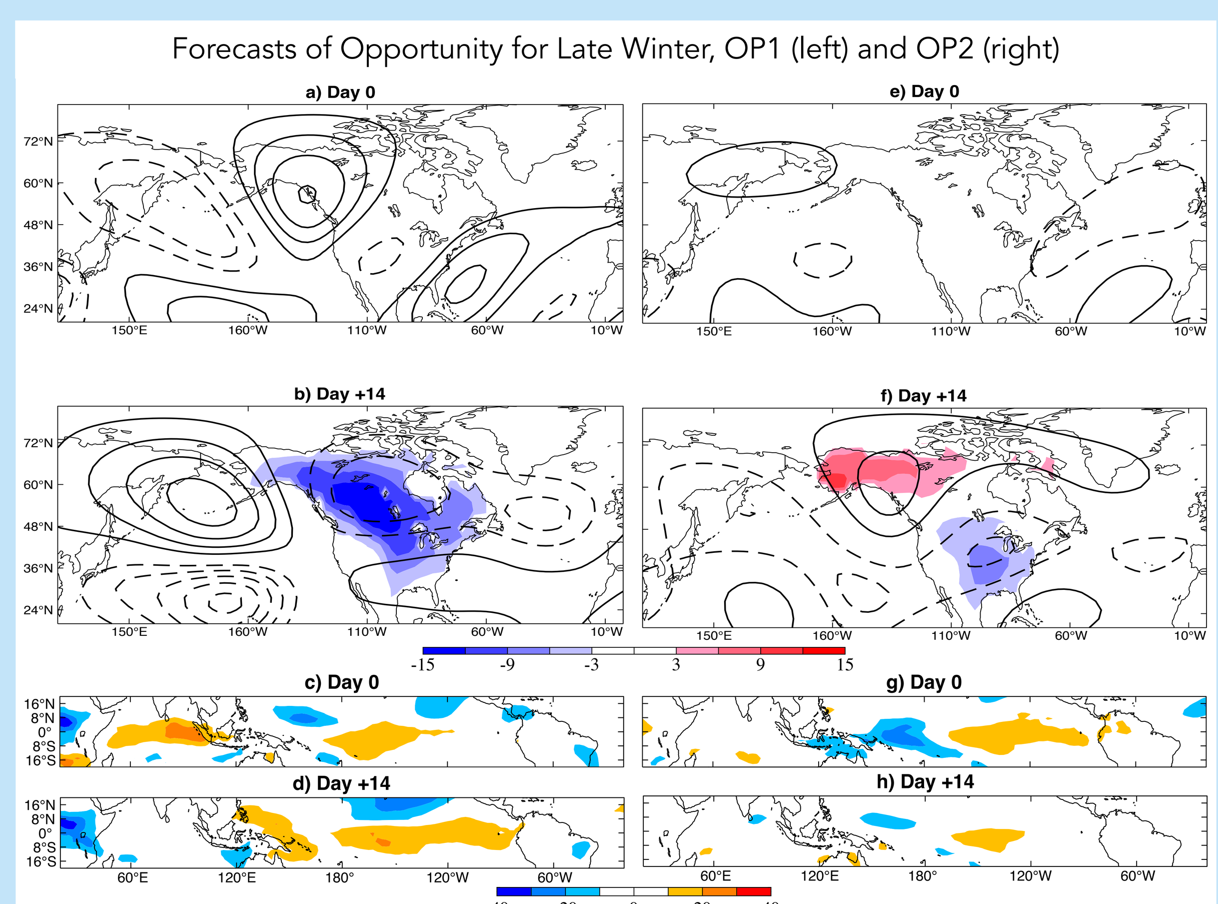


Figure 6: First (a-d) and second (e-h) optimal patterns (OP1, OP2) maximizing North American 2-meter temperature growth, over a 14-day period, during the winter jet phase. The color shading in a), b), e), f) is anomalous 2mT in units degrees Celsius, and the black contours are 200-hPa streamfunction anomalies (positive in solid, negative in dashed). The contour interval for streamfunction is +/- $5*10^6$ kg m^2 s^{-1} contoured at intervals of $5*10^6$. The color shading in c), d), g), h) is anomalous OLR in units W m^{-2}.

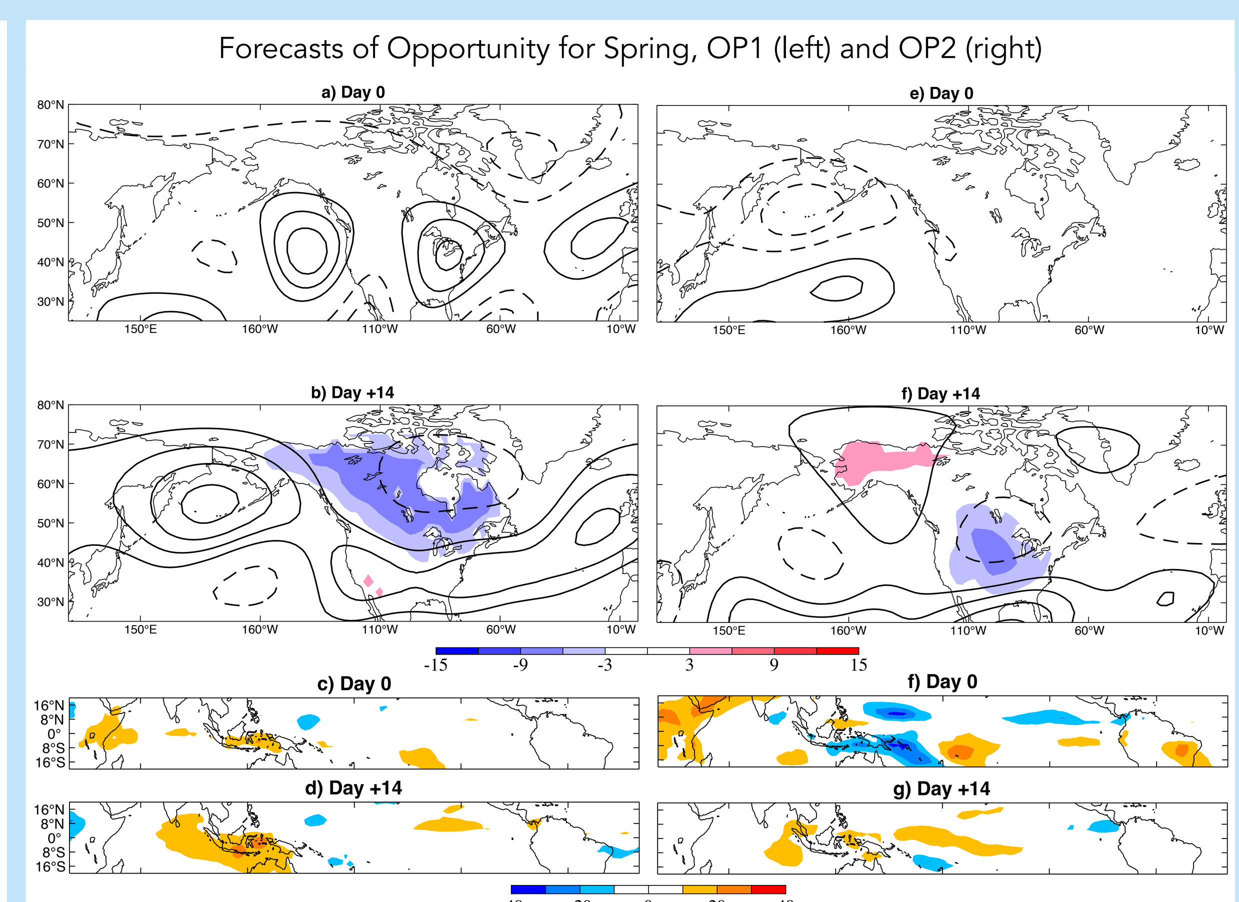


Figure 7: As in Figure 6 but for spring optimal temperature patterns.

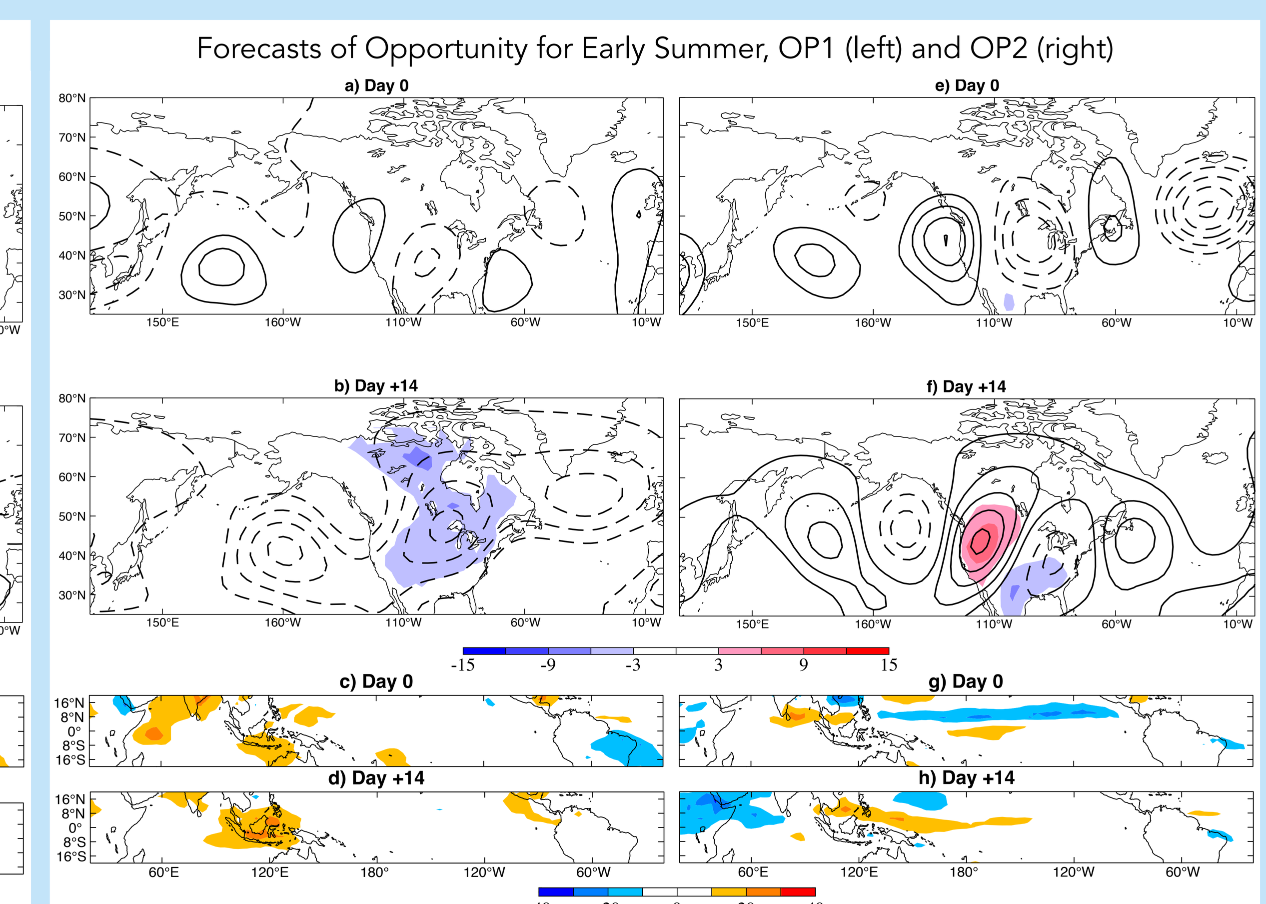


Figure 8: As in Figure 6 but for summer optimal temperature patterns.

Figure 3: Anomaly correlation coefficient (ACC) for weeks 3-4 temperature forecasts. The left column shows ACC using all forecasts during a) winter, b) spring and c) summer phases of the spring transition. The middle column shows ACC for the 20% of forecasts with the strongest projection onto the optimal initial conditions associated with OP1, and the right column shows ACC for the 20% of forecasts with the strongest projection onto the optimal initial conditions associated with OP2. Stippling on panels d) – i) indicates where skill changes are significant at the 95% confidence level.
Taken from Breeden et al., MWR, in review.

Figure 4: As in Figure 3 but for weeks 5-6 forecasts.

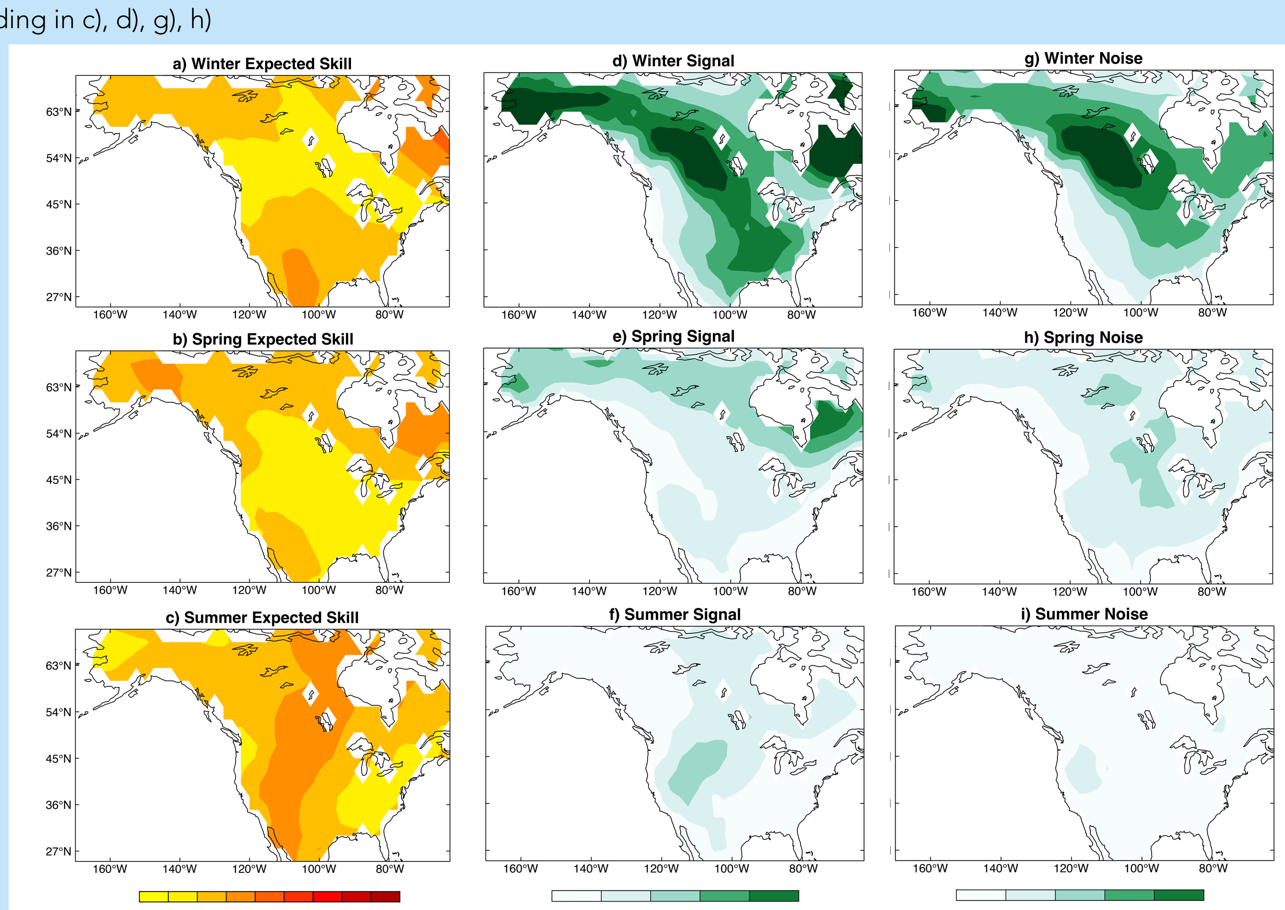


Figure 5: Panels a) – c) show expected skill (units ACC) calculated for the three phases of the spring transition. Panels d) – f) show the forecast signal covariance component of expected skill, and panels g) – i) show the error covariance component of expected skill .

Research Questions

A1: There is a skill minimum in spring (Figures 3-4), consistent with a theoretical minimum in spring forecast signal covariance (Figure 5).

A2: Yes, forecasts of opportunity (Figures 6-8) are frequently associated with elevated skill, with the greatest success during winter and summer.

References

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