J7.6 **LONG-LEAD WINTERTIME POTENTIAL PREDICTABILITY: AN ASSESSMENT FROM NCEP'S CLIMATE MODEL**

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1. Introduction

It is well established that when the tropical forcing is El Nino (La Nina) like, the North Pacific jetstream strengthens (weakens) and extends eastward (retracts backward), and accompanying the change is a below (above) normal Northeast Pacific height anomaly (e.g. Hoskins and Karoly 1981, Rasmusson and Wallace 1983, Wallace and Blackmon 1983, Simmons et al. 1983, Chen and Van den Dool 1997a, Palmer 1998). The simulation and prediction of this prominent interannual variability have been the focus of many research and development institutions (e.g. Gates 1992, and the references therein). The recent efforts have achieved promising results. Barnston and Coauthors (1994) review the progresses made in the long-lead seasonal forecasts. Anderson et al. (1999) evaluate the present-day capability of statistical and numerical models for the atmospheric extratropical seasonal simulation and prediction.

The recent findings indicate that the simulation and skill of the statistical models are on average better than the present-day numerical models. This is still the case even when the systematic biases of the dynamical models are accounted for. This article is not intended for a similar kind of comparison. Instead, we would like to examine the modification of the skill of a dynamical model when it undergoes a change of it basic state. The resulting distinctive skill level associated with an El Nino versus a La Nina type of tropical forcing will be interpreted and its implications discussed.

2. Model and DATA USED

A Seasonal Prediction System has been developed by the NCEP's seasonal prediction modeling group. For detailed description of the system please refer to Kanamitsu et al. (2001). Very briefly, the major schemes of the model are (placed inside the parentheses): resolution (T42L28), convection (relaxed Arakawa Schubert scheme), short and long wave radiation (by M.D. Chow), clouds (Sligo), planetary boundary layer (non-local), gravity wave drag (Albert et al.), land processes (Oregon State University 2-layer soil), orography (smoothed mean), ozone (climatology), and sea surface temperatures (ensemble mean of 16-member coupled forecast).

The Climate Prediction Center is undertaking an extensive evaluation of the model's capability on long-range prediction. For that endeavor, three major categories of model simulations have been conducted:

(1) An ensemble of 10 AMIP 50-year long runs. For which the observed sea surface temperatures (SSTs) for the last 50 years were used as major forcing. Several other 50-year long runs were also conducted for examination of other model behaviors.

(2) An ensemble of 10 7-month long hindcast for every month of the last 21 years (1979 to 1999). These are also being forced by the prescribed SSTs.

(3) An ensemble of 20 7-month long forecasts for every new month as time goes on. For these, the forecasted SSTs are used.

For this article, we place our focus on the modification of the forecast skill when the basic state undergoes a change from an El Nino like to a La Nina like one. The model data used were drawn from the hindcast runs. For verifications, the NCEP/NCAR re-analyses (Kalnay, Kanamitsu et al. 1995) were used.

3. Climatology and Standard Deviation: MDL vs OBS

The simulation of Z500 climatology and variability are examined first. Figure 1 compares the results between the model (MDL) and the observed (OBS). The target season of the simulation is January-February-March (JFM). The period covered is from 1979/1980 to 1999/2000. The MDL results were obtained from the 10 hindcasts initialized in the first five days of their preceding December.

The gross features are similar between the MDL and the OBS. The model shows stronger ridge on the western side of the continents while the polar low is not as deep. Also relevant to this article is the good simulation of the model's variability, as shown in the lower panels. The

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standard deviation (sd) of each individual run was obtained first. The average of 10 runs was then obtained and compared in this figure. As shown, the model's sd is weaker. The smaller variability is most visible over the northeastern Pacific, the Europe, and the eastern Siberia.

4. Simulation of the extratropical response to ENSO anomalous forcing

Before studying the modification of the forecast skills, we would like to get a feel of how well the mean response is of the model to tropical anomalous forcing. And, which region of the globe is most sensitive to the ENSO anomalous forcing. We are particularly interested in a possible change of skill level over this ENSO sensitive region. For this purpose, three categories of JFM atmospheric basic states are examined. They are associated respectively with EL Nino, La Nina, and neutral state of atmospheric circulations. The years that an ENSO episode occurred have been sorted out and posted on the CPC's web site (www.cpc.ncep.noaa.gov). Over the period of 1979/1980 to 1999/2000, six moderate to strong episodes for both the El Nino and La Nina JFMs can be identified from that site. They are:

El Nino JFMs: 1980, 1983, 1987, 1992, 1995, and 1998.

La Nina JFMs: 1984, 1985, 1989, 1996, 1999, and 2000.

And neutral JFMs: 1981, 1982, 1986, 1988, 1990, 1991, 1993, 1994, and 1997.

Figure 2 contrasts the composites of the JFM mean response of each category to those of the observed. The model mean response appears to be well behaved. The height anomaly over the Northeast Pacific is most dominant, for both the OBS and MDL. And, the MDL's mean response over this sensitive region is well simulated. A minor bias of the MDL is to yield more linear response than the real atmosphere, over this ENSO sensitive region as well as over the North America and North Atlantic. However, the ENSO signals are much weaker in these two latter regions. For neutral JFMs, there is not much ENSO signal to talk about, as expected of the near-zero tropical anomalous forcing. The simulations faithfully reflect this feature (the bottom panels).

Since the mean responses are well simulated, we proceed to investigate the modification of the hindcast skill associated respectively with the El Nino and La Nina type of tropical anomalous forcing, resorting to the model run's advantage to generate as many realizations as the computer resource allows. The OBS data do not have this advantage due to its nature of yielding only one single realization.

5. Hindcast skills without correction of systematic model biases

The spatial anomaly correlation (AC) metric is used here to gauge the skill level of the hindcasts. There are four sets of 7-month long ensemble runs that yield January-February-March (JFM) hindcasts: those initialized from September, October, November, and December atmospheric initial conditions, respectively. Figure 3 displays the AC kills of these four sets in three categories: the El Nino, La Nina and neutral JFMs, respectively. What is shown here is for a domain that covers most of the North Pacific/North American (NPNA) region (170E-60W and 25-70N), where most of the relevant information that we try to digest is located. The AC scores for the rest of the Northern Hemisphere, from 60W eastwards through Eurasian continent to 170E, was also evaluated, but it was found to contain very little relevant information.

The stratification, into three categories as shown in Fig. 3, indicates that the skills are much higher when there is an extra tropical forcing. This is entirely expected, for an extra forcing will generate extra extratropical signals which in turn enhance the hindcast skill. What is not entirely expected is the result seen here that there is a decent AC skill even during the ENSO neutral winters (the right-hand 4 panels). Intuitively, the understanding is: for no extra forcing, there is no extra climate signal and therefore zero extratropical predictability. In addition to this puzzle, the AC scores for the La Nina JFMs, as shown here, are almost as high as those of the El Nino JFMs. This is not in agreement with what has been observed by Chen and Van den Dool (1997 a and b). These inconsistencies prompt us to investigate in great detail for an explanation.

6. Hindcast skills with correction of model systematic biases

As shown in Fig. 1, there are systematic biases with this climate model. The error can degrade the model's predictive skill. Correction of the systematic biases to raise the predictive skill is a common practice at most of the forecast operation centers (e.g. Barnston and Authors1997, Anderson et al. 1999). Fig. 4 shows the new AC scores after the correction of the systematic biases. Very dramatically, the average AC scores for the neutral JFMs drops to near zero, as expected. Also as dramatically, the difference in hindcast skill between the El Nino JFMs and the La Nina JFMs becomes widely apart and convincingly distinct

7. Discussion

Another important conclusion to draw from the above results is:
the atmospheric initial conditions are no longer relevant as far as AC skill is concerned. Note the closeness of the AC scores among four sets of hindcasts, which were initialized with a widely different atmospheric initial conditions with at least one month or up to three months apart. Therefore, regarding the SST forced long range prediction problem, the atmospheric initial conditions become irrelevant. The predictive skill becomes a boundary dependent problem and not an atmospheric initial value problem. For the same reasoning, the dependency of an AC skill on the atmospheric initial conditions, as shown in Fig. 3, can now be understood to be just a manifestation of the model biases. There are biases not only between the model and the verification fields, but also between model hindcasts themselves because there are climate drifts as forecast lead-time lengthens (not shown).

Figure 5 gives a feel of how the predicted and the verification look like. It gives example for an El Nino JFM that yields an exceedingly good forecast, a La Nina JFM that yields only a marginally skillful forecast, and a couple of neutral JFMs. As shown, the neutral forcing may produce an exceedingly good forecast as well as an outrageously bad forecast, due entirely to natural variability alone. During an El Nino type of tropical forcing, the climate signals are overwhelmingly strong and the AC skills are consistently high. During La Nina winters, the climate signals are not as strong on average, as seen in Fig. 2. Their AC kills are therefore distinctively inferior.

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Fig. 1 Z500 climatology (clim) and standard deviation (sd) for JFM season, for period of 1980 to 2000

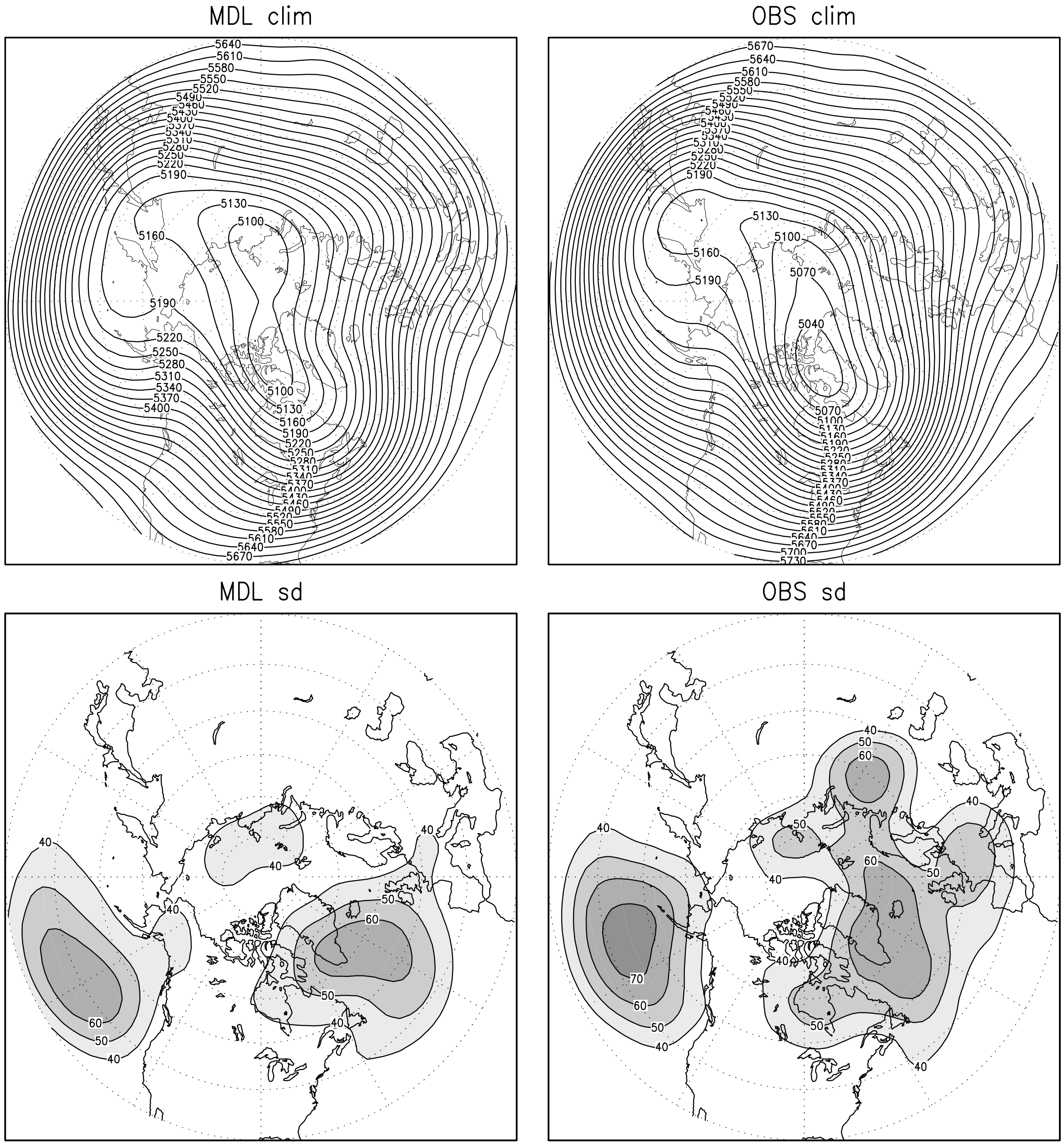

Fig. 2 Comparison of composites of Z500 JFM seasonal anomalies

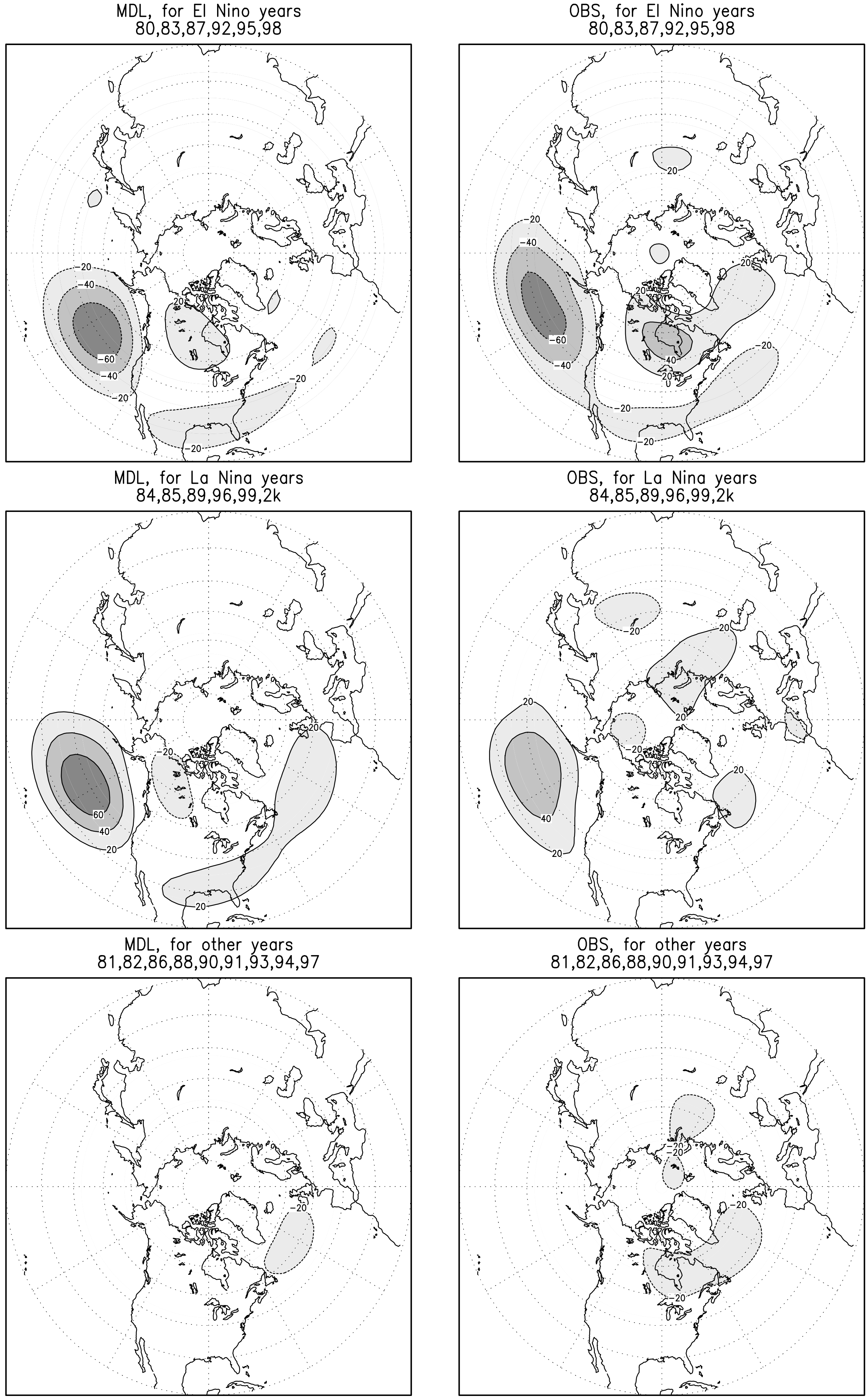

Fig. 3 Z500 hindcast anomaly correlation skills for JFM season
for the N Pacific/N America domain (170E–60W & 25–70N)

for El Nino JFMs for La Nina JFMs for Neutral JFMs

evaluated from hindcasts initialized in the preceding

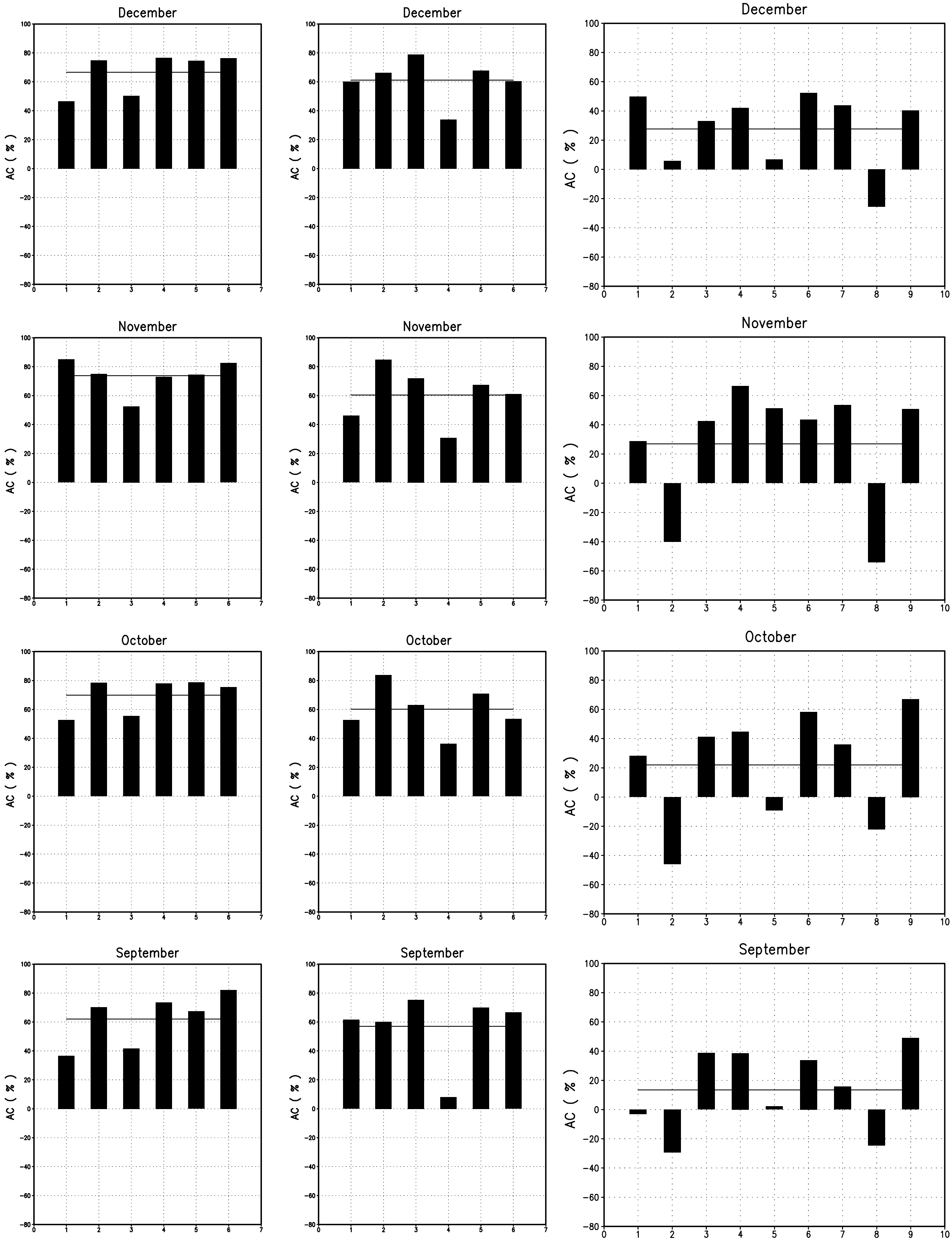

Fig. 4 Modification of Z500 AC scores if biases are corrected
for the N Pacific/N America domain (170E–60W & 25–70N)

for El Nino JFMs for La Nina JFMs for Neutral JFMs

evaluated from hindcasts initialized in the preceding

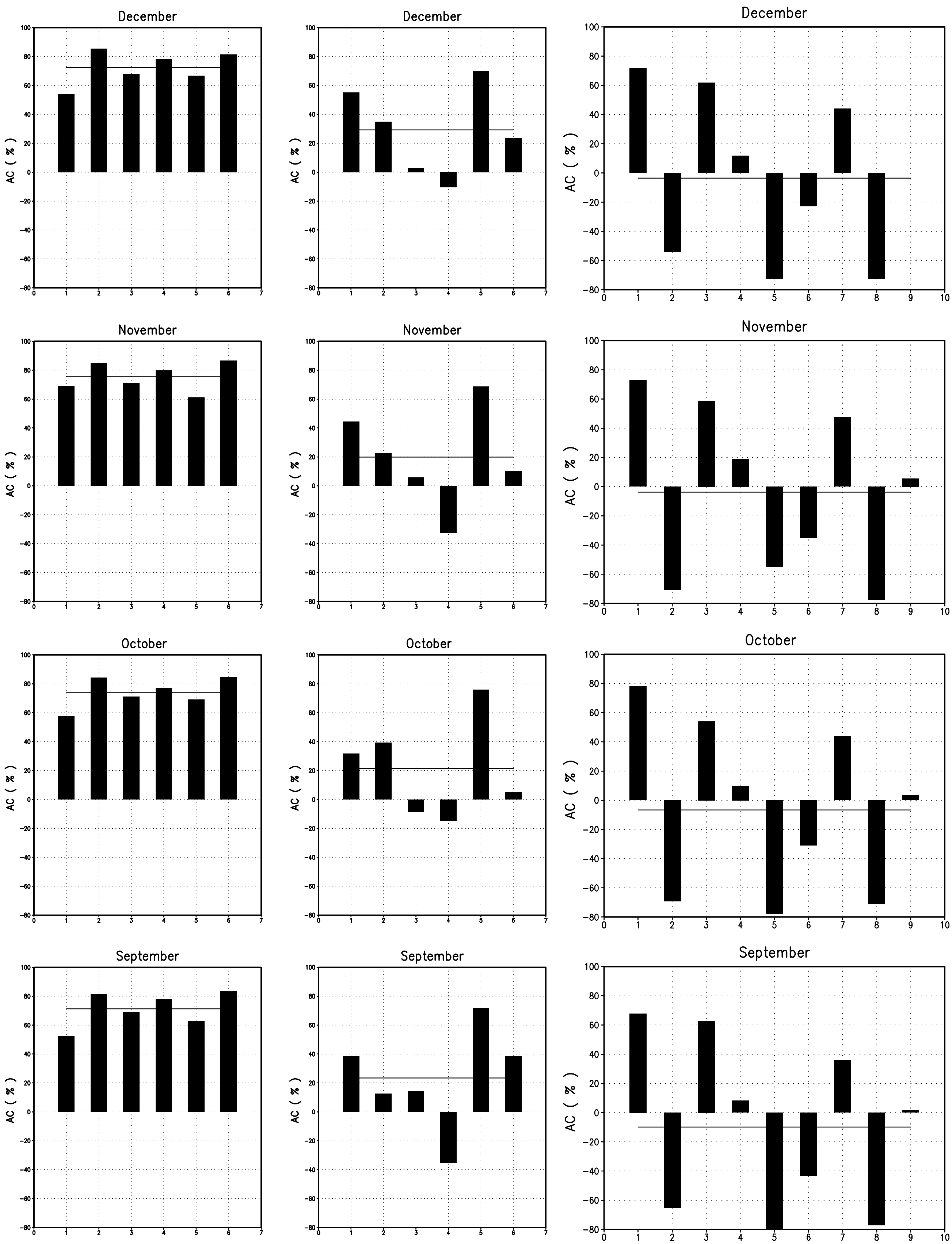

Fig. 5 Verification of Z500 seasonal hindcast