Contributions of tropical-extratropical oceans to the prediction skill of ENSO after 2000

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Abstract

The skill of most ENSO prediction models has declined significantly since 2000. This decline may be due to a weakening of the correlation between tropical predictors and ENSO. Moreover, the effects of extratropical ocean variability on ENSO have increased during this period.

The authors investigate the influence of the extratropical Atlantic and Pacific oceans on ENSO during the pre-2000 and post-2000 periods, and find that the influence of the northern tropical Atlantic sea surface temperature (**NTA SST**) on ENSO has significantly **increased** since 2000. There is a much earlier and stronger correlation between NTA SST and ENSO over the central-eastern Pacific during June-July-August in the post-2000 period compared with the pre-2000 period.

Furthermore, the extratropical Pacific SST predictors for ENSO retain an approximate 10-month lead time after 2000. The authors use SST signals in the extratropical Atlantic and Pacific to predict ENSO using a statistical prediction model. This results in a significant improvement in ENSO prediction skill and an obvious decrease in the spring predictability barrier phenomenon of ENSO.

Results

As shown in Figure 1a, there is no distinct difference in Niño3.4 index variance between these two periods in winter (November–January, NDJ) because of so-called phase-locking. In contrast, the magnitude of WWV variance throughout the year changes noticeably after 2000 (Figure 1b; the annual variance changes from 1.42 before 2000 to 0.72 after 2000). Figure 1c indicates that the peak correlation coefficient between these two indices decreases from 0.75 before 2000 to 0.66 after 2000 (significant at the 95% confidence level), and the time by which WWV leads the Niño3.4 index also decreases (from seven to **four** months).

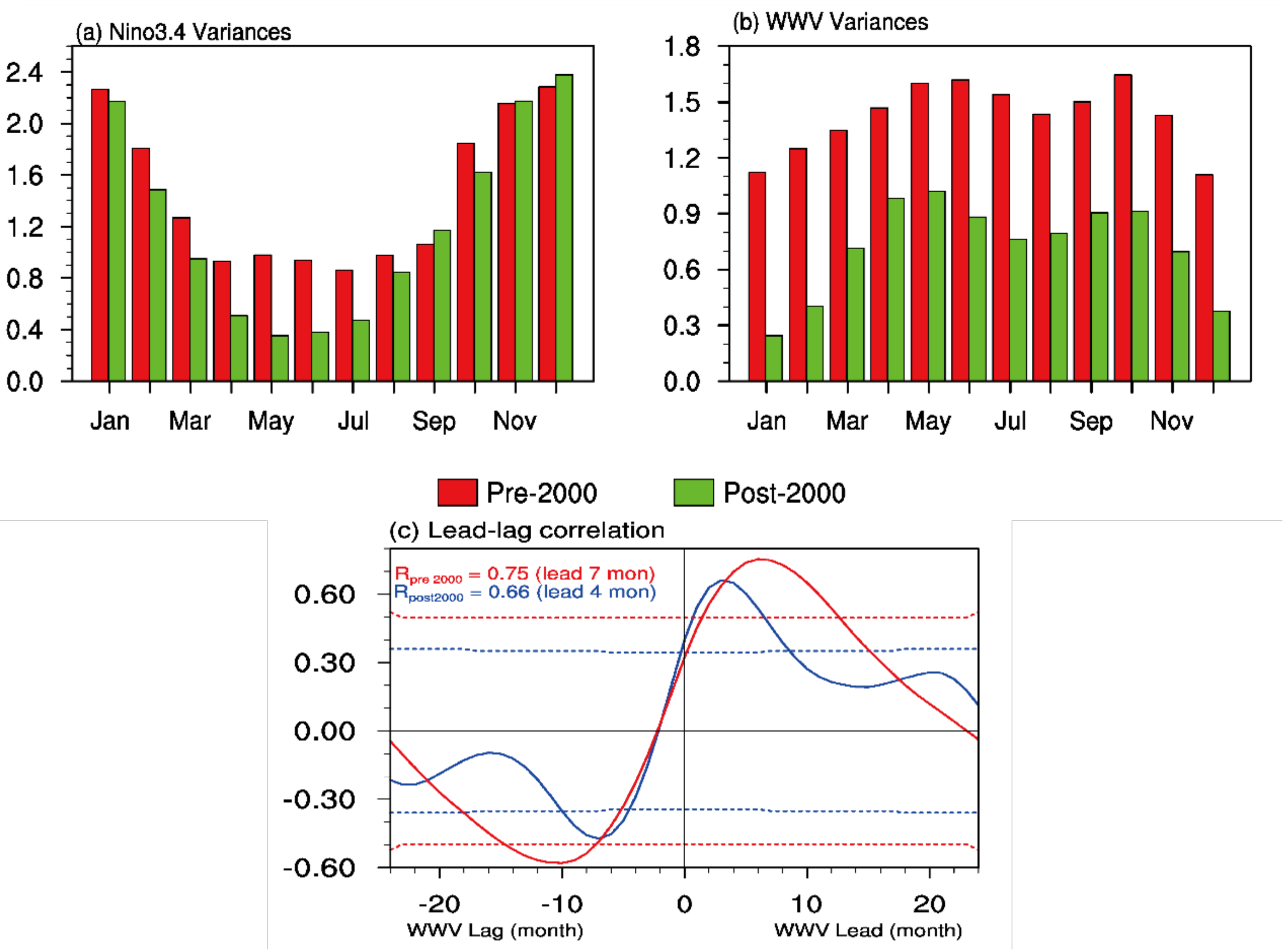

Figure 1. a-b Variances of WWV and Nino34 indices during pre-2000 and post-2000. c the lead-lag correlations between WWV and Niño34 indices.

Results

We investigate the relationship FMA NTAI and Niño34 indices for the two study periods (Figure 2). The magnitude of the correlation coefficient for these two indices is larger after 2000 (−0.36 before 2000; −0.59 after 2000). Results using a 15-year sliding-window correlation analysis also indicate that the relationship between the FMA NTAI and the NDJ Niño3.4 index becomes much stronger after 2000 (Figure 2b).

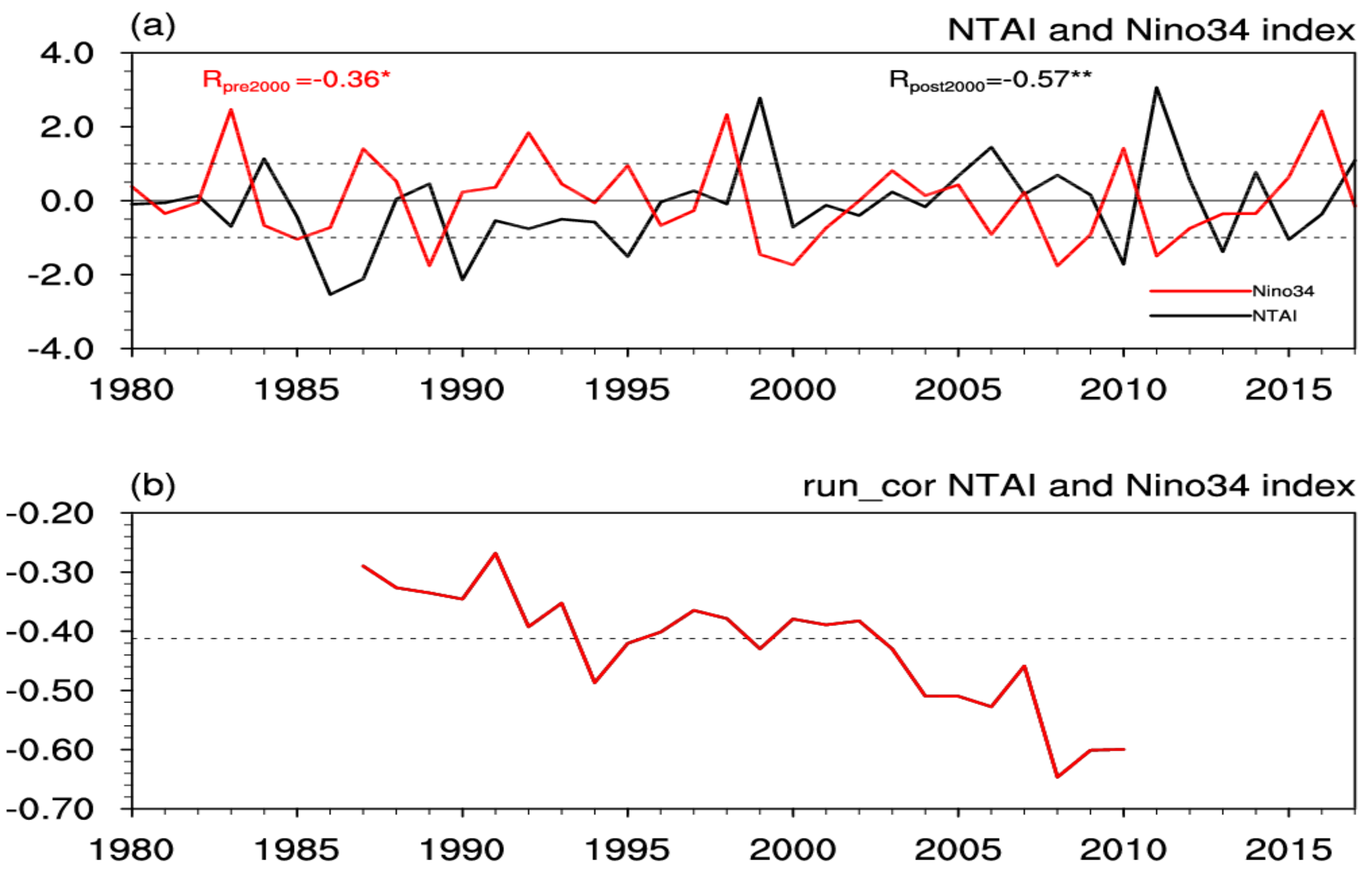

Figure 2. Time series of the FMA(0) NTAI (black line) and DJF(1) Niño3.4 index (red line) for the period 1980–2017, after removing interdecadal variability. The 15-year sliding-window correlation between the FMA(0) NTAI and NDJ(+1) Niño3.4 index for the period 1980–2017.

Results

Compared with the correlation maps before 2000 (Figure 3a–d), the most distinct changes are the range of the negative correlations of the FMA NTAI with the SST over the central-eastern Pacific (black box; 10° S–15° N, 155° E–135° W), which **widens** in June–August (JJA), September–November (SON), and NDJ (Figure 3f–h). In addition, the correlation of the FMA NTAI with SST after 2000 (Figures 3f–h) is **stronger** during JJA, SON, and NDJ, compared with the pre-2000 period.

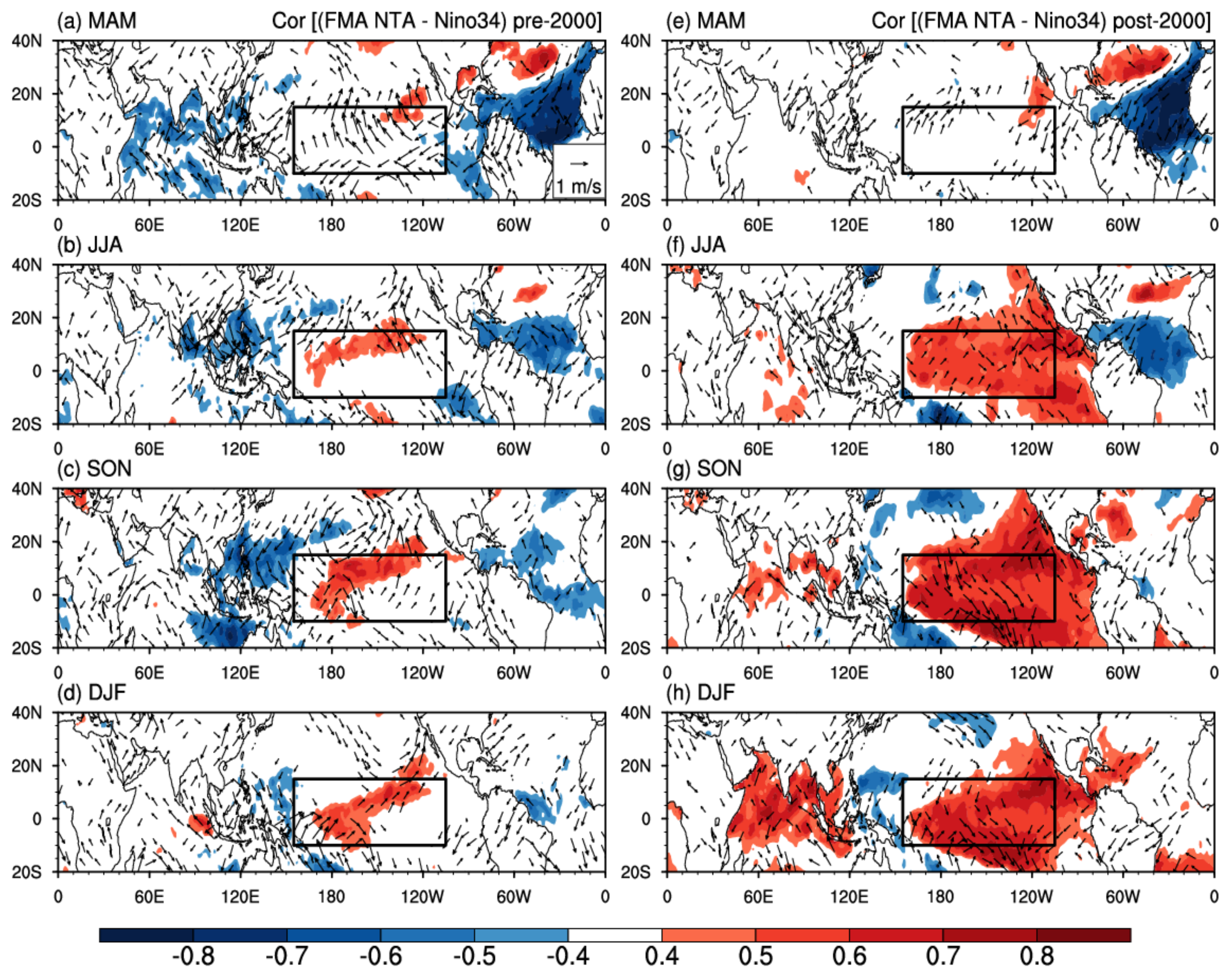

Figure 3. Correlation maps of the FMA(0) NTAI with SST anomalies and near-surface for the pre-2000 and post-2000 periods.

ENSO Prediction model

To test whether the prediction skill of the new ENSO prediction model is improved by considering signals from the extratropical oceans, we incorporate this "extratropical term" into the statistical ENSO prediction model of **Tseng et al. (2016)**, which only considers tropical signals:

$$\mathrm{EPI}_{\mathrm{extratropical}}(t) = \alpha\mathrm{NTAI} + \beta\mathrm{VMI} + \gamma\mathrm{SPQI}, \quad (1)$$

$$\mathrm{EPI}(t) = f\left(\mathrm{EPI}_{\mathrm{tropical}}(t), \mathrm{EPI}_{\mathrm{extratropical}}(t)\right), \quad (2)$$

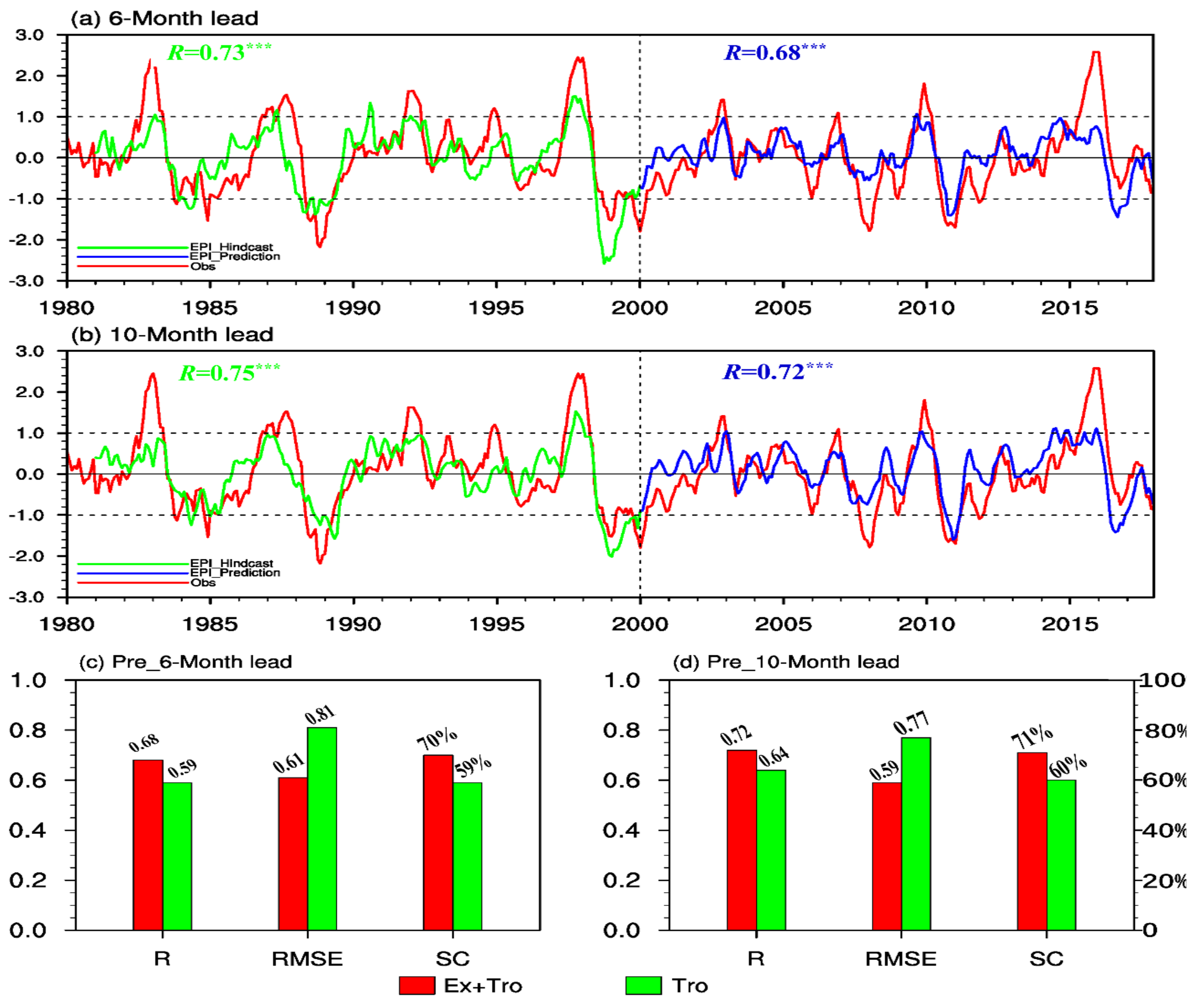

Figure 4. (a-b) Time series of the EPI for a lead time of 6 and 10 months superimposed on the Niño3.4 index . (c-d) The correlation coefficient (R), root-mean-squared error (RMSE), and sign consistency (SC; %) for the new (red) and original (green) ENSO prediction models with lead times of 6 and 10 months.

Conclusions

Based on the noticeably stronger relationship between the Niño3.4 index and three extratropical oceanic signals (NTAI, VMI, and SPQI) after 2000, we include a new term ($\mathrm{EPI}_{\mathrm{extratropical}}$) in the ENSO prediction model of Tseng et al. (2016) with the aim of improving the ENSO prediction skill. The hindcast and prediction skills for the Niño3.4 index are better than when only considering tropical signals, in terms of monthly correlation, RMSE, and SC. Notably, results indicate that the prediction skill (R, RMSE, and SC) with a 10-month lead time is better than that with a 6-month lead time. Results also indicate that our new ENSO prediction model can effectively predict ENSO events during the last decade with a lead time of 10 months.

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