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Decadal/Interdecadal variations in ENSO predictability in a hybrid coupled model from 1881-2000

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1. Introduction

- There are decadal variations in the ENSO amplitude and frequency.
- There are also decadal variations in ENSO's predictability
- The possible mechanism of decadal variations in ENSO predictability
  The decadal change in:
  (1) mean and irregularity
  (2) uncoupled atmospheric noise
  (3) the strength of interannual variability.
- Limitation
  (1) Hindcasts for 20-30 years due to the limited observations
  (2) Chen et al (2004) performed a 148-yr hindca[...]
  they did not explore reasons.

•The Objective of this work

Decadal/interdecadal predictability variations of the equatorial tropical Pacific SSTA in a hybrid coupled model (HCM) during the recent 120 years.

Associated mechanism under this variability by statistical techniques based on 120-yr observation and hindcast experiments.

References：Munich et al. 1991; Jin et al. 1994; Gu and Philander,1997; Kleeman et al. 1999; Kleeman,1999; Barnett et al. 1999; Timmerman and Jin et al. 2002;Latif et al. 1998; Chen et al. (1995) and Ji et al. (1996) Balmaseda et al,1995; Kirtman et al. 1998; Chen et al. 2004 ;Battisti 1989, Kleeman 1994; Kirtman el al.1998)

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2. Data, model, initialization and diagnostic methods

- Data: (ERSST.v2), NCEP-NCAR wind stress
- HCM: A statistical atmosphere model (SVD) coupled to an OGCM(OPA9), domain:30N-30S,122E-70W
- Initial conditions: Initialized by an SST ensemble Kaman filter data assimilation scheme(480 initial conditions, Jan, Apr, Jul and Oct).
- Diagnostic methods: WT, FFT,EOF
- 20-yr running scheme

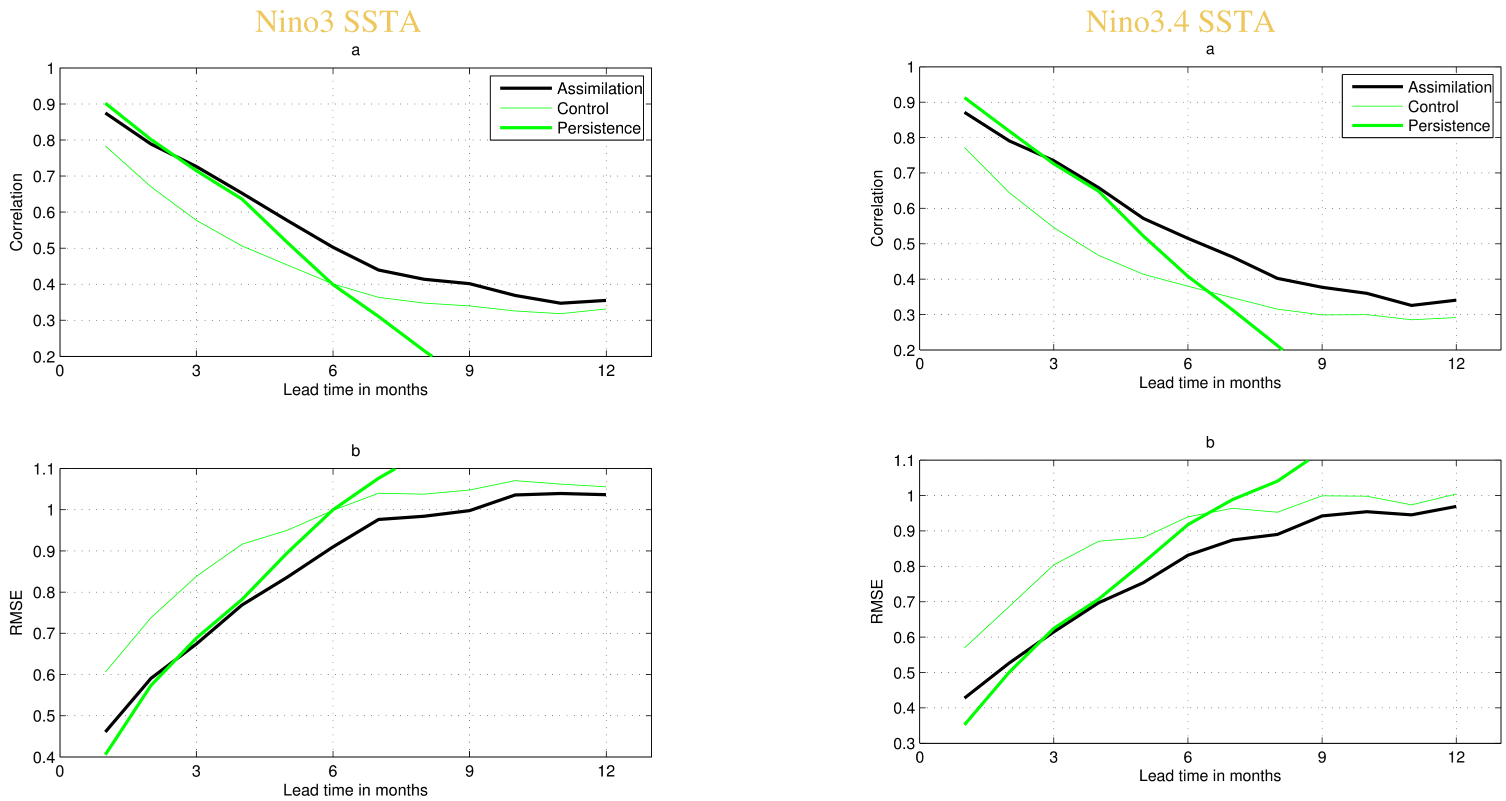

FIG. 1. (a) Correlation and (b) rmse between observed and predicted SST anomalies in the Niño3 (nino3.4)region as a function of lead time. Shown are the calculated persistence (thick gray line), prediction with control simulation initial conditions (thin gray line) and prediction with SST EnKF assimilation initial conditions (thick black line). The skills are based on 480 predictions initialized by January, April, July and October initial conditions for the period 1881-2000.

3. Variations in prediction skills

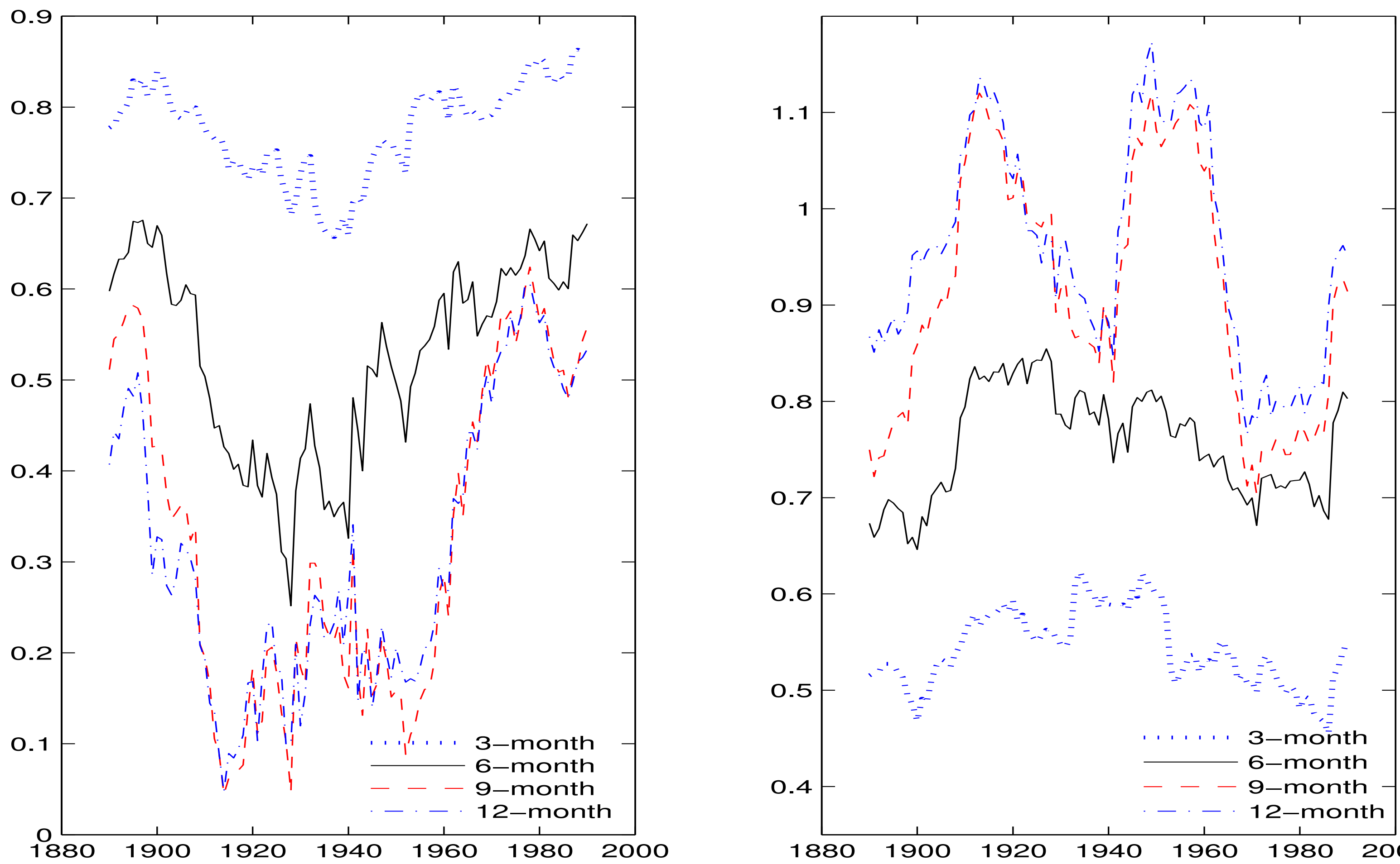

Fig.2. 20-yr running anomaly correlations (left) and RMSE (right) between observed and predicted NINO3 index at lead time 3-month (dotted), 6-month (solid line), 9-month(dashed line) and 12-month (dash-dotted line).

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4. Impact of ENSO features on the predictability

- Amplitude of ENSO variability (V-nino3, VPC1)
- Persistence (persistence at 6-month lead)
- Periodicity (WT power spectrum, V-special band)
- Noise (V-<3month)

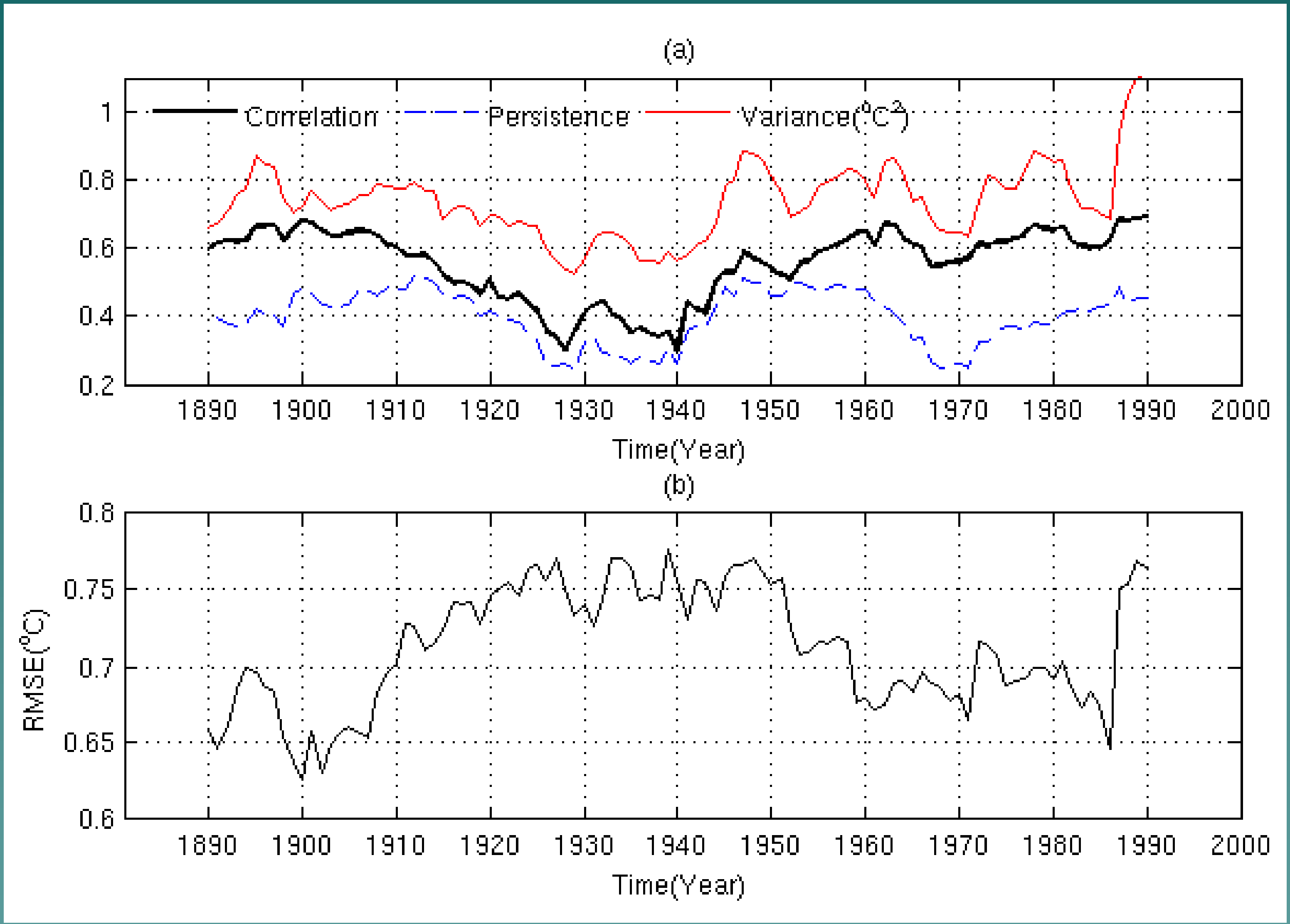

FIG.3. (a) Anomaly correlation between observed and predicted NINO3 SSTA index (thick-solid line), at lead time of 6 months; the persistent correlation prediction skill at lead time of 6 months (thin-dashed line) and the variance of observed NINO3 index (thin-solid line). (b) Anomaly RMSE between observed and predicted NINO3 SSTA index at lead time of 6 months. All time series are obtained using the 20-yr running scheme

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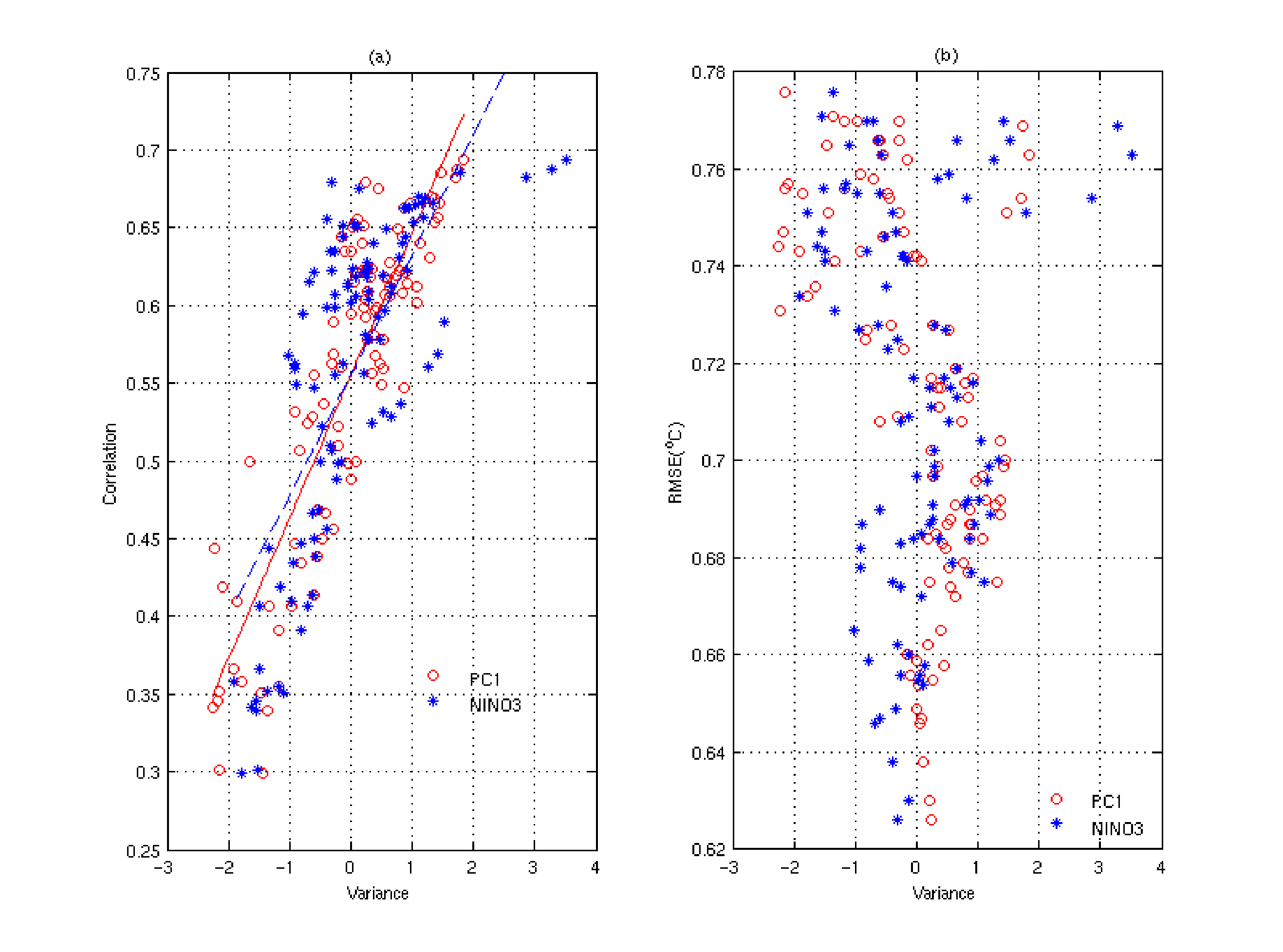


Fig.4 (a) The scattered plot of the correlation skill of predictions at 6-month lead against the variance accounted for by EOF1 (V_PC1) (circle) and against the variance of NINO3 SSTA index (asterisk). The solid (dashed) line was obtained by linear regression to fit the relationship of V_PC1 - Correlation skill (V_NINO3 – Correlation skill). (b) As in (a) but for RMSE.The variances were calculated using the 20-yr running scheme and normalized.

FIG.5. The wavelet power spectrum of NINO3

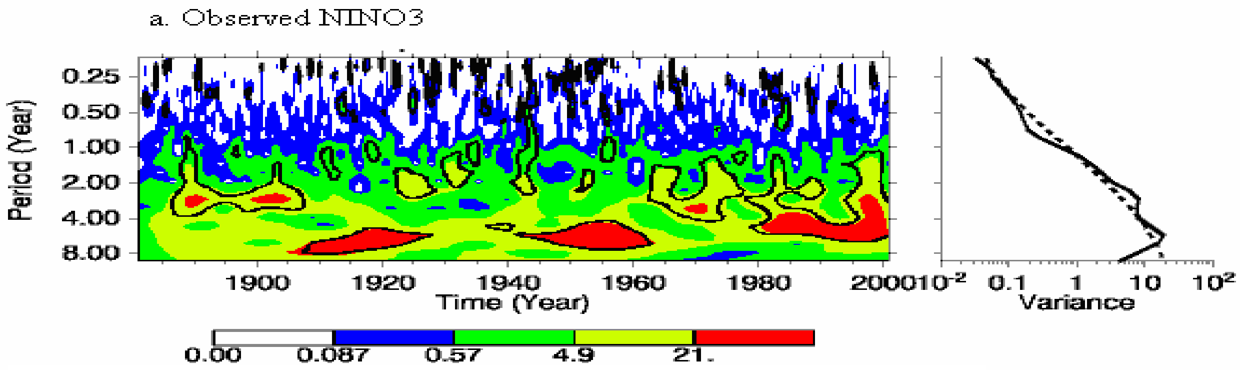
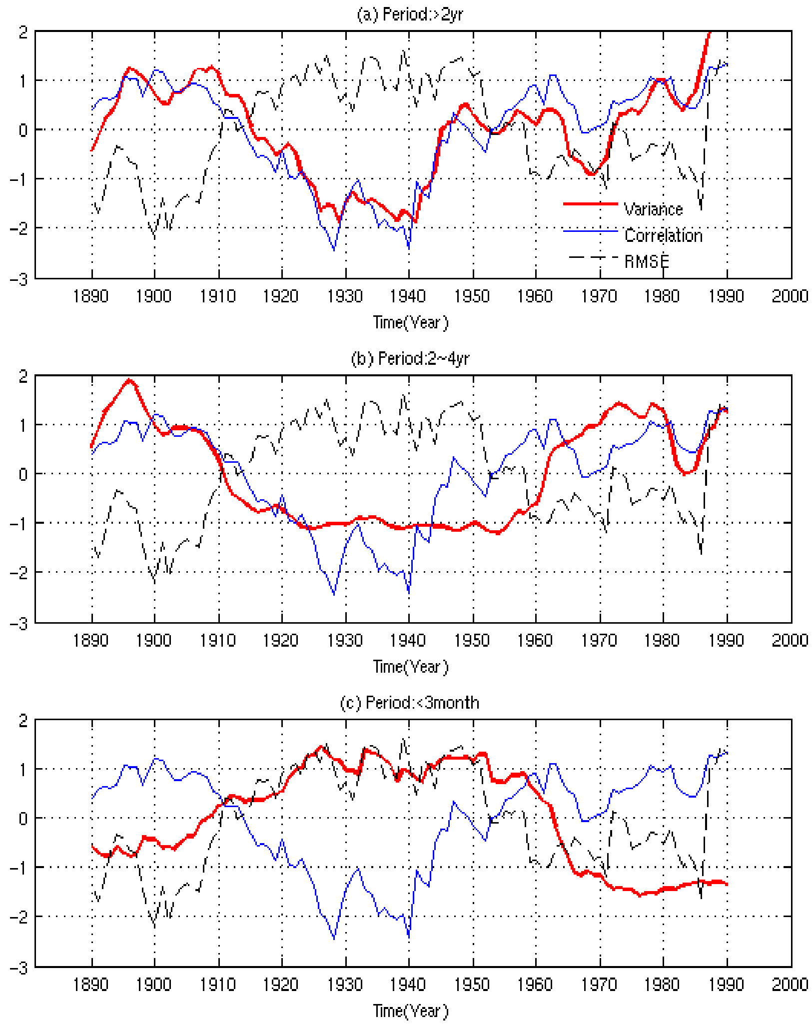


FIG.6. The prediction skills of NINO3 SSTA index at the 6-month leads (thin line for correlation and dashed line for RMSE) and the variance of several decomposed NINO3 SSTA indices (think line), with the signals of (a) greater than 2 yr periods; (b) 2-4 yr periods and (c) less than 3 months. The normalization was performed for each variable for the comparison of different variables.



5. Impact of initial conditions on the predictability

- Initial error in SST
- Surface zonal current and thermocline depth
- Zonal tilt of the equatorial thermocline
- Bred vector growth rate

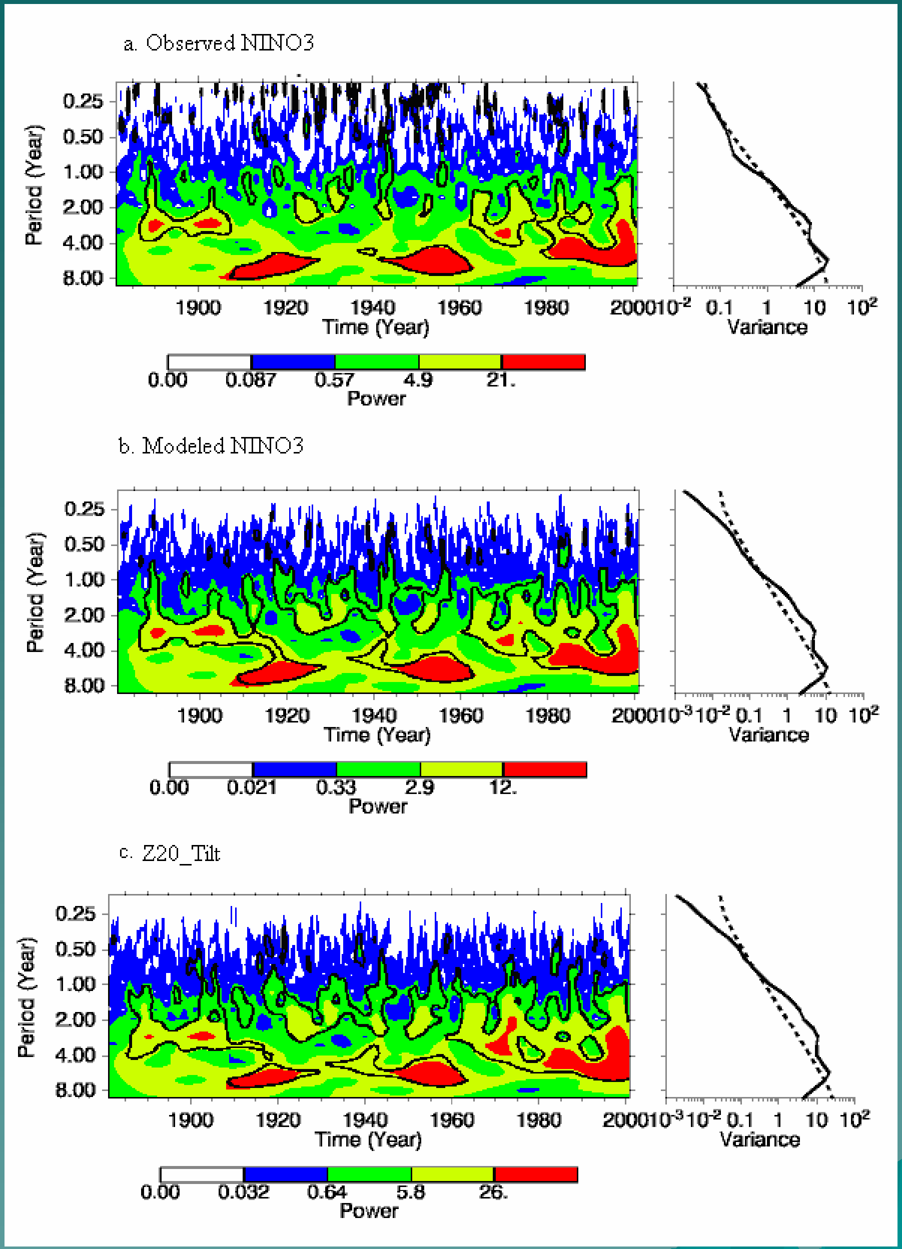


FIG.7. The wavelet power spectrum of (a) observed NINO3 SSTA index, (b) modeled NINO3 SSTA index and (c) Z20_Tilt.

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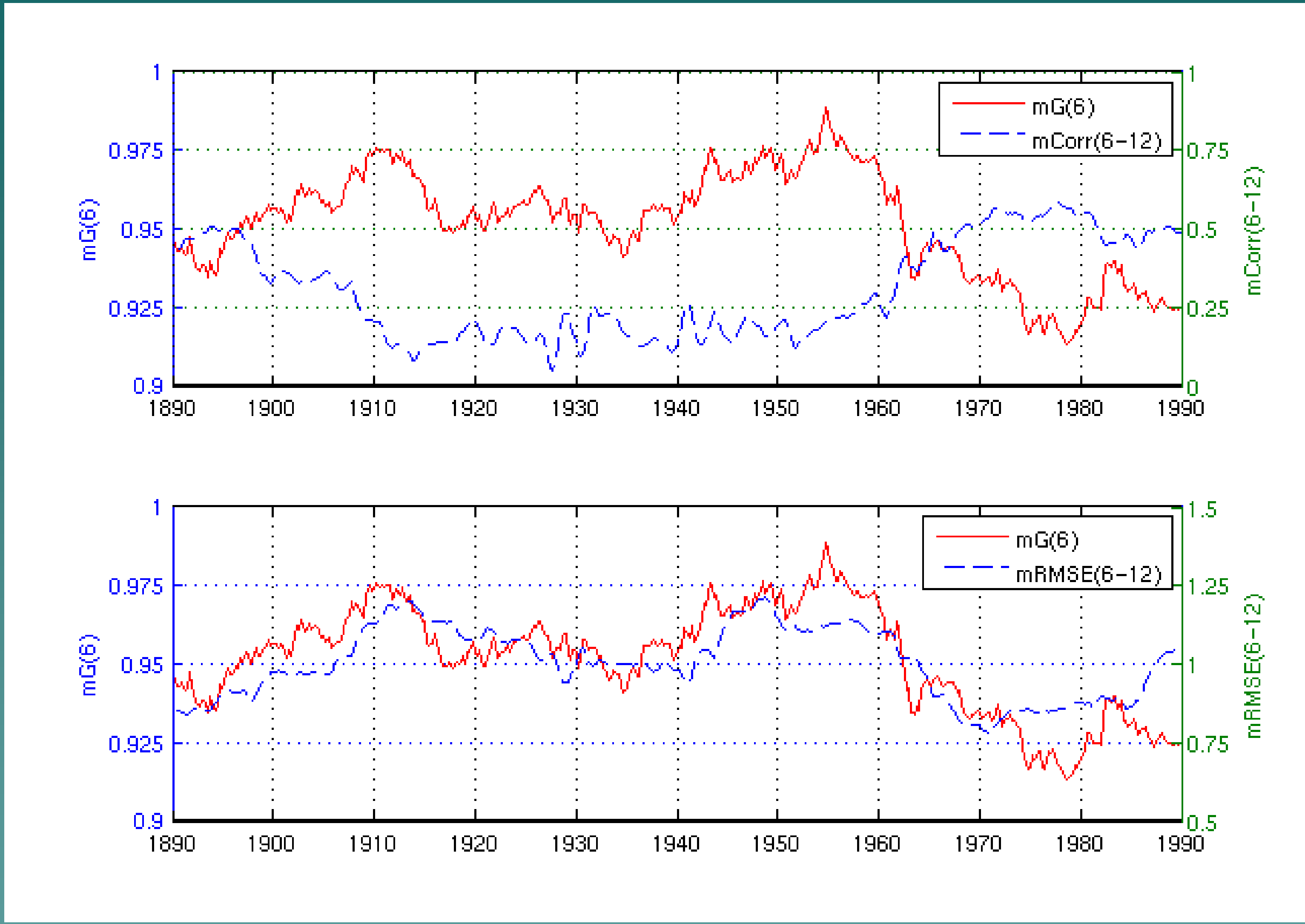

FIG.8 The relation between bred vector growth rate G(6) and the averaged Nino3 SSTA prediction skill Corr(6-12) and RMSE(6-12).

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6. Summary

- ENSO predictability in the HCM shows obvious decadal/indecadal variations that are in general consistent with those in other models (such as Lamont model).

- The decadal/interdecadal predictability variations are in very good agreement with the decadal/interdecadal variations of strength of ENSO signal (period >2yrs).

- The high frequency noise limits ENSO predictability especially when the ENSO signals are weak.

- Since the atmospheric component of the HCM is a simple linear statistical model, it can not resolve high frequency nonlinear variation, this may limit the model's predictability. Hindcast experiments using real Coupled GCM are necessary for the future research.

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Thank you !