The Effect of SST Forcing on Seasonal Prediction by Nonlinear Multimodel Ensemble

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Motivations

◆Nonlinear multimodel ensemble approach is adopted to improve the skill of seasonal prediction.

- It has been long known that an ensemble average of global forecasts from different operational centers is far more skillful than the best individual forecast (e.g., Kalnay and Ham, 1989; Fritsch et al., 200).
- Krishinamurti et al. (2000) have shown that if the mutimodel ensemble includes correction of the systematic errors by regression, the quality of the ensemble system is further significantly improved.

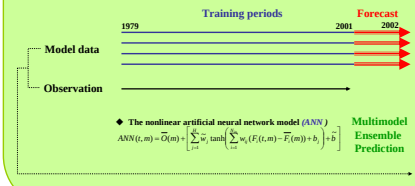
◆Sea Surface Temperature Forcing in two-tier systems

- The atmospheric initial state is more important than external forcing for predicting the evolution of anomalous atmospheric circulation features on timescales up to about 1 month. As the length of prediction extends beyond a month or season, the external forcing, especially sea surface temperature anomalies, has much more impact on atmospheric development than initial conditions.
- The response of AGCM to SST forcing is important to seasonal prediction.

Nonlinear Multimodel Ensemble Prediction System

◆Brief descriptions

- The mutimodel ensemble with correction of the systematic errors by nonlinear neural network model is developed.
- Model forecasts are trained, using hindcast data of participating AGCMs and observation data.



$$ANN(t,m)=\bar{O}(m)+\left[\sum_{i=1}^{n}\tilde{w}_i\tanh\left(\sum_{k=1}^{m}w_{ik}(F_i(t,m)-\bar{F}_i(m))+b_i\right)+\tilde{b}\right]$$

◆Participating models

- ➔ Four AGCMs in cooperation with three Universities in Korea
- METRI AGCM / METRI
- CCM3 / Pusan Universities
- CAM2 / Seoul National University
- CCSR AGCM / Kongju University

◆ Hindcast data

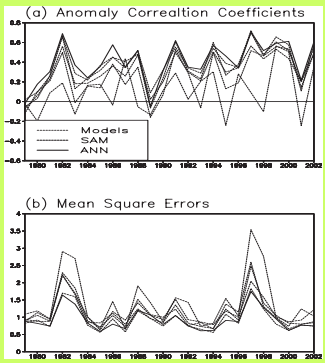
- Period : winter for 1979/80-2002/03
- Initial condition : NCEP/DOE reanalysis
- SST : OISST
- Individual ensemble : 10 member with lagged I.C.

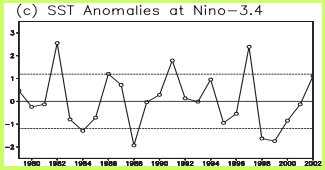
Results and Discussion

❖Relation between SST forcing and prediction of precipitation

◆ Results of ANN and its relation with SST forcing

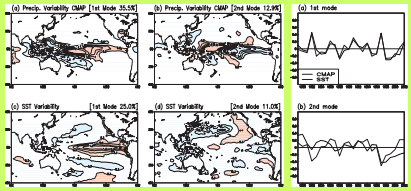
✓Cross-validation is adopted





- The skill of precipitation prediction by nonlinear multimodel ensemble (ANN) technique is better than those of each participating models.
- Figures showed that years of high skill are almost strong ENSO phase.
- It shows that there are strong relation between SST forcing and skill of prediction.

◆EOF Analysis of precipitation and SST



- The EOF analysis of boreal winter precipitation shows two leading mode, which are ENSO (El Nino-Southern Oscillation) and PDO-like (Pacific decadal oscillation) modes.

◆Correlation between prediction and observation

		Model 1	Model 2	Model 3	Model 4	SAM	ANN
Time series	1st Mode	0.940	0.972	0.968	0.320	0.940	0.972
	2nd Mode	0.827	0.950	0.904	0.471	0.905	0.937
Spatial pattern	1st Mode	0.653	0.725	0.625	0.713	0.772	0.915
	2nd Mode	0.541	0.709	0.580	0.628	0.756	0.807

✓Pattern correlations coefficients of the spatial patterns and temporal correlation coefficients of time series for two leading modes obtained from EOF analysis of precipitation by participating models and multimodel ensemble with observation.

- The improvement of predictability by NME technique is due to the correction of the spatial structure of the variability of precipitation in response to SST forcing.

❖Sensitivity of SSTA to ANN

◆Description of sensitivity experiment

Node	Data for training period	Data for forecast period	Consistency of data
ExpOO	OSSTA	OSSTA	Consistent
ExpPP	PSSTA	PSSTA	Consistent
ExpOP	OSSTA	PSSTA	Inconsistent

- OSSTA: Prediction with observed sea surface temperature anomaly
  - ➔ SIMP type
- PSSTA: Prediction with persisted sea surface temperature anomaly
  - ✓ Observed October SSTA + monthly Climatology
  - ➔ SMIP/HFP type

◆Results of experiment : prediction of precipitation

	Model		SAM		ANN		
	OSSTA	PSSTA	OSSTA	PSSTA	ExpOO	ExpPP	ExpOP
ACC	0.264	0.198 (-0.250)	0.357	0.276 (-0.227)	0.405	0.302 (-0.254)	0.261 (-0.356)
MSE	1.206	1.380 (+0.144)	0.935	1.082 (+0.157)	0.931	1.048 (+0.126)	1.286 (+0.381)

( ) : Ratios of the difference from control experiments (OSSTA or ExpOO).
➔ (PSSTA-OSSTA)/OSSTA or (ExpXP-ExpOO)/ExpOO

- The ANN with persisted SSTA degrades predictability about 25 % against observed SSTA.
- In case there is the inconsistency of data between training and forecast periods, forecast skill of ANN is degraded additional 10 %.

◆Correlation between prediction and observation

		ExpOO	ExpPP	ExpOP
Time series	1st Mode	0.972	0.858	0.857
	2nd Mode	0.937	0.848	0.846
Spatial pattern	1st Mode	0.915	0.914	0.816
	2nd Mode	0.807	0.796	0.728

- Intraseasonal variation of SST anomaly affects temporal variability of precipitation reproduced by ANN.
- Inconsistency between training data and forecast data affects on both temporal and spatial variability.

Summary

❖ According to the forecast results of boreal winter precipitation, the prediction skill reproduced by nonlinear multimodel ensemble (ANN) is better than individual model skill.
❖ The improvement of predictability by ANN technique is likely due to the correction of the spatial structure of the variability of precipitation in response to SST forcing.
❖ The ANN with persisted SSTA degrades predictability about 25 % with respect to potential predictability.
❖ In case there is the inconsistency of data between training and forecast periods, forecast skill of ANN is degraded additional 10 %.
❖ It is found that the intraseasonal variation of SSTA affects the temporal variability of ENSO and PDO-like mode in predicted precipitation, and the inconsistency of data between two periods affects both temporal and spatial structure of variability.