

Improvement of the APCC Probabilistic Multi-Model Seasonal Prediction by Model Calibration and Combination

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Motivation and Goals

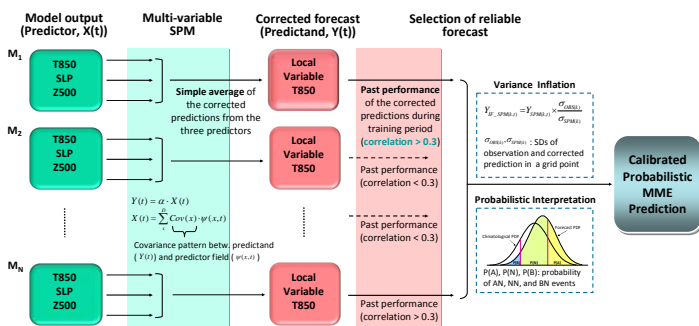
Motivated by the superiority of a **step-wise pattern projection method (SPM)** to correct errors in the predicted anomalies (e.g., Kang and Shukla 2005; Kug et al. 2008a, b)

Possibility of improving the forecast skill by **selecting skillful models** among all possible candidates for multi-model combination (e.g., Stephenson et al. 2005; Lee et al. 2011)

Improvement of a probabilistic multi-model prediction (PMMP) system in the APCC

- ① To calibrate single-model prediction → a **multi-variable version of SPM**
- ② To calibrate the probabilities of multi-model predictions → **inflation of model variance**
- ③ To combine the single-model predictions → **skill-based model selection** for multi-model combination

Methods for PMMP improvement



◆ **SPM** is a kind of regression model based on pattern projection and it is based on the large-scale patterns of the predicted variables by models (i.e., predictors) correlated with a local (or grid) observed variable (i.e., predictand).

Data and Experimental Design

- ◆ **Period:** 23-year retrospective (1981-2003) and 3-year real-time (2008-2010) forecasts
- ◆ **Target:** seasonal mean temperature and precipitation for June-July-August (JJA)
- ◆ **Observation for verification:** CAMS-OPI for precipitation, NCEP/NCAR Reanalysis II for temperature

Model	Institution (Country)	Resolution	Ensemble (H/F)	SST Specification (H/F)	Reference
CWB	CWB (Chinese Taipei)	T42 L18	10/10	Predicted SST/Predicted SST	Liou et al. (1997)
GCPS	SNU (Korea)	T63L21	12/12	Predicted SST/Predicted SST	Kang et al. (2004)
GDAPS	KMA (Korea)	T106 L21	20/20	Predicted SST/Predicted SST	Park et al. (2002)
GEM	MSC (Canada)	2½x2½ L50	10/10	Persistent ERA40-SST/Persistent CMC SST	Cote et al. (1998)
AGCM2	MSC (Canada)	T32L10	10/10	Persistent ERA40-SST/Persistent CMC SST	McFarlane et al. (1992)
SEF	MSC (Canada)	T95 L27	10/10	Persistent ERA40-SST/Persistent CMC SST	Ritchie (1991)
NIMR	NIMR (Korea)	5½x4½ L17	10/10	Persistent NOAA OISST/Persistent NOAA OISST	Back et al. (2002)
NCEP	NCEP (USA)	T62 L64	15/15	Predicted SST/Predicted SST	Saha et al. (2006)
PNU	PNU (Korea)	T42L18	5/5	Predicted SST/Predicted SST	Park et al. (2004)
POAMA	BMRC (Australia)	T47L17	10/30	Predicted SST/Predicted SST	Zhong et al. (2005)

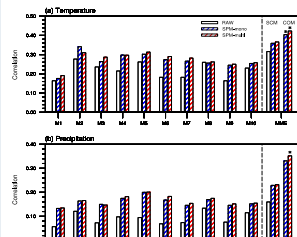
Set of experiments to assess the benefits of the proposed model calibration and combination methods

Experiment	Acronym	Description
None	RAW	Single (or multi)-model ensemble from raw model output
Correction	SPM-mono	Corrected single (or multi)-model ensemble using the mono-variable version of SPM
	SPM-multi	Corrected single (or multi)-model ensemble-mean using the multi-variable version of SPM
Combination	SCM	Simple multi-model ensemble with equal weighting (i.e., simple composite method)
	COM	Simple multi-model ensemble obtained from the SPM-based corrected single-model predictions of the skill-based selected models
Inflation	INF	Inflated simple multi-model ensemble obtained from the SPM-based corrected single-model predictions of the skill-based selected models (i.e., inflated COM)

Result and Summary

Sensitivity Test for Proposed Methods

Temporal Correlation



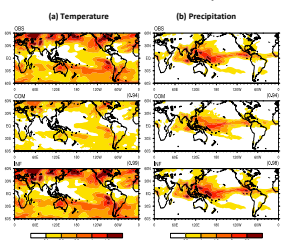
Benefits of an upgraded multi-variable SPM (SPM-multi)

- The SPM-multi skill is slightly higher than the SPM-mono one.
- Main advantage: not a significantly large improvement in a certain case, but rather the **consistently better performance of the SPM-multi** when considering all aspects of the predictions.

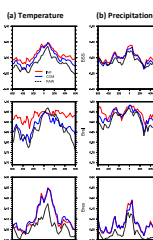
Benefits of model combination (COM)

- The thing to note from a comparison of the corrected SCM and COM predictions is the **increased skill when considering only the skill-based selected models** for multi-model combination.
- **Combined method** of model correction using the SPM-multi and combination is the **most effective** over the globe, indicating the estimated TCCs being statistically significant at the 5% level.

SD of Interannual Variability



Brier Skill Score



Benefits of variance inflation (INF)

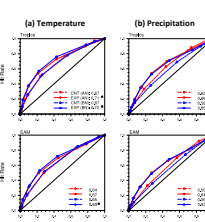
- The INF of model forecasts can contribute to the **accurate estimation of forecast uncertainty** and then to the **increase in forecast reliability** that leads to the **improvement of probabilistic forecast skill**.
- Given the improvement of both the reliability (due to variance inflation) and the resolution (due to model correction and combination), it can improve the BSS with respect to the reference forecast.

◆ The combined method of model calibration (using the SPM-multi with variance inflation) and combination (based on skill-based selected model) is **effective way** to improve the multi-model probabilistic prediction.

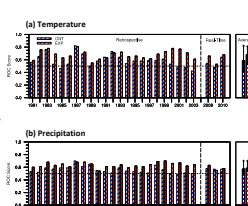
◆ This provides a basis for consideration of the use of the proposed methods for improvement of the operational version of uncalibrated PMMP system (Min et al. 2009).

Improvement of the PMMP

ROC Curve and Score



ROC Score



Calibrated probabilistic forecasts

- A **better resolution** (or potential skill) not only for the tropics but also the EAM region, which has been recently pointed to as a major challenge in seasonal prediction.
- **Consistently better performance** than the uncalibrated system both for the retrospective and real-time forecasts.
- Its **year-to-year forecast skill** is more stable, indicating the range of interannual variations being small.

- ◆ The calibrated PMMP with the proposed model calibration and combination method has **significantly higher skill** than the current version of (uncalibrated) operational PMMP system for both variables over the globe during the period 1981-2003.
- ◆ It is further shown that the new PMMP system has also improved forecast skill during the real-time forecast period 2008-2010 than the current operational system.

SUMMARY: Efforts has been devoted to improving a probabilistic multi-model prediction system in the APCC.

The novelty of the proposed system lies in (i) the use of the upgraded multi-variable version of the SPM to calibrate single-model predictions and obtain more reliable forecast probability, and (ii) the combination based on skill-based model selection among calibrated single-model predictions to formulate multi-model probabilistic prediction. A comprehensive assessment of the benefits of the proposed methods in the new PMMP system indicates that both the calibration and combination significantly contribute to improve the prediction skill for the most regions of the globe. As a result, the calibrated PMMP show consistently better and stable performance than the uncalibrated one.