Dynamic Seasonal Prediction System in KMA
- National Report -

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In KMA we are using both statistical and dynamic models for the long-range weather forecast. The dynamic ensemble forecast became the primary tool since we started using new supercomputer since June 1999.

1. Dynamic Models

KMA has a global spectral model with horizontal resolution of T106 and 21 vertical levels with 10hPa of P-top for operational long-range forecast. The boundary condition over the ocean is fixed throughout the forecast period with the latest weekly SST anomalies added to the monthly AMIP climatology. Initial soil moisture, initial snow depth, roughness length and albedo are climatological. This model uses Kuo (1974) scheme for cumulus parameterization, Mellor and Yamada (1982) scheme for PBL and SiB model (Sellers et al., 1986) for land surface process.

We developed a new long-range forecast model with the same dynamics as the operational model, but different physics to improve predictability of East Asia precipitation. It has been conducted together with Seoul National University research team. The main differences between operational model and experimental model are shown in this table.

Table 1. Comparison of main physical processes between operational and experimental model

	Operational model	Experimental model
Cloud Convection	Kuo (1974)	Simplified Arakawa-Schubert, Diffusion type-Shallow Convection, Le Treut & Li (1991)
Land Surface & PBL	SiB; Yamada-Meller (1982)	LSM (Bonan,1996); Non-local PBL/Vertical Diffusion (Holtslag & Boville, 1993)
Radiation	Lacis & Hansen (1974) for SW, Roger & Walshaw (1966); Glodman & Kyle (1968); Houghton (1977) for LW	Nakajima & Tanaka (1986, 2-stream k-distribution radiation scheme)

1.1 Model Operation

Lagged Average Forecast (LAF) method is applied for ensemble prediction with different initial conditions produced by our global analysis and prediction system. The number of ensemble members is 20 with 12-hr initial conditions using.

The operational model integration is performed everyday for 130 days. We produce 1-month forecast every 10 days with 1 week of lead time, and seasonal forecast with 1 month of lead time four times a year. KMA has issued 6-month forecast since 2001. For 6-month forecast, We perform the model integration for 7 months two times a year and produce it with 1 month of lead time.

1.2 Supercomputer of KMA

KMA's Main computer system for operational weather forecasts is NEC SX-5, which is a parallel vector processor machine with 2 nodes connected by Internode Crossbar Switch. Two nodes consist of 28CPUs, 16 and 12 CPUs each, and performance of each CPU is 8GFlops, so all together 224GFlops. SX-5 has main memory of 224GB and 4.5TBl disk size.

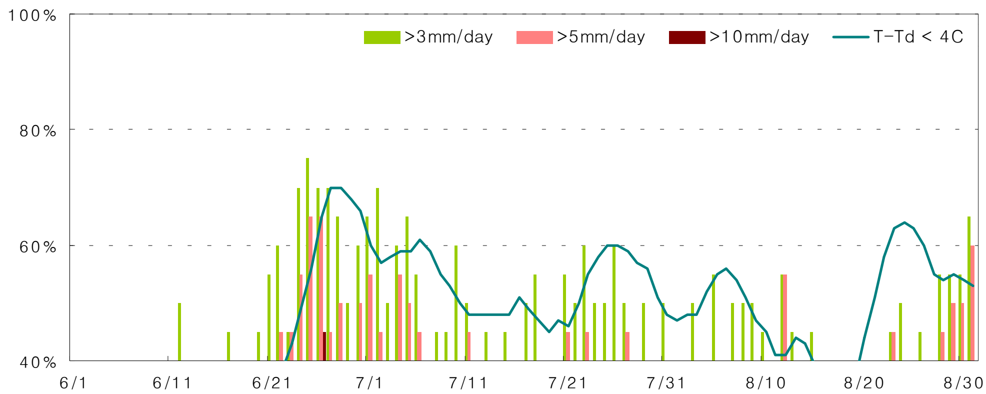
Currently, SX-5 can accommodate operational model runs for short-term, medium and long-range weather forecasts, and some research and development for operational models.

1.3 Model Results

The operational model results of temperature, precipitation, geopotential height, sea level pressure and Moisture flux for 1-month and seasonal forecasts are provided in KMA internet homepage at:

<u>*http://www.kma.go.kr.*</u>

KMA also produce probability charts of temperature and precipitation which are very reliable and effective to predict events or intensity that we can hardly forecast with averaged fields (Fig. 1).



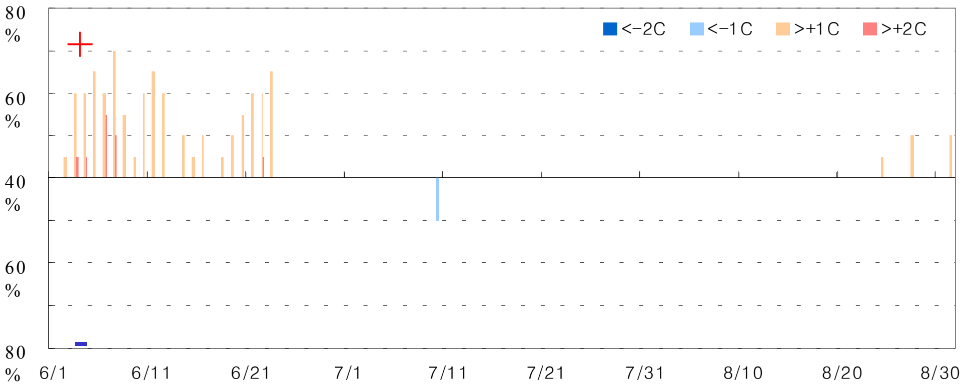


Fig. 1. Precipitation Probability for 2001 summer forecast (above) and Temperature Probability for 2002 summer forecast (below).

2. The Structure of El Nino Prediction Model

For the tropical SST prediction, KMA is using Intermediate dynamic El Nino prediction model which is similar to, but improved, Cane-Zebiak model (Zebiak and Cane, 1987). This model has a simple statistical atmosphere interfaced with the tropical ocean dynamic model which interact through SST and wind stress. SST is determined by two terms, horizontal temperature advection and upwelling. The upwelling term is a function of vertical temperature gradient, which is one of the most challenging term to calculate in simple ocean models. The vertical temperature gradient is obtained from the difference between temperatures at the surface and sublayer. Once SST is determined, the wind stress is computed statistically to give a forcing to the ocean model (Fig. 2).

Since this model is not fully coupled, determination of wind stress is problematic in many simple El Nino prediction models including CZ type model. So we introduced simple, but more reliable way of computing wind stress using simple statistics. We computed Singular Value Decomposition (SVD) using observed SST anomalies and observed wind stress, and used two primary modes in the transform function. Therefore, ocean model gives the surface ocean temperature anomaly information, it is transformed to provide wind stress by the simple statistical transformation (Fig. 3).

KMA has improved the El-Nino prediction model by changing the subsurface temperature parameterization (Kang and Kug, 2000). The parameterization of subsurface temperature is replaced by a statistical relationship constructed based on SVD of the 20℃ isotherm depth and the water temperature at 45m depth from the NCEP ocean assimilation data. As a result, the predictability has been improved by replacing the computation of subsurface temperature from hyperbolic tangent function to empirical method. This result is verified by model run for 20 years from 1980 to 1999. It is available on the KMA Internet homepage.

KMA also improved the model by using NCEP reanalysis instead of FSU data for initial wind stress. A historical wind stress data was obtained based on the 925hPa winds of NCEP reanalysis data and was compared to the FSU wind stress. The time evolution of FSU zonal wind stress along the equator is compared to that of the NCEP zonal wind stress. The hindcast experiments are carried out with the same ocean model but with the two different sets of wind stress data for the period from January 1970 to December 1999.

The prediction experiments with an intermediate ocean and statistical atmosphere model indicate that the prediction skill of the tropical Pacific SST with the NCEP wind stress data is better than that of FSU wind stress for the period of 1980-1999 (Figs. 4b and 4c). The NCEP reanalysis wind stress is used for the initialization of the intermediate El Nino prediction model, and the forecast skill is improved compared to that using FSU wind stress (Fig. 5). We emphasize that this does not necessarily imply that NCEP wind stress is closer to truth than the FSU wind stress. However, the NCEP wind stress is most likely better balanced with the large scale SST forcing because of the model-based assimilation system with observed SST forcing that is used to produce it. This balance can be important for prediction with intermediate models in particular.

The improved model results for 6-month predictions of tropical SST anomaly, thermocline depth, and Nino 3 index are provided on the KMA Internet home page.

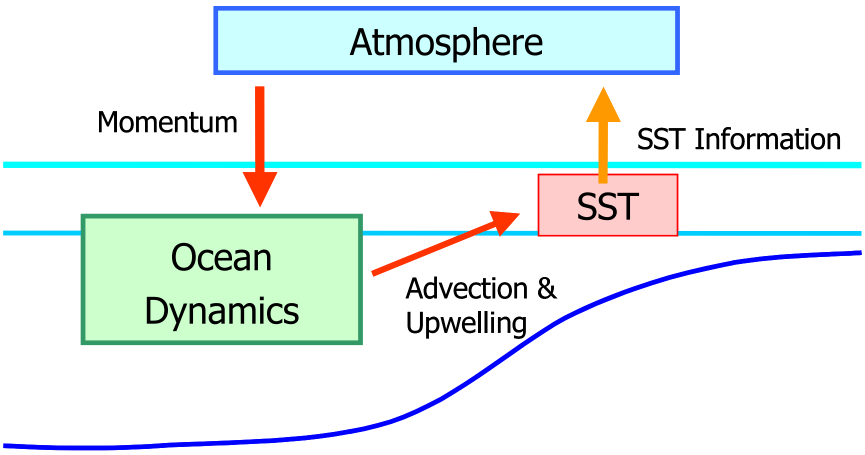


Fig. 2. Structure of El Nino prediction model.

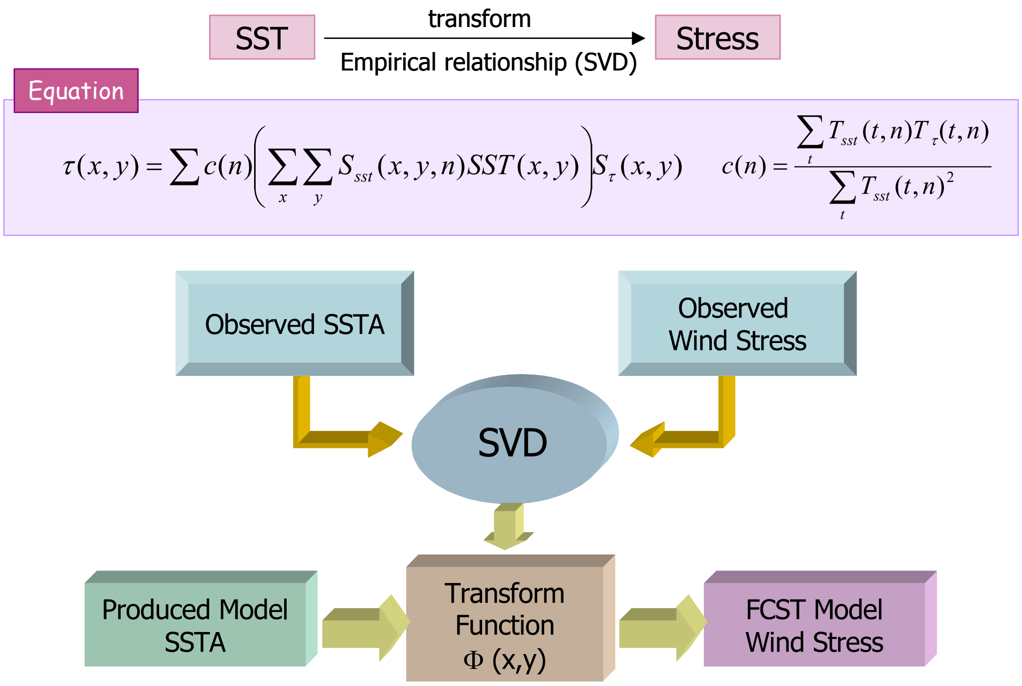


Fig. 3. Structure of the statistical atmosphere of El Nino prediction model.

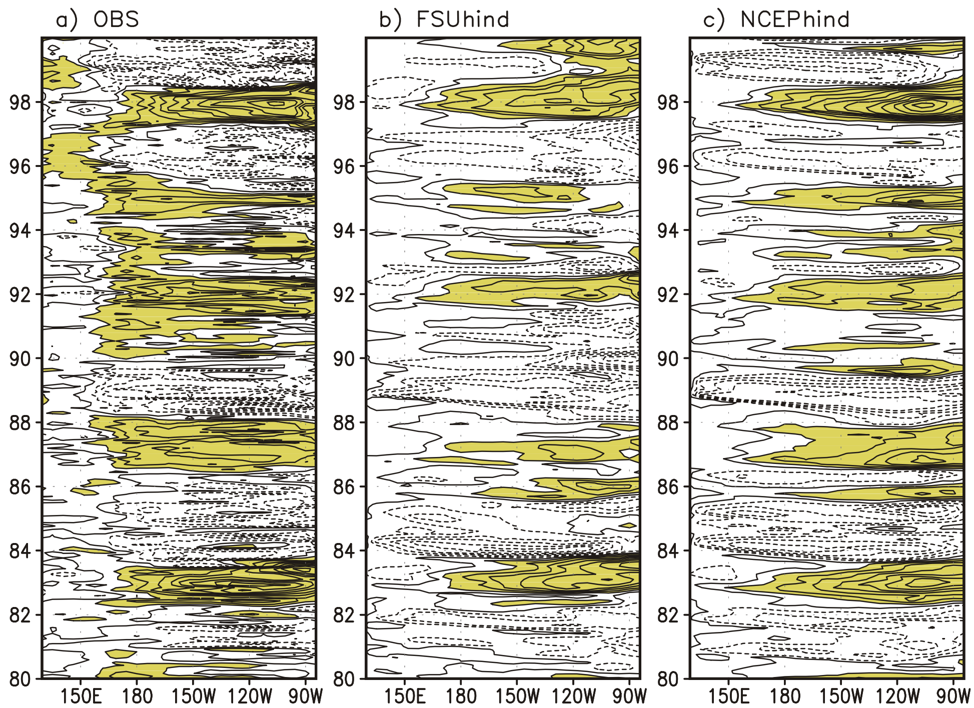


Fig. 4. (a) NCEP SST anomaly along the equator. (b) and (c) are intermediate model SST simulations with (b) FSU and (c) NCEP wind stress. Contour interval is 0.5℃, positive and negative values are plotted by the solid and dash lines, respectively. Shading indicates values more than 0.5℃.

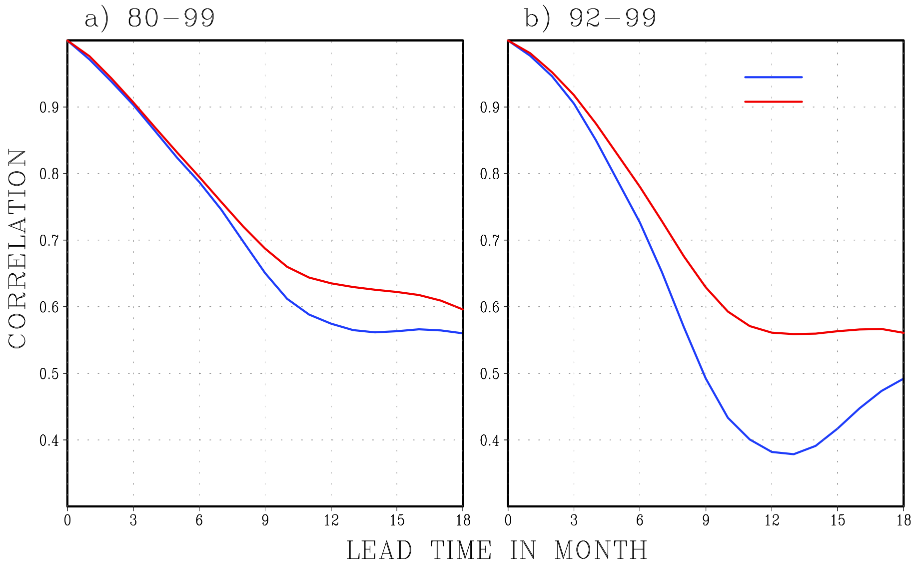


Fig. 5. Correlation coefficient between the model forecast and observed NINO3 SST, as a function of lead time, for the verification periods (a) 1980-99 and (b) 1992-1999.

3. Regional Climate Prediction System

KMA has a plan to construct the regional climate prediction system which consists of two sub-systems. The statistical prediction system was constructed with 4 statistical models and is operationally used for seasonal forecast.

The dynamical-statistical prediction system is currently under development by KMA and SNU. In this system, global prediction is produced using multi-model ensemble with the prediction results of AMIP type and SMIP type. For this job, we are carrying out SMIP (Seasonal prediction Intercomparison Project) program for winter and summer period to obtain better climatology.

The regional prediction is also produced through statistical downscaling using Coupled Pattern Projection Model. And then, ensemble results from both systems are merged using super-ensemble technique and finally optimized regional climate prediction is produced.

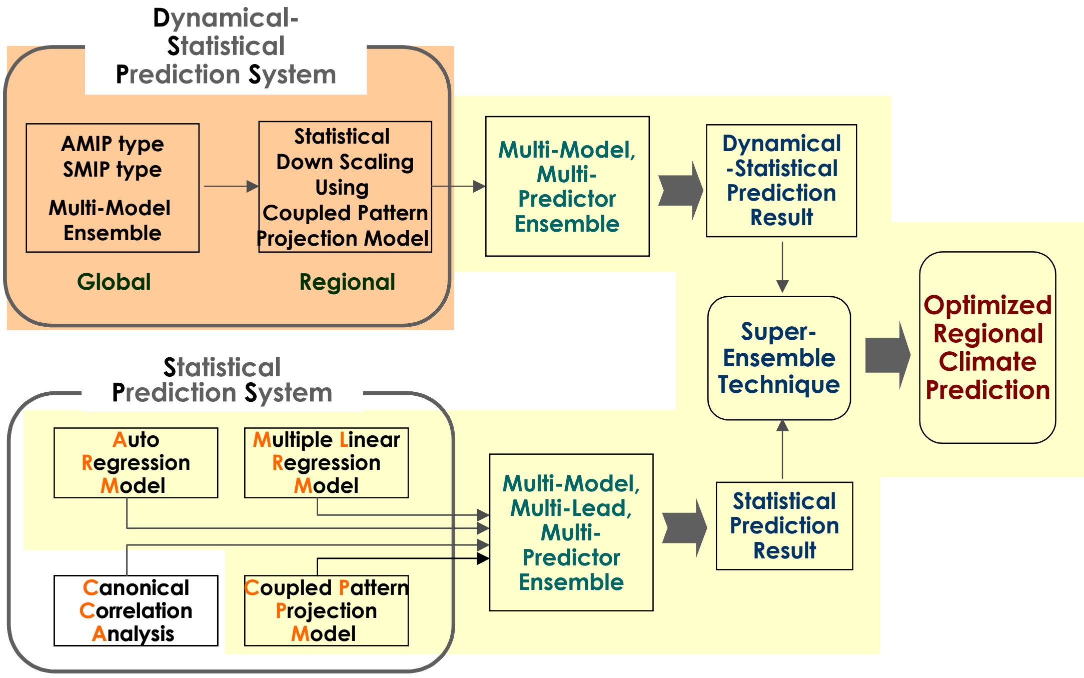


Fig. 6. Structure of Regional Climate Prediction System

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