

Climate 2030: A Japanese Project for Near-Term Climate Projection

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Abstract

A Japanese project for near-term climate projection, called climate 2030, is to produce an ensemble prediction up to year 2030 with a high-resolution coupled AOGCM initialized by historical observations and forced by anthropogenic climate forcing. An AOGCM called MIROC will be used with 60 km atmosphere and 20x30 km ocean resolution as a high-resolution version and a lower-resolution version will be used to develop physics and assimilation/initialization schemes. The physics package of the model is under renovation from its version used in the WCRP CMIP3 coordinated experiment.

In order to assimilate observational data into the coupled model, we developed a system called SPAM (system for prediction and assimilation by MIROC). Decadal prediction with initialized coupled models is a novel scientific challenge and we test several options for assimilation, initialization, and ensemble generation.

For observations, we currently use either a gridded ocean subsurface temperature and salinity data set (Ishii et al. 2006) or profiles of individual soundings. The former is assimilated into the model by nudging or incremental analysis update (IAU) methods, while the individual profiles are assimilated by a three-dimensional variational scheme (3DVAR; Ishii et al. 2003) or by an ensemble Kalman filter (EnKF), which is under development. For the generation of ensemble members, simple lagged average forecasts, in which only the atmospheric initial condition is perturbed, ensemble assimilation which starts historical data assimilation from an ensemble of forced, but uninitialized, coupled model runs. Since one may miss important decadal growing mode in these ensemble generation methods and underestimate ensemble spread, a breeding growing mode (BGM) method is being tested.

So far, we found small, but significant impact of initialization in decadal hindcasts/forecasts, which encourages further development in the scientific exploration of decadal prediction or near-term climate projection.

Several outstanding issues are to be addressed in order to establish a feasible decadal prediction scheme:

- Avoiding climate drift.

We adopt anomaly initialization and have found for our model that weaker constraint to the observations is necessary to prevent drift in predictions. As the model is improved, one should be able to assimilate total, rather than anomaly fields, but at present it does not seem feasible at least for our model. We also tried assimilating low-frequency (5-yr running average) fields but it turned out it is not necessary for drift prevention.

- Assimilation of sea ice, atmospheric and land surface variables.

At present, we only assimilate ocean temperature and salinity, which, as a starting point, appears reasonable. But, our assimilation which keeps areas around sea ice free underestimates observed trends and decadal variability of sea ice, and especially fails to reproduce recent drop in summertime arctic sea ice

extent. Thickness information is not available for sea ice and sophisticated schemes may be required for successful sea ice assimilation/initialization.

- Model bias in variability

Even with anomaly assimilation, biases in model climate variability may act to prevent successful decadal prediction. In our model, too weak thermocline variability in the equatorial western Pacific makes it difficult to follow observed decadal change. An experiment of a simple assimilation for sea ice concentration indicated that even though the initial sea ice field can be made more realistic, the model rapidly drifts to its climatology, which suggests the need for model improvement.

- Importance of aerosol emission scenario

An analysis of our 20th century reproduction experiments in CMIP3 indicates that at least in the 20th century, the effects of greenhouse gas and anthropogenic aerosols are comparable, and opposite in large areas, for long-term trends in Asian monsoon precipitation. This is expected to continue for decades in the future. Therefore, emission scenario for aerosols has to be carefully chosen and their effects have to be represented quantitatively in the model.

- Future volcanos?

In the near-term prediction, it will be assumed that there is no major volcanic eruption. An experimental prediction to investigate the impact of hypothetical 2010 "Pinatubo" eruption on decadal predictability has been made and it indicates that such volcanic signal may contaminate the natural variability and that most of the decadal predictability can be lost. This necessitates an adaptive prediction strategy for near-term climate prediction.