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Given the probabilistic nature of climate evolution, a complete solution of numerical climate prediction is the temporally-varying probability density function (PDF) of climate states in the future time. One of major challenges to make numerical climate prediction is how to sample the initial PDF. Traditional ``perturbation'' approach -- imposing noises on certain components of coupled model -- only is an artificial approximation of the initial PDF and the introduced numerical artifacts may contaminate projections of signal. This study is a pioneering effort in producing coherent ensemble initial conditions for a fully-coupled climate system by incorporating observed data into model dynamics. In the Ensemble Coupled Data Assimilation System (ECDAS) that was designed and implemented in this study, various historical records about some aspects of climate states are absorbed into every components of coupled model by a continuous filtering process using the joint distribution function derived from coupled dynamics. Within the ECDAS, both the reconstruction of historical climate states and the production of numerical climate prediction become a natural process -- a set of continuous coupled model simulations with or without constraints of observed data. In this procedure, the consistent coupled components in each ensemble member ensure that the model integration is the dynamical projection of initial signals on the future time.

Not only did this study present extraordinary technical achievement (super-parallelization, sparse observation processing technique etc.) but also highlighted the   
importance to the global circulation of maintaining realistic physical relationships among model variables -- like water mass properties in the ocean, and geostrophy in the atmosphere -- and demonstrated the ability of the coupled ensemble filter to maintain those relationships.  The study also performed some clever model experiments to assess the adequacy of the historical observing system for reconstructing 20th-century variations and trends in ocean heat content.

This study has already had profound and far-reaching impacts on the field   
of climate research (in the 5 months since its publication in October 2007, this paper has received four citations).  In addition to pioneering the field of ensemble coupled data assimilation, it has produced a highly flexible assimilation system that is now being used at GFDL to generate improved global seasonal-to-interannul forecasts, to assess climate variability and trends over the 20th century, and to assess the skill of decadal predictions. One of major applications of this system in the near future will be to initialize the coupled states for decadal projections of the meridional overturning circulations which is an important theme for the next IPCC assessment report. Another extension of the application of the outlined ECDAS is the initialization of high-resolution coupled model which may be able to produce the forecast for the genesis of hurricane. Then, although new challenges still exist for applying to the new generation coupled model with much higher resolution and much more complicated physical processes the work outlined in this paper will have more impacts on numerical weather and climate predictions in the future.