Improving seasonal climate prediction using ocean information through variational data assimilation

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Ocean Surface Topography Science Team meeting, St Petersburg, FL, USA, Nov 4-6, 2004

Aim of the project
- At seasonal to interannual time scales, the upper ocean memory is one major source for climate predictability. In the framework of seasonal climate prediction, it is therefore highly suitable to initialise as properly as possible the ocean component of any coupled ocean atmosphere forecast system. Conversely, the uncertainty associated with any forecast's ocean initial condition can usefully be exploited for the estimation of the forecast uncertainty.
- The DEMETER project (2000-2003):
  - Construction of a Multi-Model forecasting system with 7 partners: nEuropean Centre for Medium-Range Weather Forecasting, (ECMWF)
nMeteorological Office, UK
nMétéo-France, France
nMax-Planck Institute for Meteorology, Germany
nNational Institute for Geophysics, Italy
nLaboratoire d'Océanographie Dynamique et de Climatologie, France
nEuropean Centre for Research and Advanced Training in Scientific Computation, France
- This paper summarises the CERFACS contribution to the DEMETER project and to the oncoming ENSEMBLES projects.

The ocean analysis system
- 3D-Var FGAT formulation, allows for exact innovation computation
- Adaptation of the original tropical variational system to the global case (in particular, observation operator designed for a stretched grid)
- In modelling:
  - Flow dependent error variance
  - Multivariate balanced/unbalanced formalism (Derber and Bouttier)
  - Flow dependent multivariate T-S preservation scheme
  - Flow dependent density/currents scheme (extended geostrophy)
  - Allows for assimilation of altimeter data
  - Interfaced with (SST assimilation)
- Results illustrated using 1990-1999 averages, only in-situ T is assimilated
- The development of the system, in particular towards 4D-Var, is continued under the ENACT project

The coupled hindcast system
- Atmosphere: ARPEGE T63, 31 levels (Duguet, 2001)
- Ocean: OPA 8.2 global 2° x 1.5°, 31 levels (Madec et al., 1998)
- Coupler: OASIS 2.4
- Atmosphere initialisation: ERA40
- Ocean initialisation: ERA40 winds and fluxes forced experiments
- Experiments description:
  - 6 month lead time
  - 4 seasons (February, May, August, November) starts
  - 9 members
  - Verification against ERA40
  - All experiments run and archived at ECMWF
- Results from 1980 to 1999 for the assimilated ocean IC (and 1980 to 2001 for the unassimilated ocean IC (-500 years of simulation)

Ensembles of 3D-Var ocean reanalyses

Seasonal hindcasts

Precipitation and temperature indices and probabilistic scores

Data assimilation impact on temperature drift and variability (unassimilated is in blue, assimilated in red, other models are plotted)

Summary
- A global ocean analysis system and seasonal climate prediction has been developed, run and evaluated in the Demeter project framework, and contributes to the Demeter multimodel.
- The 3D-Var analysis system gives good results in improving the ocean state and variability.
- The coupled hindcast system proves skilfull in ENSO prediction, as well as prediction over the European region, in particular in winter; skill is weaker in summer.
- The impact of data assimilation on the coupled prediction is significantly positive, in terms of mean state, variability and scores during the 1997 ENSO event.

References