Improving seasonal climate prediction using ocean information through variational data assimilation

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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:
- European Centre for Medium-Range Weather Forecasting, (ECMWF)
- Meteorological Office, UK,
- Météo-France, France
- Max-Planck Institute fur Meteorology, Germany
- National Institute for Geophysics, Italy
- Laboratoire d'Océnographie Dynamique et de Climatologie, France
- European Centre for Research and Advanced Training in Scientific Computation, France

•This paper summarises the CERFACS contribution to the DEMETER and to the upcoming ENSEMBLES projects.

The ocean analysis system

• 3D-Var FGAT formulation, allows for exact innovation computation

•Adaptation of the original tropical variationnal system to the global case (in particular, observation operator designed for a stretched grid)

•Jb 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 (Déqué, 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: ER40 winds and fluxes forced experiments

•Experiments description:

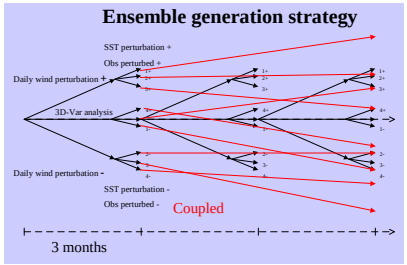
- •6 month lead time
- •4 seasons (February, May, August, November) starts
- •9 members
- •Verification against ERA40

•All experiments run and archived at ECMWF

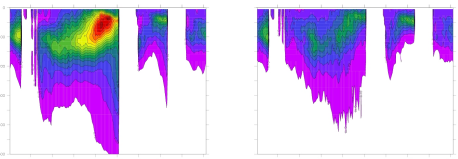
• Results from 1990 to 1999 for the assimilated ocean ICs and 1980 to 2001 for the unassimilated ocean ICs(~500 years of simulation)

Ensembles of 3D-Var ocean reanalyses

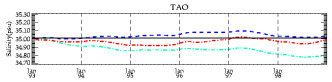
Ensemble generation strategy



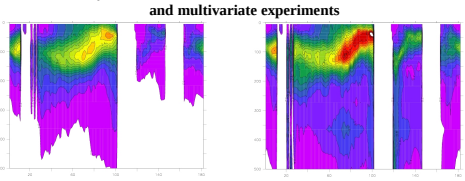
Reduction of the mean ensemble spread through data assimilation



Impact on the ocean variability



Mean salinity in [160E,280E][10S,10N][0-300m] for control, univariate and multivariate experiments



Impact on the subsurface temperature interannual variability

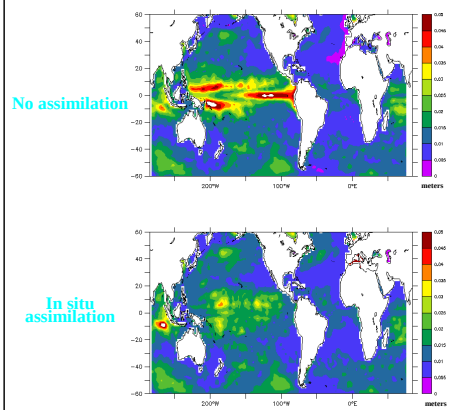
• 3D-Var assimilation of in situ data improves both mean state and variability of the model

• The introduction of a multivariate background error term allows the conservation of the water masses and the dynamical properties; it also allows assimilation of other observations (salinity, altimetry, …)

• Ensemble generation, done through perturbed forcing and observations, reduces the ensemble tropical spread of the oceanic initial conditions for coupled hindcasts

Impact on the sea level spread

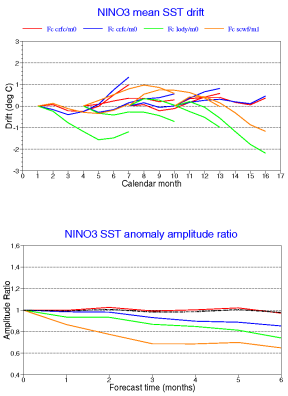
Ocean initial condition uncertainty in terms of sea level

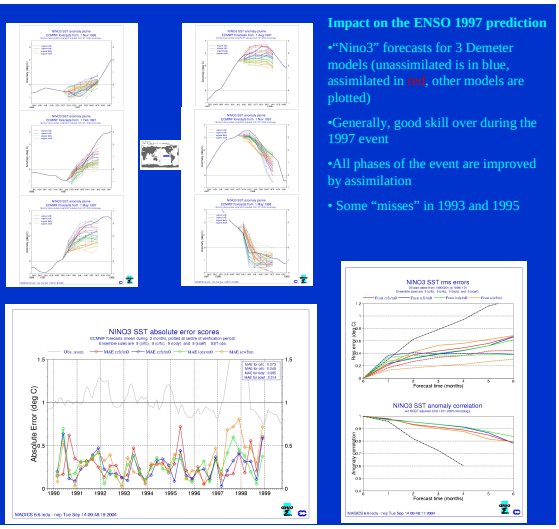


Seasonal hindcasts

Data assimilation impact on temperature drift and variability

(unassimilated is in blue, assimilated in red, other models are plotted)





Impact on the ENSO 1997 prediction

•"Nino3" forecasts for 3 Demeter models (unassimilated is in blue, assimilated in red, other models are plotted)

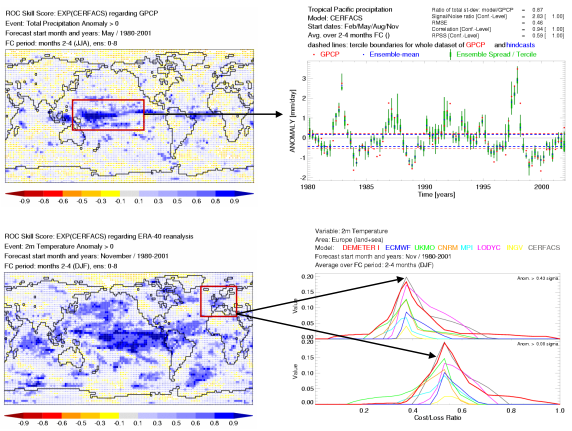
•Generally, good skill over during the 1997 event

•All phases of the event are improved by assimilation

• Some "misses" in 1993 and 1995

Precipitation and temperature indices and probabilistic scores

(unassimilated case)



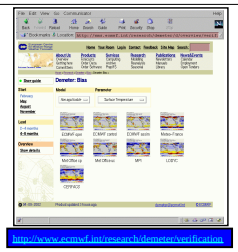
Summary

• 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 ocean analysis system gives good results in improving the ocean state and variability.

• The coupled hindcast system proves skillful 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.



http://www.ecmwf.int/research/demeter/verification

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