Decadal Predictions at CMCC

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1.1 The Consortium Members

- Centro Italiano Ricerche Aerospaziali
- Istituto Nazionale di Geofisica e Vulcanologia
- Università degli Studi del Salento
- Consorzio Venezia Ricerche
- Fondazione Eni Enrico Mattei
- Università degli Studi del Sannio
3. **Six Integrated Divisions**

- Energy Scenarios
- Mitigation & Adaptation Policies
- Economic Impacts
- Numerical Experimentations Climate Scenarios
- Impacts on agriculture
- Impacts on Soil & Coast

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**Scientific Computing & Operations**

**Climate Service**
2.3 Training Activities

- **Doctorate School in Global Change Science and Policy – ChangeS**
  In partnership with: University of Venice, University of Salento, University of Sassari

- Aim: promoting and coordinating advanced studies on climate change impacts and policy

- Activities: advanced training and research activities with emphasis on the development of innovative management strategies for both physical and socio-economic climate related phenomena.

**4 Ph.D. programs** currently active on:
- Science and Management of Climate Change – Venice, Bologna
- Environmental and Energy Systems – Lecce
- Climate Change Sciences - Lecce
- Agriculture and Forestry Systems – Sassari

- A structured **Winter and Summer Schools Programme**
Decadal Predictions at CMCC

The CMCC-CM model

- **ATMOSPHERE**
  - ECHAM5 T159L39 (~ 80 Km)

- **OCEAN**: OPA 8.2/ORCA2 (2º-1/2º)
- **SEA-ICE**: LIM
Decadal Predictions: experiment setup

- 30-year hindcast/forecast simulations grouped into 3-members ensembles, for different start dates.

- CMCC CGCM (ECHAM5+OPA/LIM)
- CMIP5 GHG & aerosol RF
- RCP4.5 scenario (2005 onward)
- Solar variability
- Ocean init.: from CMCC-ODA

RCP4.5
Initialization

- Ocean Initialization: Full fields from CMCC ocean analyses (OI and 3DVAR)
- Sea-ice: model climatology

Sea-Ice & Snow thickness init.: model climatology

OCEAN: different analyses (strategy adopted to generate the ensemble spread)

- CMCC - OI
- CMCC – 3DVAR1
- CMCC – 3DVAR2
• Decadal Predictions : Stream1 completed
ENSO 1965 Prediction

Surface Temperature Anomaly
Predictability limits: loss of consensus between ensemble members
Predictability limits: loss of consensus between ensemble members

* each curve is an average over all possible $C_{ij}$ couplets $(i,j=1,2,3)$ computed for each start date.

**evolutive cross-correlation:**

$$C_{i,j}(t) = \int_{0}^{T+t} m_i(t')m_j(t')dt'$$  \hspace{1cm} i,j=1,2,3
MOC is affected by drift, although with a slower adjustment, wrt to SST. Adjustment towards model attractor occurs in a ~20 yrs time scale.
AMOC in CMCC ODA affected by large uncertainties

**OI: T,S (1960-2005)**


- Bryden et al. [2005]
- Cunningham et al. [2007]
MOC initialized with two different ocean analyses follow very different trajectories.
MOC Prediction vs Analysis: hindcast show a much weaker variability wrt analyses
Conclusions (?)

◆ The use of ocean analyses to initialize DP differing by both assimilation technique (OI & 3DVAR) and assimilated data (T,S profiles & SLA) yields a sufficiently large spread.
◆ Influence of IC 1-5 years
◆ Some predictability in some fields
◆ Predictability in interesting parameters still to be investigated

◆ Future model … T255/321 -- 0.25 ocean
◆ Coupled assimilation
The three Global Ocean analysis systems at CMCC

1) **Optimal Interpolation (OI)** analysis system assimilating hydrographic data of (T, S) from EN3 dataset and using bivariate EOFs computed from model climatological anomalies for representing model-error vertical covariances (Bellucci et al., 2007, Masina et al., 2011);

2) **3DVAR** data assimilation system assimilating hydrographic data of (T, S) from EN3 dataset and along-track altimetric observations (1992-onward). The same set of EOFs as in the OI is used (Storto et al., 2011);

3) **3DVAR** data assimilation system as the previous but with a different set of vertical EOFs, derived from the differences between 6 ensemble members and the ensemble mean within an ensemble variational assimilation experiment (1993-2005) with perturbed observations, surface forcing and model parameterization tendencies.

On the left: 0-100 m summertime temperature st. dev. for EOF first set (top) and EOF second set (bottom). The latter shows a smaller error signal and peaks only in mesoscale areas.

On the right: North-Atl. averaged profiles of summer and winter model-error vertical (cross-)correlations between 55 m salinity and the other model levels for the two EOF sets. The ensemble derived set exhibits a stronger salinity upper ocean auto-correlation in Summer, but generally a smaller cross-correlation.