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Mediterranean Forecasting System: Toward Environmental Predictions

OGCM
- 3D primitive equation
- Z coordinates
- Horizontal resolution 1/8° · 1/8°
- 31 vertical levels

Simulations
- Forecast: 10 days
- Assimilation each week
- Forcing: Rigid lid, Atlantic box, Heat fluxes from atmospheric fields

Realized in the INGV of Bologna: www.bo.ingv.it

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Assessment of the Sea Surface Temperature: The problematic

Simulations

Comparison

Observations

Snap shot view: no spatial or temporal context
Assessment of the Sea Surface Temperature: The Mean Square Error

\[ \text{MSE} = \left[ (S - O) \right]^2 \]

O: Satellite observations available every week

S: Simulations from the OGCM

Hindcasts \( H_i \) are provided every day

Hindcasts = Forecast + assimilation

\[ S = \left( \sum_{i=D1}^{D7} H_i \right) / 7 \]

Period: September 1999 – August 2000

Region: the whole Mediterranean Basin

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Error Decomposition Method (EDM) : the principle

Inspired by ‘E. E. Ebert and J. L. McBride 2000’.

- \[ \text{MSE} = \left[ (S(i,j,t) - O(i,j,t))^2 \right] \]
  where \( S \) : Simulations, \( O \) : Observations
  \( i, j \) : grid points
  \( t \) : weeks

- Parameters optimization
  \( J \) the temporal shift,
  \( (d_x, d_y) \) the bi-dimensional translation,
  \( T_i \) the bias
  minimizing the Mean Square Error

- \[ \text{MSE} = \text{MSE}_{\text{Trs Time}} + \text{MSE}_{\text{Trs Space}} + \text{MSE}_{\text{Intensity}} + \text{MSE}_{\text{pattern}} \]
Evaluation of the time positioning parameter $J$ and of its corresponding error

Translation in time: \[ J \in [J_1 - \text{lim}, J_1 + \text{lim}] \]

\[
\text{MSE}_{M1} = \{ [ S(i,j,t+J) - O(i,j,t) ]^2 \} \quad \text{is minimum}
\]

\[
\text{MSE}_{\text{Trs time}} = \text{MSE}_O - \text{MSE}_{M1}
\]
Translation in space: \((dx, dy)\) \([-2, +2]\) as

\[
MSE_{M2} = \{ [ S(i+dx, j+dy, t) - O(i,j,t) ]^2 \} \text{ is minimum}
\]

\[
MSE_{\text{Trs space}} = MSE_{\text{Trs time}} - MSE_{M2}
\]
Error Decomposition Method (EDM): 3<sup>rd</sup> step and 4<sup>th</sup> step

- **Evaluation of the intensity parameters** $T_i$ **and of its corresponding error**

Intensity: \[ T_i \]

\[
\text{MSE}_{M3} = \left\{ \left[ S(i,j,t) - O(i,j,t) + T_i \right]^2 \right\} \text{ is minimum}
\]

\[
\text{MSE}_{\text{Intensity}} = \text{MSE}_{\text{Trs space}} - \text{MSE}_{M3}
\]

- **Evaluation of the pattern error**

Pattern:

\[
\text{MSE}_{\text{Pattern}} = \text{MSE}_O - \text{MSE}_{\text{Trs time}} - \text{MSE}_{\text{Trs space}} - \text{MSE}_{\text{Intensity}}
\]

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Problem of time and space domain of optimization: the problematic

\[ \text{T. Domain S. Domain} \]

\[ \text{MSE} (i,j,t) = \sum_t \sum_i \sum_j \left( S(i,j,t+J) - O(i,j,t) \right)^2 / (Ls.Ls.Lt) \]

\[ \text{MSE} (i,j,t) = \sum_i \sum_j \left( S(i+dx,j+dy,t) - O(i,j,t) \right)^2 / (Ls.Ls) \]

\[ T_i = \sum_i \sum_j \left( S(i,j,t) - O(i,j,t) \right) / (Ls.Ls) \]

where \( Lt \) is the length of the time domain (nbr of weeks used)
\( Ls \) is the length of the space square domain (nbr of grid pts)

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**Local analyze** (Step by step analysis)

**Choice of the temporal length** $L_t$

**Choice of the spatial length** $L_s$

**Result**

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Global analyze  

(one by one analysis)

1st week of October, spatial length $L_s=14$ ($1.75^\circ, 160$ km), time length $L_t=5$ days

Translation in time

Gain: 58% MSE resolved
Error Decomposition Method (EDM) : Application 2

Translation in space

Gain : 25% MSE resolved

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Error Decomposition Method (EDM) : Interest of the method

- **Analyze of the parameters themselves**

- **Correlation Type – Source of the errors**
  - **Temporal shift**
    - Forcing : filtering
    - Assimilation : synopticity
  
  - **Spatial shift**
    - Bathymetry : discretization
    - Parameterization

  - **Intensity shift**
    - Forcing : bias
    - Missing information

  - **Pattern error**
    - Parameterization : turbulence
    - Model discretization

- **Solution of the double penalty**

  Comparison of $\text{MSE}_{\text{Pattern}}$

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E. E. Ebert, and J. L. McBride 2000. ‘Verification of precipitation in weather systems: determination of systematic errors’

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Thank you for your attention