The INGV Mediterranean Forecasting System

The INGV Mediterranean Forecasting System (MFS) is a numerical ocean prediction service that produces analyses, short term forecasts and reanalyses for the entire Mediterranean Sea.
Two different implementations of the system are available:

- ECMWF MFS, forced by analyses and forecasts from the ECMWF Integrated Forecasting System which have a horizontal resolution of 1/8° (~13.5 Km);
- COSMO MFS, forced by analyses and forecasts from the COSMO model in the COSMO-ME configuration, run by the Italian Air Force meteorological centre, which have a horizontal resolution of 1/22° (~5 Km);

The MFS is a two-way coupled hydrodynamic-wave system with a data assimilation component.
The hydrodynamic component is an implementation of the NEMO model version 3.4 (Nucleus for European Modelling of the Ocean, [1]) while WAVEWATCH III model version 3.14 [2] is its wave component.
For both system implementations the NEMO model has a horizontal grid resolution of 1/16° (6-7 km, approximately), a vertical grid resolved over 72 unevenly spaced *z* vertical levels with partial steps and it is daily nested into the Atlantic Ocean through the CMEMS GLOBAL_ANALYSIS_FORECAST_PHY_001_024 product.
Seven rivers are considered as climatological freshwater input into the domain: Ebro, Rhone, Po, Vjose, Seman, Buna/Bojana and Nile. The Dardanelles Strait inflow is modeled as a river input, with monthly climatological net inflow rates and salinity values from Kourafalou and Barbopoulos [3].
The WWIII model solves the wave action balance equation in slowly varying depth domain, considering a superposition of the following source/sink terms: wind input growing action based on Janssen's quasi-linear theory of wind-wave generation [4,5], a dissipation source term and whitecapping theory [6,7] and nonlinear resonant wave-wave interactions modeled using the Discrete Interaction Approximation (DIA) [8,9]. The spectral discretization is obtained through 30 frequency bins ranging from 0.05 Hz (20 s) to 0.79 Hz (1.25 s) and 24 equally distributed directional bins.
The coupling between the hydrodynamic and wave component [10] has an hourly frequency: every hour the hydrodynamic model provides estimates of air-sea temperature difference and surface currents to the wave model, which returns back to the hydrodynamics the neutral component of the surface drag coefficient, taking into account the wave induced effect at the air-sea interface.
The data assimilation is based on OceanVAR software, a 3D variational assimilation system [11,12]. The assimilated data include: sea level anomaly from satellite data, in situ temperature profiles from VOS XBTs, in situ temperature and salinity profiles from ARGO floats and gliders.
Satellite objectively analyzed Sea Surface Temperature is used for the correction of surface heat fluxes.
The quality assessment of the system is monitored weekly by the calculation of the root mean square statistics of difference between observations and model background fields (so-called misfits). The system's performance is also evaluated by considering independent data at fixed stations around the Mediterranean Sea. Both are publicly available on dedicated sections of the system's website (https://medforecast.bo.ingv.it/).
For both systems analyses are produced weekly for the previous 14 days. Every day ECMWF MFS produces a 10-days forecast as daily mean outputs and a 5-days

forecast as hourly mean outputs, while COSMO MFS produces a 3-days forecast both with hourly and daily mean outputs.
Two reanalysis datasets (Mediterranean Sea Reconstruction-Reanalysis 1955-2015 [13] - https://doi.org/10.25423/medsea_reanalysis_phy_006_009 and Mediterranean Sea Reanalysis 1987-2018 [14,15] - https://doi.org/10.25423/MEDSEA_REANALYSIS_PHYS_006_004) are available through ERDDAP (Environmental Research Division's Data Access Program) service (http://oceano.bo.ingv.it/erddap/index.html).
Analysis and forecast products are operationally made available to the Italian Air Force meteorological centre through a dedicated FTP service.
Analysis and forecast fields visualization, along with evaluation metrics, is made available through the https://medforecast.bo.ingv.it/ website and the dissemination of the products through ERDDAP service will be soon available.

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