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Reanalysis of biogeochemical properties in the Mediterranean Sea

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In the 3D variational (3DVAR) assimilation approach the error covariance matrix can be decomposed in a series of operators. The decomposition makes the 3DVAR particularly suitable for marine biogeochemistry data assimilation, because of the reduced computational costs of the method and its modularity, which allows to define the covariance among the biogeochemical variables in a specific operator.
In the present work, the results of 3DVAR assimilation of surface chlorophyll concentration in a multi-annual simulation of the Mediterranean Sea biogeochemistry are presented. The assimilated chlorophyll concentrations are obtained from satellite observations (Volpe et al. 2012). The multi-annual simulation is carried out using the OPATM-BFM model (Lazzari et al. 2012), which describes the low trophic web dynamics and is offline coupled with the MFS physical model (Oddo et al. 2009). In the OPATM-BFM four types of phytoplankton are simulated in terms of their content in carbon, nitrogen, phosphorous, silicon and chlorophyll.
In the 3DVAR the error covariance matrix has been decomposed in three different operators, which account for the vertical, the horizontal and the biogeochemical covariance (Teruzzi et al. 2014). The biogeochemical operator propagates the result of the assimilation to the OPATM-BFM variables, providing innovation for the components of the four phytoplankton types. The biogeochemical covariance has been designed supposing that the assimilation preserves the physiological status and the relative abundances of phytoplankton types. Practically, the assimilation preserves the internal quotas of the components for each phytoplankton as long as the optimal growth rate condition are maintained. The quotas preservation is not applied when the phytoplankton is in severe declining growth phase, and the correction provided by the assimilation is set equal to zero. Moreover, the relative abundances among the phytoplankton functional types are preserved.
The 3DVAR has been applied to the Mediterranean Sea for the period 1999-2010 with weekly assimilation. The results of the multi-annual run show that the assimilation improves the model skill in terms of a better representation of the mean chlorophyll concentrations over the Mediterranean Sea sub-regions and also in terms of spatial and temporal definition of local bloom events. Furthermore, the comparison with nutrients climatology based on in situ measurements show that the non assimilated variables are consistent with observations. The application of the 3DVAR revealed that in specific cases the correction introduced by the assimilation is not maintained by the model dynamics. In these cases, the satellite observations are characterized by local patchy bloom events, which are not well captured by the model. It has been observed that, since the bloom events are strongly affected by the vertical mixing dynamics, which support nutrients to the surface layer, a possible source of error are the mixing conditions provided by the physical model.

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