Inter-comparing numerical model simulations in the Ionian Sea with Argo T/S profiles for the period 2008-2012

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Abstract

During the period 2008-2012 a substantial increase in the number of Argo profiling floats has been recorded for the Ionian and Adriatic Seas with time, mainly due to the combined activities of Euro Argo RI and several multinational initiatives. In turn, these observational T/S profiles are used to validate the output of the Southern Adriatic North Ionian (SANI) hydrodynamic model, developed for IONIO INTERREG-III project being integrated for the same time period. The inter-comparison of the two data sets shows interesting aspects of the model performance regarding the representation of the major water masses characteristics of the SANI area.

Keywords: water masses, temperature, salinity, autonomous floats, hydrodynamic forecasting

1. Introduction

The Ionian basin plays a key role in controlling the multiannual variability of the whole Eastern Mediterranean Sea. The typical water mass structure of this area consists of the Modified Atlantic Waters (MAW) that occupy the upper 25-100 m and are characterized by a salinity minimum, the Levantine Intermediate Waters (LIW) that occupy typically the 100-500 m layer and are characterized by a salinity maximum, the Transitional Waters (TW) occupying the 500-1200 m layer and the Eastern Mediterranean Deep Waters (EMDW) that fill the layers below 1200 m. The area has been characterized as transitional and apart from the synoptic and seasonal scale signals that appear to be dominant, one can also observe important inter-annual variability such as the appearance of a strong LIW signal at intermediate depths during 2009 and 2010 (Kassis et al., 2011). The expansion of the Argo Network into regional seas has upgraded monitoring and forecasting capabilities in enclosed sea basins and gives the opportunity for more enhanced studies of the mesoscale and sub-mesoscale dynamics dominating in basins like the Ionian. At the same time this information is crucial for the development and validation of ocean forecasting activities at a regional scale. In this study a first inter-comparison of these in-situ data with the outputs of SANI hydrodynamic model is presented. The numerical circulation model, SANI (Southern Adriatic-Northern Ionian) is based on the Princeton Ocean Model and has been implemented within the framework of the IONIO Interreg-III Project. The model is now part of the POSEIDON operational system (Nittis et al., 2006), which runs on a daily basis to generate 5-days weather, sea state, sea circulation and ecosystem forecasts for the Mediterranean and the Aegean Seas.

2. Materials and methods

SANI model covers the geographical area 15ºE - 21.76ºE & 35ºN - 42.5ºN with a spatial resolution of 1/50° x 1/50° in horizontal and 25 sigma-layers along the vertical with a logarithmic distribution near the surface and the bottom. It has been integrated for a 5 years period (2008-2012) forced with the POSEIDON/Eta analyses and nested within the MyOcean MFS model. To benefit from the data assimilation that takes place in latter model, SANI was periodically (weekly) initialized from the MyOcean MFS model using variational initialization techniques to dump gravity waves and achieve a smooth solution. The period of the comparison of the SANI model temperatures and salinities against Argo temperature and salinity profiles is January 2008 to December 2012. Data from 21 Argo profiling floats in the Ionian Sea are used to compare with model results at or near the same position for this period. Some of the older floats were programmed to execute 10-day cycles, drift at 1000 m depth and descend to 2000 m in order to acquire the ascending profile according to International Argo specifications, whereas a number of newer floats are following the recommendations of MedArgo (Poulain et al., 2007). In that case, drifting depth is 350 m which is near the depth of the Levantine Intermediate Water (LIW) core. The cycle length was reduced to 5 days in order to obtain useful estimates of currents, as longer cycles are not able to represent the circulation in the vicinity of the intricate coastlines of regional Mediterranean Seas. Moreover, the assimilation of profiler displacements becomes inefficient to correct modelled velocities if the cycle length is longer than the typical Lagrangian integral time scale characteristic of the circulation at 350 m (Molcard et al., 2003). The profiling depth for this configuration was set to 1000 m and, depending on the float telecommunication technology, a time span from 30 min to 6 h is estimated to be the surface time for the localization and data transmission. A subset of 946 valid Argo profiles was analyzed over a total of 966 in the area of study (Fig. 1). An apparent increase of the Argo profiles over time (42 profiles during 2008, 69 during 2009, 162 during 2010, 217 during 2011 and 476 during 2012) reflects the increased deployments activity in the area during this period.

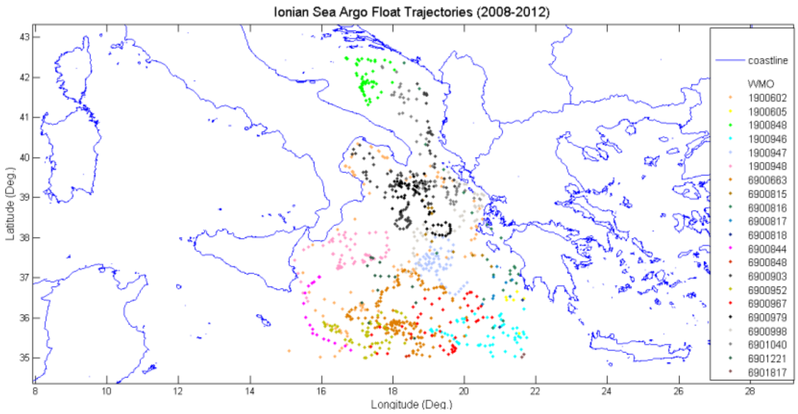

Fig. 1. Argo floats profile coverage in the Ionian and South Adriatic Seas from 21 Argo profilers (WMO numbers on the right) for the period 2008-2012.

3. Results

The temperature and salinity profiles from both model and ARGO floats depict the two major water masses at the first 1000 m of the water column in the Ionian Sea. The MAW is observed at the depth layer of 50 m while the LIW maximum is presented at approximately 300 m, for both datasets. The inter-comparison of the 5-year average profiles shows that the model underestimates the temperature in the surface layer (0.1-0.75°C) and below 125 m (0.1°C), which is accentuated at deep layers 900-1000 m (0.22°C). In the layer between 20 and 125 m the model temperature appears greater than Argo’s with a maximum of 0.4°C at 80 m. Regarding salinity there is an overestimation at subsurface (20-75 m) and deeper (>600 m) layers between 0.01-0.03 psu while at intermediate depths (100-500 m) the LIW is presented saltier in Argo data reaching a maximum average of 38.89 psu which is approximately 0.02 psu saltier than the model’s estimation (Fig.2). The Root Mean Square Errors (RMSE) of temperature and salinity between model and Argo data with depth (shown in Fig. 3) ranges, in the case of temperature, from 0.15-1.13°C with its maximum at 50 m depth, while in the case of salinity from 0.02 to 0.18 psu, with maximum values at 20 m. This is also shown from the residuals of parameters per profile for 5 discrete depths which is presented higher at the subsurface layers (Fig. 3). In order to exclude surface layers high variability, in Fig. 4 we show the TS diagram of intermediate waters (100-500 m) and deeper waters (500-1000 m) corresponding to the two datasets. Between 100 and 500 m both datasets present similar distributions, with the model characterized by slightly denser water masses. On the contrary, at the deeper layers the model shows much denser water masses (below the 29.2 kg/m^3 isopycnal), mainly due to the temperature underestimation at these layers, as described previously, which is then translated into large differences in the density field.

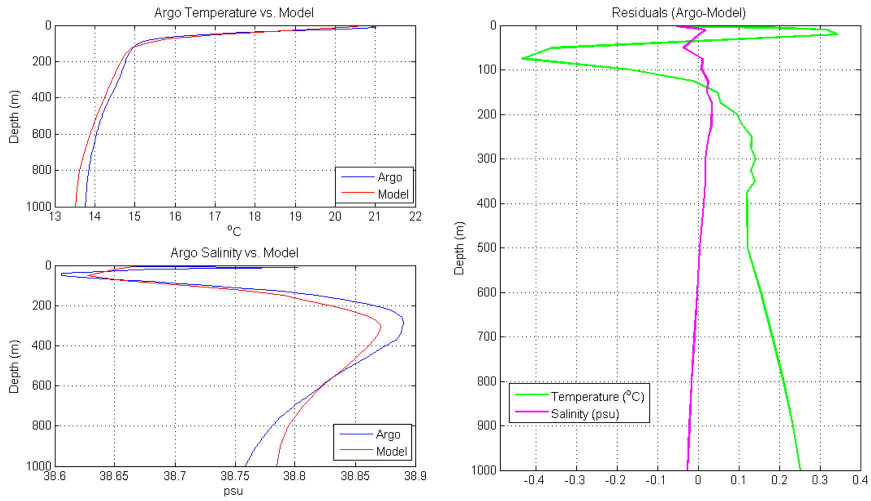

Fig. 2. Average temperature (upper left panel) and salinity (lower left panel) profiles for Argo data (blue line) and model (red line), along with their differences (right panel) for 2008-2012.

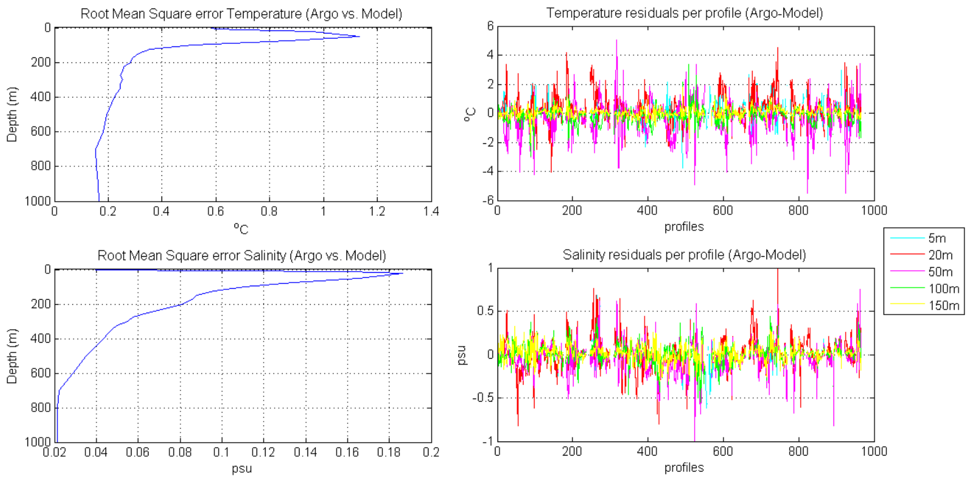

Fig. 3. RMSEs of temperature and salinity between Argo data and model (left panels), along with their differences per profile for 5 different depth levels during 2008-2012.

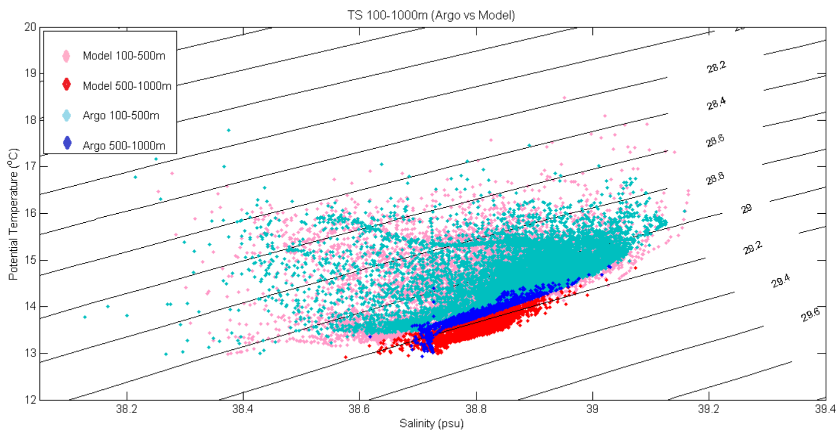

Fig. 4. T-S diagram of Argo data and model for two different depth layers: 100-500 m (pink and cyan dots for model and Argo respectively) and 500-1000 m (red and deep blue dots for model and Argo respectively).

4. Conclusions/Discussion

SANI model seems to represent adequately the general variability of the Ionian Sea water column physical properties at an interannual scale. Nevertheless, the comparison with Argo temperature and salinity profiles for the period 2008-2012 revealed some interesting differences. The intermediate waters (200-600 m) as reproduced by the model appear to be less saline and colder in comparison with the Argo data although the signal of LIW appears at the same depth in both datasets. Deeper than 600 m, the model shows higher salinity values (~0.02 psu) and lower temperatures (~0.2°C) with respect to observations. This latter difference in temperature seems to determine the model's misrepresentation of the deep Ionian waters compared to in-situ measurements. At the surface layers the model - Argo disagreement on both temperature and salinity may be due to a variety of attributes such as Argos weakness whilst measuring at these layers, and the high variability of coastal processes. Nevertheless the warmer MAW presented by the model at subsurface layers should be attributed to its systematic errors. These preliminary results indicate the need for more detailed comparative studies in the near future that will include careful filtering of the datasets, subdivision of the study area into smaller regions with similar physical characteristics, annual and seasonal analysis of each sub-region.

5. Acknowledgements

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