IMPACT OF OPTICAL WATER TYPES ON THERMOHALINE PROPERTIES AND DYNAMICS OF THE ADRIATIC SEA

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Abstract
Optical properties in the Adriatic show large variation in space and time. The effect of changed optical types was tested, with the simplified assumption for the two optical types, via the Z-coordinate nonlinear levels model during the four cold months in 2005-2006, with the available atmospheric forcing. Significant vertical and regional differences were observed in warming between the utilized optical types. This indicate differences in stability of the water column between the two cases. The currents were also changed.
Keywords : Adriatic Sea, Temperature, Currents, Models.

Introduction
Solar energy propagation in the water depends on water transparency. Seasonal differences of optical properties, and transparency decreasing trends in some Adriatic regions cover a full scale of optical types, and hydrodynamical modeling should take this into account. Recent PAR attenuation measurements enabled the determination of present optical types in the Adriatic, while historical measurements [1] allowed an assumption about earlier types. Although a variety of types were found for different sites of the Adriatic, especially in the coastal region, the simplified experiment that utilized two optical types has already demonstrated significant differences in results. Changes of optical water properties lead to different warming of the water column and a different stability, causing changes of other properties too.

Methods and data
A numerical experiment was performed with the Z-coordinate nonlinear levels model developed by Bone [2, 3], exploring the effects of the different optical water types. A description of the model and the source code can be found at www.math.izor.hr. The integration area was the Adriatic Sea from Otranto northward, and the integration time was four months, in the cold period from December 1st 2005 to March 31th 2006. The wind, cloudiness and other meteorological data were the Aladin model reanalysis for 10 m height above the sea surface, at the spatial scale of 8 km every 3 hours, obtained from the Meteorological and Hydrological Service of Croatia. In the numerical experiments a complex forcing included surface fluxes (momentum, heat and evaporation), river runoffs (heat and salinity), solar and backward radiation, and tides. Ane horizontally equally spaced Arakawa E grid, with the vertical z-coordinate divided in layers of equal thickness, was used in the model, split into external and internal mode with some common variables insuring feedback binding. The horizontal grid step was 10 km with 5 m level thickness. The heat fluxes in the water from infrared and visible spectrum are introduced in the model via the respective attenuation coefficients. The experiment was performed using the coefficients for visible spectrum for optical water types I and II [4], which enabled different heat transfer conditions.

Results and discussion
Consequences of introducing higher attenuation coefficients were observed in all the layers. Changing the optical type, notable differences of temperature through the integration time were obtained. Consequently, the density field also changed. The corresponding currents also changed considerably, and differences were observed down to the deepest layers of the south Adriatic Pit. Different conditions of heat transfer changed the Richardson number i.e. vertical turbulent exchange of momentum. After the integration period, in the surface layer, the largest temperature differences have been found in the Northern Adriatic and in the shallow areas close to the Italian coast (Fig.1, left). The temperature differences at 150 m depth (Fig.1, right) showed that the south Adriatic Pit becomes slightly warmer while Jabuka Pit becomes slightly colder, after the optical type was changed.

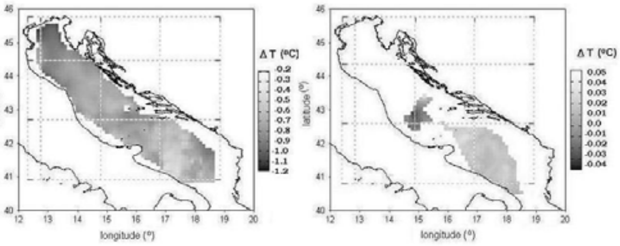

Fig. 1. Predicted spatial distribution of temperature differences after integration period at 2.5m depth (left) and at 150m (right), for the Adriatic Sea, resulting as a change in optical water type, after four months of integration.

The results demonstrate that thermal energy was trapped in the shallower layer, producing higher vertical density gradients and increase of water stability, i.e. decrease of turbulent energy. They also demonstrate that there are considerable differences between the two optical types, pointing to the need for better definitions of the water attenuation coefficients in hydrodynamical modeling. This may be particularly important for seas with high seasonal and regional variations of optical properties.

We have demonstrated that light conditions in the water influence thermohaline and dynamical properties, but light also influences photosynthesis, metabolic processes, fluorescence, primary production rates etc. Changed light conditions therefore, create complex feedbacks between biological and physical systems, which should be further studied and taken into account in ecological modeling.

References

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