IMPACT OF NUMERICAL MODEL RESOLUTION ON OPEN-OCEAN CONVECTION REPRESENTATION: CASE STUDY OF WINTER 1986-87

Marine Herrmann [1] *, Samuel Somot [2], Florence Sevault [2] and Claude Estournel [1]

[1] Laboratoire d'Aérologie, Université Paul Sabatier, Toulouse, France - herm@aero.obs-mip.fr

[2] Centre National de Recherches Météorologiques, Météo-France, Toulouse, France

Abstract

A strong open-ocean convection episode occured during winter 1986-87 in the NWMS (Northwestern Mediterranean Sea). Two numerical 3D simulations of 1968-87 have been performed using an eddy-permitting and an eddy-resolving model. The convection is reproduced similarly in both simulations on a global scale. However, mesoscale structures are better reproduced by the eddy-resolving model, explaining most of the differences between both simulations

Keywords : Western Mediterranean, Circulation Models, Mesoscale Phenomena.

Open-ocean convection is one of the major dynamic processes in the NWMS (Fig. 1a), where it plays an important role in the functioning of pelagic planktonic ecosystems. It is therefore important to reproduce correctly this process with 3D circulation models. Somot [2] performed a realistic numerical study of winter 1986-87 using an eddy-permitting model (EPOM). Given the importance of mesoscale structures during convection episodes, it would be interesting to perform a realistic study of this winter with an eddy-resolving model (EROM). In the present study, we investigate the impact of model resolution on the representation of the 1986-87 convection episode by comparing results of two realistic 3D simulations performed with respectively an EROM and an EPOM.

A Mediterranean limited area version of the 1/8° resolution (∼10 km) circulation model OPA [2], and a 3 km-resolution model, SYMPHONIE [3], are used. Since the Rossby radius in the NWMS is about 10 km, the present version of OPA, resp. SYMPHONIE, is an EPOM, resp. an EROM. The atmospheric forcing is provided by the air-sea fluxes coming from the ERA40 reanalysis [4]. A correction of -130 W/m^2 is added to correct the difference between the ERA40 heat flux and the observations [5]. During winter 1986-87 five meteorological events (highlighted in grey on Fig. 1) were observed.

Both models reproduce similarly the convection episode on a global scale: position of the convection area (4°30' E - 41°30'N), timing consistent with the atmospheric forcing (see the mean mixed layer depth (MLD) evolution on Fig. 1a), total volume of newly formed deep water (DW, ρ >29.10 kg/m^3) exported from the NWMS (Fig. 1d).

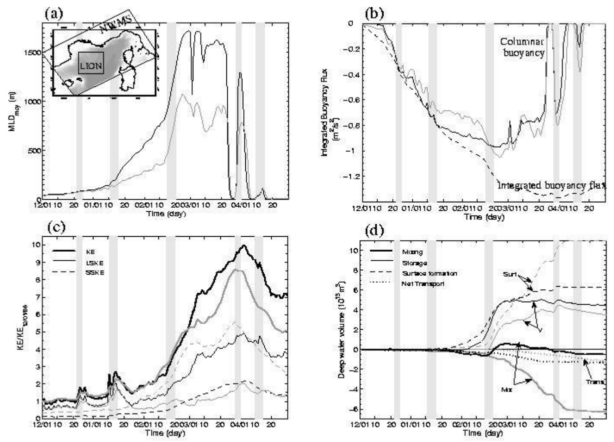

Fig. 1. Water column characteristics from 12/01/1986 to 05/30/87. MLD (a), columnar buoyancy and integrated buoyancy flux (b) and KE (c) averaged over the LION area. DW surface formation, storage, net transport and mixing in the NWMS (d).

The main difference between both models is the mesoscale structures representation. We observe on sea surface density that mesoscale structures of scale smaller than 60 km are much more important, and in better agreement with previous studies [1,6] in EROM than in EPOM. This is confirmed by the kinetic energy (KE) analysis, where we observe the evolution of KE associated to processes of scale larger (LSKE) and smaller (SSKE) than 60 km (Fig. 1c). These mesoscale processes are known to be responsible for the lateral advection of positive buoyancy into the convection area [1], as confirmed by a buoyancy analysis (Fig. 1b): the difference between the columnar buoyancy and the integrated surface buoyancy flux means that lateral advection of positive buoyancy, more important in EROM than in EPOM, occurs. Consequently, the mesoscale structures slow down the MLD deepening, help to the restratification and limit the lateral extension of the convection area. This corresponds to the difference both models. Indeed, in EROM, the MLD deepening is slower, the restratification is faster and the convection volume, proportional to the mean MLD, is smaller (Fig. 1a). The maximum MLD being similar in both models, this volume difference is mainly due to a smaller convection surface in EROM. Moreover these structures play an important role in the mixing of DW formed at the surface with lighter surrounding water (Fig. 1d). This mixing is much more important in EROM (57%) than in EPOM (8%), consequently less DW is stored in the NWMS in EROM. The DW formation rate is 1.7 Sv for EROM vs. 2 Sv for EPOM. For more details about these analysis, see [7].

In conclusion, EROM and EPOM reproduce convection similarly on a global scale. However, EROM finer spatial resolution enables to reproduce mesoscale structures better.

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