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Interactive comment on "Modelling Seasonal Circulation and Thermohaline Structure of the Caspian Sea" *by* M. Gunduz E. Özsoy

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Reviewer's original comments are in *italics*,
Our responses are as follows.

This manuscript discusses the structure of seasonal circulation of the Caspian Sea. The subject of this manuscript corresponds to that of this journal.

We would like to thank referee $\#2$ for reviewing the manuscript.

First of all, the title of this manuscript includes 'Thermohaline Structure', so it is appreciated if the authors show the contour maps or water temperature and salinity in both horizontal and vertical sections. Particularly, it is reported that the cyclonic gyre is formed by the baroclinic process in closed water in the northern hemisphere (e.g., Schwab , O'Connor, Mellor, 1995, J Phys Oceanogr, Kitazawa, Jang, 2012, Journal of Marine Science and Technology). Water density is lower in the northern and southern Caspian Sea due to low salinity (river inflow) and high temperature (climate), respectively.

The model generated temperature is in agreement with the observed climatological temperature. The climatological feature of the temperature (its north-south gradient, warm water intrusion, etc) was studied in other publication. We thought that the reader can obtain this information from these previous studies. However, the temperature transect for the February and August months were drawn. Another figure (figure-1) and below explanation was added to the text.

"The most challenging task for modelling of enclosed-seas like Caspian Sea is to properly represent the annual thermal cycle, since the thermal regime changes from an entirely thermally mixed one in winter, to a strongly stratified one in summer (Beletsky and Schwab 2001, who detected the same sequence in the case of lake Michigan). Our simulations with the HYCOM Caspian Sea model were able to reproduce the following main features of the Caspian Sea thermal structure.

Fig.1 shows the temperature cross sections along $50°E$ in February and August. In this figure, the white line shows the base of the mixed layer. In February, there are considerable differences in mixed layer depth (MLD) between the two deep basins of the Caspian Sea. While the MLD in MCS is about 100 m in winter, it only reaches

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to 20 m in the SCS. The most striking feature of the temperature stratification is the sharp contrast between the vertical gradients and the relative levels of temperature in the MCS and SCS basins, which results from the difference in mixing and the effect of the Apsheron sill separating the two basins.

Since the density in the Caspian Sea is largely determined by temperature (in the absence of a strong salinity stratification), the temperature contrasts between basins reflect pressure gradients developing as a result of density differences. The largest temperature differences at sill level develop in late winter and early spring when differential mixing and cooling occurs in the two basins. As a result, the dense water in the MCS is expected to flow south across the Apsheron sill to the SCS. The weakness of thermal stratification in the SCS during the following periods appears partly to be a result of the sill overflow and ensuing thermocline level injections of dense water from the MCS into the SCS. Temperature isolines of colder water on the Apsheron sill area connected to those at thermocline level of the SCS provides limited evidence in this direction.

A well-developed thermocline generally persists throughout the summer (Figure-1 (b)) when the mixed layer depth typically decreases to about 15 m. As the stratification develops in either the MCS and the SCS basins the level of the thermocline becomes distinctly different between the basins. While the 11 $^{\circ}C$ temperature is occurs at about 50 m depth in MCS in August, it occurs at a depth of about 130 m in the SCS."

Above references mentioned by referee was also added to the manuscipt.

In addition, the horizontal maps of wind vector, solar radiation, etc., are helpful for readers to understand the feature of seasonal circulation and thermohaline structure of the Caspian Sea.

We agree to the referee, the variation of the wind direction in the Caspian Sea may effect the surface circulation pattern, especially it could be very important for the changing of the cyclonic gyre in winter to the anti-cylocic gyre in summer in MCS. This mechanism was investigated by

Gunduz, M., 2014.
Caspian Sea Surface Circulation Variability Inferred from Satellite Altimeter and Sea Surface Temperature. *J. Geophys. Res. Oceans*, 119, 1420–1430, http://dx.doi.org/10.1002/2013JC009558.

Below paragraph was added to explain this mechanism.

"There are two dominant wind regime in the Caspian Sea. During the winter, wind blows toward to west, and in summer the wind direction changes dramatically and wind start to blow toward to south. Gunduz 2014 has shown that variation of the wind speed and direction (Fig.5 in the paper) may have influence on the changing of the cyclonic circulation in winter to the anti-cyclocic one in summer in the MCS"

(Above mention figure (Fig.5) from the Gunduz 2014 was attached to this document (figure-2) for referee to see the wind pattern).

Finally, the ice dynamic was not modeled in the present study, while its effect should be considered by proper condition. The presence of ice changes the fluxes of momentum, heat and salinity through water surface, and then affects the circulation in the northern Caspian Sea in winter.

Actually, the current model has an ice model. An explanation was added to the model set-up in the manuscript clarifying this ice model. Although the climatological variation of ice amount is underestimated in the model (see figure-3 in this document), we believe that it is satisfactory for the purpose of this manuscript.

If the manuscript is corrected according to the above comments, it can be published in this journal.

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Thank you very much to referee #2 for constructive comments.

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Interactive Comment