First of all, we are very thankful to the reviewer for very constructive and concrete comments which certainly helped us to improve the manuscript.

1) **Referee Comment**:

Recent studies using realistic numerical model simulations provide dynamical setup, development and the fate of the whole Adriatic Sea circulation, hence SAG as well (i.e. Benetazzo et al., 2014; Janekovic et al., 2014). Unfortunately, authors didn't use any of the data sets or studies, or even to relate and comment them in order to reinforce their findings.

Author's response:

The cited papers consider specific climatic conditions related to the extreme winter conditions of the year 2012 so it is hard to include the two suggested references in our paper. Moreover, in a new version of the ms. we do not consider any more winter mixing and the dense water formation since we, as suggested by both reviewers, eliminate the entire portion of the ms. treating the phytoplankton phenology as related to winter mixing.

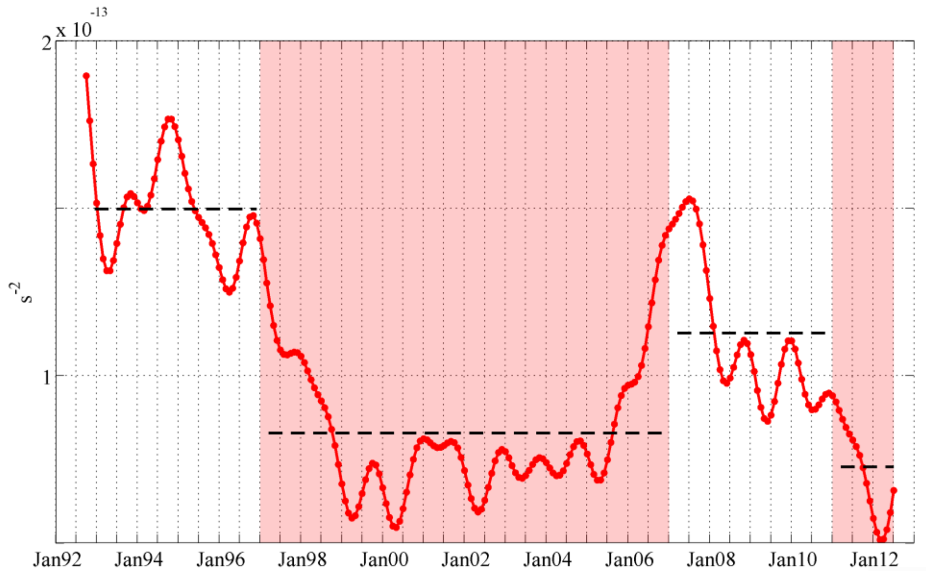
2) **Referee Comment**:

Using only lagged correlation between SAG and northern Ionian Sea vorticity they conclude about possible mechanism of advection from Ionian region into SAG. However, lagged correlation does not imply that mechanism, it just states that this two data sets are lagged correlated and having something in common with shifted phase in time.

Author's response:

The importance of the advection mechanism as a source of vorticity in the South Adriatic Gyre is not arrived only by calculating the lagged correlation between the current vorticities in the SAG and northern Ionian Sea. As it is explained in the manuscript, first, we evaluated the different terms of the vorticity equation and obtained the equation 8 (page 210, line 21), which shows that the wind stress vorticity is not the only possible source of vorticity but the vorticity advection from the adjacent area should also be taken into consideration. Only then, we calculated the lag correlation between flow vorticities in SAG and northern Ionian Sea in order to find evidences on the advection speed valid only for the statistically SIGNIFICANT correlation coefficient. This correlation coefficient is 97% significant for the 15 month phase-lag.

We also added in a revised version of the ms. the time-series of the advection term assuming constant speed as obtained from the lagged correlation calculations.



The figure clearly shows that during the cyclonic phases (red-marked areas) the vorticity gradient Ionian-Adriatic is smaller than in the anticyclonic one resulting presumably in the reduced importance of the vorticity advection term. However, more explanation about the role of the advection term and its relation with BiOS will be given in the revised version of the ms.

<u>Author's changes in manuscript</u>:

P 211, line 14: 'The vorticity in the northern Ionian was analysed in order to estimate the vorticity advection through the Strait of Otranto.'

was replaced by:

'For this purpose, the vorticity in the northern Ionian was calculated in order to estimate the vorticity advection through the Strait of Otranto.'

P 211, line 25: 'In order to study whether possibly the vorticity advection from the Ionian plays a role in controlling the curl of the flow in the South Adriatic'

was replaced by:

‘Second term which may contribute to the vorticity tendency in the SAP is the advection term. In order to study to what extent the vorticity advection from the Ionian plays a role in controlling the curl of the flow in the South Adriatic’

P 212, first line: we added: ‘(97% significant)’ after: ‘about 15 months’

P 212, line 3 to 16: ‘advection from the Ionian may contribute to variations of the intensity of the SAG. It is interesting to note that the correlation between the wind-stress curl, i.e. the local vorticity input, and the current vorticity was apparently stronger in the period 1997-2006 than in the rest of the studied period. This can be explained by the fact that the period 1997-2006 was characterized by the cyclonic phase of BiOS in the Ionian and in that case the vorticity advection term was proportional to the differences between absolute values of the Adriatic and Ionian vorticities. Before 1997 and after 2006 the Ionian was characterized by the anticyclonic circulation mode and the vorticity advection term was proportional to the vorticity sum. Therefore, in the Ionian cyclonic circulation phase the local input, i.e. the wind-stress curl, has a prevailing effect on the current vorticity and thus the correlation between the two is stronger. On the other hand, in the BiOS anticyclonic phase the vorticity advection term may become significant and probably of comparable importance as the wind-stress curl. Consequently, the correlation between the flow vorticity tendency and wind-stress curl is weaker.’

was replaced by:

‘advection from the Ionian may contribute to variations in the intensity of the SAG. It should be stressed that advection term is not equally important in all situations; while the Ionian circulation is in the anticyclonic phase the advection term is more important than in the cyclonic phase (Fig. 5). In earlier case the advection term is proportional to the vorticity sum of the Ionian and Adriatic while in the latter case the advection term is proportional to the difference between the two. Therefore, the local current vorticity input prevailed in the period 1997-2006 when the Ionian was in the cyclonic phase and the advection term is proportional to the vorticity differences between the Ionian and the Adriatic. Before 1997 and after 2006 the Ionian was characterized by the anticyclonic circulation mode and the vorticity advection term was proportional to the vorticity sum and thus more important. Therefore, in the Ionian cyclonic circulation phase the local input, i.e. the wind-stress curl, has a prevailing effect on the current vorticity and thus the correlation between the two is probably stronger. On the other hand, in the BiOS anticyclonic phase the vorticity advection term may become significant and probably of comparable importance as the wind-stress curl. Consequently, the correlation between the flow vorticity tendency and wind-stress curl is very likely weaker.'

P 224, before figure 5:

We added the above figure.

Caption: Figure 5. Time-series of the low-pass filtered (13 months) current vorticity advection from the North Ionian Sea to the South Adriatic Sea. Areas shaded in red correspond to the time periods of cyclonic circulation and the black dashed lines show the average values of the advection over each cyclonic/anticyclonic period.

P 212, line 20 (Fig. 5a) was changed to (Fig. 6)

P 213, line 11 (Fig. 6a) was changed to (Fig. 7a)

P 213, line 15 (Fig. 6b) was changed to (Fig. 7b)

P 224: number of figure 5 was changed to figure 6.

P 225: number of figure 6 was changed to figure 7.

P 226: figure 7 was deleted.

3) **<u>Referee Comment</u>**:

The same follows later in the manuscript for NAO index, which can easily be miss-interpreted as direct cause for dynamics, it is not following and is result from the analysis presented. This is my major objection with the manuscript; using simple statistical tool as correlation to give possible mechanism for complex phenomena of SAG and it's relation to different forcing sources and inter annual climate variability.

<u>Author's response</u>:

Our conclusion is not that NAO is the direct cause of the circulation variations of the SAG and calculations of the correlation coefficients is not the only tool used to explain the mechanism. We first correlate wind-stress curl and the flow vorticity tendency considering also the vorticity advection from the Ionian. Then we analyzed the wind pattern for the negative and positive modes of NAO (showing that the stronger wind vorticity occurs during NAO- and vice versa) in order to explain the statistically significant negative correlation between NAO and wind curl obtained from figure 5a. (r= 0.6, sig. 95%).

Author's changes in manuscript:

P 212, line 23: 'revealed negative correlation' was replaced by 'revealed the significant (95%) negative correlation'

4) **Comment from Referee**:

In Figure 3 there is correlation between low passed vorticity and wind stress giving range of -0.8 and 0.8 at small area (yellow-red region close to 19E, 41.5N). How does authors explain that results of almost uncorrelated to high correlated values in such a small area?

Author's response:

We added more explanations in the manuscript attributing these small-scale spatial variability to the orographically-induced shear in the Adriatic wind field.

Author's changes in manuscript:

P 211, line 16 to 24: 'First we compared the low passed (seasonal signal filtered out) time-series of the time-derivative of current vorticity with the curl of the wind-stress calculating the linear correlation coefficient in each data point of the study domain. The spatial distribution of the correlation coefficient over the study area shows that the maximum positive correlation coincided rather well with the center of the SAG, i.e. with the minimum of the sea level height (Fig. 3). This suggests that the Ekman suction controls the strength of the SAG determining the valley in the center of the gyre. Therefore, in accordance with the quasi-geostrophic equation of the vorticity conservation, the most important mechanism responsible for the variations of the current vorticity is the wind-stress curl.'

was replaced by:

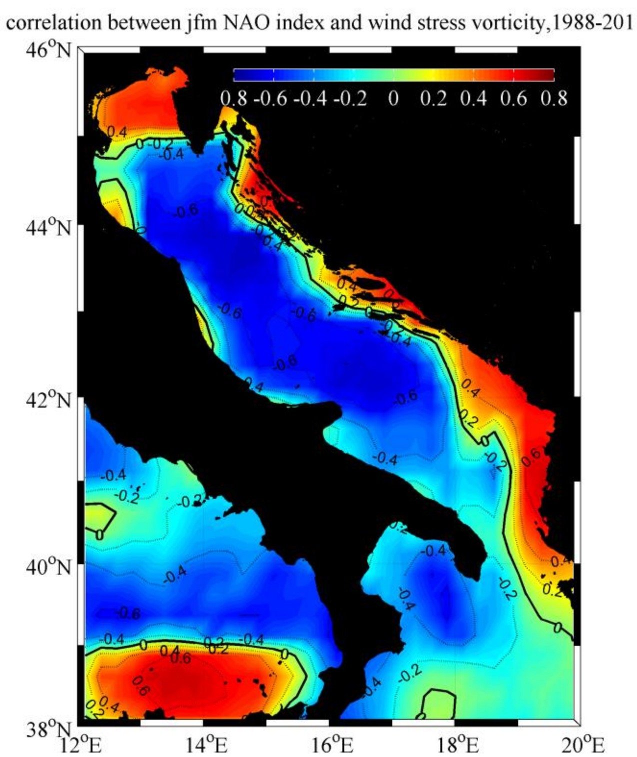
'First to estimate the importance of the local input in the vorticity equation, we compared the low passed (seasonal signal filtered out) time-series of the current vorticity tendency with the curl of the wind-stress calculating the linear correlation coefficient in each data point of the study domain. The spatial distribution of the correlation coefficient over the study area shows along the eastern border of the SAG the small-scale variability of the correlation coefficients probably due to orographically induced small-scale shear in the wind field. In addition, an area of the statistically significant (95%) positive correlation coefficient close to the centre of the SAG coincides rather well with the minimum of the sea level height (Fig. 3). This suggests that the Ekman suction controls the strength of the SAG determining the valley in the centre of the gyre. Therefore, in accordance with the quasi-geostrophic equation of the vorticity conservation, the mechanism partially responsible for the variations of the current vorticity is the wind-stress curl.'

5) Comment from Referee:

In Figure 5 they give correlation coefs. In a rage of -0.2 and 0.1 for SAG region; how significant is that in statistical sense?

Author's response:

We presented in figure 6 the correlation between JFM NAO index and curl of wind stress instead of the low-pass time-series. It reveals the significant (>95%) and relatively high correlation (r= 0.6 in the SAG).



Author's changes in manuscript:

P 212, line 18: … 'we compared time-series of the low-passed NAO index (13 month moving average) with the wind-stress curl' was replaced by 'we compared time-series of the wintertime NAO index with the wind-stress curl'

P 212, line 23: 'revealed negative correlation' was replaced by 'revealed the significant (95%) negative correlation'

P 224, fig. 5a: we changed the map to JFM,

Caption: 'Figure 5. Spatial distribution of the correlation coefficient of (a) the low passed filtered NAO index and wind-stress vorticity, and (b) JFM NAO index and the frequency of northerly winds, 1988-2011. The black solid line indicates the 0 correlation'

was replaced by:

Figure 6. Spatial distribution of the correlation coefficient of the JFM NAO index and wind-stress vorticity.

6) **Comment from Referee**:

Calculation of the wind stress vorticity shown at the Figure 6 is hard to anticipate, as there are large regions (i.e. below 41N) where wind stress vectors are parallel, however giving high vorticity (color).

Author's response:

The flow doesn't have to have an apparent vortex to have vorticity. The concept of vorticity is very well explained in "An Introduction to Dynamic Meteorology" by James R. Holton, Gregory J. Hakim. In the figure 4.6 a, (page 103) the linear shear flow with vorticity and the curved flow with zero vorticity is clearly shown.

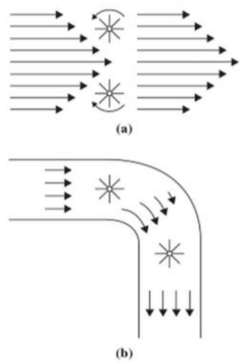


FIGURE 4.6 Two types of two-dimensional flow: (a) linear shear flow with vorticity and (b) curved flow with zero vorticity.

In the figure 6 of the manuscript, although the wind vectors are parallel, the vorticity is generated by the gradient of the zonal (maridional) component of the wind in the y (x) direction.

7) **<u>Comment from Referee</u>**:

At the end of manuscript they briefly link the results with phytoplankton dynamics, for which I think needs more focused and extended study or even separate manuscript (like Yamada and Ishizaka; Navarro et al., 2012; Zhai et al.,2013).

<u>Author's response</u>:

We accepted fully the suggestions by both referees and removed the entire part of the ms. treating the pytoplankton phenology.

<u>Author's changes in manuscript</u>:

P 205, line 25 to p 206, line 13: 'winter convective mixing …. and rates of the vertical mixing.' was removed from the manuscript.

P 206, line 16:

'(from wind and advection), and then to large-scale climatic regime (NAO index will be considered). Subsequently, the dependence of the northerly winds responsible for the winter convection, on the NAO will also be studied. Finally, a possible relationships between climatic forcing and the phytoplankton biomass, as well as with the timing of bloom onset will be analysed.'

was replaced by:

‘(from wind and advection), and then possibly to large-scale climatic regime (NAO index will be considered).’

P 213, line 27 to p 215, line 6: ‘Convection and mixing are the most important… climate change on the SAG ecosystem’ was deleted.

The other changes in the manuscript:

Title was changed to:

‘Long-term variability of the South Adriatic circulation in relation to large scale climatic pattern’

P 204, line 4: ‘altimetry’ was replaced by ‘altimetric’.

P 204, line 14: ‘characterized by lower positive values’ was replaced by ‘characterized by lower positive or slightly negative values’.

P 210, line 1: ‘The different terms of the vorticity equation were analysed in order to evaluate the various sources of current vorticity.’

was replaced by:

‘The vorticity equation was analysed in order to evaluate the importance of various sources of current vorticity’

P 210, line 8: ‘Since we assume the barotropic flow, the internal pressure gradient (the third term on the right) can be negligible. We also ignore the bottom stress.’

was replaced by:

‘Since we assume the predominance of the barotropic flow, the internal pressure gradient (the third term on the right) can be ignored. We also neglect the bottom stress.’

P 211, line 4: ‘The interannual variability prevailed in both wind-stress curl and current vorticity in the South Adriatic (Figs. 2a and 2b),’

was replaced by:

‘The interannual variability prevailed also in the wind-stress curl (Fig. 2a),’

P 211, line 10: ‘current vorticity Eq. (8)’ was replaced by: ‘flow vorticity equation (8)’

P 212, line 22: ‘was practically null’ was replaced by ‘was statistically insignificant’

P 215, line 10: ‘Possible local forcing is sought’ was replaced by ‘Local forcing is analysed’

P 215, line 11: ‘were looked for in the vorticity from the adjacent area’ was replaced by ‘were looked analysing the vorticity in the adjacent area’

P 215, line 17: ‘current vorticity was partially induced by the local wind vorticity input’ was replaced by ‘current vorticity tendency can partially be explained in terms of the local wind vorticity input’

P 215, line 25: ‘evidenced’ was replaced by ‘revealed’

P 215, line 27 and P 216, line 1: ‘become more important’ was replaced by ‘become larger and presumably more important’

P 216, line 20: ‘The ESA Ocean Colour CCI Team is thanked for providing OC-CCI chlorophyll data; NASA for providing SeaWiFS, MODIS and MERIS chlorophyll data.’ is removed.

P 217, line 16: ‘convention’ was replaced by ‘convection’

The following references related to the phytoplankton phenology were deleted:

P 217, line 8: ‘Collins, A. K., Allen, S. E., Pawlowicz, R.: The role of wind in determining the timing of the spring bloom in the Strait of Georgia, Canadian Journal of Fisheries and Aquatic Sciences, 66, 1597-1616, 2009.’

P 217, line 10: ‘Dutkiewicz, S., Follows, M., Marshall, J., and Gregg W.: Interannual variability of phytoplankton abundances in the North Atlantic, Deep-Sea Research II, 48, 2323-2344, 2001.’

P 217, line 12: ‘Moline, M.A., and Prézelin B.B.: Palmer LTER 1991-1994: Long-term monitoring and analyses of physical factors regulating variability in coastal antarctic phytoplankton biomass, in situ productivity and taxonomic composition over subseasonal, seasonal and interannual time scales. Marine Ecology Progress Series, 145, 143-160, 1996.’

P 218, line 19: ‘Racault, M.-F., Le Quéré, C., Buitenhuis, E., Sathyendranath, S. and Platt, T.: Phytoplankton phenology in the global ocean. Ecological Indicators, 14(1):152163, 2012.’

P 218, line 25: ‘Santoleri, R., Banzon, V., Marullo, S., Napolitano, E., D’Ortenzio, F., and Evans, R.: Year-to-year variability of the phytoplankton bloom in the southern Adriatic Sea (1998–2000): Sea-viewing Wide Field-of-view Sensor observations and modeling study, J. Geophys. Res., 108(C9), 8122, doi: 10.1029/2002JC001636, 2003.’

P 218, line 32: ‘Siegel, D.A., Doney, S.C., and Yoder, J.A.: The North Atlantic spring phytoplankton bloom and Sverdrup's critical depth hypothesis. Science, 296: 730-733, 2002.’

P 219, line 1: ‘Sverdrup, H.U.: On conditions of the vernal blooming of phytoplankton. Journal du conseil international pour l'exploration de la mer 18, 287-295, 1953.’

P 219, line 7: ‘Williams, R. G. and Follows, M. J.: Physical transport of nutrients and the maintenance of biological production, In Ocean Biogeochemistry, pp. 19-51, Springer Berlin Heidelberg, 2003.’

P 219, line 9: ‘Xu, Y., Cahill, B., Wilkin, J. and Schofield O.: Role of wind in regulating phytoplankton blooms on the Mid-Atlantic Bight, Continental Shelf Research, 6, S26–S35, 2012.’

P 219, line 11: ‘Yamada, K. and Ishizaka, J.: Estimation of interdecadal change of spring bloom timing, in the case of the Japan Sea. Geophysical Research Letters 33: doi: 10.1029/2005GL024792. issn: 0094-8276, 2006.’