CYCLOGEOSTROPHIC CORRECTION OF THE AVISO SURFACE VELOCITIES FOR INTENSE SURFACE EDDIES AND ITS APPLICATION TO THE MEDITERRANEAN SEA.

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Abstract

The surface geostrophic velocities derived from the satellite altimetry allows to quantify surface eddies. However, the neglect of centrifugal accelerations results in an over estimation (underestimation) of the velocities in the cyclonic (anticyclonic) eddies. . The main goal of this study was to identify the range of parameters where the cyclogeostrophic correction is needed. Iterative and perturbative methods were both studied to provide a robust algorithm able to converge for a wide range of parameters. This ageostrophic correction was tested on the 1/8° AVISO regional product available for the Mediterranean Sea and correction up to 50% or 120% were accounted.

Keywords: Mesoscale phenomena, Remote sensing, Water transport, Algerian Basin, North-Eastern Mediterranean

The recent progress in automated eddy detection algorithms enables to identify coherent structures at the ocean surface. Several algorithms [1,2] use the surface geostrophic velocities derived from the satellite altimetry to quantify the size and the intensity surface eddies. However, neglecting the centrifugal accelerations results in an over estimation (underestimation) of the velocities in the cyclonic (anticyclonic) eddies. Errors up to 50cm/s were found for the intense eddies of the Mozambique chanel when centrifugal accelerations is neglected [3]. For an horizontal, stationary and non-dissipative flow, the momentum equation that rely the sea surface deviation *h* with the horizontal velocity ***u*** is given by:

$$\mathbf{u}.\nabla\mathbf{u} + f\mathbf{k}\times\mathbf{u} = -g\nabla h$$

Solving this non-linear equation leads to a complex inversion problem that may not always converge. Exact solution exists only for a circular eddy but the wide majority of oceanic structures are not axisymmetrical. The geostrophic assumption allows a simple linear inversion for all cases but its validity is restricted to small Rossby numbers. The main goal of this study was to identify the range of parameters where the cyclogeostrophic correction is needed to quantify accurately the vortex Rossby number of surface eddies:

$$Ro = \frac{V_{max}}{f\, R_{max}}$$

where V_{max} is the maximal azimuthal velocity and R_{max} the corresponding radius. The perturbative and iterative methods were both tested to calculate the ageostrophic terms. We found that combining the iterative method with a quintic interpolation provides the best accuracy when the vortex Rossby number do not exceed 0.3. We then apply this algorithm on the AVISO ADT geostrophic velocities, gridded at 1/8°, in the Mediterranean Sea. We first select the intense surface eddies, having a vortex Rossby number larger than 0.12, detected by the angular momentum eddy detection algorithm [2] during the 15 year period between 2000 and 2015. We consider only meso scale eddies having a typical radius equal or larger than the local deformation radius and exclude smaller vortices. Then we compute the ageostrophic corrections of the velocity component in a restricted area centered on the detected eddy.

An example of corrected velocity profile is given in Figure 1 for the Ierapetra anticyclone. The amplitude of the maximal cyclogeostrophic velocity is 30% higher than the geostrophic one while the characteristic eddy radius is reduced by 10%. The global analysis for the various eddies show an asymmetry between cyclonic and anticyclonic structures. The ageostrophic correction is much weaker for the intense cyclones than for the anticyclones. Moreover, we found that anticyclones with an initial geostrophic Rossby number of 0.2 need a significant ageostrophic correction up to 30% or 40% (120% when Ro was around 0.26). The amplitude of this correction depends on the Rossby number but also on the ellipticity and the shape parameter of the velocity profile. Circular anticyclones with a steep velocity gradient will lead to the strongest ageostrophic correction. Our analysis shows that the geostrophic velocities of anticyclones derived from the satellite altimetry should be corrected even for relatively weak geostrophic Rossby number of 0.1

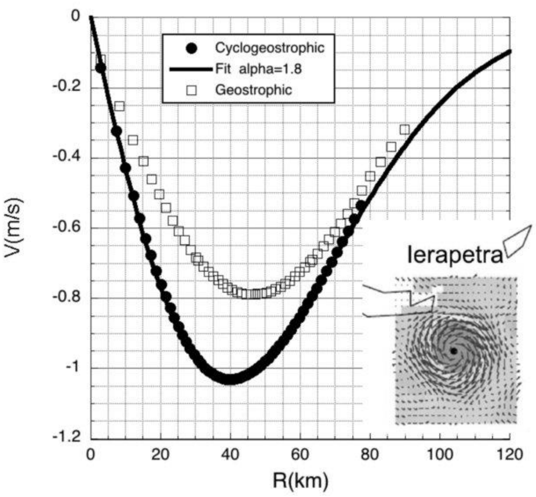

Fig. 1. Geostrophic (open square) and cyclogeostrophic (filled circle) velocity profile computed from the AVISO absolute dynamical topography for the Ierapetra eddy August 12, 2014.

Hence, in the Mediterranean Sea the intensity of a large number of meso scale eddies are underestimated by the standard AVISO geostrophic velocties and a optimized algorithm is proposed to compute these ageostrophic component of motion.

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