OCEAN SURFACE GEOSTROPHIC CIRCULATION CLIMATOLOGY AND ANNUAL VARIATIONS INFERRRED FROM SATELLITE ALTIMETRY AND GOCE GRAVITY DATA.

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ABSTRACT

In this work we study for the first time absolute Surface Geostrophic Currents (SGC) variations using only satellite data. The proposed approach combines 18 years altimetry data, which provide reliable measurements of the Absolute Sea Level (ASL) height with a GOCE geoid model to obtain a Dynamic Topography with an unprecedented precision and accuracy. Our proposal allows overcoming the main limitations of existing approaches based solely on altimetry data (that suffer the lack of an independent reference to derive ASLmaps), and approximations based on in-situ data (which are characterized by a sparse and non homogeneous coverage in time and space). Features of the SGC annual variations are also addressed.

As a result of our study we provide a new climatology of absolute SGC in the form of a 52 weeks data set of surface current fields, gridded at a quarter degree longitude and latitude resolution resolving spatial scales as short as 140 km. For presentation, this data set is averaged monthly and the results, presented as monthly climatology, are compared with a climatology based on in-situ observations from drifter data.

DATA AND METHODOLOGY

Geoid Model:
We use the 3rd generation of GOCE data to determine the geoid, in particular we use the Earth Gravity Model (EGM) solution produced by the time-wise approach. The time-wise approach offers a GOCE-only model in a rigorous sense. The GOCE gravity model is given after application of the usual corrections (GOCE-C 2009). In order to match the grid of altimetry data we evaluate the GOCE geoid also in a quarter degree grid.

Sea Surface Height:
Weekly and monthly maps of the absolute sea level height are estimated by restoring the Sea Level Anomalies (SLA) to the Mean Sea Surface (MSS) of reference. Sea level maps are provided by AVISO (www.aviso.oceanobs.com) as a weekly merged solution from several altimetry satellites (ERS-1/2, Topex/Poseidon (T/P), ENVISAT and Jason-1/2) and with time span from 1992/20/24 to 2012/12/01. These maps are given as anomalies with respect to the CLS-G1-MSS. In order to obtain the ASL from these anomalies, the CLS-G1-MSS was back added to each SLA map in order to make feasible the computation of the DT and their derived SGC. Usual corrections are already applied to all data sets (see SEATO/NOACK User Handbook).

Time-variable surface geostrophic currents:
The SGC speed \( \mathbf{u}_{SGC} = \mathbf{u}_n + \mathbf{u}_e \), in terms of the zonal or eastward component, \( \mathbf{u}_e \), and the meridional or northward component, \( \mathbf{u}_n \), along the east (x) and north (y) directions, follows immediately via the geostrophic equation for the balance of the pressure gradient force and the Coriolis parameter:

\[
\mathbf{u}_{SGC} = \frac{-f}{\partial_y \xi} \mathbf{v} + \frac{f}{\partial_x \xi} \mathbf{u},
\]

where \( \xi \) is the ASL, \( f \) is the Coriolis parameter that depends on the latitude. The Coriolis parameter vanishes at the equator, therefore the numerical computation. We treat this problem by estimating the SGC for the equatorial band (5°S, 5°N) following the methodology proposed in (LARIGEDEL et al. 1999).

Drifter Buoy Data:
A monthly climatology for the ocean surface currents based on in-situ drifter buoy measurements is provided by the Global Drifter Program on a one degree grid covering latitudes between 77°S and 87°N (see www.pmel.noaa.gov/shco/buoy/ drifter_climatology.html, and LUMPAWI and GARAFBO). Drifters observations include geostrophic currents and several other signals (tide currents, Elna currents, inertial currents and high-frequency geostrophic currents), hence the drifter data must be corrected in order to achieve consistency in the comparison with the geostrophic velocities derived from the geodetic DT.