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

M.I. VIGO, J.M. SÁNCHEZ-REALES, and M. TROTTINI

UNIVERSIDAD DE ALICANTE

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 ASL maps), 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 (GOCE)

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 (EGG-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 1992/10/14 to 2010/12/01.

These maps are given as anomalies respect to the CLS01-MSS. In order to obtain the ASL from these anomalies, the CLS01-MSS was added back 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 SSALTO/DUACS USER HANDBOOK).

Time-variable surface geostrophic currents

The SGC speed $U_s=u_s+iv_s$ in terms of the zonal or eastward component, u_s, and the meridional or northward component, v_s, 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:

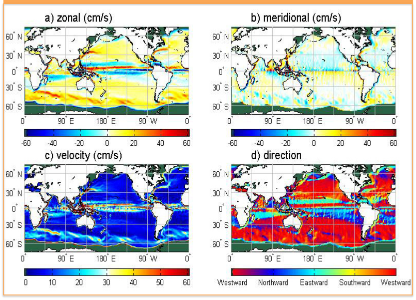
$$u_s(t) = -\frac{g}{f}\frac{\partial ADT(t)}{\partial y}, \qquad v_s(t) = \frac{g}{f}\frac{\partial ADT(t)}{\partial x}, \quad (1)$$

where ADT(t) is the ASL(t) minus the geoid, g is gravity, and 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 (LARGELOEF et al. 1999).

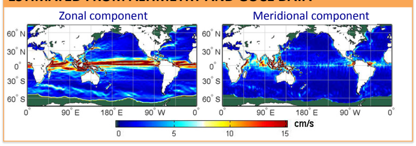
Drifter Buoys data

A monthly climatology for the ocean surface currents based on in-situ drifter buoys measurements is provided by the Global Drifter Program on a one degree grid covering latitudes between 73°S and 85°N (see www.aoml.noaa.gov/phod/dac/drifter_climatology.html, and LUMPKIN AND GARRAFFO 2005). Drifters observations include geostrophic currents and several other signals (tide currents, Ekman currents, inertial currents and high-frequency ageostrophic 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.

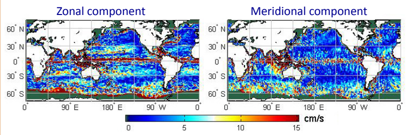
ANNUAL MEAN SGC CLIMATOLOGY ESTIMATED FROM ALTIMETRY AND GOCE DATA



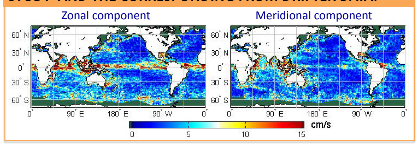
STANDARD DEVIATION OF THE MONTHLY SGC CLIMATOLOGY ESTIMATED FROM ALTIMETRY AND GOCE DATA



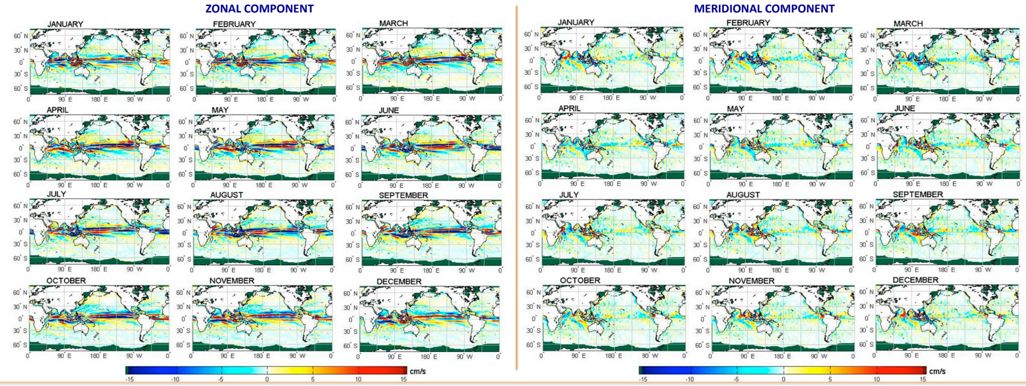
ABSOLUTE DIFFERENCES BETWEEN ANNUAL MEAN SGC CLIMATOLOGY ESTIMATED FROM ALTIMETRY AND GOCE DATA THE CORRESPONDING CLIMATOLOGY OBTAINED BY DRIFTER DATA.



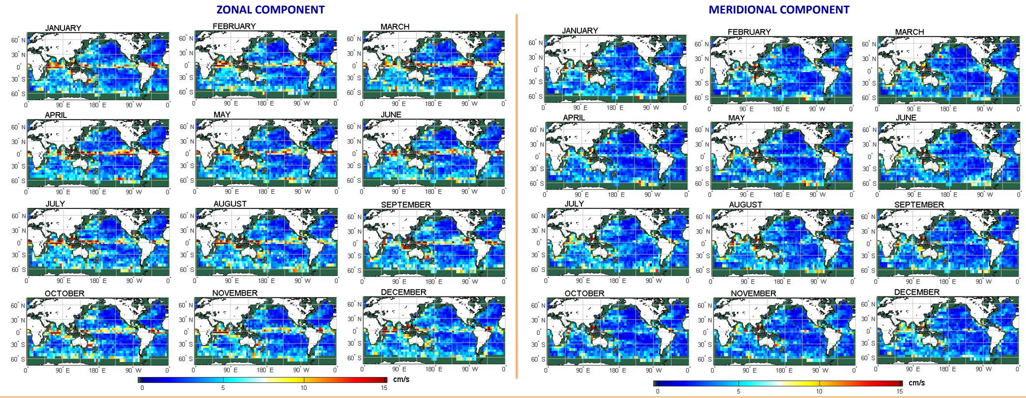
RMS OF THE DIFFERENCES BETWEEN ANNUAL MEAN SGC FROM ALTIMETRY AND GOCE DATA FOR THE 18 YEARS OF STUDY AND THE CORRESPONDING FROM DRIFTER DATA.



MONTHLY SGC CLIMATOLOGY ANOMALIES ESTIMATED FROM ALTIMETRY AND GOCE DATA.



RMS (FOR EACH 5 DEGREE BIN) OF THE MONTHLY DIFFERENCES BETWEEN ALTIMETRY AND GOCE AND DRIFTER-BASED SGC CLIMATOLOGY.

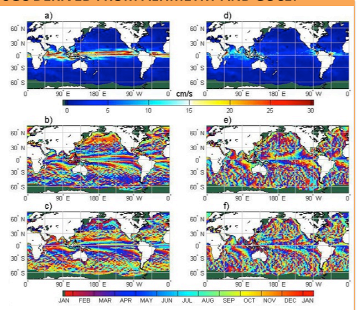


ANNUAL VARIATION OF SGC DERIVED FROM ALTIMETRY AND *GOCE*.

Annual amplitude, half range:
(a) Zonal component.
(d) Meridional component.

Month at which the maximum is achieved:
(b) Zonal component.
(e) Meridional component.

Month at which the minimum is achieved:
(c) Zonal component.
(f) Meridional component.

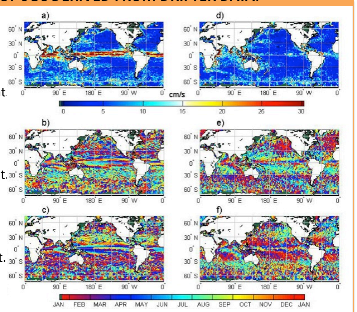


ANNUAL VARIATION OF SGC DERIVED FROM DRIFTER DATA.

Annual amplitude, half range:
(a) Zonal component.
(d) Meridional component

Month at which the maximum is achieved:
(b) Zonal component.
(e) Meridional component

Month at which the minimum is achieved:
(c) Zonal component.
(f) Meridional component.



REFERENCES

-EGG-C (European GOCE Gravity Consortium) (2009). *GOCE high level processing facility: GOCE level 2 product data handbook*. GO-MA-HPF-GS-0110.

-Lagerloef, G. S. E., G. T. Mitchum, R. B. Lukas, and P. P. Niiler (1999), Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data, *J. Geophys. Res.*, 104(C10), 23,313–23,326, doi:10.1029/1999JC900197

-Lumpkin R., and Garraffo Z., (2005) Evaluating the Decomposition of Tropical Atlantic Drifter Observations. J Atmos Ocean Techn I 22, 1403-1415. doi: http://dx.doi.org/10.1175/JTECH1793.1

-Niiler, P. P., (2001), The world ocean surface circulation. In Ocean Circulation and Climate, G. Siedler, J. Church and J. Gould, eds., Academic Press, Volume 77 of International Geophysics Series, 193-204.

-Ssalto/Duacs User Handbook: M(SLA) and M(ADT) Near-Real Time and Delayed-Time. SALP-MU-P-EA-21065-CLS

New frontiers of Altimetry – Lake Constance, Germany - October 2014

›OSTST meeting

Acknowledgement: This work was funded and realized in the framework of the project CGL2010-12153-E from the Spanish Department of Science and Innovation (MICINN).