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Validating geostrophic currents of a dynamic ocean topography with data of ARGO floats and surface drifters

Felix Müller, Wolfgang Bosch, and Denise Dettmering

Deutsches Geodätisches Forschungsinstitut der TU München (DGFI-TUM), München, Germany,

(felix-lucian.mueller@tum.de)

Introduction The time-variable dynamic ocean topography (DOT) estimated by Bosch et al. (2013) along the ground tracks of altimeter satellites (iDOT-profiles) allows to study temporal variations of the DOT on spatial scales close to meso-scale structures. In the present study, we validate this DOT by interpolating the iDOT-profiles on a regular grid, computing the associated geostrophic velocity field and comparing this with gridded surface currents observed by ARGO floats and surface drifters, both corrected for wind and Ekman drift. Both velocity fields agree quit well on a quarterly basis, chosen in order to have a sufficient density of the in-situ data. To prevent unnecessary smoothing we also perform a pointwise comparison by interpolating the iDOT profiles to the in-situ positions.

Using iDOT-profiles

DOT-estimates along the ground tracks of Envisat and Jason1/2 altimeter missions (iDOT-profiles, Fig. 1) are taken from the OpenADB data base of DGFI-TUM (Schwatke et al. 2014). They have been derived by applying a Gauss filter to the altimetric sea surface heights h reduced by geoid heights N from the GOCO03S satellite-only gravity field (Bosch et al. 2013).

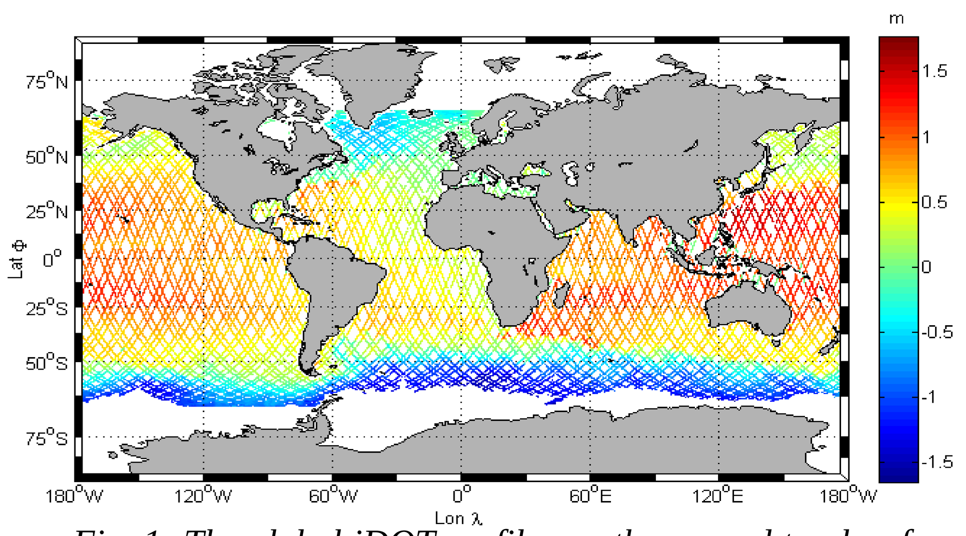


Fig. 1: The global iDOT profiles on the ground tracks of Cycle 36 from Jason-2 in June 2009.

iDOT-profiles transformed to geostrophic velocities

Two methods have been used to convert iDOT-profiles to geostrophic velocities:

a) Gridding of DOT heights on a 1°x1° grid by weighted averages with weights set by a Gauss function depending on the distance between data points and grid nodes. Subsequently grid gradients were used to obtain u- and v-components by the geostrophic equations.

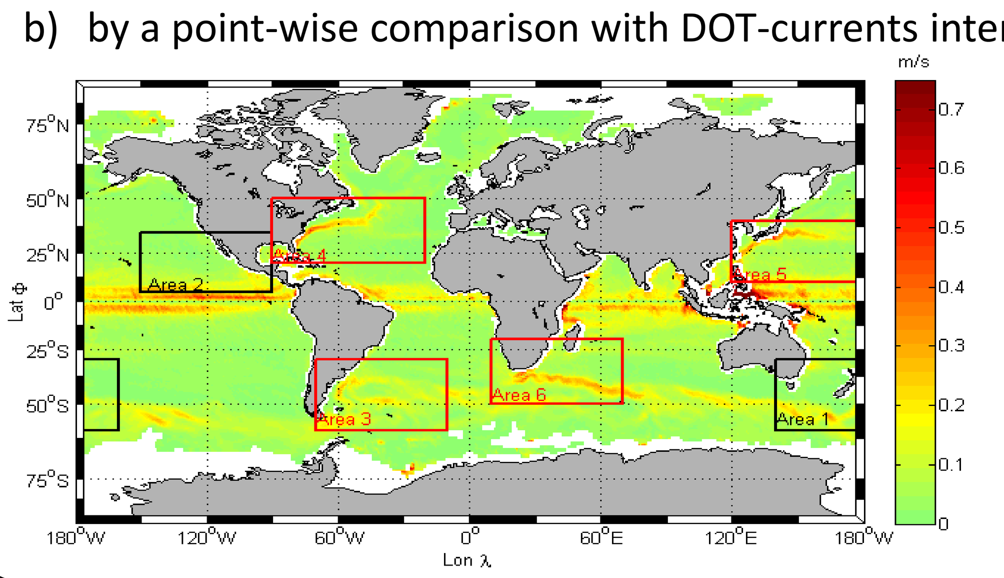
b) A least-squares fit of a slant plane to the location of the in-situ data with weights set by Gauss functions of the distance and the time-lag between DOT and in-situ data. The slopes of the plane give u- and v-components of the geostrophic current.

Methodology: Quarterly gridded (a) and pointwise comparison (b)

The DOT and the in-situ data sets are compared

a) by means of gridded currents (1°x1°) averaged for quarterly (three-month) periods and

b) by a point-wise comparison with DOT-currents interpolated to the in-situ observations.



Study Areas

Comparison is focused on six study areas with four of them containing strong western boundary currents.

Fig. 3: The location of the six study areas.

Comparison a) Quaterly averaged currents on a 1°x1° grid

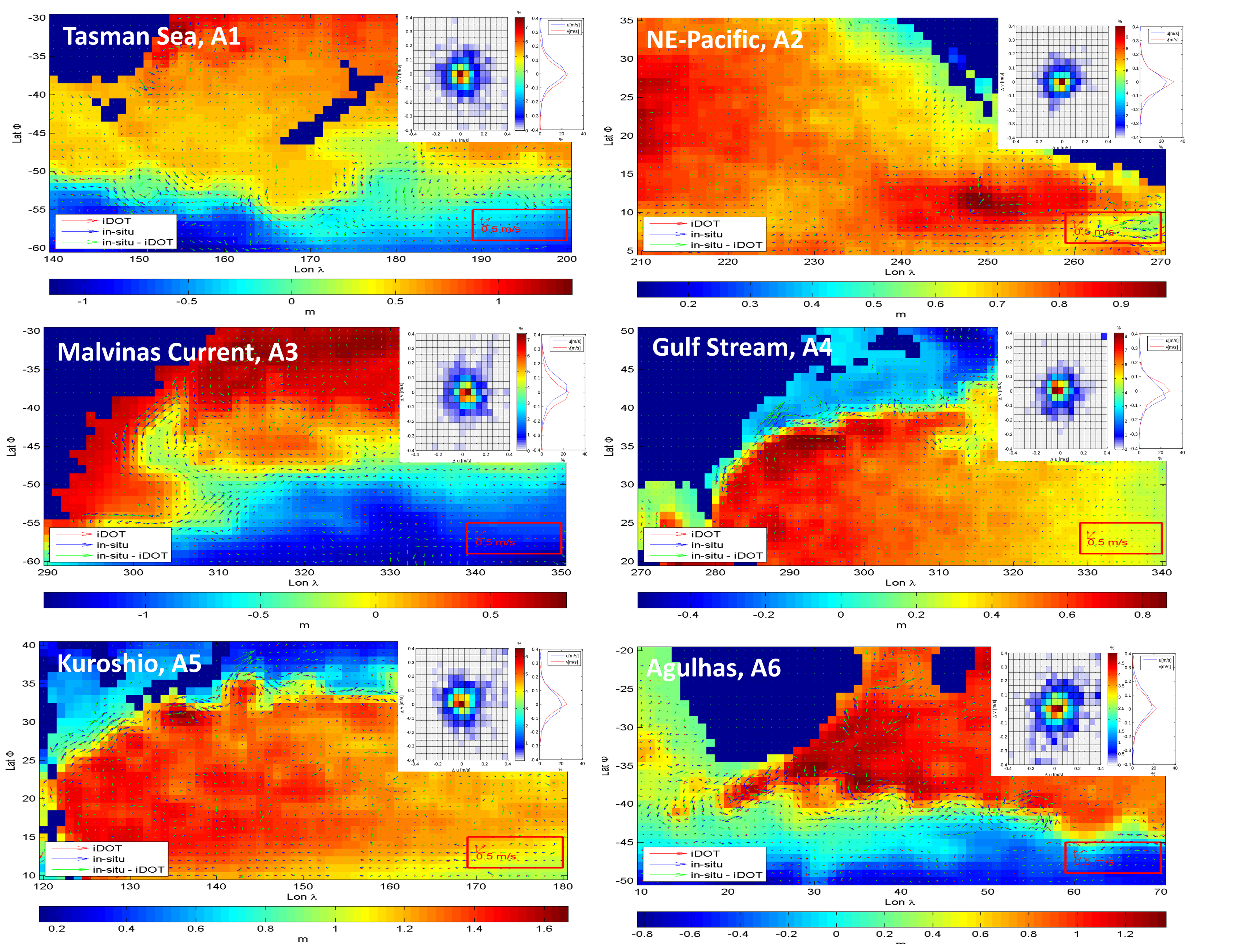


Fig. 4: Zoom to the study areas (cf. Fig. 3) with the geostrophic velocity fields derived from iDOT-profiles (red), the in-situ velocity vectors (blue) and the vector differences (green) for the second quarter 2009. The background color shows the DOT (from iDOT-profiles) for the same quarter. Additionally the distribution of the residual vector fields (in-situ minus iDOT) are shown for each area in a scatter plot.

ARGO floats and surface drifter

To improve the sparse in-situ data distribution, surface drifter from AOML [Lumpkin et al. 2013] and ARGO-float data of the "YoMaHa07" data set [Lebedev et. al, 2007] are merged. Drifter data are used only with the drogue attached. The time period 2007 – 2010 is selected for validation as a maximum of ARGO floats are available for this time period.

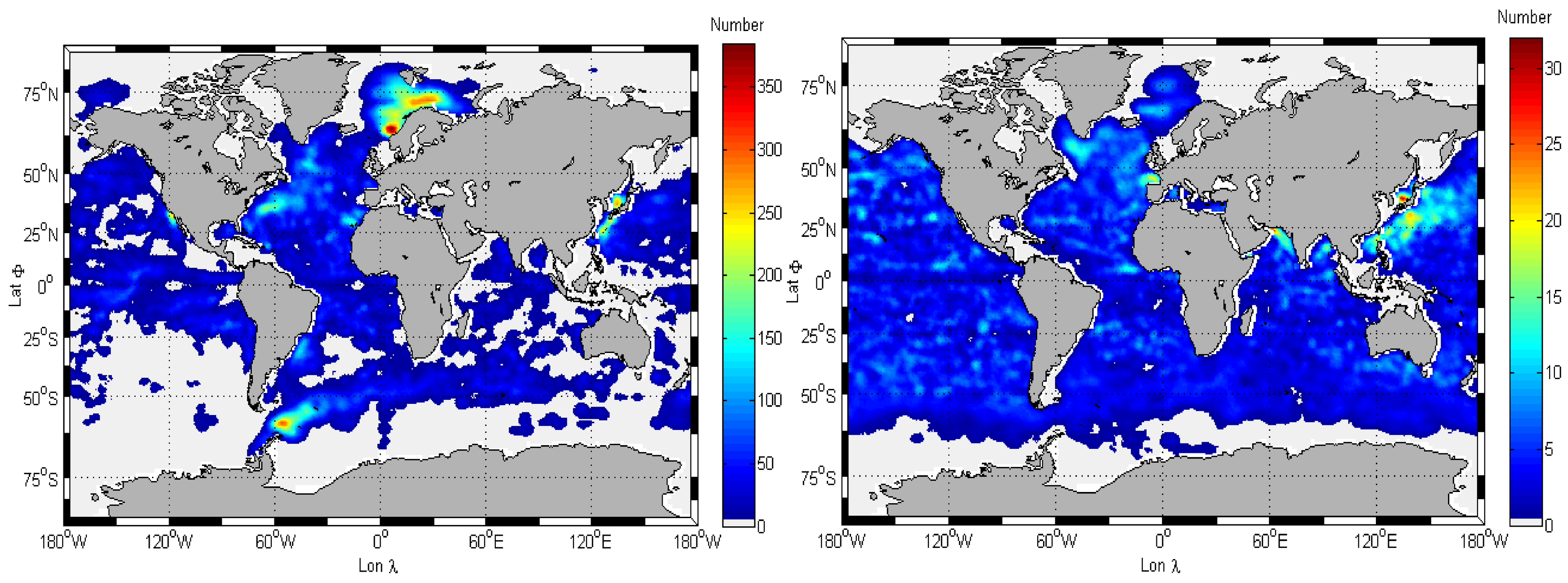


Fig. 2: Mean monthly geographic distribution of surface drifter (left) and ARGO floats (right) for the validation period 2007 – 2010. Averaging on 1°x1° grid nodes with a 210 km cap size radius around each grid node.

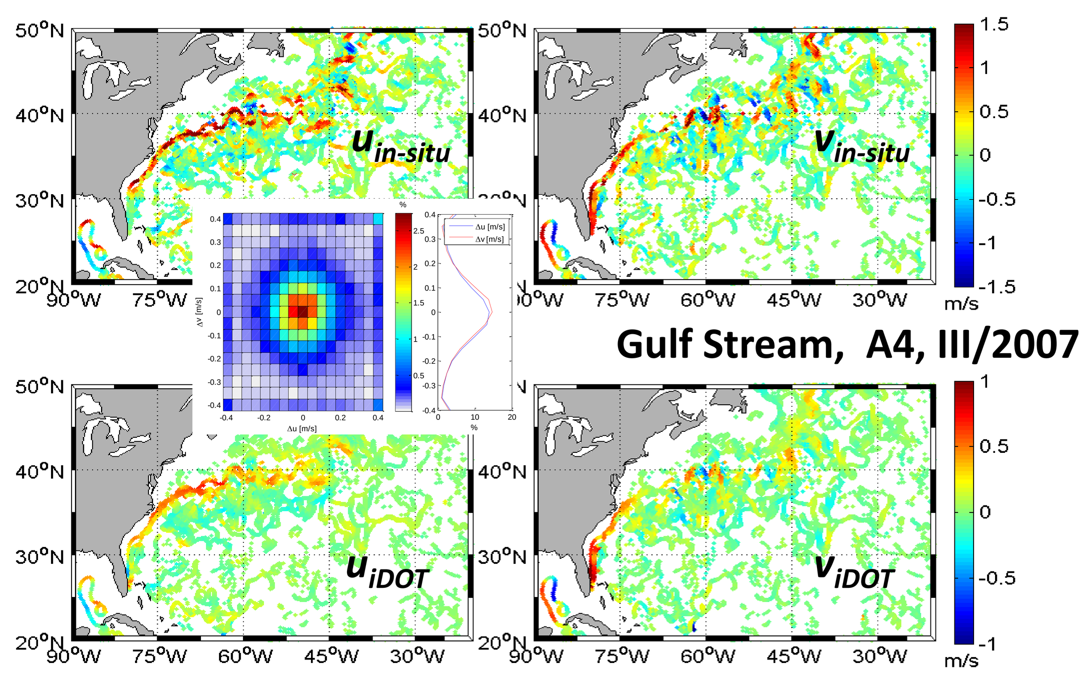
Ekman and local wind influence corrected in-situ velocities

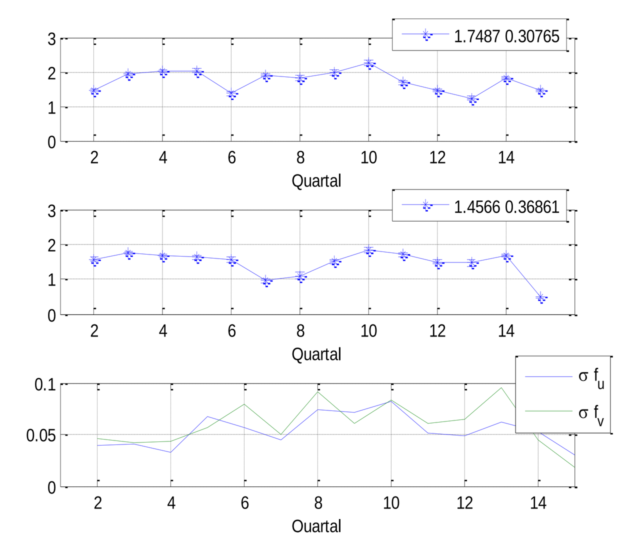
The in-situ data is affected by local wind and the Ekman drift. In order to compare in-situ velocities $U_{in\text{-}situ}$ and geostrophic velocities U_g the data of drifters and floats are to be corrected for a-geostrophic influences. This is done by

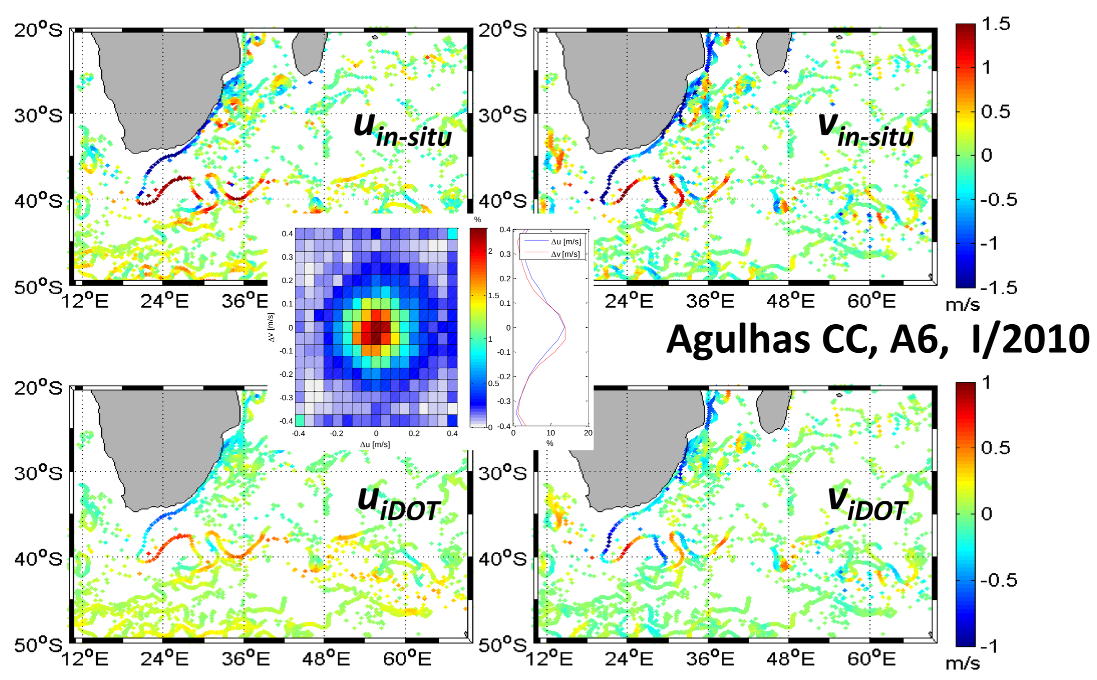
$$U_g = U_{in-situ} - \left(a_2\tau + \frac{cW_{u,v}}{10}\right)$$

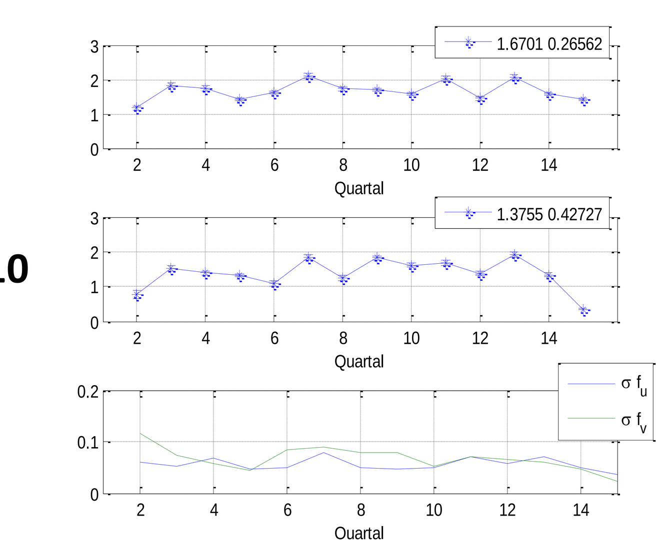
Where τ is the wind stress, $W_{u,v}$ is the wind speed. The coefficient a_2 is derived by the approach of Lagerloef et al. (1999) and wind speed- and wind stress fields are taken from the NCEP/NCAR Re-analysis 2.

Comparison b) Pointwise at in-situ locations shown for 2 study areas









▼▲Fig. 5: Geostrophic velocity components for the Gulf Stream (top) and the Agulhas area (bottom) of in-situ data (upper rows) and from interpolated iDOT-profiles (lower rows) show consistent meso-scale features with smoothed iDOT-components. The central scatter plot is an unbiased 2-d distribution of the component differences (in-situ minus iDOT) with most differences inside the interval ± 0.15 m/s.

▼▲ Fig. 6: Least-squares estimates of scaling factors (in-situ divided by iDOT) for the zonal (top row) and meridional (middle row) component and their formal errors (bottom row) as a function of the quarter 2-15 (II/2007 – III/2010)

Conclusions:

- Comparison a) with quarterly averages shows that in general both velocity fields agree quite well – the differences of velocity components have zero means and remain for 67% between ± 0.075 m/s.
- The pointwise comparison b) using un-smoothed in-situ data shows neither systematic deviations nor outliers between the two data sets. The differences exhibit normal distribution with zero mean and most differences located inside the interval ± 0.15 m/s.
- The smoothing of DOT-derived geostrophic currents is inevitable (even for the pointwise comparison) and manifests itself by the estimated scaling factors. Nevertheless the DOT currents exhibit temporal meso-scale structures and provide a quasi global availability.
- For the time series of 15 quarters (I/2007 – III/2010) no significant variations were detected – indicating that iDOT and in-situ data represent the same temporal variations.

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