Space-based time-variable dynamic ocean topography validated by in-situ surface currents from ARGO floats and surface drifters

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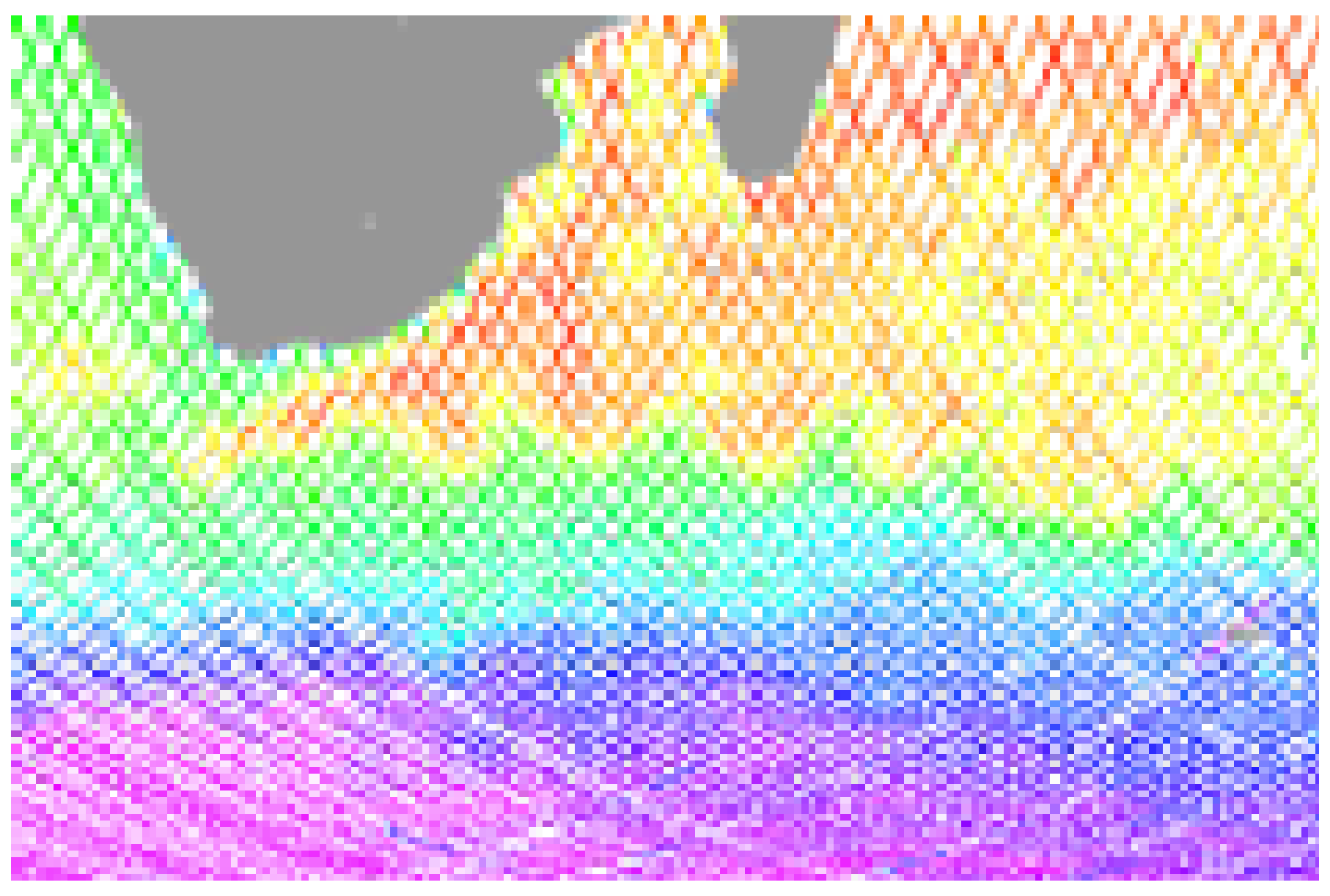
Introduction

With the latest satellite-only Earth gravity field from GRACE and GOCE a space-based dynamic ocean topography (DOT) can be derived by subtracting geoid heights *N* from altimetric sea surface heights *h*. As *N* is smooth compared to the spatial along-track resolution of altimetry a consistent filtering of both, *N* and *h*, is essential. A dedicated “profile approach” (Bosch & Savcenko 2010) applies a consistent filtering and provides estimates of the instantaneous dynamic ocean topography (iDOT) along individual ground tracks of any altimeter mission. Thereby multi-mission iDOT-profiles allow studying the variability of the DOT.

In the present study we validate the time-variable DOT by gridding the iDOT-profiles, compute the geostrophic velocity field and compare this with in-situ surface currents from ARGO floats and surface drifters, both corrected for wind and Ekman-drift. Spatial and temporal resolution were adapted to the availability of the surface current data observed in the period 2007 – 2010 .

Gridding of iDOT-profiles

iDOT-profiles generated by the “profile-approach” (Bosch & Savcenko 2010) are available for nearly all individual passes of all satellite altimeters operated since 1993 (Bosch et al. 2013) (ftp.dgfi.badw.de/pub/iDOT/gaussfilter.69.GOCO03S). Based on the compound ground tracks of ESA and NASA/CNES altimeter missions the iDOT-profiles for a one month period provide sufficient dense sampling of DOT-heights to be gridded and averaged to 1°x1° blocks .



Gridding is performed by an Least-Squares interpolation with weights decreasing by a Gauss function (70 km half weight width) of the distance and inverse proportional to the standard deviations of the observed DOT-heights.

Fig. 1: The iDOT profiles on the common ground tracks of Topex (extended mission with shifted orbit) and Jason1 at the Agulhas Counter Current south of Africa.

Geostrophic velocities from space based DOTs

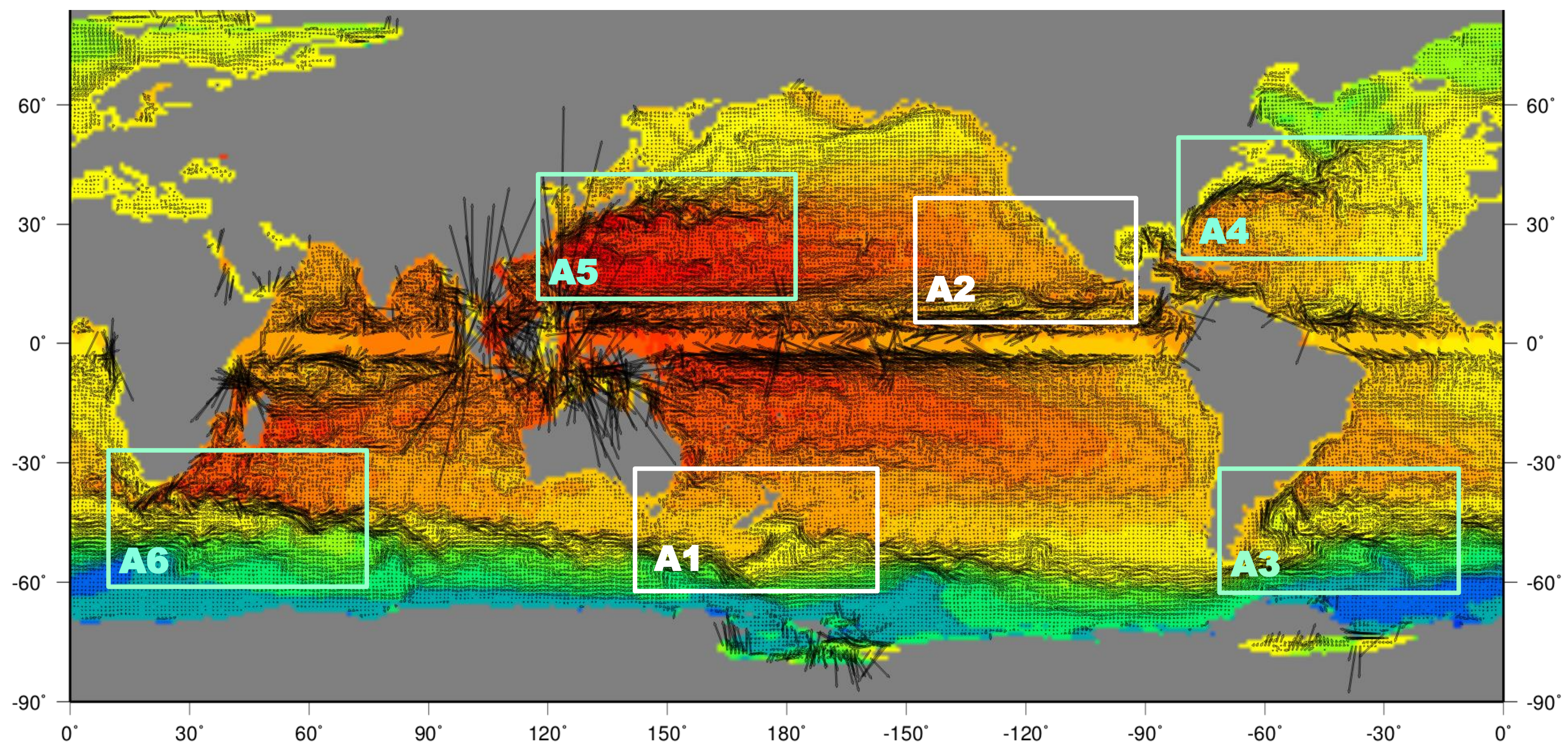


Fig.3: Example of a gridded mean DOT for the first quarter of 2008 (color coded) with geostrophic velocity vectors superimposed. A ± 2° latitude band has been excluded to circumvent a zero Coriolis factor. In South-East Asia gridded heights and velocities are too noisy due to the complex land/ocean distribution. However, Western boundary currents and the large scale circulation are well represented. Rectangles indicate dedicated areas for comparison either with moderate variability (white) or strong variable western boundary currents (light green).

ARGO floats and surface drifter

As in-situ data the combination of ARGO floats (Lebedev et al. 2007) and surface drifters recently reprocessed by Lumpkin et al. (2013) were taken. Inspecting the sparse data availability of both in-situ data sets (c.f. Fig. 2) we decided to perform the comparison with the global iDOT-data on a quarterly basis with a spatial resolution of 1°x1°.

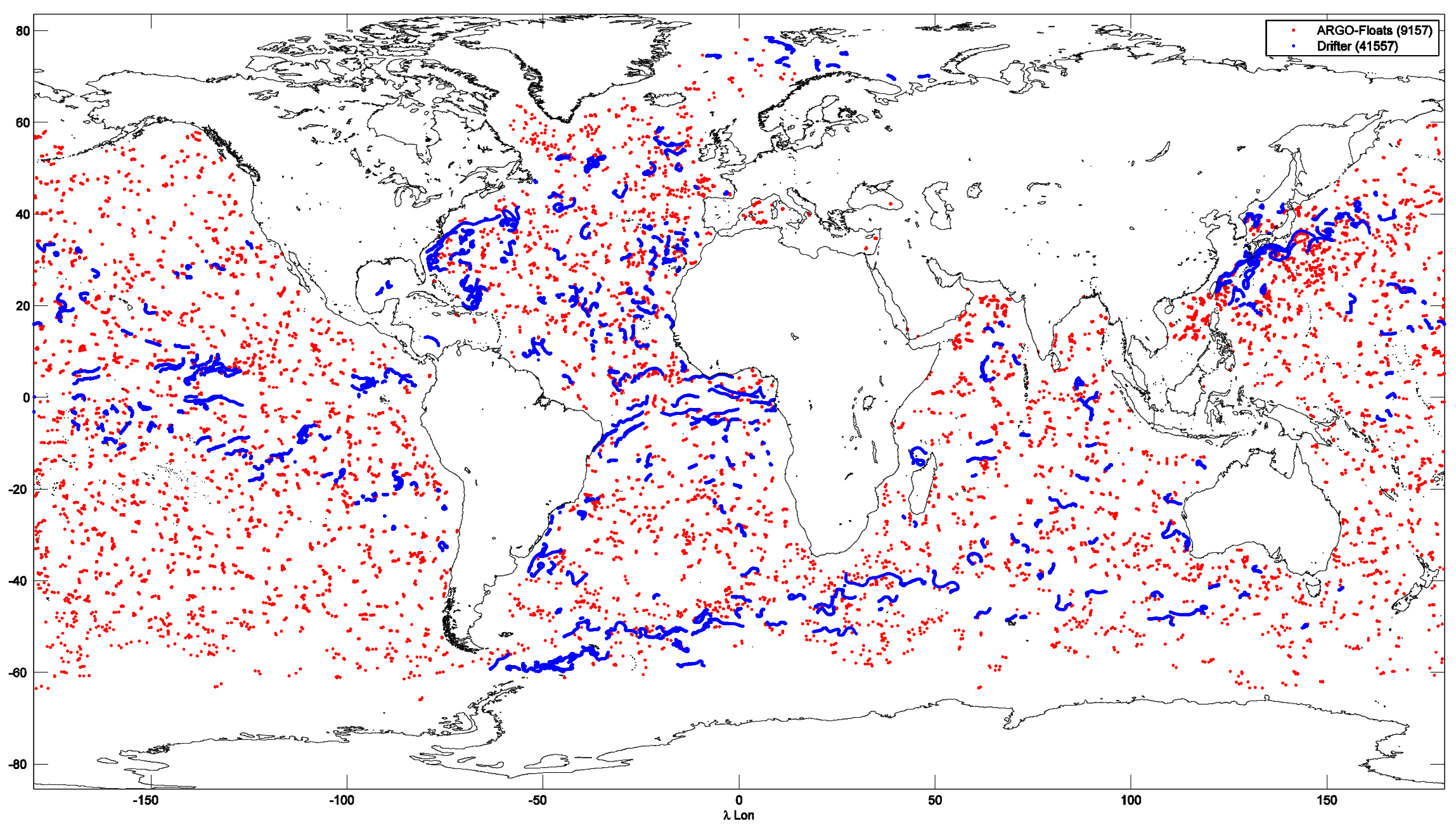


Fig. 2: Common distribution of ARGO floats (red) and surface drifters (blue) for a one month period.

A maximum of ARGO float data was observed within period 2007 – 2010, which is taken for comparison.

Ekman corrected in-situ velocities

As the in-situ data is affected by wind we correct the observed velocities for the Ekman drift, following the approach of Lagerloef et al. (1999). Monthly wind field and the wind stress were taken from NOAA’s NCDC (http://www.ncdc.noaa.gov/oa/rsad/air-sea/seawinds.html) Drifters were taken only if no loss of the wind sack was flagged or if correction for defect sensors were applied according to Lumpkin et al. (2013, 2014).

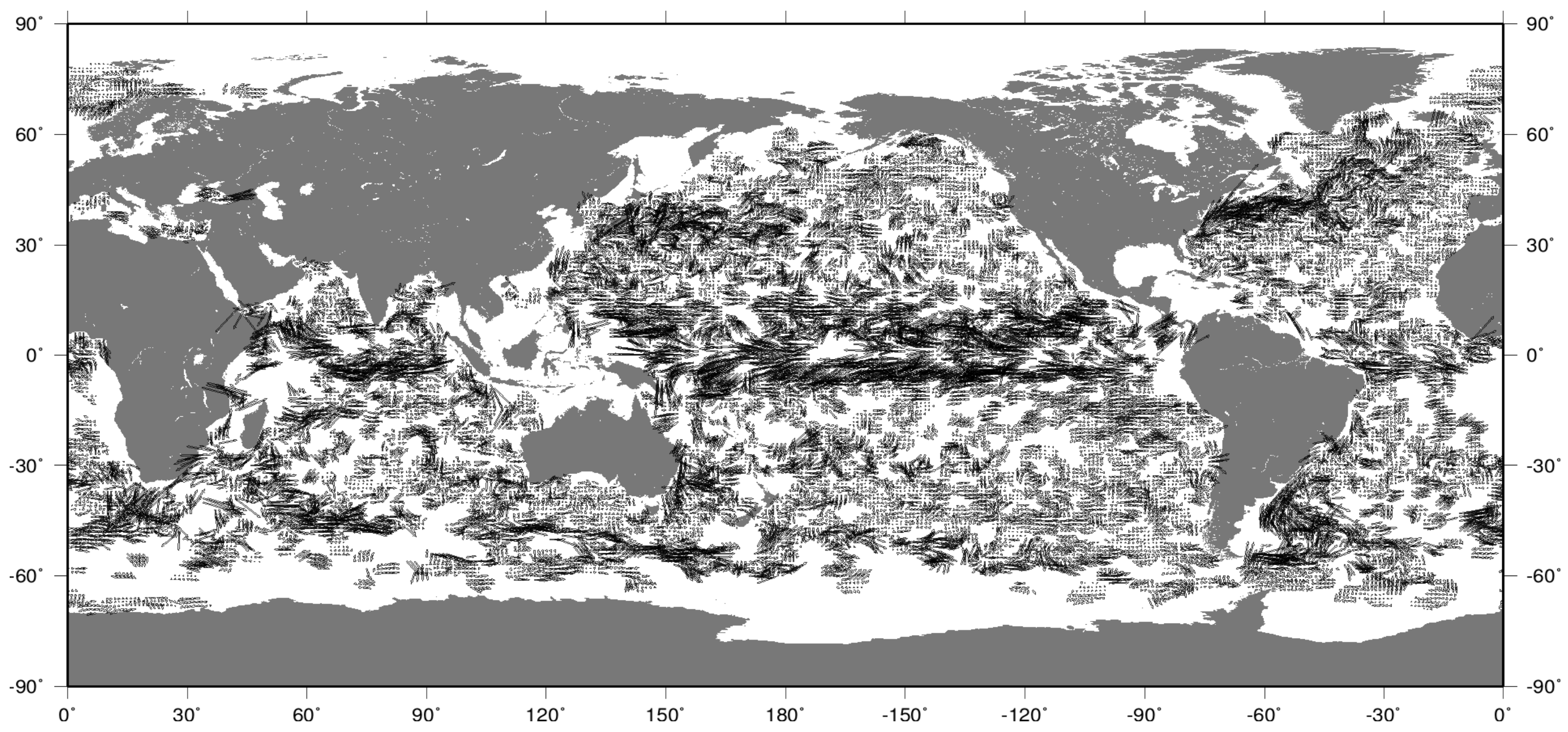


Fig.4: Mean in-situ velocity vectors for the first quarter of 2008 (same as in Figure 3 left hand)

Comparisons in dedicated areas with Distribution of vector differences

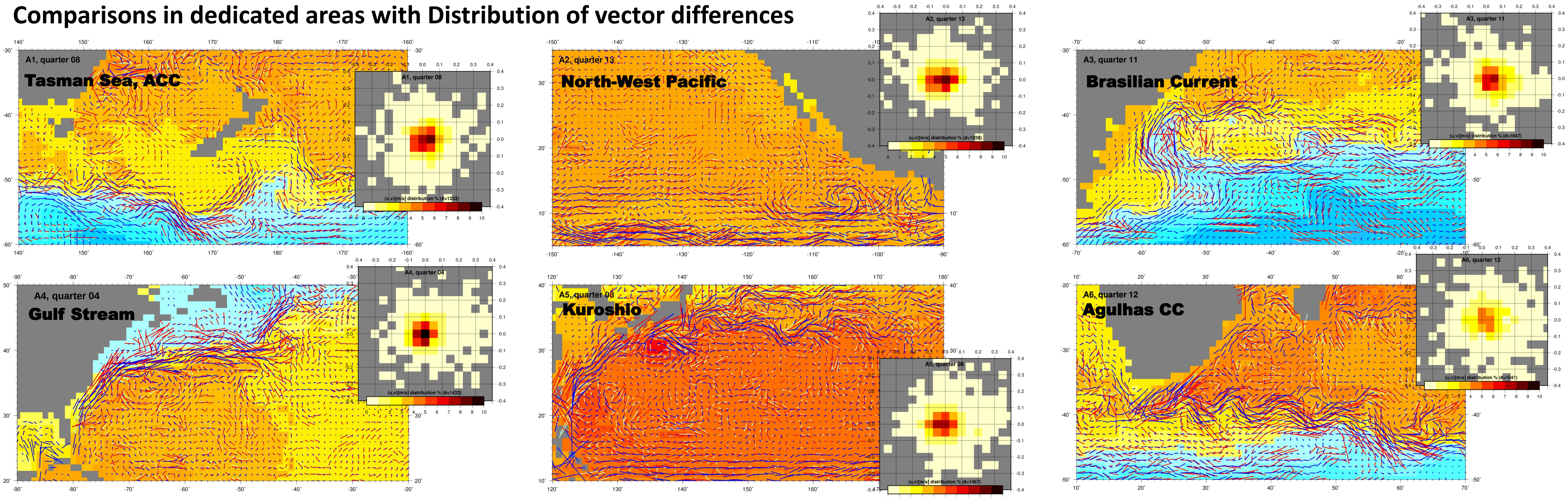


Fig.5: Zoom to the areas indicated in Figure 3 with the geostrophic velocity fields derived from iDOT-profiles (blue), the in-situ velocity vectors of ARGO floats and drifters (red) and the vector differences of both (light green). The plots always show the scenario of a particular quarter. The background color represents the associated pattern of the gridded ocean topography derived from IDOT profiles for the same quarter. Attached to the area plots are scatter plots indicating the distribution of the residual vector field (in-situ minus iDOT). The percentage number of vector differences for cell size of 0.05 m/s in each component is color coded in the range 1% (light yellow) to 10% (dark red).

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Conclusions

- Due to the sparse data availability of ARGO floats and surface drifters the comparison was performed on a 1°x1° grid with quarterly basis. This doesn‘t cope the potential high temporal and spatial resolution of the multi-mission iDOT-profiles.
- Although the gridded iDOT time series is a smoothed snapshot of the dynamic ocean topography the differences to the in-situ data (smoothed accordingly) is rather good. On average the residual vector field exhibits velocities below ± 0.1 m/s (even at western boundary currents) with no systematic deviation in azimut.
- In order to demonstrate that the iDOT time series performs better than any long-term mean dynamic topography the comparison will be repeated on an expensive pointwise basis.

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