Validation of HF radar ocean surface current observations in the Ibiza Channel using lagrangian drifters, moored current meter and underwater gliders

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Abstract

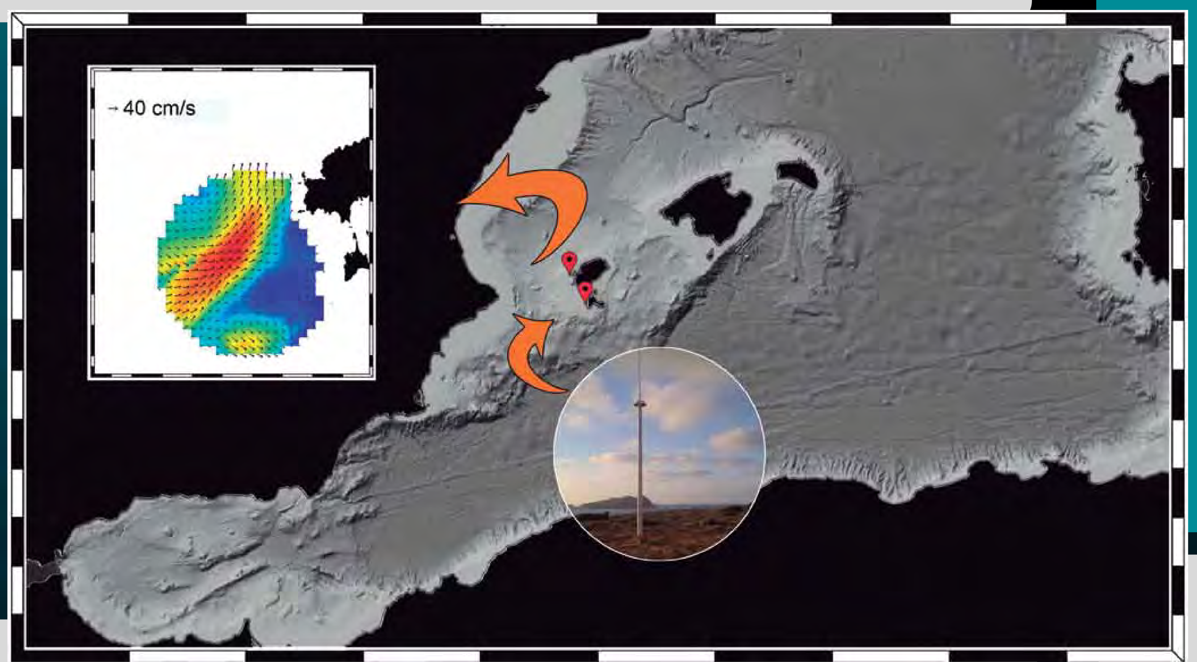
SOCIB High Frequency (HF) radar is one component of the multi-platform system located in the Balearic Islands and made up of Lagrangian platforms (profilers and drifting buoys), fixed stations (sea-level, weather, mooring and coastal), beach monitoring (camera), gliders, a research vessel as well as an ocean forecast system (waves and hydrodynamics).

The HF radar system overlooks the Ibiza Channel, known as a "choke point" where Atlantic and Mediterranean water masses interact and where meridional exchanges of water mass properties between the Balearic and the Algerian sub-basins take place. In order to determine the reliability of surface velocity measurements in this area, a quality assessment of the HF Radar is essential.

We present the results of several validation experiments performed in the Ibiza Channel in 2013 and 2014. Of particular interest is an experiment started in September 2014 when a set of 13 surface drifters with different shapes and drogue lengths were released in the area covered by the HF radar. The drifter trajectories can be examined following the SOCIB Deployment Application (DAPP): http://apps.socib.es/dapp. Additionally, a 1- year long time series of surface currents obtained from a moored surface current-meter located in the Ibiza Channel, inside the area covered by the HF radar, was also used as a useful complementary validation exercise.

Direct comparison between both radial surface currents from each radar station and total derived velocities against drifters and moored current meter velocities provides an assessment of the HF radar data quality at different temporal periods and geographical areas. Statistics from these comparisons give good correlation. The results are shown for different months, geographical areas and types of surface drifters and wind exposure. Moreover, autonomous underwater glider constitutes an additional source of information for the validation of the observed velocity structures and some statistics will be presented.

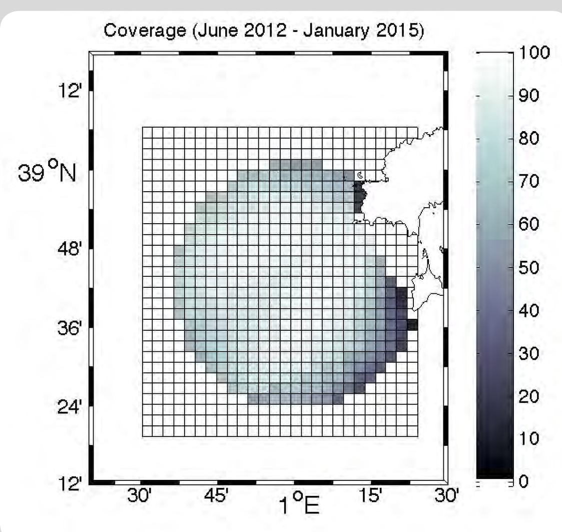
HF Radar system:
Two Tx-Rx antennas situated Ibiza and Formentera
Tx Central Frequency: 13.5 MHz, Bandwidth: 90 kHz
Radial Resolution: 3 km, angular resolution: 5 deg
Radial Range ~ 80 Km
Temporal Coverage: 75 min, moving average, hourly data
Grid resolution: 3 km

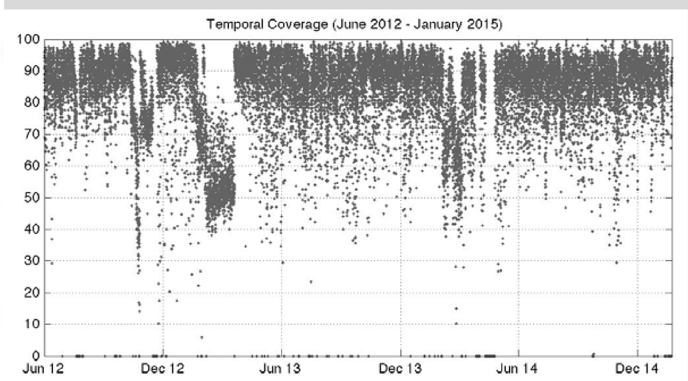


QA/QC

QA/QC procedures - additionally to CODAR QC, based on international references, MARACOOS (Roarty et al., 2012) and UCSB (Emery and Washburn). Radial parameters selected as system performance quality:

- **Signal to Noise Ratio**
- **Total number of Radial Vector solutions**
- **Averaged Bearing of all radial vectors**
- **Comparison between radial ideal and measured Bearing**





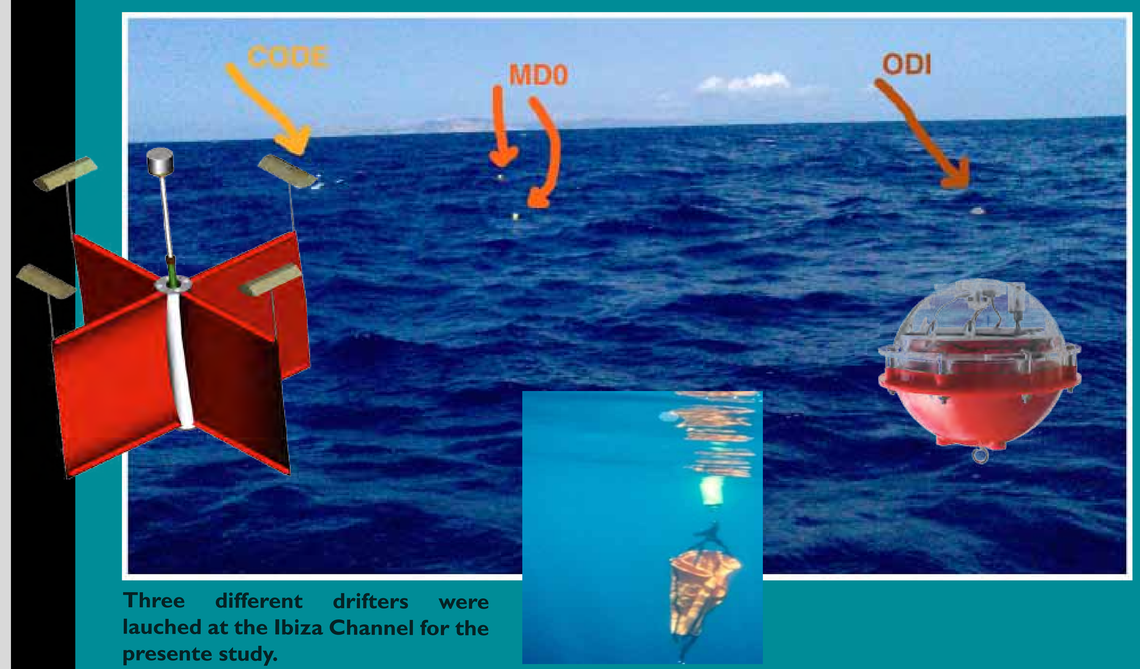
Temporal and Spatial coverage of SOCIB HF Radar for the period of functioning taking into account the QC flags applied to the SOCIB HF Radar facility. For the period between June 2012 - January 2015.

References:

QC reports:
Emery and Washburn, "Evaluation of SeaSonde Hardware Diagnostic Parameters as Performance Metrics", *UCSB, technical Report.*
Roarty et al 2012 "Automated Quality Control of High Frequency Radar Data", *OCEANS*
Bouffard, J., Renault, L., Ruiz, S., Pascual, A., Dufau, C., Tintore, J., 2012. Sub-surface small-scale eddy dynamics from multi-sensor observations and modeling. Prog. Oceanogr. 106, 62–79. http://dx.doi.org/10.1016/j.pocean.2012.06.007, http://www.sciencedi- rect.com/science/article/pii/S0079661112000705.
Troupin C., A. Pascual, G. Valladeau, I. Pujol, A. Lana, E. Heslop, S. Ruiz, M. Torner, N. Picot, J. Tintoré. Illustration of the emerging capabilities of SARAL/AltiKa in the coastal zone using a multi-platform approach. Advances in Space Research. Vol. 01/2015; 55(1). DOI: 10.1016/j.asr.2014.09.011

System validation

In order to ensure the highest quality of HF Radar data, comparison exercises were performed with the use of lagrangian drifters, the moored current meter and underwater gliders in the Ibiza Channel. HF Radar system (operating at a frequency of 13.5 MHz) measures an average of the first meter depth of the water column.

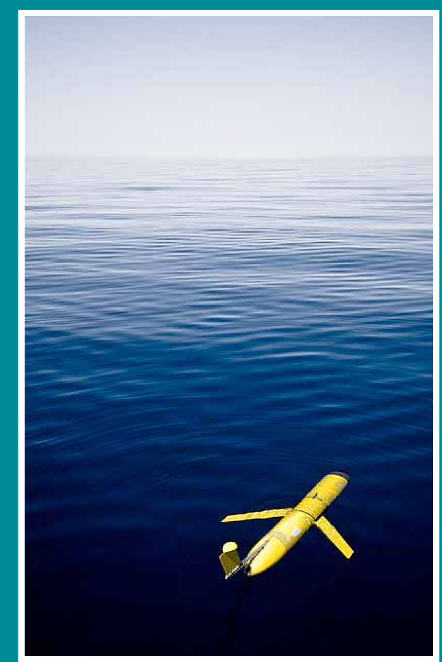


Three different drifters were lauched at the Ibiza Channel for the presente study.

Lagrangian drifters are highly influenced by wind effect. The 13 drifters used in this study (September 2014) carried different kind of drogues, in order to asses the effective depths of the HF radar. Three different kinds of drifters, being different both in shape (i.e. windage exposure effect) and the drogue-shape: 1) Four MetOcean DOCE oceanographic surface drifter with drogue vanes between 30 and 100 cm deep, long life battery and low wind-exposure, 2) Five MD03i with surface current tracker, flexible and rigid drogue and low wind-exposure, 3) ODI drifter with a small 5 kg weight drogue, high wind-exposure.

An oceanographic moored buoy equipped with a surface (1 m) **current-meter** was deployed in the Ibiza Channel on September 2013, inside the HF radar coverage. The FSI current meter provides pointwise subsurface currents averaged between minutes 0 and 4 of each hour. In spite the differences with the HF radar measurements, the current meter is a very valuable tool of velocity information to be compared against the radar-derived velocities.

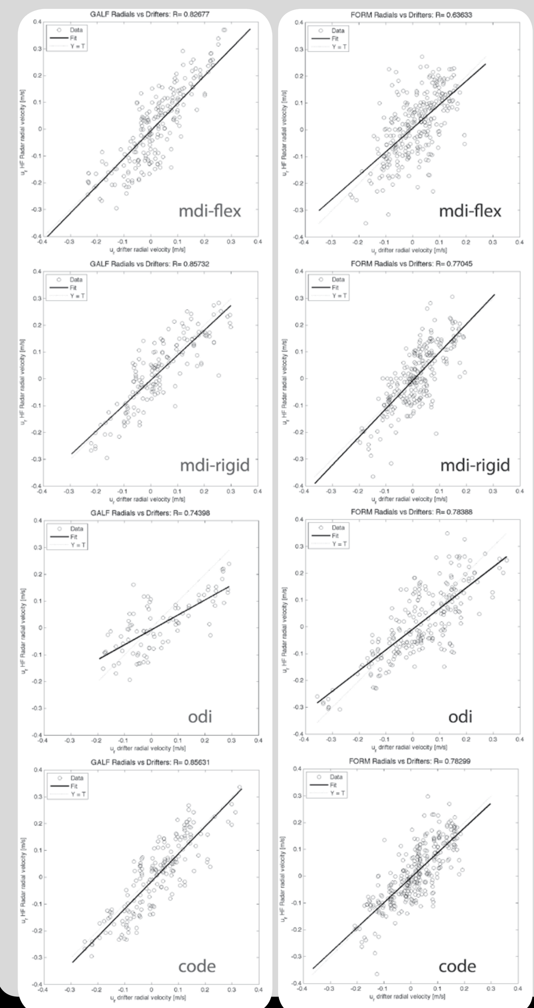
G-Altika mission was performed in the Ibiza Channel combining the satellite altimetry measurements from SARAL-Altika, HF radar and **glider data**, coincident with the satellite track for August 2013. The depth-averaged velocity was estimated with the deep Slocum glider, using the glider positioning system (GPS): the glider makes a calculation of the current experienced since its last surfacing from the difference between both estimated and its current actual location.



(Top) Deep Slocum glider in the Balearic Sea. (Left) Oceanographic moored buoy in the Ibiza Channel, by SOCIB.

Lagrangian drifters validation

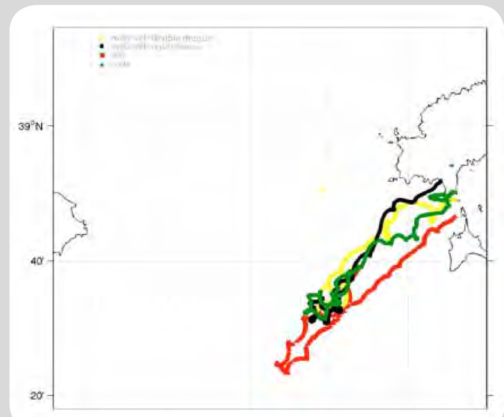
Ibiza antenna | **Formentera antenna**



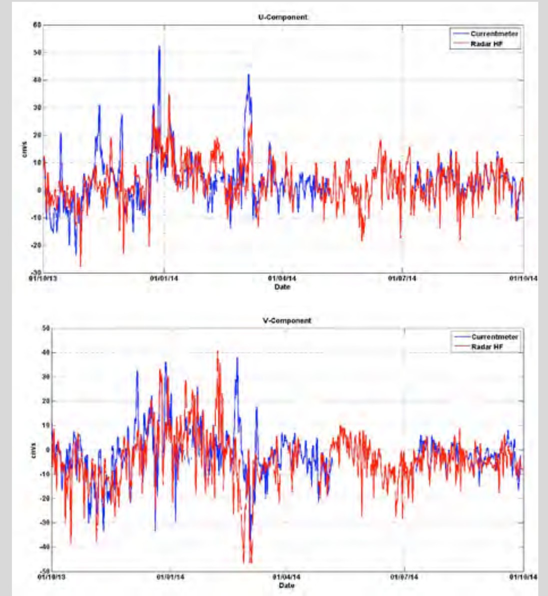
The drifter experiment perfomed in the Ibiza Channel show different results according to each of the drifter shapes, drogues and points where launched. The drifter trajectories are shown in the map, however, we focus our attention in an specific point where the four different drifters were launched: MDI drifter with a flexible drogue, MDI with a rigid drogue, ODI drifter and CODE drifter. The radial HF data are compared with the derived radial components of the drifter trajectories. The HF radar radial velocity are 75 min running mean average, therefore, in order to be consistent with the processing of radar data for the sake of comparations, drifter derived velocities have been averaged each 75 min centered at each integer hour. The radial drifter derived component are compared with the closest radial data that fall in a circle of diameter 1.5 kms from the location of the radial data. For Ibiza antenna comparations the correlations coefficients vary between 0.74 and 0.85, and for Formentera antenna between 0.63 and 0.78. In both cases, the CODE drifter derived velocity has the highest correlation with the radial HF radar velocities at that point.

Right. Drifter trajectories released in the area of the HF radar for the Ibiza Validation Experiment (bottom) and the four drifters launched in the Souteasternest point (right).

Left. Scatterplots of radial drifters derived velocity versus radial HF radial data for Ibiza antenna (left) and Formentera antenna (right).



Moored current meter validation

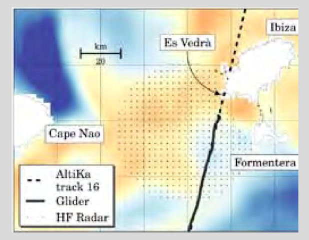


Temporal evolution of filtered U and V velocity components for surface current meter and HF radar for the total period of comparison betwee October 2013 and October 2014.

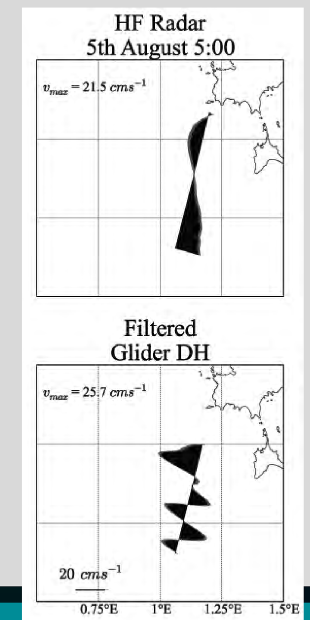
The closest radar grid point has been selected to compare total Radar HF velocities with the velocity from the currentmeter. The mean distance between mooring and the closest Radar node is ~1400 m. We have chosen the period from 1th October 2013 until 30th sept 2014 (1 year of data) to perform the totals vs. current point wise data comparison. In order to evaluate the difference between the subinertial currents in the current meter and the closest radar HF node, both time series have been filtered with a 30 h low-pass filter. The plots show the temporal evolution of U and V components for the Mooring and the closest Radar node for the total length time series. Note, however, that there is a general tendency of the North-south velocity except for the month of February 2014 where Radar and Current meter have opposite behavior. The correlation values are between 0.58 and 0.84 for U-component, and between 0.4 and 0.72 for V-component. Generally, U-component has a better correlation than V-component; this must be due to the fact that both radars are closer to the X-axis.

Underwater glider validation

The glider sampled, during the G-Altika mission, the whole water column with a high-resolution, especially in the coastal area (the last 20 km of the track). The depth-averaged absolute (DAV) currents retrieved from the GPS glider positioning were used to correct the surface geostrophic current, following the method described in Bouffard et al. (2012). The estimated depth-averaged velocity (DAV) ranges from 2 cm/s in the southernmost part of the glider trajectory to 10 cm/s near the end point, with a preferred north-westward orientation. The difference between the relative depth-averaged geostrophic currents (computed from DH) and the absolute DAV (computed from glider GPS) constitutes a reliable estimation of the absolute geostrophic current at the reference level. The dynamic height (DH) is obtained by integrating the density, calculated from the glider temperature and salinity, between a level of reference and the surface. The HF radar data and the filtered glider DH show consistencies, as they have a zero-crossing at about 38.65°N and flow to the west north of that latitude. The glider has the unique capability of profiling the water column with an horizontal resolution below 1 km. The HF radar system has the unique capacity to combine an extended spatial coverage (more than 70 km offshore) with a temporal resolution of 1 h. In spite the difference, this initial validation/inter-comparison exercise is of particular value in assessing the quality of SARAL/AltiKa data in the coastal band. It also emphasises the relevance of cross-platform approaches in the study of the coastal ocean dynamics and of the additional sources of validation for the currents (details at Troupin et al., 2015).



(Top) Study area and data. HF radar, glider and altimetry data locations. (Bottom) Cross-track velocities obtained by HF radar and by geostrophy for filtered glider data.



Conclusions

The study of oceanographic mesoscale processes using high resolution observations constitues a new challenge in oceanography, and this challenge has to be tackled by a **multi-platform** approach. However, the comparison between different measuring systems is not straighforward since each system measure currents over different temporal and spatial scales. In this study the use of different intruments to compare/validate the HF radar currents shows promessing results to assure the hight quality of the surface ocean measurements:

- Thirteen drifters were lauched in the exercise, with different shapes and drogues and at different points of the coverage area. The radial components show good agreement with the correlations coeficients between 0.5 and 0.8 for Ibiza antenna, and between 0.4 and 0.8 for Formentera antenna. The lower values are generally associated with high radial angels, or areas with very low number of radials.
- The total current vectors measured by the moored buoy and total vector at the closest radar grid points are compared. The general result for the whole year shows a good agreement with correlation coefficients of 0.67 and 0.57 respectively for U and V components.
- The comparison between the underwater glider and the HF radar currents is a challenge since the along-track data of the glider do not allow a two-dimensional description of the HF radar. However, according to the result, it is an interesting exercise to examine different ways to obtain current data.