SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: ES1402

STSM title: Spatial interpolation of high-frequency radar velocities in the northern Adriatic Sea
STSM start and end date: 03/09/2018 to 31/10/2018
Grantee name: Charles Troupin

PURPOSE OF THE STSM:

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The main goal of this STSM is to improve the reconstruction of the surface velocity field in the Gulf of Trieste (northern Adriatic Sea) by applying advanced spatio-temporal interpolation techniques on in situ and remote-sensing measurements, in particular those provided by a high-frequency radar system covering the Gulf of Trieste. Such a velocity field is particularly relevant in several applications, among which: oil and pollution spill detection, search and rescue activities, ports and harbours management, storm surge and flooding. It can also be used for data assimilation purposes in numerical forecast models.
The Adriatic Sea is a challenging area in terms of observations and modelling, due to:
- its size, approximately 800 km length by 200 km width along a northwest-southeast direction;
- its topography composed of a narrow continental shelf, a steep continental slope and a flat abyssal plain;
- the surface forcing, especially the wind stress, with events of *Bora* (polar continental air coming from the north) and *Sirocco* (warm and humid air from the Sahara);
- the freshwater balance driven by the strong river runoff of the Po.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

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Analysis of the data coverage
The data availability is hightly variable with respect to time, due to possible malfunctioning of the antenas on one or the other side (Italia or Slovenia). When only one site is measuring currents, it is then impossible to reconstruct the total velocity fields as only *radials* are avaible.
Reading functions for the total and radial velocities
A set of reading functions has been designed to ingest the velocities measured by the HF radar system. The first step consists of converting the manufacturer binary files to ascii files, human-readable files. Once this step has been performed, a second step consists in reading the information with a Julia function designed for this purpose. The files contain:
1) metadata: date of measurements, location and name of the site.
2) grid description: coordinates and spatial resolutions of the grid on which the velocities are measured.
3) velocity measurements: along with the velocity, other useful variables are also provided: the accurary, the variance and the power.
Preparation of the interpolation grid
The longitudes and latitudes of the output grid are chosen to be the same as the combined velocity field. The temporal resolution is also set to the same value as for the combined product: every 30 minutes.
The spatial resolution is set to 1.5 km in each direction.

Data quality control
As the observations will be spatially and temporally smoothed after the application of the interpolation, it is decided not to apply strict quality check on the observations. As a general principle, data are never deleted, but rather marked or flagged as suspicious or bad.
1. Range check: The main test consists in checking if the measured values lie in an acceptable range. That range can be considered as uniform for the grid, in our case 2 m/s, but it could also be evaluated for each grid point, based on the available past measurements. With this second approach, the regional variability within the grid can be taken into account.
2. Accuracy check: Each measurement is assigned an *accuracy*, computed from the signal-to-noise ratio, the variance and the number of available measurements. The accuracy threshold is set at 0.025 m/s.
3. Temporal variation at a given grid point: Each grid point can be considered as an individual current-meter. The threshold is set to a maximal velocity change of 0.35 m/s per hour.
Spatial interpolation of velocities
See next section “Main results”.

Additional work
1. A seminar explaining the DIVAnd interpolation tool was organised for the interested scientists of the institute (October 16) . The PDF of the presentation is available at http://hdl.handle.net/2268/229041
2. Following the seminar, there was a request by a participant to apply the method to sediment fraction measurements. See next section for the results.
3. A more general presentation of the tools and techniques, as well as the oceanographic data available at the University of Liège was performed on October 26.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

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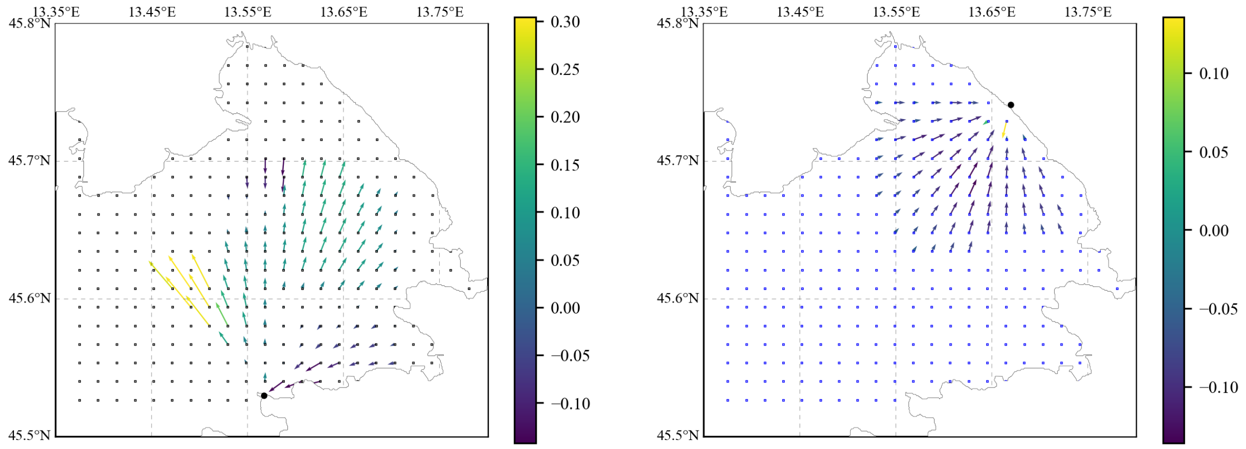
Interpolation of velocities
All the available data files corresponding to 2018 (both sites, Piran and Trieste) were downloaded and processed to obtain ascii files. Only a few days of the year had current measurements from both sites.
The final grid, similar to that of the radial grid, has a size of 22 x 20 points.

The DIVAnd method turned out to be particulary adapted to the problem size, with each interpolation (i.e. one time instance) taking a few seconds, meaning that it could be easily applied to the whole data set (several years). Another conclusion is the relatively low availability of velocity measurements with respect to the theoretical grid (see Figure below).



In the figure, the panels shows the radial velocities from each site (left: Piran, right: Trieste). Positive values mean that the velocity vector points toward the measuring site.
Even with sophisticated interpolation techniques, velocities in the outermost part of the domain (i.e. far from the sites) could not be recovered with a great confidence.
Different constraints will then be applied to the resulting combined velocity field:
- Velocity near the coast: it is assumed that the component of the velocity that is normal to the coast has to be close to zero.
- Low divergence: it is assumed that the resulting interpolated velocity field has a near-zero divergence.

- Temporal constraints: a temporal correlation is included to take into account that the velocities measured at a given time T can be assumed to be close to the velocities at T – ΔT, with ΔT on the order of a few hours. In addition, the Coriolis force can be added in order to obtain a geostrophically balanced mean flow.

Additional results

Following the request to adapt the DIVAnd method to the sediment fraction data, some adaptations to the software code have been performed. To summarise the novelty: these sediment data consists of a set of observations of fractions of sild, sand and clay and different locations in the Gulf of Trieste. While the constrait that the sum of all the fractions has to be 1 (100%) at each observation point, this constraint is not necessarily respected for the interpolated fields corresponding to each fractions. This constraint can now be activated in the DIVAnd tool. Some preliminary tests were carried out and an application using realistic data was initiated. The preliminary results show that the method is applicable to this new type of observations and could be also extented to other context, for instance in EMODnet Biology, for the production of maps of relative abundance of some species.

FUTURE COLLABORATIONS (if applicable)

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Several elements of future collaboration are foreseen.

1. Production of gridded products in the Adriatic Sea: the advantages of the DIVAnd method (numerical cost and separation of basins) are seen as valuable features for the production of new gridded products, specifically in the northern Adriatic Sea. As products are already made available by SeaDataCloud and EMODnet, it is necessary to find an added value by either working on new variables or by improving the resolution of the products by increasing the data coverage.

2. Follow on of the work with sediment data: based on the results obtained with the spatial interpolation, one can attribute a type of sediment in each grid point, for instance: sandy sild, clayey silt, silty sand, and then create a final map consisting of contours for each type of sediment. This is the final objective the process, that could eventually be extended to larger areas.

3. A research stay at the GHER (Liège) has been considered for one of the staff member of the NIB to study the DIVA/DIVAnd method for the interpolation of the data and the preparation of gridded fields to use in the regional oceanic model.