# *Surface circulation patterns in the Ibiza Channel from HF Radar Data: Initial results and QC procedures*

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IMEDEA, 9 April 2014

# Outline

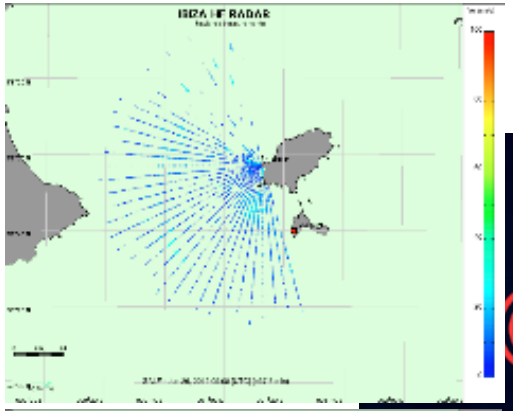
- SOCIB HF Radar **system overview and performance**
- Automated **QC procedures**
- **Data validation**: drifters and fixed current meter
- Surface **circulation patterns and variability**. Inertial, sub-inertial and tidal currents.
- Main **conclusions**
- **Discussion**: on-going work, scientific explotation of the data and next validation exercises

# SOCIB HF Radar System overview

SOCIB HF Radar

Two Tx-Rx antenna (FORM and GALF)
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.

## Working operationally since 1st June 2012

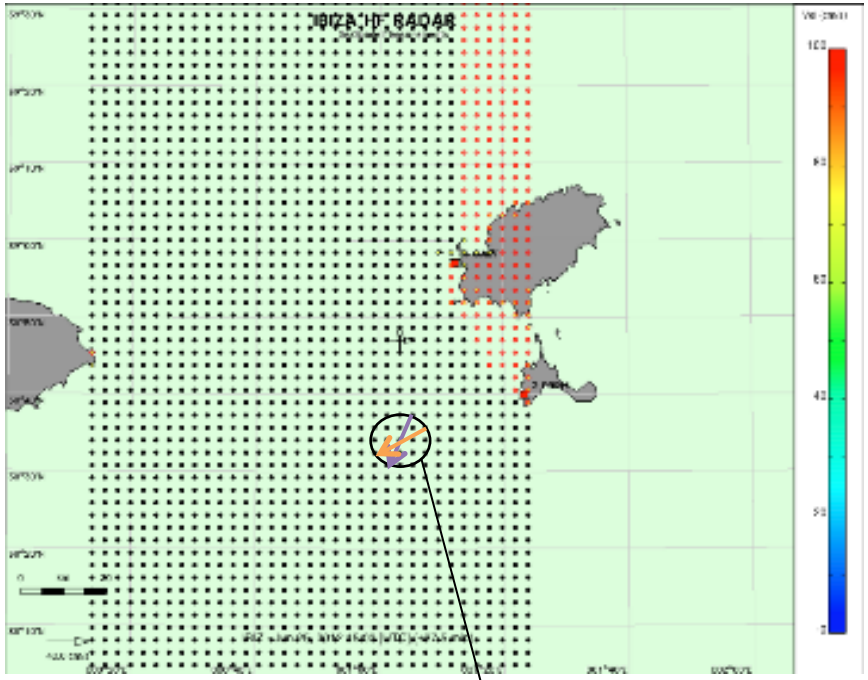



# SOCIB HF Radar System overview

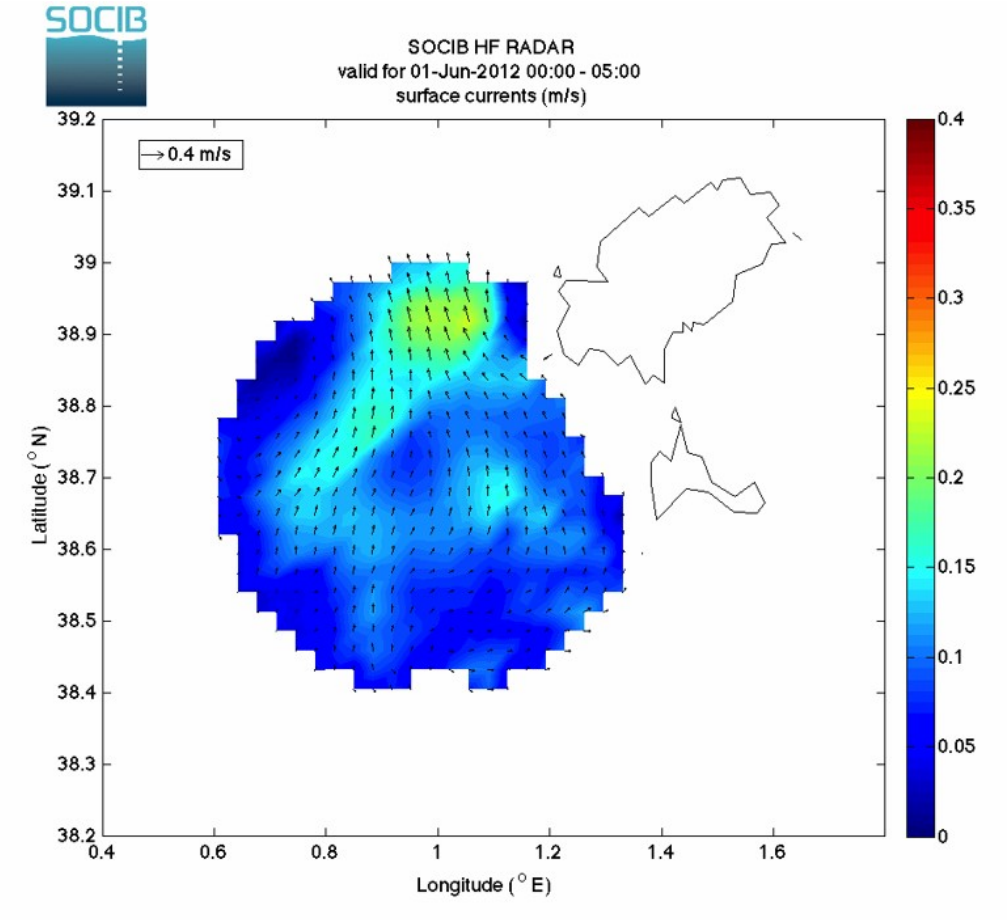
## Total Vector Combining Grid

Grid resolution: 3 Km

Averaging radius: 6 Km

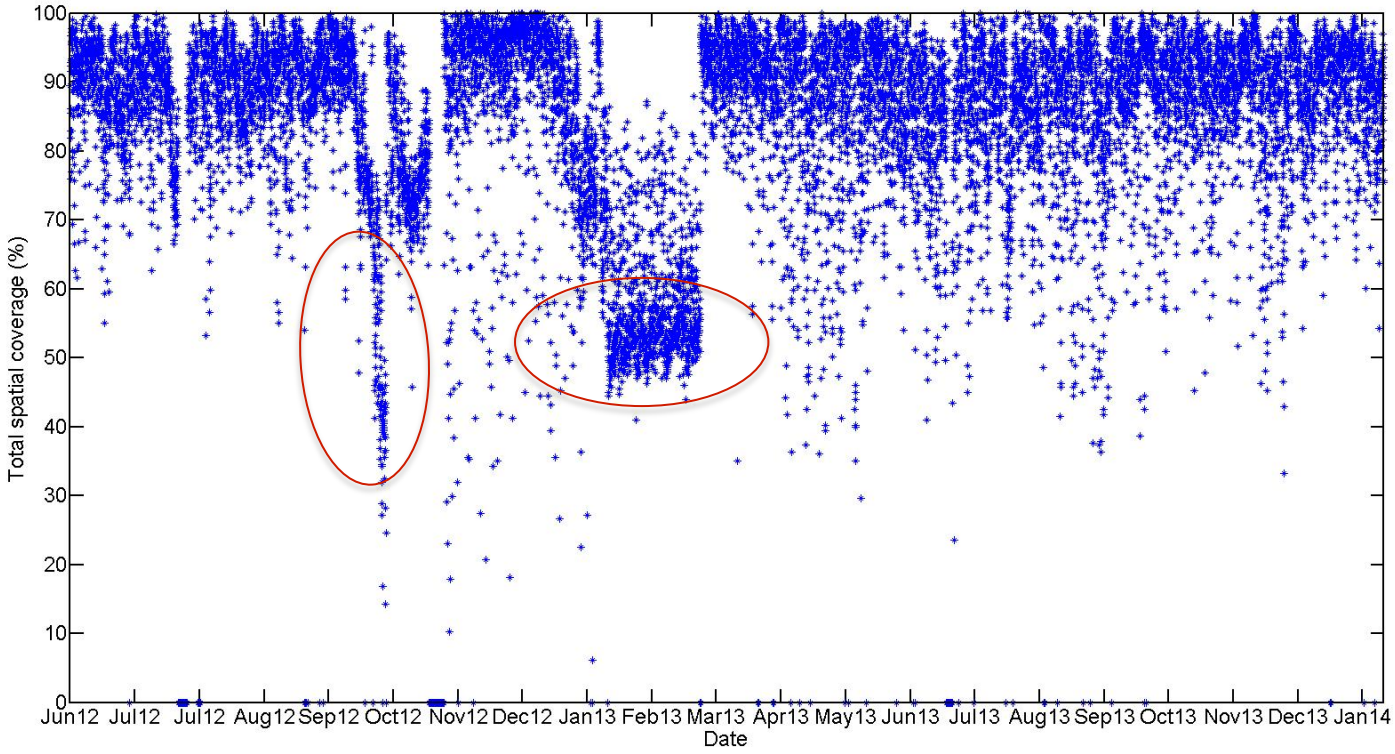


Combine (Least Square) all radials falling within this circle




**Spatial Coverage:** radial range, gaps in radial coverage (interferences, antenna problems,…)

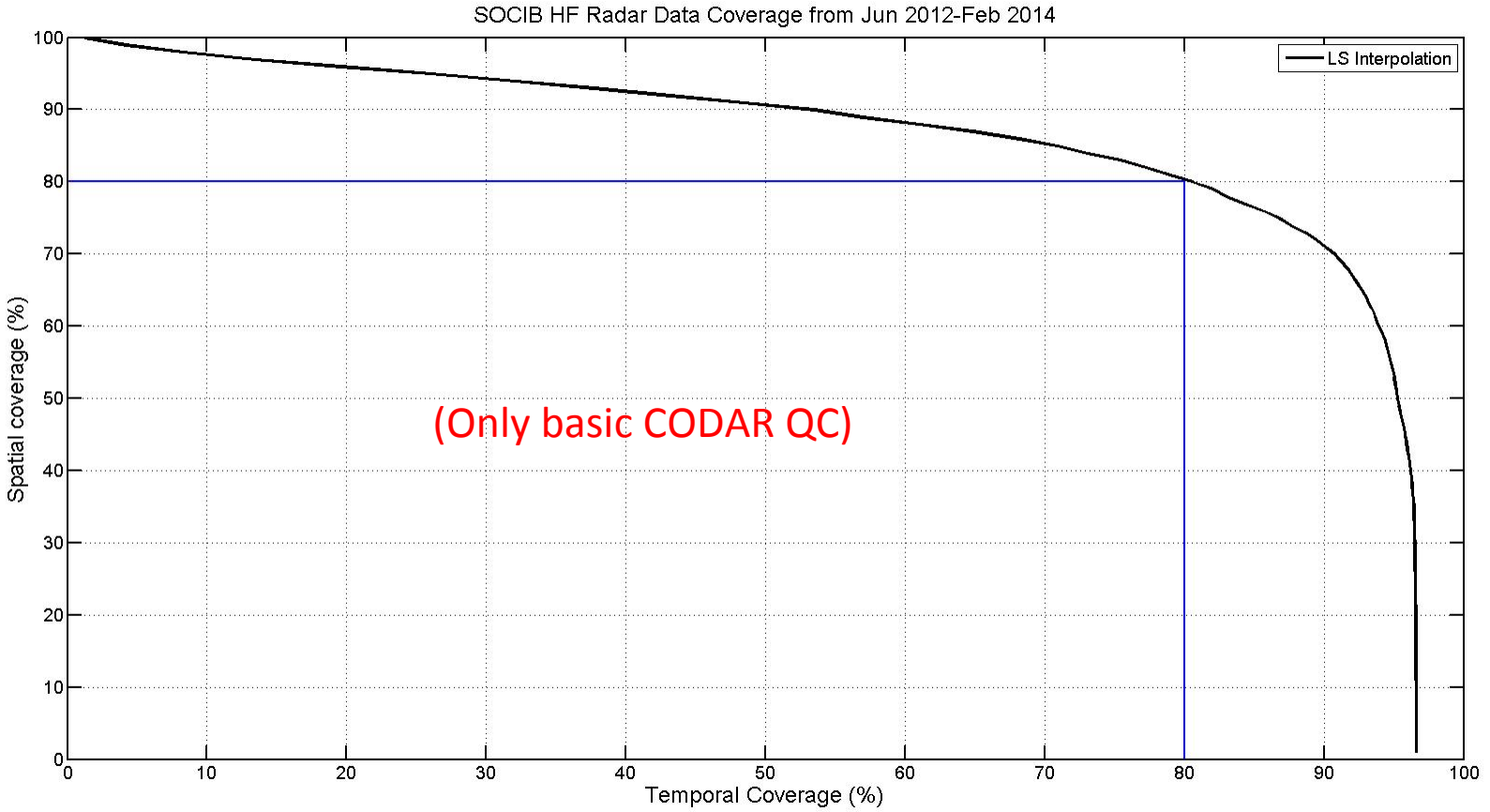
# System Performance – Total coverage metrics




- **3 % of time with NO DATA**: episodic electric shutdowns, turn off,…
- **Decrease in coverage**: Radiolectric interference at radial stations, antenna malfunctioning (gaps),…

# System Performance – Total Coverage metrics

SOCIB HF Radar provide surface currents almost 80% of the spatial region almost over 80% of the time (US Coast Guard Recommendation).

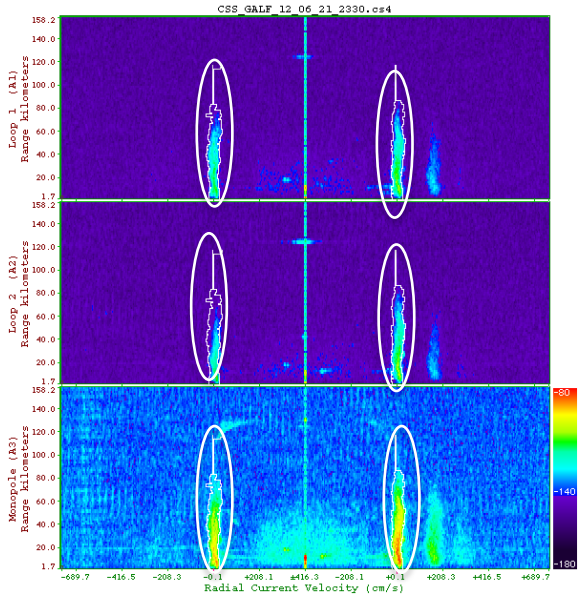



Temporal and Spatial coverage of SOCIB HF Radar for the period of functioning (since June 2012 to February 2014). Note that we excluded the period of malfunctioning (January to March 2013) in the statistics.

# SOCIB automated QA/QC procedures

## CODAR (basic) QA/QC

- **First Order Boundary Limits Setups** (tunning) and **Antenna Pattern Calibration (APM)** to prevent antenna distortions (main source of bearing determination errors)





- Automatic removal of spurious Data (e.g. **Radials above 80 cm/s and Total vectors above 70 cm/s**)

***Data available at L0 level in SOCIB Thredds Server (no quality flag):***
***http://thredds.socib.es/thredds/catalog/hf_radar/hf_radar_ibizascb_codarssproc001/L0/catalog.html***

# SOCIB automated QA/QC procedures

SOCIB HF Radar

Additionally to CODAR QC procedures, all radial and total data which enters in **SOCIB Data Center** are associated to a **quality flag** to ensure the data being produced are of the highest quality.

| Code | Meaning |
|---|---|
| 0 | No QC was performed |
| 1 | Good data |
| 2 | Probably good data |
| 3 | Probably bad data |
| 4 | Bad data |
| 6 | Spike |
| 8 | Interpolated data |
| 9 | Missing data |

***Available at L1 level in SOCIB Thredds Server (quality flag):***
***http://thredds.socib.es/thredds/catalog/hf_radar/hf_radar_ibizascb_codarssproc001/L0/catalog.html***

# SOCIB automated QA/QC procedures

**Radial Quality Control** – based on **MARACOOS** (*Mid-Atlantic Regional Association Coastal Ocean Observing System*, Roarty et al., 2012) and **UCSB** (Emery and Washburn)

Quality Flags (associated to the total field) comes from system diagnostic parameters at each radial station, i.e.:

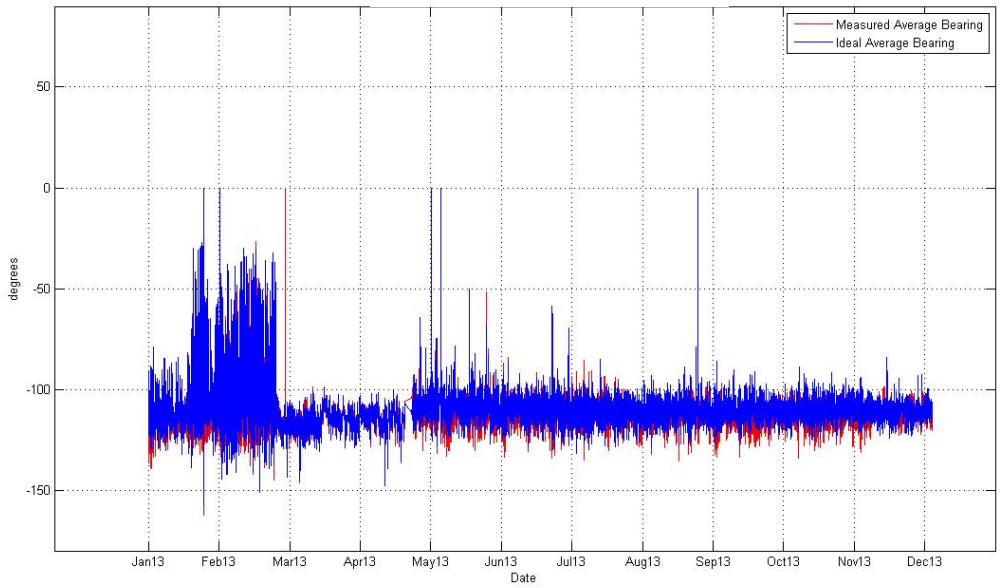
- **Signal to Noise Ratio**
- **Total number of radial vector solutions**

→ Proxie for High Interference/ hardware problem

- **Averaged Bearing of all radial vectors**
- **Comparison between averaged radial bearing for the measured and ideal Radials.**

→ Proxie for hardware problema / antenna coupling

Averange Radial Bearing



# SOCIB automated QA/QC procedures

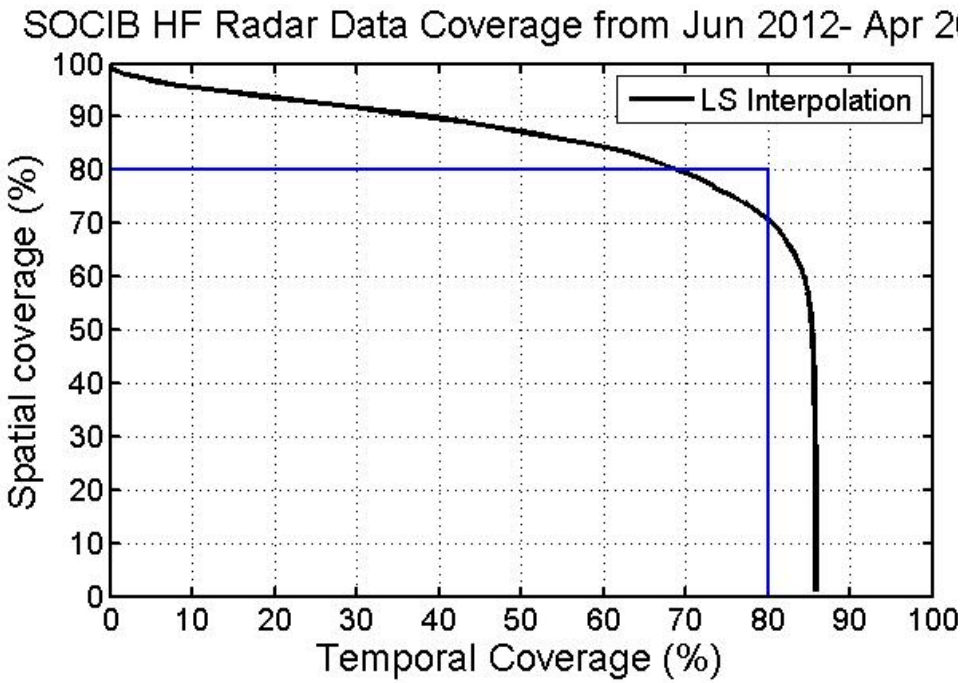
**Total Quality Control** – based on **SOCIB** standards for current meter instruments

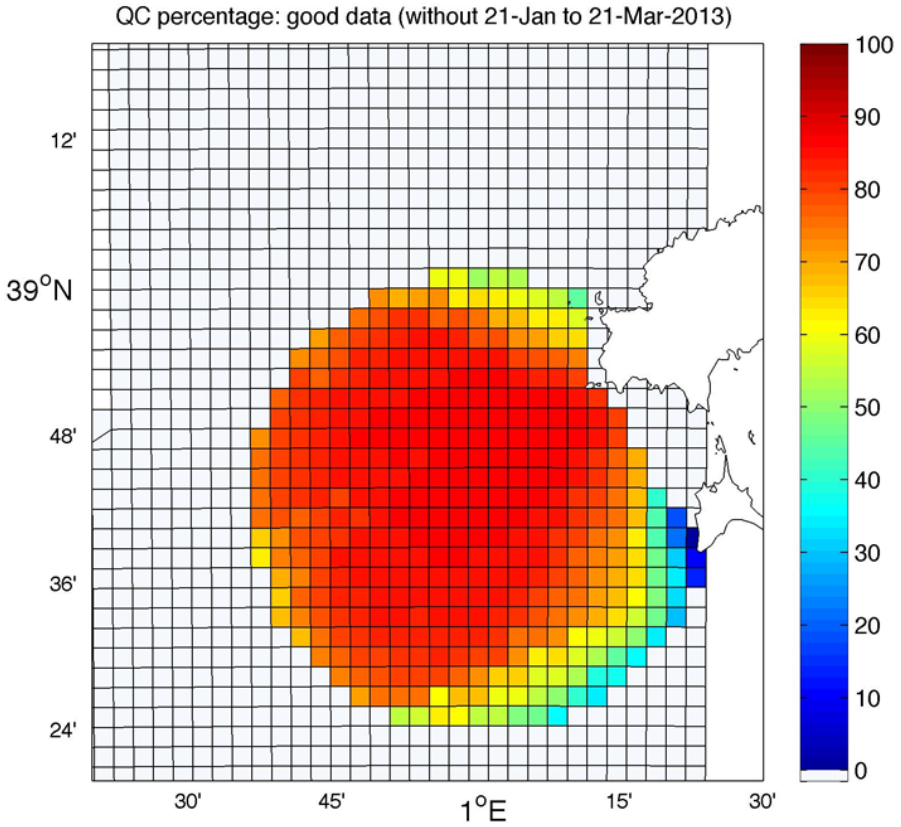
Quality Flags associated to each grid total data vector coming from a battery of tests applied to each velocity point (independently of the radial diagnostic).

- **Acyclic current direction**
- **Sea water speed**

→ **Valid Range, Spike and Gradient**

**QC flag < 3**
**('good' data or probably good data)**



# Data Validation: comparison with drifters

The use of drifters launched in the Ibiza Channel provide surface current data to compare against radial data from each antenna.

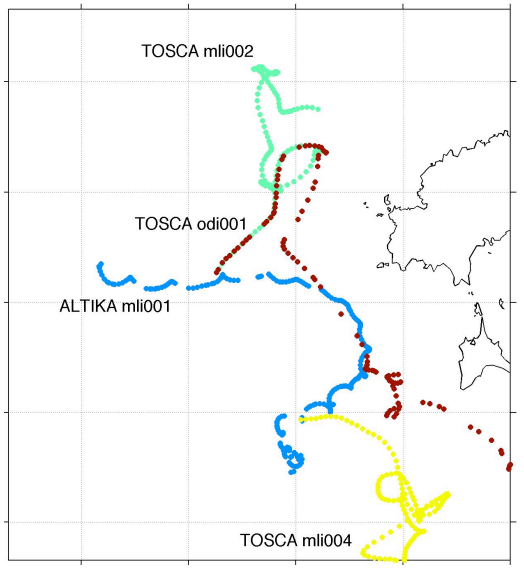
Surface drifter velocity is decomposed in radial components and compared the resulting radial vectors against the radial vectors from each of the individual radars (GALF and FORM). The radial component of the current vector (derived from the drifter) toward the radar is given by:

$$u_r \text{ drifter} = u \sin\theta + v \cos\theta$$

| | | GALF | | | | | | FORM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Release time | Drifter | N | RMS DRIF (cm/s) | RMS HFR (cm/s) | RMS deviation (cm/s) | CORRCOEF | N | RMS DRIF (cm/s) | RMS HFR (cm/s) | RMS deviation (cm/s) | CORR COEF |
| **ALTIKA** | 02-16 Aug 2013 | MLI001 | 211 | 11.2 | 12.3 | 8.1 | **0.8** | 239 | 10.5 | 11.5 | 9.9 | **0.7** |
| **TOSCA** | 25-31 Oct 2012 | MLI002 | 59 | 19.1 | 17.8 | 8.2 | **0.9** | 38 | 14.8 | 11.6 | 11.5 | **0.7** |
| | | MLI 004 | 15 | 20.3 | 24.3 | 15.5 | 0.7 | 61 | 22.7 | 18.7 | 22.3 | 0.5 |
| | | ODI001 | 47 | 17.7 | 16.9 | 9.1 | **0.9** | 133 | 19.5 | 15.9 | 9.7 | **0.8** |

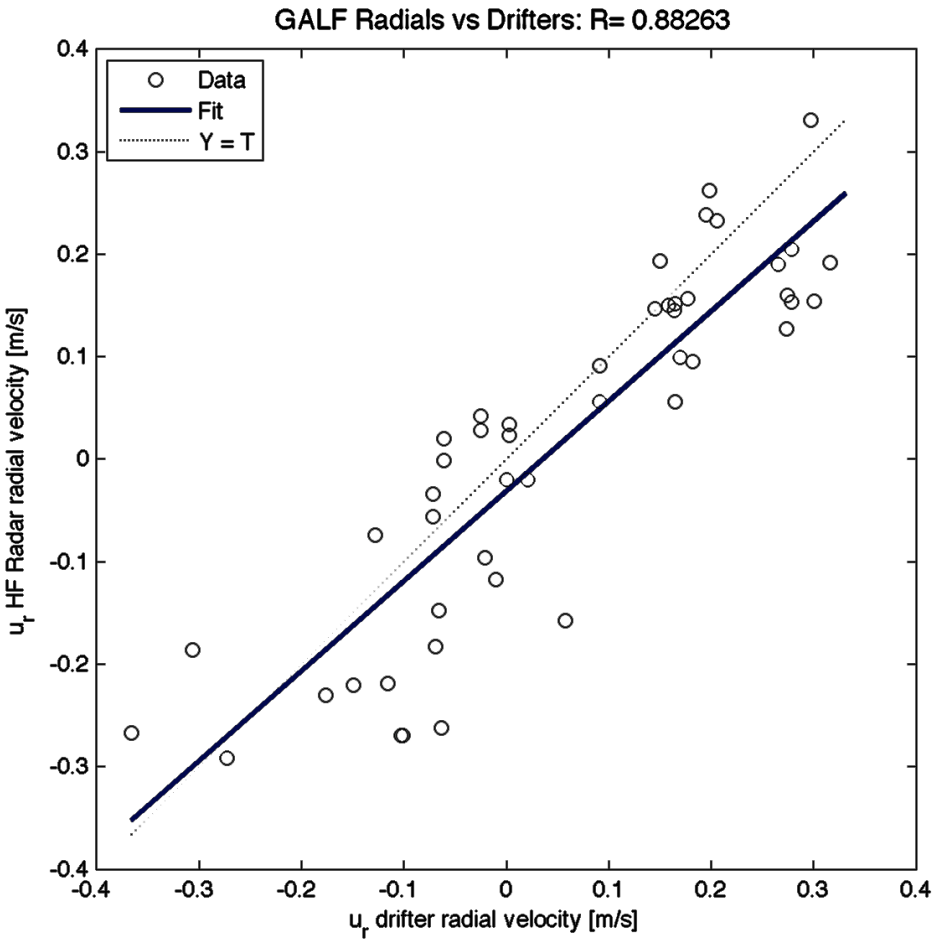
**Correlation and RMS values are in agreement with similar studies (eg. Cosoli et al.. 2013, Rubio et al., 2012, Ohlmann et al. 2007, Rypina et al. 2013)**

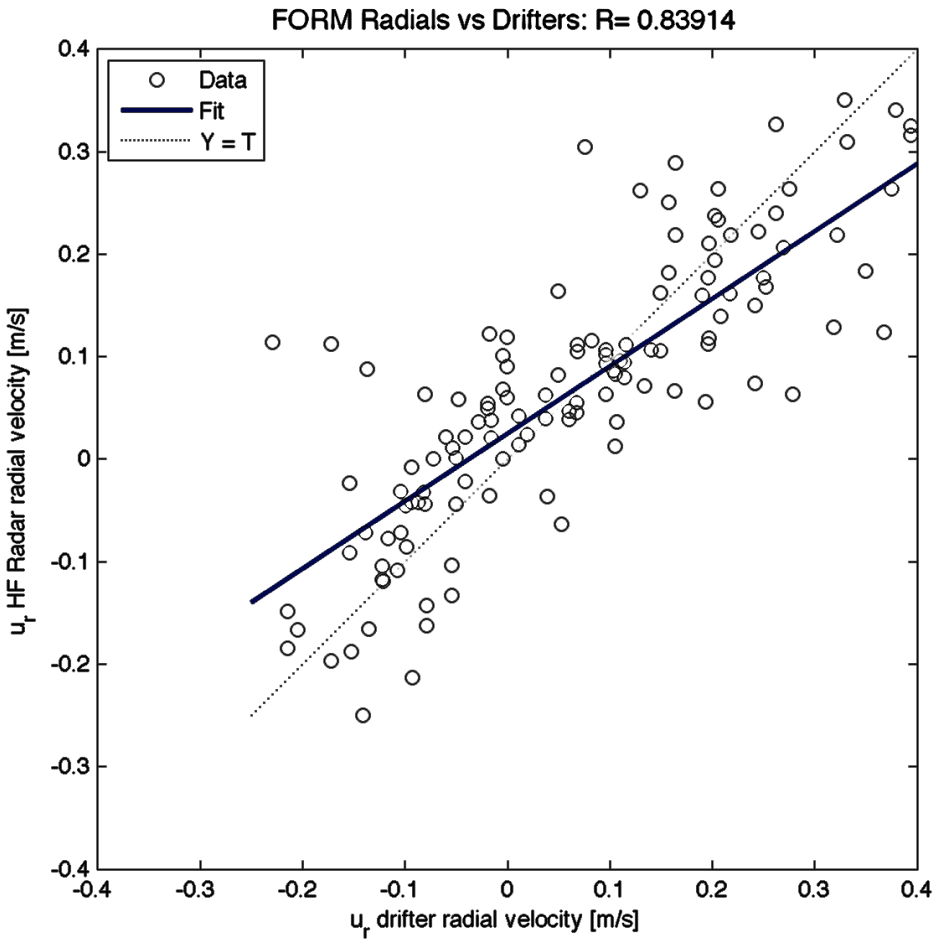
Drifter tracks



# Data Validation: comparison with drifters

Scatter plots and the temporal evolution of the HF radar radial velocity compared to the corresponding drifter-derived velocities within a 1500 m radius is calculated.

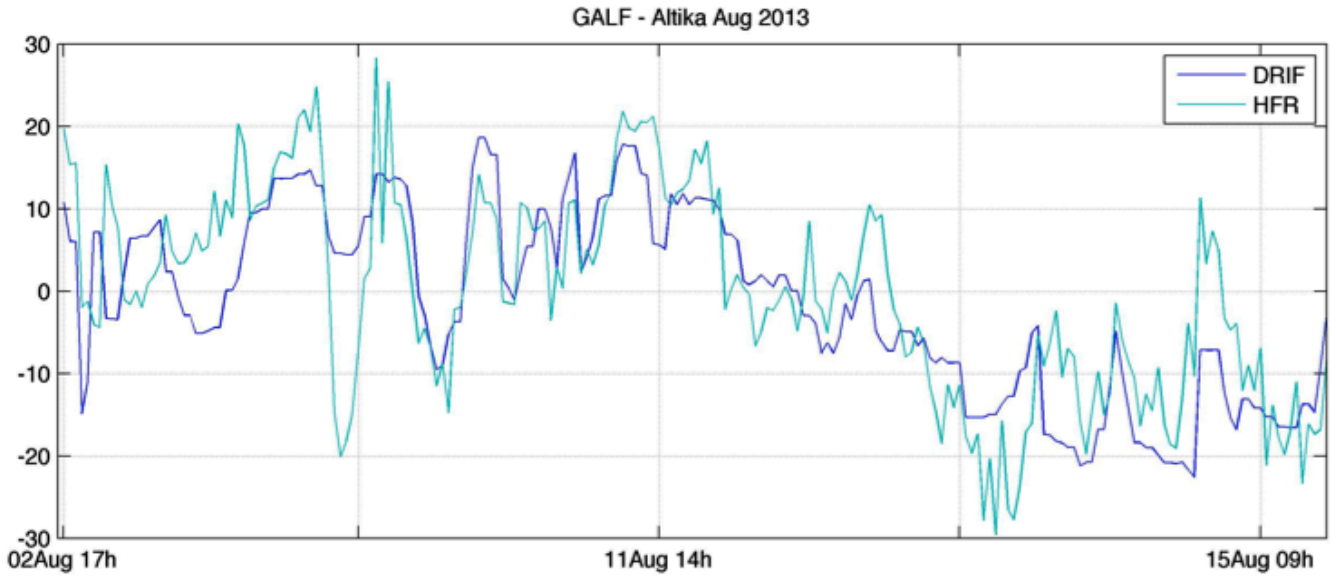


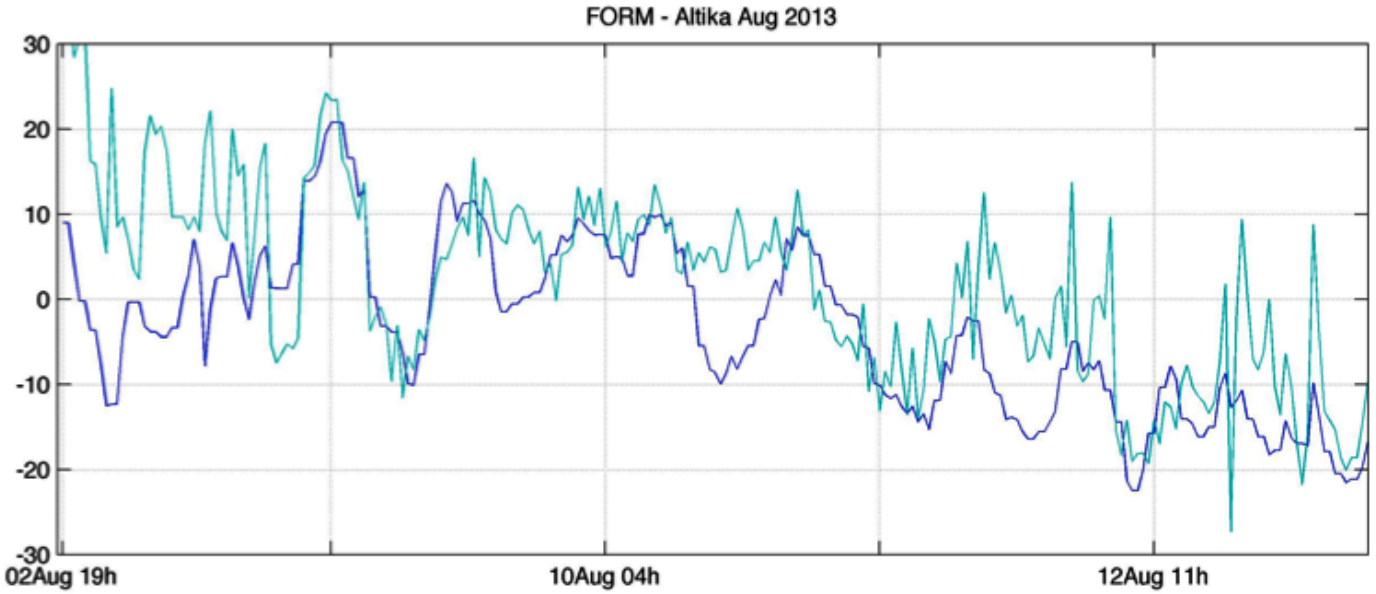



SOCIB HF Radar

## Data Validation: comparison with drifters

G-ALTIKA:
GALF vs drifter: 0.77
FORM vs drifter: 0.69

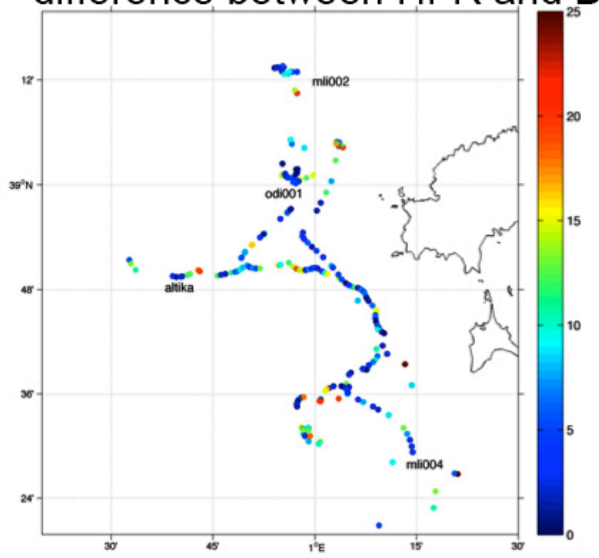


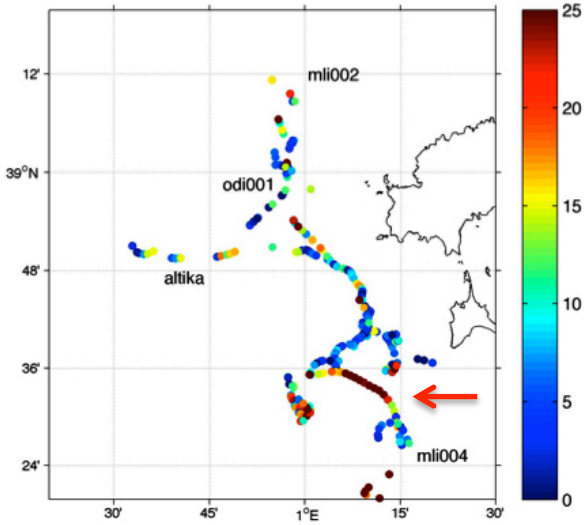
# Data Validation: comparison with drifters

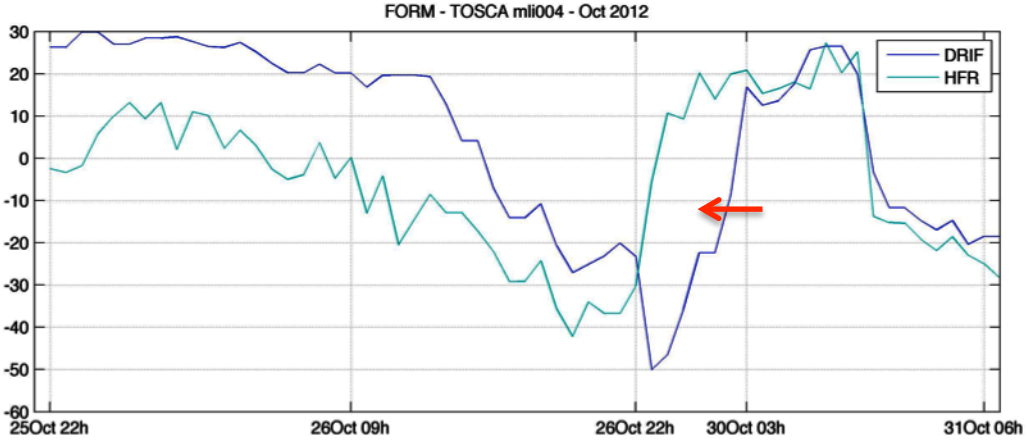
Areas where there is a higher (or lower) agreement between HF Radar radial data and drifter-derived velocity are identified.

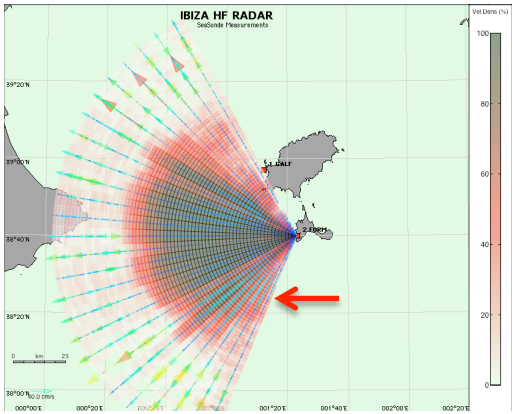
GALF- difference between HFR and Drifters




FORM - difference between HFR and Drifters

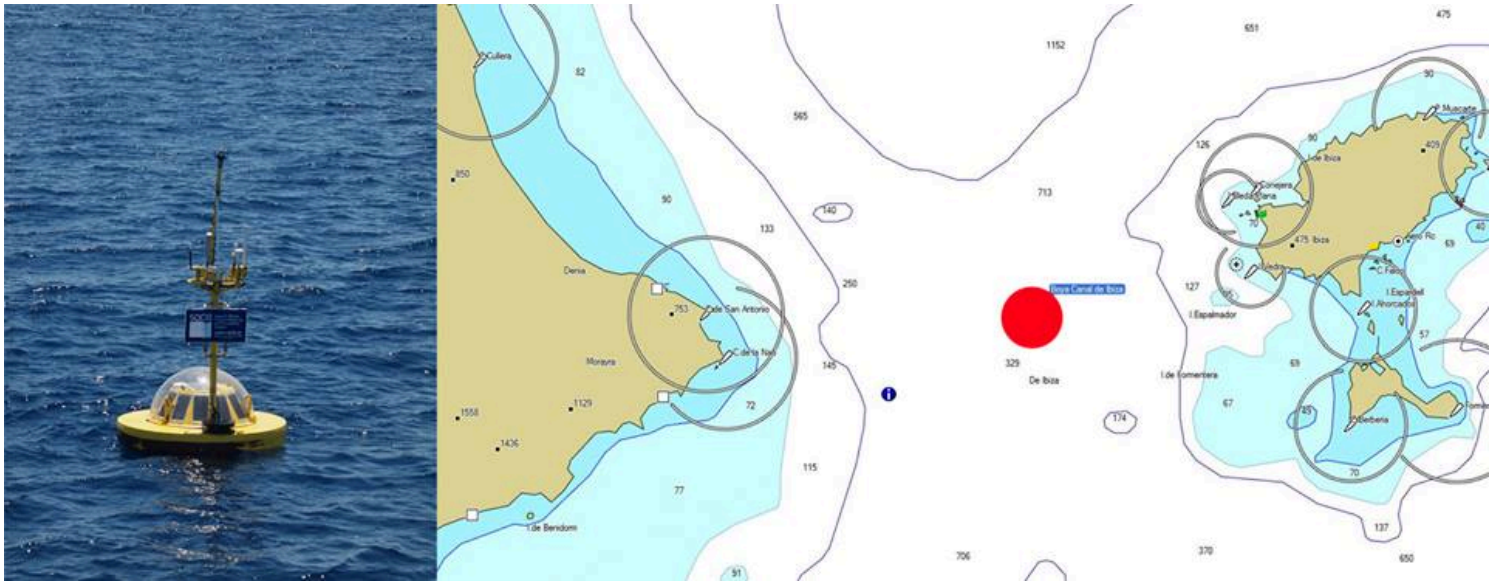


# Data Validation: Ibiza Channel Mooring

A surface (1 m depth) current meter (SCB-FSI002) was deployed in the Ibiza Channel in 24th September 2013.



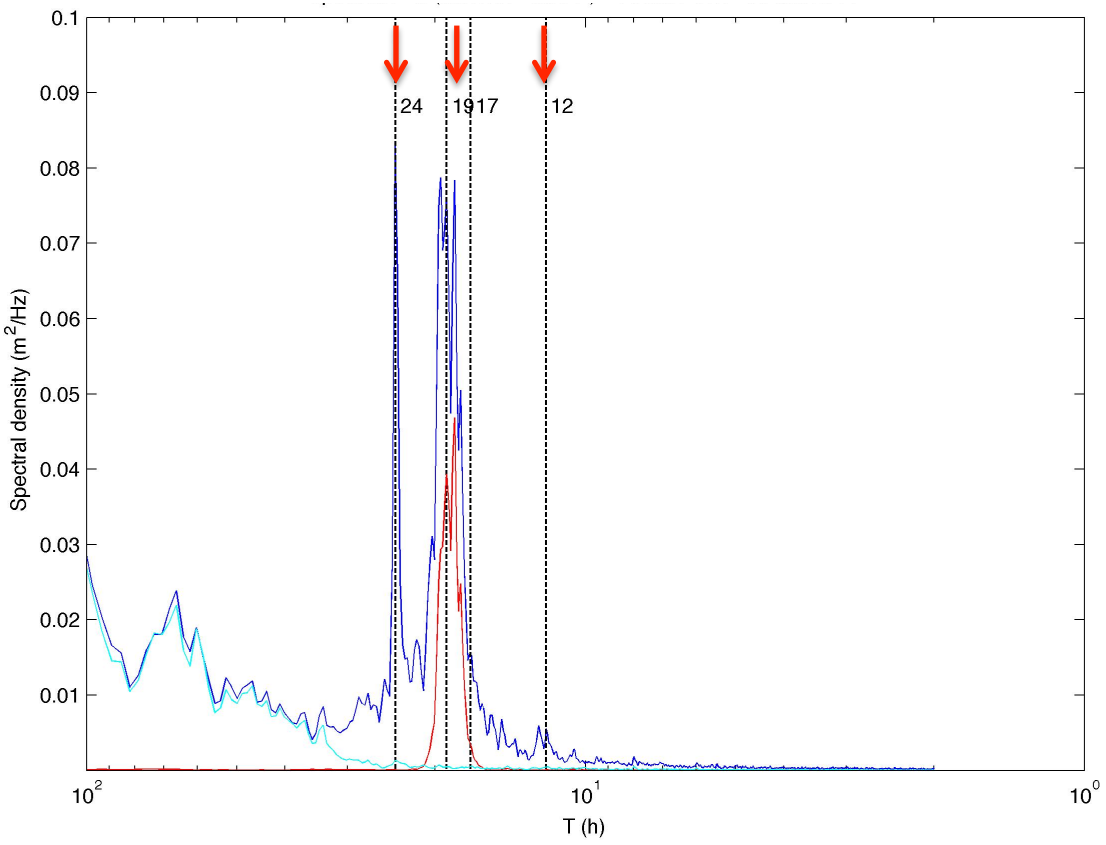

| | RMS (cm/s) | | | | RMS diff (cm/s) | | R | |
|---|---|---|---|---|---|---|---|---|
| | Buoy | | Radar HF | | | | | |
| | U | V | U | V | U | V | U | V |
| September - 2013 | 8.8 | 12.6 | 11.5 | 14.6 | 7.1 | 11.2 | 0.8 | 0.6 |
| October - 2013 | 12.1 | 11.1 | 9.7 | 16.5 | 8.4 | 13.8 | 0.7 | 0.5 |
| November - 2013 | 13.4 | 14.4 | 7.2 | 16.2 | 13.2 | 11.7 | 0.4 | 0.5 |

RMS and correlation coefficient between the current meter velocities projected over the hourly U and V components of HF radar velocities.

# Surface circulation patterns and variability: spectrum analysis

Power spectra are used to identify inertial and tidal (diurnal and semidiurnal) signals in the surface ocean currents from HF Radar

Spectrum U (38.72N – 0.95E) – 1 June 2012 – 31 January 2014

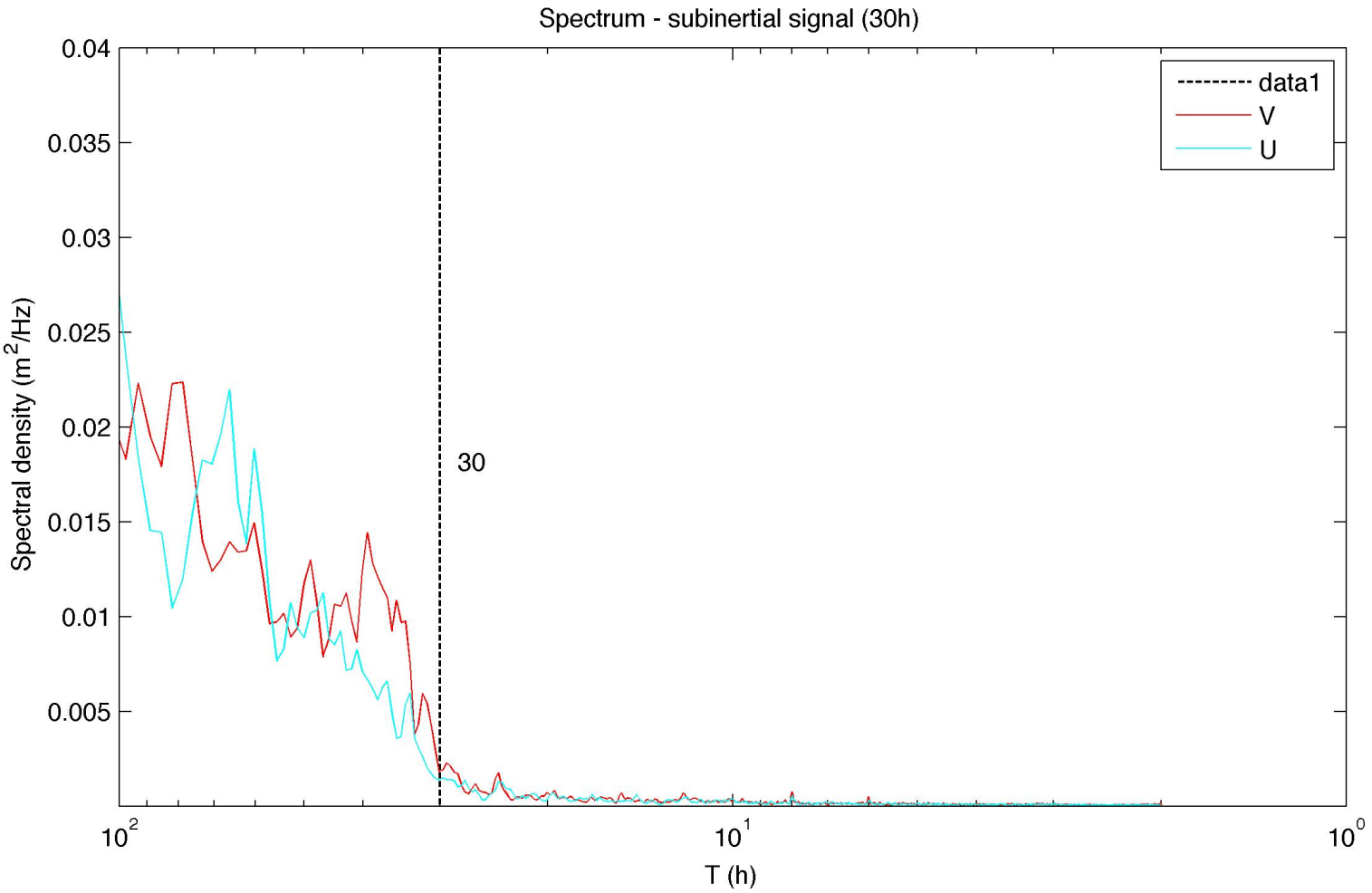



Dominant peaks are observed in the spectral energies. A Lanczos filter was applied to the time series at each node in order to analyse the surface current patterns at different time scales of variability.

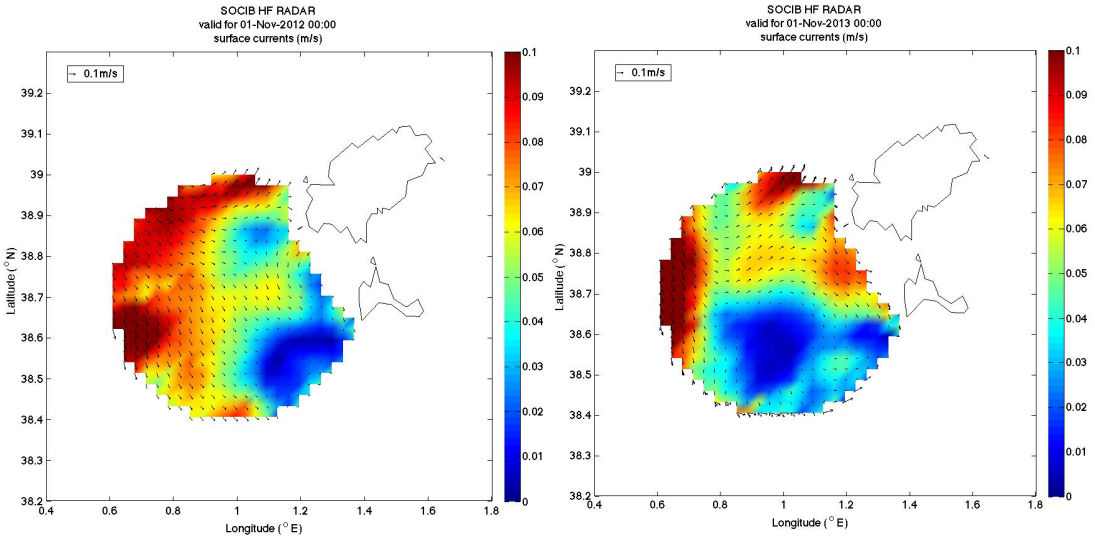
A low-pass filter (filtered out T<30h signal) to isolate sub-inertial and a band-pass (keeping 17<T<20h signal) to isolate the inertial oscillations.

# Surface circulation patterns and variability: sub-inertial

Seasonal variability: low frequency sub-inertial currents.
After filtering with a low-pass filter (30 h)



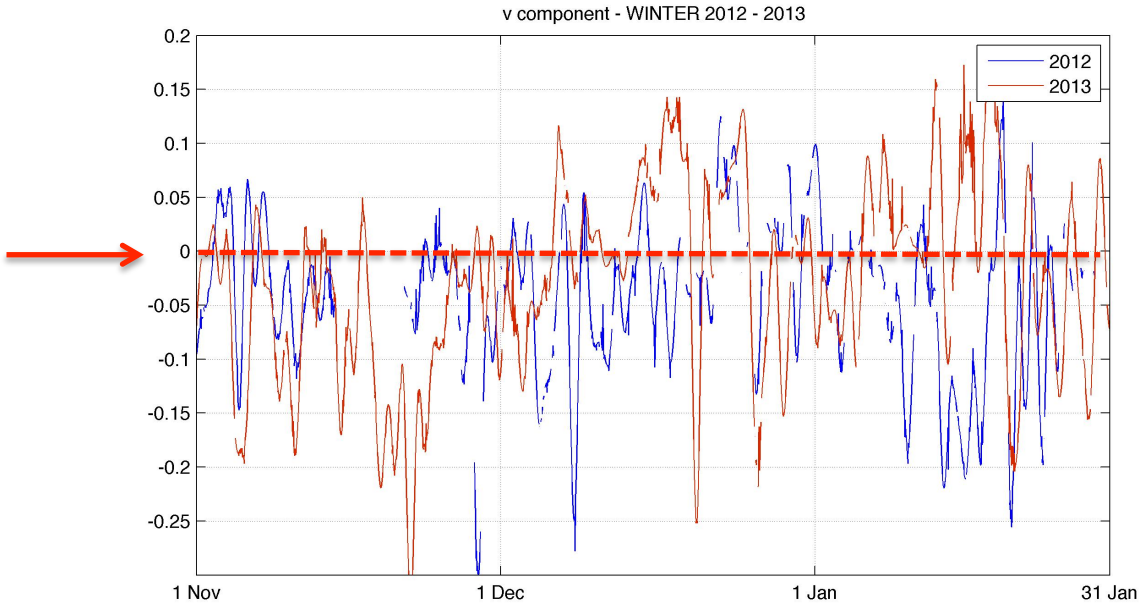
# Surface circulation patterns and variability: sub-inertial



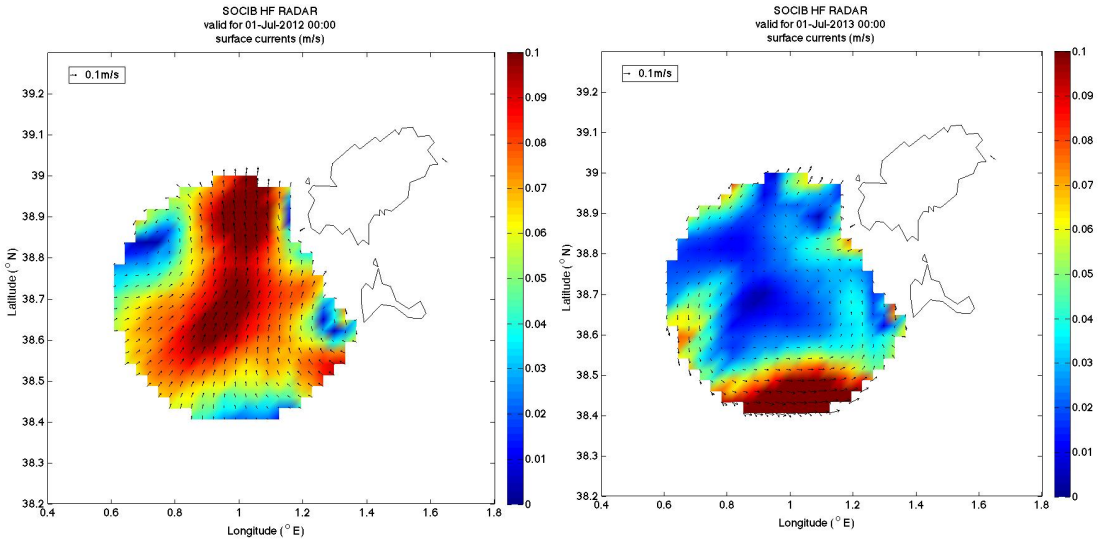

The resulting low-frequency surface velocity fields were averaged for summer and winter periods to study the seasonal variability of the observed surface fields.

WINTER - Temporal evolution of the medirional transport (north-south component) through an horizontal section (at 38.7N) in the Ibiza Channel.

There is a mean (-3.4 cm/s) southern current for the winter period.

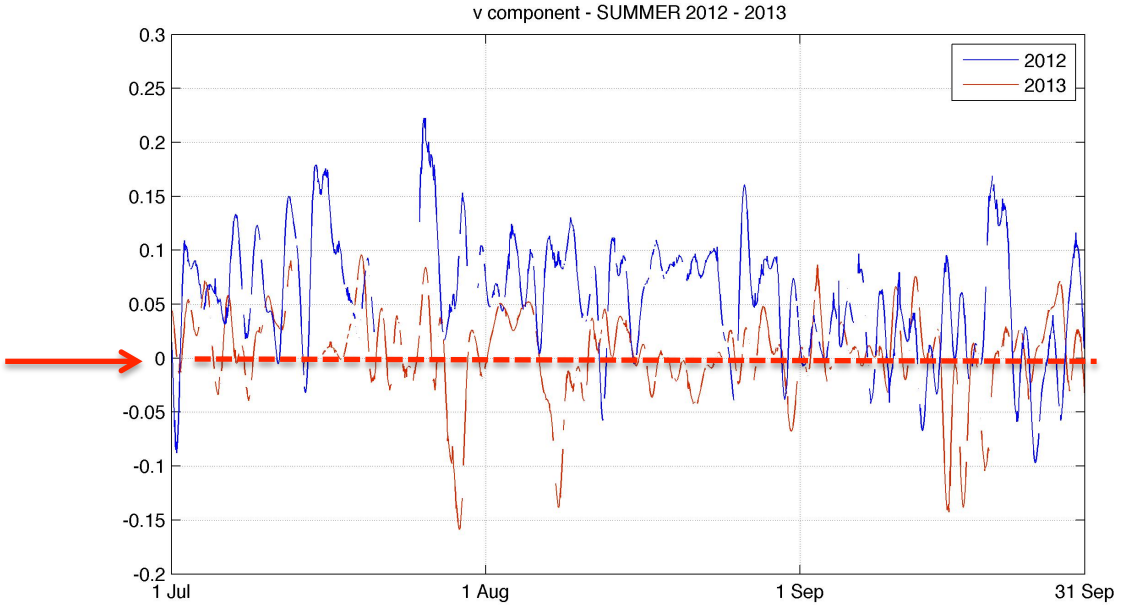


# Surface circulation patterns and variability: sub-inertial



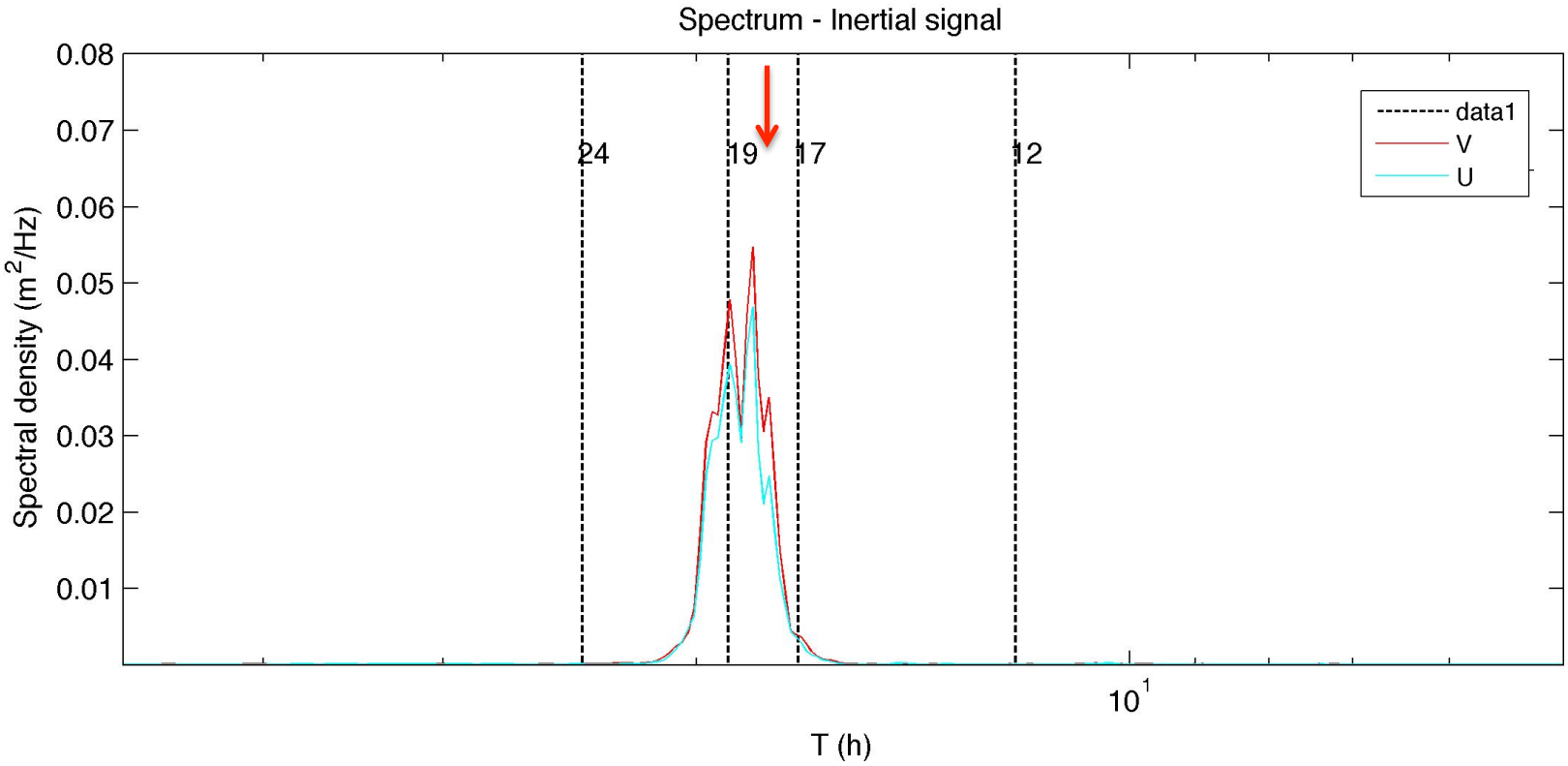

SUMMER - Temporal evolution of the medirional transport (north-south component) through an horizontal section (at 38.7N) in the Ibiza Channel.

Note the discrepancy between summer 2012 and summer 2013.

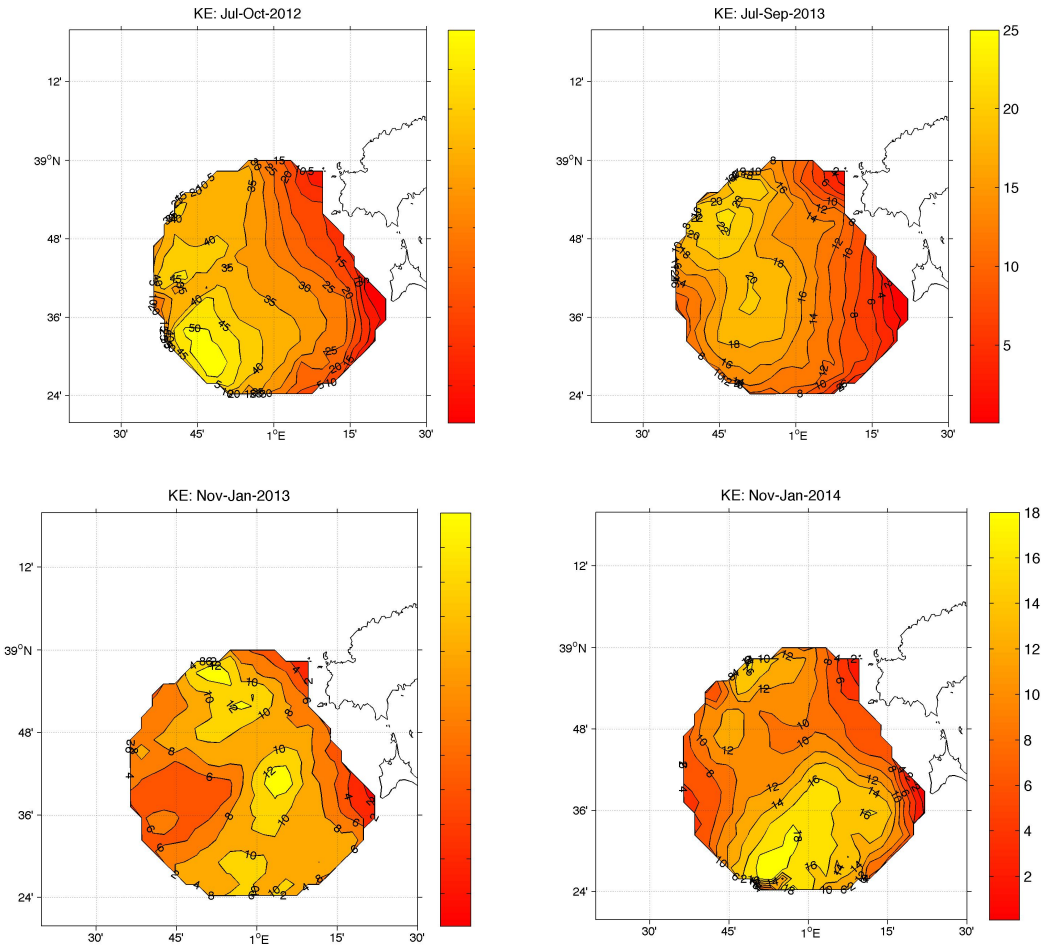


## Surface circulation patterns and variability: inertial component

The inertial filter was applied to all the radar HF gridpoints, for the whole HF Radar domain. The filtered data series were then integrated to calculate the KE distributions as the sum of the square of the two velocity components. For the KE maps, the analysis was performed for two different period: winter and summer.



# Surface circulation patterns and variability: inertial component



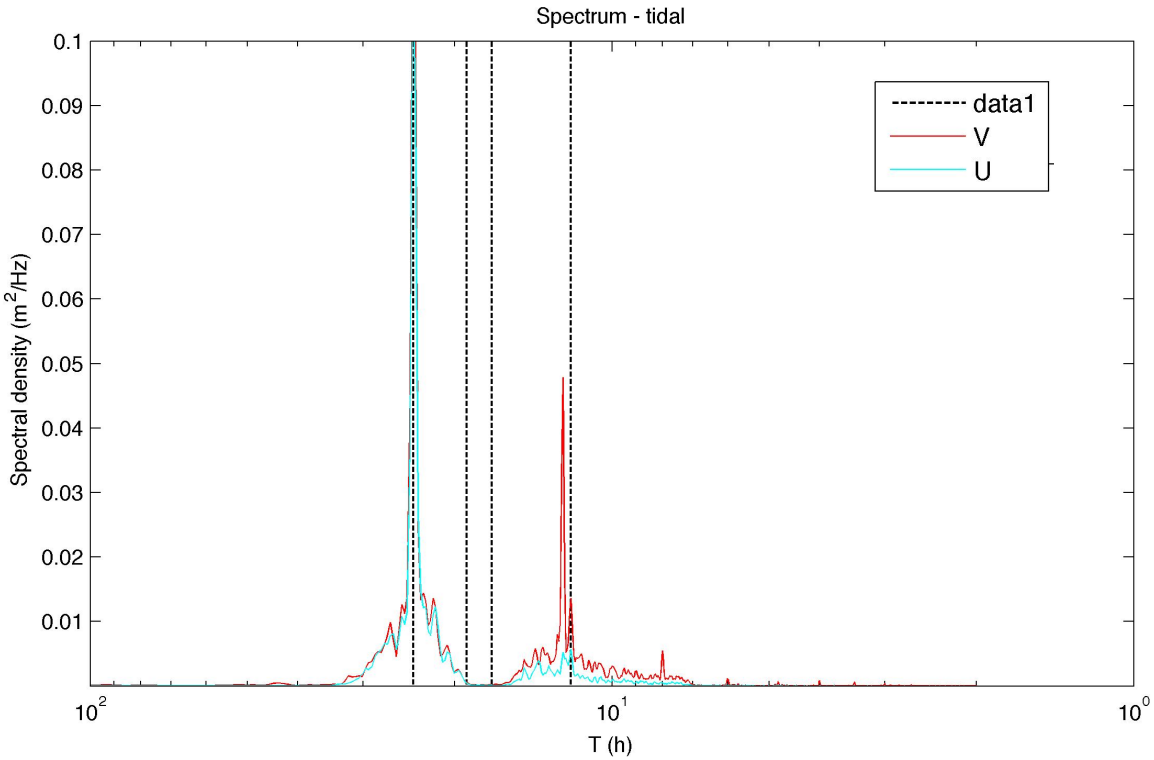

Summer KE. There is a gradient in the KE – more energetic in the slope area. The inertial currents are smaller in coastal areas than in open ocean.

Winter KE. Homogeneous distribution – KE much smaller than during summer periods.

The inertial component contribution to the total velocity in winter in no generally larger than 10%. Its contribution during summer period is much larger, around 22%.

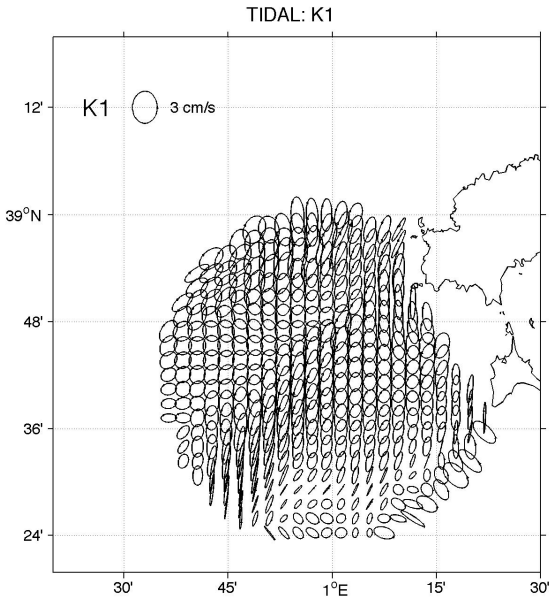
# Surface circulation patterns and variability: tidal component

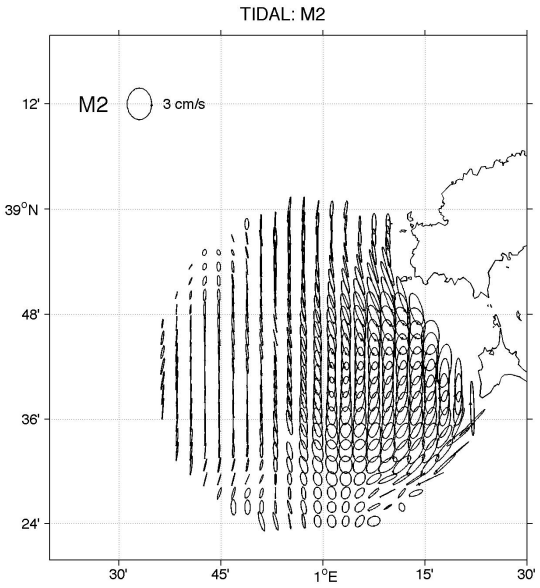
Power spectra inferred from HF radar surface velocities are used to tidal (diurnal and semidiurnal) signals in the ocean currents.

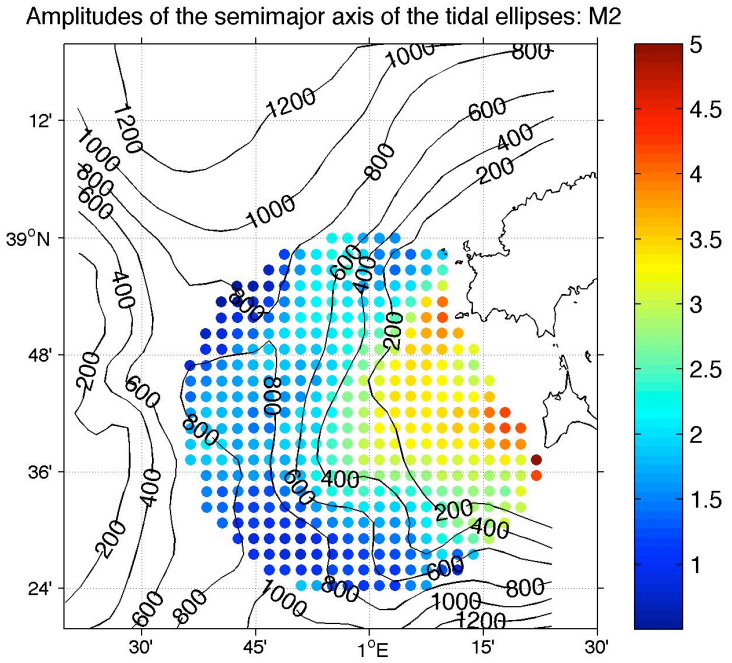



| Symbol | Name | Period | Amplitude of major axis (mean cm/s) | Phase (mean degrees from Greenwich) |
|---|---|---|---|---|
| K1 | Lunisolar diurnal | 24h | 2.26 | 85.10 |
| M2 | Principal lunar semi-diurnal | 12.42 | 2.1 | 142.09 |
| S2 | Principal solar semi-diurnal | 12h | 0.84 | 175.25 |

# Surface circulation patterns and variability: tidal component



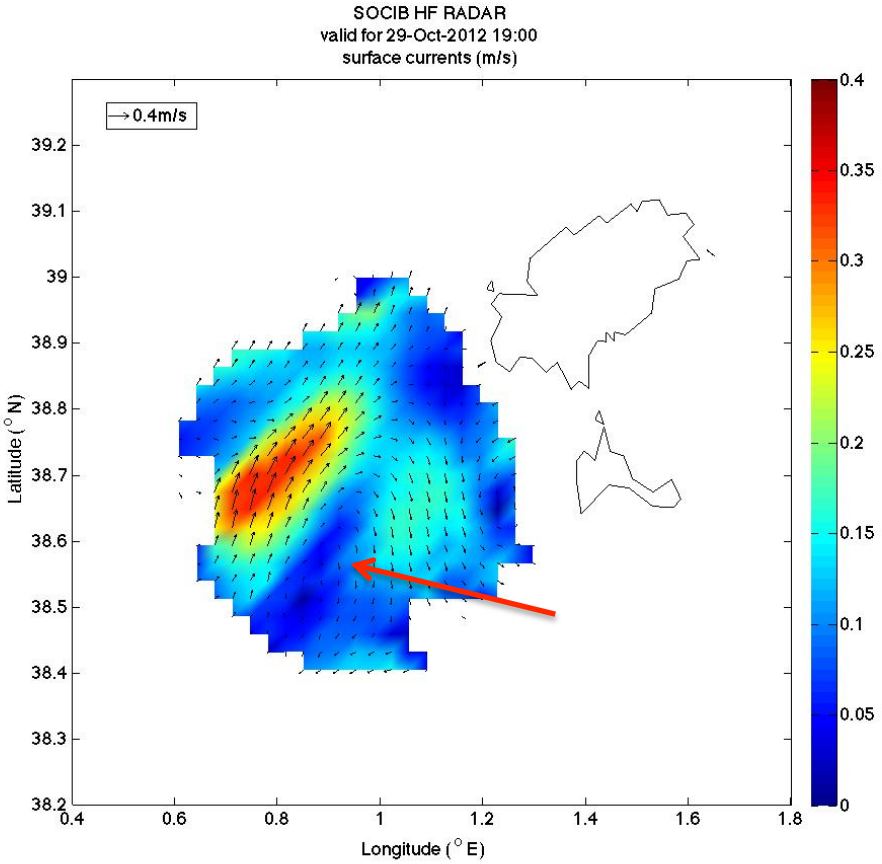




M2 tidal amplitude is related to the bathymetry distribution. The principal lunar semidiurnal M2 major amplitude distribution is distributed according to the bathymetry of the area.

# Surface circulation patterns and variability

## Identification of mesoscale structures:

HF Radar surface data is a valuable tool to identify the formation and evolution of mesoscale structures.




According to the type of structure we want to identify, we filter the subinertial signal, inertial signal, tidal signal, or use the original data.

Eddy anticyclonic structure identified during the TOSCA experiment

## Main Conclusions

- An automated QC procedure in accordance with international standards has been implemented in SOCIB HF Radar facility

- The RMS difference between drifters derived velocities and radial data is on the order of 5 to 10 cm/s for both radial sites. Values are similar to those obtained by other authors (e.g. Cosoli et al.. 2013, Rubio et al., 2012, Ohlmann et al. 2007, Rypina et al. 2013).

- Dominant peaks in the Spectrum are located around the diurnal, semi diurnal and local inertia
- (T ~ 19 h) for both U and V components.

- Inertial velocities range from 4-5 cm/s, while in winter they range from 2 to 3 cm/s. Sub-inertial velocities range from 8-12 cm/s.

- Inertial currents represent from 5 to 20% of the total variability in winter and from 10 to 40% in summer stratified period.

- Low-pass filtered sub-inertial currents show a seasonal variability: southward in winter period and northward in summer.

- For the first time it has been measured the magnitude of the main tidal currents (2.3 cm/s for the K1 constituent) and its relation with the bottom topography (larger amplitude in the shelf area).

## On-going work

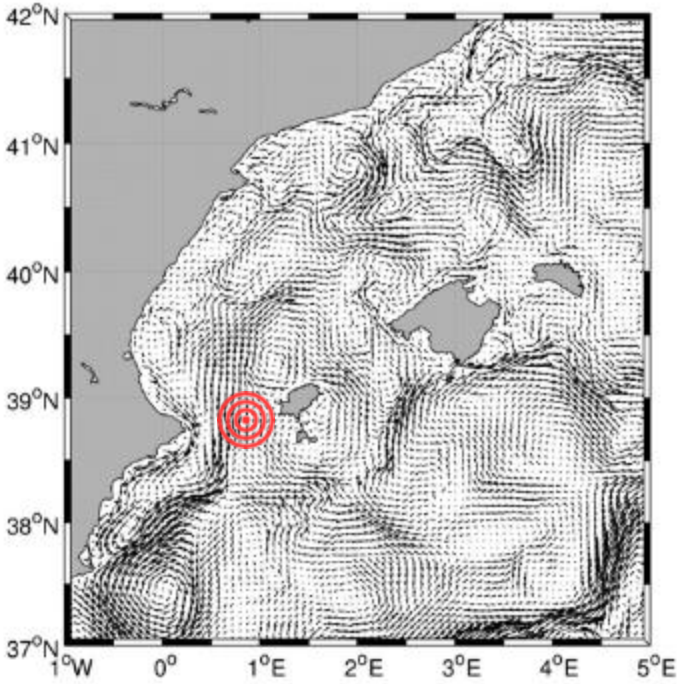
### HF Radar - drifters experiments:

- **Ibiza channel mooring (surface current meter)** in the Ibiza channel
- Drifter release experiment
- ADCP near IBIZA (for GALF) in Es Vedrá

### Numerical model validation

- Comparison against the Western Mediterranean Sea (WMOP) modeling and forecasting operational system, based in ROMS.

- HF Radar data assimilation by WMOP



SOCIB HF Radar

# HF Radar - Drifters experiment

## Goals:

- Test the performance of the drifters (types, wind influence and drogue shape)
- Asses the spatial errors of the HF Radar system
- Investigate the effects of the HF Radar spatial and temporal resolution
- Asses the effective measurements depths of the HF Radar

**Three different kind of drifters: differences to wind-drag exposure**

- Surface (1 m) current tracker
- Iridium
- Long life battery (3-12 months)
- **Low wind-exposure**

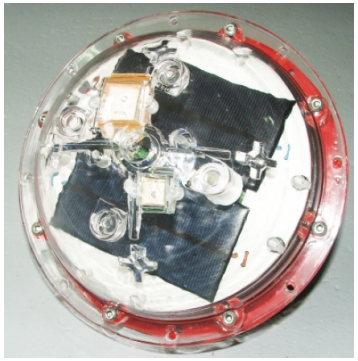
**CODE/DAVIS**

- Surface (1 m) current tracker
- Iridium
- Long life battery (3-12 months)
- **Low wind-exposure**

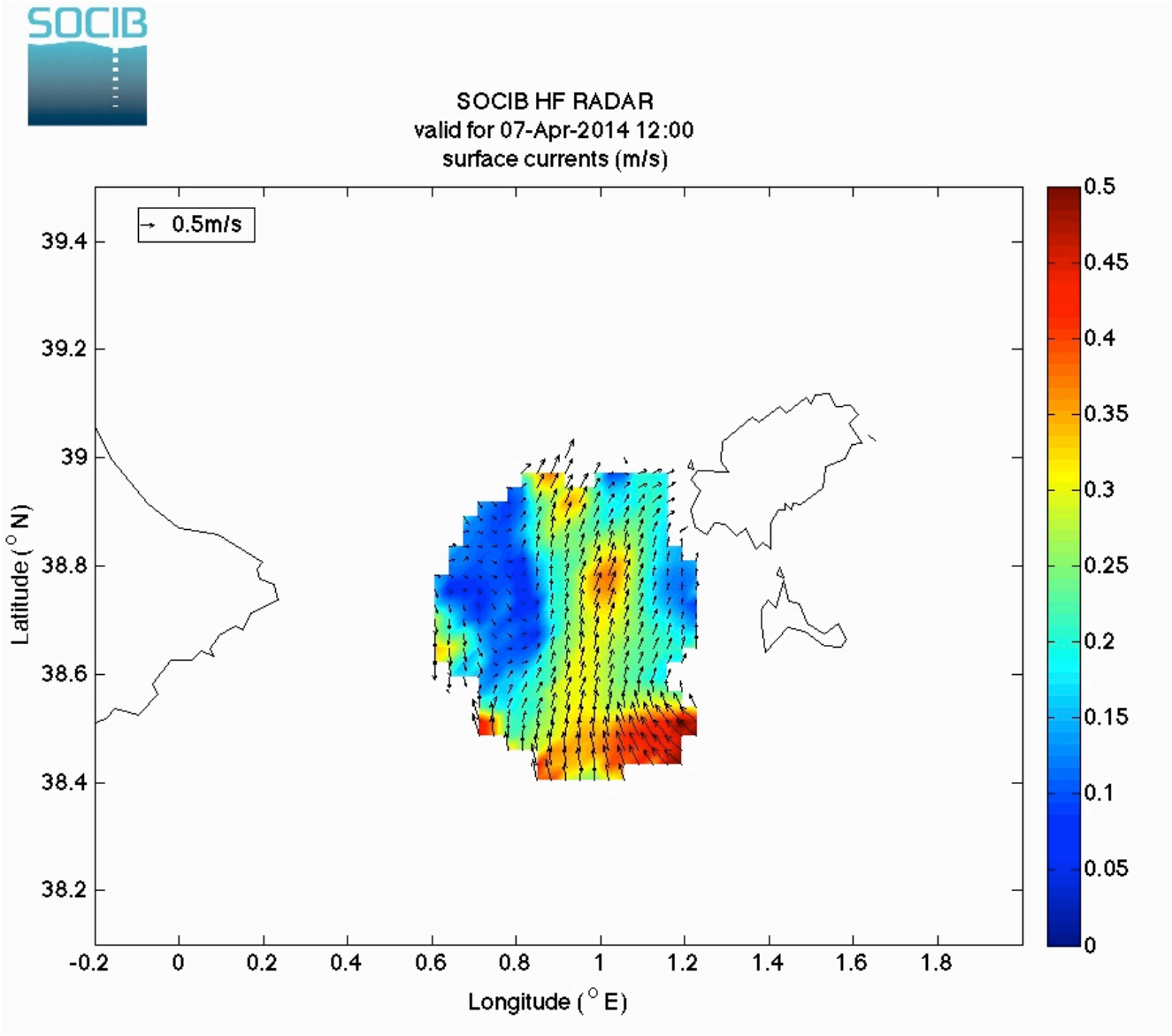
**MD03i**

- Surface (drogue) current tracker
- Iridium
- Long life battery (3 weeks)
- **High wind-exposure**

**ODi**



# Real-time data: Southern Atlantic water surface currents



*Thank you*