CONTEXT

HF radar complements the Coastal Ocean Observing and Forecasting System

LOCATION: Ibiza Channel

- Multiplatform approach (Glider, surface drifter, HF radar … but also modelling, mooring, profiler drifter, research Vessel, Turtle…)
- Choke point (Heslop et al. 2012)

From http://apps.socib.es/dapp/?status=all&platformtypes=glider,surfacedrifter

OUTLINE

SOCIB's HF radar system: characteristics, system performance and data quality

- Main features
- Coverage
- Data distribution and quality control
- Radar vs Current-meter and ADCP

Surface current variability in the Ibiza channel

- HF radar based: Hovmuller, Rotary spectrum analysis, Variability ellipses, EOF decomposition
- Multi-platforms: HF radar / AltiKa / Glider

SOCIB Western Mediterranean OPerational (WMOP) model validation using HF radar

- WMOP configuration
- WMOP vs HFradar

SOCIB'S HF RADAR SYSTEM: CHARACTERISTICS, SYSTEM PERFORMANCE AND DATA QUALITY

PRESENTATION

MAIN FEATURES + COVERAGE

CODAR SeaSonde system

- 2 HF radar stations (GALF, FORM)
- Monostatic (combined TX-RX antennas)
- TX center frequency: 13.5 MHz
- Bandwith: 90 kHz

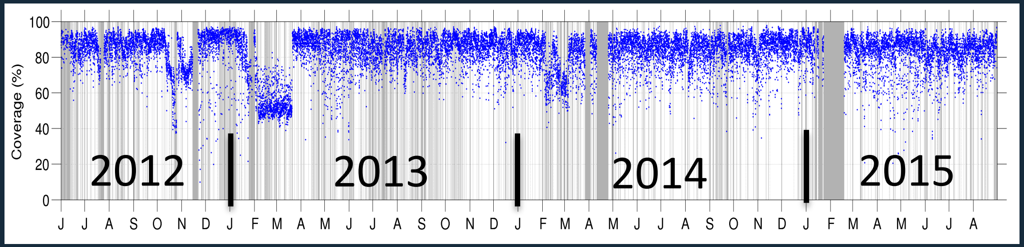
Radial

- Time sampling: hourly (75 min moving average)
- Radial resolution (Δr): 1,6 km
- Azimutal discretization ($\Delta\theta$): 5°
- Effective measurement depth (Stewart and Joy, 1974): ~0,90m

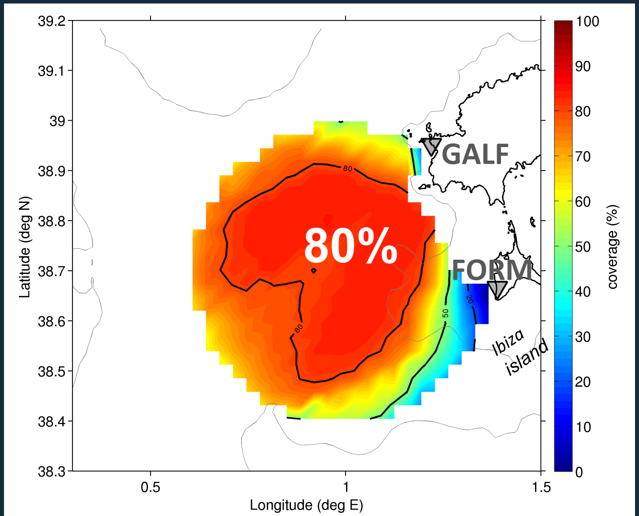
Vector

- Combination with Least Square Method
- Grid discretization: 3 km
- Averaging radius: 6 km

Total vector temporal evolution



Total vector spatial distribution



1st June 2012 – ongoing (**> 3 years**)

Data available more than **84% of the time**

80% coverage: **60 km** (West-East, North-south)

SOCIB

PRESENTATION

DATA ACCESS + QC

http://socib.es/?seccion=observingFacilities&facility=radar

- Format

  Format: NetCDF CF-1.6 compliant, monthly files
  Variables: lon, lat, time,U,V, sea water speed + direction
  Quality flags: for each variable + for individual antennas

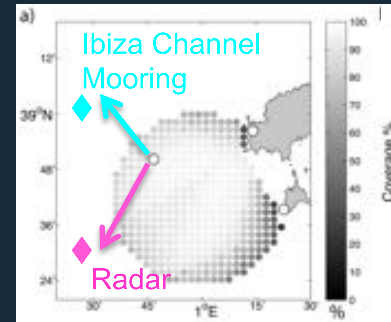
- CODAR QC procedures ⟶ L0
  - Threshold for radial (80 cm/s), total vectors (70 cm/s)
  - Angle between radial in the range 30°-150°
  - First Order Limit settings (prevent interferences and errant high radial velocities)
  - Antenna pattern calibration >> **Last APM in July 2015**.

- SOCIB Data Centre procedures and flags ⟶ L1
  - SOCIB Battery of tests for individual total vector (range, gradient, spike for module and direction).
  - System functioning diagnostic parameters at each radial station (signal-to-noise ratio, radial vector count, average radial bearing, comparison of averaged radial bearing for the measured and ideal patterns)

- More details:

  Lana et al. (2014), SOCIB Continuous Observations Of Ibiza Channel Using HF Radar Technology for Characterization and Quantification of Surface Currents, Sea Technology

SOCIB



VALIDATION

HF RADAR VS CURRENT METER (CM) AND ADCP

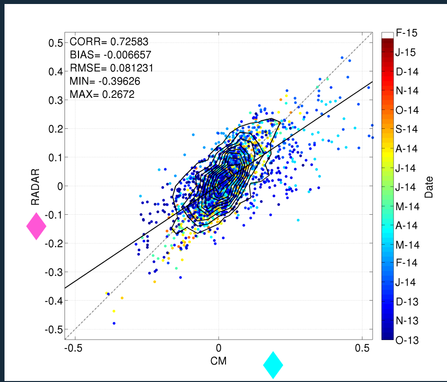
TOTAL CURRENTS

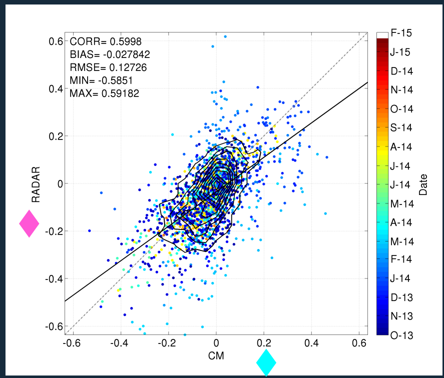
- Lana et al., Wind influence on surface current variability in the Ibiza Channel from HF-Radar, submitted

U

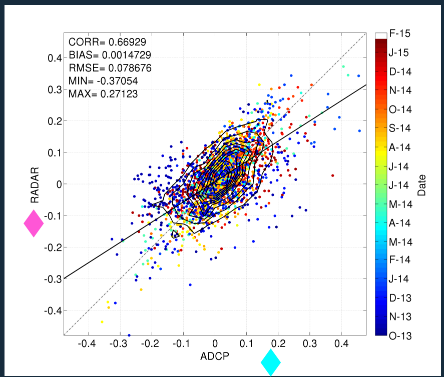
V

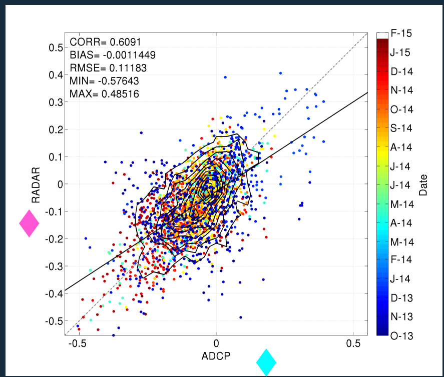
Radar vs CM





Radar vs ADCP





- 3h averaged U, V velocities from HF radar (0.9m), CM (1.5m) and ADCP (5m);
- From 2013/09/27 to 2015/01/22
- QC flags 1, 2 (good and probably good data)
- **7cm/s < RMSE < 13cm/s**
- **0.6 < correlation < 0.73**
- Good agreements with previous studies (recently Lorente et al., 2014, Cosoli et al., 2010 or Rubio et al, 2011)
- Good agreement in reproducing the strongest velocities events (not shown)
- Better agreement for the U component (geometric effect + higher variability for V)

- APM in July 2015: clear improvement

HF radar vs CM in July 2015, Old / New patterns

	RMSD (cm.s^{-1})	Corr
U	7.86 / 7.22	0.80 / 0.83
V	14.59 / 11.65	0.58 / 0.66

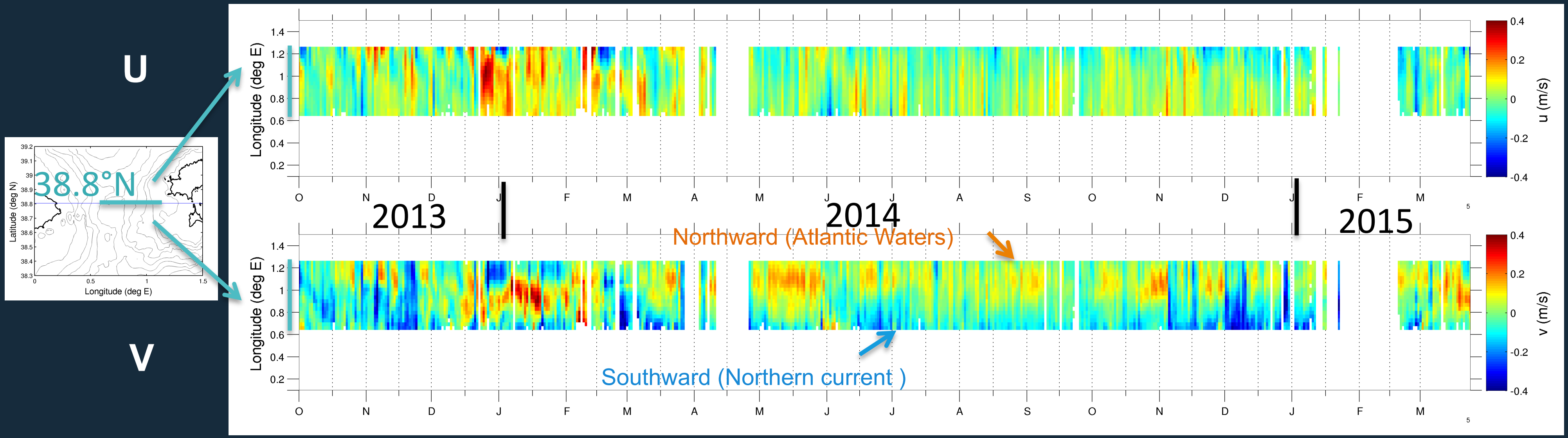
SURFACE CURRENT VARIABILITY IN THE IBIZA CHANNEL

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

HOVMULLER DIAGRAM (38.8°N)

- Time evolution of U and V along the section at 38.8°N

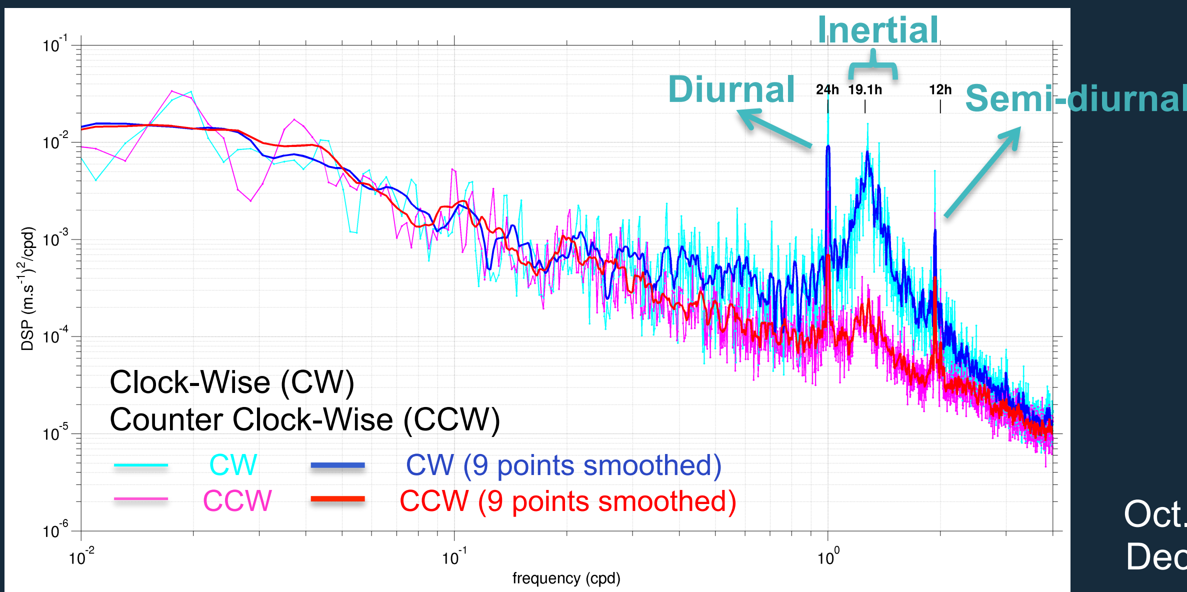


- High variability in winter
- No permanent and synoptic patterns for U-component
- Northward and southward flow on V-component: signature of Atlantic water and Northern Current

VARIABILITY STUDIES

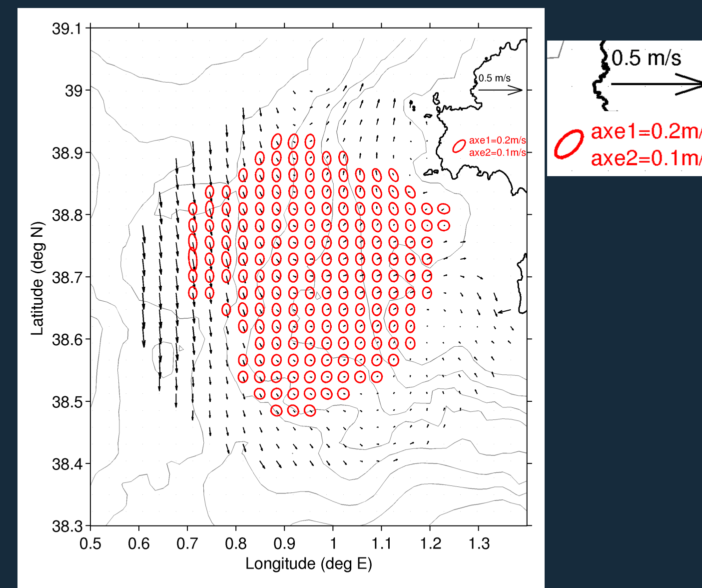
CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

ROTARY SPECTRUM ANALYSIS



VARIABILITY ELLIPSES + MEAN CURRENT

Oct. 2013-
Dec. 2014



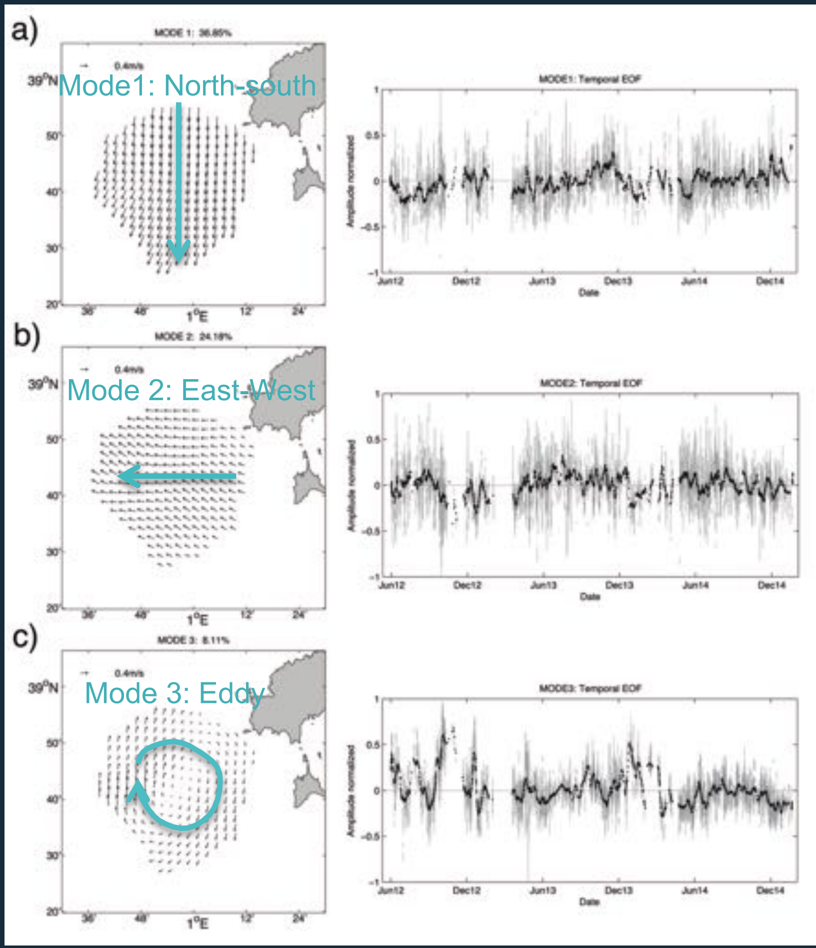
- CW >> CCW (Coriolis effect)
- Diurnal: S1 (24h), Meteorological (Wind breezes induced surface currents)
- Near-inertial oscillations
- Semi-diurnal: M2 (12.4h), Astronomical

- Northern Current signature in the Western part of Ibiza Channel
- Standard deviation in the range 10 - 20cm/s
- In general, no dominant variability direction (ellipses ≈ circles)
- Ibiza Channel = complex circulation

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

WIND INFLUENCE ON SURFACE CURRENT VARIABILITY



- Lana et al., Wind influence on surface current variability in the Ibiza Channel from HF-Radar, submitted

- **Identify the main patterns of variability**
- EOF Decomposition 2012/06/01 – 2015/01/22
- Over the 80% coverage area
- Cross –correlation: Wind U, V components and surface current temporal EOF

- 3 first modes: 69% of the total variability
- Modes 1 (37%) and 2 (24%): wind induced variability
- Mode 3 (8%): Eddy pattern

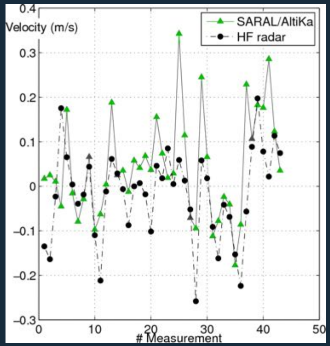
- **Assessment of wind induced (Ekman) transport**
- Between 25% and 50% of the total surface transport
- Mainly southwards
- High seasonal variability (higher in winter)

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

ASSESSMENT OF SARAL/ALTIKA ALTIMETER USING HF RADAR

Pascual et al. (2015), Assessing SARAL/AltiKa delayed-time data in the coastal zone: comparisons with HF radar observations, Marine Geodesy

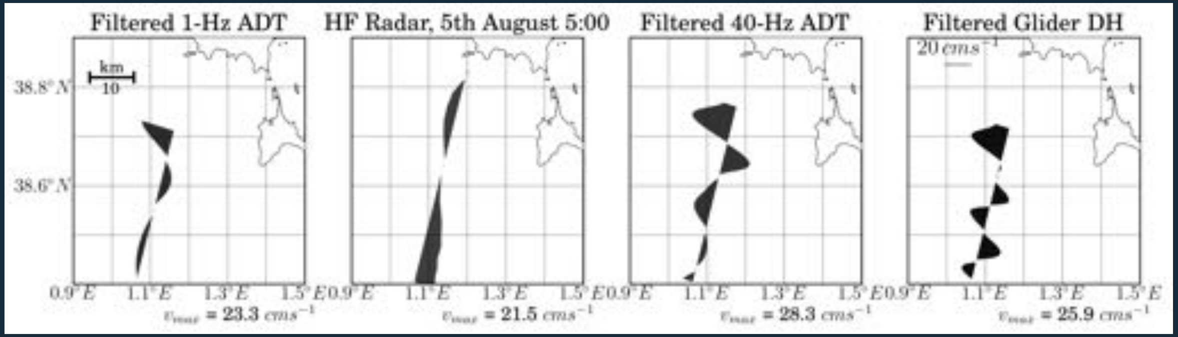


- SARAL/AltiKa absolute geostrophic velocities perpendicular to the track
- Surface HF radar velocities perpendicular to the SARAL/track

- Good agreement between HF radar and SARAL/AltiKa velocity
  - Significant correlation (0.54)
  - RMS differences: 13 cm/s

MULTI-PLATFORM EXPERIMENT: HF RADAR VS ALTIKA VS GLIDER

Troupin et al. (2015), Illustration of the emerging capabilities of SARAL/AltiKa in the coastal zone using a multi-platform approach, Advances in Space Research. doi: doi:10.1016/j.asr.2014.09.011

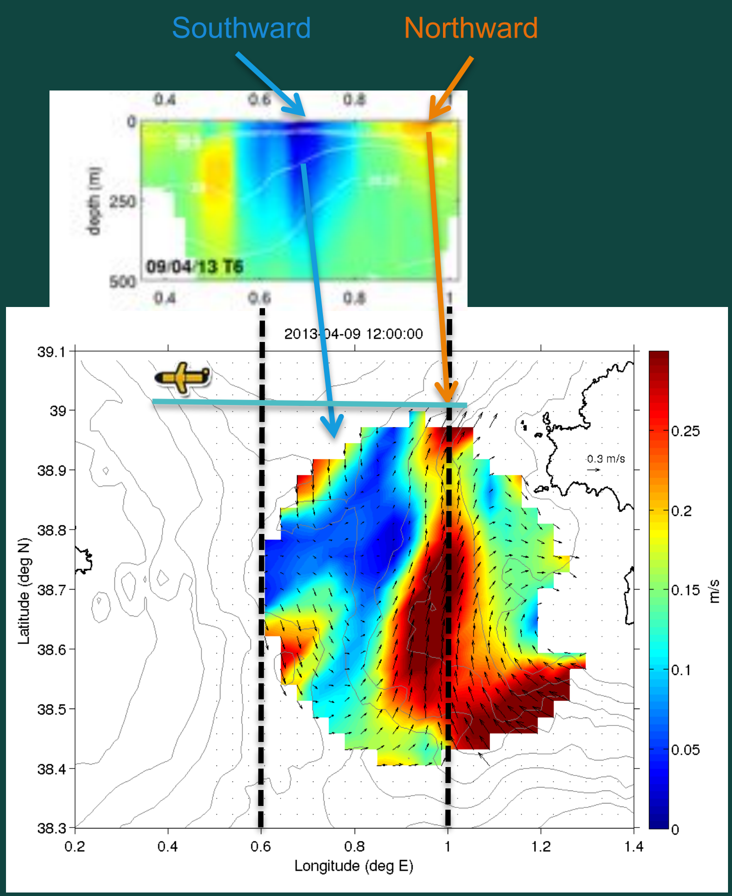


- Radar velocity closest to coast
- Northwestward current: approx. 20 cm/s
- Shown by three platforms

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

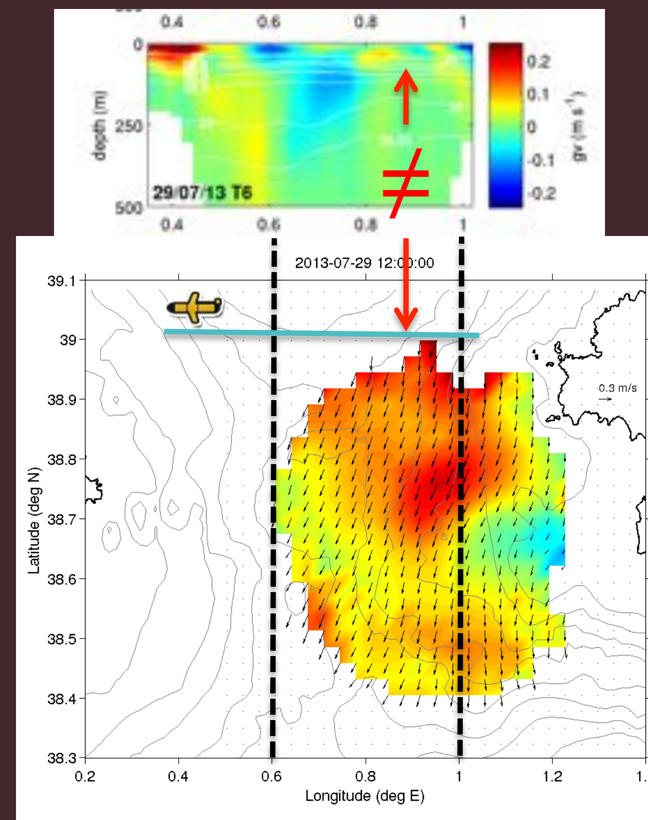
COMPARISON WITH GLIDER

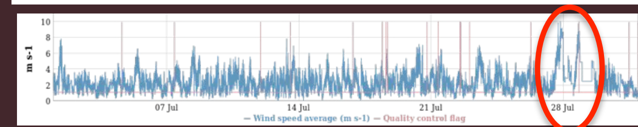


- GLIDER derived geostrophic velocities from Heslop 2015 (PhD thesis) at CANALES transect
- Daily averaged HF radar velocities

- In general, good agreement between surface velocities and GLIDER derived geostrophic velocities
- Surface currents ≈ geostrophic currents

- Bad agreements in case of high wind events
- Geostrophic currents ≠ wind currents



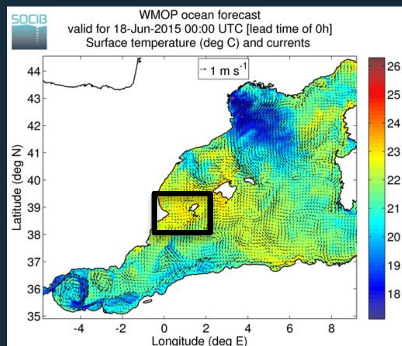


Wind speed time series for July 2013

SOCIB WESTERN MEDITERRANEAN OPERATIONAL (WMOP) MODEL VALIDATION USING HF RADAR

MODEL VALIDATION

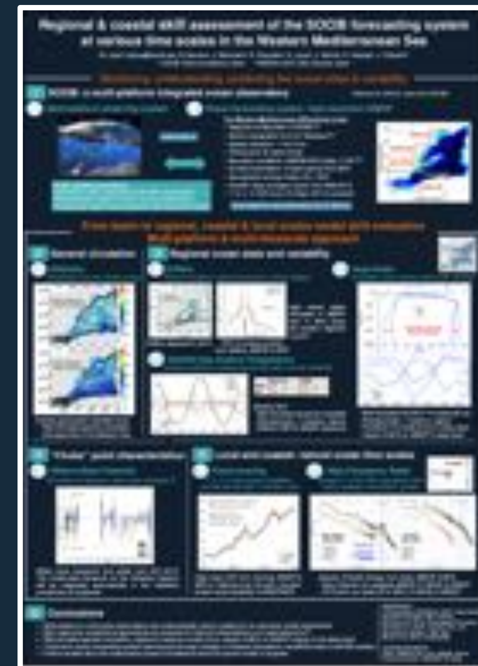
WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS



SOCIB **W**estern **M**editerranean **OP**erational (WMOP) configuration (since 2013 oct.):

- ROMS
- From Gibraltar to Sardinia (6ºW-9ºE, 35ºN-44.5ºN)
- Spatial resolution: 1.8 to 2.2 km
- Vertical grid: 32 sigma levels
- Boundary conditions from MFS
- Atmospheric forcing from HIRLAM (3 h, 1/20º)
- Rivers runoffs
- Model initialization: weekly from the outputs of a 3-weeks spin-up simulation initialized from MFS

Lana et al. (2015), “HF Radar Ocean Surface Current Observations in the Ibiza Channel: Description and Model-Data Comparisons”, Liege Colloquium, Liege, Belgium



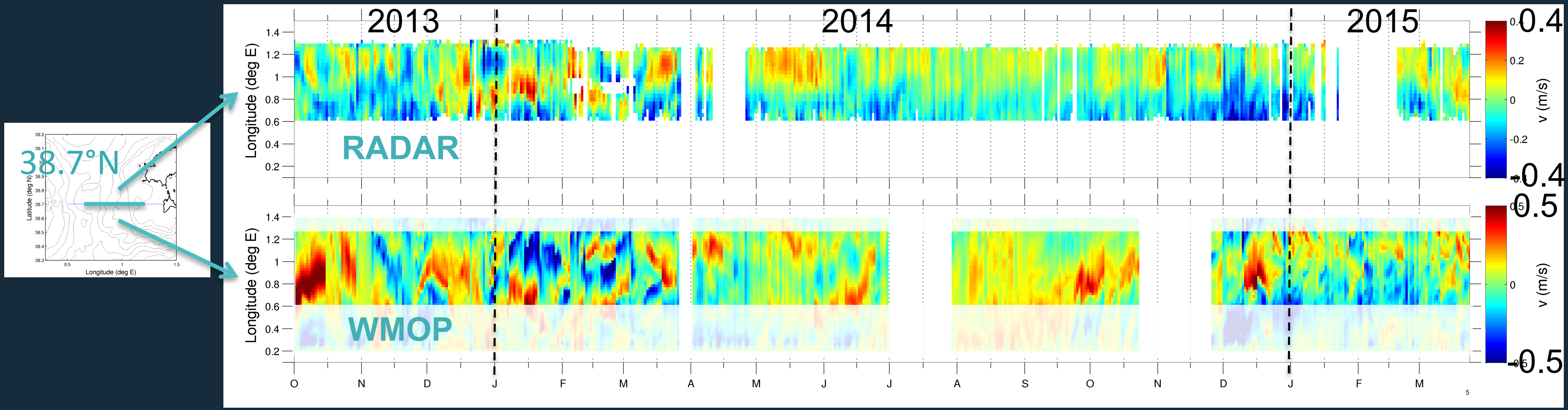
Juza et al. (2015), "Regional and coastal skill assessment of the SOCIB forecasting system at various time scales in the western Mediterranean Sea", 4th GODAE Ocean View Coastal Ocean and Shelf Seas Task Team (COSS-TT) International Coordination Workshop (COSS-ICW4), Lisbon, Portugal.

MODEL VALIDATION

WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS

HOVMULLER DIAGRAM (38.7°N)

V-component

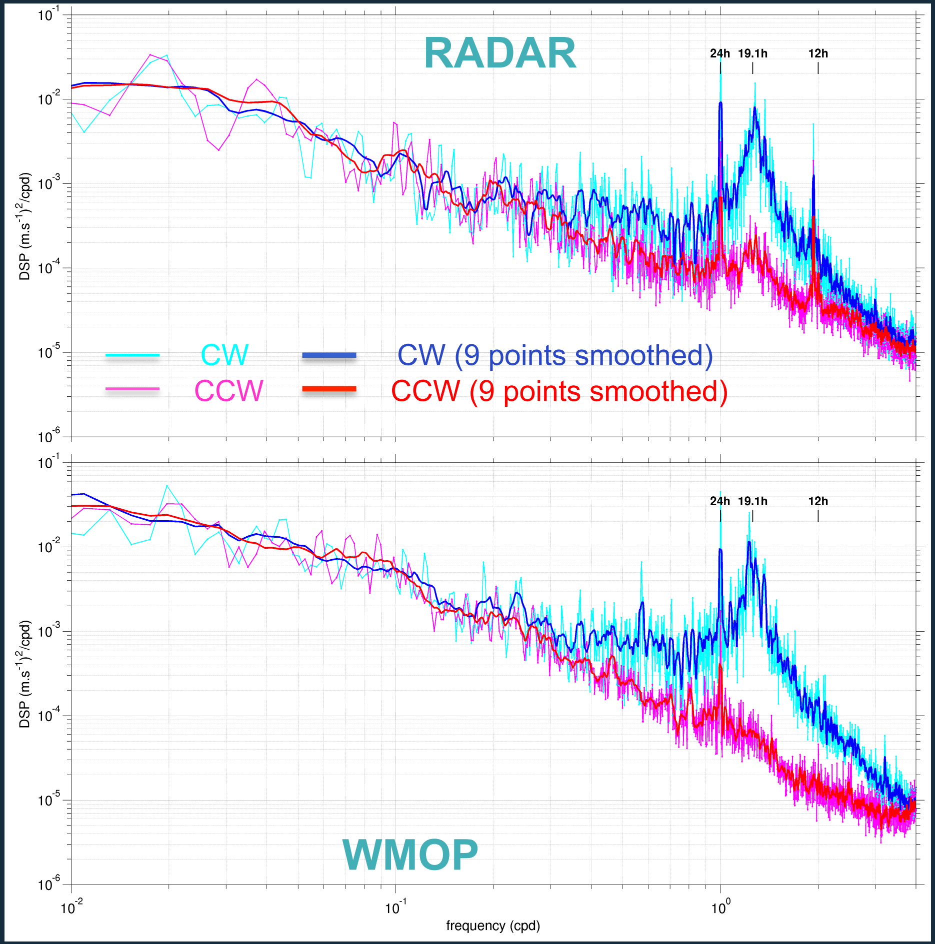


- ➢ Seasonal variability for both data sets: high (low) variability in winter (summer)
- ➢ No permanent and synoptic patterns for WMOP
- ➢ Short spatial and temporal scales in winter in both model and radar, with poor pattern correspondence, except in case of strong wind events
- ➢ General overestimation of the current intensity in the model (maximum values aprox. 30% higher).
- ➢ Higher variability for WMOP

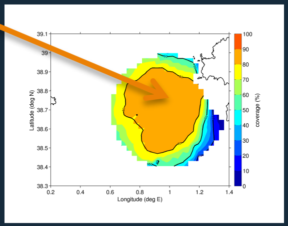
MODEL VALIDATION

WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS

ROTARY SPECTRUM ANALYSIS



- Rotary spectrum (Clock-Wise and Counter Clock-wise)
- 2013/10/01 – 2014/12/31
- Spectrum are averaged over the 80% coverage area



- CW >> CCW (Coriolis effect)
- Diurnal: S1 (24h), Meteorological (Wind breezes induced surface currents)
- Near-inertial oscillations
- Semi-diurnal: M2 (12.4h), Astronomical (Moon)
- Tidal forcing is not included in WMOP
- WMOP is more energetic

CONCLUSIONS

- HF radar: a key platform of the Balearic Islands Coastal Observing and Forecasting System
- HF radar system works operationally
- HF radar data available on line: `http://socib.es/?seccion=observingFacilities&facility=radar`
- Efficient visualization tools and apps
- High quality data
- State of the art Quality control: strive for standard procedures, flags, criteria…
- Reliable data: validation with different platforms (Current meter, ADCP, surface drifters) and comparison with Glider and coastal altimetry.
- Relevant scientific results (circulation studies, platforms validation, model validation…)

ONGOING/FUTURE WORKS

- Improve QC/QA (delayed time HF radar velocities)
- Implement in real time monitoring of HF radars "health" by comparison with in situ measurements
- Implement in real time HF radar based diagnostics for ocean forecast model validation
- Development of HF radar based products (e.g. Data-model blending) for operational applications (Search and Rescue, Oil spill...)
- Assimilation of HF radar velocities in the the SOCIB Western Mediterranean Operational Forecasting system
  - Local Multimodel Ensemble Optimal Interpolation → Mourre et al., 2015, Model state estimation and representation of observed subsurface eddies off Western Sardinia, Liege Colloquium
- Increase number of users for both operational and delayed mode product
- Towards an European/Global HF radar network
- Original use of HF radar products (wave product provided by CODAR system… to be validated!!!)

SOCIB

THANK YOU!

http://socib.es/?seccion=observingFacilities&facility=radar

jmarmain@socib.es
julien.marmain@gmail.com

EXTRA SLIDES

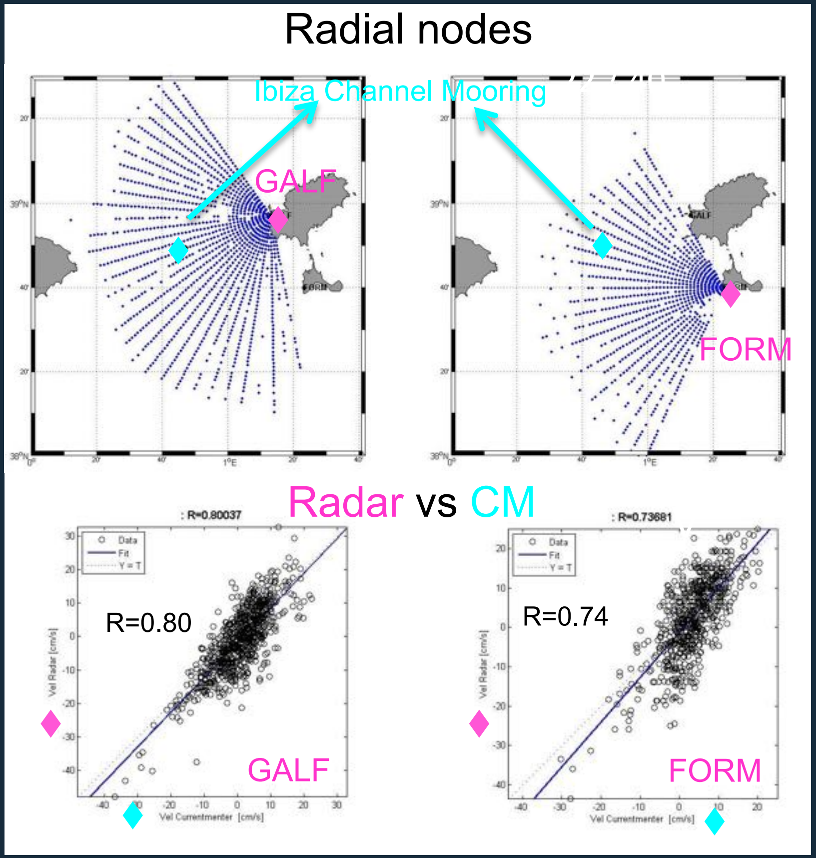
SOCIB

VALIDATION

HF RADAR VS CURRENT METER (CM) AND ADCP

RADIAL CURRENTS

- Radial velocities from HF radar (0.9m), Current meter (1.5m) and ADCP (5m)
- Radar vs CM: oct. 2013 to sept. 2014
- Radar vs ADCP: oct. 2014 to apr. 2015



Monthly statistic range:

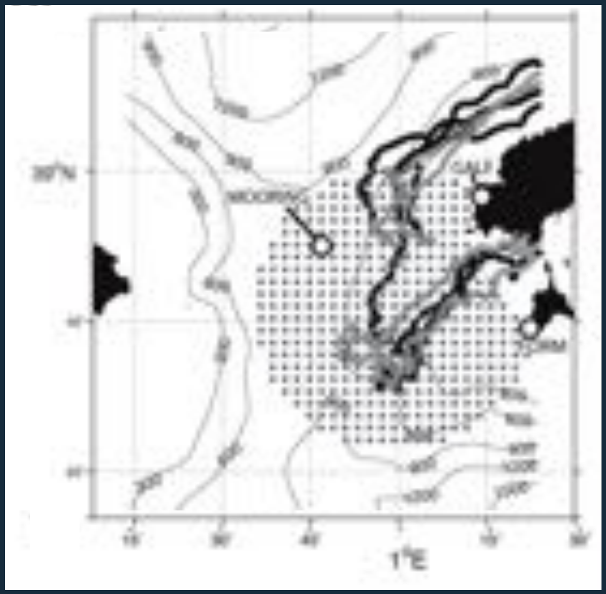
		RMSE (cm.s-1)	Correlation
GALF	CM	6.3 – 19.1	0 – 0.82
	ADCP	6.2 – 10.9	0.45 – 0.82
FORM	CM	7.0 – 16.0	0.23 – 0.79
	ADCP	7.5 – 11.6	0.30 – 0.64

- Good agreements in general
- Problems due to salt on connectors and on the DOME antennas, Interferences
- Good agreements with previous studies (Lorente et al., 2015, Cosoli et al., 2012 or Rubio et al, 2011, Emery et al. 2004)
- Better agreement for the GALF station (due to mooring-site distance)
- **CM and ADCP could be used to monitor the HF radar performance in real time**

VALIDATION

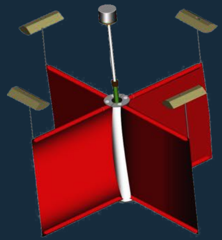
DRIFTER - HF RADAR VALIDATION EXPERIMENT

➢ Lana et al., Wind influence on surface current variability in the Ibiza Channel from HF-Radar, submitted



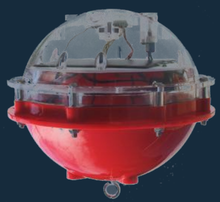
MDi

Surface (1m)
Low wind
exposure



CODE

Surface (1m)
Low wind
exposure



ODi

Surface
High wind
exposure

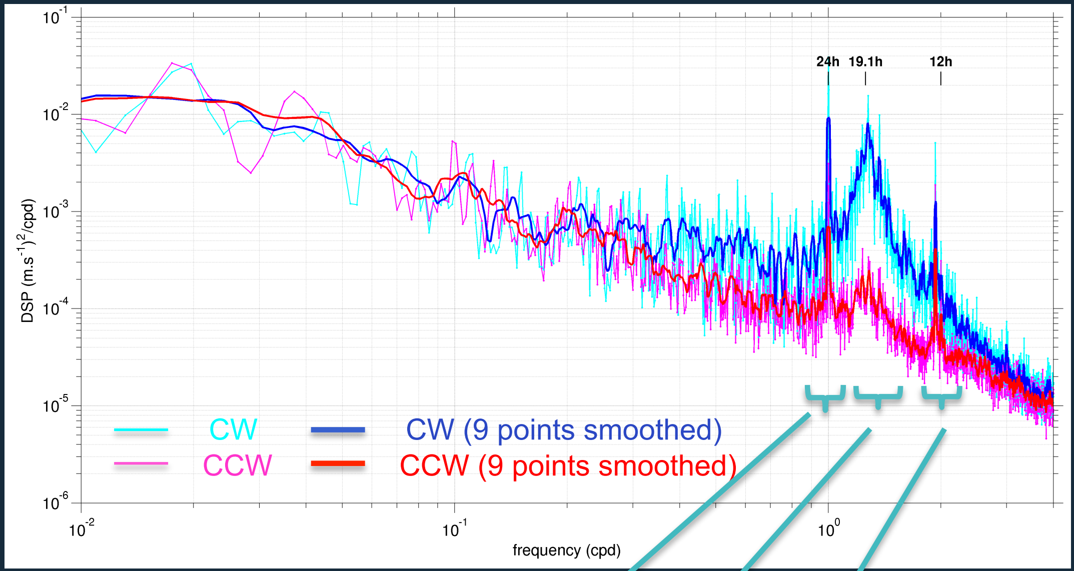
- Experiment in Sept. 2014
- 13 surface lagrangian drifters
- 3 kind of surface drifters (drogue and shape)
- Deployed in one point of the HF radar area
- **4cm/s < RMSE < 19cm/s**
- **0.44 < correlation < 0.9**
- Good agreements with previous studies (recently Lorente et al., 2014, Cosoli et al., 2010 or Rubio et al, 2011)
- Difficult to conclude on the most suitable drifter!

➢ Other studies: Bellomo et al., Toward an integrated HF radar network in the Mediterranean Sea to improve search and rescue and oil spill response: the TOSCA project experience, Journal of Operational Oceanography, in revision

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

ROTARY SPECTRUM ANALYSIS

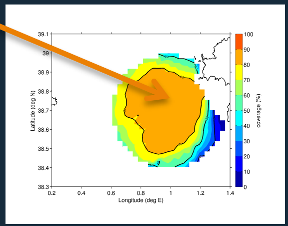


Diurnal

Inertial

Semi-diurnal

- Rotary spectrum: Clock-Wise (CW) and Counter Clock-Wise (CCW) current components
- 2013/10/01 – 2014/12/31
- Spectrum are averaged over the 80% coverage area

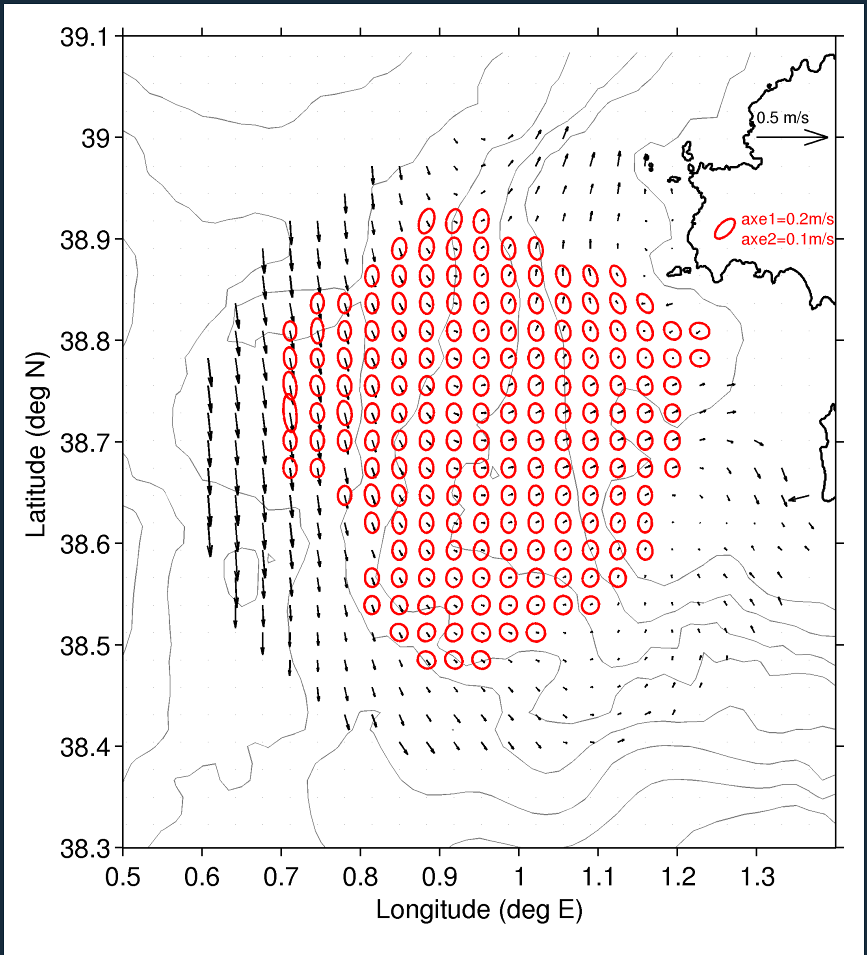


- CW >> CCW (Coriolis effect)
- Diurnal: S1 (24h), Meteorological (Wind breezes induced surface currents)
- Near-inertial oscillations
- Semi-diurnal: M2 (12.4h), Astronomical (Moon)

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

VARIABILITY ELLIPSES



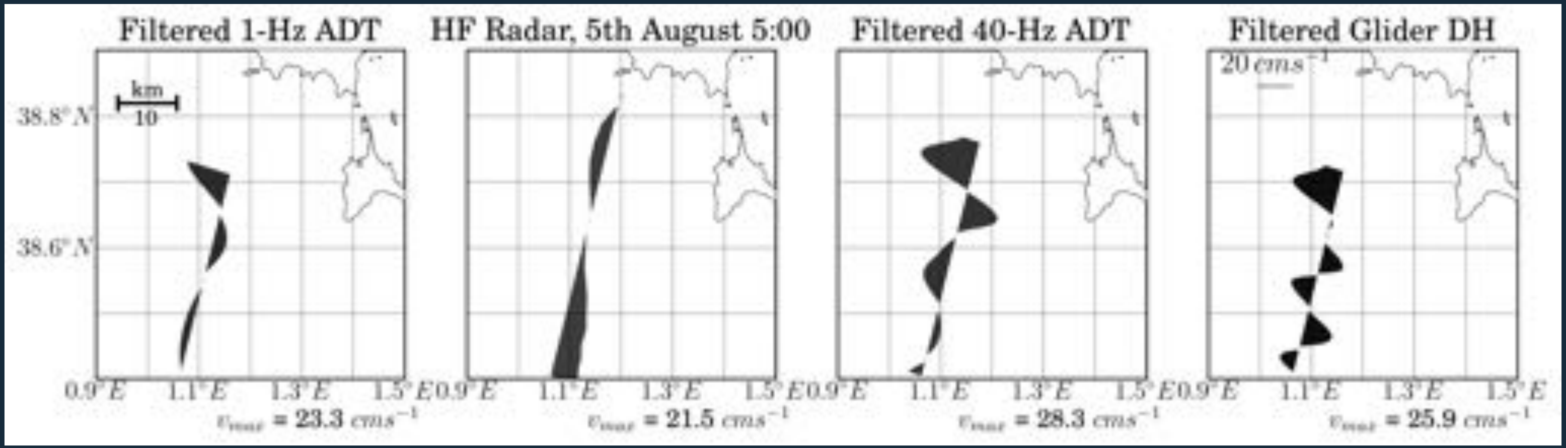
- Variability ellipses
- Determine the two main direction of current variability in each point
- Singular value decomposition of U and V
- Over the 80% coverage area
- 2013/10/01 – 2014/12/31
- Mean current is shown on the whole domain

- Northern Current signature in the Western part of Ibiza Channel
- Standard deviation in the range 10 - 20cm/s
- In general, no dominant variability direction (ellipses ≈ circles)
- Ibiza Channel = complex circulation

VARIABILITY STUDIES

CHARACTERIZATION OF THE IBIZA CHANNEL OCEANIC CIRCULATION USING HF RADAR

MULTI-PLATFORM EXPERIMENT: HF RADAR VS ALTIKA VS GLIDER



- Radar velocity closest to coast
- Northwestward current: approx. 20 cm/s
- Shown by three platforms

Troupin et al. (2015), Illustration of the emerging capabilities of SARAL/AltiKa in the coastal zone using a multi-platform approach, Advances in Space Research. doi: doi:10.1016/j.asr.2014.09.011

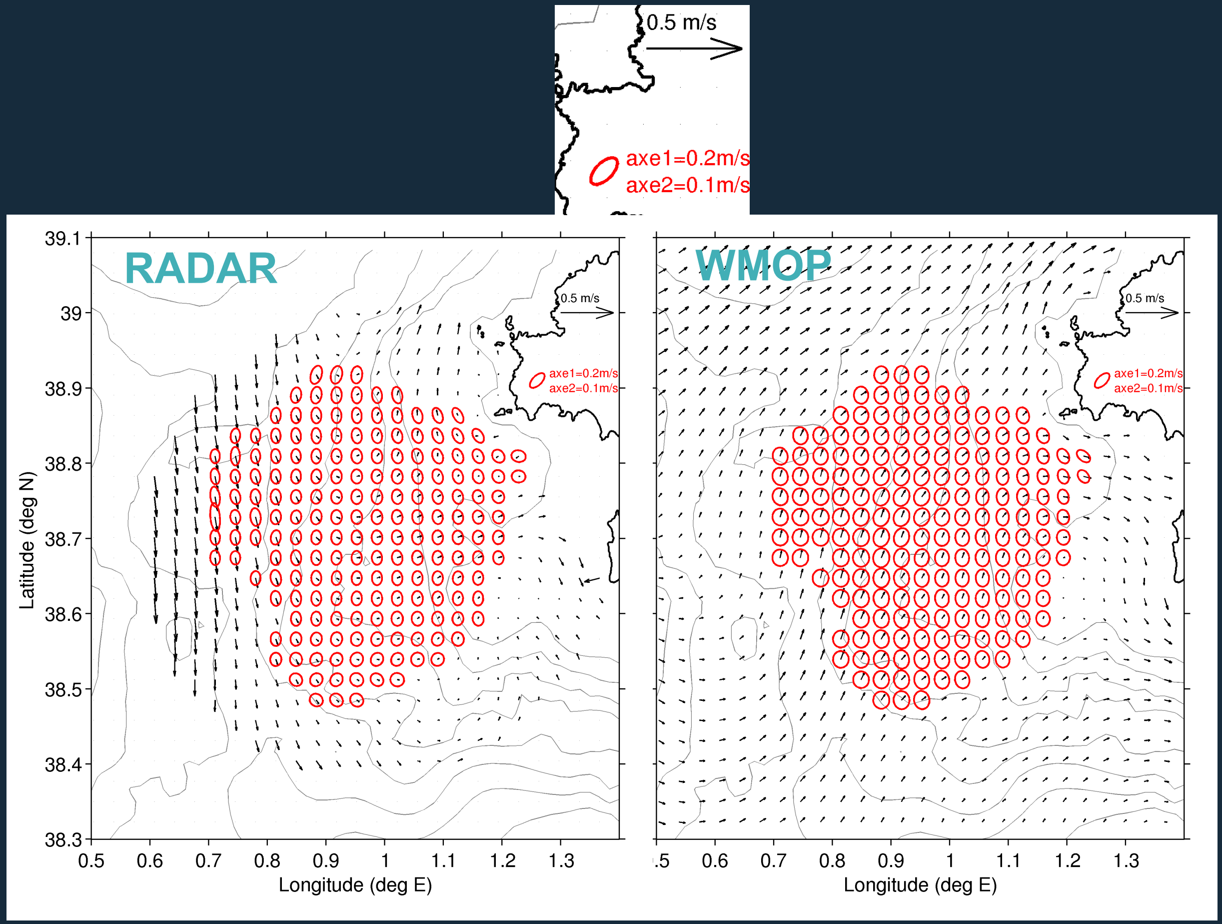
MODEL VALIDATION

WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS

VARIABILITY ELLIPSES

- Variability ellipses
- Determine the two main direction of current variability in each point
- Singular value decomposition of U and V
- Over the 80% coverage area
- 2013/10/01 – 2014/12/31
- Mean current is shown on the whole domain

- Mean currents are different
- Same direction of variability
- Higher variability for WMOP
- WMOP is more energetic (KE and EKE not shown)

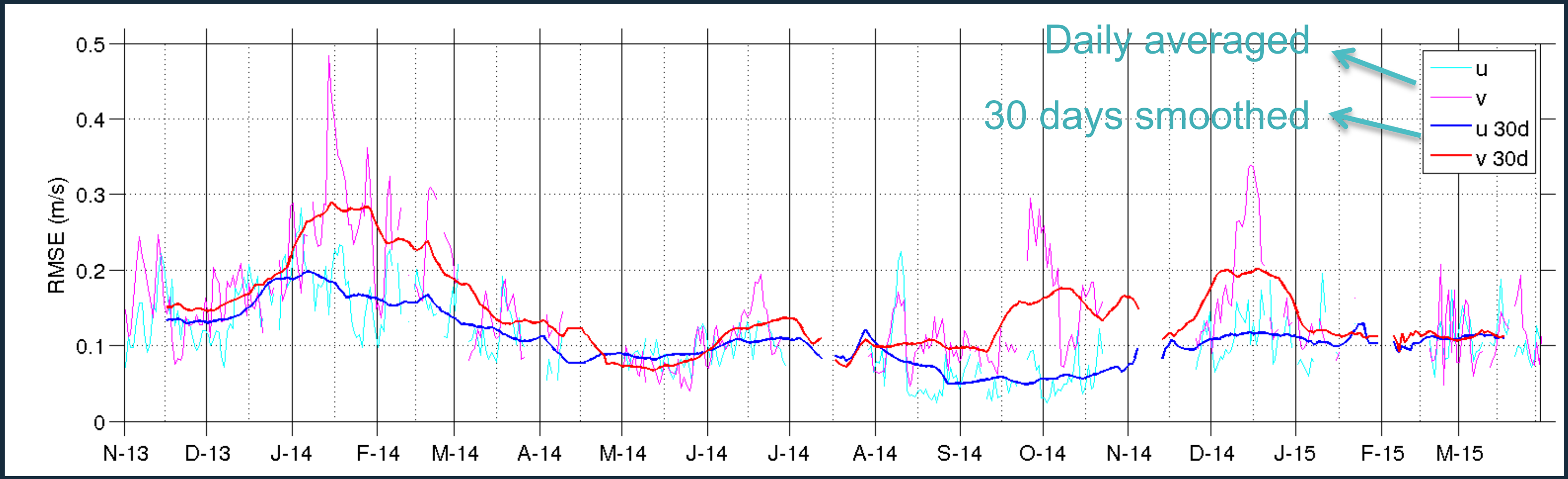


MODEL VALIDATION

WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS

STATISTIC COMPARISON

In Ibiza channel



- Root Mean Square Error (RMSE) between HF radar and WMOP velocities
- Comparison of U and V daily averaged

- In general RMSE are higher for V-component
- Seasonal variability appears, with higher RMSE in wintertime and lower RMSE in summertime.
- Related to the surface current seasonal variability (higher in winter, lower in summer)

SOCIB

SOCIB