

# living planet symposium | BONN

23–27 May  
2022

TAKING THE PULSE  
OF OUR PLANET FROM SPACE



## Towards reliable ocean surface current retrievals from the Sentinel-1 Doppler shift in the coastal zone

Artem Moiseev (NERSC), Johnny A. Johannessen (NERSC), Harald Johnsen (NORCE),  
Fabrice Collard (ODL), Bertrand Chapron (Ifremer)

26.05.2022

- Reliable observations of the ocean surface current to support emergency marine operations, energy sector, and climate research.
- Existing ocean observing system do not always provide systematic observations with required resolution and/or coverage
- SAR Doppler shift provides high-resolution all-weather day and night measurements of the surface current radial velocity.



Doppler Centroid Anomaly (DCA)

Geophysical DCA

$$f_{dca} = f_{dc} - f_{geom} \rightarrow \begin{cases} f_{dca} = 0 & \text{over land} \\ f_{dca} \neq 0 & \text{over ocean} \end{cases} \rightarrow f_{dca} = f_{ss} + f_{osc}$$

sea state      surface current

- Geophysical DCA is a measure of the total surface motion induced by the sea state and surface current in the SAR line-of-sight direction
- **Global goal:** Explore the geophysical DCA and retrieve ocean surface current radial velocity

$$f_{dca} = \underbrace{(f_{ss} + f_{osc})}_{\text{Geophysical}} + \underbrace{f_{elec} + f_{att} + f_{sca} + \Delta f}_{\text{Non-geophysical}}$$

$f_{elec}$  ↑ Electronic miss-pointing     $f_{att}$  ↑ Platform attitude     $f_{sca}$  ↑ Antenna motion     $\Delta f$  ↑ Some others?

- Challenge #1: Remove all non-geophysical contributions and derive reliable geophysical
- Challenge #2: Accurately estimate and remove the sea state induced signal
- Challenge #3: Validation

**Original idea:** Use an empirical GMF to predict the wind-wave-induced Doppler shift for the given wind field and radar configuration:

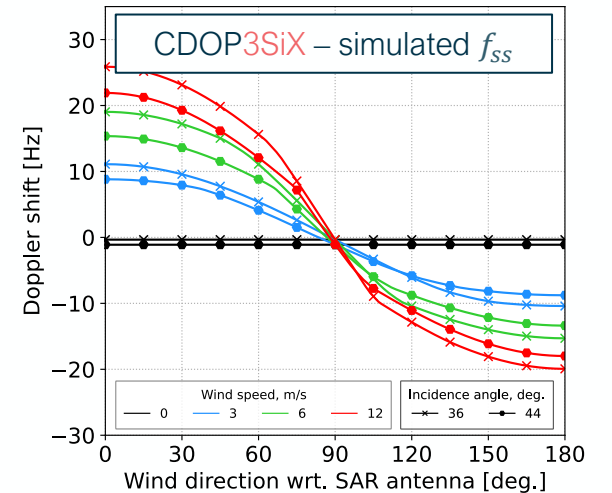
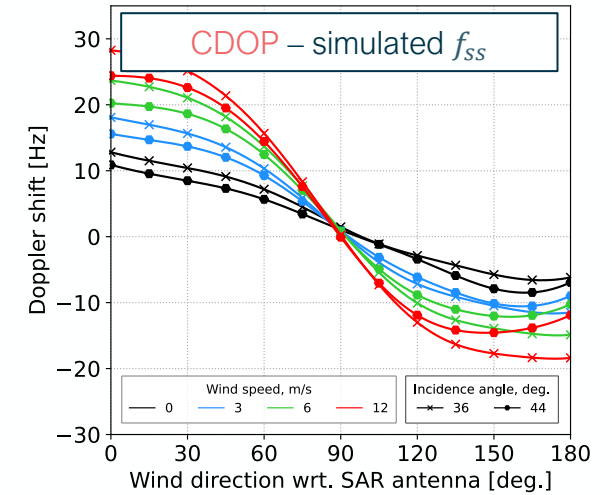
$$f_{ss} \approx f_{ww} = \text{CDOP}(u_{10}, \phi, \theta, p) \quad \text{Mouche et al. 2012}$$

Wind model (ECMWF)

**New idea:** Add range directed the wind sea ( $x_{ws}$ ) and swell ( $x_{sw}$ ) orbital velocity to provide more realistic representation of the sea state:

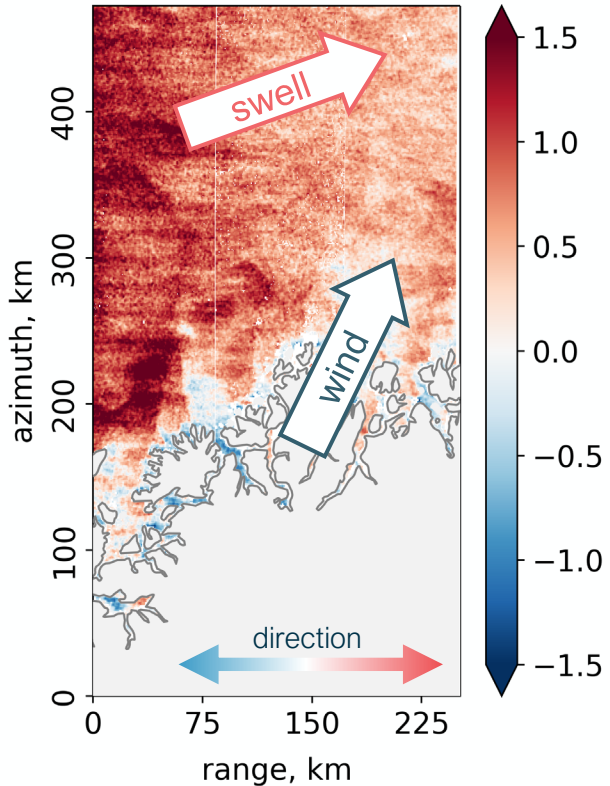
$$f_{ss} = \text{CDOP3SiX}(x_{10}, x_{ws}, x_{sw}, \theta, p) \quad \text{Moiseev et al. 2022}$$

Wave model

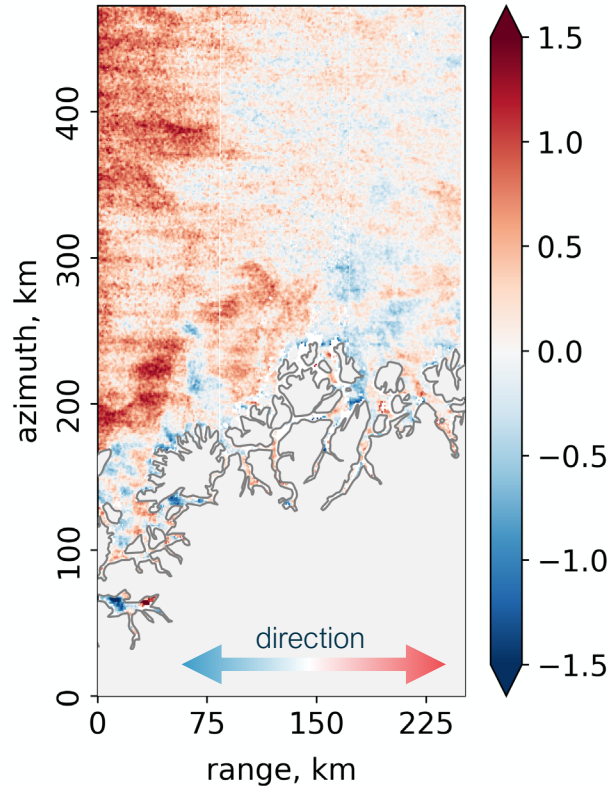


# Sentinel-1B IW VV scene from 15 January 2018

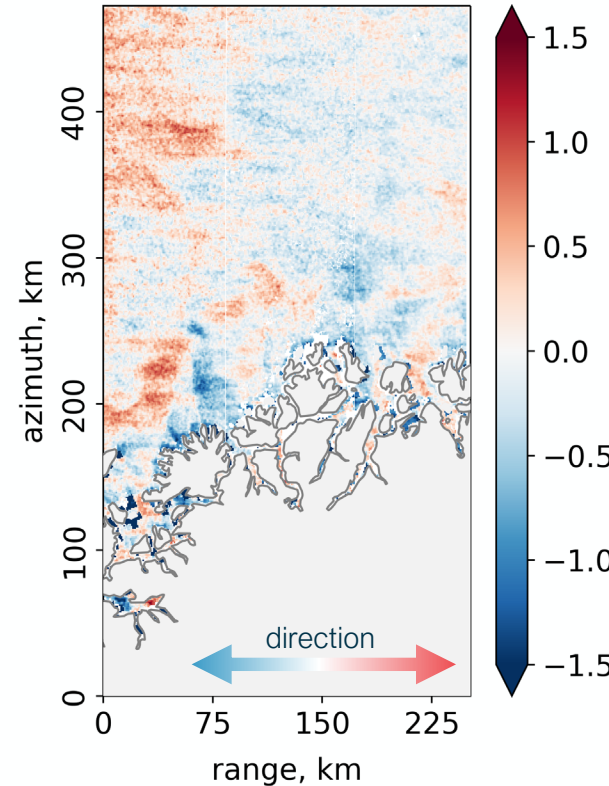
Total Surface Motion  
(sea state + current)



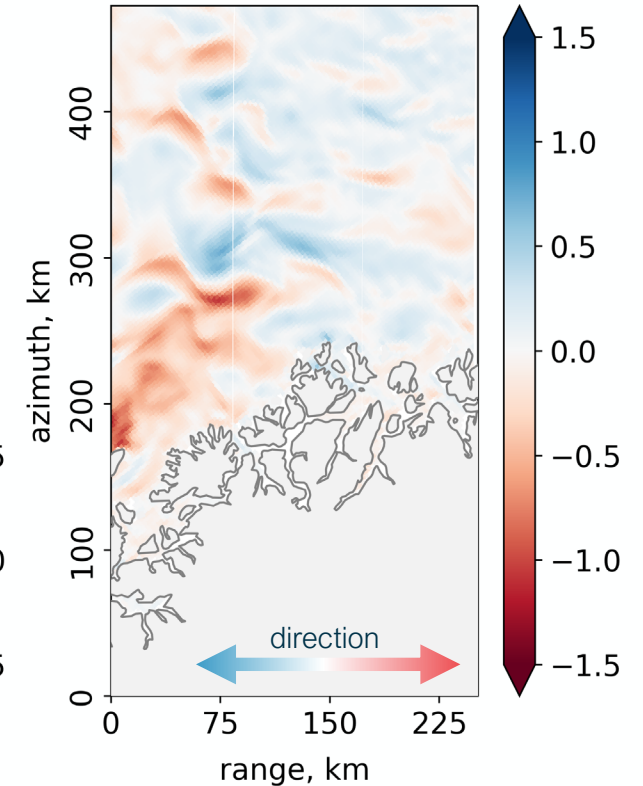
Surface Current - old  
(total - CDOP)



Surface Current - new  
(total - CDOP3SiX)



Surface Current - model  
(ROMS NorShelf)



Northern Norway



# Sentinel-1 IW A/B OSC RVL product



- **ESA World Ocean Circulation Project:** Sentinel-1A/B IW OSC RVL product (1 year - Agulhas)

The screenshot shows the 'World Ocean Circulation' website interface. At the top, there is a navigation bar with links for 'About', 'Engaged Users', 'Products', 'Visualization', 'Ocean Book', 'Documentation', 'News', and 'Contact'. The main content area is divided into several sections:

- Version:** 2.0
- Status:** Completed
- Product ID:** WOC-L2P-CUREUL-S1A-OSC\_RVL
- Product Description:** This dataset contains calibrated Sentinel-1 IW SAR Doppler frequency shift and waves bias estimates required for retrieving ocean surface current radial velocity, combined with wind from ECMWF and Stokes drift from the WW3 in the south-west Indian ocean (Agulhas current).
- Data Availability:** The data are available through HTTP and FTP; access to the data is free and open. In order to be informed about changes and to help us keep track of data usage, we encourage users to register at: <https://forms.ifremer.fr/lops-siam/access-to-esa-world-ocean-circulation-project-data/>
- Temporal Properties:** Sentinel-1 A / C-band SAR, Sentinel-1 B / C-band SAR
- Spatial Properties:** Geographic area Agulhas, Resolution 1 km, Projection WGS 84 (EPSG:4326), Bounding box Latitude -43.00 to -28.00, Longitude 12.00 to 32.00
- Access and Policy:** Access policy Unrestricted, Usage policy CC-BY (Creative Commons - Attribution), Format(s) NetCDF 4

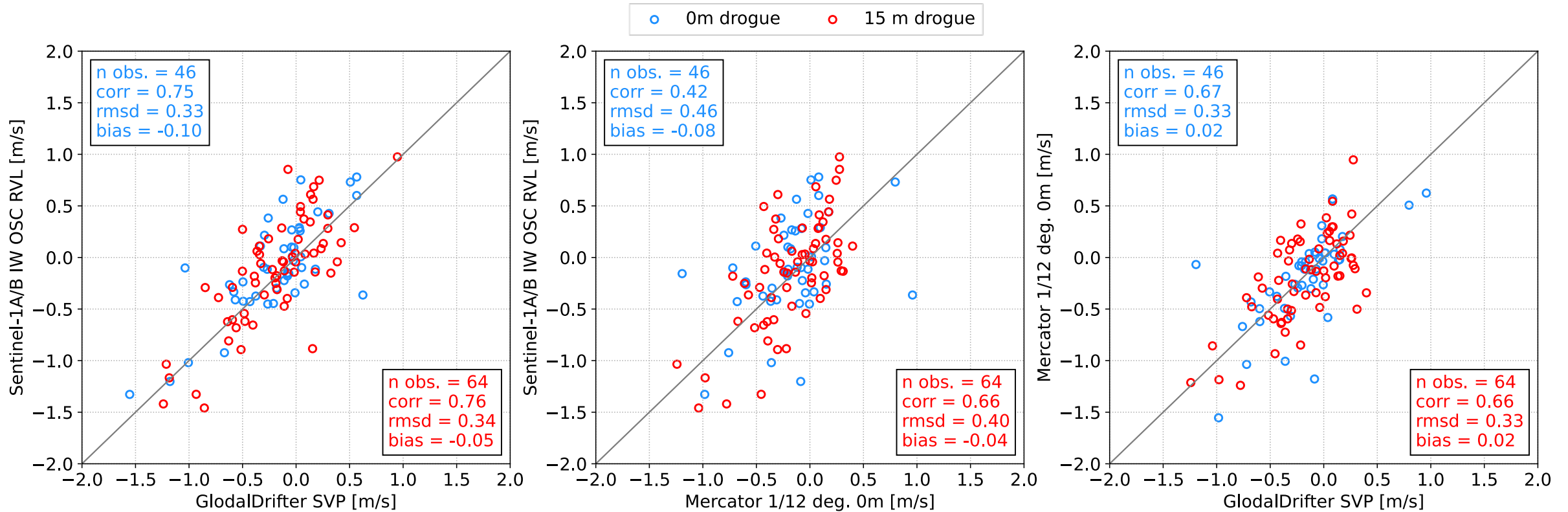
At the bottom of the page, there are links for 'Site map', 'Accessibility', and 'Legal notice / Credits'. A large URL is displayed in a box at the bottom right: <https://www.worldoceancirculation.org>







# Comparison between Sentinel-1, drifter, and model



New algorithm for estimating sea state induced Doppler



- Improved accuracy of surface current retrievals
- Relevant for other missions
- Simulation studies
- SAR-derived sea state?

Sentinel-1 derived RVLs are consistent with independent data



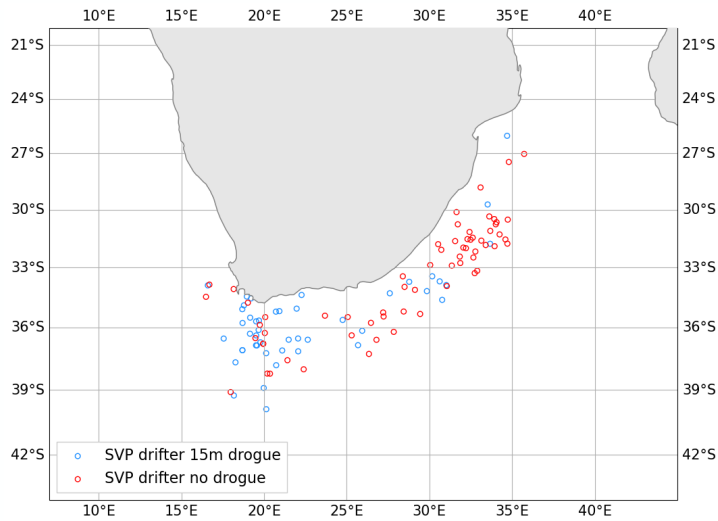
- Framework for systematic collocation and validation
- Compared with altimetry, drifters, SST, models, etc.
- Large amount of data
- Validation campaign?

SAR-derived surface currents for monitoring and marine operations



- Emergency response
- Operational oceanography and Climate
- Data assimilation?
- Reprocessing of Sentinel-1 archive?





$$\rightarrow u_{rvl} = - \frac{\pi f_{dca}}{k \sin(\theta)}$$

Ocean Surface Radial Velocity

Sentinel-1B IW VV ascending pass on 15 January 2018 at 16:06

