SUMOS : A field campaign in support of the validation of CFOSAT observations

Daniele Hauser [1] , Peter Sutherland [2], Louis Marie[2], Raquel Rodriguez Suquet[3], Christophe Le Gac [1], Nicolas Pauwels [1], Laurent Lapauw[1], Eva Le Merle[1], Christophe Dufour[1] , Patricia Schippers[4], Gilles Guitton[5], Frederic Nouguier[2], Marie-Noëlle Bouin[6] , Ruben Carrasco[7], Laura Hermozo[3]

1 : LATMOS, (CNRS, Université de Versailles Saint-Quentin-en-Yvelines, Sorbonne Université)

2 : LOPS (Ifremer, CNRS Université de Bretagne Occidentale)

3 : CNES

4 : ACRI-ST

5 : OceanDataLab

6 : Meteo France

7: Helmholtz-Zentrum Geesthacht (Germany)

❖ Objectives of SUMOS

- ✓ Gather comprehensive set of collocated observations on wind, waves and related parameters (in situ, remotely sensed)
- ✓ Contribute to continuous improvement of the SWIM data inversion, identify limitations
- ✓ Study wave hydrodynamics and wind/wave/fluxes relationships in condition of high sea-state
- ✓ Prepare SKIM-like missions (surface current and waves)

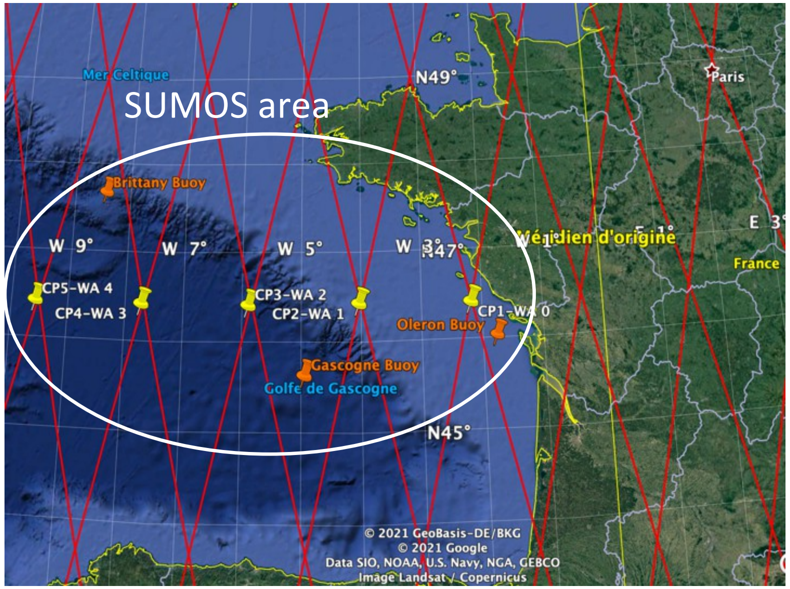
❖ Strategy and deployements

- ✓ Gulf of Biscay (off the French Atlantic coasts) 9 February 2021 - 4 March 2021
- ✓ Duration and area encompassing several CFOSAT passes
- ✓ Research vessel for shipborne measurements and drifting buoy deployments (waves, wind, turbulent fluxes, current)
- ✓ Research airplane with airborne radar measurements

Research vessel l'Atalante
(Ifremer, CNRS, IRD)

Cruise:
9 February-10 March 2021

CFOSAT nadir tracks
over 13 days



Research aircraft ATR42
(Meteo-France, CNRS, CNES)

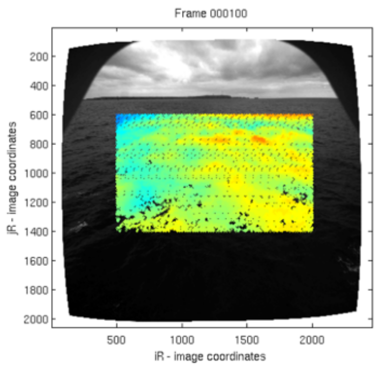
Flights from Quimper airport:
15 February, 4 March

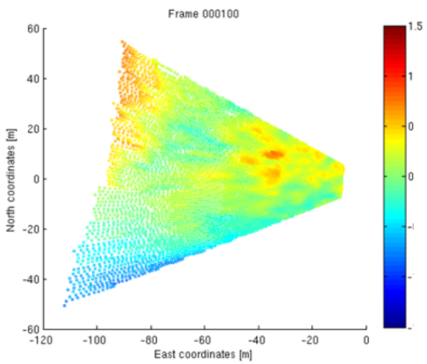
❖ Instrumentation and measurements

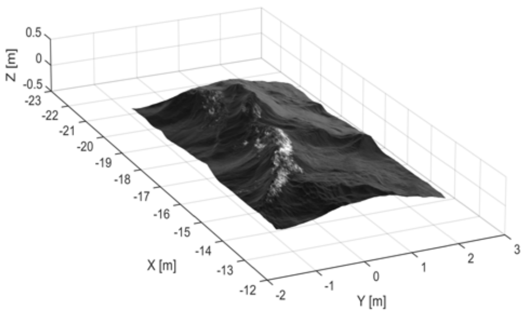
Shipboard instrumentation
PI = Peter Sutherland, LOPS

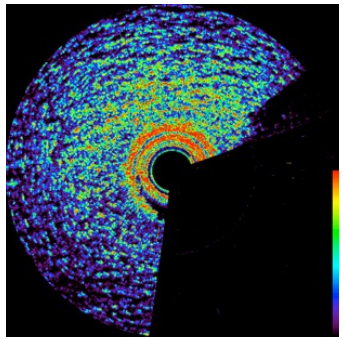
Video measurements: Stereo-video system, polarimetric imagery, and wide FOV camera.
=>Short waves properties (1cm-5m), wave breaking

X-band radar
=> Long-wave directional spectra
(in wavenumber and frequency), current





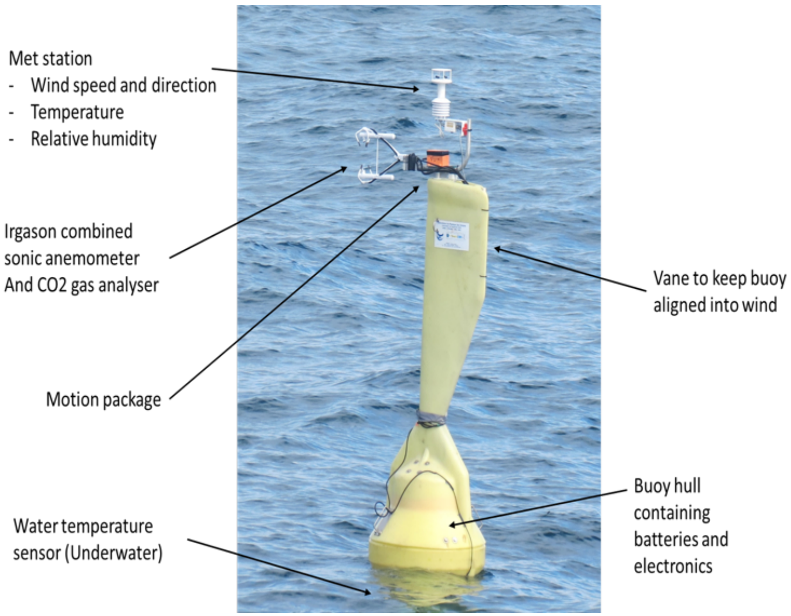


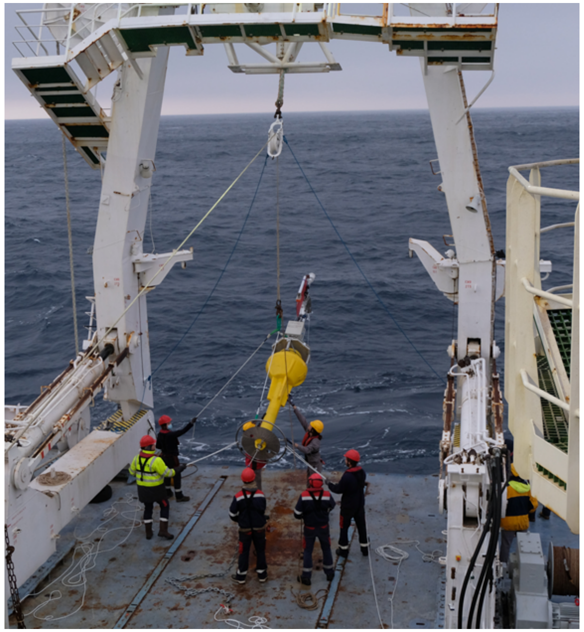


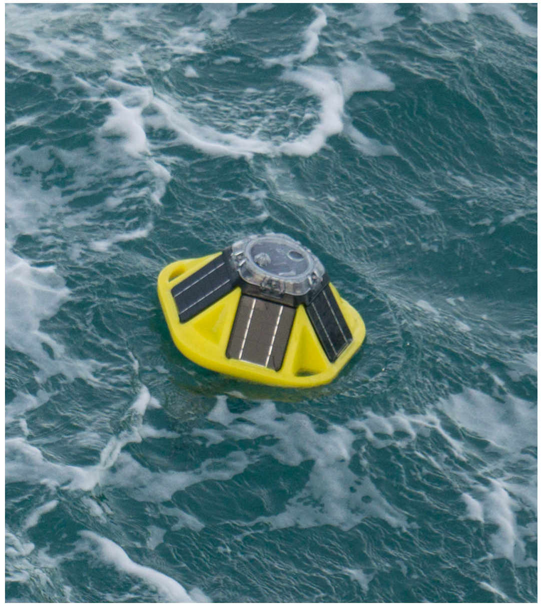
Instrumentation deployed by the R/V L'Atalante near CFOSAT crossover points
PI = Peter Sutherland, LOPS

FLAME buoy (full and Lite version)
instrumented platform
=> wind, turbulent fluxes, waves

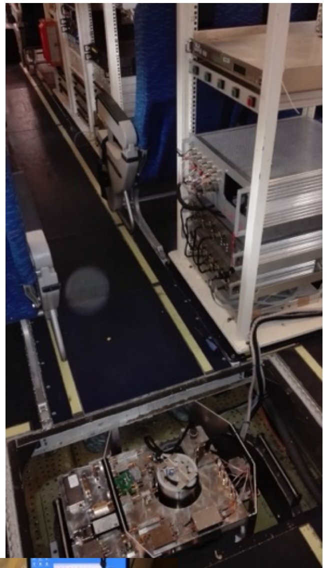
Spotter drifting buoy (from Spoondrift)
directional wave rider
=> Directional wave spectrum

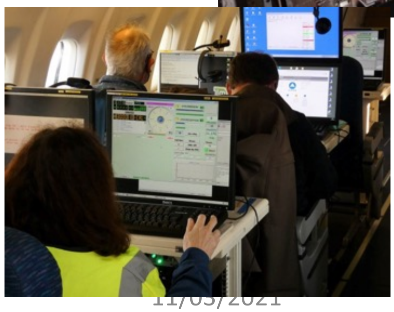






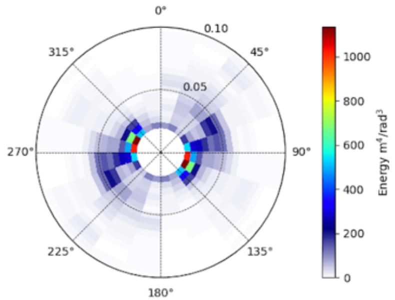
Airborne observations: KuROS radar (Ku Band)
PI: D. Hauser, LATMOS

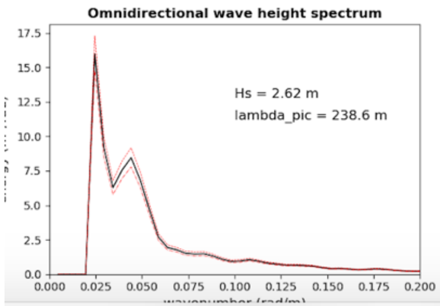




=> Directional spectra of long waves (30-300m) and normalized radar cross-section along the flight track and along and across- SWIM swath

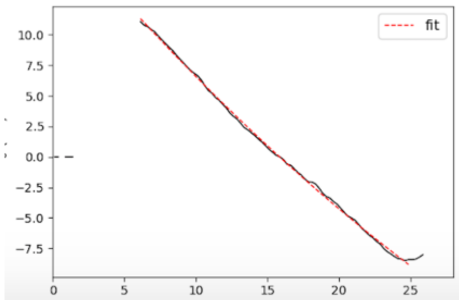
KuROS wave spectrum
(2D and omni-directionnal)

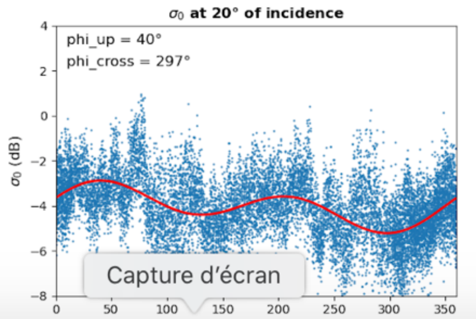




Example from
16 February 2021- 17:03-19:38 UTC

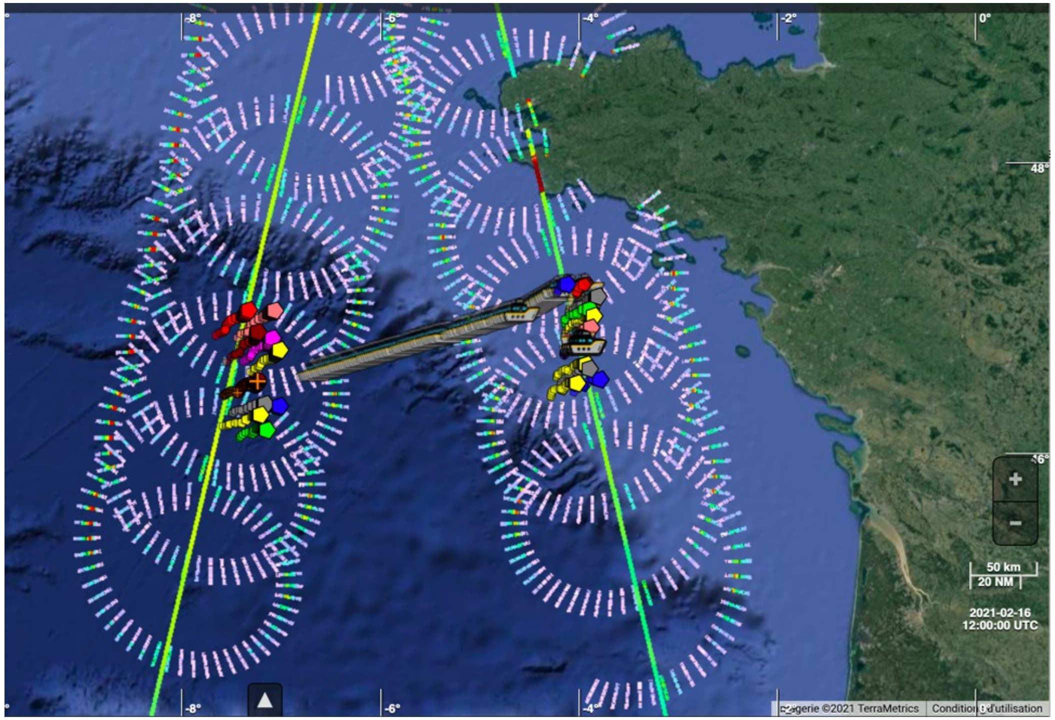
Kuros normalized radar-cross-section



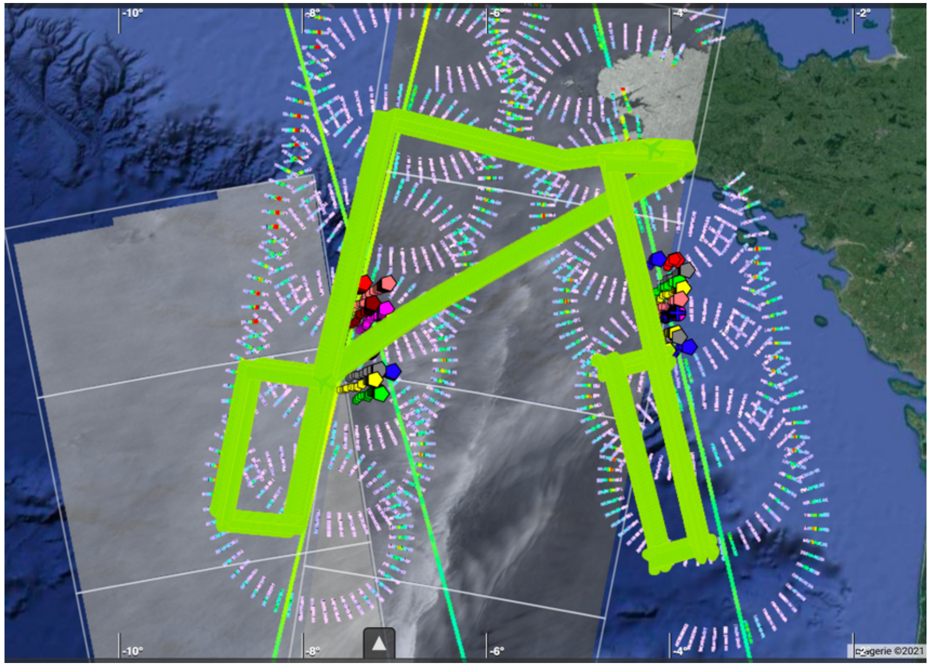


❖ Example of coordinated sampling :
on 16 February 2021 (2 CFOSAT passes at ~08 and ~19 UTC)

CFOSAT nadir, CFOSAT 10°
With RV L'atalante (grey) and drifting wave buoys (diamonds)



Same, with in addition
aircraft ATR42 (green),
Sentinel1-SAR (grey), Sentinel 3A altimeter track



Date (2021)	CFOSAT pass, crossing point, time (UTC)	Coordinated Kuros radar acquisitions (UTC)	Coordinated shipborne acquisitions	Coordinated drifting Buoy acquisitions	Meteo and wave conditions
15 february	Ascending, CP4, 19:10	17:15-20:00	CP4: X-band radar.	Network of 9 + Flame	High wind sea and swell from west (total Hs ~4-5 m)
16 February	Descending CP4, 08:15 Ascending CP2, 18:55	07:50-10:30 17-15-19:25	CP4: X-band radar, stereo, wide FOV, polarimetric.	Network of 9 + Flame Network of 10 + Flame	High Wind sea and swell from west (total Hs ~4-5 m)
17 February	Descending CP2, 08:00	07:30-09:38	CP2: X-band radar, stereo, wide FOV, polarimetric.	Network of 8 + Flame	High swell from west (3-4m)
21 February	Ascending CP5, 19:15	17:06-19:50	-	Network of 8 + Flame (but about 230 km away from CP5)	High swell from west (3-4m)
22 February	Descending CP5, 08:20 Ascending CP3, 19:00	07:11-10:15 NO	CP3: X-band radar.	NO Network of 9 + Flame + FLAMElite	Swell from W and windsea from NW
23 February	Descending CP3, 08:00 Ascending CP1, 18:45	07:30-09:45 17:15-19:15	CP3: X-band radar, stereo, wide FOV, polarimetric.	Network of 9 + Flame + FLAMElite Network of 5	Swell from W attenuating (~2m), wind sea from S-SW
24 February	Descending CP1, 07:50	07:10-09:00	CP1: X-band radar, stereo, wide FOV, polarimetric.	Network of 5 + FLAMElite	Swell from W attenuating (~2m), wind sea from ~S-SW

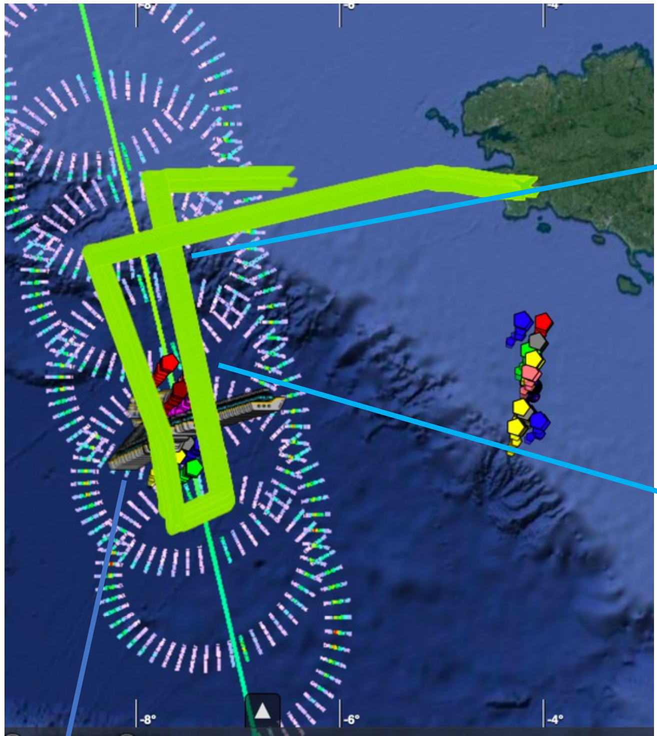
Date (2021)	CFOSAT pass, crossing point, time (UTC)	Coordinated Kuros radar acquisitions (UTC)	Coordinated shipborne acquisitions	Coordinated drifting Buoy acquisitions	Meteo and wave conditions
28 February	Ascending, CP4, 19:10	17:05-19:10	CP4: X-band radar.	Network of 10 + Flame + FLAMElite	Wind from east and remaining swell from West (total 2-3m)
1 March	Descending CP4 , 08:10 Ascending CP2, 18:55	07:10-09:50 17:10-19:20	CP4: X-band radar, stereo, wide FOV, polarimetric.	Network of 10 + Flame Network of 9 (some out of the SWIM swath) + Flame	Similar to 28 Feb
2 March	Descending CP2, 08:00	07:25-09:30	CP2: X-band radar, stereo, wide FOV, polarimetric.	Network of 9 (some out of the SWIM swath) + Flame + FLAMElite	Similar with swell attenuated, Hs < 2m
6 March	Ascending CP5	NO (end of ATR campaign)	CP5: X-band radar.	Network of 4, drifters near SWM track + FLAME + FLAMElite	
7 March	Descending CP5 Ascending CP3	NO (end of ATR campaign)	CP5: X-band radar, stereo, wide FOV, polarimetric.	Network of 4, drifters near SWM track + FLAME + FLAMElite	
8 March	Descending CP3 Ascending CP1	NO (end of ATR campaign) NO (end of ATR campaign)	NO end of campaign		

❖ Campaigned finished about one week ago but already example of comparisons

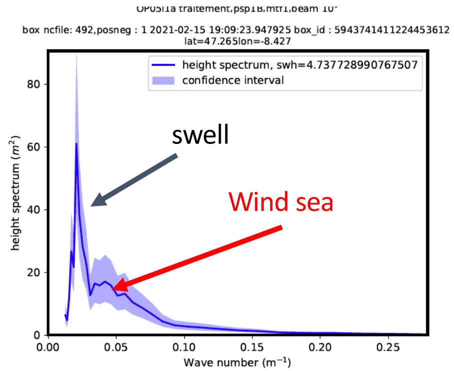
- SWIM/buoy/model/KuROS

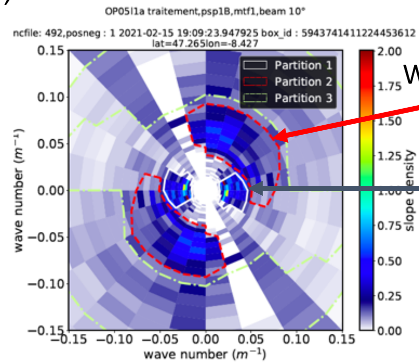
- SWIM/Marine radar/buoy

Exemple: 15 February 2021, evening: high swell from W and wind sea from SW, total SWH ~4 to 5 m



CFOSAT/SWIM

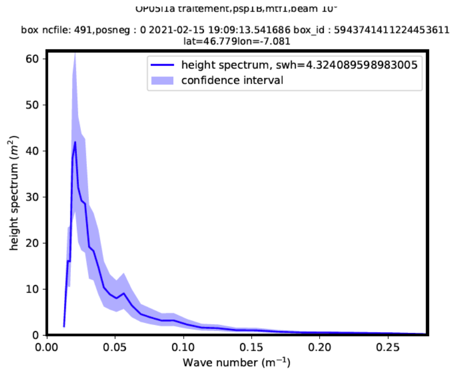


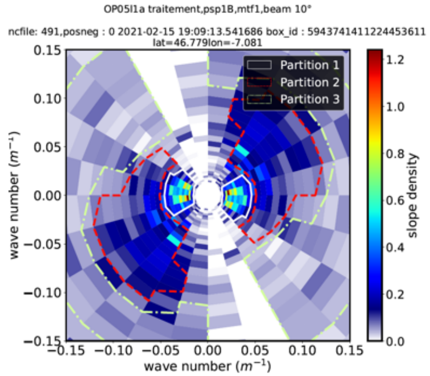


Wind sea

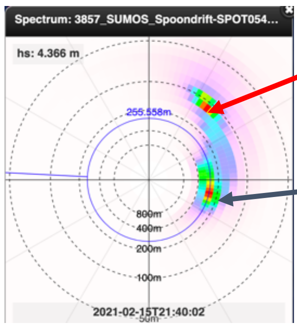
swell

CFOSAT/SWIM





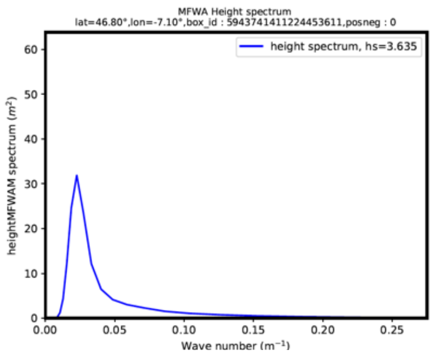
Spotter buy 0541
21 Feb 2021
21:40
46.19N , -7.58W,

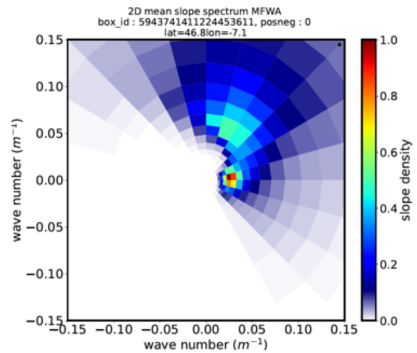


Wind sea

swell

Model MFWAM
(Météo-France)





Examples: 22 and 28 February 2021:

Comparison of 1D height spectra from

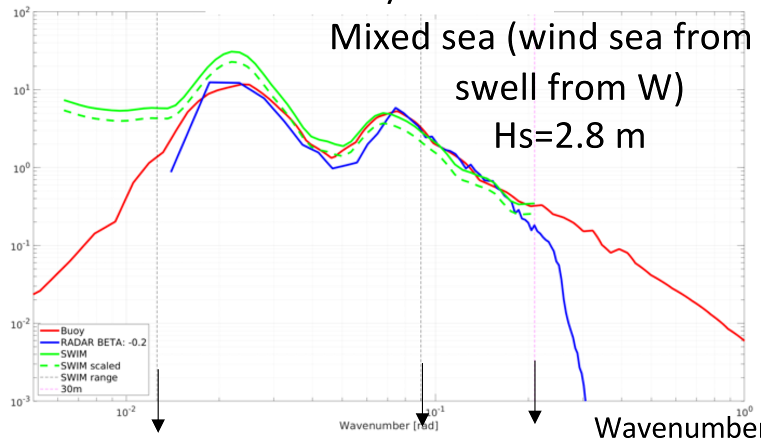
SWIM (green solid line)

Buoy (red line)

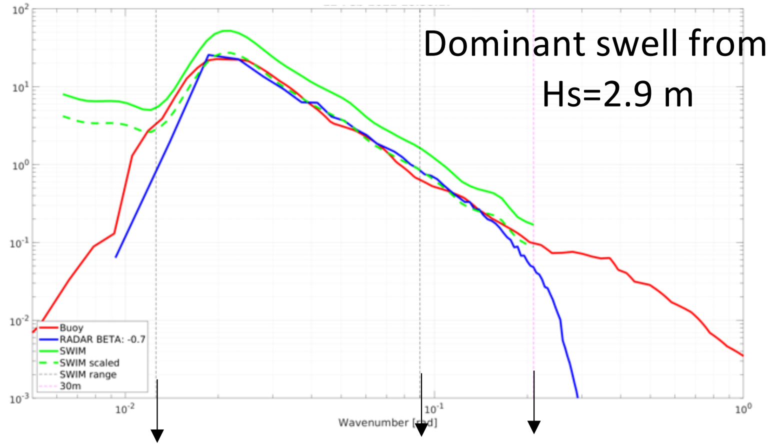
X-band marine radar (blue)

The dashed green line is the SWIM spectrum rescaled with Hs buoy as reference

28 February 19:12:35



22 February 18:58:17



- ✓ Confirms the good performance of SWIM in the 70-500m wavelength range
- ✓ Indicates the possibility to get consistent wave spectrum for SWIM up to 30 m wavelength
- ✓ Small positive bias on energy of SWIM with respect to buoy (in these cases)

Perspectives by combining all sources of data

- Comparison of directional spectra or directional parameter of ocean waves at several points within the SWIM swath. → further characterize the SWIM performance, test evolution of inversion algorithms , analyze the impact of intra-swath variability

- Analyse wave evolution in conditions of mixed sea (opposing swell and wind sea)

- Wind/wave/stress relationship in conditions of high swell or mixed sea (opposing swell and wind sea)

- Wave breaking statistics at least one point within the swath. → Studying the impact of wave breaking on correcting factors used in the SWIM data processing (speckle, Modulation Transfer Function,..).

- Sea surface slope probability density function and mean square slope (cm to m scales) → Assess the possibility of extracting this type of information from the SWIM data (nadir and off-nadir), and study their relation with wave breaking.