The MAEVA project

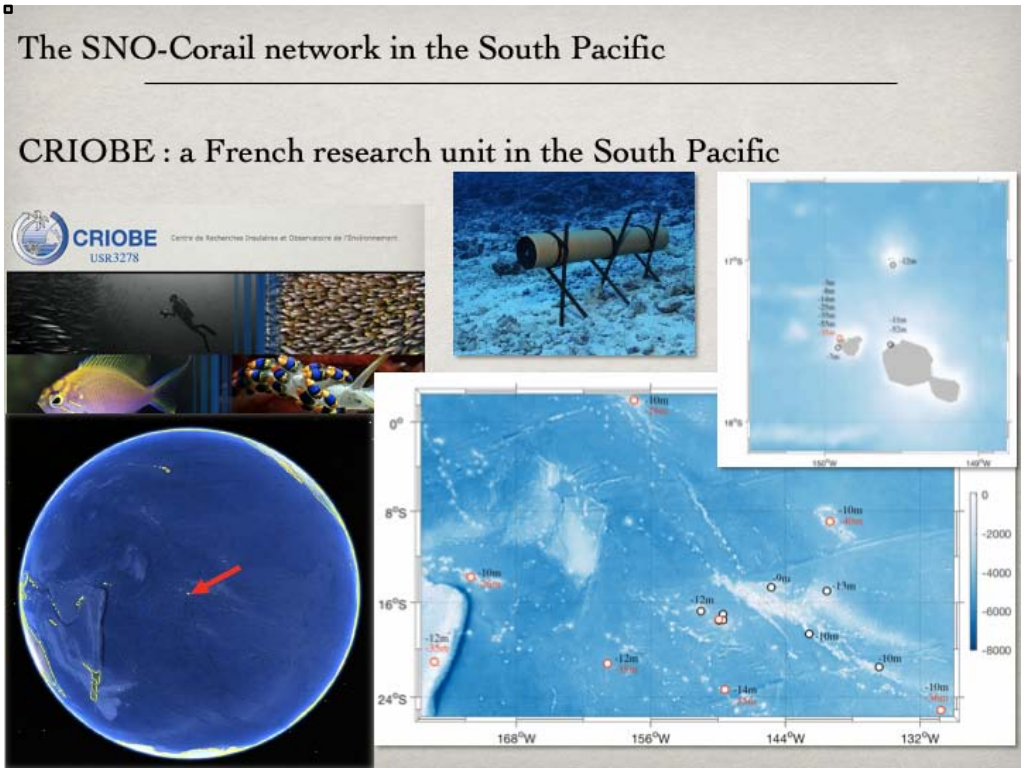
http://maeva.ens.fr

Waves generated by extreme events & their impact on atolls and islands

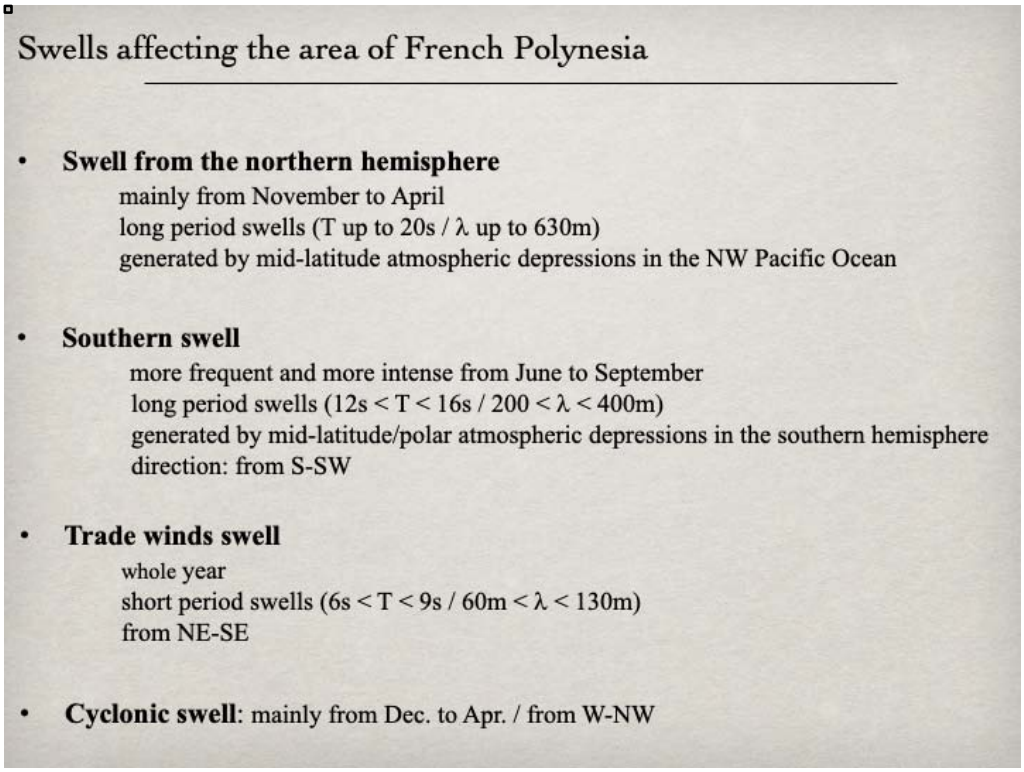
Investigation of the complementarity of SWIM and SAR instruments using *in situ* measurements in the South Pacific Ocean

E. Dormy, L. Oruba, D. Hauser

CFOSAT Meeting
March 2021



The Maeva project involves several French institutes. Among them, the CRIOBE is a French research unit in the south Pacific, which is interested in ecology, coral ecosystems and fishes. It is located in French Polynesia, in the middle of the South Pacific Ocean, with complex wave systems. Jointly with CRIOBE, we installed probes to measure the temporal variation of pressure, at fixed depth. Thanks to these pressure measurements, we can reconstruct the surface waves height as a function of time. These probes are located on the external slope of the coral reefs, between 10 and 30 meters depth.



French Polynesia is affected by numerous swell episodes generated by atmospheric depressions, which have developed at higher latitudes in both the northern and the southern Pacific, and by trade winds.

The CAL-VAL contribution from MAEVA

New Observations From the SWIM Radar On-Board CFOSAT: Instrument Validation and Ocean Wave Measurement Assessment

Danièle Hauser, *Member, IEEE*, Cédric Tourain, Laura Hermozo, D. Aouf, B. Chapron, A. Dalphinet, L. Delaye, M. Dalila, E. Dormy, F. Gouillon, V. Grousani, A. Grouazel, G. Guitton, R. Husson, A. Mouzeo, A. Mouche, A. Ollivier, L. Oruba, F. Pieau, R. Rodriguez Suquet, P. Schippers, C. Tison, and Ngan Tran

—— In situ
SWIM beams:
Nadir
6° 8° 10°

Spring 2019
SWIM L2, V4

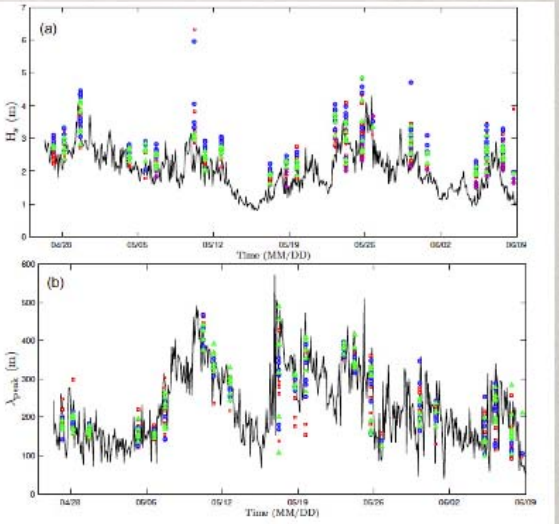


Fig. 23. Time series of (a) Hs in meters and (b) peak wavelength in meters from SWIM and OSSI probe in Moorea (−149.82° E, −17.61° N) between April 28, 2019, and June 9, 2019. The black curve indicates the *in situ* measurements. The CFOSAT nadir measurements are reported in magenta in (a). The CFOSAT 6°, 8°, and 10° beams are reported in red, blue, and green, respectively [(a) and (b)].

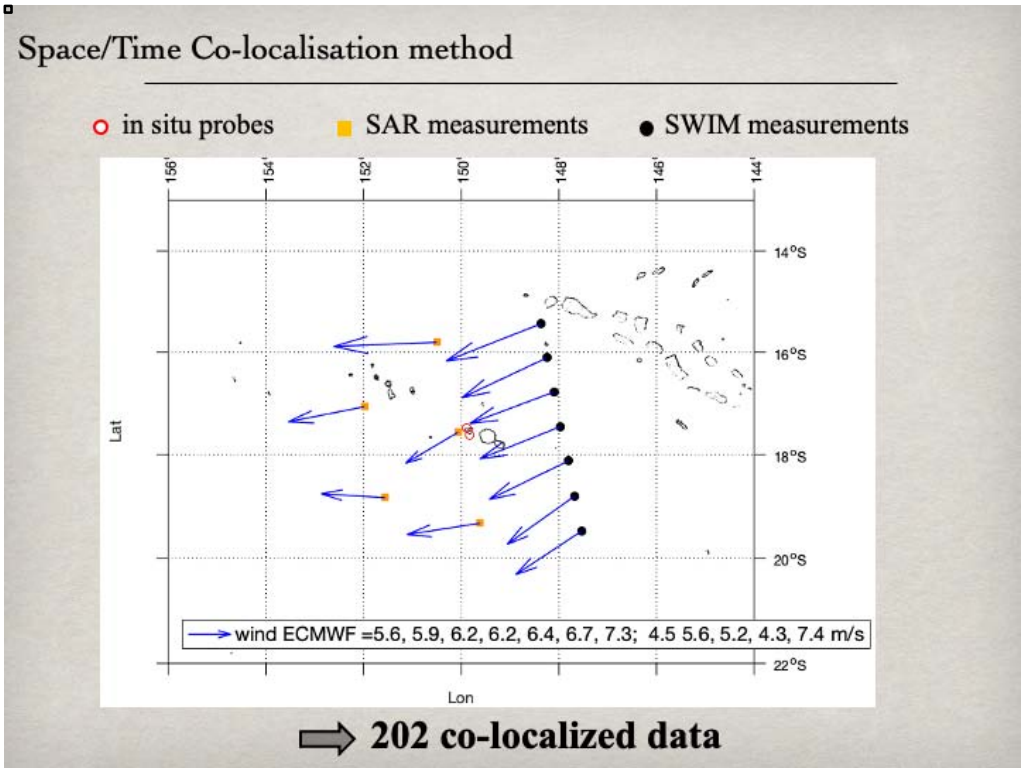
Our probe deployed in Paroa (south of Moorea Island) was used for the cal-val of SWIM.

Database constructed for our investigation

- SWIM 2D spectra (since 26 April 2019): Aviso, 5.1.2
  We use the beams 6°, 8°, 10° and their combination.
- SAR Sentinel 2D spectra (since December 2019)
- 3 OSSI probes providing omni-directional spectra reconstructed from continuous 1Hz pressure recording (since March 2018):

Tiahura -30m
Tiahura -12m

Paroa -30m



Co-localisation in space: we selected the CFOSAT tracks at less than 300km from Moorea island, and the SAR imagettes located less than 5° far from Moorea island.

Co-localisation in time: less than 1h difference

Relevant physical quantities

- Mean parameters, extracted from the 1D (probes) or 2D (satellite) spectra:

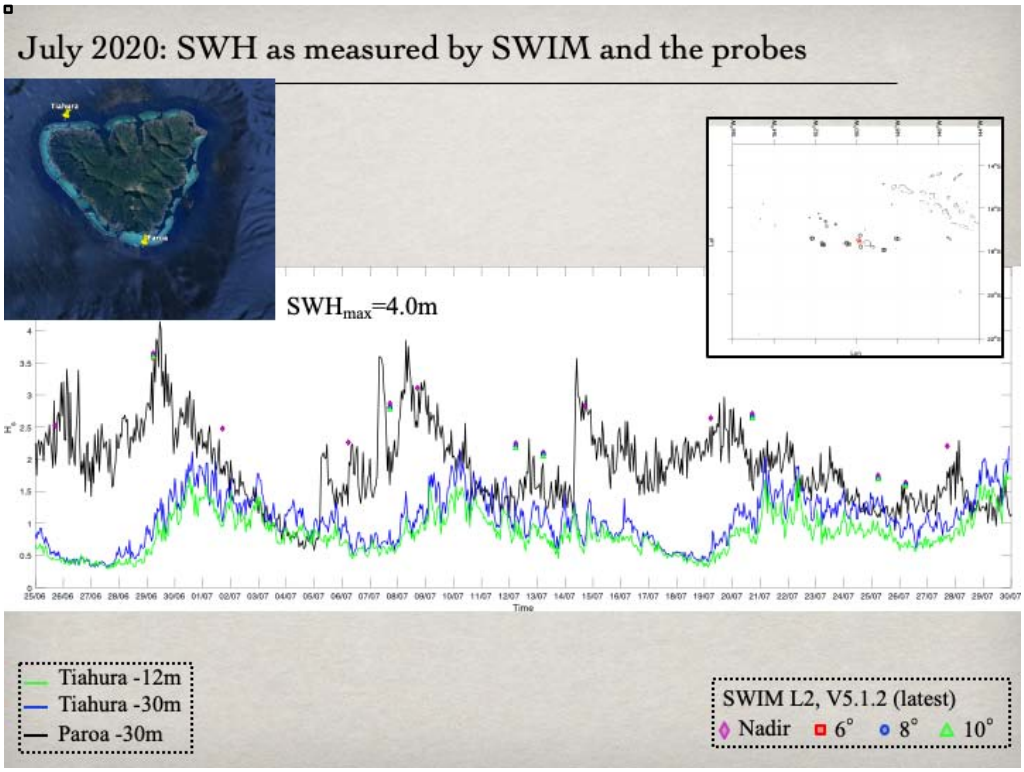
  - Significant Wave Height SWH

  - dominant wave length λ_{peak}

  - dominant direction (2D spectra only) ϕ_{peak}

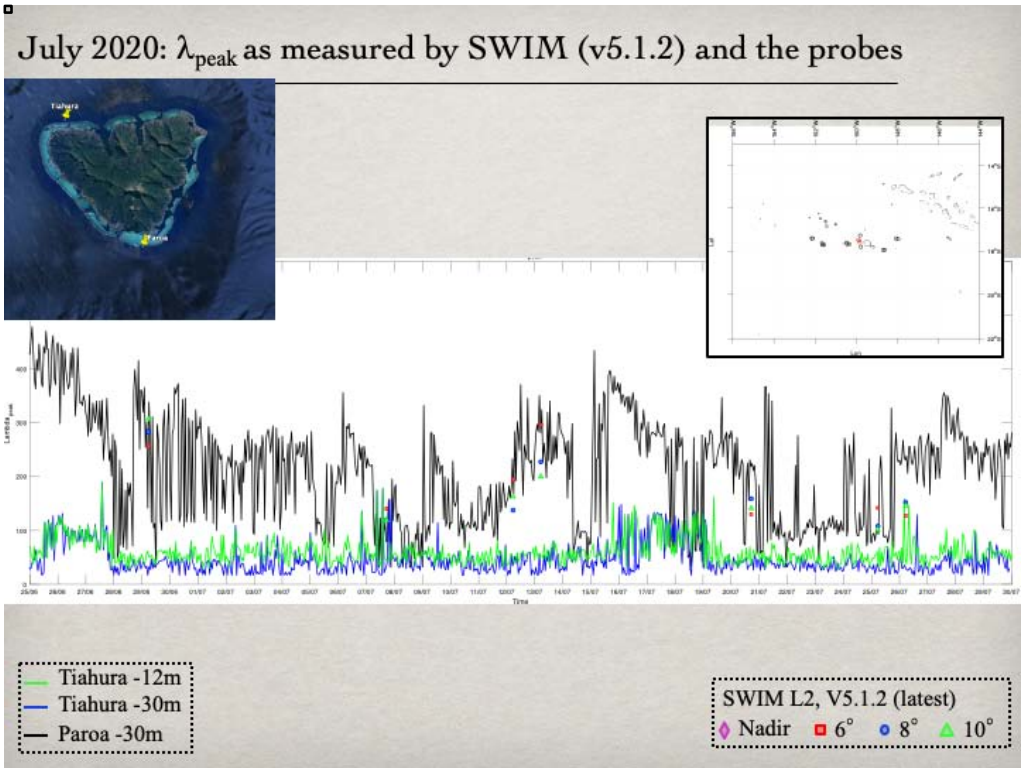
The comparison of the signal measured by the probes (which depends on the waves direction and on the possible masking by neighbouring islands) provides a rough indication of the dominant direction.

- For a finer investigation: comparison of the omni-directional spectra



In the latest version of SWIM data, all the beams (6,8,10°) provide a SWH estimation comparable to the SWH measured by the probes.

Three episodes of southern swell affected Moorea in July 2020; as expected, these swell episodes are not detected by the probes located in Tiahura (north of Moorea island).


July 2020: λpeak as measured by SWIM (v5.1.2) and the probes
Tiahura
Paroa
Tiahura -12m
Tiahura -30m
Paroa -30m
SWIM L2, V5.1.2 (latest)
Nadir
6°
8°
10°

The complementarity of SWIM and SAR instruments

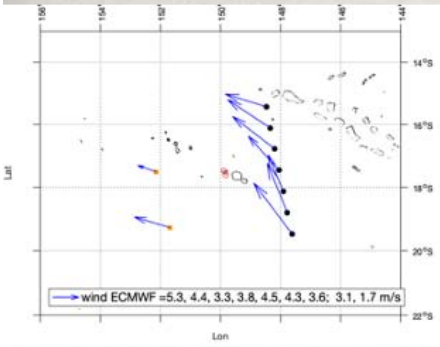
The complementarity of SWIM and SAR instruments

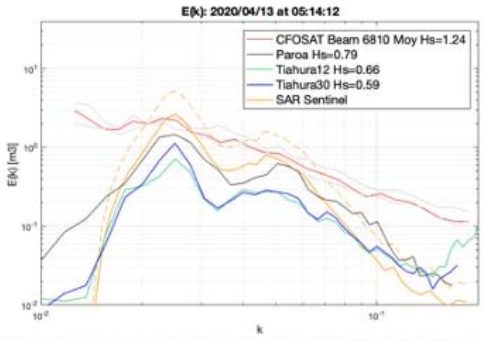
Good performance of SAR for moderate to slight sea state (SWH≤2m)

Good performance of SAR for moderate to slight sea state (SWH≤2m)

Case study: April, 13rd 2020

SWH_{SWIM}≃1.2m

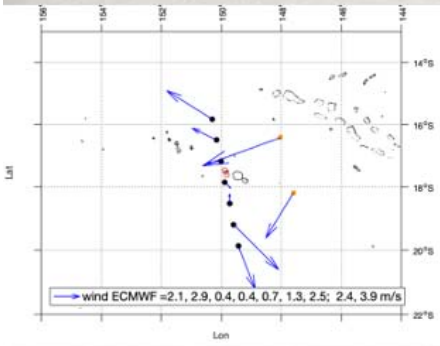


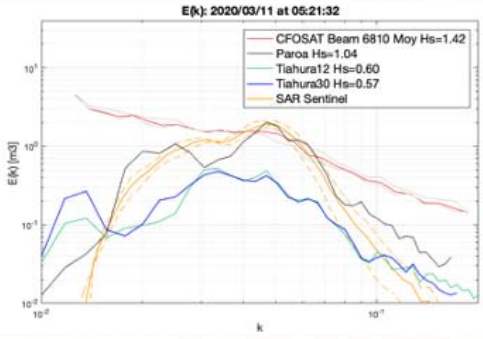


Good performance of SAR for moderate to slight sea state (SWH≤2m)

Case study: March, 11th 2020

SWH_{SWIM}≃1.4m

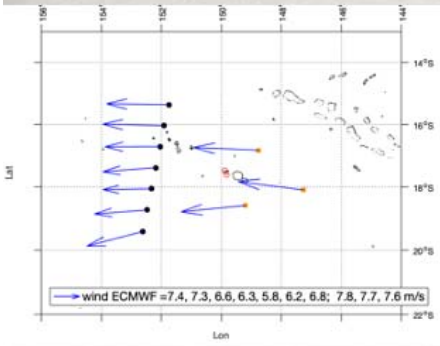


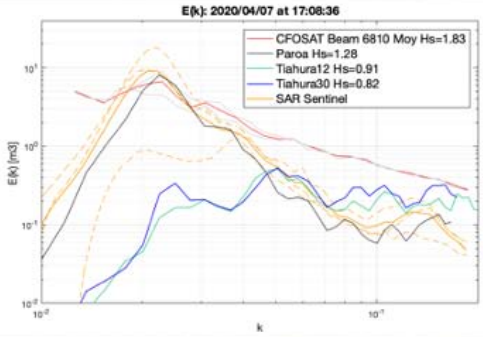


Good performance of SAR for moderate to slight sea state (SWH≤2m)

Case study: April, 7th 2020

SWH_{SWIM}≃1.8m

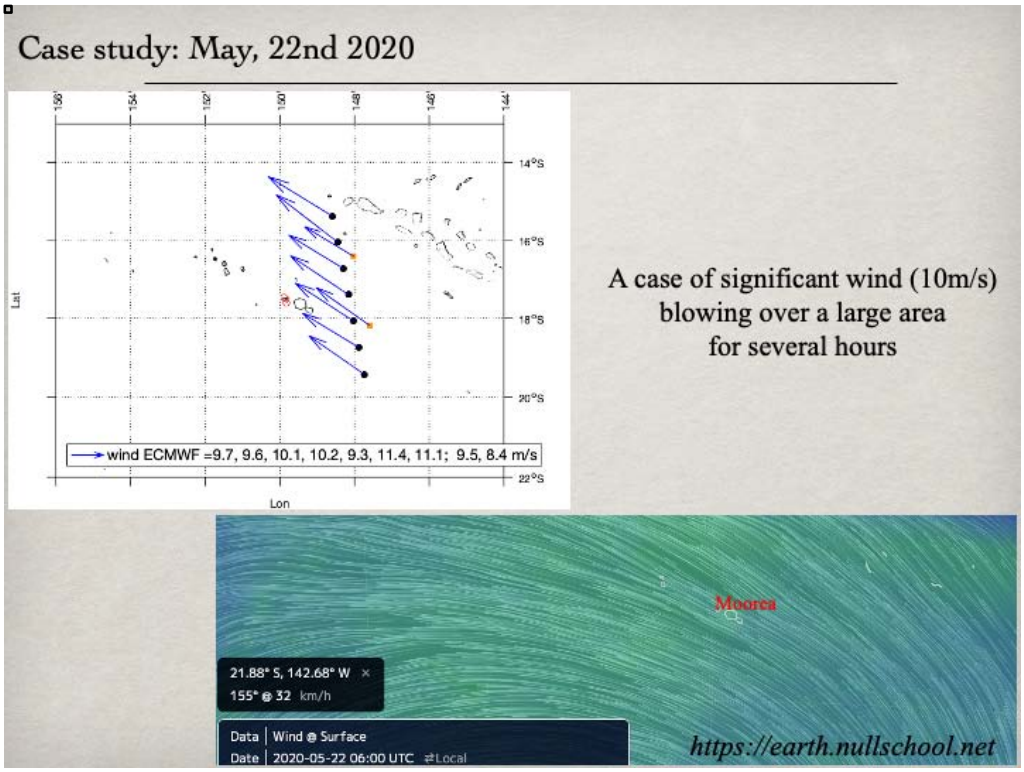




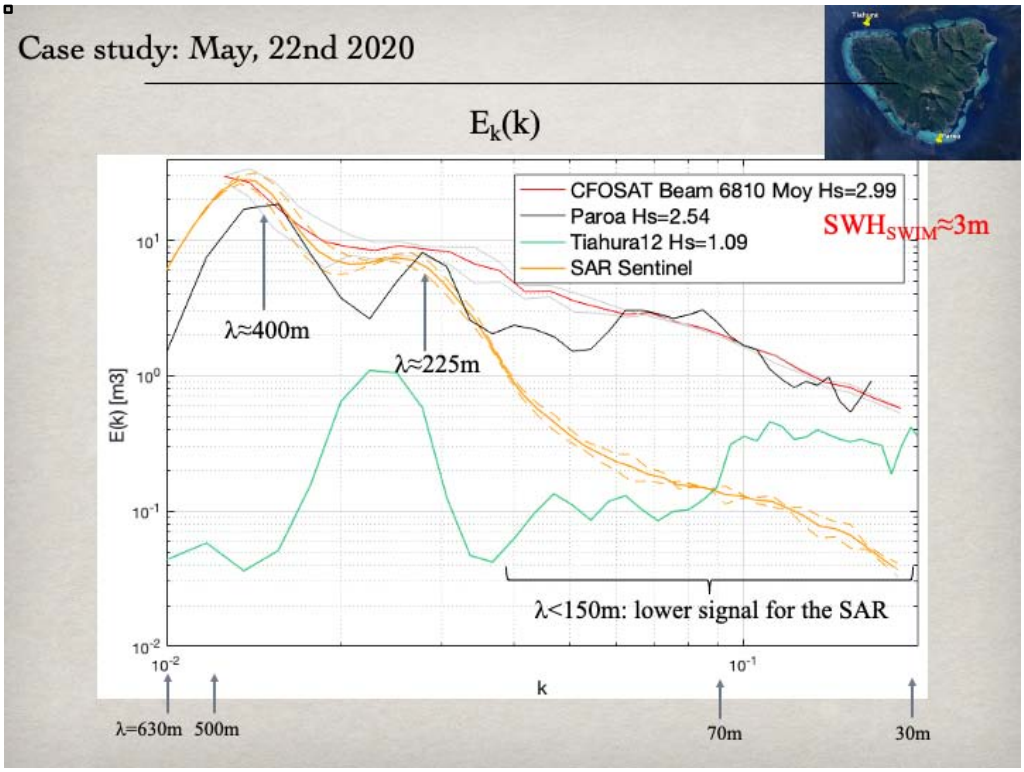
The complementarity of SWIM and SAR instruments

Good performance of SAR for moderate to slight sea state (SWH≲2m)

Good performance of SWIM for sea-wind measurements for rough sea state



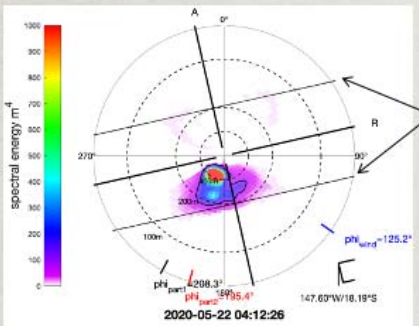
Wind blowing from the south-east at about 10m/s, since more than 12 hours.

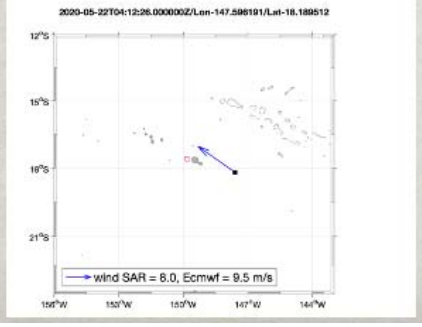


2 peaks corresponding to long-period swell are detected by SWIM, the SAR and the probe located south of Moorea. The signal measured by the probe located north of Moorea is much lower, because of a masking effect by Moorea island.

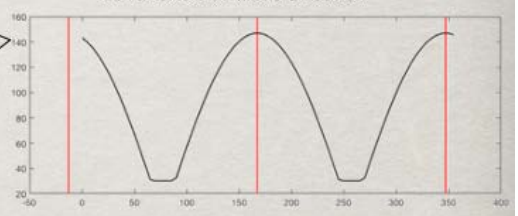
Case study: May, 22nd 2020

SAR Sentinel





azimuth cut-off wavelength
as function of wave direction

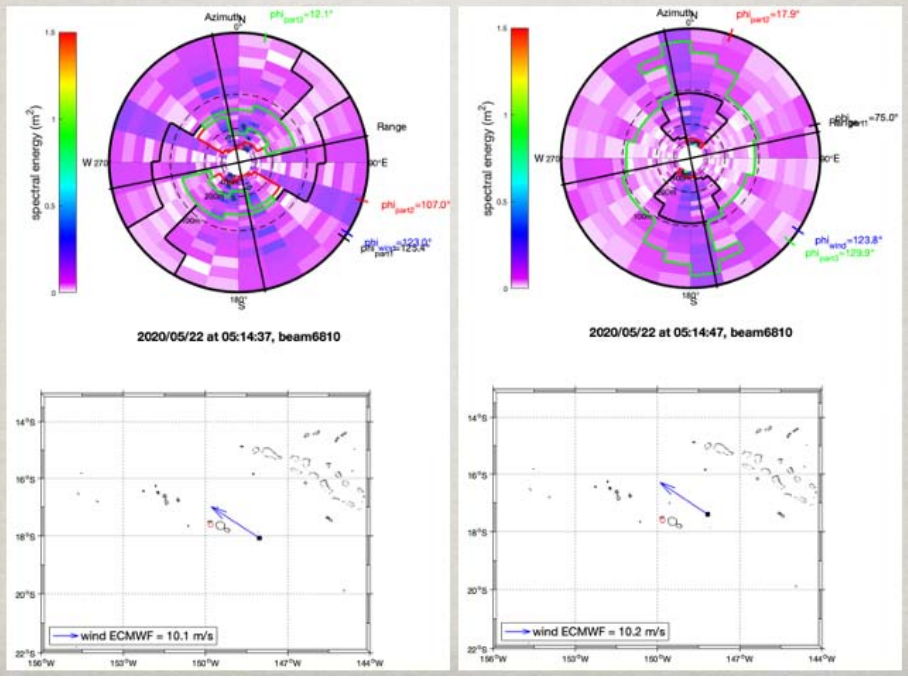


The cutoff limits the direct wind-sea measurement
(mainly along the azimuth direction)

See also *Li, Chapron, Mouche & Stopa (2019)*

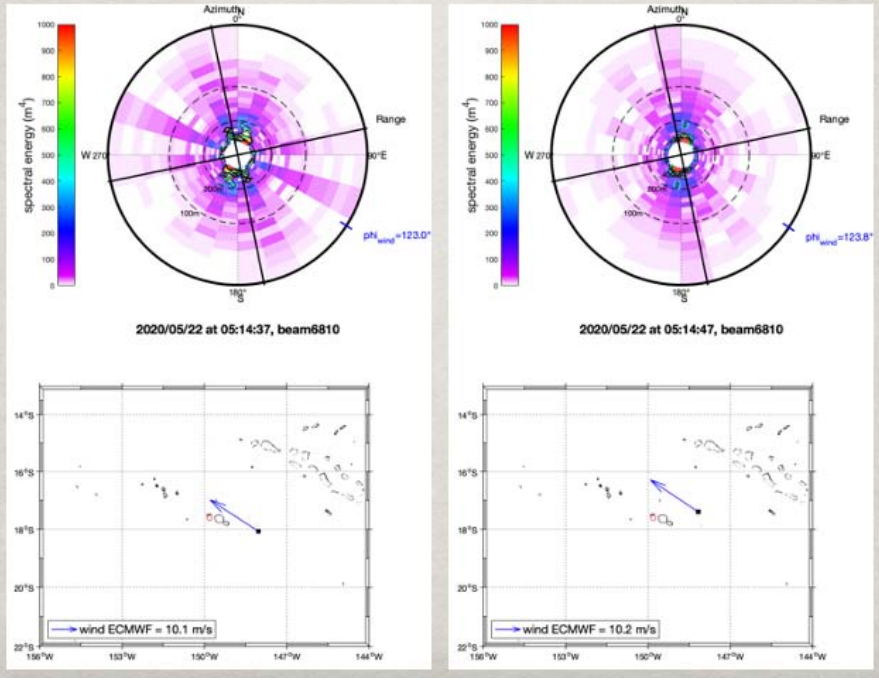
Case study: May, 22nd 2020

Wave Slope Spectra, SWIM

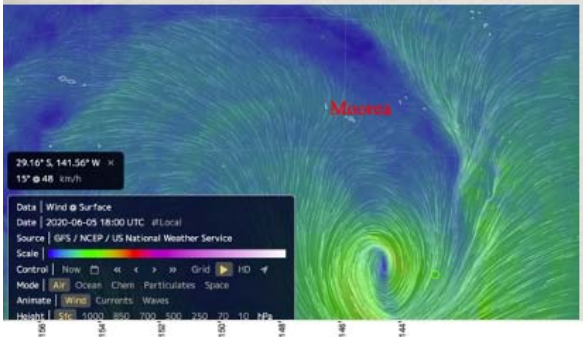


Case study: May, 22nd 2020

Wave Height Spectra, SWIM



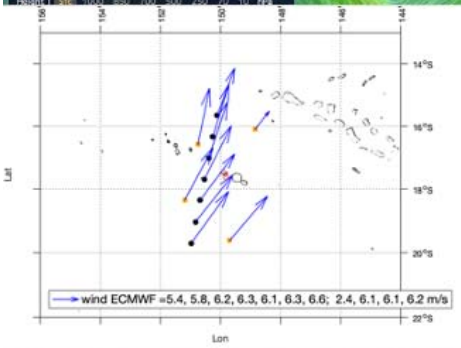
Case study: June, 5th 2020

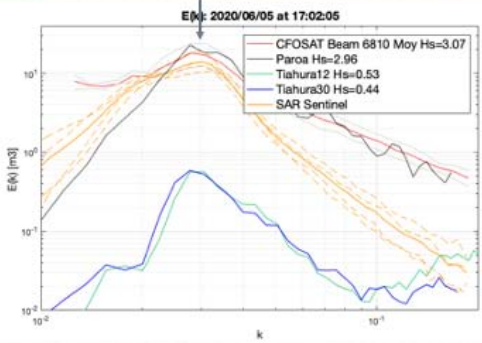


SWH_{SWIM}≈3m

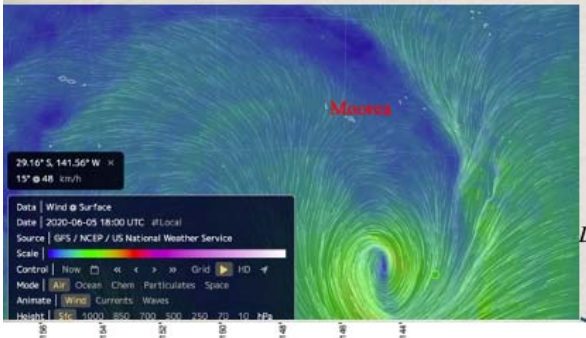
Swell from south/south-east
λ≈200m

$E_k(k)$





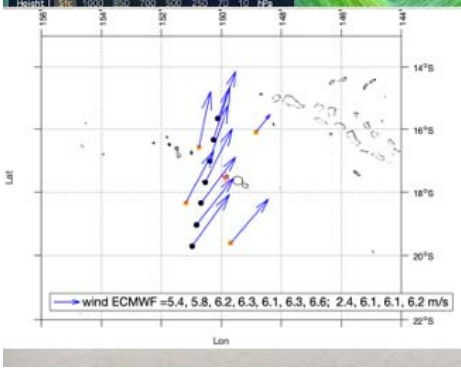
Case study: June, 5th 2020

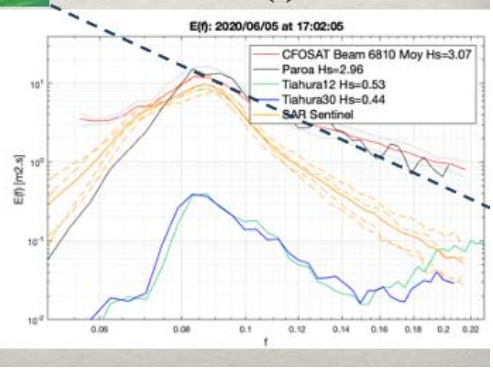


(fetch limited
Donela, Hamilton, Hui, 85)

$E(f) \sim f^{-4}$

E(f)

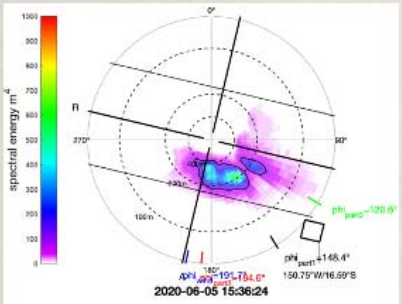


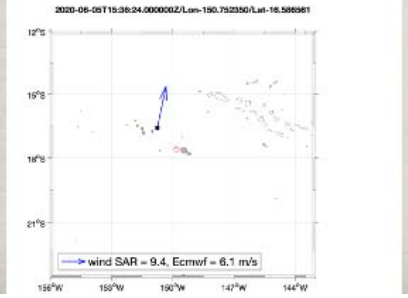


Case study: June, 5th 2020

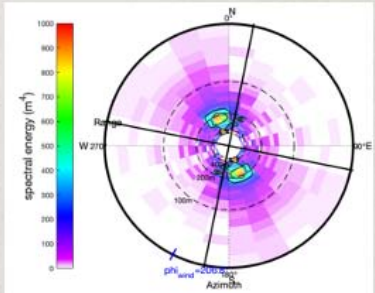
Wave Height Spectra

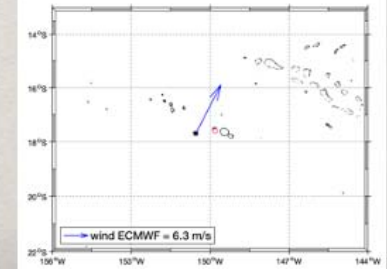
SAR Sentinel





SWIM





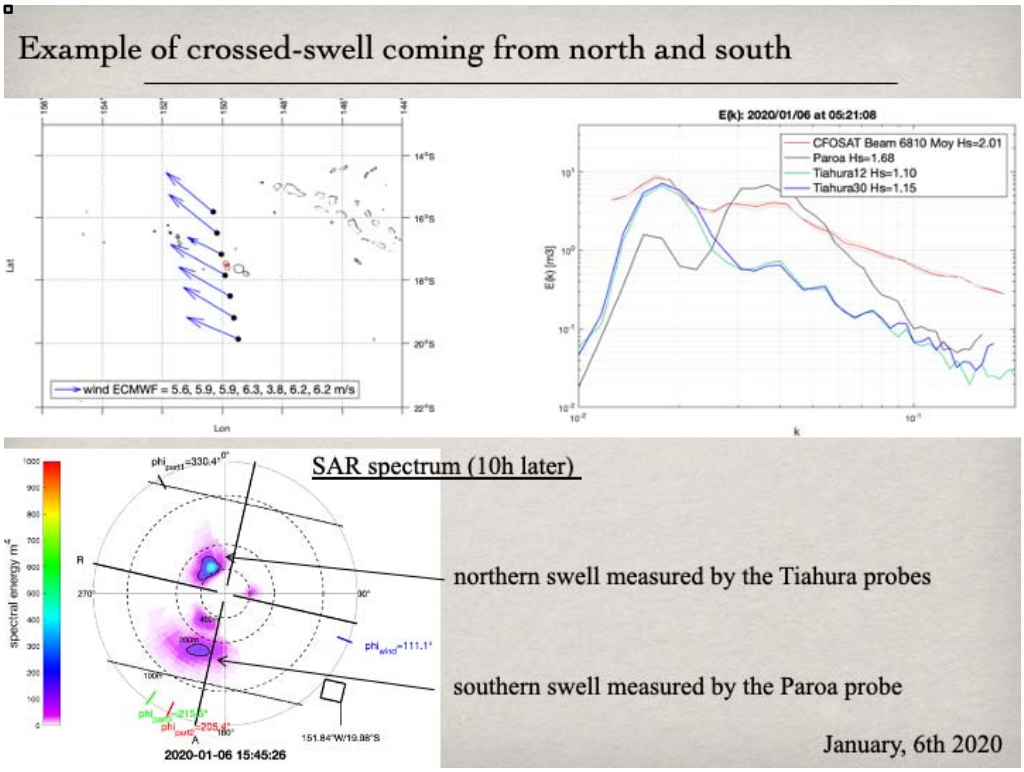
Summary/Prospect

SWIM, SAR and OSSI probes all have their own specific limitations: combining these data, through space-time co-localisation methods, offers an opportunity for improved waves reconstruction.

SWIM is complementary to SAR and offers a chance to measure the wind-sea in rough sea states. For moderate to slight sea states, however the SAR appears to provide more reliable measurements.

A further detailed analysis, including statistical study, is currently under progress.

APPENDIX

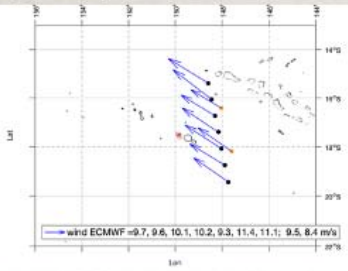


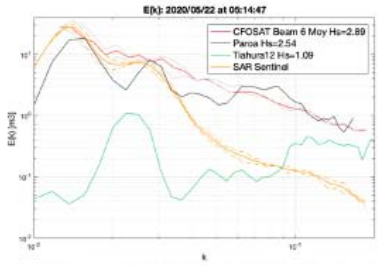
The Tiahura probes measure the northern swells, which are more frequent during winter. Both probes at Tiahura produce the same spectra despite being at different depths. This highlights that the rapid bottom increase does not significantly alter the wave properties.

SWIM spectra: robustness depending on the beam

Case study: May, 22nd 2020

Beam 6°

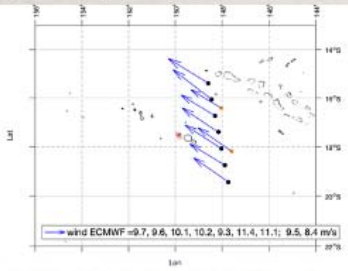


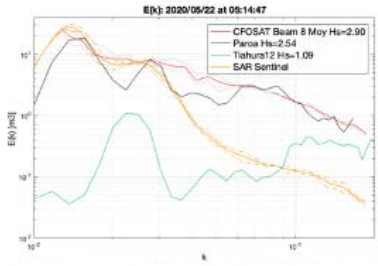


SWIM spectra: robustness depending on the beam

Case study: May, 22nd 2020

Beam 8°

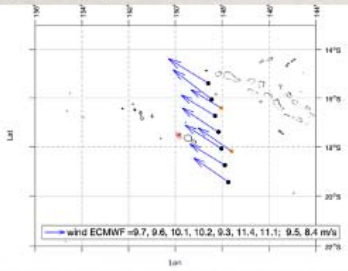


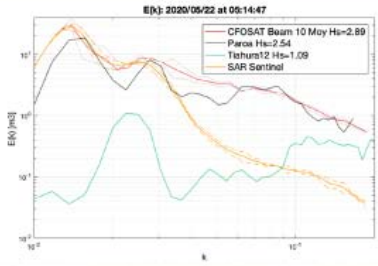


SWIM spectra: robustness depending on the beam

Case study: May, 22nd 2020

Beam 10°

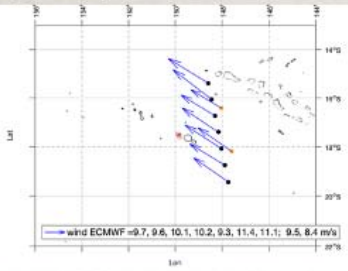


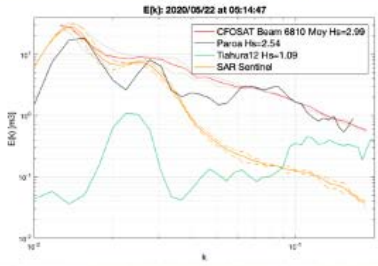


SWIM spectra: robustness depending on the beam

Case study: May, 22nd 2020

Combined

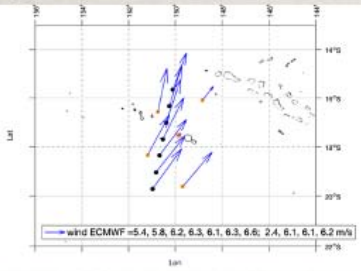


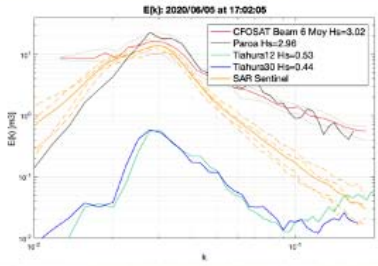


SWIM spectra: robustness depending on the beam

Case study: June, 5th 2020

Beam 6°

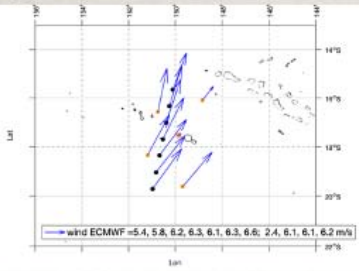


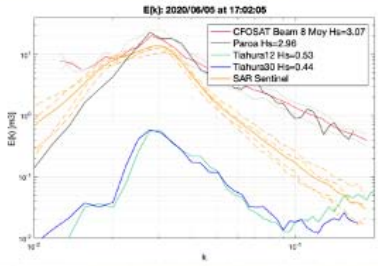


SWIM spectra: robustness depending on the beam

Case study: June, 5th 2020

Beam 8°

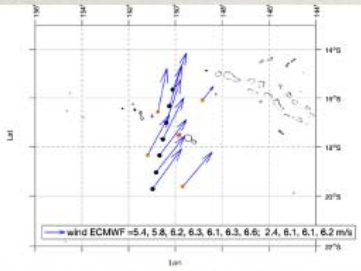


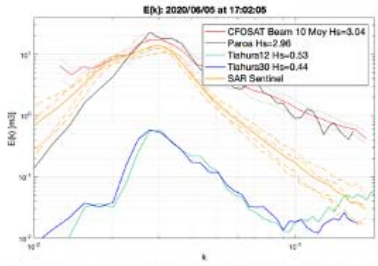


SWIM spectra: robustness depending on the beam

Case study: June, 5th 2020

Beam 10°

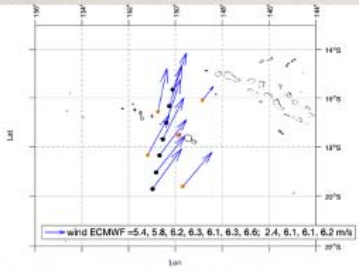


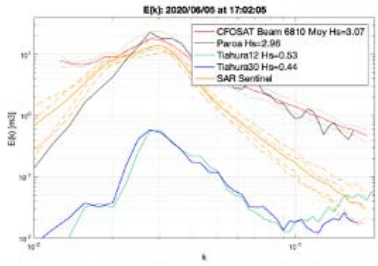


SWIM spectra: robustness depending on the beam

Case study: June, 5th 2020

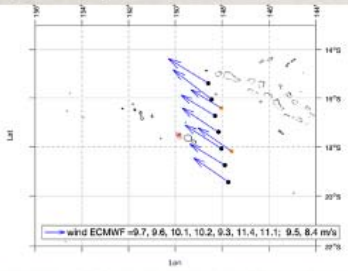
Combined



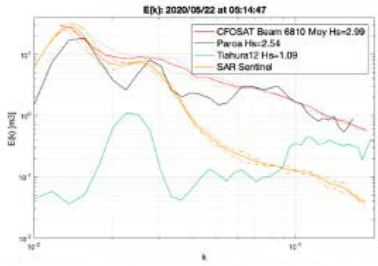


Different representations of the omni-directional spectra

Case study: May, 22nd 2020

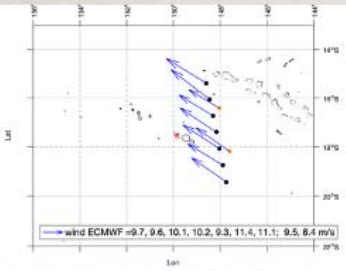


E(k), log scale

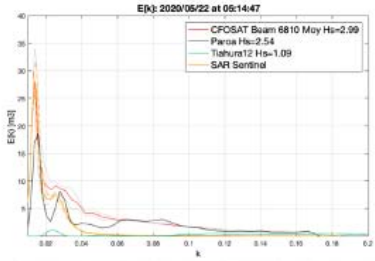


Different representations of the omni-directional spectra

Case study: May, 22nd 2020

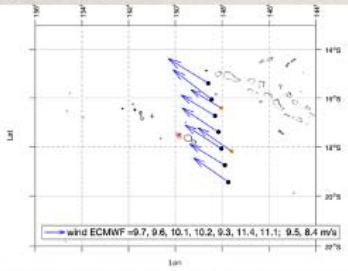


E(k), lin scale

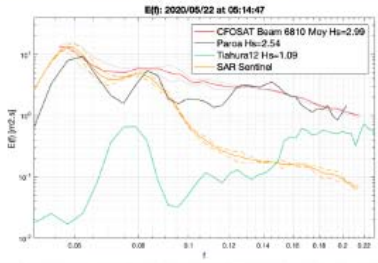


Different representations of the omni-directional spectra

Case study: May, 22nd 2020

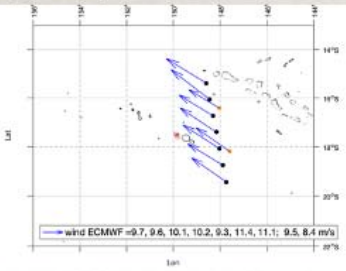


E(f), log scale



Different representations of the omni-directional spectra

Case study: May, 22nd 2020



E(f), lin scale