Coastal monitoring of sea state using airborne GNSS reflected signals.

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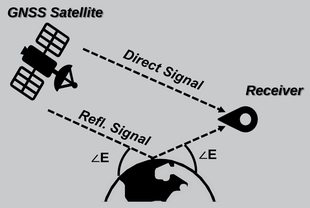
Summary

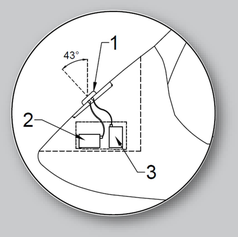
Technique: GNSS Reflectometry **GNSS – R.** Bistatic system that allows to retrieve Earth surface properties from the analysis of the Direct and Reflected signals.



Question: Is it possible to monitor the sea state in coastal areas from low-height airborne GNSS-R data?

Approach: Analysis of the Vertical Doppler Spread (σ_{f_v}) of the reflected signal estimated from the Doppler shift present in the Power Spectral Density**.**

Experiment

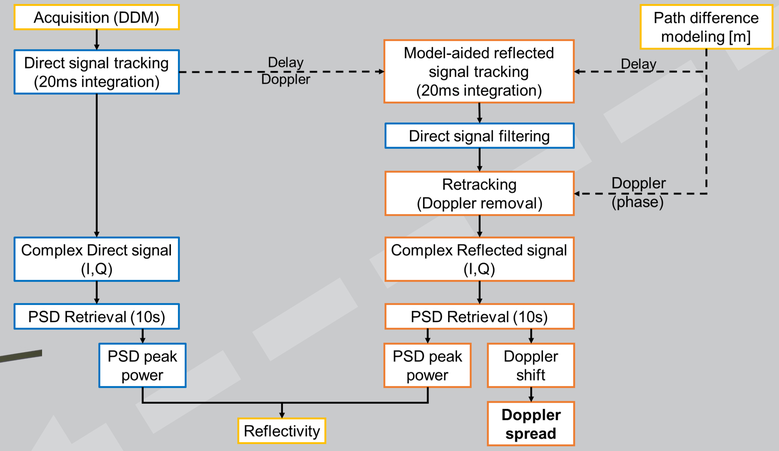


Setup:
Aircraft "Gyrocopter"
1 - Dual-polarized antenna
2 - Front-end receiver (RHCP)
3 - Front-end receiver (LHCP)
Flight control Drone GPS+IMU

Flights Details:
Location: North Sea
Calais – Boulogne, France
Flight height: ~750m
Number of flights: 4
Total flight time: 7h 40m
Date: July 2019

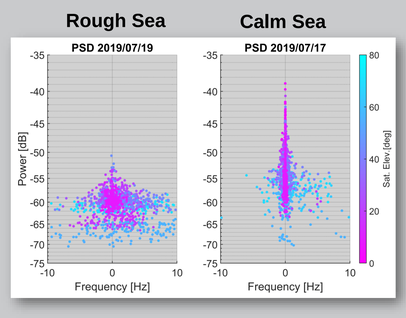
Retrievals

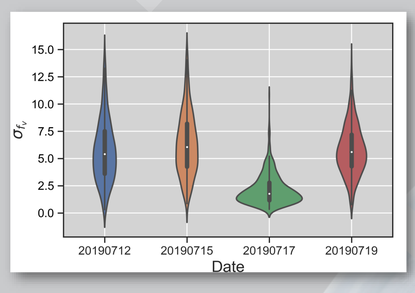
Processing flowchart:



Large Doppler shift and low Power Spectral Density, indicative of a **rougher sea.**

Low Doppler shift and high Power Spectral Density, indicative of a **calm sea**





Reduction of Satellite elevation dependency:

$$f_v = \frac{1}{\sin E} * \frac{d\varphi}{dt}$$

Vertical Doppler Spread:

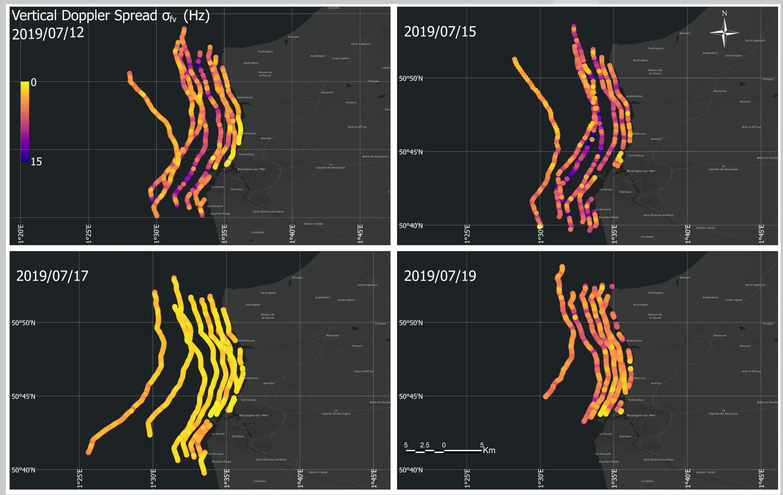
$$STD(f_v) \Rightarrow \sigma_{f_v}$$

*Every 10 seconds

Results

Correlation Sea State and Doppler Spread	
Wind Speed	0.96
Significant Wave Height	0.84

*ERA5 Model Parameters



Conclusions

Slant Doppler spread presented a **high correlation** degree with **wind speed and significant wave height** but high **sensitivity** to the **elevation angles**.

Vertical Doppler spread **reduces** the **elevation effects**. Vertical Doppler spread mean is **2.1 Hz** in a **calm sea** and above **5.0 Hz** in **rougher sea**. **Higher variations** are under study to determine the **contribution** effects of the **glistening zone**.

The experiment setup and processing approach present a **good performance** and offer the possibility to **monitor the sea state in coastal areas**.

Future work consists of the study of the **ionospheric effects** by using a higher altitude platform (**LEO Satellite**) when estimating sea state and sea level.

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