Sea state dependent Doppler spread as a limit of coherent GNSS reflectometry from an airborne platform.

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Outline

- Introduction
- Experiment
- Processing
- Results
- Conclusions

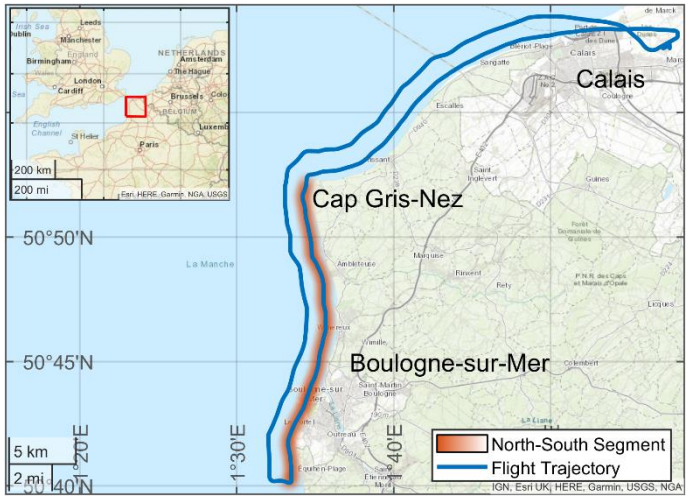
Introduction

Motivation: Sea state variability (due to climate change) impact considerably may human activities and people living in coastal zones.

Question: Possibility of detecting sea state variations in coastal areas from coherent airborne GNSS-R data using as a metric the Doppler spread.

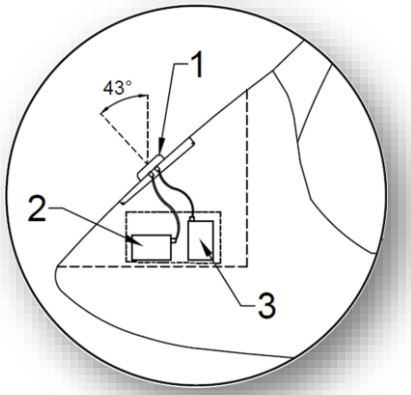
Approach: - Tracking and retracking of the reflected signal using a model-aided software receiver.
- Power Spectral Density (PSD) to retrieve power and relative Doppler shift (f).
- Doppler Spread (σ_f) estimation to correlate with sea state parameters from ancillary data.
- Residual phase and σ_f limit as indicator of GNSS-R observations coherence.

Experiment



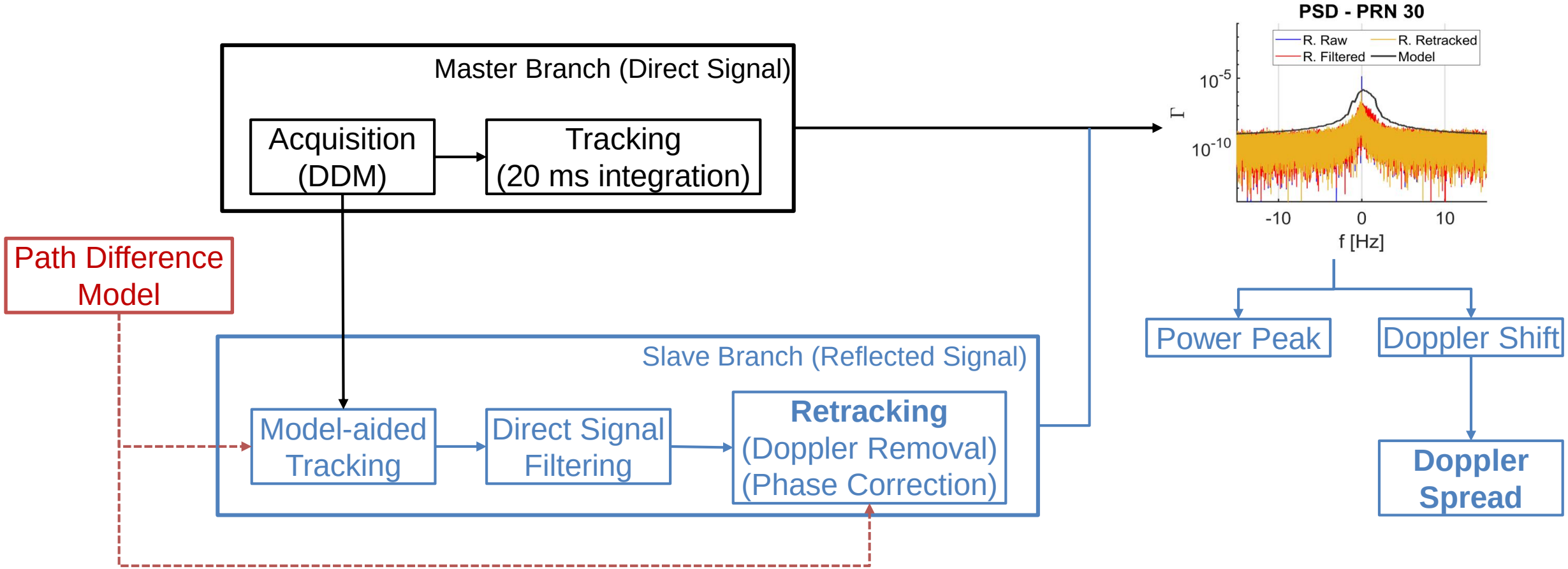
Location: North Sea Calais – Boulogne-sur-Mer, France
Number of flights: 4
Date: July 2019

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



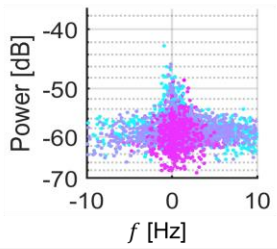
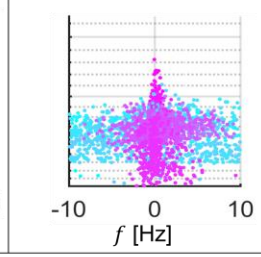
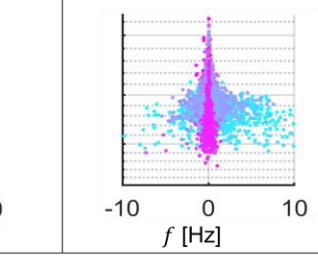
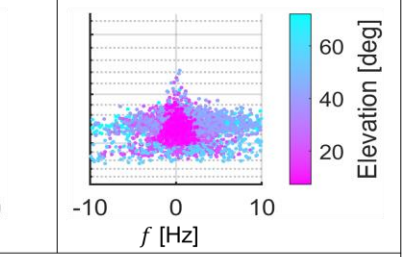
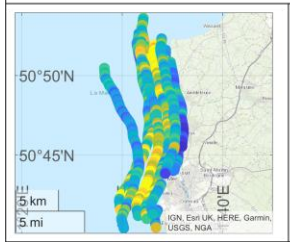
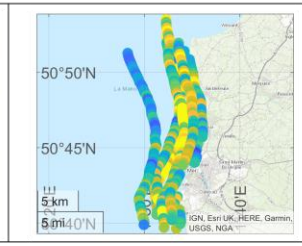
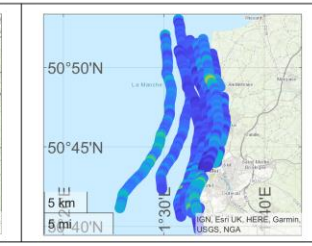
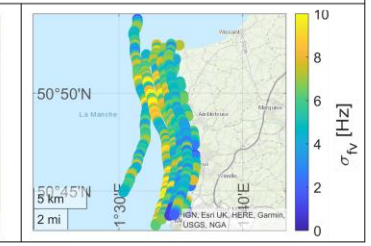
Processing

See Kucwaj, J.-C. et. al., 2017.



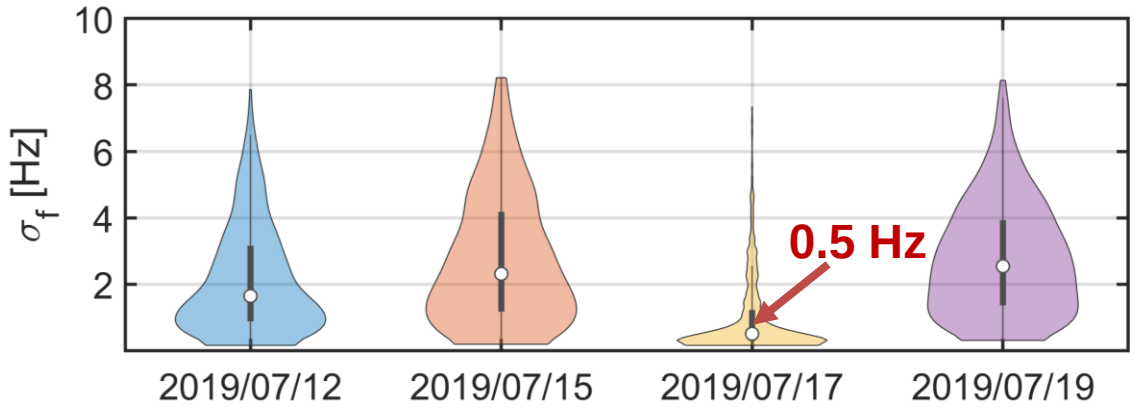
Results

Residual Doppler Spread

2019/07/12	2019/07/15	2019/07/17	2019/07/19
Sea state from ECMWF | ERA5 Model			
SWH: 0.30 m - WS: 5.49 m/s	SWH: 0.58 m - WS: 4.29 m/s	SWH: 0.26 m - WS: 2.92 m/s	SWH: 0.55 m - WS: 6.50 m/s
Power vs. Doppler shift (f) Spectrum (10s)			
			
Elevation-corrected Doppler Spread (σ_{fv}) (120s)			
			

Correlation between Sea State and EC Doppler Spread σ_{fv}	
Wind Speed	0.88
SWH	0.75

Doppler Spread Distribution

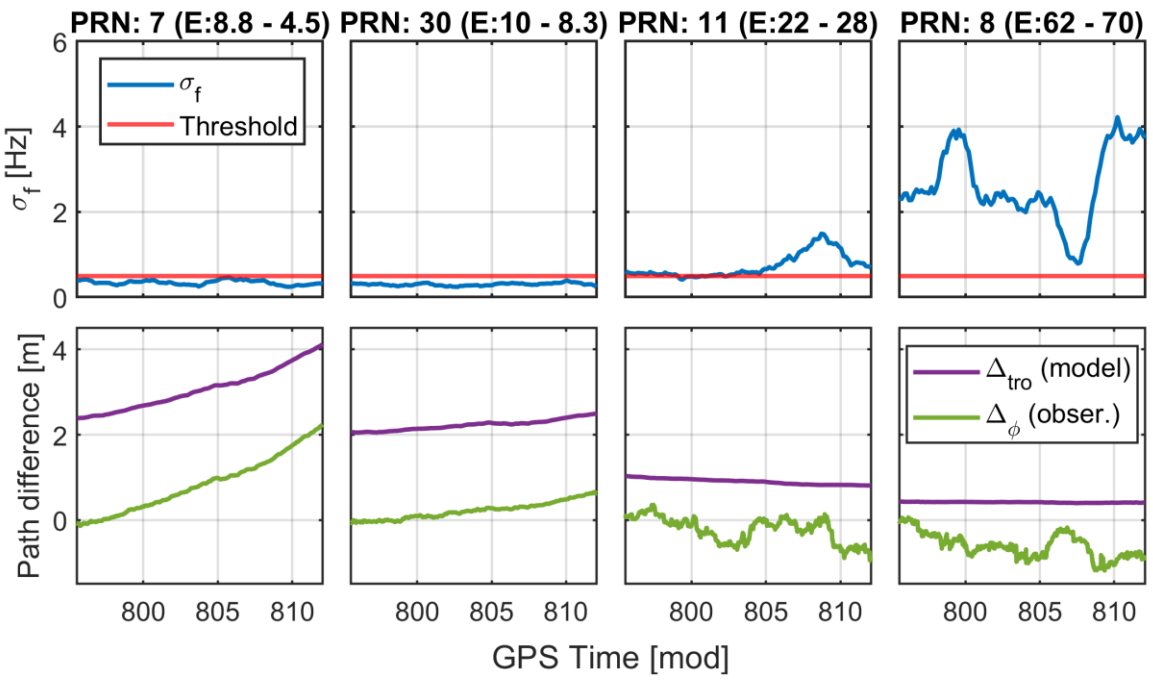


Results

Residual Carrier phase

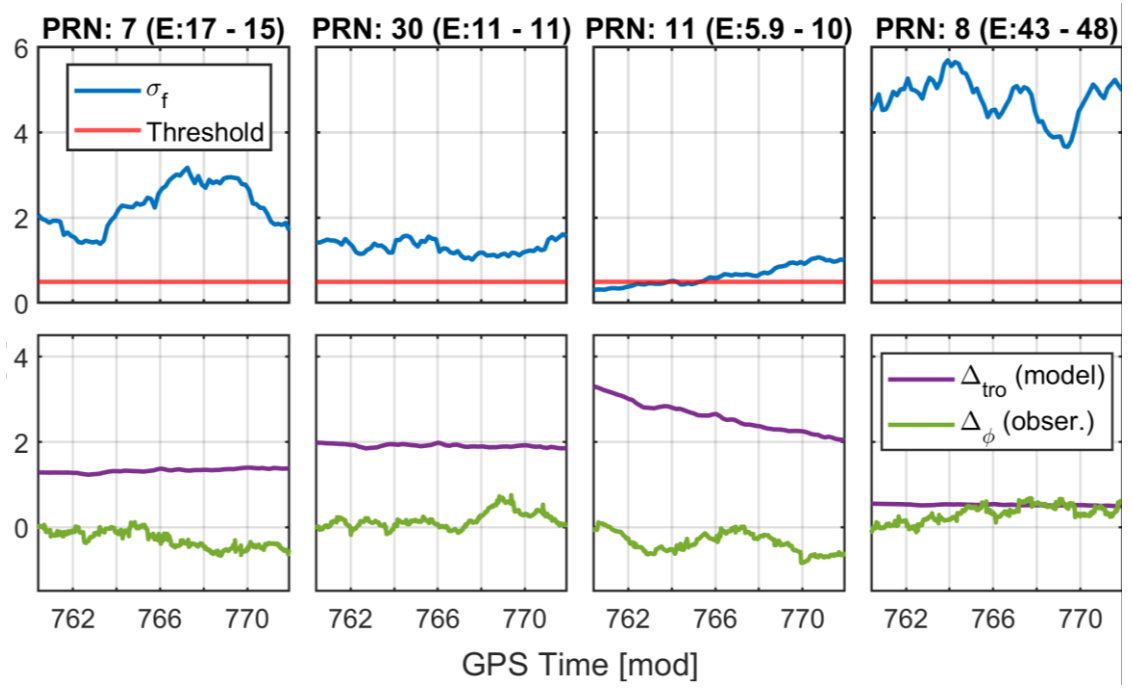
2019/07/17

SWH: 0.26 m - WS: 2.92 m/s



2019/07/15

SWH: 0.58 m - WS: 4.29 m/s



Conclusions

- The results show that **loss of coherence** in phase observations is accompanied by a **Doppler spread of more than 0.5 Hz**. The results also indicate a **major influence of sea state** in this respect followed by the elevation angle.

- **Only 15%** of the estimates correspond to **coherent observations**. Therefore, even under coastal conditions, the **coherent measurements from airborne platform are limited**. Alternative antenna(s) setup e.g. zenith- and nadir-looking array may contribute capture the direct and reflected signals improving the final results.

- The comparison of residual phase and excess path model (**tropospheric contribution**) shows agreement. Future studies may use this **sensitivity of coherent reflectometry observations** to troposphere contribution for the retrieval of related parameters, like **water vapor.**

Thank you!

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