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 ($\sigma_f$) 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

**Processing flowchart:**

1. Acquisition (DOA)
2. Direct signal tracking (20ms integration)
3. Model-aided reflected signal tracking (20ms integration)
4. Path difference modeling [m]
5. Direct signal filtering
6. Retracking (Doppler removal)
7. Complex Reflected signal (ID)
8. PSD Retrieval (10s)
9. PSD peak power
10. Doppler spread

**Results**

**Correlation Sea State and Doppler Spread**

<table>
<thead>
<tr>
<th></th>
<th>Wind Speed</th>
<th>Significant Wave Height</th>
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<tbody>
<tr>
<td>2019/07/13</td>
<td>0.96</td>
<td>0.84</td>
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<tr>
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*ERAS 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.