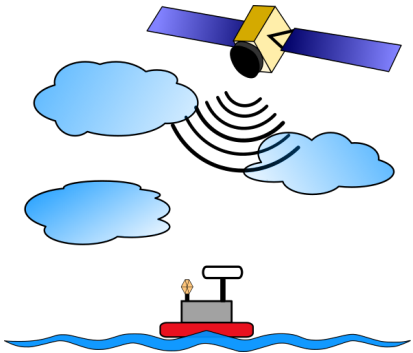

EGU General Assembly 2022 – Session G5.2 – EGU22-1811

A low-cost GNSS buoy for water vapour monitoring over the Oceans

V. Bennini[1], M. Bouasria[2], Y. Grit[3], P. Bosser [4], A. Panetier [4]

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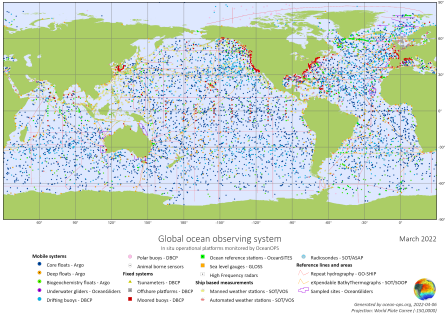
2: IUEM, Plouzané, France.
3: ENSTA Bretagne, Brest, France.
4: Lab-STICC, ENSTA Bretagne, Brest, France.

Context

- Interest in at-sea GNSS measurements for IWV retrieval
  - Origin of severe weather events
  - Area limited to surface observations or satellite remote sensing

  [Bon+12; Wan+19; Bos+21; Män+21; Wu+22]
- Recent growth of positioning / remote sensing applications using low-cost dual frequency GNSS receivers
  [Kni+20; Kri+20; Pur+21]



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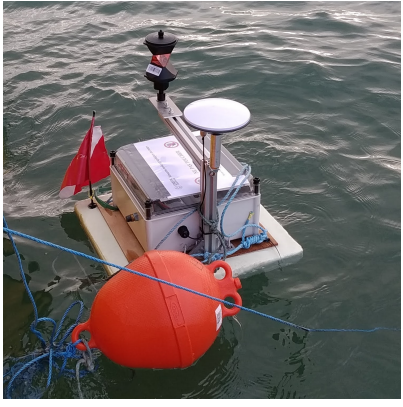
- Recent growth of positioning / remote sensing applications using low-cost dual frequency GNSS receivers [Kni+20; Kri+20; Pur+21]

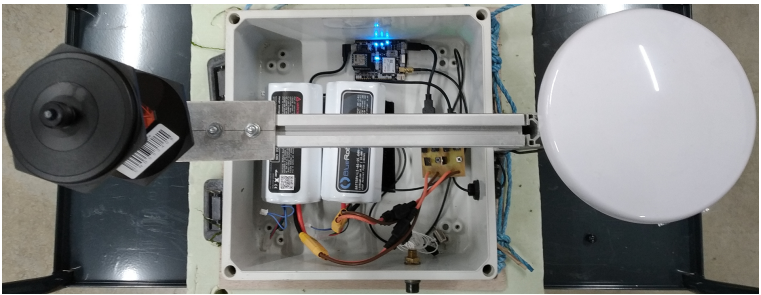
➥ Development of a **prototype of GNSS buoy** :

- **Low power consumption** (autonomy $\sim$ 1 month)
- **Raw data logging** for GNSS post-processing (PPP)
- **Accuracy around 15 mm ZTD** ($\sim$ 2 kg m^{-2} IWV), required for climatology [Off10]
- Price **500 – 800€**



Technical description

top view



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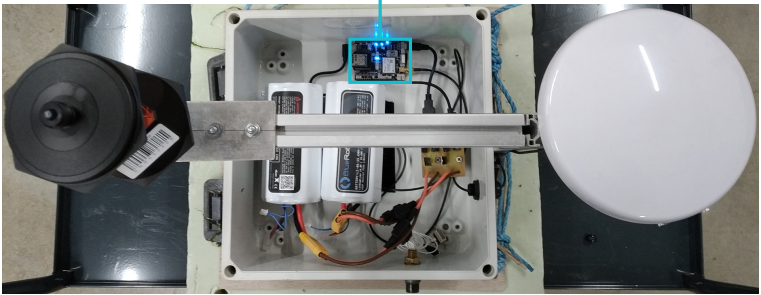
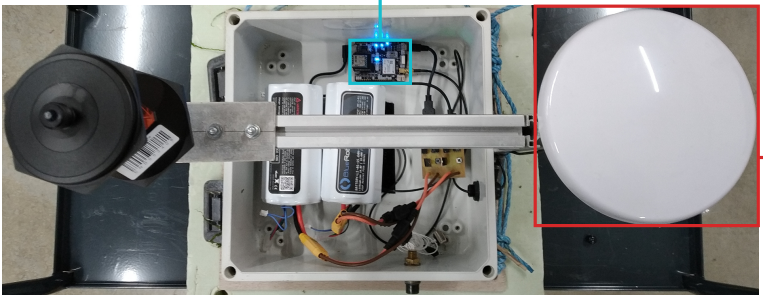


Standalone board with:

- ublox ZED F9P module
- microcontroller on Xbee socket with UART Tx
- 32Gb micro-sd card
- power consumption $\sim$ 0.75 W

Technical description

top view



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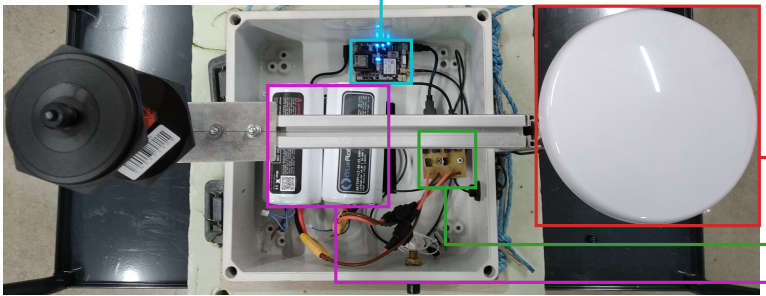
Calibrated multiband IP67 antenna

Technical description

top view



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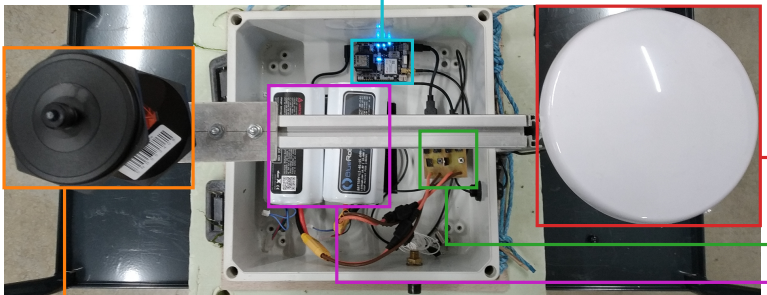
Power supply board

2$\times$ Lithium-ion battery 230 Wh

Technical description

top view



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Leica GRZ4 360^{o} prism for vertical tie [optional]

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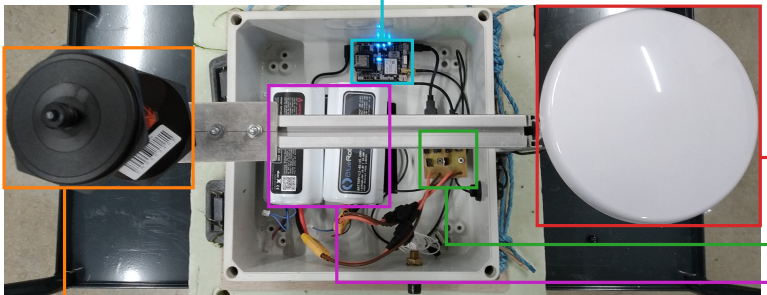

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Power supply board

2$\times$ Lithium-ion battery 230 Wh

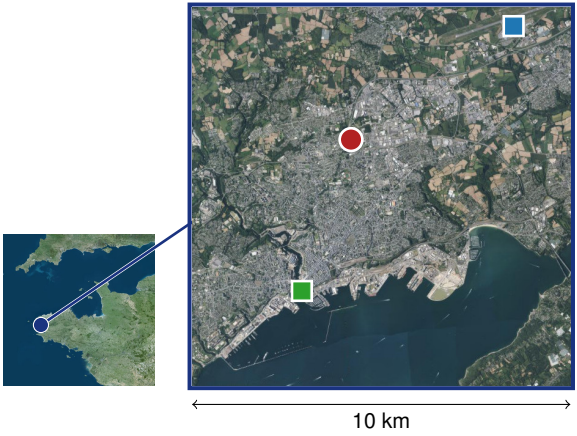
Leica GRZ4 360^{o} prism for vertical tie [optional]

Autonomy $\sim$ 24 days with 2 batteries

Price $\sim$ 900€ (including 600€ for the 2 batteries and without the prism)

Ground assessment of ZWD estimates

- **Static PPP** analysis of the **BUOY** during 12 days in August 2021
- Comparison of ZWD estimates with those from nearby (< 5 km) CORS (**BRST** & **GUIP**)



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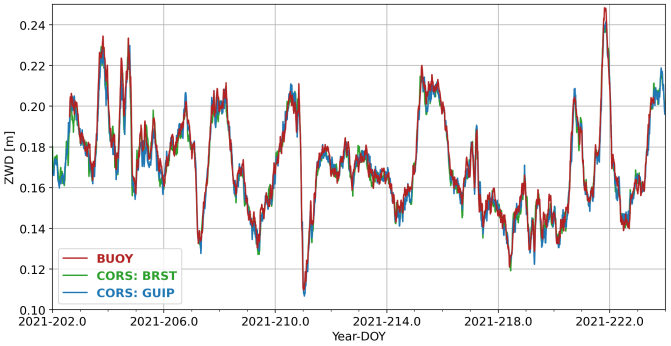
	Npts	bias $\pm$ stdev [mm]
BRST	6041	-1.5 $\pm$ 3.9
GUIP	6041	-1.5 $\pm$ 3.8

- Overall agreement despite a **small bias** (BUOY wetter than CORS)
- Standard deviations with CORS are lower than 4 mm ; a similar value is observed between CORS



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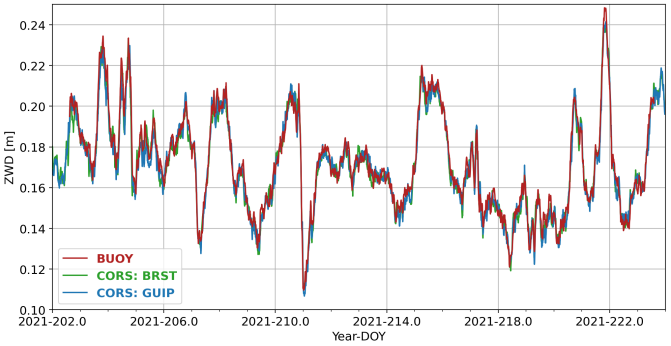
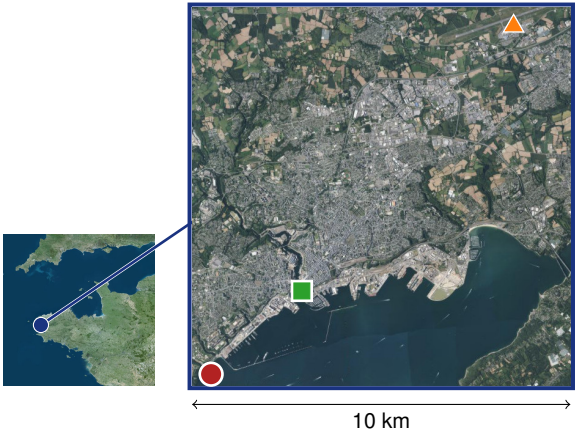


➥ **Confirmation of the abilities of these low-cost receivers for water vapour measurement**

At-sea assessment of ZWD estimates

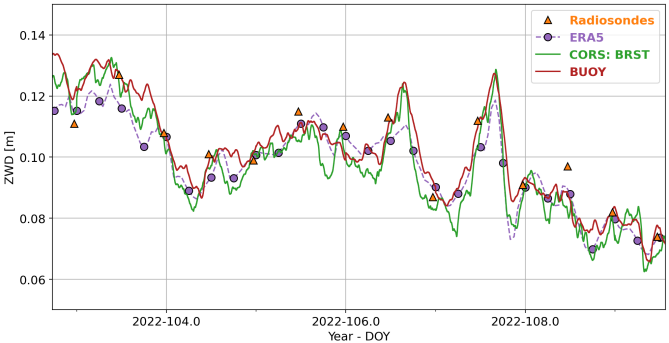
- **Kinematic PPP** analysis of the **BUOY** during 8 days in April 2022
- Comparison of ZWD estimates with those retrieved from **Radiosonde**, **ERA5** and **BRST** reference station



At-sea assessment of ZWD estimates

- **Kinematic PPP** analysis of the **BUOY** during 8 days in April 2022
- Comparison of ZWD estimates with those retrieved from **Radiosonde**, **ERA5** and **BRST** reference station

	Npts	bias ± stdev [mm]
Radiosonde	14	+0.7 +/- 4.9
ERA5	164	-3.9 +/- 5.5
BRST	19483	-4.3 +/- 4.4



- Overall agreement with all the techniques
- High negative bias / **ERA5** and **BRST** (with **BUOY** wetter) ; Low bias / **Radiosonde**
- RMS difference around 5-7 mm
- Comparing with **BRST**, 99.3% of the differences are in the ± 15 mm range

Summary & Outlook

Summary

- A low-cost GNSS buoy was **assessed for water vapour monitoring over the Oceans**
- Despite a suspected **wet bias**, differences in ZWD retrieval with more conventional techniques were lower to **7 mm RMS**, which is suitable with requirements for climatology applications

Outlook

- **Advanced analysis of the GNSS raw data**, including the search for a potential wet bias (multipath?)
- **Integration of meteorological sensors** (pressure, temperature) for ZWD to IWV conversion
- **Installation of solar panels** to increase the autonomy of the system (with a single battery)
- **Improved buoy design** for better handling in different sea states

➥ Deployment during field experiment dedicated to the understanding of climate processes can then be considered

The authors thank Alain Bertholom, Romain Schwab and Didier Tanguy for their support during this project.

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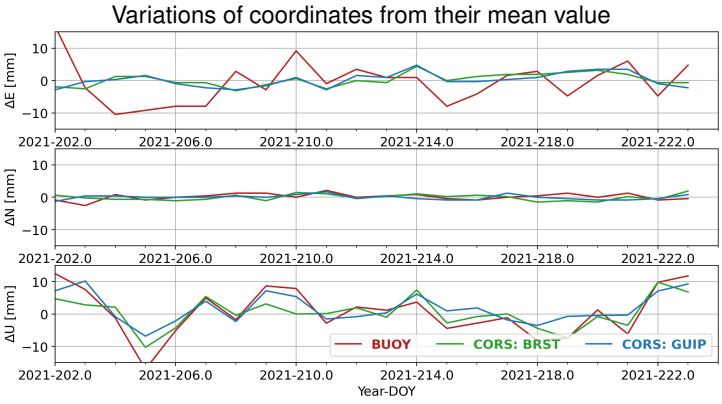
Backup slides

Static positioning : positions



Kinematic positioning : vertical assessment

Comparison with Brest Tide Gauge, located near BRST reference station

SSH time series and Van de Casteele diagram