Contribution of Direction-of-Arrival Observations for Geodetic Seafloor Positioning Using an Unmanned Surface Vehicle

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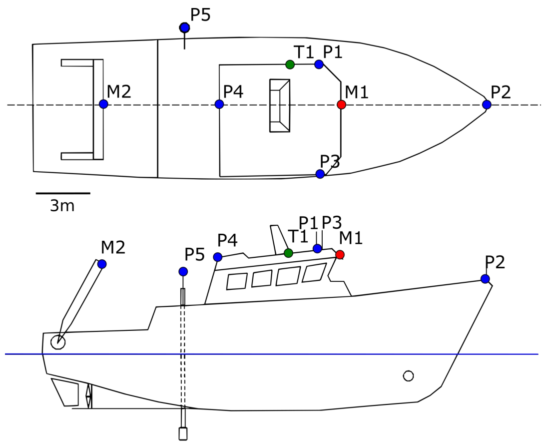
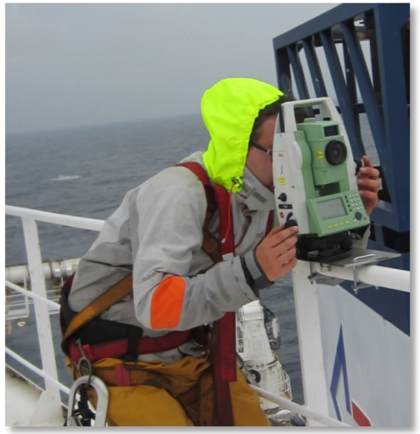
Ship's limitations for GNSS-A



Points on N/O *Tethys II* (25m)

Topo. on
N/O *Tethys II* (25m)



Topo. tests on N/O
Pourquoi Pas ? (108m)

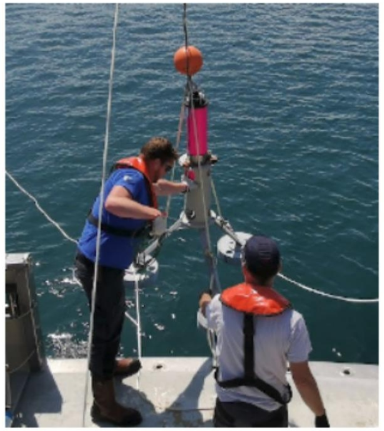
- Noise generated by the propellers
- Not cost-effective
- Reduced number of campaigns

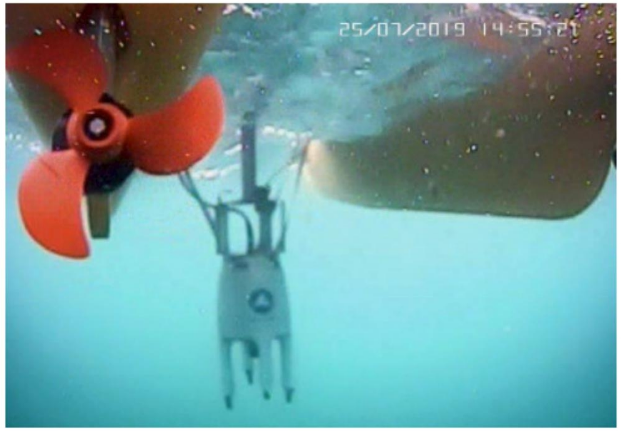
- To measure the ties (lever arms) is a complicated task
  - brings unwanted bias
  - has to be done for each new campaign

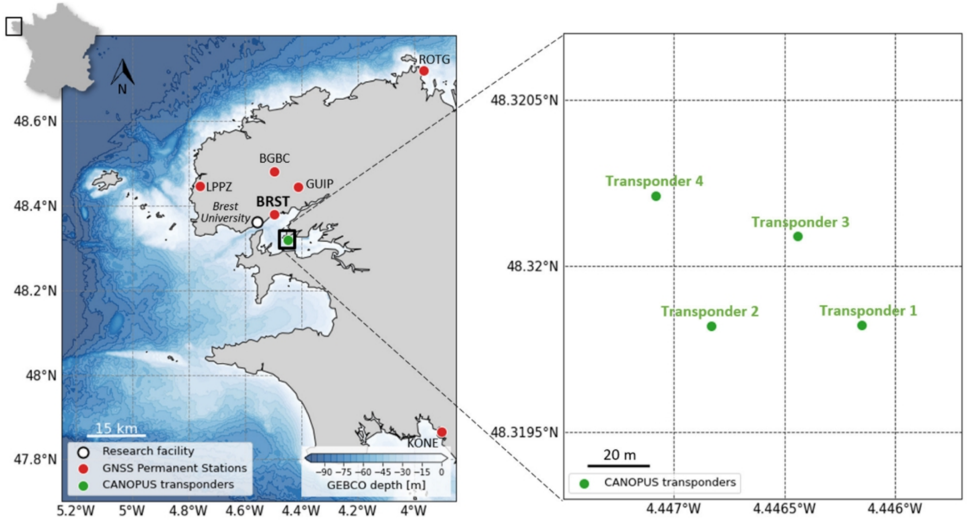
- Internal deformation (?)

Towards the use of Unmanned Surface Vehicules

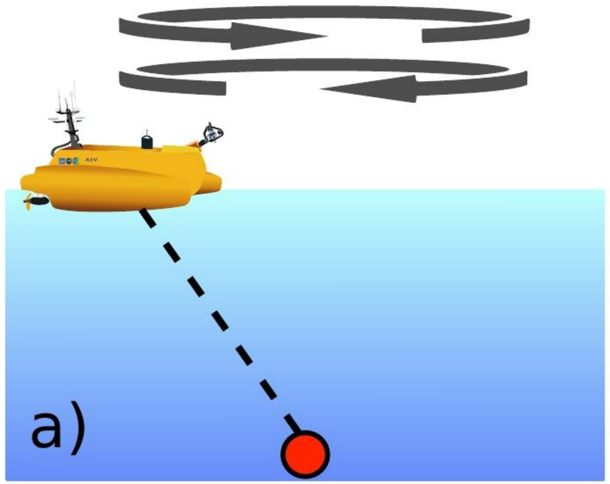
- USV PAMELi
- GEODESEA2020: 17-22 June 2015 off Brest
- operated from N/O *Albert Lucas*
- 3 operative beacons (iXBlue's CANOPUS)
- ~40m depth

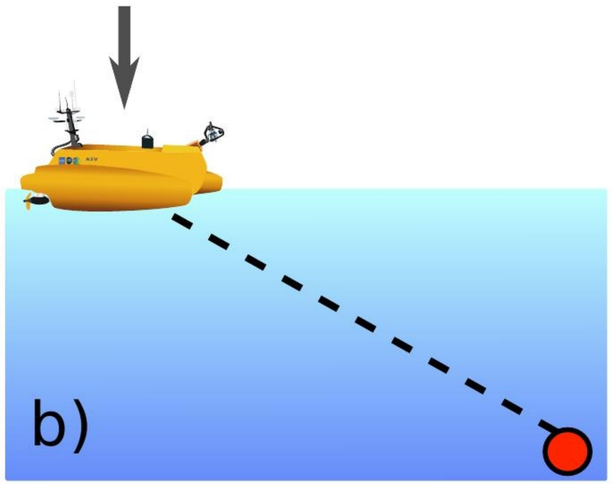


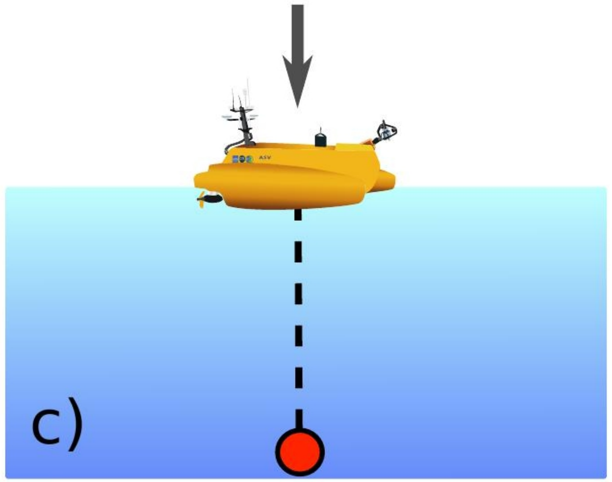




USV‘s Trajectories

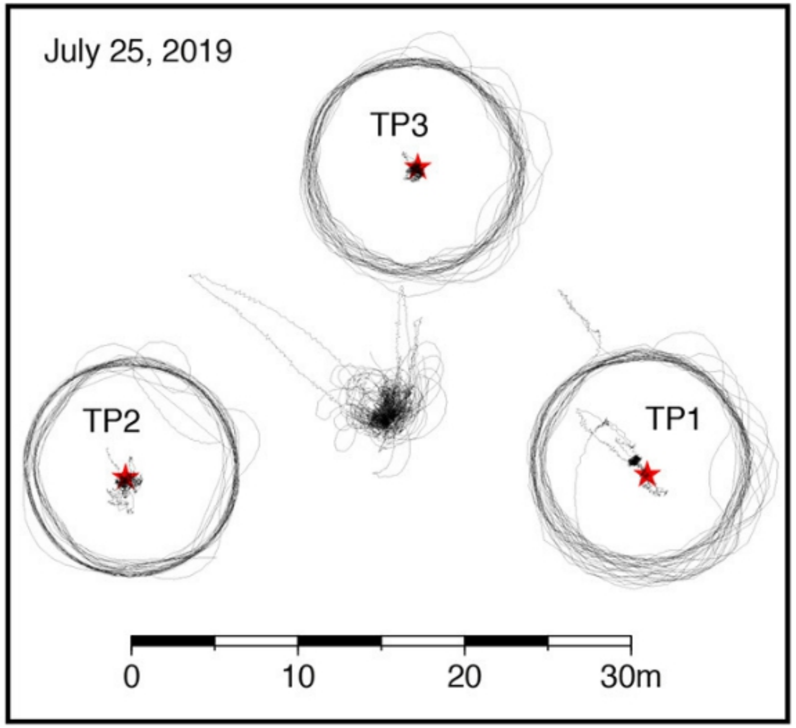






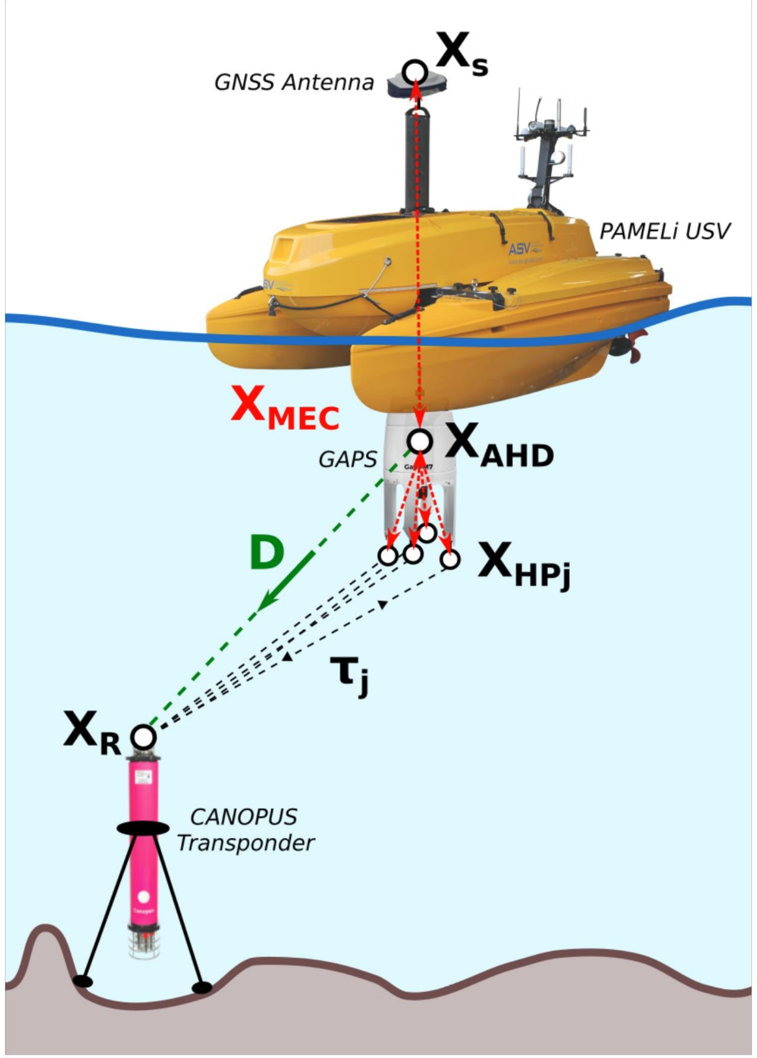
- Different trajectories tested:
  - *a)* rotations (“box-in”)
  - *b)* static/slanted ray
  - *c)* static/above beacon

- short acquisition sessions (~20 min)



Acquisition and processing strategy

- Hybridation of GNSS and INS observations with quaternions
- Use of the Directions of Arrival i.e. a vector between the USV and the beacons
- Re-estimate the sound speed



Observation functions

$$f_{TWTT} : (\mathbf{X}_R, \delta c) \longmapsto \tau$$

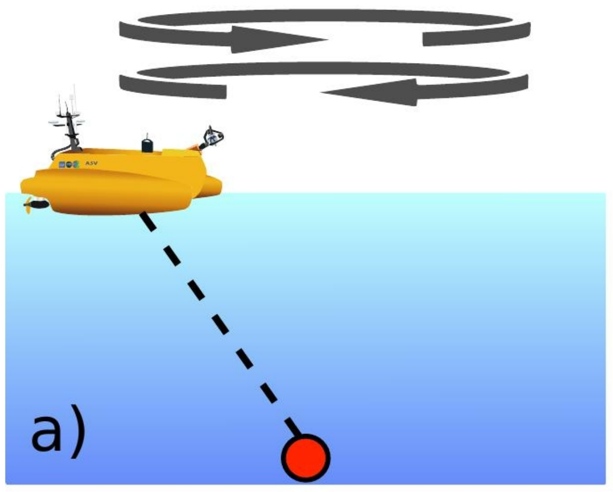
$$f_{DOA} : (\mathbf{X}_R) \longmapsto \mathbf{D}$$

$$f_{TWTT} : \frac{\|\mathbf{X}_R - \mathbf{X}_{AHD}(t_{emi})\| + \|\mathbf{X}_R - \mathbf{X}_{HPj}(t_{rec})\|}{c + \delta c} + \tau_{TAT} = \tau$$

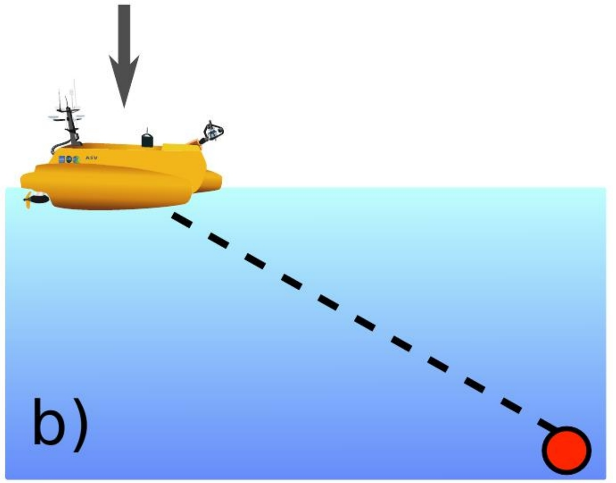
$$f_{DOA} : \frac{\mathbf{X}_R - \mathbf{X}_{AHD}(t_{rec})}{\|\mathbf{X}_R - \mathbf{X}_{AHD}(t_{rec})\|} = \mathbf{D}$$

Main Results

- Different Parameterizations in a Box-In Mode
  - δc estimated or not
  - DOA not used, loosely or strongly constrained
- **Best results obtained for DOA strongly constrained and without δc estimation**
- σ ≈ 3cm on planimetric components



- Repeatability in Static Mode
  - δc estimated or not
  - DOA not used, loosely or strongly constrained
- **Best results (w.r.t. the Box-In) obtained for DOA strongly constrained but without δc estimation**
- σ ≈ 6cm on planimetric components



Key points

- proof-of-concept experiment for underwater geodetic positioning from an Unmanned Surface Vehicle

- A least-squares model is developed to determine the transponder positions from TWTT and DOA observations, and from an estimation of the acoustic signal propagation speed.

- Using DOAs improve the repeatability of transponder positioning in box-in and static acquisitions.

More information in the dedicated article:

Sakic, P., Chupin, C., Ballu, V., Coulombier, T., Morvan, P. Y., Urvoas, P., Beauverger, M., & Royer, J. Y. (2021). Geodetic Seafloor Positioning Using an Unmanned Surface Vehicle—Contribution of Direction-of-Arrival Observations. Frontiers in Earth Science, 9(April), 1–16. https://doi.org/10.3389/feart.2021.636156