

# Investigation of shipborne GNSS ZTD retrieval processing parameters by simulation

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## OUTLINE

- Context and objectives
- Method
- Results
- Further investigation
- Conclusion



# Context and objectives

## CONTEXT

- **Precise positioning at sea** is a current key issue, especially for **hydrography, meteorology** and **climate studies** [Boniface et al., 2012, Bosser et al., 2021, Männel et al., 2021].
- Results from **previous study** [Panetier et al., 2021]: best agreement between ship-borne and ground antennas tropospheric delays with a **RMS error of 3.4 mm on ZTD**.
- Impact of filtering parameters as **cut-off angle, random walk** on ZTD and **weighting** function on elevation, with **an increased RMS up to +94% on ZTD**.

## OBJECTIVES

- **Process** the French Oceanographic Fleet **GNSS data**.
- What parameter values use for the processing?  
→ **Testing on simulations**.



# Method

## 1 - **Simulation** of a ship-borne GNSS antenna **phase observable**

[Elosegui et al., 1995, Teunissen and Montenbruck, 2017]:

$$\delta\phi_{LC,iono\ free} = \delta\mathbf{clock} + \delta\mathbf{height} \times \sin el + \frac{\delta ztd}{\sin el} + \epsilon + mp \quad (1)$$

$el$  elevation of the satellite,  
 $\delta ztd$  troposphere variations based on  
 latitude [Hadas et al., 2020],

$\epsilon$  measurement noise,  
 $mp$  multipath effect  
 [King and Watson, 2010].

## 2 - **Kalman filter estimation** of parameters over 200 simulations:

- Estimates (**kinematic**): 3D position, clock, troposphere.
- Parameters:
  - **cut-off** angle (CO),
  - elevation **weighting** (WG),
  - ZTD **random walk** (RW).

## 3 - Choice of **best filter** **parameterization**:

- compare estimates to simulation,
- mean **RMS**, **correlation** terms,
- focus on **ZTD** and **height** results.

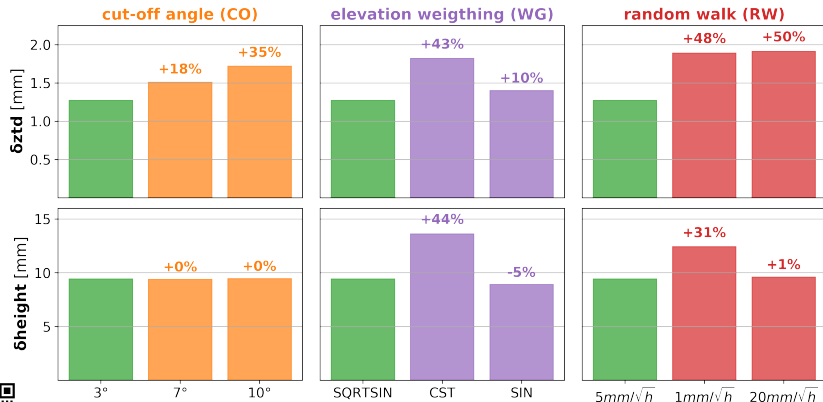


# Results

Reference simulation: **Multi-GNSS, 30s** time resolution, **45°** latitude.

Best modelling: **CO 3°**, **WG SQRTSIN**, **RW 5 mm.h<sup>-0.5</sup>**.

→ **RMS errors:  $\delta ZTD$  1.3mm,  $\delta height$  9.4mm, with a correlation of 45%.**



## Further investigation

Reference	Test	RMS	
		Height	ZTD
	→ CO 3°, WG SQRTSIN, RW 5 mm.h <sup>-0.5</sup>	9.4 mm	1.3 mm
Multi-GNSS	GPS	+61%	+46%
30s	300s	+13%	+38%
perfectly corrected	no correction	+46%	+77%
PCV	azimuthal mean correction	+4%	+8%
	false North correction	+6%	+15%
mid-latitude	Equator - 10 mm.h <sup>-0.5</sup>	+31%	+46% <sup>1</sup>
	Pole - 2 mm.h <sup>-0.5</sup>	+10%	-15% <sup>2</sup>

<sup>1</sup>+23% with 10 mm.h<sup>-0.5</sup>; instead of 5 mm.h<sup>-0.5</sup>

<sup>2</sup>-31% with 3 mm.h<sup>-0.5</sup>; instead of 5 mm.h<sup>-0.5</sup>



# Conclusion

## SUMMARY

- Simulations have been conducted to **assess the impact of filter modeling** in ship-borne GNSS processing.
- **RMS on ZTD goes from 1.3 mm to 3.6 mm** depending on the configuration used.
- Best configuration is **3° of cut-off angle, 5  $mm \cdot h^{-0.5}$  of random walk** on ZTD and **SQRTSIN weighting** function on elevation.

## OUTLOOK

- Apply the highlighted configuration to process the French Oceanographic Fleet GNSS data since 2015.

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