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# XXVI FIG Congress 2018

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# Improving Hydrographic PPP by Height Constraining

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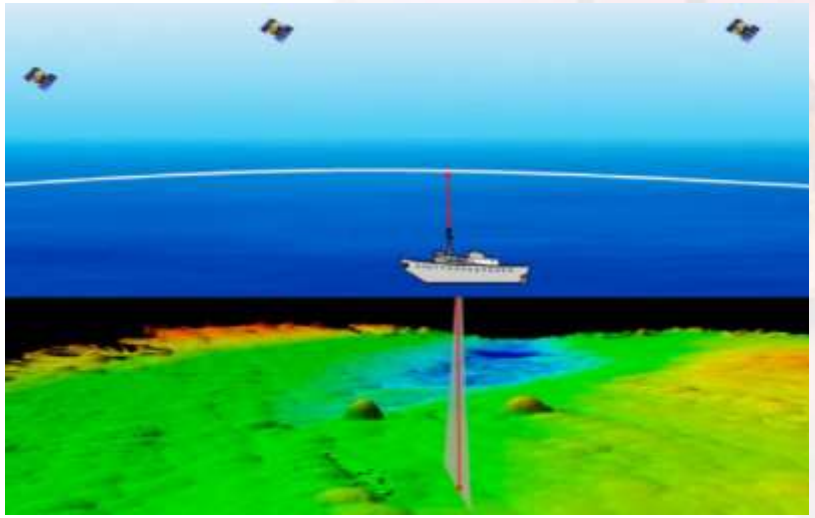
# Content

- Motivation
- Concept of PPP technique
- Bernese GNSS Software
- Experimental data
- Implementation and Evaluation
- Conclusions

# Motivation

- Hydrographic discipline is a major field of interest for positioning.

- Highly **accurate positioning** of the objects on the water resources assists on:
  - ✓ Plan, manage, and protect water resources
  - ✓ Monitor the water resource
  - ✓ Help on construction works
  - ✓ Assure the water resource for navigation
- Hydrographic survey includes:
  - ✓ **Point positioning** is obtained using GNSS technique.
  - ✓ **Water depth** is obtained using Echo-sounder.



[1]

- **GNSS point positioning technique**:

1. **Differential solution**:

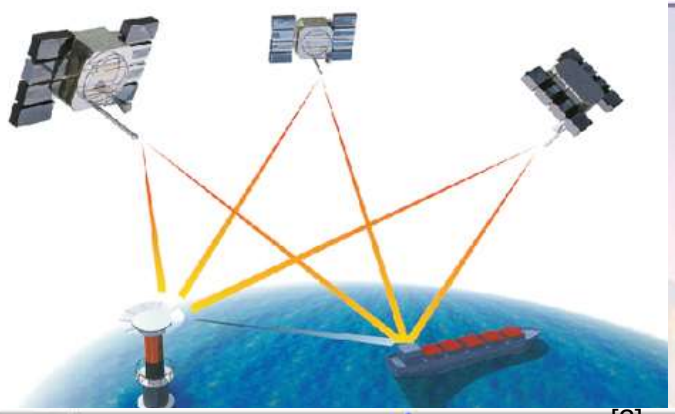
✓ Needs a known reference station

✓ Obtained by differencing the data between satellites and stations

2. **PPP solution**:

✓ No need to a reference station

✓ One dual frequency instrument



[2]

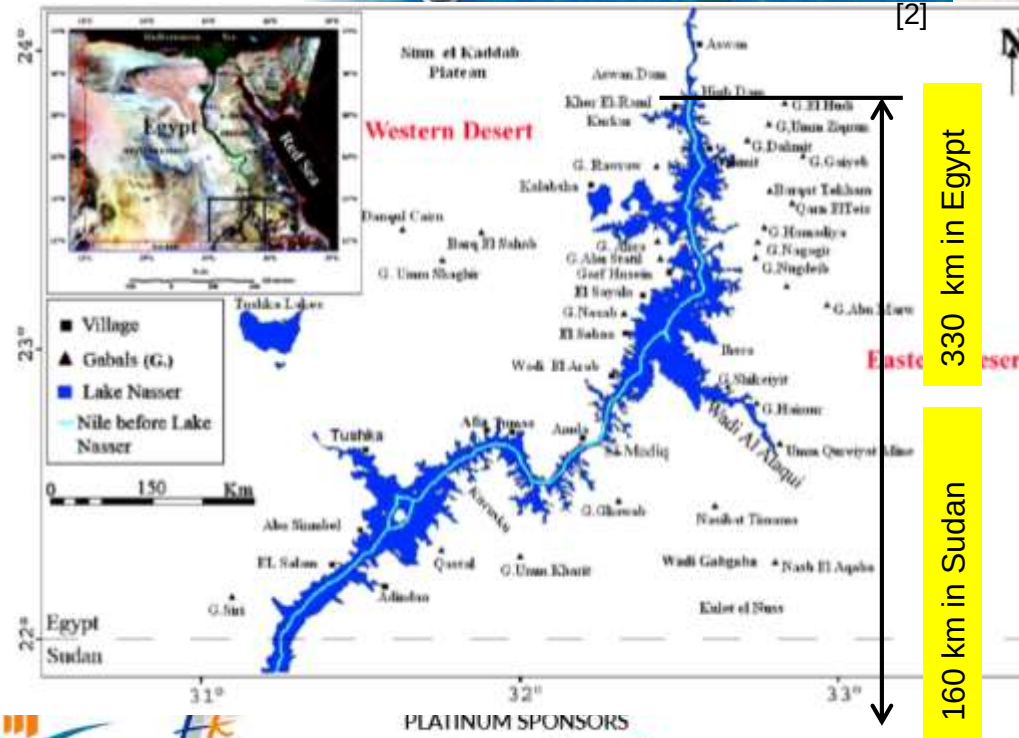
- **Egyptian Hydrographic survey**

✓ Monitor the sedimentation over the bed of Lake Nasser

✓ No reference station around Lake Nasser

✓ Lake Nasser extends for 330 km in Egypt and 160 km in Sudan

✓ PPP solution is a vital positioning solution in this case

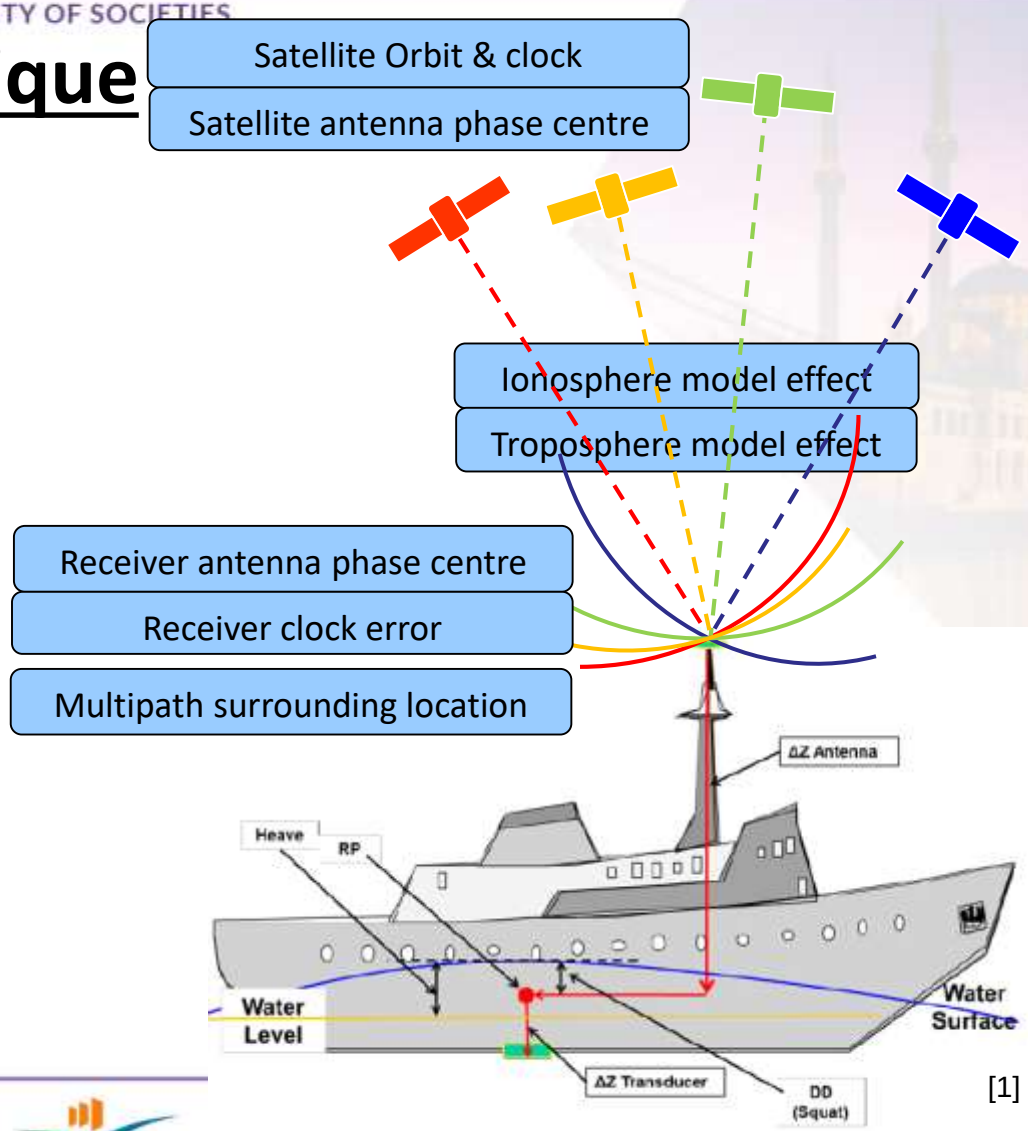



[3]

# Concept of PPP technique

**Four error** types have to be modelled or eliminated.

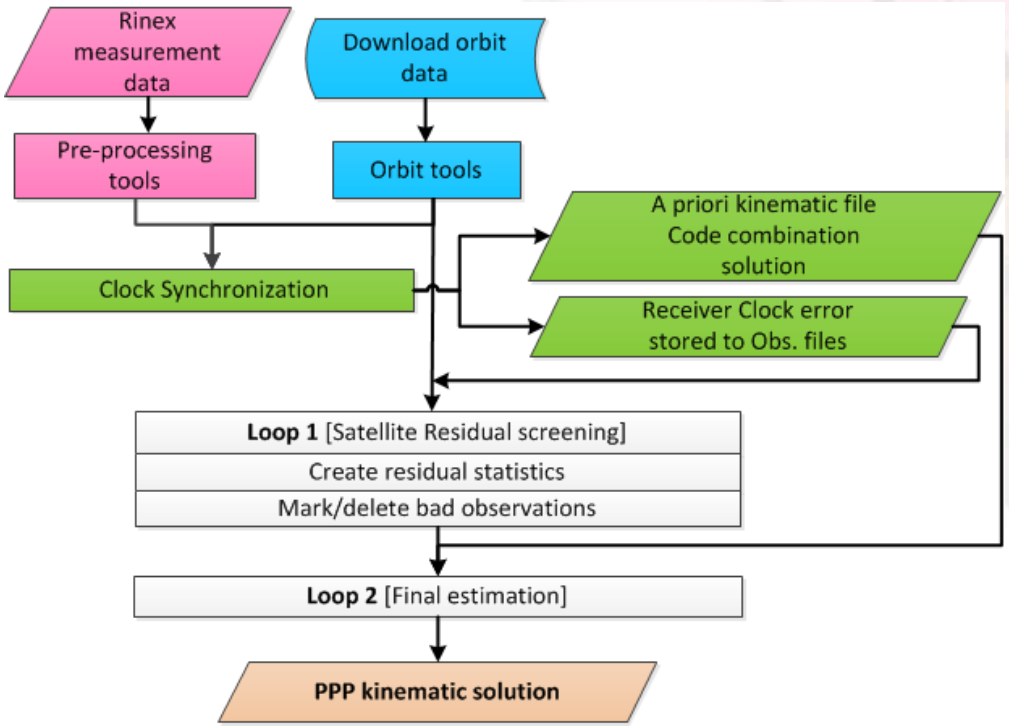
1. **Satellite dependent errors** [Satellite orbits, satellite clocks, and PCV for satellite antenna]
2. **Atmosphere errors** [Ionosphere and Troposphere]
3. **Receiver dependent errors** [Receiver clock error, PCV for receiver antenna, and multipath surround location]
4. **Geophysical errors** [solid earth tides, polar motion, ocean tide loading, and Earth rotation effect]



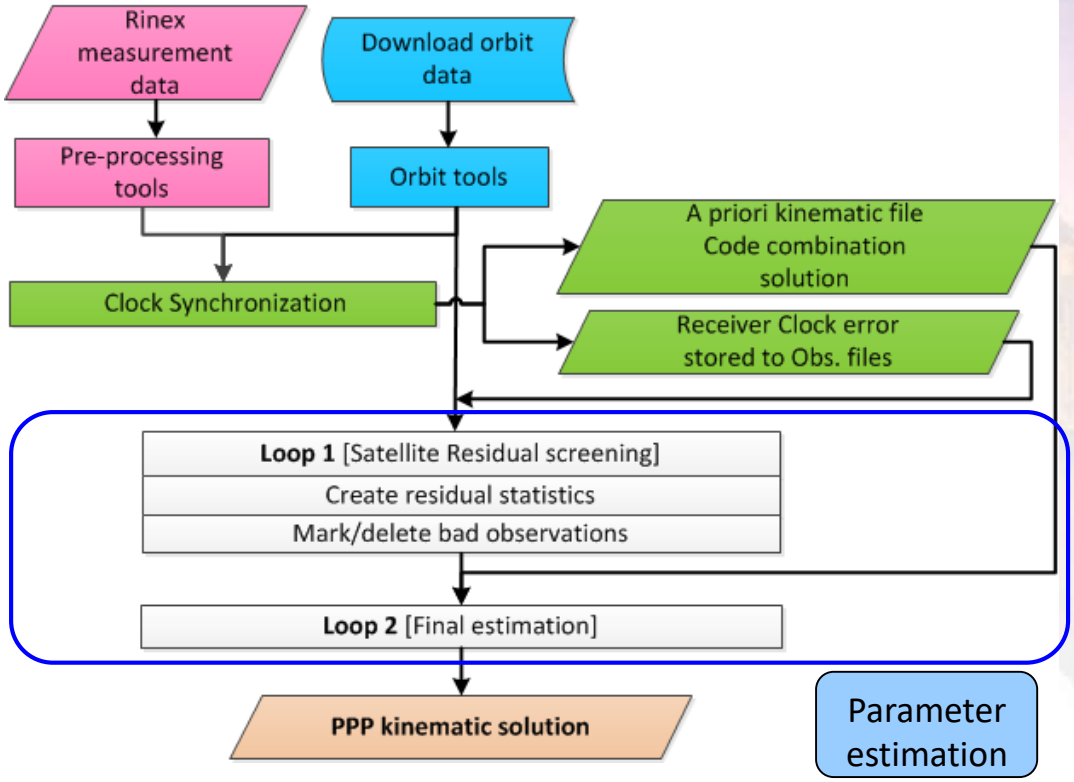

[1]

# Bernese GNSS Software

- **Bernese GNSS** software is a scientific, high quality geodetic software for post processing mode.
- It is developed at Astronomical Institute of the University of Bern (AIUB), Switzerland.
- It is used mainly by **CODE center** [Center for Orbit Determination in Europe].
- It process the observation data for **differential and PPP solution**.
- Satellite orbits and clocks and earth orientation parameter are downloaded from CODE ftp server.

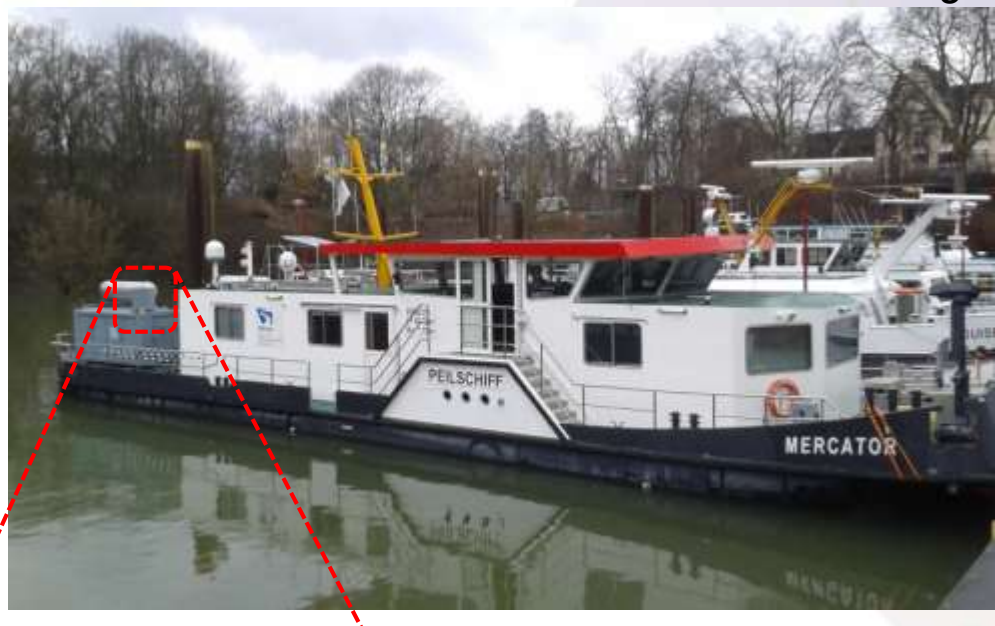


- **Orbit tools**: generate satellite clock in processing format and prepare standard orbit file
- **Pre-processing for RINEX files**: smooth data from outliers and convert data to binary format
- **Clock Synchronization**: Receiver cock error estimation and create a code combination a priori file
- **Parameter estimation**: using least square adjustment. Two Loops for estimation:



# Experimental data

- **Rhine River data [two trajectories]**

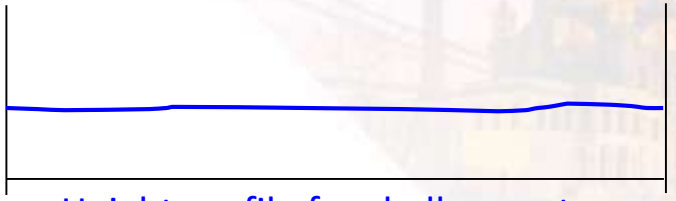

# Experimental data

- **Nile River data [One trajectory]**

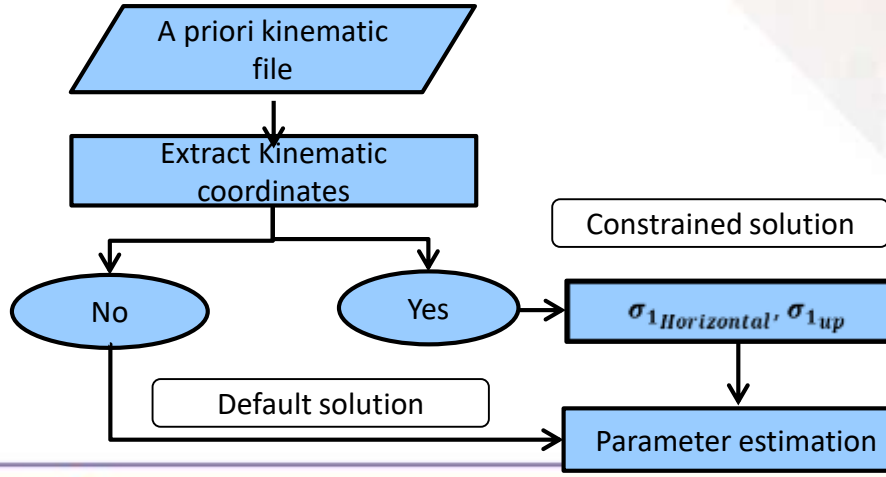

# Implementation and Evaluation

- **Land height profile** is varying during moving.
- **Hydrographic survey** has the advantage that theoretically the water level is stable or varied with a small range.
- **The idea of height constraining comes from this concept to improve the 2D positions of kinematic PPP solution.**
- **Height constraining** is carried using **Bernese software.**

Height profile for land

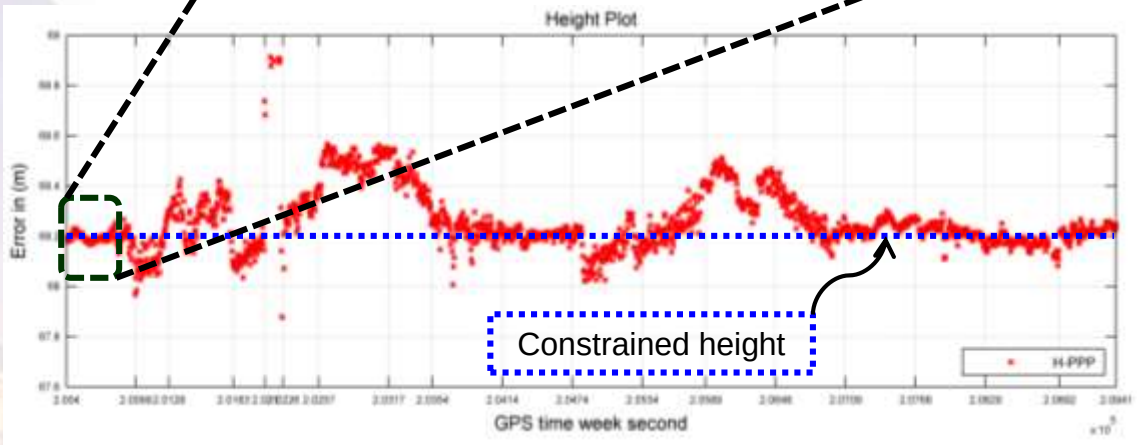


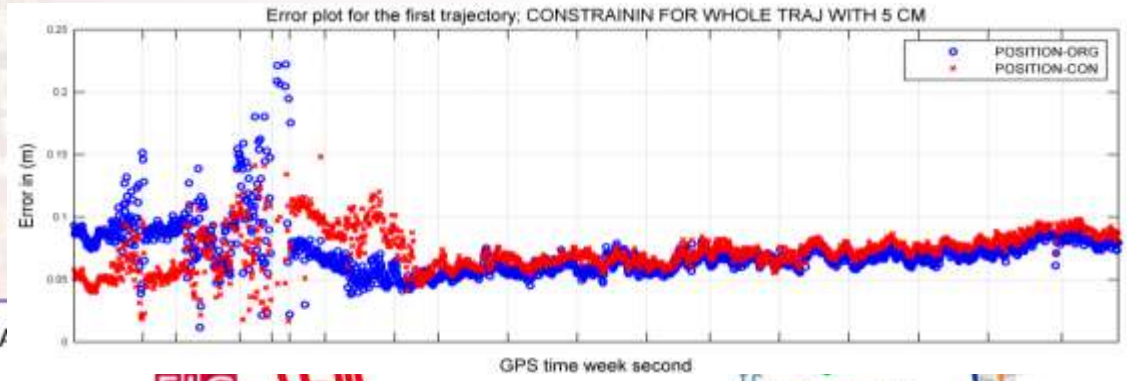
Height profile for shallow water resource



HOW IT WORKS

## ➢ Assumption of stability of water level



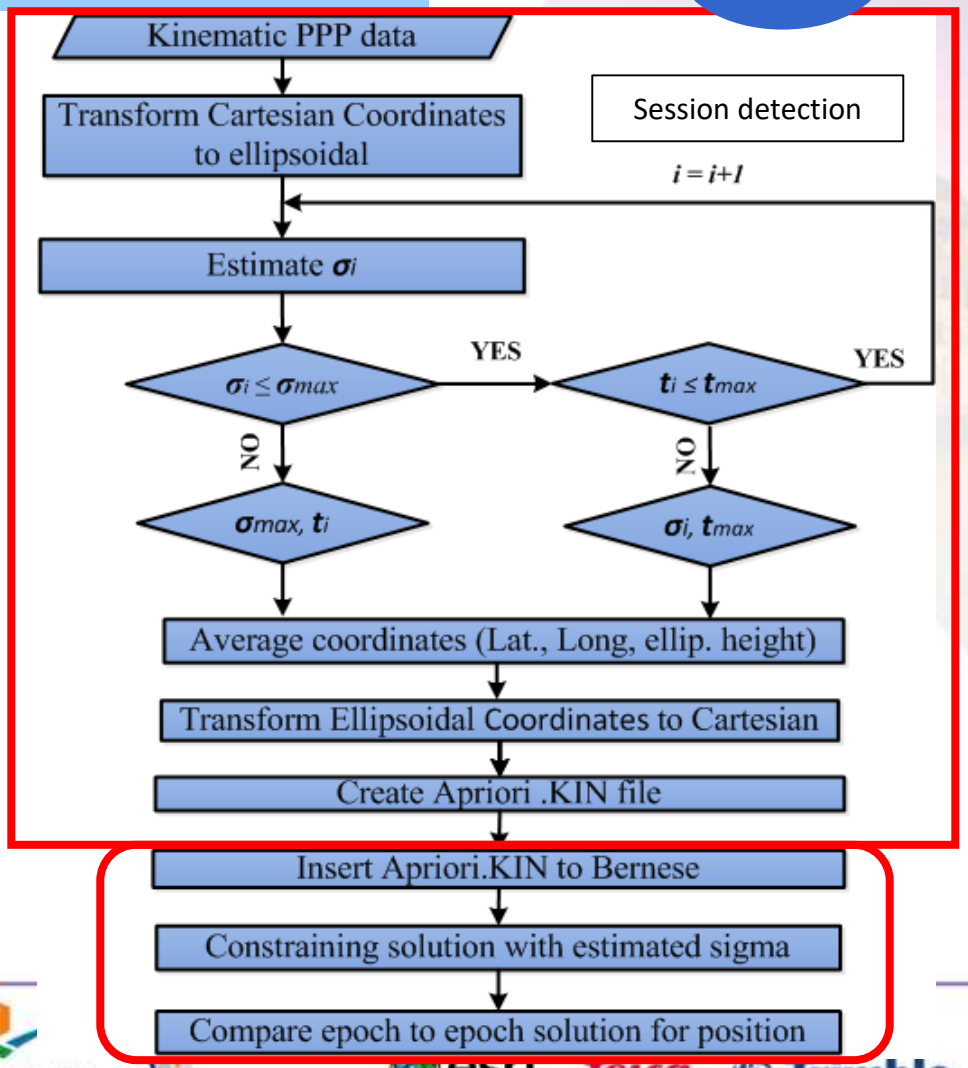

Average 10 minuts (Lat., Long, ellips. height) → Transform to Cartesian → Create Apriori .KIN file → Insert created .KIN to Bernese → Constraining solution with defined sigma → Compare epoch to epoch solution for position

- ✓ Trajectory has a constant height.
- ✓ $\sigma$ = 5 cm
- ✓ No improvement in $2D_{position}$

HOW IT WORKS

## ➢ Assumption of piecewise stability of water level

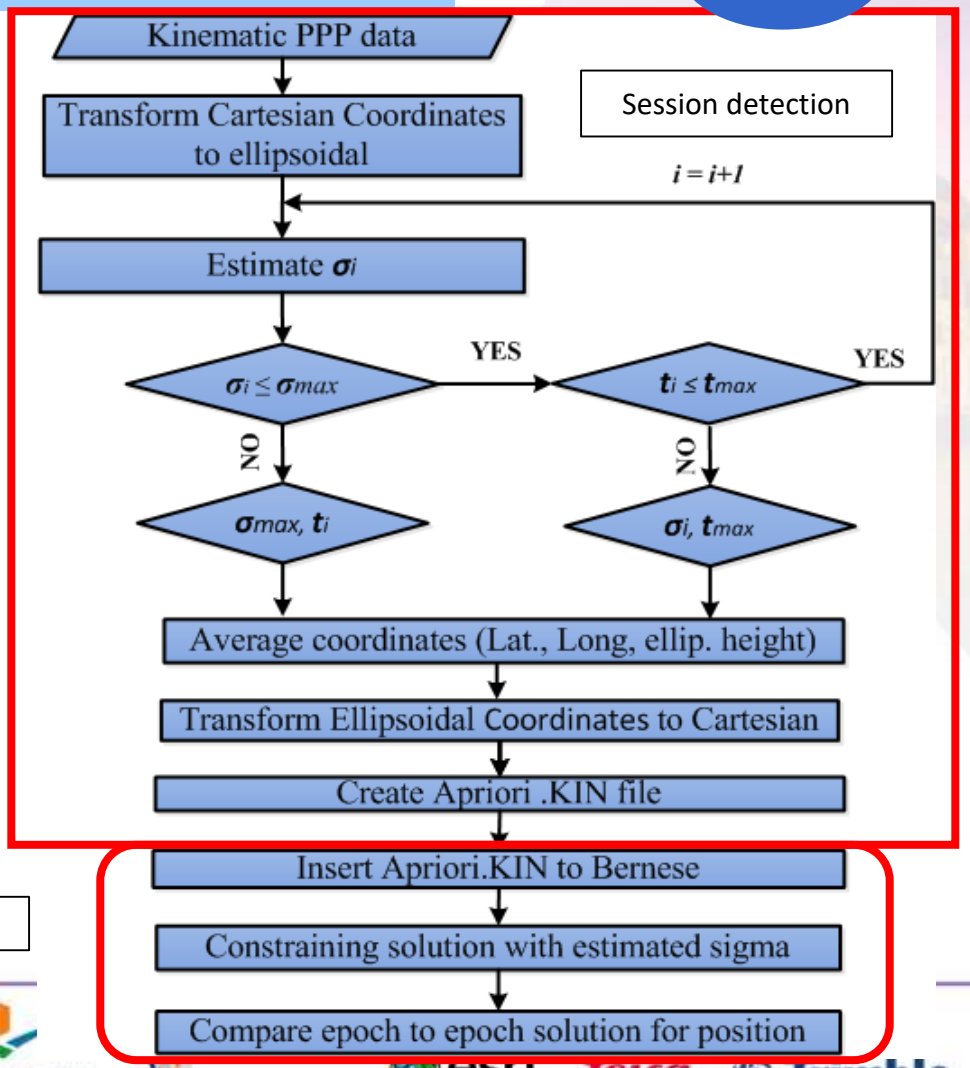
- A **new implementation** by considering different heights for the trajectory [piecewise stability]+ different ($\sigma$) for variation.
- **Automatic detection** for piecewise sessions
  - ✓ Insert default PPP kinematic file.
  - ✓ Transform Cartesian coordinates to ellipsoidal.
  - ✓ Define the max. length of each session ($t_{max}$) and maximum ($\sigma$) for height constraining ($\sigma_{max}$).
  - ✓ Check $\sigma_i$ if No take ($\sigma_{max}, t_i$).
  - ✓ Check $t_i$ if NO take ($\sigma_i, t_{max}$).



HOW IT WORKS

## ➢ Assumption of piecewise stability of water level

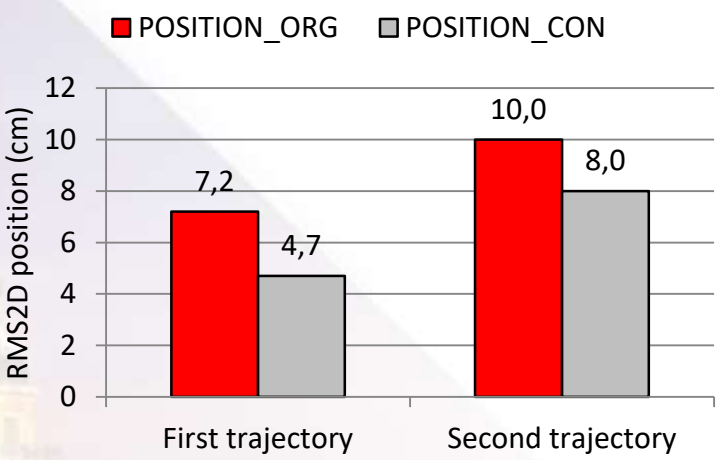
- Automatic detection for piecewise sessions
  - ✓ Take the average (Lat., Long., h)
  - ✓ Transform ellipsoidal coordinates to Cartesian.
  - ✓ Create a priori kinematic file.
  - ✓ Insert the new created kinematic file to Bernese software.
  - ✓ Insert $\sigma_i$ for each session in height component.
  - ✓ Compare the constrained coordinates in $2D_{position}$ with double-difference solution.



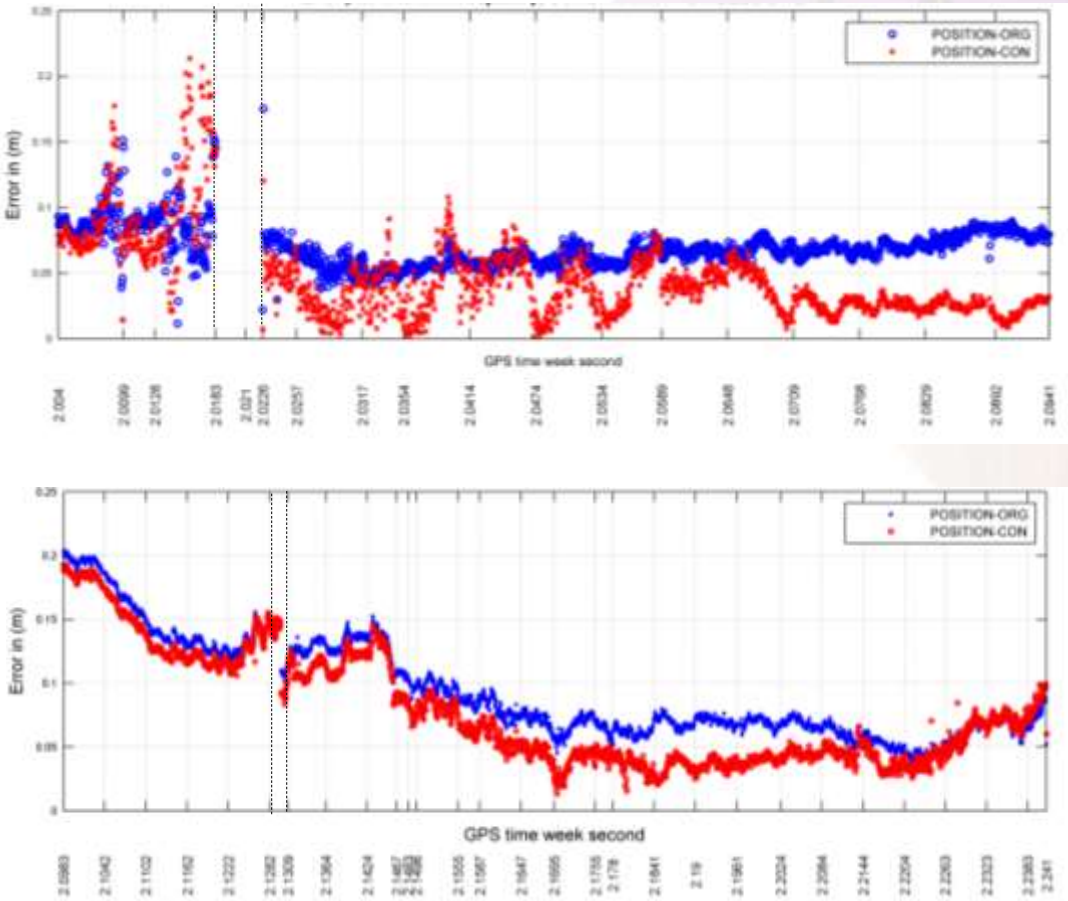
HOW IT WORKS



# ➢ Assumption of piecewise stability of water level

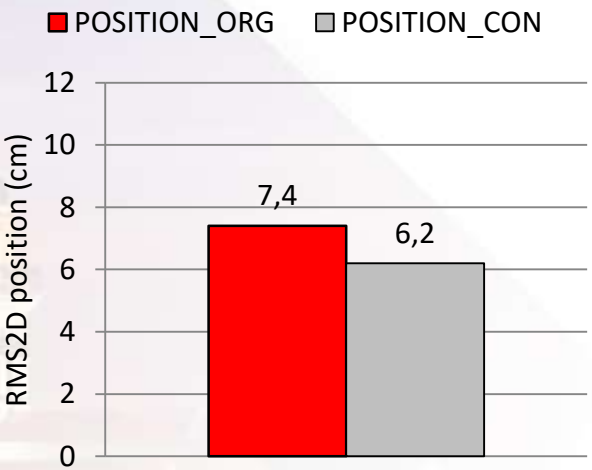



**RMS2D position (cm)**

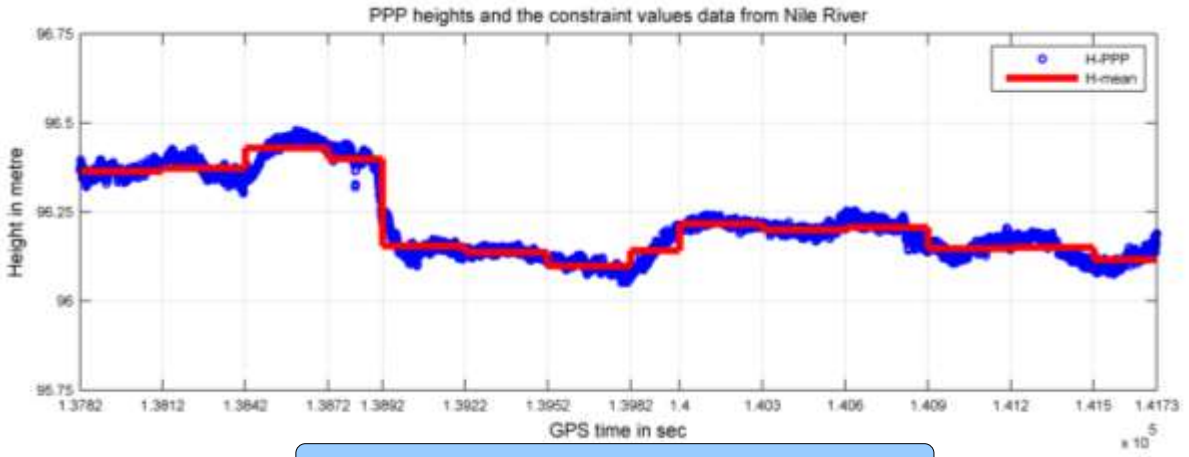


# ➢ Assumption of piecewise stability of water level

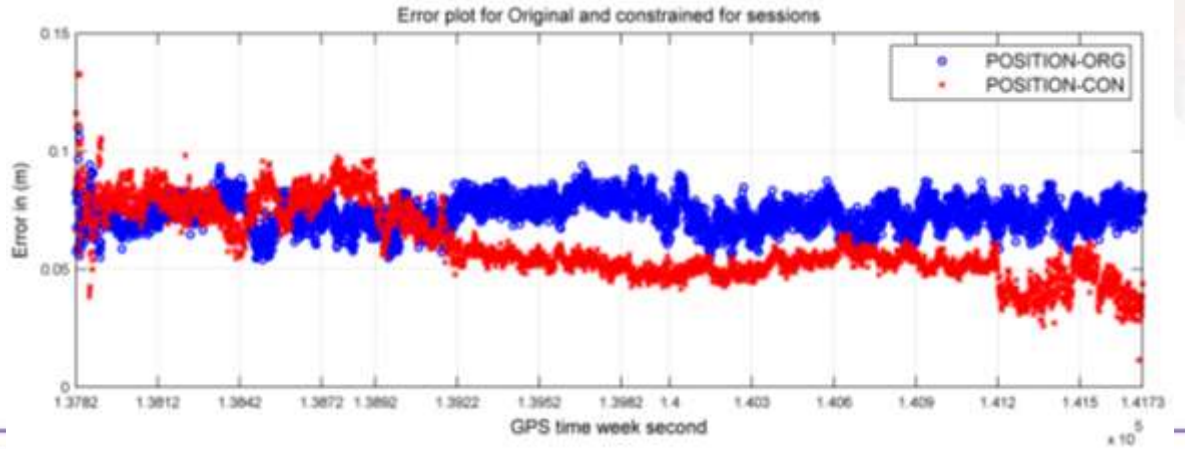
- OneTrajectory [Nile River]
- $t_{max}$= 10 min
- $\sigma_{1max}$= 4 cm
- 14 sessions




RMS2D position (cm)




Default PPP and constrained height profile



# Conclusions

- Concept of **stability of water level** did not provide any improvement for 2Dposition.
- **Piecewise stability** of the height delivered an effective procedure to improve the 2Dposition.
  - ✓ **Rhine River: 20% - 35%**
  - ✓ **Nile River: 16%**

# Thank you for your attention!

# References


- [1]: Mills, J., Dodd, D. (2014): FIG Publication No. 62: Ellipsoidally Referenceed Surveying for Hydrography. Denmark: The International Fedration of Surveyors (FIG).
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