Leveraging inland radar altimetry over rivers with low cost GNSS reflectrometry

Roelof Rietbroek, Zeleke Challa, Calvince Wara, Michael Kizza

RIVFLECT
EO AFRICA
Research Project

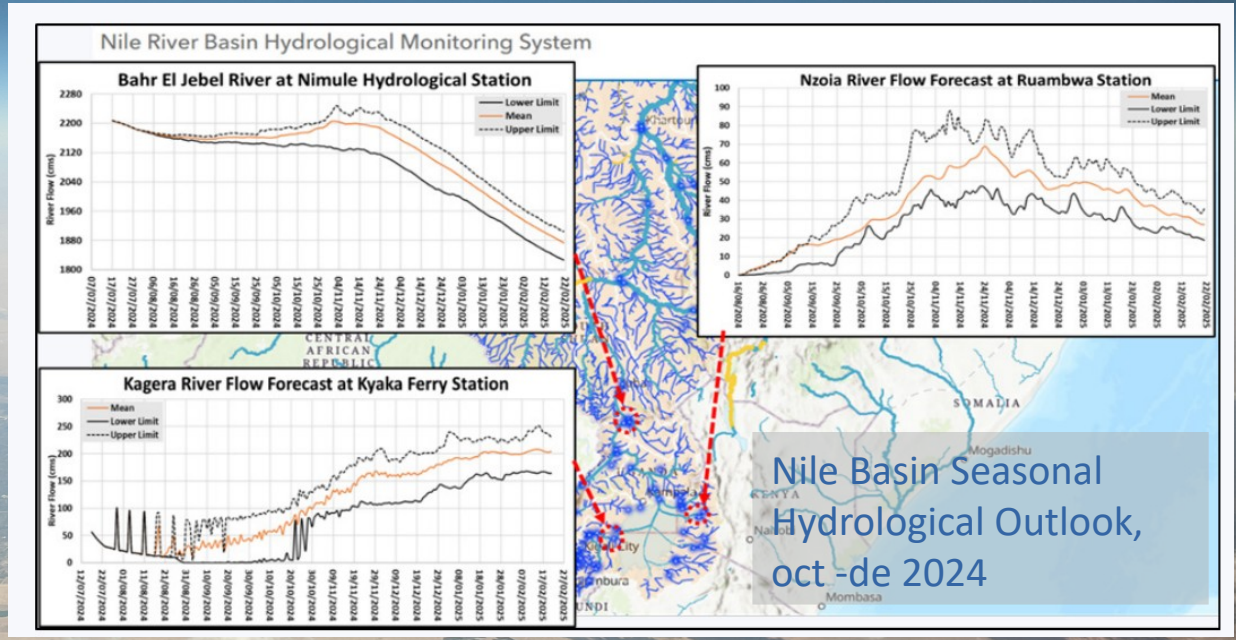
UNIVERSITY OF TWENTE.

blueskys
drstrawpants.wobbly.earth

Roelof Rietbroek
Water Resources Department
Faculty of Geo-Information Science and Earth Observation

Leveraging inland radar altimetry over rivers with low cost GNSS reflectrometry

Roelof Rietbroek, Zeleke Challa, Calvince Wara, Michael Kizza



NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

UNIVERSITY OF TWENTE.

ITC

blueskys
drstrawpants.wobbly.earth

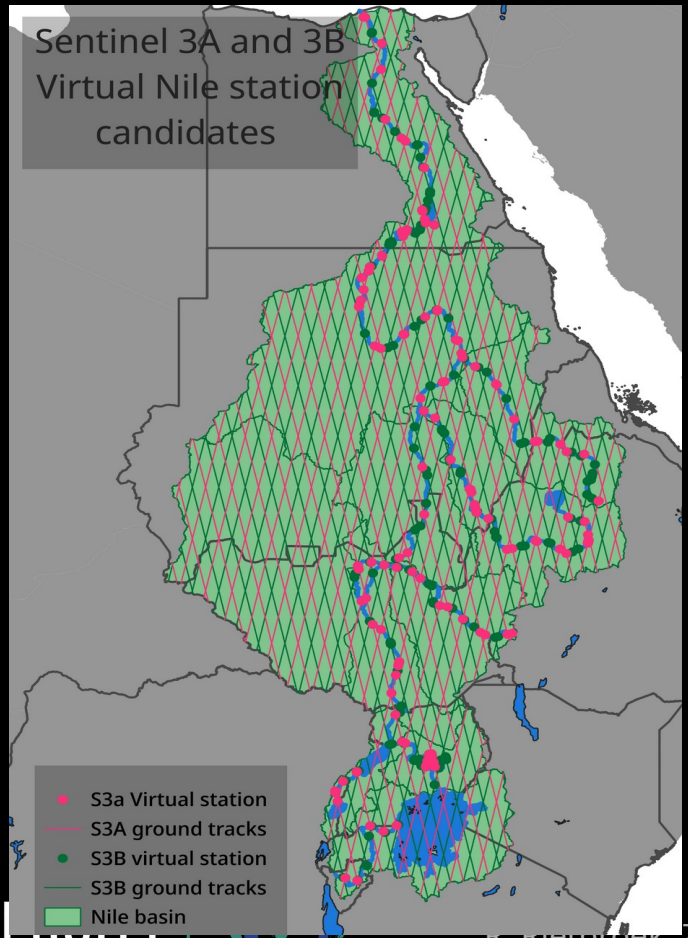
Roelof Rietbroek
Water Resources Department
Faculty of Geo-Information Science and Earth Observation

ESA EO AFRICA R&D facility RIVFLECT Pilot

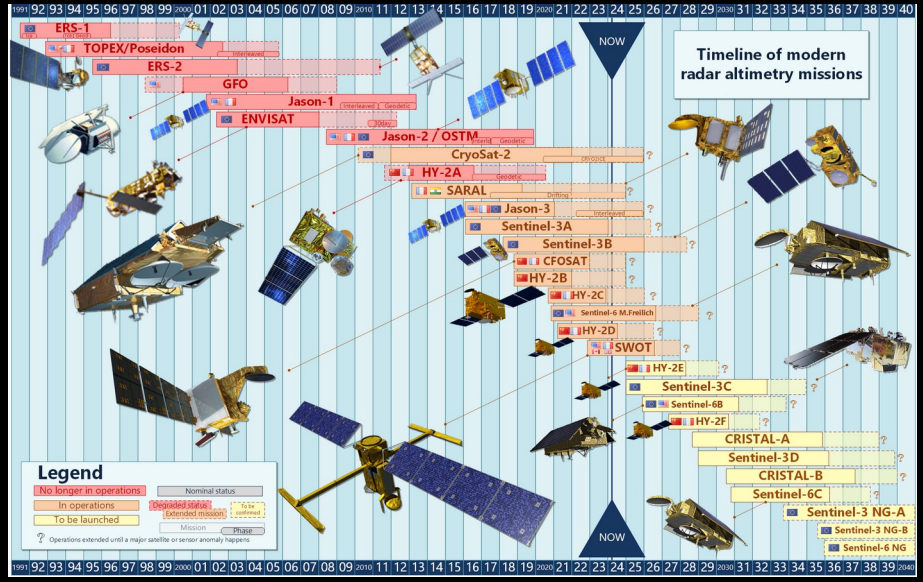
- 1 year sub-research project (2023-2024) within EO Africa R&D facility to explore possibilities of using GNSS-IR in Nile Basin for radar altimetry validation
- Goals
  - Pilot low-cost GNSS-IR in Nile Basin
  - Validate radar altimetry derived water heights
  - Provide open source tools/materials to work/build GNSS-IR receivers

Activity on github:
https://github.com/ITC-Water-Resources/gnssr4water
https://github.com/ITC-Water-Resources/gnssr-raspberry
https://github.com/ITC-Water-Resources/actinius-gnssr

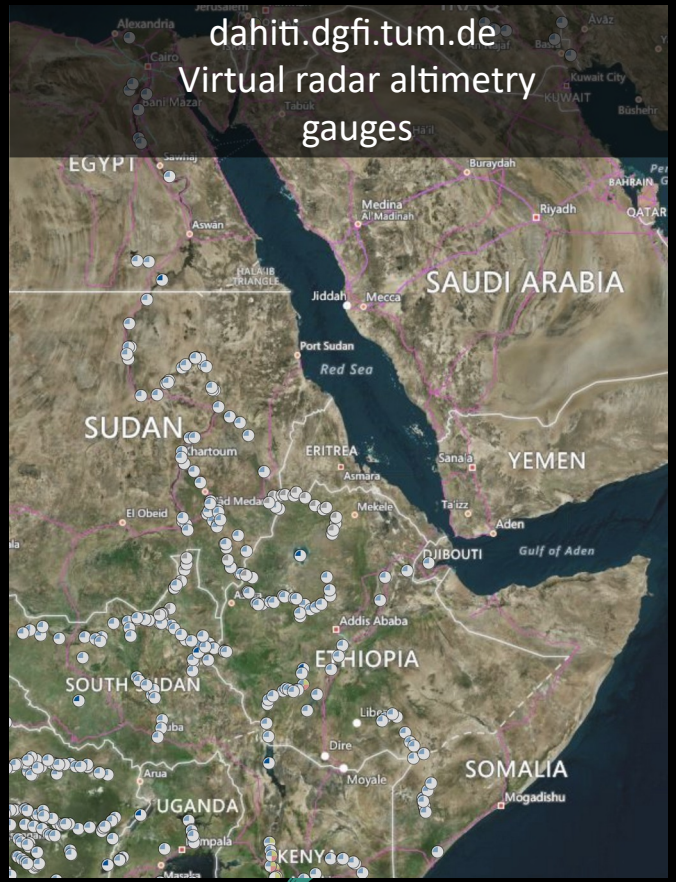
Inland Radar Altimetry



- Radar altimeters can potentially gauge the Nile at various locations (virtual gauges)
- But processing is not trivial

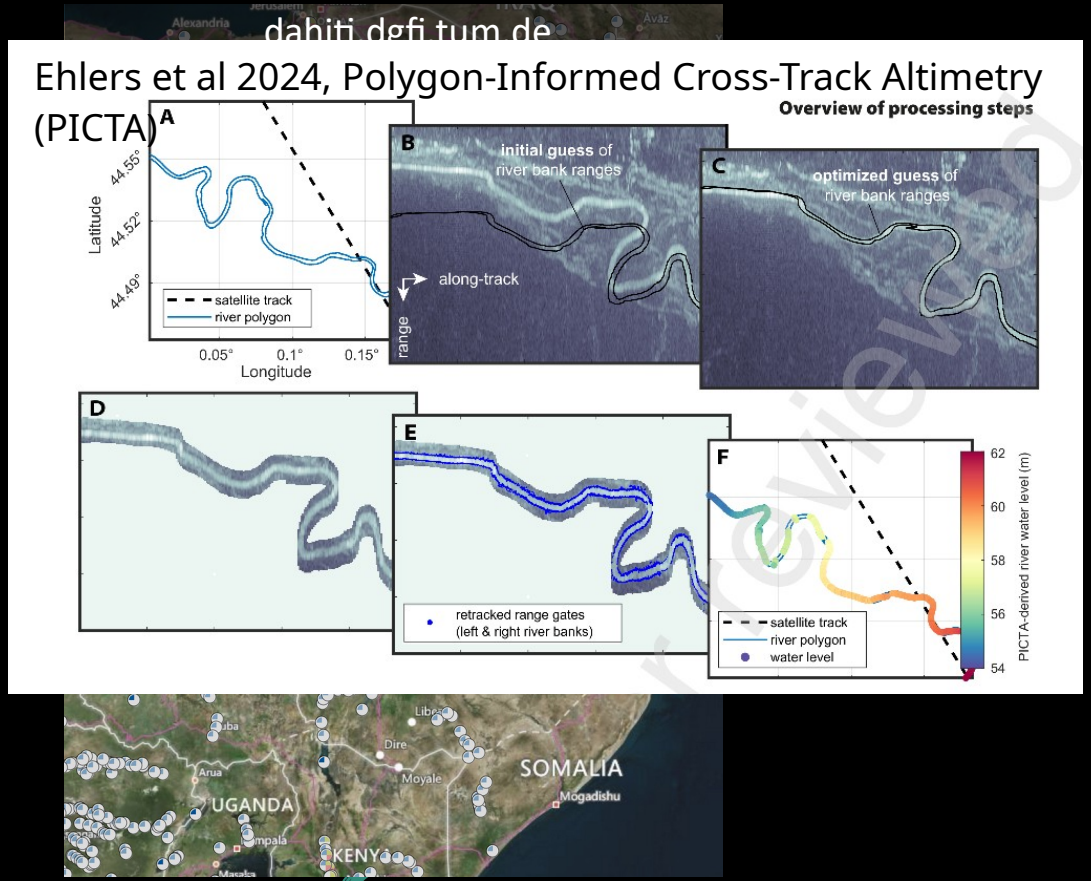


Inland Radar Altimetry developments



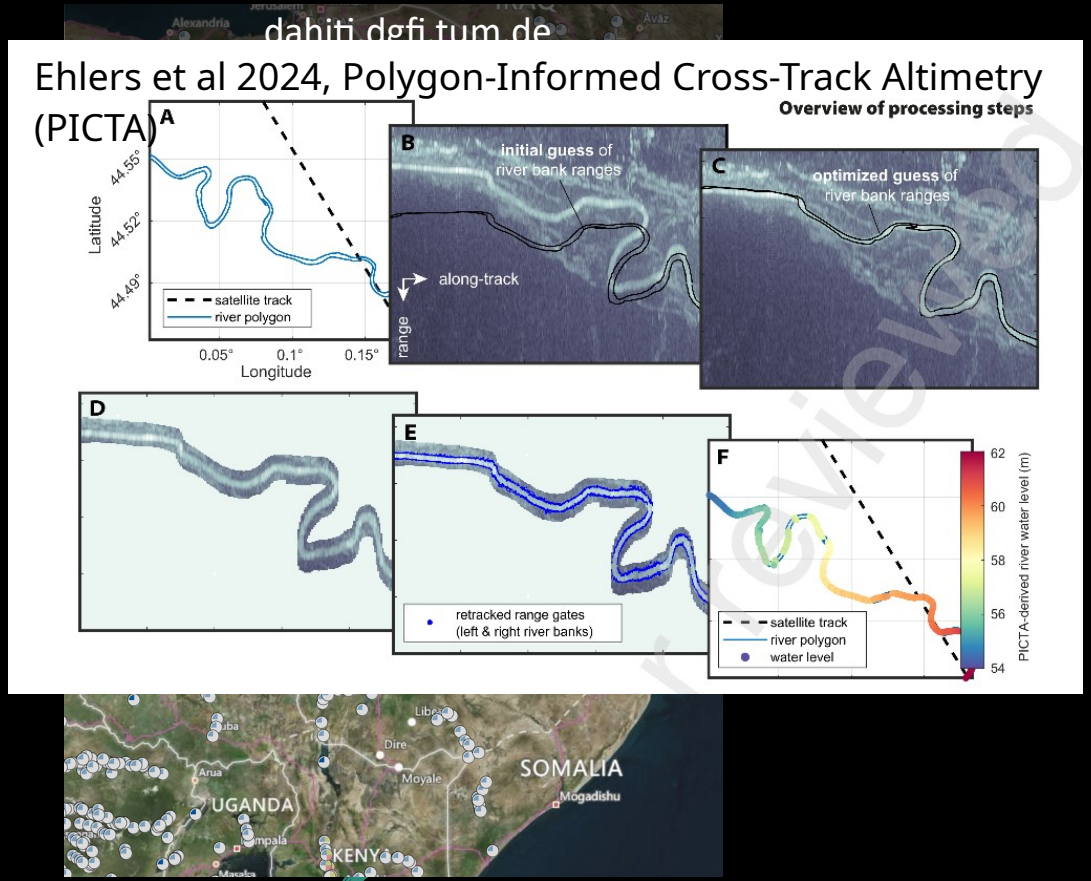
- Portals with processed altimetry data exist (e.g. dahiti, hydroweb)

Inland Radar Altimetry developments



- Portals with processed altimetry data exist (e.g. dahiti, hydroweb)
- But a lot of hidden treasures (slopes) still to be found in SAR altimetry data

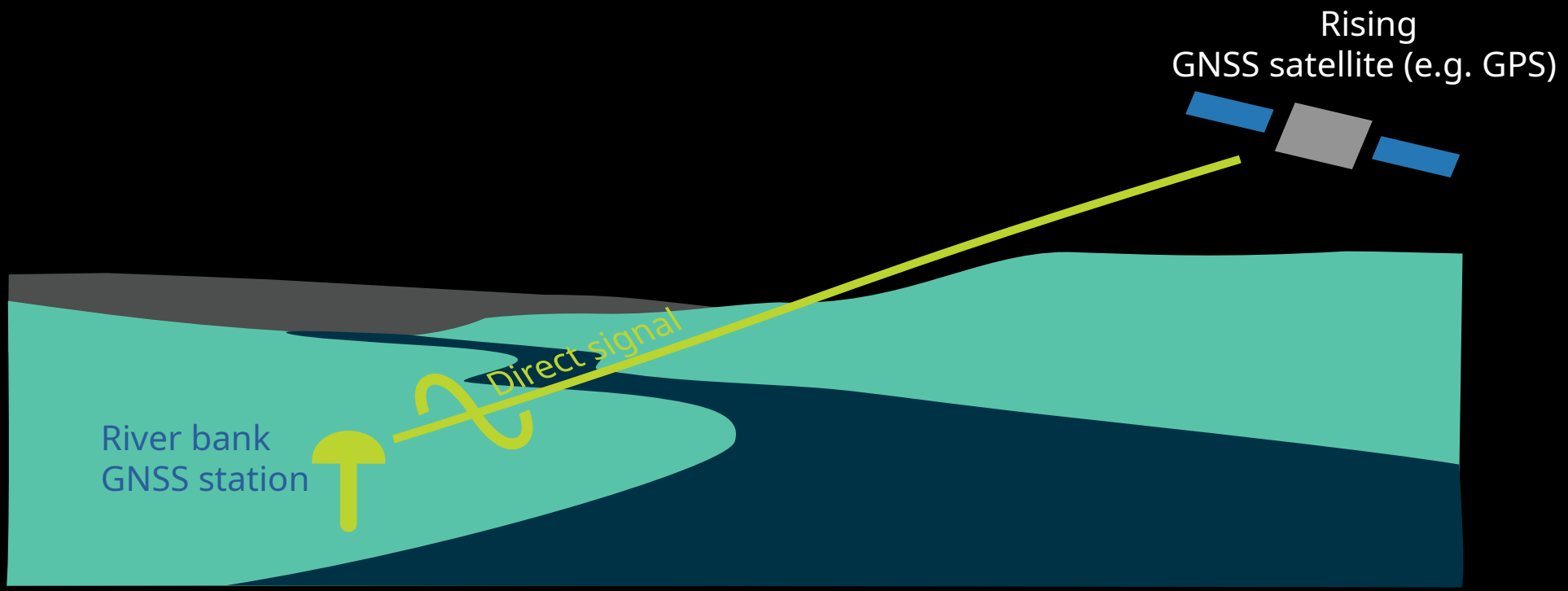
Inland Radar Altimetry developments



- Portals with processed altimetry data exist (e.g. dahiti, hydroweb)
- But a lot of hidden treasures (slopes) still to be found in SAR altimetry data
- Needed: a low-cost and portable way to measure river stage..

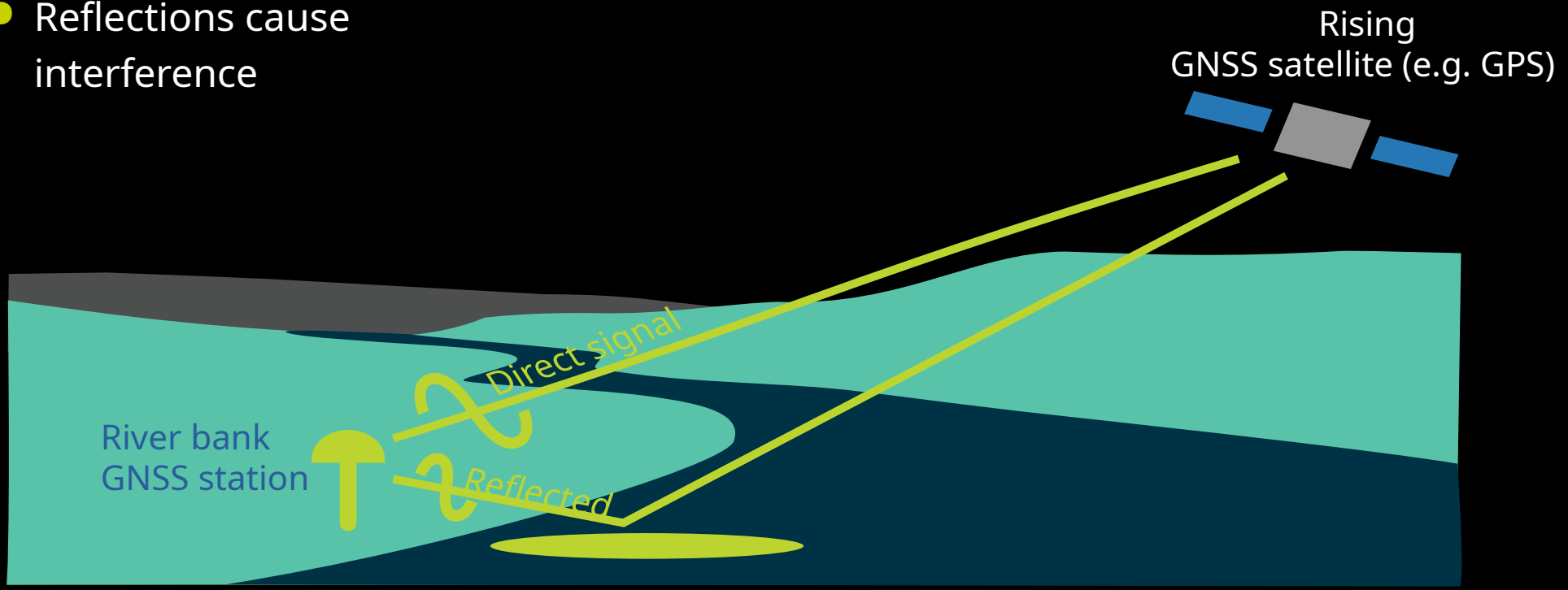
GNSS (interferometric) reflectometry?

- Rising/setting satellites



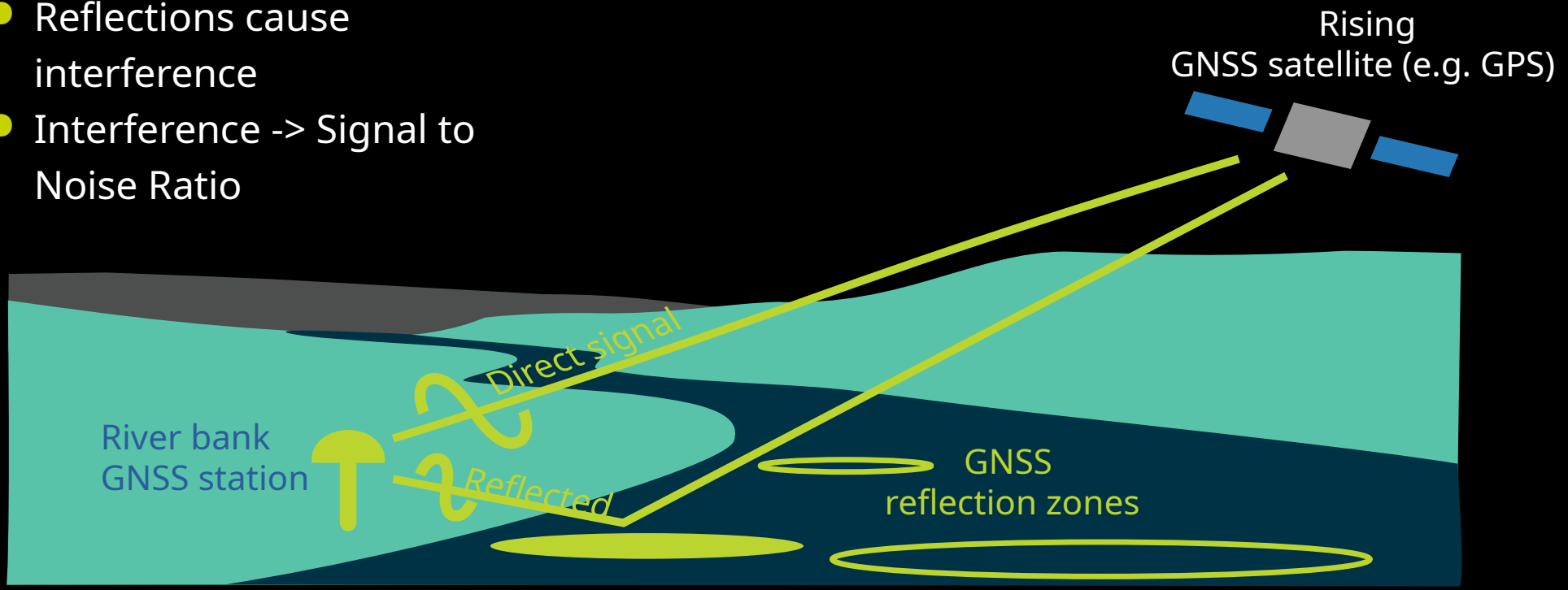
GNSS (interferometric) reflectometry?

- Rising/setting satellites
- Reflections cause interference



GNSS (interferometric) reflectometry?

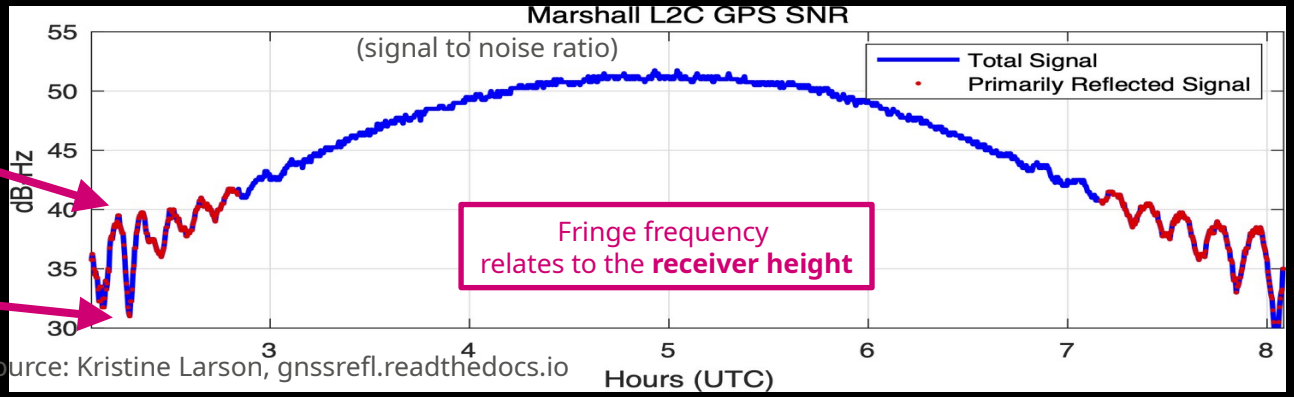
- Rising/setting satellites
- Reflections cause interference
- Interference -> Signal to Noise Ratio



Signal to noise ratio?

Reflection **enhances** direct signal

Reflection **attenuates** direct signal



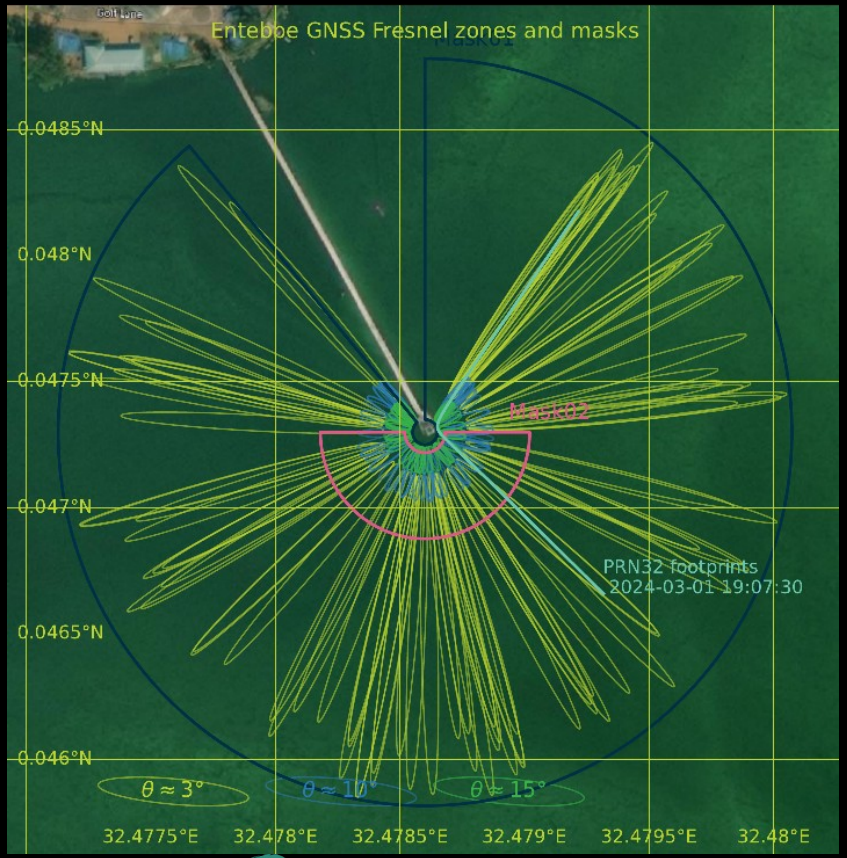
Source: Kristine Larson, gnssrefl.readthedocs.io

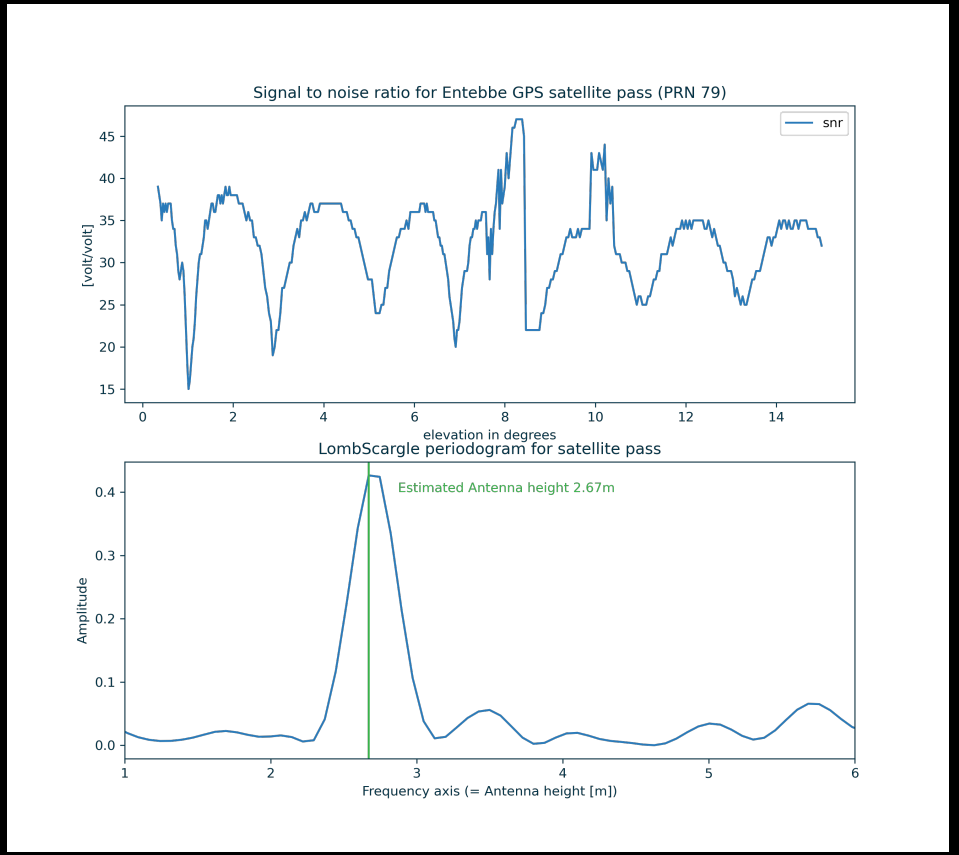
$$SNR(e) = A(e)\left(\sin\frac{4\pi h_r}{\lambda}\sin e + \phi\right)$$

$$= A(e)\left(\sin 2\pi \tilde{f} x + \phi\right), \quad x = \sin e$$

$$h_r = \frac{1}{2}\tilde{f}\lambda$$

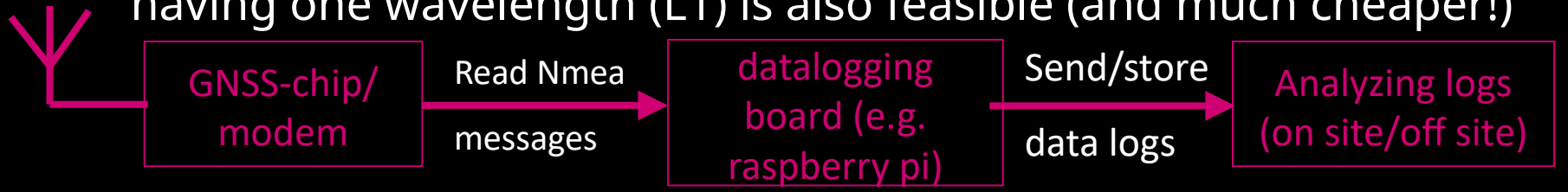
Fringe frequency → antenna height

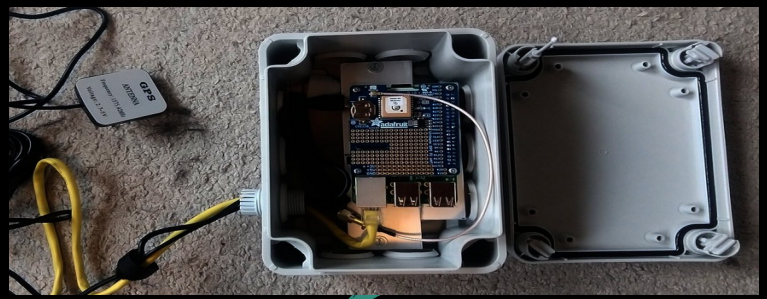




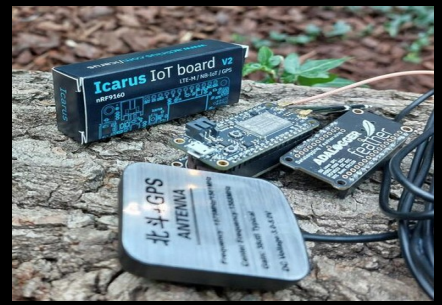
Building a low-cost GNSS reflectometer

- Satellite Signal to Noise Ratio is logged in even the cheapest GNSS chips!
- Geodetic-grade GNSS receivers are preferred (include L1 & L2) but having one wavelength (L1) is also feasible (and much cheaper!)

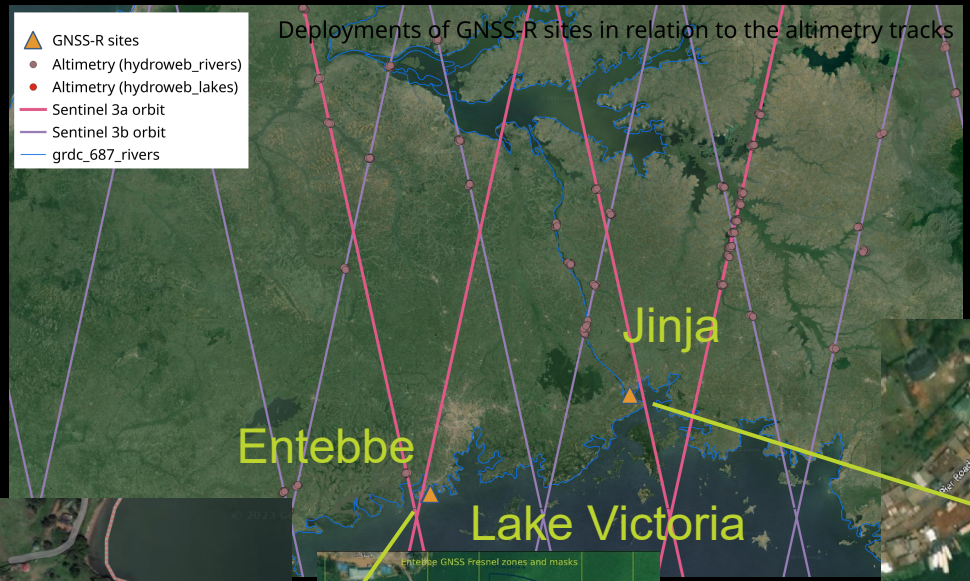


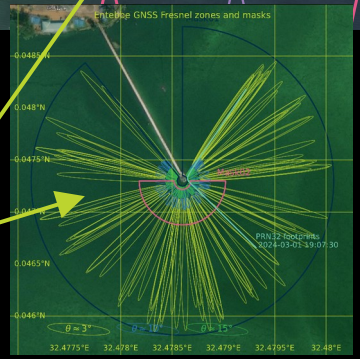


Different setups provide this functionality:
Raspberry pi's, Actinius Icarus (LTE-M connectivity), …

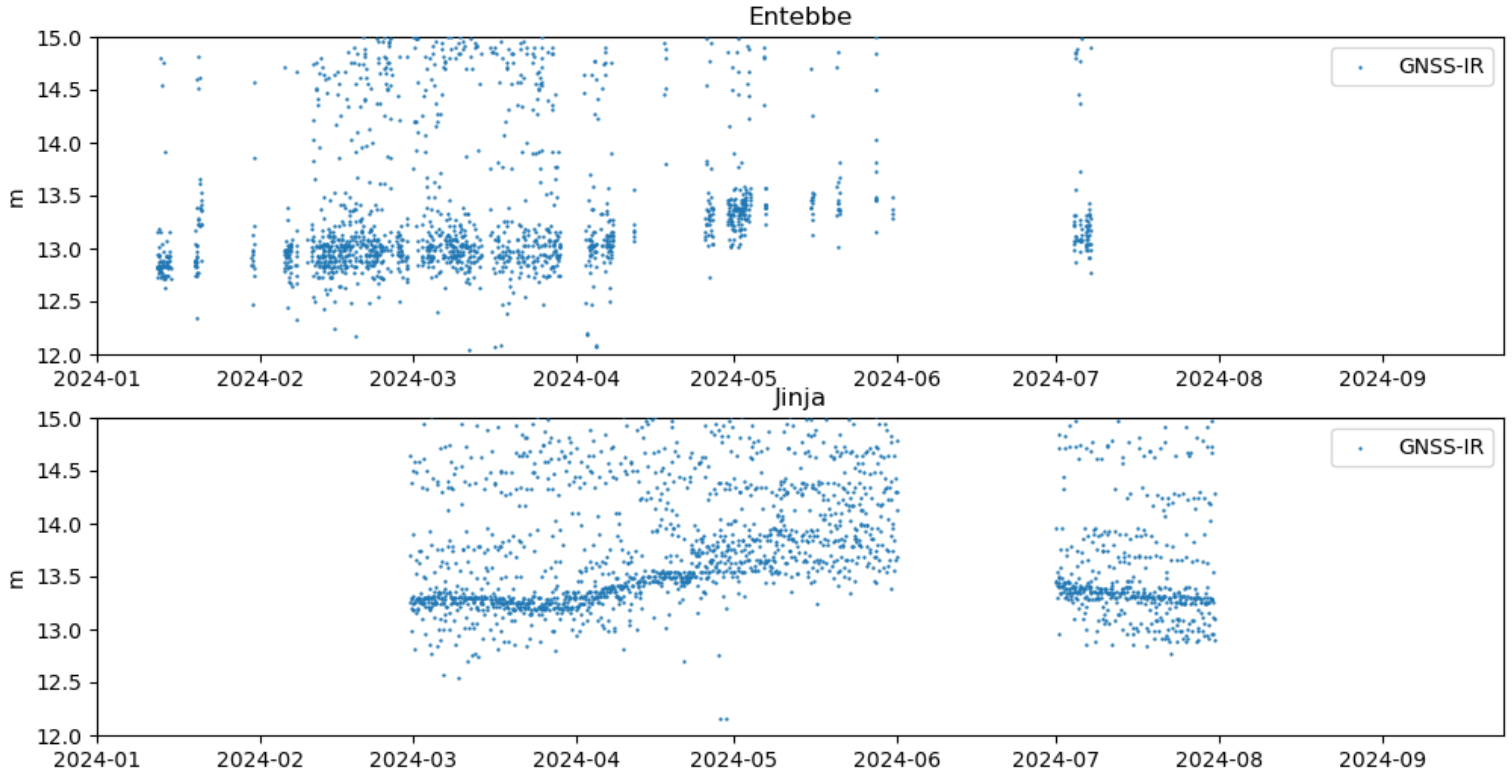


Deployments (Entebbe & Jinja)

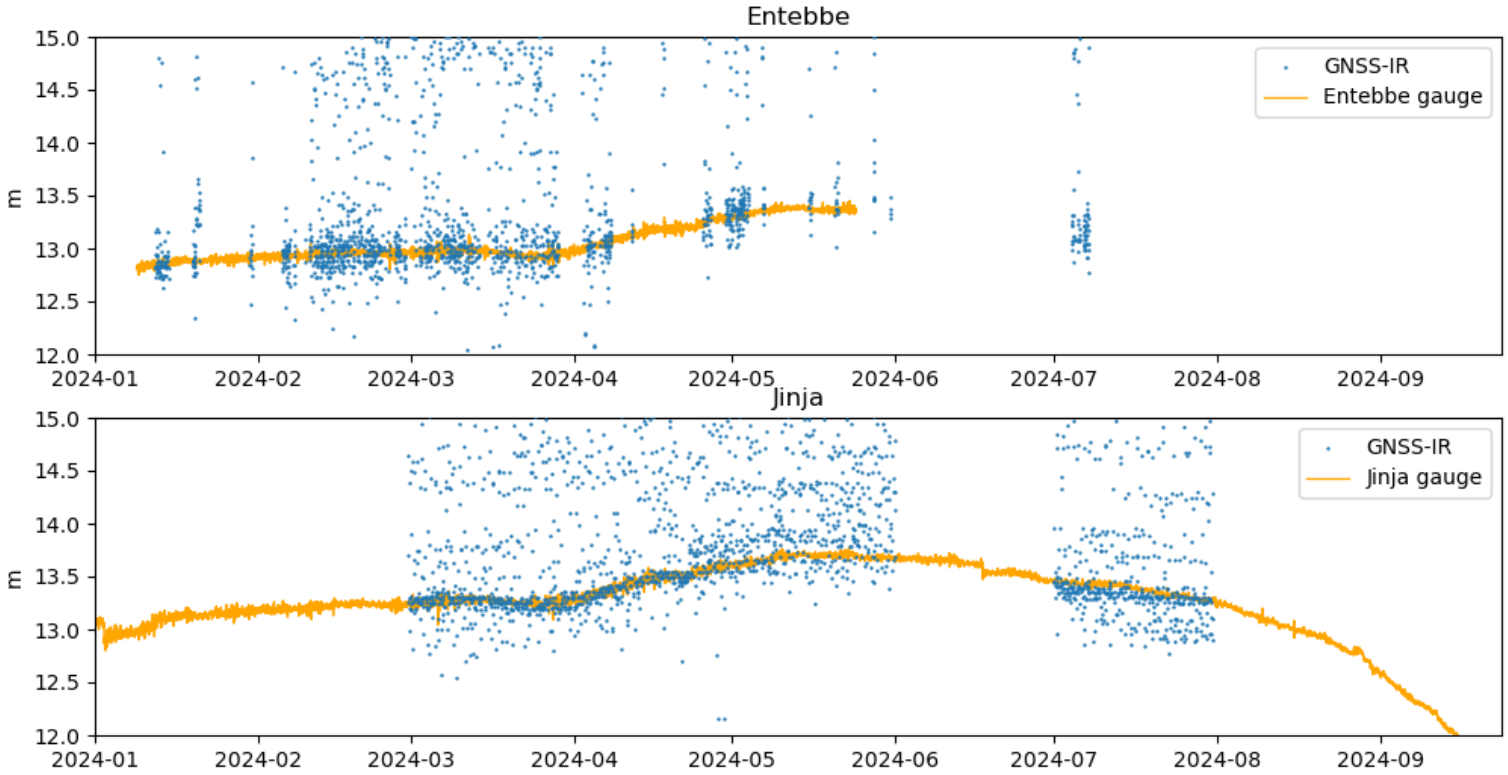




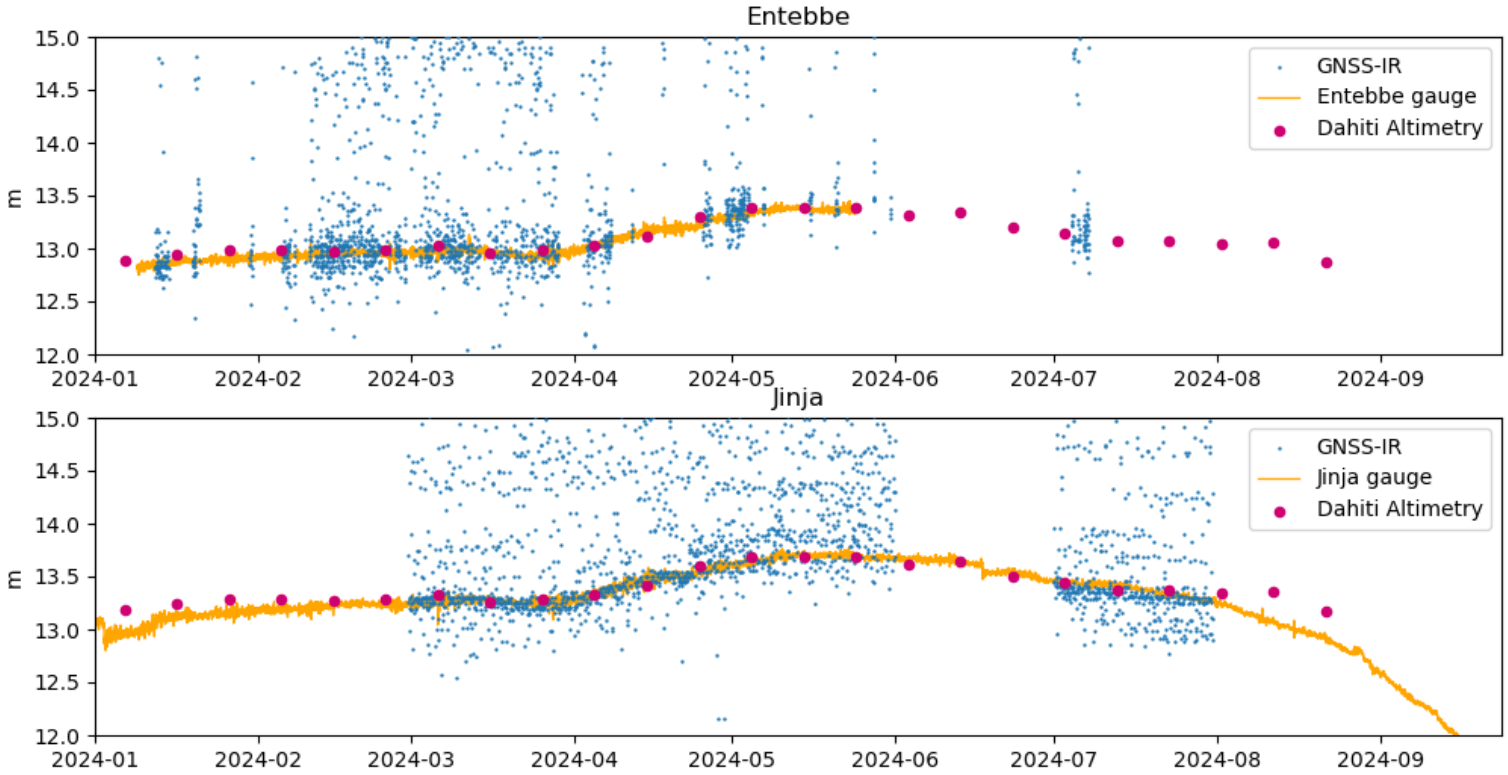
GNSS IR results



GNSS IR results with Gauge



GNSS IR results with Gauge and radar altimetry



Summary & outlook

- 2 Pilot low-cost GNSS-IR sites deployed on Lake Victoria (Entebbe & Jinja) ~€100
- Water levels influenced by bad reflection , but clear water level signals are appearing which are visible in gauge data and altimetry
- Outlook:
  - Better masks (fewer but better reflections)
  - Deploy more devices at rivers
  - On board processing
  - Enable a LTE-raspberry version for real-time heights