Introduction

- NLR – Netherlands Aerospace Centre
- ASTRON – Netherlands Radio Astronomy Institute
- ESA European GNSS Evolutions Programme (EGEP ID 89.08)

- Team

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Two ideas

1. Improve TEC observations for GNSS corrections (spatial resolution, temporal resolution)

2. Improve LOFAR using GNSS observations (calibration of outer LOFAR stations)

Experiment

- To what level can LOFAR measure the ionosphere?
- Claim: 0.01 TECU (*relative*)

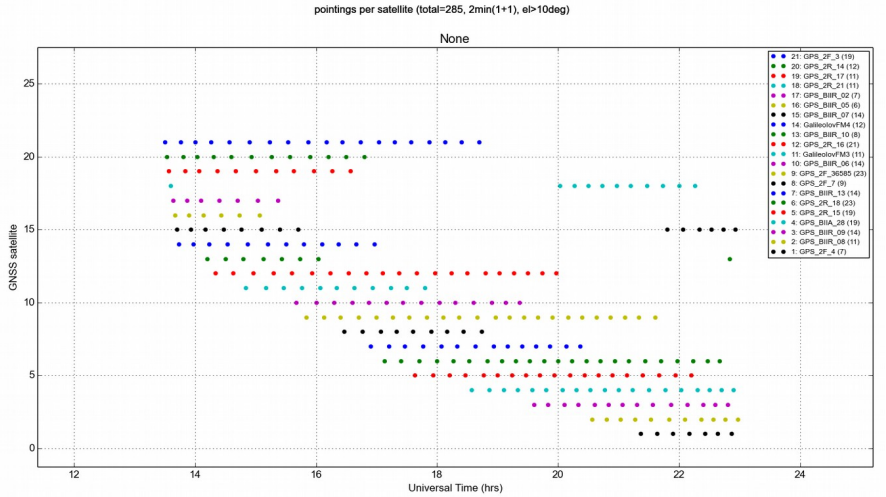
- Approach: parallel observations
- Install dual-frequency GNSS receivers
- “Track” a GNSS satellite
- Measure slant TEC

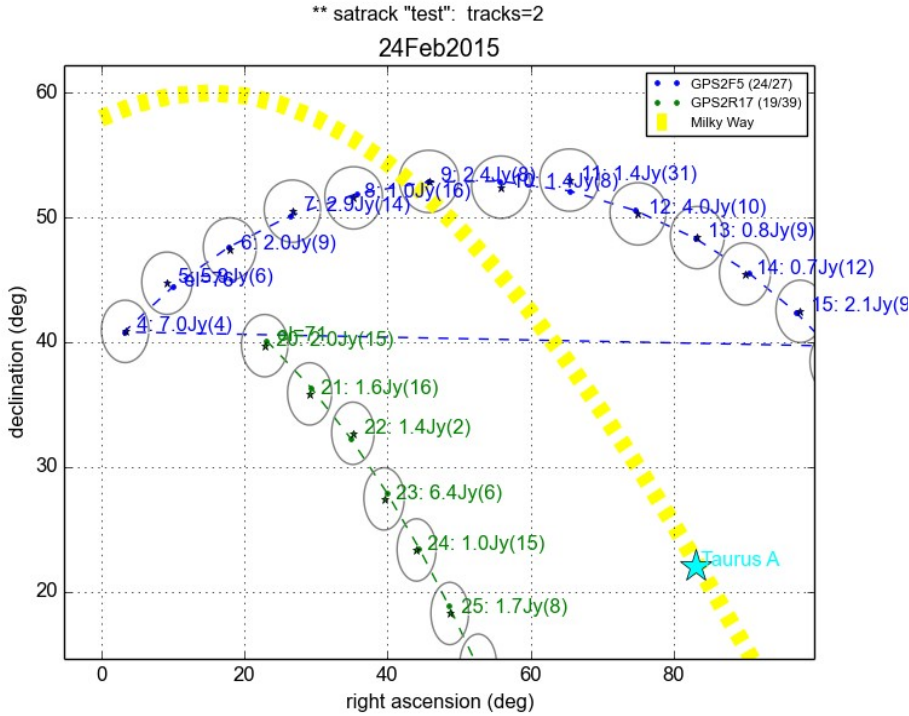
Collected data

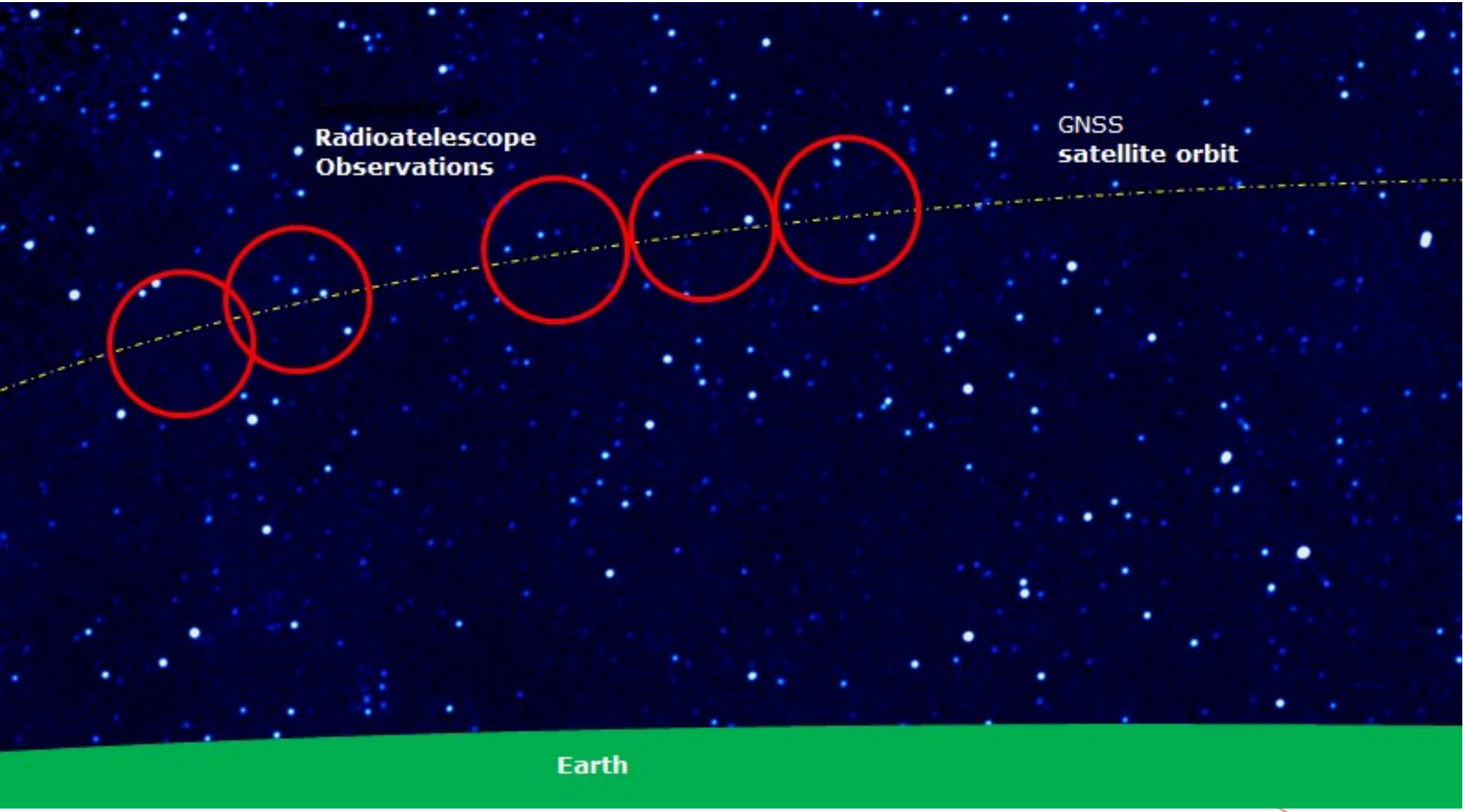
- March 25, 2015
- 13:30 – 23:00

- All GPS satellites
- All Galileo satellites

- 285 LOFAR pointings
- 6 observations of 10 seconds
- Alternate between satellites

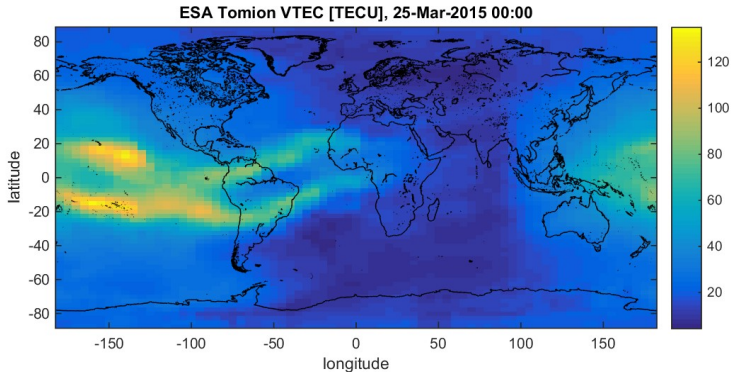




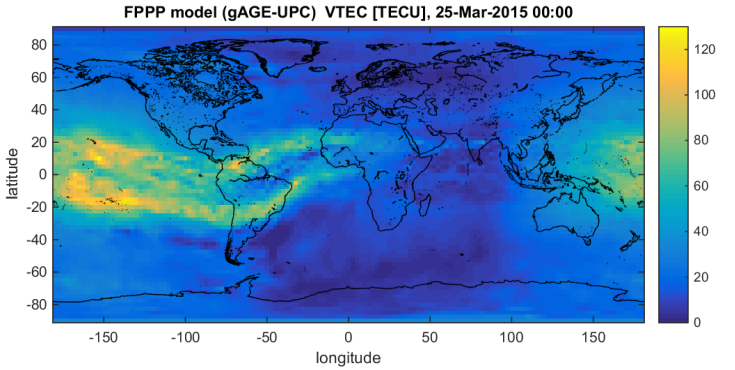

Radioatelescope
Observations
GNSS
satellite orbit
Earth

Reference data sets

- 1-layer GIM (ESA Tomion)
- 5 degree resolution, 15 minute time step
- Inter-frequency bias calibration

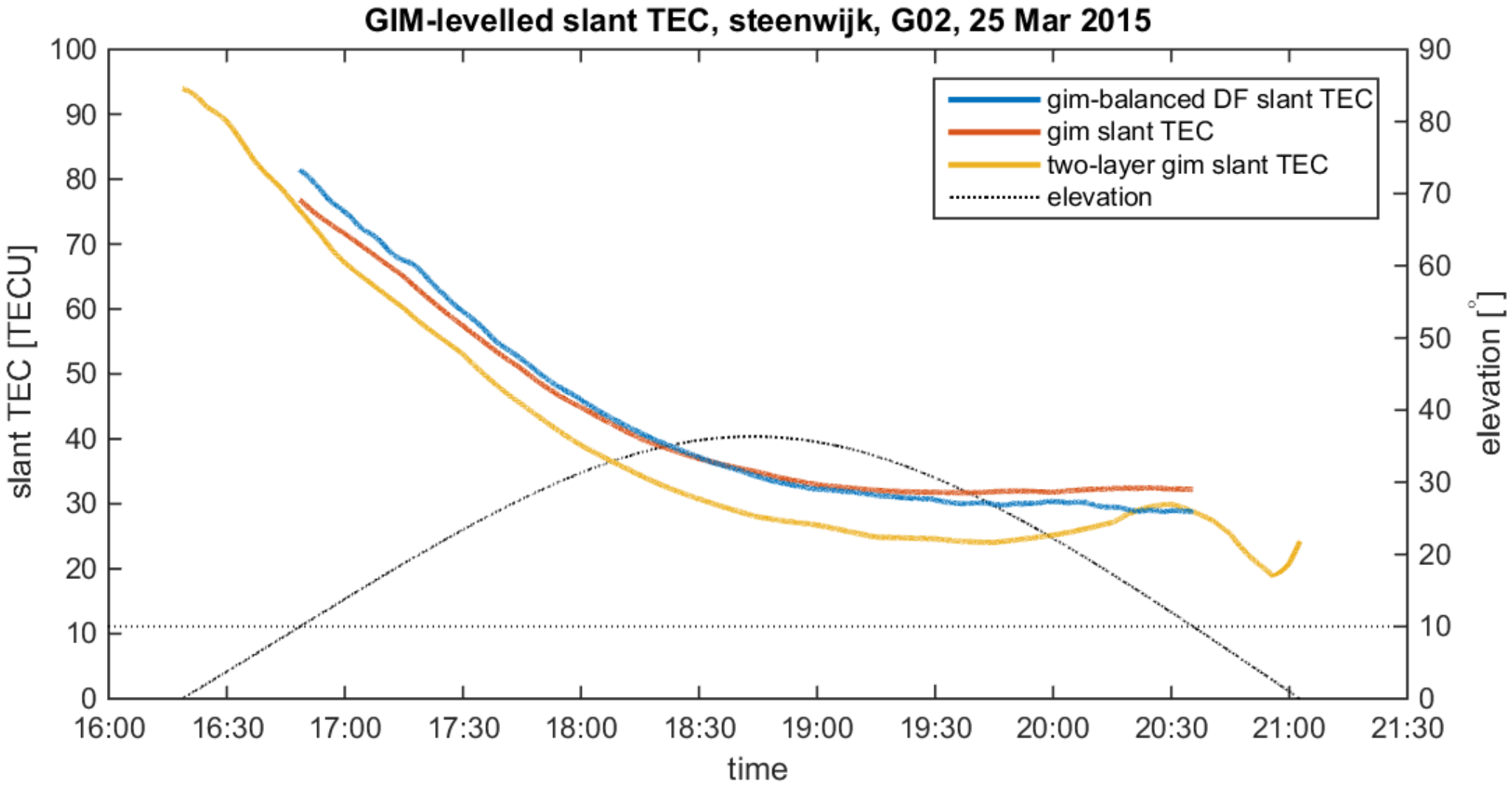


- 2-layer GIM (FPP, gAGE-UPC)
- 5 degree resolution, 15 minute time step
- Reference “truth”

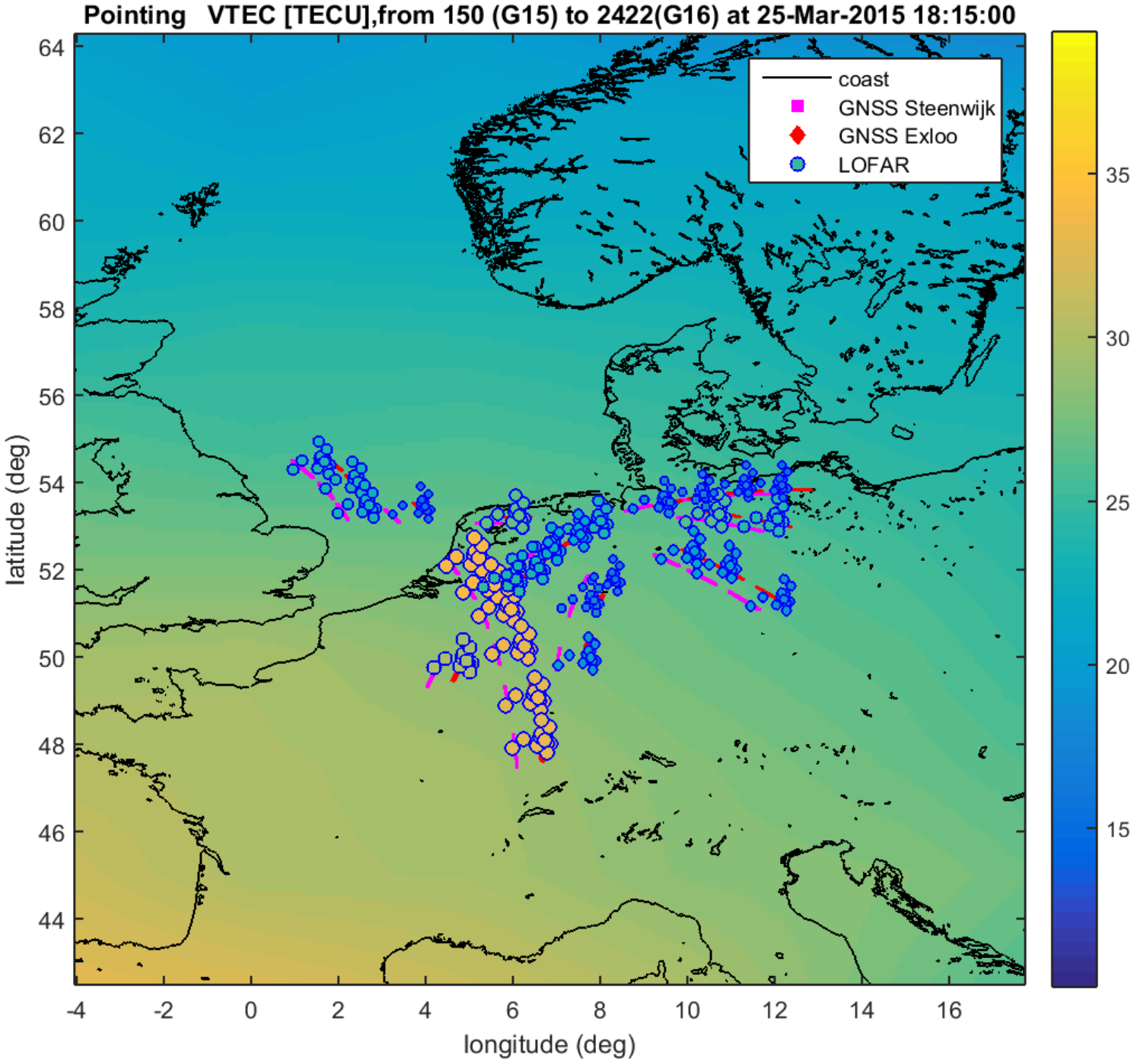


- Galileo NeQuick-G model
- GPS Klobuchar model

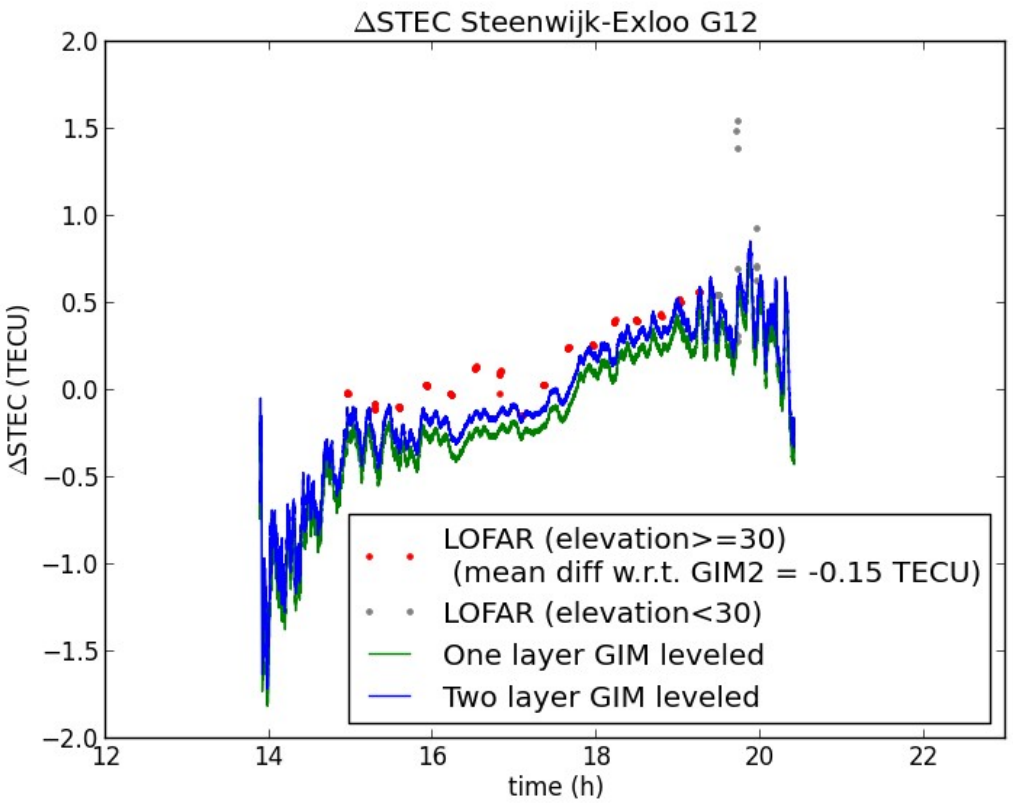
Results (GNSS)

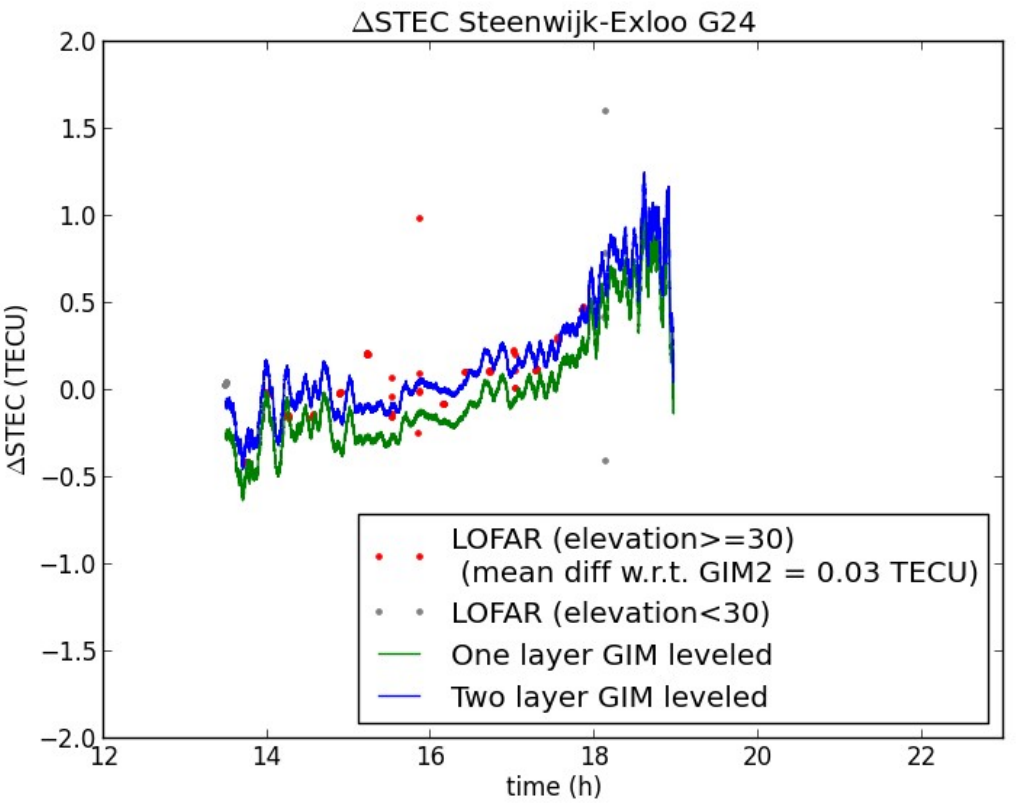


Results (LOFAR)



Comparing LOFAR and GNSS





Applications

Improving GNSS

- LOFAR accuracy is high (< 0.01 TECU relative)
- Good spatial and temporal coverage
- Difficult to merge and make absolute
- Best option: assimilate in ionospheric model?

Improving LOFAR

- Most promising: imaging calibration step
- Increase spatial resolution near outer stations
- High accuracy demands 0.01 TECU relative, 0.1 TECU absolute

Conclusions

- LOFAR observations of TEC very promising
- Next: assimilation in ionospheric models
- Ready for follow-up experiments

- Potential for LOFAR calibration with GNSS receivers
- Requires further research

- New LOFAR observation mode
-
- added MM:
  - GPS based ionospheric models suffer from large bias
  - accuracy relative GPS is high (~0.01TECU)

Dedicated to innovation in aerospace

Thank you for your attention.

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