



# Total Electron Content Monitoring Complemented with Crowdsourced GNSS Observations

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R. Weinacker, T. Sturn, I. McCallum, and V. Navarro

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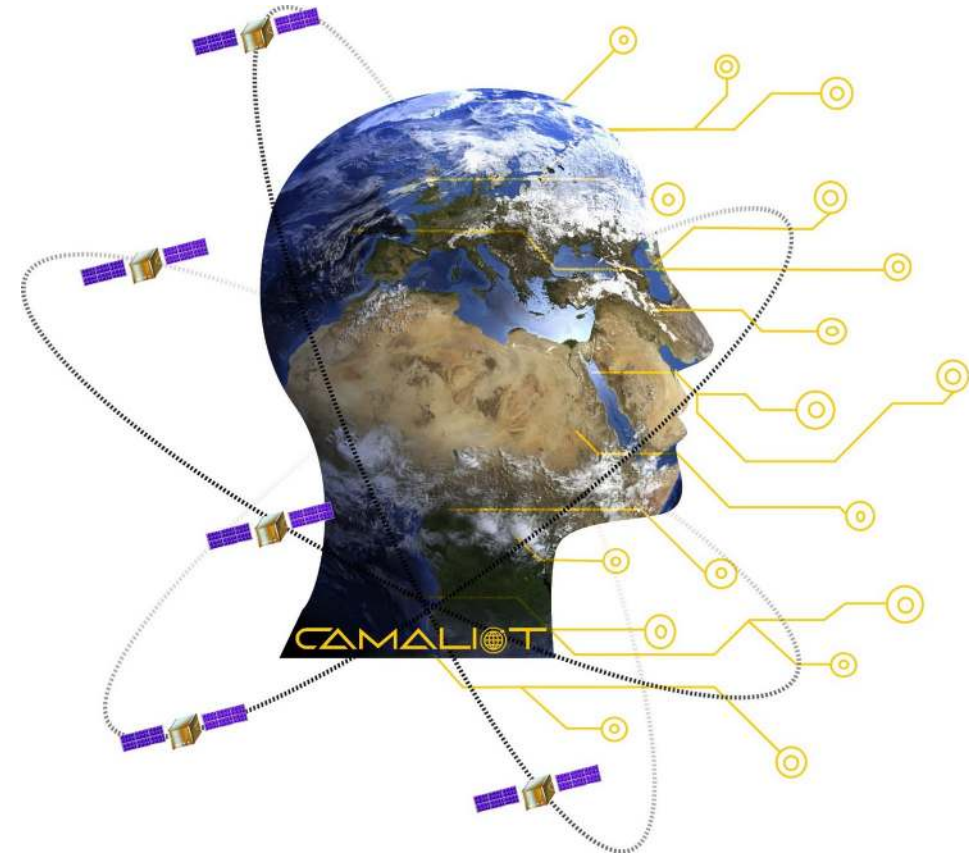


# CAMALIOT

## Application of machine learning technology for GNSS IoT data fusion

([NAVISP-EL1-038 bis](#))

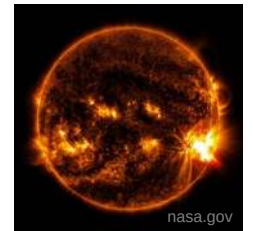
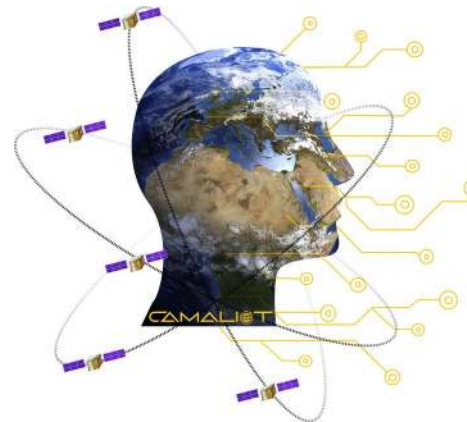
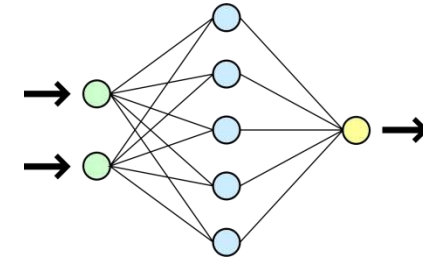
funded by ESA NAVISP Programme Element 1,  
dedicated to innovation of the PNT technology



# CamalioT - Goals

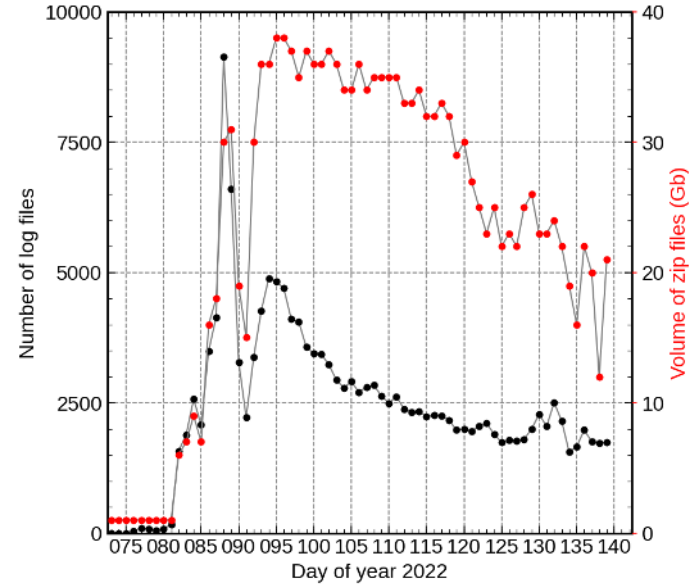
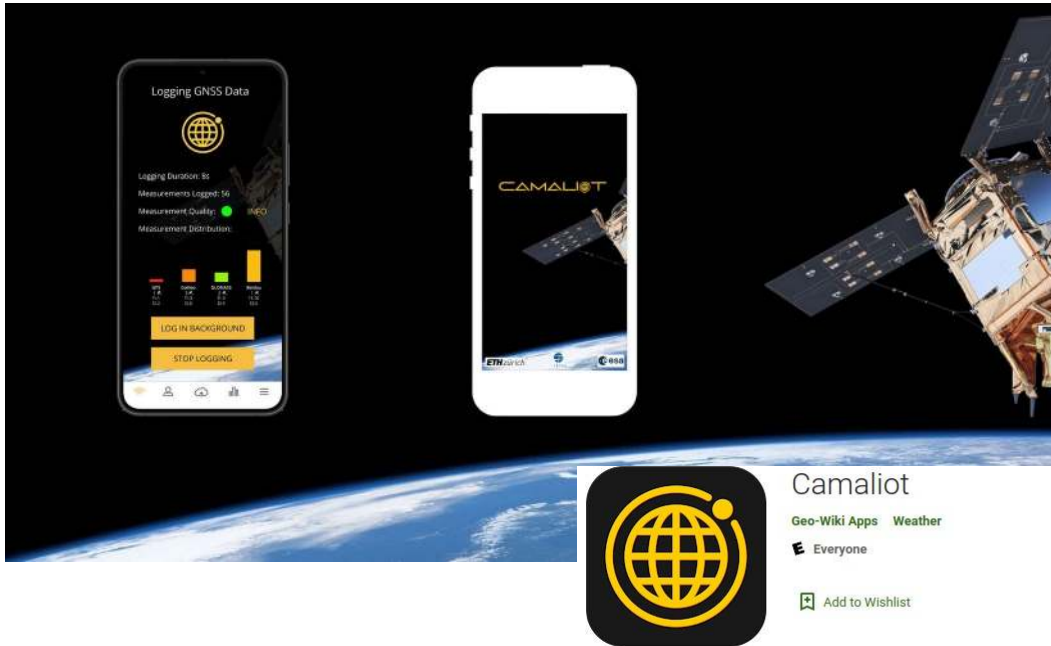


- GNSS IoT Data
  - Investigate alternative sources of GNSS observations
  - **Collection of GNSS community data**
- GNSS Big Data Processing
  - Framework for an automated, robust and scalable GNSS processing
  - Fusion of indices and models with huge and heterogeneous data sets of various quality
- Science Use Cases
  - Troposphere – Earth Weather
  - Ionosphere – Space Weather

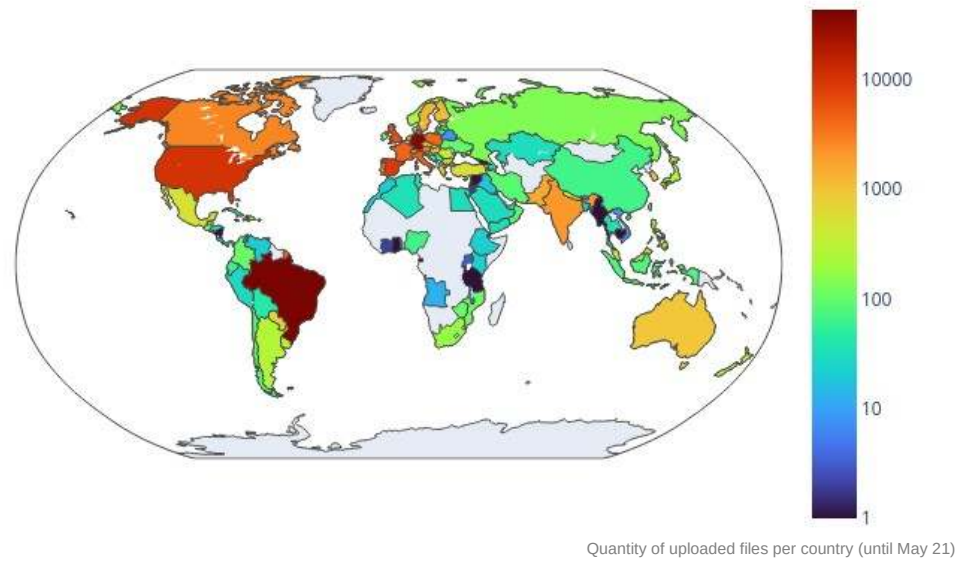


# Camaliot - Crowdsourcing Campaign

- Started March 17, 2022
- Android app with 35k+ installations
- 11k+ registered users
- Over 55 billion GNSS observations collected so far



Size and number of received files expressed per day



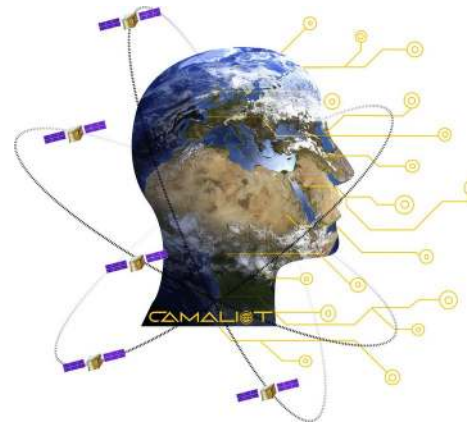
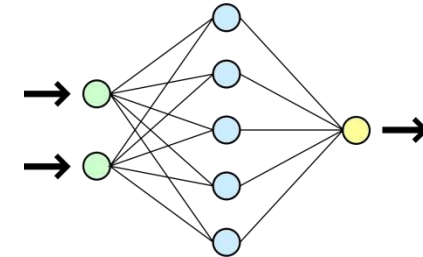
Quantity of uploaded files per country (until May 21)



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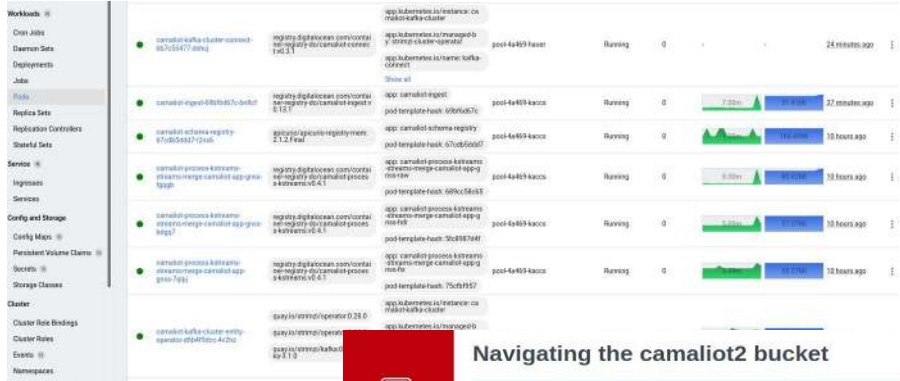


# CamalioT Functional SW Architecture

Development of a self-contained SW running on Kubernetes and communicating with GSSC



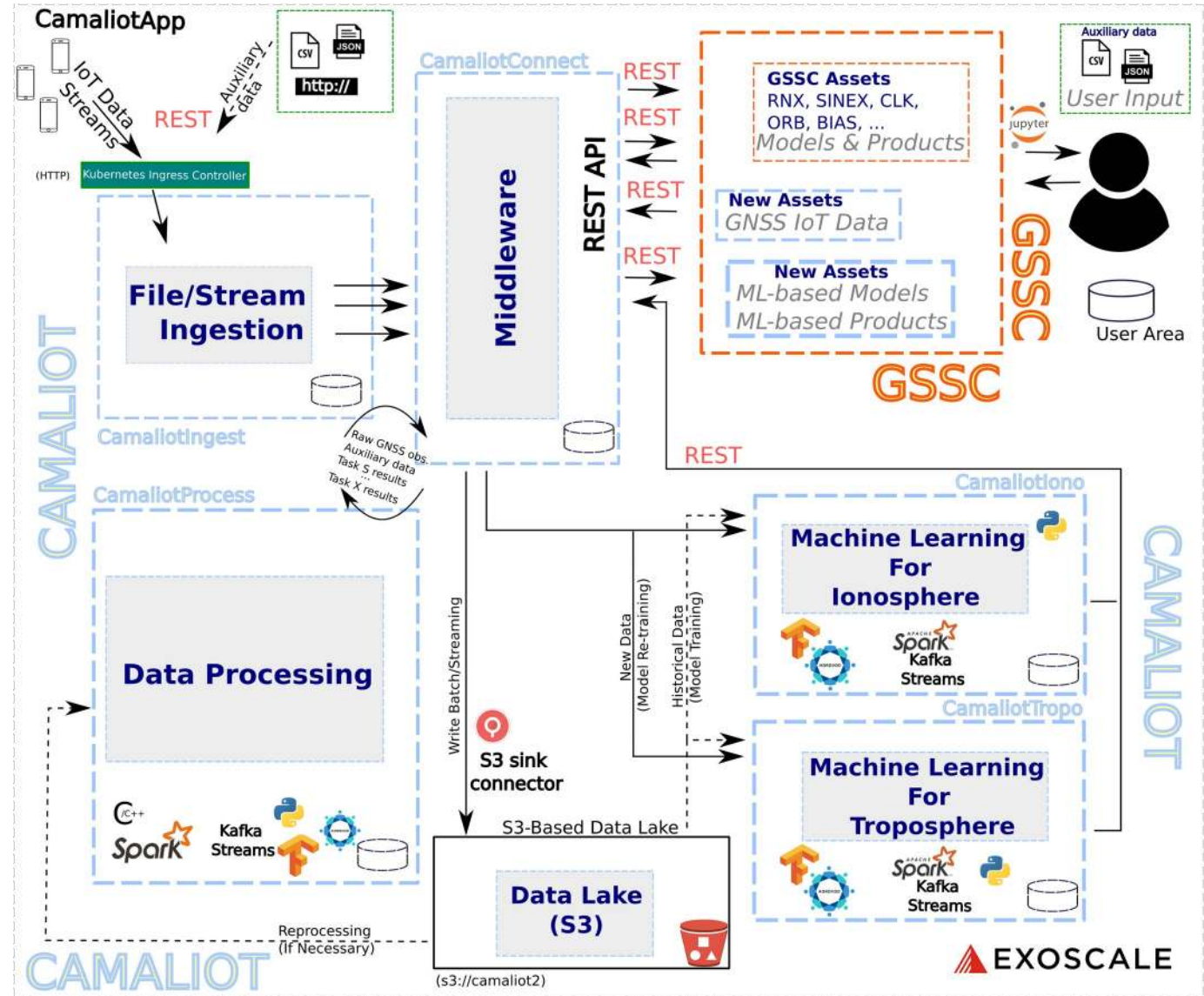
Kubernetes Cluster



Object Store



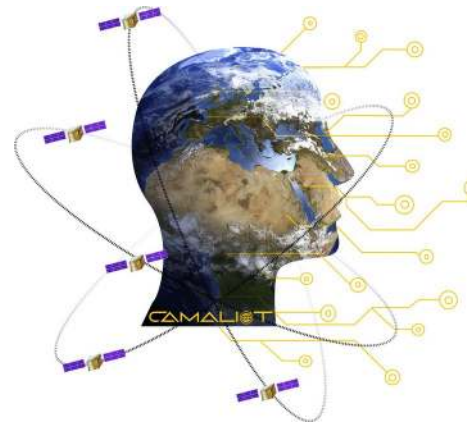
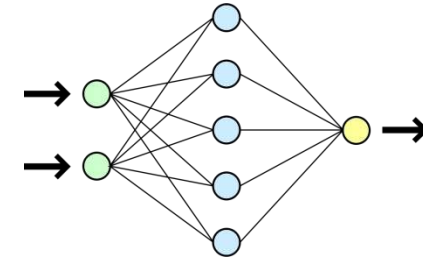
- File/Stream Ingestion
- Data/Stream Processing
- Real-time Data Enrichment
- Data offload/aggregation



# CamalioT - Goals



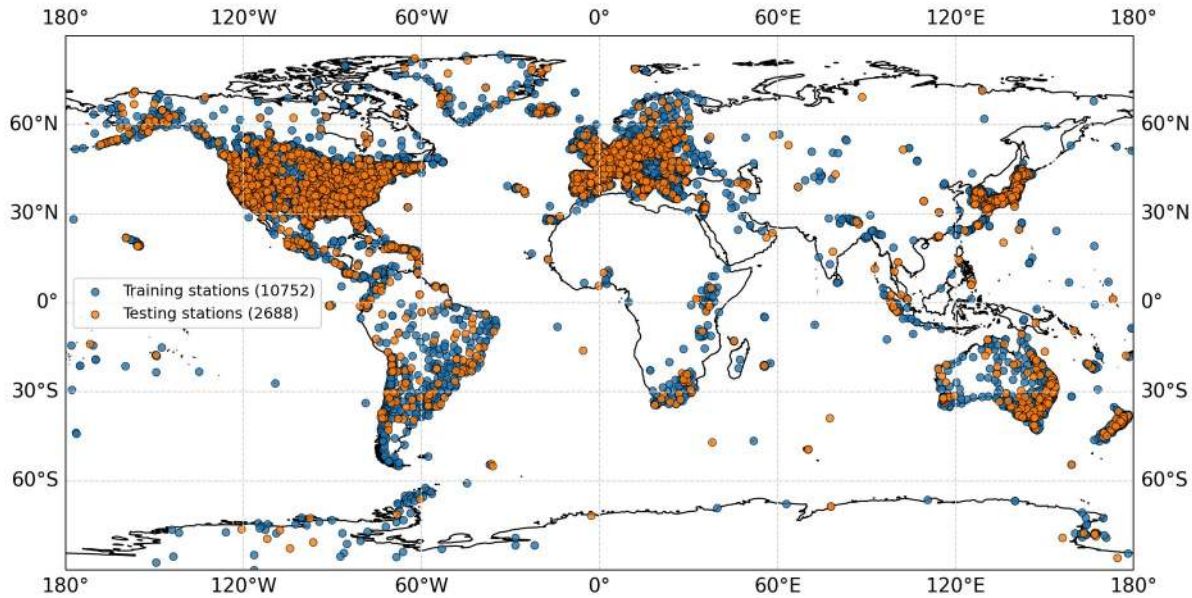
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# Machine Learning For Spatial Interpolation and Forecasting

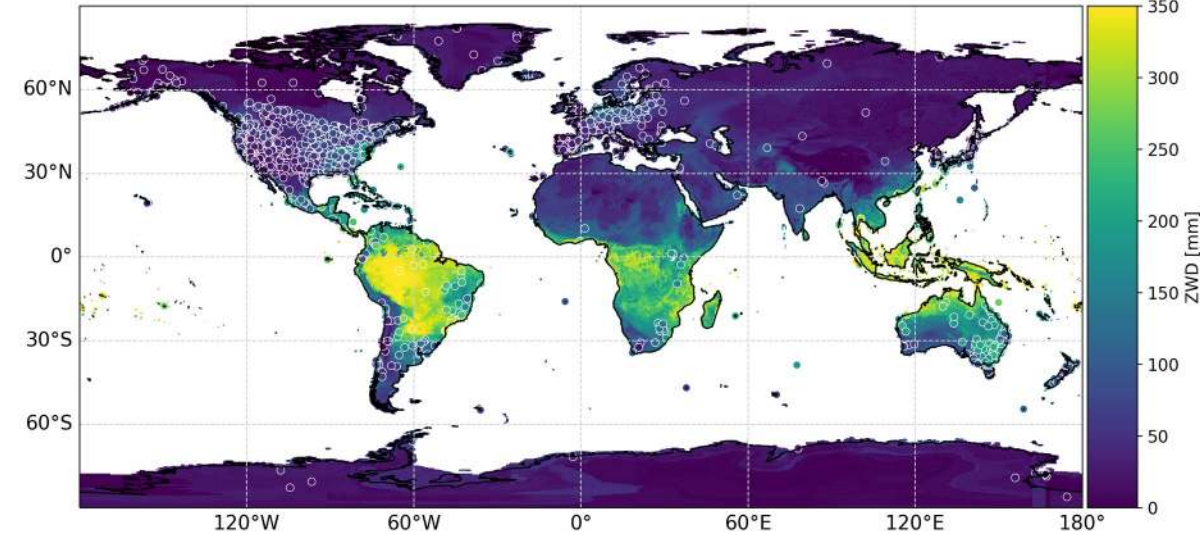
Example: Data fusion for the spatial modelling of ZWD

Distribution of training and test stations for all available stations (2019)

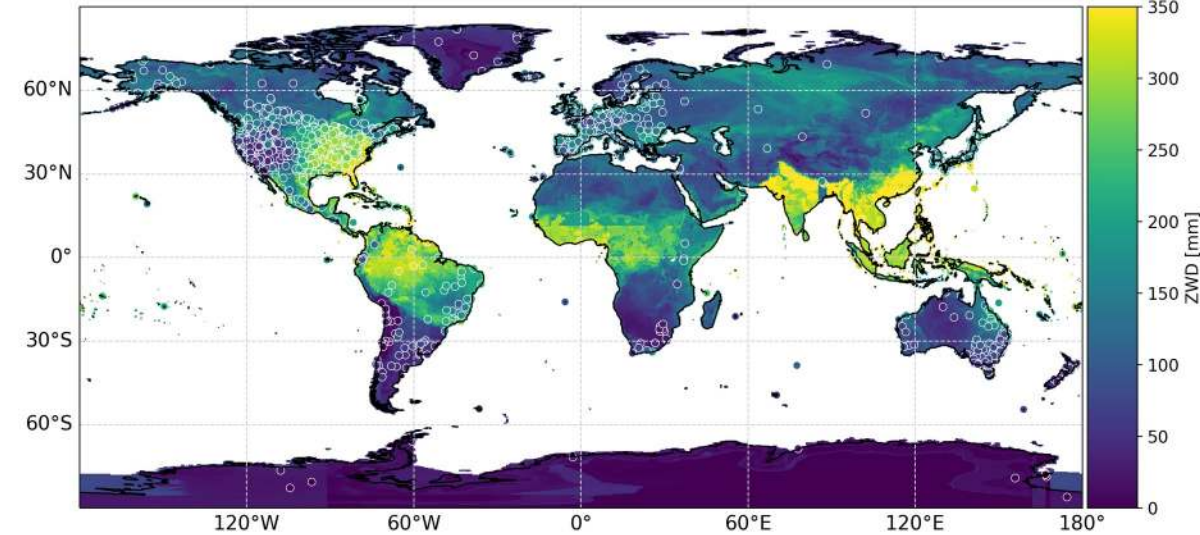


Talk by Laura Crocetti  
G1.3: Fri, 27 May, 09:45

RF - 2019-01-05 00:00:00



RF - 2019-07-05 00:00:00





# GNSS IoT Data Collection & Exploration

Exploring smartphone-based observations with dedicated measurement campaigns

ETH2



Pixel 4



Mi8



Mi8



Platform for horizontal/vertical smartphone orientation during measurements

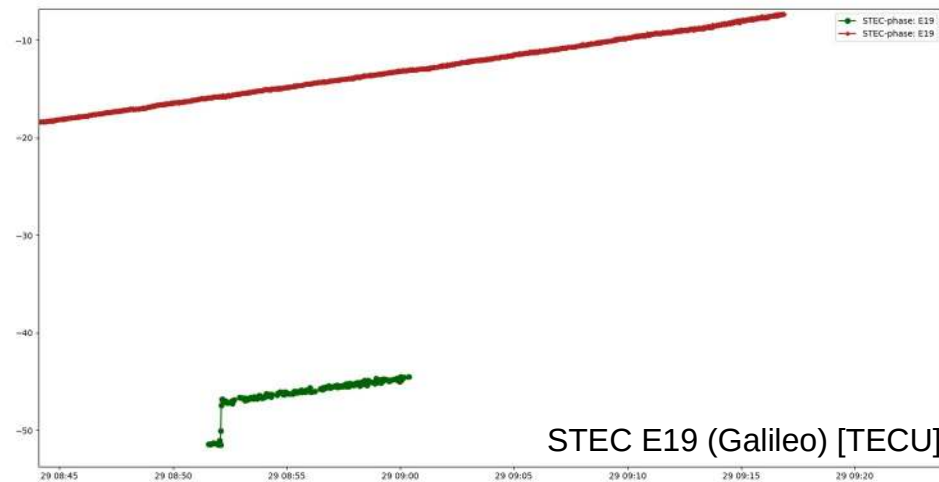
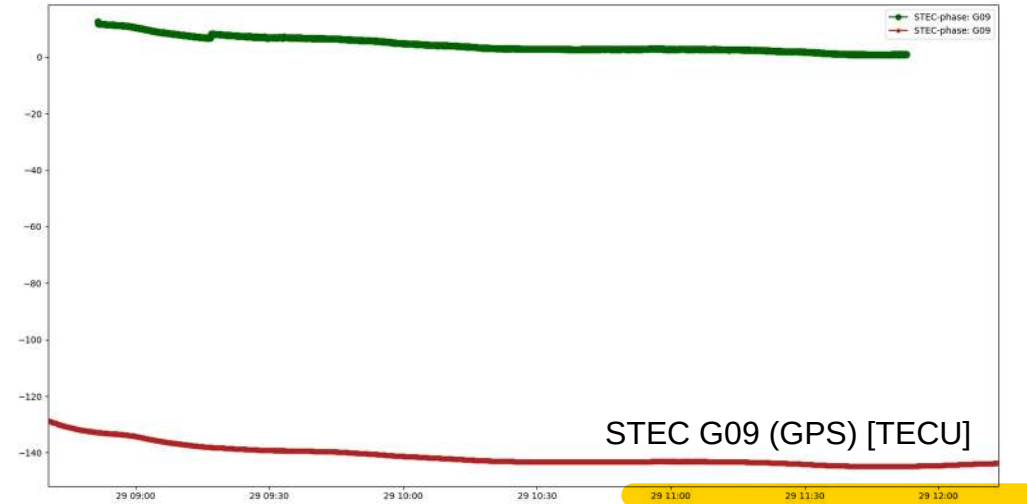
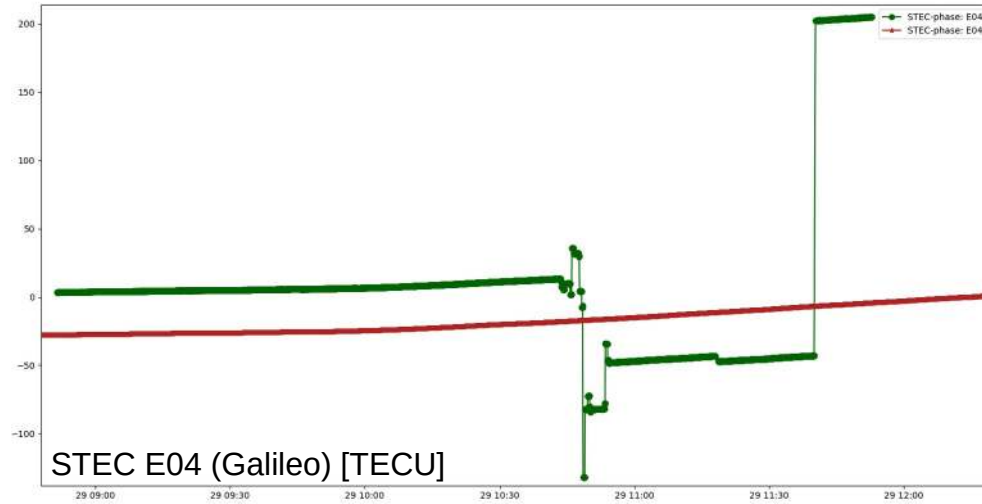
## Smartphones for STEC:

- Observations in the vicinity of the AGNES ETH2 station
- Geometry-free (L1/L5) combination for STEC
- Observations in the RINEX-3 format (Geo++ RINEX Logger)
- Investigating “raw” satellite-specific STEC time series for smartphones and ETH2



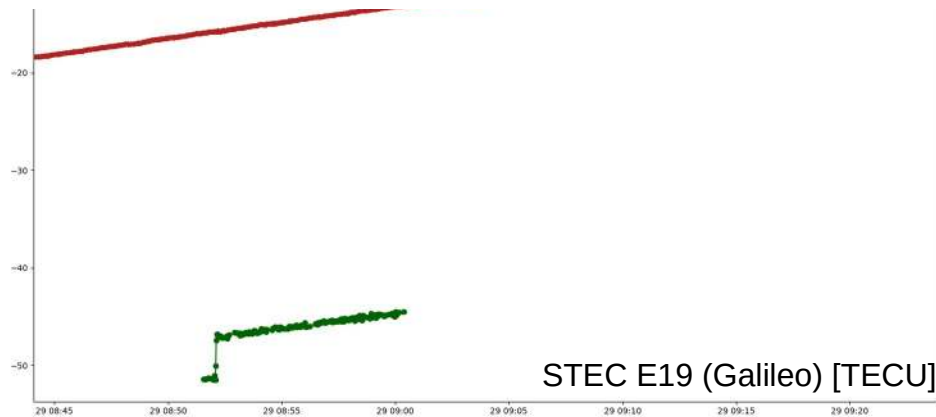
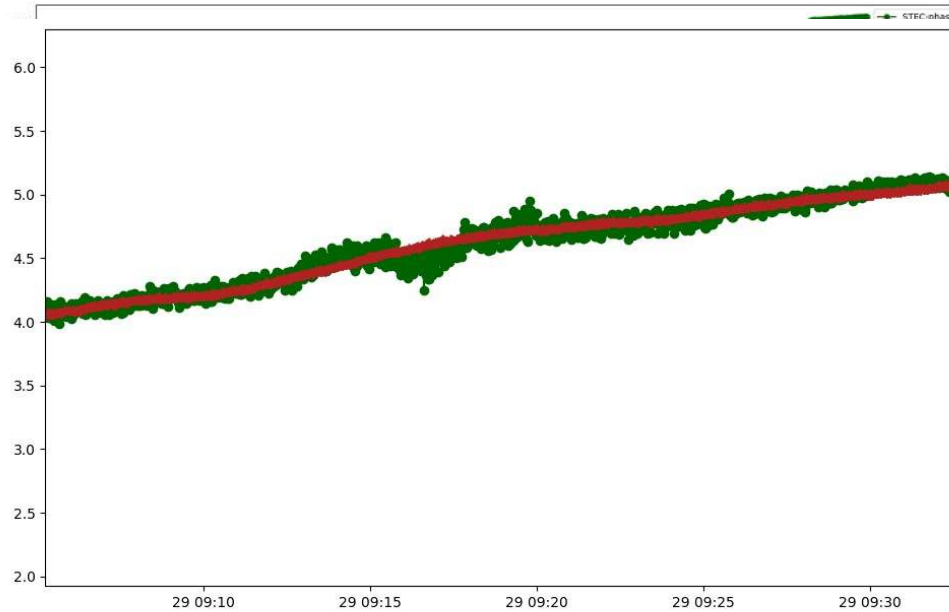
# GNSS IoT Data Collection & Exploration

Examples of STEC time series from Xiaomi Mi8 (green) and ETH2 (red)

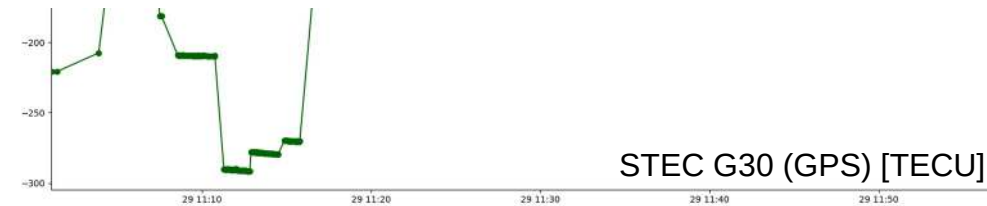
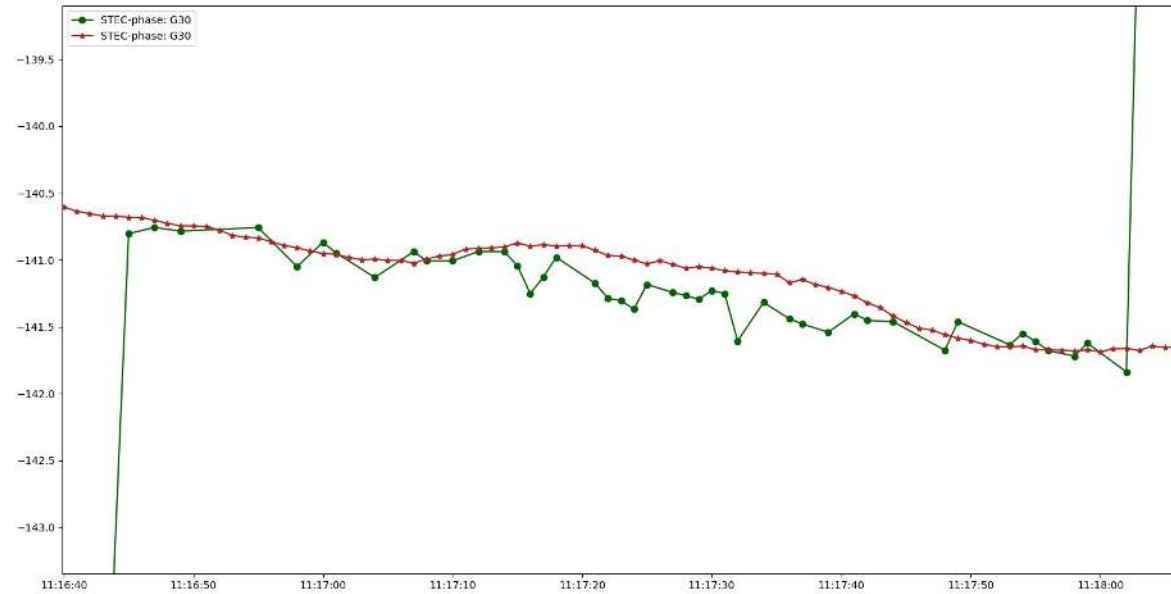


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Examples of STEC time series from Xiaomi Mi8 (green) and ETH2 (red)



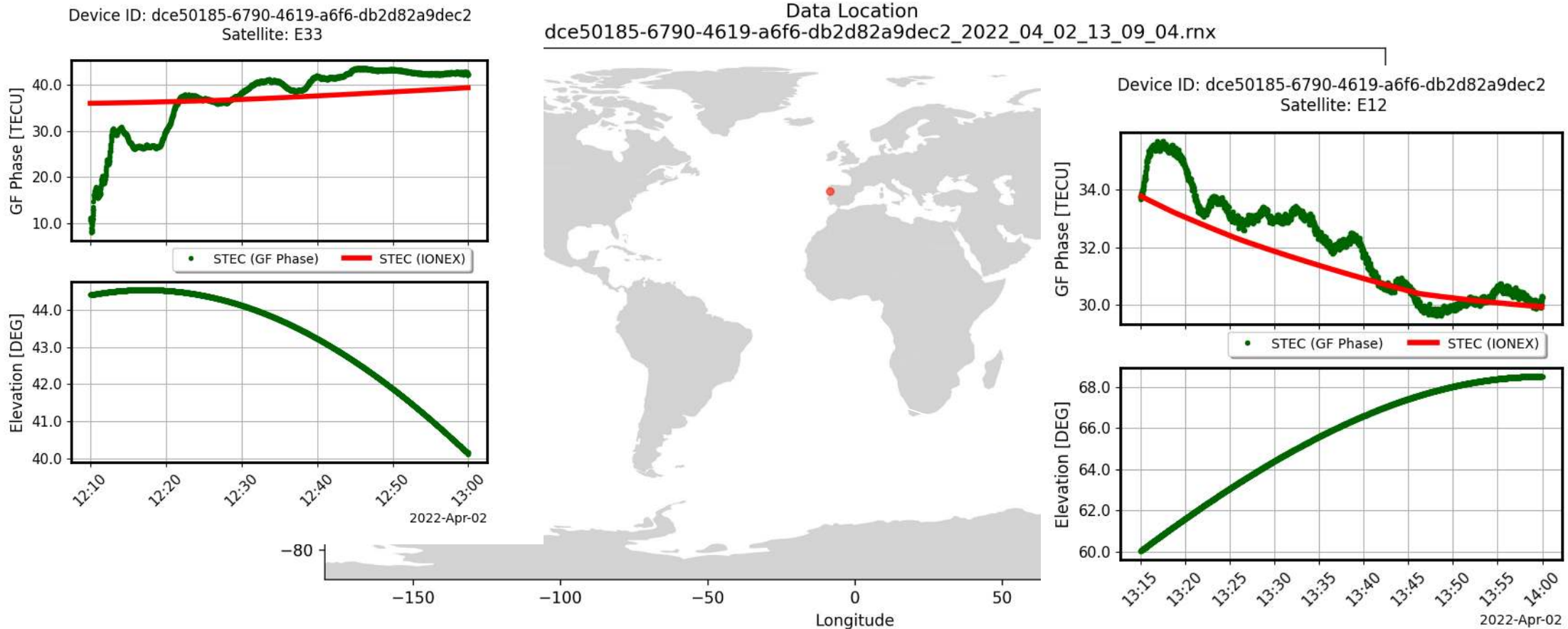
- STEC from Xiaomi Mi8 aligned (offset) manually to STEC from ETH2



# GNSS Community Data

Examples of STEC time series from crowdsourced observations (as acquired from the Camalot app)

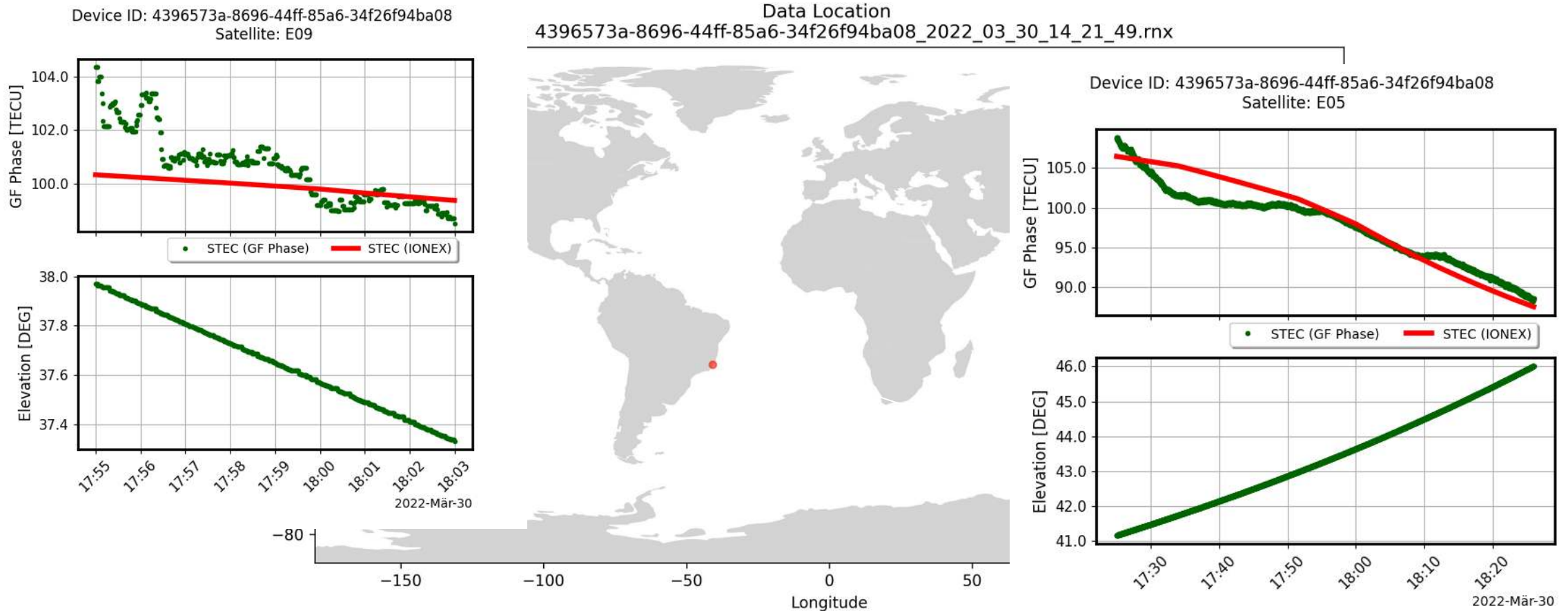
- Observations uploaded by the users
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- Observations in the RINEX-3 format (Camalot RINEX Converter)
- Investigating “raw” satellite-specific STEC aligned to the IONEX-based STEC time series (GIM from IGS)



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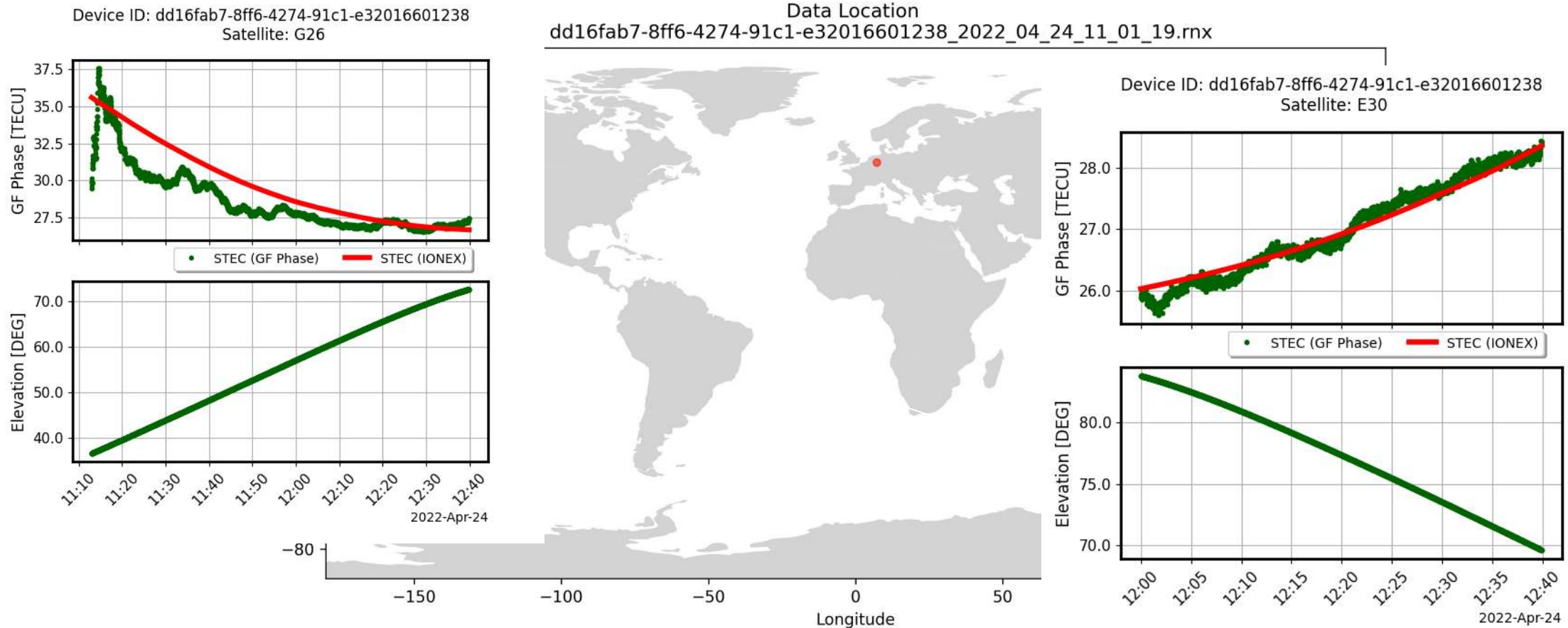
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# GNSS Community Data

Examples of STEC time series from crowdsourced observations (as acquired from the Camaliot app)

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## Camalio Project:

- Collection of GNSS community data during the dedicated crowdsourcing campaign
- Development of the GNSS big data processing framework for the ML-based data fusion at scale

## Smartphone-based GNSS observations:

- With the potential to be exploited for ionospheric monitoring (to a certain extent)
- Quality much lower compared to the conventional GNSS observations
- Frequent occurrence of observation gaps and cycle slips
- Dedicated screening and preprocessing stages needed to extract reliable ionospheric information

Visit [www.camalio.org](http://www.camalio.org) for more!

Try out the Camalio App today!



THANK YOU FOR YOUR ATTENTION!

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