GNSS Meteorology at the Met Office

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IGS Workshop, June 2022.

Contents

- Met Office GNSS processing
- Products and impact
- Met Office future GNSS plans
- Involvement in international projects

Data Processing and reliance on IGS data and products

- GNSS signals contain information on atmospheric water vapour which plays a key role in weather and climate; related to precipitation and atmospheric energy and also dominant greenhouse gas accounting for 60-70% of global warming

- Met Office operate 5 x operational GNSS processing services operating 24/7.

- IGS an essential source of raw data (CDDIS, BKG, IGN etc).

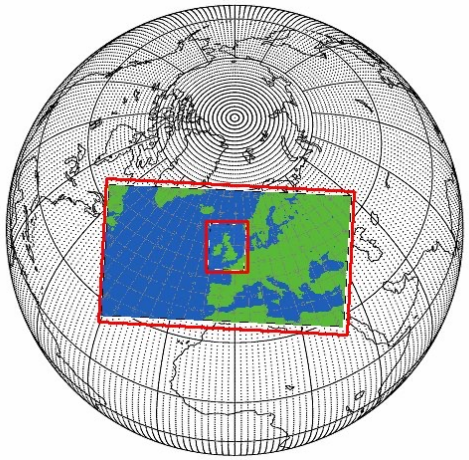
- IGU Ultra Rapid products used for NRT processing and Final Products used for daily PPP used to generate a-priori coords.

- Use BKG NTRIP client (BNC) to retrieve IGS-RT, EUREF, other real-time RTCM data streams.

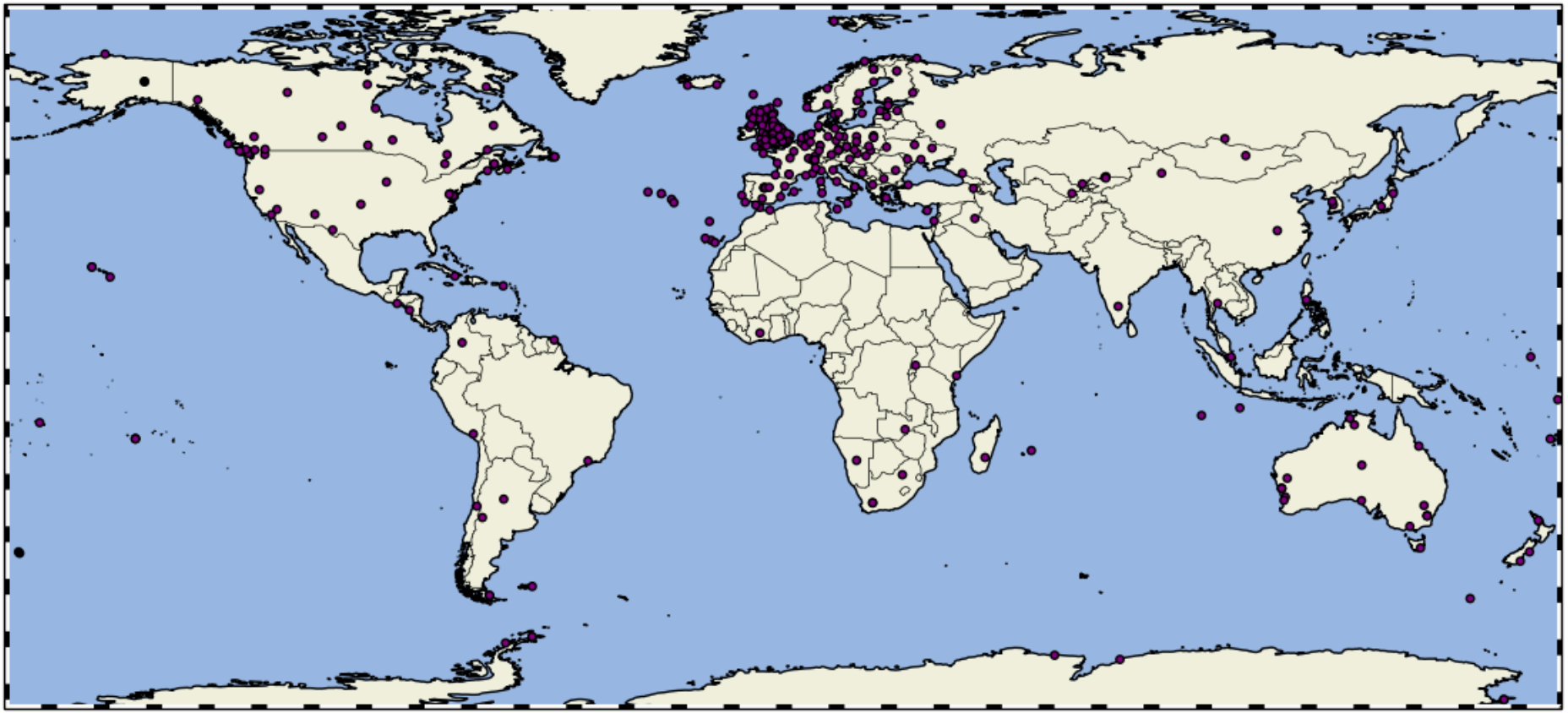
- Daily download of 2000+ 'IGS-style' log files.

MTGH and MIGH

MetOffice Tropospheric/Ionospheric Global Hourly

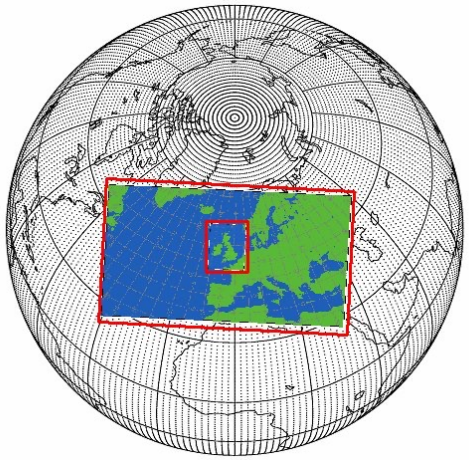


GNSS stations processed by MTGH (371)

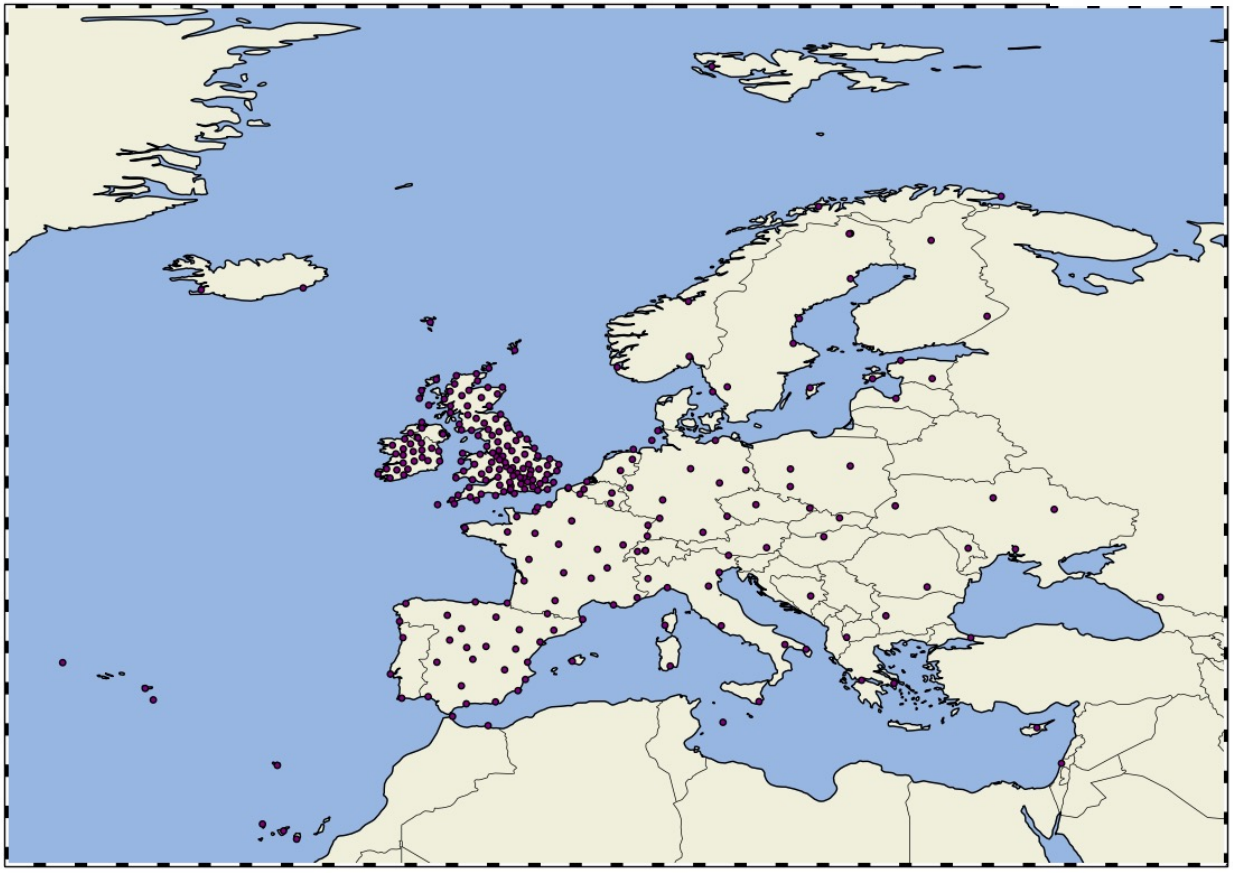


MTRH

MetOffice Tropospheric Regional Hourly

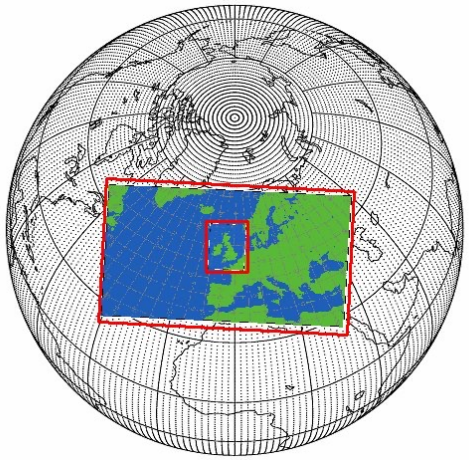


GNSS stations processed by MTRH (282)

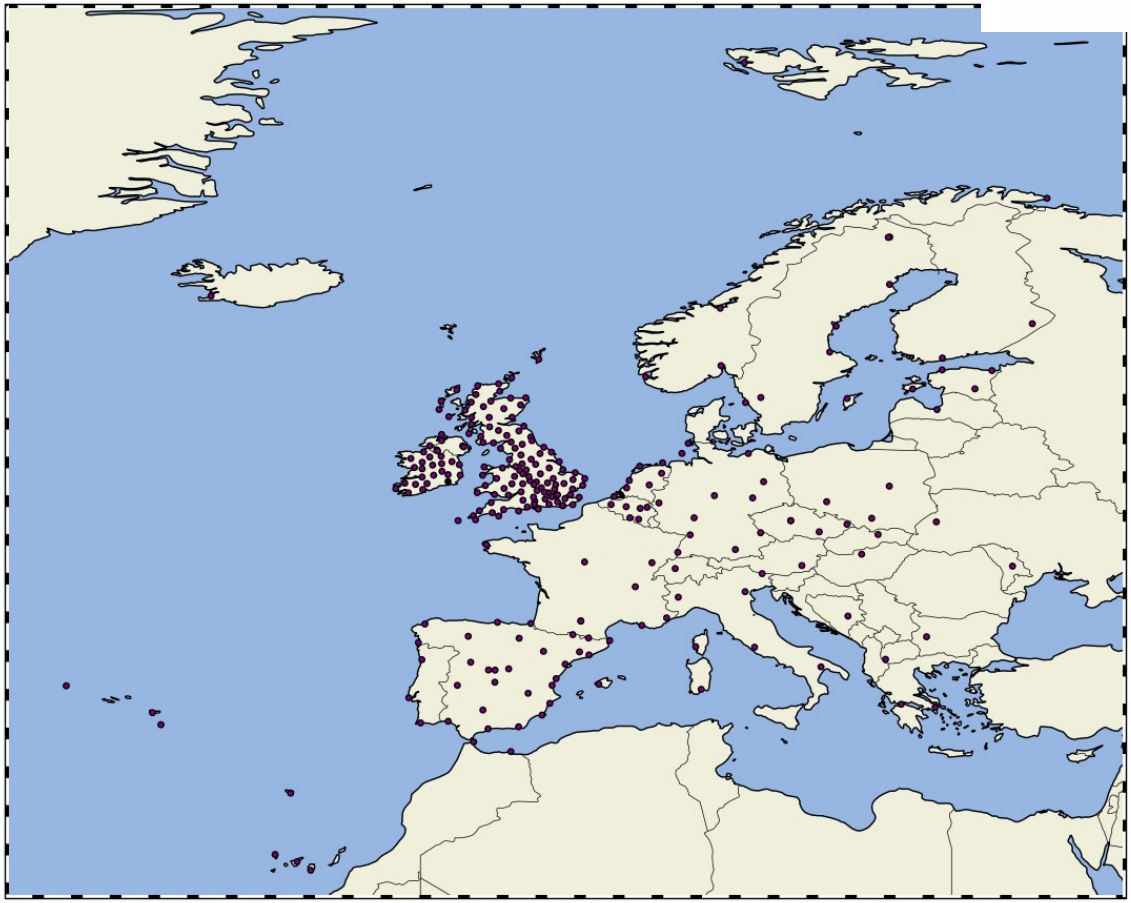


MTRS and MIRS

MetOffice Tropospheric/Ionospheric Regional Sub-hourly

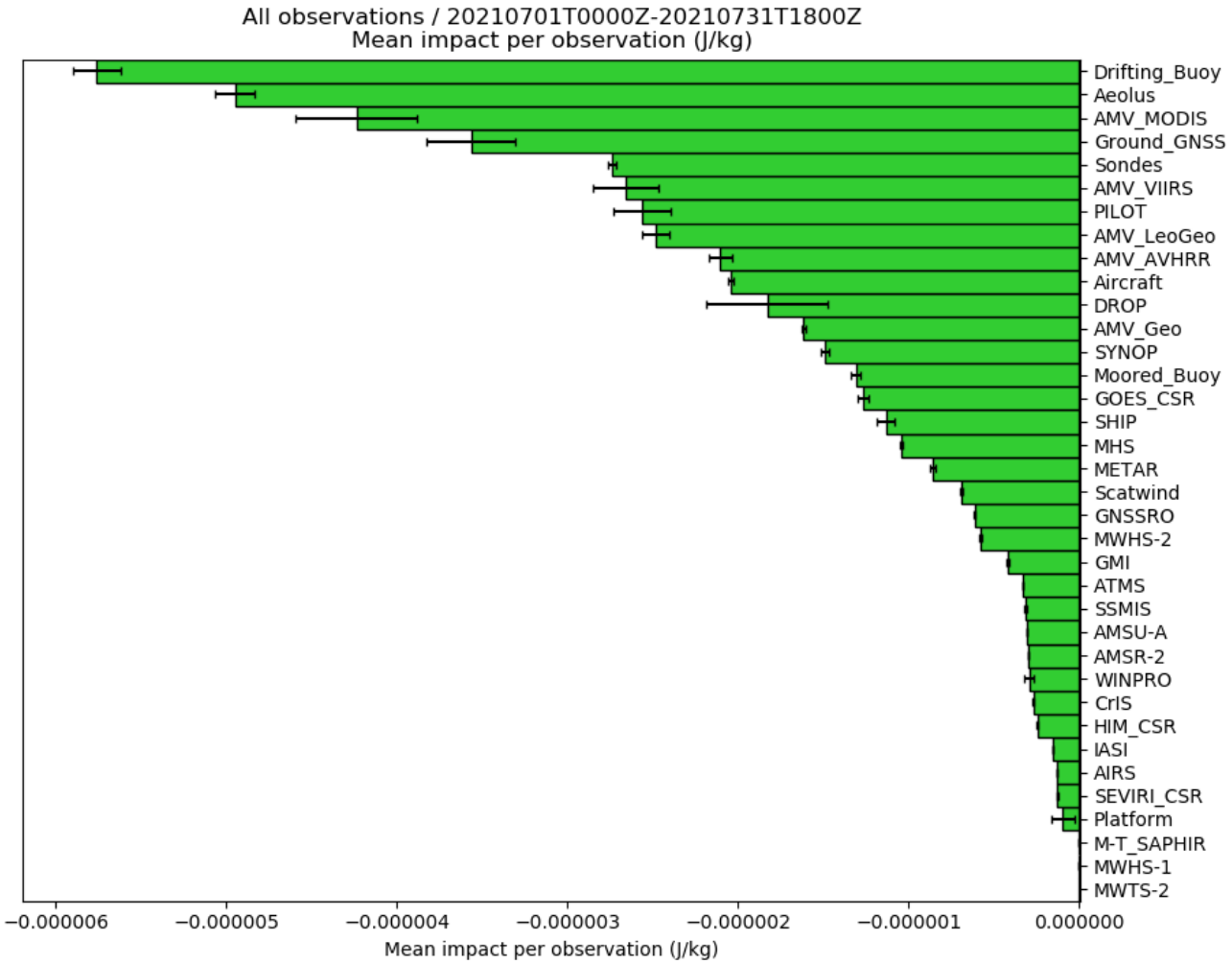


GNSS stations processed by MTRS (261)



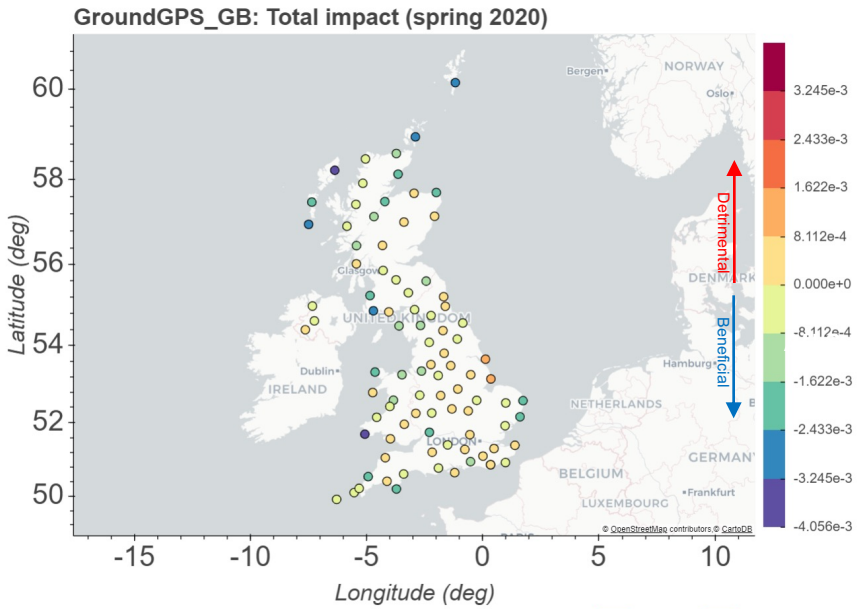
Plotted at 06:37ut 28-Jun-2022

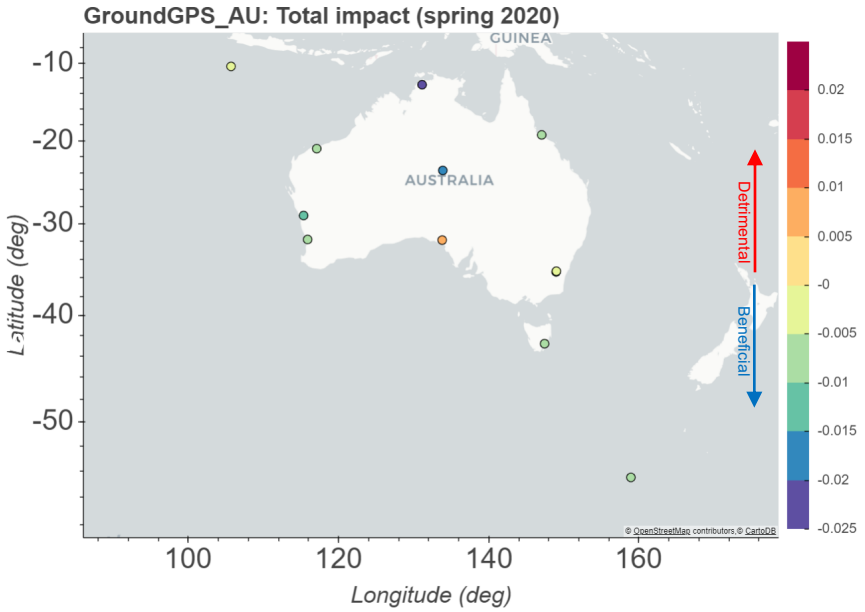
ZTD NWP impact



ZTD NWP impact of individual sites

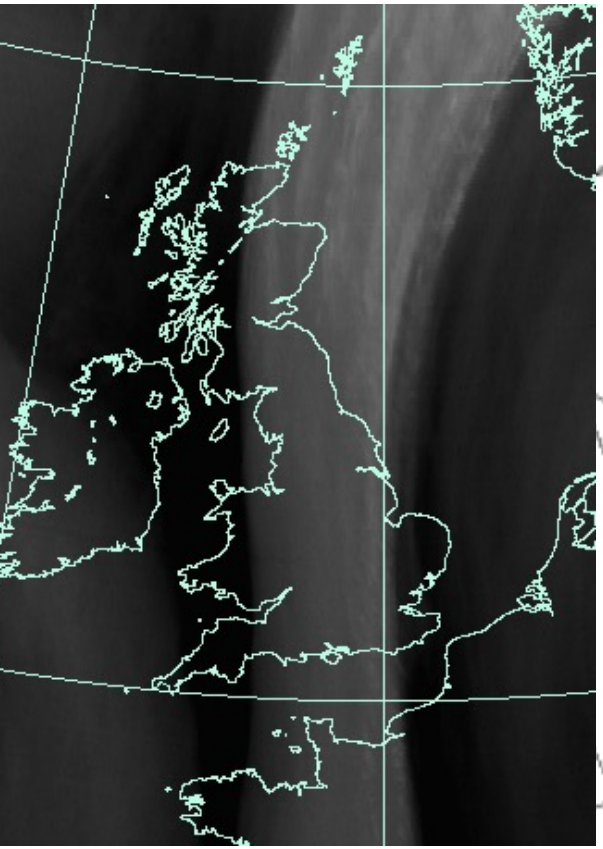
- Site-specific FSOI analysis – helps network planning
- Static data can be shown on a Bokeh map
- Note differences in colour scale: Australian impacts are generally ~ 5x higher than GB sites highlighting impact of sites in relatively data-sparse regions



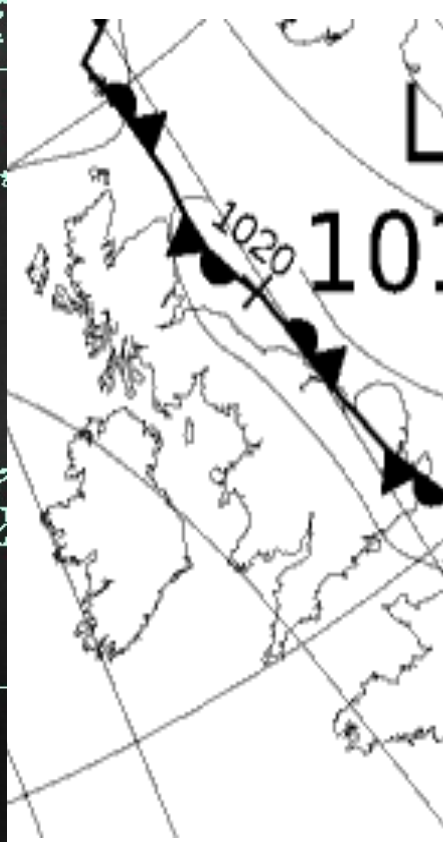


IWV Maps

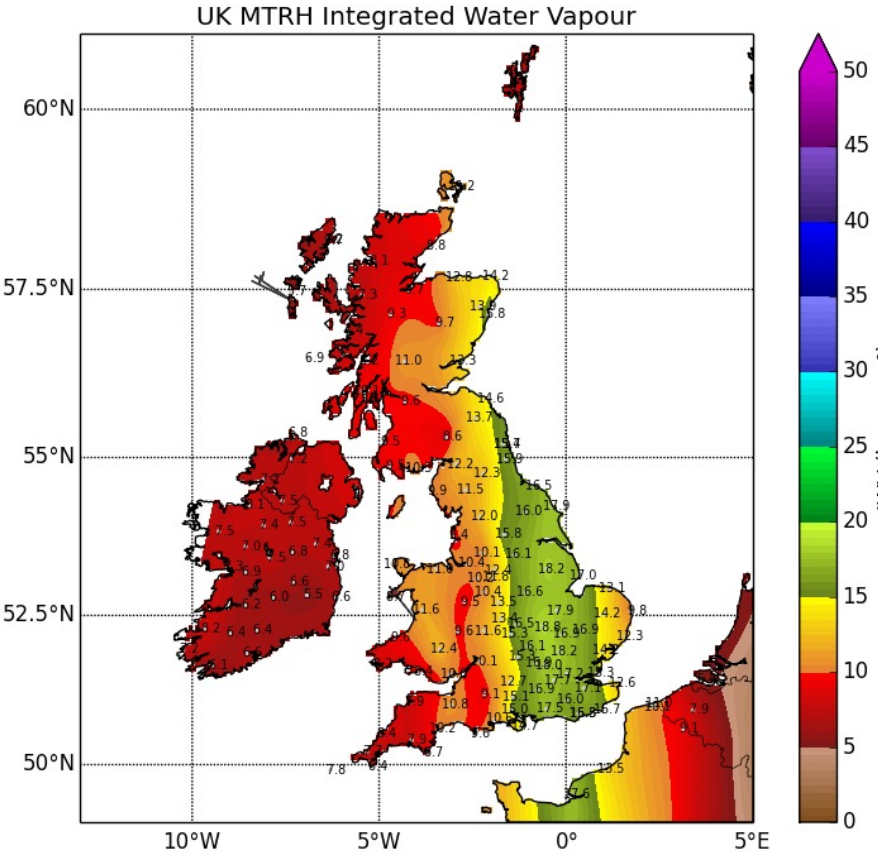
MSG 6.2 micron



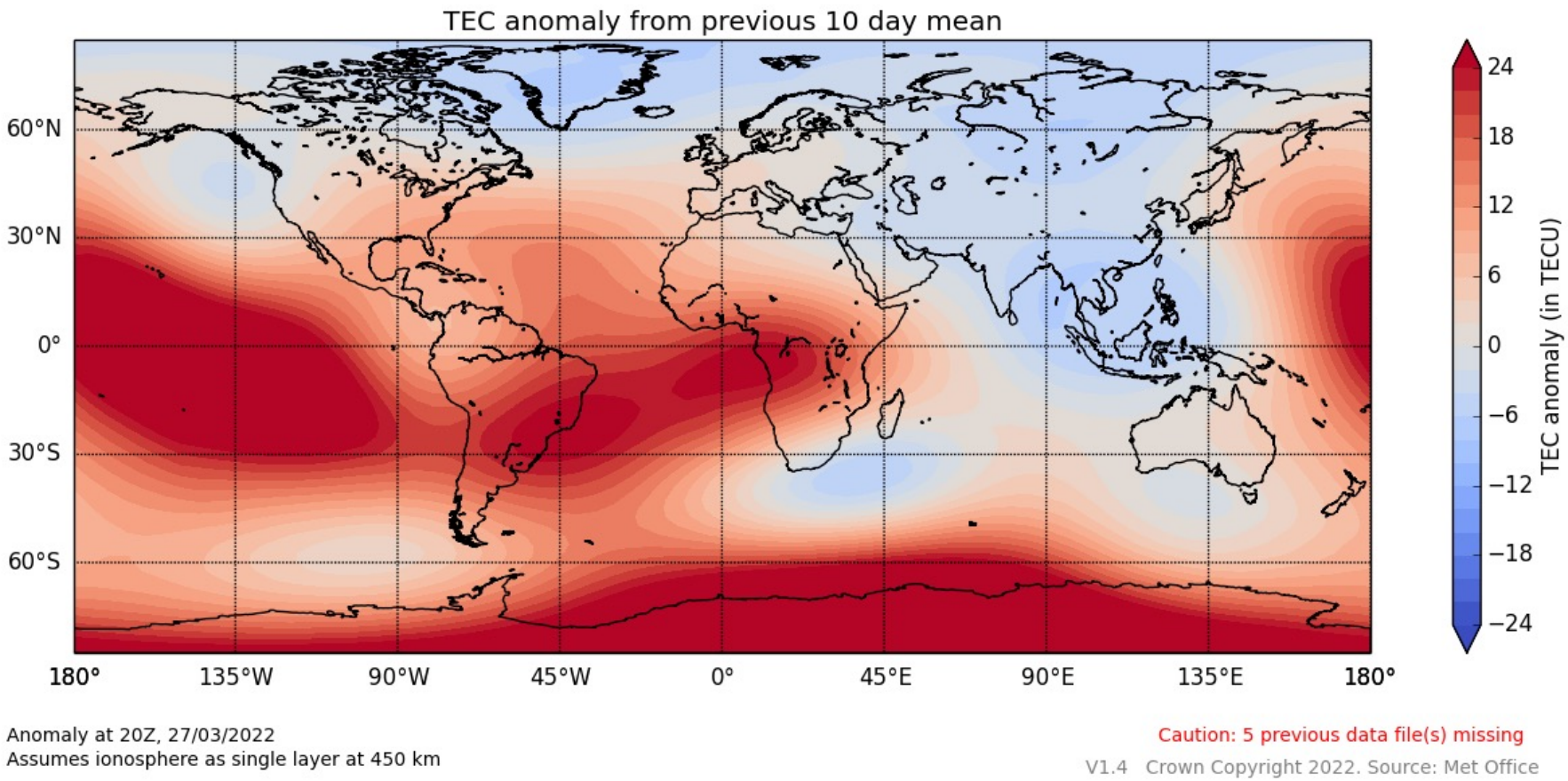
Surface pressure chart



GNSS IWV Image



TEC Maps and anomalies



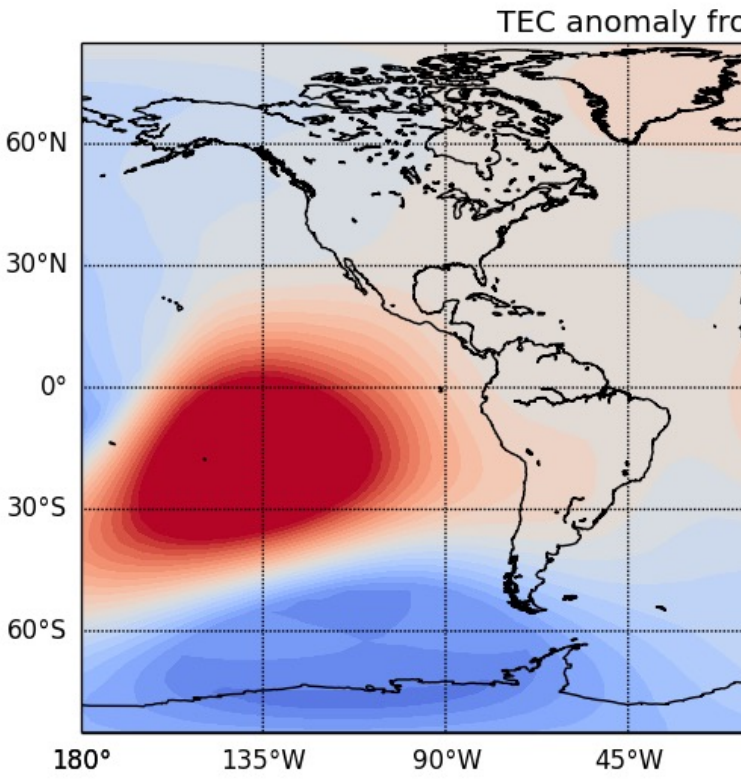
Anomaly at 20Z, 27/03/2022
Assumes ionosphere as single layer at 450 km

Caution: 5 previous data file(s) missing

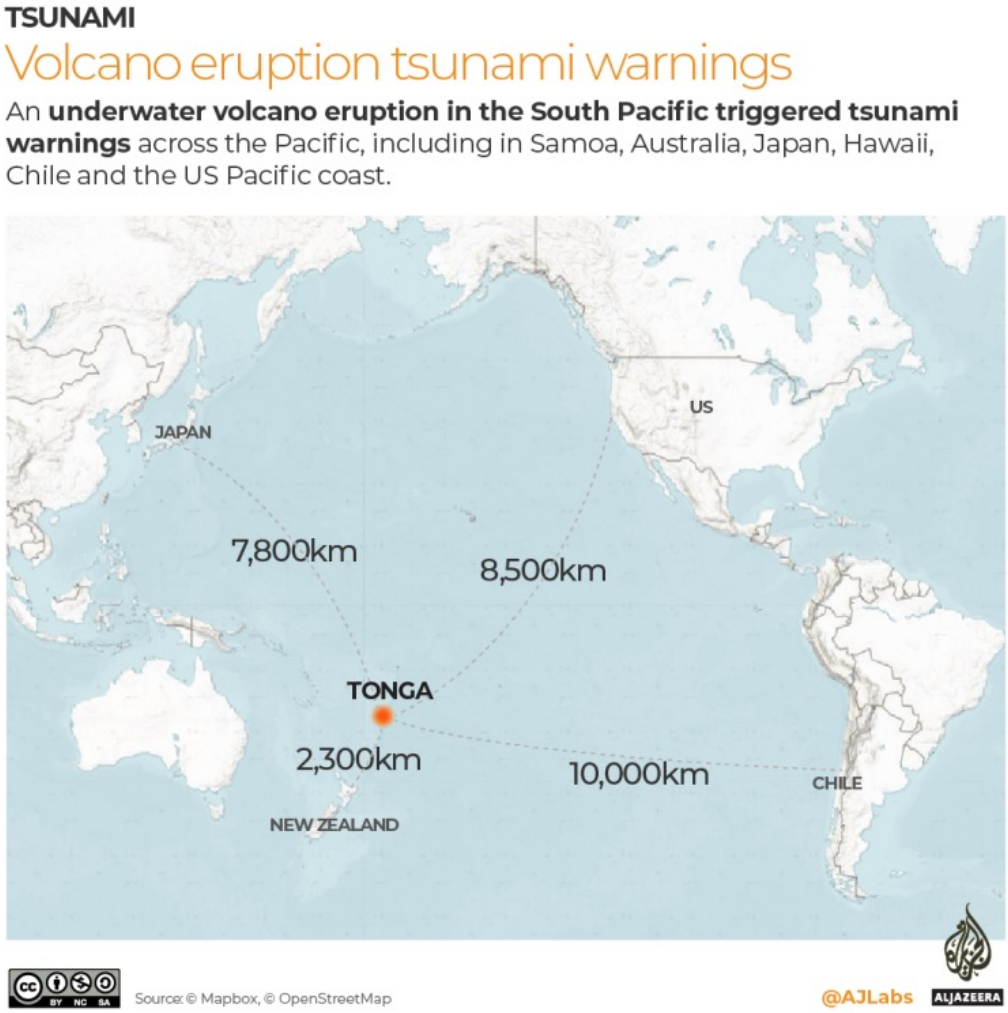
V1.4 Crown Copyright 2022. Source: Met Office

TEC Maps and anomalies

15th Jan 2022



Anomaly at 06Z, 15/01/2022
Assumes ionosphere as single layer at 450 km



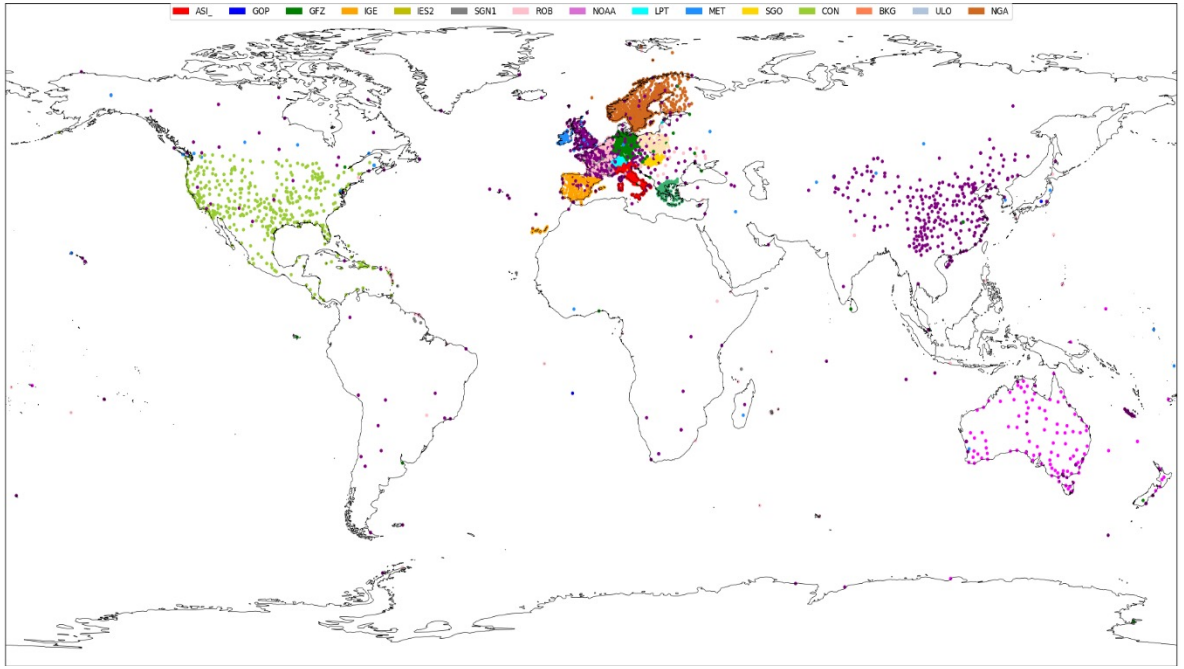
Met Office GNSS Plans

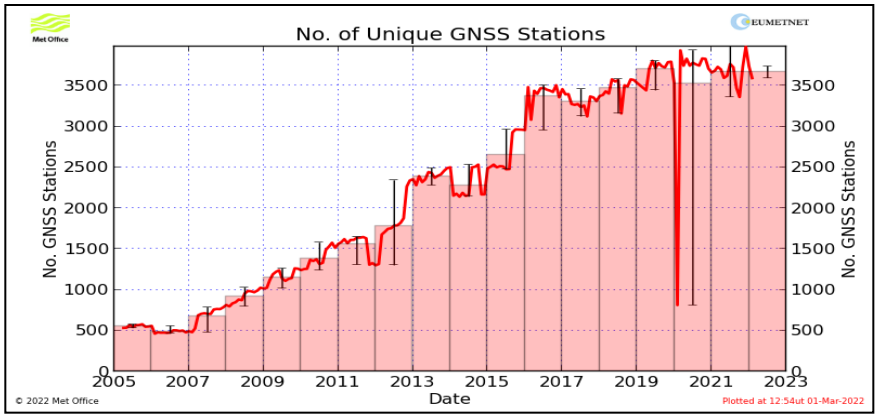
- New Met Office £1.2B Supercomputer.
- GNSS identified as low-risk technology to help fill humidity observing capability gap.
- Secured funding for:
  - Met Office 45-station GNSS network
  - Update and upgrade GNSS processing systems (move to AWS, BSW54, RINEX4, MGNSS, gradients, slants etc).
- GNSS-R for soil moisture and snow depth.
- Many more GNSS obs. in future with cheap dual-freq. receivers -> 3D tomographic reconstruction of atmospheric humidity?

E-GVAP

http://egvap.dmi.dk/

- EIG EUMETNET Project coordinating the near real-time delivery of data from **~3700 GNSS sites delivering ~25M ZTDs pcm.**
- Met Office (along with DMI and KNMI) founding partner.
- Met Office hosts ftp server for central BUFR encoding and dissemination.
- Active Quality Control (AQC).
- Data access MoUs in place with EUREF and EUPOS.
- MetO processes data on behalf of Ireland, Iceland and Canada.
- Phase V (2024-2028) in preparation: more focus on real-time, slants and gradients.

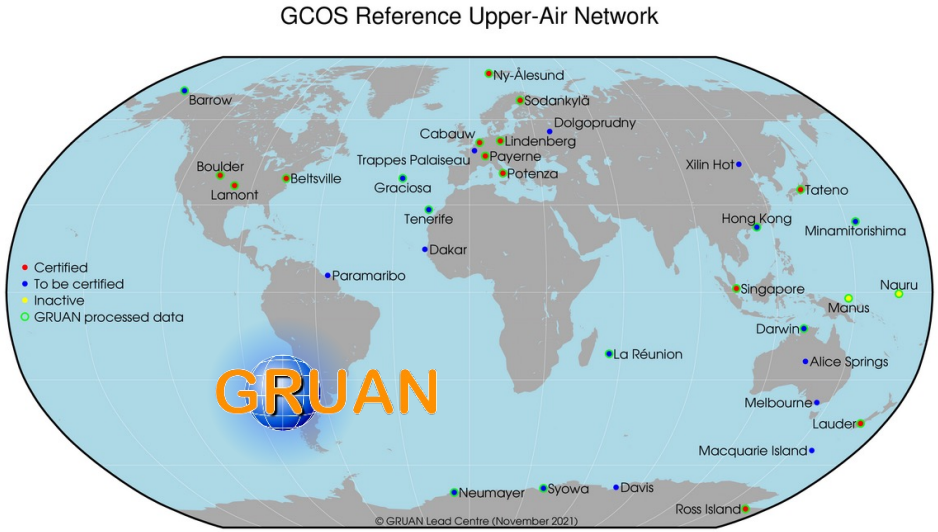




GRUAN GNSS PWV TT

https://www.gruan.org/

- WMO **G**lobal Climate Observing System (GCOS) **R**eference **U**pper-**A**ir **N**etwork (GRUAN): International reference observing network measuring WMO Essential Climate Variables (ECVs)
- Data used to determine trends, constrain and calibrate other instruments and to study atmospheric processes.



- GNSS-PWV identified as Priority 1 ECV.
- GNSS PWV Task Team established in 2010 to:
  - Define, implement and update requirements for ZTD and PWV observations
  - Develop methods to calculate ZTD and PWV uncertainties.
  - Recommend experiments and research pertinent to GNSS in collaboration with other projects
- Example current tasks:
  - Achieve metrological closure between GNSS and other instruments (e.g. RS)
  - Define and implement GNSS PWV NetCDF

Copernicus Climate Change Service (C3S)

https://climate.copernicus.eu/

- GCOS IP describes the proposed implementation of a global observing system for climate, building on current actions and meeting the needs of the UN Framework Convention on Climate Change.
- GCOS IP Action 22 will develop and populate a globally recognized repository of GNSS ZTD and PWV data and associated metadata for climate reanalysis.
- Letter sent to IAG President: “Cooperation with the IAG, in particular with the IGS for its high-quality reprocessed global products are central to the aims of this GCOS Action, and we hope that we can continue and extend long-term collaboration between both geodetic and climate communities.”
- Action to be achieved via Copernicus Climate Change Service:
  - Establish a long-term global, RINEX archive (in collaboration with the IGS)
  - Establish a long-term, global, climate quality (Repro) GNSS PWV archive
  - Perform required uncertainty analysis
  - Data accessible to all via Climate Data Store (CDS)

Questions