



HOW

UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

MODERNISING GEOSPATIAL REFERENCE SYSTEM CAPACITY DEVELOPMENT WORKSHOP

Options for African countries to align their datums
with ITRF

Nicholas Brown
Head of Office, UN-GGCE

Day 1, Session 4 [1_4_1]

Acknowledgements: Zuheir Altamimi (FRA); Jan Dostal (UN-GGCE); Guorong Hu (AUS).

Summary

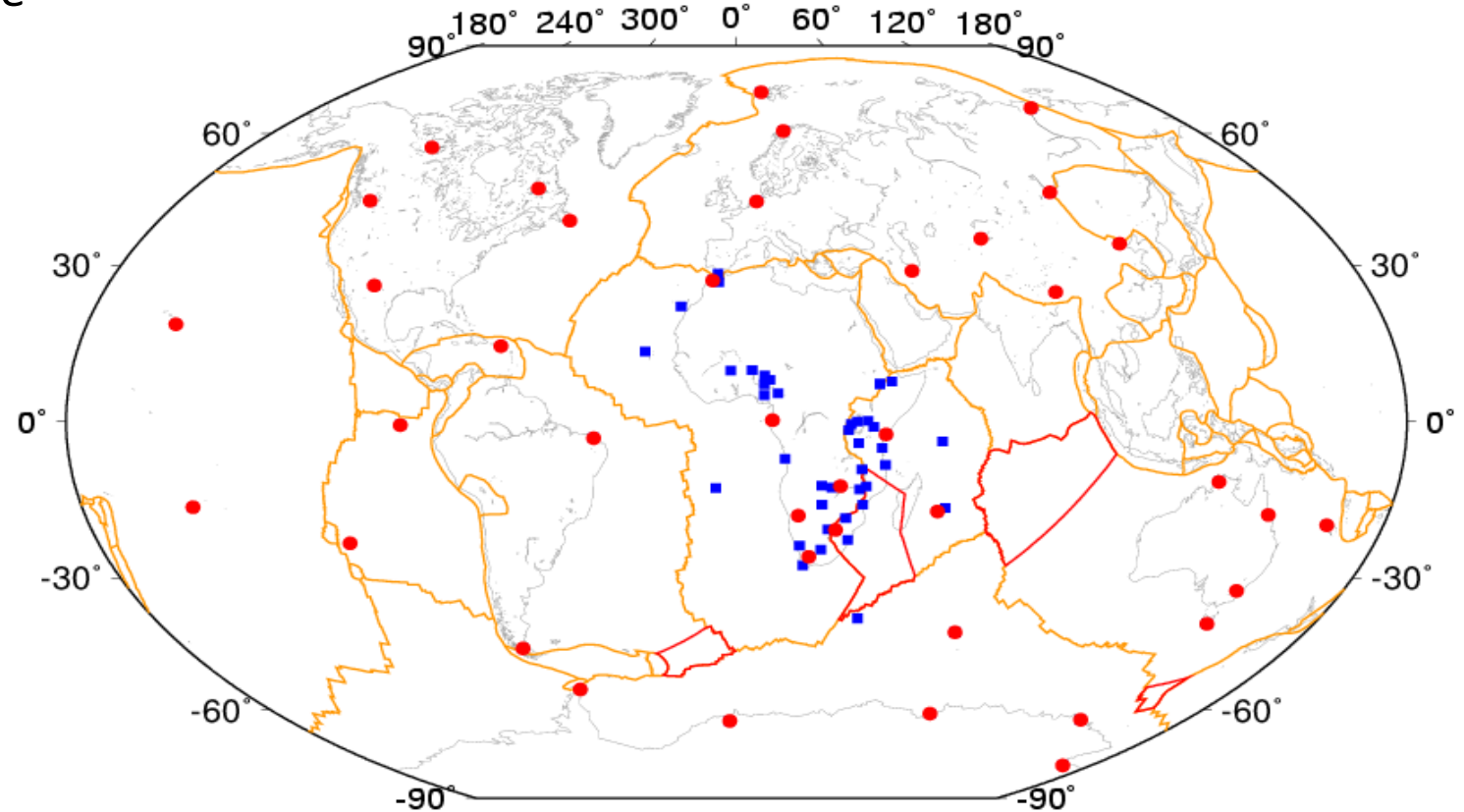
- If you don't have a regional reference frame, you can link your national geodetic datum to the International Terrestrial Reference Frame (ITRF) by analysing GNSS data with International GNSS Service products (orbit, clocks, Earth Rotation Parameters) all expressed in, and consistent with, the ITRF.
- An example is shown how this is done using the online GPS processing tool – AUSPOS – which uses Bernese processing software.



APREF Example

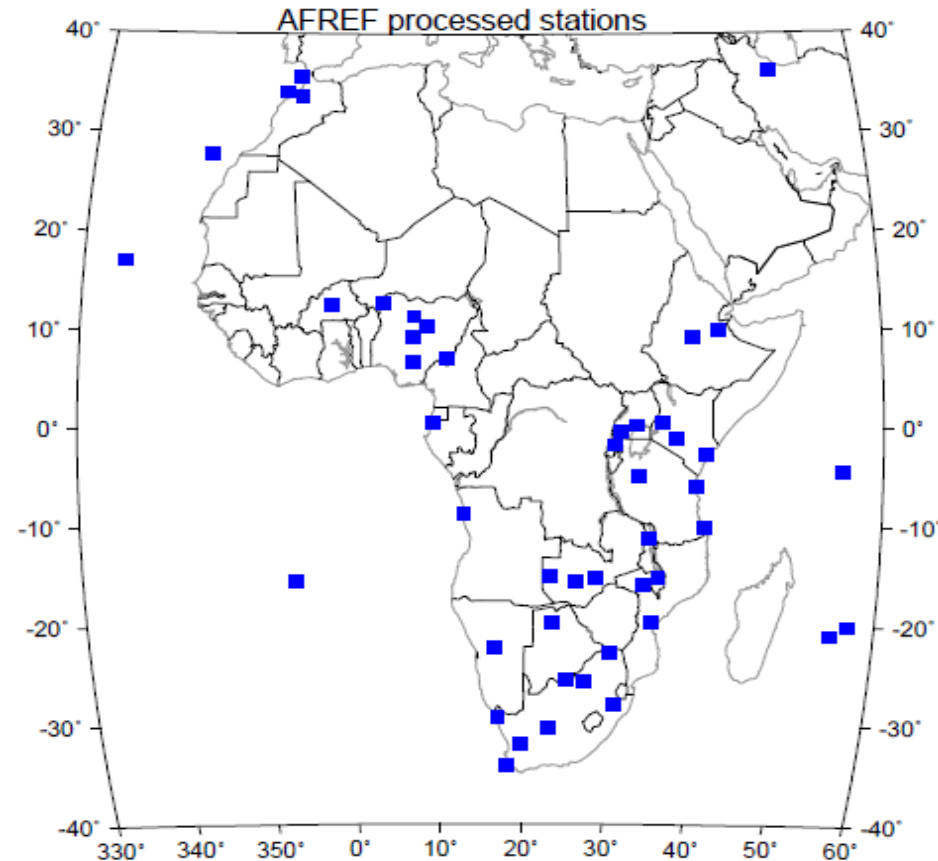
Distribution of processed sites:

- **Red:** ITRF/IGS sites used in the alignment to ITRF
- **Blue:** African sites



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APREF sites processed

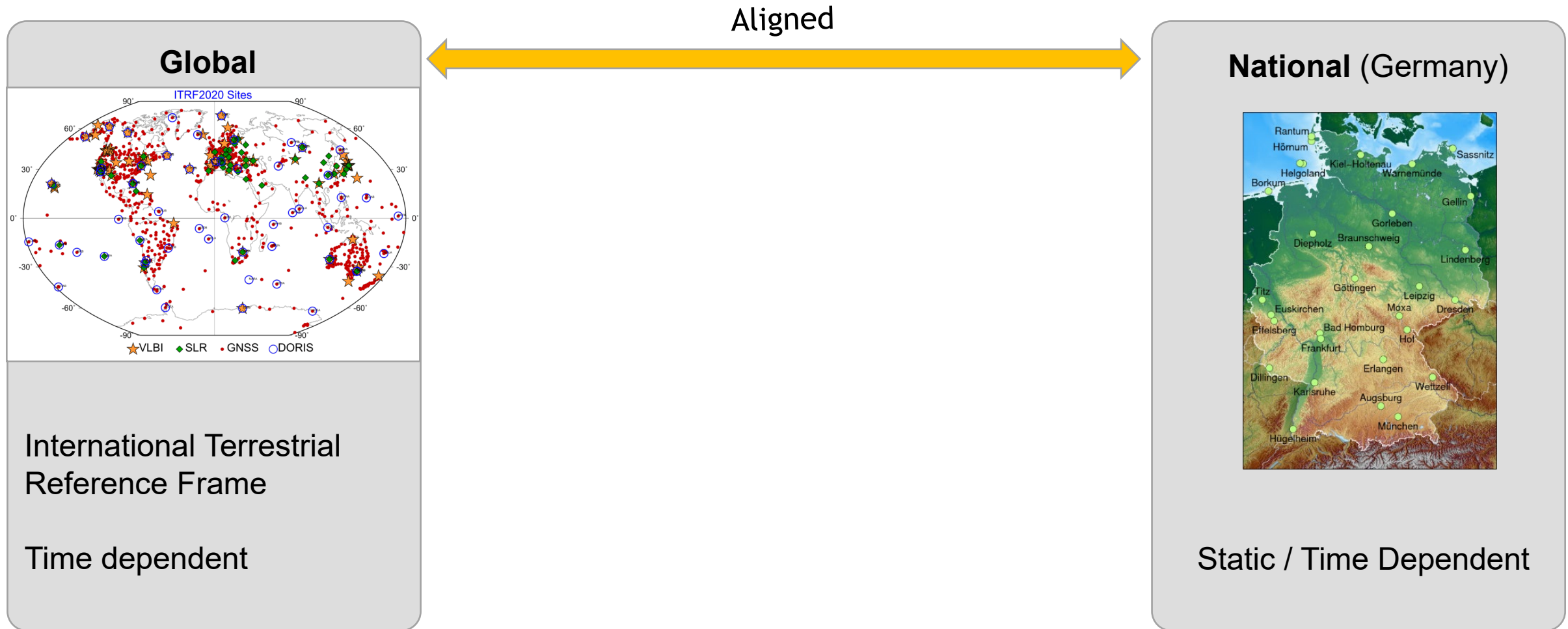


Distribution of AFREF sites processed.
Note gap from Angola through Congo, Sudan and across North Africa.



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If you don't have a regional reference frame



Côte d'Ivoire example

- Analysis of GNSS CORS data
- Aligned to ITRF2020 Reference frame
- Usage of International GNSS Service (IGS) core network station data and products
- Processing with AUSPOS which uses the Bernese GNSS Software
- AUSPOS can accept a GNSS-Network with up to **20 of your own GNSS sites**
- Network augmented with **15 IGS GNSS CORS sites**
- **Results**
 - Coordinates and Uncertainties of GNSS-Sites in ITRF2020
 - Uncertainties at 95% confidence level



AUSPOS Online GPS Processing Service

<https://www.ga.gov.au/scientific-topics/positioning-navigation/positioning-australia/geodesy/auspos>



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AUSPOS - Online GPS Processing Service

Page last updated: 19 August 2024

[Home](#) > [Scientific topics](#) > [Positioning and navigation](#) > [Positioning Australia](#) > [Enabling positioning through geodesy](#) >
AUSPOS - Online GPS Processing Service

Observation Data Collection

- Observations in STATIC MODE
- Static dual frequency GPS carrier phase and code data
 - Processing GPS data only
- Measurement interval
 - Equal to or larger than one second
 - Preferable 30 seconds
 - Preferable the same interval rate for all observation files
- Observation duration
 - At least 1 hour (recommended minimum of 2 hours)
 - Maximum of 7 consecutive days
 - Add some observation time at the beginning and end of the intended session
 - 6+ hours observation for cm accuracy
- Data Format RINEX
 - No raw observation file in proprietary format (transformation in RINEX)
 - Accepted RINEX Versions 2,3,4
- RINEX files overlapping time period more than 1 hour



Observation Data Submission

- Data Format RINEX
 - Receiver Independent Exchange Format
 - RINEX Version 2,3 or 4
 - Data File ending “o” (Observations)
 - or “d” for Hatanaka Compression
 - Example: ABJN0660.25o
- RINEX File Naming
 - English alphabet
 - No special characters - spaces, parentheses or symbols
- Scan or fill
 - Antenna Height (m)
 - Antenna Type

Online GPS Processing Service

System Status: ●

Load RINEX Files*

ABEN0660.25o, A

Choose File(s)

| File Name | | Height (m) | Antenna Type |
|--------------|-----------------|-------------------|------------------------------------|
| ABEN0660.25o | <div>Scan</div> | <div>1,2345</div> | <div>TRM159900.00 NONE x</div> |
| ABJN0660.25o | <div>Scan</div> | <div>1,512</div> | <div>LEIAR25.R4 LEIT x</div> |
| ADZO0660.25o | <div>Scan</div> | <div>0</div> | <div>DEFAULT(NONE) x</div> |

Email Address*

nicholas.brown@un.org

[Submission Checklist](#)

Clear

Submit



Data Processing

- Only GPS data is used for processing
 - Dual-frequency measurements from GPS L1 and L2 signals
 - RINEX file can contain also observations other systems
- Submitted data is resampled (thinned) to a 30-second epoch interval
- Network solution (relative positioning) using a double-difference strategy
- Strategy: Simultaneous multi-baseline processing



When to Submit the Data

- DO NOT submit measurements for the current UTC day
- The time submitting your data can influence the result
- Geodetic products for your processing are needed
- AUSPOS calculate your result with the products available at the time of your submission

Orbit products availability:

- FINAL - the best available quality orbits after 2-3 weeks
- RAPID - very good quality orbits after 2 days
- ULTRA RAPID - less accurate orbits close after observation

CORS data:

- Collection of CORS data (at least UTC 3 AM following day)
- Missing CORS data influence the choice of reference sites



AUSPOS Exercise

- Use the prepared directory with the RINEX files from CORS
 - Find the stations RINEX files with the ending “o” or “d”
- Open the file and check the file header and the data
 - Find the antenna type and the receiver height information
 - Header information can not be trusted. They may be incorrect or incomplete
- Open the AUSPOS website and
 - Upload the RINEX files
 - Include the height information
 - Chose the antenna type from the list
 - Using button SCAN antenna height and type from file header is used
 - Enter your email address
- Submit processing
- You obtain
 - Email information about the submission
 - With some time delay you obtain an email with the result pdf-file



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AUSPOS Exercise Dataset

South Africa stations

- RINEX 2
- Daily files
- Interval 30 sec
- GPS week 2356
- Julian Day 061 to Day 067 or
- Calendar day 2 March to 8 March 2025.

Data from 10 Trignet stations

BETH, DEAR, ELDA, ERAS, HNUS,
KMAN, PBWA, PLET, RBAY, SBOK

Cote d'Ivoire stations

- RINEX 3.02
- Daily files
- Interval 30 sec
- GPS week 2356
- Julian Day 060 to Day 066 or
- Calendar day 1 March to 7 March 2025.

Data from 3 stations

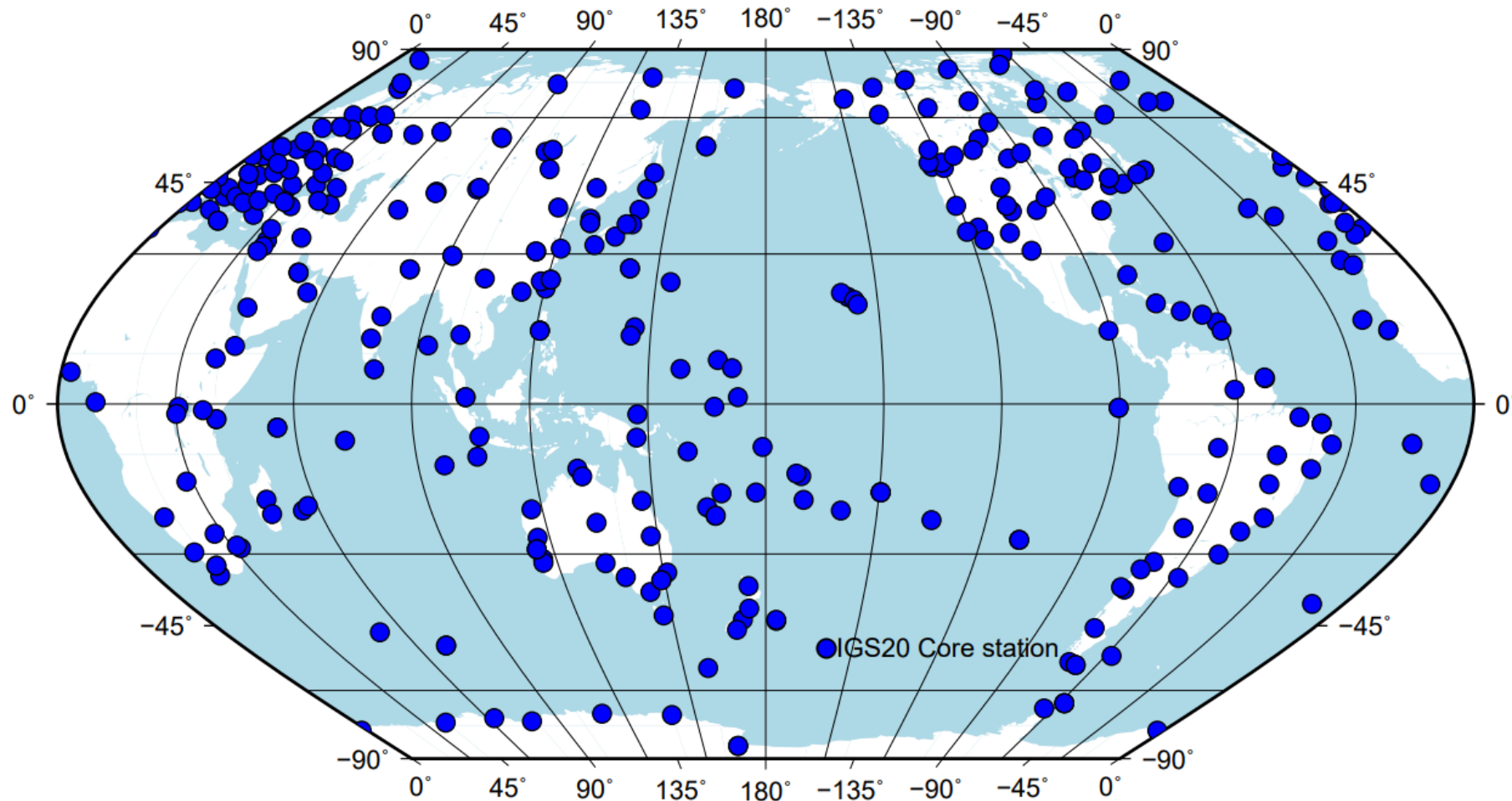
ABEN, ABJN, ADZ



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IGS20 sites

IGS Station used as reference station for processing with AUSPOS.



AUSPOS GPS Processing Report



Australian Government
Geoscience Australia

AUSPOS GPS Processing Report

March 27, 2025

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 3.0). The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

AUSPOS Processing Report – Input Data

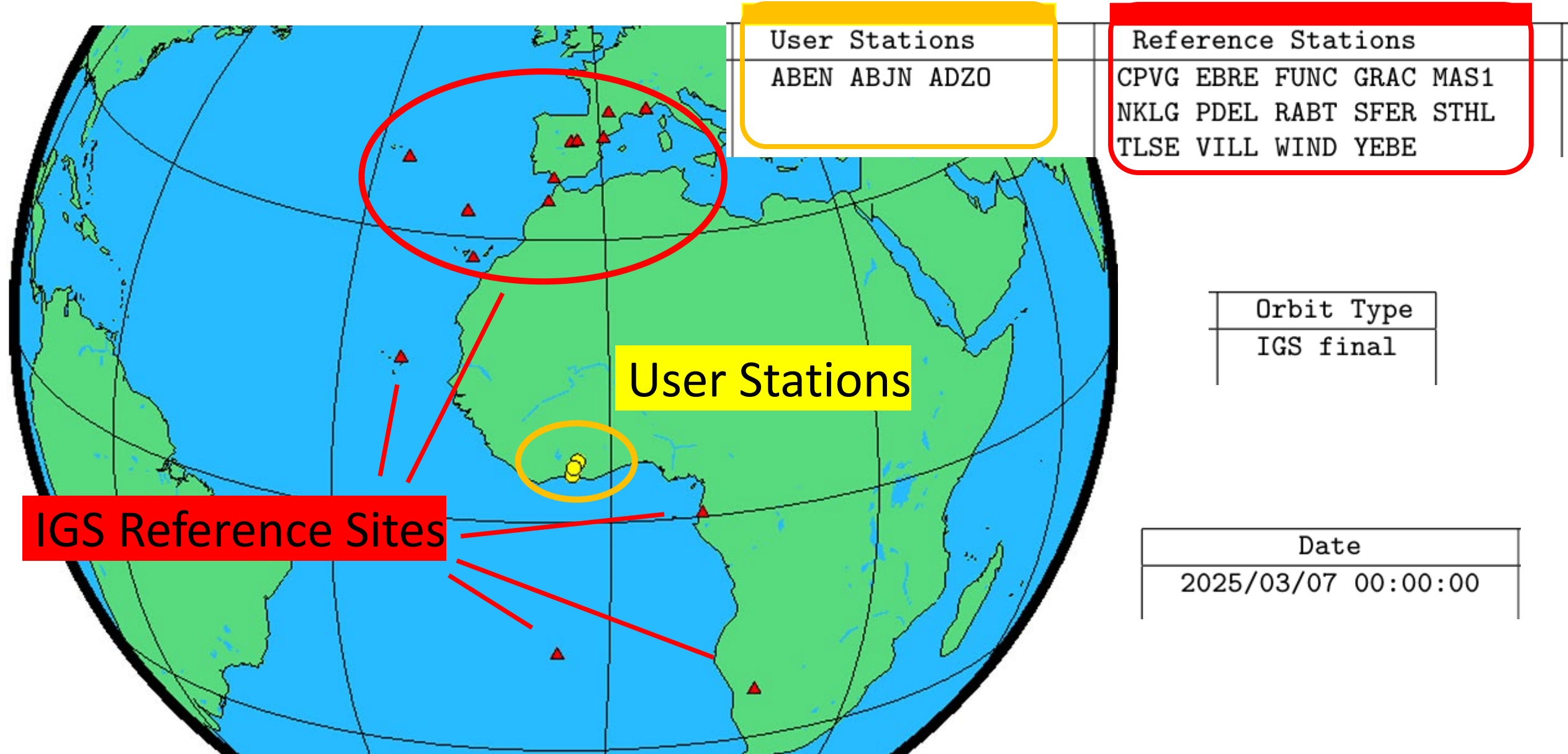
3 Sites from Cote d'Ivoire

1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

| Station (s) | Submitted File | Antenna Type | Antenna Height (m) | Start Time | End Time |
|-------------|----------------|-------------------|--------------------|---------------------|---------------------|
| ABEN | ABEN0660.25o | TRM159900.00 NONE | 0.000 | 2025/03/07 00:00:00 | 2025/03/07 23:59:30 |
| ABJN | ABJN0660.25o | TRM159900.00 NONE | 0.000 | 2025/03/07 00:00:00 | 2025/03/07 23:59:30 |
| ADZO | ADZO0660.25o | TRM159900.00 NONE | 0.000 | 2025/03/07 00:00:00 | 2025/03/07 23:59:30 |

AUSPOS Processing Summary



AUSPOS Computed Coordinates, ITRF 2020

Cartesian (X,Y,Z)

| Station | X (m) | Y (m) | Z (m) | ITRF2020 @ |
|---------|-------------|-------------|------------|------------|
| ABEN | 6322881.964 | -385538.225 | 743276.322 | 07/03/2025 |
| ABJN | 6335352.923 | -442773.911 | 588525.427 | 07/03/2025 |
| ADZO | 6327921.847 | -426651.703 | 674257.590 | 07/03/2025 |

IGS Reference Stations

| | | | | |
|------|-------------|--------------|-------------|------------|
| CPVG | 5626883.450 | -2380932.244 | 1824484.067 | 07/03/2025 |
| EBRE | 4833519.928 | 41537.507 | 4147461.787 | 07/03/2025 |
| FUNC | 5143339.177 | -1563412.406 | 3421191.852 | 07/03/2025 |
| GRAC | 4581708.075 | 556133.018 | 4389341.503 | 07/03/2025 |
| MAS1 | 5439192.129 | -1522055.111 | 2953455.147 | 07/03/2025 |

AUSPOS Computed Coordinates, ITRF 2020

Geodetic (Lat, Long, Height)

- GRS80 Ellipsoid
- Geoid Height derived from EGM2008

| Station | Latitude (DMS) | | | Longitude (DMS) | | | Ellipsoidal Height(m) | Derived Above Geoid Height(m) |
|---------|-------------------|----|----------|--------------------|----|----------|--------------------------|----------------------------------|
| ABEN | 6 | 44 | 12.89563 | -3 | 29 | 21.46051 | 237.315 | 209.719 |
| ABJN | 5 | 19 | 47.71587 | -3 | 59 | 52.31740 | 63.519 | 38.112 |
| ADZO | 6 | 06 | 32.36383 | -3 | 51 | 26.11344 | 131.867 | 104.700 |

IGS Reference Stations

| | | | | | | | | |
|------|----|----|----------|-----|----|----------|---------|--------|
| CPVG | 16 | 43 | 55.43000 | -22 | 56 | 05.75038 | 94.066 | 63.284 |
| EBRE | 40 | 49 | 15.20782 | 0 | 29 | 32.52086 | 107.790 | 57.605 |
| FUNC | 32 | 38 | 52.62360 | -16 | 54 | 27.40550 | 78.406 | 29.187 |

AUSPOS Computed Coordinates, ITRF 2020

UMT Grid

- GRS80 Ellipsoid

| Station | East (m) | North (m) | Zone | Ellipsoidal Height (m) | Derived Above Geoid Height(m) |
|---------|-------------|--------------|------|---------------------------|----------------------------------|
| ABEN | 445926.565 | 744693.028 | 30 | 237.315 | 209.719 |
| ABJN | 389433.871 | 589222.900 | 30 | 63.519 | 38.112 |
| ADZO | 405143.745 | 675328.099 | 30 | 131.867 | 104.700 |

IGS Reference Stations included

| | | | | | |
|------|------------|-------------|----|----------|----------|
| CPVG | 293716.368 | 1850918.067 | 27 | 94.066 | 63.284 |
| EBRE | 288524.406 | 4521900.781 | 31 | 107.790 | 57.605 |
| FUNC | 321080.515 | 3613867.040 | 28 | 78.406 | 29.187 |
| GRAC | 332612.208 | 4846706.382 | 32 | 1319.866 | 1268.805 |

AUSPOS Uncertainties

Positional Uncertainty for geodetic coordinates

- 95% Confidence Level

| Station | Longitude(East) (m) | Latitude(North) (m) | Ellipsoidal Height(Up) (m) |
|---------|---------------------|---------------------|----------------------------|
| ABEN | 0.006 | 0.004 | 0.012 |
| ABJN | 0.006 | 0.004 | 0.010 |
| ADZO | 0.006 | 0.004 | 0.011 |
| CPVG | 0.005 | 0.003 | 0.010 |
| EBRE | 0.004 | 0.003 | 0.007 |
| FUNC | 0.005 | 0.003 | 0.008 |
| GRAC | 0.005 | 0.003 | 0.009 |
| MAS1 | 0.004 | 0.003 | 0.007 |

Accuracy: Horizontal 4-6 mm; Vertical 10-12 mm

AUSPOS Processing Information

- Ambiguity Resolution – Per Baseline
 - Baseline Length
- Computation System
 - Software, GNSS System
- Preprocessing, Measurement Modelling, Used Parameters
 - Data type, Elevation mask, Sampling rate
 - Ionosphere and Troposphere parametrization
 - Antenna Offset, Satellite parametrization,
- Estimation Process
- Reference Frame and uncertainty information

Campaign observations

- For countries that lack permanent GNSS Continuously Operating Reference Stations (CORS), the annual Asia Pacific Regional Geodetic Project (APRGP) GPS campaign GPS Campaign offers a vital opportunity to participate in high-precision geodetic analysis using campaign-style GNSS data collected over short periods each year.
- Through the campaign's regional processing and analysis, participating countries receive accurate station coordinates and velocity estimates tied to the regional reference frame (APREF) and therefore the latest realization of the International Terrestrial Reference Frame.
- This enhances their national geodetic datums, supports monitoring of crustal motion, and contributes to better hazard assessment and mapping.
- Additionally, countries gain access to shared regional expertise and data, strengthening their technical capacity and integration into broader geospatial initiatives.

Campaign observations

- The annual Asia Pacific Regional Geodetic Project (APRGP) GPS campaign is an activity of the Geodetic Reference Frame Working Group (WG) of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP).
- Data analysis of the APRGP GPS campaign undertaken over a week (roughly) at the same time of year (mid September).
- In 2023, campaign GPS data collected at 124 sites in nine countries across the Asia Pacific region were processed using version 5.2 of the Bernese GNSS Software in a regional network together with selected IGS (International GNSS Service) sites.
- The GPS solution was constrained to the ITRF2020 reference frame by adopting IGS20 coordinates on selected IGS reference sites and using the final IGS earth orientation parameters and satellite ephemerides products.

Campaign observations

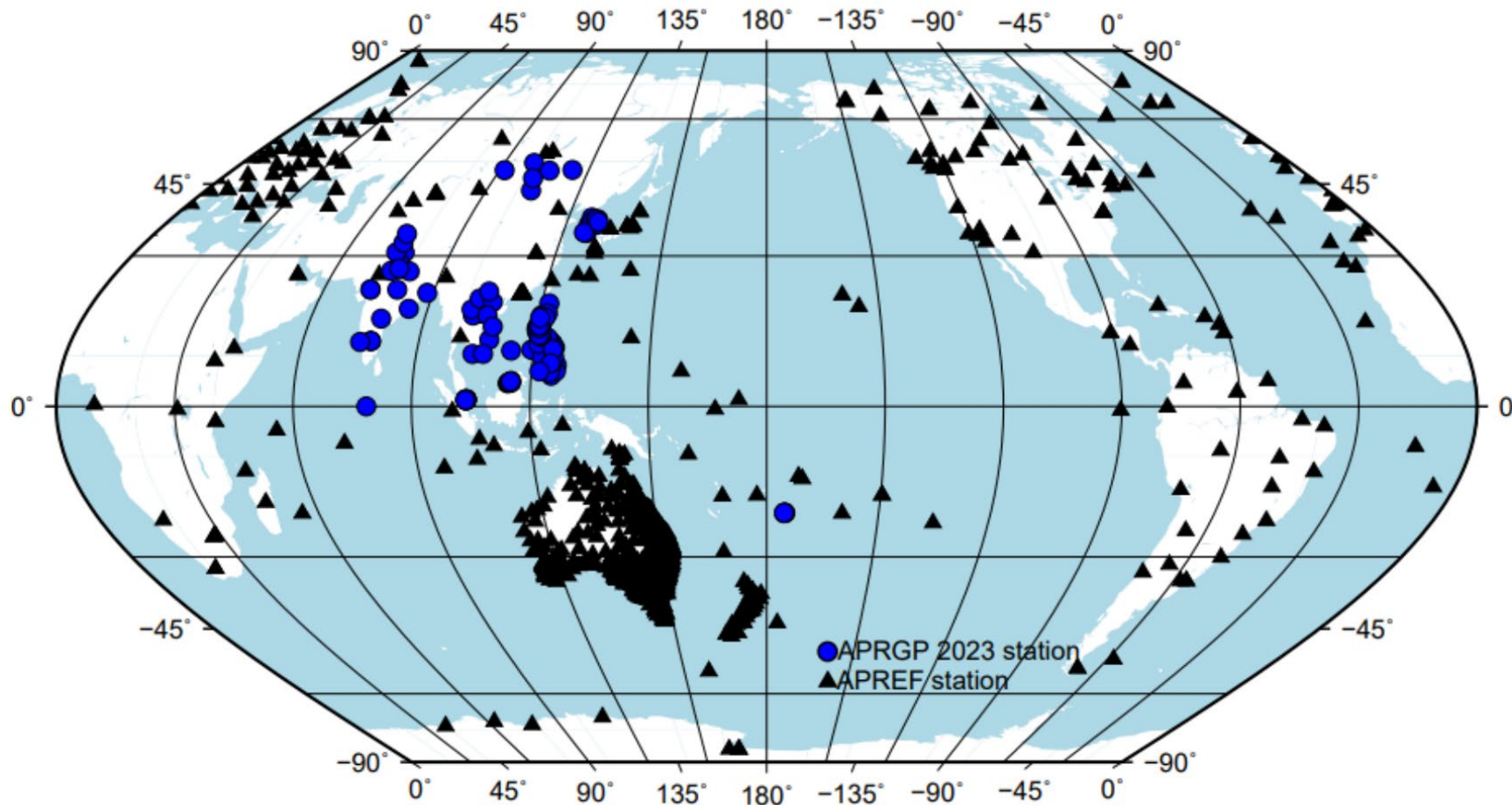


Figure 1 APRGP stations in the APRGP 2023 GPS campaign analysis along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.

Campaign observations

- Running at the same time every year:
 - reduces the effects of seasonal variations (e.g., atmospheric conditions, ground moisture, thermal expansion), ensuring that observed changes are primarily due to tectonic or geodetic phenomena, not seasonal cycles.
 - standardizes the observation period allowing analysts to apply the same processing models and parameters, which increases the reliability and comparability of results across years and sites.
 - makes it easier for participating countries to plan fieldwork, equipment deployment, and data submission, especially for those with limited resources or no permanent GNSS infrastructure.
- This provides a higher-quality time series of station positions and velocities which is crucial for detecting subtle crustal movements or long-term trends like land subsidence or tectonic strain.

Further Information

AUSPOS Tool and Submission Checklist:

<https://www.ga.gov.au/scientific-topics/positioning-navigation/positioning-australia/geodesy/auspos>

A Practical Guide to AUSPOS:

https://www.spatial.nsw.gov.au/data/assets/pdf_file/0015/230622/2022_Janssen_and_McElroy_APAS2022_practical_guide_to_AUSPOS.pdf

International GNSS Service:

<https://igs.org>

Bernese GNSS Software Manual:

<https://www.bernese.unibe.ch/docs/DOCU52.pdf>

Observation Data Advice

- Data Format
 - RINEX - Receiver Independent Exchange Format
 - Data Files ending with
 - “o” - Observations or
 - “d” - Hatanaka Compression of Observations
- Antenna
 - Height - vertically from Ground Mark to Antenna Reference Point (ARP)
 - Type
- File Header information can not be trusted. They may be incorrect or incomplete
- DO NOT use special characters for "MARKER NAME" and "MARKER NUMBER" in the RINEX header.
- After the "END OF HEADER" line in the RINEX header, only observation data should be present



Data Prioritization for Processing I

Priority list for observations included in the RINEX file:

For RINEX version 2:

L1 frequency carrier phase: L1

L2 frequency carrier phase: L2

L1 frequency pseudo-range: P1 C1

L2 frequency pseudo-range: P2 C2

For RINEX version 3 (and version 4):

L1 frequency carrier phase: L1P L1W L1C L1X

L2 frequency carrier phase: L2P L2W L2C L2D L2X

L1 frequency pseudo-range: C1P C1W C1C C1X

L2 frequency pseudo-range: C2P C2W C2C C2D C2X

For each RINEX file, ensure there is at least one observation type for each of the two frequencies and for both carrier-phase and pseudo-range measurements.



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Data Prioritization for Processing II

RINEX V2:

- if BOTH C1 and P1 (C2 and P2) code measurements exist, P1 (P2) is given priority. In this case, ensure all GPS satellites contain P1 (P2) measurements.
- if only C1 (C2) code measurements exist, ensure all GPS satellites contain C1 (C2) measurements.

RINEX V3 and V4:

- Currently accepted measurements from frequency:
 - **L1:** C1P and L1P; C1W and L1W; C1C and L1C; and C1X and L1X
 - **L2:** C2P and L2P; C2W and L2W; C2C and L2C; C2D and L2D; and C2X and L2X
- **NOT accepted** C2S (code) and L2S (phase) from L2 frequency

