



HOW

## UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

### MODERNISING GEOSPATIAL REFERENCE SYSTEM CAPACITY DEVELOPMENT WORKSHOP

Options for Asia-Pacific countries to align their  
datums with ITRF

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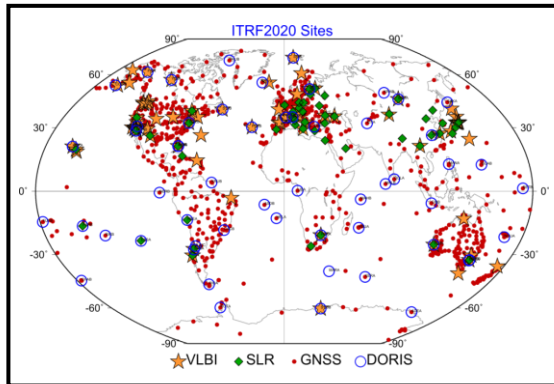
Day 1, Session 4 [1\_4\_2]

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# How to align NGD with ITRF

## ITRF2020

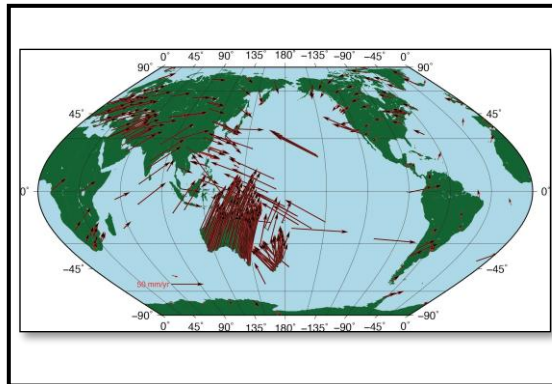
VLBI + SLR + GNSS + DORIS



- International Terrestrial Reference Frame
- Time dependent
- Developed by IAG Services

## Regional Reference Frame

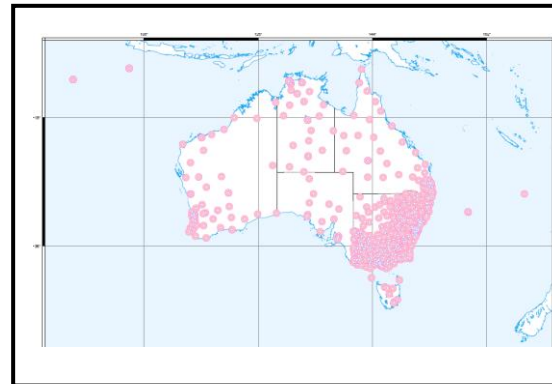
GNSS



- Asia-Pacific Reference Frame
- Time dependent
- Developed by regional scientific organisations (Geoscience Australia)

## National GNSS Network

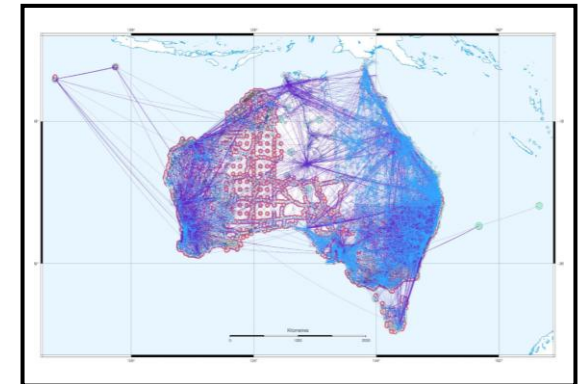
GNSS



- Australian GNSS CORS network on the Australian continental plate
- Time dependent
- Developed by regional scientific organisations (Geoscience Australia)

## National Geodetic Datum

GNSS + Terrestrial



- Australian geodetic adjustment
- Constrained to the GNSS CORS network on the Australian continental plate
- Time dependent datum (ATRF) and Static datum (GDA2020)
- Developed by regional scientific organisations (Geoscience Australia)

# How to align a country GNSS network to the ITRF

## 1. Select Global Reference Stations:

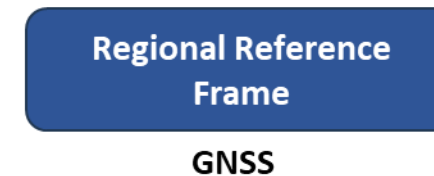
- Select a set of well-distributed global and regional GNSS stations with known coordinates in ITRF2020.
- Obtain the corresponding RINEX observation data for these reference stations from IGS data centres (e.g., CDDIS).
- Access high-quality GNSS products provided by the International GNSS Service (IGS), including precise orbits, satellite and station clocks, and Earth Rotation Parameters (ERPs), all of which are consistent with ITRF2020.

- *In the case of the Asia-Pacific countries, you could use all or a subset of the APREF stations.*
- *Get the RINEX data from Geoscience Australia which is an IGS regional data centre.*
- *Access high-quality GNSS products provided by the International GNSS Service (IGS), including precise orbits, satellite and station clocks, and Earth Rotation Parameters (ERPs), all of which are consistent with ITRF2020.*

## 2. Process your national GNSS network with GNSS Software:

- Use high-precision GNSS processing software (e.g., Bernese, GAMIT/GLOBK, GIPSY).
- In your processing:
  - Include your national GNSS stations along with the selected ITRF2020 reference stations in a combined solution.
  - Fix the IGS-provided orbits, clocks, and ERPs to ensure alignment with ITRF2020.
  - Constrain (or fix) the coordinates of the reference stations to their published ITRF2020 values.
- Through the combined processing and constraints, your national GNSS stations will be positioned relative to the fixed reference frame, thus aligning them with ITRF2020.
- The output coordinates of your national stations will be expressed in the ITRF2020 reference frame.

- *This step requires some specialist knowledge of GNSS processing.*
- *Consider partnering with another country which has skills in this area.*



# How to align a country survey network to the ITRF (without a GNSS network)

- For countries that do not have permanent GNSS Continuously Operating Reference Stations (CORS), you could perform annual regional geodetic GPS campaigns to offers an 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 (SIRGAS-CON) and therefore the latest realization of the International Terrestrial Reference Frame.
- GNSS campaign observations are not obviously made at each survey mark in the country, but you could consider making observations at important points around the country which are the *backbone* of your national datum.
- 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

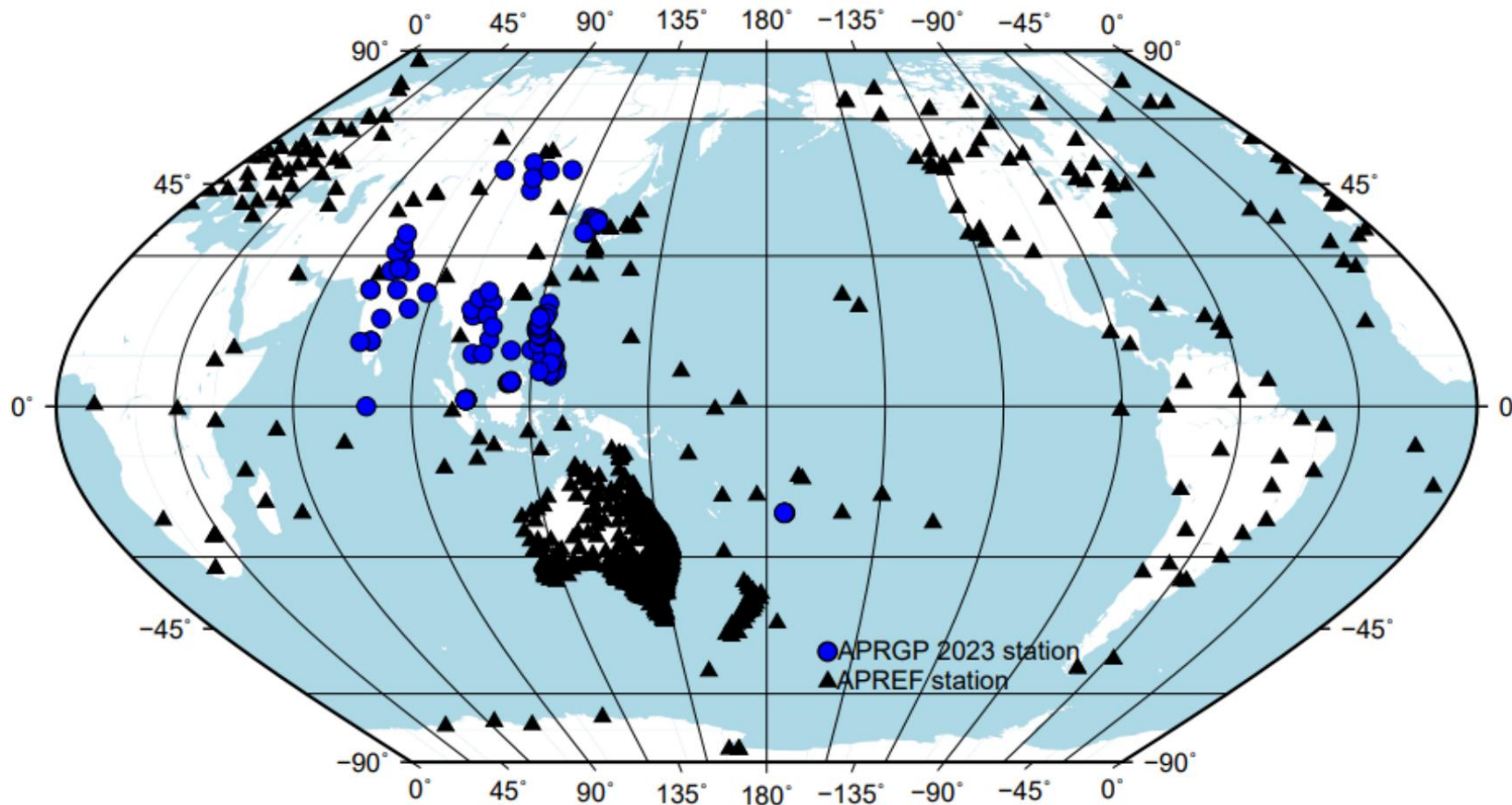


Figure 1 APRGP stations in the APRGP 2023 GPS campaign analysis along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.



# 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.
- The outcome is a set of ITRF coordinates and velocities aligned with APREF are critical points in your country which are the *backbone* of your national datum.

# Discussion

- How do you plan on developing your modern national geodetic datum ensuring alignment with ITRF?
- What is stopping you from taking the first (or next step)?



# 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](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>