UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

MODERNISING GEOSPATIAL REFERENCE SYSTEM CAPACITY DEVELOPMENT WORKSHOP

National geodetic adjustments

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HOW

Day 2, Session 2 [2_2_1]

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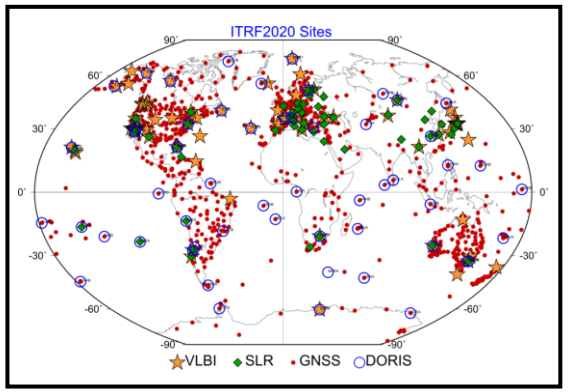
How to align NGD with ITRF

ITRF2020

VLBI + SLR + GNSS + DORIS

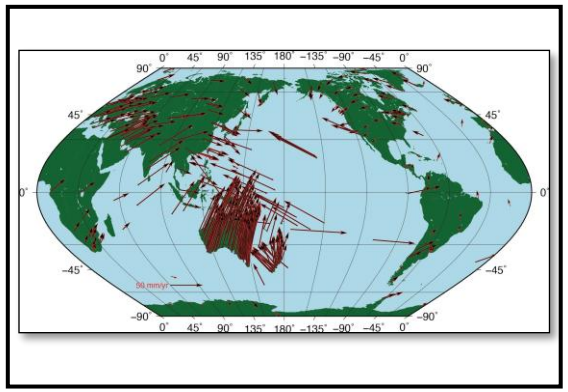


- International Terrestrial Reference Frame
- Time dependent

- Developed by IAG Services

Regional Reference Frame

GNSS

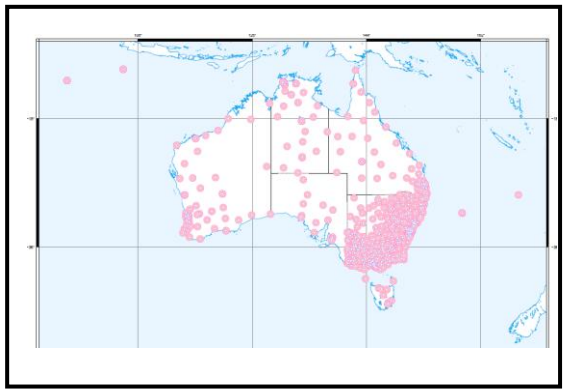


- Asia-Pacific Reference Frame
- Time dependent

- Developed by regional scientific organisations (Geoscience Australia)

National GNSS Network

GNSS

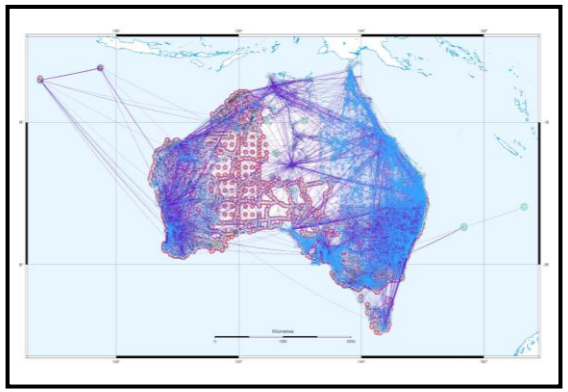


- Australian GNSS CORS network on the Australian continental plate
- Time dependent

- 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.

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.

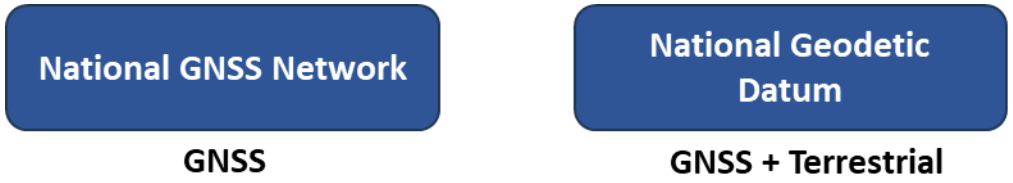
- *In the case of the Asia-Pacific countries, you could use all or a subset of the APREF stations.*
- *Get the RINEX data from Geoscience Australia which is an IGS regional data centre.*
- *Access high-quality GNSS products provided by the International GNSS Service (IGS), including precise orbits, satellite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

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

How to align NGD with ITRF

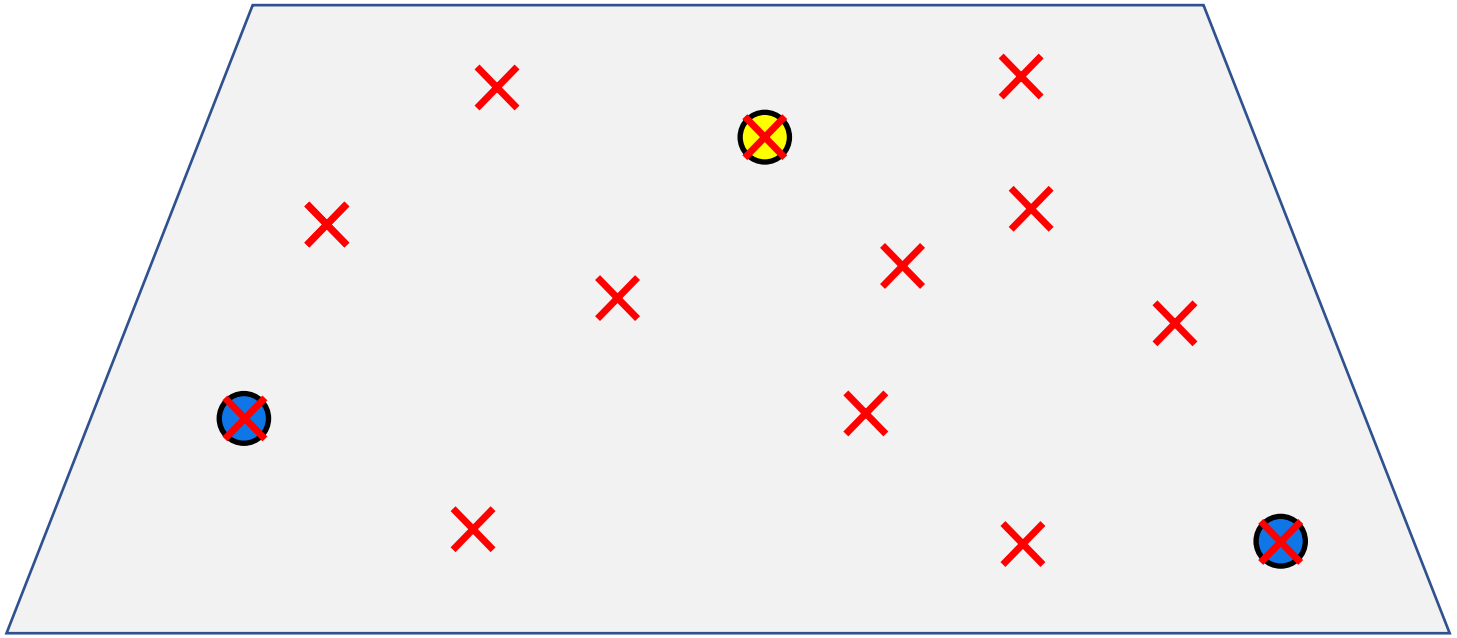
Perform a National Geodetic Adjustment:

- Use the National GNSS Network station coordinates as control / datum points in a comprehensive national geodetic adjustment.
- Integrate all available national geodetic data in a national geodetic adjustment (GNSS, terrestrial, levelling, etc.) to establish a consistent and modern national geodetic datum aligned with ITRF2020.
- This can be done using software like DynAdjust
- This propagates the GNSS station coordinates down to the local survey marks.



How to align NGD with ITRF

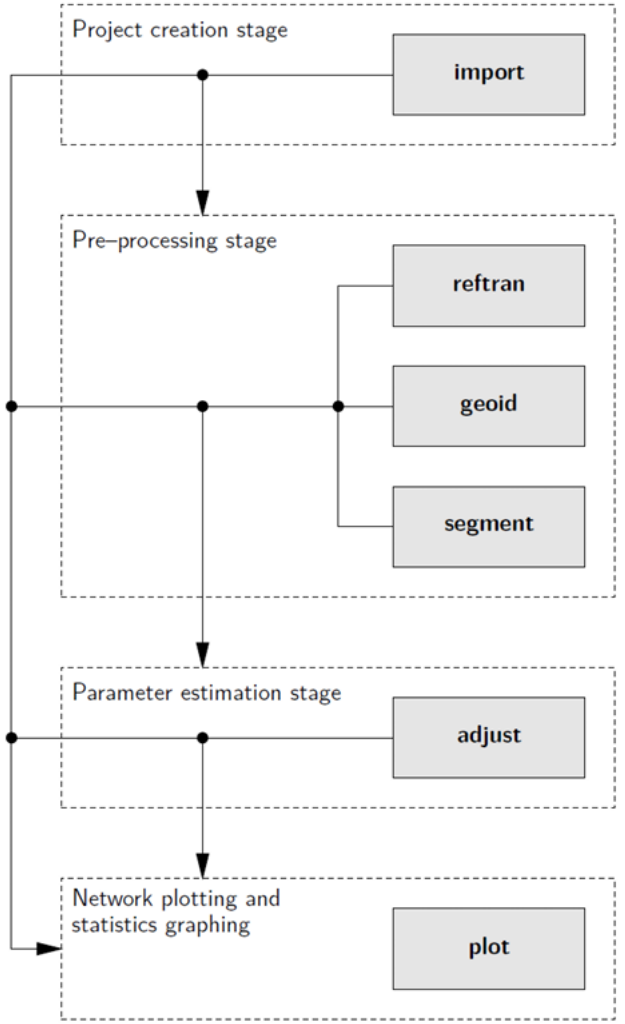
- GNSS CORS included in International or regional reference frame
- GNSS CORS included in National GNSS Network
- National survey marks



STRONGER.
TOGETHER.

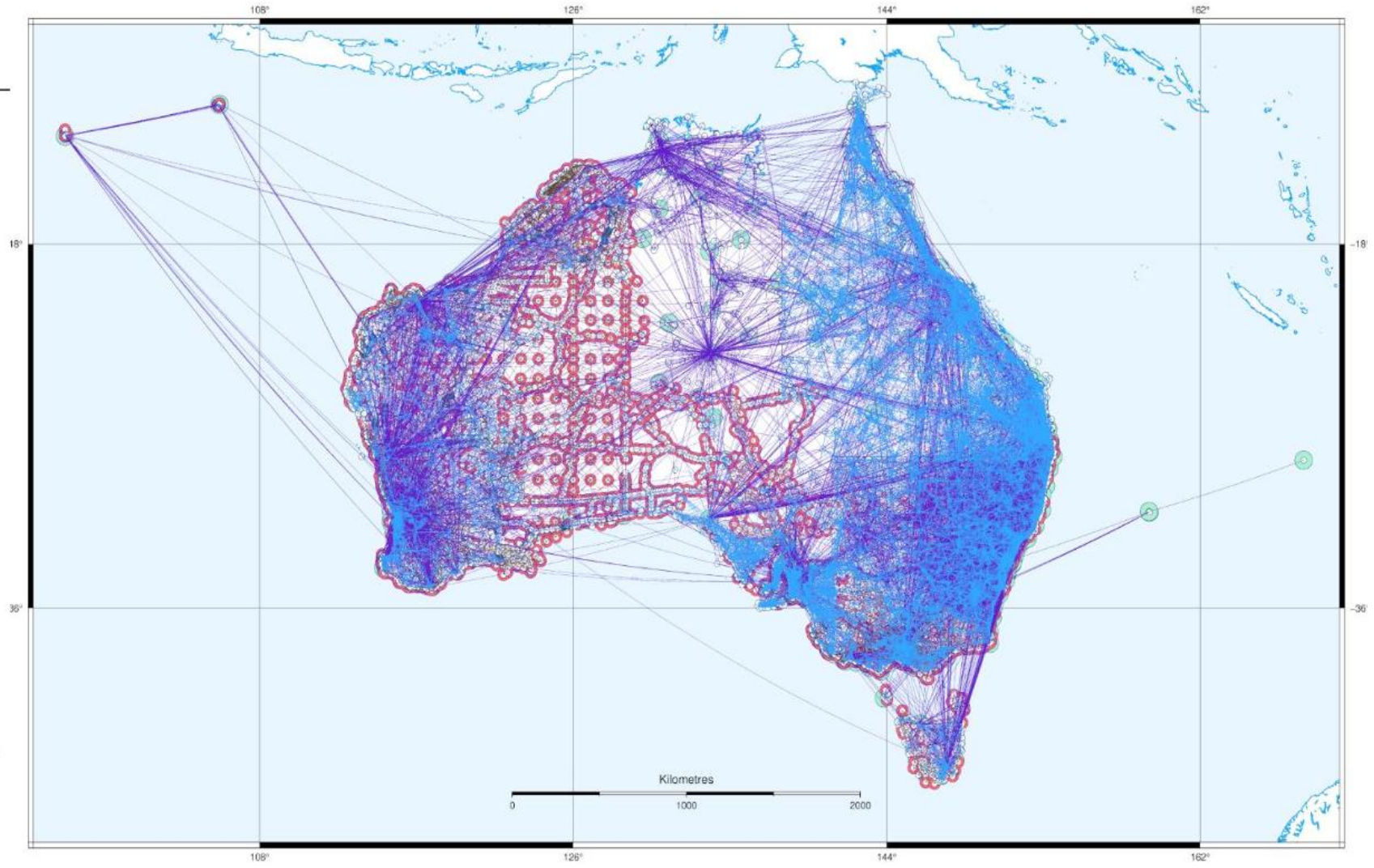
Fully automated adjustment approach

- Import all data
  - SINEX, GNSS baselines, terrestrial measurements, levelling
- Align stations and measurements to an epoch (e.g. 2020)
  - Datum/frame transformation (ITRF2000,2005,2008,2014)
  - Apply plate motion model if no direct parameters are available
- Apply geoid model to convert orthometric data to ellipsoidal
  - (Gravity) deflections of the vertical
  - Ellipsoid-geoid separations
- Automatic network segmentation
- Parallel or sequential phased adjustment
- Export uncertainties



National adjustment

333,164	**Stations**
2,400,419	**Measurements**
1,542	Geodetic azimuth
132	Astronomic azimuth
215	Zenith angle
484,696	Direction set
201,213	MLS arc
186,479	Ellipsoid arc
46,464	Slope distance
1,171,545	GNSS baseline
89,175	GNSS baseline cluster
2,178	GNSS point cluster
230	Ellipsoid height
204,178	Orthometric height
12,372	Level difference



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DynAdjust

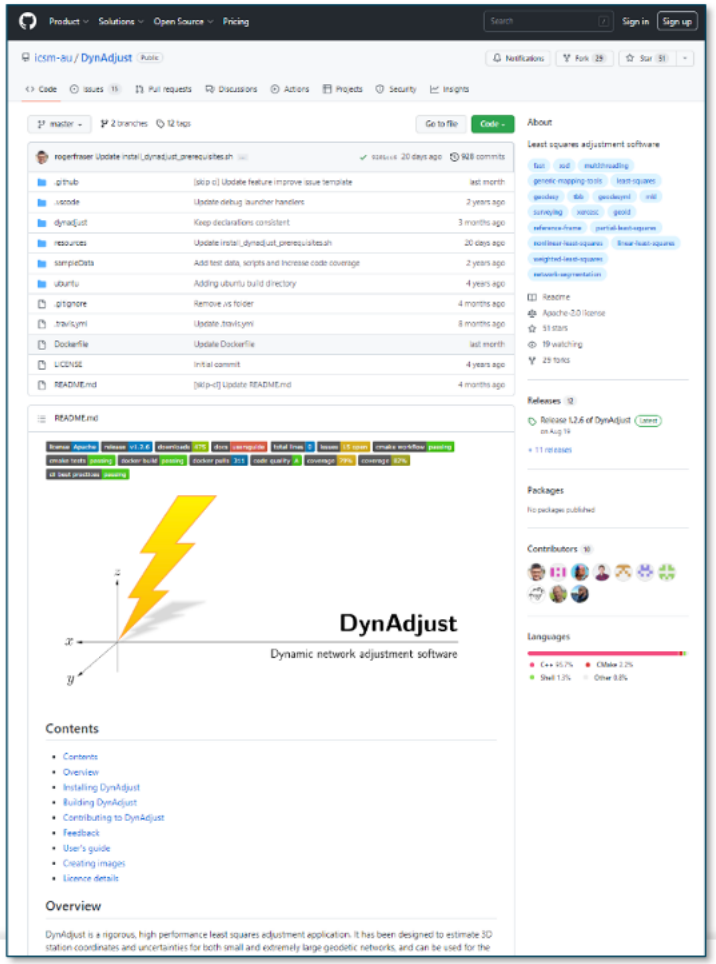
DynAdjust: open source adjustment package

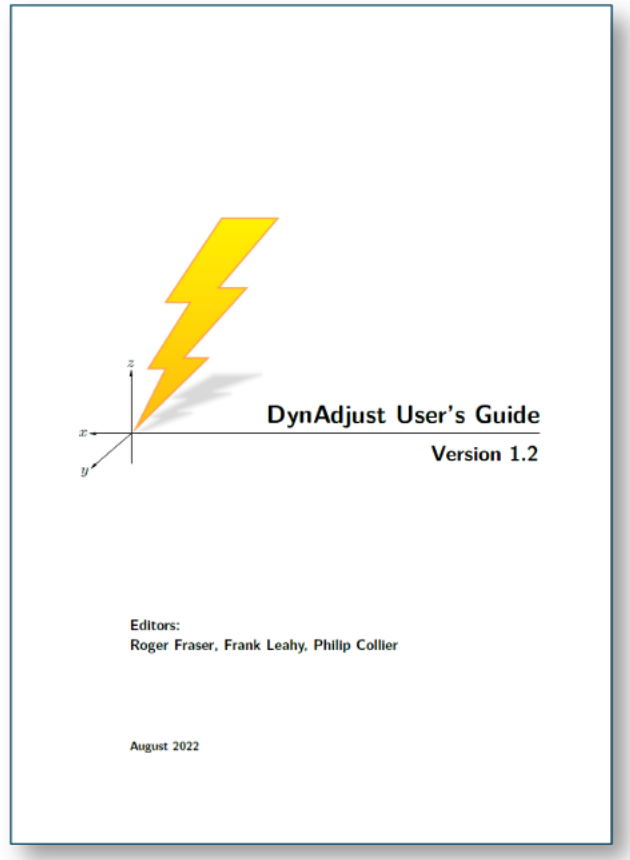
Generic Mapping Tools

DIA

gnuplot

LaTeX





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https://github.com/icsm-au/dynadjust

Resources

- GNSS analysis
  - BERNESE – network GNSS analysis
  - AUSPOS – GPS site analysis https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/auspos
  - OPUS – GNSS site analysis https://geodesy.noaa.gov/OPUS/
- GNSS quality checking (Anubis) https://gnutsoftware.com/software/anubis/
- GNSS checking, repairing and manipulating https://kg4-dmz.gfz-potsdam.de/services/gfzrnx
- Geodetic Adjustment
  - DynAdjust (https://github.com/icsm-au/DynAdjust)
- Least Squares training presentation
  - Full presentation – https://www.youtube.com/watch?v=T5YB_1Jpjp0 (1hr 42 mins)
  - Chapter 1 – What is Least Squares and why are we using it in DCM? https://youtu.be/0YkjHsVgGMk (26 mins)
  - Chapter 2 – Why do we iterate? https://youtu.be/_iFg3Ho_cRI (18 mins)
  - Chapter 3 – Weighting Observations https://youtu.be/2yQCWblrQGs (10 mins)
  - Chapter 4 – Constraints https://youtu.be/WcwKv-vWUtk (7 mins)
  - DynAdjust Q&A https://youtu.be/WZN38NrPBeY