GNSS overview and RINEX

DARA @ Hart 2024/11/14

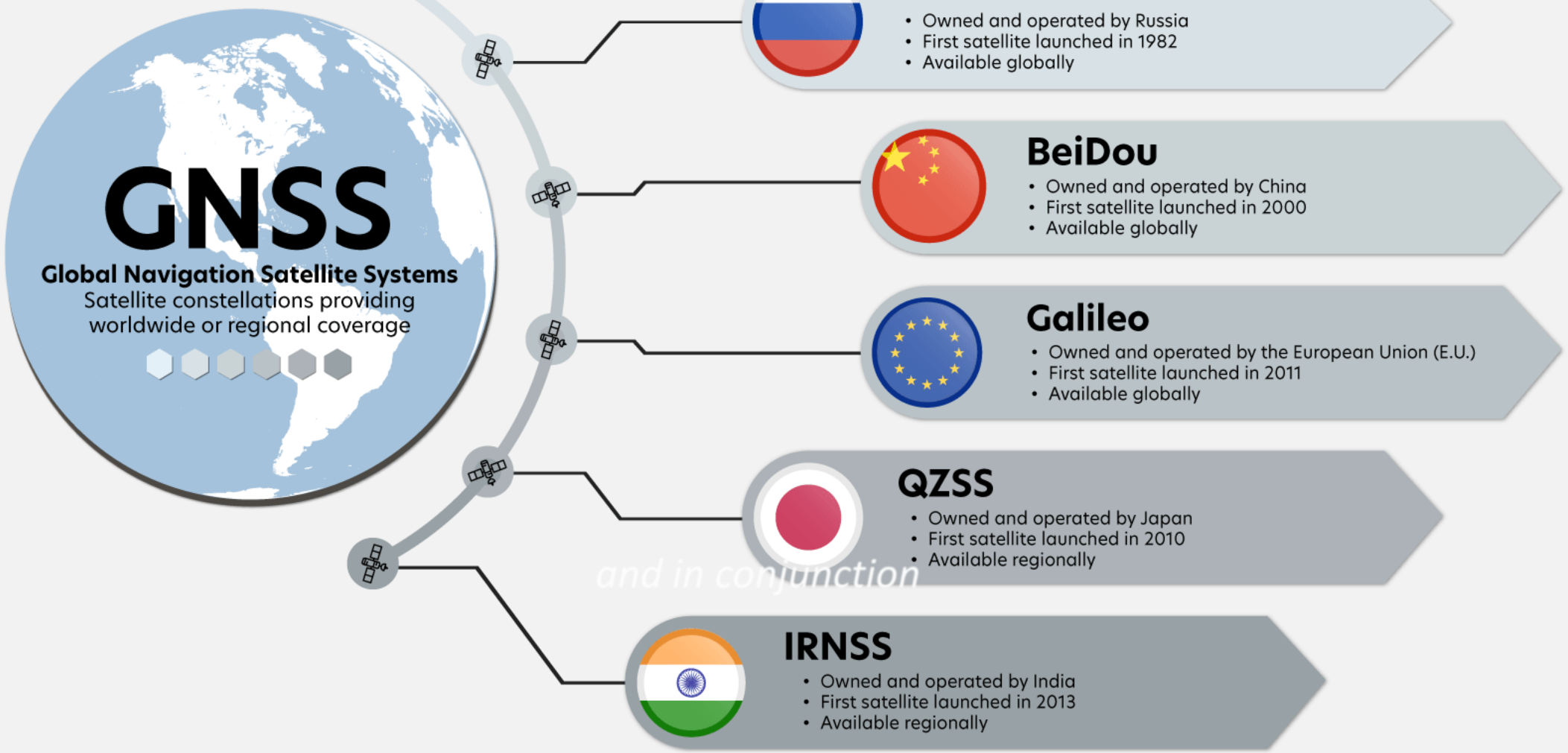
Roelf Botha

Manager: Geodesy

OVERVIEW

- Global Navigation Satellite Services
- RINEX
- RINEX Practical
- Software for processing

GNSS Overview



https://eos-gnss.com/knowledge-base/gps-overview-1-what-is-gps-and-gnss-positioning

International GNSS Service

IGS INTERNATIONAL GNSS SERVICE

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View and learn more about the global network of all IGS ground tracking stations.

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STATION OPERATOR RESOURCES

Access Station Guidelines, the Site Log Manager User Guide, and more.

FILE ACCESS

Visit our secure, https file access to view station info, logs, formats, and more

NETWORK

NETWORK RESOURCES

Download Maps/Station List
Sitelog (4char)
Sitelog (9char)
Propose a New IGS Site
New Site Checklist

STATION OPERATOR RESOURCES

IGS Site Guidelines
Site Log Manager
Monumentation
Recommendations

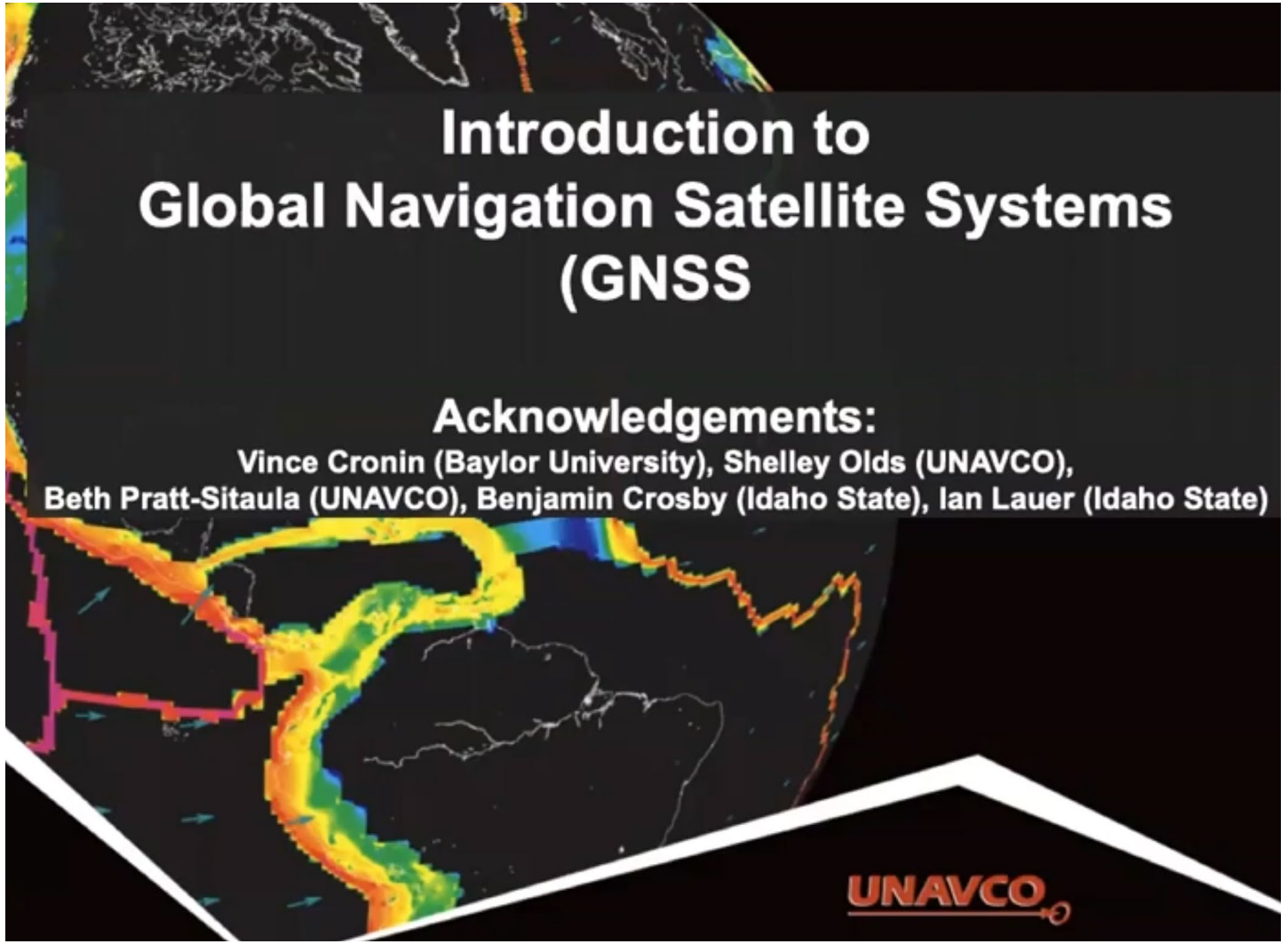
FILE ACCESS

Formats
Station Info
Receiver/Antenna File (rcvr_ant.tab)
SINEX File

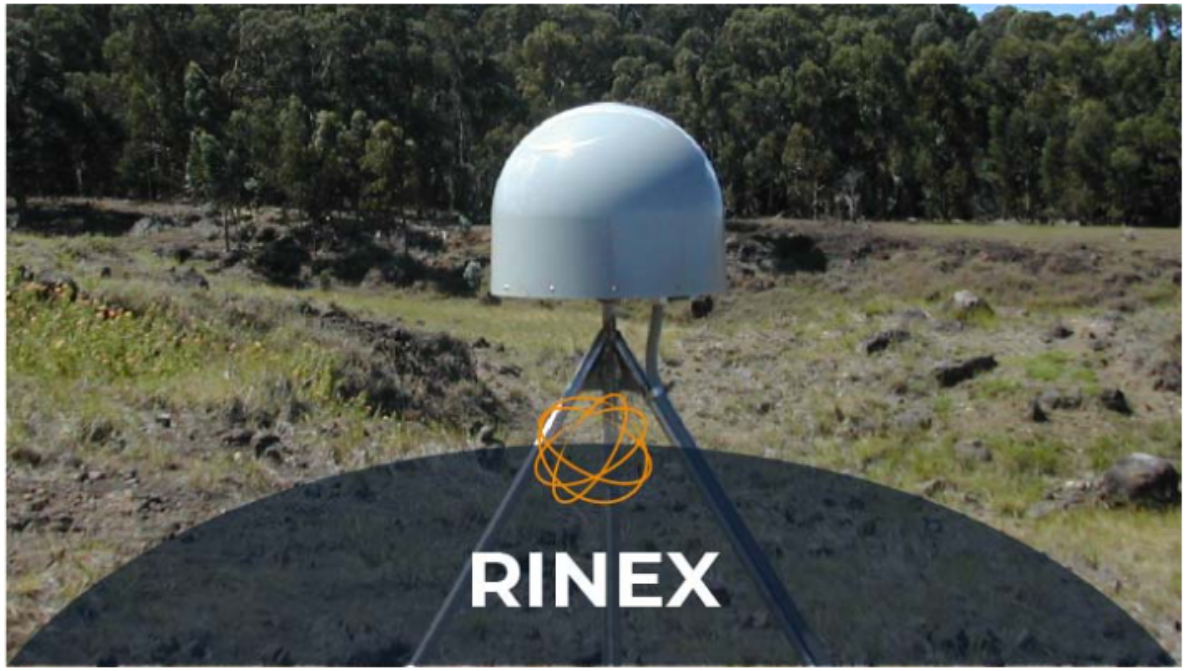
https://igs.org/network-resources

GNSS: US + international collaborator

GNSS – Introduction (UNCAVCO)



GNSS – RINEX



RINEX Committee

Established: 2011

Acting Chair: Francesco Gini (ESA)

Formats and Standards: RINEX Formats and Standards

Mailing List: IGS RINEX Committee Mailing List

The IGS Receiver INdependent EXchange (RINEX) Working Group (RINEX-WG) was established in December of 2011 to update and maintain the RINEX format to meet the needs of the IGS and the GNSS Industry. Since the RINEX format is widely used by the GNSS industry it was decided that it should be jointly managed by the IGS and Radio Technical Commission for Maritime services-Special Committee 104 (RTCM-SC104). As a result the working group consists of both IGS and RTCM-SC104 industry members. Document approval will follow the IGS/RTCM-SC104 consensus based approach and majority voting will be used if a consensus cannot be reached in a reasonable amount of time. RINEX documents will continue to be freely distributed both by the IGS and RTCM-SC104.

https://igs.org/wg/rinex/#documents-formats

GNSS – File naming conventions – Rx2

a)

File name	Description	Example
SSSSDDD0.YYT	Daily file	hrao0010.17o
SSSSDDD[a-x].YYT	Hourly file	hrao001a.17o hrao001b.17o
SSSSDDDD[a-x]MM.YYT	Sub-hourly file	hrao001b22.17o hrao001b45.17o

b)

Placeholder	Description	Example
SSSS	4-char. station identifier	hrao
DDD	Day of year	001
YY	2-digit year	17
MM	Minute of data start	22, 45
T	Data type (d, g, m, o, etc)	o

Table 3.1: RINEX 2 naming convention, with a) depicting the file naming patterns and b) describing the placeholders.

GNSS – File naming conventions – Rx2

File extensions / types:

- .yyc: Clock information
- .yyd: Hatanaka compressed (from .yyo observation file), see Sections 3.1.1.2 and 3.1.2.3. This results in file size of about 30% the original size.
- .yyf: Beidou navigation message data
- .yyg: GLONASS navigation message data
- .yyh: SBAS payload navigation message data
- .yyl: GALILEO navigation message data
- .yym: meteorological data
- .yyn: GPS navigation message data find
- .yyo: observation data
- .yyp: mixed GNSS navigation message data
- .yyq: QZSS navigation message data
- .yys: observation summary files (extracted from RINEX header)

GNSS – File naming conventions – Rx3

a)

SSSSMRCCC_S_YYYYDDDHHMM_NNN_FRQ_TT.FMT[.CMP]
eg. HRAO01ZAF_R_20170010000_01H_30S_MO.rnx.bz2

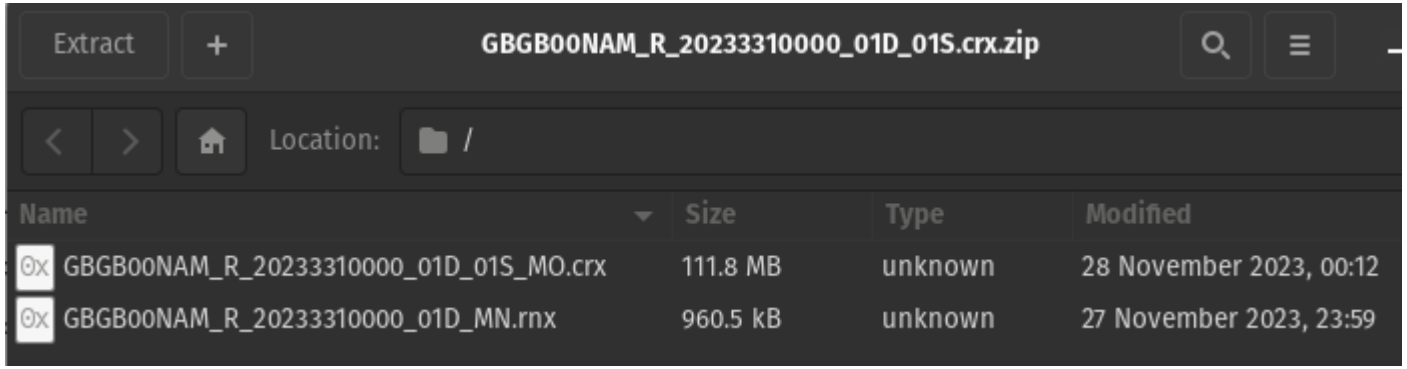
SSSSMRCCC_S_YYYYDDDHHMM_NNN_TT.FMT[.CMP]
eg. HRAO01ZAF_R_20170010000_01H_MN.rnx.gz

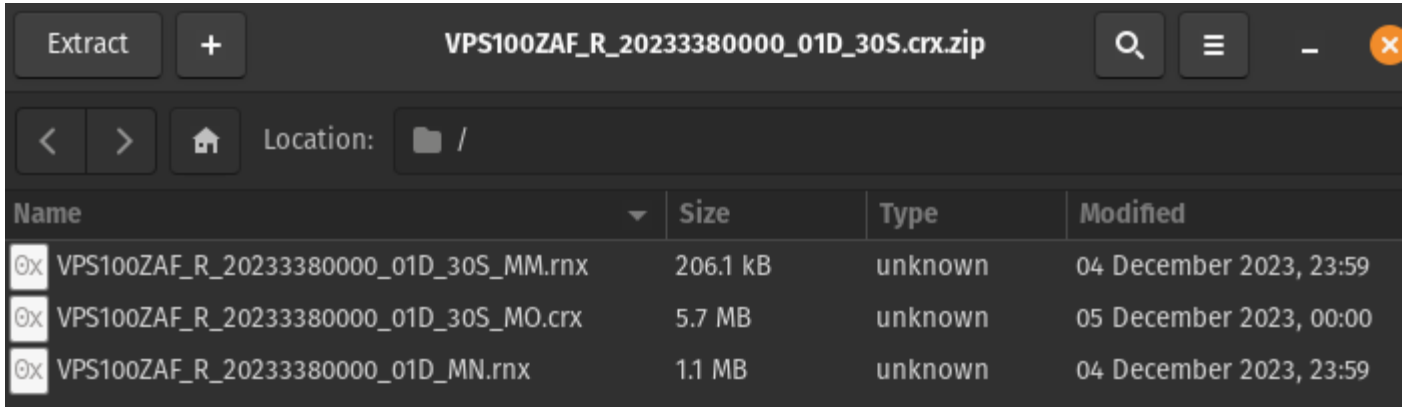
Placeholder	Description	Example
SSSSMRCCC	Station Identifier	HRAO01ZAF
SSSS	4-char station identifier	HRAO
M	Monument number	0
R	Receiver number	1
CCC	ISO country code	ZAF
S	Data Source	R (Receiver) / S (Stream) / U (Unknown)
YYYYDDDHHMM	Start epoch	20170010000
NNN	Nominal file period	01H
FRQ	Data frequency	30S
TT	Data type	MO (mixed obs.), RN (GLONASS nav.)
FMT	File format extension	rnx (RINEX), crx (Hatanaka Compressed)
CMP	Compression method	gz, bz2, zip, Z

RINEX 3 Content types:

- GO = GPS Obs.
- RO = GLONASS Obs.
- EO = Galileo Obs.
- JO = QZSS Obs.
- CO = BDS Obs.
- IO = IRNSS Obs.
- SO = SBAS Obs.
- MO = Mixed Obs.
- GN = Nav. GPS
- RN = GLONASS Nav.
- EN = Galileo Nav.
- JN = QZSS Nav.
- CN = BDS Nav.
- IN = IRNSS Nav.
- SN = SBAS Nav.
- MN = Nav. (All GNSS Constellations)
- MM = Meteorological Observation

GNSS – Practical / Example





GNSS – Practical RINEX Header

Loading **GBGB00NAM_R_20233310000_01D_01S_MO.crx** from **~/.cache/.fr-NQAY2e**

```
     3.0                 COMPACT RINEX FORMAT                    CRINEX VERS   / TYPE
RNX2CRX ver.4.0.7                       27-11-23 23:59          CRINEX PROG / DATE
     3.04                OBSERVATION DATA    M: MIXED            RINEX VERSION / TYPE
GR10 V4.61               SARAO Geodesy Progra20231126 235942 UTC PGM / RUN BY / DATE
SNR is mapped to RINEX snr flag value [1-9]                      COMMENT
LX:      < 12dBHz -> 1; 12-17dBHz -> 2; 18-23dBHz -> 3           COMMENT
        24-29dBHz -> 4; 30-35dBHz -> 5; 36-41dBHz -> 6           COMMENT
        42-47dBHz -> 7; 48-53dBHz -> 8; >= 54dBHz -> 9           COMMENT
GBGB                                                             MARKER NAME
0                                                                MARKER NUMBER
Roelf Botha              SARAO Geodesy Programme                 OBSERVER / AGENCY
1702578                  LEICA GR10          4.61/6.525          REC # / TYPE / VERS
3831216                  TPSCR.G3        NONE                    ANT # / TYPE
  5085381.2202  2668300.2132 -2768754.4237                       APPROX POSITION XYZ
        0.1280        0.0000        0.0000                       ANTENNA: DELTA H/E/N
G   16 C1C L1C D1C S1C C2S L2S D2S S2S C2W L2W D2W S2W C5Q       SYS / # / OBS TYPES
       L5Q D5Q S5Q                                               SYS / # / OBS TYPES
R   12 C1C L1C D1C S1C C2P L2P D2P S2P C2C L2C D2C S2C           SYS / # / OBS TYPES
E   16 C1C L1C D1C S1C C5Q L5Q D5Q S5Q C7Q L7Q D7Q S7Q C8Q       SYS / # / OBS TYPES
       L8Q D8Q S8Q                                               SYS / # / OBS TYPES
C    8 C2I L2I D2I S2I C7I L7I D7I S7I                           SYS / # / OBS TYPES
S    4 C1C L1C D1C S1C                                           SYS / # / OBS TYPES
DBHZ                                                             SIGNAL STRENGTH UNIT
     1.000                                                       INTERVAL
  2023    11    27    00    00    0.0000000     GPS             TIME OF FIRST OBS
  2023    11    27    23    59   59.0000000     GPS             TIME OF LAST OBS
     0                                                           RCV CLOCK OFFS APPL
G L1C                                                            SYS / PHASE SHIFT
G L2S -0.25000                                                   SYS / PHASE SHIFT
G L2W                                                            SYS / PHASE SHIFT
G L5Q -0.25000                                                   SYS / PHASE SHIFT
R L1C                                                            SYS / PHASE SHIFT
R L2P  0.25000                                                   SYS / PHASE SHIFT
R L2C                                                            SYS / PHASE SHIFT
E L1C  0.50000                                                   SYS / PHASE SHIFT
E L5Q -0.25000                                                   SYS / PHASE SHIFT
E L7Q -0.25000                                                   SYS / PHASE SHIFT
E L8Q -0.25000                                                   SYS / PHASE SHIFT
C L2I                                                            SYS / PHASE SHIFT
C L7I                                                            SYS / PHASE SHIFT
S L1C                                                            SYS / PHASE SHIFT
 24 R01  1 R02 -4 R03  5 R04  6 R05  1 R06 -4 R07  5 R08  6 GLONASS SLOT / FRQ #
    R09 -2 R10 -7 R11  0 R12 -1 R13 -2 R14 -7 R15  0 R16 -1 GLONASS SLOT / FRQ #
    R17  4 R18 -3 R19  3 R20  2 R21  4 R22 -3 R23  3 R24  2 GLONASS SLOT / FRQ #
C1C  -71.940 C1P  -71.940 C2C  -71.940 C2P  -71.940          GLONASS COD/PHS/BIS
    18    18  1929     7                                     LEAP SECONDS
                                                             END OF HEADER
```

Open | **VPS100ZAF_R_20233380000_01D_30S_MM.rnx** ~/.cache/.fr-ZNm2SE | Save

```
     3.04                METEOROLOGICAL DATA                     RINEX VERSION / TYPE
GR10 V4.52               SARAO Geodesy Progra20231203 235942 UTC PGM / RUN BY / DATE
VPS1 GeoStation                                                  MARKER NAME
0                                                                MARKER NUMBER
     7    PR    TD    HR    WD    WS    RI    HI                # / TYPES OF OBSERV
Vaisala WXT520       R5011021                                 PR SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 TD SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 HR SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 WD SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 WS SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 RI SENSOR MOD/TYPE/ACC
Vaisala WXT520       R5011021                                 HI SENSOR MOD/TYPE/ACC
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 PR SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 TD SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 HR SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 WD SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 WS SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 RI SENSOR POS XYZ/H
  5236433.8613  1750640.3109 -3184489.8814     1070.6637 HI SENSOR POS XYZ/H
                                                             END OF HEADER
2023 12  4  0  0  0  898.8   13.1   60.4  206.0    2.1    0.0    0.0
2023 12  4  0  0 30  898.8   13.1   60.4  204.0    3.5    0.0    0.0
2023 12  4  0  1  0  898.8   13.1   60.6  202.0    2.4    0.0    0.0
2023 12  4  0  1 30  898.8   13.1   60.6  207.0    3.2    0.0    0.0
2023 12  4  0  2  0  898.8   13.0   60.7  203.0    3.6    0.0    0.0
2023 12  4  0  2 30  898.8   13.0   60.7  207.0    2.4    0.0    0.0
2023 12  4  0  3  0  898.8   13.0   60.3  198.0    3.0    0.0    0.0
2023 12  4  0  3 30  898.8   13.0   60.3  199.0    3.8    0.0    0.0
2023 12  4  0  4  0  898.8   13.0   60.4  216.0    2.7    0.0    0.0
2023 12  4  0  4 30  898.8   13.0   60.4  210.0    2.7    0.0    0.0
2023 12  4  0  5  0  898.9   13.0   60.6  205.0    3.3    0.0    0.0
2023 12  4  0  5 30  898.9   13.0   60.6  202.0    3.7    0.0    0.0
2023 12  4  0  6  0  898.9   13.0   60.5  213.0    2.2    0.0    0.0
2023 12  4  0  6 30  898.9   13.0   60.5  204.0    2.9    0.0    0.0
2023 12  4  0  7  0  898.9   13.0   60.7  209.0    2.9    0.0    0.0
2023 12  4  0  7 30  898.9   13.0   60.7  218.0    3.9    0.0    0.0
2023 12  4  0  8  0  898.9   13.0   60.7  212.0    3.3    0.0    0.0
2023 12  4  0  8 30  898.9   13.0   60.7  209.0    3.8    0.0    0.0
2023 12  4  0  9  0  898.9   13.0   60.9  208.0    3.9    0.0    0.0
2023 12  4  0  9 30  898.9   13.0   60.9  202.0    2.6    0.0    0.0
2023 12  4  0 10  0  898.9   13.0   61.0  204.0    2.4    0.0    0.0
2023 12  4  0 10 30  898.9   13.0   61.0  192.0    2.9    0.0    0.0
2023 12  4  0 11  0  898.9   13.0   60.8  199.0    2.2    0.0    0.0
2023 12  4  0 11 30  898.9   13.0   60.8  198.0    2.8    0.0    0.0
2023 12  4  0 12  0  898.9   12.9   61.1  207.0    2.6    0.0    0.0
2023 12  4  0 12 30  898.9   12.9   61.1  206.0    2.6    0.0    0.0
2023 12  4  0 13  0  898.9   12.9   61.5  223.0    2.2    0.0    0.0
2023 12  4  0 13 30  898.9   12.9   61.5  206.0    1.8    0.0    0.0
```

GNSS – Ready to do some processing…

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GAMIT/GLOBK

Welcome to the GAMIT and GLOBK home page at the Department of Earth, Atmospheric and Planetary Sciences, MIT.

The current release is 10.71 (9 March 2020).

GAMIT, GLOBK and TRACK form a comprehensive suite of programs for analyzing GNSS measurements primarily to study crustal deformation. The software has been developed by MIT, Scripps Institution of Oceanography and Harvard University with support from the National Science Foundation.

The software may be obtained without written agreement or royalty fee by universities and government agencies for non-commercial education and research purposes. To obtain the download password and be added to the mailing list for future updates, please submit an application for a license here and send an e-mail to Dr. Robert W. **King**. You must include in the e-mail the full name, address, and telephone and fax numbers of your institution. If you are a student, you must also include the name and email of your advisor or other permanent staff member who will receive the announcements and be responsible for the terms of the license.

For any commercial purposes, please visit the MIT Technology Licensing Office web page for GAMIT for information on applying for a commercial license. Please also send an e-mail to Dr. Robert W. **King**, as described above, to be added to the mailing list.

GAMIT ("**G**NSS **a**t **MIT**") is collection of programs to process phase data to estimate three-dimensional relative positions of ground stations and satellite orbits, atmospheric zenith delays, and Earth orientation parameters. The software is designed to run under any UNIX operating system.

GLOBK ("**Glob**al **K**alman filter") is a Kalman filter whose primary purpose is to combine various geodetic solutions such as GPS, VLBI, and SLR experiments. It accepts as data, or "quasi-observations", the estimates and covariance matricies for station coordinates, Earth orientation parameters, orbital parameters, and source positions generated from the analysis of the primary observations. The input solutions are generally performed with loose a priori uncertainties assigned to all global parameters, so that constraints can be uniformly applied in the combined solution.

Bernese GNSS Software

AIUB ¦ CODE ¦ IGS

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- Update description for version 5.4
- Course Tutorial
- PDF Flyer

Bernese Course
27.01 - 31.01.2025

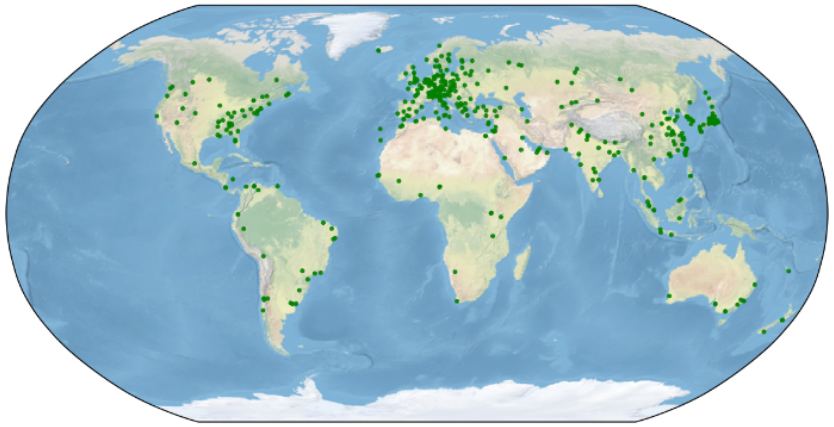
Referencing
You are kindly asked to refer the use of the Bernese GNSS Software by

- Dach, R., S. Lutz, P. Walser, P. Fridez (Eds); 2015: **Bernese GNSS Software Version 5.2.** User manual, Astronomical Institute, University of Bern, Bern Open Publishing. DOI: 10.7892/boris.72297; ISBN: 978-3-906813-05-9.

The Bernese GNSS Software is used all over the world

Currently, more than 800 institutions from all over the world are registered in the user database of the Bernese GNSS Software. The locations of these institutions are indicated in the map below.

Geographical Distribution of Institutions using the Bernese GNSS Software



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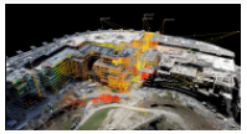
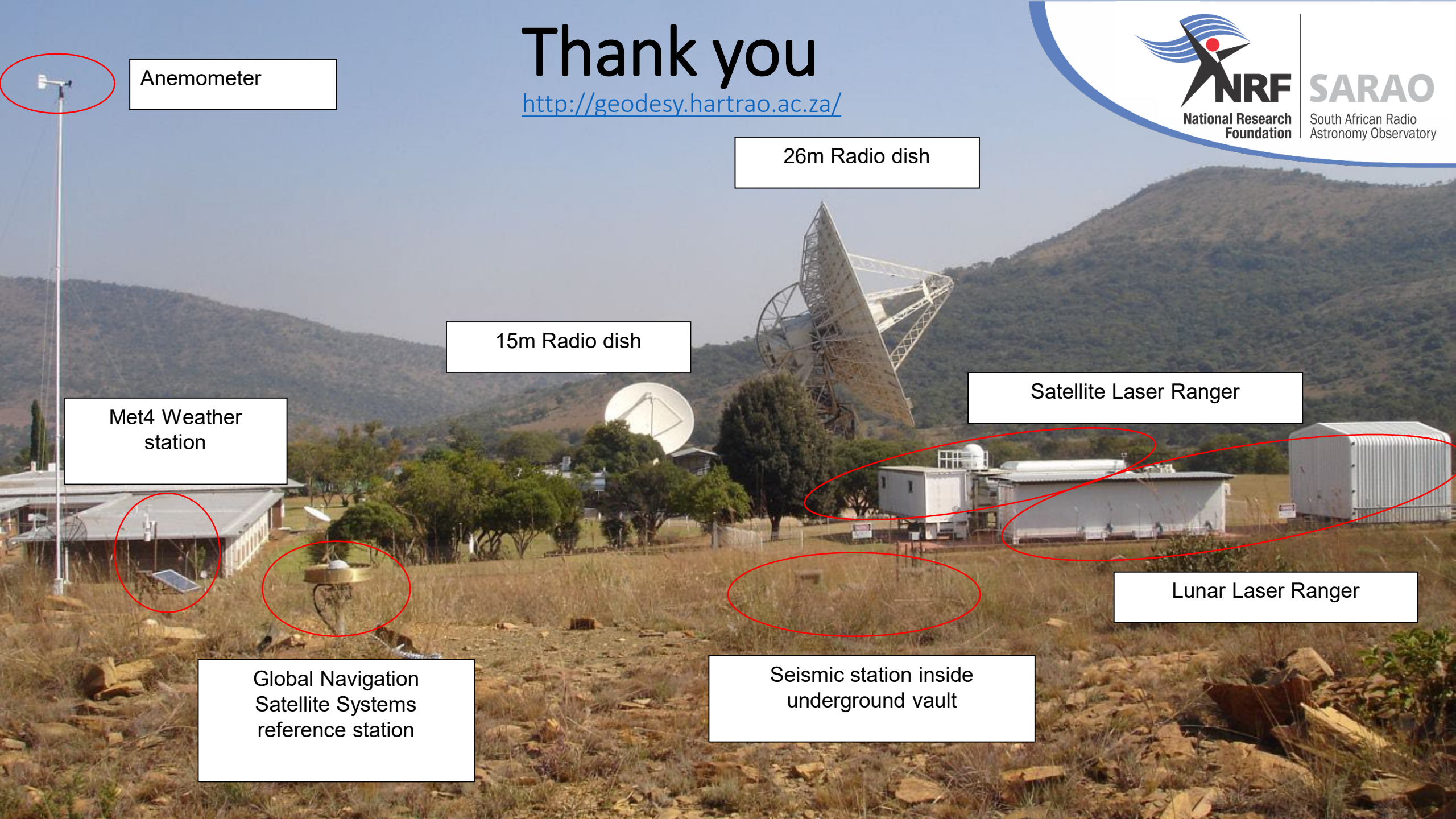
Leica Infinity

Leica Infinity is the user-friendly geospatial office software for the measurement professionals. The surveying software is designed to manage, process, analyse and quality check all field survey measure data, including total stations, digital levels, GNSS and UAVs.



Thank you

http://geodesy.hartrao.ac.za/



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