



LAB 3

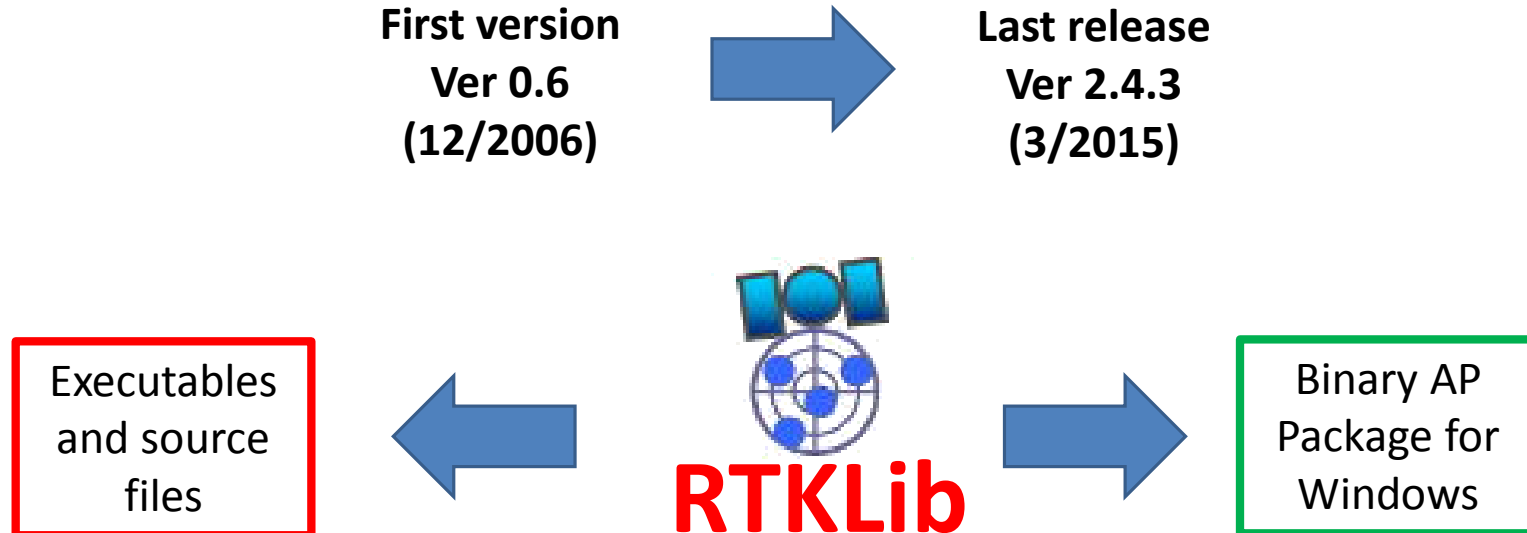
GNSS data post-processing

MARCO PIRAS



<http://www.rtklib.com/>

RTKLIB is a suite composed of numerous tools and applications, developed by Tomoji Takasu of the Laboratory of Satellite Navigation, Tokyo University of Marine Science and Technology.



<http://wiki.openstreetmap.org/wiki/RTKLIB>



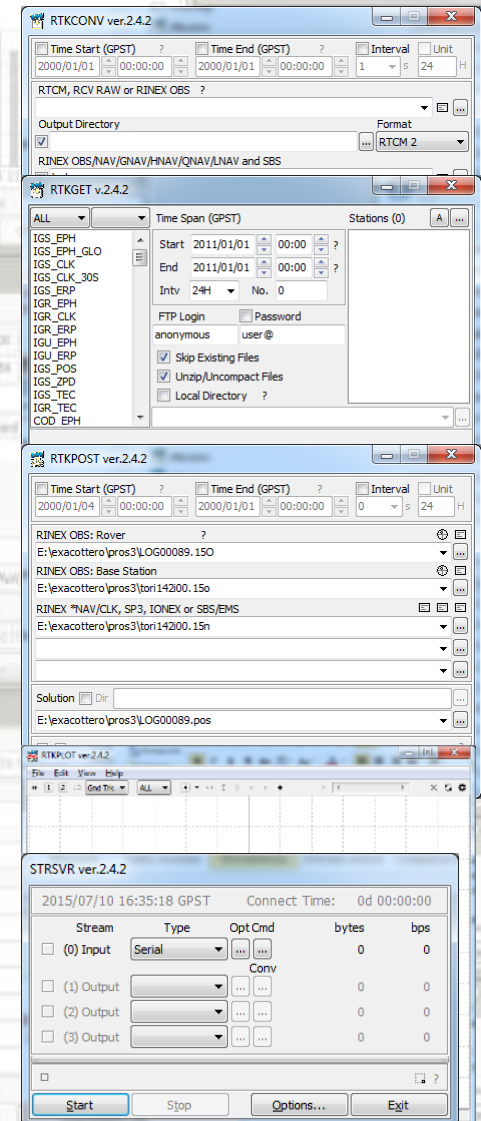
- **Supported satellite constellations:** GPS, GLONASS, GALILEO, BEIDOU, QZSS, SBAS
- **Types of positioning obtainable:** Single, DGPS / DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed
- **Supported protocols:** RINEX 2.10, 2.11, 2.12 OBS / NAV / GNAV / HNAV / LNAV / QNAV, RINEX 3.00, 3.01, 3.02 OBS / NAV, RINEX 3.02 CLK, RTCM ver.2.3, RTCM ver.3.1 (with amendment 1-5), ver.3.2, BINEX, NTRIP 1.0, RTCA / DO-229C, NMEA 0183, SP3-c, ANTEX 1.4, IONEX 1.0, NGS PCV and EMS 2.0
- **External communications available:** Serial, TCP / IP, NTRIP, local log file (record and playback) and FTP / HTTP (automatic download)
- **Supported GNSS receivers:** NovAtel: OEM4 / V / 6, OEM3, OEMStar, Superstar II, Hemisphere: Eclipse, Crescent, u-blox: LEA-4T / 5T / 6T, SkyTraq: S1315F, JAVAD: GRIL / GREIS, Furuno: GW -10 II / III and NVS NV08C BINR



RTKLIB

RTKlib is made up of the following modules:

- RTKconv (data conversion)
- RTKget (download data and products from webserver)
- RTKpost (post-processing data)
- RTKnavi (RTK positioning)
- RTKplot (visualization of the GNSS solution)
- STRSVR (streaming data to server)





obs: observation for receiver ;
auxiliary files (rinex, nav.....)



RTKPOST is the tool dedicated to GNSS data processing.

RTKPOST ver.2.4.3 b33

☐ Time Start (GPST) ? ☐ Time End (GPST) ? ☐ Interval ☐ Unit

2000/01/01 00:00:00 2000/01/01 00:00:00 0 s 24 H

RINEX OBS ?

RINEX OBS: Base Station

RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM

Solution ☐ Dir

☐ ☐ ?



This tool allows to process GNSS data considering different positioning techniques and different frequencies

RTKPOST ver.2.4.3 b33

☐ Time Start (GPST) ? ☐ Time End (GPST) ? ☐ Interval ☐ Unit

2000/01/01 00:00:00 2000/01/01 00:00:00 0 s 24 H

RINEX OBS ?

RINEX OBS: Base Station

RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM

Solution ☐ Dir

☐ ☐

☐ Plot... ☐ View... ☐ KML/GPX... ☐ Options... ☐ Execute ☐ Exit

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode Single

Frequencies / Filter Type L1+L2 Forward

Elevation Mask (°) / SNR Mask (dBHz) 15 ...

Rec Dynamics / Earth Tides Correction OFF OFF

Ionosphere Correction Broadcast

Troposphere Correction Saastamoinen

Satellite Ephemeris/Clock Broadcast

☐ Sat PCV ☐ Rec PCV ☐ PhWU ☐ Rej Ed ☐ RAIM FDE ☐ DBCorr

Excluded Satellites (+PRN: Included)

☒ GPS ☐ GLO ☐ Galileo ☐ QZSS ☐ SBAS ☐ BeiDou ☐ IRNSS

Load... Save... OK Cancel

it's possible changing constellations.



It is possible to fix the phase ambiguity for GPS, GLONASS and Beidou satellites, in different ways:

- FIX and HOLD
- Instantaneous
- Continuous
- PPP-AR

possible to fix ambiguity not as an integer but as a float

It is also possible to consider only FLOAT solutions without seeking to fix the phase ambiguity.

Options						
Setting1	Setting2	Output	Stats	Positions	Files	Misc
Integer Ambiguity Res (GPS/GLO/BDS)	Fix ar	ON	ON			
Min Ratio to Fix Ambiguity	3					
Min Confidence / Max FCB to Fix Amb	0.9999	0.25				
Min Lock / Elevation (°) to Fix Amb	10	0				
Min Fix / Elevation (°) to Hold Amb	10	0				
Outage to Reset Amb/Slip Thres (m)	5	0.050				
Max Age of Diff (s) / Sync Solution	30.0	ON				
Reject Threshold of GDOP/Innov (m)	30.0	30.0				
Number of Filter Iteration	1					
<input type="checkbox"/> Baseline Length Constraint (m)	0.000	0.000				

Buttons: Load... Save... OK Cancel



The fixing strategies for the GPS constellation are:

- **OFF:** No ambiguity fixing
- **Continuous:** ambiguities are continuously estimated and resolved in full
- **Instantaneous:** ambiguities are estimated and resolved era by era (epoch - by - epoch)
- **Fix and Hold:** ambiguities are continuously estimated and resolved in full. If the validation is OK (ratio test), the ambiguities are kept fixed at the values estimated at the previous time.
- **PPP - AR:** resolution of ambiguity in PPP (Experimental)



The solutions can be exported in different formats

- Lat/Lon/Height
- X/Y/Z - ECEF
- E/N/U baseline
- NMEA 0183 message

It is possible to export both ellipsoidal heights and orthometric heights, considering different geoid models:

- EGM2008
- EGM96
- Internal model (low res)

Options

Setting1 Setting2 Output Stats Positions Files Misc

Solution Format: Lat/Lon/Height

Output Header/Processing Options: ON ON

Time Format / # of Decimals: hh:mm:ss GPST 3

Latitude / Longitude Format: ddd mm ss.sss

Field Separator: ;

Datum/Height: WGS84 Ellipsoidal

Geoid Model: Internal

Solution for Static Mode: Single

NMEA Interval (s) RMC/GGA, GSA/GSV: 0 0

Output Solution Status / Debug Trace: OFF OFF

Load... Save... OK Cancel



Particular attention must be paid to the insertion of the correct antenna model for both the master and the rover.

It is possible to constrain the coordinates of the master station in different ways:

- RINEX header position
- Lat/lon/height
- X/Y/Z-ECEF
- from file

Options

Setting1 Setting2 Output Stats Positions Files Misc

Rover

Lat/Lon/Height (deg/m) ▾ ...

-90.000000000 0.000000000 -6378137.0000

☐ Antenna Type (*: Auto) Delta-E/N/U (m)

▾ 0.0000 0.0000 0.0000

Base Station

RINEX Header Position ▾ ...

-90.000000000 0.000000000 -6378137.0000

☐ Antenna Type (*: Auto) Delta-E/N/U (m)

▾ 0.0000 0.0000 0.0000

Station Position File

...

Load... Save... OK Cancel



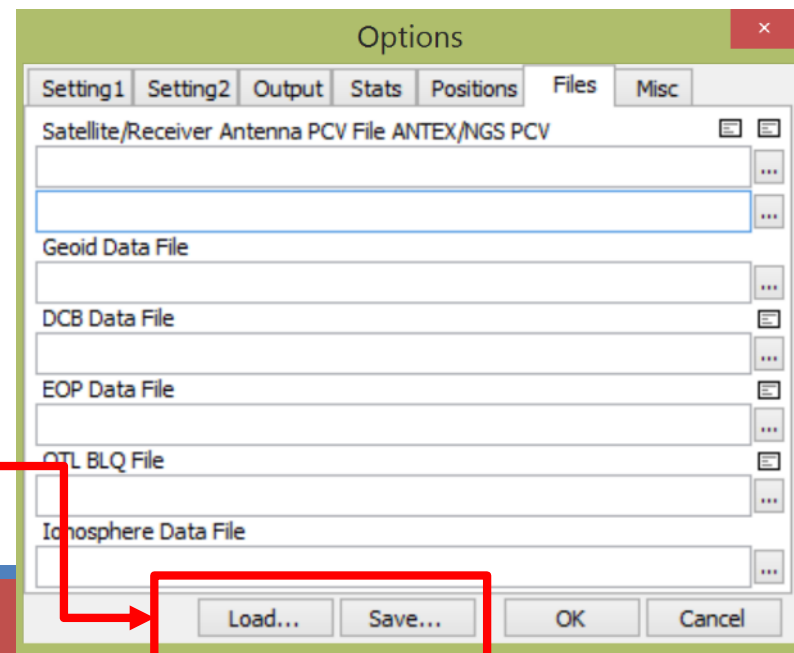
Other input files can be considered, especially for precision applications (e.g. geodetic points, CORSs ...):

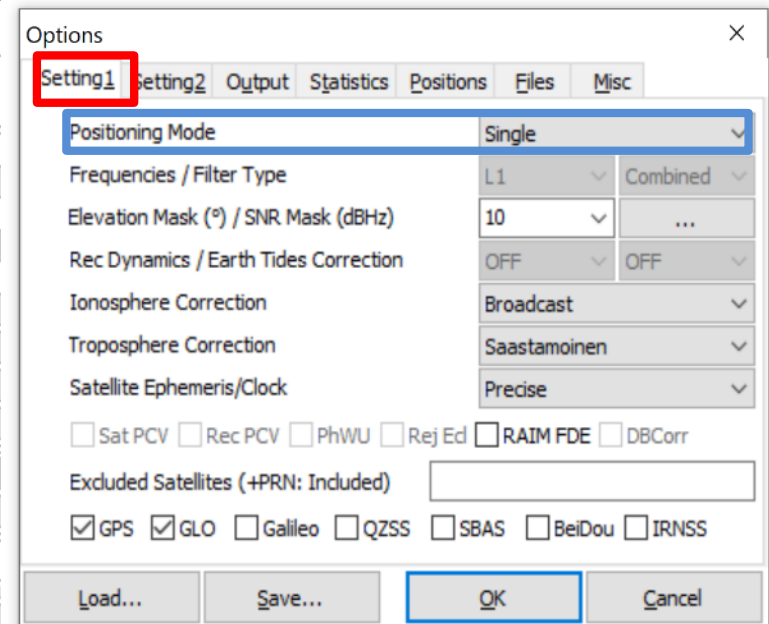
- PCV for satellite antennas/rec
- DCB files
- EOP
- OTL BLQ
- Ionospheric delays

Which can be
downloaded with
RTKGET

It is also possible to consider further
geoid models

Configuration files can be saved and loaded
to speed up processing





RTKLIB – Relative positioning

RTKPOST ver.2.4.3 b33

☐ Time Start (GPST) ? ☐ Time End (GPST) ? ☐ Interval ☐ Unit
2000/01/01 00:00:00 2000/01/01 00:00:00 0 s 24 H

RINEX OBS: Rover ?
D:\Università\Didattica\POLITO\2020 - Geomatica\LAB_2 - GNSS_processing\Data\blox\blox.170

RINEX OBS: Base Station
D:\Università\Didattica\POLITO\2020 - Geomatica\LAB_2 - GNSS_processing\Data\TORI SP\tori30700.170

RINEX NAV/CLK, SP3, FCB, IONEX, SBS/EMS or RTCM
D:\Università\Didattica\POLITO\2020 - Geomatica\LAB_2 - GNSS_processing\Data*

Solution ☐ Or
D:\Università\Didattica\POLITO\2020 - Geomatica\LAB_2 - GNSS_processing\Data\blox\PP_GPS_GLO_pre.p

☐ Plot... ☐ View... ☐ GML/GPX... ☐ Options...

Options

Setting1 Setting2 **Output** Statistics Positions Files Misc

Solution Format Lat/Lon/Height

Output Header / Output Processing Options ON ON

Time Format / # of Decimals hh:mm:ss GPST 3

Latitude Longitude Format / Field Separator ddd.dddddd

Output Single if Sol Outage / Max Sol Std (m) OFF 0

Datum / Height WGS84 Ellipsoidal

Geoid Model Internal

Solution for Static Mode Single

NMEA Interval (s) RMC/GGA, GSA/GSV 0 0

Output Solution Status / Output Debug Trace OFF OFF

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics Positions Files Misc

Positioning Mode Static

Frequencies / Filter Type L1 Combined

Elevation Mask (°) / SNR Mask (dBHz) 10 ...

Rec Dynamics / Earth Tides Correction OFF OFF

Ionosphere Correction Broadcast

Troposphere Correction Saastamoinen

Satellite Ephemeris/Clock Broadcast

☐ Sat PCV ☐ Rec PCV ☐ PhWU ☐ Rej Ed ☐ RAIM FDE ☐ DBCorr

Excluded Satellites (+PRN: Included)
☒ GPS ☐ GLO ☐ Galileo ☐ QZSS ☐ SBAS ☐ BeiDou ☐ IRNSS

Load... Save... OK Cancel

Options

Setting1 Setting2 Output Statistics **Positions** Files Misc

Rover

Lat/Lon/Height (deg/m) ...
90.00000000 0.00000000 -6335367.6285

☐ Antenna Type (*: Auto) Delta-E/N/J (m)
0.0000 0.0000 0.0000

Base Station

RINEX Header Position ...
90.00000000 0.00000000 -6335367.6285

☐ Antenna Type (*: Auto) Delta-E/N/J (m)
0.0000 0.0000 0.0000

Station Position File

Load... Save... OK Cancel

Options

Setting1 **Setting2** Output Statistics Positions Files Misc

Integer Ambiguity Res (GPS/GLO/BDS) Continu ON ON

Min Ratio to Fix Ambiguity 3

Min Confidence / Max FCB to Fix Amb 0.9999 0.25

Min Lock / Elevation (°) to Fix Amb 0 0

Min Fix / Elevation (°) to Hold Amb 10 0

Outage to Reset Amb/Slip Thres (m) 5 0.050

Max Age of Diff (s) / Sync Solution 30.0 ON

Reject Threshold of GDOP/Innov (m) 30.0 30.0

Max # of AR Iter/# of Filter Iter 1 1

☐ Baseline Length Constraint (m) 0.000 0.000

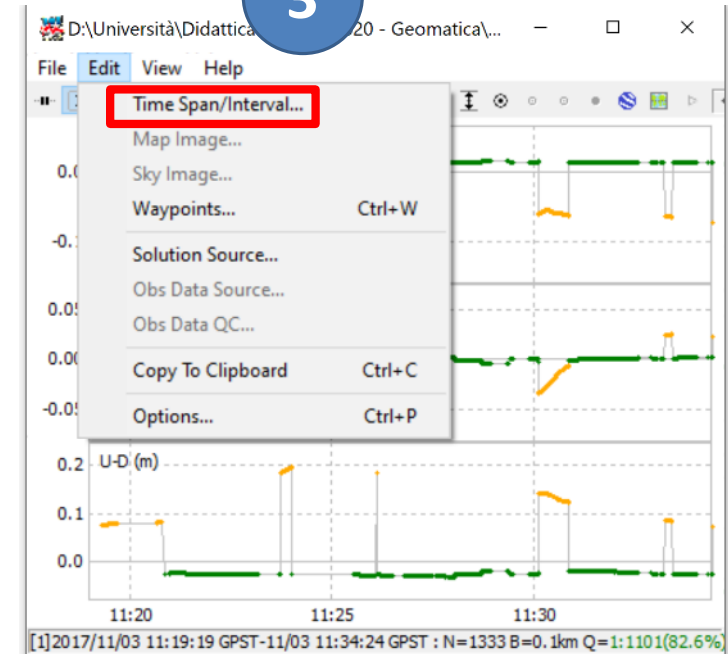
Load... Save... OK Cancel



3



1





Ex. 1 GNSS data processing

INPUT: The available dataset is composed of:

Static: 2018/03/20 11:37:00

- **Static data**

- A folder called **TORI** which contains:
 - tori307l00.18o → observation file (code and phase measurements)
 - tori307l00.18n → GPS navigation file
 - tori307l00.18g → GLONASS navigation file
- A folder called **VIRTUAL RINEX** which contains:
 - vref079j00.18o
 - vref079j00.18n
 - vref079j00.18g
- A folder called **IGM** which contains:
 - 1000790.18o
 - 1000790.18n
 - 1000790.18g

Reference Station
TORINO (ETRF2000)

UTM Nord (m):	4990861.136	Lat:	45° 03' 48.112513" N
UTM Est (m):	394604.567	Long:	7° 39' 40.599491" E
Qta ort. (m):	261.67	h ell. (m):	310.74

Virtual Station

Static survey:
(see monograph:
[igm_assoc1.pdf](#))



Ex. 1 GNSS data processing



TORINO (Piazzale Duca di Aosta - Ass.1)

056906

155 sez II

056 III SE

Nazione: ITALIA
Provincia: TORINO
Comune: TORINO
Carabinieri: TORINO

Proprietà: Politecnico di Torino

Indirizzo: Corso Duca degli Abruzzi, 24
Comune: TORINO
Cap: 10129
Provincia: TORINO

Tel: 0115646200

Fax:

... con foro accecato al centro, infisso nella pavimentazione asfaltata, l'Italia", al centro della piazza ubicata lungo il Corso Duca d'Abruzzi di

Geografiche (Roma40)

Φ: 45°03'41.1663"
λ: -04°47'18.8948"

Quota s.l.m.: 246.066

La coordinata nel Sistema Roma40 sono state calcolate, dalle coordinate WGS84, tramite algoritmo di trasformazione.

Piane (Gauss-Boaga)

N: 4.000
E: 1.000

N: 295.070

La coordinata nel Sistema WGS84 sono state determinate nell'anno 1996.

Geografiche (WGS84)

Φ: 45°03'43.5550"
λ: 07°39'48.0040"

Quota ell.: 295.070

La coordinata nel Sistema WGS84 sono state determinate nell'anno 1996.

Piane (UTM-WGS84)

N: 4.000
E: 394.000

N: 295.070

La coordinata nel Sistema WGS84 sono state determinate nell'anno 1996.



...no di vario tipo DH = 0,000

Rete primaria di inquadramento (IGM95)

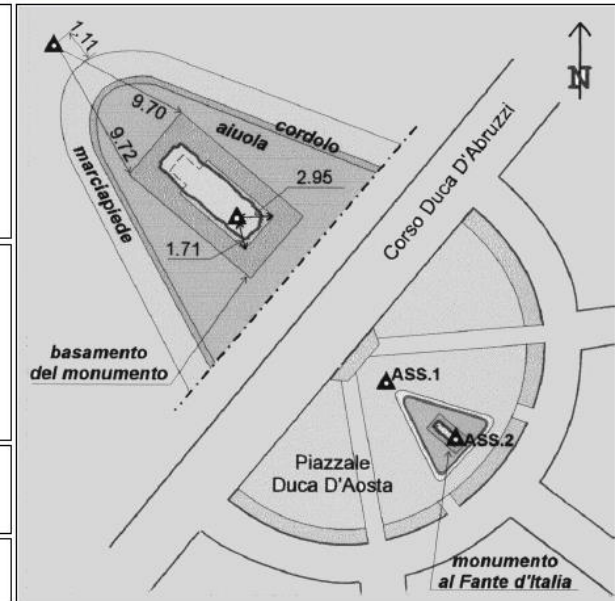
Con quota derivata da caposaldo di livellazione (Rete Fond.)

Produttore: IGM

Stazioni astronomiche:

98 Cart. Maseroli Renzo

2-2003 Cart. Deninno Francesco





Ex. 1 GNSS data processing

INPUT: The available dataset is composed of:

- **Kinematic data**

- A folder called **MONV SP** which contains:
 - monv020i00.20o
 - monv020i00.20n
 - monv020i00.20g
- A folder called **SnowGroomer** which contains:
 - 20200120_COM3_165803.20o
 - 20200120_COM3_165803.20n
 - 20200120_COM3_165803.20g

Reference Station
MONDOVÌ

Kinematic data

Kinematic: 2020/01/20 17:00:00



Ex. 1 GNSS data processing

GOALS:

1_A) Single point positioning of IGM station point

1_B) Relative Static positioning

- IGM station post processing using TORI as Ref (GPS only)
- IGM station pp using TORI as RF (GPS+GLONASS)
- IGM station pp using Virtual Rinex as RF (GPS+GLONASS)
- Results comparison

1_C) Kinematic positioning

- Snow groom data pp using MONV as Ref (FIX & Hold)
- Snow groom data pp using MONV as Ref (Continuous)
- Results comparison