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gLAB Upgrade with SBAS data processing

Software User Manual for SBAS processing

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Document Change Log

Iss./Rev.	Date	Section / Page	Change Description
1.0	5/09/2016	All	First version of the document.
1.1	26/09/2016	2.4	Added input parameter '-model:initcoordnpa' for SBAS.
1.2	21/10/2016	2.4,3.5.1	Added input parameter '-model:brdctranstime' in gLAB. The '[NPA only]' tag from SBASUNSEL message number 36 has been erased.

Contents

1 INTRODUCTION

The GNSS-Lab Tool suite (gLAB) is an interactive educational multipurpose package to process and analyse GNSS data. The first release of this software package allows processing only GPS data, but it was prepared to incorporate future module updates, such as an expansion to Galileo and GLONASS systems, SBAS and differential processing.

With the current upgrade, gLAB is able to process SBAS data for GPS positioning, as well as being capable of reading and converting RINEX-B and EMS files to Pegasus format. Furthermore, the plotting functions have been upgraded, in order to be able to create Stanford plots and worst integrity ratio plots.

In the current version, these new functionalities are only available using command line. Future updates will be done to update the GUI.

1.1 DOCUMENT SCOPE AND PURPOSES

This document contains detailed information related to the new functionalities added to gLAB and the new plotting functions, including an explanation of the new parameters available, output messages and usage examples through command line.

1.2 DOCUMENT OVERVIEW AND STRUCTURE

This document is split in sections, which describe:

- A list of all the new parameters for gLAB with their explanation.
- A description of the new output messages in gLAB.
- gLAB usage examples through command line.
- A list of all the new parameters for the plotting functions
- Plotting functions usage examples through command line.

1.3 APPLICABLE AND REFERENCE DOCUMENTS

1.3.1 Applicable documents

The following documents refer to the applicable documents for the project.

AD-01 RTCA-DO229D. “Minimum Operational Performance Standards For Global Positioning System / Wide Area Augmentation System Airborne Equipment”. RTCA Inc. SC-159. December 2006.

AD-02	RTCA-DO229C. “Minimum Operational Performance Standards For Global Positioning System / Wide Area Augmentation System Airborne Equipment”. RTCA Inc. SC-159. November 2001
AD-03	PEGASUS Interface Control Document. PEG-ICD-02
AD-04	GNSS Lab Software User Manual, gAGE/UPC, 2009

1.3.2 Reference Documents

RD-1	RINEX-B 2.11 (ftp://igscb.jpl.nasa.gov/igscb/data/format/geo_sbas.txt)
RD-2	EMS (http://www.egnos-pro.esa.int/ems/EMS_UID_1_1_final.pdf)

1.3.3 Acronyms and Terms

AD	Applicable Document
AWGN	Additive White Gaussian Noise
CRC	Cyclic Redundancy Check
DoY	Day of Year
EGNOS	European Geostationary Navigation Overlay Service
EMS	EGNOS Message Server
ESA	European Space Agency
FTP	File Transfer Protocol
gAGE	Research Group of Astronomy and Geomatics
gLAB	GNSS-Lab tool
GEO	GEOstationary
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HE	Horizontal Error
HPL	Horizontal Protection Level
ICD	Interface Control Document
IGS	International GNSS Service
IGP	Ionospheric Grid Point
IOD	Issue of Data
IODE	Issue of Data Ephemeris
IODF	Issue of Data Fast Correction
IODI	Issue of Data Ionospheric
IODP	Issue of Data PRN mask
IODS	Service Issue of Data
IONEX	IONosphere map Exchange format
IPP	Ionospheric Pierce Point
LTC	Long Term Corrections
MT	Message Type
MOPS	Minimum Operational Performance Standards
NPA	Non Precision Approach
OS	Operative System
PA	Precision Approach
PEGASUS	Prototype EGNOS and GBAS Analysis System Using SAPPHIRE
PRC	Pseudo Range Correction
PRN	PseudoRandom Noise
RD	Reference Document
RINEX-B	Receiver Independent EXchange format Binary
RRC	Range Rate correction
RSS	Root Sum Square
SAPPHIRE	Satellite and Aircraft Data Base for System Integrity Research
SBAS	Satellite Based Augmentation System
SIS	Signal In Space
SNR	Signal to Noise Ratio

SOW	Statement Of Work
S/W	Software
TBC	To Be Confirmed
TBD	To Be Determined
TBW	To Be Written
TGD	Total Group Delay
TOW	Time of Week
UDRE	User Differential Range Error
UDREI	User Differential Range Error Indicator
UIVE	User Ionospheric Vertical Error
UPC	Technical University of Catalonia
URA	User Range Accuracy
URL	Uniform Resource Locator
VE	Vertical Error
VPL	Vertical Protection Level

2 gLAB PARAMETERS

These are the new parameters added to gLAB for SBAS processing. This list is included in the help message of gLAB (which is shown by executing the command 'gLAB –help'):

2.1 HELP PARAMETERS

-usererrorfile	Shows an example of user-defined error configuration file
-sigmamultipathfile	Shows an example of user multipath model configuration file

2.2 INPUT PARAMETERS

-input:sbasiono <file>	Sets the input RINEX-B or EMS SBAS file for ionospheric corrections
-input:sbas <file>	Sets the SBAS data file (RINEX-B v2.11 or EMS). Activates SBAS processing mode
-input:sigmpath <file>	Sets the data file for user sigma multipath model for SBAS (execute 'gLAB -sigmamultipathfile' for details)
-input:usererror <file>	Sets the data file for adding user defined noise signal to raw measurements (execute 'gLAB -usererrorfile' for details)

2.3 PREPROCESSING PARAMETERS

-pre:geoexclude #	Exclude GEO satellite from SBAS. Data from this GEO will be ignored for SBAS corrections # = PRN number
-pre:geosel #	Select GEO satellite for SBAS corrections # = 0 => Use data from all GEO (all GEO mixed)[default in NPA if mixing GEO data is enabled] # = 1 => Use GEO from the first line of SBAS data read [default in PA] # = 2 => Use the GEO with highest elevation 120 <= # <= 210 => Use the GEO with the given PRN
-pre:snr	Enable SNR (Signal to Noise Ratio) deselection. The SNR is read from the observation file. [default off]. If no SNR is present in the observation file, no deselection is done. The default threshold is 35 dBHz

-pre:snrsel g# <val>	Set a SNR threshold for a given satellite. If this option is given, SNR deselection will be activated **g** = character determining GNSS system (G->GPS) **#** = PRN number. If #=0, then the threshold will be applied to all satellites of the selected GNSS system **<val>** Value for SNR threshold in dBHz. This value is compared to the SNR obtained from the RINEX file in all code and carrier phase measurements. If no SNR value is present in the RINEX file, this value will be omitted.
-pre:smoothmin <val>	Number of seconds of continuous code smoothing before steady-state operation [default 0 for non SBAS processing, 360 for SBAS processing] Satellites will be excluded until reaching this steady-state

2.4 MODELLING PARAMETERS

-model:iono <val>	**<val> = no** Do not correct ionosphere [default in PPP] (equivalent to '--model:iono') **<val> = Klobuchar** Correct measurements with Klobuchar model [default in SPP] = BeiDou Correct measurements with BeiDou model **<val> = IONEX** Correct measurements with IONEX file data **<val> = FPPP** Correct measurements with FPPP file data **<val> = NeQuick** Correct measurements with NeQuick model **<val> = SBAS** Correct measurements with SBAS iono corrections (but do not apply any other SBAS correction)
-model:brdctranstime	Only valid when using broadcast products. Check that transmission time of message is equal or before of current time [default on for non SBAS processing, off for SBAS processing]
-model:alarmmsgtype2	When reading an SBAS message type 0, parse it as type 2 [default off]
-model:ignoretype0	Ignore all SBAS messages type 0 [default off]
-model:sbasmode <val>	Select navigation mode for SBAS processing: **<val> = PA** Precision Approach [default] **<val> = NPA** Non Precision Approach
-model:geoswitch	Enable GEO switch for SBAS processing [default off]

-model:geofallback	If GEO switch for SBAS is enabled, always try to return to the initial selected GEO [default off] By default, gLAB will try to keep the same GEO during SBAS processing, independently of how it has been selected
-model:sbasmodeswitch	Enable navigation mode switching for SBAS processing [default off]
-model:mixedgeo	Enable the usage of mixed GEO data (messages from all GEO are treated as if there were from an unique GEO) [default off]
-model:initcoordnpa	In SBAS mode, if receiver coordinates are to be calculated without giving any initial condition (parameter -pre:setrecpos calculate), compute the first epochs using Klobuchar until the receiver coordinates have converged. This is useful due to the initial gLAB coordinate may do that the IPPs (Ionospheric Pierce Point) fall outside the SBAS region, making all satellites unavailable due to the lack of ionosphere. This option only has effect if SBAS mode switch is disabled and receiver coordinates are set to 'calculate' [default on]
-model:sbasreceiver #	Set receiver class type for SBAS (for computing variance of the airborne receiver) # = 0 User defined receiver model (given in file with parameter '-input:sigmpath') # = 1 Class 1 equipment # = 2,3,4 Class 2,3,4 equipment (all equivalent) [default 2]
-model:geoadqtime #	Set the minimum time (in seconds) to consider that gLAB has received enough SBAS corrections from a GEO counting from the first message received [default 300] This timer is set to ensure that we have received enough corrections from the GEO we want to switch to. If this timer is set too low (few seconds), it may happen that we switch to a GEO with not enough data (due to we are in initialization or the GEO has received an alarm message gLAB will not switch to any GEO before this time, except for when an alarm message is received and there is no other GEO available
-model:switchtime #	Set the minimum time (in seconds) between a GEO or mode switch and the following one [default 20] This timer is set to avoid continuous switching in the same epoch when all GEO do not have enough data. If this timer is set to zero, a maximum of 2 switches per epoch (for both mode and GEO) will be done
-model:sbastmout <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in both modes, PA and NPA **<n>** is the message type number **<val>** is the time out value (in seconds)
-model:sbastmoutpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in PA mode **<n>** is the message type number **<val>** is the time out value (in seconds)

-model:sbastmoutnpa <n> <val>	Set time out value for SBAS messages (except for fast and range rate corrections) in NPA mode **<n>** is the message type number **<val>** is the time out value (in seconds)
-model:sbastmoutfc <val>	Set time out value for fast corrections in both modes, PA and NPA **<val>** is the time out value (in seconds)
-model:sbastmoutfcpa <val>	Set time out value for fast corrections in PA mode **<val>** is the time out value (in seconds)
-model:sbastmoutfcnpa <val>	Set time out value for fast corrections in NPA mode **<val>** is the time out value (in seconds)
-model:sbastmoutrrc <val>	Set time out value for range rate corrections in both modes, PA and NPA **<val>** is the time out value (in seconds)
-model:sbastmoutrrcpa <val>	Set time out value for range rate corrections in PA mode **<val>** is the time out value (in seconds)
-model:sbastmoutrrcnpa <val>	Set time out value for range rate corrections in NPA mode **<val>** is the time out value (in seconds)
-model:sigmpath <val1> <val2>	Set parameters a,b for sigma multipath for SBAS airborne receiver, being sigma=a+b*e^(-satelevationº/10) **<val1>** a value (in meters) **<val1>** b value (in meters)
-model:sigdiv <val>	Set a fixed value (in meters) for sigma divergence for SBAS airborne receiver
-model:signoise <val>	Set a fixed value (in meters) for sigma noise for SBAS airborne receiver

2.5 FILTER PARAMETERS

-filter:stepdetector	Check for jumps in measurements using the prefits residuals [default off] Use '--filter:stepdetector' to disable it
-filter:stfdesa	Compute values for Stanford-ESA plot (only available for SBAS processing) [default disabled] The output data is written in a separate file (which has to be processed with graph.py). See parameter '-output:stfdesa'
-filter:stfdesa:xmax <val>	Set the maximum value for the horizontal axis (error axis, in meters) for Stanford-ESA plot [default 50]
-filter:stfdesa:ymax <val>	Set the maximum value for the vertical axis (protection level axis, in meters) for Stanford-ESA plot [default 50]
-filter:stfdesa:xres <val>	Set the horizontal resolution (error axis, in meters) for Stanford-ESA plot [default 0.1]
-filter:stfdesa:yres <val>	Set the vertical resolution (protection level axis, in meters) for Stanford-ESA plot [default 0.1]

2.6 OUTPUT PARAMETERS

-output:rinexb	Generate a RINEX-B file without incorrect messages from the SBAS data (only for SBAS) [default off]
-output:ems	Generate a EMS file without incorrect messages from the SBAS data (only for SBAS) [default off]
-output:pegasus	Generate Pegasus file format from the SBAS data (only for SBAS) [default off]
-output:pegstrictrinex	When generating a RINEX-H file for Pegasus, follow the RINEX 2.11 rules for transmission time, health flag and URA (only active if -output:pegasus has been set) [default off]
-output:pegspace	Set the field separator in Pegasus files to space character (' ') instead of a semicolon (';') [default off]
-output:pegfilealign	Print Pegasus files with all columns aligned [default off]
-output:sbasdir <name>	Set the directory where to write the output SBAS files ('.' for current directory) [default "SBAS"]
-output:stfdesa <name>	Set the filename where to write the output data for Stanford-ESA plots [default "observationfilename_stdESA"] The output file has to be processed with graph.py to generate the Stanford-ESA plots
-onlyconvert	Convert EMS or RINEX-B file to RINEX-B, EMS or Pegasus and exit without processing any GNSS data [default off]

NOTE: Incorrect messages from RINEX-B or EMS files are messages which grant any of these conditions: CRC mismatch, invalid header, unknown message type, invalid time of applicability (time is over 86400 seconds).

2.7 VERBOSE PARAMETERS

-print:sbascor	Print SBASCORR messages (only for SBAS) [default off]
-print:sbasvar	Print SBASVAR messages (only for SBAS) [default off]
-print:sbasiono	Print SBASIONO messages (only for SBAS) [default off]
-print:sbasout	Print SBASOUT messages (only for SBAS) [default on]
-print:sbasunsel	Print SBASUNSEL messages (only for SBAS) [default off]
-print:sbasunused	Print messages from discarded satellites due to SBAS GEO switch (only for SBAS) [default off]. The discarded messages are MODEL, SBASCORR, SBASVAR, SBASIONO and SBASUNSEL, but only the ones selected from user parameters will be printed. Also, an asterisk '*' will be added at the end of the first field to indicate that it is a discarded measurement.
-print:usererror	Print user added error to raw measurements [default on]

NOTE: Use -print:... to activate, --print:... to deactivate.

3 gLAB OUTPUT MESSAGES

Here is the description for the new output messages in gLAB for SBAS processing. This list is included in the help message of gLAB (which is shown by executing the command 'gLAB –messages'):

3.1 USERADDEDERROR MESSAGE

User-defined error added to measurements before cycle-slip detection and smoothing.

#	FIELD	DESCRIPTION	UNITS
1	USERADDEDERROR	Fixed word indicating the data stored.	-
2	Year	Year number (4 digits).	Years
3	DoY	Day of Year (3 digits).	Days
4	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
5	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
6	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
7	GNSS system	Satellite constellation (GPS, GAL, GLO or GEO).	-
8	PRN	Satellite identifier.	-
9	Measurement identifier	String with the measurement observation code.	-
10	Measured pseudorange	Value of the measured pseudorange (phase measurements are prealigned).	Meters
11	Measured pseudorange with user-defined error	Value of the measured pseudorange (phase measurements are prealigned) with the total user-defined error.	Meters
12	Active user-defined error functions	Total number of active user-defined errors in the current epoch.	-
13	Total user-defined error functions	Total user-defined error in the current epoch.	Meters
14	Active Step function error	Number of active Step function error in the current epoch.	-
15	Step function error value	Sum of all Step function errors in the current epoch.	Meters
16	Active Ramp function error	Total number of active Ramp function error in the current epoch.	-
17	Ramp function error value	Sum of all Ramp function errors in the current epoch.	Meters
18	Active Sinusoidal function error	Number of active Sinusoidal function error in the current epoch.	-
19	Sinusoidal function error value	Sum of all Sinusoidal function errors in the current epoch.	Meters
20	Active AWGN function error	Number of active AWGN function error in the current epoch.	-
21	AWGN function error value	Sum of all AWGN function errors in the current epoch.	Meters

3.2 SBASCORR MESSAGE

SBAS corrections breakdown. It is shown when a model can be fully computed using SBAS corrections for GPS C1C measurement.

#	FIELD	DESCRIPTION	UNITS
1	SBASCORR	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS system	Satellite constellation (GPS, GAL, GLO or GEO).	-
5	PRN	Satellite identifier.	-
6	Year	Year number (4 digits).	Years
7	DoY	Day of Year (3 digits).	Days
8	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	Prefit	Residual pseudorange value (measurement – model) used as prefit residual for the satellite.	Meters
13	Measured pseudorange (C1C raw)	Value of the measured pseudorange (C1C raw).	Meters
14	Measured pseudorange (C1C smoothed)	Value of the measured pseudorange after smoothing (C1C smoothed).	Meters
15	Geometric range (ρ)	Geometric distance between the satellite and the receiver location (with SBAS corrections).	Meters
16	Relativistic delay	Delay associated to relativistic effects (with SBAS corrections).	Meters
17	Satellite clock offset	It includes the clock offset correction broadcast by the satellite itself together with the satellite clock offset broadcast in the Long Term Corrections for the satellite.	Meters
18	Total group delay (TGD)	Delay associated to the group of GPS satellites. From GPS navigation message.	Meters
19	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	Degrees (-90..90º)
20	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	Degrees (0..360º)
21	Ionospheric delay	Delay associated to ionospheric effects	Meters
22	Tropospheric delay	Delay associated to tropospheric effects.	Meters
23	PRC	Pseudorange correction to be applied to the satellite.	Meters
24	RRC	Range rate correction to be applied to the satellite.	Meters
25	a_i	Fast Correction degradation factor.	Meters/ seconds^2
26	PRC time-out	Time-out interval for current pseudorange correction.	Seconds
27	RRC time-out	Time-out interval for current range rate correction (smallest PRC time out for all satellites).	Seconds

28	PRC time reference	Time (seconds of day) used for computing PRC timeout.	Seconds
29	UDRE time reference	Time (seconds of day) used for computing sigma UDRE (User Differential Range Error) timeout.	Seconds
30	Fast correction degradation time reference	Time (seconds of day) used for computing fast correction degradation.	Seconds
31	X	X component of the satellite position in WGS84 system at emission time with SBAS corrections.	Meters
32	Y	Y component of the satellite position in WGS84 system at emission time with SBAS corrections.	Meters
33	Z	Z component of the satellite position in WGS84 system at emission time with SBAS corrections.	Meters
34	ΔX	Long term correction to be applied to the X component of the satellite.	Meters
35	ΔY	Long term correction to be applied to the Y component of the satellite.	Meters
36	ΔZ	Long term correction to be applied to the Z component of the satellite.	Meters
37	Δt	Long term correction to be applied to the satellite clock.	Meters
38	IODP fast corrections	IODP (Issue of Data PRN mask) used for fast corrections. If no IODP is available, the value is -1.	-
39	IODF	IODF (Issue of Data Fast Correction) in messages type 2-5, 24 for fast corrections. If no IODF is available, the value is -1.	-
40	Fast correction satellite slot	Satellite slot in the fast correction mask (1..51). If no IODP is available, the value is -1.	-
41	IODP long term corrections	IODP used for long term corrections. If no IODP is available, the value is -1.	-
42	Long term corrections satellite slot	Satellite slot in the long term correction mask (1..51). If no IODP is available, the value is -1.	-
43	IODE	IODE (Issue of Data Ephemeris) used for broadcast ephemeris. If no IODE is available, the value is 999. If an IODE is used that does not match the one broadcast in the long term corrections (only in NPA mode), the value will negative.	-
44	IODS	IODS (Service Issue of Data) used for service message. If no IODS is available or it is not used, the value is -1.	-
45	IODP clock-ephemeris covariance matrix	IODP used for clock-ephemeris covariance matrix. If no IODP is available or it is not used, the value is -1.	-
46	Clock-ephemeris covariance matrix slot	Satellite slot in the clock-ephemeris covariance mask (1..51). If no IODP is available or it is not used, the value is -1.	-
47	Ionosphere model flag	Flag to indicate which ionosphere model is used. Its possible values are '-1' for no ionosphere model, '0' for SBAS ionosphere model, '1' for Klobuchar ionosphere model and '2' for any other ionosphere model.	-
48	Elevation	Elevation angle between the satellite and the receiver location.	Degrees

49	Azimuth	Azimuth angle between the satellite and the receiver location.	Degrees

3.3 SBASVAR MESSAGE

SBAS variance contributions breakdown. It is shown when a model can be fully computed using SBAS corrections for GPS C1C measurement.

#	FIELD	DESCRIPTION	UNITS
1	SBASVAR	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS system	Satellite constellation (GPS, GAL, GLO or GEO).	-
5	PRN	Satellite identifier.	-
6	Year	Year number (4 digits).	Years
7	DoY	Day of Year (3 digits).	Days
8	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	σ_{total}	Sigma of the total residual error associated to the satellite.	Meters
13	σ_{flt}	Sigma of the residual error associated to the fast and long-term corrections.	Meters
14	σ_{UDRE}	Sigma of the UDRE (User Differential Range Error).	Meters
15	δ_{UDRE}	Delta UDRE (User Differential Range Error) factor.	-
16	δ_{UDRE} data source	Data source (SBAS message type number) for Delta UDRE. It may have the following values: 27 or 28 for their respective message type, -27 or -28 if received any of these message types but there was missing data for current satellite or was timed out, 0 if no message type received or both received.	-
17	ε_{fc}	Degradation parameter for fast correction data.	Meters
18	ε_{rrc}	Degradation parameter for range rate correction data.	Meters
19	ε_{ltc}	Degradation parameter for long term correction data or GEO navigation message data.	Meters
20	ε_{er}	Degradation parameter for en route through NPA applications.	Meters
21	RSS_{UDRE}	RSS (Root-Sum-Square) flag in message type 10.	-
22	σ_{UIVE}	Sigma of the residual error associated to the ionospheric corrections.	Meters
23	σ_{tropo}	Sigma of the residual error associated to the tropospheric corrections.	Meters
24	σ_{air}	Sigma of the total airborne receiver error.	Meters
25	σ_{noise}	Sigma of the airborne receiver noise.	Meters

26	$\sigma_{multipath}$	Sigma of the airborne receiver multipath.	Meters
27	σ_{divg}	Sigma of the airborne receiver divergence.	Meters
28	Elevation	Elevation angle between the satellite and the receiver location.	Degrees
29	Azimuth	Azimuth angle between the satellite and the receiver location.	Degrees

3.4 SBASIONO MESSAGE

SBAS ionosphere breakdown. It is shown when SBAS ionosphere can be computed.

#	FIELD	DESCRIPTION	UNITS
1	SBASIONO	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS system	Satellite constellation (GPS, GAL, GLO or GEO).	-
5	PRN	Satellite identifier.	-
6	Year	Year number (4 digits).	Years
7	DoY	Day of Year (3 digits).	Days
8	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
11	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
12	IPP Latitude	Latitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	Degrees (-90..90º)
13	IPP Longitude	Longitude corresponding to the Ionospheric Pierce Point used to compute the ionospheric delay.	Degrees (0..360º)
14	Interpolation mode	Interpolation mode. 0 for square interpolation, [1-4] indicates the vertex not used in triangle interpolation.	-
15	IODI vertex 1	IODI (Issue of Data Ionospheric) for vertex 1.	-
16	Band Number for vertex 1	Band Number for vertex 1.	-
17	IGP vertex 1	IGP Number for vertex 1.	-
18	Vertex 1 IGP reception time	Time of reception of last bit of vertex 1 IGP (seconds of day).	Seconds
19	Vertex 1 IGP latitude	Latitude of the IGP for vertex 1 (-90..90º).	Degrees
20	Vertex 1 IGP longitude	Longitude of the IGP for vertex 1 (0..360º).	Degrees
21	Vertex 1 delay	Ionosphere delay (raw value from MT26) for vertex 1.	L1 meters
22	Vertex 1 variance	Ionosphere variance (raw value from MT26) for vertex 1.	L1 meters^2
23	Vertex 1 ε_{iono}	Degradation term for vertex 1.	L1 meters
24	Vertex 1 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 1.	L1 meters

25	Vertex 1 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 1.	L1 meters^2
26	Vertex 1 weight	Interpolation weight for vertex 1.	-
27	IODI vertex 2	IODI (Issue of Data Ionospheric) for vertex 2.	-
28	Band Number for vertex 2	Band Number for vertex 2.	-
29	IGP vertex 2	IGP Number for vertex 2.	-
30	Vertex 2 IGP reception time	Time of reception of last bit of vertex 2 IGP (seconds of day).	Seconds
31	Vertex 2 IGP latitude	Latitude of the IGP for vertex 2 (-90..90º).	Degrees
32	Vertex 2 IGP longitude	Longitude of the IGP for vertex 2 (0..360º).	Degrees
33	Vertex 2 delay	Ionosphere delay (raw value from MT26) for vertex 2.	L1 meters
34	Vertex 2 variance	Ionosphere variance (raw value from MT26) for vertex 2.	L1 meters^2
35	Vertex 2 ε_{iono}	Degradation term for vertex 2.	L1 meters
36	Vertex 2 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 2.	L1 meters
37	Vertex 2 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 2.	L1 meters^2
38	Vertex 2 weight	Interpolation weight for vertex 2.	-
39	IODI vertex 3	IODI (Issue of Data Ionospheric) for vertex 3.	-
40	Band Number for vertex 3	Band Number for vertex 3.	-
41	IGP vertex 3	IGP Number for vertex 3.	-
42	Vertex 3 IGP reception time	Time of reception of last bit of vertex 3 IGP (seconds of day).	Seconds
43	Vertex 3 IGP latitude	Latitude of the IGP for vertex 3 (-90..90º).	Degrees
44	Vertex 3 IGP longitude	Longitude of the IGP for vertex 3 (0..360º).	Degrees
45	Vertex 3 delay	Ionosphere delay (raw value from MT26) for vertex 3.	L1 meters
46	Vertex 3 variance	Ionosphere variance (raw value from MT26) for vertex 3.	L1 meters^2
47	Vertex 3 ε_{iono}	Degradation term for vertex 3.	L1 meters
48	Vertex 3 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 3.	L1 meters
49	Vertex 3 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 3.	L1 meters^2
50	Vertex 3 weight	Interpolation weight for vertex 3.	-
51	IODI vertex 4	IODI (Issue of Data Ionospheric) for vertex 4.	-
52	Band Number for vertex 4	Band Number for vertex 4.	-
53	IGP vertex 4	IGP Number for vertex 4.	-
54	Vertex 4 IGP reception time	Time of reception of last bit of vertex 4 IGP (seconds of day).	Seconds
55	Vertex 4 IGP latitude	Latitude of the IGP for vertex 4 (-90..90º).	Degrees
56	Vertex 4 IGP longitude	Longitude of the IGP for vertex 4 (0..360º).	Degrees
57	Vertex 4 delay	Ionosphere delay (raw value from MT26) for vertex 4.	L1 meters
58	Vertex 4 variance	Ionosphere variance (raw value from MT26) for vertex 4.	L1 meters^2
59	Vertex 4 ε_{iono}	Degradation term for vertex 4.	L1 meters

60	Vertex 4 delay interpolated	Ionosphere delay after interpolation (if required) for vertex 4.	L1 meters
61	Vertex 4 variance interpolated	Ionosphere variance after applying degradation and interpolation (if required) for vertex 4.	L1 meters^2
62	Vertex 4 weight	Interpolation weight for vertex 4.	-
63	Mapping function	Value of the mapping function.	L1 meters
64	Slant delay	Total slant delay.	L1 meters
65	Slant sigma	Total slant sigma.	L1 meters
66	Elevation	Elevation angle between the satellite and the receiver location.	Degrees
67	Azimuth	Azimuth angle between the satellite and the receiver location.	Degrees

NOTE: Vertex 1 is the IGP north east to IPP, vertex 2 is the IGP north west to IPP, vertex 3 is the IGP south west to IPP and vertex 4 is the IGP south east to IPP.

3.5 SBASUNSEL MESSAGE

SBAS satellite unselection message. When a satellite is discarded due to MOPS criteria, this message details the reason.

#	FIELD	DESCRIPTION	UNITS
1	SBASUNSEL	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	GNSS system	Satellite constellation (GPS, GAL, GLO or GEO).	-
5	PRN	Satellite identifier.	-
6	Year	Year number (4 digits).	Years
7	DoY	Day of Year (3 digits).	Days
8	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
9	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
10	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
11	GEO PRN	GEO from which the SBAS corrections are used (‘0’ means all GEOs).	-
12	Error code	Number identifying the reason for discarding the satellite.	-
13	Error message	Message detailing the reason for discarding the satellite.	-

NOTE: The error code in field 12 is a number which identifies the discard reason with a range from 1 to 45 (useful for parsing purposes). Field 13 will be always between quotes in order to ease parsing purposes.

3.5.1 SBASUNSEL ERROR MESSAGES

Here is the list of possible errors in the SBASUNSEL message.

ERROR CODE	ERROR MESSAGE
1	“No GEO satellites available”
2	“No data for user selected GEO”
3	“Not enough almanac or GEO navigation message to determine the GEO with highest elevation”
4	“Received alarm message for current GEO at epoch <YYYY DoY SoD>. Time remaining to finish alarm: <seconds> seconds”
5	“Received 4 or more consecutive messages with errors”
6	“Missed 4 or more consecutive messages”
7	"No PRN mask"
8	"PRN mask timed out"
9	"Satellite is not monitored in any of the PRN mask available"
10	"No message type 10 available [PA only]"
11	"Message type 10 timed out [PA only]"
12	"No fast correction data received for current PRN [PA only]"
13	"Sigma UDRE timed out [PA only]"
14	"Satellite flagged as 'Not monitored' (UDREI=14)"
15	"Satellite flagged as 'Do not use' (UDREI=15)"
16	"Satellite has an UDREI value of <value> [PA only]
17	"No fast correction degradation data [PA only]"
18	"Fast correction degradation data timed out [PA only]"
19	"Last PRC received timed out [PA only]"
20	"Only one PRC received. RRC calculation not possible [PA only]"
21	"RRC timed out (under alarm condition) due to time difference between PRC used [PA only]"
22	"RRC timed out (under alarm condition) due to excessive PRC propagation in time [PA only]"
23	"RRC timed out due to time difference between PRC used [PA only]"
24	"RRC timed out due to excessive PRC propagation in time [PA only]"
25	"Service message timed out [PA only]"
26	"Not received a full set of service messages with the same IODS [PA only]"
27	"No clock-ephemeris covariance matrix data for current satellite [PA only]"
28	"Clock-ephemeris covariance matrix data timed out [PA only]"
29	"No navigation data for ranging GEO"
30	"Ranging GEO navigation data timed out"
31	"URA index value of <value> for ranging GEO satellite"
32	"No long term correction data for current satellite [PA only]"
33	"Long term correction data timed out [PA only]"
34	"No broadcast block with IOD <value> [PA only]"
35	"No broadcast block available for current satellite (regardless of SBAS IOD) [NPA only]"
36	"Could not compute transmission time for current PRN measurement"
37	"No ionospheric grid mask [PA only]"
38	"Ionospheric grid mask timed out [PA only]"
39	"IGPs around ionospheric pierce point not found in MOPS grid [PA only]"
40	"Not enough IGPs available in ionospheric grid mask [PA only]"
41	"One IGP is set as don't use [PA only]"
42	"One or more IGPs is set as not monitored or has timed out [PA only]"

43	"Data not available for one or more IGPs [PA only]"
44	"Ionospheric pierce point is outside triangle [PA only]"
45	"External ionosphere model not available"

3.6 SBASOUT MESSAGE

Receiver solution message. This message provides the estimated receiver position, protection levels and satellites used in solution computation.

#	FIELD	DESCRIPTION	UNITS
1	SBASOUT	Fixed word indicating the data stored.	-
2	Receiver id	Receiver identification.	-
3	Mode	SBAS processing mode: PA, NPA.	-
4	Year	Year number (4 digits).	Years
5	DoY	Day of Year (3 digits).	Days
6	Seconds of day	Seconds elapsed since the beginning of the day.	Seconds
7	GPS week	Week number in GPS Time. This field is related to the GPS week of the data snapshot used for the computations.	Weeks
8	Time of week	Seconds elapsed since the beginning of the week. This field is related to the GPS number of seconds of the data snapshot used for the computations.	Seconds
9	GEO PRN	GEO from which the SBAS corrections are used ('0' means all GEOs).	-
10	ΔN	Receiver North difference in relation to nominal a priori position.	Meters
11	ΔE	Receiver East difference in relation to nominal a priori position.	Meters
12	ΔU	Receiver Up difference in relation to nominal a priori position.	Meters
13	HE	Receiver horizontal error.	Meters
14	HPL	Horizontal protection level.	Meters
15	VPL	Vertical protection level.	Meters
16	Receiver clock offset	Offset associated to the receiver clock.	Meters
17	Satellites in view	Number of satellites in view suitable for SBAS.	-
18	Satellites used in filter	Number of satellites used in SBAS solution computation.	-
19	List of satellites	Satellite list. Each satellite will have as a first character, a '+' if it was used in the solution computation, or a '-' if it was not. The second character will be the system identifier (G->GPS, E->Galileo, R->GLONASS, S->GEO). The next two characters will be the PRN identifier. The list will be sorted, showing first the satellites used in the computation and at the end the ones not used.	-

4 gLAB USAGE EXAMPLES

Usage examples to run gLAB with SBAS data processing:

Standalone navigation with SBAS ionosphere (without any other SBAS correction):

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbasiono M1202000.06b -model:iono SBAS > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbasiono M1202000.06b -model:iono SBAS > outputfile.txt
```

Convert RINEX-B file to EMS and Pegasus format and exit without processing:

Linux/Cygwin:

```
./gLAB_linux -input:sbas M1202000.06b -output:ems -output:pegasus –onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:ems -output:pegasus –onlyconvert
```

Convert EMS file to RINEX-B and Pegasus format and exit without processing:

Linux/Cygwin:

```
./gLAB_linux -input:sbas M1202000.ems -output:rinexb -output:pegasus –onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.ems -output:rinexb -output:pegasus –onlyconvert
```

Convert RINEX-B file to Pegasus format (using space as column separator) and exit without processing:

Linux/Cygwin:

```
./gLAB_linux -input:sbas M1202000.06b -output:pegasus –output:pegspace –onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus –output:pegspace –onlyconvert
```

Convert RINEX-B file to Pegasus format (aligning all columns with spaces), exit without processing and write files Pegasus files in current directory:

Linux/Cygwin:

```
./gLAB_linux -input:sbas M1202000.06b -output:pegasus -output:pegfilealign -output:sbasdir "." -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus -output:pegfilealign -output:sbasdir "." -onlyconvert
```

Convert RINEX-B file to Pegasus format (using space as column separator and aligning all columns with spaces) and exit without processing:

Linux/Cygwin:

```
./gLAB_linux -input:sbas M1202000.06b -output:pegasus -output:pegspace -output: pegfilealign -onlyconvert
```

Windows:

```
gLAB.exe -input:sbas M1202000.06b -output:pegasus -output:pegspace -output:pegfilealign -onlyconvert
```

Standard SBAS processing:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b > outputfile.txt
```

Standard SBAS processing with file conversion from RINEX-B to Pegasus:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -output:pegasus > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -output:pegasus > outputfile.txt
```

Standard SBAS processing printing only SBASOUT messages:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -print:none -print:sbasout > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -print:none -print:sbasout > outputfile.txt
```

Standard SBAS processing enabling the step detector and also compute the Stanford-ESA plot values:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stepdetector > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -filter:stepdetector > outputfile.txt
```

NOTE: The Stanford-ESA plot values will be written in the file "`<observationfilename>_stdESA`" (which in this case would be "`madr2000.06o_stdESA`")

Standard SBAS processing computing the Stanford-ESA plot values with the output file for Stanford-ESA plot values as "`std-ESA-madr`",and set the maximum values for the 'x' axis (error axis) to 40 meters, the 'y' axis (protection level) to 70 meters, the 'x' pixel resolution to 1 meter and the 'y' pixel resolution to 1 meter:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -output:stfdesa "std-ESA-madr" -filter:stfdesa:xmax 40 -filter:stfdesa:ymax 60 -filter:stfdesa:xres 1 -filter:stfdesa:yres 1 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -filter:stfdesa -output:stfdesa "std-ESA-madr" -filter:stfdesa:xmax 40 -filter:stfdesa:ymax 60 -filter:stfdesa:xres 1 -filter:stfdesa:yres 1 > outputfile.txt
```

SBAS processing disabling the steady state operation for smoothing and decimating at a 30 second rate:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -pre:dec 30 -pre:smoothmin 0 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -pre:dec 30 -pre:smoothmin 0 > outputfile.txt
```

SBAS processing using the GEO with highest elevation, enabling SNR deselection to all GPS satellites with a threshold of 38 dBHz and fixing the $\sigma_{multipath}$ of the airborne receiver to 5 meters:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -pre:geosel 2 -pre:snr -pre:snrsel G0 38 -model:sigmpath 5 0 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -pre:geosel 2 -pre:snr -pre:snrsel G0 38 -model:sigmpath 5 0 > outputfile.txt
```

SBAS processing with timeout for message type 26 to 10 minutes in NPA, timeout for fast corrections of 30 seconds in both PA and NPA, timeout for range rate corrections to 40 seconds in PA, enabling mode switching, setting the $\sigma_{multipath}$ of the receiver to a fixed value of $\sigma_{multipath} = 5 + 3e^{\frac{-satelevation}{10}}$, the $\sigma_{divergence}$ to a fixed value of 10 meters and the σ_{noise} to 13 meters:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbastmoutnpa 26 600 -model:sbastmoutfc 30 -model:sbastmoutrrcpa 40 -model:sbasmodeswitch -model:sigmpath 5 3 -model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbastmoutnpa 26 600 -model:sbastmoutfc 30 -model:sbastmoutrrcpa 40 -model:sbasmodeswitch -model:sigmpath 5 3 -model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

SBAS processing enabling GEO switch and mode switch, deselecting GEO 136, selecting GEO 120 as primary GEO, ignore type 0 messages and setting the GEO acquisition time to 100 seconds and the switch time to 10 seconds:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:sbasmodeswitch -pre:geoexclude 136 -pre:geosel 120 -model:ignoretype0 -model:geoadqtime 100 -model:switchtime 10 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:sbasmodeswitch -pre:geoexclude 136 -pre:geosel 120 -model:ignoretype0 -model:geoadqtime 100 -model:switchtime 10 > outputfile.txt
```

SBAS processing in NPA mode, treating MT0 as MT2, using data from mixed GEO and enabling the step detector:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmode NPA -pre:geosel 0 -filter:stepdetector > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:sbasmode NPA -pre:geosel 0 -filter:stepdetector > outputfile.txt
```

SBAS processing enabling GEO switch, enabling GEO switch to mixed GEO data, setting timeout for MT10 to 100 seconds for both PA and NPA and setting the SBAS receiver to type 1:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:mixedgeo -model:sbastmout 10 100 -model:sbasreceiver 1 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -model:geoswitch -model:mixedgeo -model:sbastmout 10 100 -model:sbasreceiver 1 > outputfile.txt
```

Show help message and an example on how to create a user-defined error file for adding error to raw measurements:

Linux/Cygwin:

```
./gLAB_linux -usererrorfile
```

Windows:

```
gLAB.exe -usererrorfile
```

Show help message and an example on how to create a user-defined sigma multipath model:

Linux/Cygwin:

```
./gLAB_linux –sigmamultipathfile
```

Windows:

```
gLAB.exe –sigmamultipathfile
```

SBAS processing with user-defined error:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:usererror usererrorfile > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:usererror usererrorfile > outputfile.txt
```

SBAS processing with user-defined sigma multipath model:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile > outputfile.txt
```

SBAS processing with user-defined sigma multipath model, user-defined error, $\sigma_{divergence}$ to a fixed value of 10 meters and the σ_{noise} to 13 meters::

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile -input:usererror usererrorfile -model:sigdiv 10 -model:signoise 13 > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b -input:sigmpath usersigmamultipathmodelfile -input:usererror usererrorfile -model:sigdiv 10 -model:signoise 13  > outputfile.txt
```

SBAS processing but using IONEX ionosphere model instead of SBAS ionosphere model:

Linux/Cygwin:

```
./gLAB_linux -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b –input:inx igrg2000.06i –model:iono IONEX > outputfile.txt
```

Windows:

```
gLAB.exe -input:obs madr2000.06o -input:nav brdc2000.06n -input:sbas M1202000.06b –input:inx igrg2000.06i –model:iono IONEX > outputfile.txt
```

5 PLOTTING FUNCTIONS PARAMETERS

These are the new parameters for the new plots implemented in the graph.py program (the plotting tool for gLAB). These parameters are shown by executing the command 'graph –h':

5.1 STANFORD PLOTS

--stanford, --sf, --sp	Make a Stanford plot.
--AL, --al	Set the alarm limit for the protection level, if no value is provided, AL is set to 35 [DEFAULT].
--clean	Make a Stanford Plot without failure patches.
--xr, --xresolution	Set the resolution in x-direction of the plot. If no value is provided, it is set to 0.5 [DEFAULT].
--yr, --yresolution	Set the resolution in y-direction of the plot. If no value is provided, it is set to 0.5 [DEFAULT].

5.2 STANFORD-ESA PLOTS

--stanfordESA, --sfesa, --spesa	Make a Stanford-ESA plot.

5.3 WORST INTEGRITY RATIO PLOTS

--map	Make a worst integrity ratio plot.
--projection, --pj	Set the projection of the map. 'Equidistant Cylindrical Projection' is set as [DEFAULT]. User can set the value of projection as 'lcc' or 'lambert' to switch to "Lambert Conformal Projection"
--cbarMin,--cbarmin,--cmin	The minimum value for the colorbar, if no value is provided, automatic limits are set.
--cbarMax,--cbarmax,--cmax	The maximum value for the colorbar, if no value is provided, automatic limits are set.
--cbarInterval,--cbarN,--cn	The value of interval for colorbar's tick, if no value is provided, 8 is set as [DEFAULT].
--continentColor,--cc	The continent's color, if no value is provided, 'yellow' is set as [DEFAULT].
--lakeColor, --lc	The lake's color, if no value is provided, 'white' is set as [DEFAULT].
--boundaryColor,--bc	The continent's color, if no value is provided, 'white' is set as [DEFAULT].

6 PLOTTING FUNCTIONS USAGE EXAMPLES

Usage examples to create plots with the plotting tool graph.py:

Create a plot with North, East Up error (using the output file of gLAB after doing a normal SBAS processing) and show it in the screen:

Linux:

```
./graph.py -f "glabOutputFileSBAS" -x4 -y18 -s.- -c ‘($1==”OUTPUT”)’ -l "North error" -f "glabOutputFileSBAS" -x4 -y19 -s.- -c ‘($1==”OUTPUT”)’ -l "East error" -f "glabOutputFileSBAS‶ -x4 -y20 -s.- -c ‘($1==”OUTPUT”)’ -l "UP error" --yn -8 --yx 8 --xl "time (s)" --yl "error (m)" -t "NEU positioning error"
```

Windows:

```
graph.exe -f "glabOutputFileSBAS" -x4 -y18 -s.- -c "($1=='OUTPUT')" -l "North error" -f "glabOutputFileSBAS" -x4 -y19 -s.- -c "($1=='OUTPUT')" -l "East error" -f "glabOutputFileSBAS‶ -x4 -y20 -s.- -c "($1=='OUTPUT')" -l "UP error" --yn -8 --yx 8 --xl "time (s)" --yl "error (m)" -t "NEU positioning error"
```

Cygwin:

```
graph.py -f "glabOutputFileSBAS" -x4 -y18 -s.- -c ‘($1==”OUTPUT”)’ -l "North error" -f "glabOutputFileSBAS" -x4 -y19 -s.- -c ‘($1==”OUTPUT”)’ -l "East error" -f "glabOutputFileSBAS‶ -x4 -y20 -s.- -c ‘($1==”OUTPUT”)’ -l "UP error" --yn -8 --yx 8 --xl "time (s)" --yl "error (m)" -t "NEU positioning error"
```

Create a plot with HPE and HPL (using the output file of gLAB after doing a normal SBAS processing) and show it in the screen:

Linux:

```
./graph.py -f "glabOutputFileSBAS" -c ‘($1==”SBASOUT”)’ -x 6 -y 13 -s.- -l "HPE" -f "glabOutputFileSBAS" -c ‘($1==”SBASOUT”)’ -x 6 -y 14 -s.- -l "HPL"
```

Windows:

```
graph.exe -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" -x 6 -y 13 -s.- -l "HPE" -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" -x 6 -y 14 -s.- -l "HPL"
```

Cygwin:

```
graph.py -f "glabOutputFileSBAS" -c ‘($1==”SBASOUT”)’ -x 6 -y 13 -s.- -l "HPE" -f "glabOutputFileSBAS" -c ‘($1==”SBASOUT”)’ -x 6 -y 14 -s.- -l "HPL"
```

Create a plot with VPE and VPL (using the output file of gLAB after doing a normal SBAS processing) and show it in the screen:

Linux:

```
./graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' -x 6 -y '(math.sqrt($12*$12))' -s.- -l "VPE" -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' -x 6 -y 15 -s.- -l "VPL"
```

Windows:

```
graph.exe -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" -x 6 -y "(math.sqrt($12*$12))" -s.- -l "VPE" -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" -x 6 -y 15 -s.- -l "VPL"
```

Cygwin:

```
graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' -x 6 -y '(math.sqrt($12*$12))' -s.- -l "VPE" -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' -x 6 -y 15 -s.- -l "VPL"
```

Create a Stanford plot with HE and HPL (using the output file of gLAB after doing a normal SBAS processing) and show it in the screen:

Linux:

```
./graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' --sf -x 13 -y 14
```

Windows:

```
graph.exe -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" --sf -x 13 -y 14
```

Cygwin:

```
graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' --sf -x 13 -y 14
```

Create a Stanford plot with VE and VPL (using the output file of gLAB after doing a normal SBAS processing), with an alarm limit of 30 meters and save the image to file "stfd_vertical.png":

Linux:

```
./graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' --sf -x 12 -y 15 --al 30 --sv "stfd_vertical.png"
```

Windows:

```
graph.exe -f "glabOutputFileSBAS" -c "($1=='SBASOUT')" --sf -x 12 -y 15 --al 30 --sv "stfd_vertical.png"
```

Cygwin:

```
graph.py -f "glabOutputFileSBAS" -c '($1=="SBASOUT")' --sf -x 12 -y 15 --al 30 --sv "stfd_vertical.png"
```

Create a Stanford plot with VE and VPL (using the output file of gLAB after doing a normal SBAS processing), with the vertical label set to “EGNOS VPL (meters)”, without failure patches and save the image to file “stfd_vertical.eps”:

Linux:

```
./graph.py -f “glabOutputFileSBAS” -c '($1=="SBASOUT")' --sf -x 12 -y 15 --clean --yl “EGNOS VPL (meters)” --sv “stfd_vertical.eps”
```

Windows:

```
graph.exe -f “glabOutputFileSBAS” -c “($1=='SBASOUT')” --sf -x 12 -y 15 --clean --yl “EGNOS VPL (meters)” --sv “stfd_vertical.eps”
```

Cygwin:

```
graph.py -f “glabOutputFileSBAS” -c '($1=="SBASOUT")' --sf -x 12 -y 15 --clean --yl “EGNOS VPL (meters)” --sv “stfd_vertical.eps”
```

Create a Stanford-ESA plot (using the dedicated output file of gLAB for Stanford-ESA plots) and show it in the screen (it will show two plots, one for the HE and HPL and another for the VE and VPL):

Linux:

```
./graph.py -f “glabStanfordESAFile” --sfesa
```

Windows:

```
graph.exe -f “glabStanfordESAFile” --sfesa
```

Cygwin:

```
graph.py -f “glabStanfordESAFile” --sfesa
```

Create a Stanford-ESA plot (using the dedicated output file of gLAB for Stanford-ESA plots) and save the VE and VPL plot to file “stfd-ESA-VE.png” and the HE and HPL plot to file “stfd-ESA-HE.png”:

Linux:

```
./graph.py -f “glabStanfordESAFile” --sfesa --sv “stfd-ESA-VE.png” --sv “stfd-ESA-HE.png”
```

Windows:

```
graph.exe -f “glabStanfordESAFile” --sfesa --sv “stfd-ESA-VE.png” --sv “stfd-ESA-HE.png”
```

Cygwin:

```
graph.py -f “glabStanfordESAFile” --sfesa --sv “stfd-ESA-VE.png” --sv “stfd-ESA-HE.png”
```

NOTE: For creating worst integrity ratio plots, a text file is needed with at least the station name, the station geodetic coordinates and its worst integrity ratio. The values have to be given in columns. It can be in any order as long as the column number for each value (coordinates and worst integrity ratio) and correctly given in the parameters. For the following examples to work, the file must have the columns in this order: station name, longitude (in degrees), latitude (in degrees) and the worst integrity ratio (unit less). An example of the file is shown below:

```
acor -8.3989 43.3644 66.8996 1.33608
casc -9.4185 38.6934 76.0213 0.448299
kir0 21.0602 67.8776 498.0980 0.0326527
kiru 20.9684 67.8574 391.0312 0.0281741
klop 8.7299 50.2198 222.4568 0.0294406
kokb -159.6649 22.1263 1167.3588 0.0303347
mala -4.3935 36.7261 119.8279 1.34595
mall 2.6246 39.5526 62.0412 0.0263054
reyk -21.9555 64.1388 93.0295 0.0250726
stas 5.5986 59.0177 104.9182 2.44836
```

Create a worst integrity ratio plot using the input file “sta_list_wir.txt” showing the map for the whole world in the screen:

Linux:

```
./graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5
```

Windows:

```
graph.exe -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5
```

Cygwin:

```
graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5
```

Create a worst integrity ratio plot using the input file “sta_list_wir.txt” showing the map only for latitudes between 20º and 80º and for longitudes between -60º and 60º:

Linux:

```
./graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --xmax 60 --xmin
-60 --ymin 20 --ymax 80
```

Windows:

```
graph.exe -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --xmax 60 --xmin -
60 --ymin 20 --ymax 80
```

Cygwin:

```
graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --xmax 60 --xmin -
60 --ymin 20 --ymax 80
```

Create a worst integrity ratio plot using the input file “sta_list_wir.txt” showing the map for the whole world, with the colorbar divided in 10 intervals, a maximum value of 3 and saving the file to “wir.png”:

Linux:

```
./graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --cn 10 --cmax 2.5 --sv "wir.png"
```

Windows:

```
graph.exe -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --cn 10 --cmax 2.5 --sv "wir.png"
```

Cygwin:

```
graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --cn 10 --cmax 2.5 --sv "wir.png"
```

Create a worst integrity ratio plot using the input file “sta_list_wir.txt” showing the map for the whole world, with Lambert projection:

Linux:

```
./graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --pj lambert
```

Windows:

```
graph.exe -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --pj lambert
```

Cygwin:

```
graph.py -f "sta_list_wir.txt" --map -x 2 -y 3 -z 5 --pj lambert
```

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