PROJECT: SERVUS - SERVice Volume User SBAS		WP Number: WP-0000003
WP TITLE: WP3. User Position Performance Computation		Issue: 1.0
LEAD CONTRACTOR	GNSS Academy	
CUSTOMER	ESA	WP LEADER: Student
ESTIMATED EFFORT	30 hours	

OBJECTIVE

The main goal of this Work-Package 3 is to implement **POS** and **PERF** Module of SERVUS using an output file information from LOS module with all the necessary user-satellite Line-Of-Sight information to compute the user XPE and XPL as well as the service performances in terms of availability, integrity and accuracy across the service volume.

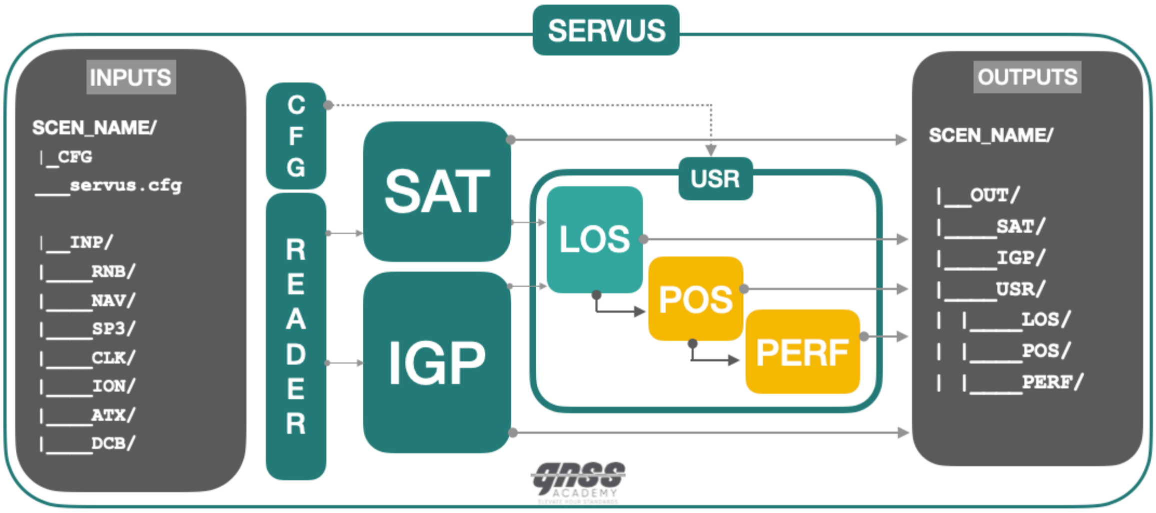
SCOPE

SERVUS is a branch of the SBPT Tool Suite.

SERVUS tool is in charge of providing the following Service Performance over a given service volume over the EGNOS Service Area (ECAC)

- **Accuracy** Maps represented by the XPE95% (HPE95%, VPE95%)
- **Availability** Maps represented by the Percentage of time HPL<HAL & VPL<VAL
- **Integrity Risk** as the probability to have Misleading information or Safety Indices HSI = HPE/HPL, VSI=VPE/VPL greater than 1.
- **Continuity Risk** Maps represented by the Probability to have transitions of PL>AL in seconds sliding windows

The High level Architecture is:



USR Module is in charge of computing the following main performance indicators: the instantaneous user position errors (HPE, VPE) and the protection levels (HPL, VPL).

The computation of the position errors (XPE) and protection levels (XPL) require the projection of the range errors and associated sigma bounds through the LSE transference function range-to-position based on the Geometry Matrices in the following way:

1. On the one side, the Position Errors are estimated from the projection of the range errors through the LSE transfer matrix as follows:

$[XPE] = ([G]^T[W][G])^{-1}[G]\ [W]\ \{RNGE_{ERROR}\}$

2. On the Other side, the Protection Levels are obtained from the Covariance Matrices of LSQ process.

   $[D] = ([G]^T[W][G])^{-1}$

   $HPL = K_H\ d_{MAJOR}$
   $VPL = K_V\ \ d_{UP}$

Where:

- **[G]** is the Geometry Matrix,
- **[W]** Weighting Matrix composed of the inverse sigmas of the range errors [$1/Sigma_{UERE}^2$]
- **$\{RNGE_{ERROR}\}$** is the range error vector.
- **K_F** is the gaussian factor to reach HPL and VPL to the required confidence levels

These range errors **$\{RNGE_{ERROR}\}$** and their associated Sigmas are composed of:

- Satellite orbit and clocks errors (SREU) and Sigmas (SigmaFLT)
- Ionospheric delay errors (UISDE) and Sigmas (UIRE)
- Tropospheric delay errors (TropoE) and sigmas (SigmaTROPO)
- Local Environment errors due to interferences, multipath and receiver noise and iono-divergence (AirE) and its associated sigmas (SigmaAIR)

Range Error is composed of:

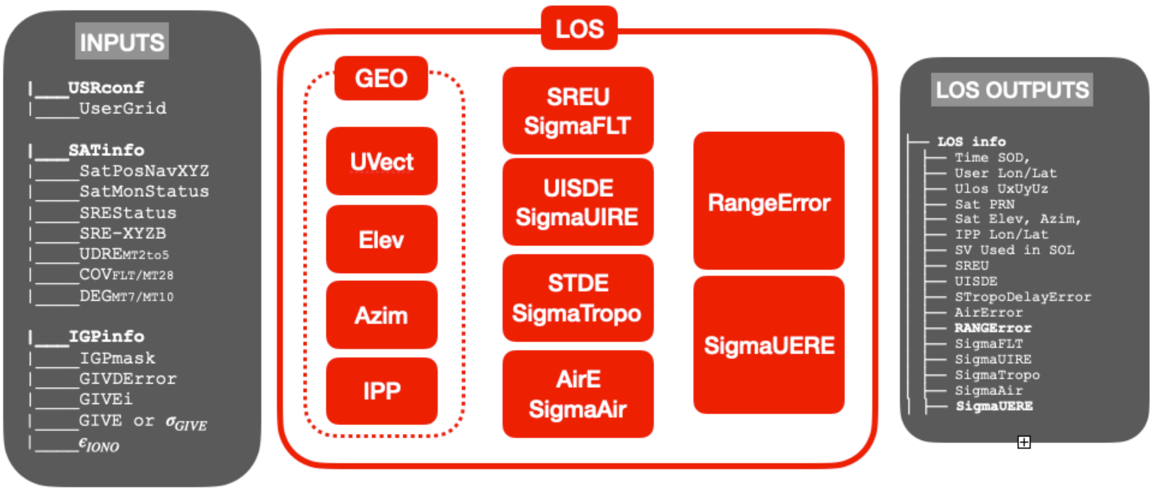
```
RangeError = SREU + UISDE + TropoE + AirE
```

The associated Range Error Sigmas are given by the Sigma UERE

```
SigmaUERE² = SigmaFLT² + SigmaUIRE² + SigmaTropo² + SigmaAIR²
```

SERVUS "LOS" module in charge of computing the necessary the user-satellite LoS information from the satellite and ionosphere to the range level for a grid of fictitious users on the Earth Surface.

LOS module extracts this Satellite and IGP information in order to compute satellite-User LOS errors and Sigmas, taking into account the contributions of the troposphere error and local error contributors.



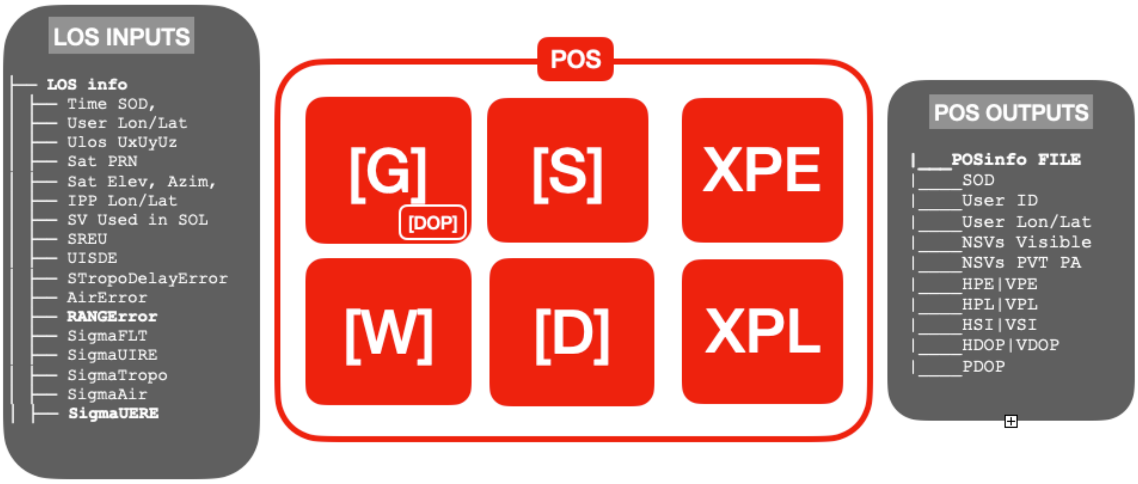
LOS module produces a daily file with all the instantaneous information per User-Satellite Line-Of-Sight allowing to later estimate the Position Errors and Protection levels by POS module

<u>This Work-package WP3 aims at implementing the POS and the PERF Module at User level</u>

For this, the WP3 is split in to 2 main parts:

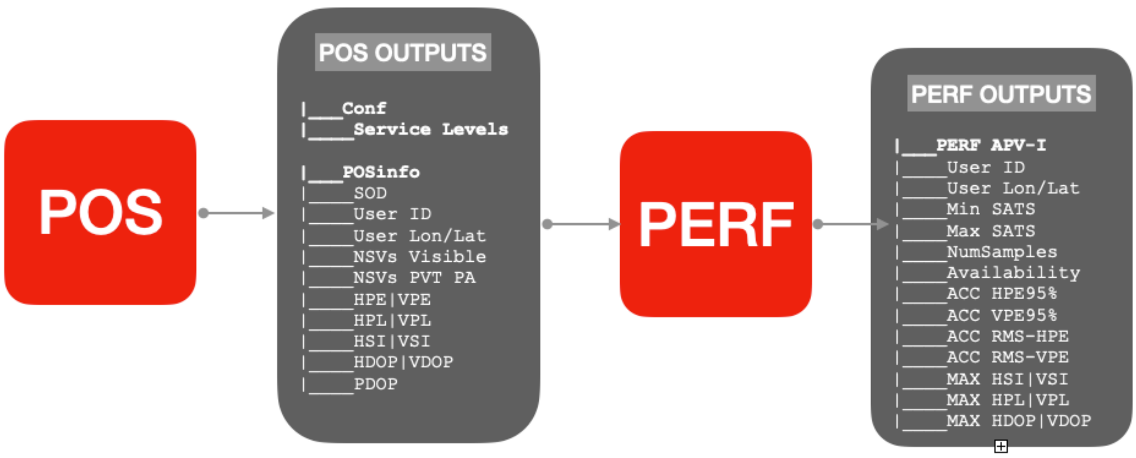
WP3.1 USER POS Module

- Read and Extract the User-Satellite LoS Range Level information from an input LOS file
- Build the observation/geometry and weighting matrices ([G] and [W]
- Compute the position errors XPE and protection levels XPL.
- Compute some additional indicators at user level (NSVs, DOPs)



WP3.2 USER PERF Module

Create a daily file and related plots containing the main Service Performances for APV-I Service Level (Note that Continuity Risk is not required in a first stage)



These are the main requirements of POS Module:

REQ. ID	TYPE	TITLE	BODY
SERVUS-POS-REQ-010	FUN	HPL and VPL	The SERVUS shall determine the user SBAS protection levels (HPL and VPL) in line with Appendix J of MOPS Standard for all the users across the Service Volume

SERVUS-POS-REQ-020	FUN	HPE and VPE	The SERVUS shall determine the user horizontal (HPE) and Vertical (VPE) for all the users across the Service Volume
SERVUS-POS-REQ-030	FUN	HDOP and VDOP	The SERVUS shall determine the instantaneous receiver PDOP and TDOP, as well as HDOP and VDOP for all the users across the Service Volume
SERVUS-POS-REQ-040	FUN	Service Volume Performances	The SERVUS shall compute the following user daily and global performances for all the users across the Service Volume * Availability * RMS HPE, VPE * HPE95%, VPE95% * Max HPE, Max VPE * Maximum Safety Indices HSI, VSI * Min/Max Number of Satellites * Min/Max HPL and VPL * …

[POS] PROCESSING LOGIC

POS Pseudo-Code to guide you in the process. Note that this is not real code but it helps to understand the main processing logic and SW architecture.

```
# Loop over days in scenario
For days in SCENARIO.
```

computeUsrPos()

```
 # OPEN LOS daily input file
 LOS = openLosInfoFile()

 # Loop over all epochs in the file
 For seconds in DAY.

        # READ LOS file epoch by epoch
        LOSepoch = Read_LOS_file()

        # Loop over All Users in this epoch
        For Users in GRID:

                # Loop over Satellites Lines-Of-Sights for each User in this epoch
                For Sats in NSATS:

                   # Check Satellite Visibility with Elevation Angle greater than 5 degrees.
                   If Sat.Elevation > USER.MASK_ANGLE (fix it to 5 degrees)

                   # Check Flag is 1 for PA Solutions. (We ignore NPA solutions)
                   If FLAG_PA == 1

                   # Count the Number of Valid Satellites for PA Solution for this user and epoch
                     NumSatsPA = NumSatsPA + 1

                    # Build Ranging Error Vector by adding all the different contributors
                     RANGEERROR= SREU + UISDE + TropoE + AirE

                    # Build the SigmaUERE² in line with MOPS Standard
                    SigmaUERE²=SigmaFLT²+SigmaUIRE²+SigmaTropo²+SigmaAIR²
```

$$\sigma_i^2 = \sigma_{i,flt}^2 + \sigma_{i,UIRE}^2 + \sigma_{i,air}^2 + \sigma_{i,tropo}^2$$

```
                    # Build G: Observation and W: Weighting Matrices for PA Solution
                    #------------------------------------------------------------------------

                    # Build Geometry matrix in line with SBAS Standard
```

```
([G_PA])= buildGmatrix();

Build the Geometry Matrices using the satellite elevation and azimuth
```

$$\mathbf{G}_\mathrm{i} = \begin{bmatrix} -\cos El_i \sin Az_i & -\cos El_i \cos Az_i & -\sin El_i & 1 \end{bmatrix} = \mathrm{i^{th}}\ \text{row of}\ \mathbf{G}$$

```
# Build Weighting matrix in line with SBAS Standards
([W_PA])= buildWmatrix();

Build the Weighting Matrix [W] with the inverses of SigmaUERE²
```

$$\sigma_i^2 = \sigma_{i,flt}^2 + \sigma_{i,UIRE}^2 + \sigma_{i,air}^2 + \sigma_{i,tropo}^2$$

$$w_i = 1/\sigma_i^2$$

$$W = \begin{bmatrix} w_1 & 0 & \cdots & 0 \\ 0 & w_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & w_N \end{bmatrix}$$

```
# END OF LOOP For Sats in NSATS:


# Compute Position Errors and Protection levels
#-------------------------------------------------------------------------------

# Compute PA Solution if at least 4 Satellites are valid for solution
if NumSats_PA >= 4:

    # Compute PDOPs (Ref.:  ESA GNSS Book Vol I Section 6.1.3.2)
    PDOP_PA = ComputeDOPs(([G_PA]);
        Compute the DOP Matrix [Q]=([G]^T G])^-1
        Compute the PDOP=sqrt(q_E^2+q_N^2+q_U^2)

    # Check if the PDOP is below a threshold (e.g: 10000)
    # If PDOP is greater, no solution position is given.
    if (PDOP_PA <= Conf.PDOP_MAX):

        # Compute the Position Error Vector through the LSE process
        {EPE, NPE, UPE} = ([G]^T[W][G])^-1[G]^T [W] {RNGE_ERROR}

        # Compute the HPE from EPE and NP
        HPE = SQRT(EPE^2+NPE^2)

        # Compute the VPE from UPE.
        VPE = ABS(UPE)  = SQRT(UPE^2)

        # Compute Protection levels in line with Appendix J of MOPS
        [HPL_PA VPL_PA] = computeProtectionLevels([G], [W]);

                    [D]  =  ([G]^T[W][G])^-1
```

$$\begin{bmatrix} d_{east}^2 & d_{EN} & d_{EU} & d_{ET} \\ d_{EN} & d_{north}^2 & d_{NU} & d_{NT} \\ d_{EU} & d_{NU} & d_U^2 & d_{UT} \\ d_{ET} & d_{NT} & d_{UT} & d_T^2 \end{bmatrix} = \left(\mathbf{G}^T \mathbf{W} \mathbf{G}\right)^{-1}$$

$$d_{major} \equiv \sqrt{\frac{d_{east}^2 + d_{north}^2}{2} + \sqrt{\left(\frac{d_{east}^2 - d_{north}^2}{2}\right)^2 + d_{EN}^2}}$$

```
# Horizontal Protection level→ HPL= K_HPA d_MAJOR  (K_HPA=6.0)
# Vertical   Protection level→ VPL= K_V d_U        (K_V=5.33)
```

```
                    # Print POS information into a file
                    PrintPosfile()

                    # Update Performance intermediate information
                    # Start computing the daily statistics RMS, PRC95%, MAX.
                    # Note that some statistics area applied only when service level is available.
                    PerfInter = updatePerfo(PE, PL, SI, PerfInter);

                # Otherwise, no position can be estimated.
                else:
                     POSFLAG = NOK

                # End of if (PDOP_PA <= Conf.PDOP_MAX):

            else NSVSPASOL < 4:

                POSFLAG = NOK

            # End of if NSVSPASOL >= 4:

        # END OF For Users in GRID:

# END OF For Seconds in DAY.

     # Print PERF information into a file
     PrintPERFfile()

# End of computeUsrPos()
```

Here below the list of tasks proposed to compute the user performances.

INPUTS

This Work-package uses 1 input daily file as the output of the LOS module.

1. **LOS_INFO_Y19D014_G123_150s.dat** (sampled at 150s)

Column	Content	Format	Units	Description
C1	SOD	%05d	SEC	Second of Day
C2	DOY	%03d	DAYS	Day of Year
C3	USER ID	%5d	-	User ID as a number
C4	ULON	%f	DEG	User Longitude
C5	ULAT	%f	DEG	User Latitude
C6	FLAG	%d	-	Flag to indicate if this LOS can be used for PA or NPA or any of them 0: Not Used 1:Used for PA and NPA 2: Used in NPA)
C7	CONST	%s%02d	-	Satellite Constellation (G: GPS, E:Galileo)
C8	PRN	%02d	-	Satellite PRN
C9	ELEV	%f	DEG	Satellite Elevation angle
C10	AZIM	%f	DEG	Satellite Azimuth angle
C11	IPPLON	%f	DEG	IPP Longitude
C12	IPPLAT	%f	DEG	IPP Latitude
C13	RERROR1	%f	METER	Range Error Orbit and Ionospheric Component SREU + UISDE
C14	UERE1	%f	METER	UERE from the Orbit&Clock and ionospheric component $SigmaFLT^2 + SigmaUIRE^2$
C15	SI1	%f	-	Safety Index at Range level from Orbit&Clock plus Ionosphere

C16	**RERROR**	%f	METER	Total Range Error with all the contributors SREU + UISDE + TropoE + AirE
C17	**UERE**	%f	METER	Sigma UERE including all the contributors $SigmaFLT^2 + SigmaUIRE^2 + SigmaTropo^2 + SigmaAIR^2$
C18	**SI**	%f	-	Safety Index at Range level with all the contributors
C19	**SREU**	%f	METER	Satellite Residual Error at the User Position
C20	**UDREI**	%f	-	Satellite UDRE Index
C21	**SFLT**	%f	METER	Satellite SigmaFLT (Sigma of the Satellite Orbit and Clock error after corrections)
C22	**STROPOE**	%f	METER	Slant Tropospheric Model Error
C23	**SIGMTROPO**	%f	METER	Sigma of the Troposphere Model Error
C24	**AIRERR**	%f	METER	Airborne Error including Multipath, Receiver Noise and the Iono divergence
C25	**SIGMAIR**	%f	METER	Sigma Airborne including Multipath, Receiver Noise and the Iono divergence
C26	**UISDE**	%f	METER	User Ionosphere Slant Delay Error
C27	**UIRE**	%f	METER	User Ionospheric Range Error
C28	**UISD**	%f	METER	User Ionospheric Slant Delay
C29	**SIGMAMP**	%f	METER	Sigma of Multipath Error
C30	**SIGMANOISE**	%f	METER	Sigma of Receiver Noise

OUTPUTS

Two main kind of outputs for this Work Package are required:

- A file including instantaneous information per User. **POS_INFO_Y19D014_G123.dat**

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Column	Content	Format	Units	Description
C1	**SOD**	%7d	SEC	Second of Day
C2	**USER ID**	%6d	-	User Identifier as a number
C3	**ULON**	%10.3f	DEG	User Longitude
C4	**ULAT**	%10.3f	DEG	User Latitude
C5	**SOL-FLAG**	%7d	-	Solution Flag to indicate if solution is valid or not valid 0: Not Valid Line-Of-Sight 1: Valid for PA and NPA 2: Valid only for NPA
C6	**NSV_{VISBLE}**	%9d	-	Number of Visible satellites (>5 DEG)
C7	**NSV_{PA}**	%10d	-	Number of Satellites used in the PA solution
C8	**HPE_{PA}**	%10.3f	METER	Horizontal Position Error for PA solution
C9	**VPE_{PA}**	%10.3f	METER	Vertical Position Error for PA solution
C10	**HPL_{PA}**	%10.3f	METER	Horizontal Protection Level for PA solution
C11	**VPL_{PA}**	%10.3f	METER	Vertical Protection Level for PA solution
C12	**HSI_{PA}**	%10.3f	-	Horizontal Safety Index for PA solution
C13	**VSI_{PA}**	%10.3f	-	Vertical Safety Index for PA solution
C14	**$HDOP_{PA}$**	%10.3f	-	Horizontal Dilution Of Precision for PA solution
C15	**$VDOP_{PA}$**	%10.3f	-	Vertical Dilution Of Precision for PA solution
C16	**$PDOP_{PA}$**	%10.3f	-	Position Dilution Of Precision for PA solution

- A file including Service Performances for APV-I for all Users in the Grid
  `PERF_APVI_Y19D014_G123.dat`

Column	Content	Format	Units	Description
C1	**USER ID**	%d	-	User ID as a number
C2	**ULON**	%f	DEG	User Longitude
C3	**ULAT**	%f	DEG	User Latitude
C4	**TOTALSAMP**	%d	-	Total Number of samples with Solution (NSVs>4 & PDOP<PDOPmax)
C5	**NSVMIN**	%d	-	Minimum number satellites used in solution (NSVs>4 & PDOP<PDOPmax)
C6	**NSVMAX**	%d	-	Maximum number satellites used in Solution (NSVs>4 & PDOP<PDOPmax)
C7	**SAMPAVAIL**	%d	-	Total Number of available samples (Samples with HPL<HAL and VPL<VAL) APV-I: HAL=40m and VAL=50m
C8	**AVAILABILITY**	%f	-	Availability of integrity APV-I as the Percentage of time HPL<HAL and VPL<VAL Ratio between the Number of Available Samples and the total samples in the day.
C9	**HPERMS**	%f	METER	RMS of the Horizontal Position Error (HPE) in APV-I (HPL<HAL and VPL<VAL)
C10	**VPERMS**	%f	METER	RMS of the Vertical Position Error (VPE) in APV-I(HPL<HAL and VPL<VAL)
C11	**HPE95%**	%f	METER	95th-Percentile of the Horizontal Position Error in APV-I (HPL<HAL and VPL<VAL)
C12	**VPE95%**	%f	METER	95th-Percentile of the Vertical Position Error in APV-I (HPL<HAL and VPL<VAL)
C13	**HPEMAX**	%f	METER	Maximum reached Horizontal Position Error in APV-I (HPL<HAL and VPL<VAL)
C14	**VPEMAX**	%f	METER	Maximum reached Vertical Position Error in APV-I (HPL<HAL and VPL<VAL)
C15	**HSIMAX**	%f	-	Maximum reached Horizontal Safety Index (HSI=HPE/HPL) **Not Service level dependent, all samples shall be considered, not only those available APV-I**
C16	**VSIMAX**	%f	-	Maximum reached Vertical Safety Index (VSI=VPE/VPL) **Not Service level dependent, all samples shall be considered, not only those available APV-I**
C17	**HPLMAX**	%f	METER	Maximum reached Horizontal Protection Level for APV-I Service level (HPL<HAL and VPL<VAL)
C18	**VPLMAX**	%f	METER	Maximum reached Vertical Protection Level for APV-I Service level (HPL<HAL and VPL<VAL)
C19	**HPLMIN**	%f	METER	Minimum reached Horizontal Protection Level or APV-I Service level (HPL<HAL and VPL<VAL)
C20	**VPLMIN**	%f	METER	Minimum reached Vertical Protection Level or APV-I Service level (HPL<HAL and VPL<VAL)
C21	**HDOPMAX**	%f	-	Maximum reached Horizontal DOP or APV-I Service level (HPL<HAL and VPL<VAL)
C22	**VDOPMAX**	%f	-	Maximum reached Vertical DOP for APV-I Service level (HPL<HAL and VPL<VAL)
C23	**PDOPMAX**	%f	-	Maximum reached Position DOP for APV-I Service level (HPL<HAL and VPL<VAL)

TASKS

ID	DESCRIPTION
T0. PRELIMINARY	Downloading and Understanding
T0.1 INPUT FILES	Download following TAR file: **STEP1. Download SERVUS-TOOL folder tree and files** → **`SERVUS_WP3_USR.tgz`**

	STEP2. Place it here
	
	➔ `cd SBPT/SERVUS/SERVUS_V1.0/`
	
	STEP3 untar the file.
	
	`tar xvfz SERVUS_WP3_USR.tgz`
	
	Check that all the following information is available:
	
	`SERVUS_WP3_USR/`
	`|____SRC`
	`| |____UsrPerformances.py (empty)`
	`| |____UsrFunctions.py (empty)`
	`| |____COMMON`
	`| | |____GnssConstants.py`
	`| | |____Dates.py`
	
	`|____SCN`
	`| |____EGNOS-SIS-GEO123-JAN19`
	`| | |____CFG`
	`| | | |____usrperformances.cfg`
	
	`| | |____OUT`
	`| | | |____LOS`
	`| | | | |____LOS_INFO_Y19D014_G123_150s.dat`
	
	LOS_INFO files are sampled at 150 seconds in order to speed-up the execution process.
	
	Output Files will be generated in:
	
	`SERVUS_WP3_USR/`
	`|____SCN`
	`| |____EGNOS-SIS-GEO123-JAN19`
	`| | |____OUT`
	`| | | |____POS`
	`| | | | |____POS_INFO_Y19D014_G123_150s.dat`
	`| | | |____PERF`
	`| | | | |____PERF_APVI_Y19D014_G123_150s.dat`
	
	Check that you have also available 2 reference files in order to validate your outputs.
	
	`| | |____OUT`
	`| | | |____REF`
	`| | | | |____POS_INFO_Y19D014_G123_150s.ref`
	`| | | | |____PERF_APVI_Y19D014_G123_150s.ref`	

T1. IMPLEMENTATION	Functions Implementation: Open/Reading/Loading	
T1.1	Implement the necessary Python functions and routines to: Read the configuration file Read, extract and load LOS file information.	
T2. POS file	**Create POS FILE**	
T2.1	Create a file with instantaneous information user position information in time.	

	Please, follow the guidelines above to implement the right steps to compute the XPE and XPLs.
	
	Reference file here to validate your results:
	
	`| | |____OUT`
	`| | | |____REF`
	`| | | | |____POS_INFO_Y19D014_G123_150s.ref`	

T3. PERF FILE	Create PERF file	

T3.1	Read Previous User Position information file and create the Service Performance file. `file: PERF_APVI_Y19D014_G123.dat`
	
	Note that to create the daily performances file, you can either do it directly while processing the position solution or with an independent code that reads previous POS_INFO file and generates the statistics.
	
	Note that you have a reference file here to validate your results:
	
	`| | |____OUT`
	`| | | |____REF`
	`| | | | |____PERF_APVI_Y19D014_G123_150s.ref`
	
	--- 	
	
	Computation of HPE95% and VPE95%
	
	One of the most critical statistics is the Percentile 95% on the fly following the next steps.
	
	STEP1. Define statistical XPE bins of a given resolution (e.g 0.001 meters). A bin is defined by a lower and an upper extreme. (Bi=[Li,Ui))
	
	STEP2. Count, on the fly, the number of samples where XPE falls into each bin.
	
	Once the processing is finished,
	
	STEP3. Compute the Ratio ($R1=N1/N_{TOTAL}$, $R21=N2/N_{TOTAL}$,$R3=Ni/N_{TOTAL}$ …) for each statistical bin.
	
	STEP4. Compute the cumulated sum of the ratios from bin 1 to last bin. (C1=R1,C2=R1+R2,Ci=R1+R2+…Ri …)
	
	STEP5. Select the 95% percentile as the upper extreme (Ui) of the lowest bin Bi whose cumulated sum (Ci) is greater than 0.95 (min Ui | Ci >0.95)
	
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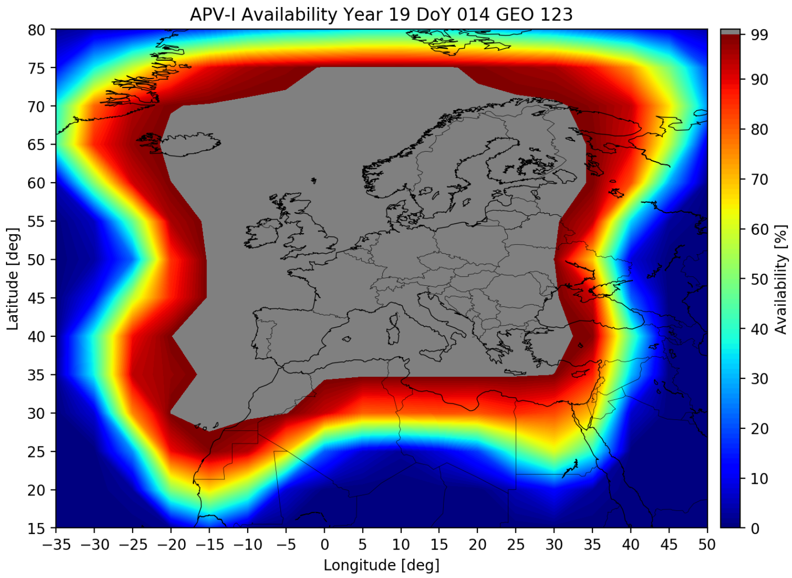
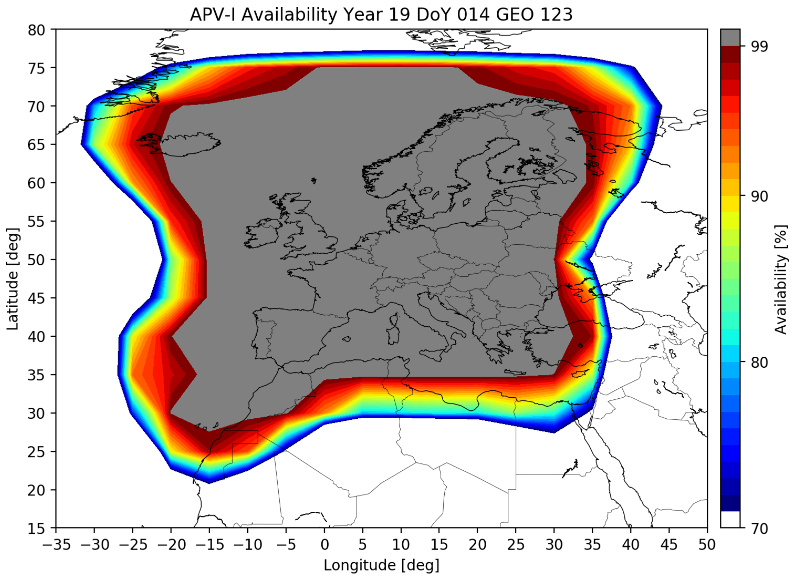
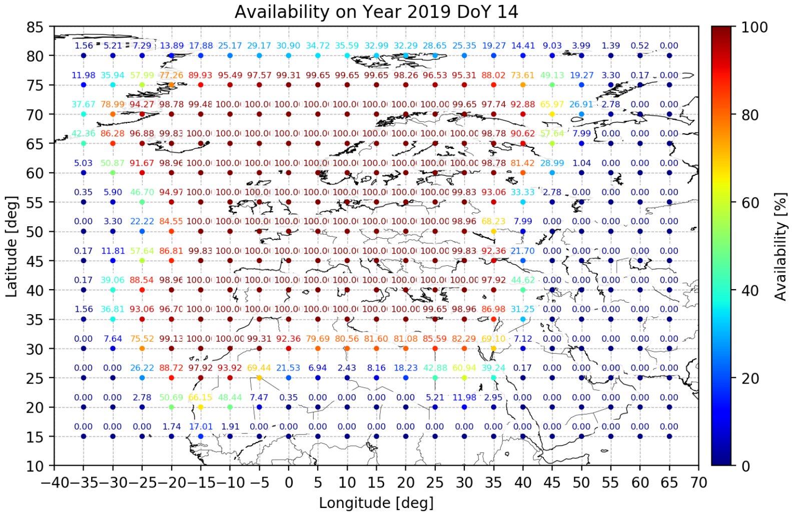
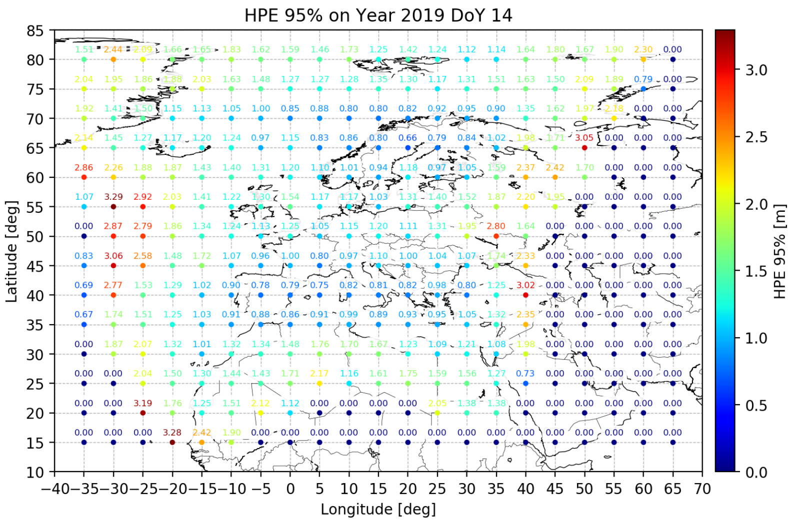
T4. MAPS PERF Plots	Plot Maps with previous information
AVAILABILITY APV-1 0-100%	Map of APV-I Availability  EGNOS-SIS-GEO123-D014Y19_APV-I_AVAILABILITY_0_100.png
AVAILABILITY APV-1 70-99%	 EGNOS-SIS-GEO123-D014Y19_APV-I_AVAILABILITY_70_99.png

AVAILABILITY APV-I No Interpolation



APV-I HPE95%

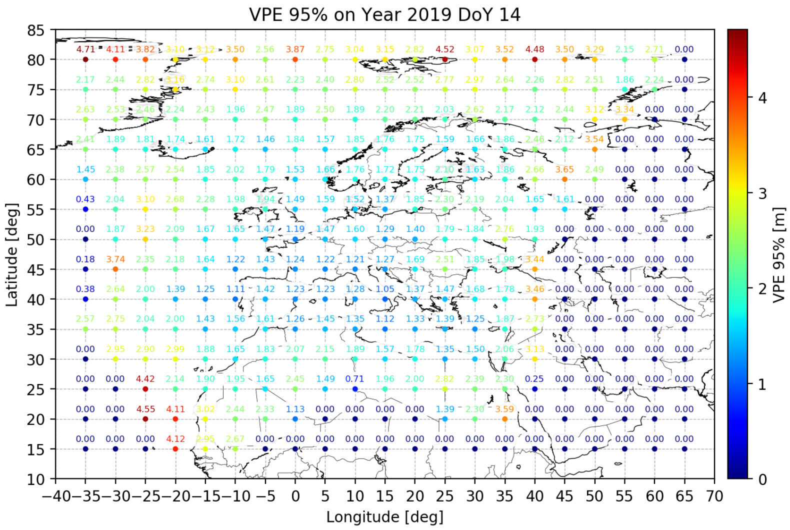
Map of APV-I Horizontal Position Accuracy at 95%



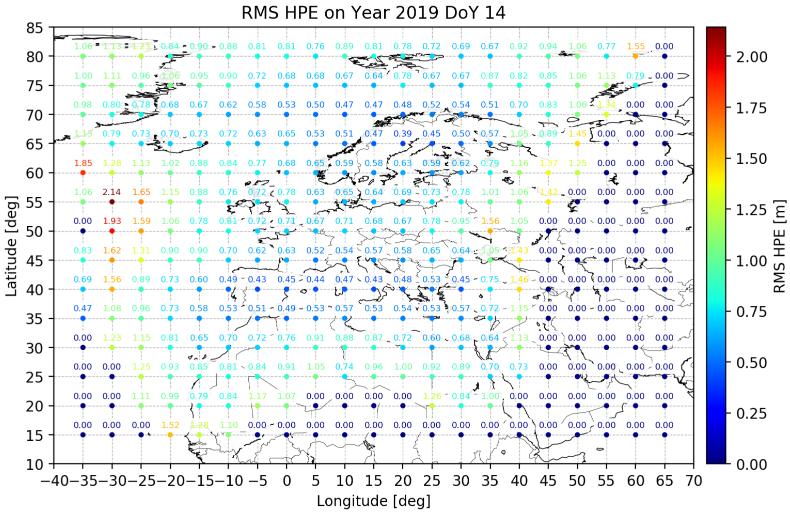
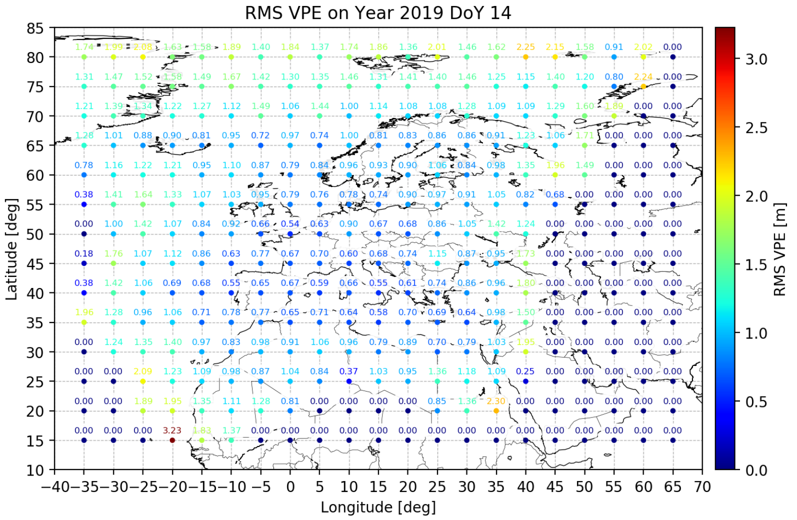
EGNOS-SIS-GEO123-D014Y19_APV-I_HPE95%.png

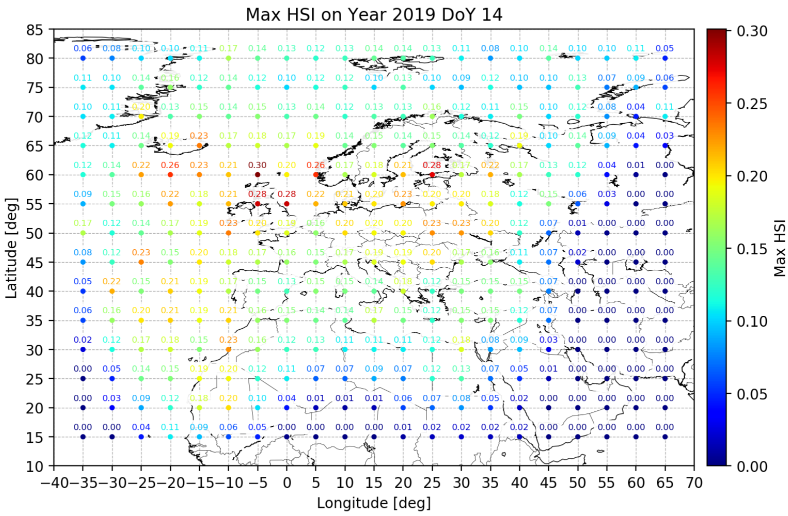
APV-I VPE95%

Map of APV-I Vertical Position Accuracy at 95%



EGNOS-SIS-GEO123-D014Y19_APV-I_VPE95%.png

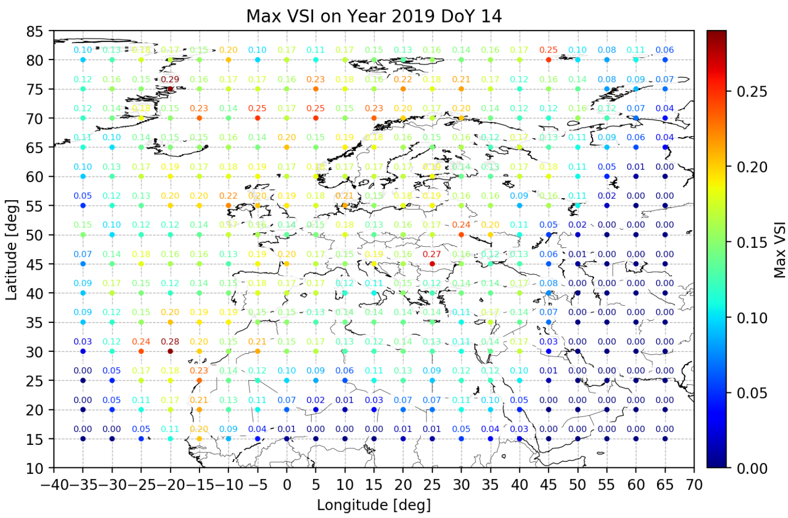
APV-I RMS HPE	Map of RMS APV-I Horizontal Position Accuracy  **EGNOS-SIS-GEO123-D014Y19_APV-I_RMS-HPE.png**	
APV-I RMS VPE	Map of RMS APV-I Vertical Position Accuracy  **EGNOS-SIS-GEO123-D014Y19_APV-I_RMS-VPE.png**	
MAX-HSI	Map of the Maximum HSI reached during the day (Note that this figure is not APV-I dependent)	



EGNOS-SIS-GEO123-D014Y19_MAX-HSI.png

MAX-VSI

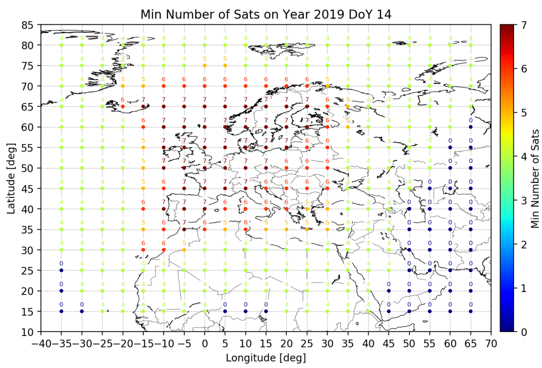
Map of the Maximum VSI reached during the day (Note that this figure is not APV-I dependent)



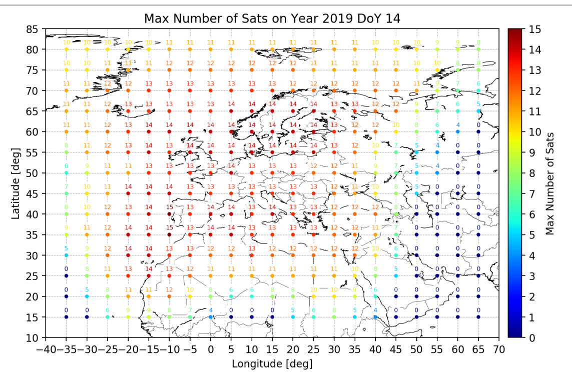
EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-VSI.png

MIN/MAX-SATS

Map of the Minimum Number of satellites

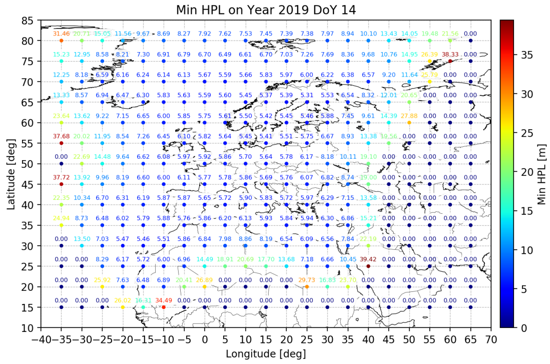


EGNOS-SIS-GEO123-D014Y19_APV-I_MIN-NSVS

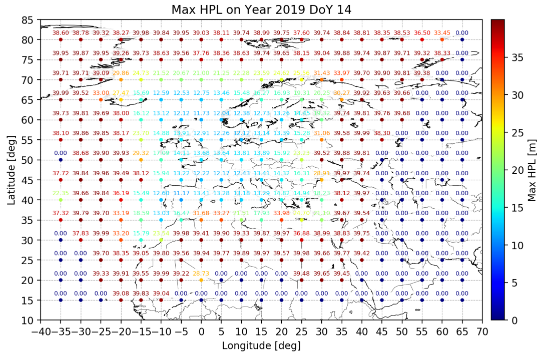


EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-NSVS

MIN/MAX-HPL Map of the Maximum HPL reached during the day

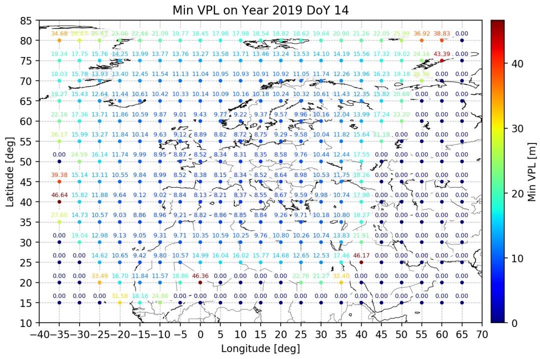


EGNOS-SIS-GEO123-D014Y19_APV-I_MIN-HPL.

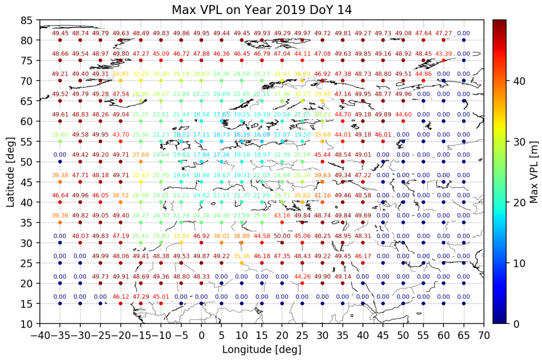


EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-HPL

MIN/MAX-VPL Map of the Maximum VPL reached during the day

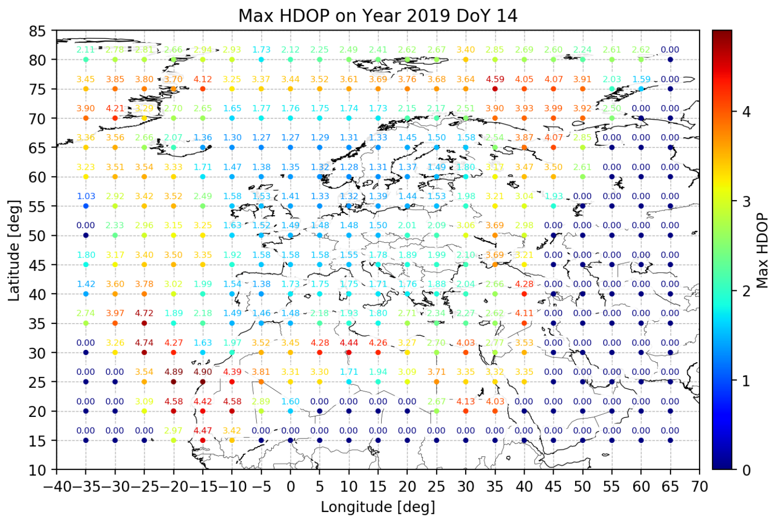


EGNOS-SIS-GEO123-D014Y19_APV-I_MIN-VPL



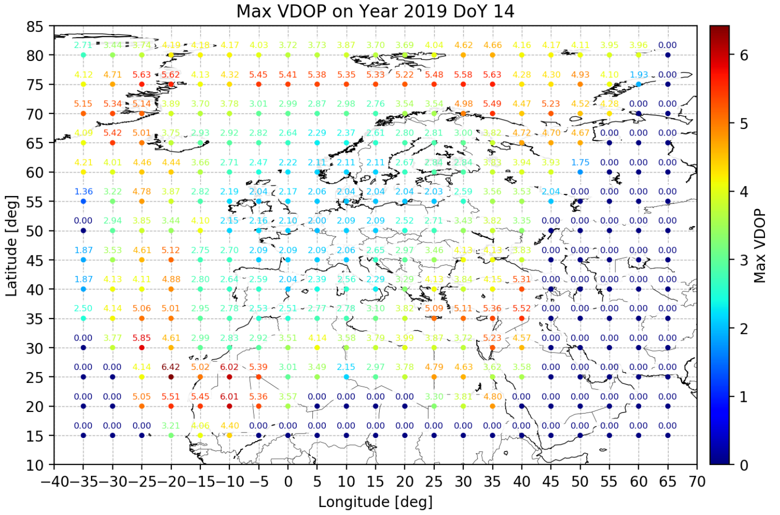
EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-VPL

MAX-HDOP Map of Maximum HDOP reached during the day



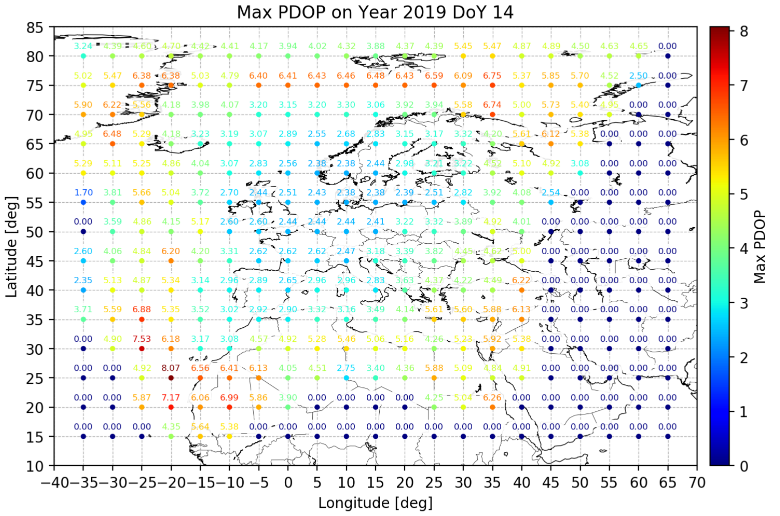
EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-HDOP.png

MAX-VDOP Map of Maximum VDOP reached during the day



EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-VDOP.png

MAX-PDOP Map of Maximum PDOP reached during the day

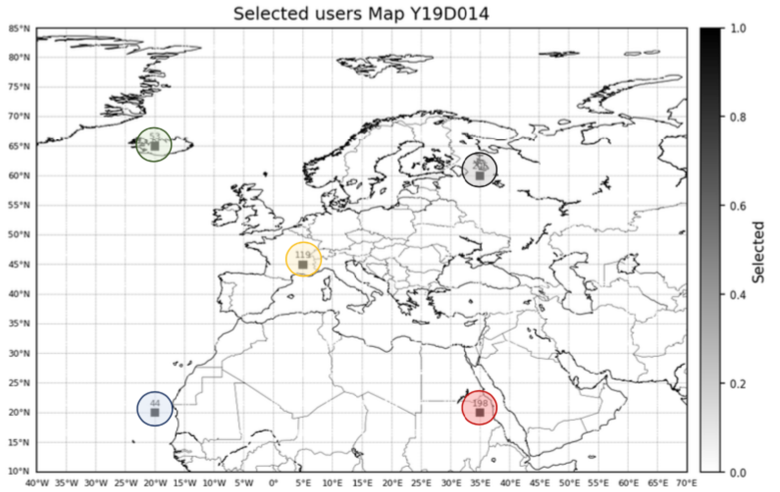
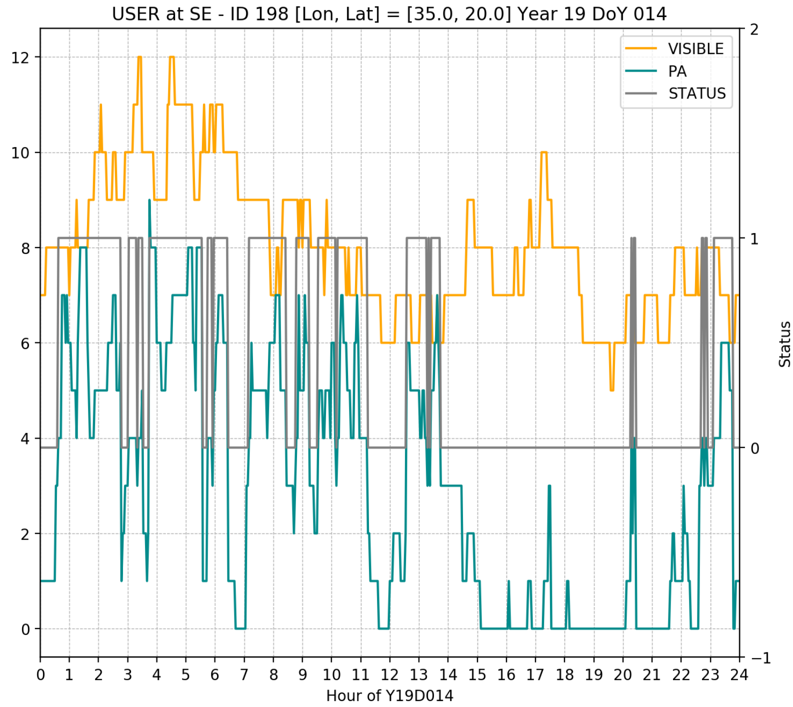


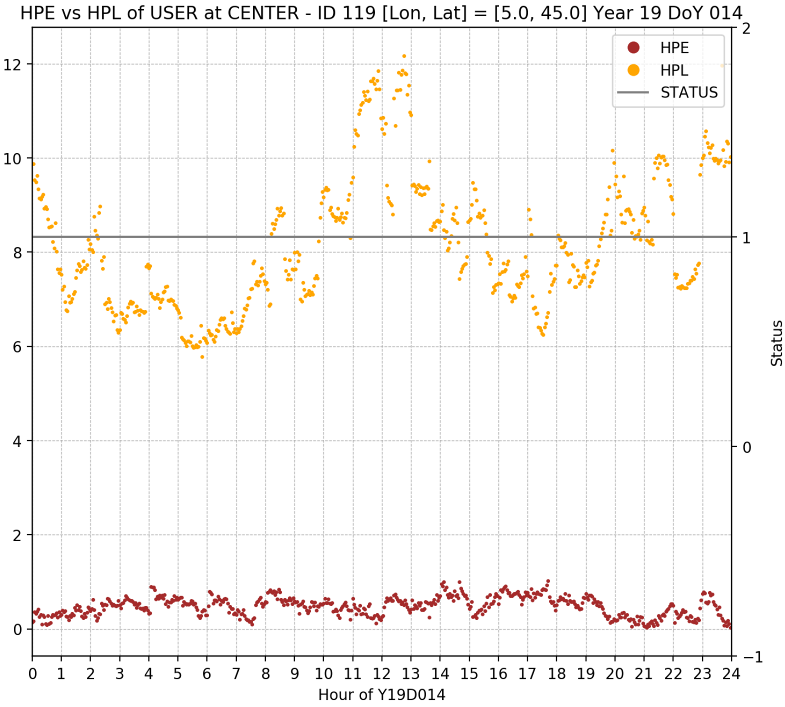
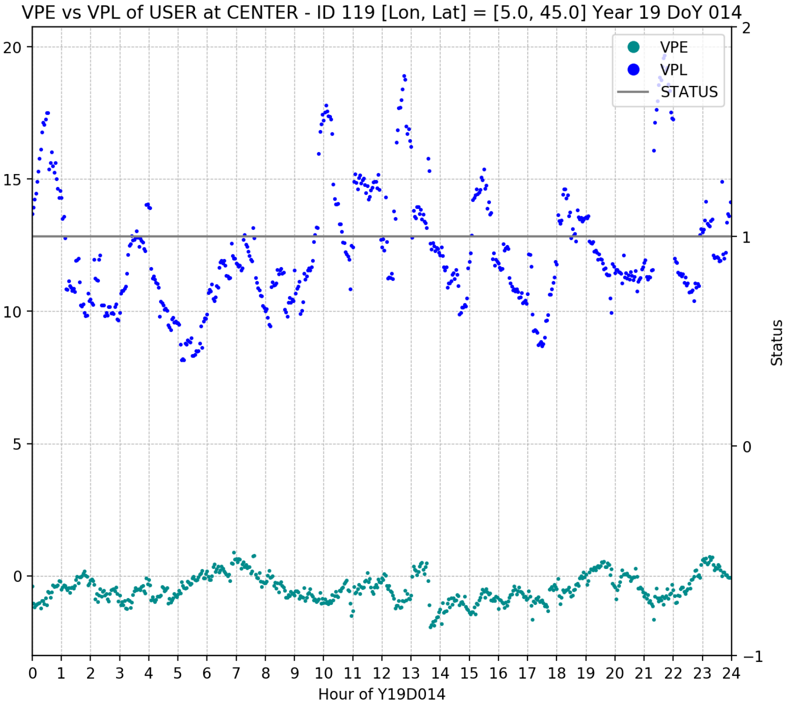
EGNOS-SIS-GEO123-D014Y19_APV-I_MAX-VDOP.png

T5. TIME User Plots — OPTIONAL

Select 5 Users in Europe, one in ECAC Center and the 4 different Corners, and plot the following information along the day.

Location	LON [deg]	LAT [deg]	ID
Center	5	45	119
SW	-20	20	44
SE	35	20	198
NW	-20	65	53
NE	35	60	206

		
NSATS	Number of Satellites Visible and used on PA solution as a function of time. Example: 	
HPE and HPL	Horizontal Position Error and Protection level as a function of time.	

		
VPE and VPL	Vertical Position Error and Protection level as a function of time. 	
XDOPS	DOPS	

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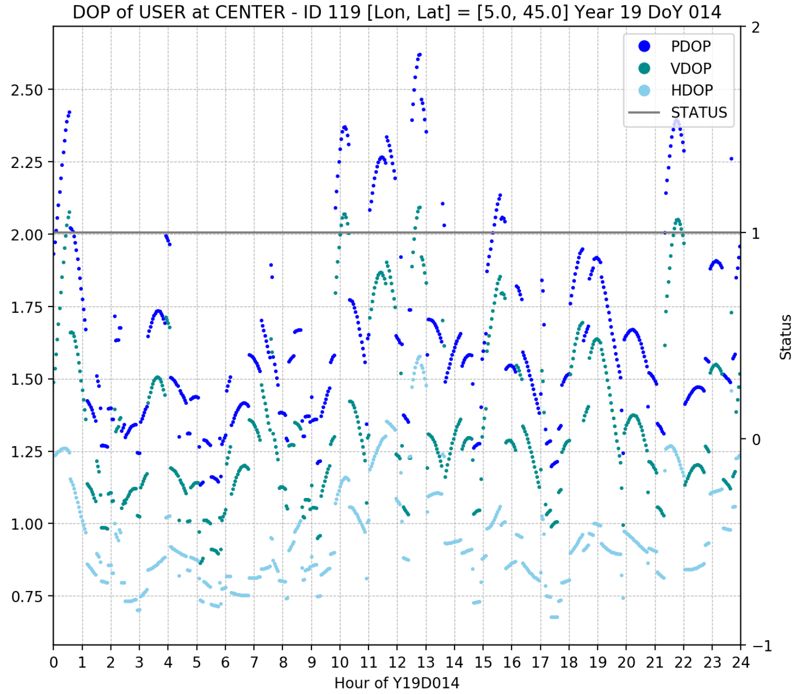

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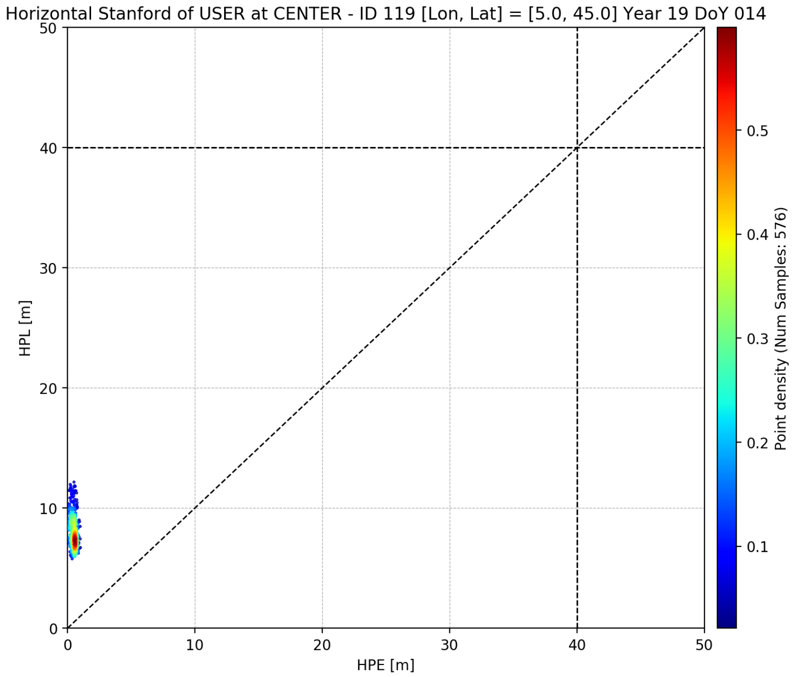
<tr>
<td>Stanford diagram</td>
<td>Stanford Diagram at the Horizontal and Vertical domain
Examples:


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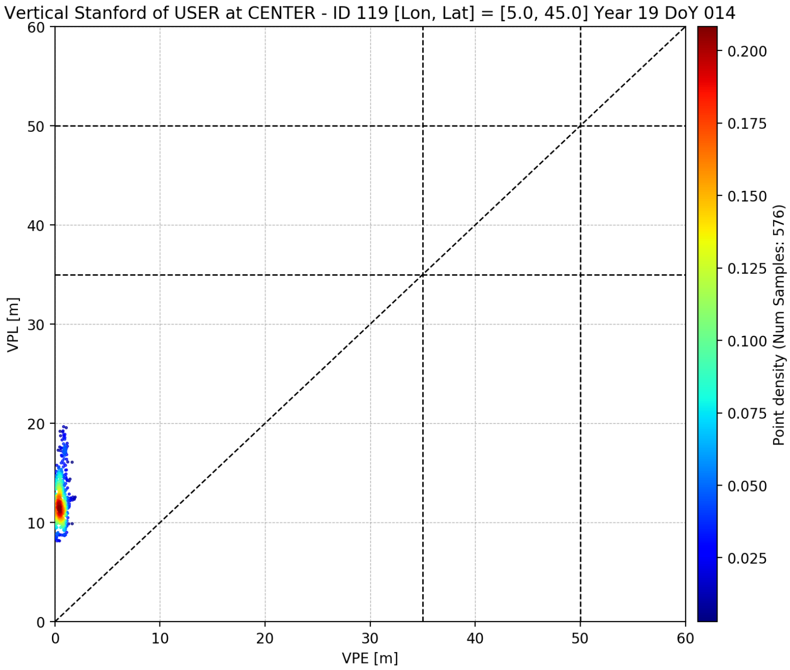
Vertical Stanford of USER at CENTER - ID 119 [Lon, Lat] = [5.0, 45.0] Year 19 DoY 014
VPL [m]
VPE [m]
Point density (Num Samples: 576)
0
10
20
30
40
50
60
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200