Kongsberg Discovery AS

To: Seapath users's

Date: 2024-07-10

Subject: Influence of increasing ionospheric activity on GNSS performance

Author: Finn Otto Sanne, Product Line Manager, Inertial Solutions

Increased ionospheric activity.

Description and background

The Earth is approaching the peak of solar cycle 24 activity. The peak is predicted to be in 2025 (Nasa.gov). Space weather is known to effect availability and accuracy of GNSS (Global Navigation Satellite Systems) causing biases and noise into measurements. The GNSS receiver might get problems acquiring and maintaining lock on some of the signals due to scintillation and plasma bubbles. The region around equator is mostly affected, but scintillations often cause problems with tracking and maintaining precision at high latitudes.

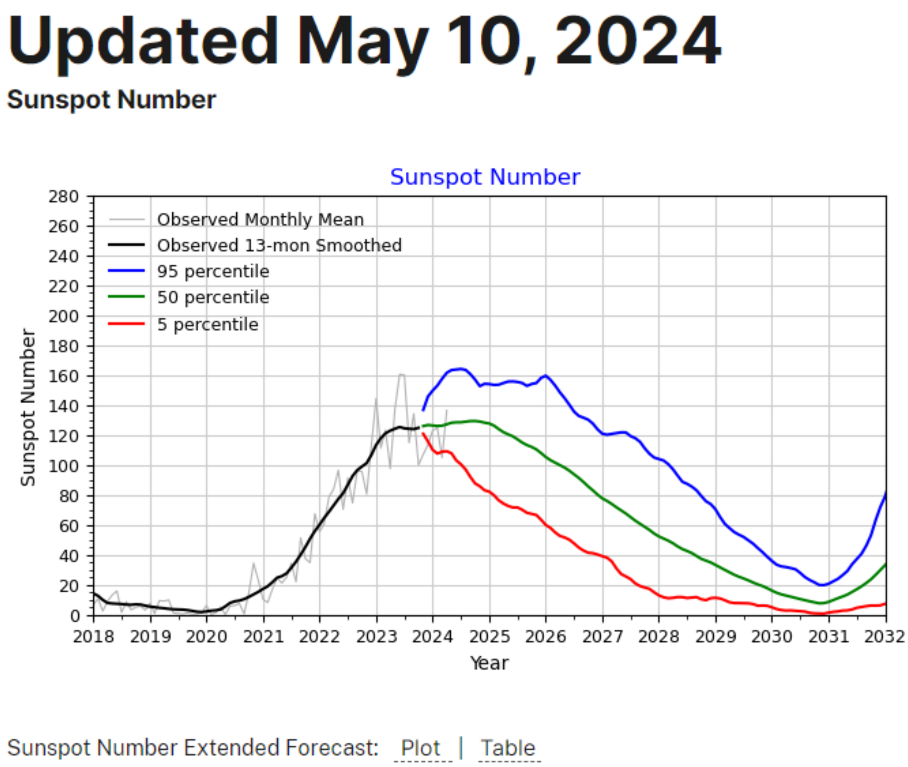


Figure 1 From Nasa.gov\solar-cycle-progression-and-forecast.

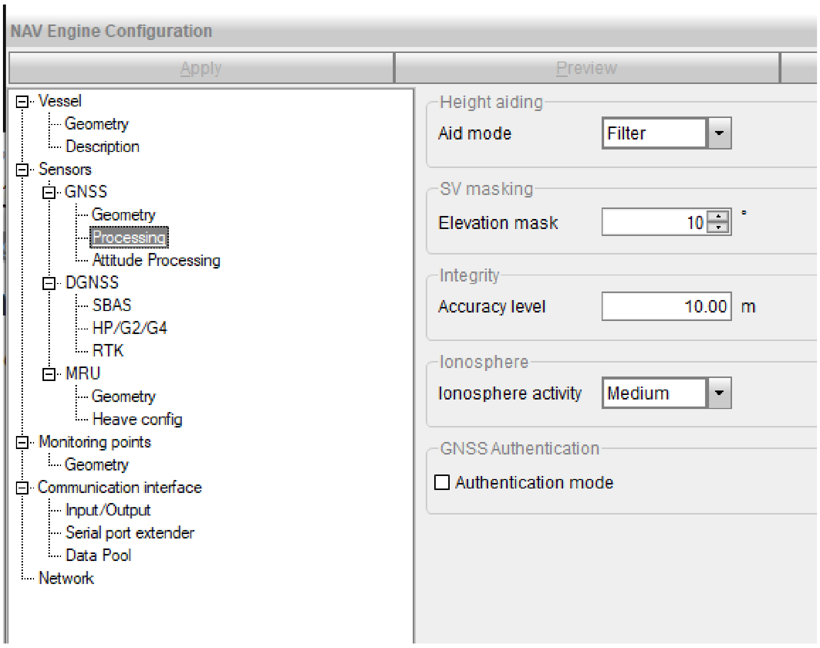
Impact of ionospheric activity on GNSS

- Decreased precision, reduced availability and increased convergence time of PPP and RTK.
- During ionospheric storms long baseline RTK and high precision PPP might not be available at all, due to scintillations affecting tracking and carrier phase.
- Single frequency GNSS users will in periods of high activity, get significantly reduced position accuracy due to uncompensated ionospheric delay.
- Dual frequency users applying single frequency corrections will in periods of high activity, get significantly reduced position accuracy, especially at long baselines.
- Loss of track of L-band correction services.
- Low elevation satellites are in general more affected than high elevation due to longer passage through the ionosphere.
- The region around equator is particularly affected.
- High ionospheric activity and scintillation might also affect post processing.

What to do with Seapath?

- Upgrade to the latest Seapath software with latest GNSS receiver firmware.
- Dual frequency non-differential multi-constellation will perform much better than using single frequency RTCM 2.3 corrections. The preferred solution is to turn off use of all single frequency corrections as RTCM 2.3 including QZSS SAIF service and IALA. Preferably also turn of SBAS.
- If present, turn of reception of RTCM through the IALA link. If not possible, force the IALA receiver to track the nearest station. Some IALA stations does not transmit its own position. The received correction data is assumed to be near, but atmospheric radio conditions vary and stations at long distance corrections might be received and treated as if the reference station was close by.
- If you got a Fugro G2/G4/XP subscription, turn of use of single frequency RTCM 2.3 corrections (standard configuration).
- Set ionosphere activity parameter to medium or high depending on activity. This will weight down single frequency reference stations with long baseline.
- If using a lower elevation mask than 10 degrees, increase elevation mask back to default (10 degrees). If using multi-constellation RTK, consider increase to 15 degrees.
- If possible, use all available GNSS systems. This will reduce noise and periods of few satellites due to scintillation.
- L-BAND reception: Receive corrections from more than one GEO satellite. Ensure NTRIP (3610 or 3710 DGNSS Receiver) is enabled for the L-band. NTRIP will be a backup when ionospheric disturbance effects the signal in sky.

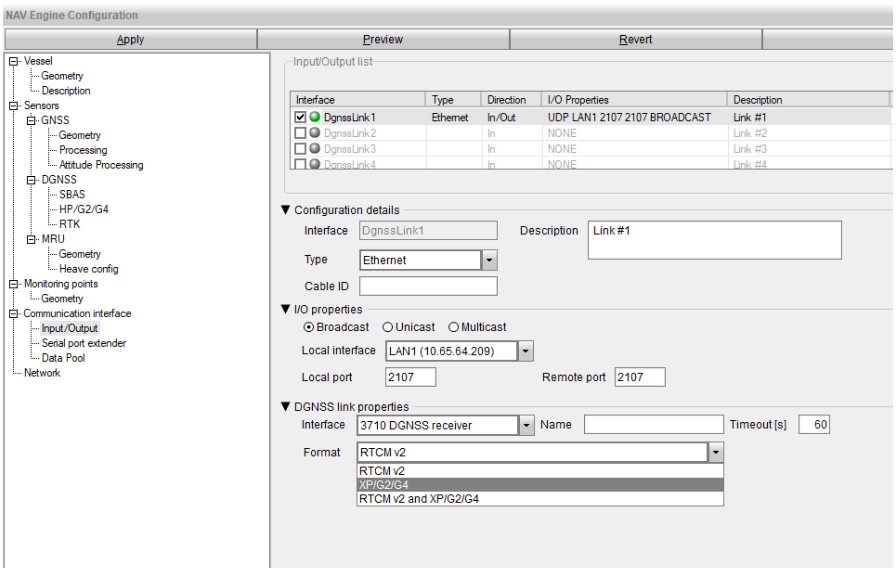
1: Set ionosphere activity level and elevation mask.



Proceed as follows in the Standard configuration:

1. Select Ionosphere activity level (medium or high).
2. Elevation mask should be at least 10 degrees.

2: Disable RTCM 2.x (single frequency corrections).



Proceed as follows in the Standard config – Input/Output:

1. Disable RTCM only DgnssLinks (Disable by removing x from DgnssLink).
2. Remove use of RTCM v2 from the 3710/3610 DGNSS Receiver (Selected in DGNSS receiver Format).
3. Disable use of IALA, usually DgnssLink1 (Disable by removing x from DgnssLink1).

Seapath 130 and older Seapath 380 with one single frequency and one dual frequency receiver:

- Seapath 130 and Seapath 380 users with one single and one dual frequency receiver might get integrity warnings due to large differences in position between dual and single frequency calculations.

Do I have a single frequency receiver?

In all Seapath 130 products the second receiver is single frequency. Older Seapath 330 and 380 have on single and one dual frequency receiver. Check data viewer tracking:

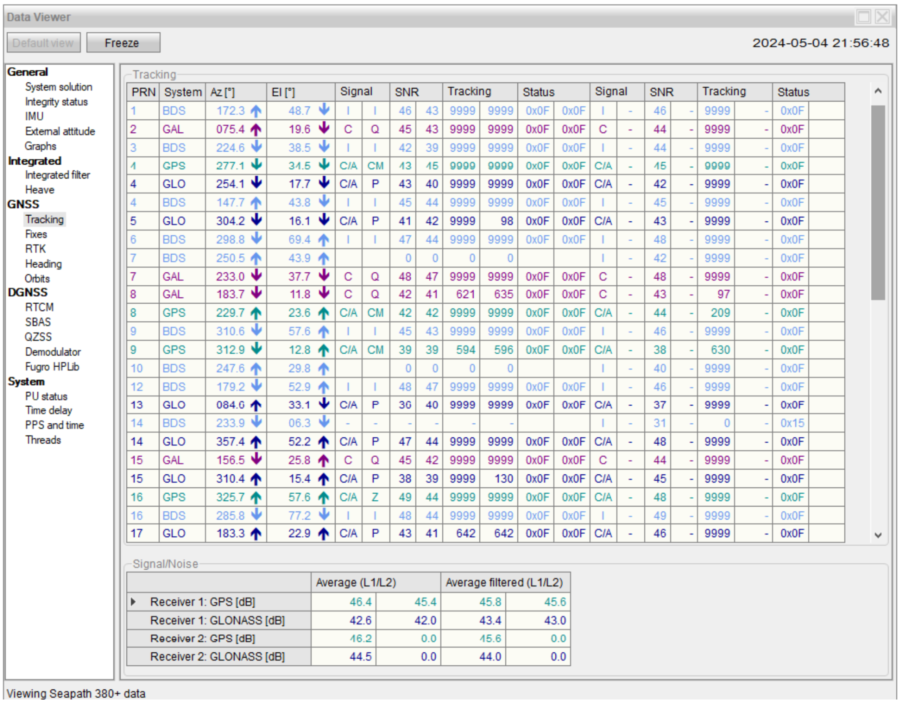
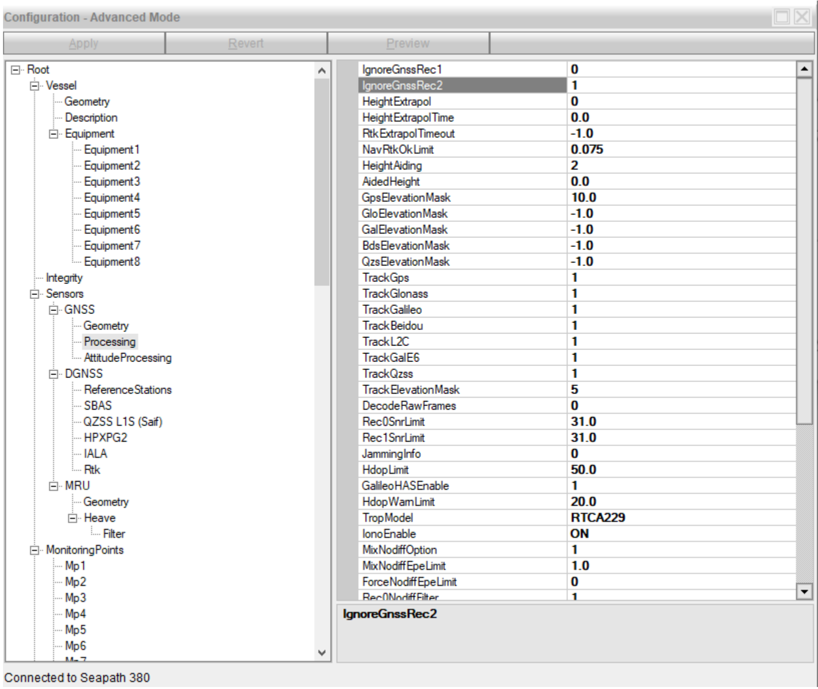


Figure 2 If right column for Signal, Snr, Tracking and status for receiver 2 is empty (as in this figure), receiver 2 is a single frequency receiver.

What to do?

- Turn of use of the single frequency receiver for position calculation (IgnoreGnssRec2 advanced configuration). Data will still be used to calculate GNSS heading.
- If no RTK or HP corrections are present: For better precision turn on HAS. HAS will increase the accuracy significantly but are still experimental and we need more experience to recommend HAS for safety critical applications.
- If no RTK or high precision corrections are present: Turn on the non-differential filter for all dual frequency receivers. Non-differential filter might be combined with HAS.
- Enter the **Advanced Config** and proceed as follows:



- In the folder Sensor/GNSS/Processing, consider the following changes:
  - Set item 2, IgnoreGnssRec2, to 1 and receiver 2 will be ignored (this option is only available in Seapath sw version 2.02.01 or later).
  - Set item 19, TrackGalE6, to 1 and tracking of Galileo E6 will be enabled.
  - Set item 27, GalileoHASEnable, to 1 and Galileo HAS corrections will be enabled (used).
  - Set item 34, Rec1NodiffFilter, to 1 and no differential filter for receiver 1 is enabled.
  - Set item 35, Rec2NodiffFilter, to 1 and no differential filter for receiver 2 is enabled.

Galileo HAS datum considerations for high precision applications.
As per European GNSS (Galileo) HAS service definition document.

"The GTRF is a highly accurate realization of the ITRS. At any time, the alignment between the GTRF and the latest physical realization of the ITRF is such that the difference between the ITRF and the GTRF coordinates of the ITRF stations/markers used in the realization of the GTRF is less than 3 cm (2σ)".

For the Seapath, the Galileo HAS is not corrected for geoidal height. Position and height might differ from the local RTK network. RTK is prioritized when present. If HAS is present and RTK is not present or fails to converge, the position output will be HAS and GTRF.