SAR-GNSS CROSS-CALIBRATION FOR ACCURATE ATMOSPHERIC PHASE SCREEN ESTIMATION.

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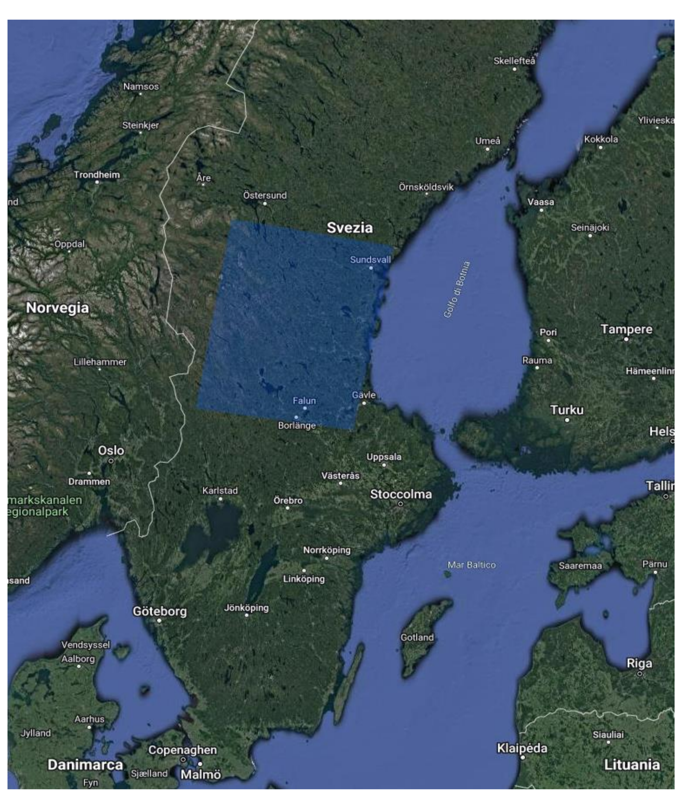
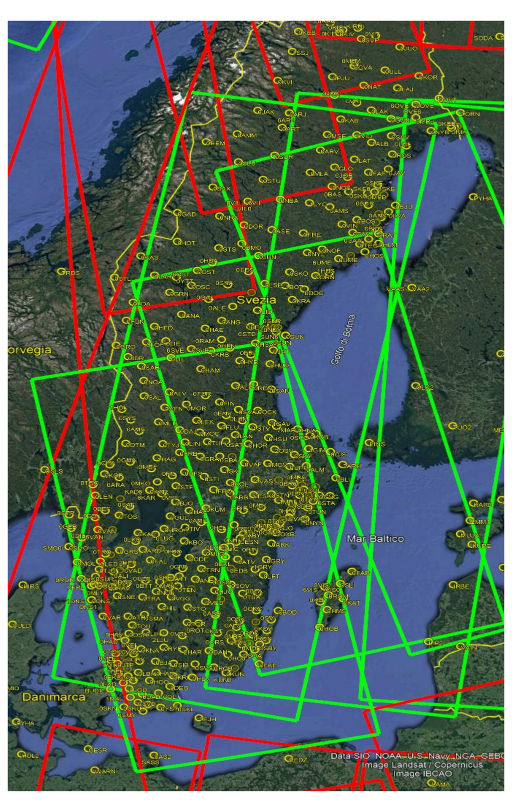
1. Abstract

Synthetic Aperture Radar (SAR) meteorology is gaining much interest in the scientific community. Spaceborne SAR can provide large-scale, dense, and reliable Atmospheric Phase Screen (APS) maps that can be used in the ingestion process into Numerical Weather Prediction Models (NWPM). These maps are handy when other ingestion products, such as radiosonde, weather station data, and ground-based radar data, are unavailable.The main issue, however, is that APS maps must be corrected for residual orbital errors. If the satellite's trajectory is not perfectly known, residual low-frequency trends may appear in the maps, leading to significant errors in the ingestion process. This poster describes a method to estimate and remove orbital errors by jointly exploiting SAR data and Global Navigation Satellite System (GNSS) data. The method is much more reliable than a simple trend removal, and it can work even with a few GNSS stations. In this poster, preliminary results are proposed.

3. Test site

- **33 SLC** images, **IW** mode from May 2021 to November 2021;
- Mixed stack of **S1A** and **S1B** with **6 days** temporal baseline;
- **double frame**: 250 km (range) and 340 km (azimuth)
- Focused and coregistered by Aresys®;
- **101 GNSS stations** available in the scene ;
- GNSS data have been processed by GReD® to obtain atmospheric Zenith Total Delay

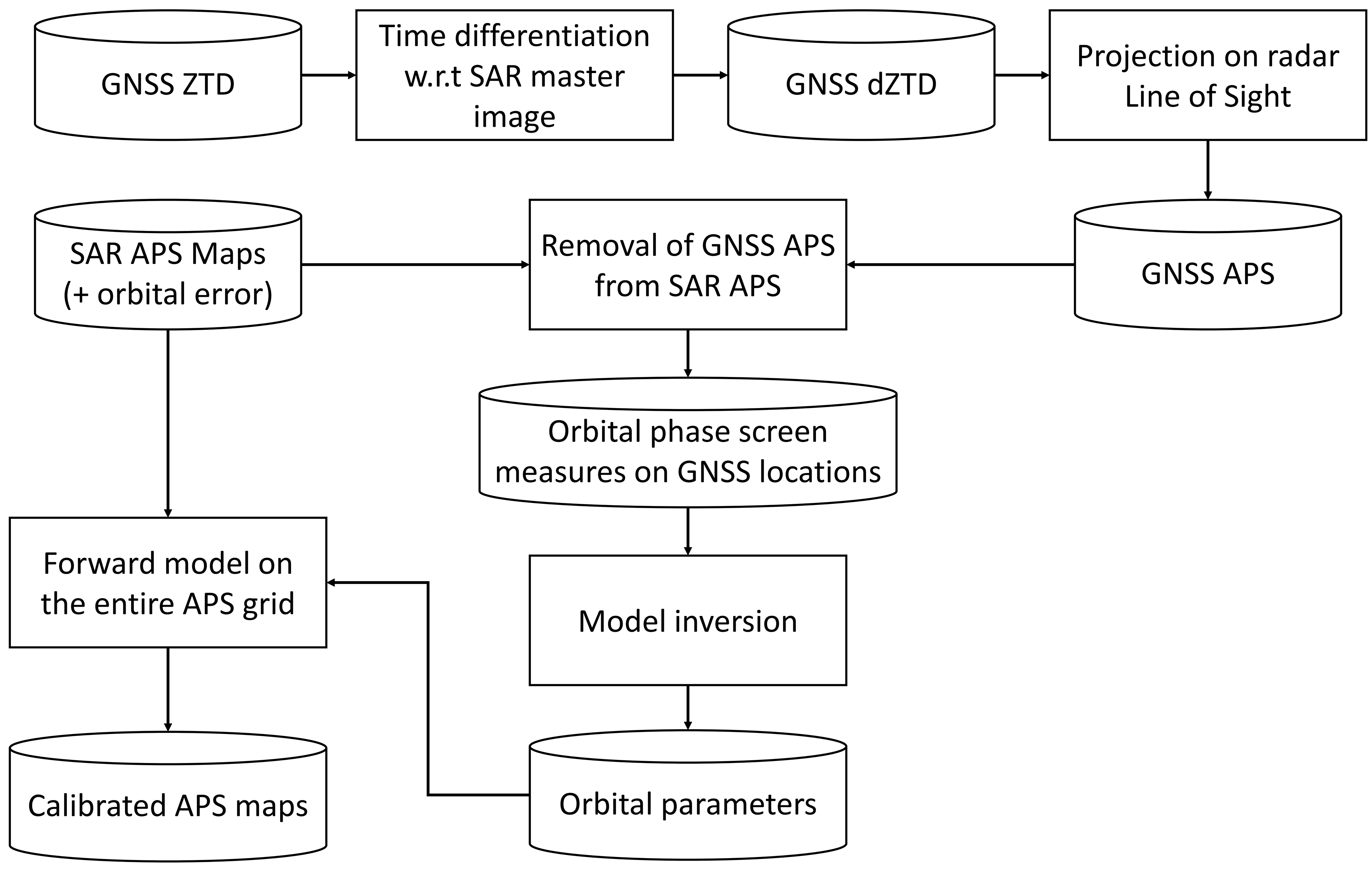




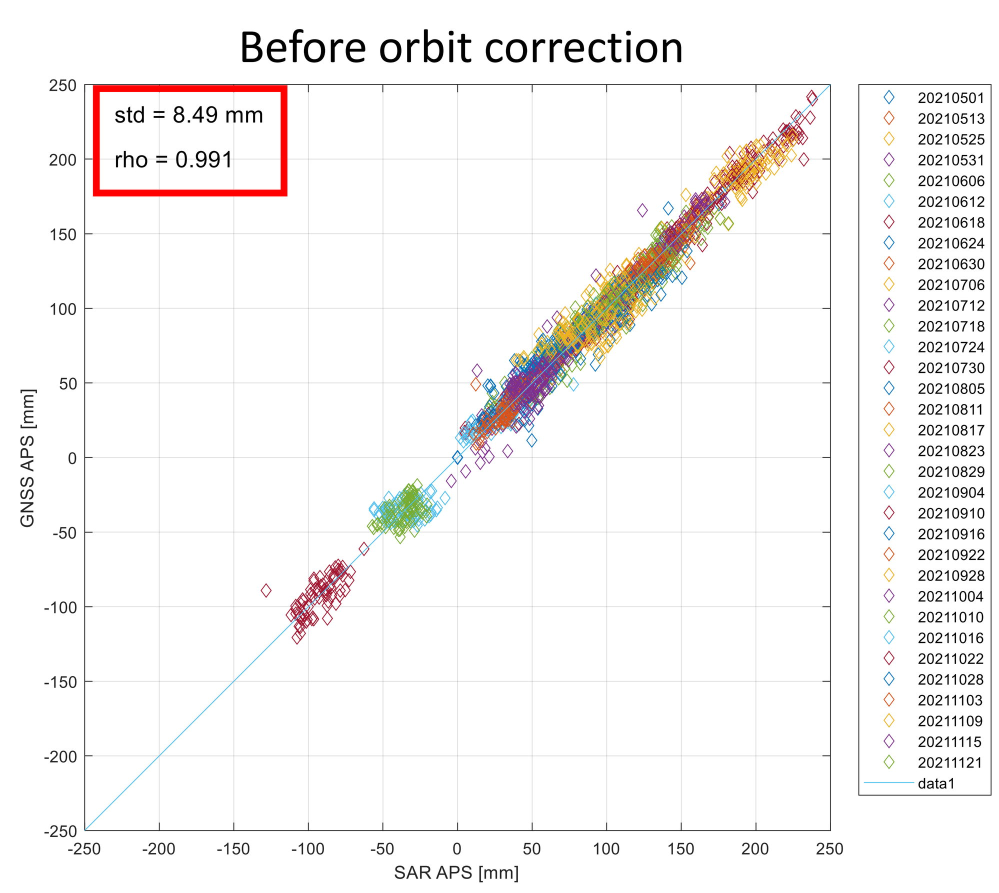
5. Discussion

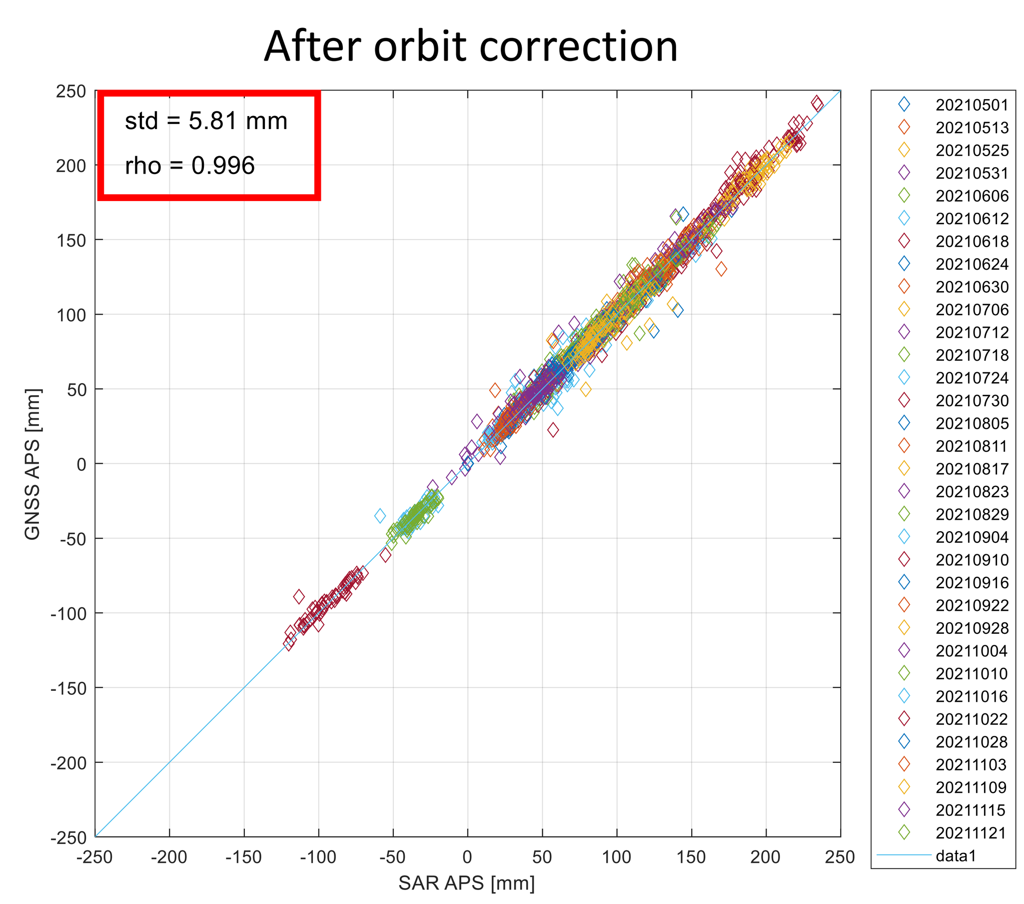
In this work, we used the GNSS data as the ground truth both for the **estimation** and validation. It is essential to highlight that this method differs from fitting a plane or a polynomial function into the APS. This latter solution is unsuitable for atmospheric monitoring since the atmosphere itself may contain low-frequency trends; thus any filtering may remove useful signal.
The process involves estimating two parameters; thus **a few GNSS stations may be used**. More measurements mean a high-quality estimate in practice, as in all estimation problems. In this work, we used **31 GNSS stations** (measurements) for the estimation part, reaching accuracies in estimating the normal baseline in the order of a few millimeters.
The effect of orbital correction is evident in the reduction of the standard deviation between SAR APS and an independent set of GNSS-derived APS.

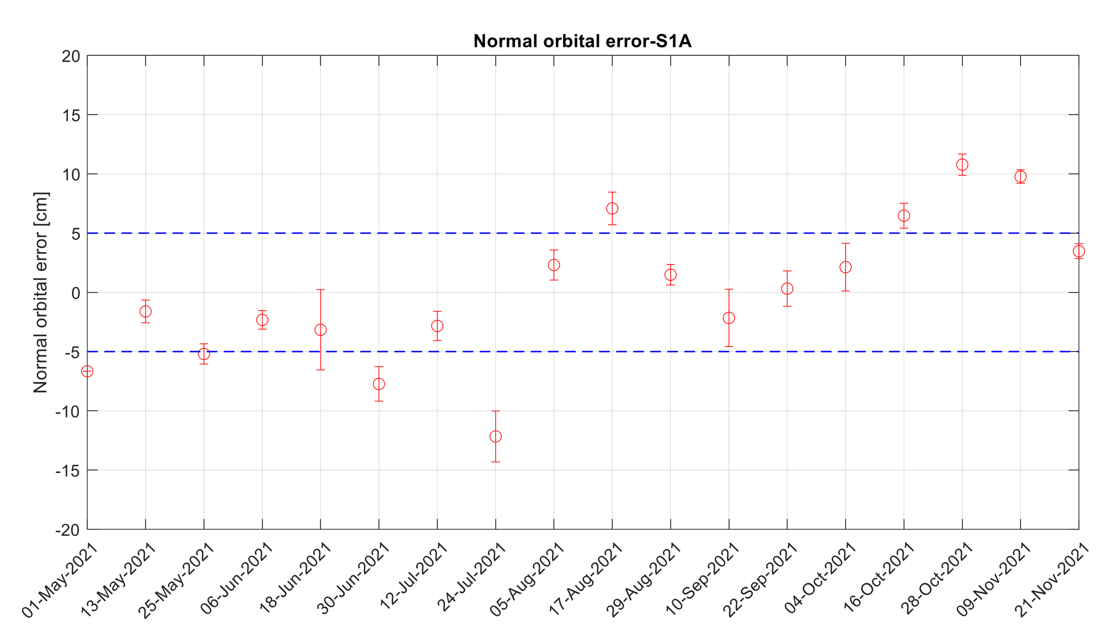
2. Method overview



4. Results







31 GNSS stations has been used for the parameter's estimation, while 70 used for validation. The standard deviation between the SAR APS and the GNSS APS is improved by almost 50%, while the correlation coefficient reaches almost the unity. The estimated errors are almost always within the bounds provided by precise orbital state vectors.

4. Conclusions

- SAR APS maps are affected by low spatial frequency trends due to small orbital inaccuracies. These trends are normally neglected for deformation monitoring, but they can't be discarded for large-scale atmospheric mapping.
- This poster proposed a way to estimate and compensate for orbital errors using a set of GNSS stations on ground.
- The method is validated using 33 SAR image acquired over Sweden by the Sentinel-1 satellite. 31 stations are used for the estimation of orbital parameters, while 70 are used for validation. The error between SAR APS and GNSS APS decreases (in standard deviation), by almost 50%, while the correlation coefficient reaches almost the unity.
- Assimilations experiments into NWPM are ongoing