

# Assessing ground deformation in the Central Andes (NW Argentina) with InSAR analyses: First results of Sentinel-1 data

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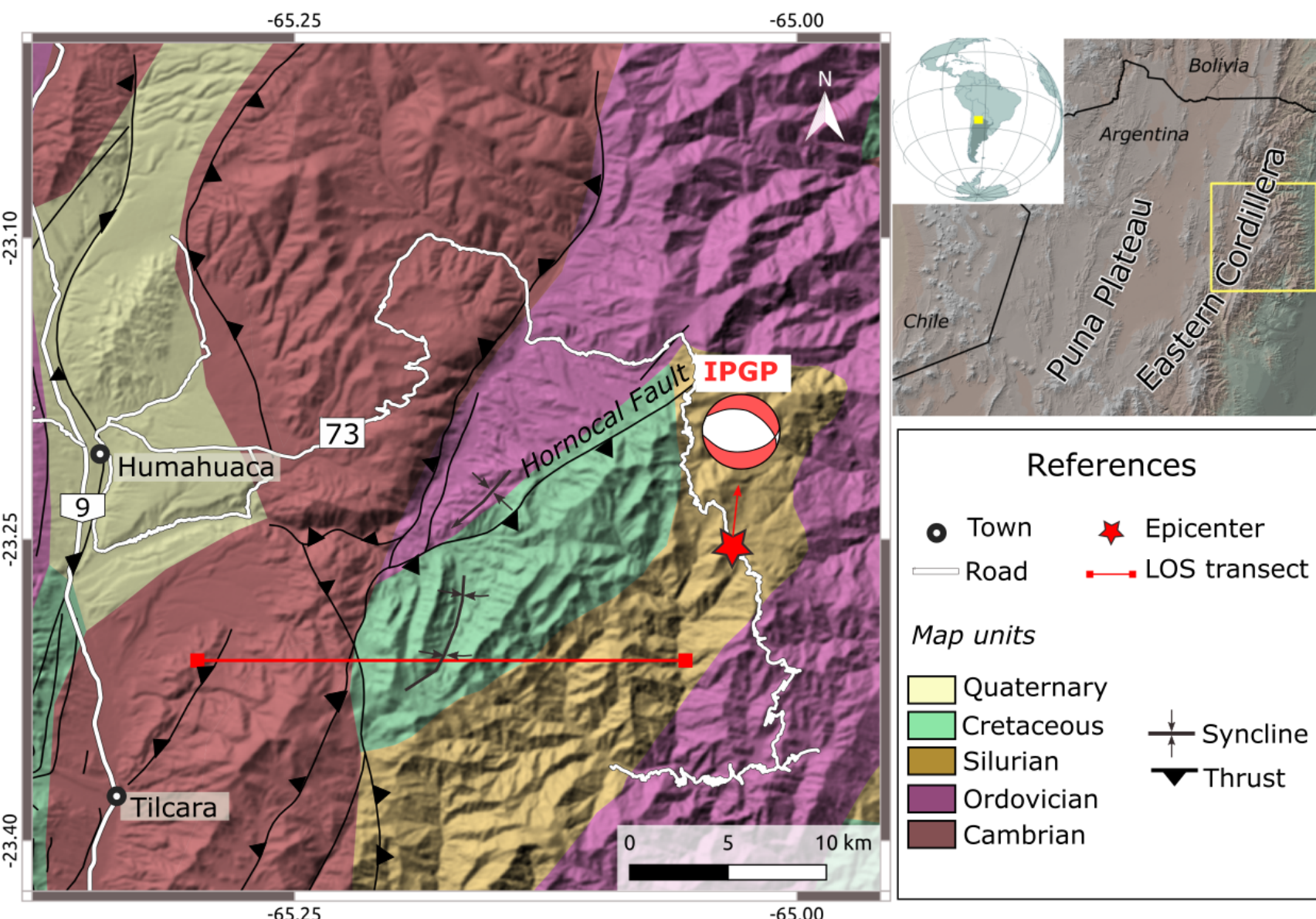


Figure 1:Geologic map of the interest area of , showing the epicenter and the focal mechanism solution by the Institute of Earth Physics of Paris (IPGP).

## Introduction

The region of the Argentine Central Andes located between 21°S and 25°S is characterized by multiple morphotectonic provinces that strongly control structural and geomorphologic surface deformation. This work focuses on the Eastern Cordillera, a fold-and-thrust belt with peaks that reach up to 6000 m a.s.l., which lies at the Puna's eastern edge. Both areas are repeatedly affected by earthquakes with surface deformation but seldom surface ruptures.

Here we present the preliminary results on surface deformation analysis associated with the 5.7 magnitude earthquake that took place on 29 November (2020), with epicenter close to Humahuaca village (23.2591°S– 65.0281°W, source: USGS; Fig 1). It is worth mentioning that although the tremor was related with the Hornocal fault [1], described as a reverse fault, the focal mechanism solutions suggest displacement associated to a normal fault (see Fig. 1).

Our analysis is based on time series created from two stacks of interferograms in descending and ascending orbits from the C-band Sentinel-1 satellite. Determinations of displacement in the satellite's line of sight (LOS) show that the area of maximum surface deformation is constrained to 23.29°S–65.25°W and 23.34°S–65.10°W. We observe an subsidence of around 8 cm in LOS after the earthquake.

## Materials and Methods

We use 64 and 32 acquisitions from the C-band Sentinel-1 satellite in ascending (Track 76) and descending (Track 10) passes, respectively (January 2020 to January 2021). We pair each acquisition with the following 4 in time and apply the D-InSAR<sup>2</sup> technique to create stacks of interferograms through the ISCE<sup>3</sup> environment [2]. The interferograms are multilooked with factors of 7 (range) and 2 (azimuth), filtered with the Goldstein filter (strength 0.5) and phase-unwrapped with Snaphu [3].

We invert the stacks into time series and correct them for tropospheric delays and topographic residuals, using the MintPy<sup>4</sup> software package [4]. In order to correct tropospheric delays, we use the numerical weather model ERA5 provided by the ECMF<sup>3</sup> [5] (LOS ERA5-corrected). To remove topographic residuals, we rely on SRTM Digital Elevation Model with a spatial resolution of 30 m and void filled (LOS ERA5+demErr-corrected).

## Results

At least two and a half interferometric-phase cycles are distinguished on interferograms from ascending and descending passes with secondary images from December 2020. The LOS displacements range from 8 to 10 cm (Figs 3) and are negative for both passes, suggesting that the area subsided.

The W-E transects of cumulative LOS displacements, with central latitude at 23.31°S (i.e. the latitude of maximum displacement for both passes), show that the subsided area is constrained between 65.25°and 65.10°W (Fig. 3). Therefore, the deformation pattern is located around 15 km west from the epicenter presented by international seismic-monitoring agencies (e.g., USGS) over a syncline - the Hornocal syncline.

<sup>1</sup> Differential Interferometric Synthetic Aperture Radar

<sup>2</sup> InSAR Scientific Computing Environment

<sup>3</sup> Miami InSAR time series software in Python

<sup>4</sup> European Centre for Medium-Range Weather Forecasts

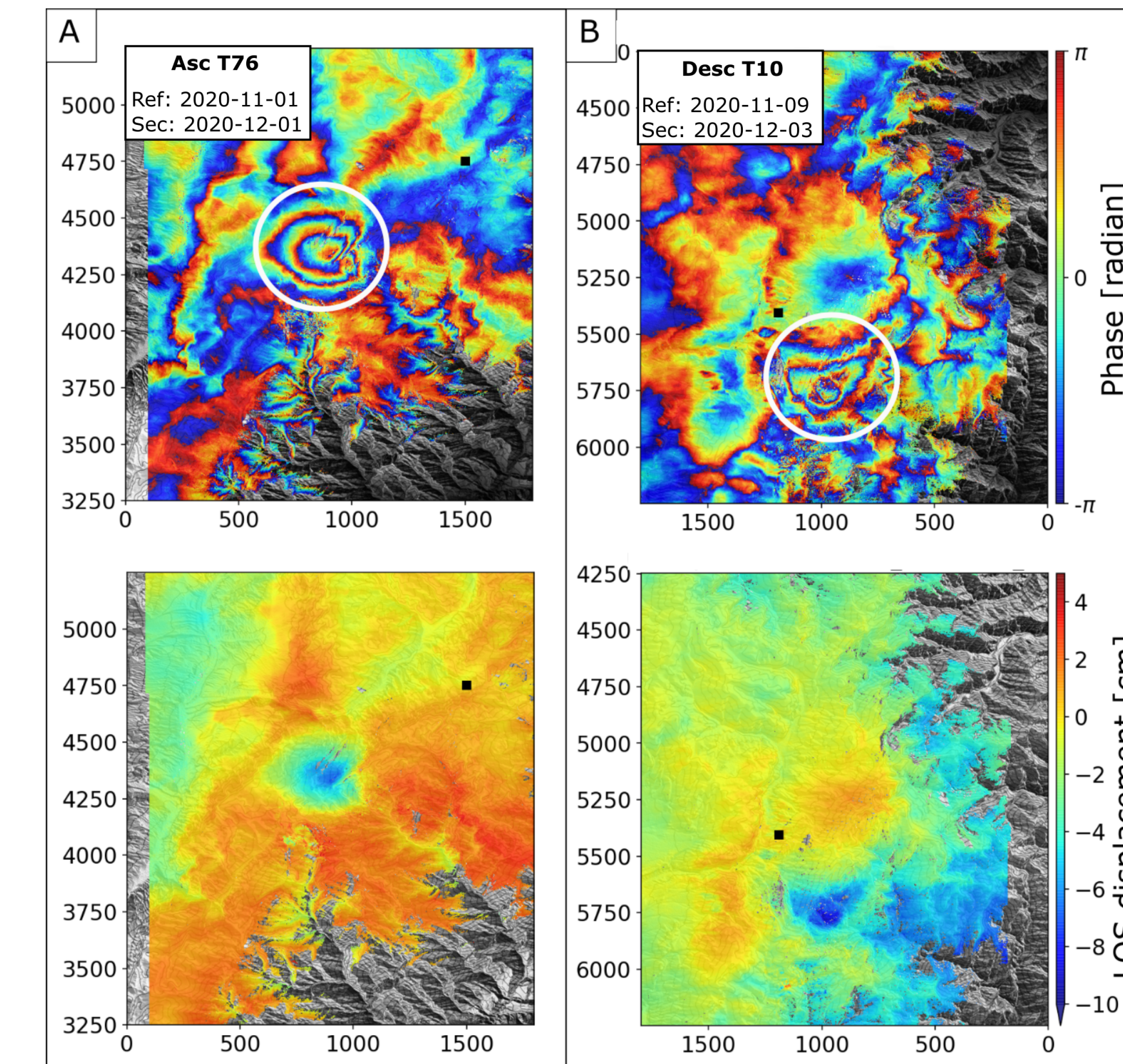


Figure 2:Wrapped interferograms and their corresponding LOS displacement in radar coordinates, for the ascending (A) and descending tracks (B). The location of the reference points for phase-unwrapping are shown as black dots.

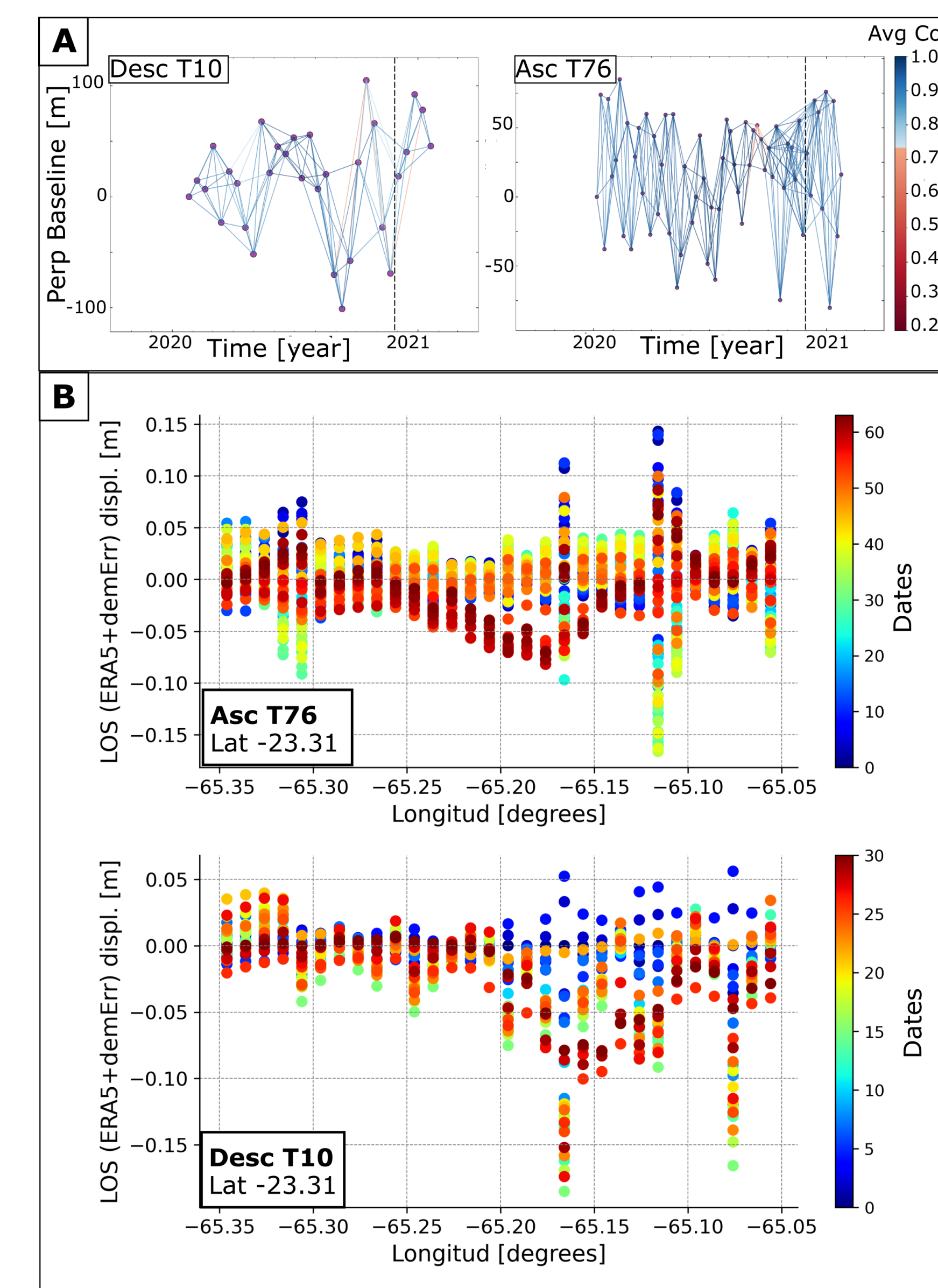


Figure 3:A: Networks of interferograms for ascending and descending tracks used to create the time series. B: W-E transects of cumulative displacement in LOS corrected by tropospheric delay and topographic residuals. The plot displays temporal evolution of LOS displacements from the first (blue) to the last (red) dates in each network. It is important to note that dots located between 65.25°and 65.10°W suffered the larger displacements

## Final remarks

These results are part of a work in progress. Our next steps are:

- Extension of the Sentinel-1 time series in order to study interseismic deformations before the main event.
- Analysis of different climatic models to perform tropospheric delay corrections.
- Generation of interferograms with SAOCOM 1-A data and subsequent comparison.

## References

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