IONOSPHERIC D-REGION INFLUENCE ON SAR SIGNAL PROPAGATION

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Many studies have suggested that the signals used for satellite observations can be interrupted by the influence of a certain part of the ionosphere. In the course of our research we observed the perturbed D-region and its influence on the Synthetic Aperture Radar (SAR) signal delay that occurred as a consequence of the perturbation induced by a solar X-ray flare. To model the D-region plasma disturbance we analyse a very low frequency signal emitted by the DHO transmitter located in Germany and recorded in Serbia using Wait's model of the ionosphere. The results of the conducted research can help in further improvement and precision in modeling and measuring regarding SAR instruments.

Observations

- X-ray solar flare which happened on 1 May, 2013
- 23.4 VLF signal emitted by the DHO transmitter located in Rhauderfehn, Germany, and received at the Institute of Physics in Belgrade, Serbia

Satellite signal frequencies:

f_1 = 1.257 GHz: NISAR (L-band, 1-2 GHz)
f_2 = 5.405 GHz: Sentinel-1 (C-band, 4-8 GHz)
f_3= 9.6 GHz: COSMO-SkyMed (X-band, 8-12 GHz)

Modelling

The phase delay P_D produced by the D-region (divided in N_D horizontal layers of thickness δH_D) is calculated by [1]:

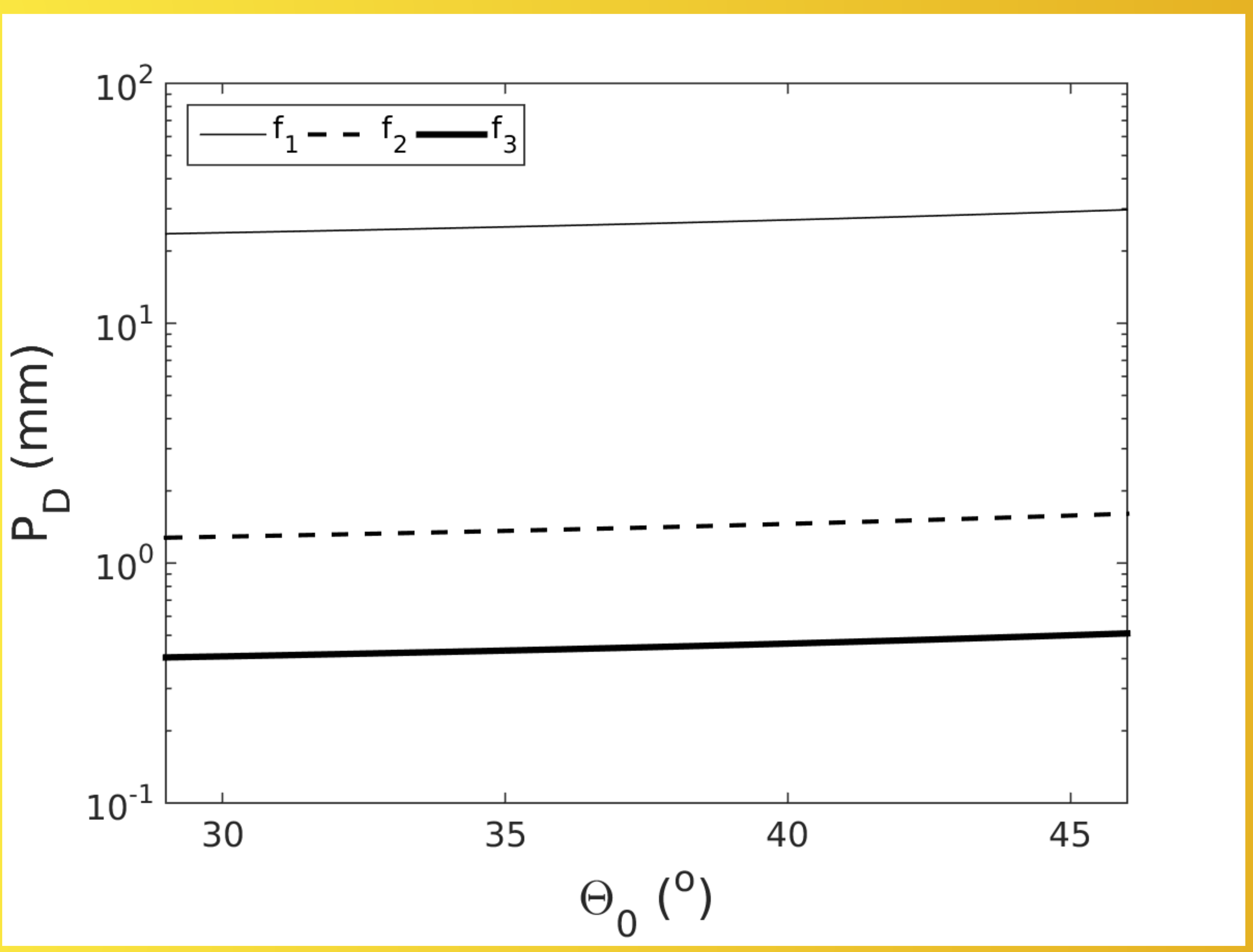
$$P_D = \frac{C\,\delta H_D}{f^2} \sum_{i=1}^{N_D} \frac{N_{ei}\, n_i}{\sqrt{n_i^2 - \left(n_0 \sin\left(\Theta_0\right)\right)^2}}$$

where C=40.3 and n_i is the refractive index in the layer *i*. Θ_0 is the incident angle of the SAR signal in the D-region and f stands for the signal frequency. The electron density N_{ei} in the layer I is calculated by equation [2]:

$$N_e(h,t) = 1.43 \times 10^{13}\, e^{-\beta(t) H'(t)}\, e^{(\beta(t) - 0.15)h}$$

[1] Nina et al.: 2020, IEEE *Geosci. Remote Sens. Lett*. **17**(7), 1198-1202
[2] Tomson, N.,R.: 1993, *J. Atmos. Terr. Phys.*, **55**, pp. 173–184

Results and conclusions



The signal delay increases with incident angle for each of the three frequencies. Apparently the signal delay is the smallest for the highest frequency which is in our case f_3 and the highest for the lowest frequency which is f_1 frequency. It is worth noting that the value of P_D decreases as the value frequency is doubled, (see Eq. (3)) which implies that with increasing the frequency value one can get smaller ionospheric D-region influence on the signal.

The highest signal delay is obtained for the lowest, f_1, frequency and it reaches 30 mm which is not negligible for modeling and applications of SAR signals. Bearing in mind the above-mentioned one can conclude that the signal delay induced by the X-ray solar flare needs to be taken into account.