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A Report on the Increase of PALSAR-2 Geometric Errors due to Ionospheric Effects

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1. Introduction

The ionosphere is ionized parts of atmosphere at altitudes between 50 and 1000 km above the ground that delays the propagation of microwaves used in ALOS-2 PALSAR-2. This delay leads to geometric errors of PALSAR-2 images, the amount of which depends on the total electron content (TEC) of the ionosphere. Since 2021, solar activity has been on an increasing trend, and TEC has been increasing rapidly. We confirmed that the geometric error is also changed in our accuracy assessment of the PALSAR-2 products. This report describes the details of the phenomena and some points to be noted in the use of the data.

2. Product assessment results

Figure 1 shows the evaluation result of geometric errors in PALSAR-2 images from the start of operations in 2014 to the end of May 2022. Each value is based on PALSAR-2 images over the corner reflector sites in Japan and is calculated by comparing the corner reflector positions in the images with the ground survey results. The geometric error in slant range direction varied from 2014 to 2016 and then became small and stable for the next few years. Then, after 2021, the error tended to increase again, and showed about 5 m increase in 2022 compared to the average between 2016 and 2021. The errors in azimuth direction did not show large variations compared to slant range direction.

Figure 2 shows the results of estimating the ionospheric delay in the slant range direction in PALSAR-2 images using atmospheric TEC maps generated from GNSS (Global Navigation Satellite System) observations from various locations on the ground. There is the same trend as in Figure 1, indicating that the variation in PALSAR-2 geometric errors is mainly caused by ionospheric variations. Figure 3 shows the predicted solar activity published by NOAA (National Oceanic and Atmospheric Administration) and the observed solar radio flux (F10.7). According to this prediction, solar activity is expected to continue to increase. TEC is also expected to increase accordingly, and the geometric error of PALSAR-2 is expected to be equivalent to that of the early years of operation (2014-2016).

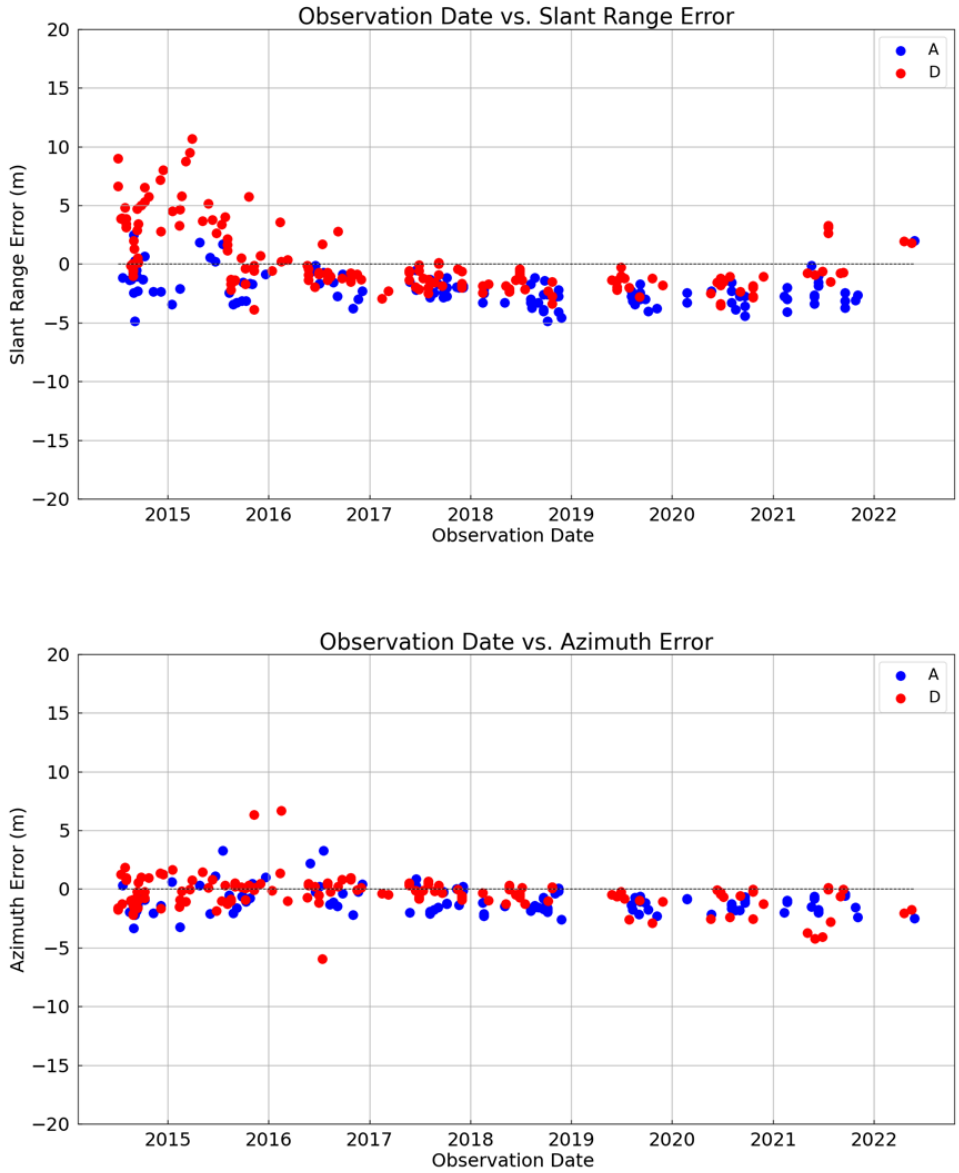

Figure 1　Evaluation results of geometric errors in PALSAR-2 images (top: slant range direction, bottom: azimuth direction) at the corner reflector sites in Japan. Blue dots show ascending orbit (night observation), red dots show descending orbit (daytime observation).

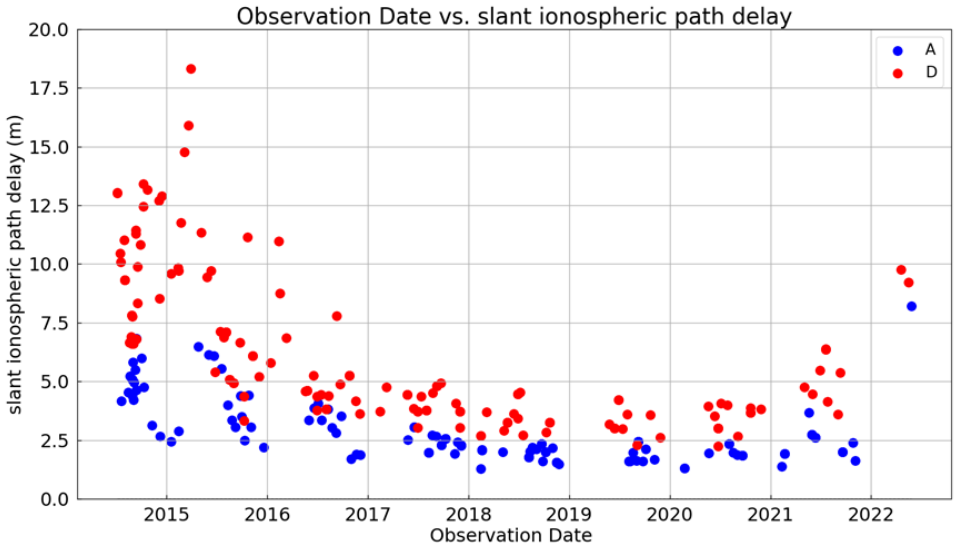

Figure 2　Estimation results of ionospheric delays in PALSAR-2 slant range direction at the corner reflector sites in Japan shown in Figure 1. Each value is calculated with the global TEC data published by the Center for Orbit Determination in Europe (CODE), the University of Bern.

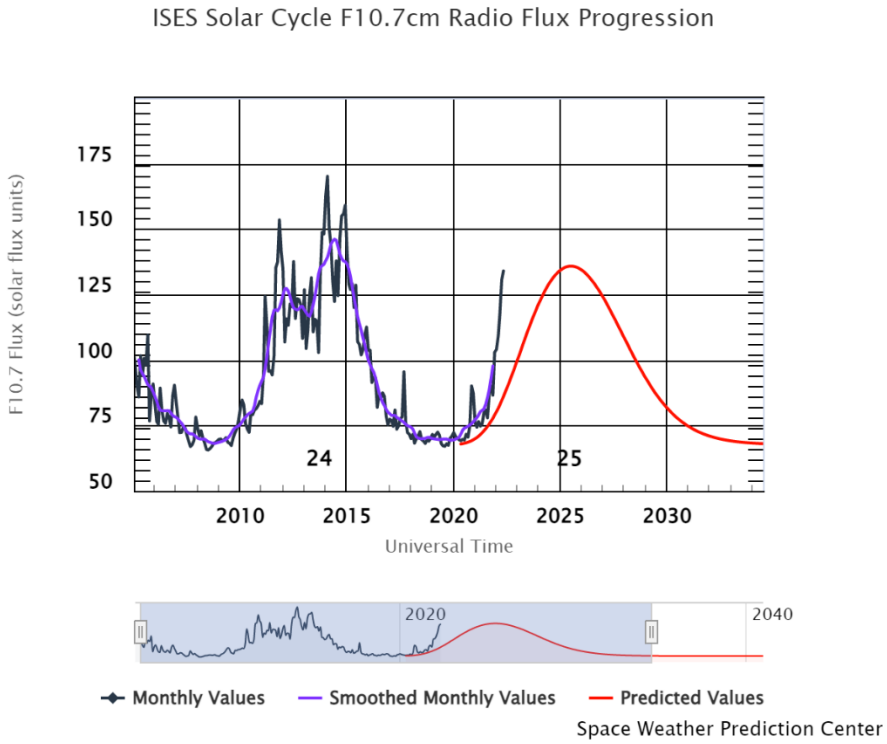

Figure 3　Predicted solar activity and observed solar radio flux (F10.7) published by NOAA Space Weather Prediction Center (https://www.swpc.noaa.gov/)

3. Notes on the use of PALSAR-2 data

In high-resolution observations such as the Stripmap [3 m] mode, the geometric error due to ionospheric delay can be larger than the pixel size, which can introduce errors in the analysis for comparison with previous images. If it happens, the errors can be mitigated by performing image-to-image co-registration. Examples are shown in Figure 4 and 5.

JAXA has been investigating how to correct for the errors, but at this time, we have not yet implemented such methods in the standard product processing. JAXA will continue to study error reduction methods and their implementation. The results of the product accuracy evaluation are published annually on JAXA's website as described in Section 4 below.

4. References

- Previous results of PALSAR-2 product accuracy assessment (published once a year):
  [Japanese] https://www.eorc.jaxa.jp/ALOS/jp/alos-2/a2_calval_j.htm
  [English] https://www.eorc.jaxa.jp/ALOS/en/alos-2/a2_calval_e.htm

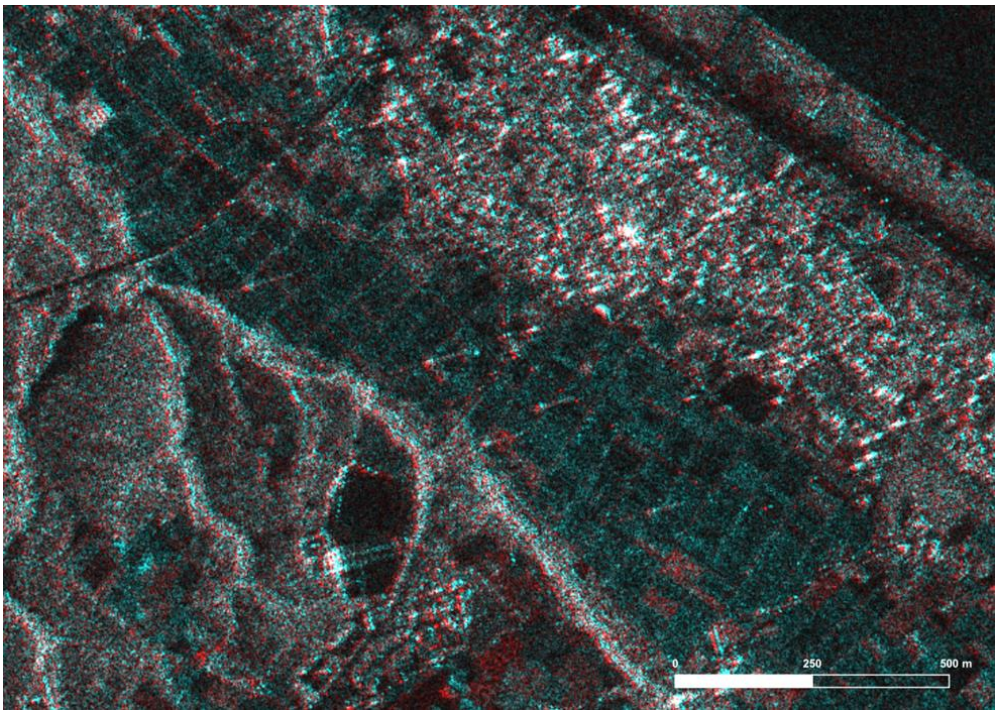

Figure 4　Color composite image of PALSAR-2 L1.5 product images (blue: Oct. 19, 2018, red: May 27, 2022, Stripmap [3 m] mode, ascending orbit, left observation, at Chiba, Japan). Geometric errors of a few meters are observed, which seems to be due to ionospheric delay.

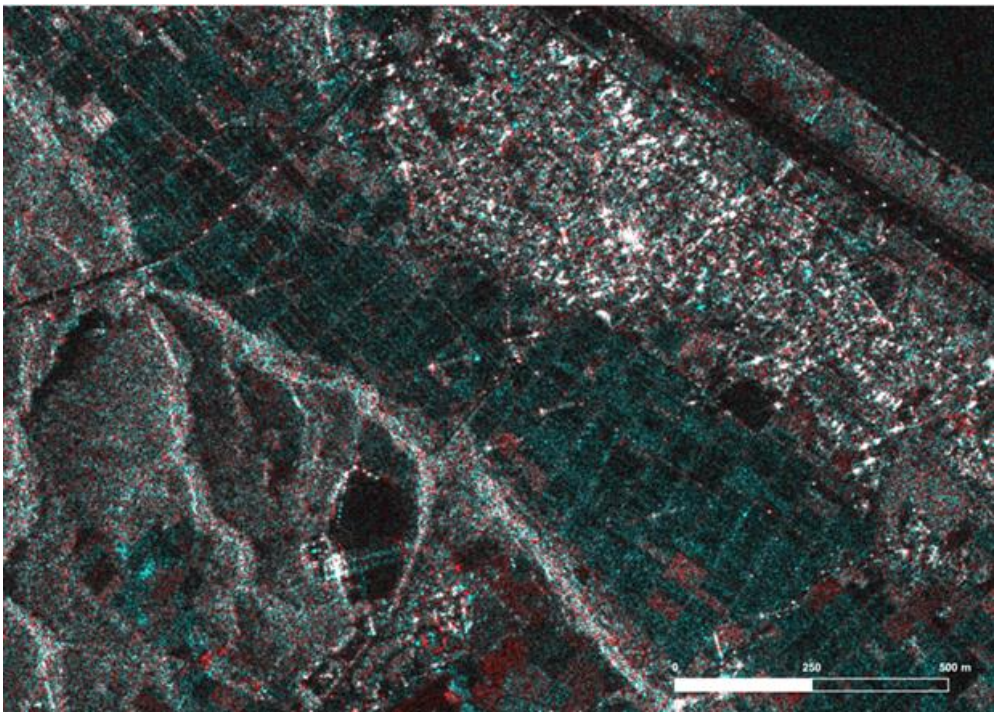

Figure 5　Color composite image with co-registration (parallel shift) applied to the scene in Figure 4.