# Displacement in Kushiro-shitsugen (wetland) induced by heavy rainfall in 2016 detected by ALOS-2 SAR

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## Introduction

The Geospatial Information Authority of Japan (GSI) has been monitoring ground surface deformation of earthquakes, volcanic activities, land subsidences and landslides throughout Japan by interferometric SAR (InSAR) analysis using ALOS-2 data. In the interferograms, we have found many displacements caused by variety of reasons except for the above four main targets. It is worthy to clarify the reasons for detecting the deformations of the main targets.

A wetland is a land area that is saturated with water such that it takes on the characteristics of a distinct ecosystem and it is important to monitor the water system in a wetland for the preservation of the ecosystem. Radar signals usually bounce once on an open water surface and scattered away, however they bounce twice (the water surface and vegetation of the wetland) and return to the satellite (Wdowinski and Hong, 2015) and we get good coherence in the wetland to monitor the displacement.

## Kushiro-shitsugen and heavy rains in 2016 summer

Kushiro-shitsugen in eastern Hokkaido is the largest wetland in Japan and registered in the List of Wetlands of International Importance (the "Ramsar List"). Typhoon No.7, 11 and 9 hit Hokkaido on August 17, 21 and 23 respectively, 2016, moreover typhoon No.10 caused heavy rain on August 30. Then, Hokkaido had record breaking heavy rain and water level at Iwabokki along Kushiro river (see attached figure) increased more than 1m quickly in the late August and continued in September.

## SAR observations

We constructed five interferograms of ALOS-2 SAR and found the following displacement in the wetland:

Before August 6, at most 10 cm line-of-sight (LOS) shortening along some rivers in the wetland.

From August 6 to September 12, at most 60 cm LOS shortening along some rivers and a large (more than 1 m) LOS shortening by descending orbit observations (from ESE) and extension by an ascending orbit observation (from WSW) in Tsurui village and size of the large displacement area is approximately 900 m by 650 m.

From September 12 to October 29, at most 60 cm LOS extensions along some rivers.

We applied a Pixel Offset method that can measure large displacement and found that there is several tens of centimeter LOS shortening along some rivers from July 4 to September 12, however the displacement in the azimuth direction (SSW) is very small. It means that the displacement along the rivers is almost up-down direction. In the large displacement area in Tsurui village found in the interferograms, the largest LOS shortening is 1.3 m and the largest SSW displacement is 1.5 m by the descending orbit observations.

## Discussions

From above observations, our interpretations are as follows:

(1) According to the water level increase in the rivers, the surface of the wetland rises along the rivers. When the water level decreases, the height of the wetland returns to the former level.

(2) The large displacement in Tsurui village appeared from August 6 to September 12 and it coincides with the quick and large increase of the water lever caused by the heavy rains. The large displacement

 

remained after the decrease of the water level. From combination of several observations, the large displacement is mainly composed of horizontal displacement and the largest horizontal displacement is approximately 2.5 m toward SW direction (downstream direction). From a preliminary model simulation, a lateral flow at a depth of several tens of meters likely occurred and the area moved like a floating island.

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