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A step-by-step recipe of band-splitting technique for isolation of ionospheric signal in L-band InSAR data

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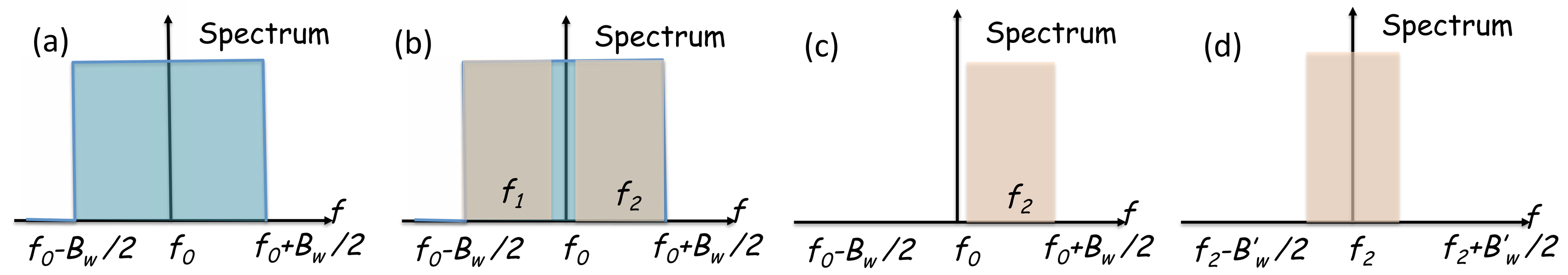
Introduction

Ionospheric signals are widely regarded as nuisance in low-frequency InSAR data, and thus a variety of correction techniques have been proposed. Although band-splitting of range spectrum has been shown to be effective (Brcic et al., 2010; Rosen et al., 2010; Gomba et al., 2015), the band-splitting technique seems to have not been widely used. Whereas this would be partly because the impacts of ionosphere on InSAR data are not necessarily serious, we consider that this could be also because the details of the technique have not been reproducibly shown.

Here we show our step-by-step recipe of the band-splitting technique, and demonstrate two case studies that reveal the effectiveness of the technique.

Theory and Processing Steps



(a) Original range spectrum with bandwidth, B_w, around the carrier frequency f_0, but it is baseband-ed. (b) We split the original B_w into two new narrower bands with newer center frequencies, f_1 and f_2. Besides the band pass filtering in (c), we need to further demodulate so it is baseband-ed (d).

(0). Original point target response with the delay τ (=2R/c)

$$s(t) = \frac{T}{\pi} e^{-j2\pi f_0 \tau} \cdot \mathrm{sinc}[\pi B_w (t-\tau)]$$

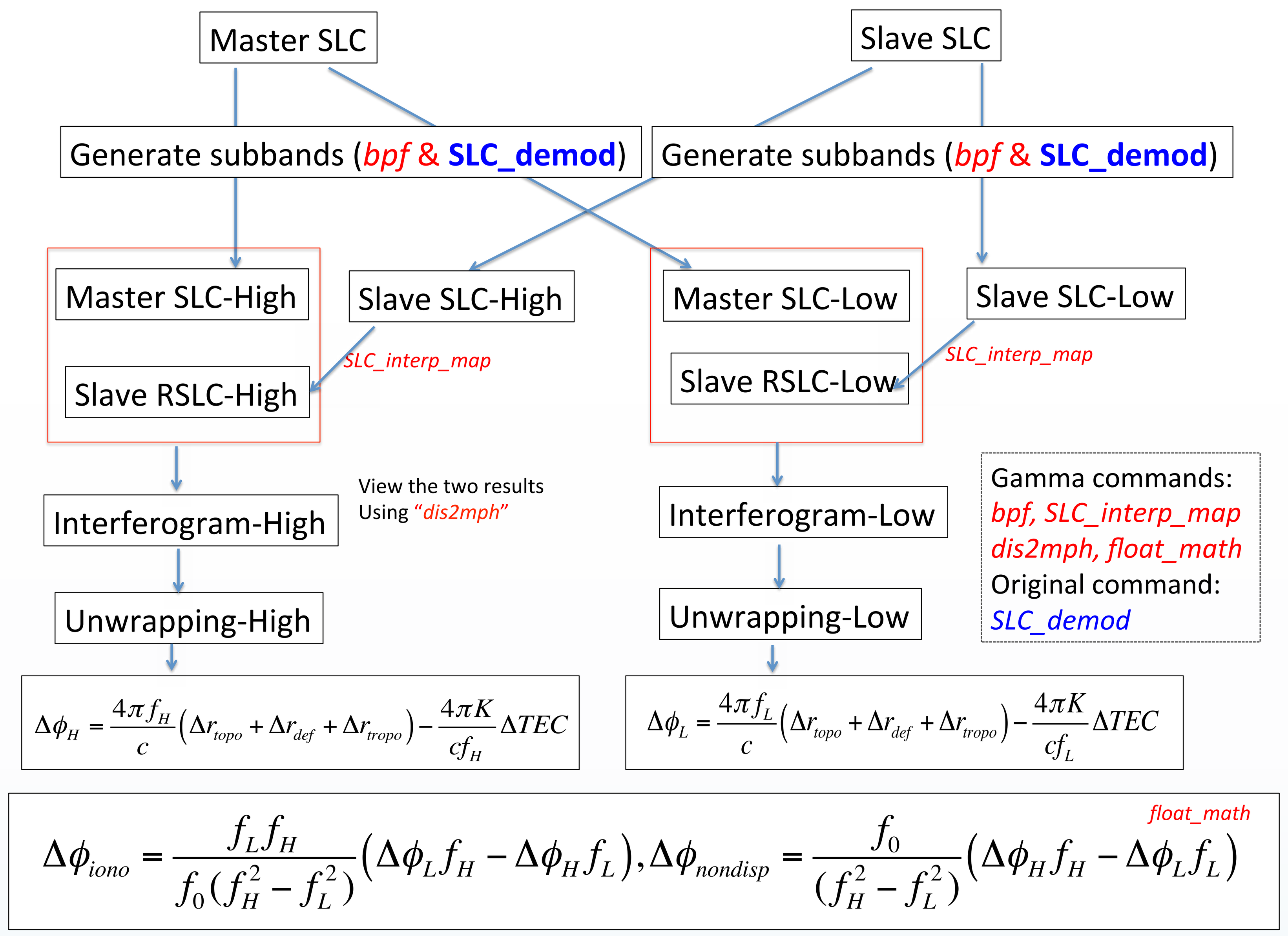
(1). Band-passed point target response includes modulated phases.

$$s_i(t) = \frac{T_i}{\pi} e^{-j2\pi f_i \tau} \cdot e^{j2\pi (f_i - f_0)\tau} \cdot \mathrm{sinc}[\pi B_w^i (t-\tau)]$$

(2). Baseband-ed point target response with the new frequency f_i and B_w^i.

$$s_i^{bb}(t) = \frac{T_i}{\pi} e^{-j2\pi f_i \tau} \cdot \mathrm{sinc}[\pi B_w^i (t-\tau)]$$

(3). We multiply the demodulation phase from the nearest to the farthest range.



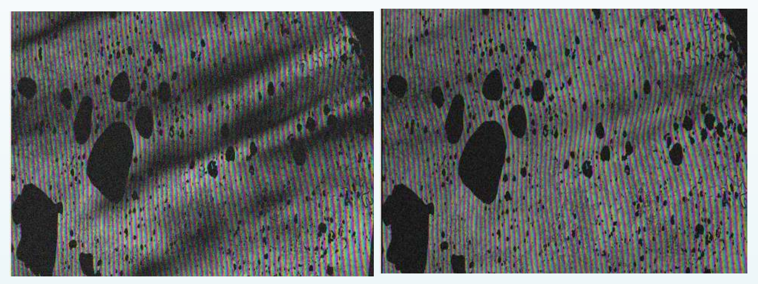
$$\Delta\phi_H = \frac{4\pi f_H}{c}(\Delta r_{topo} + \Delta r_{def} + \Delta r_{tropo}) - \frac{4\pi K}{cf_H}\Delta TEC$$

$$\Delta\phi_L = \frac{4\pi f_L}{c}(\Delta r_{topo} + \Delta r_{def} + \Delta r_{tropo}) - \frac{4\pi K}{cf_L}\Delta TEC$$

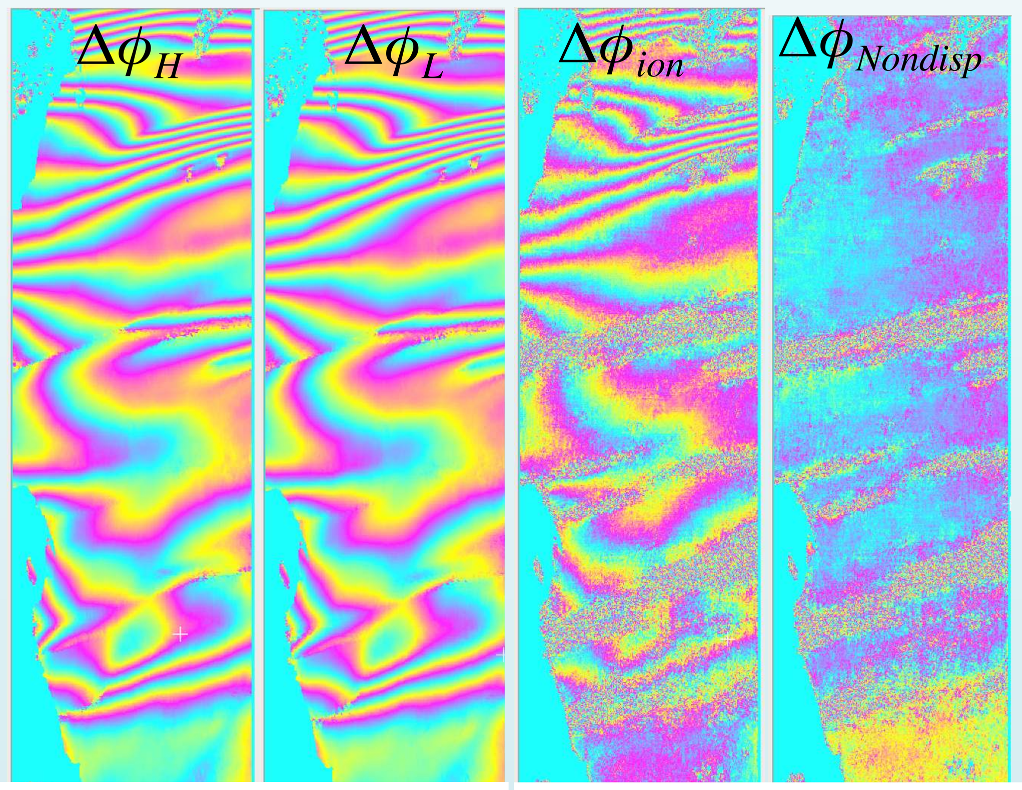
$$\Delta\phi_{iono} = \frac{f_L f_H}{f_0(f_H^2 - f_L^2)}(\Delta\phi_L f_H - \Delta\phi_H f_L), \Delta\phi_{nondisp} = \frac{f_0}{(f_H^2 - f_L^2)}(\Delta\phi_H f_H - \Delta\phi_L f_L)$$

Strong Ionospheric Signal in Polar Region

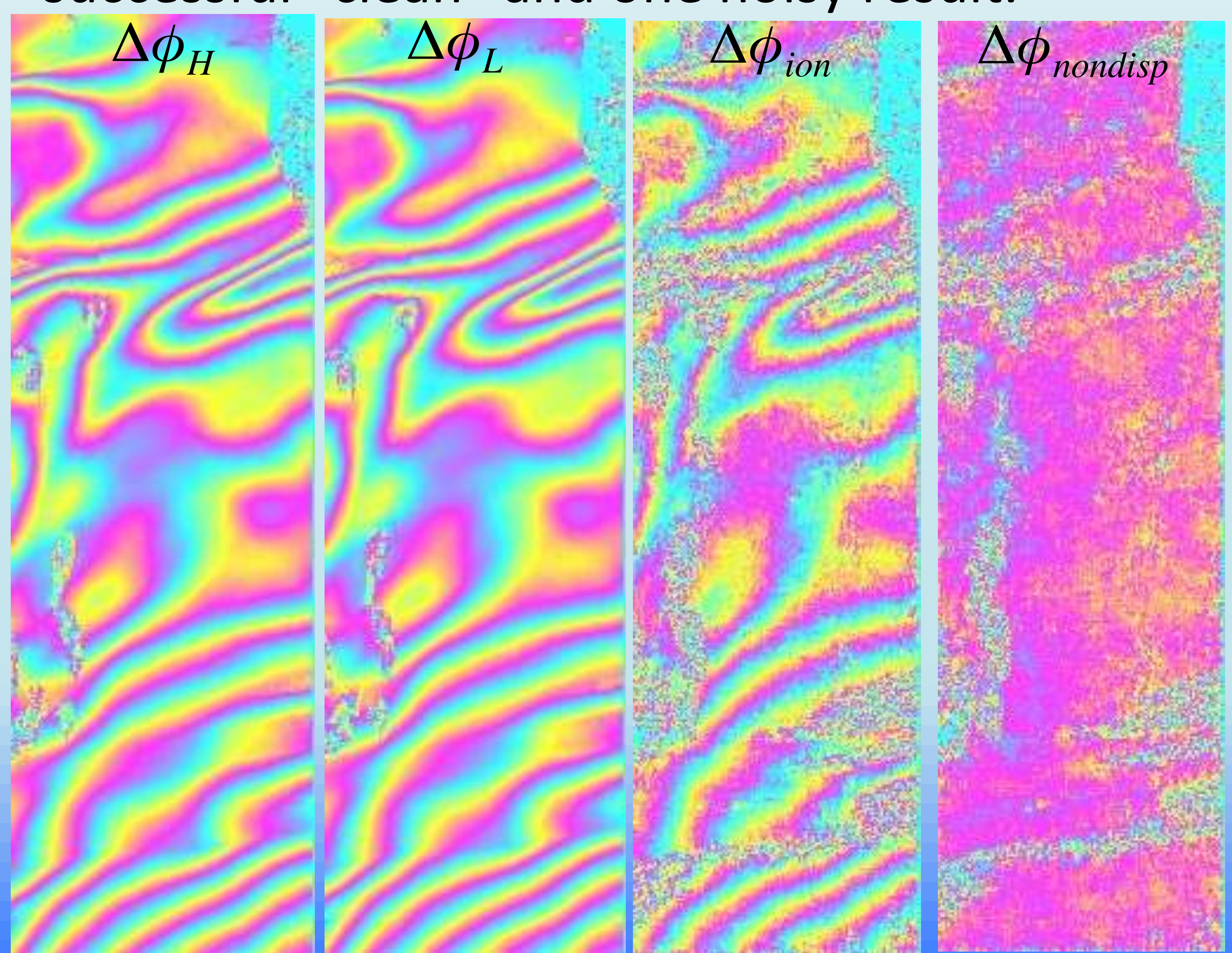
Yamal Peninsula, NW Siberia, includes numerous thermokarst lakes and characteristic landforms related to permafrost processes. In 2014, several holes with its diameter of ~40 m were identified. Examining any related surface displacements, however, we encountered many anomalous phases that were unlikely due to the deformation but presumably due to the ionosphere. This will be the case at nearly all the L-band InSAR studies at polar region, and the SB-InSAR is indispensable. We show two successful "clean" and one noisy result.



Initial interferograms with (left) and without (right) consideration of image offsets in the co-registration. Strong ionosphere can cause errors in registrations.

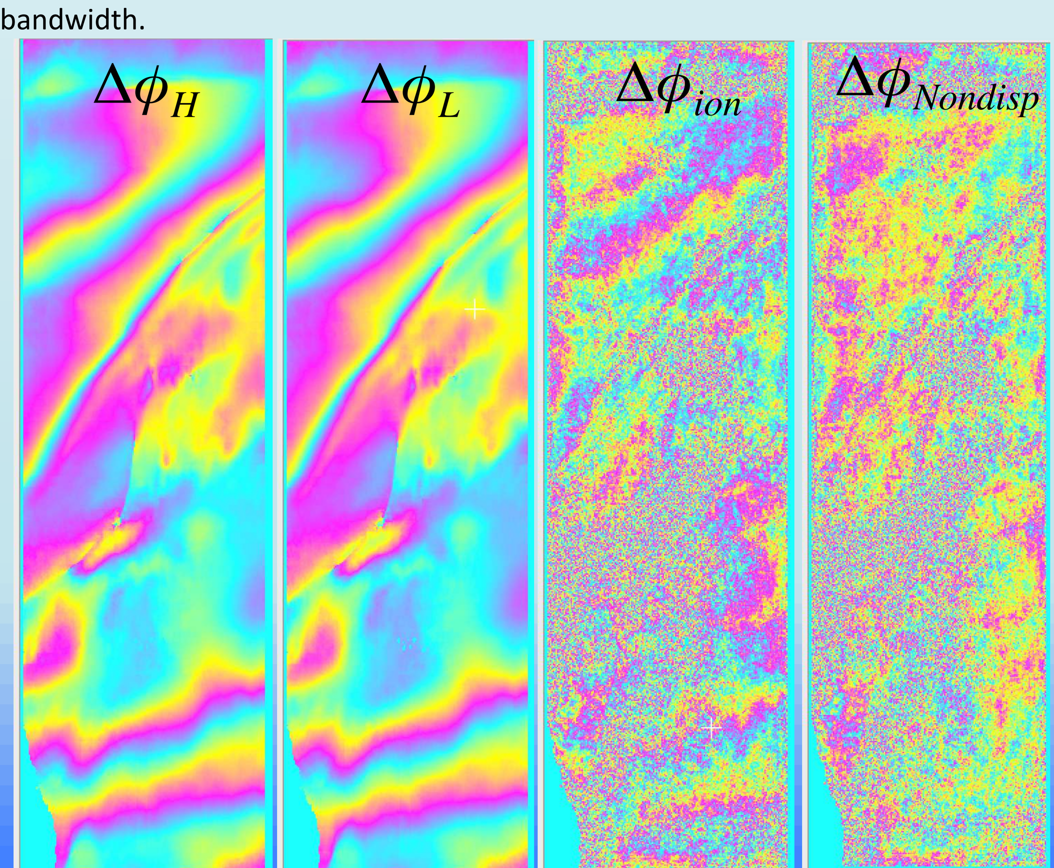


ALOS2: 2015/08/27_2015/09/24 Bperp= 103.8 meter, Bw=8.3 MHz



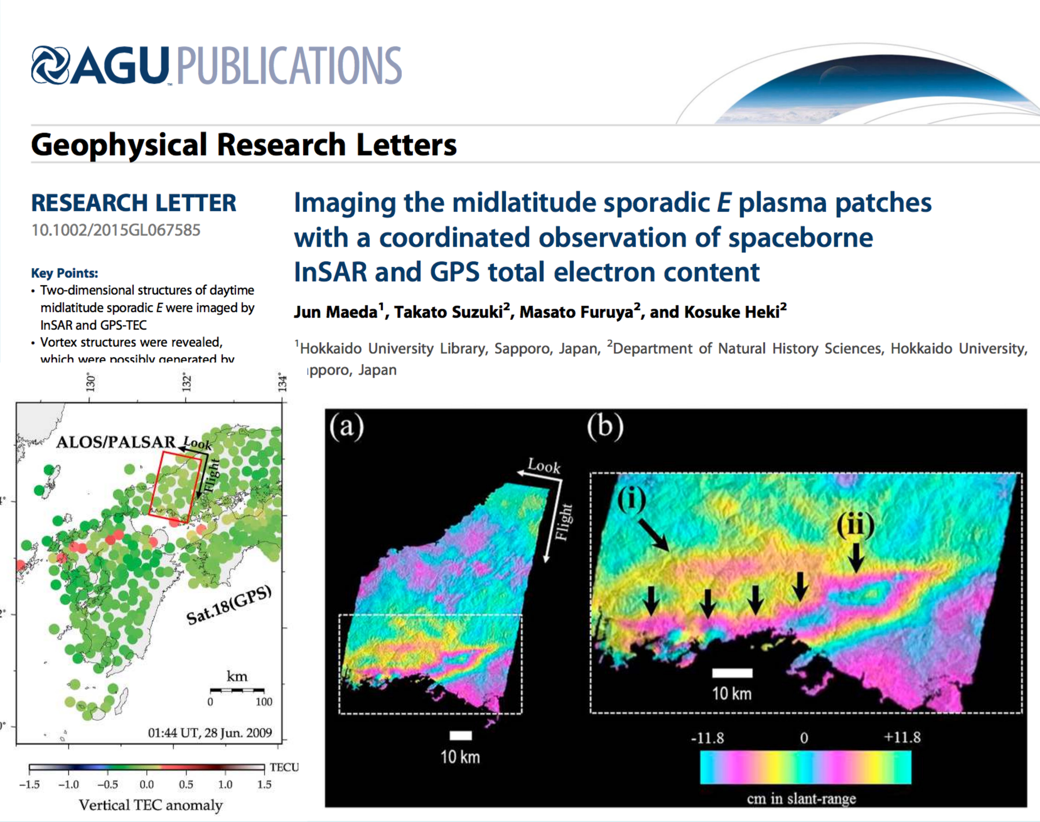
ALOS2: 2015/08/17_2015/09/14 Bperp= -102.2 meter, Bw=8.0 MHz

The noisy result below is presumably due to both the long baseline and the narrow bandwidth.



ALOS1: 2007/07/14_2007/10/14 Bperp= 973.0 meter, Bw=4.6 MHz

Mid-latitude Sporadic-E Episodes Detected by SB-InSAR



AGU PUBLICATIONS

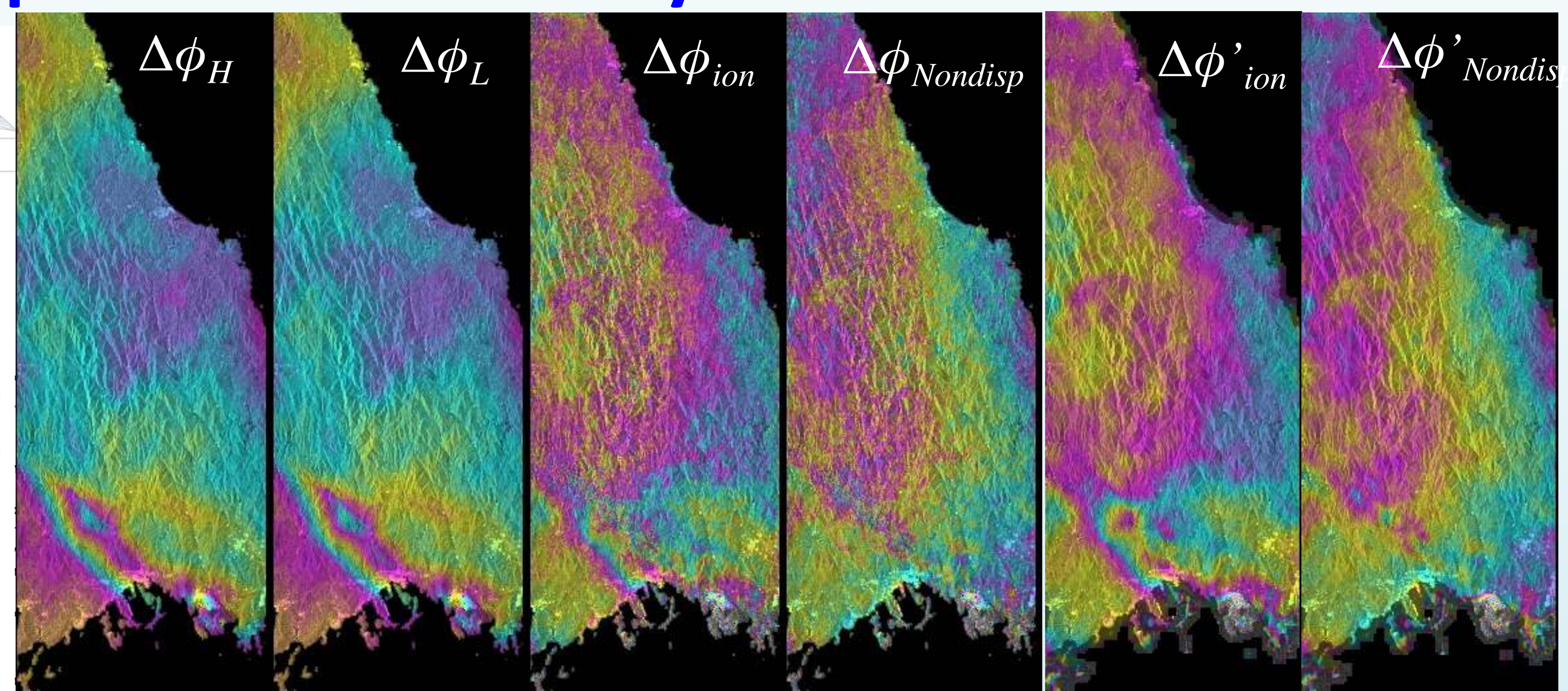
Geophysical Research Letters

RESEARCH LETTER

10.1002/2015GL067585

Imaging the midlatitude sporadic E plasma patches with a coordinated observation of spaceborne InSAR and GPS total electron content

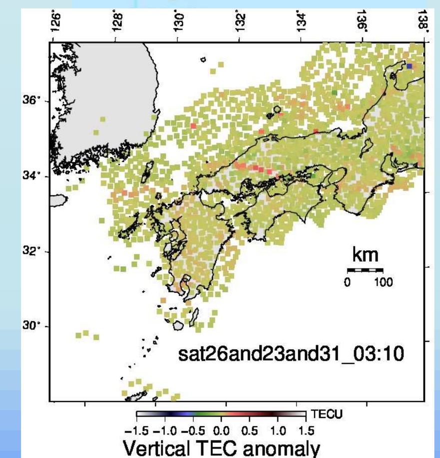
Jun Maeda[1], Takato Suzuki[2], Masato Furuya[2], and Kosuke Heki[2]

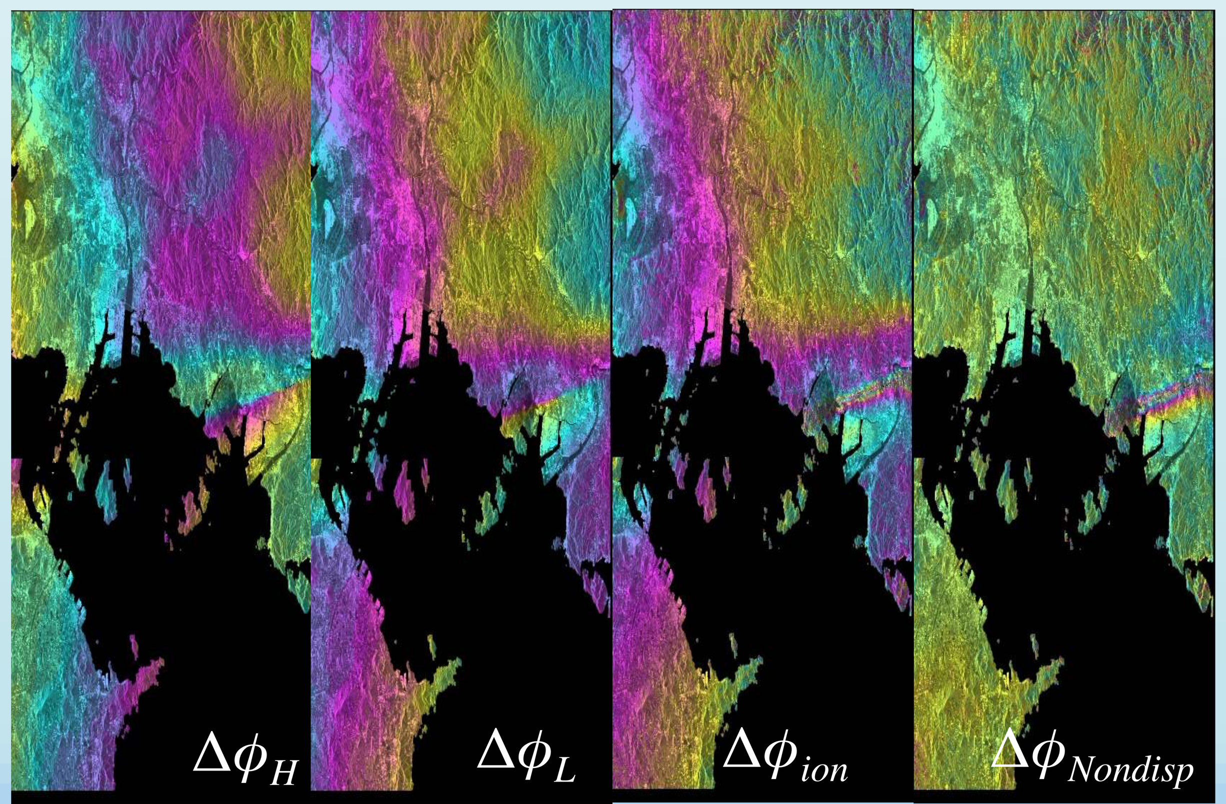


ALOS1:2009/03/28_2009/06/28 Bperp= 154.6 meter, Bw=8.4 MHz

Using ALOS1 data, Maeda et al (2016) first reported the sporadic E (E_s) phases in InSAR with the aid of GNSS TEC, but the InSAR phases were not decomposed into the dispersive and non-dispersive signals. Suzuki et al (2016) reported the 2nd successful detection of E_s, using ALOS2. Comparing the TEC ($\Delta\varphi_{ion}$) and non-dispersive effect ($\Delta\varphi_{nondisp}$), we realize the similarity in the phase anomaly shape. We may associate the $\Delta\varphi_{nondisp}$ with the phase delay due to the presence of positive charges around the E_s signals.

< **ALOS-2** >
2016/05/25 03:10 UT
Path: 22, Frame: 2920
Mode: **SM1 (Bw 79MHz)**
Descending





ALOS2: 2016/02/17_2009/05/25 Bperp= -63.4 meter, Bw=11.9 MHz

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