Analysis of Strain of Landfast Sea Ice near Jang Bogo Station, Antarctica, using Satellite InSAR

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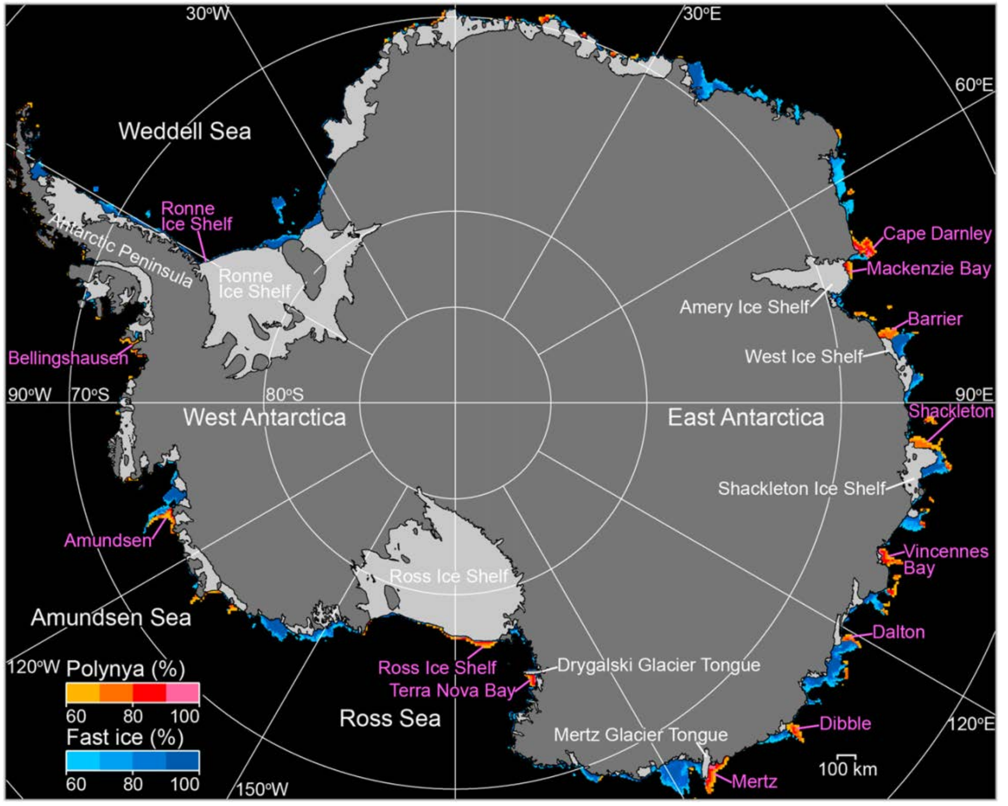
Antarctic Landfast Sea Ice

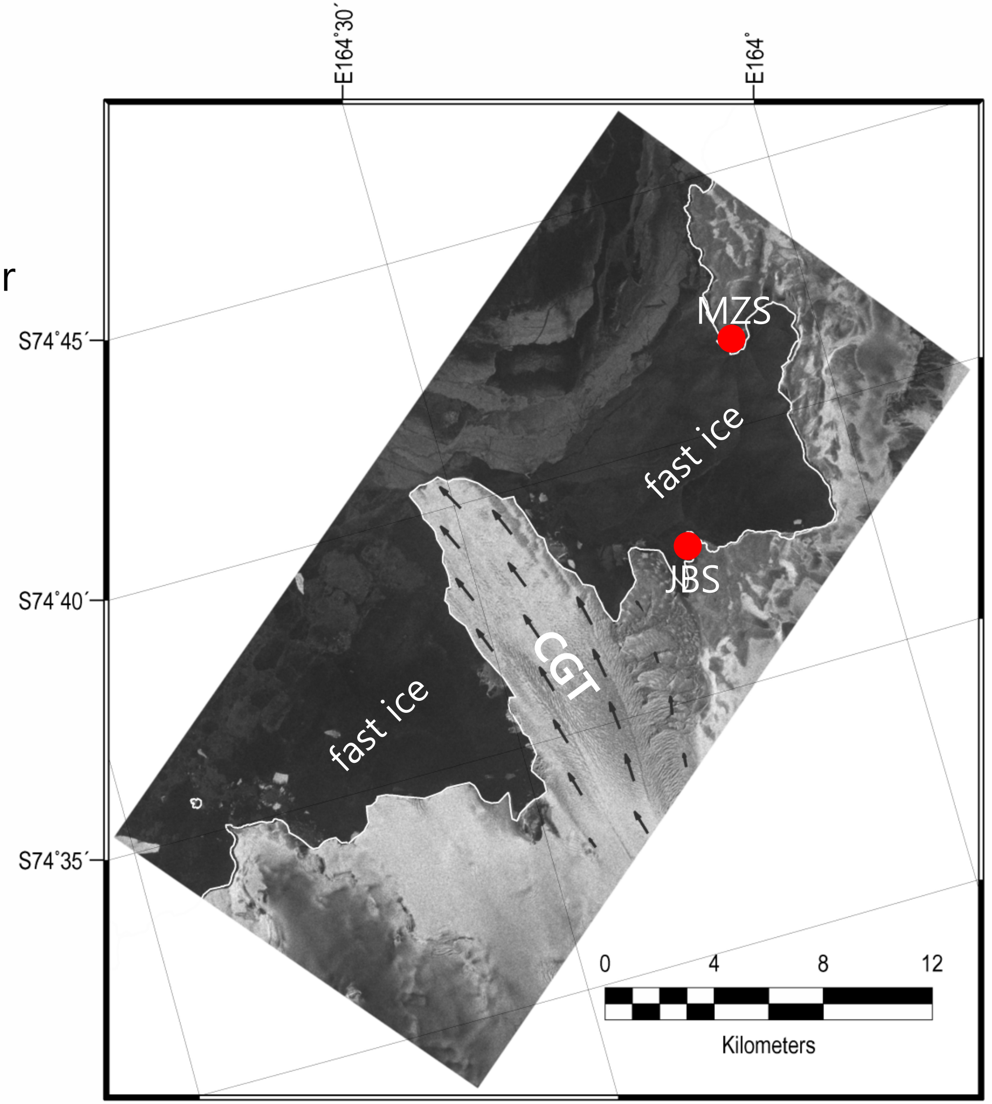
- A type of sea ice fastened to the coastline and ice shelves
- In the Antarctic Ocean, fast ice accounts for about ~5% of total sea ice area
- Significantly influences the variability of coastal polynya, sea ice production and marine ecosystem



(Nihash and Ohshima, 2015)

Landfast Sea Ice near JBS

- A section of Terra Nova Bay (TNB), East Antarctica
- Landfast sea ice around Campbell Glacier Tongue (CGT)
  - Daily flow of ~67 cm
  - Sea surface tilt by tide of ~60 cm
- Affects logistics of research stations
  - Jang Bogo Station, Korea
  - Mario Zucchelli Station, Italy
- Interaction with TNB polynya
  - Controls sea ice production



Synthetic Aperture Radar (SAR)

- Advantages of SAR
  - All weather
  - Day-and-night imaging
- SAR Interferometry (InSAR)
  - Using the difference of phases between two or more SAR images
  - Widely used to extract topography and deformation of surface
  - can observe small displacement of surface
- InSAR with short temporal baseline
  - Necessary for measuring displacements of sea ice or glaciers
  - A series of InSAR pairs with short temporal baseline is required to understand fast ice dynamics

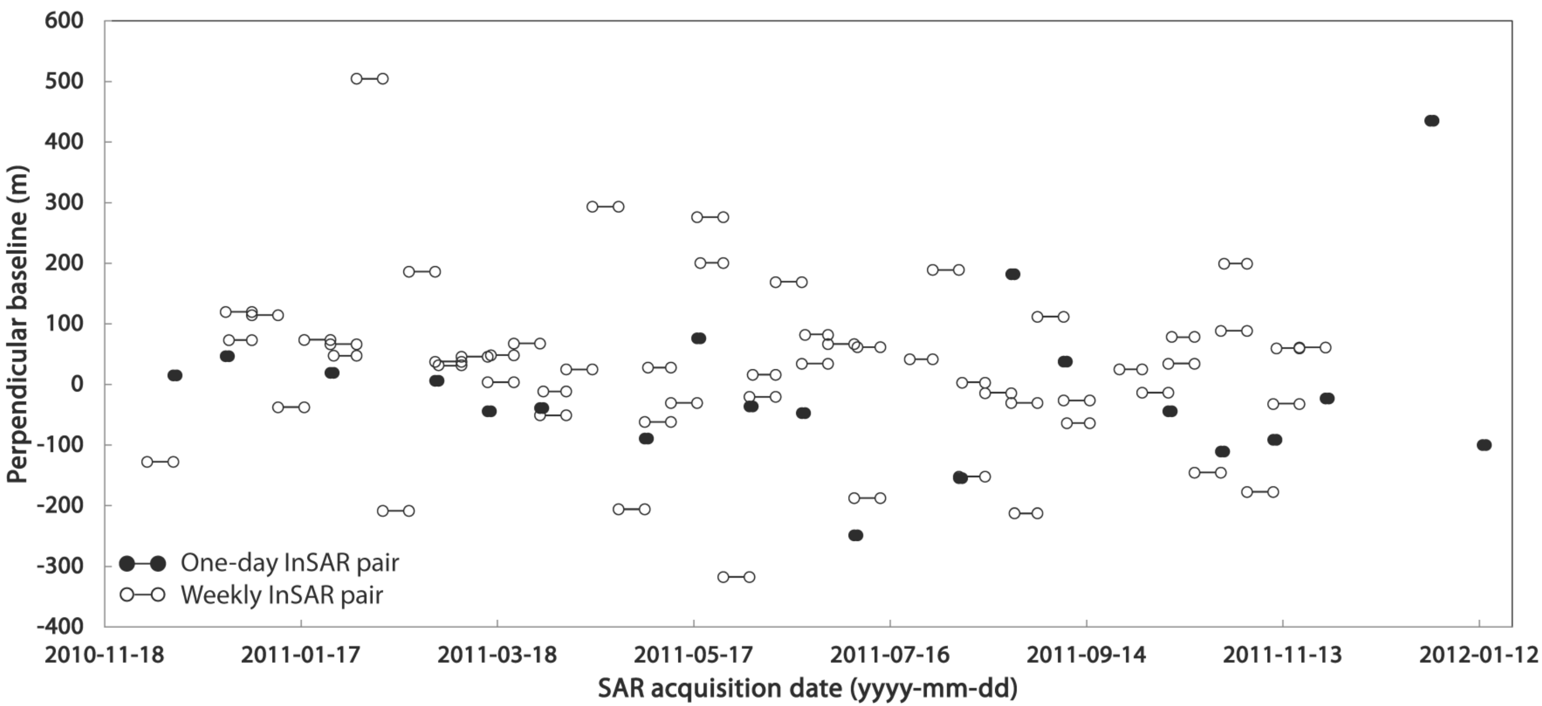
Objectives

- **To identify strain components of landfast sea ice near Jang Bogo Station using a series of InSAR pairs**

- **To separate the strain components of landfast sea ice from one-day InSAR signals**

Data – SAR

- **COSMO-SkyMed (CSK) Constellation**
  - X-band, strip map, 3 m resolution, VV-pol, descending orbit
  - 13 months of observation period from Dec 2011 to Jan 2012 (70 images)
  - 20 one-day InSAR images
  - 57 weekly (18 seven-days and 39 eight-days) InSAR images
  - Perpendicular baselines from -320 to 504 m

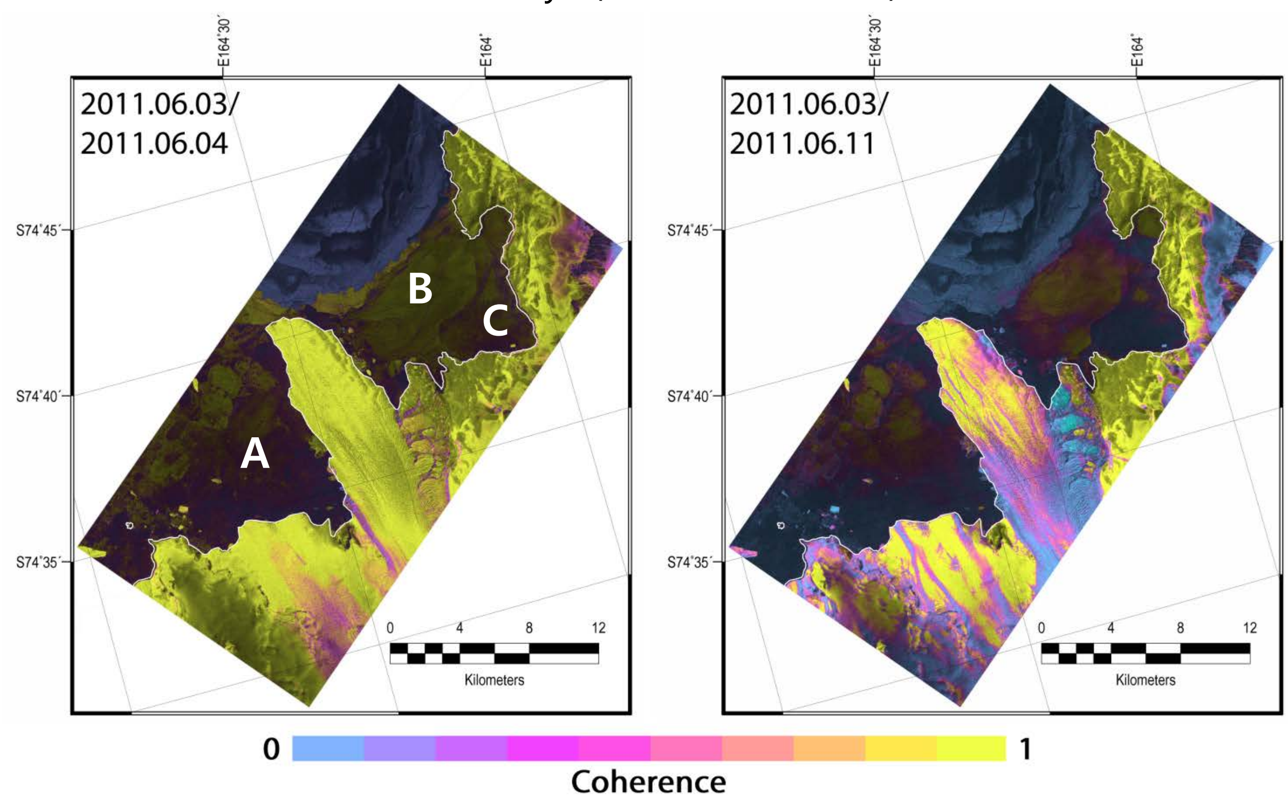


Data – Tide model

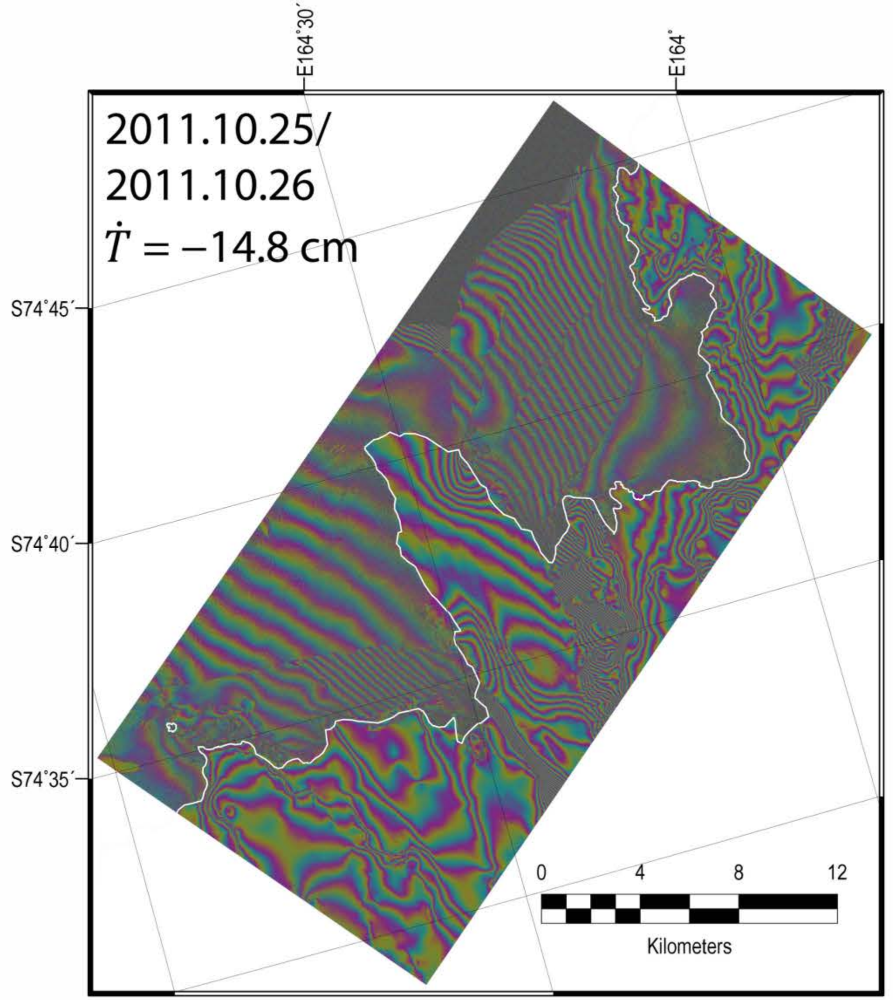
- **Ross_Inv tide model**
  - To predict tide height at fast ice areas
  - The optimum tide model in TNB (error of 4.1 cm, Han et al., 2013)
  - Inverse barometric effect (IBE) was corrected by using AWS measurements
  - Load tide effect was corrected by using TPXO Load Tide Model

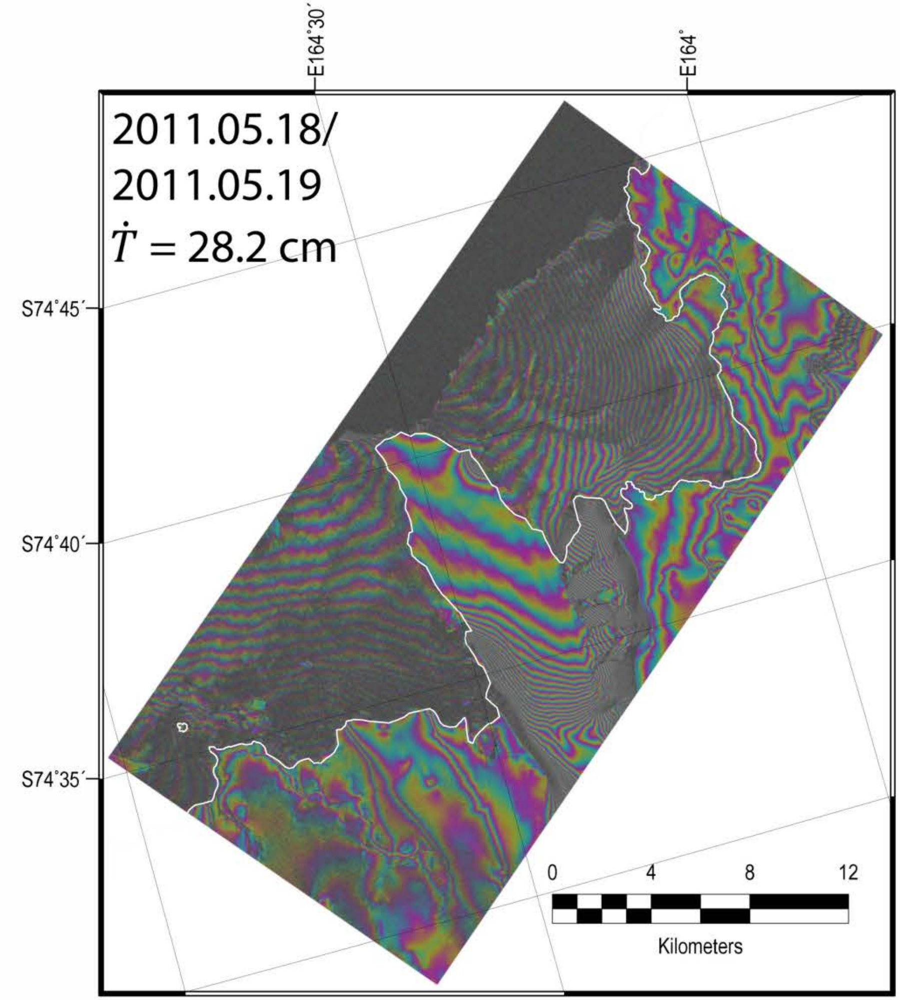
Detection of fast ice area

- **Fast ice**
  - High coherence in one-day InSAR
- Pack ice
  - Low coherence, cracks and leads, traceable by multi-temporal SAR images
- Ocean
  - Low coherence, dark in calm days (or nilas, frazil ice)



Equi-displacement lines from one-day InSAR





Fast Ice Stress

- Air Stress
  - No correlation with fringes
- Water Stress
  - No correlations with fringes
- Coriolis Force
  - Significant influence on pack ice and ice berg
- **Sea Surface Tilt by tide (tidal strain)**
  - Tide of ~60 cm
- **Campbell Glacier Tongue (glacial strain)**
  - Daily flow of ~67 cm

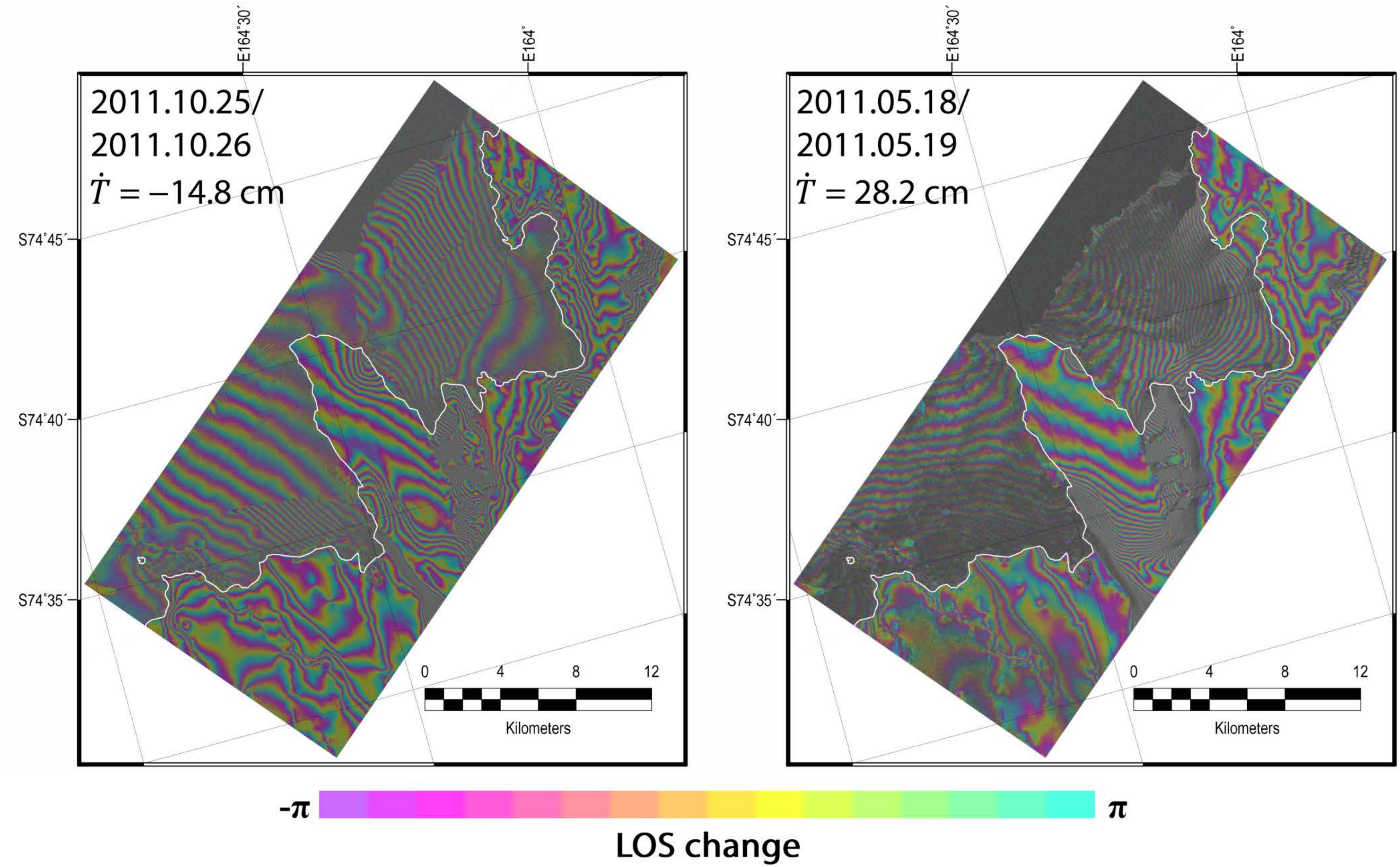
} Mixed in one-day InSAR signals

Tidal strain & Glacial strain

- Glacial strain
  - Ice flow velocity and direction of CGT is spatiotemporally constant
  - The flow direction of CGT is slightly tilted towards the east
  - Lateral shear drag along the sides of CGT (very small)
  - Compression or expansion in a direction perpendicular to the sides of CGT

- Tidal strain
  - Fast ice is bended by sea surface tilt by tide
  - The magnitude of tidal deformation increase from the hinge line
  - Not be influenced by the CGT which experiences almost the same tidal motion with fast ice

Equi-displacement lines from one-day InSAR



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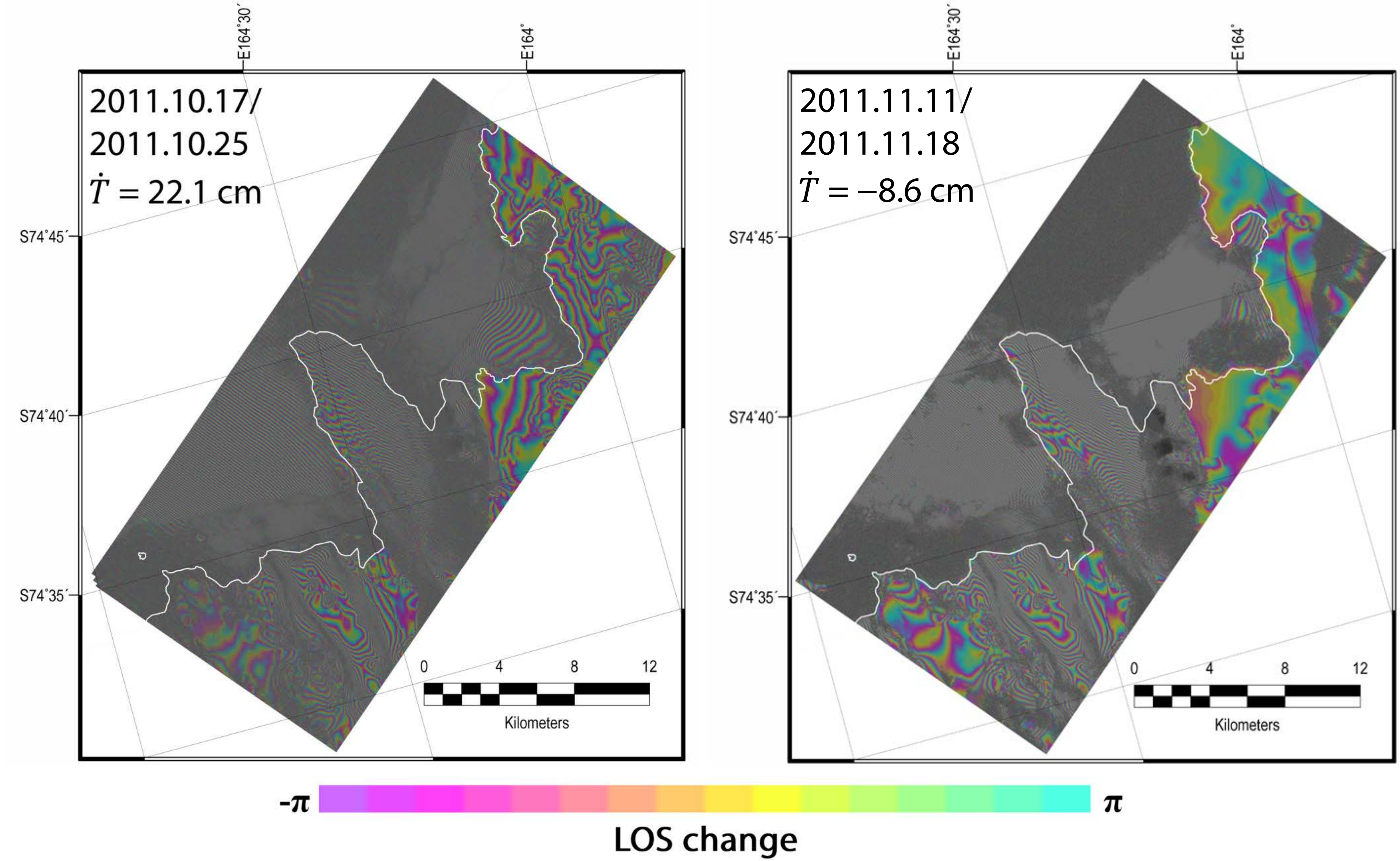
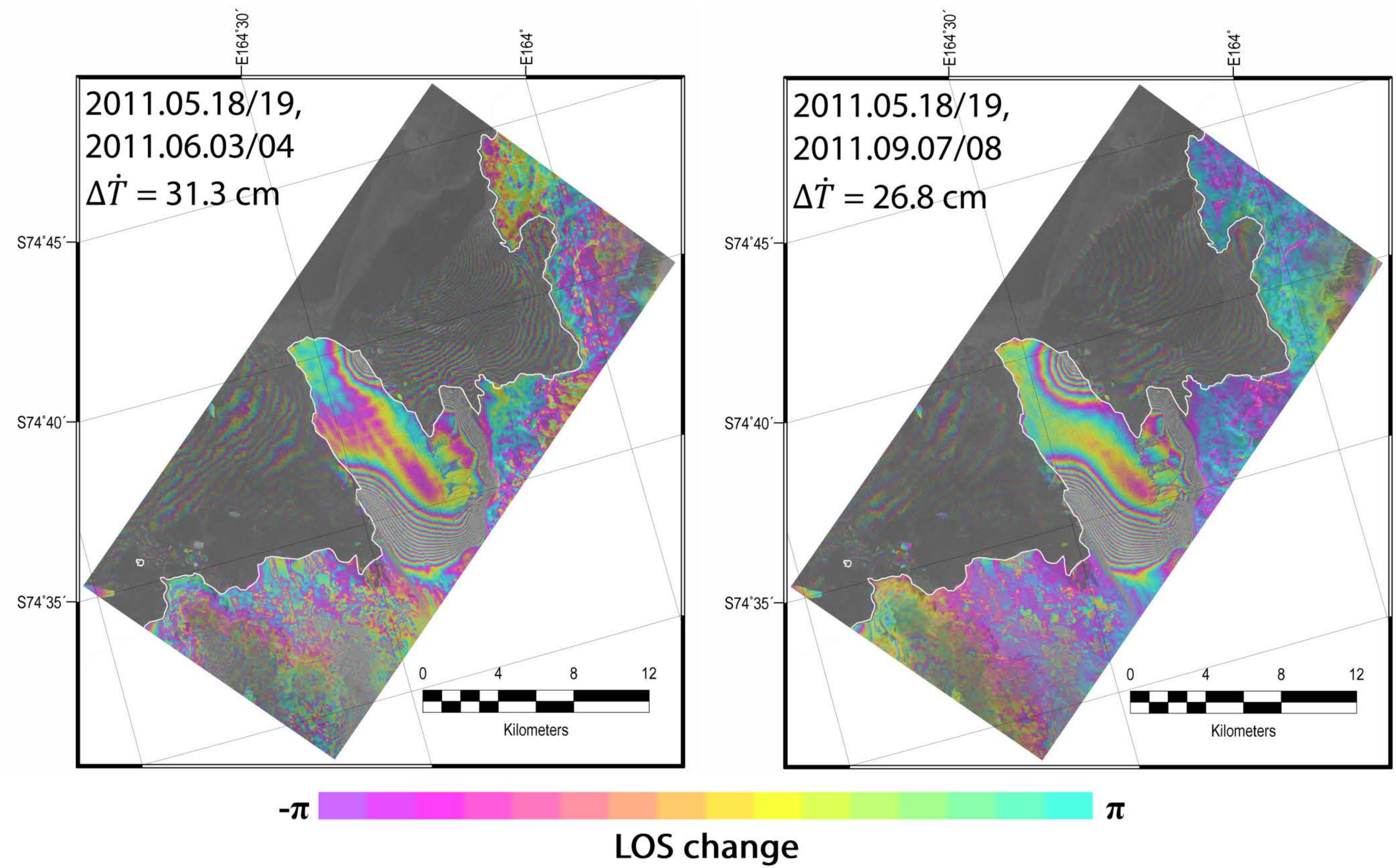
- Stress from tide is oscillatory while that from the flow of CGT is cumulative with time
  - Glacial strain -> weekly InSAR
  - Tidal strain -> Double-differential InSAR (DDInSAR)

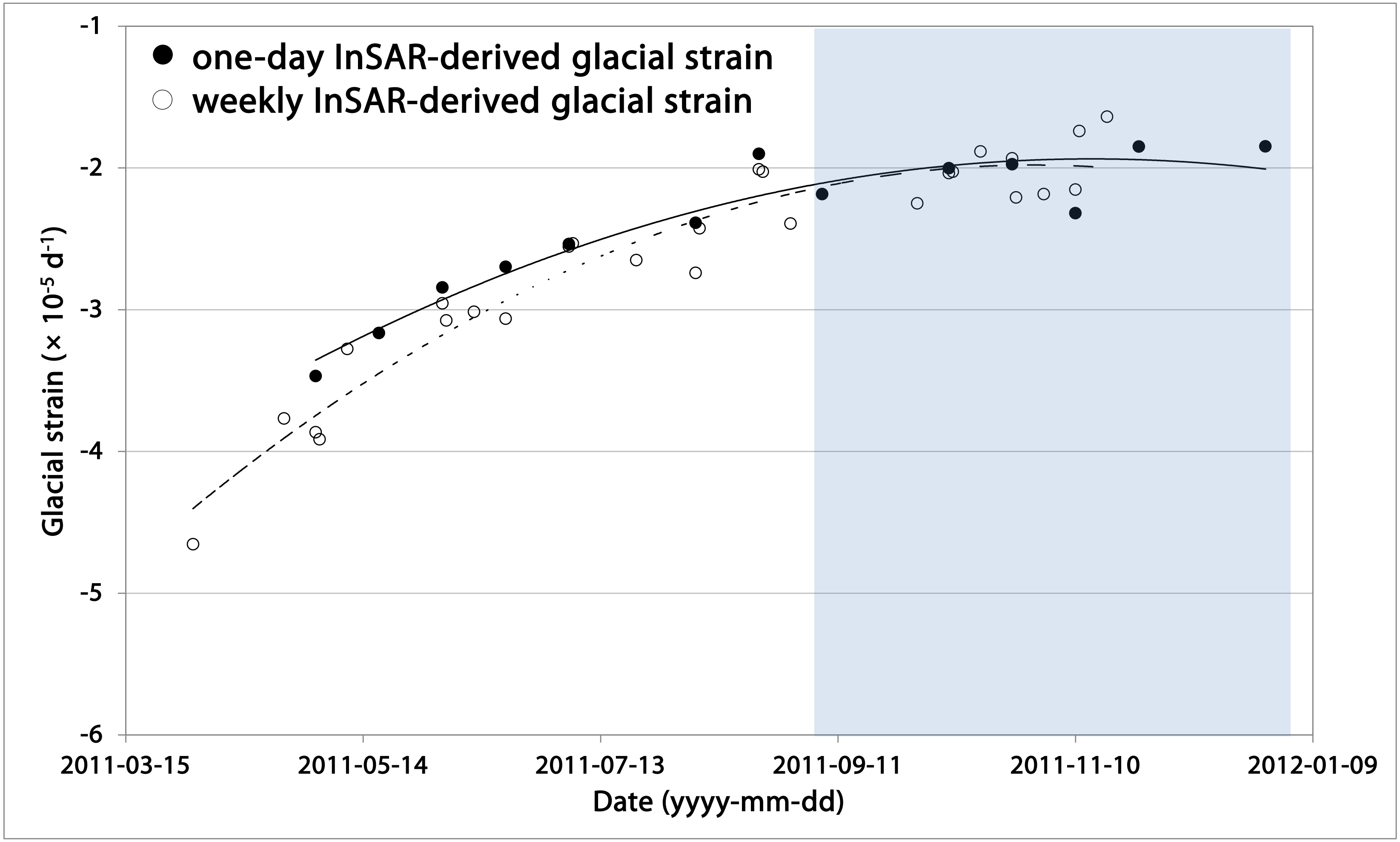
Equi-displacement lines from weekly InSAR



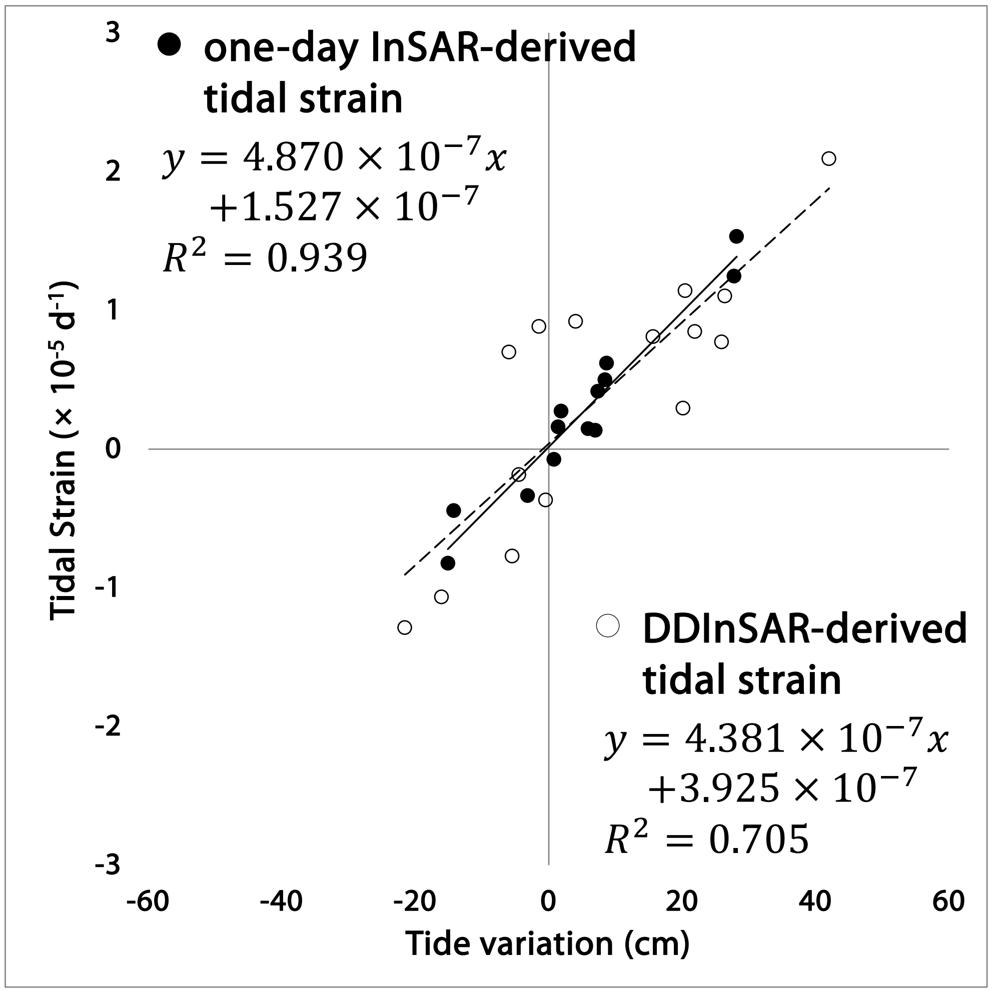
Equi-displacement lines from DDInSAR



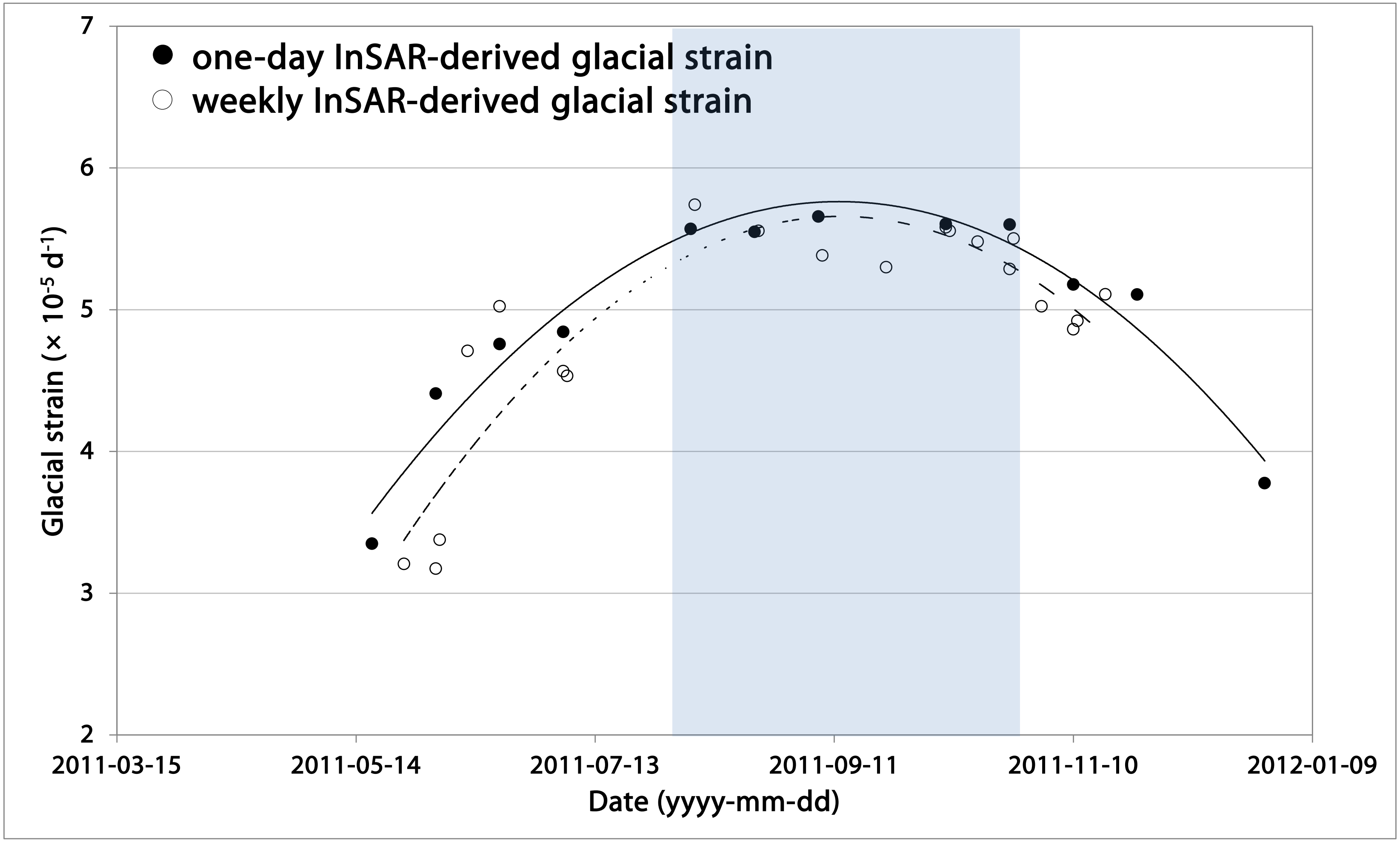
Glacial strain of fast ice region A (East of CGT)



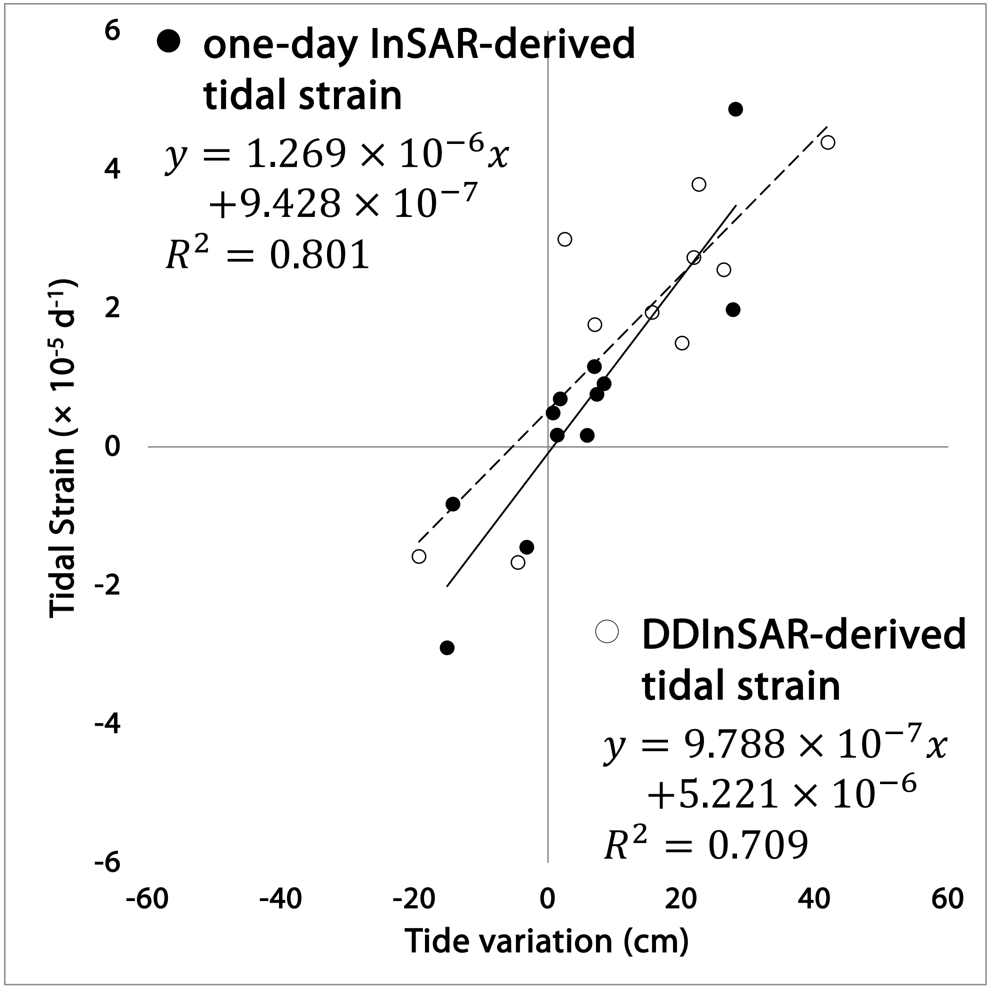
Tidal strain of fast ice region A (East of CGT)



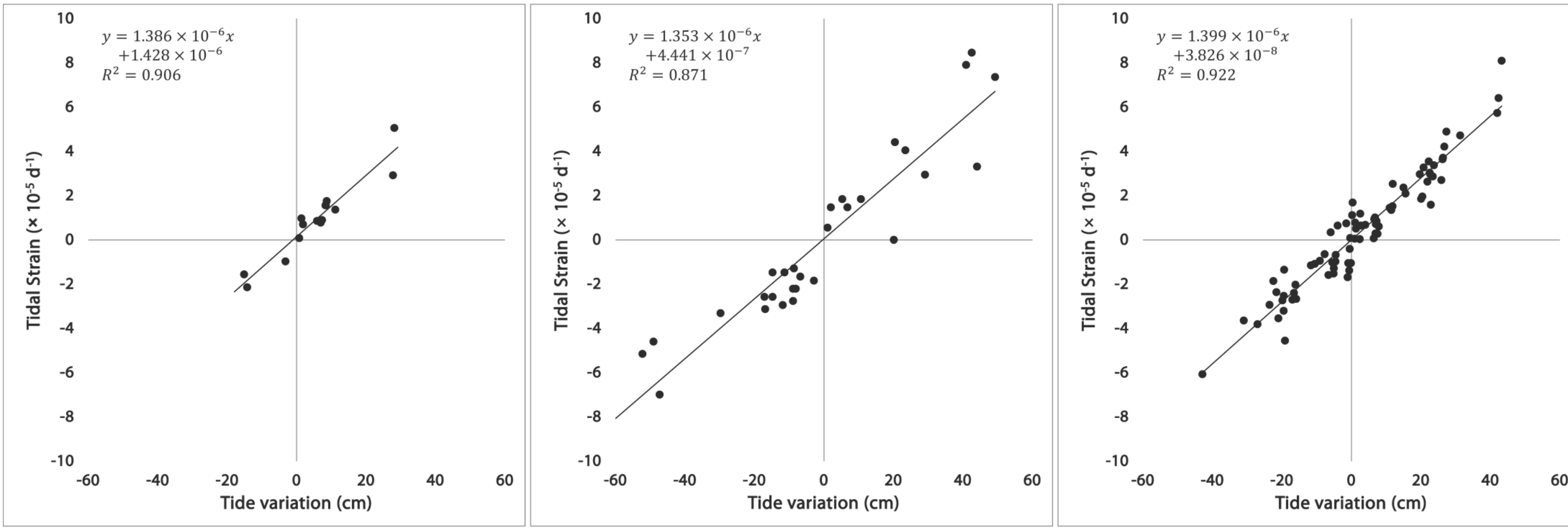
Glacial strain of fast ice region B (West of CGT)



Tidal strain of fast ice region B (West of CGT)



Tidal strain of fast ice region C (Isolated from CGT)



Conclusions

- Strain of fast ice near JBS was investigated from a series of COSMO-SkyMed one-day InSAR images.
- Fast ice attached to the east of CGT is compressed due to the slightly eastward flow of CGT.
- Fast ice to the west of CGT is expanded by the pull of CGT.
- Fast ice near JBS, isolated from CGT showed tidal strain only.
- Tidal strain of the fast ice was strongly correlated with the magnitude of tide variations.
- The glacial and tidal strain derived from the one-day InSAR images was similar to those from the weekly InSAR and DDInSAR images.

Thank You