Monitoring of sudden discharge of multi-year ice on Lützow-Holm Bay, Antarctica using SAR and Altimeter data

Tsutomu Yamanokuchi
(Remote Sensing Technology Center of JAPAN)

Koichiro Doi, Kazuo Shibuya
(National Institute of Polar Research)

Kazuki Nakamura
(Nihon Univ.)

Shigeru Aoki
(Institute of Low Temperature Science, Hokkaido University)
What’s happened?

Sudden discharge of fast ice (multi-year ice) occurred during only 1.5 month at Lützow-holm bay. Discharged area length is 60km, close to the size of Tokyo Bay.
Introduction

• Lützow-Holm bay: Located on 35-40 °E, 65-70 °S, face to Japanese Antarctic expedition base, Syowa Station.
• Quasi-periodic discharge of fast ice (approx. 10 years) occurred on 1987, 1997, 2003 (Ushio, 2005)
• Thickness of fast ice attains to several meters
• No physical mechanism and explanation about this event.
Objectives

• To understand the state of before and after the sudden discharge event using dense time series SAR data

• To check the long-period height variation of sea ice and ice shelf using satellite altimeter data
  ✓ First time to have such dense time series SAR data acquired
  ✓ Need 10 years for next chance
  ✓ Good opportunity to understand the inside of the bay
  ✓ No understandings for sudden discharge
Time series analysis of SAR data

- ALOS-2/PALSAR-2 and Sentinel-1A

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Images used in this study

Landsat/MSS, 1973-1974

151001

160316

160326

160407
Images used in this study
Images used in this study

- 2015/10/1-2016/5/3: 11 scenes
Animation from 2015/10/1 to 2016/5/1
Topic-1: Sudden discharge of fixed sea ice

- Seems no change of fast ice between Oct/01/2015 and Mar/16/2016
- Sudden discharge from Mar/16/2016 to May/03/2016
- Retreat distance attains to 60km!! (Yellow line)
Topic-2: Separation of Kaya lacier tongue

- Ice tongue flowed approx. 41 km between 0326 and 0407 (12 days, 3.4 km/day)
- Flow distance between 0407 and 0409 was approx. 31.3 km (15.6 km/day, 0.18 m/s)
Topic-3: Change of sea (ice) surface backscatter

- 0414a: Sea surface shows complex feature of ice shelf, ice tongue, fast ice, brash ice and open water
- 0423: Strong backscatter by wind-driven wave developed on the open water area.
Topic-4: Visualization of sea surface current

- After the discharge event, broken small iceberg works as a surface tracer and it shows the ocean surface current.
- Eddy on sea surface can be seen and it is related to the existence of Shirase Submarine canyon.
Analysis of satellite altimeter

• In case of discharge of ice shelf, clear thinning was observed before the event.

• Although this event is “NOT” ice shelf but fast ice, we try to monitor the change of fast ice.

• Altimeter data used in this study are ICESat / GLAS (2003-9), and CryoSat-2/SIRAL (2015-16)
Analysis of satellite altimeter

【Definition of altimeter product】

• ICESat/GLAS:
  – GLAS/ICESat L2 Sea Ice Altimetry Data, Version 34 (GLA13)
  – Product Var name: Sea Surface Elevation (i_elev)
  – Description: Surface elevation w.r.t. ellipsoid at the spot location determined by range using the sea ice specific fitting procedure after atmospheric delays and tides have been applied.

• CryoSat-2/SIRAL:
  – SIRAL/SARIN L2 Data
  – Product: Height of surface w.r.t. reference ellipsoid
  – over sea-ice covered water, data will also include an estimate of ice thickness and other information derived from the echo power
Analysis of satellite altimeter

Oct–Feb GLAS

Sum of 2003 to 2009 October to February

- It seems no thinning trend from GLAS data to SARIN data Before and after the event,
- Altimeter detected the fast ice

Geoid Height on Syowa Station 22.37m (Shibuya, 1991)
Summary

• It is able to monitor the sudden fast ice discharge event on Lützow-holm by using high-temporal resolution SAR data with combined use of ALOS-2 and Sentinel-1A data.
• Fast ice area retreated approx. 60km only in 48 days.
• After the discharge of fast ice, sea surface backscatter intensity changed by complex interactions of iceshelf, iceberg, sea water and surface wind.
• It is able to estimate the northwestward flow velocity (15km/day) by tracing the separated Kaya Glacier tongue.
• Brash ice has a role of tracer and it is able to visualize the sea surface current.
• From altimeter analysis, there are no significant thinning trend of fast ice, while it is able to detect the discharge event.
• It is necessary to monitor the re-freezing of fast ice for understanding the mechanism of ice discharge event.
Thank you very much for your attention

Acknowledgements

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What is measured by altimeter

1. Observe instantaneous sea surface height
2. Model sea surface

Ref: ICESat/CryoSat-2 high-resolution altimetry for land/lake/river studies