ApRES Measurement on the western Getz Ice Shelf

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ABSTRACT: In January 2016, during the 2015/2016 Amundsen Sea Expedition, we deployed four autonomous phase-sensitive radio echo sounders (ApRES) on the Getz Ice Shelf (GIS) to measure the ice-shelf basal melt rates. The four sites are located on the west side of GIS: GW1 near the Siple Island and GW2~GW4 to the southwest from GW1. The radars deployed at GW2 and GW4 are still alive although other two stopped sending their data in August 2016. The melt rates were calculated from the ice-shelf thinning rates, offset by the strain rate through the ice column. The estimated melt rates show temporal variations and slightly different patterns between western and eastern parts of the western GIS. We will further discuss on analyzing the ApRES data in terms of relationship between melt rates and other forcings (i.e., tide oscillation, atmospheric forcing, mean flow, etc.) and defining vertical boundaries and structures in the west side of GIS. Additionally, some methods of ice mass balance estimation using ApRES and satellite data will be introduced for the future research.

INTRODUCTION

◆ Motivation

- The strongest thermal forcing and highest melt rates were found near the deep grounding line of some glciers, and melt rates are strongly correlated with ocean thermal forcing (*Rignot & Jacobs, 2002*)
- Half of the meltwater comes from 10 small Southeast Pacific ice shelves occupying only 8% of the area (Fig.1) and basal melt exceeds a calving flux (*Rignot et al., 2013*)
- Antarctic ice-sheet loss driven by basal melting of ice shelves (Fig.2, *Pritchard et al., 2012*)

Name	Basal Melt Gt/yr (m/yr)
Antarctic Peninsula	191 (1.5)
East Antarctica	480 (0.7)
West Antarctica	654 (0.9)
Total surveyed	1,325(0.85)
Getz	144.9 (4.3)
Pine Island	101.2 (16.2)
Thwaites	97.5 (17.7)
Dotson	45.2 (7.8)

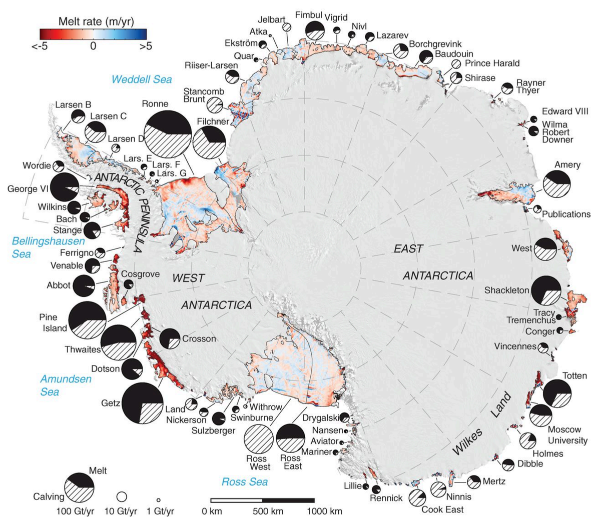


Fig.1 Basal melt rates (2003-2008) (*Rignot et al., 2013*)

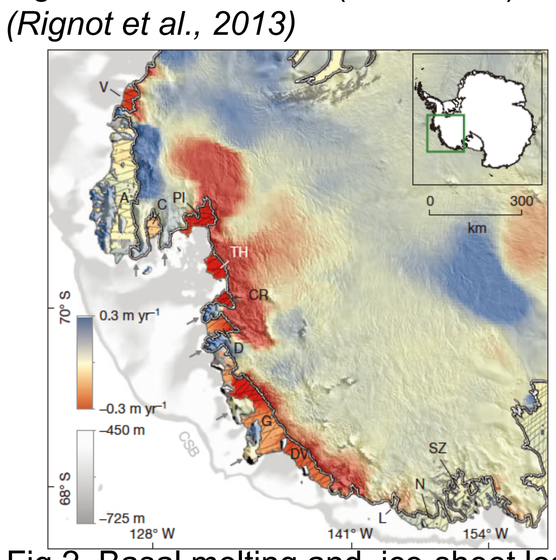


Fig.2 Basal melting and ice-sheet loss (*Pritchard et al., 2012*)

◆ NECKLACE program

- The NEtwork for the Collection of Knowledge on meLt of Antarctic iCe shElves, SOOS-endorsed activity
- Aim to install instruments on all the major Antarctic ice shelves to collect measurements of the rate of ocean-driven melting (Fig.3, *www.soos.aq/news/current-news/162-necklace*)

◆ Measurement of ice shelf basal melt rates

- An Autonomous phase-sensitive Radio Echo Sounder (ApRES) can provide the variability of key parameters from seasonal down to a day, such as the melt rate at an ice-shelf base (*Brennan et al., 2014; Nicholls et al.,2015*)

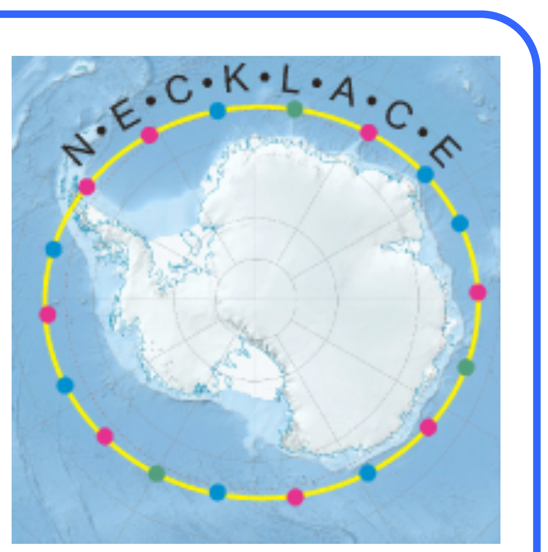
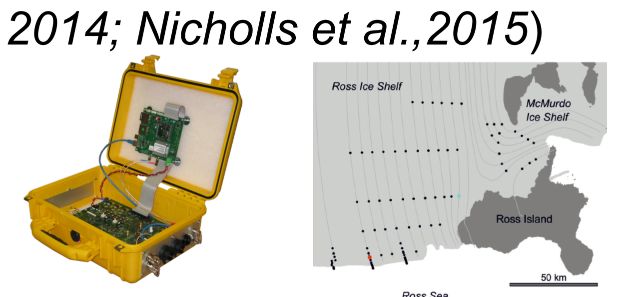


Fig.3 NECKLACE program logo



◆ Research objective

- To determine the sensitivity of the ice shelves around the Amundsen Sea to changes in ocean circulation and temperature using ApRES and ocean mooring measurements

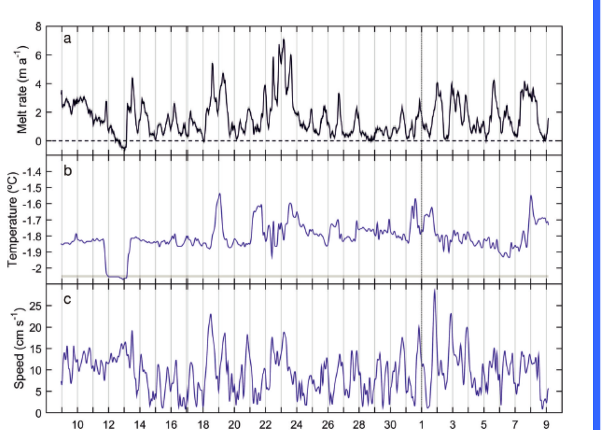


Fig.4 Observed basal melt rate on Ross Ice Shelf (*Nicholls et al., 2015*)

METHODS

◆ Installation of ApRESs on the western GIS

- Four ApRESs deployed on 27 Jan. 2016: GW1~GW4 (Table 1 & Fig. 5)
- Initial burst samples to find ice base (Fig. 6)

◆ Data transmission via Iridium

- Current status: GW2 and GW4 are still transmitting data but GW1 and GW3 is not working.

◆ Comparison to remote sensing observations

- Ice velocity, basal melt rate, etc.

Site	Latitude (S)	Longitude (W)	Start Time (UTC)	Approx. Base Depth (m)	Status
GW1	74º13.808'	125º20.930'	27 Jan 2016, 15:58	545	Stopped (Aug/2016)
GW2	74º23.993'	125º44.312'	27 Jan 2016, 09:36	475	ON
GW3	74º29.982'	125º59.938'	27 Jan 2016, 11:55	421	Stopped (Sep/2016)
GW4	74º36.018'	126º17.931'	27 Jan 2016, 13:55	551	ON

Table 1. Information on ApRES deployment and status.

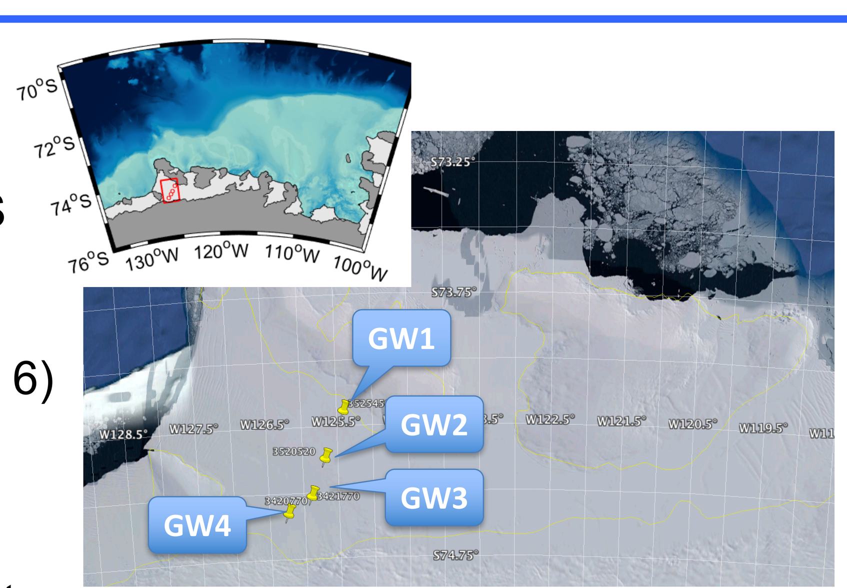


Fig.5 ApRES sites on the western Getz Ice Shelf

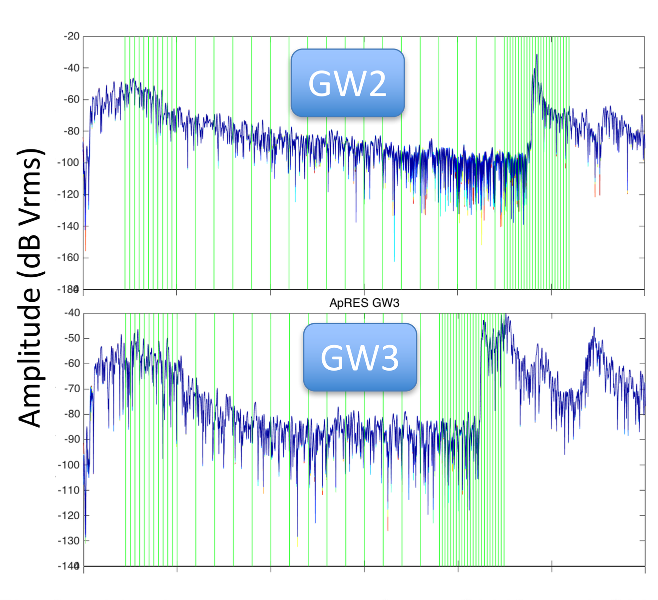


Fig.6 Initial burst samples from GW2 and GW3.

RESULTS - I

◆ Ice velocity from ApRES GPS

- GPS monitoring: 15-day averaged location (Fig.7a, b)
- Moving northwestward (downstream) with ~ 350 m a^{-1} speed (Fig.7c)
- Speeds between GW2 and GW4 are in phase during austral summer but out of phase during austral winter

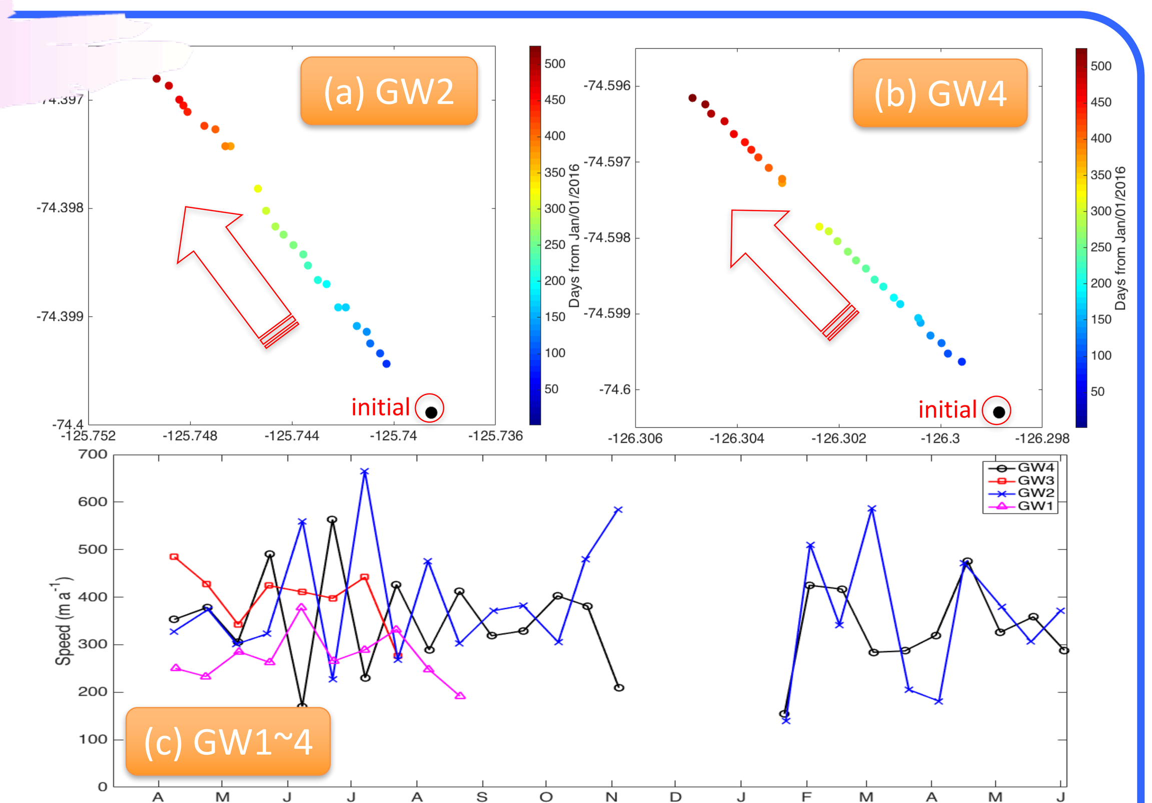


Fig.7 GPS monitoring: ice movement over 7 days at GW2 (a) and GW4 (b), and ice speed averaged over 15 days (c).

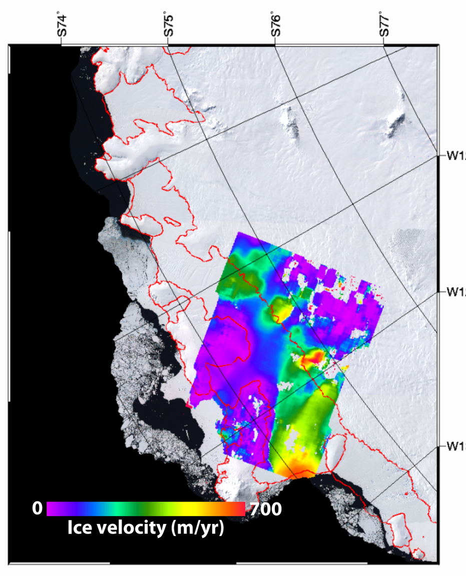


Fig.8 Ice velocity of Getz Ice Shelf from Sentinel-1 SAR offset tracking (16 & 28 June 2016)

◆ Ice velocity from SAR observations

- Using SAR images obtained over the same area
- Very useful to measure ice velocity of fast-flowing ice shelves where InSAR is not applicable
- Ice velocity with a few 100-m grid spacing
- Sentinel-1 SAR can measure a seasonal changes of ice velocity around the Amundsen Sea

RESULTS - II

◆ Basal melt rates from ApRES

- Calculated from the ice-shelf thinning rate, and offset by the strain rate through the ice column
- Strong tidal frequency: semidiurnal, diurnal, and spring-neap (~15d) signals (Fig.9)
- At GW2 and GW3, O1 and K1 tidal constituents are significant (red arrows in Fig. 10): This implies that tidal mean current might be dominant following the main channel.

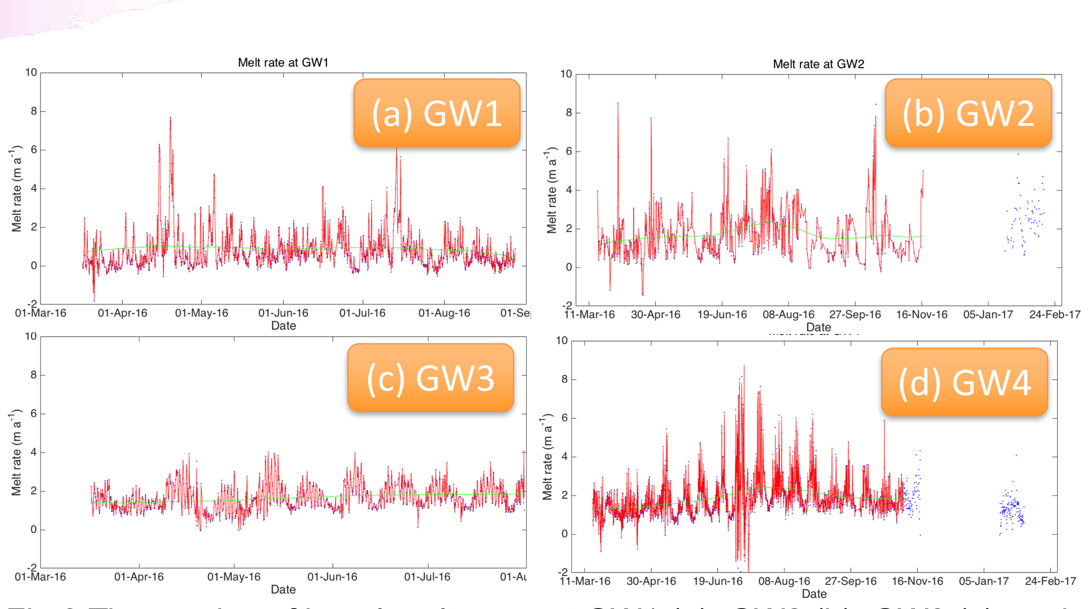


Fig.9 Time series of basal melt rates at GW1 (a), GW2 (b), GW3 (c), and GW4 (d).

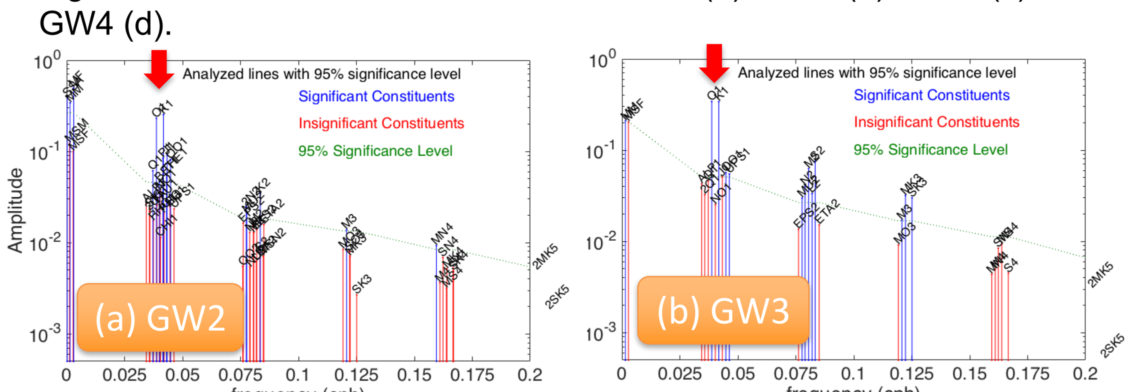
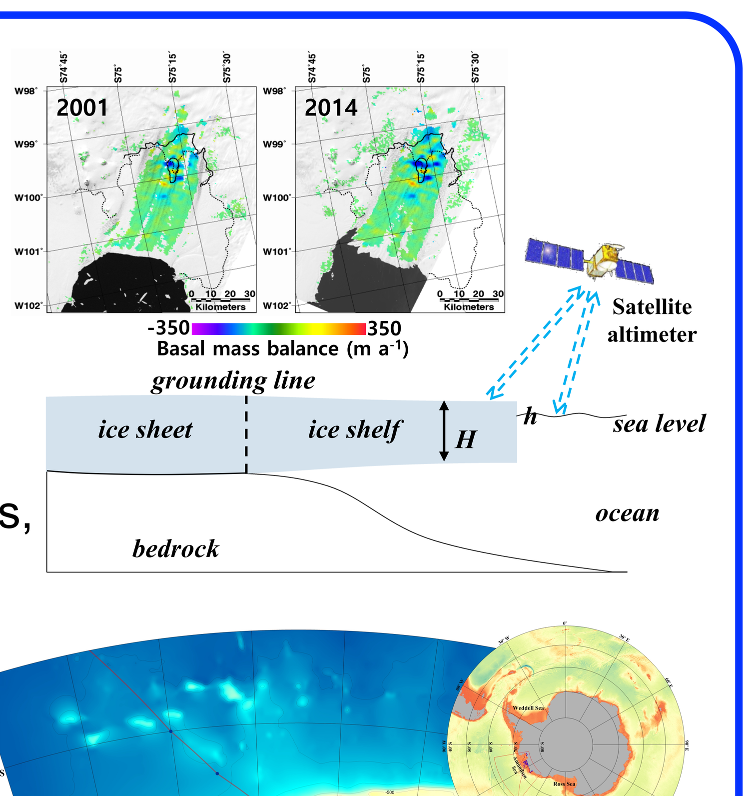


Fig.10 Tidal harmonic analysis of melt rates at GW2 (a) and GW3 (b).

FUTURE WORK

◆ Basal melting rate by remote sensing

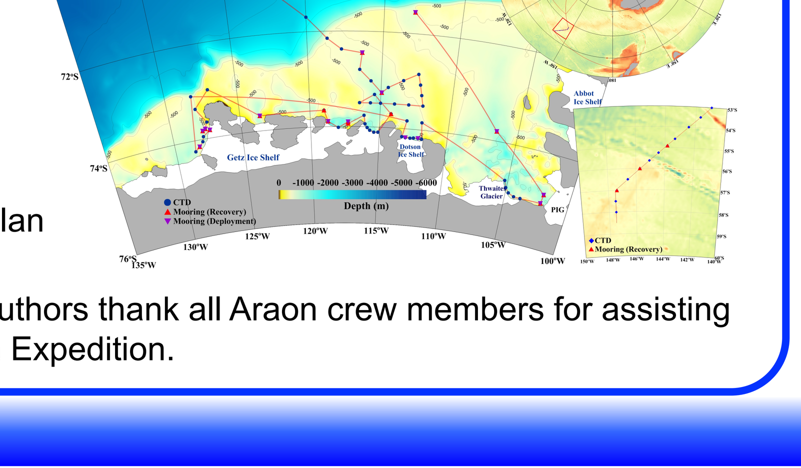
- Mass conservation assumption
  Ice thickness change(ITC)= ice flux discharge(IFD) + surface mass balance (SMB) + basal melting (BM)
- ITC and IFD can be estimated from satellite altimeter data, SMB estimated using climate models, and then basal melt rate can be derived.



◆ Amundsen Sea Expedition 2017/2018 plan*

- Period: Dec. 2017 ~ Feb. 2018
- 74 CTD stations
- ApRES: Getz IS, Dotson IS, and Thwaites G.
- Gravity survey: GIS & TG
- T-POPs, Ocean mooring, Glider, etc.

* Please contact T.-W. Kim (twkim@kopri.re.kr) for the detailed plan



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