2017년 한국해양학회 추계학술회의, 경주, 11월 2~3일

아라온을 활용한 극해역 해빙 및 빙붕 현장관측 소개

조경호[1]*, 김주홍[2], 최영석[1], 나형술[1], 박태욱[1], K. Shimada[3], E. Yoshizawa[1], 강성호[1], 이상훈[1], 김태완[1], MIZ team[4], AIS team[5]

[1]극지연구소 극지해양과학연구부
[2]극지연구소 북극해빙예측사업단
[3]일본동경해양대학교 해양과학과
[4]Marginal Ice Zone team
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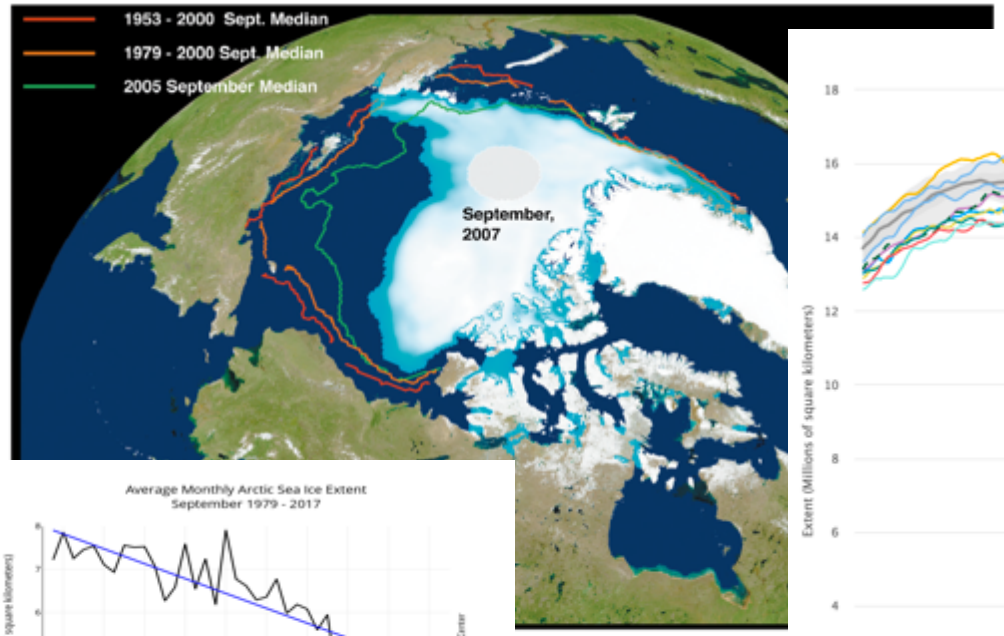
KOPRI
Korea Polar Research Institute, KIOST

목차

북극해빙관측: 해빙면적 감소



(Stroeve et al., 2008, EOS)

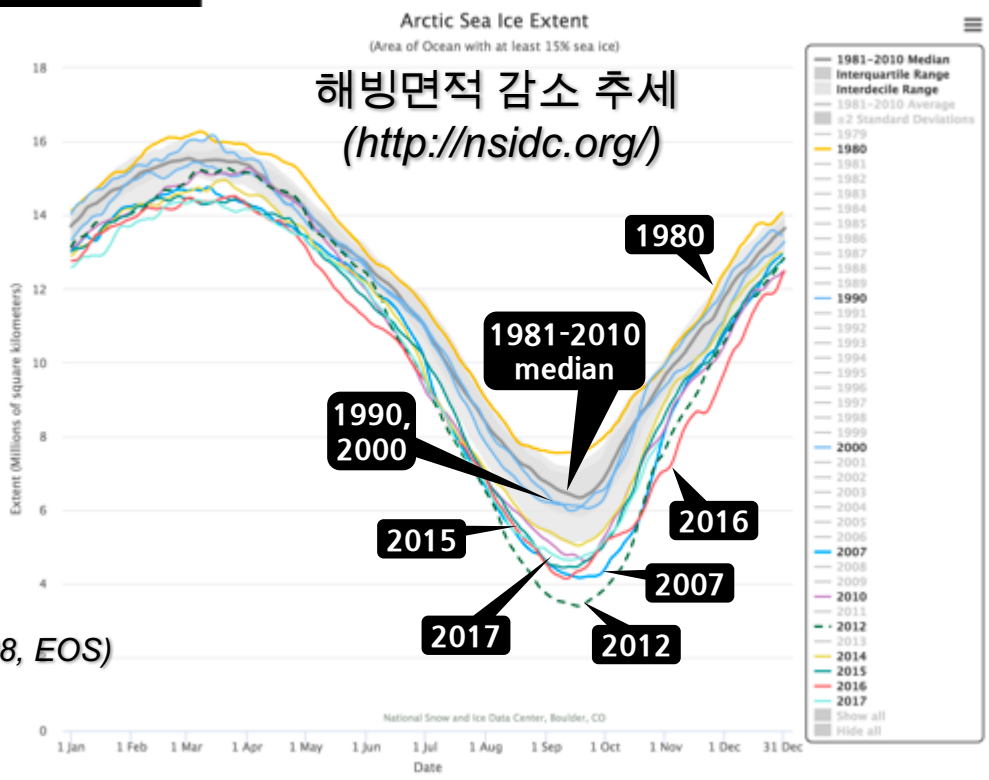


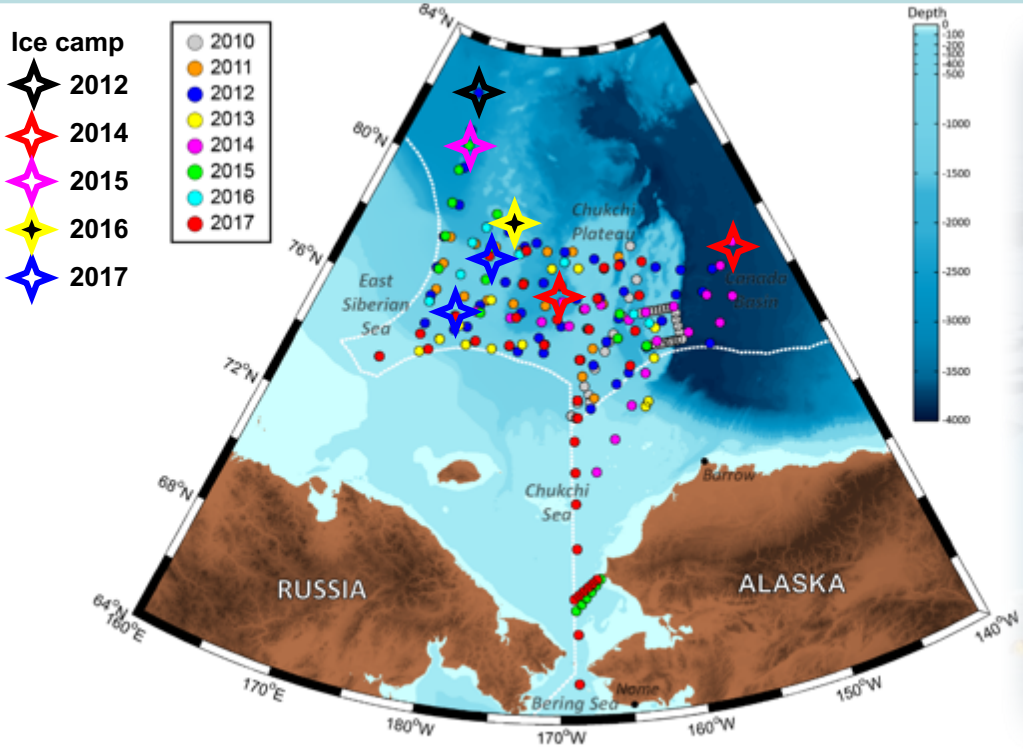
Fig. 1. Sea ice concentration for September 2007, along with Arctic Ocean median extent from 1953 to 2000 (red curve), from 1979 to 2000 (orange curve), and for September 2005 (green curve). September ice extent time series from 1953 to 2007 is shown at the bottom.

서북극해 여름철 해빙 면적이 꾸준히 감소되고 있고 연간 변동성을 보임.

해양-해빙-대기 간 상호작용과 이에 따른 해양환경 변화를 이해하기 위해 현장 관측 수행.

북극해빙관측: 해빙캠프

- 쇄빙연구선 아라온을 활용한 서북극해 현장조사 수행 (2010년부터 매년 8~9월)
- 현장조사 기간 총 7회의 해빙캠프를 수행 (2012, 2014~2017)

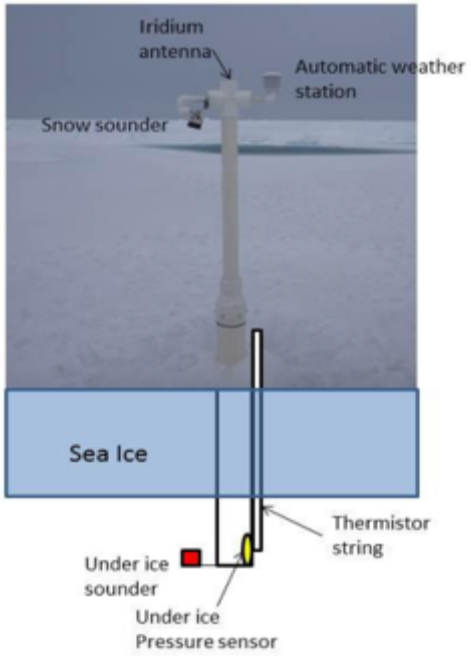


	2010	2011	2012	2013	2014	2015	2016	2017
CTD	38	18	44	16	32	42	34	35
Ice Camp			1		2	1	1	2
Period	07/20~08/10	08/02~08/16	08/04~09/06	08/24~09/01	08/01~08/23	08/01-08/21	08/05-08/21	08/06-08/24

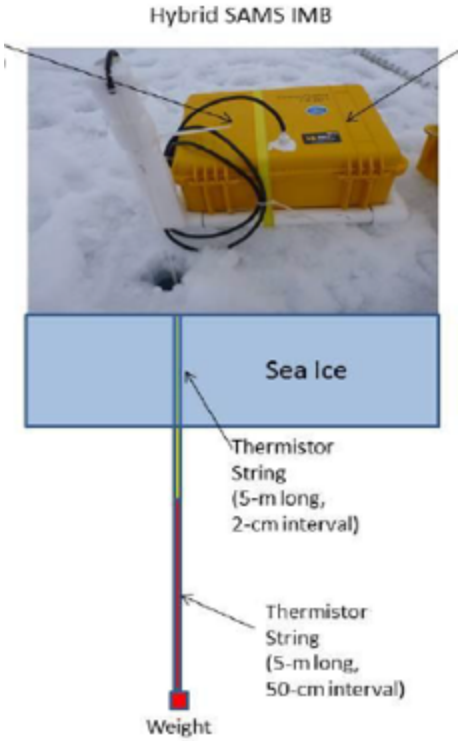
북극해빙관측: 해빙부이

- 관측장비 및 관측항목

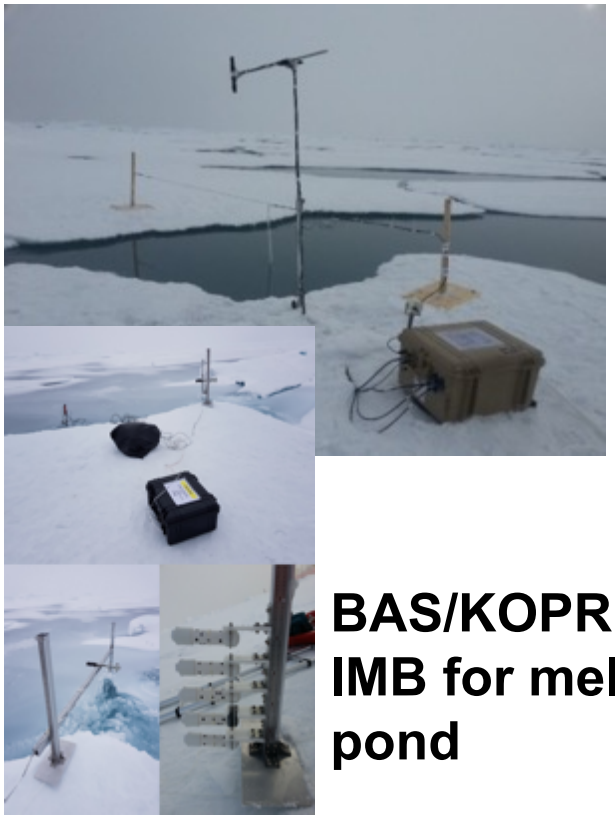
  - IMB (Ice Mass Balance) buoy: 적설량, 해빙내 온도, 해빙하 수온, 기온, 습도, 바람, 위치정보 -> ice mass balance 측정 (CRREL, SAMS, BAS)



CRREL-IMB



SAMS-IMB

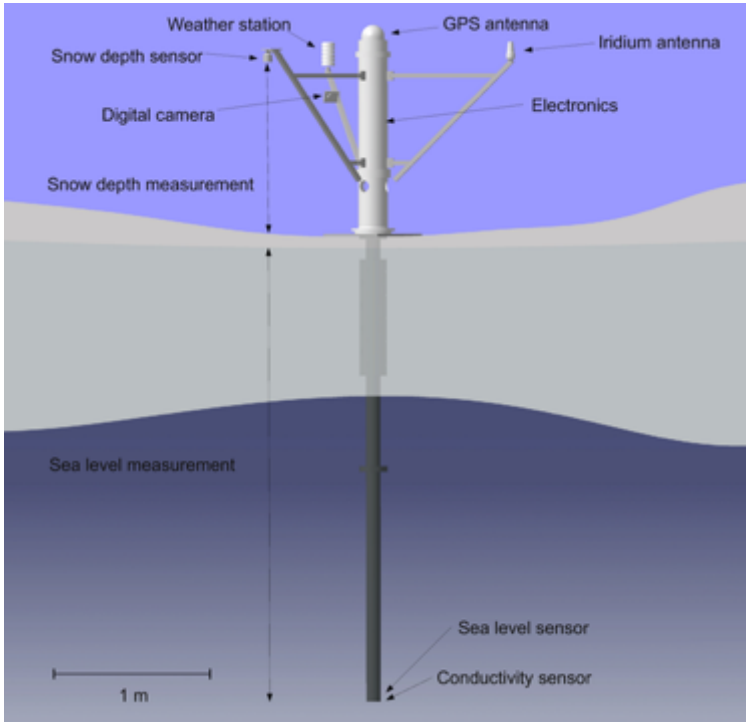


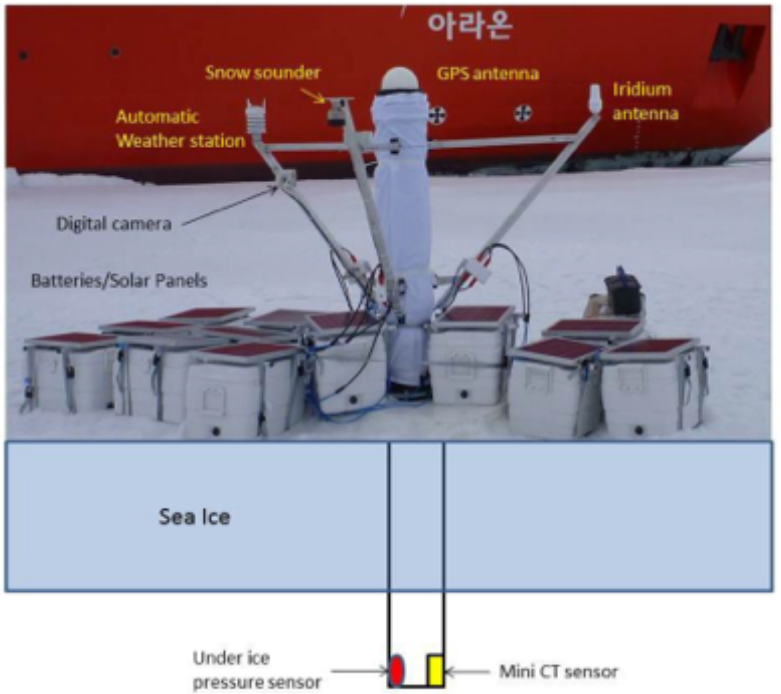
BAS/KOPRI-IMB for melt pond

북극해빙관측: 해빙부이

- 관측장비 및 관측항목

  - SATICE buoy: 적설량, 해류, 수온, 염분, 수위, 위치정보, weather, ice mass balance, 등 (ICM/CSIC, Spain)

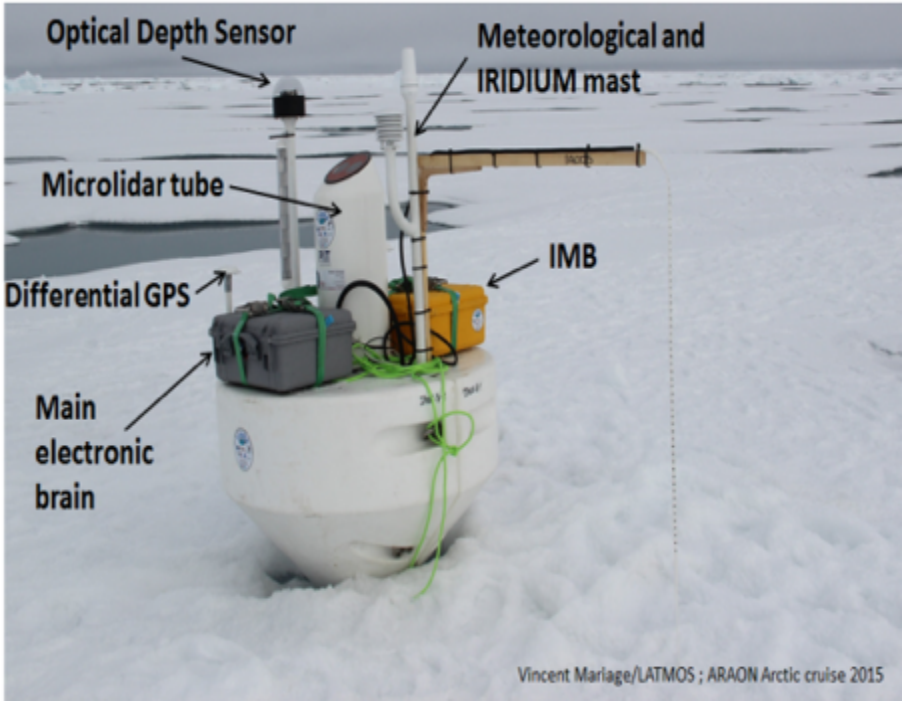




북극해빙관측: 해빙부이

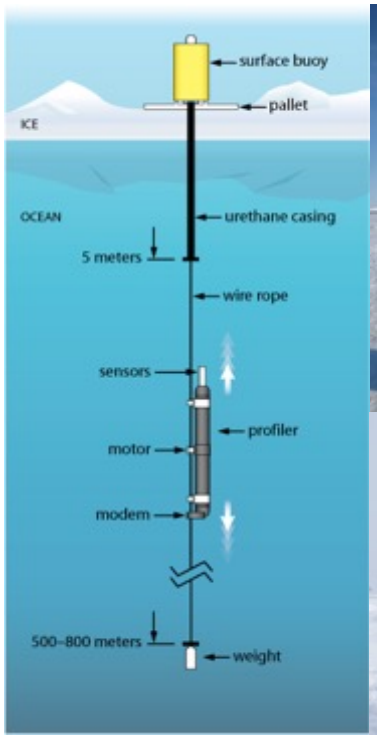
- 관측장비 및 관측항목

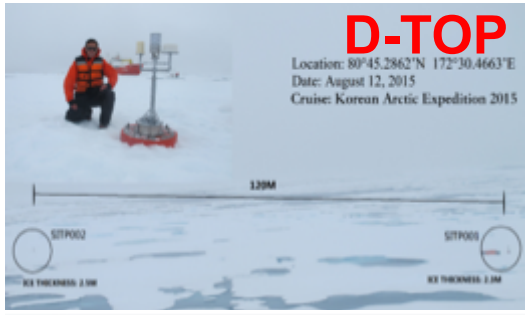
  - IAOOS (Ice-Atmosphere Arctic Ocean Observing System): 수온, 염분, 용존산소, 해빙내 온도, 해빙두께 , 기압, 기온, 운량, 위치정보 등 (UPMC/LOCEAN)



북극해빙관측: 해빙부이

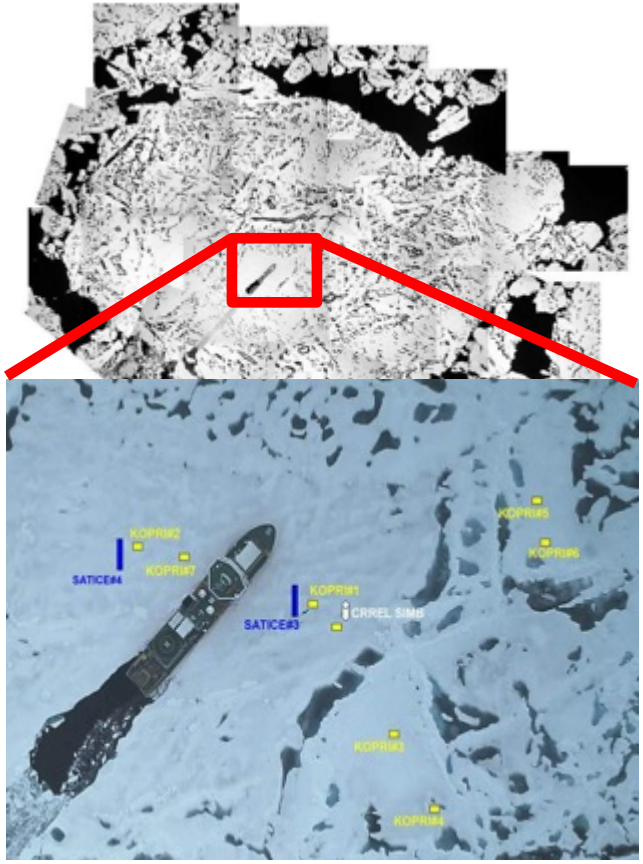
- 관측장비 및 관측항목
  - ITP-V (Ice-Tethered Profiler): 수온, 염분, 해류, 위치정보 등 (WHOI)
  - D-TOP: 수온, 염분, weather, 위치정보 등 (OUC)
  - UpTempO: 수온, 염분, 위치정보 등 (APL/UW)
  - Wave buoy: wave (OBS-VLFR, France)

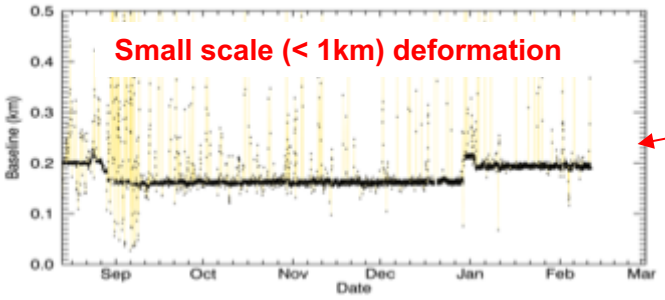


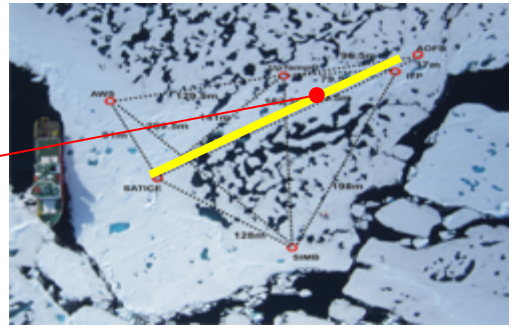


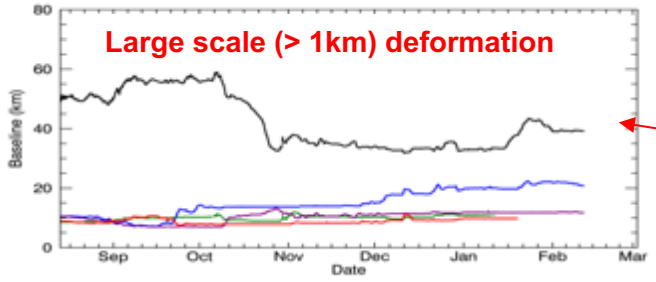
북극해빙관측: 해빙부이

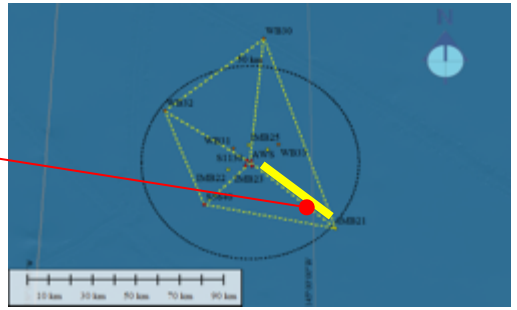
- GPS 정보 이용: 해빙의 시간적 변형 측정





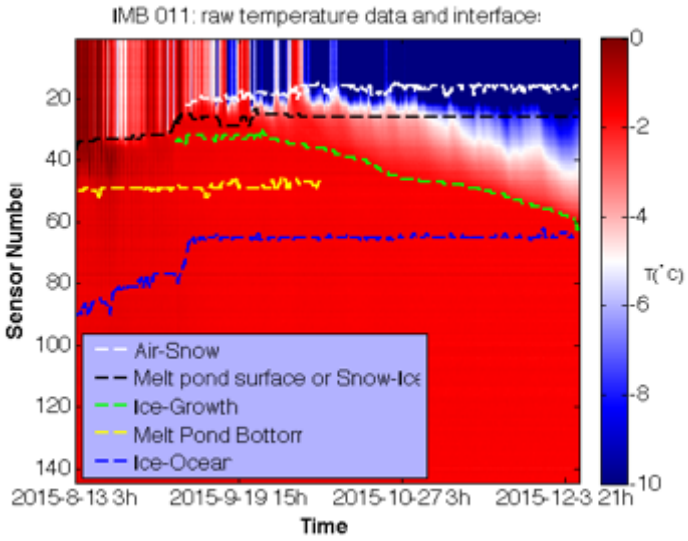


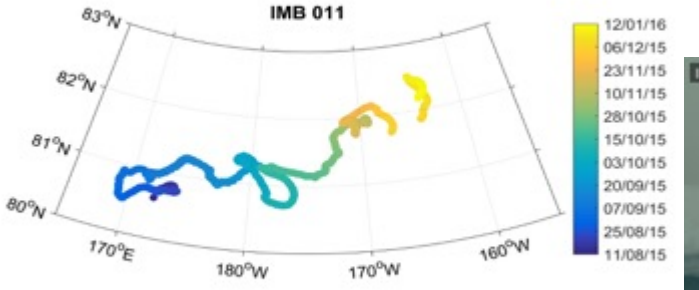




북극해빙관측: 해빙부이

- IMB를 이용한 온도 프로파일, 경계면 탐지, 해빙 이동 추적
- 카메라를 이용한 해빙상 변화 모니터링

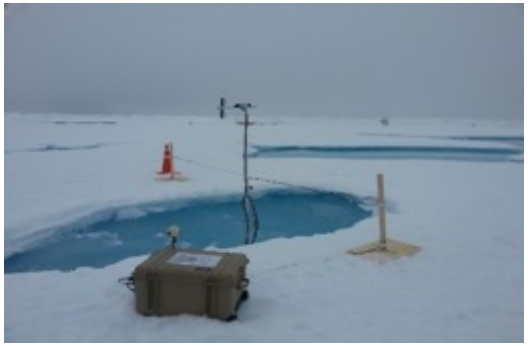




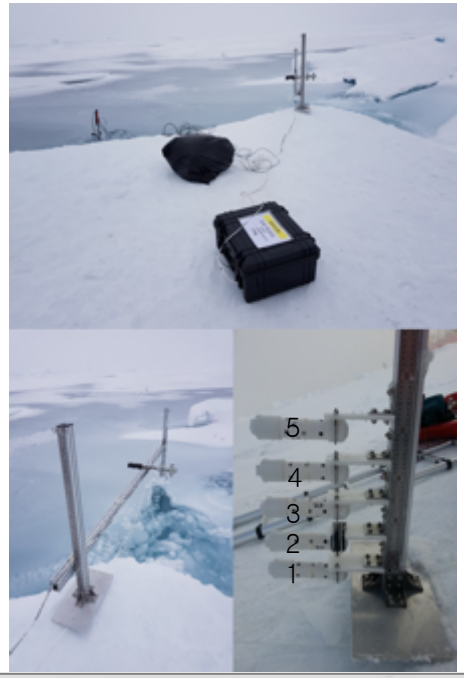
북극해빙관측: 해빙부이

● 2017년 융빙호 IMB 설치: 융빙호 물리특성 관측

IMB 설치

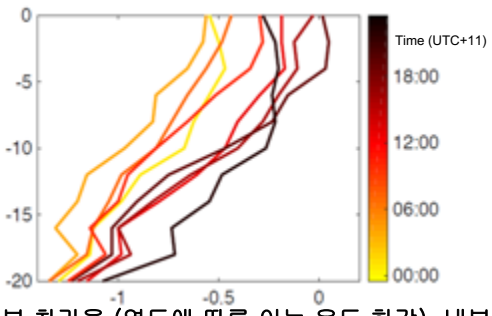


융빙호 관측 시스템 제작



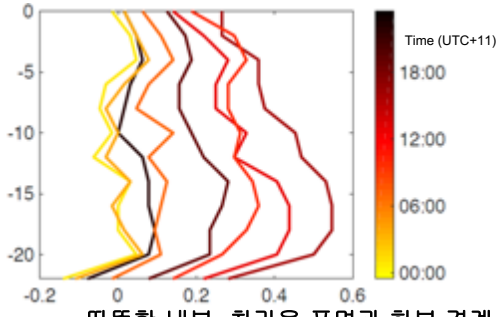
IMB 관측 융빙호 온도 프로파일 비교 (여름철 대기온도 0도 주변일 때)

염수호

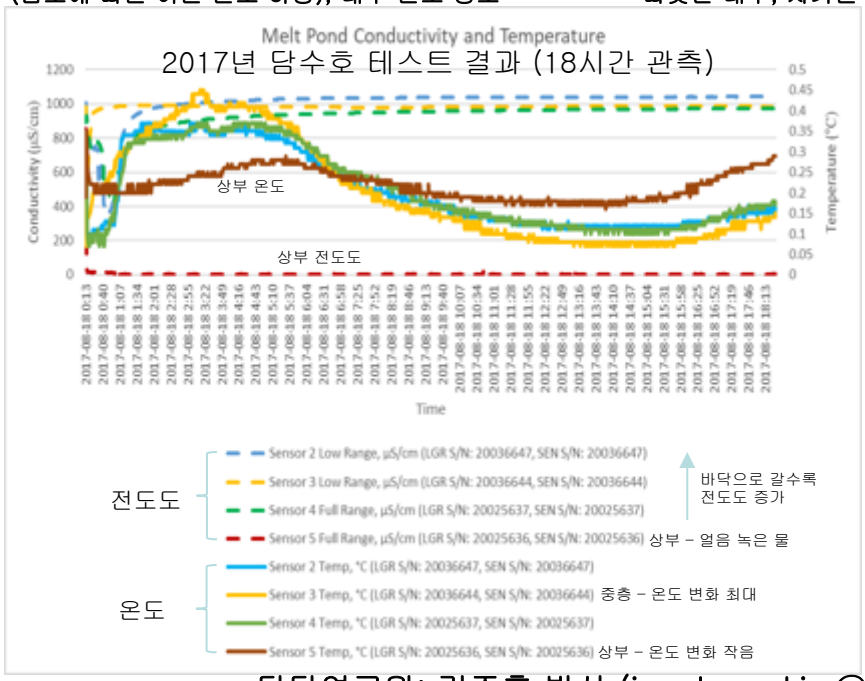


하부 차가움 (염도에 따른 어는 온도 하강), 내부 온도 경도

담수호



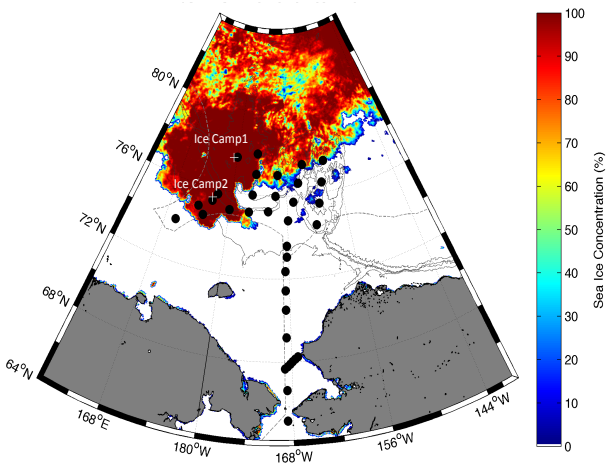
따뜻한 내부, 차가운 표면과 하부 경계



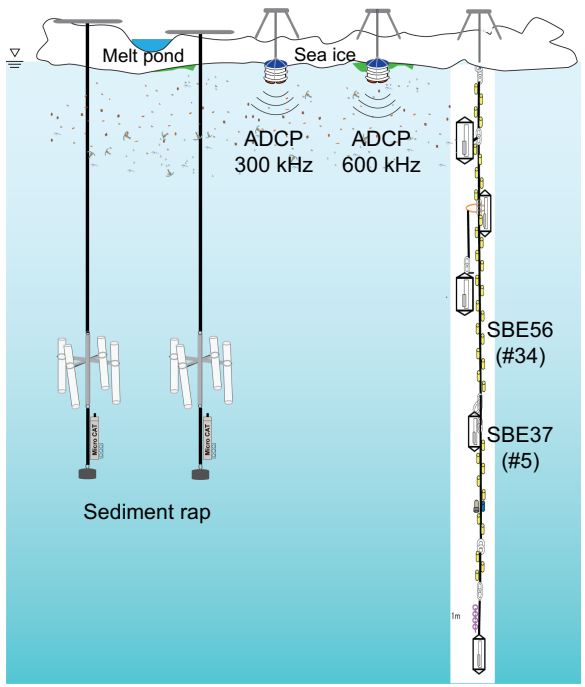
담당연구원: 김주홍 박사 (joo-hong.kim@kopri.re.kr)

북극해빙관측: 해빙무어링

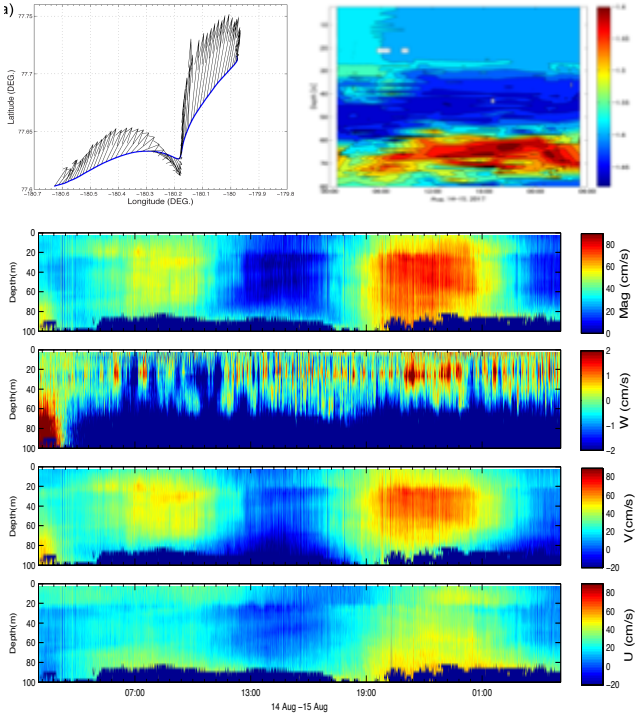
- 해빙무어링 설치
  - 해빙캠프동안 sea ice – upper ocean 간 상호작용 이해
  - 해빙하 표층에서의 성층, 혼합, 관성류 등의 단기간 변화 측정



Ice camp stations on the sea ice concentration



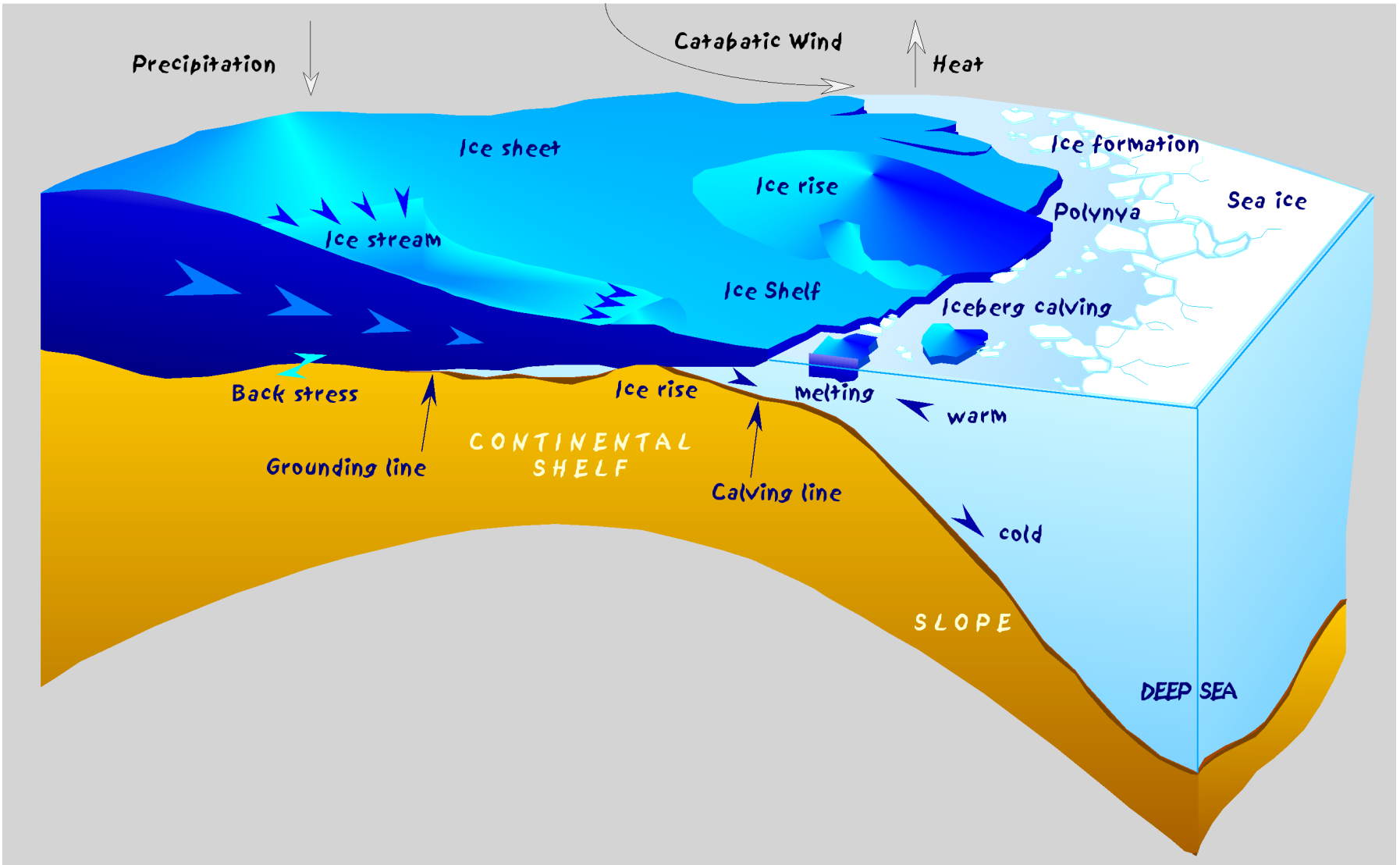
Schematic design of sea ice mooring



Time series of sea ice motion, temperature, and current speed at Ice camp 1

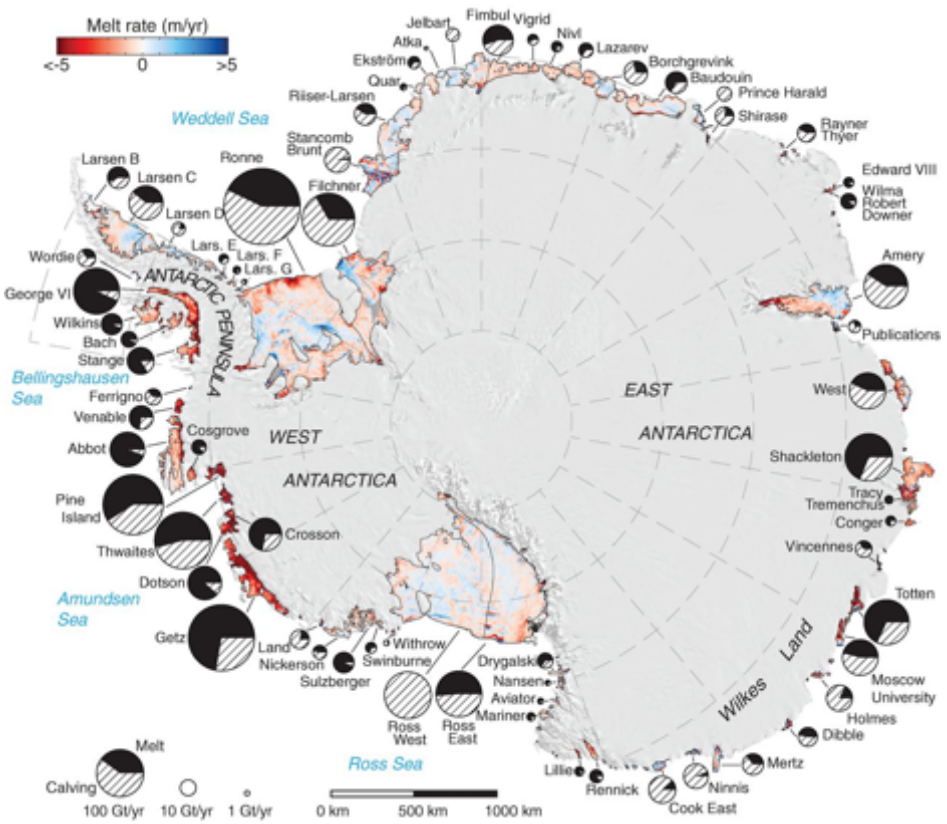
담당연구원: 나형술 박사 (hsla@kopri.re.kr)

아문젠해 빙붕관측

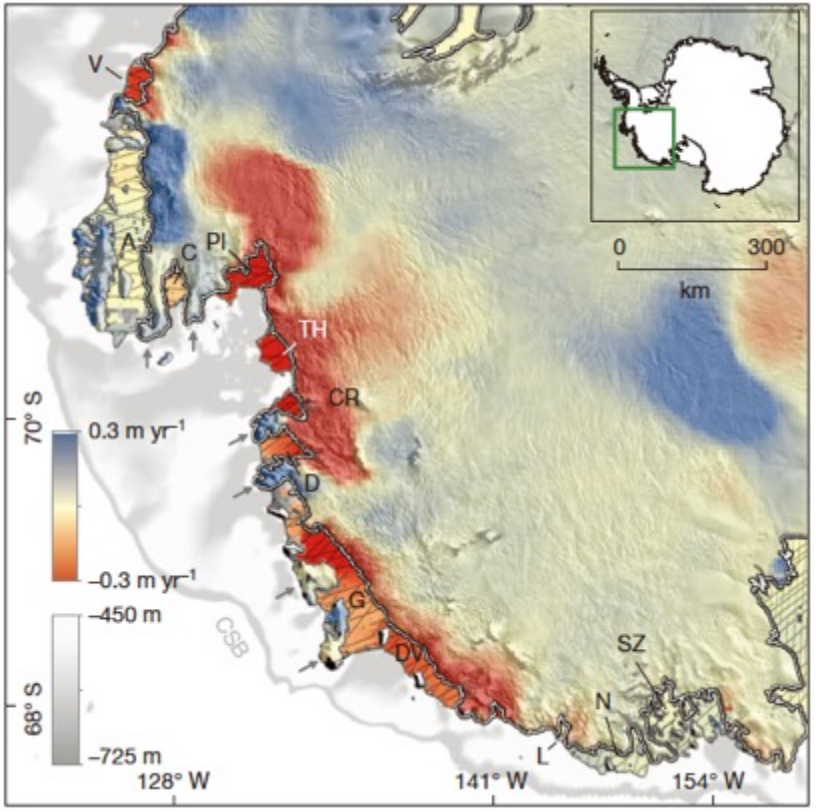


From Wikipedia: Designed by Hannes Grobe (AWI, Germany)

아문젠해 빙붕관측: 빙붕 저면 융빙율 증가



Basal melt rate (Rignot et al., 2013)



Basal melt rate and ice-sheet loss (Pritchard et al., 2012)

위성관측의 한계성 극복하고 빙붕 후퇴와 해양-빙붕 간 상호작용에 따른 해양환경 변화를 이해하기 위해 현장 관측 수행

아문젠해 빙붕관측: NECKLACE

SOOS SOUTHERN OCEAN OBSERVING SYSTEM

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Ice Shelf Melt Observations

The NECKLACE Initiative: NEtwork for the Collection of Knowledge on meLt of Antarctic iCe shElves

NECKLACE is a SOOS-endorsed, international initiative led by the British Antarctic Survey to coordinate the collection of ice-shelf melt observations from around Antarctica using newly developed cheap, easily deployed Auto-phase-sensitive Radio Echo Sounding instruments. The time series of melt rates from point locations will complement the satellite-derived maps of spatially-smoothed time-averaged melt rates that are now becoming available, and will be a valuable source of data for assimilation into, or validation of, models of the interaction between the Southern Ocean and the Antarctic Ice Sheet. Click here for more information on this initiative.

SOOS is currently working with the NECKLACE community to provide NECKLACE data. Please contact the SOOS data officer for information on data availability. For information on the instrument or how to contribute to this initiative, please contact NECKLACE leader Keith Nicholls. If you have an ApRES location to add to this map, please contact the SOOS data officer.

Click on the points in the map below to find deployment and data archive details about NECKLACE sensors. The data in this map are partial and will be regularly updated as we improve our knowledge of extant and historic NECKLACE sensors.

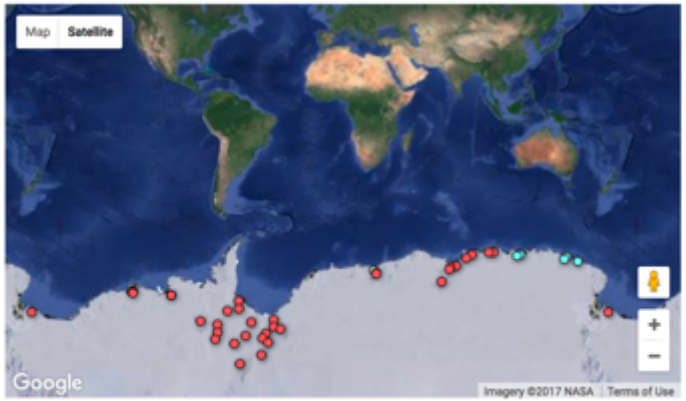

Fig. 1. Map of Southern Ocean NECKLACE locations. Red = currently deployed, yellow = retrieved, turquoise = planned.

If you wish to edit the tabular data underlying this map, please click here. To view a full-screen version of the map, click here. And if you can help us improve the information in the map and table, please contact the SOOS data officer.

ACTIVITIES

- Implementation Plan
- System Design
- Regional Working Groups
  - WAP
  - Indian Sector
  - Ross Sea
- Capability Working Groups
  - CAPS
  - SOFLUX
  - eEOVs
  - OASIS
- Task Teams
- SOOS at Sea
  - Progress
  - Moorings
  - NECKLACE
  - DueSouth
- SOOS Endorsement
- Calendar

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- Get Involved
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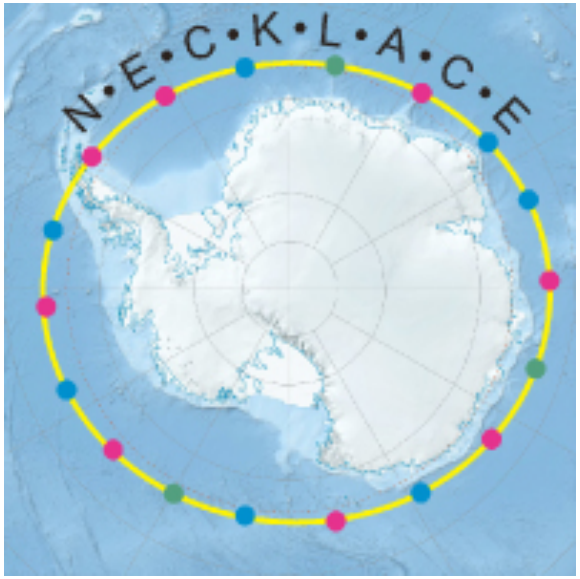
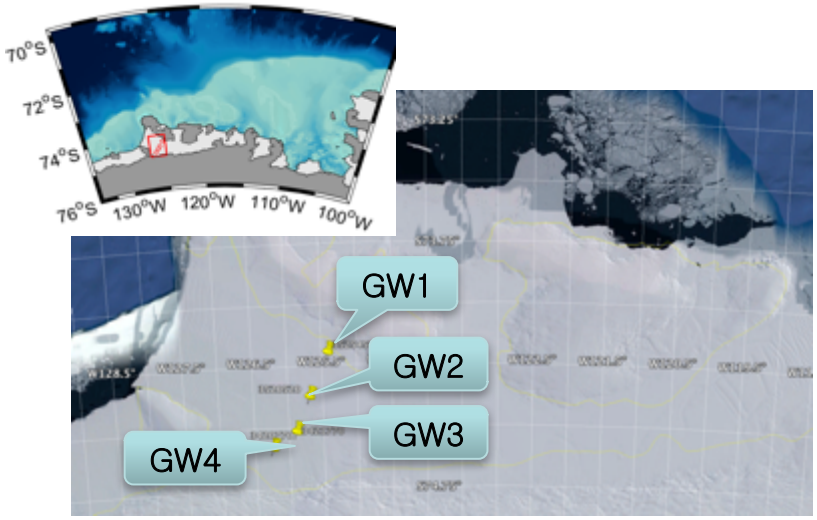
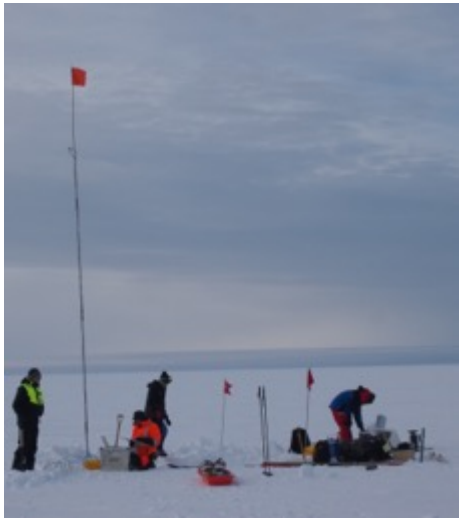


Autonomous phase-sensitive Radio Echo Sounding (ApRES)

아문젠해 빙붕관측

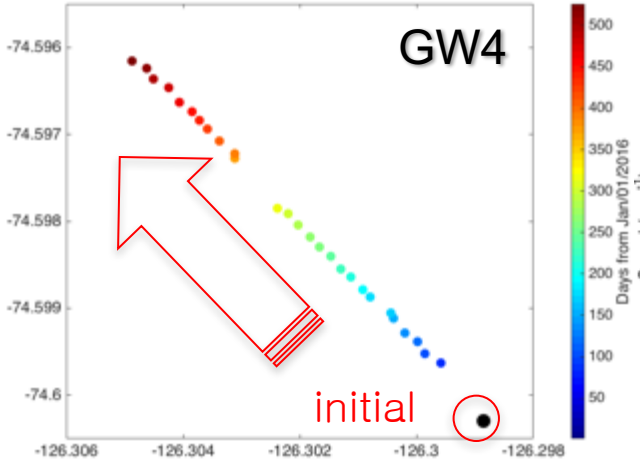
- 관측장비 및 관측항목
  - ApRES radar: basal melt rate, 빙붕 이동 속도

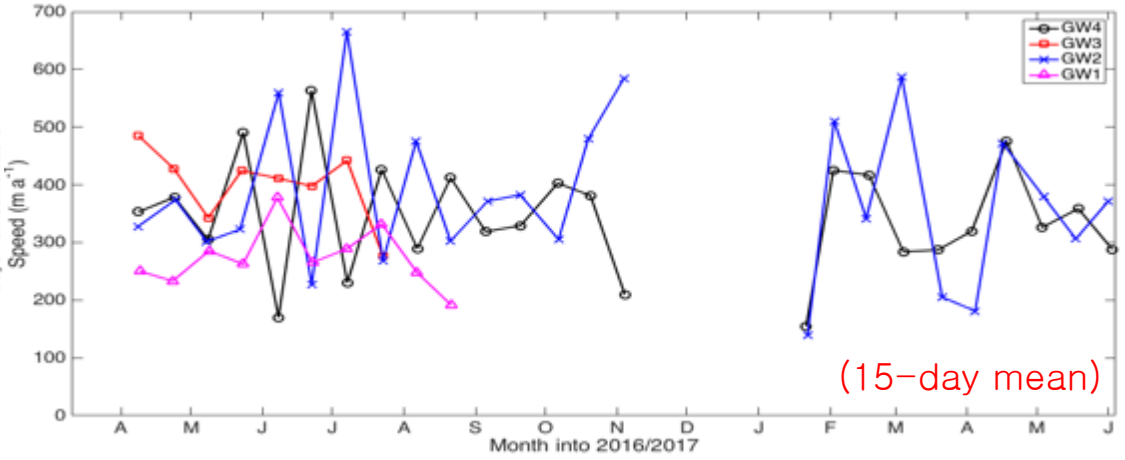


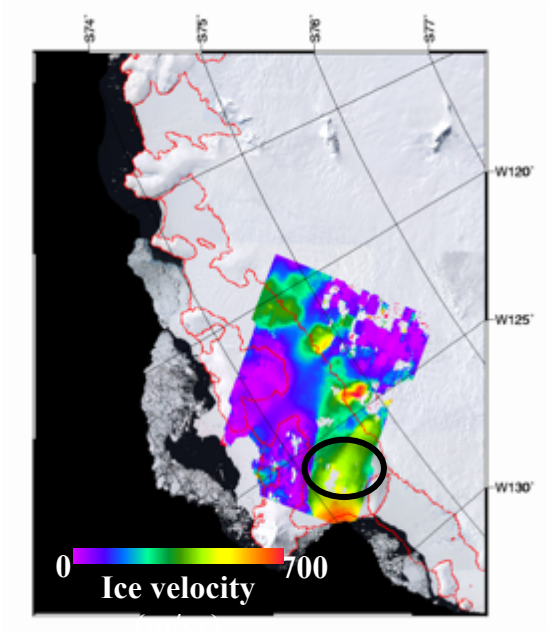


2015/2016 아문젠해 현장조사 기간 동안 western Getz Ice Shelf 위에 4대의 ApRES 설치

아문젠해 빙붕관측

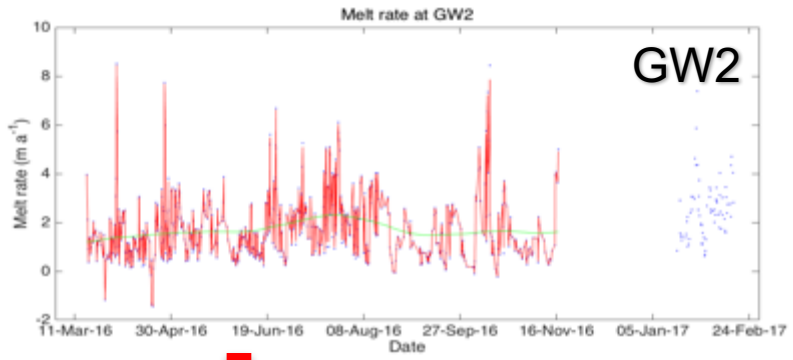


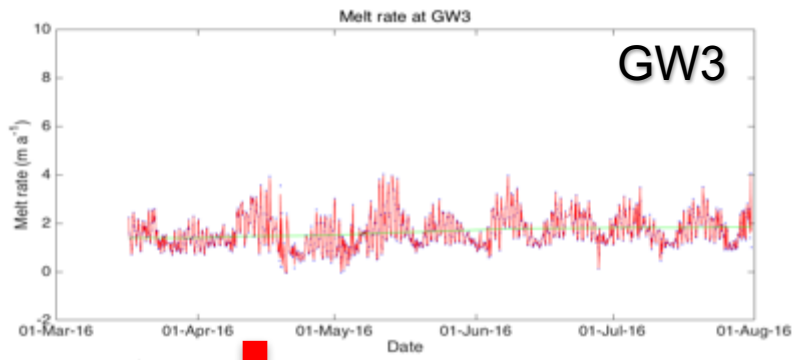


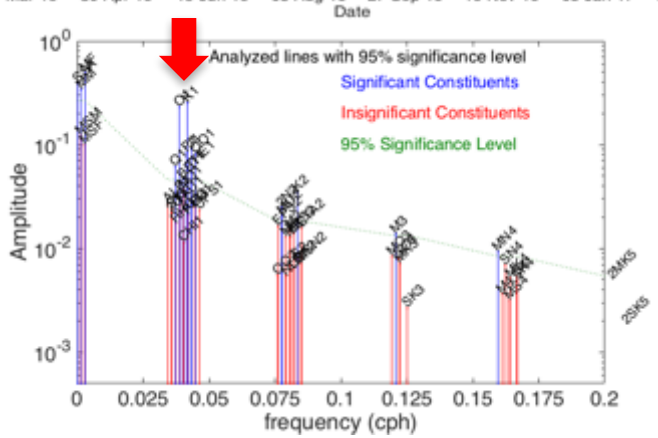


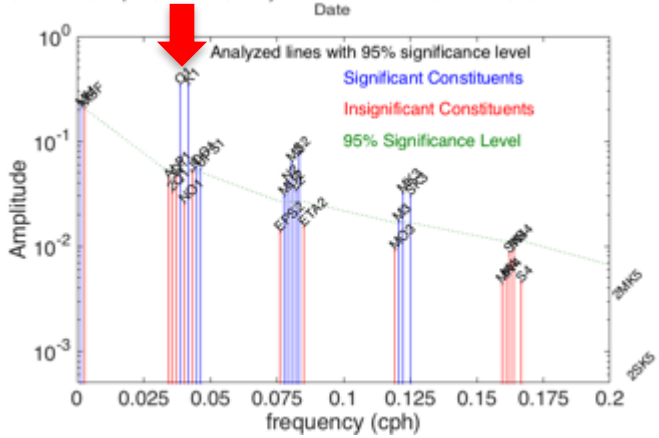
- 빙붕 이동 (확장) 방향은 북서쪽 (downstream)
- 빙붕 이동 (확장) 속도는 대략 350 m a^{-1} 정도
- GW2과 GW4: out of phase (겨울), in phase (여름)
- 2017년 6월 Sentinel-1 SAR로 추정한 속도와 비슷

아문젠해 빙붕관측









- **Basal melt rates calculated from ice-shelf thinning rate and offset by strain rate**
- **Strong tidal frequency: diurnal, semidiurnal, and spring-neap signals**
- **GW2, GW3: O1 and K1 tidal constituents are significant – tidal mean current might be dominant following the main channel**

요약

- 극지연구소에서는 아라온을 활용하여 극해역 해빙 (서북극해)과 빙붕 (서남극 아문젠해) 현장관측을 활발하게 수행하고 있음
- 해빙부이와 빙붕레이다에 GPS와 Iridium 센서를 부착하여 실시간 현장 자료를 취득하고 있음
- 비교적 저렴한 비용으로 장기간 해빙 및 빙붕의 변동성을 자동적으로 관측함
- 국제협력을 통하여 국제공동 프로젝트 참여 및 고도의 해빙 및 빙붕 현장관측 기술 습득함

사사

- **Marginal Ice Zone team**
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  - Jeremy Wilkins, Lovro Valcic (BAS, UK)
  - Craig Lee, Mike Steel (APL/UW, USA)
  - Martin Doble (OBS-VLFR, France)
  - Tim Stanton (NPS, USA)
  - John Toole, Rick Krishfield (WHOI, USA)
  - Christine Provost, M. Labaste, S. Gouellain (UPMC/LOCEAN, France)
  - Oriol S. Garcia, Manual Dall'Osto (ICM/CSIC, Spain)
  - Jinping Zhao, Xupeng Ji (OUC, China)

- **Amundsen ice-shelf team**
  - Keith Nicholls (BAS, UK)
  - Povl Abrahamsen (BAS, UK)
  - Anna Wåhlin (GU, Sweden)
  - Karen Assmann (GU, Sweden)
  - Elin D. Chiche, (UiB, Norway)

** 극해역 해빙 및 빙붕 현장관측 연구는 해수부 수탁사업인 "북극해 환경변화 통합관측 및 활용연구 (PM17040)" 과제와 극지연구소 주요사업인 "아문젠 빙붕 소멸 속도와 해양변동 추세연구 (PE17060)" 과제로 수행되었습니다.*

아문젠해 빙붕관측

- 관측장비 및 관측항목
  - GT-1A kinematic gravimeter: 빙붕하 해저지형, 자기력

GT1a Sensor and restraint cage

GT-1A installed aboard AS-350B onboard RVIB Araon.

Base station GPS receiver and antenna installed on Compass Deck of RV Araon during gravity data acquisition flights.

GPS antenna for the GT-1A while the AS350 was hangered. The rigid framed backpack strapped to the helo deck proved to be adequate as an antenna

GT1a Power electronics and GPS receiver