

# Korea Country Report

Sung-Ho Kang

Member, PAG Executive Committee

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Korea Polar Research Institute (KOPRI), Incheon, Korea

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Seattle, USA



<http://pag.arcticportal.org/>

# 2017 Korean Arctic Ocean Expedition (70 days)



2017 expedition periods: from 21st July to 29th September (Incheon-Nome-Barrow-Busan)

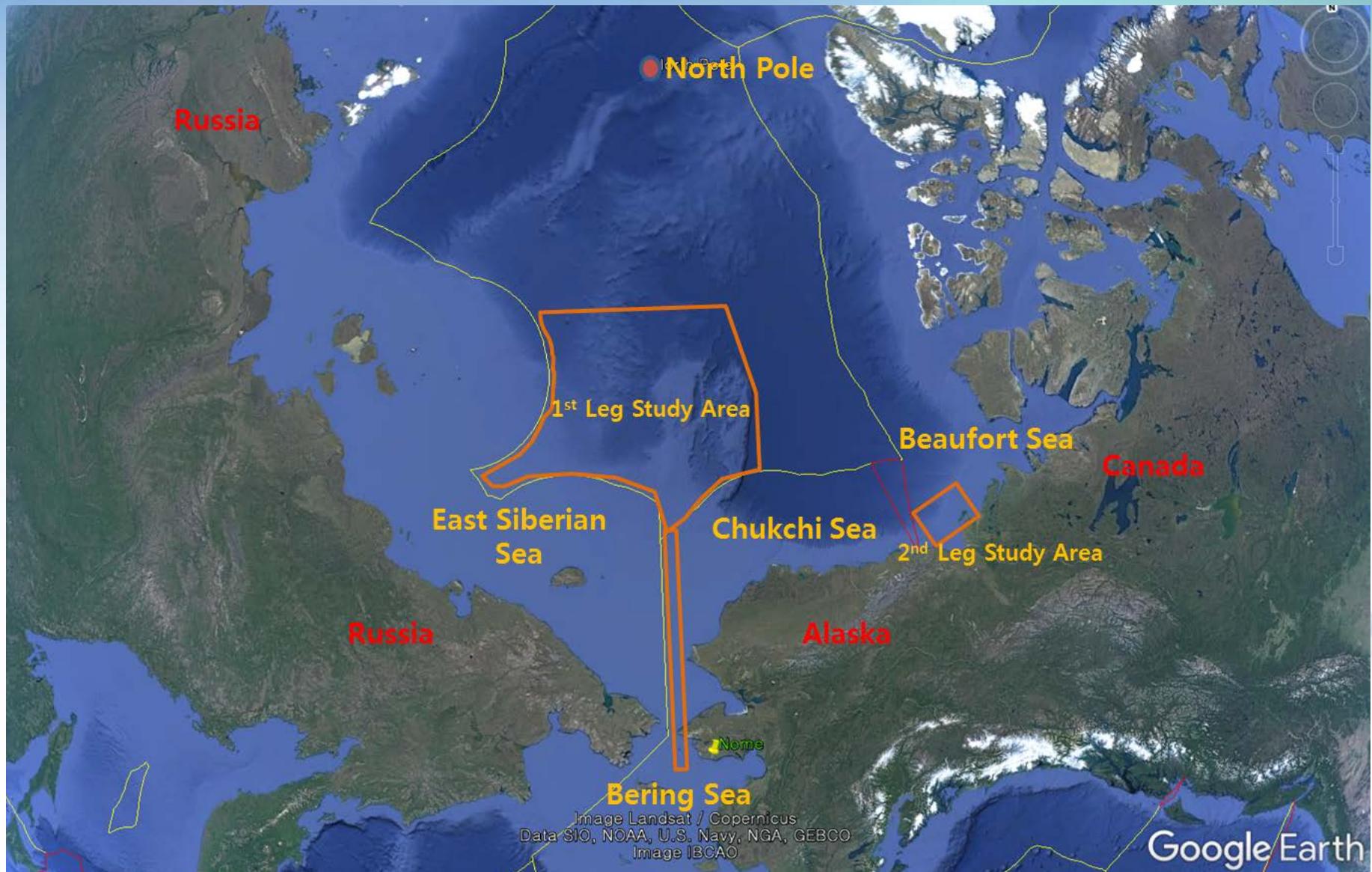


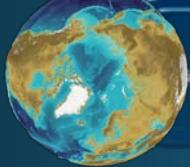
# 2017 KOPRI Arctic Research activity

First Leg: 2017. 8. 6 ~ 8. 25

Second Leg: 2017. 8.27 ~ 9.16

Sea ice-covered area in the Pacific Central Arctic Ocean (CAO) is a major study site of the Korean Arctic program, regularly visited by its flagship and an icebreaker, Araon.



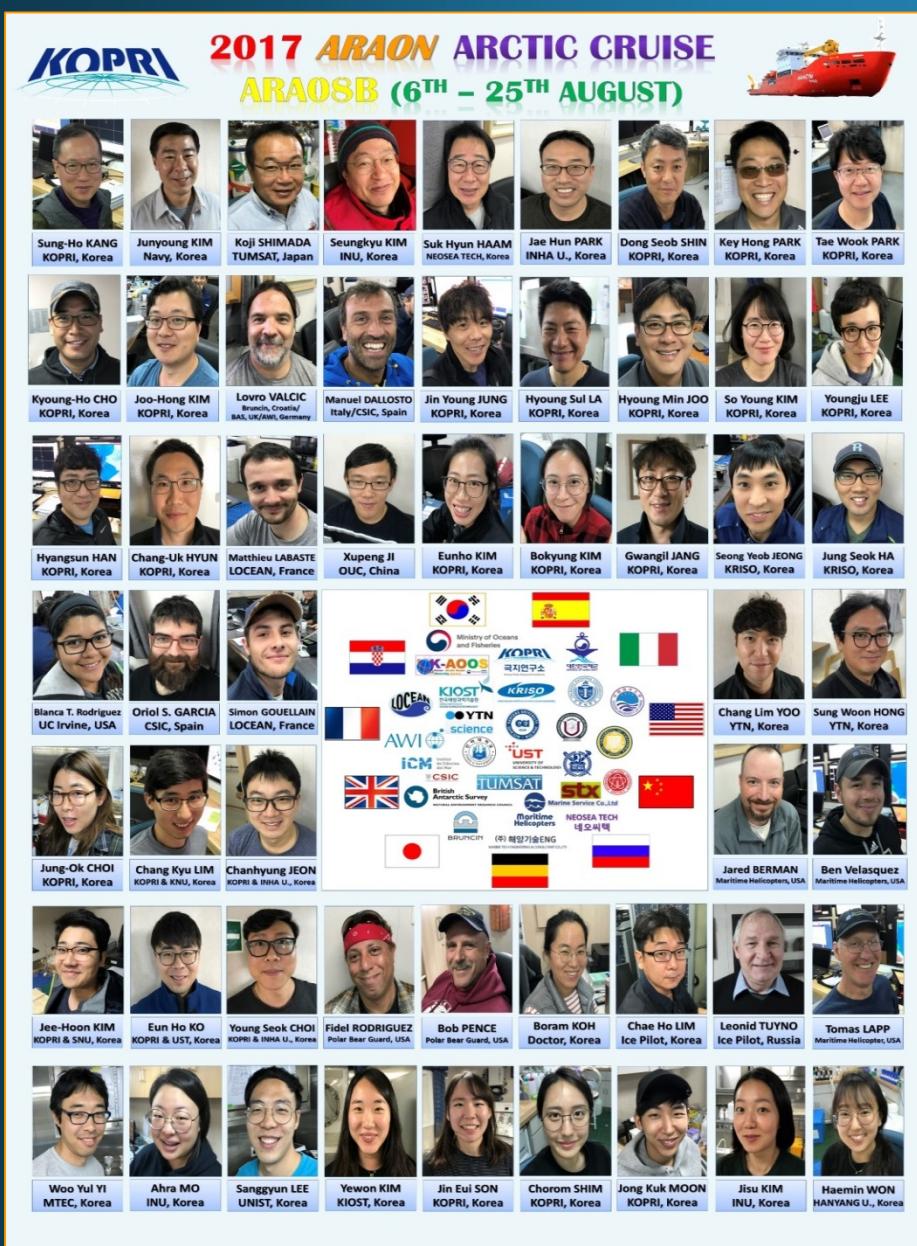


# 2017 KOPRI Arctic Cruise (1<sup>st</sup> leg)

- Ocean-Sea Ice-Atmosphere Integrated Observations  
(Bering/Chukchi/East Siberian Seas of Pacific CAO)
- Aims of the cruise:
  - To identify key environmental parameters (physical and biogeochemical) in rapid transition due to the sea-ice decrease in the Pacific Central Arctic Ocean (CAO) and predict environmental change patterns.
  - To understand sea ice dynamics and sea ice ecosystem
- Period: 2017. 8.6 - 8.25 (from Nome to Barrow)
- Chief Scientists: Sung-Ho Kang ([shkang@kopri.re.kr](mailto:shkang@kopri.re.kr))
- Participating nations: Korea, USA, Japan, China, France, Spain, UK, Germany, Italy, Croatia, Russia (11 Countries, 52 Scientists)



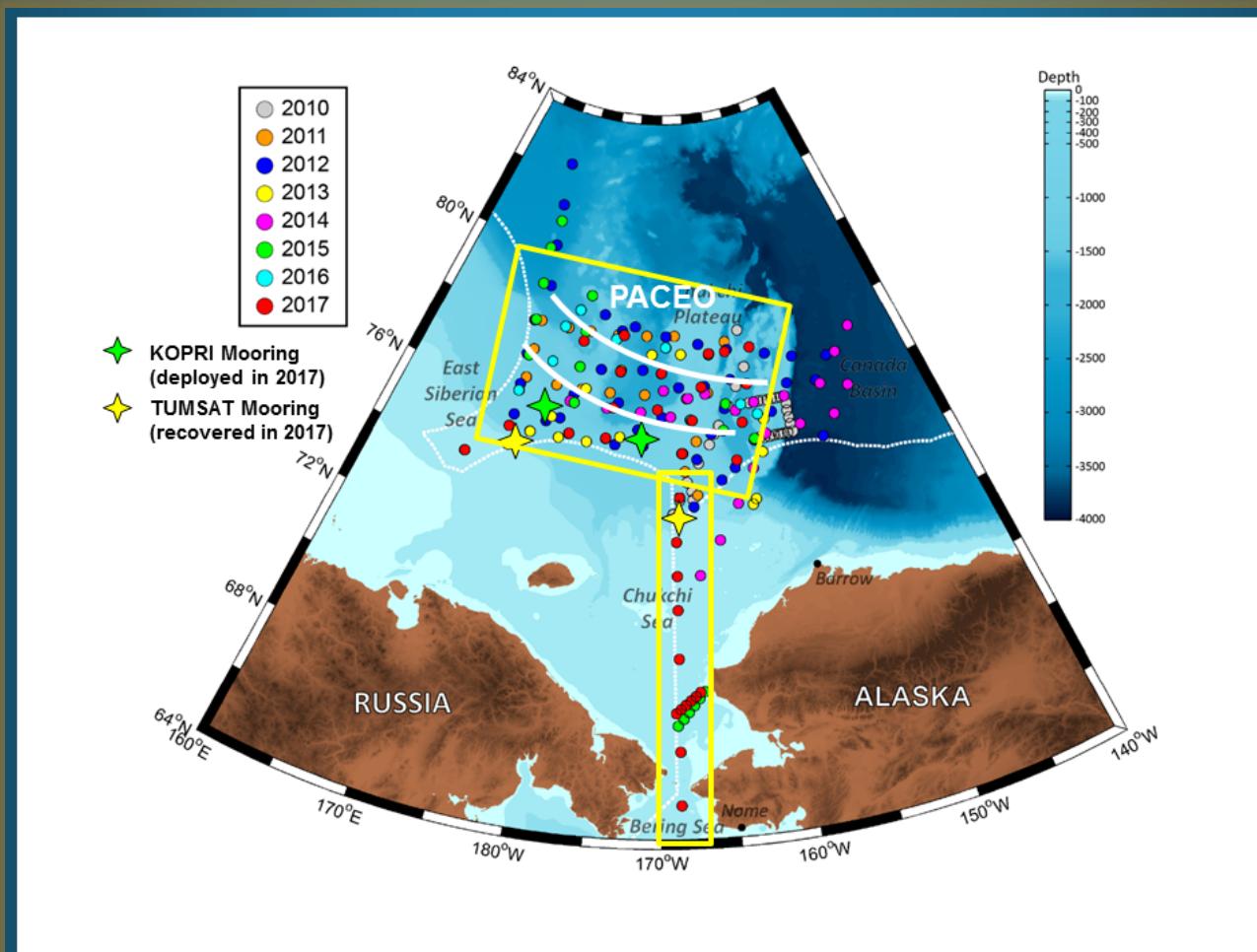
*The 8<sup>th</sup> Araon Arctic Cruise – 2017 Arctic survey (1<sup>st</sup> Leg, ARA08B)*



Total 11 countries, 25 institutes, 52 scientists

Providing a platform of international cooperation, welcoming numerous foreign scientists on board, providing instrument deployment opportunities and accommodating the ongoing and planned research initiatives.

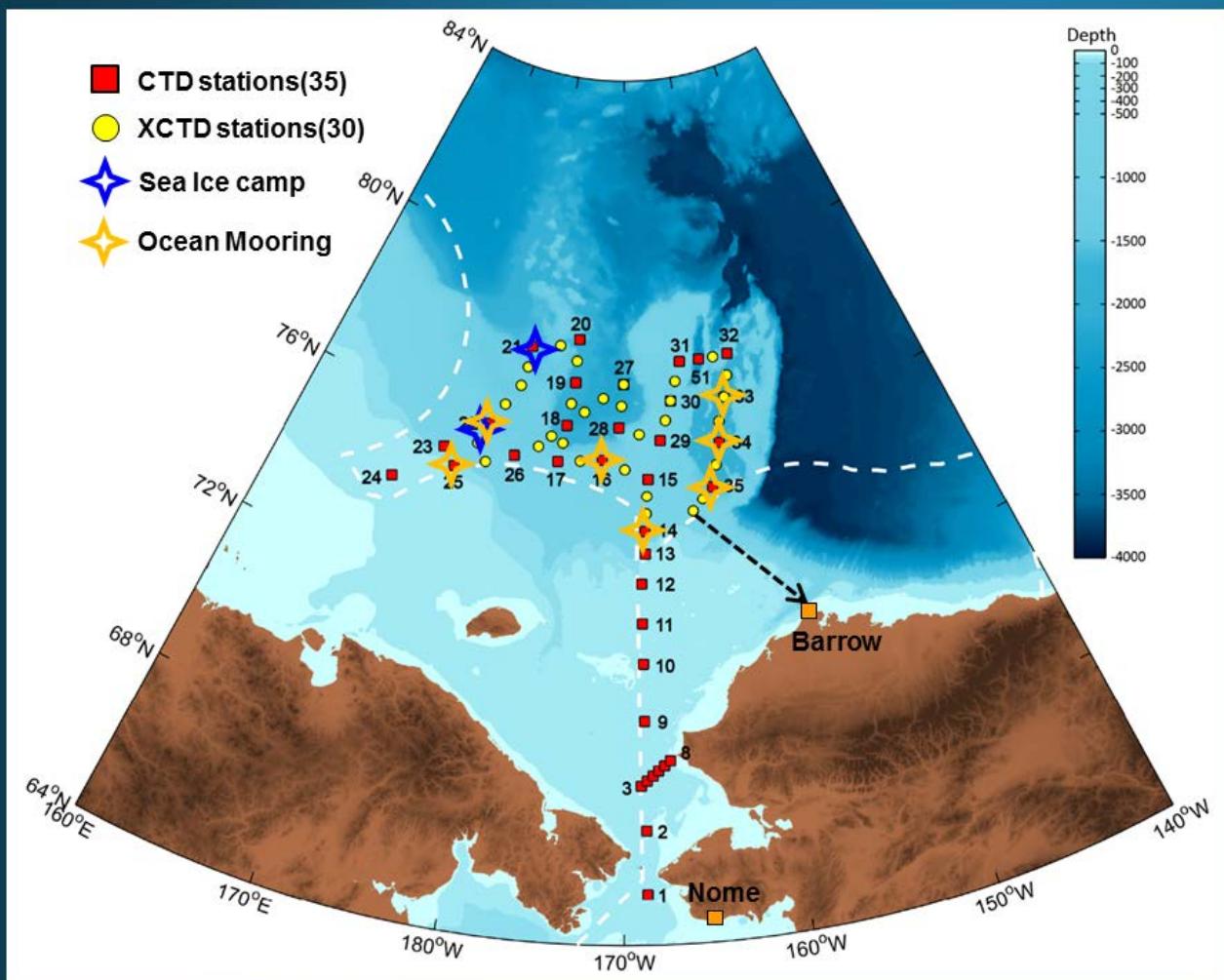
# IB R/V ARAON Arctic Cruises (2010~2017)



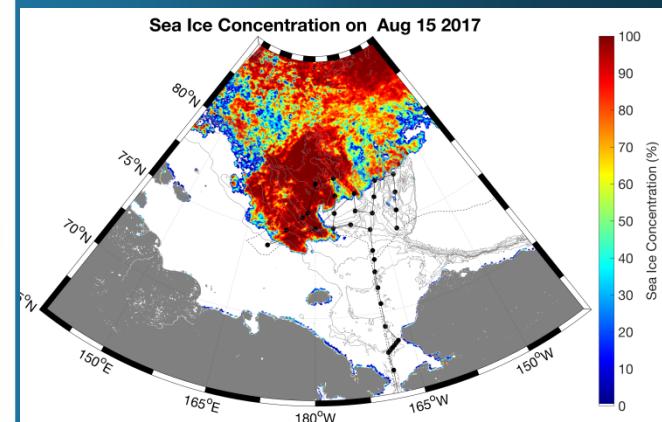
	2010	2011	2012	2013	2014	2015	2016	2017
CTD	38	18	44	16	32	42	34	35
XCTD	*	33	48	36	51	61	38	30
Period	07/20~08/10	08/02~08/16	08/04~09/06	08/24~09/01	08/01~08/23	08/01~08/21	08/05~08/21	08/06~08/24

# 2017 Arctic Survey

## 1<sup>st</sup> Leg (ocean-sea ice-atmosphere)



- Northern Bering Sea to Southern Chukchi Sea (DBO 3)
- Chukchi shelf
- Chukchi Borderland to East Siberian Sea
- 2 Sea Ice stations



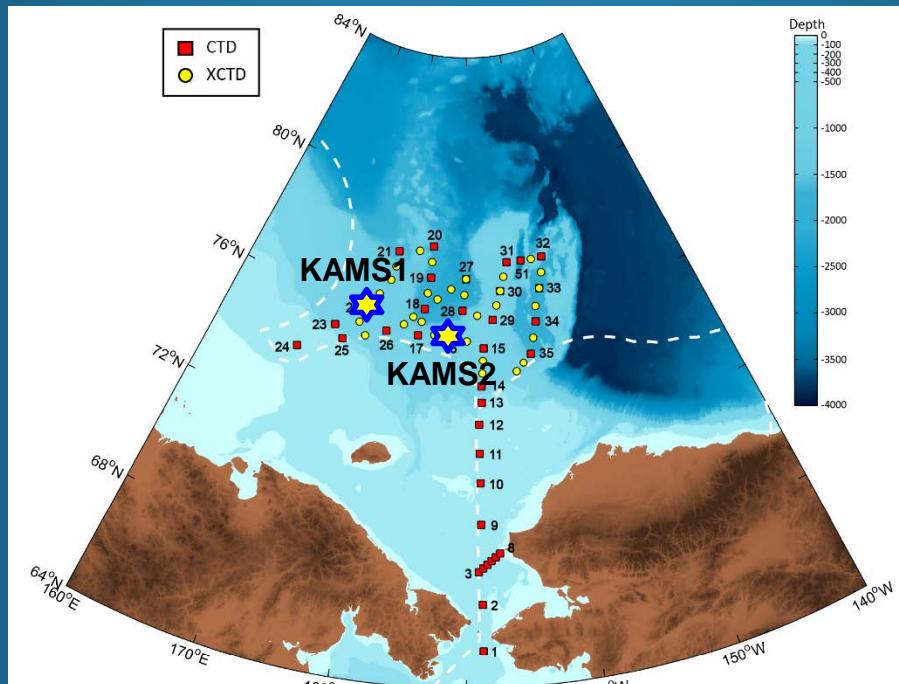
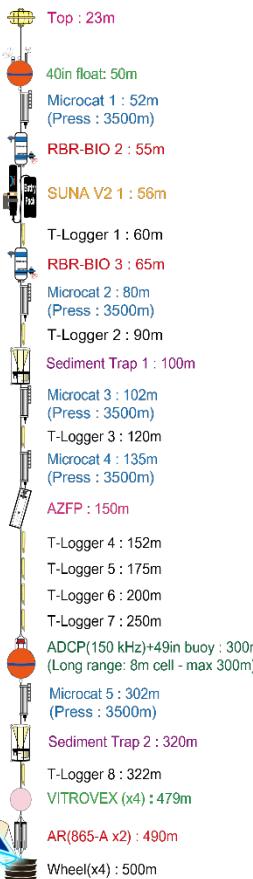
- Objective: to investigate the variation of water mass distribution around the Chukchi Borderland to East Siberian Sea
- Equipment: CTD, XCTD, Lowered ADCP, ocean mooring system
- Measurement: S, T, water velocity, pressure, ice properties
- Hydrographic Survey (multi-beam, ship-borne ADCP, EK60, ...)
- Ocean buoy: D-TOP (from Ocean Univ. of China)



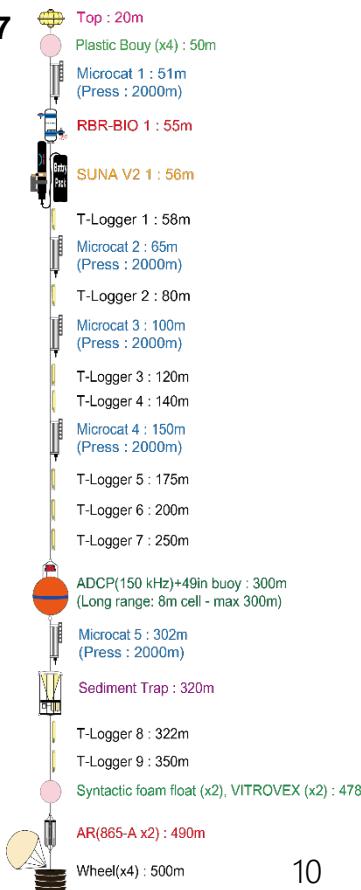
## KOPRI ocean mooring system

- Objective: to monitor the long-term variation of marine environment
- Mooring sites: East Siberian Sea (KAMS1) and Chukchi Sea (KAMS2)
- Equipment: ADCP (150, 300 kHz), microCAT CTD, temperature logger, sediment trap, AZFP, UV nitrate sensor (SUNA V2), Fluorescence & PAR sensors, ULS, hydrophone

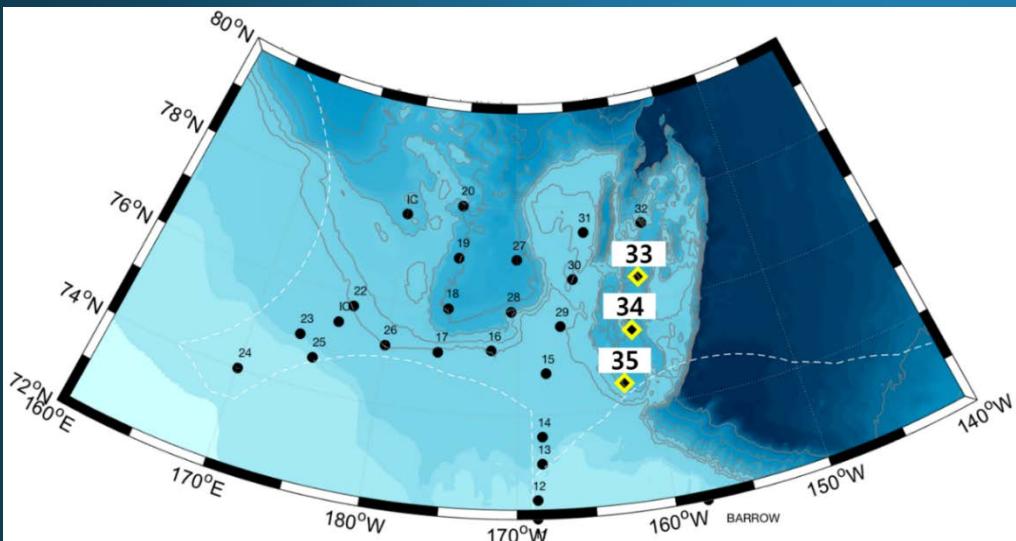
KAMS1-17



KAMS2-17

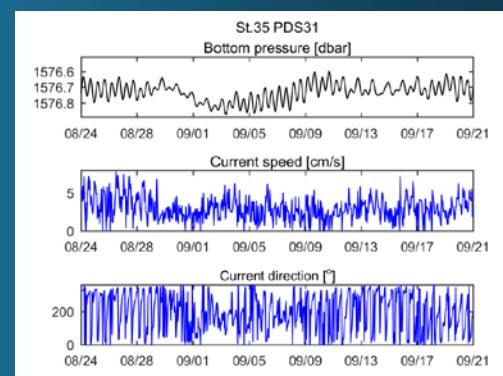
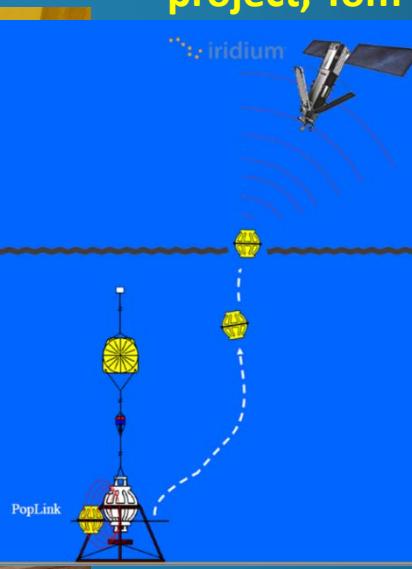


## PDS-CPIES deployment at 3 sites



Jae-Hun PARK ([jaehunpark@inha.ac.kr](mailto:jaehunpark@inha.ac.kr))

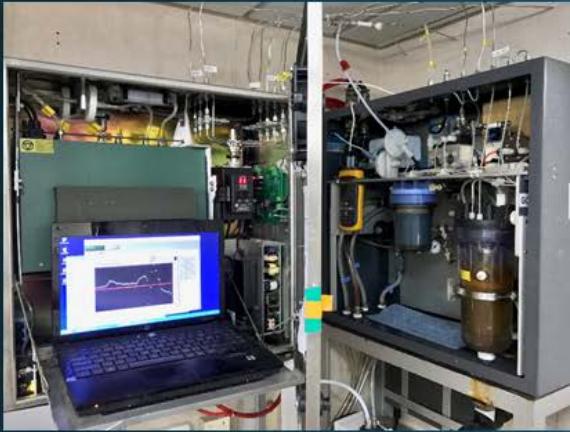
- PDS-CPIES: Pop-up Data Shuttle Current and Pressure-recording Inverted Echo Souder
- Measuring acoustic echo time from the bottom to the surface, near-bottom current speed, direction and pressure every hour until summer 2020
- A part of US ONR-funded Stratified Ocean Dynamics in the Arctic (SODA) project, Tom Peacock ([tomp@mit.edu](mailto:tomp@mit.edu))



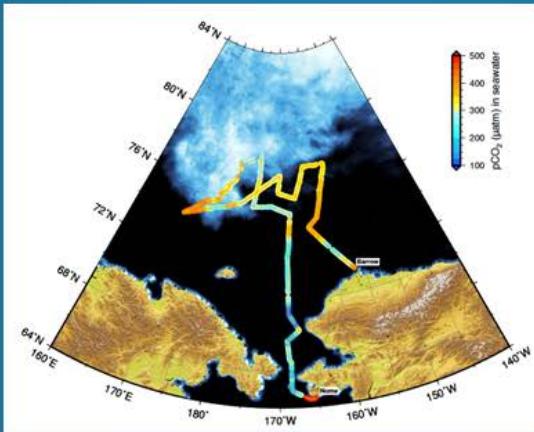
## Inorganic Carbon System and Gas measurement

Keyhong PARK ([keyhongpark@kopri.re.kr](mailto:keyhongpark@kopri.re.kr))

- Pursuing spatial and temporal variation of  $p\text{CO}_2$  system in the Arctic Ocean



Continuous observation system of  $p\text{CO}_2$



Dissolved  $\text{CO}_2$  along the track

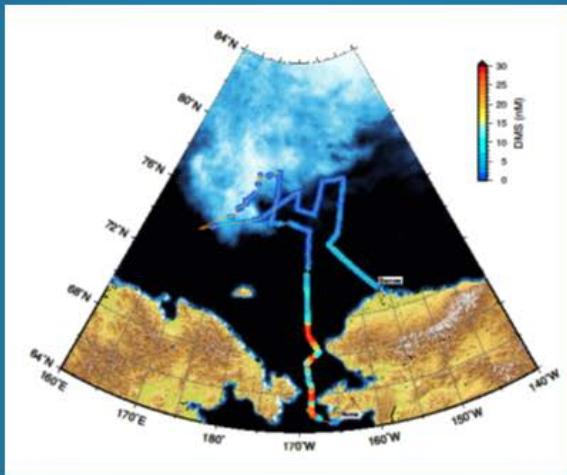


Seawater sampling for DIC and TA

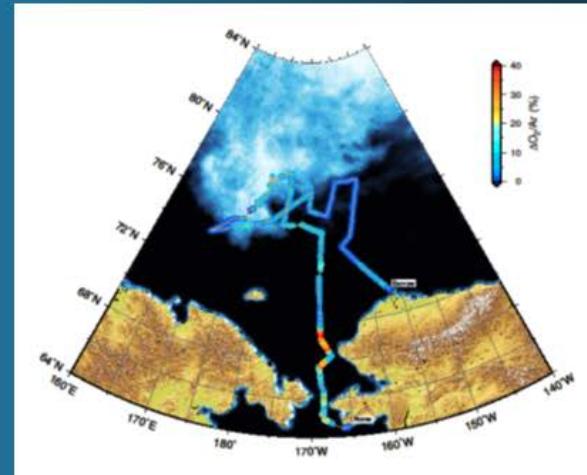
- Net community production(NCP) and DMS using MIMS(Membrane-inlet Mass Spectrometry)



Continuous observation system of NCP and DMS



Dissolved DMS along the track

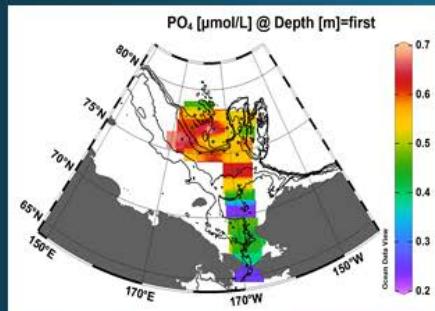


Dissolved  $\text{O}_2/\text{Ar}$  along the track

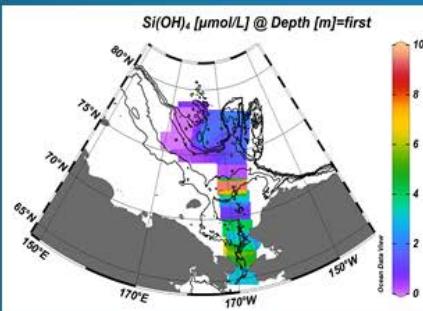
## Nutrients and organic carbon

Jinyoung JUNG ([jinyoungjung@kopri.re.kr](mailto:jinyoungjung@kopri.re.kr))

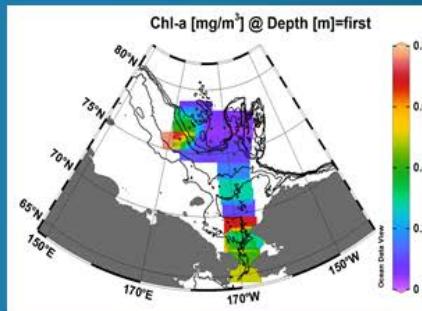
- Distribution and behavior of nutrients ( $\text{NH}_4$ ,  $\text{NO}_2 + \text{NO}_3$ ,  $\text{PO}_4$  and  $\text{SiO}_2$ )
- Comparison with biological variables



Spatial distribution of  $\text{PO}_4$



Spatial distribution of  $\text{Si}(\text{OH})_4$

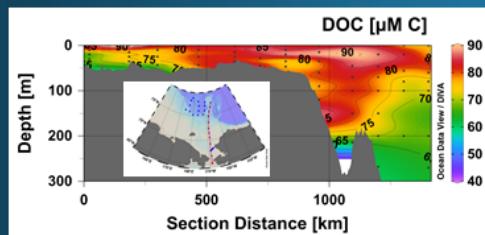


Spatial distribution of chl-a

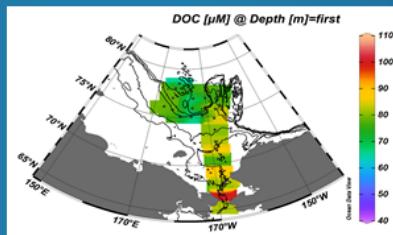


Seawater auto analyzer

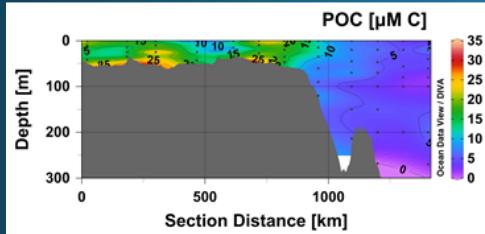
- Characteristics of dissolved and particulate organic matters (DOM and POM)
- Variability of DOM and POM associated with biological activities



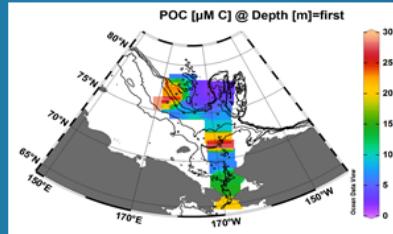
Vertical section of DOC



Spatial distribution of DOC



Vertical section of POC



Spatial distribution of POC



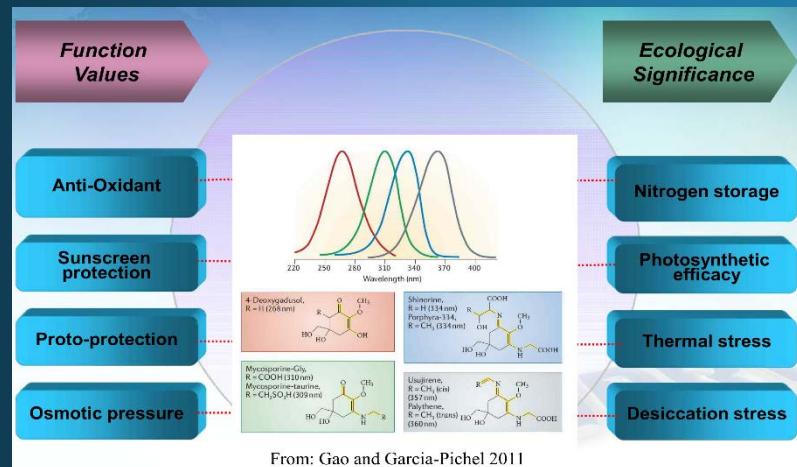
TOC-TN analyzer



CHN analyzer

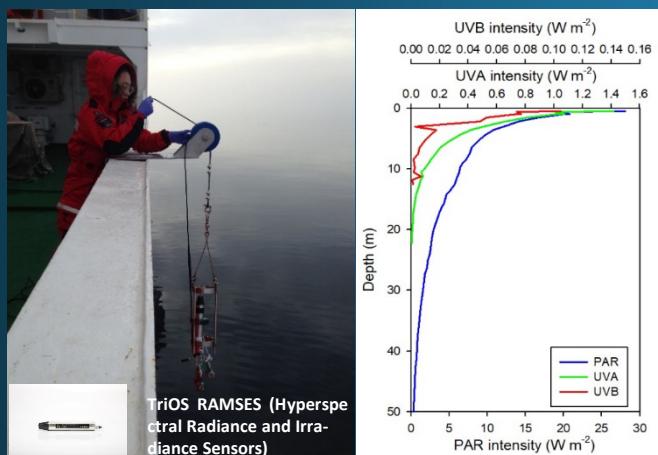
## UV compounds

### Mycosporine-like amino acids (MAAs) as versatile elements



Modified from Bhatia et al. (2011)

- To provide the distribution of MAAs on the Chukchi Sea and the East Siberian Sea as fundamental information of Arctic marine ecosystem
- To understand the photo-protection of net phytoplankton on community



Vertical profiles of UV and photo-synthetically active radiation (PAR)



Sea water sampling



Analysis of each compounds

## Microplastics (MPs)

Seung-Kyu KIM ([skim@inu.ac.kr](mailto:skim@inu.ac.kr))  
Ji-Su Kim ([0206wltn@naver.com](mailto:0206wltn@naver.com))

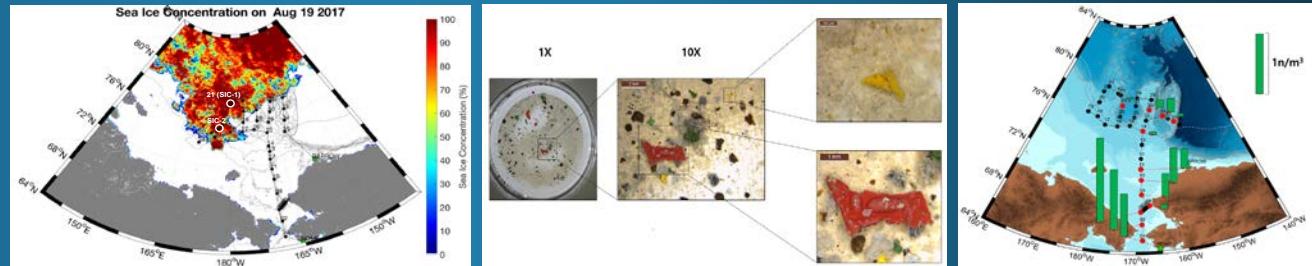
- To investigate abundance, fate, and distribution of microplastics in Arctic region
- To get basic data to predict the effect of MPs on Arctic ecosystem and sea-ice melting/formation

### Analytical components;

- Microplastics
- TEP & CSP

### Sample Collection;

- Surface water (MTN), subsurface water (BN), sediment (Box corer), snow, sea ice, and air for MPs
- Seawater (Surface/SCMD/bottom layer) for TEP



▲ Filtration systems for collecting TEP/CSP

▲ Sampling for MPs (MTN for surface water, BN for subsurface water, Box corer for sediment, Snow & sea-ice sample at ICE-camp

# Chemical Oceanography

## Nitrogen source identification

Kyung Hoon SHIN ([shinkh@hanyang.ac.kr](mailto:shinkh@hanyang.ac.kr))

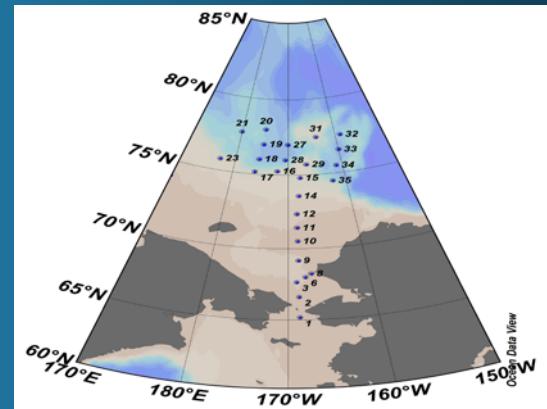
- To investigate Nitrogen source in western Arctic Ocean using nitrogen stable isotope ratio

- Analytical components;

- Nitrogen stable isotope ratio of POM and DIN
- Amino acids nitrogen stable isotope ratio of zooplankton
- Oxygen stable isotope ratio of seawater

- Sample Collection;

- POM (>0.7 µm, GF/F)
- DIN (<0.7 µm, GF/F)
- Zooplankton (>500µm, Bongo net)
- Seawater (<0.2 µm)



▲ Zooplankton sampling sites



▲ Filtration systems for collecting the particle organic matters



▲ *Calanus Hyperboreus*  
sorted from bongo  
net(500µm) samples



▲ Filtration for  
oxygen stable  
isotope ratio

## Pelagic ecosystem

- Distribution of bacteria and virus and community structure
- Species compositions of phytoplankton
- Abundance and community structure of heterotrophic protists
- Mesozooplankton community and grazing impacts on phytoplankton biomass
- Primary production, new production, and photosynthetic pigments
- Food web interaction between phytoplankton and zooplankton

Youngju LEE ([yjlee@kopri.re.kr](mailto:yjlee@kopri.re.kr))

Eun Jin Yang ([ejyang@kopri.re.kr](mailto:ejyang@kopri.re.kr))

Hyoung Sul LA ([hsla@kopri.re.kr](mailto:hsla@kopri.re.kr))

Hyoung Min JOO ([hmjoo77@kopri.re.kr](mailto:hmjoo77@kopri.re.kr))



Phytoplankton Net



Zooplankton Net



Deck Incubation

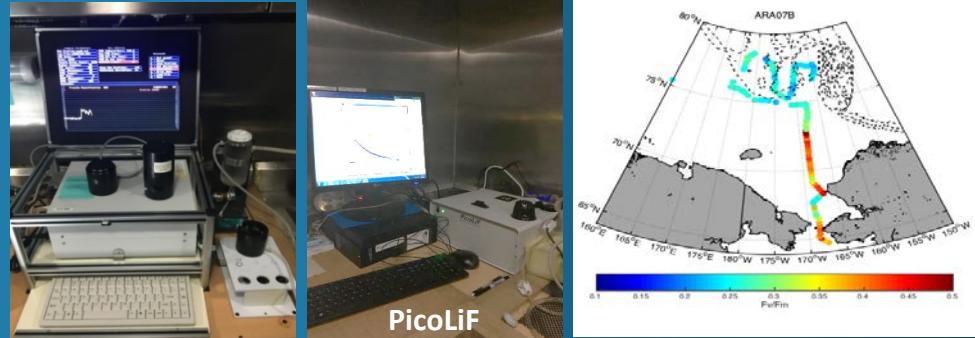


Collecting the seawater



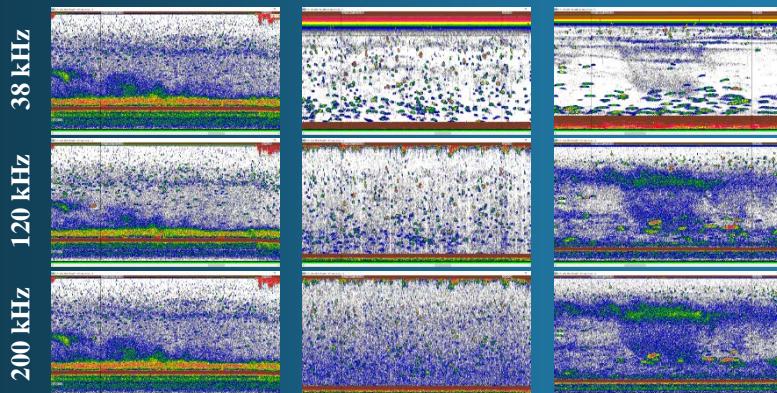
## Phytoplankton physiology

- To understand the photosynthetic characteristics of phytoplankton
  - > Photochemical efficiency (FIRe II)
  - > Quantum yield of fluorescence (PicoLiF)

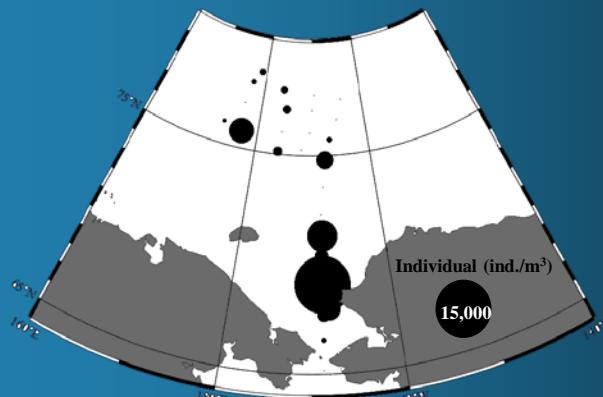


## Zooplankton acoustic survey

- Vertical variation of sound-scattering layers with multi-frequency scientific echosounder (EK60)
- Horizontal variation of copepods abundance estimated by acoustic backscatter data



[Vertical variation of acoustic backscatter]

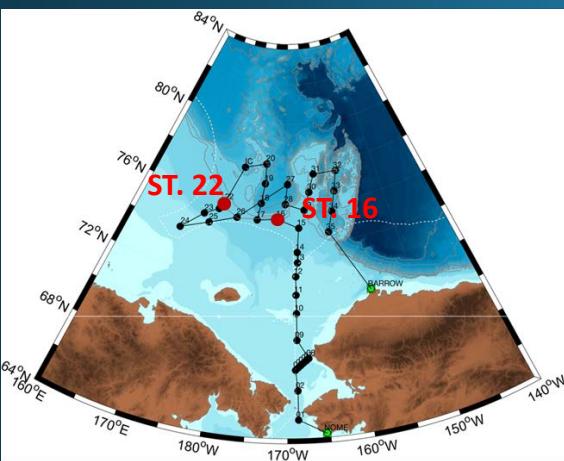


[Horizontal variation of copepods abundance]

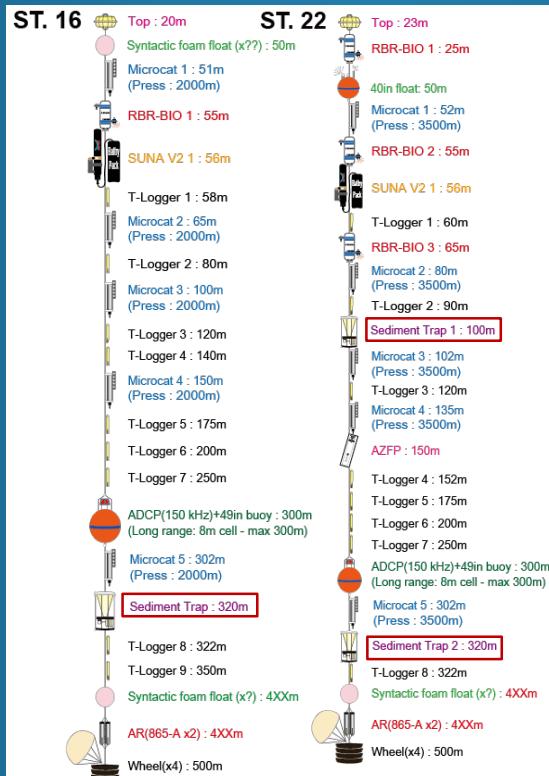
## Sediment trap

So Young KIM ([kimsy@kopri.re.kr](mailto:kimsy@kopri.re.kr))  
Dongseon KIM ([dkim@kiost.ac.kr](mailto:dkim@kiost.ac.kr))  
Yewon KIM ([yewonkim@kiost.ac.kr](mailto:yewonkim@kiost.ac.kr))

- To determine annual variations of biogenic fluxes in the western Arctic Ocean associated with sea ice changes
- Future collaboration with JAMSTEC (Naomi Harada and Jonaotaro Onodera)



Sediment trap locations



Deployment of a time-series sediment trap during the ARA08B expedition



Deployment of a time-series sediment trap during the ARA08B expedition

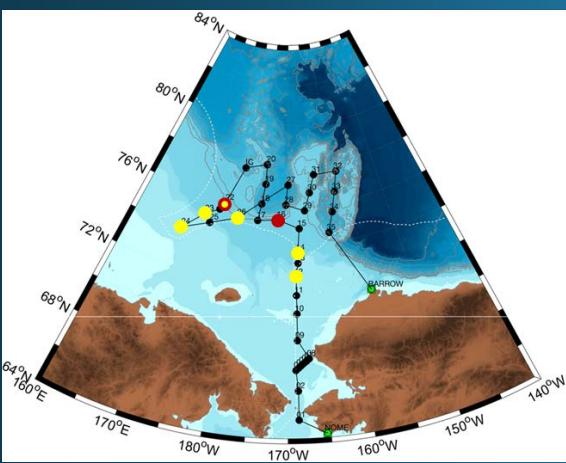
### Analysis

- organic carbon,  $\text{CaCO}_3$ , biogenic opal
- aluminum
- $^{13}\text{C}$  &  $^{15}\text{N}$  stable isotopes
- phytoplankton & zooplankton communities
- fecal pellets

# Sediment core study

So Young KIM ([kimsy@kopri.re.kr](mailto:kimsy@kopri.re.kr))

- To investigate environmental and climatic controls on spatio-temporal distribution of fossilized microflora and biogeochemical components in seafloor sediments of the western Arctic Ocean

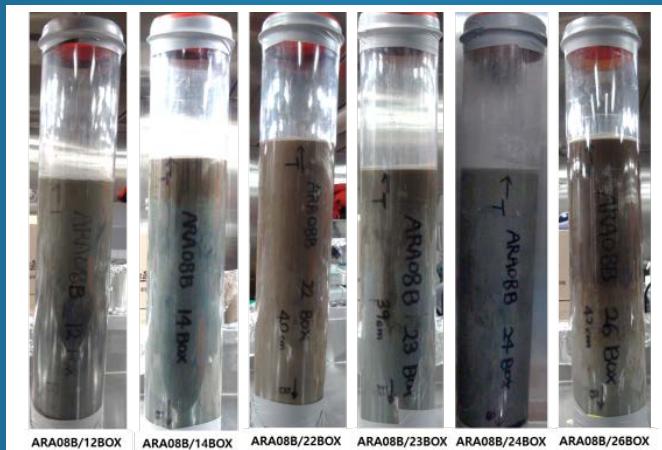


- Sediment trap
- Box coring

Push core subsamples taken from the box core sediments



Box coring for recovery of undisturbed upper sediments



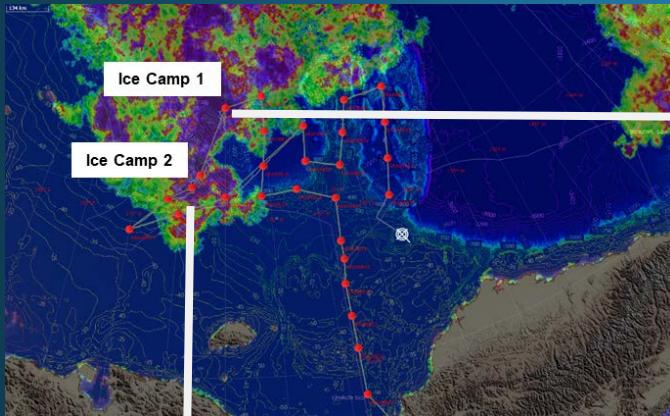
## Analysis

- dinoflagellate cysts, pollen & spores, freshwater algae, etc
- biogenic opal, TOC, TN, TS, etc

## ● 2 Ice Camps - Buoy deployments and in-situ measurements for observing sea ice physical properties

- To measure in-situ physical parameters of atmosphere, melt pond, ice and ocean
- To study the air-ice-ocean interaction, ice deformation, melt pond energy budget, etc.

## ● International collaboration: KOPRI, BAS(UK), OUC(China), CSIC(Spain), UPMC(France), AWI(Germany), U Miami(US)



### <Observed variables>

- ice drift, temperature (air, ice, ocean), salinity, snow deposition, clouds, radiation, meteorology

### Ice Camp 2 (16-17 August)

#### In-situ melt pond observation (KOPRI)



Melt pond Ice Mass Balance (IMB) with radiation sensors (KOPRI & BAS)



### Ice Camp 1 (13-14 August)

#### SATICE (Spain)



#### SATICE (Spain) & Reflector (US)



#### IMB (AWI)



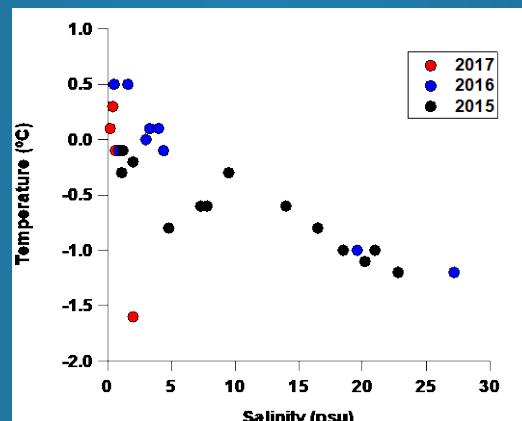
#### IAOOS (France)



# Melt Pond Study

Jinyoung JUNG ([jinyoungjung@kopri.re.kr](mailto:jinyoungjung@kopri.re.kr))  
Keyhong PARK ([keyhongpark@kopri.re.kr](mailto:keyhongpark@kopri.re.kr))  
Hyoung Sul LA ([hsla@kopri.re.kr](mailto:hsla@kopri.re.kr))  
Youngju LEE ([yjlee@kopri.re.kr](mailto:yjlee@kopri.re.kr))  
Hyoung Min JOO ([hmjoo77@kopri.re.kr](mailto:hmjoo77@kopri.re.kr))

- To define environmental characteristics of various melt ponds on sea ice floes in the Arctic Ocean
- To understand food web interaction associated with melt pond condition
- To estimate the carbon contribution of entire sea ice floes in the western Arctic Ocean.



Melt pond study site from 2017 (Ice camp 1)

Temperature & Salinity

Melting pond study (Ice camp 2)

- Research components;
  - Plankton composition, diversity and physiology
  - Gas interaction between air and surface of ponds
  - Biochemical parameters (Carbon and Nitrogen ...)

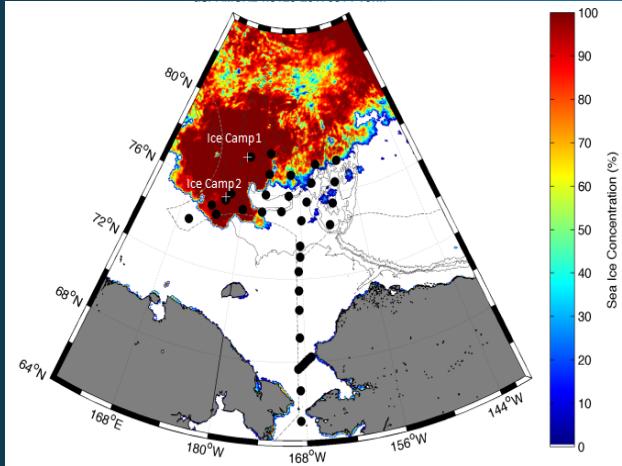


Ice core sampling

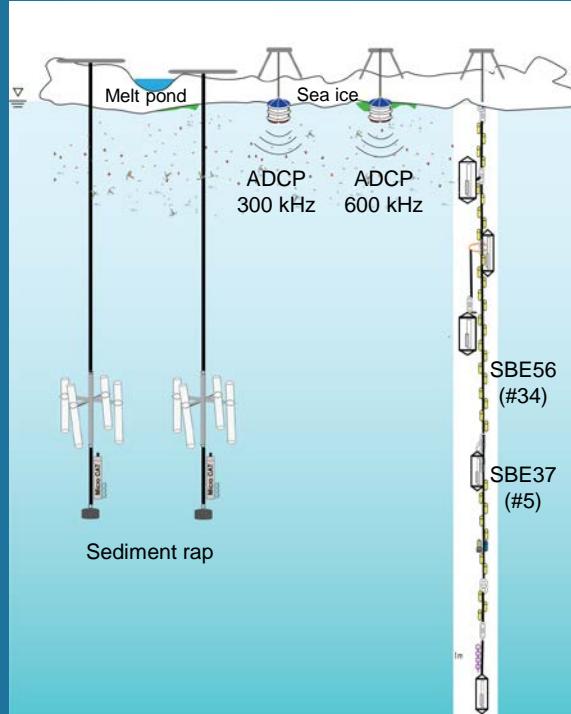
# Underwater Sea Ice Physics

Hyoung Sul LA ([hsla@korpri.re.kr](mailto:hsla@korpri.re.kr))

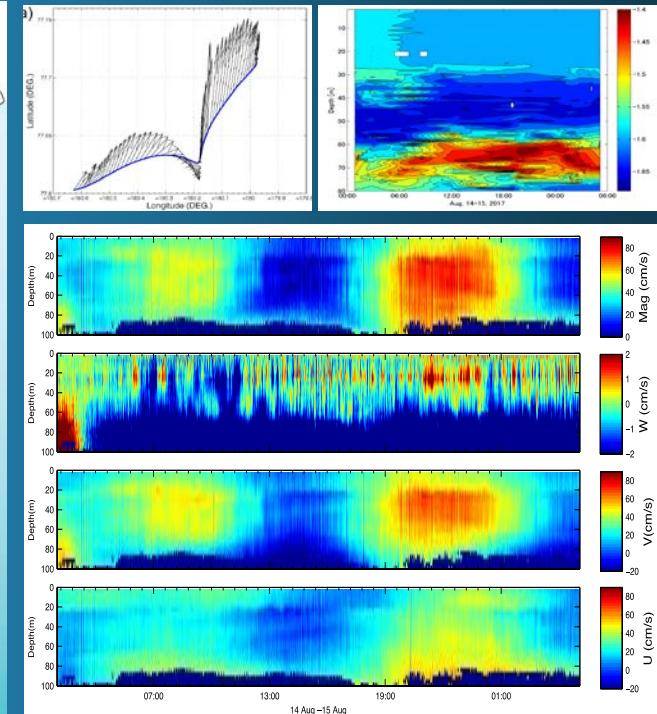
- Understand the momentum transfer between sea ice and upper ocean under small-scale fluctuations of sea ice motions
- Observe the density stratification and vertical shear of horizontal velocity to estimate vertical eddy viscosity depends on sea ice floe



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

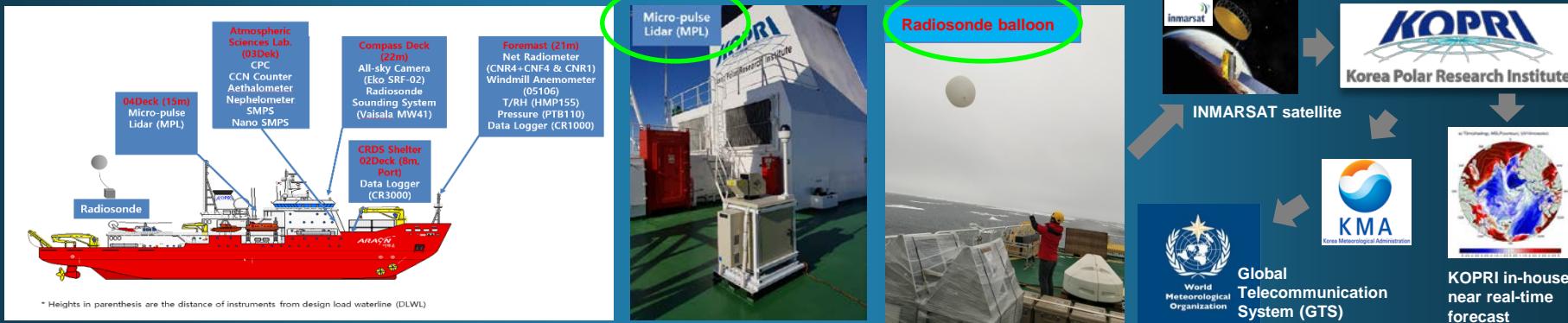
# Atmospheric Observations

Joo-Hong KIM ([joo-hong.kim@kopri.re.kr](mailto:joo-hong.kim@kopri.re.kr))

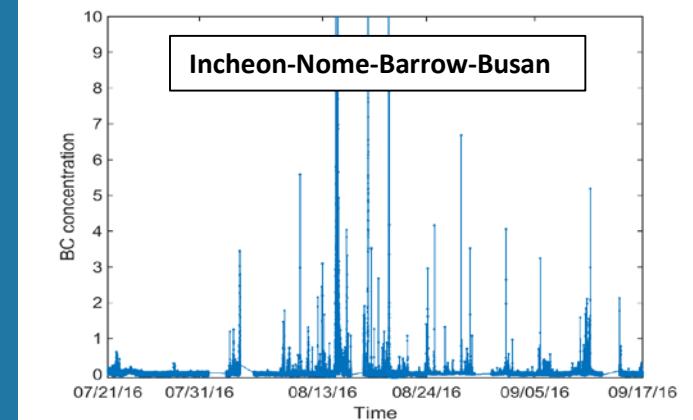
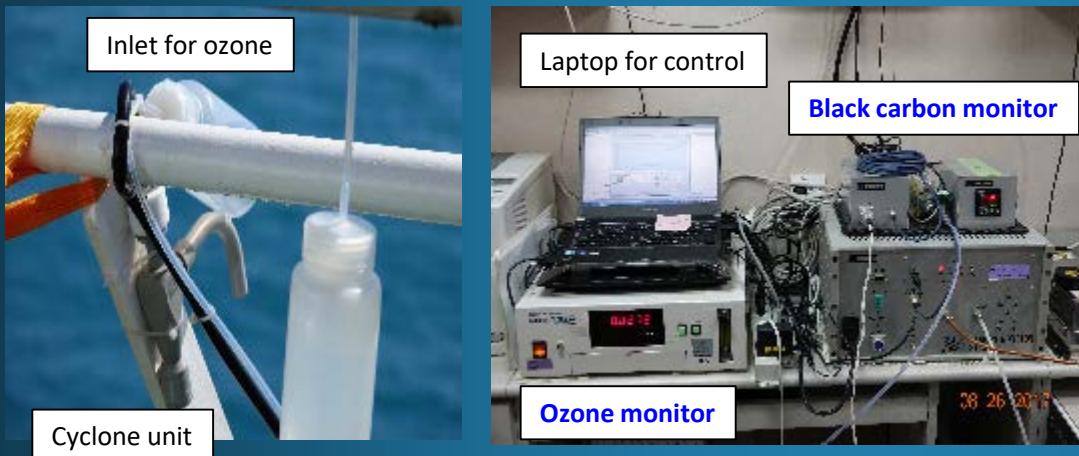
Jinyoung JUNG ([jinyoungjung@kopri.re.kr](mailto:jinyoungjung@kopri.re.kr))



- Surface and upper-air meteorological variables: understanding and prediction of weather events
- Radiative fluxes and clouds: clouds' role in radiation budget, cloud amount & vertical distribution



- Aerosols and gases: Black carbon (BC), ozone, cloud condensation nuclei (CCN), PM10, etc.



## Remote Sensing

Hyun-Cheol KIM ([kimhc@kopri.re.kr](mailto:kimhc@kopri.re.kr))  
Hyangsun HAN ([hyangsun@kopri.re.kr](mailto:hyangsun@kopri.re.kr))  
Chang-Uk HYUN ([chyun@kopri.re.kr](mailto:chyun@kopri.re.kr))

### Ice Surface Scanning (ice surface roughness measurements)

- Sea ice surface roughness was measured by using 3D laser scanner with 0.3 mm accuracy
- High-resolution satellite SAR images were acquired during the ice surface scanning
- measured ice roughness will be compared to microwave backscattering derived from the SAR
- It is expect an algorithm for sea ice surface roughness estimates from satellite SAR is developed



Ice surface roughness measurement using 3D scanner



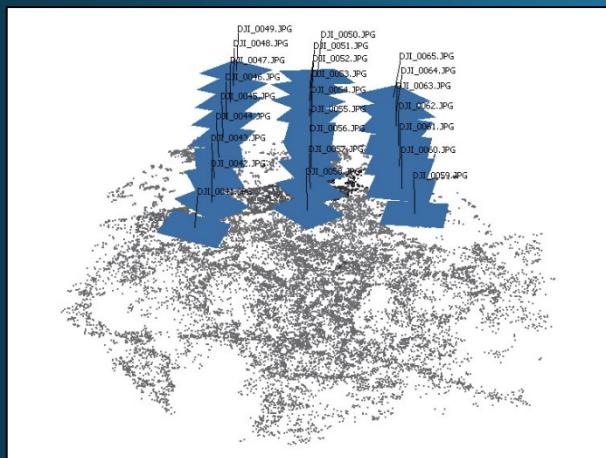
Preliminary result of ice surface roughness

## Remote Sensing

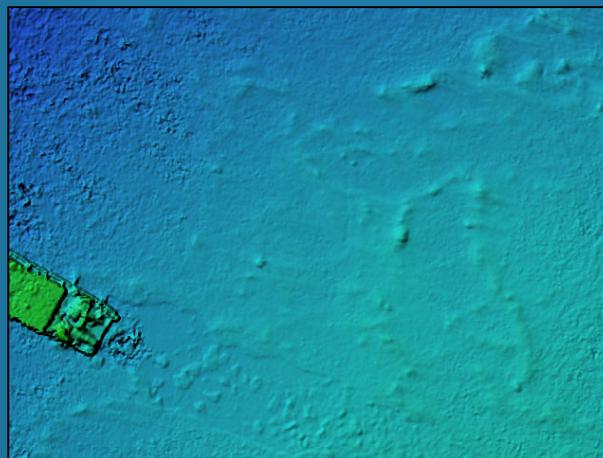
Hyun-Cheol KIM ([kimhc@kopri.re.kr](mailto:kimhc@kopri.re.kr))  
Hyangsun HAN ([hyangsun@kopri.re.kr](mailto:hyangsun@kopri.re.kr))  
Chang-Uk HYUN ([chyun@kopri.re.kr](mailto:chyun@kopri.re.kr))

### UAV (unmanned aerial vehicle) observation (high-resolution image acquisition)

- Very-high-resolution (VHR) image acquisition using UAV over drifting arctic sea ice was tested.
- The VHR images (a spatial resolution of few centimeters) were acquired in unfavorable cloudy conditions for optical satellite imagery acquisition.
- Digital elevation model and mosaicked image can be used for further analyses, e.g., sea ice surface roughness measurement, melt pond distribution analysis and satellite data derived sea ice product validation.



UAV image acquisition strategy



Preliminary result of sea ice surface topography



Preliminary result of mosaicked image

# Sea-Ice Prediction modelling

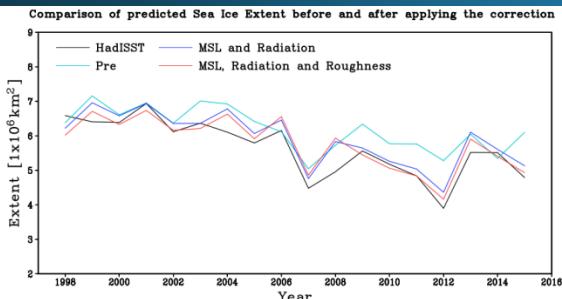
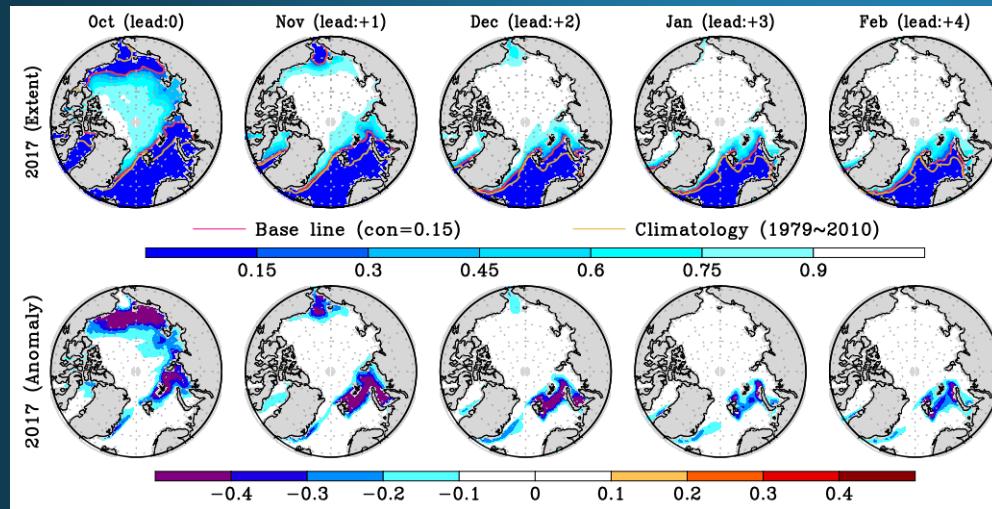
Baek-Min KIM ([bmkim@kopri.re.kr](mailto:bmkim@kopri.re.kr))

Jee-Hoon JEONG ([jjeehoon@jnu.ac.kr](mailto:jjeehoon@jnu.ac.kr))

- To develop the seasonal prediction system of Arctic sea ice (concentration & depth)

- Statistical prediction model:

- The sea ice concentrations over the Arctic domain (>65N) in 1 degree, monthly resolution are being produced operationally.

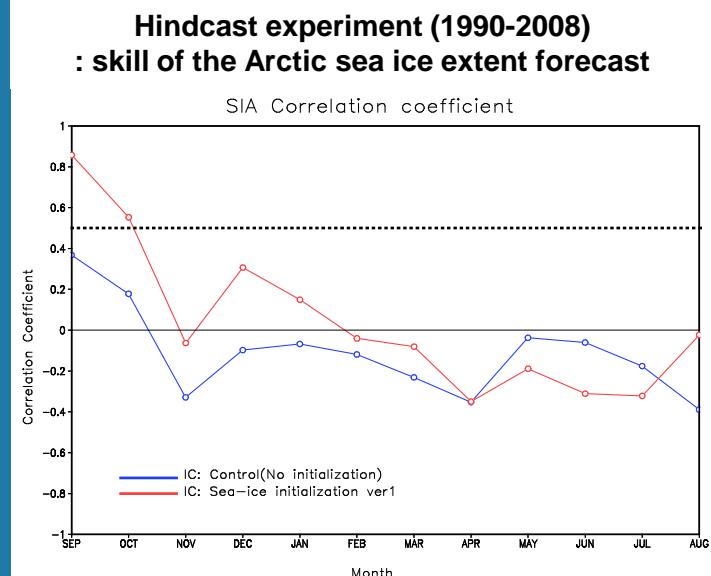


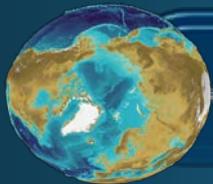
(up) Oct 2017 – Feb 2017 SIC forecasted

(down) September Arctic sea ice extent predicted at July

- Dynamical prediction model:

- Offline CSIM forced with atmospheric/oceanic forcing are under development.
- The initialization (nudging) method of sea ice of different categories is developed.



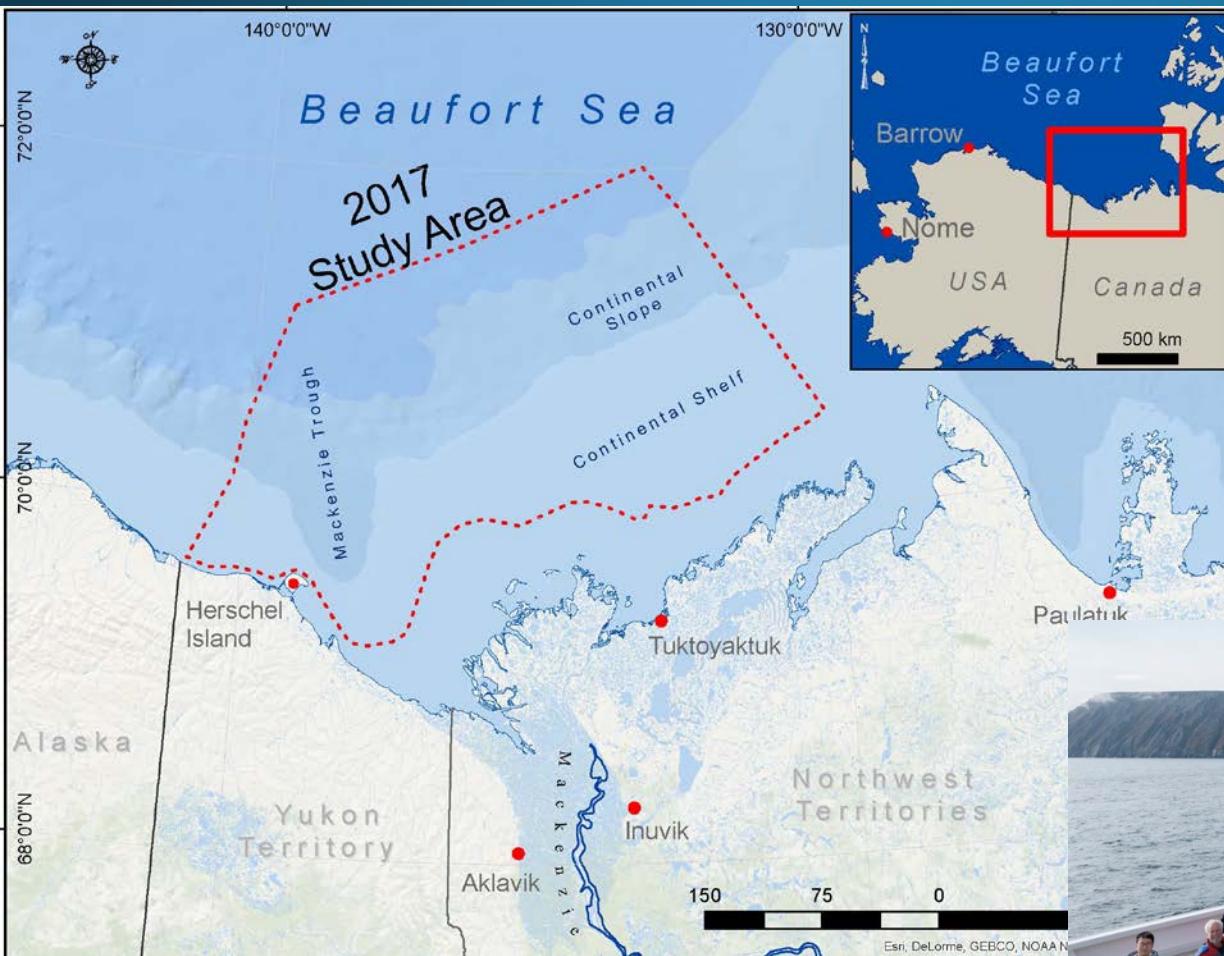


# 2017 KOPRI Arctic Cruise (2<sup>nd</sup> Leg)

- **Marine geology/geophysics (Canadian Arctic EEZ, Beaufort Sea)**
- **Aims of the cruise:**
  - To map geological features/structures in the Arctic continental margin
  - To understand geological processes related to melting subsea permafrost and gas hydrate in the Arctic
  - To evaluate the interactions and linkages in terms of methane cycle in the Arctic
- **Period:** 2017. 8.27 - 9.16 (from Barrow to Nome)
- **Number of participants:** 51
- **Chief Scientists:** Dr. Young-Keun Jin ([ykjin@kopri.re.kr](mailto:ykjin@kopri.re.kr))
- **Participating nations:** Korea, Canada, USA, Norway, China



# Arctic MArine Geoscience Expedition (AMAGE)

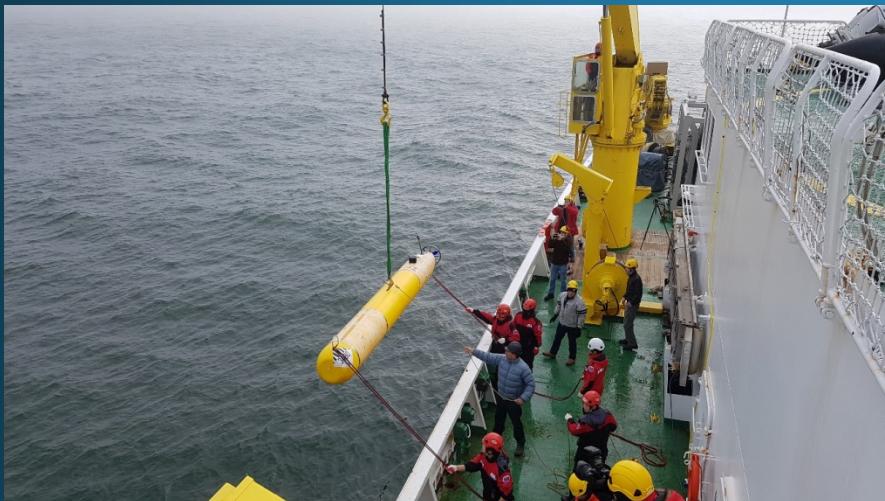


- Research items;
  - Seismic survey
  - Sub-bottom profiling
  - bathymetric mapping
  - Sediment coring
  - Heat flow measurements
  - ROV/AUV dives
  - Water column study
  - Methane flux study
  - Microbiological study

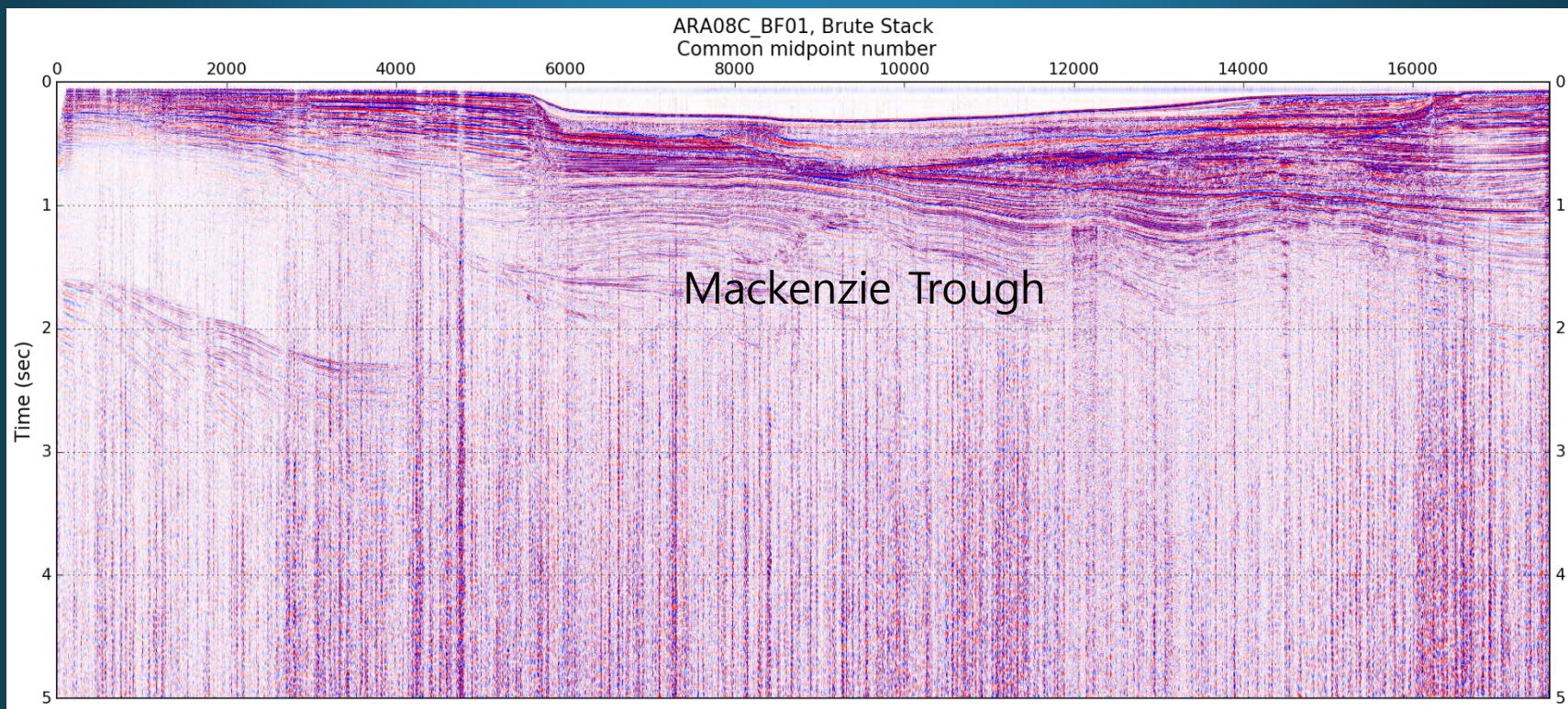
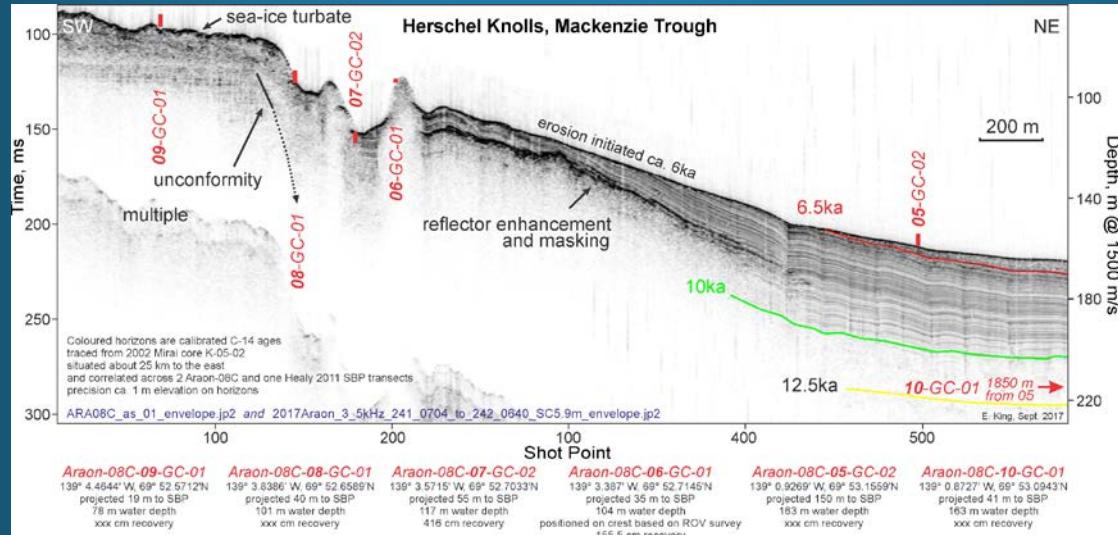


Map showing the survey location of the 2017 Canadian Arctic Expedition.

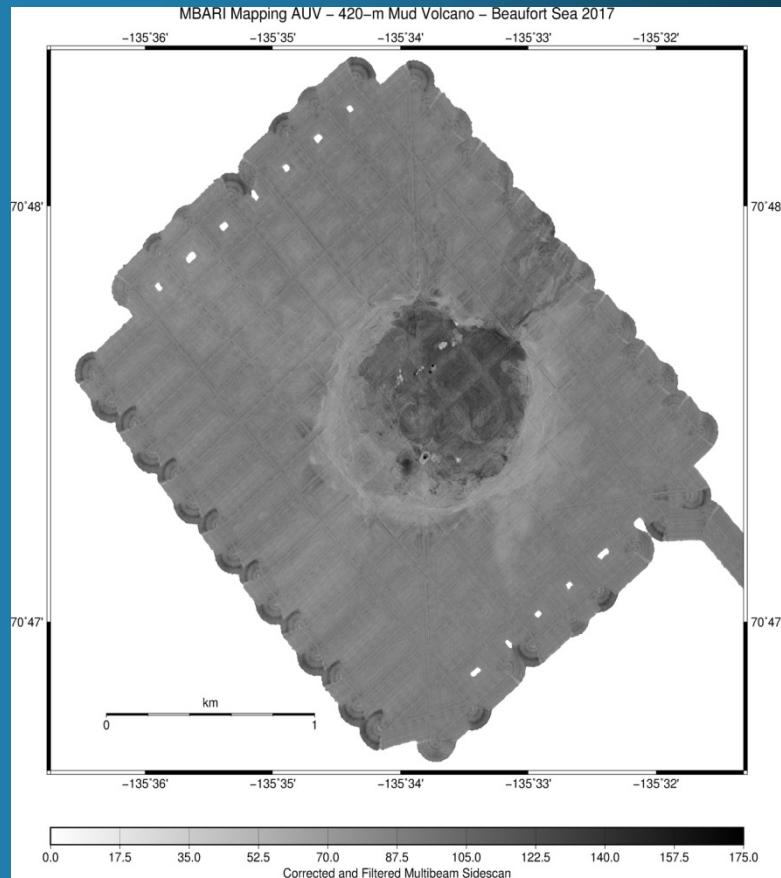
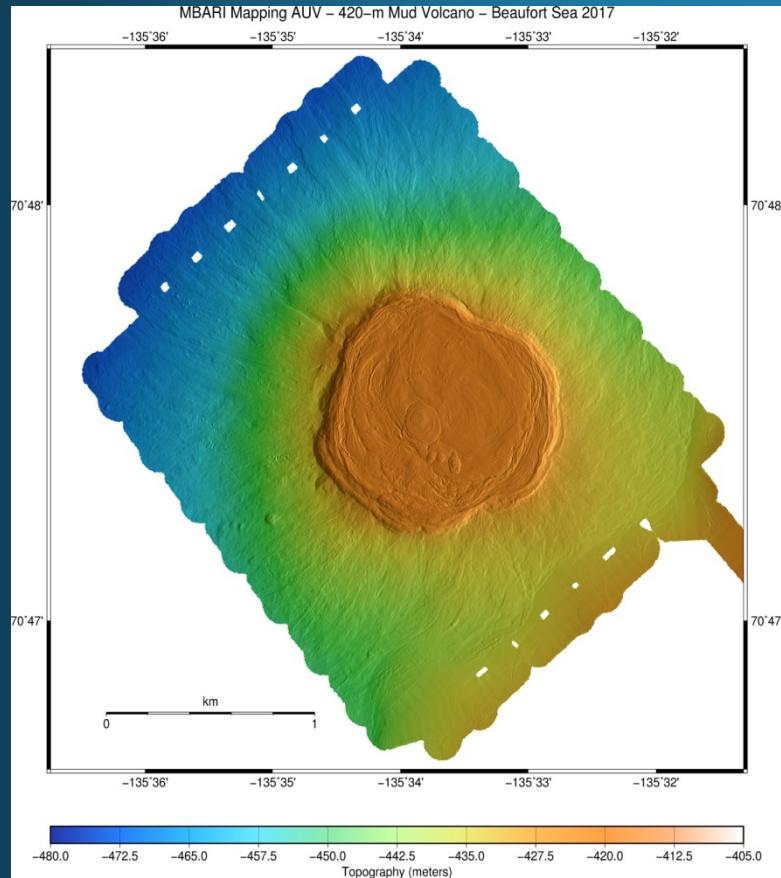
# AMAGE field works @ the Beaufort Sea



## Sub-bottom Profile

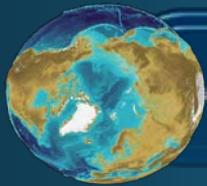


# AUV (Autonomous Underwater Vehicle) mapping @ 420 m Mud Volcano



## Sampling by ROV (Remotely Operated Vehicle)



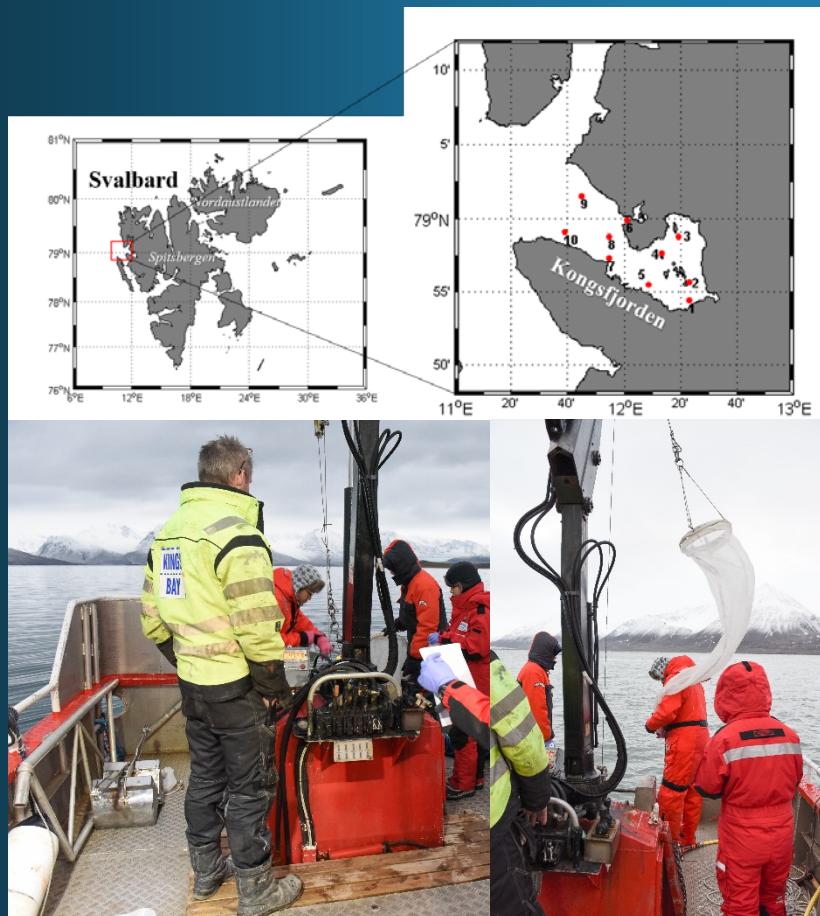


# Sea ice ecosystem in the Atlantic and Canadian Arctic

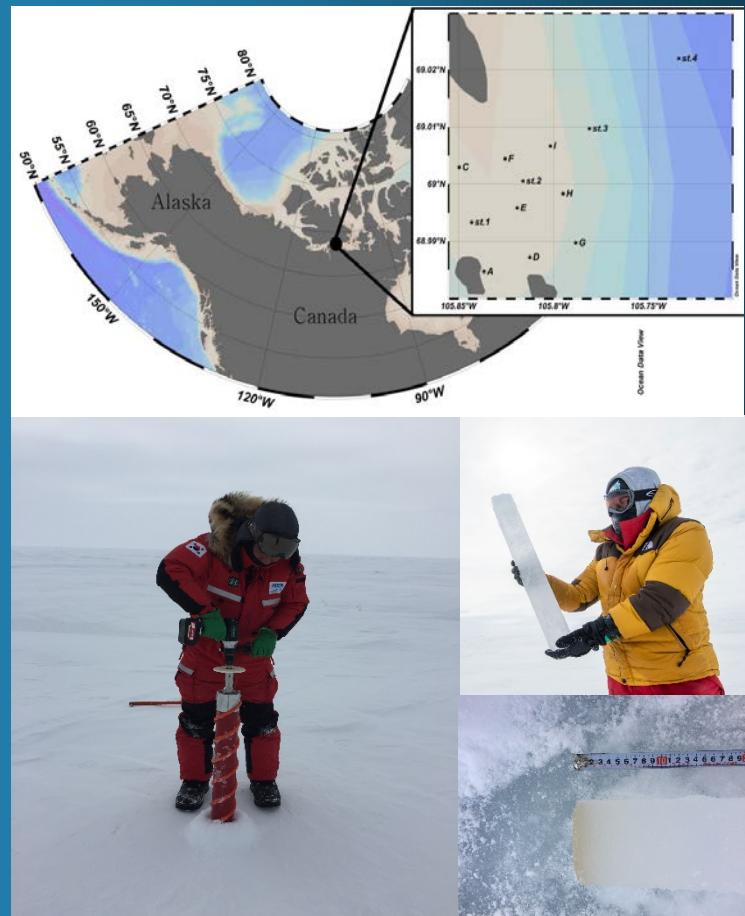
- Carbon assimilation rate of sea ice ecosystem in the Kongsfjorden MIZ, Arctic
- Aims of the study:
  - Assessment of carbon assimilation rate of sea ice ecosystem according to the environmental change in the Kongsfjorden and Cambridge Bay marginal ice zone and understanding the carbon behavior according to the sea ice growth stage
- Period: 2017 – 2019
- Principal Investigator: Sun-Yong Ha ([syha@kopri.re.kr](mailto:syha@kopri.re.kr))
- Co-operation nations: Korea (KOPRI), UK (University of Plymouth), Canada (University of Manitoba)



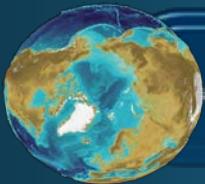
- Primary production of sea ice algae (Carbon assimilation rate of sea ice growth stage)
- Organic composition of sea ice algae (Energy flow processes in sea ice ecosystems)



Kongsfjorden, Svalbard



Cambridge Bay, Canada



# Paleoceanography in the Atlantic Arctic

- RV Helmer Hannsen Korea-Norway Joint cruises in the northern Svalbard Wijdefjorden

- Aims of the study:

- The investigation of sedimentary processes in Svalbard fjord system
- Reconstructions of climate and environment, on Svalbard, as well as glacier dynamics and sea-ice extent in Spitsbergen fjords from the last glacial until the present
- Testing of the sea-ice proxy IP<sub>25</sub>
- Pore water in water masses and core sediments
- Microbiology in surface sediments

- Period: 2017 – 2019

- Principal Investigator: Seung-II Nam ([sinam@kopri.re.kr](mailto:sinam@kopri.re.kr))

- Co-operation nations: Korea (KOPRI), Norway (UiT, The Arctic University of Norway)





## Scientific objectives

The cruises were carried out in the frame of the following research projects:

- *Research on environmental changes in fjorden and coastal geomorphology of Svalbard archipelago*  
(project leader: Seung-II Nam, **KOPRI**)
- *Mapping bathymetry and aquisition of sub-bottom profiles using chirp & sparker* (project leader: Moo-Hee Kang, **KIGAM**)
- *Holocene history of Svalbard ice caps and glaciers*  
(prosjektleder: Anders Schomacker, **UiT, Norway**)
- *Sedimentary processes and palaeoenvironment in fjords on Spitsbergen and in northern Norway*  
(project leader: (Matthias Forwick, **UiT, Norway**)

