PAG Fall Meeting 2015 (KOPRI, Incheon, South Korea)

KOPRI's PACEO Pilot Activities and Plans: Atmospheric and Sea Ice Observations

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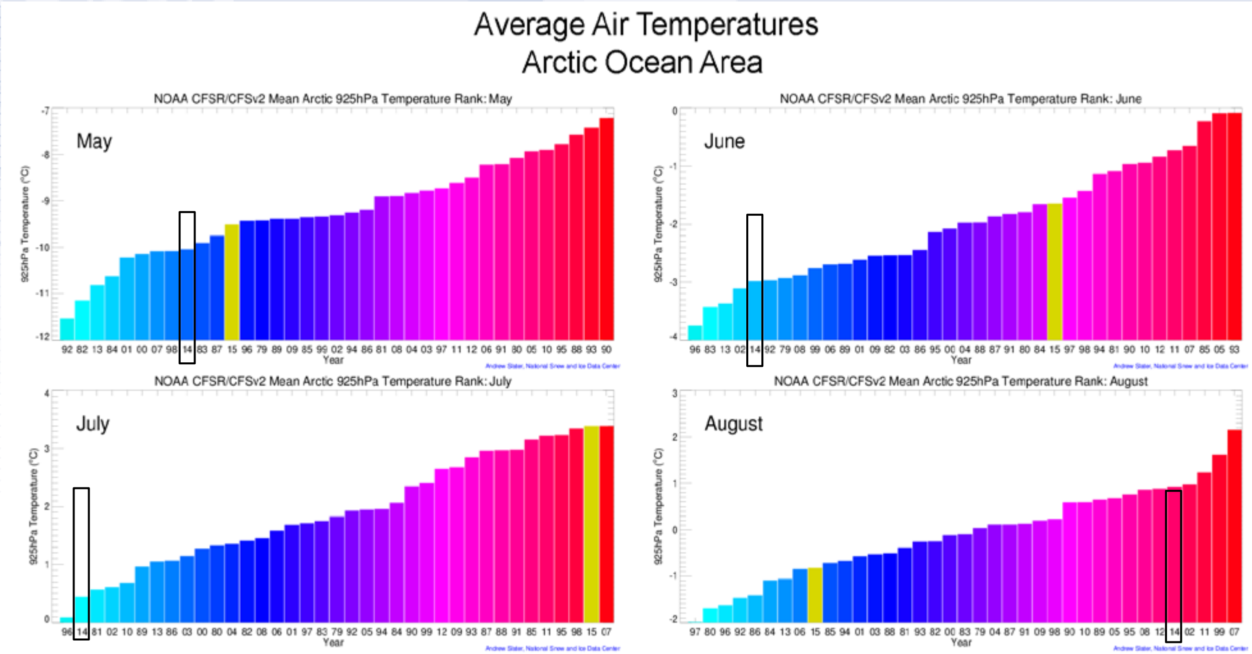
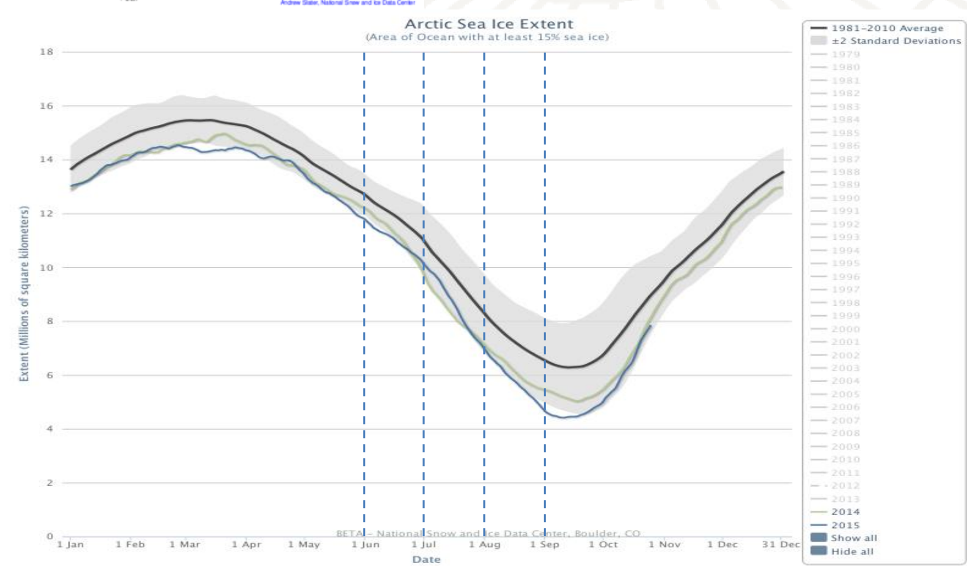
Atmospheric and sea-ice state: 2014 vs. 2015



Credit: D. Slater (NSIDC)



http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/

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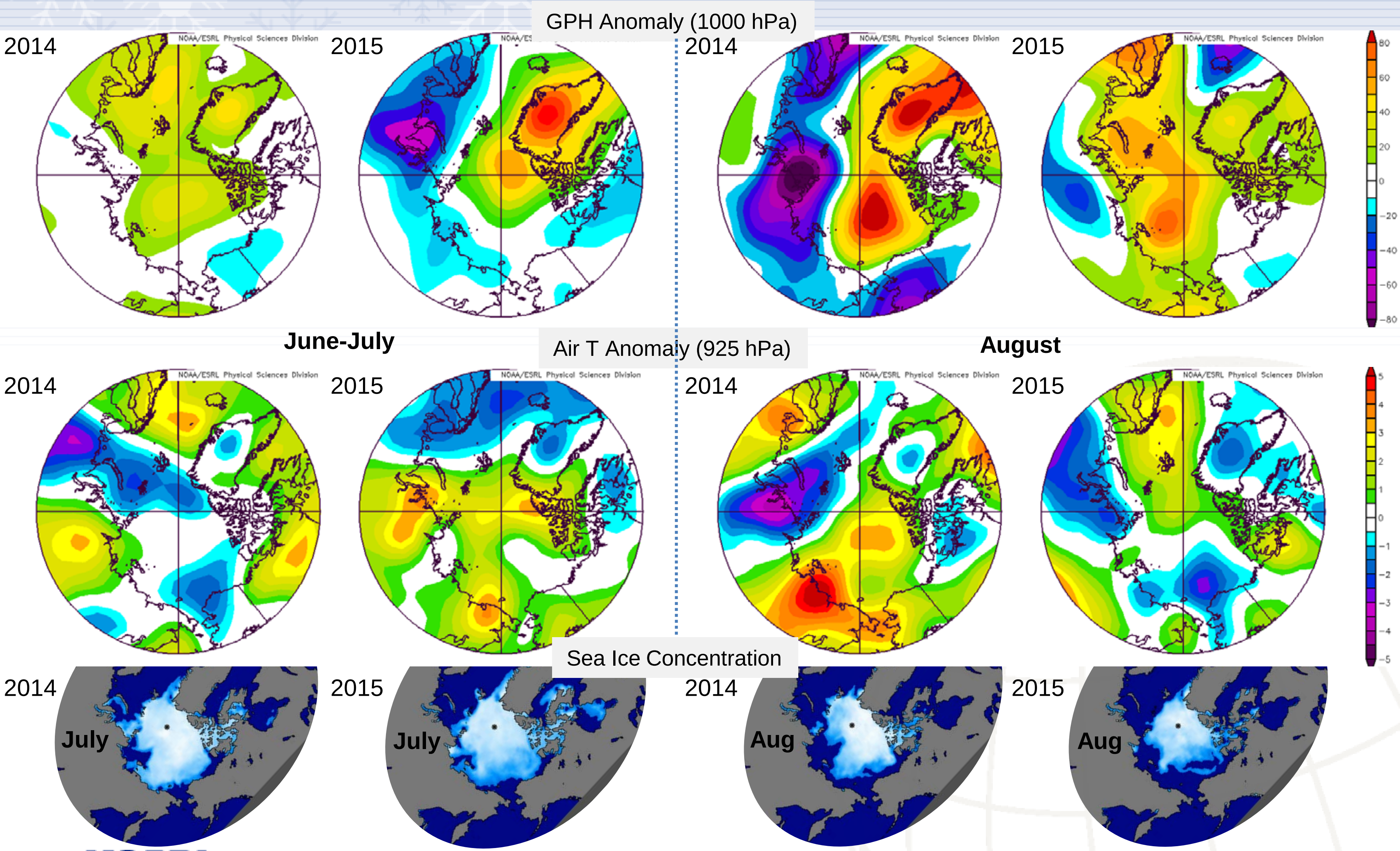
Atmospheric and sea-ice state: 2014 vs. 2015



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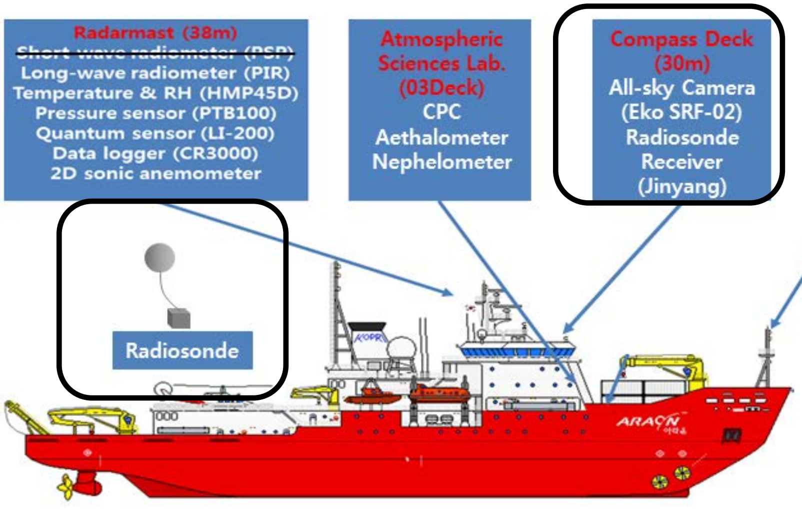
Topics included

- Updates & Planning
  - Arctic summer research cruise with ARAON (August 2015)
    - Atmospheric observations
      - On-board instruments & Target observations
    - Deployment of sea ice buoys
      - On-ice collaborative activities

On-board atmospheric observing instruments in 2015



* Heights in parenthesis are the distance of instruments from design load waterline (DLWL)

<Objectives>

- Surface basic meteorological variables: physical understanding of weather events, numerical weather prediction, assessment of reanalysis data
- Radiosonde launch: physical understanding of weather events, numerical weather prediction, assessment of reanalysis data, cloud and radiation
- Cloud and radiative fluxes: cloud radiative effect on surface, assessment of reanalysis data, physical understanding of weather events

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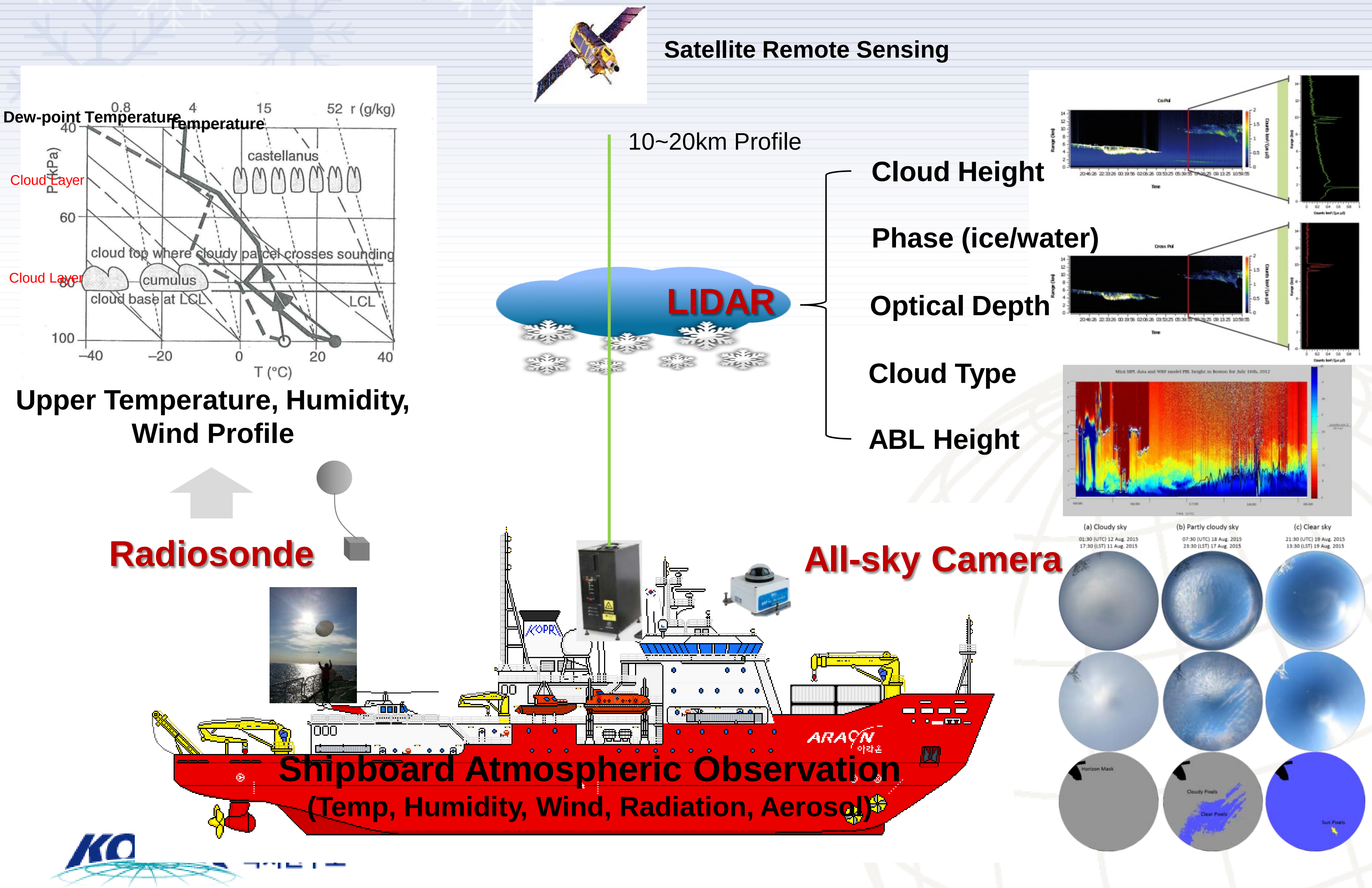
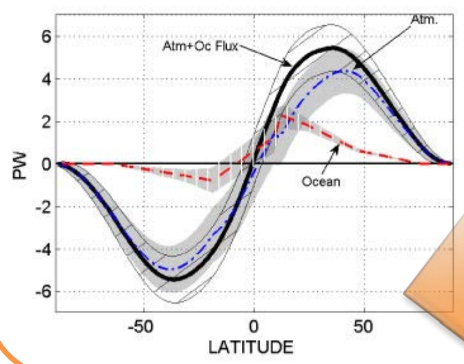
Further strengthening (2017~)



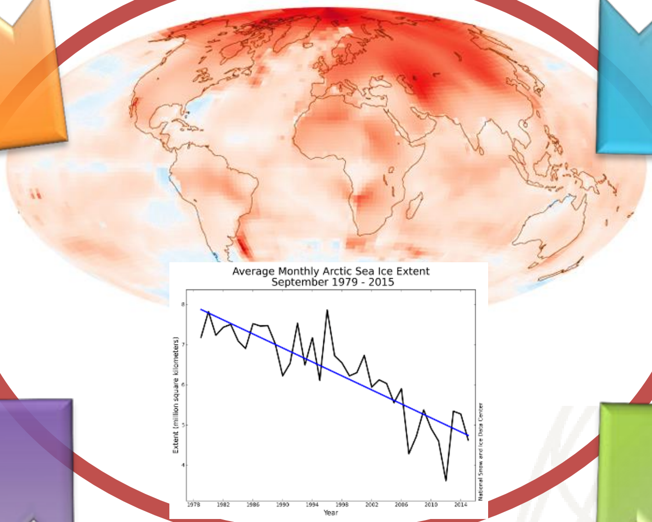
Scientific motivation

Poleward Heat Transport by Atmosphere and Ocean

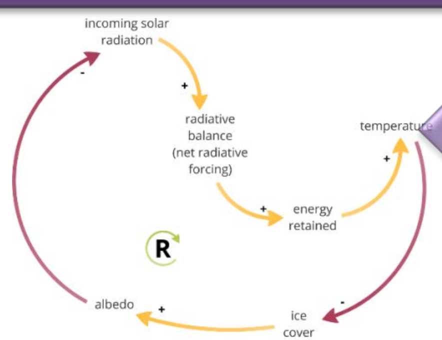


Greenhouse Effect of Clouds and Water Vapor

Arctic Amplification and Sea Ice Reduction



Ice-Albedo Feedback



Increased Mobility of Thinner Ice

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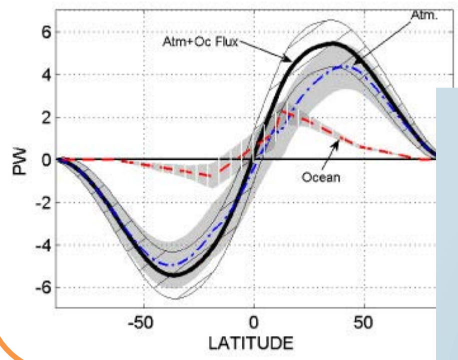
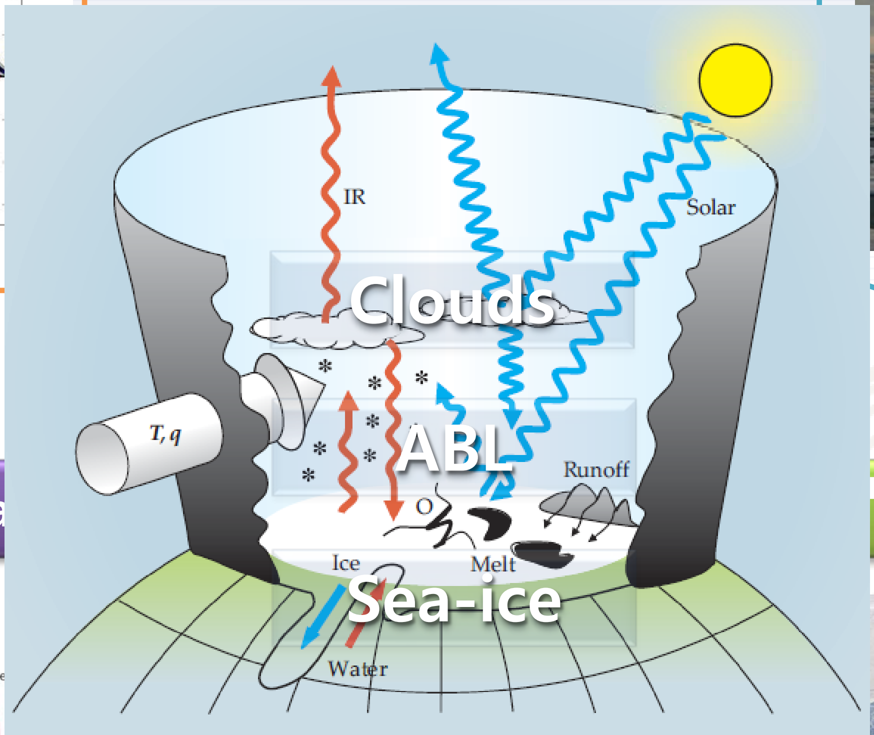
Scientific motivation

Poleward Heat Transport by Atmosphere and Ocean

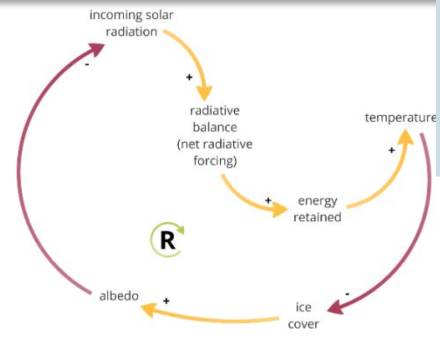


Greenhouse Effect of Clouds and Water Vapor



Kwok and Untersteiner (2011)

Ice-Albedo Feedba



ncreased Mobility of Thinner Ice

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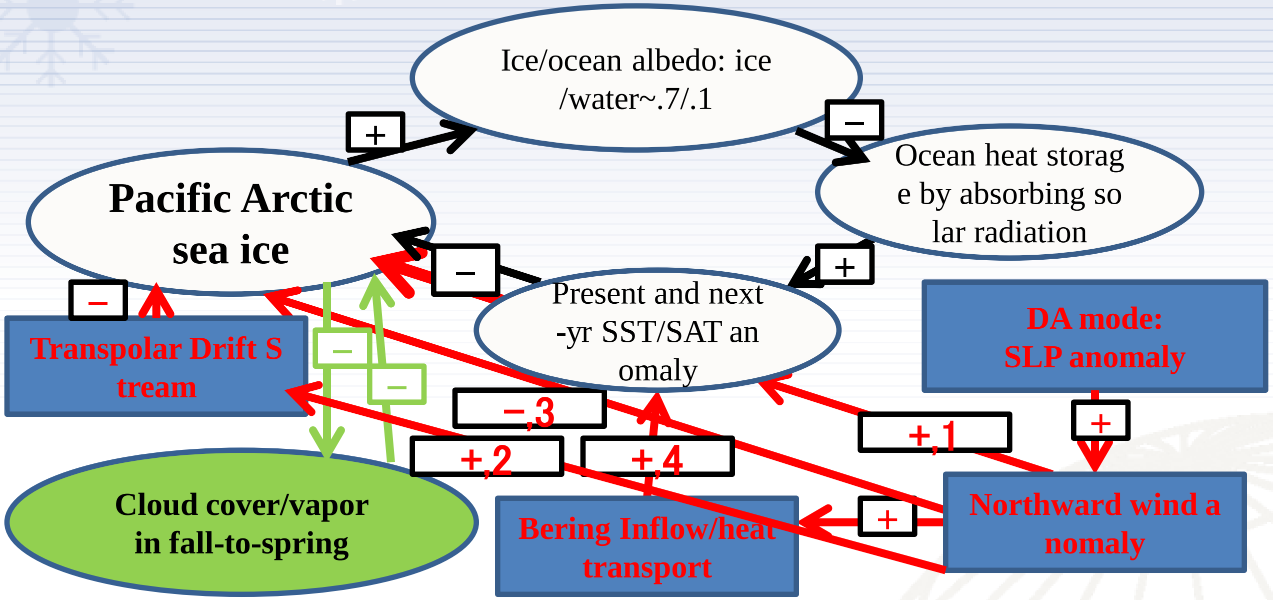
PACEO – feedbacks among physical climate components



Wang et al. (2014b, Springer Book, Ch 4)

- An ice/ocean albedo feedback loop and ice/cloud feedback loop are accelerated by a series of intermittent +DA forcings.
- The red arrows are associated with +DA forcing, which applies the positive feedback to the SST/SAT, or negative feedback to the sea ice, causing the unprecedented loss of Arctic summer sea ice and a series of record-breaking ice minima. + and – signs denote the positive and negative feedback, respectively. The positive feedback means that a change in one item (say *A*) affects the other item (say *B*), which feeds back so that *A* makes the change in the same direction as the original change.
- Note that associated with +DA, red arrow 1 indicates the northward advection of warmer SAT in the northern North Pacific to the Arctic by the anomalous meridional wind; Red arrow 2 denotes that anomalous meridional wind directly accelerates the TDS, which promotes export of more ice out of the Arctic; Red arrow 3 indicates the direct advection of sea ice by the anomalous meridional wind; and red arrow 4 denotes the warming impact of the ocean heat transport from the Bering Sea promoted by the anomalous northward (or meridional) wind.

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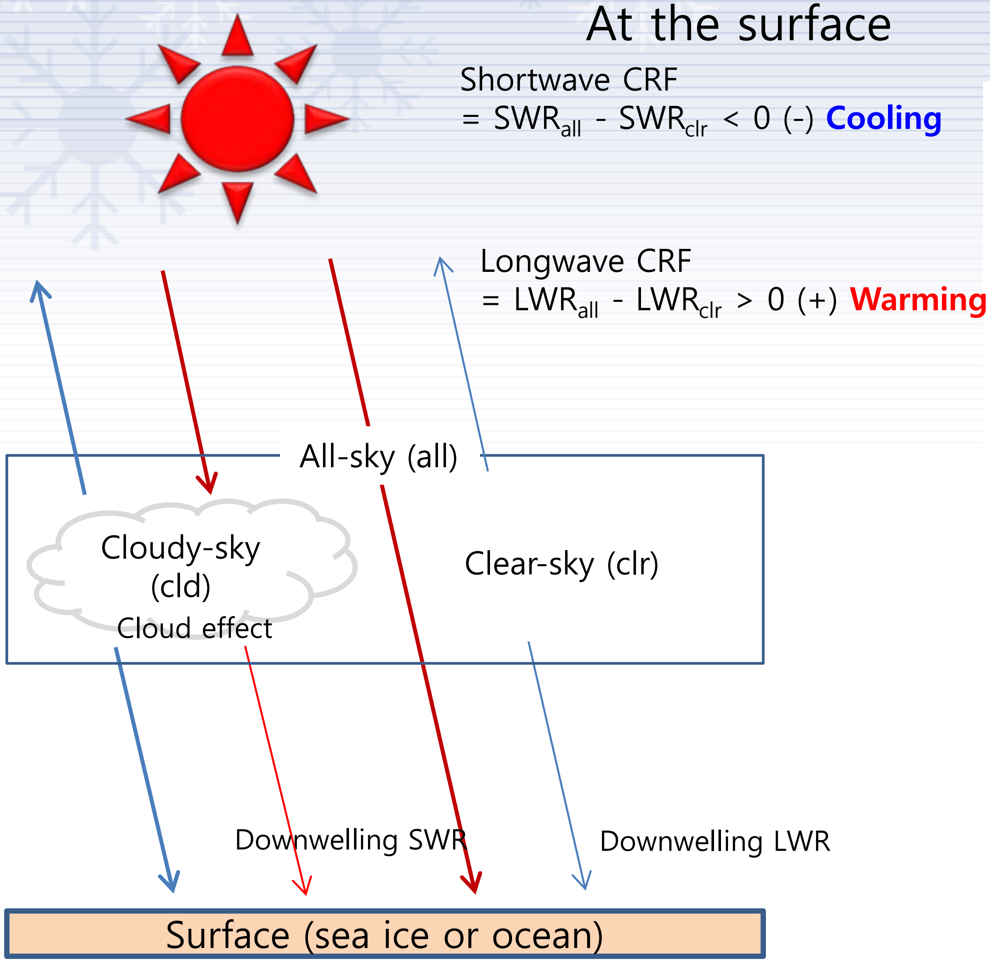
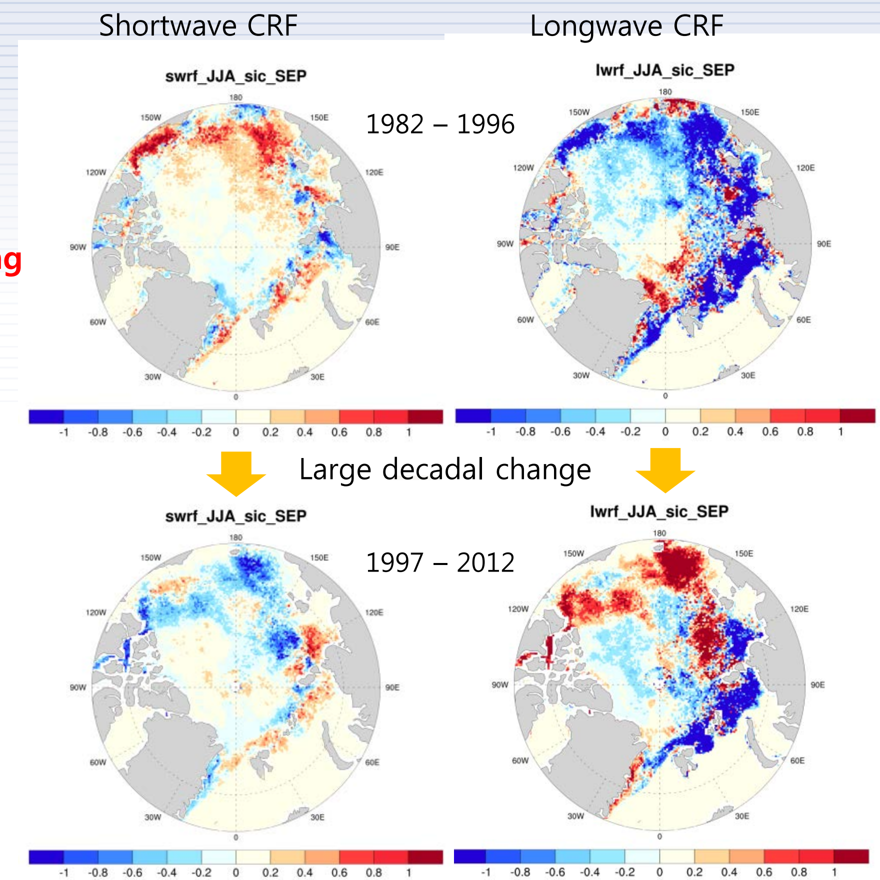
Adapted from "Planning for New PAG Climate Observations" (PAG 2014 Fall Meeting)

Results from satellite data provide us a nice motivation…



Regression Analysis (JJA CRF, SEP Sea Ice Conc.)



Change in cloud - sea ice relationship? Why?

In the Pacific Arctic Sector, In the middle-to-late 1990s

- Former: Positive (Negative) correlation between S(L)WRF & SIC-> less SEP SIC during more JJA clouds when clouds were more -> LW CRF during summer might have a role in sea ice melting
- Later: Emerging role of SW CRF in sea ice melting

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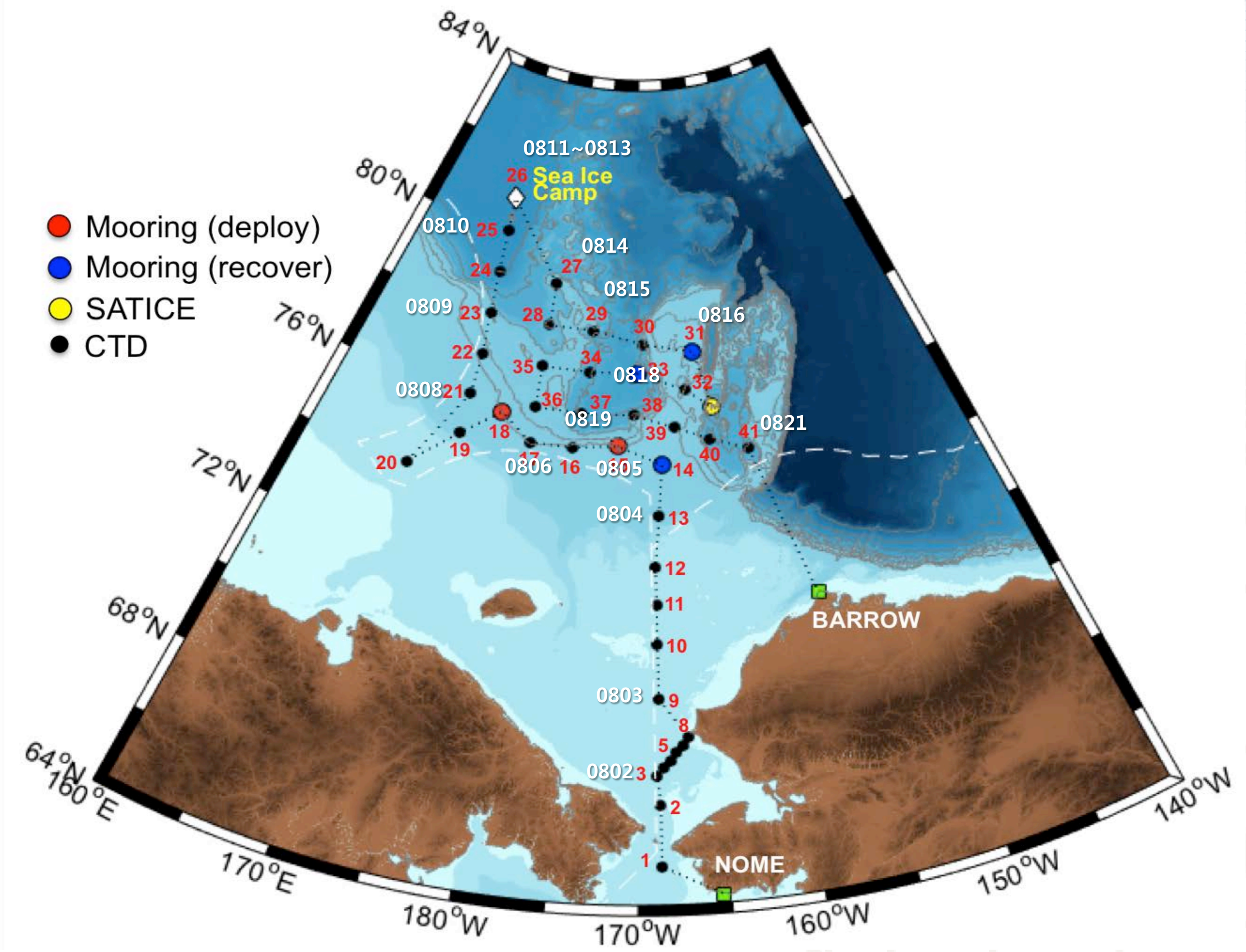
2015 ARAON Arctic cruise (Leg 1)

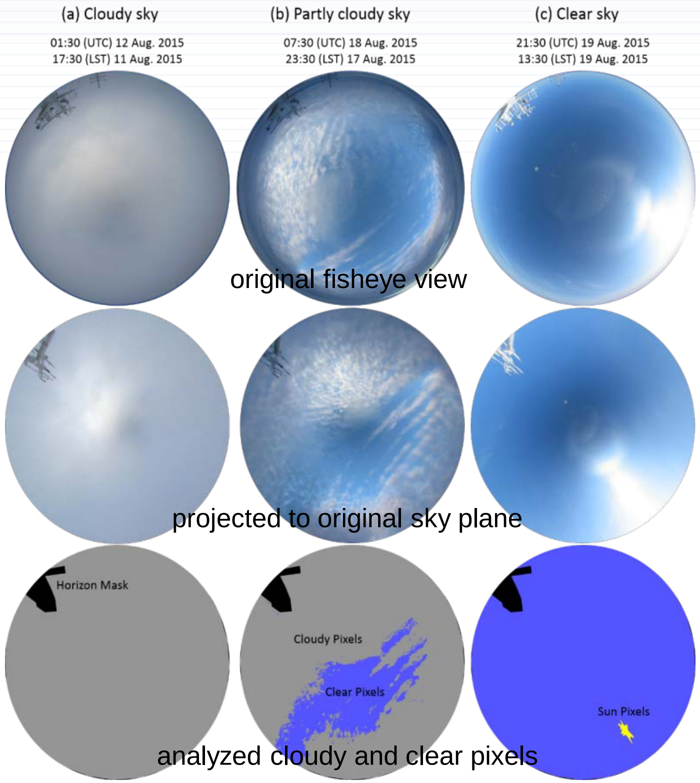
- ARA06B (2 August to 21 August)

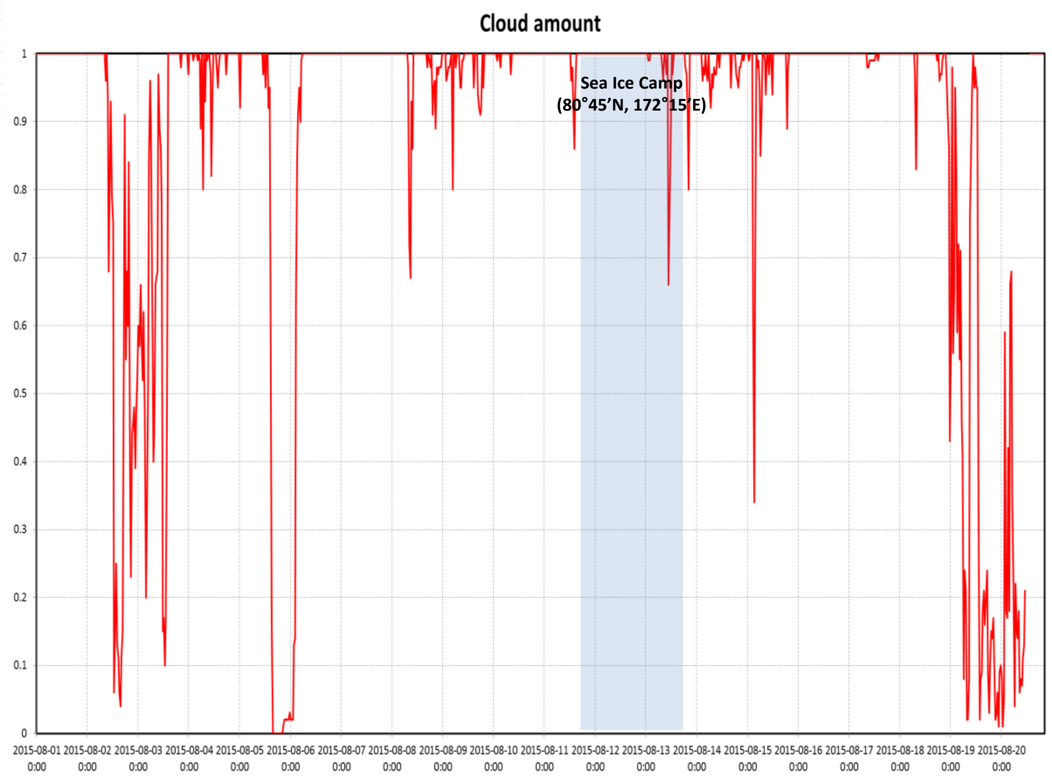


Cho et al. (ARA06B Cruise Report)

Cloud observation

- Original plan: three-way observations of shipboard LIDAR, all-sky camera and radiosonde
  - Shipboard DPL did not operate – cancelled
- Sky pictures taken by all-sky camera
  - Observing frequency: 15-minute intervals
  - Cloud amounts were retrieved at 30-minute intervals





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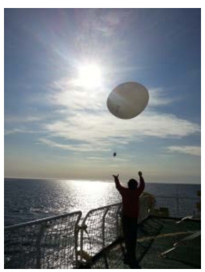
Radiosonde launch

- Observing frequency
  - Twice daily (00, 12 UTC)
  - 4-times daily (00, 06, 12, 18 UTC) around the ice camp period (18 UTC 11 Aug. ~ 12 UTC 14 Aug.)
- Total number of launch: 50
  - 43 succeeded, 7 failed (Success rate: 86%)
  - Average ascending height: 30 km (mid-stratosphere)
- Striving for on-line data
  - Among 37 launches at 00 and 12 UTC, 29 of them were successfully transmitted to the KOPRI server
    - Data transmission: 1st data (surface to 100-hPa) during ascent, 2nd complete data after termination



Shipboard observation

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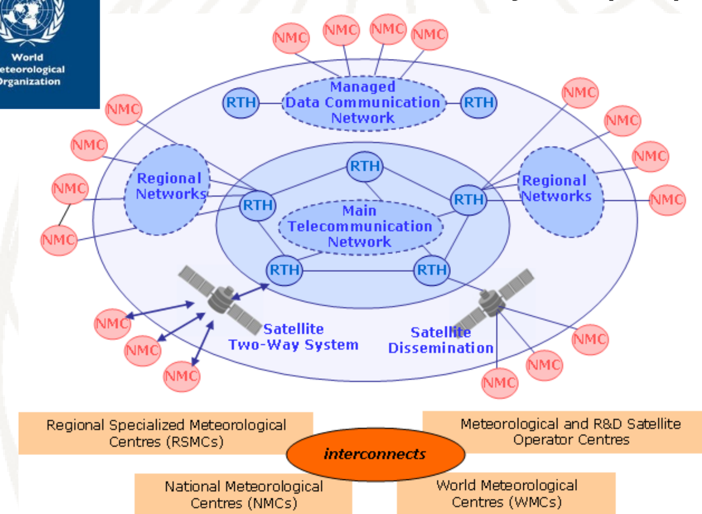
INMARSAT satellite

KOPRI server

KMA
Korea Meteorological Administration

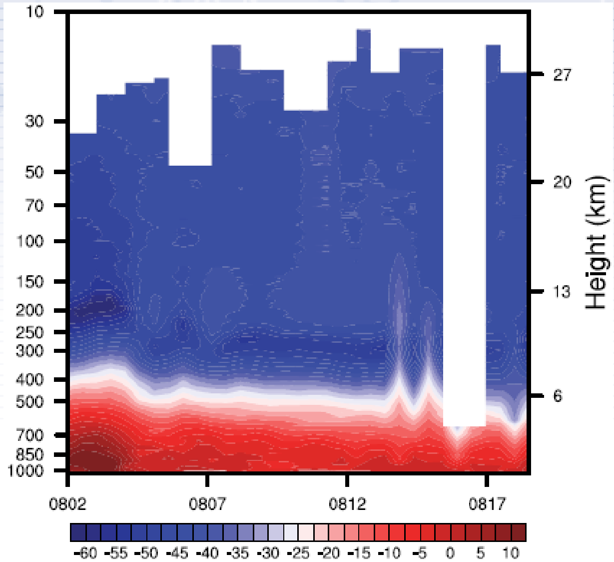
World Meteorological Organization

Global Telecommunication System (GTS)

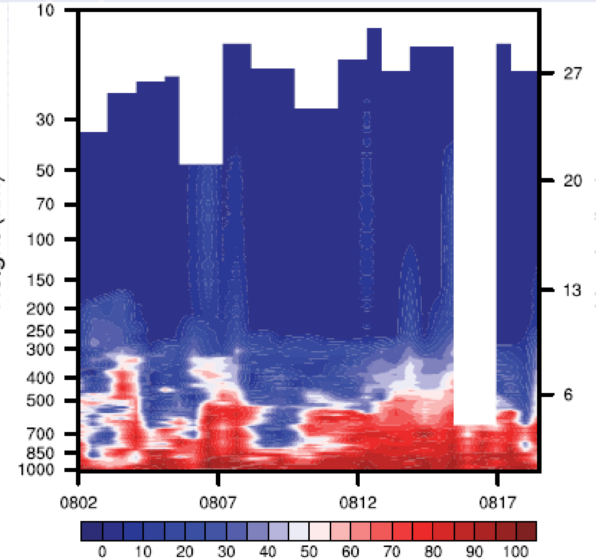


Radiosonde profile

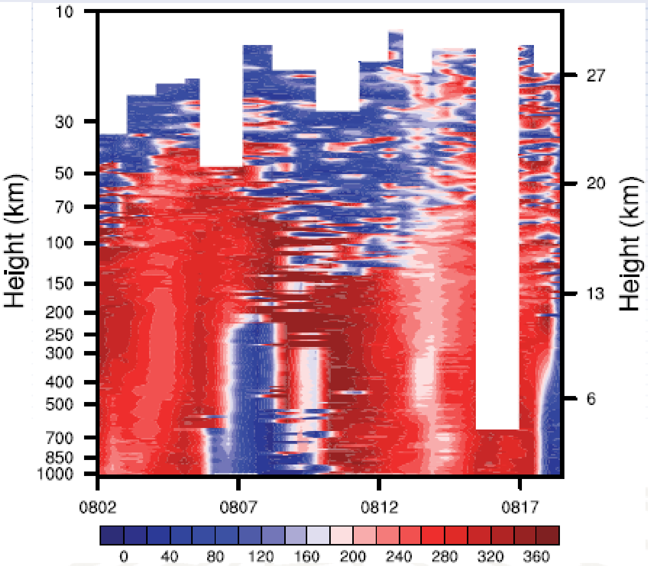
Temperature



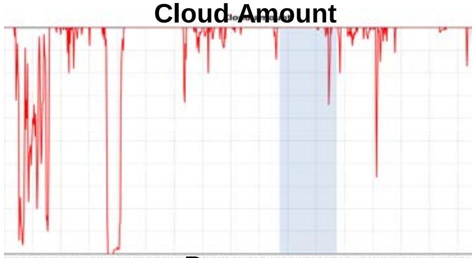
Relative Humidity



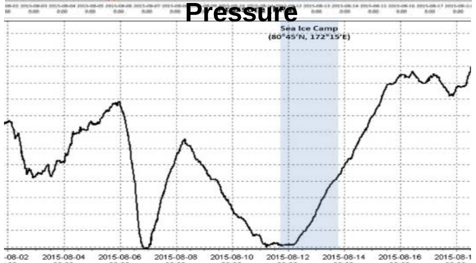
Horizontal Wind Direction



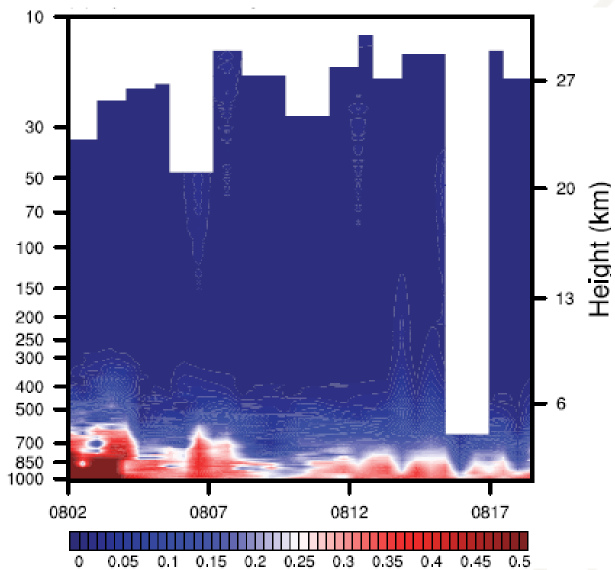
Cloud Amount



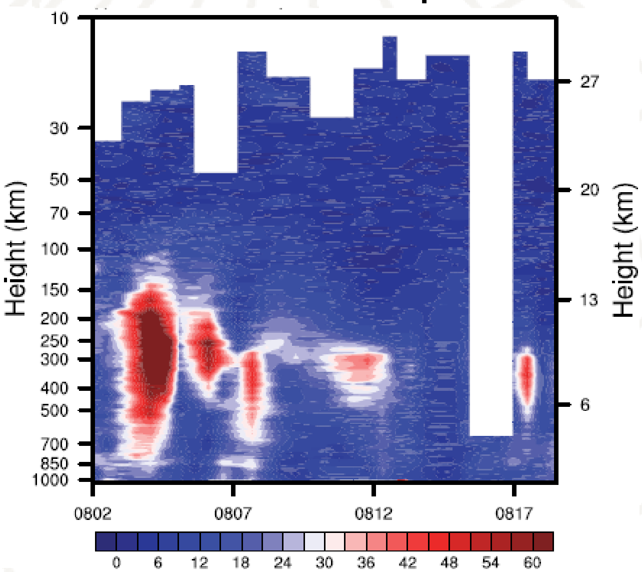
Pressure



Specific Humidity



Horizontal Wind Speed



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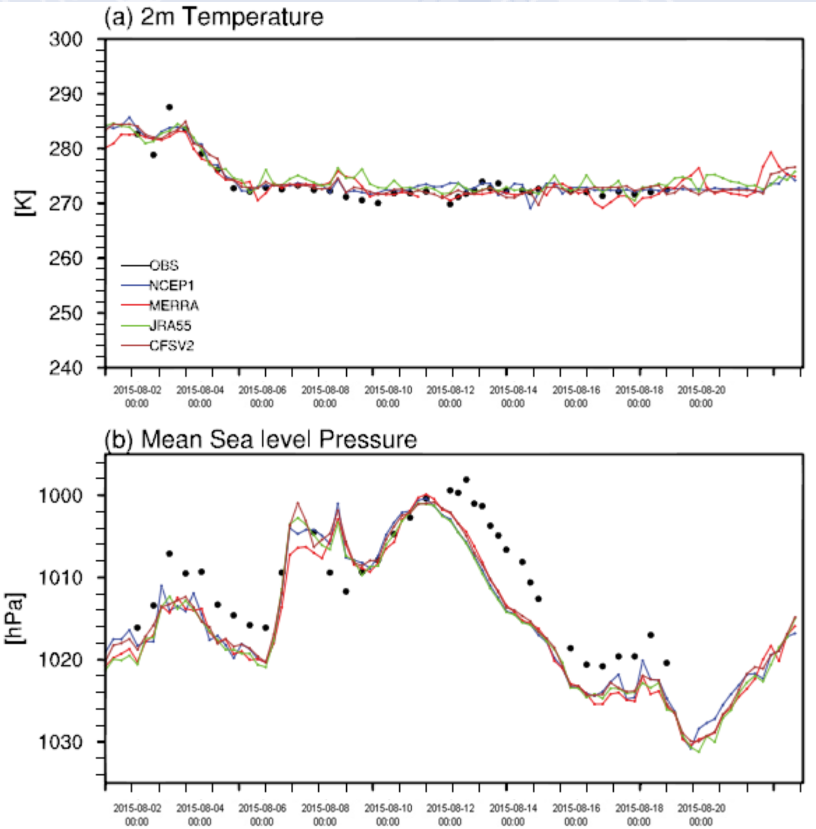
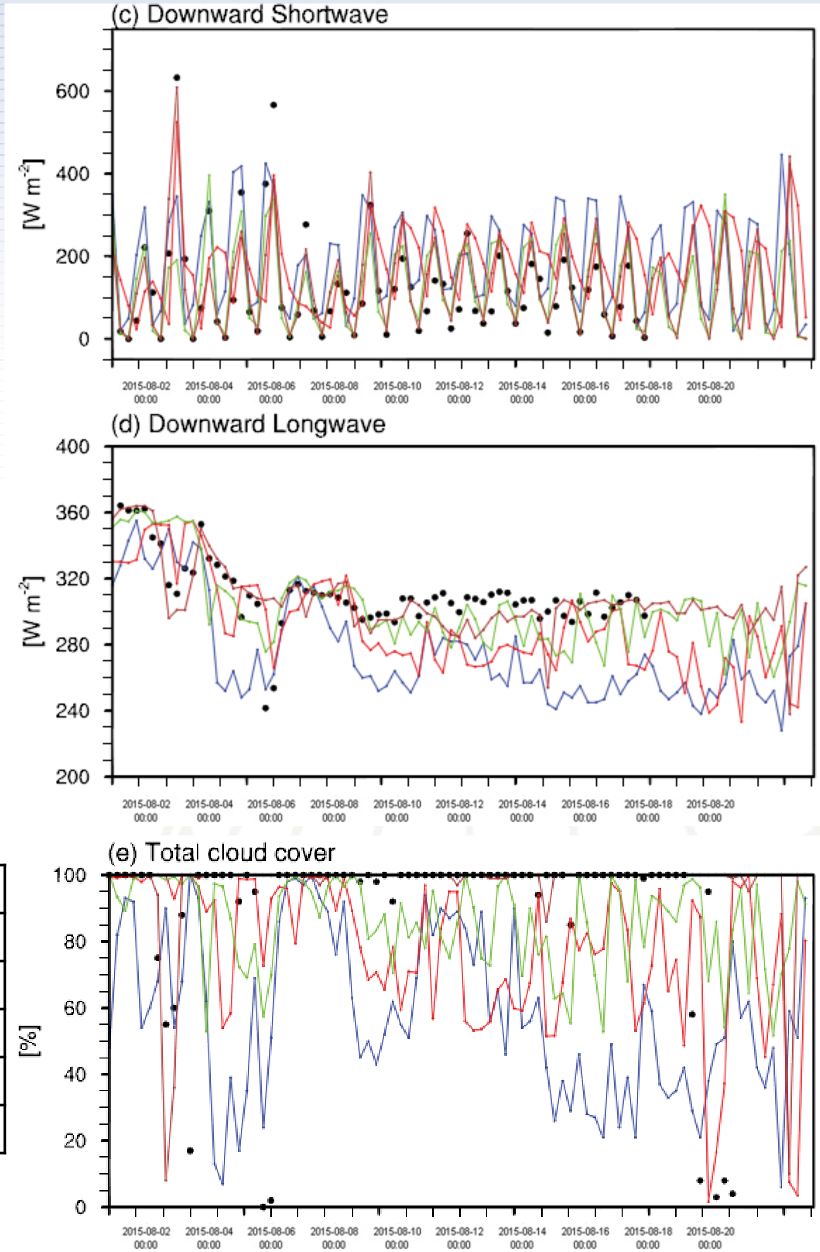
Preliminary comparison with available reanalysis datasets





COR / RMSE	NCEP1	MERRA	JRA55	CFSv2
T2m	0.88 / **1.47**	0.89 / 1.60	0.83 / 1.94	**0.90** / 1.49
MSLP	0.72 / 6.24	**0.76** / 6.34	0.74 / 6.19	0.75 / **5.82**
DSWR	0.59 / 125.53	0.57 / 114.48	0.69 / 89.96	**0.86 / 63.72**
DLWR	0.69 / 38.28	0.56 / 25.70	**0.75** / 18.43	0.72 / **15.45**
TCC(CA)	0.08 / 46.59	0.04 /35.04	**0.15** / **28.73**	**0.15** / 29.43

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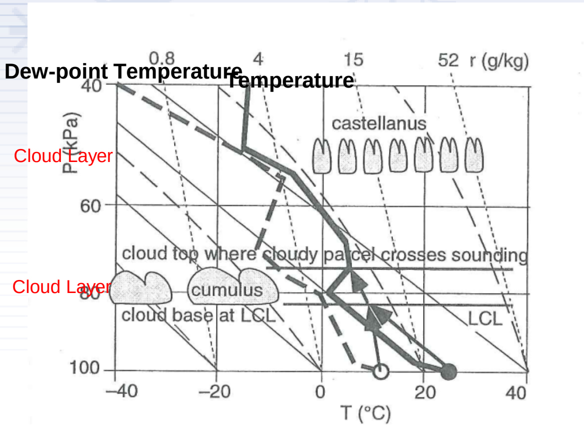
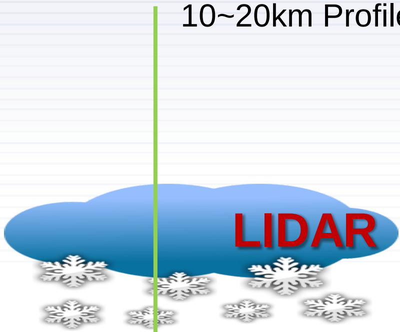
Further strengthening (2017~)



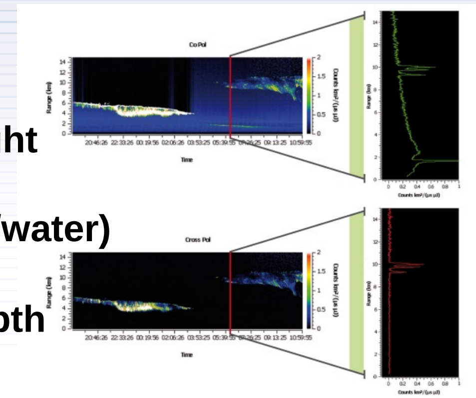
Upper Temperature, Humidity, Wind Profile

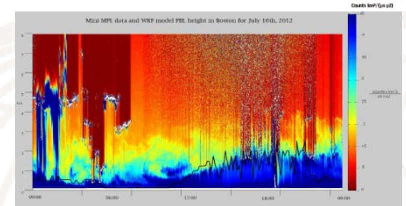
Satellite Remote Sensing

10~20km Profile

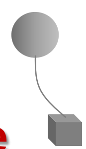


- **Cloud Height**
- **Phase (ice/water)**
- **Optical Depth**
- **Cloud Type**
- **ABL Height**

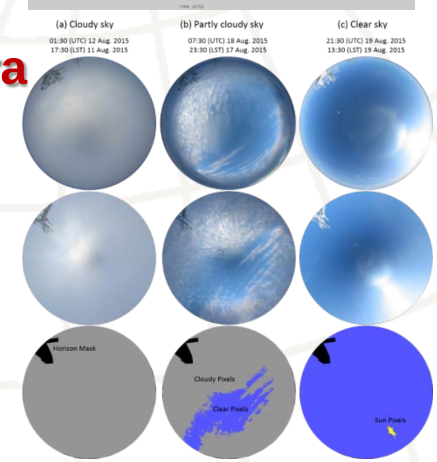


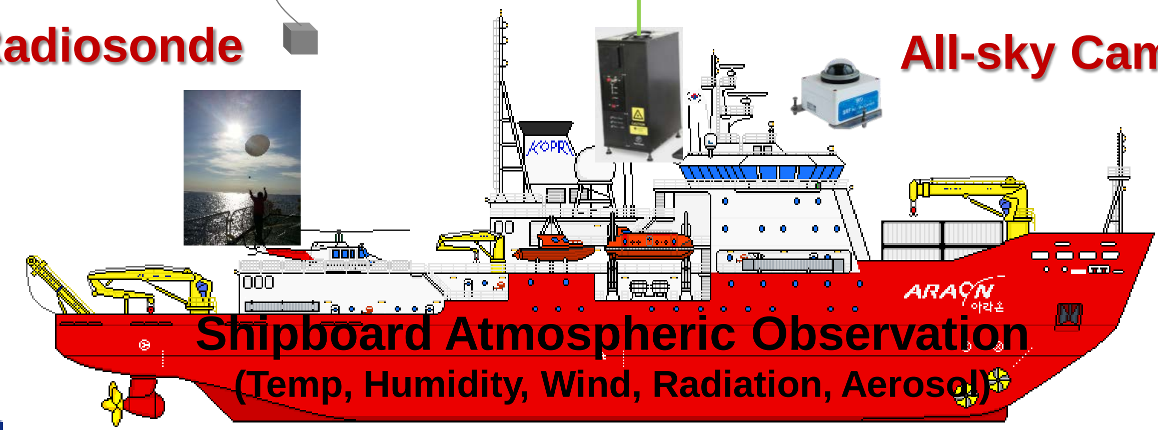


Radiosonde



All-sky Camera



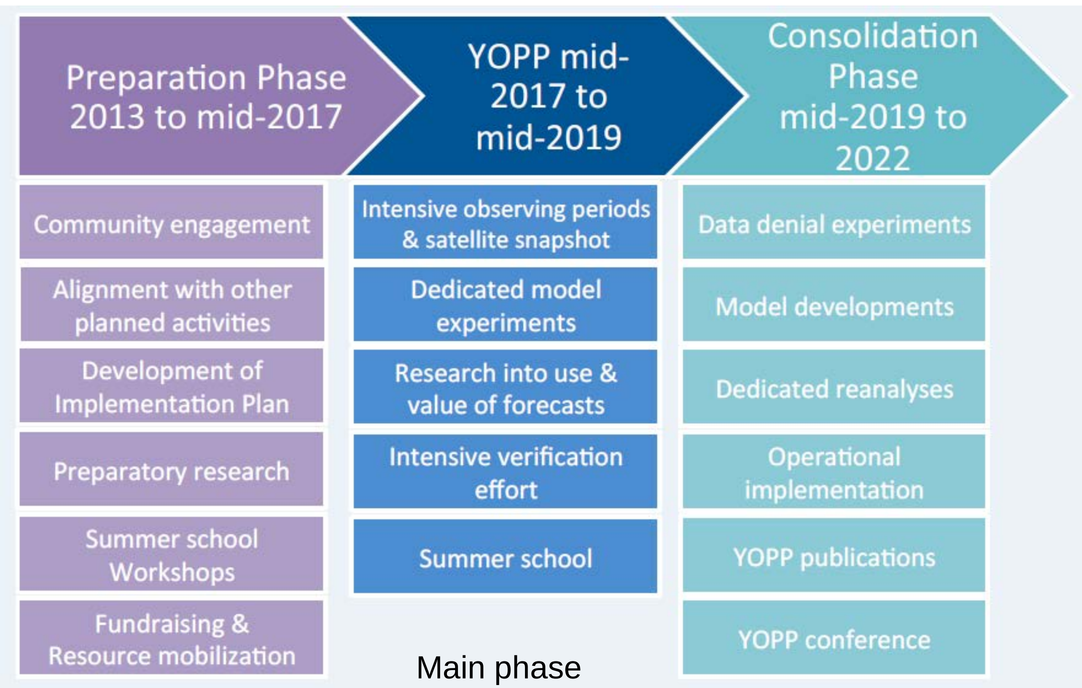


Shipboard Atmospheric Observation

(Temp, Humidity, Wind, Radiation, Aerosol)

YOPP (Year of Polar Prediction)

- **An extended period of coordinated intensive observational and modelling activities**, in order to improve prediction capabilities for the polar regions and beyond, on a wide range of time scales from hours to seasons
- A key element of the WWRP-PPP



WORLD METEOROLOGICAL ORGANIZATION

WORLD WEATHER RESEARCH PROGRAMME

WWRP/PPP No. 3

WWRP Polar Prediction Project

Implementation Plan
for the Year of Polar Prediction
(YOPP)

World Meteorological Organization

October 2014

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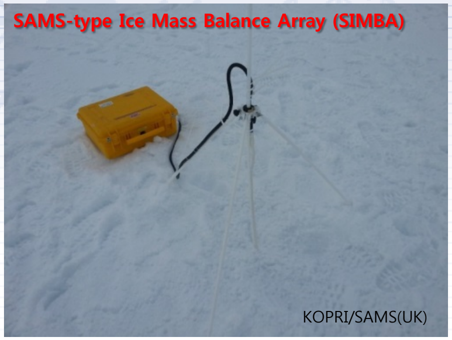
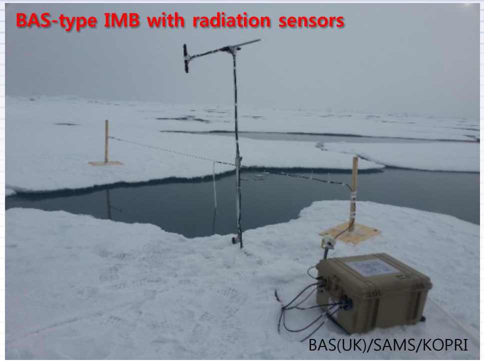
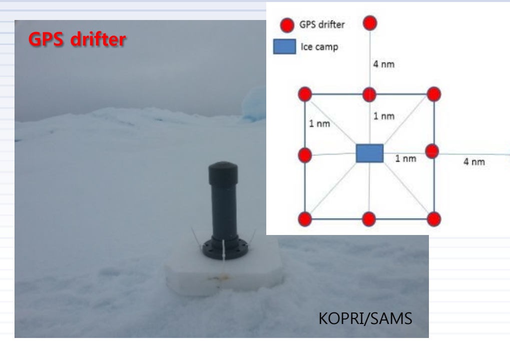
We are about to submit our application form for YOPP endorsement.

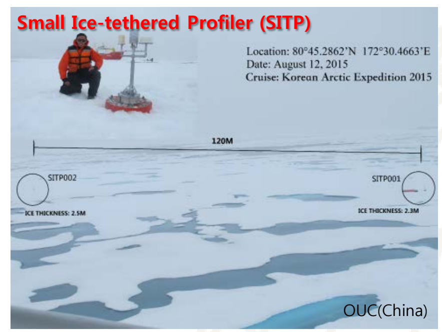
Activities on sea ice

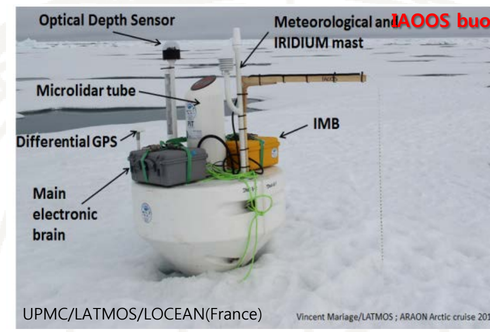
- Sea ice buoy deployments for physical observation







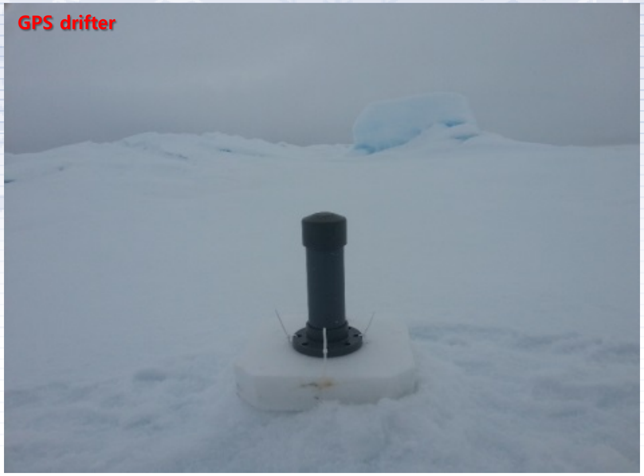




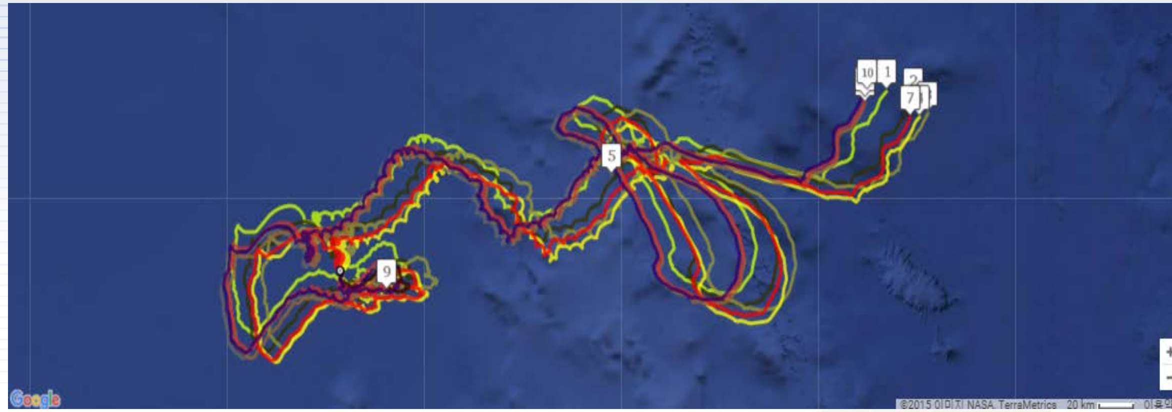
<Objectives>

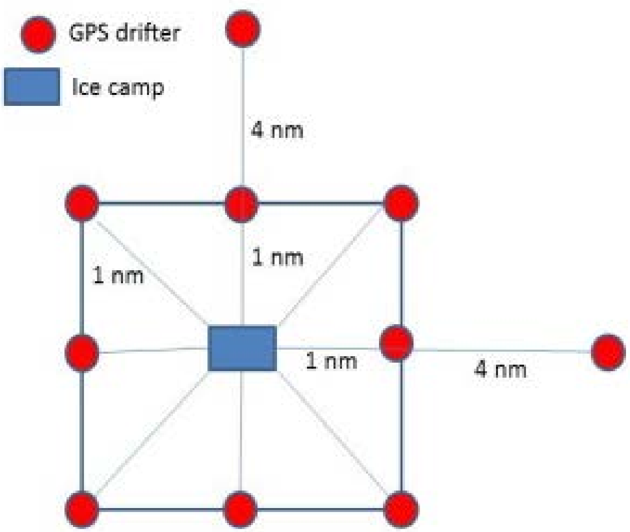
- To measure in-situ physical parameters of atmosphere, ice and ocean autonomously throughout the annual cycle
- To understand key physical processes operating between and within atmosphere-ice-ocean
- To study the energy balance at the atmosphere-ice-ocean interface

KOPRI-SAMS drifting buoys (Drifter 01 – 10)



Drifter 01~10 tracks





Status Monitoring

(As of 2015-10-18)

= DRIFTERS =

	Drifter 01 300234062941850	81 28.1820 81.46970	-172 26.9928 -172.44988	02:23 hours ago	10.33 (V)
	Drifter 02 300234062940880	81 26.3718 81.43953	-171 41.2218 -171.68703	02:23 hours ago	10.28 (V)
	Drifter 03 300234062949830	81 23.6190 81.39365	-171 15.7542 -171.26257	07:23 hours ago	10.41 (V)
	Drifter 04 300234062947770	81 22.8930 81.38155	-171 29.3724 -171.48954	02:23 hours ago	10.24 (V)
	Drifter 05 300234062945880	81 10.6662 81.17777	179 43.1652 179.71942	25 days ago	10.05 (V)
	Drifter 06 300234062946880	81 25.6176 81.42696	-173 3.4260 -173.05710	08:23 hours ago	10.39 (V)
	Drifter 07 300234062943850	81 22.7904 81.37984	-171 45.4128 -171.75688	07:23 hours ago	10.1 (V)
	Drifter 08 300234062329110	81 26.6076 81.44346	-173 2.7372 -173.04562	08:23 hours ago	10.39 (V)
	Drifter 09 300234062949850	80 45.1188 80.75198	173 17.7558 173.29593	66 days ago	10.54 (V)
	Drifter 10 300234062941760	81 28.3812 81.47302	-173 0.6900 -173.01150	02:23 hours ago	10.41 (V)

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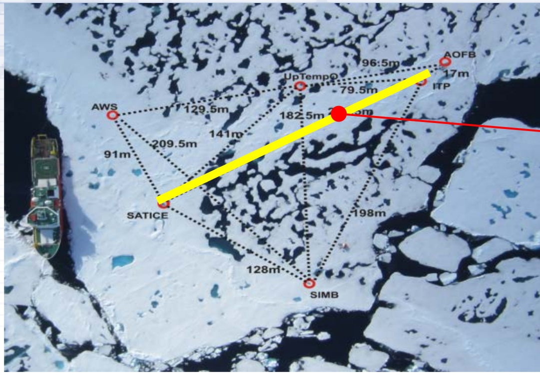
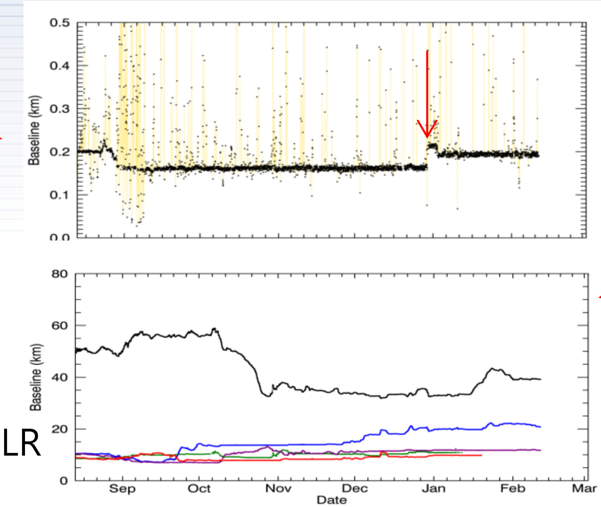
Sea ice dynamics – effects of scales on deformation

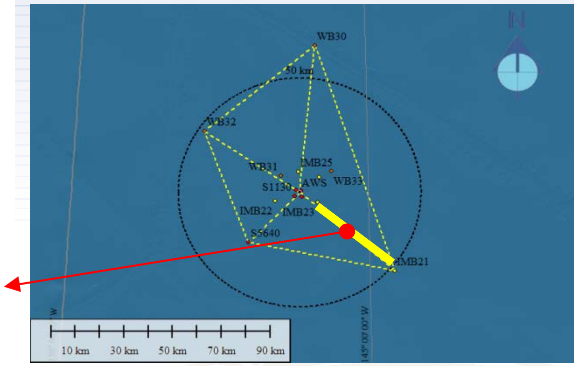
Phil Hwang, SAMS, Pedro Elosegui, ICM-CSIC/MIT, Jeremy Wilkinson, BAS

Small scale (< 1km) deformation

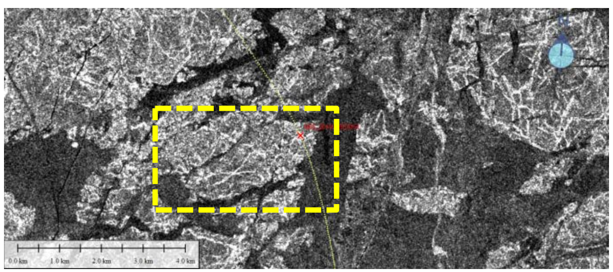
Large scale (> 1km) deformation



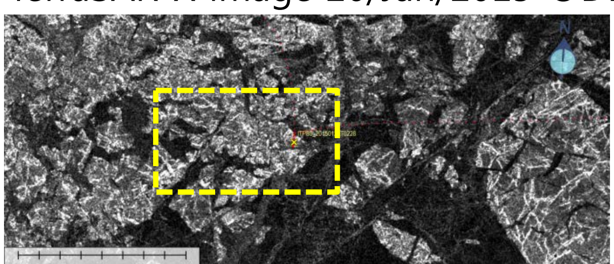




TerraSAR-X image 28/Nov/2014 ©DLR



TerraSAR-X image 20/Jan/2015 ©DLR

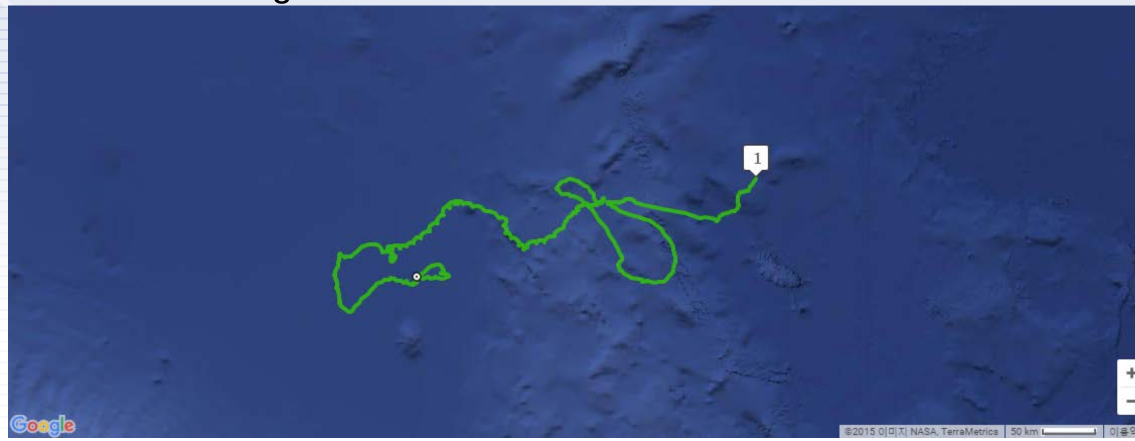


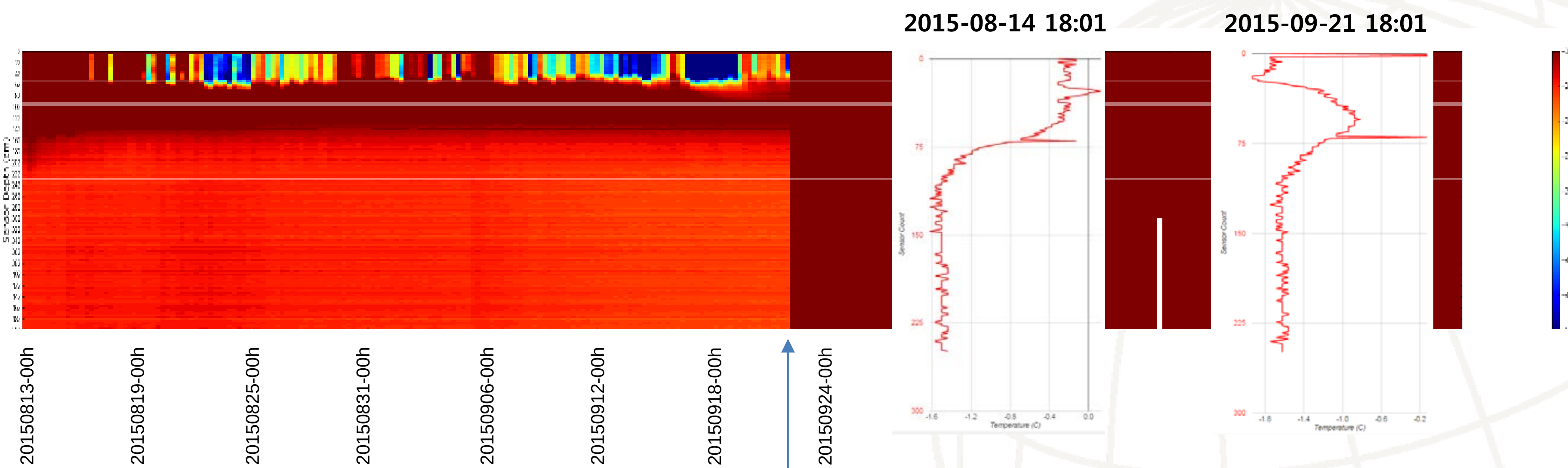
Early January the buoys deploy
ed on the floe detected "displac
ement" (see red arrow above), i
ndicating deformation of the fl
oe. SAR images taken across thi
s period show significant defor
mation of the floe (see yellow r
ectangles in the images on the
right).

- *How atmospheric forcing is related to sea ice defo rmation at different scal es?*
- ***What is the spatial and t emporal correlation acro ss the scale?***
- ***Can we parameterize ice deformation across the s cale?***

KOPRI-SAMS IMB 01

IMB 01 - Drifting track





Temperature chain died at 20150922-00h~06h

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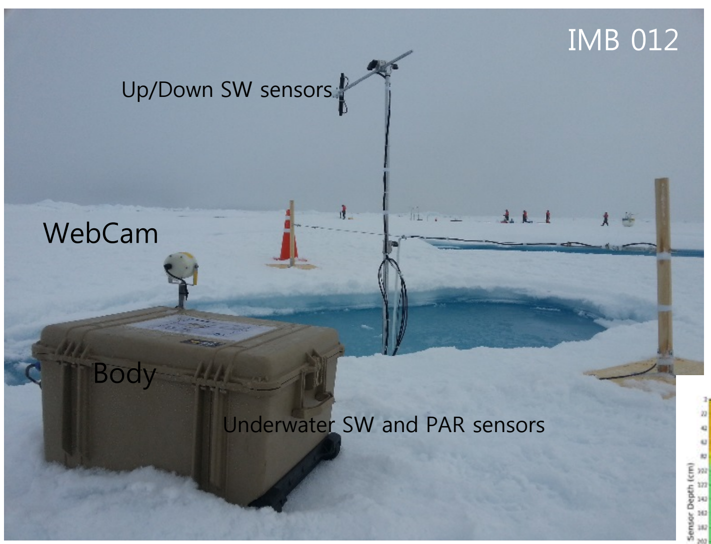
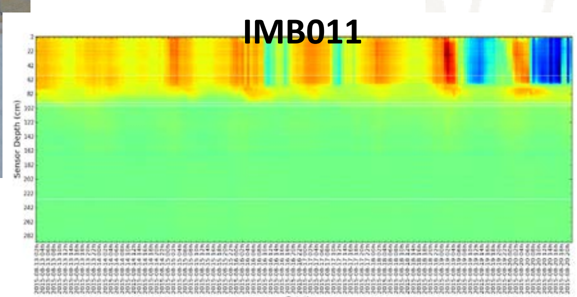
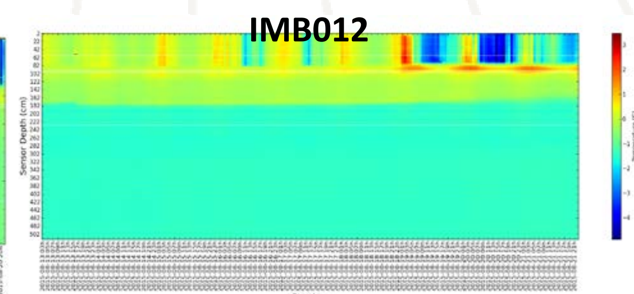
BAS-type IMB (011 & 012) with radiation sensors



- Two new-type buoys with radiation sensors were experimentally deployed in different melt ponds
  - IMB 011 : deployed in saline pond (Salinity: 20 psu)
  - IMB 012 : deployed in fresh pond (Salinity: 2.3 psu)
  - Objectives
    - In order to capture thermal and thickness variation of the pond water and ice all together throughout the annual cycle
    - To understand the effect of pond salinity on evolution characteristic during transition (melting/freezing) season





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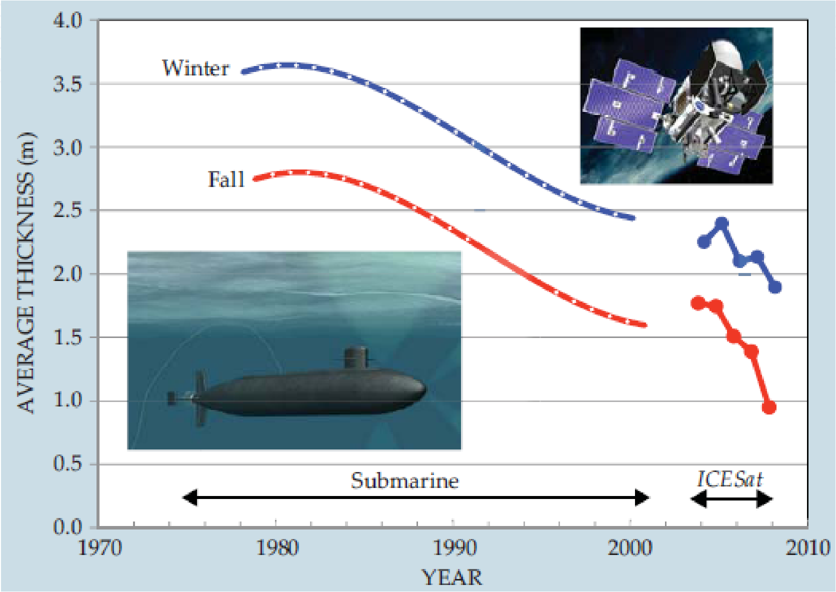
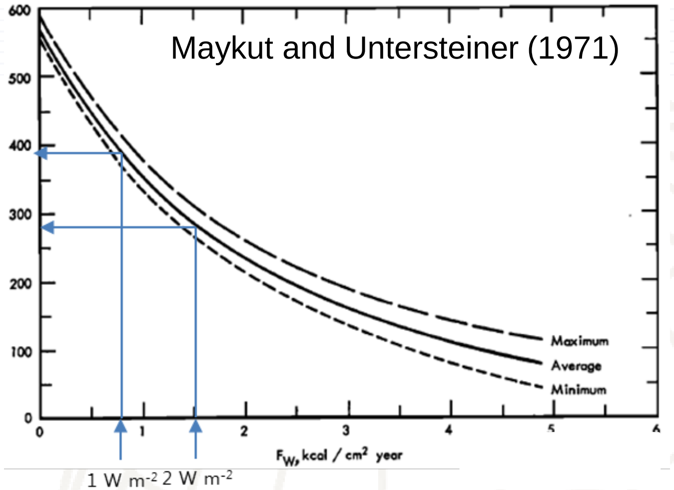
Ocean heat flux

"The surplus heat needed to explain the loss of Arctic sea ice during the past few decades is on the order of 1~2 W m^{-2}. Observing, attributing, and predicting such a small amount of energy remain daunting problems."

Kwok and Untersteiner (2011)



Kwok and Untersteiner (2011)



- Sensitivity of equilibrium thickness to ocean heat flux variations

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Evolution of sea ice – energy balance

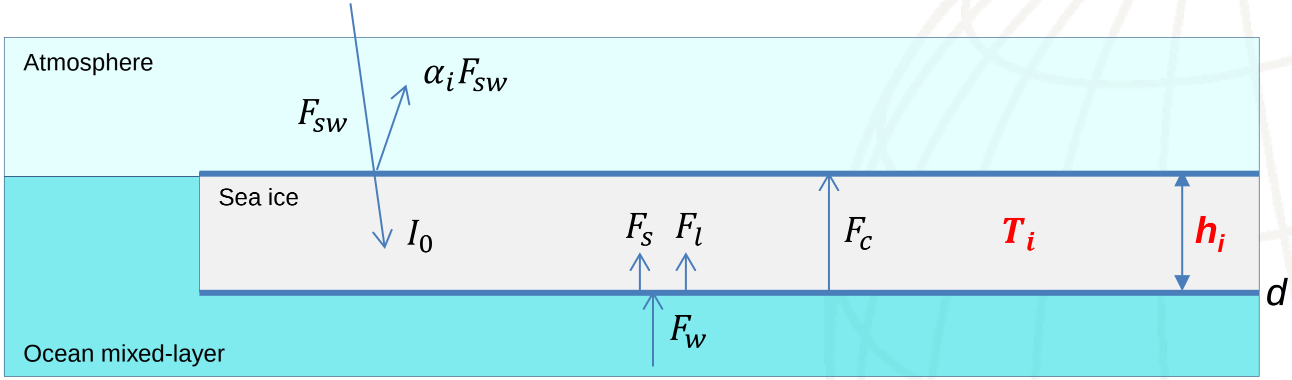
- Inner energy balance: vertical gradient of conductive heat flux(F_c) and absorbing insolation(I_0)

- Bottom energy balance: ocean heat flux(F_w), conductive heat flux(F_c), latent heat flux due to phase change(F_l), specific heat flux due to ice temperature change (F_s)

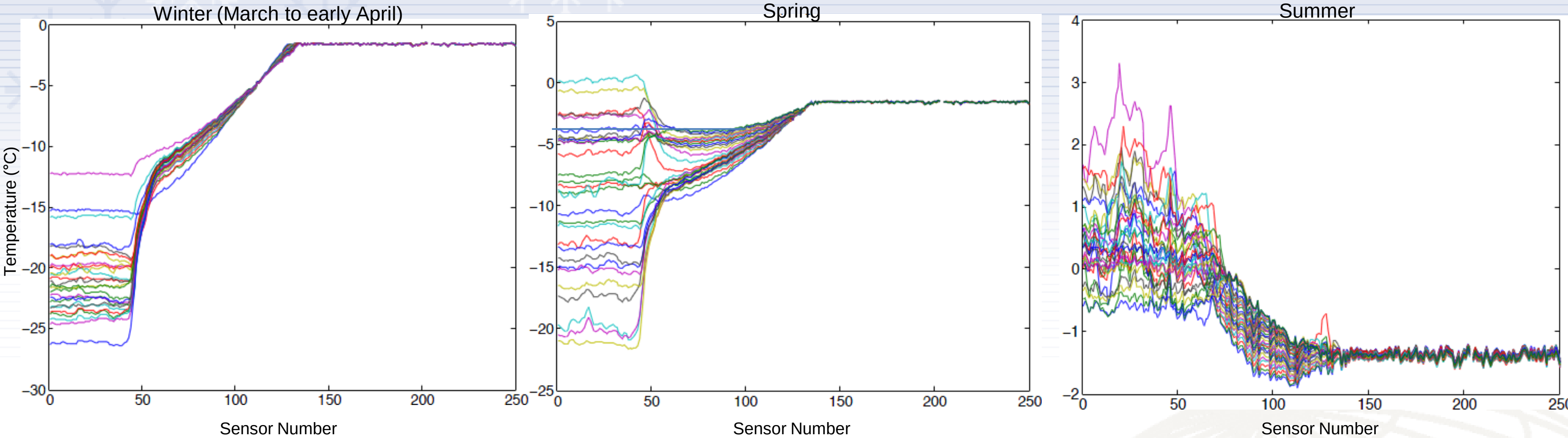
$$F_w - (F_c + F_l + F_s) = 0$$

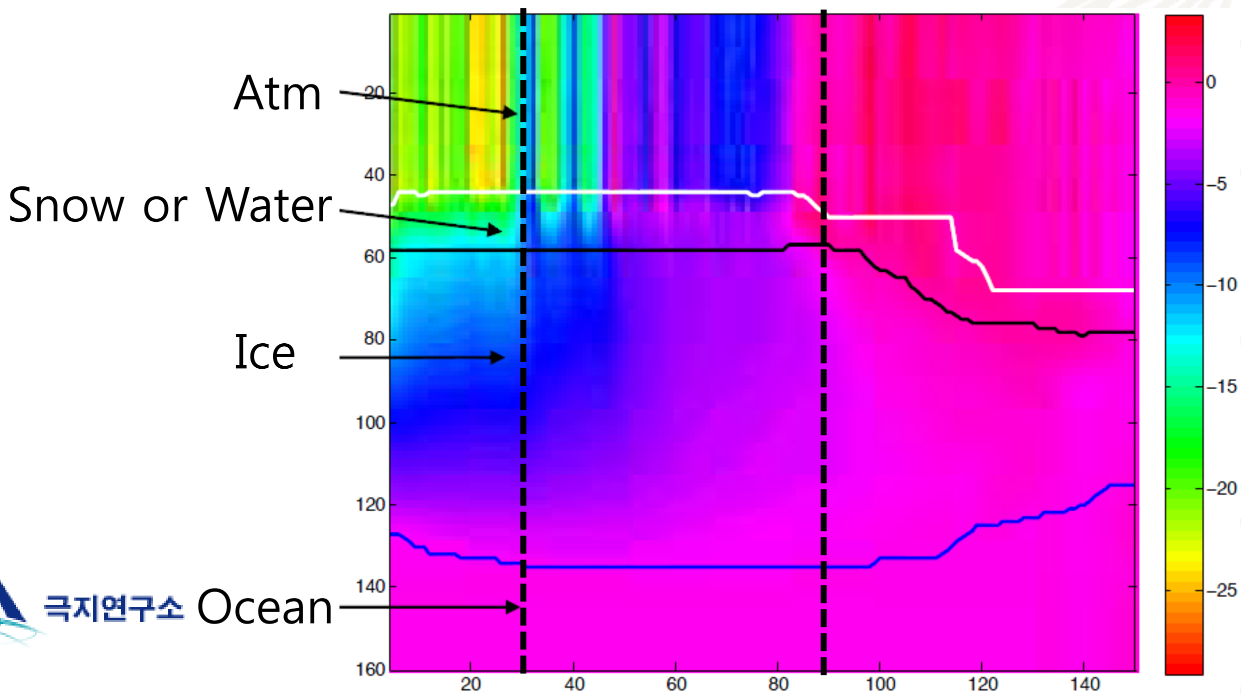
Estimation of ocean heat flux by "Residual Method" McPhee and Untersteiner (1982)

$$F_c = k_i(S_i, T_i)\frac{\partial T_i}{\partial z} \qquad F_l = -\rho_i L_f(S_i, T_i)\frac{\partial h_i}{\partial t} \qquad F_s = \rho_i c_i(S_i, T_i)\frac{\partial T_i}{\partial t}\Delta d$$



Example of IMB temperature profile (Deployed in March 2014)





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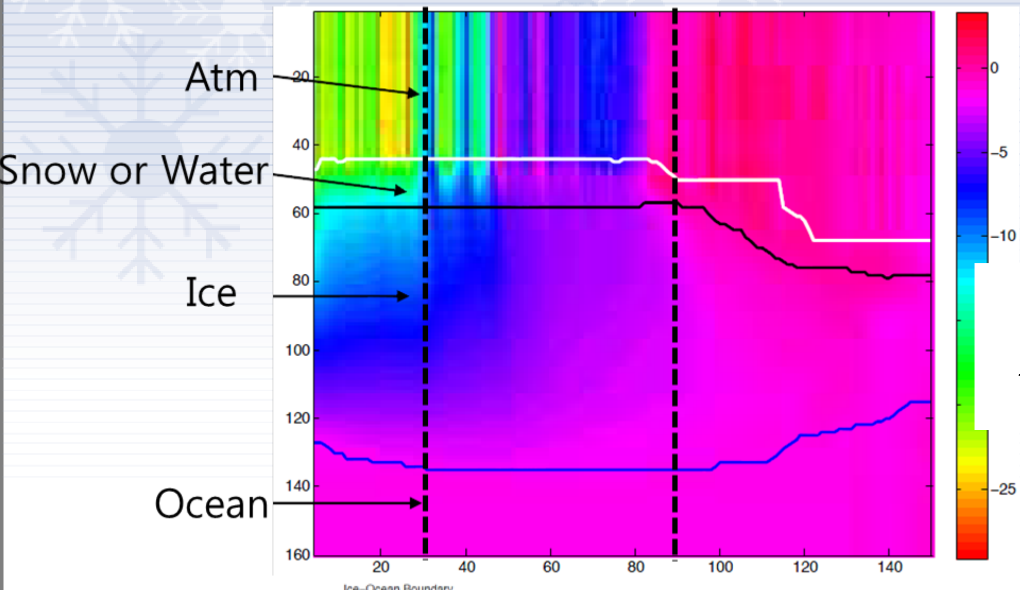
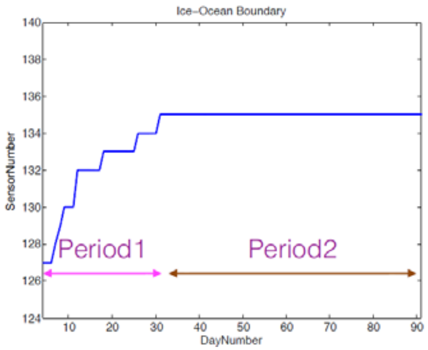
Estimation of ocean heat flux using “residual method”



$$F_w - (F_c + F_l + F_s) = 0$$

$$F_w \approx k_i \frac{\partial T_i}{\partial z} - \rho_i L_f \frac{\partial h_i}{\partial t} + F_s$$

small



$$\langle F_w \rangle \sim \left\langle k_i \frac{\partial T_i}{\partial z} \right\rangle - \left\langle \rho_i L_f \frac{\partial h_i}{\partial t} \right\rangle$$

$\langle \cdot \rangle$ **: Time Average**

- Period 1 (14~16) – (18~20) ~-4 W m^{-2}
- Period 2 (6~9) – 0 ~7 W m^{-2}

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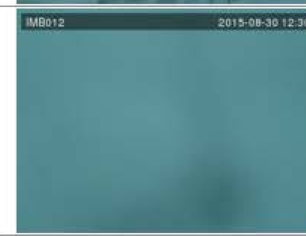
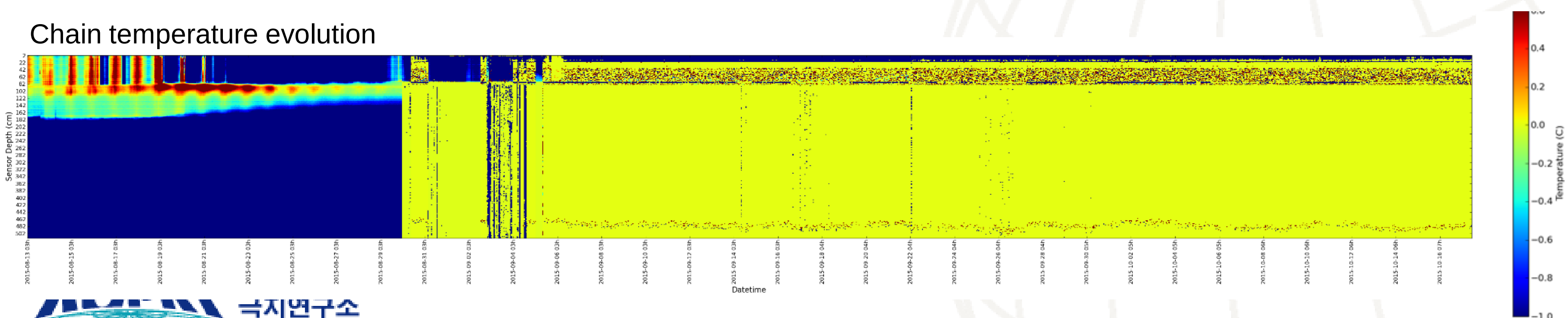
Natural hazard

- IMB 012 temperature chain was broken end of August highly likely by a visitor.

Dates	00:30	06:30	12:30	18:30
31/08/2015 DAY 243				
30/08/2015 DAY 242				
29/08/2015 DAY 241				

Chain temperature evolution



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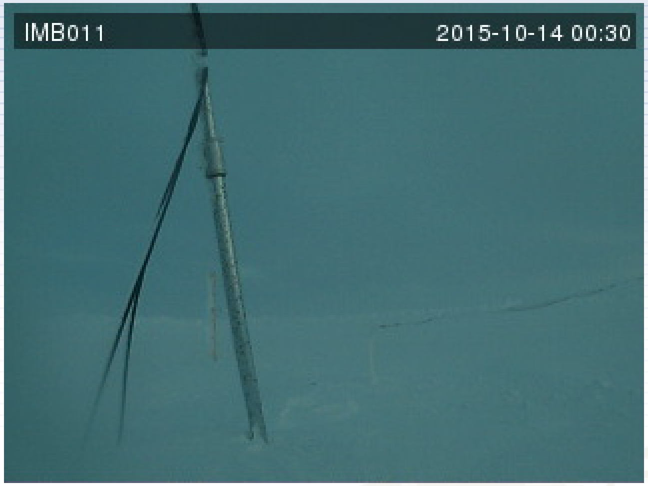
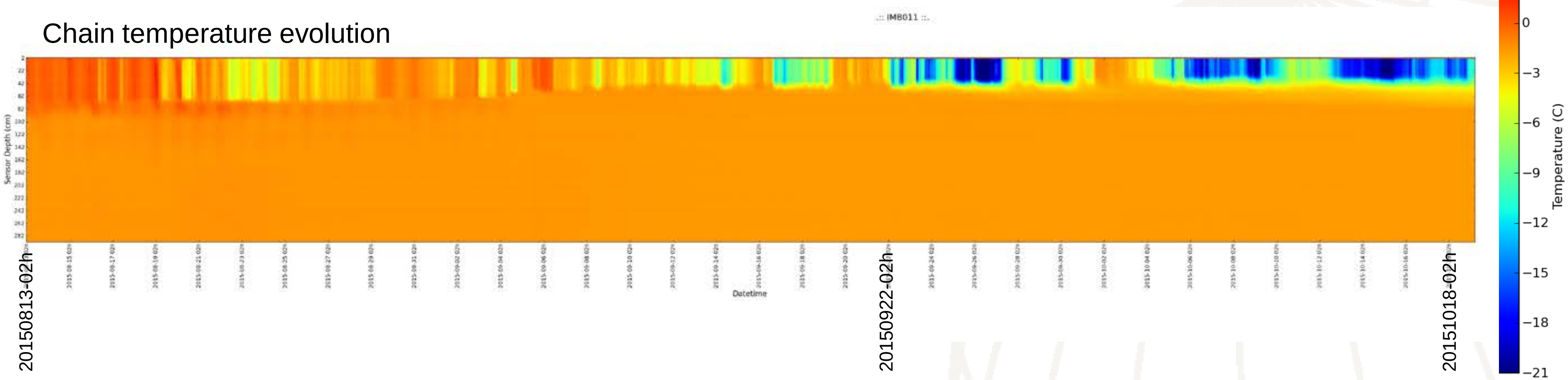
IMB 011

- Last communication: 8 days ago
- Frozen and covered by snow
- Still Working fine!

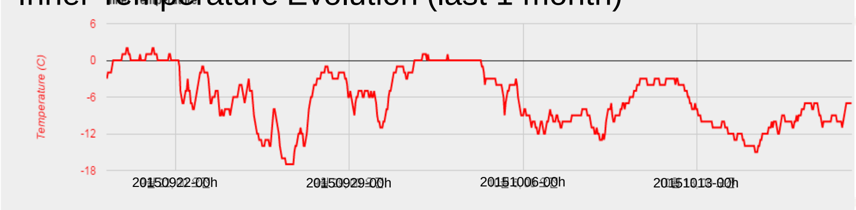
Most recent discernible webcam image



Chain temperature evolution



Inner Temperature Evolution (last 1 month)



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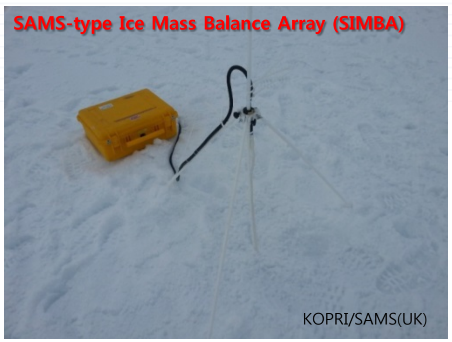
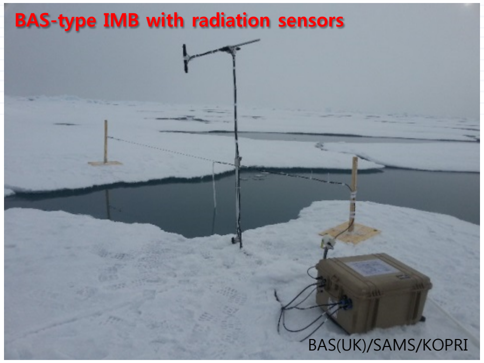
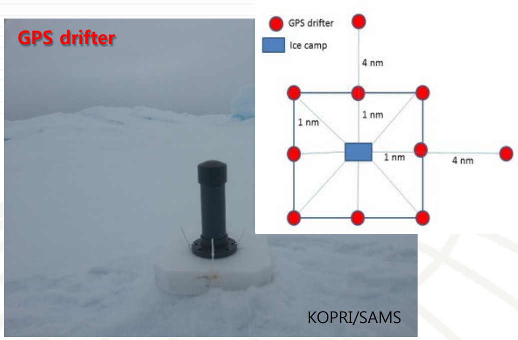
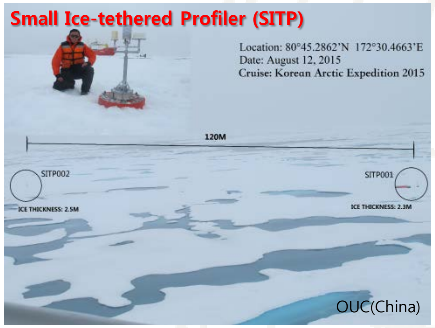
Autonomous platform on sea-ice

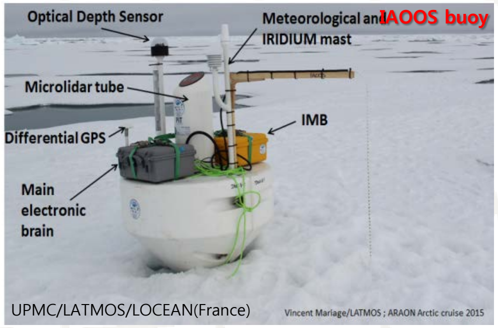
- Continue buoy deployments through international collaborations
  - BAS, SAMS, CRREL, ONR, CSIC, OUC, UPMC, WHOI etc.
- Develop challenging scientific questions can be solved by this effort
  - Melt pond parameterization, Recovery of salinity profile, etc.











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Thank You

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