

# Arctic sea ice observations in summer 2016

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Engineering

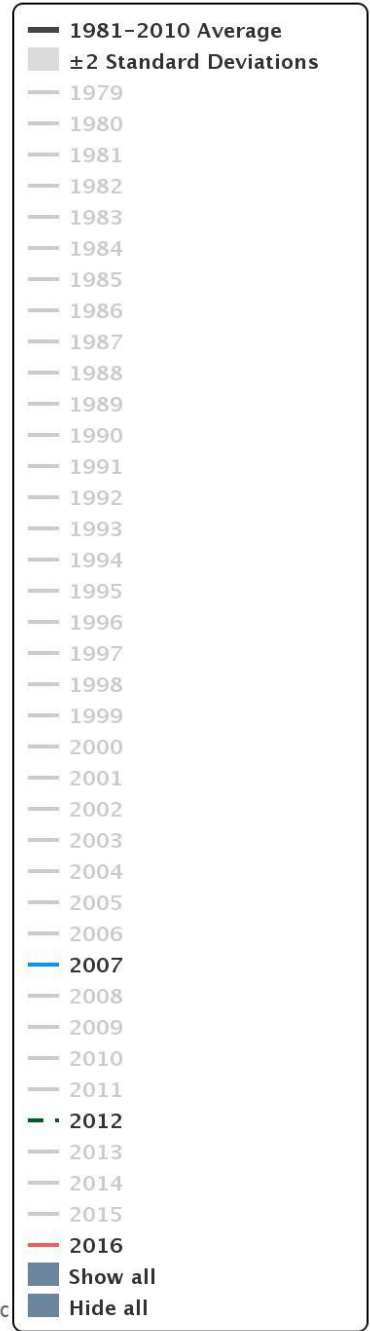
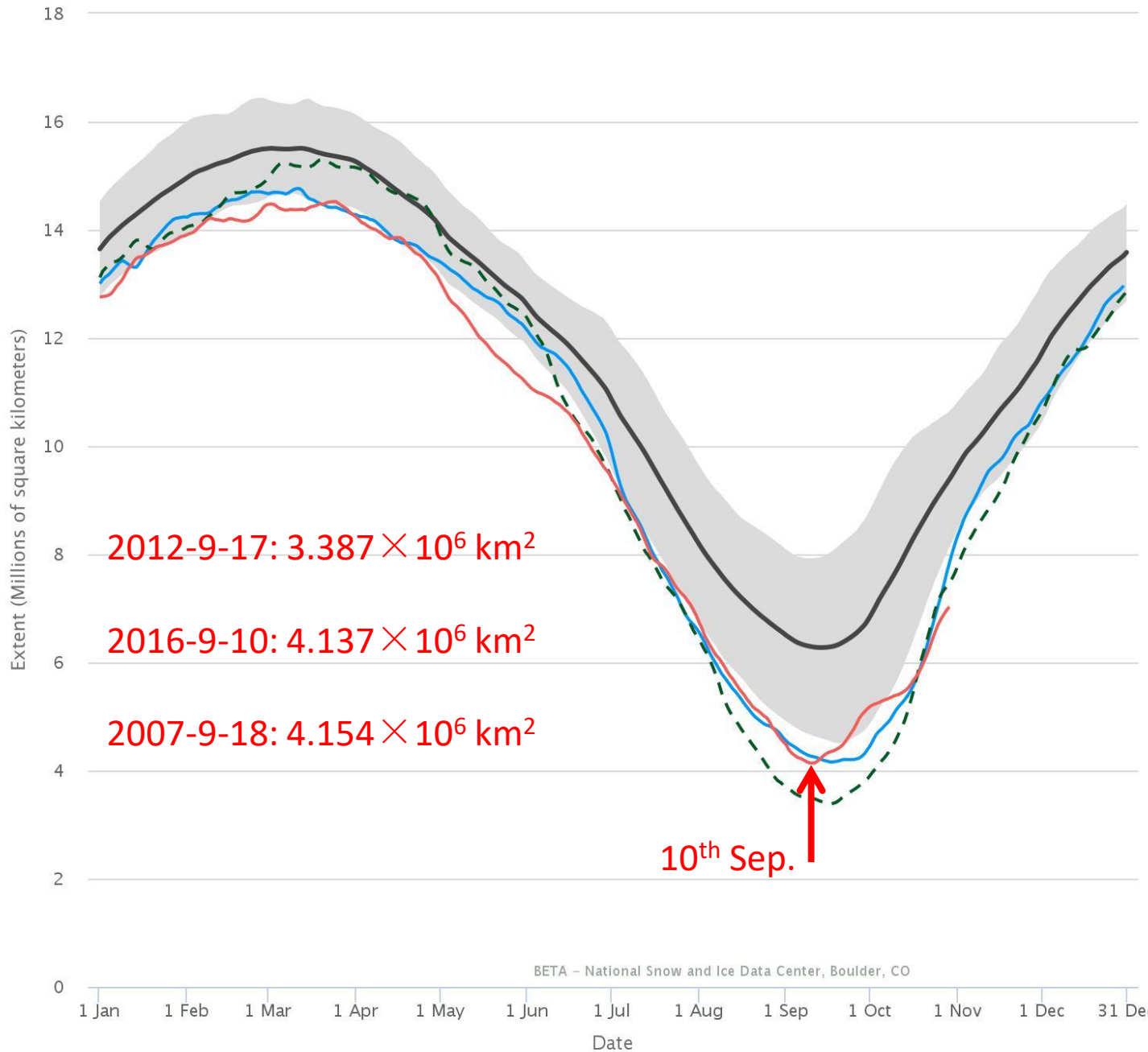
Polar Ocean Engineering Research Center

Dalian University of Technology, Dalian, CHINA

11. 8. 2016

# Arctic Sea Ice Extent

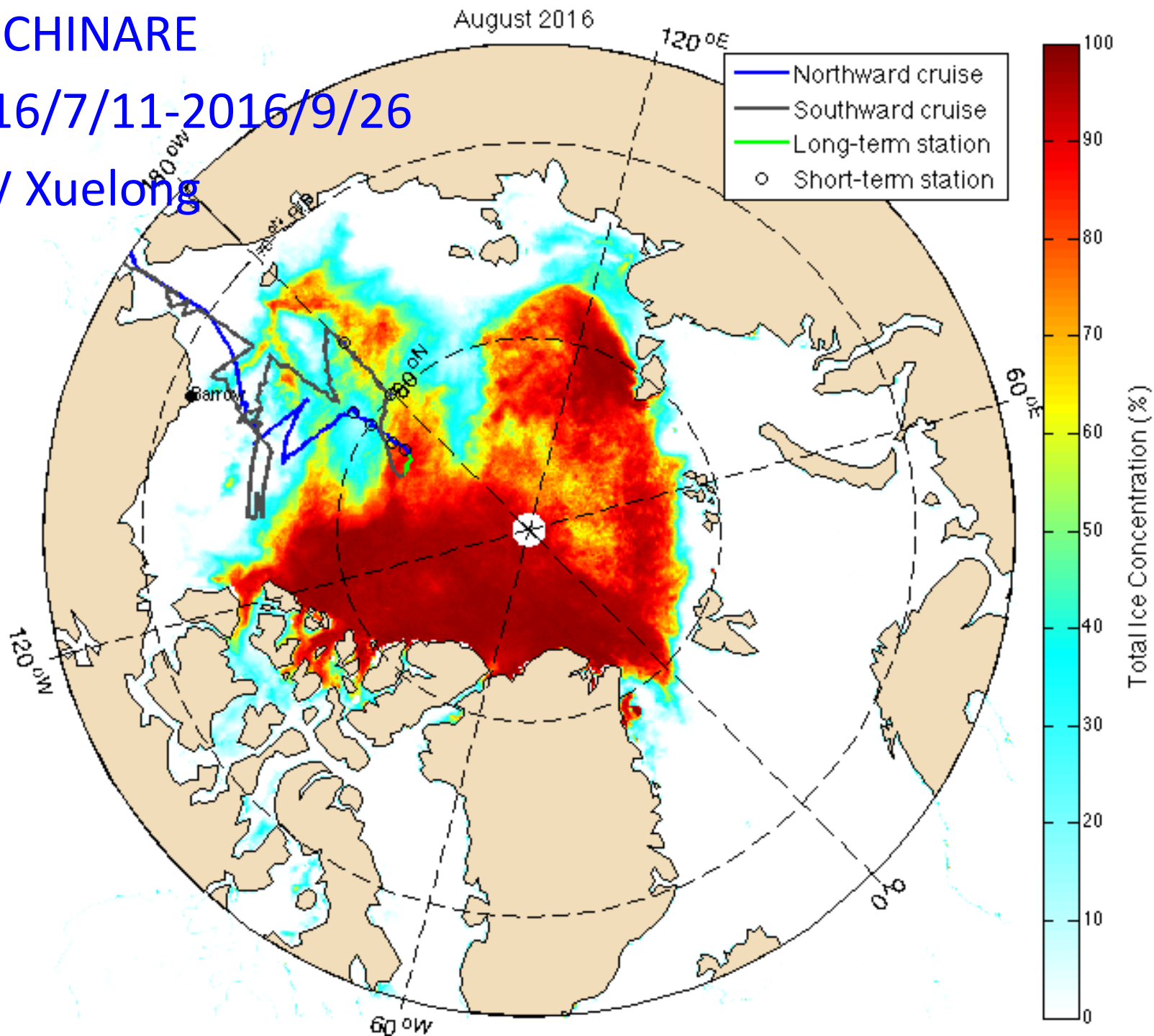
(Area of Ocean with at least 15% sea ice)



- 7<sup>th</sup> CHINARE

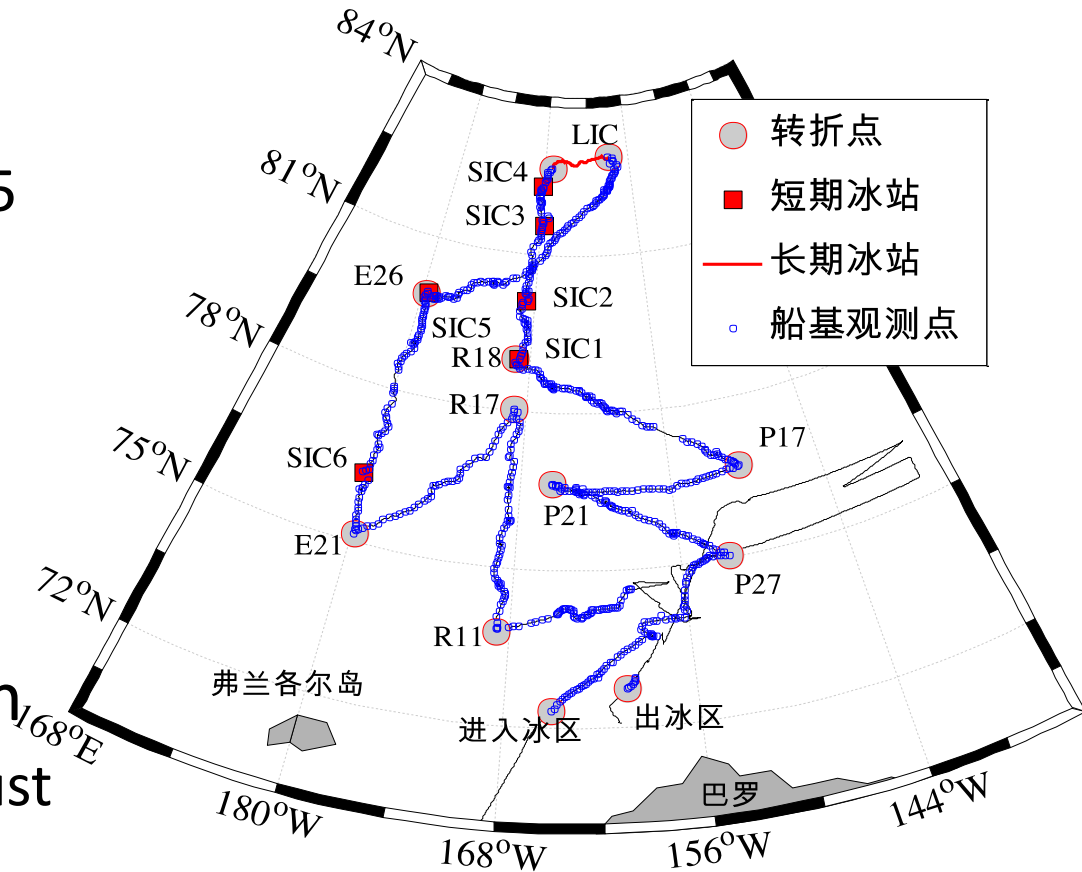
- 2016/7/11-2016/9/26

- R/V Xuelong



# Field investigation date

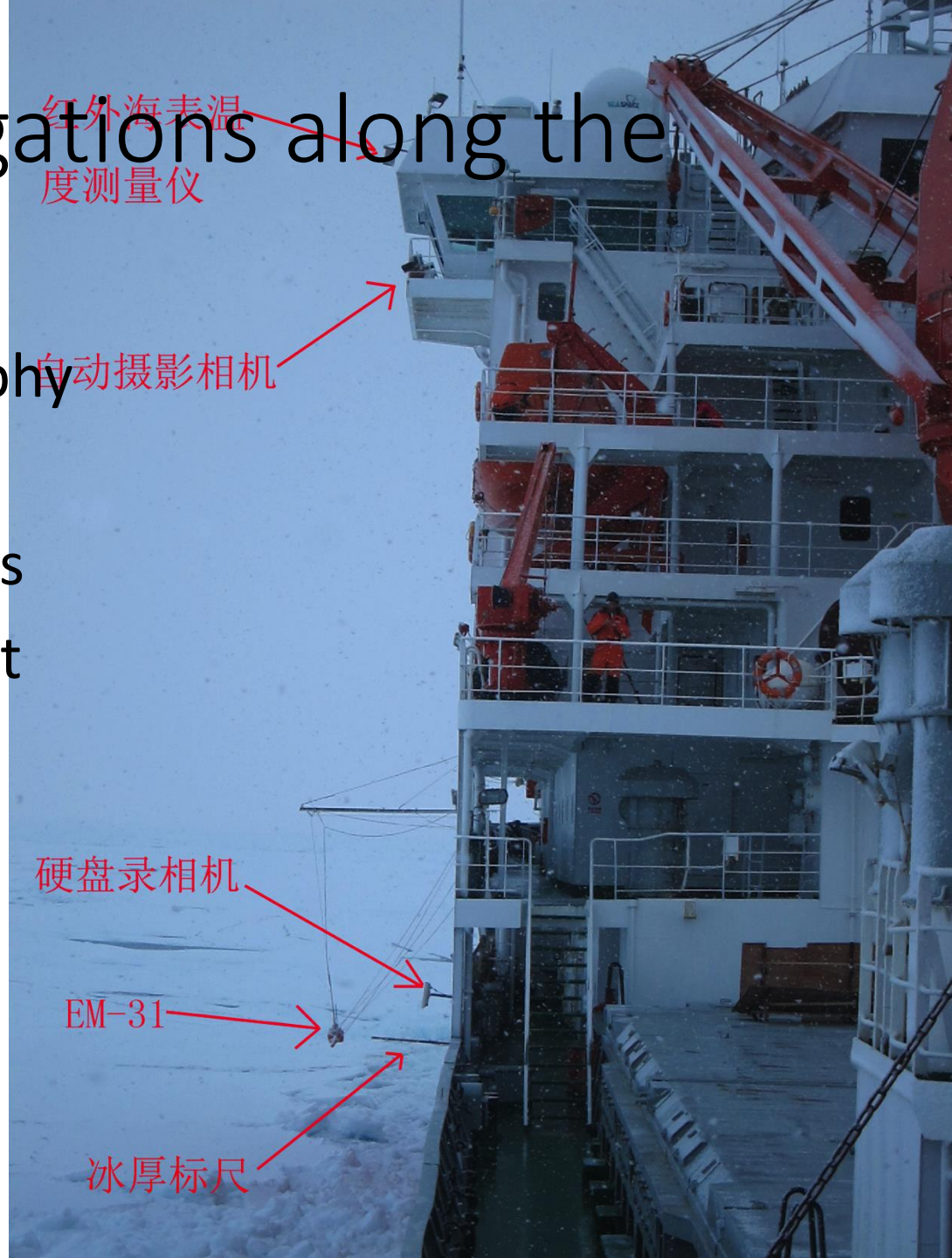
- Along cruise track
  - Northward: 7.15-8.7
  - Southward: 8.15-8.25
- Long-term ice station
  - 8.7-8.15
- Short-term ice station
  - 4,5,6,7,18,20 in August



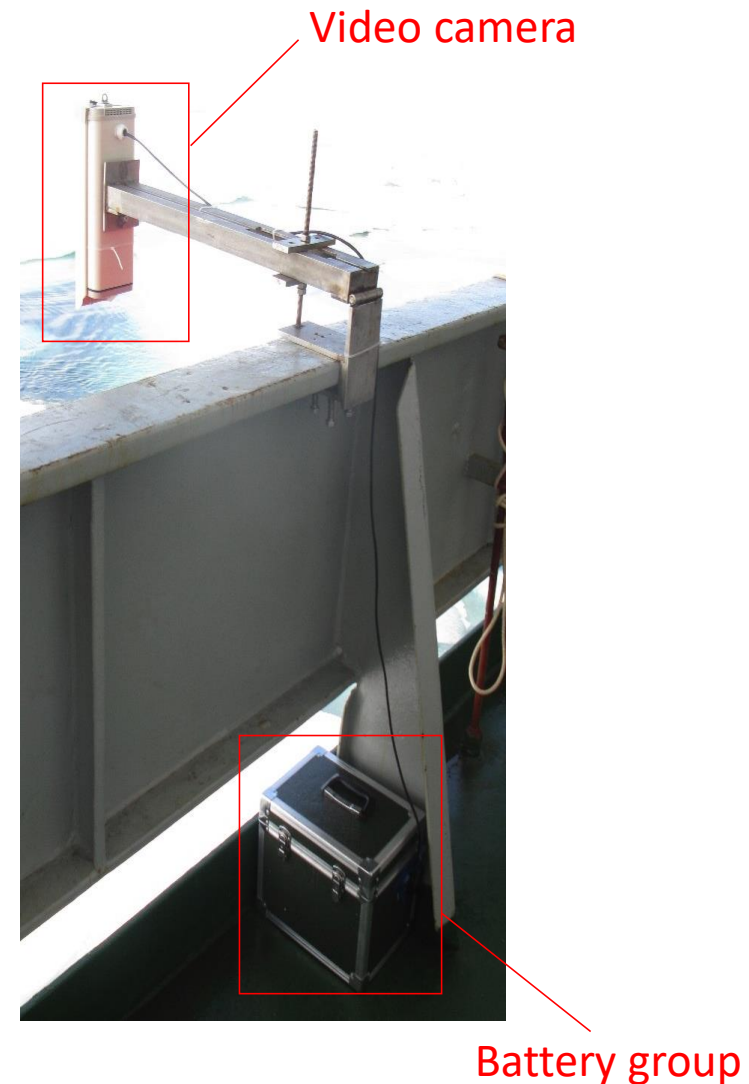
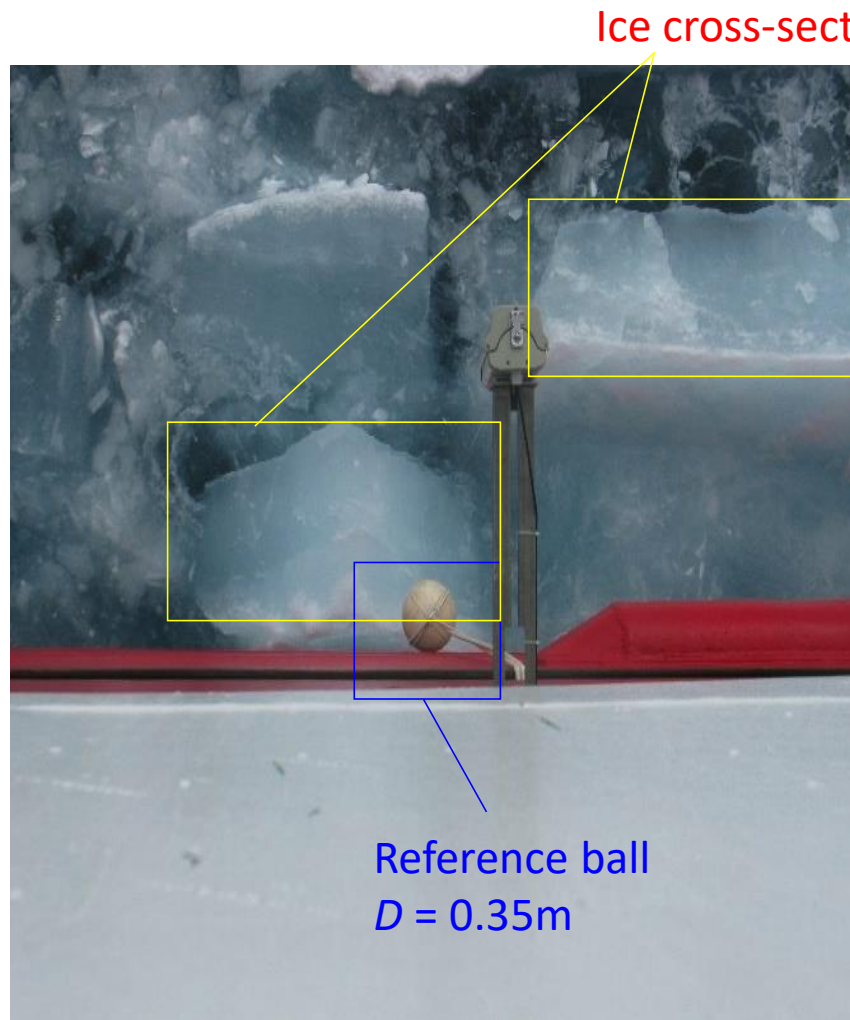


# Part 1. Investigations along the cruise track

- Shipboard photography
- EM-31
- Artificial observations
- Optical measurement

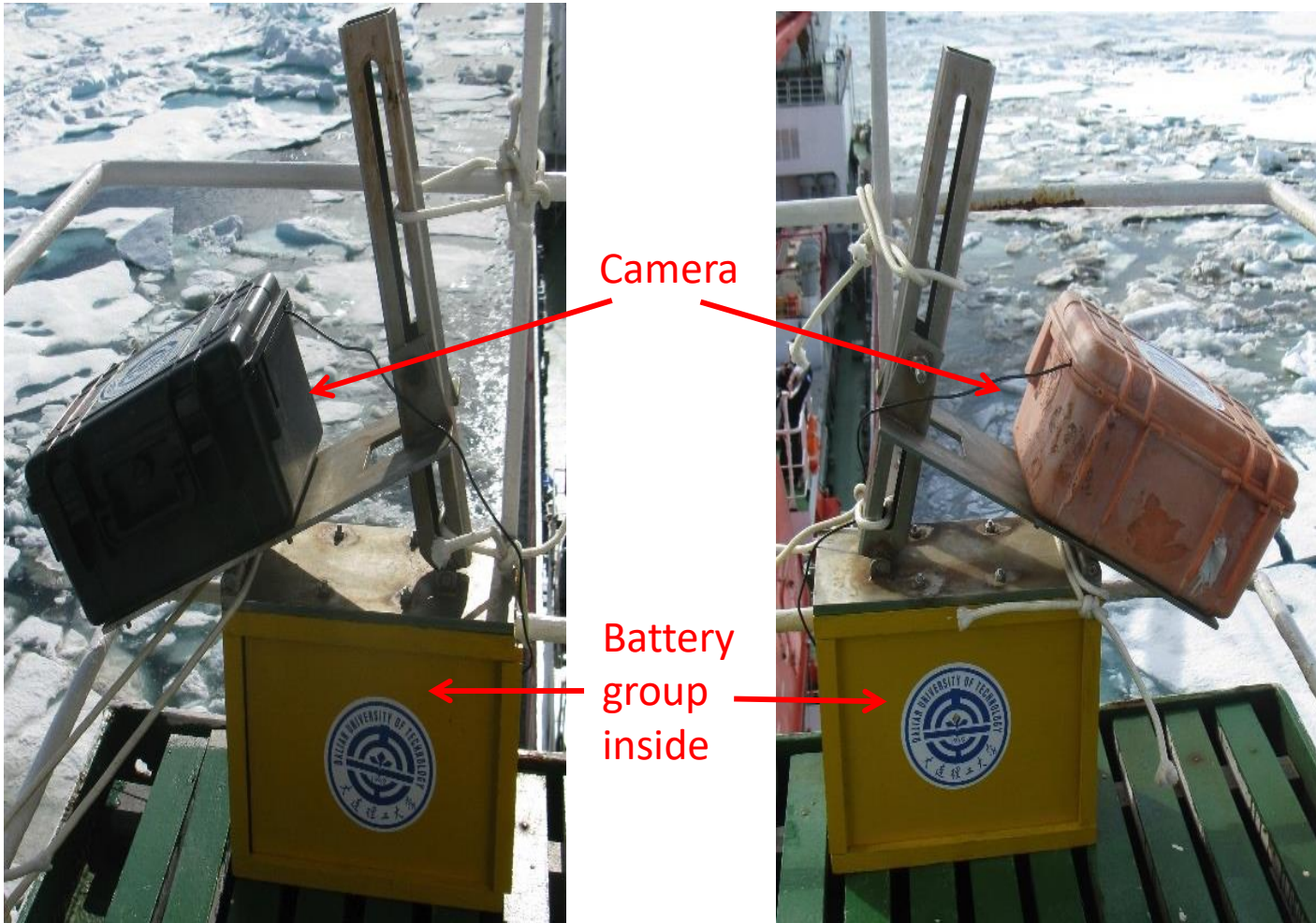


# (1) Shipboard photography on ice thickness

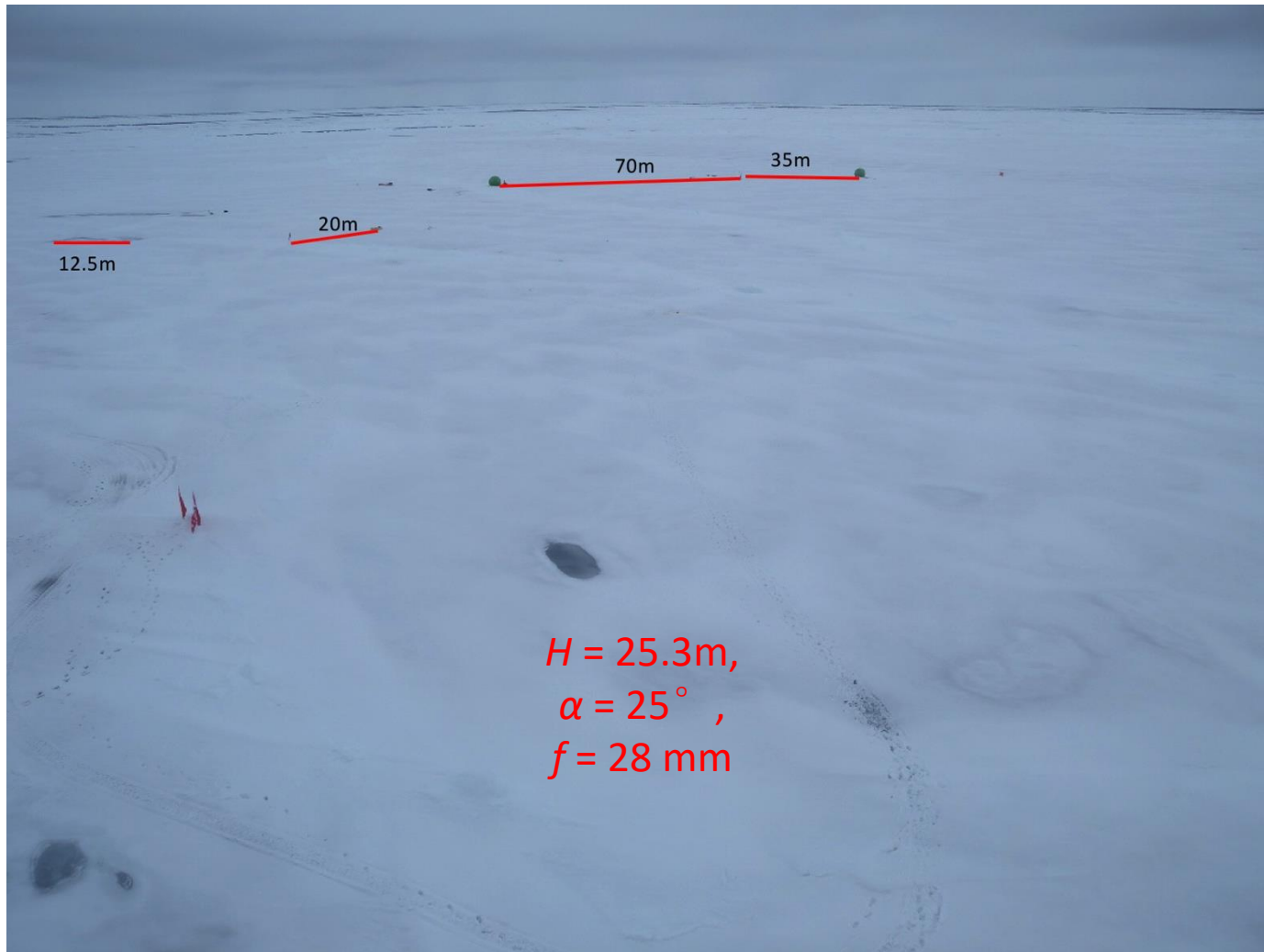




## (2) Shipboard photography on ice conditions

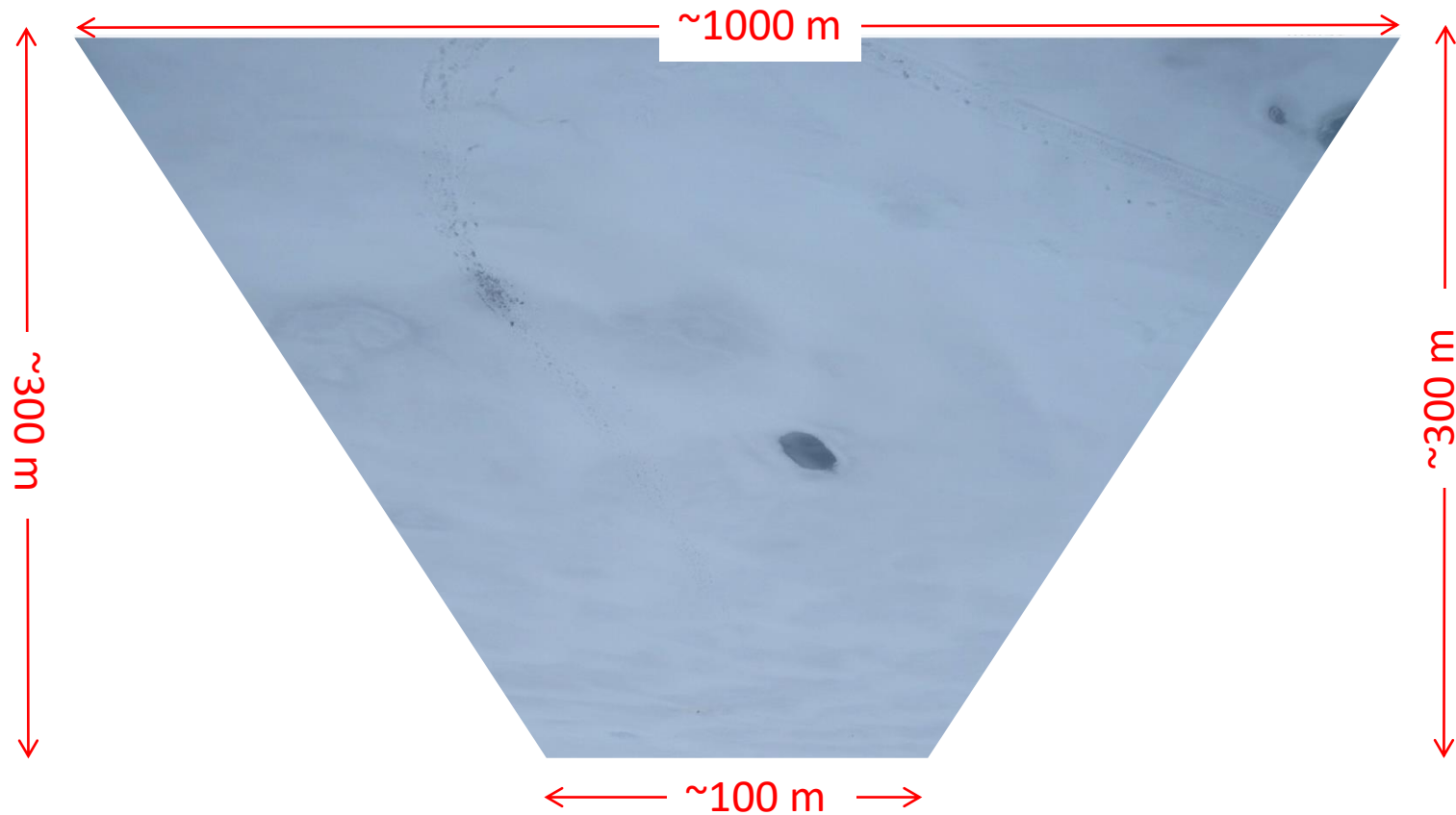


# Field calibration of oblique photography





# Actual observed area





74° 9.43'N  
156° 11.57'  
W  
July 27



76° 14.7'N  
160° 57.53'W  
July 29



78° 3.34'N  
160° 24.24'W  
August 2



79° 44.89'N  
168° 55.55'W  
August 4



82° 18.79'N  
168° 14.87'W  
August 6

Northward cruise



Southward cruise

76° 6.75'N  
175° 8.22'W  
August 21



76° 8.36'N  
179° 59.53'E  
August 20



77° 51.11'N  
179° 44.11'W  
August 19



79° 37.19'N  
179° 21.93'W  
August 18



80° 50.42'N  
168° 12.28'W  
August 16



# (3) Shipboard artificial observations

Total SIC  
SIC of three main  
types

$C_m$ , melt pond fraction  
 $C_d$ , dirty ice fraction  
 $C_r$ , ridging degree

$S$ , type of thickness  
 $F$ , type of ice range  
 $Th$ , ice thickness

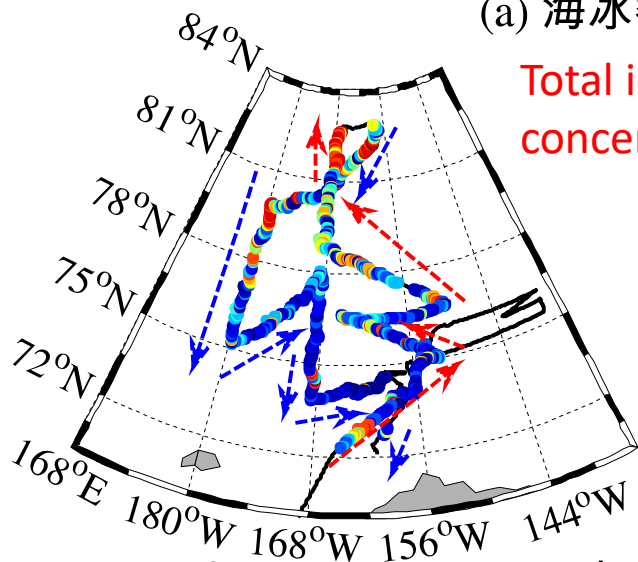
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Date	Time (UTC)	Lat.	Long.	$C_t$	$C_a$	$C_b$	$C_c$	$C_m$	$C_d$	$C_r$	$S_a$	$S_b$	$S_c$	$F_a$	$F_b$	$F_c$	$Th_a$ (cm)	$Th_b$	$Th_c$	$Th_z$	Comments

- Ice watch
- Every 30 minutes
- Within the range of 1 km



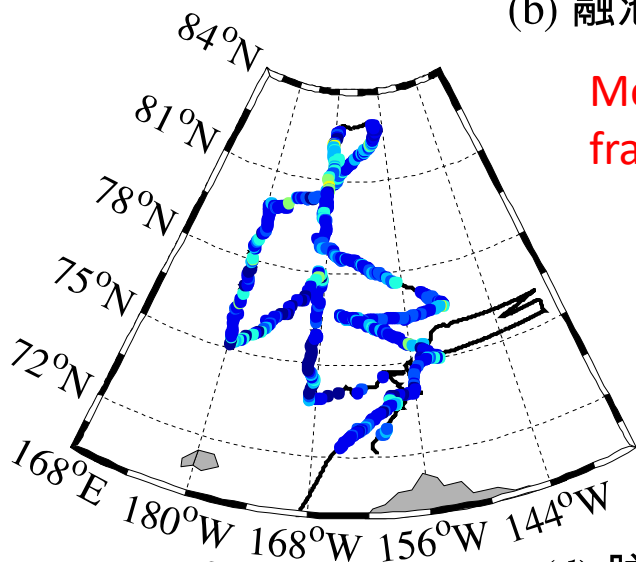
(a) 海冰密集度

Total ice concentration



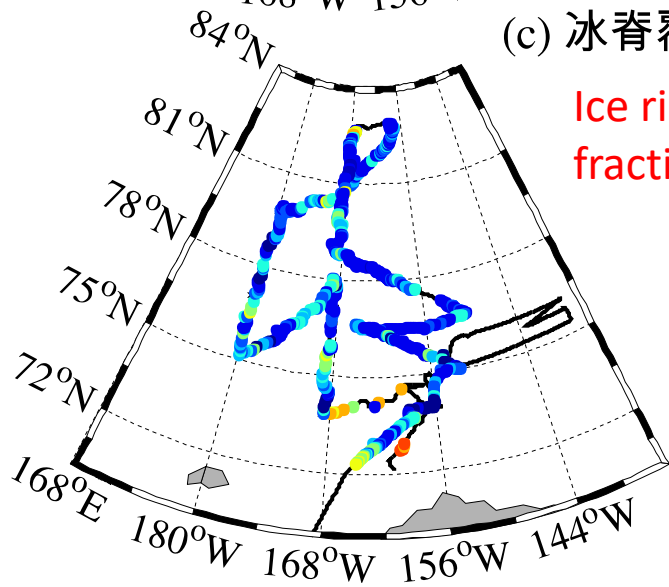
(b) 融池覆盖率

Melt pond fraction



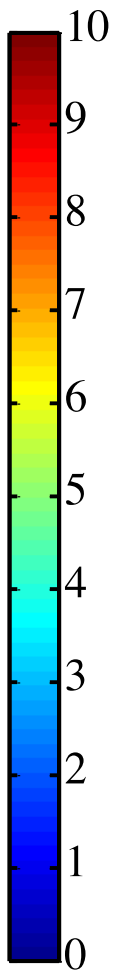
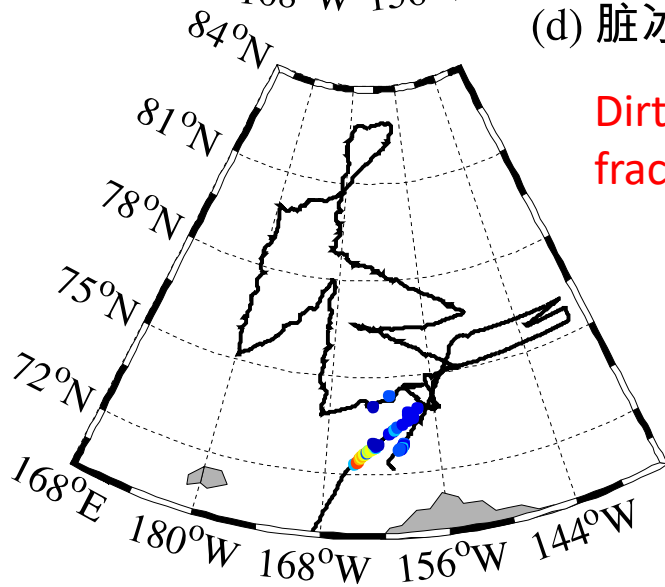
(c) 冰脊覆盖率

Ice ridge fraction

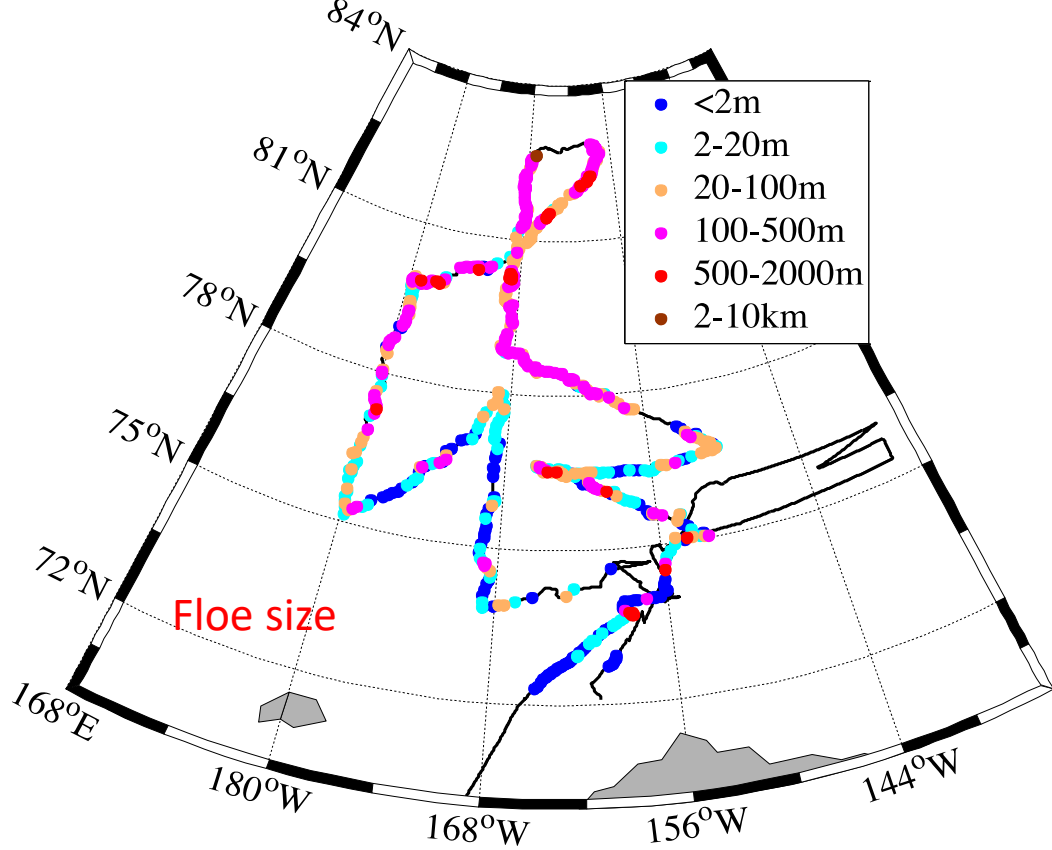


(d) 脏冰覆盖率

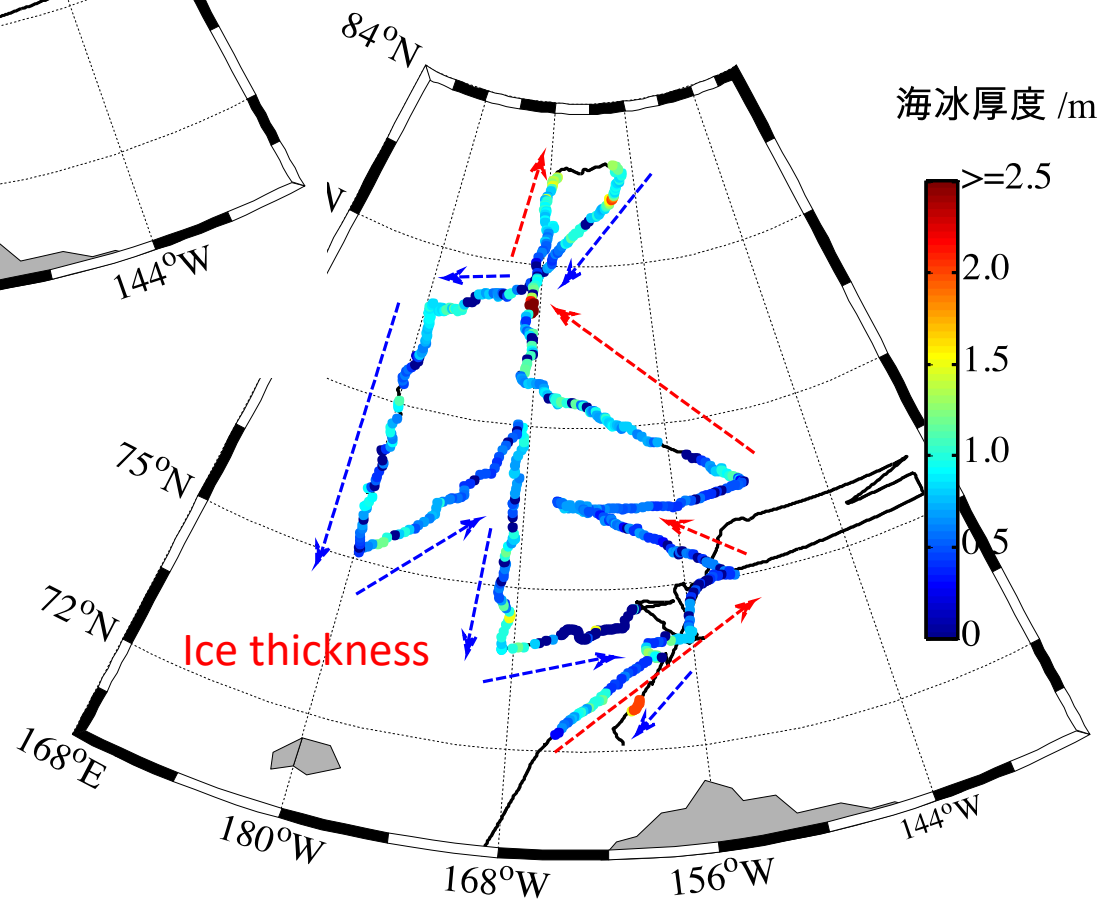
Dirty ice fraction



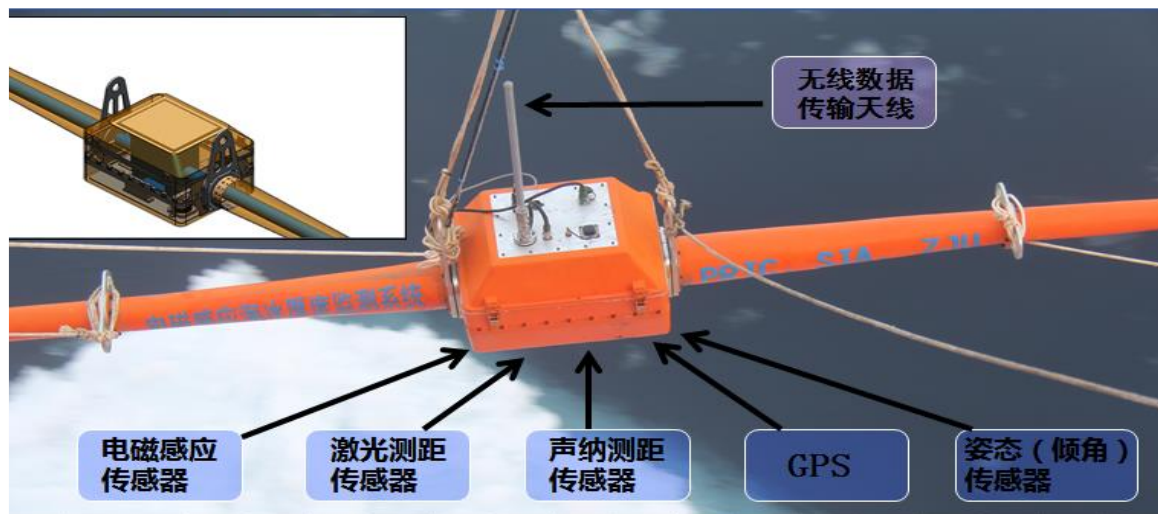
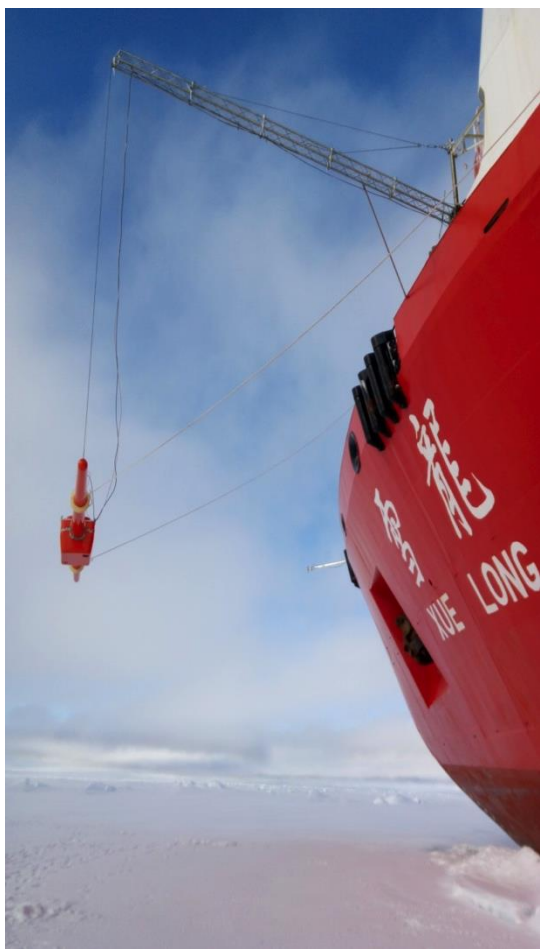




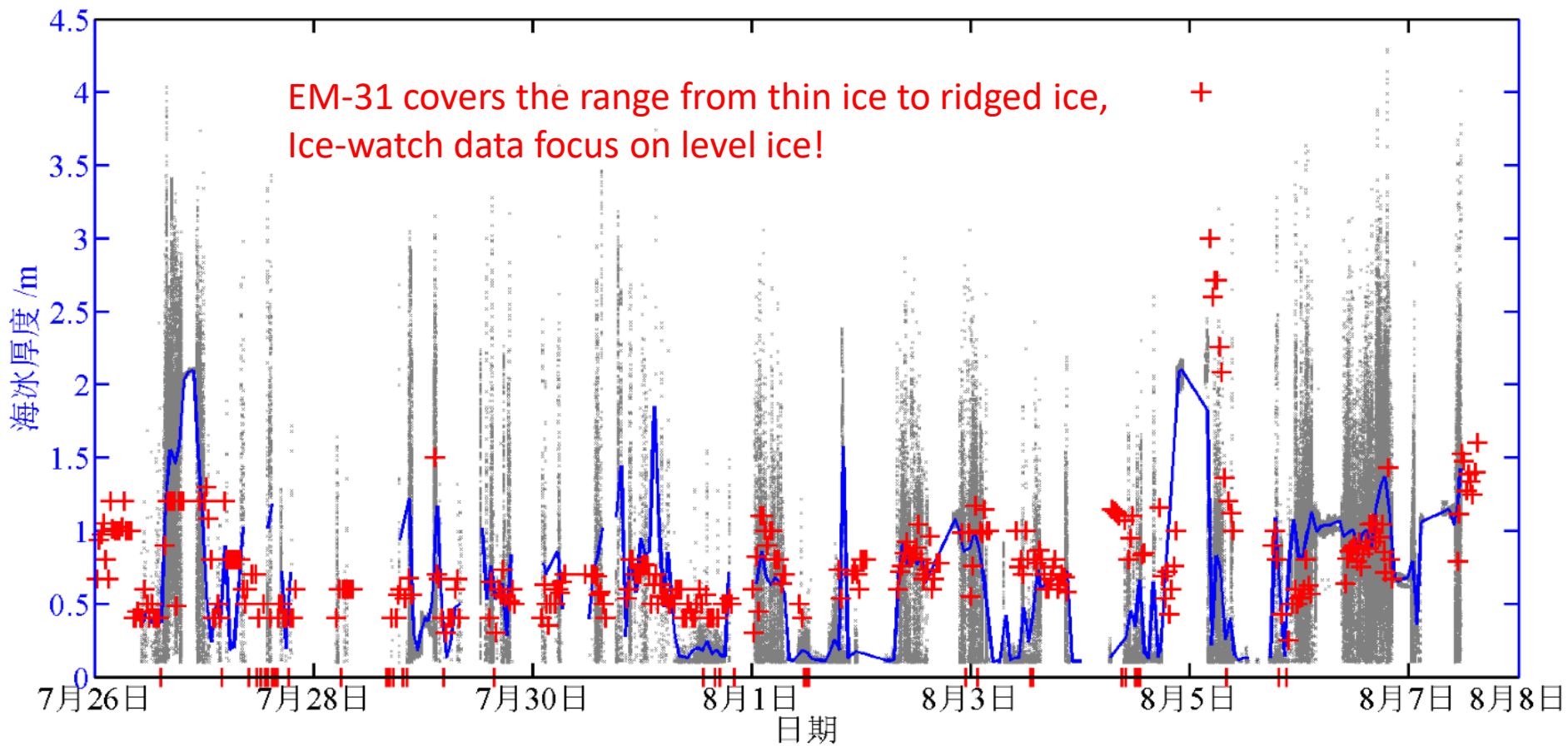
**No large floes!  
No thick ice!**



# (4) Shipboard EM-31

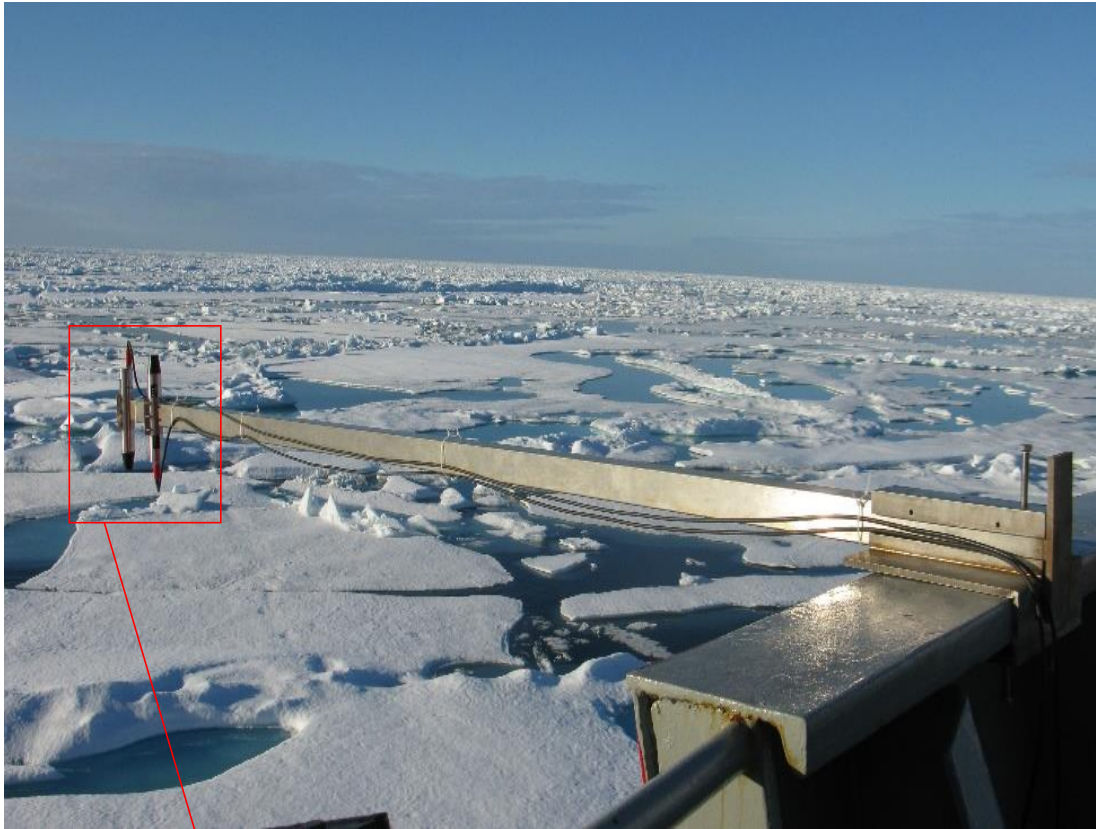


	A	B	C	D	E	F	G	H	I
1	时间	经度	纬度	EM31 (Q)	EM31 (I)	激光	声纳	倾角1	倾角2
2	163859.1	120.006	86.8178	16	818	3.781	3.714	-1.41	-6.59
3	163900.1	120.006	86.8177	15	818	3.784	3.715	-0.81	-6.22
4	163901.2	120.006	86.8177	15	818	3.816	0	-0.51	-6.75
5	163902.1	120.006	86.8177	17	818	3.97	3.9	-0.56	-6.31
6	163903.1	120.006	86.8177	18	818	4.016	3.962	-1.38	-6.15
7	163904.1	120.006	86.8176	18	818	4.052	3.976	-1.05	-5.66
8	163905.1	120.006	86.8176	19	818	4.142	4.083	-1.22	-5.32

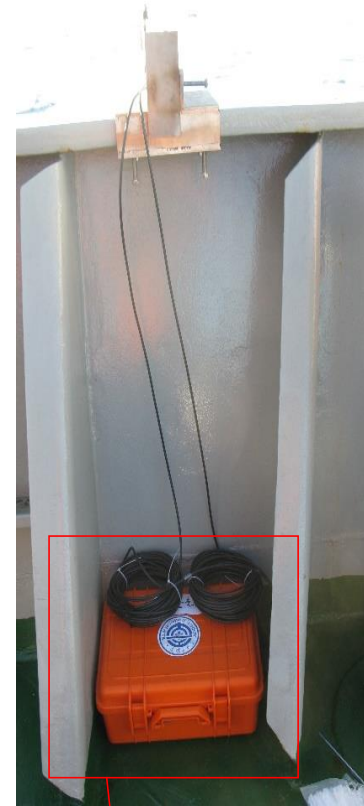


Variations in sea ice thickness measured by EM31 (grey for secondly measurement and blue for hourly average) and ice watch from the bridge.

# (5) Shipboard optics measurement



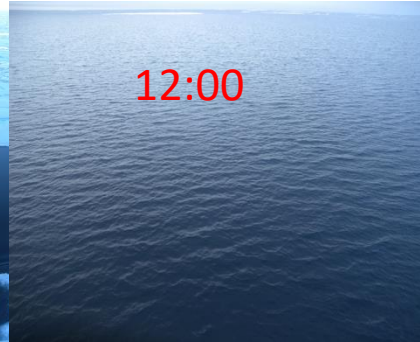
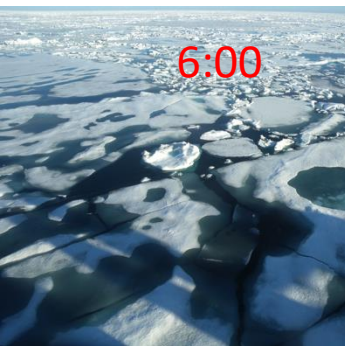
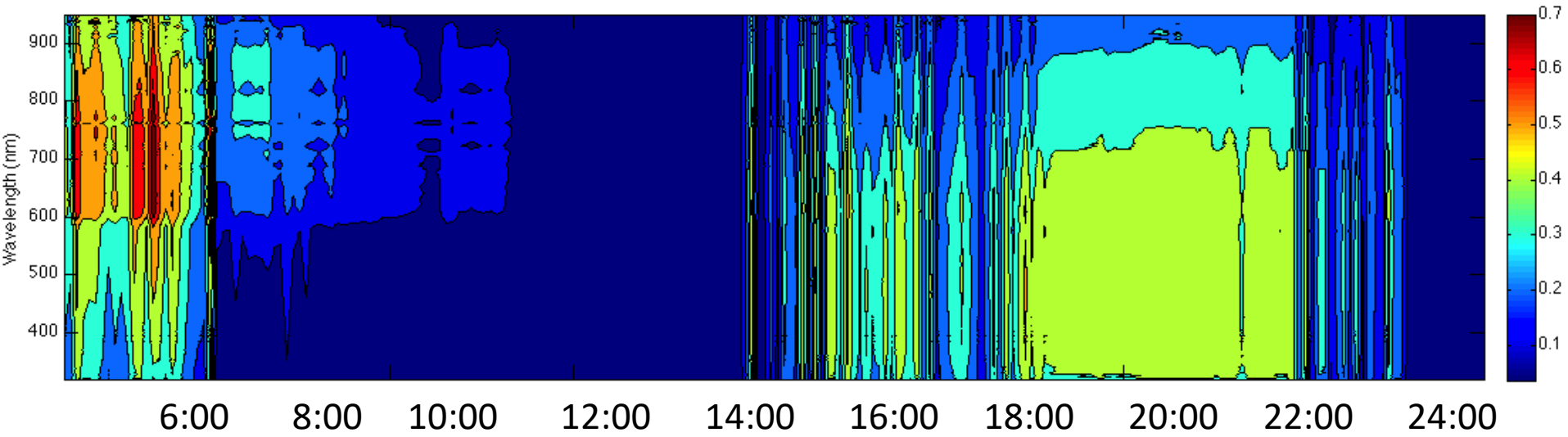
TriOS Ramses ACC-VIS  
Hyperspectral Irradiance Sensors  
320-950 nm



Tribox 3 controller  
Battery group



# Surface albedo

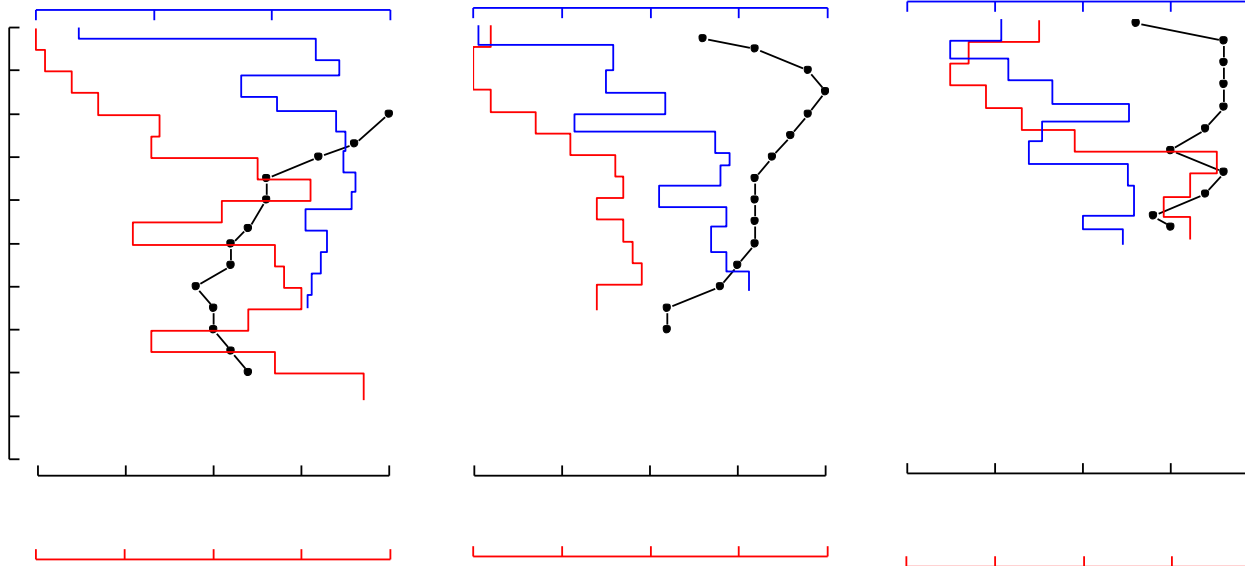
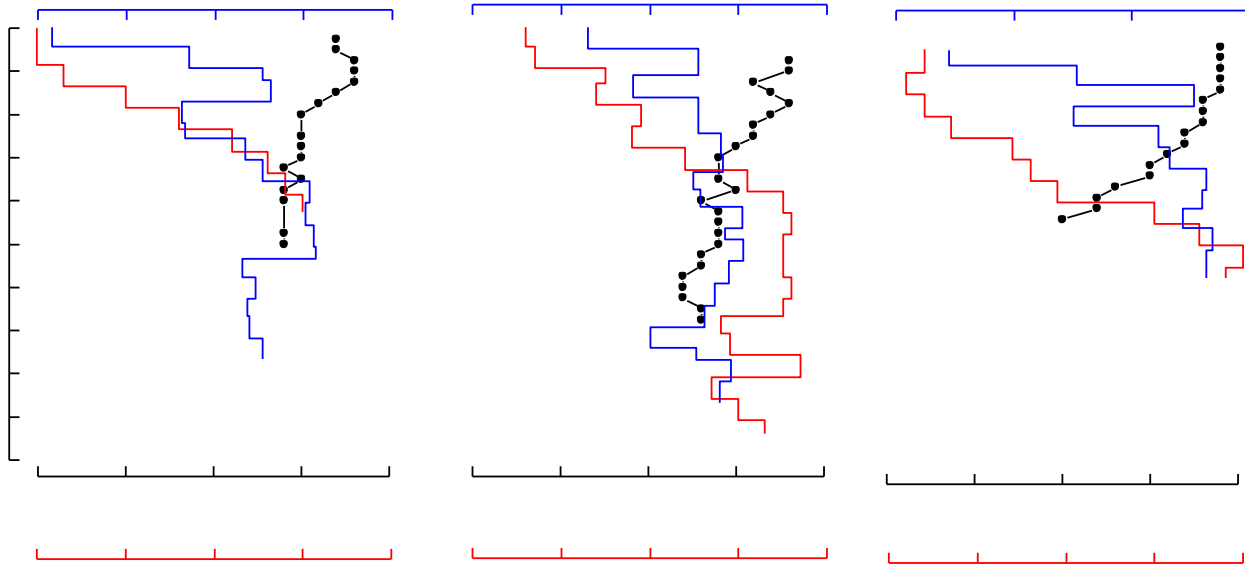


# Part 2. On short-term ice stations

- Six ice stations, about 3 hours for each

Station	Date	Location		Optics	Ice cores	Ice physics			
						<i>T</i>	<i>S</i>	$\rho$	<i>C</i>
SIC01	2016/8/4	78° 58.273' N	169° 13.569' W	S/I	4	1	1	1	1
SIC02	2016/8/5	80° 6.155' N	168° 59.277' W	S/I	4	1	1	1	1
SIC03	2016/8/6	81° 33.096' N	167° 40.734' W	S/I	4	1	1	1	1
SIC04	2016/8/7	82° 17.202' N	168° 09.153' W	S/I	4	1	1	1	1
SIC05	2016/8/18	79° 56.433' N	179° 21.248' W	M.P.	4	1	1	1	1
SIC06	2016/8/20	76° 18.684' N	179° 35.778' E	M.P.	4	1	1	1	1

# (1) Ice physics



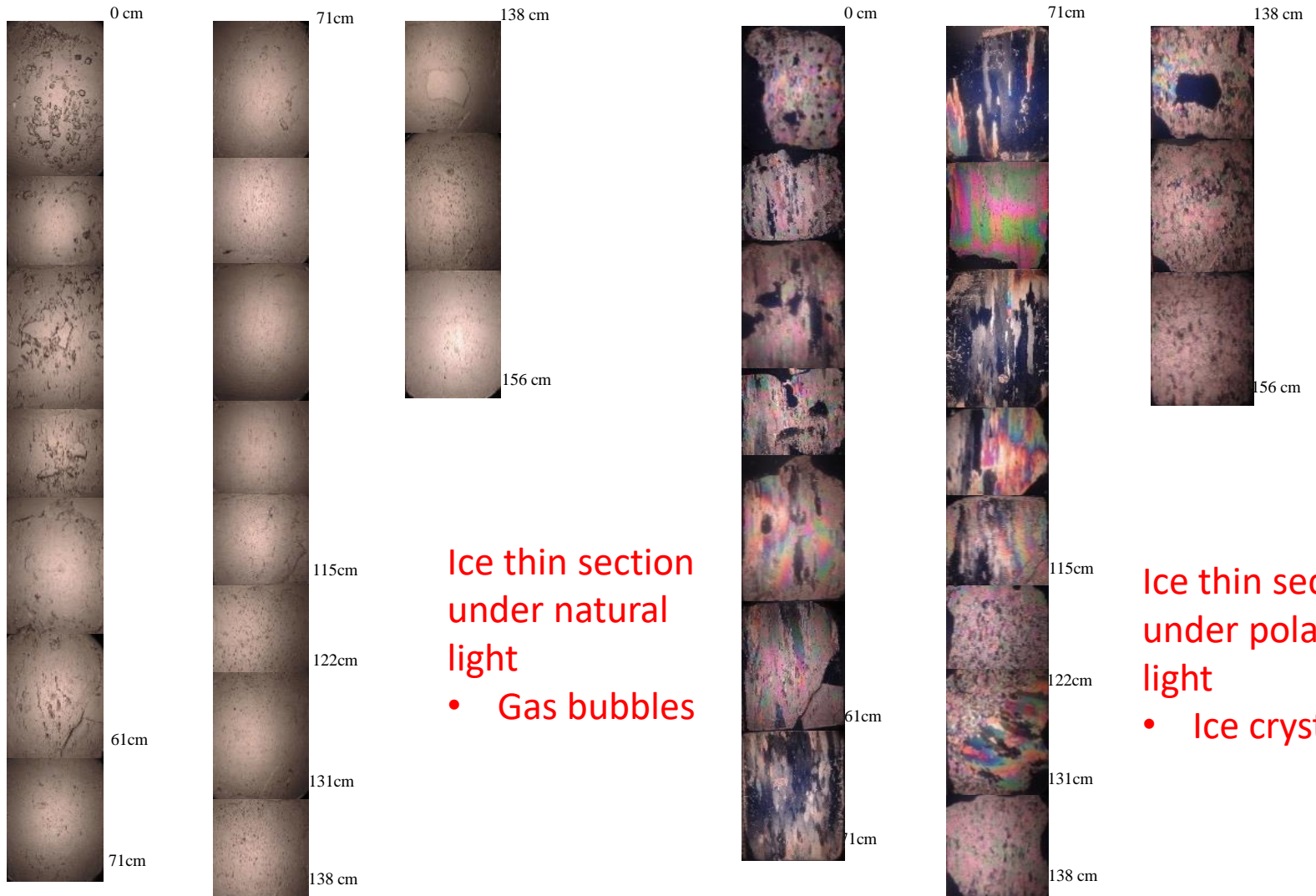
Along depth,

*Temp.*    ↘

*Density*    ↗

*Salinity*    ↗

## (2) Ice microstructure



**Ice thin section  
under natural  
light**

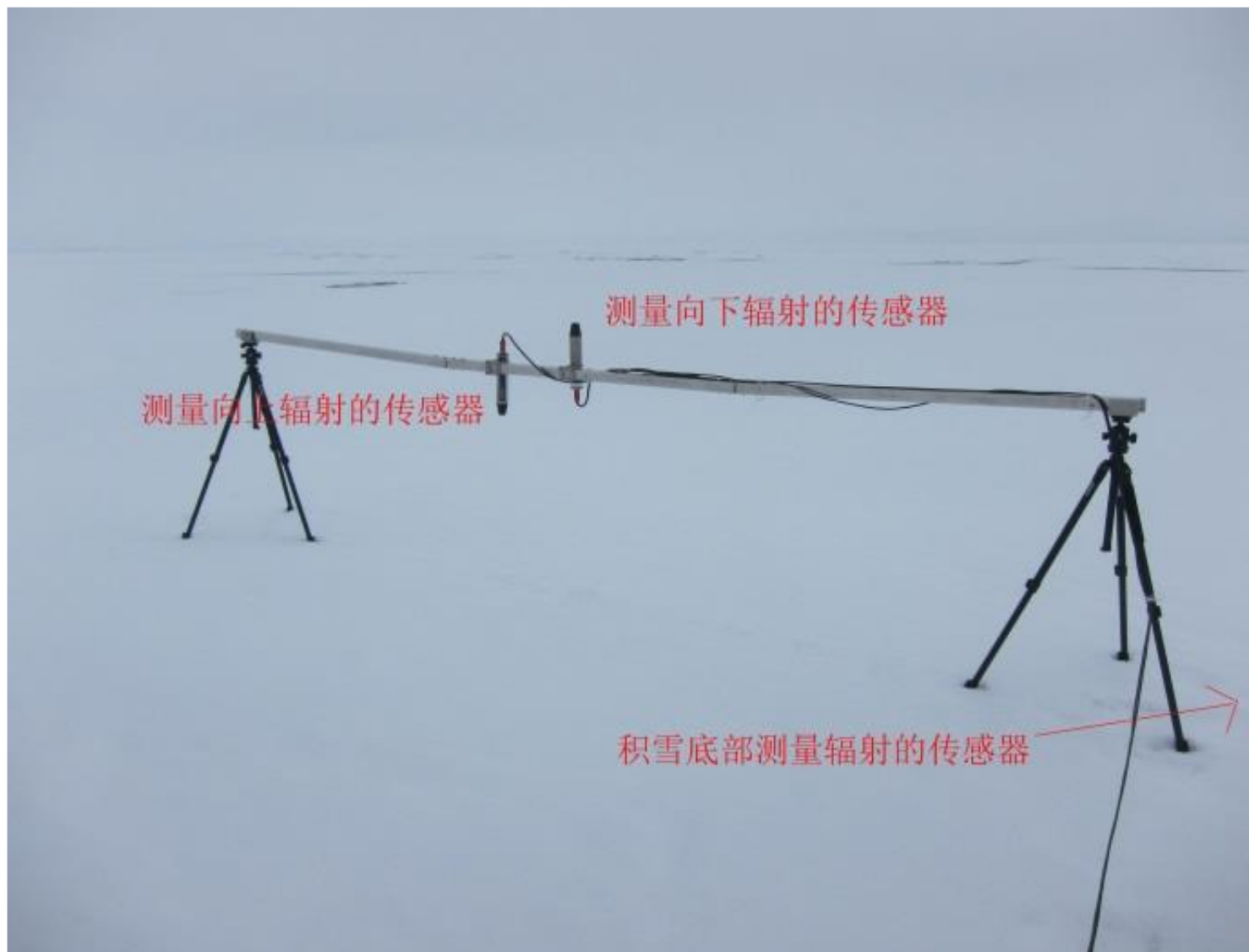
- Gas bubbles

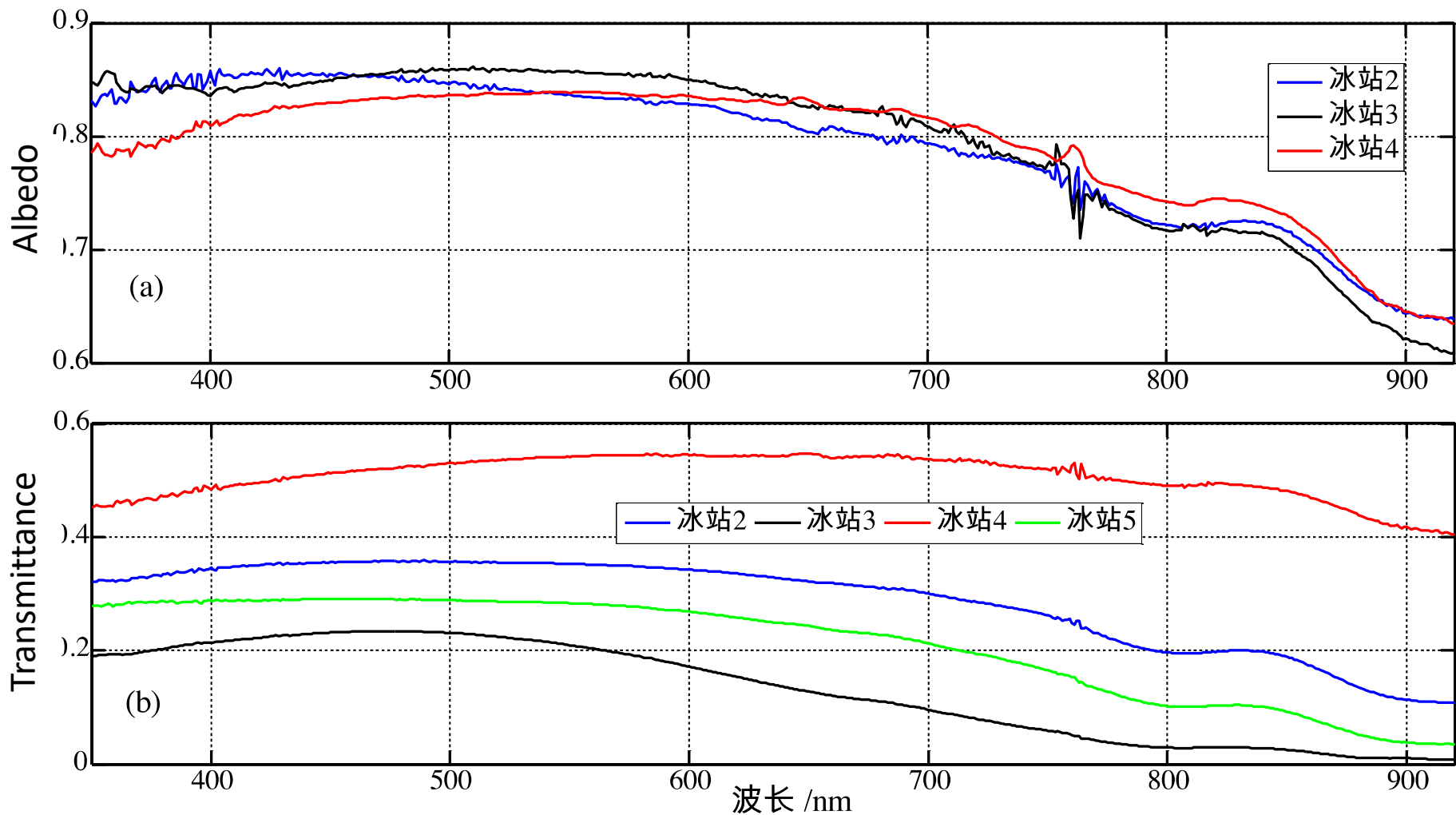
**Ice thin section  
under polarized  
light**

- Ice crystal



### (3) Snow albedo

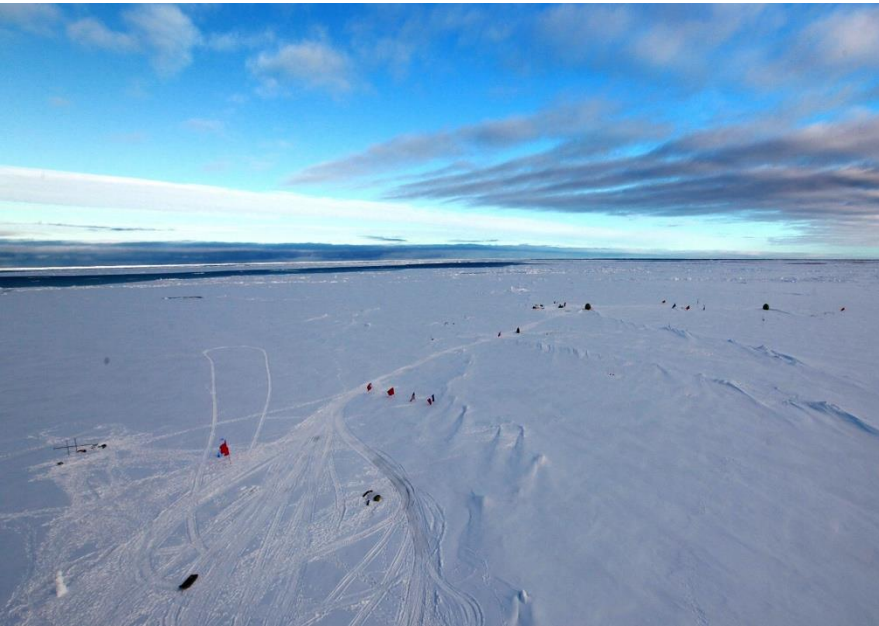
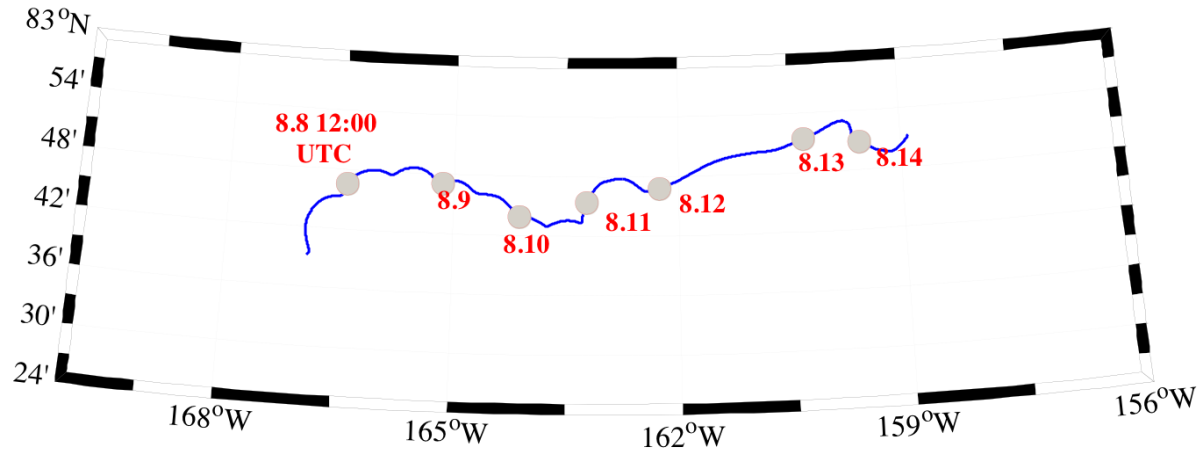




Snow spectral albedo (a) and radiation transmittance (b)

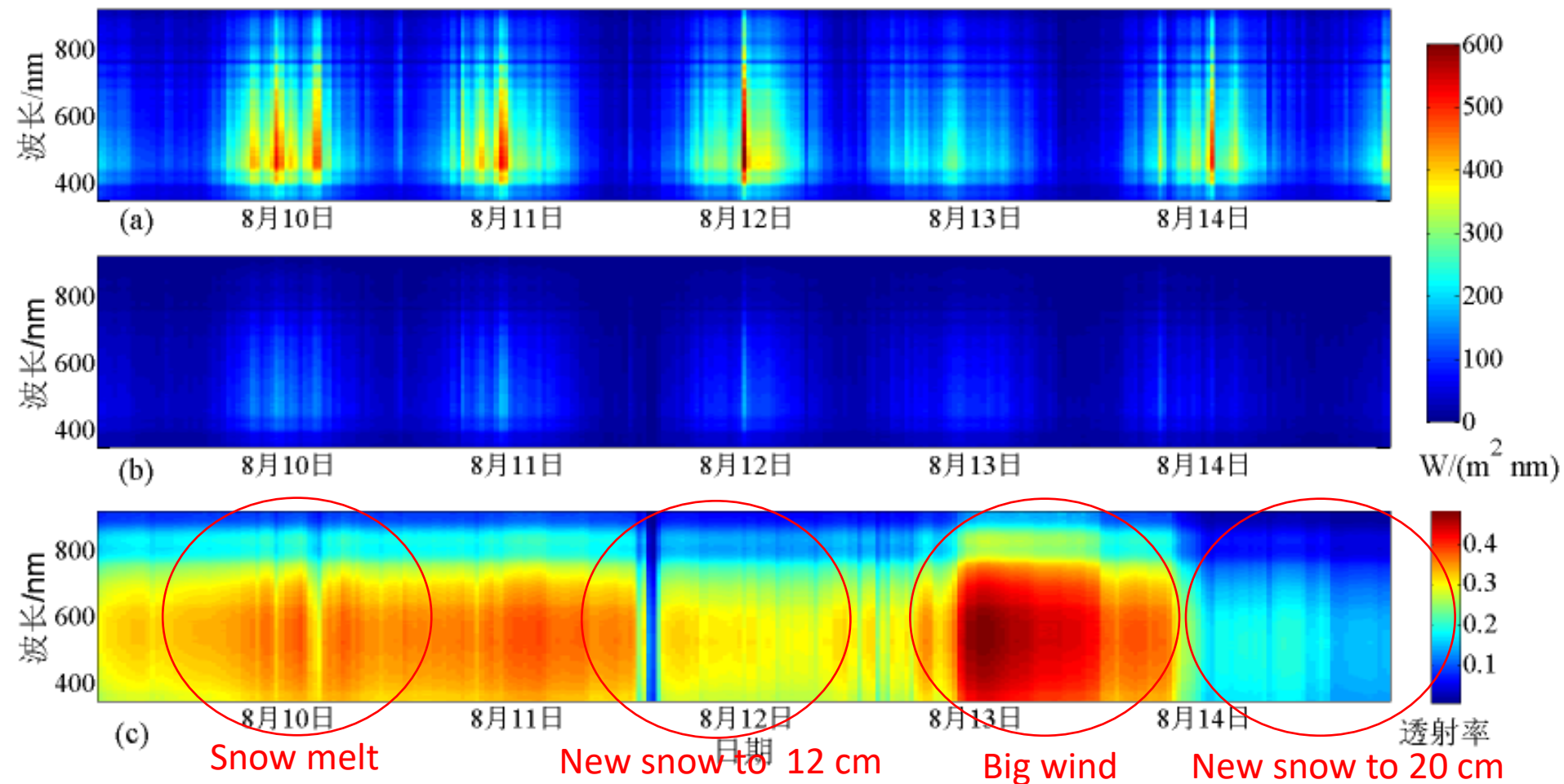
	Dry snow	Wet snow
SIC 2	11 cm	
SIC 3	10 cm	10 cm
SIC 4	3 cm	

# Part 3. On long-term ice station



7-15 in August  
Snow and pond optics  
Ice thickness  
Ice temperature  
Ice underside topography

# (1) Snow transmittance

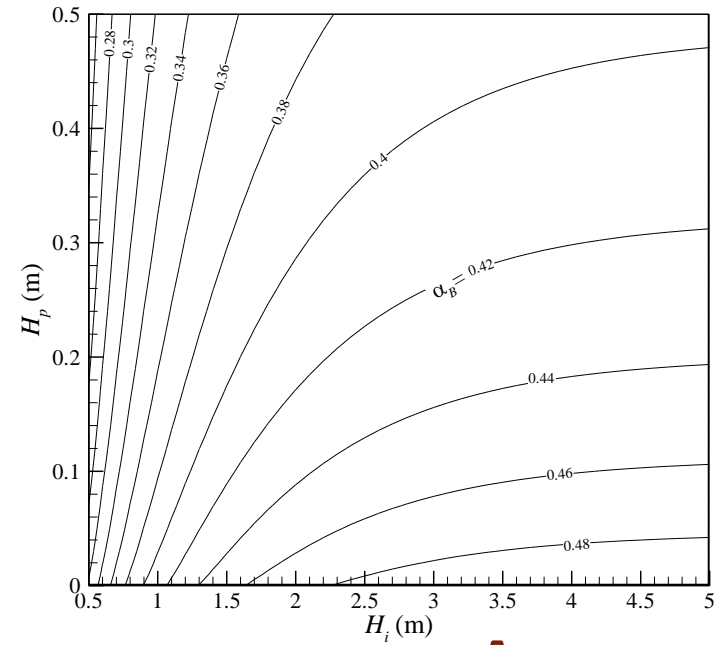


Incident spectral radiation (a), transmitted spectral radiation (b) and snow cover radiation transmittance (c)

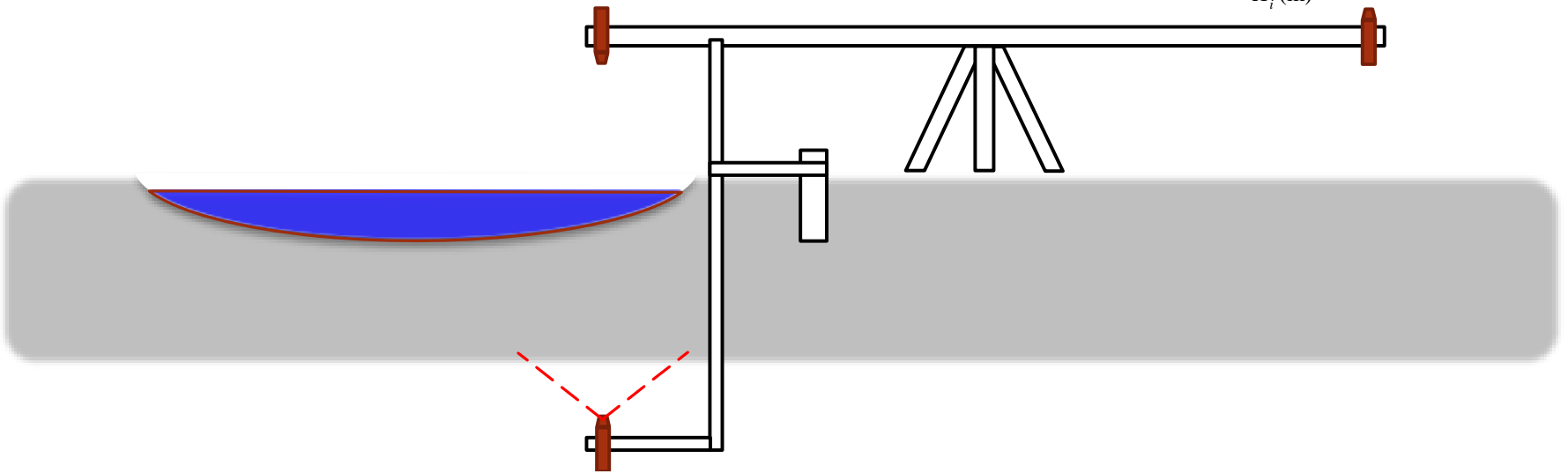


## (2) Melt pond optics

Lu P., et al. 2016. CRST, 124, 1-10

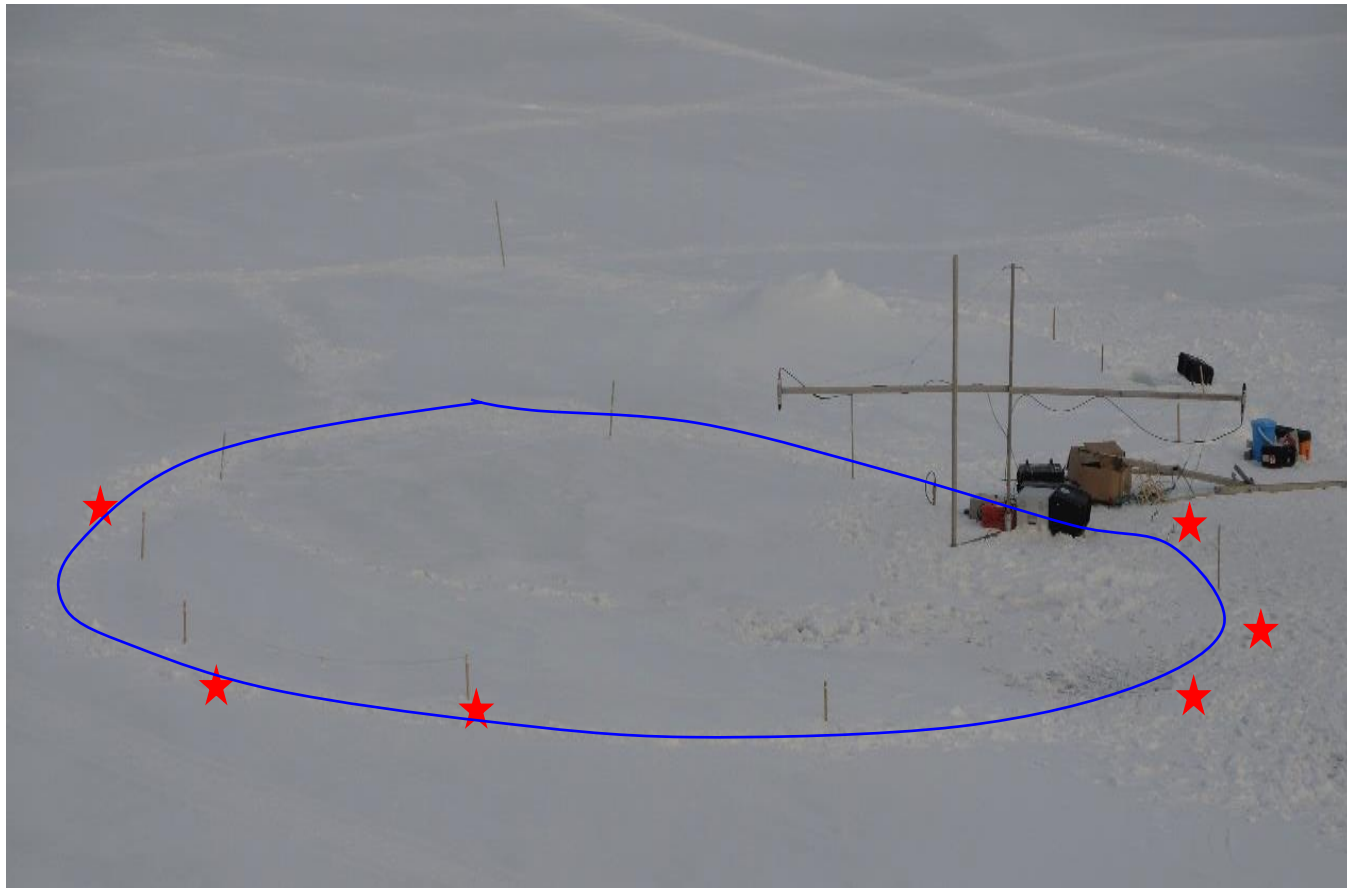


(a)



Our plan of optical measurements on Arctic melt ponds, including albedo and transmittance, together with pond depth, ice thickness

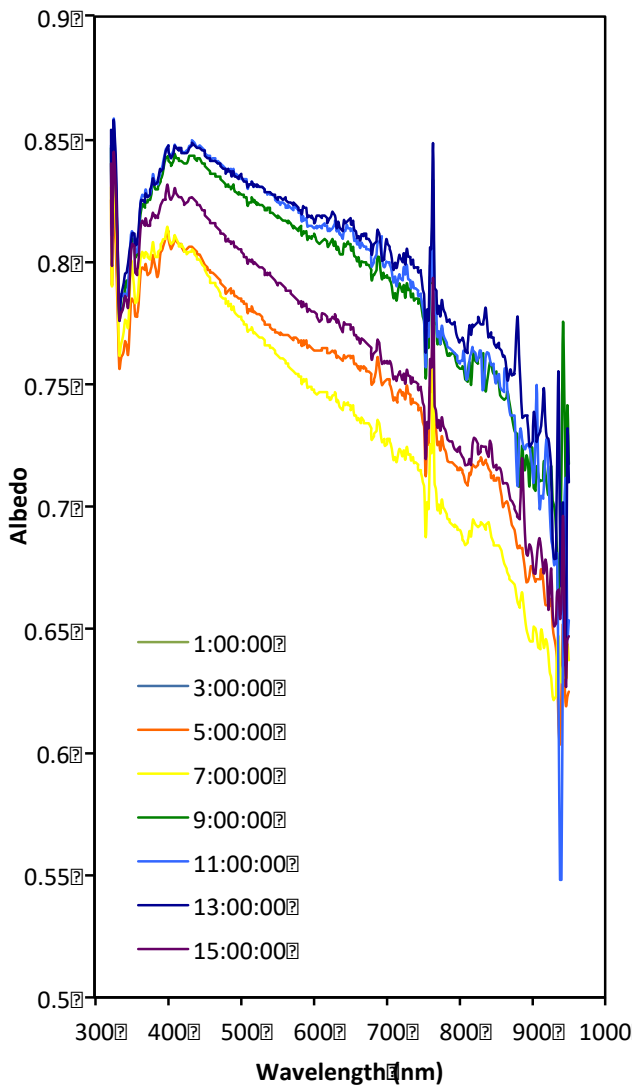
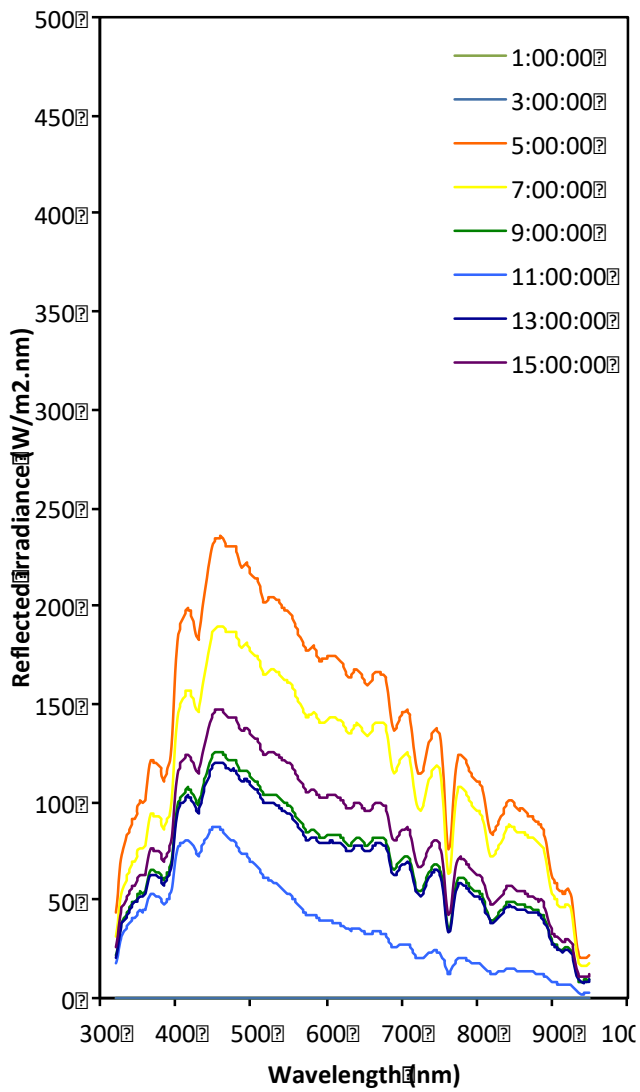
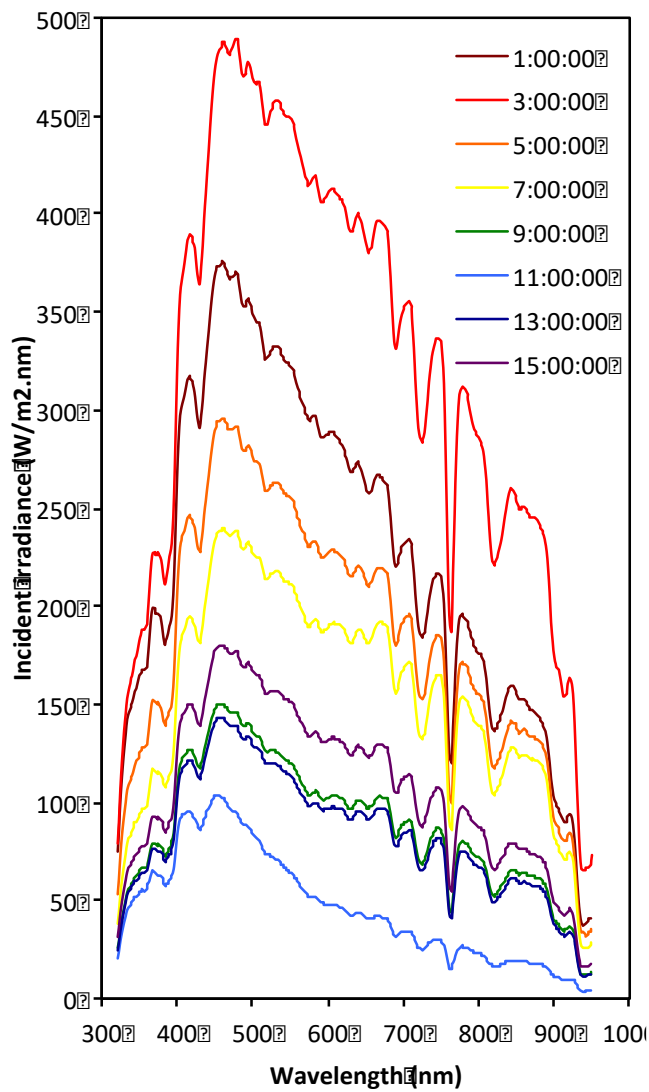
# Ice-covered melt pond



Pond depth: 20 cm, 38 cm, 42cm, 25 cm, 27 cm, 18.5 cm

Snow cover thickness: 1.5 cm

Total ice thickness: 115.5 cm, 112 cm, 108 cm



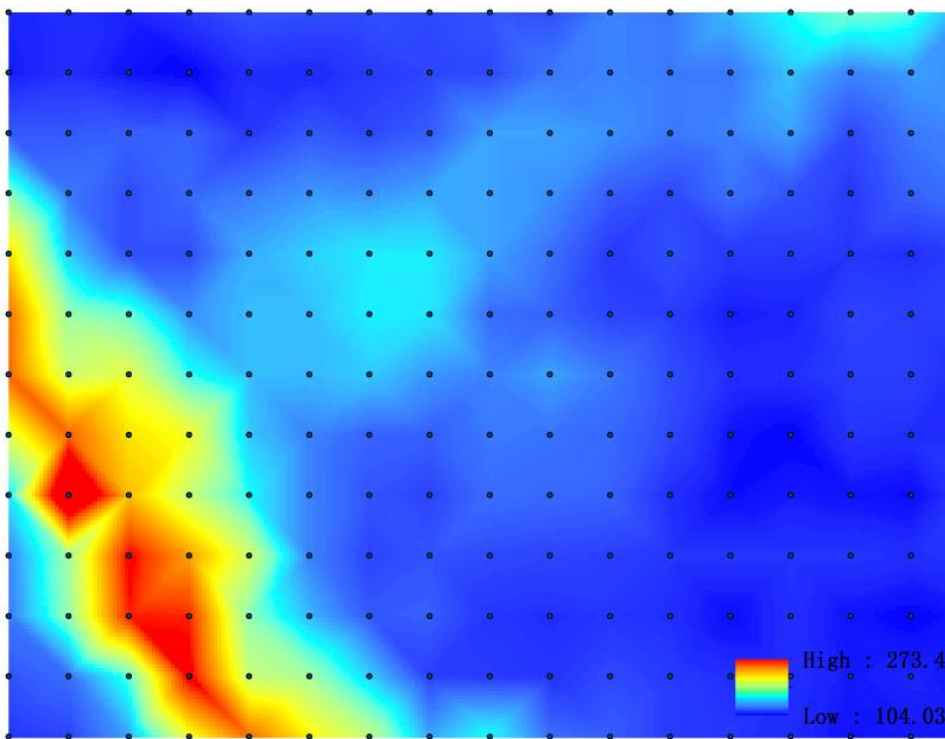
Variations in irradiance and albedo in August 10, 2016

### (3) Ice thickness profile

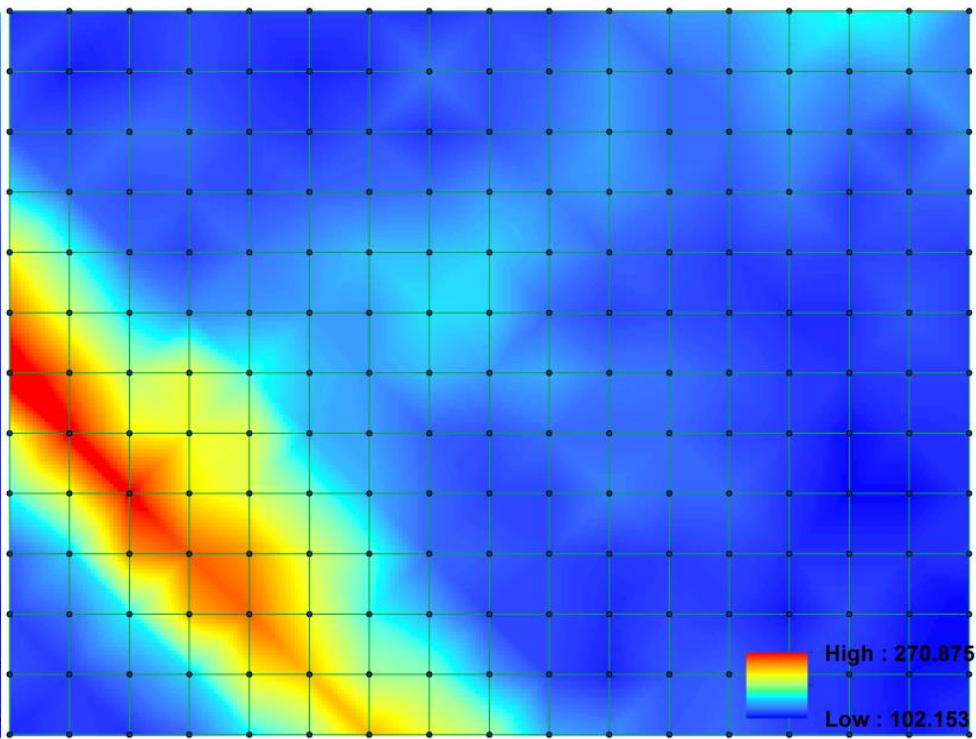


EM-31  
Ice drilling





1<sup>st</sup> data, August 10



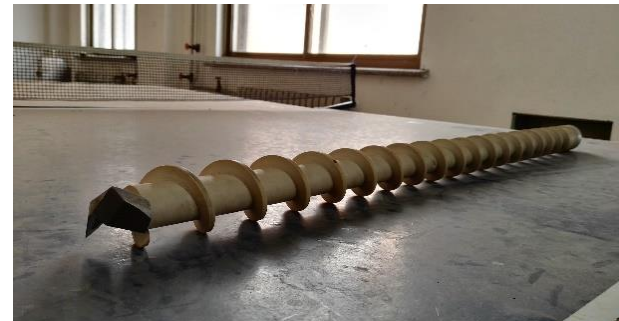
2<sup>nd</sup> data, August 13

Level ice thickness: 1.0-1.6 m

Ridged ice thickness: 2.0-2.7 m

A snow event occurred on August 11

# (4) Ice temperature profile

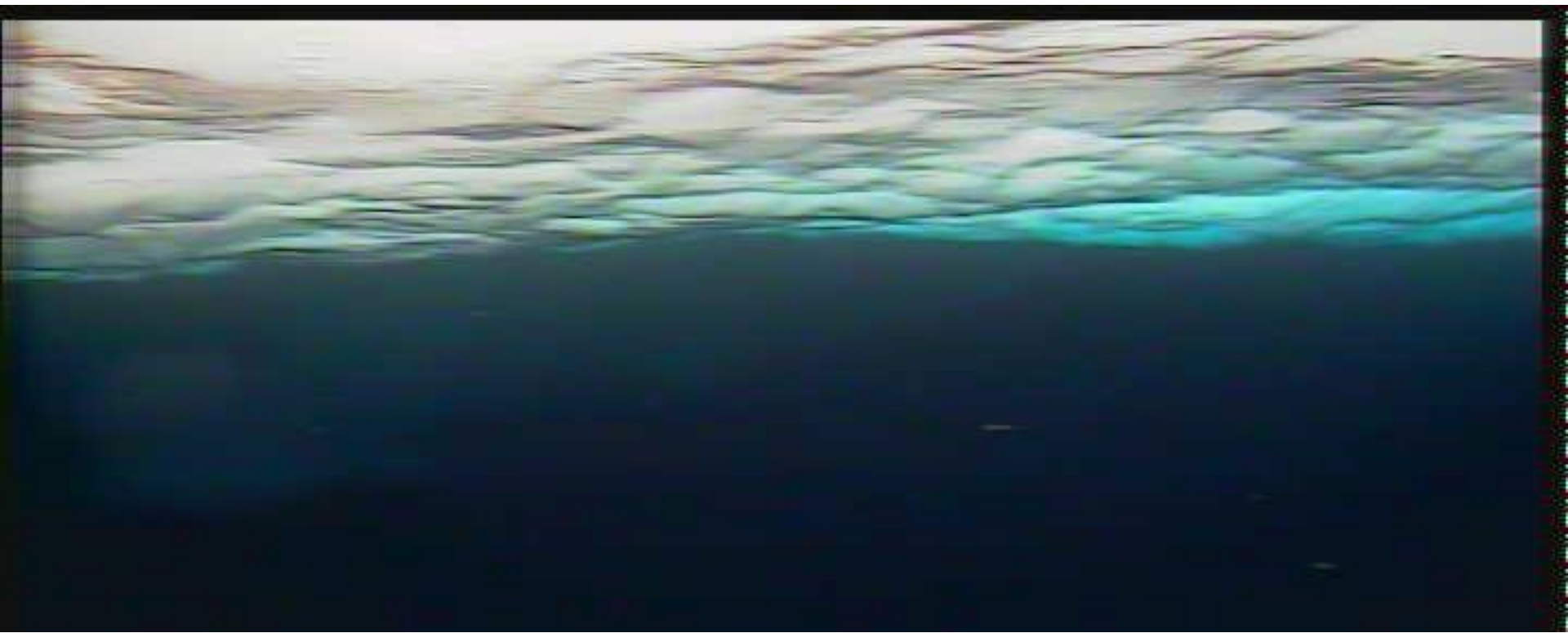


Ice auger with temperature sensors



# (5) Ice underside topography

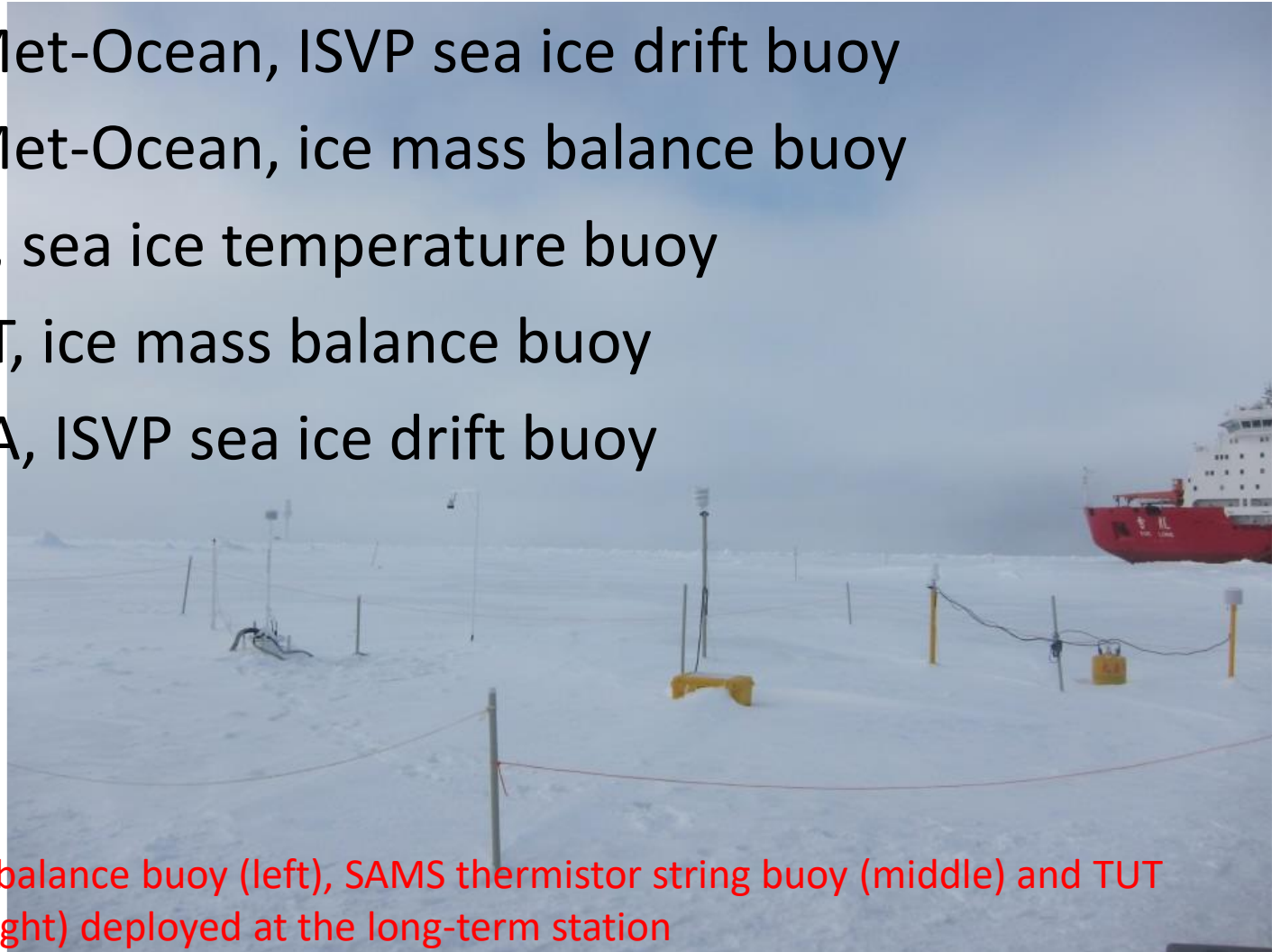






## (6) Buoys

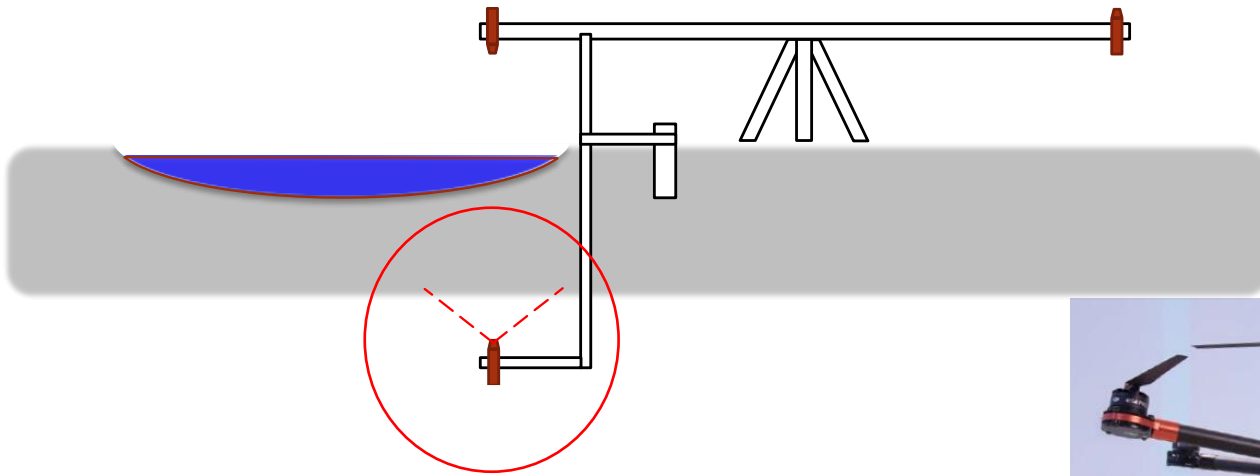
- Canada, Met-Ocean, ISVP sea ice drift buoy
- Canada, Met-Ocean, ice mass balance buoy
- UK, SAMS, sea ice temperature buoy
- China, TUT, ice mass balance buoy
- China, SOA, ISVP sea ice drift buoy



Met-Ocean sea ice mass balance buoy (left), SAMS thermistor string buoy (middle) and TUT thermistor string buoy (right) deployed at the long-term station

# Plans on lake ice in this winter

- Transmission measurements
- UAV photography or UAV Hyperspectral Imager



Welcome to our lake!



Thanks for their works!  
Thanks for your attention!



T. Zhang

L.J. Yu

Q.K. Wang

R.B. Lei

Q. Ji

G.Y. Zuo

X.Y. Sun