CCI sea ice project

Science leader: Stein Sandven,
Nansen Environmental and Remote Sensing Center

Consortium Members

logica

Meteorologisk institutt met.no

DTU

UCL

FMI

Ifremer

Max-Planck-Institut für Meteorologie

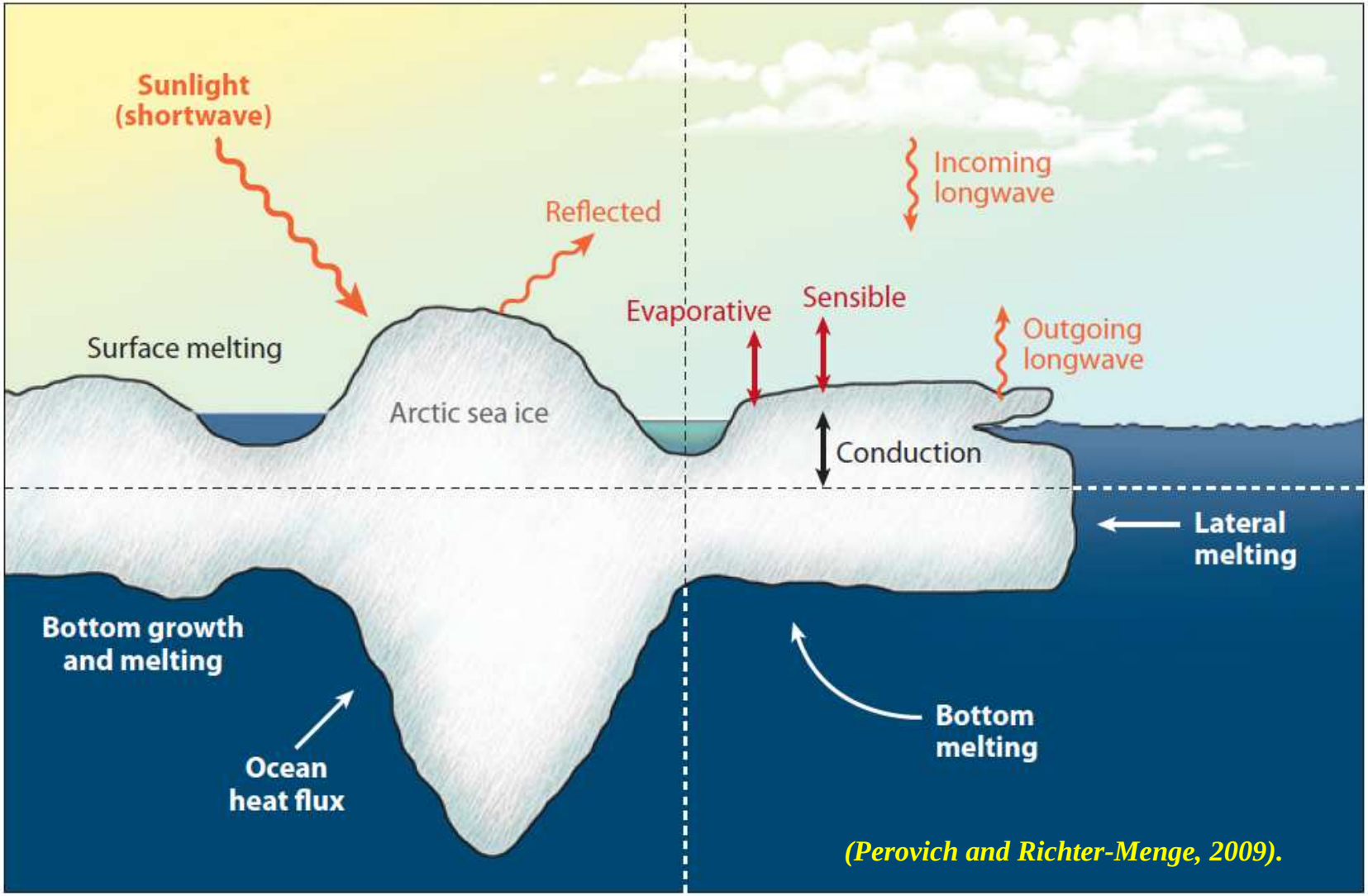
DMI Vejr, klima og hav

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

UNIVERSITY OF CAMBRIDGE

Universität Bremen

Sea ice processes



(Perovich and Richter-Menge, 2009).

Over-arching science challenges

- Observe global sea ice variability and change for several sea ice parameters: concentration (area, extent), thickness (mean, modal, distribution), drift, volume, fluxes, albedo, etc.
- Understand and quantify the role of sea ice in the climate system
- Develop modelling and prediction capabilities for sea ice on seasonal, interannual and longer time scales

ECV Sea Ice Products

Product name	Sensors	Areas	Spatial grid	Period	Temporal resolution
Sea ice concentration	Passive microwave radiometer	Arctic and Antarctic	L3: 25 x 25 km	1978-2008	Daily
Sea ice thickness	Radar altimeter	Arctic	L3: 100x100 km	1993-2012	Monthly (Oct-April)

Other sea ice parameters required by users, but not yet developed as ECV products: ice drift, snow depth on ice, surface temperature, ice type/age, ice volume, ice salinity, albedo, melt pond fraction, melt onset/duration, lead fraction, polynyas (localization, size), ice freeboard, snow water equivalent on ice, surface roughness.

NERSC

Round Robin data set for ice concentration

Brightness temperature are used from:
- **SMMR data (1978-1987) obtained from NSIDC**
- **SSM/I data (1987-2009) obtained from EUMETSAT Climate Monitoring -SAF**
- **AMSR-E data (2002-2011) obtained from NSIDC**

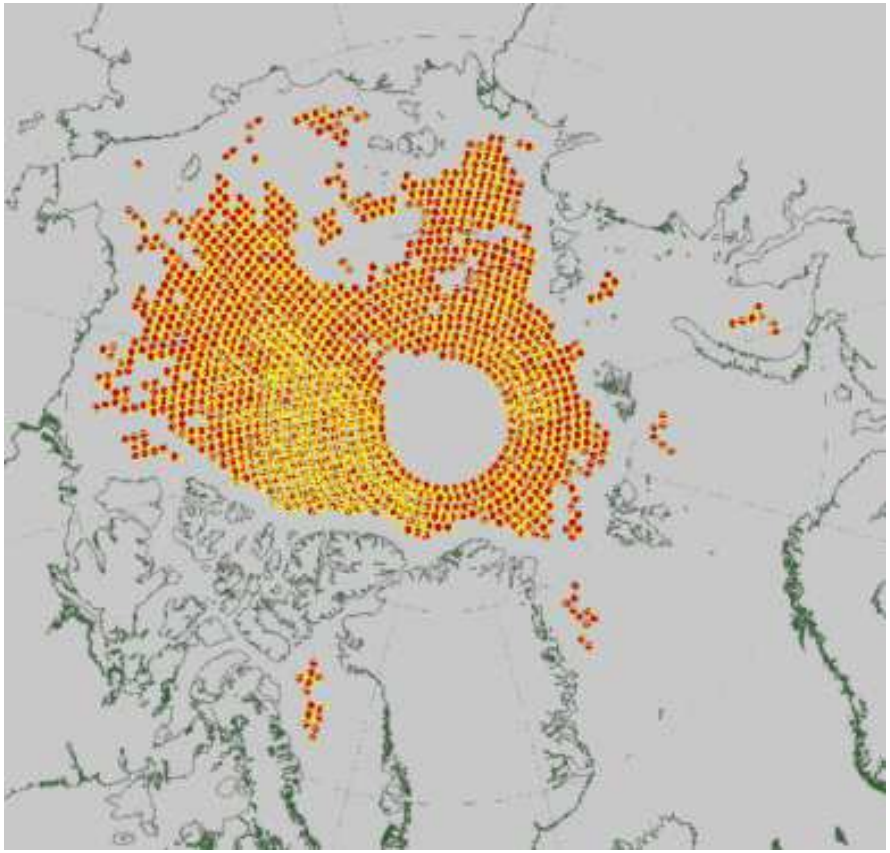
The data are swath data with accurate geolocation from Arctic and Antarctic. All data are averaged to 75x75 kilometer resolution in all channels.

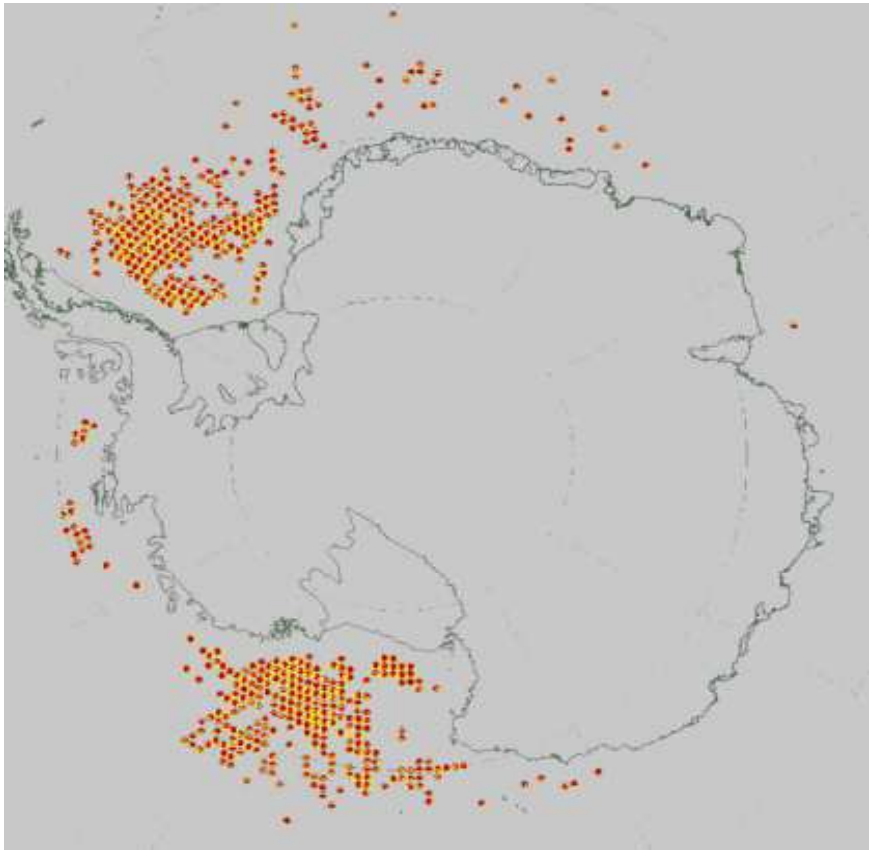
The following validation data sets are used:
- **Ice deformation using ice convergence and divergence fields from SAR ice drift (DTU)**
- **High latitude open water regions from ice-charts (DMI)**
- **Melt-pond dataset from MODIS (Uni Hamburg)**
- **Thin ice dataset from SMOS (Uni Bremen)**
- **Simulated thin ice and snow dataset using microwave model MEMLS-I (DMI)**
- **Simulated open ocean/atmosphere dataset using Wentz RTM (DMI)**
- **Atmospheric corrected TBs from AMSR and SSMI with reference SIC (DMI)**

Algorithm comparison

No	Algorithm	Reference	Channels
1	ASINWF	Kaleschke et al. 2001	85V, 85H P
2	Near 90 GHz	Svendsen et al., 1987	85V, 85H P
3	P90	This study	85V, 85H P
4	Bootstrap_P (BP)	Comiso, 1986	37V, 37H P
5	NRL	Lo, 1983	37V, 37H P
6	P37	This study	37V, 37H P
7	P18	This study	18V, 18H P
8	P10	This study	10V, 10H P
9	Bristol	Smith, 1996	19V, 37V, 37H P G
10	ECICE NWF	Shokr et al., 2008	19V, 19H, 37V, 37H P
11	NASA Team NWF	Cavalieri et al., 1984	19V, 19H, 37V P G
12	NASA Team 2 NWF	Markus and Cavalieri, 2000	19V, 19H, 37V, 85V, 85H P G
13	OSISAF	Eastwood (ed.) 2012	19V, 37V, 37H P G
14	TUD	Pedersen, 1998	19V, 37V, 85V, 85H P G
15	UMass-AES	Swift et al., 1985	19V, 37V G
16	Bootstrap_F (BF)	Comiso, 1986	19V, 37V, 37H P G
17	CalVal	Ramseier, 1991	19V, 37V G
18	NORSEX	Svendsen et al., 1983	19V, 37V G
19	(NT+BF)/2	This study	19V, 19H, 37V P G
20	(NT+BF+P90)/3	This study	19V, 19H, 37V, 85V, 85H P G
21	(P37+P90)/2	This study	37V, 37H, 85V, 85H P
22	(P37+P90+BF)/3	This study	19V, 37V, 37H, 85V, 85H P G
23	(BF+(BF**2)*P90)/(1+BF**2)	This study	19V, 37V, 85V, 85H P G
24	(BF+(BF**3)*P90)/(1+BF**3)	This study	19V, 37V, 85V, 85H P G
25	(BF+P90)/2	This study	19V, 37V, 85V, 85H P G
26	(BF+BF*P90)/(1+BF)	This study	19V, 37V, 85V, 85H P G
27	One channel	Pedersen, 1991	GH

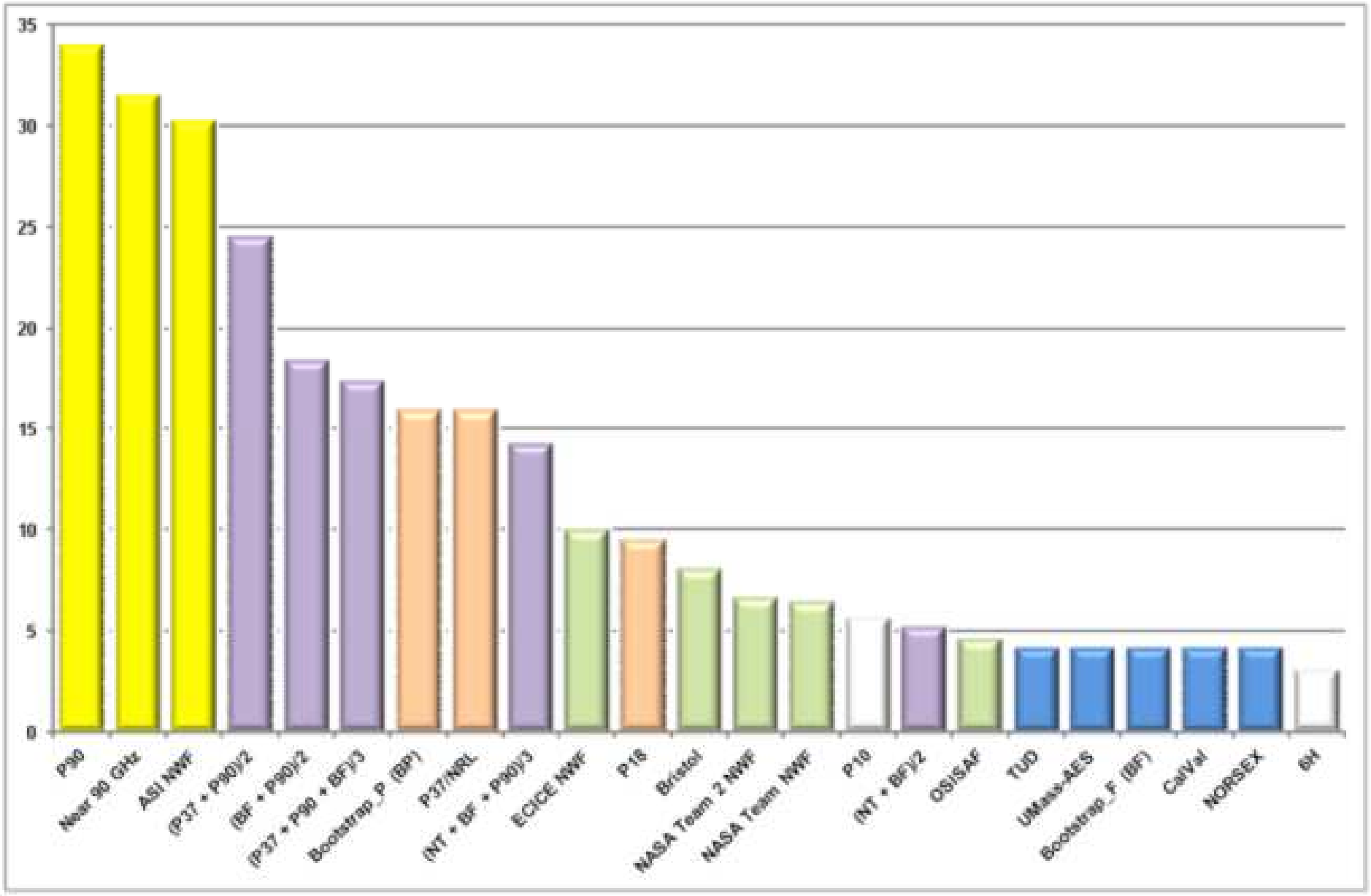
Location of validation data





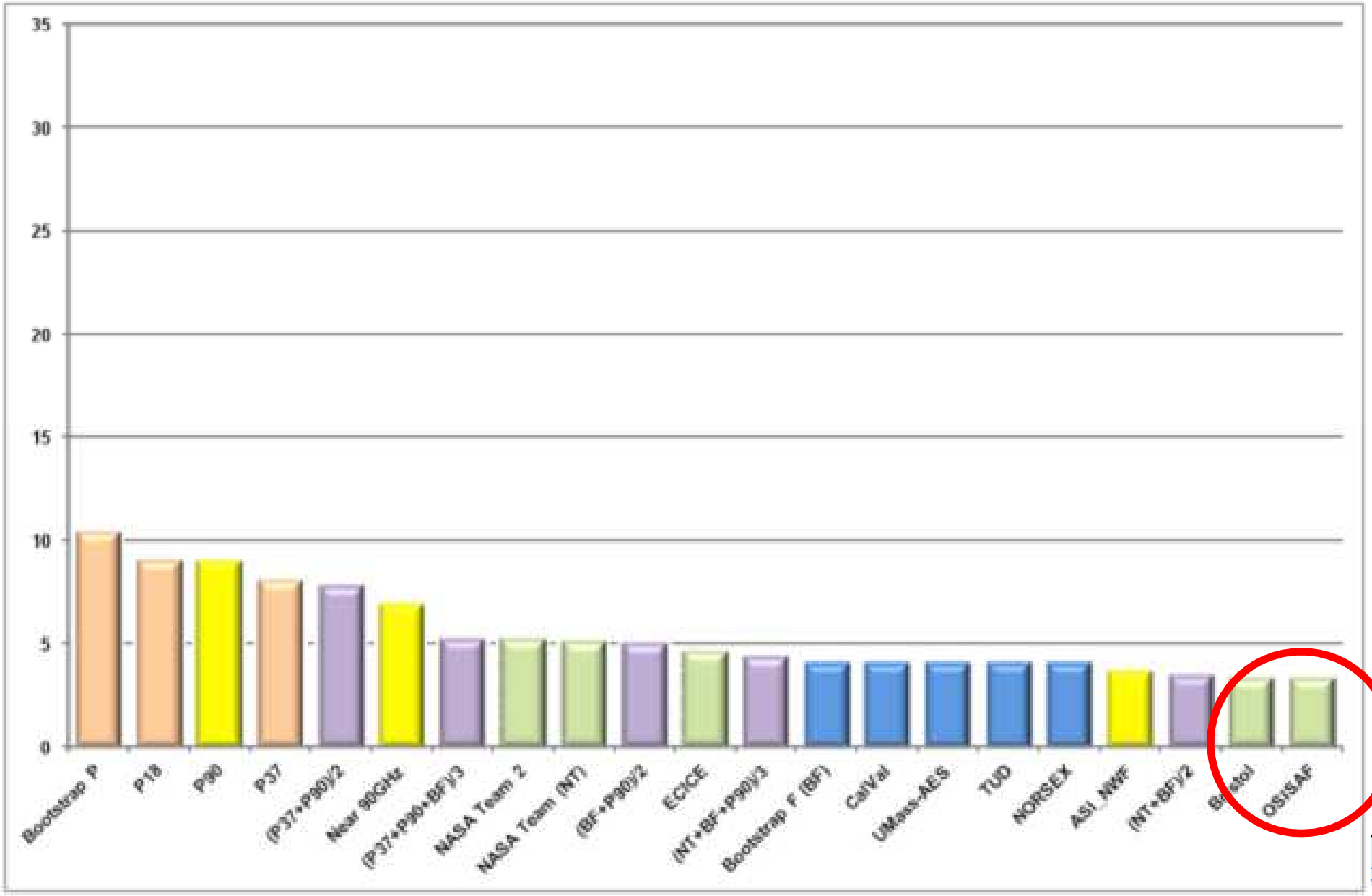
Location of all validation data from 2008 where ice concentration is 100 % for Arctic, and Antarctic. All locations used during the year are shown, some locations are used several times, others only once during the year .A total of 2700 datasets in the Arctic and 1500 in the Antarctic were obtained for 100% ice in 2008 .

Algorithm comparison for 0% conc



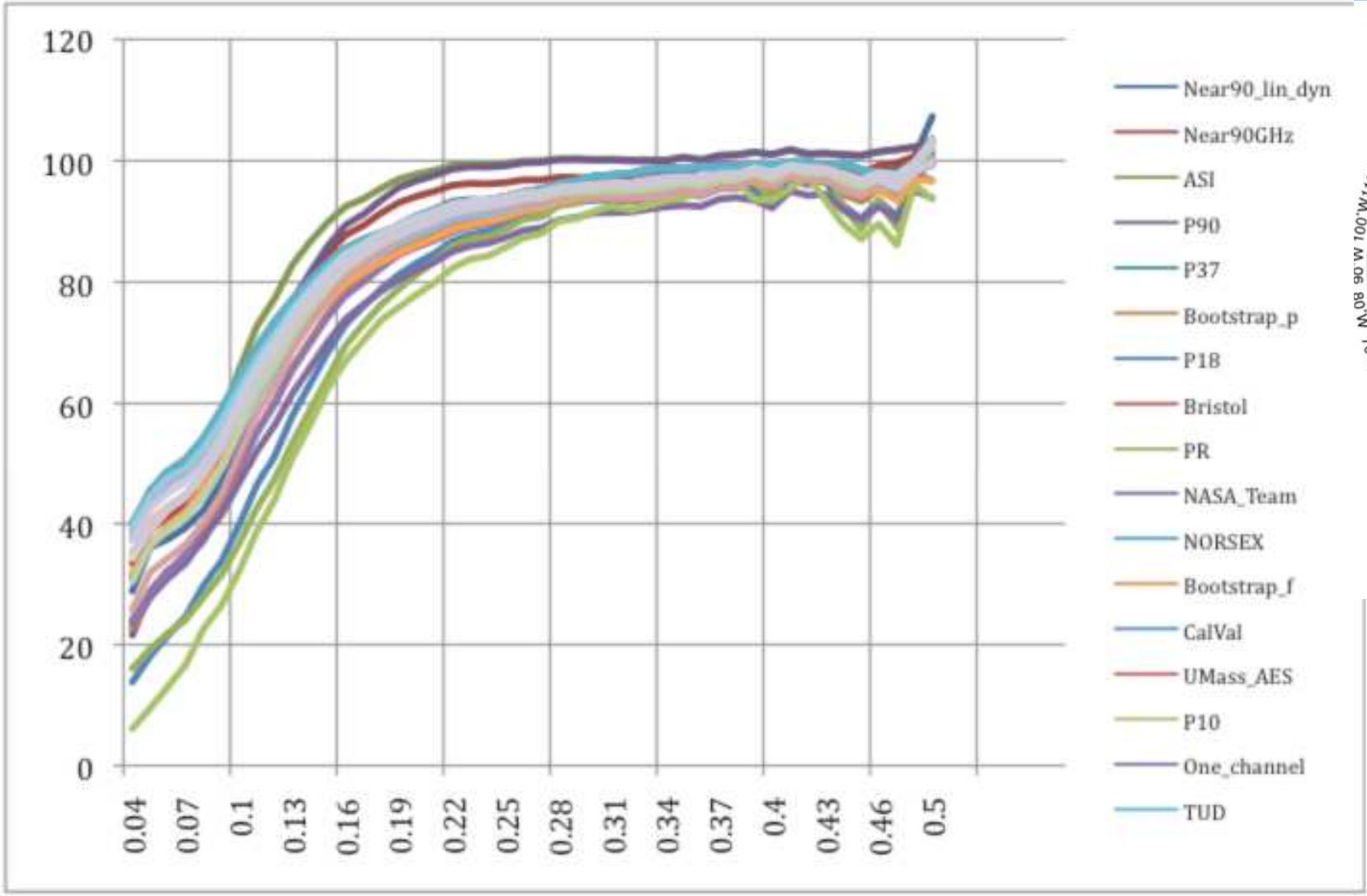
Standard deviation of SIC = 0 retrievals in Northern Hemisphere winter from AMSR data

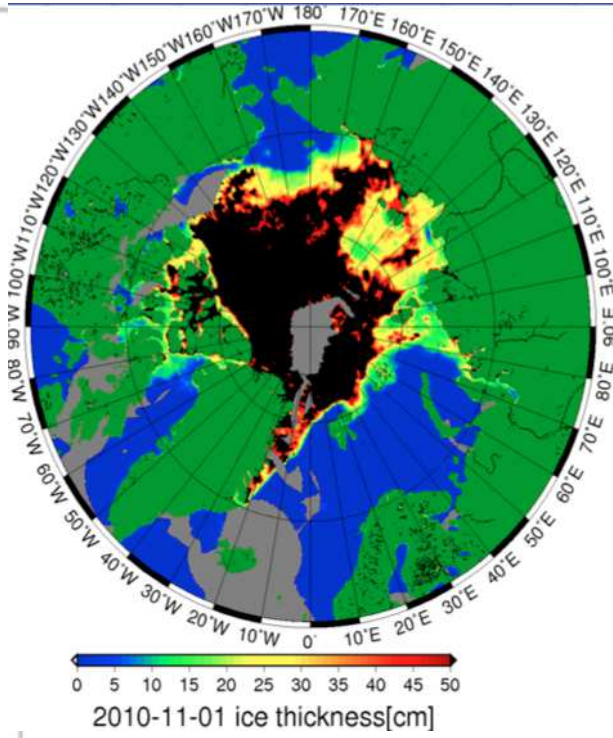
Algorithm comparison for 100% conc



Standard deviation of SIC =10 0 retrievals in Northern Hemisphere winter from AMSR data

Ice concentration versus thin ice



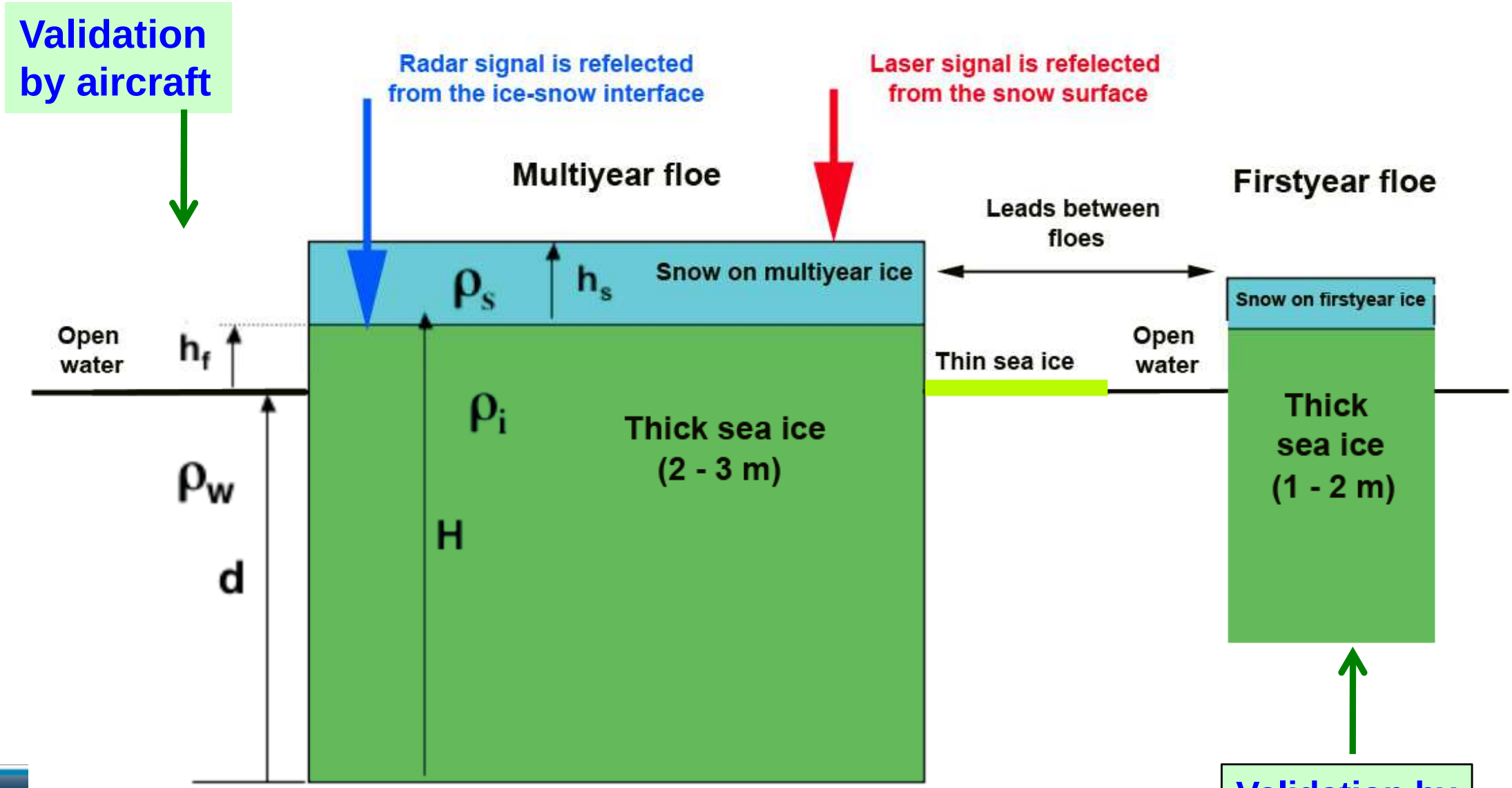


Sea ice concentration from 21 algorithms versus thin ice thickness from SMOS for selected test areas in the Arctic. Inset map shows sample of SMOS sea ice thickness from Nov. 1, 2010; grey regions indicate data gaps due to RFI.

Round Robin data sets for ice thickness

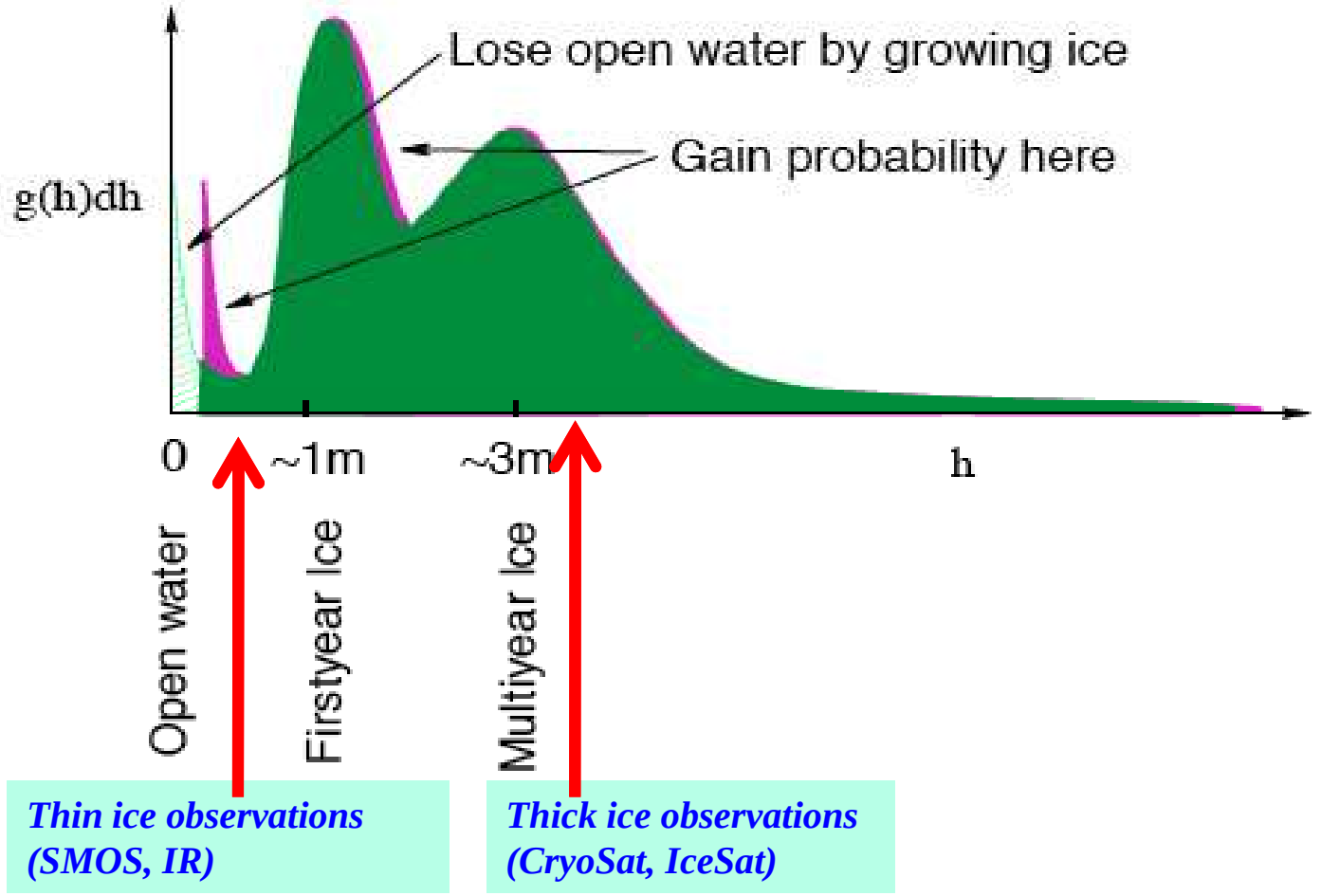
Year	Location	Parameter	Source
2003-2008 Oct-March	Circum-arctic, below 82N	ice freeboard	ENVISAT RA2
2003-8	Beaufort Sea	ice draft, snow depth	Moored ULS data from the Beaufort Gyre Exploration Project (BGEP) moored ULS and AMSR-E
Apr 1994	Beaufort Sea	ice draft	Submarine ULS data from NSIDC
		ice freeboard	ERS-RA
Oct 1996	Beaufort Sea	ice draft	Submarine ULS data from NSIDC
		ice freeboard	ERS-RA
Mar 2007	Fram Strait/ Beaufort Sea	ice draft, snow depth	UK submarine ULS data (Tireless) and AMSR-E
May 2011	Fram Strait	ice freeboard, snow depth	Airborne Laser Scanner (ALS) and ASIRAS data from DTU, and AMSR-E data
Apr 2008	Fram Strait	ice freeboard / thickness, snow depth	ALS and ASIRAS data from DTU, AMSR-E and in-situ data
April 2009/10	Western Arctic	snow depth, ice thickness / freeboard	Operation IceBridge
Climatology 1954 - 1991	Circum-arctic, mainly MY ice	snow depth and density	In situ data from NP drifting stations (Warren et al., 1999)

Measure freeboard by altimetry

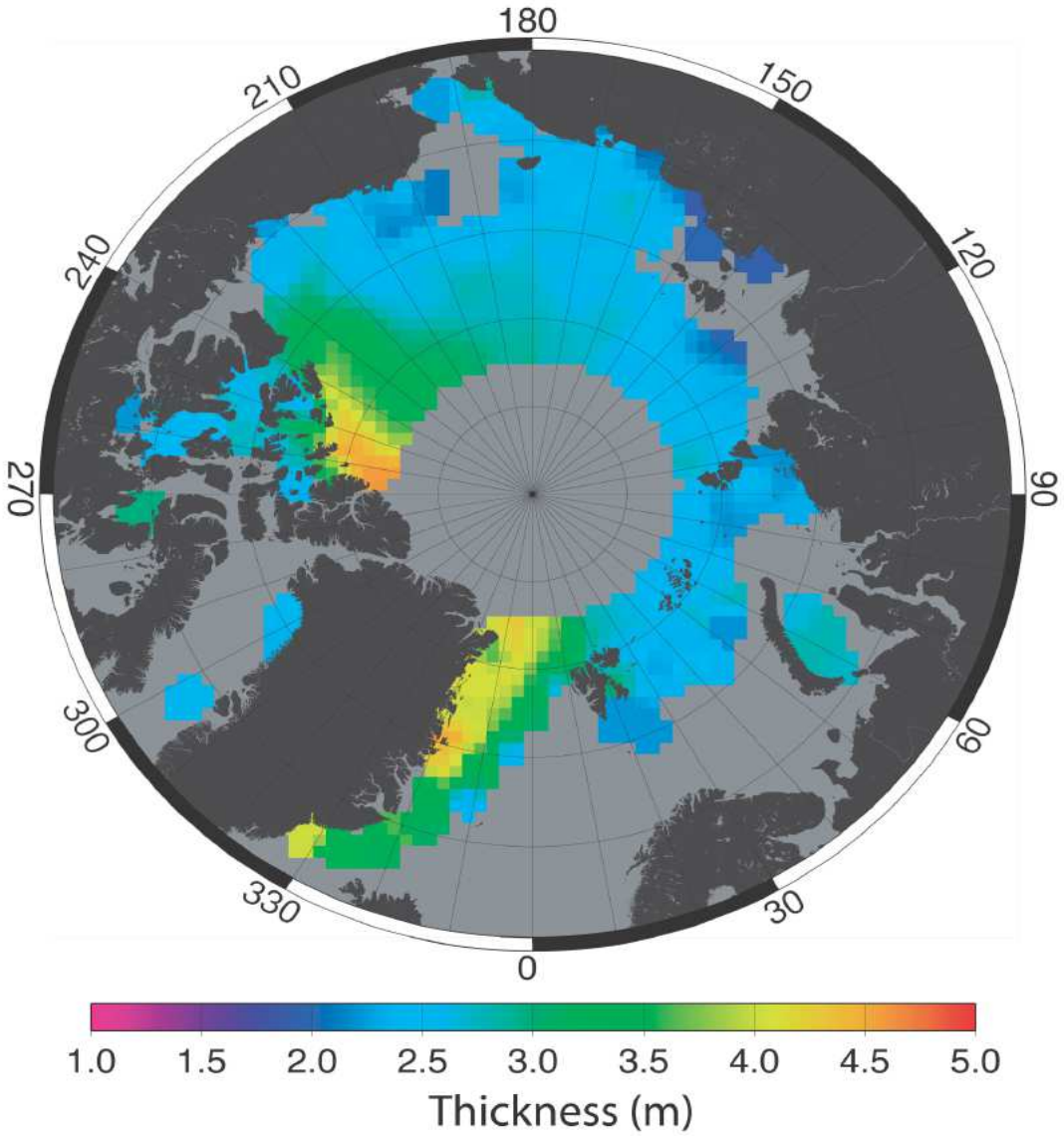


Ice thickness distribution

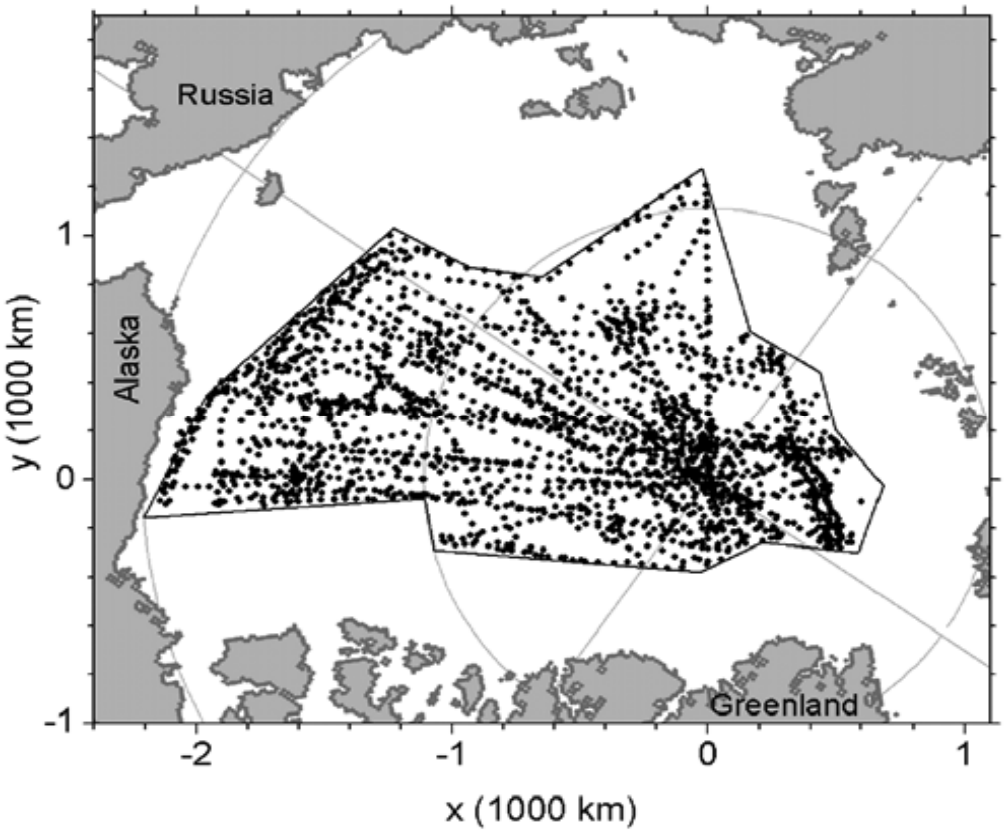
(probability density function – pdf)



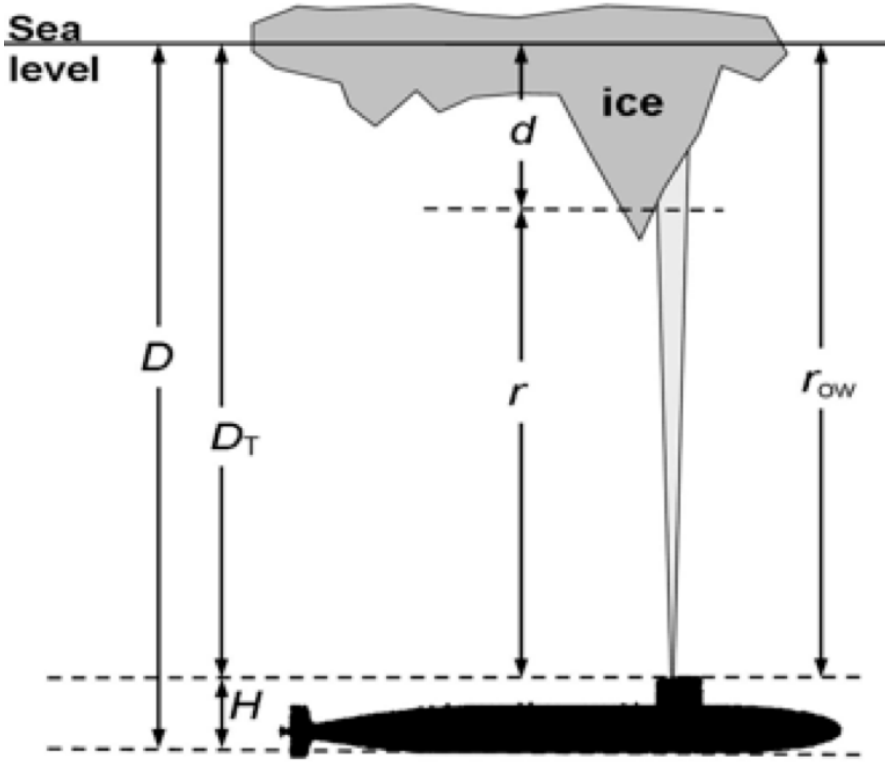
Ice thickness from ERS and ENVISAT RA

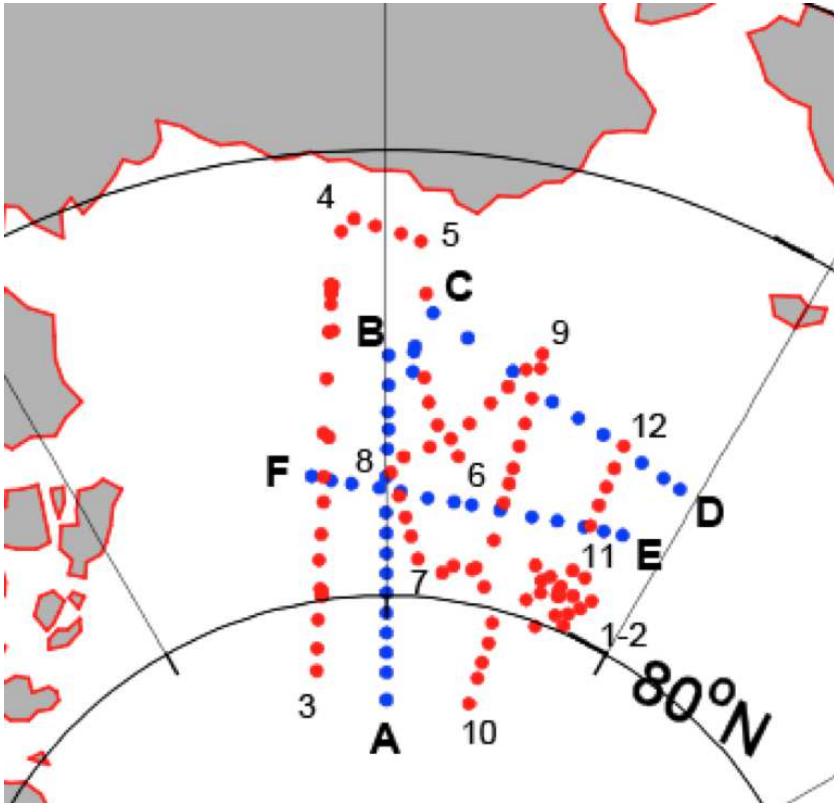


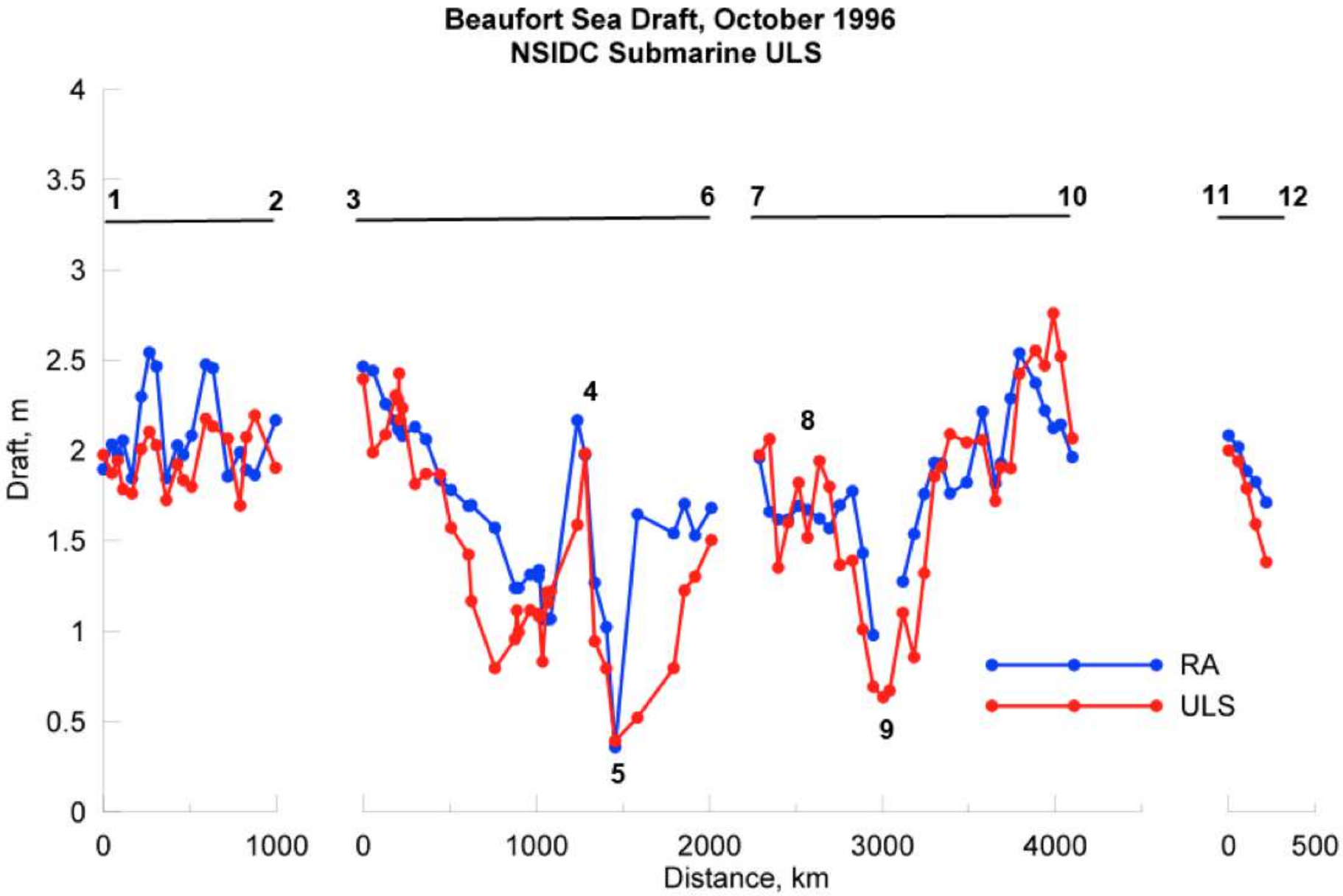
Validation data from submarine cruises



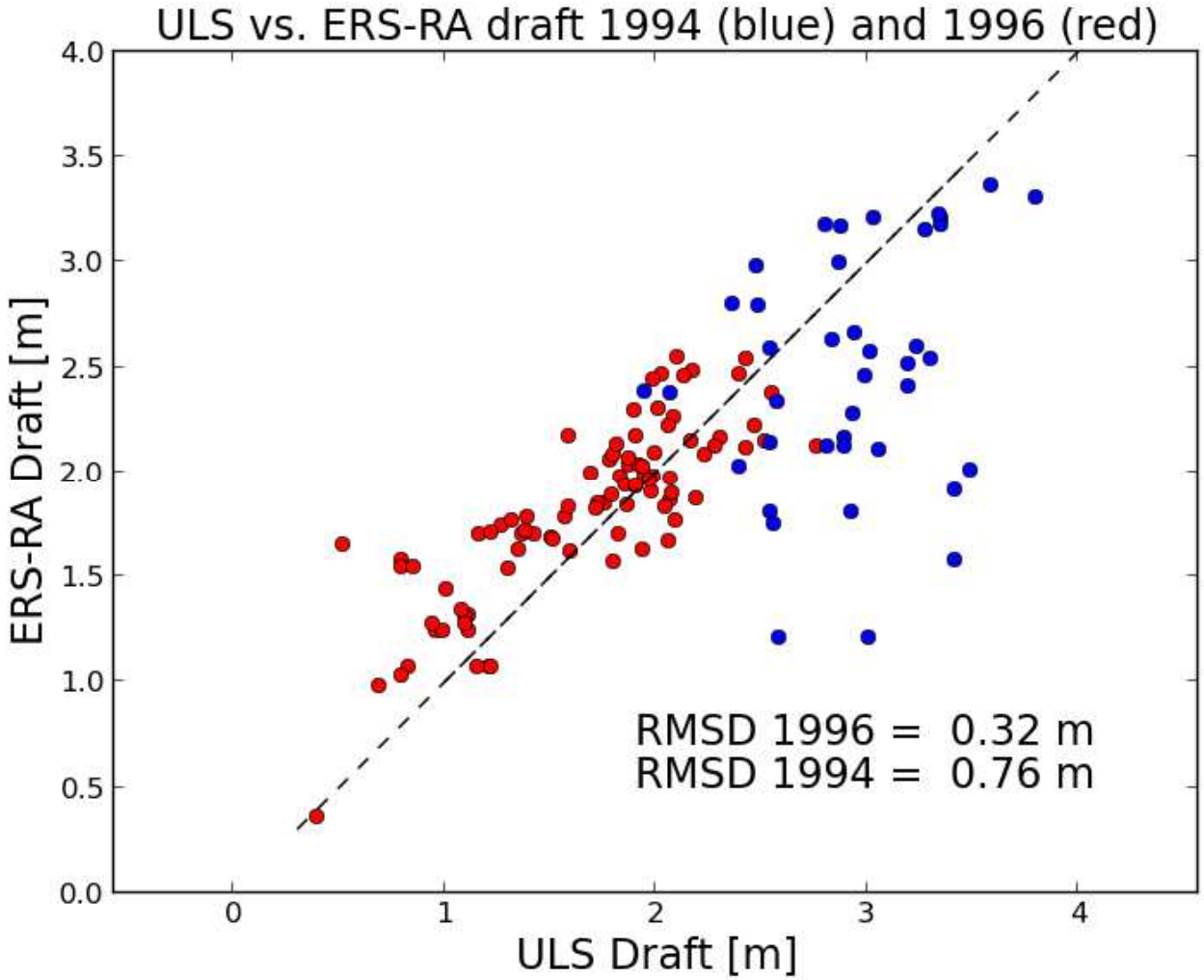
Validation of ice draft by submarine ULS data in Beaufort Sea



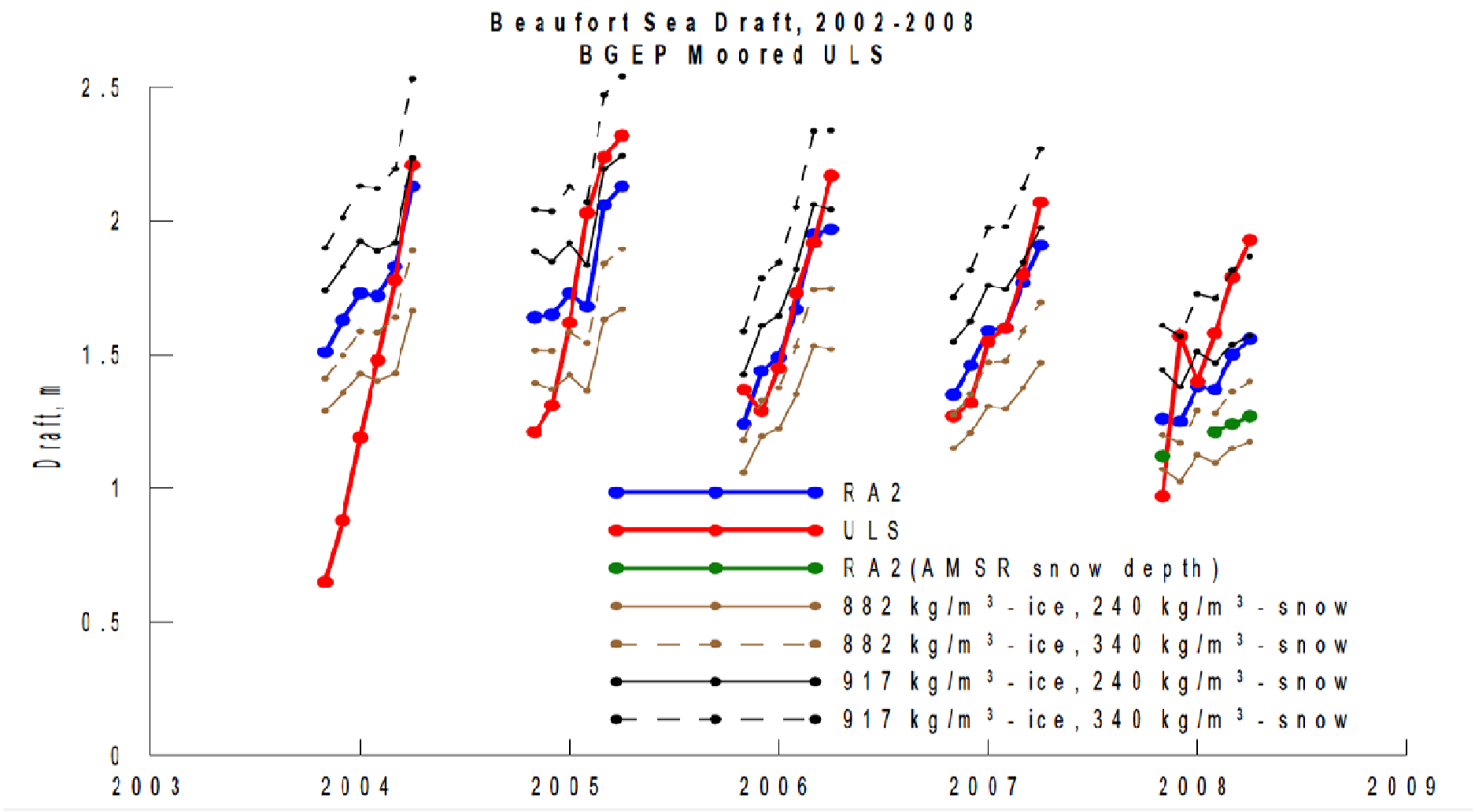



Beaufort Sea Draft, October 1996
NSIDC Submarine ULS
Draft, m
Distance, km
RA
ULS
1
2
3
4
5
6
7
8
9
10
11
12

ULS draft versus RA draft



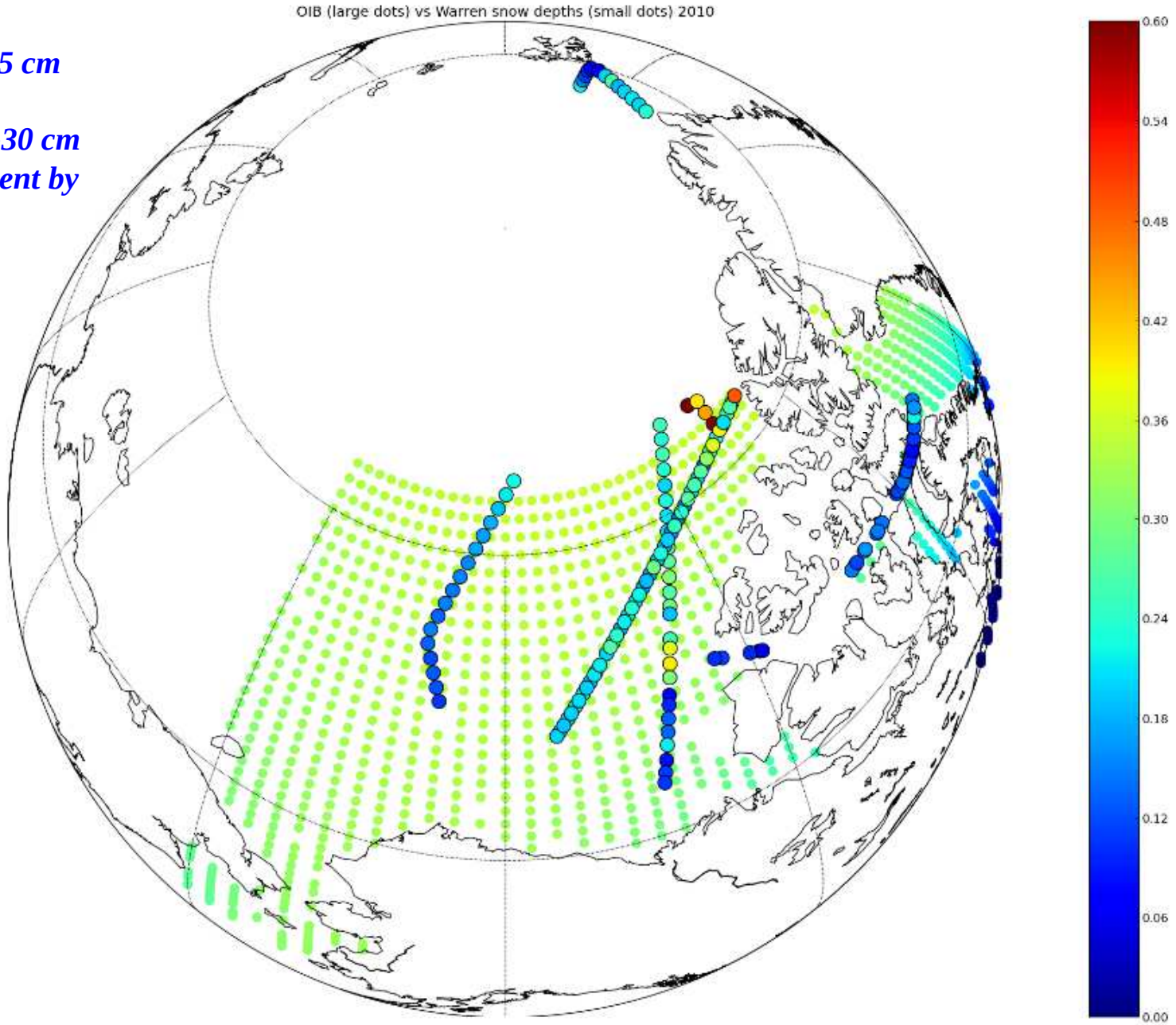
Sensitivity of thickness to snow and ice density



Snow thickness data: a challenge

Warren climatology: 30-35 cm

Operation Ice Bridge: 10-30 cm (based on direct mesurement by snow radar)



Conclusions from the RRDP studies

- Ice concentration: several algorithms give similar results,
- ECV products will use OSI-SAF or similar alg.
- Ice thickness: retrieval from freeboard depends on snow thickness, ice and snow density. Need to establish the best possible climatological fields based on aircraft, underwater and in situ measurements.