Pacific Arctic Group (PAG) – Climate Line Workshop
Tue. 21 April, 2015, TUMSAT Shinagawa, Tokyo

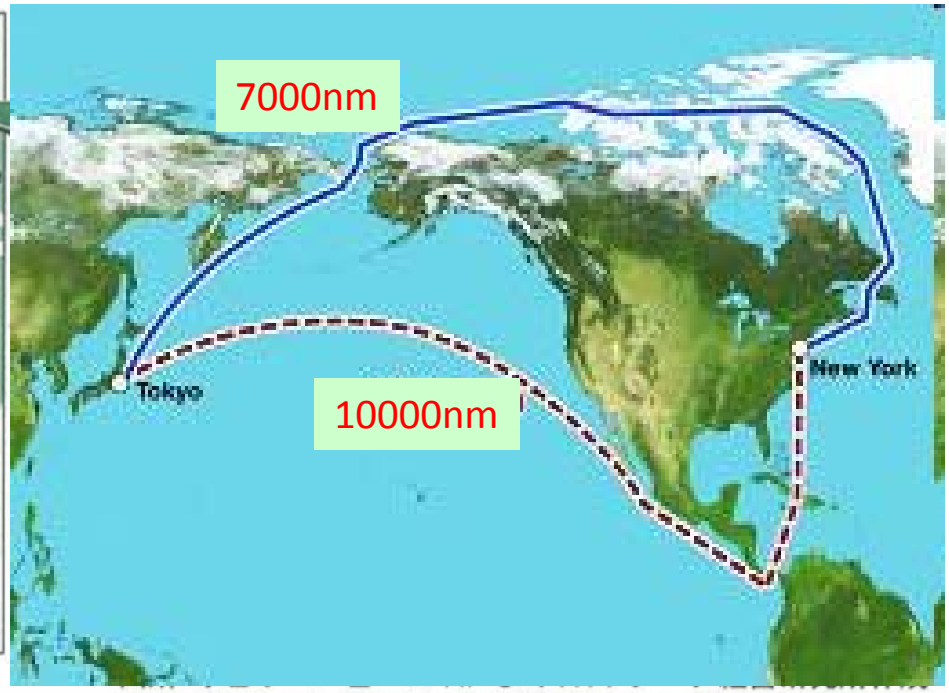
Study of the Arctic sea routes

-- GRENE Arctic sea route study and Its Extension --

Hajime Yamaguchi

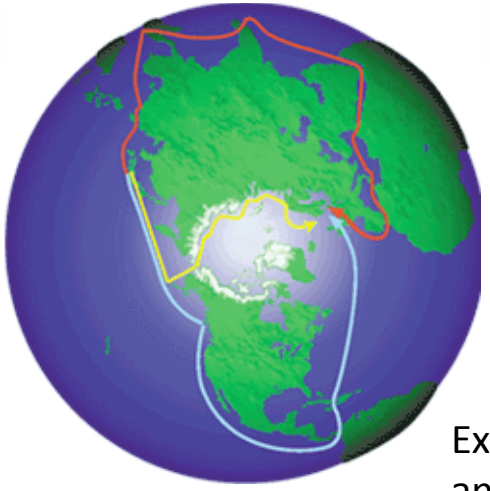
The University of Tokyo

Comparison of Sailing Route Distance



nm = Nautical Mile = 1.852 km

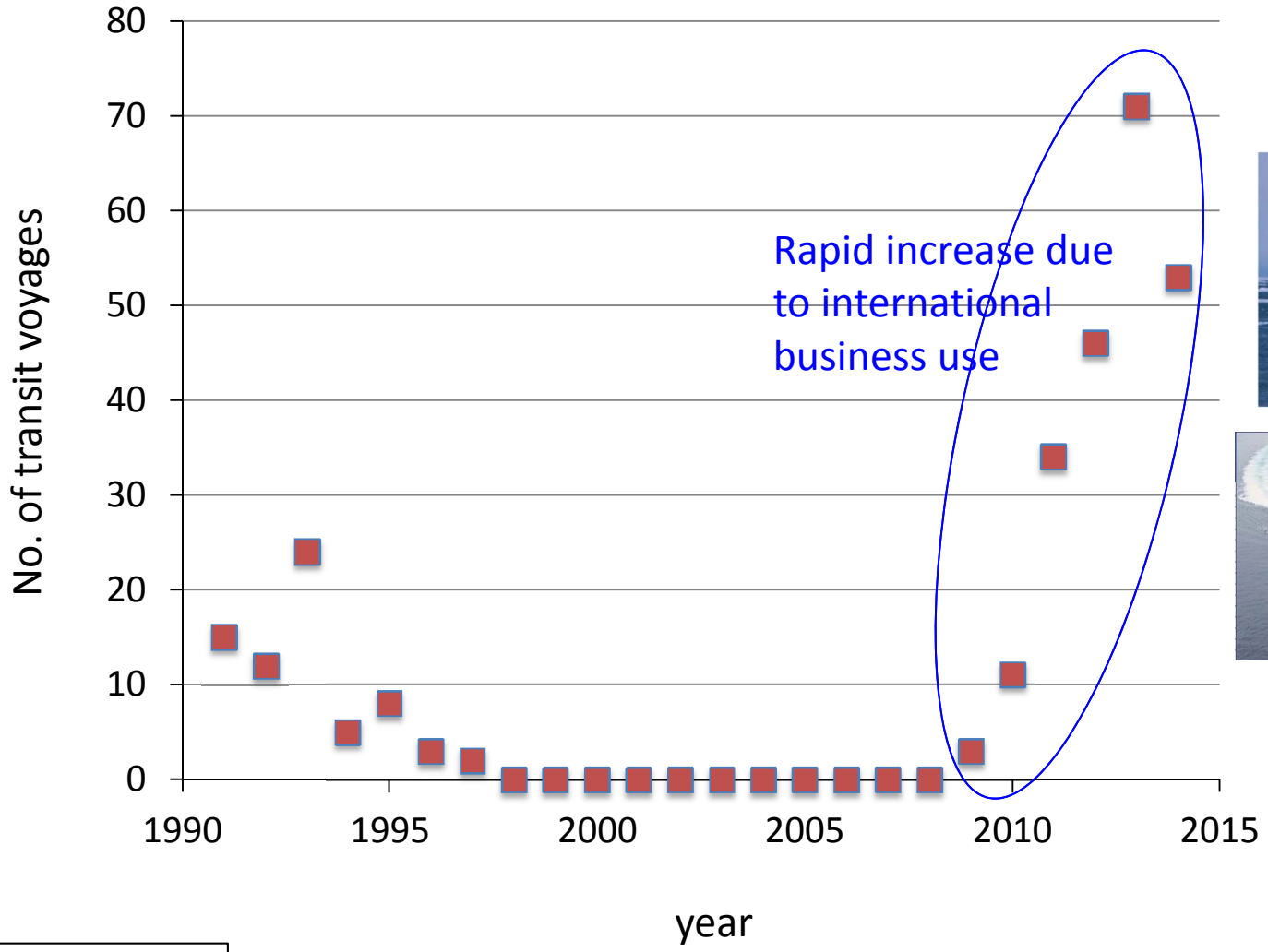
http://weathernews.com/jp/c/press/2008/080708.html



Arctic sea routes	
Northeast passage (NEP) Northern Sea Route (NSR)	Northwest passage (NWP)

Exact definition of the Northern Sea Route is the route between the Kara Gate and the Bering Strait under the NSR Administration Agency.

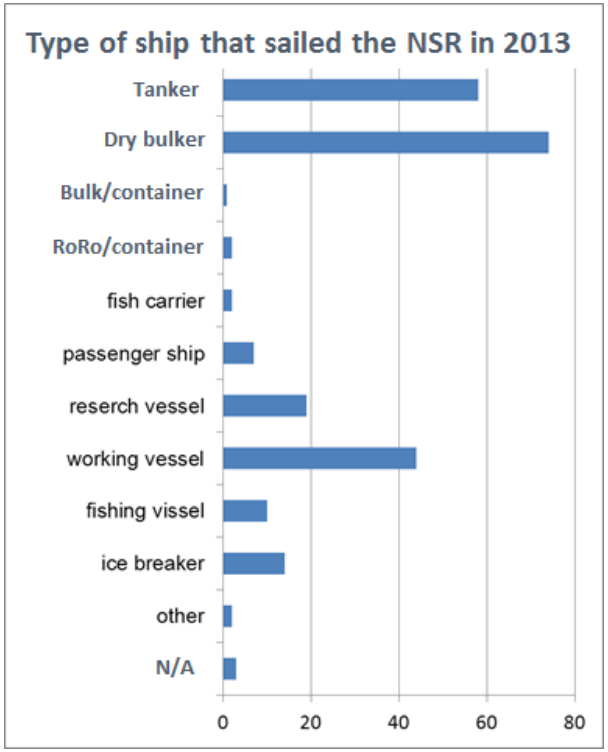
Northern Sea Route transit voyages

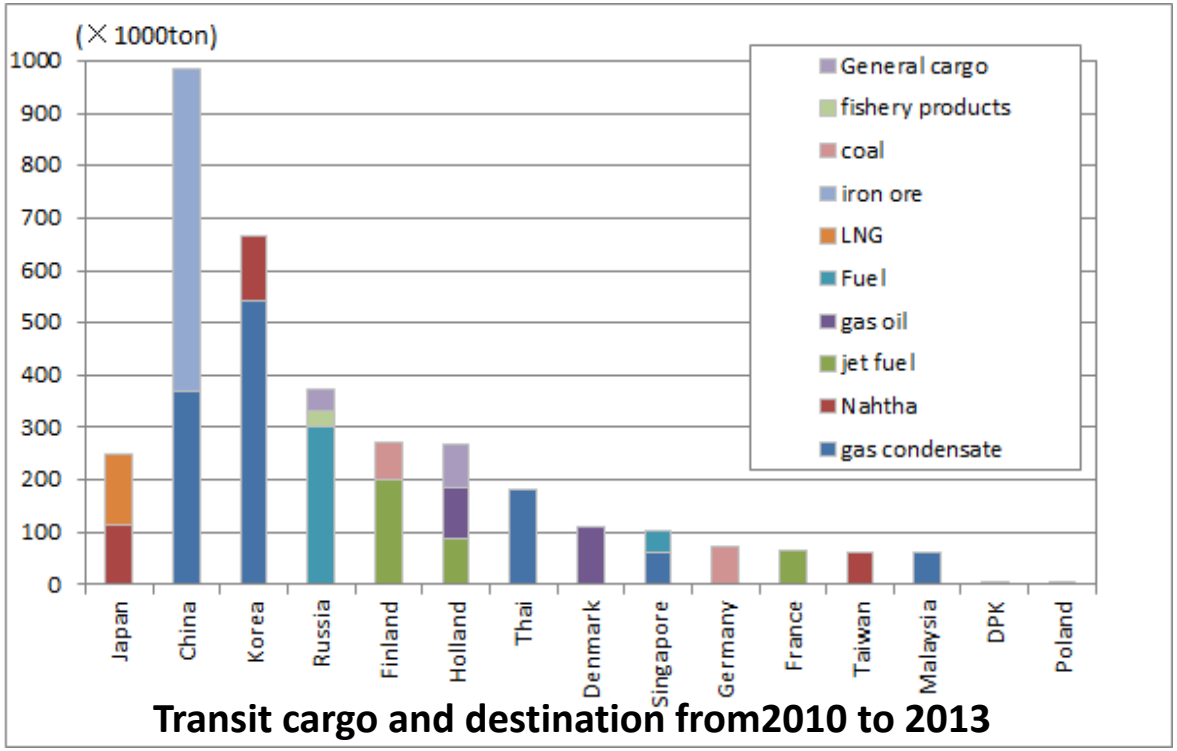


Majority of the cargo has been gas condensate and iron ore to China and Korea.

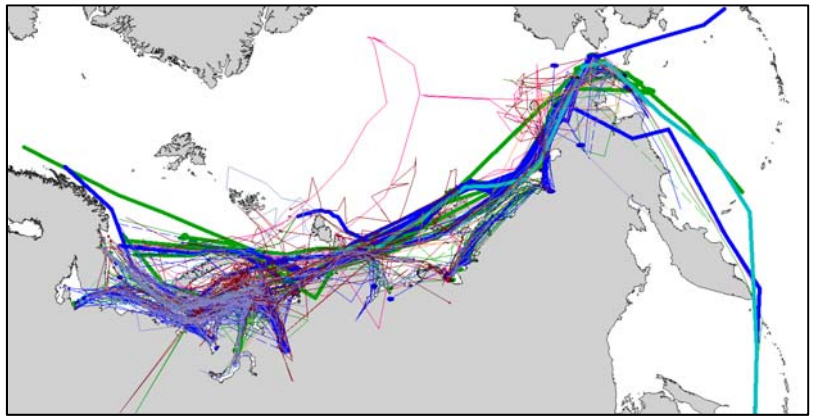
Kitagawa, 2015

Sailed Ships and Cargo Destinations via NSR





Transit cargo and destination from2010 to 2013



Furuichi & Otsuka, 2014

Japan is one of the pioneers of the Northern Sea Route study.

INSROP

International Northern Sea Route Programme 1993-1999

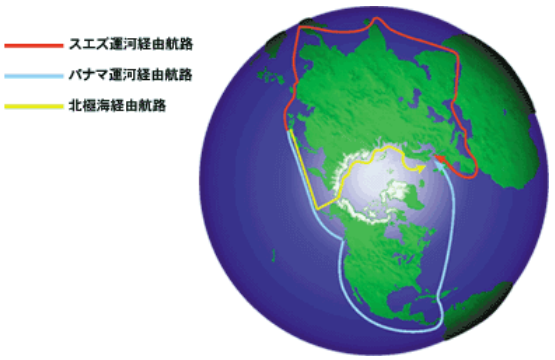
Organized by

CNIIMF, Central Marine Research & Design Institute, Russia

SOF, Ship & Ocean Foundation, Japan

FNI, The Fridtof Nansen Institute, Norway

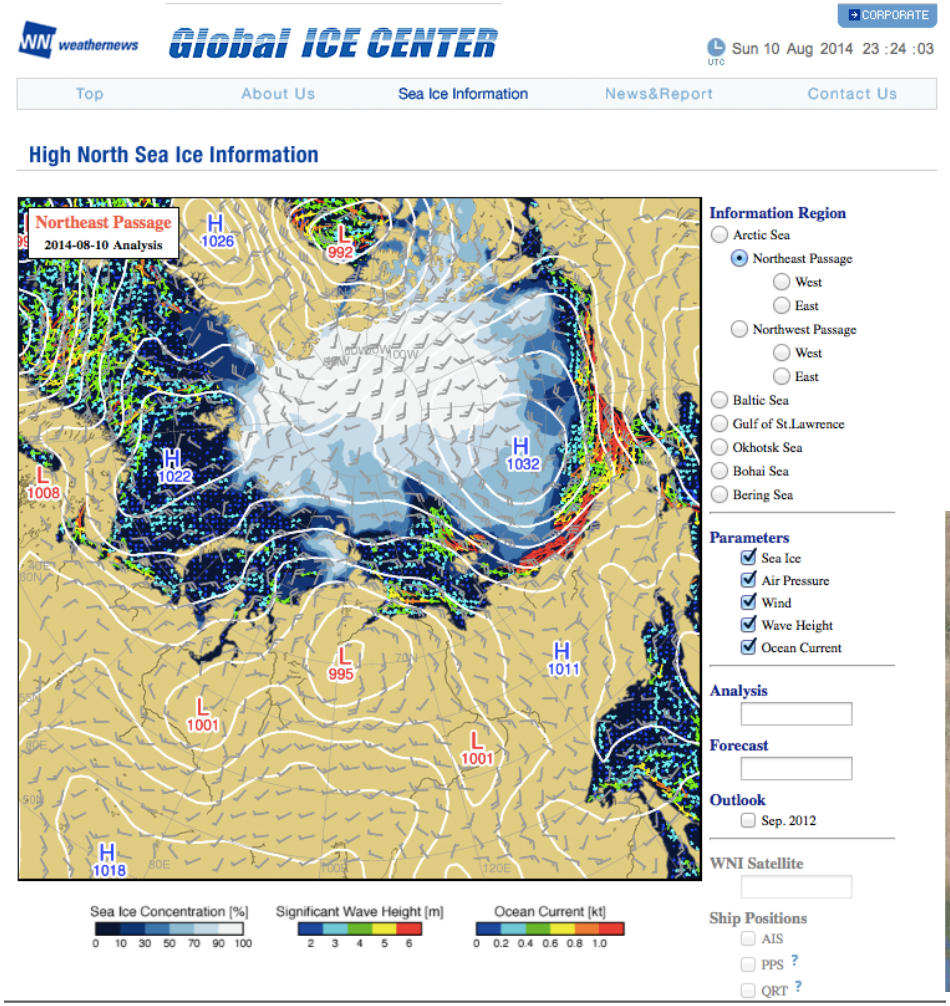
- Russia
- Japan
  - Canada
  - Finland
- Norway
  - Finalnd
  - Russia



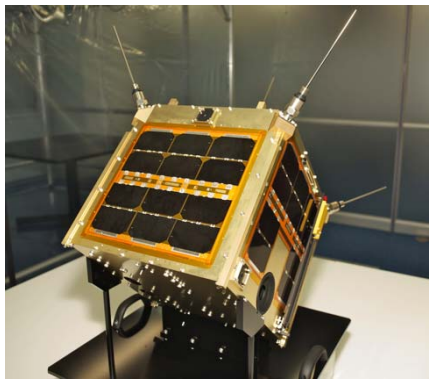
However, the industrial action was delayed.

Weathernews, Inc., Navigation support business

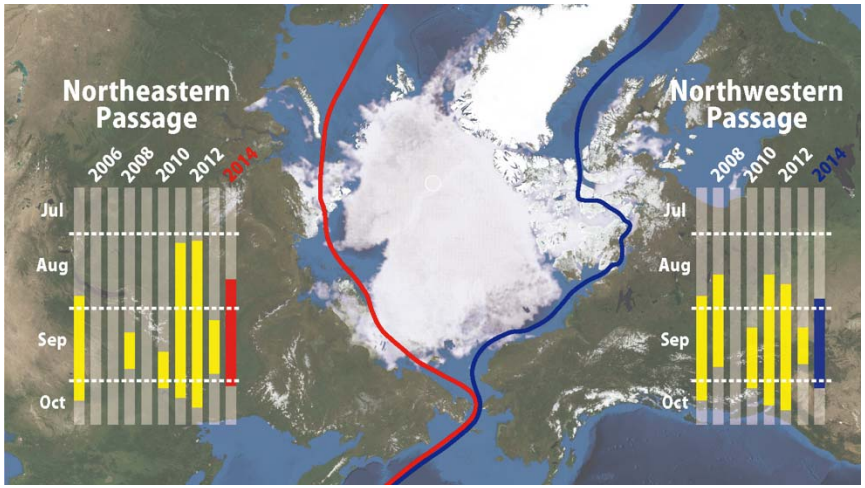
The world's largest weather forecast company.
Support about 6,000 vessels everyday.



Global Ice Center, since 2008



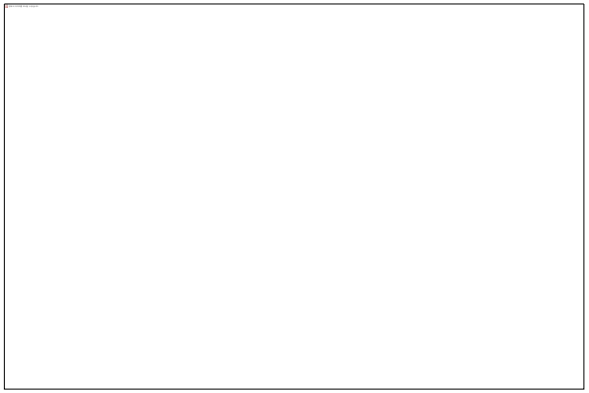
WNISAT: World's 1st privately owned satellite, launched in 2013.



Route navigability forecast
(released on July 23, 2014)

Mitsui O.S.K. Line, Yamal LNG Project

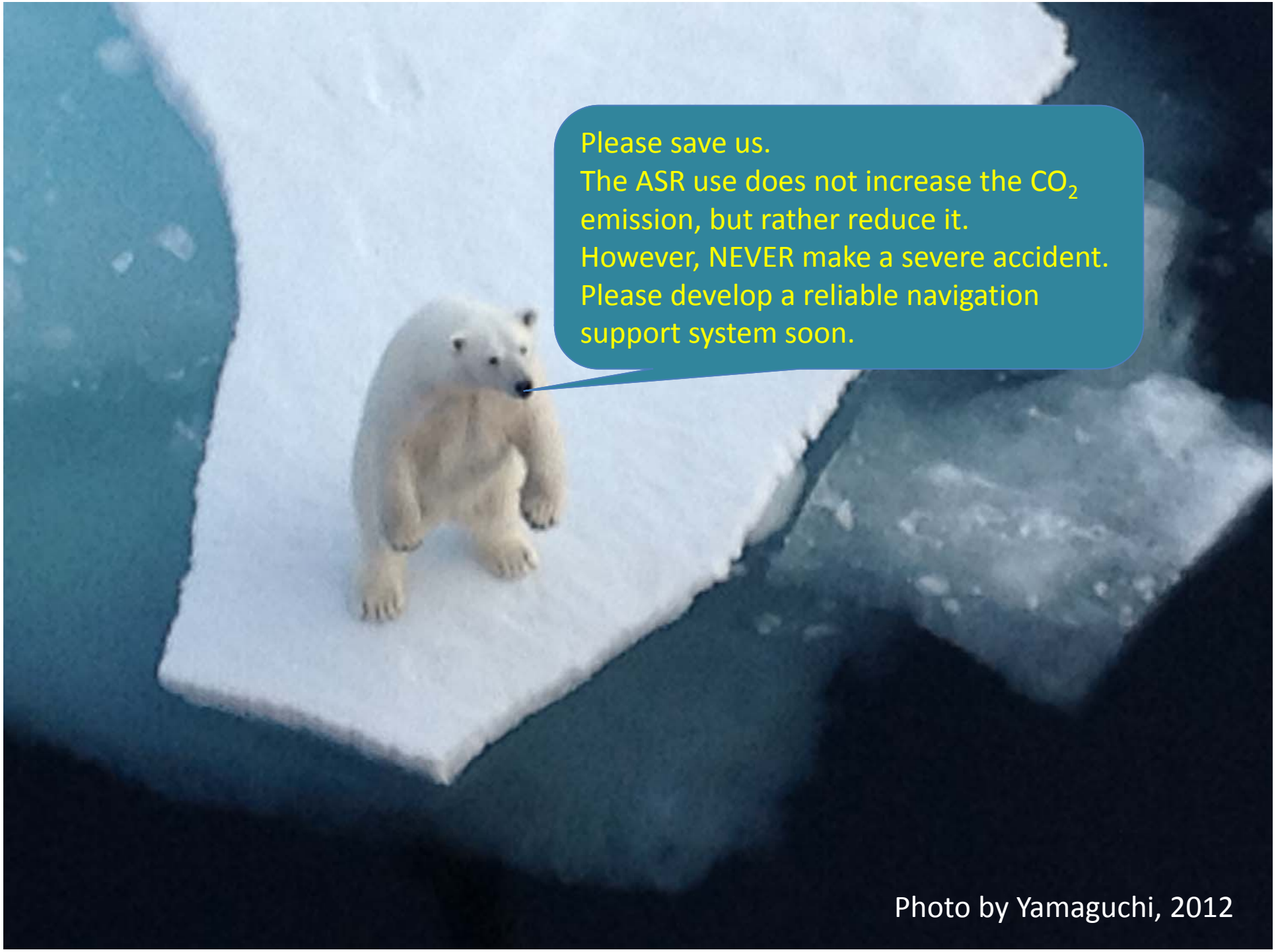
Yamal LNG Project



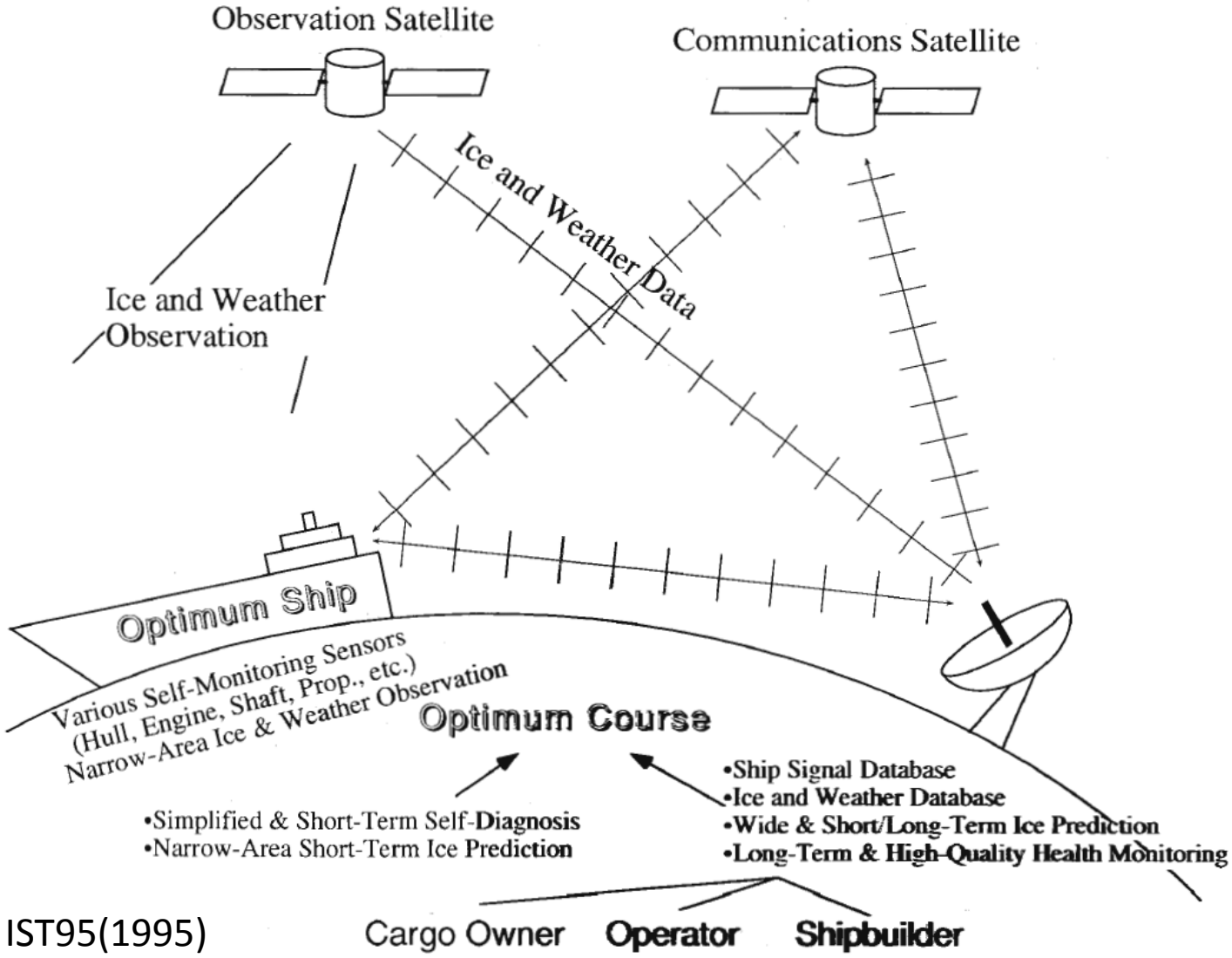
17,200 m^3 membrane type LNG carrier
Double Acting, L=299m, B=50m
Ice Class = RMRS ARC7
(no need for icebreaker assistance)
3 POD prop.
Max. 2.1m cont. icebreaking (astern)
Daewoo Shipbuilding, Korea

- 15 vessels including normal type
- The operation will start in 2018.

- Summer (July – Nov.): to Asia via NSR.
- Winter: to Europe, including transshipment to normal type vessels going to the other areas.


Please save us.
The ASR use does not increase the CO_2 emission, but rather reduce it.
However, NEVER make a severe accident.
Please develop a reliable navigation support system soon.
Photo by Yamaguchi, 2012

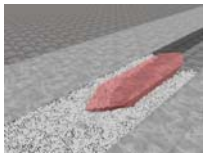
Target System for Safe and Efficient Navigation



Yamaguchi, IST95(1995)

GRENE Project for the Development of Navigation Support System

2011 – March, 2016



Issues on ships in ice:
Ship-ice contact and Icing

Ice conditions

Ice distribution

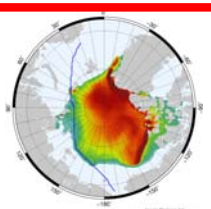
Ice monitoring along the sea route

Safe and efficient navigation along the Arctic sea routes

Data

Ice distribution

Ice prediction along the sea route



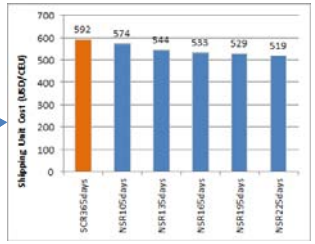
Optimum route search with forecast uncertainty taken into account

Route

Ice distribution

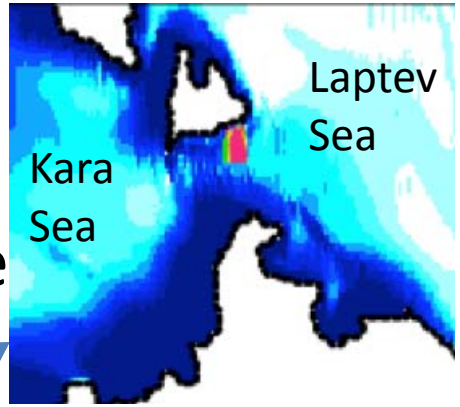
Proposal of shipping scenario with economics taken into account

Shipping cost estimates for various cargos

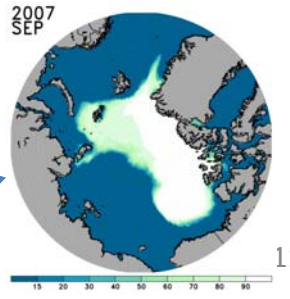


Ice Condition Predictions Necessary for the Ship Sailing Information

- Several months predictions → Decision of taking the Arctic route or normal southern route.
- abt. 1 week predictions → Decision of navigation route after entering the ice are
- 10-30 years predictions → Long term evaluation, for example, decision of a new vessel construction.



Short-term prediction of sea ice and spilled oil expansion

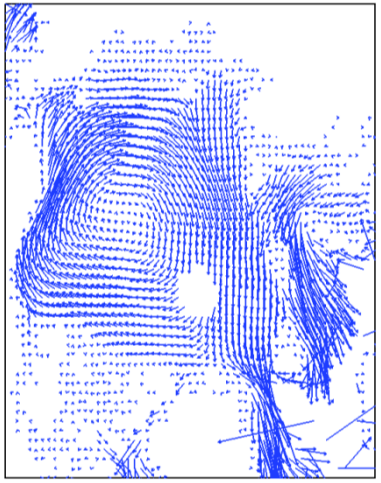


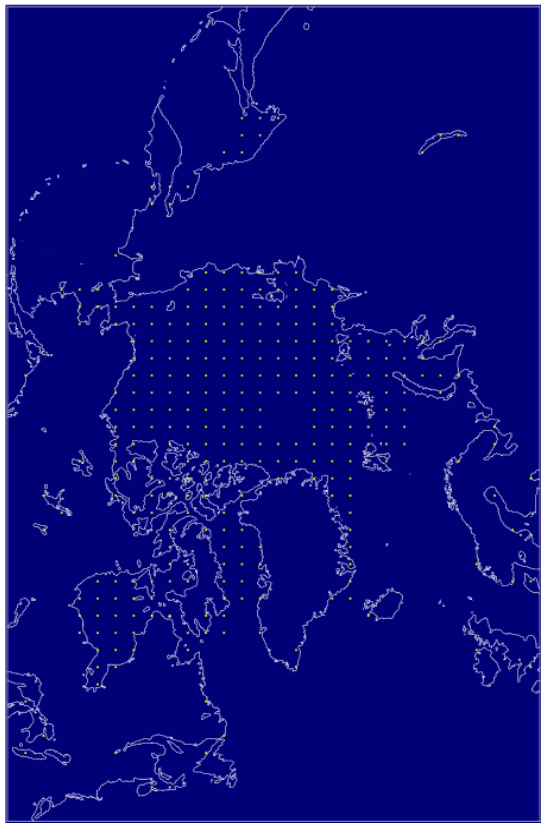
Long term comp. of the whole Arctic Ocean

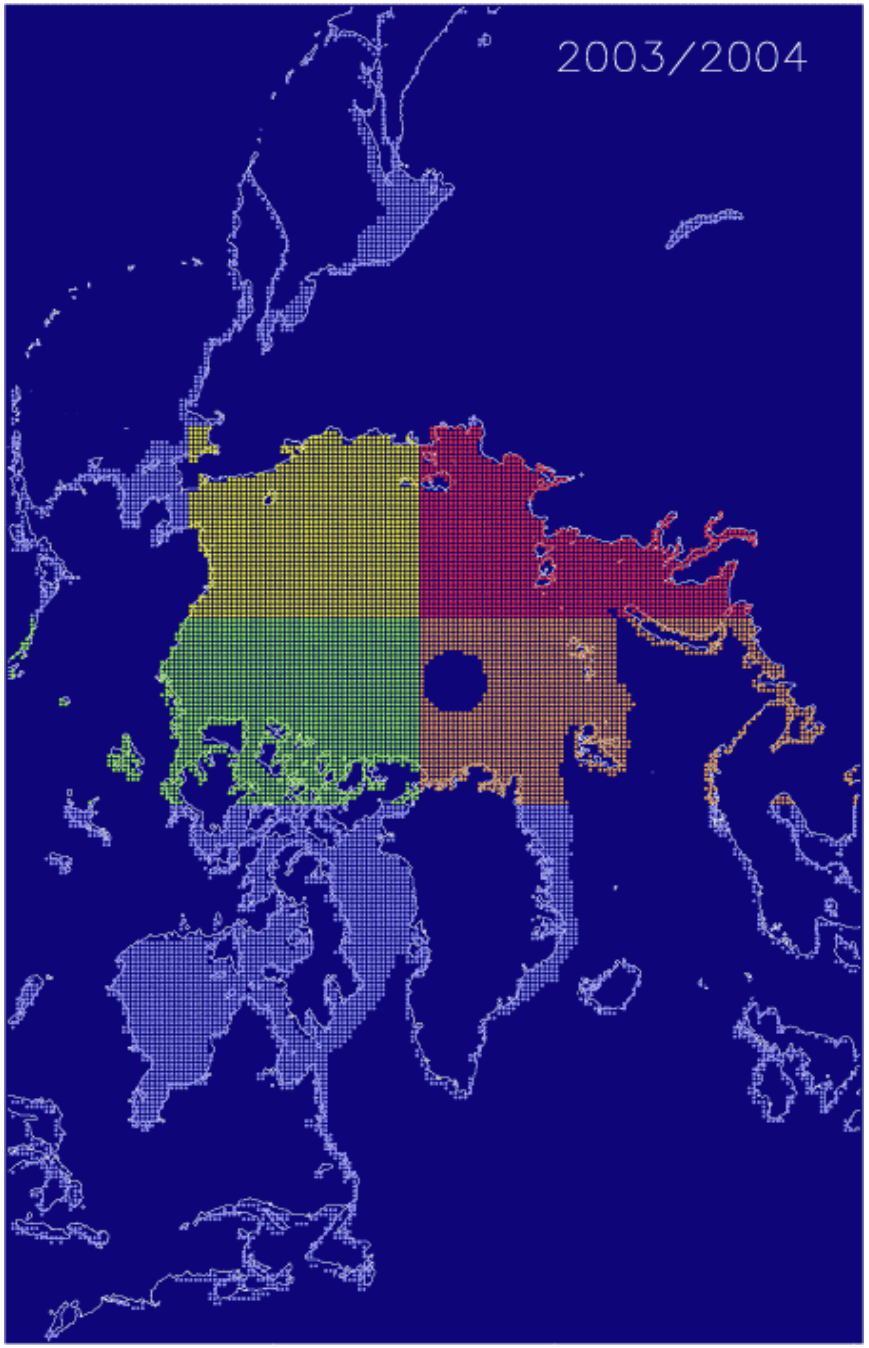
Several months prediction by processing satellite data

Winter ice motion > Ice diverging part >
Thin ice > likely to melt in summer

2003/12/01 - 2004/04/25



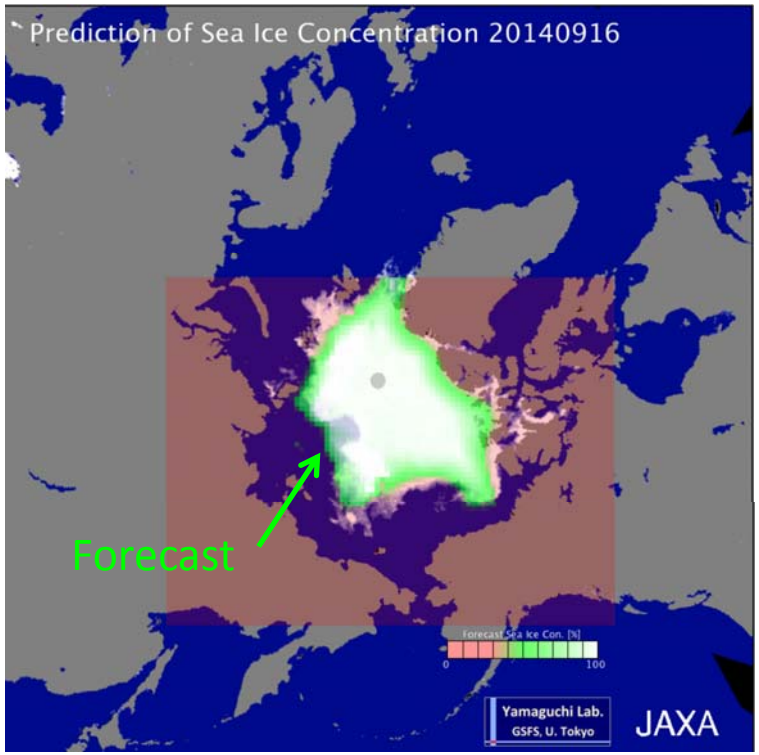




We have been announcing forecasts from the labo web since 2012.

Several months prediction – 2014

Web announcement at the end of May

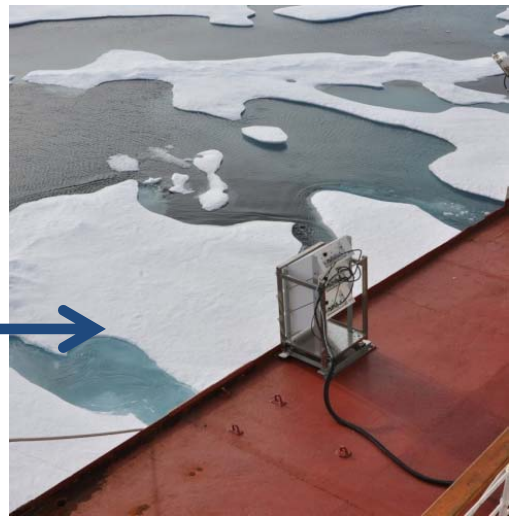


Comparison of ice distribution on Sep.16, 2014.
The forecast hit the real one. The route opening date was also well forecasted.

Study for ice monitoring

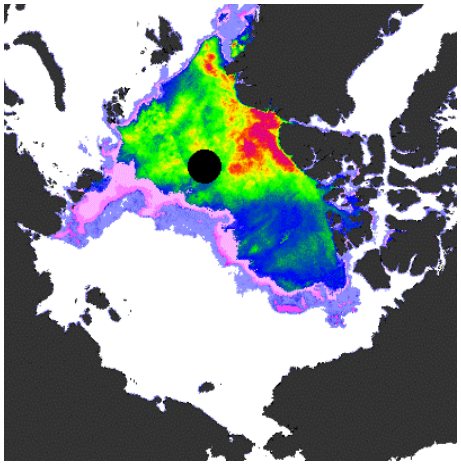
- Application to satellite data analysis -

Passive-Microwave Radar



EM sensor for ice thickness measurement

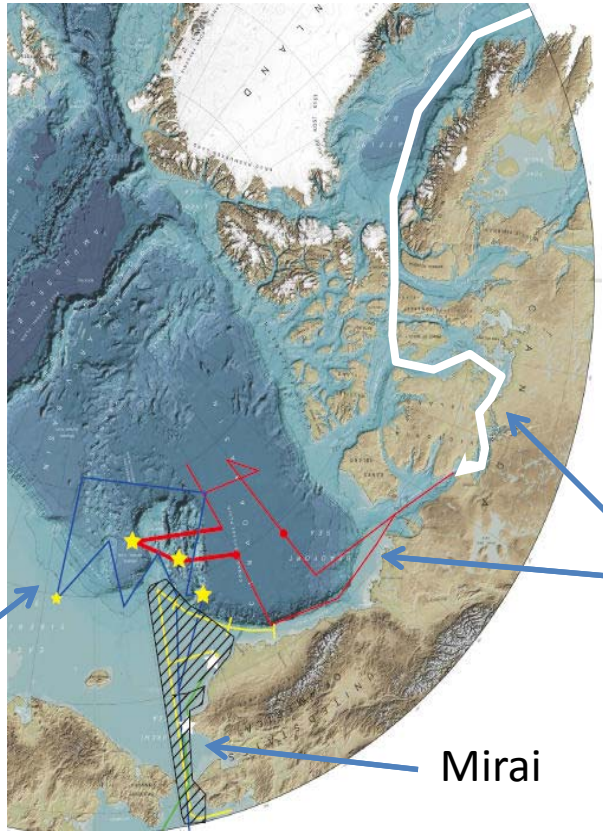
Ice Thickness and Melt-pond Algorithms



Field Measurements in GRENE

- Canadian Side, every year

+ Okhotsk Sea & Antarctica



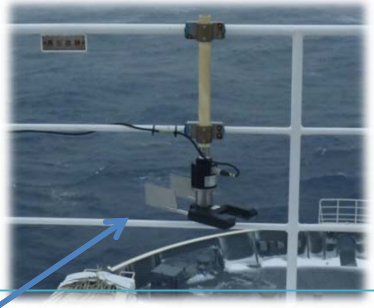
Canadian Icebreaker, LSSL

Araon

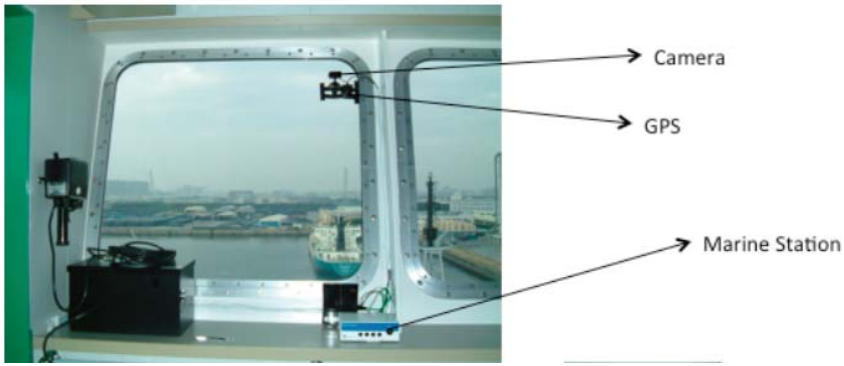
Mirai

On-board Measurements so far: Major items

- Navigation monitoring
- Visual ice observation
- EM and PMR ice measurements for ice monitoring study
- Sea-water spray measurements for ship icing study
- Ship motion measurements by portable ship motion sensor, Marine Station, developed by the Weathernews, Japan

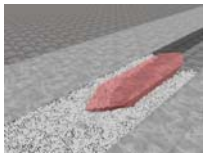


Water particle counter



3 component accelerometer + 3 component gyro

GRENE Project for the Development of Navigation Support System, and Its Extension Plan



Issues on ships in ice:
Ship-ice contact and Icing

Atmosphere and weather (Inoue)

Ice conditions

Ice distribution

Ice monitoring along the sea route

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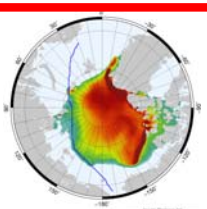


Optimum route search with forecast uncertainty taken into account

Route

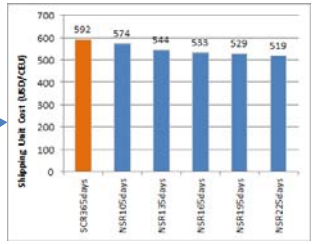
Ice distribution

Proposal of shipping scenario with economics taken into account

Waves (Waseda)

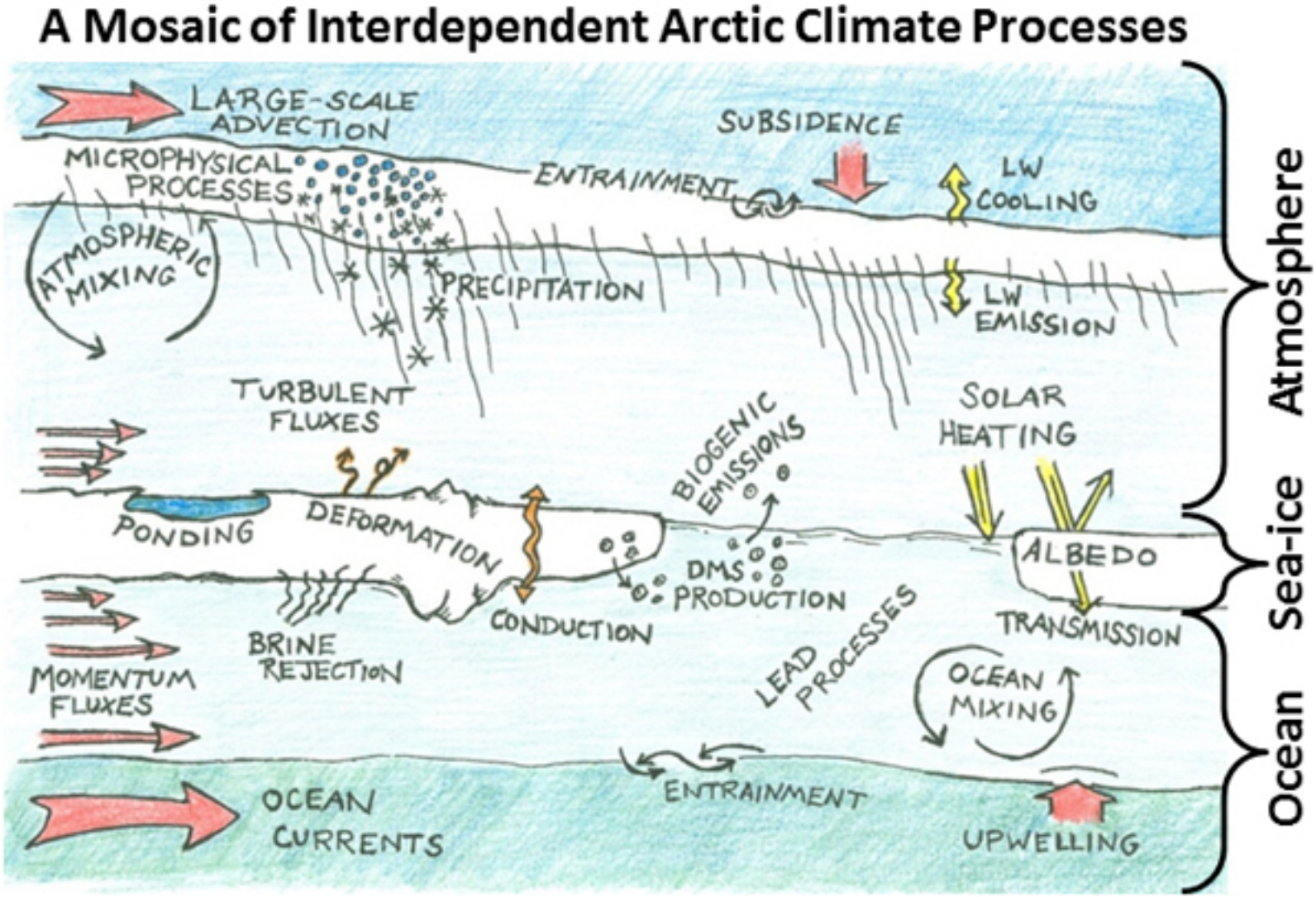
We would like to put more emphasis on the Northern Sea Route (Russian side) than that in GRENE.

Shipping cost estimates for various cargos

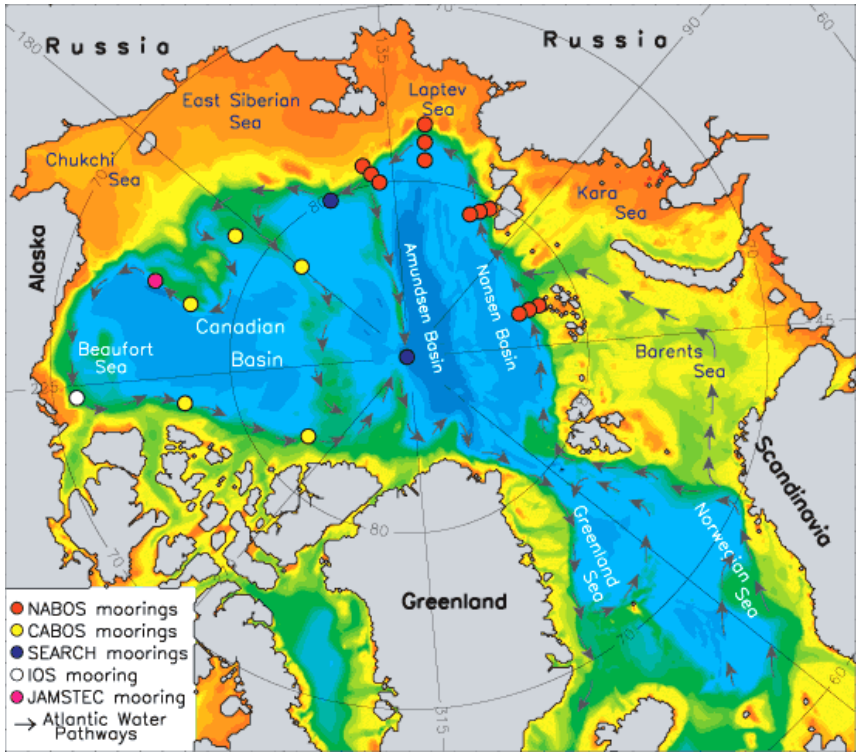


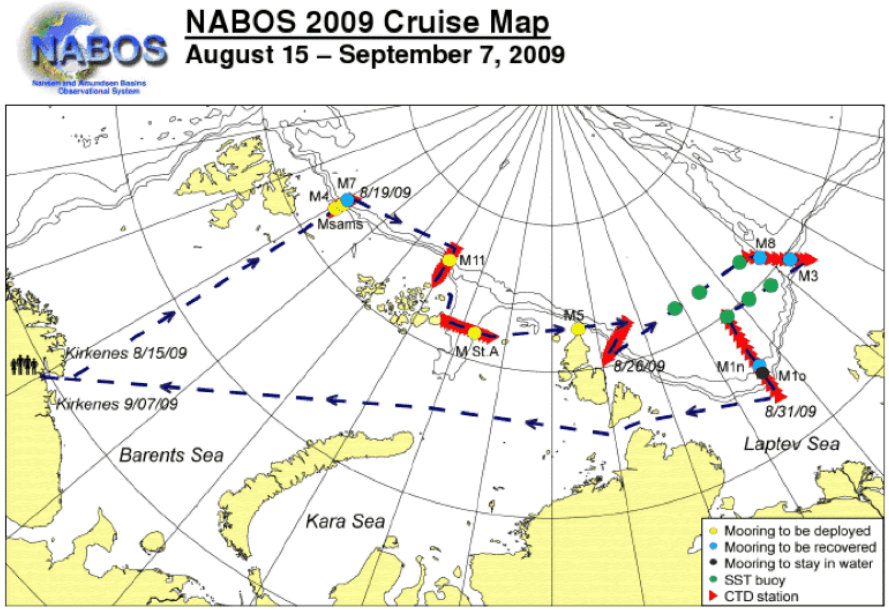

Thank you

MOSAiC

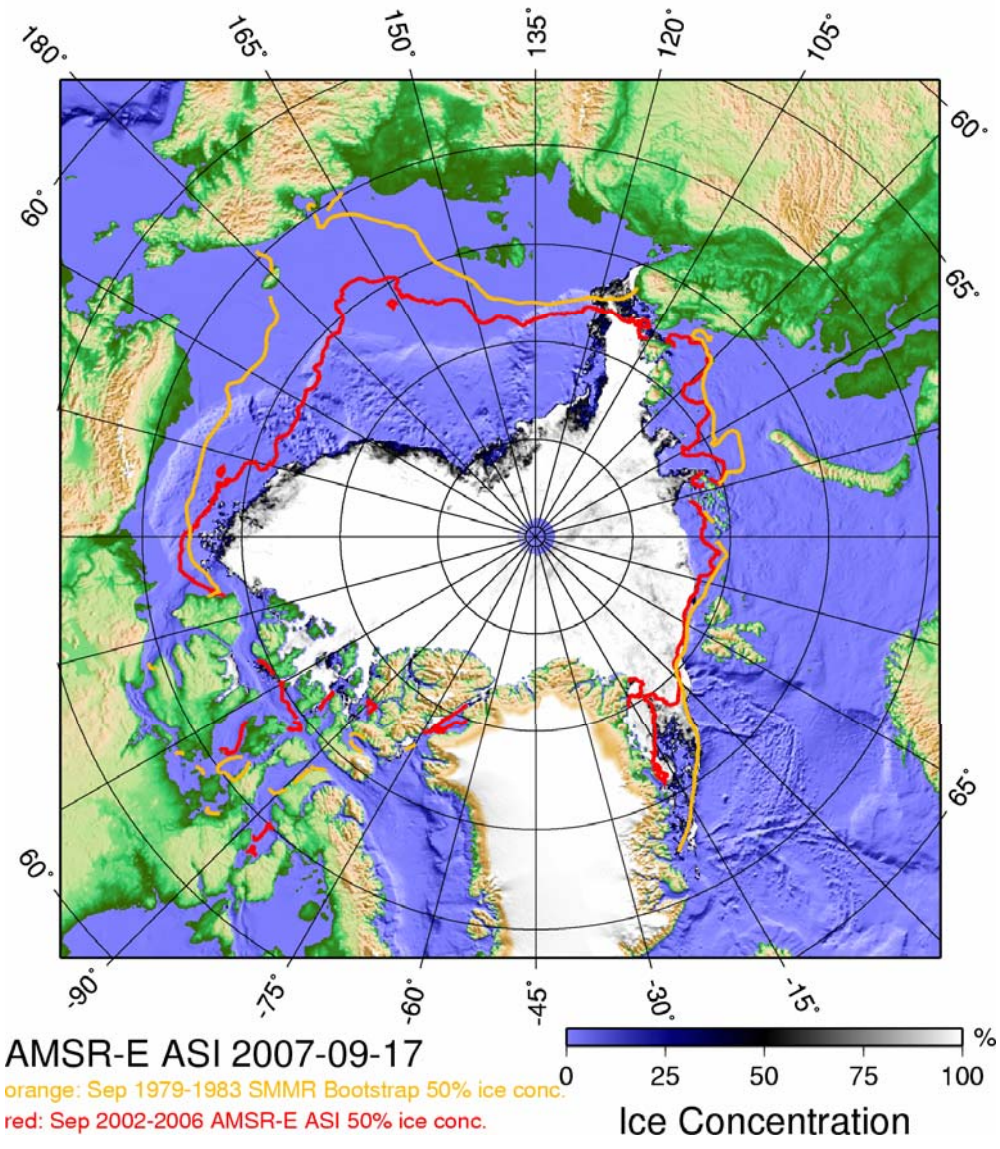

A Mosaic of Interdependent Arctic Climate Processes
LARGE-SCALE ADVECTION
SUBSIDENCE
MICROPHYSICAL PROCESSES
ENTRAINMENT
LW COOLING
ATMOSPHERIC MIXING
PRECIPITATION
LW EMISSION
TURBULENT FLUXES
SOLAR HEATING
BIOGENIC EMISSIONS
PONDING
DEFORMATION
ALBEDO
DMS PRODUCTION
CONDUCTION
TRANSMISSION
BRINE REJECTION
MOMENTUM FLUXES
LEAD PROCESSES
OCEAN MIXING
ENTRAINMENT
OCEAN CURRENTS
UPWELLING
Atmosphere
Sea-ice
Ocean

NABOS Nansen and Amundsen Basins Observational System/ IARC





Sea Ice Minimum in 2007 Summer



Sep 17, 2007

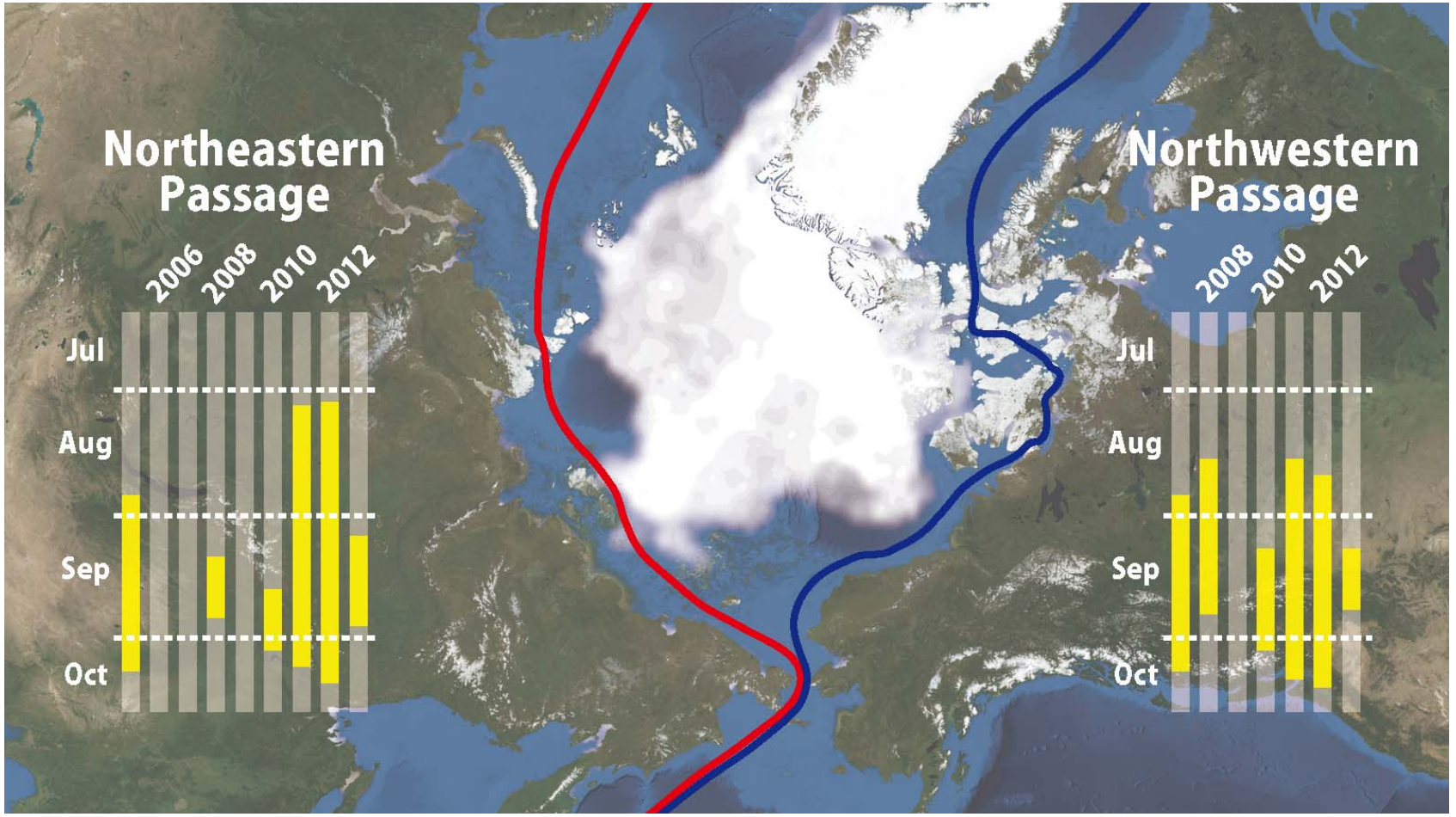
Orange; Mean sea ice extent in Sep 1979-1983

Red: Mean sea ice extent in Sep 2002-2006

First opening of the Northwest Passage.

http://www.iup.uni-bremen.de:8084/amsr/amsre.html

Opening Terms of Northeast and Northwest Passages in Recent Years



Yellow bars denote the opening terms of each route, which means that the whole route can be drawn without touching the ice extent of 15% ice concentration.

NSR cargo transit, 2013

Type of cargo	Amount of vessels	Cargo volume (tones)	Eastbound cargo (tones)	Westbound cargo (tones)
Liquid	31	911,869	588,659	323,208
Bulk	4	276,939	203,439	73,500
LNG	1	66,868	66,868	0
General cargo	13	100,223	36,868	63,377
Ballasting, Reposition	22	0	0	0
TOTAL	**71**	**1,355,897**	895,812	460,085

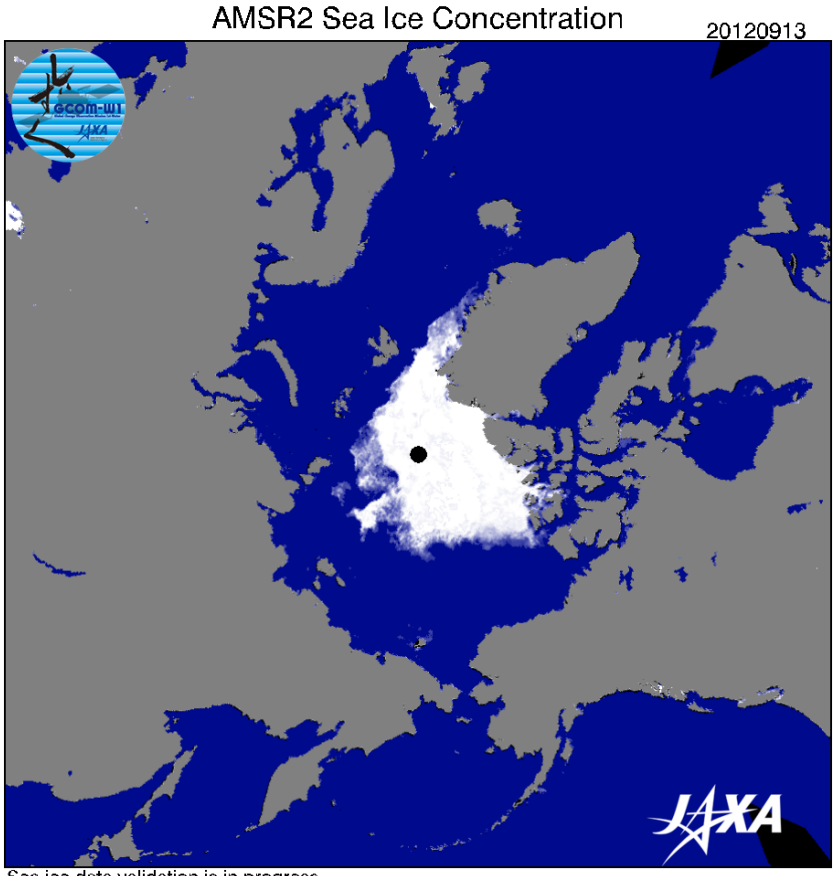
after www.arctic-lio.com

Cargoes to Japan

- Dec.5, 2012: First LNG vessel arrival via NSR. 54,000t LNG for Kyushu Electric Power.
- Aug., 2013: 80,000t naphtha from Norway for Asahi Kasei Chemicals and Mitsubishi Chemicals.
- Sep., 2013: Oil-based products. Oct., 2013: LNG (Newly built vessel)

Several months prediction – 2012

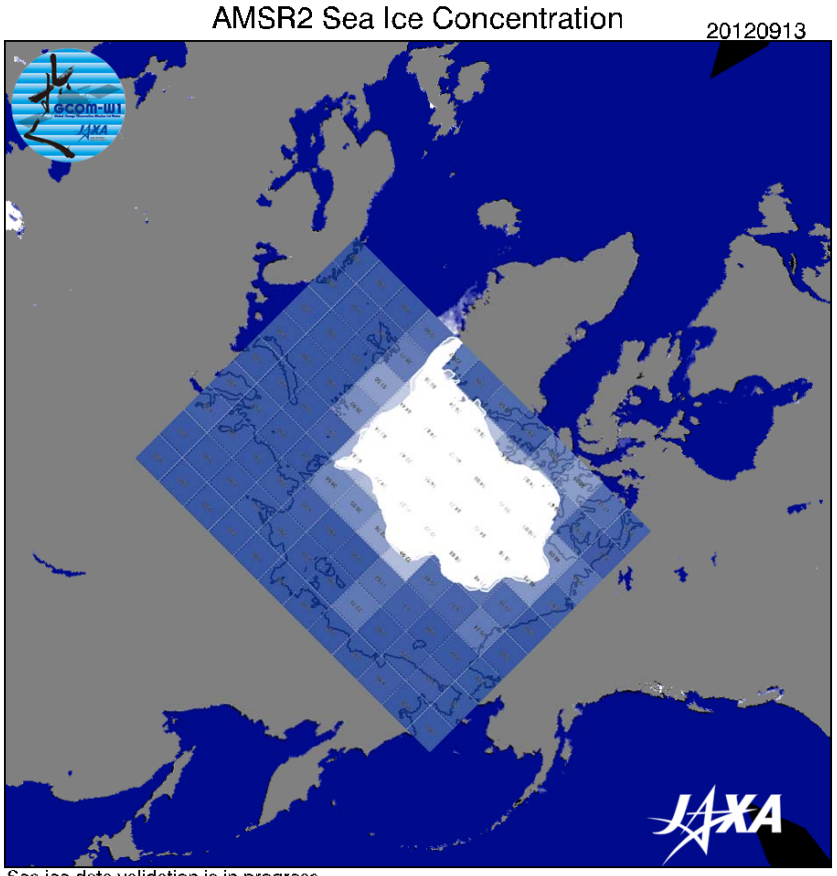
Web announcement at the end of May



Observed ice distribution on Sep.13,2012

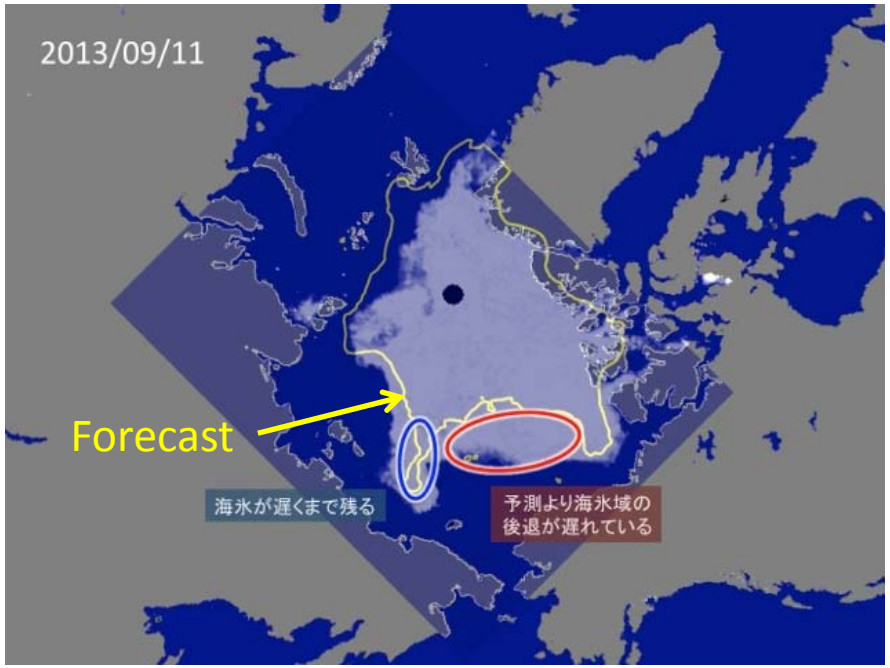
Several months prediction – 2012

Web announcement at the end of May

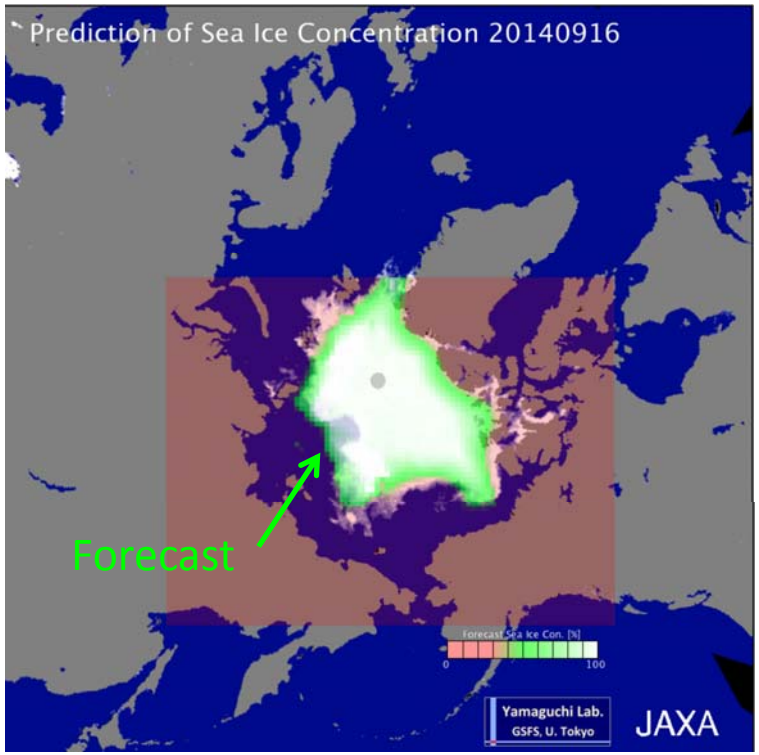


Forecasted ice extent is overlaid, forecasted at the end of May.

Several months prediction – 2013, 2014



Comparison of ice distribution on Sep.11, 2013. Yellow line was forecasted in May. The shape of ice extent resembles each other. But more ice remained particularly in Canada Basin, perhaps due to unusually cold and cloudy weather in summer.



Comparison of ice distribution on Sep.16, 2014.
The forecast hit the real one. The route opening date was also well forecasted.