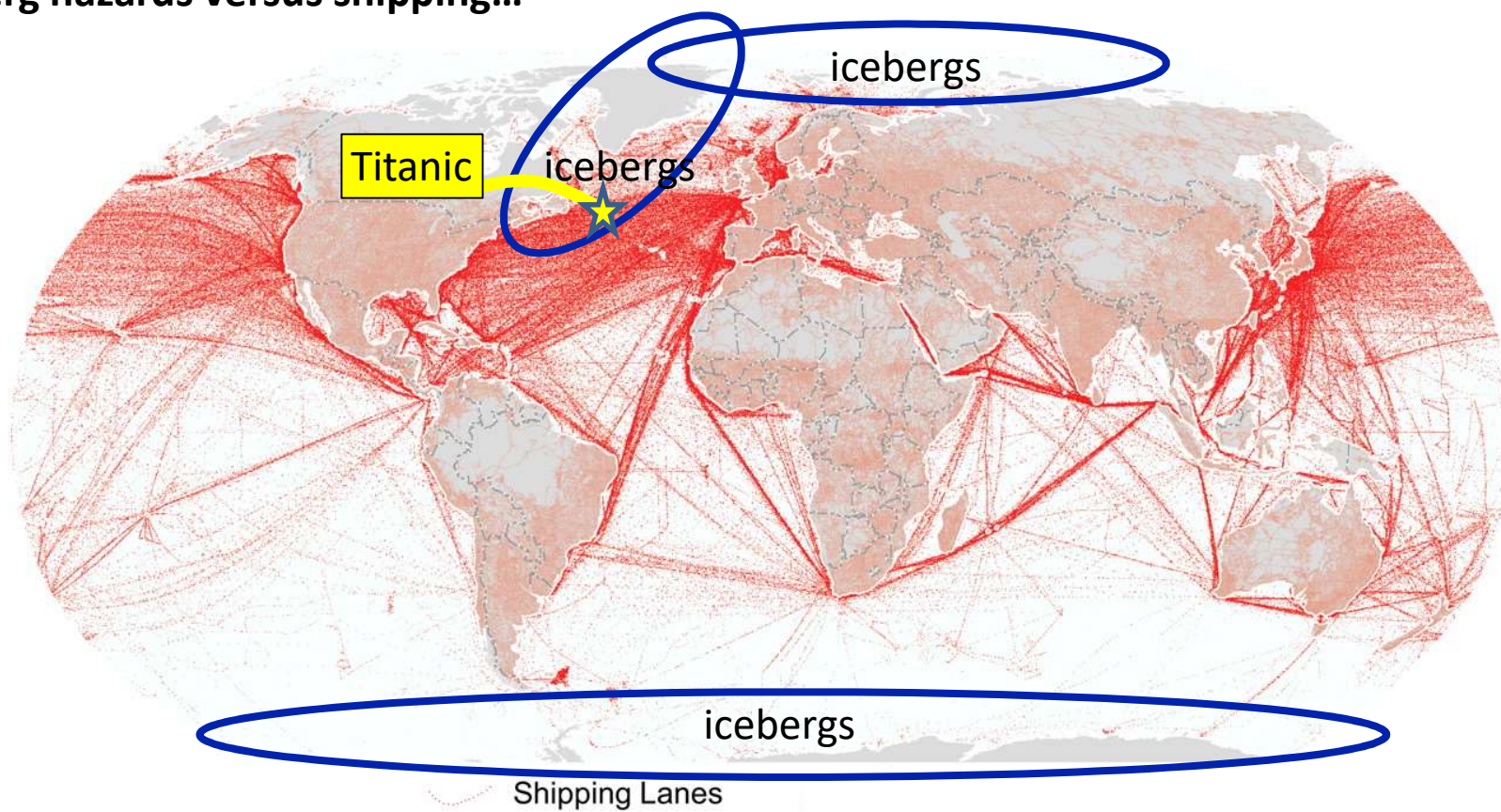


# Ice Information for Safe Navigation in Polar Waters

Presented by Keld Qvistgaard, DMI Greenland Ice Service  
E-mail: [KQH@DMI.DK](mailto:KQH@DMI.DK)

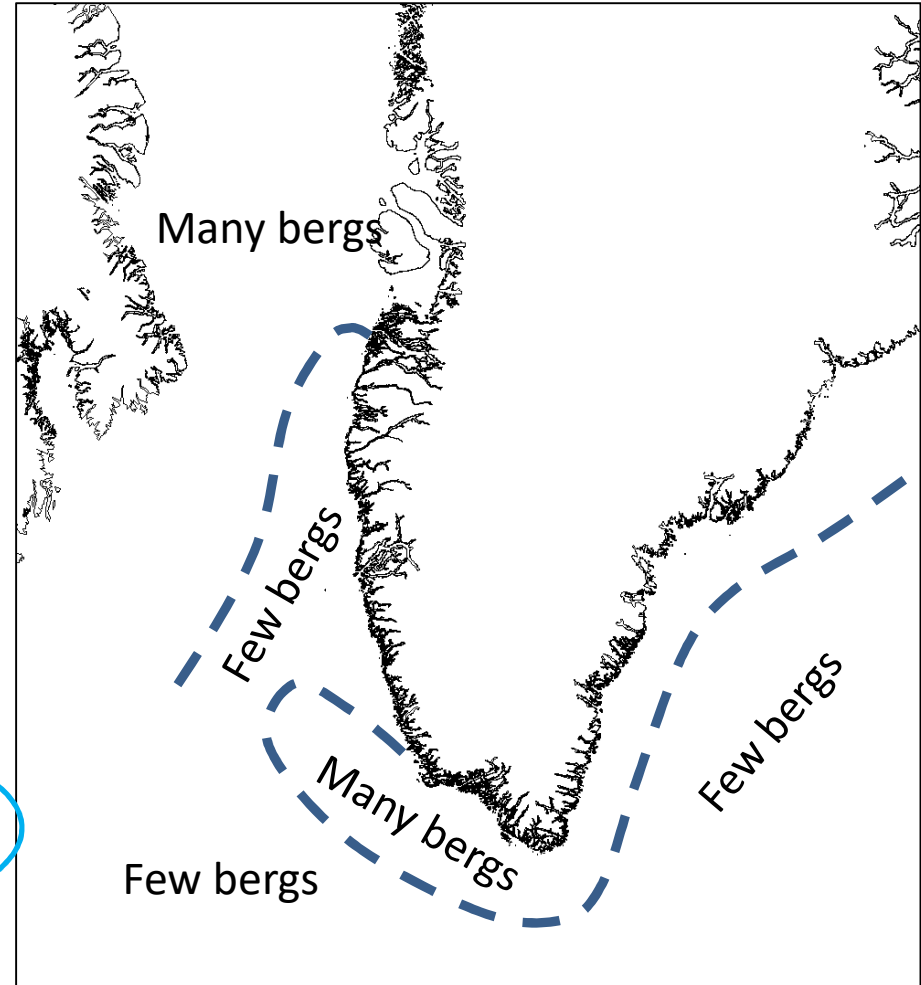
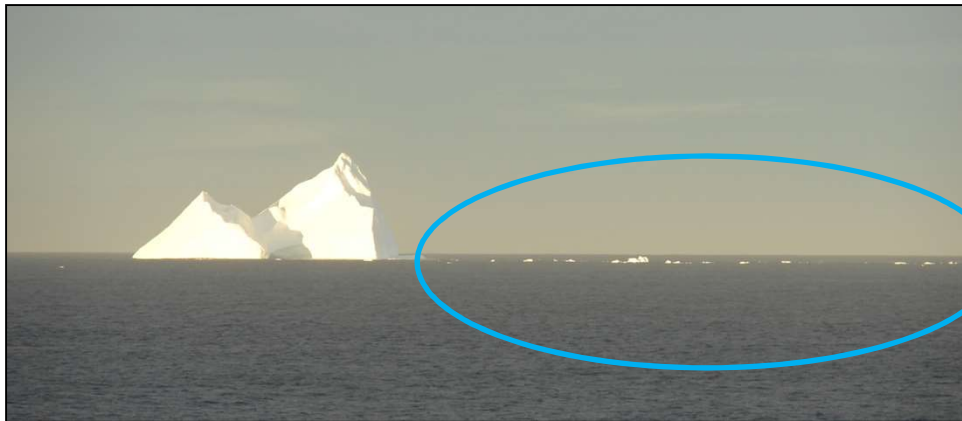
World Congress of the Ocean 09-11 January 2023 - WCO 04: Emerging Ocean Science and Technology

## Iceberg hazards versus shipping...



# Icebergs

- HAZARD !





## Risks and Hazards related to Shipping in Ice-Covered waters

- Extreme weather
- Sea Ice
- Icebergs
- Remoteness
- Limited infrastructure
- Polar night



## How to navigate safely in ice-covered waters

- National, international regulations
- Vessel design, ice class
- Vessel equipment
- Voyage planning
- Seasonality, interannual variability
- Mariner training, experience
- Patience, respect for the extremes
- Ice-metoccean products and services**

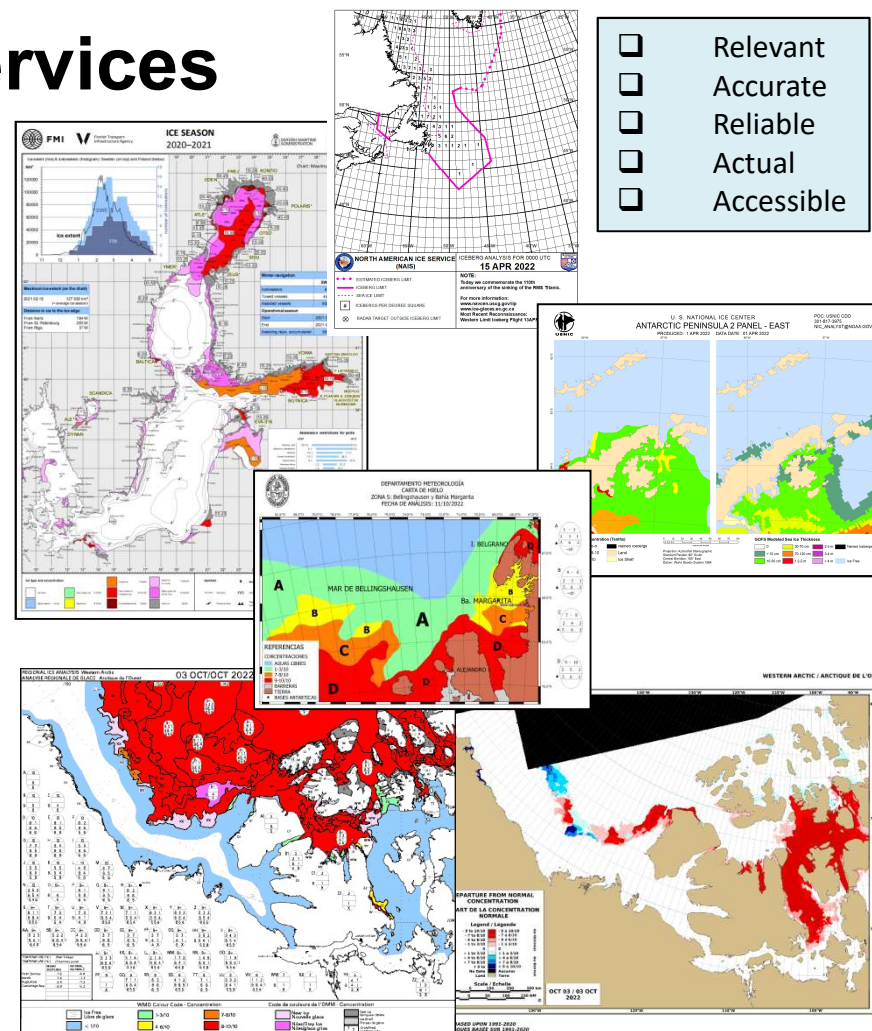




# The National Ice Services

- Relevant
- Accurate
- Reliable
- Actual
- Accessible

- Organized under national meteorological services or marine agencies
- Provides a **suite of products** targeted planning, strategic and tactical navigation in ice-covered waters
- Using **agreed standards** approved by World Meteorological Organization
- Reference to **SOLAS Chapter V, Regulation 5 and Polar Code**
- Ice information to ships via **GMDSS (NAV/METAREAS)**
- Freely available regional ice information, bulletins** via a variety of communication channels, time critical
- Local/tailored ice information** for tactical navigation or vessel specific requirements
- Ice climatology**
- Routine ice analysis and forecasting**, also outside Polar Code area (Baltic, Grand Banks, ...)
- Guidance, advice** to marine community and authorities
- Sharing** best practices
- Co-production** in certain regions
- Close collaboration** on user needs, technology advances, production in IICWG





## International Standards for Ice-Metocean Information

Maintained / developed by World Meteorological Organization

- WMO No. 259 – Sea Ice Nomenclature Volume I, II, III
- WMO No. 574 – Sea Ice Information and Services
- WMO No. 558 – Manual on Marine Meteorological Services
- WMO No. 471 – Guide to Marine Meteorological Services
- WMO No. 1214 – A Vector Archive Format for Sea Ice Charts
- WMO No. 1215 – Ice Chart Color Code
- JCOMM TR. 80 – Electronic Chart Systems Ice Objects Catalogue
- JCOMM TR. 81 – S-411 Ice Information Products Specifications for ENC
- .....

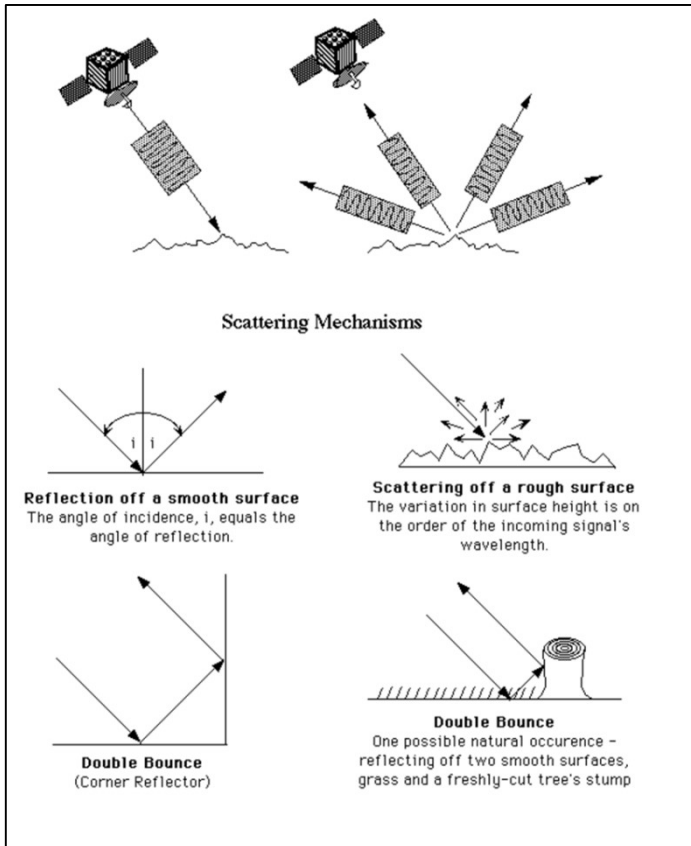
Managed by  
WMO Service Commission

Standing Committee on  
Marine Meteorological  
and Oceanographic  
Services



# Backbone in Operational Ice Monitoring: Synthetic Aperture Radar

## Principles in space-based radar



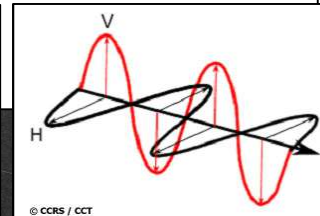
**Wavelength:**

C-band: 5.6 cm

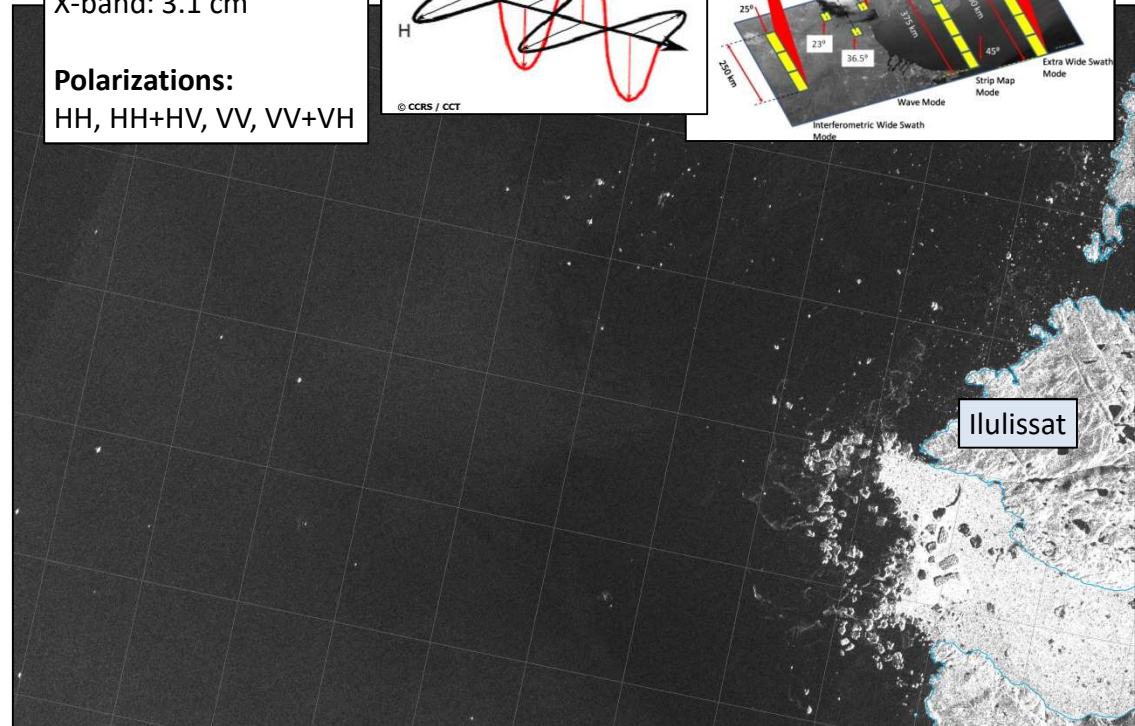
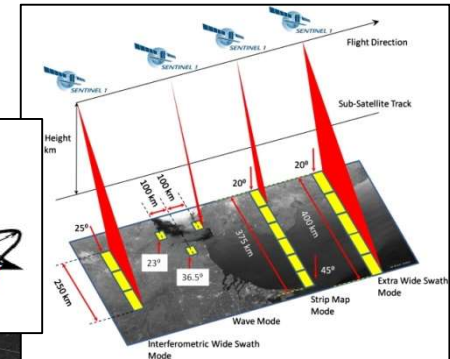
X-band: 3.1 cm

**Polarizations:**

HH, HH+HV, VV, VV+VH

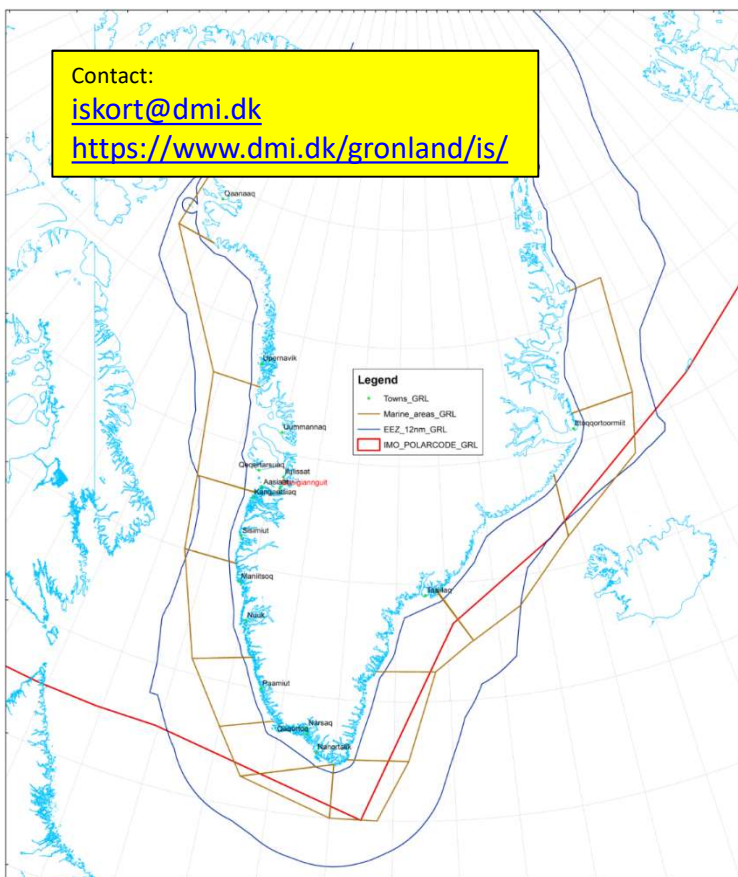


© CCRS / CCT





# DMI Greenland Ice Service 2023

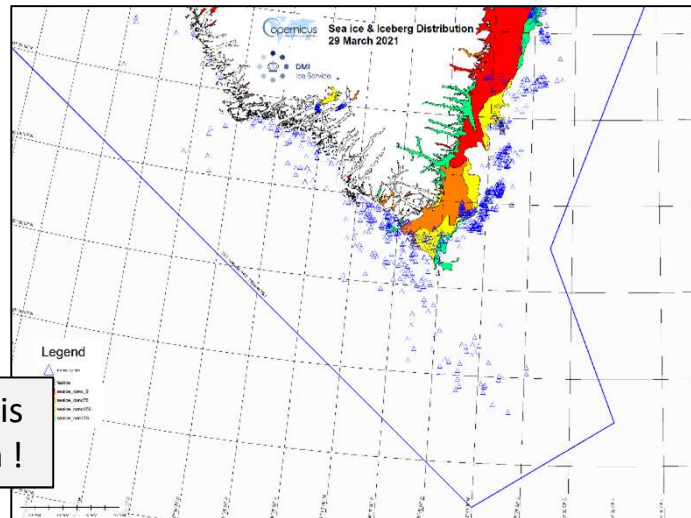


- SOLAS Convention, Chapter V, Regulation 5
- IMO Polar Code, national regulations

- Primary Near Real Time Data Sources:**
- Sentinel 1
  - Sentinel-2
- Copernicus Contribution Missions:**
- Radarsat 2
  - TerraSAR-X / Tandem-X
  - PAZ-X
  - CosmoSkyMed Constellation
  - Radarsat Constellation Mission

- Ice products to mariners:**
- Relevant
  - Accurate
  - Reliable
  - Actual
  - Accessible

**Production is User Driven !**

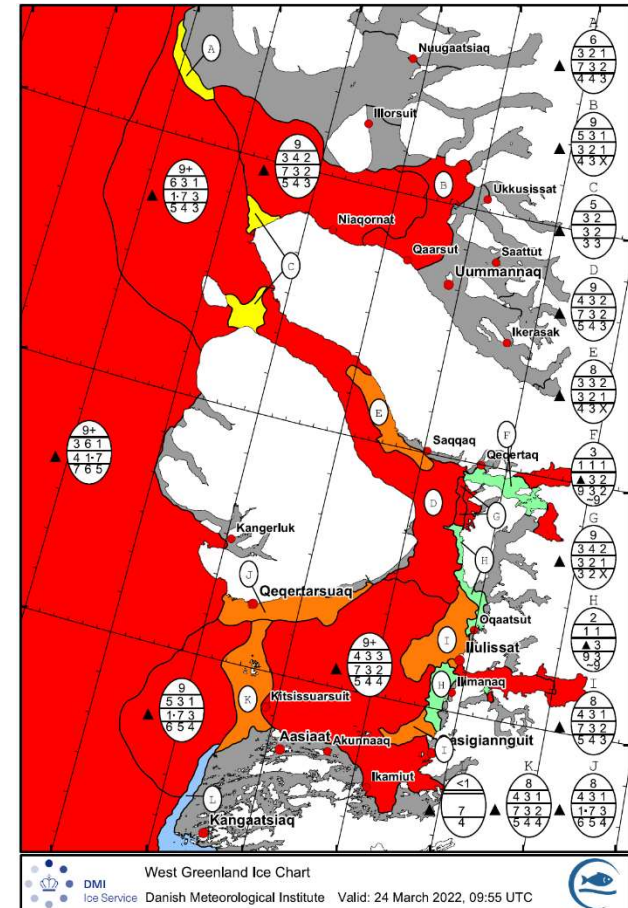


**Near Real Time data on Copernicus Marine Service portal:**  
 SEAIICE\_ARC\_SEAIICE\_L4\_NRT\_OBSERVATIONS\_011\_002 (Sea ice)

- Trends since launch of Sentinel-1:**
- Sea ice products more than doubled, enhanced details
  - Routine iceberg products introduced to shipping

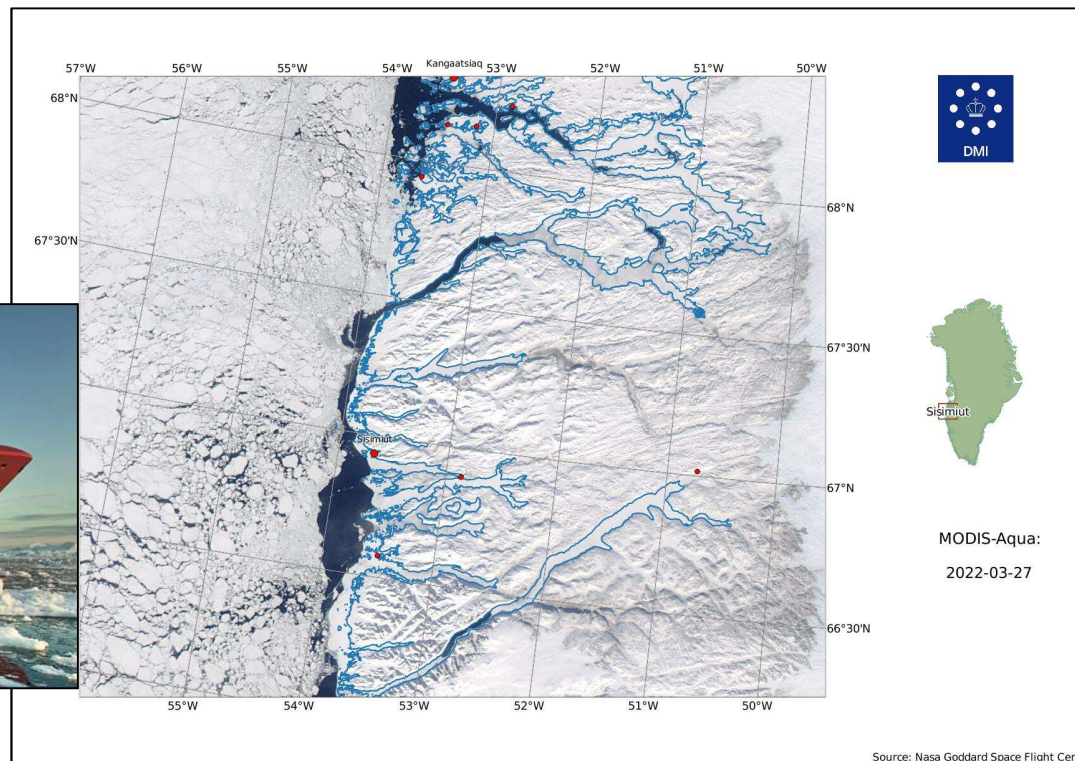
## Re-supply of Disko Bay Winter 2022

- Several re-supply attempts in March 2022 failed due heavy ice enroute
- About 10.000 people impacted
- Onsite supplies very low in late March
- Situation critical, discussed at political level
- ALTERNATIVE: Re-supply via Air bridge?
- One last ship-based attempt decided for late March



## The Re-supply Attempt - preparation

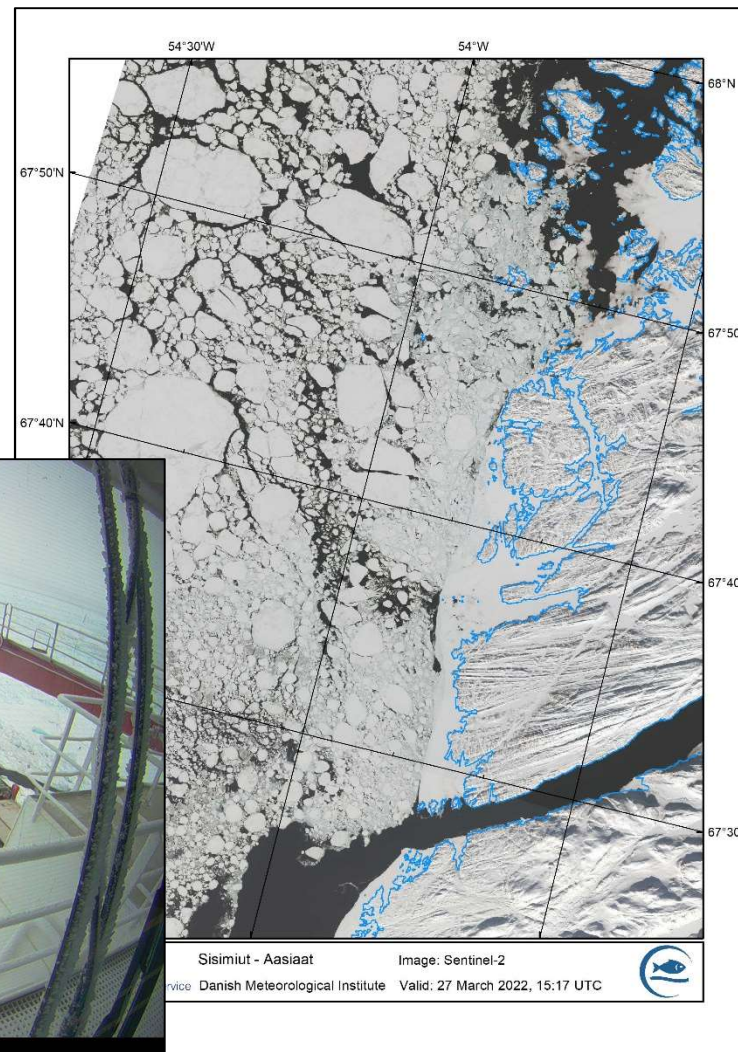
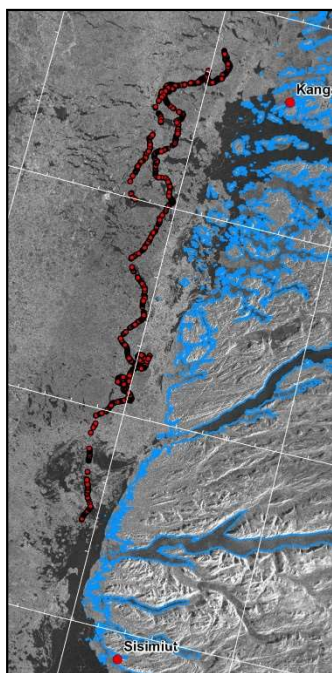
- Mary Arctica (1A Super)
- Most experienced captain on the bridge
- DMI download of all relevant sat data
- Re-Supply highest ice service priority



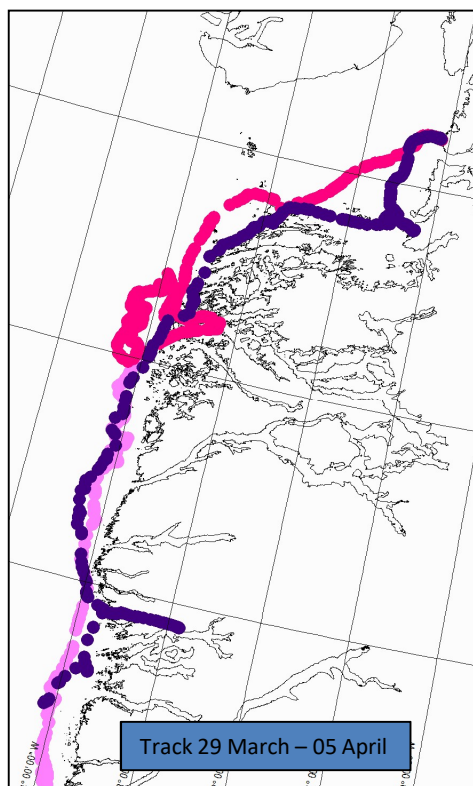


# The Re-supply Attempt

- Automated satellite image delivery to Mary Arctica
- 2-3 updates daily to vessel
- Floe tracking, lead dynamics
- Briefings



## Patience... find tidal openings



## The Wall of Icebergs off Qasigiannuit



### Aasianni nuannaartoqartoq - Mary Arctica tikikkiartorpoq

Umiarsuaq illoqarfimmi nioqutissanik pisariaqartinneqarlunnartunik  
useqarpoq.





# After maths

- The 2022 winter was cold with heavy ice, but not usual (similar winters in 2018, 2015, 2009, 2008...)
- People (incl. decision makers) get used to open water / light conditions and regular re-supply
- In the old days the Disko Bay was closed from Mid-December til June
- The tailored support of Mary Arctica worked well. Weather friendly and the captain was outstanding
- Political discussions about re-supply and local responsibilities





# International Ice Charting Working Group



## International Ice Charting Working Group Charter Signatories – Operational Ice Services

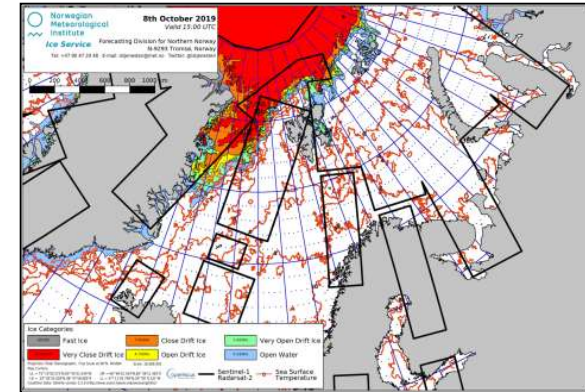
|            |   |
|------------|---|
| Argentina: | Argentine Naval Hydrographic Office                     |
| Canada:    | Canadian Ice Service                                    |
| Chile:     | Chilean Navy Weather Service/Ice Service                |
| Denmark:   | DMI Greenland Ice Service                               |
| Finland:   | Finnish Meteorological Institute                        |
| Germany:   | Federal Maritime and Hydrographic Agency                |
| Iceland:   | Iceland Meteorological Office                           |
| Norway:    | Norwegian Meteorological Institute                      |
| Poland:    | Polish Institute of Meteorology and Water Management    |
| Russia:    | Arctic and Antarctic Research Institute                 |
| Sweden:    | Swedish Meteorological and Hydrological Institute       |
| UK:        | British Antarctic Survey                                |
| USA:       | US National Ice Center<br>USCG International Ice Patrol |

Observers: Australia, China, Japan, New Zealand, South Africa

IICWG welcomes participation by private ice services, mariners and offshore operators, Coast Guards, research institutes, et al.



## IICWG IMPROVING BEST PRACTICES



### Ice services and marine community:

- MAINTAIN, DEVELOP RELATIONS
- ADDRESS CLIMATE CHANGE, OPERATING WINDOWS...
- TECHNOLOGY ADVANCES, POLAR CODE, TRAINING, SHARING...

→ International Collaboration



# International Ice Charting Working Group - 2022

Update from IICWG-XXIII (Buenos Aires, 26-30 September 2022)

Theme: Re-Connecting

## Completed tasks

- Iceberg Modelling Case Studies
- Implementation and use of L-band Synthetic Aperture Radar
- Enhanced Ice Information to Mariners
- Development and Test of Iceberg Risk Products
- Test of Sea Ice Pressure products



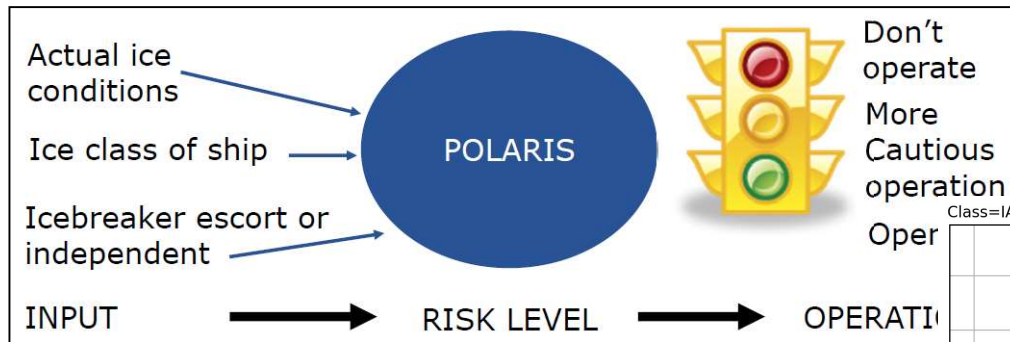
## New/continuing task teams

- Data Assimilation Workshop
- Ice Analyst Workshop
- Roadmap for NAIS Iceberg Model Development
- Sea Ice Pressure Products
- Iceberg Risk Portrayal
- Uncertainty in Ice Charting Products
- Southern Ocean Limit of known Ice
- Multi Spectral SAR in Southern Ocean Ice Charting
- Polar Code POLARIS Practice, Use, Gaps and Opportunities**



# RISK ASSESSMENT – IMPLEMENTATION OF POLARIS

RIO = Risk Index Outcome  
 = Sum of (Partial Ice concentrations x Risk Values)  
 $RIO = (C_1 \times RIV_1) + (C_2 \times RIV_2) + (C_3 \times RIV_3) + (C_4 \times RIV_4)$   
 $C_1, \dots, C_4$  - concentrations of ice types within ice regime (maximum of four from Egg Code)

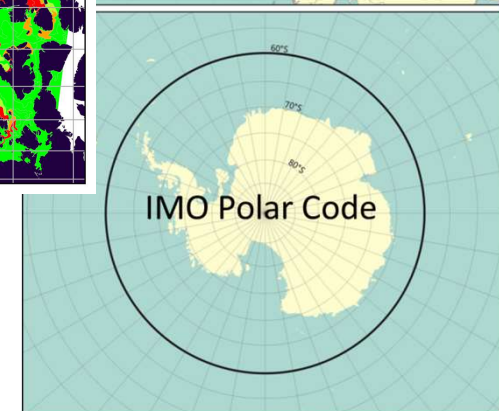
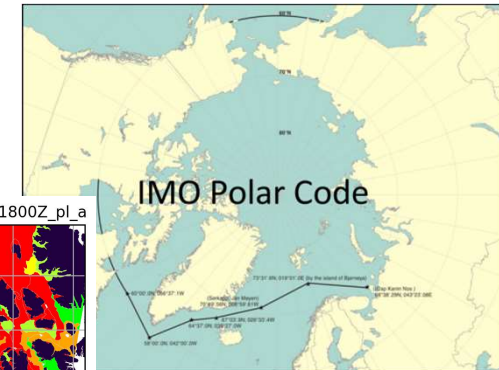
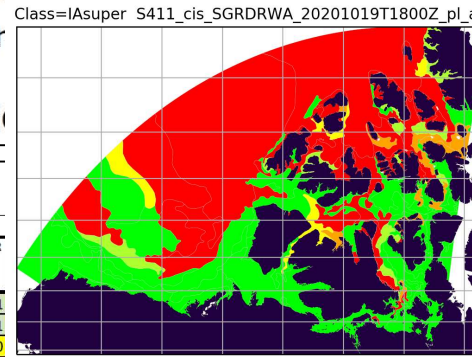


Increasing ice thickness (severity) →

|              | RISK INDEX VALUES (RIVs) for each Ice Type |         |          |                |                           |                           |                   |                             |                  |             |            |
|--------------|--|---------|----------|----------------|---------------------------|---------------------------|-------------------|-----------------------------|------------------|-------------|------------|
|              | ICE FREE                                   | NEW ICE | GREY ICE | GREY WHITE ICE | THIN FIRST YEAR 1ST STAGE | THIN FIRST YEAR 2ND STAGE | MEDIUM FIRST YEAR | MEDIUM FIRST YEAR 2ND STAGE | THICK FIRST YEAR | SECOND YEAR | MULTI YEAR |
| PC 1         | 3  | 3       | 3        | 3              | 2                         | 2                         | 2                 | 2                           | 2                | 2           | 1          |
| PC 2         | 3  | 3       | 3        | 3              | 2                         | 2                         | 2                 | 2                           | 2                | 1           | 1          |
| PC 3         | 3  | 3       | 3        | 3              | 2                         | 2                         | 2                 | 2                           | 2                | 1           | 0          |
| PC 4         | 3  | 3       | 3        | 3              | 2                         | 2                         | 2                 | 2                           | 1                | 0           | -1         |
| PC 5         | 3  | 3       | 3        | 3              | 2                         | 2                         | 2                 | 1                           | 0                | -1          | -2         |
| PC 6         | 3  | 2       | 2        | 2              | 2                         | 1                         | 1                 | 0                           | -1               | -2          | -3         |
| PC 7         | 3  | 2       | 2        | 2              | 1                         | 1                         | 1                 | 0                           | -2               | -3          | -3         |
| IAS          | 3  | 2       | 2        | 2              | 2                         | 1                         | 0                 | 0                           | -3               | -4          | -4         |
| IA           | 3  | 2       | 2        | 2              | 1                         | 0                         | -1                | -2                          | -4               | -5          | -5         |
| IB           | 3  | 2       | 2        | 1              | 0                         | -1                        | -2                | -3                          | -4               | -5          | -6         |
| IC           | 3  | 2       | 1        | 0              | -1                        | -2                        | -3                | -4                          | -5               | -6          | -7         |
| No Ice Class | 3  | 1       | 0        | -1             | -2                        | -3                        | -4                | -5                          | -6               | -7          | -8         |

↑ Increasing ice class

Increased Risk





# INNOVATING USER-DRIVEN ARCTIC EUROGEO PILOT SERVICES

## PS6: Improving Safety for Shipping in the Polar Seas' Service



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003472

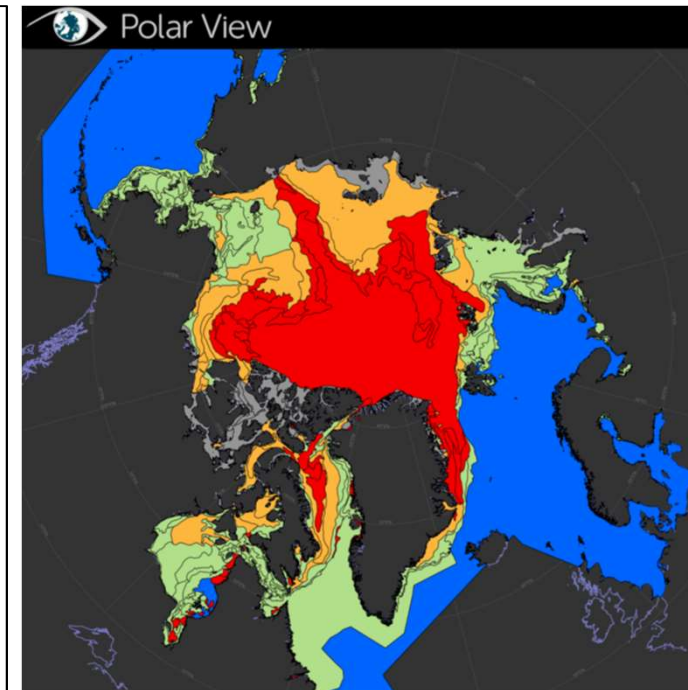
### High level Objectives:

Scientific, societal, and economic challenges associated with the changing Arctic

43 partners from 17 countries  
Program period: 2021-2025

### Pilot service development:

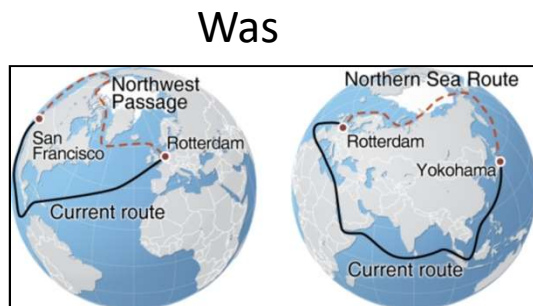
- Historical analysis of ice regimes and ships AIS tracks
- Assess routine ice information for risk management
- Situational awareness, forecast using POLARIS
- Provide risk products via web-portal
- Obtain feedback from marine community



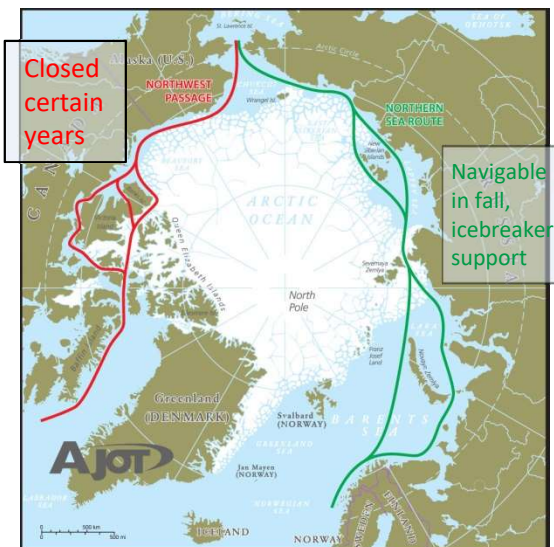
POLARIS Risk Map for PC6 Ships

## Global Warming – Future of Polar Shipping (transits, destinational)

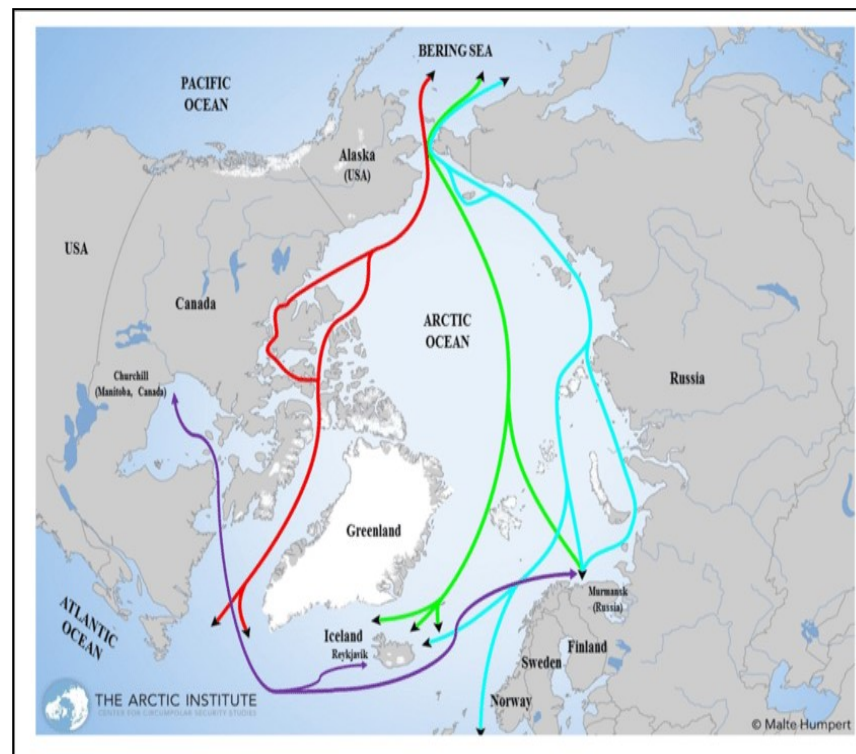
Primary routes  
via  
Panama, Suez



Shorter routes  
via  
Arctic Ocean



2045 scenario due sea ice retreat...?



Trans-Arctic Ocean route developing...?



Thank you

