Session 15: Arctic Navigation - Practical Application of Sea Ice Information in Current and Future Maritime Operations

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Deriving novel IMO Polar Code POLARIS sea ice risk forecasts from models to mitigate sea ice hazards

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Introduction on Polar code and POLARIS

- Polar code
  - goal based international code
  - for ship operating in polar waters
  - maritime safety
  - environmental protection
  - built on **IMO** conventions **SOLAS** and **MARPOL**
  - into force January 1st 2017

- POLARIS(the Polar Operational Limit Assessment Risk Indexing System)
  - operational risk management guidance under polar code
  - assessing ship operational capabilities and limitations caused by sea ice
  - AIM: avoid hazardous conditions
  - based on an evaluation of the level of risk imposed to ship by ice condition and ship’s assigned ice class
  - Usage
    - voyage planning
    - real-time decision making

RIO(RISK INDEX OUTCOME)

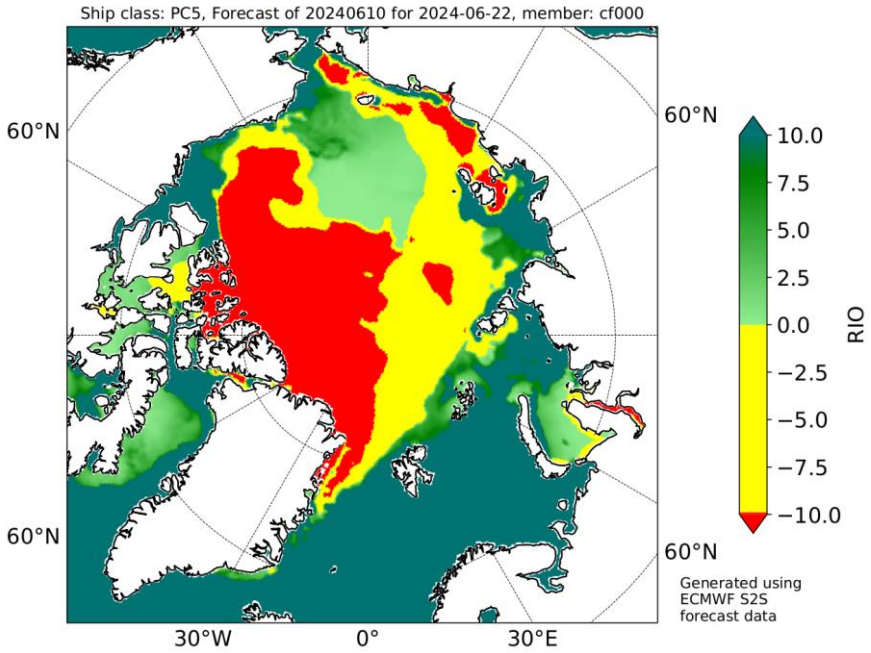
a single numerical value to represent operational risk

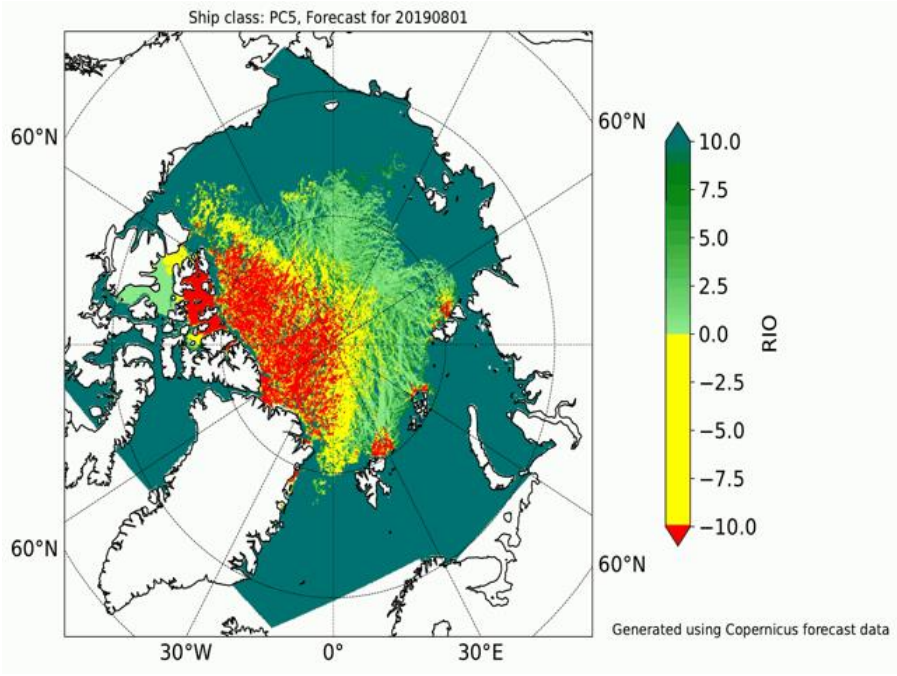
Risk Index Values

$$RIO = C_1 \cdot RIV_1 + C_2 \cdot RIV_2 + \ldots + C_n \cdot RIV_n$$

N th ice category

Sea ice concentration





Novel algorithm

Mapping available sea ice data to POLARIS ice types + ship class ➡ RIV

1. Sithick only

POLARIS ice type	Ice thickness
Ice-Free	0 cm – 1 mm
New Ice	1 mm – 10 cm
Grey ice	10 cm – 15 cm
Grey white ice	15 cm – 30 cm
Thin FY 1st stage	30 cm – 50 cm
Thin FY 2nd stage	50 cm – 70 cm
Medium FY < 1 m	70 cm – 100 cm
Medium FY > 1 m	100 cm – 120 cm
Thick FY	120 cm – 200 cm
Second year Ice	200 cm – 250 cm
MY < 2.5m	250 cm – 300 cm
MY	> 300 cm

2. Sithick +sisal

POLARIS ice type	Ice thickness	Ice salinity
Ice-Free	0 cm – 1 mm	any
New Ice	1 mm – 10 cm	any
Grey Ice	10 cm – 15 cm	any
Grey White Ice	15 cm – 30 cm	any
Thin FY 1st stage	30 cm – 50 cm	any
Thin FY 2nd stage	50 cm – 70 cm	any
Medium FY < 1 m	70 cm – 100 cm	any
Medium FY > 1 m	100 cm – 120 cm	any
Thick FY	120 cm – 200 cm	< 5 ppt
Second Year Ice	120 cm – 200 cm	> 5 ppt
	200 cm – 250 cm	< 5 ppt
MY < 2.5 m	200 cm – 250 cm	> 5 ppt
MY	>250 cm	any

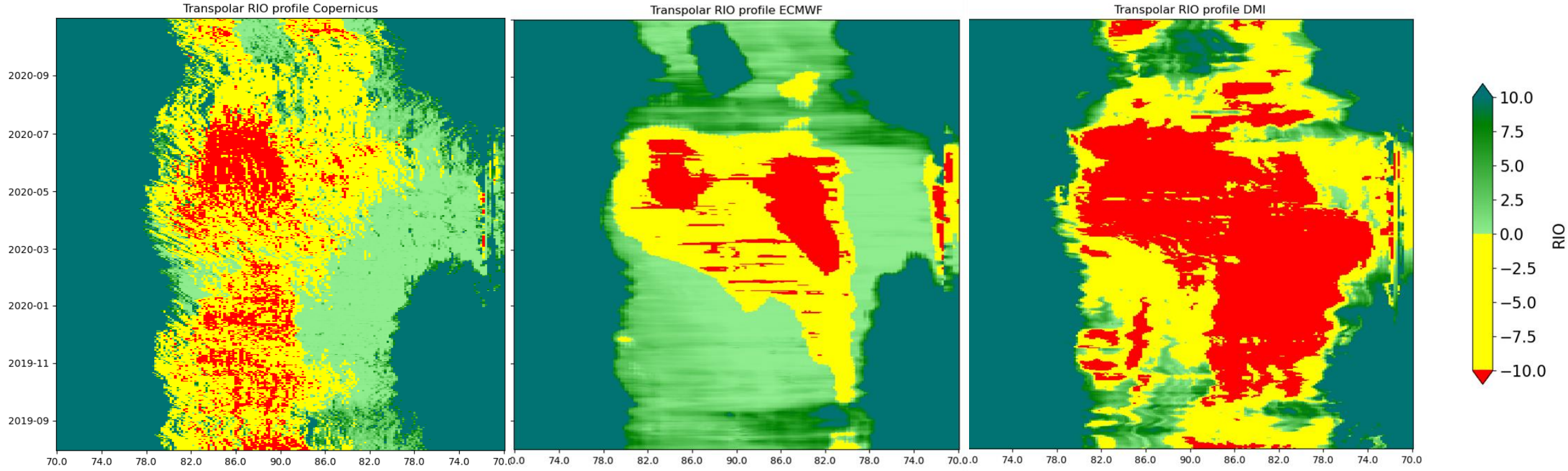
3. Sithick +siage

POLARIS ice type	Ice thickness	Ice age
Ice-Free	0 cm – 1 mm	any
New Ice	1 mm – 10 cm	any
Grey Ice	10 cm – 15 cm	any
Grey White Ice	15 cm – 30 cm	any
Thin FY 1st stage	30 cm – 50 cm	any
Thin FY 2nd stage	50 cm – 70 cm	any
Medium FY < 1 m	70 cm – 100 cm	any
Medium FY > 1 m	100 cm – 120 cm	any
Thick FY	120 cm – 200 cm	0 – 1
Thick SY	120 cm – 200 cm	1 – 2
Thick MY	120 cm – 200 cm	> 2
Second Year Ice	200 cm – 250 cm	0 – 2
MY < 2.5 m	200 cm – 250 cm	> 2
MY	>250 cm	any

Polaris ice Type	PC1	PC2	PC3	PC4	PC5	PC6	PC7	1ASuper	1A	1B	1C	Noclass
Open Water	3	3	3	3	3	3	3	3	3	3	3	3
New Ice	3	3	3	3	3	2	2	2	2	2	2	1
Grey Ice	3	3	3	3	3	2	2	2	2	2	1	0
Grey White Ice	3	3	3	3	3	2	2	2	2	1	0	-1
Thin FY Ice, 1st stage	2	2	2	2	2	2	1	2	1	0	-1	-2
Thin FY Ice, 2nd stage	2	2	2	2	2	1	1	1	0	-1	-2	-3
Medium FY Ice,<1 m	2	2	2	2	1	1	0	0	-1	-2	-3	-4
Medium FY Ice	2	2	2	2	1	0	-1	-1	-2	-3	-4	-5
Thick FY Ice	2	2	2	1	0	-1	-2	-2	-3	-4	-5	-6
Second Year Ice	2	1	1	0	-1	-2	-3	-3	-4	-5	-6	-7
Light MY Ice, <2.5 m	1	1	0	-1	-2	-3	-3	-4	-5	-6	-7	-8
Heavy MY Ice	1	0	-1	-2	-2	-3	-3	-4	-5	-6	-8	-8

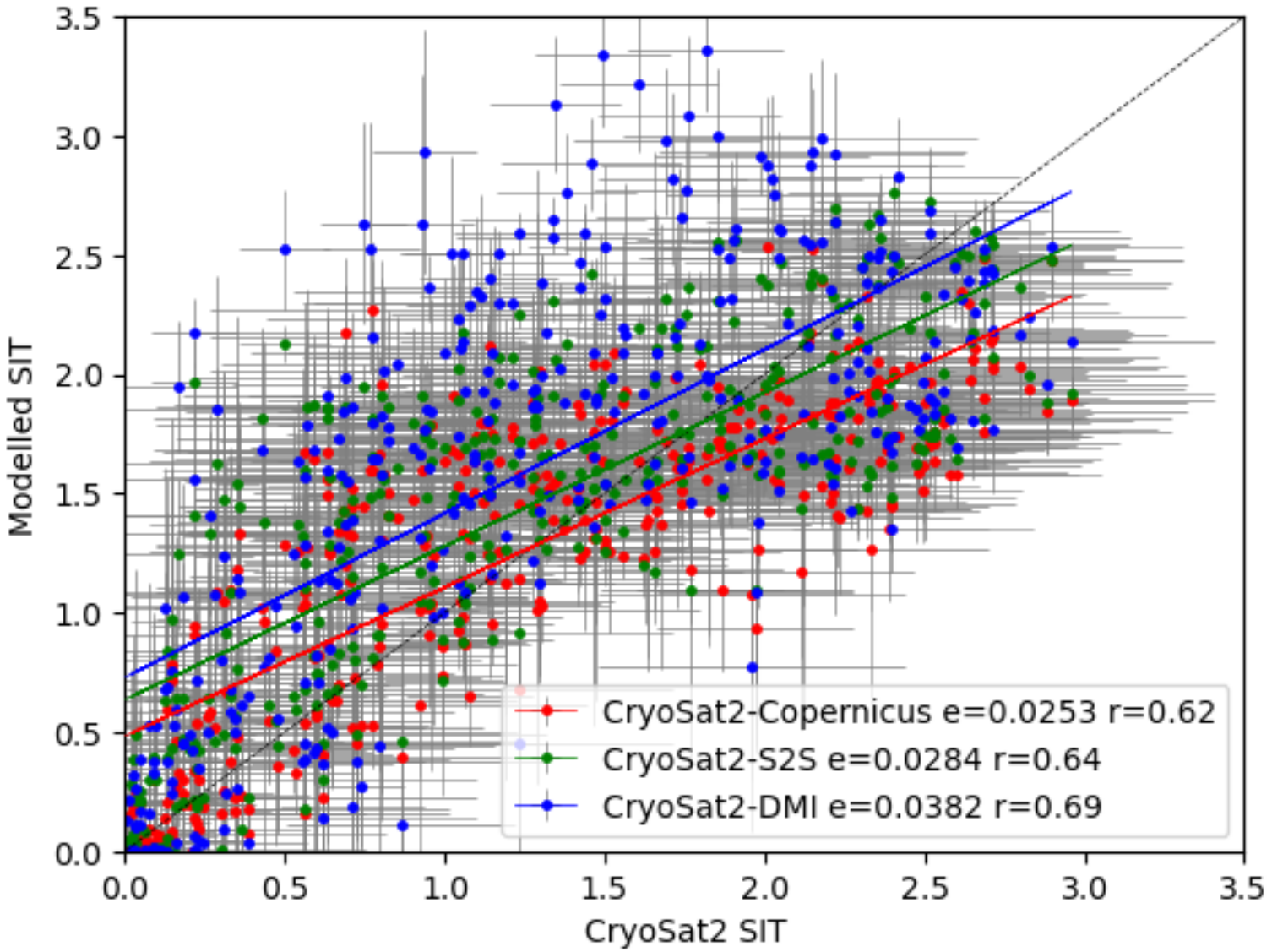
Arctic Transpolar Route RIO

WHY? Possible accessibility till 2050
WHERE? 0+-5 –180+-5, 70N-90N-70N
WHEN? MOSAIC expedition period 8/2019-10/2020
WHAT? Copernicus, ECMWF S2S, DMI HYCOM-CICE



https://github.com/dmidk/NOCOS/tree/main/rio

SEA ICE THICKNESS(CroSat--Models)



Model strength and limitations

- Model has good simulation on ice edge.
- DMI HYCOM-CICE being overly conservative when estimating risk in ice
- Copernicus overlook potential risk in ice
- Models tend to overestimate thin ice thickness and underestimate thick ice thickness
- Awareness in polar navigation tactics
- Next step: apply second run of DT climate model output to RIO algorithm, and compared the output with current statistics