Toward user-relevant monthly to seasonal forecasts of Arctic sea ice: The FRAMS project

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About FRAMS

Forecasting Regional Arctic Sea Ice from a Month to Seasons (**FRAMS**) is a three-year project funded by Canada's Marine Environmental Observation Prediction and Response (**MEOPAR**) network. It is endorsed by the Year of Polar Prediction (**YOPP**).

Objectives

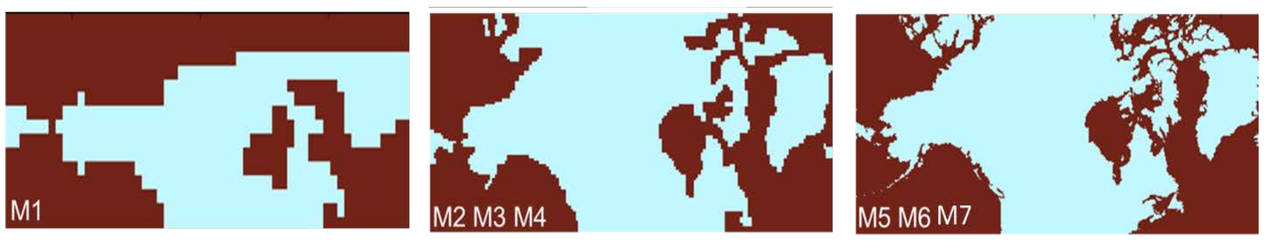
1) Advancing the science of **multi-model sea ice forecasting** on time scales of a month to seasons
2) **Developing Arctic sea ice forecast products** and services for the new WMO Arctic Polar Regional Climate Centre (**ArcRCC**)
3) Identifying physical processes and aspects of initial states that enable sea ice to be skillfully predicted
4) Co-developing, with the Canadian Ice Service and end users in the Arctic marine transportation sector, sea ice forecast products that are **useful for decision making**

FRAMS forecasting component

- The forecasting component of FRAMS is assembling data from the following models to support **research and development of products and services**:

label	name	centre	sea ice component, properties, rheology	max resolution / forecast range
M1	CanCM3/4	ECCC/MSC	concentration/thickness, cavitating fluid	≈200 km / 12mon
M2	GEM-NEMO	ECCC/MSC	CICE, 5 ice categories, EVP	≈ 40 km / 12mon
M3	CFSv2	NOAA (US)	GFDL SIS, 5 ice categories, EVP	≈ 40 km / 9 mon
M4	System 5	Météo France	GELATO, 4 ice categories, EVP	≈ 40 km / 7 mon
M5	GloSea5	Met Office (UK)	CICE, 5 ice categories, EVP	≈ 10 km / 5 mon
M6	SEAS5	ECMWF	CICE, 5 ice categories, EVP	≈ 10 km / 7 mon
M7	En-GIOPS	ECCC/MSC	CICE, 10 ice categories, EVP	≈ 10 km / 1 mon

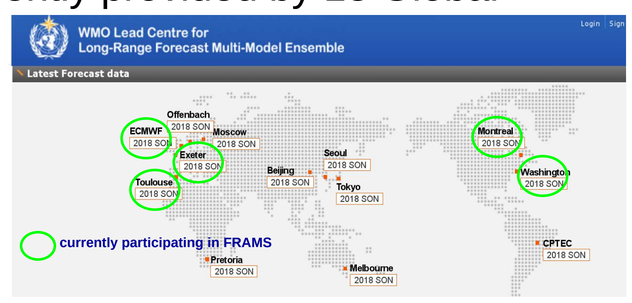
- These models differ in their spatial detail:



- **M1** somewhat skillful despite coarse grid → development platform
- **M2-M4** reflect typical resolution in current sea ice forecast models
- **M5-M7** reflect leading-edge current and emerging capabilities

WMO seasonal forecasting and the ArcRCC

- WMO seasonal forecasts currently provided by 13 Global Producing Centres **(GPCs)**
- Of the GPCs whose models have interactive sea ice, **5** are currently participating in FRAMS ⟶



- The ArcRCC has 3 nodes, in Norway, Russia and Canada. The Canadian node in Montreal is tasked with providing forecast information, including for sea ice.

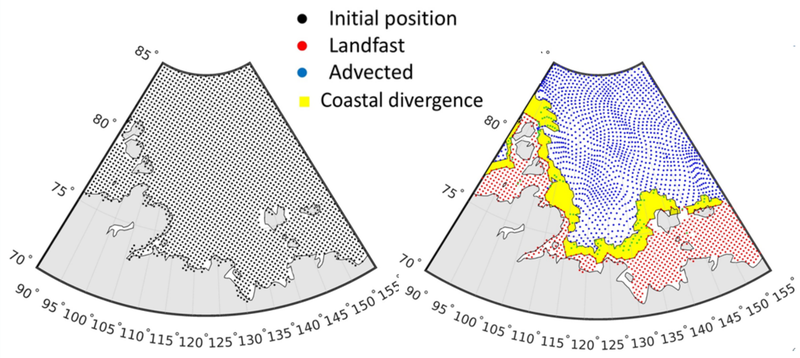
FRAMS analysis component

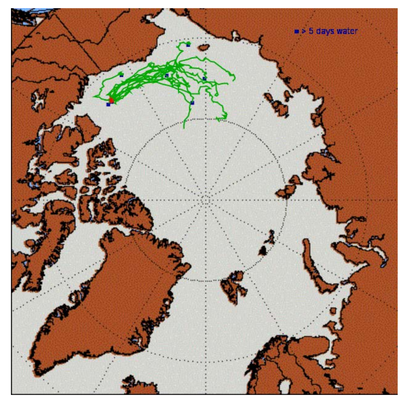
Questions asked:

- What are the sources of skill in sea ice forecasts?
- How are models deficient in representing these key processes?
- How do current model forecasts compare to empirical predictions?

Key tool: Lagrangian Sea Ice Tracking System (LITS)

- Follows sea ice trajectories based on Polar Pathfinder ice motions ⟶ (Williams et al. 2016)





12-month sea ice trajectories from initial location in the Beaufort Sea, from Sep 2000-2013

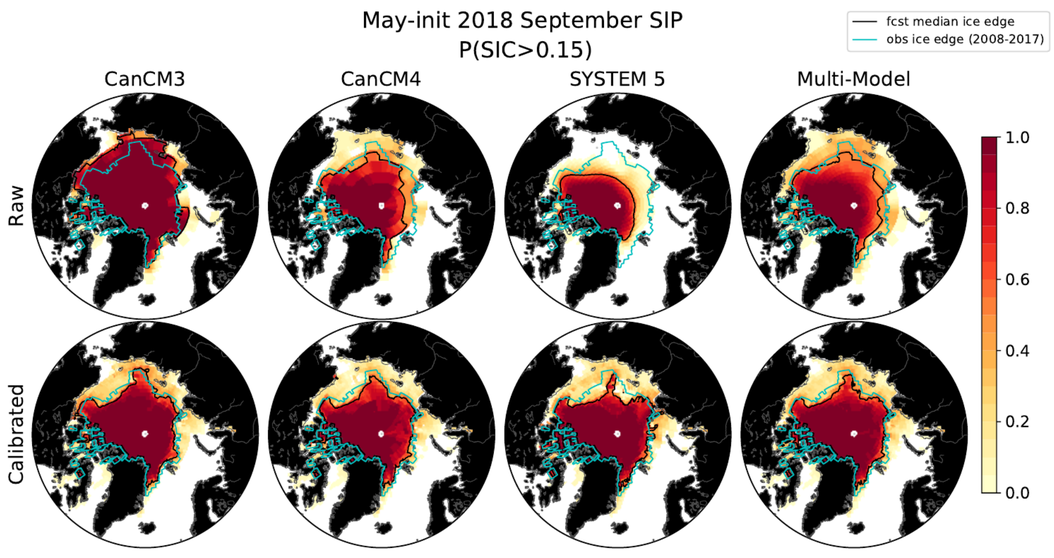
Coastal divergence in the Laptev Sea results in thinner ice, lower September ice extent ⟵
C. Brunette/McGill

FRAMS end user component

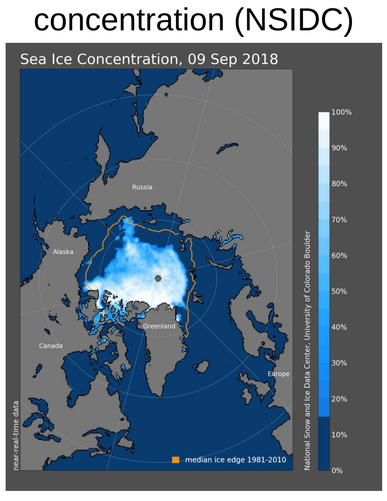
- Aim is to **co-develop** with end users & Canadian Ice Service forecast products relevant to Arctic navigability, decision making
- Emphasizing **communication** of forecast uncertainty
- **Workshop** with end users in May 2018, another in 2020

Initial products

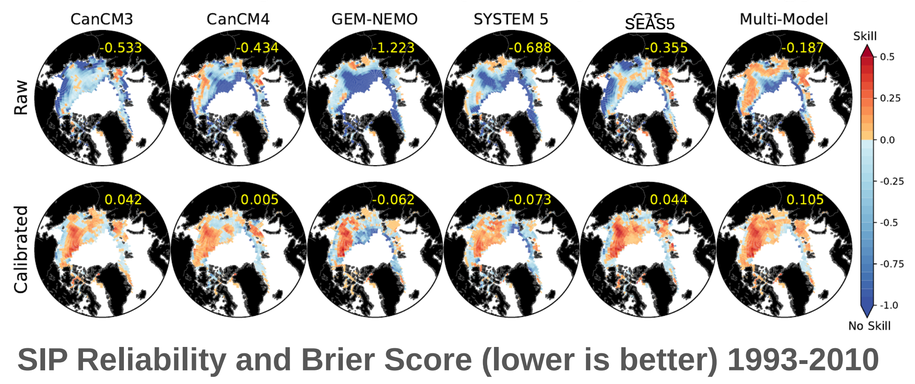
Sea ice probability (SIP) for concentration > 15%: raw ensemble values vs calibrated using method of Dirkson et al. (2018)



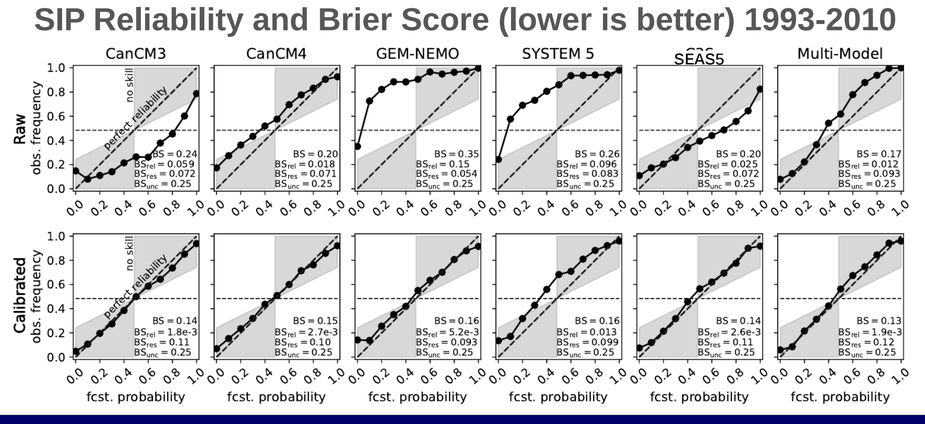
Observed sea ice concentration (NSIDC)



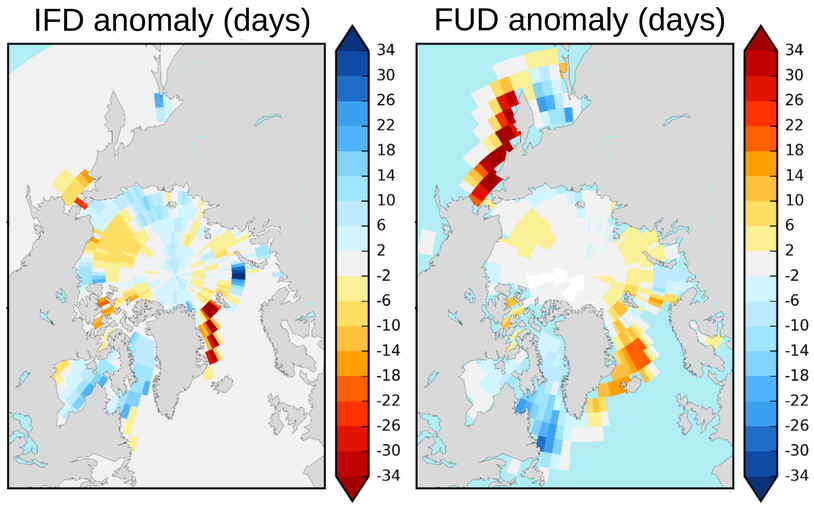
Continuous Rank Probability Skill Score (CRPSS) vs climatology 1993-2010



SIP Reliability and Brier Score (lower is better) 1993-2010



Ice-free date (IFD) and freeze-up date (FUD): anomalies from 2009-2017 means for CanCM3+CanCM4 using method of Sigmond et al. (2016) with 50% concentration threshold, from May 2018 ⟶



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