The role of sea ice physics in modeling and prediction of Arctic climate change

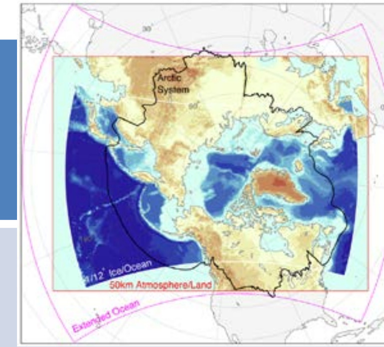
Wieslaw Maslowski[1]

Robert Osinski[2], Anthony Craig[*], Younjoo Lee[1], Jaclyn L. Clement Kinney[1], Mark Seefeldt[3], John Cassano[3] and Bart Nijssen[4]

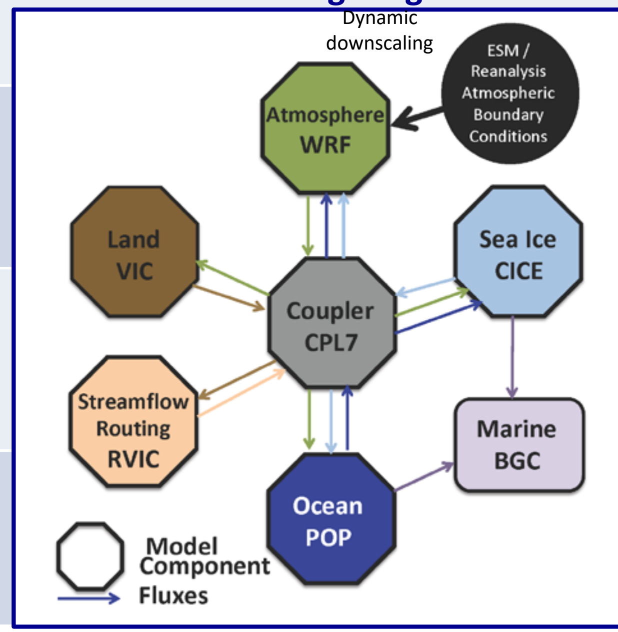
[1]Naval Postgraduate School (NPS), [2]Institute of Oceanology, Polish Academy of Sciences (IOPAS), [*]Contractor, [3]University of Colorado, [4]University of Washington

Regional Arctic System Model (RASM) Overview

RASM 2.0 (RBR)	Code	Configuration Pan-Arctic domain (down to ~30ºN in N. Pacific and ~45ºN in N. Atlantic) including all NH sea ice
Atmosphere	WRF371	50km / 25km, 40 levels
Land	VIC4	50km / 25km, 3 Soil Layers
Ocean	POP2	1/12º (~9km) & 1/48˚ (~2.4km) 45 / 60 levels (20m@5m/100m@5m)
Sea ice	CICE6	1/12º/1/48˚, 5 thickness categories **Anistropic(EAP)/Isotropic(EVP) rheology**
Coupler	CPL7x	Flux exchange every 20/10 min, inertial resolving w/ minimized lags



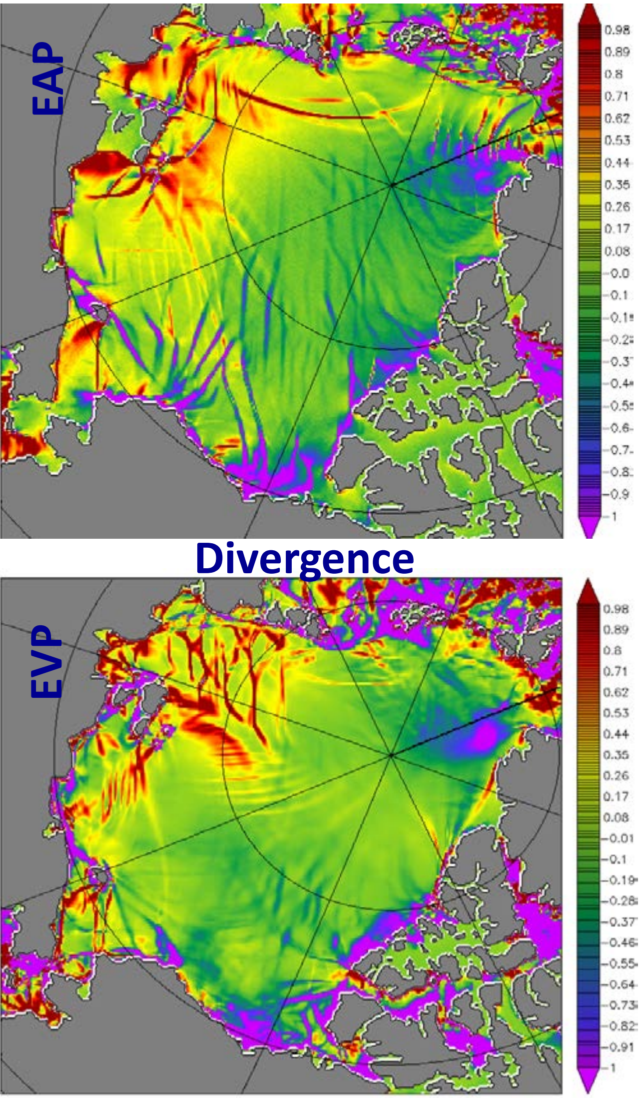
RASM Wiring Diagram



Lateral boundary conditions and (T_{air}, U_{air}, V_{air}) nudging above 500mb in WRF from NCEP reanalysis or NCEP interannual forecasts. No data assimilation!

Synopticallly accumulated storm forced sea ice deformations and growth

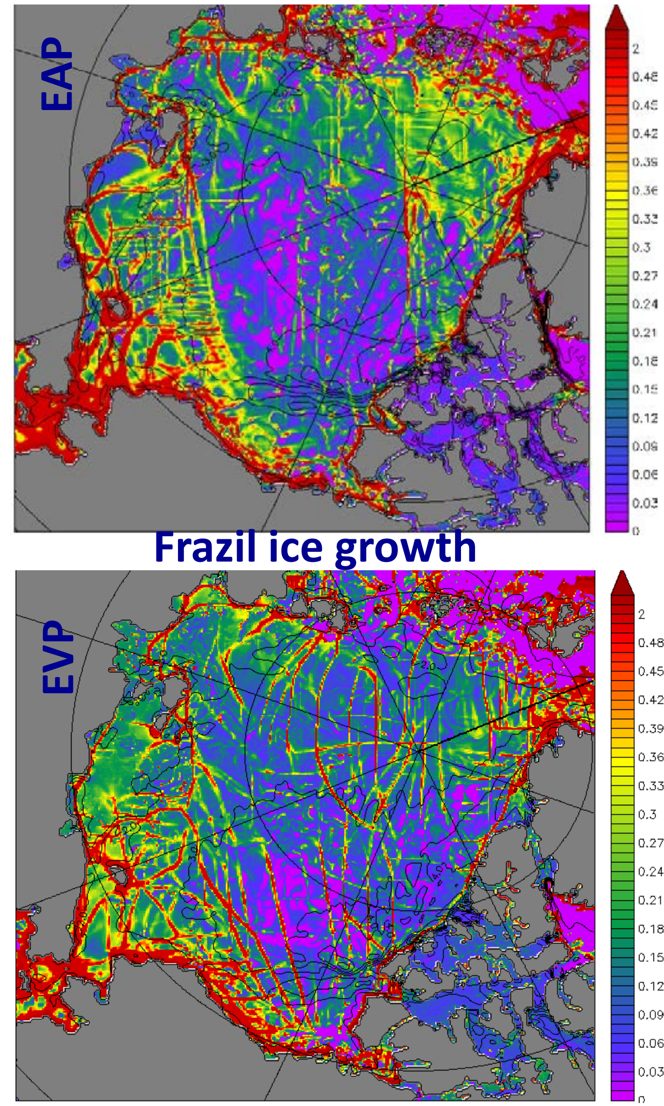
01/22-27/1980



In RASM simulations,
EAP rheology relative to EVP:

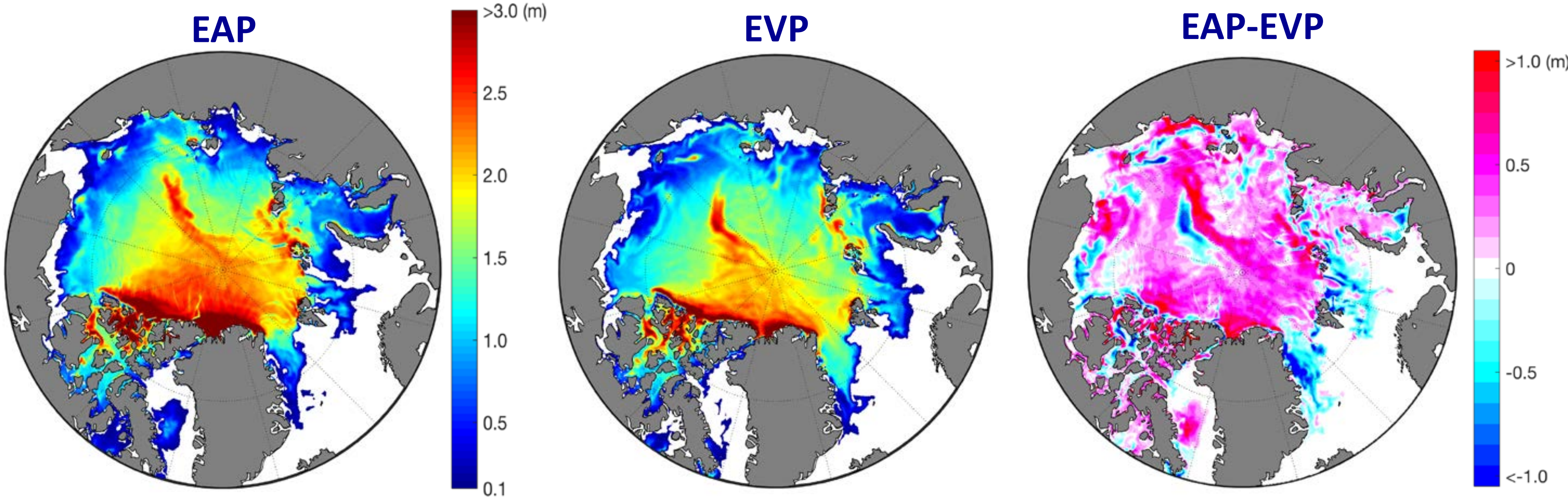
1. Produces more realistic linear kinematic features (LKFs: e.g. leads & ridges);

2. Over 40 years increases SIV:
   - total by 17%
   - ridged by 22%
   - level by 11%



RASM Sea Ice Initial Conditions: July 1, 2019

Based on separate RBR 1979-2019 hindcasts forced along the boundaries with NCEP CFSR/v2 reanalysis.

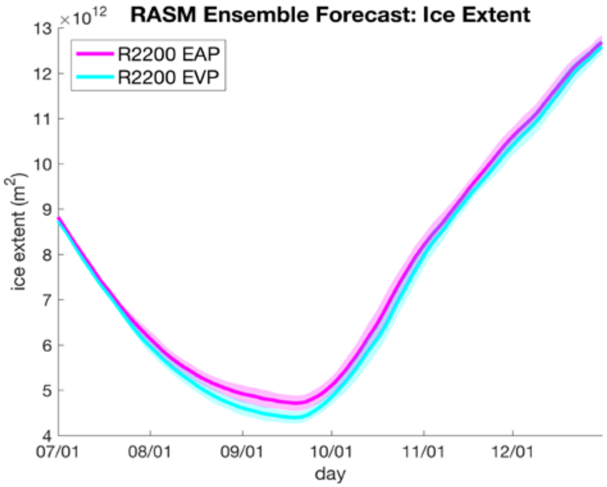


No data assimilation!

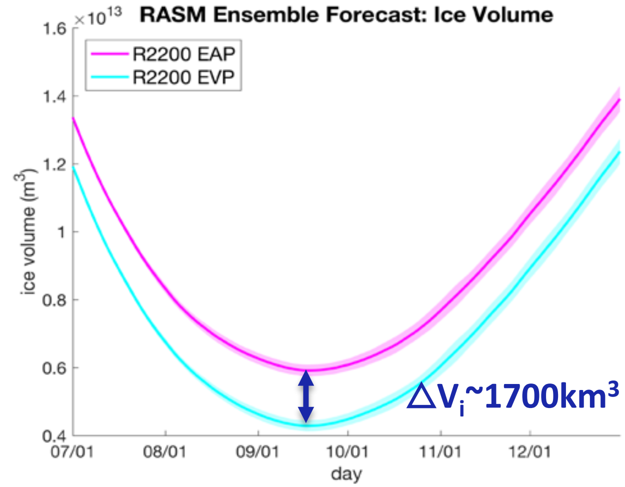
Initial conditions are physically consistent across all coupled model components!

RASM 6-month Ensemble Mean Forecast for 12/31/2019

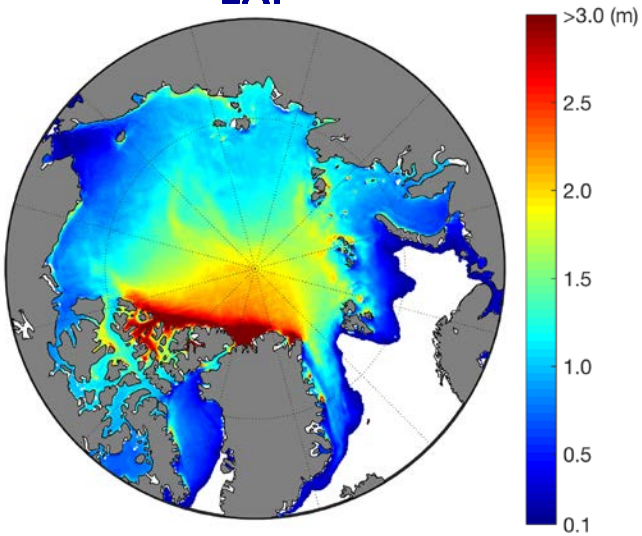
10-member ensembles, each initialized on July 1, 2019



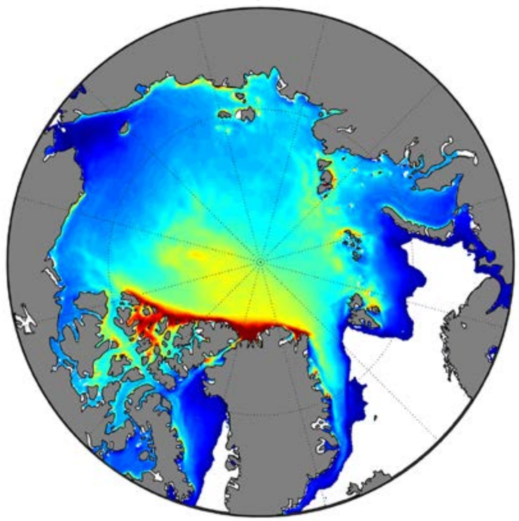
- Negligible sensitivity in sea ice extent (SIE)
- Large sensitivity in sea ice volume (SIV)
- SIE is not a sufficient metric of model predictive skill!



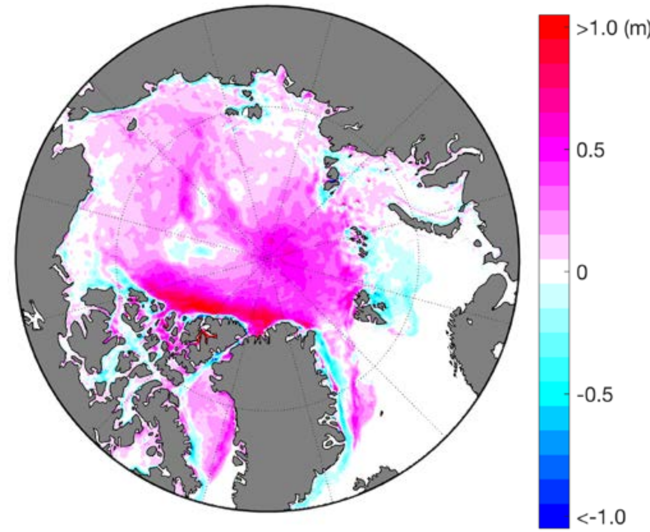
EAP



EVP



EAP-EVP



The initial difference in sea ice thickness and volume persist in forecasts for 6 months!

Summary

1. A single change in sea ice model physics (e.g. sea Ice rheology) can change mean ice volume by 17% of the total;
2. High-frequency coupling is key to representing the impact of varying sea ice model physic (e.g.: **synoptic storms** → **inertial oscillations** → **sea ice deformations**);
3. Regionally optimized model physics improves the realism of initial conditions and sub-seasonal to decadal projections.