Regional Arctic System Model: An approach for dynamical downscaling of global climate reanalyses and projections at seasonal to decadal timescales

Wieslaw Maslowski[1]

Mark Seefeldt[2], John Cassano[2], Anthony Craig[*], Younjoo Lee[1],

Jaclyn L. Clement Kinney[1], Robert Osinski[3]

[1]Naval Postgraduate School (NPS), [2]University of Colorado

[*]Contractor, [3]Institute of Oceanology, Polish Academy of Sciences (IOPAS)

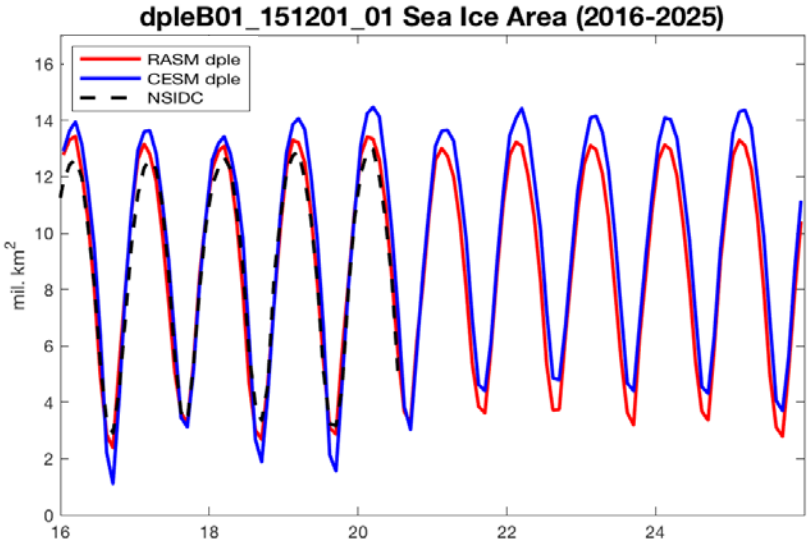
Hypothesis: Explicitly resolving mesoscale processes in the Arctic Ocean and atmosphere enhances the predictability of sea ice.

Dynamical donwscaling of CESM DPLE with RASM: 2016-2025

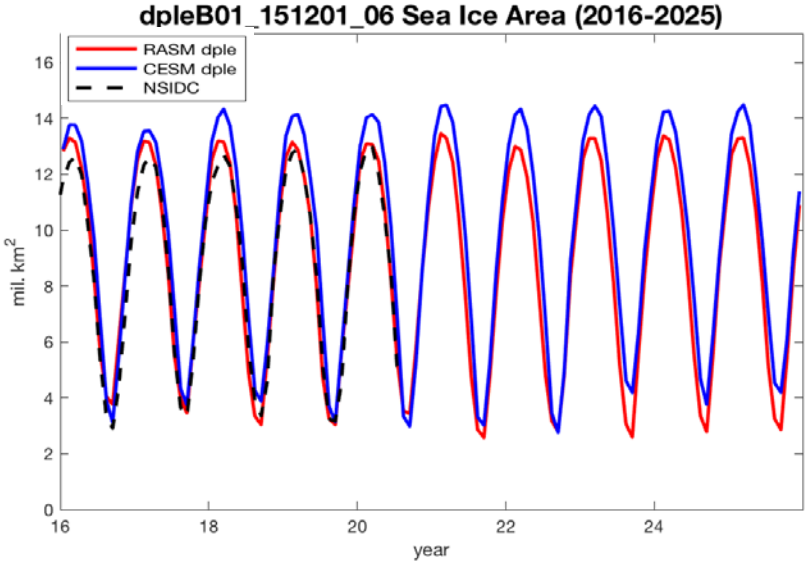
Sea Ice Area x10^6 km^2

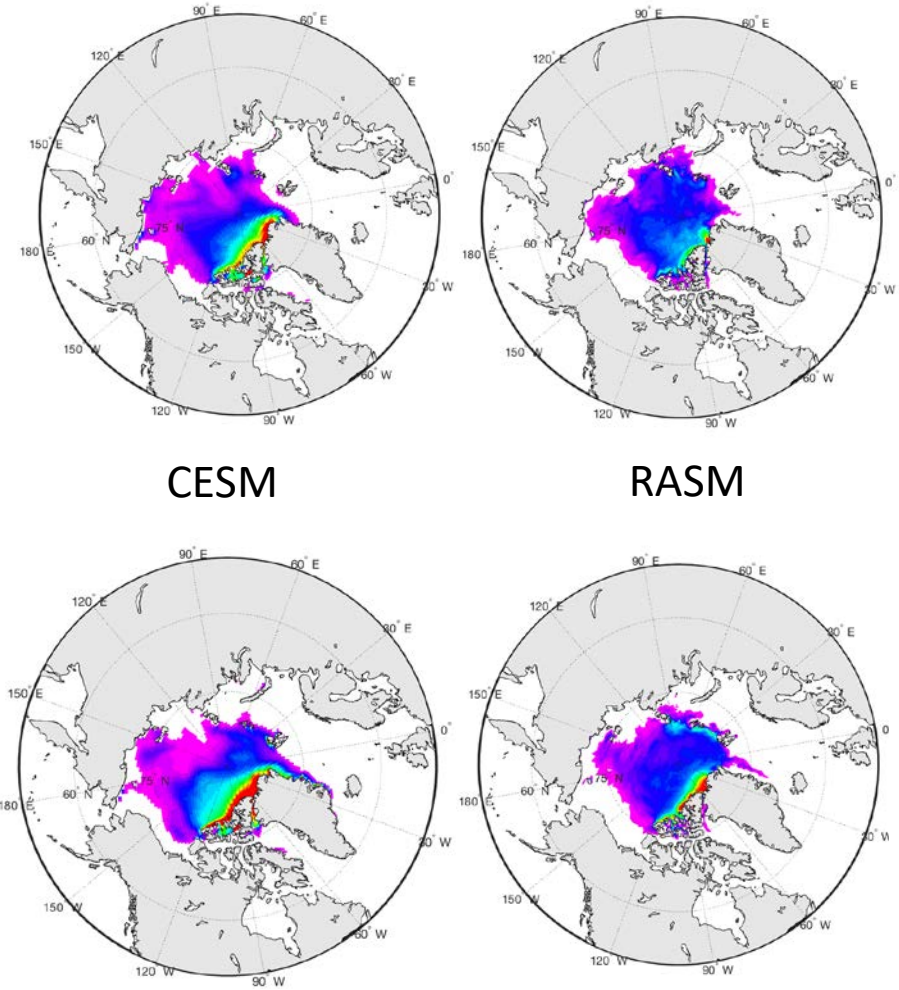
Sea Ice Thickness – 09/2020

Ensemble member #1



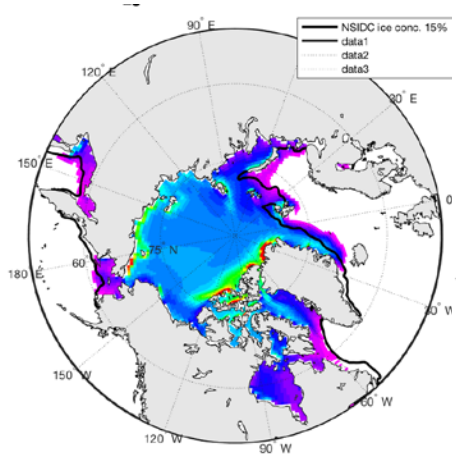
Ensemble member #6



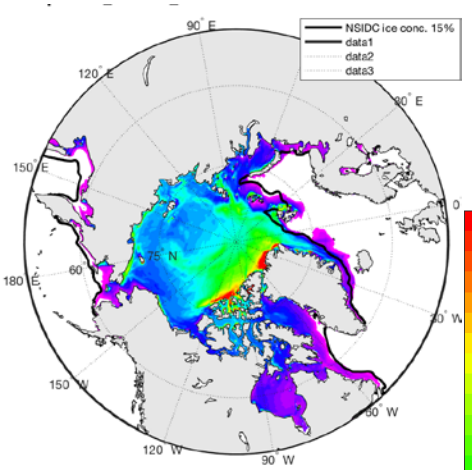


Dynamical donwscaling of CSM DPLE with RASM: 2016-2025 (#1)

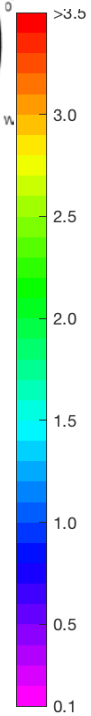
Sea Ice Thickness – 01/2016



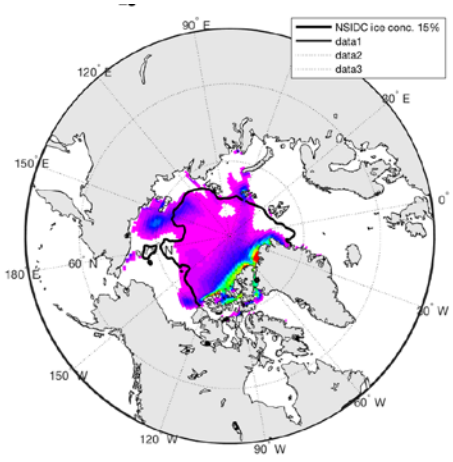
CESM



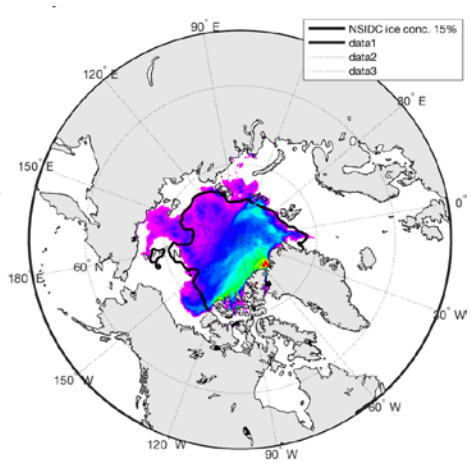
RASM



Sea Ice Thickness – 01/2016



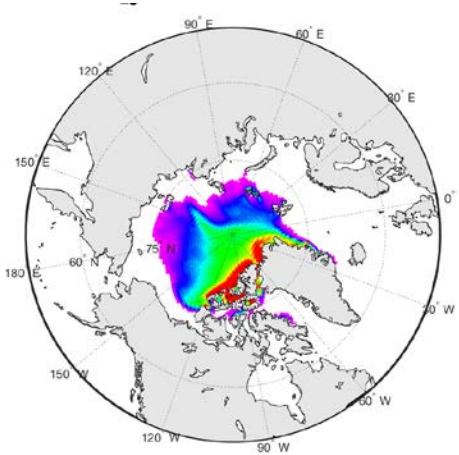
CESM

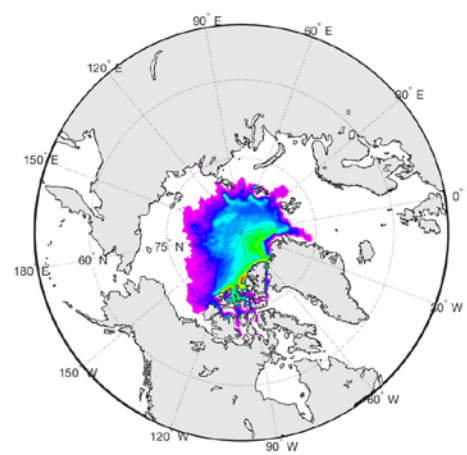


RASM

- Initial conditions for each model derived from reanalysis forced ice-ocean hindcasts
- CESM generally shows thinner ice early on
- … and thicker after 10 years

Sea Ice Thickness – 09/2025

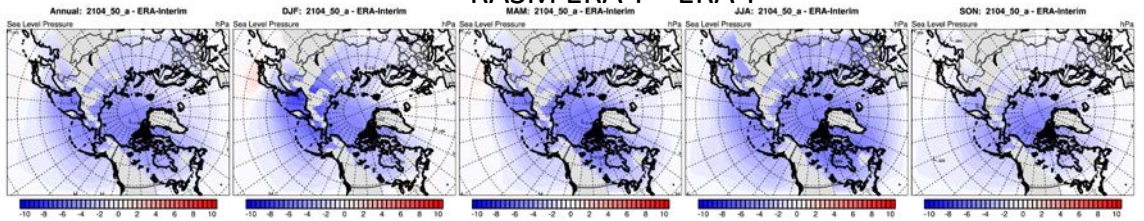




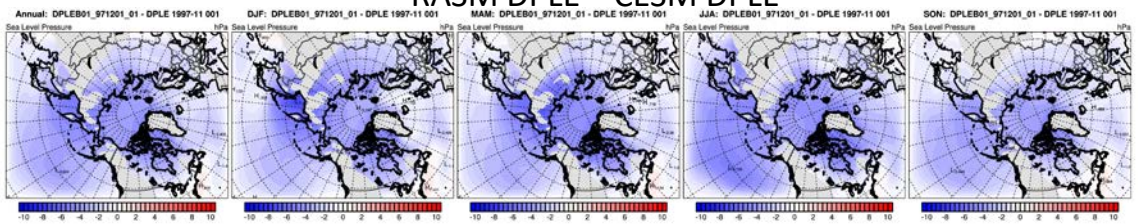
Dynamical donwscaling of CSM DPLE with RASM: Seasonal SLP Biases

- RASM has an overall negative SLP bias relative to the driving data used (top two rows – RASM driven by ERA-I and RASM driven by CESM DPLE)
- CESM DPLE simulation has regions of negative and positive SLP biases (3rd row)
- The RASM simulation driven by the CESM DPLE simulation when compared to ERA-I (bottom row) has a bias pattern that is a combination of the CESM DPLE biases (third row) and the overall negative RASM SLP bias (top two rows)
- **This suggests that RASM inherits circulation biases from the driving data while also maintaining a signal from RASM's own inherent circulation biases**

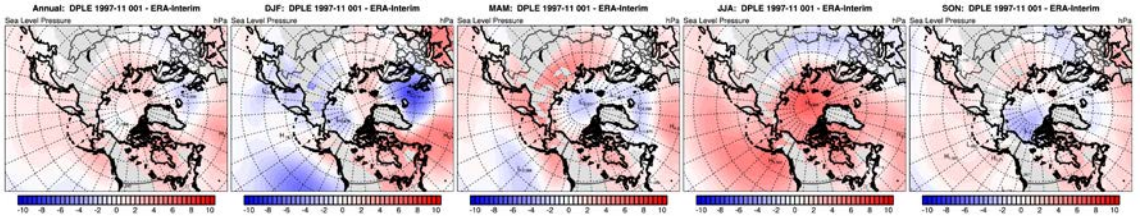
RASM ERA-I – ERA-I



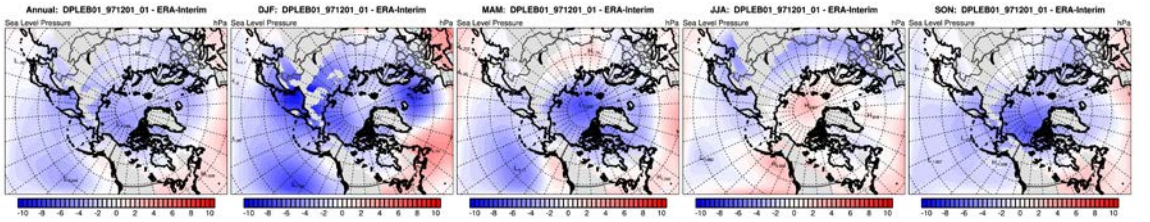
RASM DPLE – CESM DPLE



CESM DPLE – ERA-I



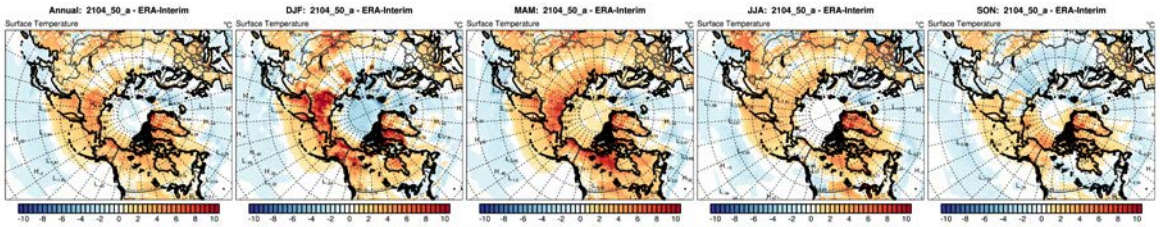
RASM DPLE – ERA-I



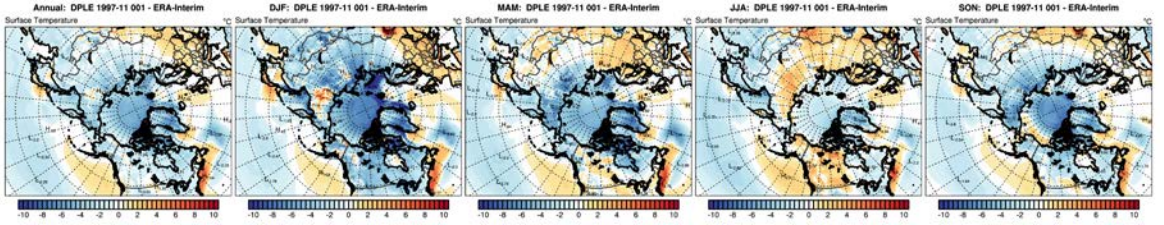
Dynamical donwscaling of CSM DPLEwith RASM: Seasonal Tsfc Biases

- RASM has a warm bias relative to ERA-I (top row) over land areas and a cool bias over lower latitude ocean regions
- CESM DPLE simulation has an overall cold surface temperature bias (second row) that is noticeably different from RASM's surface temperature bias (top row)
- Despite the cold bias in the CESM DPLE driving data the RASM simulation driven by CESM DPLE (bottom row) has similar surface temperature biases to the RASM simulation driven by ERA-I (top row)
- **This result indicates the dominance of the RASM / WRF physics in controlling the near surface state regardless of the driving data and its biases**

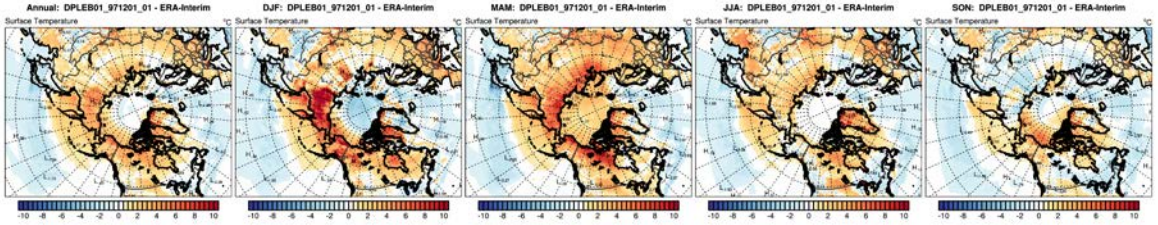
RASM ERA-I – ERA-I



CESM DPLE – ERA-I



RASM DPLE – ERA-I



Dynamical donwscaling of CSM DPLE with RASM

- Lateral BCs and upper level nudging in WRF allow RASM to reproduce large-scale features and intra- and inter-annual variability of driving data (reanalysis or CESM) at upper levels;

- In contrast to ESMs, RASM can reproduce observed mean state, variability, trends and extreme events in space and time, which facilitates model improved physics and optimization;

- WRF/RASM physics dominate the lower atmosphere and surface state, which is largely insensitive to the driving data or biases in the driving data;

- This CESM DPLE downscaling evaluation has so far demonstrated that **RASM can be successfully used to downscale ESM projections while retaining the benefits of RASM's higher resolution, polar optimized physics and computational costs.**