



Insights on Sea Ice Data Assimilation from Perfect Model Observing System Simulation Experiments (OSSEs)

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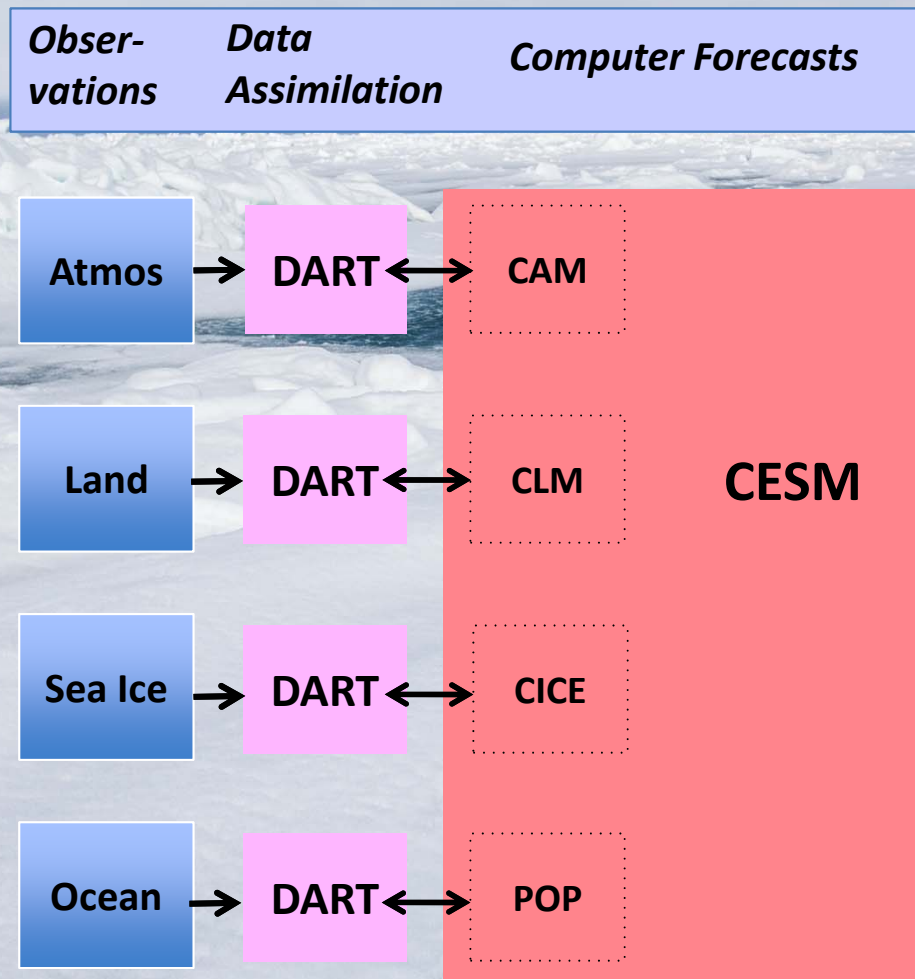
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2017 CESM Workshop

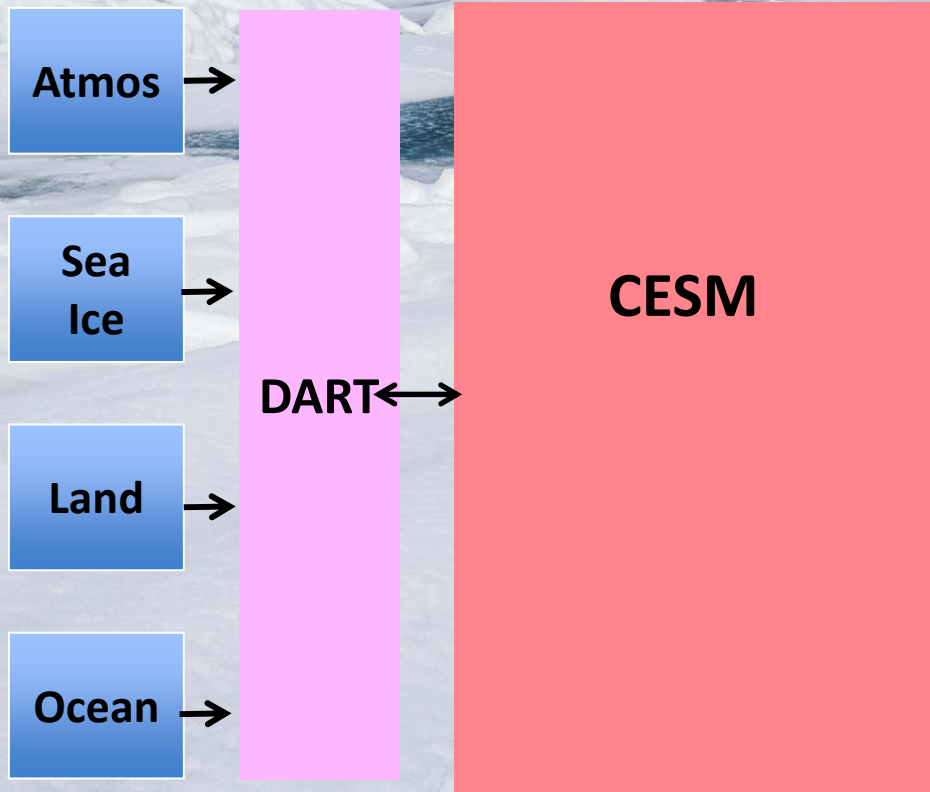
CICE/DART

- CICE5 in CESM1
- Data atmosphere and slab ocean



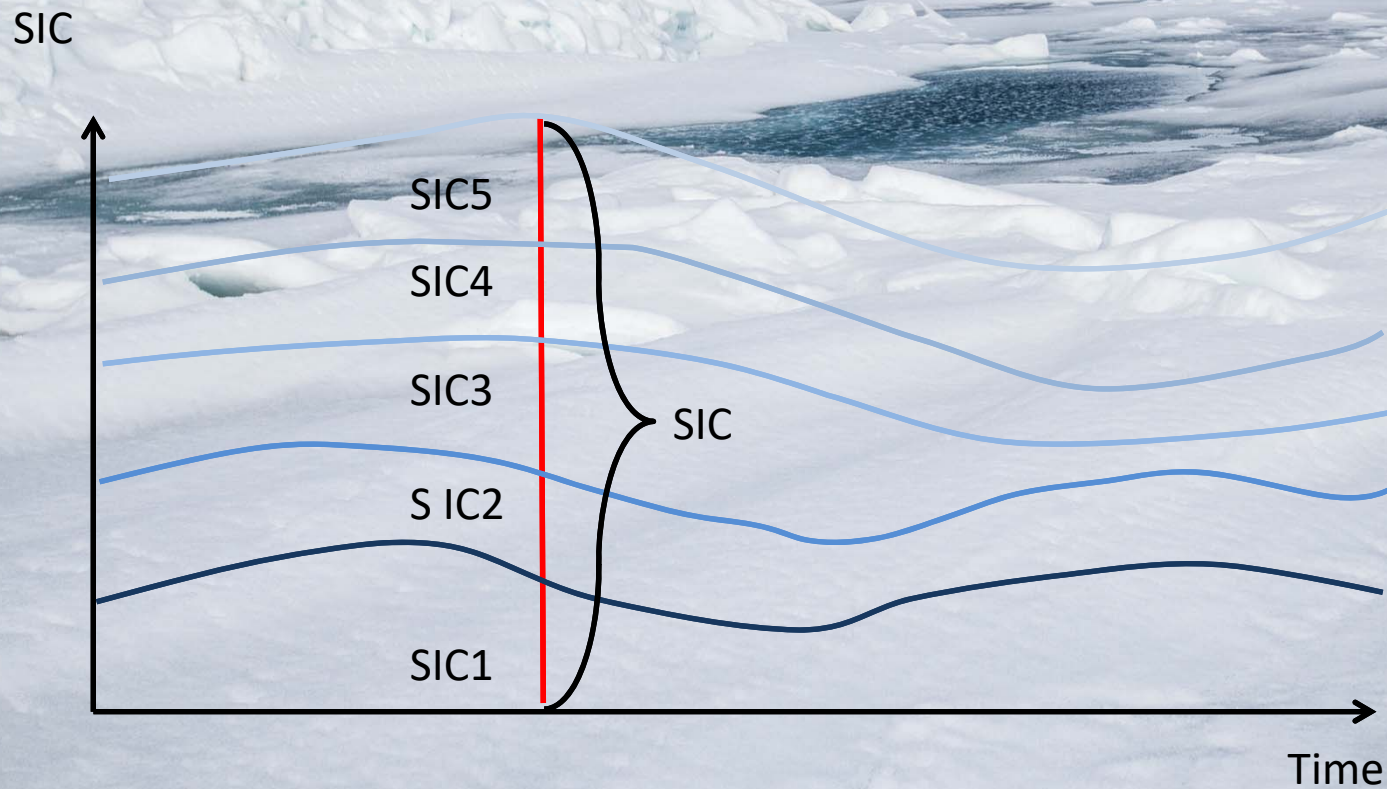
Strong Coupling

Observations *Data Assimilation*

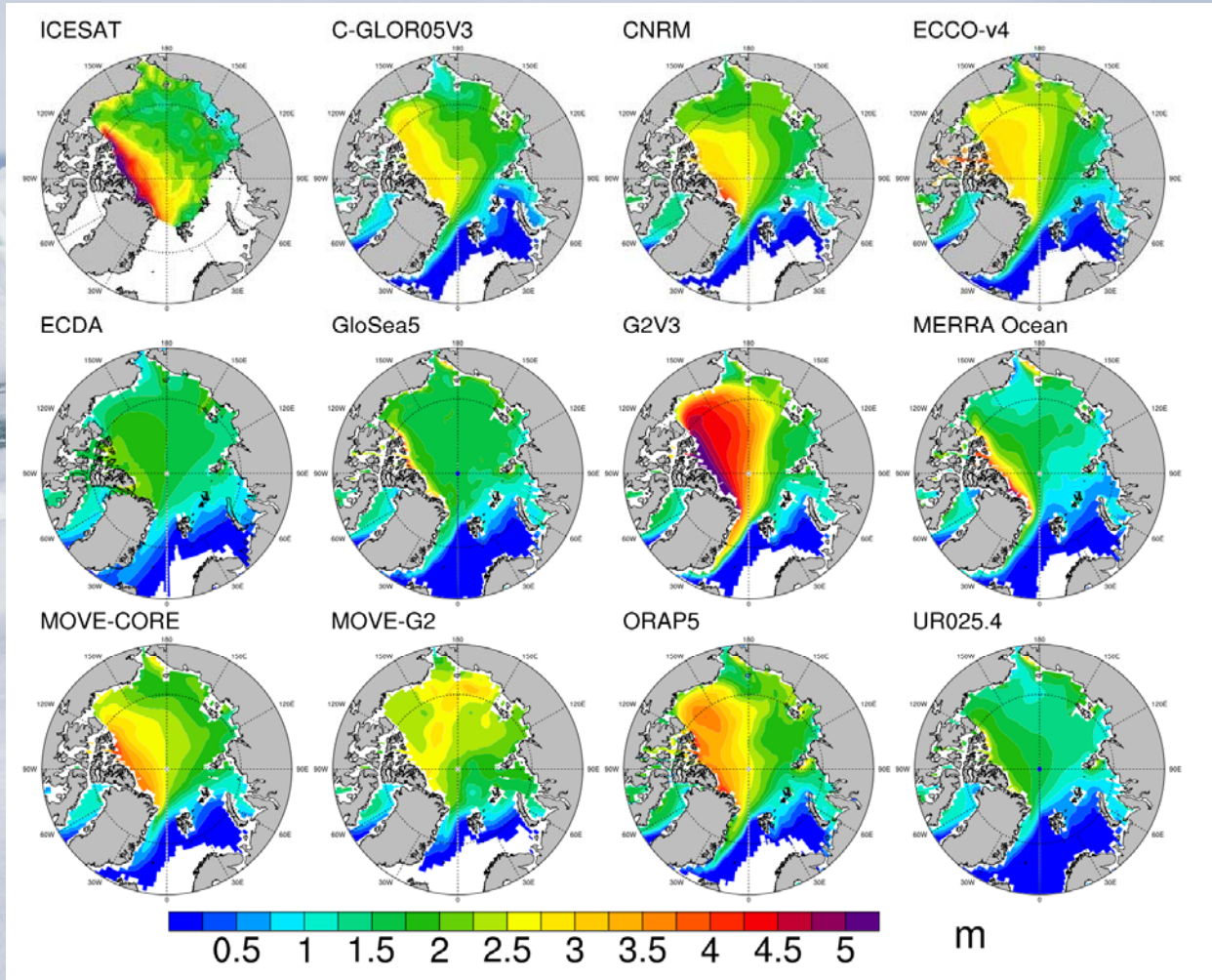


Observations

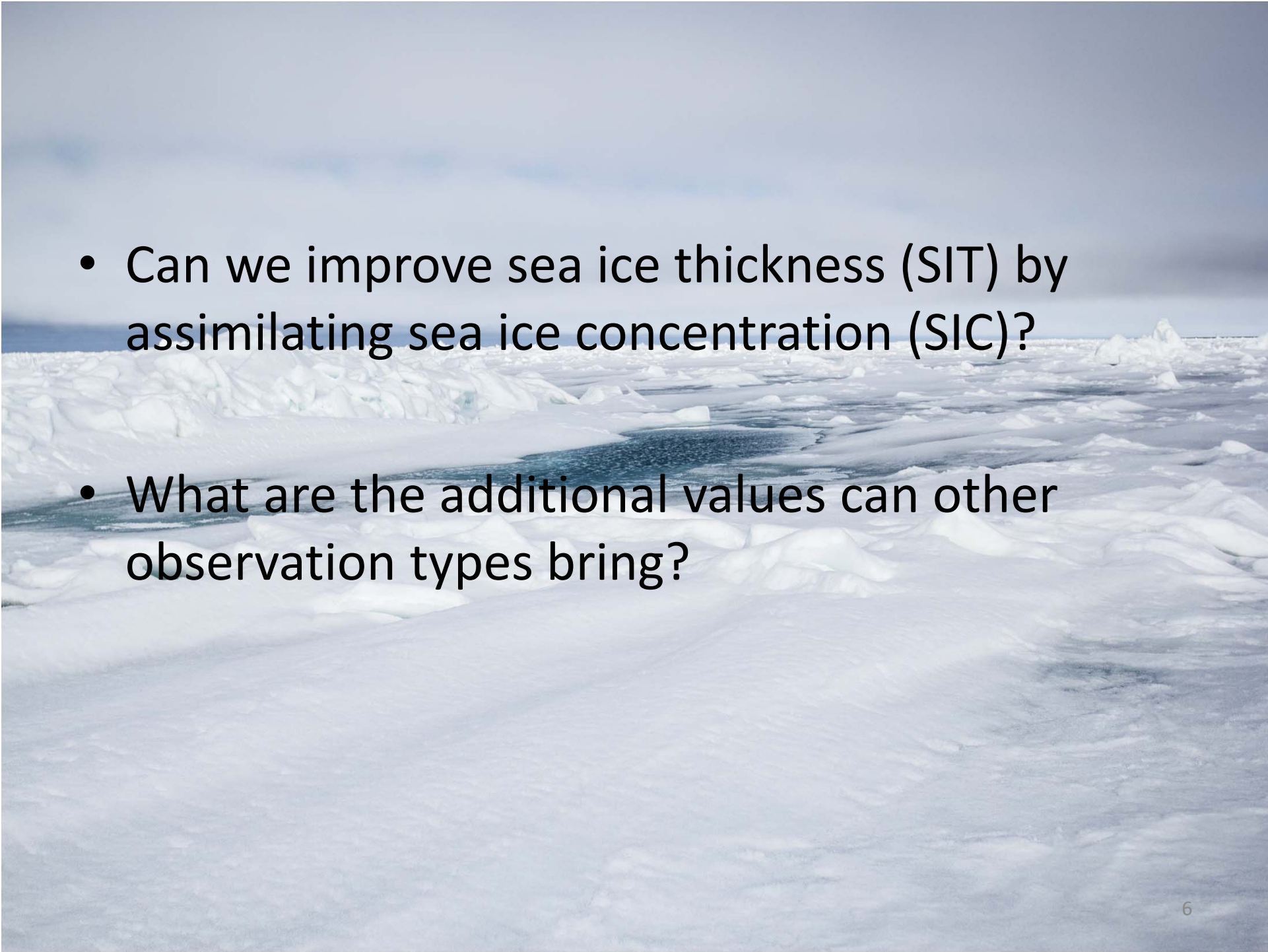
- In-situ observations are usually point-wise
- A satellite gives an “aggregate” estimate for all ice types at its resolution



Mean March 2003-2007 Sea Ice Thickness (m) in global ocean-sea ice reanalyses with assimilation of sea ice concentration



Chevallier et al (2016)

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- Can we improve sea ice thickness (SIT) by assimilating sea ice concentration (SIC)?
 - What are the additional values can other observation types bring?

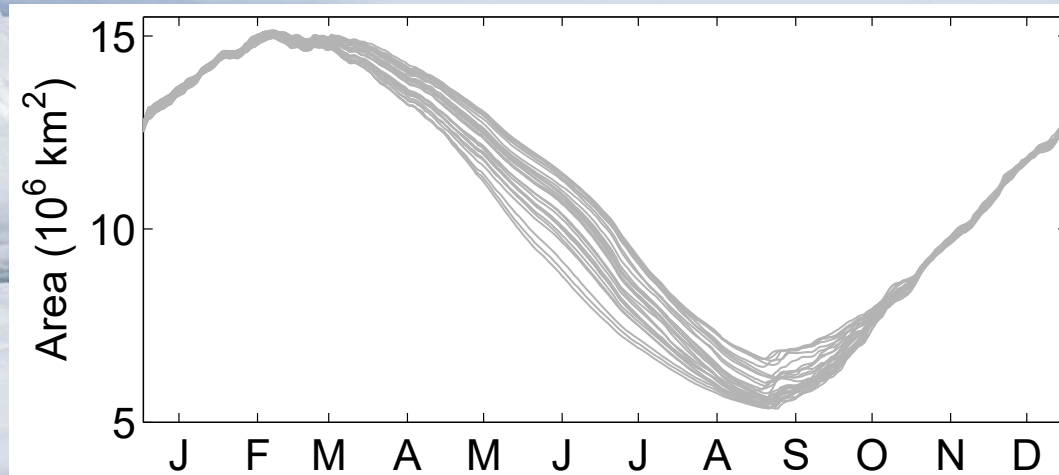
Observations

- Sea ice concentration (SIC)
 - Has a good coverage in time and space
 - Is relatively more reliable than other observations
- Sea ice thickness (SIT)
 - Conventional measurements are sparse in time and space
 - Substantial errors in satellite retrievals
- Sea ice age (AGE)
 - Represented as the first-year sea ice fraction
 - Can partially provide thickness information as first-year sea ice is usually thinner than multi-year sea ice
 - Relatively more reliable than SIT observation

OSSEs

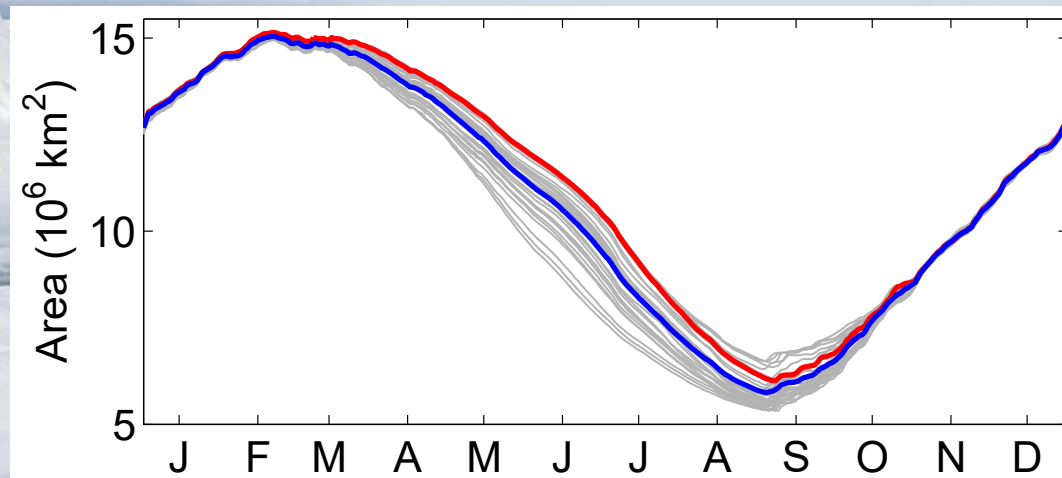
Perfect Model Observing System Simulation Experiments (OSSEs)

We create an ensemble without data assimilation (open-loop):



- In all our runs, CICE5 is coupled to a **slab ocean** and has **prescribed atmospheric forcing** from an ensemble reanalysis atmosphere.
- The spread is enhanced by perturbing albedo and ice strength.

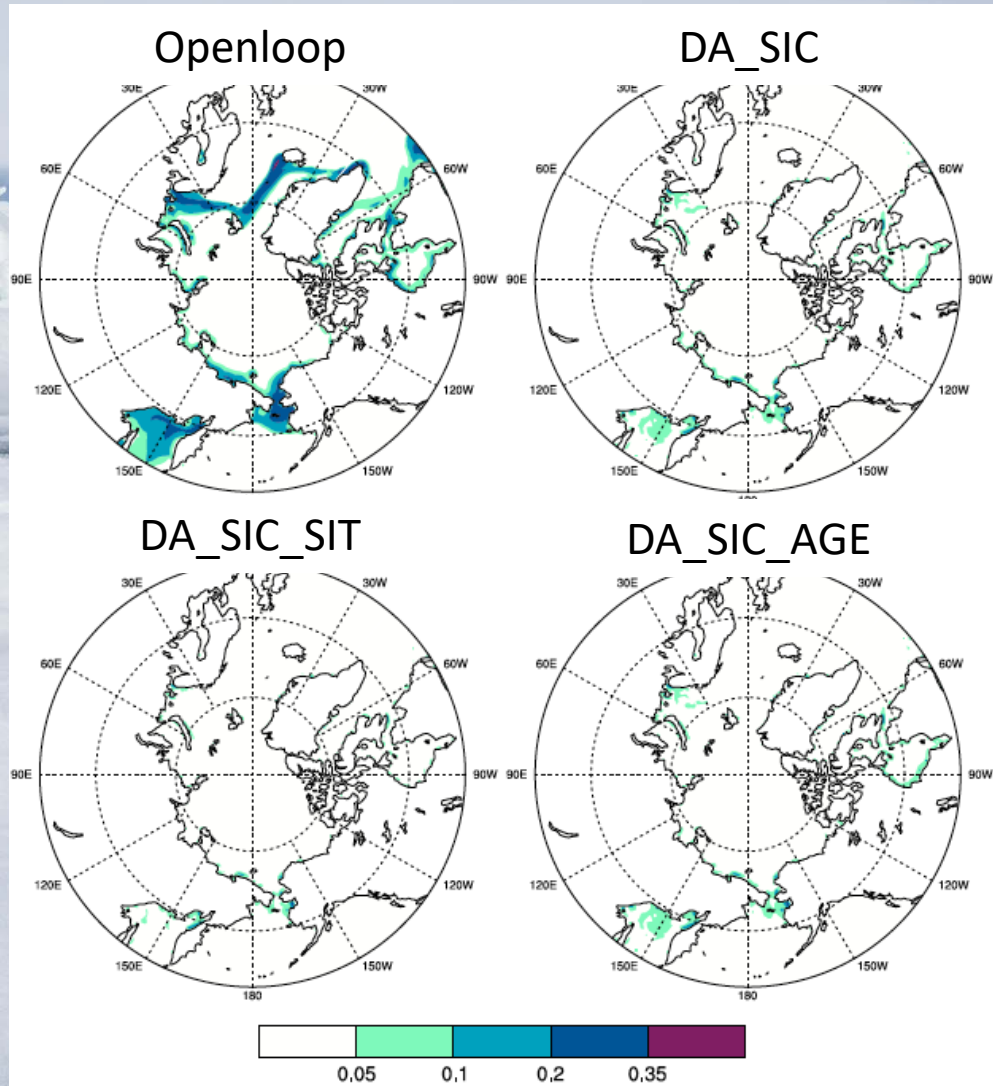
We create an ensemble without data assimilation (open-loop):



- We chose one ensemble member as the “truth”
- and add some noise to make “synthetic observations”: 15% random error is added to SIC

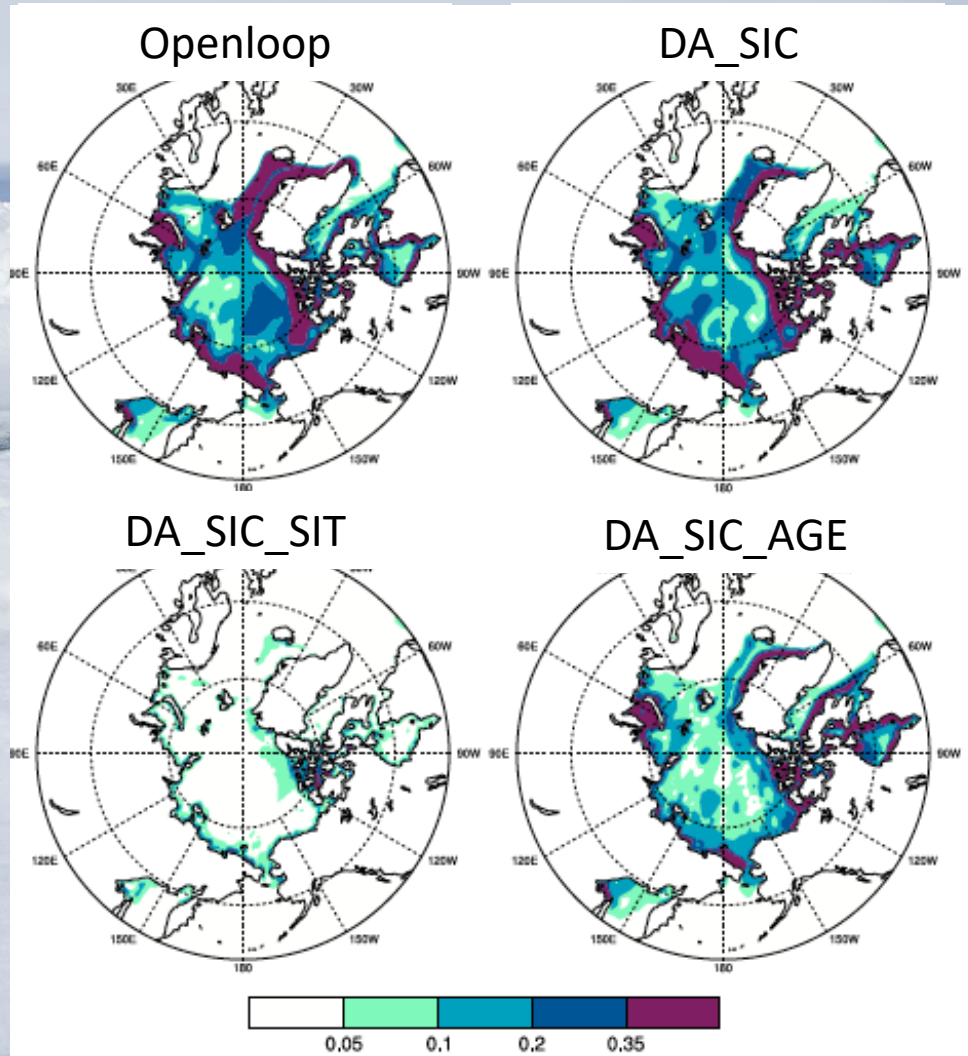
RMSE of SIC

Apr and May, 2001—2003



RMSE of SIT

Apr and May, 2001—2003



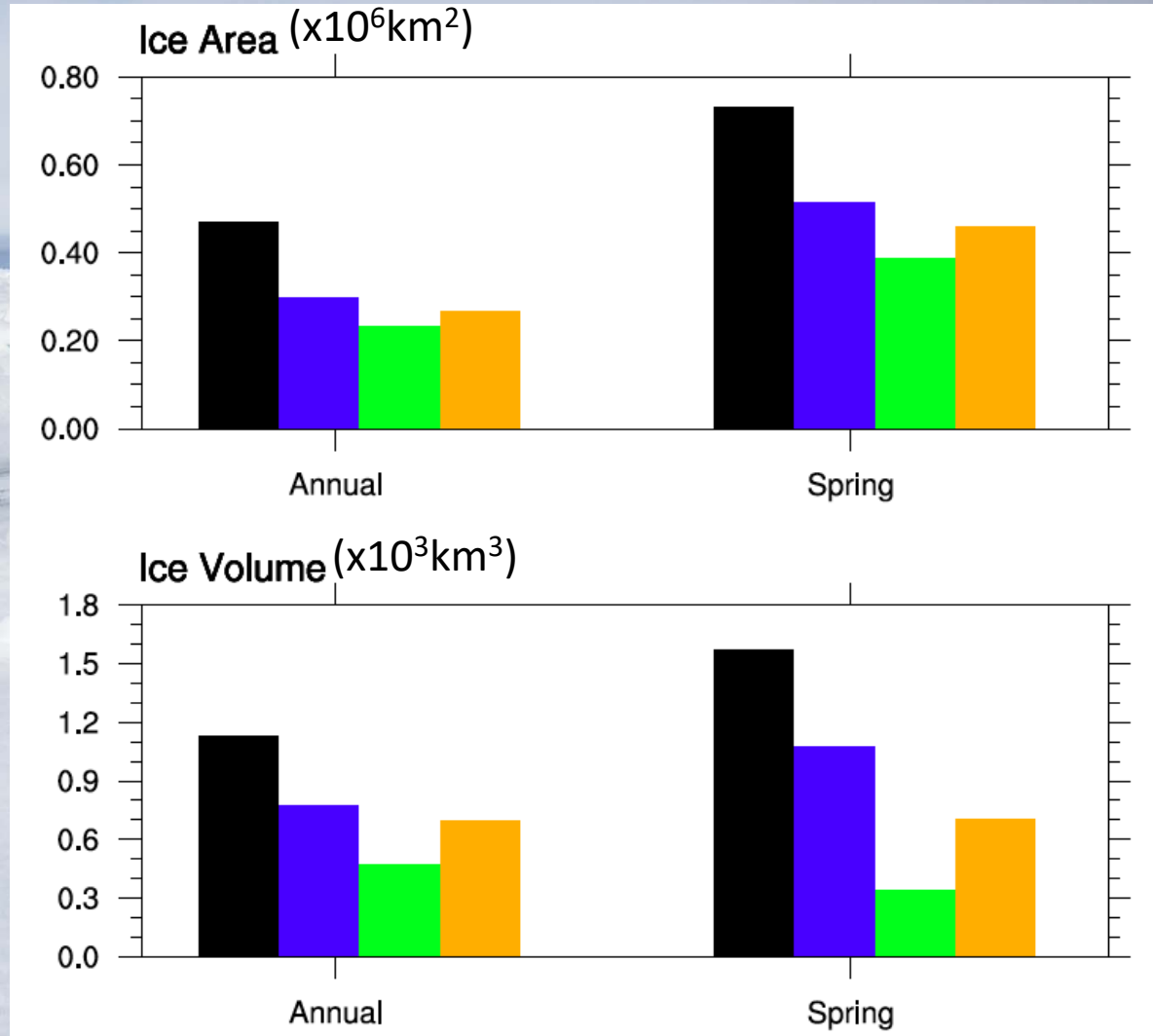
RMSE of Arctic sea ice area and sea ice volume

OL

DA_SIC

DA_SIC_SIT

DA_SIC_AGE





Assimilation of Sea Ice Concentration Satellite Observations

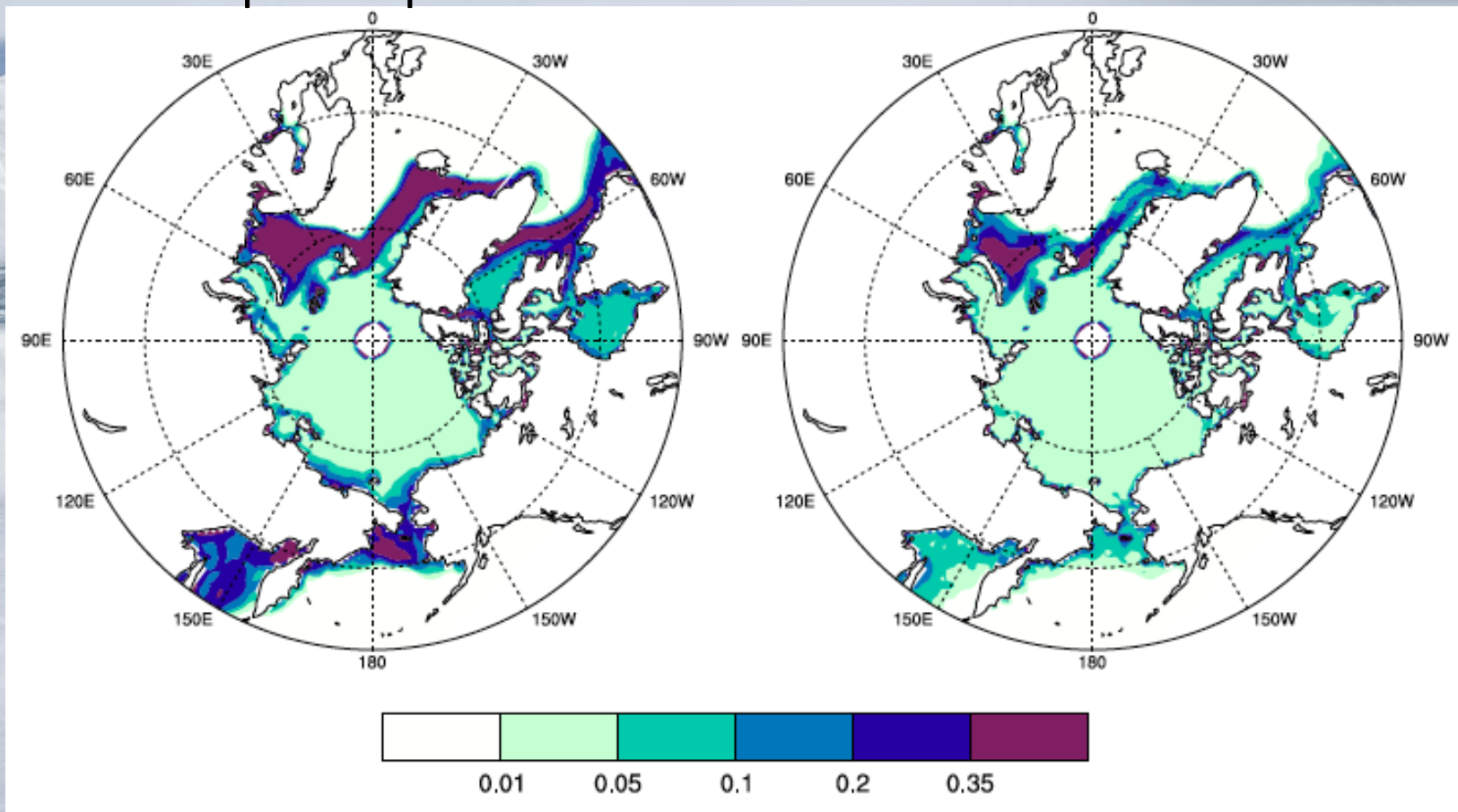
- The Bootstrap SIC retrievals from SSM/I microwave observations
 - 25 km
 - 15% error

RMSE of SIC

Apr and May, 2001—2003

Openloop

SIC DA

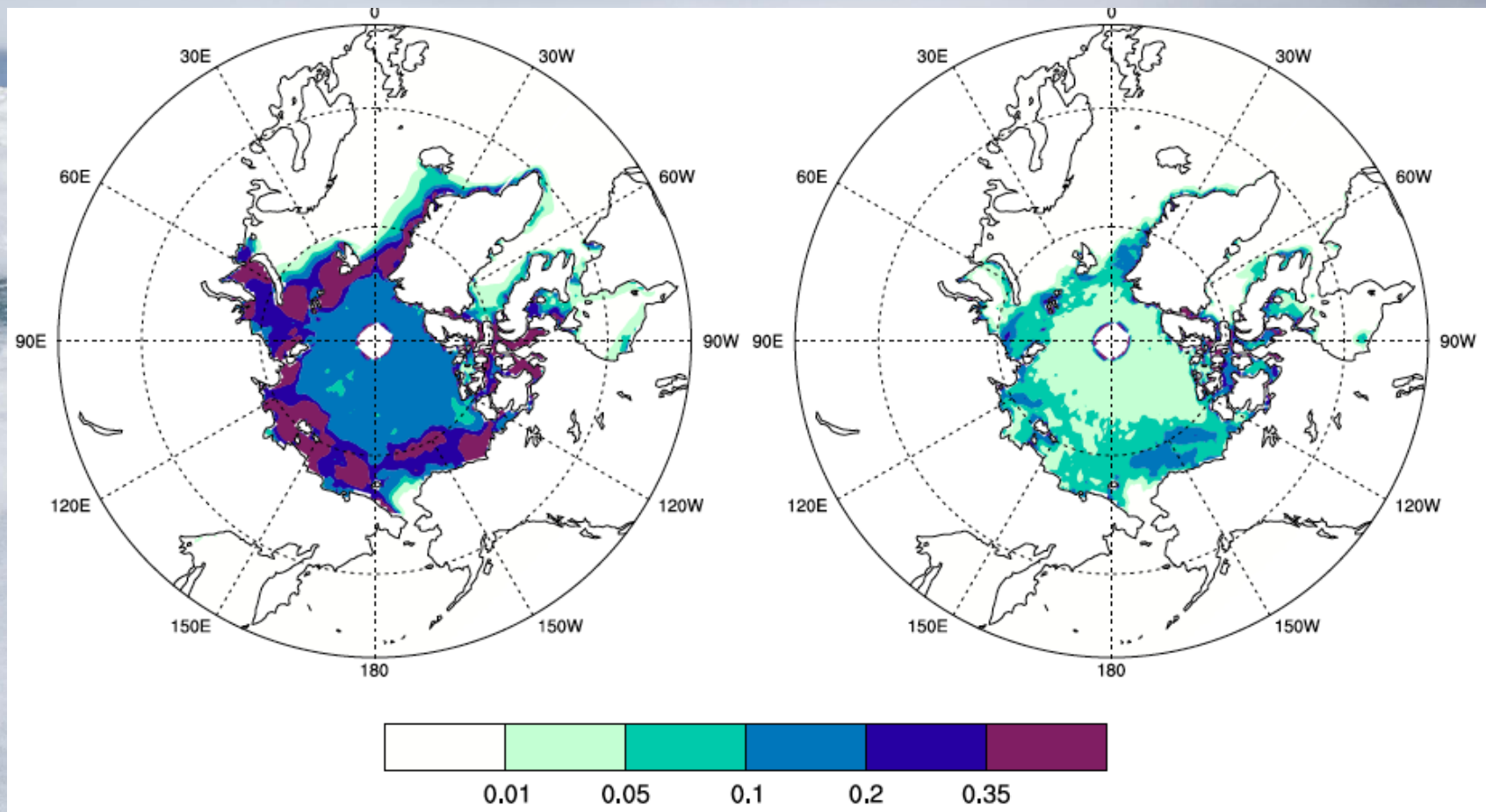


RMSE of SIC

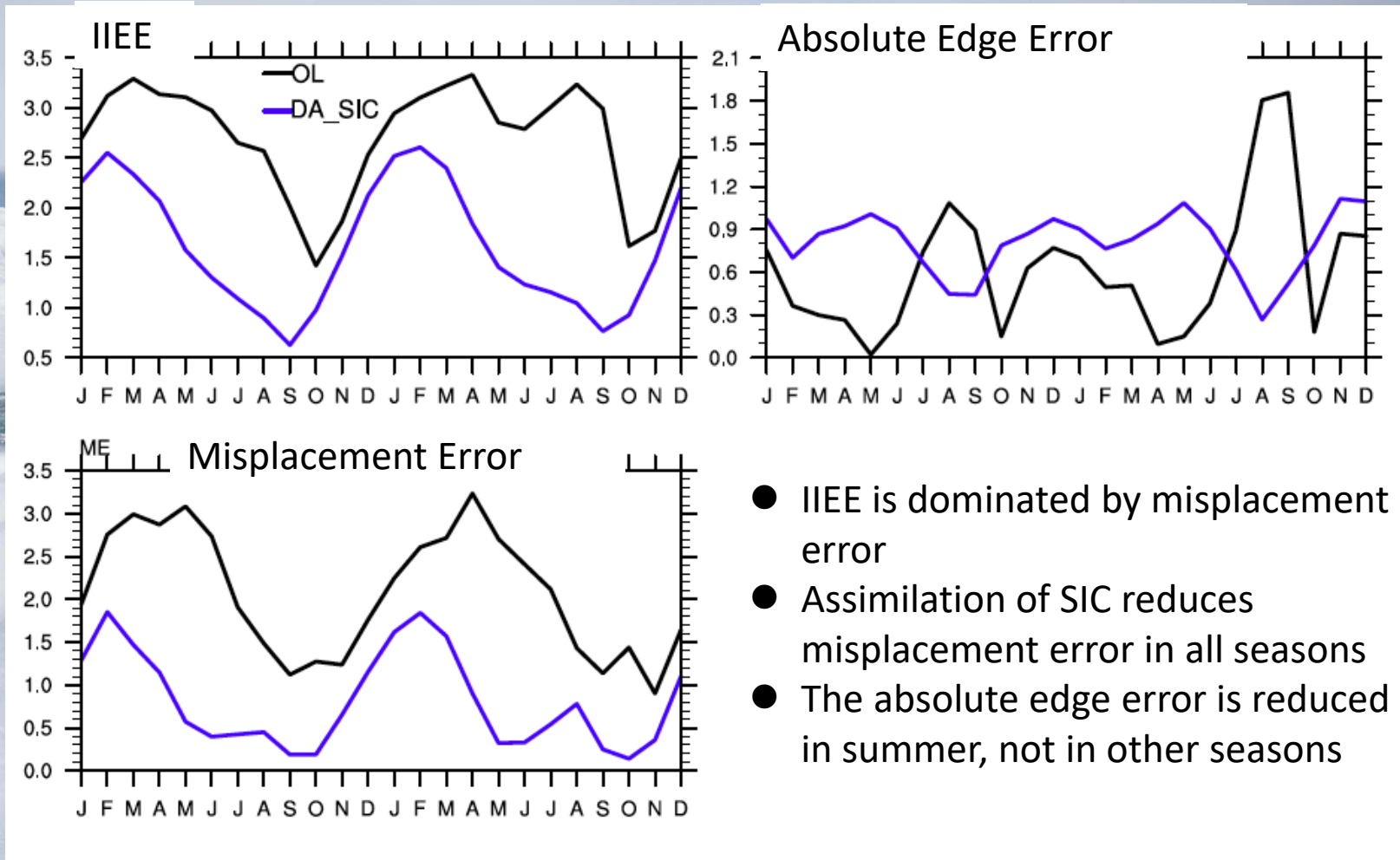
Aug and Sep, 2001—2003

Openloop

SIC DA



Integrated Ice Edge Error (IIEE)



Conclusions

- Assimilating aggregate SIC can improve SIC, and assimilating SIT further improves SIC.
- SIC DA has limited influence on SIT mainly along the sea ice edges. AGE DA improves SIT both along the edges and in the interior. SIT DA is the most efficient in reducing SIT error.
- The parameters and algorithms chosen based on results from OSSEs perform well for real SIC data assimilation.

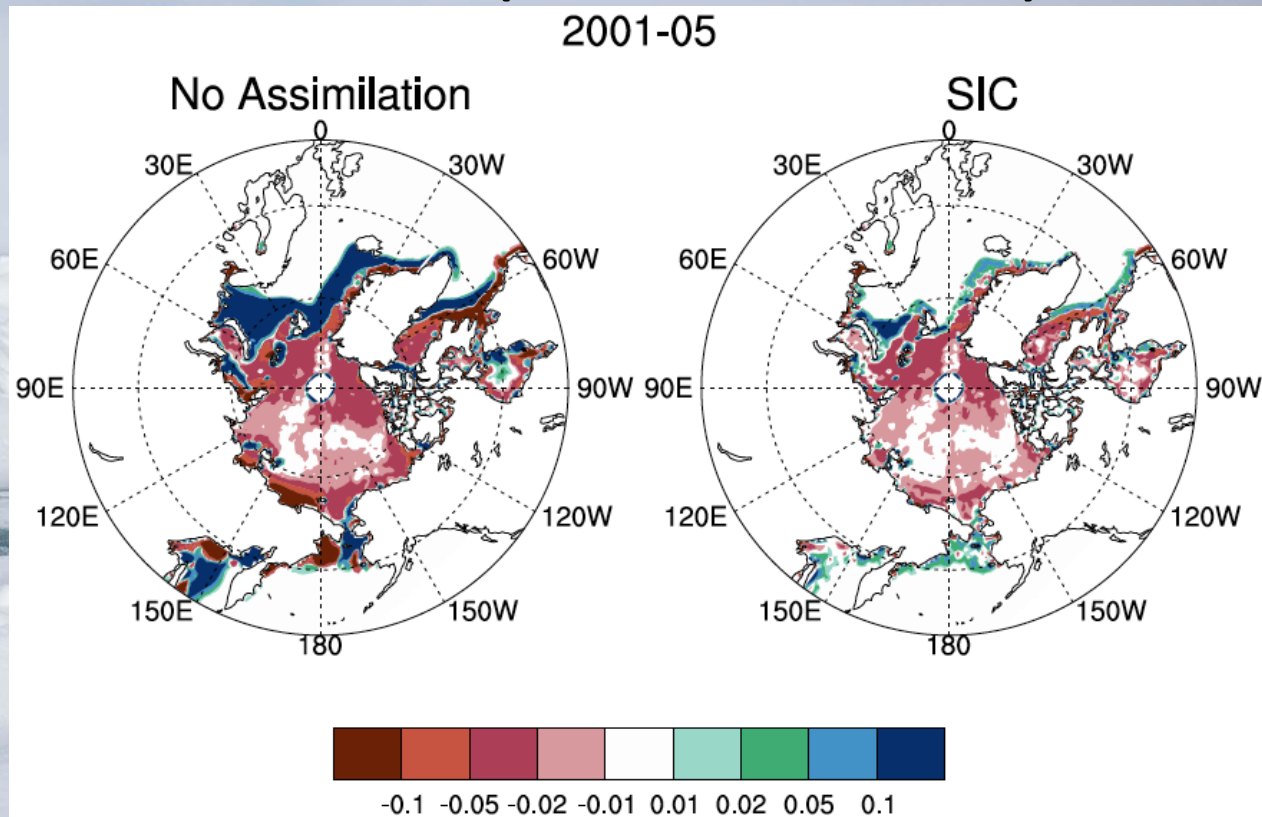
Thanks!



1. Results on Real SIC DA

SIC Bias (Model – OBS)

Spring

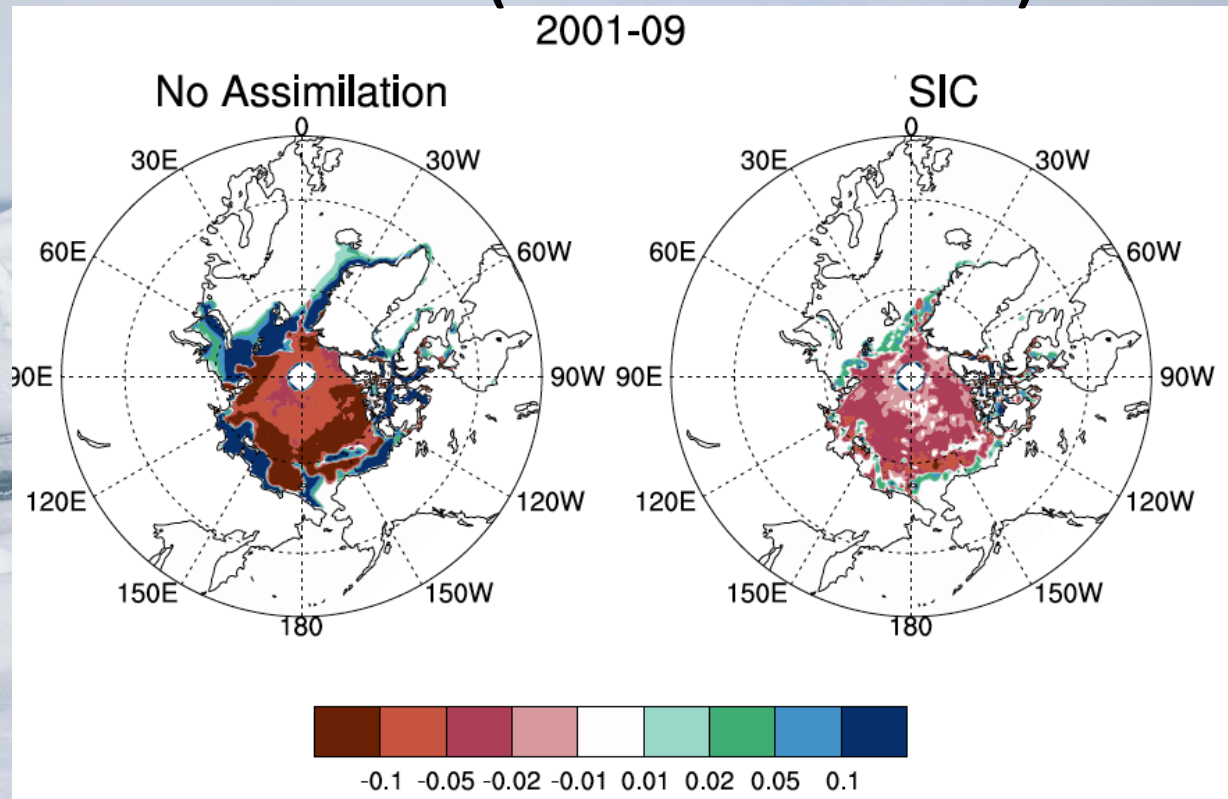


- The positive bias of Arctic sea ice area is mainly caused by an overestimation of SIC along the ice edges, and the negative bias in the interior compensates for it partly.
- DA significantly removes the positive bias along the ice edge and does not remove the negative bias in the central Arctic as much, which leads to an overall underestimation of Arctic sea ice area

1. Results on Real SIC DA

Summer

SIC Bias (Model – OBS)



In summer, as model becomes more uncertain in SIC in the interior, DA is able to reduce the biases to a larger extent.