CLIMATE PROGRAM OFFICE
Advancing scientific understanding of climate, improving society's ability to plan and respond

Arctic Portfolio

Physical Atmos-Ice-Ocean

CPO-JPSS/STAR

Technical Interchange Meeting

v.03.29.2017

Sandy Starkweather (sandy.starkweather@noaa.gov)

Sandy Lucas (sandy.lucas@noaa.gov)

As of December 8, 2016

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ARCTIC PROGRAM

NOAA Arctic Research Program Line of Effort:	Topical Foci	Sustained Observations	NOAA Line Offices Involved
1. Conducted annual occupations of the Distributed Biological Observatory (DBO)	• Biological/ecological • Physical ocean • Biogeophysical ocean	• 7 sampling transects • X moorings, buoys	OAR, NMFS, NOS
2. Support and expand the International Arctic Systems for Observing the Atmosphere (IASOA)	• Radiation • Sens/Lat Flux • Clouds • Aerosols • GHG's	• 3 radiative flux towers • 3 turbulent/carbon flux towers • 3 ancillary energy & composition sites	OAR, NWS, NESDIS
3. Conduct annual surveys of the Arctic ocean and atmosphere using unmanned drones, gliders and aircraft.	• Physical ocean • Biogeophysical ocean	• X waver gliders • X sail drones	OAR, NMFS
4. Support expanded modeling of climate, sea ice, and ecosystem response to changing environmental conditions in order to better inform observational needs	• Climate • Sea ice • Ecosystem response	• X Sea ice drifting buoys • 2 Sea ice mass balance buoys	OAR, NWS, NESDIS, NOS, NMFS
5. Support the US AON project office and its role in developing integrated products using existing Arctic observing assets.	• Sea Ice Forecasting • Biogeochemistry • Ship Tracking	Cross-cutting support to develop data products from sustained observations	OAR, NWS, NESDIS, NOS, NMFS

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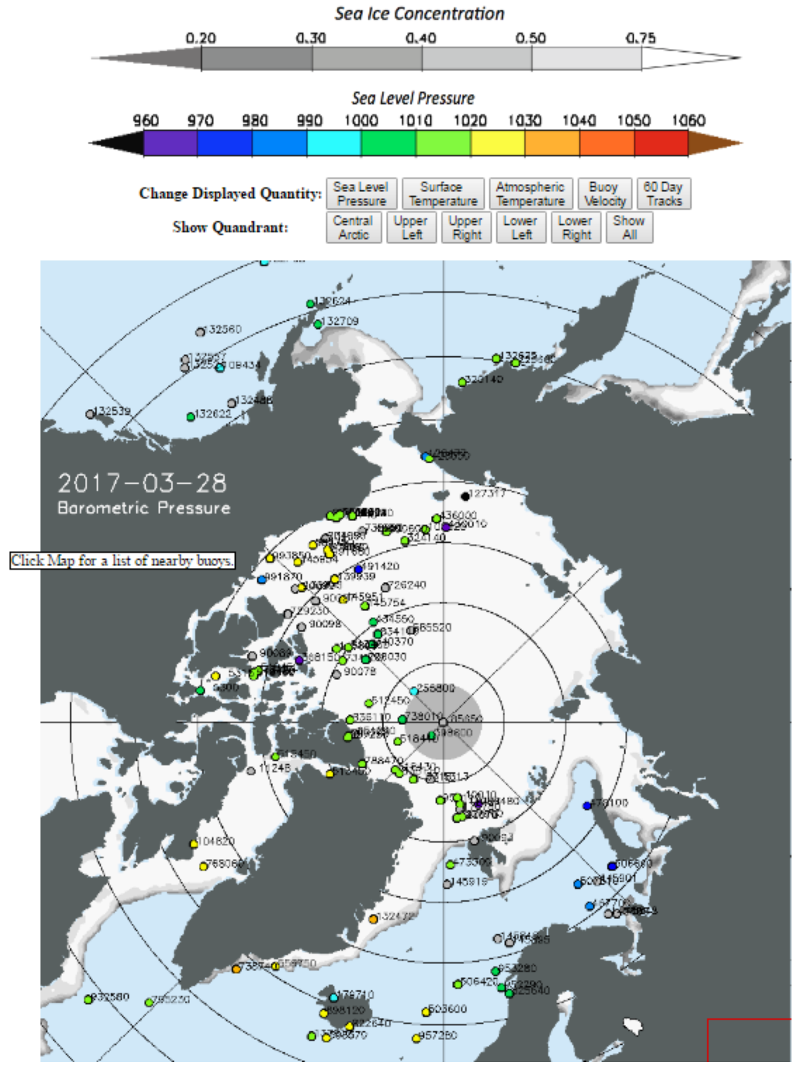
Sea Ice Obs

[IDBs](#) Sea Level Pressure (BP), Surface Temperature (Ts), and Atmospheric Temperature(Ta).

[IMBs](#)

[UpTempOs](#)

[ITPs](#)



http://iabp.apl.washington.edu/index.html

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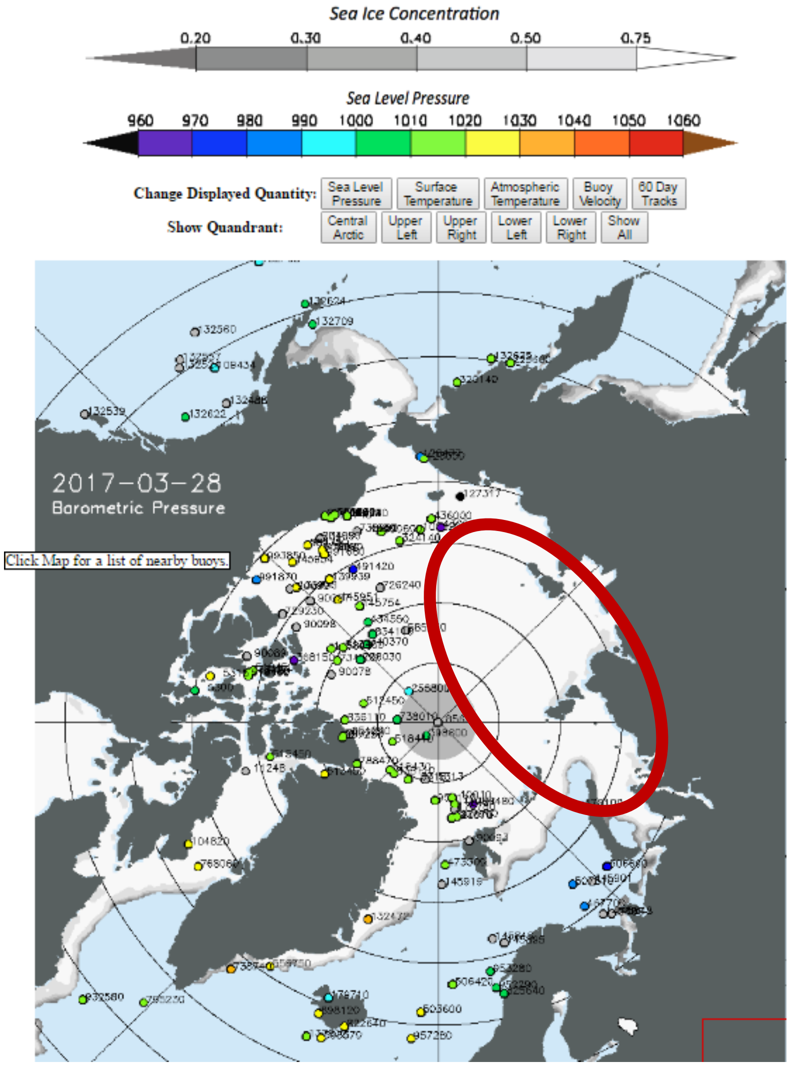


http://iabp.apl.washington.edu/index.html

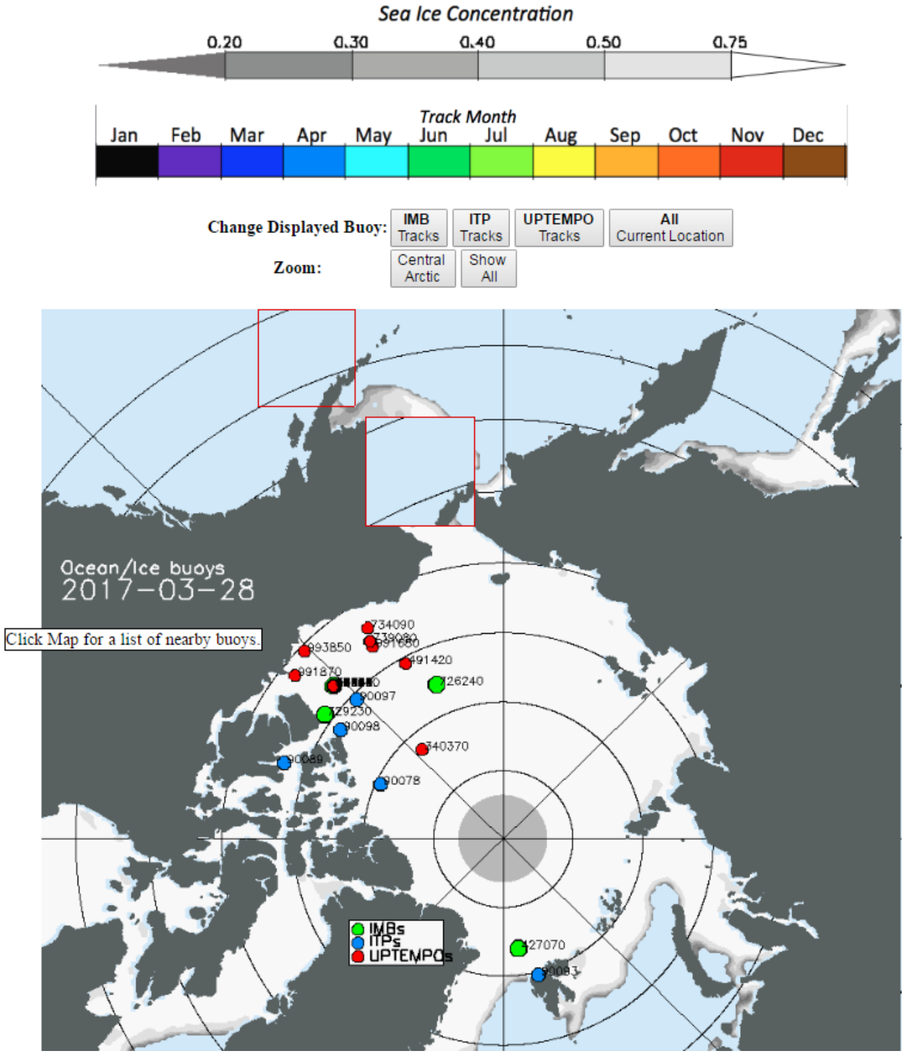
Sea Ice Obs

IDBs Sea Level Pressure (BP), Surface Temperature (Ts), and Atmospheric Temperature(Ta).

IMBs have high resolution temperature readings of the ice layer & report thickness;

UpTempOs typically have a 60m thermistor string to sample ocean temperatures;

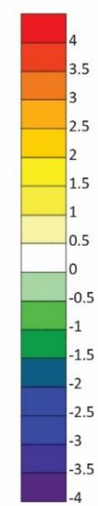
ITPs actually profile the water column down to 500m or more.



http://iabp.apl.washington.edu/index.html

Atmosphere Obs

Data Portal hosts ~1000 raw datasets; IASOA WG's produce value-added, pan-Arctic data products for dozens of obs.

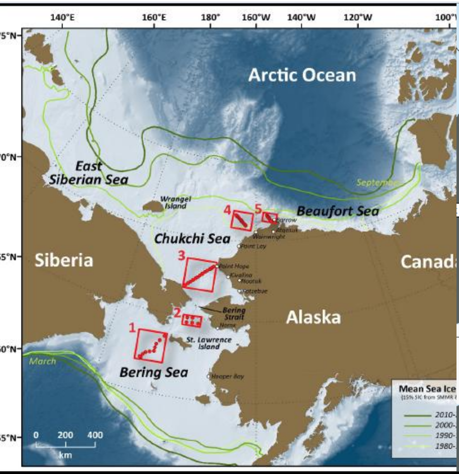


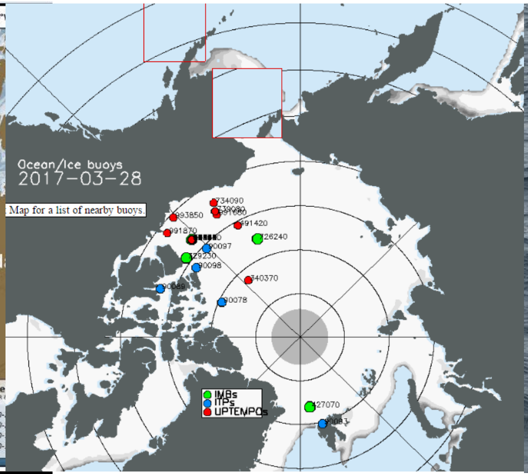
NCEP-NCAR Composite mean air temperature anomalies (1000mb); 2001-2012 compared to 1971-2000. NOAA/ESRL – PSD.

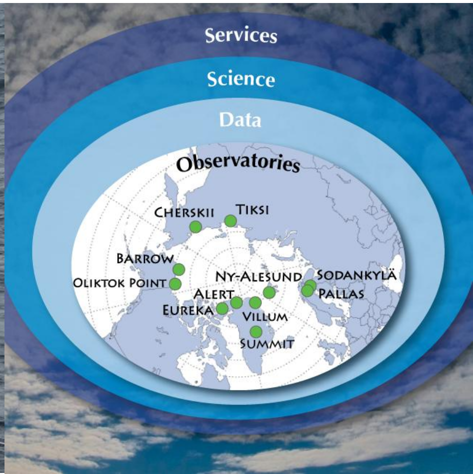
http://iasoa.org

US AON

Mobilizing 1) NOAA, 2) interagency, and 3) international contributions towards integrated and well-defined pan-Arctic observing networks that enable access to high quality data, expertise and information in support of scientific understanding, local needs, and agency operations.







Understanding Arctic Sea Ice Mechanisms and Predictability

Competitively Funded Projects: Climate Variability and Predictability Prgm (PM: **Sandy Lucas**)

In 2015, CVP called for proposals that advance the understanding of Pan- Arctic sea ice interactions in any of the following areas:

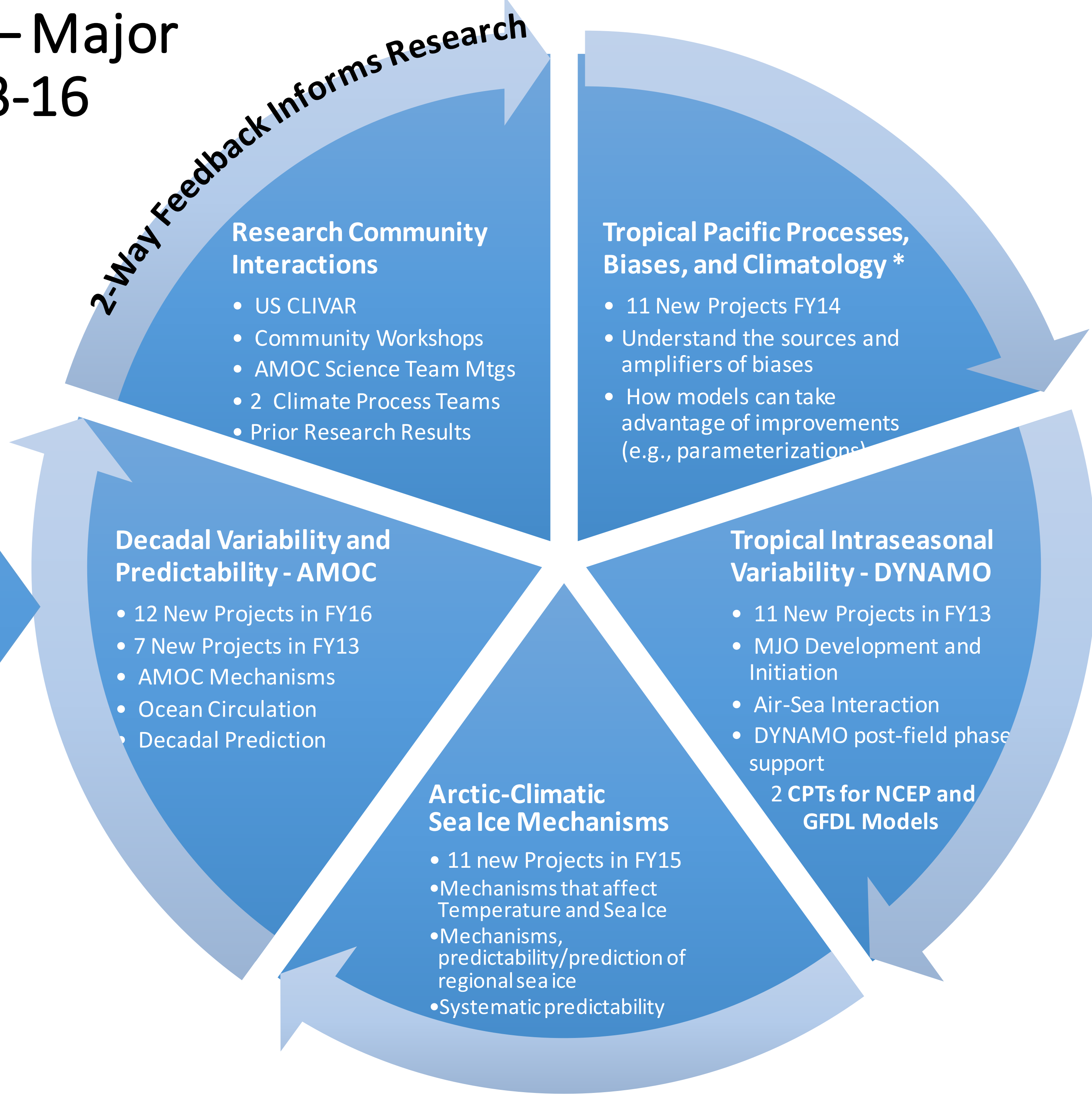
- Climatic mechanisms that affect Arctic temperatures and growth and/or loss of sea ice.
- Mechanisms, predictability and prediction of regional sea ice variation and change.
- Systematic predictability of the fully coupled climate--ocean--ice system, its driving factors, its state dependence as external forcings change, and whether such predictability can be achieved in operational--like predictions.

Funded 11 new projects.

These projects will conduct analysis and experimentation in a varied set of models including CMIP-5 class models from NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), the National Center for Atmospheric Research (NCAR), as well as NOAA/National Centers for Environmental Prediction (NCEP) model CFSv2.

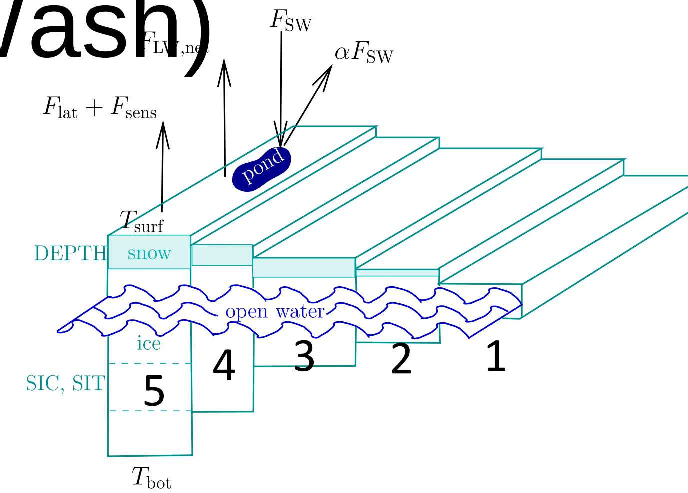
CVP Portfolio – Major Activities FY13-16

CVP Goal:
To advance the knowledge of the dynamics, and sources of predictability, of the coupled ocean-atmosphere-land-ice system across all climate time scales by using observations, modeling, research, analysis, and field studies to gain a process-level understanding of how the system interacts.



#1) Approaches for Forecasting Sea Ice C. Bitz, et al. (U Wash)

Partnering with NCAR to use the DART system to add data assimilation to the sea ice component (CICE5) of the Community Earth System Model (CESM)



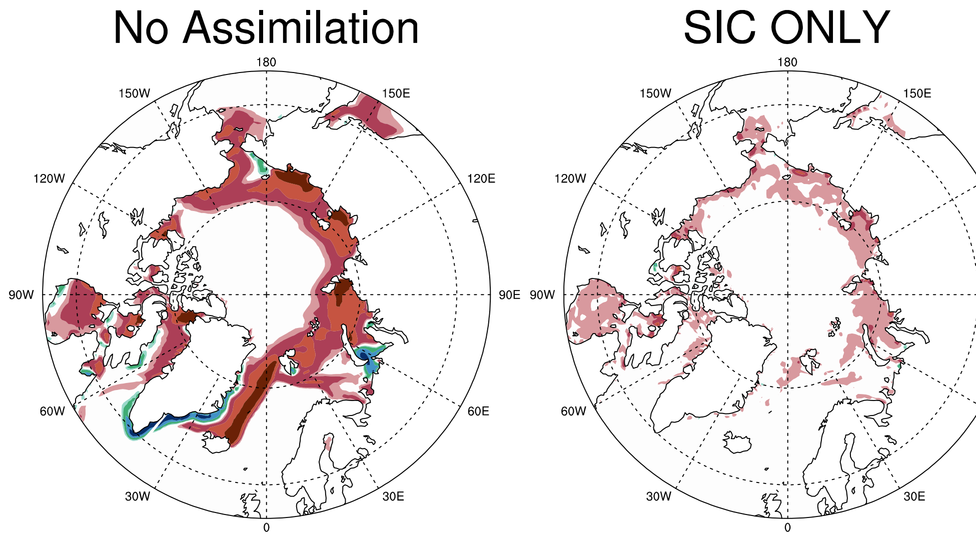
The CICE5 sea ice model is interfaced with the ensemble Kalman filter to do data assimilation. Model schematic from Notz and Bitz (2017) shows the subgrid distribution of thickness in the model.

In Observing System Simulation Experiment (OSSE) the following variables were assimilated

1. "Aggregate" sea ice concentration (SIC)
2. "Aggregate" sea ice thickness (SIT)
3. "Aggregate" first-year ice concentration (AGE)

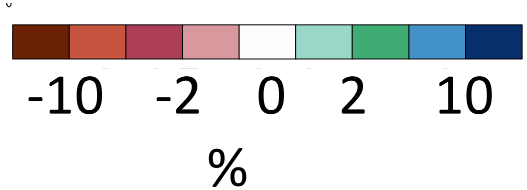
None of these are prognostic variables is in the model. Instead, the model simulates their distributions. The aggregate is the sum or mean of the distribution. Ensemble Kalman filter allows the aggregate to be

Sea Ice Concentration (SIC) Bias – All Months

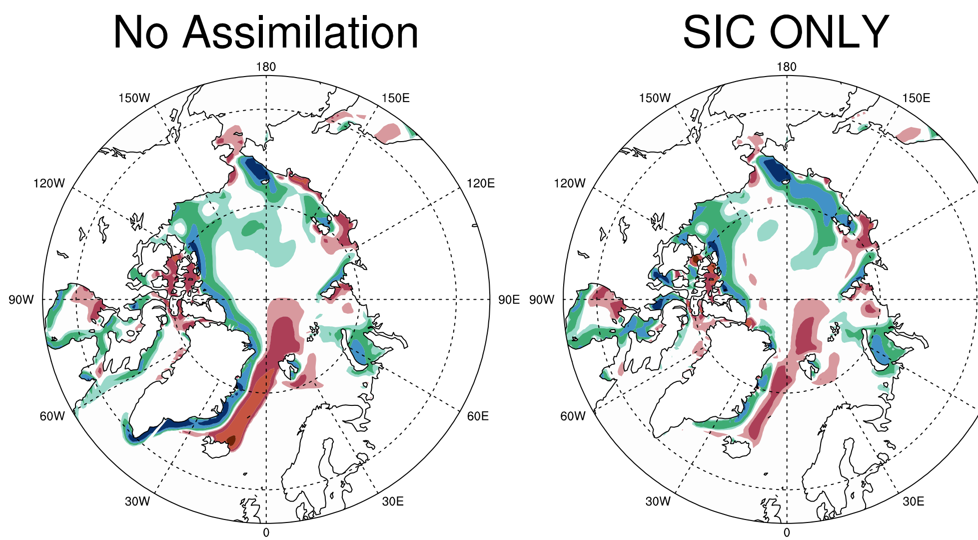


Assimilating SIC alone successfully reduces the bias

Assimilating thickness (SIT) too reduces the bias further



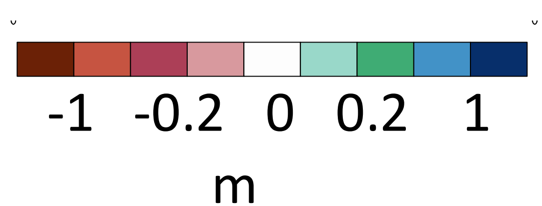
Sea Ice Thickness (SIT) Bias – April-May



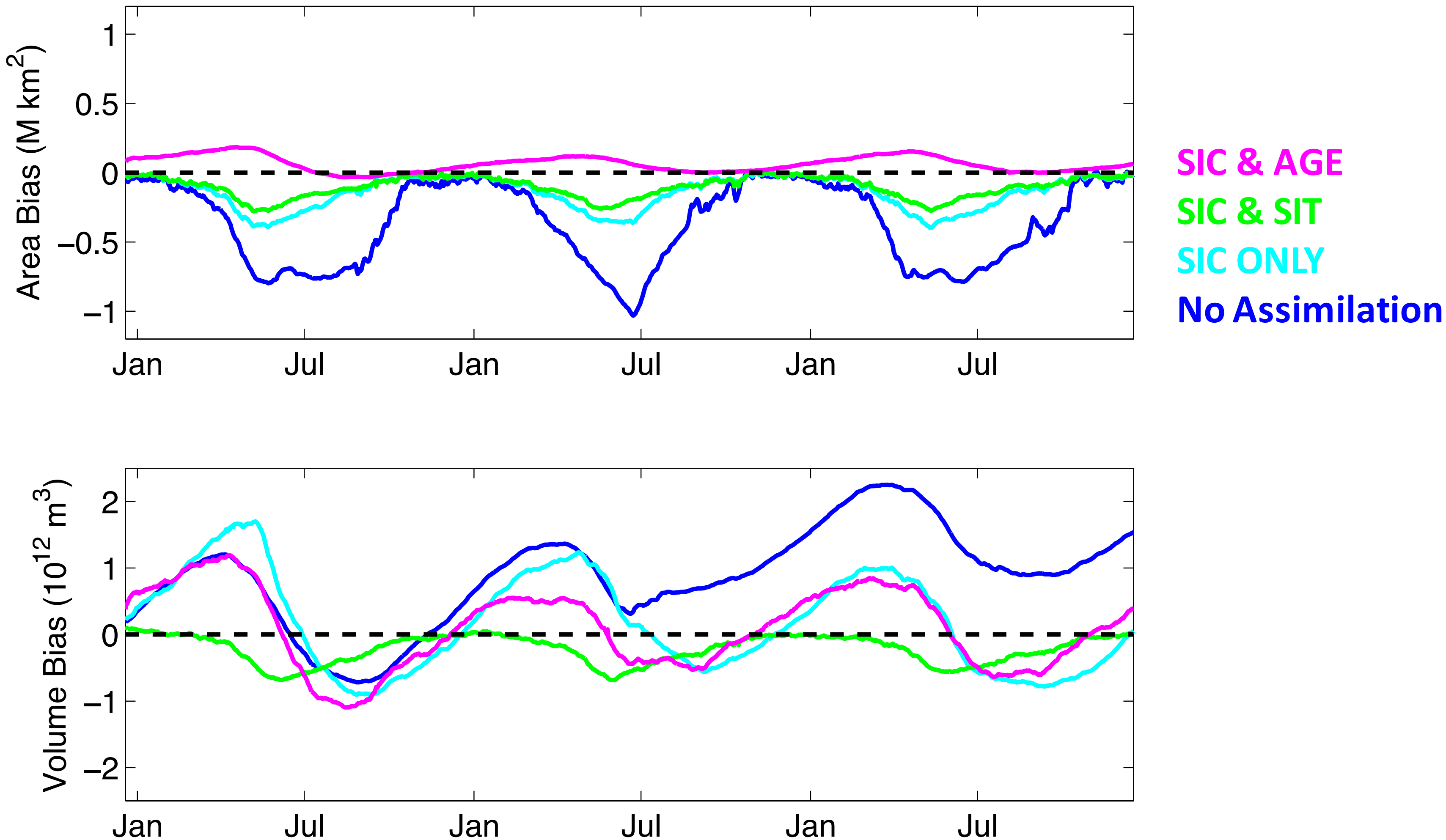
Assimilating SIC alone does LITTLE to reduce the bias

Assimilating thickness (SIT) is essential to reduce the bias

Assimilating AGE instead of SIT is reasonably successful too



Bias of Pan-Arctic Area and Volume



#2) NWS - Model Enhancement Project

Liu (SUNY-Albany) and **Grumbine** (NCEP/EMC) will examine improving seasonal predictability and prediction of Arctic sea ice and associated feedbacks on mid- and high-latitude climate in CFSv2.

- Assimilate the newly available satellite-based sea ice thickness in the Arctic for sea ice initial conditions for the CFSv2.
    - processed and interpolated NASA and ESA satellites (ICESat, CryoSat-2 and SMOS) to the regular grid, making them ready for assimilation.
- Incorporate a prognostic model of melt ponds in the sea ice model component of the CFSv2, which allows for changing pond conditions, with implications for the ice-albedo feedback.
- Implement a more incremental modification of the existing radiative transfer scheme used in the sea ice model component of the CFSv2, and integrate it with the melt pond model.

#3) GFDL Model Formulation Initialization

Rym Msadek, Mitch Bushuk, Gabe Vechi and **Mike Winton** (GFDL) assess the impact of model formulation and model resolution on Arctic sea ice variability and regional predictability.

<u>Recent Paper</u>: "Summer Enhancement of Arctic Sea-Ice Volume Anomalies in the September-ice Zone" 2017 Journal of Climate

- Arctic sea-ice thickness (SIT) is a potential source of predictability for summer sea-ice extent (SIE).
- Using FLOR with SIS1, looked at Arctic sea-ice volume anomalies in a 700-year control integration and a suite of initialized ensemble forecasts.
- Analysis is focused on the September sea-ice zone, where thickness anomalies have potential to impact the SIE minimum.

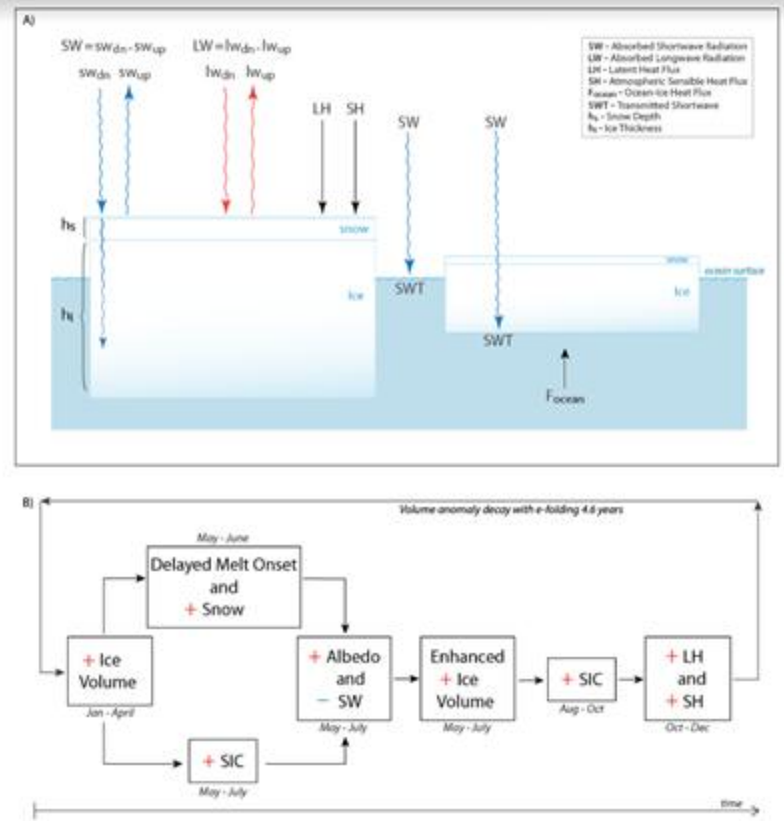


FIG. 11. (A): Schematic of the heat fluxes in the surface energy budget. (B): Summary of the mechanism for summer enhancement of sea-ice volume anomalies.

- Sea-ice volume anomalies display a summer enhancement in which anomalies tend to grow between the months of May and July.
- This indicates a promising potential for improvements in winter and spring SIT initialization to impact and improve seasonal forecasts of September sea ice.
- This highlights the crucial importance of accurate SIT initialization and representation of ice-albedo feedback processes in seasonal forecast systems

Details on all 11 Projects and Abstracts

www.cpo.noaa.gov/cvp, funded projects "2015"

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Climate Divisions > Earth System Science and Modeling > Climate Variability and Predictability > Funded Projects

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Funded Projects

Browse records in Year Initially Funded that start with 2015 Search Reset Search

Sort by: Title | Principal Investigator (s) | Program (s) | Year Initially Funded

Oceanographic controls on Arctic sea ice and its future evolution

View Abstract

Principal Investigator (s): Anand Gnanadesikan & Thomas Haine, Johns Hopkins University

Keywords:

Year Initially Funded:	2015
Award Number:	NA15OAR4310172
Program (s):	Climate Variability and Predictability
Competition:	Understanding Arctic Sea Ice Mechanisms and Predictability
Publications:	View on Google Scholar

Advancing understanding of sea ice predictability with sea ice data assimilation in a fully-coupled model with improved region-scale metrics

View Abstract

Principal Investigator (s): Cecilia Bitz, University of Washington; Adrian Raftery, University of Washington

Year Initially Funded:	2015
Award Number:	NA15OAR4310161
Program (s):	Climate Variability and Predictability
Competition:	

About Climate Variability & Predictability (CVP)

The Climate Program Office (CPO) manages competitive research programs in which NOAA funds high-priority climate science, assessments, decision support research, outreach, education, and capacity-building activities designed to advance our understanding of Earth's climate system, and to foster the application of this knowledge in risk management and adaptation efforts. CPO-supported research is conducted in regions across the United States, at national and international scales, and globally.

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Contact Us

Sandy Lucas, *CVP Program Manager*

Email: sandy.lucas@noaa.gov

Project Titles

Advancing understanding of sea ice predictability with sea ice data assimilation in a fully-coupled model with improved region-scale metrics (Bitz, Raftery)

Seasonal to interannual variability and predictability of Arctic summertime sea ice associated with tropically forced planetary wave patterns (Ding, Schweiger Battisti, L'Heureux , Zhang)

Oceanographic controls on Arctic sea ice and its future evolution (Gnanadesikan, Haine)

Improving seasonal predictability and prediction of Arctic sea ice and associated feedbacks on mid- and high-latitude climate in CFSv2 (Liu, Wu, Grumbine)

Assessing the impact of model formulation and resolution on Arctic sea ice variability and regional predictability (Msadek , Vecchi, Winton)

Extreme moisture transport (atmospheric rivers) into the Arctic and its effect on sea-ice concentration (Magnusdottir)

Using Snow Cover to Advance Sea Ice Forecast Models (Stroeve, Serreze, Slater)

Sea Ice Mechanics and Ice Thickness Distribution: Development, Evaluation & Application of an Elastic Decohesive Sea Ice Model (Sulsky)

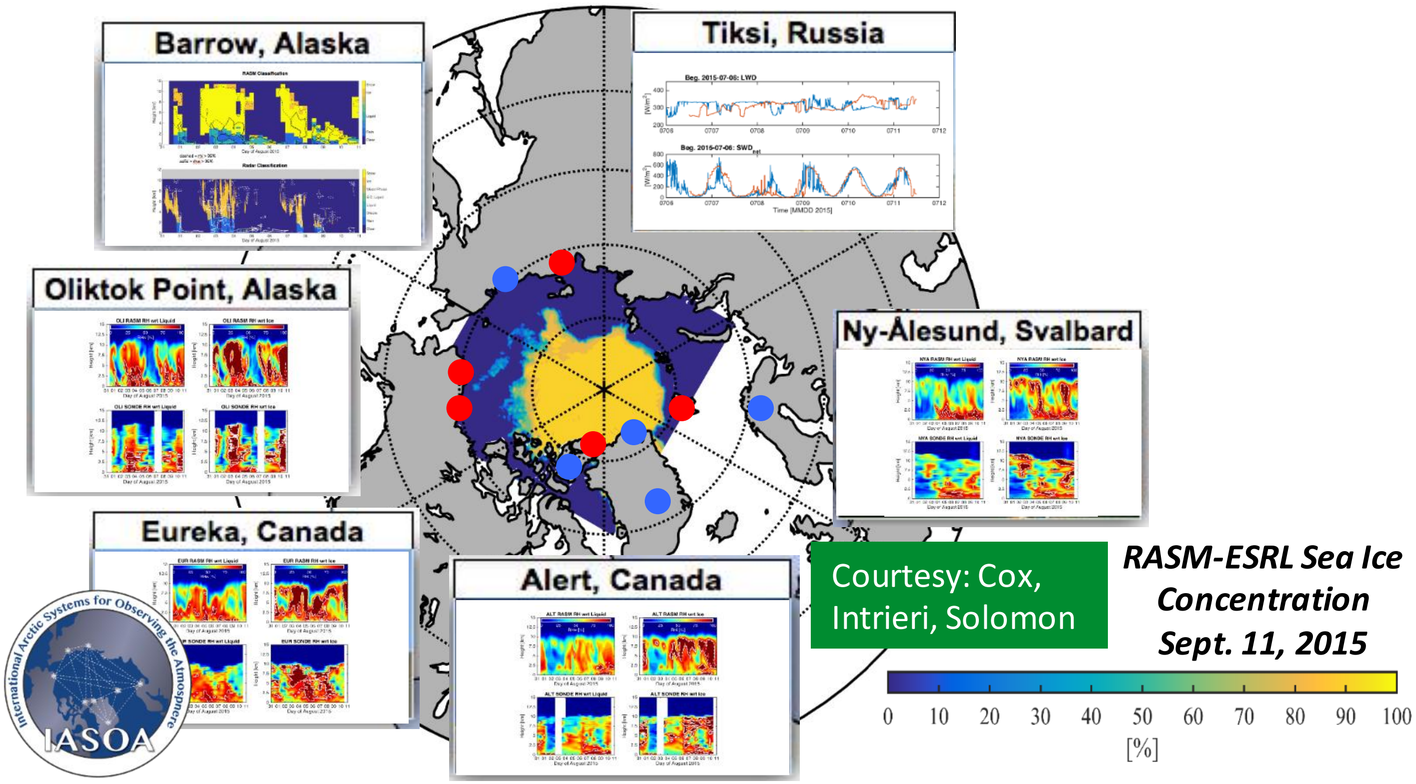
The predictability of extreme Arctic sea ice variations in a rapidly changing climate (Vavrus, Holland, Wang)

An analog system to enhance seasonal predictions of sea ice (Walsh)

Improving Initialization of Arctic Sea Ice in NCEP's Climate Forecast System for Advancing Long-Range Predictions (Wang, Zhang, Kumar)

EXTRA MATERIAL - Discussion

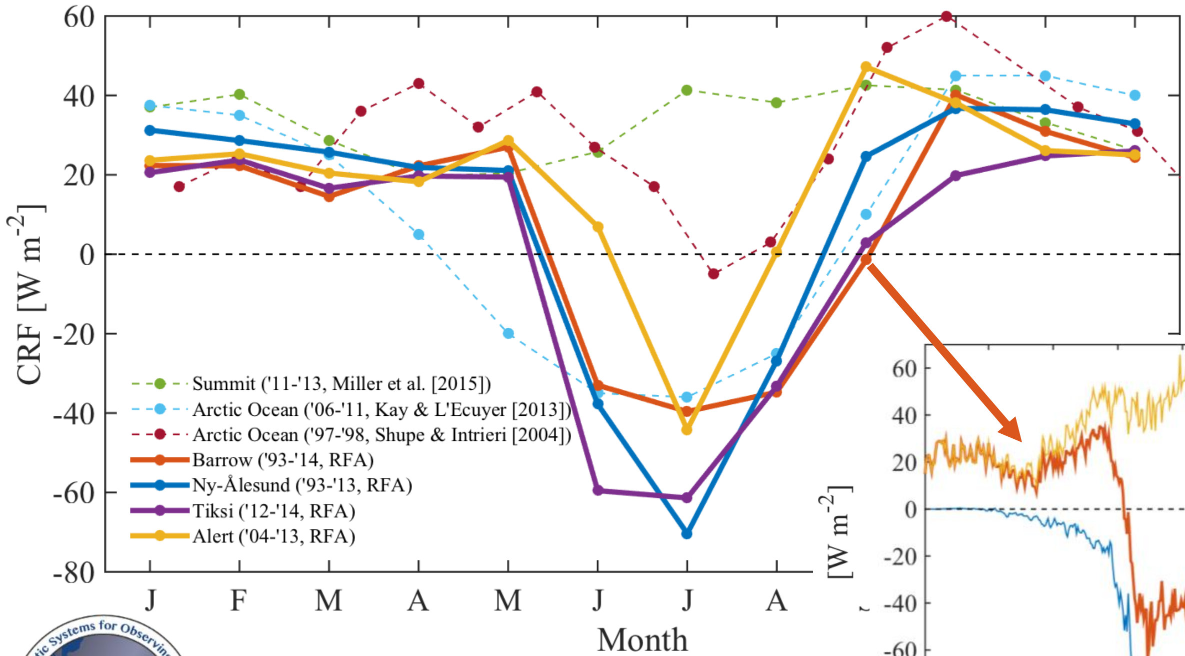
Experimental Sea Ice Forecast – Validating Atmospheric Forcing

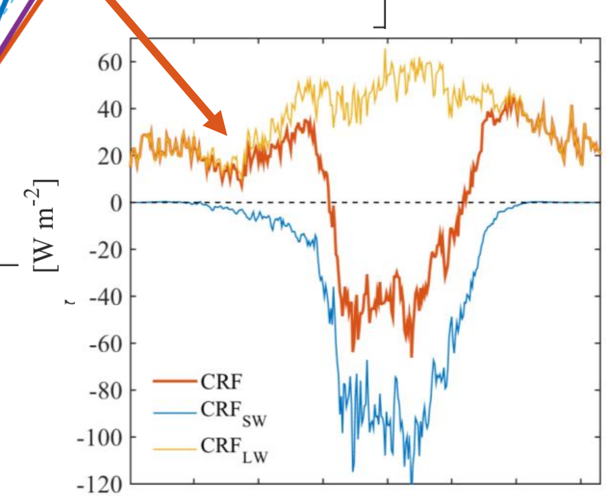


Courtesy: Cox, Intrieri, Solomon

RASM-ESRL Sea Ice Concentration Sept. 11, 2015

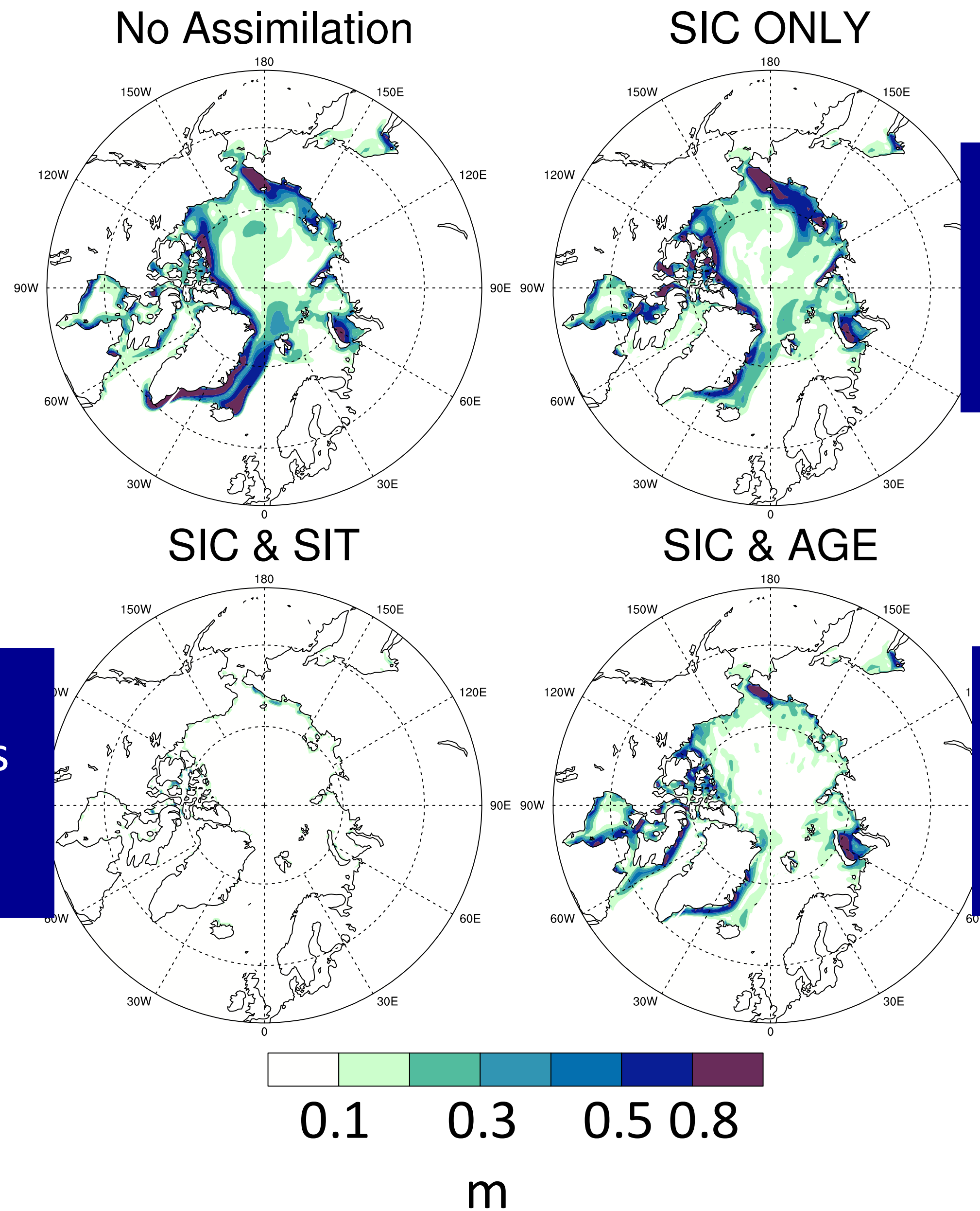
Assessing the Regional Variability in Cloud Radiative Forcing





Courtesy: C. Cox

Sea Ice Thickness (SIT) RMSE – April-May



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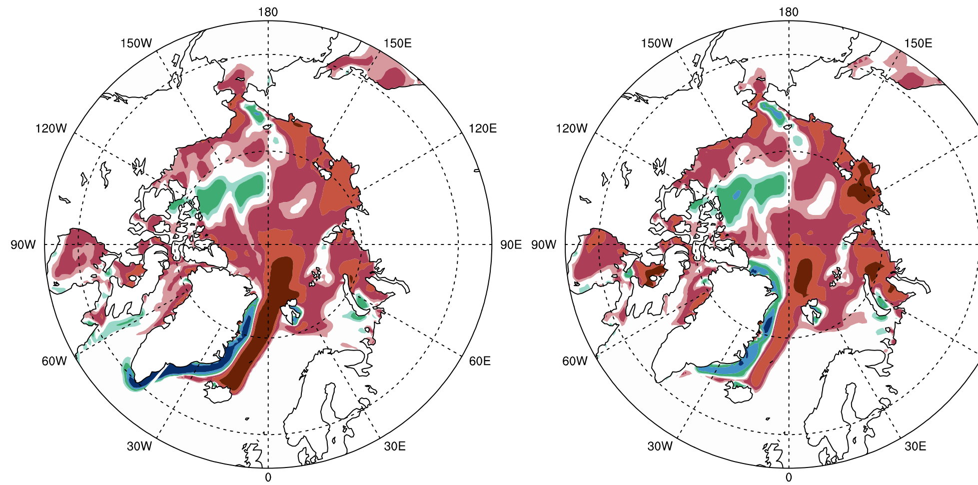
Assimilating AGE instead of SIT is reasonably successful too

Snow Depth Bias – April-May

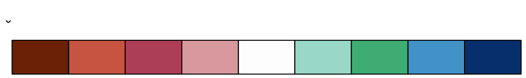
No Assimilation | SIC ONLY



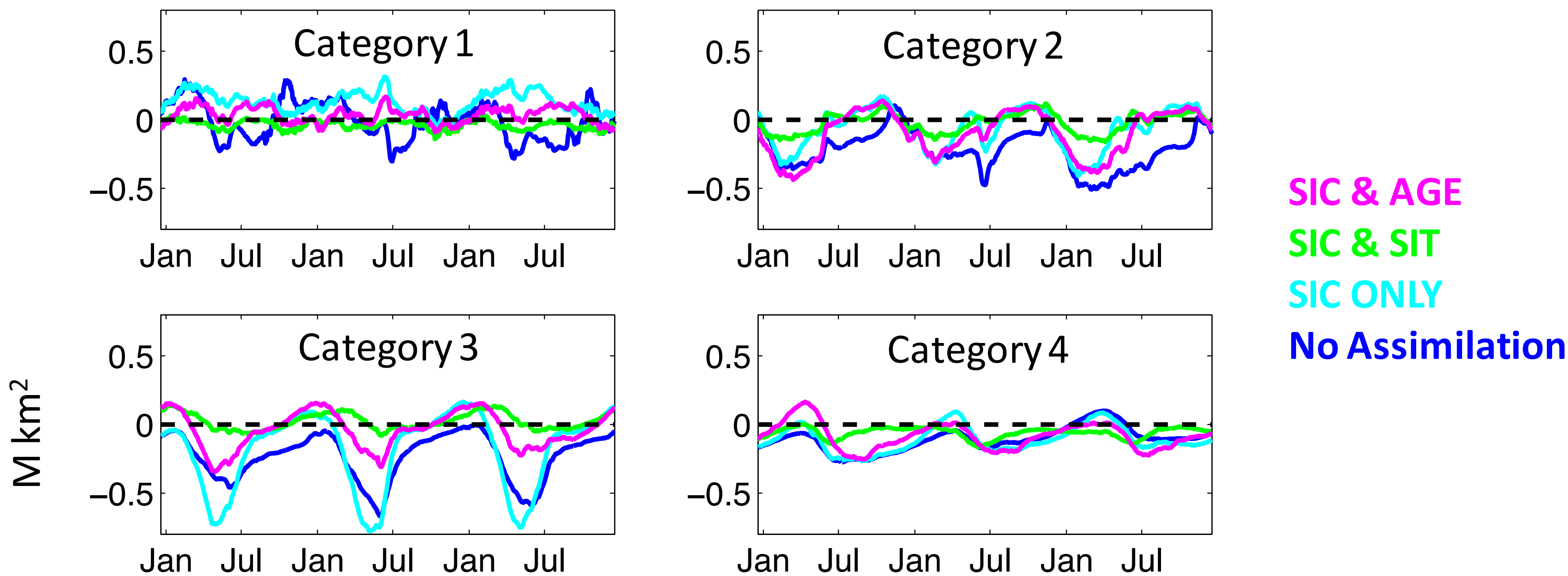
Assimilating SIC alone does LITTLE to reduce the bias

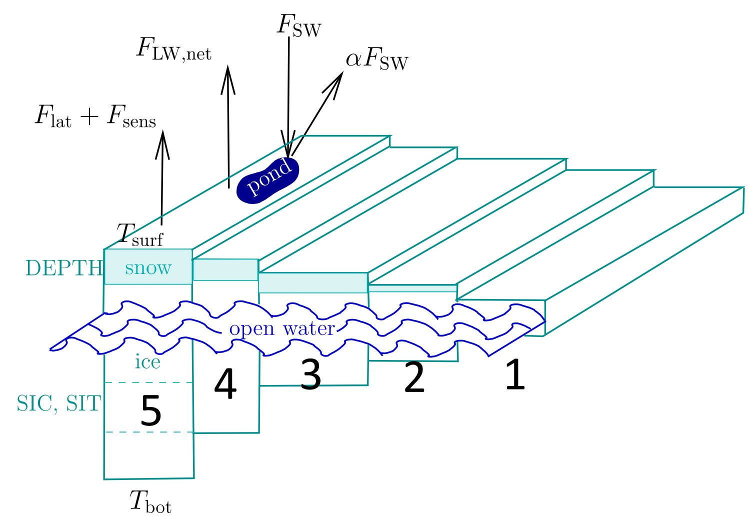
Assimilating thickness (SIT) is an improvement

Assimilating AGE instead of SIT does little



Bias of Pan-Arctic Area By Category





Summary

We successfully combined observations with CICE5 using EnKF

To reconstruct thickness with data assimilation

Sea ice concentration only	Does a poor job
Including sea ice **thickness**	**Is Excellent**
First-year ice concentration instead of thickness	Is Good

What's next? – test necessary data coverage, sea ice state estimate starting in 1999, forecast

Observations needed most: sustained measurements of thickness, first-year ice concentration, snow depths, and concentration

NWS - Atm Circulation/Impacts on Sea Ice

Ding (U Washington/UCSB), **L'Heureux** (CPC) and co-PIs investigate how teleconnections between tropical SSTs and high latitude circulation patterns can be exploited for sea ice predictions.

Recent Paper: "Influence of high-latitude atmospheric circulation changes on summertime Arctic sea ice " (2017) Nature Climate Change 10.1038/nclimate3241 (Qinghua Ding, Axel Schweiger, Michelle L'Heureux, David S. Battisti, Stephen Po-Chedley, Nathaniel C. Johnson, Eduardo Blanchard-Wrigglesworth, Kirstin Harnos, Qin Zhang, Ryan Eastman & Eric J. Steig)

- Connection between September sea-ice extent and the preceding summer (June–July–August, JJA) atmospheric circulation.
- Trends in summertime atmospheric circulation may have contributed as much as 60% to the September sea-ice extent decline since 1979. A tendency towards a stronger anticyclonic circulation over Greenland and the Arctic Ocean with a barotropic structure in the troposphere increased the downwelling longwave radiation above the ice by warming and moistening the lower troposphere.
- Model experiments (ECHAM5), with reanalysis data constraining atmospheric circulation, replicate the observed thermodynamic response and indicate that the near-surface changes are dominated by circulation changes rather than feedbacks from the changing sea-ice cover.
- Internal variability dominates the Arctic summer circulation trend and may be responsible for about 30–50% of the overall decline in September sea ice since 1979.

CVP/NWS Initialization Project

Wanqiu **Wang** (CPC) and Jinlun **Zhang** (U Washington) will work towards improving initialization of arctic sea ice in NCEP's climate forecast system for advancing long-range predictions.

- Analyzed errors in the initial CFSR sea ice extent and sea ice volume which adversely affect the sea ice prediction in the CFSv2.
- Carried out experiments to the impact of model physics and initialization.
- Conducted PIOMAS runs from March 2015 to April 2016 and provided PIOMAS sea ice thickness distribution fields as initial conditions for CFSv2 seasonal experimental sea ice forecast. This will be continued regularly for each month for comparison with the NCEP operational CFSv2 forecast.
- Explored the possibility of using CFS forecast data to force PIOMAS sea ice seasonal forecast. This work is ongoing. Carried out experimental forecasts initialized from March 2015 to April 2016 using PIOMAS initial sea ice thickness and the improved forecast system with modified treatment for atmospheric stratus clouds and ocean water/ice heat flux.

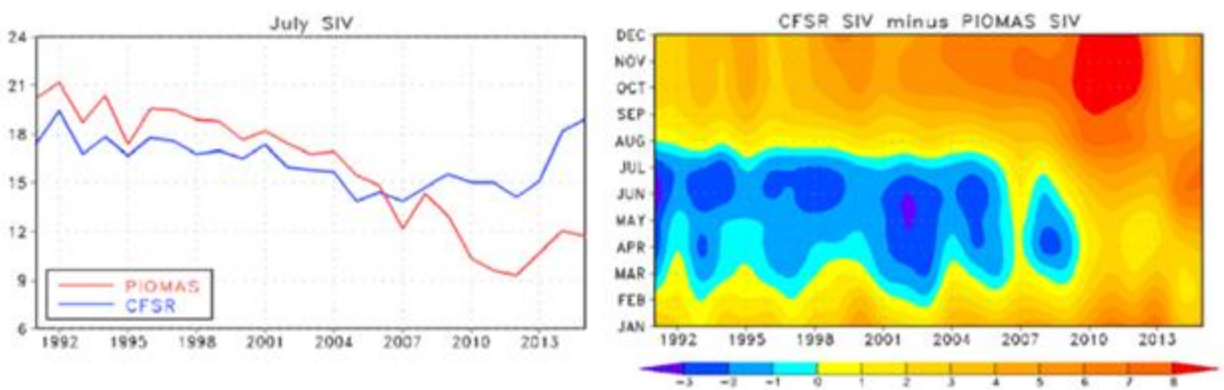


Fig.2. Left: July total sea ice volume (SIV, 10^3 km^3) from CFSR (blue) and PIOMAS (red). Right: differences in SIV between CFSR and PIOMAS.