Update: Ocean/Ice shelf interactions

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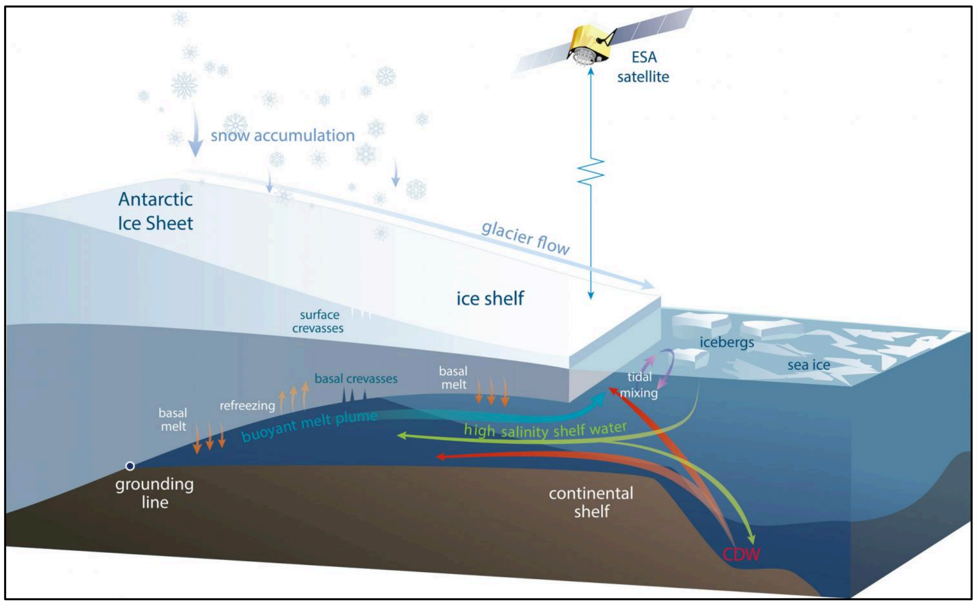

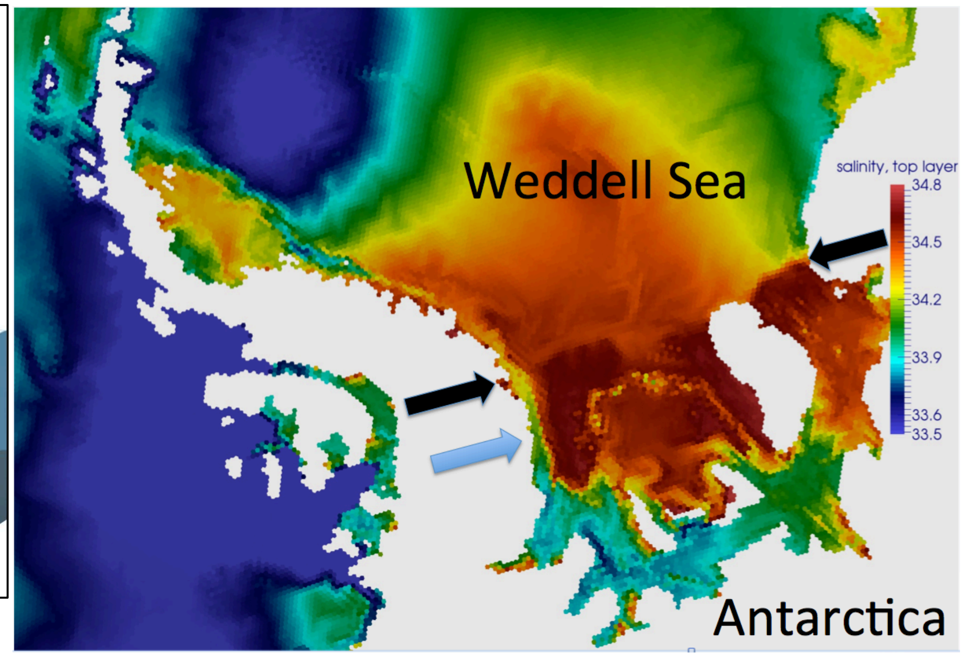

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Status of ACME ocean / ice shelf simulations

- Static ice shelves functioning in MPAS-Ocean since May 2016
- Simulations underway:
  - G-Case (active ocean/sea ice, CORE-II forced data atmosphere)
  - B-Case (active ocean, sea ice, atmosphere, land)
  - Low resolution and medium resolution (EC60o30 and RRS30to10 ocean)
- Runs from ACME master
- MPAS-Ocean not yet capable of running with dynamic ice shelves. We still need wetting/drying of ocean columns, moving grounding lines, steeply tilted layers.
- Highlight: CORI-KNL early access 10 year simulation at mid-resolution
- Highlight: ALCC proposal granted 87 million CPU hours

Highlight: Cori-KNL simulation, 10 year, medium resolution

- CORI-KNL early access, Dec 2016
- Led by Noel Keen at LBL
- G-Case CORE-forced medium resolution (RRS30to10).
- 10 year simulation
- 301 nodes: 150 ICE/CPL, 150 OCN, 1 for others. Get 1.8 to 2 SYPD

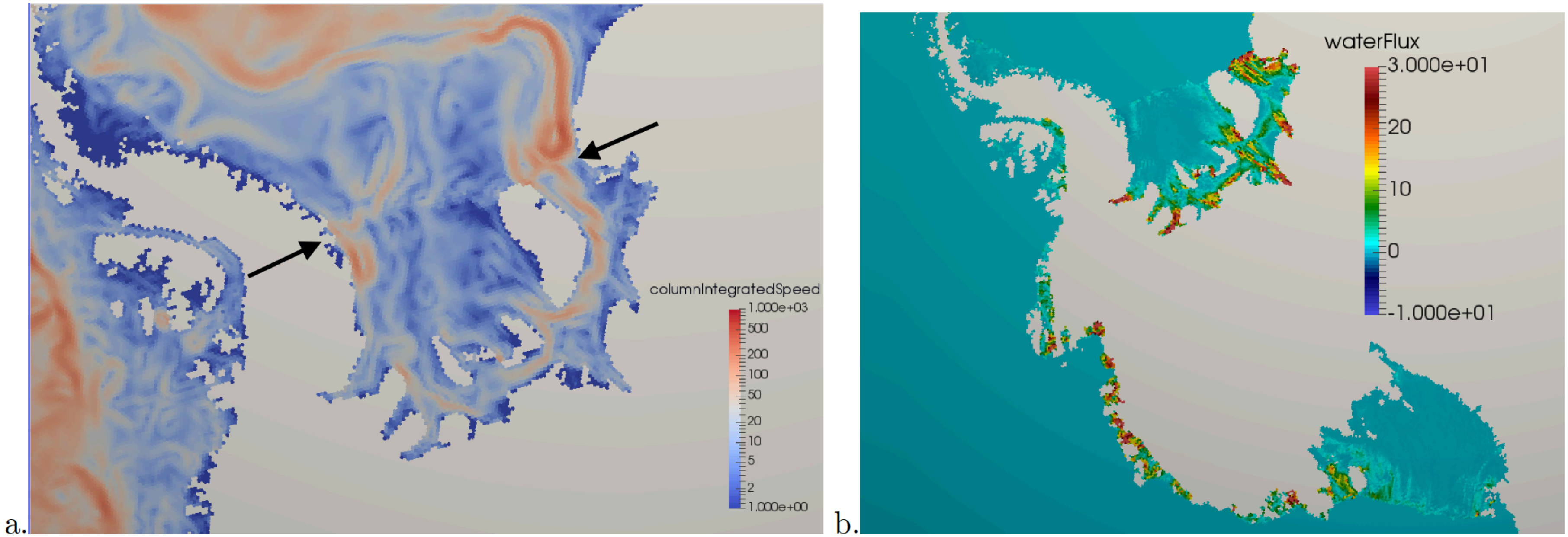


Figure 1: A view of sub-ice shelf statistics after ten years of the Cori-KNL simulation: (a) Column-integrated speed [m^2/s] shows ocean currents that extend from the open ocean to below the ice shelf. The black arrows indicate the edge of the Filchner-Ronne ice shelf. (b) Rate of ice melt from the bottom of the ice shelf into the ocean, in meters of water per year.

Highlight: 2017 ALCC on Ice-Shelf/Ocean Interactions

- Title: Understanding the Role of Ice shelf-Ocean Interactions in a Changing Global Climate
- Mark Petersen (PI), with Stephen Price, Todd Ringler, Jones Philip, Luke Van Roekel, Jeremy Fyke, Xylar Asay-Davis, Phillip Wolfram
- Purpose:
  - Compare to observations
  - Tune and adjust model and initial conditions
  - Altered Southern Ocean wind experiment
  - Advanced analysis, including Lagrangian Particles
- July 2017 to June 2018

Cori-I/Edison	35M core-hrs	NERSC	
Cori-II KNL	25M	NERSC	
Theta	25M	Argonne	
Titan	2M	Oak Ridge	

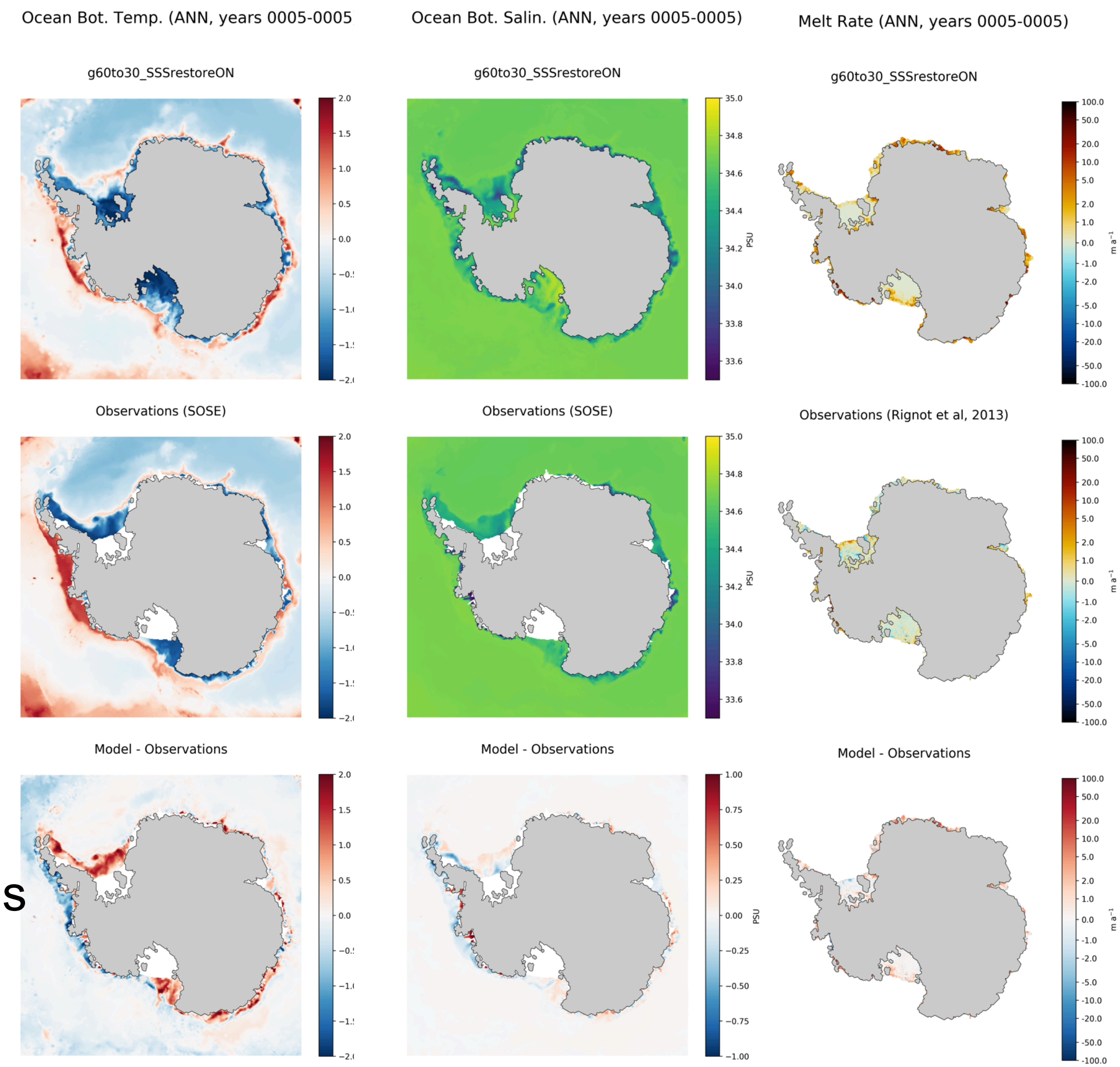
Current simulations: G-case, low rez, on edison

- Model ocean below ice shelf is too warm, producing higher melt rates.

Model:

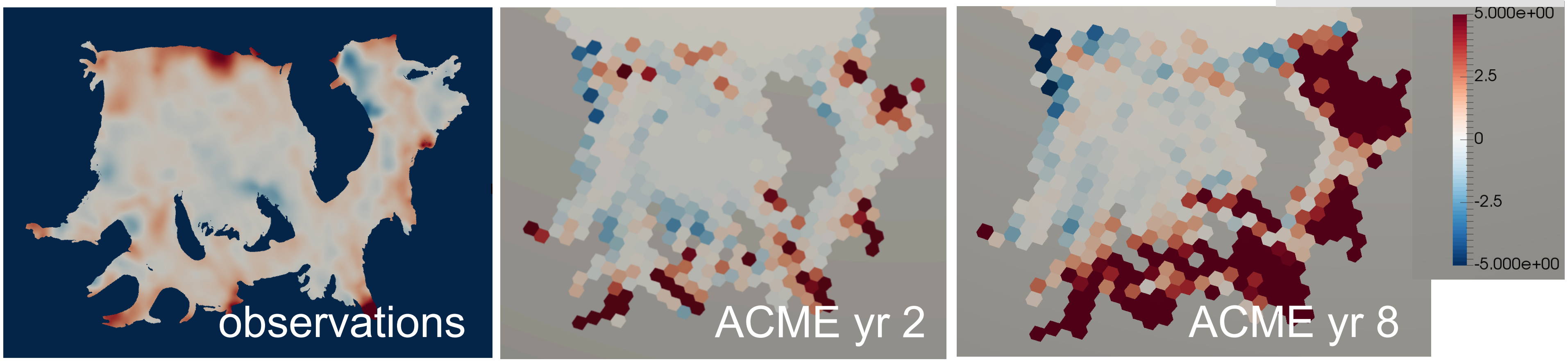
Observations:
(SOSE)

Model - observations



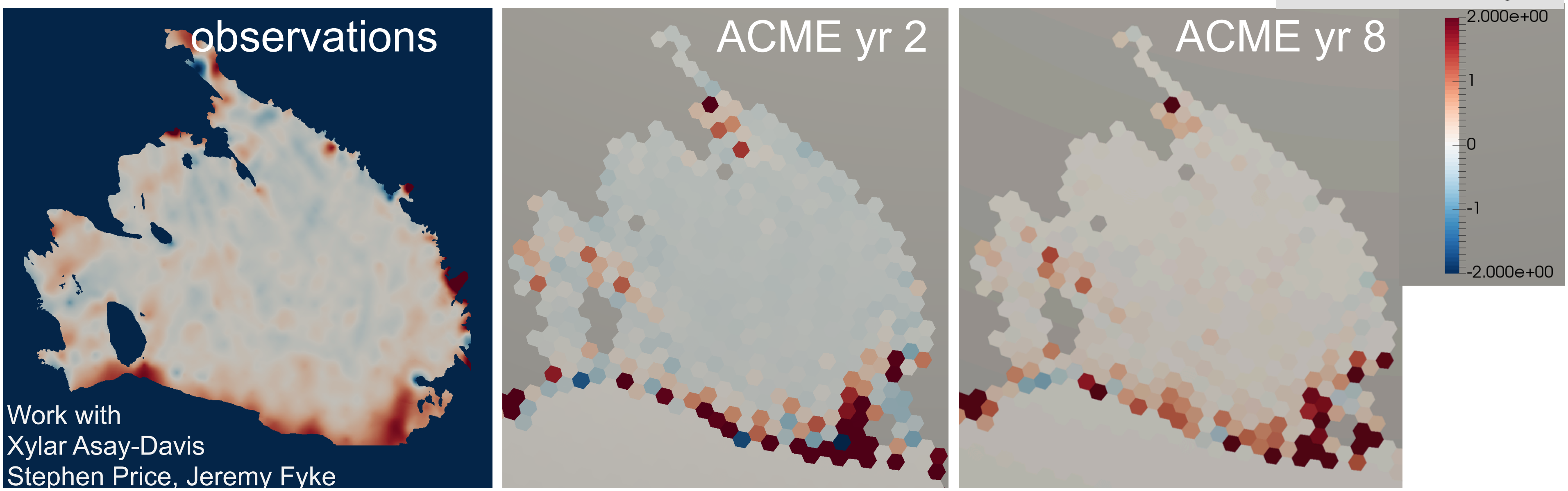
Comparing Melt Rates to Observations

Filchner-Ronne Ice Shelf



after Moholdt et al.
(*GRL*, **119**, 2014)

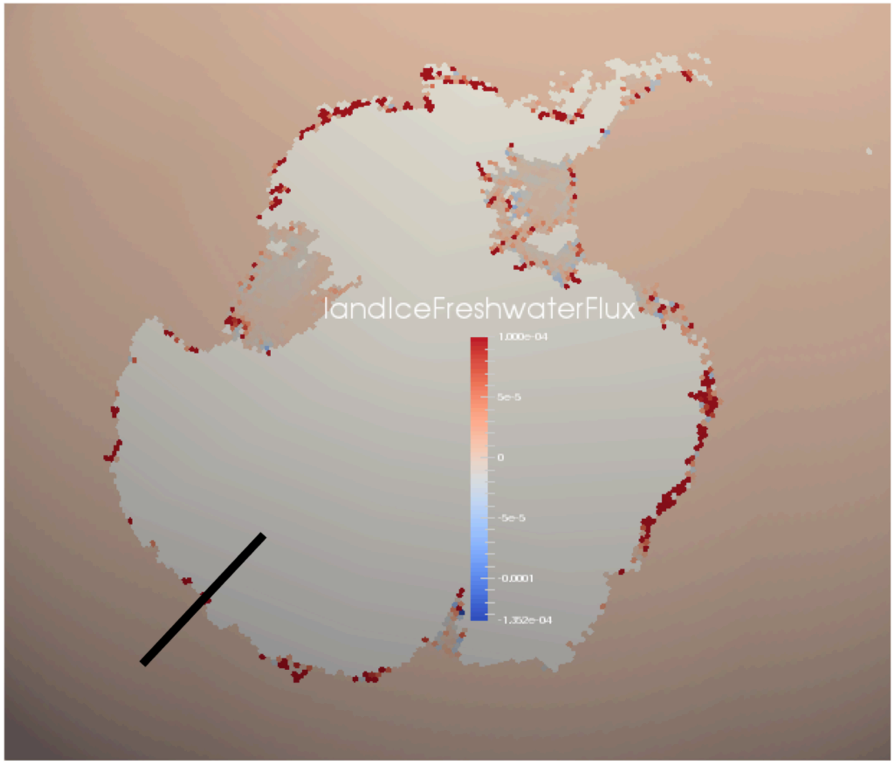
Ross Ice Shelf

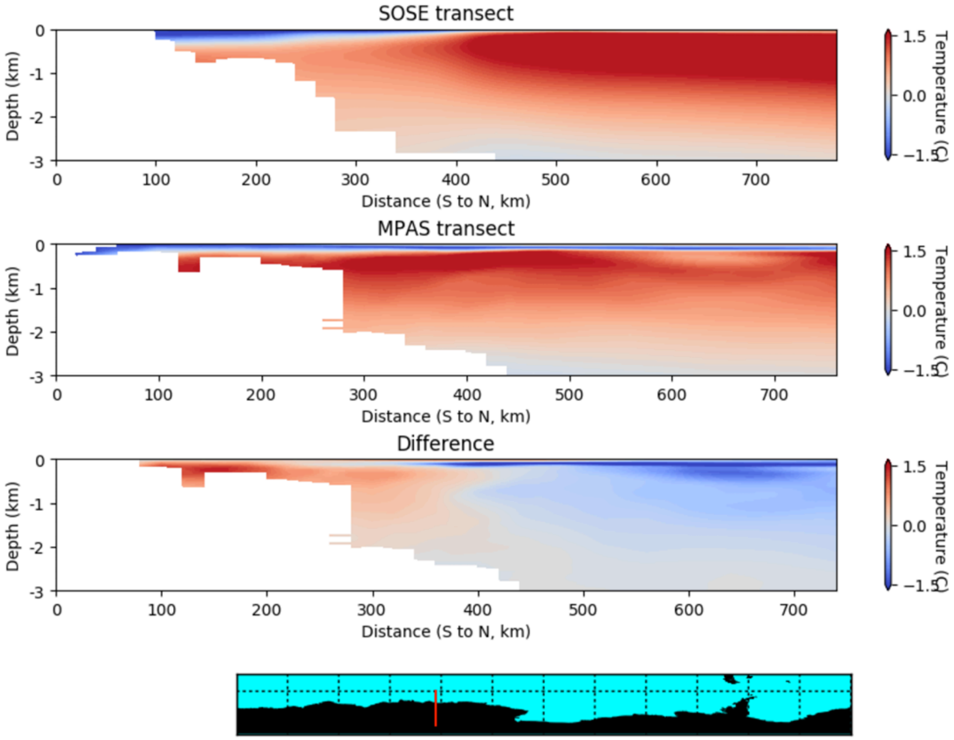


Current simulations: G-case, low rez, on edison

- Cross-section tool, created by Jeremy Fyke

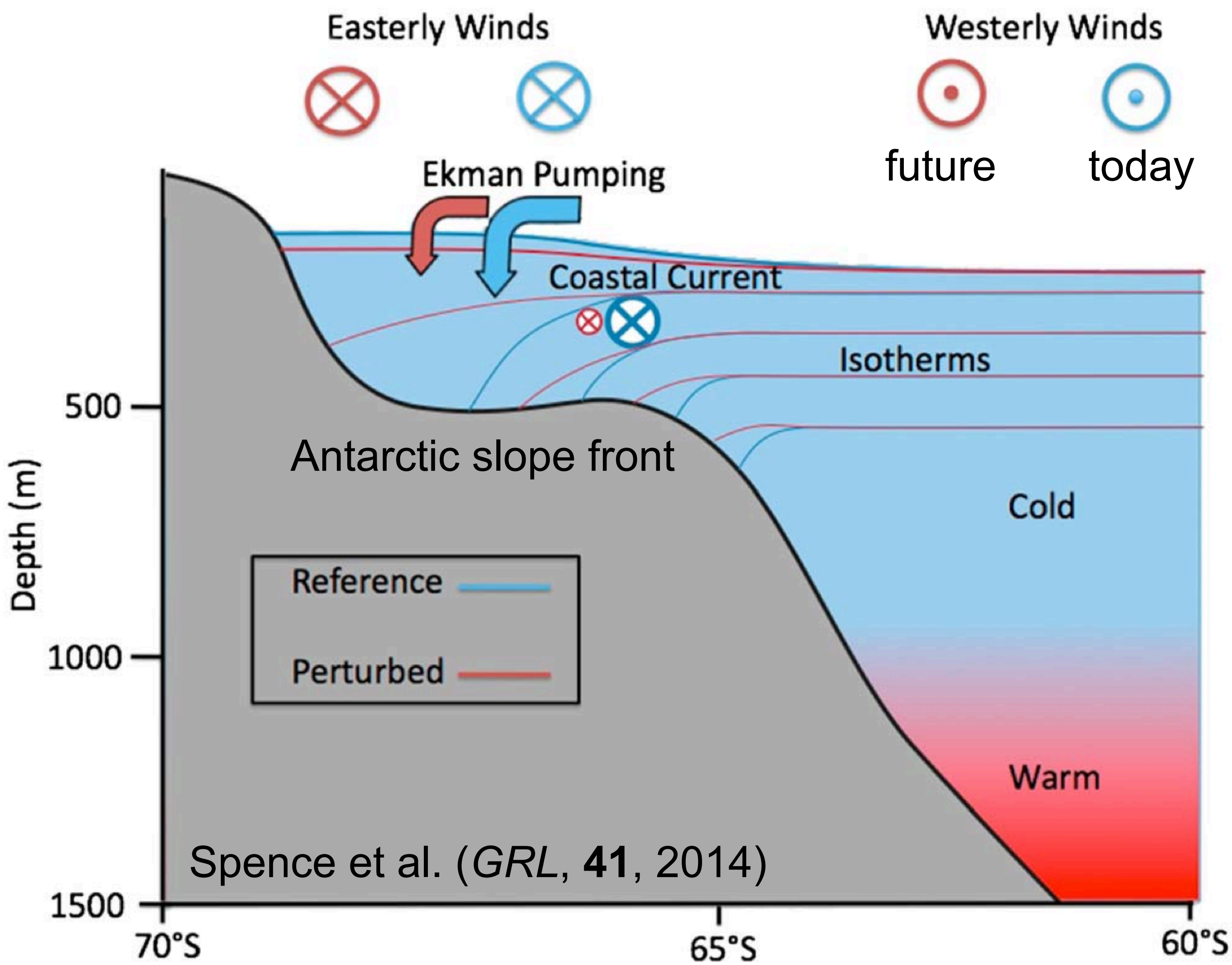
- **Analysis:**
  - ec60to30-based B-compset with ice shelves
    - Year 10 against SOSE 2005-2010 climatological annual average





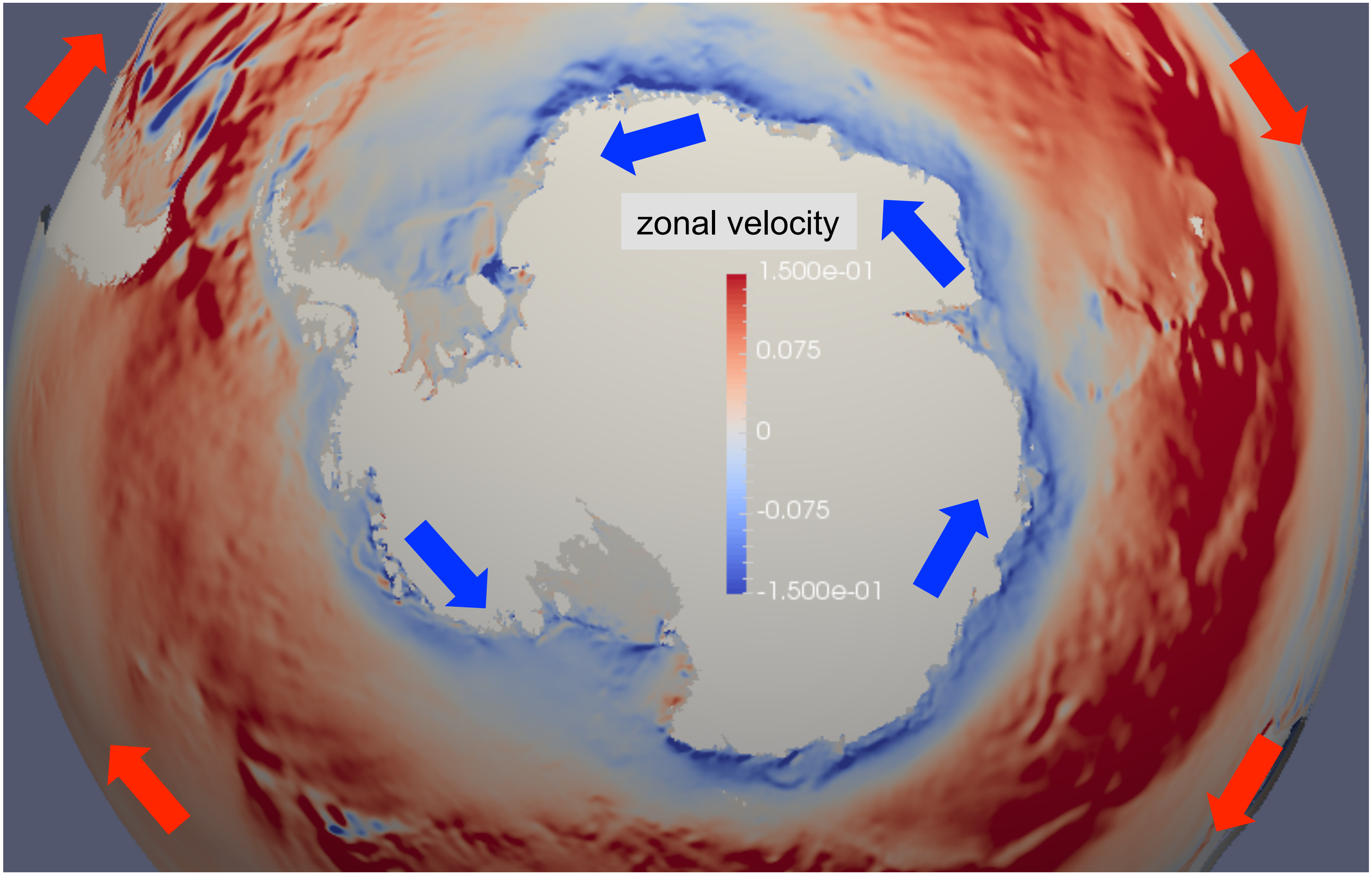
https://docs.google.com/presentation/d/1GLM5ZrVWXVmk0mhmr24FbU3-bahn05CtvzxCQr7pVIQ/edit#slide=id.g1d8200cf2f_0_35

An experiment with perturbed winds



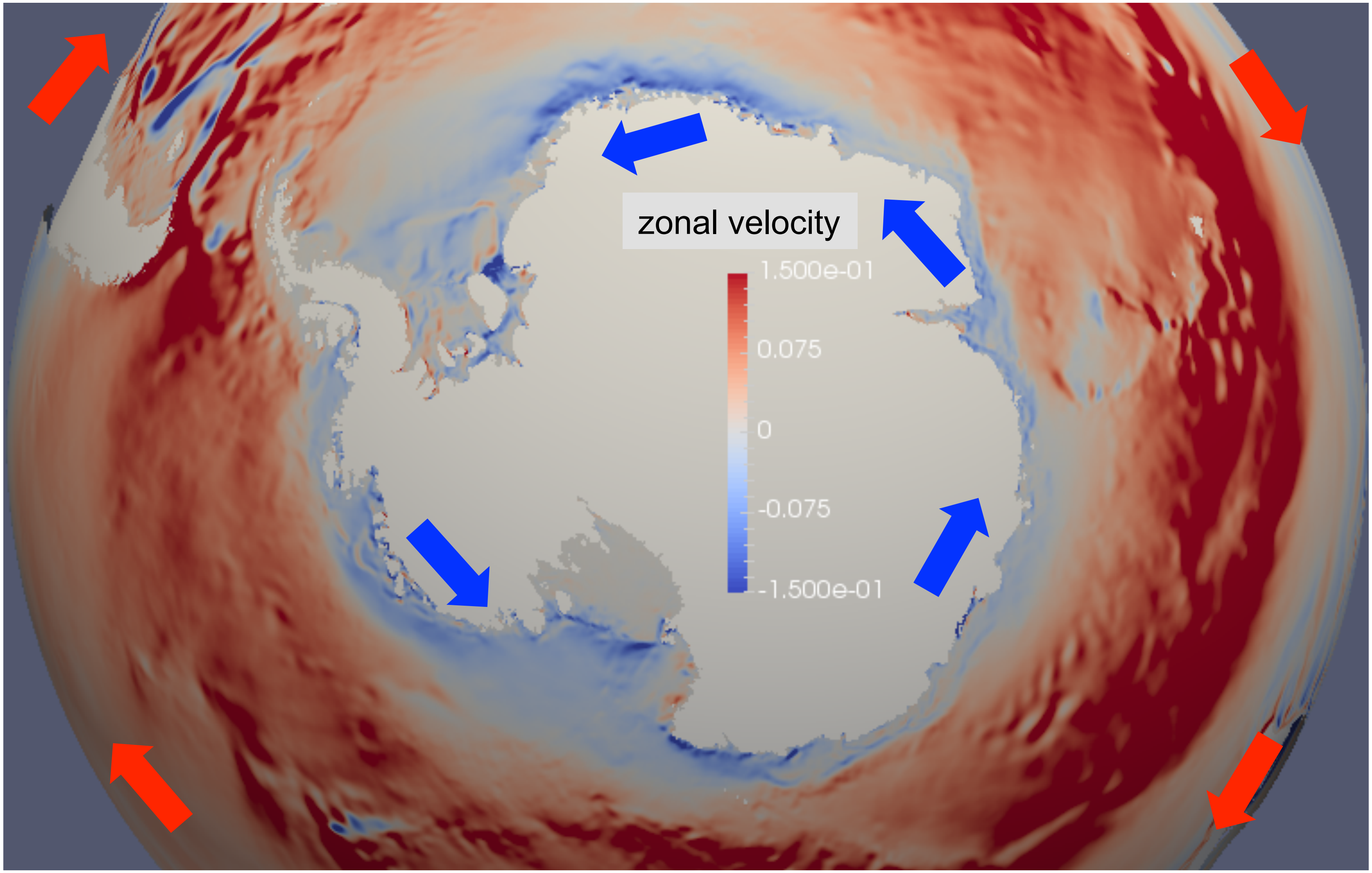
1. Winds move south
2. Westward currents weaken
3. Isotherms lift along coast (Antarctic slope front flattens)
4. Warmer water increases ice shelf melt rates.

Control: Historical winds



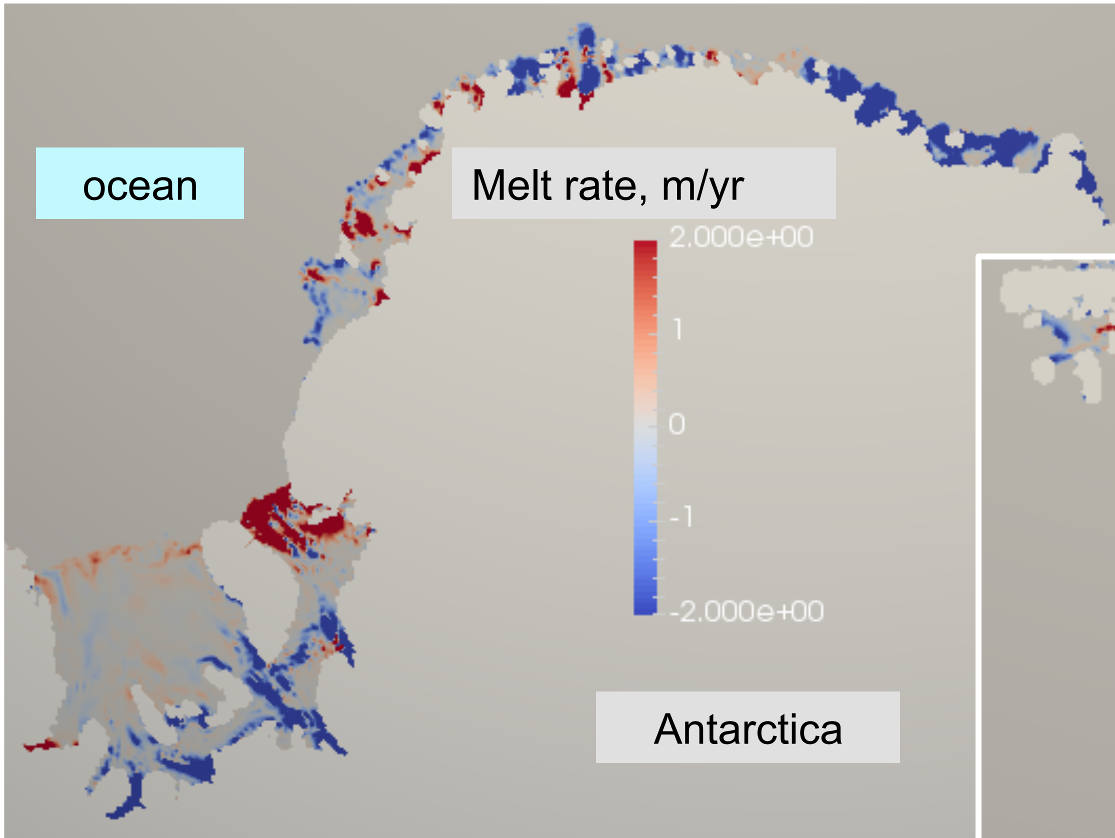
Work with Xylar Asay-Davis, Stephen Price, Jeremy Fyke, Noel Keen

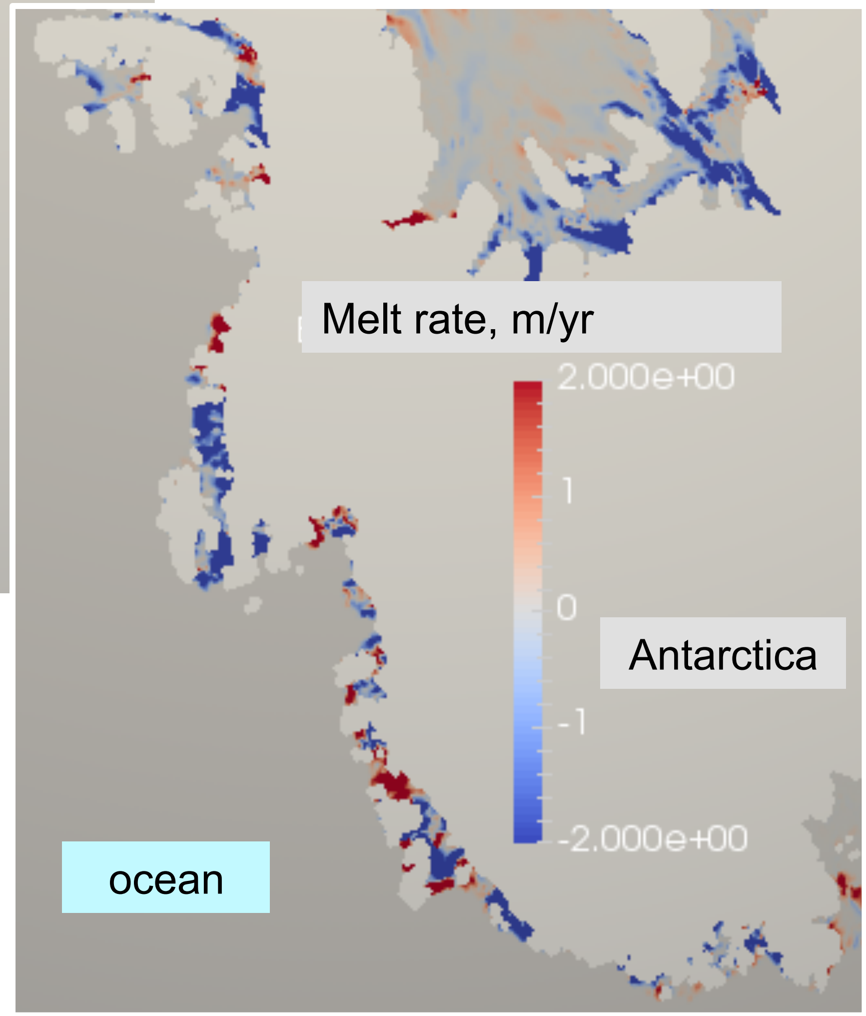
Experiment: Perturbed winds



Work with Xylar Asay-Davis, Stephen Price, Jeremy Fyke, Noel Keen

Melt rates below ice shelf (perturbed minus control)





Blue: melt rates are higher in the perturbed experiment, which is what we expect to see because more warm water is on the shelf

Work with Xylar Asay-Davis, Stephen Price, Jeremy Fyke, Noel Keen

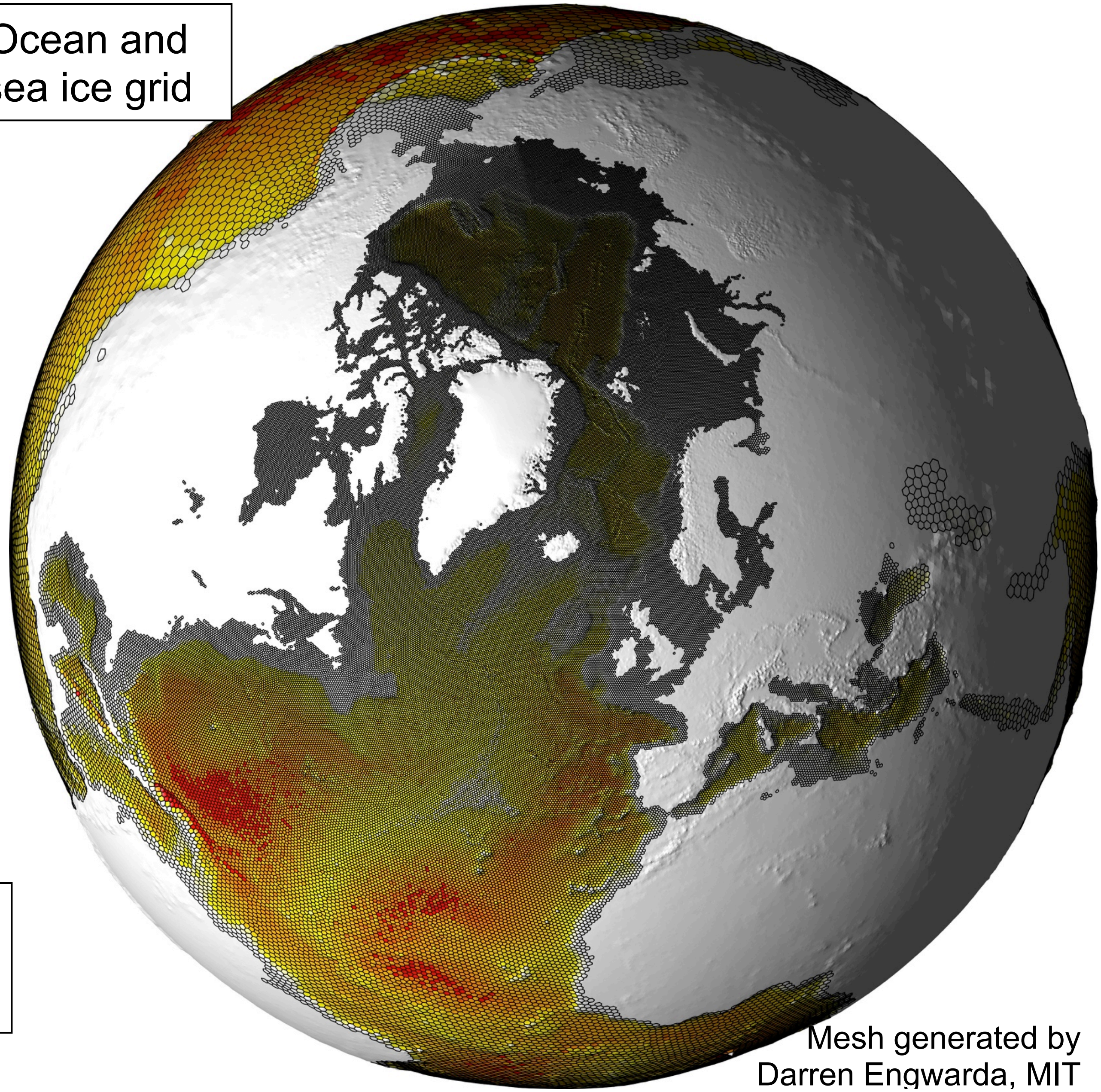
Proof of concept: ACME Arctic Enhanced Mesh

Ocean and sea ice grid

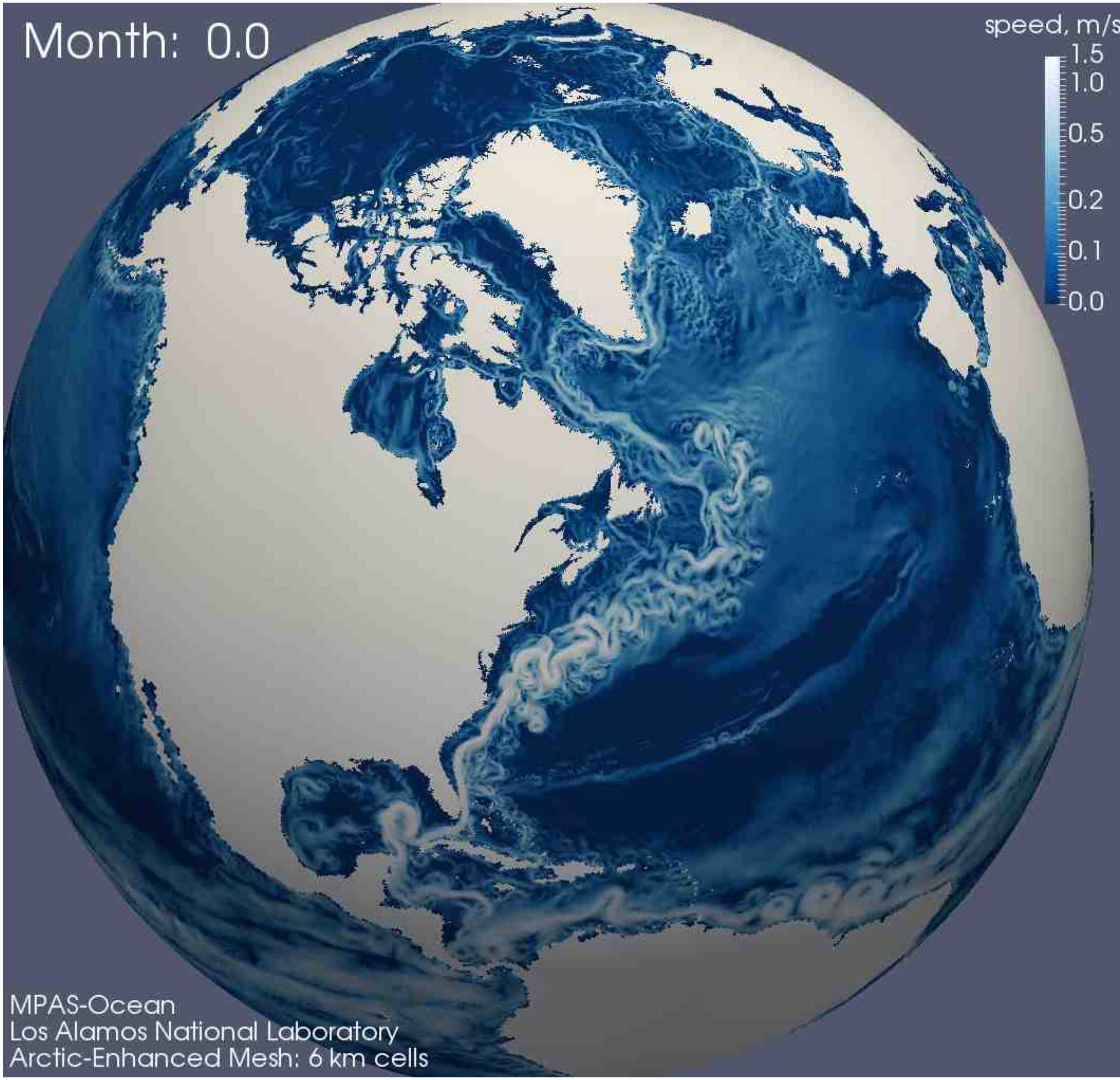
High resolution Artic
6 km cells

Mid-resolution N. Atlantic,
10-20 km cells

Low resolution Pacific and
southern hemisphere
30 to 60 km cells



Mesh generated by
Darren Engwarda, MIT


Month: 0.0
speed, m/s
1.5
1.0
0.5
0.2
0.1
0.0
MPAS-Ocean
Los Alamos National Laboratory
Arctic-Enhanced Mesh: 6 km cells

Highlight: Publications by Xylar Asay-Davis

- **Asay-Davis, X. S**., + 13 co-authors (2016):
  Experimental design for three interrelated marine ice sheet and ocean model intercomparison projects:
  MISMIP +, ISOMIP + and MISOMIP1.
  Geoscientific Model Development, *9*(7), 2471–2497.

- Dinniman, M.S., X.S. **Asay-Davis**, B.K. Galton-Fenzi, P.R. Holland, A. Jenkins, and R. Timmermann. 2016.
  Modeling ice shelf/ocean interaction in Antarctica:
  A review. *Oceanography* 29(4):144–153,

Plan for coming year: ocean / ice shelf simulations

- Planning simulations for 87M cpu-hours, on four machines.
- Address biases at low resolution first (EC60to30). Why are melt rates too high?
- Create a Southern Ocean enhanced mesh
- Topics for publications:
  - Characterization and methods of MPAS-Ocean ice shelf cavities
  - How does the addition of ice shelf cavities effect the global circulation, in particular the Southern Ocean?
  - Perturbed wind experiment

Highlight: 2017 ALCC on Ice-Shelf/Ocean Interactions

Table 1: Resolutions of MPAS-Ocean and MPAS-Sea Ice. All have 100 vertical levels. The abbreviations correspond to the global mesh density function: gridcell size in RRS domains scale with the Rossby Radius of deformation in latitude; SO is enhanced Southern Ocean; EC is low resolution and requires an Eddy Closure parameterization.

resolution	maximum gridcell, km	minimum gridcell, km	horizontal gridcells $\times 10^6$	file size for one sim. month, GB
high: RRS18to6	18	6	3.7	106
medium: RRS30to10	30	10	1.4	40
enhanced: SO60to10	60	10	0.47	14
low: EC60to30	60	30	0.23	6

Table 2: Proposed number of simulated years for three simulations. The latter two include ice shelf (IS) cavities. "By ACME" denotes simulations that will be carried out by the core ACME effort, and are not included in this proposal's allocation.

Simulation	high resolution	medium resolution	enhanced Southern Ocean	low resolution
Standard: no IS cavities	by ACME	200	650	by ACME
Control: with IS cavities	125	200	650	1000
Perturbation: IS cavities, altered winds	125	200	650	1000
total	250	600	1950	2000

Highlight: 2017 ALCC on Ice-Shelf/Ocean Interactions

Table 3: Measured ACME performance, using active ocean/sea ice and data atmosphere.

resolution	platform	cores	SYPD	million CPU–hrs per simulated century
high: RRS18to6	Edison	1,200	0.2	14.1
high: RRS18to6	Cori KNL	26,000	1.2	52.0
high: RRS18to6	Titan	8,192	1.2	31.8
medium: RRS30to10	Edison	12,000	7.3	4.0
medium: RRS30to10	Cori KNL	17,000	2.5	16.3
low: EC60to30	Edison	6,500	22.0	0.7
low: EC60to30	Cori Haswell	3,000	7.5	1.0
low: EC60to30	Cori KNL	3,800	3.1	2.9

Table 4: Computing requirements of simulations in million CPU-hrs, based on measured performance and the partitioning amongst platforms described in the text. Compare to plan for simulated years in Table 2.

Simulation	high resolution	medium resolution	enhanced Southern Ocean	low resolution	total
Standard: no IS cavities	by ACME	13	11	by ACME	24
Control: with IS cavities	28	13	11	12	63
Perturbation: IS cavities, altered winds	28	13	11	12	63
total	56	39	32	23	150

Table 5: Allocation request

platform	million CPU–hrs
Edison & Cori Haswell	60
Cori KNL	40
theta	40
titan	10
total	150