ACCESS-OM2 update

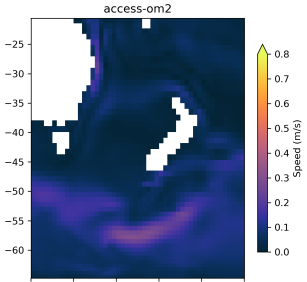
Andrew Kiss (ANU)
and many, many contributors
from the COSIMA community

Consistent global configurations at **three horizontal resolutions**

ACCESS-OM2

- not eddy-resolving
- 1° horizontal grid
  360 × 300 cells, 24–111 km
- 50 z^* levels
  Δz = 2.3–220 m
- fast and cheap

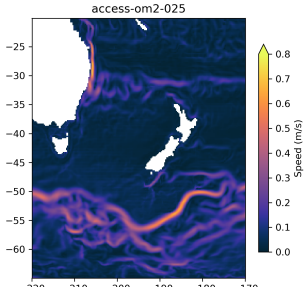
  ∼ 24min/yr, 0.1 kCPU hr/yr
  on 252 PEs, dt=5400 s
- suits many-century experiments



ACCESS-OM2-025

- eddy "permitting"
- 0.25° horizontal grid
  1440 × 1080 cells, 6.0–27.8 km
- 50 z^* levels
  Δz = 2.3–220 m
- fairly fast, less cheap

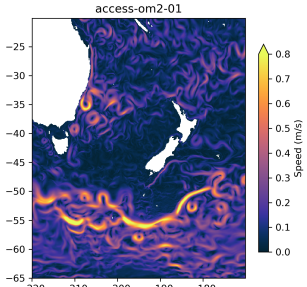
  105 min/yr, 4.5 kCPU hr/yr
  on 1824 PEs, dt=1800 s
- suits few-century experiments



ACCESS-OM2-01

- eddy-rich
- 0.1° horizontal grid
  3600 × 2700 cells, 2.2–11.1 km
- 75 z^* levels
  Δz = 1.1–198 m
- slow, expensive

  9 hr/yr, 55–65 kCPU hr/yr
  on 5096 PEs, dt=600 s
- suits multi-decade experiments



Linkages

The ACCESS-OM2 suite links Australia's climate modelling, ocean forecasting, and university oceanographic research communities:

- **ACCESS-OM2 at 1° is the ocean and sea-ice component used in the new ACCESS-CM2 coupled climate model**, as part of NESP Earth Systems and Climate Change Hub Project 2.1 "Preparing ACCESS for CMIP6" (Marsland, Bi, Dobrohotoff, Sullivan, Dias and Savita)
- **ACCESS-OM2-01 to be used for the next generation of Bluelink**, starting with reanalysis (BRAN2020), leading to OceanMAPSv4.0 with ocean and sea-ice ensemble data assimilation, extending Bluelink reanalyses and forecasts to global coverage, including sea ice (Sandery, Sakov, Brassington, Chamberlain, Divakaran, Oke, Fiedler, et al.)
- **ACCESS-OM2 code, multi-resolution configurations, inputs and outputs are freely available to researchers**

Research projects using the ACCESS-OM2 suite

1. **Advective and eddy-induced transports in global ocean heat & salt budgets**
   F. Boeira Dias, C. Domingues, S. Marsland, R. Matear, S. Rintoul, R. Fiedler, S. Griffies
2. **Tracer transport in thermodynamics coordinates**
   R. Holmes, J. Zika, M. England, C. Bladwell, M. Huguenin-Virchaux, P. Spence, K. Stewart, A. Hogg, S. Griffies
3. **Sensitivity of Southern Ocean heat and momentum uptake to vertical resolution at the ocean surface**
   Kial Stewart, Andy Hogg
4. **Ocean heat recycling during El Nino**
   Maurice Huguenin-Virchaux, Ryan Holmes, Matthew England
5. **Understanding drivers and mechanisms for the Southern Ocean heat uptake and redistribution**
   Kewei Lyu, Xuebin Zhang, and John Church
6. **Sensitivity of marine heatwave metrics to ocean model resolution**
   Gabriela S. Pilo, Neil Holbrook, Andrew Kiss, Andy Hogg

Research projects (cont'd)

7. **Lagrangian methods to examine future change in ocean tracer movement**
   Annette Stellema, Alex Sen Gupta
8. **Analysis of September 2016 extreme Antarctic sea ice loss**
   Will Hobbs, Andrew Kiss, Amelie Meyer, Matt England and Julie Arblaster
9. **Model evaluation of Antarctic sea ice volume**
   Will Hobbs
10. **Antarctic sea-ice distribution in ACCESS-OM2**
    Petra Heil, Phoebe Hudson, Andrew Kiss
11. **Antarctic sea ice biases, parameter sensitivity and optimisation**
    Andrew Kiss, Petra Heil, Andy Hogg, Matthew England
12. **Linkage of Antarctic coastal polynyas (sea ice properties and water mass properties) to climate indices like the Southern Annular Mode**
    Zhaoru Zhang, Matthew England

Research projects (cont'd)

13. **Response of the Agulhas retroflection standing meander to climate change**
    N. Constantinou, A. Meyer, N. Bindoff, S. Wotherspoon, C. Langlais, B. Legresy, A. Hogg, R. Graham
14. **Western boundary current dynamics in ACCESS-OM2-01**
    Xihan Zhang, Andrew Kiss
15. **ACCESS-OM2 inter-comparison of key oceanic processes around Australia at 1, 0.25 and 1/10 degree**
    Earl Duran, Matthew England, Paul Spence
16. **Understanding what drives seasonality in Southern Ocean eddies**
    Shweta Sharma, Matthew England, Shane Keating, Ryan Holmes
17. **Kinetic energy trends in mesoscale eddies**
    Josué Martínez-Moreno, Andy Hogg, Andrew Kiss, Navid Constantinou, Adele Morrison
18. **Mesoscale eddy detection**
    Michael Denes, Gary Froyland, Shane Keating

Research projects (cont'd)

19. **JRA55-based repeat year forcing datasets for driving ocean-sea-ice models**
    Stewart, Kim, Urakawa, Hogg, Yeager, Tsujino, Nakano, Kiss & Danabasoglu
20. **Ocean-sea-ice responses to extreme SAM conditions**
    Stewart, England, Hogg & Chapman
21. **Changes to near Antarctic ocean circulation in response to increasing glacial meltwater inputs**
    Ruth Moorman, Adele Morrison, Andy Hogg
22. **Teleconnection of ENSO to the Amundsen Sea Low on the Southern Ocean Mixed-Layer Depth**
    Qian Li, Matthew England
23. **Biogeochemistry modelling with ACCESS-OM2**
    Hakase Hayashida, Richard Matear, Pete Strutton

Research projects (cont'd)

24. **Understanding the role of transport barriers in ocean ventilation**
    Andreas Klocker
25. **Ocean-ice interaction in subpolar Southern Ocean generates ocean pycnocline**
    A. Klocker, A. Navaira Garabato, A. Forryan, C. de Lavergne, S. Rintoul
26. **Influence of seasonal forcing variability on the mean state of the Indonesian Seas (1/25° MITgcm regional model forced at boundaries by ACCESS-OM2-01)**
    Océane Richet, Bernadette Sloyan, Beatriz Peña-Molino, Maxim Nikurashin, Susan Wijffels
27. **Interdependence of internal tide and lee wave generation at abyssal hills**
    Callum Shakespeare
28. **The Atlantic meridional overturning circulation in high resolution models**
    Hirschi, Barnier, Boning, Biastoch,... Kiss,... Spence, et al.

and more!

ACCESS-OM2 model announcement and assessment paper

Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-106
Manuscript under review for journal Geosci. Model Dev.
Discussion started: 30 April 2019
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Geoscientific Model Development Discussions
Open Access
EGU

ACCESS-OM2: A Global Ocean-Sea Ice Model at Three Resolutions

Andrew E. Kiss[1,2], Andrew McC. Hogg[1,2], Nicholas Hannah[3], Fabio Boeira Dias[2,4,5,6], Gary B. Brassington[7], Matthew A. Chamberlain[4], Christopher Chapman[4], Peter Dobrohotoff[4,5], Catia M. Domingues[2,5,6], Earl R. Duran[8], Matthew H. England[2,8], Russell Fiedler[4], Stephen M. Griffies[9,10], Aidan Heerdegen[1,2], Petra Heil[6,11], Ryan M. Holmes[2,8,12], Andreas Klocker[2,6], Simon J. Marsland[2,4,5,6], Adele K. Morrison[1,2], James Munroe[13], Peter R. Oke[4], Maxim Nikurashin[2,5], Gabriela S. Pilo[2,5], Océane Richet[4,14], Abhishek Savita[2,4,5,6], Paul Spence[2,8], Kial D. Stewart[1,8], Marshall L. Ward[9,15], Fanghua Wu[16], and Xihan Zhang[1,2]

ACCESS-OM2 (1°) (Abhishek Savita)

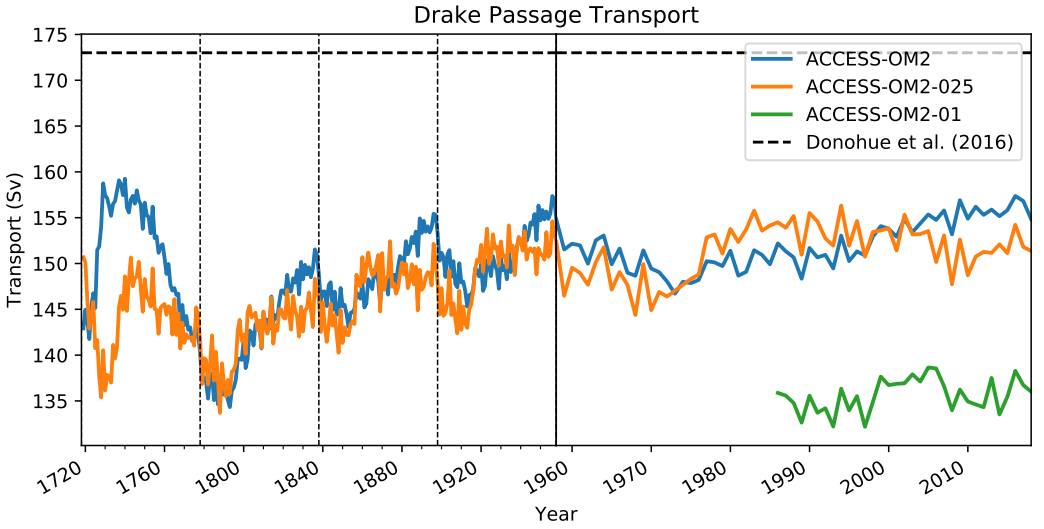
- 300-yr run: five 1958–2017 JRA55-do cycles starting from WOA13

ACCESS-OM2-025 (0.25°) (Andy Hogg)

- 300-yr run: five 1958–2017 JRA55-do cycles, starting from WOA13

ACCESS-OM2-01 (0.1°) (Andrew Kiss)

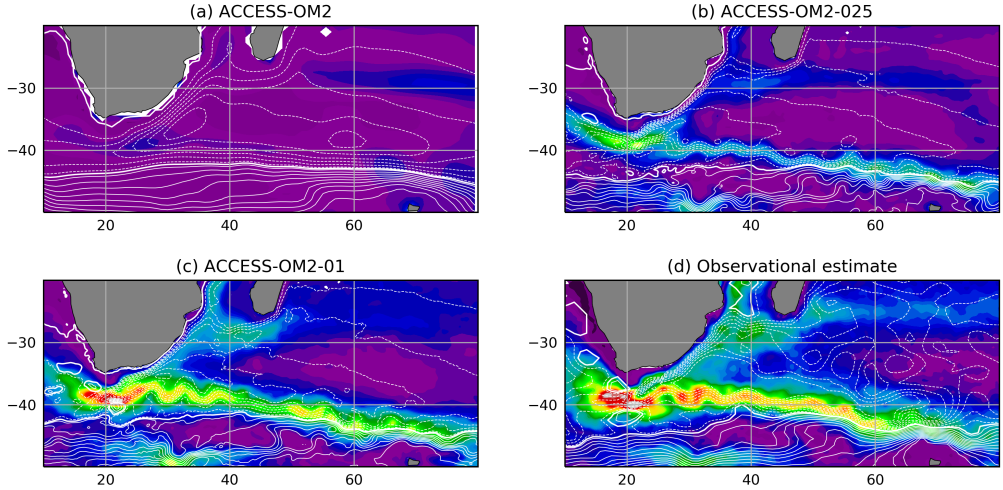
- 33-yr run, JRA55-do 1985–2017, spunup with 40 years of repeated May 1984 – April 1985 JRA55-do forcing starting from WOA13



Four 60-year JRA55-do cycles

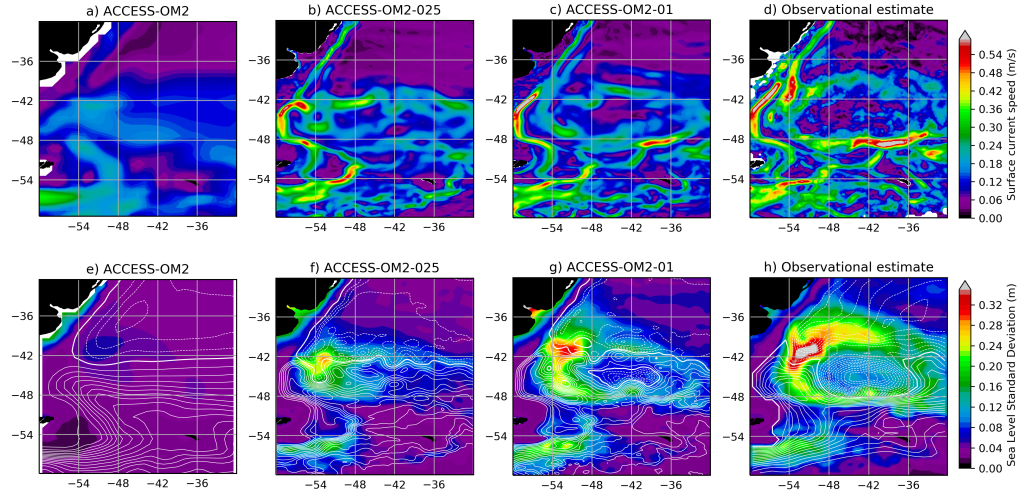
Fifth cycle (expanded time scale)

Agulhas barotropic streamfunction and SSH variability



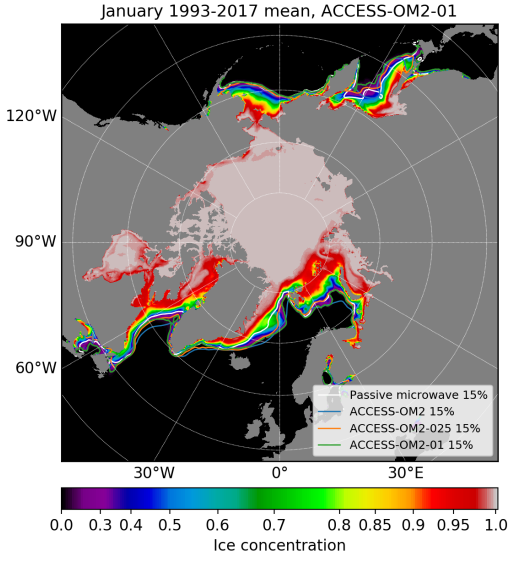
Obs: AVISO and Colin de Verdiére & Ollitrault, JPO 2016

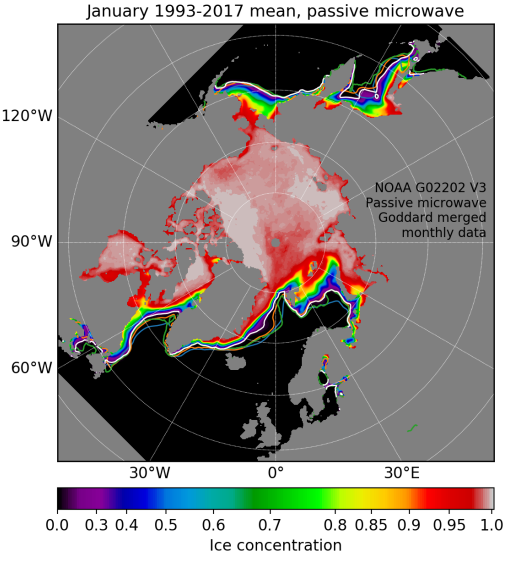
Brazil-Malvinas speed, barotropic streamfunction and SSH variability



Obs: Laurindo et al., DSR 2017, AVISO and Colin de Verdiére & Ollitrault, JPO 2016

Ice concentration (1993–2017 monthly mean)





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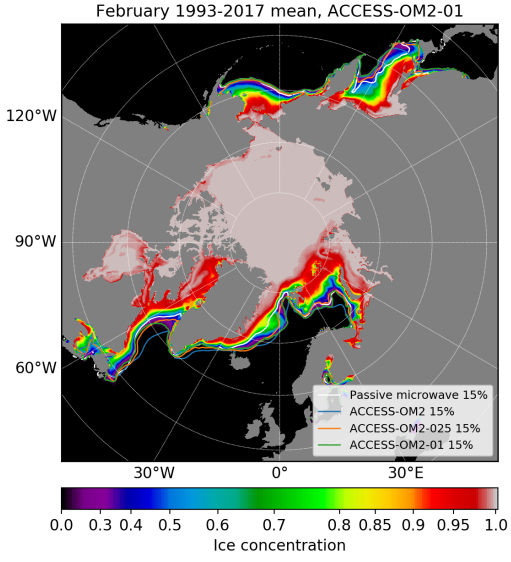

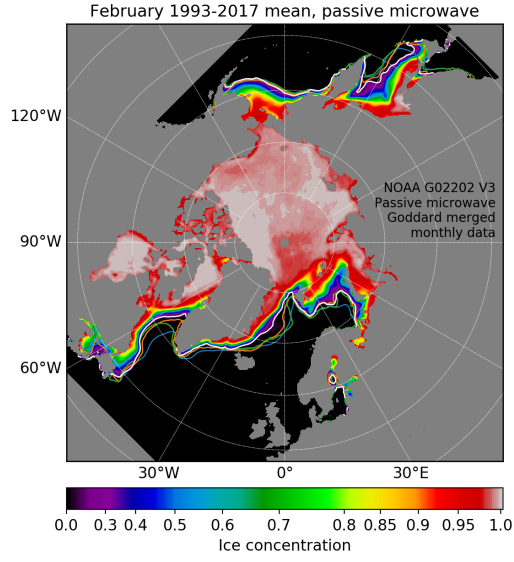

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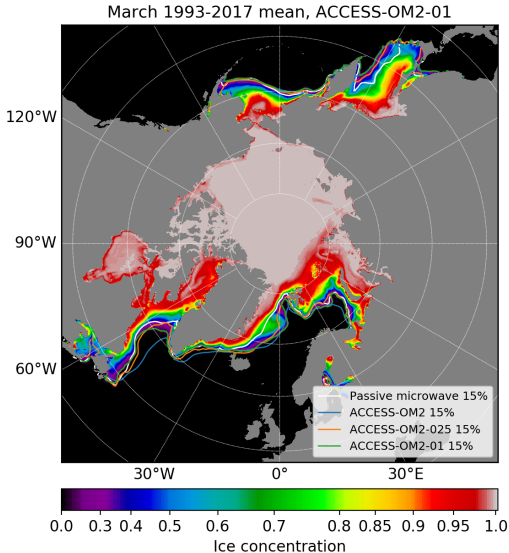

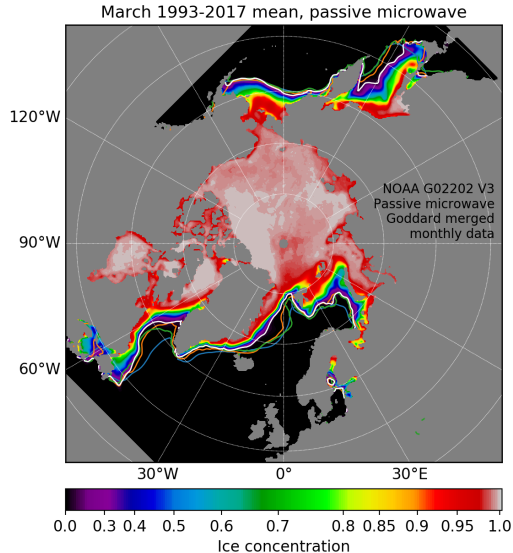

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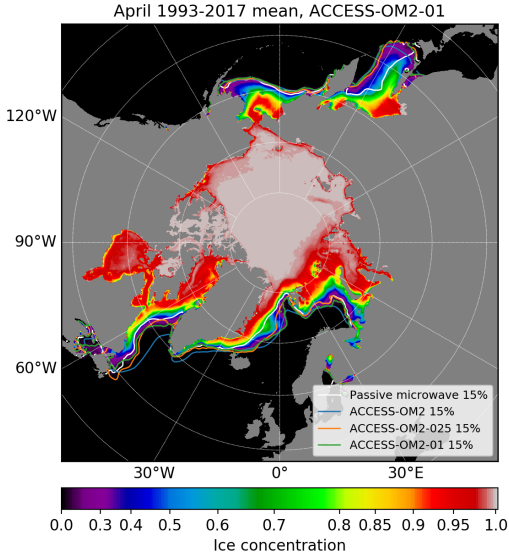

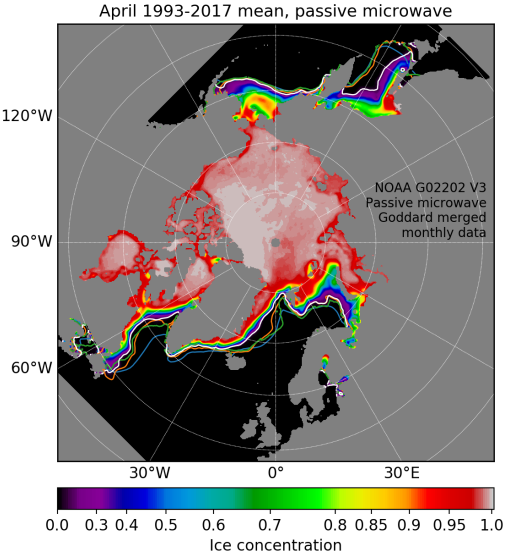

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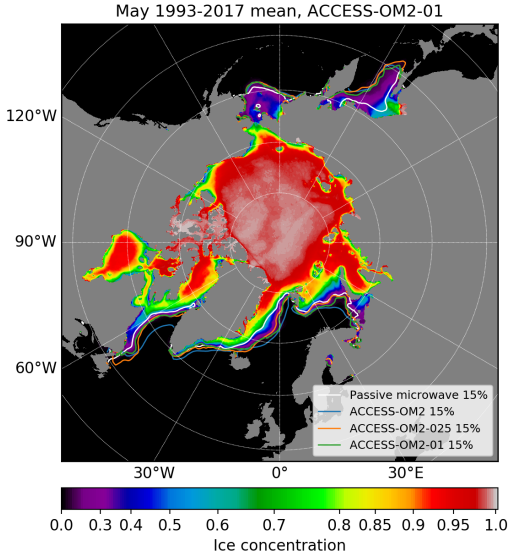

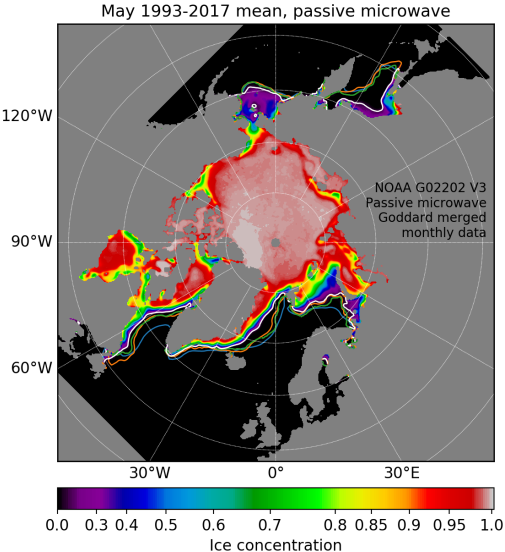

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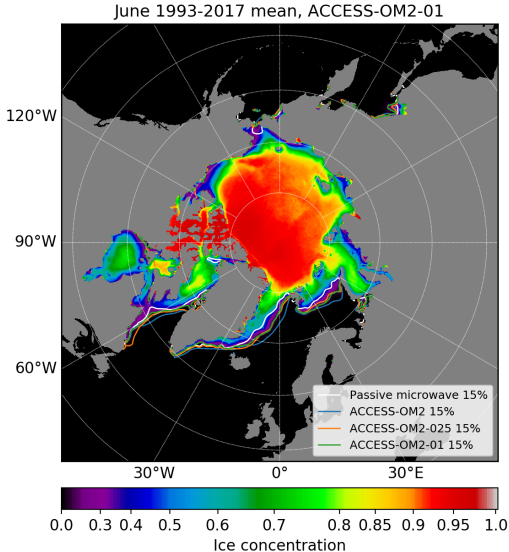

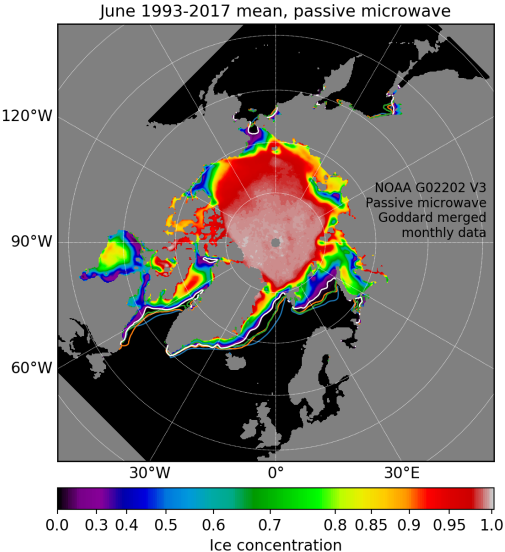

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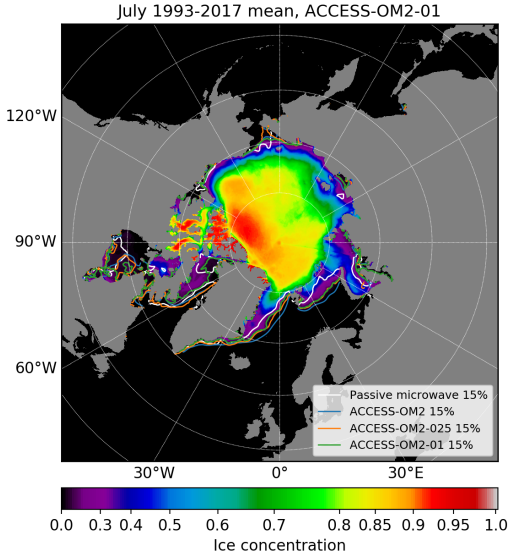

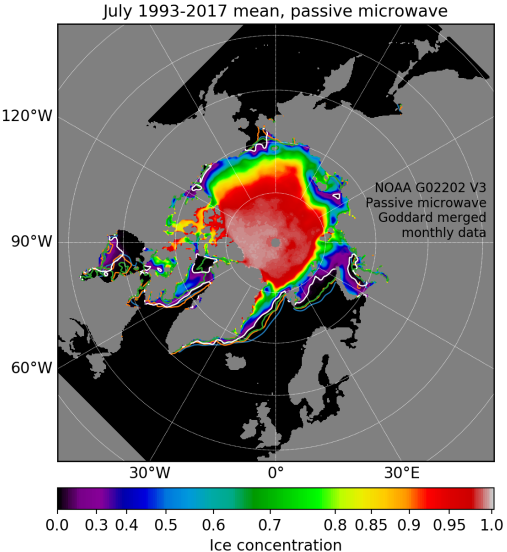

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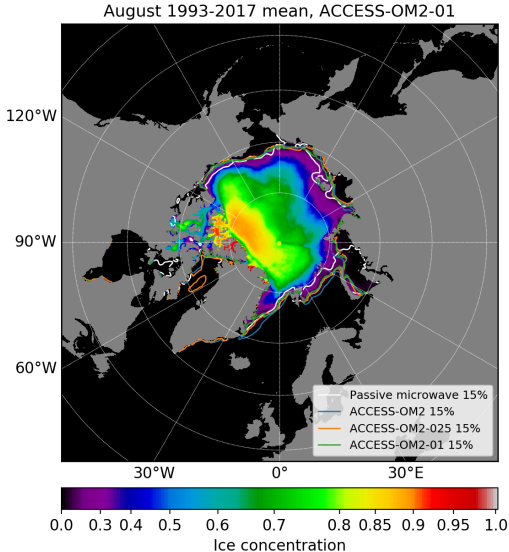

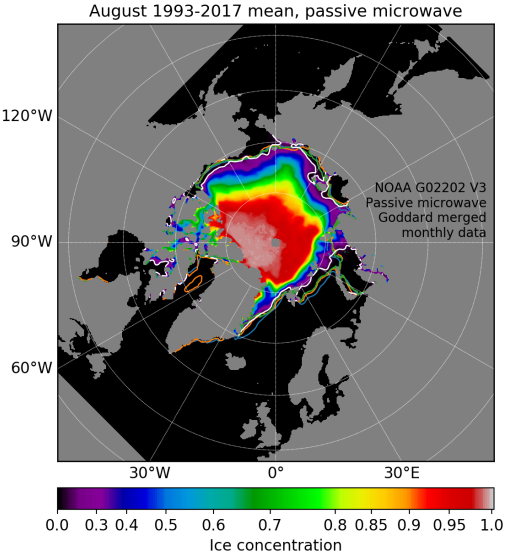

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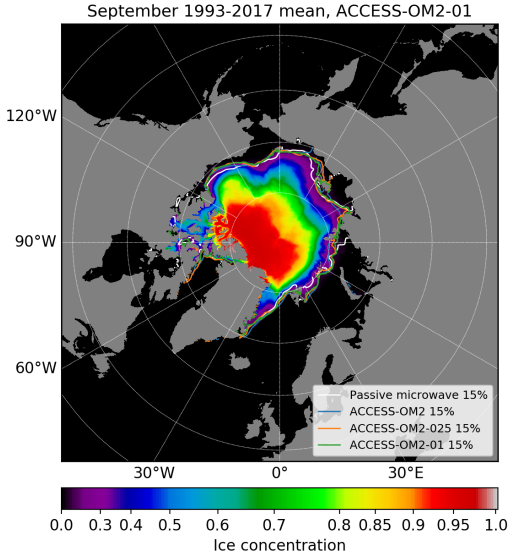

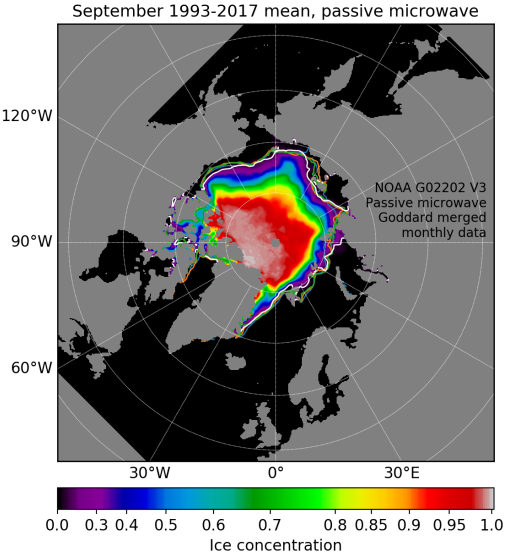

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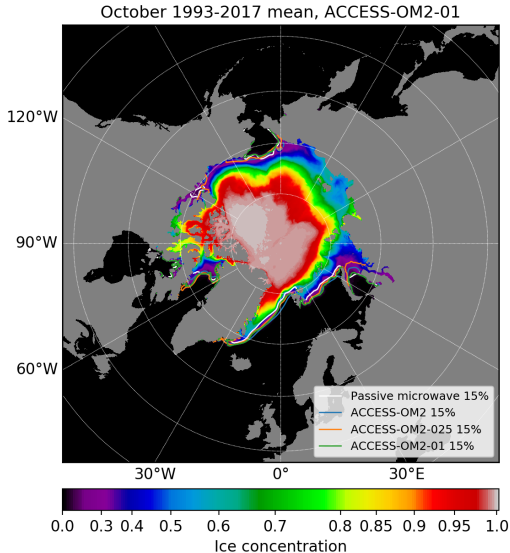

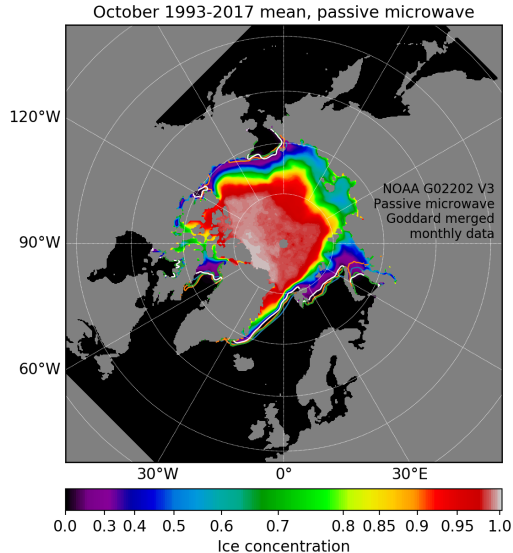

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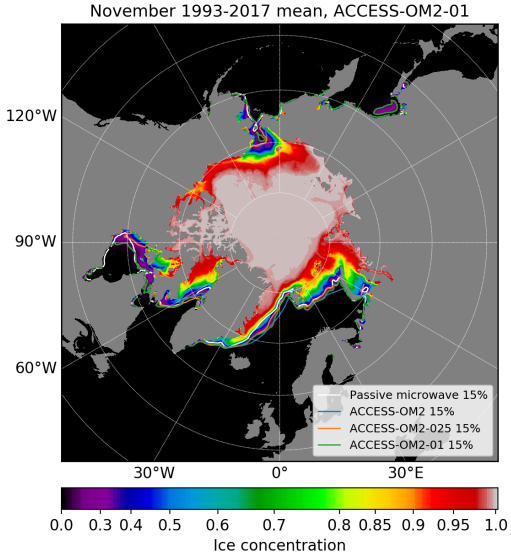

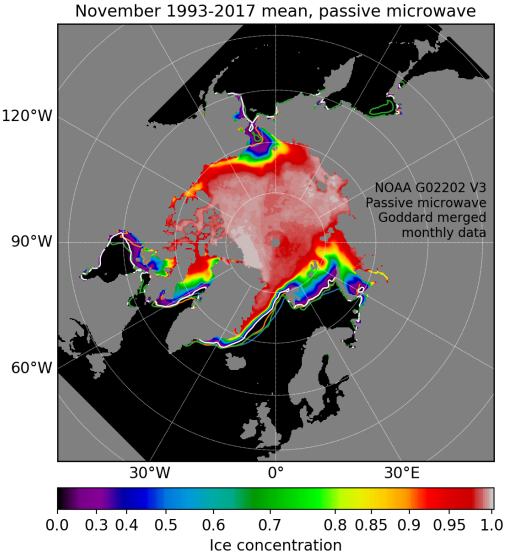

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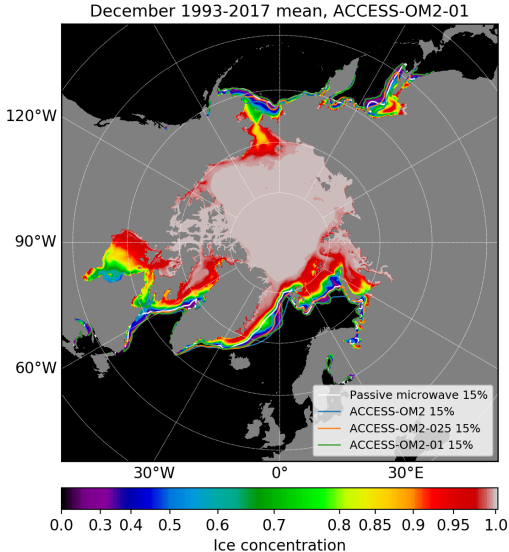

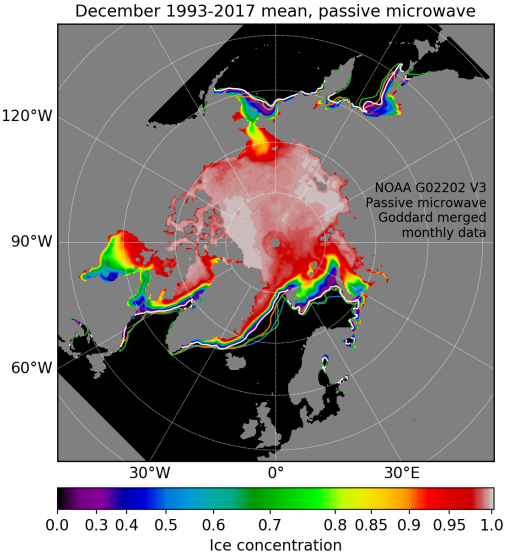

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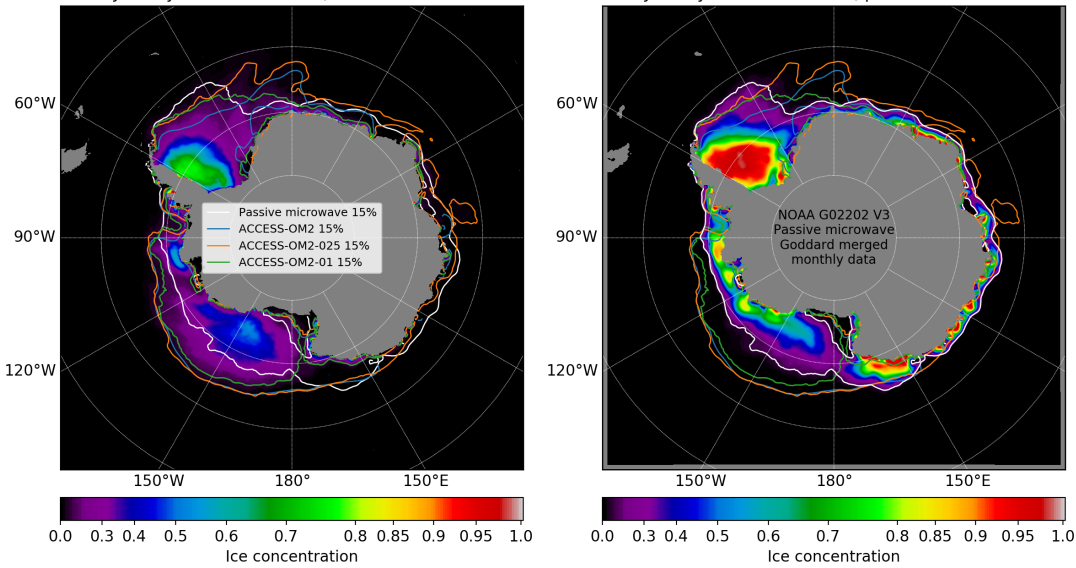

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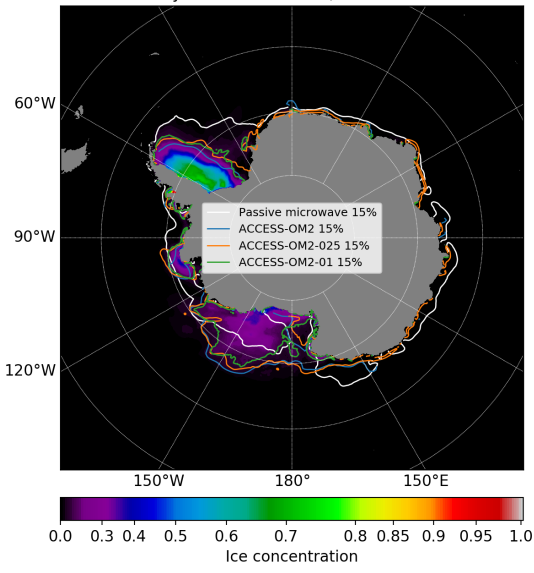

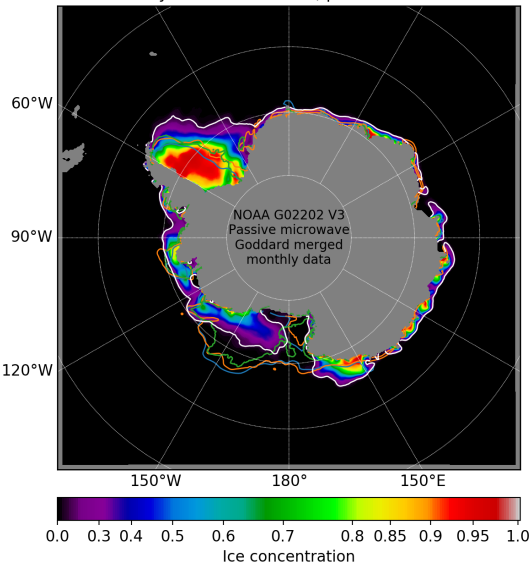

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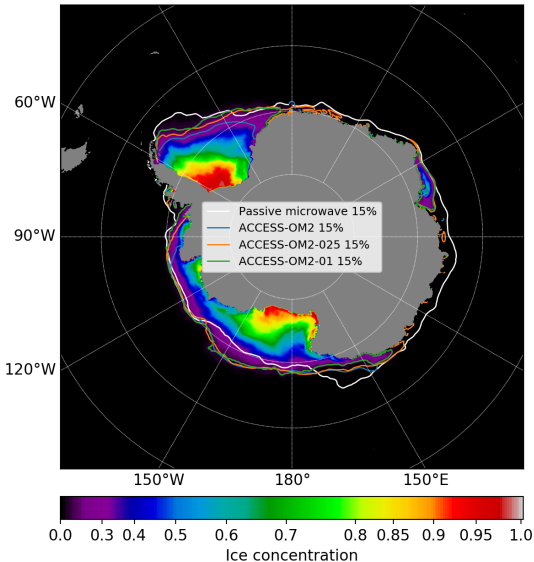

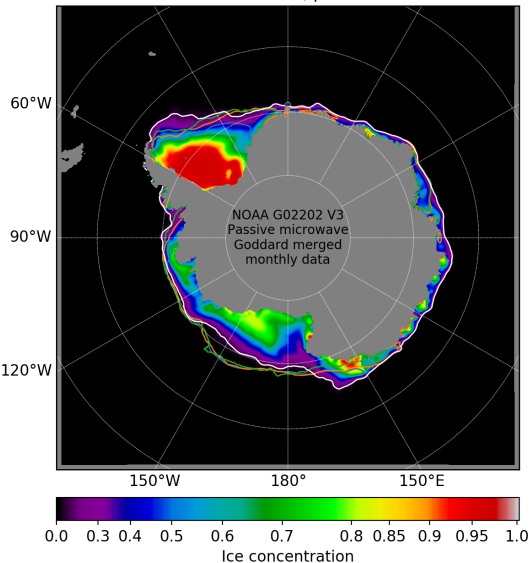

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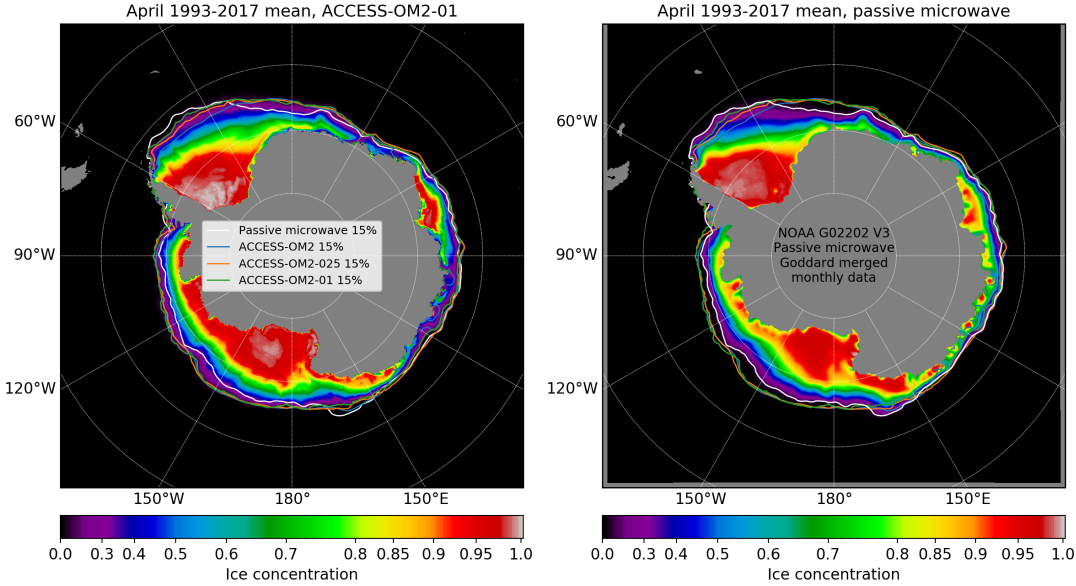

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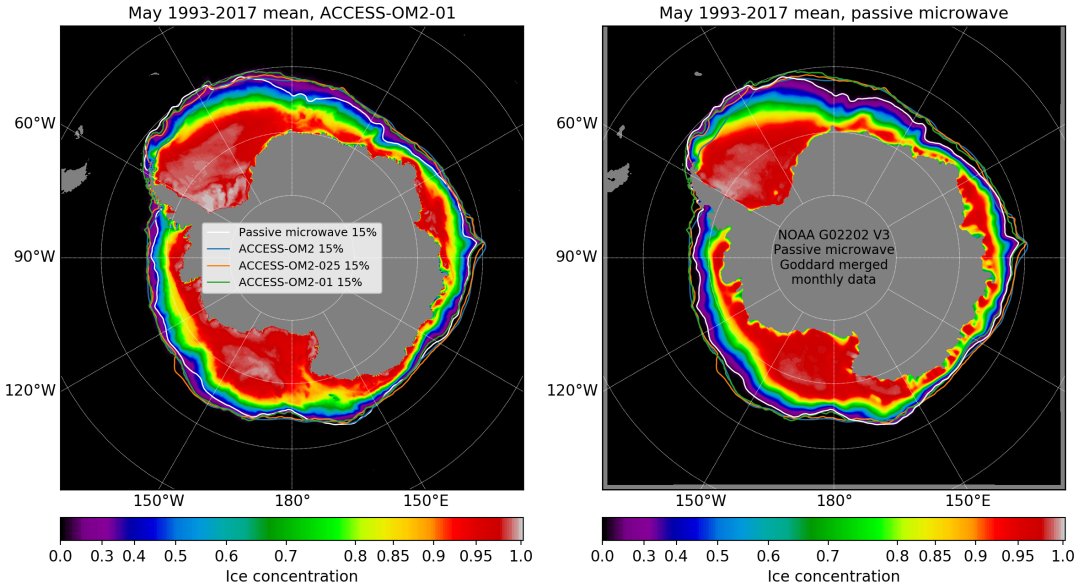

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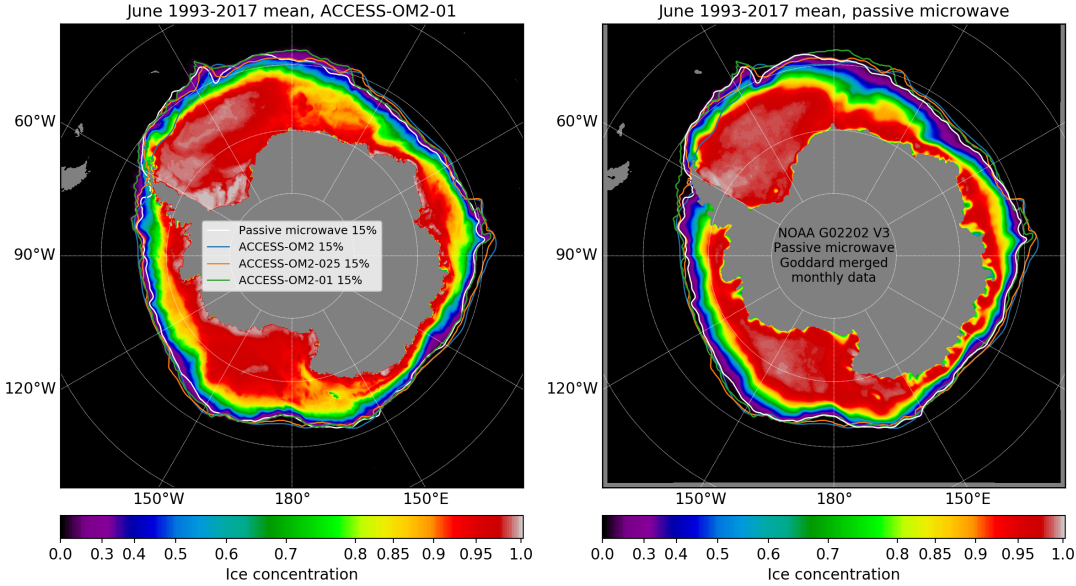

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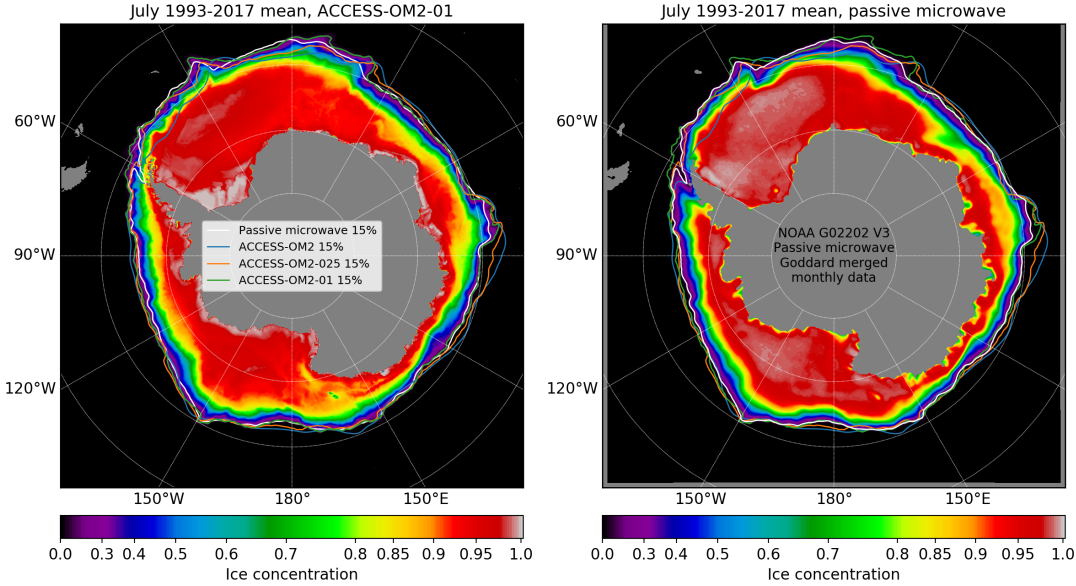

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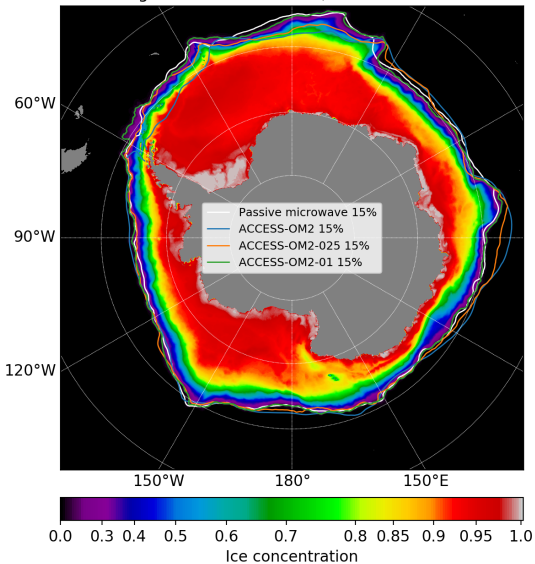

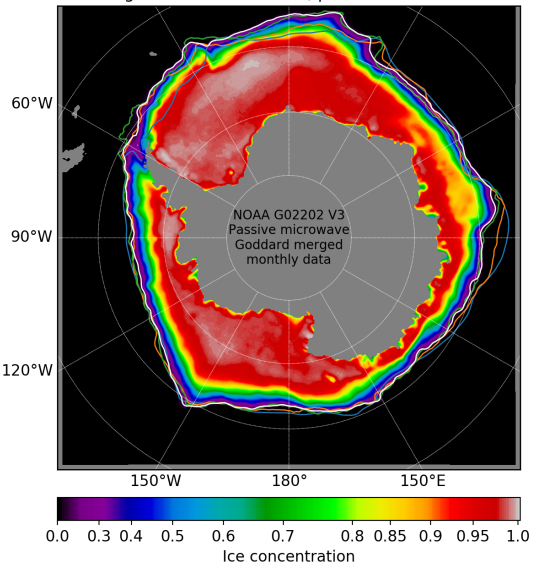

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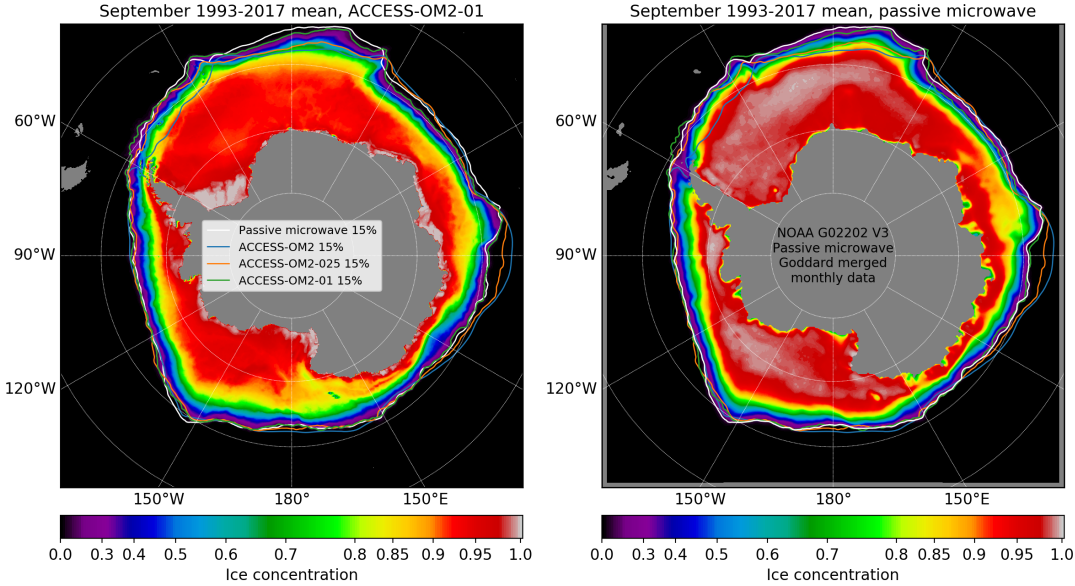
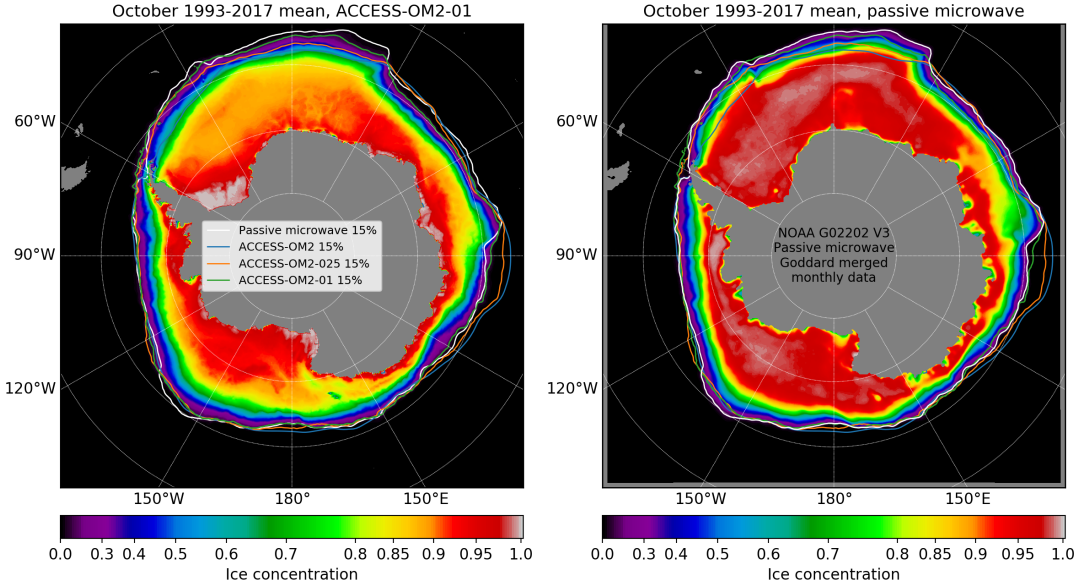
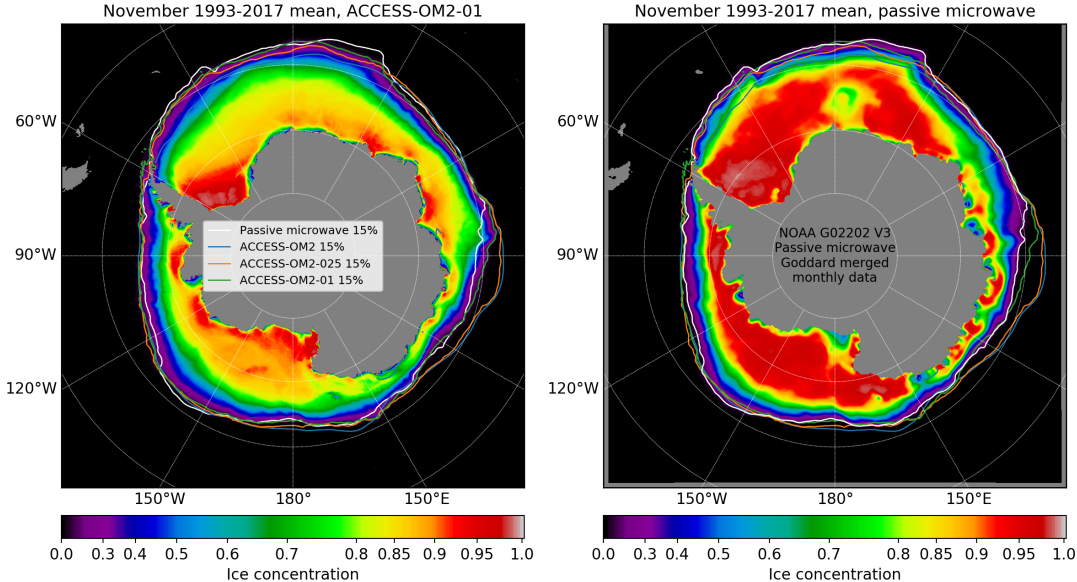


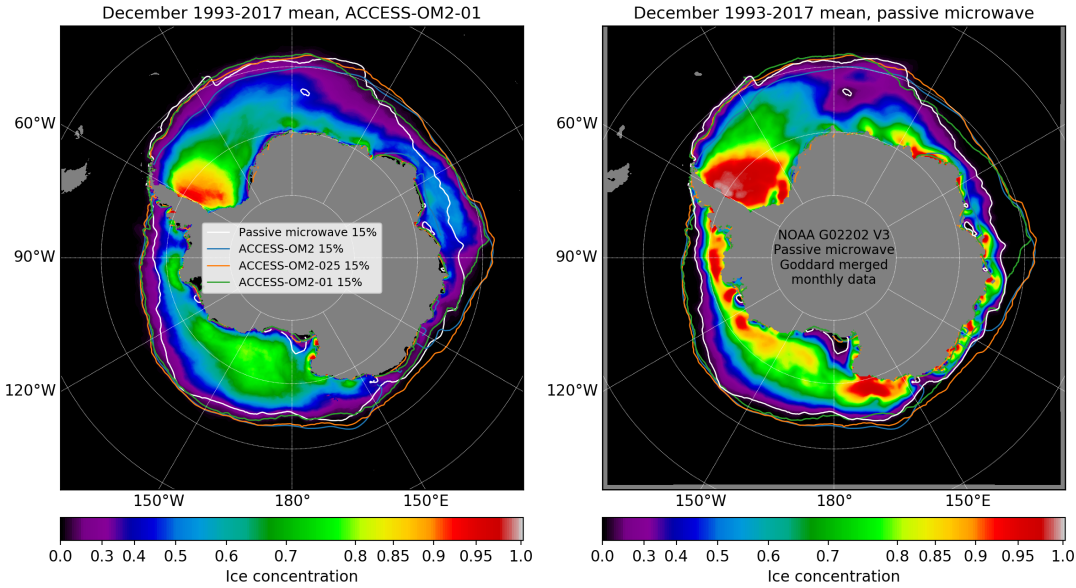
Ice concentration (1993–2017 monthly mean)



Ice concentration (1993–2017 monthly mean)

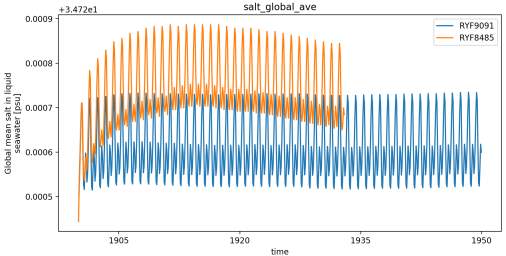


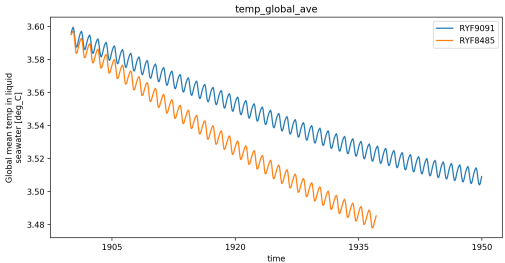
Ice concentration (1993–2017 monthly mean)



New 0.1° 1990–91 repeat-year run (Andy Hogg)

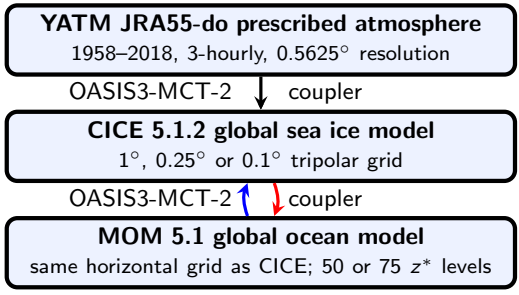
- Repeat-year-forcing (RYF) used for perturbation experiments (e.g. Ruth's talk)
- Previous May 1984 – April 1985 RYF control run had varying parameters
- ⇒ New, uniform control run, under May 1990 – April 91 RYF (more neutral)
- 50 years done; additional decade or two to begin very soon
  - **Let us know what diagnostics you need!**

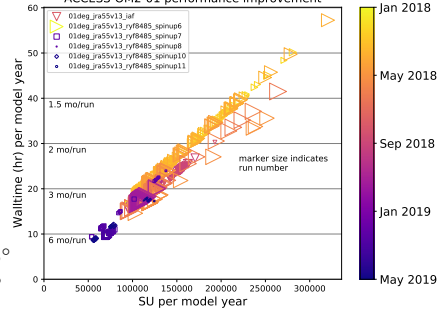


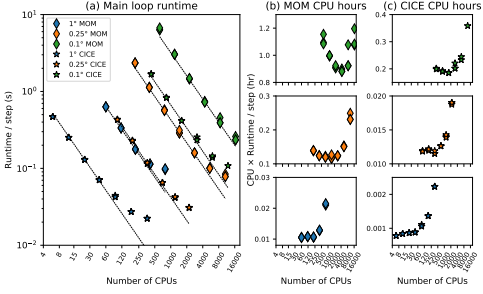


Run	years	submissions	crashes	MSU	walltime	human time
RYF8485	48	662	184	6.5	1,108 hr	11 mo.
RYF9091	50	202	6	3.3	512 hr	2 mo.

ACCESS-OM2 coupled model components and performance







Major development effort greatly improved model performance and stability, particularly at 0.1°:

- MOM scales linearly up to 16,000 CPUs.
- CICE scales linearly up to 2000 CPUs.
- Now able to complete 6 model months within 5 hr job limit.

Technical progress

- YATM file-based atmosphere to support interannual forcing (Nic Hannah)
- ACCESS-CM2 and ACCESS-OM2 harmonisation (Aidan Heerdegen, Russ Fiedler, Peter Dobrohotoff, Marshall Ward, et al.)
- Code profiling (Marshall Ward)
- Halved ACCESS-OM2-01 walltime and SU (Russ Fiedler, Andrew Kiss, Nic Hannah)
- Run manifests automatically store complete run logs for reproducibility (Aidan Heerdegen)
- FAFMIP support (Russ Fiedler)

Coming soon

- Getting ACCESS-OM2 ready for Gadi — new compilers and Open MPI and NetCDF libraries (Rui Yang, NCI)
- New standard ACCESS-OM2 configurations (Andrew Kiss)
- New 1958–2017 IAF spinup at 0.1° (Andrew Kiss)
- WOMBAT biogeochemistry (Russ Fiedler)
- JRA55-do 1.4.0 support (Andrew Kiss)
- Additive and multiplicative forcing perturbations (Nic Hannah, Andrew Kiss)
- Parallel I/O in CICE (Nic Hannah)
- Major COSIMA Cookbook improvements (Angus Gibson, James Munroe)
- Investigating high-resolution regional MOM6 (Angus Gibson)

Summary

- ACCESS-OM2 is a global coupled ocean - sea ice model at 3 resolutions, unifying and improving ACCESS-CM2 and Bluelink codebases and configurations
  - Multiple resolutions are suitable for studies of resolution dependence and parameterisation
  - Parallel scaling to very high CPU counts
  - Model biases reduced at high resolution
  - Collaborative development: code, configs, inputs, outputs, analysis scripts etc. all freely available
    - code: **https://github.com/COSIMA/access-om2**
    - output: **/g/data3/hh5/tmp/cosima** on NCI
  - Many projects now using ACCESS-OM2 suite output data and models
- Model description paper in review at Geosci. Model Dev. Discussions; preprint: **doi:10.5194/gmd-2019-106**