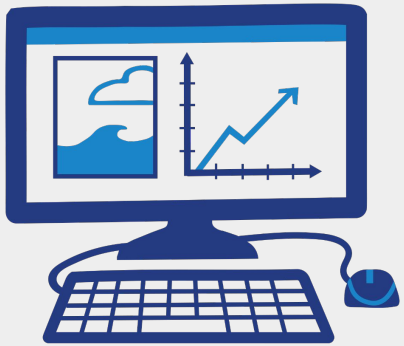

Q1: AI / Machine Learning in the MOM6 Ocean Model

Alistair Adcroft, Princeton CIMES/GFDL

Q1: Concerning GFDL's core strength of building and improving models of the weather, oceans, and climate for societal benefits, how can GFDL leverage advances in science and computational capabilities to improve its key models? What are the strengths, gaps, and new frontiers?

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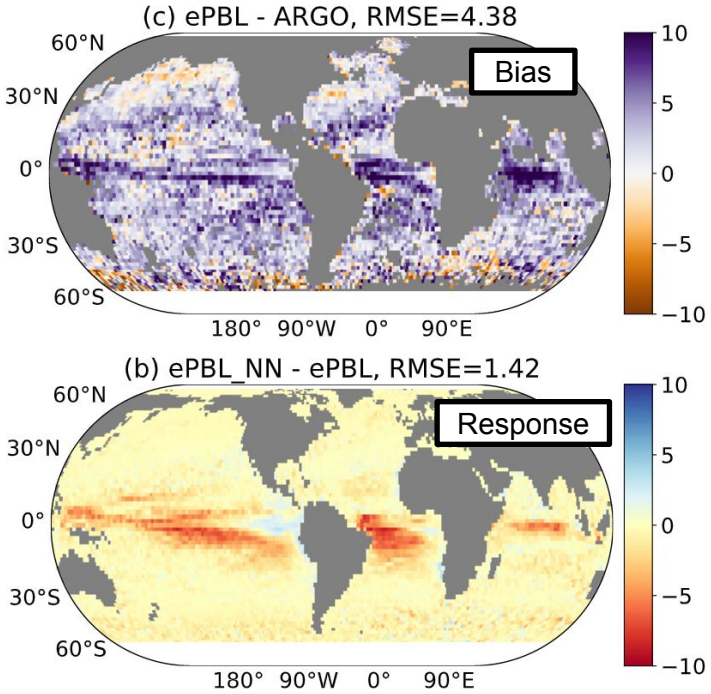
Machine Learned Parameterization for Mixed Layers

- To address systematic bias in Summer Mixed Layer Depth

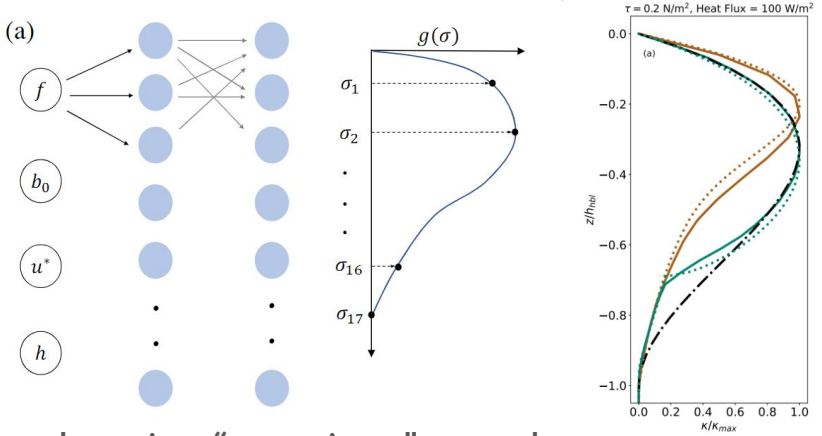


Neural networks used to predict

a) vertical profile

b) amplitude

of diffusion in the active boundary layer



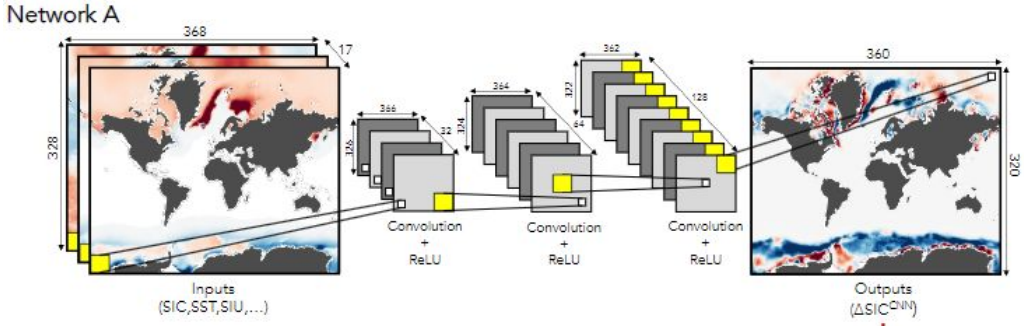
Now learning “equations” to make the same improvement.

Research by Aakash Sane (M²LInES/Princeton) & Brandon Reichl (GFDL)

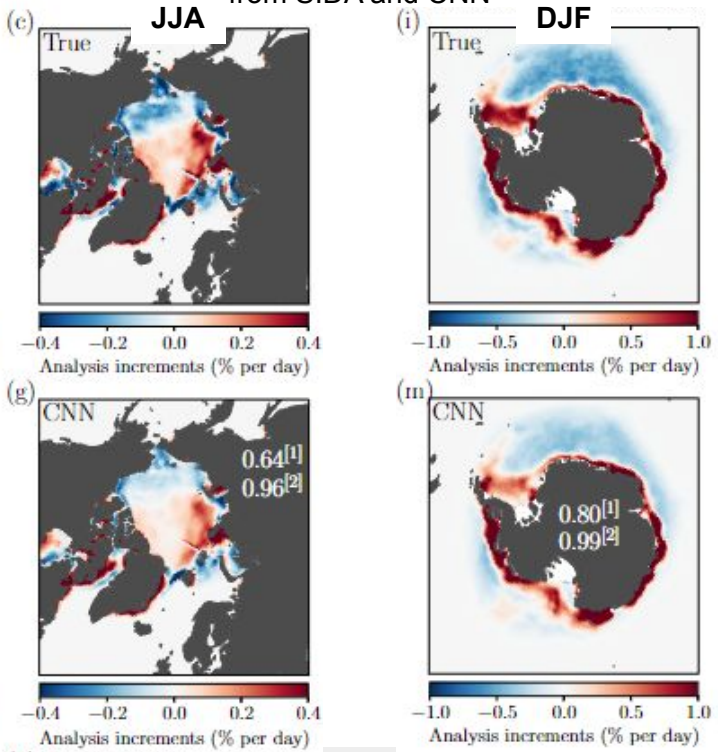
Sane et al., 2023 (doi:10.1029/2023MS003890)

Deep Learning of systematic sea ice model errors

- Convolutional Neural networks used to predict increments from sea-ice data assimilation (SIDA)
  - Very good [offline] skill
  - Corrects the bias in the increments



Seasonal climatologies of SIC increments from SIDA and CNN



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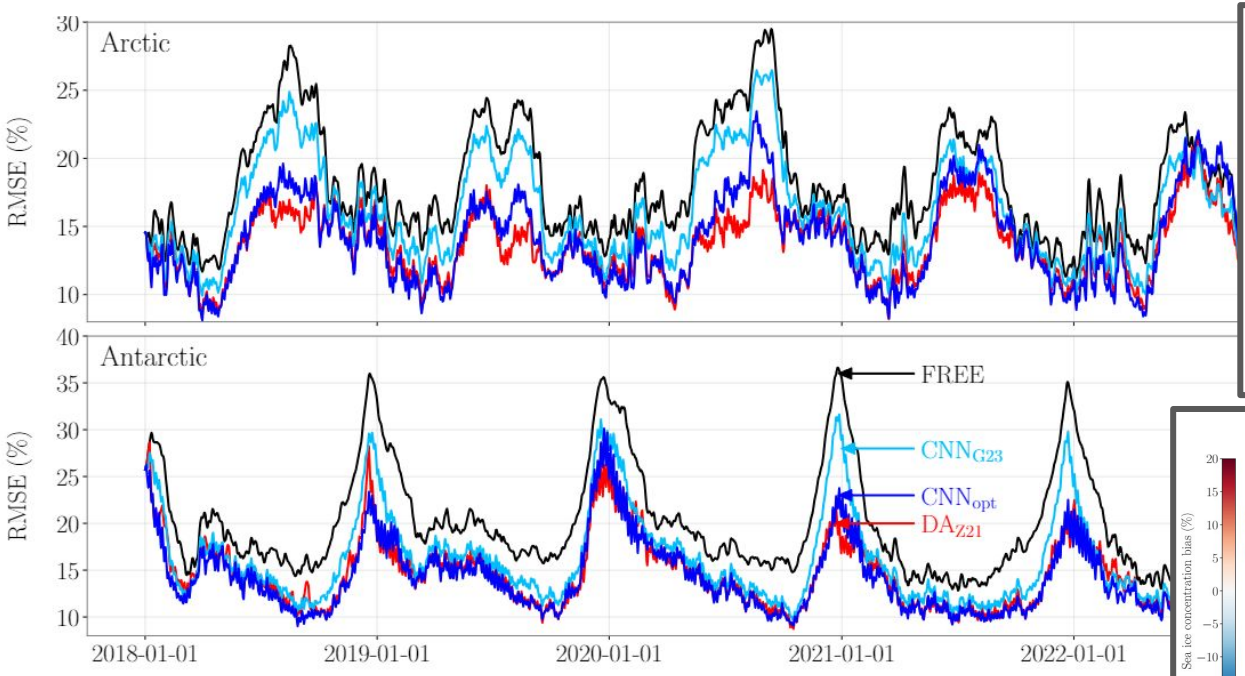
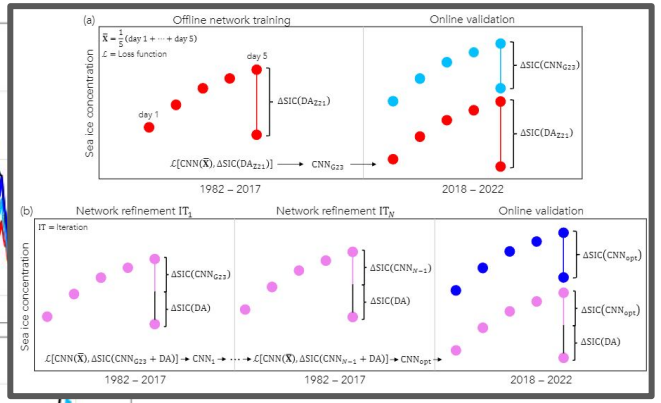
Research by William Gregory (M²LInES/Princeton) & Mitch Bushuk (GFDL)

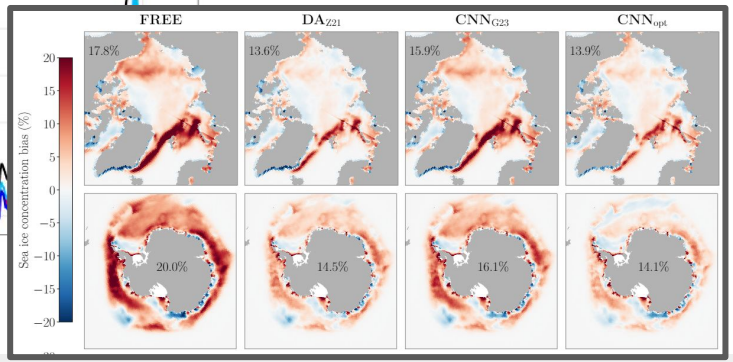
Gregory et al., 2023 (doi:10.1029/2023MS003757)

Refinement of SIDA-CNN for online performance

- Re-running SIDA with CNN allows refinement of CNN







Research by William Gregory (M^{2}LInES/Princeton), Yongfei Zhang (CIMES/Princeton) & Mitch Bushuk (GFDL)

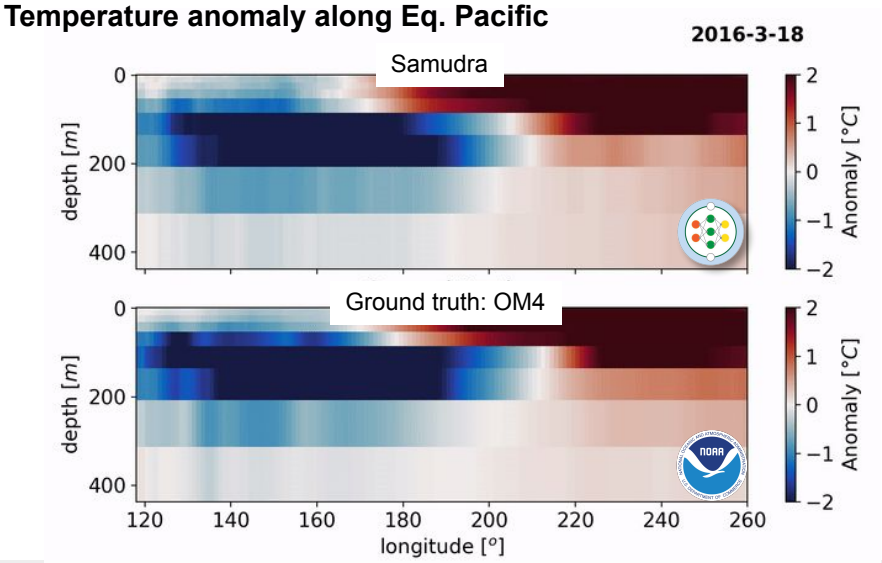
Gregory et al., 2024 (doi:10.1029/2023GL106776)

Samudra: an AI emulator of the Global Ocean

- Trained on output of forced ice-ocean model, GFDL-OM4
- Stable rollouts for multiple centuries
- ~1850 simulated years per day (on a single A100 GPU)
  - OM4: ~12 SPYD on 4671 CPUs
- Developed / trained by *M²LInES* (a *VESRI* funded project)

- What Samudra can be used for?

  Large ensembles, Data assimilation, Accelerate model development, …



Machine learning in climate modeling

- Parameterizations
  - Showed data-driven improvements to parameterizations can be learned from process models
    - Demonstrated online improvements in real climate model
- Structural error corrections
  - Proved that we can learn from observations to correct a prediction system
    - Demonstrated improved predictive skill in existing forecast system
- Emulation
  - Developed a skillful emulation of OM4 for contemporary climate
    - 150x speedup allows very large ensembles to help UQ and DA
- Using ML in contemporary climate models is opportunity in context of changing hardware landscape
  - Climate models [mostly] run on CPUs
  - Machine learning [mostly] run on GPUs
  - Hybrid ML models utilizes all hardware

Work done as part of the M2LInES project led by Laure Zanna (NYU) funded by VESRI