2025 CESM Tutorial

Challenge exercices: Lab intro

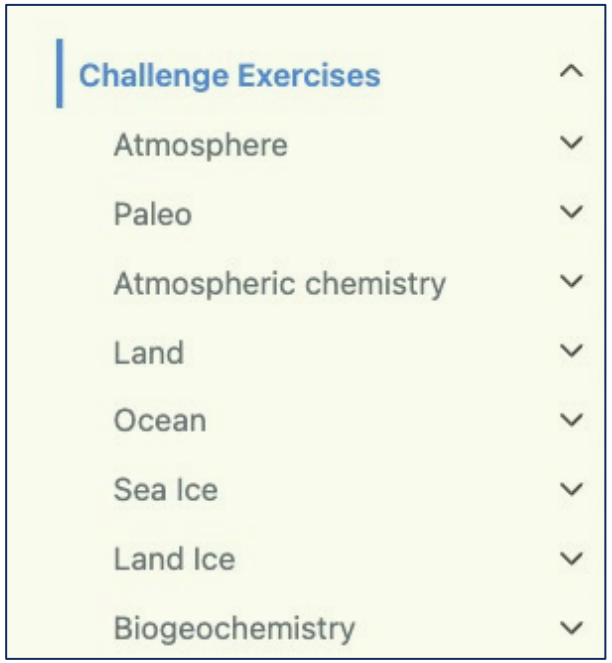
Multiple speakers
CGD

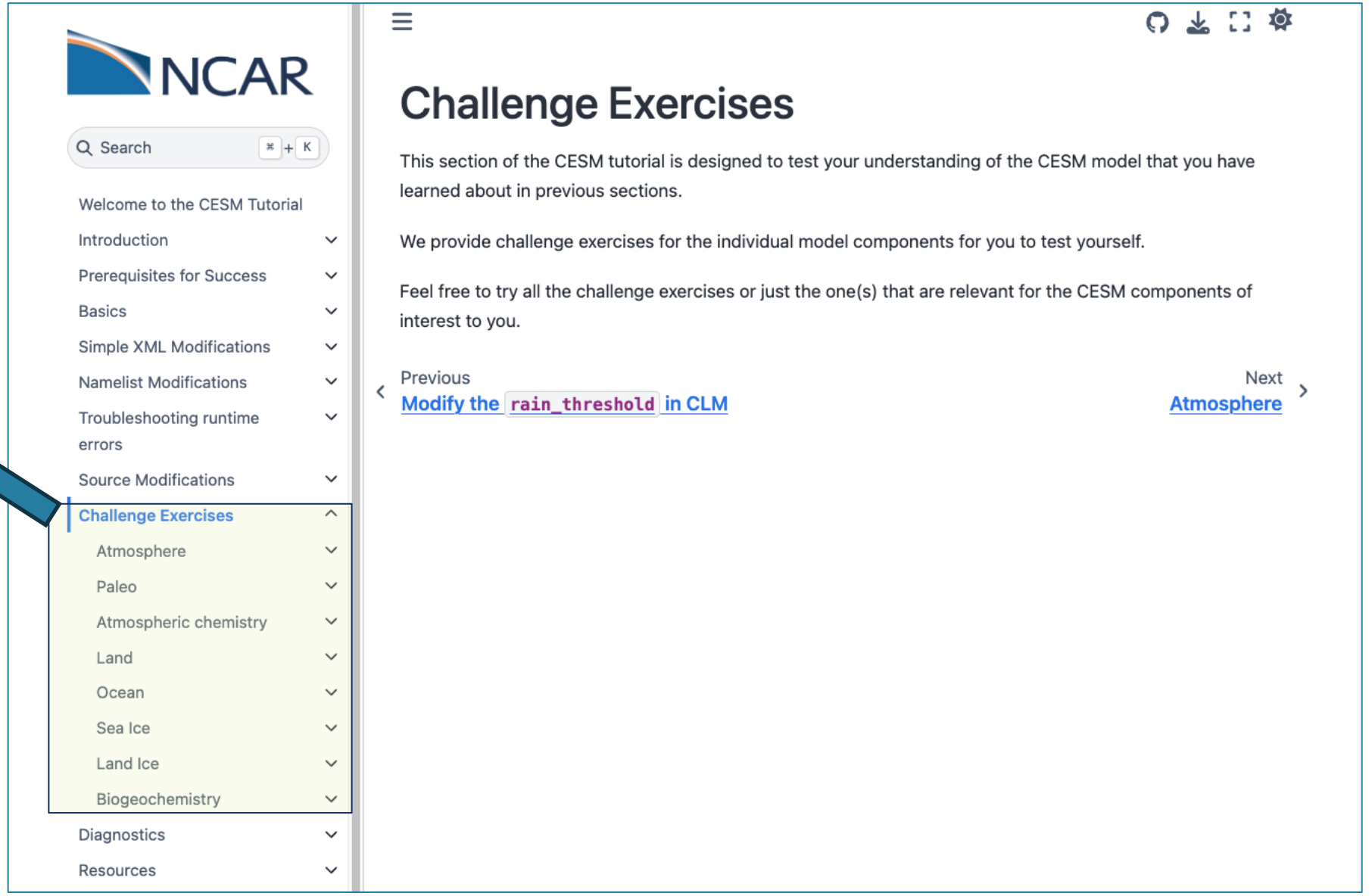
Jul 7-11, 2025

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsor ed by the National Science Foundation under Cooperative Agreement No. 1852977.

Challenge Exercises

https://ncar.github.io/CESM -Tutorial/README.html





Breakout leads for challenge exercises

Cecile Hannay
Atmosphere

Sophia Macarewich
Paleo

Gunter Leguy
Land Ice

David Bailey
Sea Ice

Kristen Krumhardt
Biogeochemistry

Alper Altuntas
Ocean

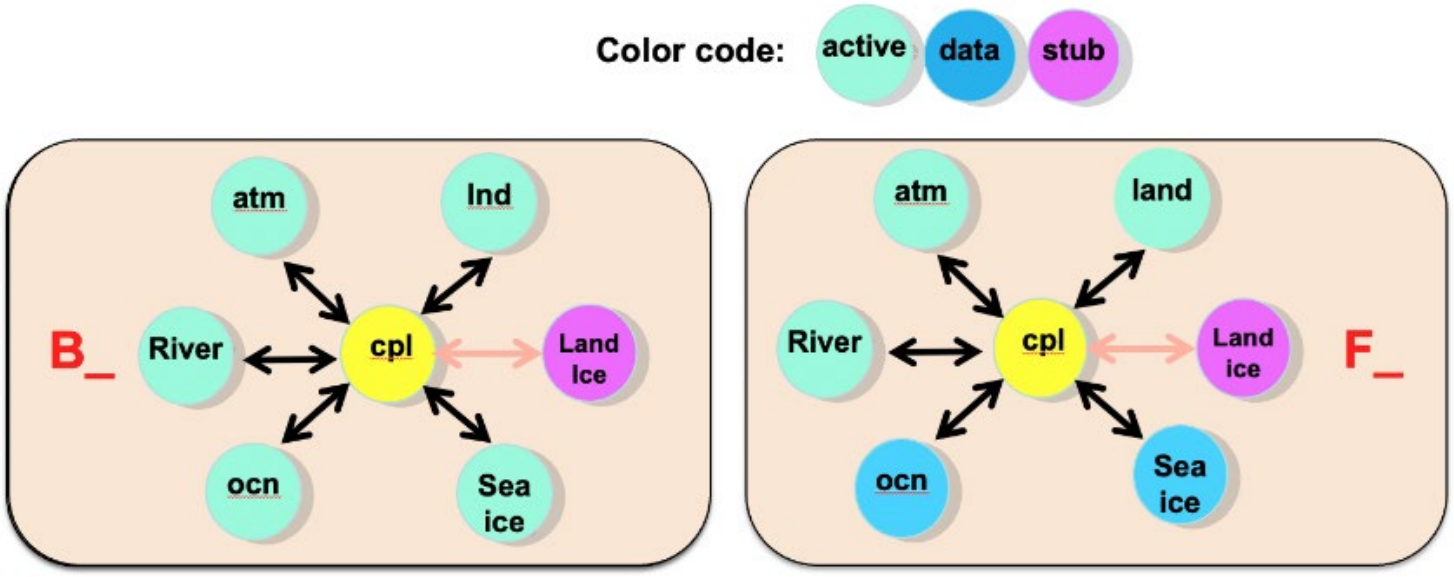
Rebecca Buchholz
Atmospheric Chemistry

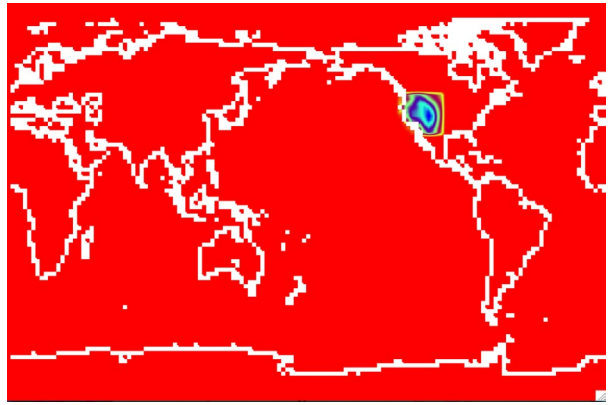
Erik Kluzek
Land (SE)

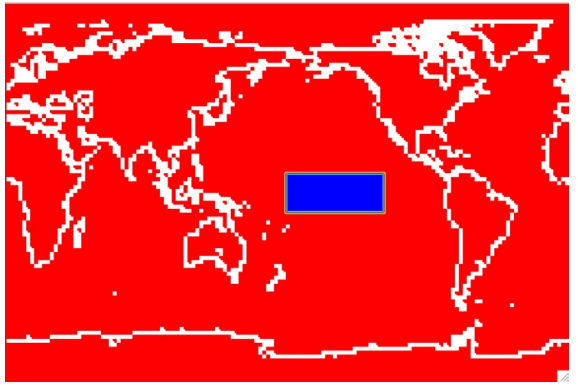
You are welcome to do exercises from different components

Atmosphere

Difference between a B case and a F case

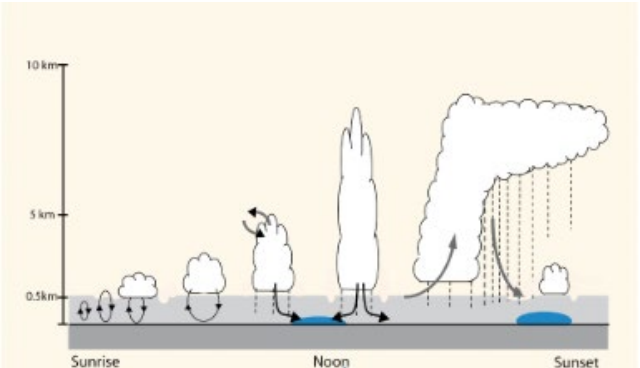






Proposed exercises

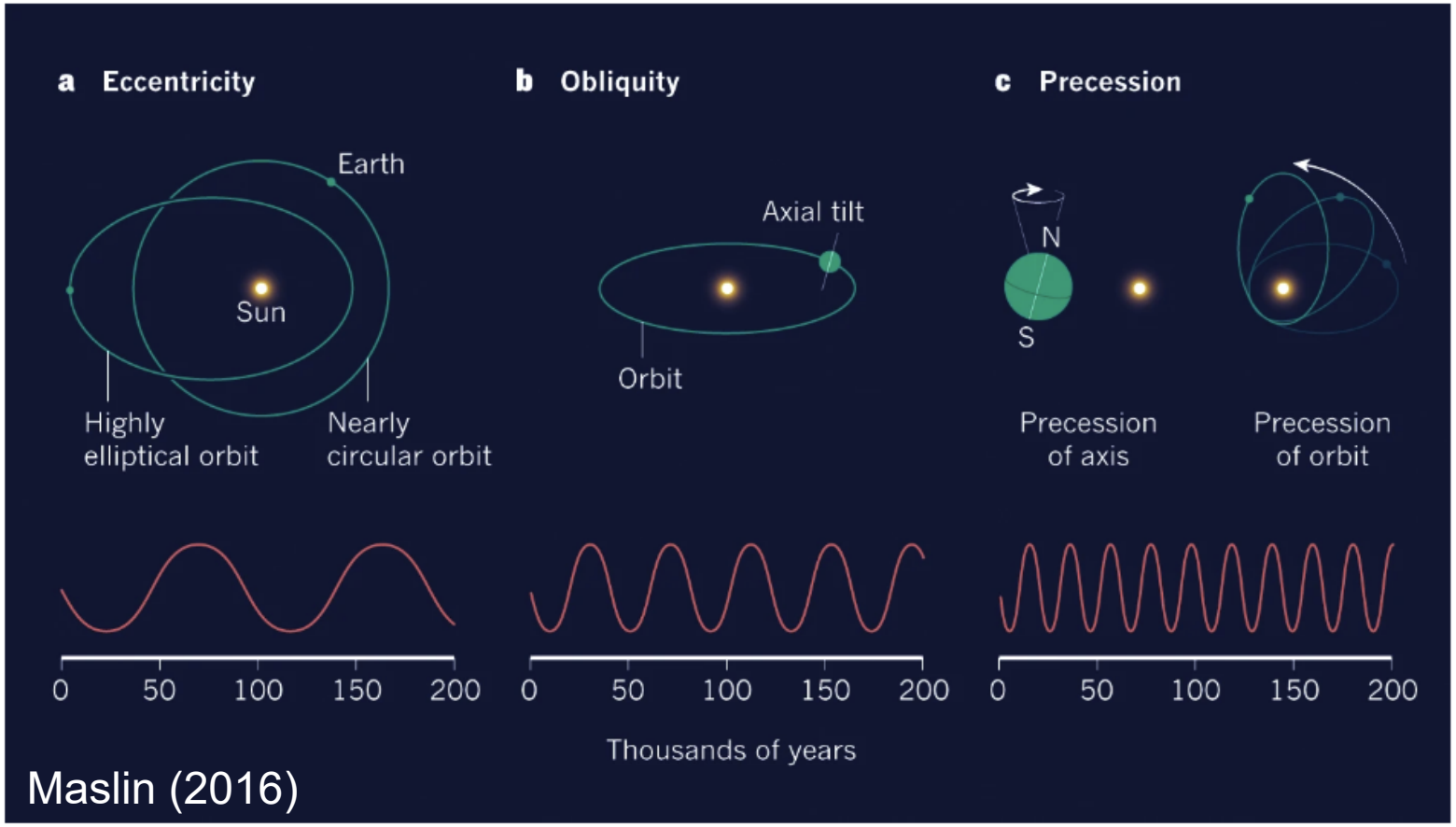
- Use historical SSTs/forcings instead of fixed forcing
- Change run starting date
- Increase orographic height over the western US
- Modify sea surface temperature in the tropics
- Increase the triggering threshold for deep convection over land



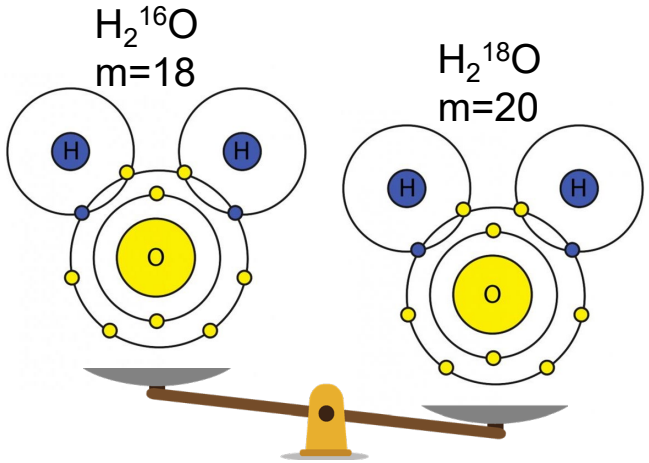
Paleo

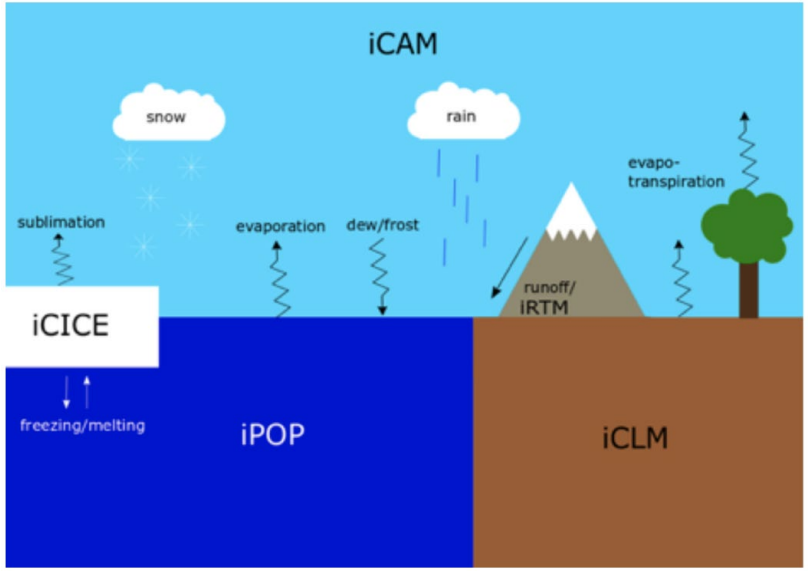
Proposed exercises

- Modify orbital parameters to mid -Holocene (~6 ka) and calendar-adjust monthly CAM output
- Run a CESM simulation with water isotope tracers



Maslin (2016)





Atmospheric Chemistry: CAM -chem or WACCM

Using F cases

Proposed exercises with CAM-chem (FCHIST) or WACCM (FWHIST)

1. **Control** : Run chemistry with daily output
2. **Test**: Change reaction rate in the chemical mechanism
3. **Test**: Change emissions

Bonus

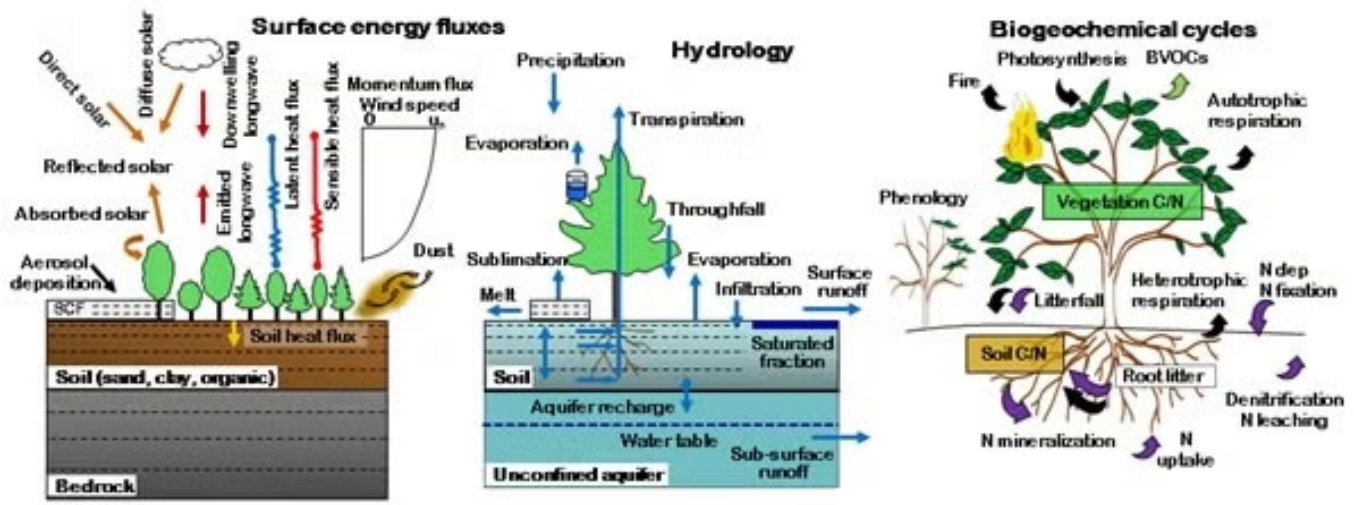
1. **Visualization** : Quick analysis using GEOV tool

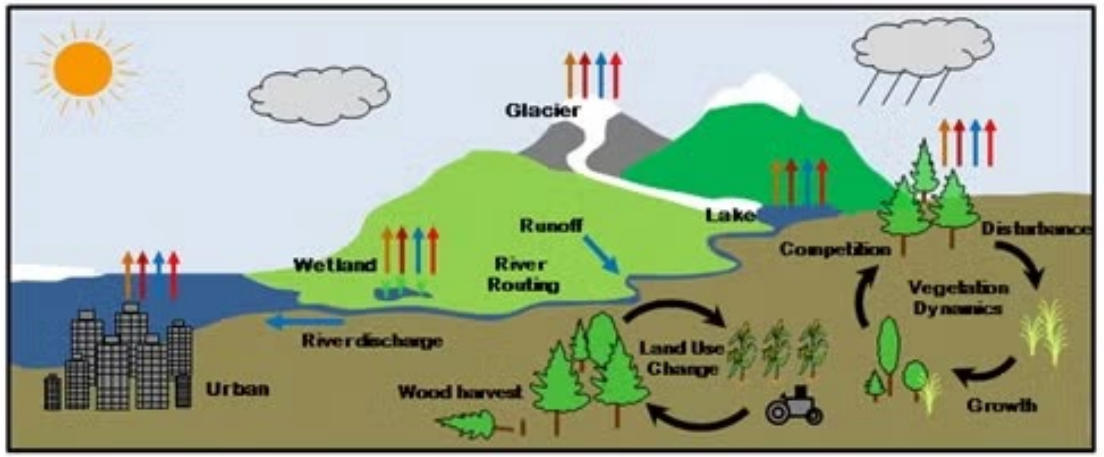
e.g. of super-simple chemistry mechanism

```
 SPECIES
      Solution
O3, O, O1D -> O, O2, O2_1S -> O2, O2_1D -> O2
      End Solution

      Fixed
M, N2
      End Fixed
 End SPECIES

 Solution Classes
      Explicit
       CH4, N2O, CO, H2, CH3CL, CH3BR, CFC11, CFC12
      End explicit
      Implicit
       O3, O, O1D, O2, O2_1S, O2_1D
      End implicit
 End Solution Classes

 CHEMISTRY
      Photolysis
[jo2_a] O2 + hv -> O + O1D
      End Photolysis

      Reactions
 [cph1,cph] O + O3 -> 2*O2       ; 8e-12, -2060
      End Reactions
END CHEMISTRY
```

https://ncar.github.io/CESM-Tutorial/notebooks/challenge/cam-chem_waccm/cam-chem_waccm.html#

Land


Surface energy fluxes
Direct solar
Diffuse solar
Downwelling longwave
Momentum flux
Wind speed
Reflected solar
Emitted longwave
Latent heat flux
Sensible heat flux
Absorbed solar
Dust
Aerosol deposition
SCF
Soil heat flux
Soil (sand, clay, organic)
Bedrock
Hydrology
Precipitation
Transpiration
Evaporation
Throughfall
Sublimation
Evaporation
Surface runoff
Infiltration
Melt
Saturated fraction
Soil
Aquifer recharge
Water table
Sub-surface runoff
Unconfined aquifer
Biogeochemical cycles
Photosynthesis
BVOCs
Fire
Autotrophic respiration
Phenology
Vegetation C/N
Litterfall
Heterotrophic respiration
N dep
N fixation
Soil C/N
Root litter
Denitrification
N leaching
N mineralization
N uptake


Glacier
Lake
Runoff
Wetland
River Routing
River discharge
Urban
Land Use Change
Wood harvest
Competition
Disturbance
Vegetation Dynamics
Growth

Introduction to land only cases ("I" compsets)

Control: SP (Satellite Phenology) vegetation

Test: BGC (Biogeochemistry) vegetation

Test: Change an input parameter

Proposed Exercise:

1. Run a control case: compset: I2000Clm50Sp at f09_g17_gl4
2. Run the experiment: compset: IHistClm50BgcCrop (at what resolution?)
3. Compare results – what's different about them?
4. Run a new experiment based on the SP case changing an input parameter
5. Compare results – what's different between this and the control in "1"?

Questions?

Shameless Plug for Computing Survey

- *Survey on your comfort with HPC computing* and comfort with languages used in CESM
- Also we want to *hear about your experiences*
- So that we can see *how we can best provide help and resources* for you

https://forms.gle/dSpjLdt3rzxaP1sD8

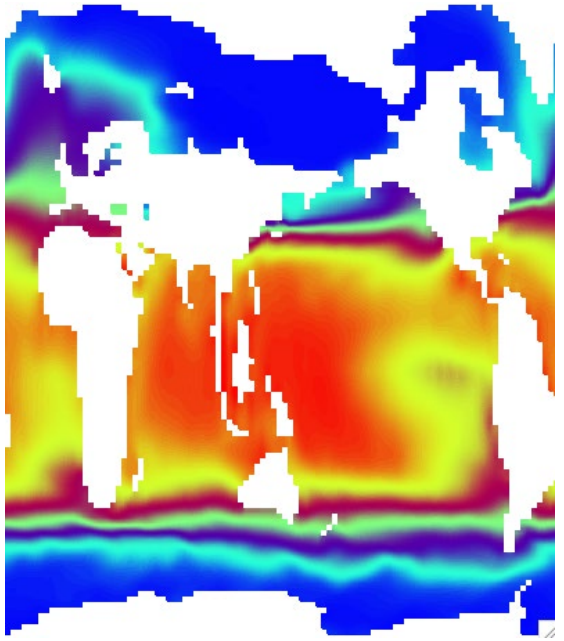
Poster

QR code

Ocean

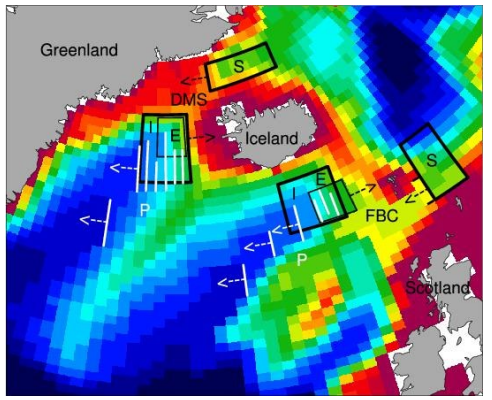
CESM-POP2 exercise:

1. Run a G compset with “normal year forcing” as a control case.
2. Turn off overflow parameterization to assess its impact.
3. Modify wind stress.
4. Turn on the ecosystem.



CESM-MOM6 exercise:

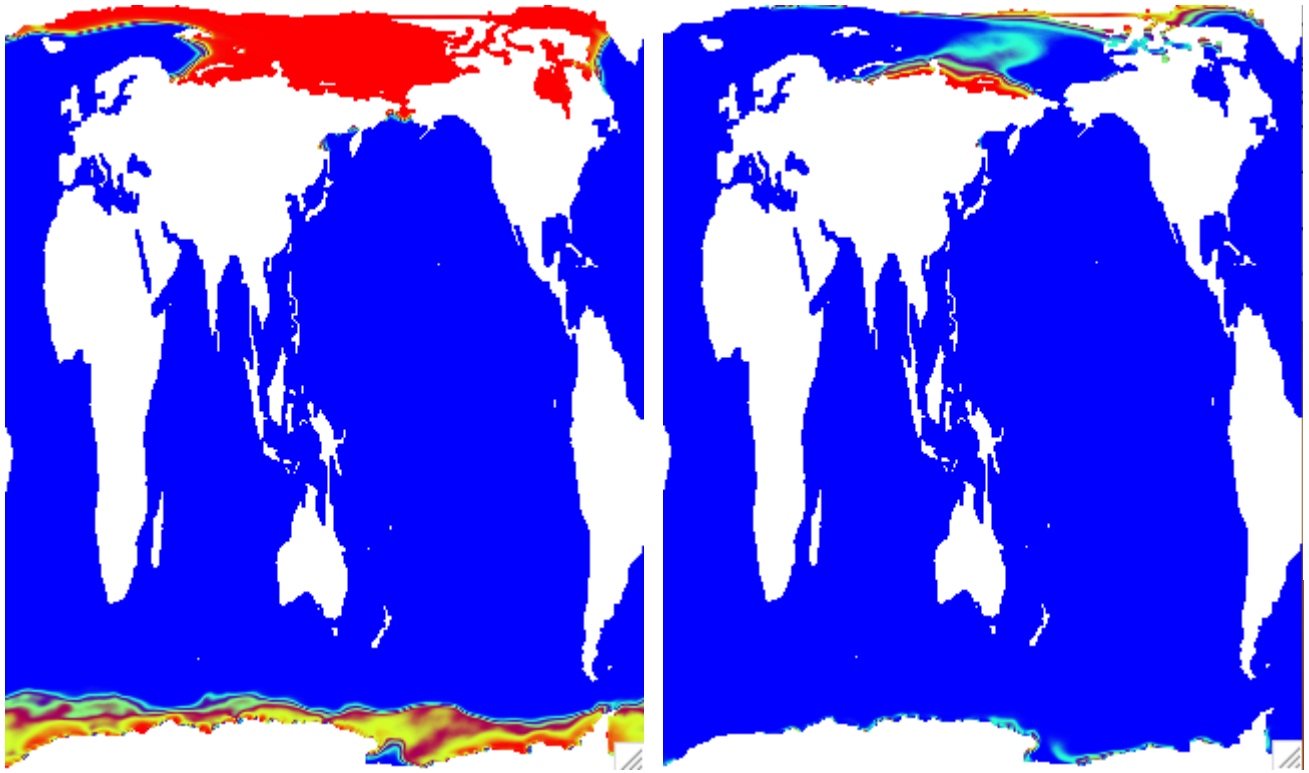
1. Download a CESM version including MOM6.
2. Run a G compset with “normal year forcing” as a control case.

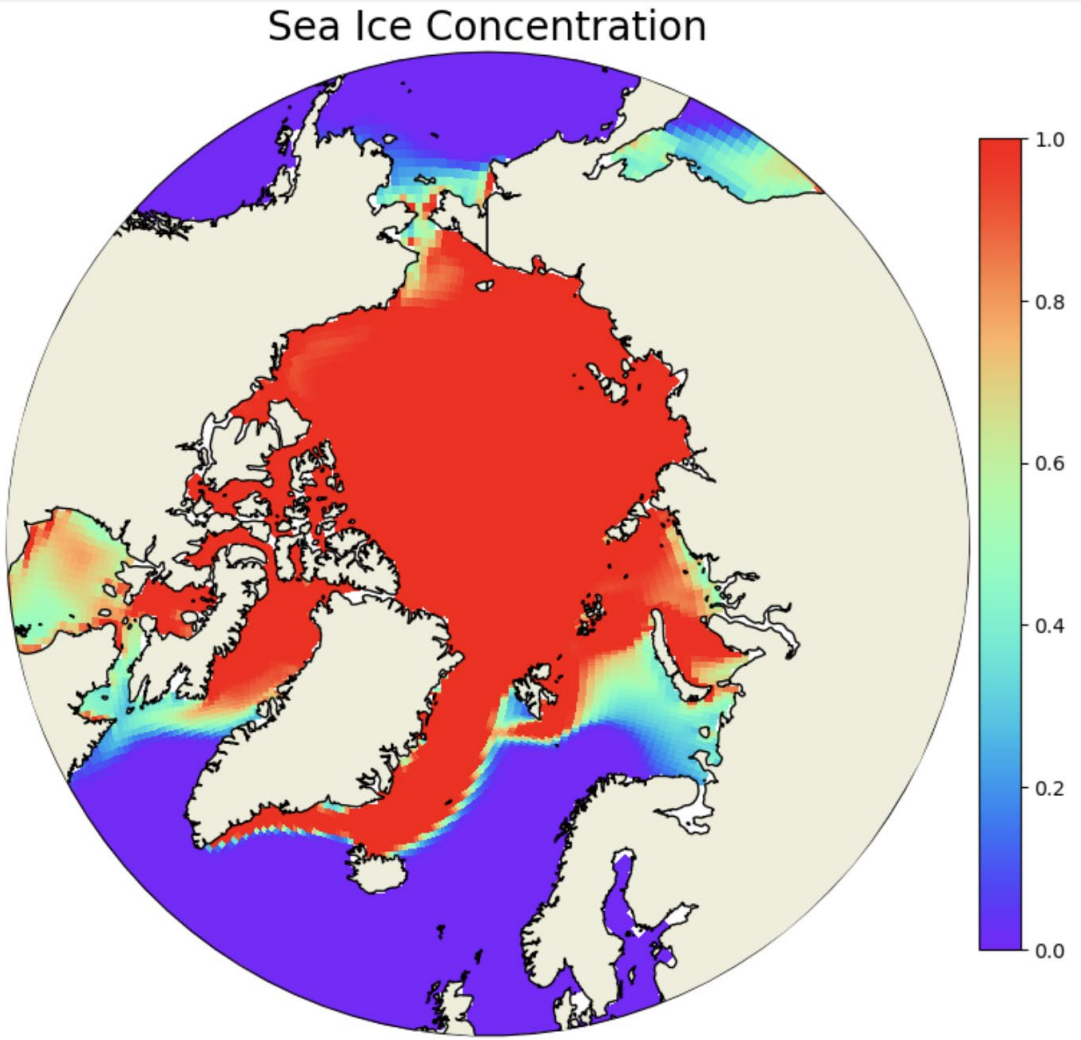


Sea ice

Proposed exercises

- Run a G compset with “normal year forcing”.
- Adjust the sea ice “albedo”.
- Modify the snow conductivity.



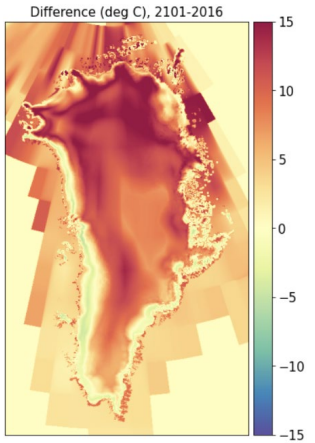


Land ice

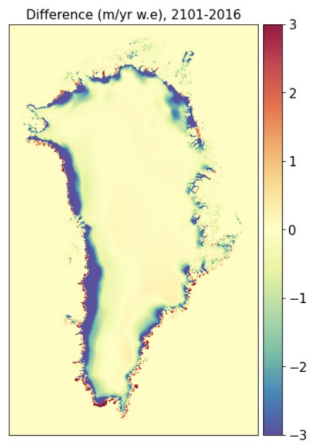
Proposed exercises

- Run a T compset and simulate the Greenland ice sheet evolution in CESM.
- Compute offline global sea level contribution from ice sheet.

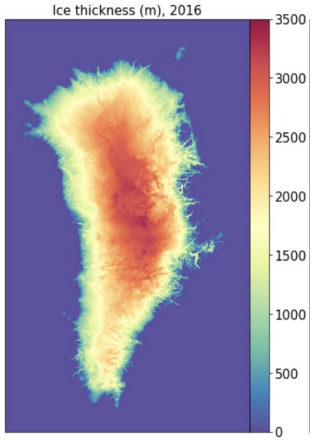
SMB



Temperature

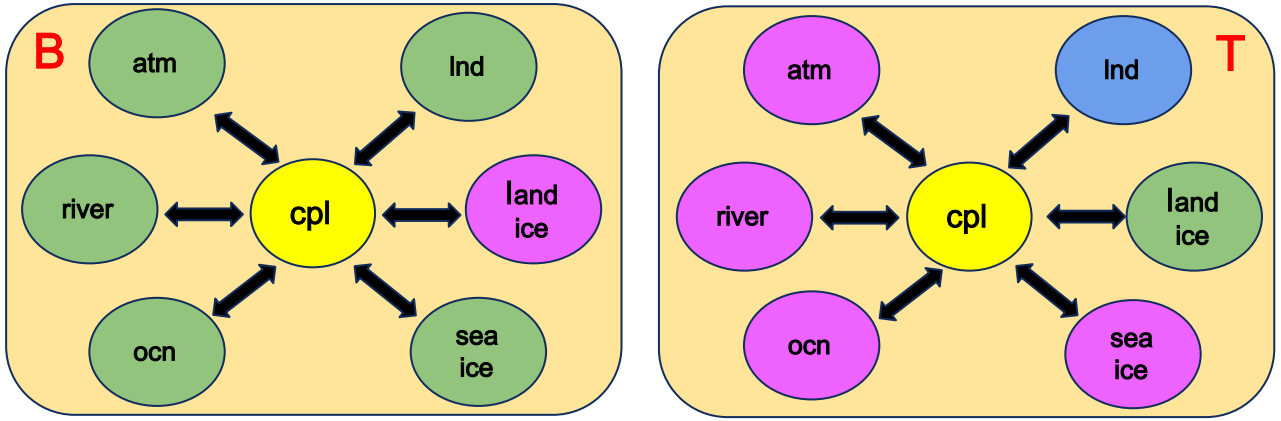


Ice thickness



Difference between a B and a T case

Color code: active data stub

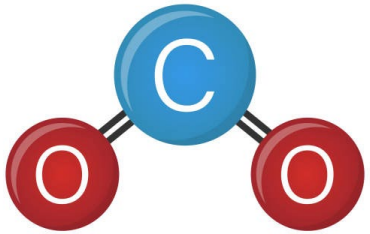


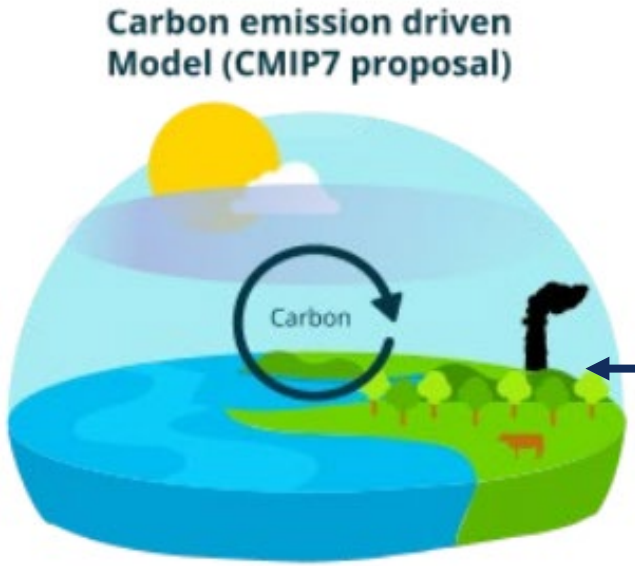
Biogeochemistry

Proposed exercises

- Set up two different BGC cases and compare case directories (you will **not** be running the model for this exercise)
- Compsets: B1850 and B1850_BPRP
- Both have f19_g17 resolution

Differences concern how CO_2 is handled:





Closed carbon cycle. CO_2 concentrations, aerosols and calculated as a function of human emissions and land use

Figure from Sanderson et al., 2023

Prognostic CO_2

- Compset = B1850_BPRP
- "Emission-driven"
- Predicted atmospheric CO_2 concentrations, computed from surface fluxes

Diagnostic CO_2

- Compset = B1850
- "Concentration-driven"
- Prescribed atmospheric CO_2 concentrations that are read from a file

See setup script and analysis notebooks:

https://github.com/NCAR/CESM-emission-driven-run-tutorial