Evaluating Water Isotope Tracers in the Variable -Resolution Community Earth System Model using USNIP (US Network for Isotopes in Precipitation)

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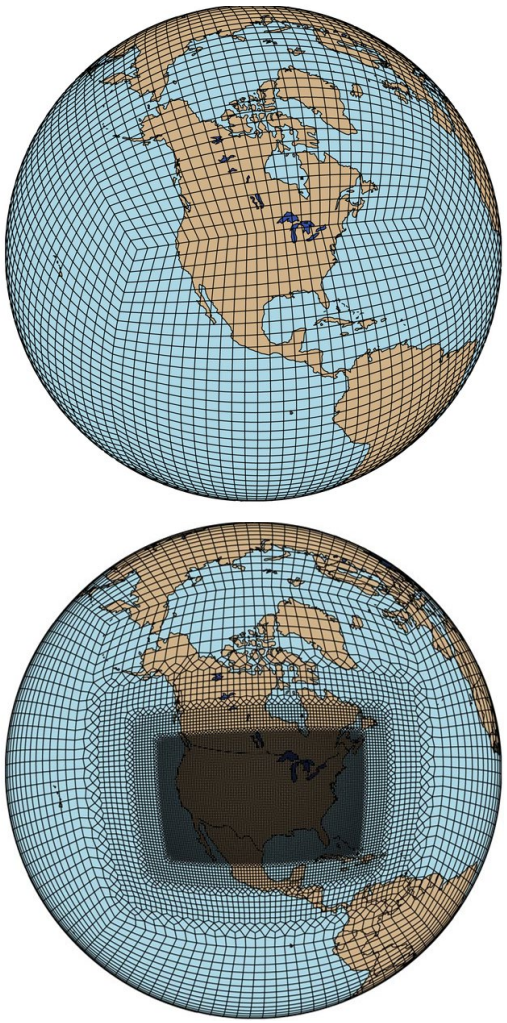
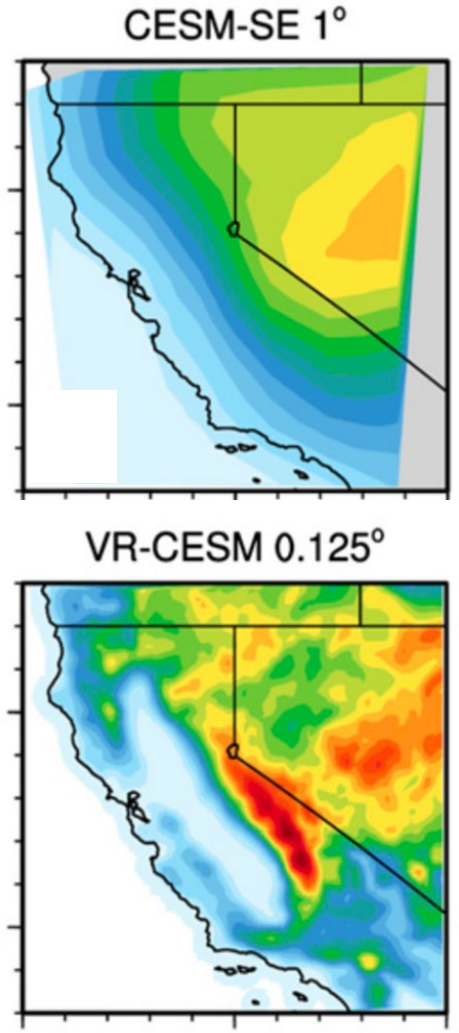
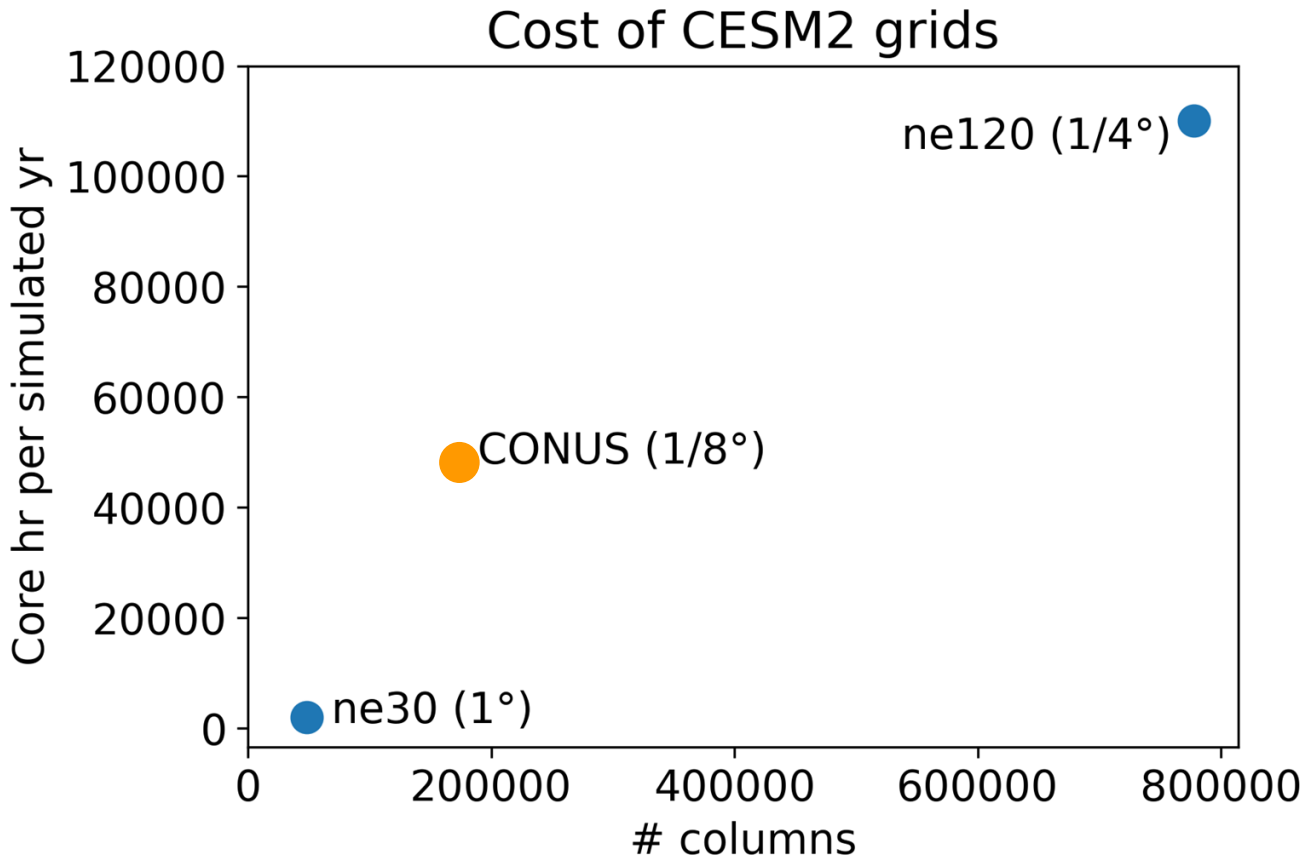
Variable-res captures global climate & complex regional terrain at a low cost



Grid



Topography



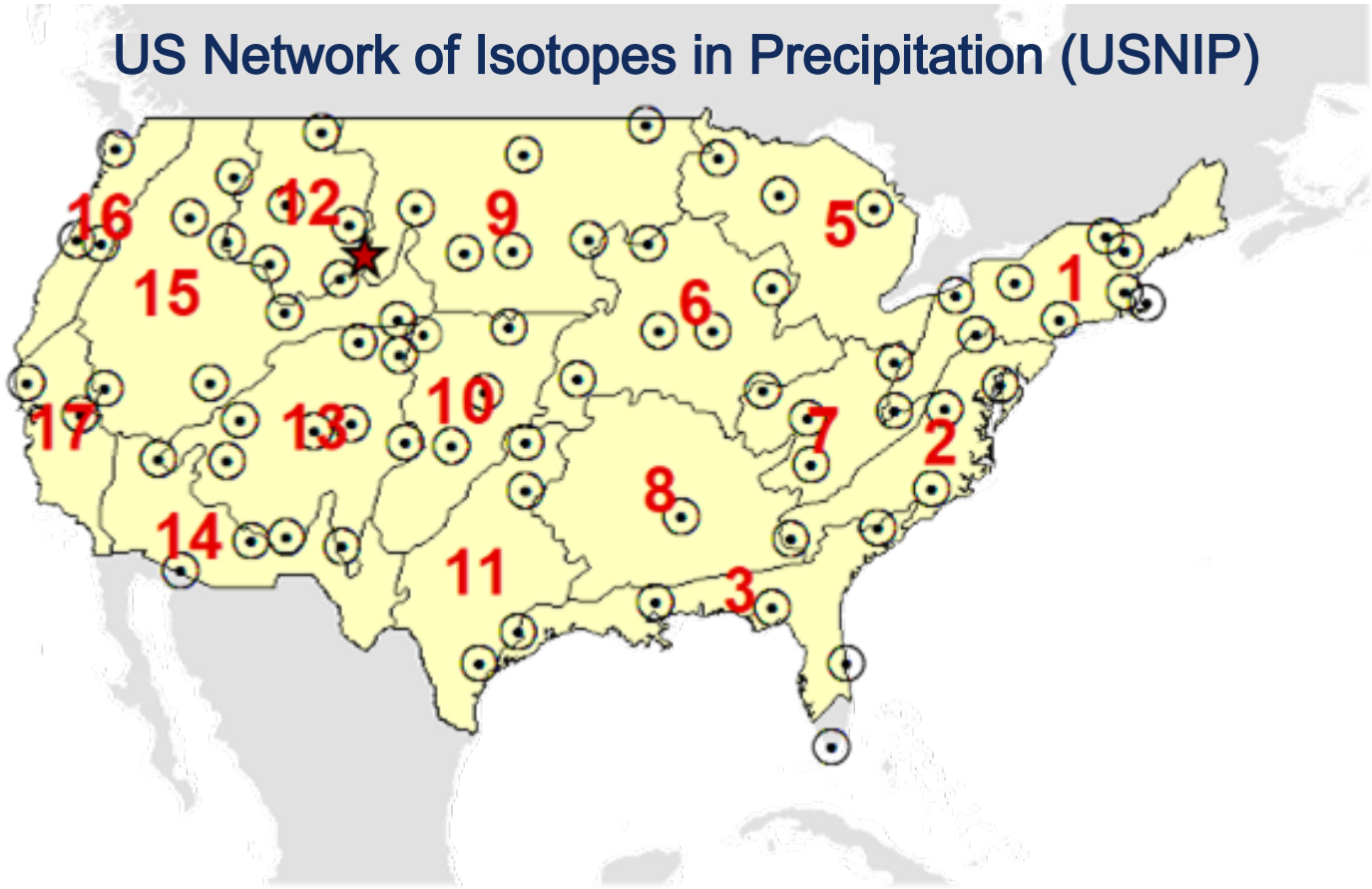
USNIP: 25 years of precipitation isotopic compositions across the US

USNIP includes weekly observations from 1989–2014 of precipitation $\delta^{18}O$ and δD at 73 sites over contiguous US, which can be used to:

1) Quantify the spatial-temporal variability in precipitation isotopes across contrasting climate zones

1) Validate (high-resolution) isotope-enabled climate models over the contiguous US

Jeff Welker
Shaakir Dar
Univ. Alaska, Univ. Oulu

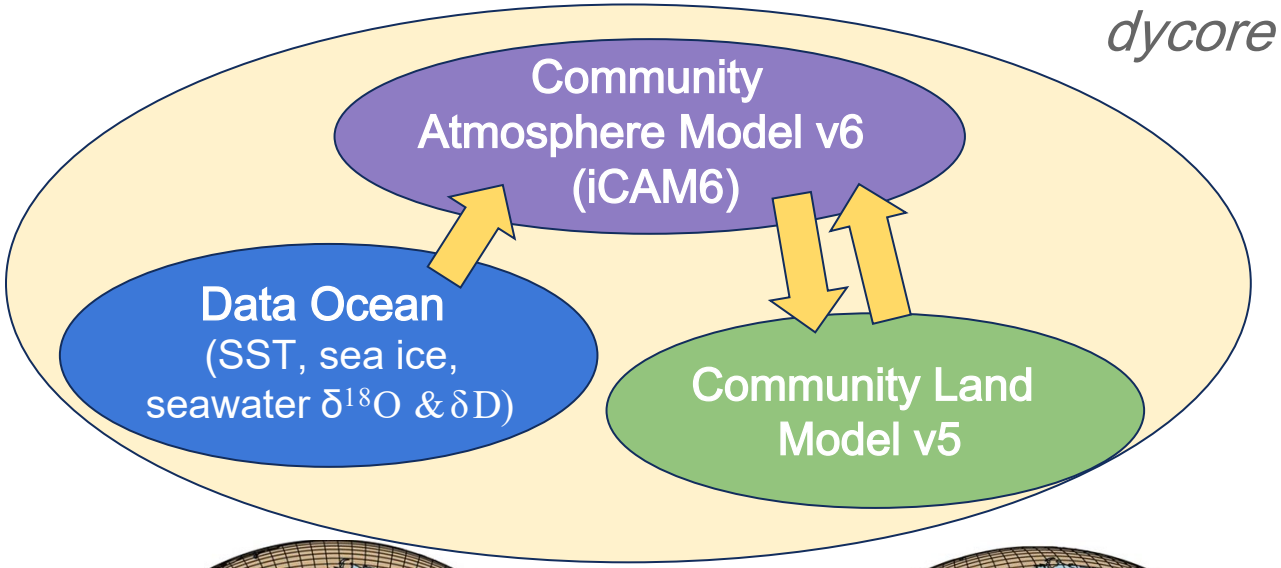


Case Study: precipitation isotopes over the contiguous US from 1990 -2015

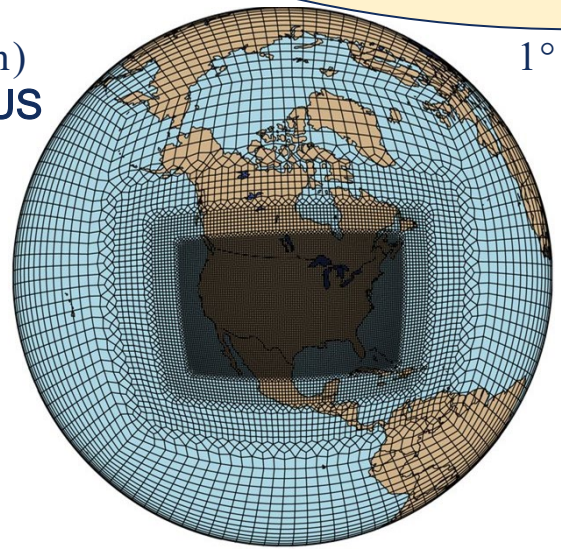
- Two iCAM6-CLM5 simulations over the 1990-2015 historical period
- T, U, V nudged to MERRA2 reanalysis

Jiang Zhu ***NCAR***
Jesse Nusbaumer
Adam Herrington
Bette Otto-Bliesner
Esther Brady

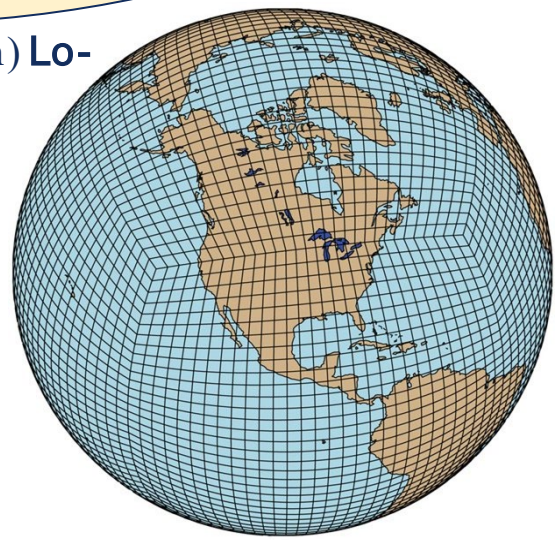
Community Earth System Model 2 *SE-dycore*



⅛° (12.5 km) **Hi-res CONUS**



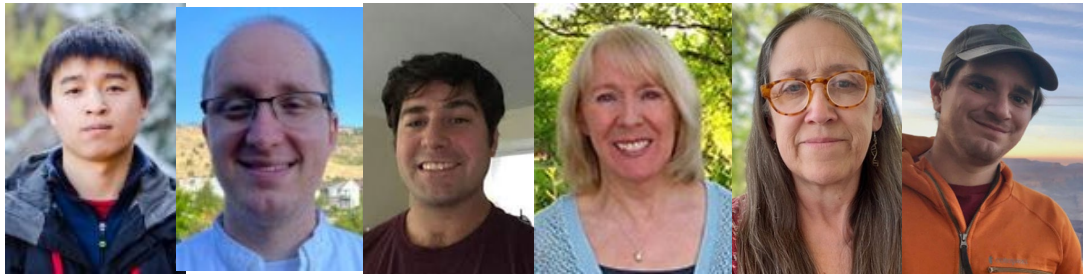
1° (100 km) **Lo-res**



Case Study: precipitation isotopes over the contiguous US from 1990 -2015

- Two iCAM6-CLM5 simulations over the 1990-2015 historical period
- T, U, V nudged to MERRA2 reanalysis
- ~1° simulation contains process-oriented water tags that track:
  - Rayleigh rainout effect
  - Evaporative source $\delta^{18}O$ and RH
  - Condensation T
  - Mean evaporation source location

Rich Fiorella ***LANL***



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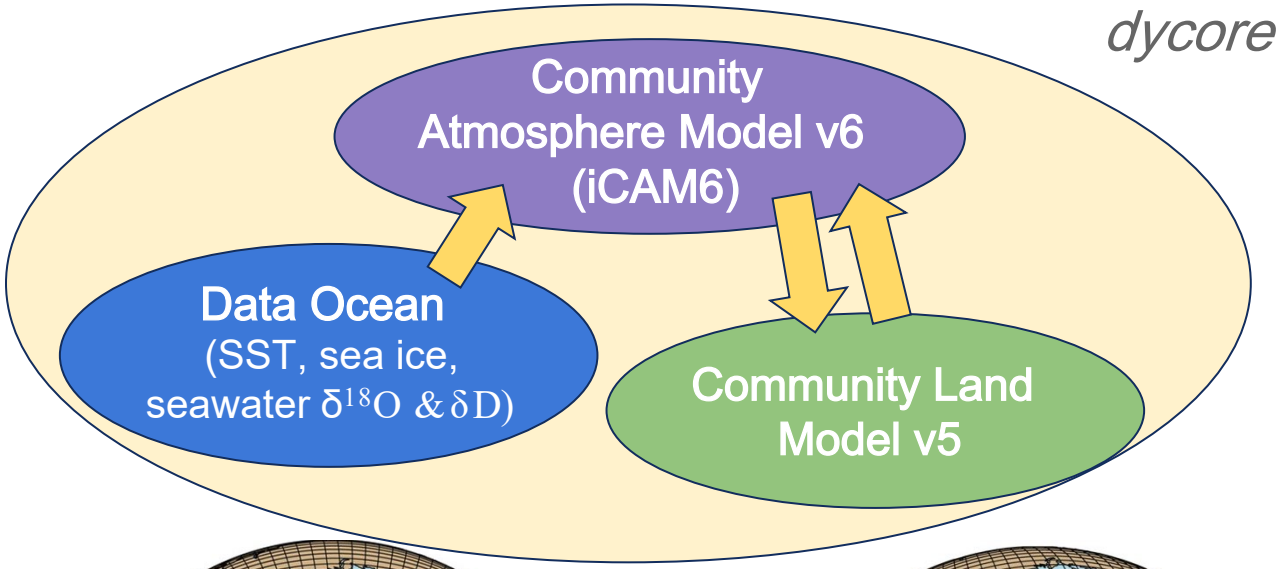

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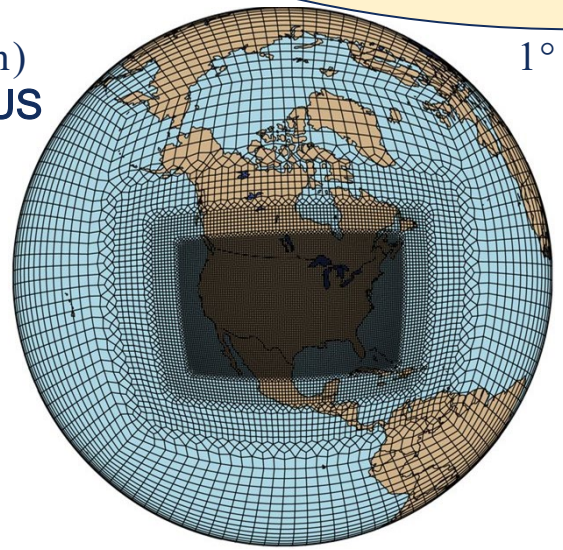

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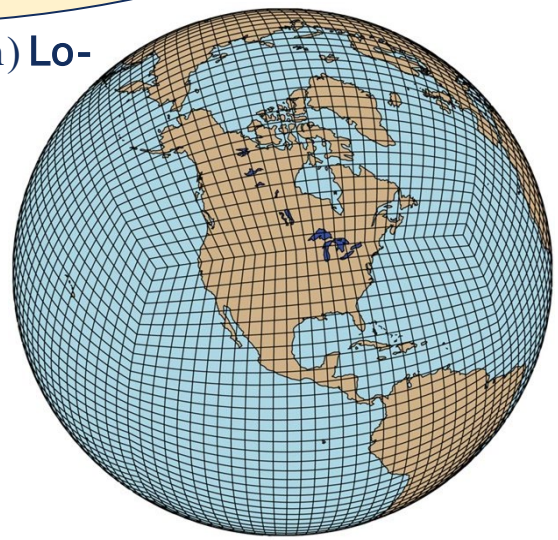
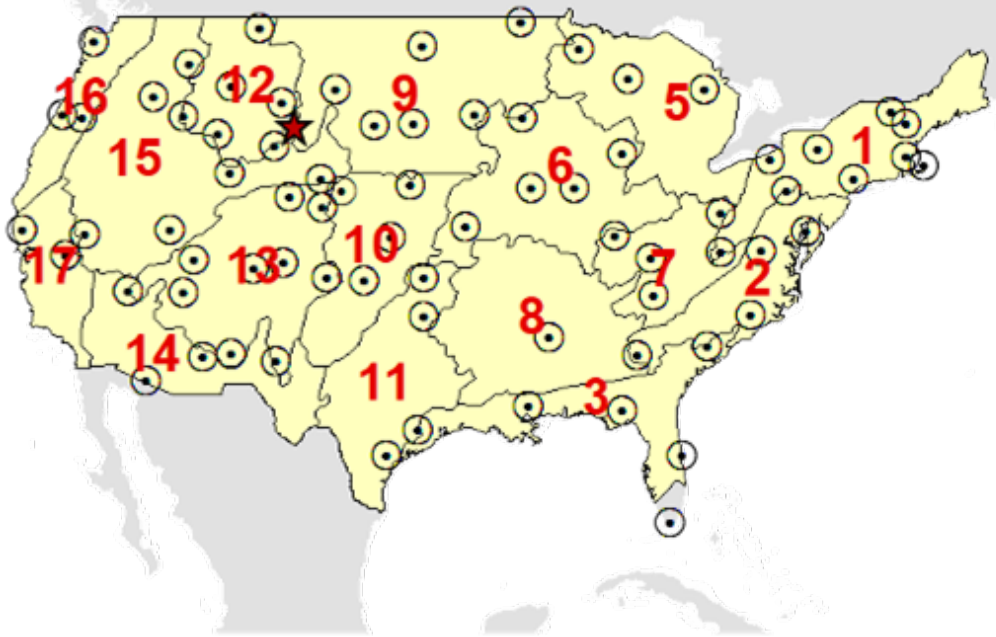


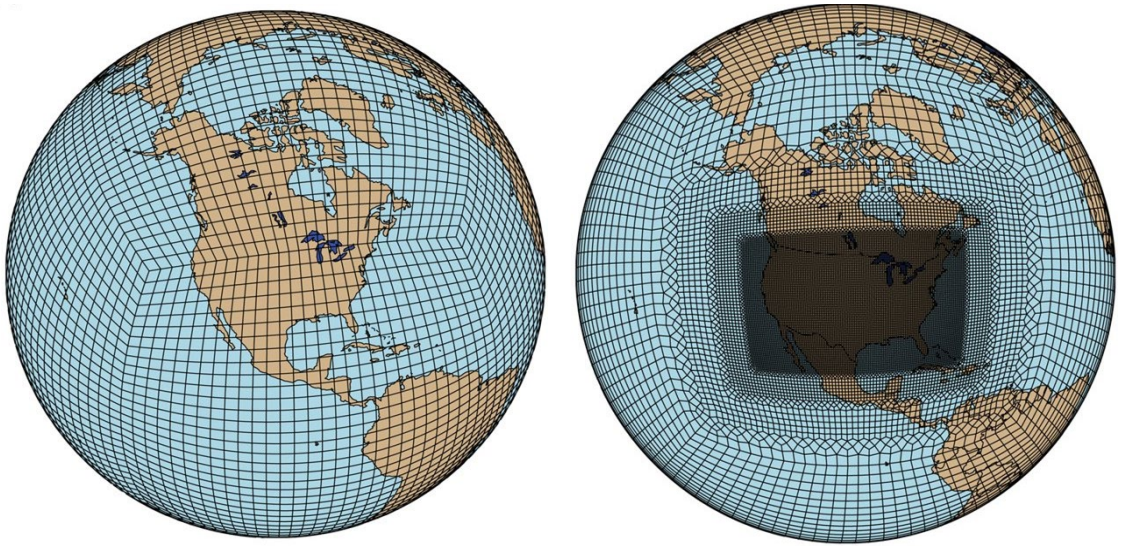
Data-model comparison of precipitation $\delta^{18}O$ and d-*excess* over contiguous US

US Network of Isotopes in Precipitation (USNIP)



Model validation

- Where & why do simulated isotopic variations capture observations?
- Where does the higher grid resolution fit the data better?

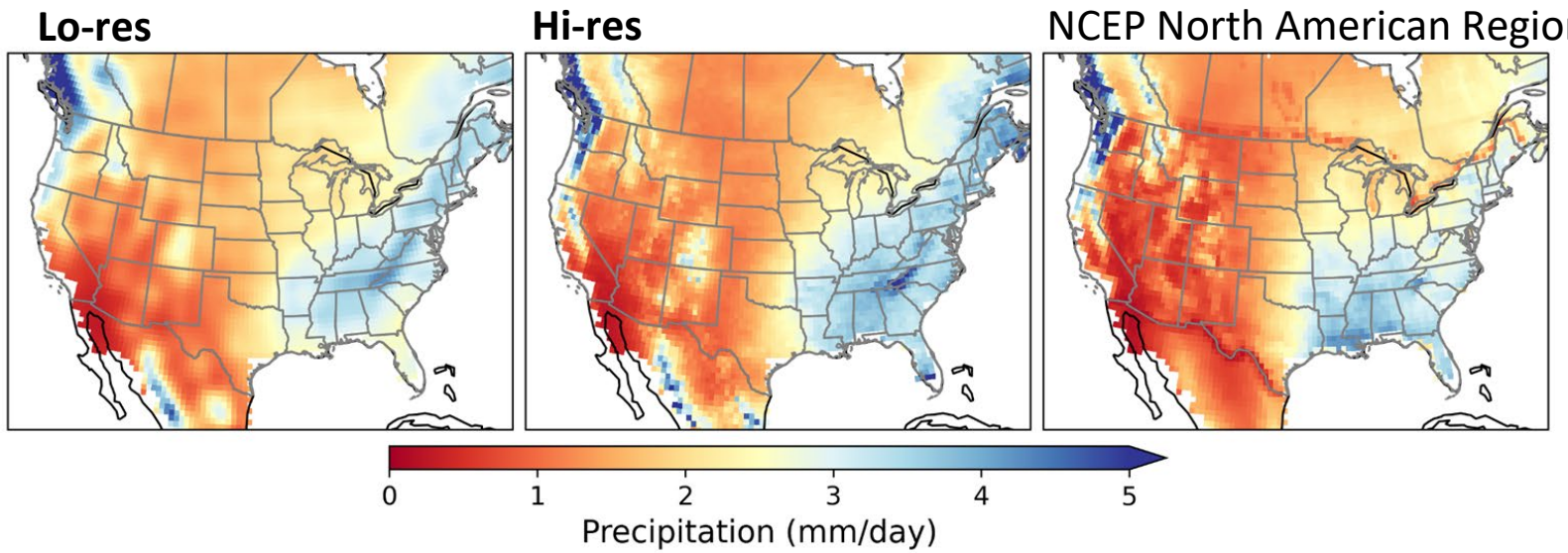


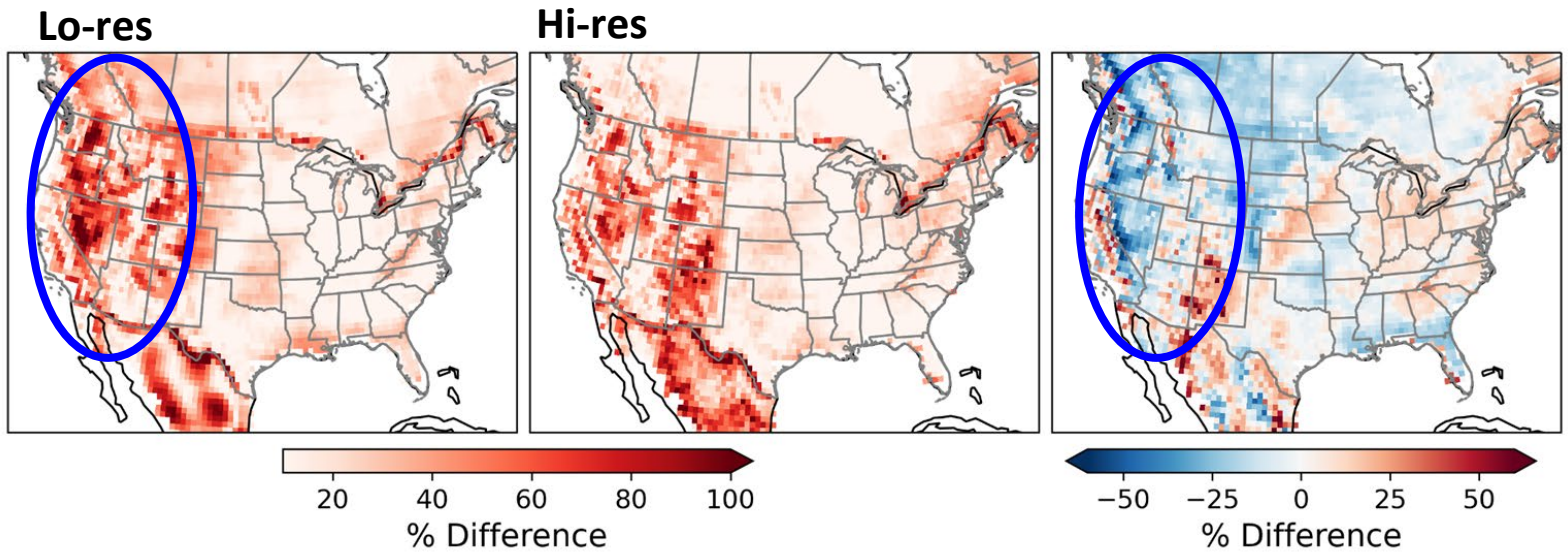
isotope -enabled Community Earth System Model

Controlling conditions

- What are the dominant drivers of monthly-mean isotopic variation over the US?

Grid refinement over US provides overall improvement in precipitation amount

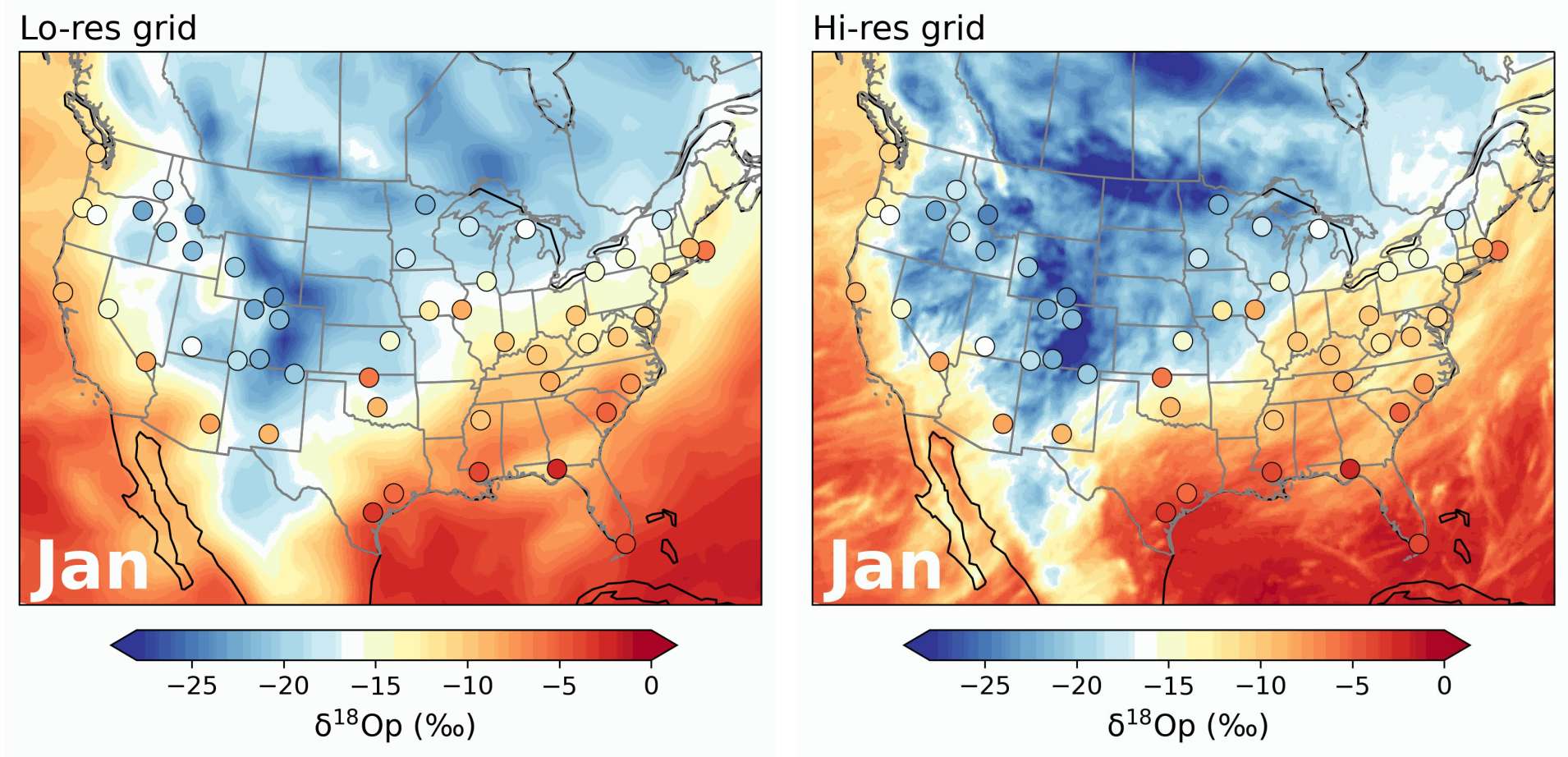




hi-res provides improvement where error is highest in western US

Overview of spatiotemporal variability in precipitation $\delta^{18}O$ over US

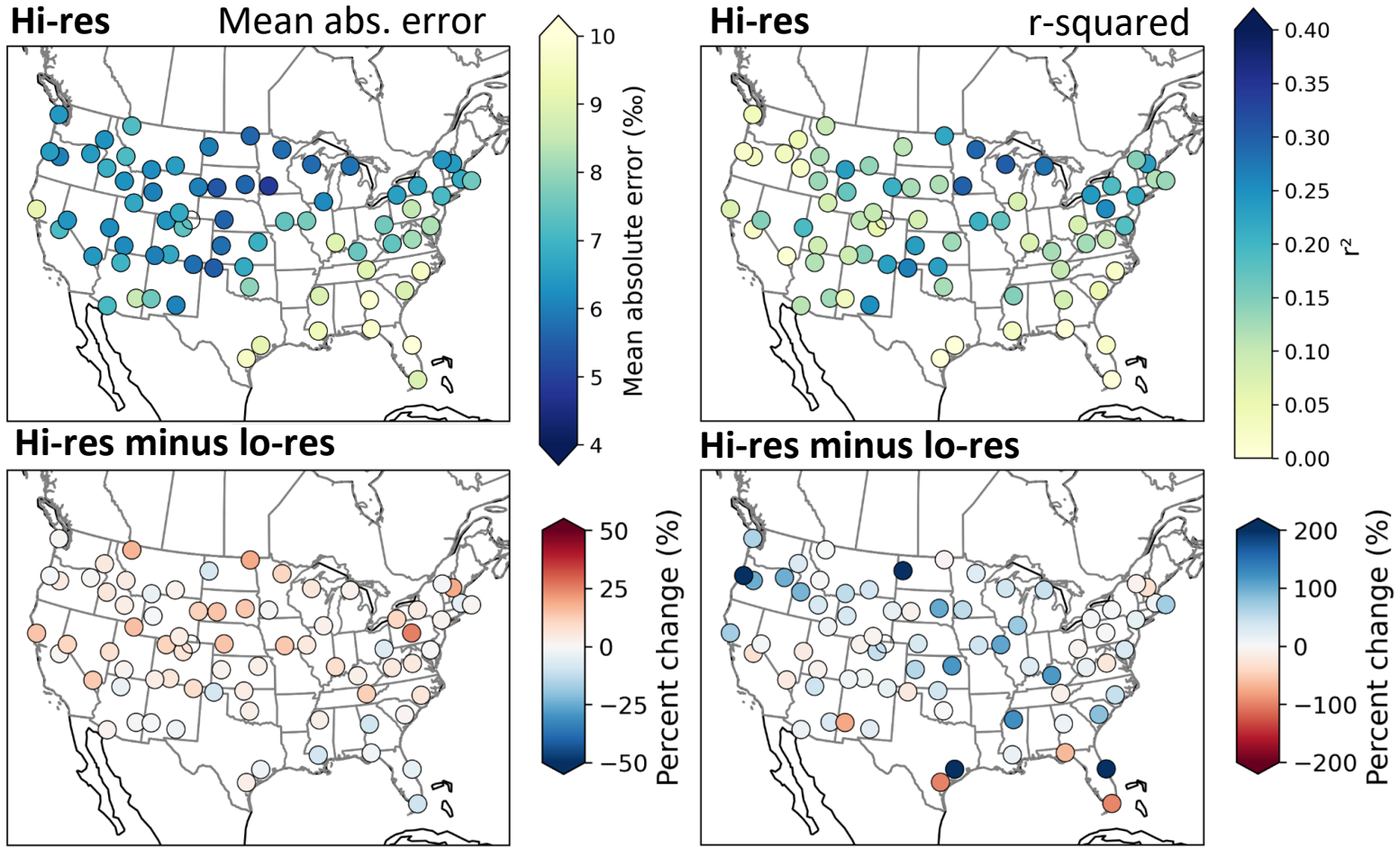
more rainout = lower precipitation $\delta^{18}O$



more spatial-temporal variability with hi-res

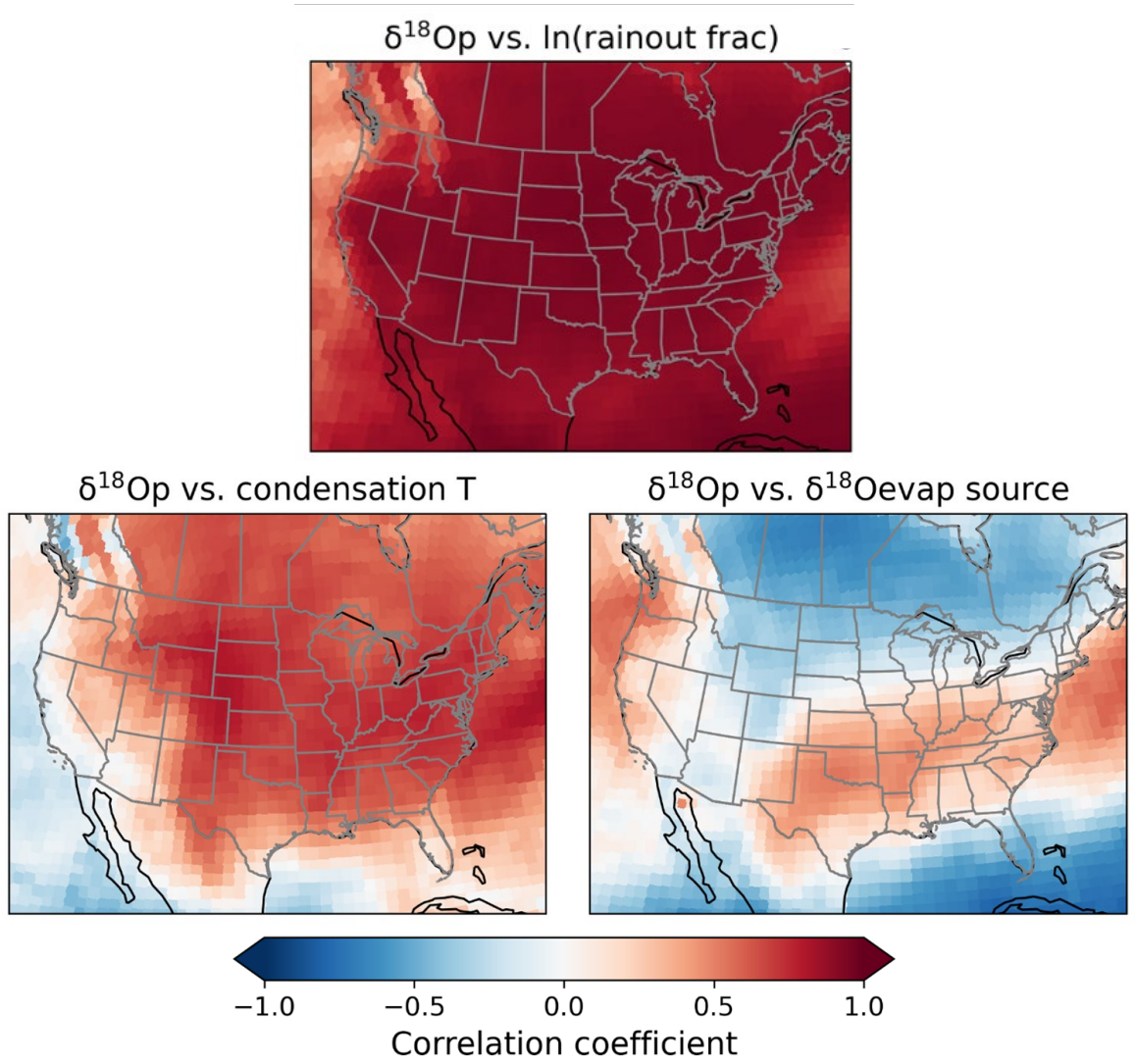
iCAM6-USNIP $\delta^{18}Op$ is best in continental interior and worst along the coast

- Simulations capture monthly precipitation $\delta^{18}O$ similarly, with some improvement in US interior with hi-res
- E.g., in the South, iCAM6 predicts lower $\delta^{18}Op$ than USNIP that is not improved with hi-res

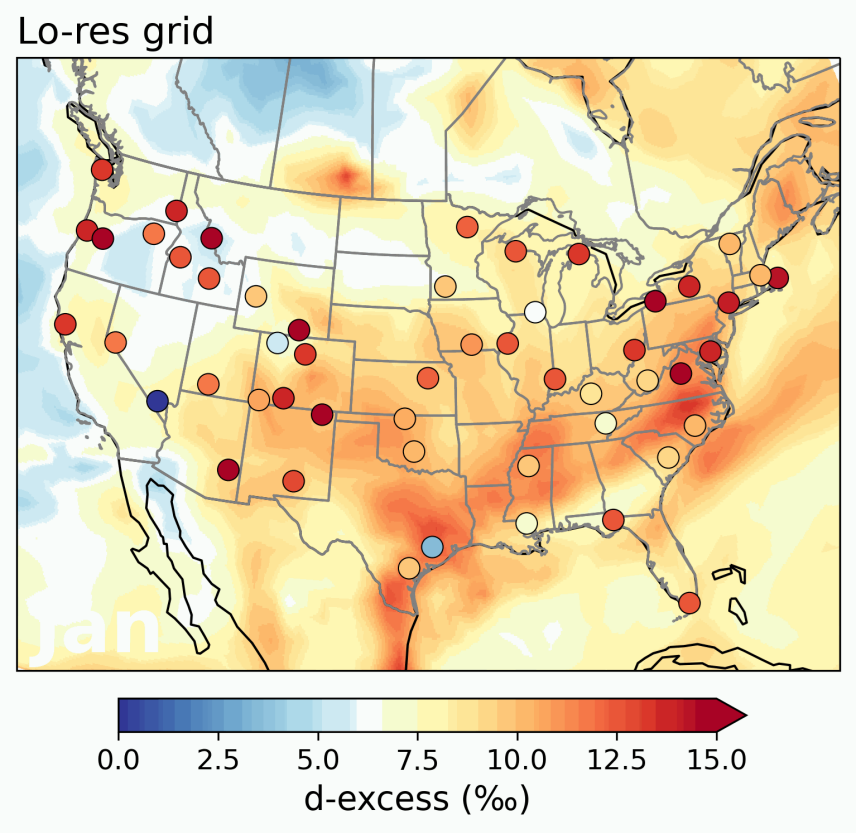


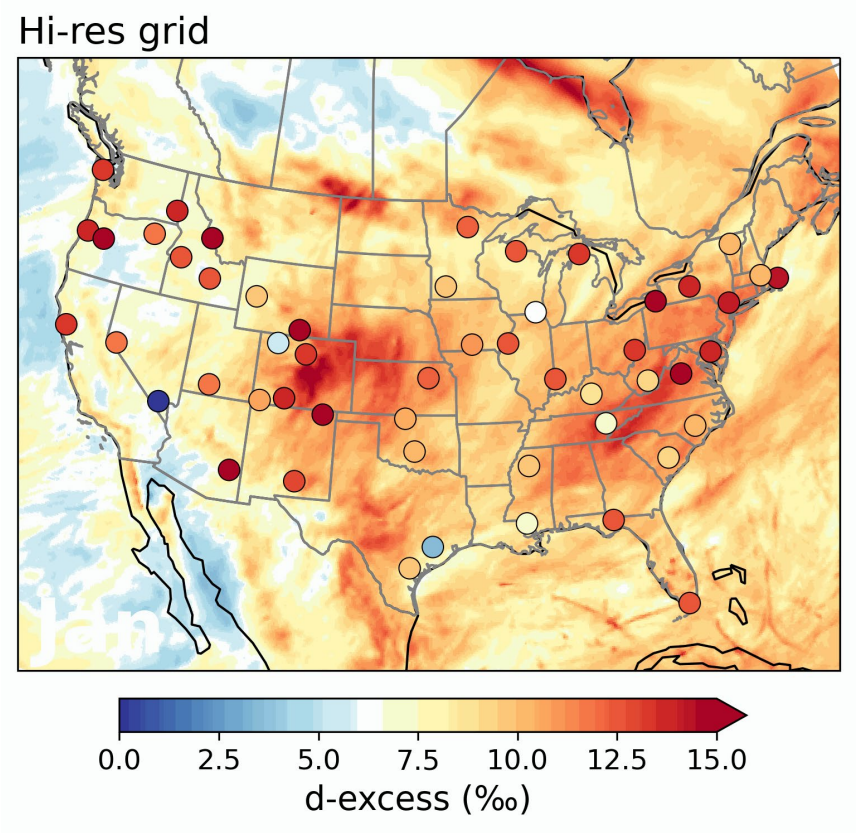
Precipitation $\delta^{18}O$ bias in coastal regions may be due to evaporative source conditions

- Typically in coastal regions (e.g., South), T is high and rainout is low, so initial evaporative conditions become important
- Improving representation of model $\delta^{18}O_{seawater}$ (only 1° resolution) may improve coastal precipitation $\delta^{18}O$



Spatiotemporal variability in precipitation d -*excess* over US

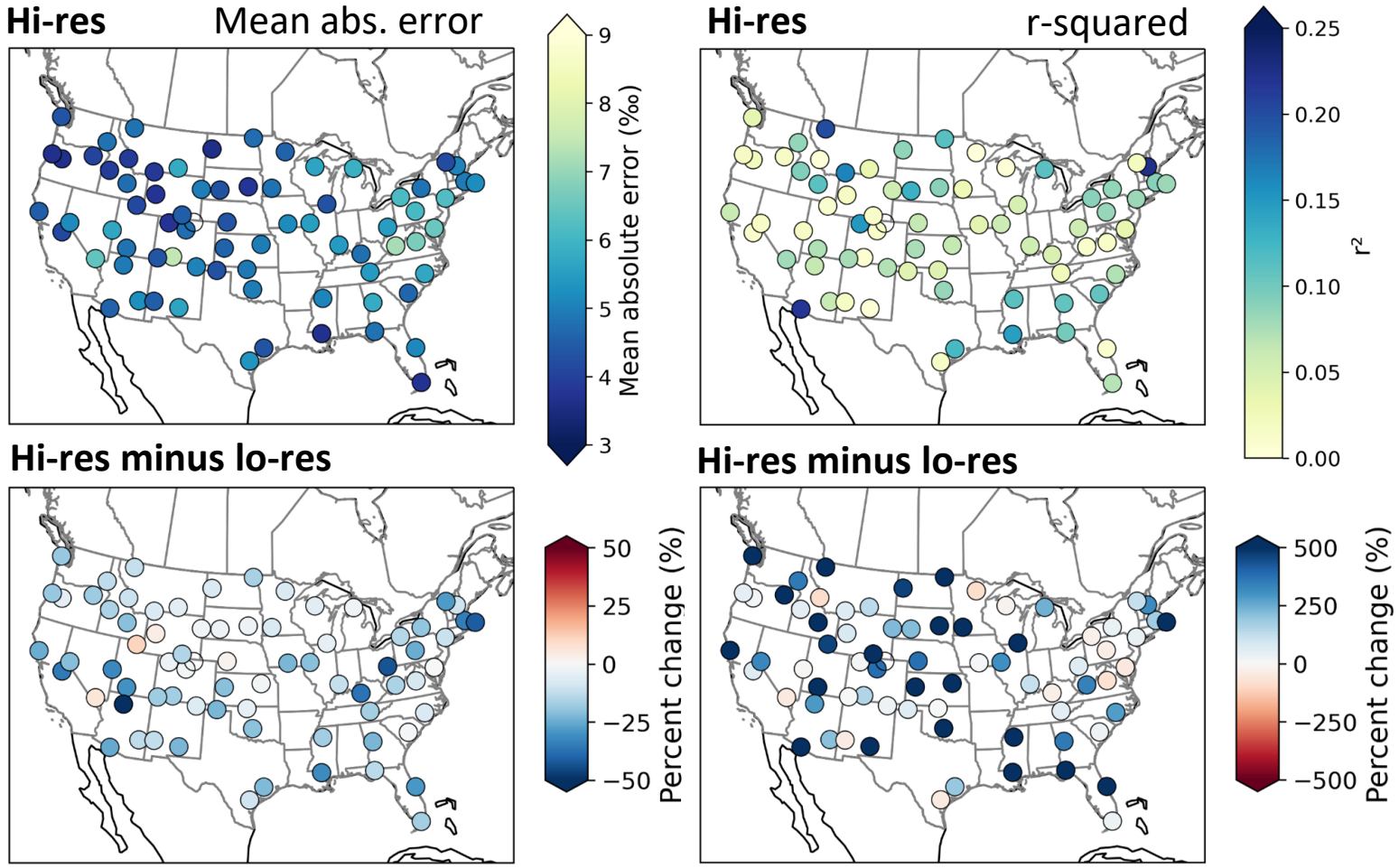




more spatial-temporal variability with hi-res

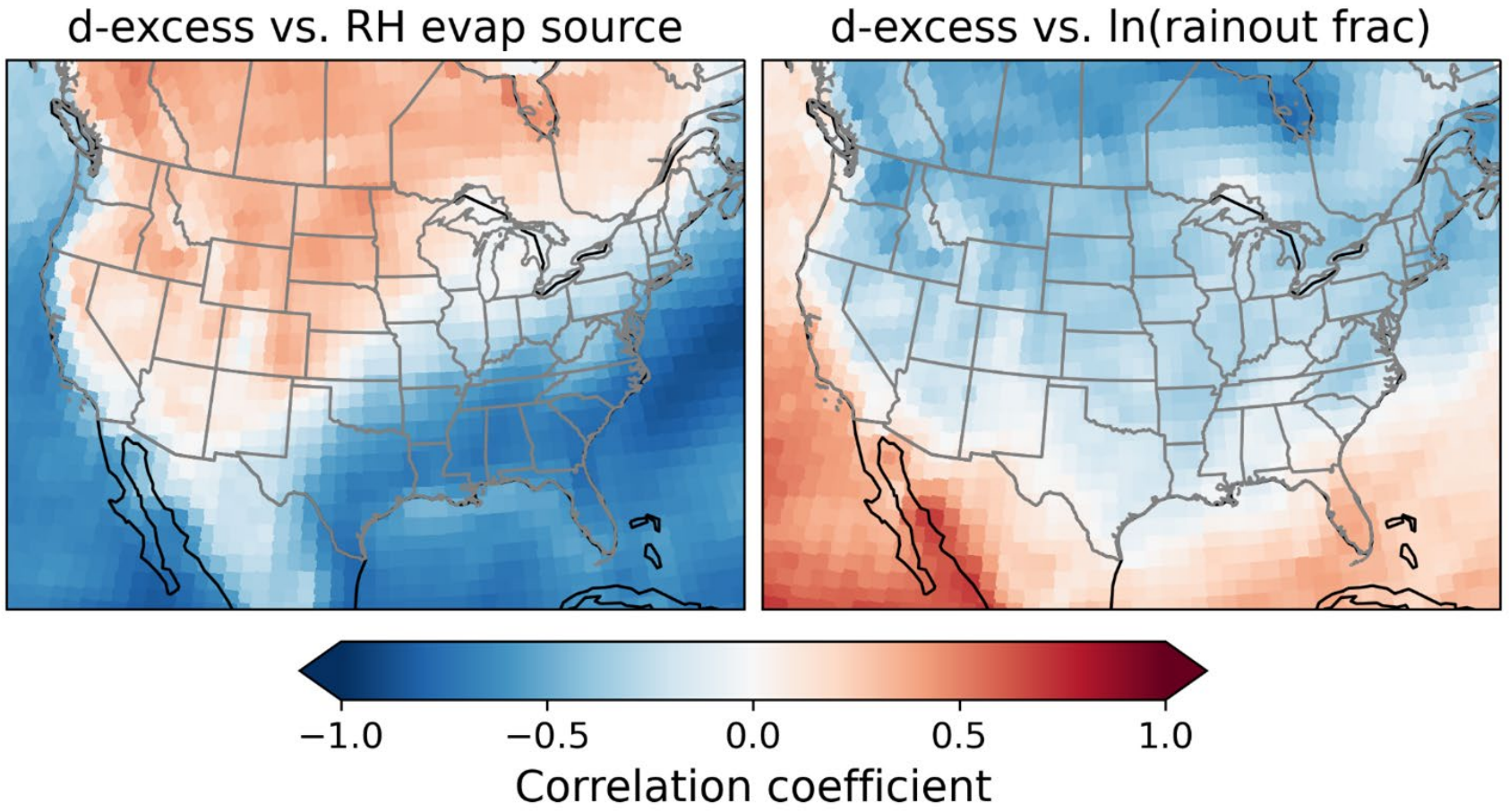
Regional grid refinement in iCAM6 improves d -*excess* across the US

- Overall, data-model fit for precipitation d -*excess* is lower than $\delta^{18}O$, but substantially improves with hi-res

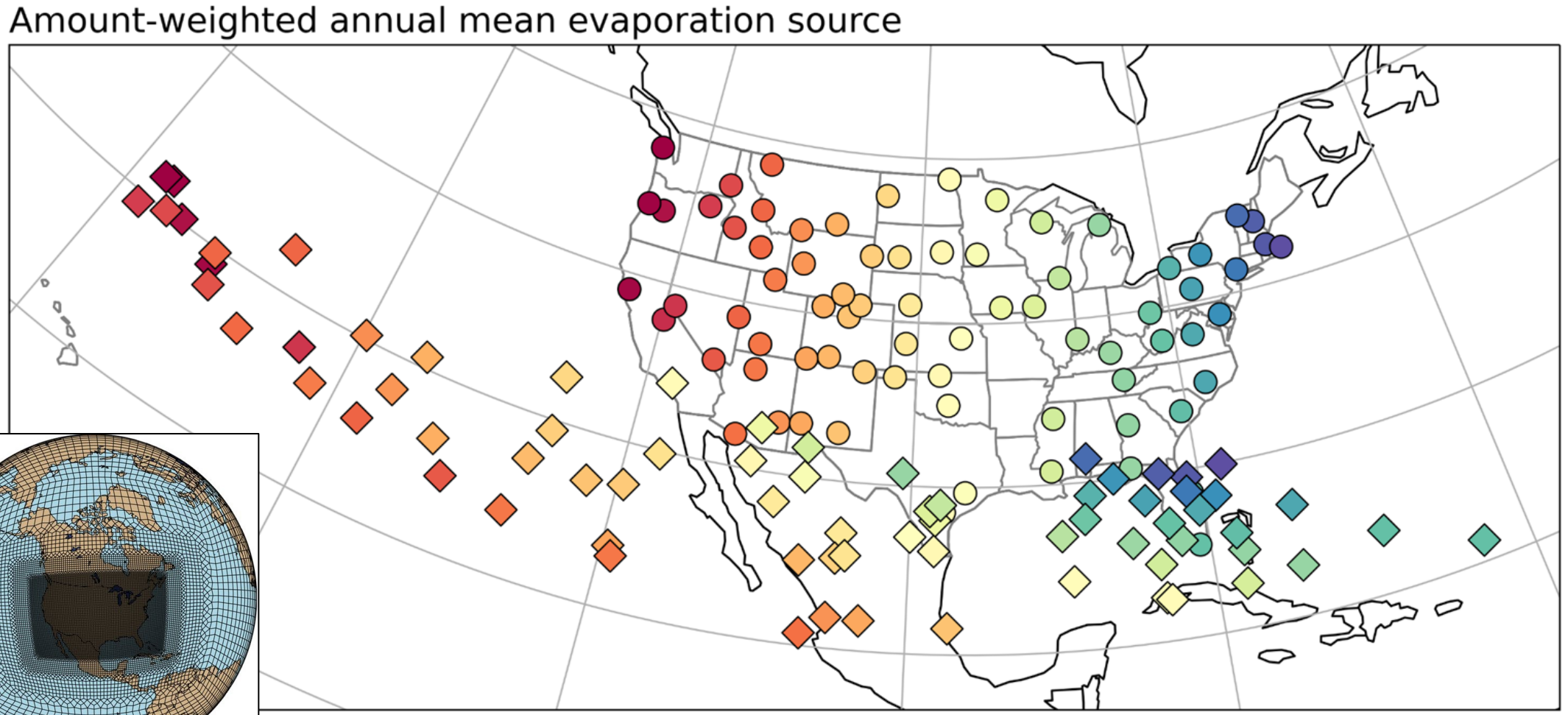


Precipitation d -excess controlled by rainout fraction and source conditions

Evaporative source conditions particularly important in coastal regions and southeast



Extent of grid -refined region captures evaporative conditions recorded by d -*excess*



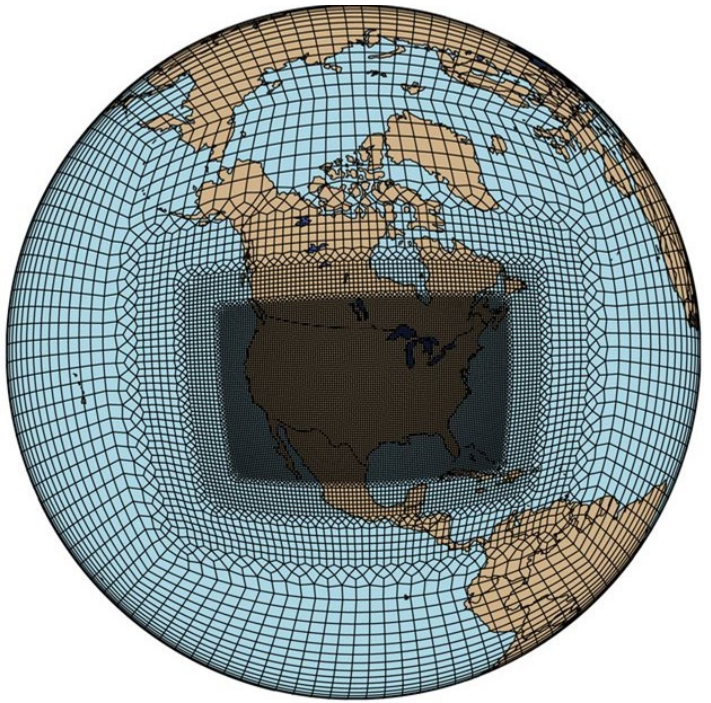
Preliminary lessons for VR paleo applications from US case study

- Using process-oriented tags in a global low-resolution simulation is a great first step to learn about primary isotopic controls in your region of interest

- For VR-iCESM, in the region of grid refinement…

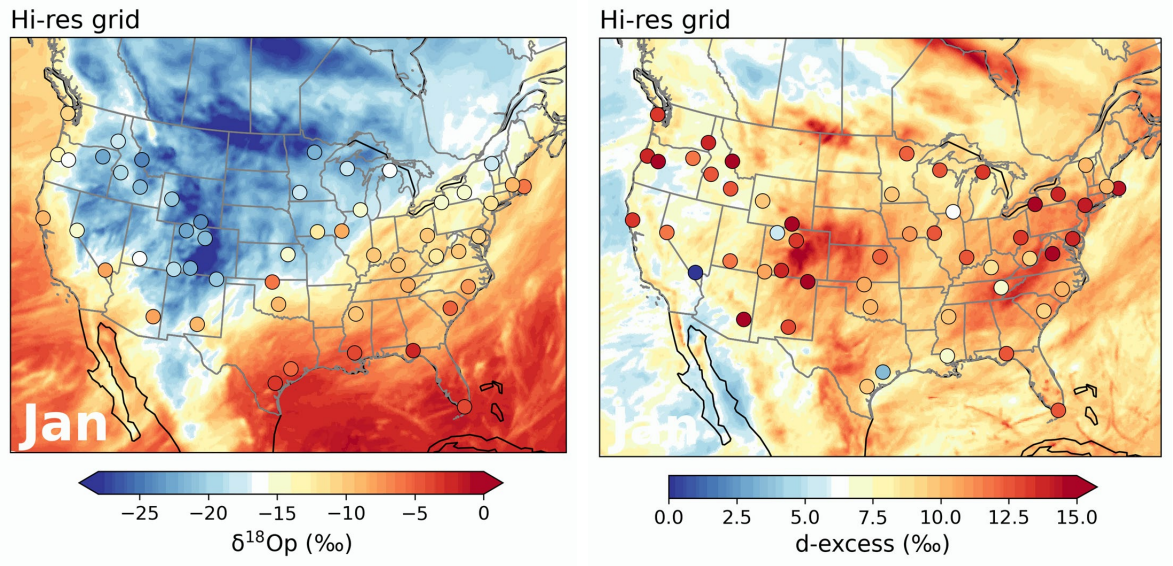
  - For prescribed sea surface, incorporate finer-scale seawater $\delta^{18}O$ based on high-res simulation or available proxy data→best results for coastal precip $\delta^{18}O$

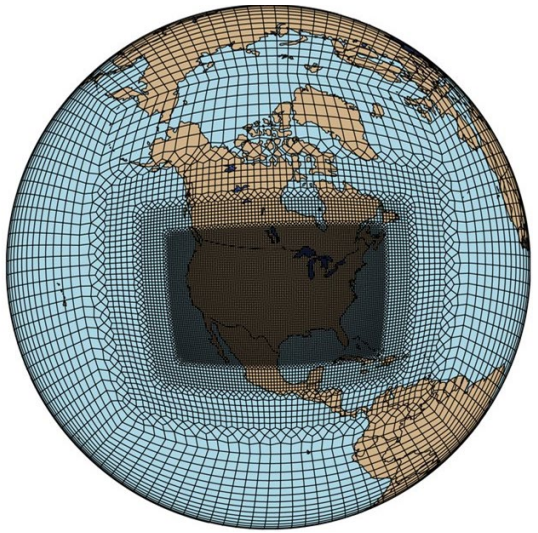
  - Including important evaporative source regions→best results for precip d-*excess*



Preliminary Conclusions & Future Directions

- Variable-resolution iCESM is a powerful & cost effective approach for:
  - Providing insight into the controlling conditions of observed isotopic variation
  - Evaluating isotopic models at fine spatial scales closer to observations (e.g., USNIP)
- Hi-res provides improvements in d-*excess* over CONUS & precip amount over western US
- Future plans include using VR-iCESM for paleoclimate applications (i.e., Last Deglaciation)





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