Improved Subseasonal-to-Seasonal Precipitation Prediction of Climate Models with Nudging Approach for Better Initialization of Tibetan Plateau-Rocky Mountain Circumglobal Wave Train and Land Surface Conditions

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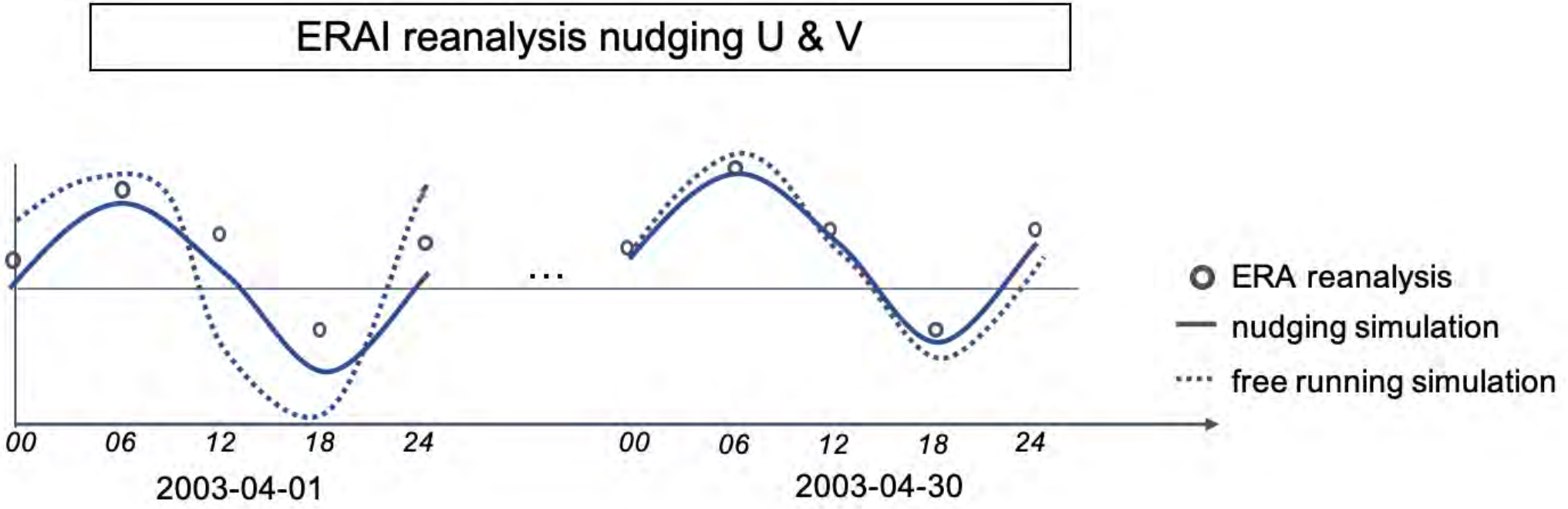
Qin et al., Climate Dynamics, in revision

Global climate model is difficult to match time-specific obs.

- Hypothesis: More realistic initial conditions are necessary for LS4P experiment.
- Solution: 1-month nudging is applied.



AMIP-type experiments for generating initial condition (***April 1 to April 30, 2003***)

Short name	**Description**	**Simulation period**
EXP0	Experiment **without nudging**	1 month (April 1 to April 30)
EXP0-Nudg	Experiment **with nudging**	As above

The generated initial condition on May 1, 2003 is used for standard LS4P experiments (May 1 to Jun 30, 2003).

All experiments were conducted for two models: E3SMv1 (Golaz et al., 2019) and CIESM (Lin et al., 2021).

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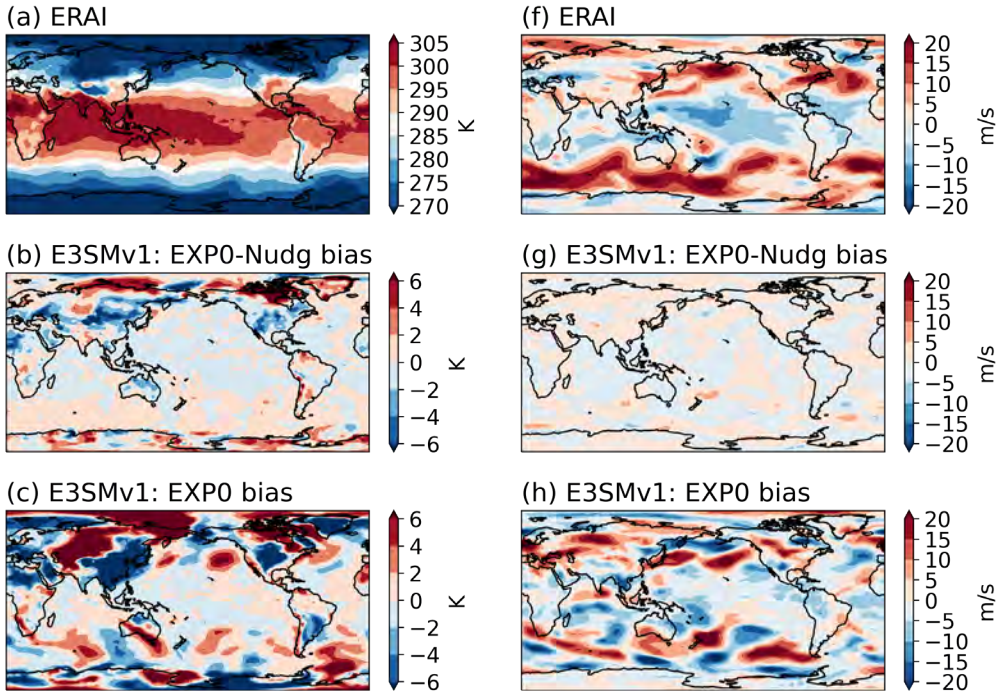
2m temperature **850 hPa zonal wind**

ERAI

With nudging

Without nudging

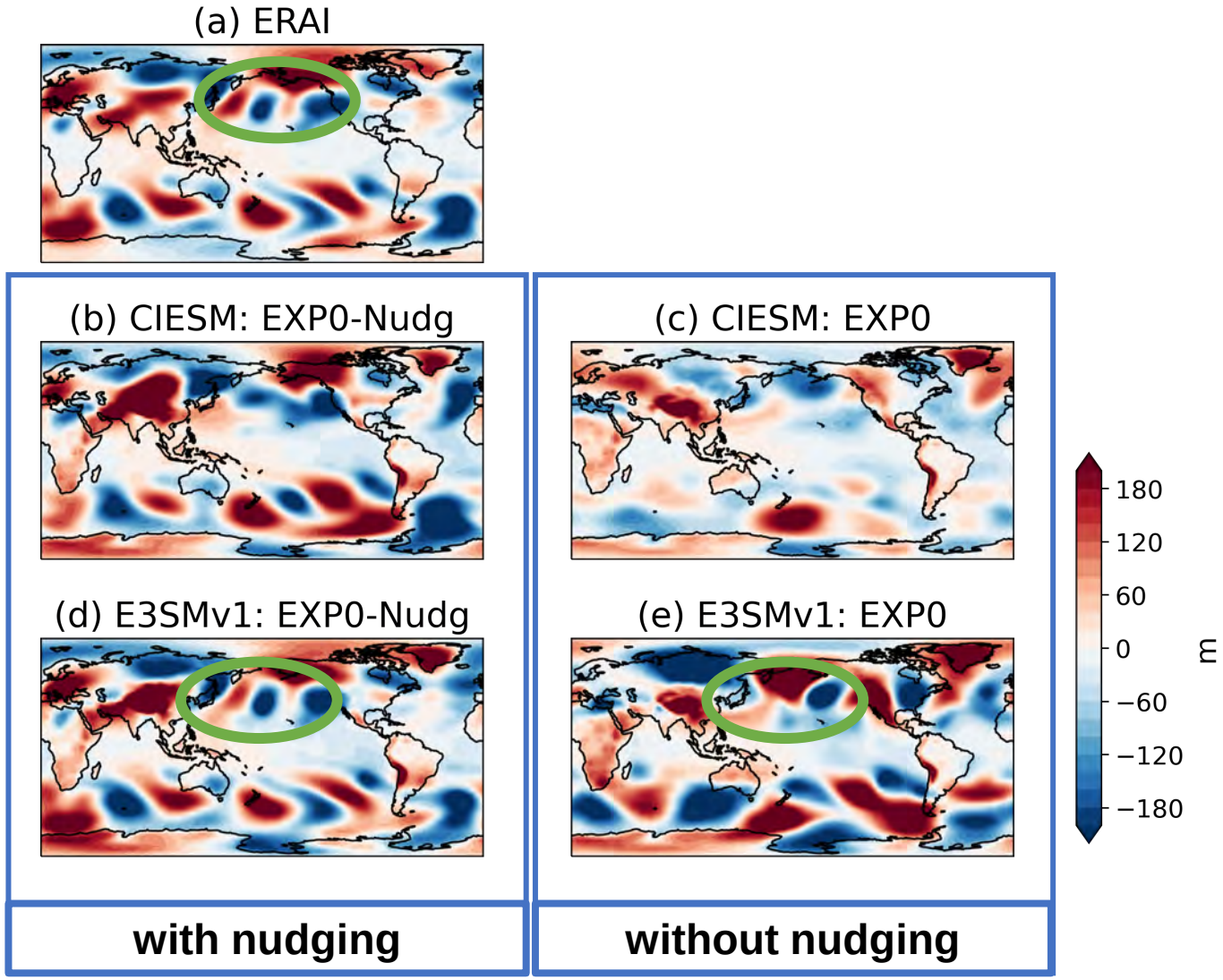


After 1-month nudging, near-surface atmospheric variables are closer to the observation at the beginning of LS4P-I experiments (May 1, 2003).

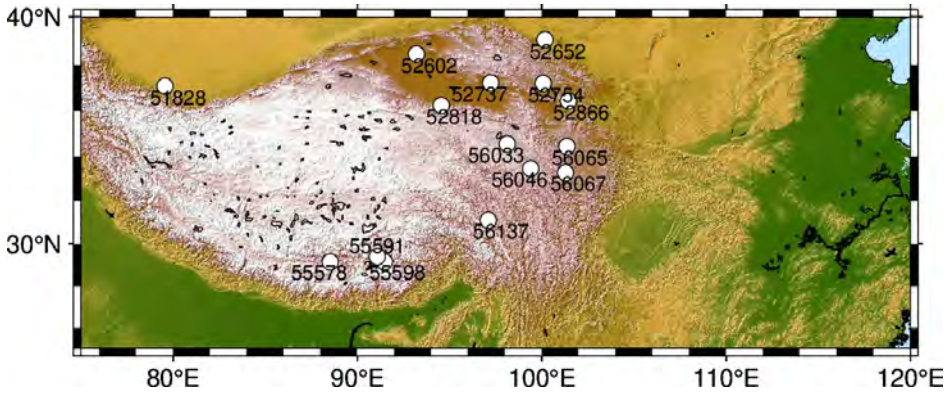
Qin et al., under review

Substantially improved large-scale patterns

(200 hPa geopotential height with zonal mean removed)

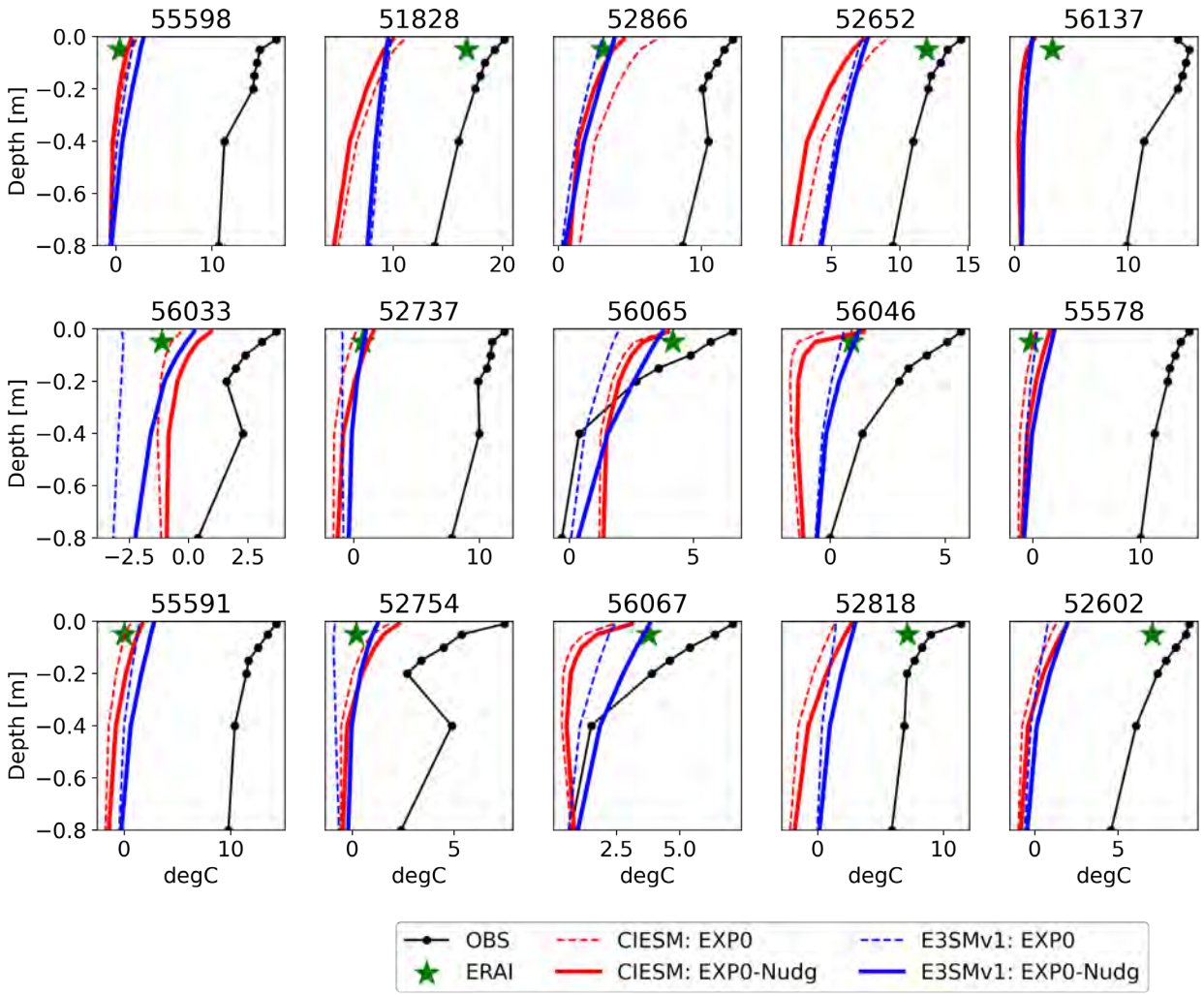


Large-scale patterns are largely improved, which is crucial for capturing precipitation responses globally.



Improved soil temperature profiles over TP sites are better for adding LS4P temperature perturbations for S2S prediction.

Solid line: with nudging; *Dashed line: without nudging*



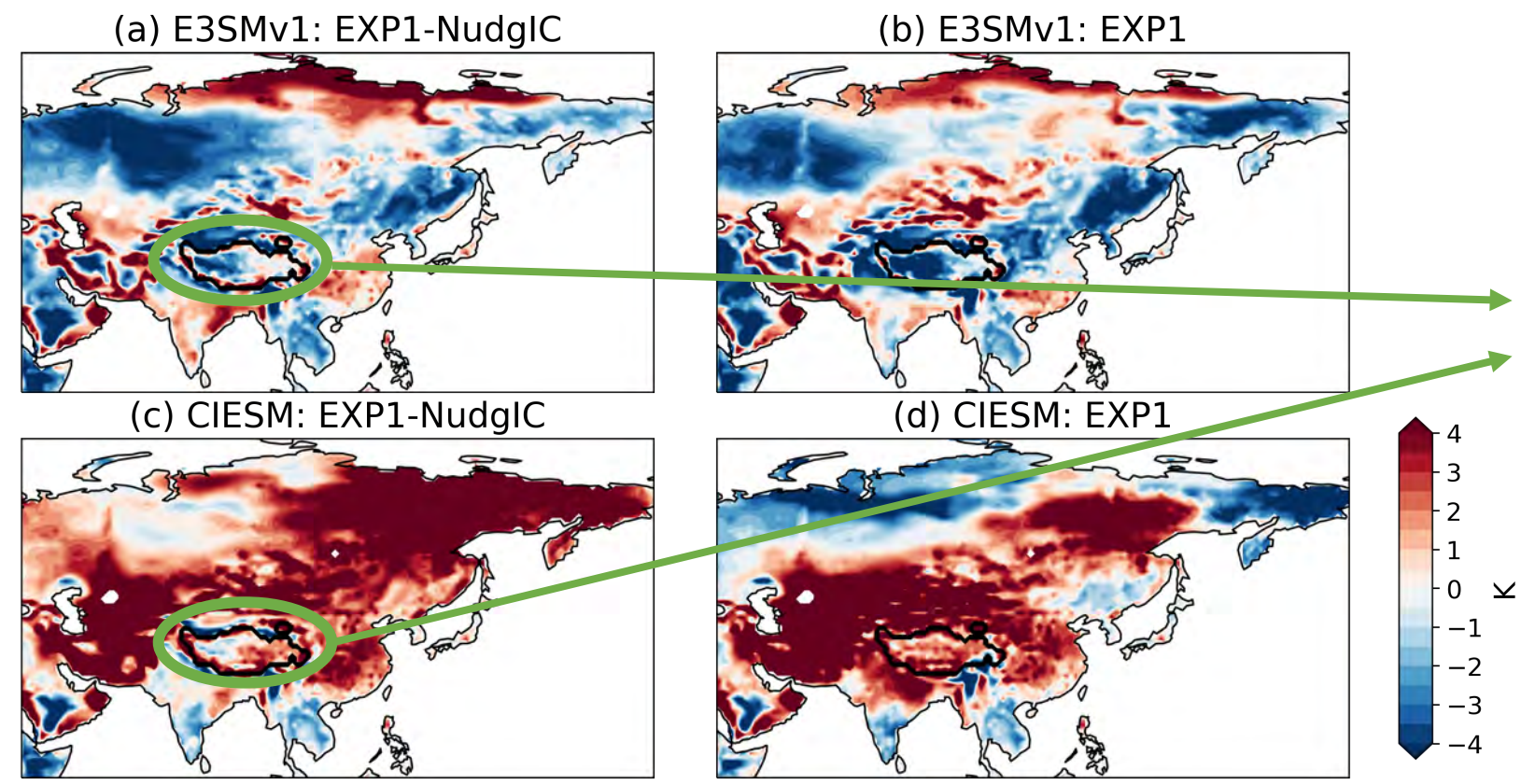
LS4P experiments
(*May 1 to June 30, 2003*)

Short name	Description	Simulation period
EXP1	Experiment without nudged initial conditions (IC)	2 months (May 1 to June 30)
EXP2	Experiment without nudged IC + imposed TP anomaly	As above
EXP1-NudgIC	Experiment with nudged IC	As above
EXP2-NudgIC	Experiment with nudged IC + imposed TP anomaly	As above

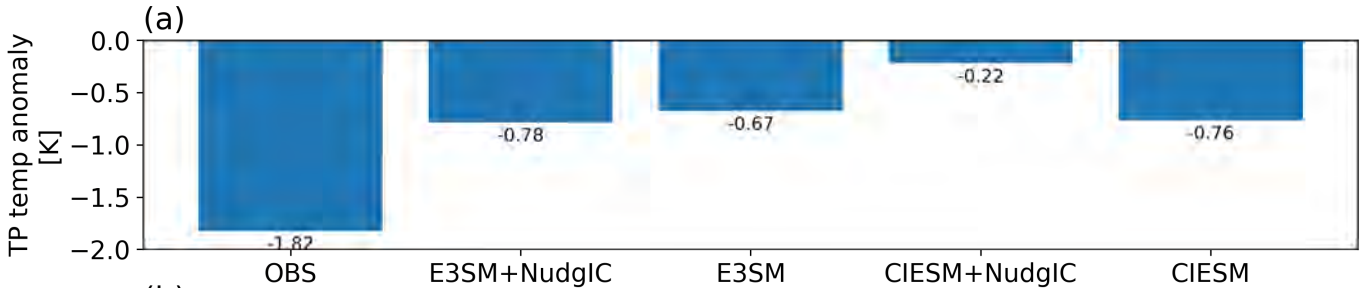
May 2-m air temperature simulation

with nudged IC

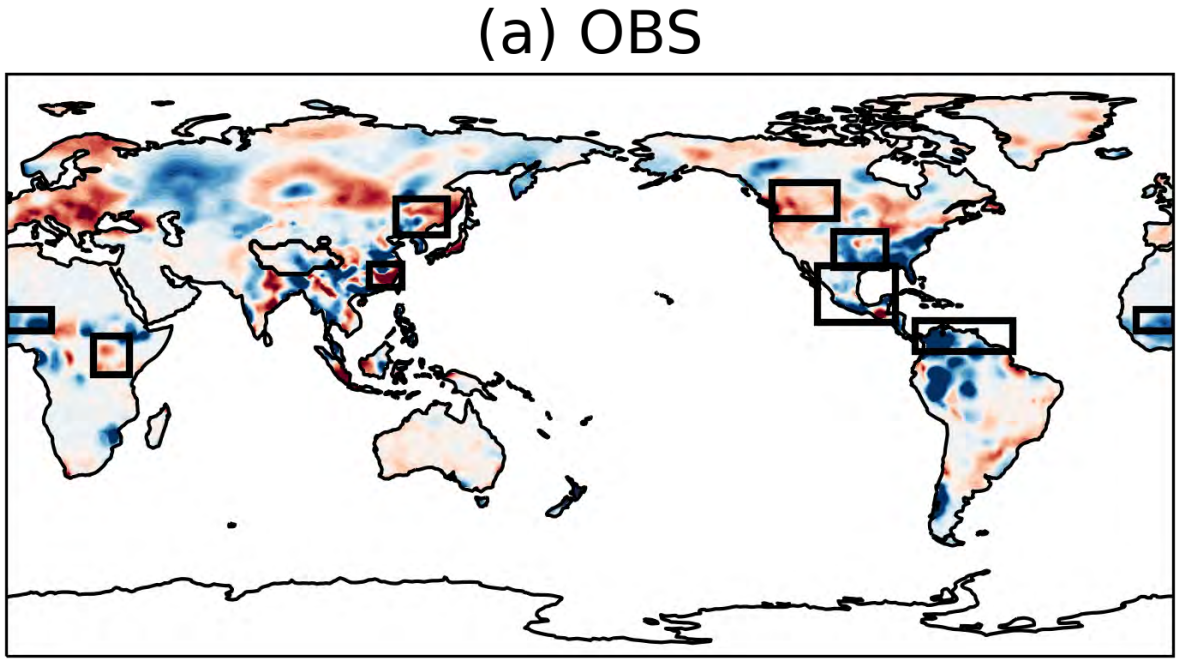
without nudged IC

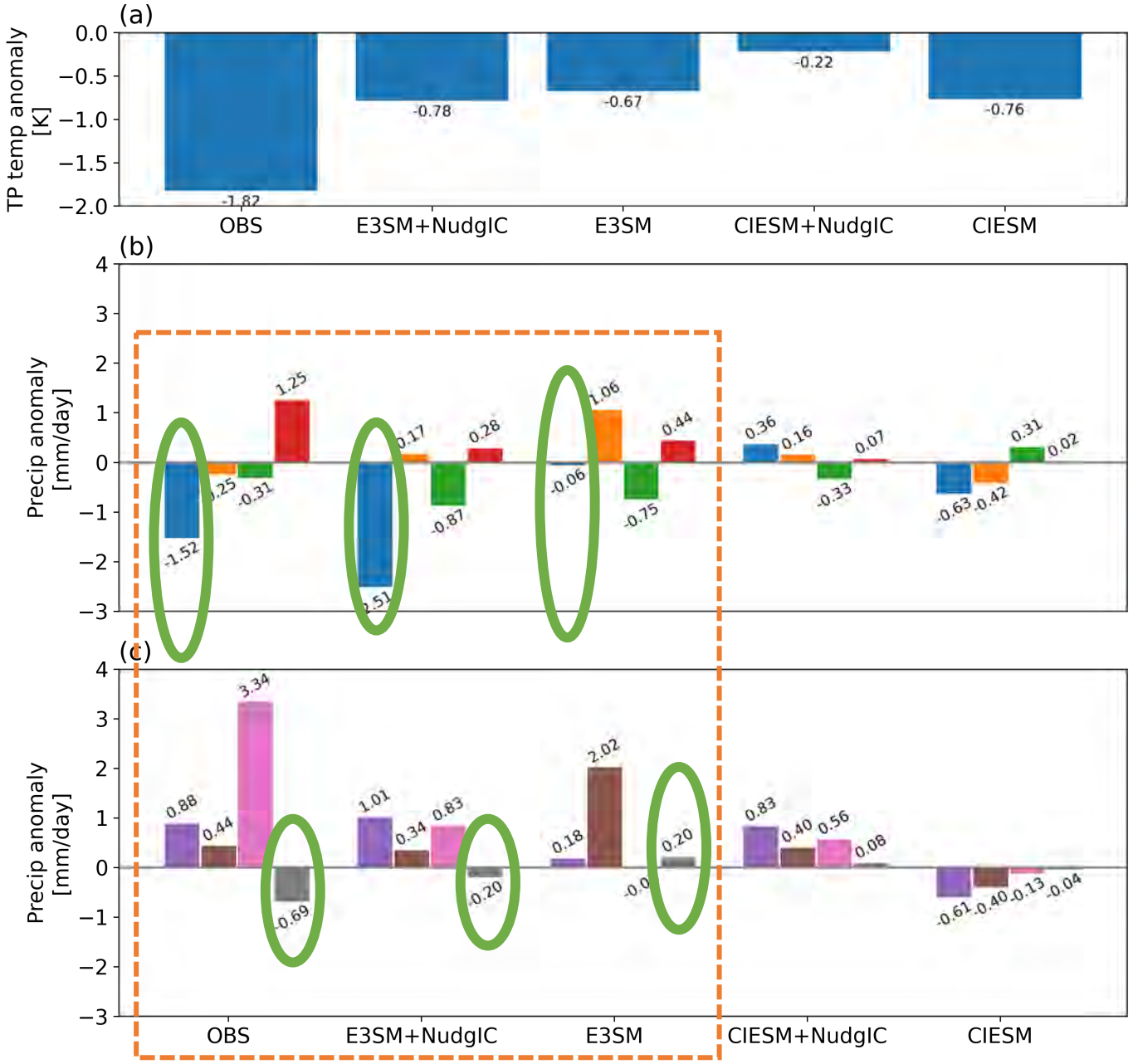


for generating land mask



Models can generate the TP cooling after applying the imposed land temperature anomaly.





With nudged ICs: better reproduced precipitation response over defined hotspots.

Summary

- The nudging approach generates **more realistic initial conditions**, including atmospheric and land variables and large-scale wave pattern.
- Using the nudged initial conditions can **better capture the precipitation response** to land temperature anomaly over the Tibetan Plateau region.
- **Nudging** is necessary for global climate models for subseasonal to seasonal (S2S) predictions, e.g., LS4P.
- Further work
  - Coarse spatial resolution for topography and small-scale weather systems → high resolution model (e.g., E3SM NARRM)
  - Biased land initial conditions → develop nudging framework in land model
  - Better way to preserve land temperature anomaly → bias of snow simulation? Model physics?

Thanks!

Snow water equivalent