

Performance of hydrostatic and nonhydrostatic dynamical cores in a forecast diagnostic package

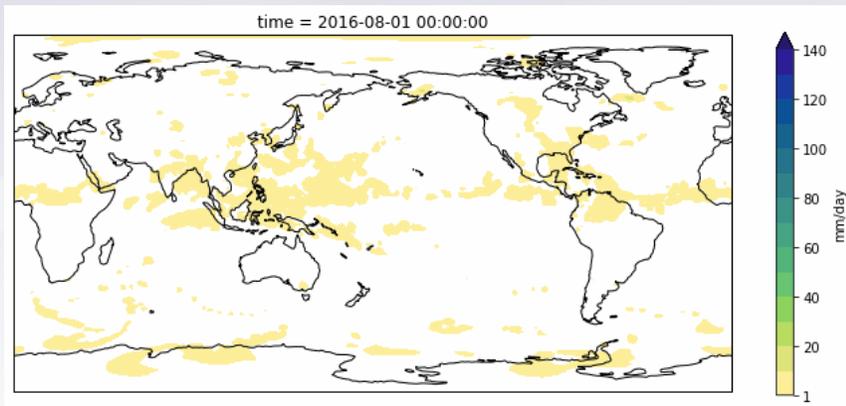
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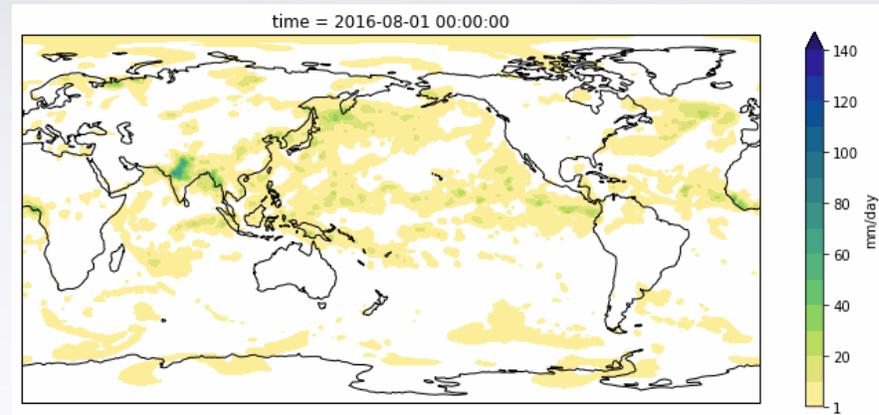
Forecast diagnostic package

- Python-based forecast diagnostic package
- Purpose: Compute diagnostics of targeted forecast simulations and generate plots for comparing the model simulation with ERA5 reanalysis
- Forecast simulations are generated from a forecast package (<https://github.com/zarzycki/betacast>)

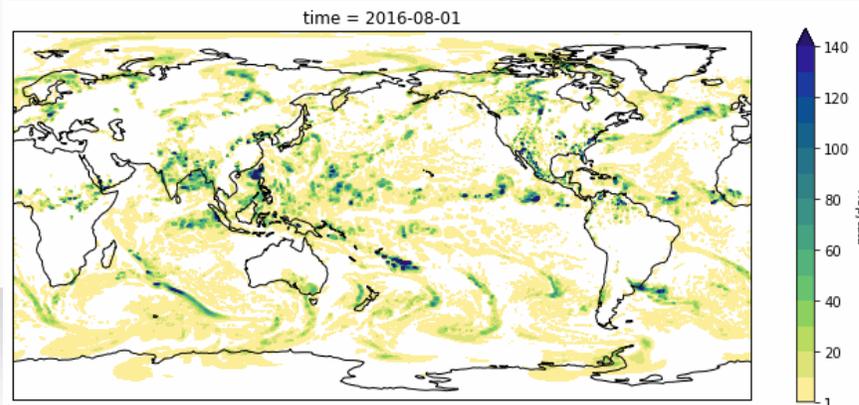
ne30
FSCREAM-LR



ne30
FSCREAM-HR



ERA5 precipitation

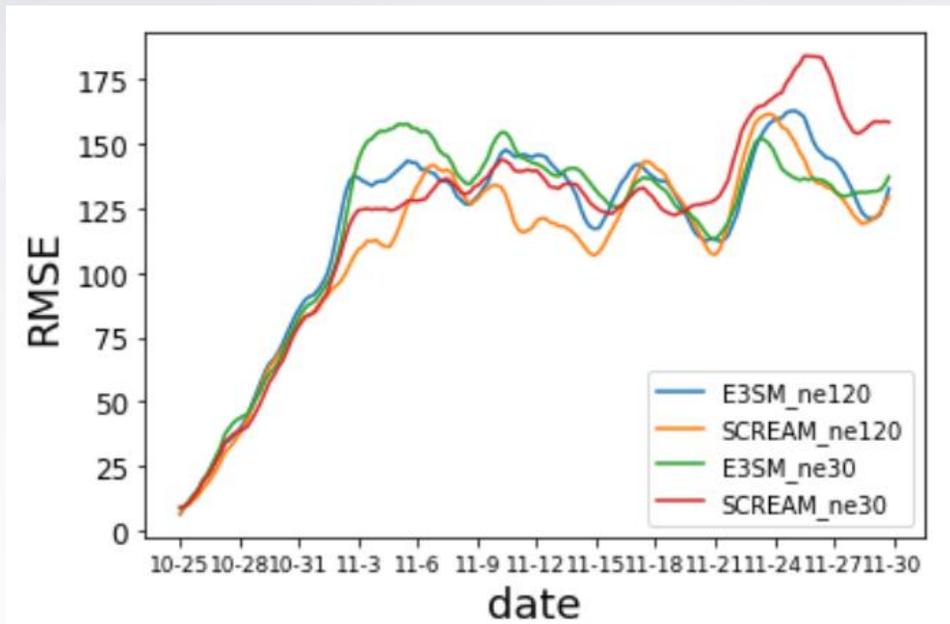


Forecast diagnostic package

- Evaluated metrics: precipitation, temperature, humidity, cloud, total column water vapor, vertical velocity, geopotential height...
- Forecast skill scores: root-mean-squared error (RMSE) and anomaly correlation coefficient (ACC)

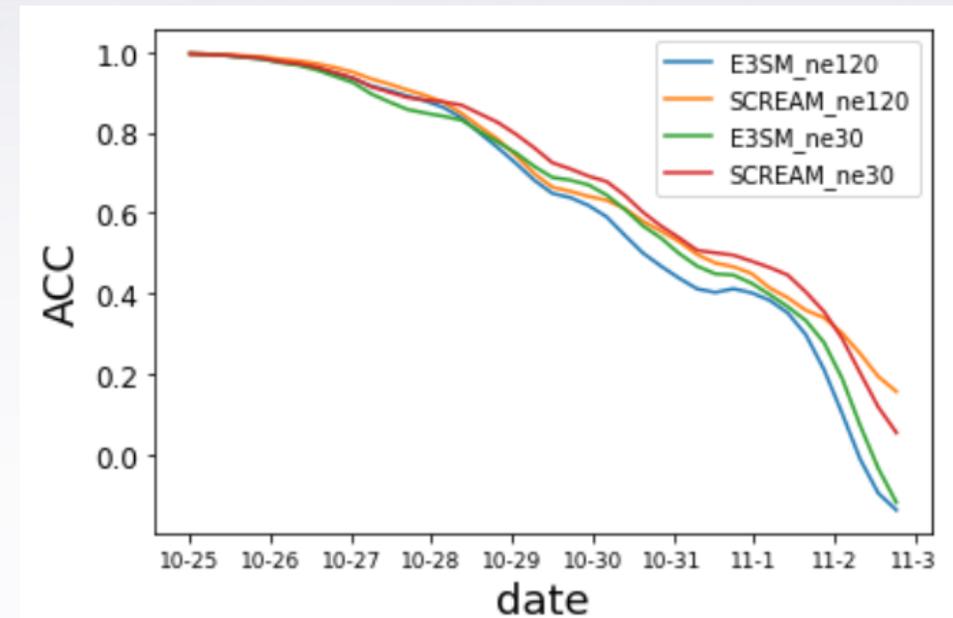
$$\text{RMSE} = \sqrt{\overline{(\mathbf{f}(t) - \mathbf{o}(t))^2}}$$

Z500



$$\text{ACC} = \frac{\overline{(\mathbf{f}(t) - \mathbf{c}(t)) \cdot (\mathbf{o}(t) - \mathbf{c}(t))}}{\sqrt{\overline{(\mathbf{f}(t) - \mathbf{c}(t))^2} \overline{(\mathbf{o}(t) - \mathbf{c}(t))^2}}}}$$

Z500



Dynamical cores: hydrostatic vs. nonhydrostatic

Objective:

- Identify **at which resolutions** the differences between hydrostatic (theta-H) and new nonhydrostatic (theta-NH) dynamical cores can be observed.
- Find **regions** that exhibit significant differences in the simulated climatology between hydrostatic and nonhydrostatic dynamical cores (here focusing on precipitation)
- Understand the **physical mechanisms** causing these differences.

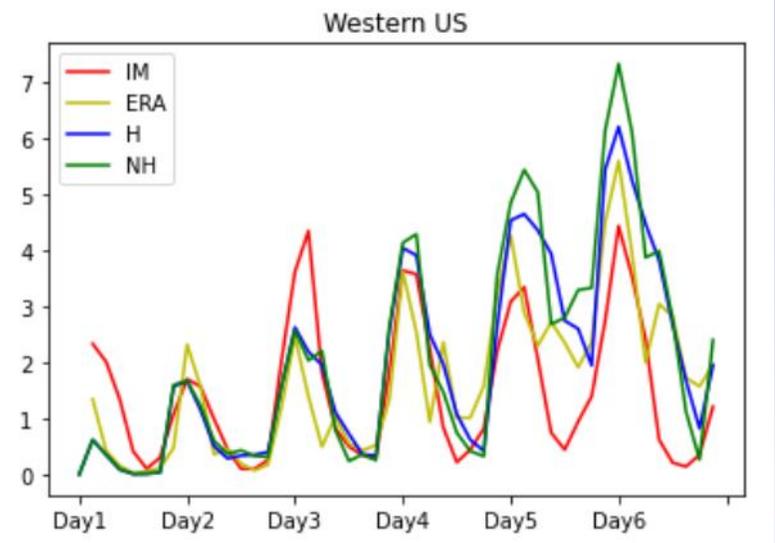
Datasets and Methodology:

- Hourly ERA5 atmospheric fields and SSTs are used as IC.
 - Horizontal resolutions: ne30 to ne256
 - Ensemble members: different IC in successive days
 - Spatial scales: Grid points
- Regional: Tropical oceans (e.g., tropical Pacific and Atlantic) and montane areas (e.g., the Western US)
- Global

Dynamical cores: Hydrostatic vs. Nonhydrostatic

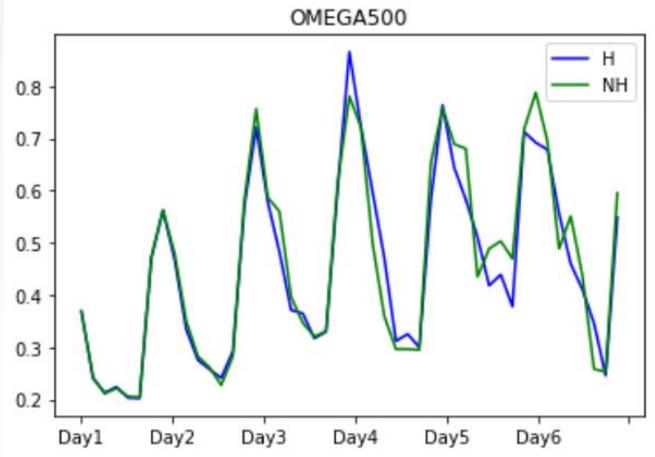
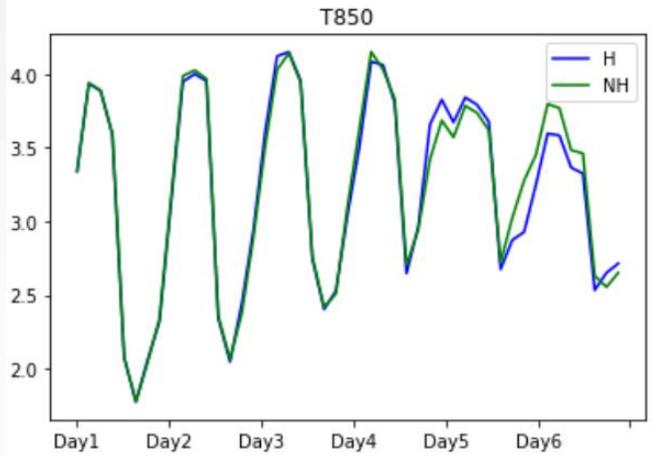
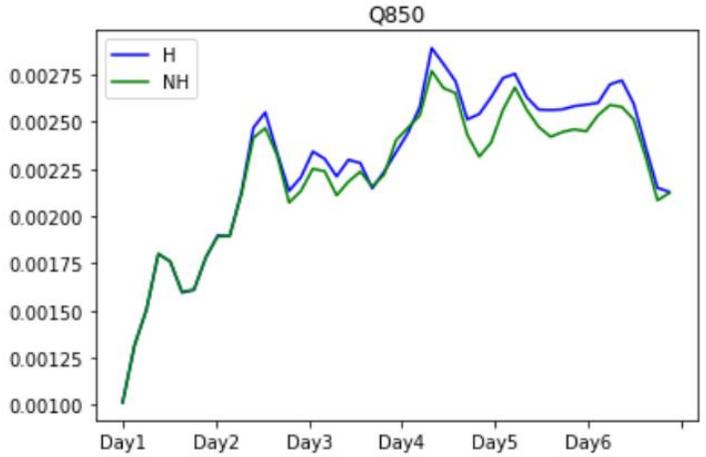
- Short-term forecasts:
7-day simulations

Regional averaged precipitation



Correlation	ERA5 pcp	IMERG
H	0.69*	0.72*
NH	0.69*	0.72*

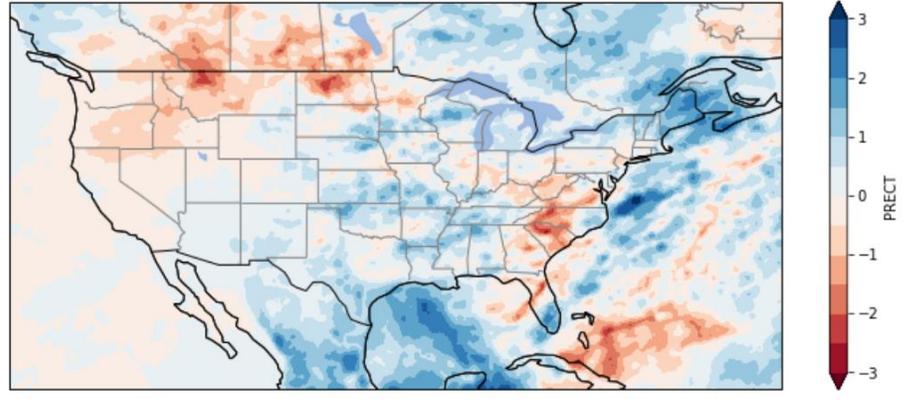
RMSE



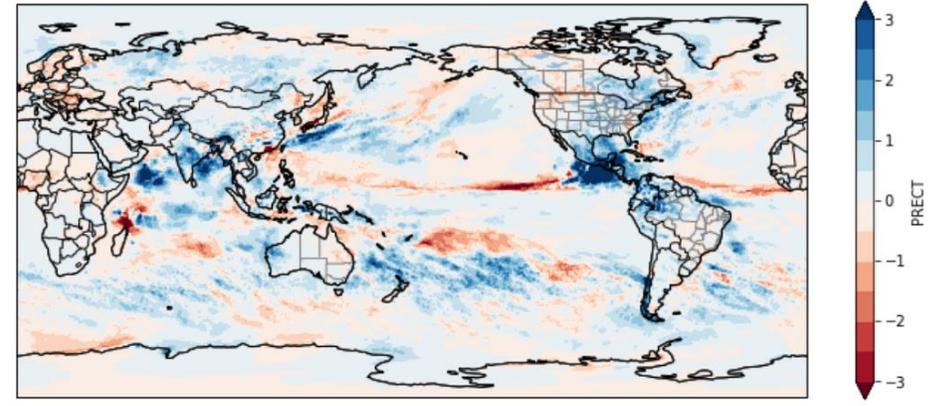
Dynamical cores: Hydrostatic vs. Nonhydrostatic

- Long-term simulations: Jun-Aug 2006.
Averaged NH-H PRECT in three ensembles

US

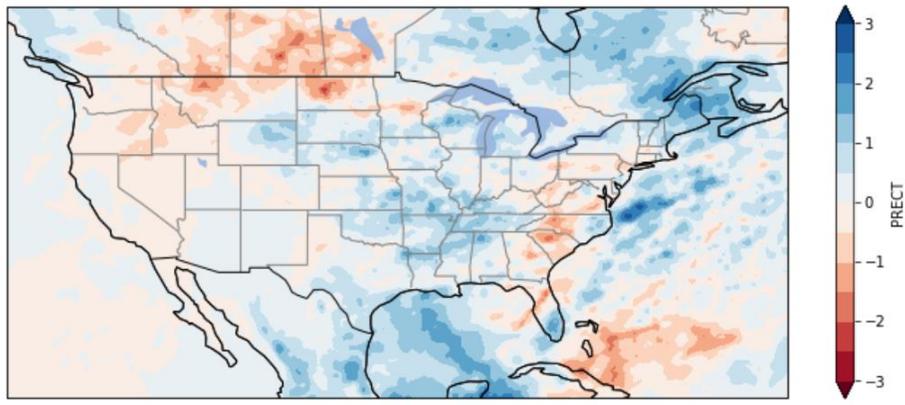


Global

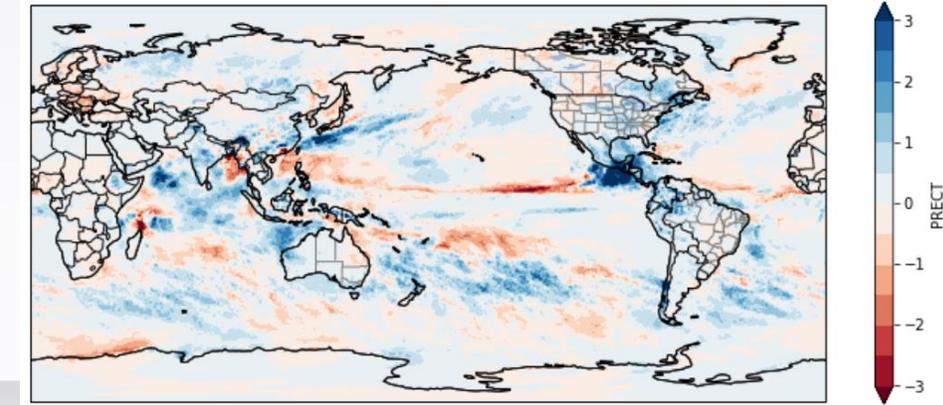


- Averaged NH-H PRECT in four ensembles

US



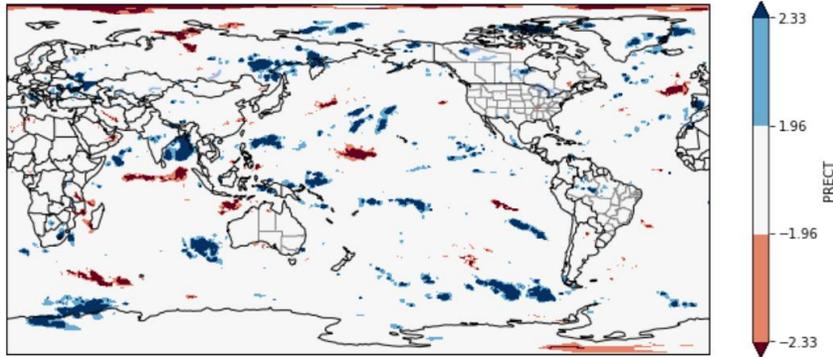
Global



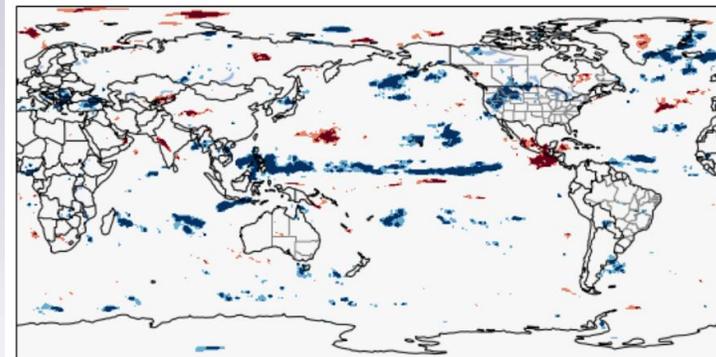
Dynamical cores: Hydrostatic vs. Nonhydrostatic

Paired two-sample test for autocorrelated data (H-NH)

Ensemble 1



Ensemble 2



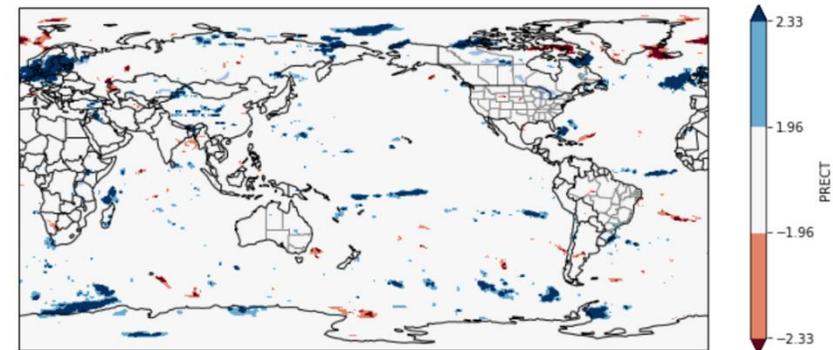
Significant (95%)

Significant (90%)

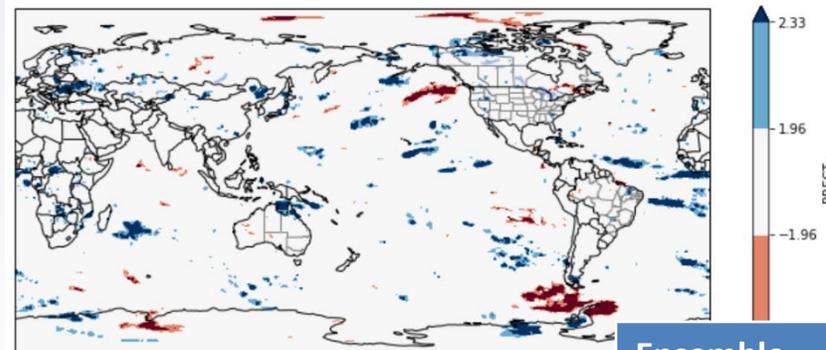
Significant (90%)

Significant (95%)

Ensemble 3



Ensemble 4



Western US

Ensemble	r1	N'	Z	90%	95%
1	0.69	16.86	-0.23	no	no
2	0.79	10.84	1.12	no	no
3	0.50	30.68	-1.96	yes	no
4	0.50	30.65	0.164	no	no

Summary

- A new **forecast diagnostic package** is used to compute diagnostics of forecast simulations and to generate plots for comparing the model simulation with ERA5 reanalysis either globally or regionally. The package includes two main **forecast skill scores** to evaluate various metrics among different resolutions.
- The Hydrostatic and Nonhydrostatic dynamical cores in SCREAM are compared in both short-time forecast and long-term simulations. Some inconsistent results exist among ensembles initialized on different days. The mean precipitation averaged over Jun-Aug 2006 at ne120 does not show statistically significant differences over the western US, contrary to expectations.