Generative assimilation and prediction for weather and climate

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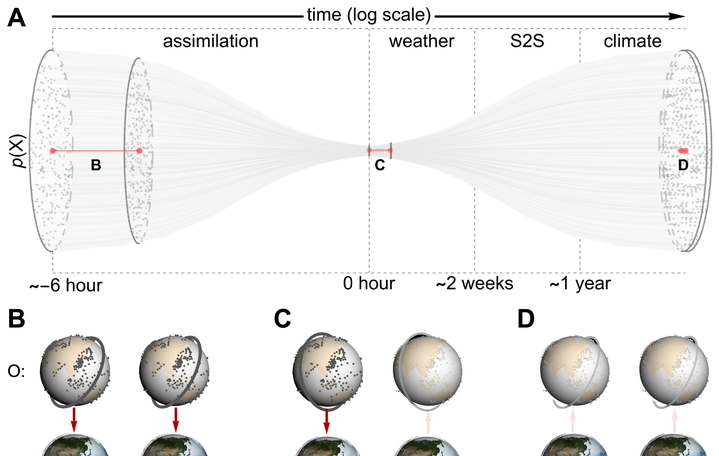
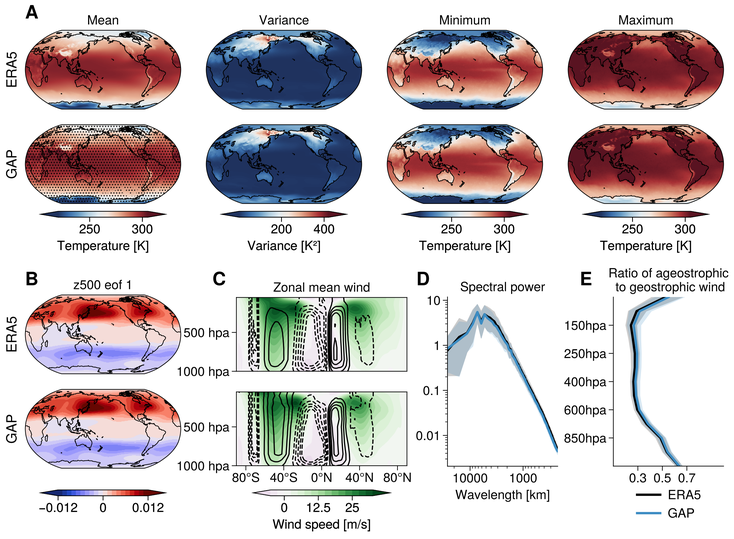
Unified Probabilistic Framework



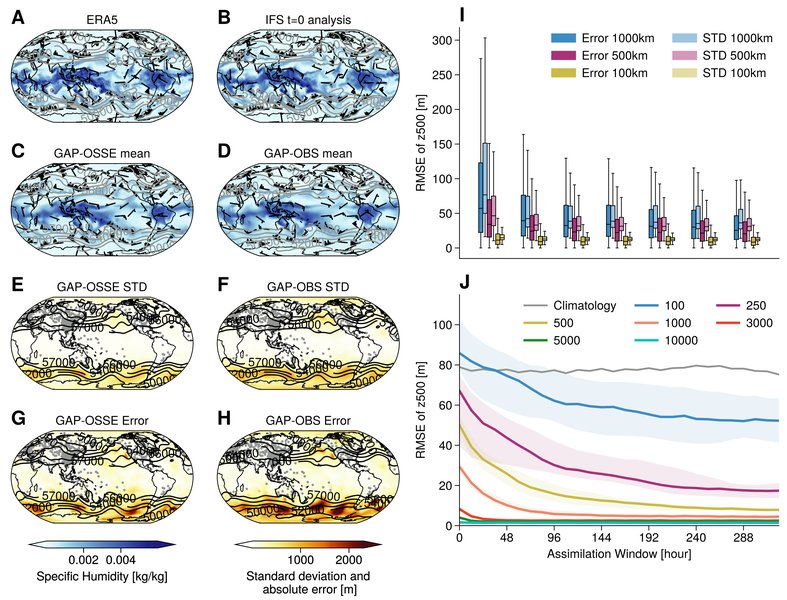
$\boldsymbol{p}$(climate state | observation, model, external forcing)

- Generative model: $p(\text{state})$
- Model operator: M
- Assimilation: $p(\text{state}_t \mid \text{obs}_t, M(\text{state}_{t-1}))$
- Weather forecast: $p(\text{state}_t \mid M(\text{state}_{t-1}))$
- Seasonal / Climate prediction: $p(\text{state}_t \mid M(\text{state}_{t-1}), \text{forcing})$

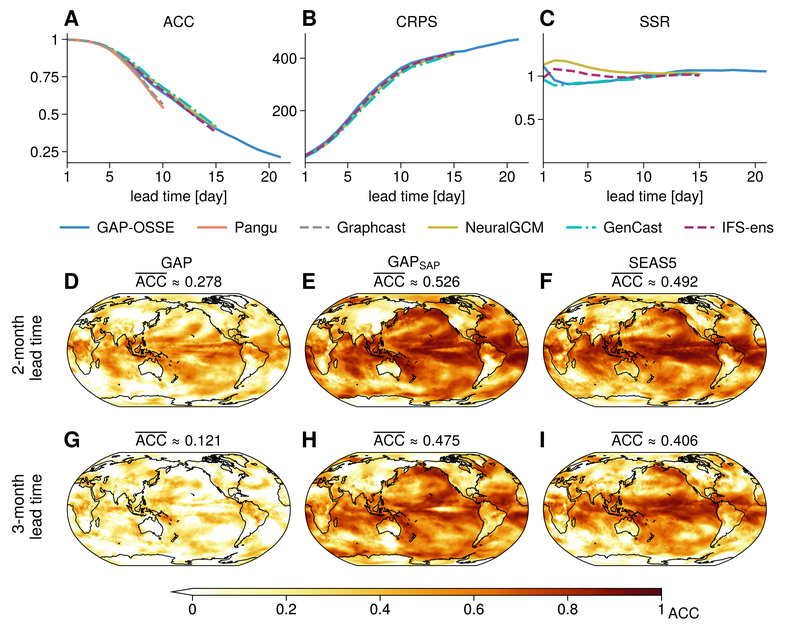
Faithful Climatology



Assimilation with Calibrated Uncertainty



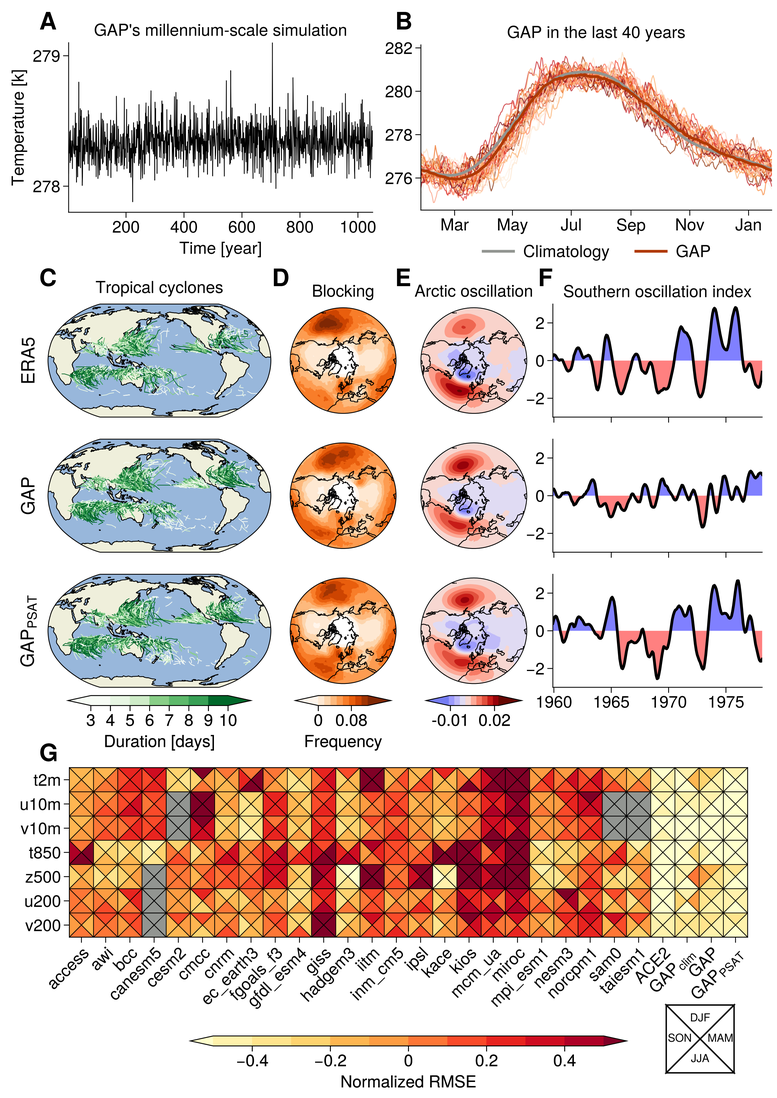
Seamless prediction: Medium-Range and Seasonal



Reference:

1. Yang, S., Nai, C., Boers, N., Yuan, H., & Pan, B. (2025). Generative assimilation and prediction for weather and climate. *arXiv preprint arXiv:2503.03038*. https://doi.org/10.48550/arXiv.2503.03038

Climate simulation and extreme events



Take home Message

- We introduce a unified generative framework that links assimilation, seamless forecasting, and climate simulation through a shared representation of the climatological distribution.
- Conditioning on observational, predictive, and forcing constraints, GAP delivers calibrated predictions across timescales and enables stable climate simulations without task-specific retraining.