

# Building Ocean Climate Emulators

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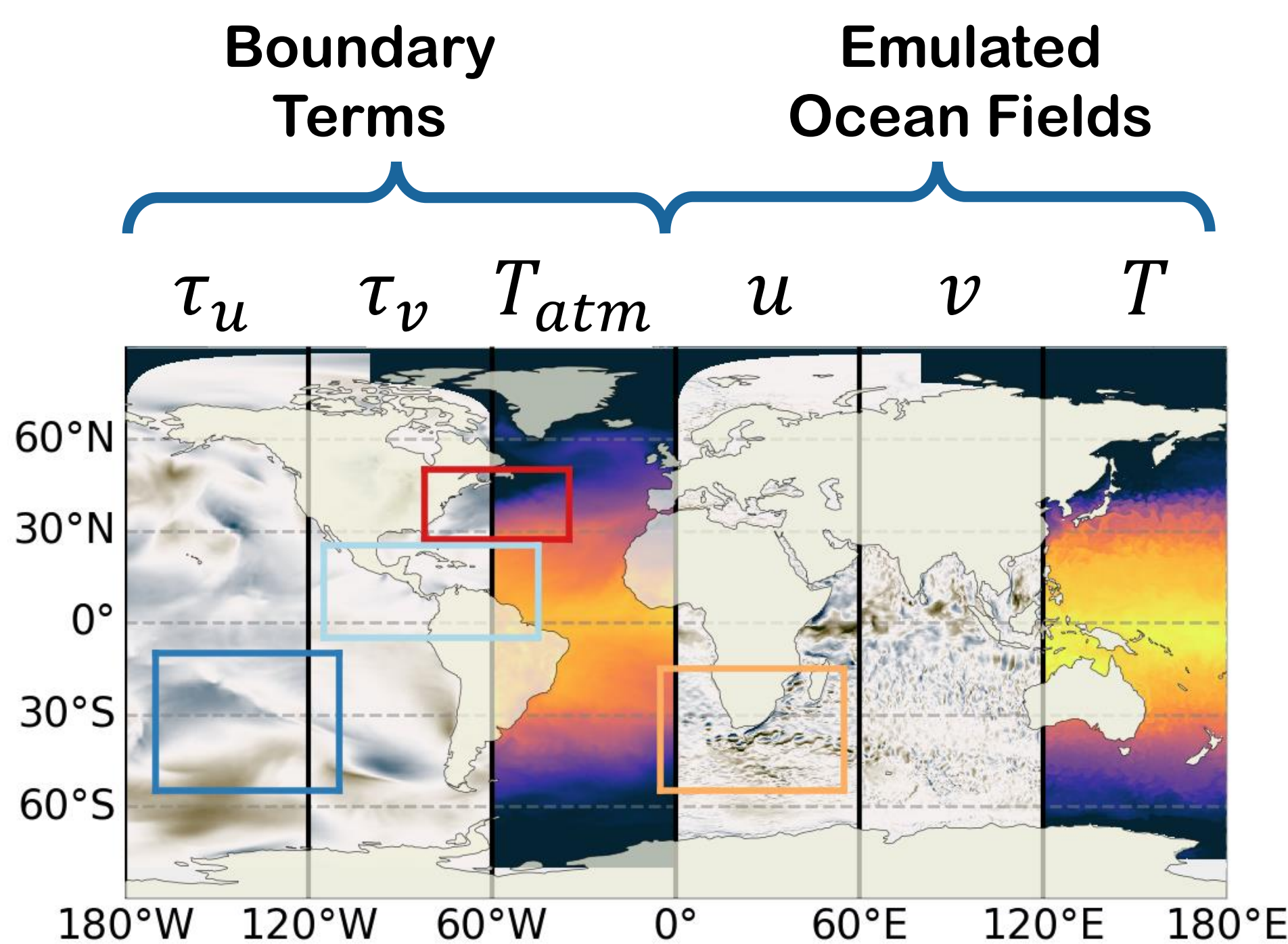
SCHMIDT FUTURES

m2lines.github.io

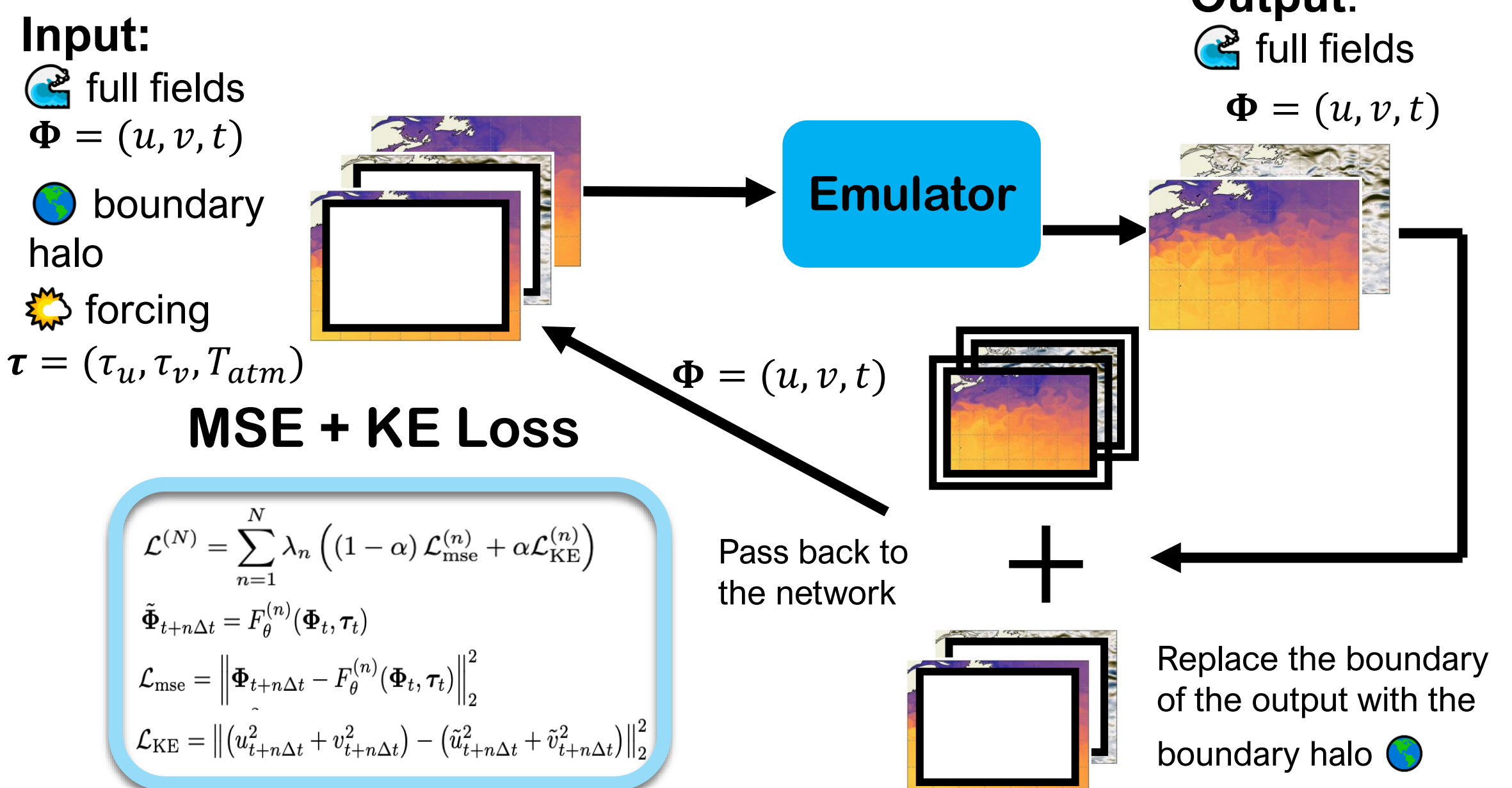
## Key Questions

### How to design decadal ocean emulator with multi-time scale dynamics ?

- What dynamics does incorporating **boundary information** enable our emulator to capture?
- What **time-step**, or **training horizon** does our model need to capture slowly evolving dynamics?



## Emulation Setup



$$\mathcal{L}^{(N)} = \sum_{n=1}^N \lambda_n \left( (1 - \alpha) \mathcal{L}_{\text{mse}}^{(n)} + \alpha \mathcal{L}_{\text{KE}}^{(n)} \right)$$

$$\hat{\Phi}_{t+n\Delta t} = F_{\theta}^{(n)}(\Phi_t, \tau_t)$$

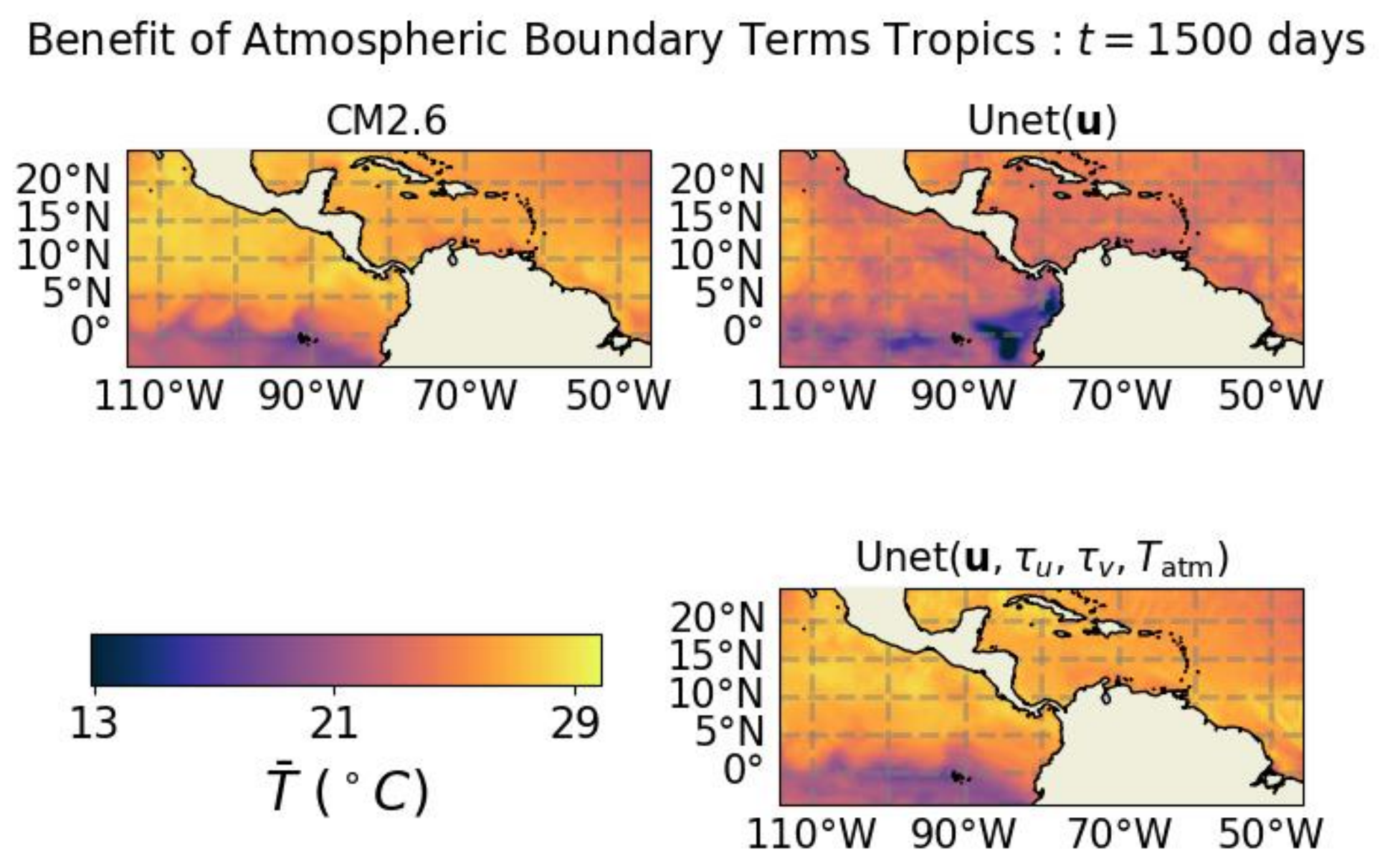
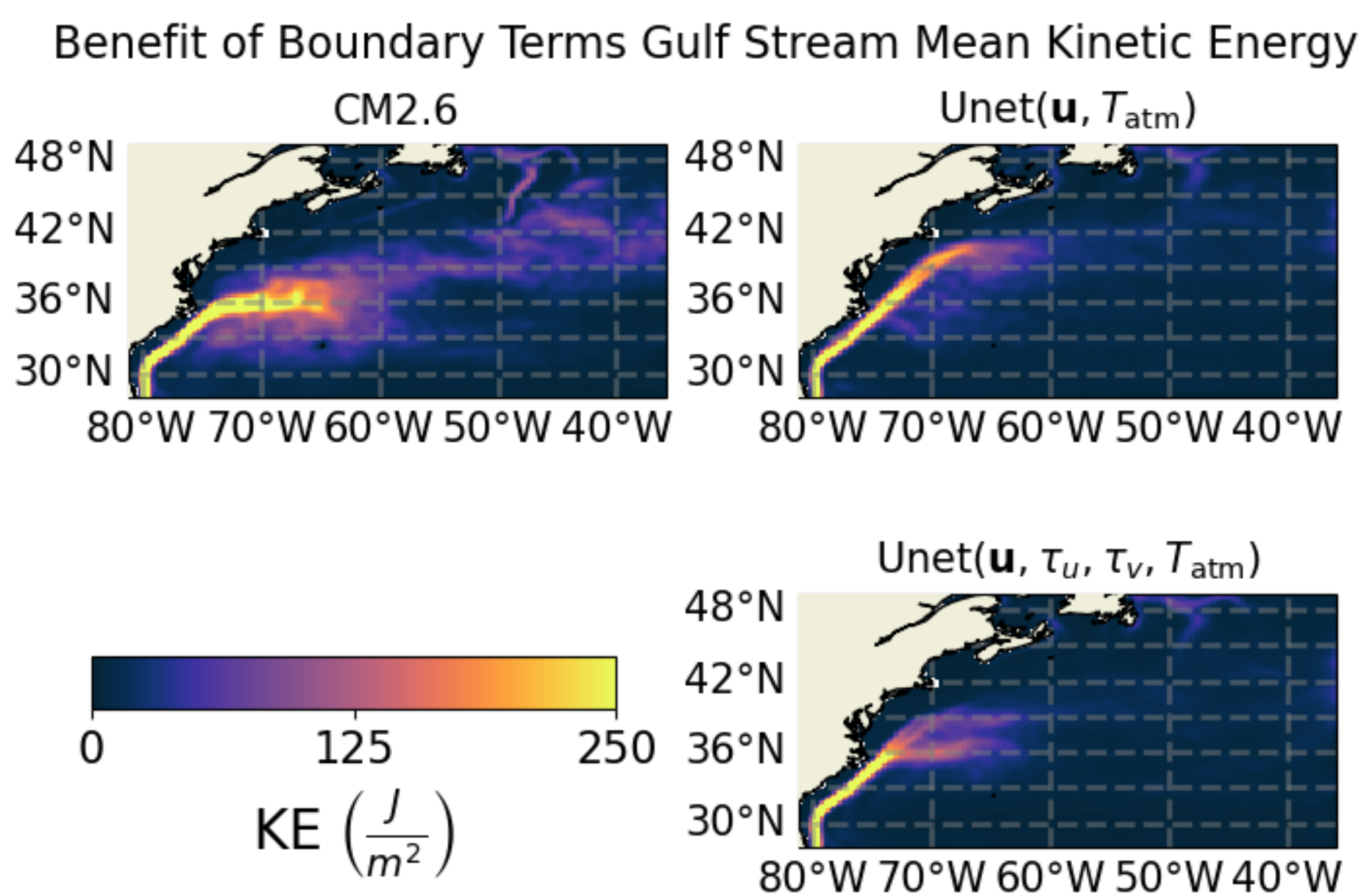
$$\mathcal{L}_{\text{mse}} = \left\| \Phi_{t+n\Delta t} - F_{\theta}^{(n)}(\Phi_t, \tau_t) \right\|_2^2$$

$$\mathcal{L}_{\text{KE}} = \left\| (u_{t+n\Delta t}^2 + v_{t+n\Delta t}^2) - (\hat{u}_{t+n\Delta t}^2 + \hat{v}_{t+n\Delta t}^2) \right\|_2^2$$

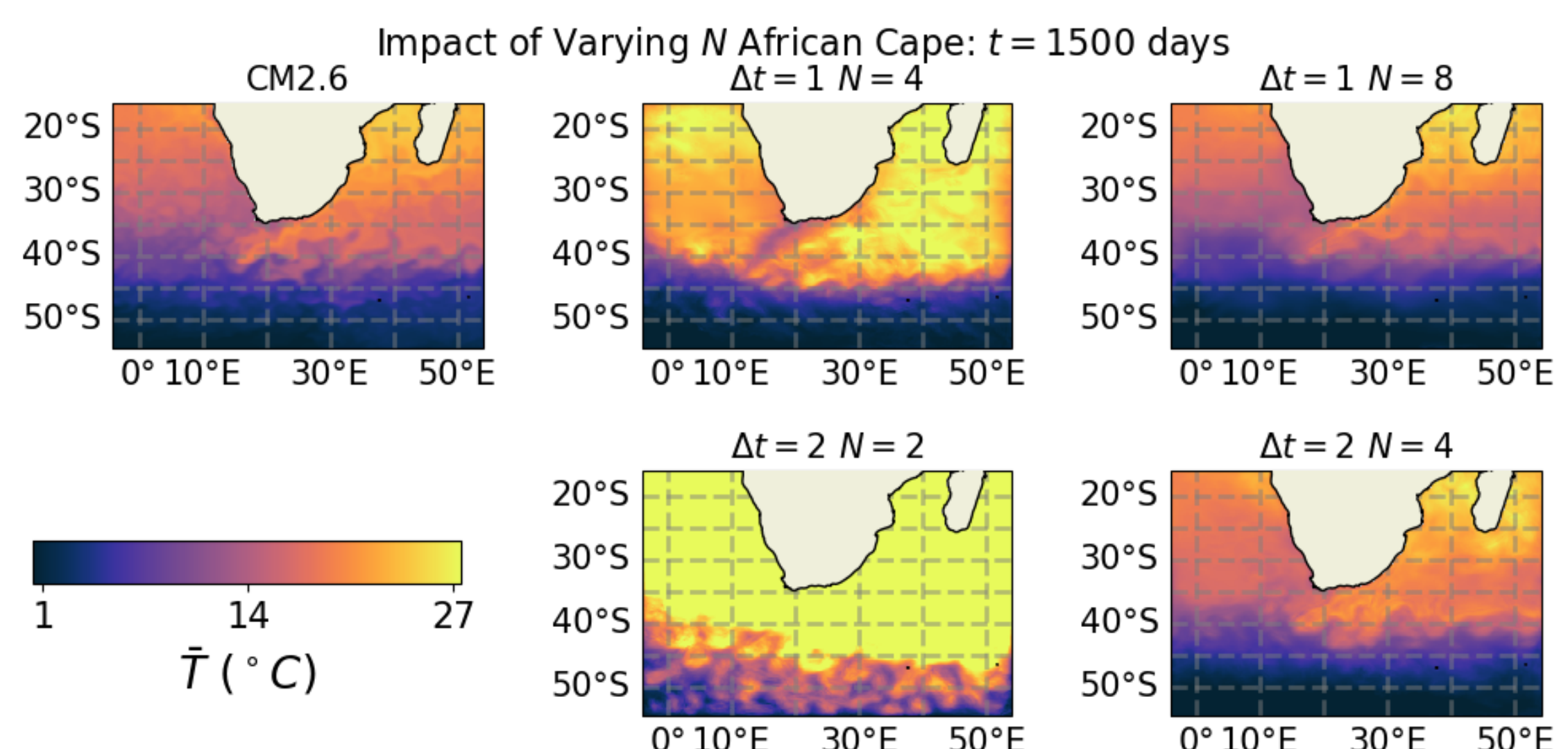
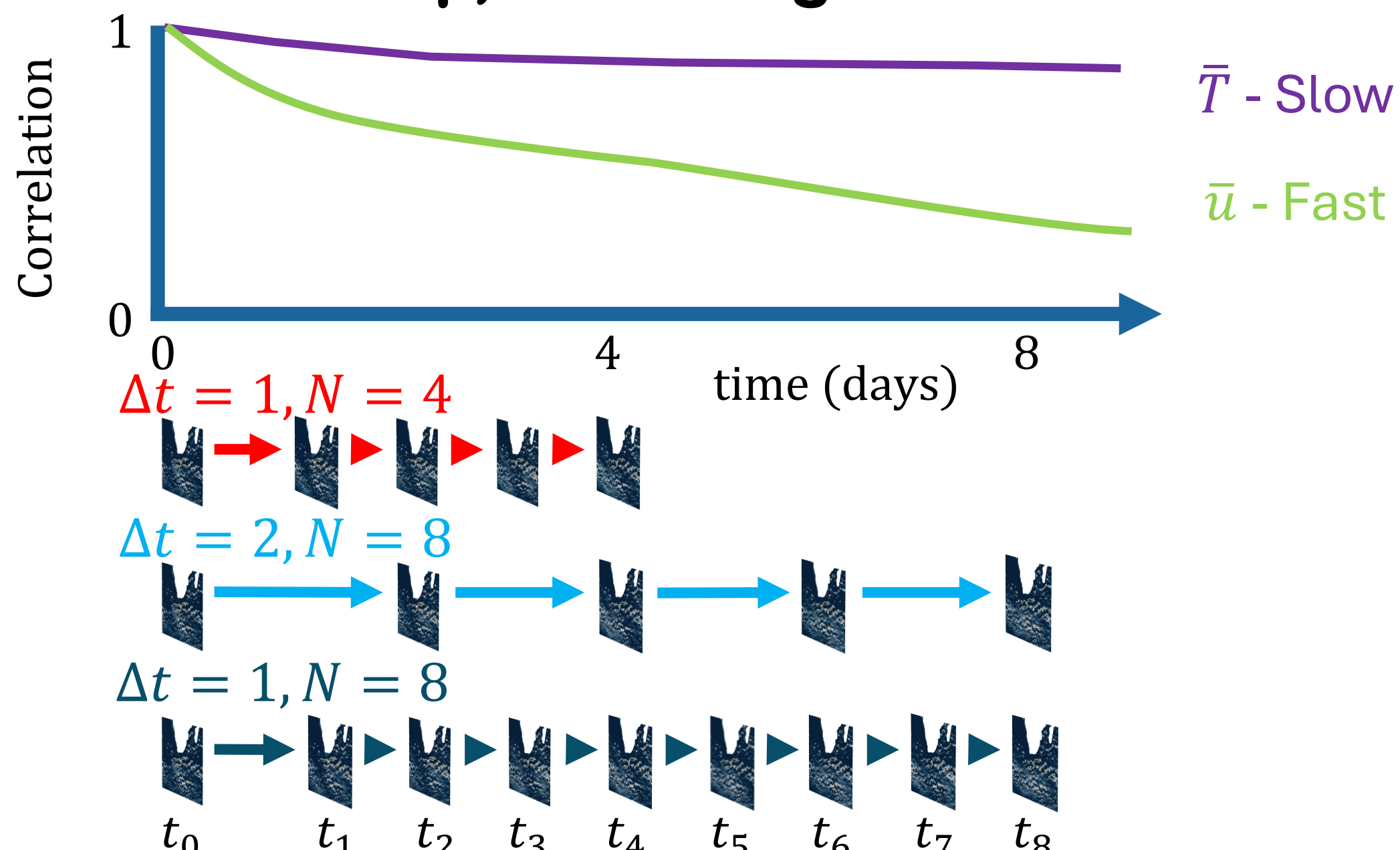
## Data

- CM 2.6 coupled climate model<sup>[1]</sup>
- $\frac{1}{10}^\circ$  grid for the ocean component
- $\frac{1}{2}^\circ$  grid for the atmosphere.
- 20 years of the preindustrial control
- Both fields regridded to  $\frac{1}{4}^\circ$
- Ocean Filtered to  $1^\circ$  to remove mesoscales

## What dynamics does incorporating boundary information enable our emulator to capture?



## What time-step, or training horizon does our model need to capture slowly evolving dynamics?



- Successfully produce emulators stable for 8 years
- Need both fast and slow boundary conditions,  $\tau_u, \tau_v$  and  $T_{atm}$
- Use longer windows to capture dynamics of slow variables

## References

[1] Thomas L. Delworth, Anthony Rosati, Whit Anderson, Alistair J. Adcroft, Venkatramani Balaji, Rusty Benson, Keith Dixon, Stephen M. Griffies, Hyun-Chul Lee, Ronald C. Pacanowski, et al. Simulated climate and climate change in the GFDL CM2.5 high-resolution coupled climate model. *Journal of Climate*, 25(8):2755–2781, 2012.

## Links

<https://arxiv.org/abs/2402.04342>  
<https://github.com/adam-subel>

## Paper

