

How should we represent unresolved processes in climate models?

A data-driven approach for Rayleigh-Bénard convection

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Climate change: 1.5C warming threshold to be passed in 9 years as emissions hit record high

ABC Science / E
Posted Fri 11 Nov 2021

Climate change report from IPCC a 'code red for humanity', United Nations chief warns

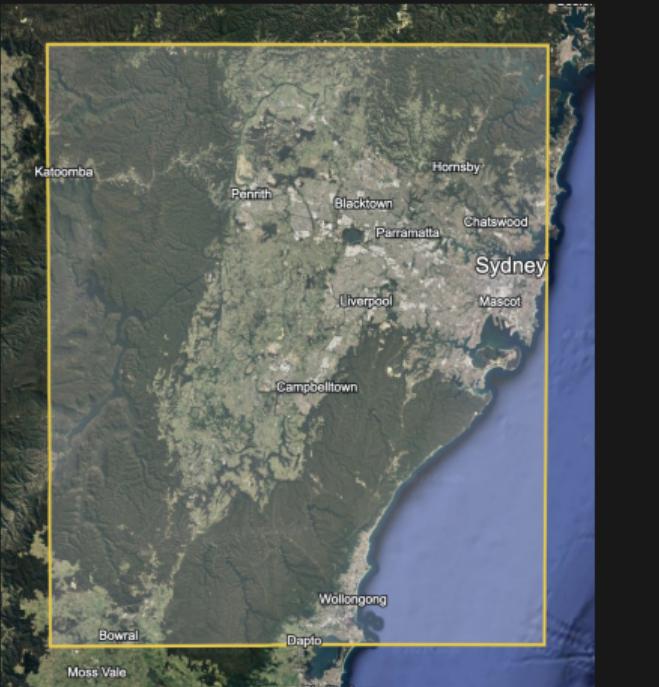
By national science, technology and environment reporter Michael Slezak and the Specialist Reporting Team's Penny Timms

Posted Mon 9 Aug 2021 at 6:01pm, updated Tue 10 Aug 2021 at 7:28am



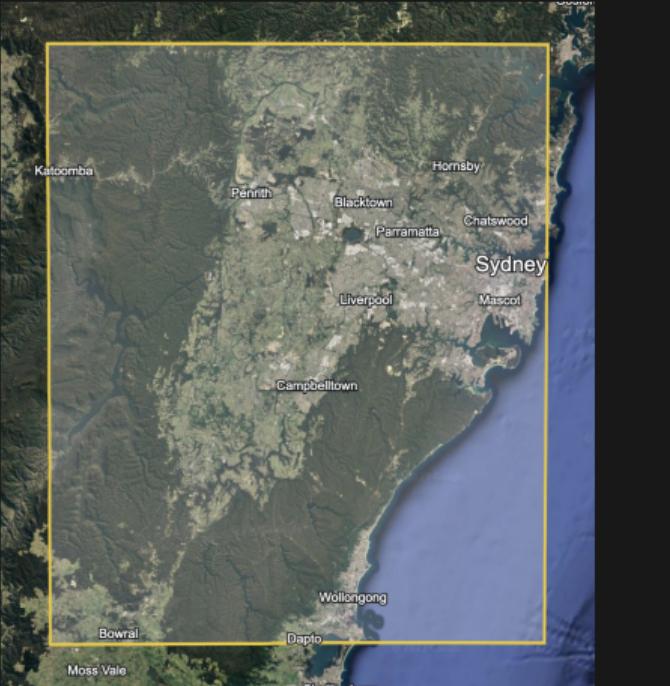
- Understanding of climate system needed to drive this action is derived, to a great extent, from numerical models of the atmosphere, oceans and other components of the Earth system that solve the governing equations on a finite-resolution grid.

$1^\circ \times 1^\circ$, $L \sim 100$ km



1

$1^\circ \times 1^\circ$, $L \sim 100$ km

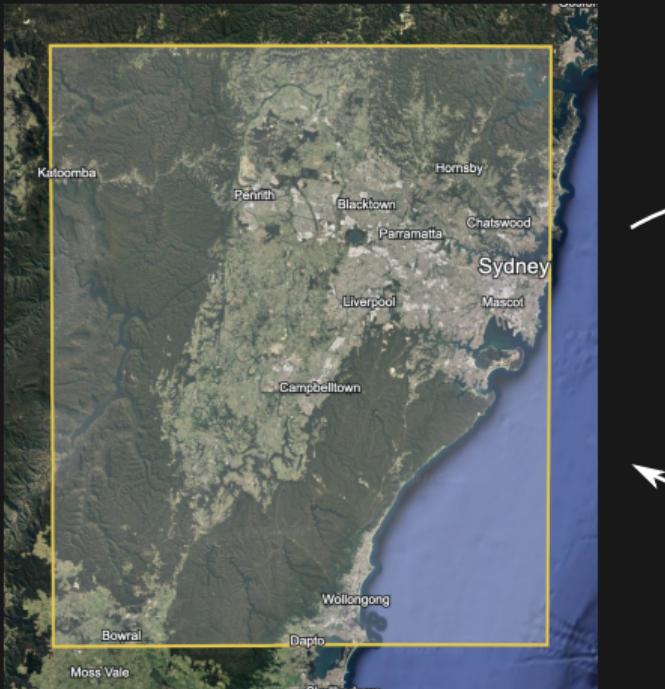


$L \sim 100$ m



- On the other hand, there are many processes that occur on spatial scales much smaller than a climate model can resolve.

$1^\circ \times 1^\circ$, $L \sim 100$ km



$L \sim 100$ m



Favourable or
unfavourable
conditions

Moisture, heat
transports

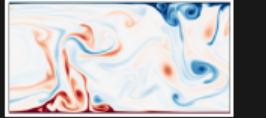
- The issue is that... For example...
- This is a question of reduced order modelling...
- Task: **parametrisation**.
- In recent years... **data-driven parametrisation**,
- In this project... analogue... from scratch

Fine state (t)



So how do we calculate...?

Fine state (t)



fine model
↓
Fine state ($t + \delta t$)

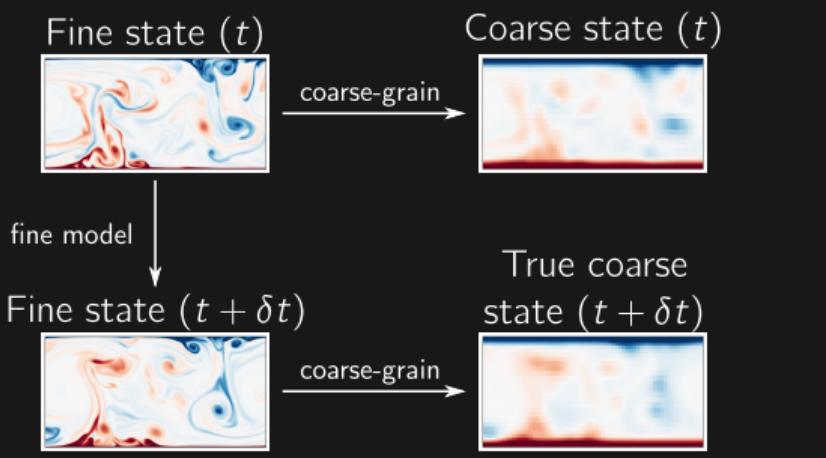


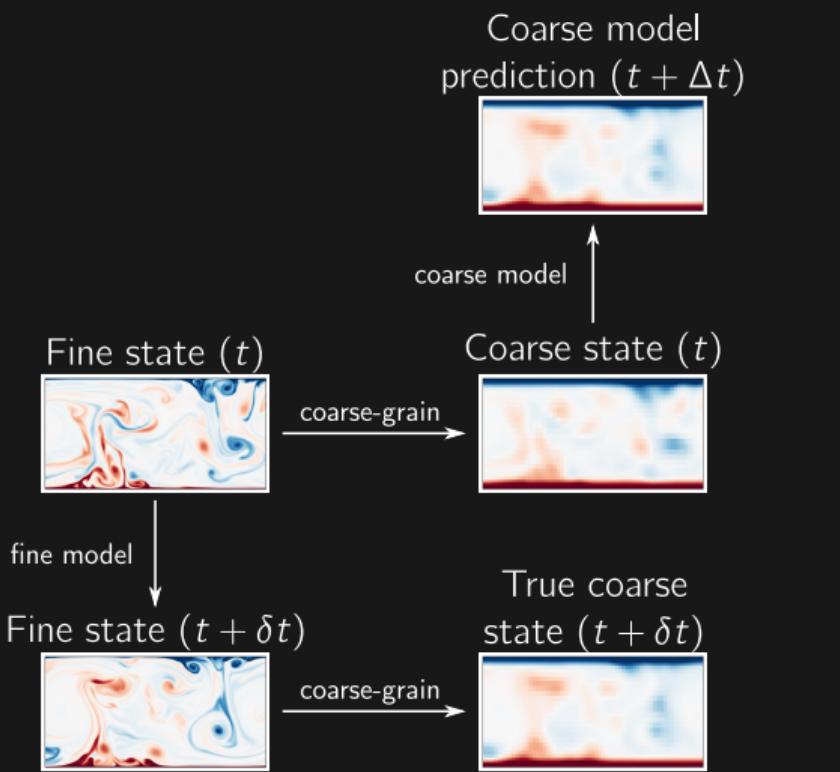
Fine state (t)

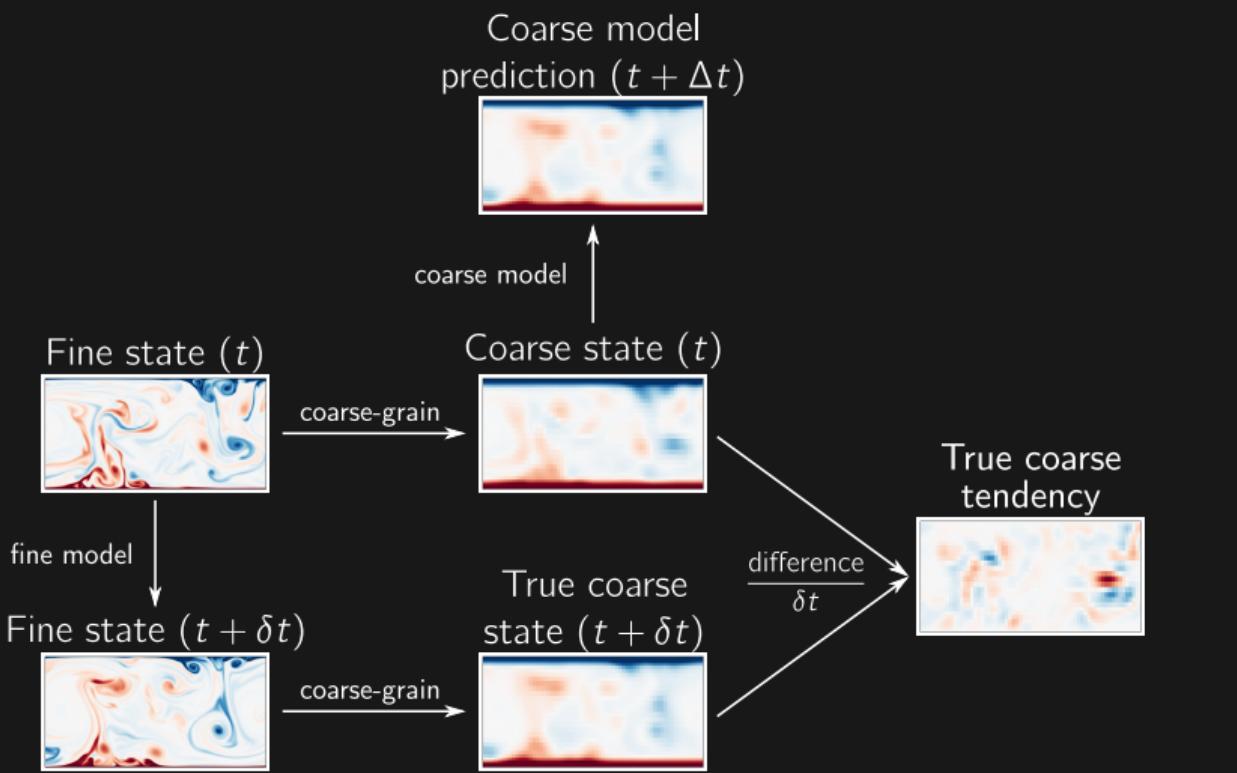


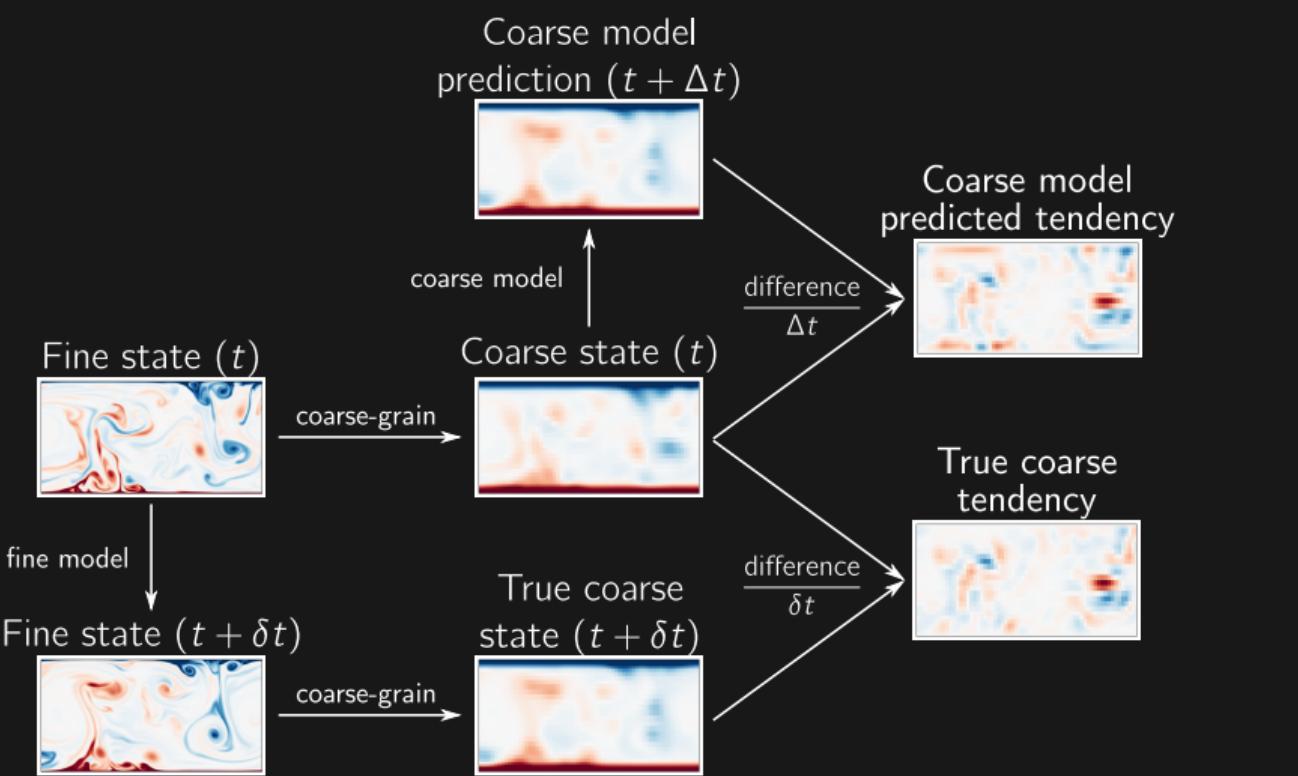
Fine state ($t + \delta t$)



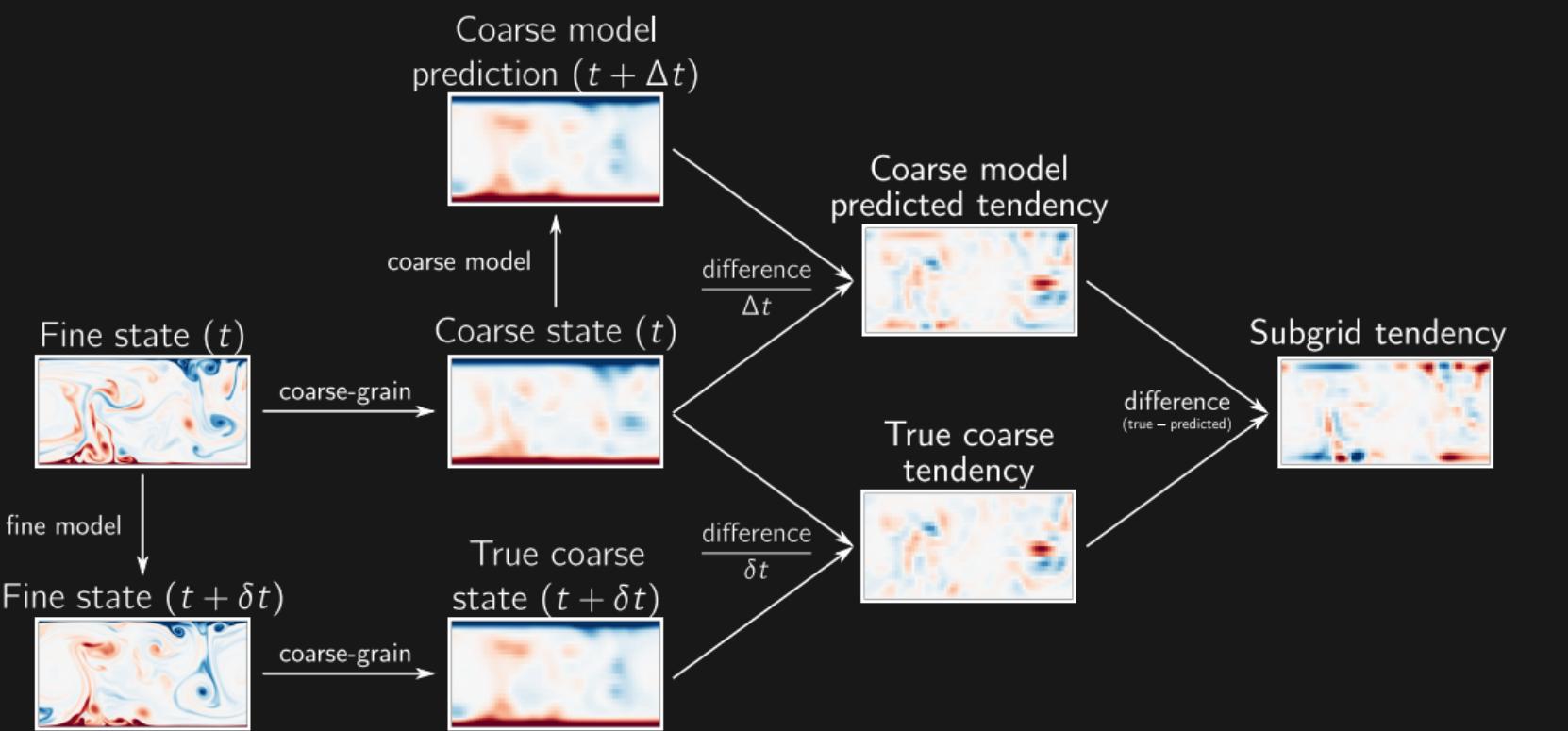






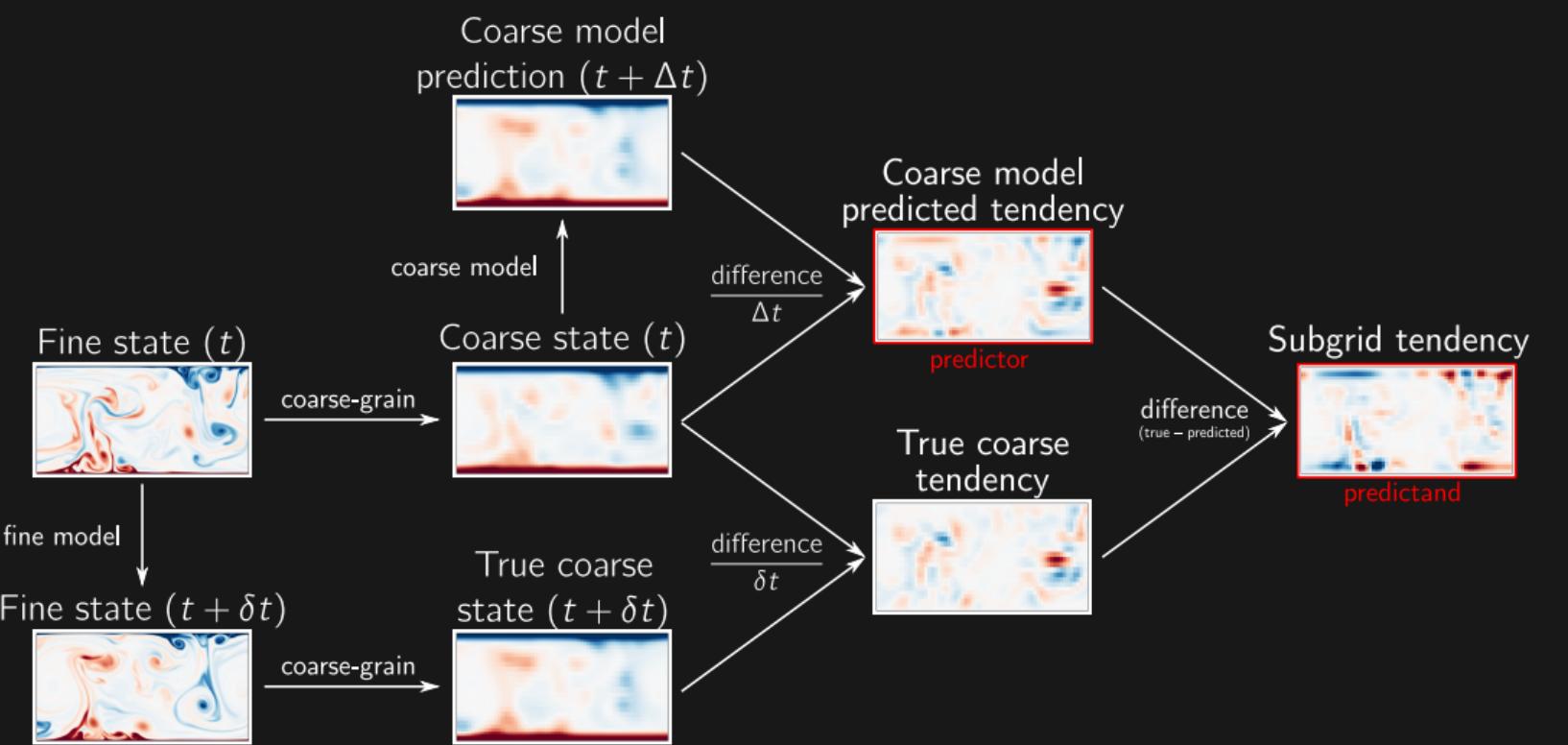


For a hypothetical perfect coarse model...



The subgrid tendency represents...

STATISTICAL MODEL: LINEAR REGRESSION



So, we're able to predict the subgrid tendency...

$$\frac{\partial \mathbf{u}}{\partial t} = \dots$$

$$\frac{\partial \theta}{\partial t} = \dots$$

$$\frac{\partial \mathbf{u}}{\partial t} = \dots$$

$\frac{\partial \theta}{\partial t} = \dots + \text{subgrid tendency model}$

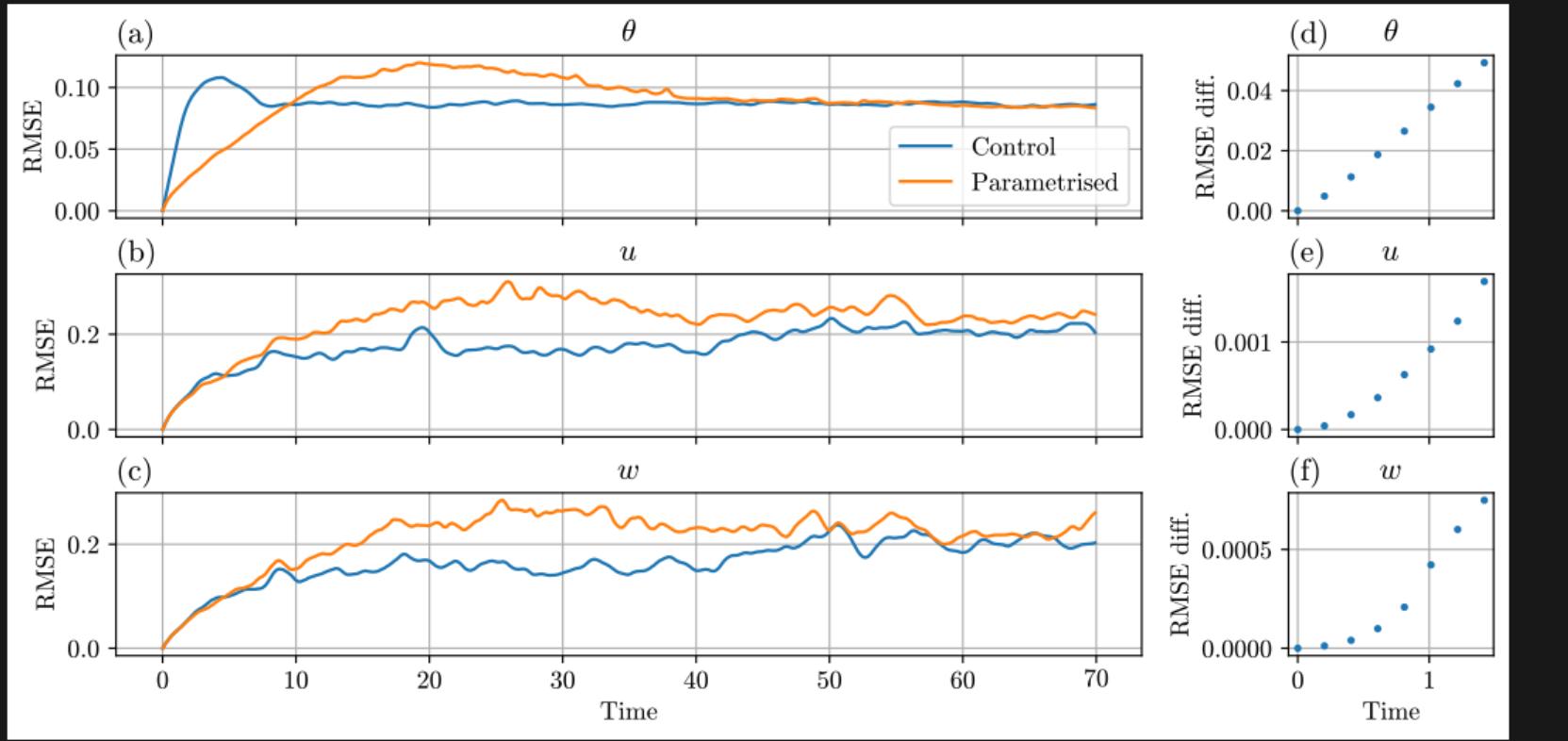
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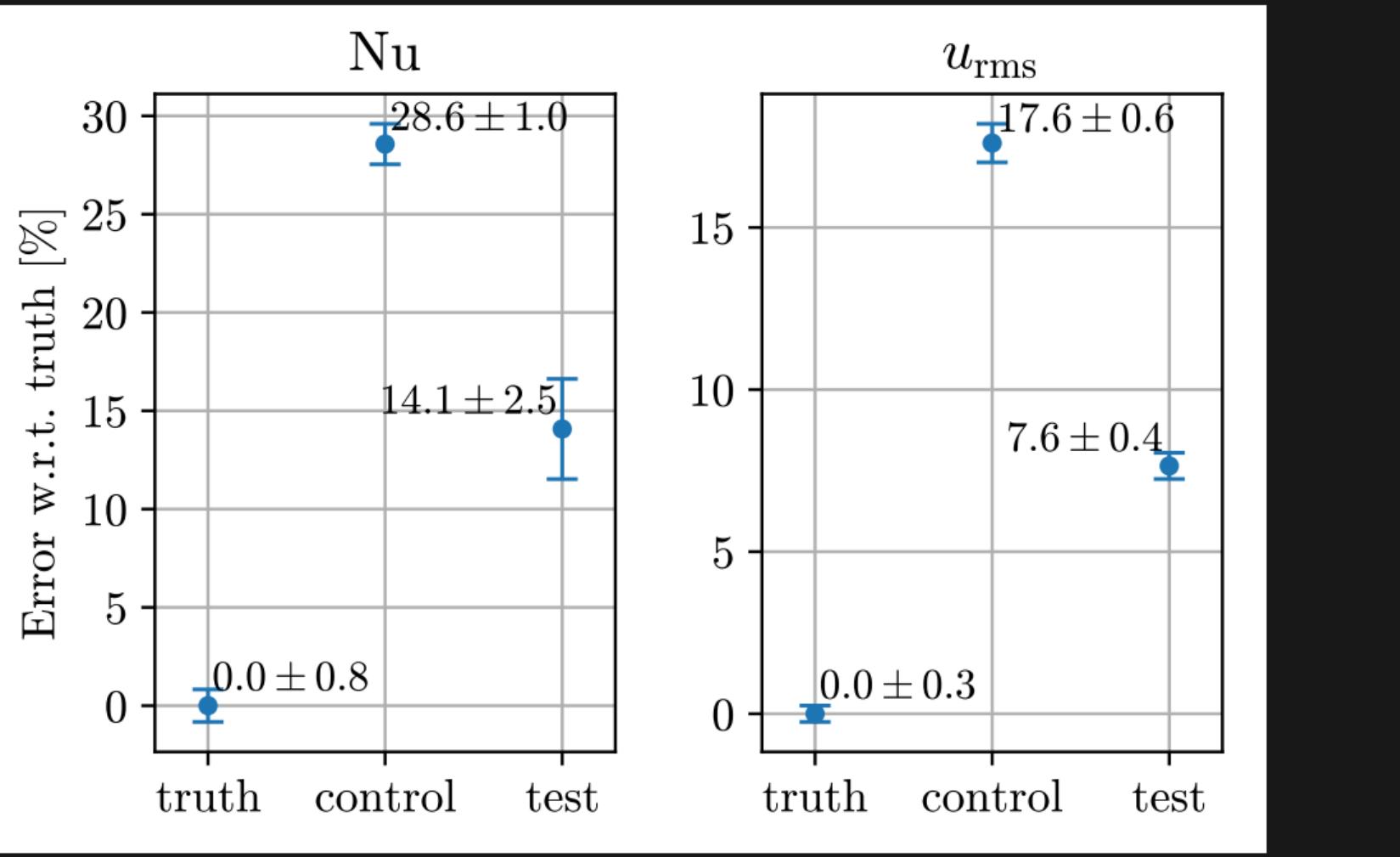
Will the parametrised model be closer to the truth...?

Truth 2048×256

Control 256×64

Parametrised $256 \times 64 +$ subgrid tendency model





- Implemented a test bed for data-driven parametrisation
- Constructed a proof of concept by:
 1. Calculating subgrid tendencies
 2. Fitting a statistical model to predict them
 3. Using predicted subgrid tendencies to force a coarse model
 4. Demonstrating improved short-term forecast and long-term statistical (“climate”) accuracy
- Future work: machine learning, stochasticity, memory

