Diagnosing CAM MJO forecast biases using nuging: A DYNAMO MJO case study

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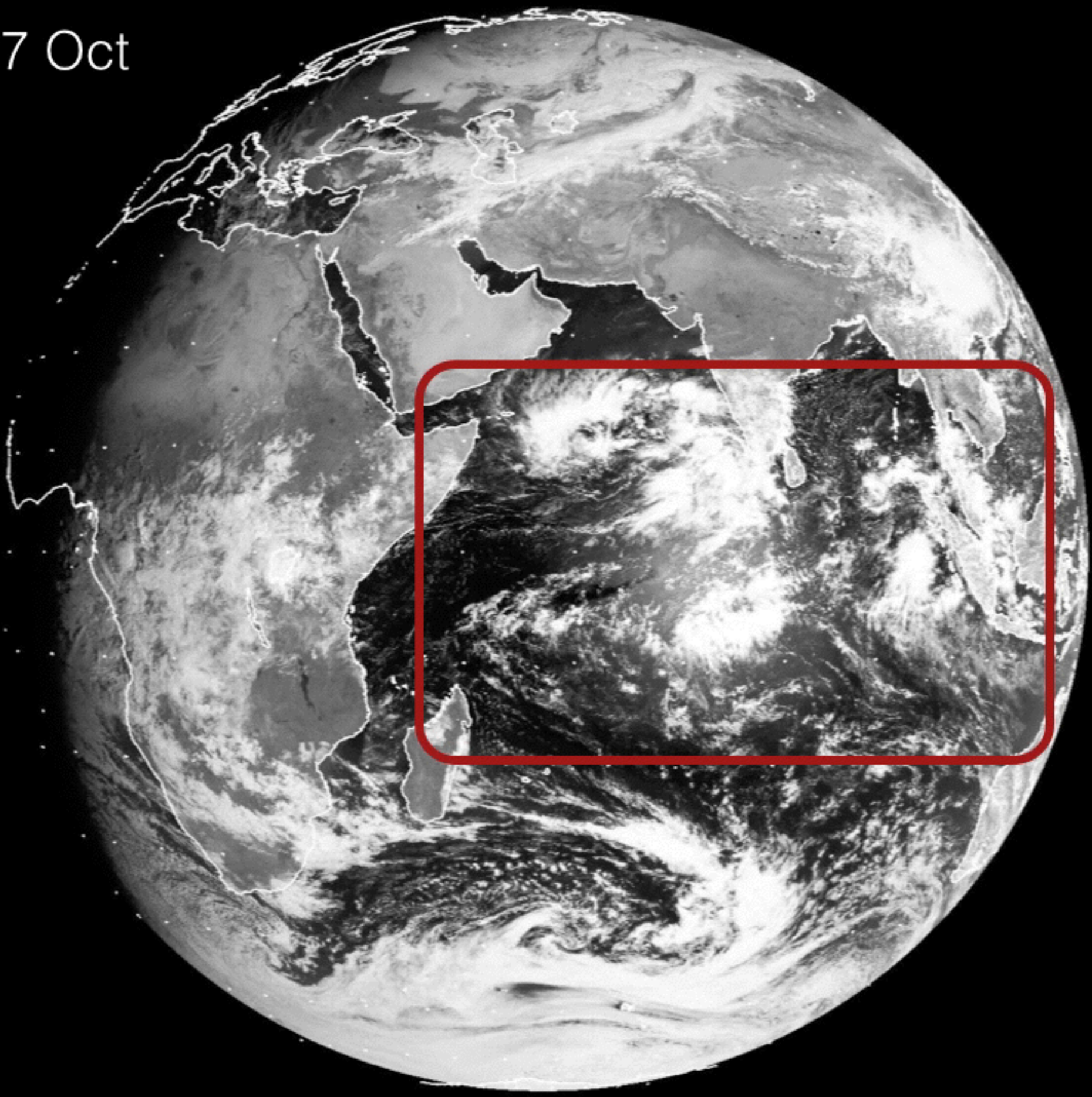
Outline

- Diagnosing DYNAMO MJO forecasts using CAM
- Description of nudged MJO evolution in the model
- Results from analysis of nudging tendencies to diagnose biases in the evolving model solutions

27 Oct



MJO Hindcast Experiment

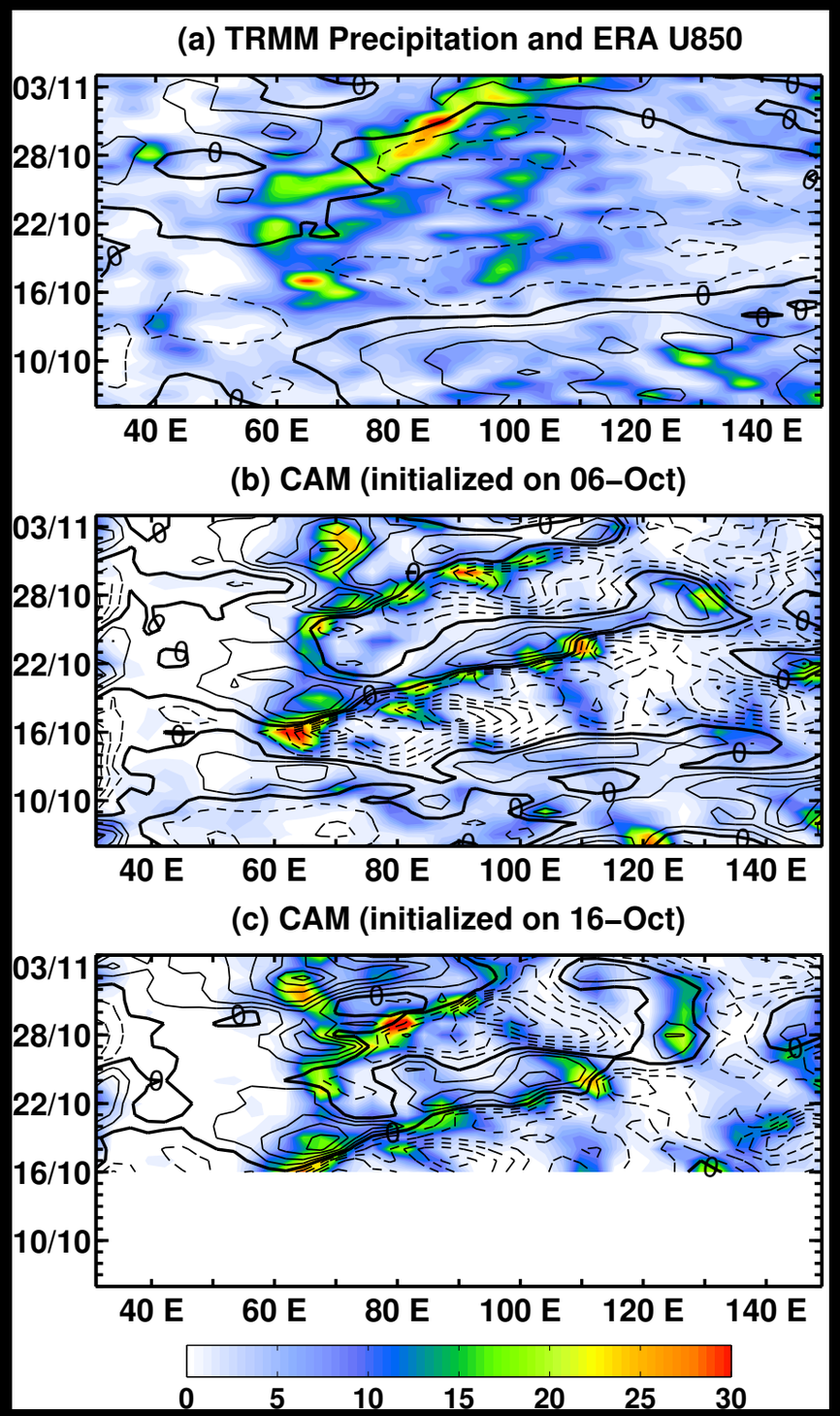
- Hindcasts are **initialized from ECMWF Reanalyses fields.**
- The model boundary is forced using Reanalysis SST.
- 26 levels in the vertical,
- ~2^{o} horizontal resolution
- Revised Zhang-McFarlane convection scheme : based on free-tropospheric quasi-equilibrium.

Precipitation and zonal winds

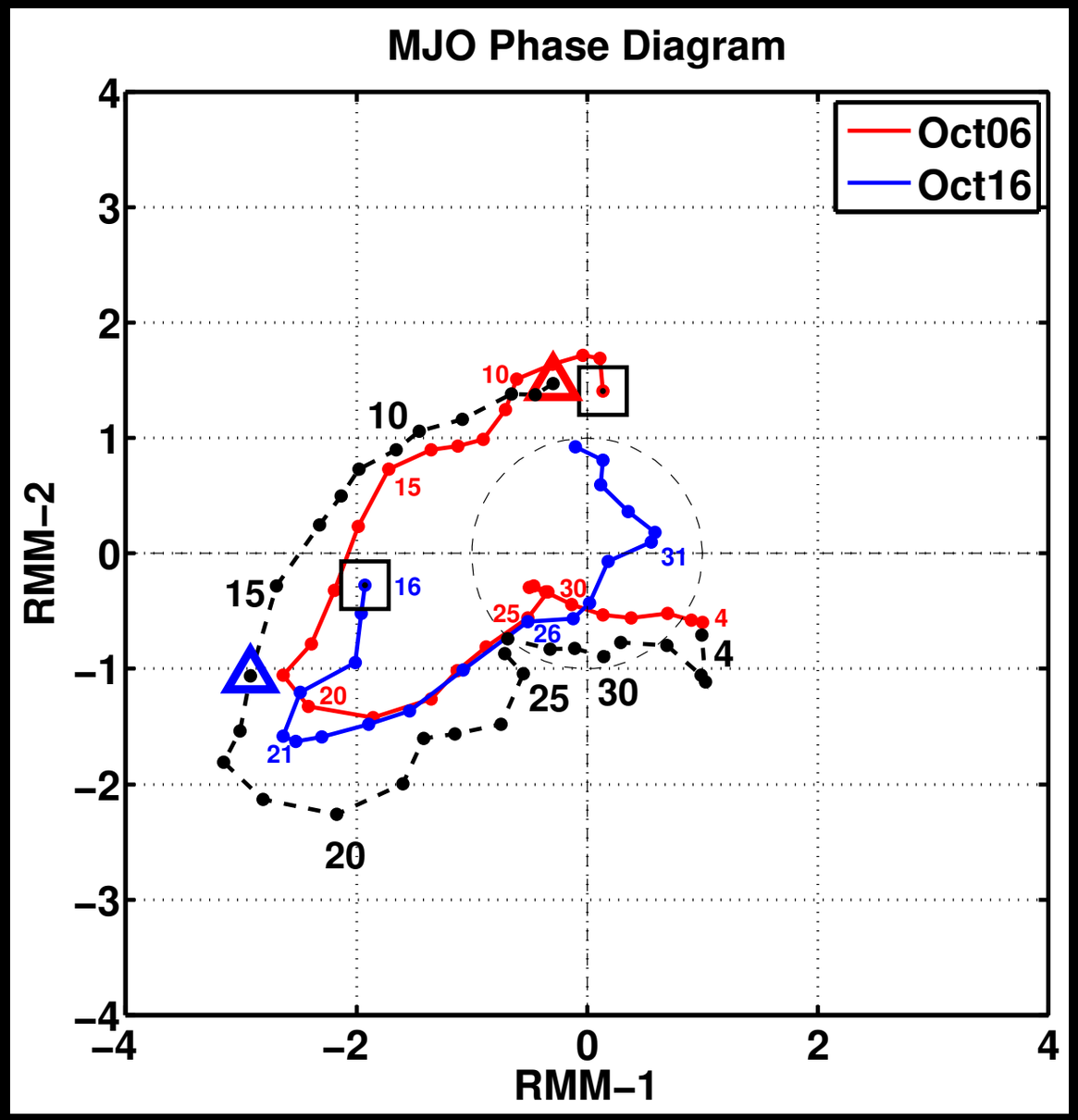
Observations

CAM Hindcast (6th Oct)

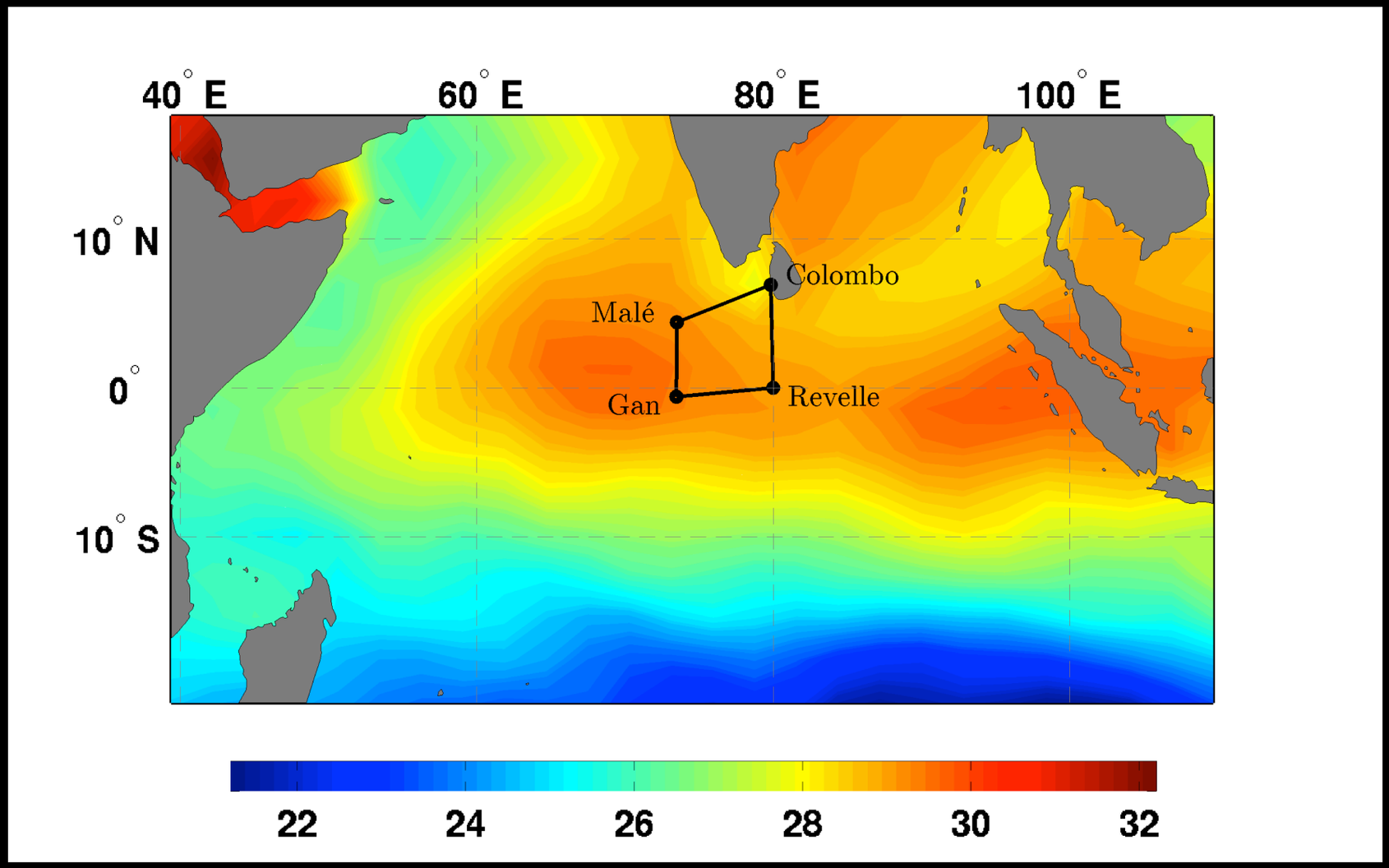
CAM Hindcast (16th Oct)



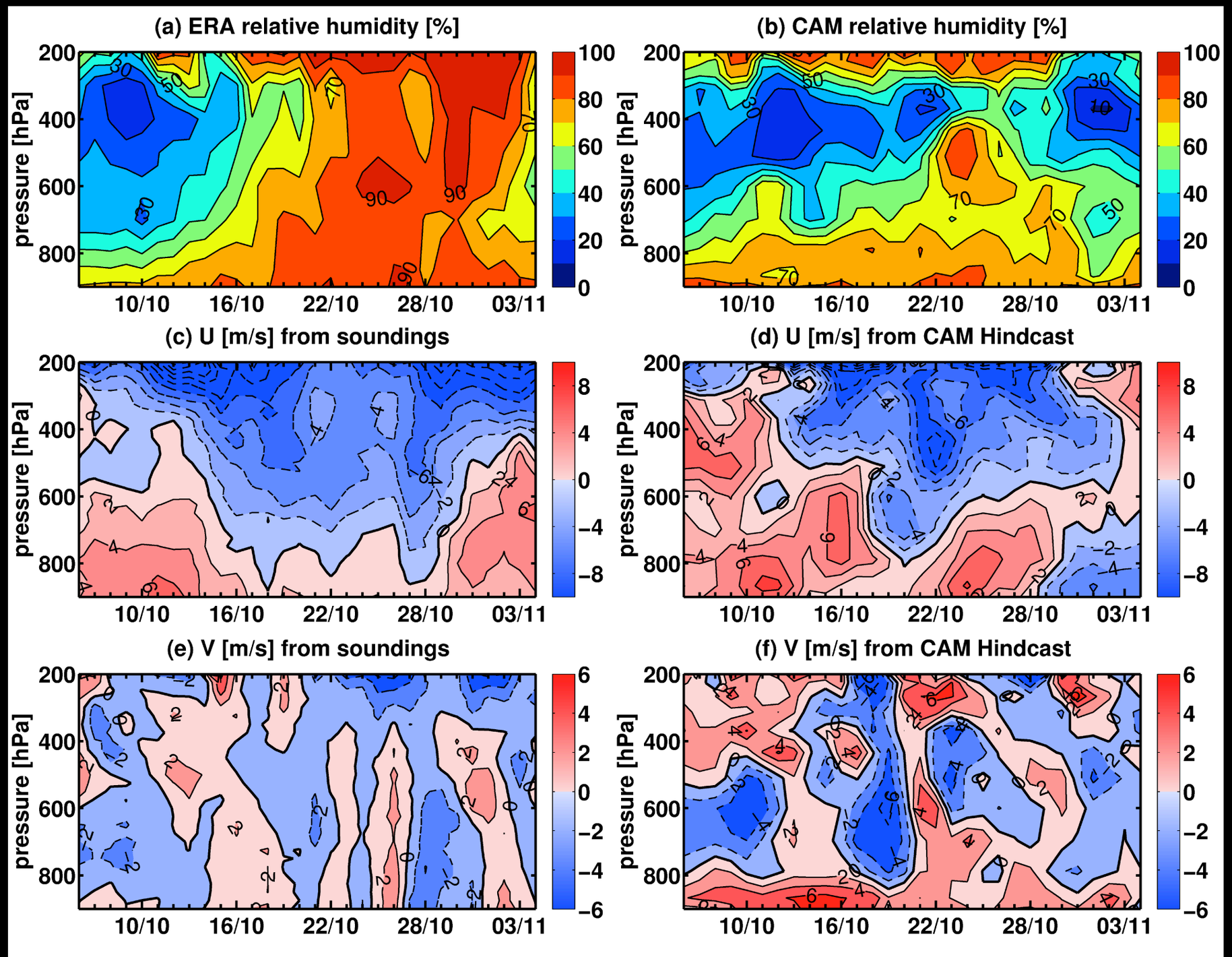
Phase diagram



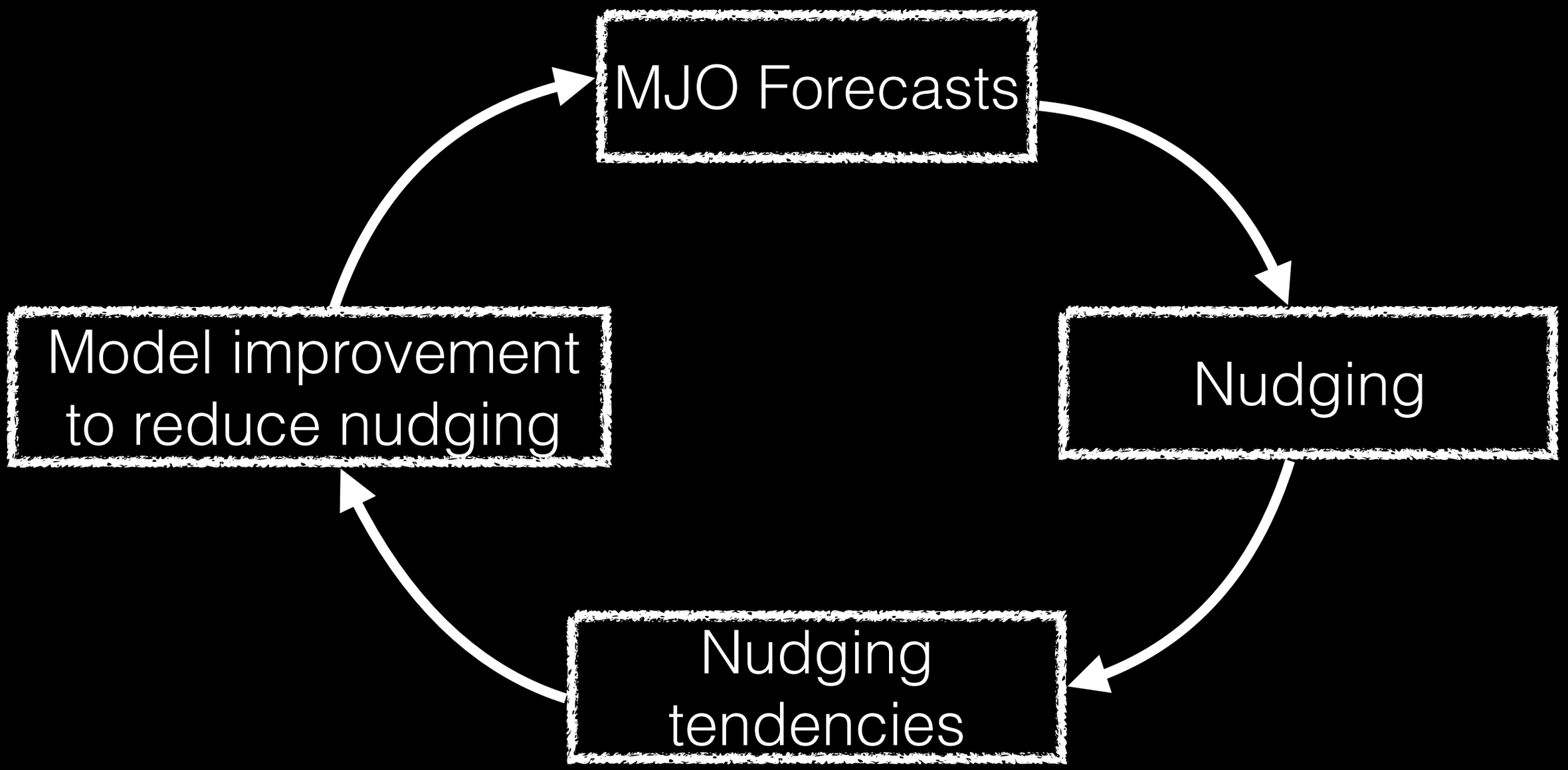
Analysis Domain



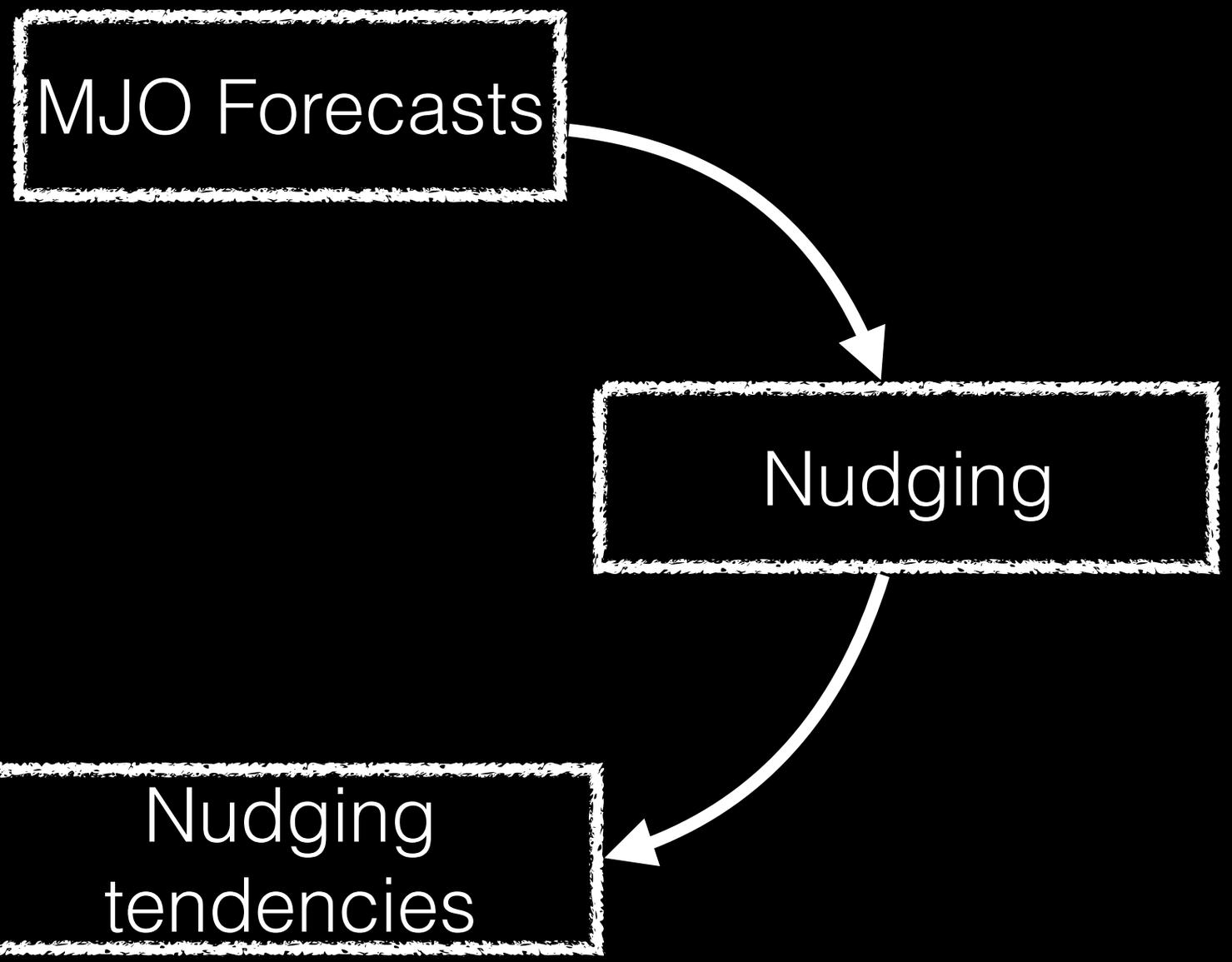
Humidity and Winds



Model Improvement



Model Improvement



Nudging

$$\left(\frac{\partial q}{\partial t}\right)_{\text{model}} = \left(\frac{\partial q}{\partial t}\right)_{dyn\_\text{model}} + \left(\frac{\partial q}{\partial t}\right)_{phys\_\text{model}} + \left(\frac{\partial q}{\partial t}\right)_{nudge}$$

$$\left(\frac{\partial q}{\partial t}\right)_{\text{obs}} = \left(\frac{\partial q}{\partial t}\right)_{dyn\_\text{obs}} + \left(\frac{\partial q}{\partial t}\right)_{phys\_\text{obs}}$$

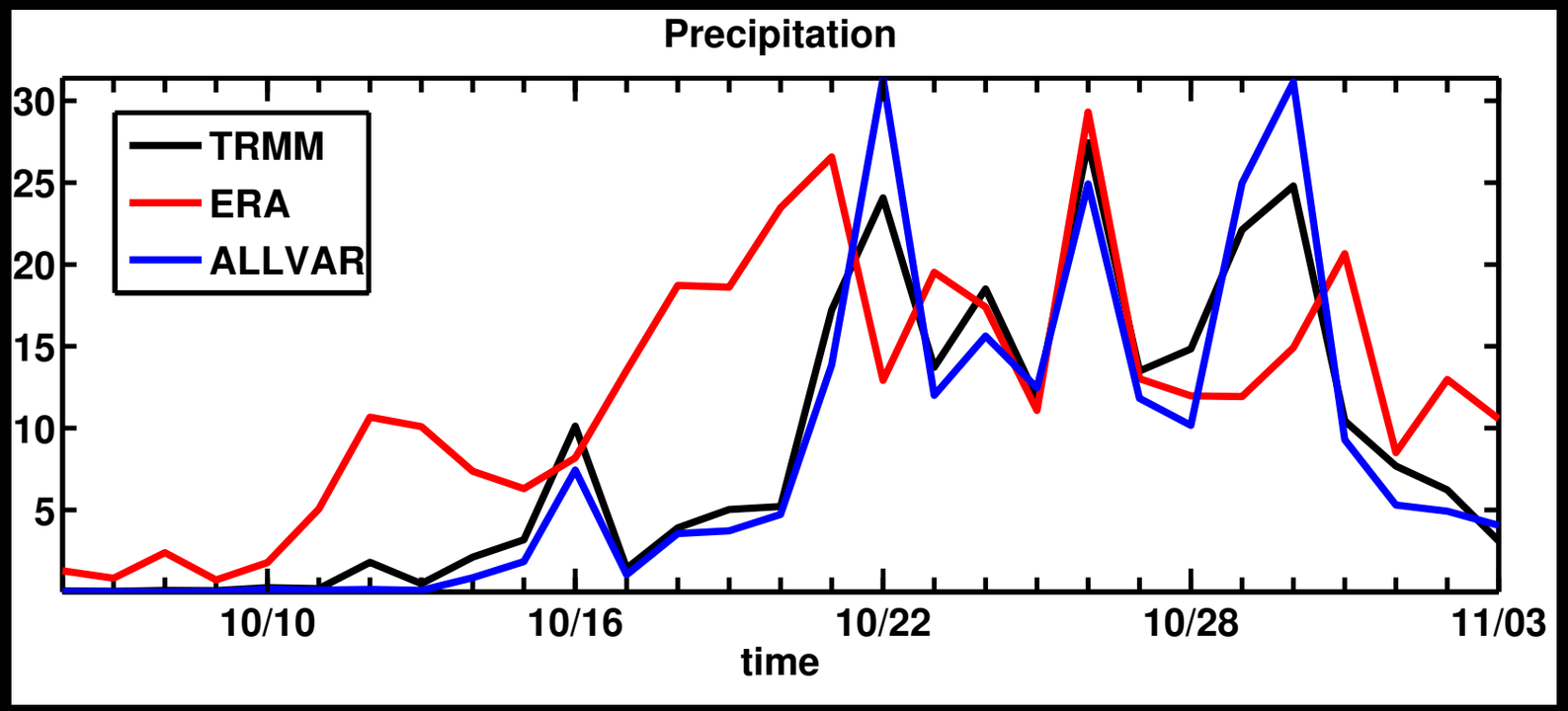
$$\left(\frac{\partial q}{\partial t}\right)_{nudge} = \left(\frac{\partial q}{\partial t}\right)_{phys\_\text{obs}} - \left(\frac{\partial q}{\partial t}\right)_{phys\_\text{model}}$$

- CAM nudged towards ECMWF during model event evolution
- Temperature, humidity, winds and surface pressure variables are nudged

Experiments

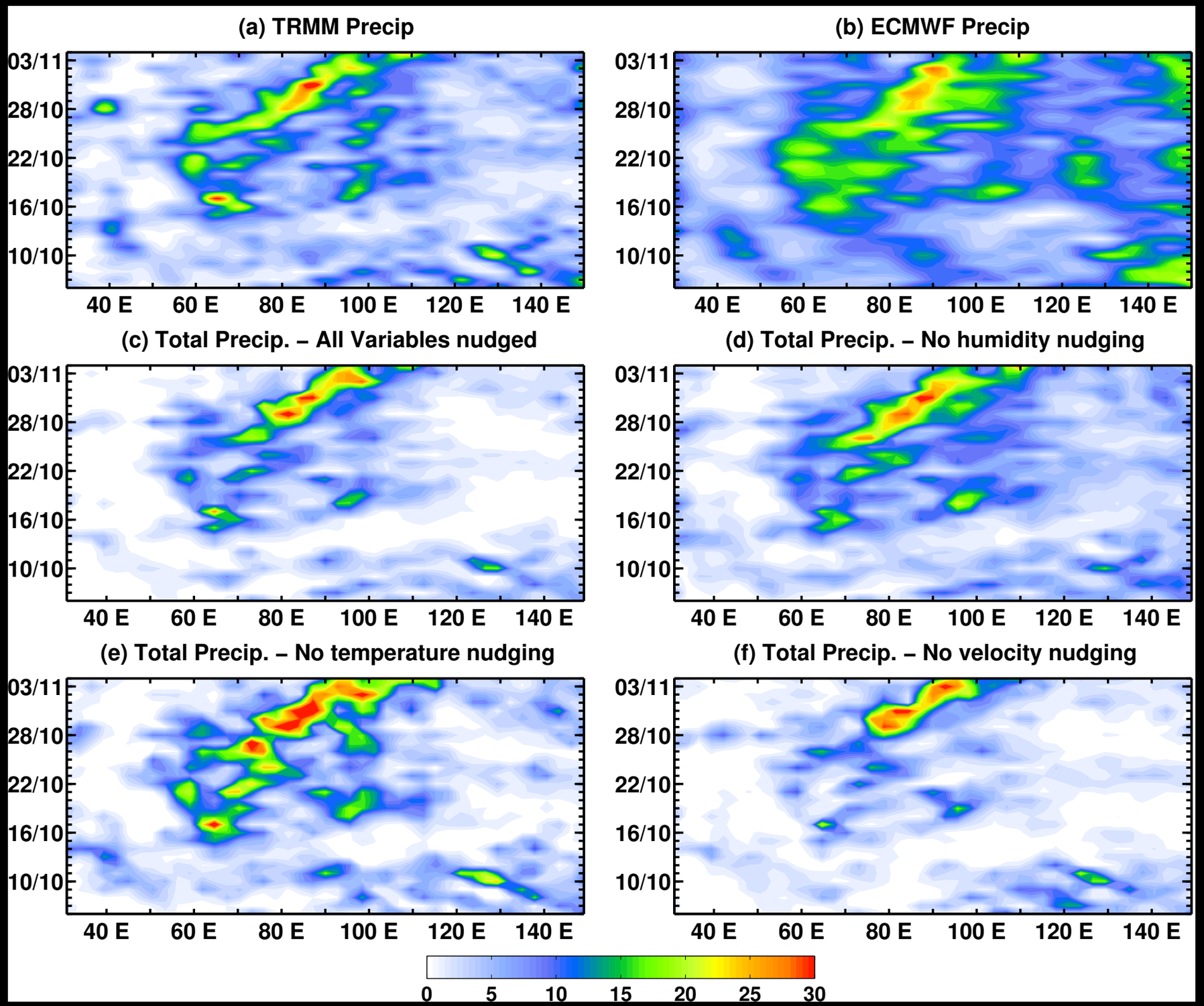
ALLVAR	All variables nudged (Q, T, U, V, PS)
NOHUM	Humidity not nudged
NOTEMP	Temperature not nudged
NOVEL	Velocity not nudged

Time series of precipitation

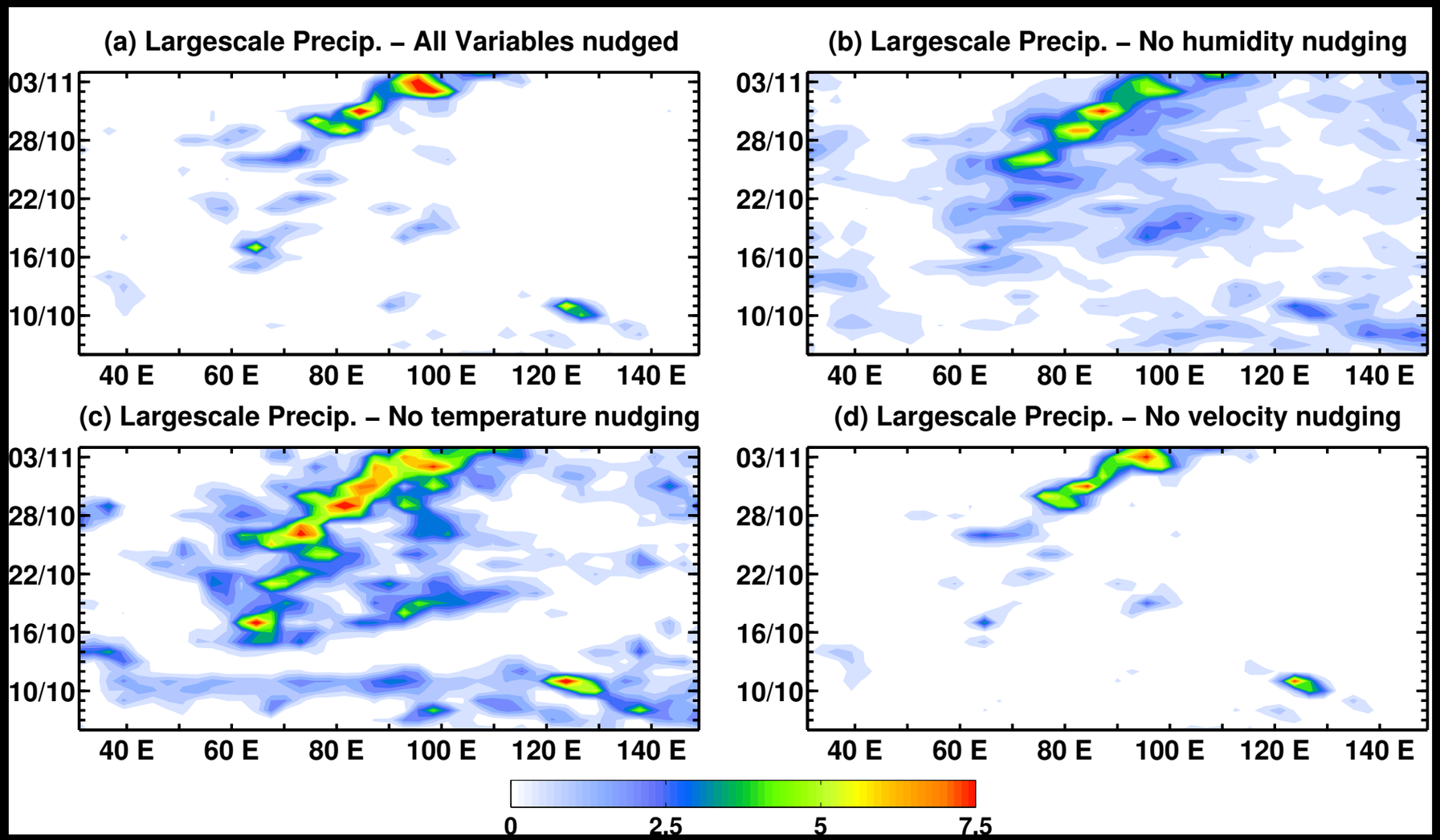


Nudged CAM reproduces TRMM precipitation better than ECMWF

Total precipitation

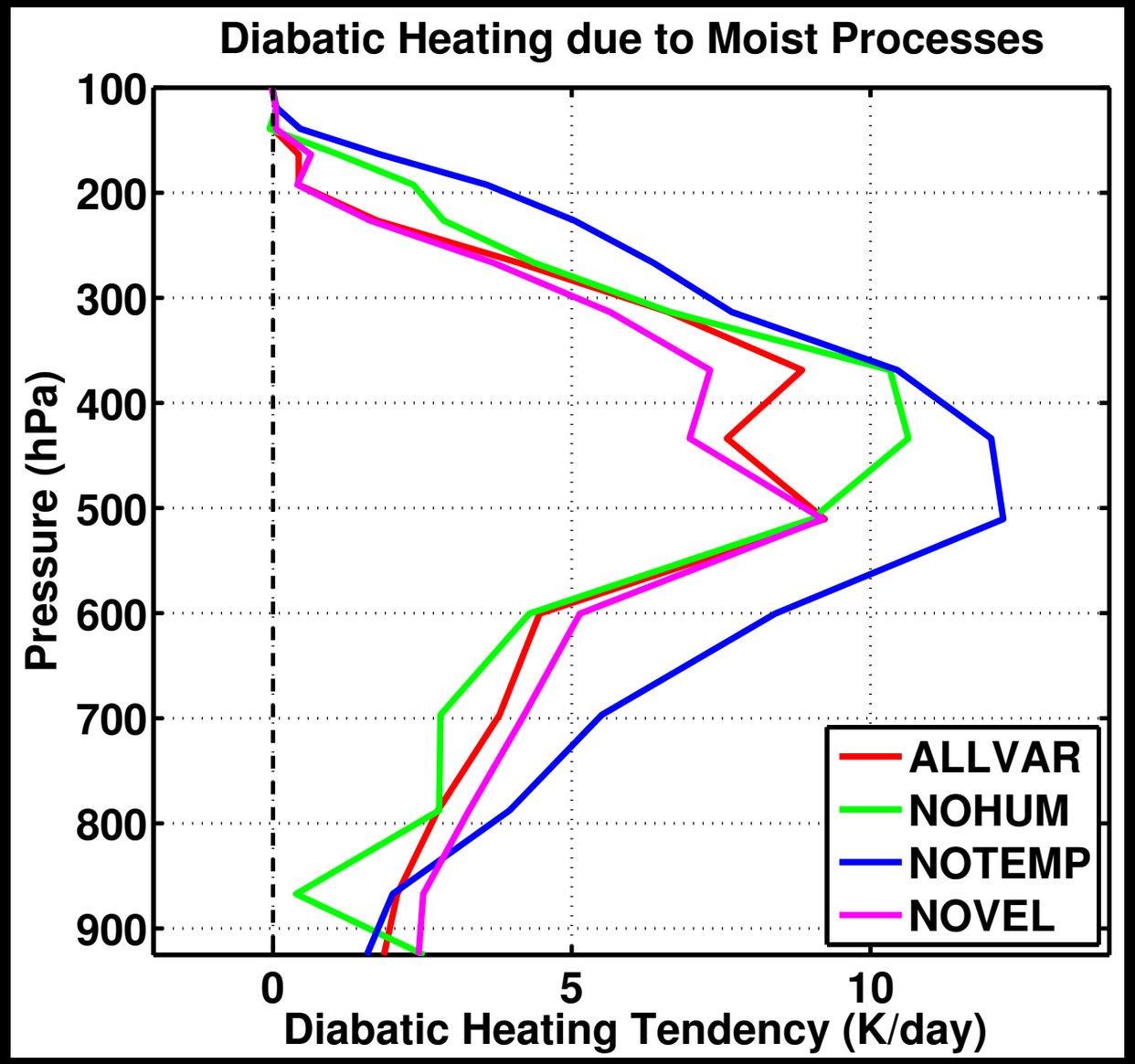


Largescale precipitation



Diabatic heating

Averaged over NSA region



Bias detection

Negative of nudging tendency = Model bias

(Model - Reanalysis)/timescale

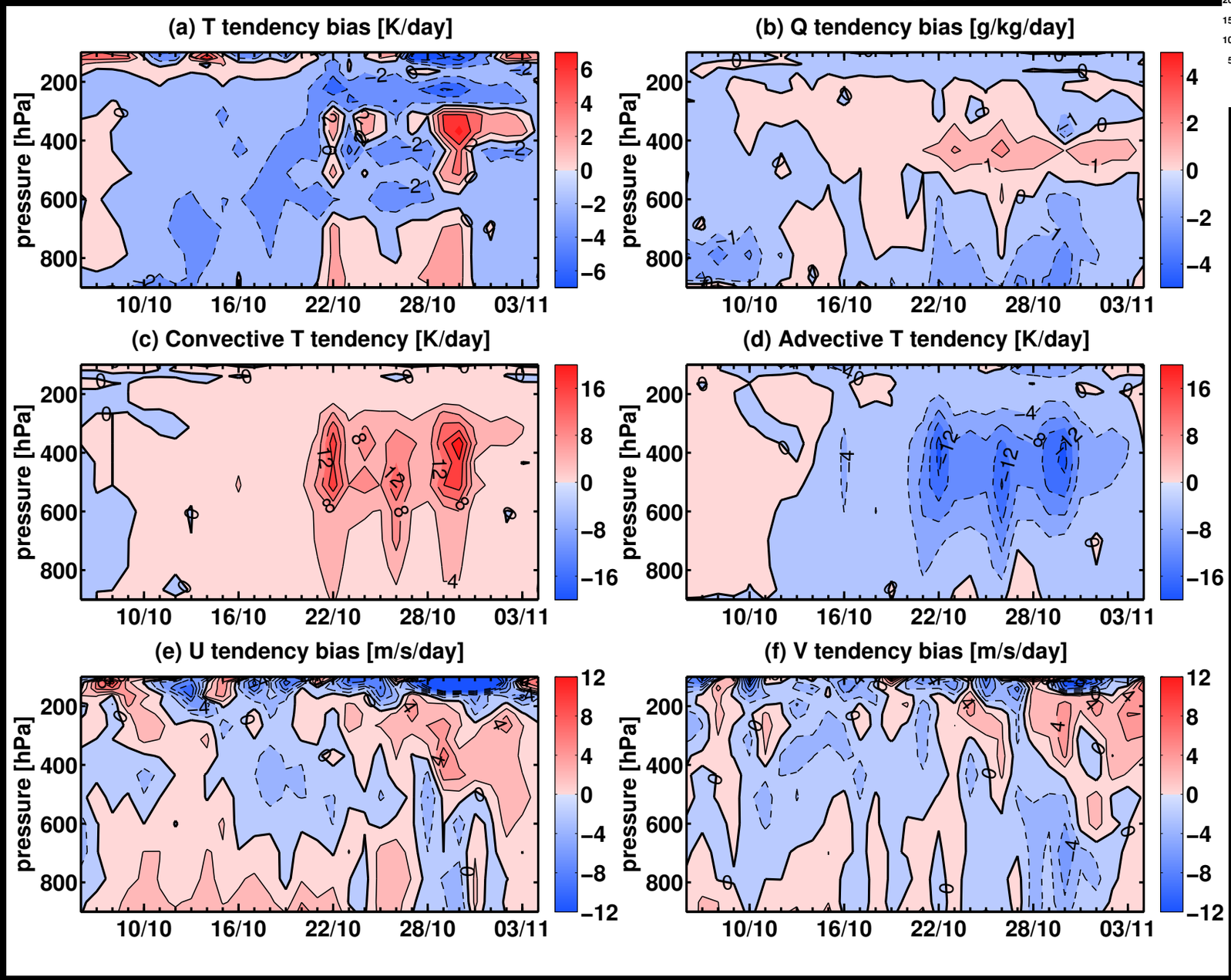
ALLVAR Nudging tendencies

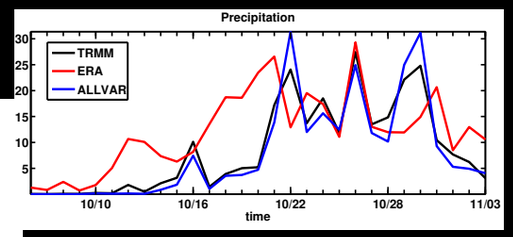
Averaged over NSA region

T, Q tendency bias

Conv, Adv tendency

U, V tendency bias





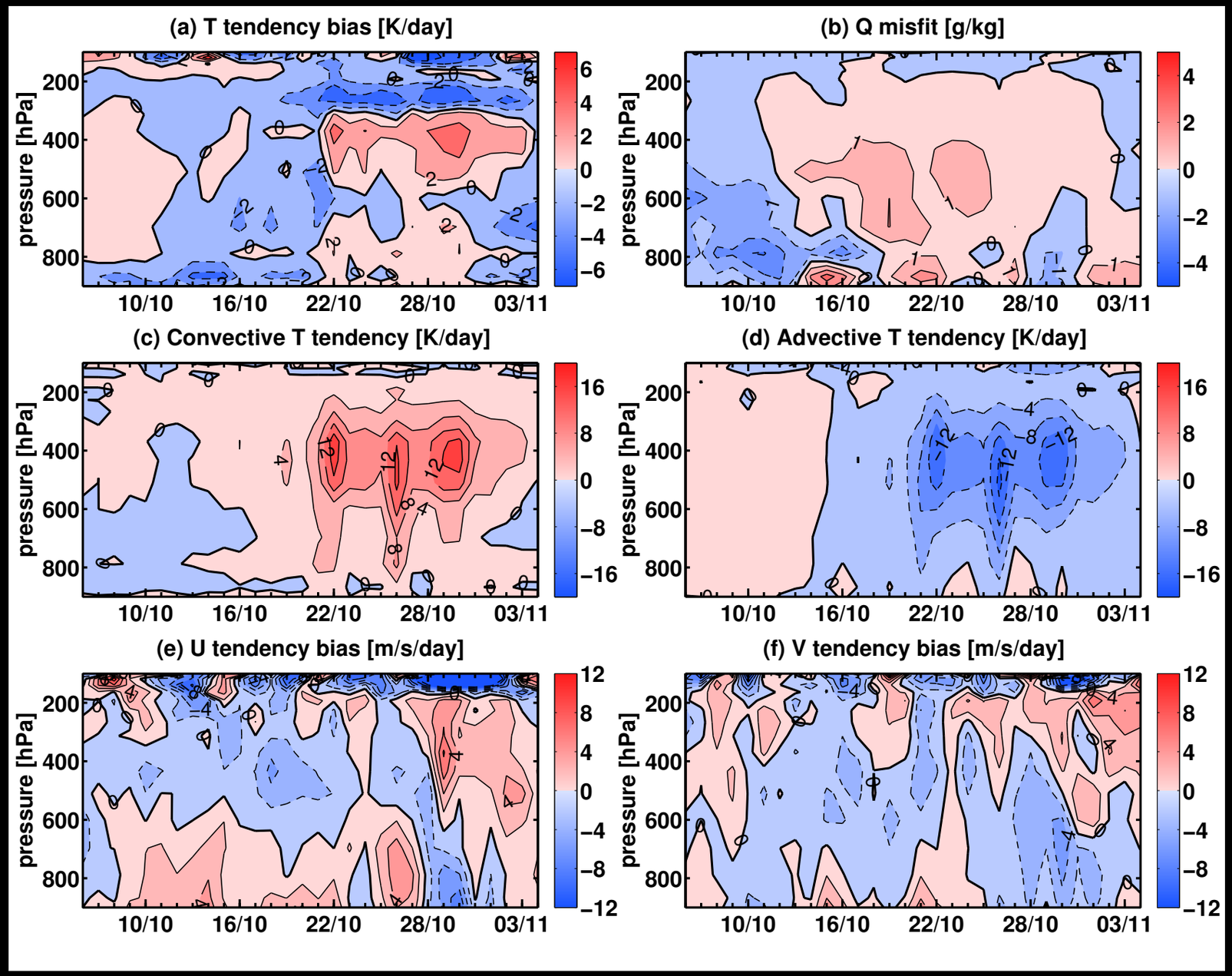
NOHUM Nudging tendencies

Averaged over NSA region

T, Q tendency bias

Conv, Adv tendency

U, V tendency bias



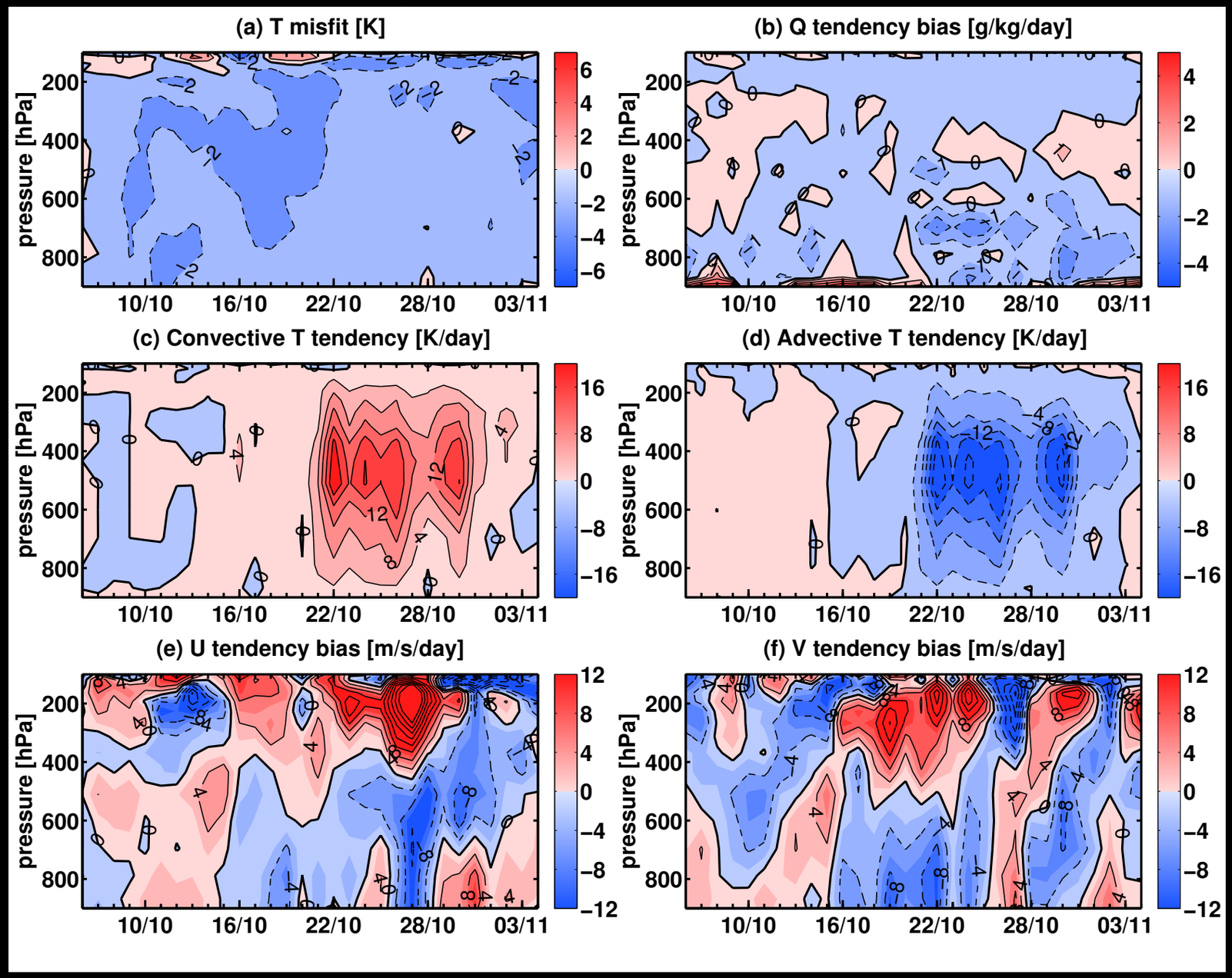
NOTEMP Nudging tendencies

Averaged over NSA region

T, Q tendency bias

Conv, Adv tendency

U, V tendency bias



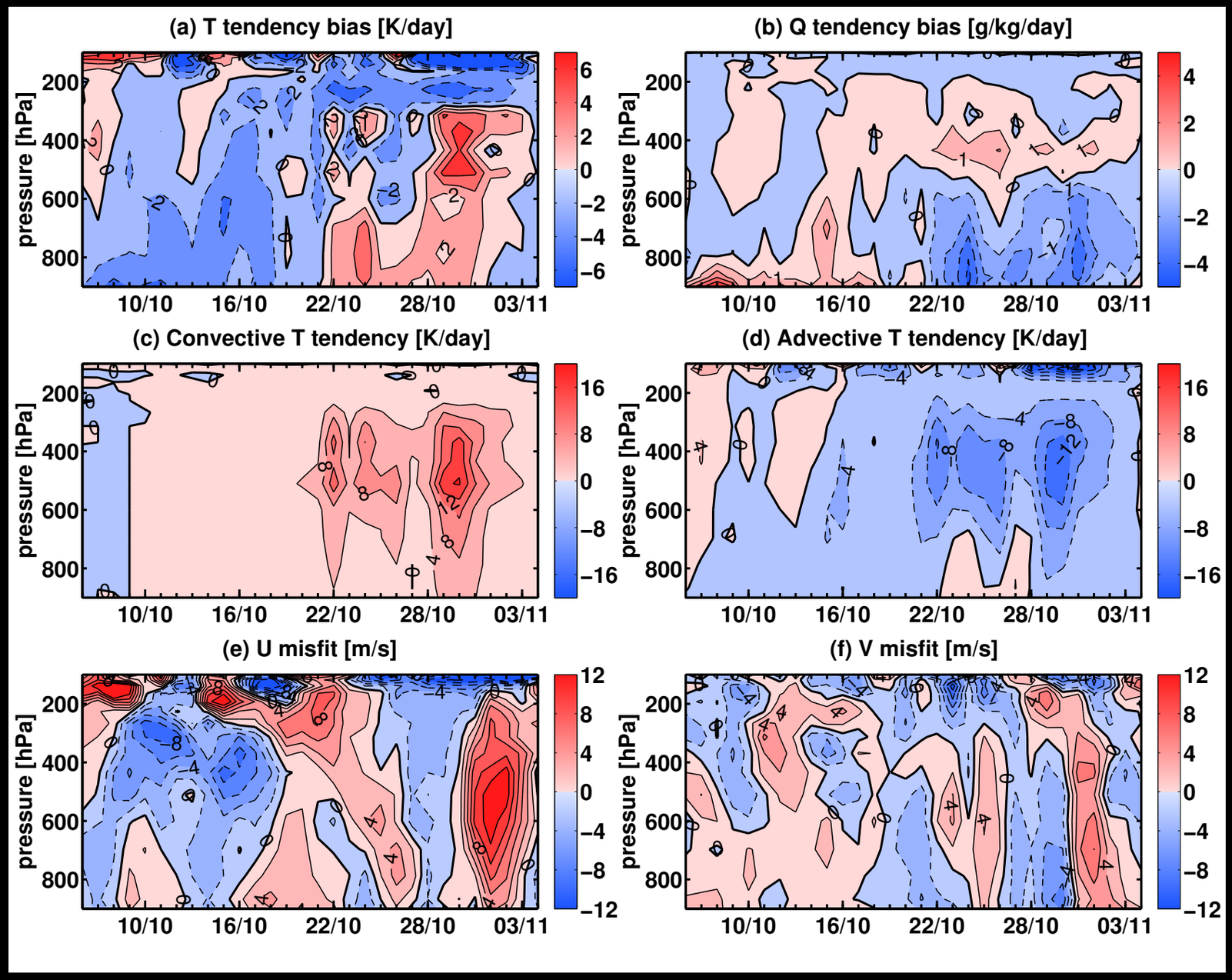
NOVEL Nudging tendencies

Averaged over NSA region

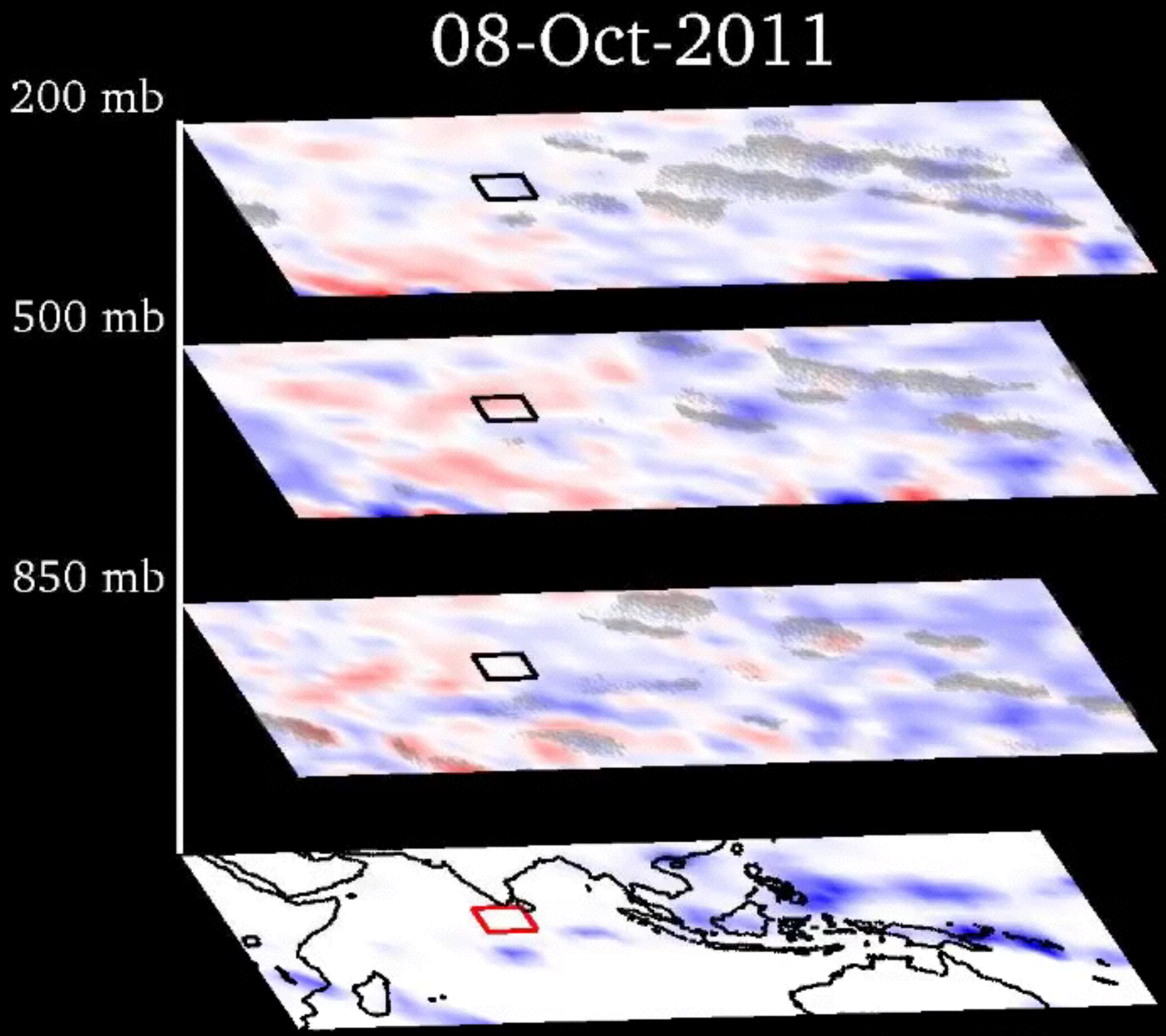
T, Q tendency bias

Conv, Adv tendency

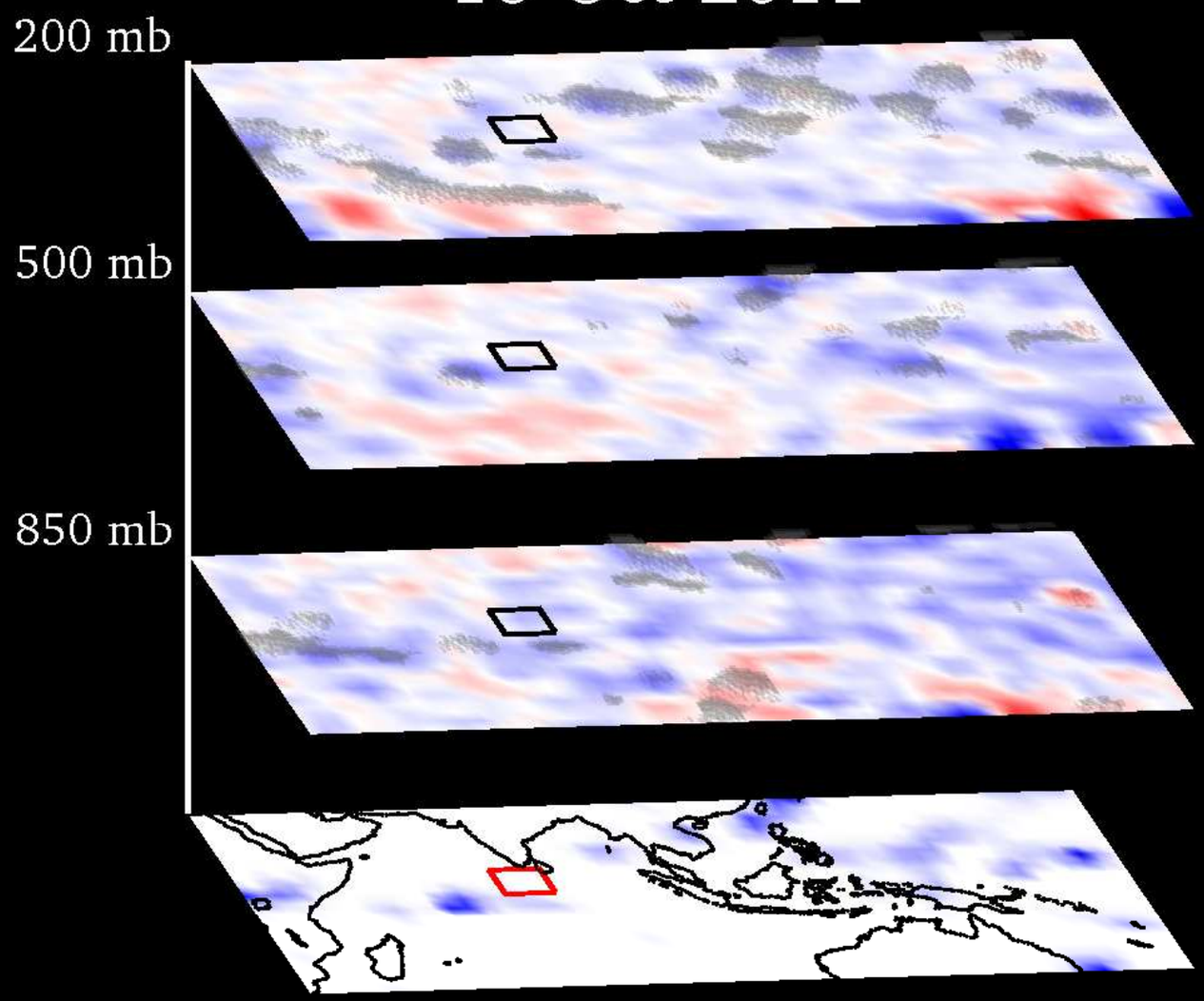
U, V tendency bias



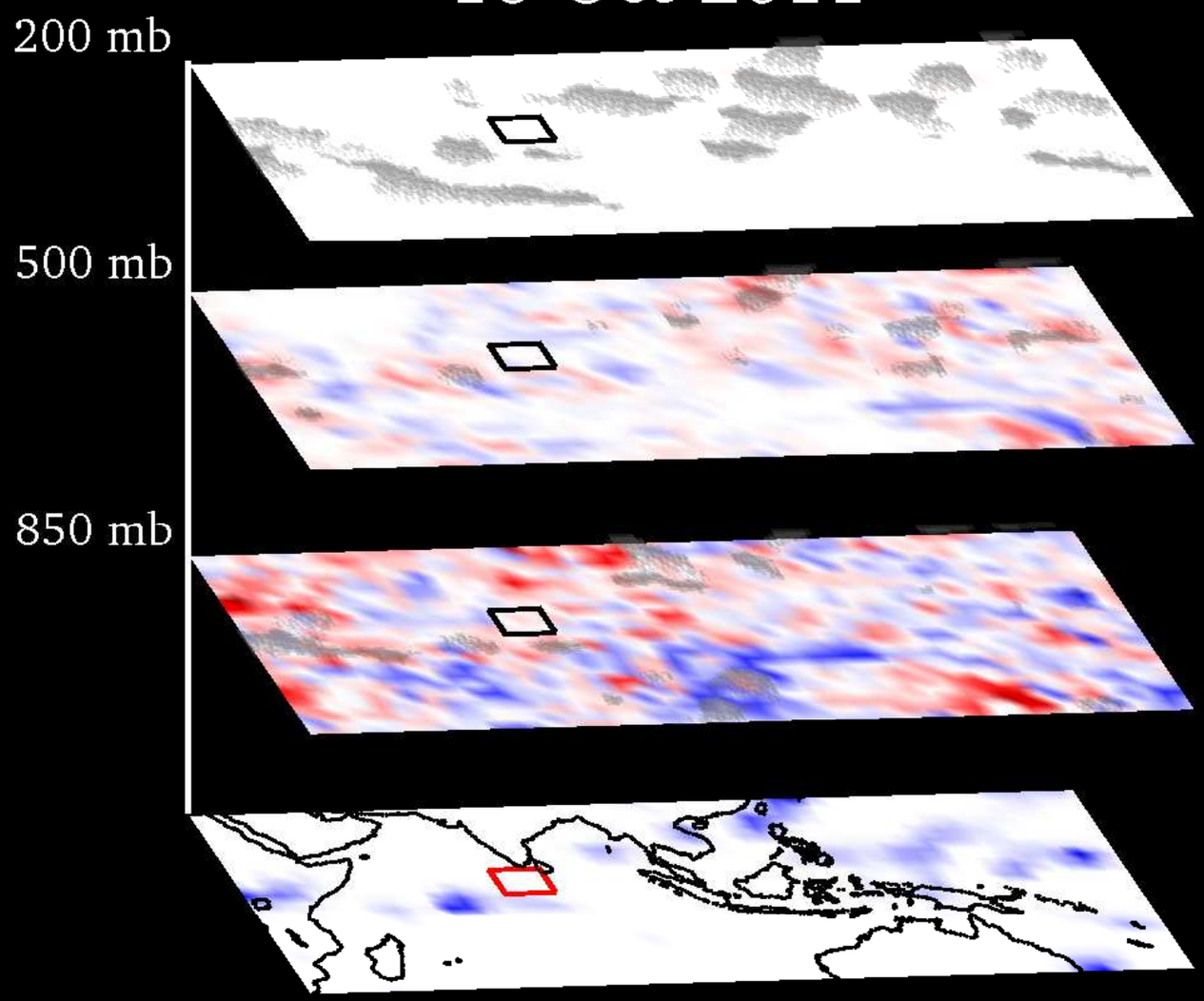
Temperature bias animaiton



Temperature nudging tendencies

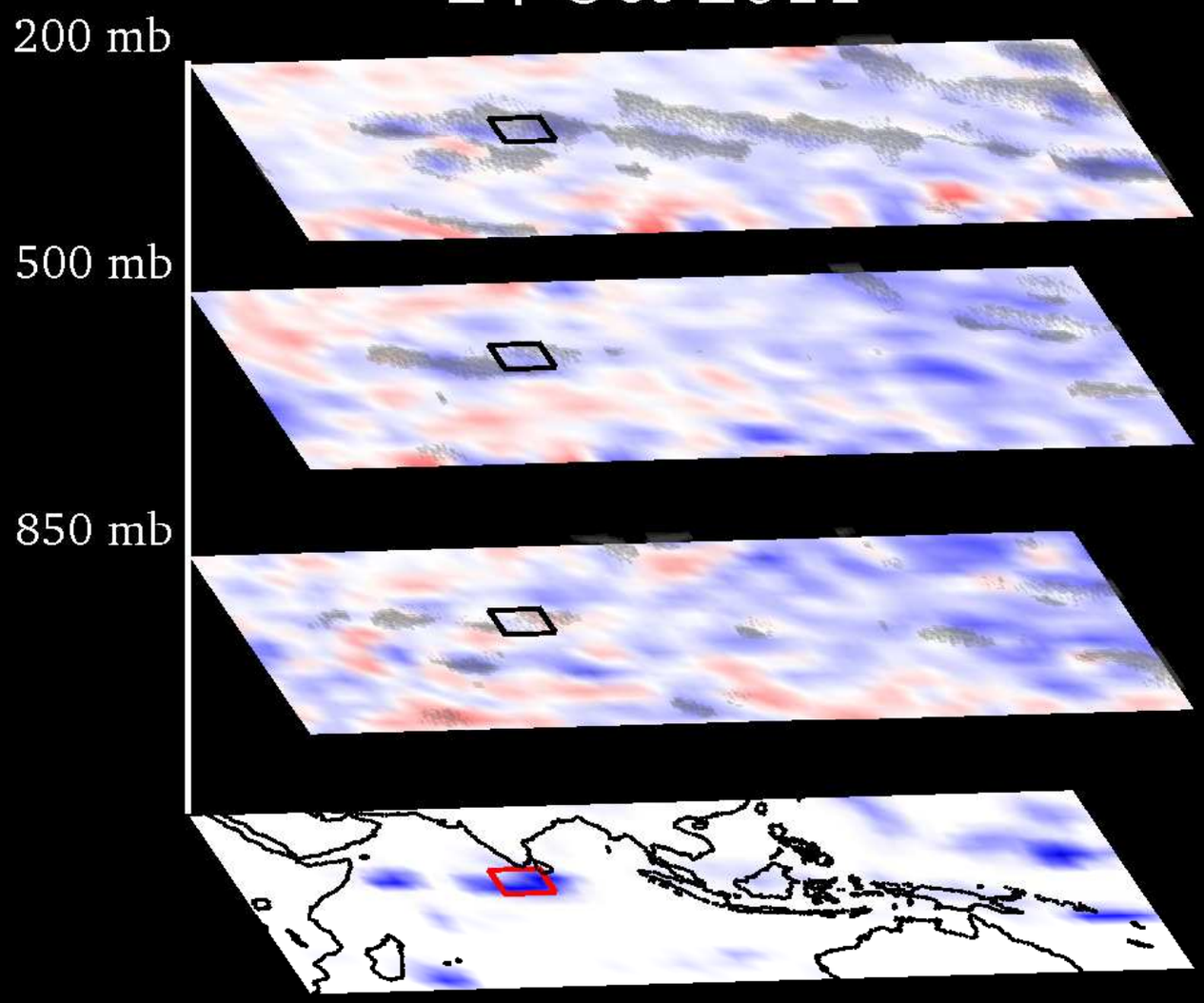


Moisture nudging tendencies

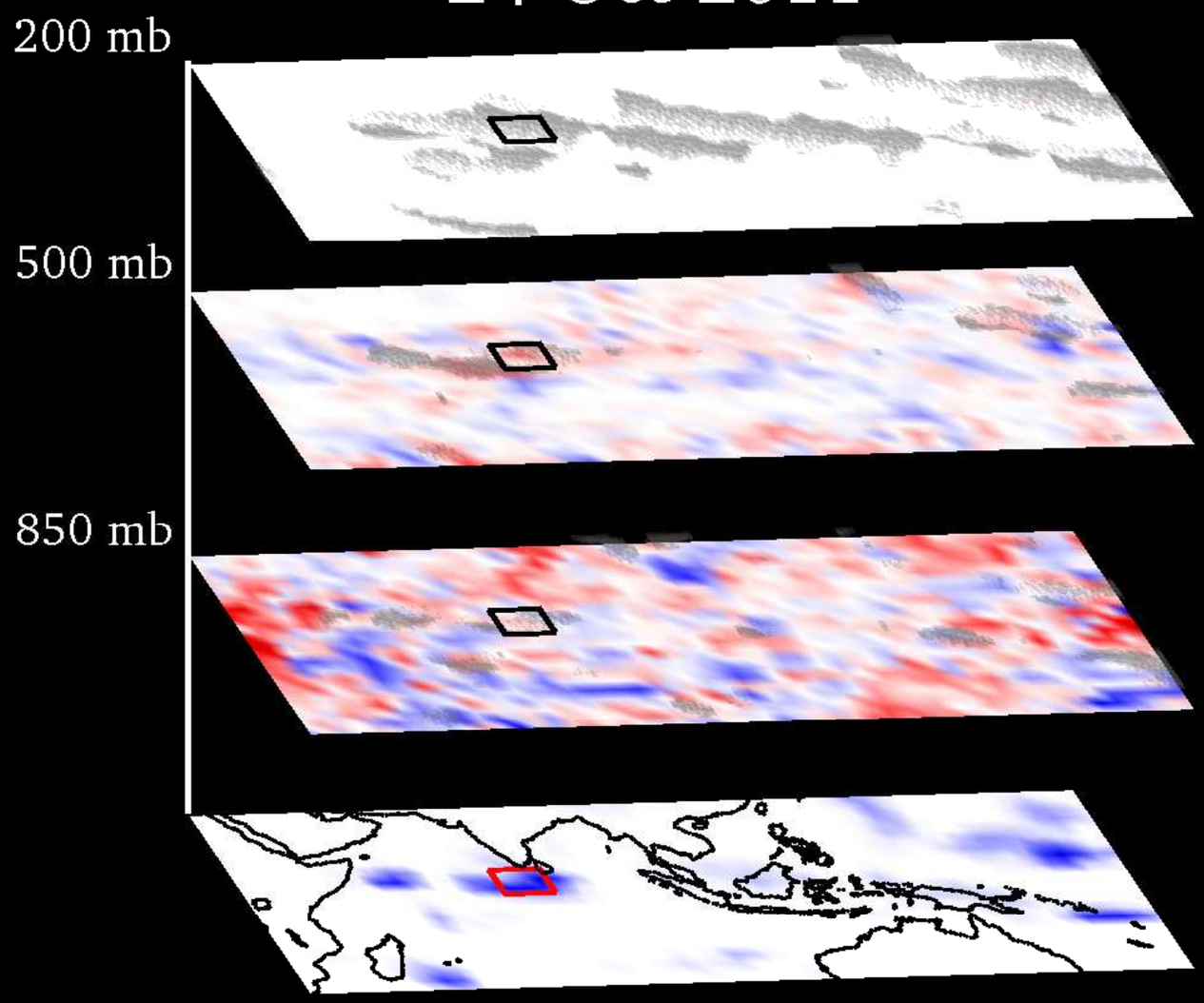


MJO Initiation phase in the Indian Ocean

Temperature nudging tendencies

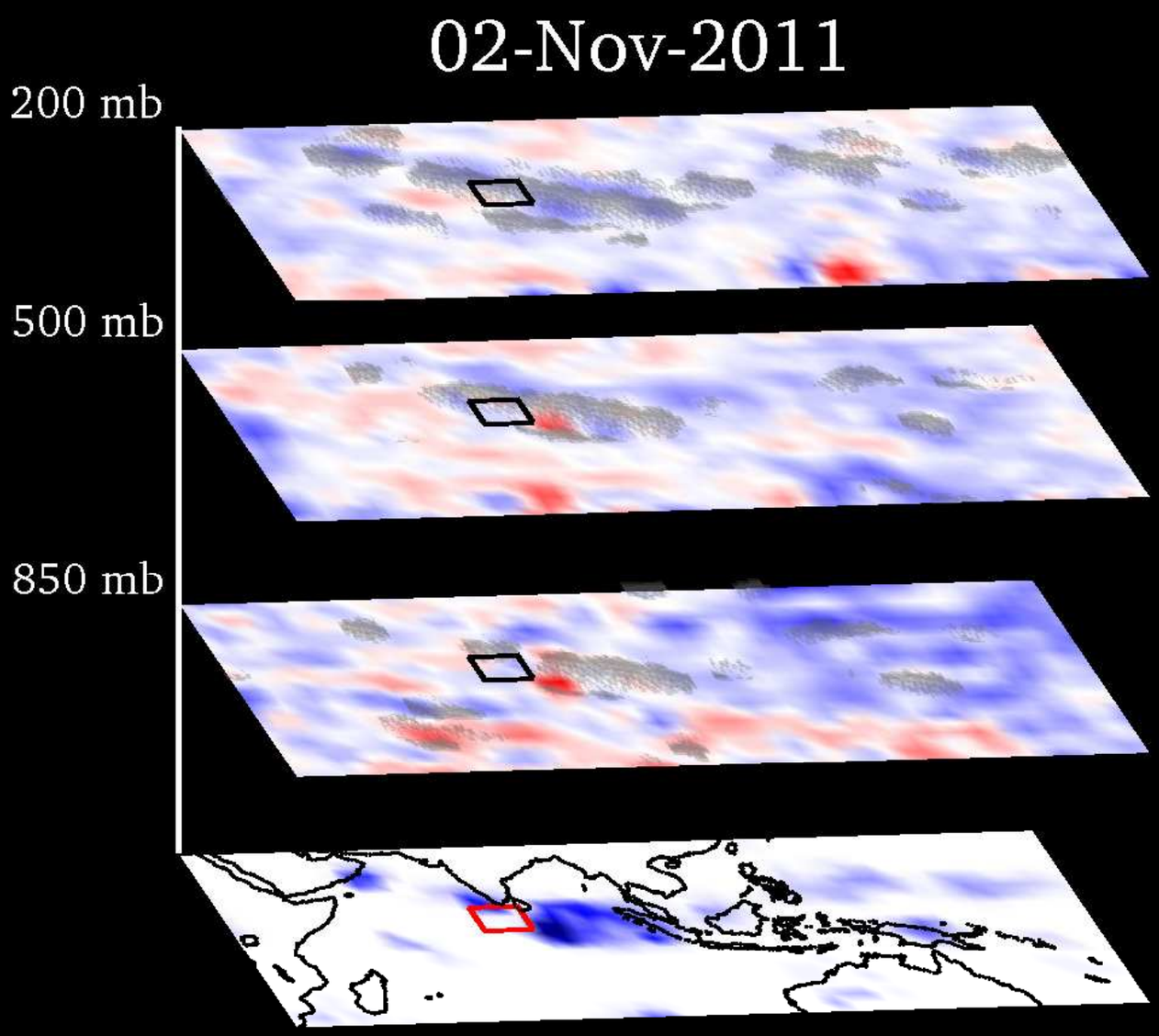


Moisture nudging tendencies

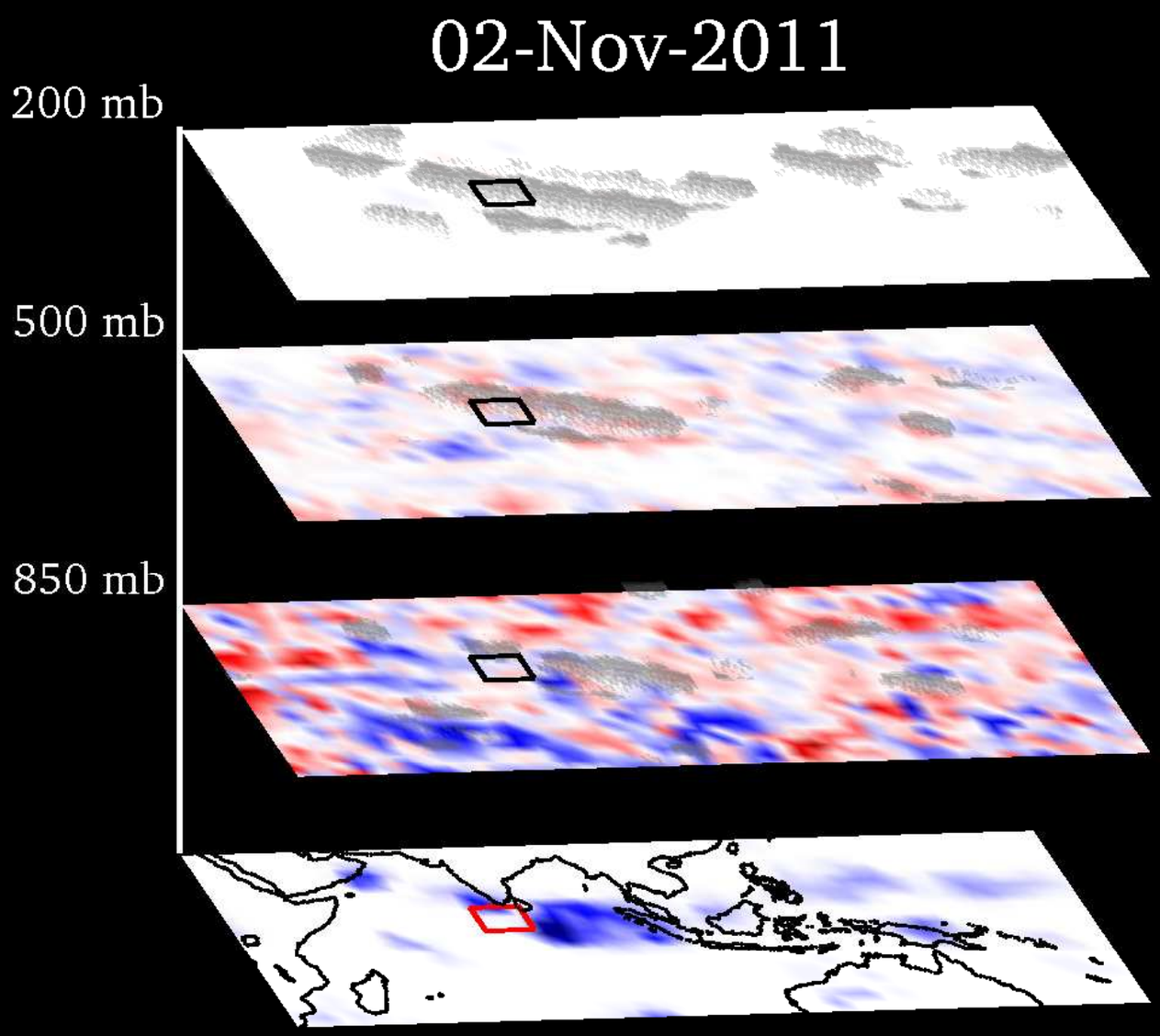


MJO mature phase in the Indian Ocean

Temperature nudging tendencies



Moisture nudging tendencies



MJO decay phase in the Indian Ocean

Summary

- The hindcast has a
  - **much faster phase speed**,
  - a **dry relative humidity bias**,
  - a **stronger zonal wind shear** and
  - a **weaker** MJO peak **amplitude**.

- Nudging tendency analysis shows
  - Not enough diabatic heating from convection during the initiation and developing phases of the MJO
  - Not enough stratiform condensation in the upper troposphere and
  - re-evaporation in the lower troposphere during the mature and decay phases
  - Too strong a zonal wind shear during the MJO evolution.


AMS
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