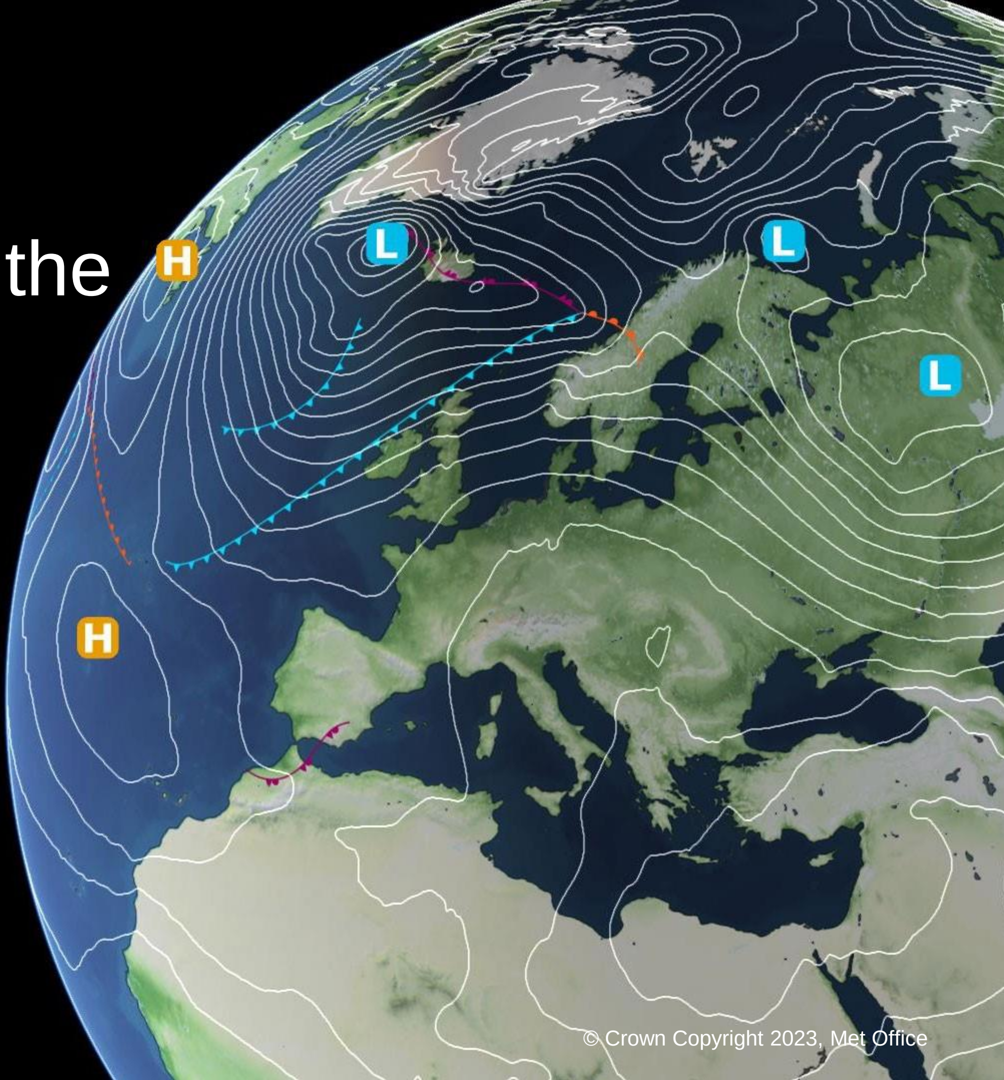
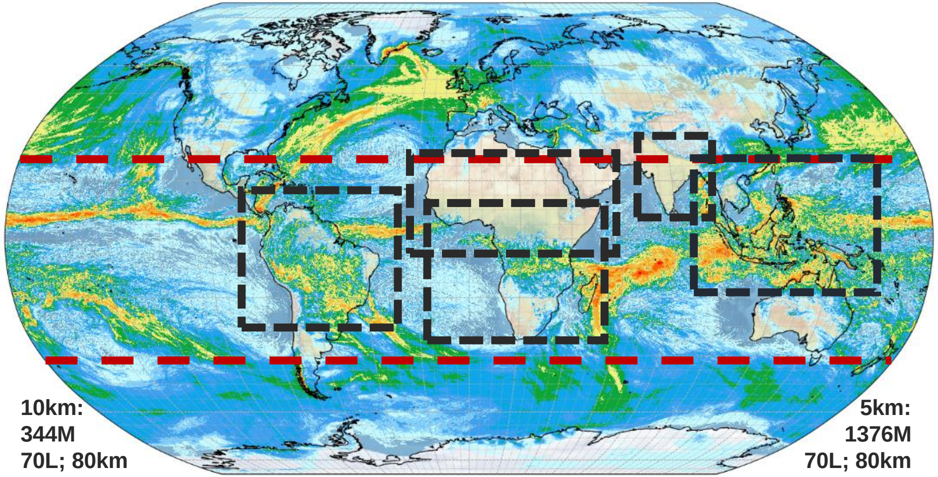
Met Office

K-SCALE: Interactions between Convection and the Tropical Easterly Jet in Tropical Channel Simulations.

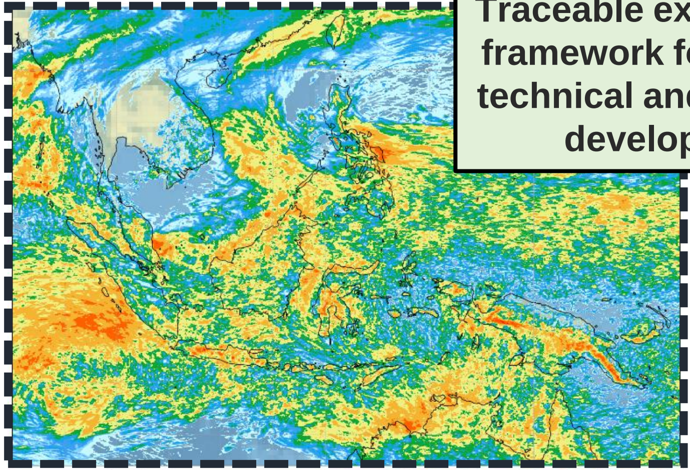


James Warner

Richard Jones, Huw Lewis, Claudio Sanchez + wider K-SCALE collaboration.



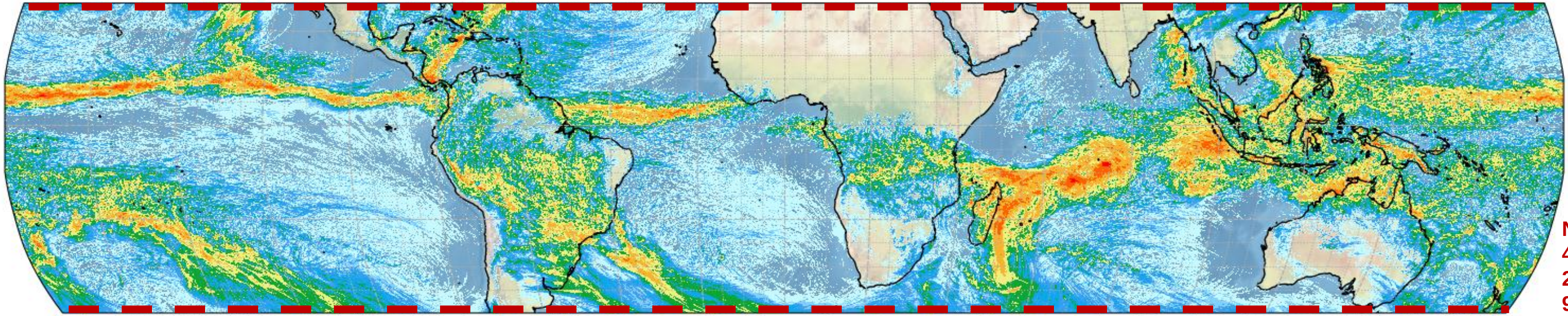
GLOBAL scale coupled ensemble '10km' and '5km' grids



Traceable experimental framework for efficient technical and scientific development

2.2km: 634M
90L; 40km

CONTINENTAL - NATIONAL scale 2.2km



N2560: 649M
4.4km: 1337M
2.2km: 5346M
90L; 40km

CYCLIC TROPICAL CHANNEL coupled ensemble: '10km', '5km', 4km and 2km grids

Huw Lewis

A model hierarchy: *domains, resolutions and timescales*

Scale interaction in the TEJ

The Tropical Easterly Jet extends across the Indian Ocean and Africa, largely a result of thermal wind balance with heating over the Tibetan Plateau.

Convection over Indian ocean distributes momentum, moisture and heat through atmospheric column.

This may impact on upper tropical easterly jet, which is mostly in geostrophic balance, and wider scale Walker/Hadley Circulation.

We can use K-SCALE hierarchy to show this scale interaction, and the upscale impact of convection in Indian Ocean and downscale impact over Africa

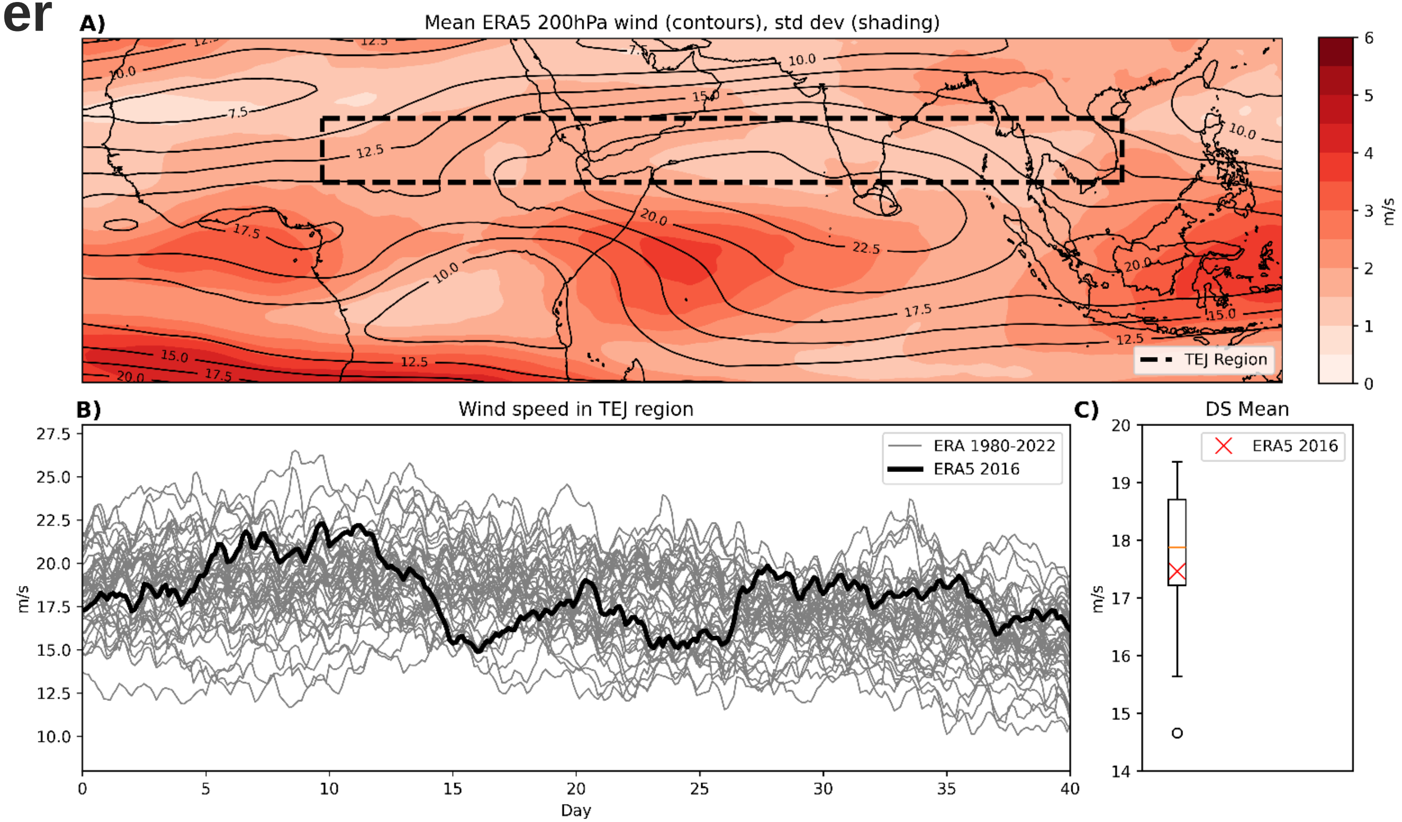
Implications for the Indian monsoon, and African deep convection (wind shear, entrainment, steering through upper jets etc.)

DYAMOND Summer

1st August – 10th September

- 40 day atmos-only simulation (free-run, but constrained by global driving model at north/south boundaries).

- Using either RAL3p2 explicit convection or GAL9 parameterised convection UM/JULES science configurations.



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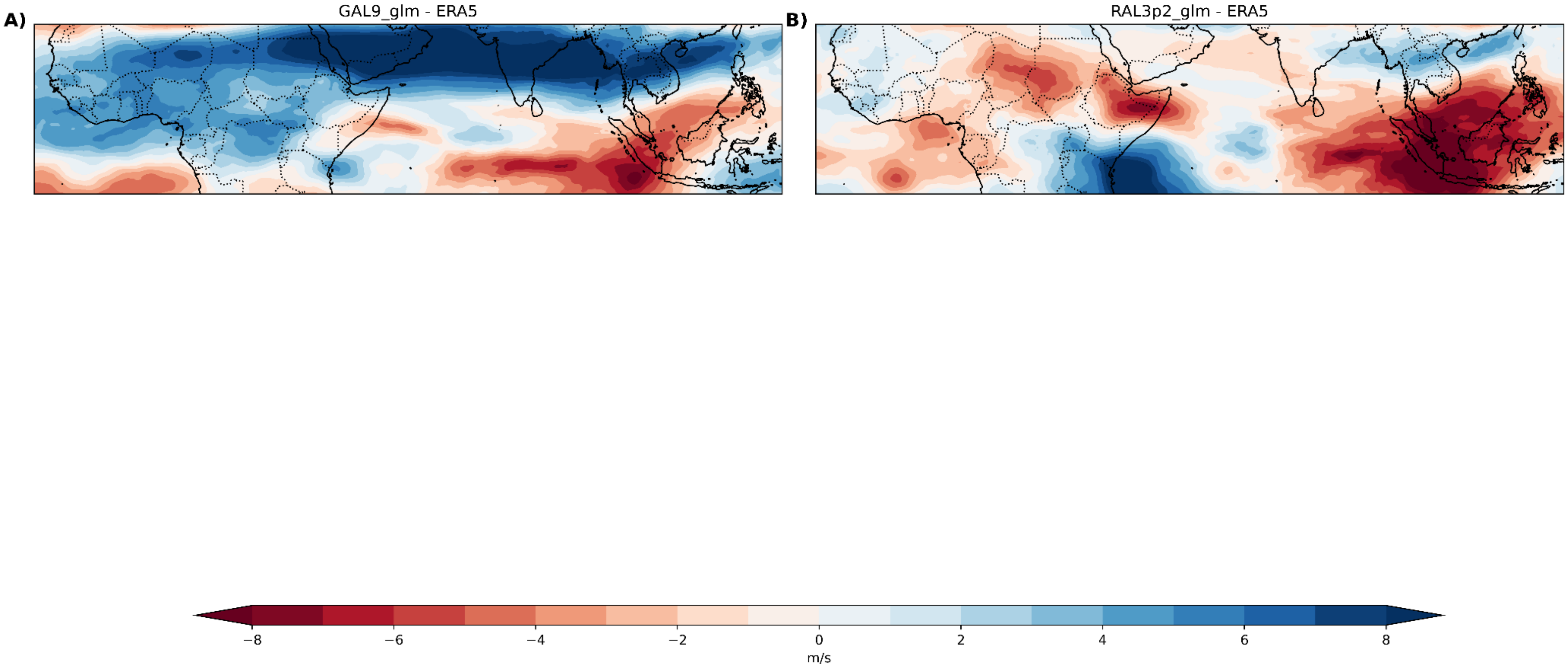
RAL3p2 explicit convection
GAL9 parameterised convection
CTC: 5km, GLM: 10km

Mean jet state over full period (200hPa)



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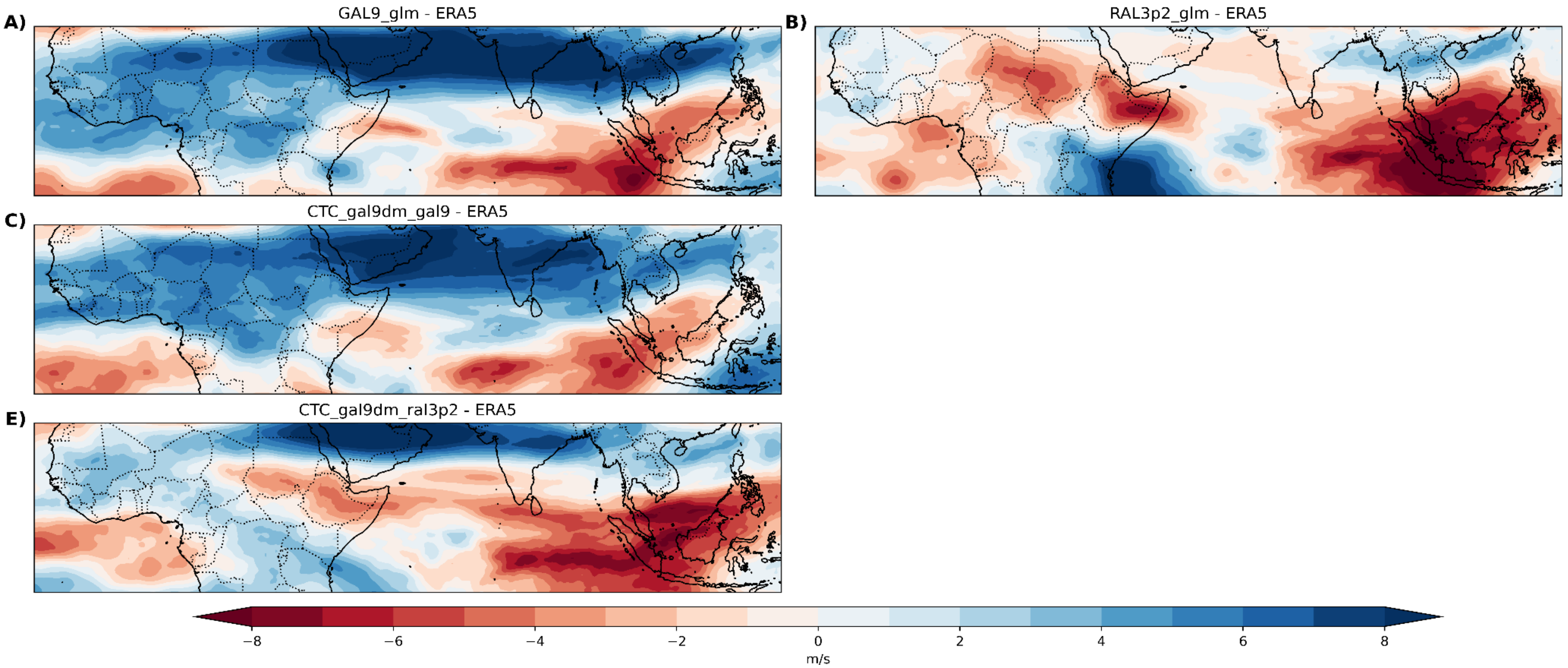

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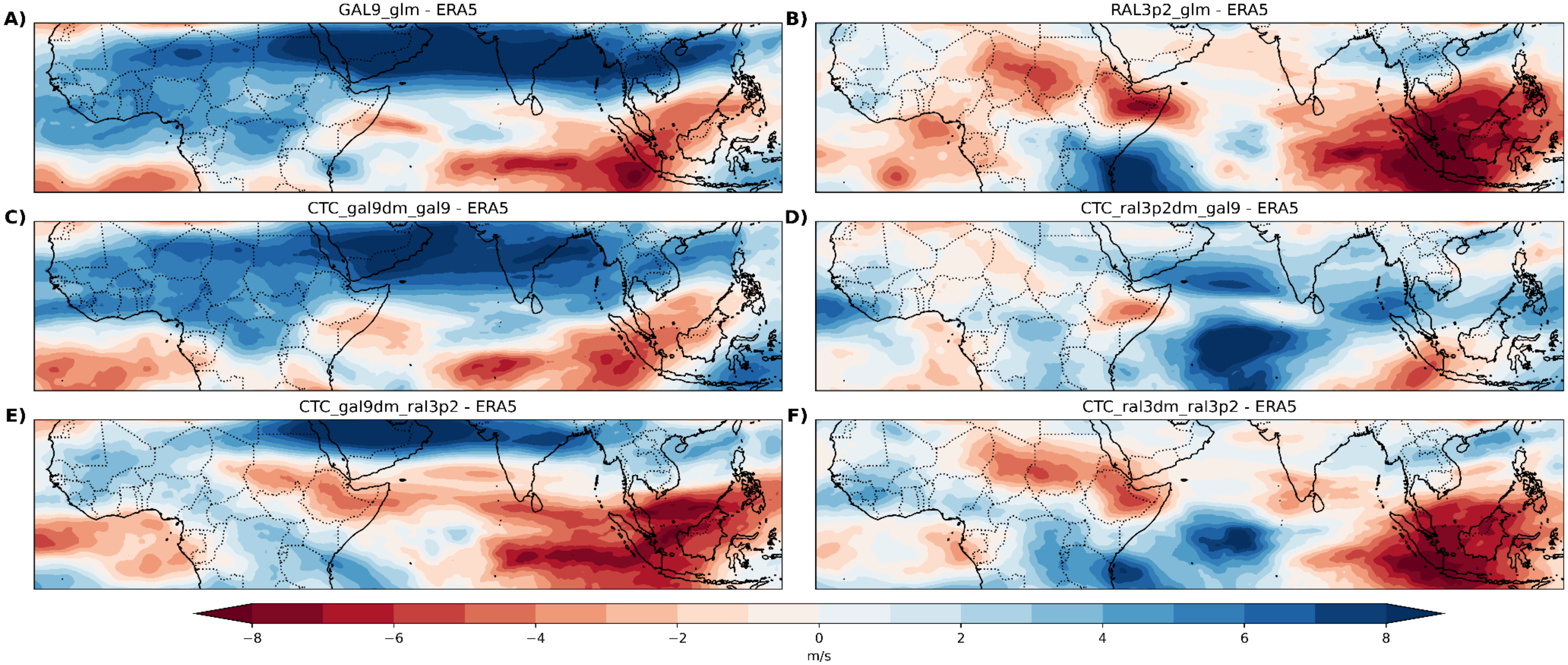
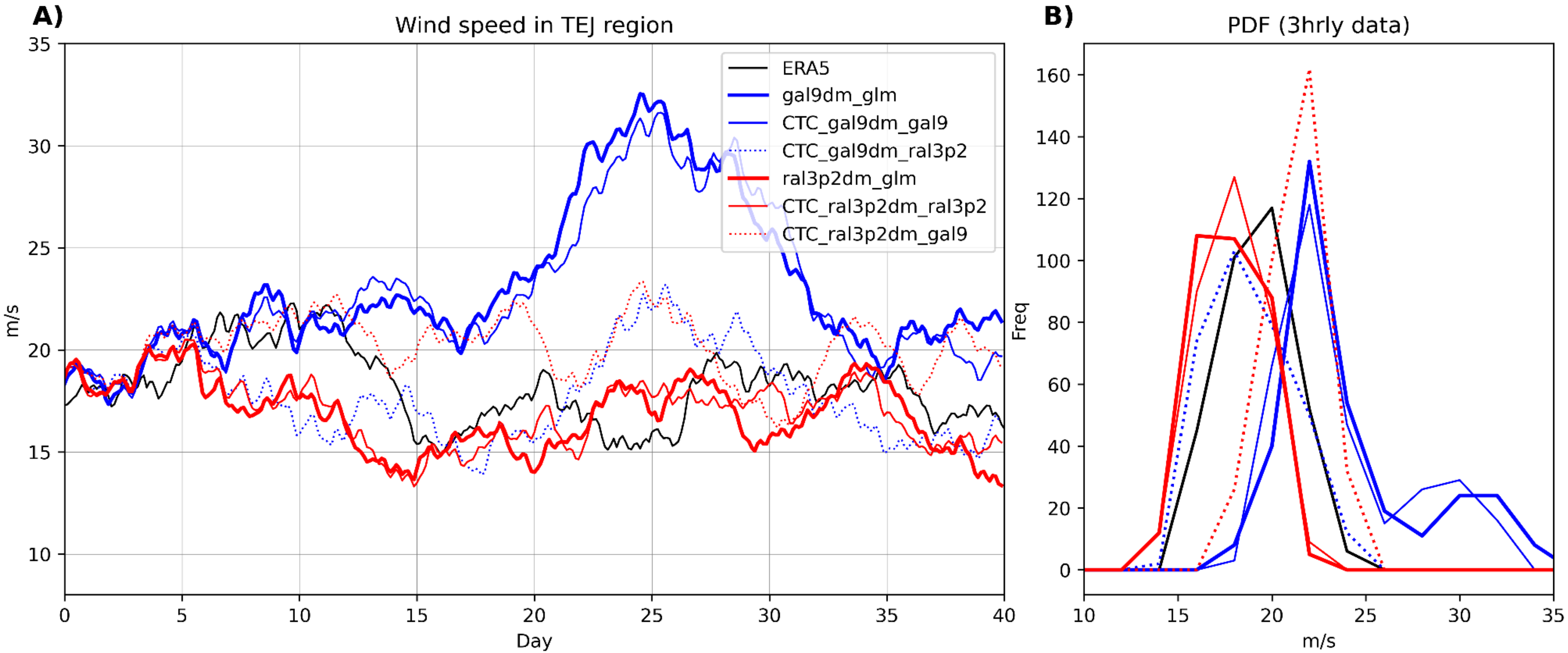


Winds averaged 10-110E, 10-18N.



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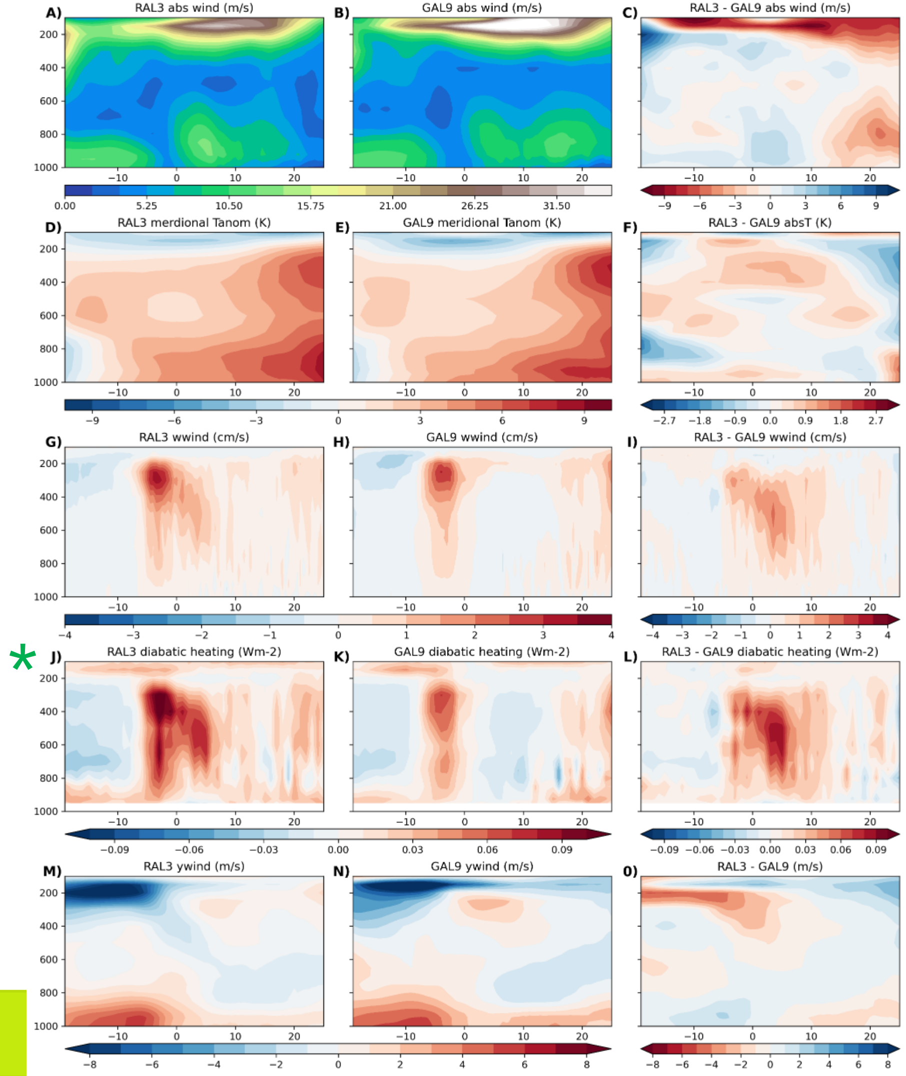
70-90E transect (India)

1. RAL 3 has a weaker zonal jet that extends across equator and mid-latitude.
2. This is related to warmer equator, thus weaker jet via thermal wind balance.
3. Increased convection around equator, 5N in RAL3 (causing the increased latent heat release).
4. This corresponds closely to atmospheric diabatic heating.
5. RAL3: continuous +y wind in upper levels (Hadley circulation), stronger in RAL3.
6. No continuous n'thly flow in GAL9, convergence at 12N. Given no change in w, must be increase in zonal wind (hence stronger jet).

*

$$Q = C_p\left[\underbrace{\frac{\partial T}{\partial t}}_{\text{Local heating}} + \underbrace{\vec{V}\cdot\nabla T}_{\text{Horizontal Advection}} + \underbrace{\left(\frac{p}{p_s}\right)^{\frac{R}{C_P}}\omega\frac{\partial\theta}{\partial p}}_{\text{Vertical motion}}\right]$$



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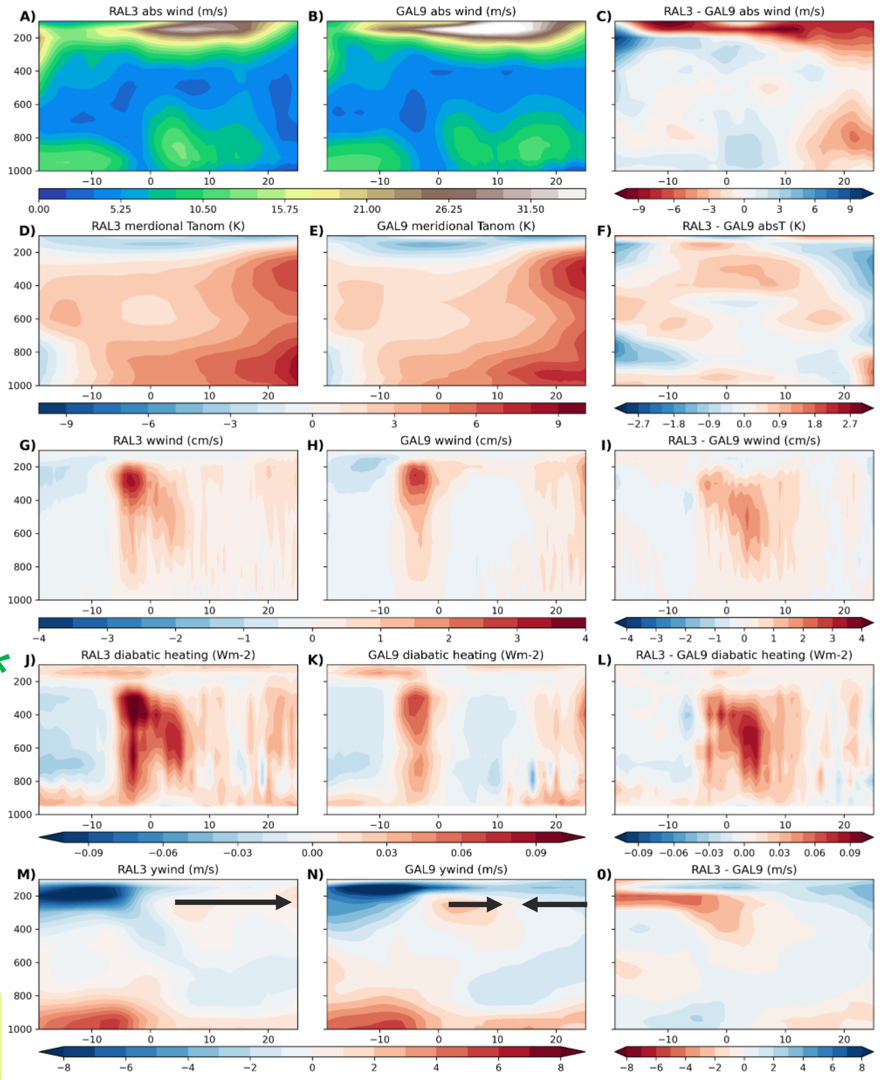
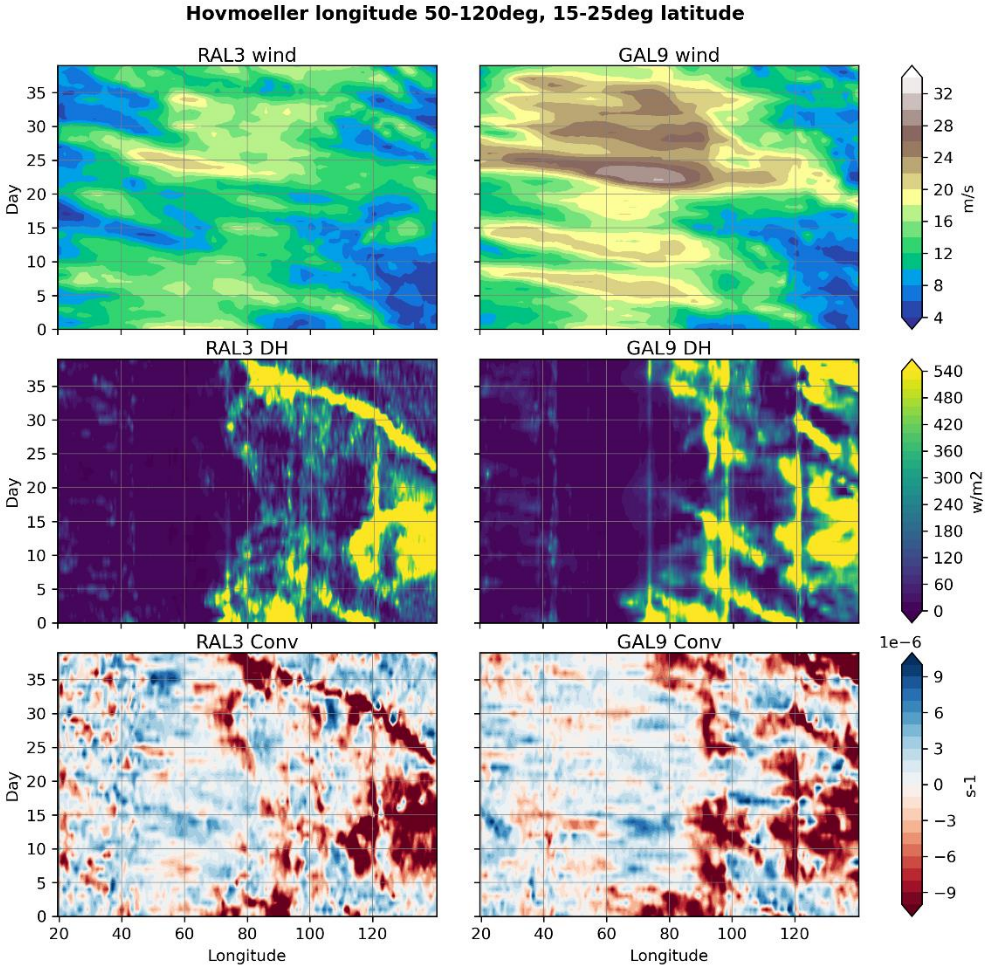


Propagating convection

1. Convection within the jet tends to slow the jet (similar to dry vs moist tropical wave propagation speed).

2. Complicated given jet can also shift latitudinally in response to heating.

3. Close relationship between diabatic heating and upper level (200hPa) divergence. Suggests both models can generate propagating convection; up to 60degrees in case of RAL3.



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Conclusions

- The representation of convection (explicit vs parameterised) has the largest impact on the tropical easterly jet, with the latter producing a stronger jet.
- Model differences in convection appear to project onto Hadley overturning, which may explain differences in jet strength.
- Differing representation of downstream processes related to the jet may be related to model biases in the Indian and West African monsoon, as well as impacting on wind shear over the Sahel.

Challenges/Opportunities

- Internal variability during 40 day period – longer simulations (DYAMOND3).
- Determining causality using dynamical principles, but other factors potentially involved.
- Opportunities for process evaluation in large-domain modelling.

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