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Modifying CoMorph-A for kilometre-scale resolutions

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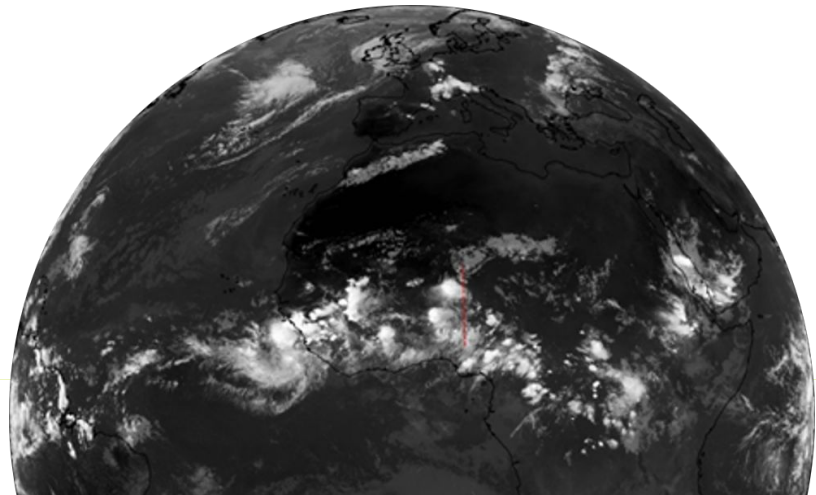
CoMorph-A: Recap

- First configuration containing the new mass-flux convection scheme (CoMorph) being developed at the Met Office
- Developed for use at NWP (10 km) – climate (150 km) res
- Released mid 2021
- Significant improvement over GA8GL9 in global, regional and idealised testing (Lock et al., Lavender et al., Zhu et al.)
- Competitive performance against GAL9 (CoMA9)
- Code on trunk

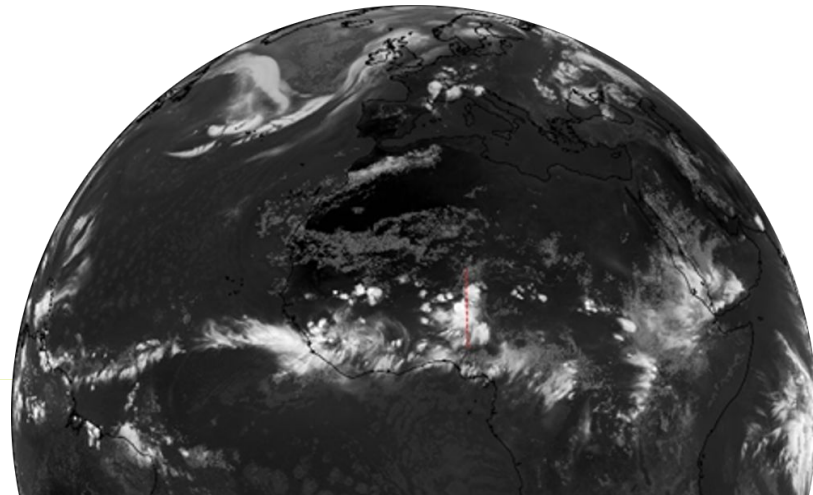
Global NWP Trailblazer

- N2560-ORCA12 (~5 km atmosphere/10 km ocean)
- Exploring convective greyzone
- Opportunity for early adoption of new physics
- Preparing for future km-scale global ensemble

MSG satellite



5km UM simulation



CoMorph-A trailblazer configuration

Referred to as **CoMA9_TBv1p2**. Small number of changes from CoMA9 based on tests at 5km resolution.

CoMA9 +

- Reduced initial moisture perturbations
- Reduced scaling of the initiating mass-flux at each height
- Increase the precipitation rate leading to the maximum updraught size
- RAL3 moisture conservation settings (not included in global config.)
- Higher rain evaporation at high rain rates

Documented in GMED ticket [#680](#)

Increase the precipitation rate leading to the maximum updraught size

$$\varepsilon = \frac{0.2}{R}$$

‘Parcel radius precip ramp’, α , is a simple representation of convective organisation when it rained in the previous timestep.

$$R_{init} = \alpha L \quad \text{where,}$$

$$L = \frac{K_m}{\sigma_w}, \quad (\text{where } K_m \text{ is turbulent viscosity and } \sigma_w \text{ is the vertical velocity standard deviation.)}$$

$$\alpha = \alpha_0 + \frac{\min(pr, pr_{max})}{pr_{max}} (\alpha_{max} - \alpha_0),$$

$$pr_{max} = 0.00035 \text{ kg m}^{-2} \text{ s}^{-1}, \quad \alpha_0 = 0.45 \text{ and } \alpha_{max} = 2$$

Parcel radius dependence on grid-mean precip rate yields too-rapid intensification and sensitivity to model-resolution.

Can we make pmax dependent on grid-spacing dx?

How should entrainment should depend on precipitation as function of grid-spacing?

Used instantaneous rain rates from 100m TWP-ICE simulations (every 20h).
 Divided domain into 50 km grid-boxes (typical of NWP simulation).

For each box:

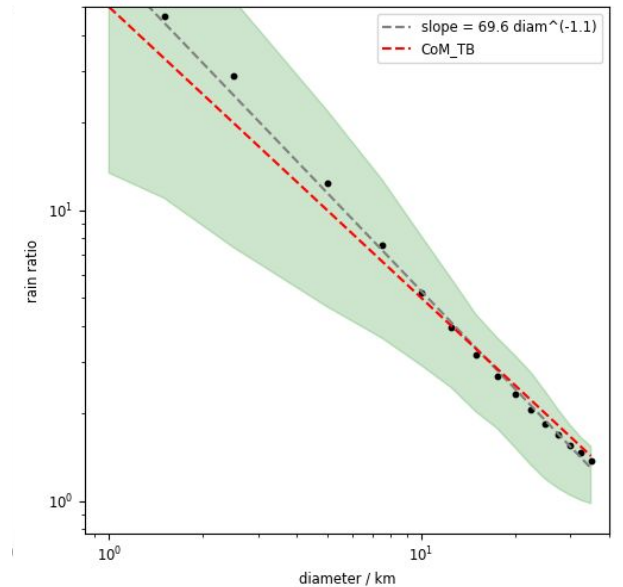
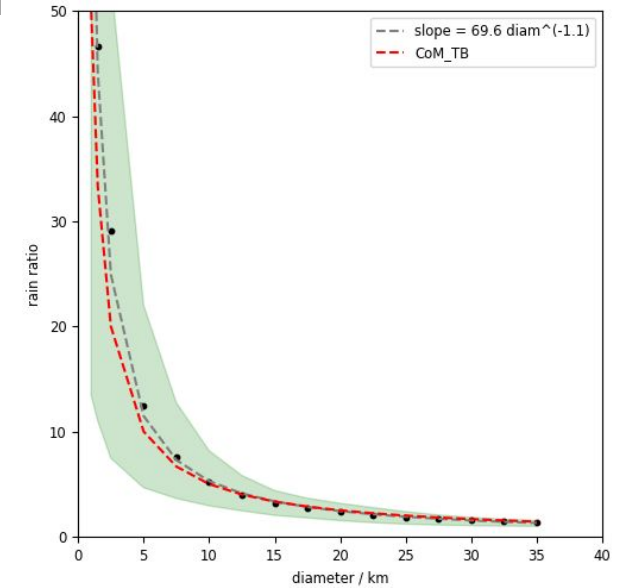
- Located the position of maximum rainfall
- From this point, calculated area-averaged rainfall in concentric circles of increasing diameter.
- Plots show the ratio of this to the mean rainfall averaged over 50 km diameter circle
 - Black dots - averages over all times and boxes.
 - Green envelope - range of values

Linear relationship in log-log plot (lower panel) suggests power law

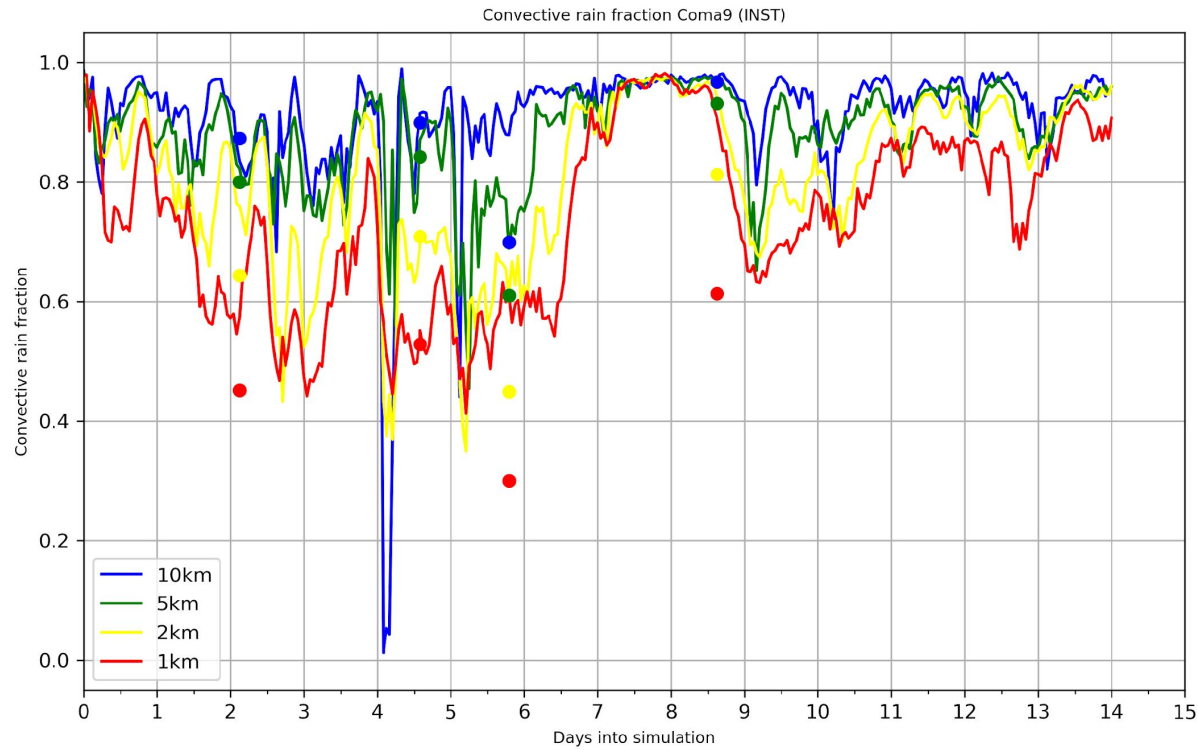
- Dashed line = best fit straight line – gives power close to -1
- Suggests inverse relationship of pmax to dx

$$p_{max}(dx) = \frac{p_{max_{ref}} * dx_{ref}}{MAX(dx, dy)},$$

where dx_{ref} is a typical NWP grid-spacing (50km) for which $p_{max} = p_{max_{ref}}$

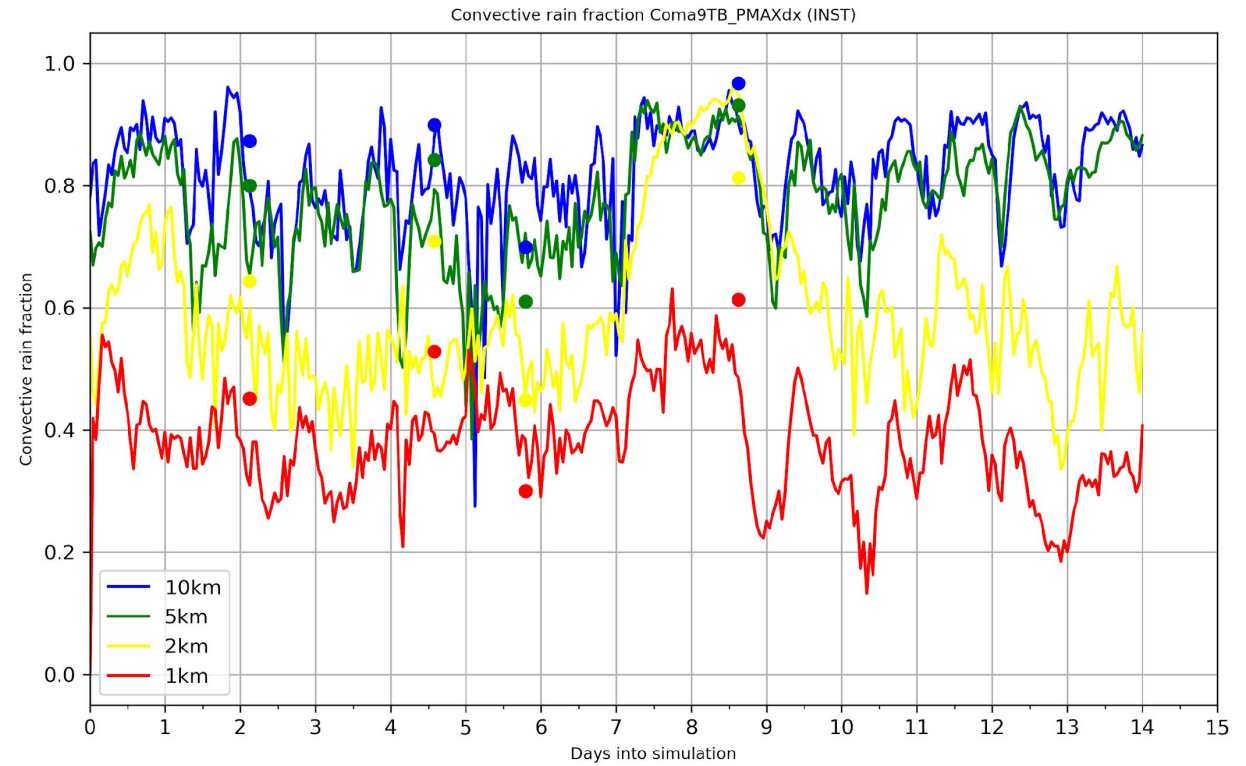


CoMA9

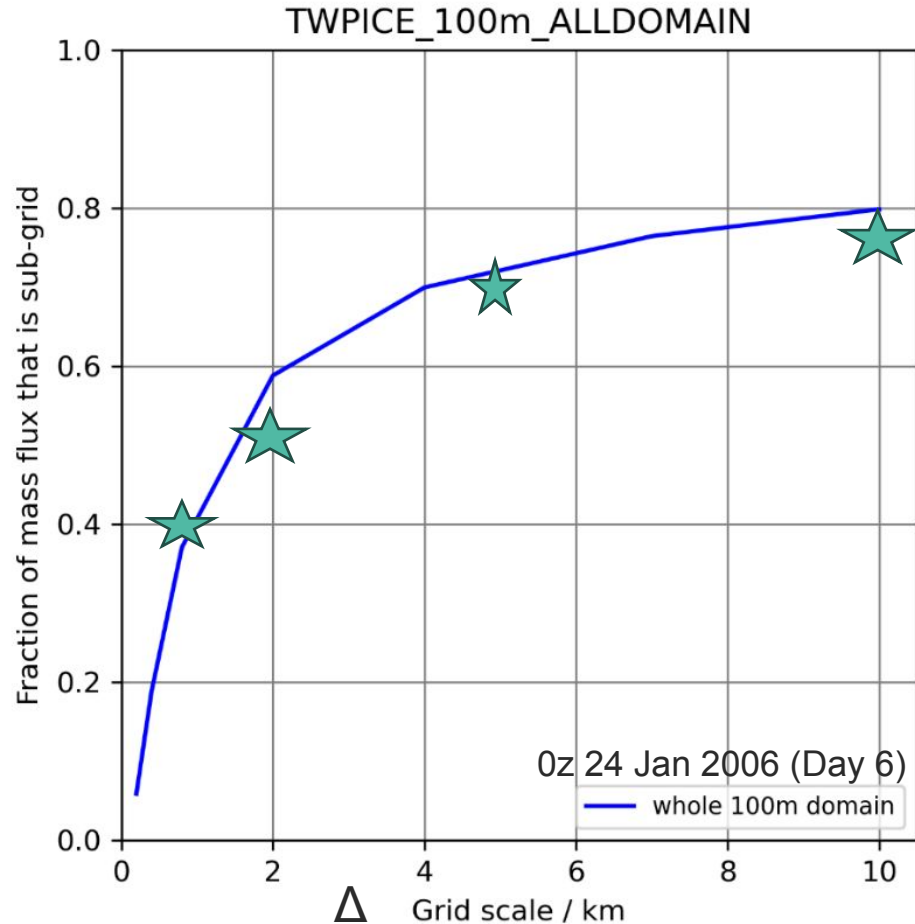


Idealised TWP-ICE simulations

CoMA9_TBv1.2 with dx-dependent PMAx



CoMA9_TBv1.2 vs 100m simulation



— Fraction of mass flux that is sub-grid (from 100m simulations)

★ Fraction of rainfall produced by convection in low-res CoMA9_TBv1 simulations

A few things to consider:

- Drizzle from anvils will always be large-scale, even though it is produced by convection - will skew results.
- Things other than cloud base mass flux likely modify convective rain amount. Might be better to look at proportion of mass flux produced by CoMorph instead.
- Need to consider how to account for effects of clustering (many small updrafts within a “grid-box” will increase mean w , even though updrafts are actually sub-grid).

Investigating other methods for comparison

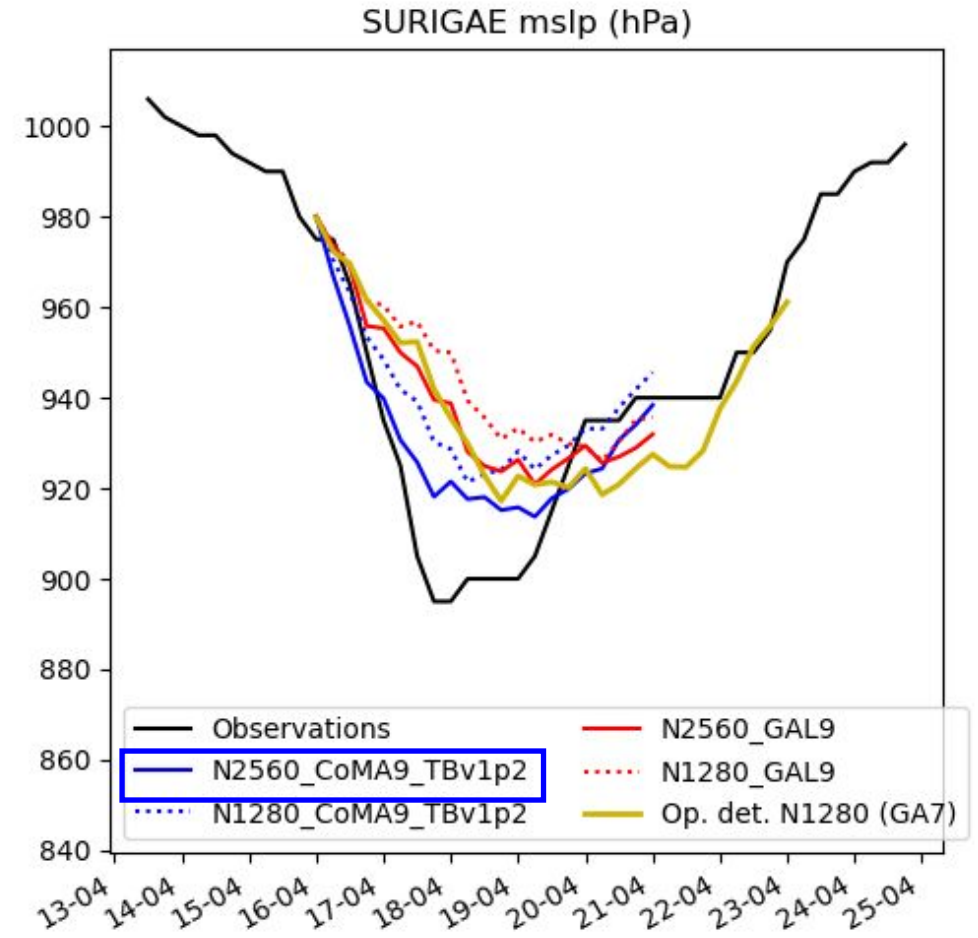
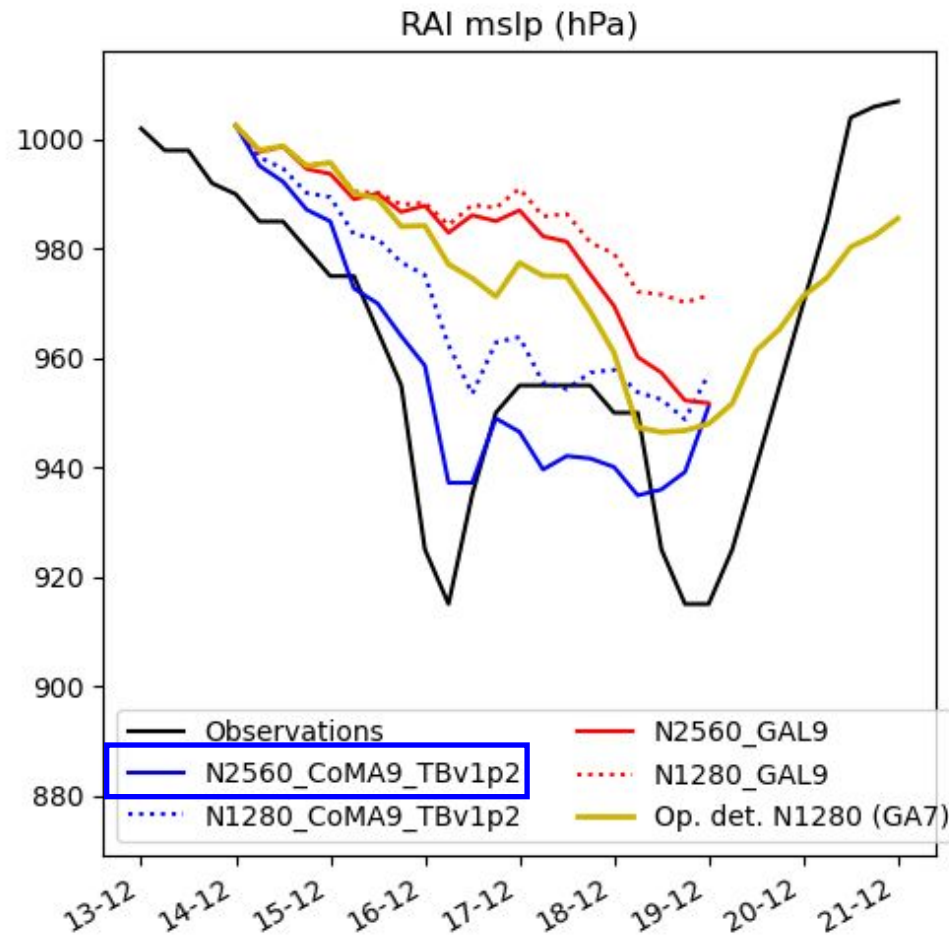


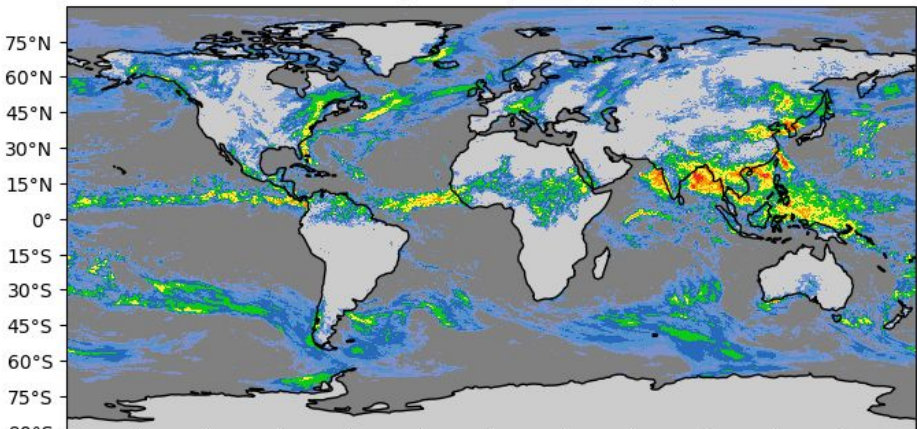
Global N2560 Results

5 days, atmosphere-only, CoMA9_TBv1p2
configuration

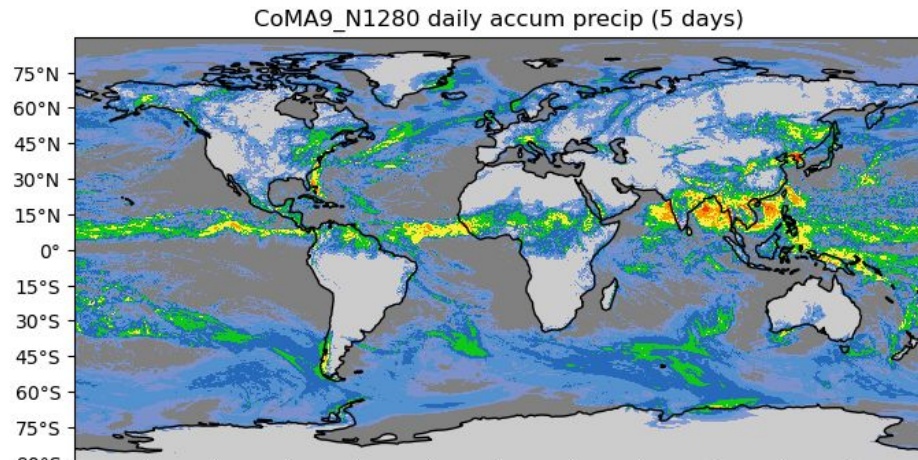
Various start-dates covering 2020/21

- NWP case-study dates
- TC cases

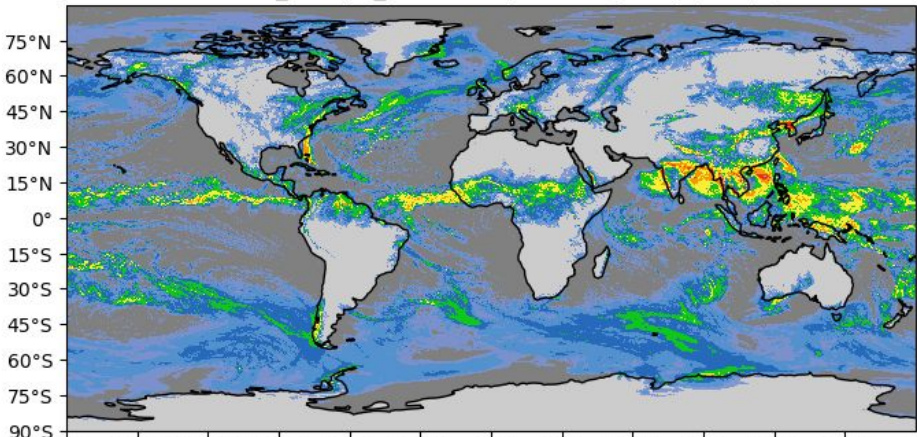




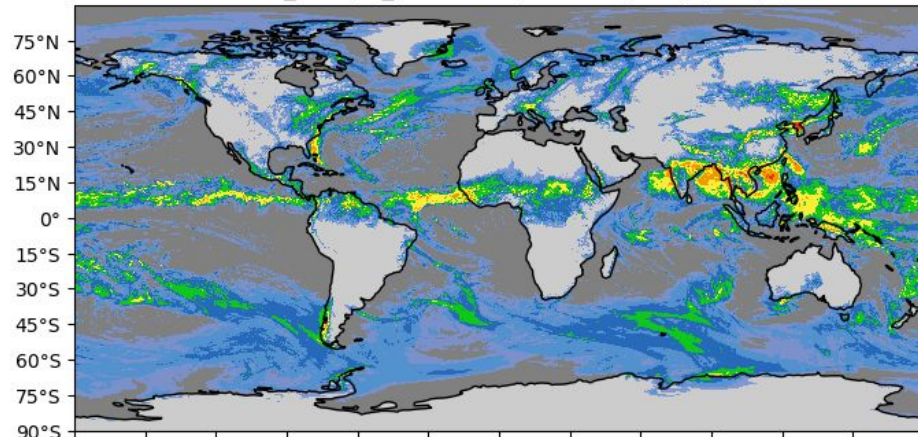
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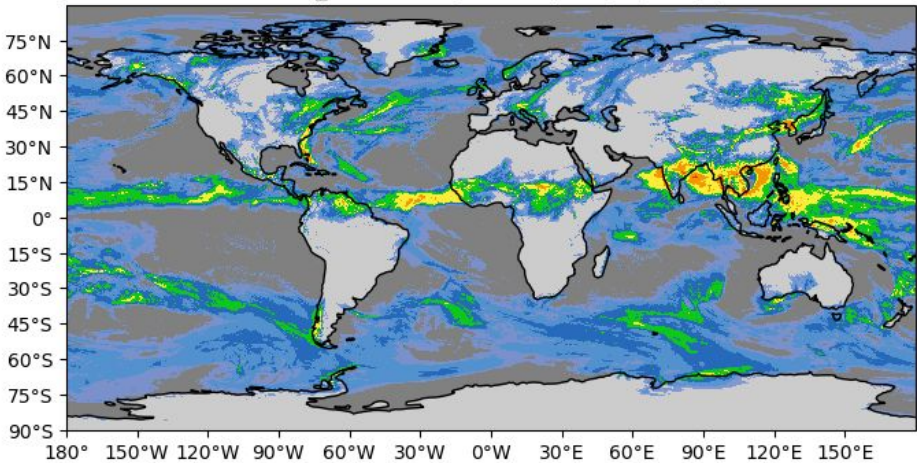
CoMA9_TBv1p2_N2560 daily accum precip (5 days)



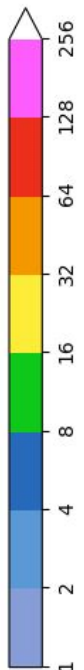
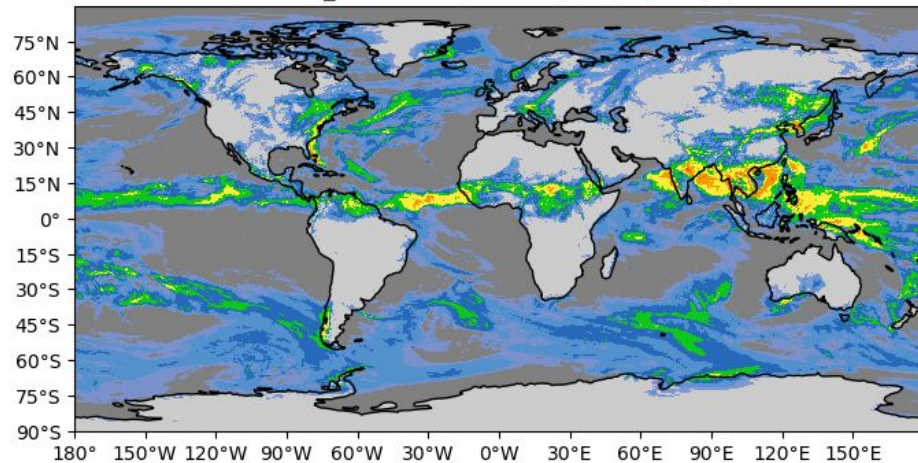
CoMA9_TBv1p2_N1280 daily accum precip (5 days)



GAL9_N2560 daily accum precip (5 days)

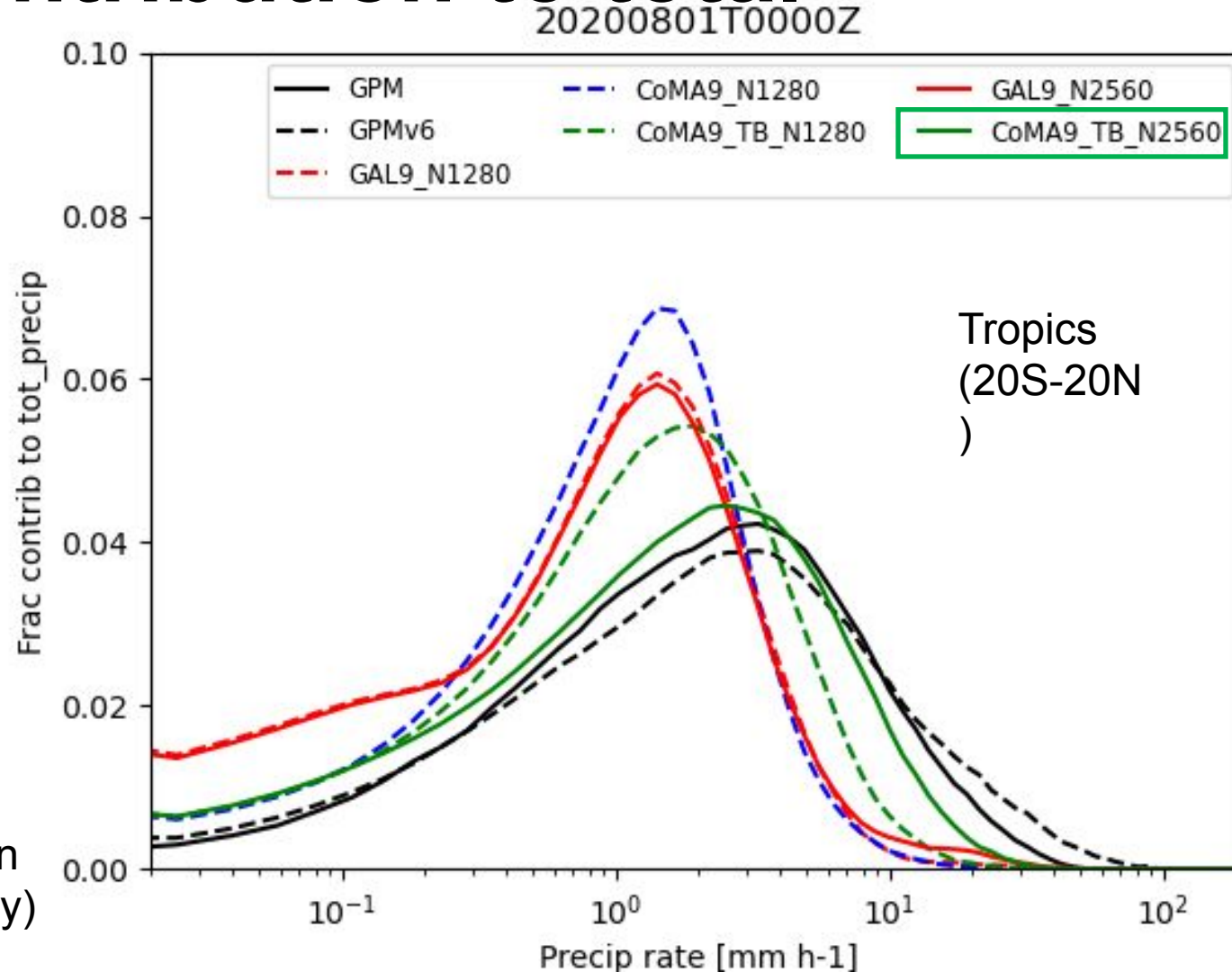


GAL9_N1280 daily accum precip (5 days)



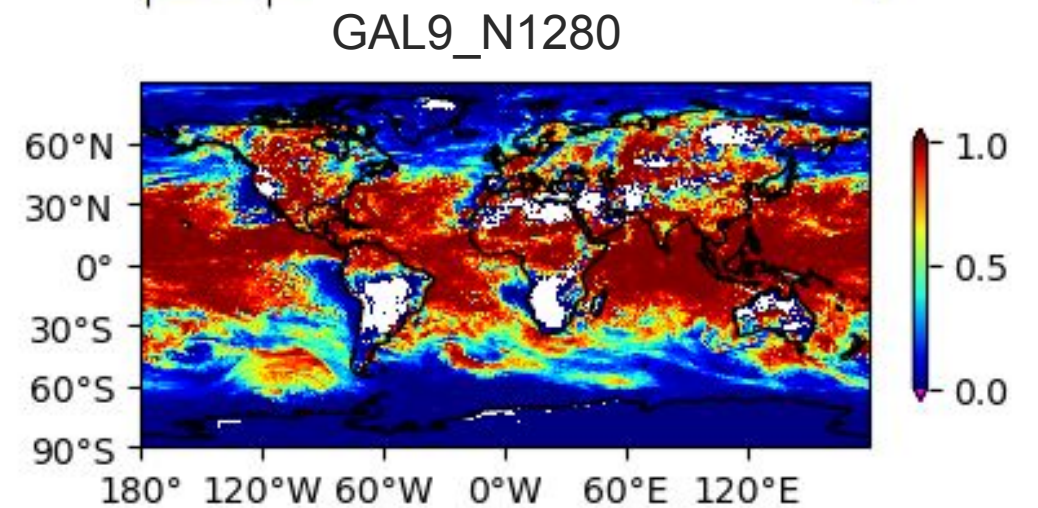
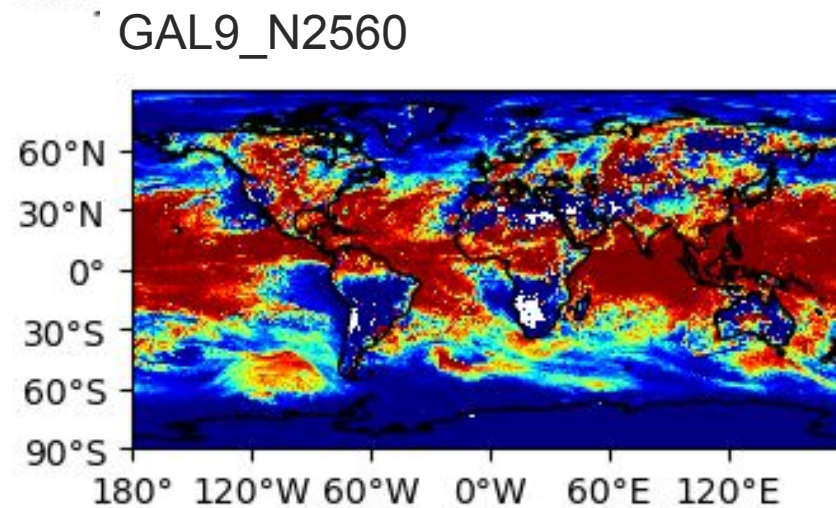
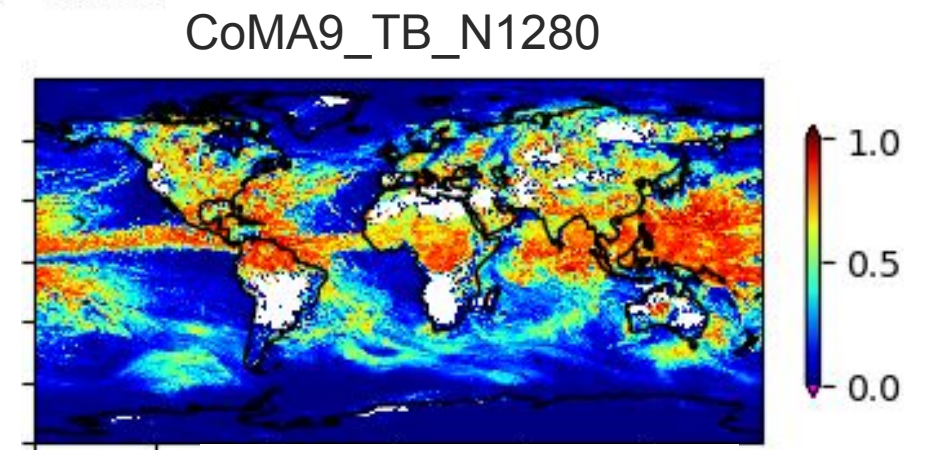
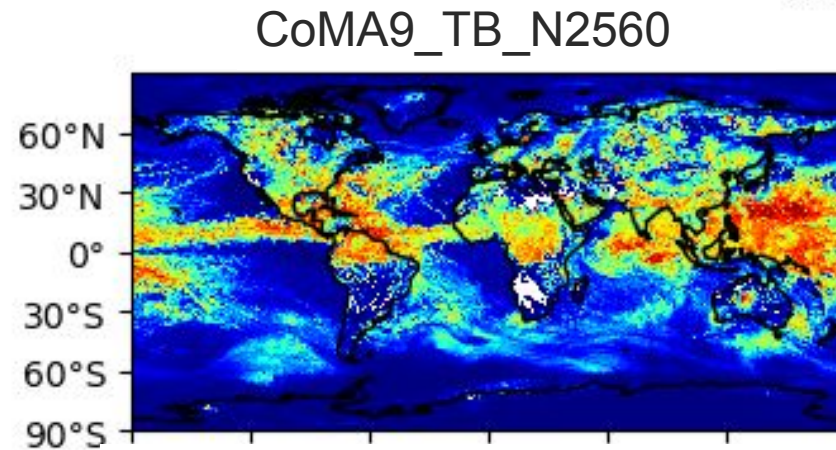
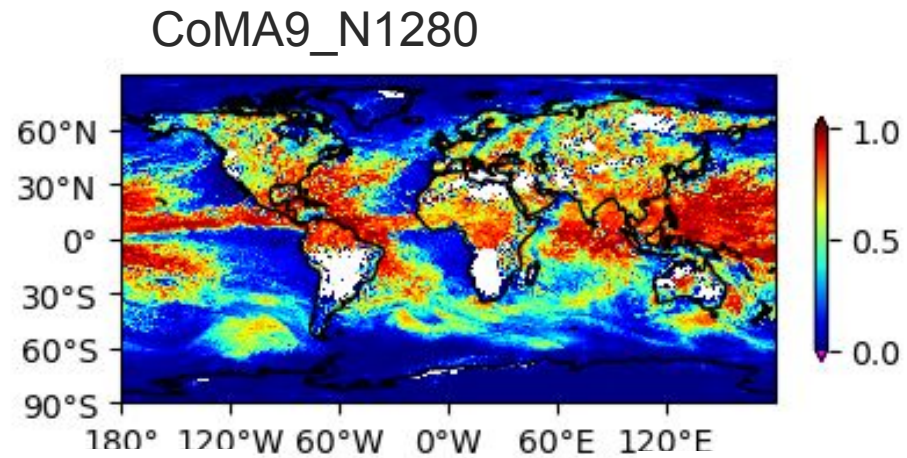
(regridded to GPM grid)

Histogram of precipitation rates over the tropics: Contribution to total



Calculated from 3-hourly accumulations (GPM 30-min means converted to 3-hourly)

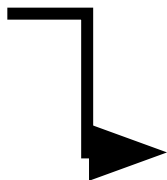
Convective fraction N2560 vs N1280



Summary

- Modified version of CoMorph-A for use at ~5 km
- First attempt at including additional scale-aware tuning
- Initial tests using this configuration in atm-only global N2560 and regional nested suites
- Competitive performance:
 - Precipitation distribution
 - Tropical temperatures
 - Global winds
- Improved tropical cyclone deepening

Current & Future plans

- CoMA9_TBv1p2 in K-Scale hierarchy (Richard Jones's talk)
- CoMA9_TBv1p2 in Global N2560 NWP Trailblazer
- Work within ParaChute to make further improvements to km-scale convection representation – See Sam Smith's poster.
 Unified Physics (Keith's talk)



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Questions?

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