Improving the representation of convective precipitation in ECMWF’s Integrated Forecasting System for the nextGEMS project

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The Challenge

- mean precipitation over NH Pacific ITCZ (5-10°N) strongly overestimated in storm-resolving nextGEMS Cycle 2 simulations with the IFS when deep convection parametrization is switched off (Deep Off)
- precipitation intensity strongly overestimated with Deep Off and strongly underestimated with Deep On
- no resolution dependence in Deep Off simulations at 9 and 4.5 km, with only minor improvements at 2.9 km
- we perform sensitivity study at 9 km to understand underlying problems and find best setup for higher resolutions

Sensitivity Experiments

Shallow Off - switching both deep and shallow convection schemes off:
- slightly less ITCZ precipitation but therefore strong degradation w.r.t. temperature and specific humidity at the top of the boundary layer
- 100x diffusion – increasing spectral diffusion (of u, v, w, T) by factor of 100:
  - less extreme precipitation and slightly larger convective cells
  - but no improvements w.r.t. zonal mean precipitation
- RH_{crit}=0.6 – increasing RH threshold at which hydrometeors can evaporate:
  - slightly less extreme precipitation but no improvements w.r.t. zonal mean precipitation
- 1/6 M – decreasing cloud base mass flux by 1/6 (as would be used at 700 m resolution):
  - precipitation intensity matches GPM IMERG, except for weak precipitation (<1 mm h^-1), which is too frequent
  - mean precipitation close to GPM IMERG over NH Pacific ITCZ
- shallow

Conclusions

- Global storm-resolving simulations (at 2.9 – 9 km) with Deep Off face the problem that processes critical for deep convection are underresolved, e.g., horizontal mixing of convective updrafts with their environment and vertical mixing prior to the triggering of convection.
- As a consequence, mean precipitation and precipitation intensity are overestimated over the Pacific ITCZ.
- With the proposed revisions to the moist physics for storm-resolving scales, the characteristics of precipitation (zonal mean, intensity and spatial pattern) are more realistic, as well as low and high clouds. These improvements are also apparent at higher resolutions.
- Skill scores can compete with the operational IFS version (unlike with Deep Off which shows big degradations).
- A remaining problem is that both with Deep Off and the revised physics, deep convective structures are too small and larger mesoscale convective systems like squall lines often cannot be represented realistically.