School of Mathematical, Physical and Computation Sciences
Department of Meteorology

University of Reading

# A convection parametrisation scheme for the grey-zone

C. C. Chui | P. A. Clark | R. S. Plant


## Abstract

**Conventional convection parametrisation (CP) schemes assume that deep convection is entirely a sub-grid process. However, at resolutions between 1 – 10 km, explicit and sub-grid convection is co-realistic. A new CP scheme for this "grey-zone" has been designed and tested. Results suggest that the scheme may improve simulations of shallow-to-deep transition in the diurnal cycle of convection at such resolutions.**


## Background

While routine ultra high resolution ($\Delta x \sim 100$ m) simulations remain unfeasibly expensive, operational forecast models are often limited to $\Delta x \sim 1$ km. However, with $\Delta x \sim L_{conv}$, sub-grid parametrisation is no longer the sole realistic representation (Figure 1). Neither employing conventional CP schemes, which have invalid assumptions on the properties of convection, nor switching off CP completely yields ideal results of convection modelling, especially the convective diurnal cycle (Figure 2).

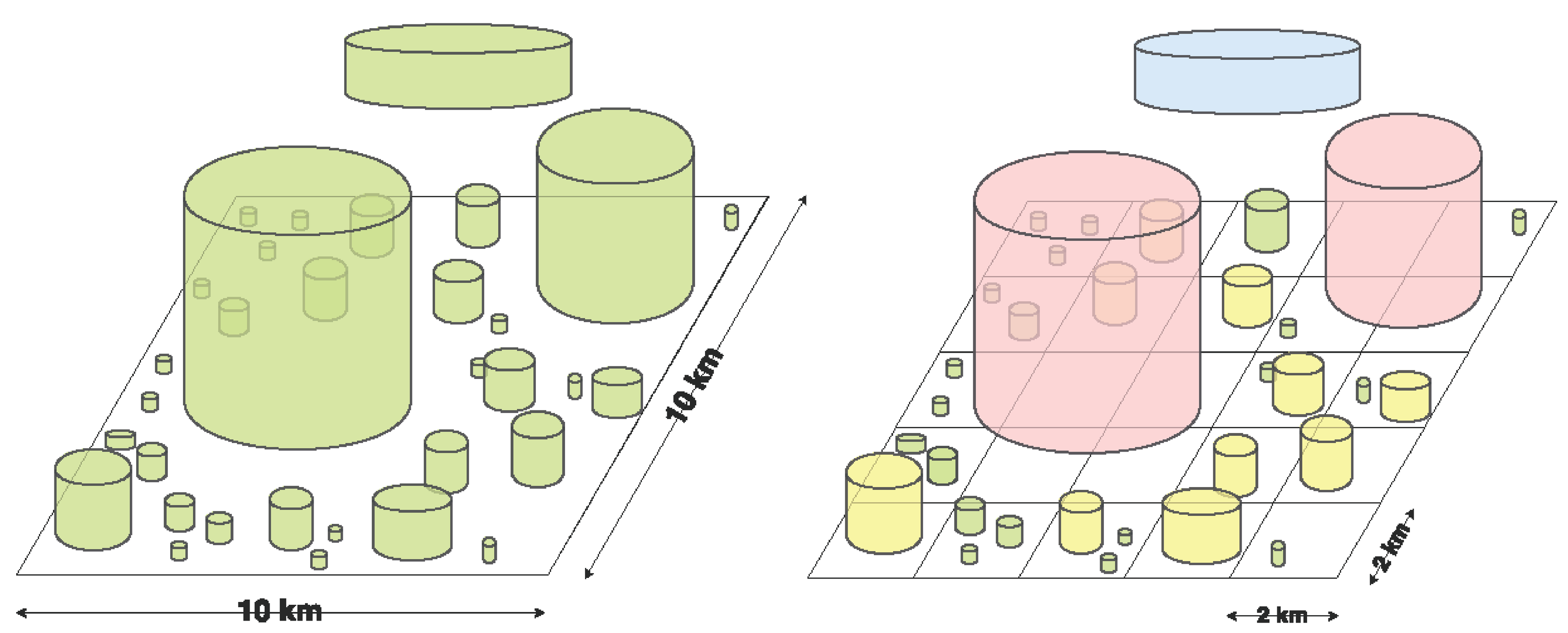



**Figure 1**. Schematics of the conventional idea of a cloud ensemble in a large grid box (top-left) versus various regimes of convection with increased resolution (top-right). Different convective regimes may occur in different grid cells with increased resolution, thus traditional assumptions are no longer uniformly realistic for all grid cells (see table).

| Assumption | $\Delta x > 10$ km | $\Delta x \sim 1$ km |
|---|---|---|
| A lot of convection in one grid box | Yes | No |
| Small fractional area of convective updraft ($\sigma_u$) | Okay | Conditional |
| Realistic explicit convection | No | Conditional |
| Quasi-equilibrium sub-grid convection | Yes | Conditional |
| Explicit vertical motion from sub-grid convection | No | Conditional |
| Neighbouring grid cells NOT affected | Yes | Conditional |

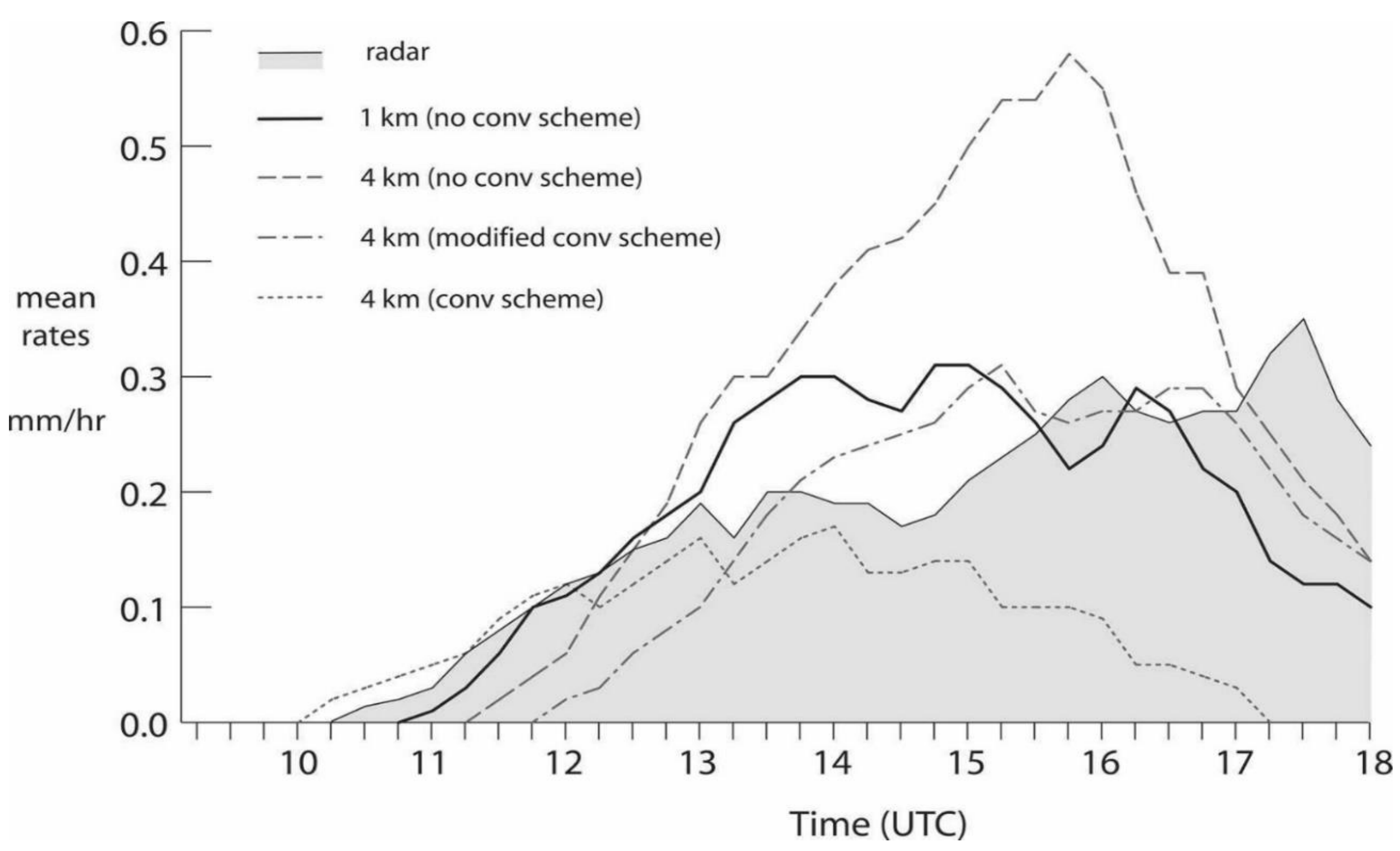
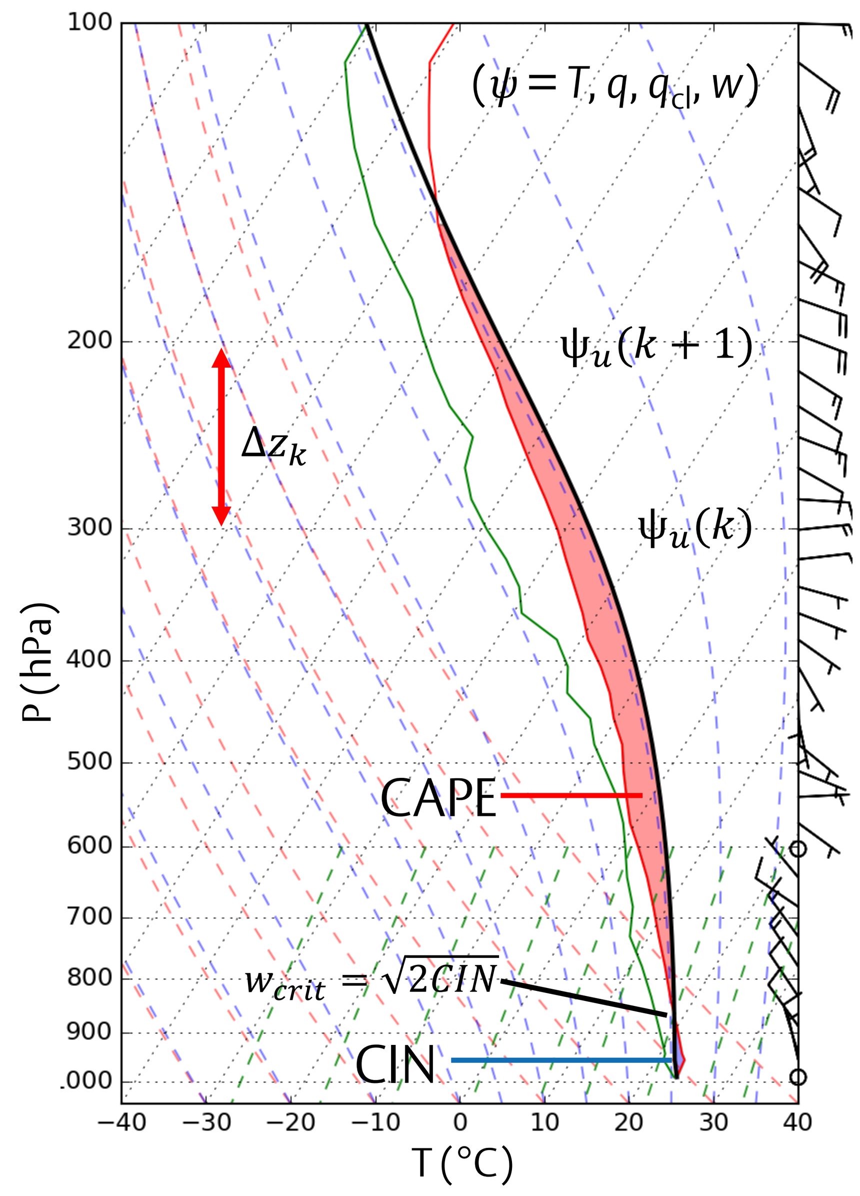



**Figure 2**. A comparison of the evolution of domain-average rain rates over the UK in MetUM simulations at different resolutions with different convective schemes against radar observations (Lean et al., 2008). The conventional convective scheme leads to an early decay of convective activities due to the quasi-equilibrium assumption (in phase with solar diurnal cycle). Without convective schemes, the onset is later than expected with a shorter delay for the higher-resolution run.

## A new scheme with prognostic plume




**1. Quantify $\sigma_u$.**

- $\sigma_u = P(w \geq w_{crit})$
- Gaussian $w$ distribution
  - Mean $= \overline{w}$
  - $w_{std} \propto w^*$ (Convective velocity scale)
- From shallow convection schemes

**2. Calculate plume ascent in one $\Delta t$**

- $w_u(z)$ calculated from CAPE
- $t_u = 2\left(\frac{\Delta z_k}{w_u(k+1)+w_u(k)}\right)$
- Continue parcel ascent to next model level until $t_u \geq \Delta t$.
- $\overline{\psi}_{new} = \overline{\psi}_{old}(1-\sigma_u) + \psi_u \sigma_u$
- $\psi_u$ saved for continuation of ascent at next time-step

**Figure 3**. The initial vertical profile of the LBA test case, annotating the parameters and variables used by the new CP scheme.

## Preliminary results

The new scheme was tested for the Large-scale Biosphere and Atmosphere (LBA) case (Grabowski et al., 2006) with the latest Met-Office / NERC Cloud (MONC) model at $\Delta x = 1.5$ km. Results (Figure 4) suggest that the scheme promotes an earlier onset of convection yet retaining a smooth shallow-to-deep transition.

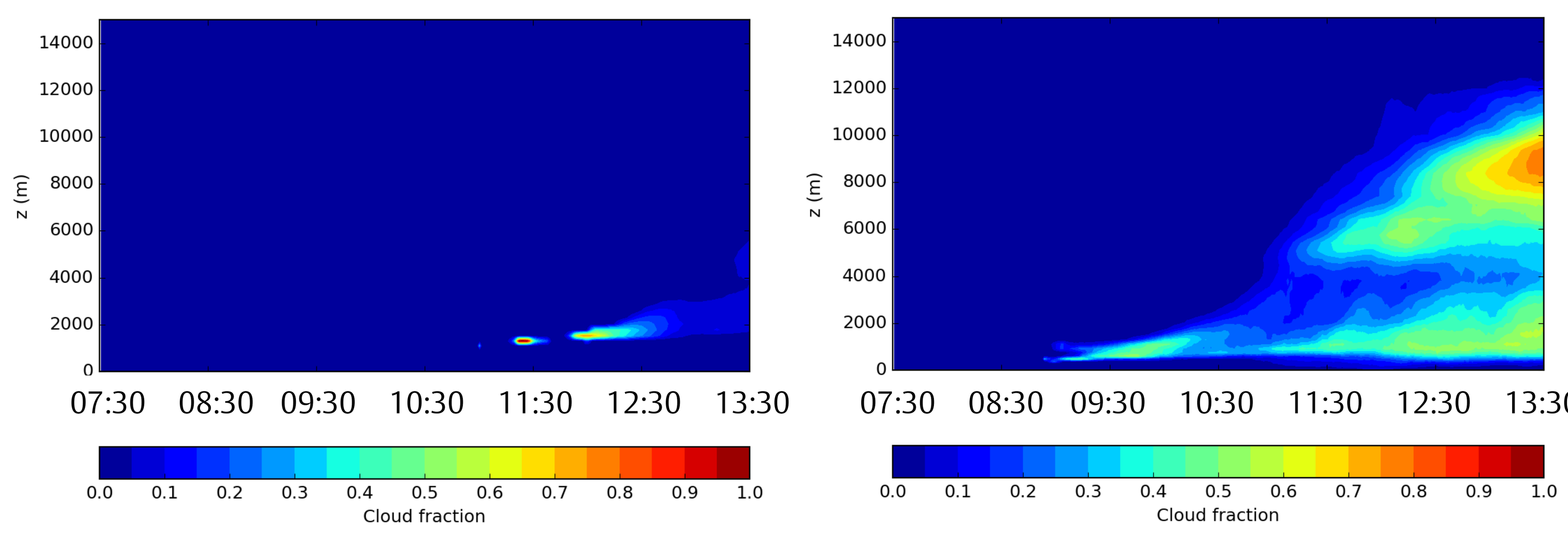



**Figure 4**. A comparison of the evolution of domain-average cloud fraction between simulations of the LBA case without (left) and with (right) the new CP scheme using MONC. For both cases, the domain sizes are 64 x 64 in the horizontal with $\Delta x = 1.5$ km, up to 30 km in the vertical represented by 101 levels. Simple all-or-nothing condensation/evaporation cloud scheme (no ice). A bug in the model has led to less-than-prescribed surface heat fluxes being input into the system. This prevents a fair comparison against the LBA benchmark simulations at present. All times are local time.

## Future Work

- Evaluate the scheme at other grey-zone resolutions.
- Add entrainment and detrainment into the plume ascent.
- Parametrise the sub-grid environment in explicit convection.
- Add microphysics into the sub-grid plume dynamics.

### References


1. Grabowski W. W., and Co-authors, 2006: Daytime convective development over land: A model intercomparison based on LBA observations. *Quart. J. Roy. Meteor. Soc.*, **132 (615)**, 317-344.
2. Lean, H. W., P. A. Clark, M. Dixon, N. M. Roberts, A. Fitch, R. Forbes, and C. Halliwell, 2008: Characteristics of high-resolution versions of the Met Office Unified Model for forecasting convection over the United Kingdom. *Mon. Wea. Rev.*, **136 (9)**, 3408-3424.



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### Contact information

- Department of Meteorology, Earley Gate, University of Reading, Whiteknights, RG6 6BB
- Email: c.c.chui@pgr.reading.ac.uk