3D experiments with a stochastic convective parameterisation scheme

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Outline

- Motivation
- Introduction to the Plant-Craig stochastic convection parameterisation scheme.
- Experiments in an idealised UM setup.
Case study: CSIP IOP18

- Starts at 25th August 2005, 07:00.
- 12 km grid with $146 \times 182$ grid points.
- Diffusion as in idealised experiments.
Ensemble of 6 runs using PC scheme
Plant-Craig scheme: methodology

- Obtain the large-scale state by averaging resolved flow variables over both space and time.
- Obtain $\langle M \rangle$ from CAPE closure and define the equilibrium distribution of $m$ (Cohen-Craig theory).
- Draw randomly from this distribution to obtain cumulus properties in each grid box.
- Compute tendencies of grid-scale variables from the cumulus properties.
PC scheme: probability distribution

Assuming a statistical equilibrium leads to an exponential distribution of mass fluxes per cloud:

\[ p(m)\,dm = \frac{1}{\langle m \rangle} \exp\left(\frac{-m}{\langle m \rangle}\right)\,dm. \]

So if \( m \sim r^2 \) then the probability of initiating a plume of radius \( r \) in a timestep \( dt \) is

\[ \frac{\langle M \rangle 2r}{\langle m \rangle \langle r^2 \rangle} \exp\left(\frac{-r^2}{\langle r^2 \rangle}\right)\,dr \frac{dt}{T}. \]
PDF of total mass flux

Assuming that clouds are non-interacting, this can be combined with a Poisson distribution for cloud number,

\[ p(N) = \frac{\langle N \rangle^N e^{-\langle N \rangle}}{N!}, \]

leading to the following distribution for total mass flux:

\[ p(M) = \left( \frac{\langle N \rangle}{\langle m \rangle} \right)^{1/2} e^{-\langle N \rangle + M/\langle m \rangle} M^{-1/2} I_1 \left( 2 \sqrt{\frac{\langle N \rangle}{\langle m \rangle} M} \right). \]
PDFs of mass flux in an SCM

- Plant & Craig, JAS, 2008
3D Idealised UM setup

- Radiation is represented by a uniform cooling.
- Convection, large scale precipitation and the boundary layer are parameterised.
- The domain is square, with bicyclic boundary conditions.
- The surface is flat and entirely ocean, with a constant surface temperature imposed.
- Horizontal diffusion, vertical diffusion of $\theta$ and targeted diffusion of moisture are applied.
PDFs of mass fluxes
PDF of number of clouds
Organisation in rainfall pattern?
Organisation in rainfall pattern? GR
Time variation of $\langle M \rangle$
PDF of $N$ in statistical experiment
PDF of $N$ with constant $\langle M \rangle$
PDF of $N$ on one gridpoint
Conclusions

• The scheme yields the correct distribution of individual cloud mass flux.

• The distribution of total mass flux $M$ is not as according to non-interacting theory, suggesting that there is some organisation of cloud structure in the scheme; however, this is less the case than in the GR scheme.

• The averaging procedure does not completely remove the time variation of $\langle M \rangle$. This time variation is the cause of the incorrect distribution of $M$.

• The scheme has potential for use in NWP ensemble forecasts; some effort needs to be made to increase the fraction of rain that is convective.