3D experiments with a stochastic convective parameterisation scheme

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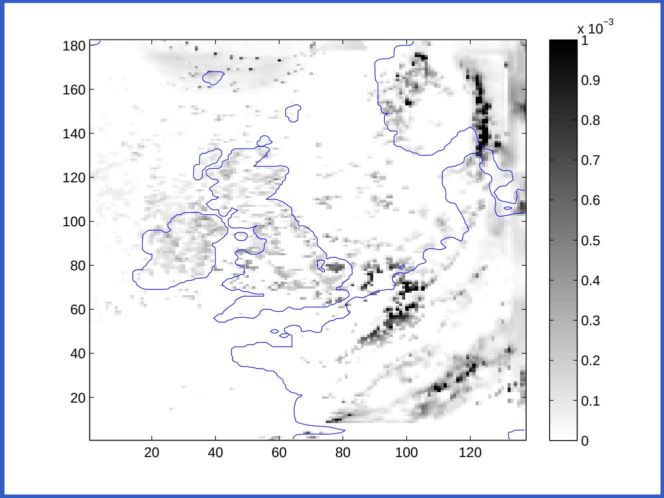
Outline

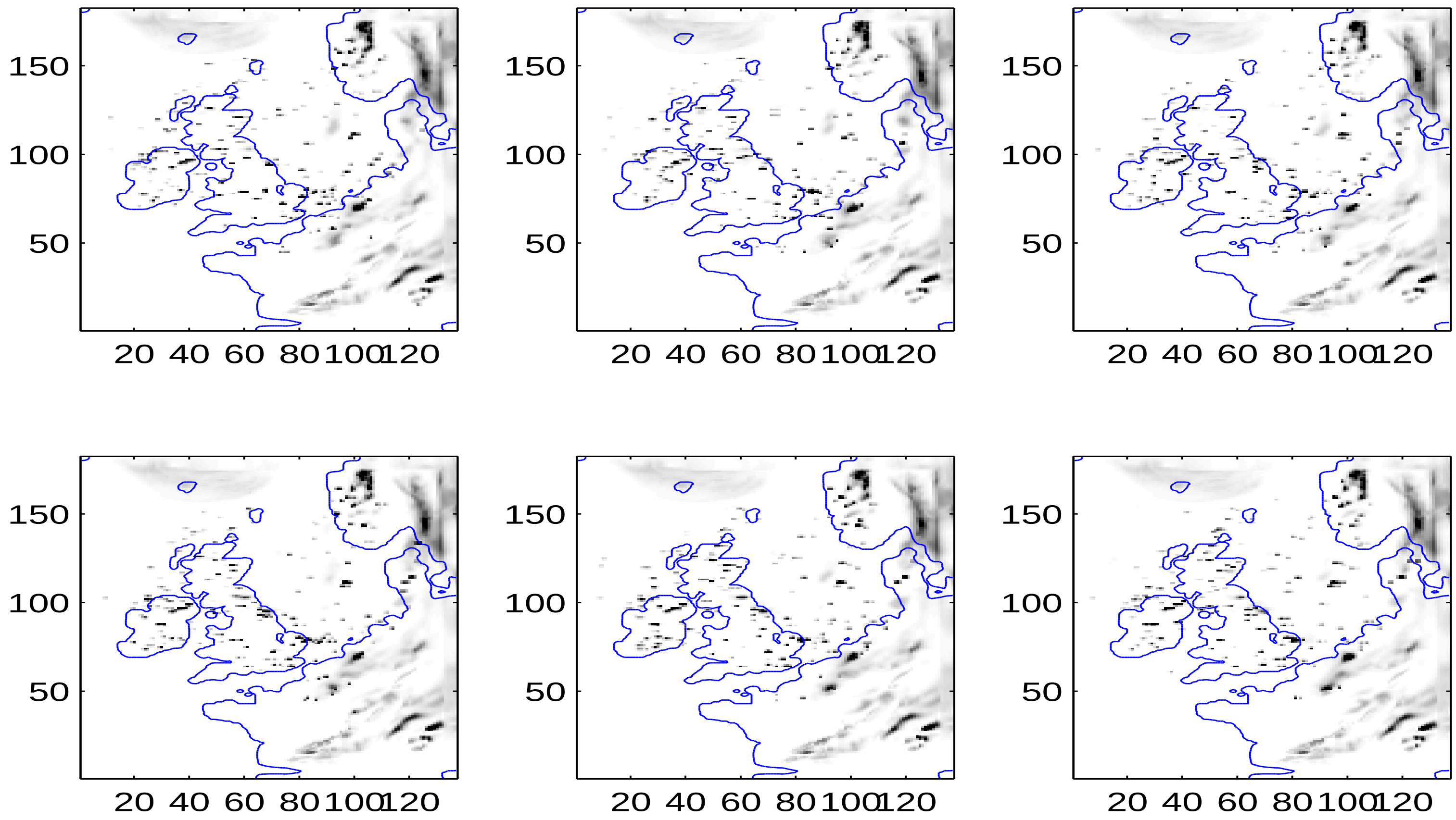
- Motivation
- Introduction to the Plant-Craig stochastic convection parameterisation scheme.
- Experiments in an idealised UM setup.

Case study: CSIP IOP18

- Starts at 25th August 2005, 07:00.
- 12 km grid with 146×182 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:

$$p(m)\mathrm{d}m = \frac{1}{\langle m \rangle} \exp\left(\frac{-m}{\langle m \rangle}\right) \mathrm{d}m.$$

So if $m \sim r^2$ then the probability of initiating a plume of radius r in a timestep $\mathrm{d}t$ is

$$\frac{\langle M \rangle 2r}{\langle m \rangle \langle r^2 \rangle} \exp\left(\frac{-r^2}{\langle r^2 \rangle}\right) \mathrm{d}r \frac{\mathrm{d}t}{T}.$$

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PDF of total mass flux

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

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

leading to the following distribution for total mass flux:

$$p(M) = \left(\frac{\langle N \rangle}{\langle m \rangle} \right)^{1/2} \mathrm{e}^{-(\langle N \rangle + M/\langle m \rangle)} M^{-1/2} I_1 \left(2\sqrt{\frac{\langle N \rangle}{\langle m \rangle} M} \right).$$

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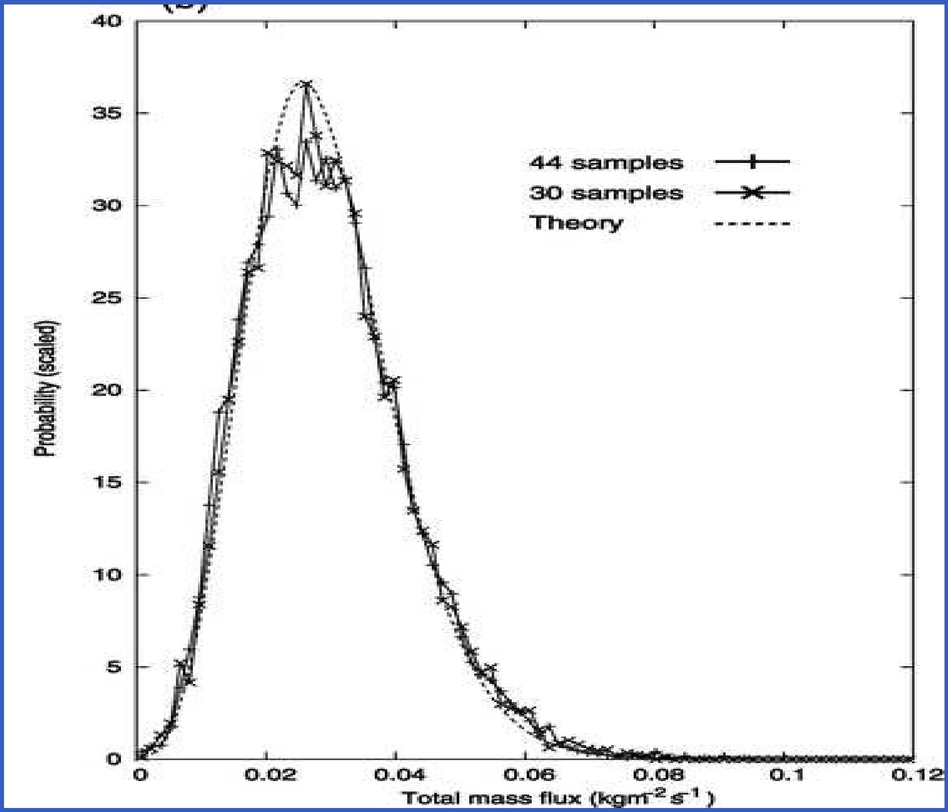
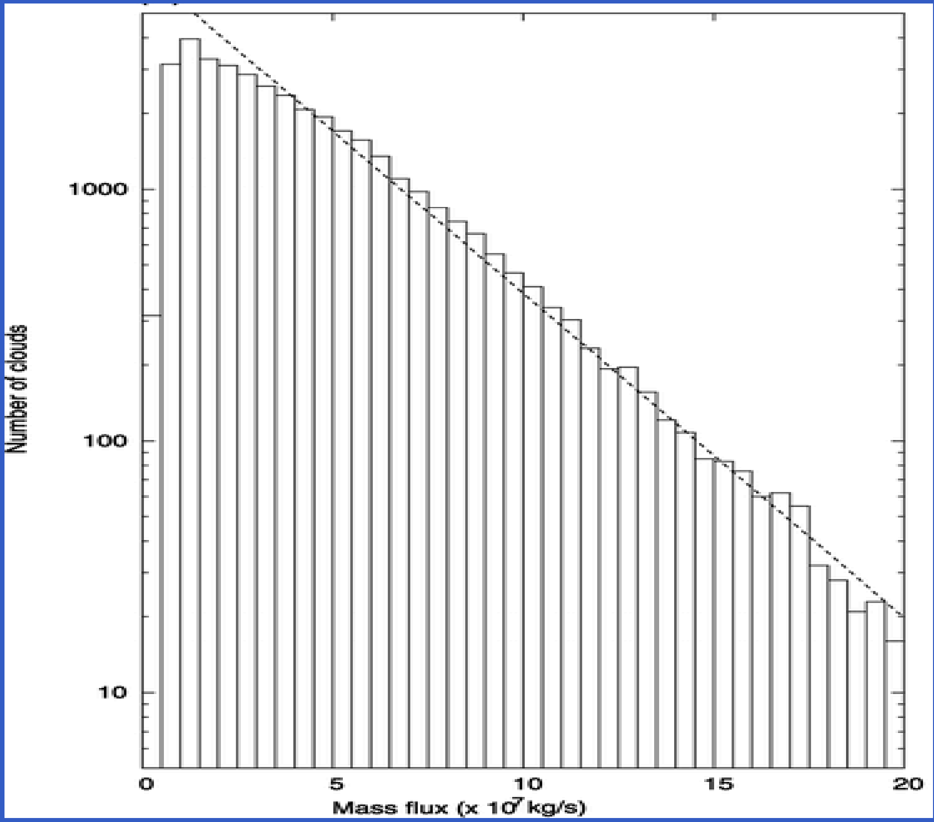
PDFs of mass flux in an SCM





- Plant & Craig, JAS, 2008

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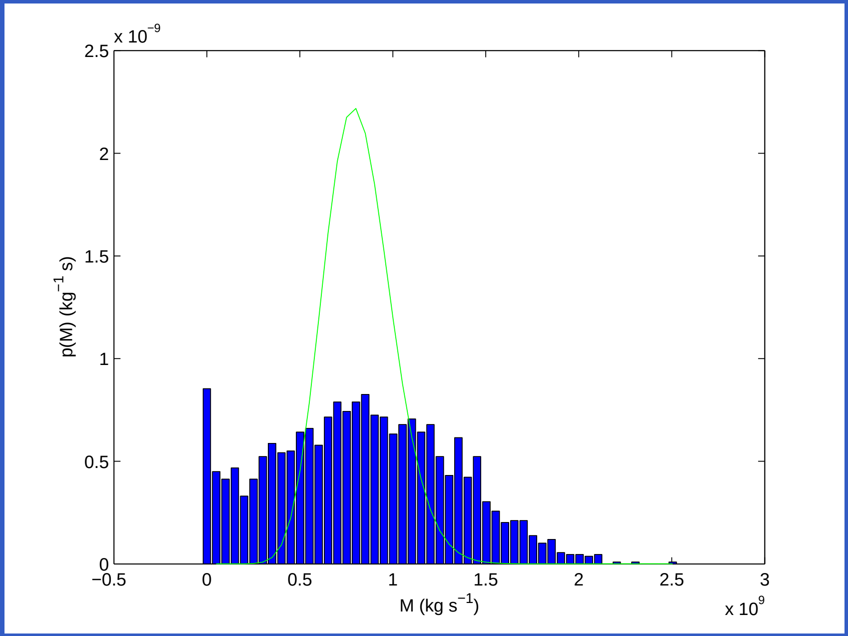
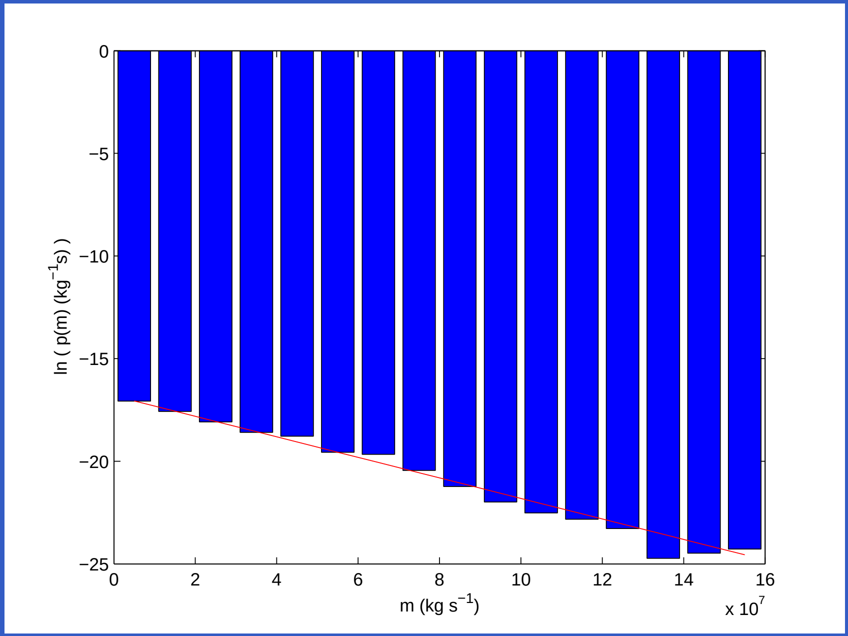
3D Idealised UM setup

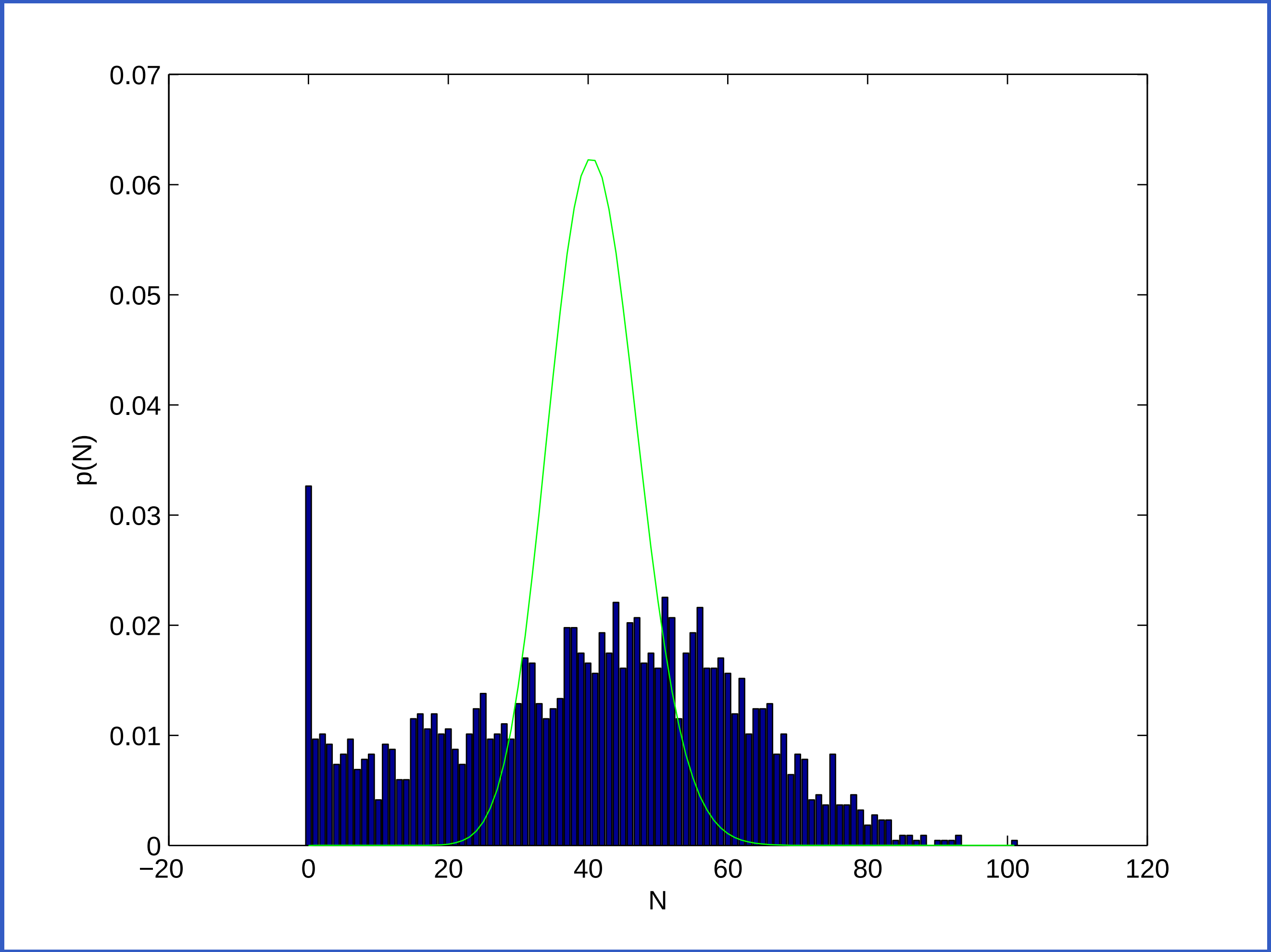
- Radiation is represented by a uniform cooling.
- Convection, large scale precipitation and the boundary layer are parameterised.
- The domain is square, with bicyclic boundary conditions.
- The surface is flat and entirely ocean, with a constant surface temperature imposed.
- Horizontal diffusion, vertical diffusion of θ and targeted diffusion of moisture are applied.

PDFs of mass fluxes

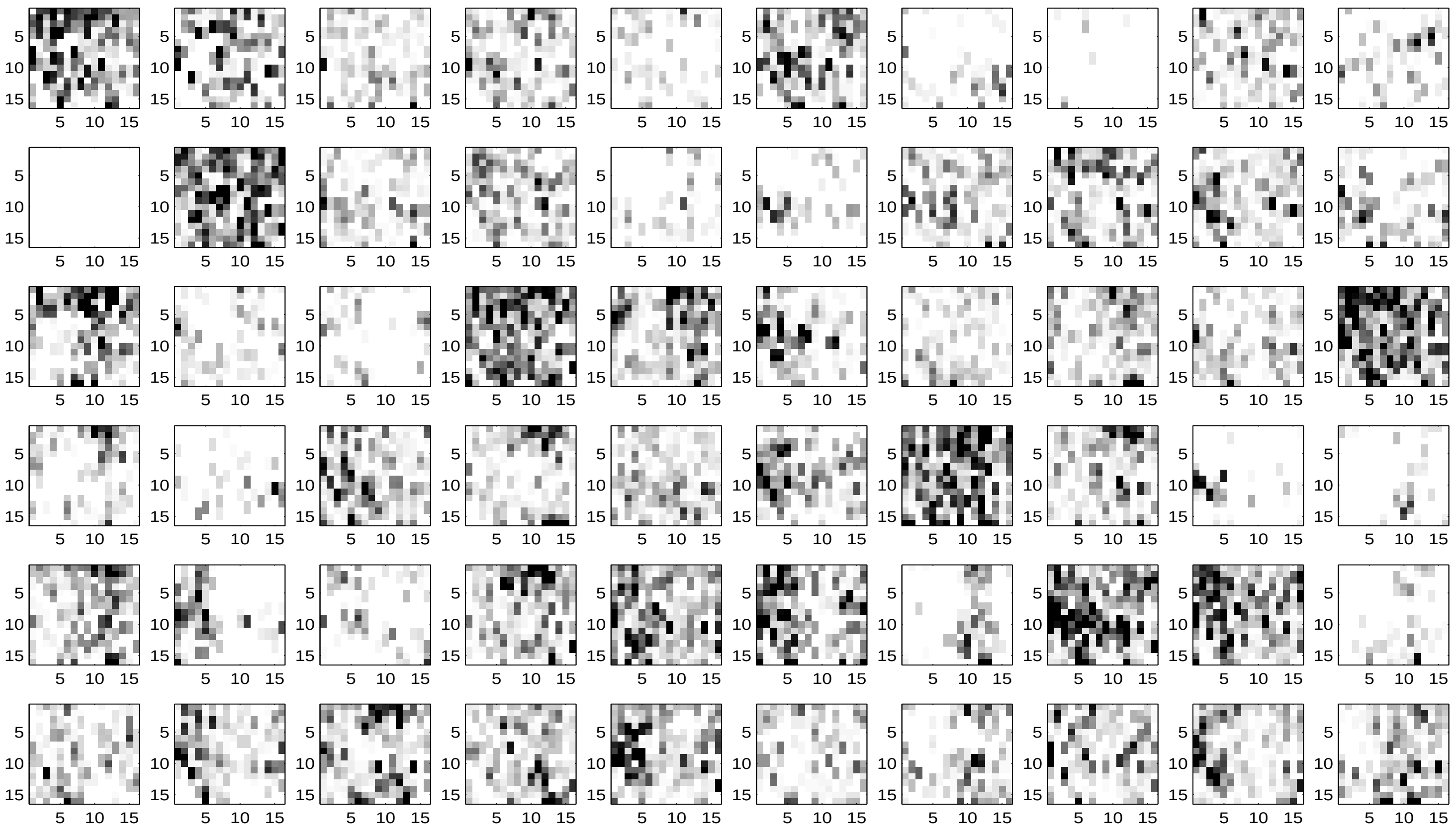




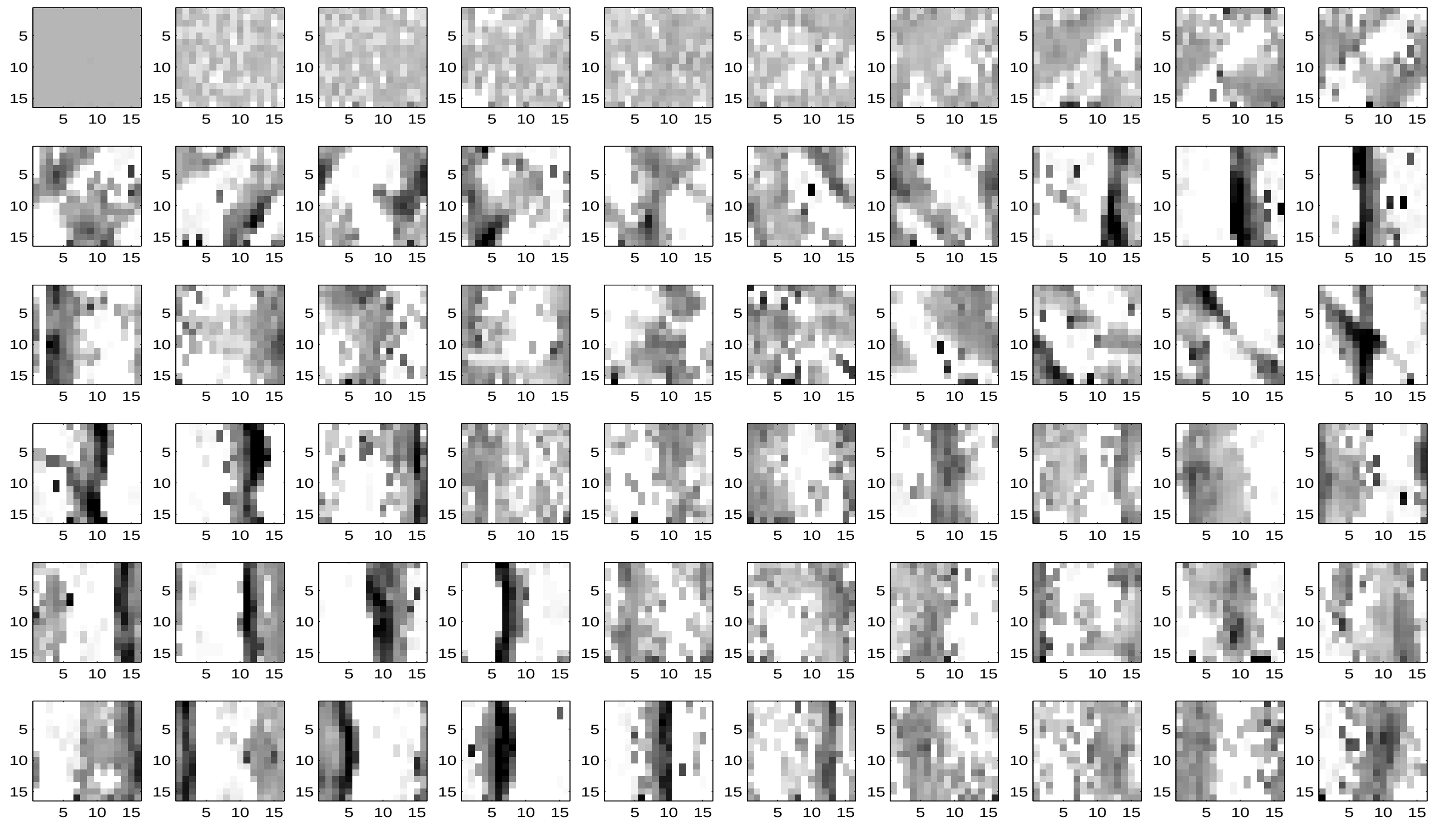
PDF of number of clouds



Organisation in rainfall pattern?



Organisation in rainfall pattern? GR



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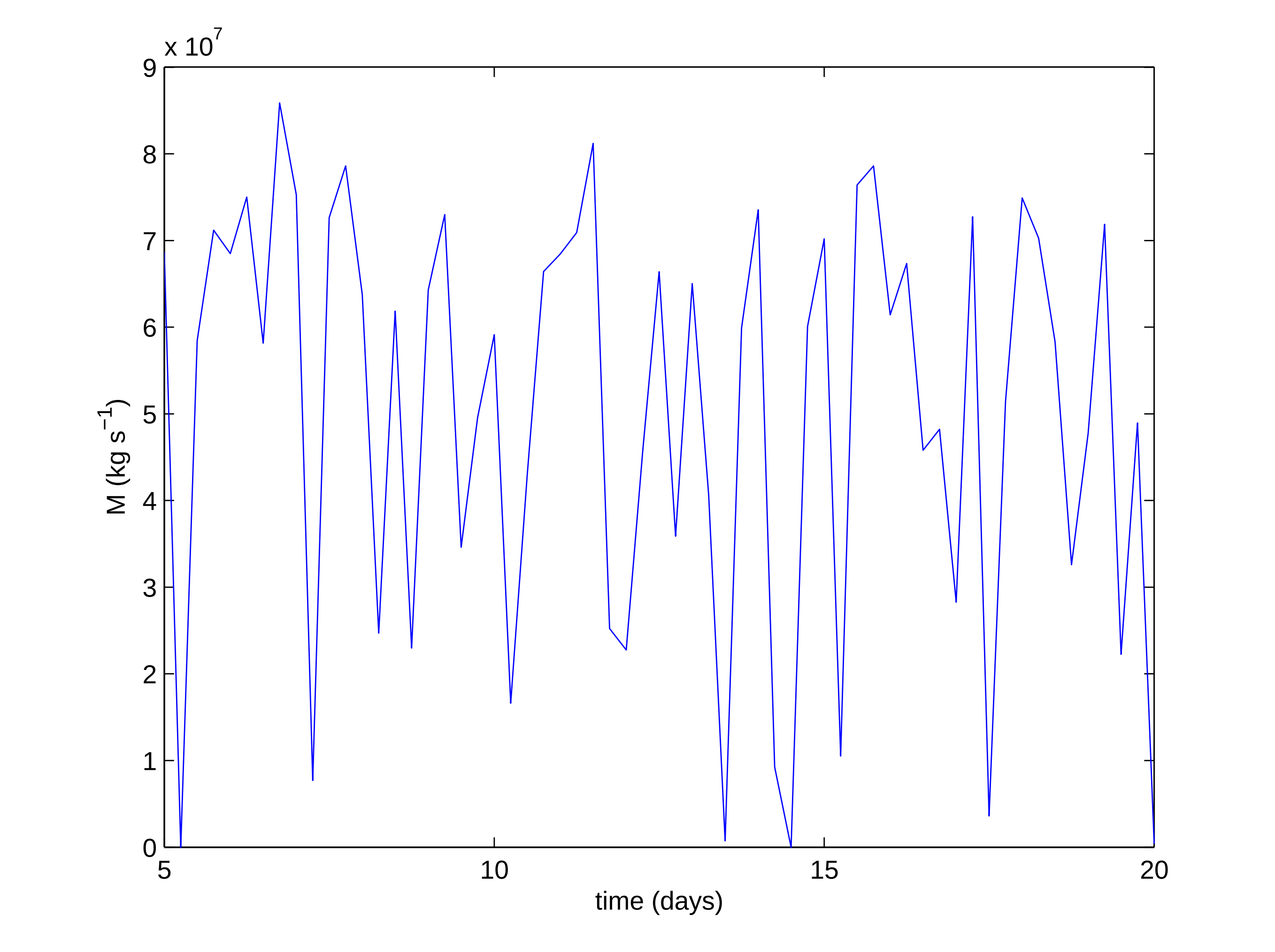
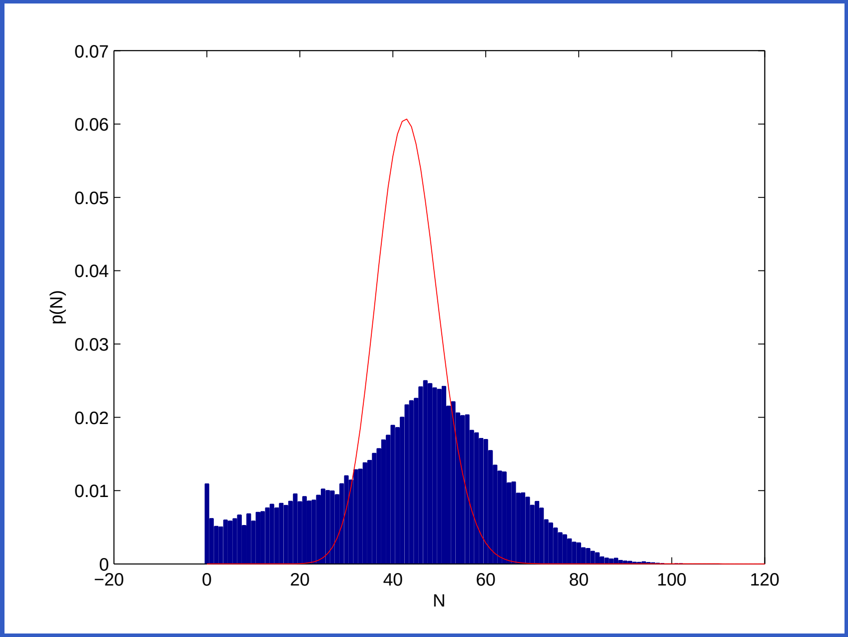
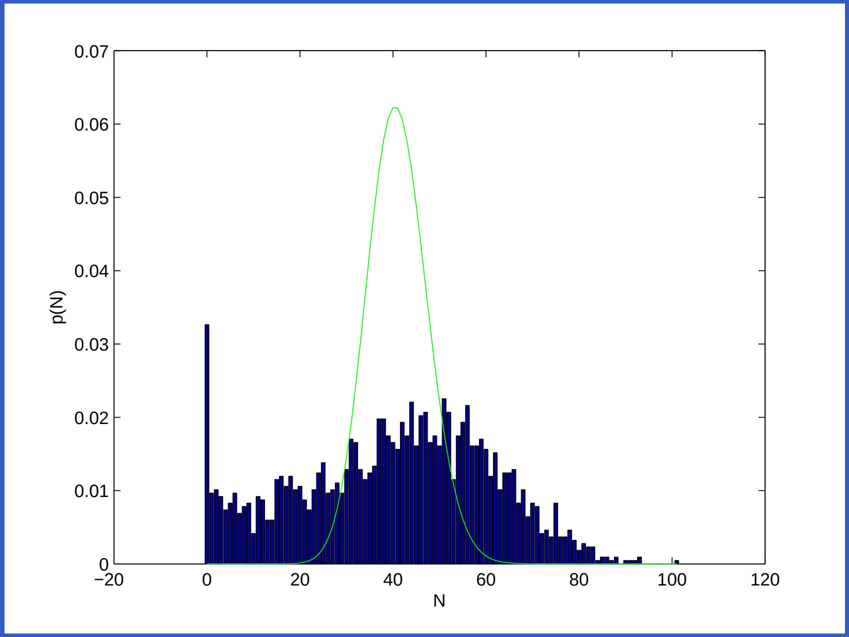
Time variation of $\langle M \rangle$



PDF of N in statistical experiment





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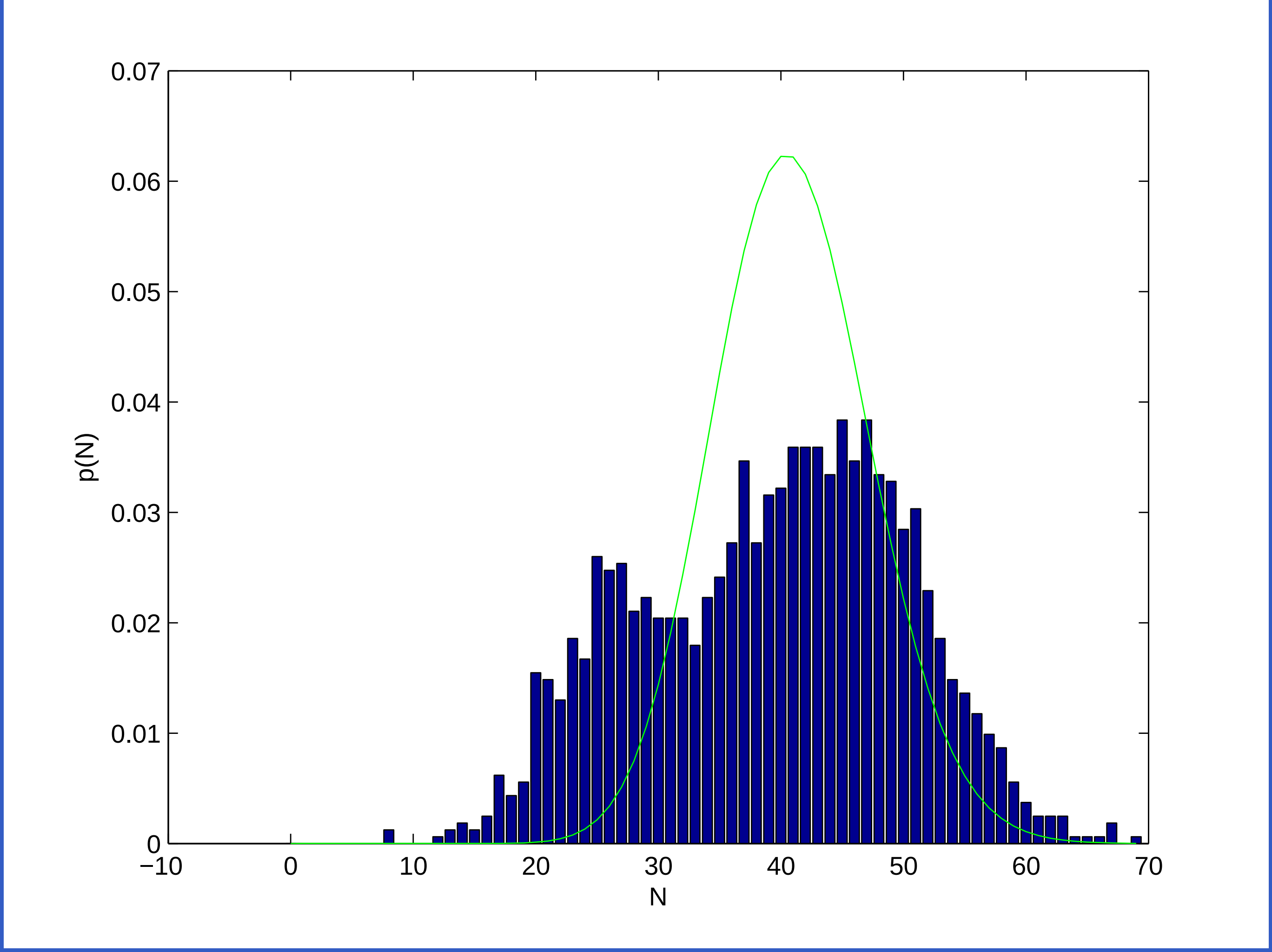
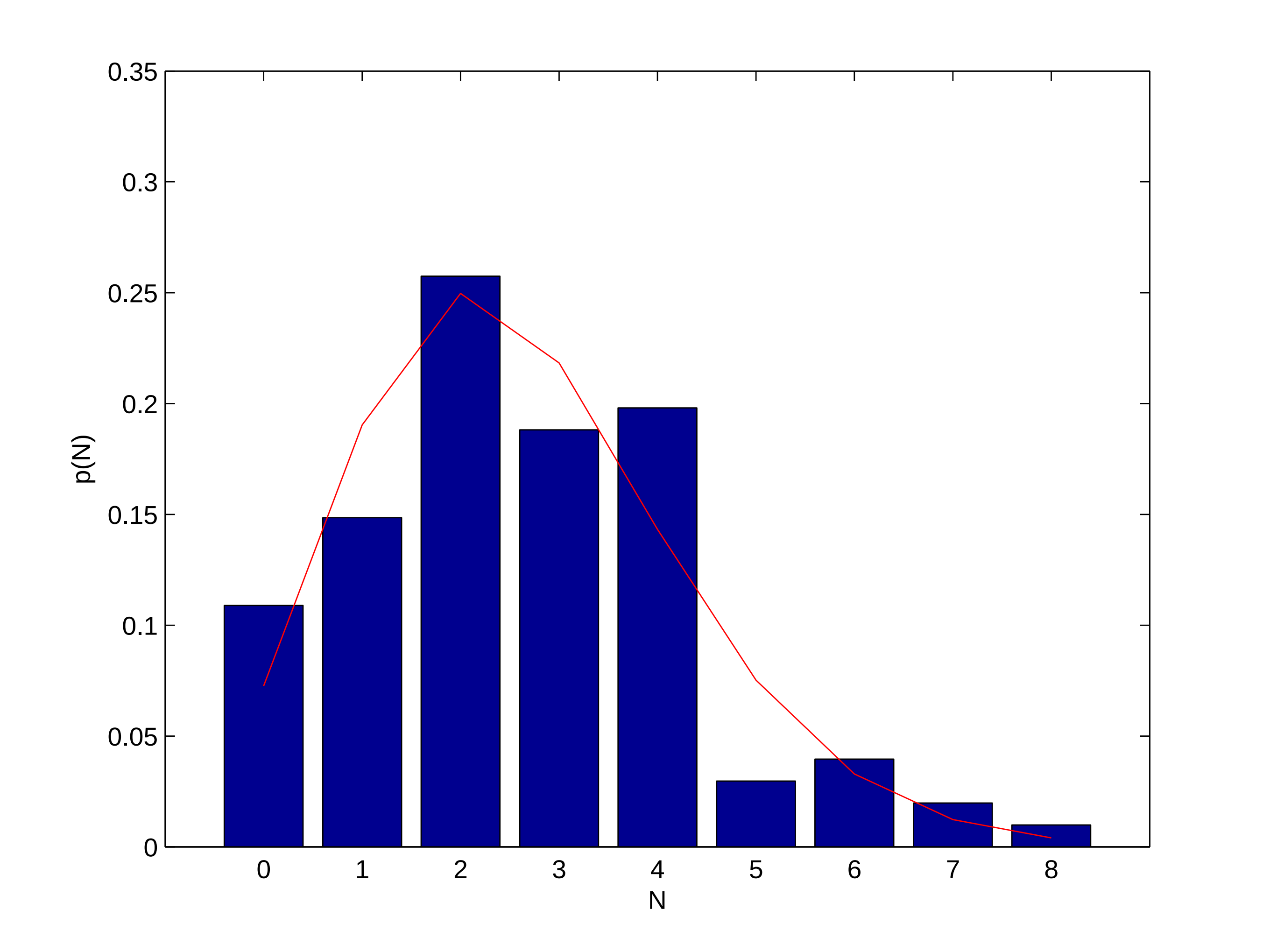
PDF of N with constant $\langle M \rangle$



PDF of N on one gridpoint



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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.