Memory properties in Cloud-Resolving Simulations of the Diurnal Cycle of Deep convection

University of Reading

Model description and simulations setup

MONC (the new **M**et **O**ffice **N**ERC **C**loud Model)

$X \times Y \times Z = 100 \times 100 \times 20\ km,\ \Delta Y = \Delta X = 0.2\ km$
Surface fluxes are horizontally uniform. Half sine function for $t = 0 - 12$ h and set to $0 W/m^2$ for $t =$ 12-24 h. Peak values at $t = 6$h.
Peak SHF =**130** W/m^2, peak LHF= **400** W/m^2, and prescribed RC =$\mathbf{-1.75}\ K/d$

Memory within the convective system:

$$\mathbf{M(A, t_0, \Delta t)} = \mathbf{P[R(A, t_0) \cap R(A, t_0 - \Delta t)]} - \mathbf{P[R(A, t_0)] \times P[R(A, t_0 - \Delta t)]}$$

Memory function — *The probability of finding rain at time t_0 and at an earlier time $t_0 - \Delta t$* — *The probability of finding persistent rainfall by random chance (or the expected probability given no memory)*

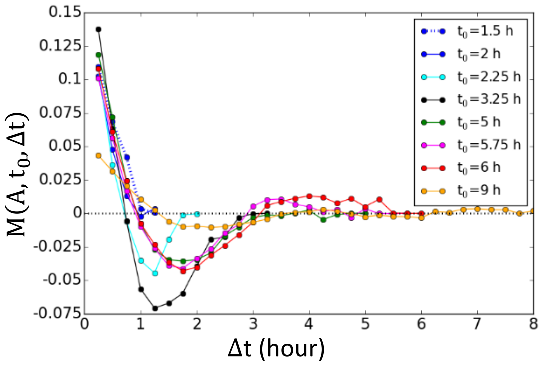

Fig.1: Memory function for A=$4 \times 4\ km^2$ for different times after triggering (t_0). Control simulation

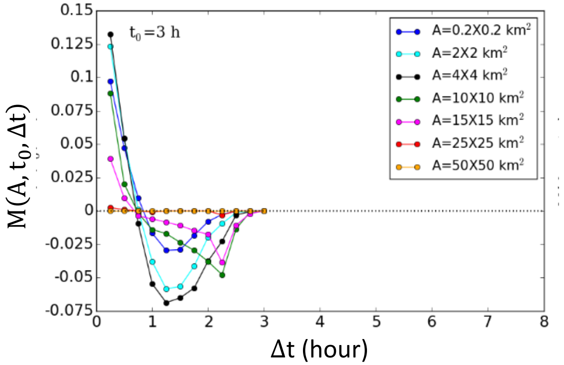

Fig.2: Memory function for different areas and $t_0 = 3$ hours after triggering. Control simulation

The memory is strongest at grey-zone scales of $4 - 10\ km$ and has 3 phases; a **1st phase** (persistence of convection for about 1 hr), a **2nd phase** (suppression of convection in regions which were raining 1 to 3 hours previously), and subsequently, a **3rd phase** (a secondary enhancement of precipitation in regions which were previously suppressed).

Impact of initial thermodynamic variability

Homogenization, $\frac{\partial \chi_{i,j}^k}{\partial t} = -\frac{1}{\tau}(\chi_{i,j}^k - \bar{\chi}^k)$ is applied:

- to temperature and specific humidity of water vapour between hours 15-24
- at all vertical levels **(greatest impact when applied below 4km)**
- The evolution of convection on the next day, following homogenization (**H**), is compared to that in the control simulation (**C**)

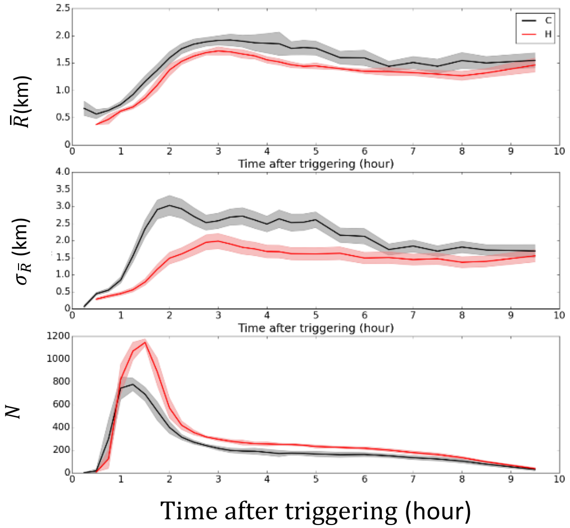

*Fig.3: mean rain cores radius $\bar{R}$, standard deviation of rain core radii $\sigma_{\bar{R}}$, and number of rainfall events N for the control simulation (**C**) and the simulation following homogenization (**H**)*

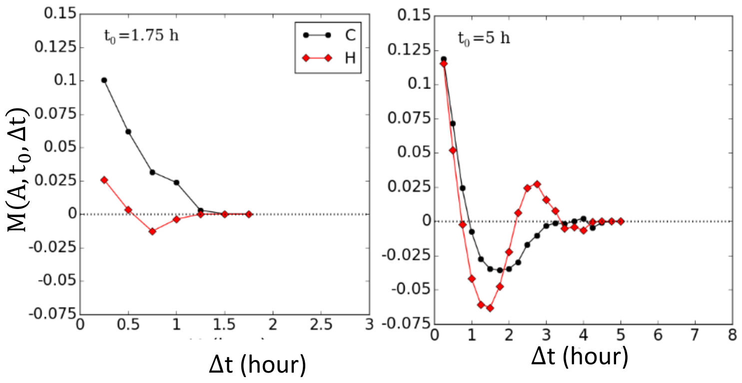

*Fig.4: Memory function for A=$4 \times 4\ km^2$ and $t_0 = 1.75$, and 5 hours after triggering for the control simulation (**C**) and the simulation following homogenization (**H**)*

When thermodynamic fluctuations resulting from the previous day are allowed to influence the development of convection on the next day:

- there are **little impact on the timing and intensity** of convection. However,
- there are **fewer rainfall events with relatively large sizes, which are more intense, thus decay and recover more slowly.**
- Memory attributed to initial thermodynamic fluctuations **resides in the lower troposphere.**

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