

What determines the growth of humidity fluctuations?

Stefan R. de Roode, A. Pier Siebesma, Thomas Frederikse, Harm.J.J. Jonker (Delft University of Technology) & Martin Janssens, Wageningen University

Motivation

Cloud Organisation can be viewed as a manifestation of growth of humidity fluctuations. So that justifies the question:

What determines the growth of humidity fluctuations?

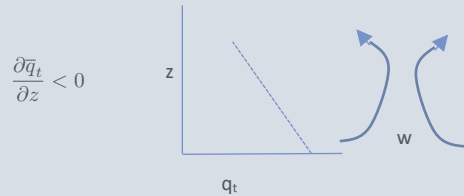
Theory

In its simplest form, humidity fluctuations q' are governed by

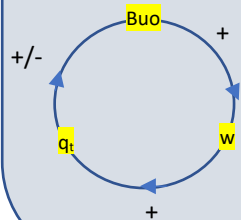
$$\frac{\partial q'_t}{\partial t} = -w' \frac{\partial \bar{q}_t}{\partial z} + \dots$$

$$\frac{\partial w'}{\partial t} = \frac{g}{\theta_0} \theta'_v + \dots$$

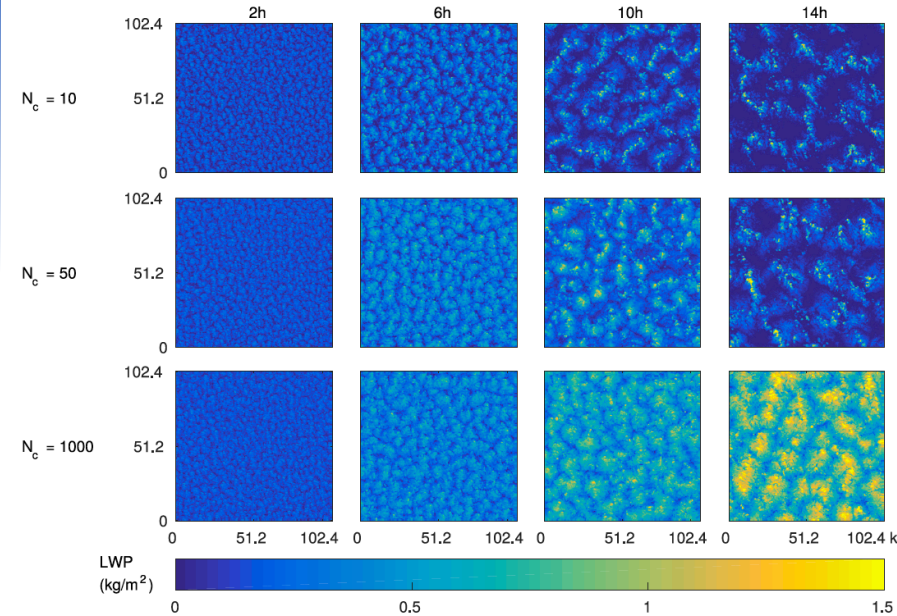
So in areas with positive w' (due to buoyancy production) humidity fluctuations will grow provided that



In order to keep this process self-sustaining a mechanism is required that maintains a negative slope of q_t . In addition a positive correlation between q_t and θ_v speeds up the feedback loop



Cold Air Outbreak (CONSTRAN 31-10-2010) , transition $Scu \Rightarrow$ Cumulus, Varying the cloud droplet number



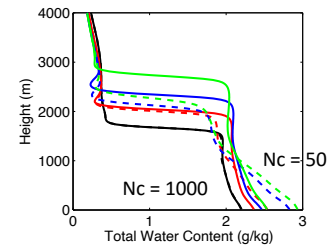
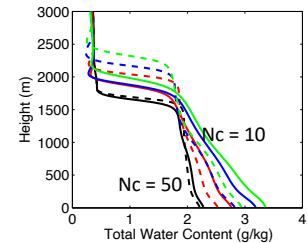
Low droplet number \Rightarrow strong precip \Rightarrow transition to open cells

Mesoscale organisation. Negative slope q_t maintained through precipitation

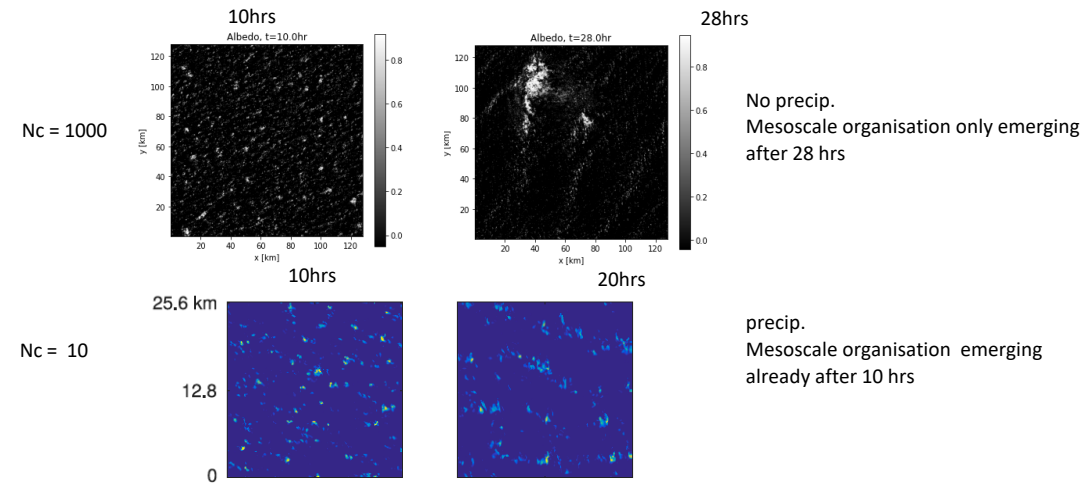
Average droplet number \Rightarrow intermediate precip \Rightarrow transition to closed cells

Large droplet number \Rightarrow no precip \Rightarrow Stratocumulus remains

Mesoscale organisation, albeit smaller scales. Negative slope q_t less strong due to absence rain. Slope maintained through dry entrainment.



BOMEX, shallow cumulus, Varying the cloud droplet number



No precip.
Mesoscale organisation only emerging after 28 hrs

precip.
Mesoscale organisation emerging already after 10 hrs

Conclusions and Outlook

- Not a new idea. Based on: de Roode et al JAS 2004 " how large is large enough" and Jonker et al JAS 1999 " Mesoscale fluctuations of scalars in CBL)
- Mesoscale organisation emerges, even in the absence of precipitation and radiation as long as there is :
 - a negative slope in q_t
 - A positive correlation between θ_v and q_t
- Mesoscale organisation emerges faster in the presence of precipitation in which case a stronger negative lapse rate of q_t can be maintained
- Outlook : Testing out the above ideas for EUREC4A days and trying out denial experiments (imposing positive slope q_t)