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Cloud Trails: Are the clouds important?

Michael Johnston, Dr. Christopher Holloway, and Prof. Robert Plant

From Observations:

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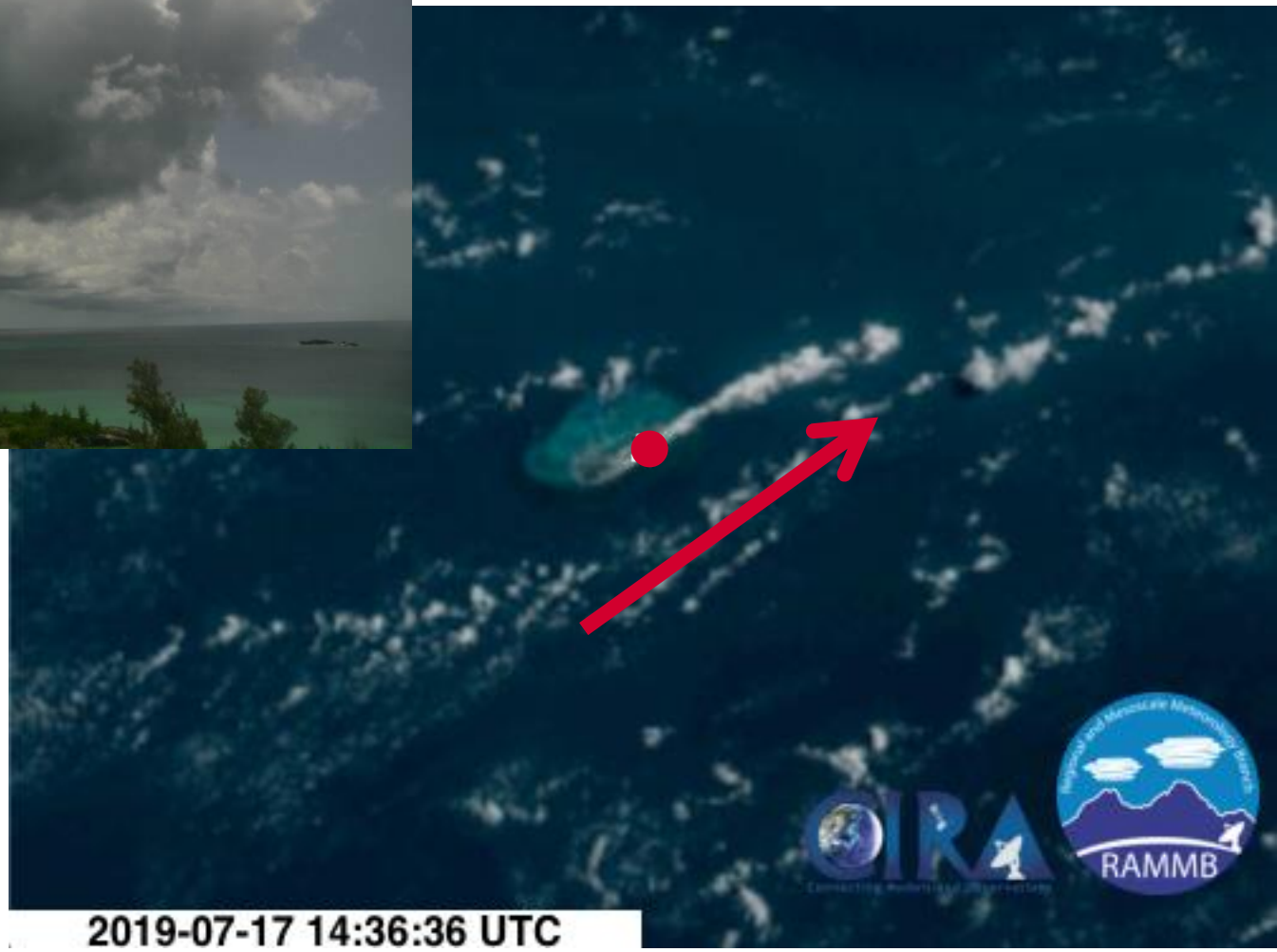
Bermuda Weather Service: 2019-07-17 14:36:04 UTC



Island:
~2 km by 25 km

Cloud band:
~2 km by >50 km

Fairly common -> e.g. Johnston et al. (2018) MWR

How small islands organise shallow convection

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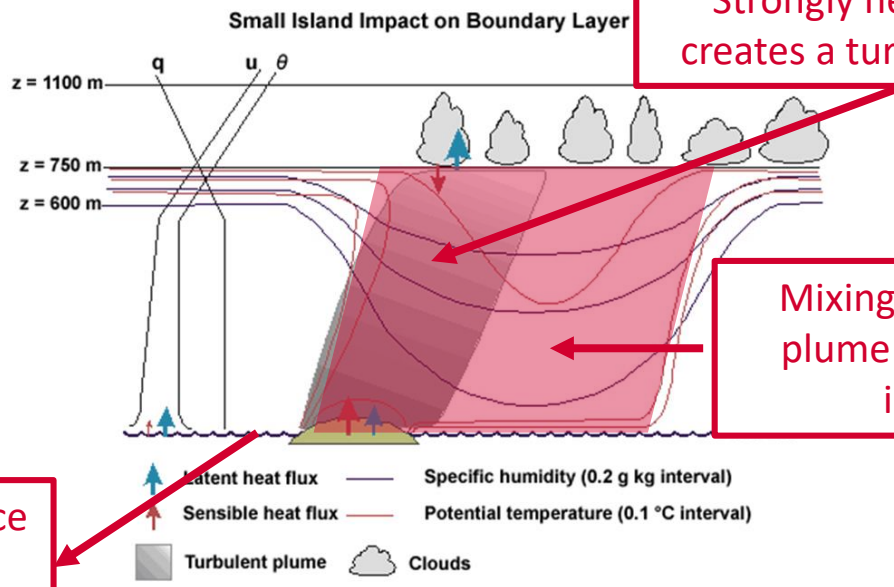
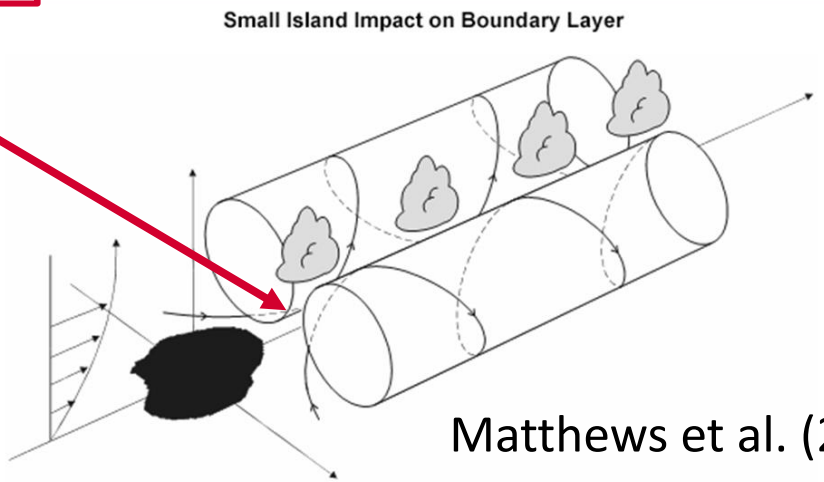


Strongly heated island creates a turbulent plume

Mixing within turbulent plume warms and dries island wake

Land/sea gradient in surface buoyancy fluxes forces circulation



Matthews et al. (2007)

The Model

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- UM10.9 with no convection scheme
- Blended boundary layer scheme
- Smith (1990) cloud scheme
- Periodic boundary conditions in E-W and N-S directions
- Prescribed cooling profile (Radiation)
- Geostrophic forcing (f plane)
- 140 vertical levels to 40 km model lid

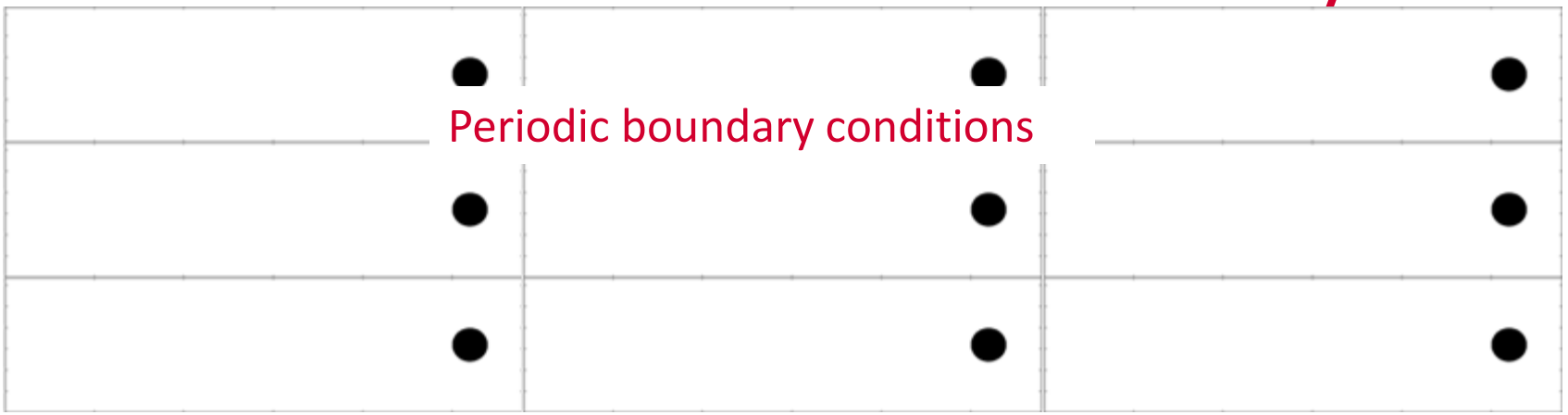
- 10-day spin-up of initial conditions on 32x32 horizontal grid with interactive surface fluxes

  -> we get nice initial profiles of theta, RH, and wind, plus ~balanced sea surface fluxes

Experiments

All Experiments:

Flat 50 km^2 island
Diurnal cycle of H and E



Control Experiment :

100 m grid spacing

Control Experiment

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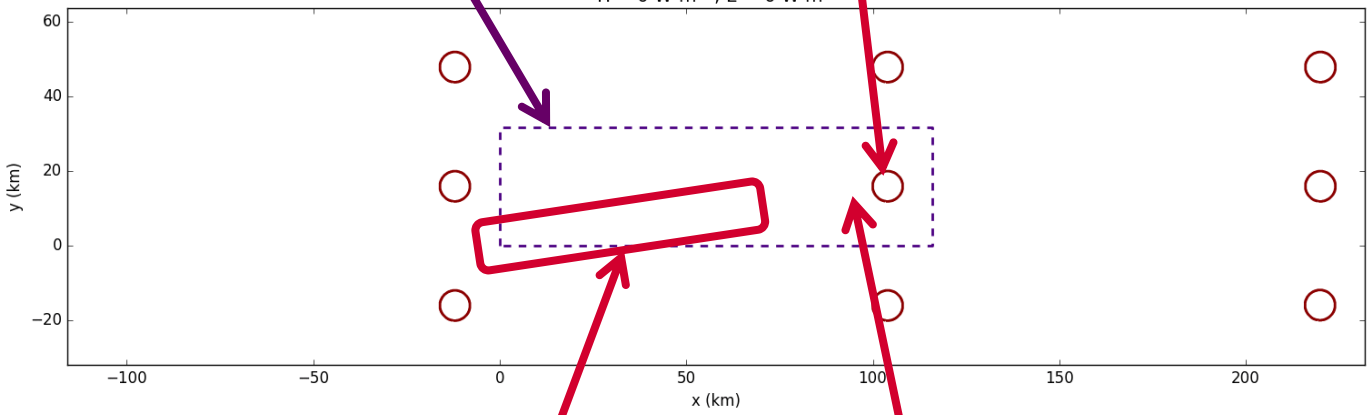
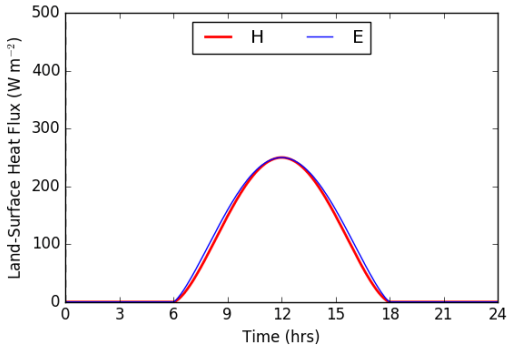
One domain

Island Coastline

Cloud mask

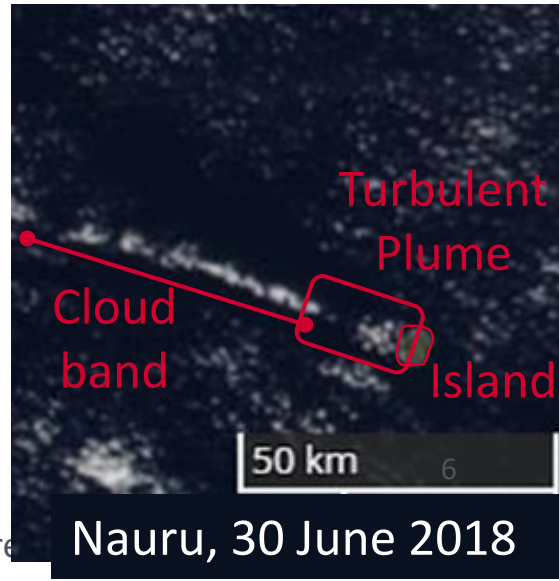


Diurnal Cycle



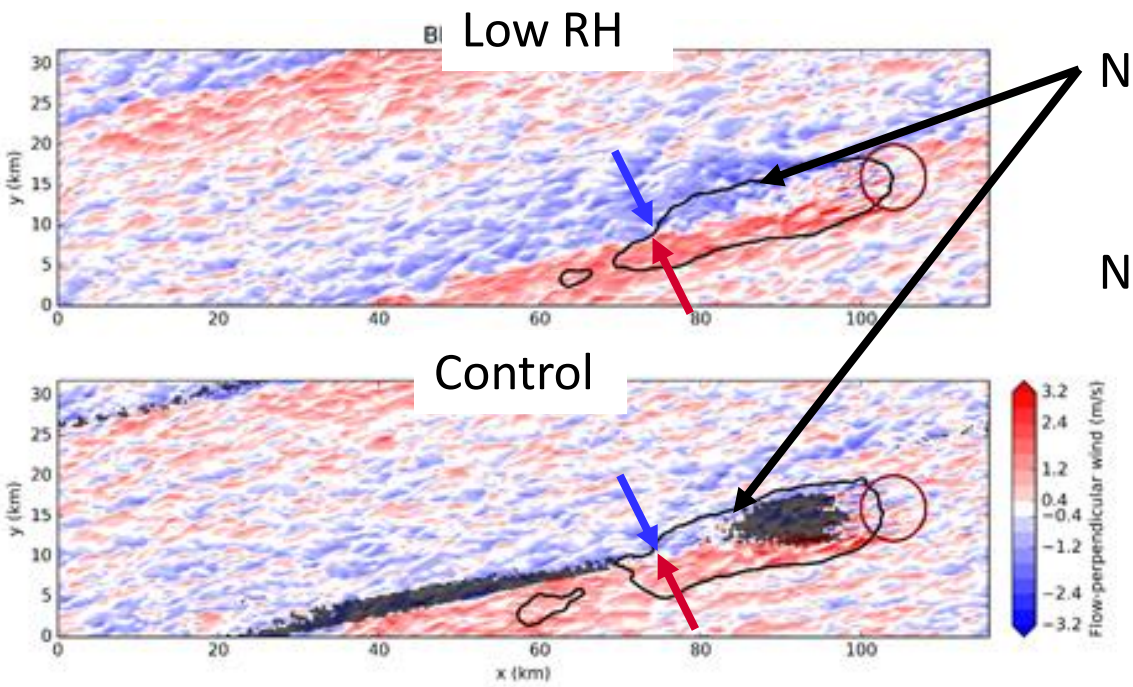
Cloud Band

Turbulent Plume



Nauru, 30 June 2018

Clouds and circulation



No change to warm plume extent

No change to circulation strength

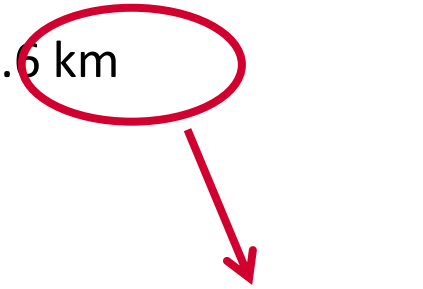
v'

Clouds are a passive signature of the circulation

How bad could it be?

We want to try out:

Grid spacing of 800 m and 1.6 km



~UKV resolution

… and use the 100 m grid spacing as the “truth”

Expectations from BOMEX

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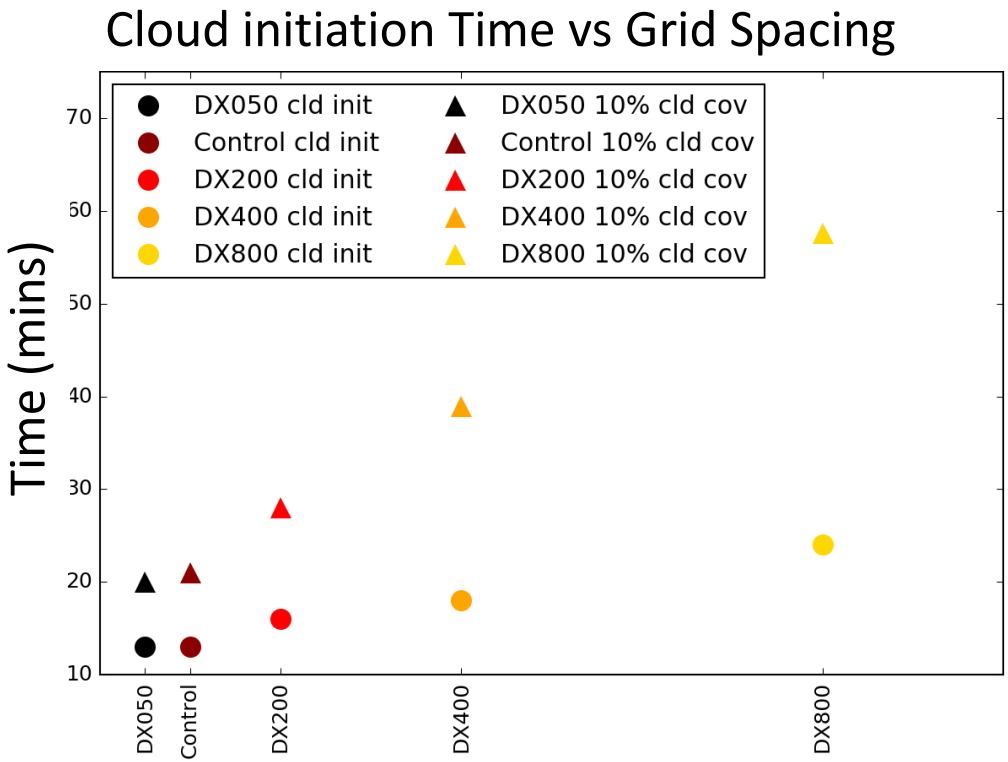
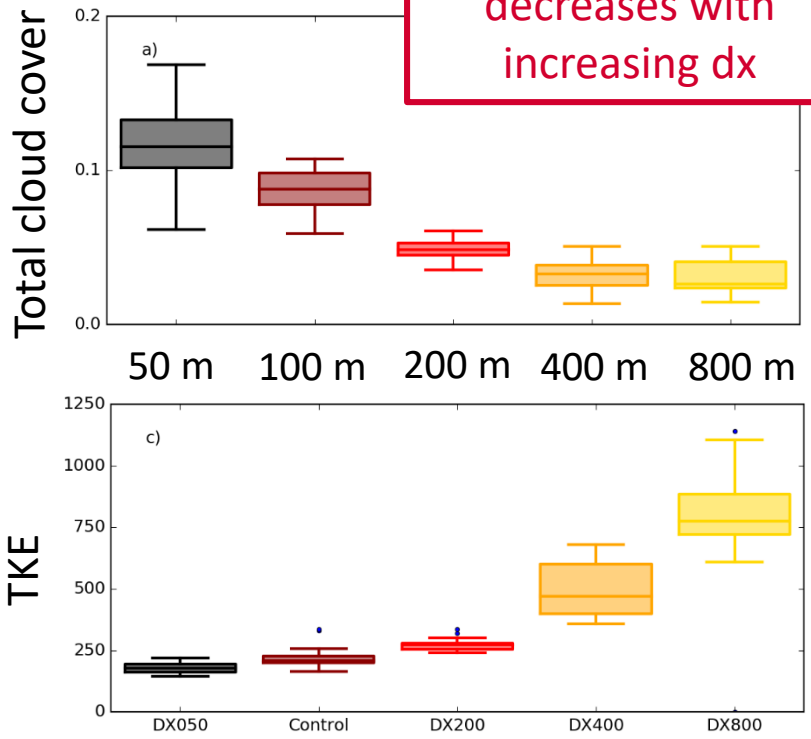


Slope of cloud initiation
~1 sec m^{-1}
Slope of 10% cloud cover
~2 sec m^{-1}

Cloud cover decreases with increasing dx



Resolved TKE increases with increasing dx

Coarse Grained Comparison

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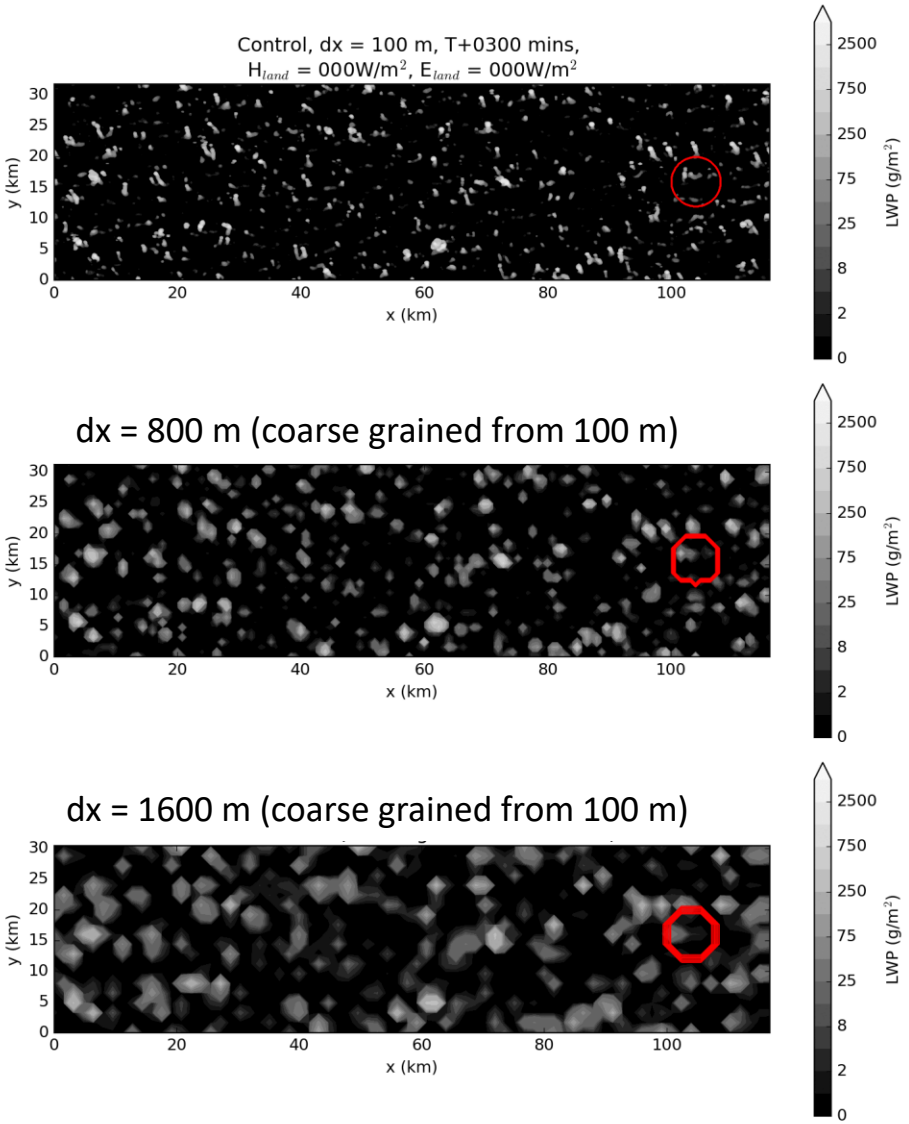
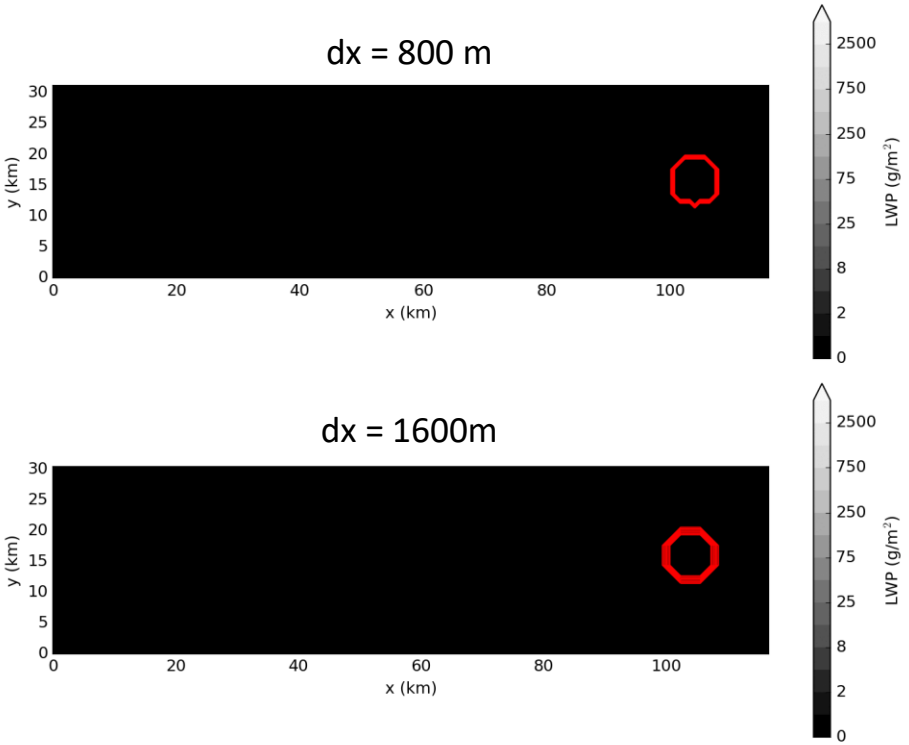


Increasing dx increases cell size and intensity with subsequent negative feedback on CT organisation



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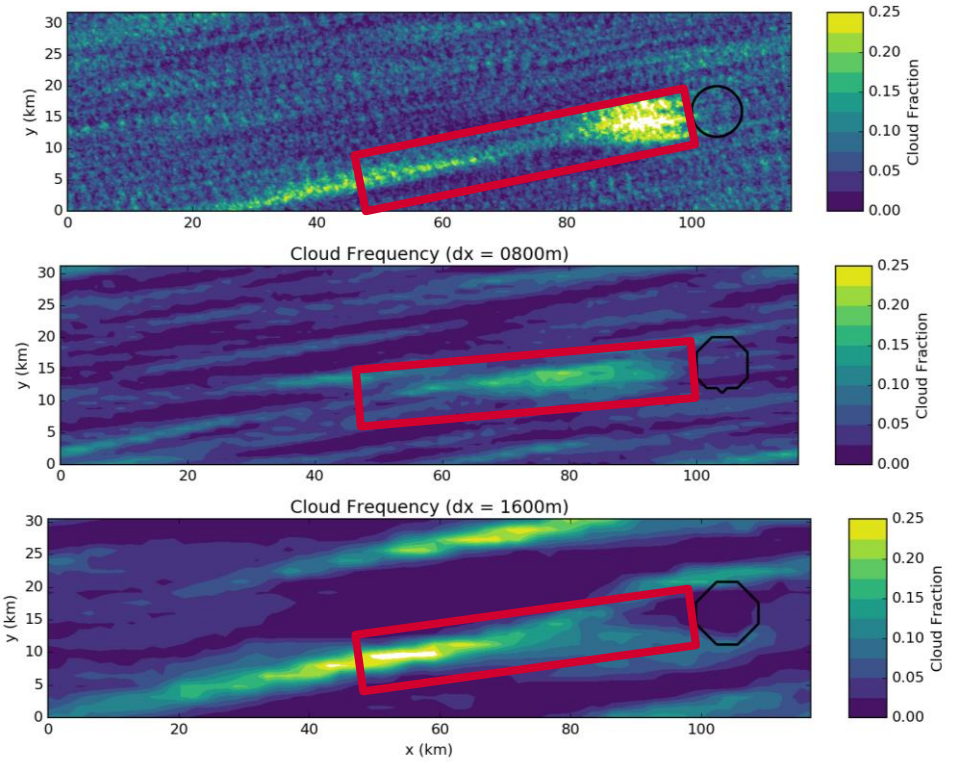
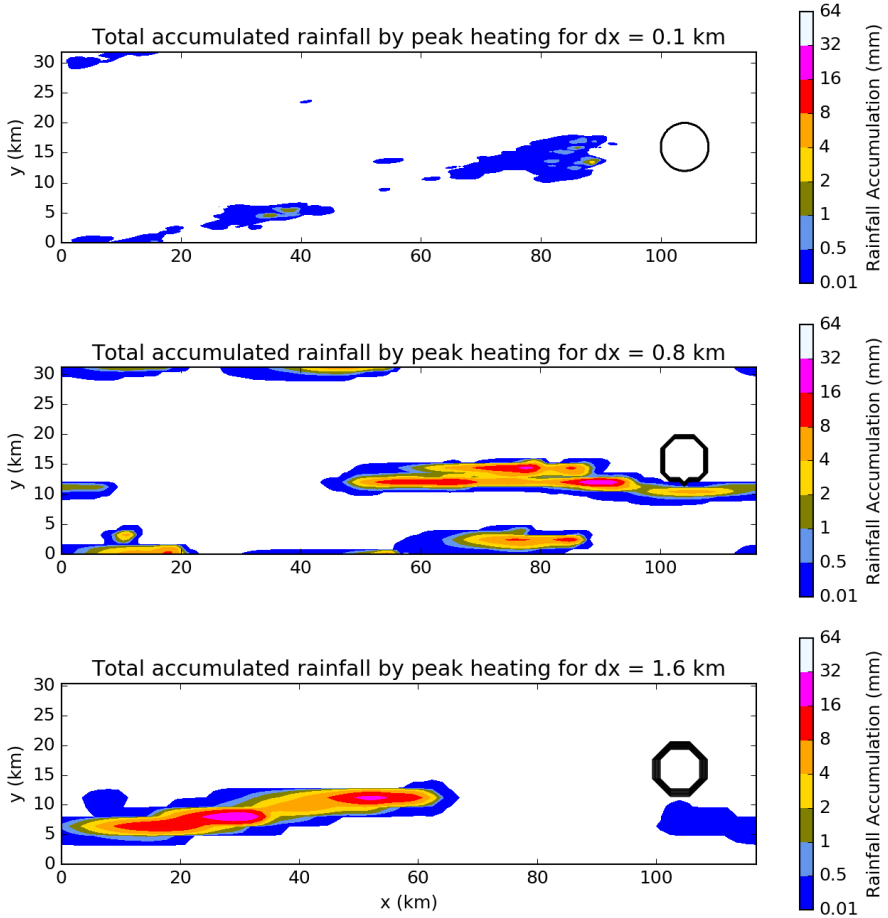
Total Rainfall between 6AM and 12PM

Cloud Frequency





Mass Flux Evolution

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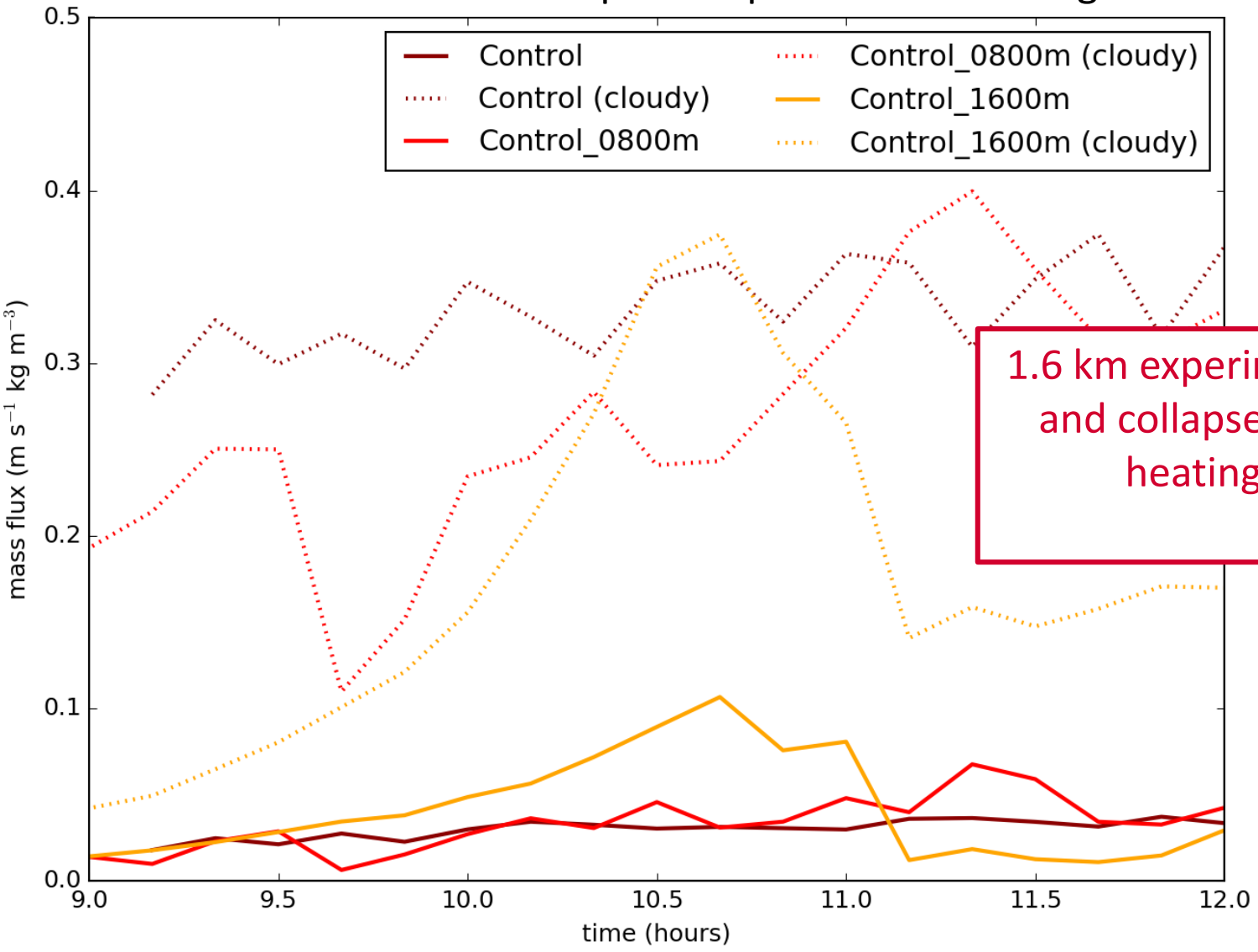
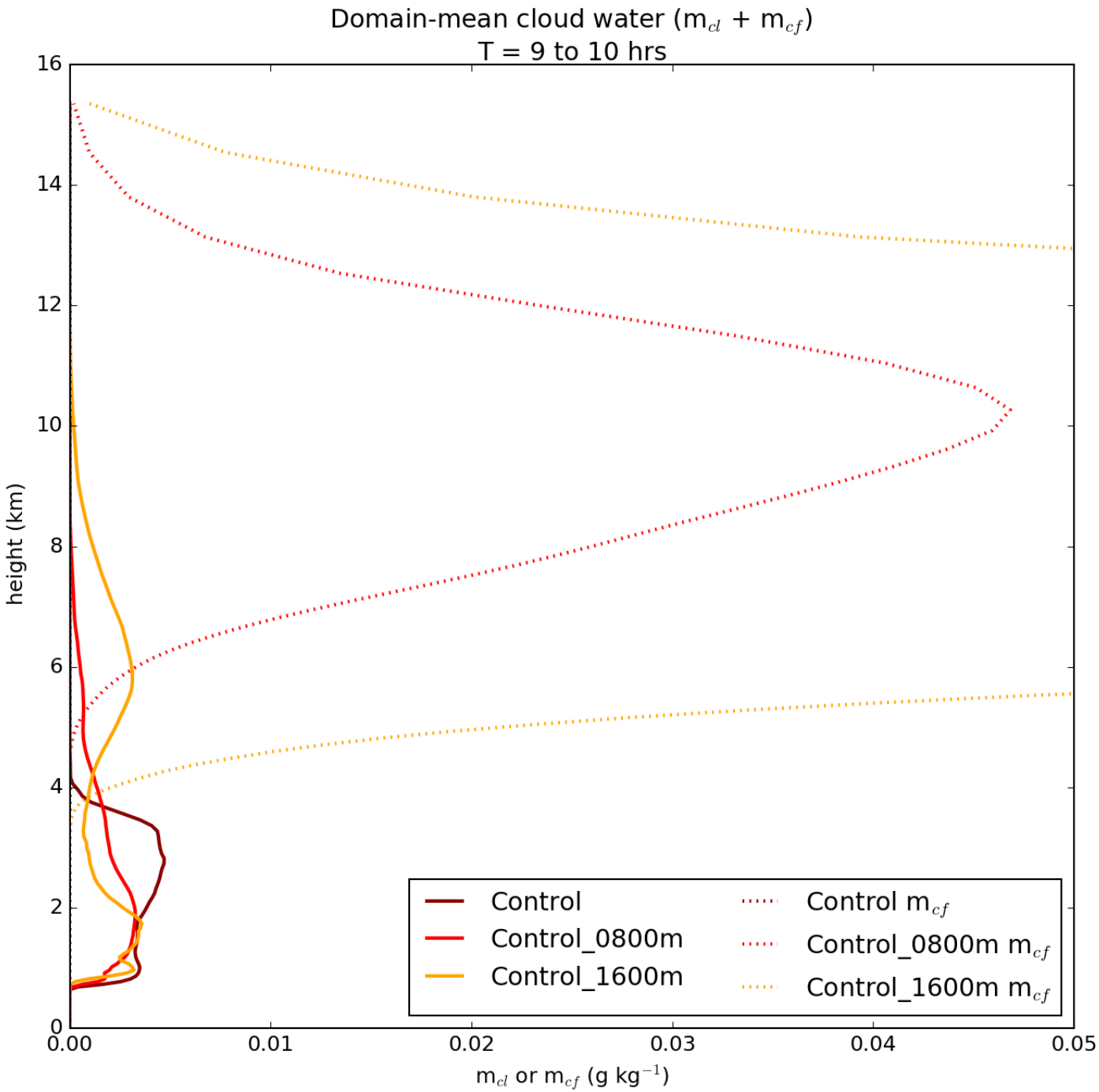
Mass flux at LCL in 3 hours prior to peak island heating



1.6 km experiment overshoots and collapses prior to peak heating (@12hrs)



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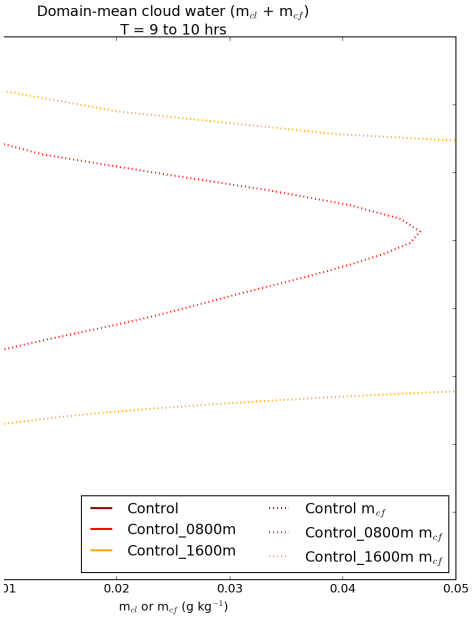

Summary

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- Do the clouds matter for cloud trails?

No*

- What happens as we increase to operational grid spacing?

Convective cells get too big

They get too intense

The resulting clouds start to matter*