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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Seeking for key meteorological parameters to better understand Hector" *by* S. Gentile and R. Ferretti

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Answers to the Specific comments: 1. Page 3622, line 12, "The strength of the convection is largely contributing to the vertical distribution of hydrometeors." The strength of the convection can be defined according to the vertical distribution of hydrometeors (as done page 3640, line 13 when writing "total condensate"). In that case, there is a tautology here. It would be helpful to give a clear definition of the strength of the convection.

The strength of convection is defined in terms of vertical velocity as reported in page 3625 line 23. According to your suggestion we will add the following sentence to avoid misunderstanding.

2. A proper definition of "convective cell" is lacking. Page 3623, line 17, a cell corresponds to the full thunderstorm Hector while page 3631, line 12, cells refer to smaller objects.

In the first case (page 3623, line 17) for convective cell we consider the Hector storm, then we change the sentence. In the second case (page 3631, line 12) we speak about of "precipitating cells" corresponding to a "Pre-Hector phase" (Gentile et al., 2014). Indeed, in a convective unstable PBL the plumes generated by the warm surface turn in convective clouds and eventually precipitate. This phase is the first step of the Hector development. So in this second case the cells are the preliminary elements triggering the convection.

3. Page 3624, line 11, "A 1 km resolution is fine enough to simulate faithfully this storm". With two different models running with 1 km grid spacing, Chemel et al. (2009) get very different results in term of injected water vapor into the stratosphere. "Faithfully" is too vague here.

Chemel et al. (2009) simulated the 30 November 2005 Hector event using two models the Advanced Research Weather Research Weather (ARW) and the Forecasting and the Me Office Unified Model (UM) with a resolution of 1 km. Both models reproduce the development of Hector fairly well even though the two simulated surface heat fluxes are very different. This would mean that the intensity of the storm is not be controlled only by this factor. Chemel et al. (2009) found that the moistening derived from the UM simulation is much larger than that derived from ARW and asserted that further research is necessary to assess the primary causes of this difference between the two models. The aim of the paper is to investigate the role of deep convection in the vertical transport of tropospheric air into the lower stratosphere. Chemel conducted a further simulation with ARW in large eddy simulation (LES) mode, refining the grid spacing to 250 m, and concluded that the characteristics of the Hector storm are basically similar in time and space to those obtained in the 1 km resolution. The term " faithfully" would mean that at 1 km resolution the timing, the structure and strength of deep convection

were reproduced well when compared with the field campaign observations (Chemel et al. (2009)). As you suggested the last sentence could be added in the paper. We change the term in correctly.

4. It is implicitly assumed that the different simulations mimic the reality. Recent TWP-ICE intercomparison studies by Varble et al. (JGR 2011, 2014) and Fridlind et al. (JGR 2012) have shown that ten 3D cloud-resolving models produced too intense updrafts. This should be the case for the MM5 simulations used here. A discussion on the uncertainties associated with the simulations and consequently on the veracity of the results would benefit to the paper.

The previous works (Ferretti and Gentile, 2009; Gentile et al., 2014) allow to assess the model ability in reproducing the dynamics and in correctly detecting the triggering factors leading to the Hector development by performing a detailed comparison with observations from radar and satellite. In addition, in Gentile et al., 2014 an analysis of the vertical velocity has been performed following the Houze's studies on the vertical structure of mesoscale convective system (MSC) in the tropical regions (Houze 1982, 1989, 1997) and a good agreement is found. Indeed, a bimodal structure at different levels and timing of the vertical velocity is clearly reproduced by MM5 as hypothesized by Houze's conceptual model (Houze 1997). In addition, the comparison of the mean vertical velocity between the observations for tropical island cases (Houze 1989) and the MM5 simulation shows fair agreement between the two maxima (Gentile et al., 2014).

5. Page 3628, line 10. At which level is the water vapor mixing ratio taken?

The water vapor mixing ratio is extracted at 950 hPa, as you suggested the level will be add to the paper.

6. Page 3628, line 15. The use of meteorological analysis 6 h later in case of double cell is not sufficiently justified. This implies that the second cell appears 6 hours after the first one (which is certainly not true). This also implies that the net effect of the

first cell has been taken into account in the ECMWF analysis (which might be not the case because of the coarse resolution of the ECMW model). At least, the time delay between two successive cells should be given. Also the uncertainties associated with the analysis should be discussed.

For November, 27 event the first cell reaches the maximum development at 13:10 LST and the second one, 3 hours later, at 16:10 LST. For November, 30 the maximum of the first cell is reached at 14:30 LST and the second one at 15:50 LST. Unfortunately, the ECMWF analysis are provided only for base time 00, 06, 12 or 18 so it is not possible to have meteorological information for a time interval less than 6 hours. As reported in the paper, the second convective cells develop in a more unstable and heterogeneous environment due to both the leftover related to the first cell and the thermal dynamics (sea breeze) at 15:30 LST is well developed. For these second cells the accuracy associated to the meteorological parameters extracted from ECMWF analysis is surely lower than the one related to the first cells. ECMW continually monitor the accuracy of their analysis and forecasts. The Technical Memorandum (http://old.ecmwf.int/publications/library/do/references/list/14) reported the main statistical index of the model evaluation, focusing on the analysis the accuracy is over 85% for the most important meteorological variables with uncertainties very small. We will add a statement clarifying the timing of the second cell development and why we had to rely on the 6h later analysis.

7. Page 3629, line 19 "... the heated and moistened surface of Tiwi Islands". How do the initial surface conditions and surface fluxes differ in the simulations? These variables should be documented as they are essential for the deep convection.

As you suggested, the role of the sensible and latent heat fluxes has been investigated. Figures 1 and 2 report, respectively, the mean value (over the Tiwi Islands surface) of the sensible and latent heat fluxes for all the Hector events during the day. The surface sensible heat flux is very similar for all the events, showing an evolution strictly related to transport from the Earth's surface of the entering solar radiation with a maximum

value varying from 240 W/m2 to 280 W/m2 (Fig. 1). Also the latent heat flux show a pattern comparable for all the events but the maximum values are spreader than the ones of the sensible heat flux (Fig. 2). More in details, three events show the biggest maximum values: 310 W/m2 for November, 17, 300 W/m2 for November, 11 and 260 W/m2 for November, 30 (Fig. 2). For N30 and N11 these values could be justified with the high values, respectively, of relative humidity and CAPE. In addition for N17 and N1, the precipitation, and consequently the evaporational cooling, starts very late (at 15:50 LST) permitting the growth of moisten which turns in an increases of the latent heat flux. This further analysis could be added in the paper.

8. Page 3630, line 9, CAPE is the vertical integral of positive buoyancy.

It is right. The sentence will correct.

9. Page 3630, line 22, it should be mixing ratio (instead of relative humidity).

Yes, it is right. The sentence will correct.

10 . Page 3633, line 8. How is defined the volume encapsulating Hector?

The volume encapsulating Hector is a parallelepiped including all the vertical structure of the convective cell, an example is reported in the Fig. 3.

11. Page 3638, line 15. It is not clear why a distance between the "real" and "ideal" points is a metrics for the contribution to the Hector development.

The lines reported in the figures 8 and 9 show the ideal conditions for the Hector development. As the "real" points get closer to the "ideal" lines and more the meteorological conditions are suitable for the Hector development. The Crook's study helps us to identify the parameters involved in the Hector developme

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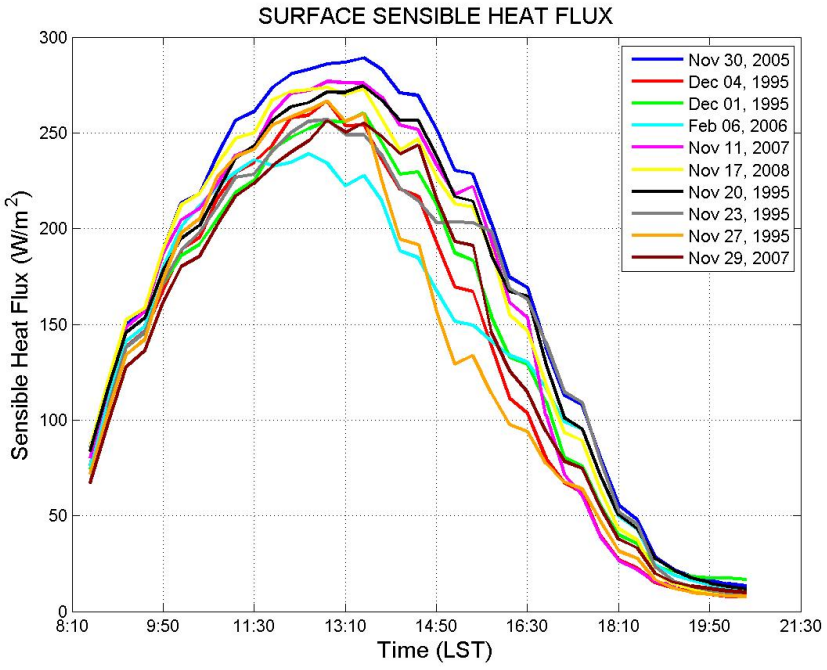

Fig. 1. Mean value (over the Tiwi Islands surface) of the sensible heat fluxes for all the Hector events during the day.

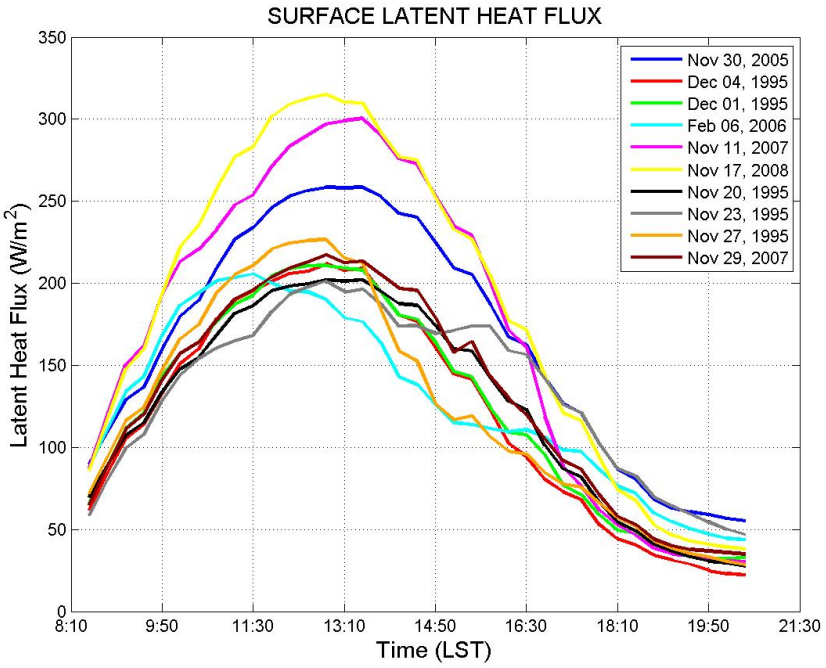

Fig. 2. Mean value (over the Tiwi Islands surface) of the latent heat fluxes for all the Hector events during the day.

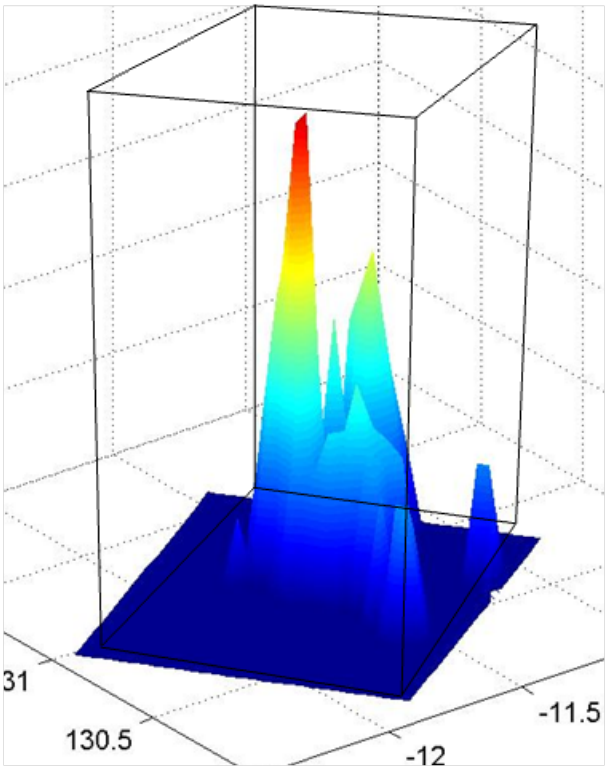

Fig. 3. The volume encapsulating Hector.