

Review of “The influence of sea- and land-breeze circulations on the diurnal variability of precipitation over a tropical island”

Scientific significance: 3

Scientific Quality: 3

Presentation Quality: 2

General comments

This work analyses the observed and modelled rainfall (especially in May and June) over Hainan Island off the coast of mainland China. It uses rain gauges and CMORPH rainfall data to compare with a number of convection permitting simulations performed using WRF with different setups, from NWP style to highly idealised. As such the work fits well into the scope of ACP. As a reviewer I felt capable of providing a review due to my experience using similar numerical weather prediction models and observational data sets, specifically focussing on the generation of convective storms. However, my specialism is not in the diurnal cycle of meteorology over tropical islands. As such, while I believe this work to be of good quality I am unable to comment on its originality compared to wider literature. The results show that: (1) WRF is capable (in this setup) of replicating the important aspects of the mean diurnal cycle compared to rainfall observations, (2) That removing the orography and coastal features made little difference to the diurnal cycle during the rainiest times of the year, (3) the dominant process that produces the diurnal cycle were shown to be the sea/land breezes caused by the relative surface heating/cooling of the island compared to the surrounding ocean and (4) that evaporative cooling as part of convective systems also plays an important role in the diurnal cycle.

I think that the structure of this paper needs some work. The abstract and methodology completely omit any detail about the range of simulations undertaken or the hypothesis that is being tested. Some of this detail is found in the results section but this means that it comes as something as a surprise when reading. I also think this work could have been presented in a more succinct way. Nineteen figures is probably too many and the structure of the work means that there is a lot of skipping between figures. For a number of figures only 1 or 2 panels are referred to in the text. Specifically I am unconvinced by the use of 2 m temperature and water vapour mixing ratio. Why not use thermodynamic quantities such as equivalent and virtual potential temperature. These give information about air masses (including temperature and moisture) and buoyancy and could still have important temperature and water vapour contours over plotted as needed. Also, from appearances it seems like NCL has been used for the creation of most figures making the calculation of such variables easy using pre-written scripts such as “wrf_eth” and “wrf_virtual_temp”.

The description of the processes that cause specific features is also lacking in some cases. If the authors have not tested what is driving the production of those features it should be

made clear, if they have then say so. Generally the written English in the manuscript reads well, however, there are a few instances when the wording is slightly odd or does not conform with standard scientific usage. For example simulations are referred to as being “convection-allowing” when it is more usual to describe them as being “convection-permitting”. While the intent is clear it should be changed to conform with previously published work. I also found the use of acronyms to be confusing “LSB” could just be referred to as “land-breeze”, “DP” could just be “diurnal precipitation” etc.

Specific comments

Abstract

23 and throughout Change “convection-allowing” to “convection permitting”.

24-26 Change to “ERA-interim reanalysis. The simulations have a slight overestimation of rainfall amounts and a 1-h delay in peak rainfall time. The diurnal cycle of precipitation is driven by the occurrence of moist convection around noon owing to low-level convergence associated with the sea-breeze circulation”

29 Change to “Generally precipitation dissipates quickly in the evening due to ...”

Introduction

Be much clearer about the novel nature of your work. You have cited many other pieces of work that look into similar processes and use similar models, what do you do that hasn't been done elsewhere.

49 What grid-spacing and model did Hassim et al., (2016) use? Include it here. Hassim looks at the importance of the sea breeze in the initiation of rainfall but focusses on large-scale atmospheric properties preferential to the propagation of systems offshore at night. This is not what you have said here, much more detail is required here.

50-51 Be specific about what was beneficial about orography and gravity waves. This is not enough detail.

52-53 In what way was island size important, how do the findings from these papers relate to the size of Hainan island?

57 Change to “Diurnal variability is only captured in some places and months where...”

61 There is a long list of references here after a very vague statement, please be much more specific.

73-76 This description of Hainan Island seems incongruous. Either remove, or, if this is part of the motivation for the work make it clear what impact your work has on Hainan and how these facts relate to that impact.

80 replace “rather” with “more”

87-96 Highlight why this work is unique.

Observation dataset and methodology

Don't describe the distribution of the gauges as homogeneous. Gauges are discrete with gaps in-between and so can never be homogeneous. Maybe just say they are "relatively evenly distributed across the island"

100 Why are they suitable for assessing the diurnal precipitation, what is the sampling frequency? Etc.

102 Give an idea of the time period you are talking about how many stations were built after 1951 and say what years new stations became operational. If a single station was built in 1951 and the rest were built in 2009 your current description would still be true. Be more specific!

103-110 Please use present tense e.g. "observations are augmented" not "observations were augmented".

105 Define NOAA and CMORPH

105 CMORPH is a retrieval not an analysis.

106-108 delete "as shown to be valuable in past studies of diurnal precipitation over China (e.g. He and Zhang 2010, ... Zhang et al., 2014)"

108 Change to "The CMORPH grid $0.7277^\circ \times 0.7277^\circ$ (approximately 8 km by 8 km) with a temporal resolution of 30 minutes.

111-121 You need to add a lot more detail about the specific experiments here. What version of WRF is used? Advanced Research WRF would be my assumption but it is not specified. A much greater amount of detail is needed about the schemes that were used with an explanation of why. If they were used to conform to Chen et al (2016) then describe the experiments performed in Chen et al (2016) too.

Each of your experiments has to be explained too, "A series of convection-allowing numerical simulations were performed" gives absolutely no detail about what you have done or why!

Observational analysis

136-137 Say that this is the monsoon season.

149-152 Replace with "No heavy rainfall or distinct diurnal variability is observed at stations along the southern coastline (blue dots on figure 1 and blue lines on figure 2).

149-165 What is the criteria for the different dot colours? I would assume that you would group them based on some geographical property e.g. southern coast, highlands, plain, northern coast, but it looks instead like they are grouped based on their diurnal cycle, which makes the grouping less useful.

157 swap “also are” to “are also”

162 change to These results indicate good agreement between CMORPH data and gauges, in particular...”

174 change to “for the whole year and over the whole island”

174-181 You need to highlight that the precipitation levels for panels a, b, c, d, k and l are so low that essentially the diurnal precipitation percentage is meaningless, or, even get rid of those panels.

177-178 delete “However, the diurnal precipitation... precipitation intensity.” You have just defined this, therefore this is obvious and not needed.

178-181 Even discussing March here seems pointless, March has almost no rainfall, so the magnitude of the diurnal component of almost nothing is not interesting at all. What seems more interesting is that rainfall amounts fall from May to July, increase in August again and then drop into October. However the diurnal percentage drops steadily throughout the season. You mention “physical processes”, what are these, be specific! Is it associated with synoptic scale storms, typhoons, prevailing winds? Say what and describe the processes too.

193 do you mean the Katabatic downhill jet, (which is a component of MPSs) which would happen on both sides of mountains. MPSs (to my understanding) are a feature of the lee side of mountain or plateaus, and given the direction of the prevailing wind it is unlikely that this would have an impact on the southern edge of Hainan.

196-198 Figure 6 discussed here is not every 3 hours as stated as panel (f) shows 1700, if this is due to this being the peak rainfall time, say this explicitly.

Numerical simulations.

228-234 This is very clearly lacking a clear description of the simulations that have been conducted as part of this study and the hypotheses that are being tested by performing them. It seems like much of the detail is included later, but this structure is confusing and should be changed.

240-241 change to “slightly higher peak values of simulated 2-meter temperature and simulated precipitation...”

242 Say “the chosen setup of WRF-ARW has the ability to...”

256 Evening rainfall along southern coast is missing, you should mention this, including why this might be.

265-269 This is an experiment setup description and should not be in the results section.

310 Fog is not the only potential reason, cold pool air could be colder, what impact does stability have on the formation of fog. It needs more detail of discussion.

311 I'm not sure that 14b does show what is stated. Maybe the colour scale of 14b is not appropriate?

316-318 15b and 15c don't show what you say they do, at 0900 the vectors does show land breezes at both coasts but at 0600 LST only one is clear in the figure.

319-325 The region that at 0900 LST had suppressed 2m temperatures has elevated 2 m temperatures at 1200 LST. You do not give an explanation for such rapid warming in one part of the domain while other areas (also over land have more gradual warming). I cannot work out what the cause might be from this work.

338 I don't believe that the deep prevailing wind is what gives that moisture pattern seen in 11e. This looks a lot more like what one would expect from low level convergence of moist air producing updraughts.

354 Quote numbers, specifically the times at which this occurs and rates.

361-364 Drying at 850 hPa and in cross section seems predominantly driven by downward limb of the circulation advecting dry air from aloft. Movement of moisture over the northern coast also seems to be much more likely associated with the dominant wind direction than land breezes.

377-382 Description of simulation should not be in results.

402-403 This statement needs investigation, how does the presence of a cold pool enhance inland penetration of the sea-breeze? What are the dynamics of the situation and what have you shown to support your assertion.

Summary

Summary needs to include the results above that I have said are lacking. Greater specificity and inclusion of the implications of this work in the broader context of previous and ongoing work.

425 Boundary conditions cannot be cyclic, they come from averaged ERA-Interim data! Do you mean lateral boundary conditions.

Figures

Latitude and Longitude should be marked on all maps and along the cross sections.

F2 Units should be mm hr^{-1}

F3 Units cannot just be mm. This has to be a rate mm hr^{-1} ? The caption is also not clear enough "Diurnal cycles of hourly average rainfall accumulations obtained from ..."

F4 This is a confusing figure given that we know that rainfall totals are inconsequential in panels a,b,c,d,k and l. More useful just to show months May-October when some rain actually falls. Also Caption and text refers to percentage, I think the values are not expressed as such given the range between 0.1 and 0.95.

F5 Units should be mm hr^{-1}

F6 Units should be mm hr^{-1} and numbers on scale are vertically squashed.

F7 Get rid of the horizontal mean lines, they are not very useful and make the plots more confusing.

F8,9,10,11,12,13,14,15,16,17 and 19 The comparison between (f) panels with F6 is at a different time. This doesn't have to change but it should be made clearer in the text that this discrepancy in comparison is present.

F13 seems almost entirely pointless as a figure. It seems like the authors have tried out some new visualisation software and were very keen to include a figure using the resultant images without considering what it is that they were trying to show with such an image. It is difficult to interpret and the colours on the only panel referred to (b) are almost impossible to distinguish.

F18 Need to include information about approximate height above the surface of the second model level, both in caption and in main text.