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# ***Interactive comment on “Atmospheric circulation patterns, cloud-to-ground lightning, and locally intense convective rainfall associated with debris flow initiation in the Dolomite Alps of northeastern Italy” by S. J. Underwood et al.***

**S. J. Underwood et al.**

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The authors would like to thank reviewer-1 for the very insightful and helpful comments regarding this manuscript. The reviewer’s time and effort is greatly appreciated.

Overview 1. Clarify the methodology Response: Will clarify by reorganizing and adding better definitions to items discussed

2. Describe all atmospheric variables used Response: Will give more detailed descriptions/definitions to each atmospheric variable used in the study

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3. Discuss why other atmospheric variable were not used Response: Will consider this, though there are so many variables that a lengthy discussion of those not used could become cumbersome.

4. Define Locally Intense Convective Rainfall and justify use in article Response: Will define LICR as it is used in the study

5. Why use both meso- $\alpha$  and meso- $\beta$  scale (remove meso- $\alpha$ ) Response: Will keep both spatial scales as there is analytical value to the meso- $\alpha$  scale in terms of confirming the widespread nature of convection (via cloud to ground lightning flashes). The meso- $\beta$  scale is at the heart of the analysis so this will be kept in the discussion as well.

6. Why not discuss the magnitude of each debris flow / the only link was the critical interval Response: The purpose of this study was somewhat limited as articulated in the hypothesis statements. There is no need in this particular study to incorporate the magnitude of each debris flow when the aim of the study is to simply related lightning and intense rainfall to the initiation of debris flow. In subsequent studies (of which there are a number in progress) the CG flash variables and rainfall rates may be related to debris flow magnitude. The use of the critical interval was intentional and was used as this 60 minute period seems to be when the “action” occurs—peak CG flashes, peak rainfall. Also if the intent is to develop warning protocol any warning that extends beyond 60 minutes (the critical interval) will be less than efficient.

7. Remove verbose language from the manuscript Response: Will do.

8. Shorten title Response: This we will discuss with the editors. As lead author I am not opposed to changing the title but also would be equally happy with the title as is.

Introduction 1. Page 5718 (line: 25-26) Irrelevant references Response: Respectfully disagree with this point. With reviewer and editors permission we would like to keep these references in place.

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2. Page 5719 (line 8) Different reference needed Response: Again the authors believe that this reference is relevant as it gives context to convective processes in the Mediterranean region.

3. Page 5719 (line: 9-10) Reference needed Response: Reference will be added

Background 1. Explain choice of atmospheric variables Response: Will add a very brief explanation of the use of atmospheric variables

2. Introduce the use of lightning in the study Response: This can be addressed here but may be adequately introduced in subsequent sections.

3. Why use multiple spatial scales Response: This may be better suited for explanation in the methods section

Study Area 1. Define “Critical Rainfall” Response: Will define “critical rainfall” at this point in the manuscript

Data and Methods 1. Again define atmospheric variables Response: Will define atmospheric variables incorporated in study

2. Elaborated on divergence field and vorticity fields Response: Will discuss vorticity at this point

3. Explain LI Response: Will define Lifted Index at this point

4. Explain method for flow regime classification Response: This is well defined but will give a more clarity to the reader

5. Page 5722 (line: 25-27): Reference table one not the Gregoretti and Della Fontana article Response: Authors prefer the reference to Gregoretti and Della Fontana as table VII in that article provides for information about each debris flow and lists those event not used in the study as well

6. Page 5723: Define “solar hour convention” / Just state that all are converted to UTC

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Response: Will simply state that all time stamps are UTC

7. Page 5724 (line: 6-7) refer to DF events not lightning so move to earlier section  
Response: Not sure what reviewer is requesting. The text seems to be adequate as is

8. Page 5424 and 5725: Add references from European Continent (Raibie 2007) Re-  
sponse: Will add suggested citation

Analysis 1. Page 5727 (line: 22) Define “omega” Response: Will define “omega”

2. Page 5729 (line: 12) Cut-off low appears at T-48 mention this at the appropriate  
point in the text Response: Will do

3. Page 5729 (line: 19) Remove “slacked configuration” Response: the text mentions  
a “stacked configuration” not slacked. A simple mis-reading, not a problem

4. Page 5729-30 (line: 1) Rephrase line 1. Response: Will re-write this sentence,  
which is “run-on”

Multi-scale 1. Too many graphics / please group events / restructure this section Re-  
sponse: Will compress this section and make more efficient for the reader

2. Page 5731 (line: 5-7) For which scale are the variables extracted? / or was it a 2.5  
x 2.5 grid Response: Will clarify the scale in the text

3. Page 5732 (line: 27) LI of -3/0 is considered unstable not very unstable / correct this  
Response: Will make this correction in text

4. Page 5745 (line: 3-5) Was there a an evaluation of RH and temp from reanalysis  
data to confirm Lines 3-5 Response: The mention of RH and Temperature will be  
removed from text

5. Page 5745: 70.62 would not be a strong correlation for n=12 and it is not significant  
at 0.01 level Response: Authors will consider this after consultation with statistical  
advisor

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Conclusion 1. Rename section “General Discussion and Conclusions” Response: Authors will consider this change as it does more clearly articulate the section’s content

2. Discuss limitations of data sets Response: Will do

3. Discuss magnitude of lightning flashes and the fact that this can only be determined after the fact Response: The authors may incorporate language to clarify this, though it is expected that the reader assumes that the magnitude can only be assessed post-storm

4. Compare results with other areas / does use of NCEP data (not soundings) bias results Response: This is beyond the scope of this particular analysis, but will be considered

Tables and Figures 1. Better captions for some figures Response: Will review and make appropriate changes

2. Figure 2 and 3 both distinguish similar elements Response: Will review and make appropriate changes

3. Figure 3, cannot read numbers (Grid ID’s) / no reference to these numbers in caption Response: The numbers are simply grid ID’s applied to the study area and have no bearing on the analysis. This will be made clear to reader in the figure caption

4. Table 1 missing reference to Degetto et al. Response: This is an oversight and will be corrected.

5. Table 4-6 cannot read number on contours of 500hPa charts / explain lines, dashes, and shading Response: Will address this by enlarging selected contour labels

6. Figure 7-18: Use figures of 6-hour CGF (now in supplement B) instead of the critical interval graphics Response: The author’s argue that the supplement would be inappropriate for this portion of the study and would prefer to illustrate the critical interval. Supplement B is important and it is hoped that the reader will make use of the supple-

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mental material

Technical Comments Response: Will address all and make corrections in text

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 5717, 2015.

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