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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-2 for their observations and critique of this manuscript. The suggestions will make the study accessible to a wider audience.

Overview: 1. Remove jargon and define better the terms used Response: Will define terms in language that all readers can comprehend

2. Discuss false positives Response: The study does not set out to do this and this request is a bit beyond the scope of the article. The primary focus of the study is to

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illustrate that there is in fact a relationship between multi-scale atmospheric processes and debris flow initiation. Subsequent studies that attempt to build warning protocols will address false positives as well as false negatives

Major Comments: 1. Again get rid of majority of meteorology jargon and make readable for broader audience and define terms when first used or make glossary of terms / Example of terms to be defined include: Meso- $\alpha$ , solar hour convention, geopotential height, etc. Response: Authors feel that these terms are necessary however we will define terms in language that all readers can comprehend

2. Need an estimate of the number of false positives if this method is to be used for warnings Response: Will not be address in this study but will be subject of subsequent studies

3. Figures 7-18 need to have debris flow time shown on the figures / ID each event as STH, AL or HL Response: The author's apologize for not making it clear that the time (UTC) is in fact the observed time of debris flow initiation. This will be made clear in figure captions. Also in figure captions the events will be identified as STH, AL, or HL

4. Sections 6.1 and 6.2 are too long / to many details / suggest shortening each discussion Response: Agreed. These sections will be condensed and made more clear and more efficient for the reader

5. Add the complete results of the correlation analysis and the lead-time analysis in two simple figures Response: Will do.

Minor Comments Page 6 (line: 24) Define "proximal" Response: Will define "proximal" in text

Page 7 (line: 18-23) Are the adverse impacts of synoptic "0-hour" varying for each event, some prior to DF and some post DF Response: Very good observation. This has not been considered and there are implications. A caveat will be added to the text when defining the zero-hour.

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Page 3 (line: 8-10) What is the approximate return period for debris flows in the Dolomites for basins in the study / add reference for such Response: This will be added along with a citation

Page 8 (line: 14) Add reference at end of this sentence Response: Authors are not sure that a reference is needed in this case, however we will add a citation for a study that has used these parameters in the past

Page 9 (line: 5-10) State how many groups were identified Response: Will do.

Page 9 (line: 27) Which ArcGIS applications were used Response: Will provide basic explanation of how ArcGIS was employed

Page 10 (line: 4) Which atmospheric variables were used Response: This is addressed elsewhere in the manuscript

Page 10: Was lead-time analysis used for both synoptic and meso scale data Response: This will be addressed in text

Page 10: Discuss the details of the correlation analysis Response: Authors provide citations for reader

Page 13: What is “mature phase” / define and give significance Response: This will be defined more clearly for the reader

Page 14: Who defined the “critical interval” / give reference Response: The critical interval is defined and discussed in the text. The authors are the first to use the term critical interval to describe the 60 minute interval preceding debris flow initiation

Page 16: Define “lifted index” in methods section Response: Will define “Lifted Index”

Page 28: Rainfall in mm/ min but claim was only five minute resolution / Explain Response: Five minute temporal resolution has been the standard for cloud to ground lightning analysis, however both lightning and rainfall data is available at higher resolution. Language can be changed to lessen confusion for reader

Page 32: Revise language regarding the significance of correlation between CGF and LICR Response: Will change language based on consultation with statistical references

Table 2: Add group type (STH, AL, HL) for each / Explain why most peak charges are negative and why one is positive / implication of the polarity Response: Will add STH, AL, and HL to each caption. Will explain flash polarity for the reader

Figure 2: Label elements of the figure—meso- $\alpha$ , meso- $\beta$ , synoptic,... Response: Authors will provide more detail regarding scale in figure captions

Figure 3: Label elements of the figure—meso- $\alpha$ , meso- $\beta$ , synoptic,... Response: Authors will provide more detail regarding scale in figure captions

Figure 4: Provide definitions of line, dashes, arrows, shading / meso- $\beta$  dot to figures, and add STH, AL, HL to caption Response: Authors will define the symbols, lines, etc. to assist reader in interpretation and label each as STH, AL, or HL

Figure 5 and 6: Same as above Response: Authors will define the symbols, lines, etc. to assist reader in interpretation and label each as STH, AL, or HL

Figure 10: Why is CGF absent from figure Response: There was no CGF during the critical interval for this event

Editorial Comments Response: All will be addressed in text

Please also note the supplement to this comment:

<http://www.nat-hazards-earth-syst-sci-discuss.net/3/C2873/2016/nhessd-3-C2873-2016-supplement.pdf>

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

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