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Natural Hazards and Earth System Sciences
Discussions
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Interactive comment on "A fast monitor and real time early warning system for landslides in the Baige landslide damming event, Tibet, China" *by* Yongbo Wu et al.

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We are appreciated for the referee's comments and their careful reading of our MS. Please find bellow our answers to all items raised.

1. The MS describes a monitoring and warning system for the Baige landslide, which occured twice. Two types of sensors were installed, fracture sensors and GPS sensors, using the Beidou satellite system. The first part of the MS handles the overall concept of the system, whereas the second part describes the models and algorithms used to detect the slide. Comments: There is only a poor connection from the first part to the second one. It remains unclear, why this kind of installation was used and

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why only one type of sensors was used in the second part. There are no references to other systems that are on the market, which act in a similar way. Reply: As for the reason about why this kind of installation is used, we are sorry not mention it clearly. Actually, it is described in section 2.3. There are no monitoring device before and the monitoring system should be built immediately to ensure the safety of the emergency rescue working for dredging Barrier Lake which is great threat to the life of millions people living downstream of Jinsha River. The two types of sensors mentioned in this paper take a short time to installation and need not do much geotechnical engineering work comparing with other sensors. Meanwhile, this place has no phone signals, so the Beidou satellite communication system is used to transmit the measure data outside. Ad-hoc network is used to build the on-site monitoring system, which on the one hand, improves the system robust, and one the other hand, needs less Beidou communication terminal unit. That why we choose this system with only two types of sensors and on-site ad-hoc network to undertake the monitor mission. We have look forward to the recently references that concern the Landslide Early Warning Systems(LEWS), there sure have no other similar system on the market, but the technical used in the system is mature and it can be called an integrated innovation. As to the relationship of the first part and the second part, our opinion is that the second part is supplement of first part. The precursor character early warning is always an unsolved problem in the LEWS according references. So we try to build an early warning model that can find the precursor character of specific landslide. The model discussed in this paper is a try to do that only with the deformation information of specific landslide. So the connection between the two parts is that the fast monitor system in the first part provide only the deformation data of specific landslide and the second part describes how to use the deformation data to make precursor character early warning.

2. Figure 4: Please indicate the fault scarp and describe why the sensors has been installed at the specific locations. Reply: Thanks again for the valuable suggestion. The fault scarp has been marked out in figure 4 in red bold line. Also an explanation of why the sensor has been installed at the specific locations is add at the end of

section 2.3 which is: “The sensor is located nearby the back edge fault scarp, neither too far away nor too close. Because too far away from the fault scarp the deformation of landslide got by the sensors is not real, while too close the installation work can be dangerous.”

3. How are the data monitored (measuring interval versus recording interval), accuracy of the sensor data. Reply: The measuring interval and recording interval is 10 minutes. The Beidou receiver accuracy given by the manufacture are horizontal direction within 2mm and vertical direction within 3mm. The fracture monitor accuracy given by the manufacture is within 1mm.

4. The second part of the MS starts with a description of methods used. At this time the reader does not know why the different methods were used and what is the benefit of combining these methods instead of just using the Beidou data? Reply: The reason we use these methods is that we want to find the precursor character of specific landslide implicit in deformation data measured by Beidou receiver.

5. What data are really measured? Horizontal displacement, spatial displacement (x,y,z)..? Figure 8: time axis is wrong, mention the time of failure What does 30 minutes statistics mean (running average?), also in connection with the warning time (Fig. 9). What is the difference in using raw data or averaged data? Reply: In this paper the horizontal deformation data is used. Time axis in figure 8 have been corrected. The 30 minutes statistics means 30-minute interval sampling not just running average and the warning time at the follow discussion is under the basic unit of 30-minute. The raw data is sampled at the interval of 10 minutes and the deformation of specific landslide in 10 minutes may be 0 mm so it cannot reflect the dynamic character of specific landslide. If we use the 30 minutes statistic data the deformation data of specific landslide is a dynamic curve in Fig.9.

6. Kalman filtering chapter: Please check the indices (seems to be wrong) Chapter 3.4.:what does . . .deformation monitored in infinite time... mean? Fig. 7: Seems to be

the key of the MS: Please indicate and describe the steps: What is the input to one model, what is the output, how to integrate the results to the next model step. . ..in order to get a warning message. This is the method and has to be clearly presented. Why you used displacement, velocity and acceleration. These data are of same origin? Figure10: velocity and acceleration does not have the unit [mm]. What are the results from BD1 – 4? FFT: Why you chose 64 frequency bands? Hz is defined as number per second, but this is not true in that case. The time base may be 10 or 30 minutes???? SVM training: How to differentiate precursor slide character to other data? Reply: We have check the indices in Kalman filtering chapter, there sure have some mistakes. “infinite time” in chapter 3.4 should be “finite time”, it is a spelling mistake, we have corrected it. Fig.7 has been redrawn and the input, output of the model is clearly described in chapter 3.4. The displacement, velocity and acceleration is used to build the Kalman filter model, they all derive from the beidou receivers in this paper. The unit of velocity and acceleration should be mm/Ts and mm/(Ts)ˆ2 respectively. Fig.10 is redrawn. The result from BD1 – BD4 is draw in red curve in Fig.10 while the blue curve is the original data. We have chosen 64 numbers of acceleration data between November 3 and November 4,which is the time around the secondary landslides happening, to conduct FFT analysis. So 64 is not the frequency bands, actually it the FFT Length. In this paper, we simplify the sampling interval(30-minite) to 1s, so the biggest frequency band can be treat as 1Hz, we think it is more easy to express the FFT result by this way. In the SVM training, we made the precursor slide character sequences according FFT result, for example if the FFT give a character frequency of 0.2Hz, then we choose k=5 to form training sequence A’n like that A’n=[An,A(n+1),. . .,A(n+4),label]. Principle of the label value in there is that the data between November 3 and November 4 are marked with label “+1” which represents the precursor slide character, others are marked with label “-1” which represents the non-precursor slide character. The we train the SVM until it converges, then we use the SVM to give a predication of An and the result Bn is a sequence of “+1” and “-1”.“+1” represents the precursor slide date and “-1” represents the other. That how we differentiate precursor slide character to other

data.

7.Is there a difference in the data of fracture and Beidou sensors? How long does it take to issue a warning with this system (6*10 oder 30 minutes)? Reply: Yes, the fracture sensor measures the width of a fracture, it is a relative displacement. The Beidou sensor measures the absolute displacement and it have a big measuring rang than fracture sensor, that's why in the early waring model we only use the Beidou data. It depends on the interval Ts and "step k" , as to the time take to issue a warning. Generally it takes Ts*k to issue a warning. In this paper, Ts=30 minutes, k=5, and it takes 150 minutes to issue a warning.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-48/nhess-2019-48-AC1-supplement.pdf

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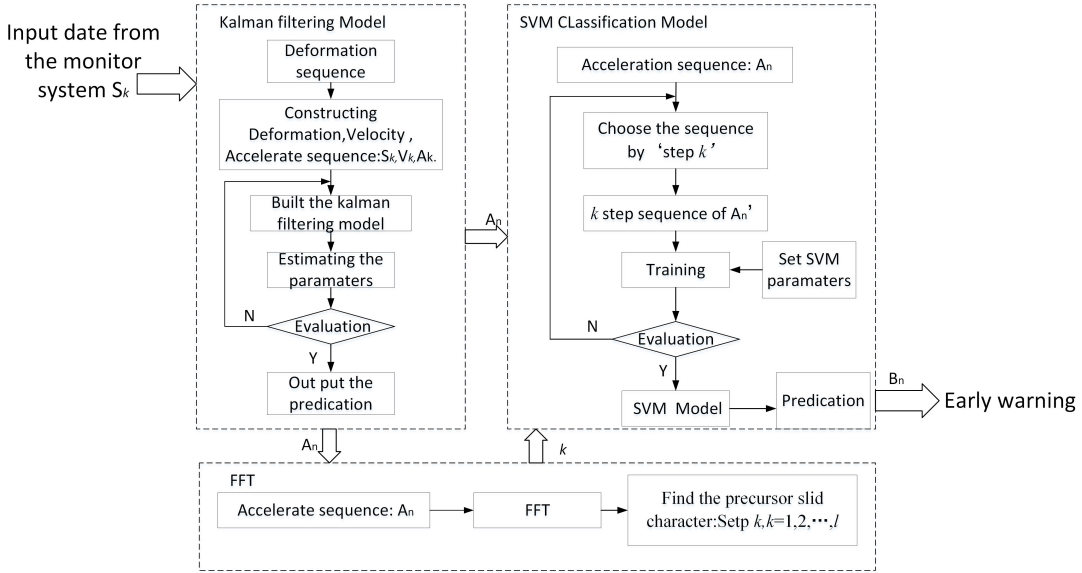

Fig. 1.

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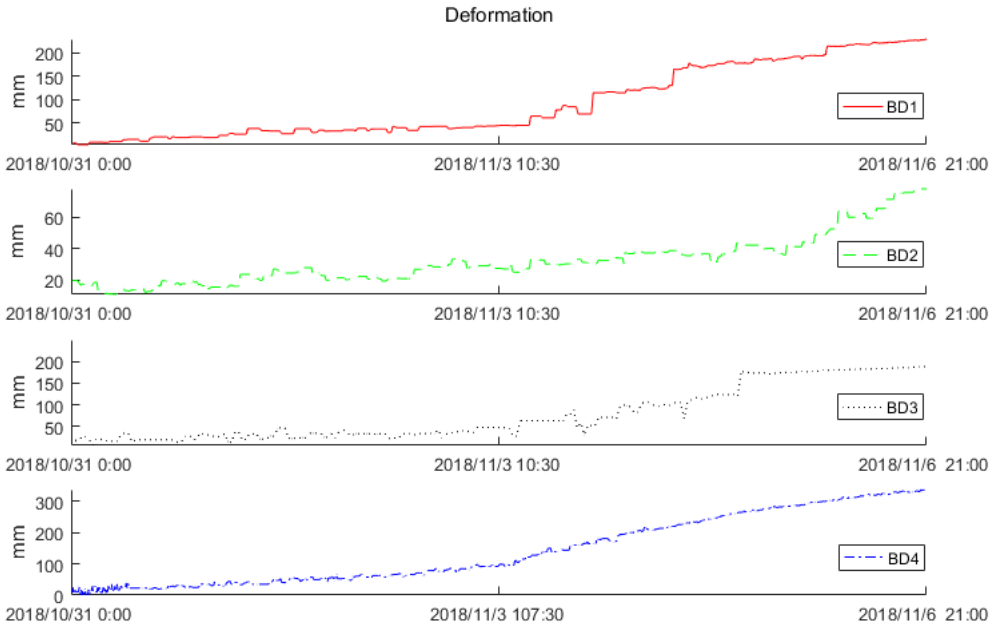

Fig. 2.

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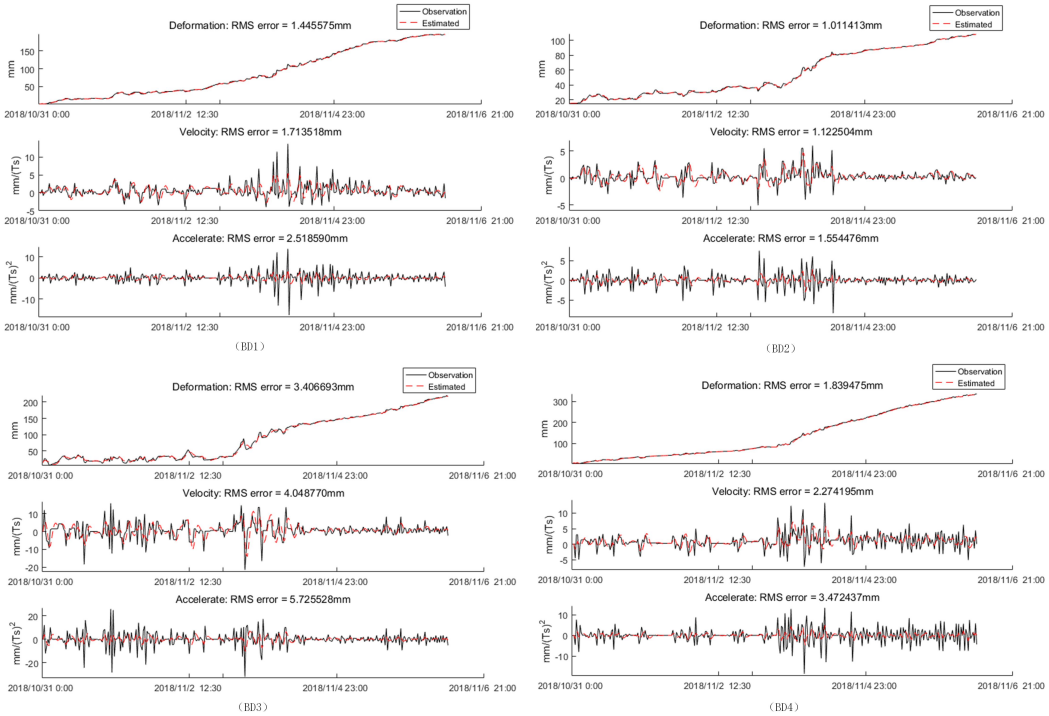

Fig. 3.

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