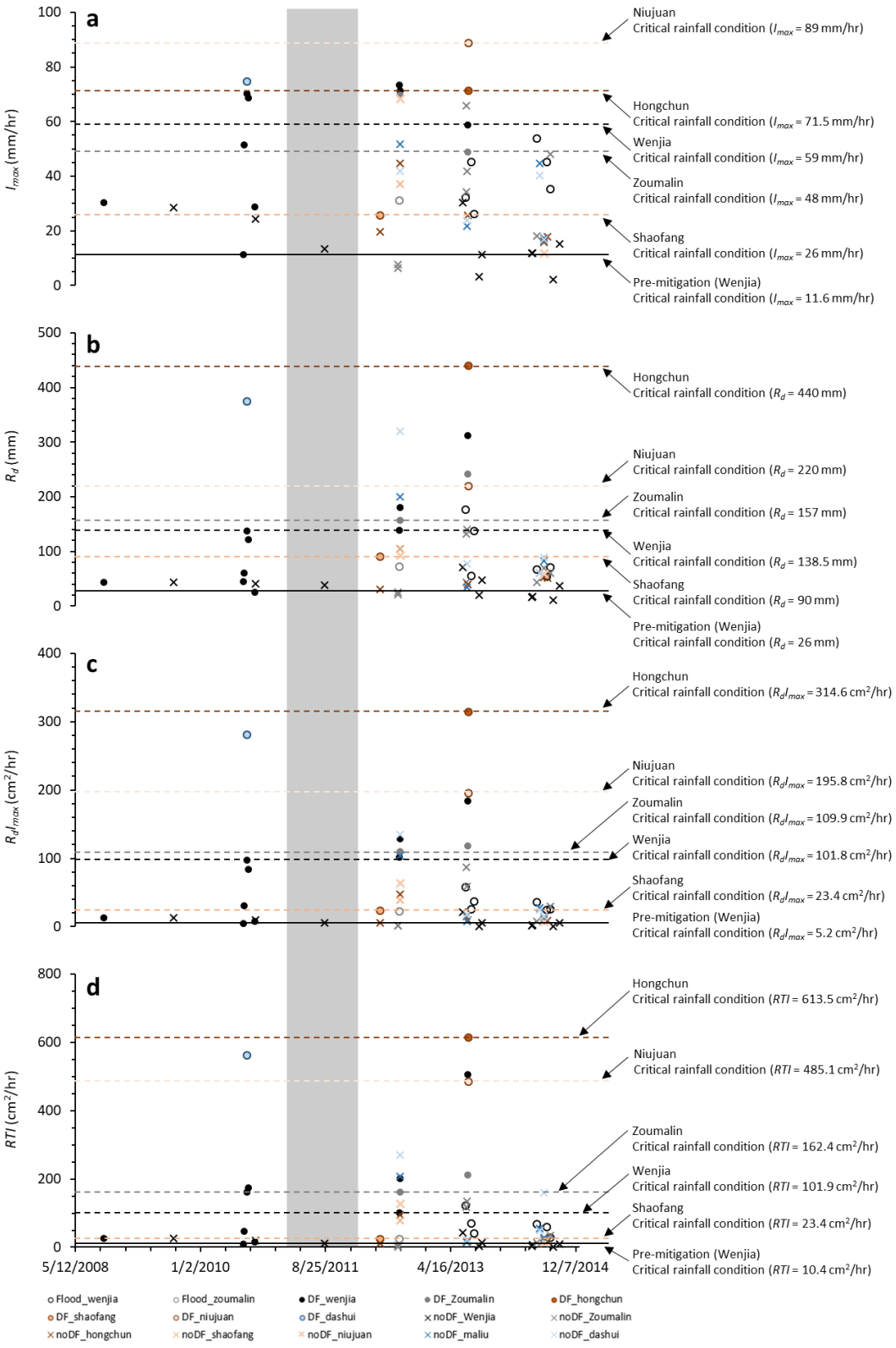

Fig. 6. The variations in the rainfall parameters contributing to the pre- and post-mitigation debris flows in the studied gullies. The gray region represents the period of the construction of the mitigation system, during which no dataset was collected systematically, and thus not included in the analysis.

References

Burchfiel, B.C., Royden, L.H., van der Hilst, R.D., Hager, B.H., Chen, Z., King, R.W., Li, C., Lü, J., Yao, H., and Kirby, E., 2008, A geological and geophysical context for the Wenchuan earthquake of 12 May 2008, Sichuan, People's Republic of China: GSA Today, v. 18, p. 4, doi:10.1130/GSATG18A.1.

Chen, J.C., Jan, C.D., and Huang, W.S., 2013, Characteristics of rainfall triggering of debris flows in the Chenyulan watershed, Taiwan: Natural Hazards and Earth System Science, v. 13, p. 1015–1023, doi:10.5194/nhess-13-1015-2013.

Cui, P., Zhou, G.G.D., Zhu, X.H., and Zhang, J.Q., 2013, Scale amplification of natural debris flows caused by cascading landslide dam failures: Geomorphology, v. 182, p. 173–189, doi:10.1016/j.geomorph.2012.11.009.

Dai, F.C., Xu, C., Yao, X., Xu, L., Tu, X.B., and Gong, Q.M., 2011, Spatial distribution of landslides triggered by the 2008 Ms 8.0 Wenchuan earthquake, China: Journal of Asian Earth Sciences, v. 40, p. 883–895, doi:10.1016/j.jseaes.2010.04.010.

Fan, X., Juang, C.H., Wasowski, J., Huang, R., Xu, Q., Scaringi, G., van Westen, C.J., and Havenith, H.-B., 2018, What we have learned from the 2008 Wenchuan Earthquake and its aftermath: A decade of research and challenges: Engineering geology, v. 241, p. 25–32.

Gorum, T., Fan, X., van Westen, C.J., Huang, R.Q., Xu, Q., Tang, C., and Wang, G., 2011, Distribution pattern of earthquake-induced landslides triggered by the 12 May 2008 Wenchuan earthquake: Geomorphology, v. 133, p. 152–167, doi:10.1016/j.geomorph.2010.12.030.

Guo, X., Cui, P., Li, Y., Ma, L., Ge, Y., and Mahoney, W.B., 2016, Intensity-duration threshold of rainfall-triggered debris flows in the Wenchuan Earthquake affected area, China: Geomorphology, v. 253, p. 208–216, doi:10.1016/j.geomorph.2015.10.009.

Huang, R., and Fan, X., 2013, The landslide story: Nature Geoscience, v. 6, p. 325–326, doi:10.1038/ngeo1806.

Huang, J., Ju, N.P., Liao, Y.J., and Liu, D.D., 2015, Determination of rainfall thresholds for shallow landslides by a probabilistic and empirical method: Natural Hazards and Earth System Science, v. 15, p. 2715–2723.

Huang, R., and Li, W., 2009, Analysis of the geo-hazards triggered by the 12 May 2008 Wenchuan Earthquake, China: Bulletin of Engineering Geology and the Environment, v. 68, p. 363–371.

Huang, R., and Li, W., 2014, Post-earthquake landsliding and long-term impacts in the Wenchuan earthquake area, China: Engineering Geology, v. 182, p. 111–120.

Iverson, R.M., 1997, The Physics of Debris Flows: Reviews of geophysics, v. 35, p. 245–296.

Iverson, R.M., Reid, M.E., Logan, M., LaHusen, R.G., Godt, J.W., and Griswold, J.P., 2011, Positive feedback and momentum growth during debris-flow entrainment of wet bed sediment: Nature Geoscience, v. 4, p. 116–121, doi:10.1038/ngeo1040.

Jan, C., and Chen, C., 2005, Debris flows caused by Typhoon Herb in Taiwan, *in* Debris-Flow Hazards and Related Phenomena, Springer, p. 539–563.

Jan, C.D., and Lee, M.H., 2004, A debris-flow rainfall-based warning model: J Chin Soil Water Conserv, v. 35, p. 275–285.

Jan, C., Lee, M., and Huang, T., 2002, Rainfall Threshold Criterion for Debris-Flow Initiation: National Cheng Kung University, p. 9104–9112

Liu, F.Z., Xu, Q., Dong, X.J., Yu, B., Frost, J.D., and Li, H.J., 2017, Design and performance of a novel multi-function debris flow mitigation system in Wenjia Gully, Sichuan: Landslides, v. 14, p. 2089–2104.

Ma, C., Wang, Y., Hu, K., Du, C., and Yang, W., 2017, Rainfall intensity–duration threshold and erosion competence of debris flows in four areas affected by the 2008 Wenchuan earthquake: Geomorphology, v. 282, p. 85–95.

National Development and Reform Commission, 2008, The state overall planning for post-Wenchuan Earthquake restoration and reconstruction.:

Ouimet, W.B., Whipple, K.X., Royden, L.H., Sun, Z., and Chen, Z., 2007, The influence of large landslides on river incision in a transient landscape: Eastern margin of the Tibetan Plateau (Sichuan, China): Geological Society of America Bulletin, v. 119, p. 1462–1476, doi:10.1130/B26136.1.

Parker, R.N., Densmore, A.L., Rosser, N.J., de Michele, M., Li, Y., Huang, R., Whadcoat, S., and Petley, D.N., 2011, Mass wasting triggered by the 2008 Wenchuan earthquake is greater than orogenic growth: Nature Geoscience, v. 4, p. 449–452, doi:10.1038/ngeo1154.

Shen, Z.-K., Sun, J., Zhang, P., Wan, Y., Wang, M., Bürgmann, R., Zeng, Y., Gan, W., Liao, H., and Wang, Q., 2009, Slip maxima at fault junctions and rupturing of barriers during the 2008 Wenchuan earthquake: Nature Geoscience, v. 2, p. 718–724, doi:10.1038/ngeo636.

Tang, C., Van Asch, T.W.J., Chang, M., Chen, G.Q., Zhao, X.H., and Huang, X.C., 2012, Catastrophic debris flows on 13 August 2010 in the Qingping area, southwestern China: The combined effects of a strong earthquake and subsequent rainstorms: Geomorphology, v. 139–140, p. 559–576, doi:10.1016/j.geomorph.2011.12.021.

Tang, C., Li, W., Ding, J., and Huang, C., 2011, Field Investigation and Research on Giant Debris Flow on August 14, 2010 in Yingxiu Town, Epicenter of Wenchuan Earthquake: Earth Science, v. 36, p. 172–180 (in Chinese).

Wang, Q., Qiao, X., Lan, Q., Freymueller, J., Yang, S., Xu, C., Yonglin, Y., Xinzhao, Y., Tan, K., and Chen, G., 2011, Rupture of deep faults in the 2008 Wenchuan earthquake and uplift of the Longmen Shan: Nature Geoscience, v. 4, p. 634–640, doi:10.1038/ngeo1210.

Xu, Q., Zhang, S., Li, W.L., and Van Asch, T.W.J., 2012, The 13 August 2010 catastrophic debris flows after the 2008 Wenchuan earthquake, China: Natural Hazards and Earth System Science, v. 12, p. 201–216, doi:10.5194/nhess-12-201-2012.

Zhang, L.M., Zhang, S., and Huang, R.Q., 2014, Multi-hazard scenarios and consequences in Beichuan, China: The first five years after the 2008 Wenchuan earthquake: Engineering Geology, doi:10.1016/j.enggeo.2014.03.020.