Linking long-term debris flow and typhon activity in the Japanese Alps: insights from tree-ring records

*Juan Antonio Ballesteros Canovas[1], Ryoko Nishii[2], Yoshihiko Kariya[3], Fumitoshi Imaizumi [4], Norikazu Matsuoka[5], Markus Stoffel[6]

1. The National Museum of Natural Sciences, Spanish Scientific Research Council, Madrid, Spain, 2. Center for Transdisciplinary Research, Niigata University, Japan, 3. Senshu University, Japan, 4. Faculty of Agriculture, Shizuoka University, Japan, 5. Environmental Sciences University of Tsukuba, Japan, 6. Climatic Change and Climate Impacts, Institute for Environmental Sciences, University of Geneva, Boulevard Carl-Vogt 66, CH-1205 Geneva, Switzerland

In Japan, mass-movements such landslide or debris flow processes are common in mountain areas favoured by a rugged topography and specific geological and climate conditions. The occurrence of these events causes large damages and losses to infrastructures and inhabitants, as involve an important sediment transport capacity. These events can evolve far-reaching impacts downstream as well. Debris flow research in Japan has been profusely developed over the last decades, with important advance in the physical process understanding. However, the monitoring of these events is highly challenging since the initiation areas are normally located in inaccessible slopes of the upper mountain catchments. Thus, observation of past debris flow events is generally constrained to the last decades. There is, consequently, a lack of long-term records of occurrence of debris flow events, avoiding the recognition of variability and analyses of trigger mechanism. Here we present a multicentury tree ring debris flow reconstruction in two torrential catchments, with contrasting size (11.8 km^2 and 1.4 km^2), in the Japanese Alps. Overall, more than 200 affected trees were sampled along the debris-flow fans. Debris flow dating was based on the analyses of growth disturbances, but also on the spatial location of each tree. The identification of the debris flow events is at seasonal scale. Our results are then correlated with local rainfall data and the historical tropical storm and typhoon tracks. We identified 38 and 24 debris-flow events for the period 1800-2018, respectively. Overall, we also observe an intensification of debris-flow activity during the 1960s and recently since the 2000s (~ 0.6 events *x* $year^{-1}$). The long-term debris-flow variability correlates with averaged sea surface temperatures in the Pacific Ocean from May to November. Since 1956, the reconstructed debris flows records correlate well with the passage of historical typhoons. In particular, we observe 14 matches with extratropical cyclones, 11 matches with severe tropical storms, 9 matches with tropical depressions and 7 typhoons, as the recent cases of Sinlaku (September 2008) and Halong (July 2014). These results imply that intensive rainfall is needed for occurrence of debris flows in the region. Moreover, our results represent a success use of tree-ring records to decipher mass-movement in Japan, pointing to a potential linkage with the warming of the Pacific Ocean.

Keywords: debris flow, historical typhoons, tree rings, Japanese Alps

