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Impact of the 2018 drought on soil moisture across different agricultural and forest sites in Southwestern Germany

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The effects of the 2018 drought were significant in Southwestern Germany. The lack of precipitation caused the soils to dry out so that soil moisture often reached minimum levels and crop yield was well below average. However, the spottiness of the scarce precipitation led to strong regional differences. In the framework of a long-term monitoring program, we investigated soil moisture development at two agricultural sites in the province of Baden-Württemberg. The two field sites, which differ in terms of soil physical properties and cultivated crops, are located in the Upper Rhine Graben near Heidelberg ("Grenzhof") and in the Kraichgau near Pforzheim ("Katharinentaler Hof"). The Katharinentaler Hof site is on a loess plateau, where the soils are deep and show a cohesive structure, while the Grenzhof site is characterised by more sandy soils, which developed on quaternary gravel from the Rhine and its tributaries. Another interesting feature is the crop irrigation at the Grenzhof site during the drought. Our measurements were carried out with TDR and FDR probes at hourly intervals and in five different depths with triple replication. Furthermore, the observations were compared with soil moisture data from a forest monitoring site in Rhineland-Palatinate ("Merzalben"), approx. 60 km away from the Grenzhof site. Therefore, we investigated how drought affects two different kinds of ecosystems. In addition to the measurements, water balance and soil moisture were simulated with three different hydrological models: TRAIN was applied for the three sites, DAISY for the agricultural sites, and LWF-BROOK90 for the forest. The measurements at Grenzhof showed that the average soil moisture in the root zone during the main growing season in summer 2018 did not drop below the values of summer 2017. Here, irrigation prevented excessive soil water stress. In 2018, the mean soil moisture at Katharinentaler Hof only fell below the lowest values of summer 2017 at greater depths (90 cm). There, field capacity of the soil is higher than at Grenzhof and the few precipitation events during summer 2018 were sufficient to counteract excessive dehydration at all soil depths. The simulation of soil moisture with the TRAIN model showed good results for the Grenzhof site over the period 1st April to 27th September 2018. The natural development of the drought at Grenzhof without anthropogenic control was demonstrated by a scenario with the TRAIN model, in which the irrigation events were not taken into account. According to this, soil moisture would already have dropped to wilting point by the end of June 2018, which would have caused extreme drought stress for the plants. This clearly shows that agricultural irrigation can have a strong influence on soil moisture in soils with comparatively low field capacity during drought and thus should be considered in hydrological models.