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Impact of climate change on intense rainfall events in the Ligurian Sea region due to strong MCSs

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Intense rainfall events occasionally occur in the area around the Ligurian Sea as strong mesoscale convective systems (MCSs) form and back-build. These events almost exclusively occur during the autumn months and can produce rainfall amounts over 500 mm, leading to severe flooding in portions of southeastern France and northwestern Italy. Often the events are tied to strong convergence zones that develop when larger-scale southeasterly flow over much of the western Mediterranean Sea collides with north or northwesterly flow that spills over the relatively low passes of the northwestern Apennine mountains in Liguria and over nearby areas of the Sea.

It is well-known that the waters of the Mediterranean have been warming even faster than the global average in recent decades. It seems plausible that the warmer waters could result in greater tropospheric water content and potentially more extreme rainfall events, or greater peak rainfall during an event. Prior research, however, has been mixed regarding rainfall trends in the larger Mediterranean region.

We specifically examine tendencies in heavy rainfall events that are linked to MCSs by comparing historical and future climate simulations performed with a 12 km horizontal grid spacing version of the Weather Research and Forecasting (WRF) model run for the EXPRESS-Hydro (EXtreme PREcipitation and Hydrological Climate Scenario Simulations). Events are identified using thresholds of convergence and precipitation rate at grid points, along with rain volume over the Ligurian Sea region for both the past climate (1979-2005) and a future climate (2023-2049) forced by EC-Earth. Events themselves are found to increase by roughly 15-25% in the future climate, depending on the criteria used for classification. Meanwhile, the number of grid points meeting the criteria and the number of 3 hour time windows where the conditions are met increase even more, by roughly 30-50%, implying broader areal coverage and more persistent systems in the future climate. Peak 3-hourly rainfall volume within systems also increases by roughly 10%. The increases in frequency of the extreme MCS events is especially pronounced in the late autumn, with the greatest increases during the month of December, as might be expected with a warmer climate allowing autumn conditions to extend later into the year.