World Weather Attribution

Likely influence of climate change in severe flooding in Santa Catarina, January 2025

The event

Record-breaking rainfall along the coast of Santa Catarina state led to extensive flooding and landslides on Thursday 17th January 2025. Thirteen municipalities declared a state of emergency, including the capital, Florianópolis. One person died, and several were displaced, with many roads and highways blocked.

Rainfall accumulations exceeded 300 millimetres (mm) in less than 48 hours in some regions, especially along the coastal zone. For example, in the municipality of Florianópolis, volumes reached 390 mm, almost twice what was expected for January. The EPAGRI-CIRAM and CEMADEN stations recorded 340 mm in Biguaçu and Tijucas, 211 mm in São João Batista, 206 mm in Antônio Carlos, 152 mm in Ilhota, 149 mm in Santo Amaro da Imperatriz and Palhoça, 146 mm in Itajaí and 140 mm in Balneário Camboriú.

The extreme rainfall was driven by intense moisture flow from the ocean associated with cyclonic circulation off the coast, which caused extreme orographic rainfall. The locals know this phenomenon as “lestadas” (rain from the east). Lestadas are known to bring excessive rainfall to the coastal regions of Santa Catarina during summer. These events are common during weak La Niña years, such as the event of December 1995, when a 165 mm fell over the Florianópolis metropolitan region in 36 hours. However, the volume of rain this recent event brought in such a short time is unprecedented. Here we review the available evidence to evaluate whether climate change may be exacerbating the intensity of such events.

Insights from previous studies

Rainfall trends and variability in Southern Brazil (comprising the states of Paraná, Santa Catarina, and Rio Grande do Sul) are influenced by a combination of the seasonal patterns, interannual climate phenomena such as the El Niño Southern Oscillation (ENSO), decadal oscillations, and climate change. This region is characterised by a subtropical climate (transition between tropical and temperate climate) with a continuous supply of moisture from the Atlantic Ocean and the Amazon region (Teixeira and Satyamurthy, 2007). Mesoscale convective systems (an organised complex of thunderstorms) are the most important rain-producing weather systems in this region mainly during spring/summer (from September to February).

To date, recent trends in extreme precipitation in the region are overwhelmingly increasing. For instance, Ávila et al. (2016) analysed precipitation trends and their link to flash floods and landslides in southeastern Brazil, revealing a significant increase in extreme rainfall from 1978 to 2014, especially over mountainous areas. These changes in precipitation patterns have already impacted streamflow in the region, with an increasing trend in floods between 1980 and 2015 over most of the river basins in southern Brazil (Chagas et al., 2022). Specifically in Santa

Catarina, the majority of weather stations in the Itajaí river basin exhibit increasing trends in extreme precipitation indices (Murara et al., 2019). Summarising the evidence to date, the IPCC AR6 (Seneviratne et al., 2021) reported increases in the frequency and intensity of heavy precipitation events over this region. These trends are also projected to increase across most of southern Brazil with further warming (Avila-Diaz et al., 2020).

Extreme event attribution studies for specific events add further insight to the picture of changing extremes. A recent World Weather Attribution study on the April-May 2024 flooding in Rio Grande do Sul followed the rapid attribution protocol. This involves synthesising evidence from observed trends and climate models to investigate the role of global mean surface temperature and ENSO in the likelihood and intensity of a given event.

This study found that both climate change and the El Niño conditions led to increases in the likelihood and intensity of the extreme rainfall event, with each driver roughly doubling the likelihood and increasing the intensity by 6-9% compared to a preindustrial world and neutral ENSO phase, respectively. It additionally found that in a world a further 0.8 °C warmer than present, such events would double in likelihood again and become a further 4% more intense.

Implications for Santa Catarina floods

There is little evidence on the role of the current La Niña on this event, though such events are known to be common during La Niña years. For the probable influence of climate change on this event, there is a combination of evidence from increasing trends in extremes at different scales and attribution studies of recent extremes. This is also in agreement with our physical understanding of short-term precipitation extremes, which are amplified in a warmer atmosphere due to its tendency to hold more moisture, by roughly ~7% per °C. This gives us confidence in concluding that the extreme rainfall that resulted in the recent flooding in coastal Santa Catarina was made more likely and more intense by anthropogenic climate change, and similar events will continue to become more likely and intense as long as the world burns fossil fuels.