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# Assessment and sensitivity studies of Numerical Weather Prediction Models during Catastrophic Flooding in Rio Grande do Sul

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## Abstract

The catastrophic flooding in Rio Grande do Sul (RS), from late April to mid-May, impacted over 300 municipalities, causing millions of dollars in damages, over 170 fatalities, and displacing thousands. This event was driven by a combination of meteorological factors, including atmospheric blocking over the Pacific and Atlantic Oceans; stagnation of cold air masses over RS; continuous influx of moisture and warm air from Northern Brazil at low levels; and the influence of El Niño, which tends to amplify rainfall in RS. These factors resulted in severe storms, heavy rainfall, hail, and reports of strong wind gusts. Intense precipitation caused flash floods, urban flooding, and landslides, particularly in the Metropolitan Area of Porto Alegre, the capital of RS.

The Center for Weather Forecasting and Climate Studies (CPTEC) of the National Institute for Space Research (INPE) provided numerical weather predictions during the RS floods using one global model (BAM) and three limited-area models (WRF, BRAMS, and ETA) from April 29 to May 2. This study aimed to compare these models with the Global Forecast System (GFS) of the United States National Centers for Environmental Prediction (NCEP) and the Integrated Forecast System (IFS) coupled with the Nucleus for European Modelling of the Ocean (NEMO). The INPE models indicated a misplacement of precipitation maxima. Even the GFS and IFS models struggled to accurately represent the amount and location of heavy rainfall in RS. Overall, WRF better represented the spatial distribution of precipitation three days in advance, while GFS more accurately forecasted the area and intensity 48 hours in advance. BAM had limitations in representing rainfall areas, often placing them more centrally in the state. Conversely, ETA and BRAMS misplaced the main rainfall areas, shifting them south of RS even 24 hours in advance. All models underestimated rainfall in northern and northeastern RS.

Our objective is also to identify potential sources of model errors through numerical experiments using the new generation CPTEC/INPE global model, named Model for Ocean-land-Atmosphere prediction (MONAN), which employs an unstructured grid based on the Model for Prediction Across Scales (MPAS) dynamical core. By conducting sensitivity tests on boundary conditions such as soil moisture and sea surface temperature, we aim to pinpoint the inaccuracies in the location and intensity of rainfall from April 29 to May 2 on the short-range.

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