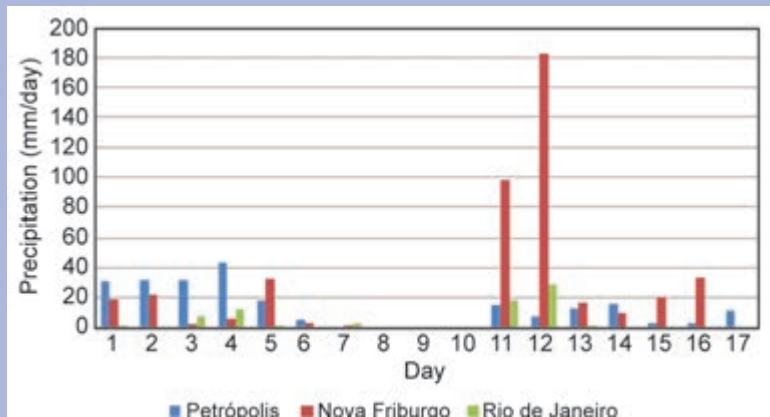


## SIDEBAR 7.1: THE 2011 INTENSE RAINFALL AND FLOODS IN RIO DE JANEIRO—J. A. MARENGO AND L. M. ALVES

During January 2011, heavy rainfall sparked flash flooding and mudslides across the highlands of the state of Rio de Janeiro in southeastern Brazil, devastating mountain towns. According to Brazilian official sources, the floods and landslides claimed the lives of 916 people and left 35 000 people homeless. This was one of the worst natural disasters in Brazil's history.

During the first half of January, rainfall in Brazil was primarily concentrated in a swath from the states of São Paulo, Minas Gerais, Goiás, and southeastward to Rio de Janeiro. While the 1961–90 average rainfall for January in that region is about 230 mm, the rainfall accumulated during January 2011 was approximately 460 mm. According to the Brazilian Meteorological agencies CPTEC INPE (<http://www.cptec.inpe.br>) and INMET (<http://www.inmet.gov.br>), the anomalous rainfall was caused by the South Atlantic convergence zone (SACZ), a typical

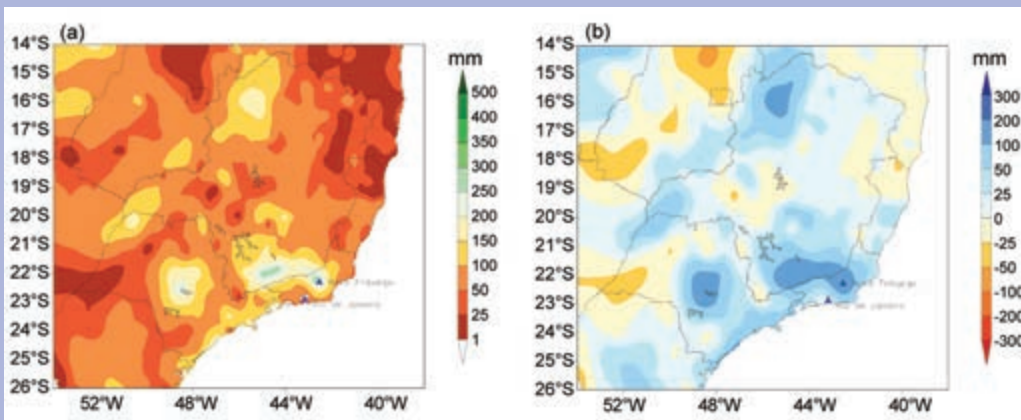
summer time rainfall-producing mechanism that was fed by moisture transport coming from the Amazon region during that period and by a favorable signal of convection and precipitation by the Madden–Julian oscillation (MJO), that persisted until mid-January. The large-scale pattern was characterized by a weakening of La Niña in the equatorial Pacific Ocean, while over the South Atlantic Ocean, off the coast of southeastern Brazil, sea surface temperatures were 2°C above normal. Three episodes of SACZ were detected: 1–7 January, 11–17 January, and 18–21 January. The two earlier episodes produced intense low-level convergence over southeastern Brazil,



**FIG. SB7.2.** Daily precipitation (mm) during 1–17 January 2011 in Petrópolis (blue bar), Nova Friburgo (red bar), and Rio de Janeiro (green bar). Monthly January average (1961–90 base period): Nova Friburgo: 232.5 mm; Petrópolis: 201.5 mm; and Rio de Janeiro: 136.4 mm. (Source: INMET)

intensified by plenty of moisture coming from the Amazon region. As a consequence, rainfall in the highlands of Rio de Janeiro during 1–7 January was about 86 mm–160 mm and about 300 mm in 11–17 January (Fig. SB7.1), well above the January average.

These conditions favored weeks of saturated soil, and together with the intense rainfall from 11 to 13 January, floods and mudslides were triggered. Numerous houses located in risk areas on the deforested slopes of the mountains were buried, killing hundreds of people. In one of the most affected cities, Nova Friburgo, rainfall on 11–12 January was 182.8 mm, 79% of the monthly average of 232.5 mm (Fig. SB7.2). According to the Civil Defense of the state of Rio de Janeiro, 428 people died in this city alone. Croplands were destroyed. Highways, roads, hospitals, and sewage systems all collapsed. The isolation of these cities and the risk of epidemics left the population and local governments in a permanent state of alert.



**FIG. SB7.1.** (a) Accumulated rainfall (mm) 11–17 January 2011 in the southeastern Brazil region and (b) rainfall anomalies (mm) for the same period from the 1961–90 base period. The cities of Rio de Janeiro and Nova Friburgo are marked on the map. (Source: CPTEC-INPE)