EXTREME RAINFALL AND THE FLOOD OF THE CENTURY IN AMAZONIA 2009—JOSE. A. MARENGO

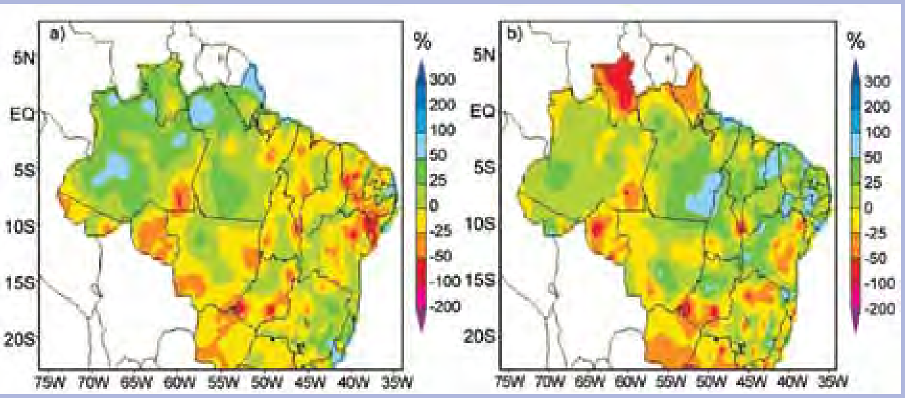

Fig. 7.12. (a) December 2008 to February 2009 rainfall anomalies and (b) February to May 2009 rainfall anomalies (% relative to 1961–90). (Source: CPTEC/INPE.)

During the austral summer and winter 2009, the Amazon basin, drained by the Amazon River and its tributaries, was hit by heavy flooding. This year the water level rose higher and stayed longer than it has in several decades. According to national and international press, almost 376 000 people were left homeless and 40 died because of the floods. The communities living on the river banks and on the urban areas of cities like Manaus suffered the impacts of the rising waters, and the floods affected the exotic wildlife and the endangered species. Damages were estimated on the order of $200 million U.S. in the Brazilian state of Amazonas.

During the summer (December 2008–February 2009), above normal rainfall was found in the entire Amazon region (Fig. 7.12a), reaching 100% above normal in northern and western Amazonia, where the basin of the Rio Negro is located. Brazil's Center for Weather Forecasts and Climate Studies reported large rainfall anomalies during January and February 2009. During late summer and fall (Fig. 7.12b), rainfall in northern and central Amazonia was between 25% and 50% above normal, and the largest rainfall anomalies (up to +100%) were detected in the border region of eastern Amazonia and northeast Brazil. In central Amazonia, rainfall in April, May, and June was between normal and above normal. In the city of Manaus, during the first 15 days of June 2009 it rained almost 30 mm above the climatology for that month (117 mm).

According to the measurements of the State University of Manaus (UEA), the heavy rainfall of January–February in northwest Amazonia led to high water levels of the Solimões River at Tabatinga in March–April. The water levels reached 12.5 m, compared to the long-term climatology of 11.8 m. The water levels of the Rio Negro at Manaus and the Amazonas at Obidos reached high values a few months after. The level of Rio Negro at Manaus reached maximum values between May and July. The measurements at Manaus site reflected the contribution of the Rio Negro and, to some degree, the Rio Solimões that extend over Amazonia. It takes about four to five months for rain falling on the upper basin of the Rio Negro in northwest Amazonia to travel downstream to the Manaus gauge site. Therefore, the anomalously high levels measured during June and July were due to the intense rainfall that fell during January and February over northwestern Amazonia and, to a lesser degree, to the intense rainfall in May and June over central Amazonia, where the rainfall takes one month or less to reach the gauge site at Manaus.

Historically, according to the Brazilian Geological Survey, the floods in Amazonia in 2009 show the highest levels in the history. In July, the level of the Rio Negro in Manaus reached 29.75 m, a new record high since the beginning of data collection in 1903. The five previous records observed in Manaus were: 29.69 m (1953; Fig. 7.13), 29.61m (1976), 29.42 m (1989), 29.35 m (1922), and 29.17 m (1908). Levels of the Amazon River at Óbidos and the Tapajos River at Santarem also showed records highs. Furthermore, the levels of the Amazonas, Marañón, Napo, and Corrientes Rivers in the Peruvian Amazon also experienced record level/discharge highs, according to the meteorological service of Peru (SENAMHI).

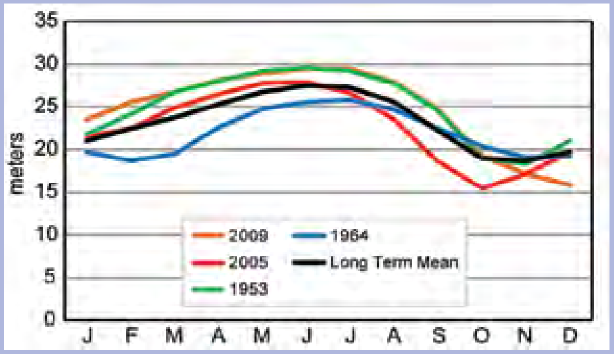

Fig. 7.13. Monthly mean water level of the Rio Negro in Manaus, Brazil, for some extreme years: dry (1964, 2005), wet (1953, 2009), compared to the 1903–86 average. (Source: CPTEC/INPE.)

During the austral fall, northeastern Brazil, Amazon region, and northern Bolivia observed normal rainfall. The largest anomalies were observed on the border between eastern Amazonia and northeast Brazil, with rainfall anomalies greater than 100 mm per month until June, which normally marks the beginning of the dry season. The ITCZ was intense. In some places in the Amazon, rainfall was 300 mm above normal. In the Peruvian Amazonia, the river levels were about 1 m–2 m above normal. In northeast Brazil, 49 deaths occurred as a consequence of floods. More than 408 000 were left homeless and damages to highways and irrigation structures were reported. In May, eight people died because of the breaking of a small dam in the state of Piauí in Northeast Brazil, and 600 families were forced to leave their houses. The estimated losses due to the floods in Brazil until July were about $800 million U.S. On the other hand, during April, a severe drought was reported in Paraguay, with negative precipitation anomalies around -160 mm in the south of the country. This represents a new historical record minimum precipitation for that month.

During the spring (September–November), when the rainy season normally starts, anomalously wet conditions were reported in most of southeastern South America, causing floods in Paraguay, where thousands of people were forced to evacuate along the Paraná River. The anomalously wet conditions detected over most of this region affected the harvest of rice and other vegetables.

In November, while extremely large rainfall anomalies were detected over Uruguay, southern Brazil, southern Paraguay, and northern Argentina, dry conditions were reported on the coast of Ecuador and the South American monsoon region. In the same region, the last two weeks of November were characterized by dry weather and relative humidity of about 15%. In December, very wet conditions (rainfalls of 100 mm–150 mm above normal) were reported in southeastern Brazil and northern Paraguay. Intense rainfall and landslides in the city of Angra dos Reis, Rio de Janeiro, killed 53 people on New Year's Eve, and intense rainfall episodes were detected in most of southeastern South America in December. From 31 December 2009 to 1 January 2010, the total rainfall was 275 mm in Angra dos Reis. The cities of Cochabamba, Chuquisaca, Tarija, and Santa Cruz in Bolivia were affected by floods, forcing more than 10 000 families into food insecurity. During the last three months of 2009, rainfall was below normal in Northeast Brazil.

3) Southern South America—M. Bidegain, M. Skansi, O. Penalba, J. Quintana, and P. Aceituno

Countries considered in the section are Chile, Argentina and Uruguay. The annual mean temperature and total rainfall anomalies for Southern South America are in Figs. 7.11a and 7.11b, respectively.

(i) Temperature

In Argentina and Uruguay, above-normal temperature was observed during austral autumn (MAM), with mean anomalies ranging from +0.5°C to +1.5°C. Anomalies from +2.0°C to +3.0°C in west-central Argentina during these months led to the warmest austral autumn over the past five decades. In contrast, the austral winter (JJA) brought cold conditions. For instance, the mean temperature in July was more than 3°C below normal in northeastern Argentina, southern Paraguay, northern Uruguay, and southern Brazil. July 2009 was the second coldest July of the past 50 years (after July 2007) for many locations in Uruguay and Argentina. In August, monthly mean temperature anomalies greater than +1.7°C were reported in northern Argentina and Uruguay, and anomalies greater than +1.4°C were found in November. During the spring (SON), positive anomalies were observed in the north and northwest of Argentina, where record high values were registered with respect to the last 50 years. In contrast, negative temperature anomalies on the order of -2°C characterized the climate of the Patagonia region during this season although the annual mean temperature remained from +0.5°C to +1°C above the climatological mean.

In Chile, very large anomalies, both positive and negative, characterized the temperature regime during 2009. The daily maximum temperatures during the austral summer were well above the climatological average, with mean anomalies of +2.3/+3.0 standard deviations for January/March, defining new records since 1914 at Santiago (33°S) and since 1961 for the region between 33°S and 37°S (Fig. 7.14). This behavior, associated with an anomalously intense subtropical anticyclone in the SE Pacific, persisted in the fall when anomalies close to +3.0°C were reported for the April mean daily maximum temperature in this region. In contrast, the 2009 austral spring (SON) was the coldest in the past 50 years in the region south of 37°S due to a large frequency of incursions of cold air masses from higher latitudes. This was particularly extreme during November, when anomalies from -2°C to -4°C were reported for the mean daily maximum temperature at stations between 35°S and 53°S, damaging the fruit ripening process in central Chile.

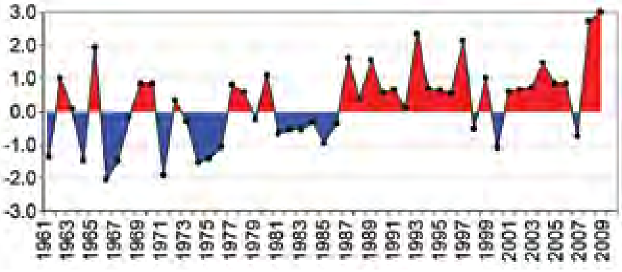

Fig. 7.14. Composite for standardized mean anomaly of daily maximum temperature along the subtropical west side of South America (Central Chile) for January-March, based on measurements at Santiago (33.5°S), Curicó (35.0°S) and Chillán (36.6°S). Standardization was done using 1971–2000. (Source: Dirección Meteorológica de Chile.)

(ii) Precipitation

During the first half of 2009, the exceptionally low precipitation in southeastern South America was driven by a La Niña episode, which began during the last quarter of 2007 and prevailed through 2008. La Niña gradually weakened during the first half of 2009. The positive SST anomalies that returned to the tropical Pacific Ocean by the middle of the year favored strong positive rainfall anomalies in southeastern South America during October–December 2009.

Large parts of eastern Argentina, Uruguay, Paraguay, and southern Brazil experienced a prolonged and intense drought during the first half of 2009, which caused severe damage to many socioeconomic sectors (agriculture, cattle farming, and hydro power generation). These conditions exacerbated the severe water shortage for the summer crops (soybean, maize, and rice) and pastures.

In particular, in Uruguay the mean rainfall deficit reached -20% during January– June, with values of -39% reported for the stations of Salto and Melo. In northern and northeastern Uruguay, rainfall returned to normal conditions in September. Exceptionally wet conditions followed in November, when monthly rainfall reached 613 mm in Artigas and 540 mm in Rivera (more than four times the monthly average) (DNM 2009). This heavy precipitation explains the fact that, although all months from January to August were drier than normal, the year ended with a positive rainfall anomaly of +31% in Uruguay.

In Argentina, the cumulative rainfall during 2009 was predominantly below the 1961–90 average. Deficits larger than -40% were observed in the Cuyo region, northeast of Patagonia, southeast of La Pampa, and north of Cordoba. In some cases the annual rainfall was the lowest since 1961. For example, the 369.1 mm measured at Pilar beat the previous record of 514.8 mm in 1962. Regarding anomalous wet conditions, above-average rains were registered in the northeast and east portion of the country (Iguazú +142% and +Gualeguaychú 149%) and also in the extreme northwestern territory and southern Patagonia (Bariloche +130%).

As in Uruguay, rains were markedly deficient in almost all the Argentinean territory until spring, giving continuity to an extremely dry period that had persisted since 2008, with important consequences for agriculture and livestock, water resources, and even some towns that had no water for consumption.

In spite of the El Niño conditions that persisted in the equatorial Pacific since May 2009, winter (JJA) rainfall in central Chile was near the climatological average, although it was characterized by a considerable intraseasonal variability at the monthly scale with May, July, and September being anomalously dry and June and August being anomalously wet. On the other hand, large-scale circulation anomalies linked to El Niño contributed to rainfall anomalies above +40% that were observed in the region 39°S to 46°S during the spring (SON).

(iii) Notable events in Argentina

The severe rainfall deficit of 2008 continued during almost all of 2009, mainly in the humid pampa and the west-central region. This reduction of rainfall not only affected the agriculture and cattle ranching, but also the lagoons and lakes.

On 2 February, a severe storm with heavy rains, high winds, and hail killed a dozen of people in the city of Rosario (second largest city in Argentina). On 8 February, local intense rain events generated landslides in Tartagal, Salta Province, northwestern Argentina, with 500 people evacuated and two deaths.

Between 21 and 23 July, a snowfall episode affected almost half the country, reaching an unusual intensity in some areas (south of Buenos Aires, La Pampa, and the eastern portion of Rio Negro).

During August, intense and persistent rainfall and snowfall episodes affected the western part of Mendoza and the provinces of Neuquén, Chubut, and Rio Negro (western and northwestern Patagonia Cuyo). During the same month, significant fires hit central Argentina (Cordoba and San Luis). A combination of lack of rainfall, high temperatures and strong winds made it difficult to control them.

During the night of 7 September, a category F4 Tornado hit the district of San Pedro, leaving 10 people dead and 17 severely injured.