and as little as 20% of normal in the Andean region (Departments of Tolima, Huila, Cauca, Valle) and Caribbean (central and northern) regions in Colombia. In Ecuador, precipitation was above normal during the first half of the year, with anomalies up to 200% of normal on the central coast. During the second half of the year, precipitation over the Amazon region was 50%–80% of normal; meanwhile, precipitation was 120%–150% of normal in the northern and central coastal regions during September–November. In Peru, extreme below-normal precipitation was observed in the northwest of the country and in the southern Andes. Above-normal precipitation prevailed during the second half of 2015 in the southern and central Amazon region.

In northern Bolivia, precipitation was above normal from January to August, with anomalies up to 159% of normal during March–May. During September–November, 88% of normal precipitation was observed. Over the Altiplano region (western Bolivia), precipitation was predominately above normal with anomalies ranging from 117% to 149% of normal throughout the year. In central Bolivia, precipitation was near normal. Above-normal precipitation (up to 150% of normal) was recorded in southeastern Bolivia during June–August. Below-normal precipitation (63% of normal) was observed during September–November.

(iii) Notable events

On 24 March, unusually heavy rainfall caused landslides in the District of Lurigancho-Chosica (Lima region), Peru, leading to eight fatalities and destroying over 150 houses.

During April, northwestern Venezuela experienced a week-long heat wave, with some stations registering daily maximum temperatures as high as 40°C (April average maximum temperature is 34.9°C).

Northern Ecuador was affected by flooding during December that caused crop and cattle losses.

Colombia and Venezuela were impacted by a severe drought during most of the year, causing restrictions in water supply for human consumption, agriculture, and hydropower generation.

2) Tropical South America east of the Andes—J. A. Marengo, J. C. Espinoza, J. Ronchail, and L. M. Alves

This region includes Brazil, Paraguay, southern Venezuela, and the Amazon lowland sectors of Peru, Colombia and Bolivia.

(i) Temperature

Monthly mean temperatures across most of the region were about 1°–3°C higher than average most of the year. In São Paulo, Brazil, the January mean temperature was 3.5°C above normal—the second warmest January since 1943. In October, temperatures were about 4°–5°C above normal in southeastern and west central Brazil, with the most notable warmth in Rio de Janeiro, which recorded a maximum temperature of 40°C, compared to the average October maximum temperature of 25°C. Maximum temperatures were slightly above average for autumn (March–May) and winter (June–August), with a mean temperature anomaly of +1.0°C. Notable temperatures of 2.0°–3.0°C above average were observed across Paraguay in June.

Various cold fronts during May–September brought well-below-freezing temperatures, hail, and the highest snowfall in 10 years in the Andean region, located more than 3500 meters a.s.l.

(ii) Precipitation

Below-average rainfall (20%–75% of normal) was observed over southeastern Brazil, eastern Bolivia, and Paraguay during January–March. An atmospheric blocking pattern and a high pressure system over large parts of tropical Brazil and the South Atlantic, together with the absence of the South Atlantic convergence zone during January, were responsible for the lack of precipitation over most of subtropical South America east of the Andes, which lasted through mid-February. Between April and December, rainfall totals of 20%–50% of normal were recorded in northeastern Brazil, north-central Amazonia, eastern Peru, and the Amazon lowland sectors of Colombia and Venezuela. A weak and/or anomalously northward displaced intertropical convergence zone contributed to the below-average precipitation.

(iii) Notable events

Drought conditions in southeastern Brazil that began in January 2014 (Nobre et al. 2016) continued through April 2015, particularly over the Cantareira reservoir system, which supplies water to nearly half of São Paulo's population (about 18 million residents). Summer (December–February 2014/15) rainfall was marginally less than average. However, during November and December 2015, above-average rain (100–150 mm month^{-1} above normal) fell over the region, allowing the Cantareira Reservoir system to recover its volume.

The drought conditions that started in 2012 in northeast Brazil continued to persist in 2015, however, with less severity (Fig. 7.12a). Figure 7.12b shows that very dry conditions were present across the northern

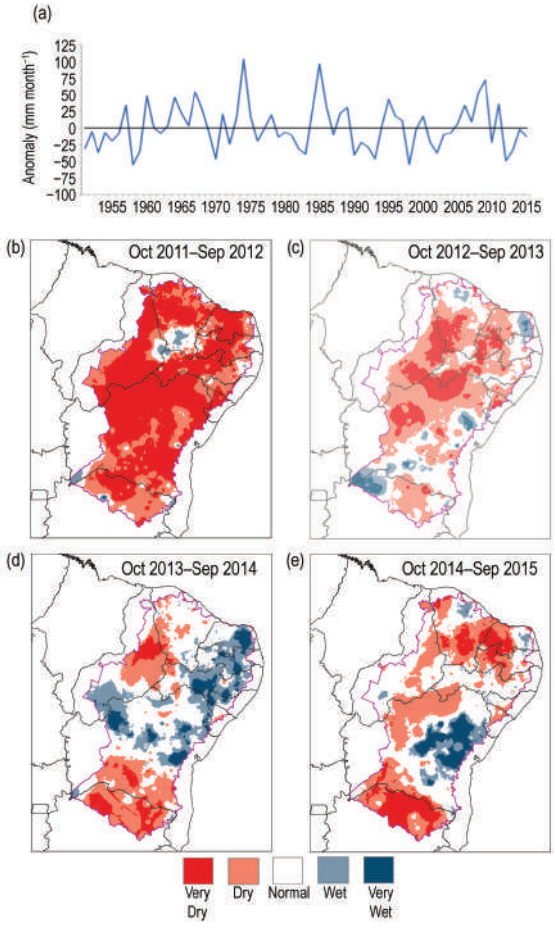

Fig. 7.12. (a) Average rainfall anomalies (mm month^{-1}) during the peak rainy season (Feb–May) in northeast Brazil for 1951–2015. (Source: Global Precipitation Climatology Centre; updates from Marengo et al. 2013.) (b) Categories of observed precipitation based on percentiles for northeast Brazil during the hydrological year Oct–September (b) 2011/12, (c) 2012/13, (d) 2013/14, and (e) 2014/15. (Source: CEMADEN.)

part of the state of Bahia, and particularly in the semiarid region of northern northeast Brazil and the region between southern Bahia and the northern parts of the state of Minas Gerais. The extreme dry conditions observed in this region contributed to an increase in wildfires and damages to crops, with local residents depending on water to be trucked in.

Between January and April, 32 000 families were affected by heavy rains in the lowlands of Bolivia, with the worst impacts occurring on 20 February when the Acre River flooded the city of Cobija, capital of Pando in western Amazonia.

As a result of heavy rains in the northwesternmost Amazonian regions (north of the Peruvian Amazon and western state of Amazonas in Brazil), the Peruvian government declared a state of emergency on 9 April. During March and April, more than 115 000 people were affected by floods. Also, in April, flooding and landslides affected more than 20 000 people in Colombia. On 29 June, heavy rainfall in southern and southwestern Venezuela caused flooding, with more than 40 000 people affected. On 4 April, a severe storm hit several towns in the department of Concepción in northern Paraguay, affecting houses, crops, and farm animals. Authorities estimate that 5000 people were affected. Precipitation patterns shifted in October, as is typical during the presence of El Niño in the tropical Pacific Ocean (see section 4b), resulting in above-average rainfall across the same region. Abundant rainfall over southern Brazil and most of the La Plata basin caused significant floods.

During 8–10 July, minimum temperatures between –18°C and –22°C were measured in high areas of the Arequipa, Moquegua, Tacna, and Puno regions of the Peruvian southern Andes. According to the Empresa de Pesquisa Agropecuaria e de Extensao Rural of the state of Santa Catarina (EPAGRI) in southern Brazil, the same cold spell affected the southern region of Brazil, with minimum temperatures ranging between –3.0°C and 2.0°C in the highland city of São Joaquim on 5 July, compared with the average July minimum temperature of 6.1°C.

The above-normal rainy season in southeastern South America, which typically starts in October and ends in May, was 100–300 mm above normal in December 2015, leading to floods in Paraguay, Bolivia, and southern Brazil due to the overflow of the main rivers. The highest levels in 110 years were recorded along the Paraguay River, which produced slow-onset flooding that forced the evacuation of 18 545 families in the city of Asunción. Four people died and 130 000 were evacuated by the end of the year.

3) Southern South America—M. Bidegain, J. L. Stella, M. L. Bettolli, and J. Quintana

Argentina, Chile, Uruguay, and adjacent areas of southern Brazil are considered here.

(i) Temperature

Above-normal temperatures were observed over most of southern South America (SSA) during 2015, with mean temperature anomalies between +0.5°C and +1.5°C (Fig. 7.11a). According to preliminary analysis of the official data for 2015, the mean temperature anomaly for Argentina and Uruguay was estimated to be +0.71°C and +0.51°C, respectively. Argentina had its second warmest year in the country's 55-year period of record, behind 2012, with the past four years (2012–15) the four warmest on record. The cities of Buenos Aires, Iguazú, Santa Fé, Rosario, and Pehuajó were each record warm in 2015. Chile observed warmer-than-