Chapter 1

Regional Climate Changes: Where and How?

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1.1 Regional Rainfall Changes

Global change fascinates scientists and authorities, and predictions for climatic and environmental impacts are rapidly advancing. Large modelling exercises, as reported by IPCC (2001) and Siedler et al. (2000), can answer many questions on climate change. Local consequences can be predicted by studying records on rainfall, river runoff and temperature. Good international cooperation has made these accessible from international databanks (NOAA 2002; BAFG 2002; NCEP 1996) through the internet.

The oldest rainfall data collected are from 1707 on in Winterthur, Switzerland, and many series have 150- to 200-year records. These data can be downloaded and checked against the information given by the IPPC-Working Group III (IPCC 2001), that rainfall trends of continents range between +50% century^{-1} and –50% century^{-1}. Thus, for example at Manaus, Brazil (Fig. 1.1) rainfall has increased by 20% since the early 20th century, and will probably continue to do so in the future. This is also reflected in the river runoff, such as for the Amazon tributary Rio Solimões (Fig. 1.2).

Decreasing rainfall of 63% century^{-1} occurs for example at La Serena, Chile (Fig. 1.3), a region which already has a low precipitation. Such a trend will have disastrous consequences for water resources of the region.

Since rainfall increases by 8.2% over the continents and decreases by 0.1% over the oceans (Semenov and Bengtsson 2000), it is clear that global warming is augmenting evaporation from the oceans, thus providing land with more rain. The annual pattern is, however, irregular, which means that for regions with increasing rainfall, the extremes with high rainfall also become more pronounced, with risks of flooding. For regions with decreasing rainfall, the low rainfall extremes will lead to higher risks of drought.

Not all climate changes are caused by the greenhouse effect. They may be due to natural atmosphere/ocean cycles. For South America, the El Niño Southern Oscillation (ENSO) is often taken as a cause of extreme flooding. However, by comparing the years of both maximum and minimum rainfall and river runoff with those of the years (+1) of El Niño and La Niña, it became apparent that a significant coincidence between rainfall and river runoff maxima (and minima) and El Niño or La Niña was practically absent (Table 1.1), except for in Ecuador and Peru.

1.2 Regional Temperature Changes

Atmospheric temperature records for the last 50 years make it possible to discern regional temperature trends for pressure levels from 1 000 hPa (surface) to 10 hPa (27 km). The

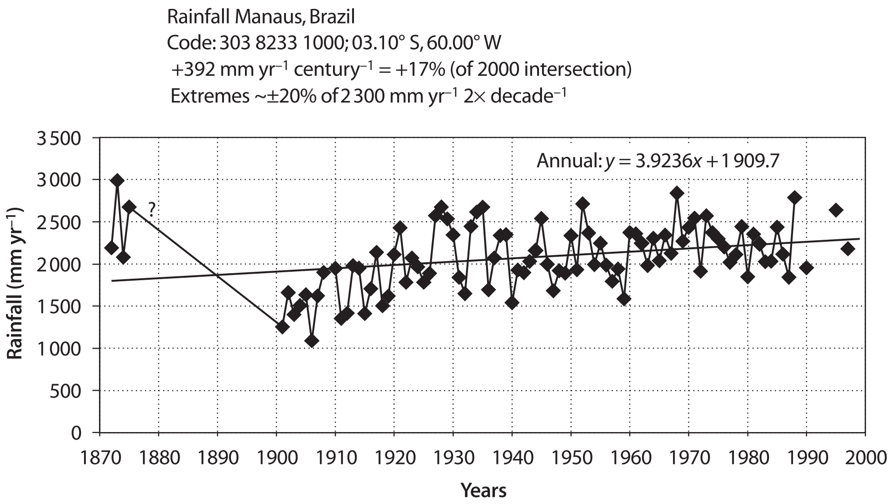


Fig. 1.1. Rainfall trend at Manaus, Brazil (after Duursma 2002)

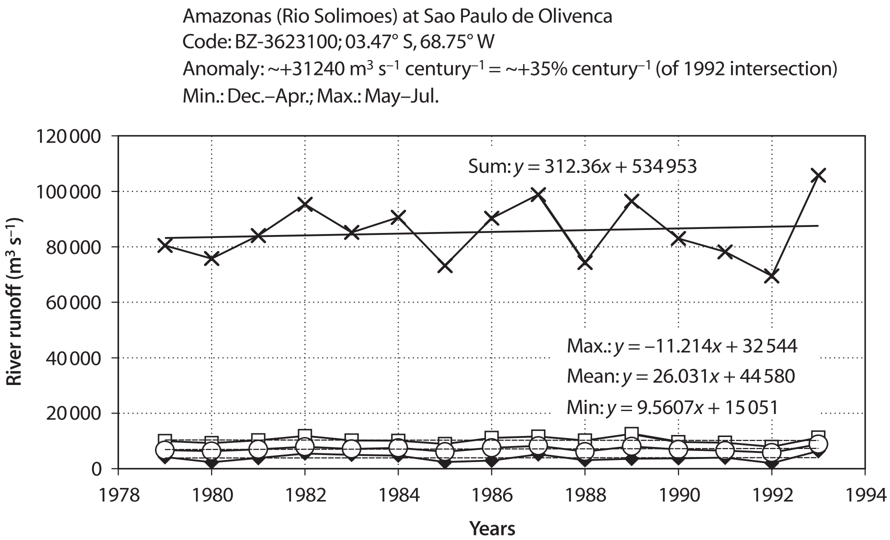


Fig. 1.2. Annual river runoff of the Amazon branch, Rio Solimões at São Paulo de Olivença and maximum, minimum and mean monthly flow

profile trend of Cartagena, Colombia (Fig. 1.4) demonstrates that "regional warming" takes place over the complete atmospheric column, with the exception of cooling in the stratosphere. At some stations elsewhere, cooling might also occur at the surface, but in general warming occurs in the troposphere. This warming can be converted into joule g^{-1} $century^{-1}$ and W m^{-2} for one century.

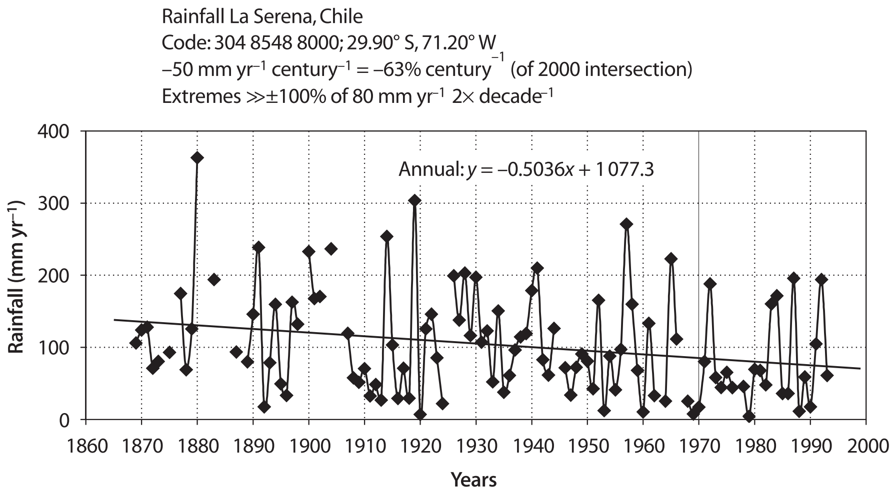
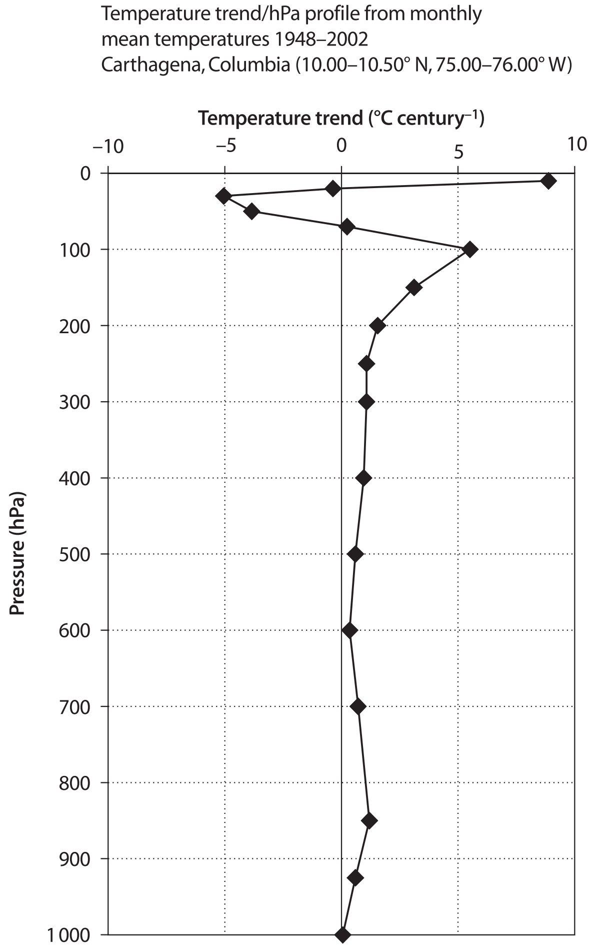


Fig. 1.3. Rainfall records at La Serena, Chile

Table 1.1 Results of some selected South American stations, concerning coincidence between years of extreme rainfall and river-flow with either El Niño or La Niña (each +1 year). See Duursma (2002) for complete comparison

Station	Rainfall trend	Ratios (%) of years of major maximum and minimum rainfalls, coinciding with years (and/or +1 year afterwards) of El Niño or La Niña			
	(mm century^{-1}) (% century^{-1})	El Niño		La Niña	
		Max.	Min.	Max.	Min.
Manaus, Brazil	+392 +15%	30	100	20	0
Portoviejo, Ecuador	−715 −204%	25	0	50	33
Arequipa, Peru	−19 −21%	60	16.7	13	25
Oruro, Bolivia	+164 +41%	43	25	29	25
La Serena, Chile	−50 −63%	60	64	40	21
Buenos Aires, Argentina	+194 +17%	42	75	8	50
River station	River-flow anomaly				
Rio Parana at Paran Tunel	+3 529 $m^3 s^{-1}$century^{-1} +23%	71	29	57	29

Fig. 1.4. Temperature profile trend at Cartagena, Colombia



What can we conclude from these temperature trends? Do changes in vertical temperatures affect the atmospheric stability with an impact on the formation of depressions?

Such results do not facilitate environmental geochemical investigations where extreme climatic conditions play a role. Therefore a large cooperation is required between the various geochemical disciplines and meteorologists who have the modelling capacity to treat existing data records on local scales. This counts in particular for those tropical and subtropical regions with a large range in wet and dry conditions.

The question "where" regional climate changes occur can be answered by determining where rainfall changes are the greatest. The question "how" is more difficult to define, because for a great number of stations, the rainfall started to change long before 1900, the moment when the temperature decrease as observed since 1000 of 0.2 °C millennium^{-1} changed into 1.5 ±0.5 °C century^{-1} (IPCC 2001). This means that the climate changes have not been solely due to the greenhouse effect. It is therefore essential to investigate climate changes "on the spot."

References

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