The Climate of Peru

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12 August 2010
Peru can be divided into three basic climate regions:

1. The desert coast
   - Subtropical climate (like Los Angeles)
   - Generally sees very little rainfall

2. The mountains/highlands
   - Cool-to-cold climate
   - Rainy summers and dry winters

3. The eastern lowlands
   - Tropical rainforest climate
   - Hot and wet throughout the year
   - No real seasonal changes in weather
What climate regions will we see?

Desert coasts

Mountains/highlands
How dry is the desert coast?

Peruvian coastal rainfall vs SoCal rainfall

- 5 in/yr = 127 mm/yr
- 10 in/yr = 254 mm/yr
- 15 in/yr = 380 mm/yr
What causes the extreme dry conditions of the Peruvian coast?

1. The Humboldt current in the ocean
2. The prevailing surface winds
3. The Walker circulation in the atmosphere
The Humboldt Current

- The Humboldt current is an eastern boundary current that brings cold water from the southern polar region into the mid-latitudes, including northern Chile and Peru.
• The Humboldt current is part of a larger ocean current system.

• You can think of the Humboldt current as an “anti-Gulf-Stream”. The Gulf Stream brings warm water to eastern North America while the Humboldt current brings cold water to western South America.
The surface winds of the southeastern Pacific follow a similar path to the ocean currents.
The surface winds and Humboldt current work together to generate upwelling of deep cold ocean water.
The Walker Circulation

The Walker circulation is an atmospheric circulation that crosses the Pacific ocean basin. Convective storm systems on the western side of the Pacific drive a circulation that delivers cold, dry air to the eastern Pacific.

Incidentally, this is a mirror image to the ocean overturning driven by the Humboldt current and meridional surface winds.
What’s the net result?

- The Humboldt current, the prevailing surface winds, and the Walker circulation all conspire to deliver cold, dry air to the western shores of the mid and southern coasts of South America. The Peruvian coast is the northern most region that desert coastal land due to this delivery of cold, dry air.

- During the southern summer, when the inter-tropical convergence zone moves southward, the Peruvian coast does get some rainfall, which is why the annual mean precipitation is higher on the Peruvian coast than on the Atacama coast in Chile. But for 9 months or more the coast of Peru is dry and sees almost no rainfall.
Let’s see it in action.

Just a snapshot. Go to video!
What’s the exception to all of this? (Hint: El Niño.)

• In an average year, the climate on the coast of Peru is cold and dry.

• But every now and then (i.e. a frequency of 2 to 5 years) the entire system is reversed and extensive rainfall is seen on the Peruvian coast.

• This is the El Niño Southern Oscillation phenomena.
What happens during El Niño?

• The normal circulation.

Fig. 6 Normally, the trade winds and strong equatorial currents flow toward the west. At the same time, an intense Peruvian current causes upwelling of cold water along the west coast of South America.
What happens during El Niño?

- The El Niño circulation.

Fig.14 Upon the advent of an ENSO event, the pressure over the eastern and western Pacific flip-flops. This causes the trade winds to diminish, leading to an eastward movement of warm water along the equator. As a result, the surface waters of the central and eastern Pacific warm, with far-reaching consequences to weather patterns.
When El Niño occurs, there is extensive rainfall on the Peruvian coast. Convective storms generate so much rain that flash flooding often occurs in the region.
Important note that will be returned to later:

The thermocline changes significantly in slope and height between El Niño and non-El Niño conditions. When the thermocline reduces slope during El Niño, less deep cold water is delivered to the surface.
Now, let’s talk about the highland climate.
The mountains and highlands receive greater amounts of rainfall for two main reasons:

1. orographic effects

2. the inter-tropical convergence zone

These two processes work together to give almost six months of precipitation in the mountains followed by a six month dry season.

The best way to see this? Again, let’s go to the video!
Alright, that’s the current Peruvian climate, which is cool, but what happened in the past?
There is evidence that during the mid-holocene (~6,000 years ago), the ENSO was reduced in strength. Thus, the western shores of South America would have been much drier for longer periods of time than the current climate.

This reduction may have been driven by the overall increase in insolation due to orbital forcing. The insolation increase would have reinforced the convective activity in the western Pacific, thus overwhelming any activity in the eastern Pacific.
Early- to Mid-Pliocene (3-5 Mya)

The early- to mid-pliocene climate was ~3 K warmer than the current climate. This would have increased ocean temperatures in the high latitudes leading to warmer deep ocean temperatures. Thus, the temperature contrast between surface and deep ocean water would have been less, which would have created a deeper mean thermocline. An annually deeper mean thermocline creates the conditions for a “permanent” El Niño.
• So, with increased regional insolation the El Niño phenomenon is suppressed and the Peruvian coast becomes extremely dry.

• With increased global mean temperatures, the El Niño phenomenon becomes amplified and essentially permanent leading to a warm and we Peruvian coast.

• The western slopes of the Peruvian Andes follow the patterns of the coast while the eastern slopes are more sensitive to the location and movement of the inter-tropical convergent zone.
Published References:


Unpublished References, but still Useful:


The tropical Pacific region, in particular, features prominently in the tropical hypothesis. The tropical Pacific climate today possesses an interesting zonal asymmetry; it is warmer to the west than in the east (Figure 2a), despite the fact that they both occupy the same equatorial latitudes. The tropical western Pacific possesses a warm pool of water exceeding 28.5 °C, and moist convection is located here as well as over the maritime continent. In the eastern Pacific, the climate is characterized by a different thermal structure and convection pattern, illustrating the zonal asymmetry of the tropical Pacific climate.