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THE TROPOSPHERE OVER THE SOUTH AMERICAN CONTINENT

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1.2 The Troposphere over the South American Continent

1.2.1 General Features:

The vertical variation of the atmospheric characteristics is the important factor for tropospheric radiopropagation. In turn, this is dependent upon the climatic condition at the surface at least for the first hundreds of meters above it.

The climatic condition of South America range from tropical very rainy regions to desertic coasts with extremely low rainfall rate and from permanently stormy high peaks to glaciers at sea level, in the longest mountain chain over the planet. This large variety of climates is the result of the combination of several factors: the large latitudinal extension of South America, the width of the northern tropical portion of the continent and its narrowing toward the southern end in middle latitudes, the temperatures of the adjacent oceanic waters, and the high altitude barrier of the Andes mountain range.

To understand the general features of the climatic situation of South America on overview of the atmospheric circulation must be given.

Fig. 1.32 and 1.33 taken form Schwedtfeger (1976), show the sea level pressure for southern summer and southern winter, averaged in each case over three months. The existence of the oceanic anticyclones in the Pacific and Atlantic sides of the continent is easily seen. At the latitudes of the equatorial belt the pressure over the Pacific side is lower than the pressure over the Atlantic. In summer the center of the continental low is clearly located over the eastern side of the central Andes and the center of the Pacific Oceanic anicyclone is located at a higher latitude compared with that of the Atlantic side, the latter being weaker. In winter both highs appears located at approximately the same latitude and show a similar strenght.

Zonal flow of the atmosphere from sea level to 25 mb level (22 to 25 km height) for summer and winter are displayed in fig. 1.34 and 1.35 (Schwerdtfeger, 1976) in longitudinal cross section roughly along the 70°W meridian. In the tropical regions, winds are weak and from the east, the result being that the air masses remain a long time in those areas and can be modified by the characteristics of the ground surface. From about 25°to 30°S to the south, winds became moderate to strong from the west and air masses from the Pacific flow above the Andes crest line toward the eastern part of the continent. Under this condition changes of the upper air characteristics can affect the climatic situation at the low levels. Gutman and Schwerdtfeger (1965) have shown that, at the subtropical latitudes, the thermal regime of the continent influences the general atmosphere stream system, in a more pronounced way than the processes induced by the high altitude barrier of the Andes.

The general rainfall regime of South America is clearly related to the atmospheric circulation over the region. Local characteristics can be associated, however, with its orographic systems, as it will be discussed in following paragraphs.

The annual variation of rainfall over the continent is shown in figure 1.36 (Burghardt et al. 1975, used data:from the Climatic Atlas of South America) where the rainfall seasonal behaviour is displaied.

The relation with the circulation pattern and with the orography of the continent appears evident in the figure. The main features that can be recognized are: a) The extremely rainy equatorial areas of the Amazon and the coastal Pacific region of northern Ecuador and Colombia; b) The tropical summer rain region of most of central Brasil, western Perú and northeast Bolivia; c) The all-year-rain subtropical region of southern Brasil, Uruguay and central eastern part of Argentina; d) The very dry coastal region of Perú and northern Chile; d) The arid region in central and southern Argentina; f) The very rainy region of southern Chile.

These features are closely related to the atmospheric flow over the continent. In particular, the arid zone of Argentina corresponds to the westerly wind pattern seen in figs. 1.34 and 1.35, centered around 30°- 40°S. An equivalent situation is found in Australia, where the longitudinal extension of the continent produces the large desert areas that covers most of it. In South America the effect of the close by Atlantic is such that reduces the longitudinal extension of the arid zone in central Argentina.

Orography influence on the rainfall is observed all over the continent. For example the rainfall on the Aconquija system in northern Argentina, is such that the eastern side receives much more rain than the western slope, almost dry. The presence of the longitudinal barrier of the Andes is also one of the causes of the heavy rainfall in southern Chile.

Temperature variations in the continent are mainly related to the seasonal excursions of the subsolar point as can be seen looking at the latitudinal movement of the main isotherms, from summer to winter (fig. 1.37, taken from: Shanahan, 1965). More details about the temperature variations over South America

can be found in the Climatic Atlas of South America prepared under the direction of J.A.Hoffmann(1975).

An important climatic parameter is the amplitude of the annual temperature. Fig. 1.38 show a map of the continent with isolines of the difference between the mean temperature of the hottest month and that of the coldest one (from J.A.Hoffmann, 1982: private communication).It can be seen that the northern equatorial and tropical region displays a very limited temperature amplitude. The arid inland area of central Argentina has the largest amplitude found in the continent with a value of 17.5°C. Oceanic currents permanent effects are also recognized in the moderate to small amplitude in the coastal regions.

1.2.2 Climatic regions:

Taking into account the combination of temperature and rainfall regimes it is possible to define a general scheme of climatic regions for South America (Fig. 1.39: J.A.Hoffmann, 1982: private communication). If will be described in the following paragraphs.

Ia: Equatorial rainy regions of the Amazon basin and the Pacific coast of Colombia and northern Ecuador. In some areas total annual rainfall can be as high as 10.000 mm. Temperature is very constant troughout the year with annual ranges of 1-5°C and average value of 25°- 28°C. Ib: Tropical wet-and-dry continental with summer rain regions of Central Brasil, north east Bolivia, Paraguay and most of Venezuela. Total annual rainfall is variable ranging from 1000 to 2000 mm: winter are almost dry. Typical annual average temperature is 23°- 26°C and temperature amplitudes are about 6°- 7°C. Ib': Tropical wet-and-dry maritime, with summer rain, region of the Central Atlantic coast of Brasil. Total annual rainfall is of the order of 1000-2000 mm with little winter rain. Average temperature is about 23-24°C with an amplitude of around 5°C. Ib": Tropical wet-and-dry maritime, with winter rain, region of the northern Atlantic coast of Brasil. Total annual rainfall is from 1200 to 2000 mm most of it between March and July. Average temperature is about 25°C and the temperature amplitude reduced to 2°- 3°C. Ic: Tropical semiarid region of the northerst of Brasil. Total rainfall during the year can be below 500 mm and most of it falls in summer. Average temperatures can reach 28°C with a temperature amplitude of only 3°C. Id: Tropical highland humid region of the Andes in Perú, Ecuador and Colombia. Total rainfall is around 1000 mm with distinct double maximun in the year. Typical average temperature is of the order of 15°- 22°C depending

on the altitude and the annual amplitude is aroun 2-3°C. Id': tropical highland arid region of southern Perú, and high plateau of Bolivia and northern Argentina. The average total precipitation is about 200-500 mm. Temperature are variable and milder around the Titicaca lake. Typical overage values are below 10°C with annual amplitudes of the order of 7-8°C. Ie: Tropical arid region of the Pacific coasts of southern Ecuador, Perú and northern Chile. This coastal area is one of the driest of the world. Total average annual precipitation is only 20 mm at Lima and 2 mm at Iquique. Average temperature is around 9°- 10°C below the expected at the latitude involved, due to the influence of the cold Humboldt current. Its values varies from about 21°C north of the region to 19°C toward the southern limit of it. Typical average amplitude is 5-7°C. One of the interesting climatic characteristics of this region is the almost permanent temperature inversion at around 1000 m above the surface, due to the effect of the cold oceanic current. IIa: Subtropical humid region of southern Brasil, Uruguay, east Paraguay and central and north cost Argentina. Precipitation is all year long. Total annual average values range from 900 to 1300 mm. Average temperature is about 16°C in the southern portion and 19°C in the northern one of the region. Temperature amplitudes are of the order of 13°C and 10°C respectively for the two portions. IIb: Subtropical semiarid and arid region of Central and norwest Argentina and southern Paraguay. Rainfall is during summer and winter is a dry season. Average annual precipitation ranges from 900 mm in the northern western portion of the region to 100-200 mm in the southern portion of it. Temperature average is between 19°C to 13°C decreasing with increasing latitude. In the Argentine Chaco area of this region the heat pole of South America is found,where almost every year temperatures of 45°C are observed. In the arid zone on the west, the highest temperature amplitude of the continent is reached with 17.5°C (see Fig. 1.38). The occurrence of temperature inversion is common in this region (see Fig. 1.42). Another characteristic there is the fohen effect that produces an hot and dry wind called "Zonda" particularly in winter. IIc: Subtropical highland arid region of central Chile and western Argentina. Annual precipitation is of the order of 200 mm concentrated during winter months and average temperatures are around 0°C, being a function of elevation. Temperature amplitude is about 10°C. IId: Subtropical maritime region of Central Chile: Precipitation is concentrated between April and October with dry summer. Annual total is about 400 mm and temperature average is around 14°C, cooler than the expected values at the latitude involved due to the cold oceanic waters. Temperature inversion are observed troughout the year at a height

of 500 m in average. IIIa: Temperate arid and windy region of Southern Argentina. Total annual rainfall overage is around 150-200 mm. Westerly wind is a permanent climatic phenomenon with average annual speed of as much as 35 km/hr. Temperature mean is of the order of 13°C, decreasing to a value of 5.5°C with increasing latitude. Annual amplitude is 14°C in the northern portion and only 7.5°C in the southern one of the region. IIIb: Temperate rainy and windy region of southern Chile. The main climatic factor in this region is the strong wind from the west that reachs an average annual speed of 45 km/hs. The constant flow founds the efficient barrier of the Andes. The air is forced to rise and also to diverge southward with the result of the very high rainfall in the region, that can reach annual values of 6000 mm. Average temperature are of the order of 12°C toward the north limit of the region and 7°C in the southern one of it.

To finalize this section, noon upper air data of temperature and relative humidity are given in Fig. 1.40 to 1.43 for sites in Argentina at different latitudes from 27°to 45°S (data taken from Velasco and Necco , 1980). They can be considered representative of the Subtropical Humid (Resistencia and Ezeiza), Subtropical semiarid (Santa Rosa) and Temperate arid windy region (Comodoro Rivadavia) climates.

1.2.3. Figure Captions

Fig. 1.32. Atmospheric pressure at sea level. Average of three summer month (Dec.-Feb.)

Fig. 1.33. Atmospheric pressure at sea level. Average of three winter months (Jun-Aug.)

Fig. 1.34. Summer (Dec.-Feb.) average of the west to east component of the wind (m/sec) form 1000 mb to 30 mb heights.

Fig. 1.35. Winter (Jun-Aug.) average of the west to east component of the wind (m/sec) from 1000 mb to 30 mb heights.

Fig. 1.36. Annual variation of rainfall over South America.

Fig. 1.37. Main isotherms. A: January; B: July; C: April and D: October.

Fig. 1.38. Annual amplitude of temperature in °C (see text)

Fig. 1.39. Climates of South America. Ia: Equatorial rainy; Ib: Tropical wet-and-dry continental; Ib': Tropical wet-and-dry maritime (summer rain); Ib": Tropical wet-and-dry maritime (winter rain) Ic: Tropical semiarid; Id: Tropical highland humid; Id': Tropical highland arid; Ie: Tropical arid; IIa: Subtropical humid; IIb: Subtropical semiarid and arid; IIc: Subtropical highland arid; IId: Subtropical maritime; IIIa: Temperate arid and windy; IIIb: Temperate rainy and windy.

Fig. 1.40. Noon upper air data (temperature and relative humidity) for Resistencia. February and August.

Fig. 1.41. Noon upper air data (temperature and relative humidity) for Ezeiza. February and August.

Fig. 1.42. Noon upper air data (temperature and relative humidity) for Santa Rosa. February and August.

Fig. 1.43. Noon upper air data (temperature and relative humidity) for Comodoro Rivadavia. February and August.

1.2.4. References

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VELAZCO, I.; NECCO, G.V.(1980) "Valores medios, extremos y desviaciones estandard de datos aerológicos de la República Argentina", Universidad de Buenos Aires, Departamento de Meteorología.

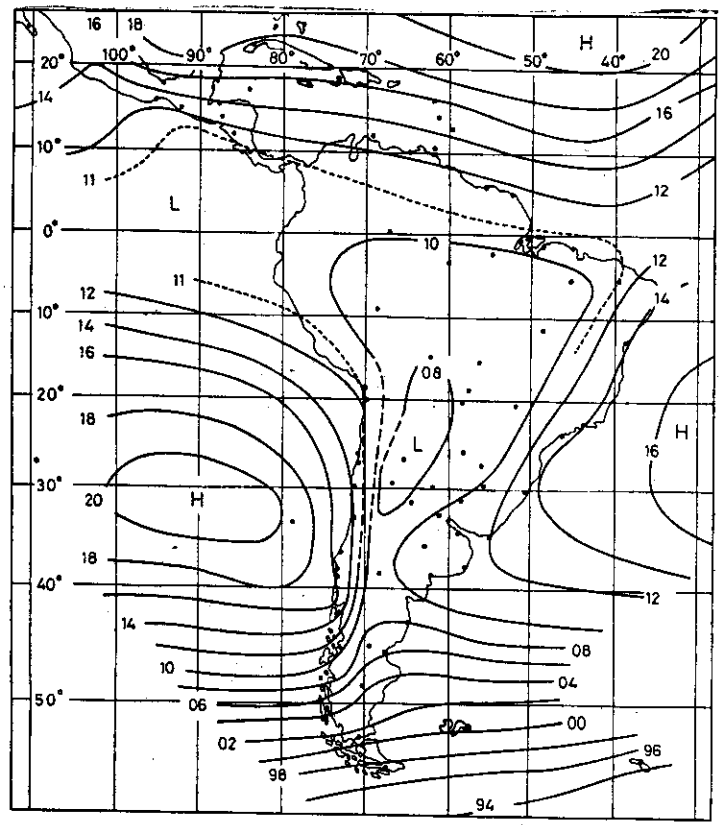

Fig. 1.32

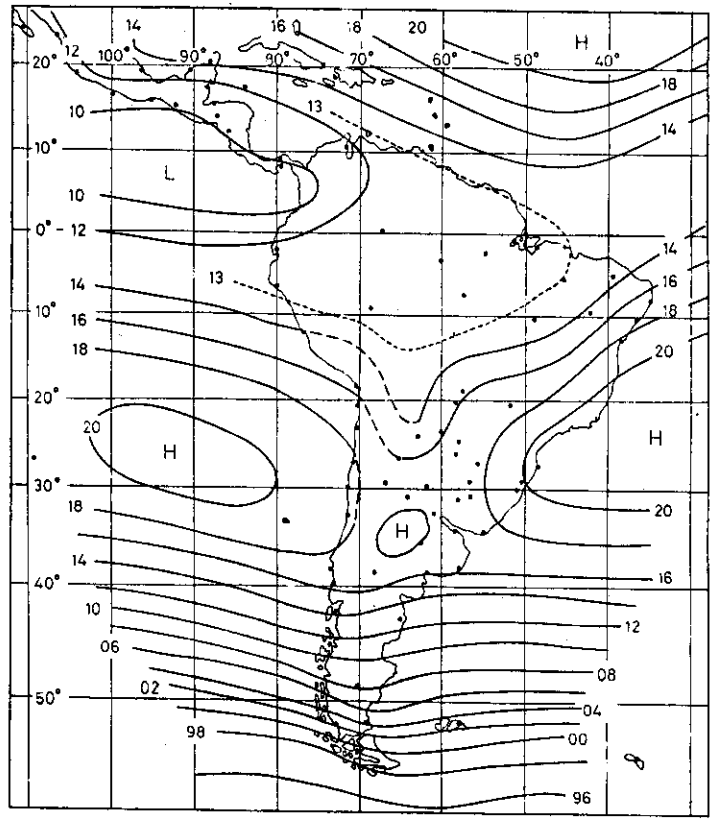

Fig. 1.33

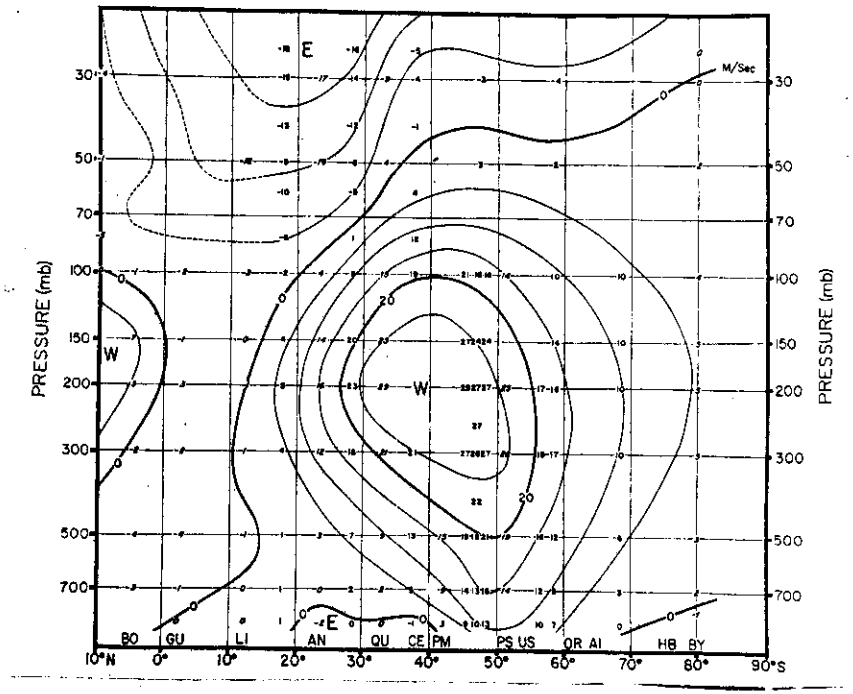

Fig. 1.34

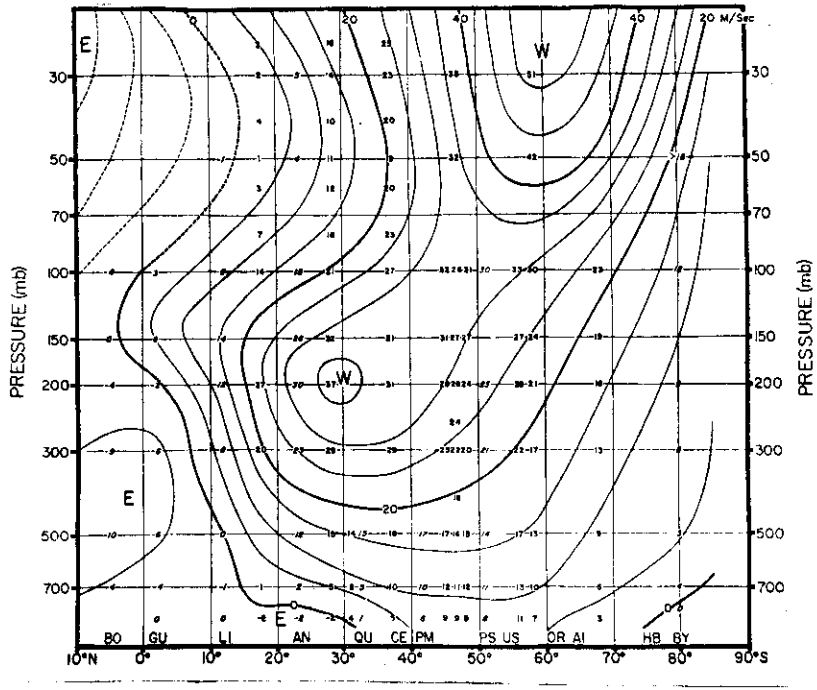

Fig. 1.35

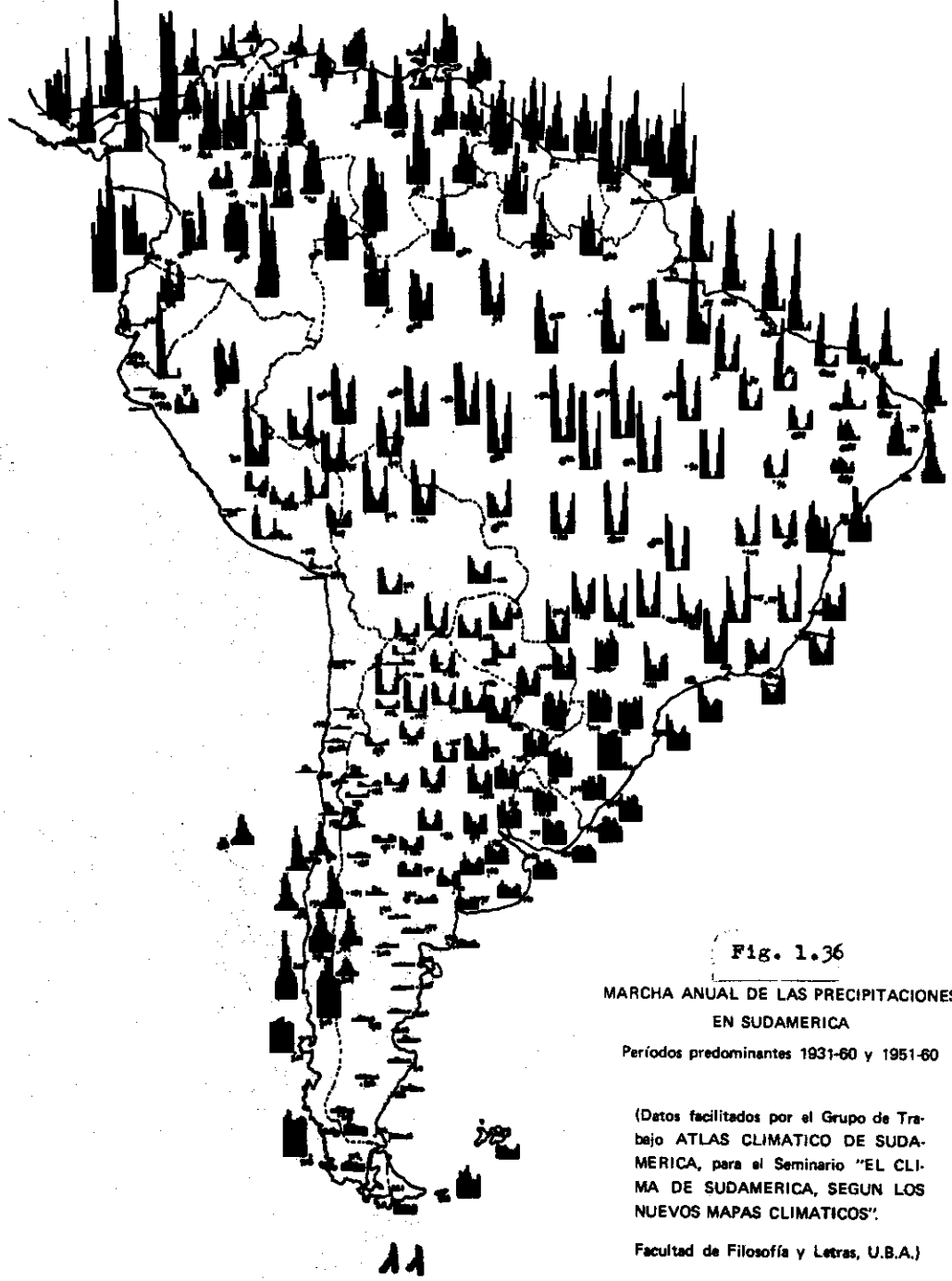

Fig. 1.36

MARCHA ANUAL DE LAS PRECIPITACIONES EN SUDAMERICA

Períodos predominantes 1931-60 y 1951-60

(Datos facilitados por el Grupo de Trabajo ATLAS CLIMATICO DE SUDAMERICA, para el Seminario "EL CLIMA DE SUDAMERICA, SEGUN LOS NUEVOS MAPAS CLIMATICOS".

Facultad de Filosofía y Letras, U.B.A.)

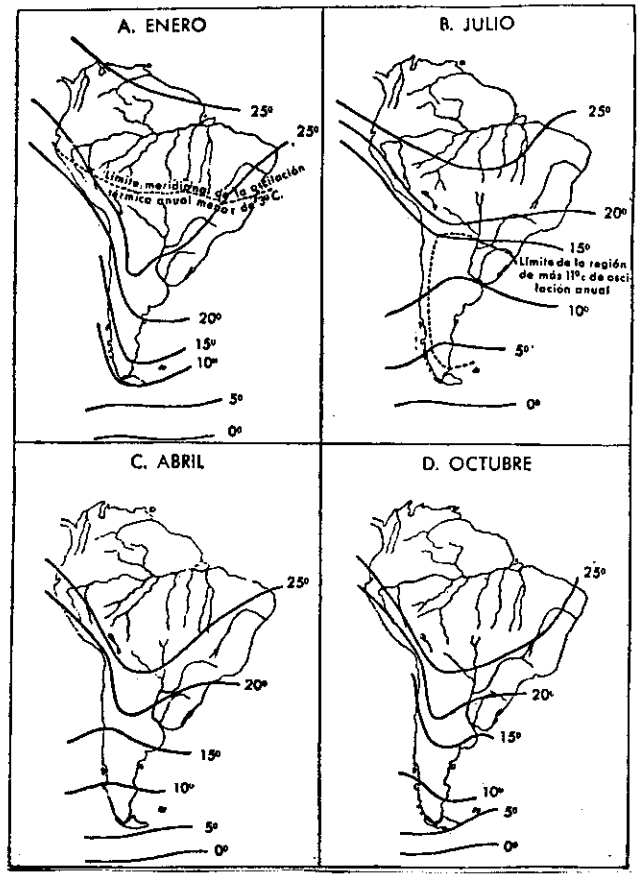

Fig. 1.37

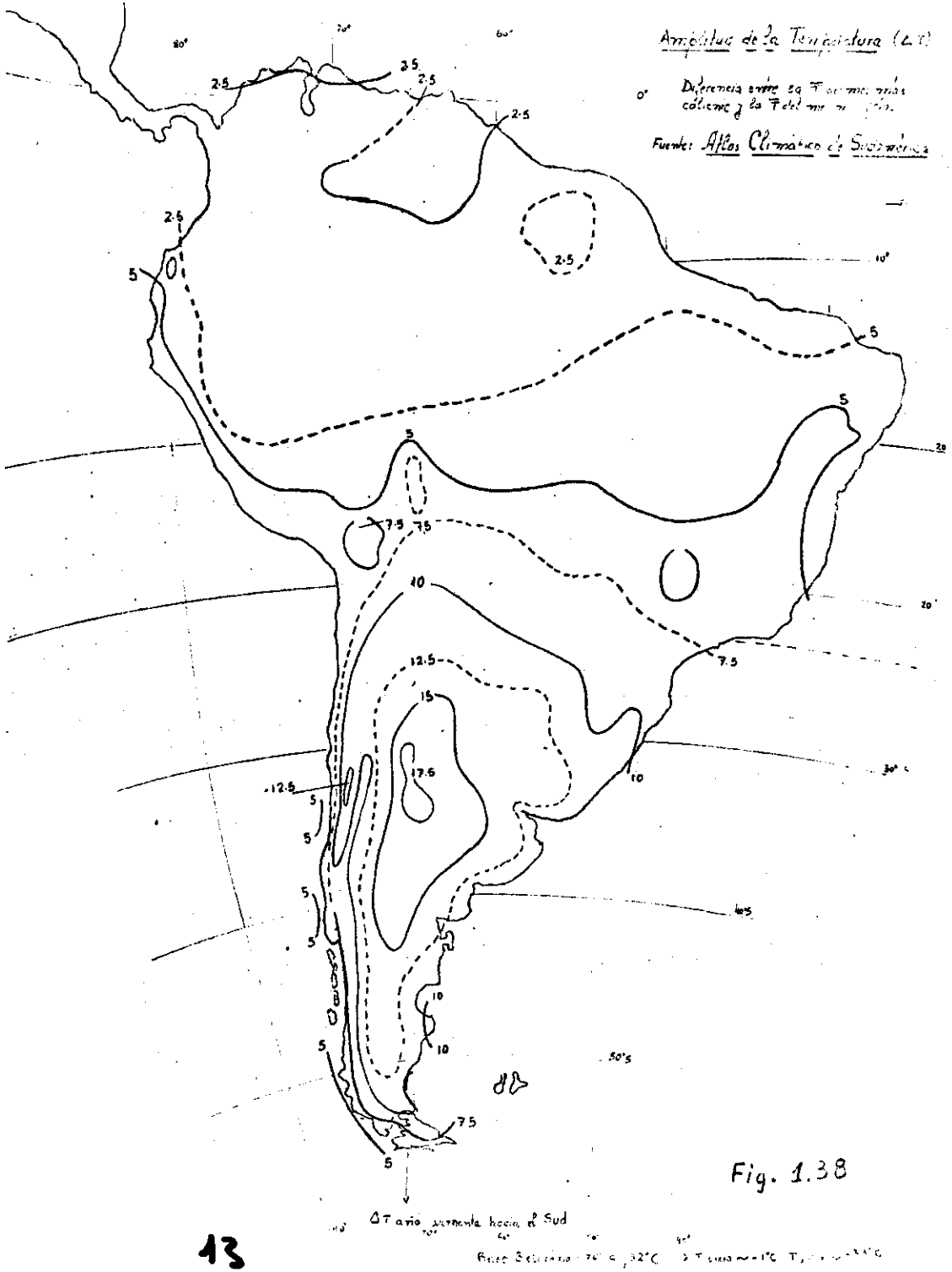

Fig. 1.38

CLIMATES OF SOUTH AMERICA

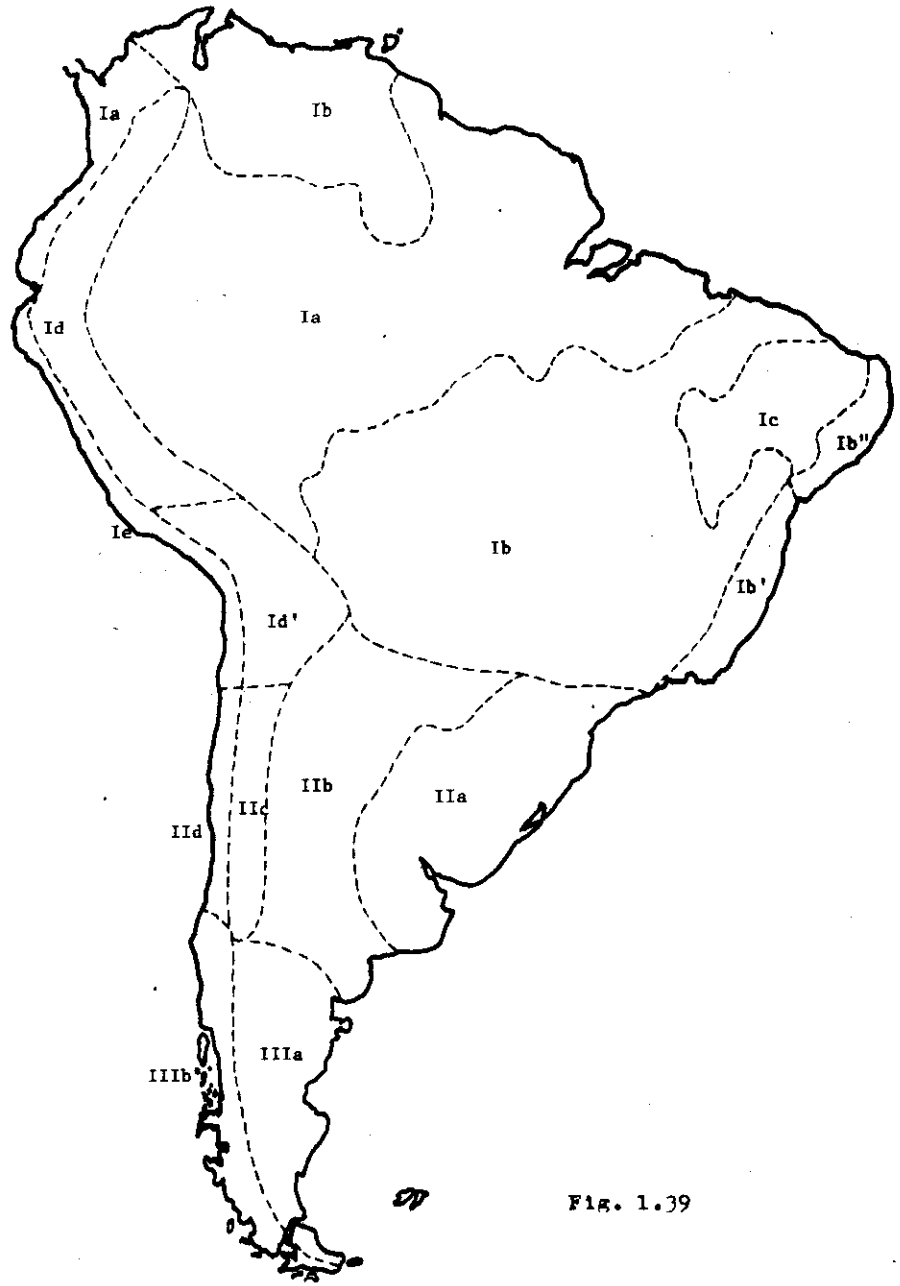

Fig. 1.39

DATOS AEROLOGICOS
RESISTENCIA (27,27°S; 59,03°W) (12,00 TL)

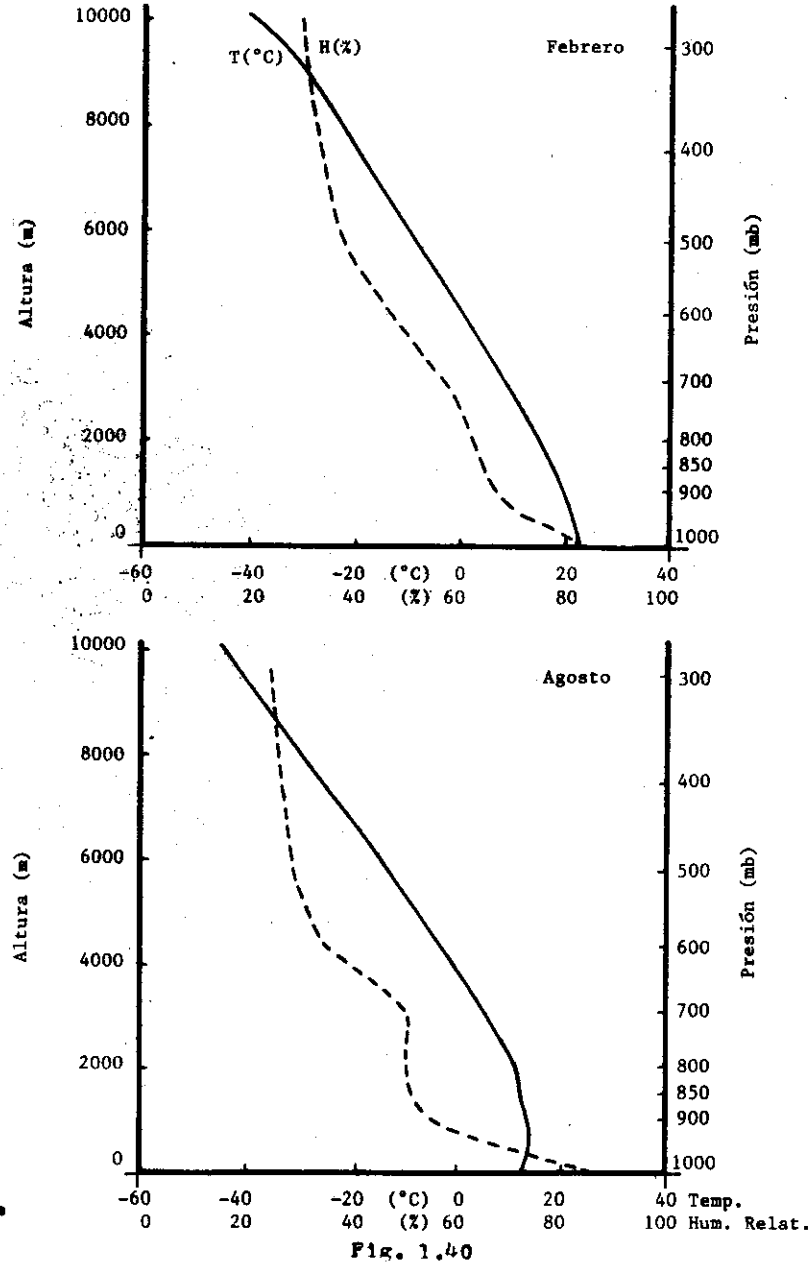

Fig. 1.40

DATOS AEROLOGICOS
EZEIZA (34,49°S; 58,32°W) (12,00 TL)

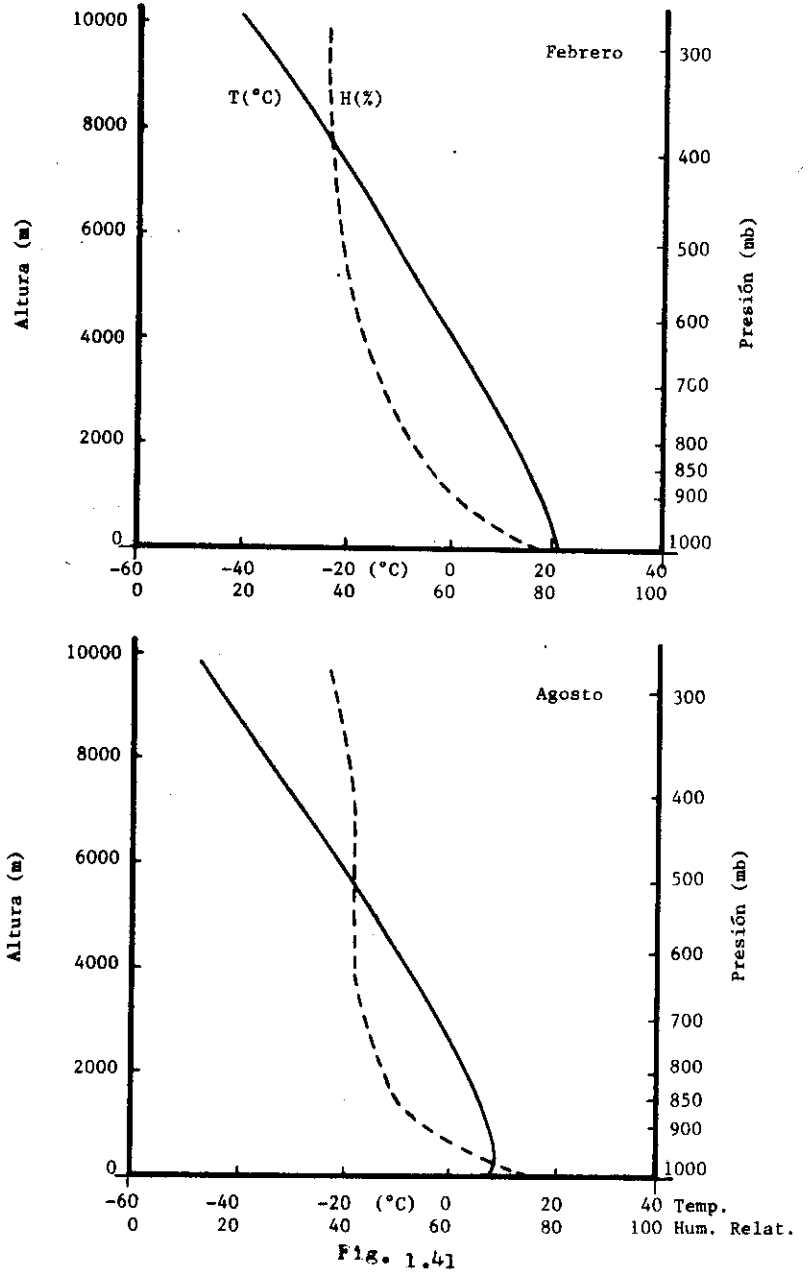

Fig. 1.41

DATOS AEROLOGICOS
SANTA ROSA (36,34°S; 64,16°W) (12,00 TL)

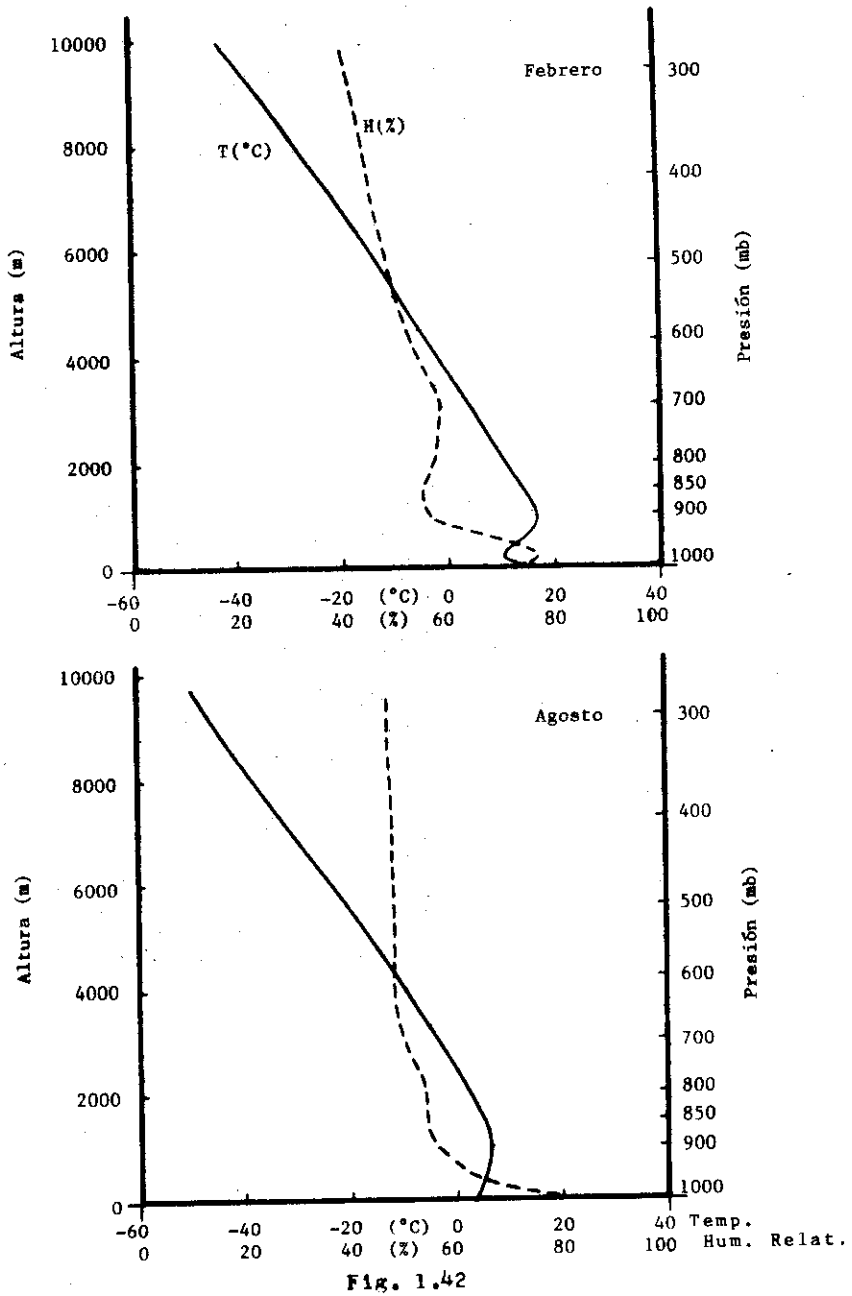

Fig. 1.42

DATOS AEROLOGICOS
COMODORO RIVADAVIA (45,47°S; 67,30°W) (12,00 TL)

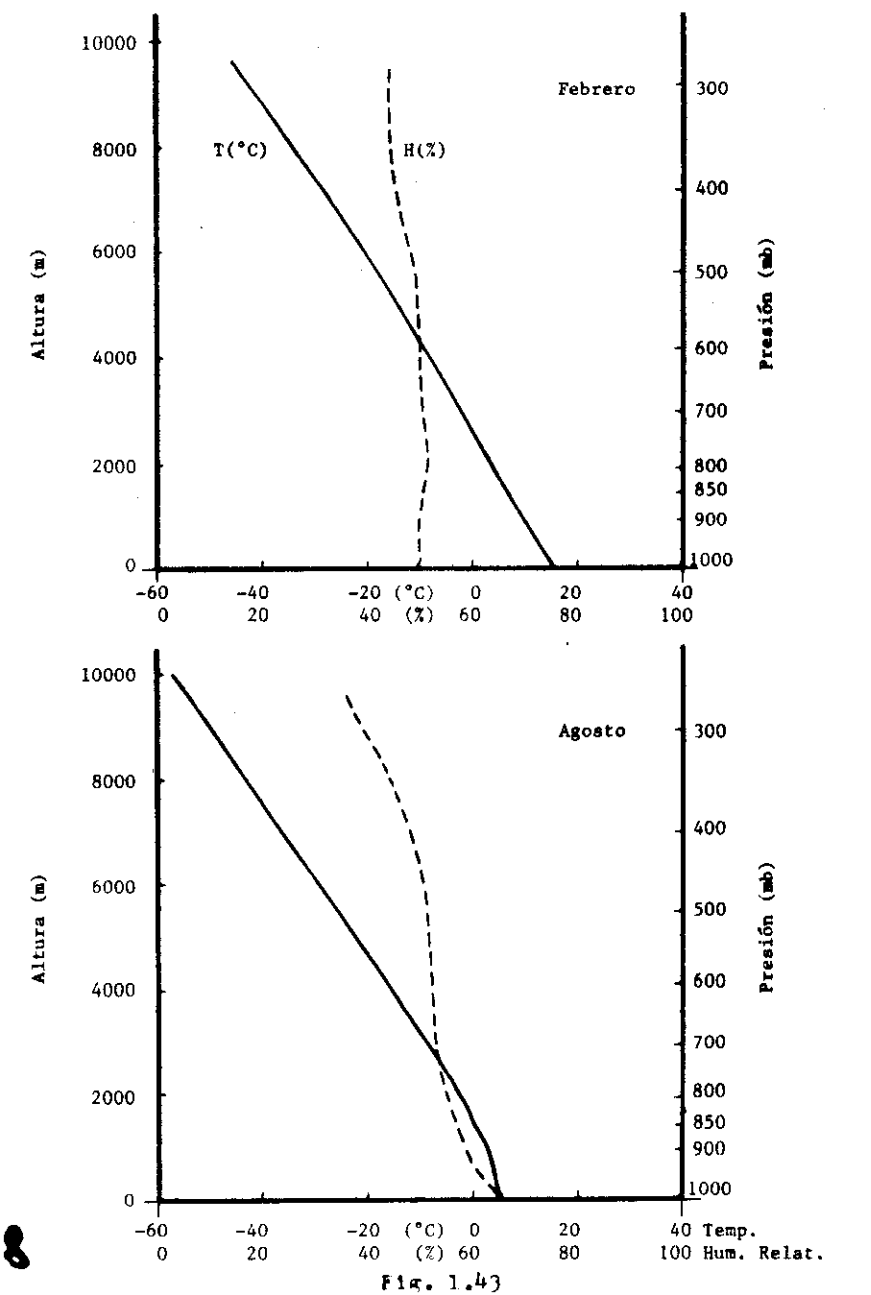

Fig. 1.43