CHARACTERISTICS OF FROSTS IN THE CENTRAL ANDES OF PERU (MANTARO RIVER BASIN) FOR THE LAST 40 YEARS

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1. Introduction

A big national project regarding Vulnerability and Adaptation to Climate Change has been developed in three main areas of Perú since November 2003. One of these areas is the Mantaro Basin, located in the central Peruvian Andes. This has been the first effort made until now in the country, for An Integrated Local Evaluation Method applied to a basin, from a Climate Change perspective.

The Mantaro Basin (34550,08 Km^2) is the largest on the central Peruvian Andes, with a mean altitude between 3400 and 4300 masl; it is located at coordinates 10º34'30"S-13º35'30"S and 73º55'00"W- 76º40'30W. Its valley is extensive and productive, and supplies Lima, the Peruvian capital, with a high percent of farming products.

From inner perception of locals obtained by the project (IGP, 2005a), the Climate Change concept and the processes involved are not recognized. There is, however, a generalized idea of change on the climate variability of the basin, mainly during the last decade, also affecting the extreme meteorological events. Regarding atmospheric phenomena that highly affect them, especially the first economical activity which is agriculture, frost is their second concern after drought.

As a part of the current vulnerability to climate change in the Mantaro Basin, the main characteristics of frosts (intensity, duration, frost-free periods, frequency, areal distribution, and historical trends) have been analysed.

2. Data and Methods

Daily minimum temperatures (Tmin) from fifteen meteorological stations spread over the basin were used, for the period between 1960 and 2002. Special emphasis was given to the rainy season (from September to April), when social-economical impacts on the basin due to frost, are the worst. Six data series with at least 30 years long, were considered on trend analysis.

Geographical Information System (GIS) data for the Mantaro Basin, compiled by the project, were processed. The orography GIS data used was contoured with a 25 m resolution.

In the process, frost was defined in local Hearings and Working Groups with the threshold value of Tmin$\leq$5°C, according to how their main crops (particularly in the valley) are affected; also it has been considered other thresholds values, defining different intensities (Tmin $\leq$ -4°C, -2°C and 0°C).

Maps of empirical frost probability occurrences for different intensities ($\leq$5°C, $\leq$0°C, $\leq$-2°C y $\leq$-4°C) were obtained for the entire basin, extrapolating with a fifth grade polynomial equation in function of the altitude.

Annual trends for the number of days with frost and the minimum value for the rainy season each year were calculated with simple regression lines, using the least squares method.

3. Main Characteristics of Frosts in The Mantaro Basin

- Frost is a frequent extreme event of low temperature in the Mantaro Basin. It occurs in general between half/end of April and August, with the highest intensity during June and July (winter).
- During the rainy season (from September to April), especially at the beginning of spring, frost can occur on intensities that vary according to the altitude of the region. On 4500 masl (e.g. Marcapomacocha), the extreme minimum values can drop to –10°C, in the valley zone (e.g. Jauja and Huayao), at altitude of 3300 masl they can reach –4°C, and for lower altitudes (less than 3000 masl) they are rare with an average length of frost-free periods between 300 and 360 days per year.
- In general, a high dependence between altitude and different frost characteristics (frequency, intensity, areal distribution, initial and end dates and frost-free periods) exists. High non-linear correlation coefficients (0,91 to 0,94) were calculated for the Tmin from September to April in the basin (IGP, 2005.b). For the rainy season the probability of frost occurrences (Tmin$\leq$ 5°C) was very high (80%-100%) for altitudes higher than 3800 masl (this is in the northern and western side of the basin); for the Mantaro Valley, with altitudes that range between 3100 and 3300 masl, the probability was low (20%-40%) and in lower zones, located in the eastern and south-eastern part of the basin, the probability decreased to an interval of 20% to 0%. Severe frosts ($\leq$ -2°C) were reduced to altitudes higher than 4500 masl, and for occurrences of tmin below –4°C the probability of occurrence is very low or near zero.
- Small positive historical trends, also for rainy season, were found in the number of days with frosts (which is increasing), and the value of the extreme values (that is, frost intensity is decreasing). A strong tendency of increasing in the intensity of frosts (–0,95°C by ten years), however, was identified in a critical area in the northern part of the Mantaro Valley (Jauja) and its surroundings (Comas, belonging to the Perene Basin).

4. Conclusion

There is a high relationship between frosts characteristics and altitude in the Mantaro Basin. This let us extrapolate some of these characteristics all over the basin using GIS orographic data. During the rainy season some changes mainly for the intensity and frequency of frosts were found in the basin, being Jauja (in the northern part of the valley) the most vulnerable zone, that is, with a strong positive tendency (increasing) in frequency, intensity and last of frosts during the last forty years.

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