On the föhn effect in the mountainous regions of Colombia

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ABSTRACT

In the Colombian territory the interaction of the atmospheric circulation with the mountain system of the Andes configures different space-time patterns of the regional climate. This presentation shows the results of the analysis of a particular type of interaction in two regions of Colombia: a valley located in the Upper Magdalena river basin, at South of Colombia, and the Valley of the Cesar River, located between the Sierra Nevada of Santa Marta and the Serranía de Perijá, in the northern side of the country. Since the Colombian territory is exposed to the action of the trade winds, the eastern slope (windward sector) of mountains leave the humidity and precipitation on this flank, while the air masses that pass to the western side (leeward sector) of the mountain are dry and warm. This interaction generates particular climate conditions in both sides of the mountains and in the valleys of Colombian territory. With the analysis of the spatial distribution of monthly mean air temperature and monthly precipitation of mentioned regions, it was confirmed this spatial configuration, which is similar to the generated in others regions of the world by the föhn effect or "rain shadow".

Background

The interaction of circulation with the orography showed in Fig 1 produces an effect called föhn in Europe or chinook in North America (Whiteman, 2000; 157); zonda in the southern cone of South America (Viale, 2010) or Puelche in Chile (Houston and Hartley, 2003; Inzunza, 2009; also known as “rain shadow” in ecology and biogeography (Hugget, 2004; 132).

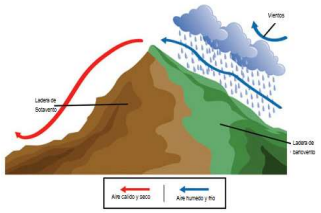

***Figure 1**. Schematic representation of the föhn or “rain shadow” effect*

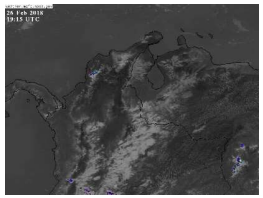

***Figure 2**. Satelite image (IR) at 19:15 UTC 26th February 2018 showing without clouds the interandean valleys of Colombia*

The Colombian territory is exposed to the action of the trade winds, the eastern slope (windward sector) of the Eastern Cordillera leave the humidity and precipitation on this flank, while the air masses that pass to the western side (leeward sector) of the mountain are dry and warm. This may be easily corroborated in any day of the year analyzing the spatial distribution of cloudiness over Colombian territory (see Figure 2).

This interaction generates particular climate conditions in both sides of the mountains and in the valleys of Colombian territory. With the analysis of the spatial distribution of monthly mean air temperature and monthly precipitation over Colombian territory (Figure 3), it is possible to confirm that in several regions of Colombia the climate conditions are governed by the effect similar to the generated in others regions of the world by the föhn effect or "rain shadow". This configuration makes more humid the inward side of the Eastern Cordillera, and the Magdalena river valley area drier.

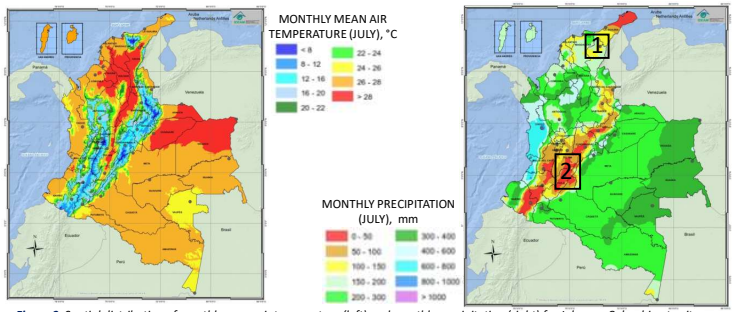

***Figure 3**. Spatial distribution of monthly mean air temperature (left) and monthly precipitation (right) for July over Colombian territory*

A detailed analysis of this effect was done for two different regions of Colombia. This presentation shows the results of the analysis of a particular type of interaction in two regions of Colombia: a valley located in the Upper Magdalena river basin, at South of Colombia (located in the box 2 of the Figure 3 right), and the Valley of the Cesar River, located between the Sierra Nevada of Santa Marta and the Serranía de Perijá, in the northern side of the country (box 1 in the Figure 3).

Data and methodology

The föhn effect was analyzed for the two regions mentioned above using both data recorded at climatological stations and from modeling. Observation data were provided by the Institute of Hydrology, Meteorology and Environmental Studies - IDEAM. In order to have an integrated view of the circulation (*u* and *v* components of the wind, as well as vertical movements), it was used data generated by the Weather Research & Forecasting (WRF) model in high spatial resolution of 10kms x 10kms (Armenta-Porras and Pabón-Caicedo, 2016).

Results

The analysis for both regions allowed to evidence the föhn effect, specially during months when the wind blows perpendicularly to the mountain range (in the analyzed case, the Eastern Cordillera).

Figure 4 shows the spatial distribution of monthly air temperature and monthly precipitation over the Valley of Cesar river. It can be seen that areas with high temperatures outstand over the southern side of the valley during the period December-March. In the spatial distribution of precipitation, less precipitation amounts are observed over the valley, situation that is more notorious during December, March and April.

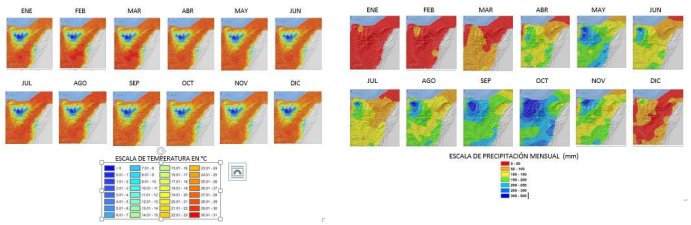

***Figure 4**. Spatial distribution of monthly mean air temperature (left) and monthly precipitation (right) over the Valley of Cesar river, the región 1 in the Figure 3, right.*

Similar results were obtained for the región 2, with the difference in the time of the year when the föhn effect is more marked: sectors with major values of temperature are observed over the valley of Magdalena river during the period June-September. Areas with less precipitation are oberved over this sector of the valley in the same period (see Armenta, 2013).

Figure 5 shows a vertical profile of the winds and vertical velocity over the Valley of Cesar river at 10°N. It is possible to observe the circulation wind and vertical velocity in different levels in the troposphere. In this profile it can be seen that during the period since December until April some cores with high values of vertical velocity appear over the valley. Over the western slope of the Serrania de Perija downward flow is observed, while over the Eastern slopes of the Sierra Nevada de Santa Marta upward flow appears in this period.

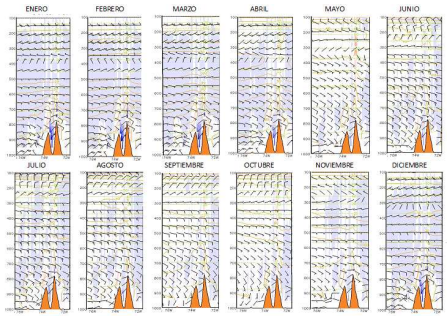

***Figure 5**. Vertical profile of the winds and vertical velocity over the Valley of Cesar river at 10°N, as simulated by WRF in 10x10 kilometers resolution (Armenta-Porras y Pabón-Caicedo, 2016). The valley of Cesar river is located at 73°W approximately, bettween Serrania de Perija (mountain at the right side) and Sierra Nevada de Santa Marta (mountain at the left side)*

Conclusions

It was confirmed the presence of the föhn effect in mountainous regions of Colombia, which induces particular features to the regional climate conditions of the foothill of the Eastern Cordillera and the Valley of Magdalena river an Valley of the Cesar river. This effect is more marked during the time of the year when the winds flow perpendicularly to the mountain ranges.

Acknowledgements

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