The 2010-2012 extreme wet season in northern South America:
causes and moisture sources
Paola A. Arias1, J. Alejandro Martinez2, Sara C. Vieira1
1. Grupo de Ingeniería y Gestión Ambiental (GIGA), Escuela Ambiental, Universidad de Antioquia, Medellín, Colombia
2. Department of Atmospheric Sciences, University of Arizona, Tucson, AZ
E-mail: paola.arias@udea.edu.co

1. Context
The record breaking precipitation associated with La Niña events during 2010-2011 affected millions of people in Colombia, and produced property damages of millions of dollars.

2. Observed rainfall anomalies
Regional rainfall anomalies
- Positive anomalies of precipitation over northern South America were observed between March 2010 and May 2012.
- Stronger anomalies took place between September 2010 and May 2011, and between September 2011 and February 2012.
- Weaker positive anomalies were observed on June-August 2011, during the transition from La Niña 2010-2011 to La Niña 2011-2012.

Local rainfall anomalies
- The annual cycle of TRMM precipitation over northern Colombia and Venezuela (Fig. 2b) exhibits above normal values during 2010 and 2011.
- Observations from rain gauges also show how precipitation was higher than average over northern and central Colombia (Figs. 2c-f).
- TRMM data shows the same type of annual cycle as the observations (e.g. bimodal in Fig. 2b), but with some biases.
- The sign and timing of deviations during 2010 and 2011 are also well represented by the TRMM data (Figs. 2c-f).

3. Circulation anomalies and water vapor transport
Anomalies of transport of water vapor
- The westerly moisture flux over western Colombia was enhanced between March 2010 and February 2011, and again between June 2011 and February 2012. Part of this flux is associated with a westerly jet of the west coast of Colombia, South America (WCCSA) (Fig. 4a). The development of this jet was due to the enhanced land-sea thermal contrast.

Schematics of the anomalous circulation
- Colder conditions over the eastern Pacific led to a stronger Choco jet, due to the enhanced land-sea thermal contrast.
- Warmer conditions over the Caribbean led to a weaker CLLJ, due to the weakening of the zonal pressure gradient.
- An enhanced meridional temperature gradient over the tropical Atlantic led to weaker easterlies.

4. Contributing factors
Sea Surface Temperature Anomalies (SSTAs)
- The eastern Pacific was warmer than usual between December 2009 and May 2010, corresponding to El Niño conditions.
- Lowerer temperatures over the eastern Pacific were observed between June 2010 and February 2011, corresponding to La Niña conditions.
- Higher temperatures than average were observed over the Caribbean between 2010 and 2011. The 2010-2011 El Niño was probably due to the 2009-2010 El Niño. The positive anomalies for the rest of the period seem to be associated with the dipole pattern over the Atlantic, which resembles the Atlantic Meridional Mode (AMM).

5. Concluding remarks
- 2010 and 2011 were the rainiest years in Colombia on record. Stronger than average La Niña conditions were observed during both years.
- Above-average precipitation over northern South America was observed, mainly between June 2010 and April 2012. This precipitation was associated with enhanced moisture flux from the Caribbean, the tropical Atlantic, and the eastern Pacific.
- The anomalous circulation leading to the anomalous transport of moisture to northern South America was associated with the effects of SSTAs. The SSTAs over the Pacific were largely associated with La Niña, but part of the SSTAs over the Caribbean and the Atlantic could also be related to non-ENSO patterns, like the Atlantic Meridional Mode.

Acknowledgements
We thank the COSMIC Program for the scholarships granted to the three authors, which allowed their assistance to the 2013 PASI course. We also thank Fundación Colciencias for the grant that allowed Paola Arias to participate in the COSMIC Program in the UK. This work was supported by the NASA grant NNX12AR41G, which was awarded to the University of Arizona.


REFERENCES