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FLASH FLOOD IN MADEIRA ISLAND IN AUTUMN 2012

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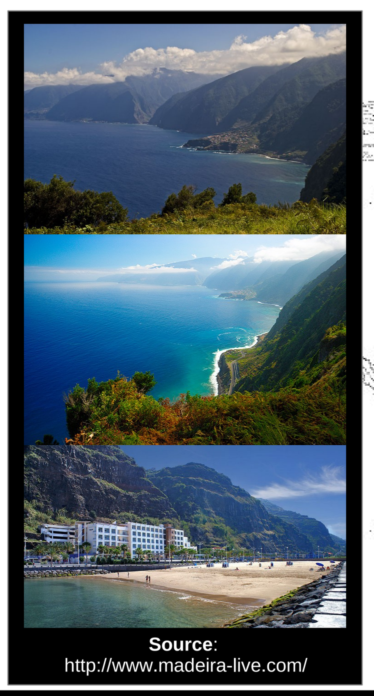
INTRODUCTION

MADEIRA ISLAND



→ is an important tourist destination;

→ located in the North Atlantic Ocean (32°75'N, 17°00'N)

→ little island with an area of ~740 km²;

→ formed by volcanic materials with a W-E elongated form (58 km long and 23 km width);

→ presents peaks above 1800 m, favoring the development of orographic precipitation;

WHY STUDY HEAVY RAINFALL EVENTS IN THE MADEIRA?

The island has shown to be vulnerable to the occurrence of extreme events, for example:

DISASTER ON 20 FEBRUARY 2010

→ flash flood and landslides in many points of the island;
→ vast range of material losses;
→ more than 40 deaths.

MOTIVATION

→ to identify the different processes leading to the generation of high rainfall amounts in Madeira.

GOALS

→ to analyze a small period of intense rainfall records in Madeira in autumn 2012 that favored the occurrence of landslides in some spots of the island, mainly in the Northern region;

→ to understand the main mechanisms and atmospheric conditions that are relevant to the establishment of extreme rainfall and consequently floods occurrences in the island;

DATA AND METHODOLOGY

Ground observation

→ **Rain gauge** data collected at Madeira meteorological stations belonging to the Instituto Português do Mar e Atmosfera – IPMA.

→ **Radiosonde** data obtained from the University of Wyoming (http://weather.uwyo.edu/upperair/sounding.html)

Remote sensing

→ **Total precipitable water** obtained from the Atmospheric InfraRed Sounder (AIRS), instrument on board of the Aqua Satellite, representing the Total Precipitable Water.

→ The AIRS data have been useful in the identification of narrow bands (plumes) with high moisture, also known as atmospheric rivers (e.g. *Ralph et. al., 2004*). In this study we considered ARs as a filament with precipitable water above 40 kg/m².

Numerical model

→ Simulations performed with the non-hydrostatic mesoscale model MESO-NH (*Lafore et. al., 1998*), with two different horizontal configurations: a single domain at a resolution of 25 km; and a three nested grids with 16, 4, and 1 km resolution (see **Table 1**, for more details).

Table 1 – Configuration of the simulations.

Horizontal resolution	**25 km**	**16 km**	**4 km**	**1 km**
Horizontal dimensions	150x150	60x60	80x80	100x72
Time step	30s	18s	6s	2s
Initial time	28 OCT and 03 NOV at 12 UTC	29 OCT and 04 NOV at 12 UTC	29 OCT and 04 NOV at 18 UTC	29 OCT and 04 NOV at 18 UTC
Run time	60 h	42 h	36 h	36 h
Parameterizations				
Microphysics	ICE3	ICE3	ICE3	ICE3
Convection	KAFR	KAFR	NONE	NONE
Surface	SURFEX	SURFEX	SURFEX	SURFEX
Radiation	ECMWF	ECMWF	ECMWF	ECMWF
Boundary layer	TKE equation	TKE equation	TKE equation	TKE equation

RESULTS

CASE STUDY: 30 OCTOBER 2012

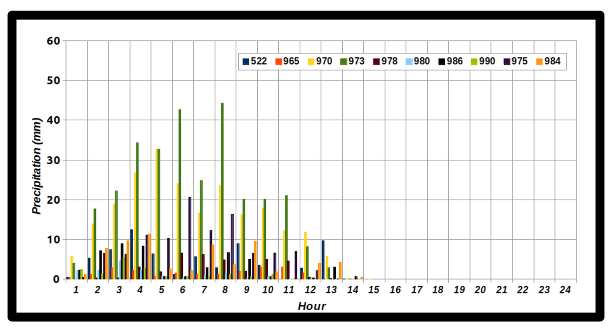


Figure 3 – Diurnal variations of total hourly rainfall (mm) for Funchal (**522**), Santana (**965**), Bica da Cana (**970**), Areeiro (**973**), Caniçal (**978**), Ponta do Sol (**980**), Ponta do sol (**986**), Calheta/Ponta do pargo (**990**), Santo da serra (**975**), and Quinta grande (**984**) station, on 30 October 2012.

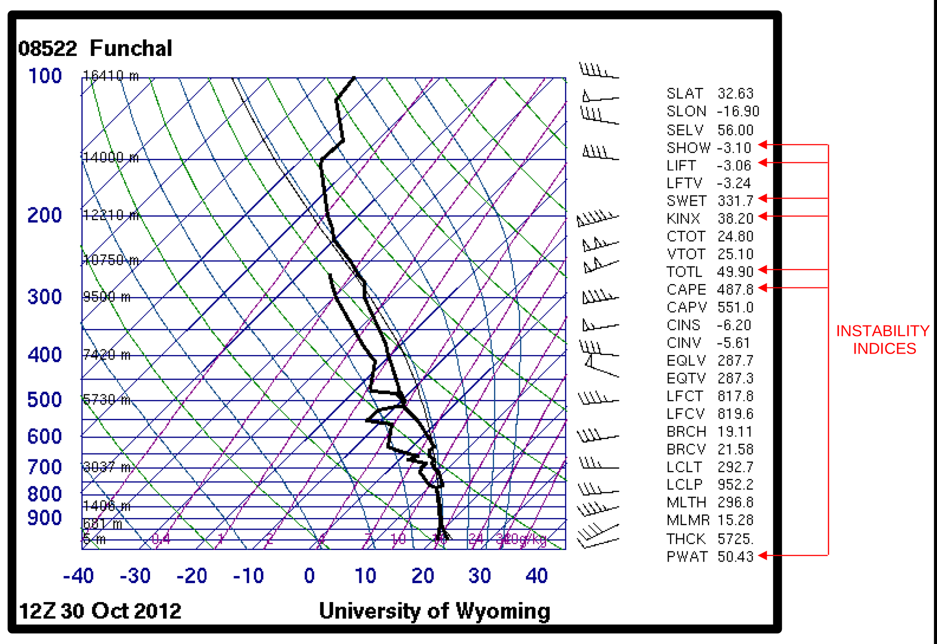


Figure 4 – Radiosonde from Funchal on 30 October 2012 at 12 UTC.

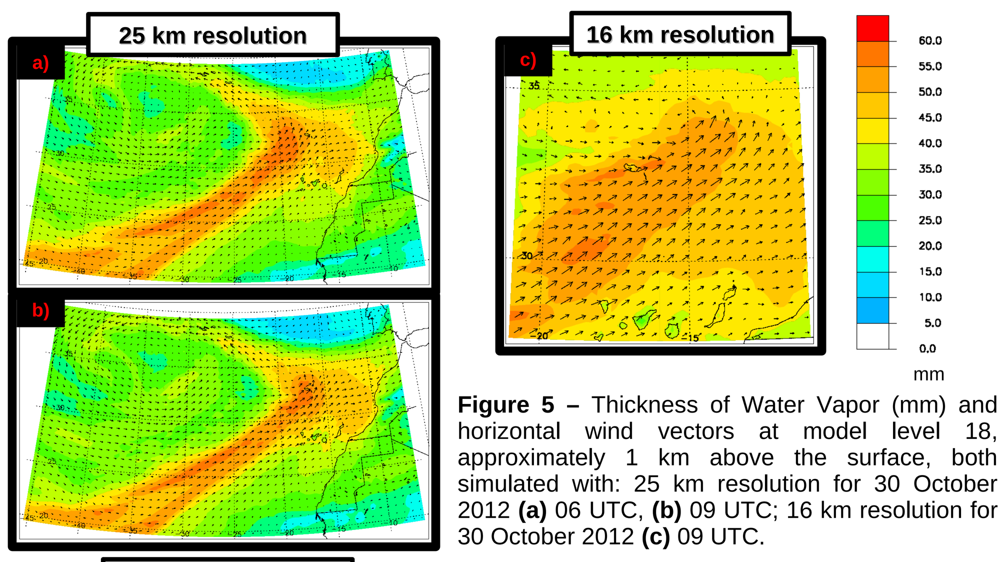


Figure 5 – Thickness of Water Vapor (mm) and horizontal wind vectors at model level 18, approximately 1 km above the surface, both simulated with: 25 km resolution for 30 October 2012 **(a)** 06 UTC, **(b)** 09 UTC; 16 km resolution for 30 October 2012 **(c)** 09 UTC.

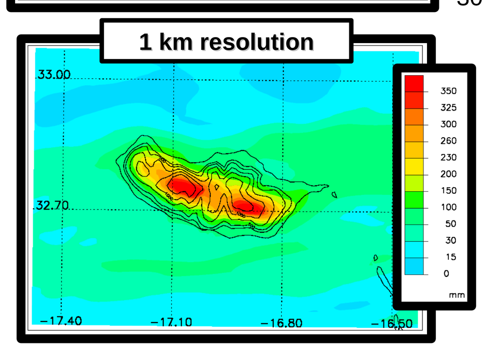


Figure 6 – Daily accumulated precipitation (mm) on 30 October 2012 (shaded areas), and the Madeira orography (m) obtained from GTOPO30 database (solid lines), both simulated with 1 km resolution.

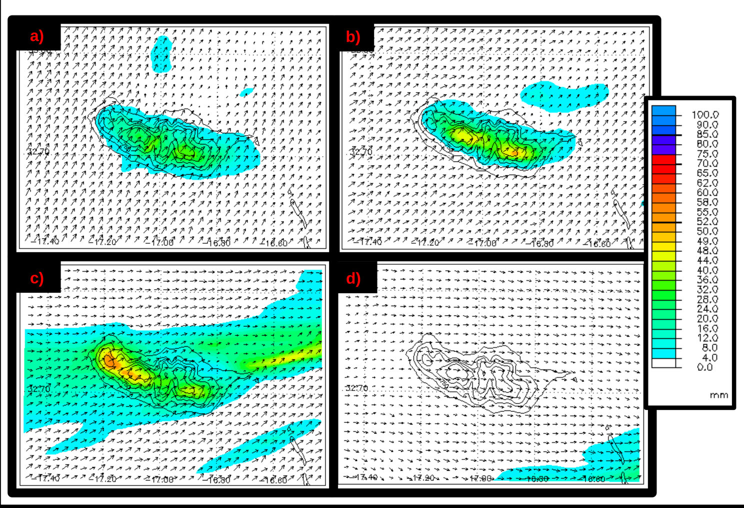


Figure 7 – The shaded areas represent the hourly accumulated precipitation (mm), and the arrows the horizontal wind vectors at model level 18, approximately 1 km above the surface, both for the inner domain, on 30 October 2012: **(a)** 03 UTC, **(b)** 06 UTC, **(c)** 09 UTC, and **(d)** 12 UTC.

PERIOD ANALYSIS AND CASE STUDIES CHOICE

RAIN GAUGE DATA

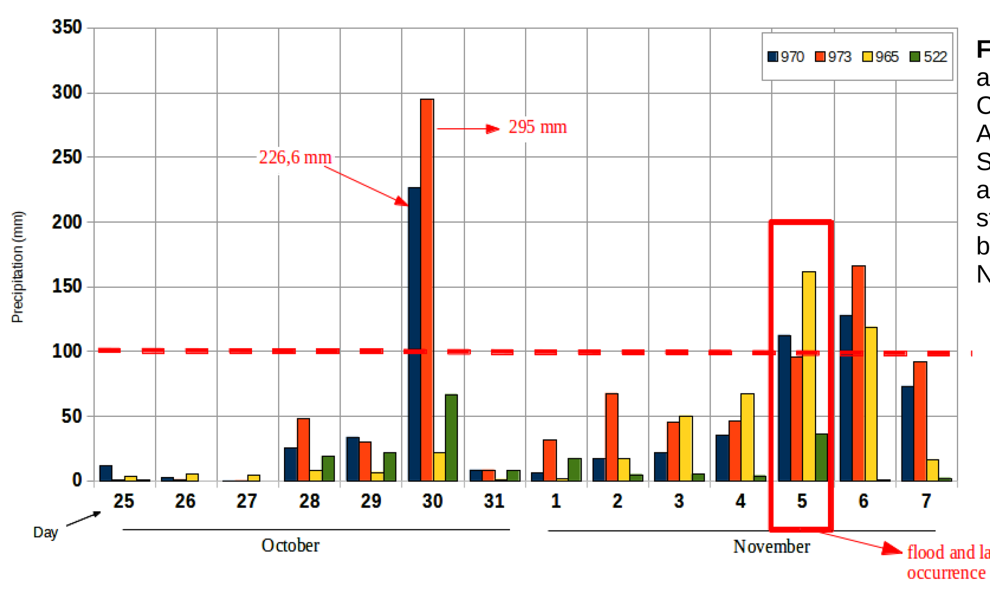


Figure 1 – Daily rainfall amounts obtained for Bica da Cana (970; Alt.: 1560 m), Areeiro (973; Alt.: 1590 m), Santana (965; Alt.: 385 m), and Funchal (522; Alt.: 58 m) station, for the period between 25 October and 05 November 2012.

SATELLITE OBSERVATION

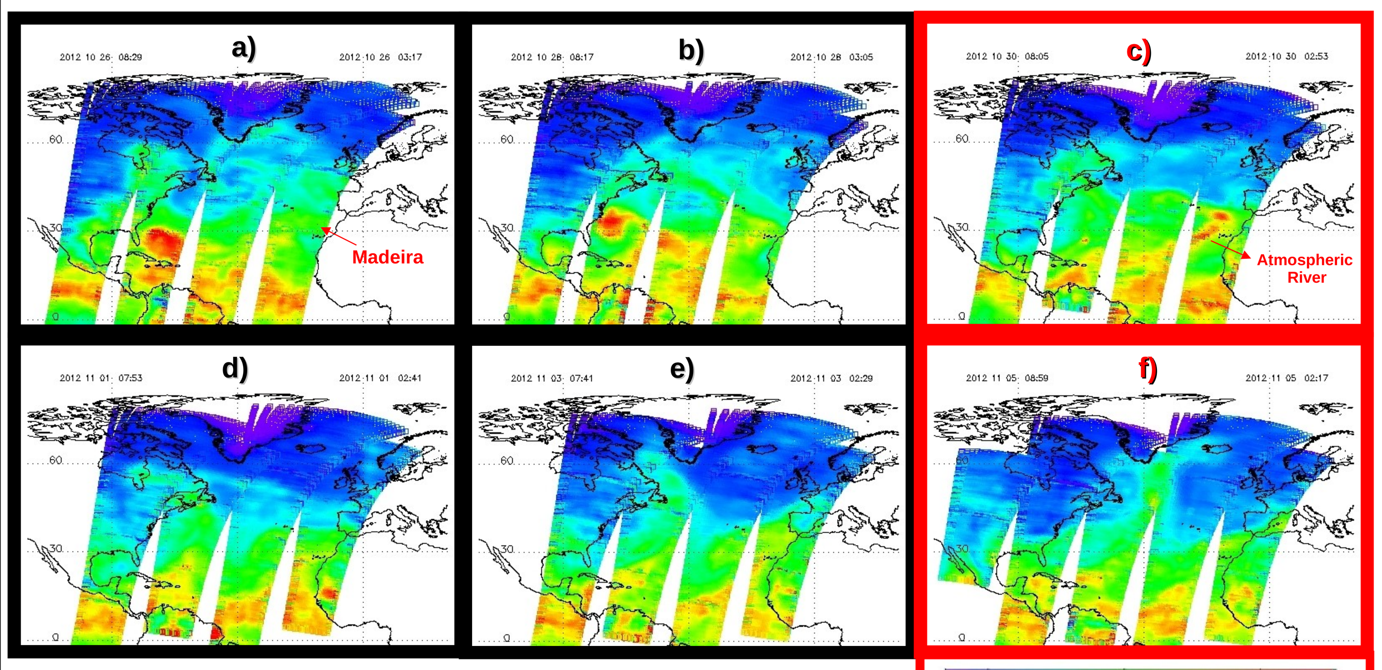


Figure 2 – Satellite images of precipitable water obtained from AIRS for **(a)** 2012/10/26, **(b)** 2012/10/28, **(c)** 2012/10/30, **(d)** 2012/11/01, **(e)** 2012/11/03, and **(f)** 2012/11/05.

CASE STUDY: 05 NOVEMBER 2012

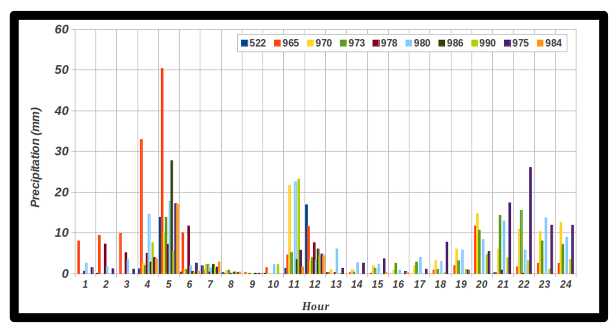


Figure 8 – Diurnal variations of total hourly rainfall (mm) for Funchal (**522**), Santana (**965**), Bica da Cana (**970**), Areeiro (**973**), Caniçal (**978**), Lombo da terça (**980**), Ponta do sol (**986**), Calheta/Ponta do pargo (**990**), Santo da serra (**975**), and Quinta grande (**984**) station, on 05 November 2012.

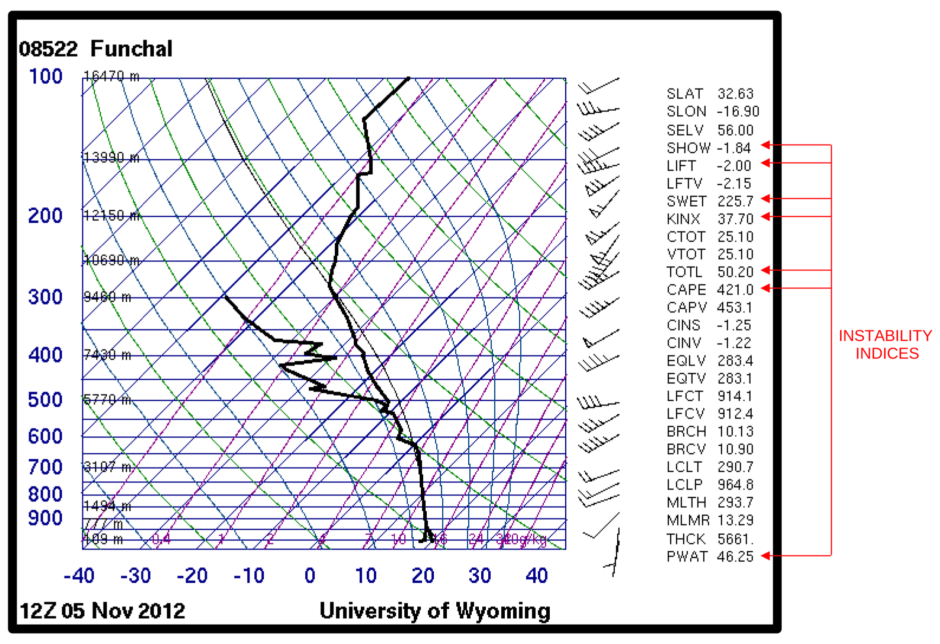


Figure 9 – Radiosonde from Funchal on 05 November 2012 at 12 UTC.

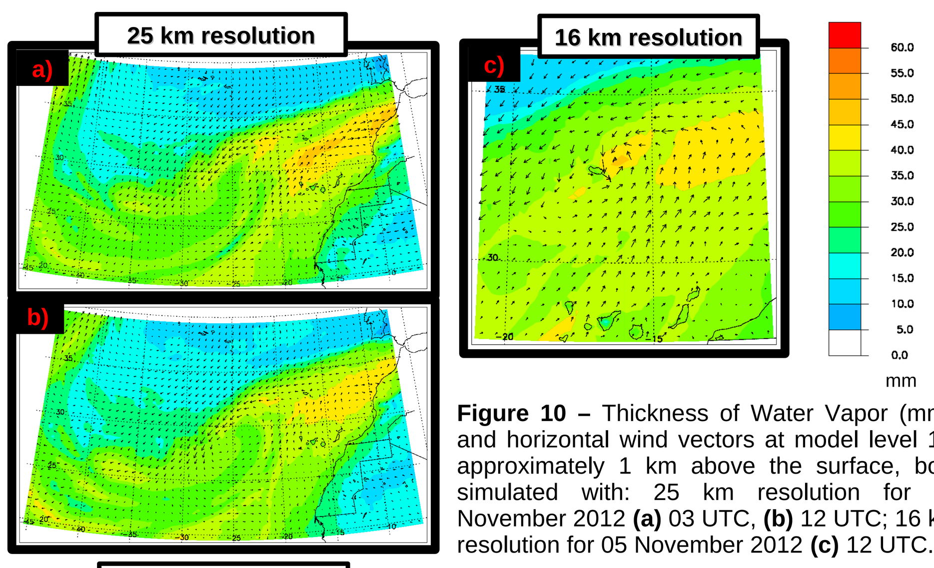


Figure 10 – Thickness of Water Vapor (mm), and horizontal wind vectors at model level 18, approximately 1 km above the surface, both simulated with: 25 km resolution for 05 November 2012 **(a)** 03 UTC, **(b)** 12 UTC; 16 km resolution for 05 November 2012 **(c)** 12 UTC.

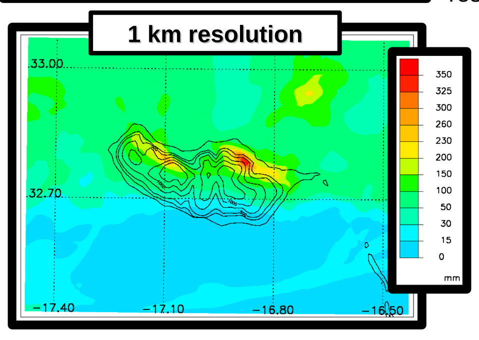


Figure 11 – Daily accumulated precipitation (mm) on 05 November 2012 (shaded areas), and the Madeira orography (m) obtained from GTOPO30 database (solid lines), both simulated with 1 km resolution.

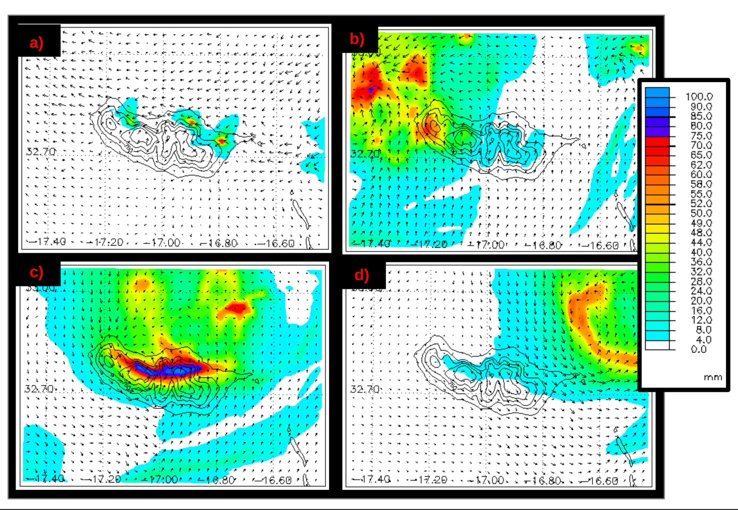


Figure 12 – The shaded areas represent the hourly accumulated precipitation (mm), and the arrows the horizontal wind vectors at model level 18, approximately 1 km above the surface, both for the inner domain, on 05 November 2012: **(a)** 06 UTC, **(b)** 11 UTC, **(c)** 12 UTC, and **(d)** 13 UTC.

CONCLUSIONS

The rainfall episodes presented in this work represented high-impact in surface, with damages being reported as a consequence of flooding on 05 November. In general, the period was marked by heavy precipitation, mainly on 30 October. The large-scale environment was characterized by the development of an extratropical cyclone near the island, where the frontal structure acting over the archipelago is evident in the first case simulated. A remarkable feature is the fact that in this case, coupled to the cold front, the main moisture source in low-levels was related to an AR structure passing over the island. On 05 November the passage of a convective system over the north region favoured the landslides, however the precipitation was more localized than on the 30 October. The precipitation in the island depends both of local and large-scale environments, and several days with intense precipitation contributed to the landslides on 05 November 2012. The AR observed on 30 October, bringing moist air poleward was important for the flooding occurrence on 05 November, such as it was the precipitation occurred in the days prior to the 20 February 2010 catastrophe (e. g. *Luna et. al., 2011*; *Couto et. al., 2012*).

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