Predictability of an intense precipitation event using the WRF model

T. Luna[1] (tiagoluna@ua.pt), A. Rocha[2], A. C. Carvalho[3], J. A. Ferreira[2], and J. Sousa[2]

[1] IDAD The Institute for Environment and Development, Campus Universitário de Santiago 3810-193 Aveiro, Portugal

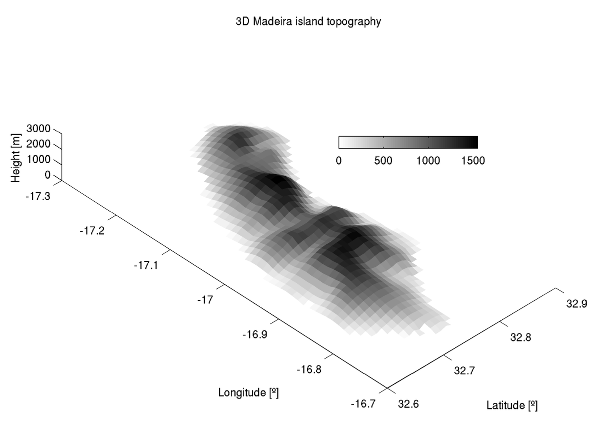
[2] Department of Physics, CESAM, University of Aveiro, Campus Universitário de Santiago 3810-193 Aveiro, Portugal

[3] CENSE, Department of Science Environmental Engineering, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal

EMS2011-708-2

Objective

In the morning of February the 20th, 2010 an extreme precipitation event occurred over the Madeira Island. This event triggered several flash floods and mudslides in the southern parts of the island, resulting in the death of 42 people, 100 injured and at least 8 people are still missing.



In this study, the WRF model is used to evaluate the intensity and predictability of this event. The synoptic/orographic nature of precipitation is also evaluated, as well as the sensitivity of the model to horizontal resolution and cumulus parametrization.

SE view of Madeira Island's topography

Methodology

Numerical Weather Prediction Model

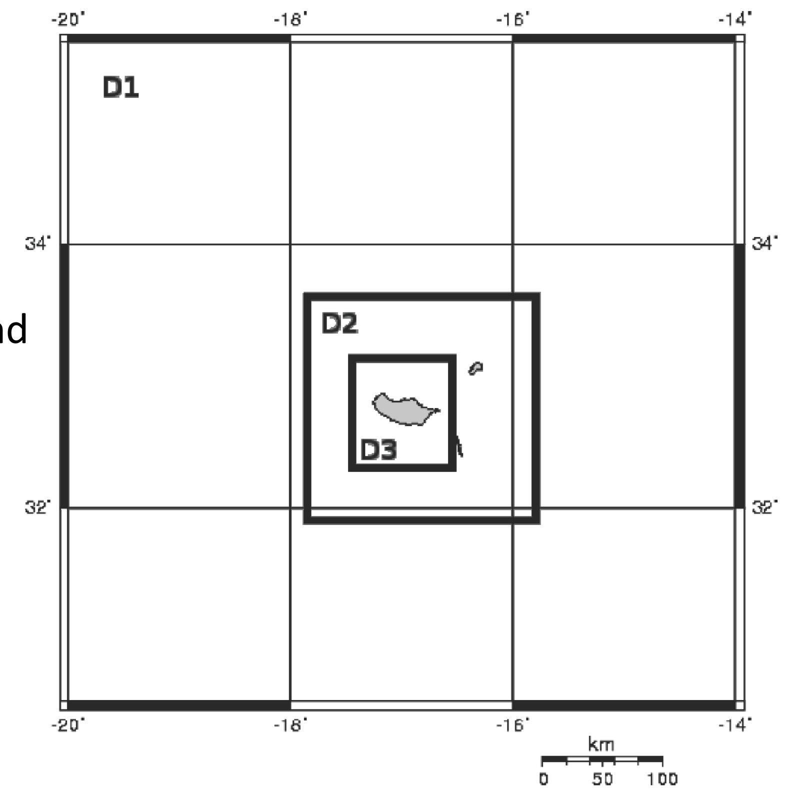
- **WRF-ARW version 3.2 (Skamarock, 2008)**

Forcing fields

- NCEP's Global Forecast System (GFS)

Model Configuration

- Highly resolved domain is centered in Madeira Island
- D1: 25 km D2: 5 km D3: 1 km resolution
- Dudhia shortwave radiation
- Rapid Radiative Transfer Model for longwave
- Yonsei University (YSU) PBL scheme
- the Noah Land Surface Model
- Kain-Fristch convective parameterization scheme
- 28 Vertical levels



Error Measurements:

BIAS

$$Bias = \frac{1}{N}\sum_{i=1}^{N}\phi'$$

Root Mean Square Error

$$E = \left[\frac{\sum_{i=1}^{n}(\phi_i - \phi_{i,obs})^2}{N}\right]^{1/2}$$

Root Mean Square Error without cte. bias

$$E_{UB} = \left[\frac{\sum_{i=1}^{n}[(\phi_i - \phi_0) - (\phi_{i,obs} - \phi_{0,obs})]^2}{N}\right]^{1/2}$$

Standard desviation

$$S = \left[\frac{\sum_{i=1}^{n}(\phi_i - \phi_0)^2}{N}\right]^{1/2}$$

WRF Simulations

RUN	Start Date	Nº. Of Domains	D3 Cu parameterization
Run00	19 Feb 06 UTC	2	NA
Run0	19 Feb 00 UTC	2	NA
Run1	18 Feb 12 UTC	2	NA
Run2	17 Feb 12 UTC	2	NA
Run3	16 Feb 12 UTC	2	NA
Run4	15 Feb 12 UTC	2	NA
Run5	14 Feb 12 UTC	2	NA
Run6	13 Feb 12 UTC	2	NA
RunPrev	20 Feb 00 UTC	2	NA
Run7	20 Feb 12 UTC	3	0
Run8	20 Feb 12 UTC	3	3

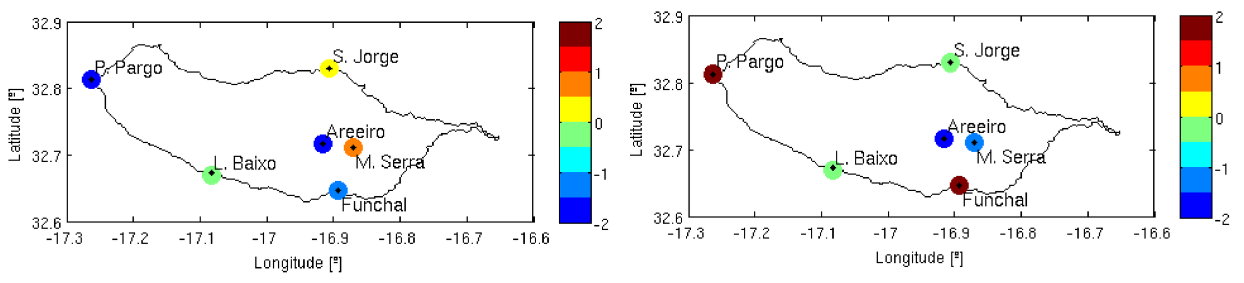
Model skill high when:

$$S \approx S_{obs} \qquad E < S_{obs} \qquad E_{UB} < S_{obs} \qquad STDE^2 \sim E^2 \Leftrightarrow Bias^2 << E^2$$

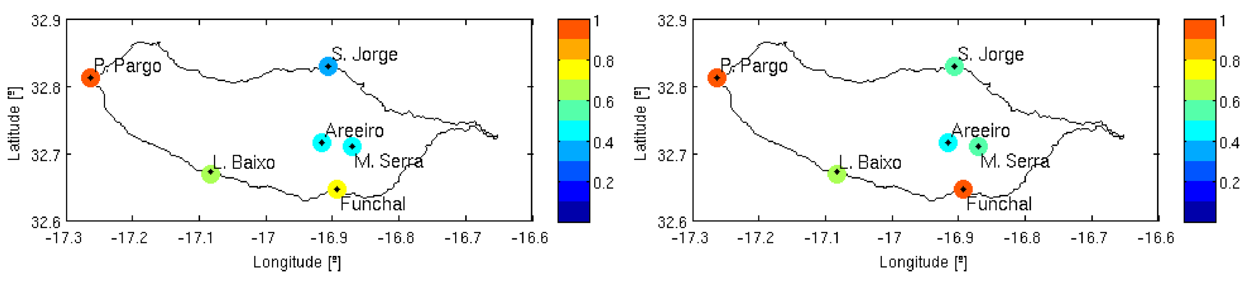
Results

Run7	Run8
Explicit Moisture	**With Cu parameterization**

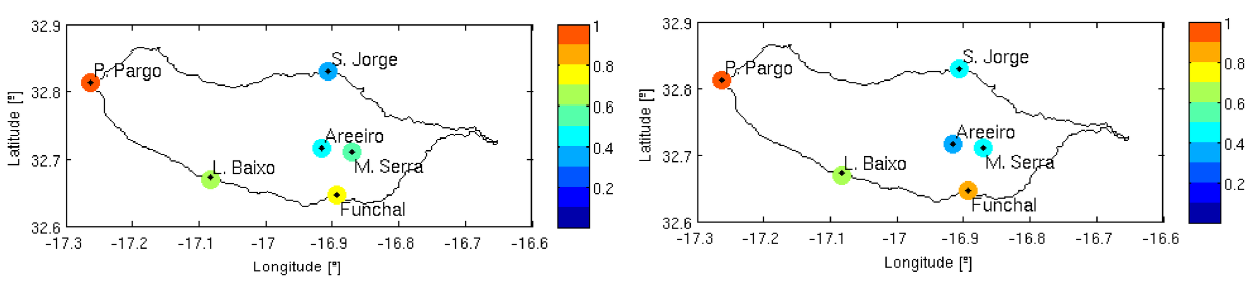
BIAS



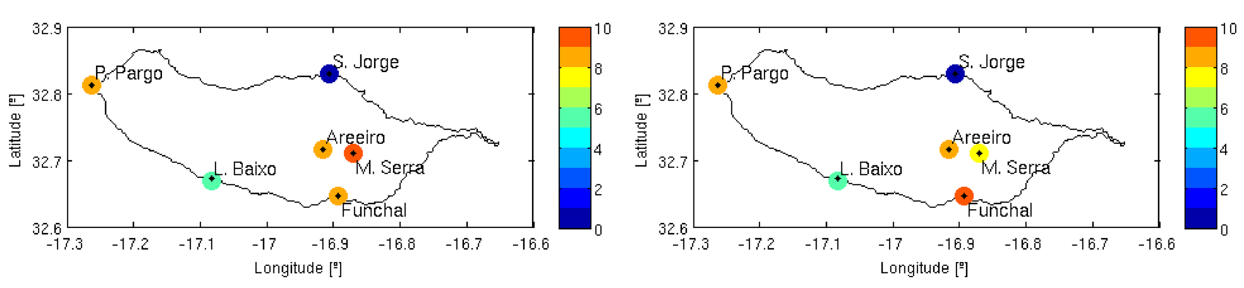
E/Sobs



Eub/Sobs

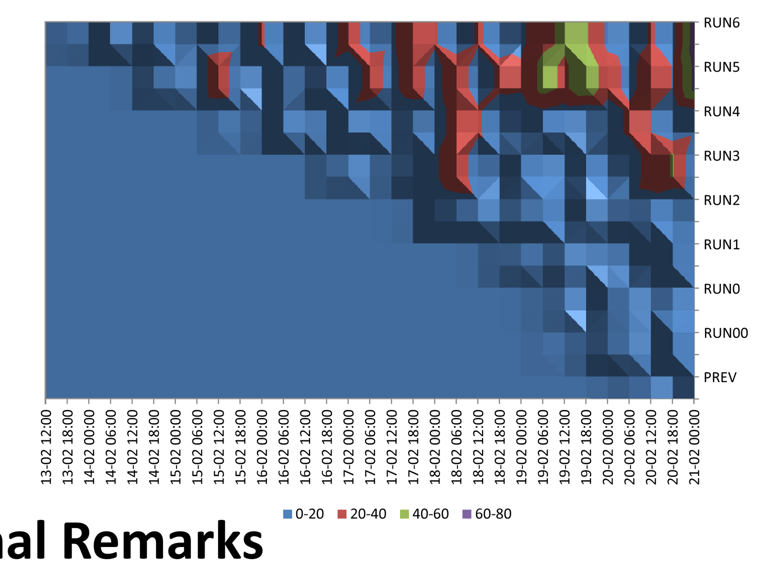


RMSE

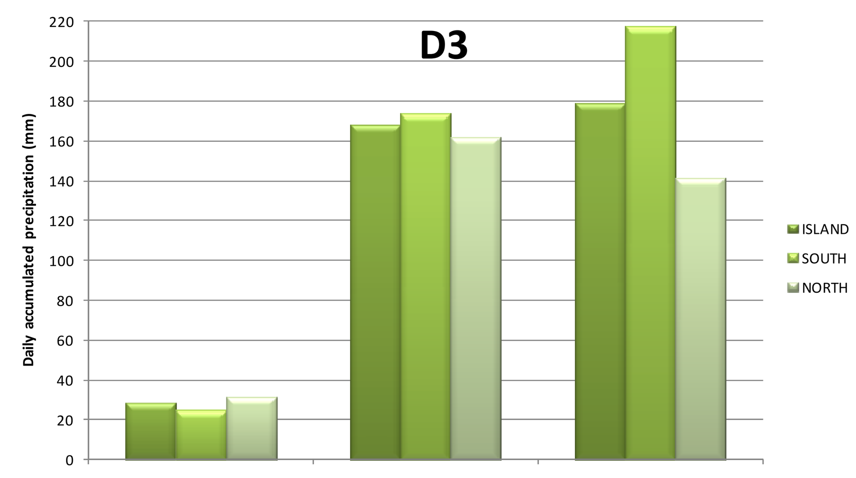


- *Areeiro*, *Funchal* and *Meia Serra* had the highest precipitation amounts (approx. 50 mm h^{-1}), which were correctly modelled both in phase and intensity.
- Great discrepancies are observed in *P. Pargo*, may be due to its location, where the terrain is very steep near the sea.
- With Cu Param. (Run8) results showed lower Bias and RMSE.

Difference (%) between area-averaged precipitable water in the GFS forecast and analysis



Influence on daily accumulated precipitation of cummulus *vs* explicit moisture *vs* no-land/no-topography



Final Remarks

- There was predictability up to three days before the event, mainly dictated by the quality of initial and boundary conditions supplied by the GFS global forecast
- Daily total precipitation is not well simulated by runs which started more than 12 h before the peak precipitation.
- Hourly local precipitation, namely its amplitude and phase, is well simulated only when simulations are initialized 12 h before the event.
- The precipitation resulted from southern flow lifting imposed by Madeira's topography, affecting mainly the center and southern parts of the Island.
- *S. Jorge* showed few discrepancies, maybe due to microphysics being the dominant process producing the precipitation.
- *P. Pargo* showed the biggest discrepancy, which could be related to its location which, in turn, could be misrepresented in the model, where landuse is water and the altitude of the station is 300 m above sea level.

Aknowledgments:
Juan Ferreira and João Sousa gratefully acknowledge their PhD grants SFRH/BD/31465/2006 And SFRH/BD/64515/2009 to Fundação para a Ciência e Tecnologia