Workshop NWP Portugal

WRF model application studies developed at the Department of Physics and CESAM Associated Laboratory of the University of Aveiro

José Manuel Castanheira

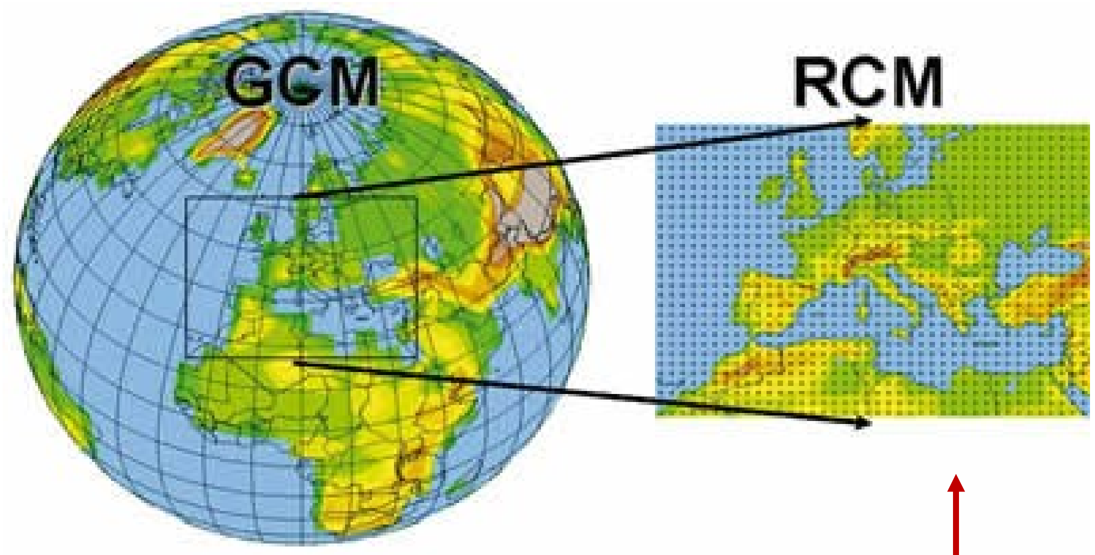
Departamento de Física & CESAM, Universidade de Aveiro

- At the Fhysics Departament of UA all atmospheric modellig studies, for weather or climatological purposes, has been based on WRF modelling system.

- We also colaborate with colleagues working in oceanography and running the ROMS model

Examples of studies performed at the Physics Department & CESAM - UA

From international cooperation



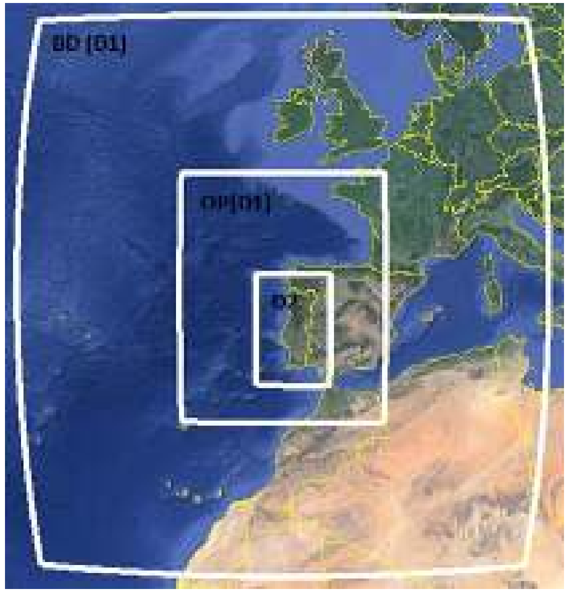
Can be performed by public and private organizations at a national level

Sensitivity of near surface forecasts to the WRF-ARW initialization versus domain configuration

Tiago Luna, José M Castanheira, Alfredo Rocha
Centre for Environmental and Marine Sciences (CESAM), University of Aveiro, Department of Physics, Portugal

Objective

- Assessment of WRF-ARW sensitivity to domain configuration
- Reducing WRF-ARW spin-up time



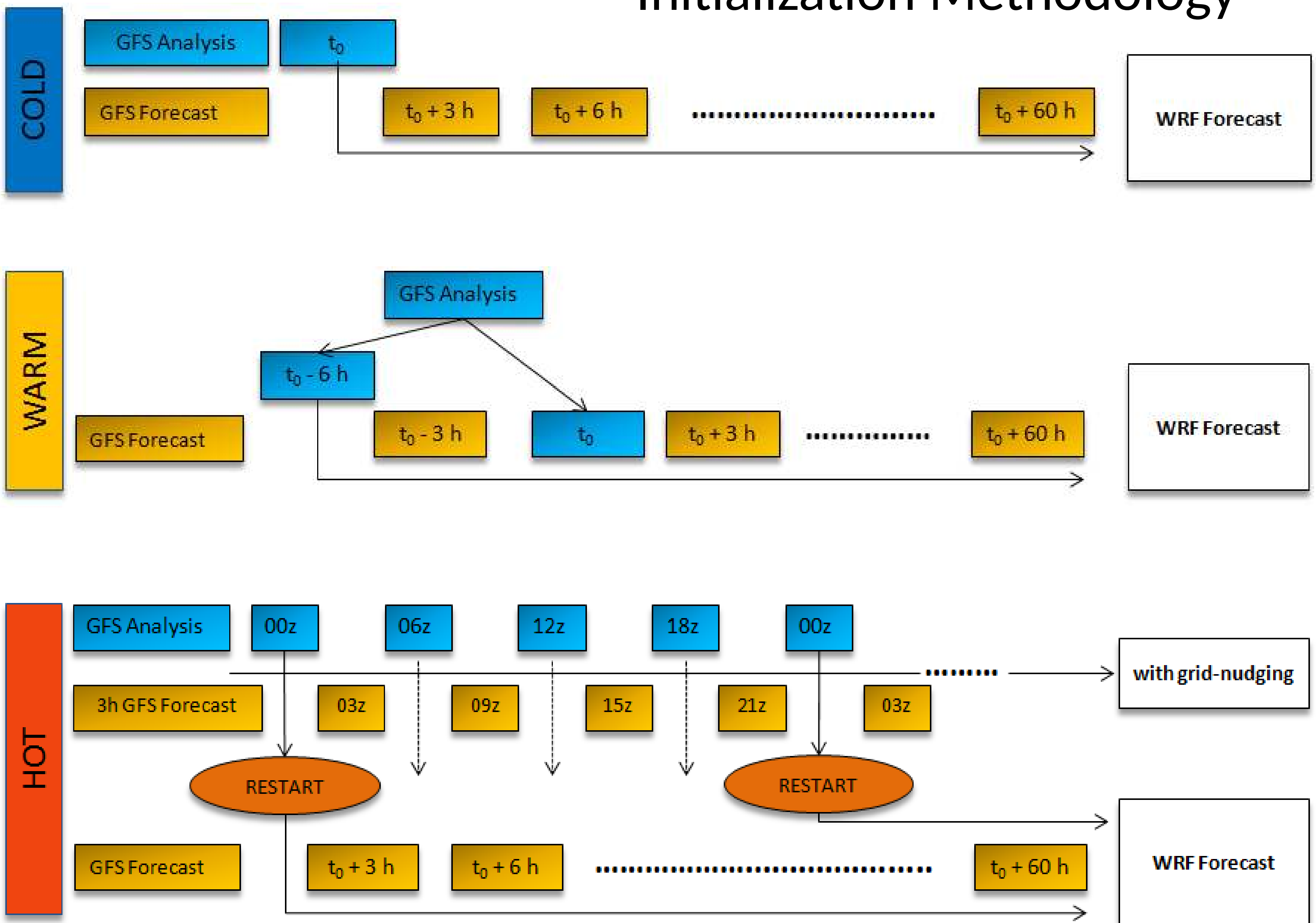
Model Setup

- Daily simulations for 60h forecast
- Different methods of initialization

- Portugal mainland is simulated using two domains configurations:
  - OP (operational domain)
    - OP(D1) = 25 km (parent)
    - L(D2) = 5 km (nested)
  - BD (big domain)
    - BD(D1) = 25 km (parent)
    - L(D2) = 5

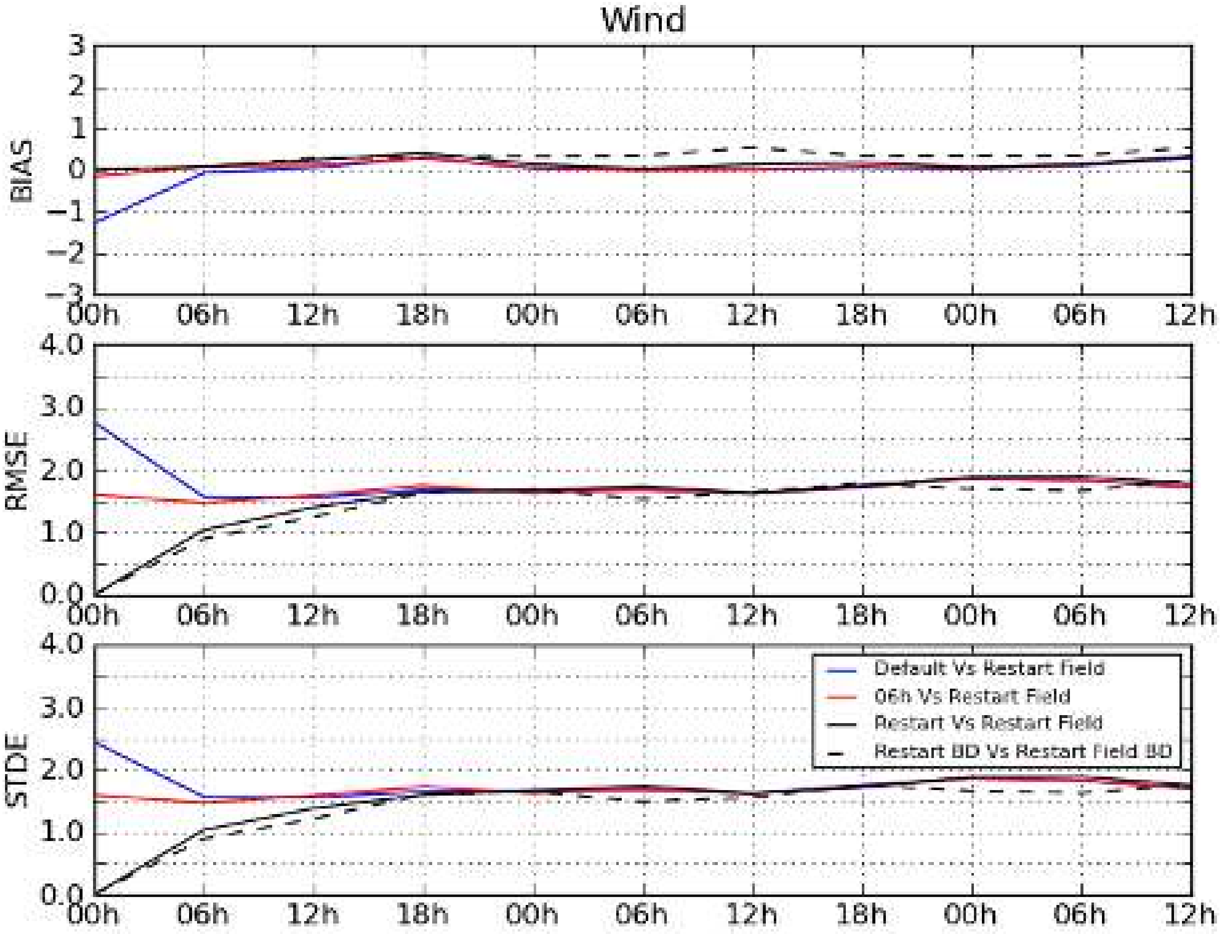
Method	Initial Condition	Bondary Conditions (60h)	Type of Initialization
1	GFS	GFS	COLD
2	GFS	GFS (0-3h,0-60h)	WARM

Initialization Methodology



Forecast errors

- 01 – 15 December 2010 (00h UTC)



$$\Phi' = |\vec{V}|_f - |\vec{V}|_{restart\ field}$$

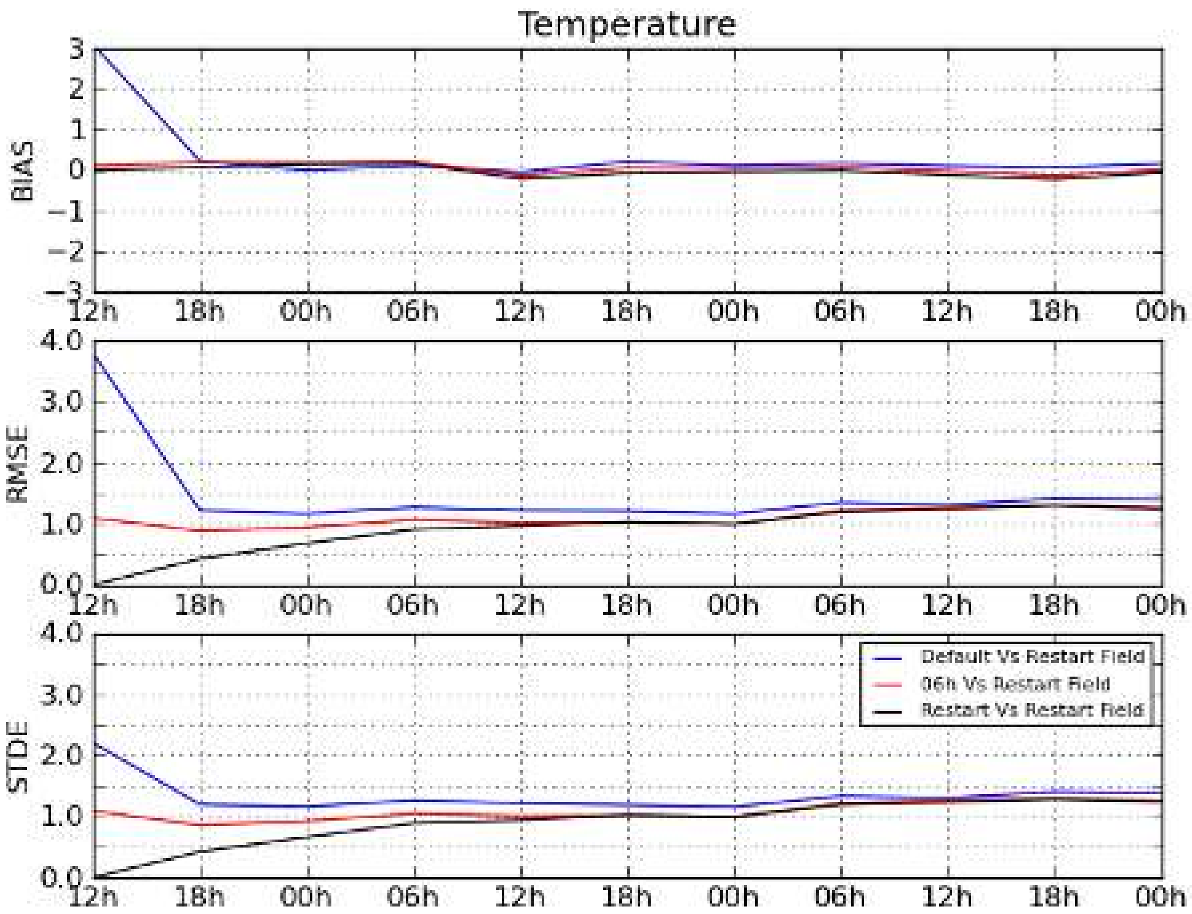
$$\text{Bias} = \frac{1}{N}\sum_i \Phi'_i$$

$$RMSE = \left[\frac{1}{N}\sum_i (\Phi'_i)^2\right]^{1/2}$$

$$STDE = \left[\frac{1}{N}\sum_i \left(\Phi'_i - \frac{1}{N}\sum_i \Phi'_i\right)^2\right]^{1/2}$$

Forecast errors

- 17 – 31 August 2010 (12h UTC)



$$\Phi' = T_f - T_{restart\ fied}$$

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

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(\Phi'_i)^2\right]^{1/2}$$

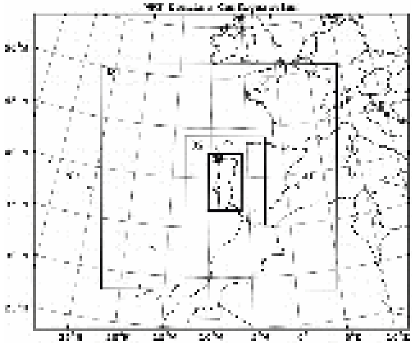
$$STDE = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\Phi'_i - \frac{1}{N}\sum_{i=1}^{N}\Phi'_i\right)^2\right]^{1/2}$$

Role of cloud microphysics and spatial resolution in precipitation simulation during an atmospheric river event in Portugal

Rui Silva and Irina Gorodetskaya
Centre for Environmental and Marine Sciences (CESAM), University of Aveiro, Department of Physics, Portugal
(ruipedrosilva@ua.pt; irina.gorodetskaya@ua.pt)

Model Setup

Event: Gong storm (19 January 2013), associated atmospheric river (AR)
Forcing data: ERA-Interim reanalysis at 0.75 x 0.75° (≈81 km)
Model: WRF v3.9
Simulation period: 16/01/2013 at 18 UTC – 20/01/2013 at 00 UTC
Downscaling approach: 27 km – 9 km – 3 km (one-way nesting)



Objective

Testing the sensitivity of the modelled precipitation using different cloud microphysics schemes and domain resolutions for an **intense precipitation event associated with an atmospheric river**

Physics Options

- Dudhia shortwave radiation
- Rapid Radiative Transfer Model (RRTM) LW
- Noah Land Surface Model
- MM5 similarity
- Yonsei University (YSU) boundary layer
- Kain-Fritsch cumulus scheme (turned off in the 3 km domain)
- **Cloud microphysics schemes:**

- WSM6 (one-moment),
- Thompson (two-moment),
- Morrison (two-moment)

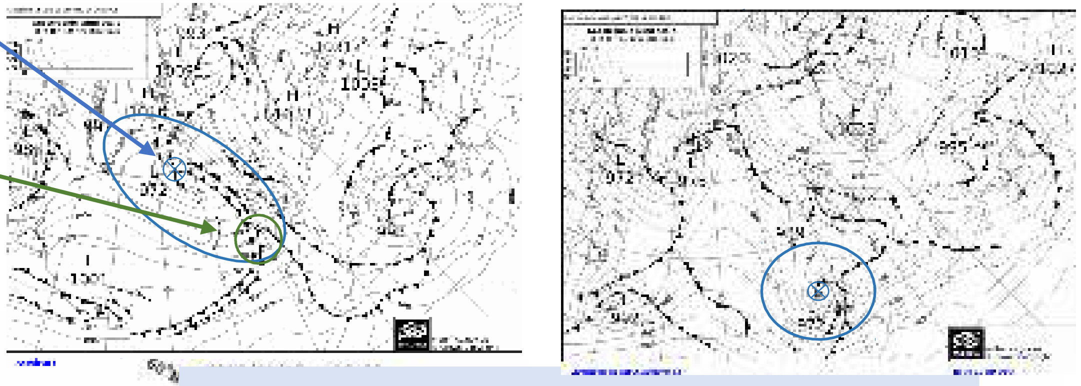
Scheme classes	WSM6	Thompson	Morrison
Water vapor	m.r.;	m.r.;	m.r.;
Cloud liquid water	m.r.;	m.r.;	m.r.;
Rain water	m.r.;	m.r.; n.c.	m.r.; n.c.
Snow	m.r.;	m.r.;	m.r.; n.c.
Ice	m.r.;	m.r.; n.c.	m.r.; n.c.
Graupel	m.r.;	m.r.;	m.r.; n.c.

Table: Prognostic variables for each scheme: mixing ratio (m.r.) and number concentration (n.c.).

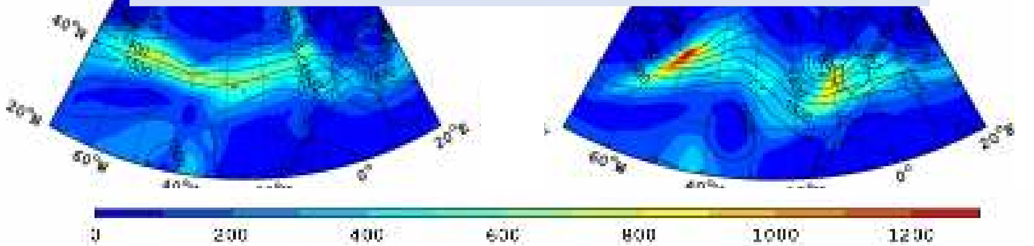
1st cyclone (17/01/2013 at 18 UTC)

2nd cyclone (Gong) 19/01/2013 at 00 UTC

Double cold front with single warm front

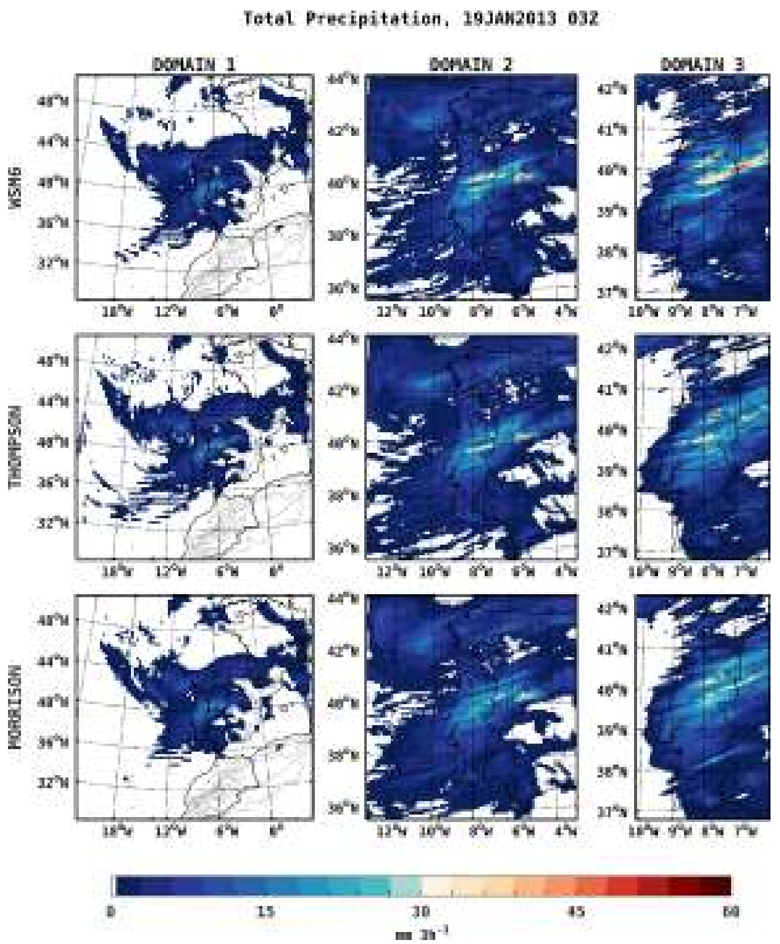


Integrated water vapour Transport, kg m^{-1} s^{-1}



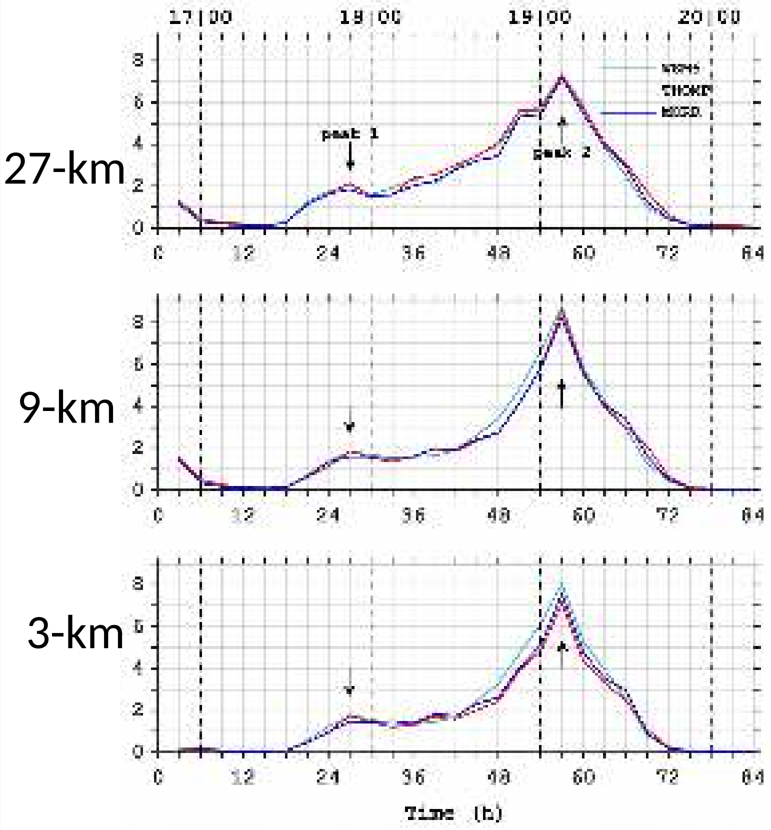
Selected results

Fields of 3-hourly accumulated precipitation at peak 2



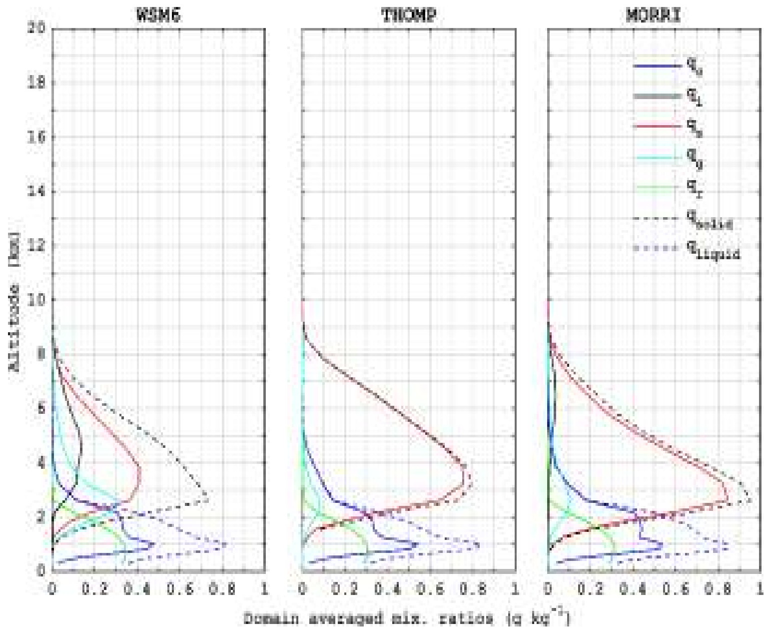
- Higher precipitation values in regions of high topography, due to orographic enhancement of precipitation and higher terrain detail;
- High resolution simulations are very important to detect local precipitation extremes;
- Single-moment WSM6 scheme produces higher extreme values.
- Comparison to EOBS (25-km resolution) shows best performance for Morrison scheme

3-hourly accumulated precipitation averaged over the 3 km domain (time evolution) for different model resolution runs (27, 9, 3-km)



- Domain resolution has more influence on the total amount of precipitation predicted than the cloud microphysics scheme.

Hydrometeors water paths averaged over the 3 km domain (19-JAN-2013 between 00 and 03 UTC)



- All the schemes have similar profiles of liquid water (cloud + rain water);
- Bigger differences are in the solid phase hydrometeors, with the WSM6 producing less snow and ice than the other schemes;
- On the other hand, the WSM6 produces more graupel.

R. Silva and I. Gorodetskaya, Role of cloud microphysics and spatial resolution in precipitation simulation during an atmospheric river event in Portugal, to be submitted to Weather and Climate Extremes.

ASSESSING THE ROLE OF ATMOSPHERIC RIVERS IN ARCTIC PRECIPITATION IN PRESENT AND FUTURE CLIMATE

Carolina Viceto[1], Susanne Crewell[2], Annette Rinke[3], Alfredo Rocha[1] and Irina Gorodetskaya[1]

[1]Department of Physics and CESAM, University of Aveiro, Aveiro, Portugal; [2]Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany; [3]Alfred Wegener Institute, Helmholtz Centre for Polar & Marine Research, Potsdam, Germany

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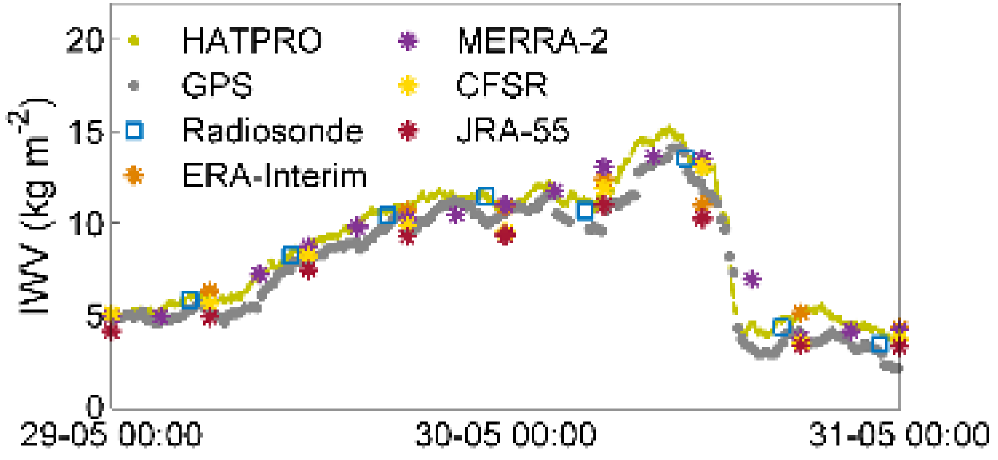
Two atmospheric rivers detected during ACLOUD campaign in Svalbard, Norway (May 22 – June 28, 2017)

- May 29-30, 2017
- June 6, 2017

Comparison with observations at Ny-Ålesund

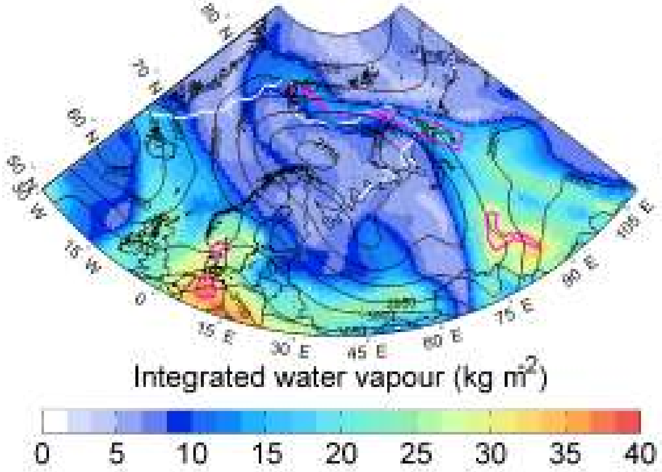


Future plan

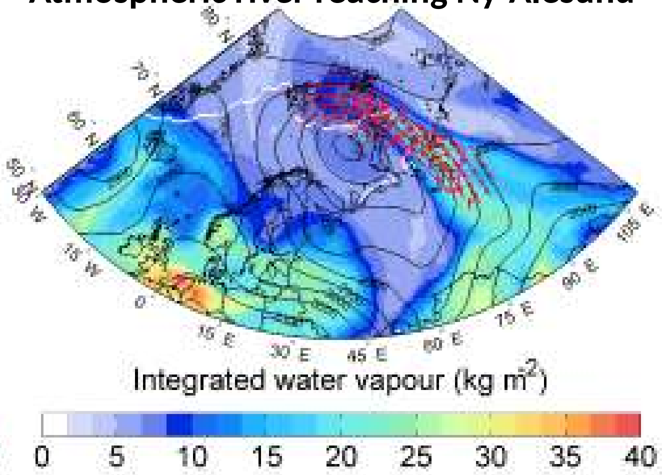
- Comparison with HIRHAM5 model output – case studies (at NY-Ålesund and Arctic domain)
- Use COSMO model - climatology and process understanding

Analysis of 29-30 May atmospheric river

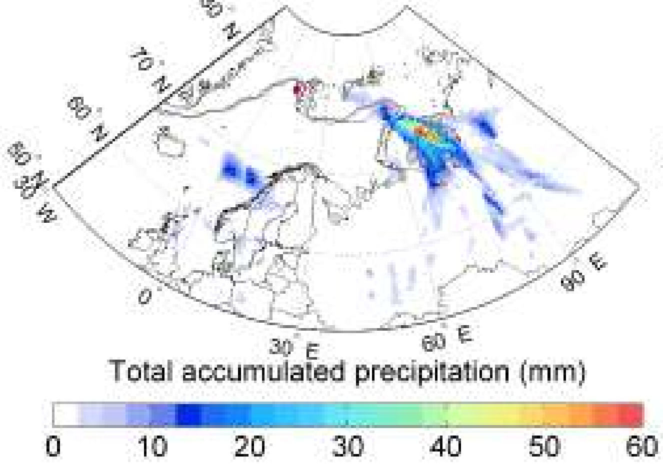
- 24 hours

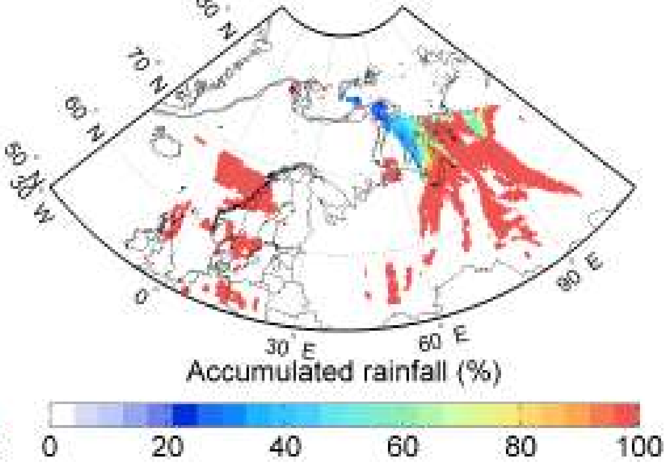


Atmospheric river reaching Ny-Ålesund



Analysis of 29-30 May precipitation patterns





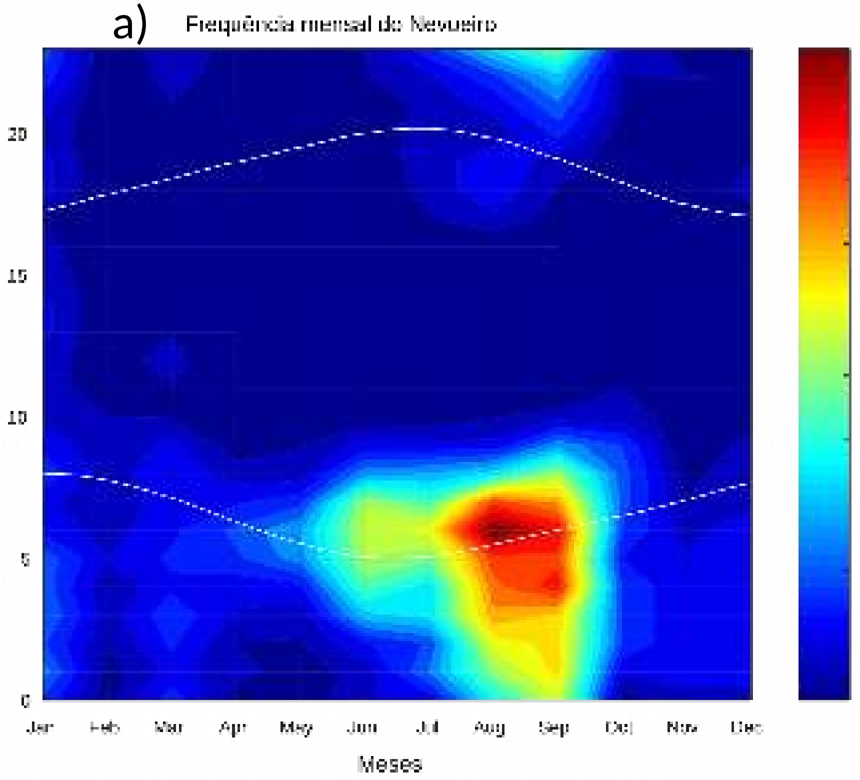
FOG SIMULATION IN THE NORTH COST OF PORTUGAL

Martín Senande[1], Pedro Serpa[1], Martinho Marta-Almeida[2], and José M Castanheira[1]

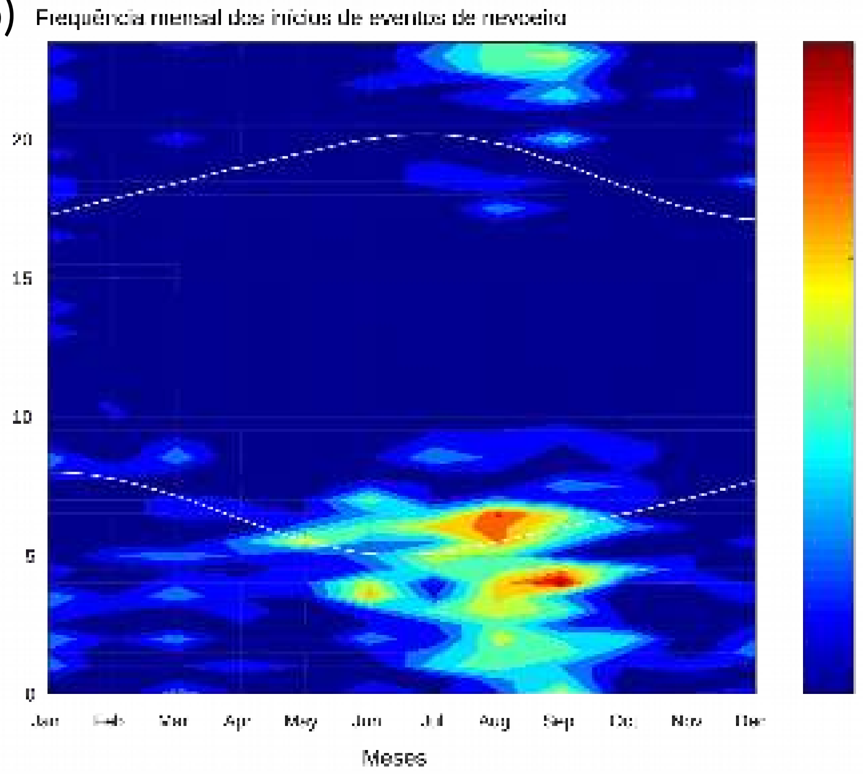
[1]Department of Physics and CESAM, University of Aveiro, Aveiro, Portugal;

[2]University of Vigo, Vigo, Spain;

a)

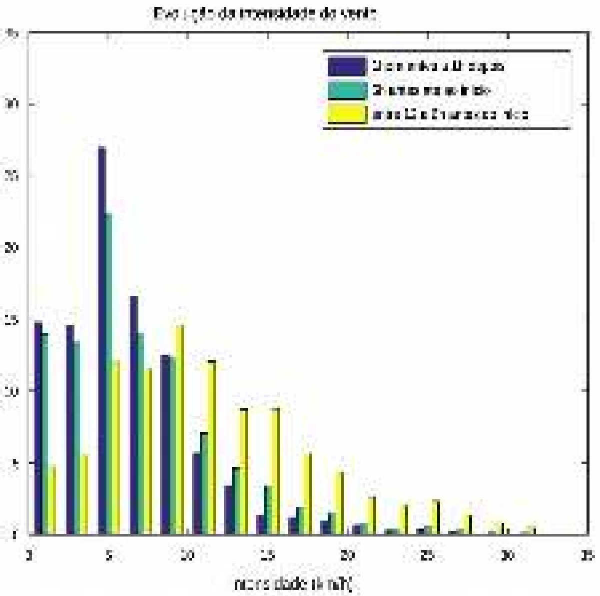


b)

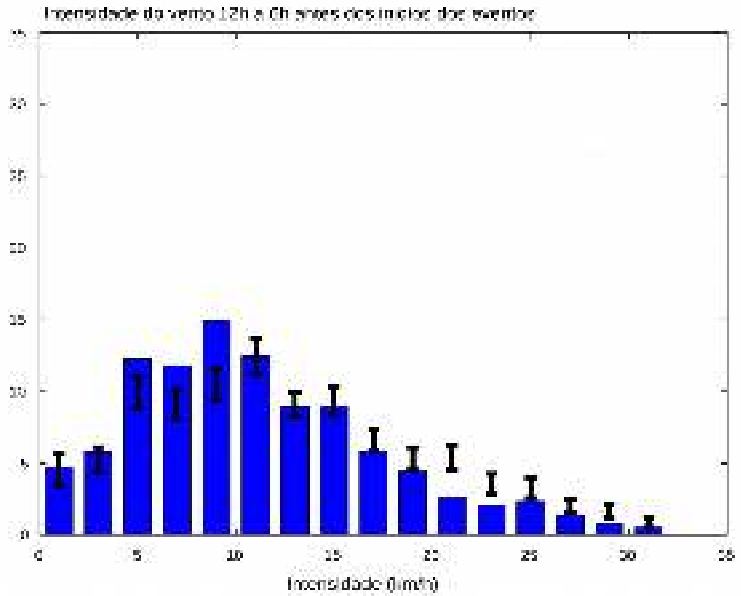


a) Hourly frequency of fog observations and **b)** hourly frequency of initiation of fog events at the airport Francisco de Sá Carneiro (Porto), as calculated from METAR data for the period 2004-2017.

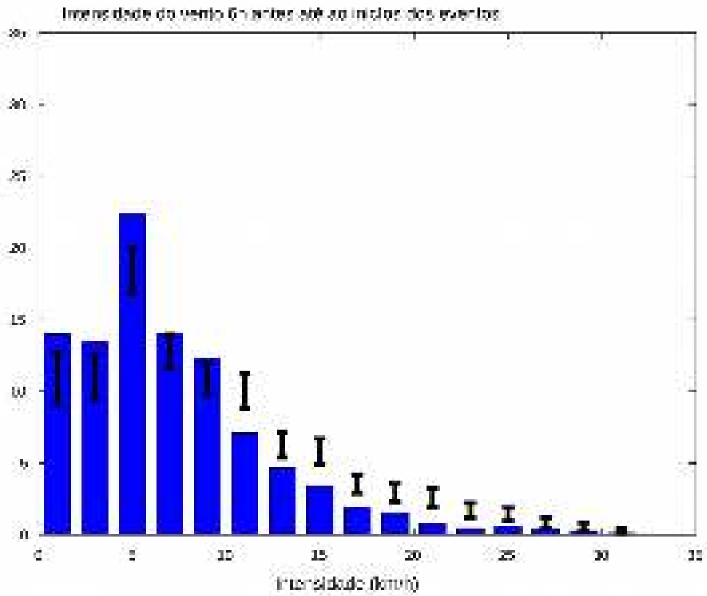
The blank lines represent the sunrise and the sunset.



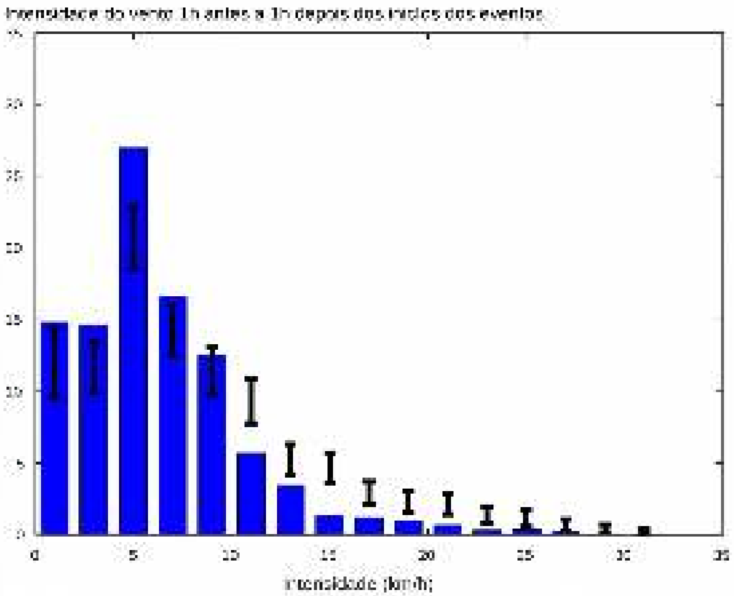
Intensidade (km/h)



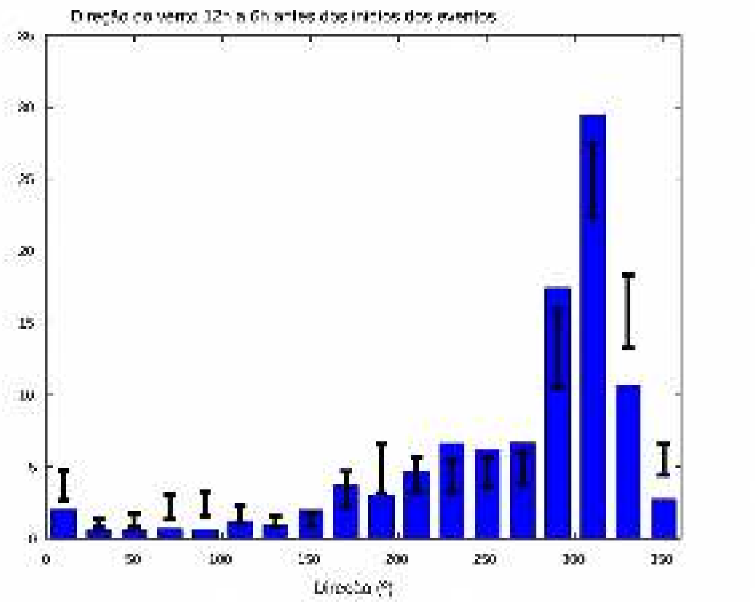
Intensidade do vento 12h a 6h antes dos inicios dos eventos
Intensidade (km/h)

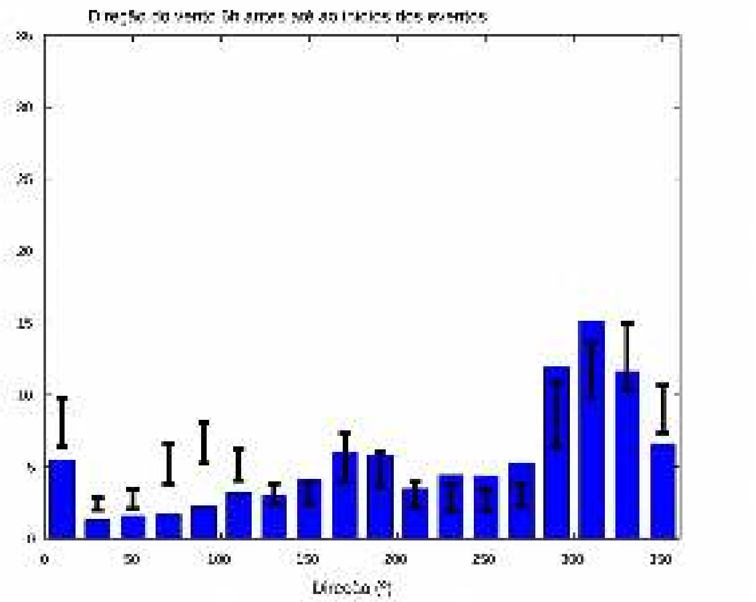


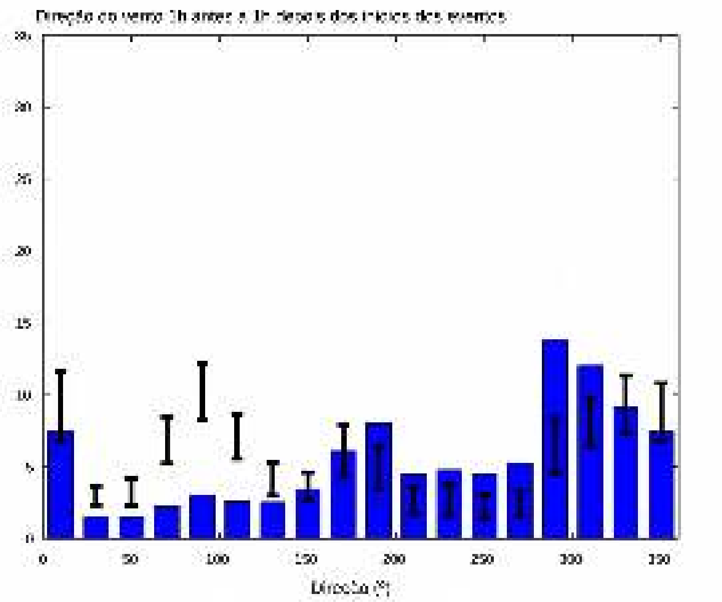
Intensidade do vento 6h antes até ao inicios dos eventos
Intensidade (km/h)



Intensidade do vento 1h antes a 1h depois dos inicios dos eventos
Intensidade (km/h)


Direção do vento 12h a 6h antes dos inícios dos eventos
0 50 100 150 200 250 300 350
Direção (°)

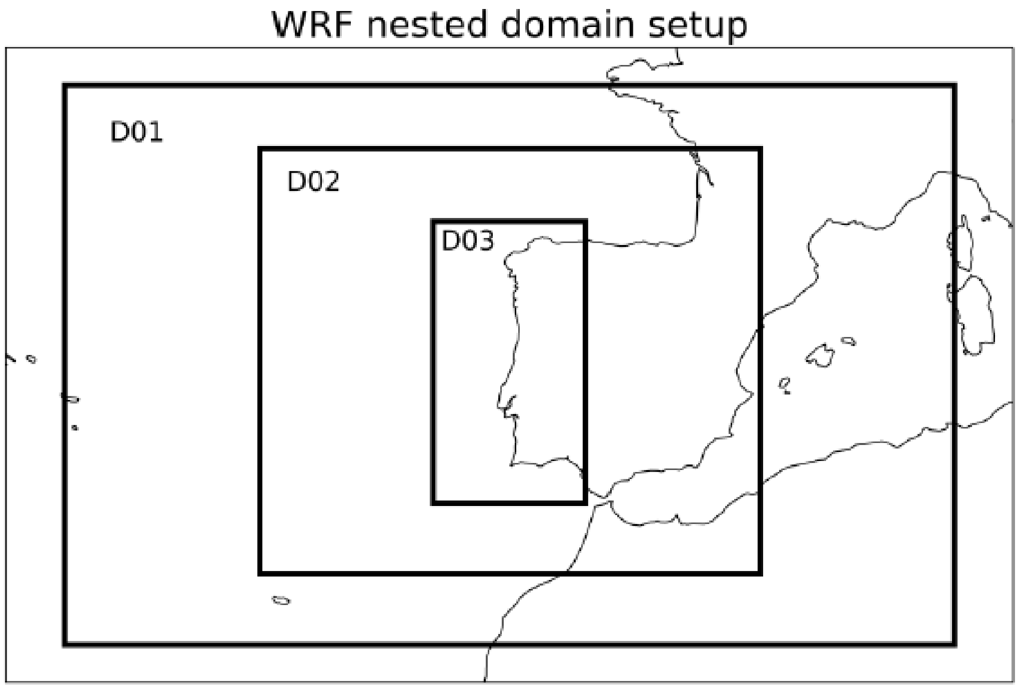

Direção do vento 6h antes até os inícios dos eventos
0 50 100 150 200 250 300 350
Direção (°)


Direção do vento 1h antes a 1h depois dos inícios dos eventos
0 50 100 150 200 250 300 350
Direção (°)

2. METHODOLOGIES

Model

- Weather Research and Forecasting (WRF)
- Boundary and initial conditions:
  - **ERA-Interim (ECMWF)**
  - **RTG NOAA**
- Grid distance:
  - **27 km (D01)**
  - **9 km (D02)**
  - **3 km (D03)**



2. METHODOLOGIES

Tests

- Parametrization tests
  - **Microphysics**
  - **Radiation**
  - **Boundary layer**
- SST tests

	REF	MP2	MP3
Microphysics	WSM6	Thompson	Morrison
Shortwave radiation	Dudhia	Dudhia	Dudhia
Longwave radiation	RRTM	RRTM	RRTM
Planetary boundary layer	YSU	YSU	YSU
Surface layer	MM5	MM5	MM5

2. METHODOLOGIES

Tests

- Parametrization tests
  - **Microphysics**
  - **Radiation**
  - **Boundary layer**
- SST tests

	REF	RA2	RA3
Microphysics	WSM6	WSM6	WSM6
Shortwave radiation	Dudhia	CAM	RRTMG
Longwave radiation	RRTM	CAM	RRTMG
Planetary boundary layer	YSU	YSU	YSU
Surface layer	MM5	MM5	MM5

2. METHODOLOGIES

Tests

- Parametrization tests
  - **Microphysics**
  - **Radiation**
  - **Boundary layer**
- SST tests

	REF	BL2	BL3
Microphysics	WSM6	WSM6	WSM6
Shortwave radiation	Dudhia	Dudhia	Dudhia
Longwave radiation	RRTM	RRTM	RRTM
Planetary boundary layer	YSU	QNSE	MYNN 2.5
Surface layer	MM5	QNSE	MYNN

2. METHODOLOGIES

Tests

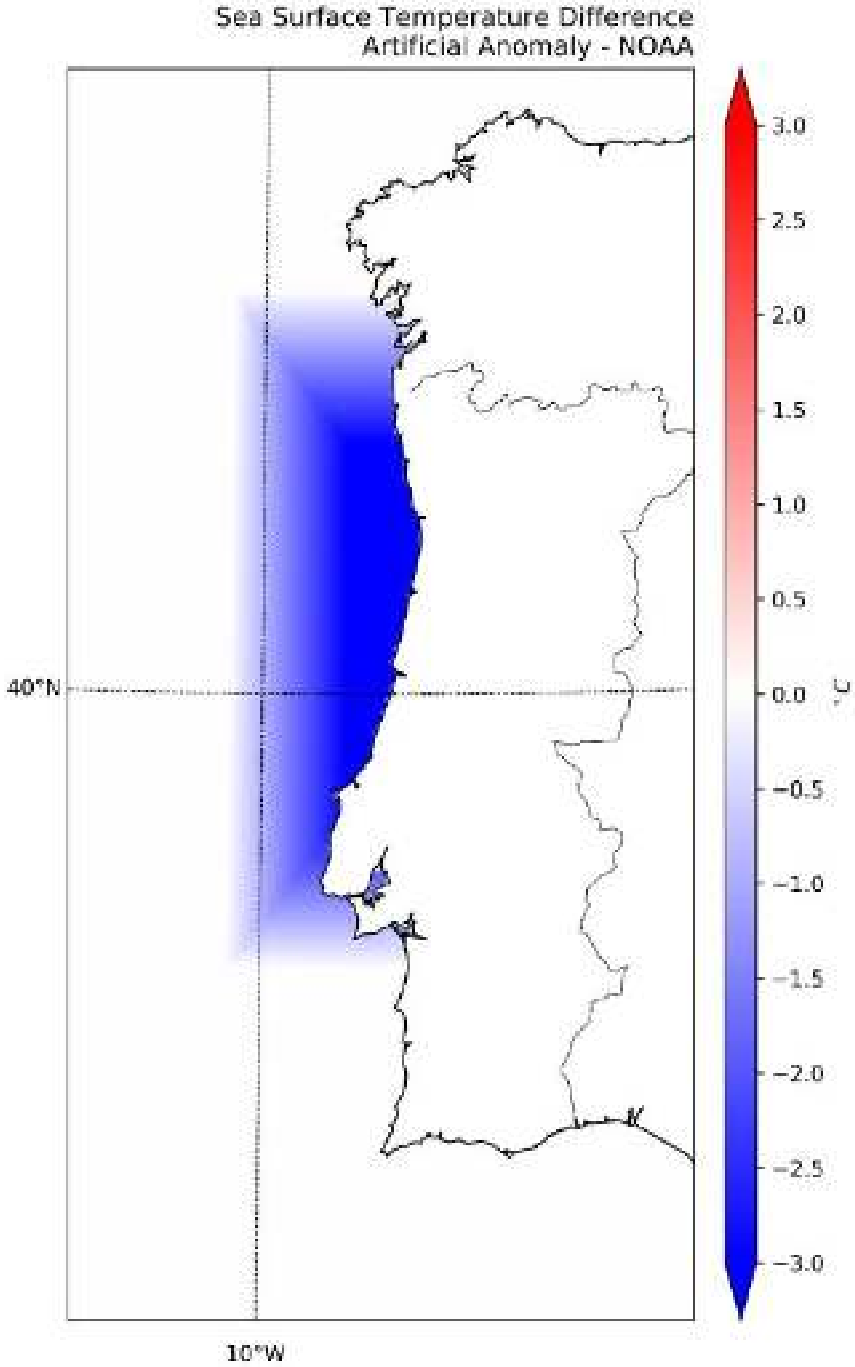
- Parametrization tests
  - **Microphysics**
  - **Radiation**
  - **Boundary layer**
  - **Combined categories**
- SST tests

	PAR1	PAR2	PAR3	PAR4	PAR5	PAR6	PAR7
Microphysics	MP	WSM6	WSM6	MP	WSM6	MP	MP
Shortwave radiation	Dudhia	RA	Dudhia	RA	RA	Dudhia	RA
Longwave radiation	RRTM	RA	RRTM	RA	RA	RRTM	RA
Planetary boundary layer	YSU	YSU	BL	YSU	BL	BL	BL
Surface layer	MM5	MM5	BL	MM5	BL	BL	BL

2. METHODOLOGIES

Tests

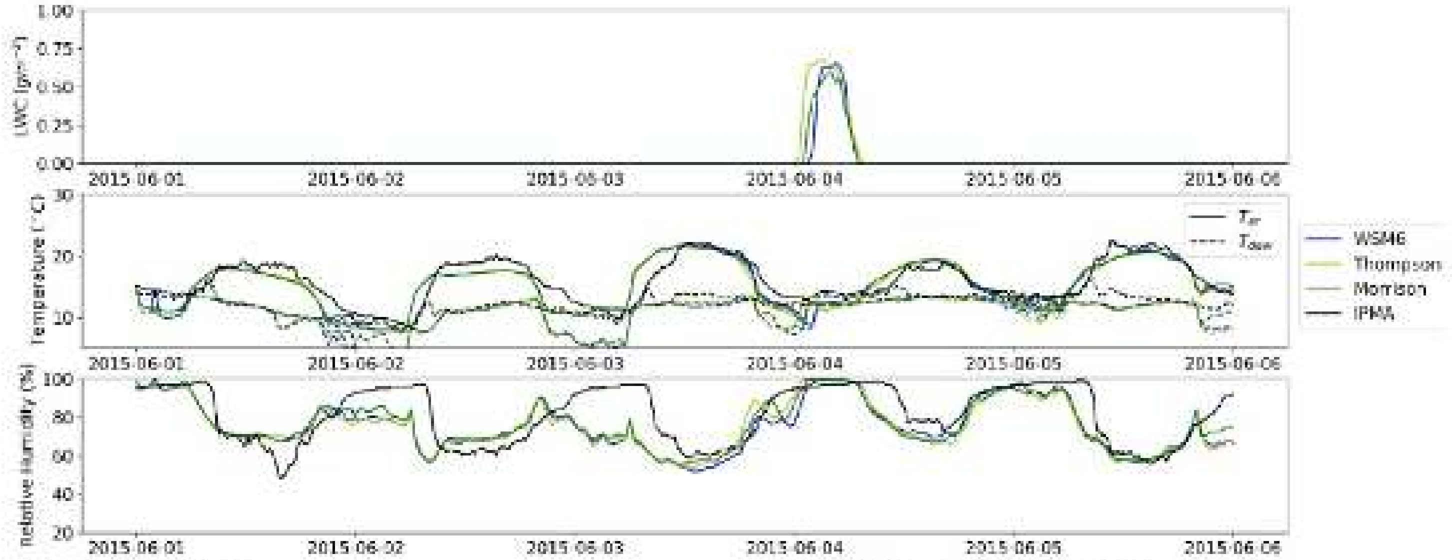
- Parametrization tests
  - **Microphysics**
  - **Radiation**
  - **Boundary layer**
  - **Combined categories**
- SST tests
  - **SST sensitivity test**



3. RESULTS

Parametrization tests

Microphysics	• Small differences
Radiation	• Big differences • CAM more humid (e.g. NEV2)
Boundary Layer	• Big differences • MYNN more humid (e.g. NEV1)



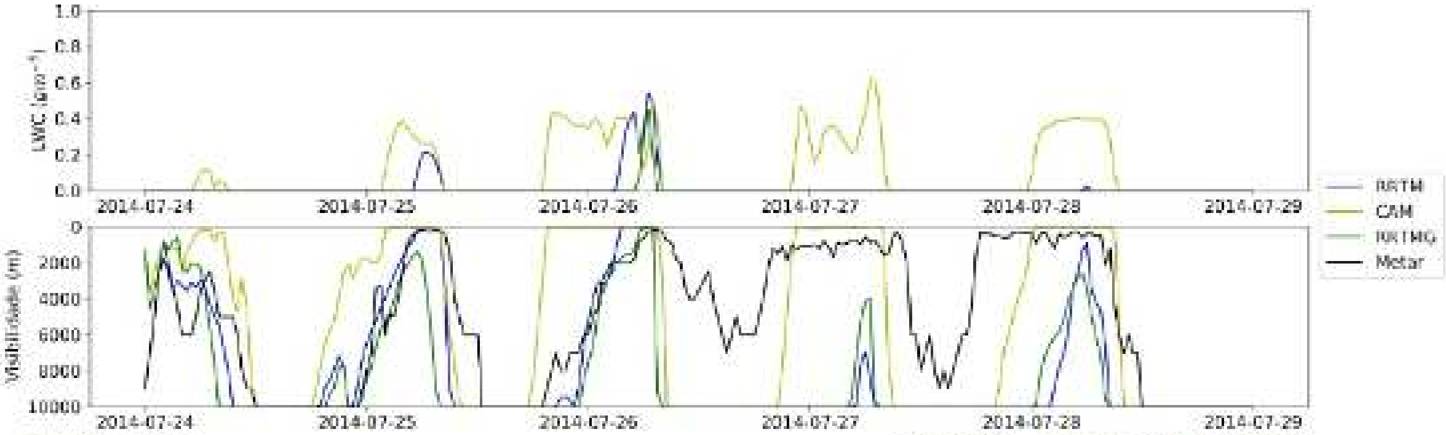
Microphysics

NEV3 – Viana do Castelo

3. RESULTS

Parametrization tests

Microphysics	• Small differences
Radiation	• Big differences • CAM more humid (e.g. NEV2)
Boundary Layer	• Big differences • MYNN more humid (e.g. NEV1)

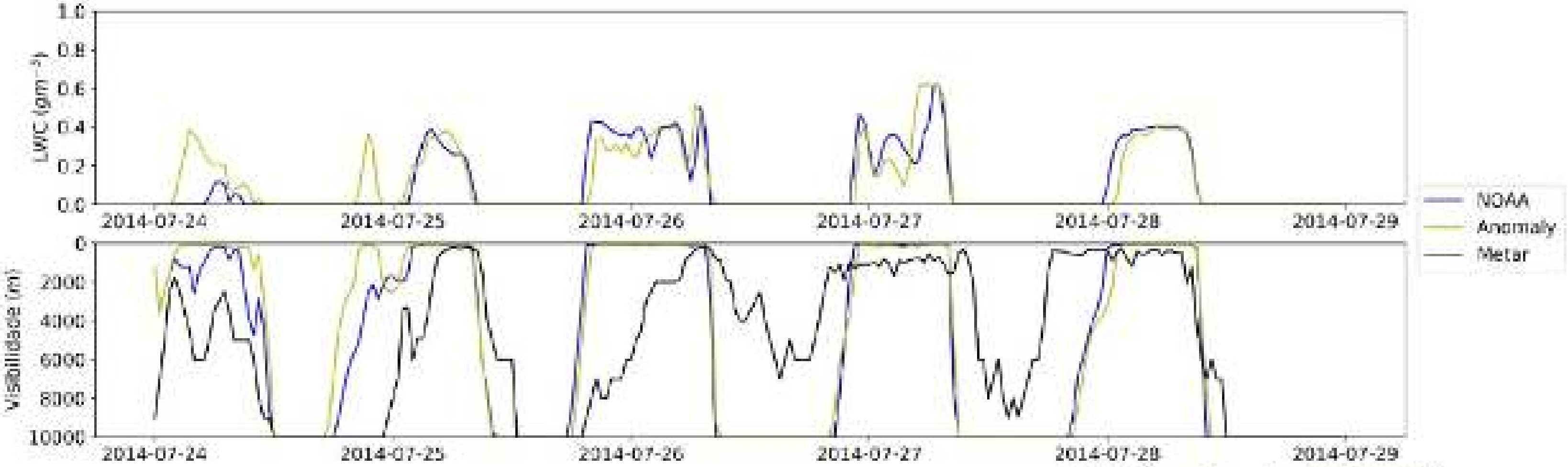


Radiation NEV2 – Porto (METAR)

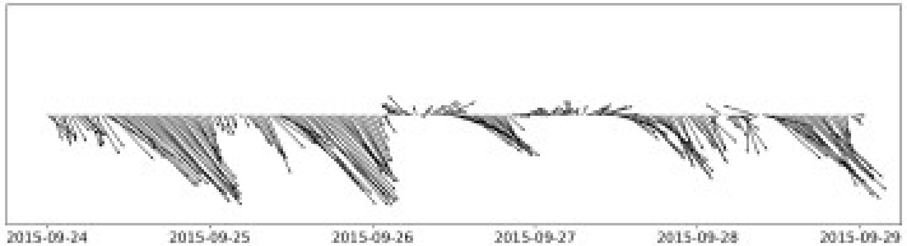
3. RESULTS

SST tests

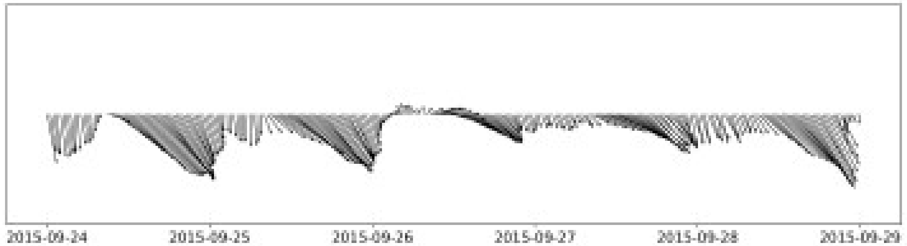
- SST sensitivity test
  - **Small differences**
  - **Anomaly increase LWC**
  - **Anomaly decrease T2m**



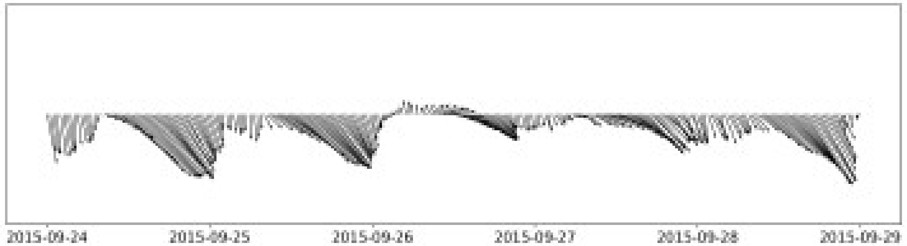
NEV2 – Porto (METAR)



(a) IPMA.



(b) NOAA.



(c) SST sensitivity test.

(d) ROMS.

Figure 90: Wind results for different SST boundary conditions and observations for event NEV3 on Pedras Rubras station.

4. CONCLUSIONS

Parametrization sets

- Radiation and boundary layer parametrizations are more relevant than microphysics
- CAM/MYNN set is the most accurate in terms of RH

SST influence

- Fog simulation with WRF is more sensitive to physical parametrizations than SST boundary conditions

Formation

- Fog can be formed in the surface or from upper levels
- Parametrization's response depends on the formation process

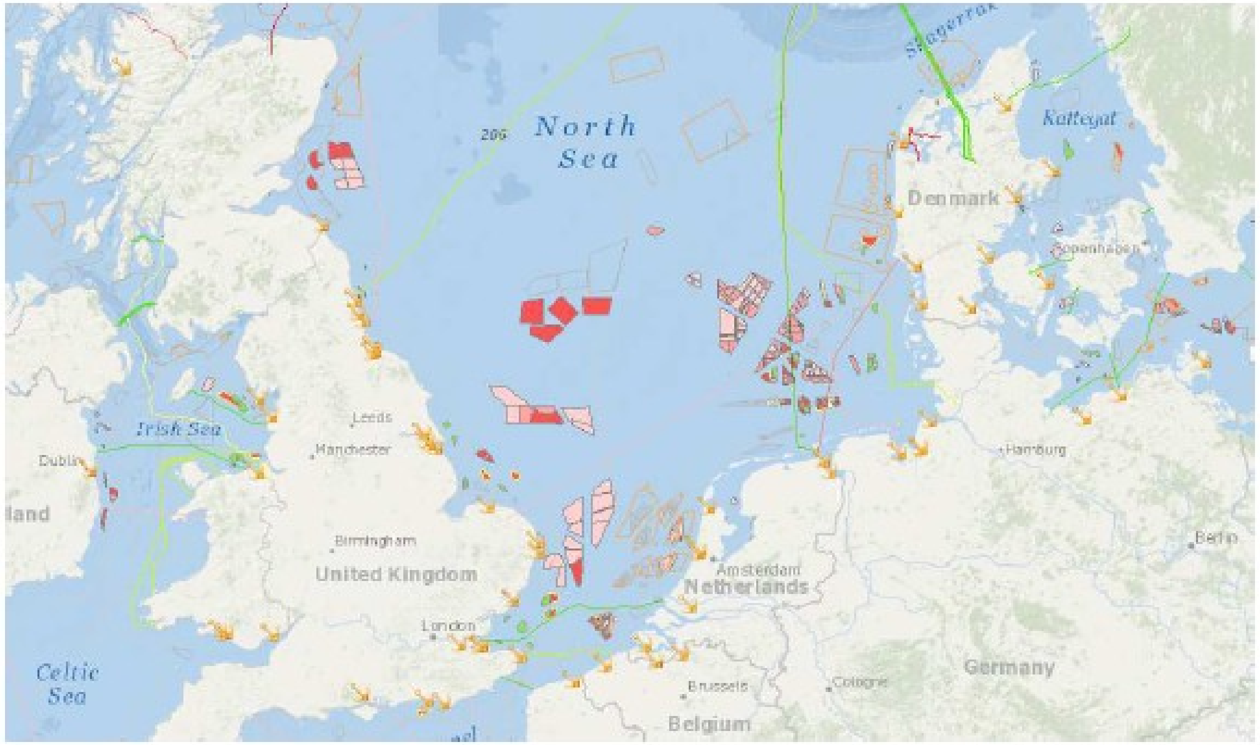
Simulation of far wake effects generated by offshore wind farms using the WRF model: The Horns Rev test case

Pedro Correia[1,2] and José M Castanheira[1]

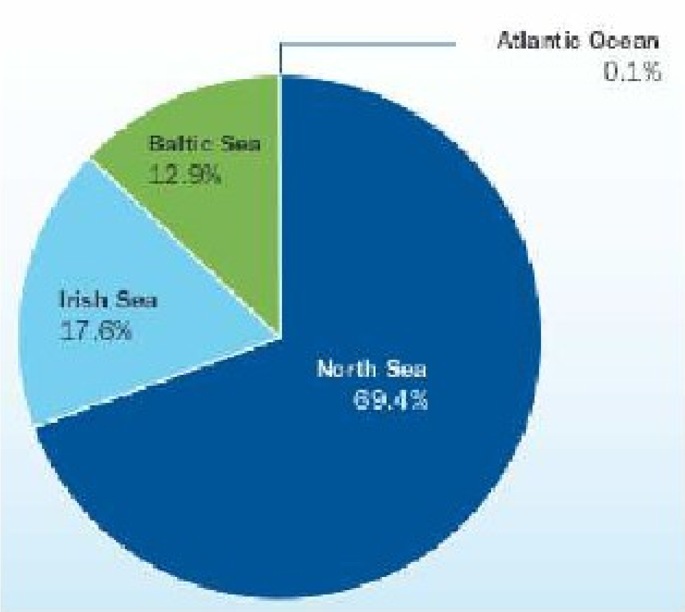
[1]Department of Physics and CESAM, University of Aveiro, Aveiro, Portugal;

[2] CENER – National Renewable Energy Centre, Spain;

Photograph by CHRISTIAN STEINESS



(a) Inst./planned/under construction wind farms



(b) Installed wind power capacity by Sea basin

Figure 1.1.3: Offshore wind farm locations in the North Sea region (left). The installed and fully operational wind farms appear represented with the color green, under construction wind farms are shown in yellow, authorized for construction in red and the concept/early planning projects are shown in pink. The figure in the right indicates the areas with higher installed wind power capacity.

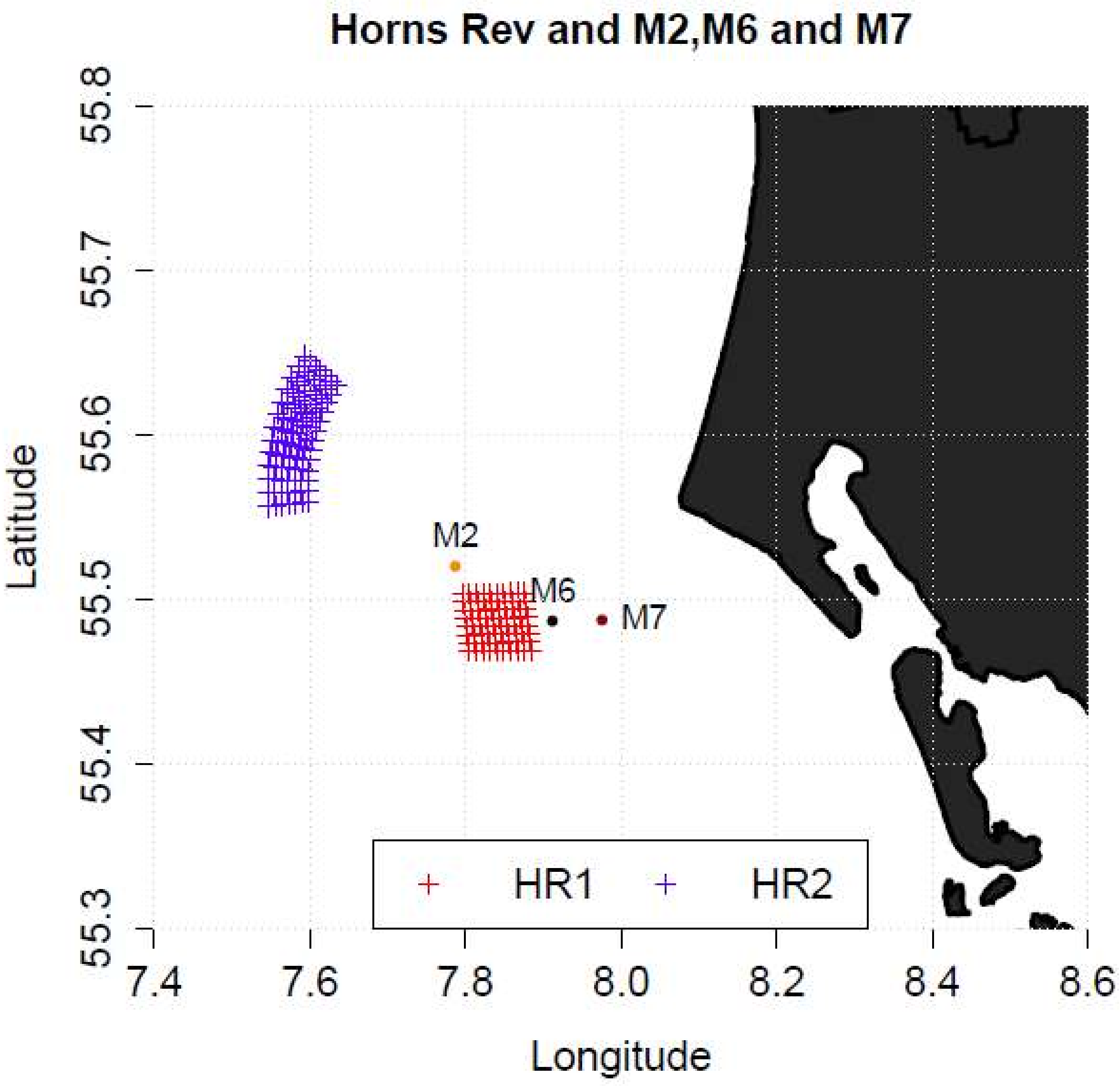


Figure 4.1.1: Locations of Horns Rev 1 (red), 2 (blue) and masts (M2, M6 and M7)

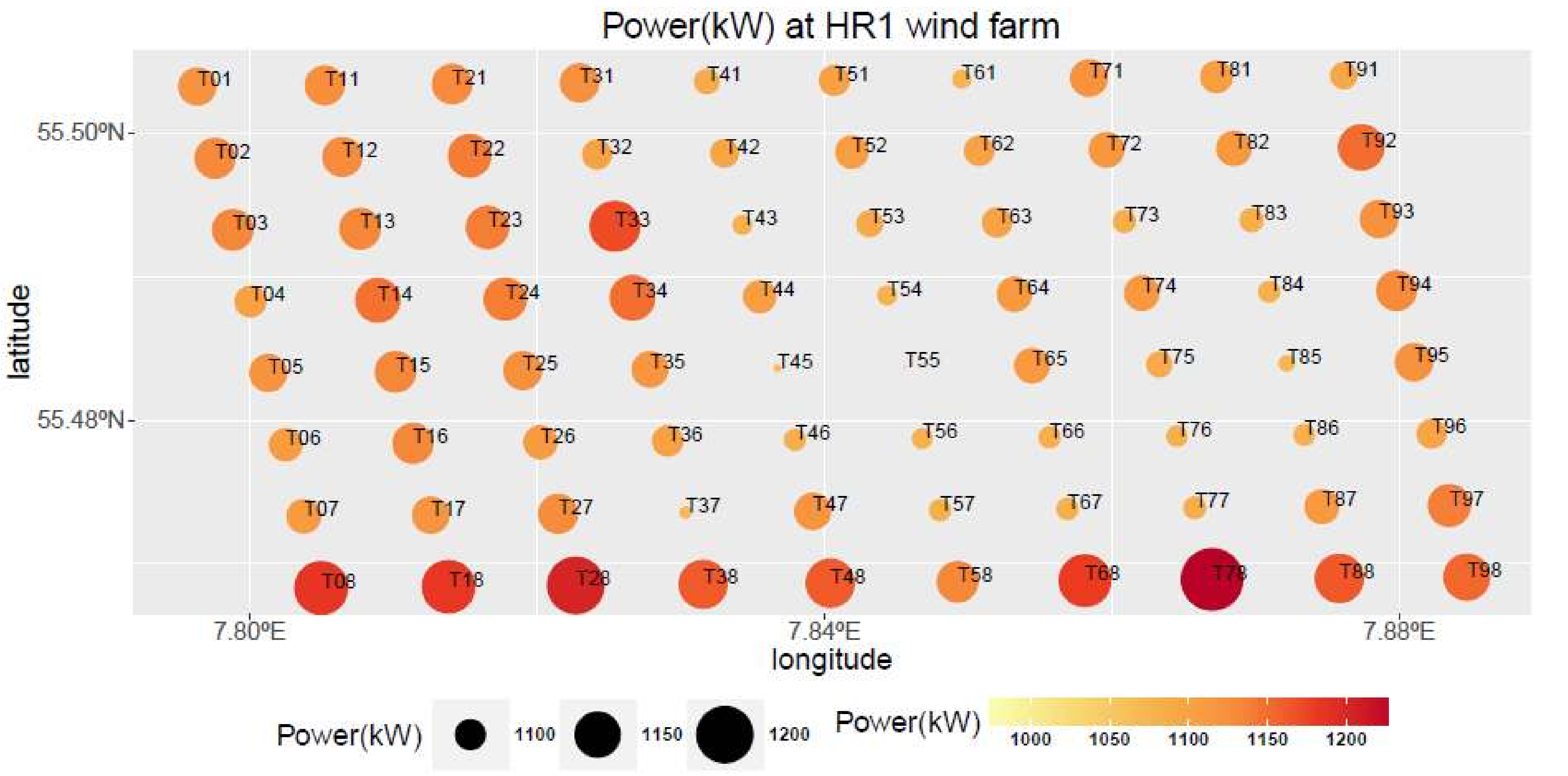


Figure 5.3.1: Mean wind power(kW) in all wind turbines at the HR1 wind farm from Sim1.

And more…

Thank you!