Sensitive Analysis of several WRF Model Parametrizations to Simulate Weather Extremes over Eastern Spain

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INTRODUCTION

The Weather Research and Forecasting (WRF) model is globally used to study a wide range of atmospheric processes at all levels, as well as to provide operational weather forecasts. In order to perform accurate investigations this model needs to be configured properly according to the research goals. Thus, it is crucial to carry out sensitivity studies to analyse the performance of the model under different meteorological conditions. The aim of the present research is to provide a WRF configuration that accurately represents extreme weather events over the Spanish Mediterranean coast which represents a key part within the VERSUS project currently ongoing.

MODEL CONFIGURATION

SIM	Radiation scheme	Cumulus scheme	Microphysics scheme	PBL scheme	SL scheme	LSM
001	New Goddard	KF-CuP	Goddard GCE	ACM2 (Pleim-Xiu)	Pleim-Xiu	Pleim-Xiu
002	RRTMG	KF-CuP	Goddard GCE	ACM2 (Pleim-Xiu)	Pleim-Xiu	Pleim-Xiu
003	RRTMG	KF-CuP	Goddard GCE	ACM2 (Pleim-Xiu)	Monin-Obukhov	Pleim-Xiu
004	RRTMG	KF-CuP	Goddard GCE	YSU	Monin-Obukhov	Pleim-Xiu
005	RRTMG	KF-CuP	Goddard GCE	YSU	Monin-Obukhov	Noah-MP
006	RRTMG	KF-CuP	Goddard GCE	ACM2 (Pleim-Xiu)	Monin-Obukhov	Noah-MP
007	RRTMG	KF-CuP	Goddard GCE	ACM2 (Pleim-Xiu)	Pleim-Xiu	Noah-MP

Table 1: Parametrizations set for WRF simulations.

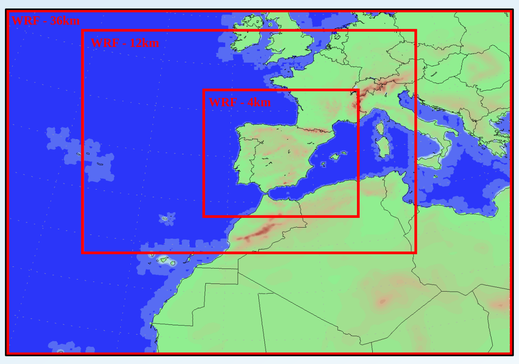


Fig. 1: WRF domains.

- ERA-Interim data is used to initialise the model, as well as to force the boundaries.
- USGS (United States Geographical Survey) land use data is set to describe the terrain.
- Three domains are defined with horizontal resolutions of 36, 12 and 4km, respectively, and 30 vertical levels.

PRECIPITATION EPISODE

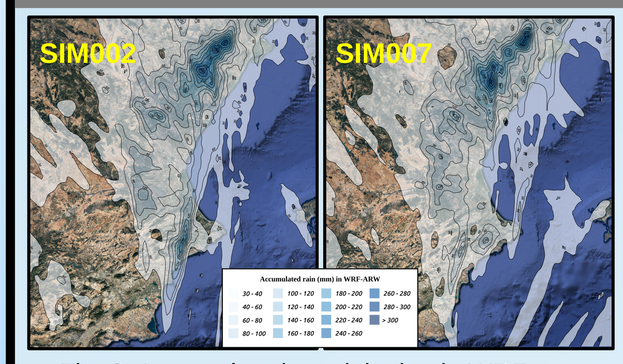


Fig. 2: Accumulated precipitation in WRF.

- Changes of the surface parametrization (eg. Land Surface Model) lead to variations in the simulated rain patterns.
- Precipitation is locally overestimated by the WRF model.
- SIM006 and SIM007 show a more accurate distribution of the precipitation.
- The integrated TPW (Total Precipitable Water) variation is not considerable.

SURFACE ANALYSIS

- The evolution of **2mT** and **2mRH** shows small differences locally among parametrizations.
- Wind speed and direction variations are similarly captured among WRF configurations in general.

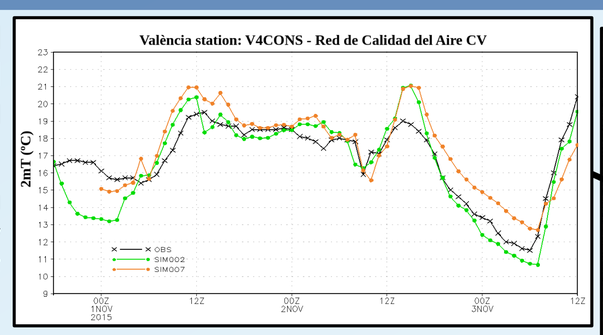


Fig. 4: **2mT** - **SIM002** and **SIM007** vs observations.

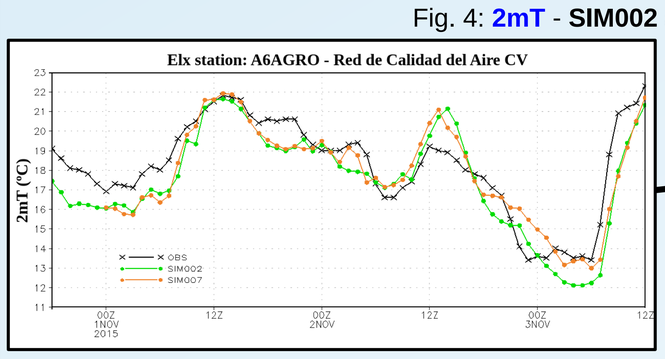


Fig. 5: **2mT** - **SIM002** and **SIM007** vs observations.

- The WRF model performs an accurate representation of the surface variables.
- Small differences among the configurations.
- Generally, SIM006 and SIM007 show slightly higher statistical values.

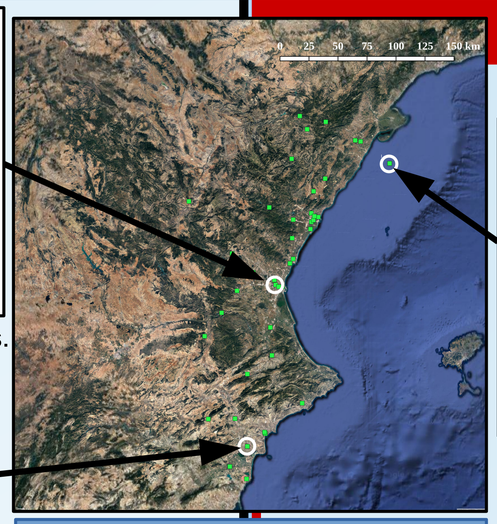


Fig. 3: Distribution of the stations used for the statistical analysis.

SIM	IA	rmse	mbe	N
001	0.921	1.923	-1.019	2388
002	0.924	1.853	-0.668	2388
003	0.906	2.111	-1.063	2388
004	0.917	1.955	-0.903	2388
005	0.920	1.908	-0.972	2388
006	0.926	1.827	-0.567	2388
007	0.928	1.816	-0.395	2172

Table 2: Average statistical scores for **2mT** (rain event).

HEAT WAVE

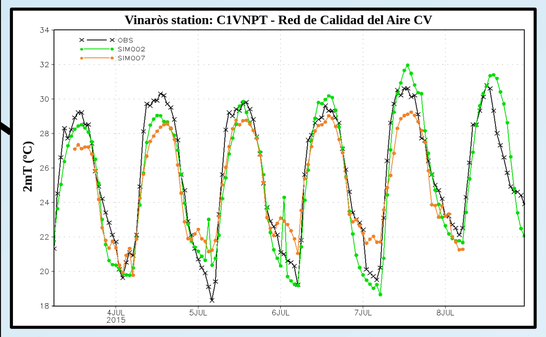


Fig. 6: **2mT** - **SIM002** and **SIM007** vs observations.

- The evolution of **2mT** and **2mRH** is similar among parametrizations.
- SIM002 and SIM007 present smalll differences during morning and noon
- In the configurations with Noah-MP LSM, evaporation rates are greater than those using Pleim-Xiu LSM.

SIM	IA	rmse	mbe	N
002	0.856	3.508	-2.577	5048
003	0.849	3.689	-2.836	5048
004	0.833	3.868	-3.068	5048
005	0.808	3.918	-2.996	5048
006	0.830	3.712	-2.754	5048
007	0.834	3.749	-2.685	4166

Table 3: Average statistical scores for **2mT** (heat wave).

- The WRF model accurately captures the evolution of the studied surface parameters.
- No great differences are noticed among the parametrizations set.
- SIM002 presents mildly higher statistical scores in general.

VERTICAL PROFILES

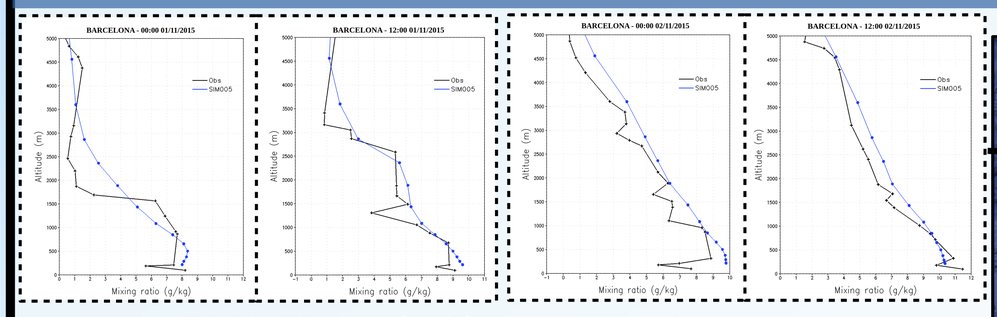


Fig. 8: WRF-SIM005 vertical profiles vs University of Wyoming soundings.

- On average, statistical scores are high for **T** and **w** (IA > 0.9) with non-significant differences.
- Statistical values variate lightly among the configuration for wind speed and direction.
- Overall, SIM002 and SIM007 show the highest statistical scores.

SIM	IA	rmse	mbe	N
001	0.809	4.264	1.183	920
002	0.826	4.037	1.150	920
003	0.823	4.119	1.296	920
004	0.834	3.910	1.369	920
005	0.817	4.275	1.744	920
006	0.823	4.200	1.553	920
007	0.833	4.030	1.223	920

Table 4: Average statistical scores for **wind speed** (precipitation event).

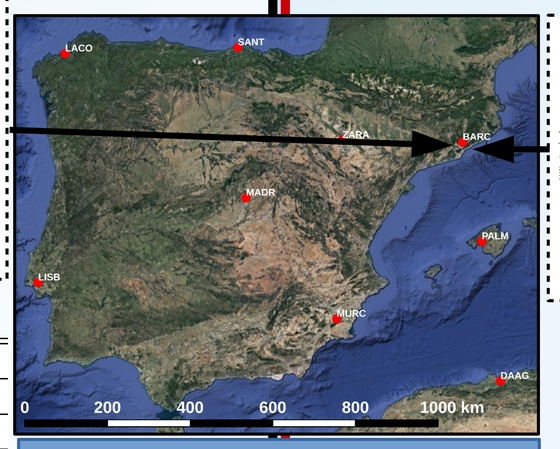


Fig. 7: Distribution of the observations used for the statistical comparison from the Wyoming University and NOAA.

STATISTICS

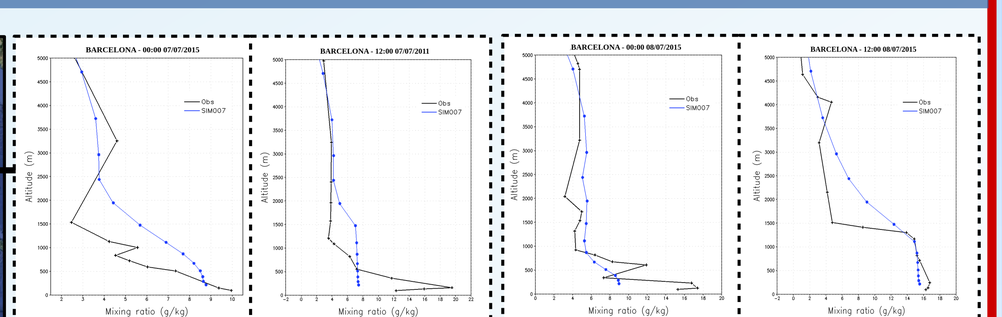


Fig. 9: **WRF-SIM007** vertical profiles vs University of Wyoming soundings.

SIM	IA	rmse	mbe	N
002	0.874	2.763	-0.590	1964
003	0.870	2.799	-0.588	1964
004	0.872	2.781	-0.566	1964
005	0.847	2.956	-0.656	1964
006	0.853	2.934	-0.716	1964
007	0.850	2.954	-0.648	1964

Table 5: Average statistical scores for **wind speed** (heat wave).

- **T** evolution is well captured by the model (IA > 0.9) on average.
- Differences are not significant among parametrizations for **T** and **w**.
- Wind speed and velocity statistical values are greater in SIM002, SIM003 and SIM004.

CONCLUSIONS

- Localised differences in the near-surface parameters studied among the configurations implemented in WRF were found despite the similar scores obtained in the statistical analysis.
- Noah-MP LSM appears to produce stronger localised evaporation rates over lakes compared to Pleim-Xiu LSM.
- SIM002 and SIM007 are finally selected to perform further analyses regarding Pleim Xiu and Noah-MP LSM, as well as land cover data sets.

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University of Wyoming – Department of Atmospheric Sciences.
NOAA/ESRL Radiosonde Database.