Agencia Estatal de Meteorología

GOBIERNO DE ESPAÑA

MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA

AEMET-γSREPS

The Spanish convection-permitting LAM-EPS: state-of-art

1ª Reunión TRAMPAS 2021 December 02/03

AEMET γSREPS Predictability Group

Alfons Callado, Juanjo Gómez

Pau Escribà, *David Gil* (*WEB collaboration*)

***Maria Cortès / Joan Montolio* (*EUMETNET SRNWP-EPS calibration/EFI*)**

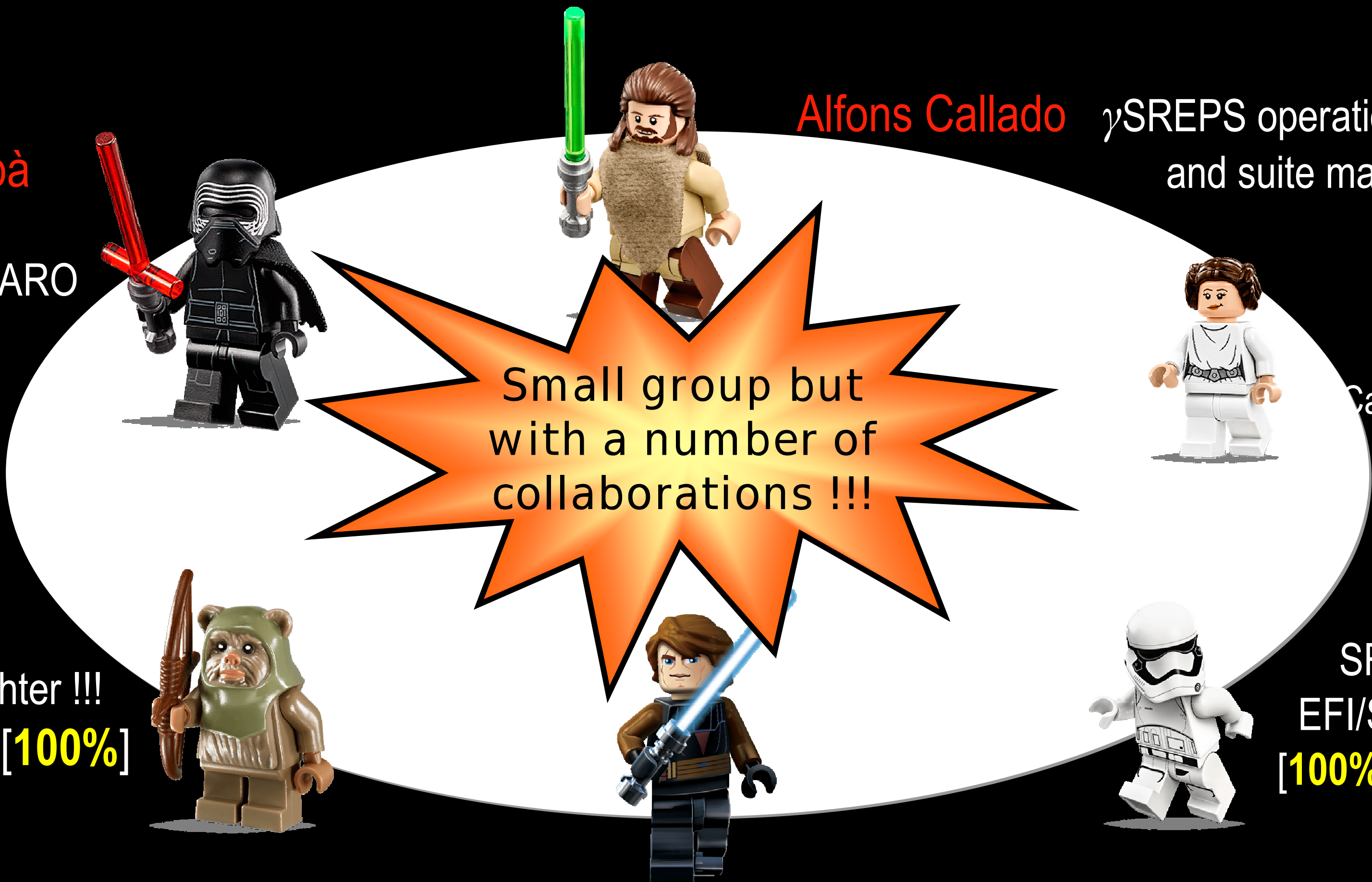
TRAMPAS (PID2020-113036RB-I00 / AEI / 10.13039/501100011033)

Who are we ?

The AEMET
Predictability-γSREPS Group

Predictability-γSREPS group

- Since 2002 an small core group working on Limited Area (LAM) Ensemble Prediction Systems (EPS) depending on AEMET Research Department (DDA)
- Members of ACCORD-HIRLAM-HarmonEPS and involved in several projects: EUMETNET SRNWP EPS 2019-2023 (managing), **TRAMPAS**, etc., and collaborations on EPSs with IPMA-AEMET, **AROME-EPS MétéoFrance**, **ALARO** people, etc.



Alfons Callado γSREPS operational development and suite maintenance [**80%**]

Pau Escribà
Assimilation
AROME-ALARO
NWP
[**60%**]

Maria Cortés
SRNWP-EPS
Calibration on extremes
[**100%**]

Juanjo Gómez
New fighter !!!
[**100%**]

Joan Montolio
SRNWP-EPS
EFI/SOT
[**100%**]

David Gil web page and technical developments[**50%**]

Full members
Projects / Collaborations

What is AEMET-γSREPS ?

2.5 km *convection-permitting* LAM-EPS


Spain Severe Weather
Renewable Energies
Detailed forecast: airports, cities, etc.
Cantábrico 2011-05-30
CAP gale (Galerna)
Fotoelectric
Cenicientos (Madrid)
Montserrat 2000-06-09
Flash-floods > 200mm
AEROgenerators
Serra De Burgo (Orense)
Valladolid 2011-05-30
Hailstorm
Tous 1982-10-20
Flash-floods>1000mm
Turia 1957-10-14
Flash flood>350mm/d
Cádiz 2009-12-24
Tornado
La Safor 2007--
Cut-off low>450mm/d
Algeciras 2012-03-06
Storm > 35 mm/h
Vista Alegre 1999-09-07
Tornado
CVal 2009-09-27/29
Cut-off low>300mm/d

AEMET-γSREPS design

- **Developing a *convection-permitting* LAM-EPS**
  - 3 sources of uncertainties
    - Multi-model Multi-Boundary Conditions LAM-EPS

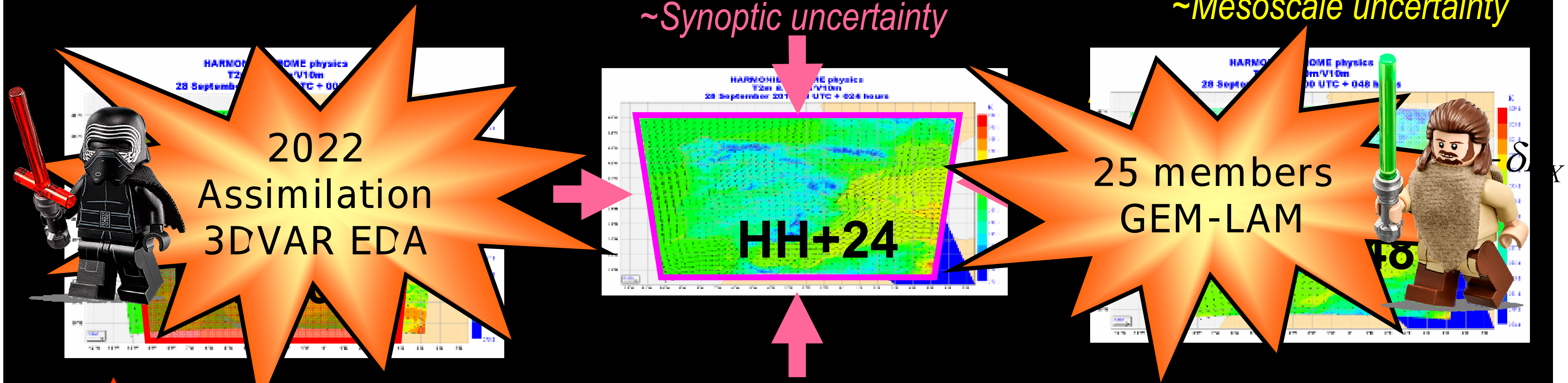
1 INITIAL CONDITIONS

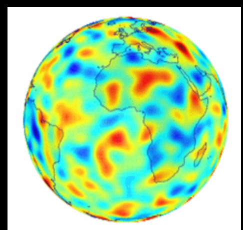
2 BOUNDARY CONDITIONS

~Synoptic uncertainty

3 MODEL *ERROR*

~Mesoscale uncertainty





Initial conditions and Multi-BCs

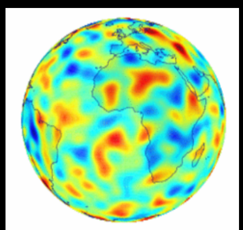
ECMWF – IFS

NCEP – GFS

MétéoFrance – ARPÈGE

CMC – GEM (Canadian)

JMA - GSM (Japanese)



LAM Multi-model

HARMONIE-AROME

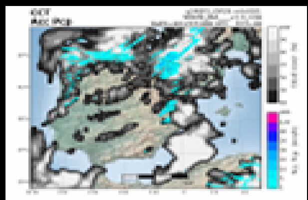
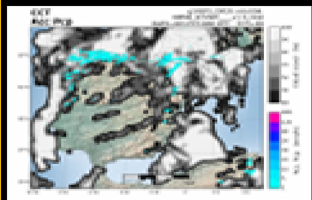
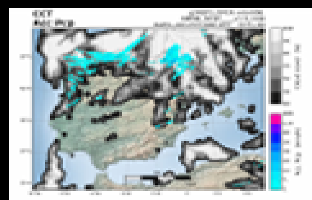
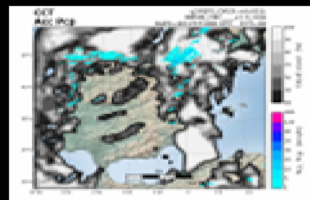
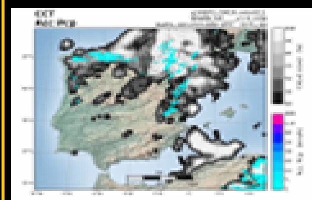
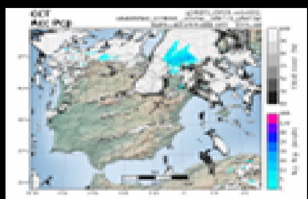
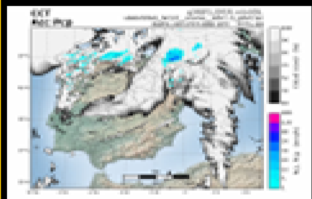
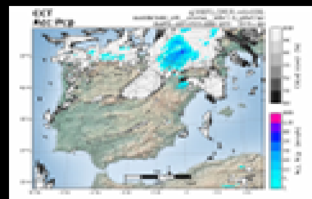
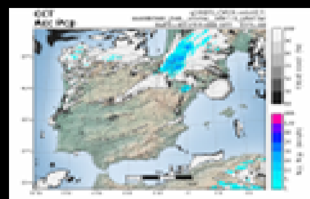
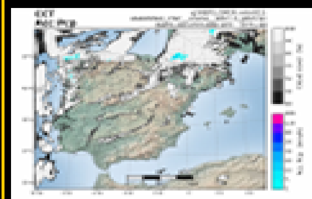
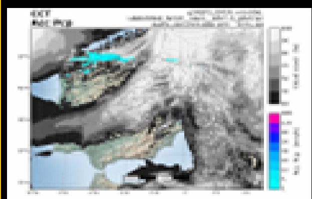
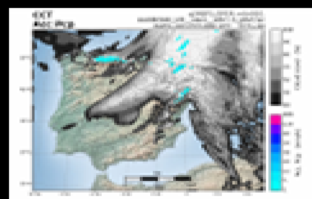
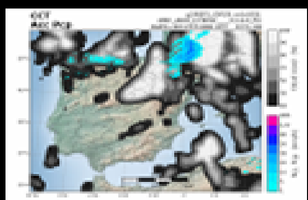
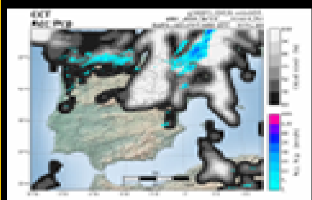
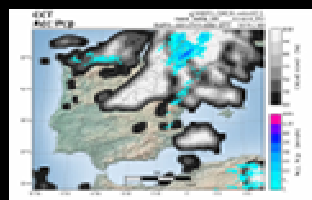
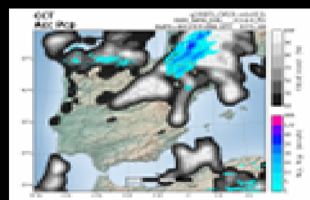
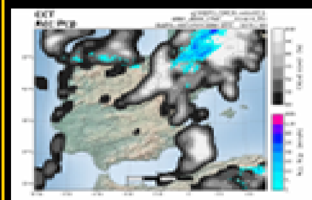
HARMONIE-ALARO

WRF-ARW (NCAR)

NMMB (NCEP)

AEMET-γSREPS system

- 20-members *non-hydrostatic convection-permitting* LAM-EPS
- Since April 2016 daily running at 00/12 UTC up to 60 hours (2020)
- 3 DOMAINS: *IBERIA_2.5*, *CANARIAS_2.5* and *LIVINGSTON_2.5* (Antarctica)

Multi-BCs / Multi-NWP	ECMWF / IFS	NCEP / GFS	MF / ARPÈGE	JMA / GSM	CMC / GEM
HARMONIE-AROME					
HARMONIE-ALARO					
WRF ARW					
NMMB					

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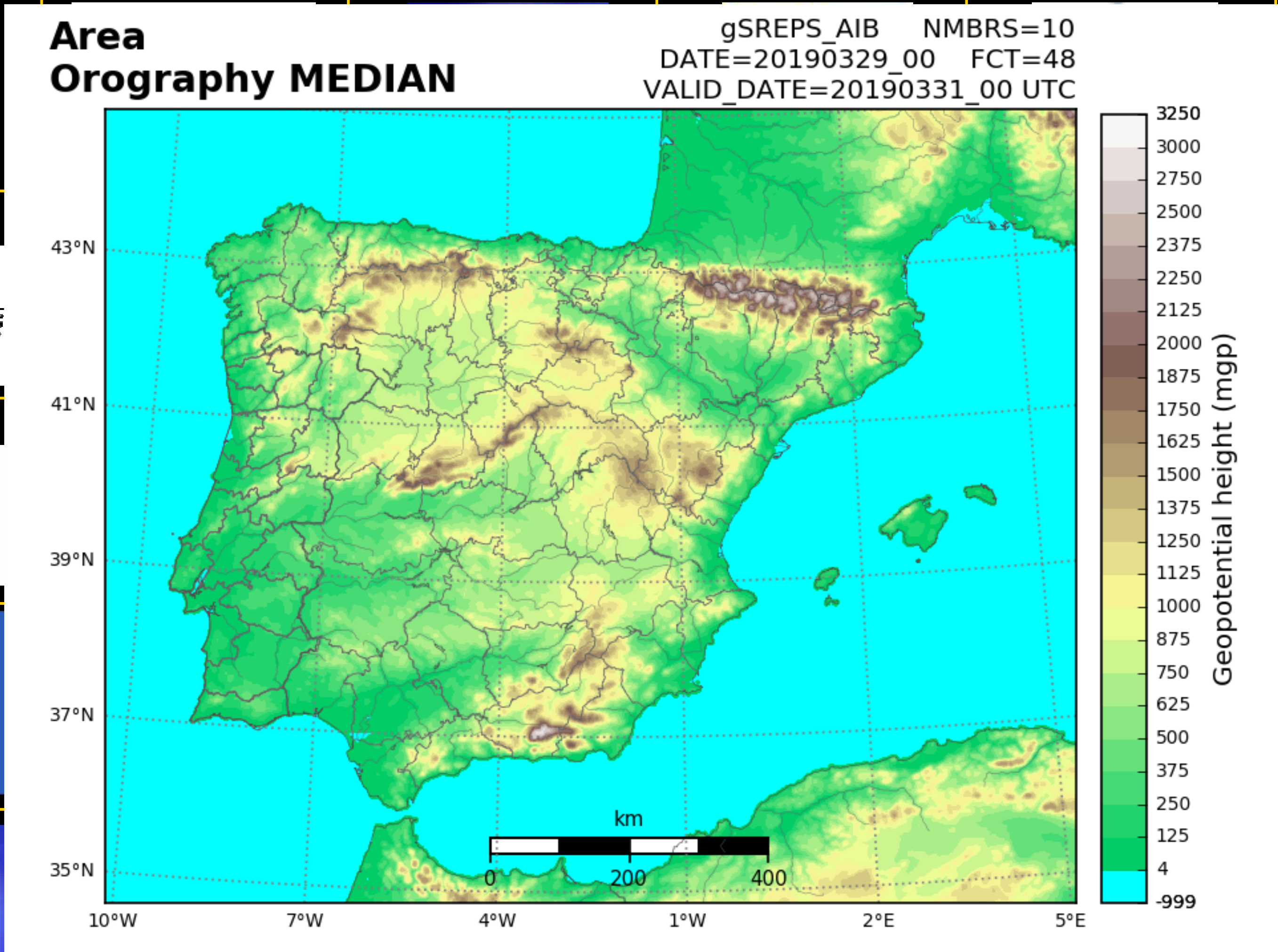

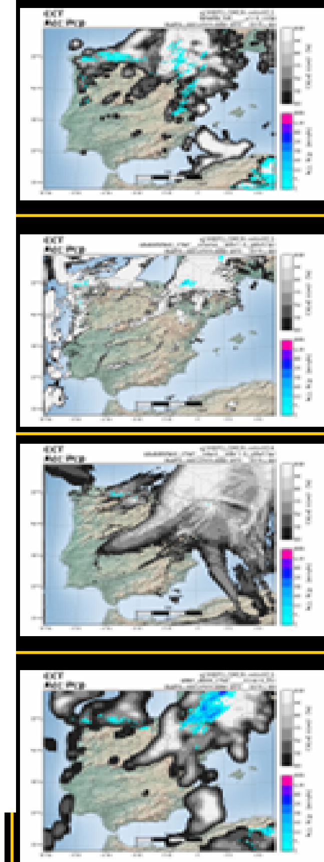

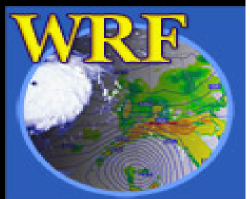

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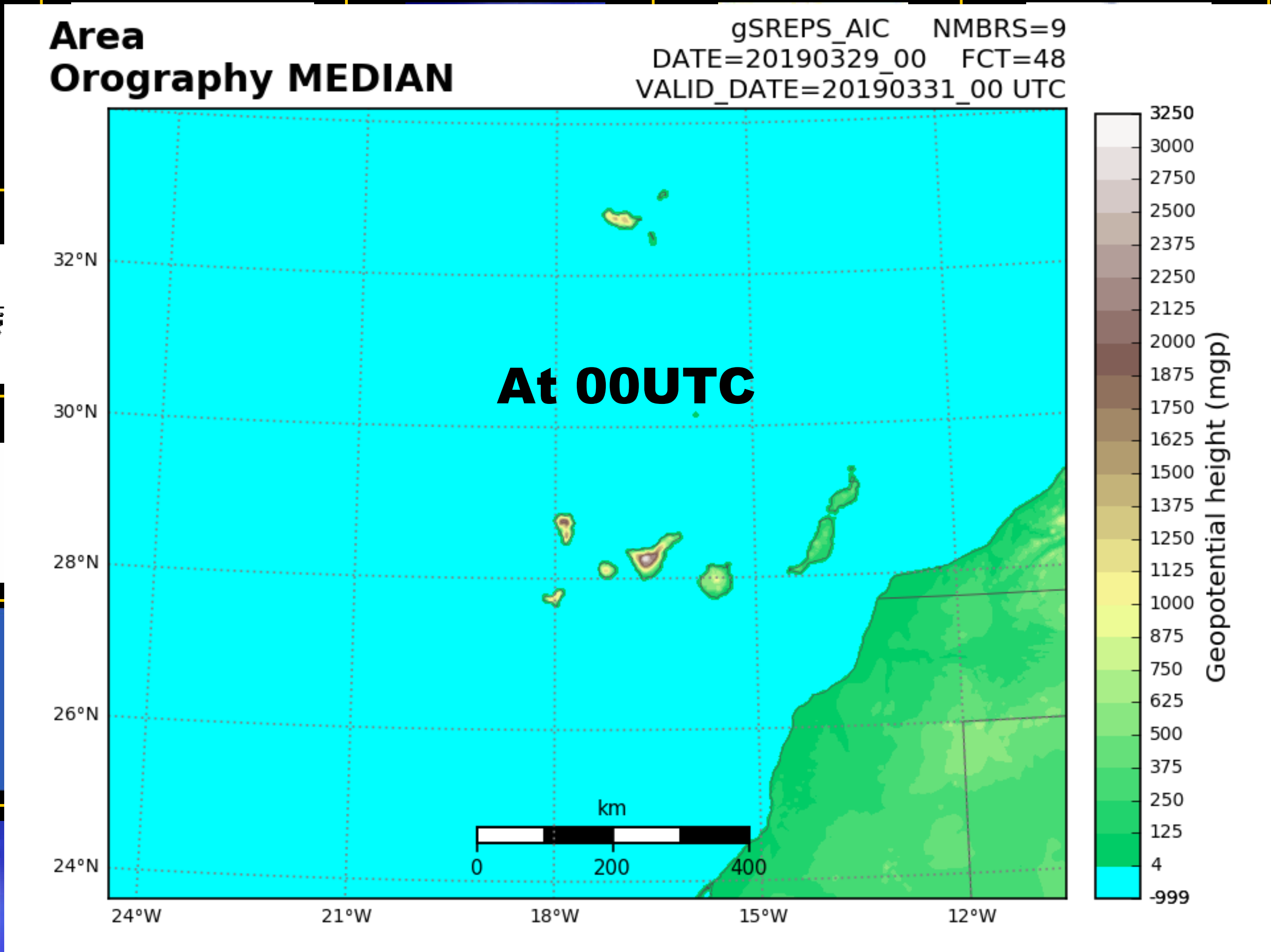

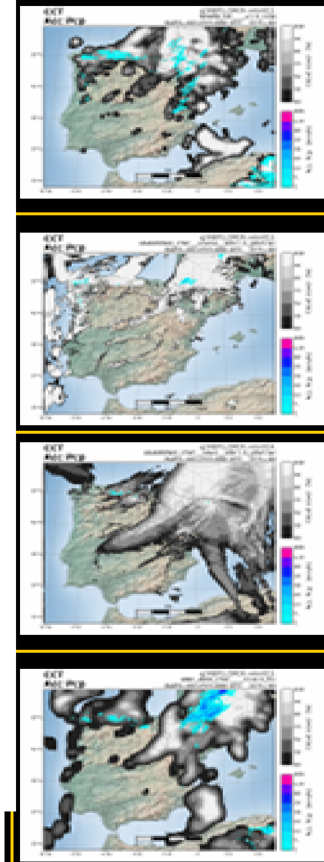

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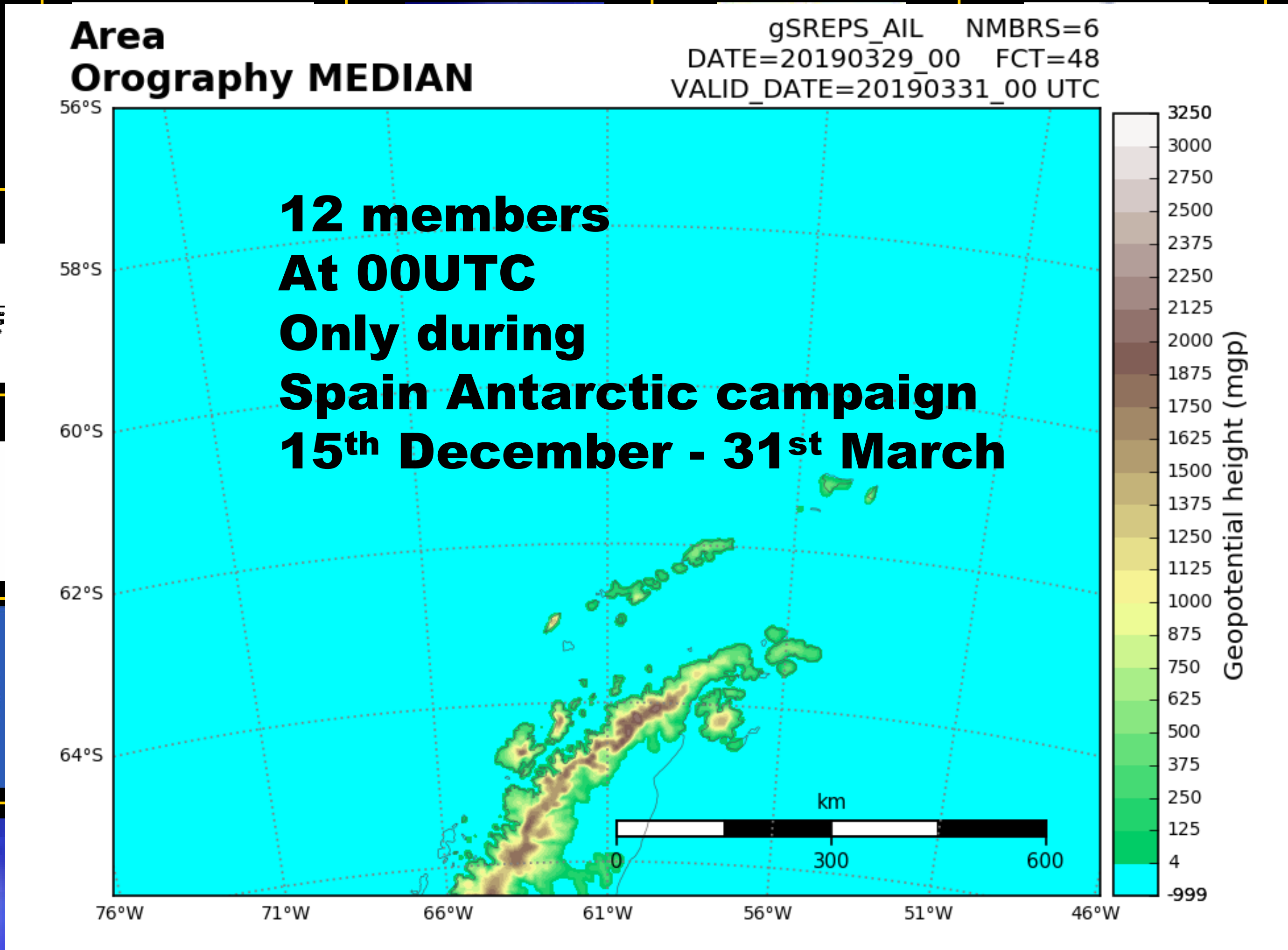
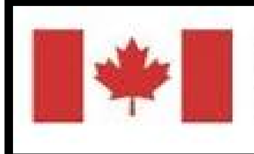
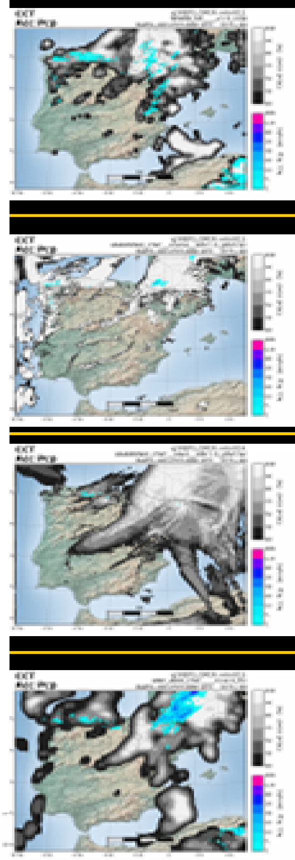




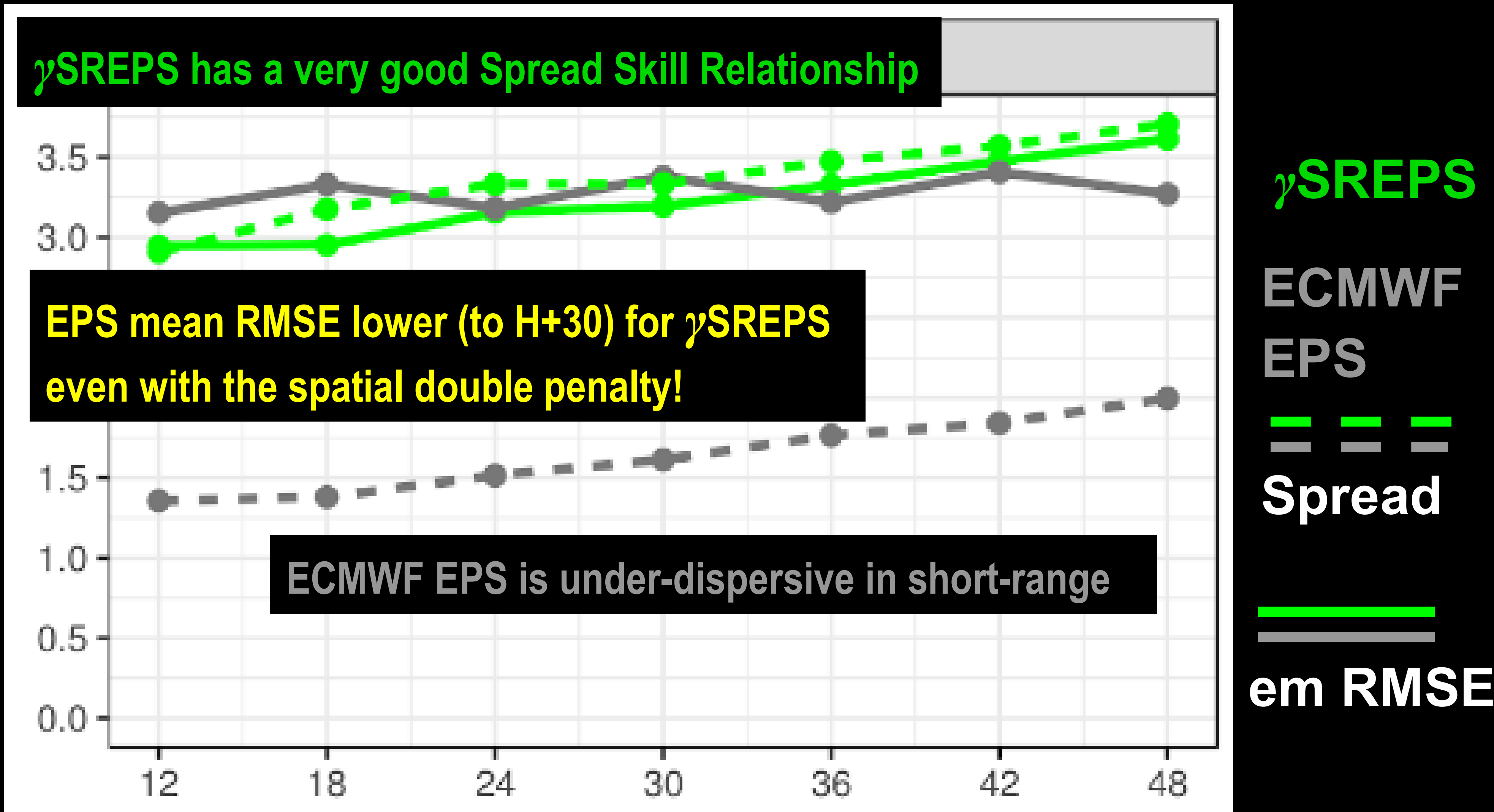


A taste of verification

OBJECTIVE

γSREPS *versus* ECMWF EPS

- HarmonEPS system paper: review of HIRLAM EPSs. Comparison of 12AccPcp for 00 / 12 cycles of November 2018



Frogner I.L. et al, 2019, "*HarmonEPS - the HARMONIE ensemble prediction system*"
Weather and Forecasting. 2019, 34, p. 1909–1937, https://doi.org/10.1175/WAF-D-19-0030.1.

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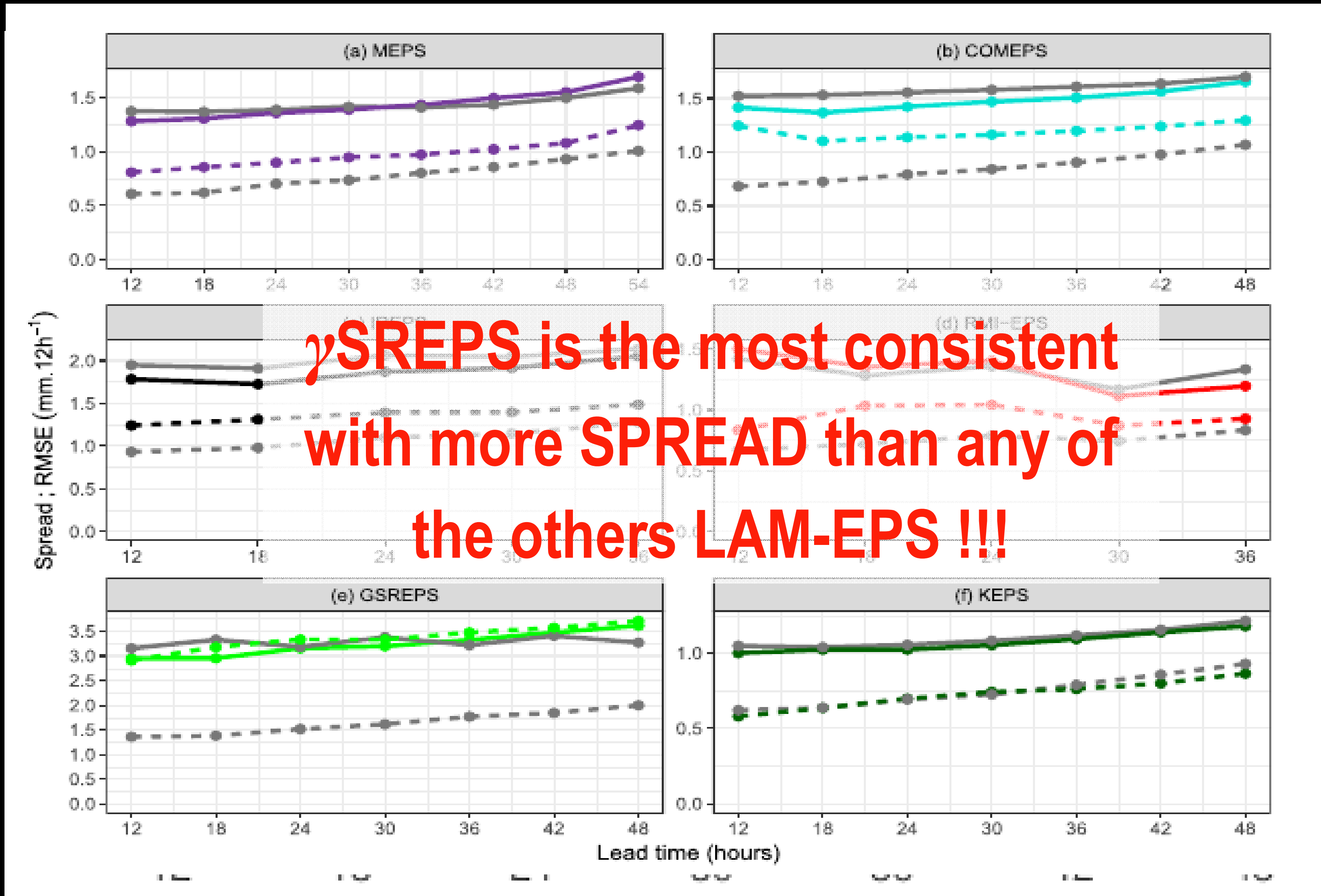

γSREPS is the most consistent with more SPREAD than any of the others LAM-EPS !!!

γSREPS

ECMWF EPS

Spread

em RMSE

Frogner I.L. et al, 2019, "*HarmonEPS - the HARMONIE ensemble prediction system*"
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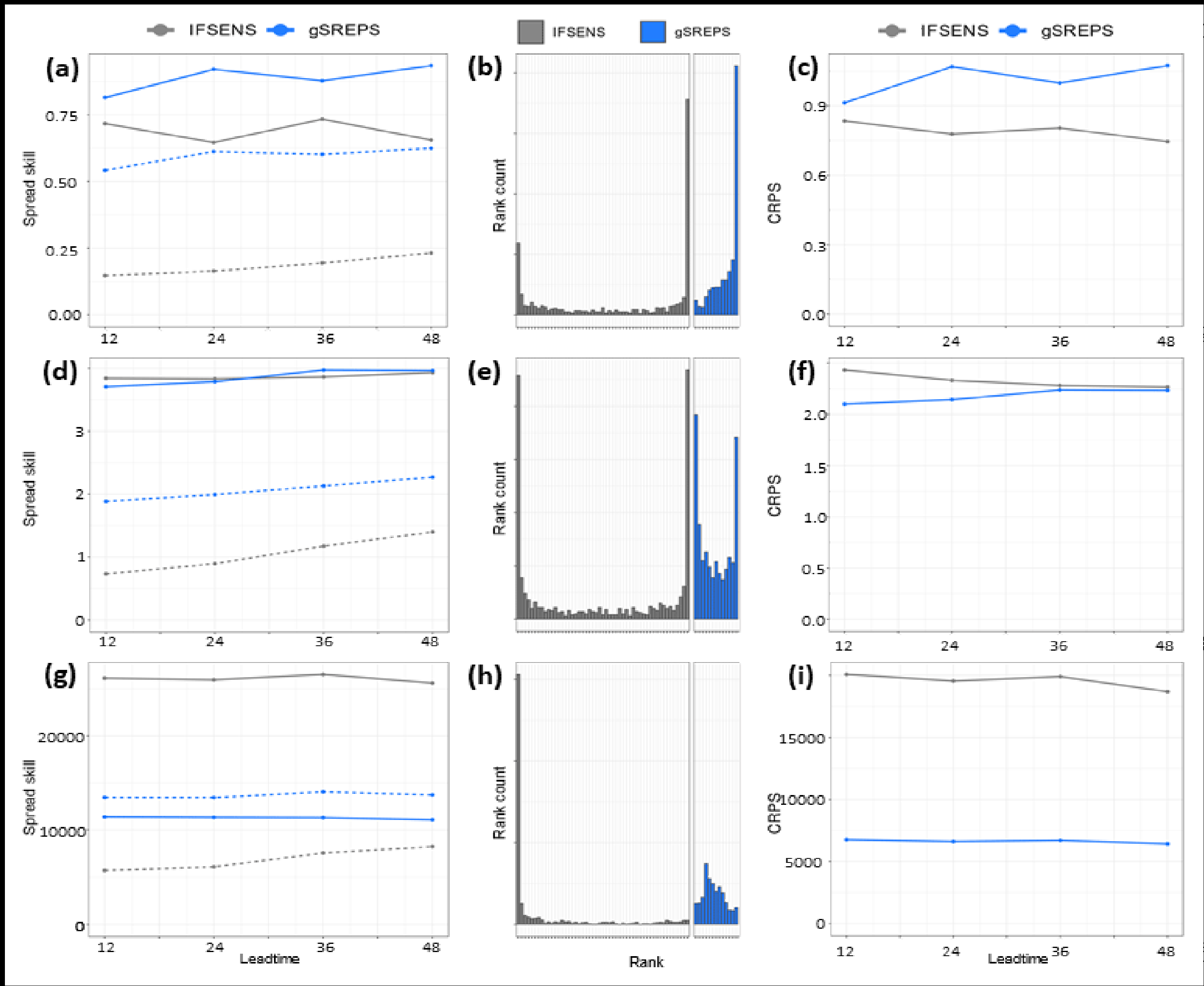
γSREPS verification *in Antarctica*



Temperature 2 m

Wind Speed 10 m

Visibility SFC

VERIFICATION
Period: 1st January – 28th March 2019
Obs: 00/12UTC SYNOPs 12 stations

KEY
Blue ⇔ **γSREPS**
Grey ⇔ **ECMWF EPS**

RESULTS
Cold bias ➔ 9 of 12 stations over sea
(see unbiased ROCA)
Double penalty issue ⇔ **BIAS / BS**

γSREPS verification *in Antarctica*

Scores / Parameters	Spread Skill	CRPS	Rank Histogram	BIAS	Reliability	ROC ROCA	BS BSS	Relative Value
Pmsl (hPa)								
T2m (K)								
Q2m (kg kg^{-1})								
S10m (m s^{-1})								
Vis (m)								
CCtot (oktas)								

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Overall γSREPS performs better than ECMWF – EPS

The higher resolution of γSREPS is probably the main key for its better performance, but it could be argued that its multi-boundary and multi-NWP model approaches play a role as well, dealing better with a widespread synoptic and mesoscale uncertainties than others LAM-EPS

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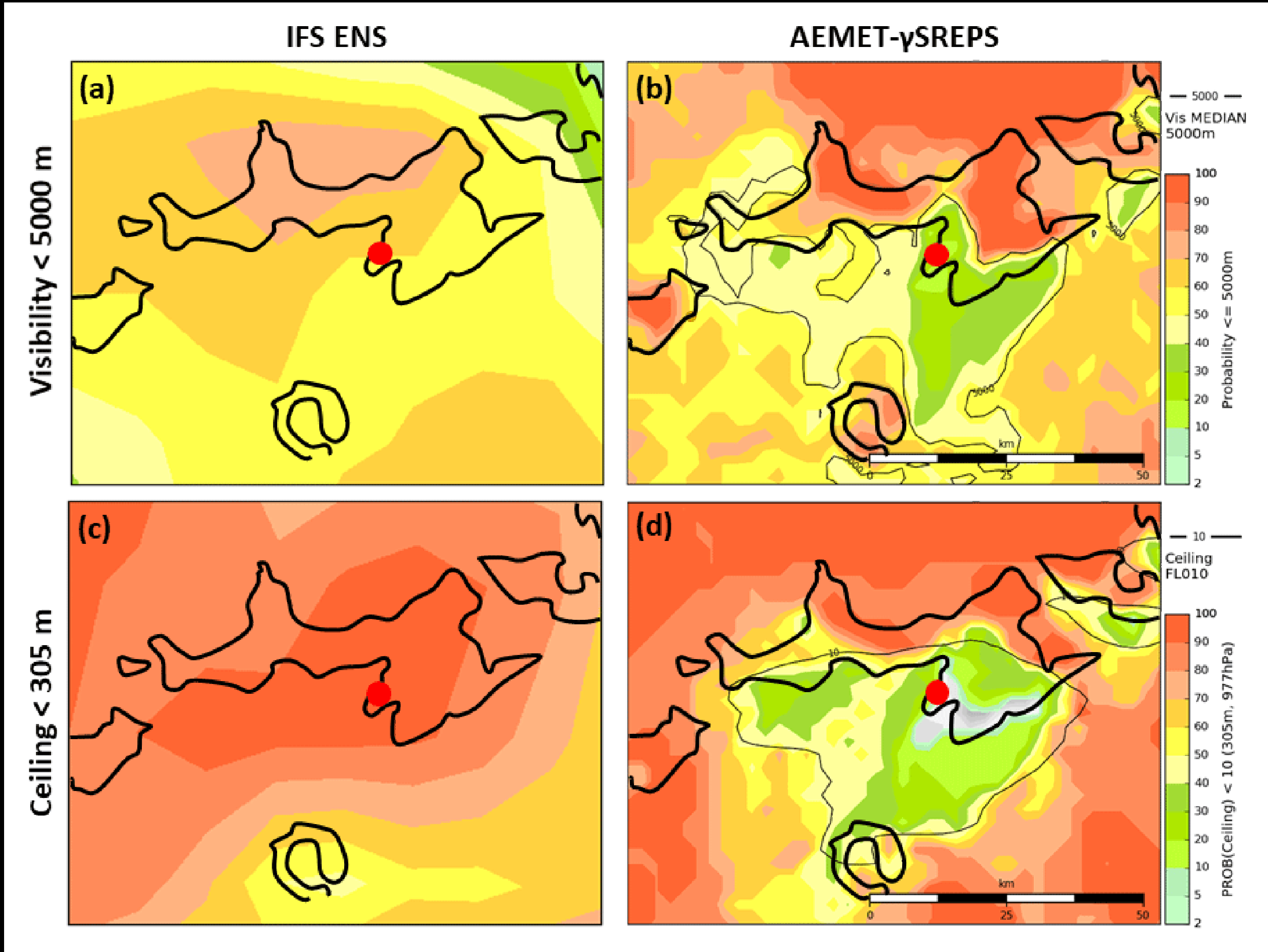
A taste of verification
SUBJECTIVE

In what forecasters
are more interested !!!

γSREPS *in Antarctica*

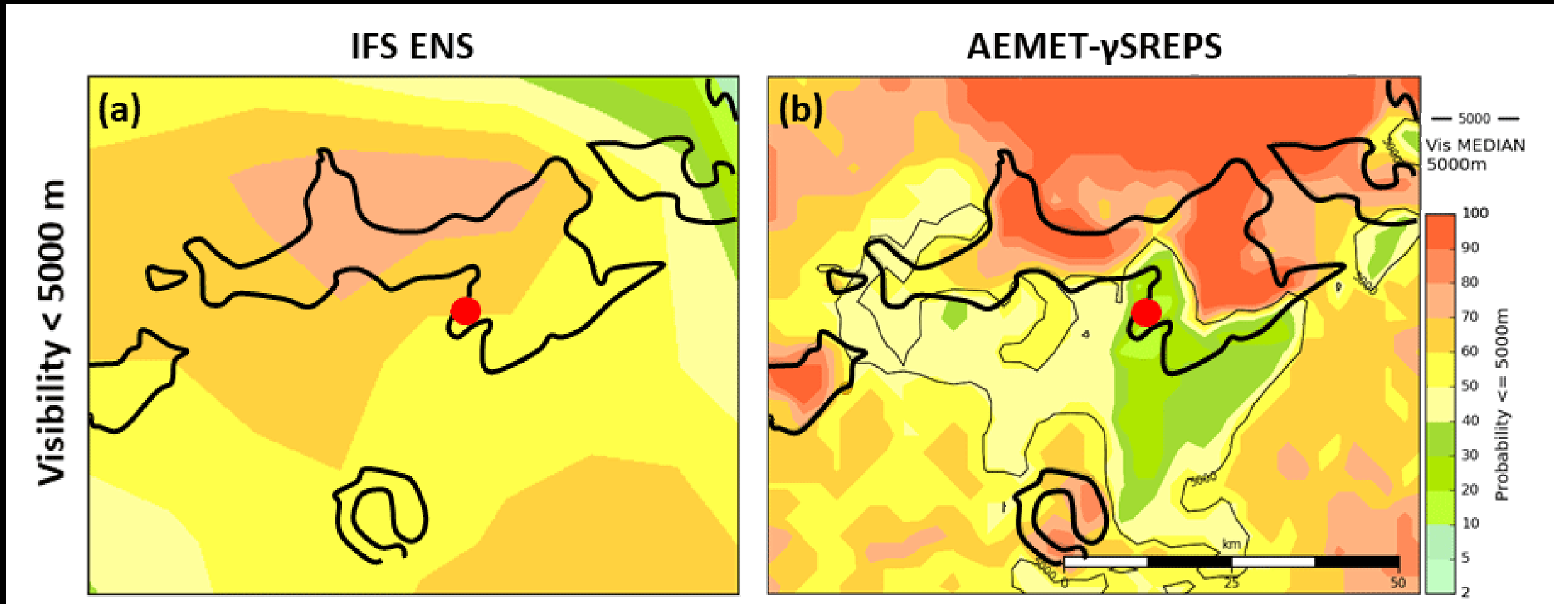


PROB Visibility Below 5000m

PROB Ceiling Below 305 m

Gonzalez, S., Callado, A., Martínez, M., and Elvira, B., "The AEMET-γSREPS over the Antarctic Peninsula and the impact of kilometric-resolution EPS on logistic activities on the continent", Adv. Sci. Res., 17, 209–217, 2020, https://doi.org/10.5194/asr-17-209-2020

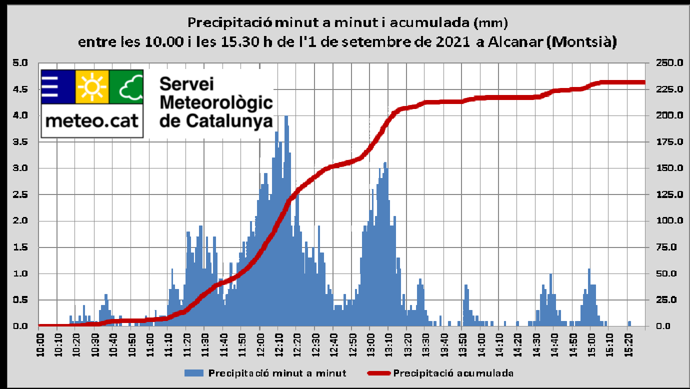
γSREPS *in Antarctica*



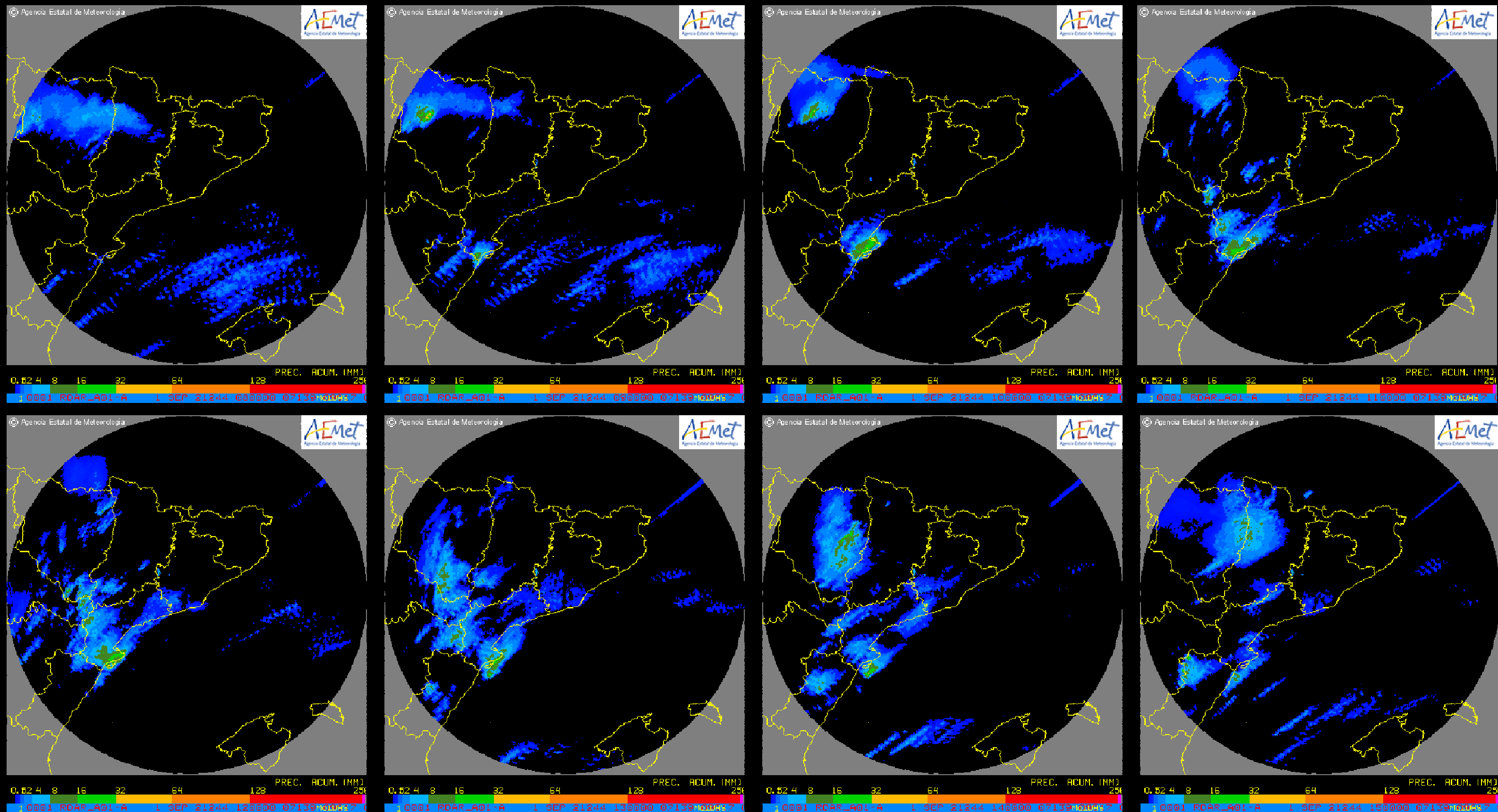
PROB Visibility Below 5000m

γSREPS-IBERIA: Alcanar flash-flood

- **1st September 2021**
- **256,7mm** were registered **in 24h**.
- More than **200mm** were registered **in 2h30min.**
- Maximum intensity of **77,7mm in 30min.**

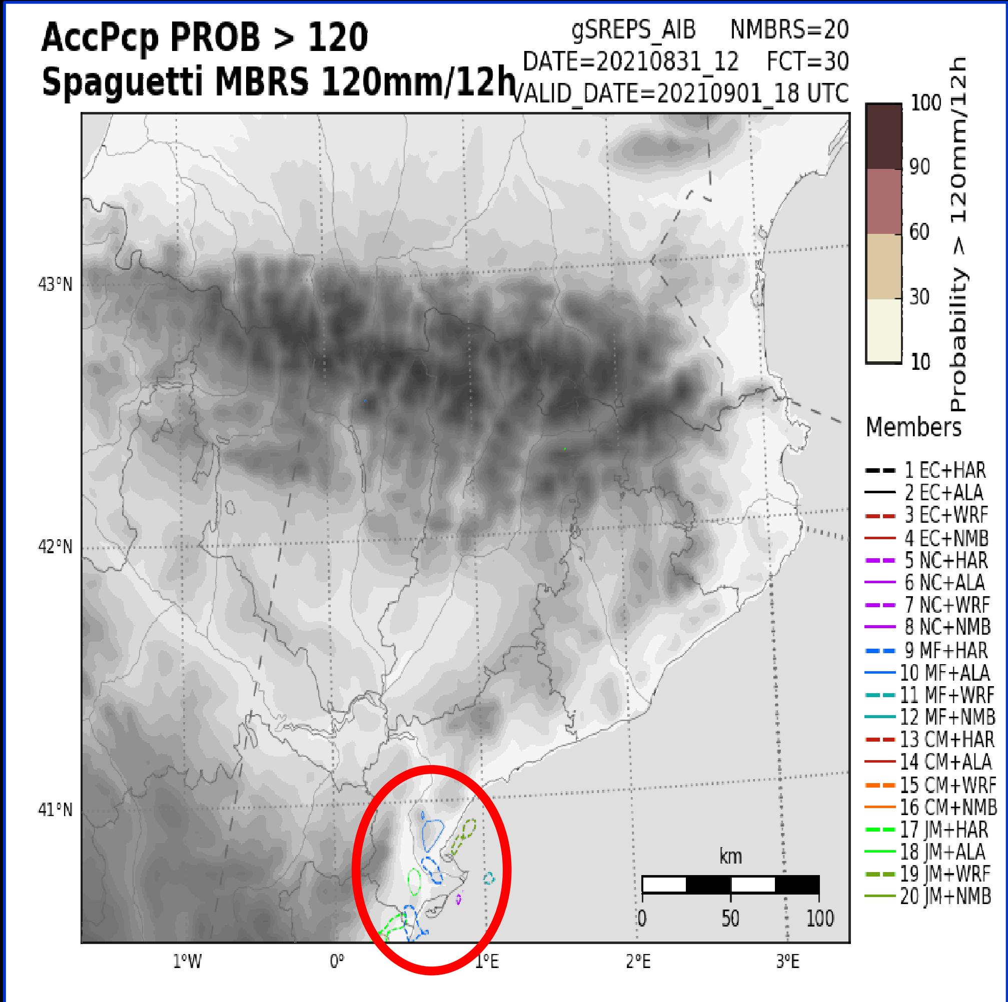


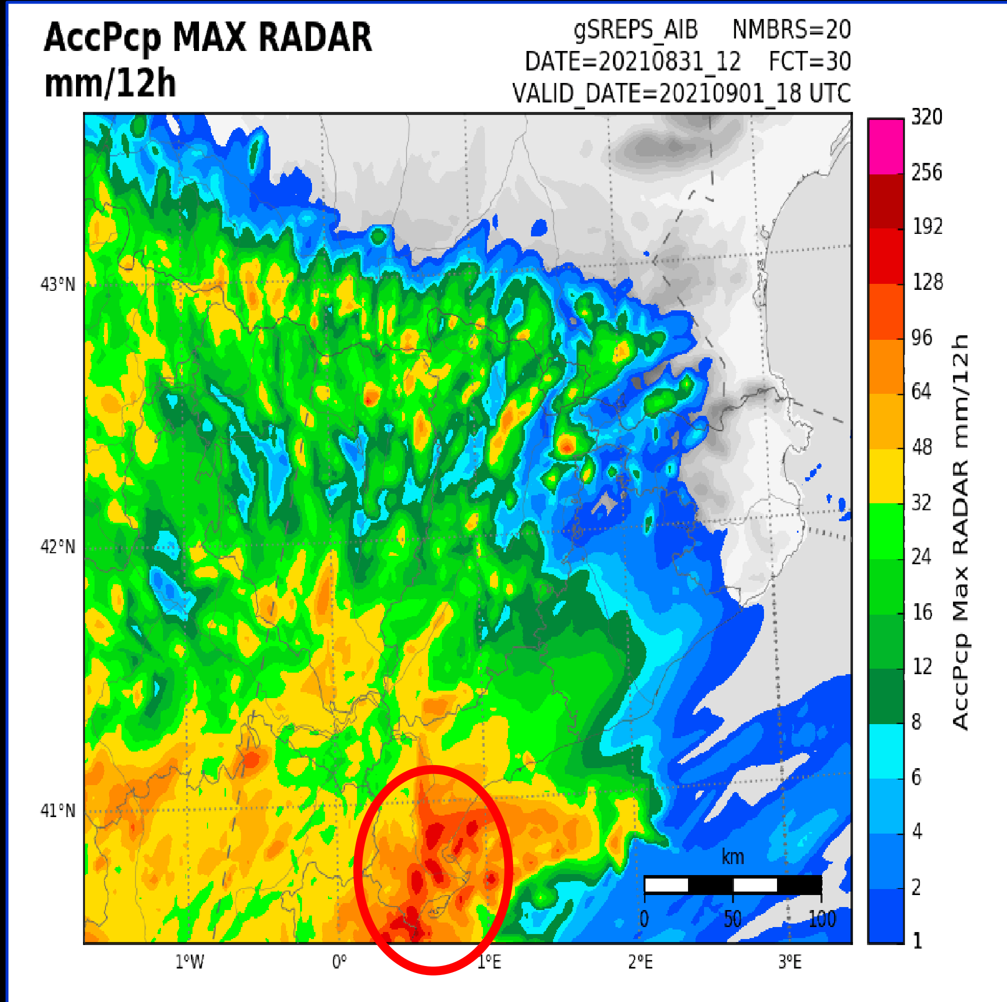
Video:https://www.youtube.com/watch?v=EGzV6QZLAYQ



γSREPS-IBERIA: Alcanar flash-flood

- **Forecast produced in the 31st August 2021 at 12 UTC, valid for 1st September 2021 at 18 UTC).**





7 members > 120mm reflect **35% of probability**
BUT with spatial uncertainty

Close to Alcanar ➔ **192-256mm/12h**
(registered **256,7**mm/24h)

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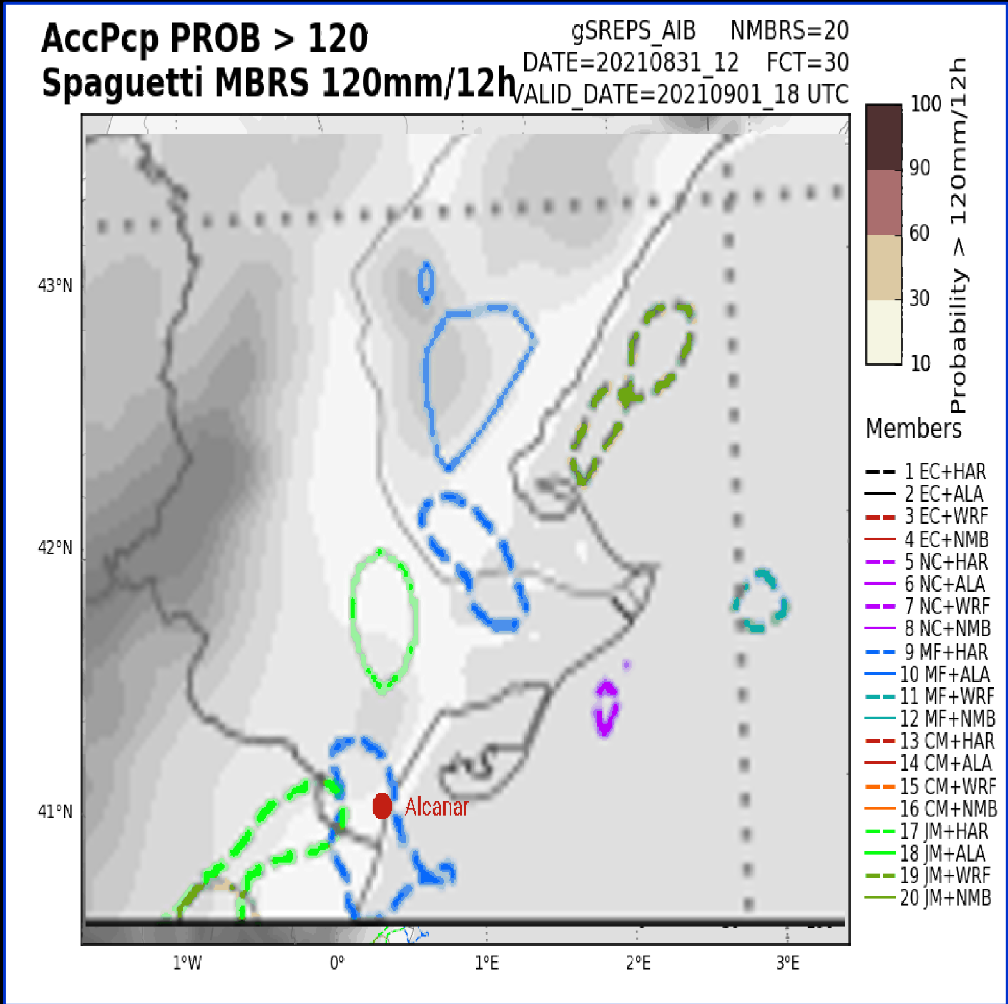

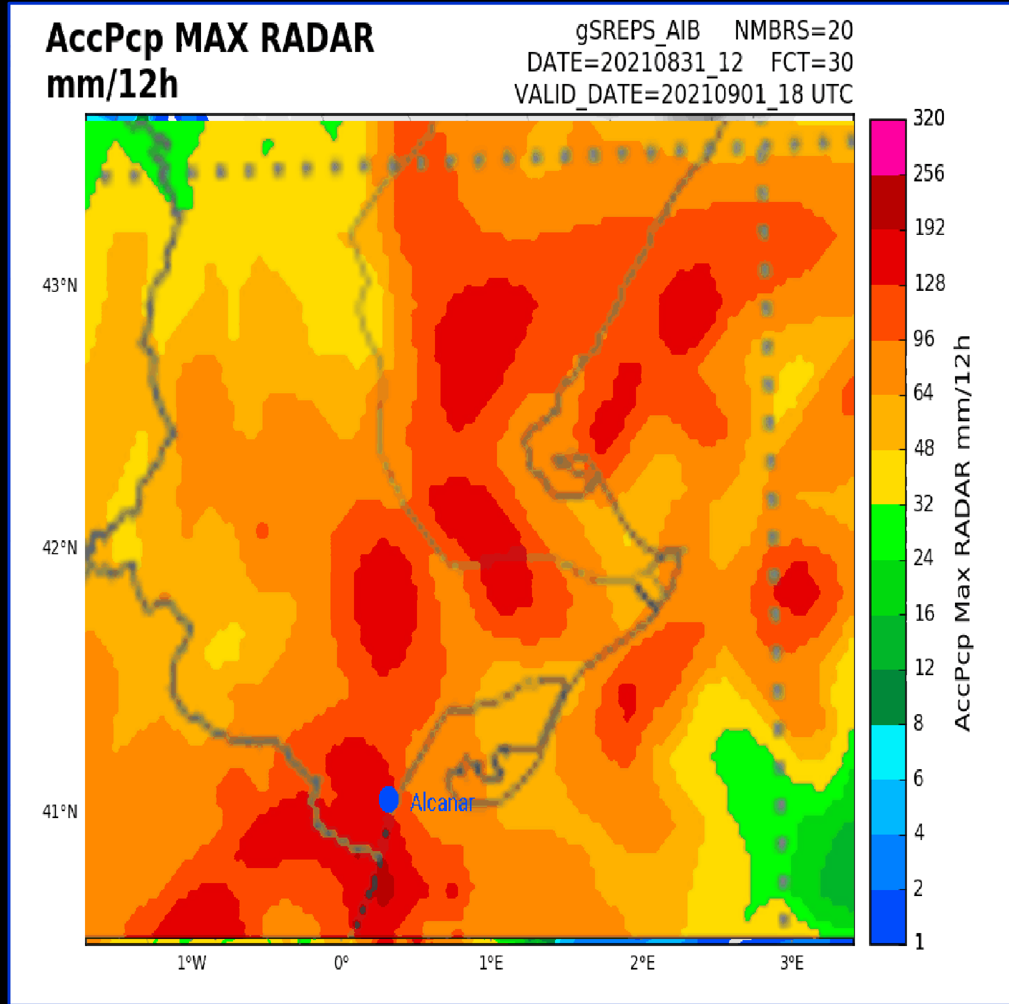

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γSREPS
Future plans and developments

Currently more focussed in operations and end-users
(e.g. products for aeronautic forecasters)
than in "LAM-EPS research"

Foreseeable future work plan: 2022

γSREPS developments:

- Assimilation: 3DVAR EDA

- 25 members ⇔ Including the 5th mesoscale convection-permitting NWP model: ¿Canadian GEM-LAM?

- **Forecasting tools** (SRNWP-EPS ItAF-REMET) focused on aeronautics
  - Thunderstorms, lightning, TAC, icing and fog

- **AEROgrammes** – EPSgrams: airports
  - NOTO web page [operational since September]

Foreseeable future work plan: 2022

γSF

- As

- 25 ... ction-
  pe ... LAM?

- Fo ... on
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  -

- AE
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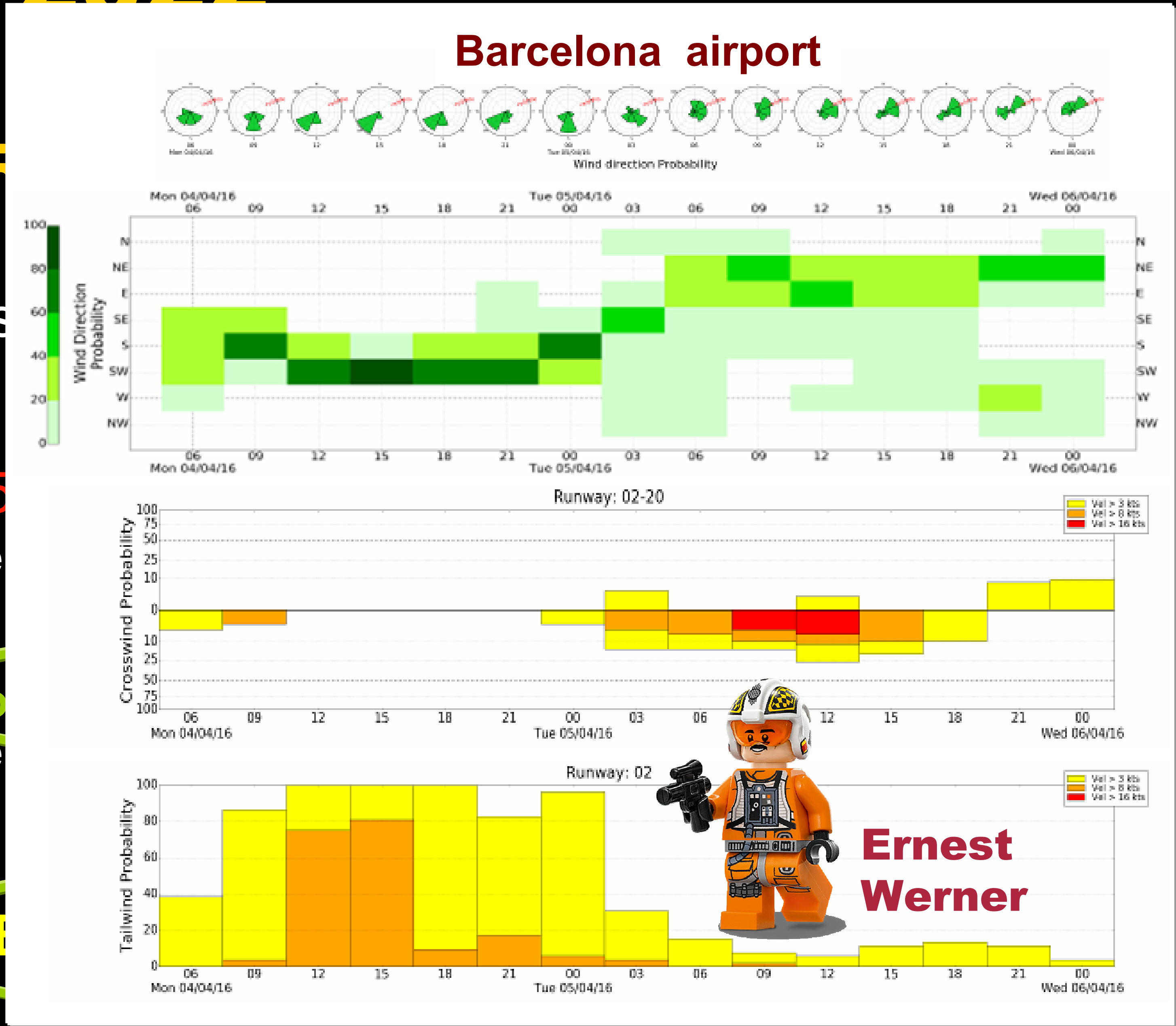

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γSR

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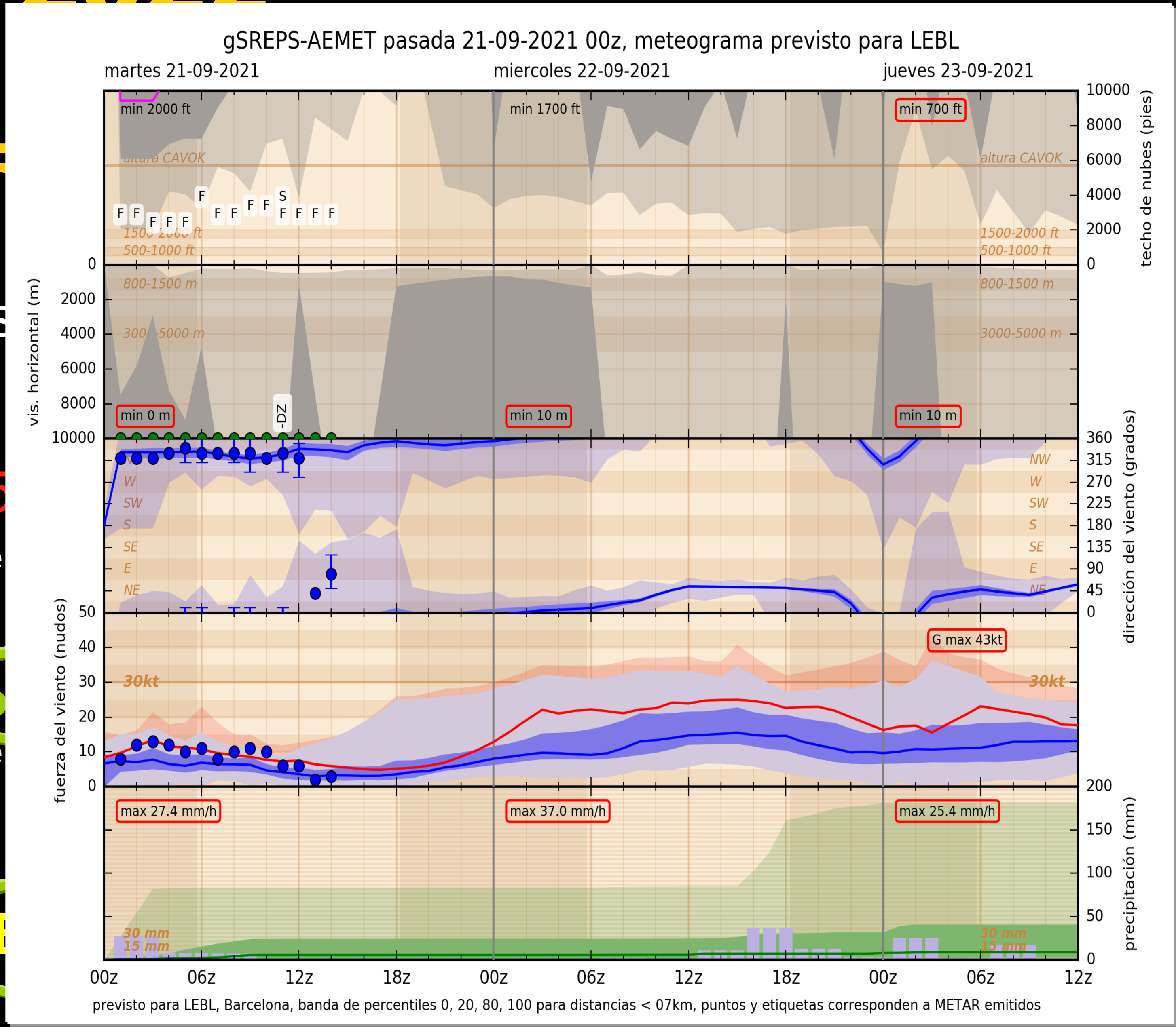


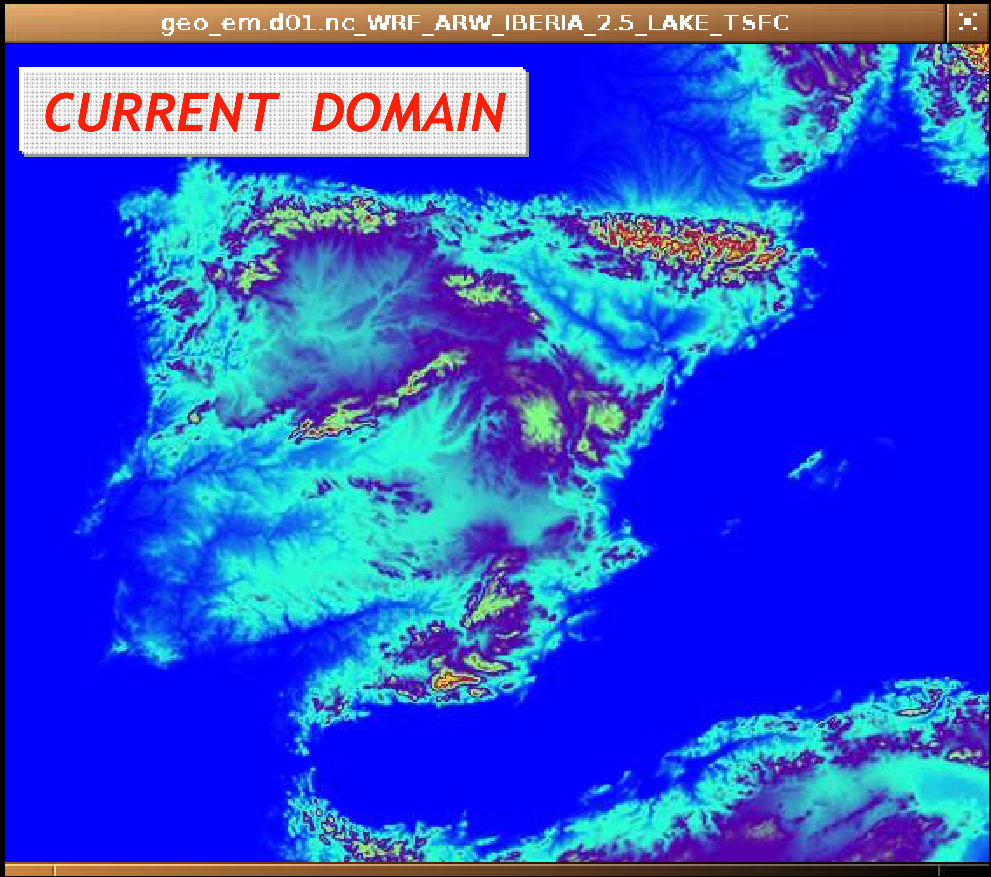
Foreseeable future work plan: 2020-2021

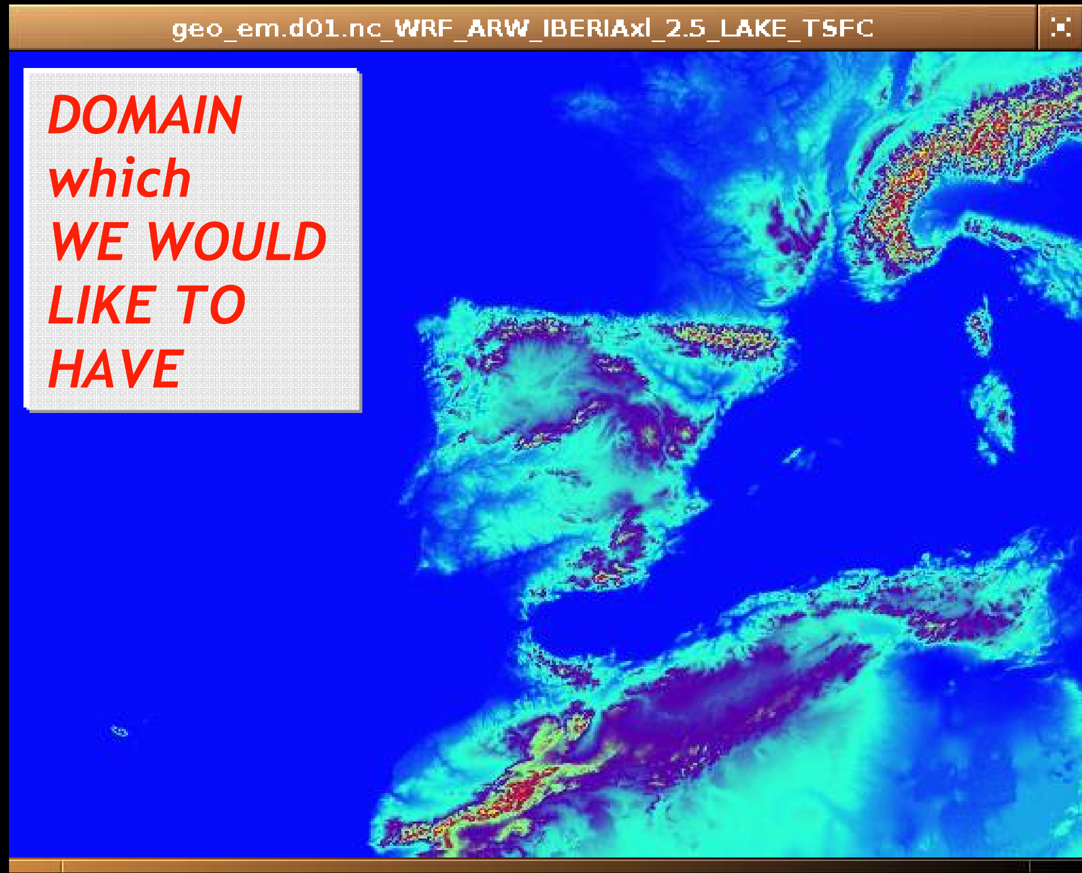
- γSREPS *IBERIA/CANARIAS/LIVINGSTON*
  - Time critical application level 2 at ECMWF
    - Explotación AEMET
  - IBERIAxxm_2.5 bigger domain (~better organized convection)
  - Up to 72 hours (currently 60) for AEMET forecasters

    ⇔ More HPCF resources → 2022 Bologna

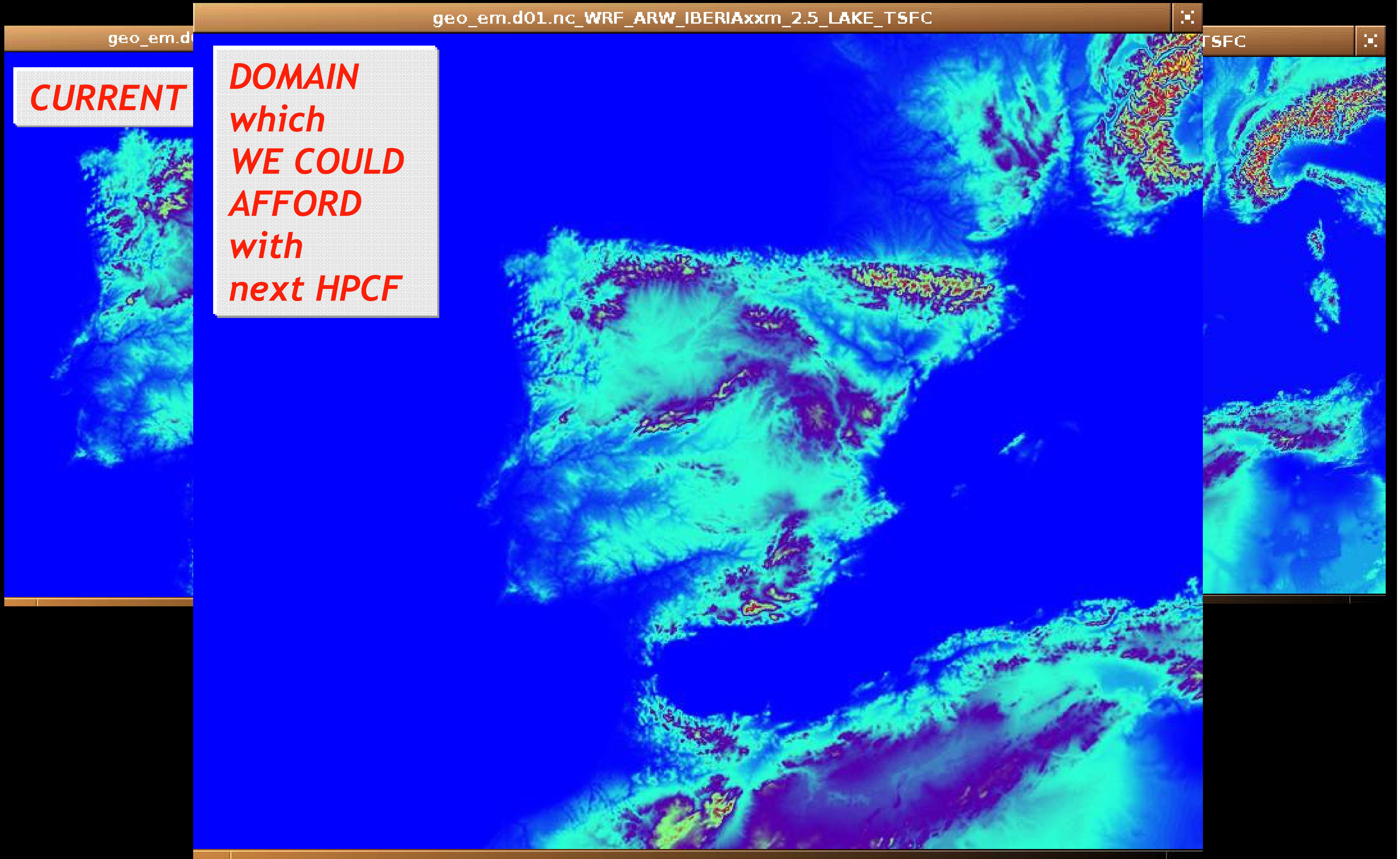
    → 2021 AEMET ATOS
  - Cycles 00 and 12 UTC in the 3 domains
- Auto-verification *each month* with HARP v3 BCs and NWP sub-ensembles verification
  - Deterministic verification for each member

γSREPS IBERIA domain





γSREPS IBERIA domain



EUMETNET

SRNWP-EPS

Calibration on extremes

EFI - SOT

Thank you for your attention !!!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1ª Reunión TRAMPAS 2021 December 02/03

AEMET γSREPS Predictability Group

Alfons Callado, Juanjo Gómez

Pau Escribà, *David Gil* (*WEB collaboration*)

***Maria Cortès / Joan Montolio* (*EUMETNET SRNWP-EPS calibration/EFI*)**

TRAMPAS (PID2020-113036RB-I00 / AEI / 10.13039/501100011033)

Joan Montolio Llenas *srnwpeps_efi@aemet.es*

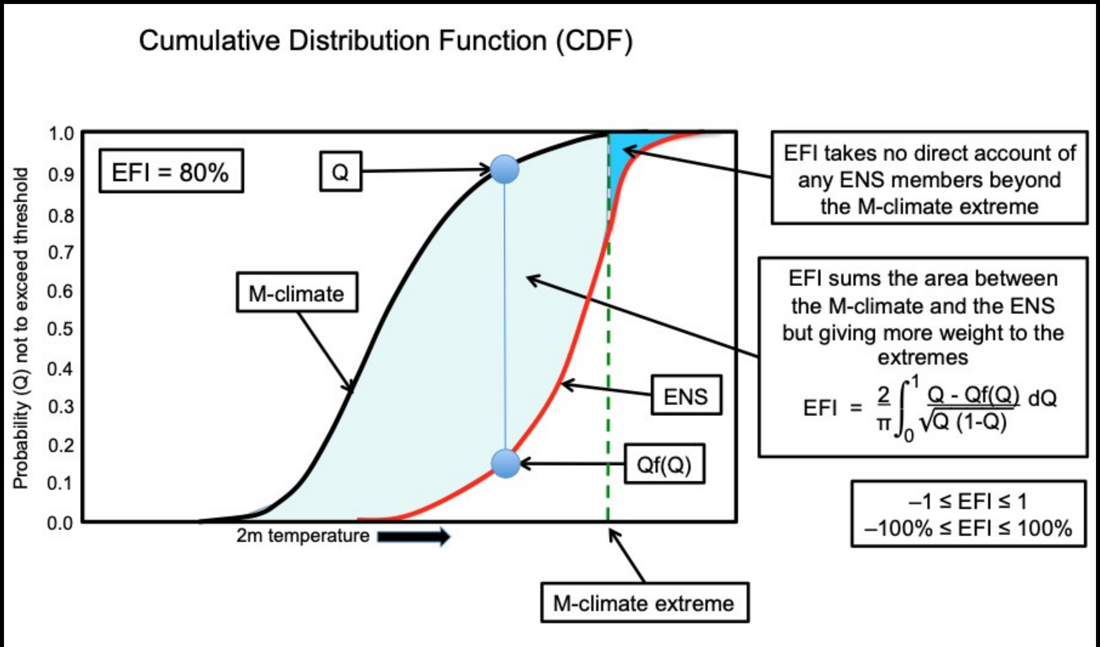
Project: EUMETNET SRNWP-EPS

Application Task: Defining an Extreme Forecast Index (EFI) and Shift Of Tails (SOT) for LAM-EPS (# req. EPS_8)

Main goal: Development of a software that implements the calculation of EFI and SOT indexes in EUMETNET LAM EPS.

It is expected to be a helpful tool for forecasters in order to improve the prediction of extreme weather events.

Application Task status



Bibliography about EFI and SOT has been reviewed in order to understand their formal definition and the methodology involved in their implementation in a EPS.

It was decided to start designing the software in **Python programming language**.

First experiment consisting in the calculation of EFI and SOT indexes in a **single grid point from AEMET γSREPS** is being performed.

Application Task status

In this experiment **historical GRIB files from γSREPS** are used to construct the EPS climatology.

Definition of a set of functions that perform the different operations involved in the process to calculate EFI and SOT. These functions are **saved in a Python library file.**

The **NumPy package** is being used as much as possible in order to obtain a **robust and synthesized code**.

In the construction of the EPS climatology a **temporal relaxation** is already implemented to **increase the size of the climatological dataset**.

In this experiment the following **meteorological variables** are considered: **24-hours accumulated precipitation** (Acc_Prec) , **2-metres daily mean temperature** (T2m) and **10-metres daily mean wind speed** (Wind10m).

Collaborative support

In order to optimize the development of the task, collaboration has been asked to two experts in the field of EFI/SOT implementation in EPS.

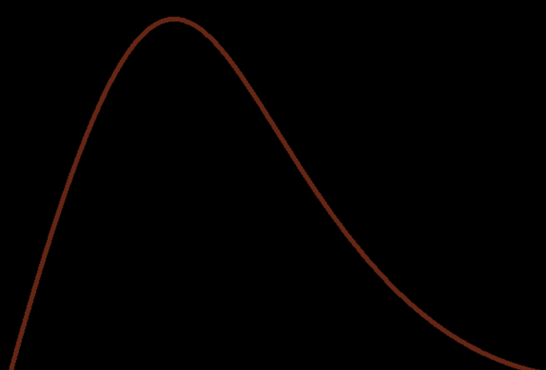
Laure Raynaud, from **Méteo-France**, is the manager of the EFI / SOT implementation in **AROME-EPS**.

Ivan Tsonevsky, from the **ECMWF**, is the manager of the EFI / SOT implementation in **IFS**.

Maria Cortès Simó srnwpeps_calibration@aemet.es

Project:
EUMETNET: SRNWP-EPS

Main goal:
Ensemble calibration, focused on extremes



Development of EPS post-processing software to calibrate different extreme variables

Ensemble Post-Processing using the SRNWP-EPS LAM EPS database

Variables: Daily precipitation, wind gust, maximum and minimum temperature

Observations: ECMWF

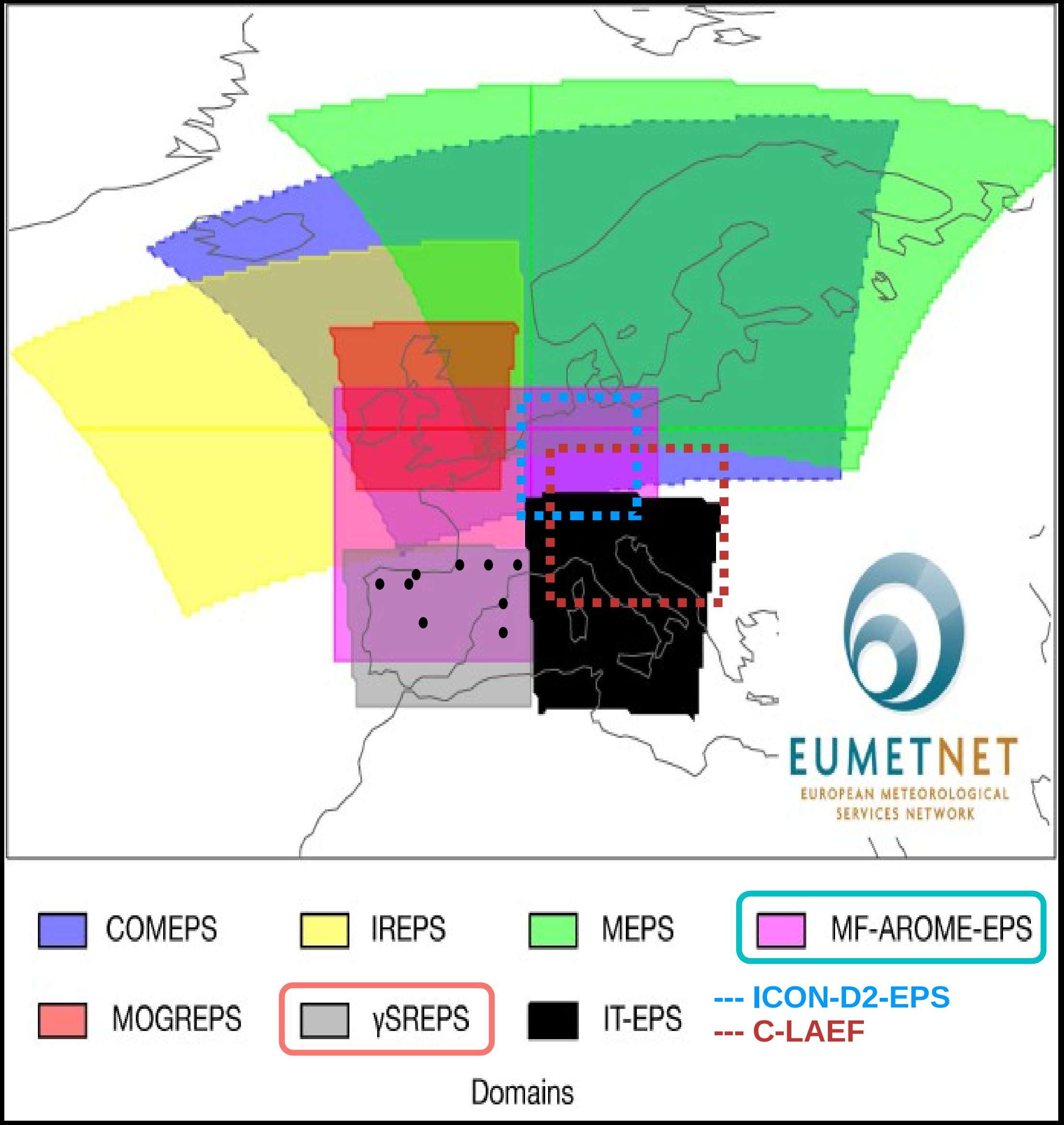
Stations: Barcelona, Biarritz, Llanes, Madrid, Montpellier, Palma de Mallorca, Puerto de San Isidro, Santiago de Compostela, Toulouse

Period: 01/06/2020 – 31/08/2021

EPS (SRNWP-EPS database):

gSREPS: runs **00**/12 UTC;
20 **distinguishable** members

MFAromeEPS: runs 09/**21** UTC;
16 **indistinguishable** members

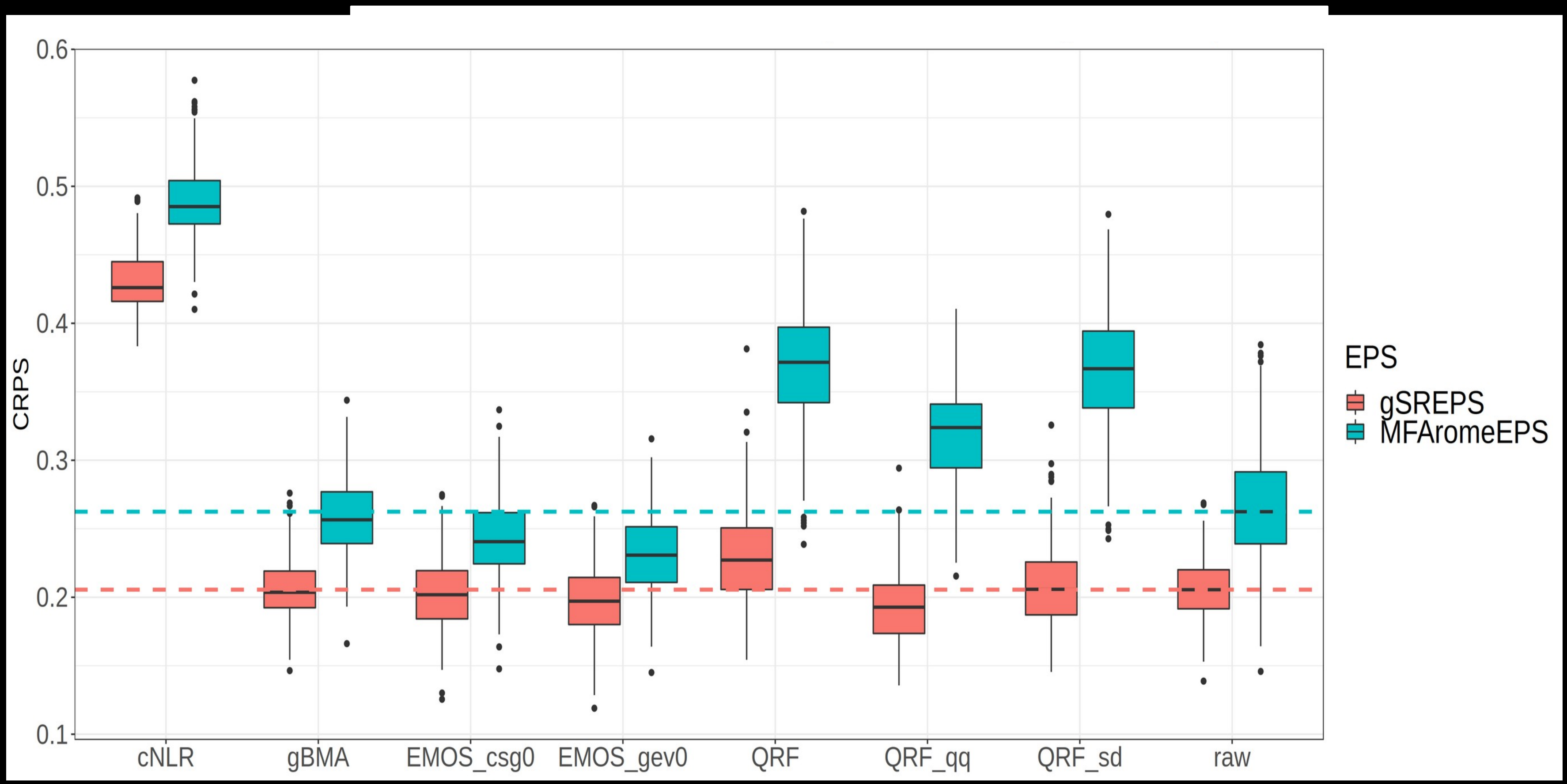


Callado, A. et al. 2020, ECMWF Newsletter No. 166, 6-7

Thanks to François Bouttier for the MFArome-EPS data

Daily precipitation – Continuous Rank Probability Score

Better



Post-processing methods

cNLR: censored Nonhomogeneous Logistic Regression
gBMA: Bayesian Model Averaging mixture with gamma 0 distribution
EMOS_csg0: censored and shifted gamma EMOS modeling
EMOS_gev0: censored generalized **extreme** value distribution EMOS modeling
QRF: Quantile Regression Forest (ensemble mean)
QRF_qq: Quantile Regression Forest (ensemble mean + 10th and 90th quantile)
QRF_sd: Quantile Regression Forest (ensemble mean + ensemble standard deviation)
raw: raw ensembles

Training period:
01/06/2020 – 28/02/2021

Test period:
01/03/2021 – 31/08/2021

Santiago de Compostela

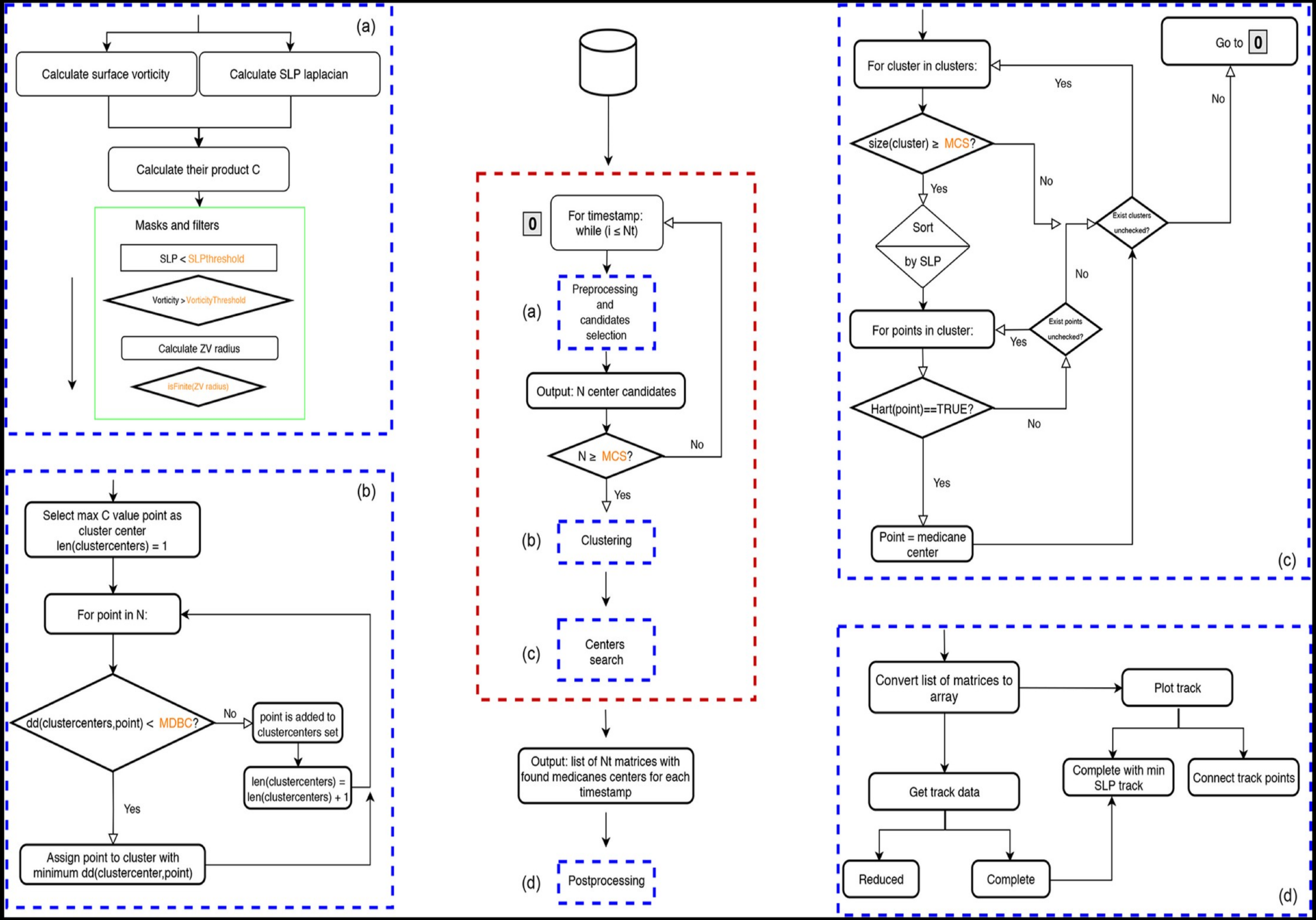
MEDICANE DETECTION AND TRACKING ALGORITHM (TITAM)

Enrique Pravia-Sarabia et al.: TITAM (v1.0): the Time-Independent Tracking Algorithm for Medicanes. https://doi.org/10.5194/gmd-13-6051-2020

- Time-independent.
- Calculate cyclonic potential

$$\mathbf{C} = \nabla^2(\mathbf{SLP}) \cdot (\nabla \times \boldsymbol{v}_{10})_z$$

- Pass filters: SLP maximum, vorticity minimum.
- Calculate zero-vorticity radius, check symmetry.
- Clustering of potential centers.
- Pass Hart conditions over each candidate: B symmetry parameter and thermal wind.
- Choose the point with the lowest SLP fulfilling Hart conditions as medicane center.



MEDICANE DETECTION AND TRACKING ALGORITHM (TITAM)

- Track multiple structures.
- The namelist-oriented approach allows flexibility in the parameters.

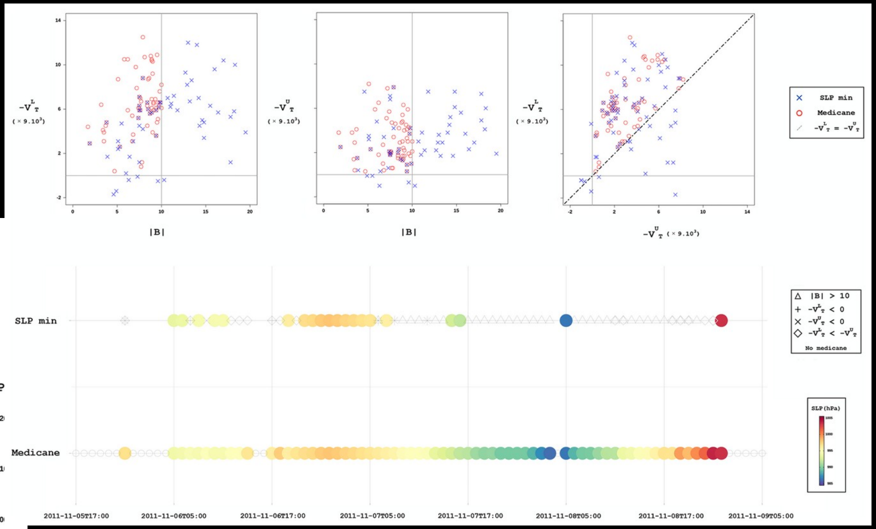


Figure 3. SLP minima and medicane centers for the Rolf medicane. In the top panels are the Hart phase space plots for points of SLP minimum (blue crosses) and centers detected by the algorithm (red circles). The bottom plot shows the temporal scheme of the detected centers and the SLP minimum track. Symbols indicate the Hart condition(s) not satisfied by the SLP minimum.

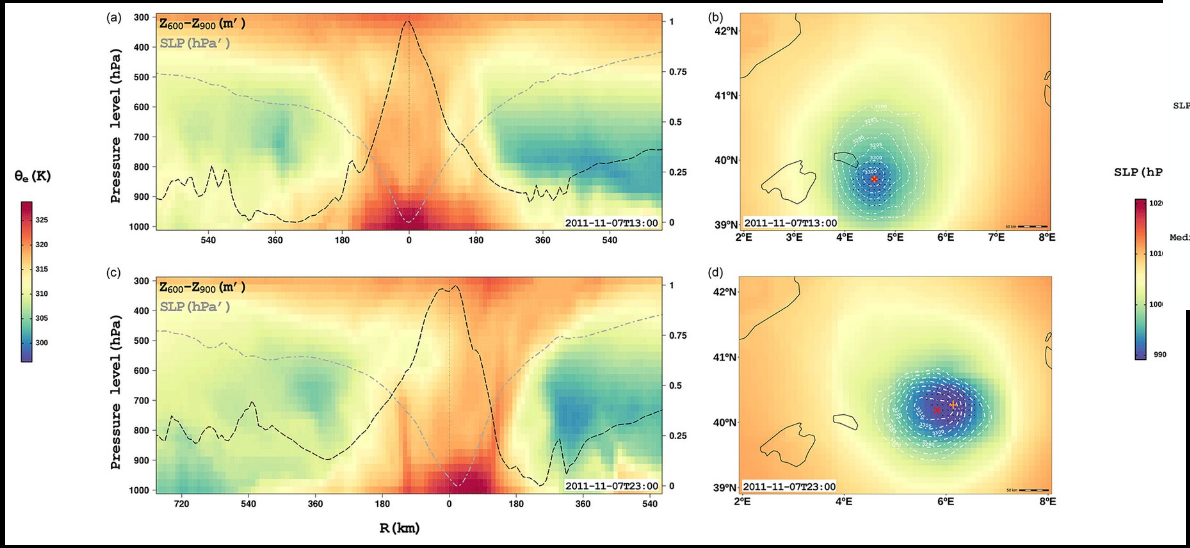


Figure 5. Depiction of the thermal structure of the Rolf medicane structure at two different time steps (a, b: 7 November 2011, 13:00 UTC; c, d: 7 November 2011, 23:00 UTC) by means of a zonal cross section (along the line of latitude passing through the medicane center found by the algorithm) of the equivalent potential temperature (colors in a, c) and a contour plot of Z600 − Z900 along with the SLP field in colors (b, d). In (a, c), the SLP (black dotted curve) and Z600 − Z900 (grey dotted curve) are also presented, both scaled to the zero–one interval (unity-based normalization). A vertical line indicates the longitudinal position of the center found by the algorithm. In (b) and (d), dashed white lines show contours of the geopotential height thickness for the 900–600 hPa layer every 5 m starting from 3280 m. Additionally, the orange plus symbol specifies the position of the SLP minimum, while the red cross denotes the position of the medicane center selected by the algorithm.

- Monitoring, for each time step, the symmetry and warm-core conditions.
- Find the ‘real’ medicate center