GOBIERNO DE ESPAÑA
VICEPRESIDENCIA TERCERA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

aemet Agencia Estatal de Meteorología

γ SREPS

Review of LAM-EPS systems at AEMET: past, present and future

The Spanish multi-NWP model LAM-EPS

AEMET-γSREPS

ACCORD
A Consortium for COnvection-scale modelling Research and Development

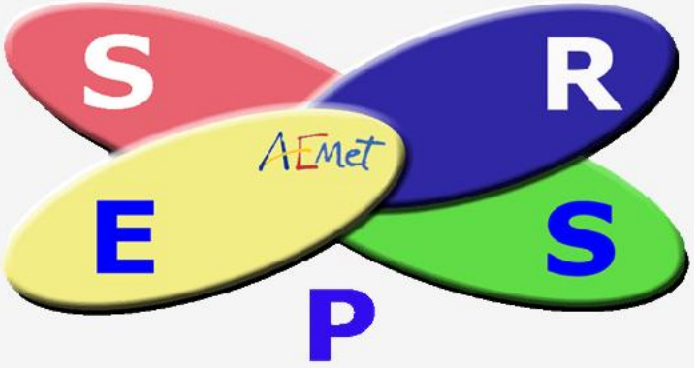
6th All Staff Workshop
Marrakech (Morocco), 13-17 April 2026

Spanish AEMET γSREPS Predictability Group
Juanjo Gómez, **Alfons Callado**
Miguel Gullón *(new member)*
Pau Escribà, David Gil (collaborations)
Matilde García-V. (EUMETNET SRNWP-EPS project)

Outline

- **Past: a brief history**
  - Multi-NWP model ensemble
- **Present: the AEMET-γSREPS**
  - Why multi-NWP model
    - Verification
    - Case studies
  - Forecasting offices
    - Extreme events
      - ➔ **Spaghetti** and **Maximum** products
- **Future:**
  - **ACCORD/UWC** uni-NWP model **HarmonEPS**

Last years quite focused on Forecasting Offices **products**, BUT last year **2025** we **update** our **NWP models**



γSREPS group currently
Alfons Callado
Juanjo Gómez



PAST: a brief history

Classic AEMET-SREPS



José Antonio García-Moya
(retired on May 2018, deceased 2019)
Head of the group 2002-2018

γSREPS group during the years
Carlos Santos
Juan Simarro
Daniel Santos

David Quintero
Mauri Martínez
Jesús Montero
Bartolomé Orfila
…

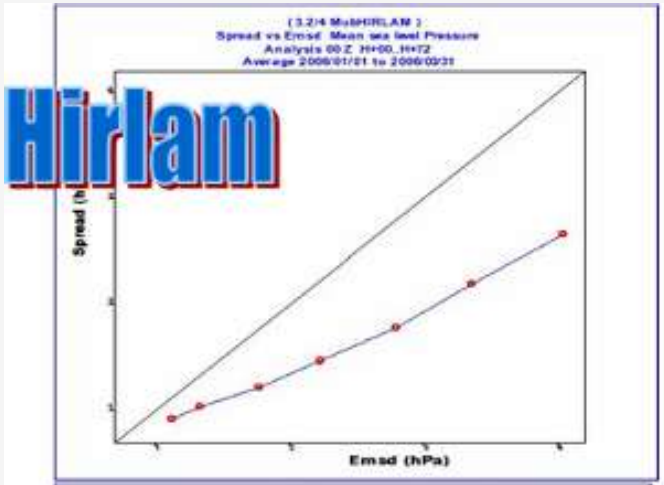
Classic AEMET-SREPS 2003-2007

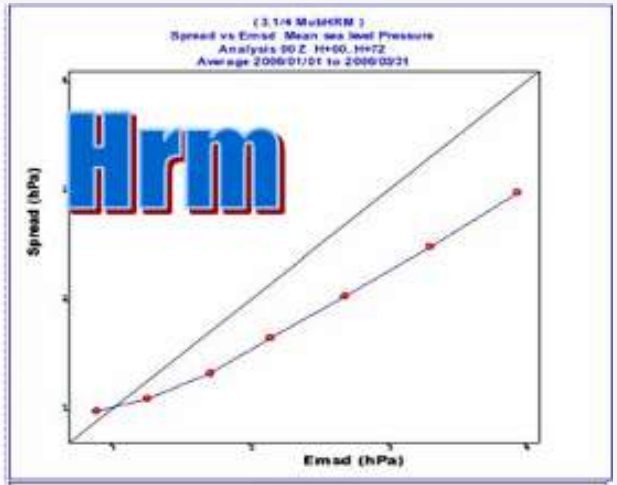
- **Multi-model** seems to be the best strategy for sampling model error: Pmsl SPREAD-SKILL relationship
  - More **CONSISTENT** LAM-EPS

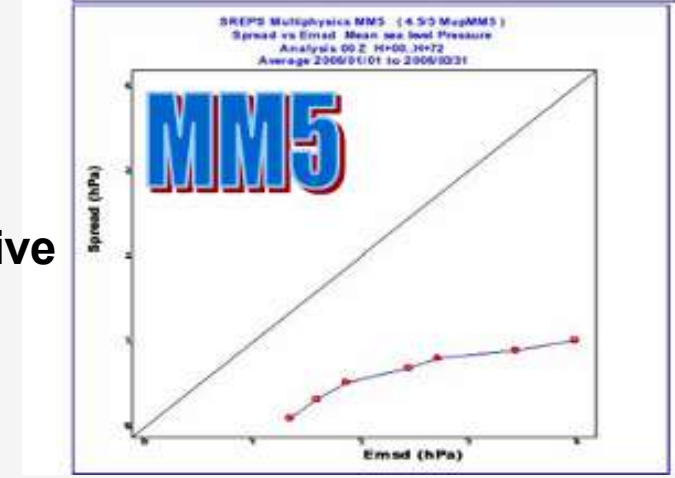


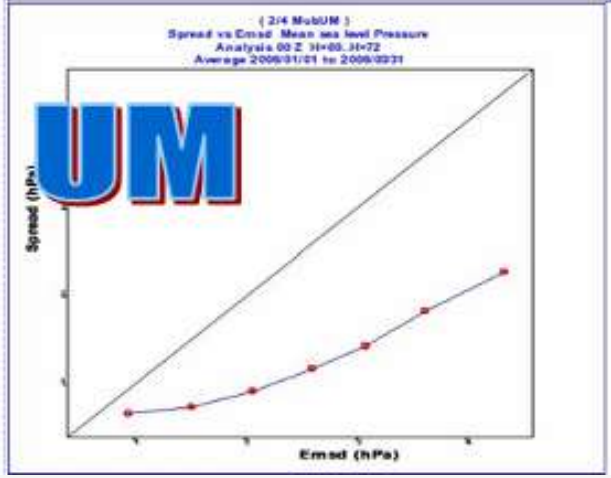
Eugenia Kalnay
(1942-2024)
University of Maryland (USA)
SAMEX

Spread-Skill
The closer to the diagonal, the better
➔ Below diagonal, underdispersive









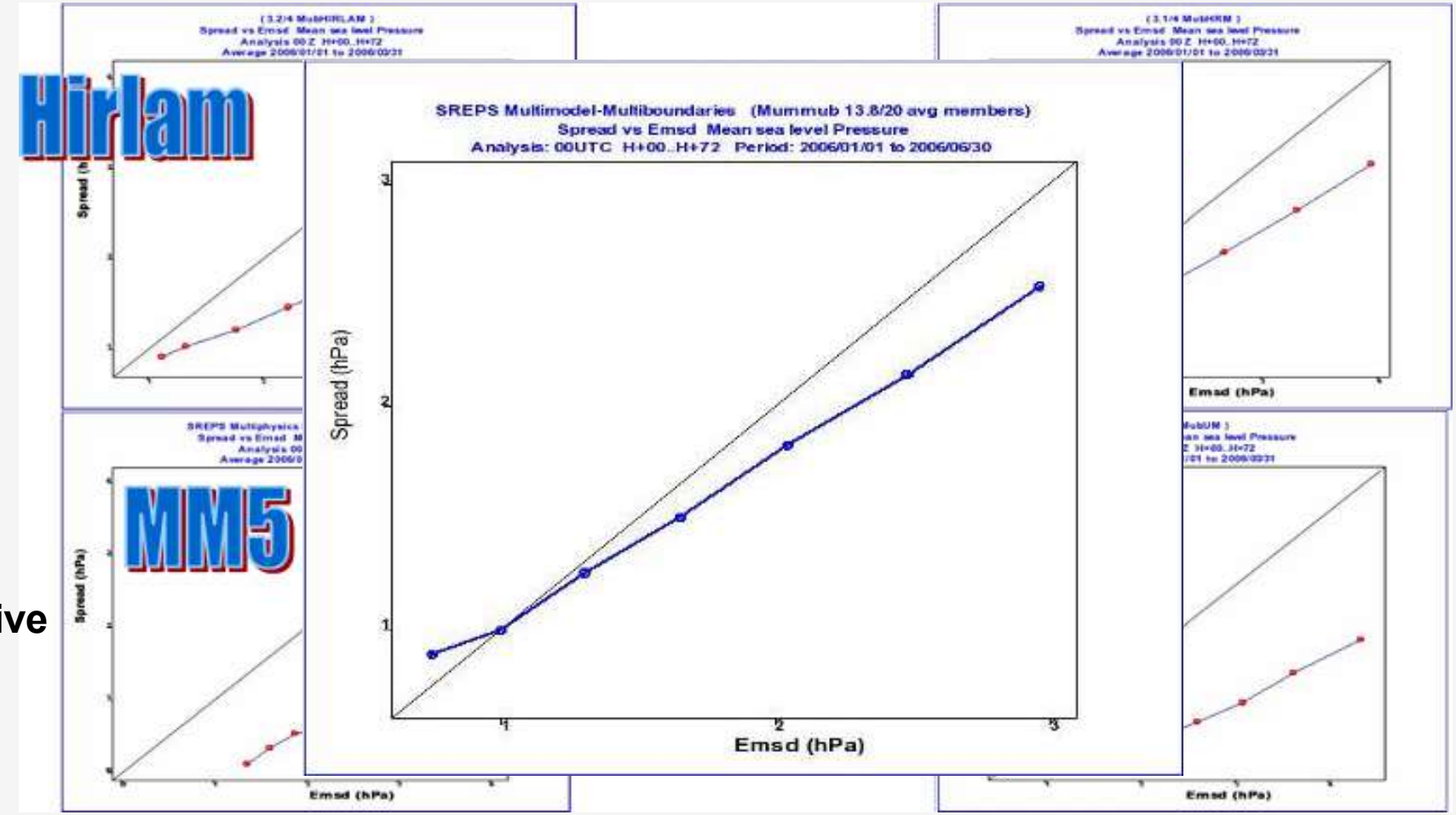
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Classic AEMET-SREPS 2003-2007

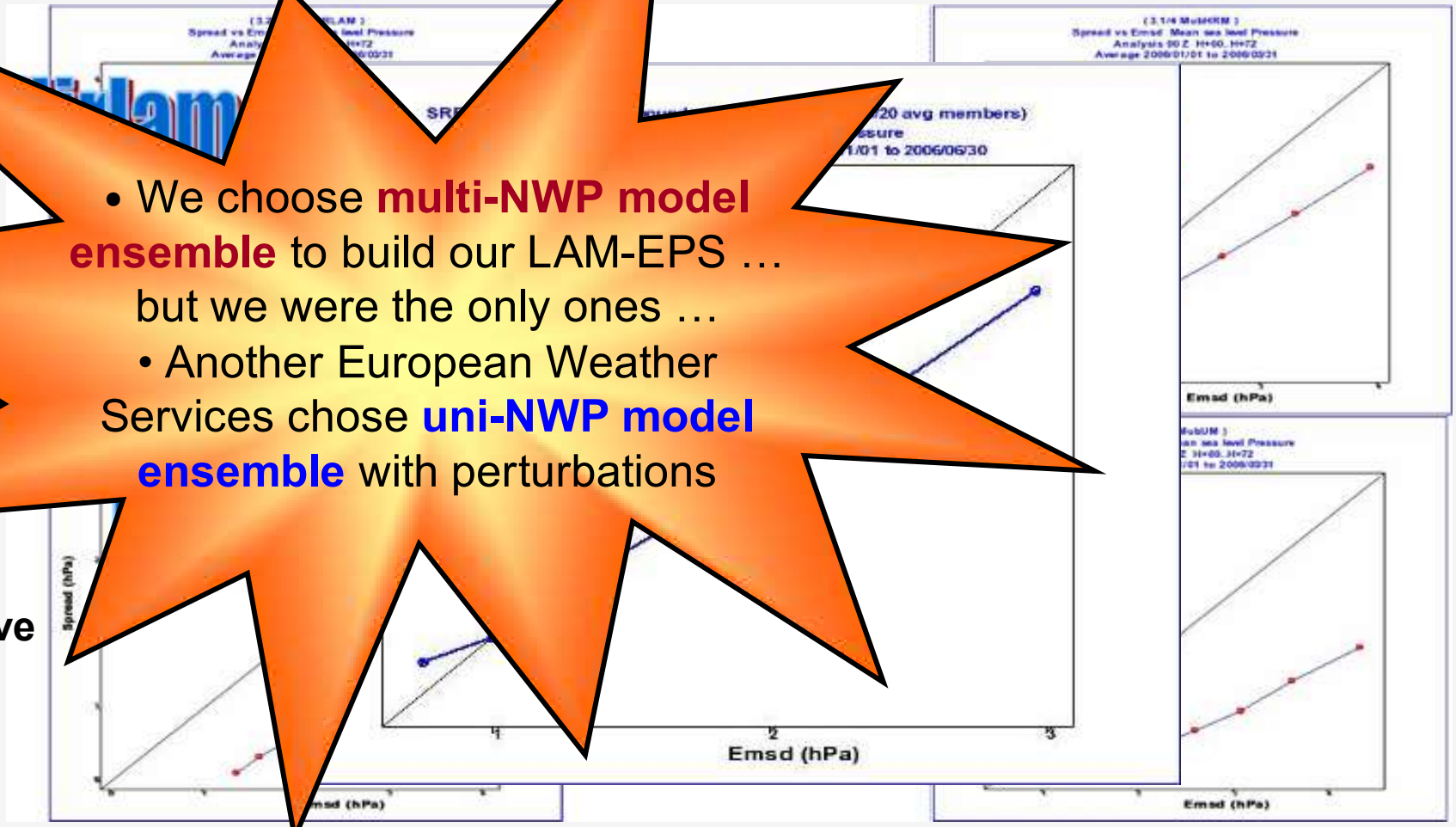
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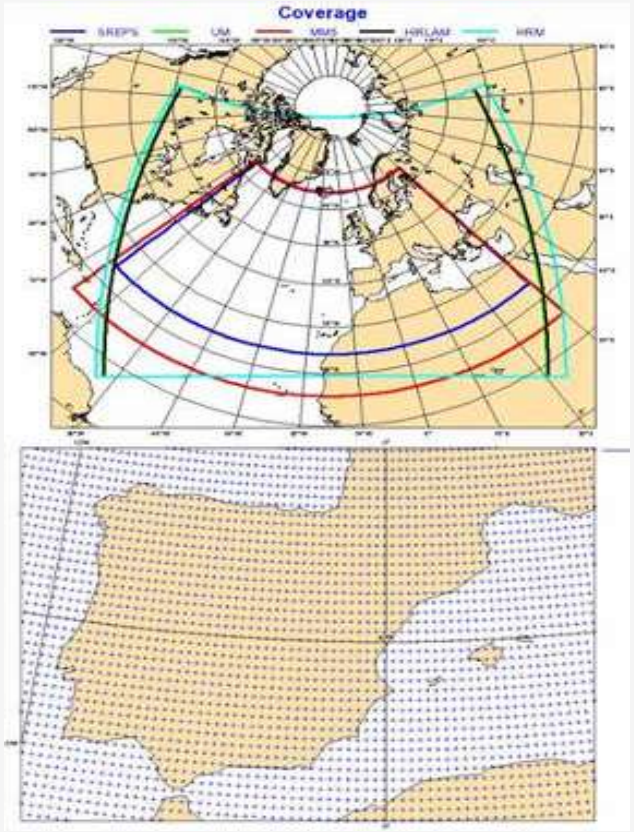
Sprea
The closer
the diagonal,
the better
➔ B
diagonal,
underdispersive

- We choose **multi-NWP model ensemble** to build our LAM-EPS …
but we were the only ones …
- Another European Weather Services chose **uni-NWP model ensemble** with perturbations



Configuration classic AEMET-SREPS 2003-2007

- **25 km** short-range **multi-model** and multi-BCs LAM-EPS

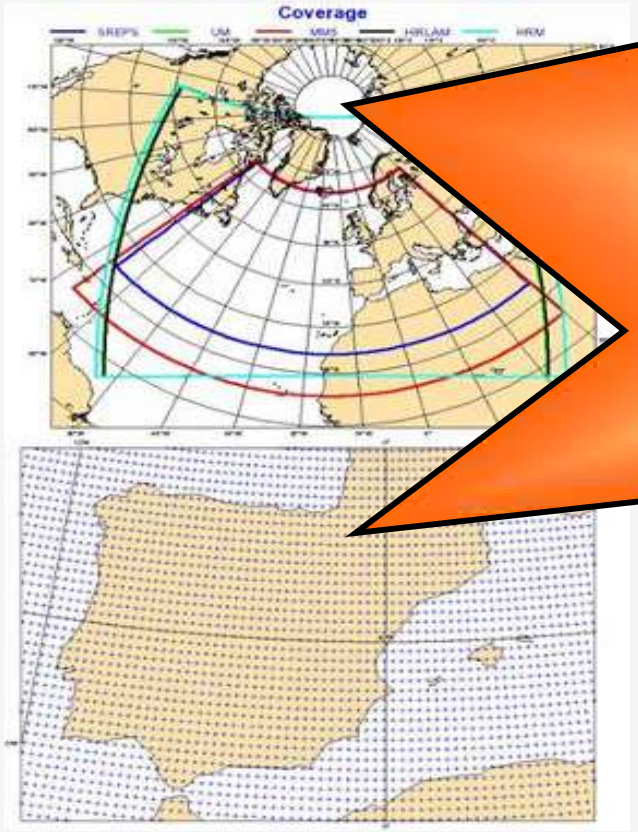


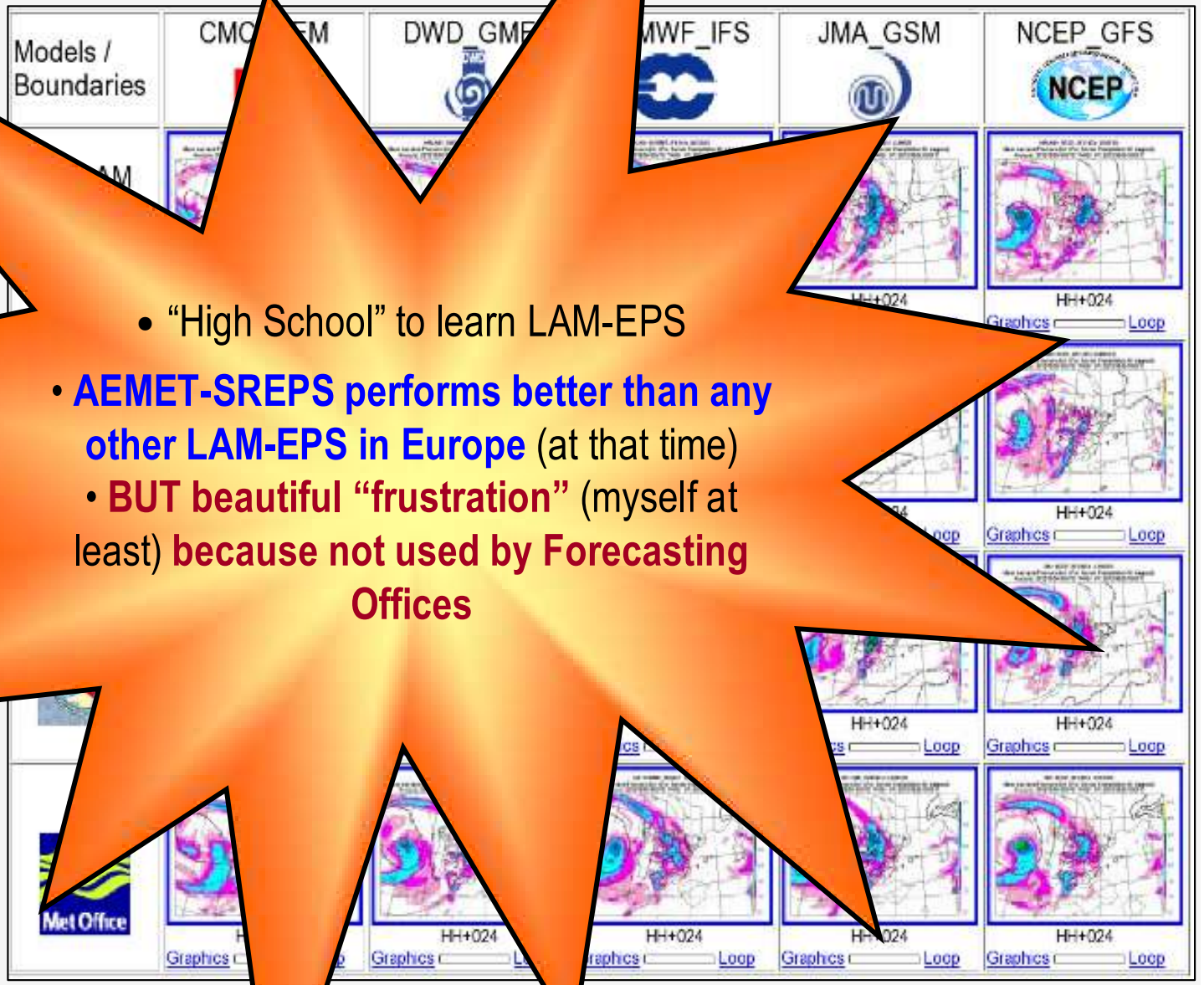
Models / Boundaries	CMC_GEM	DWD_GME	ECMWF_IFS	JMA_GSM	NCEP_GFS
HIRLAM	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop
HRM	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop
LM	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop
UM	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop	HH+024 Graphics Loop

20/25-members on AEMET-SREPS: daily running 2003-2007

Configuration classic AEMET-SREPS 2003-2007

- **25 km** short-range **multi-model** and multi-BCs LAM-EPS





- "High School" to learn LAM-EPS
- **AEMET-SREPS performs better than any other LAM-EPS in Europe** (at that time)
- **BUT beautiful "frustration"** (myself at least) **because not used by Forecasting Offices**

20/25-members on AEMET-SREPS: da running 2003-2007



GLAMEPS 2011-2019
Due to human resources limitations we decided to go directly from **25km** to **2.5km** and not to have a LAM-EPS at **~10km** BUT meanwhile HIRLAM GLAMEPS LAM-EPS was available in AEMET

Present: the AEMET-γSREPS

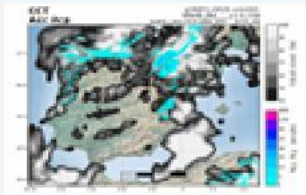
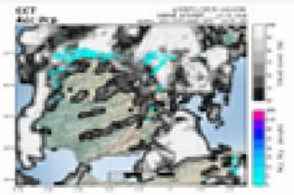
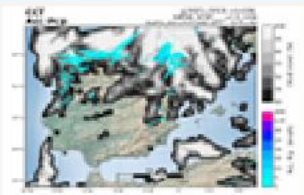
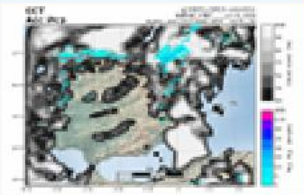
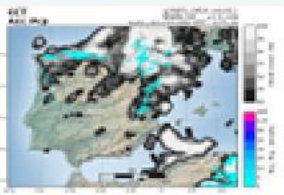
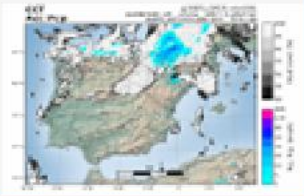
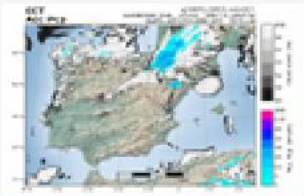
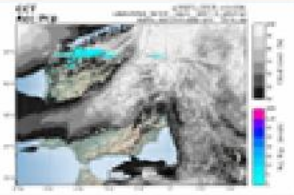
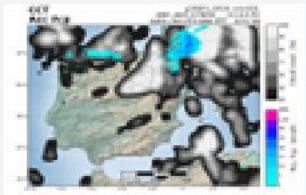
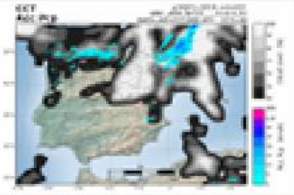
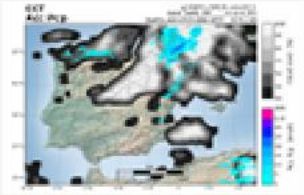
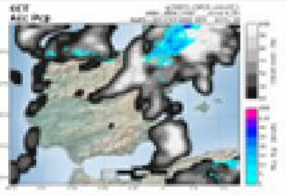
Main goal ➔ High Impact Weather

➔ Valencia DANA

Any forecast is incomplete without a measure of its uncertainty or its PREDICTABILTY

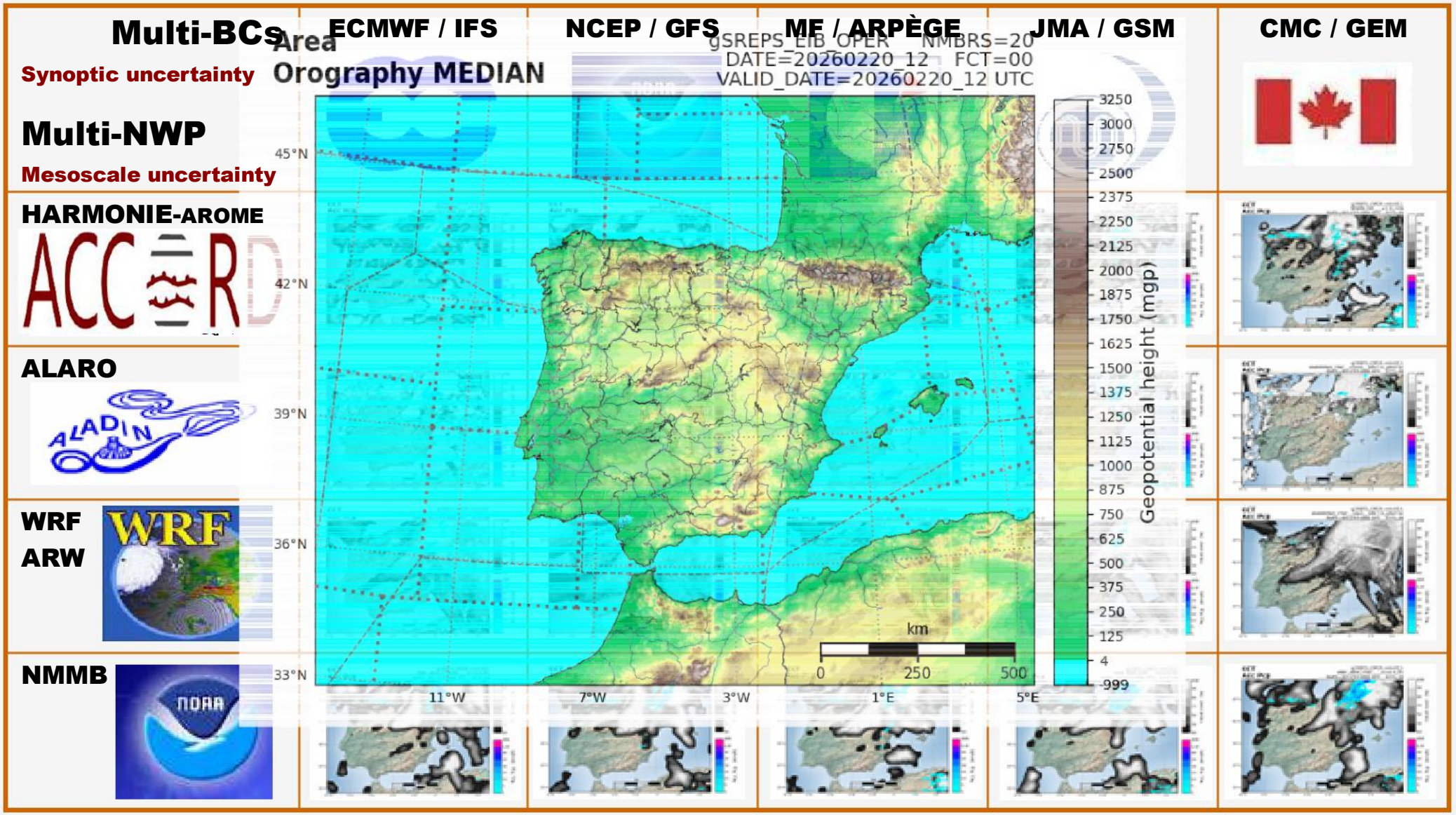
AEMET-γSREPS system

- **2.5 km 20-members** *non-hydrostatic convection-permitting* LAM-EPS
- Since April 2016 daily running at **00**/**12** UTC up to **72** hours (2023)
  - Since end 2019 products available to Forecasting Offices
- **3 DOMAINS**: *IBERIAxxm_2.5*, *CANARIAS_2.5* and *LIVINGSTON_2.5* (Antarctica)

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

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Multi-BCs | **ECMWF / IFS** | **NCEP / GFS** | **MF / ARPÈGE** | **JMA / GSM** | **CMC / GEM**

Synoptic uncertainty

Multi-NWP

Mesoscale uncertainty

HARMONIE-AROME

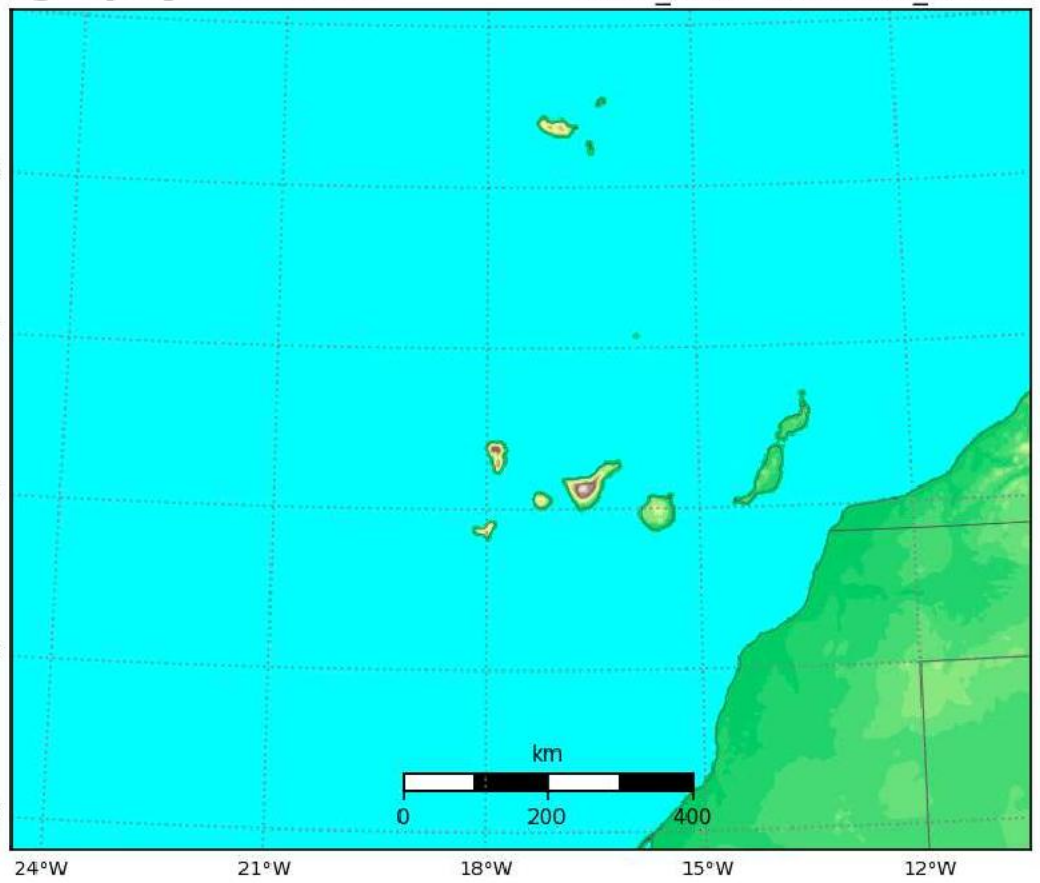
ALARO

WRF ARW

NMMB

Area
Orography MEDIAN

gSREPS_AIC NMBRS=9
DATE=20190329_00 FCT=48
VALID_DATE=20190331_00 UTC



AEMET-γSREPS system

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Multi-BCs

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Multi-NWP

Mesoscale uncertainty

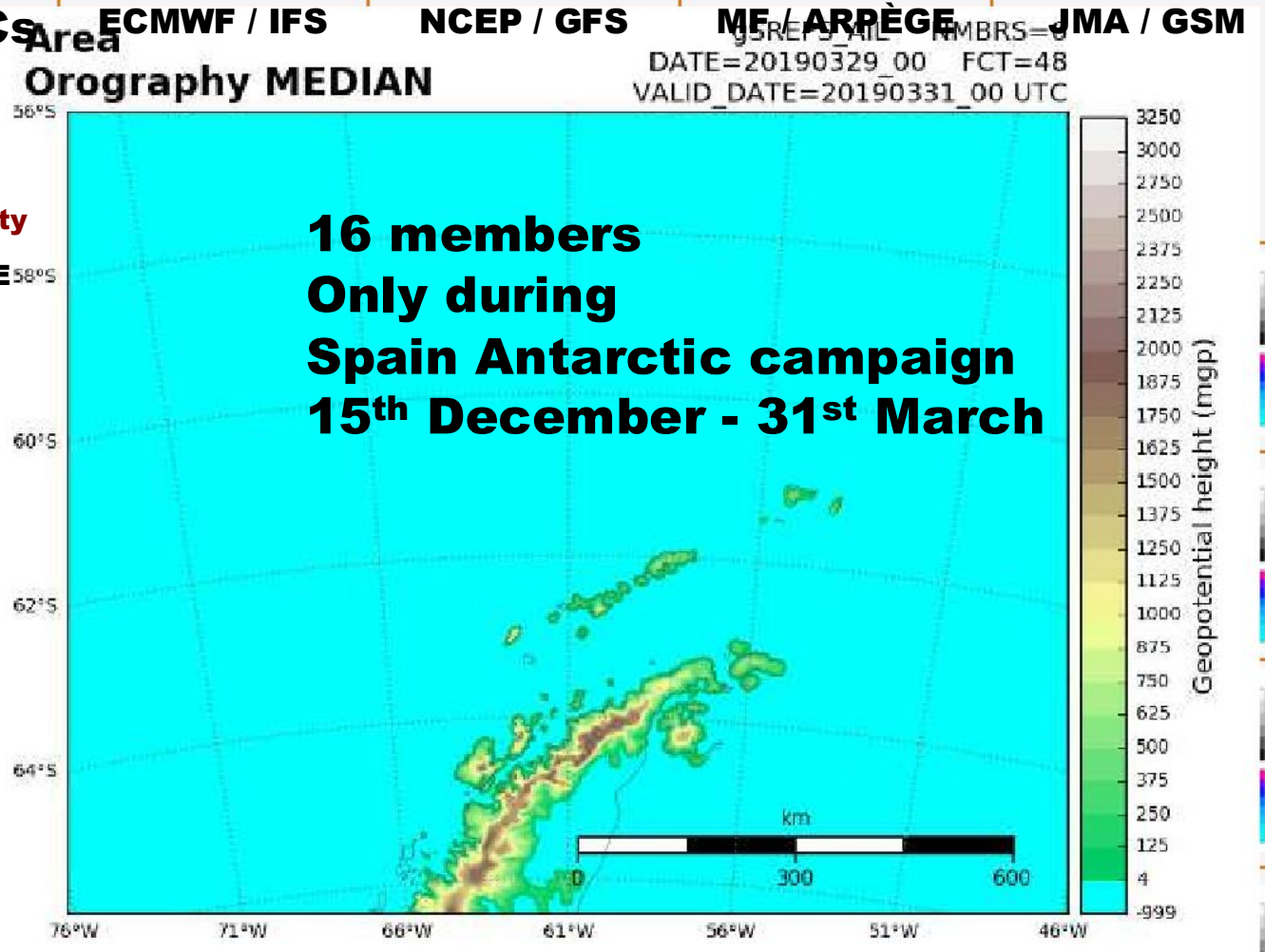
HARMONIE-AROME

ALARO

WRF ARW

NMMB

ECMWF / IFS | **NCEP / GFS** | **MF / ARPÈGE** | **JMA / GSM** | **CMC / GEM**



16 members
Only during
Spain Antarctic campaign
15th December - 31st March



Present:

the AEMET-γSREPS

Why **multi-BCs** and **multi-NWP** models ???

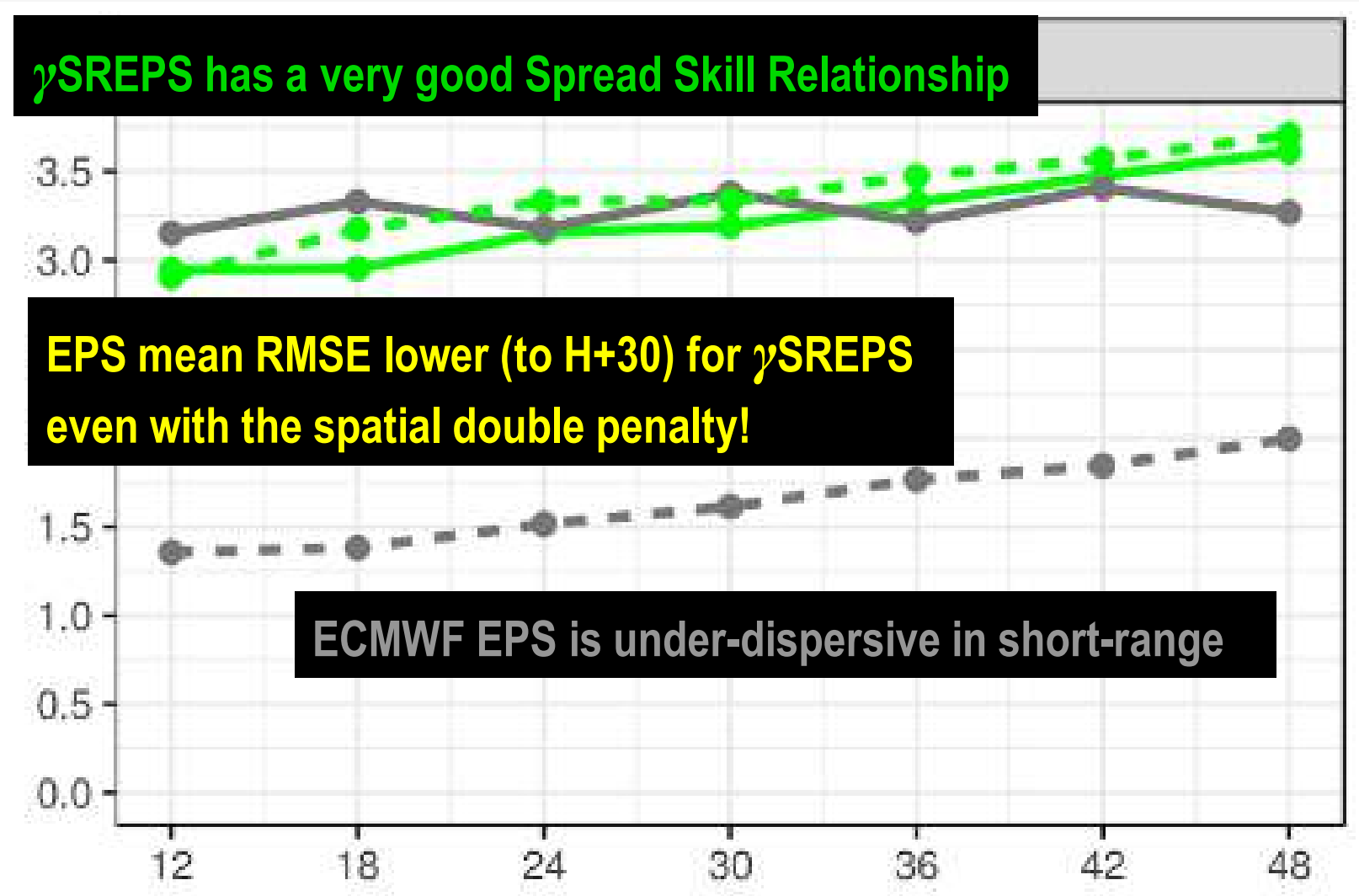
Due to **higher performance** than other LAM-EPS configurations [2013-2019]

Objective verification
Subjective verification: case studies

γSREPS *versus* ECMWF EPS

OBJECTIVE VERIFICATION

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

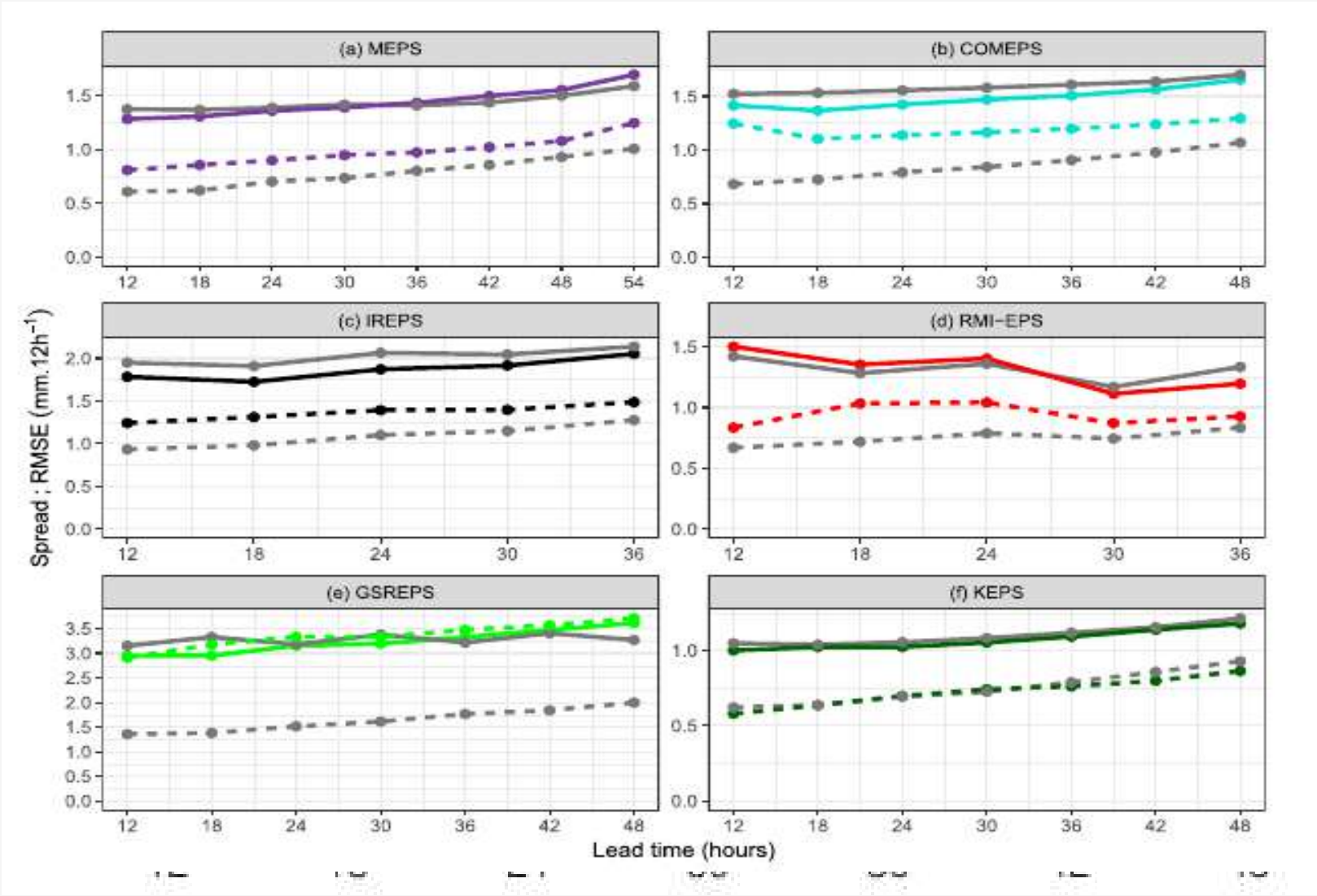


Frogner I.L. et al, 2019, "*HarmonEPS - the HARMONIE ensemble prediction system*" Weather and Forecasting. 2019, 34, p. 1909–1937, https://doi.org/10.1175/WAF-D-19-0030.1.

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γSREPS

ECMWF EPS

Spread

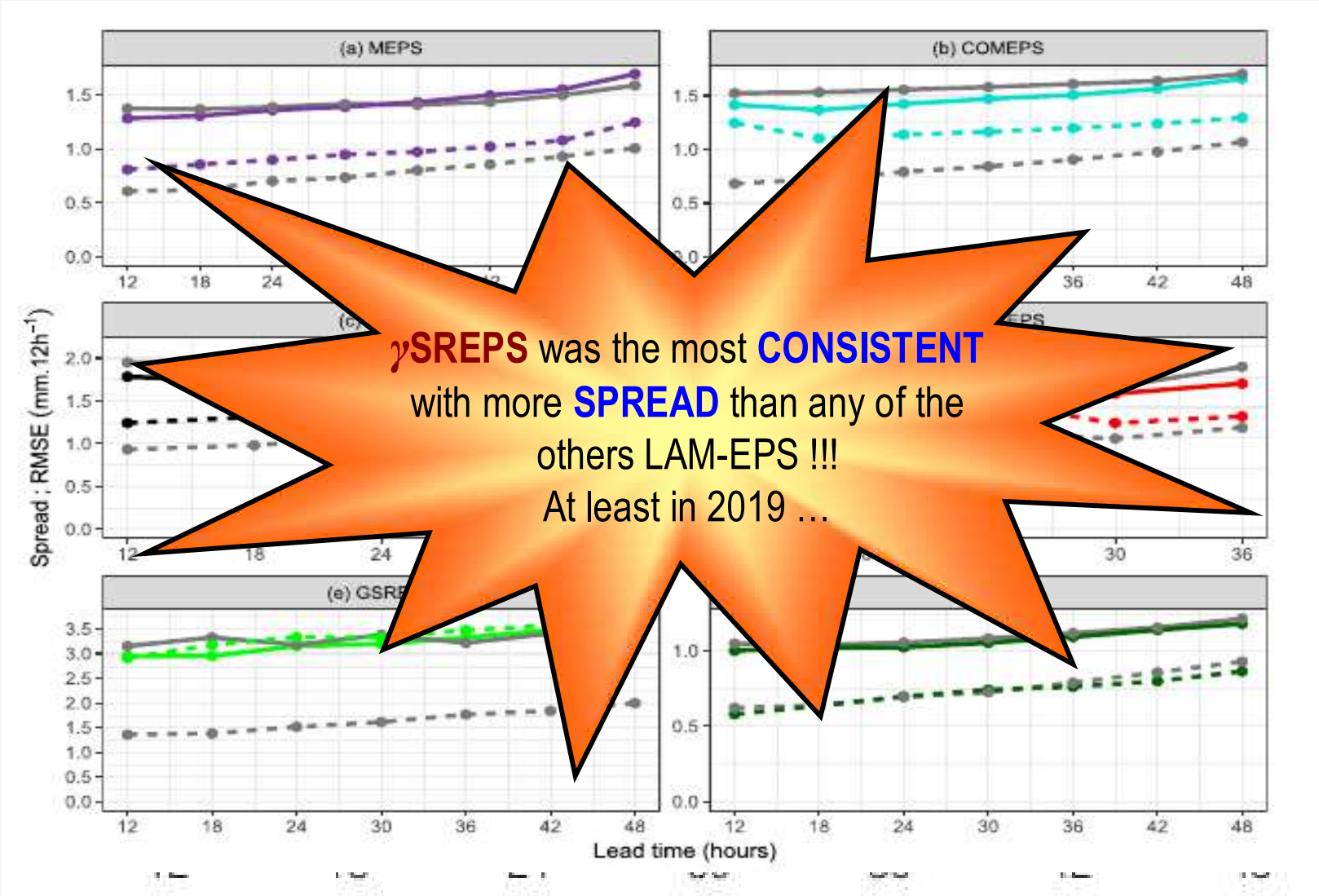
em RMSE

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γSREPS

ECMWF EPS

Spread

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γSREPS *versus* AROME EPS



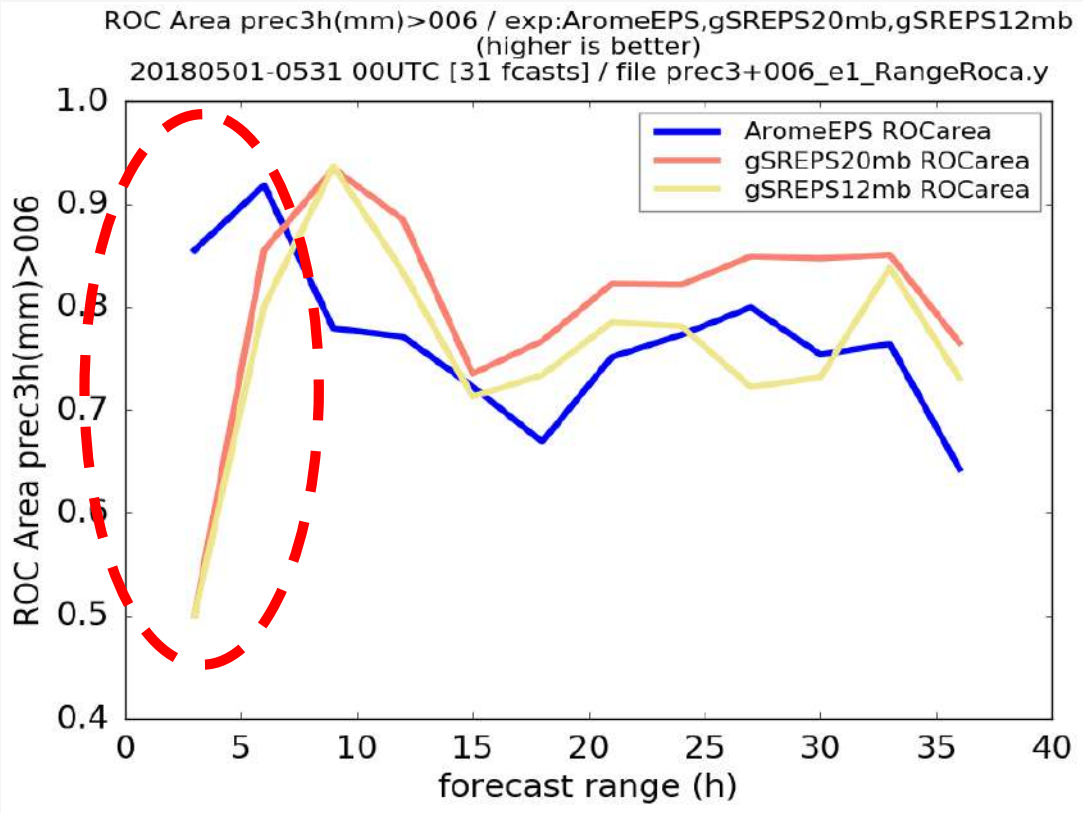
Thanks to
François Bouttier
Verification [package]

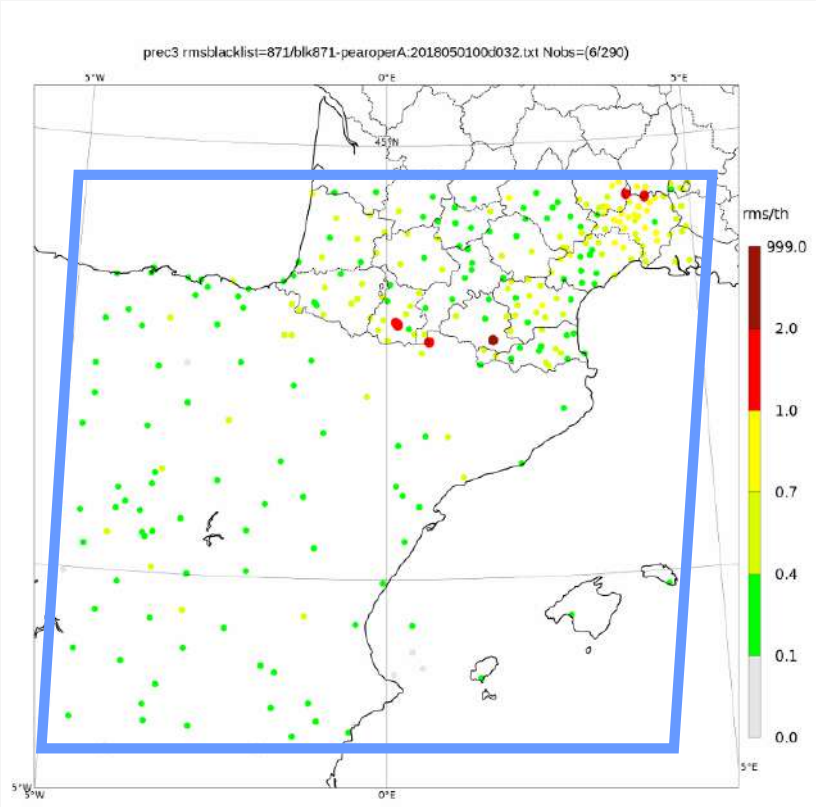
AccPcp > 6mm/3h ROC area

AROME-EPS **γSREPS**

γSREPS 12 members

➢ **1st - 31st May 2018**





γSREPS > ≈ AROME-EPS

γSREPS *versus* AROME EPS



Thanks to
François Bouttier
Verification [package]

AccPcp > 6mm/3h

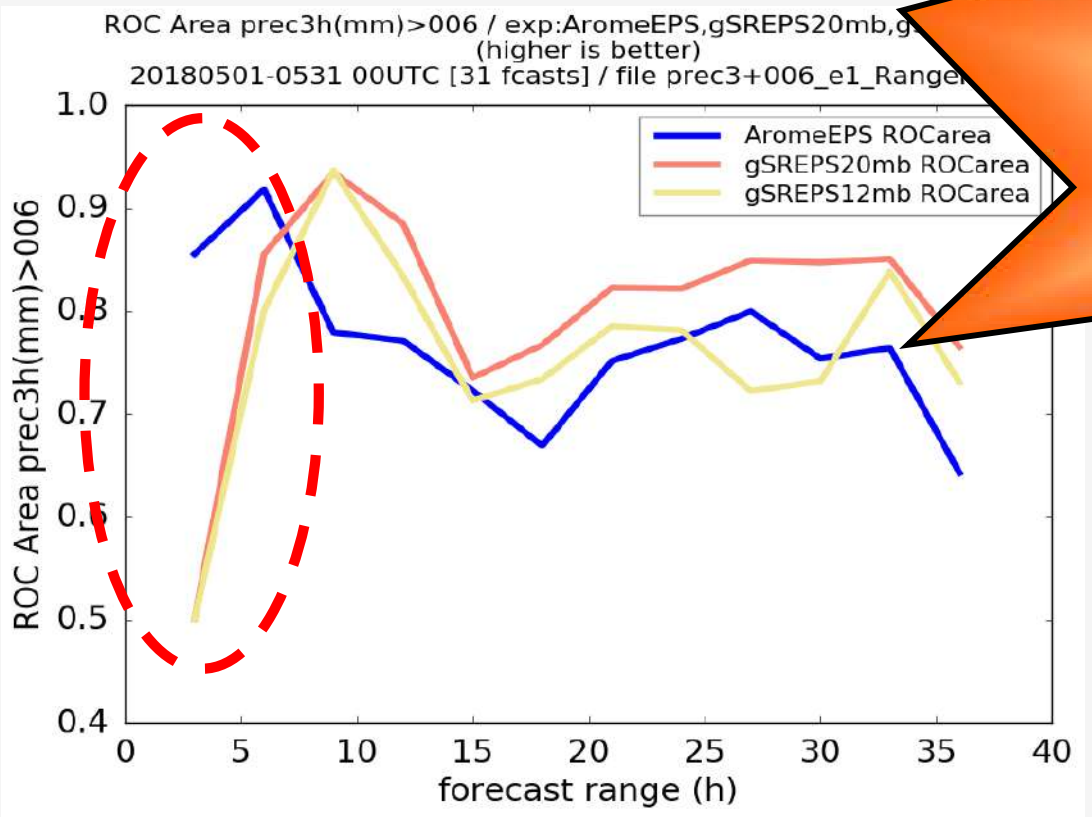
ROC area

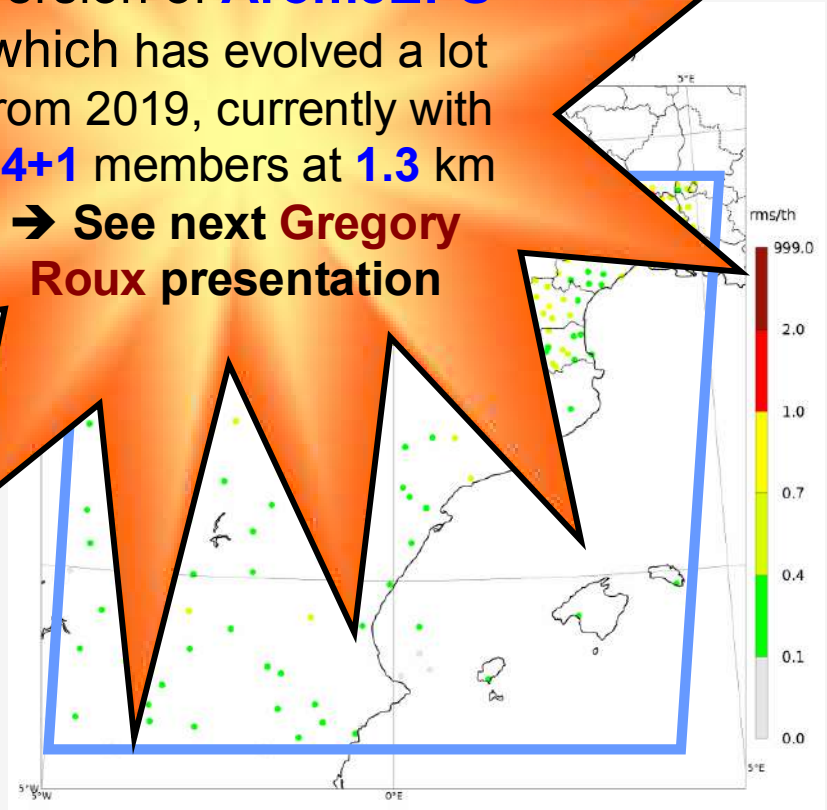
AROME-EPS **γSREPS**

γSREPS 12 members

➢ 1st - 31st May 2018

TO NOTICE: an old version of **AromeEPS** which has evolved a lot from 2019, currently with **24+1** members at **1.3** km
➔ **See next Gregory Roux presentation**





γSREPS > ≈ AROME-EPS



In what **FORECASTERS** are more interested !!!

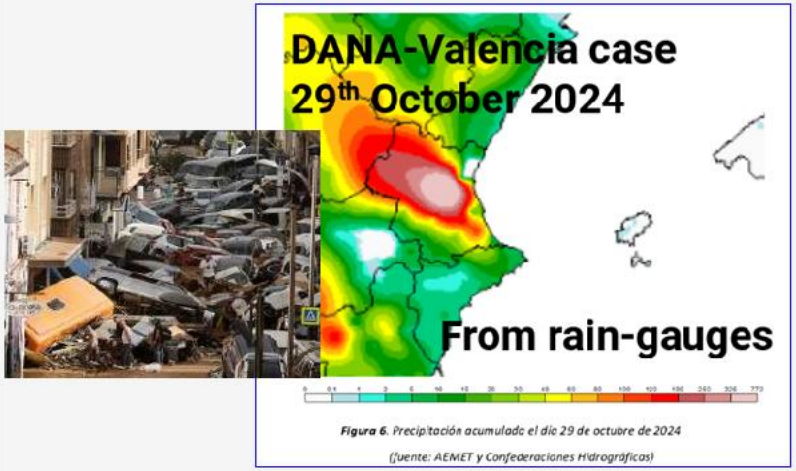
Present:

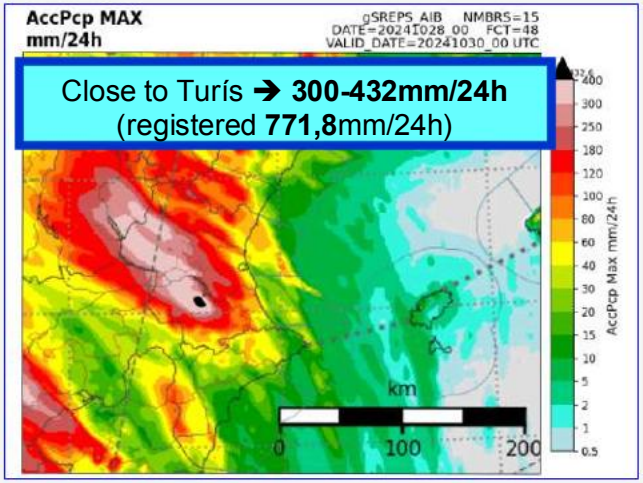
the AEMET-γSREPS

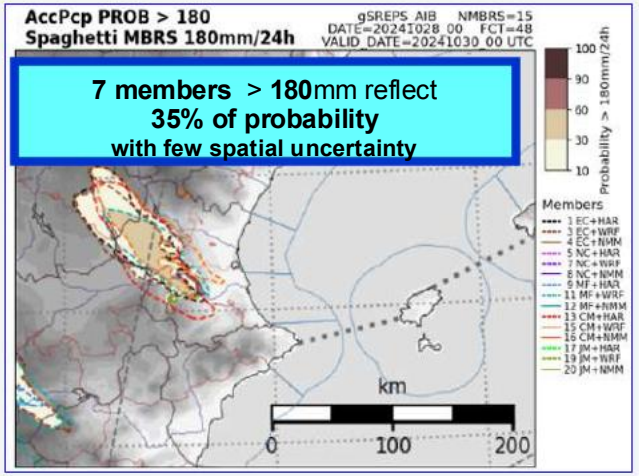
Subjective verification:
Case Studies

Spatial uncertainty – "*Spaghetti*" product

Case Studies: Dana-Valencia and Alcanar Flash-Floods





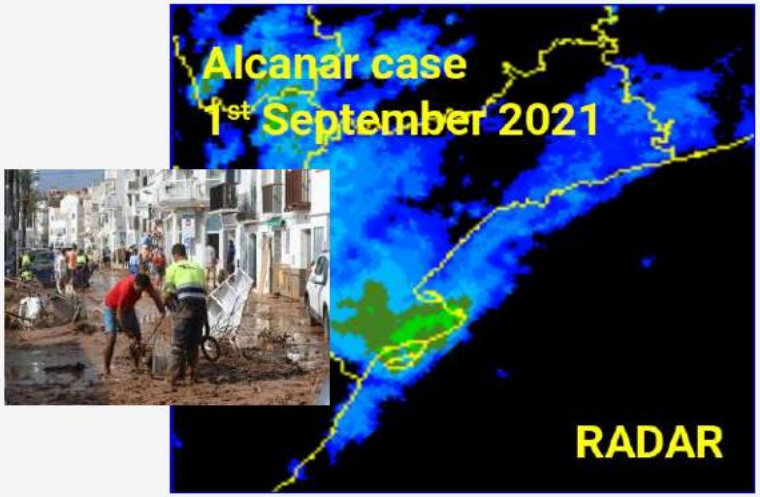


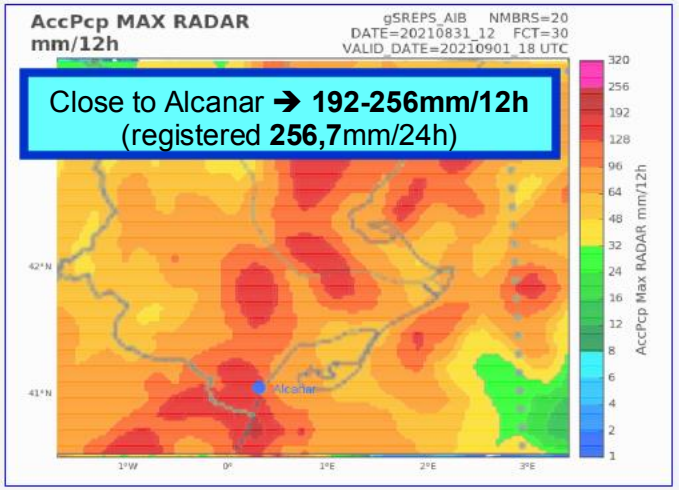
The **Alcanar** case exhibits high **spatial uncertainty,** in contrast to the **DANA-Valencia** case, as evidenced by the Spaguetti products

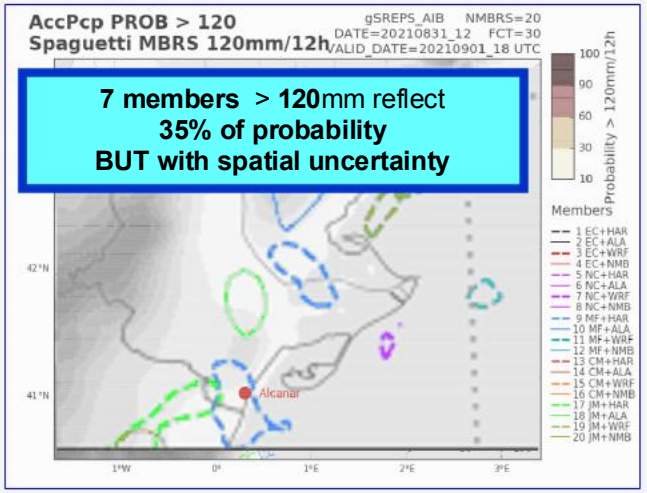
➔ Isolines of AccPcp for each member

Both cases show AccPcp maxima that are relatively "close" to the observed values.

➔ Extreme HIW events are typically well represented in the EPS maxima by a few members.







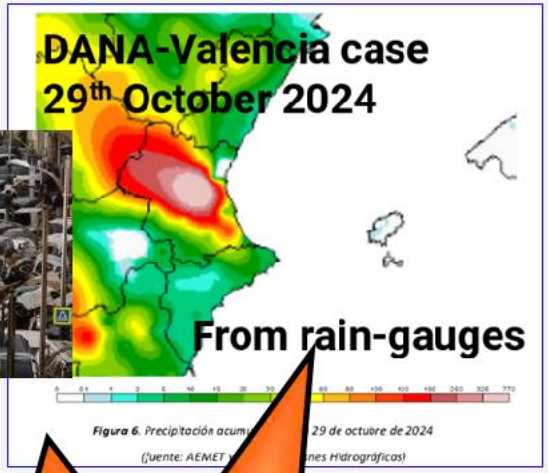
Case Studies: Dana-Valencia and Alcanar Flash-Floods

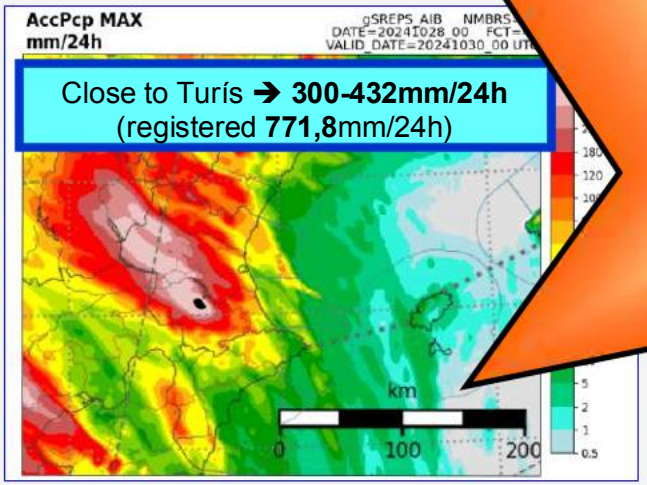
FORECASTERS rely on a lot **Maximum** and **Spaghetti** products to look for possible **HIW**

7 members > 180mm reflect **35% of probability** with few spatial uncertainty

➔ **Both are the flagship HIW products**







The **Alcanar** case exhibits high **spatial uncertainty,** in contrast to the **DANA-Valencia** case, as evidenced by the Spaguetti products

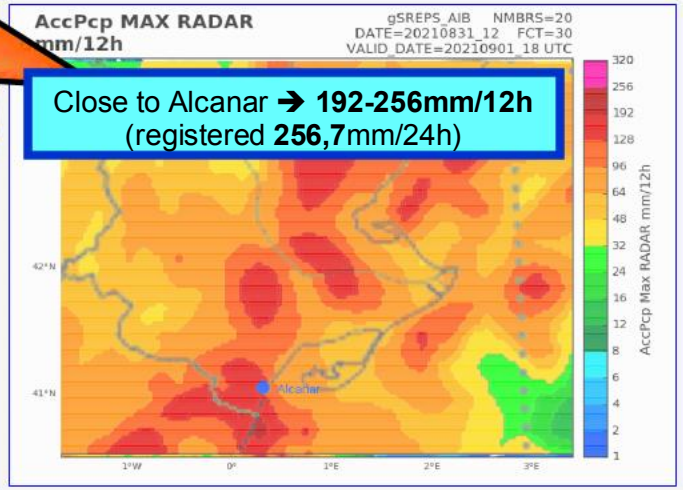
➔ Isolines of AccPcp for each member

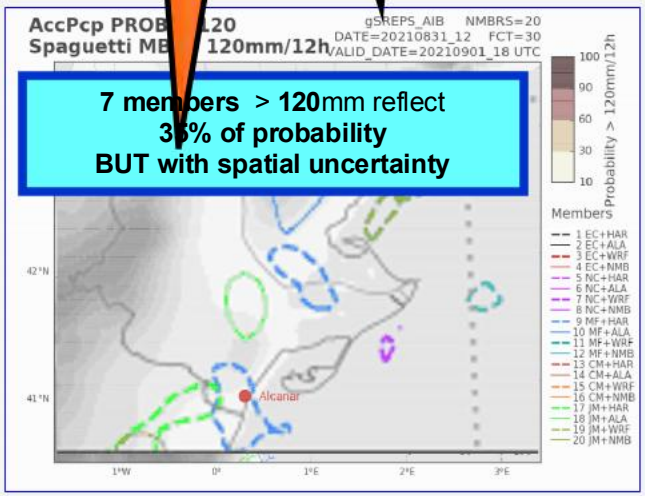
Both cases show AccPcp maxima that are relatively "close" to the observed values.

➔ Extreme HIW events are typically well represented in the EPS maxima by a few members.

Spaguetti members and **maximum** are the "starting point" products to detect **H**igh **I**mpact **W**eather events









Present:

the AEMET-γSREPS

Forecasting Offices

PANEL

PRODUCTS

With γSREPS an in order to be used to by the AEMET **FORECASTING OFFICES**, we are doing ourselves the **PROBABILISTIC PRODUCTS** with a close contact with FORECASTERS requests and needs !!!

Present:

the AEMET-γSREPS

And we have been very successful because γSREPS is an indispensable forecasting system in the Short Range forecasts in AEMET !!!

And I get over my frustration ;-)

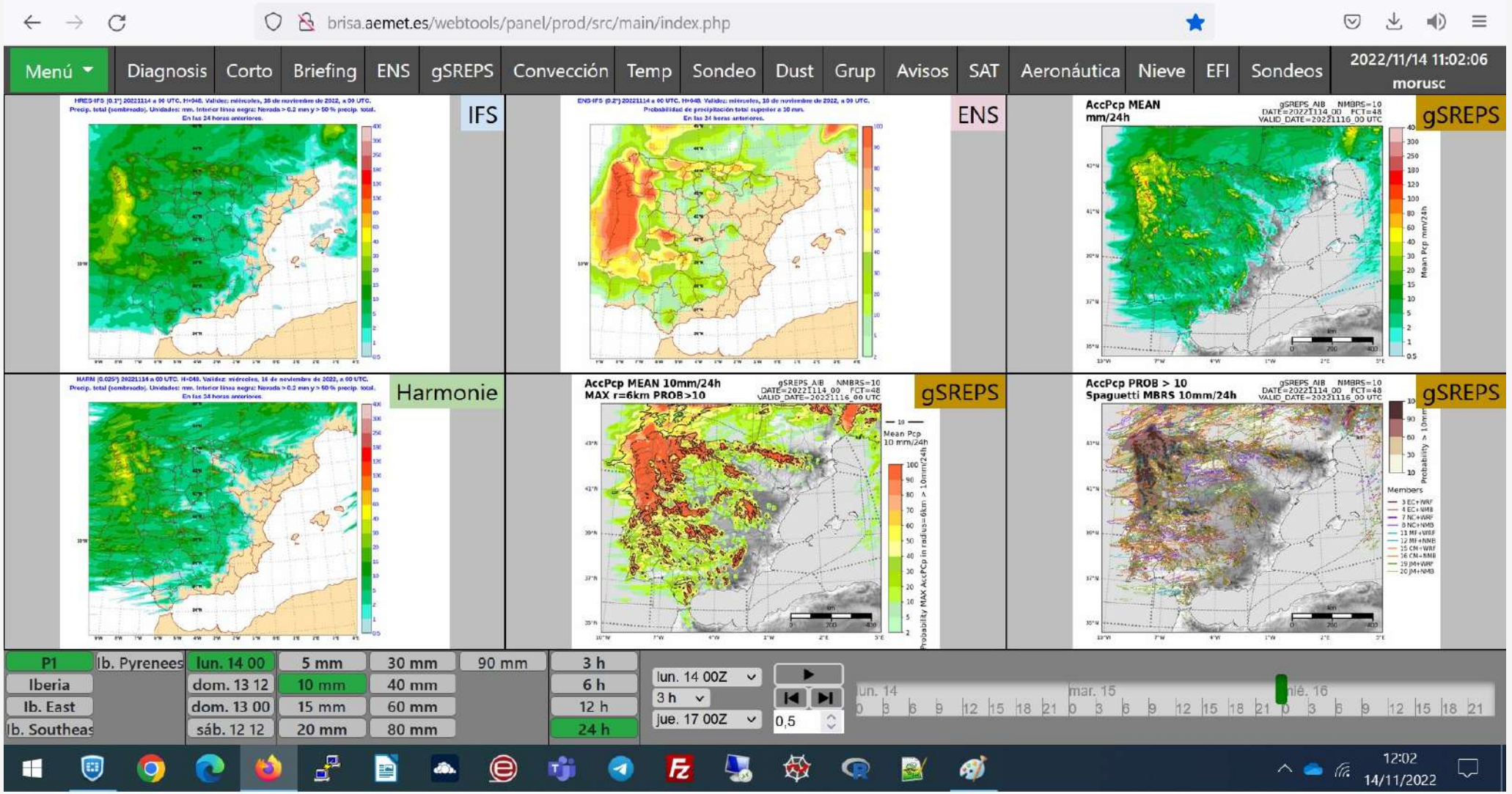
Forecasting Offices

PANEL

PRODUCTS

PANEL examples *AccPcp*

- Poor man ensemble ⇔ comparing different forecasting systems ➔ ECMWF-IFS, HARMONIE-AROME and *γ*SREPS



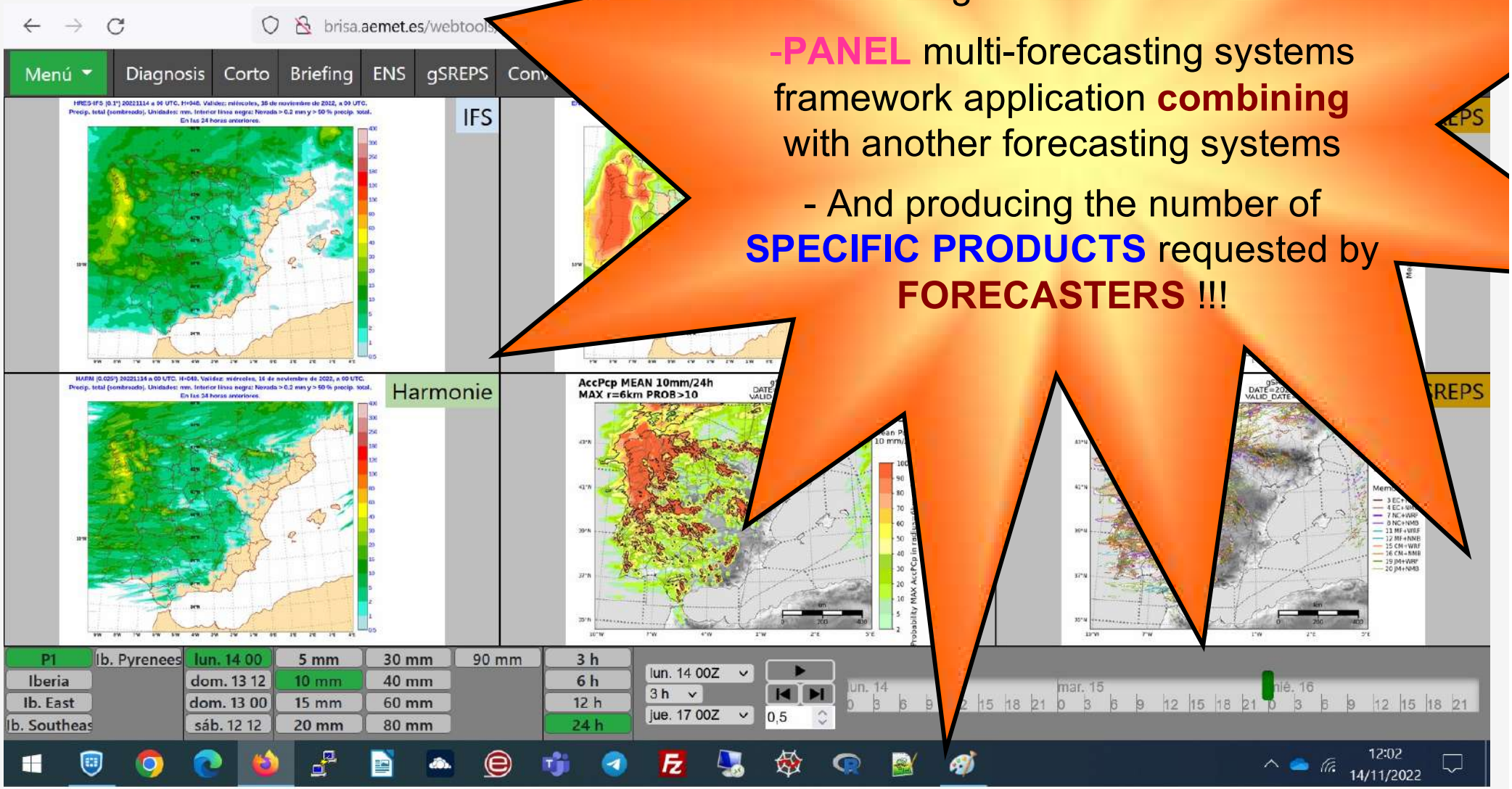
PANEL examples AccPcp

- Poor man ensemble ⇔ [illegible]ring [illegible]t forecasting systems ➔ EC[illegible] HARMONIE-AROME and γS[illegible]

γSREPS **success** into AEMET Forecasting Offices is due to both:

-**PANEL** multi-forecasting systems framework application **combining** with another forecasting systems

- And producing the number of **SPECIFIC PRODUCTS** requested by **FORECASTERS** !!!

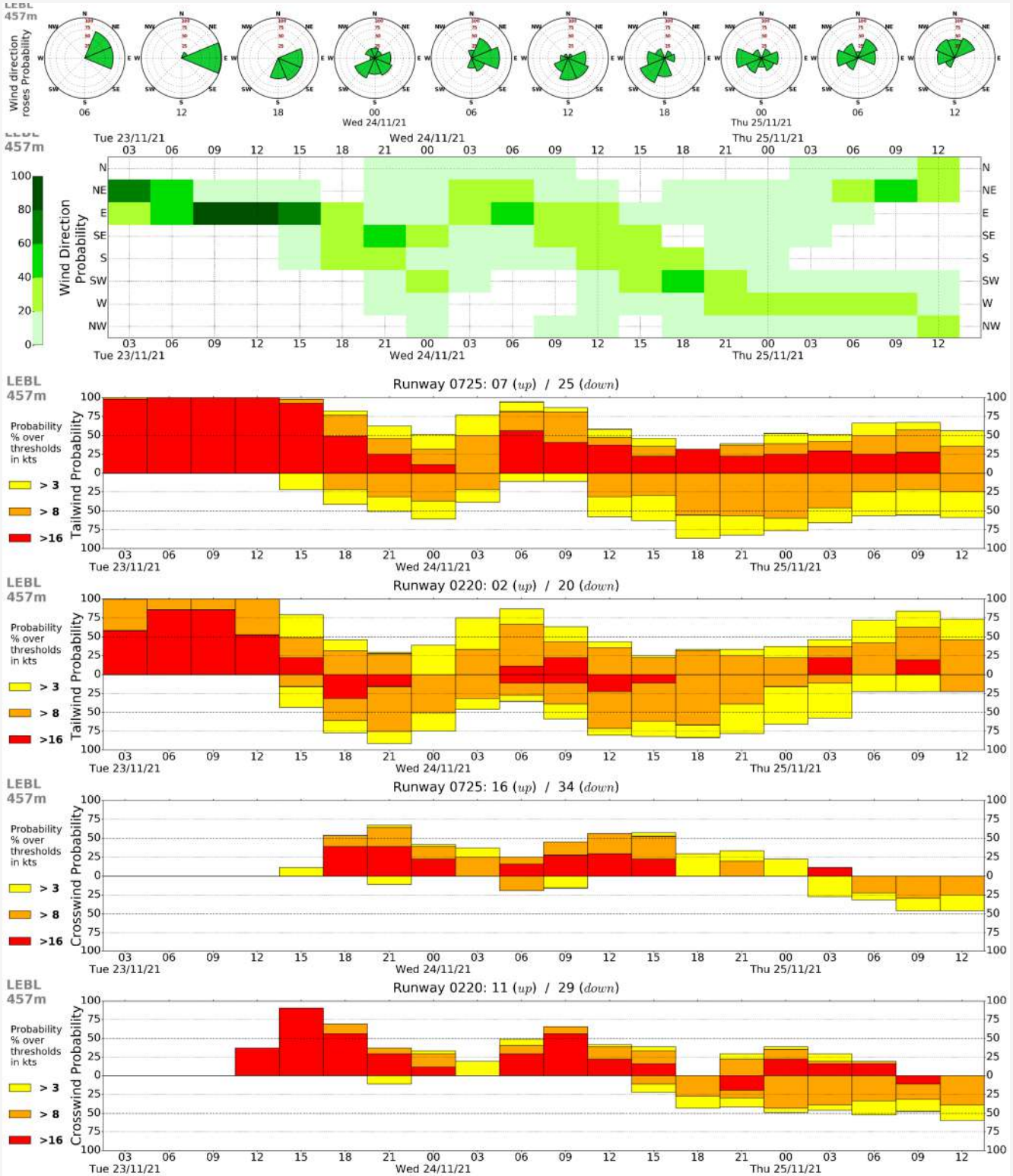


EPSgrams: *airports*

- **AEROgrams**: EPSgrams following the **runway** direction
  - Probabilities over **7**, **15** and **20** kts
  - **Tail wind**
  - **Cross wind**
  - **Shear**: trying four levels:
    - **10**, **100, 200** and **457** m

      ⇔

      ~ 001, 003, 006, 015 FL

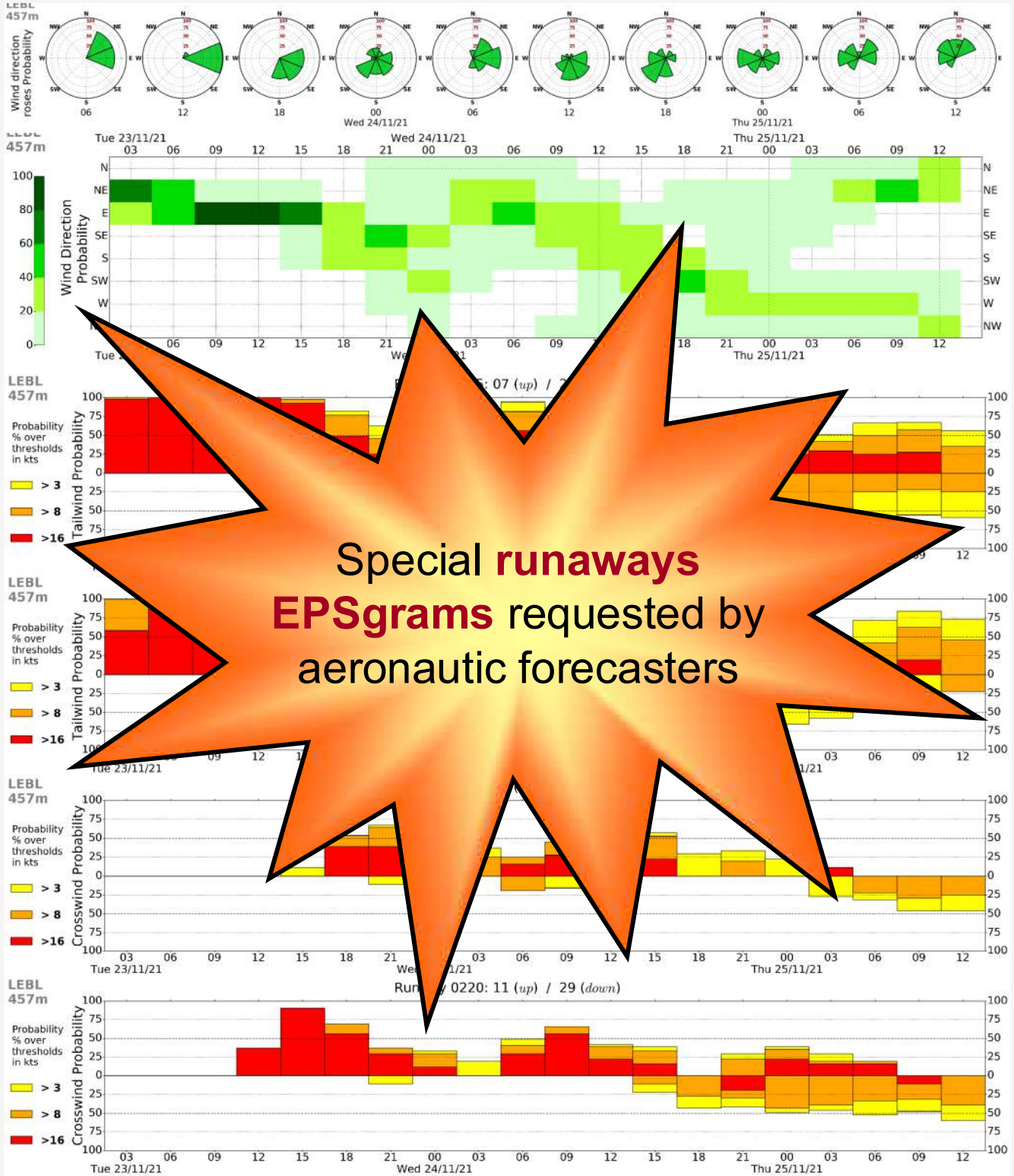


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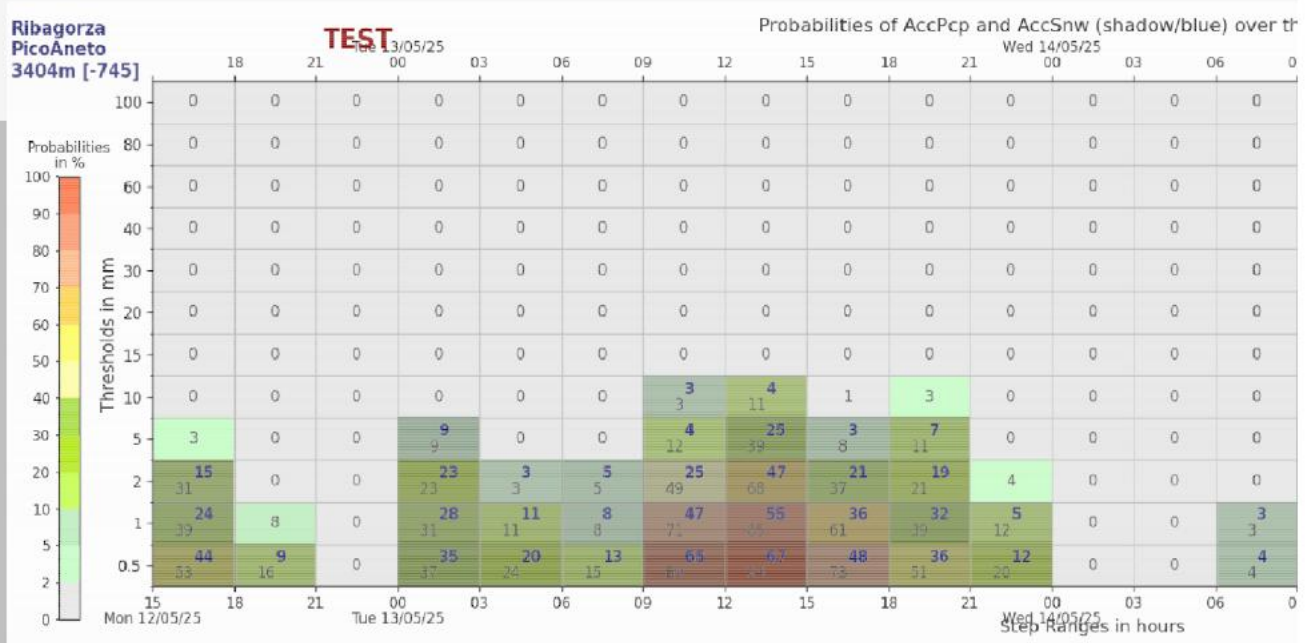
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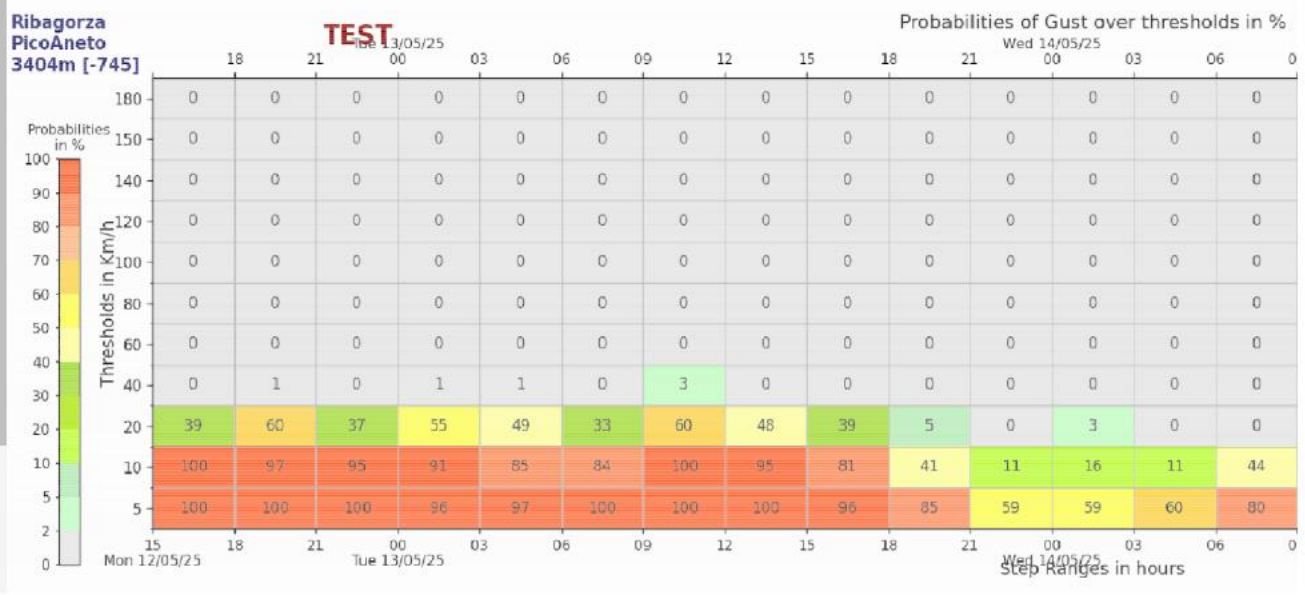


γSREPS2ATAPproject APR25

PROBABILITY MATRIXs EPSgrams

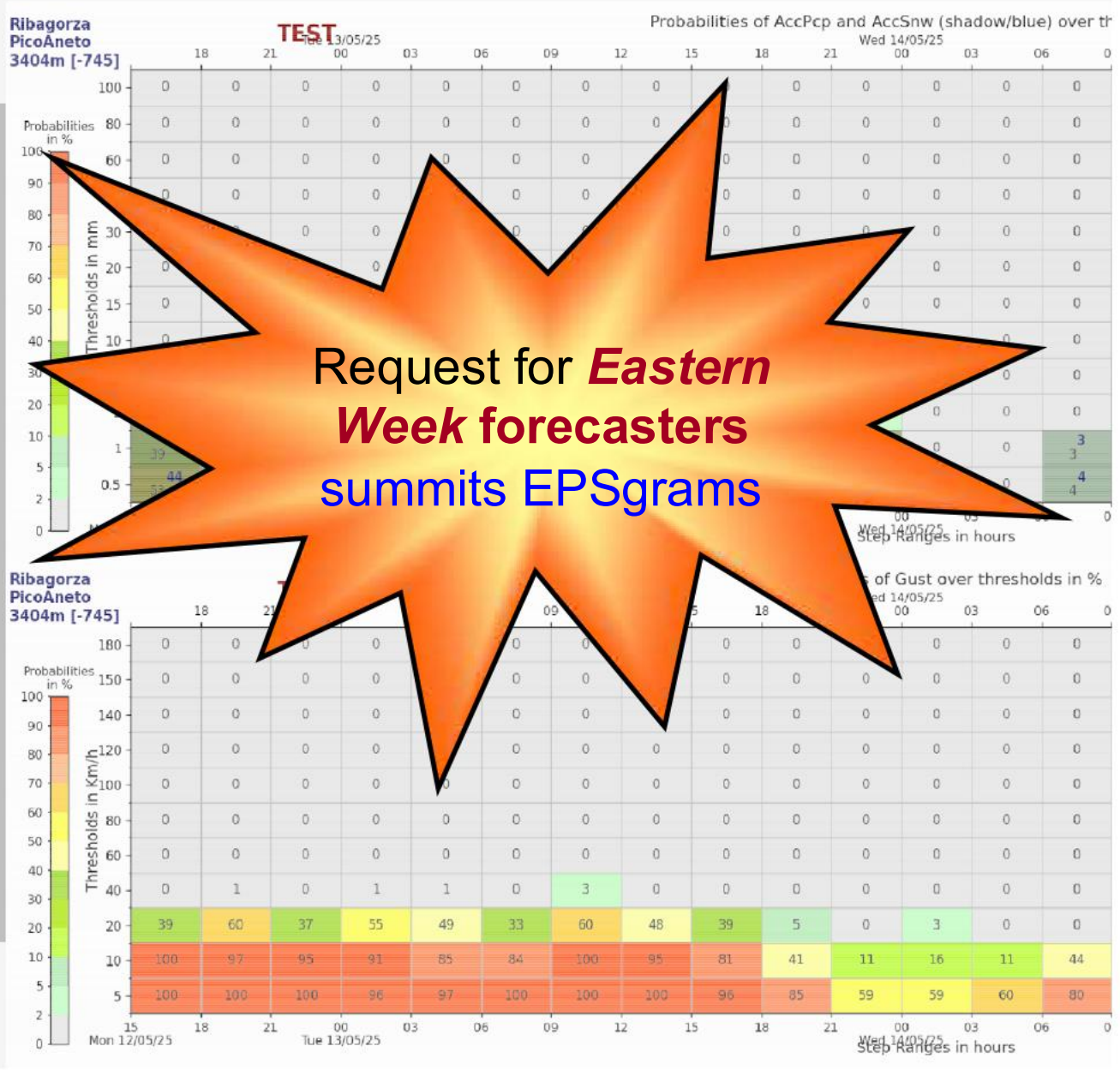
- **APR25 IFS-ENS ATAP project** [Centro Meteorológico de Málaga – Nicolás Sánchez]
  - Gust in 6/12/24h periods
  - **Updating PROB thresholds**, e.g. including 300mm
  - **CIN** below **thresholds**
  - **Location PROBABILITY MATRIXs**
  - **Full bunch of statistics:** MEAN, MEDIAN, SPREAD, MAXIMUM, MINIMUM, UPPER and LOWER QUARTILES
  - High clouds transparency
  - Specific product for SOT





γSREPS2ATAPproject APR25
PROBABILITY MATRIXs EPSgrams

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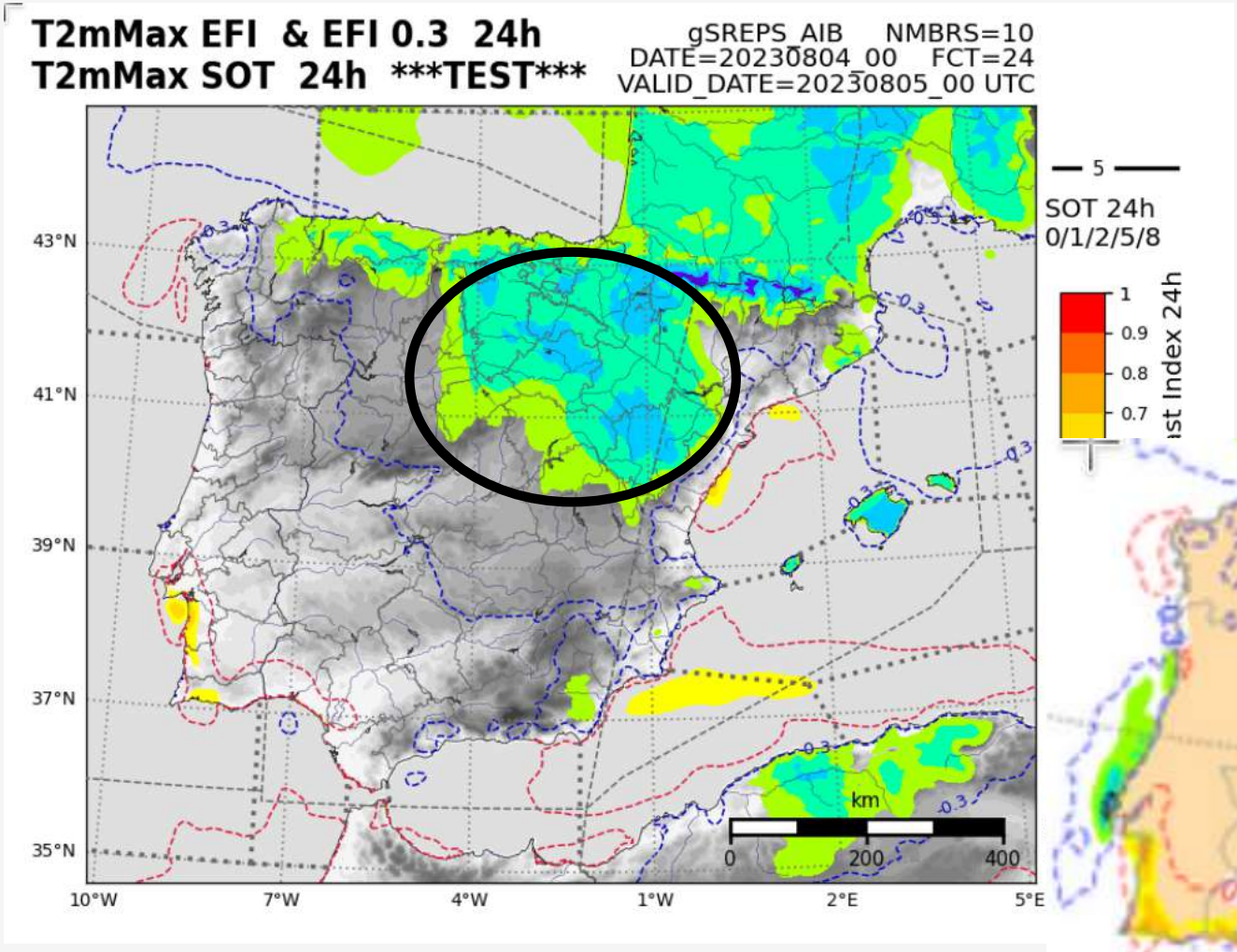


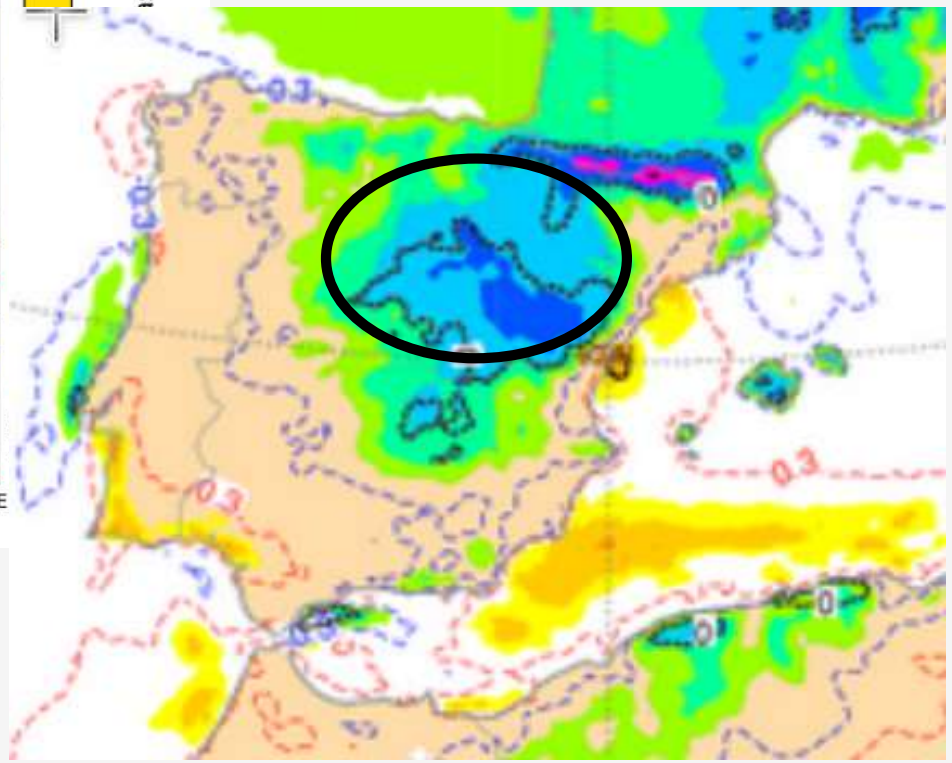
γSREPS2EFIandSOT NOV23

T2mMax γSREPS versus ECMWF IFS-ENS



IMPLEMENTATION



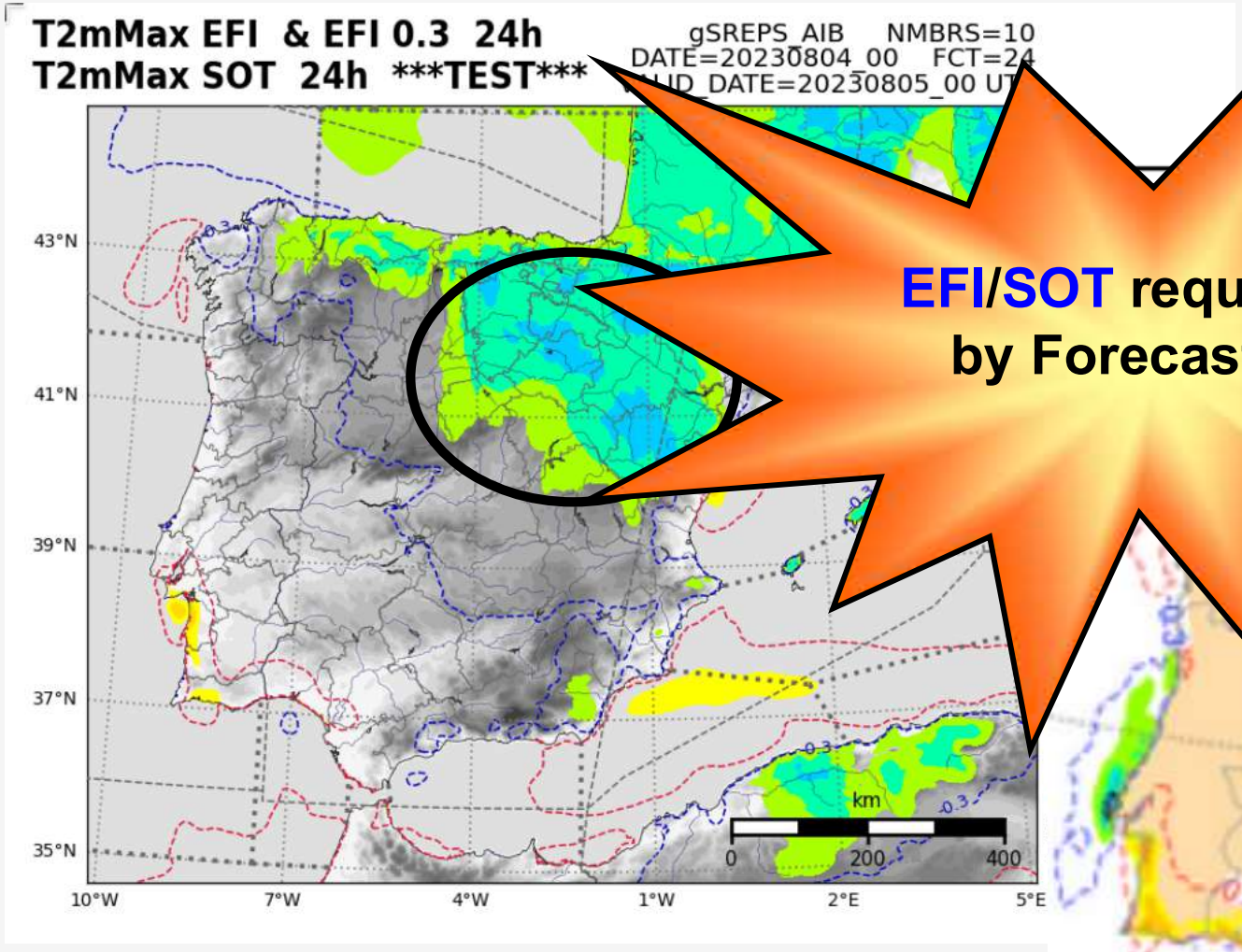


γSREPS2EFIandSOT NOV23

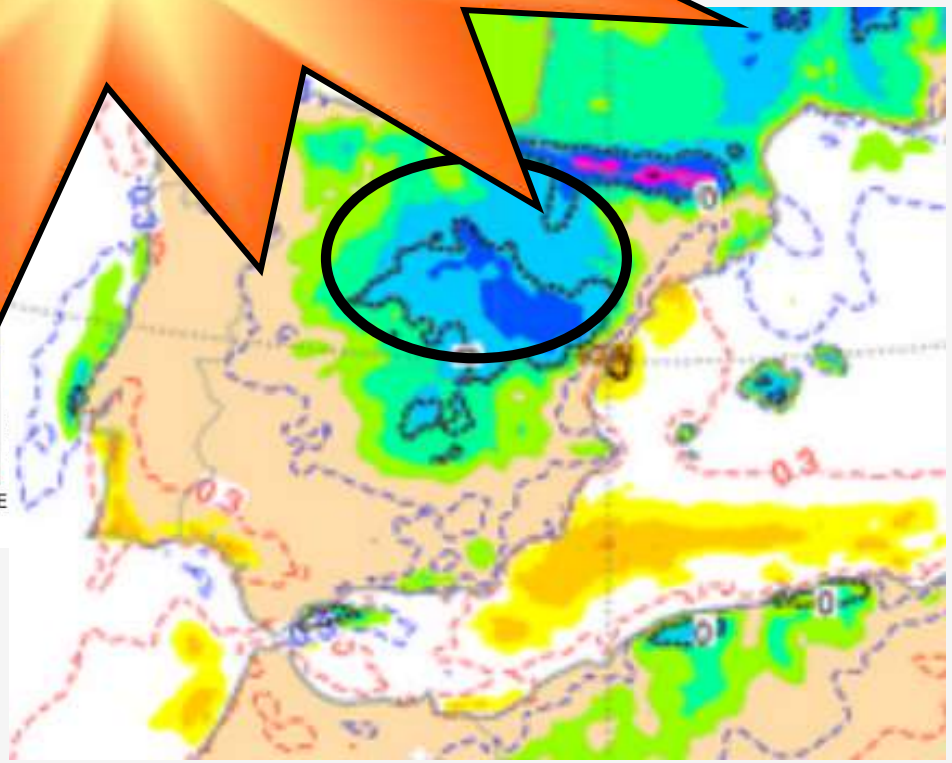
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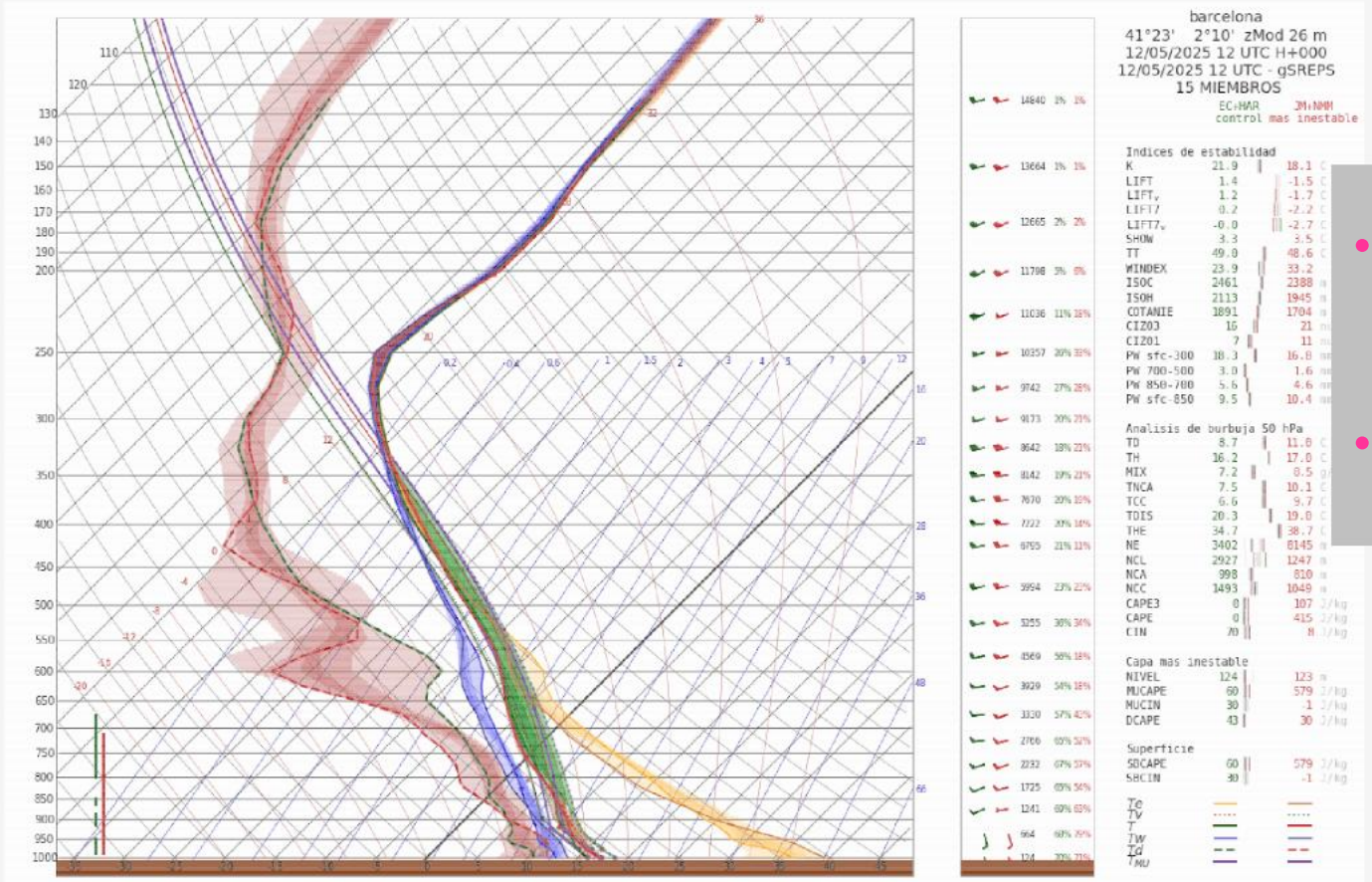


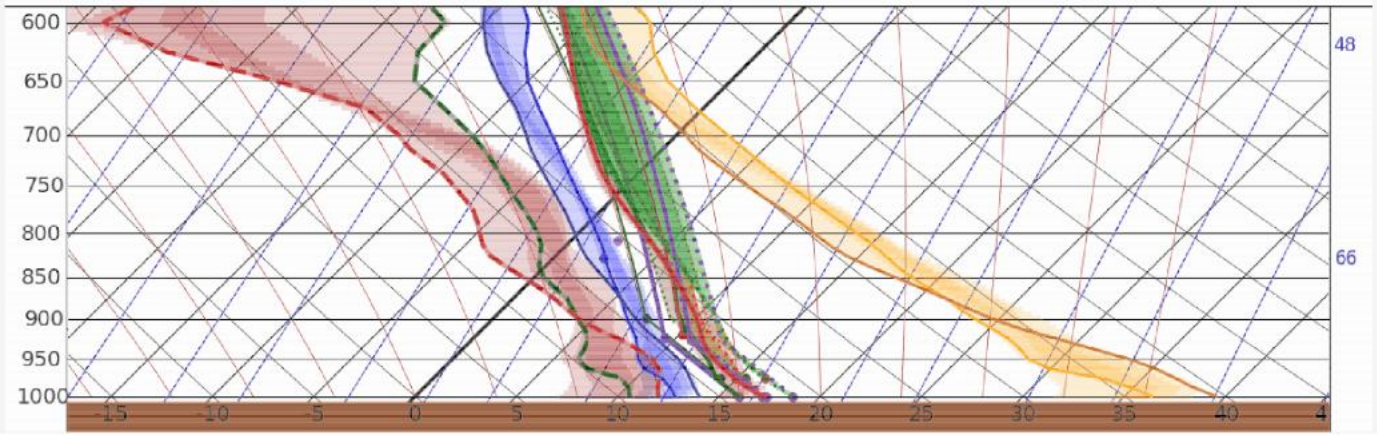
EFI/SOT requested by Forecasters



γSREPS2ATAPverticalProfiles APR25

All EPSgrams LOCATIONS





- **Available in PANEL for all EPSgrams LOCATIONS**
- **Detailed at low levels 1000-600hPa**



In what **LAM-EPS DEVEOPERS** are more interested !!!

Future:

ACCORD/UWC uni-NWP model

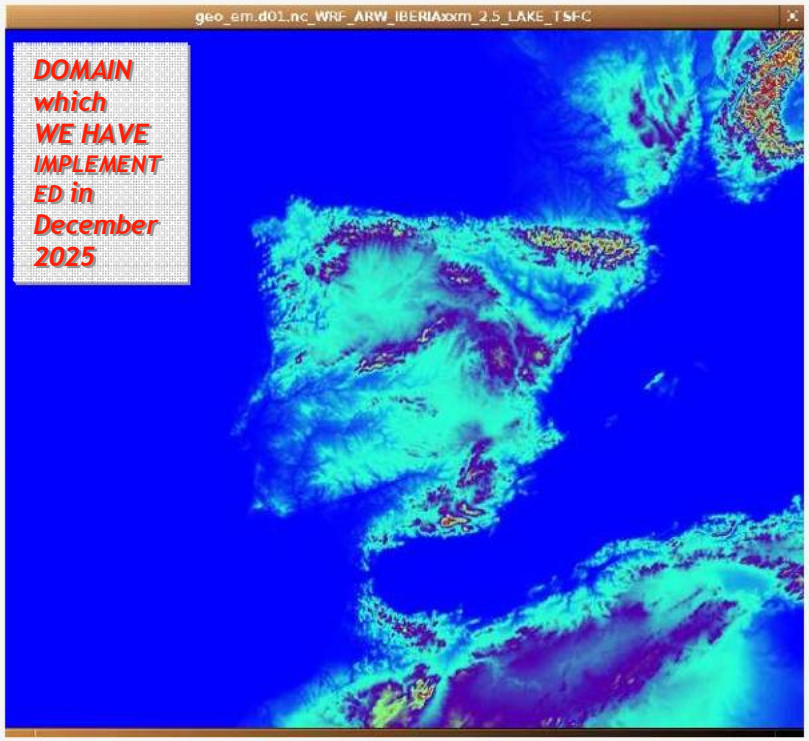
HarmonEPS

VERIFICATION

Foreseeable future Work plan: 2026-28



- **AEMET-γSREPS multi-NWP model ➔** keep *~2/3 years* but stopping further developments after **2025 update**:
  - IBERIAxxm_2.5 to a larger domain
  - NWP models' versions: **WRF**3 to **4.6** and **HARMONIE-AROME** and **ALARO** cy40h111 to **cy46h1**
  - Become **TC2** at ECMWCF HPCF





- **HarmonEPS** in IBERIAxxm_2.5 domain **2026**
  - As OPERational ➔ Daily 00 UTC integration as OPERational
  - **ACCORD EPS** DEVELopments ➔ Adequate perturbations to Iberian Peninsula, specially **SPP** or Stochastic Parameterizations Perturbations
  - Ultimate goal ➔ HarmonEPS on Iberian Peninsula and Canary islands big single domain with deterministic run as control
  - IN THE DRAWER: if more SPREAD is needed ➔ **Multi-Boundaries** ⇔ using BCs from another Global NWP models than IFS



- **PRODUCTS**
  - **ADAGUC** dynamic zoom products
  - **Warning zones'** products

Foreseeable future Work plan: 2026-28





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  - Become **TC2** at ECMWF HPCF

In Summary currently STOPping γSREPS development and to try to moving to *uni-NWP* model **HarmonEPS** being more integrated into **ACCORD** and **UWC-South**



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  - As OPERational ➔ Daily 00 UTC integration as OPERational
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Work on LAM-EPS **AI** LAM-EPS with new human resource



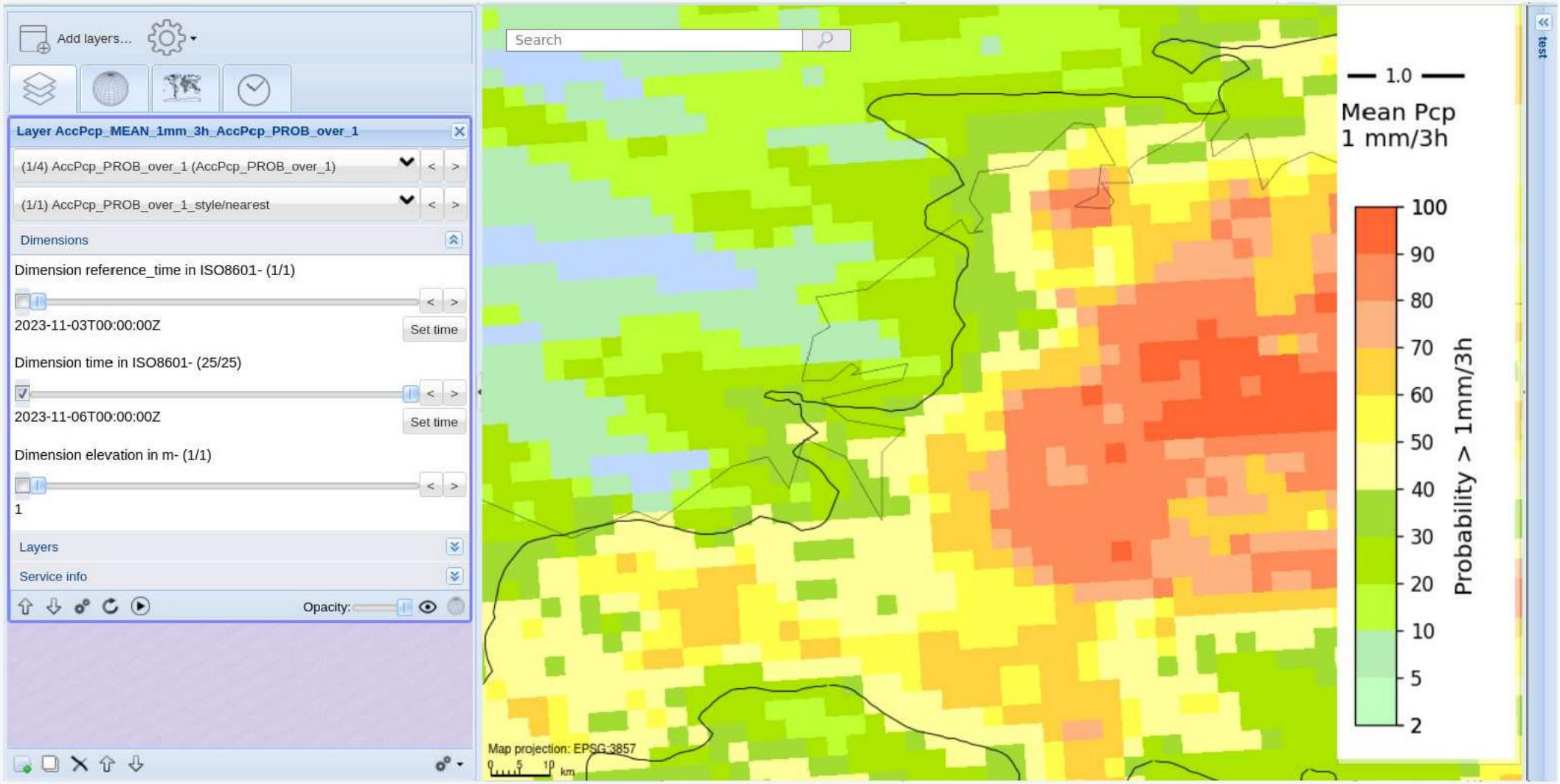
- **PRODUCTS**
  - **ADAGUC** dynamic zoom products
  - **Warning zones'** products

γSREPS2ADAGUC

Dynamic web

with zoom in PANEL





γSREPS2ADAGUC

Dynamic web

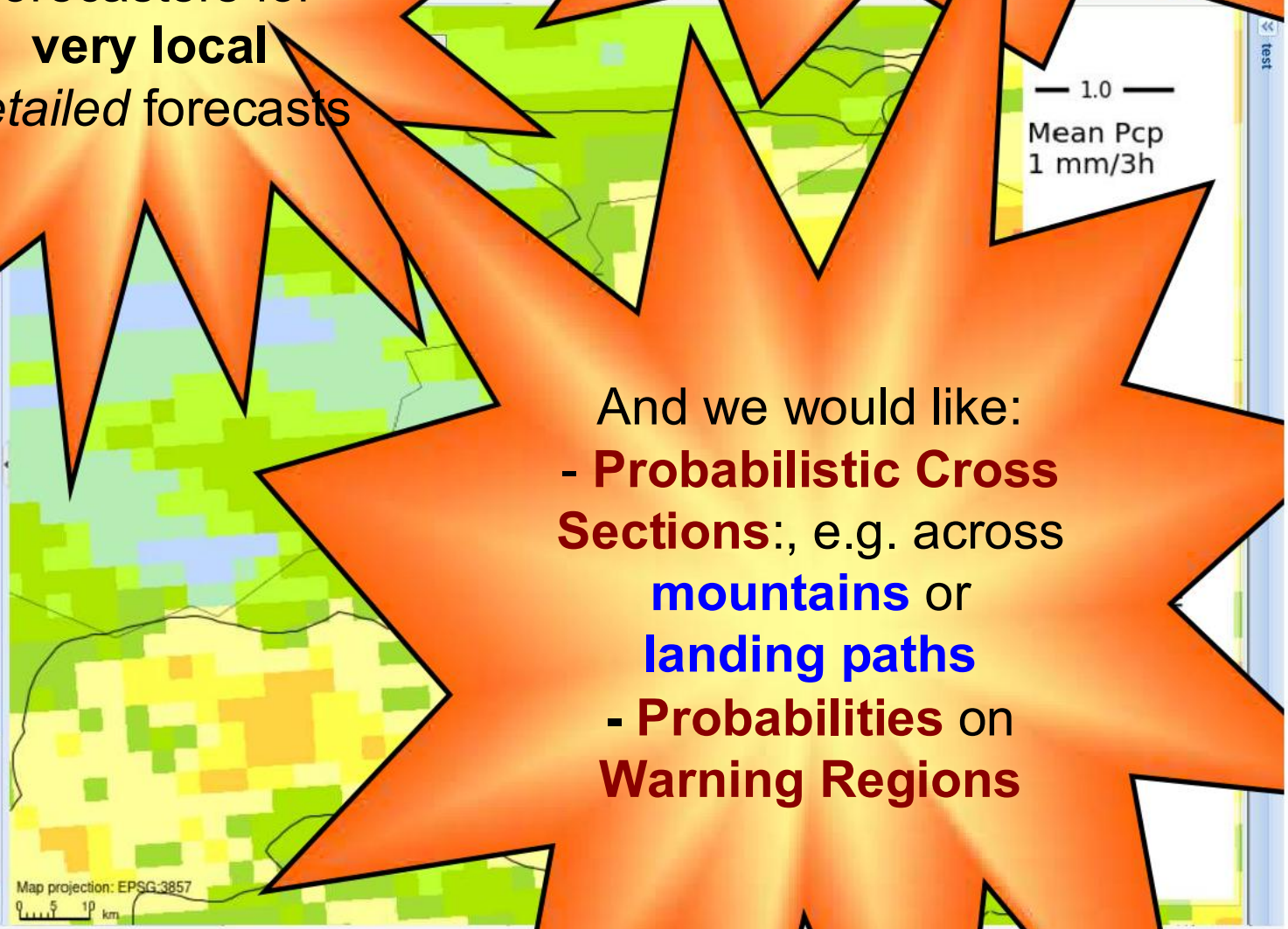
with zoom in PANEL



Requested by forecasters for **very local** *detailed* forecasts

Hopefully forthcoming **2026**
[David Gil Oliva]



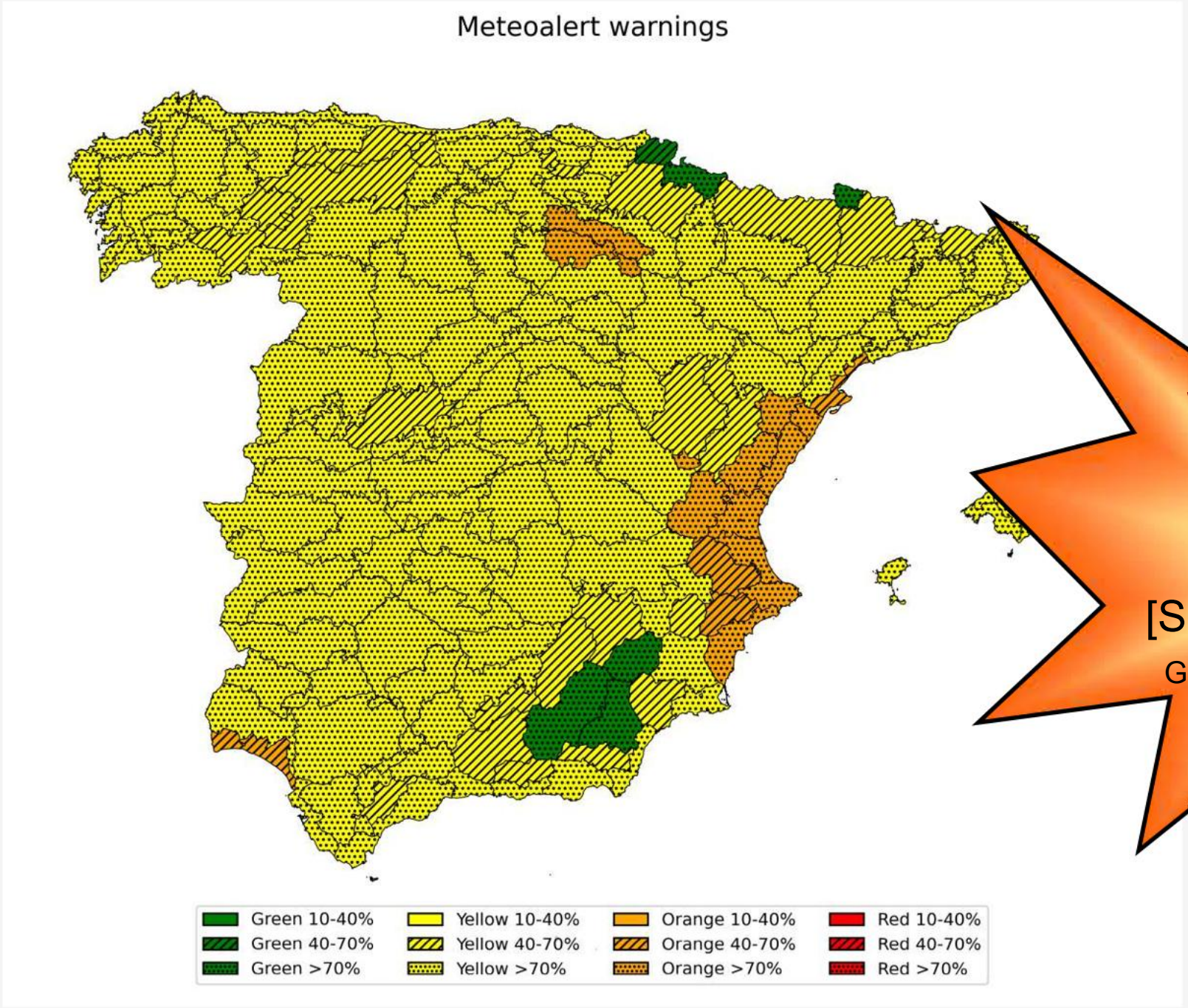


And we would like:
- **Probabilistic Cross Sections**:, e.g. across **mountains** or **landing paths**
- **Probabilities** on **Warning Regions**

γSREPS2WarningZones







Warning Zones

- **P2**
- **P1***
- **Gust**

[SRNWP-EPS: Matilde García-Valdecasas Ojeda]

Juanjo
Gómez
Navarro



2025 γSREPS update with
updated NWP models and
bigger DOMAIN

AEMET LAM-EPS VERIFICATION

IBERIA

Updated γSREPS 2026 *versus* 2016-25

HarmonEPS TEST *versus* γSREPS

To HarmonEPS: 1st step

HARMONIE uni-NWP model LAM-EPS



One month verification
10th October – 10th November 2025

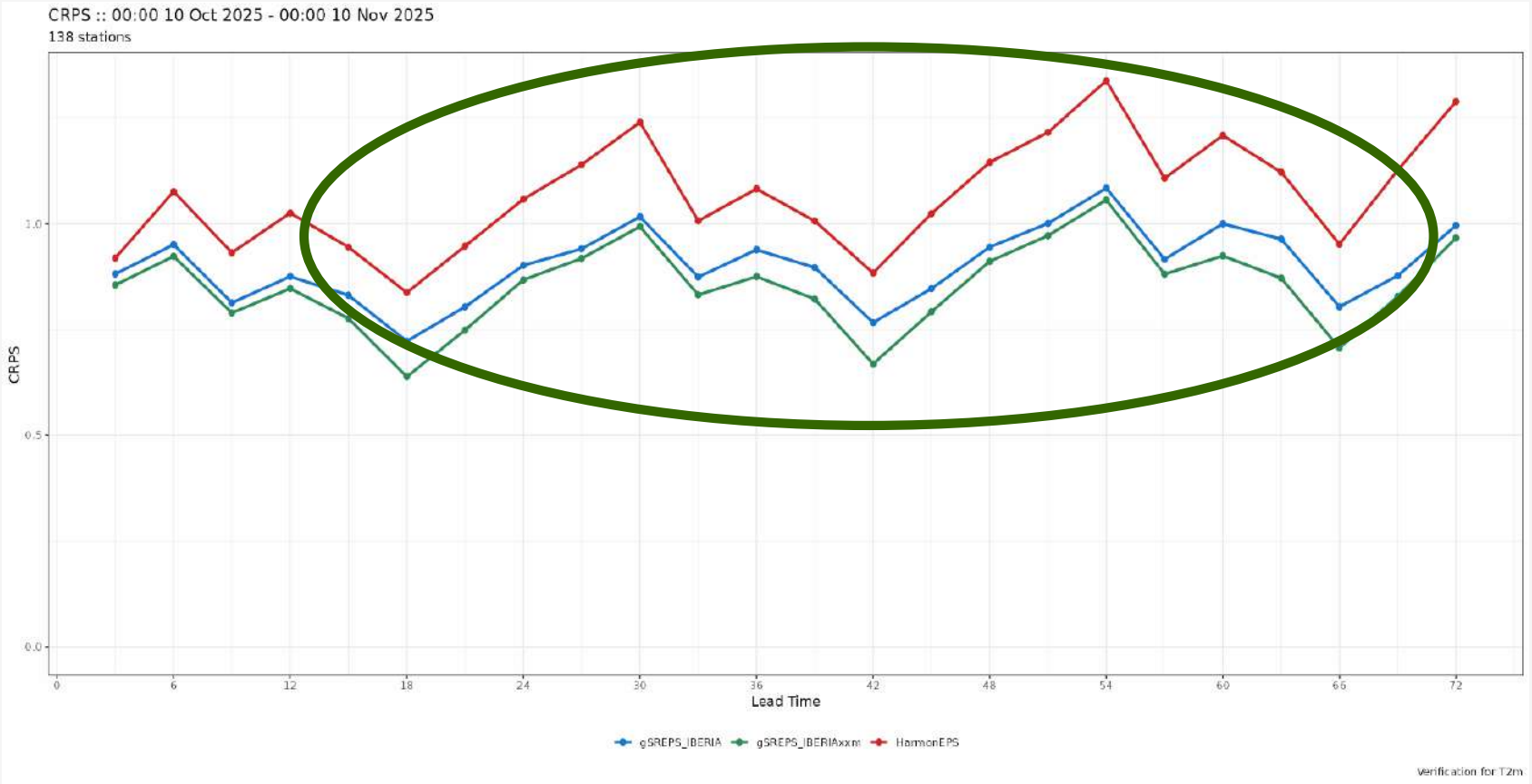
T2m

γSREPS 2016-2025
γSREPS 2026
HarmonEPS ~2027/28

CRPS
Continuous Probability Ranked Score

Through a distribution of thresholds

CRPS
The lower, the better



To HarmonEPS: 1st step

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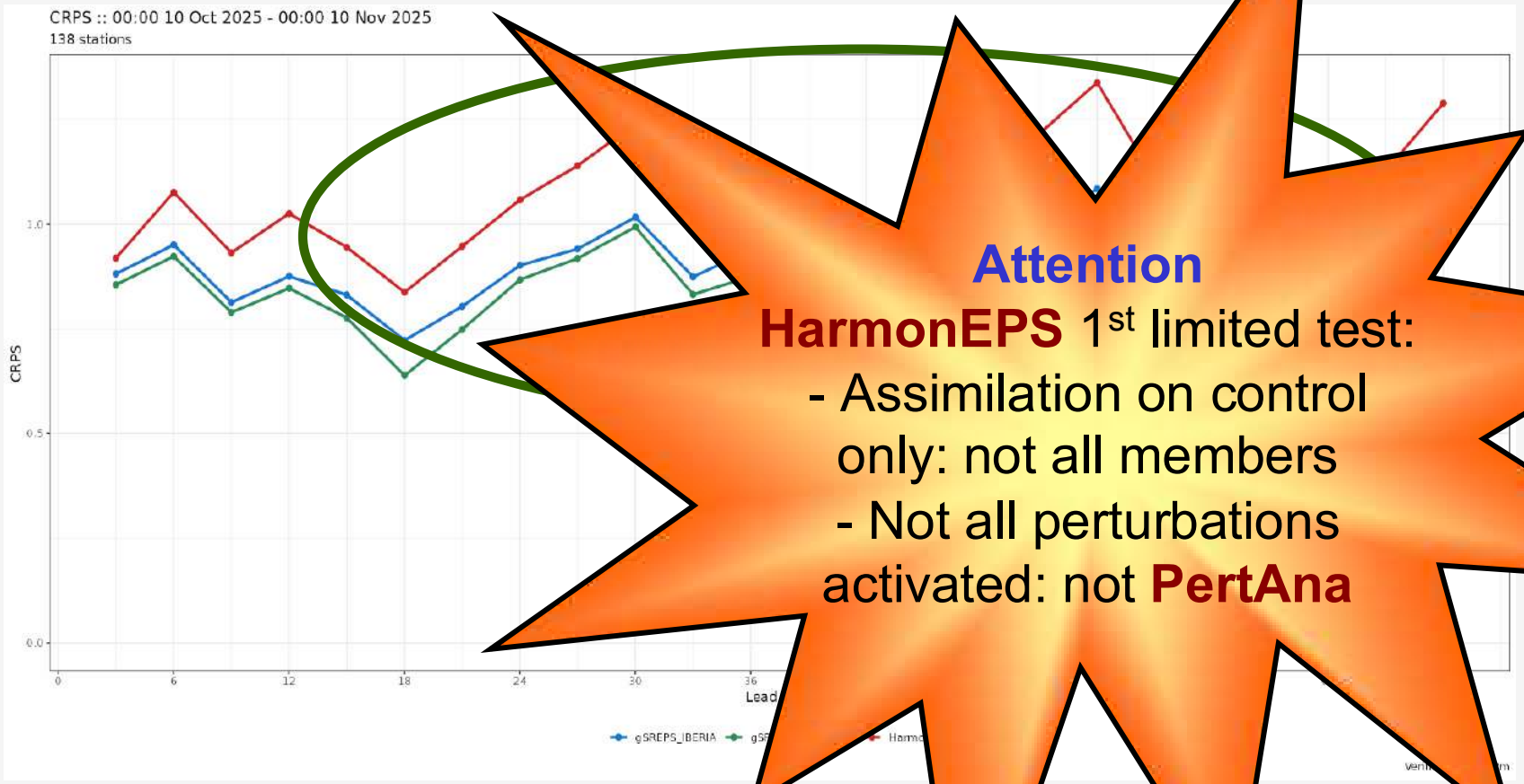
T2m

γSREPS 2016-2025
γSREPS 2026
HarmonEPS ~2027/28

CRPS
Continuous
Probability
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Through a distribution of thresholds

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The lower, the better



Attention

HarmonEPS 1st limited test:
- Assimilation on control only: not all members
- Not all perturbations activated: not **PertAna**

To HarmonEPS: 2nd step

HARMONIE uni-NWP model LAM-EPS



One week verification 24th March – 29th April 2026

T2m

γSREPS 2016-2025

γSREPS 2026

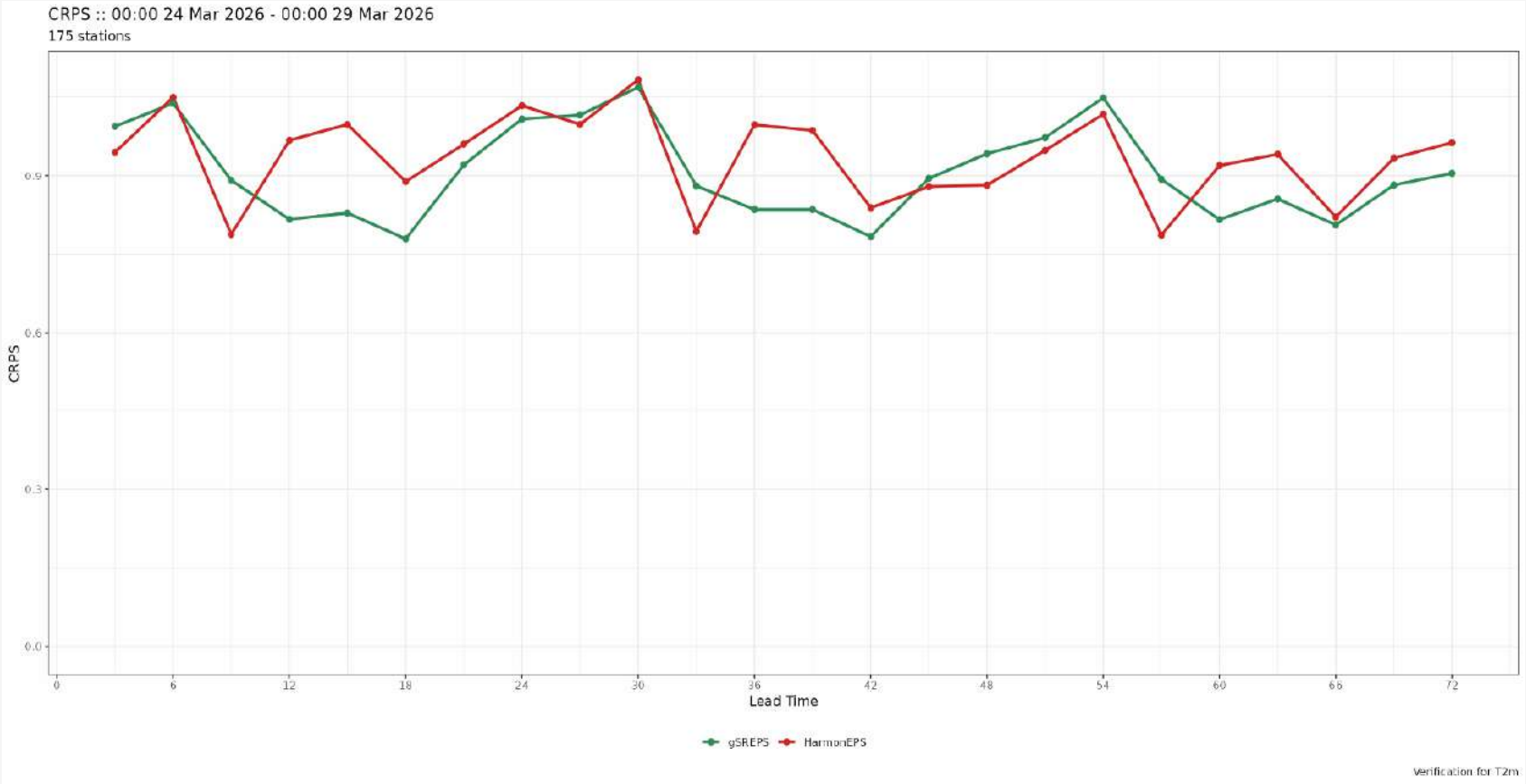
HarmonEPS ~2027/28

CRPS

Continuous Probability Ranked Score

Through a distribution of thresholds

CRPS
The lower, the better



To HarmonEPS: 2nd step

HARMONIE uni-NWP model LAM-EPS



One week verification 24th March – 29th April 2026

T2m

γSREPS 2016-2025

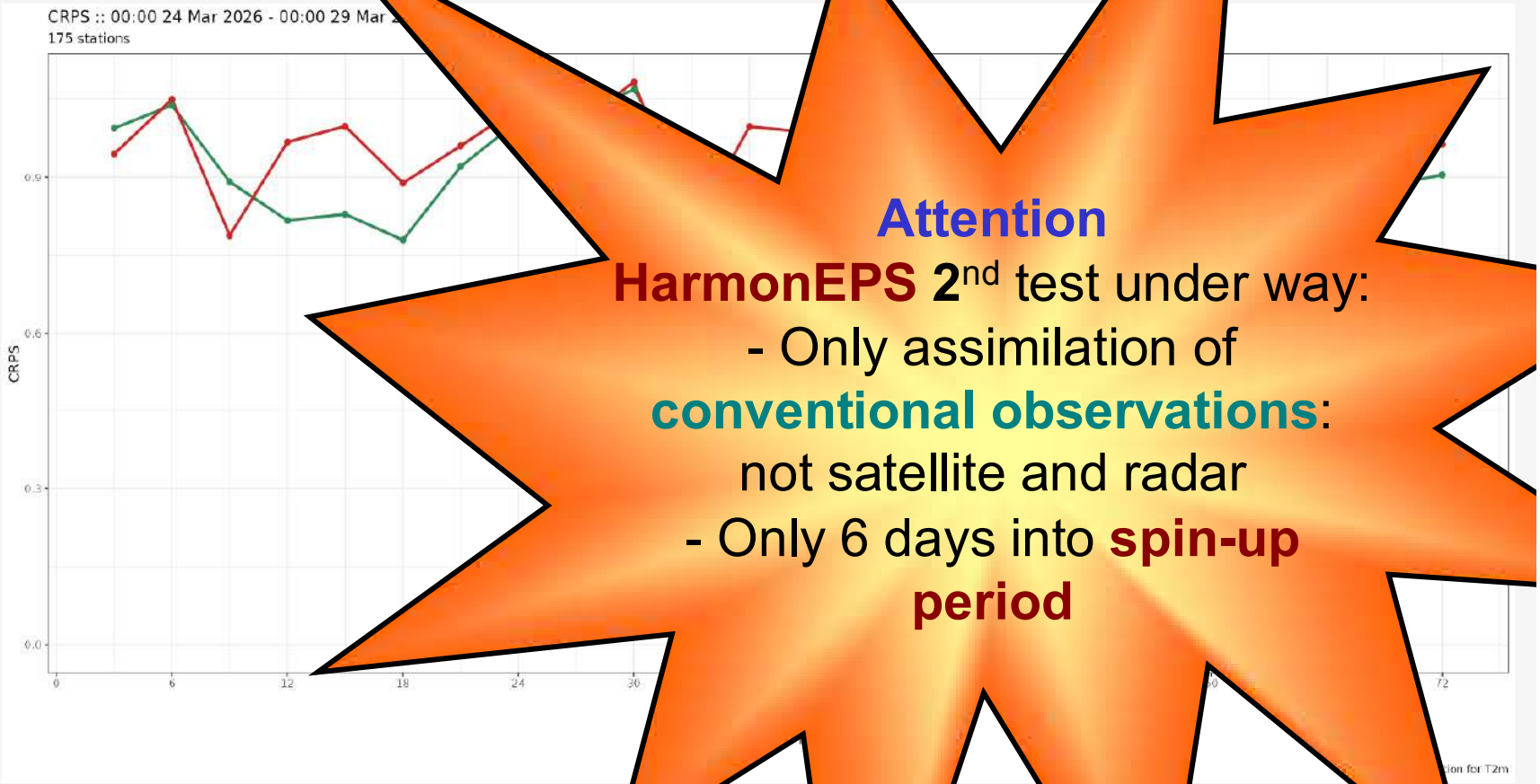
γSREPS 2026

HarmonEPS ~2027/28

CRPS
Continuous
Probability
Ranked Score

Through a distribution of thresholds

CRPS
The lower, the better



Attention

HarmonEPS 2nd test under way:
- Only assimilation of **conventional observations**: not satellite and radar
- Only 6 days into **spin-up period**

To HarmonEPS: 1st and 2nd steps

HARMONIE uni-NWP model LAM-EPS



γSREPS 2016-2025

ScoreCard

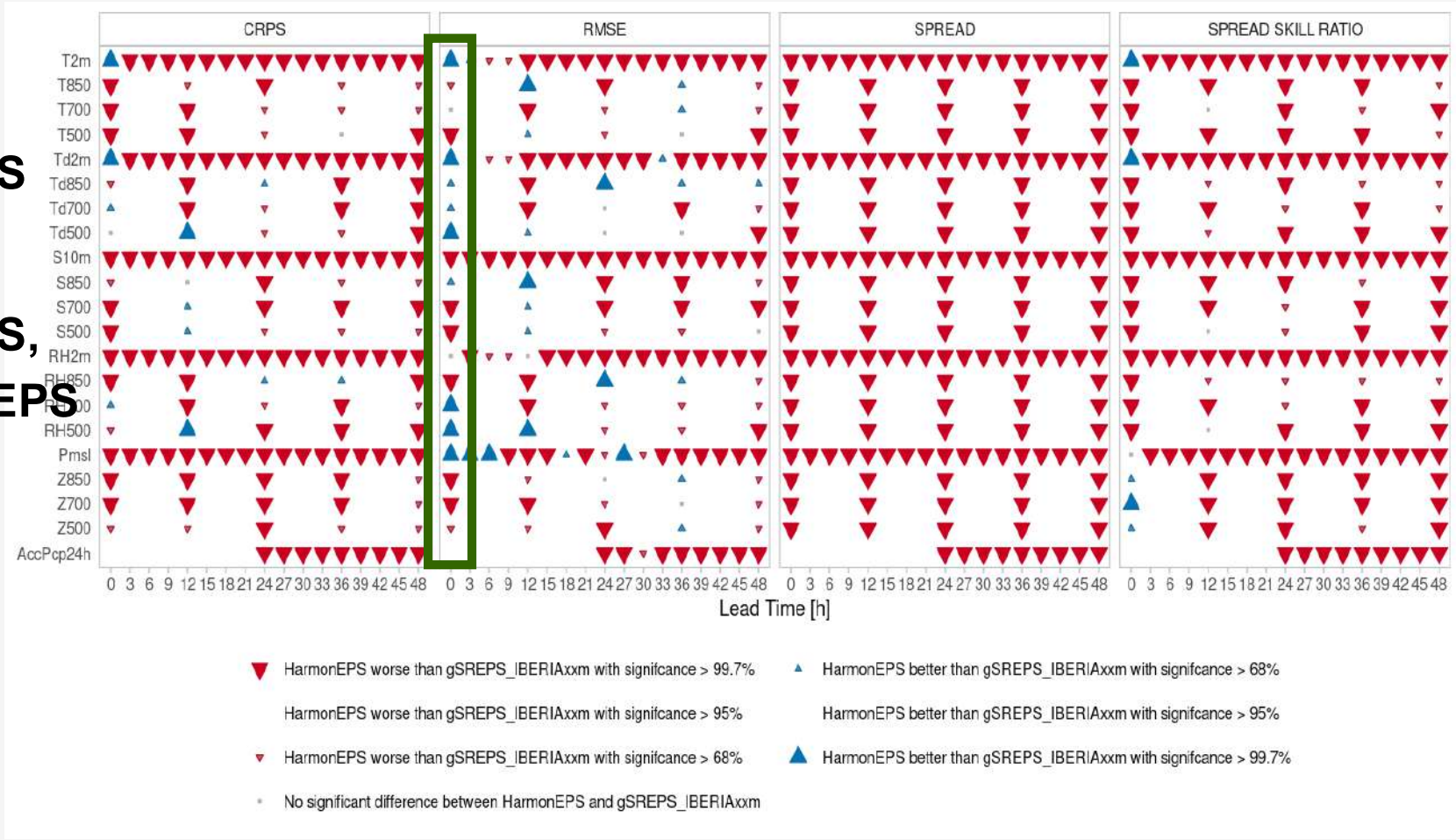
γSREPS 2026

HarmonEPS ~2027/28

CRPS RMSE SPREAD S-S RATIO
T/Td/RH 2m/850/700/500hPa
AccPcp24h

Better HarmonEPS

Worst HarmonEPS, better γSREPS



To HarmonEPS: 1st and 2nd steps

HARMONIE uni-NWP model LAM-EPS



γSREPS 2016-2025

ScoreCard

γSREPS 2026

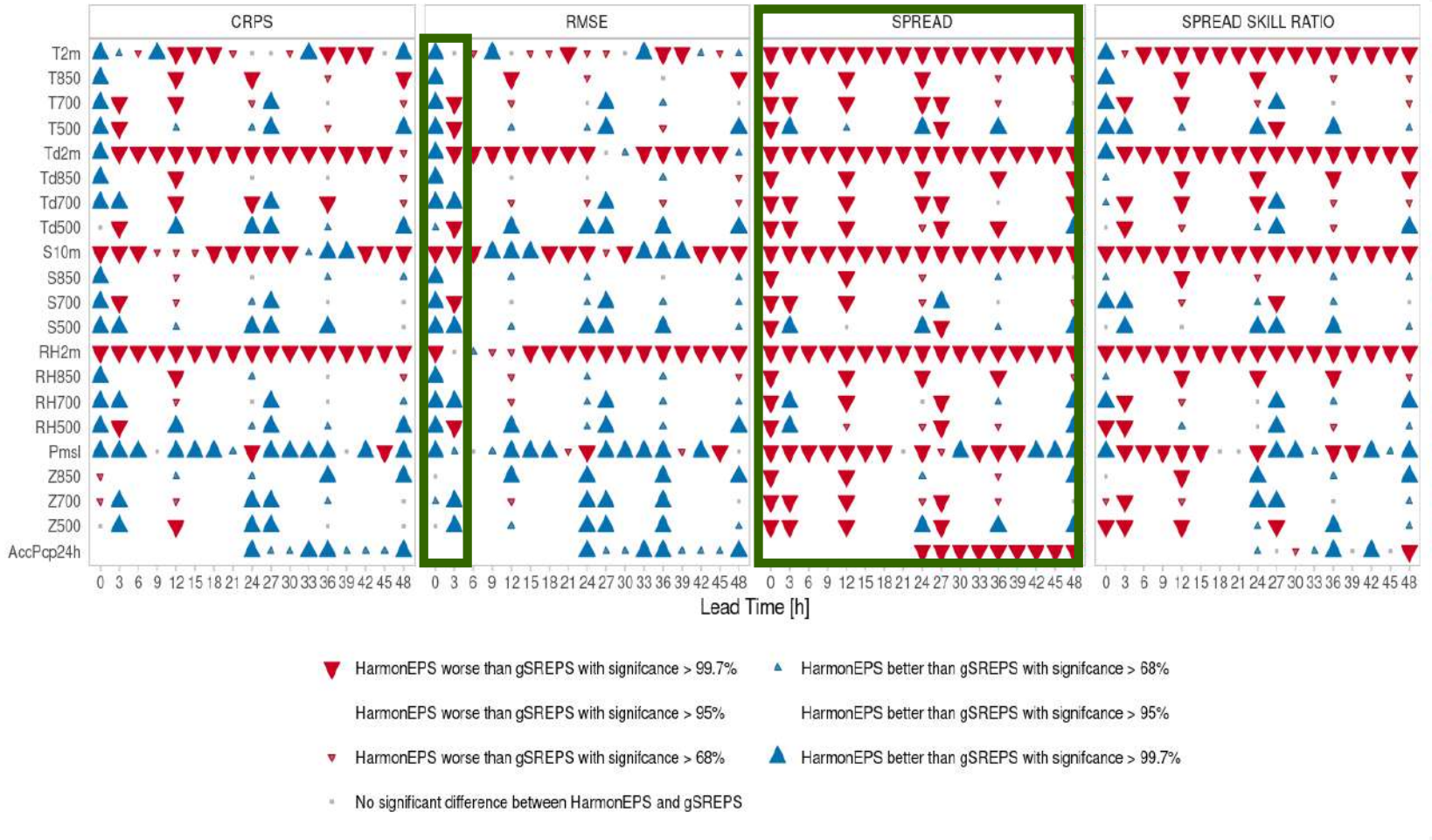
HarmonEPS ~2027/28

CRPS RMSE SPREAD S-S RATIO
T/Td/RH 2m/850/700/500hPa
AccPcp24h

Better HarmonEPS

Worst HarmonEPS

better γSRE



To HarmonEPS: 1st and 2nd steps

HARMONIE uni-NWP model EPS



Needed more testing and development for **HarmonEPS** over Iberian Peninsula

➔

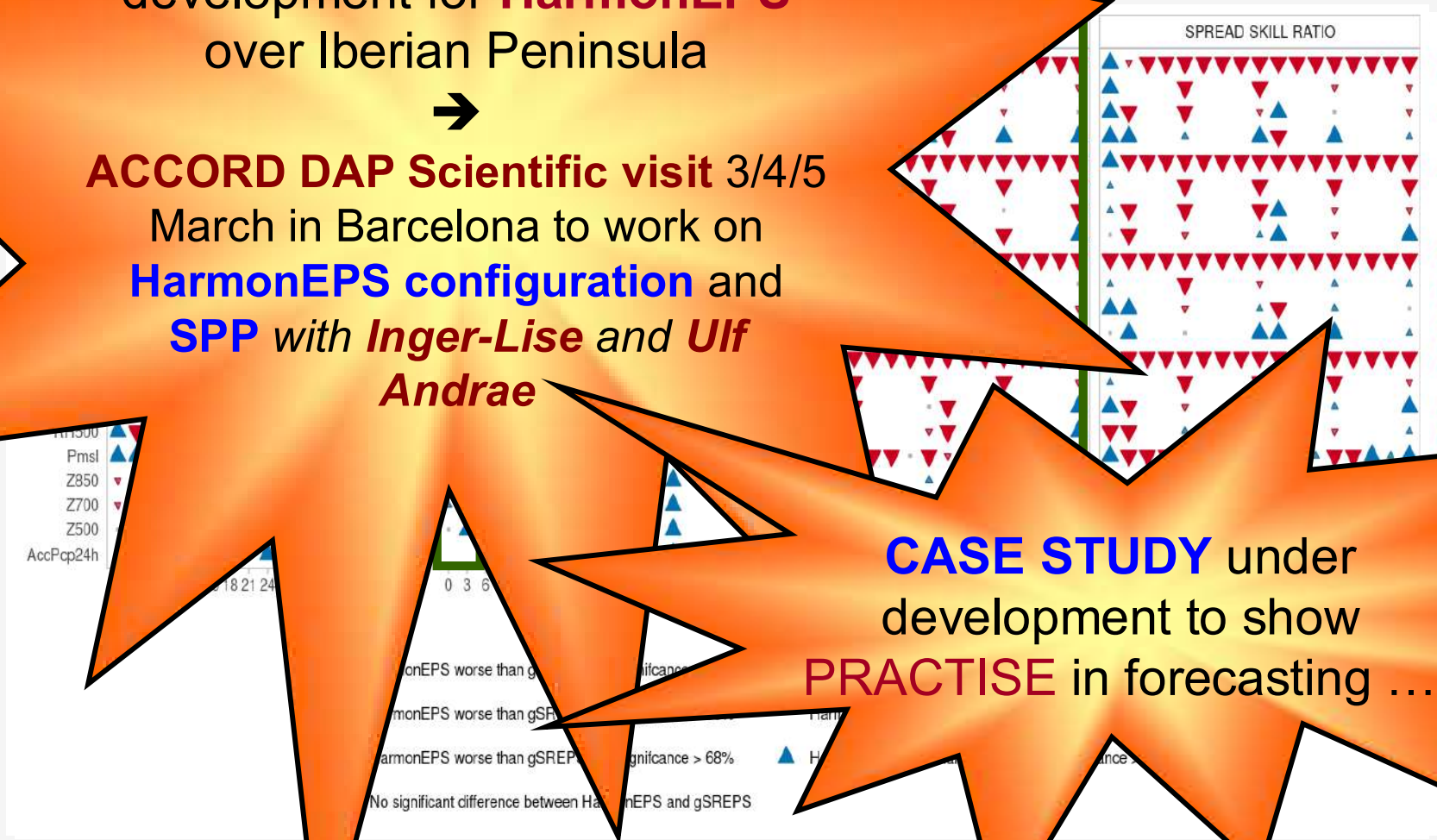
ACCORD DAP Scientific visit 3/4/5 March in Barcelona to work on **HarmonEPS configuration** and **SPP** *with* ***Inger-Lise*** *and* ***Ulf Andrae***

CASE STUDY under development to show PRACTISE in forecasting …

E SPREAD S-S RATIO
2m/850/700/500hPa

Bette
Harmon

Worst
Harmon
bette



GOBIERNO DE ESPAÑA
VICEPRESIDENCIA TERCERA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

aemet Agencia Estatal de Meteorología

γ SREPS

Thank you for your attention !!!

Questions



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ACCORD
A Consortium for COnvection-scale modelling Research and Development

6th All Staff Workshop
Marrakech (Morocco), 13-17 April 2026

Spanish AEMET γSREPS Predictability Group
Juanjo Gómez, **Alfons Callado**
Miguel Gullón *(new member)*
Pau Escribà, David Gil (collaborations)
Matilde García-V. (EUMETNET SRNWP-EPS project)