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

aemet Agencia Estatal de Meteorología

AEMET NWP Activities
## 47th EWGLAM/ 32nd SRNWP Meeting, 22-25 Sep 2025, Norrköping (Sweeden)

Deterministic e-suite

- Deterministic operational suite based on cycle 43h2.1 **2.5 km, 65L** runs 4 times per day with a forecast length of 72 hours for 2 domains (Iberian Peninsula and Canary Islands). running on two domains up to 72 hours
- e-suite based on HARMONIE-AROME cycle 46h1.1
- Runing in real time and expected to enter in operations in January 2026. **2.5 km, 65L** runs 4 times per day with a forecast length of 72 hour. A single unified domain is used what facilitates operations and improves satellite DA. Main impact is seen in upper air RH and precipitation, specially over the Canary Islands due to the increase number of observations for this area.
- Single precisión in the forecast model produce a small degradation in RH field and MSLP)
- **3DVar analysis** with **3hr cycle** incl. AMDAR humidity obs, radar reflectivities, ATOVS, GNSS ZTD, ASCAT wind, IASI and SEVIRI obs.
- SAPP preprocessing for conventional observations
- IFS humidity in the blending process (LSMIX). Assimilation of T2m and rh2m in 3Dvar radar reflectivity using OPERA from BALRAD preprocessing including Spanish, Portuguese and French radars.
- On-going tests to include
- OPERA NIMBUS preprocessing and activate radar wind data *(jsancheza@)*
- Fine tuning of DA settings: scales and observation errors [1]
- De Rooy scale aware shallow convection scheme [2]

New unified domain
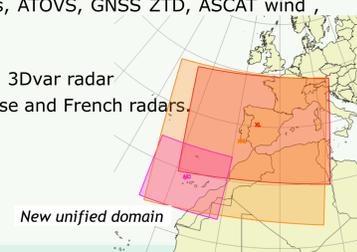
Enhanced Satellite Data Assimilation in the e-suite *(jcampinsp@, mdiezm@)*

- New microwave instruments/satellites: ATMS/Suomi-NPP, NOAA-20 and 21, and MWHS2/FY-3D and 3E
- Low-peaking channels for AMSU-A and MHS
- New infrared instrument/satellite: IASI/METOP-C, CrIS/NOAA-20 and 21
- Changes in cloud detection scheme for IASI
- SEVIRI radiances, WV6.2 and WV7.3, at all cycles over sea and land DA following Guedj. et al. (2011)[3]
- AMSU-A and MHS from NOAA-18 and 19 are not longer assimilated

SENSOR (SATELLITE)	00	03	06	09	12	15	18	21
AMSUA (METOP-B and C)				X	X			X
MHS (METOP-B and C)				X	X			X
ATMS (NPP, NOAA-20 & 21)								
MWHS2 (FY-3D)			X			X		
MWHS2 (FY-3E)			X				X	
IASI (METOP-B and C)				X	X			X
CrIS (NOAA-20 and 21)			X			X	X	
SEVIRI (METEOSAT-10)	X	X	X	X	X	X	X	X

INFRARED Channels:
SEVIRI: WV6.2 and WV7.3
IASI: 28 for CO_2 and 25 for H_2O band
CrIS: 26 for CO_2 and 14 for H_2O band

MICROWAVE Channels:
AMSUA: 5-to-9
MHS: 3-to-5
ATMS: 7-to-10 and 19-to-22
MWHS2: 11-to-14

Variational Constrains
cgeijog@, mdiezm@

Variational Constraints (VC) to reduce spin-up

A series of experiments have been carried out to evaluate the performance of VC initialization algorithm available in the official Harmonie-AROME Cy46.
- CNT control run
- CNTHD with MODE-S EHS thinning distance and obs. error both reduced by ½ with respect to the control

The aim is to study how the VC filters the induced noise and the overfitting (difference between CNT and CNTHD)
- e2 = CNTHD + VC
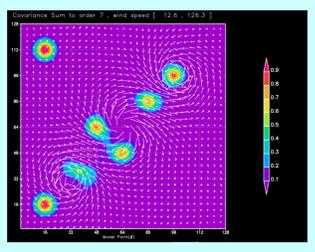- e3 = CNTHD + VC (larger VC effect)
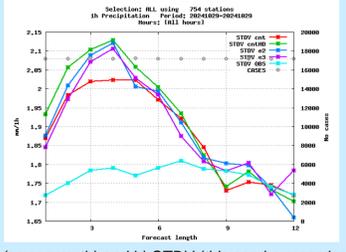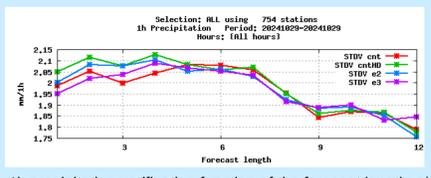
1h precipitation verification function of the forecast length: a) BIAS (error growth) and b) STDV (this can be regarded as a diagnostic for precipitation spin-up)

The two VC experiments show reduction in error and less spin-up

Gaussian Integrals
cgeijog@

Modelling Flow-Dependent Covariances with Gaussian Integrals [4]

It is possible to introduce flow-dependency to co-variance B by introducing a positive quadratic form that depends on vector field V

$$Z(S) = \int_{d\Delta_1 \dots d\Delta_N} e^{-\frac{1}{2}\left(\Delta^T B^{-1}\Delta + \mu\, tr\left[\left(\mathbf{V}\dot{\nabla}\Delta\right)\left(\mathbf{V}\dot{\nabla}\Delta\right)^T\right]\right) + \Delta^T S}$$

- The idea is appealing, in the first place, for its potential in ENVAR B → B[V]
- Implementation of a prototype and "proof-of-concept" successful
- Computing performance analysis on CPUs and with standard MPI and OpenMP parallelization APIs carried out
- Main challenge: reduce computing time to make it feasible in practical applications

4DVar activities
pescribaa@, jsancheza@

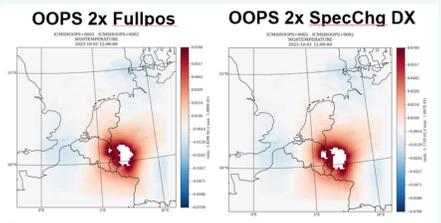### Comparison of 4DVAR with 3DVar *(jsancheza@, pescribaa@)*

- On-going test to compare performance of 4DVar DA. A period with several severe cases including Valencia flooding is used to assess the potential of 4DVar. The integrations are performed over a large domain and all the operational observations are ingested
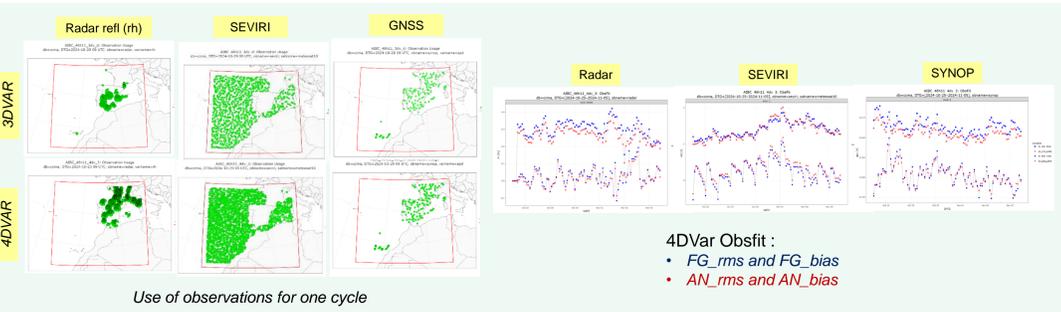
Use of observations for one cycle

4DVar Obsfit :
- FG_rms and FG_bias
- AN_rms and AN_bias

Implementation of 4DVar under OOPS *(pescribaa@)*

- Change of resolution of the increment in spectral space implemented in OOPS (like MASTERODB version)
- Equivalence of OOPS -vs- MASTERODB for a 2 outer loop (2x,1x resolution respect to background), demonstrated for a single obs experiment.
- Working for the equivalence of the convergence of VARBC coefficients, when assimilating satellite obs.
- Final step will be to perform a high-resolution (2.5 km) long run comparison of OOPS -vs- MASTERODB 4DVar in an all obs assimilated like-operational environment.

OOPS 2x Fullpos   OOPS 2x SpecChg DX

Temperature analysis increment in model level 20 for one single observation (amdar T) assimilation. Grid point change resolution of increment (left) -vs- spectral change (right)

Evident-ATOS-Bull High HPC updated

It is composed of two identical clusters each with 188 compute nodes mounted on Bull Sequana X440 A5 chasis. Each node with
- 2 AMD EPYC™7742 processors (64 cores)
- 256 GB DDR4-3200 memory
- 25% of the nodes with 384 GB

EPS activities
acallado@, jgomean@

AEMET-γSREPS

- Multi-model (4 mesoscale NWP models)
- Multi-boundary conditions (5 Global models)
- at 2.5 km on 3 domains: Iberian Peninsula, Canary Islands and Antarctica
- 2 cycles up to 72 hours each
- Running at ECMWF HPC expecting to enter in TC2 in Autumn

Soundings including uncertainty
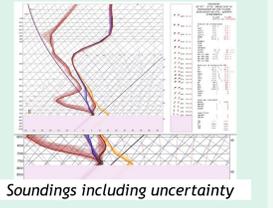
- On-going: Upgrading LAMs versions: WRF to 4.6.1 and HARMONIE & ALARO to 46h1.1, and increase Iberian domain

Plans 2026:
Move to harmEPS system in a new HPC

Probability matrix: AccPcp + AccSnw
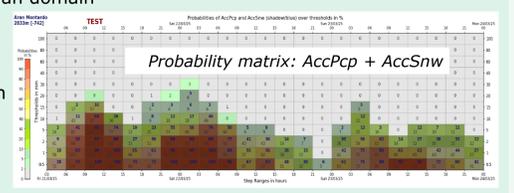
Surface Validation
svianaj@

Offline Surfex Validation System (OSVAS)

A tool to provide a systematic approach for testing NWP-like SURFEX settings over specialized ICOS stations. Still in development phase, it includes scripts for:

- Dowload forcing & validation data: Interface to the ICOS API, which automatically writes station data from any number of datasets in ASCII or Netcdf (forcing) and sqlite (validation) format.
- Namelist handling & running SURFEX : Produce CTRL and TEST offline runs both with "ideal" (e.g. accurate phisiography) and nwp-like (ECO-SG, etc) namelist settings. Plans to integrate the here the use of pysurfex.
- Validation using HARP: model output is converted to sqlite and oper-harp-verif scripts are extended for simple validation of surface fluxes and other soil variables. More specialized evaluation (SEB, soil spinup, etc) will be developed with custom scripts
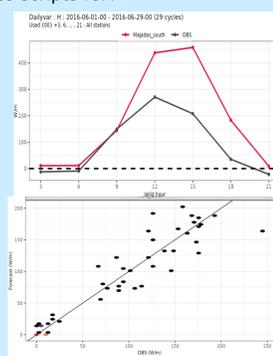

HARP verification showing a) average diurnal cycle of H and b) scatterplot of LE corresponding to a 1-month offline SURFEX simulation over Majadas del Tietar ICOS station in Spain

AI/ML forecasting

Transfer learning with Anemoi *(mtgarciag@, fbelinchonm@, jcasador@, aplicaciones_estadística@)*

We have performed transfer learning from two different checkpoints trained with CERRA data by KNMI using the Anemoi framework and a stretched-grid approach, to the Iberian Peninsula and Canary domains.
- First verifications for surface variables T2d, T2m, wind direction, wind speed and mslp show very promising results.
- One of the checkpoints is trained without rollout (AE_IB-TCNR-V2) and the other with a rollout of 10 (AE-IB-TCR10). Rollout tends to improve the results in longer lead times, especially for mslp.
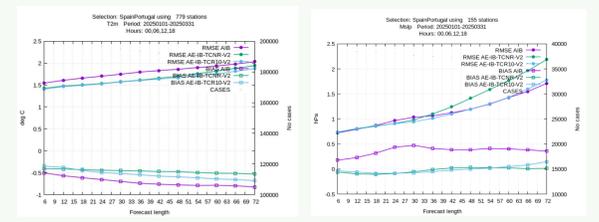
Point verification against SYNOPS including Harmonie-Arome deterministic NWP runs at 2.5 km as reference

Highlights

- ➢ E-suite based on Cy46h1 is running in real time with the aim to become operational in January 2026. It uses a large unified domain including the Canary islands. The suite includes updates in the clear sky DA with several new satellites/channels as SEVIRI over land, ATMS, NWHS2 and CrIS. The updates gives an small positive impact specially in upper level RH and precipitation. The benefit is larger over the Canary Islands due to the increase number of observations. The update also includes moving to GRIB2 output.

- ➢ Offline Surfex Validation System (OSVAS). A set of tools have been developed to facilitate the validation of Surface processes using data from ICOS station network.

- ➢ AI/ML forecasting. Using Anemoi framework, a transfer learning technique and and a stretched-grid approach is used for Iberian Peninsula and Canary domains. The AI/ML gives good results compared to the deterministic NWP forecasts at 2.5 km.

- ➢ Variational Constrains applied to wind field has shown potential to reduce spin-up effects in a nowcasting suite

See also talk by González-Alemán: "Evaluating sub-kilometric simulations in the HARMONIE-AROME model on high-impact convective storms"

References:

[1] Sanchez-Arriola et al. (2025): Evaluation of some HARMONIE-AROME cy46 data assimilation tunable settings. *ACCORD Newsletter No. 7*

[2] De Rooij, W. (2025): HARMONIE-AROME physics developments (*presentation in this workshop*)

[3] Guedj, S., F. Karbou, and F. Rabier (2011), Land surface temperature estimation to improve the assimilation of SEVIRI radiances over land, *J. Geophys. Res.*, 116, D14107, doi:10.1029/2011JD015776.

[4] Geijo, C. (2025): Scientific Note on Modelling Covariances with Gaussian Integrals. *ACCORD Newsletter No. 7*

Contributions:
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