Management Group ACCORD

NWP Activities : Data Assimilation

Wafa Khalfaoui

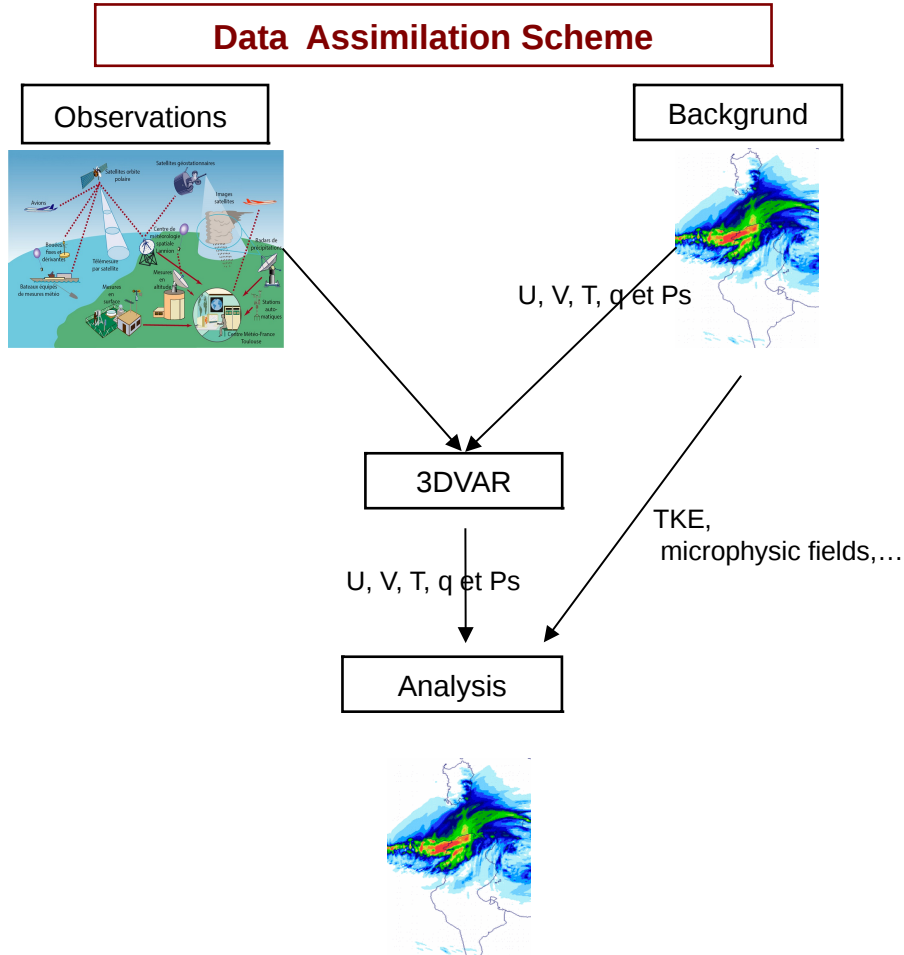Institut National de la Météorologie

Tunis, 04 May 2023

Outline

1. **Data Assimilation at INM : Scheme & observations**

2. **Status and General Progress**

3. **Surface Data Assimilation**

4. **Upper Air Data Assimilation**

5. **Scores and Results**

6. **Summary & Outlook**

Data Assimilation Scheme

Observations

Backgrund

U, V, T, q et Ps

3DVAR

U, V, T, q et Ps

TKE, microphysic fields,…

Analysis

ALADIN-Tunisie DA Configuration

- 3DVAR scheme: spin up Ensemble B matrix

- 6H cycling

- Local: Synop, Temp

AROME-Tunisie DA Configuration

Tested on Meteo-France

- 3DVAR scheme : DA ensemble B matrix

- 3H cycling

- Synop, Temp, Amdar, Buoy

- Satellite: Seviri, AMSU-A, AMSU-B, IASI

2. Status and General Progress

Implementation on HPC

Implementation of cycle 43t2.
Bator Cy43 Tested for SYNOP

Surface analysis

CANARI   GTS+local SYNOP

Upper Air Analysis : 3dvar scheme

- Ensemble B-Matrix
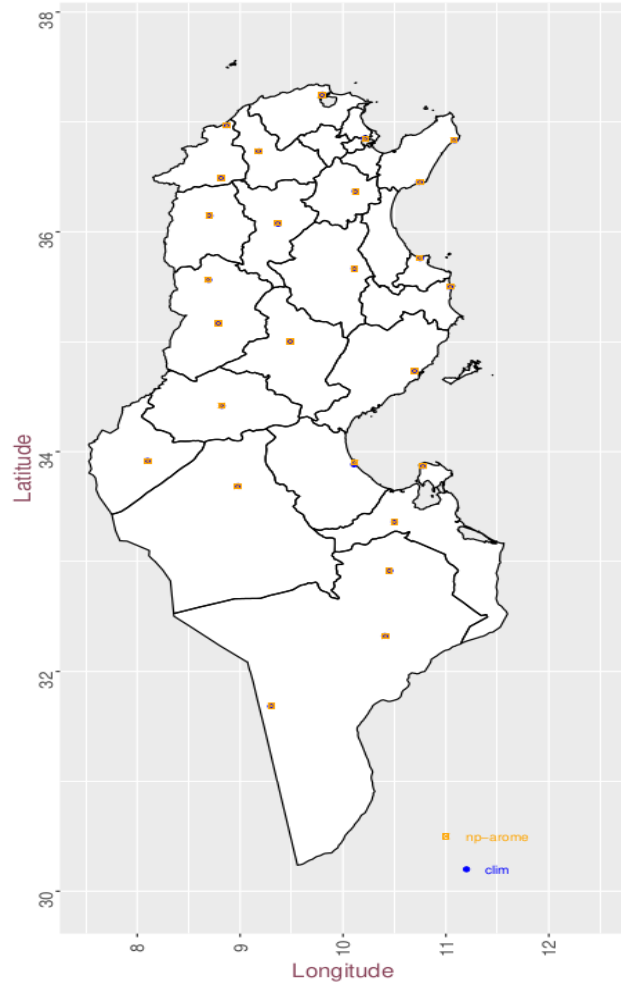- Work on progress to use Jk blending with Arome 3dvar

Observation Pre-processing

- Pre-processing : local SYNOP , Temp

- We use Alex Deckmyn python tool « Pop-rmi » to process local conventional data

Monitoring

- HARP on going implementation

3. Surface Data Assimilation

- Observations : Synop GTS
Small domain + low observations density

- Bator Adaptation and back-phasing

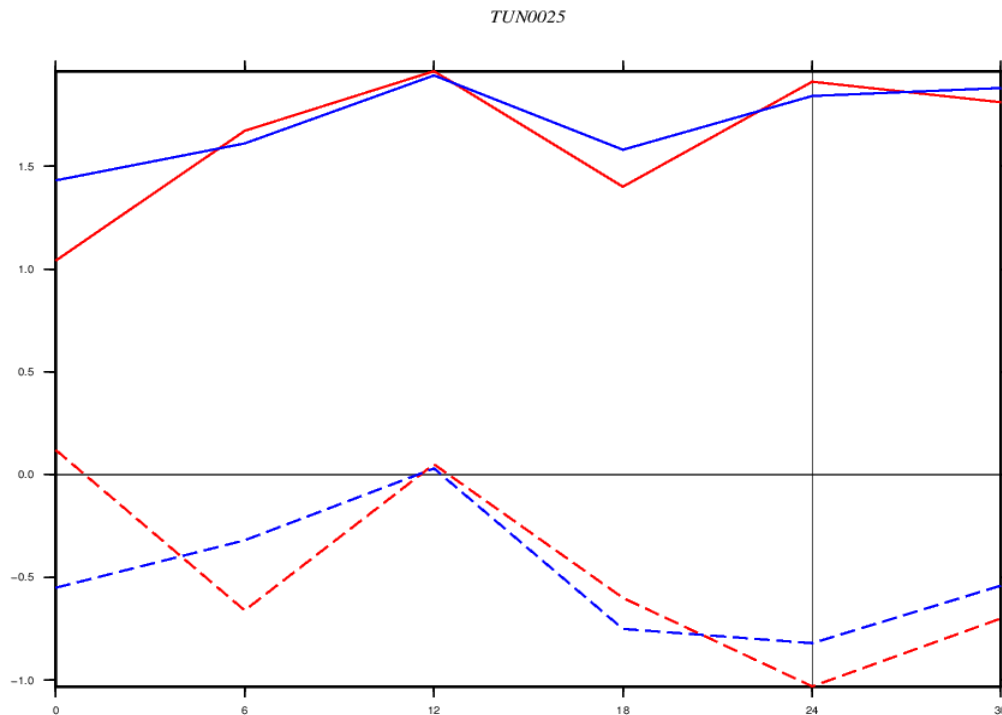bator adaptation for the synop templates for local observation

- CANARI OIMAN

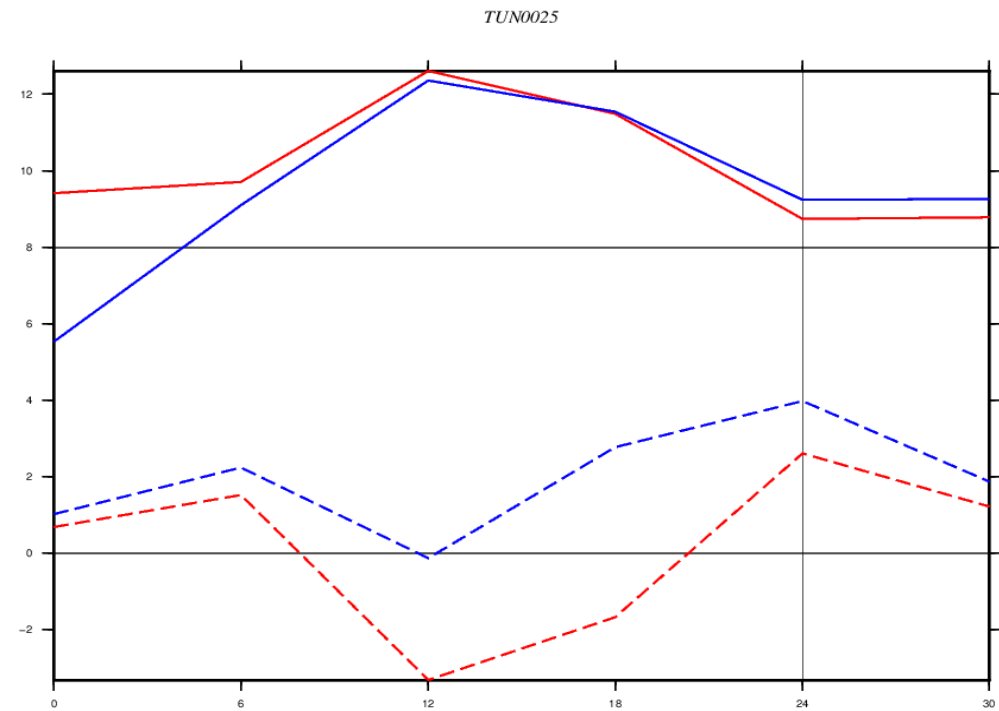default Parametrization

Synop Stations

- AROME surface scores : Mixed results

2m Temperature degradation and Relative Humidity improvement

Red: Reference
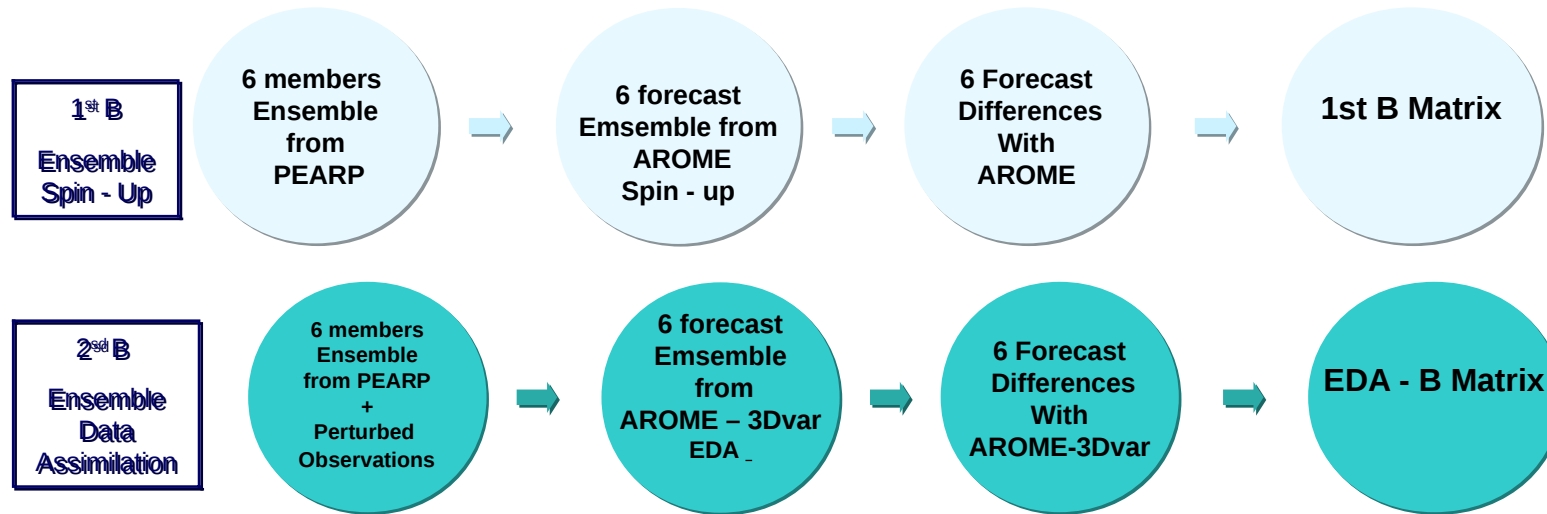Blue : Assim experiment
RMSE   —   /   Bias ----

Temperature (2m) rmse and bias verified against synop

Relative Humidity (2m) rmse and bias verified against synop

4. Upper Air Data Assimilation

1ˢᵗ B

Ensemble Spin - Up

6 members Ensemble from PEARP → 6 forecast Emsemble from AROME Spin - up → 6 Forecast Differences With AROME → 1st B Matrix

2ˢᵈ B

Ensemble Data Assimilation

6 members Ensemble from PEARP + Perturbed Observations → 6 forecast Emsemble from AROME – 3Dvar EDA → 6 Forecast Differences With AROME-3Dvar → EDA - B Matrix

Perturbed SST Observations

Perturbed SST

▪OSTIA files

▪As the Sea ~ 1/6 of Tunisian domain -> fixed perturbation

4. Upper Air Data Assimilation

▪ B matrices are the average of 3 B matrices calculated over 3 periods: winter (rainy season) , summer (Hot & humid) and Fall (convective systems) ➔ take on consideration all the Regimes that influence Tunisian Weather

▪ In order to have a positive definite B matrix , we must have the number N of differences equal to or greater than the number of vertical levels of the model (60 for Arome 2.5 km et 90 for Arome 1.3 km) :

Winter-Time 07-16 February:

   6 members ensemble * 10 days at 00H   ➔   **60**

Fall-Time ''Off season'' 25September – 04October 2015:

   6 members ensemble * 10 days at 00H   ➔   **60**

Summer-Time 16-20 August 2016:

   6 members ensemble * 5 days * 2 runs 00H & 12H (to integrate convective phenomena)   ➔ **60**

Same periods for EDA and Spin-up B matrices ➔ to be able to compare the results
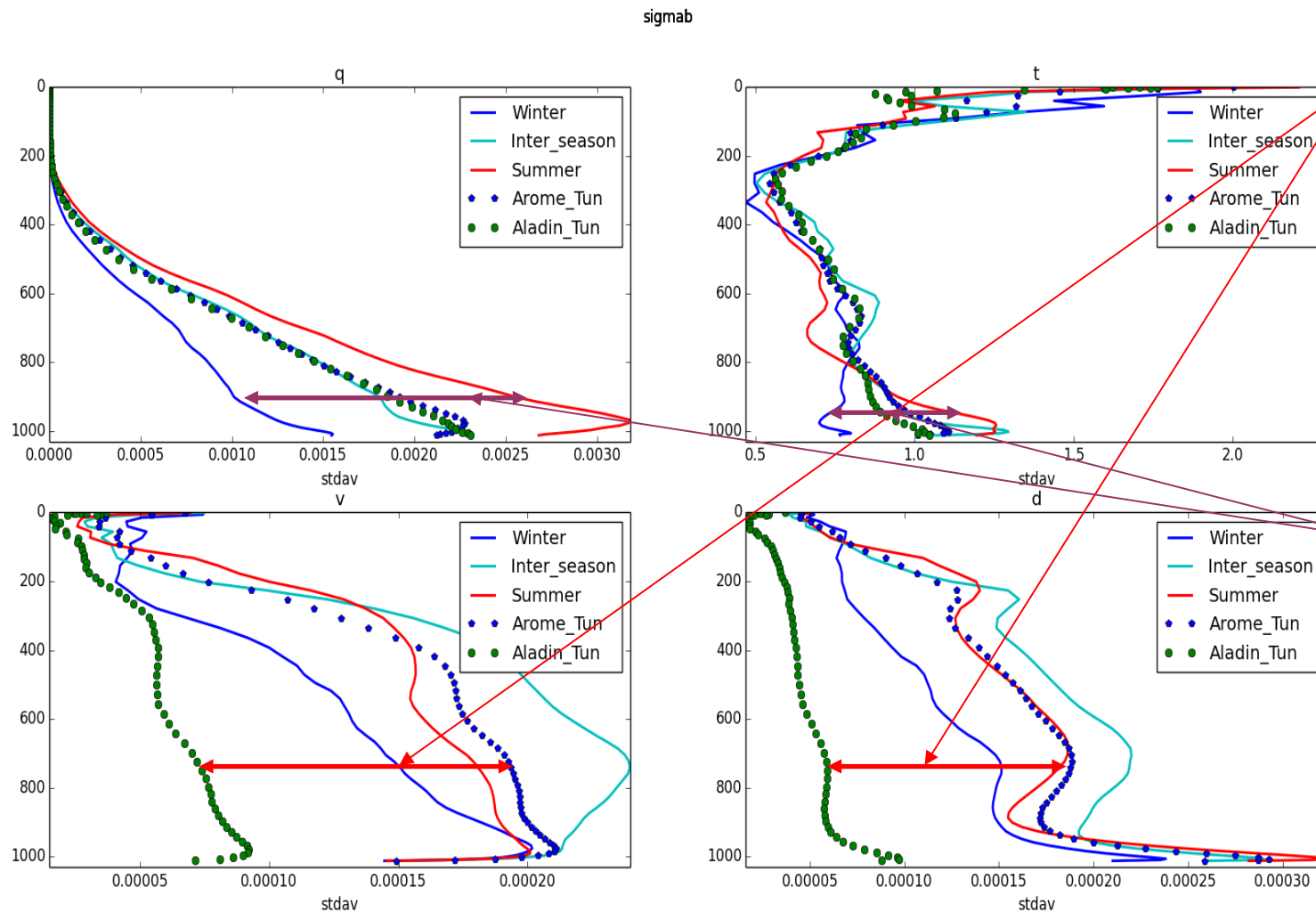
Increase in standard deviation of vorticity and divergence of Arome compared to Aladin

Differences between Summer & Winter

→ limit of the « climatologic » B matrix

Vertical profile of the standard deviation of specific humidity (q), temperature (t), vorticity (v) and divergence (d) for AROME-TUNISIE during winter (blue line), inter-season (cyan line) and summer (red line) periods; AROME–Tunisie (mean of the 3 periods) (blue dot) and ALADIN-TUNISIE (green dot)
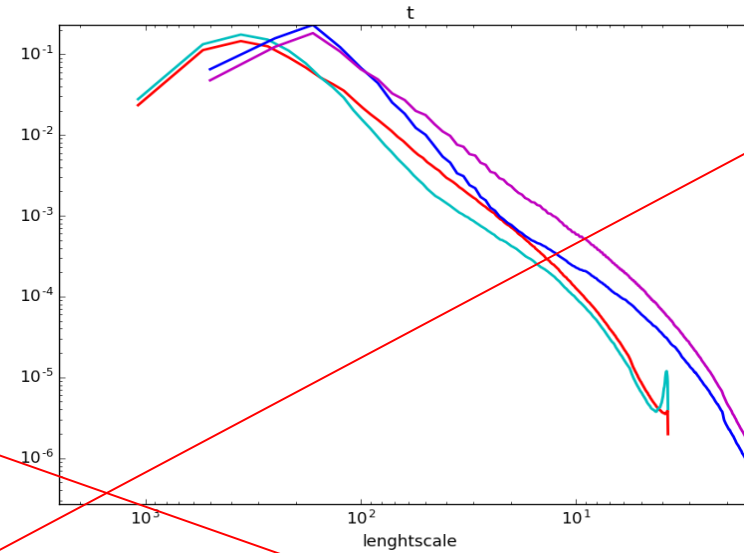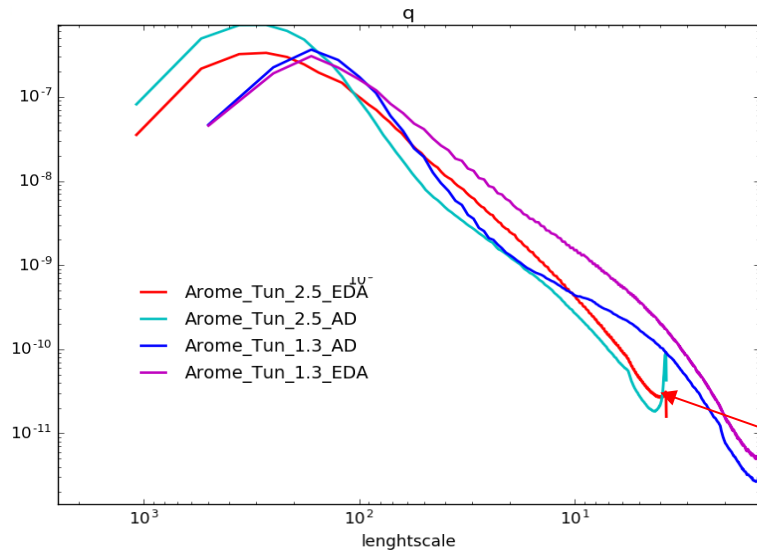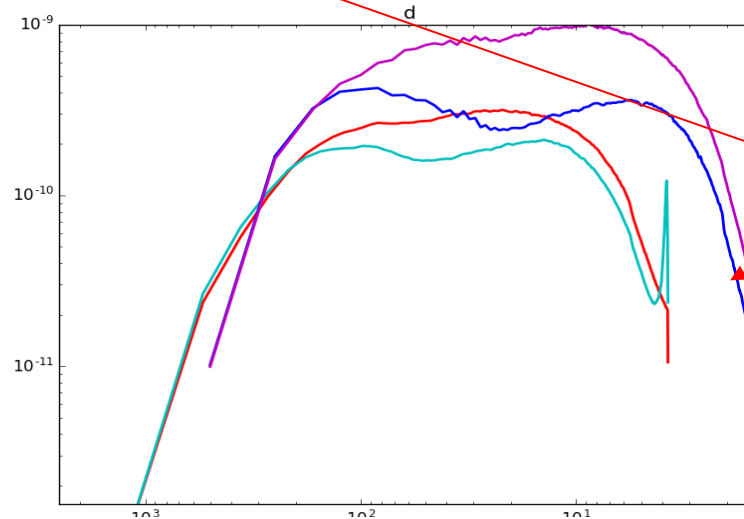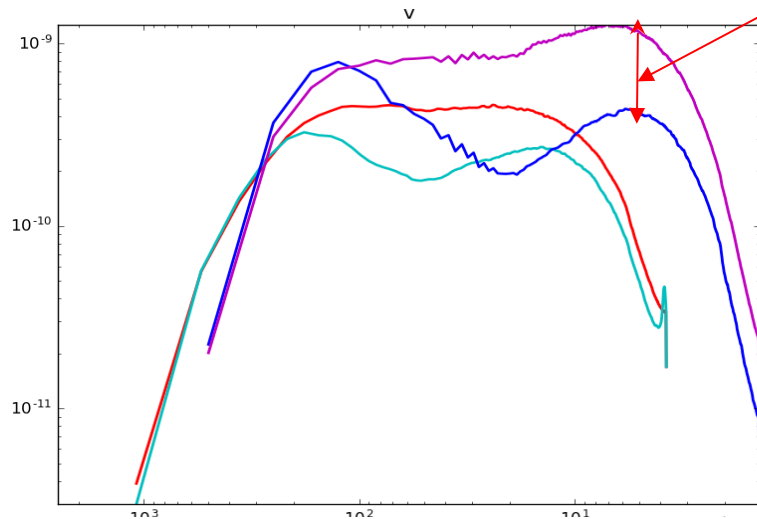
Arome EDA horizontal variance are bigger than Arome Spin up for short wavelengths

Evolving of small scale background perturbations due to EDA Cycling Effect

Noise with B matrix Spin-up

-> reduced due to DA cycling with B matrix EDA

- Motivation :
Small domain + low observations density

- V matrix computation and diagnostics :
Ensemble method
Same setup and periods of the Ensemble Data Assimilation Bmatrix
Seasonal variability:(winter, summer, convective situations)

- Namelist tuning

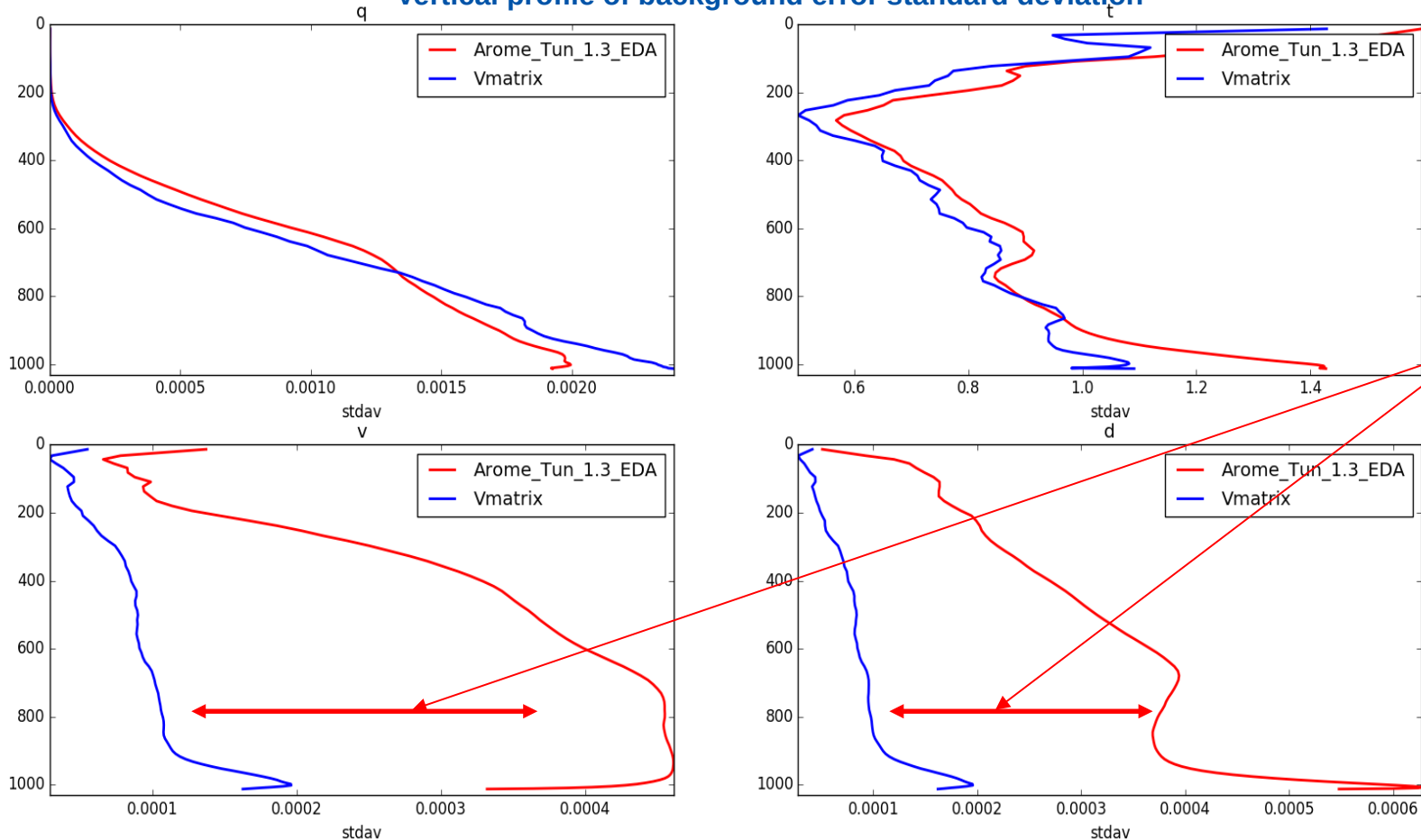**- Code modifications**

Adapting Jk ALADIN existing routines for AROME

Changing Grid point Humidity in AROME to Spectral within the code

- Experiments

crush in minimization at some dates => computation profile / out of bound arrays issue that needs to be fixed !

**Vertical profile of background error standard deviation**

Increase in standard deviation of vorticity and divergence of EDA B matrix compared to V matrix

Vertical profile of the standard deviation of specific humidity (q), temperature (t), vorticity (v) and divergence (d) for AROME-TUNISIE during winter (blue line), inter-season (cyan line) and summer (red line) periods; B matrix (mean of the 3 periods) (red line) and V matrix (blue line)

ScoreCard BEDA vs XPAD

Red: XPAD Reference
Blue : BEDA Assim experiment
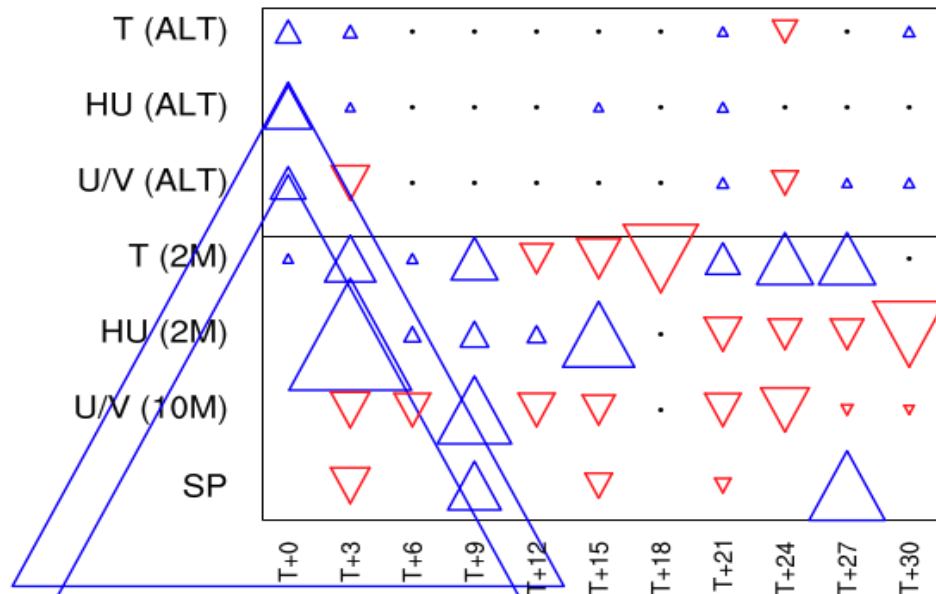
Total NWP index change (altitude) : +0.2 %
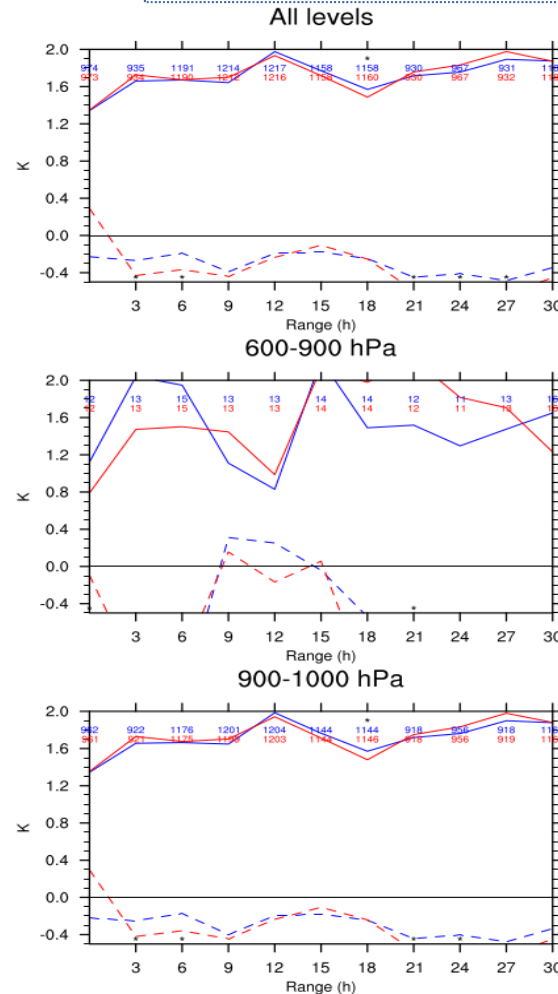Total NWP index change (surface) : +2.66 %

21 days Verification with presence of **convective situations** with **heavy precipitations** in September – October.
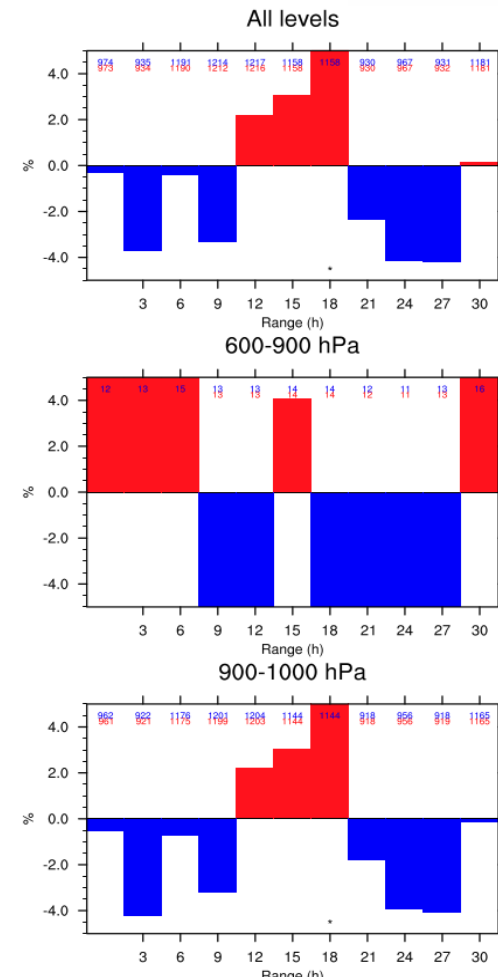
BEDA vs XPAD   :   t2m   RMSE

BEDA vs XPAD : t2m DIFF RMSE

- 2 meter Temperature scores

- 21 days Verification against Synop

- 2 meter temperature improvement up to 9H

- degradation of the scores from 12-18 : presence of convective situations

Red: Reference
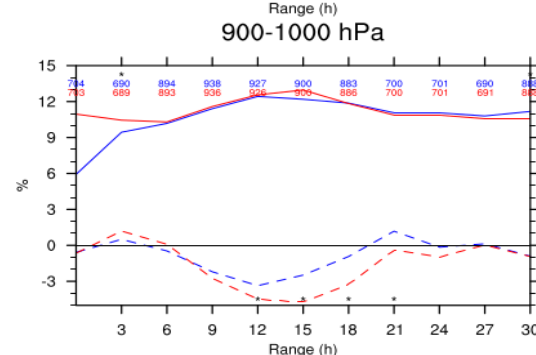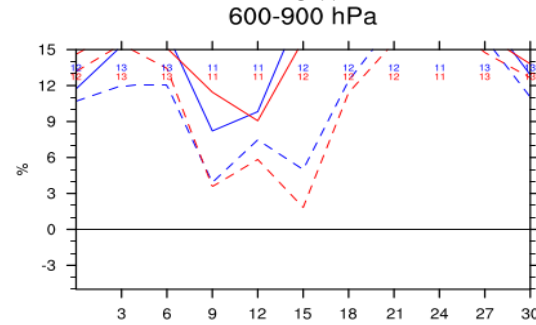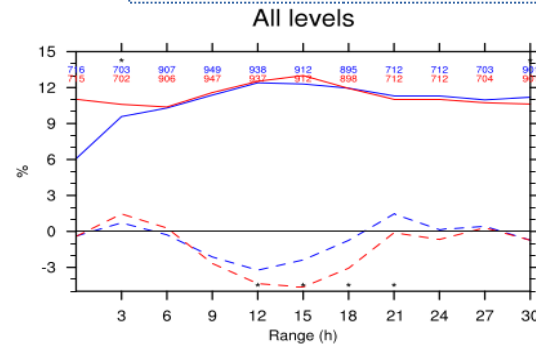Blue : Assim experiment
RMSE   —— /   Bias ----

- 2 meter RH scores

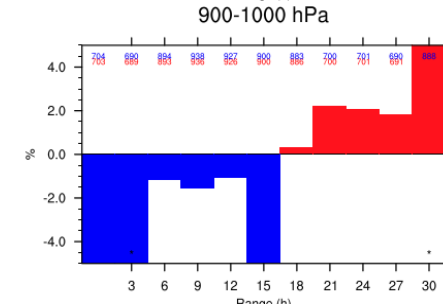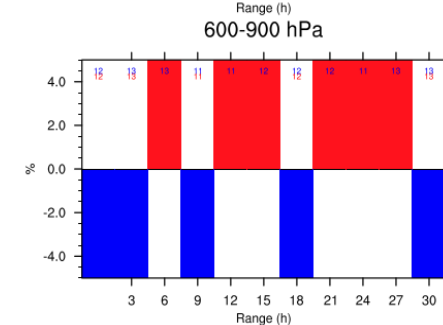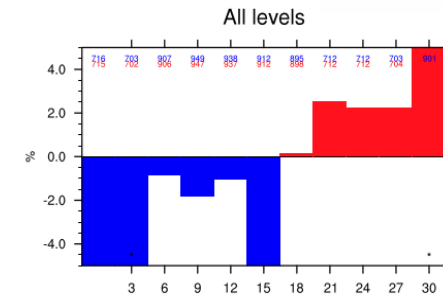-21 days Verification against Synop with convective sitations

- RH improvement up to 6H and degradation from 18H

- with DA : dryer in the morning and wetter from 18H

Red: Reference
Blue : Assim experiment
RMSE   ——   /   Bias ----

BEDA vs XPAD   : Relative Humidity RMSE

All levels

600-900 hPa

900-1000 hPa

BEDA vs XPAD : rh2m DIFF RMSE

All levels

600-900 hPa

900-1000 hPa

6. Summary & Outlook

- Observations:

    - Work on our **Local Data Base Observation**

    - Use of more observations: **AMDAR, local GNSS,**

    - Project of Purchasing **5 Radars:** implementation from 2024-2026

- **Cycling** of AROME surface and 3dvar **locally**

- **Tuning of CANARI** and 2m Temperature degradation scrores investigation
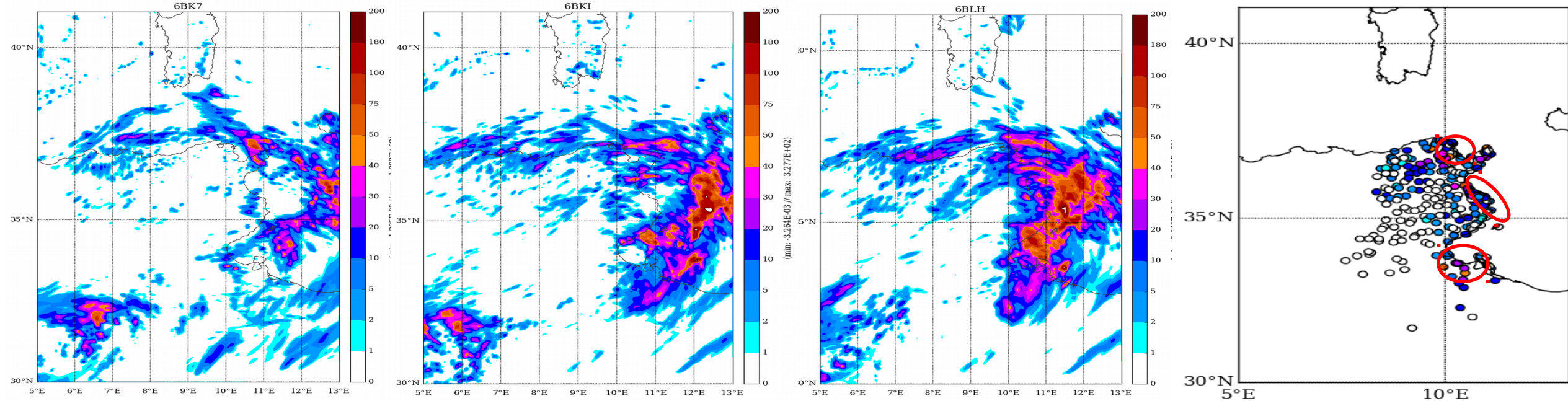
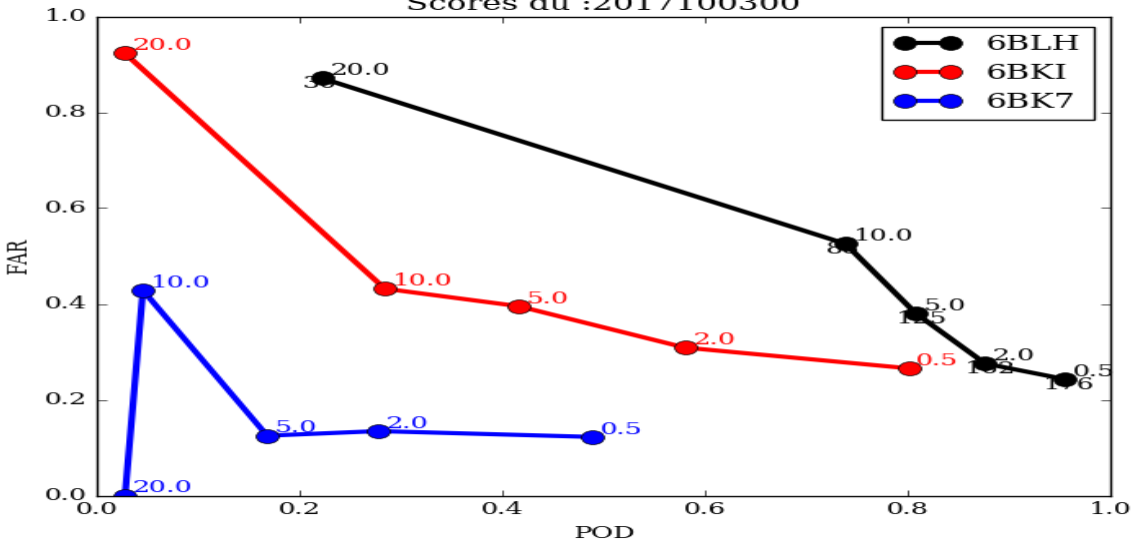- **Jk** blending further investigations

شكرا
Thank   you   ☺

www.meteo.tn

AROME Spin-up

AROME 3DVAR – Bmatrix Spin up

AROME 3DVAR – Bmatrix EDA

Observations

Scores du :2017100300

Case Study - 03 October 2017

Better Prediction for the cell localization and intensity

▪ 3 typical systems: North-East, East Cost, South-East Cells

▪ Better Prediction for the cell localization and intensity for Arome 3DVAR compared to Spin up

▪ Better scores for Arome 3DVAR EDA Bmatrix compared to Bmatrix Spin up

Convective Situation causing heavy rain & flood

AROME Spin-up

AROME 3DVAR – Bmatrix Spin up

AROME 3DVAR – Bmatrix EDA

Observations
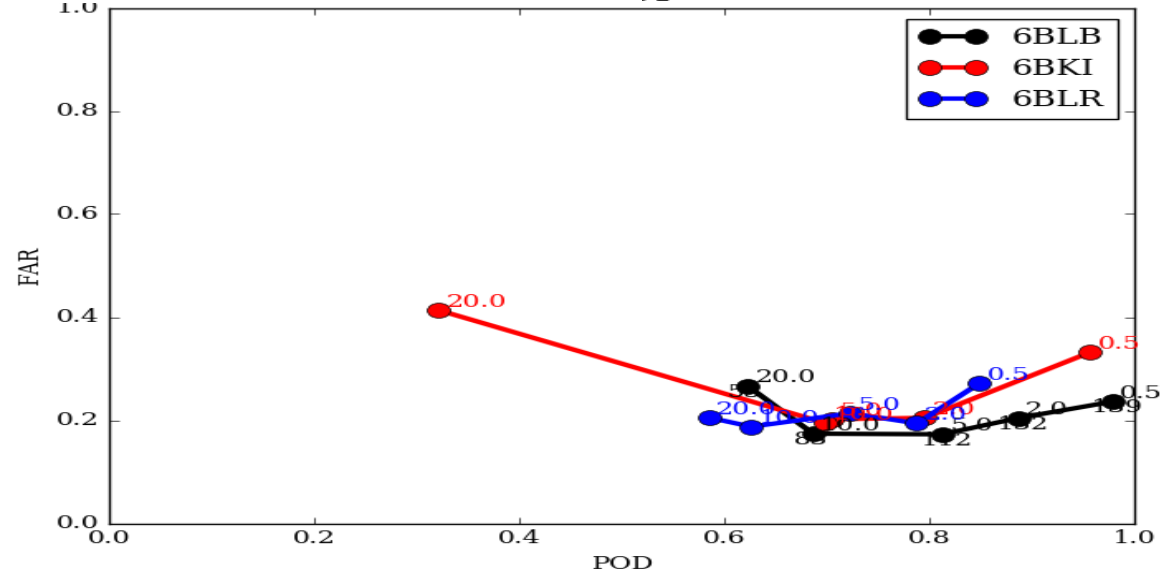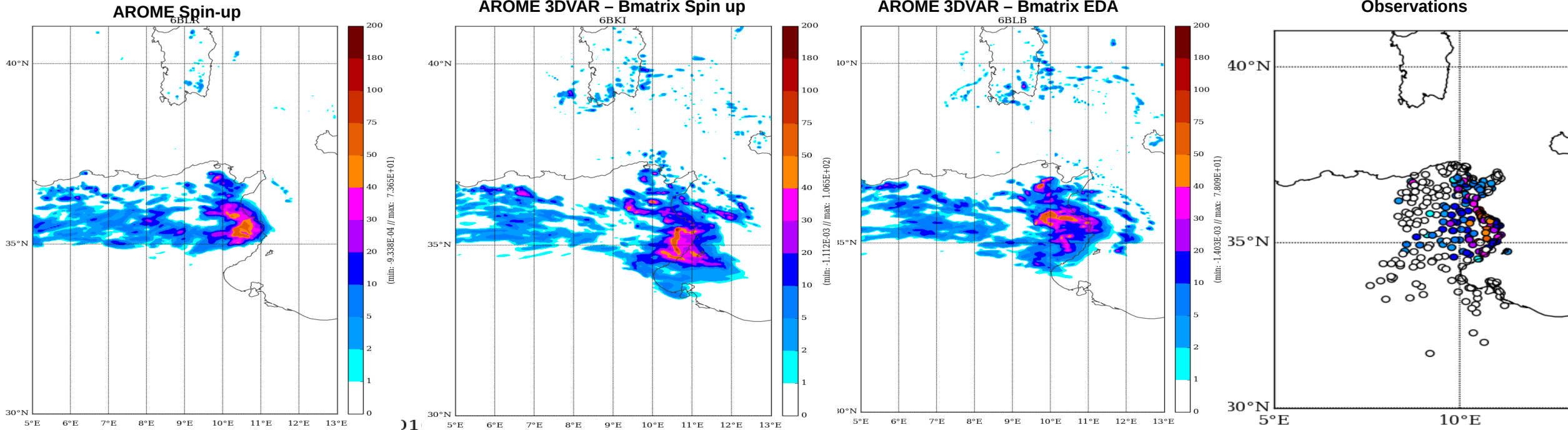
Case study - 23 September 2016

Better Prediction for the cell localization and intensity:

▪Better Prediction for the cell localization and intensity for Arome 3DVAR compared to Spin up

▪Better scores for Arome 3DVAR EDA Bmatrix compared to Bmatrix Spin up

Convective Situation causing heavy rain & flood

19