

NUMERICAL WEATHER PREDICTION IN MOROCCO IN 2009

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Summary of highlights (2009)

- No change in operational suite
- Pre operational validation on different real situations of a new cycle of the ALADIN model.
- Test the very high resolution model AROME over morocco (2.5 Km)
- Développement of an application for the prediction of extreme temperatures on moroccan cities using the statistical adaptation of model outputs
- Développement of an application of the Model verification versus ARPEGE ANALYSIS

Prediction of extreme temperatures on moroccan cities using the statistical adaptation of model outputs

An application based on R-Project software is developed and made in operational in order to produce the forecasts of minimal and maximal daily temperatures over 40 moroccan cities. This production is based on linear regression model using model output statistics combined to the observations.

The parameters are then forecasted for 3 days range every day. The data used corresponds to 2 years, and the results were tested on different set of data. The products are put into the intranet web site in order to be used by regional forecaster also.

Développement of an application of the Model verification versus ARPEGE ANALYSIS

An Application based on R-Project Software was developed in order to produce every 10 days the evolution of the scores of the NWP products compared to the ARPEGE/ANALYSIS. The model used is the operational one (ALADIN/MOROCCO) and the fields studied are : temperature, wind, humidity, geopotential and mean sea level pressure.

The computed scores are : Bias and standard deviation, and the concerned ranges of forecast are 12, 24, 36, 48 and 60h, for the both runs beginning from 00h GMT and 12h GMT.

This application is used to detect the difference in the degree of reliability between forecasts ranges, to monitor the quality of the numerical prediction and to evaluate the impact on the dynamical variables of any performed changes especially in extreme

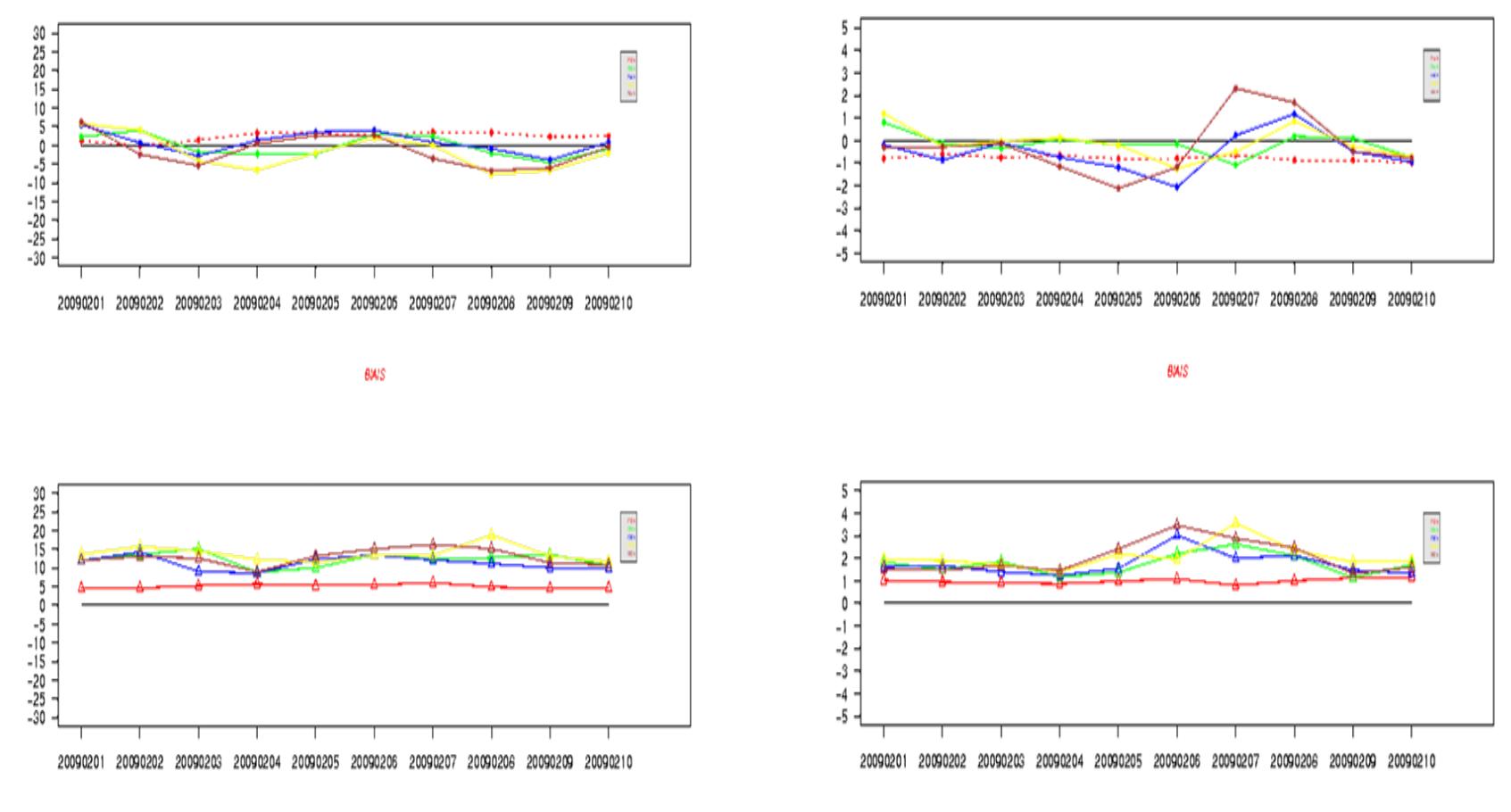


Fig 1: An example of decadal follow-up of some forecasts

Data assimilation, objective analysis and initialization

Assimilation of ATOVS radiances in ALADIN/NORAF

Recently, the Moroccan meteorological service (DMN) was equipped with a receptor system for the MSG data and ATOVS radiances provided by the EUMETCAST system. These data include AMSU-A/B (Advanced Microwave Sounding Unit A/B), HIRS (High Resolution Infrared Radiation Sounder) and MHS (Microwave Humidity Sounder). The received data are of level 1C with BUFR format.

A study was carried out to assimilate ATOVS radiances in ALADIN/NORAF. The aim of this study, was also to assess their added-value. The results show a significant impact of the assimilation of these radiances on analyzed fields, especially for Temperature, geopotential and humidity.

Calculation of B matrix for ALABCHIR

The Moroccan Meteorological service (DMN) plans to run ALADIN/MAROC (ALBACHIR) on 3D-VAR assimilation mode. So, it is essential to compute the B matrix associated to the variances/covariances of background error. This matrix was calculated using the "lagged NMC" method, which consists on making statistics on the differences of forecasts (P36h-P12h) valid at the same time. The forecast P12h uses the same lateral boundary conditions as P36h, in order to decrease the effect of "large scales" features. The statistics are calculated over a period of 3 months.

Ensemble Prediction System (EPS)

work concerning Ensemble Prediction and Assimilation System, in collaboration with Météo-France is currently under development. The purpose is to build an ensemble data assimilation using perturbed guess in addition to perturbed observations in the first assimilation cycle step. Experiments were carried out in Toulouse using the global model ARPEGE and the 3D-FGAT assimilation scheme.

In Morocco, this work was projected onto a limited area domain (ALBACHIR which is centred over Morocco) to have a data assimilation and prediction system by locally producing perturbed initial conditions and perturbed boundary conditions. The LAM ALADIN is used with the 3D-Var data assimilation scheme.

The technical part of this work is almost finished, however, the work of method validation and results verification is to be performed soon.

Evaluation from large-scale (20 Km) to meso-scale (2.5 Km) simulated rainfall in regard to October 2008 observations

The meteorological situation during the month of October 2008 is characterized by exceptionally heavy rainfall over Morocco. The country was under tropically weather conditions. In some areas records were broken, with precipitations ten times the norm (over a 30 year period).



Fig 2 : North of morocco flood during octobre 2008

Models : some general features

ALBACHIR (ALADIN OPER) :

The opérationnal moroccan domain can be seen in Figure 2. Computations are performed in spectral space with elliptic truncation at wave number 277. Grid has 16.7 Km gridmesh. The vertical computation has 37 layers. Coupling files provided by ARPEGE FRANCE every 3 hours, initial state is a dynamical adaptation. Runs are performed each day at 00 and 12 UTC, forecast terms are 60H.

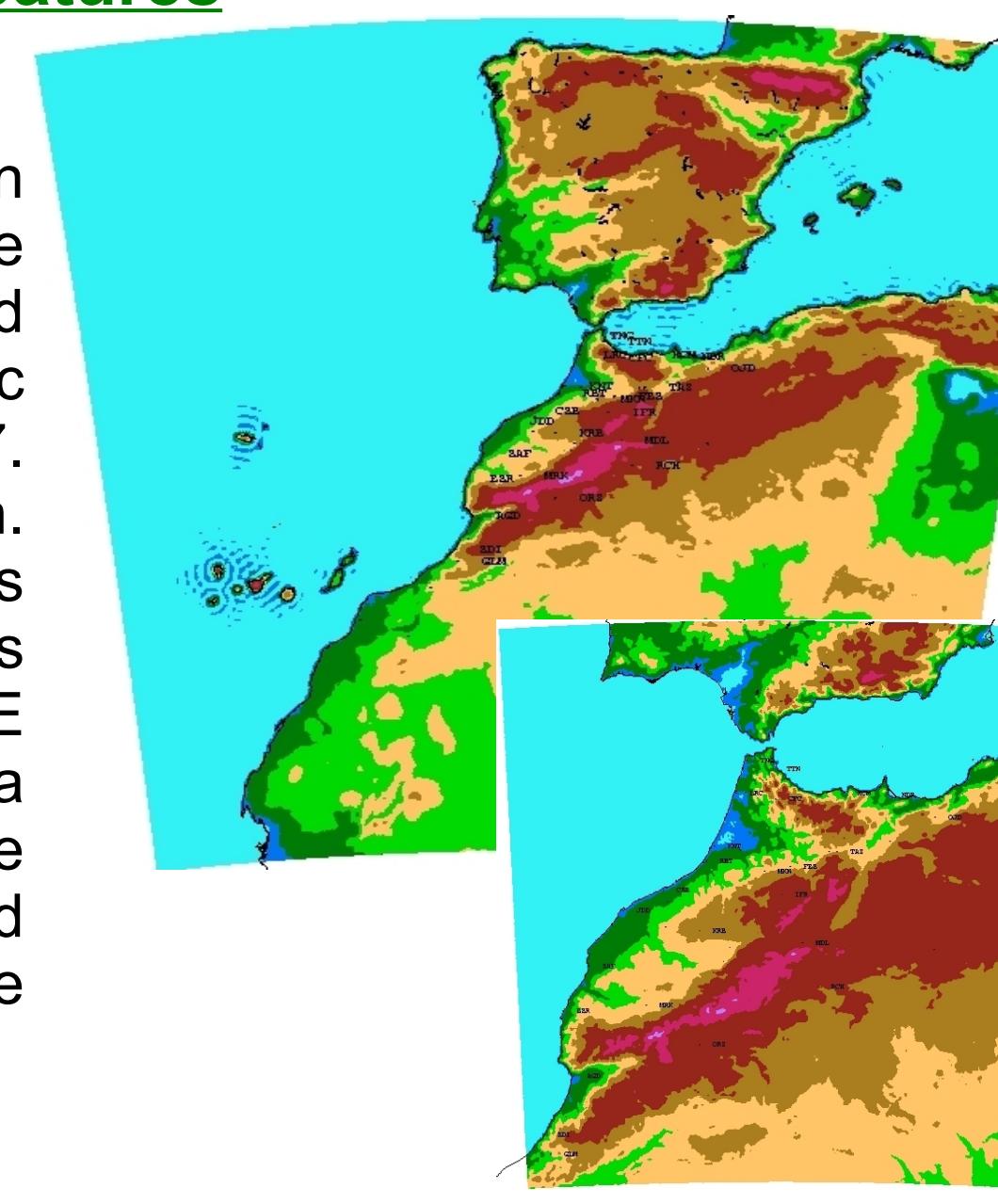


Fig 3 : The ALADIN-Maroc and AROME-NORDM domain, with the orography

ALADIN 10 Km : 10 Km horizontal resolution, 60 Layers in the vertical. Coupling files provided by ARPEGE FRANCE. Forecast term is 48H

AROME 2.5 Km : gridmesh, 46 layers in the vertical. Complex physical parametrisation. The AROME domain covers a smaller area [LAT(28.4,37.8) ; LON(-10.5,0.8)]. From the ALADIN (10km) analysis at 00 UTC, it is coupled with the forecast every three hours, Its forecasts at 24h.

CEP : The ECMWF operational IFS deterministic model, 20 Km horizontal resolution (T 799), 91 layers in the vertical

The 23d October 2008 event

The synoptic analysis of the 23d of October 2008 reveals that the altitude minima was very deep and that the temperature of cold drops was very low. In the Mediterranean region, east and North East sea winds deepened the instability, carrying an important flux of humidity inland. Thus, the Tangier region was hit by severe thunderstorms. A very serious meteorological situation attested by satellite and radar pictures were the cell that caused flooding in Tangier is clearly visible.

Furthermore, the hourly precipitation diagram from Tangier harbour shows the repartition of rain during the "black Thursday" of the 23d of October. The maximum fell between 1 et 7 PM with a climax between 3 and 4 PM lasting about 45 minutes.

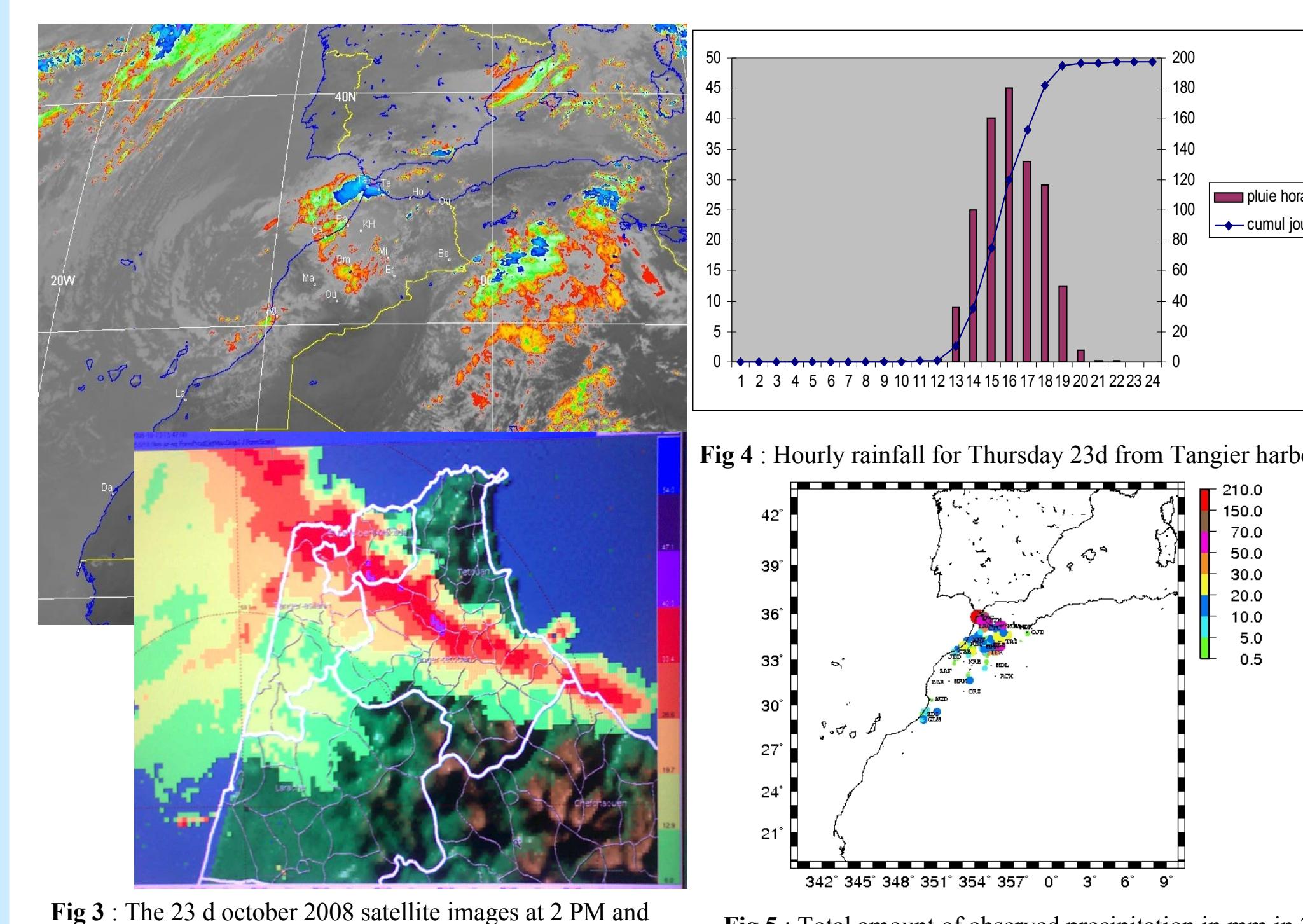


Fig 3 : The 23 d october 2008 satellite images at 2 PM and Radar image at 4 PM

Fig 4 : Hourly rainfall for Thursday 23d from Tangier harbour

24 H total precipitation predicted by models

Operational ALBACHIR model (ALADIN, 16.7Km)

The DMN operational numerical model (operational ALBACHIR 16,7 km for CY29t2) was unable to pinpoint storms and their intensity.

ALADIN 10 km

Figure 7 shows that this new version of the model has enabled to slightly meliorate the precipitating structures of the 23d of October 2008

AROME : The very high resolution model

The Cloud Resolving Model AROME was used during the whole month of October for daily forecast with a 24 h term. Figure 7 shows that AROME predicts a maximum total rainfall of 200mm per 24 h, which is what the observations show as well as the recorded flooding in the North of the country. But these maxima were localised near the South East of Tangier and were far more numerous elsewhere.

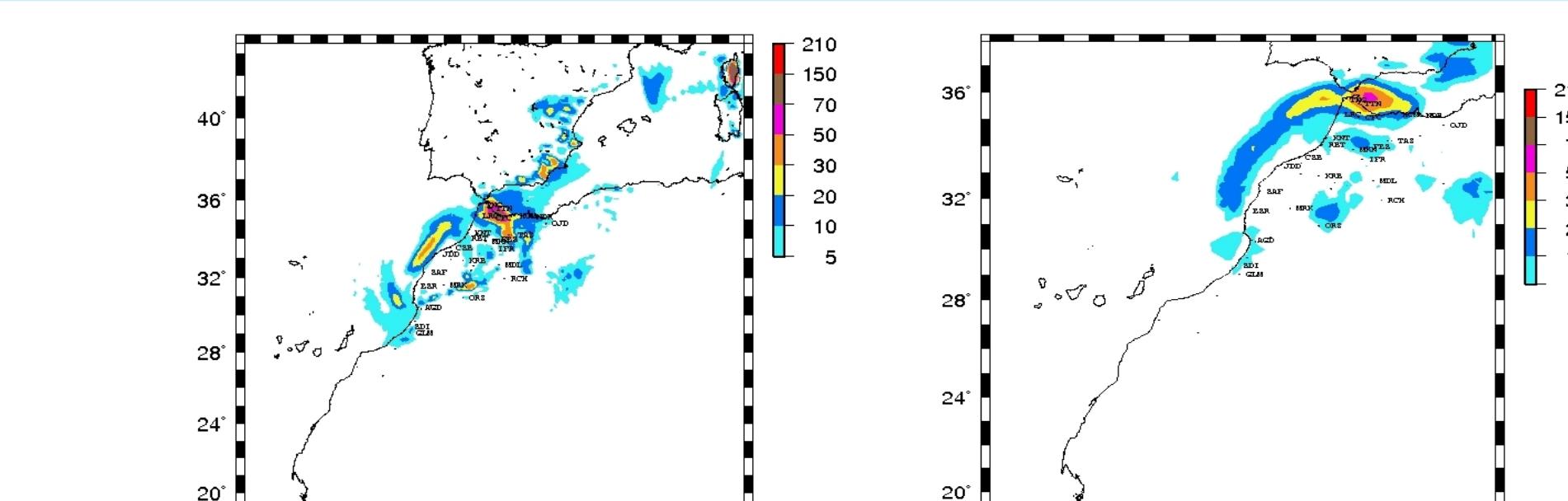


Fig 6 : 24h total amount of precipitation predicted for the 23/10/2008 from ALBACHIR OPER (left) and ECMWF (right)

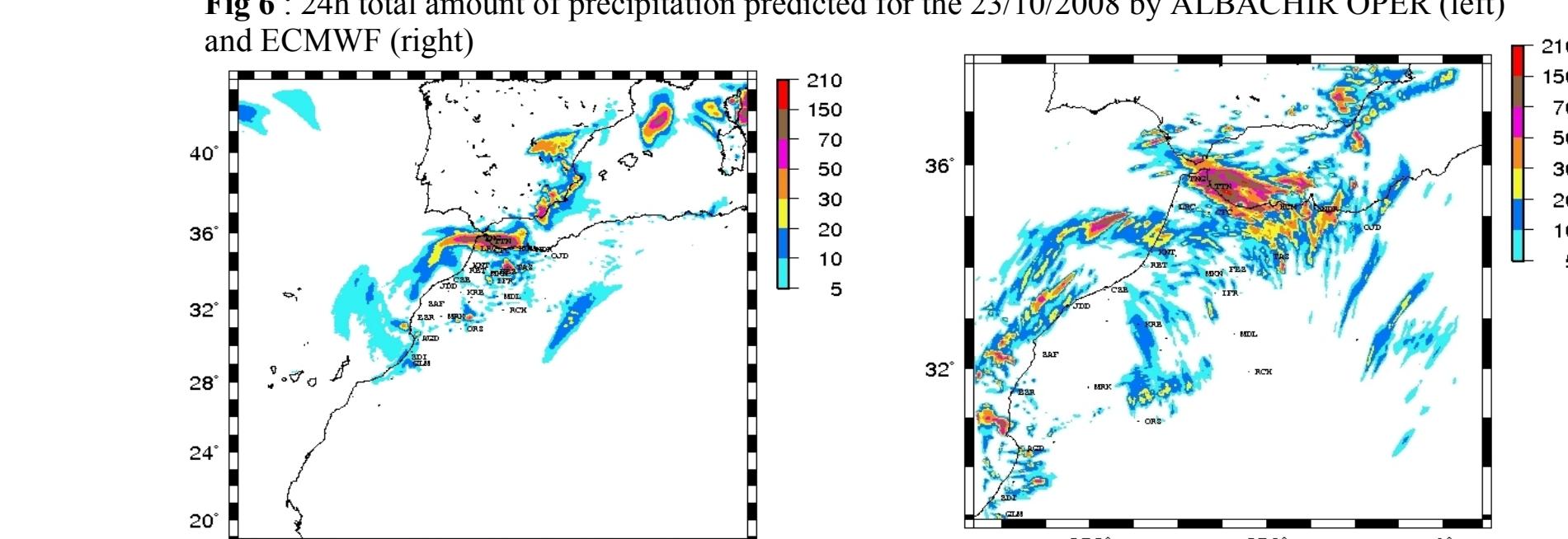


Fig 7 : 24h total amount of precipitation for the 23/10/2008 from ALBACHIR 10 Km (left) and AROME 2.5km (right)

Evaluation of simulated rainfall against observations (20 days)

For the four models, to compute bias, ETS, FAR, POD and ACC scores, first of all, we made an interpolarisation of the four predicted rainfall at the observation point (Cressman interpolation). The thresholds used for the computation of the different scores are as follow: 0.2, 1, 2, 5, 10, 20, 30 and 50 mm.

Computed scores for the period 8-29 October 2008 have shown that ALBACHIR OPER and ECMWF models tend to underestimate heavy precipitations whereas ALADIN 10km and AROME overestimate them.

ALADIN 10km and AROME better scores for heavy precipitations.

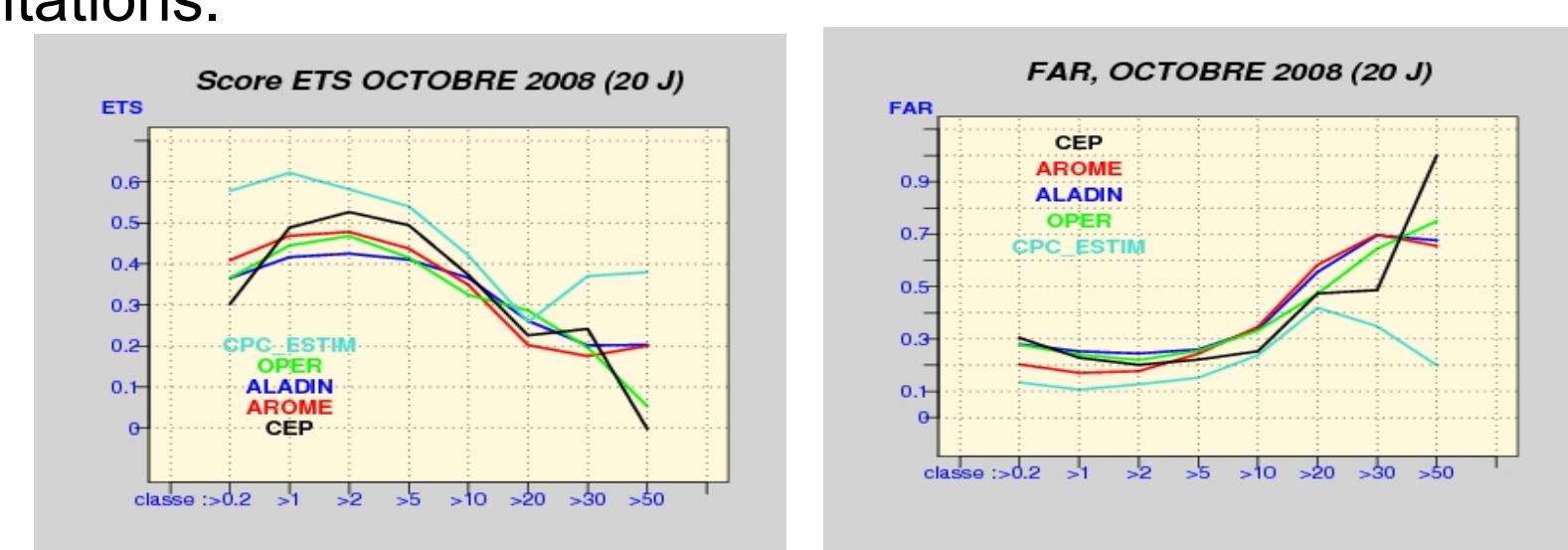


Fig 8 : The ETS and POD scores for the precipitations of the four models (ALBACHIR OPER, ALBACHIR 10km, AROME 2.5km and ECMWF) from the 8th till the 29th of October 2008

Sensitivity of the ALADIN model to the large scale coupling, ARPEGE versus IFS

Coupling with the IFS has improved the performances of Aladin as concerns the forecast of heavy rain events (high thresholds of the ETS), while we have noticed at the same time a deterioration of the forecasts of light rain. A general shortcoming is that Aladin tends to overestimate the quantities of precipitations.

Future studies on the respective impacts of coupling with ARPEGE or the IFS will concern the evaluation of more altitude and surface fields, as well as running other test periods (especially, situations of atlantic weather regimes, while the present one focussed on a period of mostly convective activity).

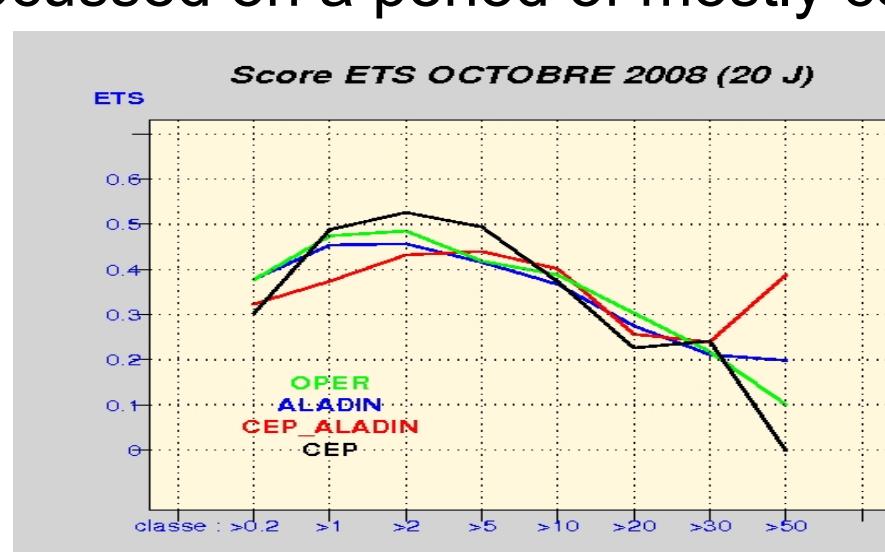


Fig 9 : Equitable Thread Score for various thresholds: OPER (operational version), ALADIN (new operational version), CEP_ALADIN (new version and coupling with IFS), and CEP (IFS data)

Assimilation of remote-sensing chemical measurements

The assimilation of remote-sensing chemical measurements aims at better characterizing their three-dimensional distributions. The objective is to get insight into the coupled chemical and dynamical phenomena. Two complementary tools are used : one is based on the three dimensional chemistry and transport model MOCAGE using the 3D-FGAT variational technique; the other is an extension of the operational suite of the numerical weather prediction ARPEGE using the 4D-Var variational technique. The chemistry-dynamics coupled assimilation in ARPEGE is used to assess the dynamical impact of ozone observation (Semane et al., ACP 2009).

Moreover, the MOCAGE-PALM limited area data assimilation system is configured to run over Morocco and assimilate ozone and nitrogen dioxide data provided by the two satellite instruments MetOp/IASI and Aura/OMI.

Plans for the future

The acquisition of a new more powerful calculation system will enable us to :

- Increase the resolution of Aladin/Noraf to 18 km, with 3dvar data assimilation
- Increase the resolution of Aladin/Maroc to 10 km
- Run Arome model over some restricted domains with a resolution of 2.5 km.
- Implementation of SEVIRI and ATOVS data in ALADIN/Morocco 3D-VAR data assimilation system.
- Implementation of ensemble-based background error statistics and assessment of their impact in ALADIN/Morocco 3D-VAR data assimilation system.
- Forecasting Fog in the international aeroport Mohammed V by Cobel-1D coupled by ALADIN/Morocco
- Do some EPS studies.