WWW Technical Progress Report on GDPFS - 2004

Country: **Italy** Centre: **CNMCA** (UGM)

1. SUMMARY OF HIGHLIGHTS

A number of changes occurred over the last year at the Italian Meteorological Service, both for several hardware and software upgrades, and for modifications in operational and forecasting procedures. This evolution, described in some details in the following paragraphs, has already been completed especially for:

- A new 3D multivariate - physical space analysis system (3DVar-PSAS) with:
  - Introduction of asynoptic observations into the variational data assimilation suite
  - Increase of the horizontal resolution and widening of the integration domain
  - Introduction of non separable background error correlation functions in the Variational Objective Analysis
  - New post processed products
- The routinely processing implementation of non-hydrostatic high resolution models at ECMWF (EURO LM)
- Deterministic post-processing package for EURO-LM model fields (AWI)
- DB based real time operations
- New web and satellite based dissemination systems (Prometeo and NUBIS systems)

2. EQUIPMENT IN USE

- GTS management:
  Message Switching System (MSS)
  Computer type: cluster of 2 Compaq AlphaServers 1200/2100
  OS: Unix
  RDBMS: Informix in High Availability
- Data collector system:
  GTS-connected DB, Operational Meteorological DB, Climatic DB
  Computer type: cluster of
  - 2 Compaq GS60E - 4 processors each
  - 2 AlphaServer 4100 - 2 processors each
    (to be replaced in 2005 with 2 Compaq ES45 – 4 processors)
  - AlphaServer 1200 (cluster management and whole system monitoring)

  OS: Unix
  RDBMS: 3 different customisations of Informix in High Availability.
- GRIB collector system:
  DISTRICO (GRIB Data Distribution System)
  Computer type: cluster of 2 DS20E
  RDBMS: Informix in High Availability

Every cluster has a dedicated File System with 5+1 RAID capacity.

- Numerical weather prediction system:
  ECMWF Service
  Computer type: IBM-P690 1-4 nodes 30/120 processors.
- NWP Testing system:
  Computer type: Compaq ES45
- Post-processing / charts-graphics production system:
  Computer type: 5 workstation Compaq DS10

The dissemination of products and of the Italian weather network observations is made in two different ways:

- PROMETEO : Web based system (Internet)
- NUBIS : Satellite based system (Broadcasting)

3. DATA AND PRODUCTS FROM GTS IN USE

Data received from GTS:

AIREP	AMDAR	BUOY	PILOT	SHIP	SYNOP	TEMP-TEMPSHIP	ERS	SATOB (MSG)	ACAR
3500	5550	200	900	3120	27000	1100	400	120000	15000

GRID from UK Met Office: 500
GRIB from UK Met Office: 150
Aeronautical facsimile products: 96

Data from other sources

AMSU-A	Seawind Quickscat	ERS2
1000	500	30

GRIB from ECMWF (Global model, EPS model, Wave model): 4244
GRIB from ECMWF (Boundary Condition): 21996

4. DATA INPUT SYSTEM

Automated.

5. QUALITY CONTROL SYSTEM

GTS messages are controlled in several ways depending on the use of data:

Foreign messages switched by RTH-ROME

- control on the transmission code (header, abbreviated header…)

- syntactic consistency control

Italian messages :
- control on the transmission code (header, abbreviated header…)
- syntactic consistency control and correction

Messages stored in the Operational DB and in the Climatic DB:
Every parameter value of observations decoded and stored in the DB's is checked with a pre-processing software to assign a degree of consistency.
The tests are:
- Gross limit checks: the parameter values are compared with gross limits for the parameter;
- Internal consistency checks: the redundancy of information allows some internal checks;
- Time continuity checks: tests regarding the position of moving platforms.

6. MONITORING OF THE OBSERVING SYSTEM

All the observations used by the NWP system are controlled by comparison to the 3DVar Analysis and to the first guesses produced by the Euro HRM Forecast Cycle.

7. FORECASTING SYSTEM

The operational forecasting system is based on:
- 2 different numerical applications of the same model with different domains, Euro HRM (Euro-Atlantic region, 28 km spatial resolution) and HRM (Mediterranean region, 14 km resolution),
- Non Hydrostatic LM (Italian region, 3km resolution), named LAMI

The Euro HRM and the HRM models are inserted in the same assimilation cycle, while the LAMI model has an own cycle.
Mayor changes planned:
In 2005, the operational forecast system will be based on EuroHRM with 14 km spatial resolution and on the Non-Hydrostatic Mediterranean LM with 7 km resolution.

7.1 Schedule of the forecasting system

The schedule of the short range forecasting system, based on 3DVar–PSAS Analysis, EuroHRM and HRM is the following:

	0000 UTC	0600 UTC	1200 UTC	1800 UTC
Cut-off	**1h 50m**	**2h 10m**	**1h 50m**	**2h 10m**
3DVAR analisys end	**02.40 UTC**	**08.50 UTC**	**14.40 UTC**	**20.50 UTC**
Euro HRM range	**72h**	**24h**	**72h**	**24h**
Euro HRM time step	**240"**	**200"**	**240"**	**200"**
Euro HRM end	**03.40 UTC**	**09.15 UTC**	**15.30 UTC**	**21.15 UTC**
HRM range	**48 h**	**--------**	**48 h**	**--------**
HRM end	**04.30 UTC**	**--------**	**16.30 UTC**	**--------**
HRM time step	**120"**	**--------**	**120"**	**--------**

The high resolution forecasting system, based on a nudging assimilation cycle and the LAMI, has the following schedule:

	0000 UTC	1200 UTC
Cut-off	**4h 00m**	**4h 30m**
Nudging	**05.20 UTC**	**17.50 UTC**
LAMI range	**72h**	**24h**
LAMI time step	**40"**	**40"**
LAMI end	**07.30 UTC**	**20.00 UTC**

7.2 Medium range forecasting system (4-10 days)

The medium range forecasting system is based on the ECMWF IFS and more specifically on following components:

MODEL	Purpose
Global Model	**Deterministic medium-range forecasts**
Ensemble Prediction System	**Probabilistic medium-range forecasts**
Global Wave Model	**Maritime forecasts on demand**
Mediterranean Wave Model	**Mediterranean Sea forecasts and Warnings**

7.3 Short range forecasting system (0-72h)

7.3.1 Assimilation, objective analysis and initialisation

The assimilation runs with a 6-hours cycle. The Objective Analysis is performed with a multivariate three dimensional variational scheme (3DVar) – physical space analysis system (PSAS).

Assimilated data	**SYNOP SHIP BOUY TEMP TEMPSHIP PILOT AIREP AMDAR AMV(Meteosat 8) AMSU-A**
Assimilation cycle	**6 hours**
Analysis method	**3D Multivariate PSAS analysis**
First guess	**6 hours EuroHRM forecasts (Otherwise 12 or 18 hours)**
Coverage	**Euro-Atlantic area**
Horizontal resolution	**0.5° x 0.5°**
Vertical resolution	**31 pressure levels**
Initialization	**Normal mode initialisation**

7.3.2 Model

Hydrostatic Modeling

The main features of the operational models running in use are summarized in the following tables:

Euro HRM

Domain size	181 x 121
Grid spacing	0.5°
Number of layers	31
Time step and integration scheme	240 sec split semi-implicit
Forecast range	72h
Initial time of model run	00/06/12/18 UTC
Lateral boundary conditions	BC ECMWF
L.B.C. update frequency	3 hours
Initial state	3D-PSAS(T,u,v,Pseudo-RH,Surf .Press.)
Initialisation	Normal Mode Initialisation
Status	Operational

HRM (Mediterranean)

Domain size	151 x 101
Grid spacing	0.25°
Number of layers	31
Time step and integration scheme	120 sec split semi-implicit
Forecast range	48h
Initial time of model run	00/12 UTC
Lateral boundary conditions	EuroHRM
L.B.C. update frequency	1 hours
Initial state	3D-PSAS(T,u,v,Pseudo-RH,Surf. Press.)
Initialisation	Normal Mode Initialisation

Status	Operational

Developments

Over the past year a number of developmental and operational changes were carried out in the CNMCA NWP Section, with experimental runs on the IBM P960 at ECMWF:

- Introduction of asynoptic observations into the variational data assimilation suite (Atmospheric Motion Vectors from Meteosat 5-7-8, Quikscat and ERS2 scatterometer winds, AMDAR-ACAR aircraft observations, Wind profilers observations). For each new observation type Observing System Experiments (O.S.E.) have been performed, showing statistically significant improvements (see, for example, Bonavita and Torrisi, 2004)
- Increase of horizontal resolution (0.5 -> 0.25 deg)
- Small increase of integration domain (fig. 1)
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- Introduction of non separable background error correlation functions in the CNMCA Variational Objective Analysis
- New post processed products

Current development activities comprise:

- introduction of direct assimilation of AMSU-A radiances in operational mode;
- introduction of ATOVS based reconstructed temperature and humidity profiles;
- experimentation with advanced analysis techniques

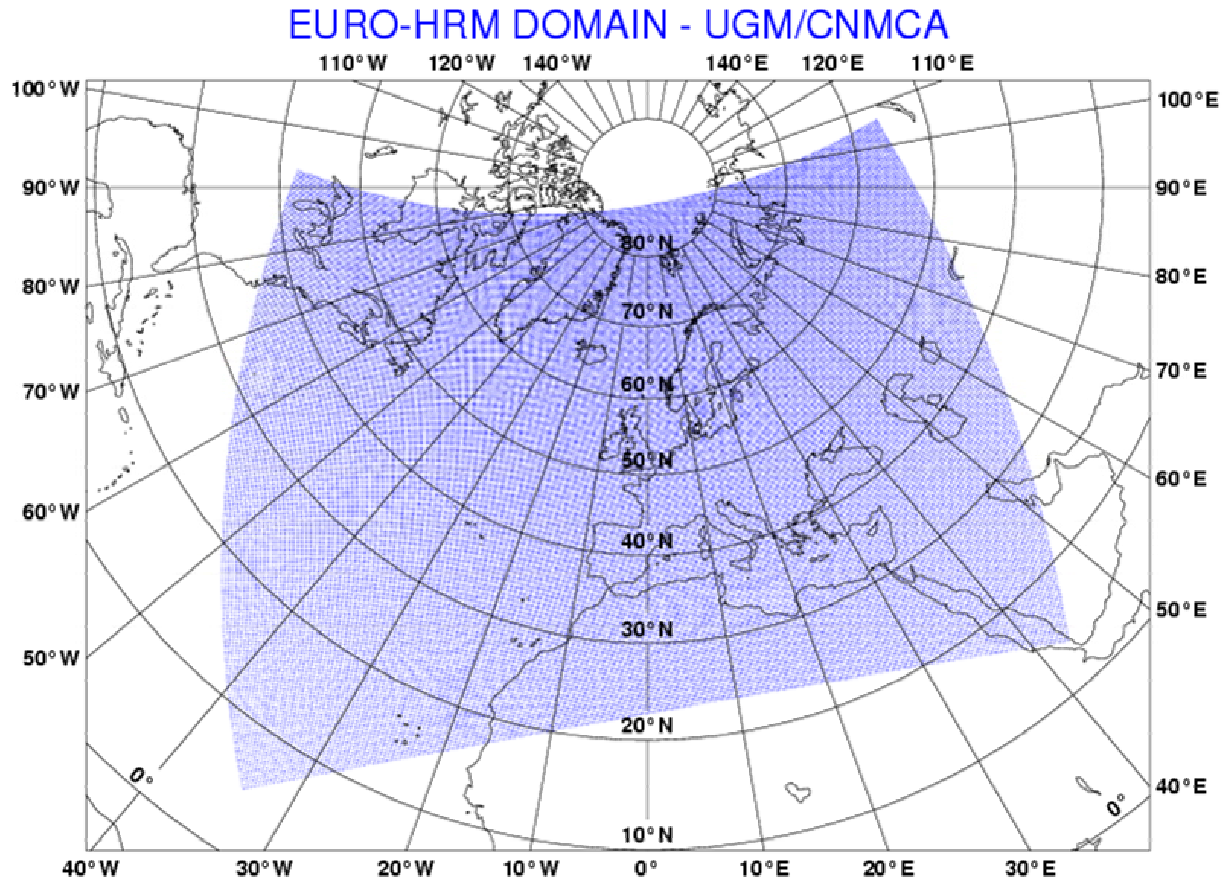

Fig.1 Integration domain for the EURO-HRM hydrostatic model

Domain size	385 x 257
Grid spacing	0.25° (28 km)
Number of layers	31
Time step and integration scheme	150 sec, split semi-implicit
Forecast range	72 hrs
Initial time of model run	00/12 UTC
Lateral boundary conditions	IFS
L.B.C. update frequency	3 hrs
Initial state	3D-PSAS(T,u,v, Pseudo-RH, Surf. Press.)
Initialisation	Normal Mode Initialisation
External analysis	None
Status	Operational
Hardware	IBM P960 (ECMWF)
N° of processors used	32 (Model Run), 60 (Analysis)

Table 1 Characteristics of EURO-HRM implementation runs

Non-Hydrostatic Modeling

The non-hydrostatic modelling is based on the following Italian version of the Local Model (LM), run at CINECA (Bologna):

Local Model (LAMI)

Domain size	**184 x 272**
Grid spacing	**0.0625° (7km)**
Number of layers	**35**
Time step and integration scheme	**40 sec 3 time level split semi-implicit**
Forecast range	**72 h**
Initial time of model run	**00/12 UTC**
Lateral boundary conditions	**GME DWD**
L.B.C. update frequency	**3 hours**
Initial state	**Nudging obs**
Initialisation	**None**
Status	**Operational**

LAMI outputs are transferred to CNMCA and quasi-operationally used in the Forecasting Section.
The non-hydrostatic Local Model over the continental Europe domain (EURO-LM), (Fig.2) has also been implemented at ECMWF using CNMCA 3D-PSAS analysis as initial and IFS forecast fields as lateral boundary conditions.
The main features of the operational implementations of the EURO-LM are summarized in Table 2.

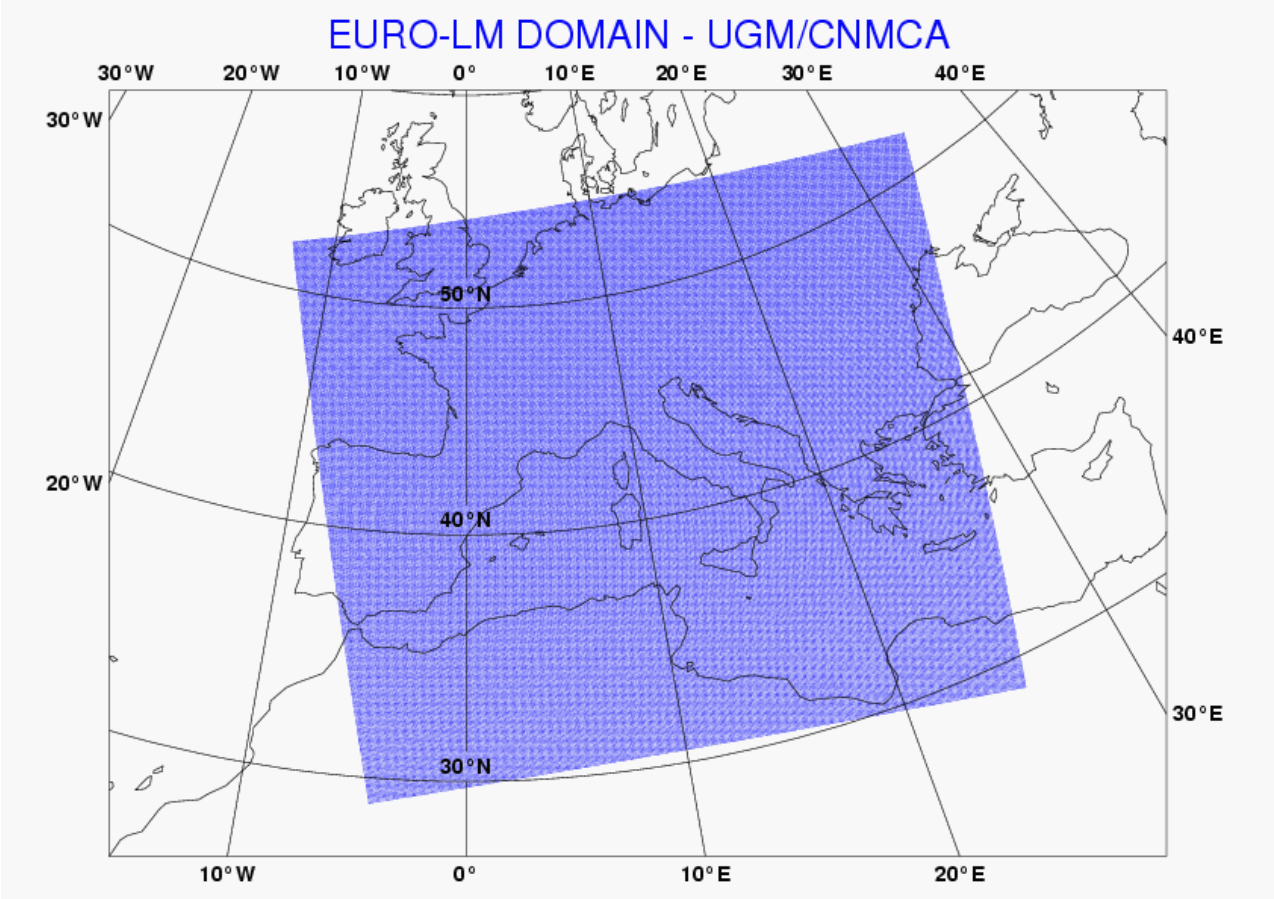

Fig. 2: Integration domain for the EURO-LM non-hydrostatic model implementation on IBM P960 at ECMWF.

7.3.3 Numerical weather prediction products

AWI

A deterministic post-processing package of the EURO-LM model fields known as Automatic Weather Interpretation (AWI) has been also implemented. Details are given in Ciciulla, 2003. An example of AWI products is given in Fig. 3.

Current work is focused on the validation of the AWI products through comparisons with actual observed weather phenomena. Further progress is expected by the foreseen upgrade of the deterministic schemes currently employed in AWI with MOS and/or neural network based algorithms.

ARGO

Statistical post-processing local forecasts from ECMWF model outputs are still regularly produced for 150 Italian stations, at 6 hours intervals and up to 144 hours.

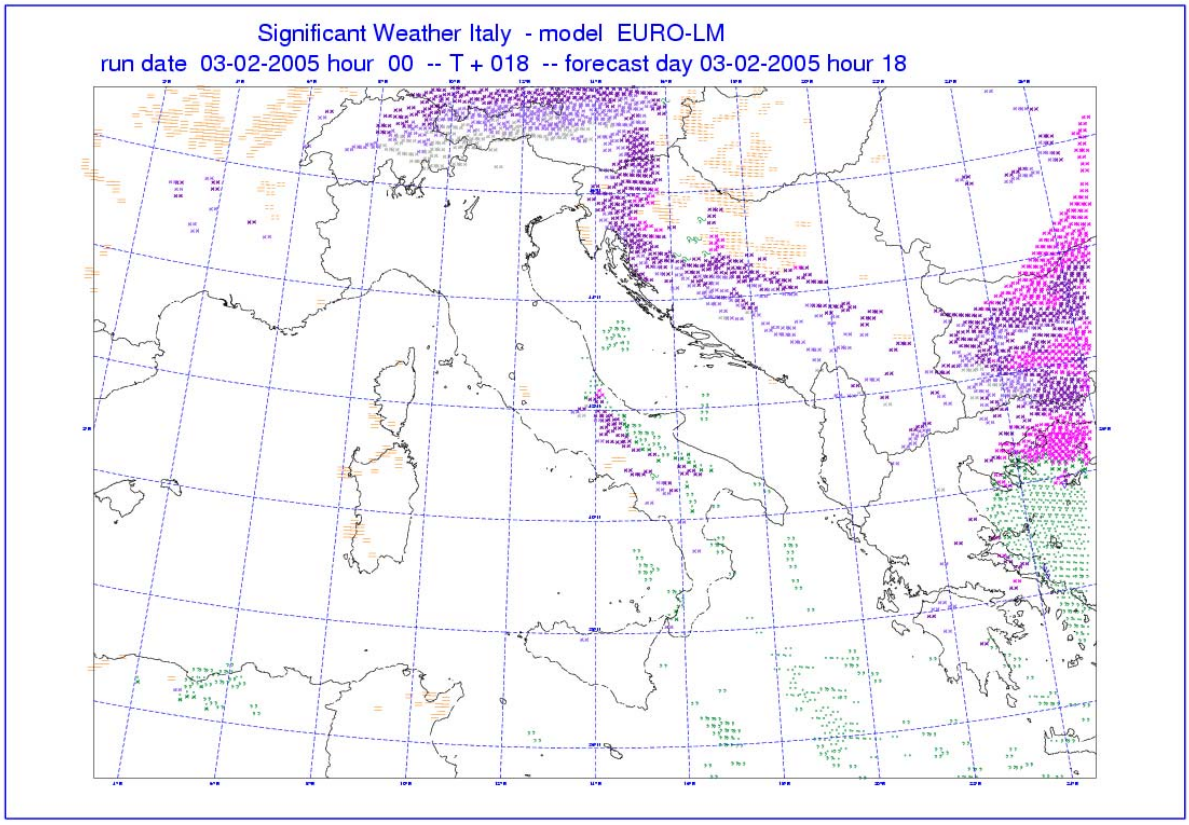

Fig. 3: Example of AWI product from post-processed EURO LM model fields.

Domain size	465 x 385
Grid spacing	0.0625 (7 km)
Number of layers	35
Time step and integration scheme	40 sec , 3 time level split-explicit
Forecast range	72 hrs
Initial time of model run	00/12 UTC
Lateral boundary conditions	IFS
L.B.C. update frequency	3 hrs
Initial state	CNMCA EURO-HRM 3D-PSAS
Initialisation	None
External analysis	None
Special features	Use of filtered horography
Status	Operational
Hardware	IBM P960 (ECMWF)
N° of processors used	120

Table 2: Characteristics of EURO LM routine implementation runs.

7.3.4 Operational Techniques for application of NWP products

DISTRICO
A product distribution system was implemented at CNMCA for the dissemination of products in GRIB format. A kind of post-processing of the GRIB data produced by the numerical models is needed to fulfil the requests of the internal and external users, as delivering of processed products to users need to be controlled and should be easy to configure and modify. The system requirements can be summarised as follows:

- Transformation of GRIB data from a grid to another one (e.g. from a rotated lat-lon grid to a geographical lat-lon grid)
- Interpolation, rotation and extraction of single point data from a GRIB file
- Processing a large number of GRIB files
- Distribution of processed GRIB to users
- Friendly graphical interface for the operator
- Easy access to system facilities through a scripting language
- Graphical real time control of the activities (processing and distribution).

DISTRICO processes 55000 GRIB records (2 GByte in volume) each day. The GRIB processed by the system are produced by the models run at the CNMCA (MedHRM, EuroHRM), the Global Model from ECMWF and the high resolution non-hydrostatic Local Model (LAMI) and are subsequently distributed to internal and external users.

7.4 SPECIALIZED FORECASTS

Pasquill categories in tables and a forest fire index are produced based on ECMWF model outputs. UV index forecasts are produced on the basis of DWD model outputs.

7.4.1 Local Weather Elements
AWI and ARGO post-processing outputs.

7.4.2 Marine
ECMWF Wave Model (0°.25 x 0°.25) is used to produce graphics and tables for marine forecasts, covering the Mediterranean and concerning: sea state, wind, swell (in- and offshore), every 6 h.

7.4.3 Trajectories
3D trajectories at different levels are computed from ECMWF outputs for special purposes (dispertion of pollutants, volcanic ash).

7.5 EXTENDED RANGE FORECASTS (10 TO 30 DAYS)

An experimental procedure for subjective extended forecast for Italy, based on ECMWF products, has been developed and is currently under test.

7.6 LONG RANGE FORECASTS (30 DAYS UP TO TWO YEARS)

A statement for Italy is prepared every month for the three following months describing the possible evidence (if any) of deviation from normal pressure, temperature and precipitation, on the basis of ECMWF seasonal production.

8. VERIFICATION OF FORECASTS

APOLLO

Quality Control of main forecast products through an automatic system named APOLLO (Autom. Procedures Of quaLity controL(O)), which is made up of temporary and permanent archives and of retrieve, elaboration and visualization software producing an updated performance verification of the (interpolated) direct model outputs normally used in the forecasting section (weather parameters). Objective verifications of the five following forecasted weather parameters:

- 2m Temperature,
- 10m wind-Speed,
- 6h Cumulated Precipitations,
- MSLP,
- 2m Dew Point Temperature

and of forecasted upper air parameters are regularly performed for each main synoptic hours and for 4 model meteograms interpolated on 90 localities. Observing and Forecasting data-set is temporally collected on:

- monthly,
- quarterly,
- annual periods

and, besides local, spatially collected in:

- 9 sub-areas (3 Tyrrhenian, 3 Adriatic, Continental North-West, Sicily, Sardinia),
- 3 sub-areas (Northern, Central and Southern Italy),
- 1 large area (Italy as a whole).

Quality aspects considered are Absolute and Relative Accuracy and Bias, that are usually measured respectively by:

a) Mean Absolute Error (MAE), Skill Scores (SS) and Mean Error (ME), for continuous variable;
b) Hit Rate (HR) (together with Threat Score (TS), Probability of detection (POD) and False Alarm Rate (FAR)), True Skill Statistics (TSS) and Frequency Bias Index (FBI), for events.

In table 3 a verification example is shown.

Europe	[…]	+12 hours	+24 hours	+36 hours	+48 hours
W250 RMSEV	m/s	5,8	7,0	7,4	8,4
W500 RMSEV	m/s	4,9	5,4	6,4	7,3
W850 RMSEV	m/s	4,4	5,0	5,4	6,1
AT250 RMSE	°K	1,2	1,5	1,6	1,8
AT500 RMSE	°K	0,9	1,2	1,5	1,7
AT850 RMSE	°K	1,4	1,6	1,7	1,9

Italy	*thresholds (mm/24hrs)*	*0*	*0,5*	*2*	*4*	*8*	*16*	*25*
	d+1	**0,38**	**0,35**	**0,38**	**0,42**	**0,49**	**0,59**	**0,73**
FAR	**d+2**	**0,40**	**0,40**	**0,47**	**0,52**	**0,56**	**0,69**	**0,80**
	d+3	**0,39**	**0,42**	**0,50**	**0,55**	**0,62**	**0,76**	**0,82**
	thresholds (mm/24hrs)	*0*	*0,5*	*2*	*4*	*8*	*16*	*25*
	d+1	**0,55**	**0,55**	**0,49**	**0,43**	**0,34**	**0,25**	**0,17**
TS	**d+2**	**0,53**	**0,48**	**0,39**	**0,34**	**0,27**	**0,19**	**0,11**
	d+3	**0,52**	**0,46**	**0,37**	**0,32**	**0,23**	**0,13**	**0,10**
	thresholds (mm/24hrs)	*0*	*0,5*	*2*	*4*	*8*	*16*	*25*
	d+1	**1,38**	**1,21**	**1,14**	**1,07**	**0,99**	**0,95**	**1,10**
FBIA	**d+2**	**1,33**	**1,18**	**1,15**	**1,09**	**0,96**	**1,10**	**1,05**
	d+3	**1,28**	**1,19**	**1,17**	**1,11**	**1,04**	**1,07**	**1,08**
	thresholds (mm/24hrs)	*0*	*0,5*	*2*	*4*	*8*	*16*	*25*
	d+1	**0,85**	**0,79**	**0,71**	**0,63**	**0,51**	**0,39**	**0,30**
POD	**d+2**	**0,80**	**0,71**	**0,61**	**0,53**	**0,42**	**0,34**	**0,23**
	d+3	**0,79**	**0,69**	**0,58**	**0,51**	**0,38**	**0,29**	**0,20**
	thresholds (mm/24hrs)	*0*	*0,5*	*2*	*4*	*8*	*16*	*25*
	d+1	**0,52**	**0,59**	**0,57**	**0,53**	**0,44**	**0,36**	**0,28**
KSS	**d+2**	**0,47**	**0,50**	**0,46**	**0,42**	**0,36**	**0,30**	**0,19**
	d+3	**0,45**	**0,45**	**0,44**	**0,39**	**0,30**	**0,20**	**0,17**

Table 3: Operational Euro HRM scores, 00 UTC run, against observations (2004 last quarterly).

9. PLANS FOR THE FUTURE

During 2005 a new operational forecasting system will be implemented, based on the EURO HRM and EURO LM, but with better vertical resolution (40 levels)

10. REFERENCES

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Ciciulla, Fabrizio (2003): **"**A deterministic post-processing program applied to the Local-Model output fields**",** presented at the 2nd SRNWP - Workshop on Statistical and Dynamical Adaptation, 5–6 May 2003, Vienna, Austria (available online at http://srnwp.cscs.ch/)

www.meteoam.it presents a selection of updated NWP products and other information