Annual Joint WMO Technical Progress Report on the Global Data-Processing and Forecasting System and Numerical Weather Prediction Research Activities

ARGENTINA – 2007
National Weather Service
(www.smn.gov.ar)

1. Summary of research development and main operational changes

The Regional Specialized Meteorological Center Buenos Aires (RSMC BUENOS AIRES) has been running a regional ten levels primitive equations model since April 1998 (ARPE). On the other hand, the numerical model ETA SMN is operational since January 2003 while a non-hydrostatic version is operational since January 2006. A low resolution wave model induced by the GFS model (NCEP) and a high resolution wave model induced by the ETA SMN model are executed in this center in collaboration with the Navy Weather Service of Argentina. All models run for the 00 and 12 UTC cycles. Selected fields obtained are displayed on the Internet while a full output is available for the NMC associated to the RSMC. Major operational changes and model error corrections in 2007:

August 2007 Oracle data base is operational. Migration from the old data base is in progress for real time data.

October 2007 Eta Code fixes to reduce bias error on surface temperatures in subtropical Argentina.

2. Equipment in use at the Centre

Function	Computer	CPUs/ Processor	Memory	Disk Storage
Oracle Data base and quality control system	HP Proliant ML350G4 Server	2 Intel Xeon 3.4 GHZ, 1mb cache	DDR ECC 2GB	
Ideafix Data base and Data quality control system	SG * CHALLENGE S Series	1 R4400 200MHz	256MB	2 GB system disk External 4 x 4 GB SCSI disk
Arpe Model	SG* INDIGO^2 IMPACT	1 R10000 175MHz	128MB	2 GB system disk External 2 x 9 GB SCSI disk
ETA SMN model Nested ETA model Wave Model	SG* ORIGIN 2004	4 R10000 500 MHz 8 R10000 250 MHz 4 R10000 30 MHz	3338MB	9 GB system disk 36 GB External SCSI disk

*SG, Silicon Graphics

Other peripheral equipment and systems are used for database purposes. The National Meteorological Centre is operating with two databases, the operative one, Oracle, and Ideafix (old data base). The latter one only supports real time data.

3. Data and Products from the GTS in use

In general all data in alphanumeric formats are obtained through the GTS. Data received operationally include: SYNOP, TEMP, SATOB, SATEM, BUOY, AIREP, AMDAR, METAR, GRID, SHIP, SIGMET, TAF, PRONAREA.

Model outputs in GRIB formats are obtained with FTP protocol.

4. Forecasting System

4.1 System run schedule and forecast ranges

(No changes since previous report)

A full cycle primitive equation model, ARPE model, is run at this centre for the 00 and 12 UTC cycles (at 3 UTC and 15 UTC). Data assimilation is performed every twelve hours. The first guess field is generally the twelve hours one predicted by the model in the previous run and in case of model divergence, the climatological field for that month. Objective analysis based on a successive correction scheme is used (Cressman). The forecast range y 36 hours and the run time is 15 minutes.

The regional ETA model is initialized with the analysis fields from the GFS model (NCEP). Boundary conditions are updated every twelve hours and are taken from the GFS model from the same cycle as well. The 00 (*12*) UTC cycle starts its integration at 01 (*13*) UTC approximately and performs a 132 hour forecast in 1hr 20 min. Graphic outputs are generated simultaneously.

The nested high resolution and non hydrostatic ETA model starts its integration after the parent model at 10:30 UTC for the 00 UTC cycle, and at 18 UTC for the 12 UTC cycle. It performs at 36 hour forecast in 1 hour and 30 minute.

4.2 Medium range forecasting system

(Not performed at this centre)

4.3 Short-range forecasting system

(No changes since previous report)

4.3.1 Data Assimilation objective analysis and initialization

ARPE Model

Objective analysis: a successive correction one (Cressman). The analyzed variables are geopotential heights, temperature, humidity and wind components for ten pressure levels (1000, 850, 700, 500, 400, 300, 250, 200, 150 and 100hPa); temperature, pressure and humidity at surface and tropopause pressure level.

Data assimilation: performed every twelve hours. The first guess field is generally the twelve hours one predicted by the model in the previous run and in case of model divergence, the climatological field for that month.

Data used: SYNOP, TEMP, BUOYS, SATEM, SATOB and GRID (global model)

Data assimilation and objective analysis is also performed on every secondary and principal hour (3, 6, 9, 15, 18, 21 UTC) to obtain analyzed surface pressure maps.

4.3.2 Model

4.3.2.1 In operation

ARPE Model

Implemented operationally the first time by the Bureau of Meteorology of Australia and adapted later for routine forecasting at New Zealand Meteorological Service. It was adapted to our region by the C.I.M.A. Group from the University of Buenos Aires directed by Dr. M. Nuñez.

Equations: primitive hydrostatic equations
Initialization: vertical mode initialization scheme
Solution technique: a semi-implicit time difference scheme
Physical processes: surface fluxes of momentum, heat and moisture, large scale and convective precipitation, surface temperature and diurnal cycle.
Grid Resolution: 150 Km on the horizontal and 10 levels in the vertical.
Coordinate system: sigma coordinate in the vertical
Forecast period: 36 hours

ETA SMN model

The development of this model began en 1972 by Fedor Mesinger and Zaviša Janjic at the University of Belgrade and the Federal Hydrometeorological Institute of Yugoslavia. During the last decades, the major developments and improvements were done at the National Centers of Environmental Prediction (NCEP).

Equations: Primitive hydrostatic equations. Non-hydrostatic version included
Grid: Arakawa E-grid in horizontal, Philips grid in the vertical.
Resolution: 25km on the horizontal and 38 layers on the vertical.
Solution technique: Split-explicit time differencing, Arakawa-type in space.
Coordinate system: rotated spherical coordinates in horizontal; eta (step mountain) coordinate in vertical. Sigma coordinate version of the model is available.
Physical processes: surface fluxes over land and water; land surface schemes; multilayer soil/vegetation/snow pack land surface model; subgrid mixing; cumulus parameterizations; radiation parameterization; grid scale precipitation parameterization.
Data used: AVN from the GFS model obtained at the NCEP ftp server. Data boundaries are updated every 12 hours. Sea surface temperature, ice/snow coverage and snowdepth information is updated daily and are included in the ETA SMN model initial conditions.

Nested ETA SMN model

This model has the capability to run on different domains between the ETA SMN boundaries. For example, guidance on severe weather conditions, zonda wind forecasts, fire control and others. The pre fixed domains defined are shown in Figure 1. A 36 hour forecast is performed on every run.

Equations: Primitive non-hydrostatic equations.
Resolution: 10km on the horizontal and 38 layers on the vertical.
Data used: Forecast from the ETA SMN model from the same cycle. Data boundaries are updated every 3 hours. Sea surface temperature, ice/snow coverage and snowdepth information is updated daily and are included in the ETA SMN model initial conditions.

4.3.2.2 Research performed in this field

4.3.3 Operationally available NWP products

ARPE model
Analysis and 6 hour forecasts of mean sea level pressure and 1000/500hPa thickness, 850hPa geopotential and dew point, 500hPa geopotential and temperature, 500hPa vertical wind component, 250hPa geopotential and wind speed, tropopasuse height and temperature are updated in the National Weather Service Intranet network twice a day. Horizontal and vertical interpolations are made to obtain analyzed horizontal wind components and temperature fields every two degrees of latitude and longitude and forecasted fields every six hours at the seven flight levels used in our region are updated twice a day. Outputs in GRID format are disseminated through the GTS.

Mean and anomaly fields at all levels are obtained, analyzed and stored on monthly basis.

ETA SMN model
Analysis and 3 hour forecasts of mean sea level pressure and 1000/500hPa thickness; 2m temperature and humidity; 10m winds; 850hPa geopotential and dew point; 500hPa geopotential and temperature; 250hPa geopotential and wind speed; tropopause lever in fl heights; freezing level in fl heights; low, medium, high and total cloud coverage; 24 hour accumulated precipitation fields (convective and large scale); meteograms for selected cities (approximately 100); clear air turbulence forecast of selected fly levels; fog; frost potential, are available on the Intranet network. Some selected fields and meteograms are available in the Internet as well. Forecasts are updated every 12 hours.

A complete set of variables every 3 hours and accumulated ones up to 120 hours of forecast are available for the forecast office of the National Meteorological Service through a web server Apache 2.2.3/PHP 5.2.0.

Mean fields at all levels are obtained, analyzed on monthly and semi-monthly basis.

Some fields from this model are used to obtain an analyzed field of precipitation through the Hydro-estimator technique from NOAA using high resolution GOES-12 pixel information.

Thirteen years of analyzed fields using the five levels model and eight years (1998-2007) of analyzed fields using the ten levels model (including the operational visualization of meteorological fields using the GRADS software) are available in this center. Analyzed fields from the ETA SMN model are also available since 2003.

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

A simplified method based on the Lagged Average Forecasting technique (Hoffman and Kalnay, 1983) is used to obtain probability of precipitation for the following days. All the available previous forecasts valid for the selected day are members of the ensemble.

Correction of maximum and minimum temperatures based on the 12 UTC cycle from the ETA SMN model valid for the following day is performed on selected locations. The information of the previous years of the model performance is used to correct the actual forecast values by a constant or linear/quadratic equation. Equations are updated on monthly basis.

4.4 Nowcasting and Very Short-range Forecasting Systems (0-6 hrs)

4.4.4.1 In operation

Short range forecasts are based only on direct observation of operational radar products and satellite images. A satellite-ETA model combined display helps subjective recognition of conceptual model signatures on satellite imagery.

4.4.1.2 Research performed in this field

Local climatology of radar echoes is under research to improve severe weather prediction.

4.4 Specialized numerical predictions:

Sea Waves

The sea wave model from is based on the 3rd generation and cycle 4 Wave Modeling Group (WAM 4). It is run and maintain by the SMARA (Argentinean Navy Weather Service) group. WAM 4 performs a time integration of the evolution of the wave action taking into account kinematics and dynamics factors that modify the spectral energy.

SMARA/WAM for the Southwest Atlantic Ocean is implemented on 1ºx1º grid that includes METAREA VI. This version counts in the effects of shallow waters without refraction on depth or currents. The model runs at 00 and 12 UTC and performs a 48 hour forecasts. These forecasts are forced by the wind at 10m above sea level from the GFS model (NCEP).

The high resolution version (0.25ºx0.25º) applied to the Argentinean Sea is forced by the 10m wind from the ETA SMN model. The model runs at 00 and 12 UTC and performs a 48 hour forecasts. In this version wave refraction on depth is accounted for.

This high resolution model feeds at the same time a model of still higher resolution of 3' (1/20º) on the La Plata River Basin. This forecast provides the wave evolution following the estuary's bathymetry on this resolution.

The retroanalysis, that gives information about the wave field at the beginning of every forecast, are performed for the three cases with 10m wind fields produced at the NCEP at a 35km resolution. The retroanalysis are updated every 6 hours (00, 06, 12 and 18 UTC).

Dispersion Model
To accomplish with our responsibilities as a Volcanic Ash Advisory Center (Buenos Aires VAAC), we make use of HYSPLIT model to produce volcanic ash dispersion plots and related VAA messages (Volcanic Ash Advisories) whenever a volcanic event occurs in our area or responsibility.

4.6 Extended range forecasts (10 days to 30 days)
(Not performed at this centre)

4.7 Long range forecasts (30 days up to two years)
(Not performed at this centre)

5. Verification of prognosis products

5.1 Annual verification summary
Objective verification of forecast products continued during 2007. The ARPE model performs routine verification of the two kinds: grid-to-observation point and area average observation-to-grid point verifications. The former evaluates temperature forecasts against observations (TEMPS) while the latter evaluates forecasts against analysis for different fields. The verification area includes the continental region. (Tables 1-4)

Maps of observed precipitations and maximum/minimum temperatures are available on daily basis for comparison with the respective ETA model forecasts for the same period and all the possible forecast ranges.

Verifications of maximum and minimum temperature and precipitation of selected cities forecasted by the ETA SMN model are performed on monthly basis (Figure 2). Statistics of the official forecasts are included as well. Corrected temperatures forecast evaluation is also monthly obtained (Figure 3) and then updated for the following year. Verification of temperature on selected levels and locations is shown on Tables 5-6.

6. Plans for the future (next 4 years)

6.1 Development of GDPFS

Continually increase computation power to run high resolution models and more sophisticated data assimilation schemes.

Send/Receive binary information through the GTS.

Develop model output from this centre in the form of bulletins that will contain data in GRIB1&2 formats

A system will be eventually implemented where all observed data obtained within our country will undergo a quality and consistency check, manually correct whenever necessary and finally resent to the GTS community.

6.2 Planned research activities in NWP, Nowcasting and Long-range Forecasting

Strengthen NMCs associations with RSMC Buenos Aires through special training programs.

Work is in progress to run the long range forecast model CSIRO modified by Lic. Juan Labraga, for anomalies predictions on monthly basis.

Elaborate a multi model ensemble forecast in collaboration with other centres following the principles established in the THORPEX project.

Adapt a suitable assimilation and objective analysis scheme to the ETA SMN model or other mesoscale model and eventually replace the ARPE model.

Use of a model for trajectory and dispersion of volcanic ashes in support of the Volcanic Ashes Advisory Center Buenos Aires. Use of trajectory model for nuclear accidents and contamination as well.

Develop an operational verification system suitable to the ETA SMN model for standard variables such as temperature, geopotential height, wind, humidity on standard levels as well a variables near the surface and precipitation.

Estimate Icing potential within the ETA SMN frame.

7. References

Operational products can be obtained at the National Weather Service webpage www.smn.gov.ar along with references regarding the models and data base (only in Spanish).

Annual Joint WMO Technical Progress Report on the Global Data-Processing and Forecasting System and Numerical Weather Prediction Research Activities for 2007. M. Suaya, M. Gatto, R. Valdivieso and Matias Armanini

Progress Report on Numerical Weather Prediction for 2005. H. Ciappesoni, L. Rosso, M. Gatto y M. Suaya.. World Weather Research Programme, WMO.

Progress Report on Numerical Weather Prediction for 2004. H. Ciappesoni, L. Rosso, M. Gatto y M. Suaya.. World Weather Research Programme, WMO.

Progress Report on Numerical Weather Prediction for 2003. H. Ciappesoni, L. Rosso, M. Gatto y M. Suaya.. World Weather Research Programme, WMO.

Progress Report on Numerical Weather Prediction for 2002. H. Ciappesoni, L. Rosso, M. Gatto y M. Suaya.. World Weather Research Programme, WMO.

- Research papers on the ETA SMN Model include the following:

Suaya M., R. Valdivieso y H.H. Ciappesoni. Uncertainties in High Resolution Model Verification: The case of ETA Model Performance in Argentina. Annals of ther 3rd International Verification Methods Workshop, ECMWF, England, February 2007.

Suaya, M., y H. H. Ciappesoni, 2004: Primera evaluación objetiva de los pronósticos operativos de los modelos ETA-SMN Y GFS-NCEP durante el año 2003. Tesis de licenciatura en Ciencias de la Atmósfera, UBA, 2004.

Suaya M. y H.H. Ciappesoni. Skill del modelo ETA SMN durante 2003-2004. *Anales de IX Congremet*, Buenos Aires, 3-7 de Octubre de 2005. Versión en CD

Suaya M. y M. Gatto. Verificación de las temperaturas pronosticadas por el modelo ETA SMN para varias localidades de la Argentina. *Anales de IX Congremet*, Buenos Aires, 3-7 de Octubre de 2005. Versión en CD.

Ciappesoni H.H y R. Valdivieso. Verificación de los pronósticos públicos y del modelo ETA SMN del Servicio Meteorológico Nacional Argentino durante El Año 2003 Y 2004. *Anales de IX Congremet*, Buenos Aires, 3-7 de Octubre de 2005. Versión en CD.

- Research papers on the Arpe Model include the following:

Nuñez, M. N., Possía, N. E., y B. Cerne, 1994: Adaptación de un modelo en ecuaciones primitivas a la región sur de Sudamérica. Estudio de situaciones particulares. *Revista Geofísica*, Nº**41**.

Leis, V. J., García Skabar, Y., y Héctor H. Ciappesoni, 2001: Comparación de valores de temperatura pronosticados por un modelo regional operativo de 10 niveles con datos reales. *IX Congreso Latinoamericano e Ibérico de Meteorología - VIII Congreso Argentino de Meteorología*

García Skabar, Y., y H. H. Ciappesoni, 1997: Análisis objetivo regional para inicializar un modelo de diez niveles en forma operativa. *Tesis de licenciatura en Ciencias de la Atmósfera, UBA, 1997.*

Ciappesoni, H. H., Leis, V. J., García Skabar, Y., y Andrea Salvatore, 2001: Primera evaluación de un modelo regional operativo de 10 niveles. *IX Congreso Latinoamericano e Ibérico de Meteorología - VIII Congreso Argentino de Meteorología*

Objective Analysis and Forecast Area director: Lic. Martina Suaya
SMN Scientific Group: M. Gatto, R. Valdivieso and Matias Armanini
Short Term Forecast group: Lic. Ximena Calle
Long Range Forecast group: Lic. Maria de los Milagros Sknasi

Fig.1: Nested high resolution ETA model domains. Each box defines different domains. The number of grid points is fixed except for the FUEGO domain.

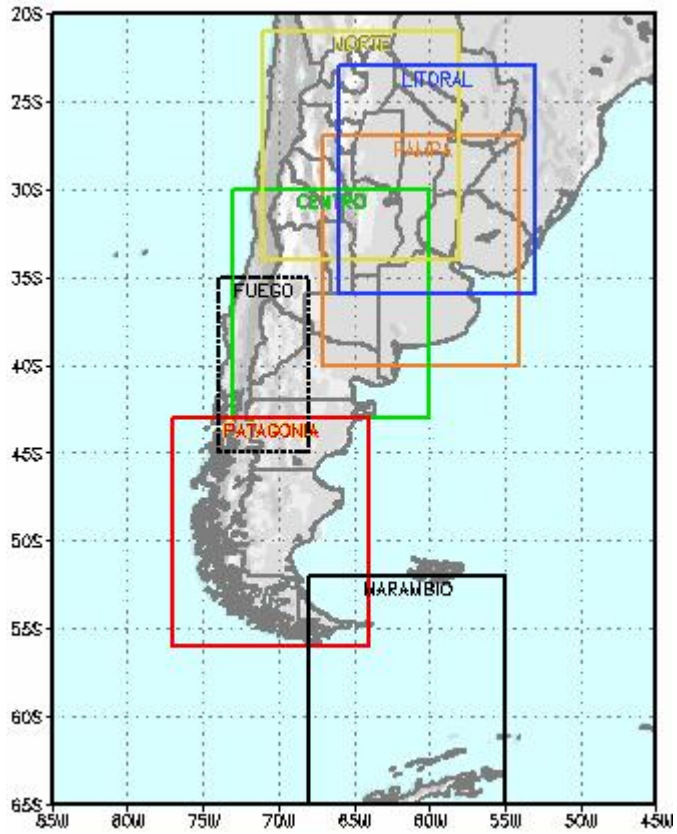


Table 1: Area average of the Skill score of Teweles (%) for the 24 hour forecast of geopotential height from the ARPE model (year 2007)

Level (hPa)	Cycle (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	**0**	-	-	42.4	36.8	31.5	30.9	34.7	38.0	43.5	43.5	42.5	48.5	**39.2**
	12	-	-	39.5	37.2	34.2	33.3	35.6	36.9	42.6	42.5	41.3	49.1	**39.2**
250	**0**	-	-	32.2	31.0	29.5	31.5	32.1	31.7	35.3	30.6	31.9	32.4	**31.8**
	12	-	-	31.4	32.3	31.8	30.1	30.4	31.8	33.0	30.0	31.0	32.2	**31.4**
500	**0**	-	-	37.7	35.7	33.8	34.1	36.0	37.6	43.4	38.1	39.5	39.6	**37.5**
	12	-	-	37.2	35.7	35.3	33.9	34.7	36.9	39.5	36.5	36.2	38.9	**36.5**
850	**0**	-	-	54.0	53.6	52.1	48.2	53.5	57.3	63.8	55.2	52.7	54.4	**54.5**
	12	-	-	53.4	51.5	50.2	48.7	51.3	54.5	60.5	53.9	51.2	52.6	**52.8**
1000	**0**	-	-	61.5	62.6	52.6	57.7	60.5	58.3	62.7	59.2	61.7	62.0	**59.9**
	12	-	-	60.2	61.2	51.8	57.9	58.0	55.8	64.1	61.3	58.5	62.4	**59.1**

Table 2: Area average of the Root Mean Square error (m/s) for the 24 hour forecast of geostrophic wind speed from the ARPE model (year 2007)

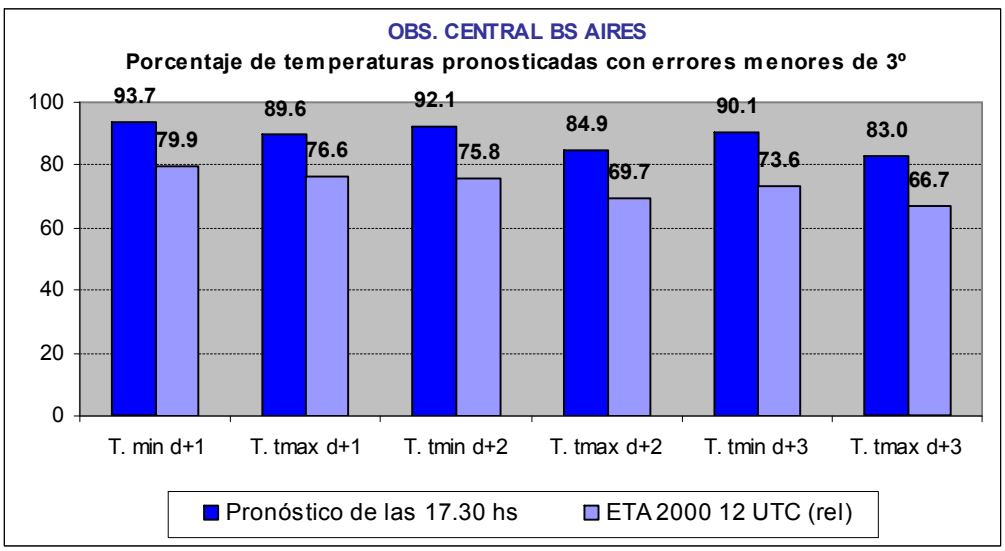
Level (hPa)	Cycle (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	**0**	-	-	5.9	7.4	8.4	8.2	9.4	10.0	10.3	9.5	9.2	8.7	**7.5**
	12	-	-	6.8	7.0	8.2	9.1	9.8	10.3	9.9	9.3	8.5	8.3	**7.6**
250	**0**	-	-	6.7	8.3	8.9	10.3	11.8	12.6	11.2	9.8	9.0	9.4	**8.3**
	12	-	-	7.5	7.7	9.1	11.6	11.1	11.4	11.1	9.7	8.8	9.6	**8.4**
500	**0**	-	-	4.4	5.6	5.8	6.4	7.2	8.3	7.5	6.8	6.6	7.1	**5.8**
	12	-	-	5.6	5.6	6.1	7.3	7.6	8.2	7.7	6.5	6.4	6.7	**5.8**
850	**0**	-	-	3.9	4.0	3.9	4.7	4.6	5.1	5.1	4.8	4.5	4.3	**3.8**
	12	-	-	3.8	3.9	3.9	4.3	4.6	5.0	5.2	4.8	4.2	4.2	**3.7**
1000	**0**	-	-	6.4	5.0	4.9	4.7	5.1	5.7	5.9	5.9	5.9	5.9	**5.2**
	12	-	-	5.6	4.6	5.0	4.8	5.6	5.8	5.7	5.7	5.4	5.2	**4.9**

Table 3: Root Mean Square error of temperature forecast from the ARPE model against observation and analysis (year 2007). Location EZEIZA: -34.35S –58.29W

Level (hpa)	DATA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	Observed	-	-	3.5	4.4	4.3	7.0	4.2	5.1	5.2	4.3	3.3	3.6	4.6
	Analysis	-	-	3.3	4.5	3.2	5.9	4.4	5.3	5.9	4.0	5.2	5.2	4.8
250	Observed	-	-	2.6	4.8	4.7	6.4	5.6	4.8	3.8	3.1	4.3	3.4	4.5
	Analysis	-	-	2.6	3.4	4.5	5.9	5.6	4.8	3.8	2.6	4.4	3.2	4.2
500	Observed	-	-	2.7	2.3	2.8	2.3	2.3	2.8	2.4	3.1	2.7	2.4	2.6
	Analysis	-	-	2.4	2.4	3.6	3.0	2.6	3.1	3.0	2.9	4.1	2.3	3.0
850	Observed	-	-	2.0	1.9	2.0	2.8	2.5	3.1	2.8	2.5	2.0	2.1	2.4
	Analysis	-	-	2.0	1.7	1.8	2.8	2.4	3.0	2.8	2.3	2.2	2.2	2.4
1000	Observed	-	-	2.7	2.6	2.3	2.5	2.4	2.5	2.6	2.5	3.6	3.2	2.7
	Analysis	-	-	2.6	2.3	2.1	2.6	2.1	2.7	2.7	2.4	3.2	2.9	2.6

Fig. 2: Rate of hits of Maximum/Minimun Temperatures ***(a)*** and Precipitation forecasts ***(b)*** from the ETA SMN Model and the Official forecast issued by the National Weather Service. The former is based on the 12 UTC cycle and the latter is based on the 17.30 local time forecast. The validity of the forecasts (day 1, 2, etc) are from 0 to 24 hour local time for the selected day.

a)



b)

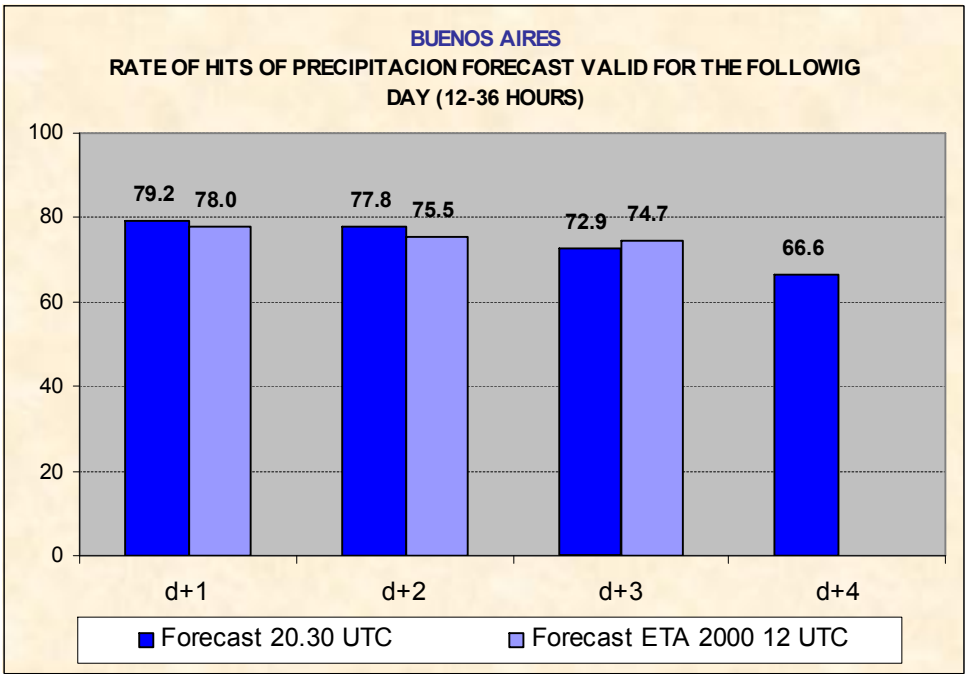
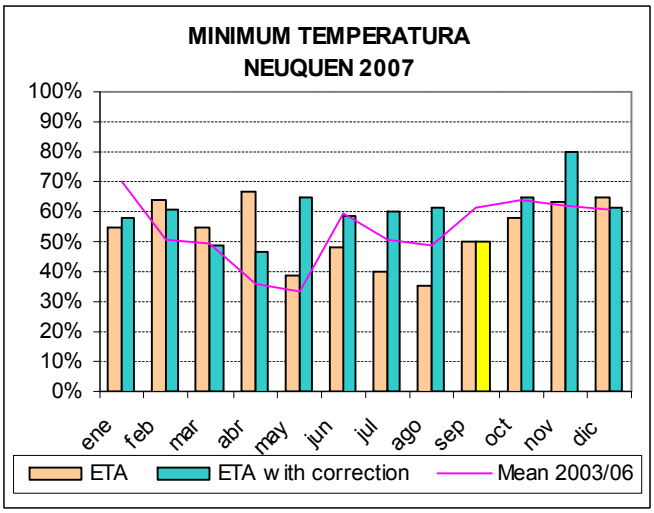


Fig. 3: Rate of hits of Maximum/Minimun Temperatures forecasts from the ETA SMN Model and the corrected forecast of the same vairables. The forecasts are based on the 12 UTC cycle and are valid for the following day.



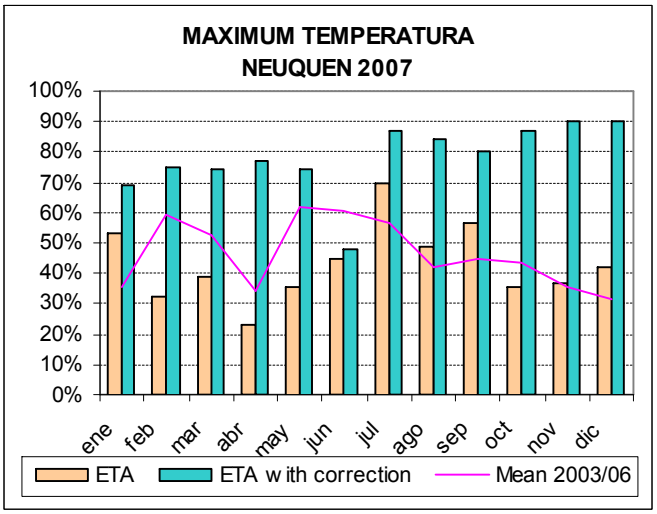


Table 4: Root Mean Square Error of temperature forecasts from the 12 UTC cycle of the ETA SMN model against observations (year 2007). Location EZEIZA: -34.35S –58.29W

		LEVEL (hpa)				
MONTH	FORECAST	100	250	500	850	1000
MAR	ANALYSIS	2.0	0.9	1.3	0.8	1.0
	24HS	3.0	1.4	1.3	1.6	1.6
	48HS	3.3	1.8	1.6	2.5	1.6
	96HS	4.5	1.9	1.9	3.7	2.8
	120HS	4.3	1.9	2.2	3.8	3.1
APR	ANALYSIS	1.9	3.7	1.0	0.6	1.3
	24HS	2.4	3.8	1.3	1.5	2.0
	48HS	3.4	3.9	1.3	1.8	2.7
	96HS	3.5	4.0	1.4	3.0	2.8
	120HS	3.8	4.2	1.9	3.1	3.3
MAY	ANALYSIS	2.0	1.1	1.2	0.9	1.3
	24HS	1.9	1.4	2.0	1.7	1.4
	48HS	2.2	1.7	2.3	2.0	1.5
	96HS	2.5	2.1	3.0	3.2	2.9
	120HS	2.9	2.1	3.2	3.2	3.0
JUN	ANALYSIS	1.7	1.3	0.9	0.8	1.6
	24HS	2.3	1.7	1.4	1.3	1.8
	48HS	2.3	1.8	1.3	1.5	2.3
	96HS	2.5	2.2	1.9	2.2	2.4
	120HS	2.2	2.6	2.1	2.6	2.9
JUL	ANALYSIS	1.6	1.6	1.1	1.0	1.9
	24HS	2.0	1.8	1.3	1.4	1.9
	48HS	2.4	2.1	1.7	1.4	2.3
	96HS	3.0	2.4	2.3	2.0	2.7
	120HS	3.0	2.1	2.6	2.4	3.5
AUG	ANALYSIS	1.7	1.4	1.1	0.8	1.6
	24HS	1.8	1.9	1.0	1.5	2.0
	48HS	2.0	2.2	1.6	1.5	2.4
	96HS	2.2	2.7	2.5	3.1	3.4
	120HS	2.6	3.4	3.4	3.7	3.4
SEP	ANALYSIS	1.6	1.2	1.1	0.6	1.0
	24HS	1.9	1.5	1.2	1.4	1.7
	48HS	2.2	2.0	1.5	2.5	2.4
	96HS	2.4	2.4	1.7	3.5	3.2
	120HS	2.6	2.4	1.8	3.7	3.9
OCT	ANALYSIS	2.5	1.4	1.1	1.1	0.9
	24HS	3.0	1.9	1.4	2.1	1.6
	48HS	3.6	2.1	1.4	2.7	2.3
	96HS	3.6	2.2	1.8	3.9	3.0
	120HS	4.2	2.2	2.2	4.5	3.6
NOV	ANALYSIS	2.0	1.4	1.0	1.0	1.1
	24HS	2.8	1.9	1.4	1.8	1.9
	48HS	3.3	2.2	1.9	2.4	2.5
	96HS	4.1	2.5	2.3	2.8	4.0
	120HS	4.1	2.8	2.5	4.6	3.8
DEC	ANALYSIS	1.6	1.4	1.2	0.8	1.3
	24HS	2.0	2.0	1.3	1.6	2.6
	48HS	2.7	2.4	1.6	2.9	3.0

	96HS	3.6	2.4	1.7	4.0	3.5
	120HS	3.8	2.4	1.8	4.6	4.0

Table 5: Root Mean Square Error (RMSE) and Bias of temperature forecasts from the 12 UTC cycle of the ETA SMN model against observations (year 2007) for Winter (W) and Summer (S) on selected locations. 87047 (Salta) -25.5S -65W; 87155 (Resistencia) -27.27S -59.03W; 87344 (Cordoba) -31.19S -64.13W; 87576 (EZEIZA) -34.35S –58.29W; 87623 (Santa Rosa) -36.34S -64.16W; 87860 (Comodoro Rivadavia) -46S -67.7W; 89055 (Marambio) -64.14S -57W

		LEVEL									
		100		250		500		850		1000	
Station	Param.	S	W	S	W	S	W	S	W	S	W
87047	BIAS	-	2.5	-	-0.2	-	-0.5	-	1.1	-	-
	RMSE	-	3.2	-	1.0	-	1.2	-	2.2	-	-
87155	BIAS	2.1	1.7	-0.7	-0.2	-0.4	-0.7	1.3	-0.2	2.6	-0.3
	RMSE	2.8	3.1	1.7	1.4	1.7	1.6	2.2	2.1	3.6	2.6
87344	BIAS	3.3	2.6	-0.6	0.3	-0.4	-0.5	2.1	0.5	-	6.4
	RMSE	4.2	3.6	1.6	1.6	2.0	1.8	4.3	3.0	-	6.4
87576	BIAS	2.9	1.3	-0.7	-0.1	-1.2	-0.5	3.5	0.6	3.3	0.7
	RMSE	3.8	2.8	2.4	2.3	1.8	1.8	4.6	2.4	4.0	2.5
87623	BIAS	4.1	1.1	0.2	0.5	-0.9	-0.4	2.9	0.0	-	2.4
	RMSE	4.8	2.7	1.7	1.8	1.7	1.8	4.5	2.2	-	3.7
87860	BIAS	3.5	0.8	0.3	0.1	-1.1	-0.5	-0.7	-1.3	-0.8	-0.6
	RMSE	3.9	2.5	2.3	2.2	2.6	2.2	2.9	2.6	4.0	2.2
89055	BIAS	0.0	0.7	0.5	-0.7	-2.8	-0.1	-1.9	-0.1	2.7	0.0
	RMSE	0.9	1.8	4.3	2.5	5.8	2.1	4.8	3.8	4.2	1.7