Progress Report on Numerical Weather Prediction - 2005

ARGENTINA

National Weather Service
(www.meteofa.mil.ar , www.meteonet.com.ar)

I. 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. Both 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 changes and error fixes in 2005:

March 2005 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.

June 2005 Probability of precipitation are forecasted using ensamble technique.

August 2005 Mean fields are obtained on semi and monthly basis.

November 2005 Forecast of Clear Air Turbulence (CAT) based on the Ellrod Index are estimated with the ETA SMN mode.

December 2005 A nested high resolution ETA model is implemented for special cases.

II. Equipment in use at the center for operational tasks

Function	Computer	CPUs/ Processor	Memory	Disk Storage
Communications 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, Ideafix, and Oracle. While the latter is used at the present time for historical datasets, work is in progress to replace the operative database with Oracle.

III. Quality control System

Synop and Temp data received at the center are permanently checked for formal and consistencies errors. Buoys, Satem and Satob data are only checked for formal errors. Manual corrections are done when necessary. Other validity checks are performed by the Arpe model objective analysis.

IV. Research and development in Data Assimilation and Numerical Forecasting

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

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 100 hPa); 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)

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. Nonhydrostatic 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/snowpack 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.

A control routine was added to the ETA model code to prevent spurius generation of kinetic turbulence energy and prevent model divergence.

Nested ETA SMN model
This model has the capability to run on different domains between the ETA SMN boundaries, and is implemented on special request. 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.

V. Research and development results for application of 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, 500 hPa 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 (Global Telecommunication System).

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

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

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 (aproximately 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 complet 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 an html based system.

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

Ensamble forecast

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

VI. Development in objective interpretation and verification procedures including performance statistics.

Objective verification of forecast products continued during 2005. 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 forecast against RAOBS observations while the latter evaluates forecasts against analysis for different fields. The area of coverage is regional and the period considered is year 2005 (Tables 1-3).

Verifications of maximum and minimum temperature and precipitation of selected cities forecasted by the ETA SMN model are performed on monthly basis (Figure 2). Evaluation of the official forecasts are included. Verification of temperature on selected levels and location is shown on Table 4.

VII. Plans for future research and development activities.

Continually increase the number/power of processors from the Origin 2004 and reduce this way the integration time required for the ETA SMN model. Incement of model resolution is planned as well.

Optimized the ETA SMN code to reduce the model elapsed time of execution.

Use of an alternative data set for initial and lateral boundaries conditions for the ETA SMN Model.

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

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

Adapt a suitable assimilation and objective analysis scheme to the ETA SMN 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 as well.

Obtain an analyzed field of precipitacion through the Hydro-estimator technique from NOAA using high resolution GOES-12 pixel information and ETA SMN model analysis.

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.

Install and run a new mesoscale model that must include an analysis and data assimilation package.

VIII. Other items

Twelve years of analyzed fields using the five levels model and eight years (1998-2005) 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.

Objective Analysis and Forecast Area director: Dr. H.H. Ciappesoni.
SMN Scientific Group: Lic. L. Rosso, Lic. M. Suaya, M. Gatto, R. Valdivieso and Matias Armanini

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.

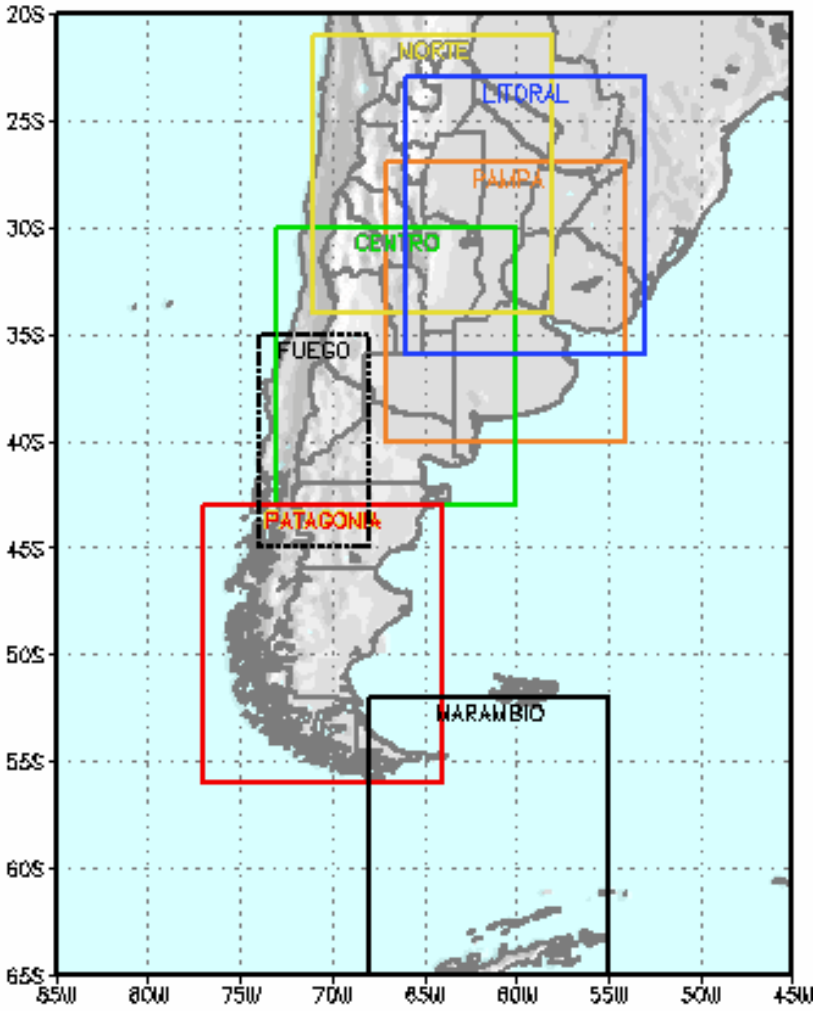


Table 1: Area average of the Skill score of Teweles (%) for the 24 hour forecast of geopotencial height from the ARPE model (year 2005)

Level (hPa)	Cycle (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	**0**	47.5	48.8	41.4	37.3	35.6	32.8	35.8	37.4	-	36.0	35.9	36.5	**38.6**
	12	44.8	50.5	40.9	36.1	35.3	33.9	35.4	37.7	-	33.5	36.7	35.9	**38.2**
250	**0**	35.3	37.4	33.0	33.0	32.0	31.1	32.5	32.2	-	30.6	29.3	29.0	**32.3**
	12	31.7	34.7	32.4	31.7	31.1	31.0	32.1	33.6	-	30.9	29.2	29.4	**31.6**
500	**0**	44.5	45.1	39.7	36.8	35.6	36.1	35.9	37.4	-	36.4	34.2	35.6	**37.9**
	12	38.1	42.3	37.4	35.5	34.6	36.7	35.3	38.8	-	35.3	32.1	32.6	**36.2**
850	**0**	56.1	65.8	55.5	52.7	51.7	57.5	50.4	56.6	-	56.8	49.3	52.0	**54.9**
	12	54.0	61.1	55.3	49.6	52.1	55.3	50.8	56.2	-	57.4	46.7	48.7	**53.3**
1000	**0**	65.8	66.8	62.3	56.8	63.3	63.7	57.2	63.3	-	63.0	59.4	61.9	**62.1**
	12	62.5	66.8	60.7	53.9	61.5	60.8	55.5	62.9	-	62.8	56.7	57.0	**60.1**

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 2005)

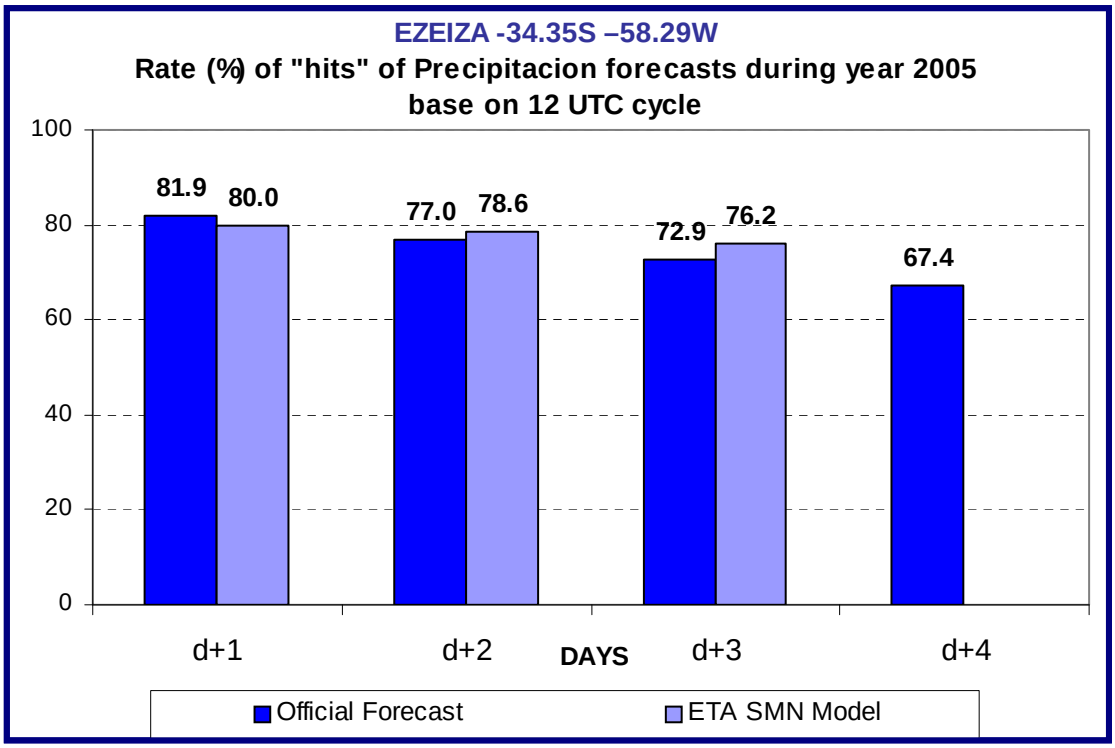
Level (hPa)	Cycle (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	**0**	8.7	7.5	8.3	9.0	9.4	9.1	9.4	9.6	-	8.3	7.0	7.1	**8.5**
	12	8.0	7.8	8.1	8.0	9.2	8.6	8.7	9.6	-	7.2	7.3	6.7	**8.1**
250	**0**	9.3	7.9	9.7	10.2	10.8	9.3	11.7	9.6	-	9.2	8.7	7.9	**9.5**
	12	8.0	7.6	8.9	9.6	10.7	9.2	11.9	10.1	-	9.9	8.7	8.2	**9.4**
500	**0**	7.2	5.1	6.2	6.2	6.9	5.9	7.1	6.5	-	6.4	5.6	5.8	**6.3**
	12	5.8	5.1	5.8	5.8	7.0	6.3	7.3	7.1	-	6.2	5.0	5.0	**6.1**
850	**0**	4.2	3.9	3.8	4.3	4.6	4.6	4.8	5.1	-	4.0	3.8	3.7	**4.3**
	12	3.8	3.8	4.0	4.0	4.8	4.5	4.9	5.2	-	4.1	3.5	3.5	**4.2**
1000	**0**	5.9	4.9	5.0	4.8	5.7	5.0	5.4	6.0	-	5.5	5.8	5.6	**5.4**
	12	5.0	4.8	4.7	4.8	5.9	5.2	5.7	6.2	-	5.5	5.1	4.5	**5.2**

Table 3: Root Mean Square error of temperature forecast from the ARPE model against observation and anlysis (year 2005). Location EZEIZA: -34.35S –58.29W

Level (hPa)	DATA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	Observ.	2.5	3.6	5.1	5.7	5.6	4.2	5.3	4.4	-	3.6	3.1	3.6	**4.3**
	Analysis	3.3	5.3	5.9	5.3	4.1	3.8	4.9	3.9	-	16.6	4.6	3.5	**6.4**
250	Observ.	2.6	2.3	3.0	3.6	5.5	3.9	4.5	5.1	-	3.6	4.0	3.8	**3.9**
	Analysis	2.3	2.4	2.8	3.2	5.2	4.1	4.2	3.7	-	12.5	3.9	3.6	**5.0**
500	Observ.	1.9	2.1	1.6	2.0	2.4	2.3	3.0	3.0	-	3.1	2.7	2.1	**2.4**
	Analysis	2.2	1.9	1.8	1.8	2.7	3.0	3.4	3.1	-	5.7	2.8	2.4	**3.0**
850	Observ.	2.5	1.4	2.3	2.3	2.5	2.6	2.6	3.1	-	1.9	2.3	1.9	**2.3**
	Analysis	2.5	1.5	2.0	2.1	2.4	2.5	2.9	3.3	-	2.2	2.0	1.8	**2.3**
1000	Observ.	3.6	2.5	2.5	2.2	2.4	2.4	2.5	2.4	-	2.9	2.7	2.7	**2.7**
	Analysis	3.5	2.4	2.5	2.2	1.9	2.4	2.4	2.4	-	3.7	2.4	2.6	**2.6**

Fig. 2: Rate of hits of Precipitation ***(a)*** and Maximum/Minimun Temperatures 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 os 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)

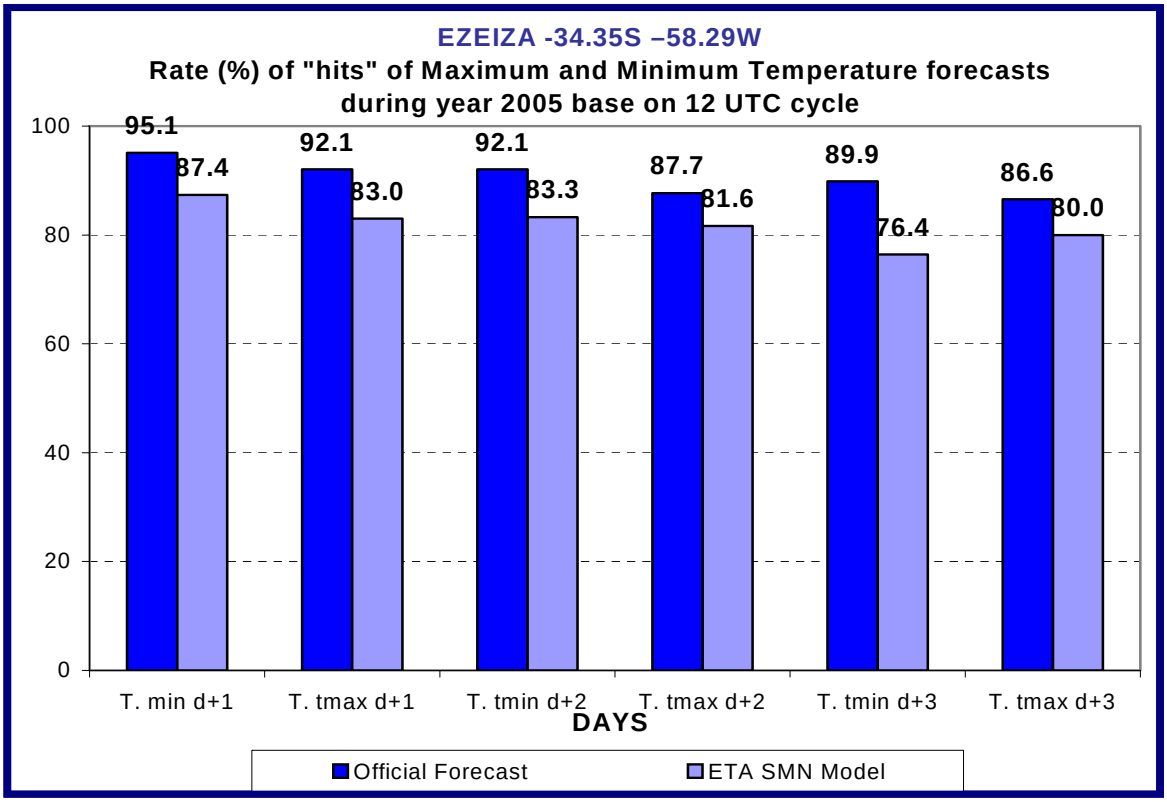


Table 4: Root Mean Square error of temperature forecast from the 12 UTC cycle of the ETA SMN model against observation (year 2005) . Location EZEIZA: -34.35S –58.29W

Month	Forecast (hour)	Level (hPa)				
		100	250	500	850	1000
Jan	24	2.0	1.5	1.6	1.6	1.6
	48	2.7	2.1	1.7	1.9	2.0
	72	3.5	2.5	2.0	2.5	3.1
	96	3.7	2.5	2.4	2.9	3.2
Feb	24	1.3	1.2	1.5	1.6	1.3
	48	1.9	1.3	1.8	1.9	1.6
	72	2.3	1.9	1.8	2.2	1.9
	96	2.5	2.5	2.2	2.5	2.0
Mar	24	2.5	1.4	1.2	1.8	2.1
	48	3.1	1.9	1.2	2.3	2.5
	72	3.7	2.4	1.2	2.7	2.8
	96	3.5	2.1	1.3	3.1	2.8
Apr	24	2.5	1.5	1.6	1.6	1.0
	48	3.1	2.0	1.7	1.8	1.5
	72	3.2	2.2	2.1	2.3	2.0
	96	3.5	2.2	2.2	3.0	2.5
May	24	1.9	1.7	1.6	1.7	2.3
	48	2.2	1.6	1.7	1.6	2.8
	72	2.4	1.7	2.1	2.6	2.9
	96	2.5	1.6	2.6	3.2	2.6
Jun	24	1.8	1.4	1.4	1.6	1.9
	48	2.5	1.8	1.6	1.9	3.0
	72	2.9	1.7	2.1	2.1	2.2
	96	3.0	1.6	2.4	2.4	3.1
Jul	24	2.1	1.7	1.6	1.5	1.2
	48	2.4	2.3	1.9	1.9	1.9
	72	2.5	2.2	1.9	2.0	2.5
	96	2.7	2.5	2.1	3.1	2.8
Aug	24	2.1	1.8	1.5	1.7	2.1
	48	2.3	1.9	2.0	1.8	2.3
	72	2.5	2.0	2.1	2.2	2.8
	96	2.7	2.0	2.4	2.6	3.3
Sep	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
	96	-	-	-	-	-
Oct	24	2.9	1.8	1.6	1.4	1.9
	48	3.2	2.2	2.0	1.8	2.7
	72	3.2	2.5	2.3	2.4	2.9
	96	3.2	2.8	2.4	3.1	3.0
Nov	24	2.3	1.4	1.6	1.3	2.1
	48	2.9	1.5	1.8	2.3	2.9
	72	3.3	1.7	1.7	2.5	3.0
	96	3.6	1.9	2.0	2.7	3.0
Dec	24	1.7	1.5	1.8	1.2	2.3
	48	2.1	1.6	1.6	2.1	3.0
	72	1.8	1.9	2.2	2.5	3.4
	96	2.6	2.1	2.2	3.5	4.1
TOTAL	24	***2.1***	***1.5***	***1.6***	***1.5***	***1.8***
	48	***2.6***	***1.9***	***1.7***	***2.0***	***2.4***
	72	***2.9***	***2.1***	***2.0***	***2.4***	***2.7***
	96	***3.1***	***2.2***	***2.2***	***2.9***	***3.0***