C P T E C - AN EMERGENT CENTER FOR WEATHER AND CLIMATE PREDICTION

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Summary: A new centre for Numerical Weather Prediction (NWP), known as CPTEC, has become operational in Brazil this year. A global spectral model with T62 L28 resolution is used for medium-range prediction and for experimental long-range ensemble prediction. Regional models for forecasting and research studies are being adapted and operationalized. The medium-range model performance statistics are presented. The communication links, computing facilities, forecast products and the data sources are described.

1. INTRODUCTION

Brazil is a large country (8.5 million km^2) extending from 5N to 35S and 70W to 40W. It occupies almost half of the total area of the South American Continent and presents tropical and subtropical climates. There is a direct and strong effect of the midlatitude weather systems over the climate of the southern and south-central states of Brazil and somewhat indirect and weak but significant effect on the climate of the rest of Brazil. Agriculture and cattle raising are important socioeconomic activities whose productivity depends heavily on the weather and climate information. Other sectors which require reliable weather information in Brazil are transportation (surface, air and maritime), civil defense (disaster mitigation), energy (hydroelectric), environment protection (control of pollution, forest fires and biomass burning) and tourism.

The Brazilian government, through a presidential decree, has entrusted the National Institute for Space Research (INPE) with the responsibility of developing and operating numerical weather prediction and climate prediction models and for disseminating the information to the sectorial institutions in Brazil. INPE has formed the Centre for Weather Prediction and Climate Studies (CPTEC) to attend the needs of the country in the crucial area of quantitative weather and climate prediction.

The objectives of CPTEC are two-fold, one is operational and the other is research leading to improvements in weather and climate prediction. Specific objectives for the coming five years are 1) to provide reliable weather forecasts for the whole Brazil up to 6 days and long-range guidance of the climate up to six months and 2) to achieve better understanding of the dynamics and physics of the weather systems affecting the region of South America, the climatic variability over the region and its causes and effects over the rest of the globe and the role of Amazonia in the regional and global environment system.

2. THE CENTRE'S FACILITIES

CPTEC has an ample building of about 5000 m^2 area and is situated at Cachoeira Paulista (23S, 45W) in the INPE's Space Centre Campus. There are plans to upgrade the building by adding another 3000 m^2 for the research staff within the coming two years. The total number of personnel

including research scientists, software engineers, meteorologists, systems analysts and technicians is presently 96. There are roughly 20 visiting scientists and scholars from abroad and from within Brazil and student trainees at the centre. The Divisions of Satellite Meteorology (DMS) and Meteorological Sciences (DCM) and the post-graduate program in meteorology are situated at the INPE's headquarters in São José dos Campos, 105 km southwest of CPTEC.

The existing computer facilities at the CPTEC include a NEC SX3-12R supercomputer with a peak speed of 3.2 GFLOPS, five DEC Alpha 3000/400 network servers, two HP9000 graphics workstations, one DEC Alpha 3000/500 dual workstation for communications, one DEC Alpha 3000/500 workstation for data archiving, more than 40 workstations and more than 20 PCs (486 and Pentiums), all on a local FDDI network and Ethernet (see Fig. 1). The communications links with external institutions, both national and international, are shown in Fig. 2. The short term plans for upgrades of the computer and communications systems are shown in Fig. 3. In this figure the existing facilities are shown in light border and the upgrades in dark border.

The global general circulation model of the COLA (Center for Ocean Land and Atmosphere Studies), a slightly different version of the MRF (Medium-range forecast) model used at the National Meteorological Center (NMC) (NMC Development division, 1988), is adapted for medium-range weather forecasting and for long-range climate forecasting. This model is now known as CPTEC/COLA model. Shortly CPTEC will have the Eta model developed at the NMC for the operational regional short-range forecasting. The RAMS (Regional Analysis Meteorological System) developed at the CSU (Colorado State University) and the FSU (Florida State University) regional model are being used at the centre for research purposes.

The objective analysis is carried out by the module borrowed from JMA (Japan Meteorological Agency) and adapted at CPTEC. It uses multivariate optimum interpolation scheme for the tropospheric standard pressure levels and a two-dimensional least square fitting method for the stratosphere. The preprocessing of the observational data is carried out by the module borrowed from ECMWF (European Centre for Medium-range Weather Forecasts). The interfaces between different modules are developed at the CPTEC.

The software for meteorological applications, called METVIEW, is developed jointly by INPE and ECMWF, and will shortly become fully operational at the centre. Presently the centre uses the GrADS (Grid Analysis and Display System), developed by COLA, for both research and operations along with SAMPC (Satellite Applications in Meteorology for Personal Computers) developed at INPE which is used for satellite imagery visualization. Another piece of interesting software for visualization in three dimensions that is nearly operational is known as VIS5D which is adapted by and improved at the CPTEC.

3. OPERATIONAL SUITE

The CPTEC/COLA spectral model with a resolution of T62 L28 (triangular truncation 62 and 28 layers in the vertical) is run twice a day with the 00 and 12 UTC NMC analyses as initial fields up to 144 hours of forecast. The 00 and 12 UTC analysis fields are received from NMC via Internet around 11 and 23 UTC respectively. A 144-hours forecast with the present resolution takes about 38 minutes of CPU.

The same model is run once a month for a 180-day climatological ensemble forecast. Presently four members of the ensemble are run with SST anomaly persistence and another four with the

climatological SST. The processing time for each member of the ensemble for one-month integration is about 3 hours. The total processing time is roughly 144 hours. The results are used internally by researchers till the forecasts are evaluated.

The preprocessing and analysis modules of the NWP software are ready to be incorporated into the routine operation and await the improvements in the communication link between GTS node at the INMET (Instituto de Meteorologia) at Brasília and CPTEC.

Figure 4 shows the actual sharing of the computer time by different runs in a day.

4. FORECAST OFFICE AND WEATHER PRODUCTS

The weather forecast group is divided into two distinct main activities: 1) Basic weather analysis and forecast and 2) Dissemination product generation. The first group is responsible for obtaining and examining the data, running the model, obtaining the analysis and forecast charts, daily weather discussion, preparation of basic weather bulletins, intercomparison of CPTEC and NMC MRF products over the South American region, validation of the forecasts and attending the inquiries from users such as large agricultural cooperatives and government and nongovernment organizations. The daily bulletins contain detailed forecasts for three days, along with an outlook for another two days whenever and wherever possible, region by region, for the whole Brasil. The second group is responsible for preparing camera-ready short and medium-range prediction products for the press, TV and radio. Examples of the daily bulletins and daily forecast products are shown in Fig. 5.

5. DATA COVERAGE AND AVAILABILITY

One major problem for the improvement of the precision of short and medium-range forecasts are the sparsely distributed data (both in time and space) over the South American region and the adjoining oceans. A joint working group of the Brazilian government institutions dealing with meteorology is making recommendations for upgrading of the observational system in Brazil. The Brazilian government, in collaboration with the neighboring countries, is planning to implement a massive project to monitor and protect the Amazonian biosphere and environment. It includes a large parcel of meteorological observations also. The whole network upgrading may take a few years. Additional data to the analysis module should come from the satellite observations and derived products such as TOVS (Tiros Observations Vertical Soundings) and satellite winds.

6. MODEL OUTPUT VERIFICATION

For understanding the regional performance of the model, synoptic evaluation methods are developed in which the positions and intensities of the centres of circulation such as the Bolivian high in the upper air and the subtropical highs at the surface in the forecast and in the analysis are compared. Systematic studies of the comparison between the performances of the CPTEC model and the MRF model over the region of South America have just started. It is also planned to obtain and compare the pentad and monthly climatologies of the analysis and the forecasts for different ranges (24 through 144-hour forecasts). A few standard verification statistics of the performance of the global model are shown in Table 1 below.

Table 1 : CPTEC / COLA model performance mean statistics for September 1995 - 500 hPa level anomaly correlations (C) and root-mean-square errors (E) of geopotential (GP) and virtual temperature (TV) for the Northern (20N - 80N) and Southern (20S - 80S) Hemispheres (NH, SH), and 850 hPa anomaly correlations of zonal (ZW) and meridional (MW) wind components and root-mean-square errors of wind speed (WS) for the tropical belt (20S - 20N) (TB).

	N H (500 hPa)				S H (500 hPa)				T B (850 hPa)		
DAY	CGP	CTV	EGP (m)	ETV (^{0}K)	CGP	CTV	EGP (m)	ETV (^{0}K)	CZW	CMW	EWS (ms^{-1})
1	94	90	17.4	1.41	98	95	16.4	1.10	91	94	4.8
2	85	80	26.6	2.04	95	89	27.6	1.68	79	81	7.7
3	78	70	32.0	2.50	89	81	38.9	2.22	38	24	4.9
4	66	60	40.3	2.97	81	72	51.6	2.71			
5	69	60	65.5	3.24	56	47	97.2	4.01			

7. TRAINING AND TECHNICAL COLLABORATIONS

Many of the centre's meteorologists and scientists have obtained their training at various leading NWP centres such as the NMC, JMA, COLA. The training in operational meteorology is mostly obtained at the International Desk of the Forecast branch of the NMC. CPTEC's scientists and engineers have made many visits to JMA, NMC, CMS (Canada), AKIMBO, ECMWF, the Haley Center (England) and COLA (USA) for obtaining the firsthand information and overall idea of the working of NWP models, climate prediction models, their operation routines and their use for prediction guidance. The ECMWF and the NMC have participated in the technical discussions which have helped the CPTEC in the specification and configuration of its computer system and its building.

CPTEC has already organized three training courses in the interpretation of NWP products, use of visualization software and climate variability and prediction techniques for the meteorologists and other professionals within the country. The training courses offered an opportunity for the CPTEC scientists to interact with the meteorological community from different regions of Brazil.

CPTEC is also an active participant of a project financed by a federal agency for the development of high performance computing skills in the country. Presently it has undertaken the task of parallelization of the RAMS for mesoscale weather prediction to be used by regional meteorological nuclei spread over the country.

Acknowledgment

The authors wish to thank Dr. C.A.Nobre, Chief of CPTEC for constant encouragement.

Reference:

NMC Development Division, 1988: Documentation of the research version of the NMC medium-range forecast model, Vol I - Hydrodynamics, physical parameterizations and user's guide. National Meteorological Center, National Weather Service, Ministry of Commerce, Washington, USA.

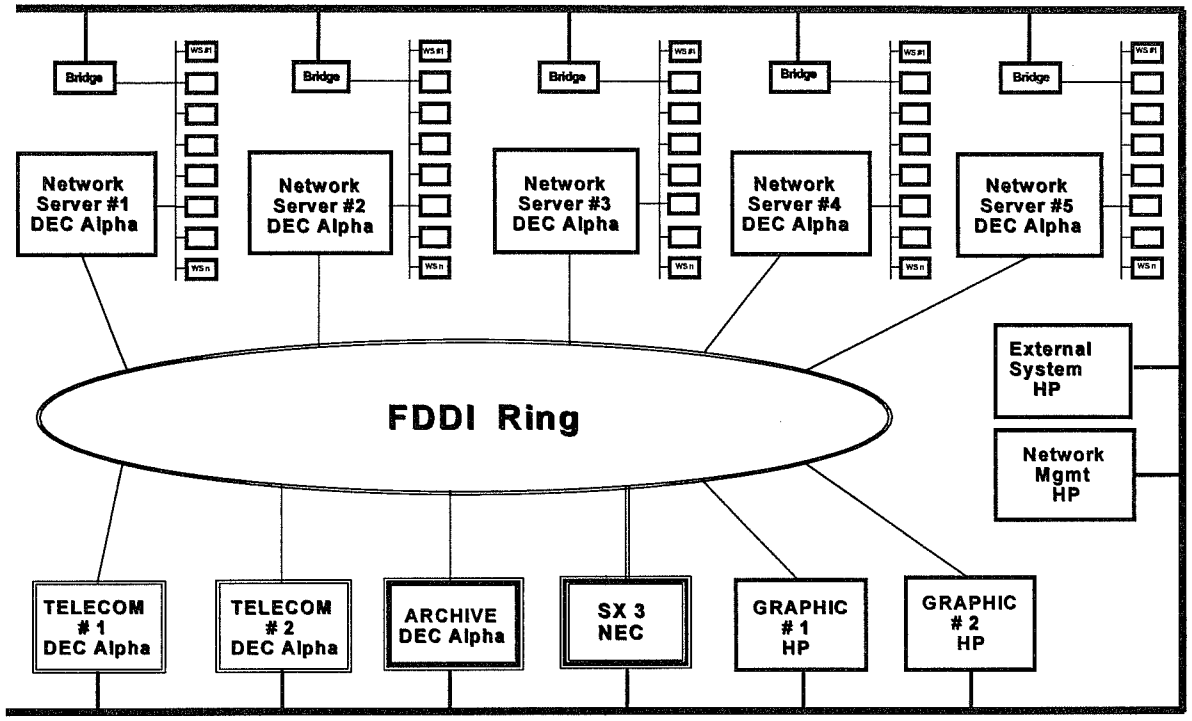


Figure 1: INPE / CPTEC - Computer System Architecture

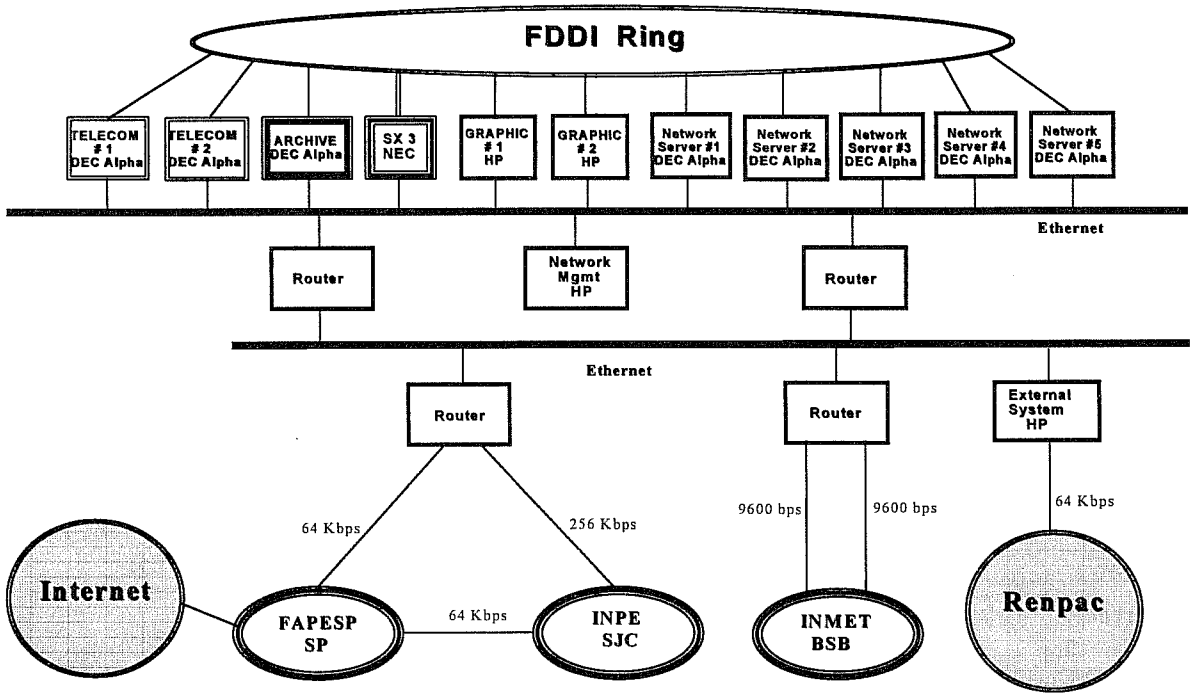


Figure 2: INPE / CPTEC - External Lines configuration

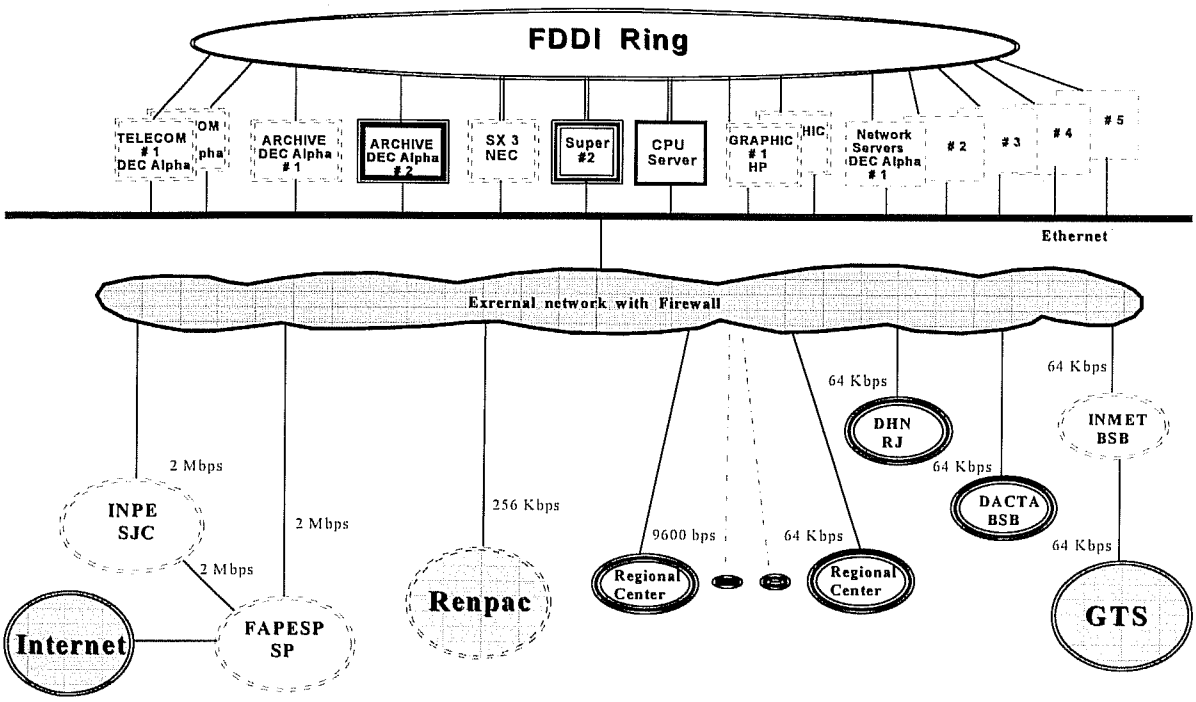


Figure 3: INPE / CPTEC - Planned upgrade of computer and communications systems

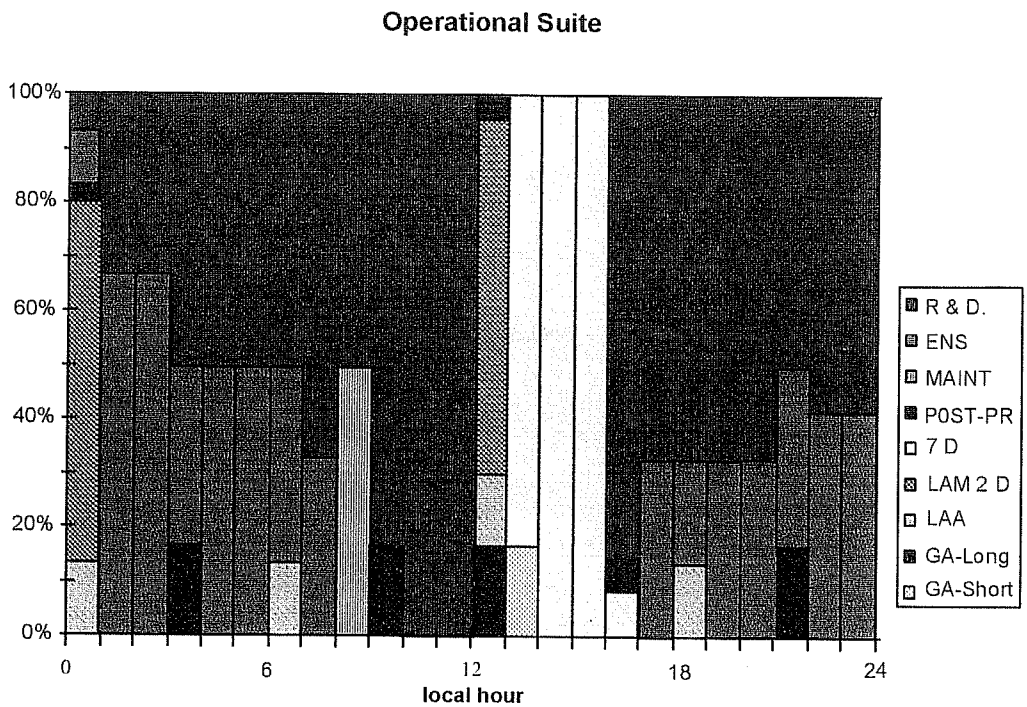
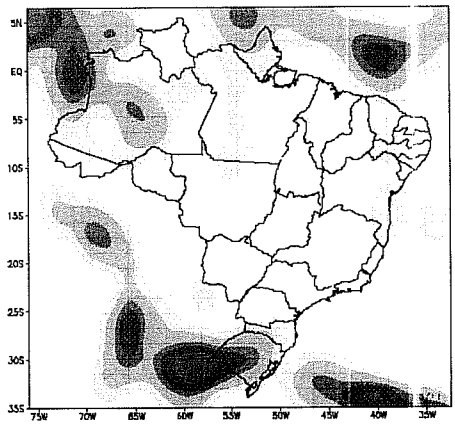
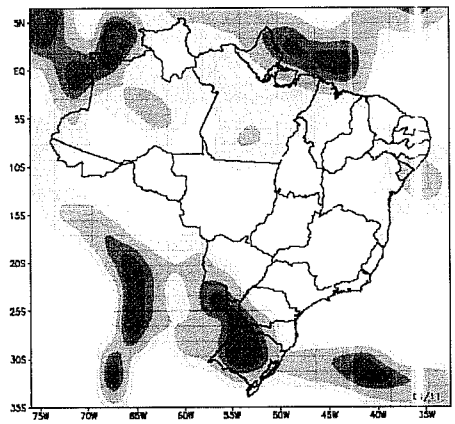


Figure 4: Distribution of time at CPTEC.

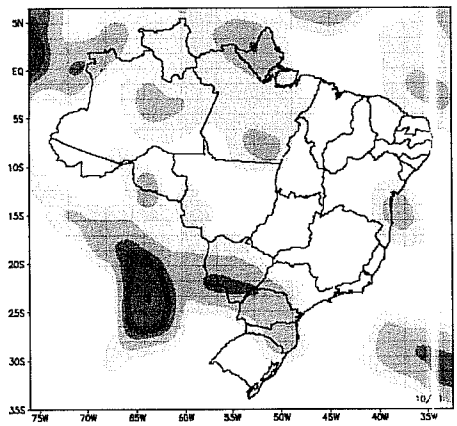
PRECIPITATION (mm)



Rains in RS e SC 08/11/95

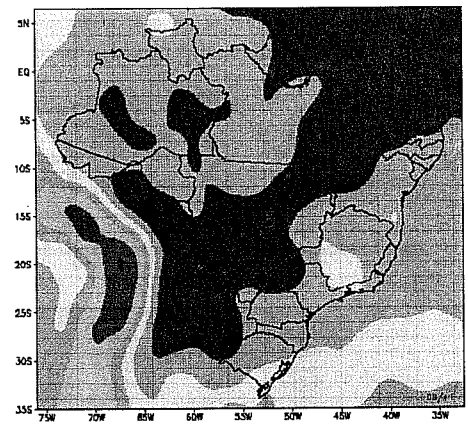


Rains in South 09/11/95

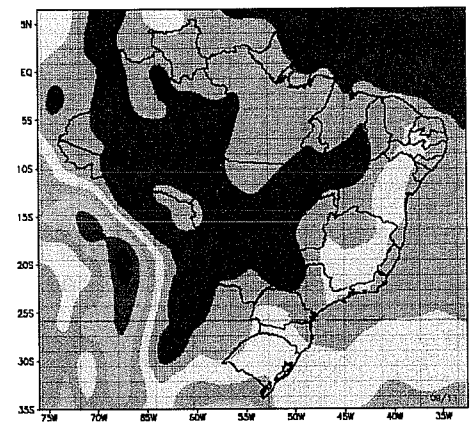


Rainy day in South 10/11/95

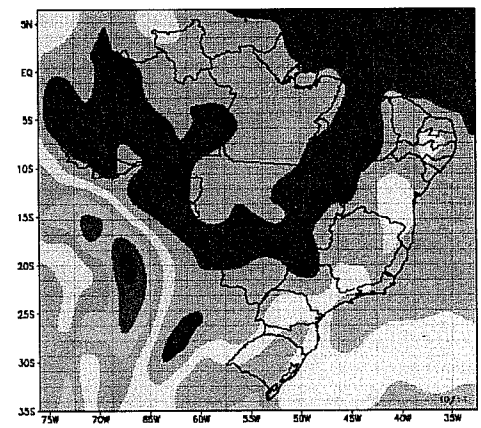
TEMPERATURE (°C)



Temperature fall in RS 08/11/95



Temperature fall in South 09/11/95



High temperatures in central Brazil 10/11/95

Figure 5: Precipitation and Temperature forecasts valid for 8, 9, 10 November 1995.