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10 Dereczynski, Claudine P.
10 Tarasova, tatiana Igor
10 Trosnikov, Igor V.
10 Nobre, carlos Afonso
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Brazilian contribution to SCAR-B project - Meteorology

Luiz F. Mattos. Claudine P. Dereczynski. Tatiana A. Tarasova. Igor V. Trosnikov and Carlos A. Nobre

Centro de Previsão do Tempo e Estudos Climáticos - Instituto Nacional de Pesquisas Espaciais. Cachoeira Paulista. São Paulo. Brazil

Abstract - *The Smoke. Clouds and Radiation - Brazil (SCAR-B) Project was conducted in Central Brazil and in the southern Amazon Basin from August 15 to September 20. 1995. This summary paper describes the Brazilian meteorological contribution to the SCAR-B mission. including a climatological study and the weather analyses and forecasts. Twice daily forecasts. based on Centro de Previsão do Tempo e Estudos Climáticos (CPTEC) and National Centers for Environmental Prediction (NCEP) model outputs and conventional observations. provided special support for the mission. These data sets are available at CPTEC's public directory. Long periods of haze. low index of relative humidity and also little cloudiness and rain occurred during the mission due to blocking of frontal systems in the South Pacific. Backward trajectory calculations show three types of air particles which have come from Pacific Ocean. Amazonia and other continental regions. Some results demonstrate the strong sensitivity of the atmosphere-surface radiative budget to the optical parameters of smoke particles at Cuiaba site.*

1. Introduction

The Smoke. Clouds and Radiation - Brazil (SCAR-B) Project. supported by the National Aeronautics and Space Administration (NASA). with collaboration of the University of Washington. Instituto Nacional de Pesquisas Espaciais (INPE). Universidade de São Paulo (USP) and Agência Espacial Brasileira (AEB). ultimately intends to estimate the smoke effects on the planet's climate and radiation balance. This paper summarizes part of the Mission's meteorological effort. based at Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais (IBAMA) Agency. in Brasília. and at Centro de Previsão de Tempo e Estudos Climáticos (CPTEC) - INPE. in Cachoeira Paulista. The data sets and some concluding remarks from a meteorological viewpoint are presented.

2. Data sources

SCAR-B's meteorological data sets are available from CPTEC's public domain as described in Figure 2.1. It can be retrieved from >ftp yabae.cptec.inpe.br: login:scarb: password:scarb: where the READ_ME file gives the description of the data files. The numeric weather prediction (NWP) models were the global CPTEC and the Medium-Range Forecast (MRF) and aviation (AVN) from National Centers for Environmental Prediction (NCEP). The Table 2.1 shows information about these models.

3. Meteorological and Climatological Features

We will show briefly the most important large scale Southern Hemisphere (SH) winter climate features in tropical South America, and analyze the main climate features during SCAR-B period. The large scale systems responsible for SCAR-B region climate are: Intertropical Convergence Zone (ITCZ), Frontal System (FS) and South Atlantic Subtropical High (SASH) (see Fig. 3.1).

In SH winter the Bolivia High (BH) and the convective areas migrate to Colombia and Venezuela [Kousky e Kagano. 1981]. The large scale rainfall on northern South America are due to ITCZ. The Andes Mountains play a fundamental role inducing throughout the year the genesis of maximum and minimum precipitation regions on their slopes [Figueroa and Nobre. 1990]. The FS's reach the lowest latitudes in South America and their trajectory follows two seasonal patterns. Their SH summer trajectories are slower and characterized by great convective activity. due to their interactions with the BH and ITCZ. Their SH winter trajectories are faster above regions of low specific humidity and high loss of heat by radiation. These FS's do not show much convective activity. but bring cold surges. known as "friagens" in Central-West and Northwestern Brazil.

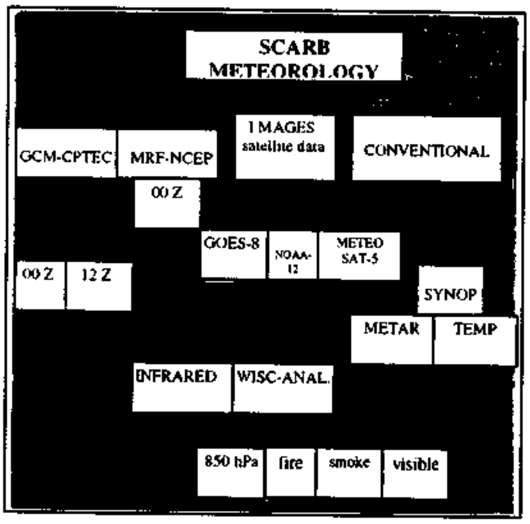

Fig. 2.1 - Box diagram of the SCAR-B directory organization. available at CPTEC public domain: yabae.cptec.inpe.br.

Table 2.1- Information related to data produced by NWP models.

Sources	CPTEC	MRF	AVN
Forecast-hour	T+24,T+48, T+72, T+96 and T+120	T+00, T+24,T+48, T+72, T+96 and T+120	T+06, T+18
Levels	surface, 1000, 850, 700, 500, 300, and 200 hPa	surface, 1000, 850, 700, 500, 300, 250 and 100 hPa	1000, 850, 700 and 500 hPa
Resolution	1.875 x 1.875	2.5 x 2.5	2.5 x 2.5
Latitude	60°S to 15°N	90°S to Equator	90°S to Equator
Longitude	100°W to 10°W	120°W to 10°W	120°W to 10°W
Analyzed fields used to forecast the weather during SCAR-B	- atmospheric pressure (hPa) at mean sea surface level and 1000/500 hPa thickness (mgp); - 850, 700 and 500 hPa streamlines and isothacs (m s^{-1}); - 850 hPa air temperature (°C); - 850 and 700 hPa relative humidity (%); - 500 hPa geopotential height (mgp); - 850 hPa divergence (s^{-1}) - cloud cover (tenths); - total precipitation (mm).	- atmospheric pressure (hPa) at mean sea surface level and 1000/700 hPa thickness (mgp); - 850 and 500 hPa streamlines and isothacs (m s^{-1}); - 850 hPa air temperature (°C). - 850 hPa relative humidity (%); - 500 hPa geopotential height (mgp); - total precipitation (mm).	- 850, 700 and 500 hPa air temperature (°C); - 850 and 700 hPa relative humidity (%); - 500 hPa geopotential height (mgp); - 1000, 850, 700 and 500 hPa zonal and meridional wind components (m s^{-1}).
Analysis Time (UTC)	00- and 12-h	00-h	00-h

MAIN SH WINTER WEATHER SYSTEMS IN SCAR-B AREA

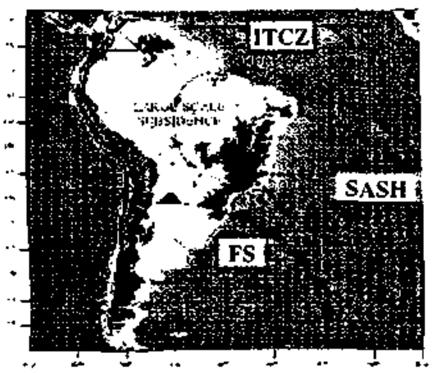

Fig. 3.1 - Main SH winter weather systems in SCAR-B area.

The stability condition with light to moderate easterly winds and moderate temperatures, typical of the Brazilian coast, results from the SASH circulation. This system drifts seasonally into the Atlantic Ocean in the summer and into the continent in the winter, when the winter SASH ridge extends over Southeast Brazil. The wind speed north of this ridge increases from the center to the border, with east winds in the east, central and northern SCAR-B region. West of the SCAR-B area, far away from the center, winds are lighter, the temperature is higher and the pressure is lower. Moreover, at the middle troposphere (near 5000 m) there is another anticyclonic circulation in Central Brazil, causing long periods of little cloudiness and rain and strong haze. The high level subsidence explains the low observed values of relative humidity [Figueroa and Nobre, 1990].

During the first 30 days of the experiment, when the mid-troposphere anticyclone was dominant in the SCAR-B area, few cold fronts reached Brazil. The FS's that managed to reach lower latitudes were diverted to the South Atlantic Ocean. Weak anticyclones merged with the SASH. FS blocking at hemispheric scale was observed since July 1995, identified by positive anomalies at 500 hPa geopotential height in the South Pacific Ocean [Climanálise Vol. 10, 8, 1995]. This configuration vanished totally, and reverted during September [Climanálise Vol. 10, 9, 1995]. At regional scale the blocking developed since August 1 through September 15, as indicated by the mid-troposphere anticyclone over the interior of Brazil. After this date, cloudiness frequency and amount increased in Northern Brazil. It occurred due to the weakening of the subsidence induced by SASH and to the easterly displacement of the mid-troposphere anticyclone.

The SCAR-B region presented negative precipitation anomalies and positive temperature anomalies. Figure 3.2 shows the temperature and precipitation anomalies on August 1995. In agreement with the climatic features, the weather conditions over the SCAR-B area were relatively stable during the SH winter, with reduced cloudiness and rainfall, increased haze and low level easterly winds. The strong dry season occurred in most parts of the country, and it was the main reason for the large number of fires observed mainly in Central-Western Brazil, where the total precipitation was less than 1 mm.

The synoptic conditions forecast for the last week of the mission (forecast of the first transient system with substantial rains) caused an earlier than antecipated end of the mission on 20 September 1995. Concerning future possible missions of the same type to be carried out in the same region, we suggest a new period: through August 1 to September 15.

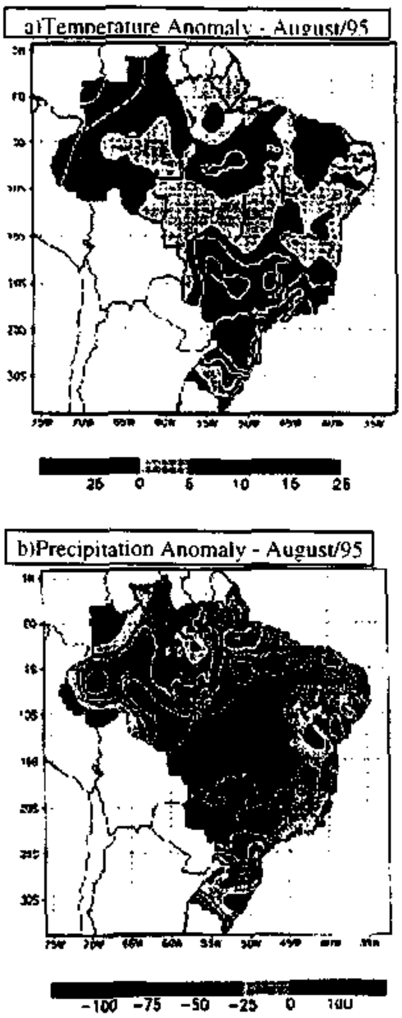

Fig. 3.2 - Temperature and precipitation anomalies - August/95, normalized by 30 year average (percentage).

4. Numerical Simulation of Trajectories of Air Particles

To estimate the spreading of gas and aerosol emissions from areas with intense biomass burning, the numerical simulation of the forward and backward trajectories of air particles on isentropic surface has been applied. The calculations were performed by using INPE-CPTEC's data base which includes analysis and 5 days forecast fields of the meteorological elements on the grid with 1.875° x 1.875° resolution. Fig. 4.1 shows an example of the backward trajectory calculations for the period from 23 through 28 August 1995. By the end of this period the air mass within 35°S to 25°S and 60°W to 55°W consists of three types of the air particles. The first type is the air particles which have come from Pacific Ocean and is located above 2 km. They moved on the isentropic surface 315 K. The second type of air particles is located between 1 and 2 km and comes from Amazonia (isentropic surface 308 K). This type air mass has brought smoke from the Amazon region. The particles below 1 km with potential temperature 305 K come from other continental regions.

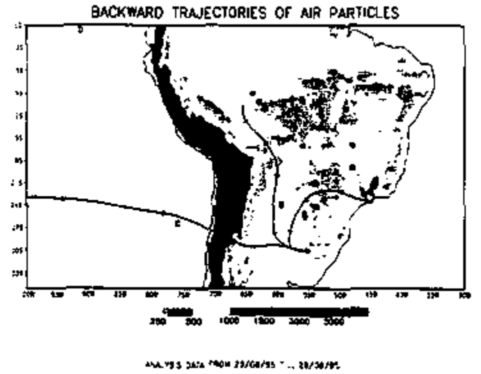

Fig. 4.1. The backward trajectories of air particles on the isentropic surfaces 305 K (A), 308 K(B), and 315 K (C)

5. Calculations of the smoke aerosols impact on the radiative bugdet of the atmosphere-surface system.

Smoke aerosol particles absorb and scatter solar radiation changing the radiative balance at the atmosphere boundaries and the heating rate inside the Earth's atmosphere. The maximum aerosol impact on solar radiation is at noon due to largest values of the solar flux. To estimate this effect we performed the calculations using approximate radiation code and developed model of the atmospheric parameters. The smoke aerosol optical thickness and the single-scattering albedo were derived from the radiation measurements carried out in Cuiaba during SCAR-B mission on 27and 28 August 1995 under the hazy cloudless conditions [Tarasova et al., 1996].

We computed the solar radiation absorption in the atmosphere-surface system and in the atmosphere and at the surface separately. Table 5.1 presents the computation results. The absolute values of the absorption by ozone and water vapor are shown as case 0. Cases 1-5 give the changes of the absorption due to the smoke loading of the atmosphere with the columnar average aerosol optical thickness τ and the single-scattering albedo ω_0 at the wavelength 550 nm. Case 1 is for the background aerosols without smoke. cases 2.4 are for the low atmosphere turbidity on August 28 and cases 3.5 are for the middle atmosphere turbidity on August 27. The wide range of uncertainty in the values of the smoke single scattering albedo ω_0=0.84...0.89 reported [Tarasova et al.. 1996] leads to the significant uncertainties in the estimate of the atmosphere-surface radiative budget as seen in Table 5.1.

Table 5.1. The solar radiation absorption (W/m^2) in the atmosphere (Atm). atmosphere-surface system (Syst) and at the surface (Surf) at noon for case 0 without aerosols and changes of absorption (W/m^2) due to aerosol influence for cases 1-5 .

Case	0	1	2	3	4	5
τ	-	0.22	0.41	0.67	0.41	0.67
ω_0	-	0.89	0.89	0.89	0.84	0.84
Syst.	1010	-6	-8	-18	-1	-7
Atm.	205	+29	+61	+92	+82	+124
Surf.	805	-35	-69	-110	-83	-131

Thus. Table 5.1 presents the solar radiative heating of the atmosphere column and cooling of the Earth's surface by smoke aerosols at noon on August at Cuiaba site. The total aerosol effect on the system absorption is weaker .

These results demonstrate the strong sensitivity of the atmosphere-surface radiative budget to the optical parameters of smoke particles.

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