A PREVIEW OF PRELIMINARY RESULTS FROM THE TroCCiBras, TROCCINOX AND HIBISCUS CAMPAIGN 2004

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TroCCiBras, TROCCINOX and HIBISCUS Teams

Abstract: The TroCCiBras (Tropical Convection and Cirrus experiment Brasil) campaign was conducted jointly with the European HIBISCUS and TROCCINOX projects from 21 January to 11 March 2004. The general objective of TroCCiBras, coordinated by IPMet/UNESP, is to obtain a set of special measurements throughout the troposphere and the lower stratosphere, to meet specific research needs of Brazilian research institutions, through the realization of the EU projects. Besides IPMet, six other Brazilian research institutions, as well as the German Max Planck Institute for Chemistry, participated actively in the field campaign. A unique data base has been established, which is of outstanding value for scientists in the State of São Paulo and Brazil. The most important *preliminary* findings are: vertical profiles of water vapor are absolutely essential for the validation of satellite-borne monitors; satellite-borne ozone monitors have been found to be relatively inaccurate, highlighting the importance of in-situ measurements by stratospheric balloons and high-flying aircraft (≥20km altitude); preliminary results indicate, that the production of NO by lightning discharges in the tropics could have been underestimated.

Key Words: TroCCiBras, State of São Paulo, radar observations, radiosoundings, lidar, aircraft measurements, trace gases, aerosols, lightning, automatic weather stations, Meso-Eta model, TROCCINOX, HIBISCUS, water vapor, satellite validation, ozone, NOx, Tropical Tropopause Layer.

Resumo: As atividades da campanha do projeto TroCCiBras (Tropical Convection and Cirrus experiment Brasil) foram realizadas em conjunto com os experimentos de campo dos projetos europeus HIBISCUS e TROCCINOX no período de 21 de janeiro a 11 de março de 2004. O objetivo geral do projeto TroCCiBras, coordenado pelo IPMet/UNESP, é a obtenção de um conjunto de medidas especiais através da troposfera e baixa estratosfera, para necessidades específicas de instituições de pesquisas brasileiras, através da realização de projetos com a União Européia. Além do IPMet , outras seis instituições de pesquisas brasileiras, assim como o Instituto Max Planck de Química da Alemanha, participaram ativamente da campanha de coleta de dados. Uma base de dados única foi adquirida, de inestimável valor para cientistas do Estado de São Paulo e do Brasil. Os resultados preliminares mais importantes são: perfis verticais de vapor d´água são absolutamente essenciais para validação de plataformas embarcadas em satélite; as informações de monitores de ozônio embarcados em satélite são de baixa acurácia, evidenciando a importância de medidas in-situ através de balões estratosféricos e aeronaves voando a altitudes ≥20km; resultados ainda preliminares indicam, que a produção de NO por descargas elétricas nos trópicos pode estar sendo subestimada.

Palavras Chave: TroCCiBras, Estado de São Paulo, observações de radar, radiossondagen, lidar, medidas de aeronave, gases traço, aerossóis, descargas elétricas, estações automáticas de superfície, modelo Meso-Eta, TROCCINOX, HIBISCUS, vapor d´água, validação de satélite, ozônio, NOx, Camada de Tropopausa Tropical (TTL).

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INTRODUCTION

During the International TROCCINOX (Tropical Convection, Cirrus and Nitrogen Oxides Experiment) Workshop, initiated by the TROCCINOX coordinators (IPA/DLR) and their Brazilian partners (IPMet/UNESP), and realized in February 2003 at IPMet in Bauru, the interest of Brazilian research groups in participating in a joint multi-disciplinary research project, which would exploit unique data provided by the TROCCINOX and HIBISCUS (a project on "Impact of tropical convection on the upper troposphere and lower stratosphere") campaigns, was tested. This Workshop was also joined by the HIBISCUS team, which was then engaged in the Pre-HIBISCUS 2003 Campaign, in preparation for the 2004 Main-Campaign. The Workshop was attended by about 35 delegates and most Brazilian research groups, specialized in Atmospheric Sciences, were represented.

It was proposed, that all relevant research organizations and University Departments be invited to submit a brief proposal, indicating intended activities during the joint campaign. The Lead Institution, IPMet/UNESP, would coordinate these short proposals and subsequently invite for complete proposals, to be submitted. These were then organized into the TroCCiBras Proposal (Tropical Convection and Cirrus experiment Brasil) for submission to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) to authorize a "Scientific Expedition", through which TROCCINOX could be invited to participate. This was essential for obtaining the required Government permission to bring the foreign aircraft laboratories into Brazil and conduct monitoring flights in Brazilian air space. On the other hand, HIBISCUS is an already ongoing joint project between CNRS and CNES on the European side and IPMet/UNESP in Brazil, and thus did not need the special status of "Scientific Expedition".

IPMet's PARTNER ORGANIZATIONS IN THIS STUDY

TroCCiBras

- Centro de Previsão do Tempo e Estudos Climáticos (CPTEC) / Instituto de Pesquisas Espaciais (INPE)
- Centro de Lasers e Aplicações (CLA) / Instituto de Pesquisas Energéticas e Nucleares (IPEN)
- Centro da Química e Meio Ambiente (CQMA) ***)** / Instituto de Pesquisas Energéticas e Nucleares (IPEN)
- Centro Técnico Aeroespacial (CTA) / Instituto de Aeronáutica e Espaço (IAE) ***)**
- Embraer, Gavião Peixoto Unit
- Centro de Ensino e Pesquisas em Agricultura (CEPAGRI) / Universidade Estadual de Campinas (Unicamp)
- Department of Communications Engineering, Osaka University (LRGOU), Japan (in cooperation with TROCCINOX)
- Grupo de Eletricidade Atmosférica (ELAT) / Instituto de Pesquisas Espaciais (INPE)
- Instituto Agronômico de Campinas (IAC)

- Instituto de Astronomia, Geofisica e Ciências Atmosféricas (IAG) / Universidade de São Paulo (USP)
- Instituto de Física (IF) / Universidade de São Paulo (USP) in collaboration with the Max Planck Institute for Chemistry, Mainz, Germany
- Instituto Nacional de Meteorologia (INMET)
- Universidade Estadual do Ceará (UECE) ***)**

***)** These Institutions could not participate in the 2004 field experiment due to a lack of funds (funding for the Brazilian participants in TroCCiBras had been requested from FAPESP, but was not available).

Partner Organizations: TROCCINOX Field Campaign 2004

The lead organization for TROCCINOX is the "Institut für Physik der Atmospäre" (IPA) of the "Deutsches Zentrum für Luft- und Raumfahrt" (DLR). The following partner organizations participated in the past field campaign:

- Eidgenössische Technische Hochschule Zürich, Switzerland
- Université Paul Sabatier / Laboratoire d'Aérologie, Toulouse, France

An additional 15 partner organizations from Russia, Germany, Italy, United Kingdom, Switzerland and France did not actively participate in the 2004 field experiment in Brazil, mostly due to the Russian aircraft Geophysica not being able to arrive on time. The complete list of partner organizations can be found at the TROCCINOX Website - http://www.pa.op.dlr.de/troccinox/

Partner Organizations: HIBISCUS

The scientific lead organization for HIBISCUS is the Service d'Aéronomie of the Centre National de la Recherche Scientifique (SA-CNRS), in close collaboration with the Centre National d'Études Spatiales, Toulouse (CNES), which is responsible for the stratospheric balloons. Other scientific partners, all of which participated in the 2004 campaign, are:

- Laboratoire de météorologie dynamique (LMD-CNRS), France
- University of Cambridge, Department of Chemistry (UCAM-DCHEM), United Kingdom
- National Physical Laboratory (NPL), United Kingdom
- Danmarks Meteorologiske Institut (DMI), Danmark
- Istituto di Scienze dell'Atmosfera e del Climat (ISAC-CNR), France
- Laboratoire de Physique et Chimie de l'Environnement (LPCE), France
- University of Manchester, Institute of Science and Technology (UMIST), United Kingdom
- Norsk Institutt for Luftforskning (NILU), Norway
- Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA), Italy
- Laboratoire de météorologie physique, Clermont Ferrand (LAMP), France
- Laboratoire de physique atmosphérique (LPA), La Reunion
- Laboratoire d'aérologie / Université Paul Sabatier (LA/UPS), France
- Laboratoire d'astrodynamique, d'astrophysique et d'aéronomie de Bordeaux (L3AB), France
- Centre d'etude de l'Environnement Terrestre et Planetaires (CNRS-CETP), France

OBJECTIVES

The general objective of the TroCCiBras project is thus to obtain a set of special measurements throughout the troposphere and the lower stratosphere, to meet specific research needs of Brazilian research institutions, through the realization of the EU project TROCCINOX and the joint Brazilian / European project HIBISCUS in Brazil.

The different research sub-projects, although classified into three main topics, viz., "Meteorology, Atmospheric Physics and Forecasting", "Atmospheric Chemistry" and "Validation of Satellite-borne and Ground-based Remote Sensors", constitute in fact a comprehensive ensemble. Table 1 lists the various sub-projects and responsible institutions. In conclusion, it can be stated that all sub-projects will contribute major milestones to the overall knowledge of the atmosphere over the State of São Paulo and thus facilitate the achievement of the two primary goals of TroCCiBras, viz., the validation of satellite-derived measurements (especially those of the HSB) and the improvement of Nowcasting methods.

The complete project proposal and other relevant documents can be downloaded from the TroCCiBras Website - www.ipmet.unesp.br/troccibras/

Table 1. TroCCiBras "umbrella projects" with the specific sub-projects. (Topics shown in *italics* could not be realized due to a limitation of funds).

AREA OF SUB-PROJECT	TITLE OF SUB-PROJECT	RESPONSIBLE INSTITUTION
Meteorology, Atmospheric Physics and Forecasting	Radar Observations, Integration of Lightning Observations, Numerical Models & Nowcasting	IPMet / UNESP
	Validation of Atmospheric and Chemistry Numerical Models	CPTEC / INPE
	The Coupling Between the Boundary Layer and the Onset and Vigor of Moist Convection	CTA and CPTEC/INPE
	Cloud Physics Studies	UECE
	Lightning and *Sprites Studies*	ELAT / INPE
	Air Pollution, Cloud and Climate Interactions	IAG / USP
Atmospheric Chemistry	Vertical Distribution of Aerosols and Trace Gases between the Ground and the Mid-Troposphere	IF / USP and MPIC
Validation of Satellite-Borne and Ground-Based Remote Sensors	Matching Measurements from Different Sensors	IPMet / UNESP
	Assessing Clear Air Detection and Cloud Boundaries	IPMet / UNESP
	Rainfall Quantification by Satellite Microwave Channels	IPMet / UNESP

The main objectives of TROCCINOX, which is an RTD Program of the European Community, can be summarized as follows:

- To improve the knowledge about lightning-produced NO_x (LNO_x) in tropical thunderstorms by quantifying the produced amounts, by comparing it to other major sources of NOx and by assessing its global impact, and
- to improve the current knowledge on the occurrence of other trace gases (including water vapor and halogens) and particles (ice crystals and aerosols) in the upper troposphere and lower stratosphere in connection with tropical deep convection, as well as large-scale upwelling motions.

Thus, the project TROCCINOX will perform first measurements of the combined properties of convection, aerosol and cirrus particles and chemical air composition (nitrogen oxides in particular) in the tropics over oceanic and continental regions (State of São Paulo and adjoining areas) in the upper troposphere and lower stratosphere, including troposphere-stratosphere exchange. Bauru was identified as the ideal base point, due to its proximity to observed high lightning frequencies over the South American continent. A modeling component aims in providing improved descriptions of processes relevant to global climate problems. Details about the TROCCINOX project can be found at the following Website -
http://www.pa.op.dlr.de/troccinox/

The general objective of the HIBISCUS project, which is also an RTD Program of the European Community, is to investigate the impact of tropical convection on the upper troposphere and lower stratosphere at local and global scale. Thus, more specific objectives of the HIBISCUS project can be summarized as follows:

- Past and present meteorological analyses
- Vertical and horizontal transport
- Clouds and microphysics
- Source of stratospheric water vapor
- Chemistry, impact of lightning and pollution
- Satellite validation (ENVISAT, SAGE-III)

Further specific objectives will characterize the impact of convection on the tropical upper troposphere and lower stratosphere, the transport pattern, radiation, micro-physics and atmospheric chemistry. Details about the HIBISCUS project can be found at the following Website -
http://www.aero.jussieu.fr/projet/HIBISCUS/

TroCCiBras DATA BASE

The campaign period extended from 21 January to 11 March 2004, and all data that have been collected under the TroCCiBras project have been assembled in a special, PassWord-protected, data base to which all participating organizations and researchers have access via FTP. This data base contains the following information/data, but not necessarily all of them for the full period:
IPMet radars: Bauru + Presidente Prudente integrated surveillance PPI (450km); individually for each radar a surveillance PPI (450km), 3.5km CAPPI (240km) of reflectivity (Z) and radial

velocities (v), as well as echo tops. These have been generated in GIF-format for ALL recorded radar data.

Radiosoundings at IPMet: In total, 105 soundings were made (PTU), of which 93 also have wind speed and direction; 3 ozone soundings and 8 DMI backscatter sondes were also flown. ASCII data files, as well as graphs for each sounding, together with a detailed catalogue, are included.

Aerosol Lidar at IPMet: A total of 67 profiles were obtained, of which about 30% reached up to 18-36km. The diurnal variation was captured by profiling in the morning, afternoon and evening (21, 20, 25 profiles each).

Bandeirante: All together 7 flights were made out of Gavião Peixoto (GPX) Embraer Airport on 5 days up to a height of 4,5km. The following monitors and samplers were installed on the aircraft: temperature & humidity sensor, CO, CO_2, H_2O, NO, NO_2, O_3, SMPS particulates, Nephelometer, Aethalometer (black carbon), OPC (Optical condensation Particle Counter), aerosol filter sampler. Maps of the flight tracks, as well as the actual GPS data are available, but the raw data can only be loaded after having been calibrated, etc.

Lightning data: The complete set of RINDAT flash records for the campaign period has been transferred by ELAT; the 2- and 3-dimensional lightning observations from the LRGOU VHF broadband interferometer network will only be available for a few cases from mid-February onwards.

Surface Automatic Weather Stations (State of São Paulo): The complete set of 22 stations has been transferred by IAC Campinas for the campaign period.

Radiosoundings from INMET/CPTEC network: ASCII files have been prepared for all available stations south of 12ºS for the campaign period, with "Skew T – Log P" diagrams in GIF-format for 7 stations in and around the State of São Paulo.

Meso-Eta model output: Three-hourly outputs of all products (10x10km grid, centered on Bauru) up to 48 hours are stored on the data base, but the complete runs up to 96 hours are available off-line.

TROCCINOX: The Falcon flew 14 missions out of GPX Embraer Airport on 13 days between 13 February and 10 March 2004. However, only flight tracks (maps) are stored in the TroCCiBras data base, but project partners can access the TROCCINOX data base after signing the Data Protocol.

HIBISCUS: From 31 January until 11 March 2004, the following stratosphere balloons were launched from IPMet: 6 short-duration ZL and SF, as well as 2 NILU cubes; 8 BP long-duration and 3 MIR balloons. However, only tabulated flight information and payloads are stored in the TroCCiBras data base, but project partners can access the HIBISCUS data base after signing the respective Data Protocol.

FIRST RESULTS OF RELEVANCE FOR BRAZIL

Although the start of the campaign had been delayed by about two weeks due to administrative problems around the TROCCINOX project (late publication of the Presidential Decree on 30 December 2003; very late publication of the MCT Portaria on 27 January 2004 in the Diário Oficial da União) and some good tropical thunderstorms had thus been missed, the month of February, nevertheless provided ample opportunities for sampling with the Falcon and Bandeirante aircraft below and around some severe storms. Figure 1 shows the range of the IPMet S-band Doppler radars, within which many of the flights had been conducted.

Radar Observations

Figure 2 depicts the maximum echo tops (10 dBZ) within the 240km range of the Bauru radar against the maximum VIL (Vertically Integrated Liquid water content; Gomes, 2002), which provides a good assessment of the severity of storms during the month of February (Gomes and Held, 2004; Figueiredo *et al.*, 2004). Tops in excess of 16,5km (28%, with almost 8% >18km) are indicative of tropopause penetration and VIL >15kg.m^{-2} (24%, indicative of extreme rainfall or hail) have been observed frequently, as can be seen from Figure 2. These figures would yield VIL Densities of ≥1,0g.m^{-3}.

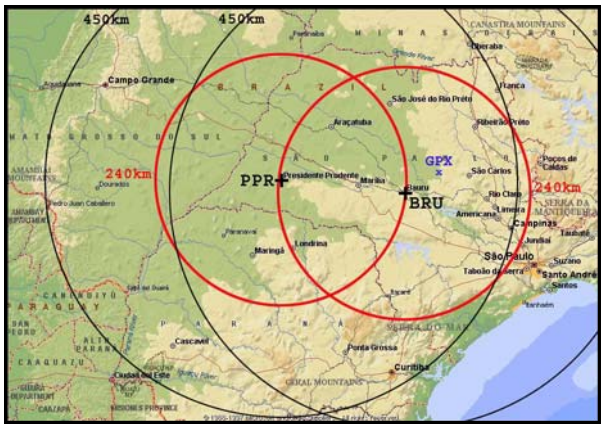

Figure 1. IPMet's Radar Network (PPR & BRU), showing 240 and 450 km range rings, as well as the location of Gavião Peixoto Airport (GPX).

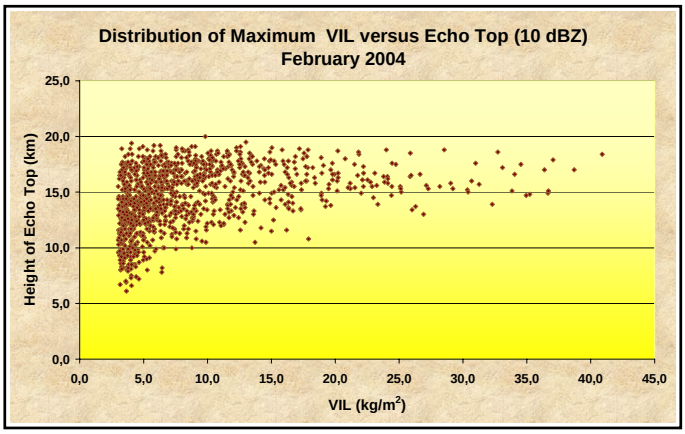

Figure 2. Distribution of maximum VIL versus maximum echo tops during February 2004, derived from the Bauru radar volume scans (240km).

Satellite Validation

Figure 3 shows the impact of the resolution of satellite sensors AMSU-A (50km) and AMSU-B/HSB (13km) on the retrieval of horizontal / vertical humidity profiles. An indication of the smoothing imposed by the sensor's Field Of View (FOV) is given in Figures 3a, b and c. A vertical cut through horizontal pixel 289 is presented in Figure 3d (original) and Figure 3e (filtered). A horizontal profile at 12,7km height is depicted in Figures 3f, g, h, without filtering, for a 13km

FOV and 50km FOV, respectively. Such an impact evaluation was possible for the first time above the area covered by the TROCCINOX Falcon aircraft. Horizontal and vertical numbers are pixel coordinates and color codes indicate relative signal intensity.

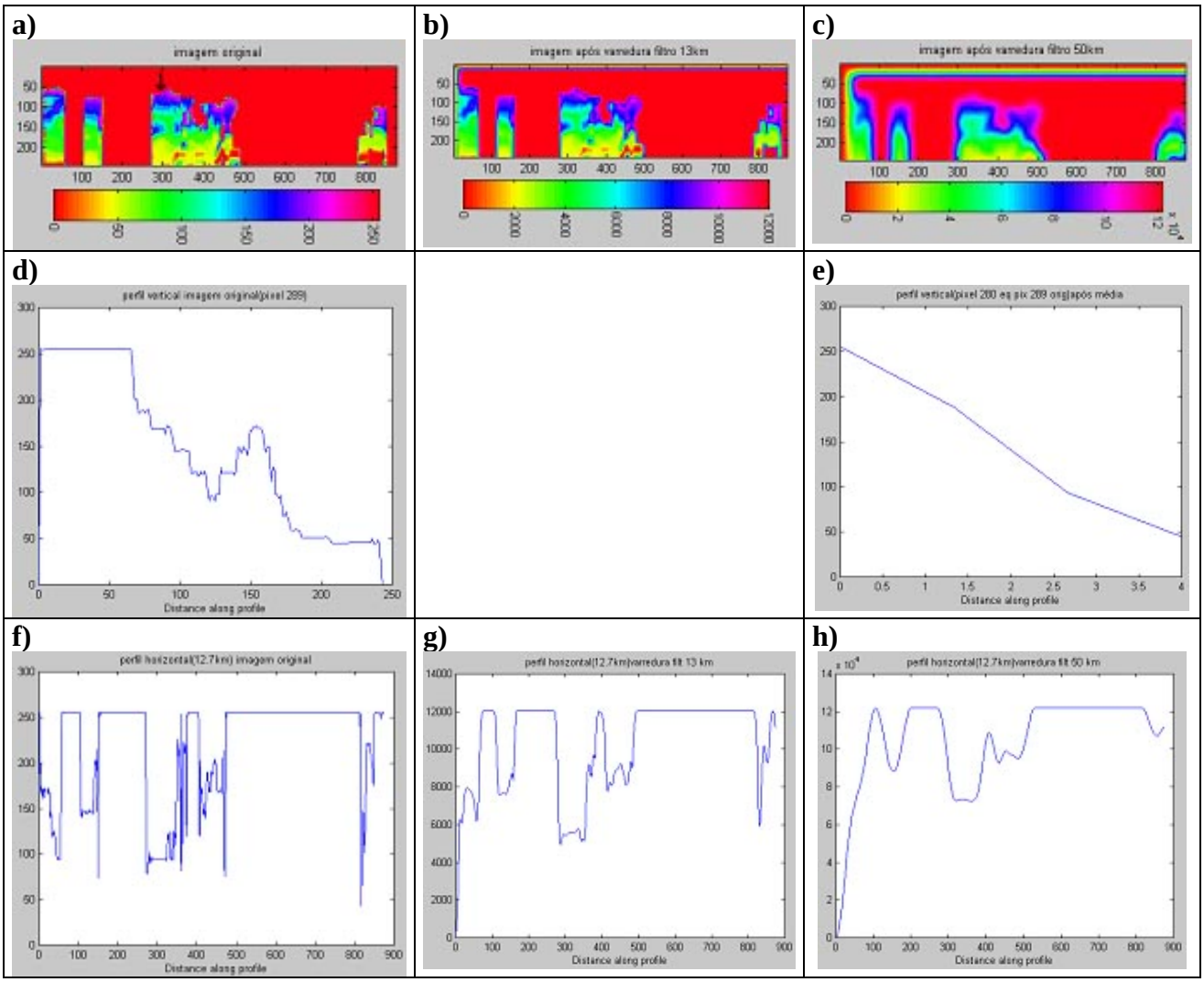

Figure 3. Impact of the resolution of satellite sensors on the retrieval of humidity profiles. This example is based on a "Quicklook" graph of measurements made by the TROCCINOX Falcon aircraft (DIAL Lidar) on 04 March 2004. The left and upper edges in Figures 3b and c are artifacts.

Aerosol Lidar at IPMet, Bauru

The Centro de Lasers e Aplicações of the Instituto de Pesquisas Energéticas e Nucleares (IPEN) moved its elastic backscattering Lidar from São Paulo to Bauru, where it was installed in a specially adapted trailer. The Lidar operated intermittently during mid-morning, mid-afternnoon and in the evening for periods of 1-2 hours, on days with fair-weather conditions, because it cannot be operated in rain, during midday or with a cloud cover. In its original configuration, it would provide aerosol backscattering profiles of up to 10 km in height, but by adding a transient recorder, operating both in analog and photo-counting mode, it could reach up to 60km under ideal conditions. This was the first time, aerosol profiles were measured in the central State of São Paulo.

A typical example of the observations is shown in Figure 4 for an evening period of just more than one hour. The profile is visualized from 855m up to 21,5km and depicts a clearly visible layer of thin clouds around 4,5km, as well as layers of aerosols around 3 and 5km. The top of the boundary layer is around 1850m, all discernible as faint layering in the shades of green and light-blue.

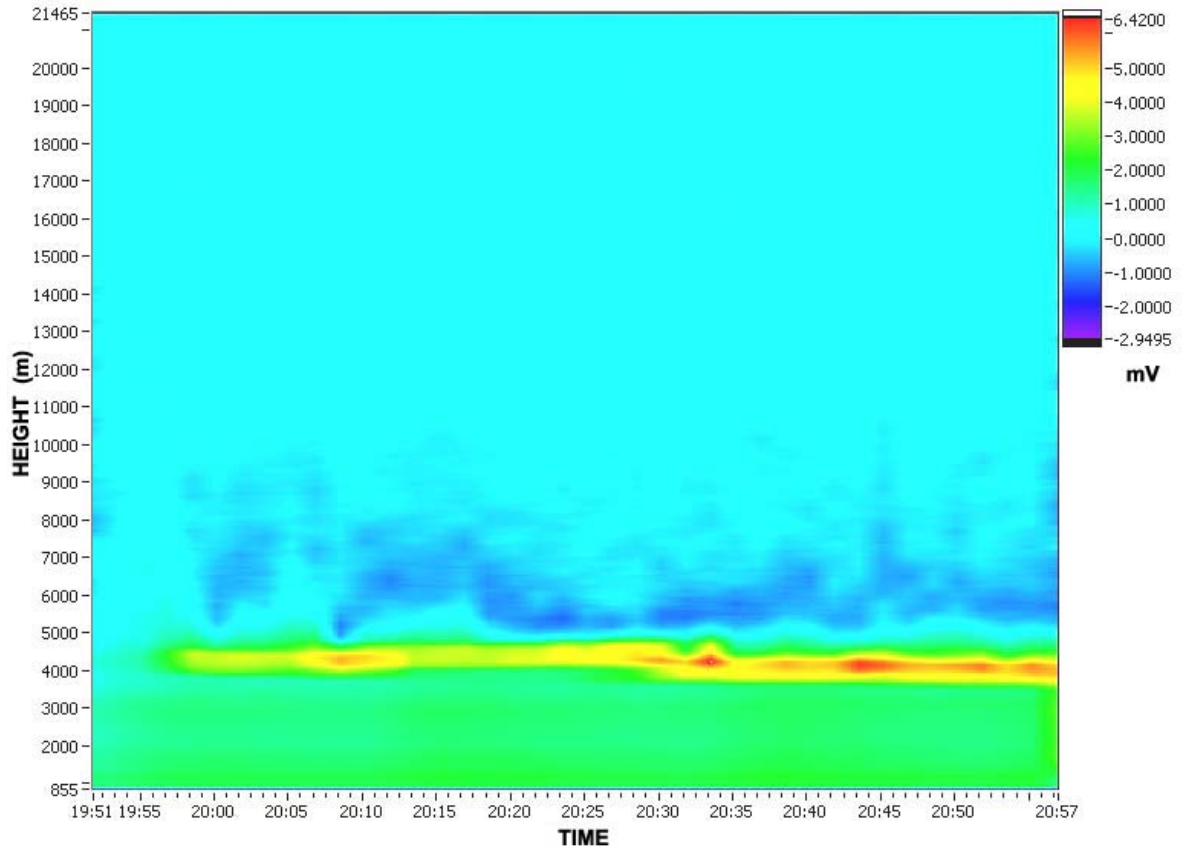

Figure 4. Lidar profiles obtained at IPMet, Bauru, on 04 March 2004 between 19:51 and 20:57 (courtesy of E. Landulfo, CLA/IPEN).

Lightning-Produced Nitrogen Oxides (LNOx)

Based on preliminary, unpublished "Quicklook" data (Schumann, 2004), NOx measurements obtained during a flight on 03 March 2004 recorded a peak of up to 70 nmol/mol in NO concentration. It should be noted that this was observed just below 6000m altitude. It is the highest NO peak from known aircraft measurements near lightning activity. As a comparison, the maximum found during EULINOX (European Lightning Nitrogen Oxides Experiment) was about 40 nmol/mol and concentrations from several US campaigns were within the 30-50 nmol/mol range (pers. comm., Dr Hans Schlager, DLR, 2004).

Observations made from balloons launched during summer 2001 into the lower stratosphere by HIBISCUS (Pommereau *et al.*, 2004), indicate, that the largest NO_2 concentrations were observed over the two continental convective areas between 12 and 14km (South America and

Africa), while the minima are located over the maritime convective area of the western Pacific and northern Australia (Figure 5), highlighting the difference between continental and maritime convection. NO_2 maxima appear highly correlated with lightning, as observed by the space-borne Lightning Imaging Sensor (LIS), with the lightning frequency being by far more abundant over continents than over oceanic areas. However, although a large part of the observed NO_2 variation in the stratosphere could be explained by horizontal transport, a local source seems to exist over South America. A tentative explanation for that could be a NOx production by Blue-Jets, that is an electric discharge between clouds and the ionosphere. A future phase of TroCCiBras, with ELAT/INPE leading the lightning studies in collaboration with Utah State University, to investigate Sprites, using high-speed cameras, could shed more light on this phenomenon (this component of the original TroCCiBras proposal could not be realized during the 2004 campaign).

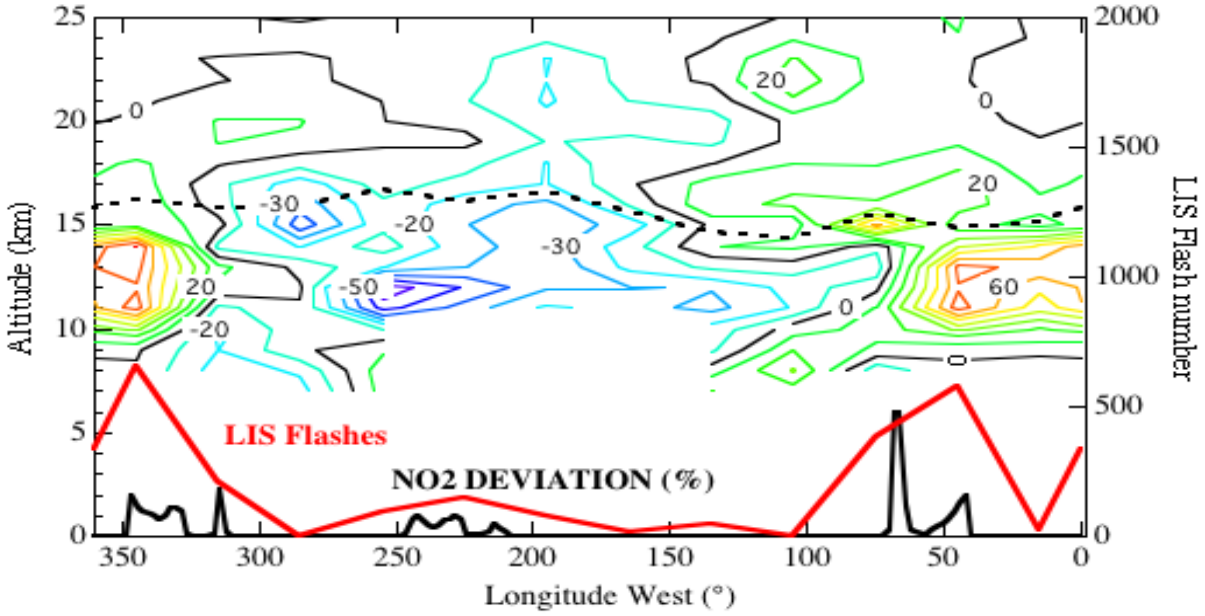

Figure 5. NO_2 % variation from the zonal mean in the upper troposphere / lower stratosphere as observed at 22°± 5°S by the SAOZ flown onboard a long-duration MIR balloon. The red line indicates the number of flashes observed over a 10°x10° area by the NASA space borne LIS during the 5 days prior to the pass of the MIR. The solid black line represents topography, while the dashed line shows the ECMWF thermal tropopause (after Pommereau *et al.*, 2004).

Figure 5 strongly suggests a NOx production by lightning. It should also be noted, that most of the flashes are located over continental convective regions and very few over the "maritime continent", where hurricanes are frequent during the season. The lightning frequency is related to the vertical speed of thunderstorm development and not to the top altitude of clouds. Furthermore, it is noteworthy, that the NO_2 maxima do not correspond to those of ozone, suggesting that the ozone photochemical production by NOx is relatively small (Pommereau *et al.*, 2004).

Preliminary results from HIBISCUS

As most results from the HIBISCUS 2004 campaign are not yet available, it seems appropriate to refer to some of the major findings based on the Pre-HIBISCUS 2003 campaign, which will most likely be confirmed, once all data from the last campaign have been analyzed.

In terms of vertical transport in the "Tropical Tropopause Layer" (TTL), it was found that N_2O and CFCs profiles measured in February 2003 by gas chromatography show very similar concentrations above and below the tropopause, but a sharp drop-off around 19 km, not seen in the 3D model. This suggests that tropospheric air is lifted more rapidly than expected in the TTL, but in contrast, far slower in the lower stratosphere. This finding could have significant implication for the penetration of water vapour into the stratosphere (Pommereau, 2004). Figure 6 shows preliminary water vapor mixing ratios obtained from different instruments designed and operated by the University of Cambridge, Department of Chemistry (UCAM-DCHEM) during one of several short-duration flights in 2004. More details are given by (Pommereau, 2004).

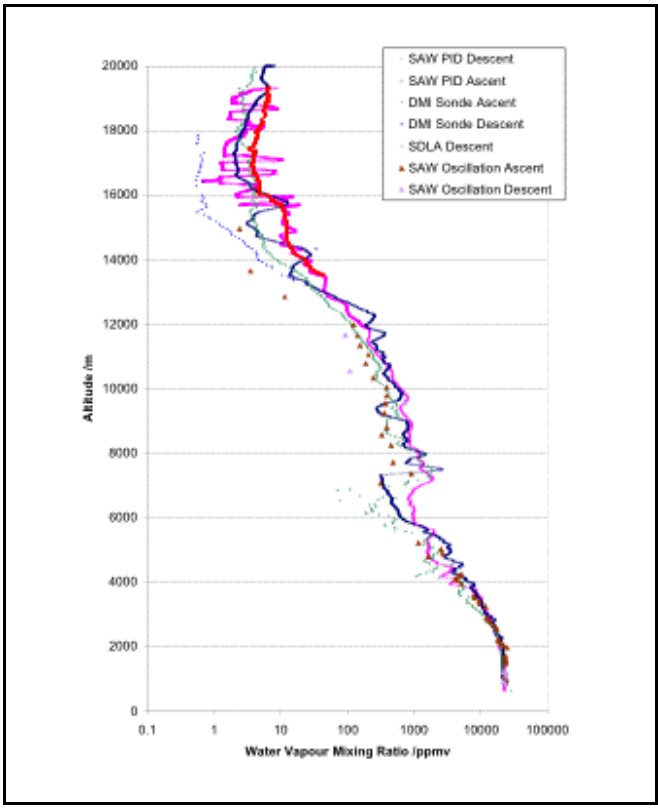

Figure 6. Water vapour mixing ratios from several instruments on flight SF2, launched on 13 February 2004 (courtesy of R.L. Jones, UCAM/DCHEM; after Pommereau, 2004).

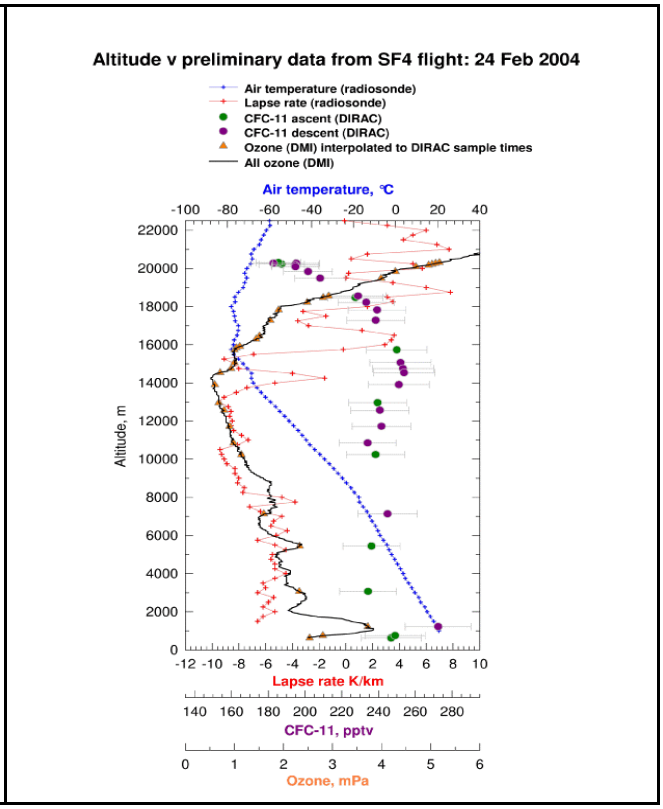

Figure 7: Preliminary CFC-11 data (purple circles) from DIRAC on the SF-4 flight (24 Febrary 2004). Air temperature and lapse rate data from a radiosonde launched by IPMet within 2 hours of the SF balloon are also shown (courtesy of A.D. Robinson, UCAM; after Pommereau, 2004).

During the HIBISCUS 2004 campaign, further developments were made with the DIRAC GC (gas chromatograph) by UCAM and Figure 7 shows preliminary results obtained during that campaign.

The microlidar, developed by the Italian partners Ente per le Nuove technologie, l'Energia e l'Ambiente (ENEA) had successfully been tested during the Pre-HIBISCUS campaign during two short-term flights and was part of a MIR payload launched on 10 March 2004. Figure 8 shows the scattering ratio (left) and the depolarisation (right). The flight was characterized by the presence of a depolarizing cloud layer showing scattering ratios of about 10 at 10km and of some scattered non-depolarizing thin cloud layers close to the ground. The Planetary Boundary Layer (PBL) structure is not clearly evident, mainly due to a very low aerosol load in the investigated region (far away from any polluted town). Just before the end of the flight a faint sub-visible cloud is clearly visible at about 16 km. Its optical thickness was 10^{-2} and its horizontal extension was estimated to be about 10km. The initial part of the plot shows higher noise, due to the sunlight still present in the field of view of the instrument, even after the sunset (Pommereau, 2004).

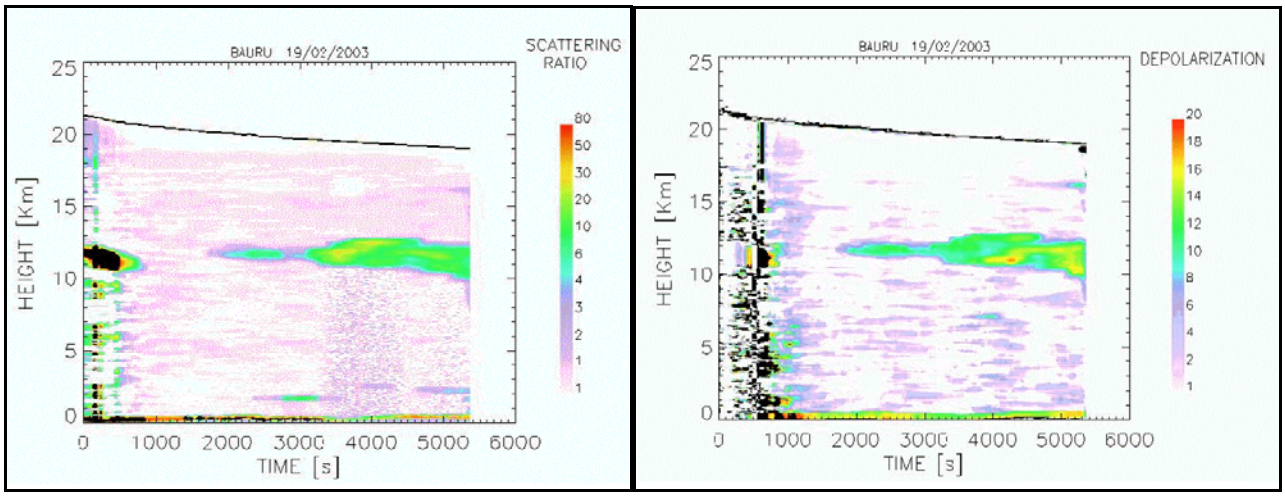

Figure 8. Time series of scattering ratio (left) and depolarization ratio (right) acquired during the flight on 19 February 2003 (courtesy of G. Di Donfrancesco, ENEA-CNR; after Pommereau, 2004).

Another important result from satellite validations highlights serious problems with the reliability of ozone measurements. Ozone profiles measured from the MIR long-duration balloons launched in 2001 and 2003 have been compared to those of the SHADOZ sonde network in the tropics, as well as to all available satellite retrievals: SAGE 2, HALOE, ODIN-SMR, ODIN-OSIRIS, and MIPAS and GOMOS onboard ENVISAT. The conclusion is, that only the first two are currently providing ozone data within 3% precision in the stratosphere, and that tropospheric ozone measured by all satellite instruments is little reliable in the TTL and the upper troposphere (UT) below 18-20 km (Pommereau, 2004).

Pommereau (2004) states, that although the data analysis for HIBISCUS 2004 is still at a preliminary stage, several findings could already be highlighted:

- high levels of water vapour have been reported in the TTL above the tropopause both regionally and globally, suggesting a strong injection by convective clouds;
- thin cirrus have been reported in the UT up to the tropopause but little, if not none, above;
- the fast lifting of short lived tracers into the TTL and the drop off around 19km is confirmed;
- a particularly long 39-days SAOZ MIR flight has been carried out, providing some 70 profiles of O_3, NO_2, clouds and for the first time also water vapour, with which their zonal distribution could be investigated to see if the 2001 findings are confirmed or not;
- a micro-Lidar has been flown successfully for the first time on a long duration balloon travelling across the Pacific, providing altitude resolved cloud measurements;
- constant altitude superpressure balloons have been flown at or immediately above the tropopause for up to 60 days, the trajectory of which could allow investigating the presence of waves of various periods.

CONCLUSION

In summary, it can be stated that TroCCiBras had achieved its objectives, despite the fact, that the Geophysica M55, high-flying aircraft laboratory could not arrive in time for the January to March 2004 campaign. In total, six Brazilian research institutions participated actively in the field campaign under the coordination of IPMet/UNESP, viz., CPTEC, CLA/IPEN, IF/USP, INMET, ELAT/INPE, IAC, as well as the German MPIC. A unique data base has been established for the experimental period (21 January to 11 March 2004), which had not been available before in the State of São Paulo. The coordination of TroCCiBras with the European Commission projects TROCCINOX and HIBISCUS resulted in an overall data set of extremely outstanding value for Brazil.

Although at this stage it is too early to come up with any conclusive statements, as the data are still being analyzed, some preliminary findings of importance to the State of São Paulo, and possibly also to Brazil, can already be highlighted -

- radar statistics, as well as actual case studies performed during the experimental period demonstrated, that the State of São Paulo, with IPMet's Doppler radars, is an ideal location for investigating the behavior of strong tropical convective storm systems and their impact regionally, as well as globally;
- reliable measurements of vertical profiles of water vapor are essential for the validation of satellite-borne monitors, directly impacting on the moisture budget of the country;

- satellite-borne ozone monitors have been found to be relatively inaccurate, highlighting the importance of in-situ measurements by stratospheric balloons (HIBISCUS) and the high-flying Geophysica aircraft (≥20km altitude) of TROCCINOX, to obtain accurate vertical profiles for investigating the exchange of ozone and other trace gases and aerosols between the upper troposphere and the stratosphere;
- the production of NO by lightning discharges in the tropics could have been underestimated, based on some in-situ neasurements near thunderstorms. This would not only impact on environmental policy issues in Brazil, but also changes the global perception of LNOx contributions to the total NOx budget, especially when considered in view of the global distribution of lightning discharges observed by satellite-borne systems (e.g., LIS) and other global networks;
- it would be extremely beneficial to install an aerosol lidar and a regular radiosonde station (or at least a vertical wind profiler with RASS capability, such as proposed for SIHESP) in Bauru, in order to monitor various important parameters in the troposphere, which would directly benefit the medium-term forecasting (modeling), as well as the nowcasting capabilities of IPMet, for the benefit of the community in the State of São Paulo.

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