




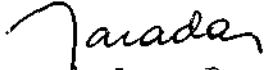
Imprimir

Fechar

## Referência Completa

**Tipo da Referência** Conference Proceedings  
**Repositório** sid.inpe.br/iris@1905/2005/07.28.05.51  
**Metadados** sid.inpe.br/iris@1905/2005/07.28.05.51.35  
**Site** mtc-m05.sid.inpe.br  
**Rótulo** 2512  
**Chave Secundária** INPE-3281-PRE/  
**Chave de Citação** Clemesha:1984:UpAtRe  
**Autor** Clemesha, Barclay Robert  
**Grupo** DAE-INPE-BR  
**Título** Upper Atmosphere Research at INPE   
**Nome do Evento** Simpósio Nipo-Brasileiro de Ciência E Tecnologia, 4.  
**Ano** 1984  
**Data** 7-9 Ago 1984  
**Localização do Evento** Sao Jose dos Campos, BR  
**Palavras-Chave** AERONOMIA, FISICA DA ALTA ATMOSFERA, PESQUISA.  
**Idioma** En  
**Tipo Secundário** PRE CN  
**Area** CEA  
**Projeto** FISAT  
**Última Atualização dos Metadados** 2015:05.08.13.50.45 sid.inpe.br/bibdigital@80/2006/04.07.15.50 administrator  
**Estágio do Documento** concluido  
**e-Mail (login)** marciana  
**Grupo de Usuários** administrator  
**Visibilidade** shown  
**Transferível** 1  
**Tipo do Conteúdo** External Contribution  
**Unidade Imediatamente Superior** 8JMKD3MGPCW/3ETL868  
**Conteúdo da Pasta source** não têm arquivos  
**Conteúdo da Pasta agreement** não têm arquivos  
**Histórico** 2015-05-08 13:50:45 :: administrator -> marciana :: 1984  
**Campos Vazios** abstract accessionnumber affiliation archivingpolicy archivist booktitle  
callnumber copyholder copyright creatorhistory descriptionlevel  
dissemination documentstage doi e-mailaddress edition editor  
electronicmailaddress format isbn issn lineage mark mirrorrepository  
nextedition notes numberoffiles numberofvolumes organization pages  
parameterlist parentrepositories previousedition progress publisher  
publisheraddress readergroup readergroup readpermission resumeid  
rightsholder secondarydate secondarymark serieseditor session shorttitle  
size sponsor subject targetfile tertiarymark tertiarytype type url  
versiontype volume  
**Data de Acesso** 23 jul. 2015  
**atualizar**

Fechar

1. Publication Nº <i>INPE-3281-PRE/604</i>	2. Version	3. Date <i>September 1984</i>	5. Distribution <input type="checkbox"/> Internal <input checked="" type="checkbox"/> External <input type="checkbox"/> Restricted
4. Origin <i>DGA/DOA</i>	Program <i>FISAT</i>		
6. Key words - selected by the author(s) <i>UPPER ATMOSPHERE RESEARCH</i>			
7. U.D.C.: <i>523.4-852</i>			
8. Title <i>UPPER ATMOSPHERE RESEARCH AT INPE</i>		10. Nº of pages: <i>14</i>	
		11. Last page: <i>12</i>	
9. Authorship <i>B.R. Clemesha</i>		12. Revised by  <i>I. J. Kantor</i>	
Responsible author 		13. Authorized by  <i>Nelson de Jesus Parada</i> Director General	
14. Abstract/Notes <p><i>Upper atmosphere research at INPE is mainly concerned with the chemistry and dynamics of the stratosphere, upper mesosphere and lower thermosphere, and the middle thermosphere. Experimental work includes lidar observations of the stratospheric aerosol, measurements of stratospheric ozone by Dobson spectrophotometers and by balloon and rocket-borne sondes, lidar measurements of atmospheric sodium, and photometric observations of O, O<sub>2</sub>, OH and Na emissions, including interferometric measurements of the OI6300 emission for the purpose of determining thermospheric winds and temperature. The airglow observations also include measurements of a number of emissions produced by the precipitation of energetic neutral particles generated by charge exchange in the ring current. Some recent results of INPE's upper atmosphere program are presented in this paper.</i></p>			
15. Remarks <i>This work was partially supported by the "Fundo Nacional de Desenvolvimento Científico e Tecnológico" under contract FINEP-537/CT. This work was presented in the Symposium "Nipo-Brasileiro" at INPE, July 1984.</i>			

## UPPER ATMOSPHERE RESEARCH AT INPE

B.R. CLEMESHA

Department of Geophysics and Aeronomy  
Instituto de Pesquisas Espaciais - INPE

### ABSTRACT

Upper atmosphere research at INPE is mainly concerned with the chemistry and dynamics of the stratosphere, upper mesosphere and lower thermosphere, and the middle thermosphere. Experimental work includes lidar observations of the stratospheric aerosol, measurements of stratospheric ozone by Dobson spectrophotometers and by balloon and rocket-borne sondes, lidar measurements of atmospheric sodium, and photometric observations of O, O<sub>2</sub>, OH and Na emissions, including interferometric measurements of the OI6300 emission for the purpose of determining thermospheric winds and temperature. The airglow observations also include measurements of a number of emissions produced by the precipitation of energetic neutral particles generated by charge exchange in the ring current. Some recent results of INPE's upper atmosphere program are presented in this paper.

1- INTRODUCTION INPE maintains an active program of research into a number of aspects of upper atmosphere science, including both experimental and theoretical studies of the dynamics and chemistry of the stratosphere, mesosphere and lower thermosphere. Experimental work involves mainly ground-based optical techniques, although balloon and rocket-borne sondes are used for studies of stratospheric ozone, and a rocket-borne photometer payload is under development for measurements of a number of emissions from the thermosphere. Theoretical studies include numerical modeling with special reference to a number of minor constituents related to the experimental measurements. In the following sections we present a brief description of INPE's experimental facilities in the area of upper atmosphere science, and outline some recent results.

2- EXPERIMENTAL FACILITIES INPE's facilities for atmospheric research are distributed between four campuses: São José dos Campos (23°S, 46°W), Cachoeira Paulista (23°S, 45°W), Natal (6°S, 35°W) and Fortaleza (4°S, 38°W).

2.1- Lidar The INPE lidar, installed at São José dos Campos, uses a flash-lamp pumped dye laser tuned to the sodium D<sub>2</sub> (5890 Å) line, and provides data on Rayleigh and Mie scattering from the stratosphere and resonant scattering from the atmospheric sodium layer situated between about 80 and 105km. The stratospheric return provides information on the vertical distribution of stratospheric aerosols, and the high altitude data give the atmospheric sodium profile. By means of a narrow angular beamwidth (0.2 mR) and a narrow band receiver (0.2 Å) it is possible to operate the lidar during the day, a capability shared with very few other lidars.

2.2- Airglow Photometers INPE operates a number of airglow photometers at its airglow observatory in Cachoeira Paulista, and has one instrument operating at Natal. In the near future it is intended to instal a second instrument in Natal or Fortaleza, and transfer one instrument from Cachoeira Paulista to the same location. Most of the photometers are multichannel instruments of the tilting filter type, and some of these are designed for scanning in elevation and/or azimuth.

Airglow emissions being measured at Cachoeira Paulista include OI 7774Å, 6300Å and 5577Å, the OH (9-4) and (8-3) bands, the 8645Å molecular oxygen band, NaD 5890Å, N<sub>2</sub><sup>+</sup> 4278Å and 3914Å and H $\beta$  4861Å. The sodium emission is also measured at Natal.

Most of the photometers have been developed by INPE, and the more recent instruments have microprocessor based control and data acquisition systems. A Fabry-Perot interferometer for measuring F region temperature and winds is being tested at São José dos Campos, and has already provided useful data. This instrument will be transfered to the Airglow Observatory at Cachoeira Paulista when it becomes fully operational.

2.3- Ozone Measurements INPE operates 2 Dobson spectrophotometers which make daily total ozone measurements at Cachoeira Paulista and at Natal. The Cachoeira Paulista instrument has been in operation since 1974 and the Natal measurements started in 1978. Twice monthly balloon-borne ECC sondes have been launched from Natal since 1978 (4 times per month since 1982) in a cooperative program with NASA. Rocket measurements of ozone up to 70km were made between 1978 and 1982. These measurements were discontinued because of problems with the calibration of the

optical ozone measuring instrument, but should be recommenced at the end of this year.

3- RESEARCH RESULTS Details of the results of INPE's work in the field of upper atmosphere research are, of course, to be found in the relevant journal publications. In this paper we present a brief synopsis of some of the results published during the last 12 months. A complete list of papers published by INPE's upper atmosphere group during the past 3 years is to be found in section 4.

3.1- Lidar Observations of the El Chichón Aerosol Lidar measurements at São José dos Campos show that the El Chichón dust cloud had reached this latitude by mid-July, 1982. The first measurement made after the eruption showed two layers with scattering ratios of 1.8 and 2.7 at 18 and 24km respectively, as compared with pre-injection values of about 1.2. These values refer to a wavelength of 5890Å, and are for a profile obtained on July 9th. Measurements made in subsequent months showed large fluctuations, particularly in the upper layer, where the scattering ratio varied between 1.2 and 5. The lower layer varied much less than the upper, with the result that the integrated backscatter, a measure of the total stratospheric aerosol burden, remained roughly constant until late August, when it increased from about  $3 \times 10^{-4} \text{ SR}^{-1}$  to about  $1 \times 10^{-3} \text{ SR}^{-1}$ . Subsequent to this date the integrated aerosol oscillated around a value of about  $8 \times 10^{-4} \text{ SR}^{-1}$  until mid-March 1983, since when it has decreased to about  $5 \times 10^{-4} \text{ SR}^{-1}$ . The height of the upper layer decreased fairly uniformly with time until late November, when it reached 20km, by which time it had merged with the lower layer. In 1983 the layer has again shown a bifurcated structure with a lower peak close to 18km and an upper one 2 to 4km higher.

3.2- Tidal Oscillations in the Atmospheric Sodium Layer The vertical distribution of atmospheric sodium has been measured at São José dos Campos over a total of about 20 complete diurnal cycles between April and August, 1981. Average time variations of the sodium density show strong oscillations with 12 and 24 hour periods. Both the diurnal and semidiurnal components of the oscillations display large amplitudes and a  $180^\circ$  phase inversion near the layer peak. These features are interpreted in terms of the propagation of tides in the layer, taking into account the interaction between the tide and the minor constituent layer. It has been shown that the vertical wind is the most important factor determining the amplitude of the oscillation in sodium density at a fixed height, thus making it possible to estimate the phase and amplitude of the wind oscillations over a limited height range. Diurnal and semidiurnal vertical wind amplitudes of  $2-6\text{cm s}^{-1}$  and  $5-20\text{cm s}^{-1}$ , respectively, have been inferred. The 12-hour component shows vertical phase propagation with a wavelength of  $\sim 50\text{km}$ , in agreement with recent theories. The 24-hour component, however, shows characteristics of an evanescent mode instead of the expected  $S_{1,1}$  mode. Maximum upward vertical velocity occurs at about 2100 LT at all heights for the diurnal component, and at 0600 and 1800 LT at 85km for the semidiurnal component. These results appear to be the first reported measurements of the vertical displacements produced by the diurnal and semidiurnal tides.

3.3- Theoretical Modelling of the Atmospheric Sodium Layer Recent results for sodium reaction rates have led to a reassessment of the relative importances of a number of sodium compounds thought to exist in the upper mesosphere and lower thermosphere. In order to evaluate the effect of these reactions, a dynamic time depen-

dent atmospheric photochemistry-vertical diffusion model has been developed to calculate the diurnal variation of sodium and compare it with recent measurements. A much larger reaction rate coefficient for the three body production of  $\text{NaO}_2$ , makes this constituent the main sodium compound at heights below about 85km, and the inclusion of photolysis results in a large diurnal variation in  $\text{NaOH}$  concentration. The diurnal variation in the abundance of free sodium is small, but the concentration at 80km varies by about one order of magnitude. Both of these results are in agreement with the measured diurnal variation of free sodium.

3.4- Tidal and Solar Cycle Effects on the  $\text{OI}5577\text{\AA}$ ,  $\text{NaD}$  and  $\text{OH}(8,3)$  Airglow Emissions The  $\text{OI}5577\text{\AA}$ ,  $\text{NaD}$  and  $\text{OH}(8,3)$  airglow emission intensities measured at Cachoeira Paulista from 1977 to 1982 have been analysed from the point of view of their nocturnal and seasonal variations. The nocturnal variations of the atomic oxygen emission and the  $\text{OH}$  rotational temperature (derived from the relative intensities of the P, Q and R branches of the 8,3 emission) show a significant semidiurnal oscillation, with the phase of maximum moving from midnight in January to early morning in June. Semiannual variations of the  $\text{OI}5577\text{\AA}$  and  $\text{NaD}$  emissions were observed, with maximum intensities in April-May and October-November. The rotational temperature, however, showed an annual variation with maximum in summer and minimum in winter, while no significant seasonal variation was found in the  $\text{OH}$  emission intensity.

3.5- The  $\text{O}_2(^1\Sigma)$  Atmospheric Band at  $8645\text{\AA}$  and the Rotational Temperature Ground based measurements of the  $\text{O}_2(^1\Sigma)(0,1)$  Atmospheric band at  $8645\text{\AA}$  and the rotational temperature, together with  $\text{OI}5577\text{\AA}$   $\text{NaD}$  and  $\text{OH}(9,4)$  band emissions have been carried



out at Cachoeira Paulista. It was found that the  $O_2$  band intensities occasionally vary from 200 Rayleighs to 1000 Rayleighs during a night and covariations with  $OI5577\text{\AA}$  emissions were observed. The rotational temperatures determined from the P branch of the  $O_2(^1\Sigma)$  vary between  $180^\circ\text{K}$  and  $230^\circ\text{K}$ . The amplitude of the nocturnal temperature variations is frequently larger than that derived from the OH emission, and the phase of the variations normally leads that of the OH. On some nights it was observed that the temperature variations of both the emissions were out of phase, suggesting a vertical phase propagation of the atmospheric wavelike perturbations.

3.6- Vertical and Horizontal Phase Propagation in the Mesopause Region Observed by the  $OI5577\text{\AA}$ ,  $O_2$  Atmospheric Band, NaD and OH(8,3) Band Nightglow Emissions

Meridional scanning observations of the NaD and OH(8,3) emissions show that on most of the nights of the observations the intensities varied uniformly along the meridional zone scanned, suggesting that the normal nocturnal variations are controlled by some regular atmospheric variation such as tides. However, on a few nights, horizontal intensity gradients and wavelike propagation of the NaD emission were observed. The observed apparent wavelength, phase velocity and period suggest the passage of internal gravity waves in the emission layer. On the night of 13-14 June 1983, both the NaD and OH(8,3) emissions showed a horizontally propagating wave structure, and simultaneously a vertical phase propagation was observed from nocturnal variations of several mesospheric emissions.

3.7- Observations of Large Scale F-Region Irregularities Using Airglow Emissions at  $7774\text{\AA}$  and  $6300\text{\AA}$  Simultaneous scanning measurements of the atomic oxygen  $7774\text{\AA}$  and  $6300\text{\AA}$  emissions, to study the dynamics of low-latitude large scale F-region irregularities,

were carried out at Cachoeira Paulista during the period October-November, 1980. The measurements were made with a two-channel photometer which permitted scanning observations both along and across the magnetic meridian. Observations at  $7774\text{\AA}$  can detect large scale irregularities near the F-region peak height, whereas observations at  $6300\text{\AA}$  detect such irregularities at an altitude about 50km to 100km lower, depending on the F-region height. On many nights, during spread-F conditions, as indicated by an ionosonde operating at the same location, the presence of large intensity depletions of short duration were detected in both emissions. These depletions were observed to move towards the east in the east-west scans, and apparently towards the south in the north-south scans.

3.8- Observations of Optical Emissions from Precipitation of Energetic Neutral Atoms and Ions from the Ring Current Observations of  $N_2^+ 1N$ , H Balmer  $\beta$  (H $\beta$ ) and other emissions due to particle precipitation have been observed at two low-latitude sites (Mt. Haleakala, Hawaii and Cachoeira Paulista, Brazil) and one mid-latitude site (McDonald Observatory, Southwest Texas). Results are compared for magnetic storms of April 12, 1981 and July 14, 1982. The emissions have the characteristics appropriate to the precipitation into the thermosphere of energetic neutral atoms and/or ions originating in the ring current. These characteristics include high rotational/vibrational excitation of the  $N_2^+ 1N$  bands and at times the occurrence of H $\beta$  emission with the same onset time as the  $N_2^+ 1N$  emission and partial correlation with it afterward. The latitude variation shows a strong increase from low to mid latitudes. The strongest emissions occur in the evening to midnight local time period, and the storm time variations shows strongest emissions during main phases. The time va-

riations of H $\beta$  and N $_2^+$  1N emissions indicate that there is more O/O $^+$  precipitation than H/H $^+$  precipitation in the latter part, and sometimes the whole duration of the precipitation events and the variations are consistent with H $^+$  being lost from the inner ring current faster than other species, such as O $^+$  and He $^+$ . Lower limits for the energy deposition rates for the strongest emissions at 40-45 $^\circ$  dip latitude are 1-2mWm $^{-2}$  and for the strongest emissions at 12 $^\circ$ S dip latitude, 0.5mWm $^{-2}$ . Ionization production at its peak altitude somewhere above 110km would be in the range from 10 $^2$ cm $^{-3}$  s $^{-1}$  to a few times 10 $^3$ cm $^{-3}$ s $^{-1}$  for the events in Texas, and from 10 $^0$  to 10 $^2$ cm $^{-3}$  s $^{-1}$  for the strongest events in Hawaii and Brazil.

3.9- Atmospheric Ozone Atmospheric ozone has been measured using ECC ozonesondes at Natal since 1978. Points of interest that have come out of the data are as follows: 1) Tropospheric ozone densities at Natal are higher by about 30% than previously published results in the equatorial region. 2) Natal total ozone measurements are about 15% higher than equatorial zone averaged satellite data. 3) In the stratosphere the ozone correlation with temperature is positive below the ozone peak and negative above it. 4) The average total ozone content over Natal measured by ECC sondes and a Dobson spectrophotometer differs by less than 4%. 5) From the correlation between O $_3$  and T it can be inferred that ozone undergoes a QBO type oscillation which at 30 mb has an amplitude of about 10% with a period of about 30 months.

#### 4- JOURNAL PUBLICATIONS 1981-1984

BATISTA, P.P.; CLEMESHA, B.R.; KIRCHHOFF, V.W.J.H.; SIMONICH, D. M. "Tidal Oscillations in the Atmospheric Sodium Layer", J. Geophys. Res., Submitted for publications, 1984.

- BITTENCOURT, J.A.; TEIXEIRA, N.R.; SAHAI, Y. and TAKAHASHI, H.  
"Mapping of Ionospheric F-Region Parameters from Atomic Oxygen  
Airglow Emissions". J. Atmos. Terr. Phys., 45, 697-705, 1983.
- CHRISTOPHE, J.; THULLIER, G.; FAHRENBACH, M.; SAHAI, Y.; WEILL, G.  
"Tropical Nightglow and Ionospheric Models Predictions". J.  
Atmos. Terr. Phys., 45, 137-148, 1983.
- CLEMESHA, B.R.; BATISTA, P.P.; KIRCHHOFF, V.W.J.H.; SIMONICH, D.M.  
"Mesospheric Winds from Lidar Observations of Atmospheric  
Sodium". J.G.R., 86, 868-870, 1981.
- CLEMESHA, B.R.; KIRCHHOFF, V.W.J.H.; SIMONICH, D.M. "Remote  
Measurements of Tropospheric and Stratospheric Winds by Ground  
Based Lidar". Applied Optics, 20, 2907-2910, 1981.
- CLEMESHA, B.R.; KIRCHHOFF, V.W.J.H.; SIMONICH, D.M. "Comments on  
"A Meteor Ablation Model of the Sodium and Potassium Layer" by  
D.J. Hunten. Geophys. Res. Lett., 8, 1023-1025, 1981.
- CLEMESHA, B.R.; SIMONICH, D.M.; BATISTA, P.P.; KIRCHHOFF, V.W.J.  
H. "The Diurnal Variation of Atmospheric Sodium". J. Geophys.  
Res., 87, 181-186, 1982.
- CLEMESHA, B.R.; SIMONICH, D.M. "Lidar Observations of the El  
Chichón Dust Cloud at 23°S". Geophys. Res. Lett., 10, 321-324,  
1983.
- CLEMESHA, B.R.; SIMONICH, D.M. "Lidar Observations of the El  
Chichón Aerosol at a Southern Latitude Station". Geofísica  
Internacional, in press, 1984.
- CLEMESHA, B.R. "Lidar Studies of the Alkali Metals". to be  
published in the Middle Atmosphere Handbook, Vol. 13, 1984.
- KANE, R.P.; SAHAI, Y.; TEIXEIRA, N.R. "Maximum Entropy Spectral  
Analysis of Total Ozone". Submitted to Pure Applied Geophys-  
ics, 1983.

- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R.; SIMONICH, D.M. "Seasonal Variation of Ozone in the Mesosphere". J. Geophys. Res., 86, 1463-1466, 1981.
- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R.; SIMONICH, D.M. "Average Nocturnal and Seasonal Variations of Sodium Nightglow at 23°S, 46°W". Planet. Space Sci., 29, 765-766, 1981.
- KIRCHHOFF, V.W.J.H. "Campos Elétricos na Região Ionizada da Atmosfera". Rev. Bras. Física, 11, 711-725, 1981.
- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R.; SIMONICH, D.M. "The Atmospheric Neutral Sodium Layer, I, Recent Modeling Compared to Measurements". J. Geophys. Res., 66, 6892-6898, 1981.
- KIRCHHOFF, V.W.J.H.; SAHAI, Y.; MOTTA, A.G. "First Ozone Profiles Measured with ECC Sondes at Natal (5.9°S, 35.2°W). Geophys. Res., Lett., 8, 1171-1172, 1981.
- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R. "The Dissipation of a Sodium Cloud". Planet. Space Sci., 31, 369-372, 1983.
- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R. "The Atmospheric Neutral Sodium Layer, II, Diurnal Variations". J. Geophys. Res., 88, 442-450, 1983.
- KIRCHHOFF, V.W.J.H.; CLEMESHA, B.R. "Eddy Diffusion Coefficients in the Lower Thermosphere". Geophys. Res. Lett., 88, 5765-5768, 1983.
- KIRCHHOFF, V.W.J.H.; HILSEN RATH, E.; MOTTA, A.G.; SAHAI, Y.; MEDRANO-B., R.A. "Equatorial Ozone Characteristics as Measured at Natal (5.9°S, 35.2°W)". J. Geophys. Res., 88, C11, 6812-6818, 1983.
- KIRCHHOFF, V.W.J.H.; BATISTA, P.P. "Calculation of the Vertical Drift of the Sodium Ion". Ann. Geophys., 1(6), 509-514, 1983.
- KIRCHHOFF, V.W.J.H. "Atmospheric Sodium Chemistry and Diurnal Variations: an up-date". Geophys. Res. Lett., 10, 721-724, 1983.

- KIRCHHOFF, V.W.J.H.; A.G. MOTTA. "Medidas de Ozônio na Troposfera e Estratosfera de Natal". Rev. Bras. Geofis., 2, 25-30, 1983.
- KIRCHHOFF, V.W.J.H.; TAKAHASHI, H. "Sodium Clouds in the Lower Thermosphere". Planet. Space Sci., in press, 1984.
- KIRCHHOFF, V.W.J.H. "Are Northern Hemisphere Tropospheric Ozone Densities Larger?" EOS, in press, 1984.
- ROHRBAUGH, R.P.; TINSLEY, B.A.; RASSOUL, H.; SAHAI, Y.; TEIXEIRA, N.R.; TULL, R.W.; DOSS, D.R.; COCHRAN, A.L.; COCHRAN, W.D. and BARKER, E.B. "Observations of Optical Emissions from precipitation of Energetic Neutral Atoms and Ions from the Ring Current, J. Geophys. Res., 88, 6317-6330, 1983.
- SAHAI, Y.; BITTENCOURT, J.A.; TEIXEIRA, N.R.; TAKAHASHI, H. "Plasma Irregularities in the Tropical F-Region detected by OI7775Å and 6300Å Nightglow Measurements". J. Geophys. Res., 86:3496-3500, 1981.
- SAHAI, Y.; BITTENCOURT, J.A.; TEIXEIRA, N.R. "Comments on "Airglow Observations of the OI7774Å Multiplet at Arecibo During a Magnetic Storm", by Roer G. Burnside, John W. Meriwether and James C.G. Walter, J. Geophys. Res., 85, 767, 1980". J. Geophys. Res., 86:4839-4840, 1981.
- SAHAI, Y.; BITTENCOURT, J.A.; TEIXEIRA, N.R.; TAKAHASHI, H. "Simultaneous Observations of OI Å and (OI) 6300Å Emissions and Correlative Study with Ionospheric Parameters". J. Geophys. Res., 86:3657-3660, 1981.
- SAHAI, Y.; KANE, R.P.; TEIXEIRA, N.R. "Low-latitude Total Ozone Measurements in the Brazilian Sector". Pure and Applied Geophysics, 120, 616-625, 1982.

SAHAI, Y.; BITTENCOURT, J.A.; TEIXEIRA, N.R.; TAKAHASHI, H.

"Observations of Large F-region Irregularities using Airglow Emissions at  $7774\text{\AA}$  and  $6300\text{\AA}$ ". *Annales Geophysicae*, 1, 271-276, 1983.

SIMONICH, D.M.; CLEMESHA, B.R. "Resonant Extinction of Lidar Returns from the Alkali Metal Layers in the Upper Atmosphere". *Applied Optics*, 22, 1387-1389, 1983.

TAKAHASHI, H.; SAHAI, Y.; CLEMESHA, B.R.; SIMONICH, D.M.; BATISTA, P.P. e TEIXEIRA, N.R. "Simultaneous Measurements of the OH(8,3) Band and  $OI5577\text{\AA}$  Airglow Emissions". *Revista Brasileira de Física*, 11, 727-741, 1981.

TAKAHASHI, H.; BATISTA, P.P. "Simultaneous measurements of OH (9,4), (8,3), (7,2), (6,2) and (5,1) bands in the airglow". *Journal of Geophysical Research*, 86, n<sup>o</sup> A7, P. 5632-5542, 1981.

TAKAHASHI, H.; BATISTA, P.P.; SAHAI, Y. "Tidal and Solar Cycle Effects on the  $OI5577\text{\AA}$ , NaD and OH(8,3) Airglow Emissions observed at  $23^{\circ}\text{S}$ ". *Planetary and Space Science*, in press, 1984.

TINSLEY, B.A.; ROHRBAUGH, R.P.; SAHAI, Y.; TEIXEIRA, N.R. "Energetic Oxygen Precipitation as a Source of Vibrationally Excited  $N_2^+$  1N Emission observed at Low Latitudes". *Geophys. Res. Lett.*, 9, 543-546, 1982.