ATMOSPHERIC STRUCTURE:
EXPLORATION OVER ANTARCTICA
AND INTERHEMISPHERIC COMPARISON

THESIS
Submitted to the
GUJARAT UNIVERSITY
for the degree of
DOCTOR OF PHILOSOPHY
(Science)
by

PARMJIT SINGH SEHRA
October 1976

Physical Research Laboratory
Ahmedabad 380009
India
DEDICATED TO

MY PARENTS

Shri Mohinder Singh Sehra
and
Shrimati Satwinder Kaur

who induced into me a great inspiration and
cultivated a keen interest for
scientific adventures and
exploratory work
CERTIFICATE

I hereby declare that the work presented in this thesis 'Atmospheric Structure: Exploration over Antarctica and Interhemispheric Comparison' is original and has not formed the basis for the award of any degree or diploma by any University or Institution.

[Signature]

PARMJIT SINGH SEHRA
( Author )

Certified by

[Signature]

P.K. Pisharoty
P. R. Pisharoty
(Guide & Professor-in-charge)
Greatly indebted to

Prof. P. R. Pisharoty
(for stimulating guidance, helpful discussions, kind encouragement, magnanimity, valuable advice and constant inspiration during all phases of this work).

Prof. P. D. Bhavsar and the late Prof. Vikram A. Sarabhai
(for providing an opportunity of exploring the South Polar Ice-Cap under a joint agreement between the Indian Space Research Organisation, Government of India and the Hydrometeorological Service of the USSR).

Prof. K. R. Ramanathan, Prof. Devendra Lal
Prof. Yash Pal and Prof. Satish Dhawan
(for ever helpful attitude and providing all necessary facilities).

Members of the Soviet Antarctic Expedition, 1971-73
(for scientific collaboration and kind co-operation).

Shri R. Sadanandan for typing the manuscript neatly and all others who helped me directly or indirectly in this work.

PARNJIT SINGH SEHRA
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement .......... ........ i - vi</td>
<td></td>
</tr>
</tbody>
</table>

**CHAPTER - I**

| INTRODUCTION .......... .......... 1 - 34 |
|-----------------------|----------|
| 1.1 General .......... ........ 1 |
| 1.2 Various techniques of sounding the atmosphere .......... 3 |
| 1.3 Present State of knowledge .......... ........ 7 |
| 1.3.1 Earlier studies of the atmospheric structure .......... ........ 7 |
| 1.3.2 Synoptic studies in the Northern Hemisphere .......... ........ 10 |
| 1.3.3 Synoptic studies in the Southern Hemisphere .......... ........ 11 |
| 1.3.4 Transient and standing eddies .......... .......... 14 |
| 1.3.5 Diurnal variations .......... ........ 15 |
| 1.3.6 Seasonal variations .......... ........ 18 |
| 1.3.7 Quasi-biennial oscillation .......... ........ 22 |
| 1.3.8 Stratospheric warmings .......... ........ 25 |
| 1.3.9 Dependence on Solar activity .......... ........ 29 |
CHAPTER - II

THE M-100 METEOROLOGICAL ROCKET SOUNDING SYSTEM 35-62

2.1 The 'RKZ-2' radiosonde 35
  2.1.1 Temperature sensor 36
  2.1.2 Humidity sensor 37
  2.1.3 Baroswitch 37
  2.1.4 Radio unit 38
  2.1.5 Sources of error 39

2.2 The M-100 rocket sounding system 41
  2.2.1 Launching of M-100 rocket 42
  2.2.2 Rocket payload 43
  2.2.3 Wind measuring sensors 47
  2.2.4 Temperature transmitters 48
  2.2.5 Temperature sensors calibration 50
  2.2.6 The M-100 radiotlemetry system 54
  2.2.7 The M-100 radar system 57
  2.2.8 The M-100 power supply unit 59
  2.2.9 General Remarks 61
CHAPTER - III

M-100 ROCKETSONDE DATA REDUCTION AND PROCESSING

3.1 Radiosonde data reduction 63
3.2 Meteor radar data reduction 64
3.3 Telemetry data reduction 66

3.3.1 Timing the film 67
3.3.2 Deciphering the signals 67
3.3.3 Converting the telemetered signals into atmospheric parameters 71

3.3.3.1 Correcting the graduated curves 71
3.3.3.2 Plotting graduated bar graph 72
3.3.3.3 Voltages conversion and plotting with typewriter 73

3.4 Computer processing of the data 75
3.5 Computing wind velocity and direction 76
3.6 Error in wind determination 78
3.7 Correction of wind errors 82
3.8 Computing the atmospheric temperature 84
3.9 Computing the atmospheric pressure and density 98
CHAPTER IV

EXPLORATION OF ATMOSPHERIC STRUCTURE OVER ANTARCTICA

4.1 Soviet Antarctic Expedition

4.2 Some physical characteristics of Antarctic Meteorology

4.3 Tropospheric and stratospheric winds over Antarctica

4.3.1 Zonal winds

4.3.2 Meridional winds

4.3.3 Tropospheric and stratospheric circulation Indices (TCI, SCI)

4.4 Upper mesospheric wind structure in Antarctica

4.4.1 Upper mesospheric zonal winds

4.4.2 Upper mesospheric meridional winds

4.4.3 Mesospheric Circulation Index (MsCI)

4.5 Seasonal wind variations over Antarctica

4.5.1 Seasonal zonal wind variations

4.5.2 Seasonal meridional wind variations

4.5.3 Seasonal wind persistence

4.6 Comparison with the Groves Atmospheric Model

4.7 Discussion of results
CHAPTER V

ATMOSPHERIC TEMPERATURE, PRESSURE AND DENSITY

VARIATIONS IN ANTARCTICA

5.1 Seasonal variations of atmospheric temperature over Antarctica

5.1.1 Tropospheric temperatures

5.1.2 Stratospheric temperatures

5.1.3 Mesospheric temperatures

5.1.4 Antarctic tropopause, stratopause and mesopause

5.1.5 Temperature departures from the annual mean

5.1.6 Temperature lapse rates

5.2 Warmings and Coolings of the Antarctic stratosphere and mesosphere

5.2.1 Atmospheric temperature disruption

5.2.2 Horizontal temperature gradients

5.2.3 Upper atmospheric warmings and coolings

5.2.4 Discussion of results

5.3 Atmospheric pressure and density variations
CHAPTER VI

STUDY OF EQUATORIAL ATMOSPHERIC STRUCTURE

6.1 Equatorial circulation pattern ........................................ 187
6.2 Berson westerly winds .................................................. 189
6.3 Strato-mesospheric circulation ....................................... 191
6.4 Relation with the tropospheric circulation .......................... 196
6.5 Equatorial tropopause, stratopause and mesopause ............... 199
6.6 Sudden mesospheric warming over equatorial region ............... 204

CHAPTER VII

SOUTH POLAR AND EQUATORIAL ATMOSPHERIC STRUCTURE

COMPARISON ............................................................. 209-244

7.1 Antarctic and equatorial atmospheric structure in southern summer ......................................................... 209
7.1.1 Zonal winds .......................................................... 211
7.1.2 Meridional winds .................................................... 214
7.1.3 Atmospheric temperatures ......................................... 216
7.2 Summer profiles comparison with Groves Model .................. 219
7.2.1 Zonal wind departures .............................................. 219
7.2.2 Temperature departures ............................................ 221
CHAPTER VII

7.3 Atmospheric circulation indices in southern summer 223

7.3.1 Tropospheric Circulation Index (TCI) 226
7.3.2 Stratospheric Circulation Index (SCI) 228
7.3.3 Mesospheric Circulation Index (MsCI) 229

7.4 Antarctic and equatorial atmospheric structure in southern winter 230

7.4.1 Zonal winds 230
7.4.2 Meridional winds 232
7.4.3 Atmospheric temperature 234

7.5 Typical temperature profiles comparison 236
7.6 Discussion and interpretation of results 237

CHAPTER VIII

INTERHEMISPHERIC COMPARISON OF ATMOSPHERIC STRUCTURE 245-266

8.1 Atmospheric structure over Heiss Island 246
8.2 Atmospheric structure over Volgograd 248
8.3 Antarctic-Arctic atmospheric structure 249
8.4 Eastern-Western hemispheric atmospheric structure 253

8.4.1 Hemispheric zonal flow 258
8.4.2 Hemispheric temperature variations 261
8.4.3 Upper atmospheric warmings and coolings 263

8.5 Epilogue 266
CHAPTER IX

SUMMARY AND PRINCIPAL CONCLUSIONS 267-277

REFERENCES 278-285