

**SURFACE OZONE VARIATIONS AT THE GREAT
WALL STATION, ANTARCTICA DURING
AUSTRAL SUMMMER**



FRANKY HERMAN

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**FACULTY OF SCIENCE AND NATURAL RESOURCES
UNIVERSITI MALAYSIA SABAH**

2020

**SURFACE OZONE VARIATIONS AT THE GREAT
WALL STATION, ANTARCTICA DURING
AUSTRAL SUMMER**

FRANKY HERMAN



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**THIS IS SUBMITTED IN FULFILLMENT FOR THE
DEGREE OF MASTER OF SCIENCE**

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Disahkan Oleh,

FRANKY HERMAN
MS1811018T

(Tandatangan Pustakawan)

Tarikh : 10 November 2020

(Prof. Madya Dr. Justin Sentian)
Penyelia

DECLARATION

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a master's degree in science. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

09 OCTOBER 2020

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MS1811018T



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CERTIFICATION

NAME : **FRANKY HERMAN**
NO. MATRIX : **MS1811018T**
TITLE : **SURFACE OZONE VARIATION AT THE GREAT WALL
STATION, ANTARCTICA DURING AUSTRAL SUMMER**
DEGREE : **MASTER OF SCIENCE**
PROGRAMME : **ENVIRONMENTAL SCIENCE PROGRAMME**
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Signature

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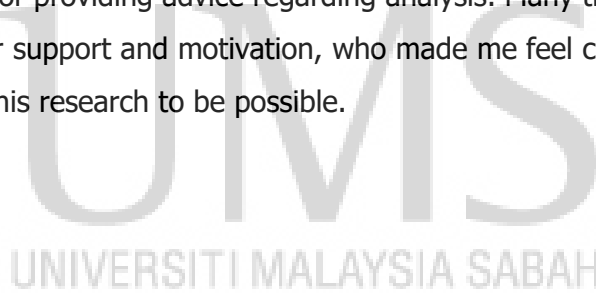
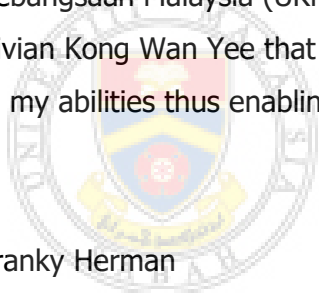
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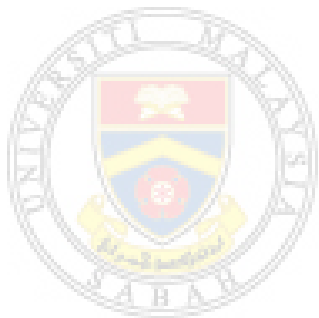


ABSTRACT

Surface Ozone (O_3) is a secondary pollutant which toxic to human health, and a greenhouse gas which is one of the prime climate forcers. Due to the clean atmospheric environment of the Antarctic region and given the complexity of O_3 chemistry, the observation of surface O_3 variability in this region is necessary in the quest to better understand the potential sources and sink of polar surface O_3 . This study highlights the observation on surface O_3 variability at the Great Wall Station (GWS) during austral summer in December 2018 and January 2019. The continuous in-situ surface O_3 measurement at the GWS, Antarctica was carried out using the EcoTech Ozone analyzer while meteorological data was obtained from the conventional auto-observational station operated at the GWS. To have a better understanding of surface O_3 latitudinal distribution, the spatial and temporal of surface O_3 data obtained online from the World Meteorology Organization of World Data Centre for greenhouse gases (WMO WDCGG) were then compared to give an indications of its spatial and temporal characteristic. The HYSPLIT model (Hybrid Single-Particle Lagrangian back-trajectory) was employed to have a better picture on the overall impact of air mass transport toward the surface O_3 formation over the region. Lastly, to have a better discernment on the potential impact of meteorology to the surface O_3 formation, statistical principal analysis (PCA) was employed to give a confidence measure over which meteorological parameter play more pivotal role on affecting surface O_3 background level. The results show that despite being characterised as stable surface O_3 concentration with standard deviation value of 0.24 ppbv throughout the entire period of observation, though the hourly summer surface O_3 distribution at GWS varies from 4.45 ppbv to 7.81 ppbv. The online dataset from WDCGG showed that the summer characteristic of surface O_3 at GWS are one-to-three times lower than what been observed at other research station. The unique characteristic of surface O_3 of GWS can temporarily emphasized by its synoptic marine air mass characteristic with coefficient correlation value of 0.17, significant at value of 0.1. The statistical result of PCA shows that three principal components factors with eigenvalues cut-off unity value of 70%, and only atmospheric pressure as well surface temperature in factor 1 shows significant positive correlation with surface O_3 with coefficient value of 0.667 and 0.563, respectively. While wind speed and wind direction in factor 3 which significant at 0.701 and 0.748 respectively, have more pivotal role to cause residual change in diurnal surface O_3 concentration. To

put something into perspective, the surface O₃ variability at the GWS suggesting that the marine air mass could be important source of low surface O₃ level, and the temporal characteristic controlled by combined local photochemical process and air mass transport subjected to the availability of its precursor, or halogen species and its weather condition.

Keywords: surface Ozone, meteorological conditions, Great Wall, austral summer, HYSPLIT



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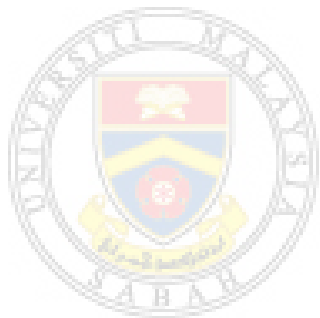
ABSTRAK

VARIASI OZONE PERMUKAAN DI STESEN GREAT WALL, ANTARTIKA PADA MUSIM PANAS AUSTRAL

Ozone (O_3) permukaan adalah bahan pencemar sekunder yang berbahaya bagi kesihatan manusia, dan gas rumah hijau yang merupakan salah satu punca utama perubahan iklim. Oleh kerana persekitaran atmosfera yang bersih di wilayah Antartika dan kerumitan tindakbalas kimia O_3 , pemerhatian terhadap variasi O_3 di rantau ini diperlukan dalam usaha untuk lebih memahami proses dan sumber-sumber yang berpotensi dalam penghasilan atau pemusnahan O_3 . Fokus kajian ini adalah pemerhatian terhadap variasi O_3 di Stesen Great Wall pada musim panas Austral iaitu sekitar bulan Disember 2018 sehingga Januari 2019. Persampelan gas permukaan O_3 secara in-situ dilakukan secara berterusan di stesen ini dengan menggunakan EcoTech Ozone Analyzer sementara data meteorologi diperolehi daripada stesen pemerhatian automatik konvensional yang dikendalikan di GWS. Untuk lebih memahami variasi berkaitan taburan variasi permukaan O_3 di kawasan-kawasan sekitar wilayah Antartika, data dalam talian daripada World Meteorology Organization of World Data Centre for greenhouse gases (WMO WDCGG) diproses dan kemudiannya dibandingkan untuk memberikan perbandingan secara spasial dan temporal terhadap variasi permukaan O_3 . Model HYSPLIT (Hybrid Single-Particle Lagrangian back-trajectory) pula digunakan untuk memberikan gambaran keseluruhan terhadap kesan daripada peredaran jisim udara keatas penghasilan permukaan O_3 dikawasan ini. Untuk mengunjurkan analisa yang lebih baik berkaitan dengan potensi kesan perubahan meteorologi terhadap penghasilan permukaan O_3 , statistik analisis melalui kaedah Principal Component Analysis (PCA) digunapakai dalam menilai tiap-tiap parameter meteorologi dan pengaruhnya terhadap paras penghasilan permukaan O_3 . Hasil kajian mendapati bahawa permukaan O_3 selama masa persampelan dilakukan di kawasan ini adalah bersifat stabil dengan nilai sisihan piawai 0.24 ppbv walaupun paras kepekatan berbeza dari 4.45 ppbv sehingga 7.81 ppbv. Analisa perbandingan data yang diperolehi secara dalam talian dari WDCGG menunjukkan bahawa permukaan O_3 disepanjang musim panas Austral adalah satu sehingga tiga kali lebih rendah daripada stesen-stesen penyelidikan lain di rantau Antartika ini. Keunikan variasi permukaan O_3 dikawasan ini ada kalanya dikesankan oleh peredaran jisim udara marin dengan korelasi 0.17 pada nilai unjuran 0.1. Hasil

analisa PCA menunjukkan bahawa terdapat 3 kelas faktor dengan total nilai varians yang diterangkan sebanyak 70%, akan tetapi hanya tekanan udara dan suhu sahaja dalam faktor 1 menunjukkan korelasi positif bersama permukaan O_3 dengan nilai korelasi 0.667 dan 0.563. Manakala kelajuan dan arah mata angin dalam faktor 3 dengan nilai unjuran korelasi 0.701 dan 0.748 dilihat memainkan peranan yang lebih penting dalam pembentukan permukaan O_3 . Dapat disimpulkan bahawa sumber utama variasi permukaan O_3 yang rendah di GWS adalah bersumberkan daripada export peredaran jisim udara daripada kawasan marin, dan ciri-ciri temporalnya dipengaruhi oleh gabungan proses fotokimia dan pergerakan jisim udara, tertakluk pada ketersediaan prekursor atau halogen spesis dan keadaan cuaca.

Kata kunci: Ozon permukaan, keadaan meteorologi, Tembok Besar, musim panas austral, HYSPLIT



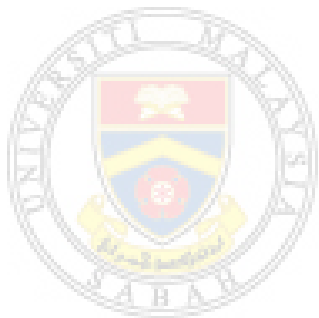
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TABLE OF CONTENTS

	Page
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
<i>ABSTRAK</i>	vii
TABLE OF CONTENTS	ix
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xv
LIST OF UNITS	xvi
LIST OF EQUATIONS	xvii
LIST OF ABBREVIATIONS	xviii
LIST OF APPENDICES	xxii
CHAPTER 1: INTRODUCTION	1
1.1 The Atmosphere and Ozone (O ₃) Gas	1
1.2 Problem Statement	3
1.3 Research Question	4
1.4 Objectives and Scope of the Study	5
1.5 Research Significant	5
CHAPTER 2: LITERATURE REVIEW	7
2.1 Overview of Tropospheric O ₃ In Mainland	7
2.2 Overview on Surface O ₃ Study at Polar Region	10
2.2.1 Background of Study on Surface O ₃ Over the Antarctica Region	11
2.3 The General Oxidation Chemistry of O ₃ in The Troposphere	14
2.4 Associated Factors Affecting Surface O ₃ Variability at Antarctica	16
2.4.1 Surface O ₃ Enhancement and Transport from the Stratosphere	18
2.4.2 Long-range Air Mass Transport from Lower Latitude	20
2.4.3 Air Mass Transport from Antarctic's Plateau and Interior	22

2.4.4	Air Mass Transport from Ocean	23
2.4.5	O ₃ Hole and Photodenitrification of Snowpack	26
2.5	Surface O ₃ Characterisation and Meteorological Parameter	29
2.5.1	Impact of Surface Local Winds	31
2.5.2	Impact of Thermal Atmospheric Conditions	32
2.5.3	Potential Impact of Radiation Exposure	34
CHAPTER 3: METHODOLOGY		36
3.1	Study Area	36
3.1.1	Research Framework	37
3.2	Surface O ₃ Observation Campaign	38
3.3	Surface Meteorological Dataset Measurement	42
3.3.1	Surface Temperature	43
3.3.2	Atmospheric Pressure	44
3.3.3	Relative Humidity	44
3.3.4	Total Radiation Exposure	45
3.3.5	Surface Wind	46
3.4	Surface O ₃ and Meteorological Interpretation	47
3.4.1	Temporal Characteristic of Surface O ₃	47
3.4.2	Secondary Data of Surface O ₃	47
3.4.3	Secondary Dataset Pre-Processing	49
3.4.4	Background Air Mass Trajectory Analysis	50
3.4.5	Synoptic Air Mass Analysis and 6-hr O ₃ Concentration	52
3.4.6	Diurnal Surface O ₃ and Meteorological Analysis	52
CHAPTER 4: RESULT AND DISCUSSION		54
4.1	Background Meteorological Condition	54
4.1.1	Surface Temperature	54
4.1.2	Atmospheric Pressure	55
4.1.3	Atmospheric Humidity	56
4.1.4	Total Radiation Exposure	58
4.1.5	Surface Wind Profile	59
4.2	Temporal Characteristic of Surface O ₃ at GWS	60
4.2.1	Inter-sequential Change of Surface O ₃	61

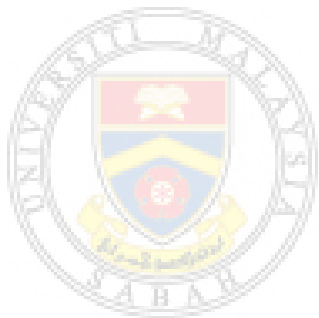
4.2.2	Day-to-day Characteristic of Surface O ₃	64
4.3	Comparison of GWS With Other Antarctic Stations	66
4.4	Backward Trajectories Analysis	71
4.5	Diurnal characteristic of Surface O ₃ With Meteorological Condition	77
CHAPTER 5: CONCLUSION AND RECOMMENDATION		83
5.1	Summary of Research Finding	83
5.2	Research Limitation	84
5.3	Recommendation for Future Research	85
REFERENCES		86
APPENDICES		119



UMS
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LIST OF TABLES

		Page
Table 2.1	Summertime average of surface O ₃ during daytime from 2000 – 2014	8
Table 2.2	Summertime surface O ₃ mean of daytime for 8-hr average from 2000 – 2014	9
Table 3.1	The major components of the Serinus 10 Model	41
Table 4.1	Inter-annual comparison of surface O ₃ during austral summer at GWS, Ushuaia, Neumayer and Trollhaugen Station from 20 December 2018 until 15 January 2019	68
Table 4.2	PCA result for O ₃ and the meteorological parameter at GWS	80



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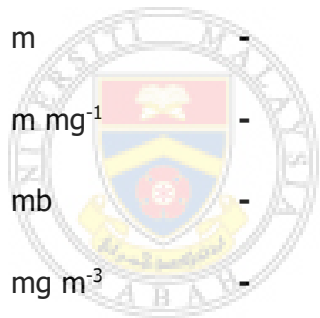
LIST OF FIGURES

		Page
Figure 2.1	Estimated O ₃ and OH production relationship based on NO taken after Crawford <i>et al.</i> (2001)	28
Figure 3.1	Location of the austral summer O ₃ measurement campaign at Great Wall Station (GWS) on the western side of Antarctica peninsula	36
Figure 3.2	Research framework for Austral summer O ₃ measurement campaign at GWS	37
Figure 3.3	Ecotech O ₃ analyser multipoint calibration plot	39
Figure 3.4	Internal components diagram of Serinus 10 model O ₃ analyser	40
Figure 3.5	Automatic weather station operated at GWS, Antarctica	42
Figure 3.6	Schematic of data logger and thermocouples. J ₁ – J ₃ indicate wire junction where Seebeck-effect voltage offsets occur (Cathles & Albert, 2007)	43
Figure 3.7	Map of Antarctica (inner circle) showing the coastal sites of Neumayer, Syowa and Trollhaugen. The blue line refers to Argentinean station of Ushuaia located at Argentina and adjacent to GWS	49
Figure 3.8	Steps used to run the HYSPLIT backward trajectory model	51
Figure 4.1	The hourly (black line) and daily (blue dot) mean state of temperature at GWS from 20 December 2018 until 15 January 2019	55
Figure 4.2	The hourly (black line) and daily (blue dot) mean state of atmospheric pressure at GWS from 20 December 2018 until 15 January 2019	56
Figure 4.3	The hourly (black line) and daily (blue dot) mean state of humidity at GWS from 20 December 2018 until 15 January 2019	57
Figure 4.4	The hourly (black line) and daily (blue dot) mean state of radiation exposure at GWS from 20 December 2018 until 15 January 2019	58

Figure 4.5	Surface wind profile at GWS from 20 December 2018 until 15 January 2019	59
Figure 4.6	Hourly averaged (blackline) and daily averaged (blue dot) of surface O ₃ at GWS from 20 December 2018 until 15 January 2019	61
Figure 4.7	Inter sequential of surface O ₃ hourly change on successive day at GWS	62
Figure 4.8	Surface O ₃ diurnal characteristic at GWS during night-time (red line) and day-time (blue line)	65
Figure 4.9	Hourly averaged of surface O ₃ concentration at Ushuaia (blue), Syowa (orange), Neumayer (red) and Trollhaugen (green) coastal site	67
Figure 4.10	Frequency distribution of hourly averaged O ₃ from 20 December 2018 until 15 January 2019 in the coastal sites of GWS (a), Ushuaia (b), Syowa (c), Neumayer (d) and Trollhaugen (e)	70
Figure 4.11	The 5-days backward trajectories and relative 6hr-O ₃ concentration starting from: (a) 20-24 December 2018; (b) 25-29 December 2019; (c) 30 December 2018-03 January 2019; (d) 09-13 January 2019	72
Figure 4.12	The 6-hr average O ₃ and the corresponding 5-day backward trajectories analysis at GWS. The black line represents the 6-hr average O ₃ . The blue line in (a) shows the trajectory length, the while the purple and green line in (b) represents the average altitude in pressure of air masses at 5-days and 3-days prior its arrival, the red line in (c) shows the residence time fraction of air masses prior to their arrival at GWS	74
Figure 4.13	Hourly averaged surface O ₃ concentration together with weather conditions during the most variant surface O ₃ concentration (a-d), and the most stable O ₃ concentration (e-h). The black line represents O ₃ concentration, the red line represent temperature, the purple line represents atmospheric pressure, the blue line represents humidity level, the yellow line represent radiation, while the green and brown lines represent wind speed and its direction	79

LIST OF UNITS

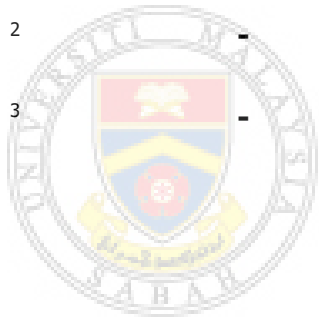
°	-	Degree
°C	-	Degree Celsius
cm	-	Centimetre
hPa	-	hectopascals
kPa	-	kilopascal
km	-	Kilometre
ppbv	-	part per billion by volume
pptv	-	part per thousand by volume
m	-	meter
m mg ⁻¹	-	meter per milligram
mb	-	millibar
mg m ⁻³	-	milligram per meter cube
MJ m ²	-	Megajoule per meter square
ms ⁻¹	-	meter per second
mW m ⁻²	-	milliwatt per meter square
nm	-	nanometre
µm	-	micrometre
V	-	Volt



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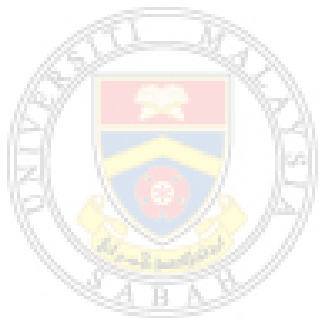
+	-	Plus, positive
-	-	Minus, Negative
±	-	Plus, minus
%	-	Percentage
>	-	Greater than
<	-	Lower than
$h\nu$	-	Sun light
x	-	Times with
²	-	Power of two, square
³	-	Power of three, cube



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LIST OF EQUATIONS

	Page
Equation 3.1 Beer–Lambert equation	40
Equation 3.2 Relative humidity equation	45
Equation 3.3 Coefficient of relative variation equation	47

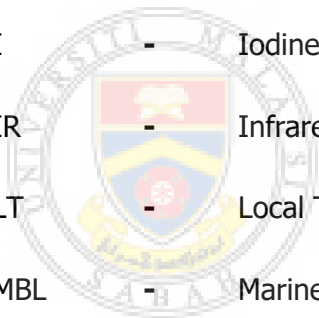


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LIST OF ABBREVIATIONS

ACC	-	Antarctic Circumpolar Current
a.g.l	-	Above ground level
a.s.l	-	Above sea level
ARL	-	Air Resource Laboratory
AWS	-	Automatic weather station
Br ₂	-	Bromine
BrCl	-	Bromine monochloride
BrO	-	Bromine oxide
CCGG	-	Carbon cycle and greenhouse gases
CHBr ₃	-	Bromoform
CH ₄	-	Methane
Cl	-	Chloride
CO	-	Carbon monoxide
CRV	-	Coefficient of relative variation
E	-	East
ECMWF	-	European Centre for Medium-Range Weather Forecasting
GAW	-	Global Atmospheric Watch
GCM	-	Global Circulation Model
GDAS	-	Global Dataset Assimilation Process
GHGs	-	Greenhouse gases
GMD	-	Global Monitoring Division

G-RAD	-	Global radiation
GWS	-	Great Wall Station
H	-	Hydrogen
HATS	-	Halocarbons and other atmospheric trace gases
HC	-	Hydrocarbon
HNO ₃	-	Nitric acid
HO ₂	-	Water vapour
HYSPLIT	-	Hybrid Single-Particle Lagrangian Integrated Trajectory Model
hr	-	Hour
I	-	Iodine
IR	-	Infrared radiation
LT	-	Local Time
MBL	-	Marine boundary layer
N ₂	-	Nitrogen
NetCDF	-	Network Common Data Form
NMHC	-	Non-Methane Hydrocarbon
NO _x	-	Nitrogen oxides
NO ₂	-	Nitrogen dioxide
NOAA	-	National Oceanographic and Atmosphere Administration
O ₂	-	Oxygen
O ₃	-	Ozone
O (¹ D)	-	Excite Oxygen

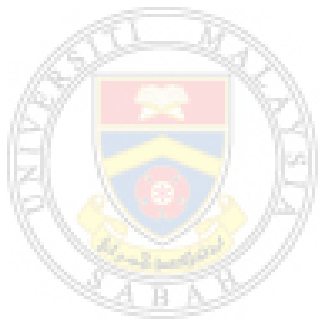


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ODEs	-	Ozone depletion events
OEEs	-	Ozone enhance events
OH	-	Hydroxyl
OZVV	-	Ozone and water vapour
PBL	-	Planetary boundary layer
PCA	-	Principal component analysis
PC	-	Principal Component
PRT	-	Platinum resistance thermometer
RH	-	Relative humidity
S	-	South
SD	-	Standard deviation
SLGHGs	-	Short-lived greenhouse gases
SPO	-	South Pacific Ocean
SO	-	Southern Ocean
SOA	-	Secondary organic aerosol
SO ₂	-	Sulphur dioxide
STT	-	Stratosphere-to-troposphere transport
SZA	-	Solar Zenith Angle
TCO	-	Total column ozone
UV	-	Ultraviolet
VOCs	-	Volatile organic compounds
W	-	West

WDCGG - World Data Centre for Greenhouse Gases

WMO - World Meteorological Organisation



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LIST OF APPENDICES

		Page
Appendix A	Spatial and Temporal Analysis of Bro Zonal Total Column (Mol/Mol) Retrieve from Mls-Aura Satellite Over Antarctic Peninsula and Its Surrounding from January 2018 To January 2019	119
Appendix B	Raw Data for O ₃ And Meteorological Dataset at GWS During Austral Summer Campaign	120



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