

**Parametrization of the Do3Se ozone flux
model for *Terminalia arjuna*, *Azadirachta
indica*, *Ficus religiosa*, *Syzygium cumini*
and *Polyathia longifolia***

Gobinder Singh

MS13125

*A dissertation submitted for the partial fulfilment of
BS-MS dual degree in Science*



Indian Institute of Science Education and Research Mohali

April 2018

Certificate of Examination

This is to certify that the dissertation titled “**Parametrization of the Do3Se ozone flux model for *Terminalia arjuna*, *Azadiracha indica*, *Ficus religiosa*, *Syzygium cumini* and *Polyathia longifolia***” submitted by **Mr. Gobinder Singh** (Reg. No. MS13125) for the partial fulfilment of BS-MS dual degree programme of the Institute, has been examined by the thesis committee duly appointed by the Institute. The committee finds the work done by the candidate satisfactory and recommends that the report be accepted.

Dr. Vinayak Sinha

Dr. Sugumar Venkataramani
Sinha

Dr. Baerbel

(Supervisor)

Dated

Declaration

The work presented in this dissertation has been carried out by me under the guidance of Dr. Baerbel Sinha at the Indian Institute of Science Education and Research Mohali.

This work has not been submitted in part or in full for a degree, a diploma, or a fellowship to any other university or institute. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due acknowledgement of collaborative research and discussions. This thesis is a bonafide record of original work done by me and all sources listed within have been detailed in the bibliography.

Gobinder Singh

(Candidate)

Dated:

In my capacity as the supervisor of the candidate's project work, I certify that the above statements by the candidate are true to the best of my knowledge.

Dr. Baerbel Sinha

(Supervisor)

Acknowledgment

I owe a great many thanks to a great many people who helped me during this one year in completing the project. This project has been a very good experience and I learnt a lot of new things.

First and foremost I would like to thank my supervisor, Dr. Baerbel Sinha, who guided me and corrected me at each every step and helped me do everything, the best I could.

Thanks and appreciation to all the lab members who helped and guided me a lot.

I would thank Department of Science and Technology, India for funding the project and Indian Institute of Science Education and Research Mohali for providing all the facilities and equipment required.

I extend a heartiest thanks to my family and friends.

List of Figures

Figure 1 Location of IISER Mohali (30.6650° N, 76.7300° E), in Google Earth**Error! Bookmark not defined.**

Figure 2 Location of the species inside IISER Mohali on Google Earth**Error! Bookmark not defined.**

Figure 3: Schematic diagram of ozone analyser. S1 stands for solenoid1, S2 for solenoid2, UV for ultraviolet lamp, F1 for flow sensor1, F2 for flow sensor2, D1 for detector1, D2 for detector2, C1 for capillary1 and C2 for capillary2, respectively.**Error! Bookmark not defined.**

Figure 4: Function of leaf porometer.**Error! Bookmark not defined.**

Figure 5: Calibration factor as a function of difference in temperature**Error! Bookmark not defined.**

Figure 6: Calibration factor as a function of instrument temperature in the year 2018**Error! Bookmark not defined.**

Figure 7: Stomatal conductance for *Polyalthia longifolia* across the day in post-monsoon season. All measurements taken during a certain hour of the day during the season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 8: Stomatal Conductance for *Polyalthia longifolia* across the day in summer season. All measurements taken during a certain hour of the day during the season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 9: Stomatal Conductance of Peepal across the day in post-monsoon season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 10: Stomatal Conductance of Peepal across the day in summer season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 12: Stomatal Conductance of Neem across the day in summer season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 11: Stomatal Conductance of Neem across the day in post-monsoon season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 13: Stomatal Conductance of Jamun across the day in post-monsoon season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 14: Stomatal Conductance of Jamun across the day in summer season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 16: Stomatal Conductance of Arjun across the day in summer season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

Figure 15: Stomatal Conductance of Arjun across the day in post-monsoon season. All measurements taken during a certain hour of the day during the entire season are binned against the start time of the hour. The lower and upper limit of the box represents 75th and 25th percentile and the line in the middle represents the median and the average is marked by a dot. The Whiskers show the 90th and 10th percentile of the data.**Error! Bookmark not defined.**

List of Tables

Table 1 t-Test: Paired Two Sample for Means For Peepal **Error! Bookmark not defined.**

Table 2 t-Test: Paired Two Sample for Means For Arjun . **Error! Bookmark not defined.**

Table 3 t-Test: Paired Two Sample for Means For Ashoka **Error! Bookmark not defined.**

Table 4 t-Test: Paired Two Sample for Means For Jamun **Error! Bookmark not defined.**

Table 5 t-Test: Paired sample for Means For Neem **Error! Bookmark not defined.**

Table 6 t-Test: Paired Two Sample for Means for peepal . **Error! Bookmark not defined.**

Table 7 t-Test: Paired Two Sample for Means for arjun ... **Error! Bookmark not defined.**

Table 8 t-Test: Paired Two Sample for Means for ashoka **Error! Bookmark not defined.**

Table 9 t-Test: Paired Two Sample for Means for jamun . **Error! Bookmark not defined.**

Table 10 t-Test: Paired Two Sample for Means for neem. **Error! Bookmark not defined.**

List of Photographs

Photograph 1: Photograph of <i>Polyathia longifolia</i> tree on IISER Mohali campus and a close up of the leaf	14
Photograph 2: Photograph of <i>Ficus religiosa</i> tree on IISER Mohali campus and a close up of the leaf leaf	15
Photograph 3: Photograph of <i>Azadirachta indica</i> tree on IISER Mohali campus and a close up of the leaf	16
Photograph 4: Photograph of <i>Syzygium cumini</i> tree on IISER Mohali campus and a close up of the leaf	17
Photograph 5: Photograph of <i>Terminalia arjuna</i> tree on IISER Mohali campus and a close up of the leaf	18

Notation (Abbreviations)

DO ₃ SE	deposition of ozone for stomatal exchange
AOT ₄₀	accumulated ozone exposure over a threshold of 40 ppb
POD _y	phytotoxic ozone dose above the threshold of Y
VOC	volatile organic compounds
ROS	reactive oxygen species
VPD	vapour pressure deficit

CONTENTS

List of Figures.....	i
Abstract.....	xiii
Introduction.....	Error! Bookmark not defined.
1.1 Tropospheric ozone as an air pollutant	Error! Bookmark not defined.
1.2 Effects of tropospheric ozone on plants and environment .	Error! Bookmark not defined.
Materials and Methods.....	Error! Bookmark not defined.
2.1 Site description	Error! Bookmark not defined.
2.2 Ozone measurements.....	Error! Bookmark not defined.
2.3 Stomatal Conductance.....	Error! Bookmark not defined.
2.3 Automatic and manual calibration of the leaf porometer...	Error! Bookmark not defined.
2.4 Tree species investigated.....	Error! Bookmark not defined.
2.6 Quantifying the effect of ozone on natural vegetation	Error! Bookmark not defined.
2.7 Statistical tests	Error! Bookmark not defined.
Results and Discussion.....	Error! Bookmark not defined.
3.1 Stomatal conductance of the top and bottom side of leaves	Error! Bookmark not defined.
3.2 Stomatal conductance of the young and old leaves.....	Error! Bookmark not defined.
3.3 Stomatal conductance of <i>Polyathia longifolia</i>	Error! Bookmark not defined.
3.4 <i>Ficus religiosa</i>	Error! Bookmark not defined.
3.5 <i>Azadirachta indica</i>	Error! Bookmark not defined.
3.6 <i>Syzygium cumini</i>	Error! Bookmark not defined.

3.7	<i>Terminalia arjuna</i>	Error! Bookmark not defined.
3.8	Parameterization of DO3SE model	Error! Bookmark not defined.

Abstract

Troposphere is the layer of atmosphere extending from the ground to a height of 6-10km. Ozone is majorly present in the stratosphere layer of atmosphere which is present just above the troposphere. But there is a minimal amount of ozone presence in troposphere as well, termed as the tropospheric or ground-level ozone. This ozone is not harmful upto certain threshold, after which it acts as a greenhouse gas and becomes damaging to the living forms. The toxic effect of ozone to plants include yield loss, leaf injury etc.. To determine an O₃ dose/plant response relationship different type of ozone metrics like Mx, W125, AOT40 are used. During this work, we are looking at a new metric known as PODy (Phytotoxic Ozone Dose) developed by Emberson and co-workers. This metric was developed based on the stomatal flux measurements as a measure of ozone that enters the stomata of a leaf. We measured stomatal conductance using a Decagon SC-1 Leaf Porometer and for Ozone measurements we used UV absorption photometry. Stomatal conductance measurements were taken on the leaves of 5 different tree species namely, Arjun, False Ashoka, Jamun, Neem and Peepal in IISER Mohali during summer and post monsoon season.

When performing a paired t-test on measurements taken on the top and bottom side of the same leaf, the t value for the test for every tree except ashokha comes higher than the t-critical value. But t value which is higher than the t-critical value suggests us that the bottom side has significantly higher stomatal conductance.

When applying a paired t-test on the measurements of unshaded younger and older leaves growing on the same branch of the same tree, for some species t-value comes under t-critical and for others the value is higher than t-critical. So, we are not sure about significant difference between the pair of younger and older leaves. Significantly higher conductance on old leaves was found on peepal, no difference between young and old leaves was found on false ashoka and jamun and a higher conductance of young leaves was found on neem and arjun.

