

HEAD OF POSTGRADUATE STUDIES REPORT ON HDR THESIS EXAMINATION



PART 1: STUDENT DETAILS

STUDENT NAME	Jesse Greenslade	DEGREE	PhD
STUDENT NUMBER	3113814	HPS	Andy Davis

PART 2: GENERAL OVERVIEW OF EXAMINATION REPORTS

Please ensure that you address the examiners' reports properly and provide clear advice for the candidate regarding any revisions to be completed. If seeking exemptions to an examiner's recommended changes, please thoroughly outline the request and justification under PART 4.

Both examiners were positive regarding the thesis and both noted that one of the thesis chapters was already published in the international literature as a first-author contribution. Examiner Hart (UNSW) noted that the candidate has an "in-depth understanding" of the research area and the work represents a "new contribution to the knowledge of ozone research". She suggested some restructuring of Chapters 1 and 2, but highlighted that additional analyses were not required. Examiner Butler (IASS, Berlin) noted that there were "novel methodological aspects" to the work. He too suggested a reorganisation of Chapter 2 and made some suggestions as to how this might be achieved.

Both examiners recommended that the candidate be awarded the degree subject to minor revisions completed to the satisfaction of the Head of Postgrad Studies.

PART 3: HPS DRAFT RESOLUTION for TEC

That the candidate:	Tick one (✓)
a) be awarded the degree without revision.	
b) be awarded the degree subject to minor revisions, specified by both examiners, being completed to the satisfaction of the HPS.	✓
c) be awarded the degree subject to substantial revisions, specified by both examiners, being completed to the satisfaction of the HPS.	
d) be awarded the degree subject to (minor/substantial/) revisions, specified by examiner....., being completed to the satisfaction of the HPS.	
e) be awarded the degree subject to substantial revisions, specified by the examiners, being completed to the satisfaction of the HPS and being sighted by Examiner {.....} for confirmation of the revisions to his/her satisfaction.	
f) be required to resubmit the thesis in revised form for examination after a suitable period of study and/or research.	
g) (in the case of doctoral theses) (i) be awarded the degree of Master of Philosophy - Research without further examination; or (ii) be permitted to submit the revised thesis for examination for a Master of Philosophy - Research	

I have liaised with the supervisors in the preparation of this report. (HPS to tick to confirm)



HPS Name: ANDY DAVIS Signed: [Signature] 22/10/19

**UNIVERSITY OF WOLLONGONG
EXAMINER'S REPORT FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**



The thesis examination has two parts:

1) This Formal Report :

Consisting of three parts: 1) Report; 2) Recommendation; and 3) Commendation

2) A Separate Written Report :

Please provide a written report of at least 1-2 pages in length which gives clear direction to the student on any revisions which need to be completed

Name of Candidate: Jesse Greenslade

Student No: 3113814

Title of Thesis: Constraining natural contributions to tropospheric ozone production over Australia and selected areas of the Southern Ocean

School: School of Earth, Atmospheric and Life Sciences

Name of Examiner: A/Prof Melissa Hart

Department/Institution: Climate Change Research Centre / University of New South Wales

Report Due: October 2, 2019

1. REPORT (Please circle appropriate responses)

I report that in my opinion:

- | | |
|---|---|
| (a) the thesis provides evidence that the candidate conducted original research; | <input checked="" type="radio"/> YES / <input type="radio"/> NO |
| (b) the thesis demonstrates that the candidate has made a significant contribution to the knowledge of the subject concerned; | <input checked="" type="radio"/> YES / <input type="radio"/> NO |
| (c) the thesis reveals that the candidate has a broad understanding of the discipline within which the work was conducted; | <input checked="" type="radio"/> YES / <input type="radio"/> NO |
| (d) the thesis contains material suitable for publication; | <input checked="" type="radio"/> YES / <input type="radio"/> NO |
| (e) the candidate has presented the thesis in a manner and level appropriate to the field of research; and | <input checked="" type="radio"/> YES / <input type="radio"/> NO |
| (f) the literary standard of the thesis is adequate. | <input checked="" type="radio"/> YES / <input type="radio"/> NO |

2. RECOMMENDATION (please select one and tick appropriate box)

After examination of the thesis (and support papers), I recommend that:

- | | |
|--|-------------------------------------|
| (a) the candidate be awarded the degree without revision; | <input type="checkbox"/> |
| or (b) the candidate be awarded the degree subject to the minor revisions specified being completed to the satisfaction of the Head of Postgraduate Studies; | <input checked="" type="checkbox"/> |

Recommendations continued overpage

- or (c) the candidate be awarded the degree subject to the substantial revisions specified being completed to the satisfaction of the Head of Postgraduate Studies; []
- or (d) the candidate be awarded the degree subject to the substantial revisions specified being completed to the satisfaction of the Head of Postgraduate Studies and being sighted by the examiner(s) for confirmation of the revisions to their satisfaction; []
- or (e) the candidate be required to resubmit the thesis in revised form for examination after a suitable period of study and/or research; []
- in this event, are you prepared to examine the revised thesis? YES / NO
- or (f) as there are exceptional circumstances, the candidate be required to attend an oral examination to determine whether a satisfactory standard of competence in the work has been attained; []
- or (g) (i) the candidate be awarded the degree of Masters of Philosophy without further examination; or []
- (ii) the candidate be permitted to submit the revised thesis for examination for a Masters of Philosophy degree;
- or (h) the candidate be not awarded the degree. []

3. COMMENDATION (please circle appropriate response)

The thesis is outstanding and I recommend it receives special commendation.

YES / NO

I commend this thesis because, in my discipline, it meets **all three (3) criteria** listed below:

1. a contribution to the field of study that is exceptionally innovative and original; and
2. suitable for publication in an esteemed book or in refereed journals of high repute; and
3. this thesis is amongst the best presented I have read.

4. RELEASE TO THE CANDIDATE OF EXAMINER'S COMMENTS

It is University policy that examiners' names and reports will be provided to candidates after the result of the examination has been determined.

Examiner

Date

7-10-2019.

Please note that failure by examiners to submit a written report, in addition to this form, will result in this report not being considered.

PhD thesis evaluation

Jesse Greenslade

Constraining natural contributions to tropospheric ozone production over Australia and selected area of the Southern Ocean

Jesse Greenslade's PhD thesis used a combination of chemical transport modelling, satellite, ozonesonde, and stationary observations to assess the contributions from chemical production and stratospheric transport to tropospheric ozone. The thesis is presented as an introduction and chapter that includes a detailed literature review, three results chapters, and a final conclusions chapter that synthesises all results and provides overarching discussion. Of the three results chapters, one has been published in the Journal- Atmospheric Chemistry and Physics.

Jesse has exhibited an in-depth understanding of the formation and source of tropospheric ozone. He has done a good job of synthesising the extensive literature in this field and interpreting his results with reference to existing literature. He has exhibited a detailed understanding of the model and datasets used and provides good justification of experimental design implemented. The figures used to illustrate results are particularly strong and easy to read and interpret.

It is my assessment that thesis has sufficient scientific merit for a PhD and represents a new contribution to the knowledge of ozone research. Well done!

I do have some suggestions for clarifications and inclusions to be made to thesis text, and some restructuring of sections of the thesis, however I do not suggest that any additional analyses is required. Given that my suggestions do not require substantial additions to the thesis, or any additional analyses, and I do not envisage they will take the candidate too long to complete, I am happy for these to be completed to the satisfaction of Head of Postgraduate Studies. I also note that the inclusion of this additional material does not impact in any way on the findings of the thesis, but would hope they may be useful when preparing future publications stemming from this important work.

General Comments

Specific Comments

- The text switches from first to third person which becomes quite confusing as a reader. Given that the published work is in 3rd person, I would suggest keeping the entire thesis the same.
- Page v- there are some problems with the formatting of the title/abstract in the version of the thesis I was sent.
- The abstract needs some re-structuring. E.g. the aims come before the need/background. I suggest starting with the need/gaps, following with the aims/approach, and then following with key results. It is also lacking key contribution- why is this work important?
- Abstract- typo "A"- 3rd paragraph
- As with the Abstract, Chapter 1 could also do with some restructuring. The chapter contains a comprehensive introduction to ozone, and review of literature, however

the gaps in knowledge that this thesis fills are hidden throughout and it is difficult to assess the context to the current study for some of the sections. Again, I suggest bearing in mind: need, gaps, aims/objectives structure while also introducing key background material and literature.

- Page 31- typo “..”
- Chapter 2, called “Data and Modelling” details the datasets and modelling undertaken in the thesis, while also including results linked to Aim 2- calculation of vertical columns of HCHO. Once again, although the material presented is relevant, and the analyses appropriate, I am going to take issue with the structure of the chapter. As I read each section I found that although each contained interesting and relevant material, I kept having to go back to the explanation of the aims of the project on page 30 to see how and why that section fit within the thesis. This is also quite a long chapter. One suggestion would be to split the first half into a data and methods chapter, and the second half into results to meet Aim 2. I also suggest moving Fig 2.37 to earlier in the chapter, and then referring to it throughout.
- Chapter 3 implements a top-down technique using satellite measurements of HCHO to calculate surface isoprene emissions. This chapter is clearly structured and easy to read and interpret. Well done. I have no suggestions for revisions to this chapter, beyond the use of 1st person mentioned above, and would suggest that it is ready to submit to a journal if this hasn’t already taken place.
- Chapter 4 looks at stratospheric ozone intrusions and has been published in Atmospheric Chemistry and Physics. My only suggestion for this chapter would be to move the contribution of authors section to the beginning of the chapter, and to make clear how much of the work, perhaps as a percentage, can be contributed to the candidate.
- Chapter 5 is clearly written and does a good job of synthesizing the work. No revisions suggested.

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Please provide a written report of at least 1-2 pages in length which gives clear direction to the student on any revisions which need to be completed

Name of Candidate: Jesse Greenslade

Student No: 3113814

Title of Thesis: Constraining natural contributions to tropospheric ozone production over Australia and selected areas of the Southern Ocean

School: School of Earth, Atmospheric and Life Sciences

Name of Examiner: Prof Tim Butler

Department/Institution: Air Quality Modelling / Institute for Advanced Sustainability Studies

Report Due: October 2, 2019

1. REPORT (Please circle appropriate responses)

I report that in my opinion:

- | | | |
|-----|---|---------------------|
| (a) | the thesis provides evidence that the candidate conducted original research; | YES / NO |
| (b) | the thesis demonstrates that the candidate has made a significant contribution to the knowledge of the subject concerned; | YES / NO |
| (c) | the thesis reveals that the candidate has a broad understanding of the discipline within which the work was conducted; | YES / NO |
| (d) | the thesis contains material suitable for publication; | YES / NO |
| (e) | the candidate has presented the thesis in a manner and level appropriate to the field of research; and | YES / NO |
| (f) | the literary standard of the thesis is adequate. | YES / NO |

2. RECOMMENDATION (please select one and tick appropriate box)

After examination of the thesis (and support papers), I recommend that:

- | | | |
|--------|---|-------------------------------------|
| (a) | the candidate be awarded the degree without revision; | [] |
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Recommendations continued overpage

or (c) the candidate be awarded the degree subject to the substantial revisions specified being completed to the satisfaction of the Head of Postgraduate Studies; []

or (d) the candidate be awarded the degree subject to the substantial revisions specified being completed to the satisfaction of the Head of Postgraduate Studies and being sighted by the examiner(s) for confirmation of the revisions to their satisfaction; []

or (e) the candidate be required to resubmit the thesis in revised form for examination after a suitable period of study and/or research; []

in this event, are you prepared to examine the revised thesis? YES / NO

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or (h) the candidate be not awarded the degree. []

3. COMMENDATION (please circle appropriate response)

The thesis is outstanding and I recommend it receives special commendation.

~~YES / NO~~

I commend this thesis because, in my discipline, it meets **all three (3) criteria** listed below:

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4. RELEASE TO THE CANDIDATE OF EXAMINER'S COMMENTS

It is University policy that examiners' names and reports will be provided to candidates after the result of the examination has been determined.

Examiner Prof. Dr. Tim Butler Date 01.10.2019

Tim
Butler

Digital unterschrieben von Tim
Butler
DN: cn=Tim Butler, o=UASS
Potsdam, ou=Modellierung der
Luftqualität,
email=tim.butler@uass-
potsdam.de, c=DE
Datum: 2019.10.01 18:14:03
+02'00'

Please note that failure by examiners to submit a written report, in addition to this form, will result in this report not being considered.

Review of the doctoral thesis of Jesse Greenslade (University of Wollongong, 2019) “Constraining natural contributions to tropospheric ozone production over Australia and selected areas of the Southern Ocean”

The overarching topic of the thesis is tropospheric ozone chemistry in remote regions of the Earth. The regions studied are the Australian continent and nearby parts of the Southern Ocean. While these regions are not well known for high levels of ground-level ozone pollution, the study of the chemistry of remote regions has the potential to improve the understanding of basic atmospheric processes. Tropospheric ozone itself is also of global interest due to its role in radiative forcing of the climate system. The doctoral thesis focuses on two aspects of current interest in tropospheric ozone science: the transport of ozone into the troposphere from the stratosphere; and the chemical production of ozone from isoprene, one of its most important precursor molecules.

During the course of the work, the candidate has demonstrated the ability to work with diverse data sources (ozonesondes, satellite observations, and in-situ measurements), and to appropriately use a CTM to synthesise new knowledge (in this case an adjusted estimate of isoprene emissions over Australia). Some of the candidate's original work has already been published as in the international peer-reviewed literature. The work on quantification of STT has already been accepted as a first-author publication through peer review, so I will not focus on this in my report. The remainder of the work in the thesis focuses on the improvement of satellite-measured column densities of HCHO (with a focus on methodological development), and the use of these improved measurements to inform an inverse-modelling study of isoprene emissions over the Australian continent (focus on scientific application). The candidate is co-author on another peer-reviewed publication which makes use of the improved HCHO column densities for another application (Lieschke et al., 2019), and is preparing the isoprene inverse modelling work for submission.

The novel methodological aspects of the work are described in Chapter 2 of the thesis. I find this chapter somewhat confusing, because it appears to have three distinct purposes. Firstly, the chapter provides some general introductory material, which has substantial overlap with the introductory chapter. Secondly, the work done by the candidate to recalculate the OMI HCHO column measurements is described. These revised data are used in the subsequent chapter on isoprene inverse modelling (and presumably also by Lieschke et al., 2019). Thirdly, several filtering techniques are described, which it seems are only relevant for the isoprene inverse modelling work. I do understand the logic of including all of this material in a chapter called “Data and Modelling”, but I think a separation into distinct chapters would help the reader, and also make it clearer what the candidate has contributed. In particular, for the “middle part” of this text, it would be good to see a section similar to Section 4.9, in which the contributions of different workers (including the candidate) are clearly described. Subsequent work published (and even in preparation) using the new HCHO dataset could also be mentioned here, which would help to show how useful this work has been for colleagues and the wider community. Perhaps the work on filtering the HCHO columns (Section 2.7) could be merged into Chapter 3, especially if this will all be submitted as a standalone paper anyway.

My main criticism of Chapter 3 is that the work is not described adequately in the context of previous studies. A top-down study by Bauwens et al. (2016) is mentioned in passing in Section 3.1.2, but almost no details are given. This study appears to be highly relevant, given that it seems to use an almost identical method. Chapter 3 must include a comparative discussion of the method used in this thesis and the method of Bauwens et al. (2016), and how the results of the two studies are influenced by their choice of methodology. Similarly, the range of values for Australian isoprene emissions (both bottom-up and top-down) given in Table 3.1 should be discussed in more detail.

What is it about the different emission models and inverse approaches that lead to such a large range of values? Can the results of this work be understood simply in terms of the way the methodologies are applied, or has something genuinely new been learnt? In praise of Chapter 3, I really appreciated the detailed examination of uncertainties in the analysis, and in particular the thorough discussion of the role of the isoprene-HCHO yield and its implications for future work.

I noticed several small apparent errors of understanding in Chapter 1 which the candidate should revisit while revising their thesis. For example, on page 3, the hydroperoxyl radical (HO_2) is referred to as “hydrogen dioxide”, a name which is never used in the relevant atmospheric chemistry literature. I was also not convinced by some aspects of the candidate’s description of ozone chemistry. For example the photolysis reaction of ozone in Equation Set 1.2 (page 4) is claimed to proceed at wavelengths less than 1180 nm. Does the candidate have a reference describing how quickly the reaction proceeds at such low photon energies? The absorption cross section for ozone photolysis used in the MCM (Master Chemical Mechanism) is only defined below 350 nm, with wavelength-dependent quantum yields for $\text{O}(^1\text{D})$ and $\text{O}(^3\text{P})$ below 350 nm (<http://mcm.leeds.ac.uk/MCMv3.3.1/parameters/photolysis.htm>). Significant amounts of ozone photolysis at lower photon energies would result in a much shorter lifetime for tropospheric ozone than predicted by the MCM (or any other model which I have used). Furthermore, the high abundance of “M” at lower altitudes is given as a reason for the existence of the ozone-layer, but M are actually required to stabilise ozone produced by photolysis in the stratosphere (Equation Set 1.2), where they are less abundant. The candidate should rethink and revise their text here.

I also think that the candidate should give a better overview of the different kinds of sources of VOC in Section 1.3. The candidate primarily focuses on biogenic isoprene, which is reasonable given the focus of the thesis, but anthropogenic and pyrogenic VOC are barely mentioned, and not until later in the text. Also, “reactivity” is listed as one of the fundamental properties of VOC near the beginning of Section 1.3, but I miss some discussion about what determines the reactivity of different VOC, and what this means for their atmospheric lifetimes. This is especially important, since the atmospheric lifetimes of both isoprene and HCHO are important concepts which are drawn upon in several places later in the thesis.

Given their importance in the thesis, I would also like to see more understanding of biogenic isoprene emissions demonstrated by the candidate in Chapter 1, especially how they are modelled, and the basis (or lack thereof) that this emissions modelling has in actual measured data. BVOC emission models, specifically MEGAN, are mentioned in several places in the thesis. In many of these cases literature references are given, and particular aspects of the potential shortcomings in these models are described, such as a poor representation of soil moisture, or an over-reliance on measurements from younger trees. Instead of scattering this information throughout the thesis it should be collected in one place where the candidate can demonstrate an understanding of how these models work and what their known shortcomings are. The results in subsequent chapters can then be related back to the material from the introduction

As a matter of style, tables and figures should not be presented in the conclusions chapter. Figure 5.2 is particularly superfluous, since it is exactly the same as Figure 3.7

Overall, I would like to congratulate the candidate on this doctoral thesis, and wish them all the best for their subsequent adventures.

Potsdam, 01.10.2019

Prof. Dr. Tim Butler

IASS Potsdam / Freie Universität Berlin