ADJOINT INVERSION OF ATMOSPHERIC DUST SOURCES FROM MULTI-SENSOR SATELLITE OBSERVATIONS

by

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A DISSERTATION

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Abstract to be filled ...

DEDICATION

To my parents, wife, sons, and friends for providing the unwavering encouragement and support that allowed me to accomplish my goal.

ACKNOWLEDGMENTS

Arma virumque cano, Troiae qui primus ab oris Italiam, fato profugus, Laviniaque venit litora, multum ille et terris iactatus et alto vi superum saevae memorem Iunonis ob iram; multa quoque et bello passus, dum conderet urbem, inferretque deos Latio, genus unde Latinum, Albanique patres, atque altae moenia Romae.

GRANT INFORMATION

The NASA Earth and Space Science Fellowship funded this project from September 2012 to August 2015. I am also grateful to the support from NASA's New Investigator Program and Radiation Science Program (to Dr. Jun Wang).

Contents

List of Figures

List of Tables

CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

1.1.1 Impacts of Atmospheric Dust Aerosol

Atmospheric aerosols play a crucial role in the global climate change. They affect earth energy budget directly by scattering and absorbing solar and terrestrial radiation, and indirectly through altering the cloud formation, lifetime, and radiative properties [Haywood and Boucher, 2000; Ramanathan et al., 2001]. However, quantification of these effects in the current climate models is fraught with uncertainties. The global average of aerosol effective radiative forcing (ERF) were estimated to range from -0.1 to -1.9 Wm2 with the best estimate of -0.9 Wm2 [Boucher et al., 2013], indicating that the cooling effects of aerosol might counteract the warming effects of 1.820.19 Wm2 caused by the increase of carbon dioxide since the industrial revolution [Myhre et al., 2013]. The climate effects of aerosol particles depend on their geographical distribution, optical properties, and efficiency as cloud condensation nuclei (CCN). Key quantities pertain to the aerosol optical and cloud-forming properties include particle size distribution (PSD), chemical composition, mixing state, and morphology [Boucher et al., 2013]. While the daily aerosol optical depth (AOD) can be well measured from current satellite and ground-based remote sensing instrumentations [e.g., Holben et al., 1998; Kaufman et al., 2002], the accurate quantification of aerosol ERF is in no small part hindered by our limited knowledge about the aerosol PSD and refractive index (describing chemical composition and mixing state). To fully understand the role of aerosol particles in the global climate change, further development in observations along with retrieval algorithms for these aerosol microphysical properties from different platforms are thus highly needed [Mishchenko et al., 2004], and the focus of this two-part series study is the characterization of aerosol properties from ground-based passive remote sensing

Koven et al. [2008] have investigated ...

1.2 Objectives

1.3 Organization of This Dissertation

CHAPTER 2

SOME TABLES AND FIGURES

First	Last
Ned	Hummel
Ned	Hummel
Ned	Hummel

Table 2.1: Arma virumque cano, Troiae qui primus ab oris Italiam, fato profugus, Laviniaque venit litora, multum ille et terris iactatus et alto vi superum saevae memorem Iunonis ob iram

✓ Foo
✓ Foo
✓ Foo

Table 2.2: Arma virumque cano, Troiae qui primus ab oris Italiam, fato profugus, Laviniaque venit litora, multum ille et terris iactatus et alto vi superum saevae memorem Iunonis ob iram

Figure 2.1: Arma virumque cano, Troiae qui primus ab oris Italiam, fato profugus, Laviniaque venit litora, multum ille et terris iactatus et alto vi superum saevae memorem Iunonis ob iram

CHAPTER 3

SOME MATH

This is a triviality, but we include it for completeness.

$$\int_0^\infty f(x)\,dx = \begin{cases} 1 & \text{if } f = \delta, \\ 0 & \text{if } f = 0. \end{cases} \tag{3.1}$$

Here is an aligned set of equations.

$$\begin{aligned} f(x) &= f(x) \cdot 1 && (3.2) \\ &= f(x) \cdot (2 - 1) && (3.3) \\ &= f(x) && (3.4) \end{aligned}$$

The clever step is (3.3).

APPENDIX A

TESTING, 1, 2, 3, . . .

This has been a test of the thesis typesetting system. Had this been an actual thesis, this would have been preceded by an actual thesis.