Aerosol Radiative Effects from combined MODIS, MISR and CERES data

Sundar A. Christopher
University of Alabama - Huntsville

• Introduction
• Aerosol effects
• MODIS/CERES
• MODIS/MISR/CERES
• Satellite AOT and PM$_{2.5}$
• Outstanding issues
Introduction

- Aerosol effects are being examined increasingly from measurement based studies since Terra/Aqua (Yu et al. ACPD-CCSP, Anderson et al. BAMS)
- Direct radiative effects include change in net radiative flux at TOA from all aerosols.
- Aerosol Climate forcing is for anthropogenic aerosols.
Aerosol Radiative Effects – Model perspective

- Model simulations – From RT equations > complex models.
- Aerosol components can be studied separately.
- Source functions/processes hard to define.
- Aerosols over land and ocean studied.
- Uncertainties difficult to assess.

$$\Delta \alpha_p = \left[ T_a^2 (1-A_c) \right] \left[ 2(1-R_s)^2 \bar{\beta}_f M \alpha_s f(RH) - 4 R_s M \alpha_s f(RH) \left( \frac{(1-\omega_0)}{\omega_0} \right) \right]$$
Aerosol Effects - Measurement

- AERONET derived forcing – Excellent validation method, limited coverage
- Satellite derived AOT (e.g. MODIS) plus RT model. Near Global AOT. RT model requires assumptions
Radiative Effects from CERES

- Direct method. No RT model required
- Large footprint size
- Cloud clearing
- Aerosol ADM’s necessary
CERES with AERONET

- Combine CERES with AERONET. Excellent diagnostic tool but limited in spatially.
Combined MODIS and CERES

- CERES ES-8 and MODIS L2
- Several regional studies used ES-8

CERES footprint AOT could be 40% lower than when compared to using MODIS L2 AOT (Sample bias)

Christopher and Zhang, GRL, 2002
CERES SSF
(Merged MODIS and CERES)

- CERES SSF
- Point spread function weighted aerosol and cloud properties within CERES
- Christopher et al (UAH)
- Loeb et al (Langley)
- Most studies focus on cloud-free pixels over near-global oceans

Recent progress
1. Sample bias accounted for Using MODIS narrowband to CERES broadband conversion (Loeb et al.)
2. Bulk sample bias adjustments Using forcing efficiencies (Christopher et al.)
3. Aerosol angular model using CERES RAP data (Zhang et al.) as function of AOT, aerosol fine mode fraction.
Aerosols from MODIS
• New Aerosol ADM’s from CERES
• TOA forcing from CERES
• Independent assessment of aerosol forcing from satellite measurements without Rad. Transfer calculations
• Estimating anthropogenic forcing using MODIS fine mode fraction and CERES measurements is now possible

Cloud-free diurnally averaged aerosol forcing: $-5.3 \pm 1.7 \text{ Wm}^{-2}$

Christopher and Zhang, GRL
Fine Mode (Anthropogenic?)
Aerosol Forcing

Cloud free anthropogenic forcing from CERES: -1.4 Wm\(^{-2}\)
From MODIS/CERES.
Anthropogenic AOT = 0.04 at 0.55 µm.

\[ \tau_f = f_a \tau_{\text{anthropogenic}} + f_m \tau_{\text{marine}} + f_d \tau_{\text{dust}} \]

\[ f_a = 0.92 \pm 0.03, \quad f_d = 0.51 \pm 0.03, \quad f_m = 0.32 \pm 0.07 \]

Kaufman et al. 2005
Merged MODIS, MISR, CERES data
Multi sensor approach for aerosol research

- MODIS for cloud clearing
- MISR for AOT
- CERES for LW fluxes
- TOMS for intercomparison
- Radisondes for water vapor

Longwave forcing: +7 Wm$^{-2}$. 

MODIS for cloud clearing
MISR for AOT
CERES for LW fluxes
TOMS for intercomparison
Radisondes for water vapor
Longwave forcing: +7 Wm$^{-2}$. 
Satellite AOT and PM2.5
Outstanding issues

- Aerosol effects over land
- Anthropogenic aerosol forcing over land
- Clear plus cloudy forcing
- Aerosol ADM’s by aerosols
- Particulate matter and AOT – aerosol height?
- Merged MODIS, MISR, CERES product – Terra MMC?