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Determination of aerosol single scattering albedo and radiative forcing from ground and space observations

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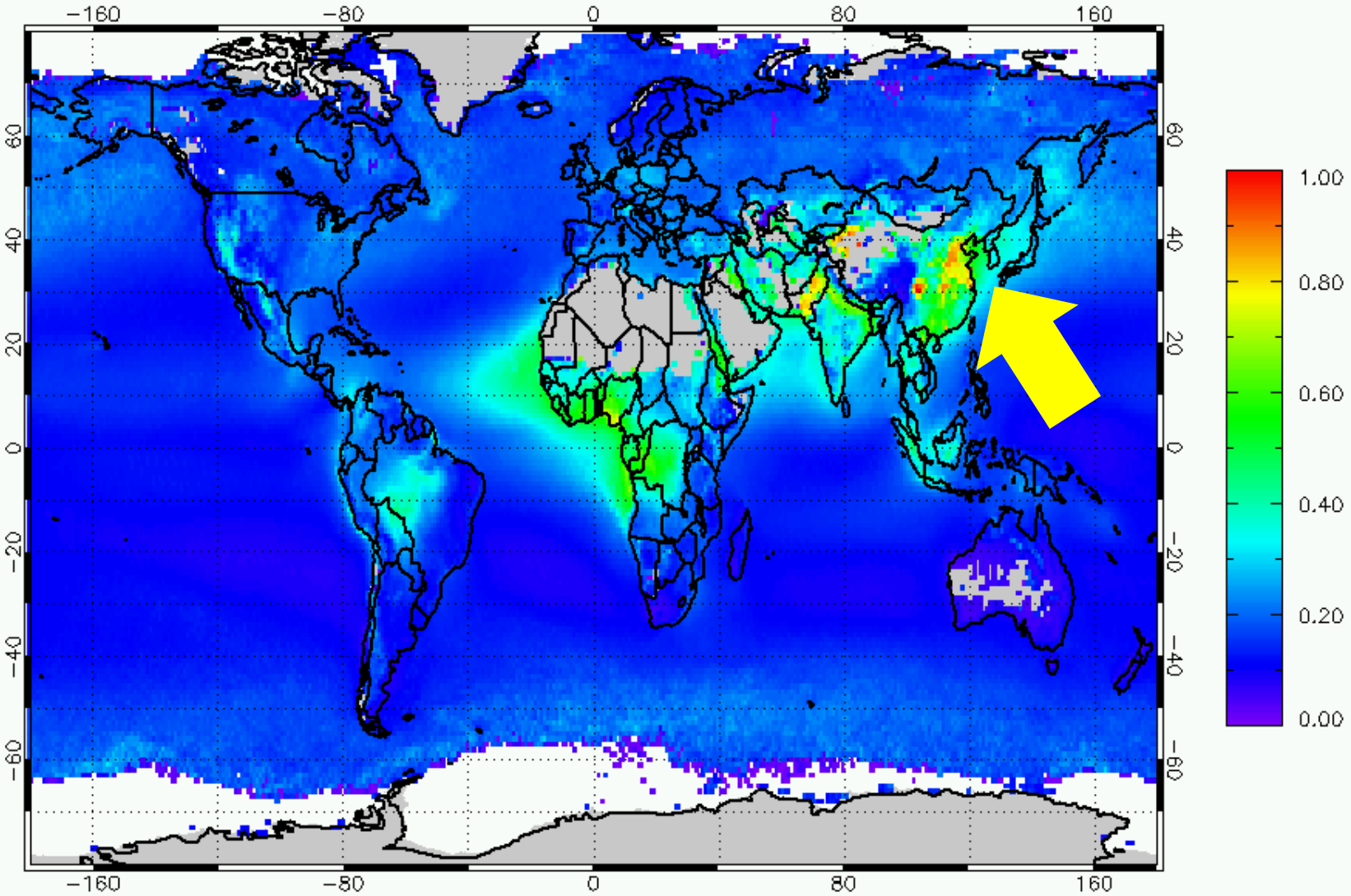
Contents

Introduction

Final objectives

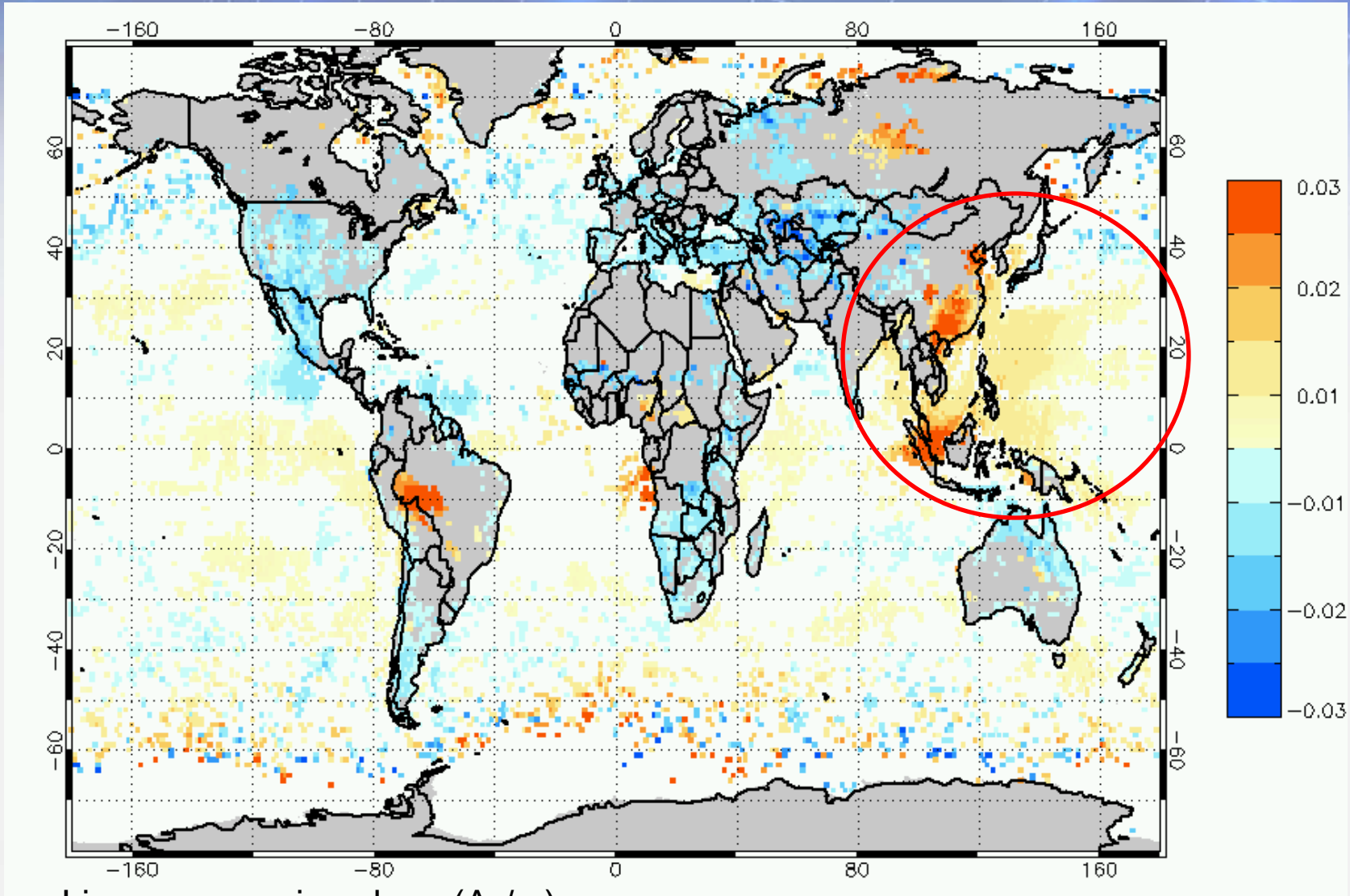
Contribution to
The East-AIRE campaign

Global Aerosol loading (2000~2006)



MODIS AOT over land & oceans during 2000~2006

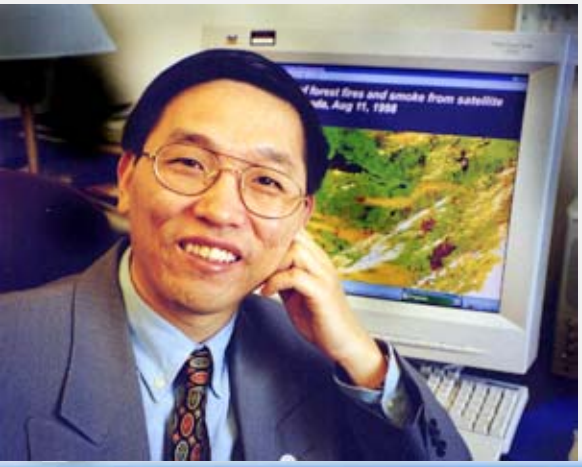
Global Aerosol Trend (2000~2006)

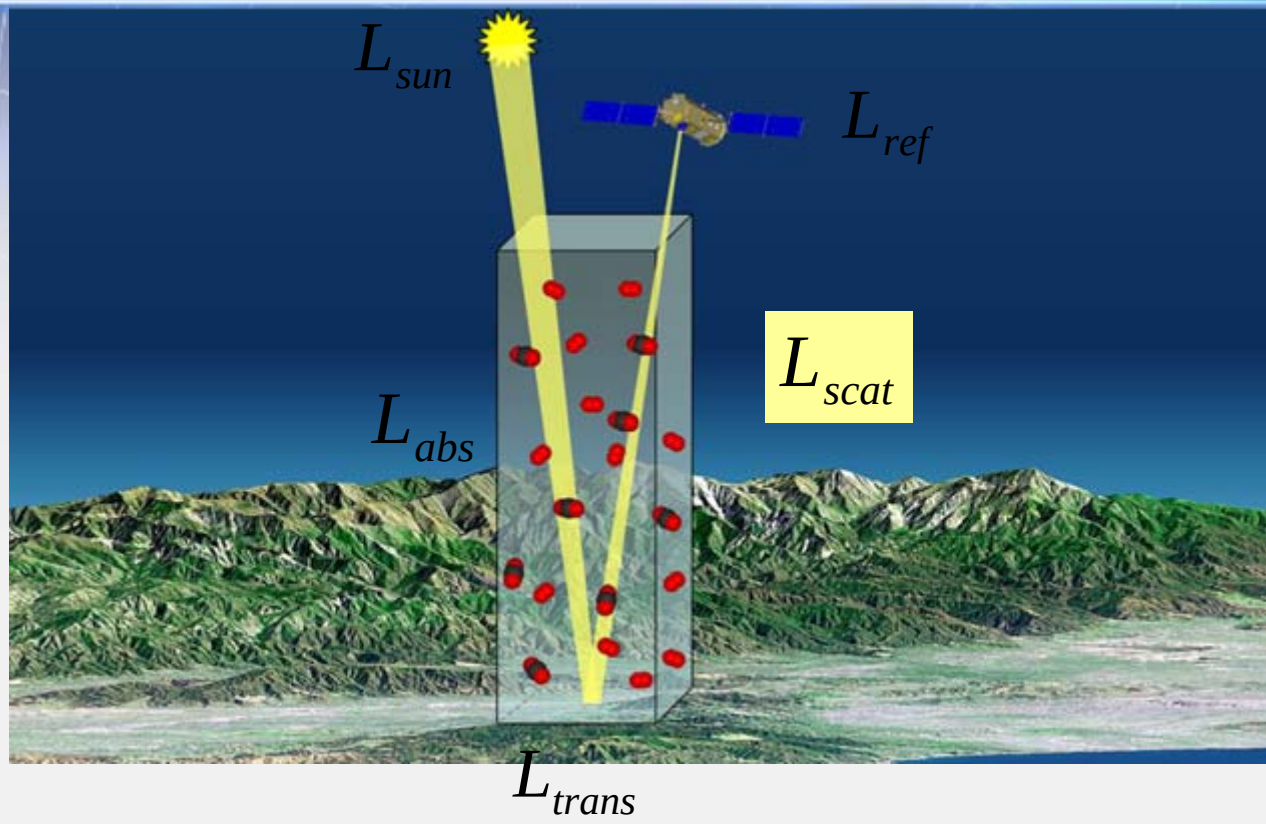


Linear regression slope (Δτ/yr)

At the beginning of SSA retrieval

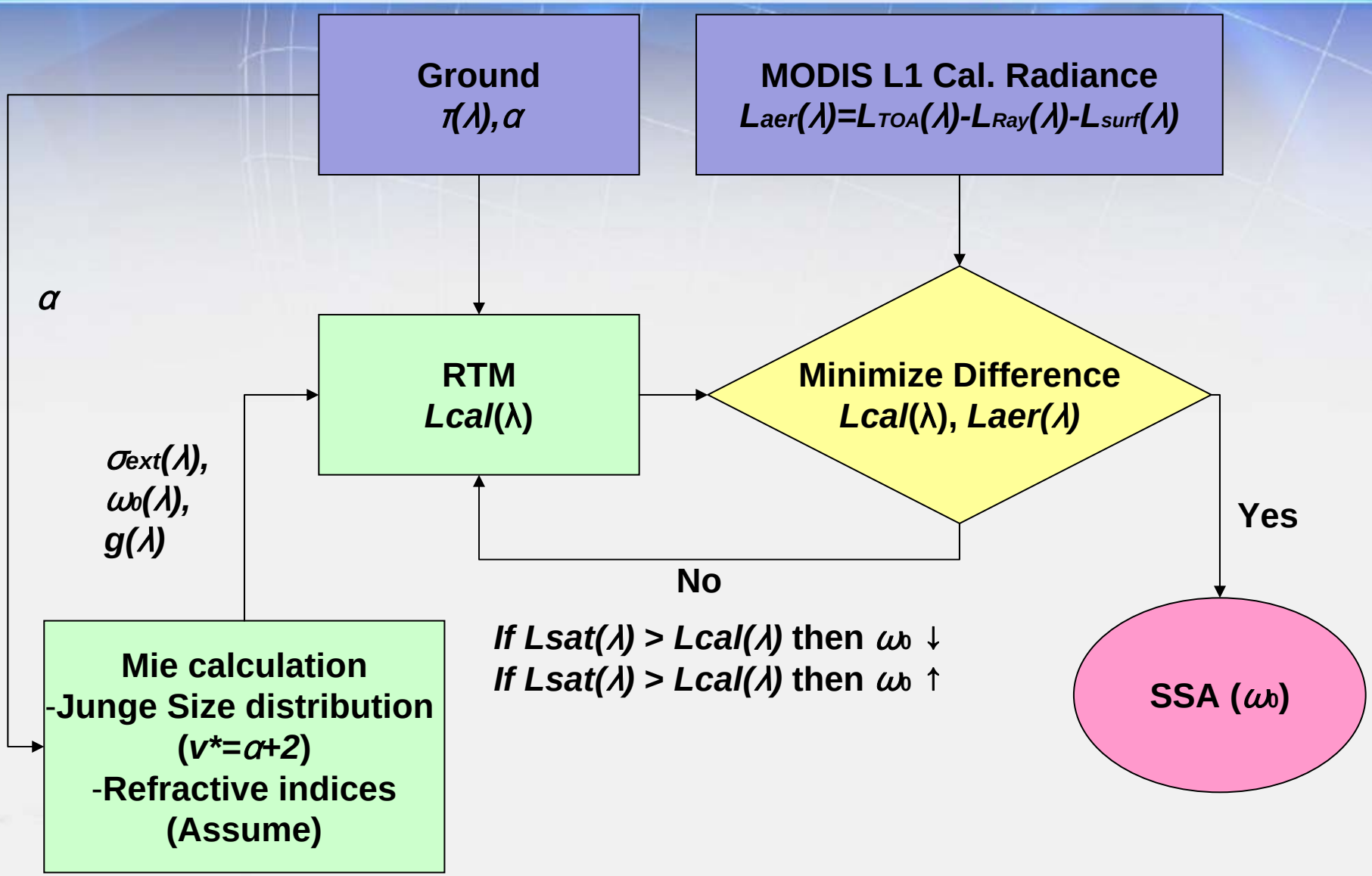
"The absorption can be inferred from the difference between transmitted and reflected radiation."
-Zhanqing Li, 2006 Apr.





$$L_{sun} = L_{trans} + L_{ref}(Atm, Surface) + L_{abs}(\omega_0)$$

SSA Retrieval Strategy

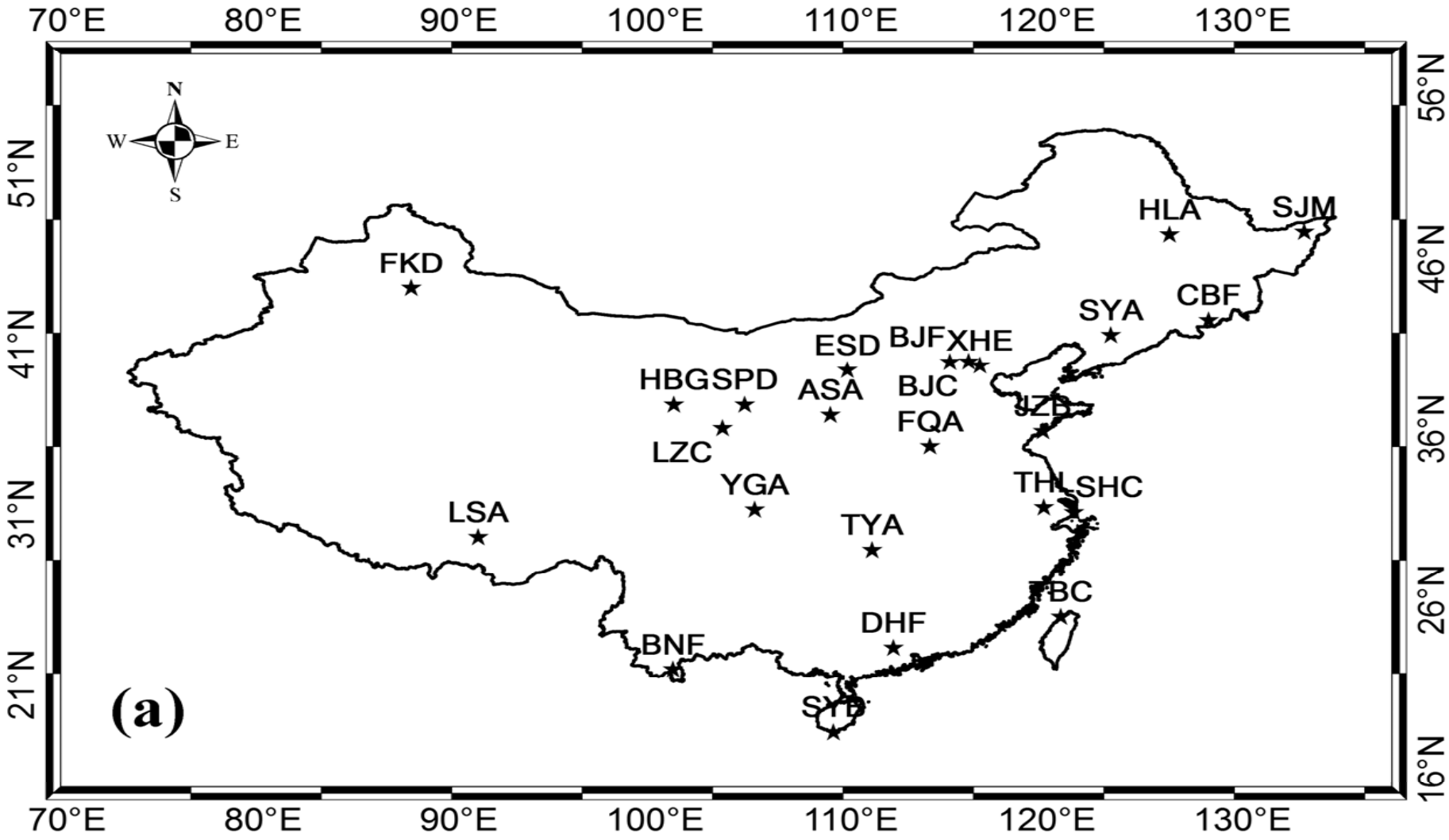


Sensitivity Study

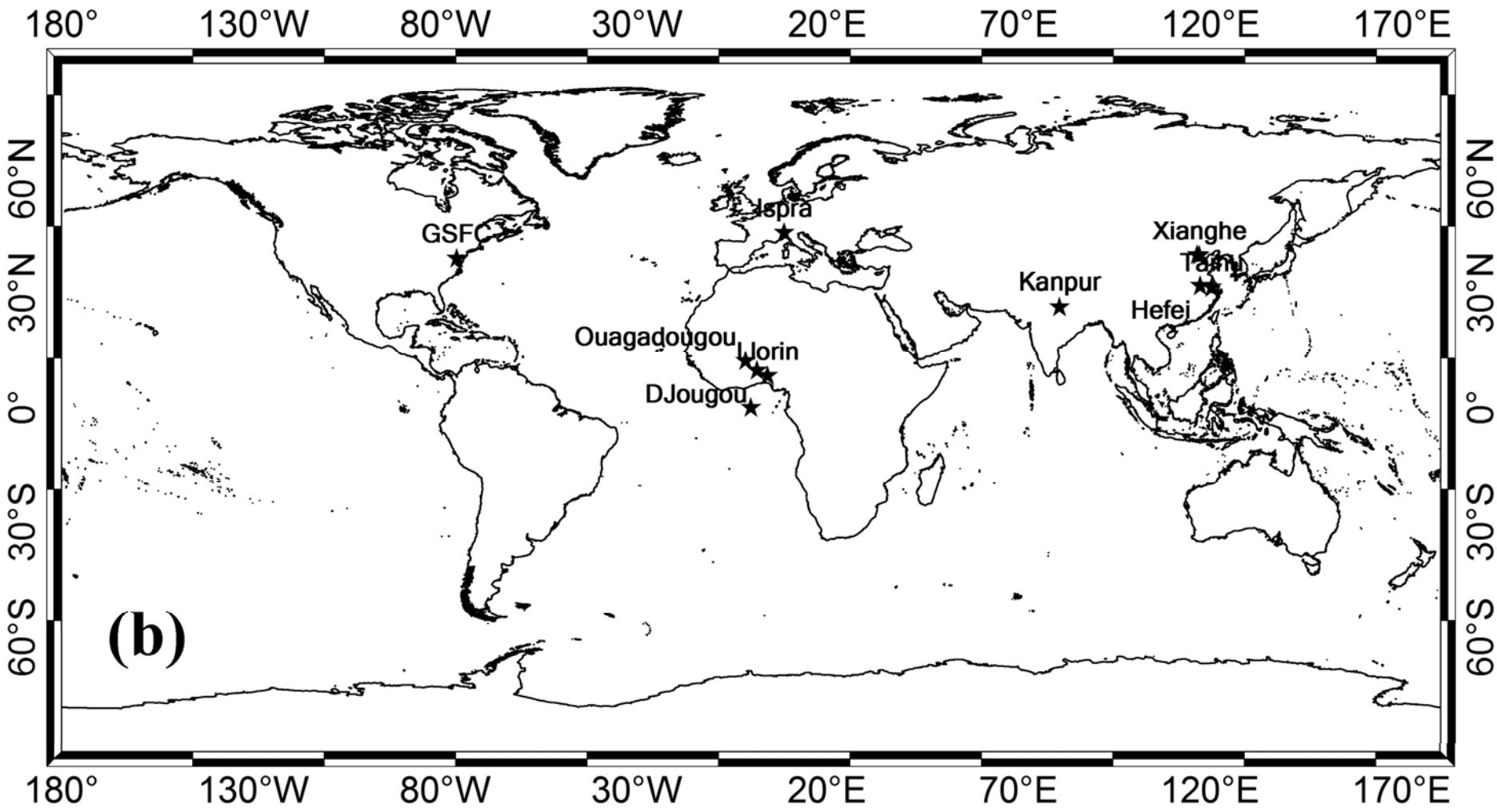
Parameter	Uncertainty	Error(%)
Hazemeter AOT	2~6%	±0.04
PSD		±0.02
Angstrom	10%	±0.02
Surface reflectance	±0.01	±0.10
vertical distribution		±0.005
Shape		±0.03
Refractive index	mr	±0.05
	mi	±0.06
sensor calibration	1%	±0.004
Combined		±0.21

Compare with ±0.15 (Hu et al.,2007)

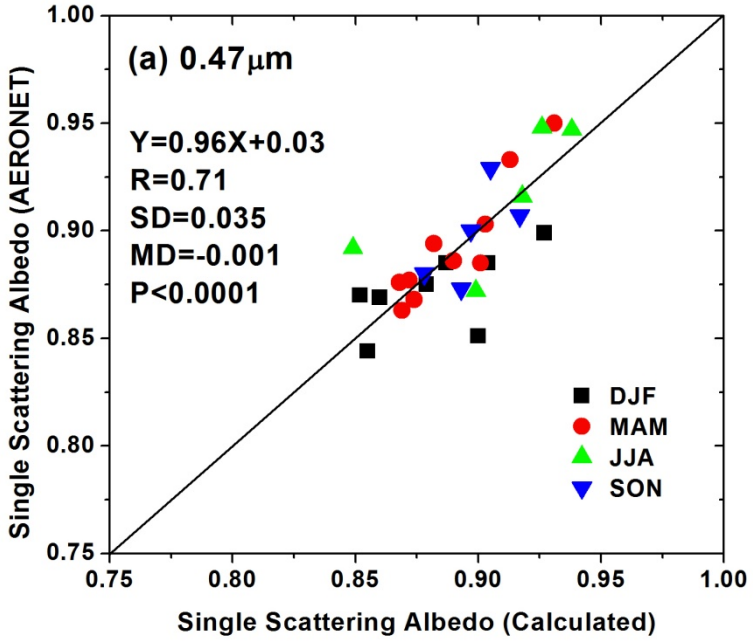
The Chinese Sun-Hazemeter Network (CSHNET)

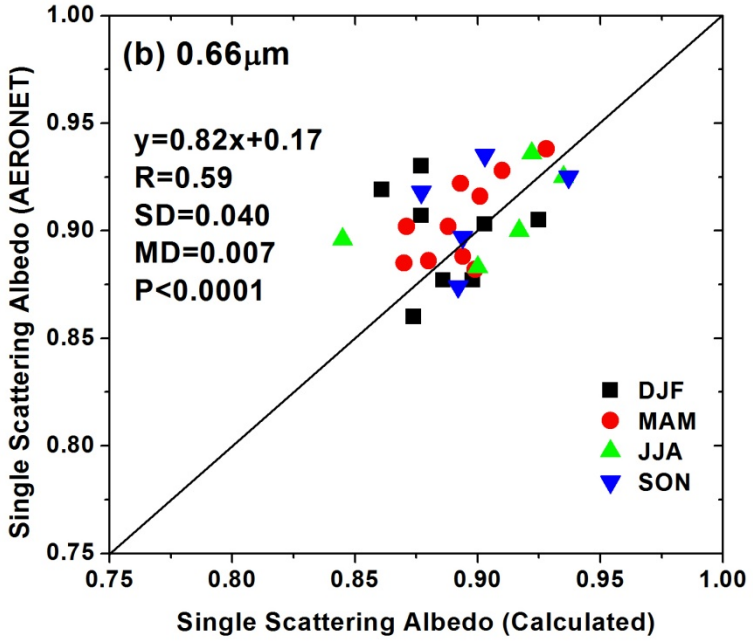


Selected AERONET sites for Comparison



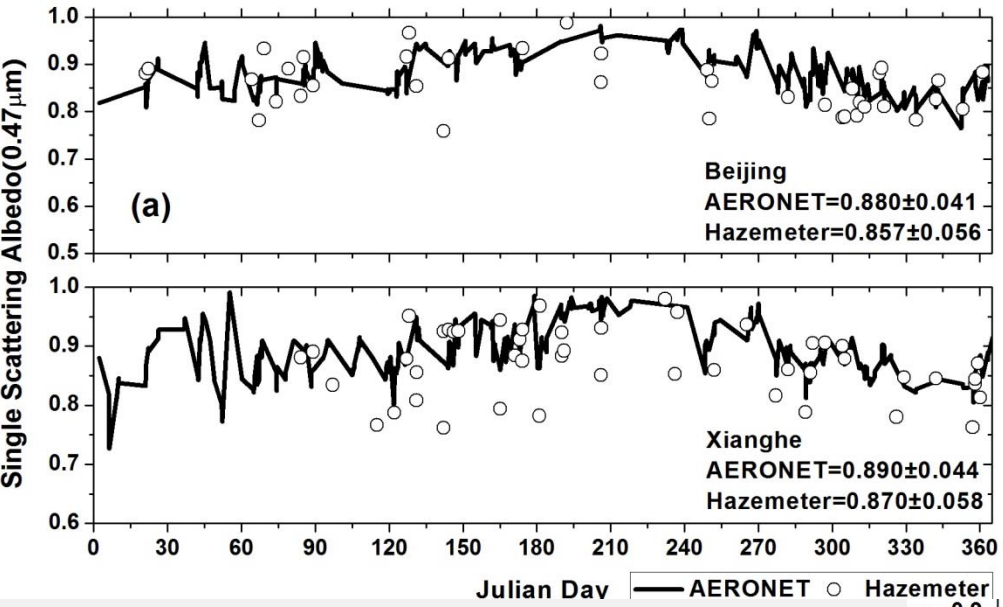
Retrieved SSA vs. AERONET SSA





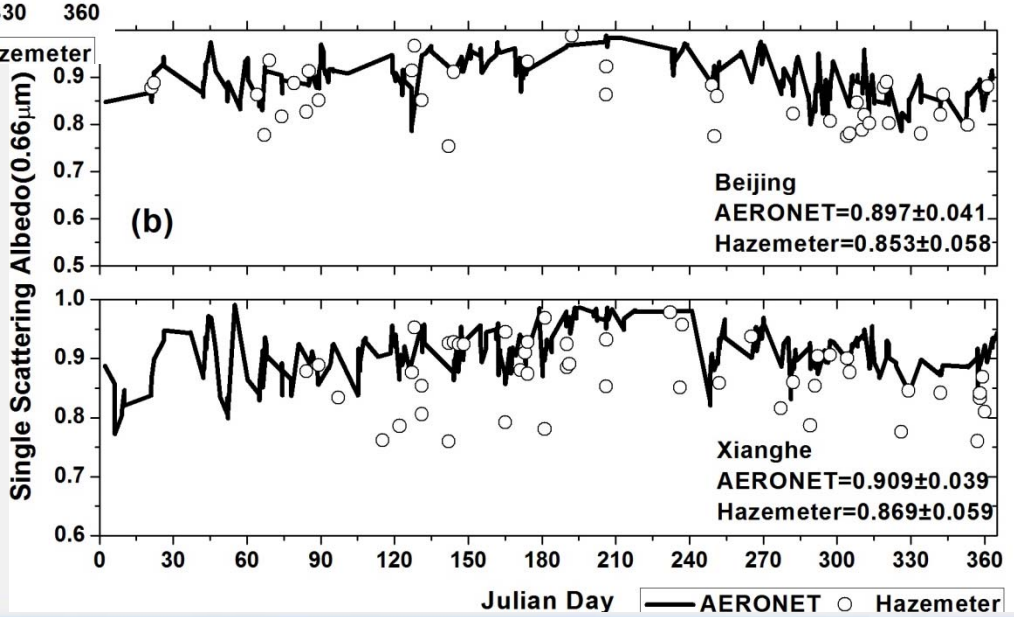
worse agreement may be due to a larger error in determining surface reflectance.

Retrieved SSA vs. AERONET SSA

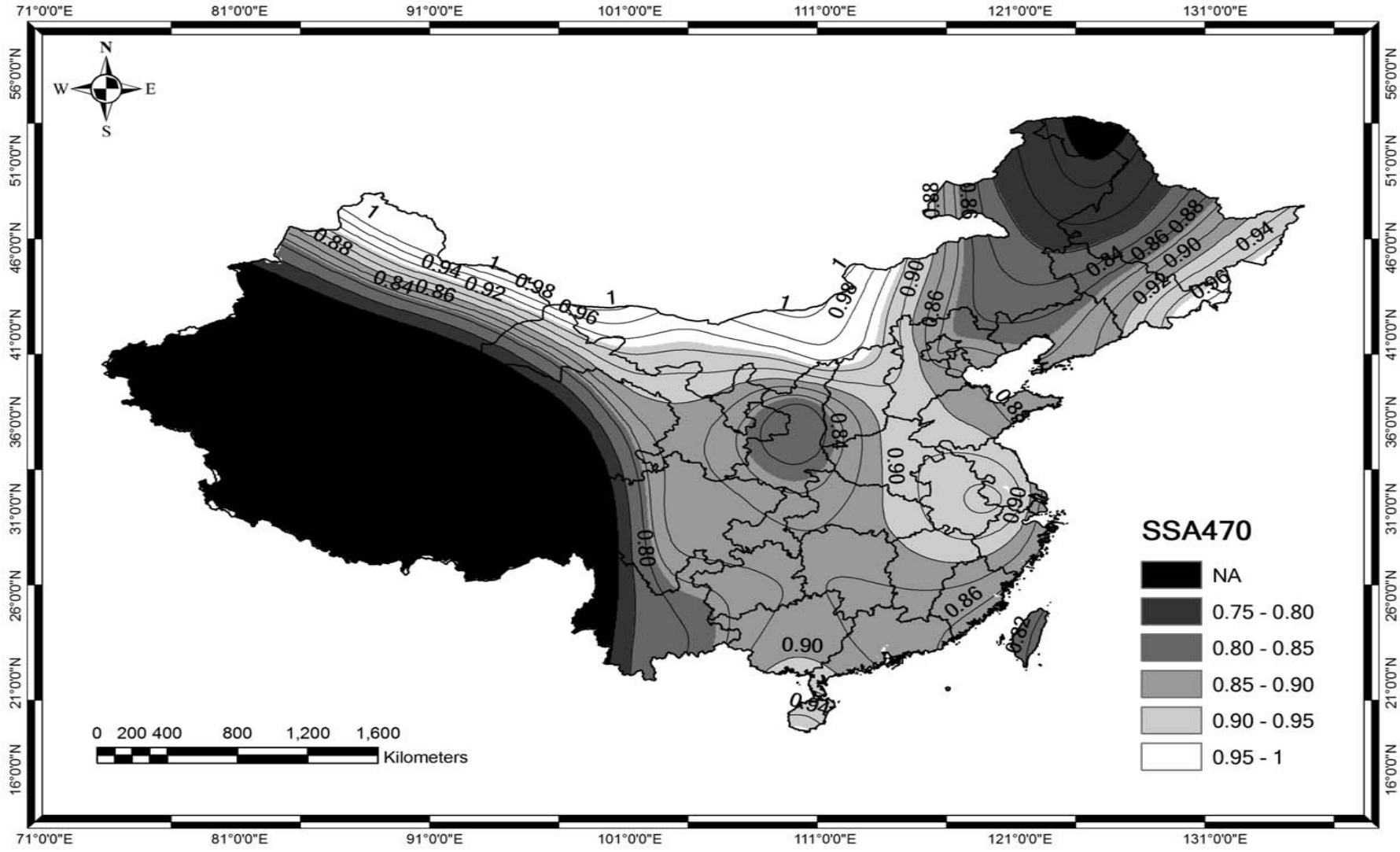


Mean values were estimated in the range of 0.86~0.88 at 0.47 mm, indicating the presence
of moderately strong absorbing aerosols.

The hazemeter retrievals at 0.66 um are slightly lower than those at 0.47um. → More variable surface reflectances are likely the major
cause of the discrepancies.



Annual mean SSA distribution Map



Calculation of Aerosol Radiative Forcing and Heating Rate

Input data for SBDART(Ricchiazzi, 1998);

<Aerosol model>

- **All AOTs and Angstrom exponents from Hazemeter (36,731 cases).**
- **Monthly mean SSAs from Lee et al. [2007].**
- **Spectral aerosol optical properties by Mie theory calculation.**
- **Extinction by different RH condition has been considered. Surface RH data for each station are from NCEP/NCAR reanalysis.**
- **Aerosol extinction profile from MPL (for Heating profile only)**

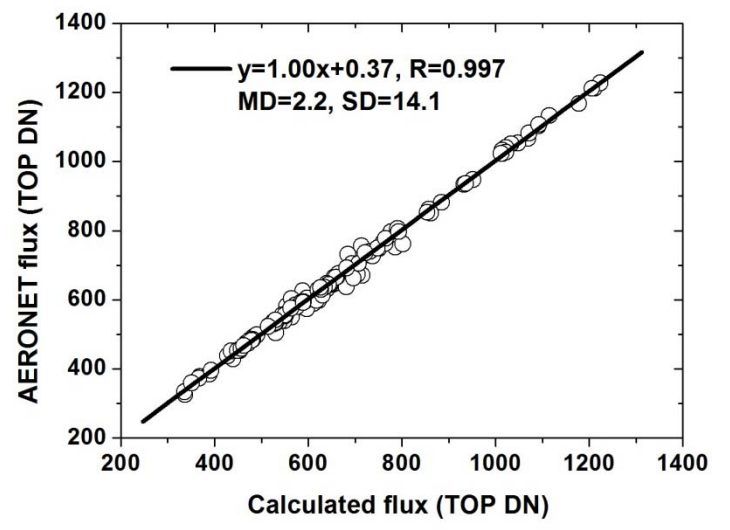
<Atmosphere model>

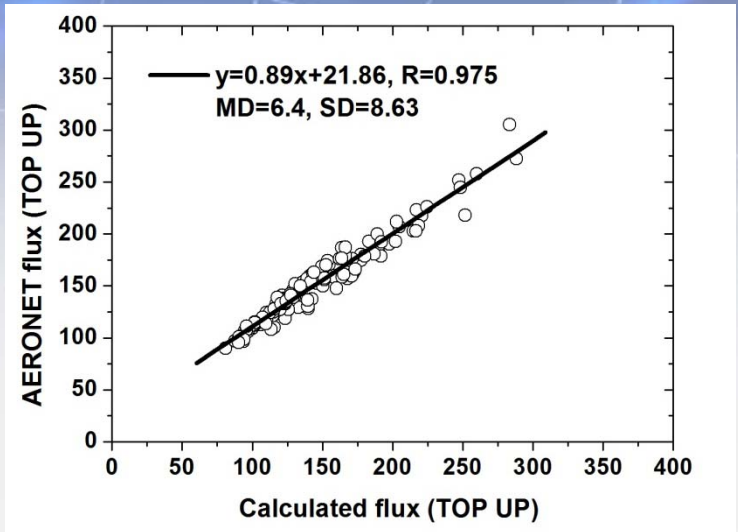
- **Atmospheric profile from NCEP/NCAR reanalysis**
- **Ozone concentration from OMI.**

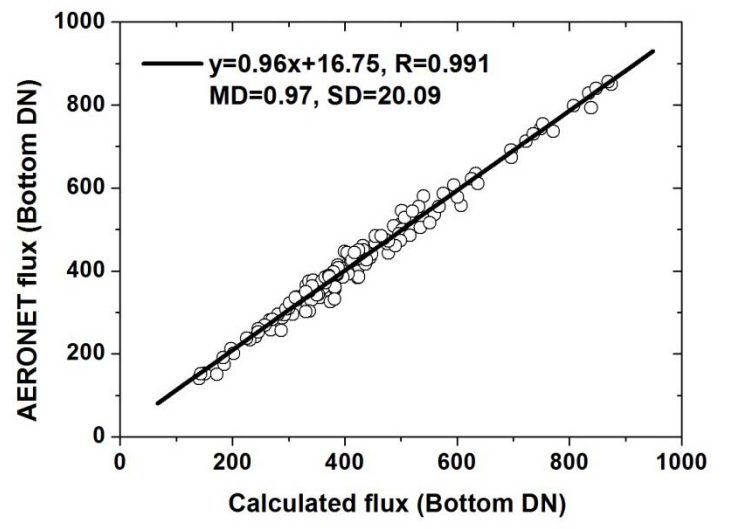
<Surface model>

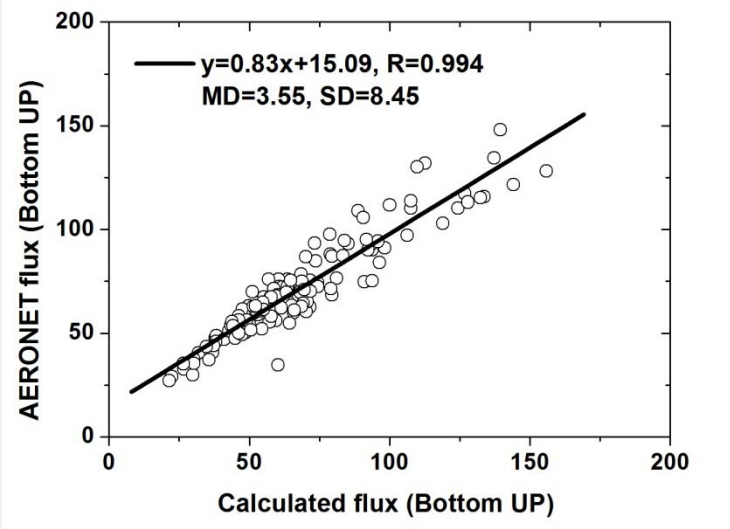
- **MODIS spectral surface reflectance products (MOD09)**

Modeled & AERONET Flux

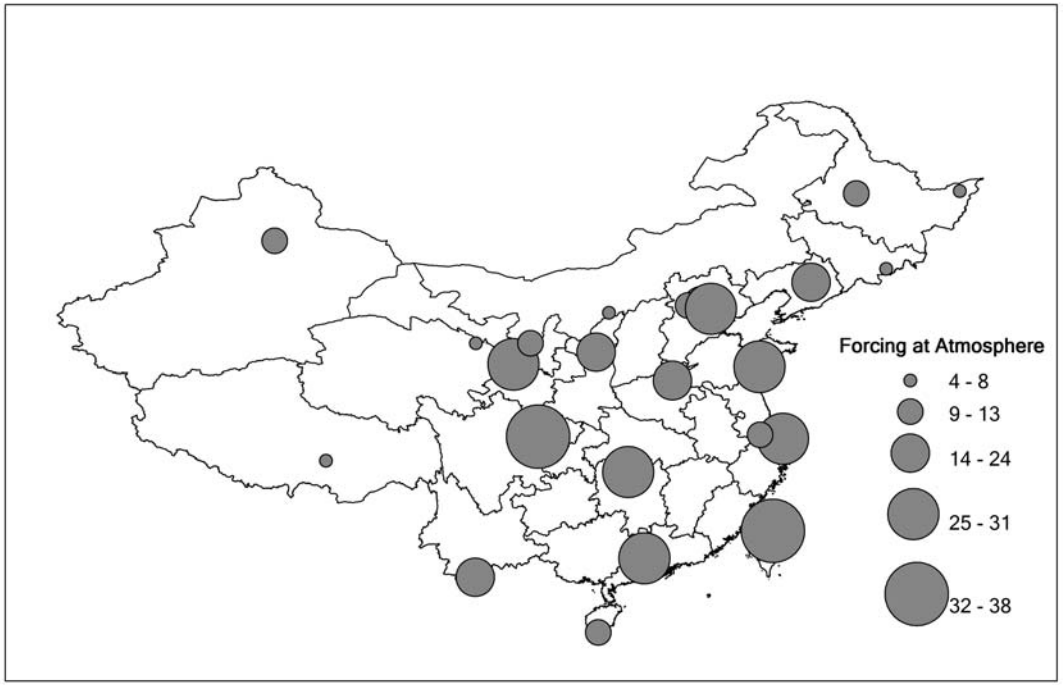


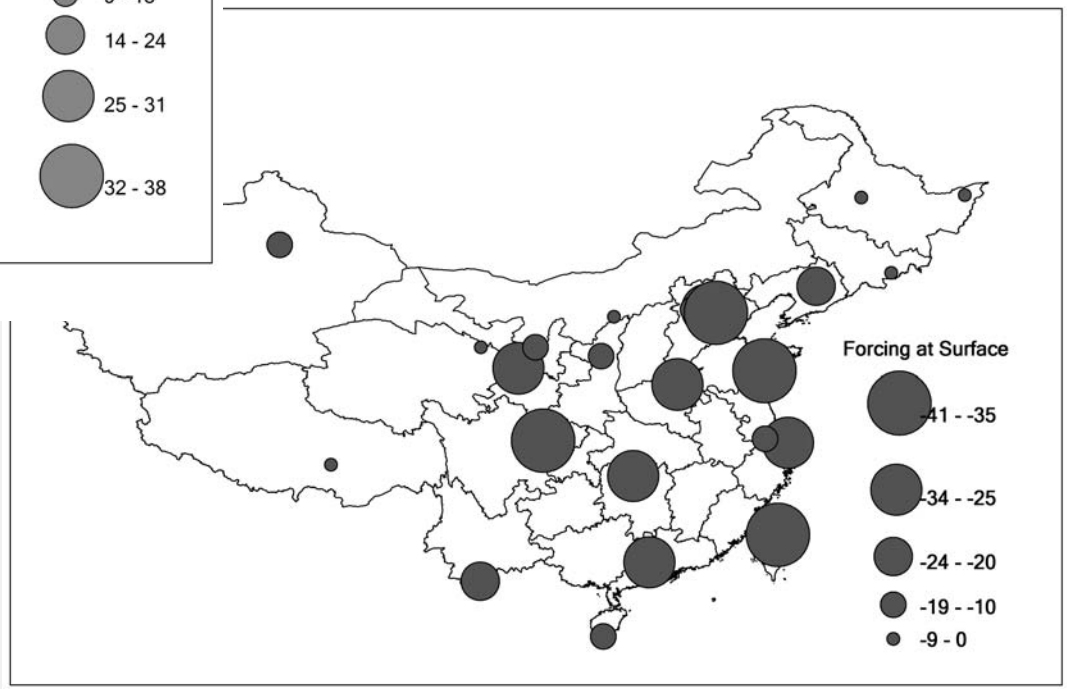






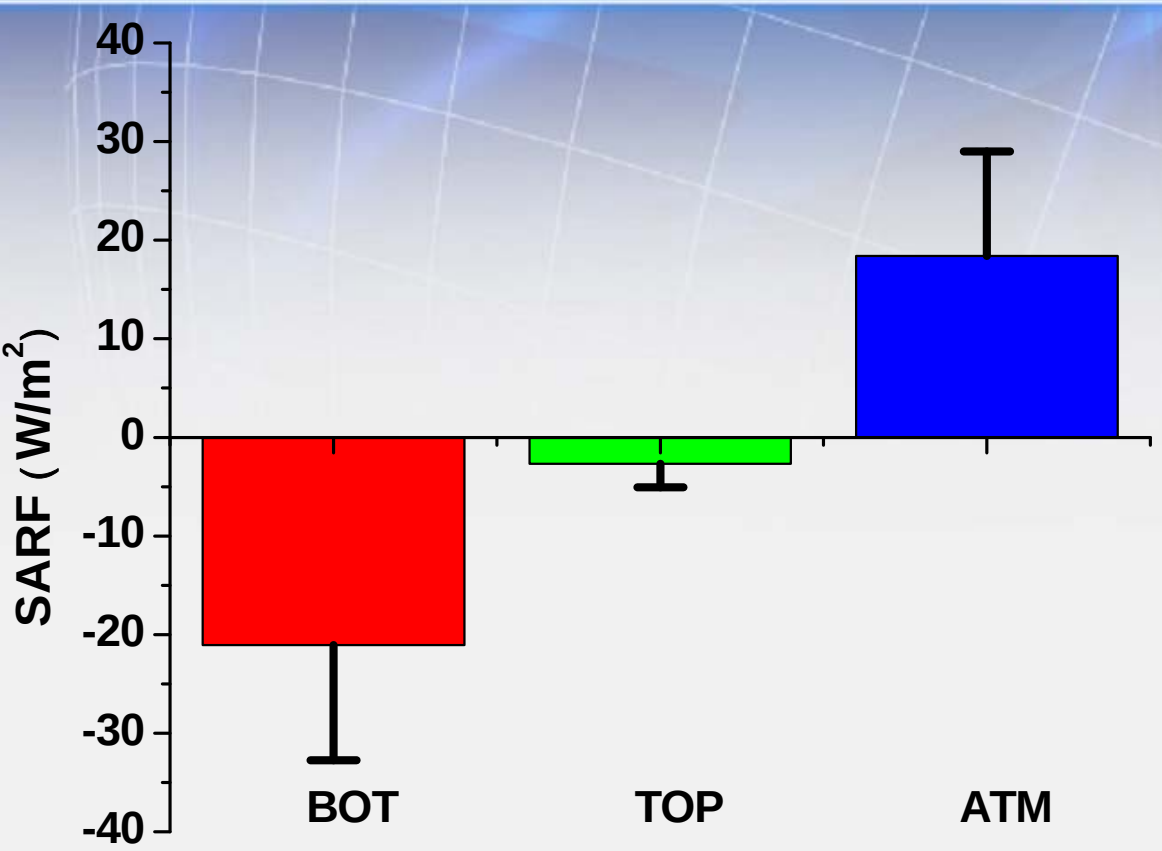
Aerosol Radiative Forcing





large negative SARF in the ran ge of -30~-40 W/m^2 at the surface and 25~38W/m^2 at the atmosphere in eastern China.

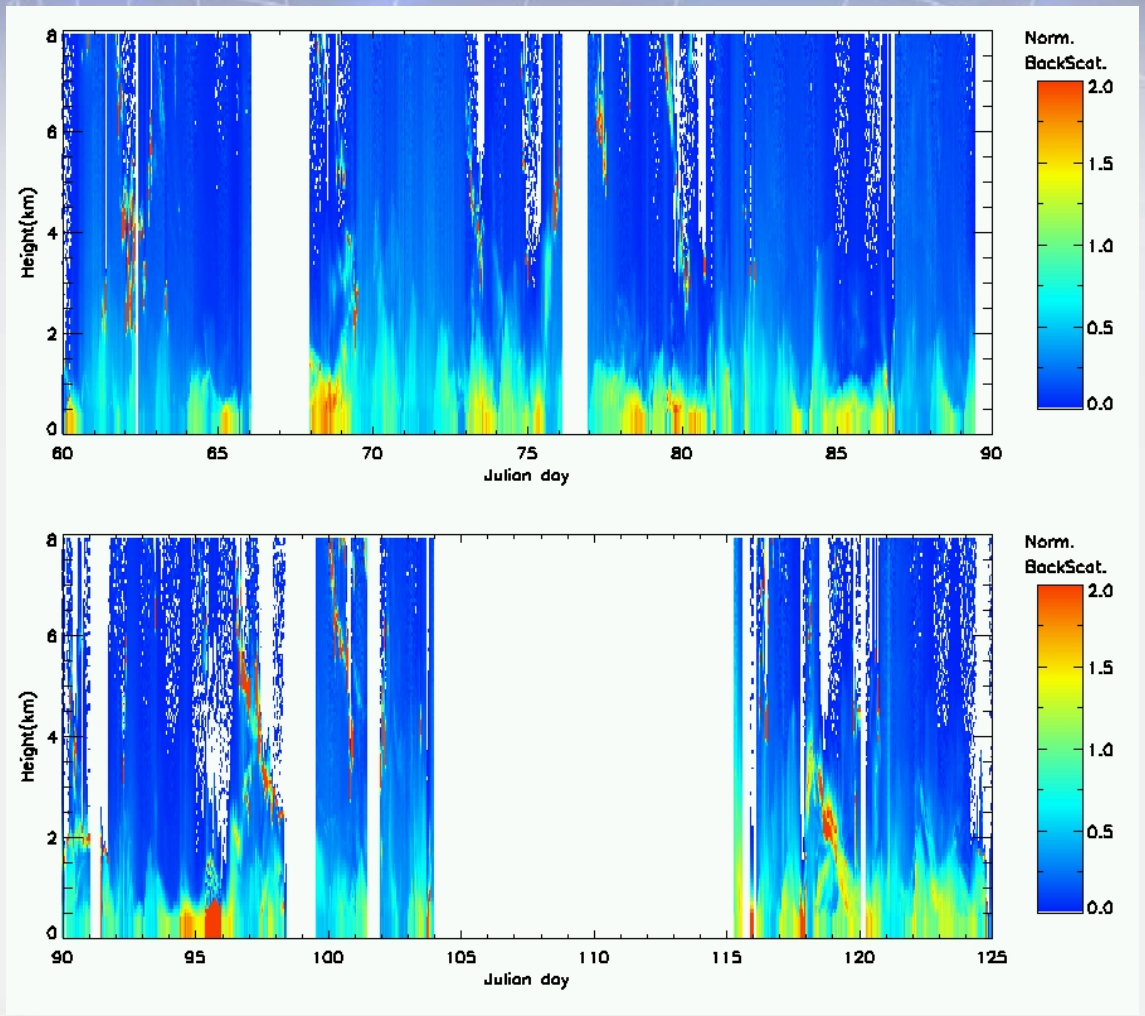
National Mean Aerosol Radiative Forcing



- The national mean annual SARF values are -21.1±11.6 (surface), -2.7±2.4 (TOA), and 18.4±10.6 (atmosphere), respectively.
- So does 87.2% of surface SARF according to the aerosol absorption in the atmosphere.

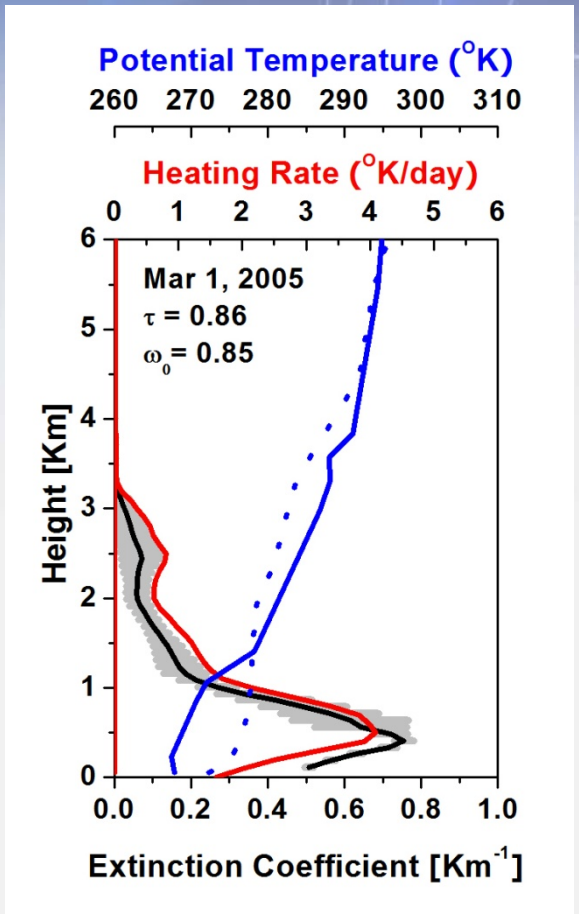
Micro Pulse LIDAR

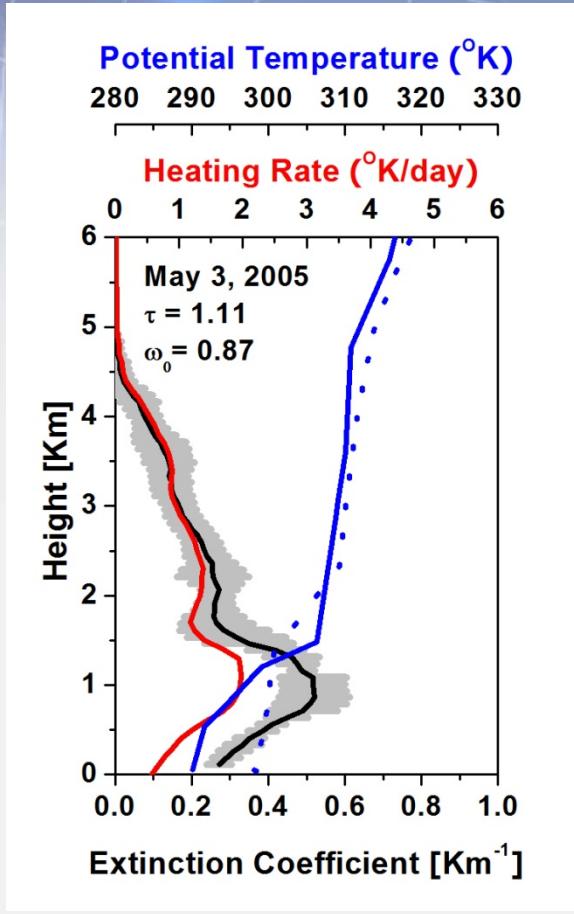
Co-Located at Xiang He AERONET site (39º 45.233' N, 116º 57.716' E, Elevation: 0.035 km asl)

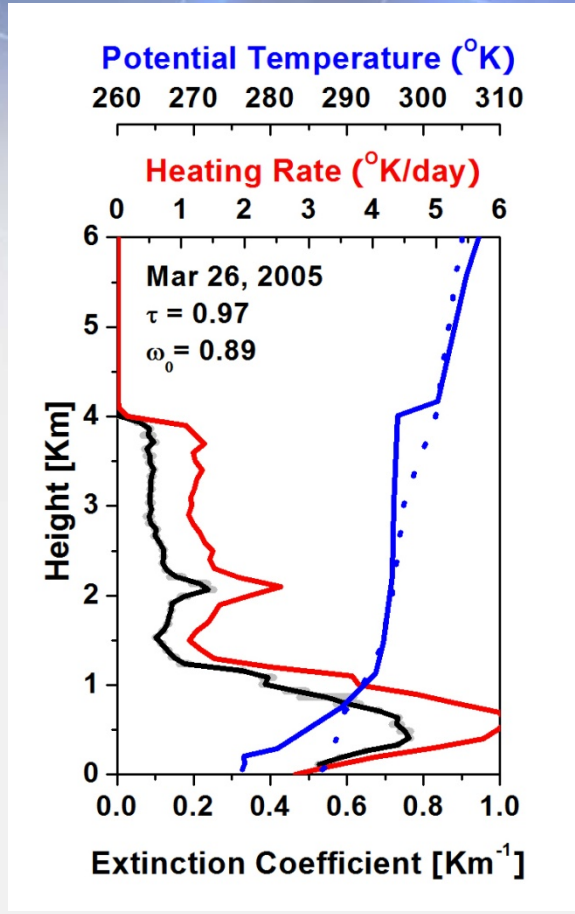


Temporal variations of the normalized relative backscatter signal profiles from MPL level 1.0 data.

Heating Rates

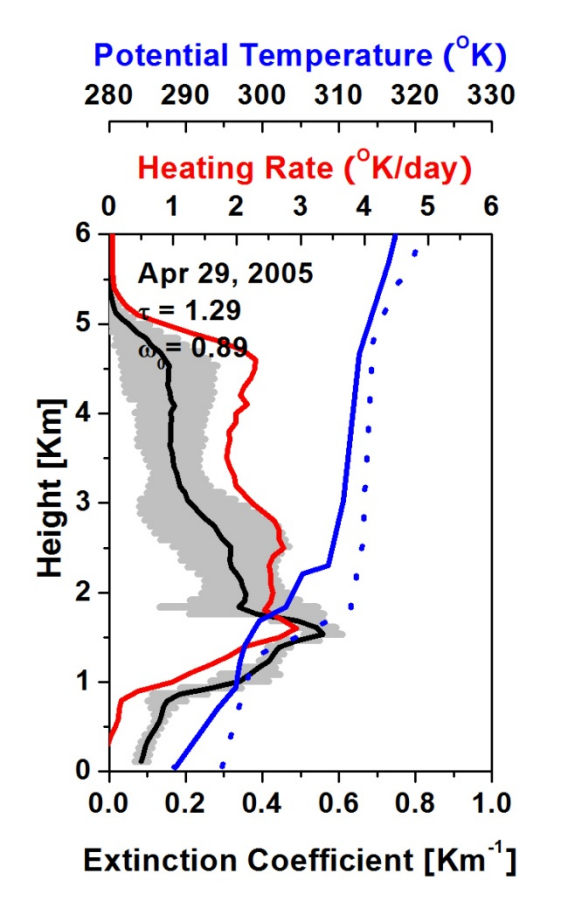


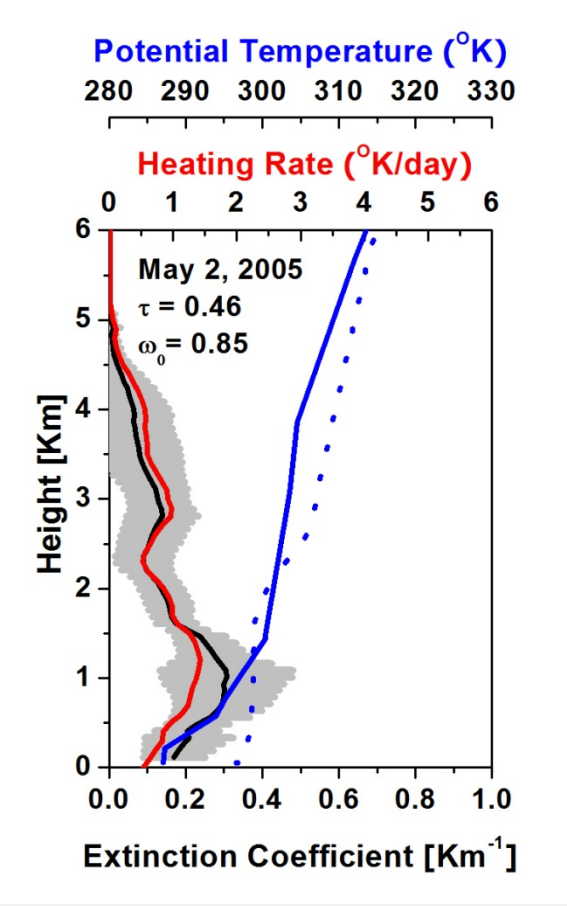


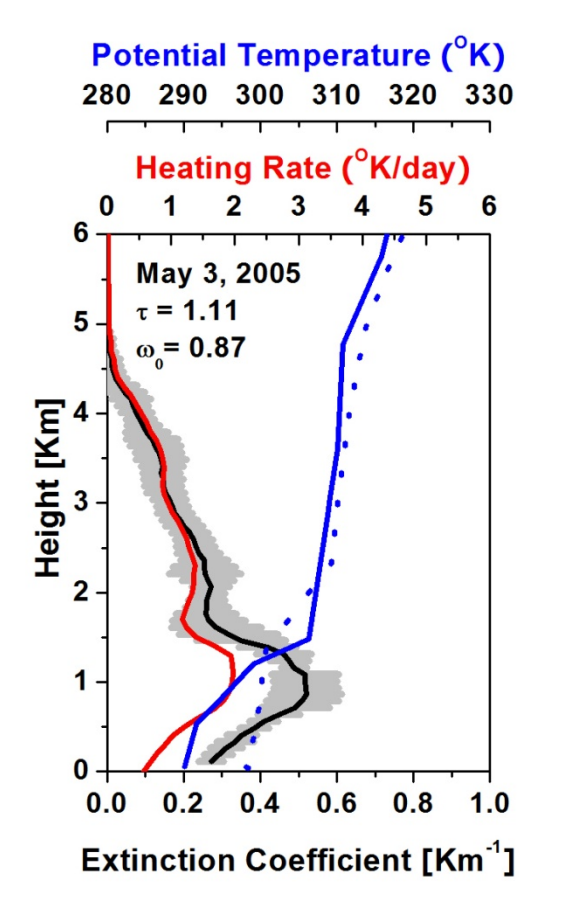


- A steep increase in the potential temperature in the upper region of the aerosol layer was found.

Heating Rates







- This increased static stability in the layer is due to the radiative heating of enhanced absorbing aerosol.

Summary

- A new method is proposed to retrieve SSA from a combination of ground based transmittance and spaceborne TOA reflectance for high-turbidity conditions (AOT > 0.4).
- The unprecedented AOD and SSA datasets allow to determine aerosol radiative effects across China for the first time.
- The solar aerosol radiative forcing (SARF) and heating rate by absorbing aerosols over China is estimated during measurements made under the EAST-AIRE campaign in 2005.
- Aerosols in the region exert a very strong cooling effect at surface and warming in the atmosphere, but little effect at the top of the atmosphere.
- Further investigation is needed to validate the dataset using other in situ, surface and airborne measurements, and to study the climatic effects of these aerosols.

Further reading

Lee, K. H. et. al. (2007), Aerosol single scattering albedo retrieval using ground-based and satellite observation data, *J. of Geophys. Res*., 112, D22S15, doi:10.1029/2007JD009077

Li, Z., et al. (2007), Preface to special section on East Asian Studies of Tropospheric Aerosols: An International Regional Experiment (EAST-AIRE), *J. Geophys. Res.*, *112*, D22S00, doi:10.1029/2007JD008853.