Ten-Year Aerosol Optical Depth Mapping from Remotely-Sensed Data over Land Surface in China

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Outline

- Introduction
- Methods
- Study area and Results
- Discussion
- Conclusion

Introduction

- During the last century, the Earth's surface temperature increased by 0.6 °C, reaching the highest levels in the last millennium.
- Climate is a reflection of our current atmosphere – including its greenhouse gases and aerosols - it is the changes in these components which will lead to climate change.
- Aerosol affects climate by scattering and absorbing radiation (the "direct effect") and by modifying amounts and microphysical and radiative properties of clouds (the "indirect effects")

Introduction

- To evaluate the effects of aerosols on climate it is necessary to estimate their spatial and temporal distributions. The only way to achieve an on-going aerosol global coverage is by satellite observation.
- Determination of aerosol optical depth from satellite remote sensing measurements is extremely complicated.
  - **"Satellite retrieved Aerosol Optical Depth (AOD) Error > 0.05 (in China region can reach to 0.2).**
  - **Accurate climate assessment need the error with in 0.01 (Mishchenko et al., 2007)"**

Methods

Xue, Y. and Cracknell, A. P., 1995, Operational Bi-Angle Approach to Retrieve the Earth Surface Albedo from AVHRR data in the Visible Band. *International Journal of Remote Sensing*, 16(3), 417-429.

$$\frac{\cos\theta'}{\rho}\frac{\delta I^{\lambda}(z,r)}{dz}=\frac{\sigma_{\lambda}}{4\pi}\int I^{\lambda}(z,r)\gamma^{\lambda}(z,r',r)d\omega'-(k_{\lambda}+\sigma_{\lambda})I^{\lambda}(z,r)$$

two-stream approximation

$$\frac{1}{\rho}\frac{dF_1}{dz}=2kB-m_1(k+\sigma\Gamma_1)F_1+m_2\sigma\Gamma_2F_2 \qquad \textit{upgoing}$$

$$\frac{1}{\rho}\frac{dF_2}{dz}=-2kB-m_1\sigma\Gamma_1F_1+m_2(k+\sigma\Gamma_2)F_2 \qquad \textit{down coming}$$

boundary conditions

$$A=\frac{(A'b-a)+a(1-A')e^{(a-b)\varepsilon\tau_0^{\lambda}\sec\theta'}}{(A'b-a)+b(1-A')e^{(a-b)\varepsilon\tau_0^{\lambda}\sec\theta'}}$$

Methods

j=1,2, respectively stand for the observation of TERRA-MOIDS and AQUA-MODIS; i=1,2,3, respectively stand for three visible spectral bands of central wavelength of 0.47 μm, 0.55 μm, 0.66 μm

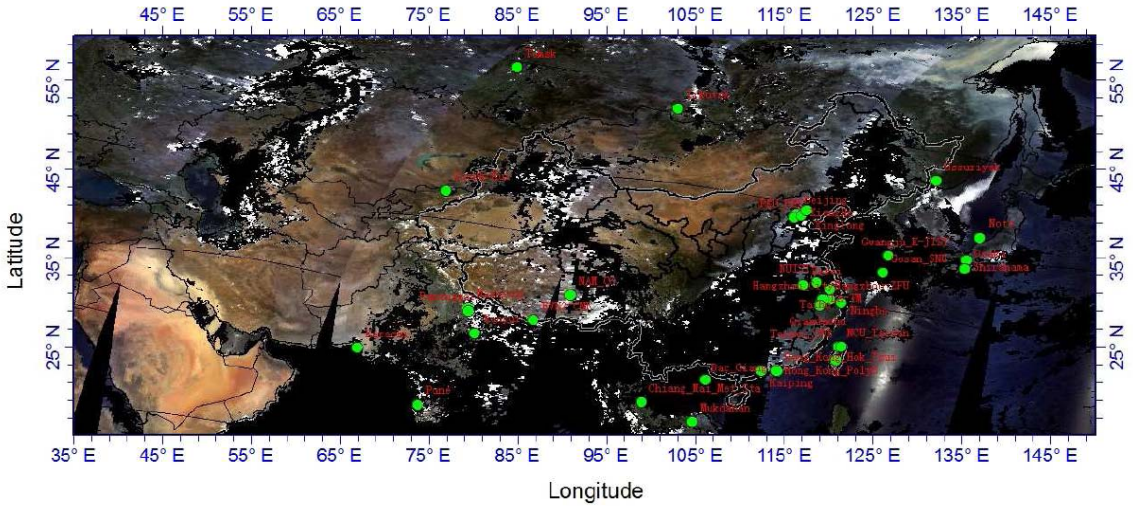
$$A_{j,\lambda_i} = \frac{(A'_{j,\lambda_i} b - a_j) + a_j (1 - A'_{j,\lambda_i}) e^{(a_j - b)\varepsilon(0.00879\lambda_i^{-4.09} + \beta_j \lambda_i^{-\alpha})\sec\theta'_j}}{(A'_{j,\lambda_i} b - a_j) + b(1 - A'_{j,\lambda_i}) e^{(a_j - b)\varepsilon(0.00879\lambda_i^{-4.09} + \beta_j \lambda_i^{-\alpha})\sec\theta'_j}}$$

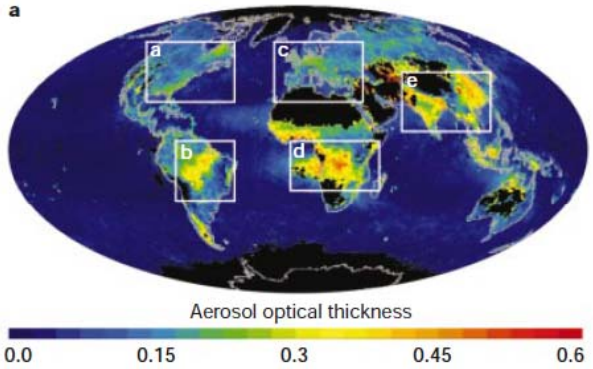
Symbol	Description
A	The Earth's surface reflectance
A'	The Earth's system reflectance (apparent reflectance observed from space)
ε	Backscattering coefficient
θ	Solar zenith angle
θ'	Zenith angle of the sensor
λ	Wavelength

$$\tau_A^{\lambda}(\infty) = \beta\lambda^{-\alpha}$$

$$K_{\lambda_i} = A_{1,\lambda_i} / A_{2,\lambda_i} = K_{\lambda=2.13\mu m}$$

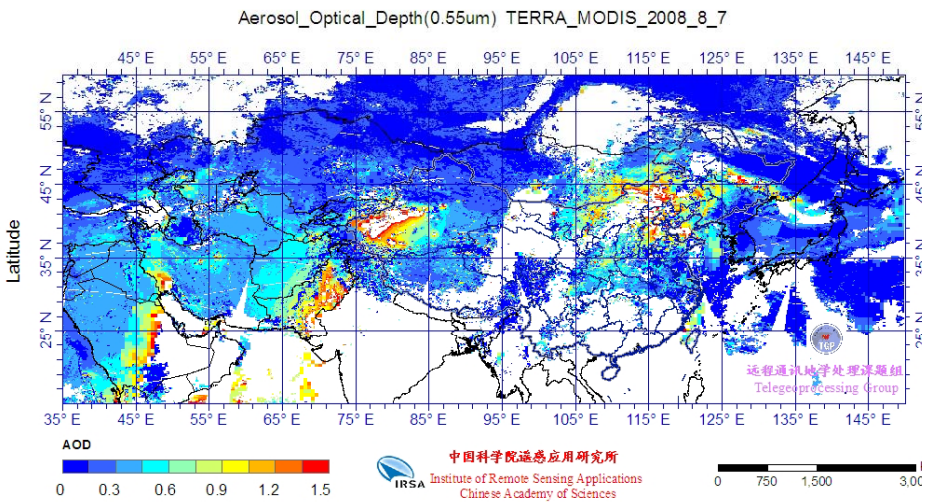
Study Area



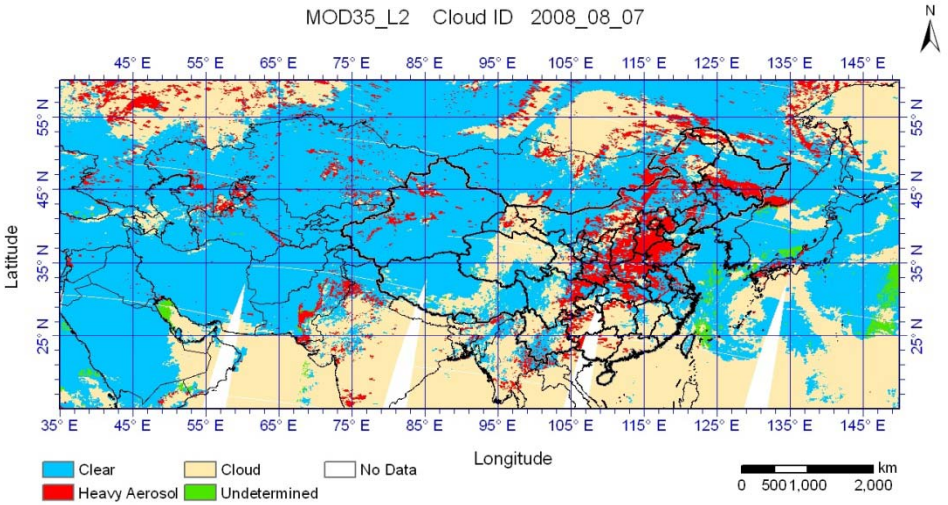


Selected 38 AERONET stations in Asian area and their location (latitude and longitude) for our aerosol retrieval validation.

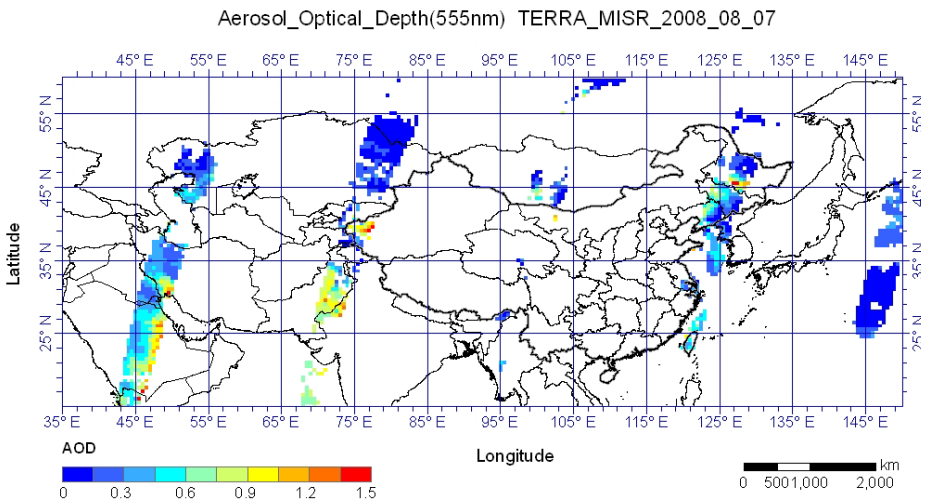
In China, the open burning of agriculture waste is a common practice. As a large agricultural country, China leads the world in the yield of straw and crop residues. Aerosol particles from agricultural biomass burning (ABB) in northern China have a significant impact on global air quality.



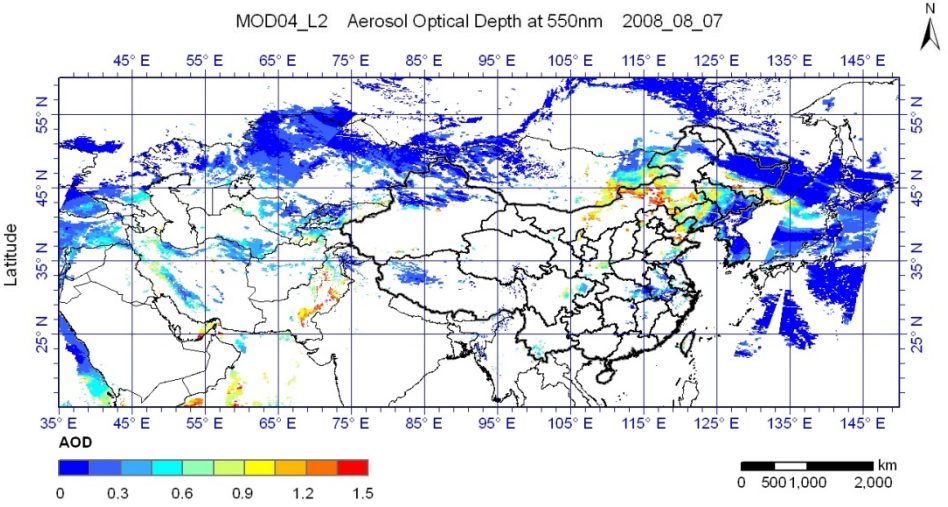
AOD Map from TERRA/MODIS data using SYNTAM algorithm at 10KM spatial resolution



TERRA/MODIS Cloud Mask Map



AOD Map from TERRA/MISR data at 50KM spatial resolution



AOD Map from TERRA/MODIS data with DDV algorithm at 10KM spatial resolution

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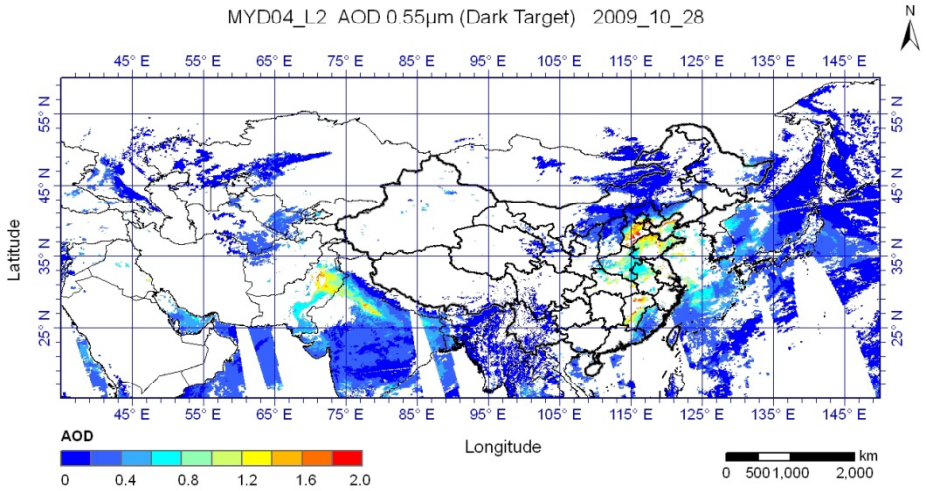
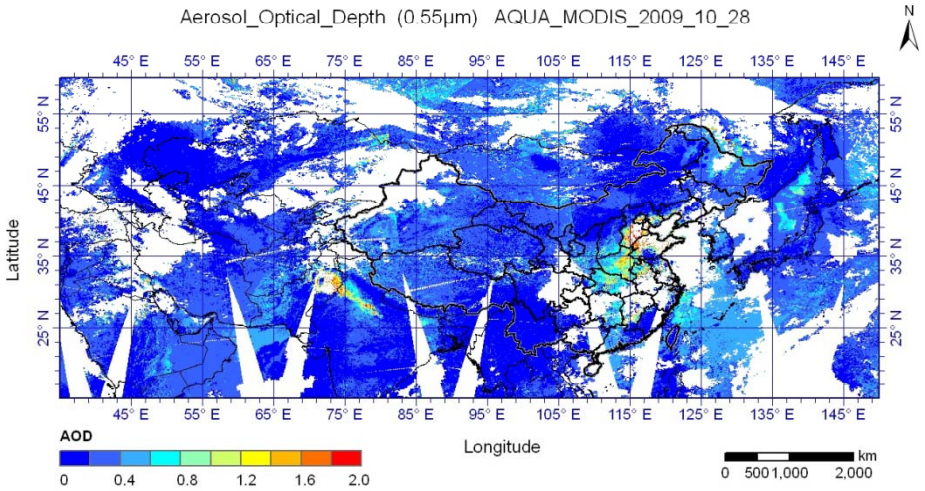
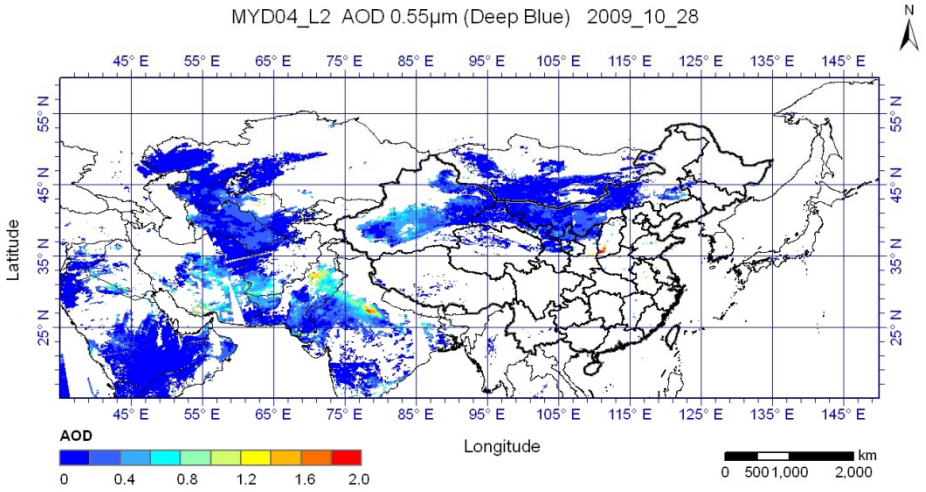
Comparisons of various AOD Datasets



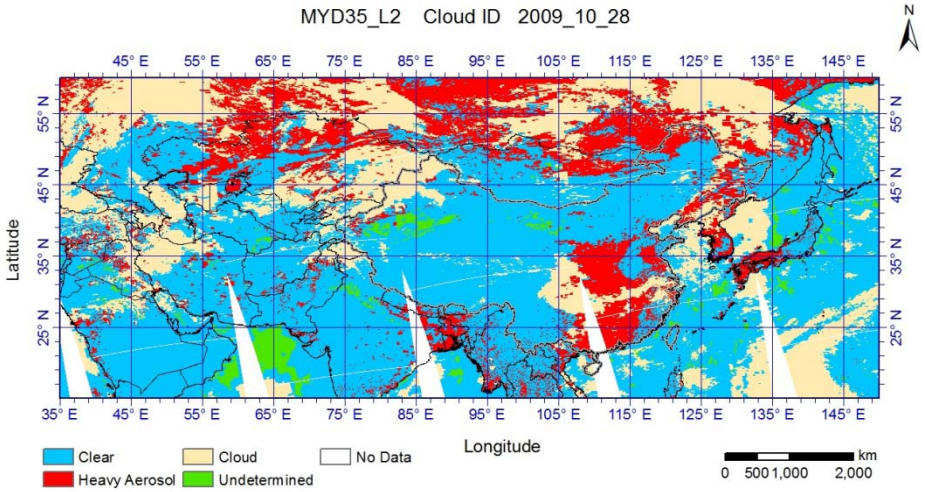
AOD Map from MODIS by DDV algorithm



AOD Map from MODIS by SYNTAM algorithm



AOD Map from MODIS by DeepBlue Algorithm



Cloud Mask Map from MODIS

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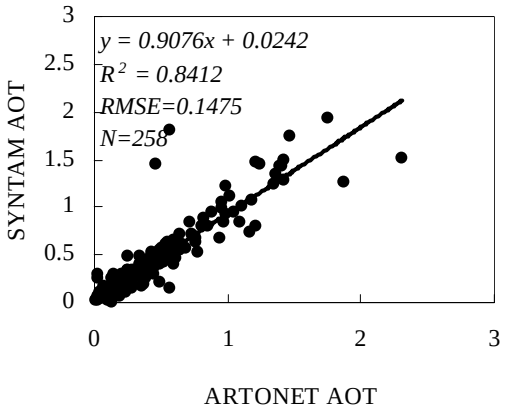
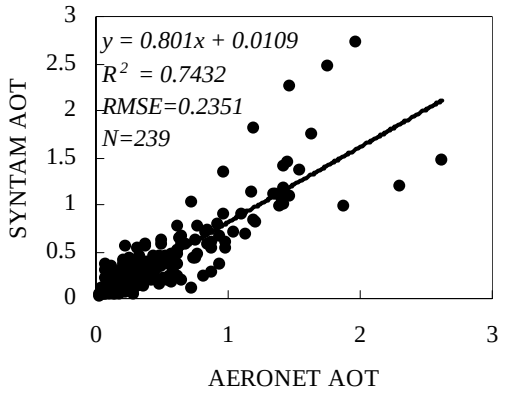
Validations with different window sizes

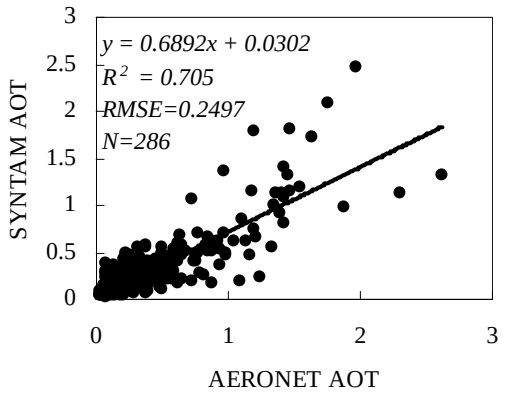
Terra AOT-10*10Km



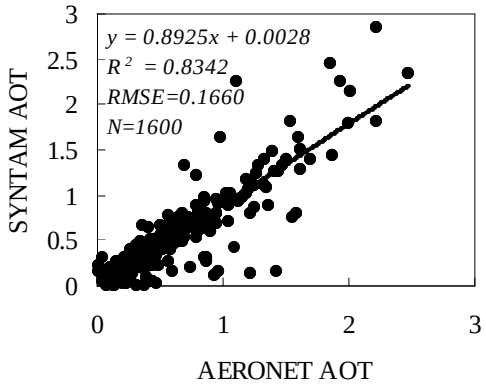
Terra AOT-30*30Km



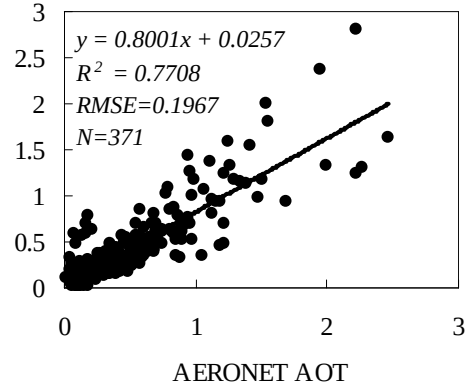
Terra AOT-50*50Km



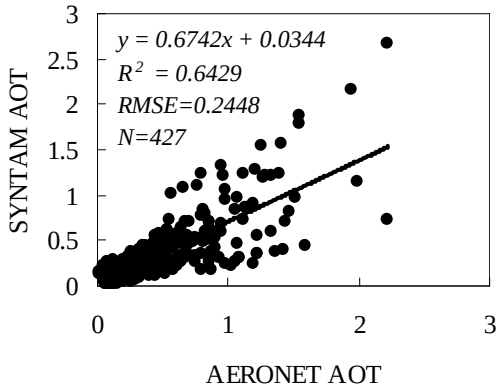
Aqua AOT-10*10Km



Aqua AOT-30*30Km



Aqua AOT-50*50Km



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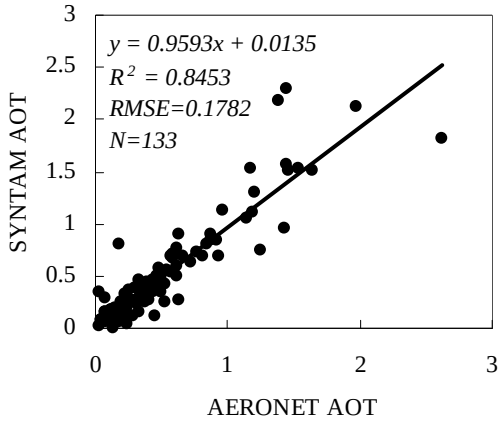
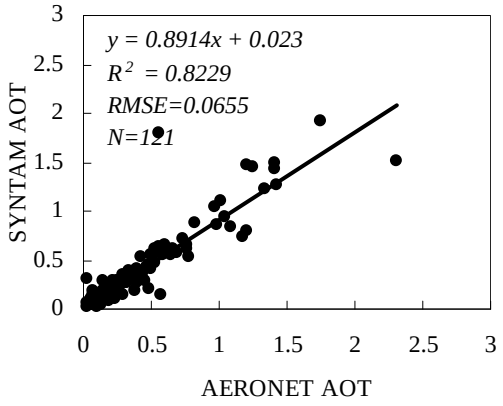
Validations at different wavelength

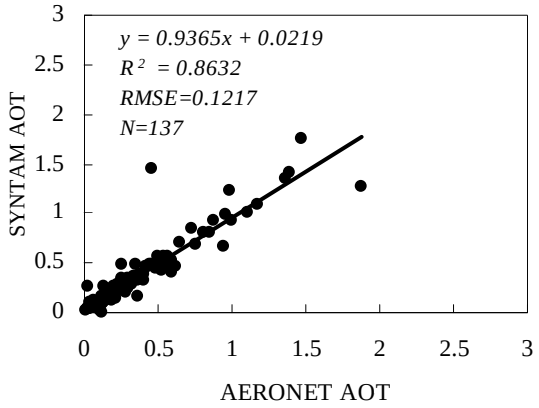
Terra AOT-470nm



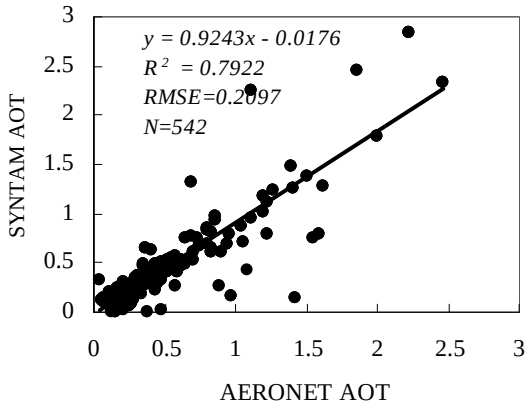
Terra AOT_550nm



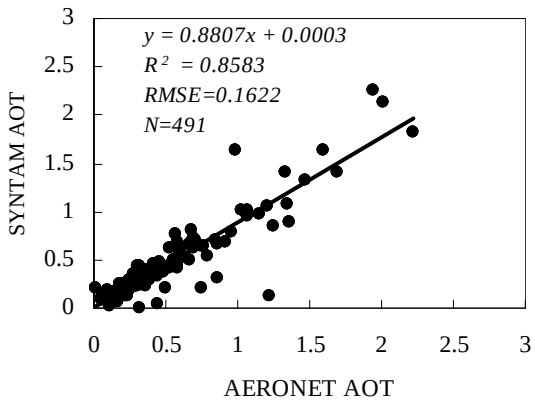
Terra AOT_660nm



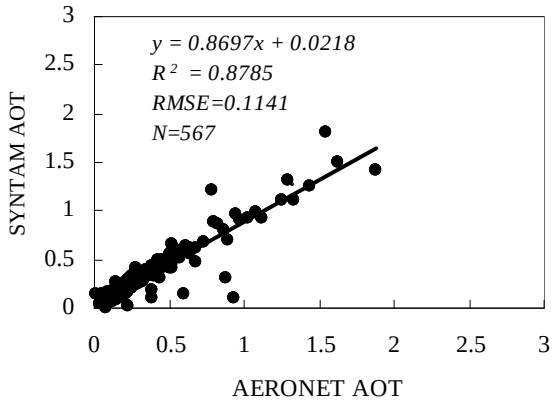
Aqua AOT_470nm



Aqua AOT_550nm



Aqua AOT-660nm



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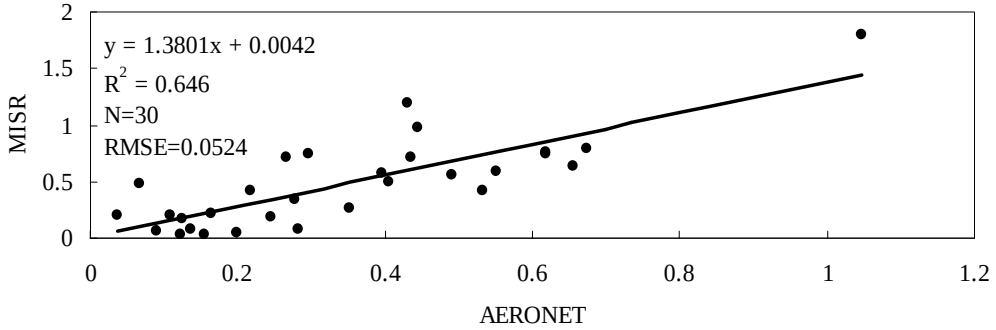
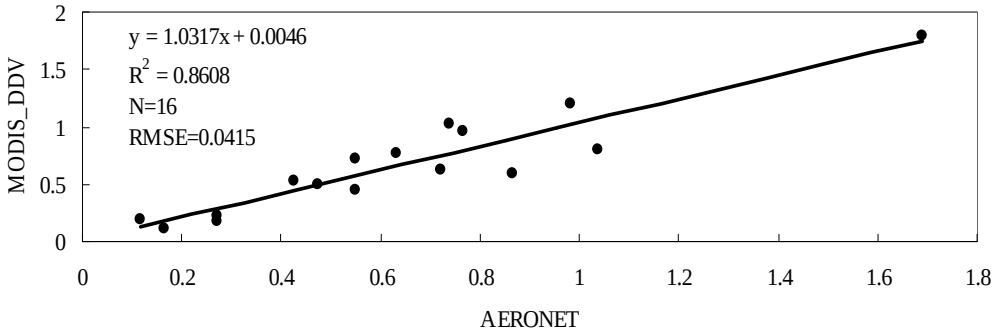
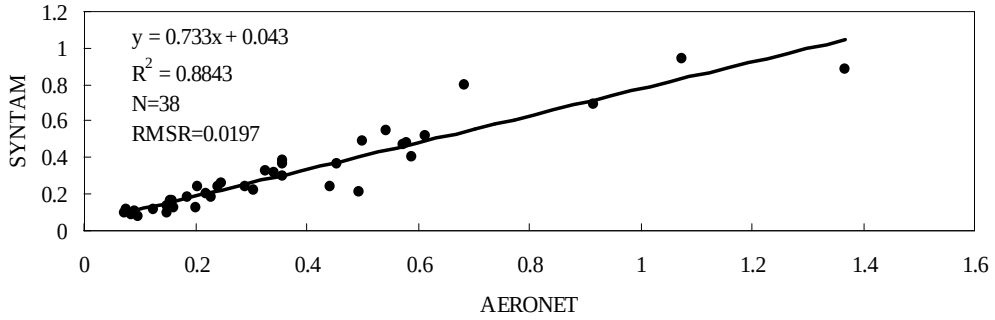
Cross Validations



MISR AOD Products (August, 2008)

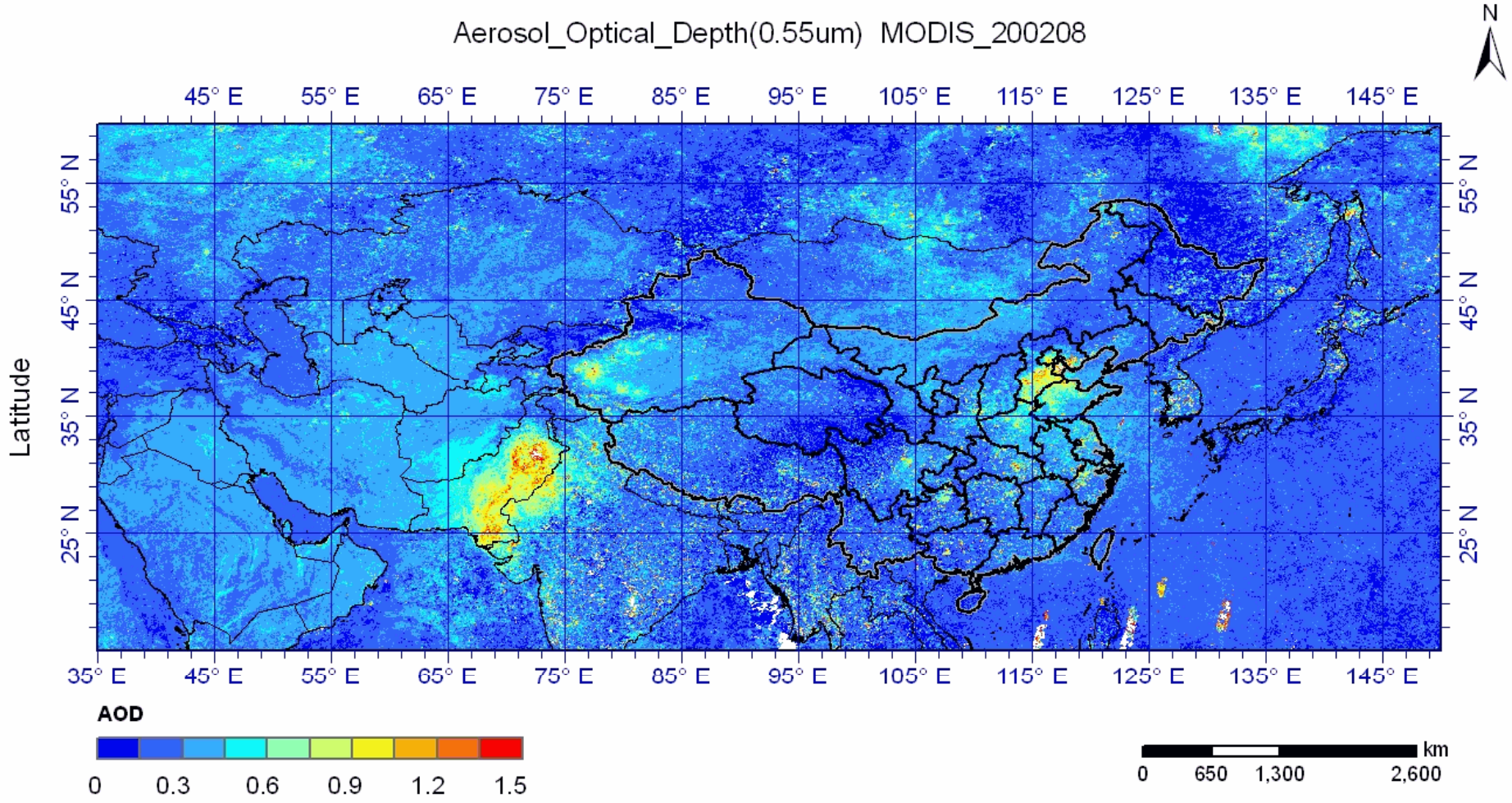


MODIS/DDV APD Products (August, 2008)



MODIS/SYNTAM AOD Products (August, 2008)

Monthly Averaged AOD Datasets



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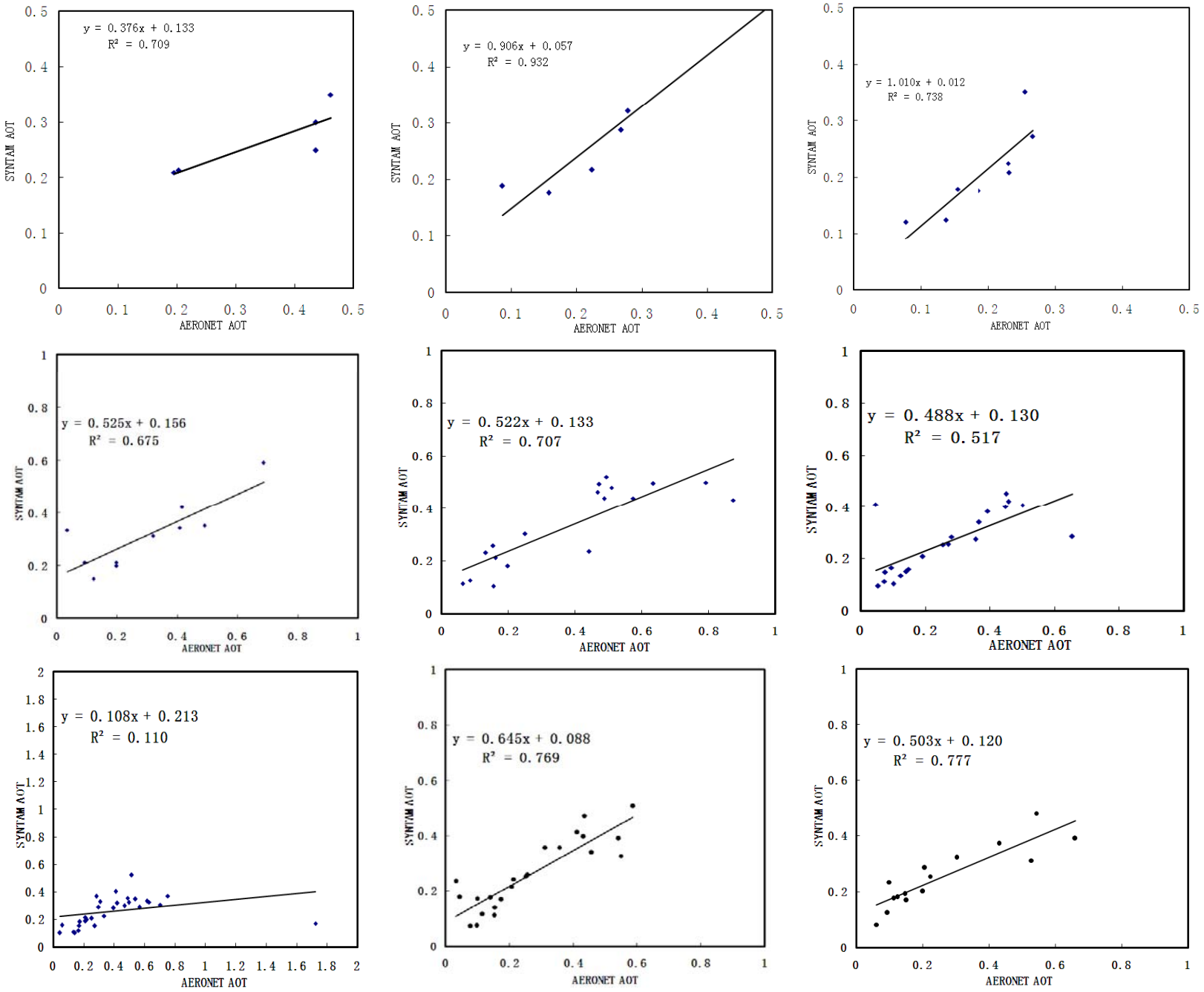
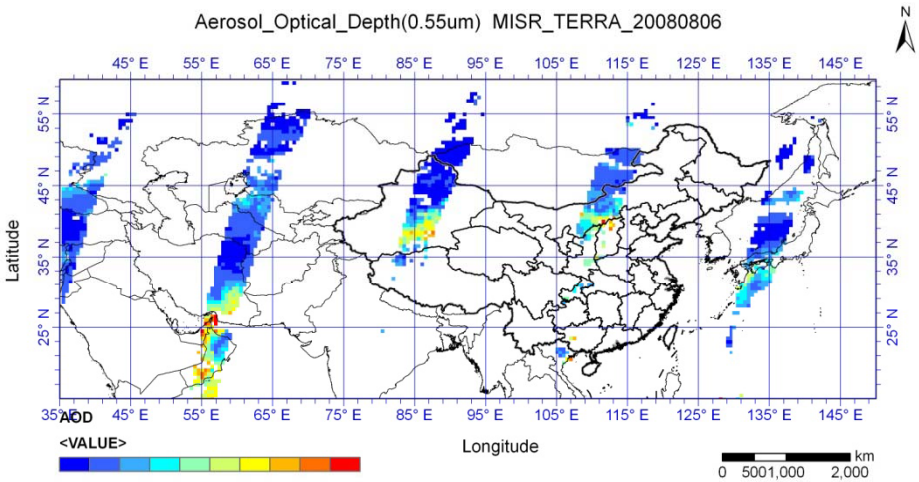
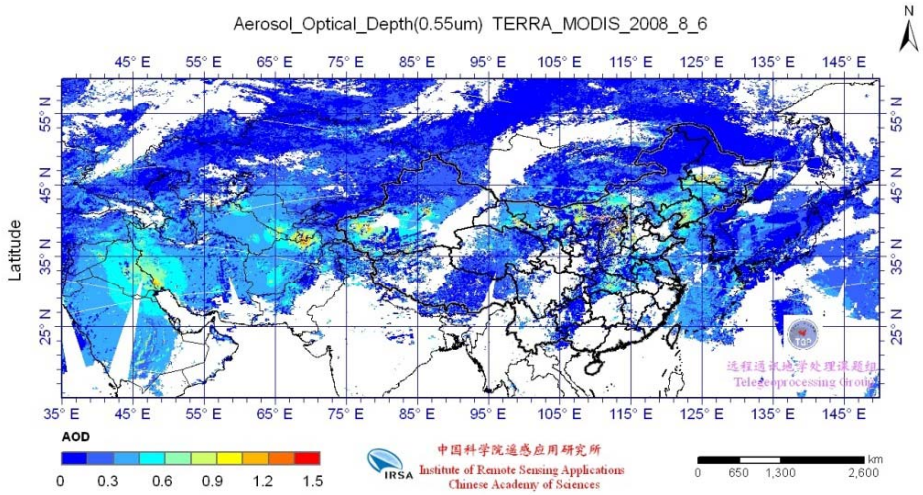
Validations



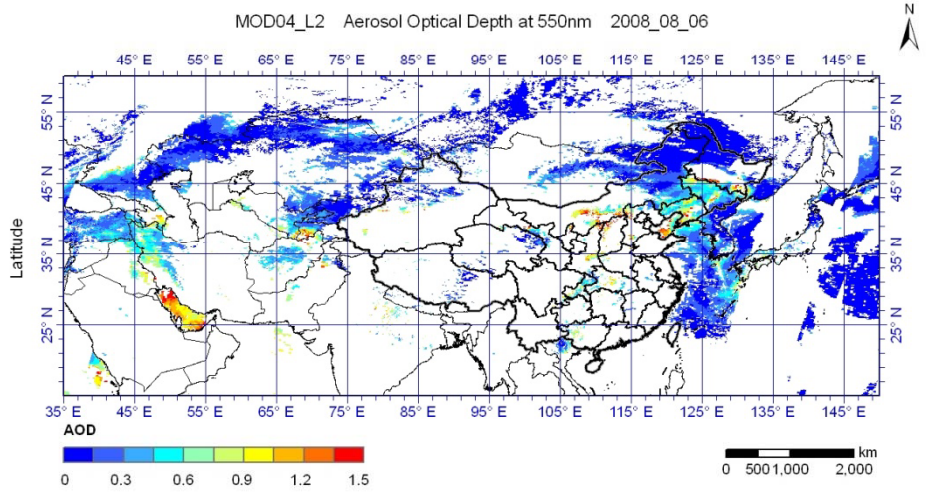
Comparisons of monthly SYNTAM AOD and AERONET AOD (10km) in Asian area in August from 2002 to 2010



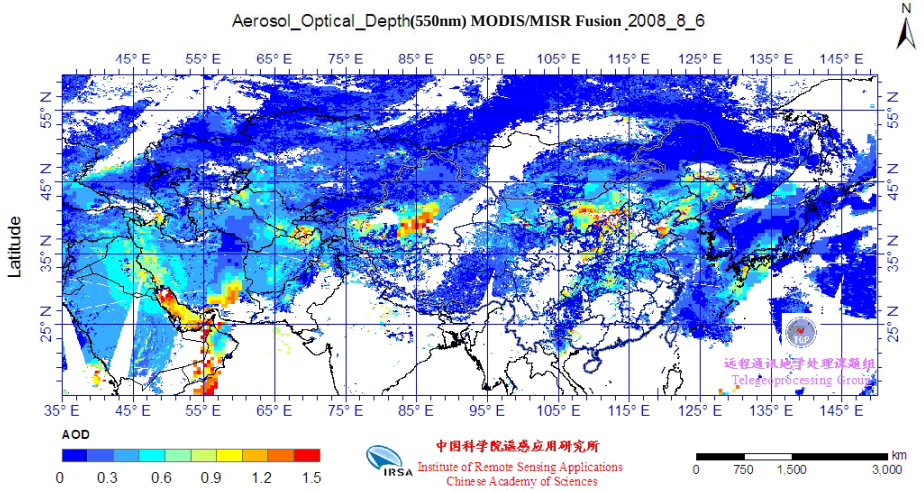
MISR AOD Map



AOD by SYNTAM from MODIS



MODIS AOD Map (MOD04)



Consistent AOD by fusion of MISR, DDV and SYNTAM AOD Maps

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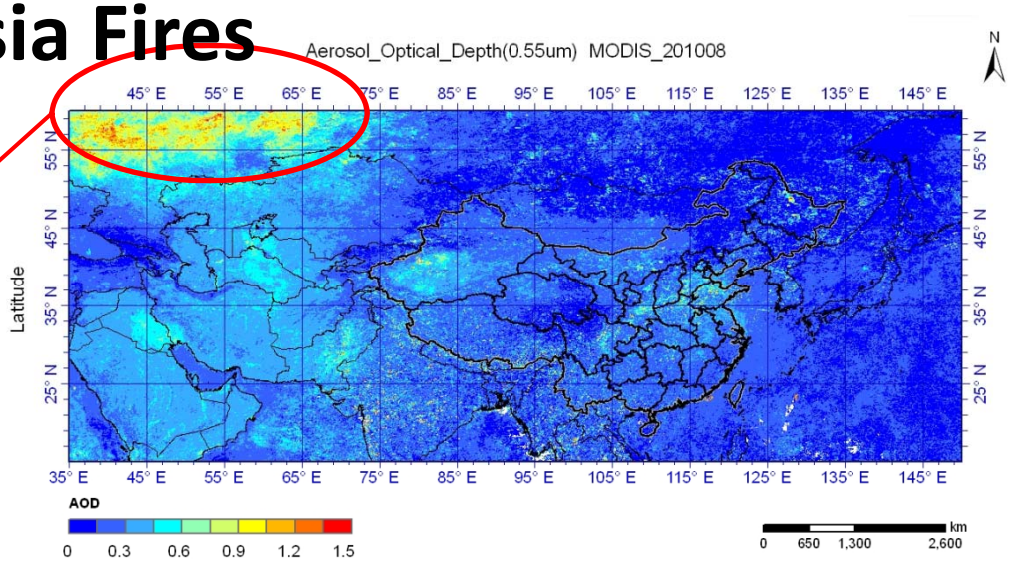
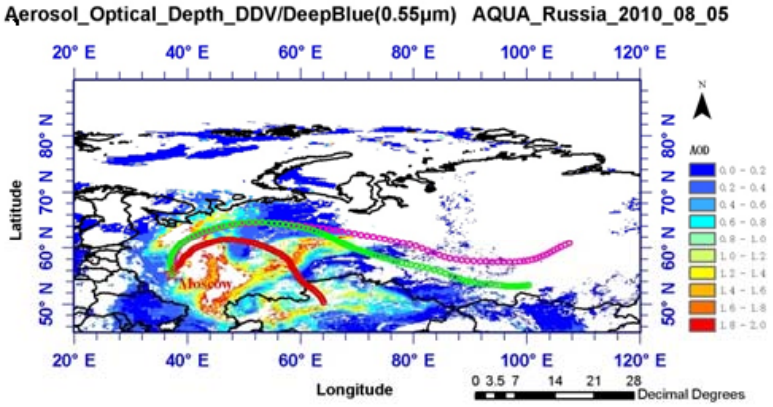
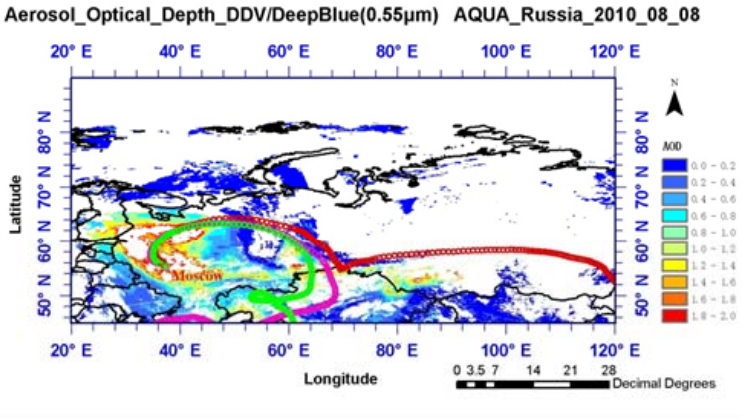
Applications

Russia Fires







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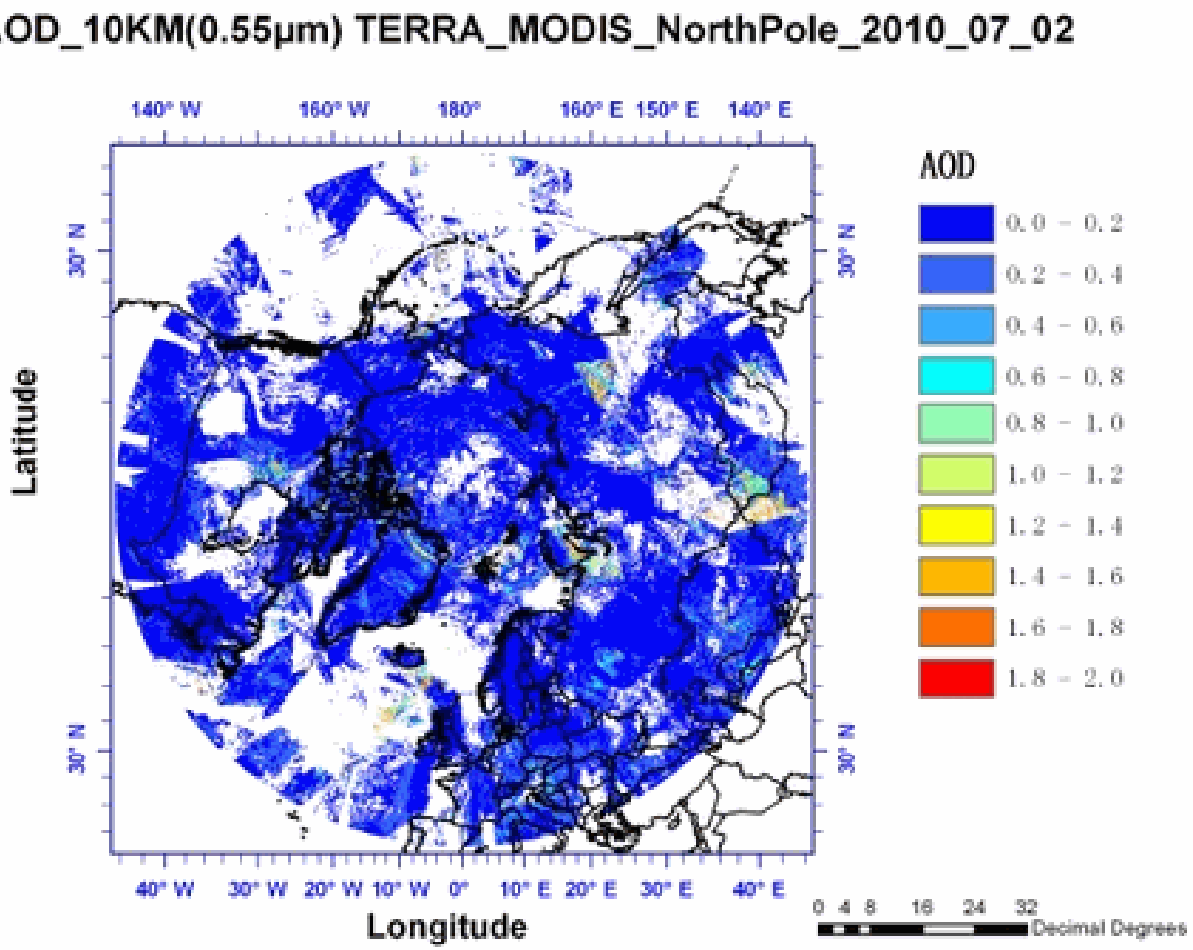
Conclusion

- Fused with the national aerosol measurement network data, the ten-year national AOT maps at 10km and 1km resolutions have been produced on the daily base. The results agreed with AERONET in situ measurement very well with averaged relative error less than 15%.
- This national climate aerosol optical thickness data will be useful for the research of regional response to the global climate change.

Aerosol Optical Depth in Arctic



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Thank you

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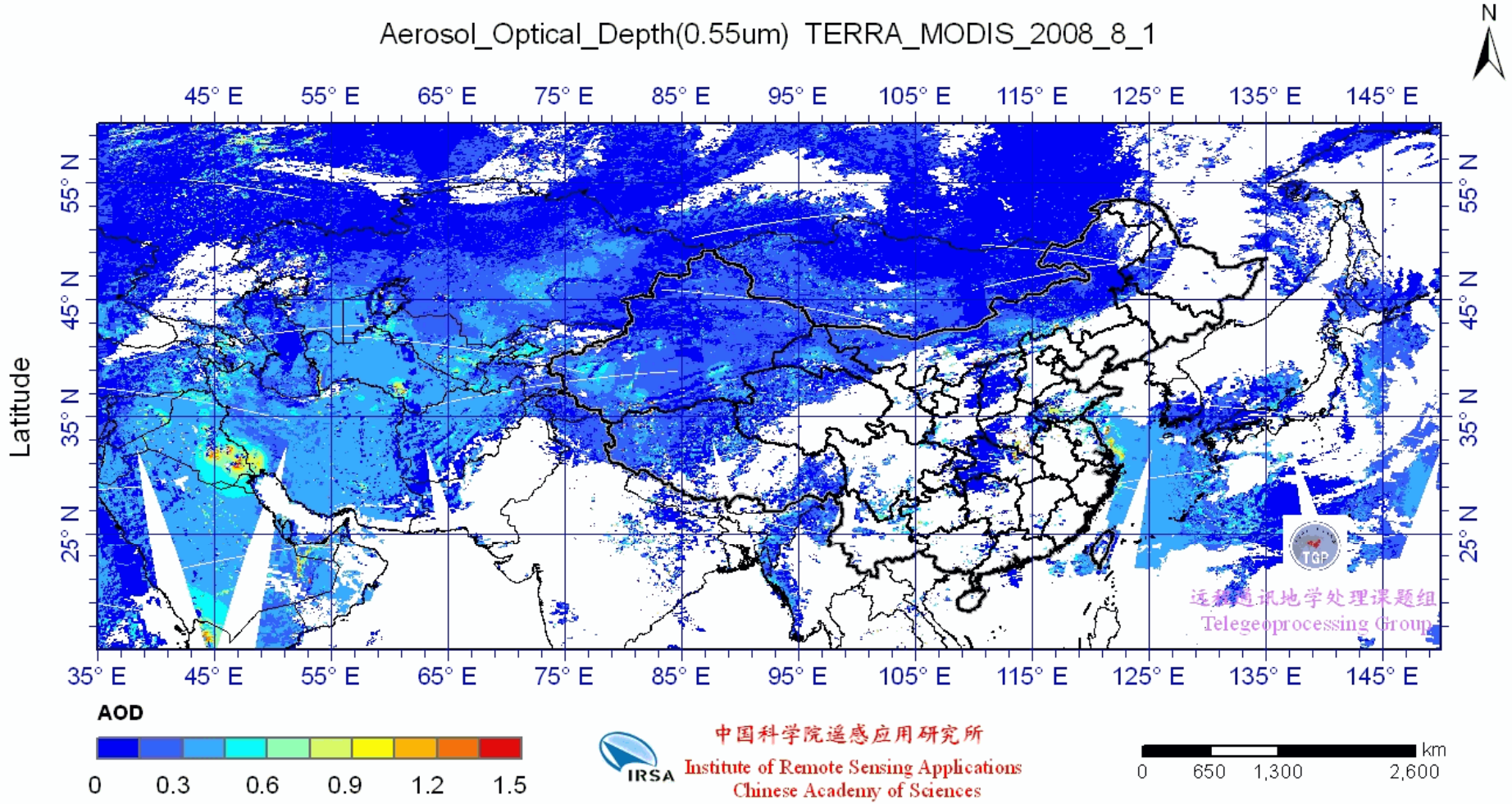
Web: www.tgp.ac.cn



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