中国科学院对地观测
与数字地球科学中心

ABCC Workshop
—— Aerosol Study

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Contents

- Aerosol Optical Retrieval over Land
  - China Collection 1.1: an AOD dataset at 1km resolution over mainland China retrieved from satellite data
  - Multi-spatial and multi-temporal AOD Data from Earth Observation
- AODs for Sao Paulo, Toronto, Sydney and Beijing
- Phase II …?

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Work Package 3: Study of aerosol distribution change over various land surface from satellite data

- Synergetic AOD retrieval from multi-resource satellite data: Algorithm and Validation

- Comparative Study of AOD Spatial and Temporal Change with different geographic, social and economic conditions because of the global change (Four Metropolitan Regions)
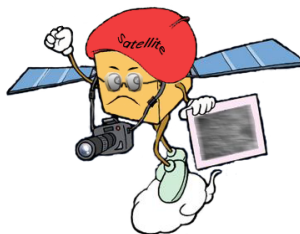

Beijing China

Toronto Canada

Sydney Australia

Sao Paulo Brazil

Aerosol Optical Thickness
0.0   0.5   1.0
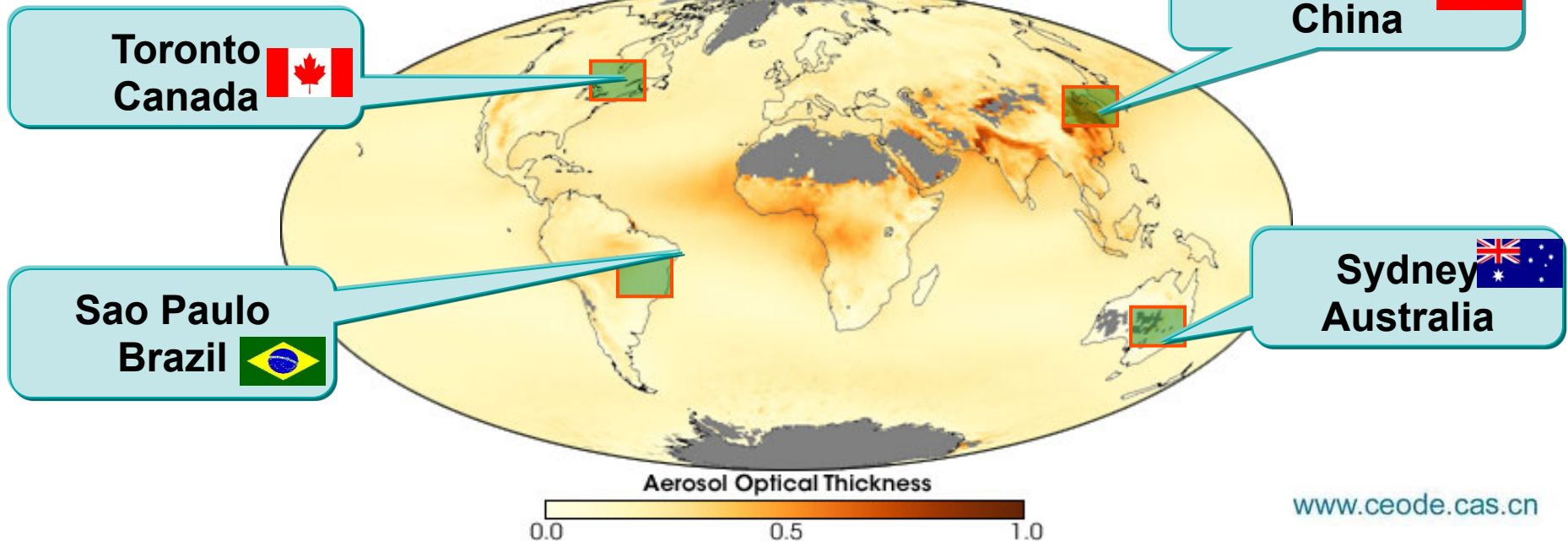
Aerosol Study

Aerosols

Global Climate Change and Radiative Forcing

Aerosol direct and in-direct Effects

Quantitative Remote Sensing – Atmospheric Correction

Public and Environmental Health

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Source of Atmospheric Aerosols

AOD Products

- There are two main AOD retrieval algorithms using MODIS data: dark dense vegetation (DDV) and deep blue.
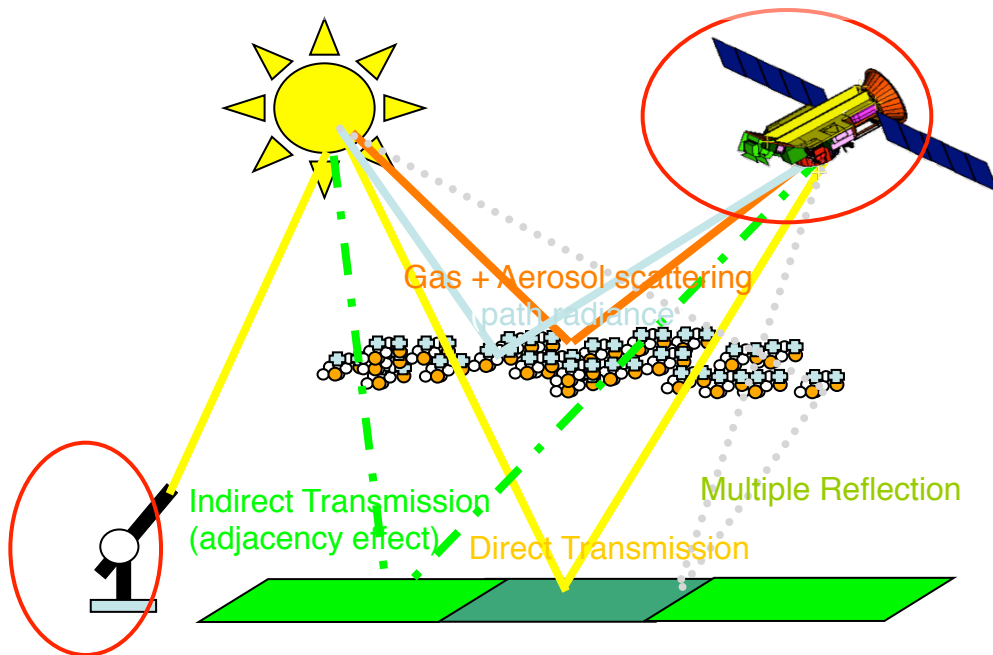
Algorithm	Features
DDV (Kaufman, 1997; Levy, 2007)	the DDV algorithm has showed excellent competence at the aerosol distribution and properties retrieval, which uses the dark-target approach and assumes the ratio of surface reflectance between 0.47μm (0.64μm) and 2.1μm is 0.25 (0.5). This assumption is valid for most vegetated land surfaces. However, over desert regions, land surface reflectance significantly deviates from this assumption. Besides, the spatial resolution of retrieved AODs is usually low and many operational satellite sensors have no short-wavelength-IR bands near 2.1μm.
Deep Blue (Hsu, 2004, 2006)	Deep blue is a new algorithm for aerosol retrieval over some bright surfaces. It employs the fact that the reflectance over bright areas is much darker in the blue spectral region than that in other spectral regions.

- SRAP model is used to retrieve AOD from Terra and Aqua MODIS data. It can be written as follows (Xue and Cracknell 1995):

$$\rho_{TOA}(\lambda, \mu_0, \mu, \phi) = \rho_{atm}(\lambda, \mu_0, \mu, \phi) + \frac{\rho_{sfc}(\lambda) \cdot T_1(\lambda, \mu_0) T_2(\lambda, \mu)}{1 - \rho_{sfc}(\lambda) \cdot s(\lambda)}$$
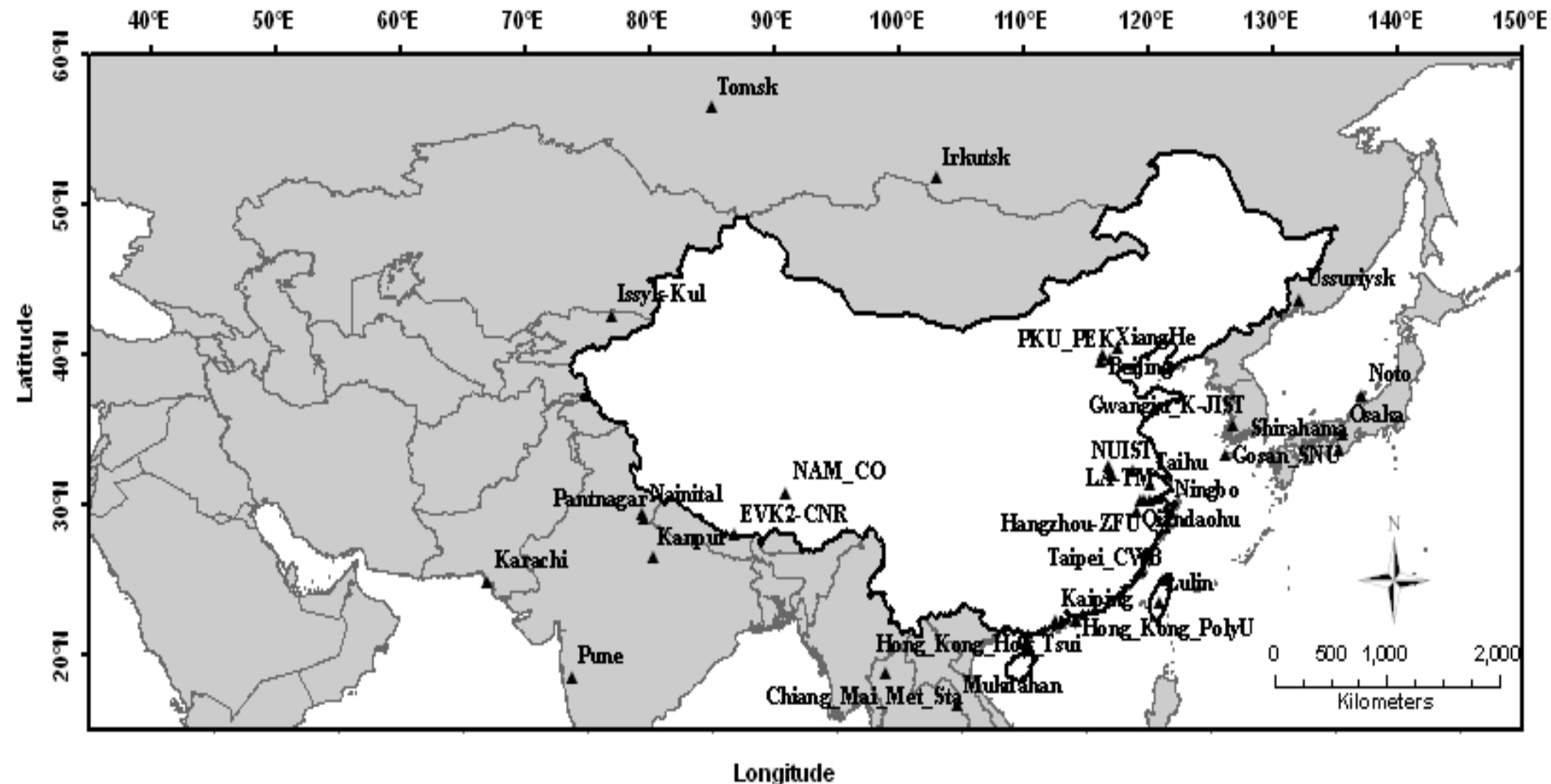

Gas + Aerosol scattering
path radiance

Indirect Transmission
(adjacency effect)

Direct Transmission

Multiple Reflection

The information obtained by satellite is very complicated, aerosol signal is very weak for most cases

- The AERONET stations in Asia used for the validation of the China Collection 1.0 and 1.1 AOD datasets.

MYD04_L2 DarkTarget_AOT_550 2010_8_1
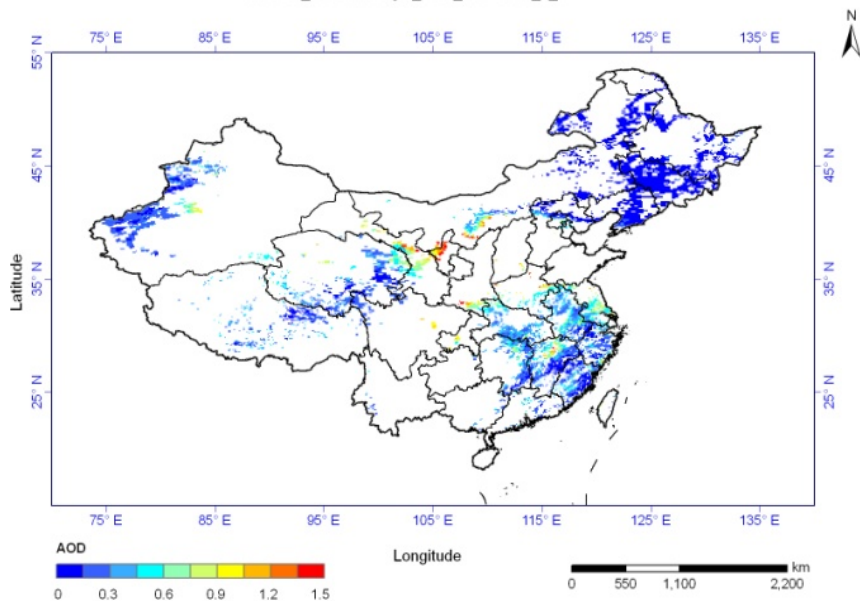
AOD from NASA MODIS aerosol product at 10km resolution using Dark Target method

MYD04_L2 DeepBlue_AOT_550 2010_8_1
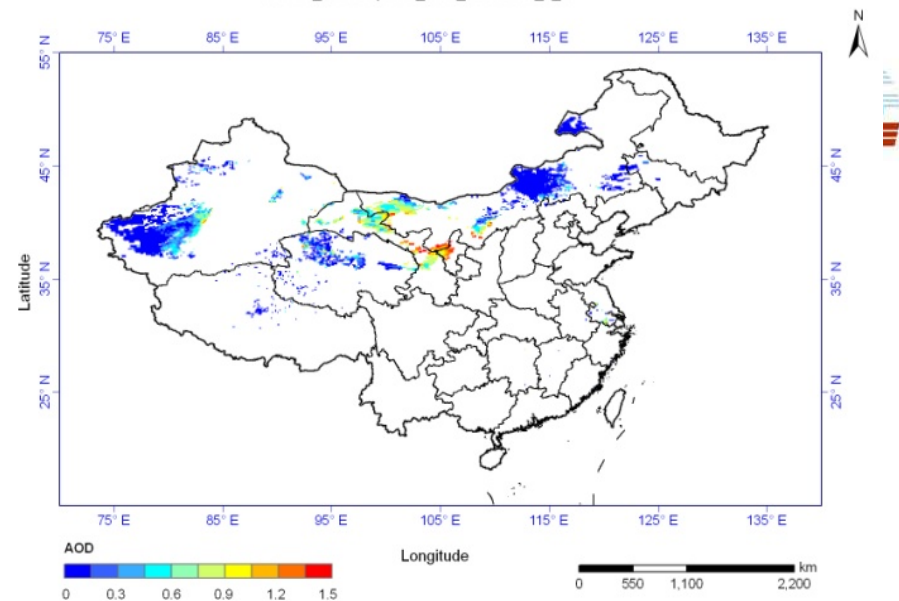
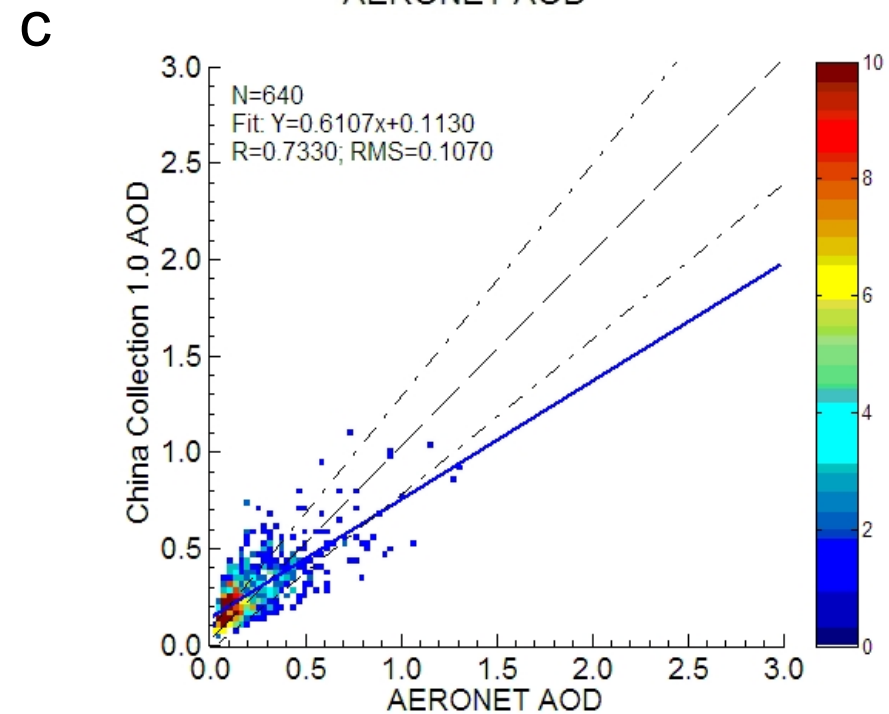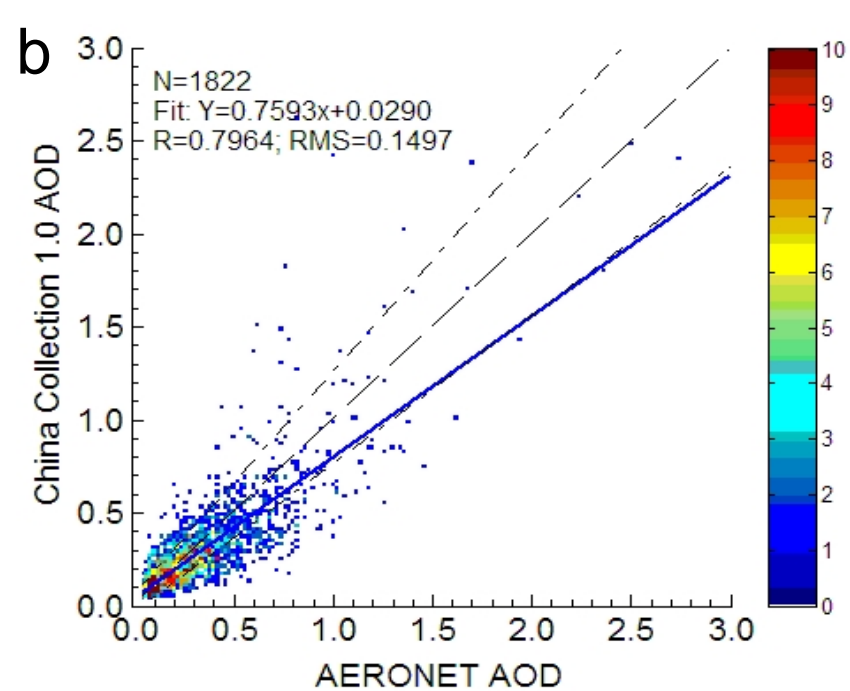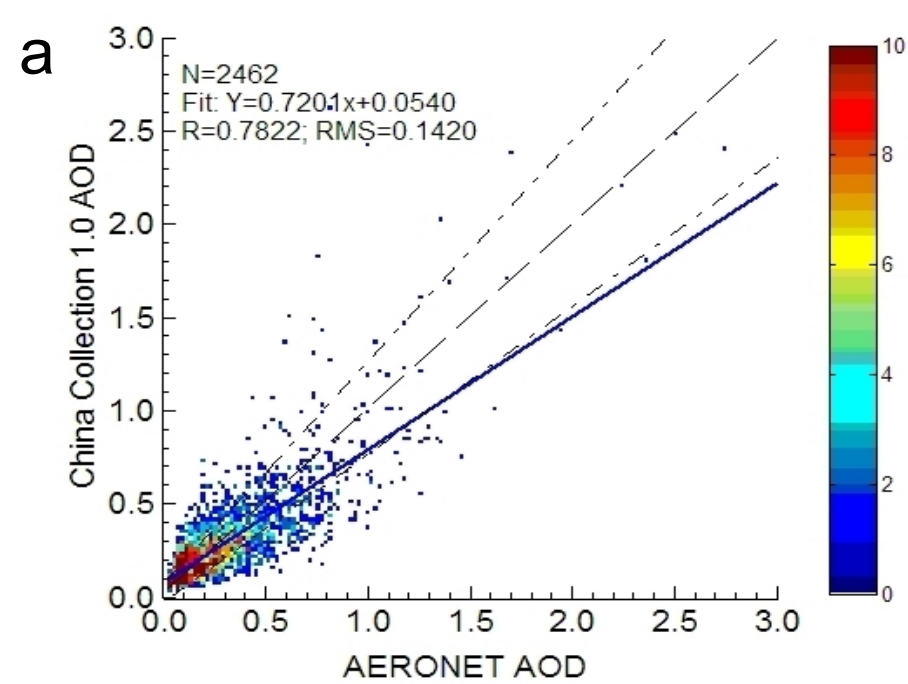AOD from NASA MODIS aerosol product at 10km resolution using Deep Blue method

Aerosol_Optical_Depth(0.55um) AQUA_MODIS_2010_8_1
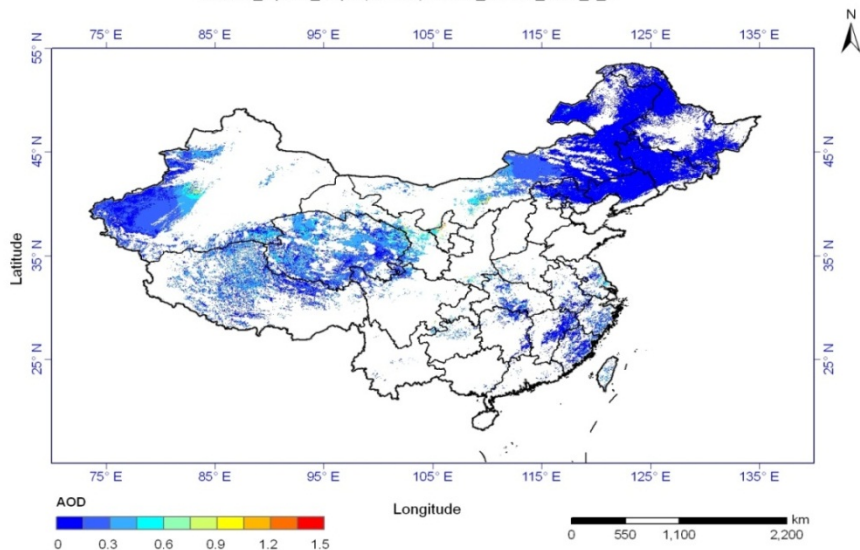
AOD by SRAP algorithm from MODIS data at 1km
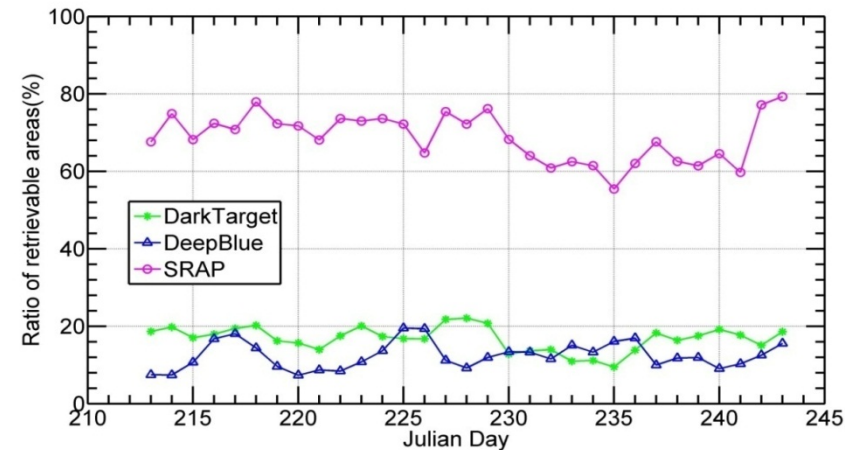
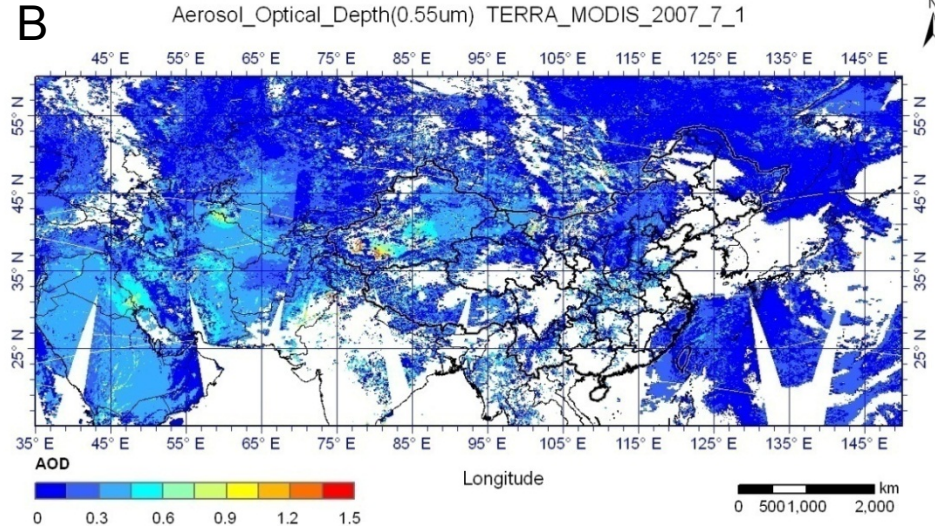The ratio of retrievable AODs areas by SRAP, the Dark Target and Deep Blue methods.

a

N=2462
Fit: Y=0.7201x+0.0540
R=0.7822; RMS=0.1420

b

N=1822
Fit: Y=0.7593x+0.0290
R=0.7964; RMS=0.1497

c

N=640
Fit: Y=0.6107x+0.1130
R=0.7330; RMS=0.1070

The China Collection 1.1 AODs at 550 nm were collocated with AERONET for the same wavelength for both the Terra and Aqua datasets for 2010. The data are sorted according to ordered pairs (AERONET, MODIS) of AODs in 0.025 intervals; each colour represents the number of cases (colour bar) with that particular ordered pair value. The dashed, dotted and solid lines are the 1-1 lines, the EE for land AOD ±(0.05+0.15), and the linear regression of the scatterplot, respectively. The text at the top describes the number of collocations (N), the percentage within expected error, the regression curve, correlation (R), and the RMS error of the fit. (a) where all data are counted; (b) where the Dark Target or Deep Blue algorithms have values; (c) where the Dark Target or Deep Blue algorithms have no values.
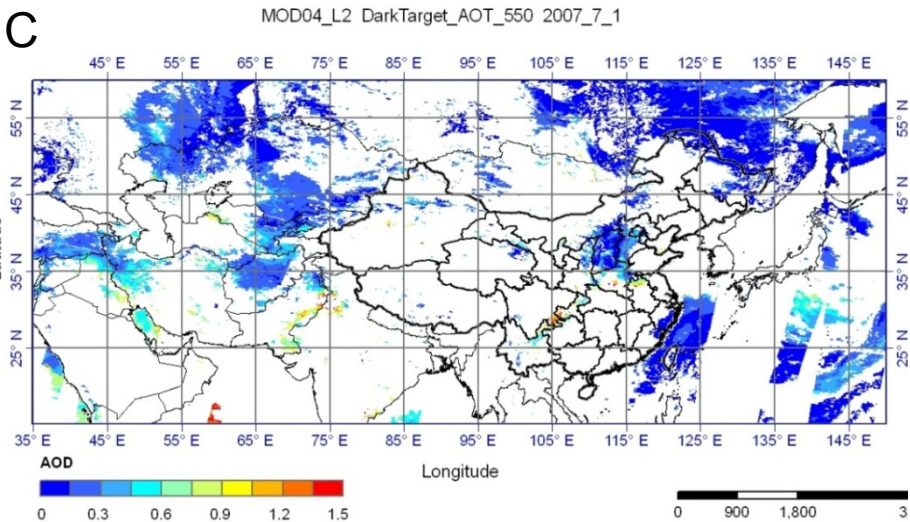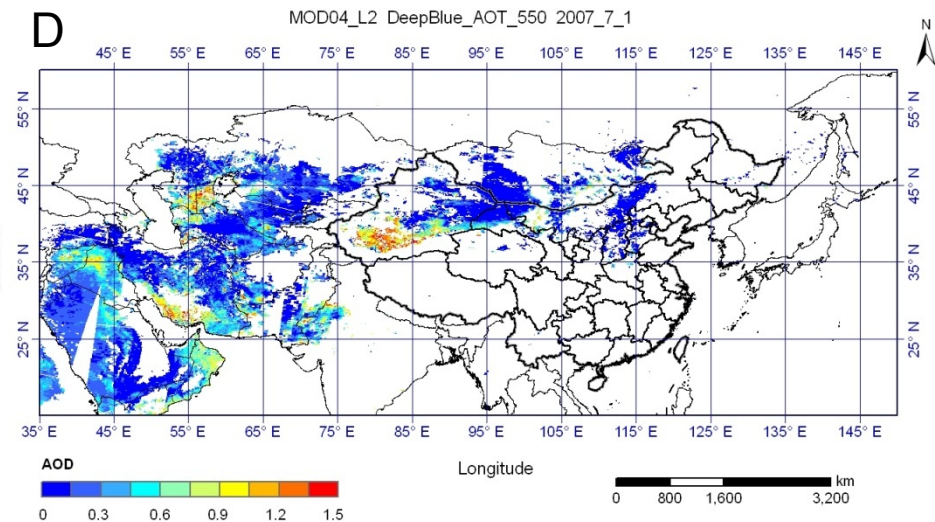
China Collection 1.1

A — Aerosol_Optical_Depth(0.55um) TERRA_MODIS_2007_7_1

AOD with NASA Cloud Mask Algorithm

B — Aerosol_Optical_Depth(0.55um) TERRA_MODIS_2007_7_1

AOD with NASA Cloud Product MOD35

C — MOD04_L2 DarkTarget_AOT_550 2007_7_1

AOD by MODIS DDV Algorithm
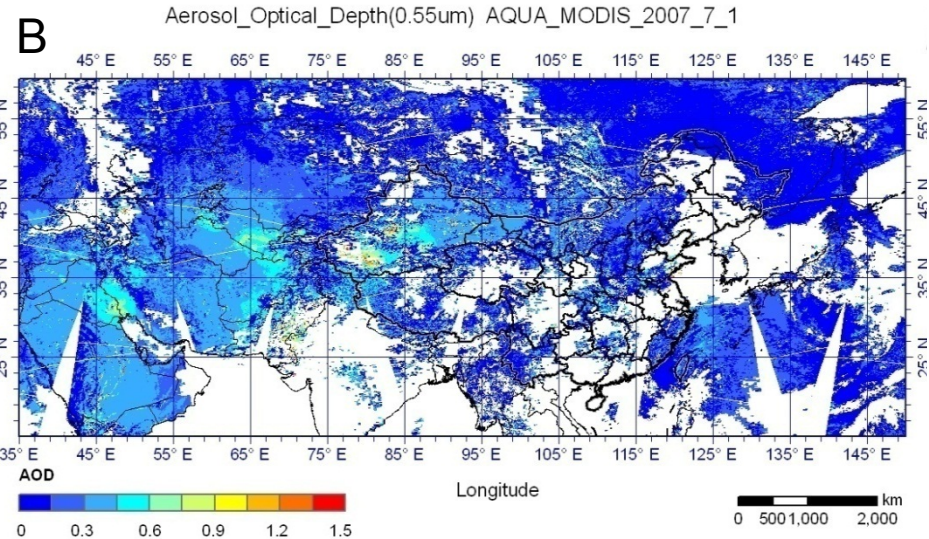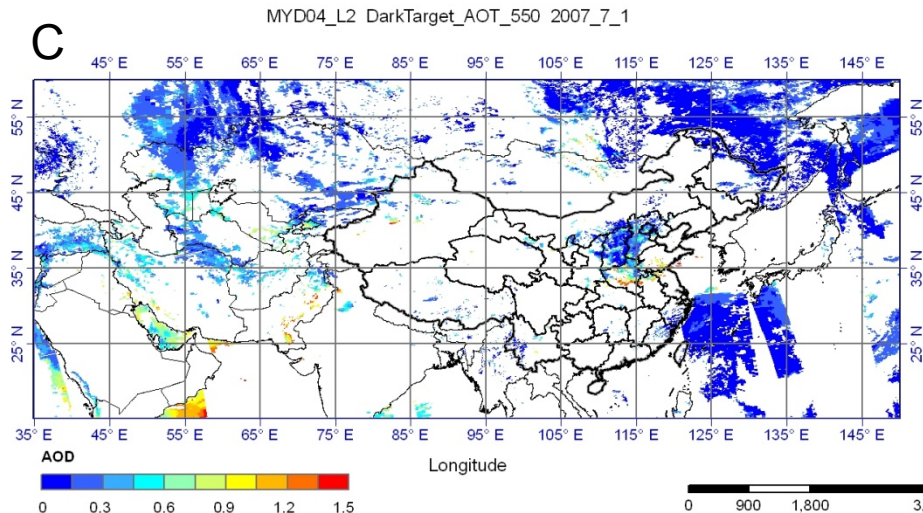
D — MOD04_L2 DeepBlue_AOT_550 2007_7_1

AOD by MODIS Deep Blue Algorithm

Comparison of AOD products
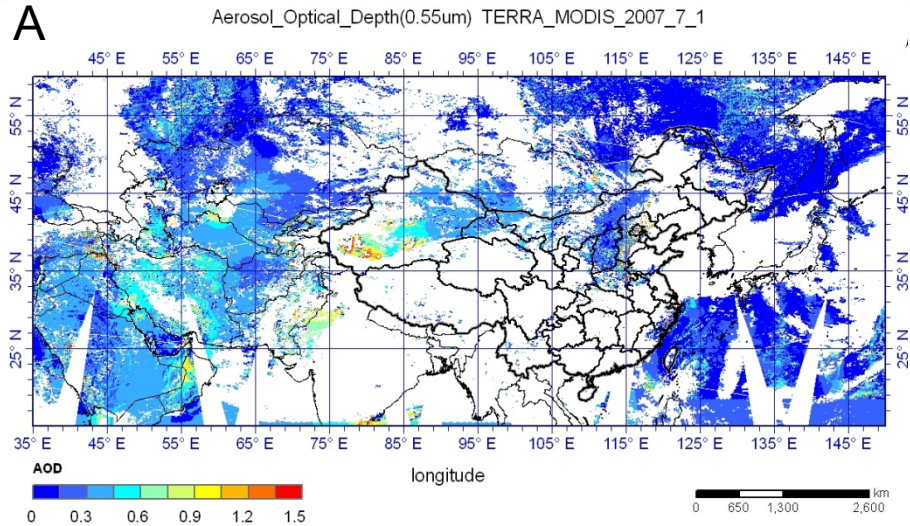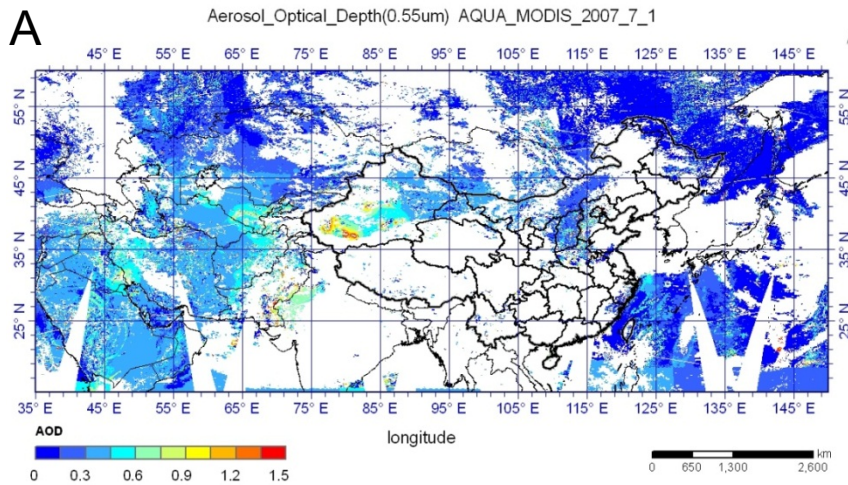
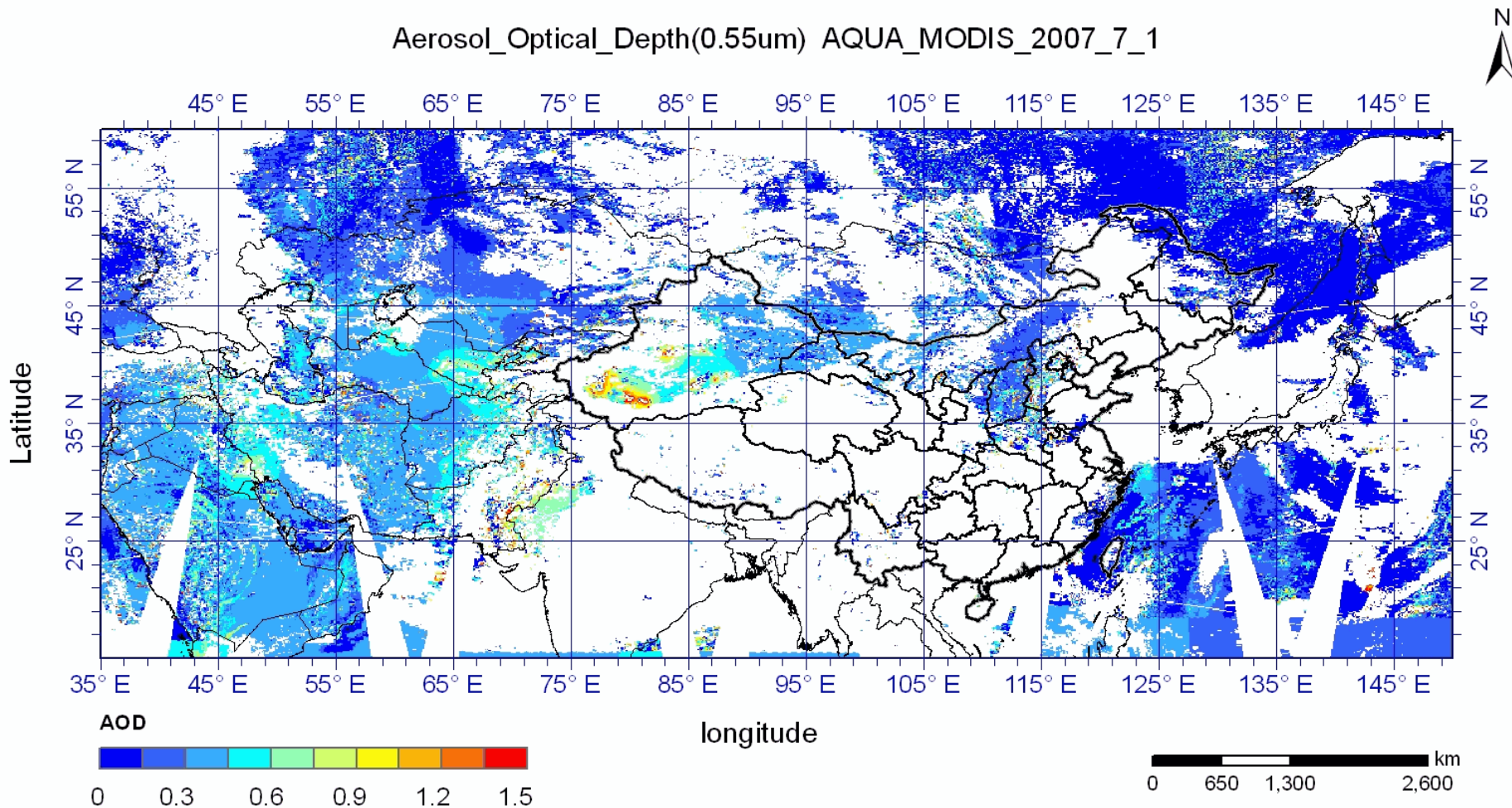AOD with NASA Cloud Mask Algorithm
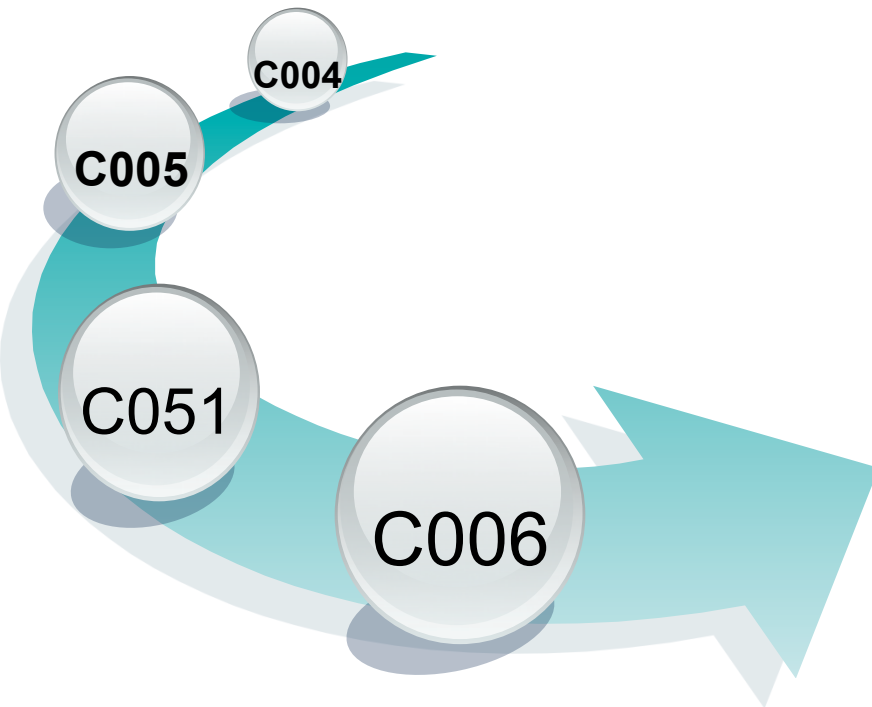
AOD with NASA Cloud Product MOD35

AOD by MODIS DDV Algorithm
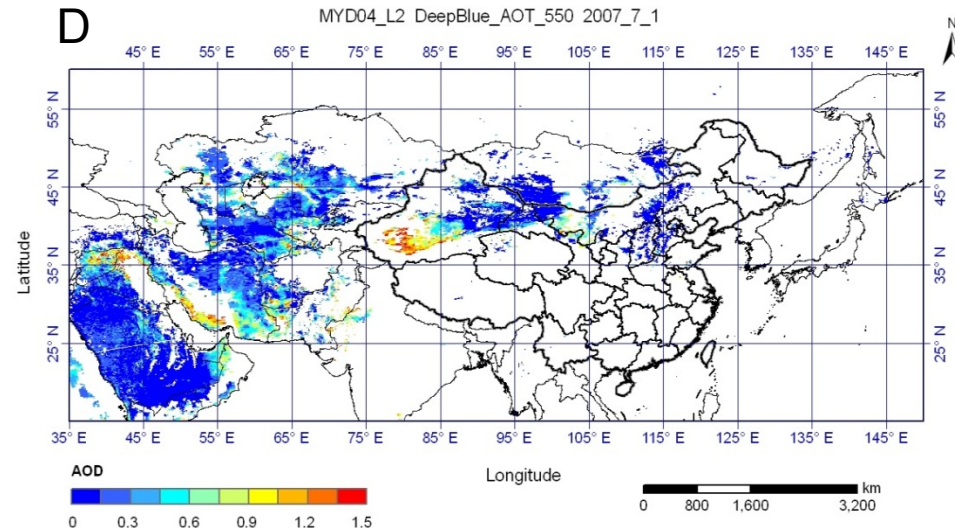
AOD by MODIS Deep Blue Algorithm

Aerosol_Optical_Depth(0.55um) AQUA_MODIS_2007_7_1

Ongoing …

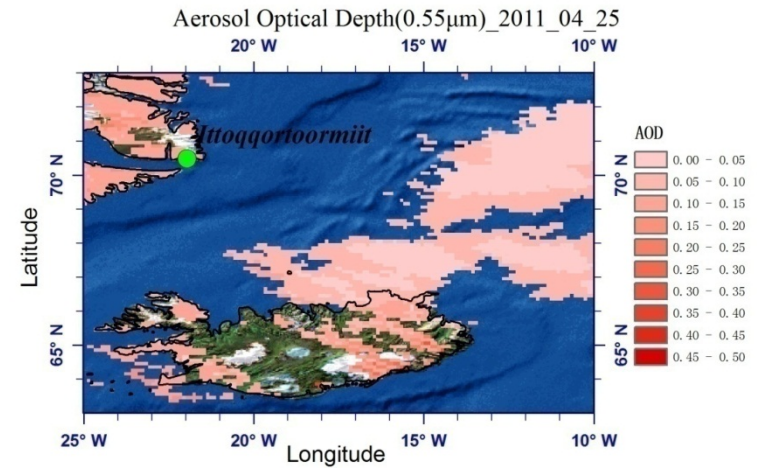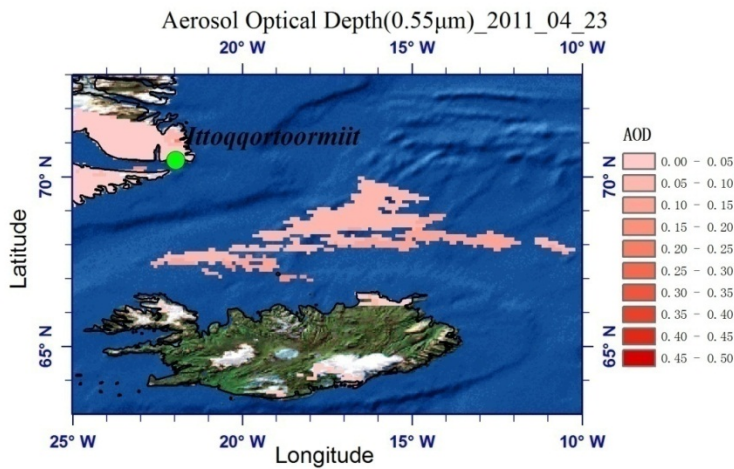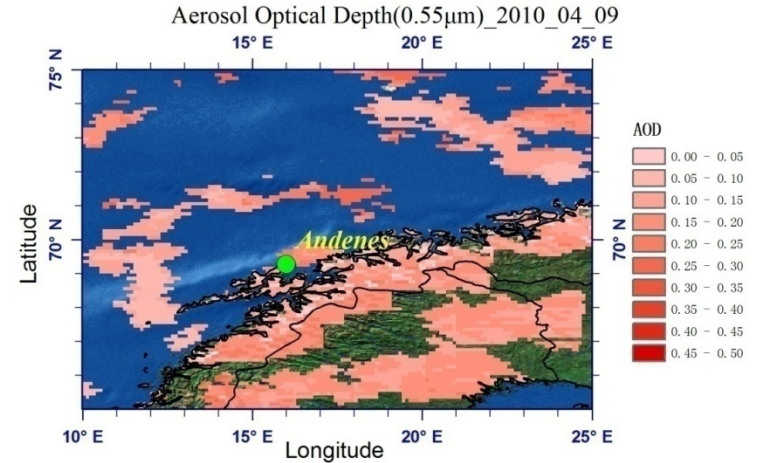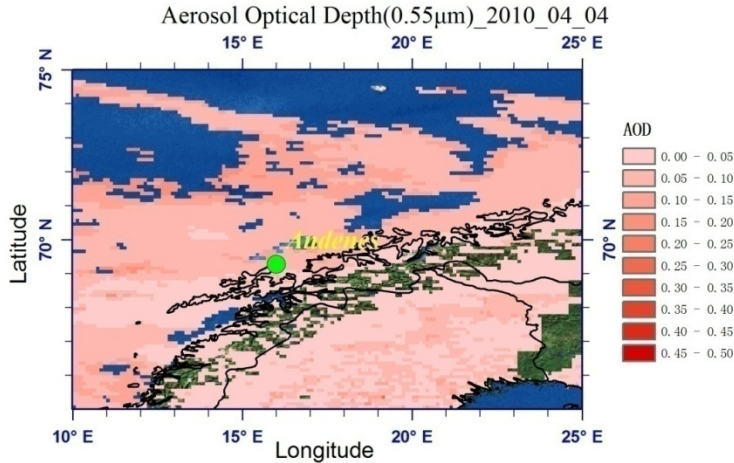**NASA DT/DB**

SRAP

C004

C005

C051

C006

China Collection 1.0

China Collection 2.0

……

Portal Grid

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Aerosol Optical Depth(0.55μm)_2010_04_04

Aerosol Optical Depth(0.55μm)_2010_04_09

Aerosol Optical Depth(0.55μm)_2011_04_23

Aerosol Optical Depth(0.55μm)_2011_04_25

L.L. Mei, Y. Xue, G. de Leeuw, W. von Hoyningen-Huene, A. A. Kokhanovsky, L. Istomina, J. Guang and J. P. Burrows, 2013, Aerosol optical depth retrieval in the Arctic region using MODIS data over snow. *Remote Sensing of Environment*, http://dx.doi.org/10.1016/j.rse.2012.10.009

AOD Retrieval from Geostationary Satellite Data
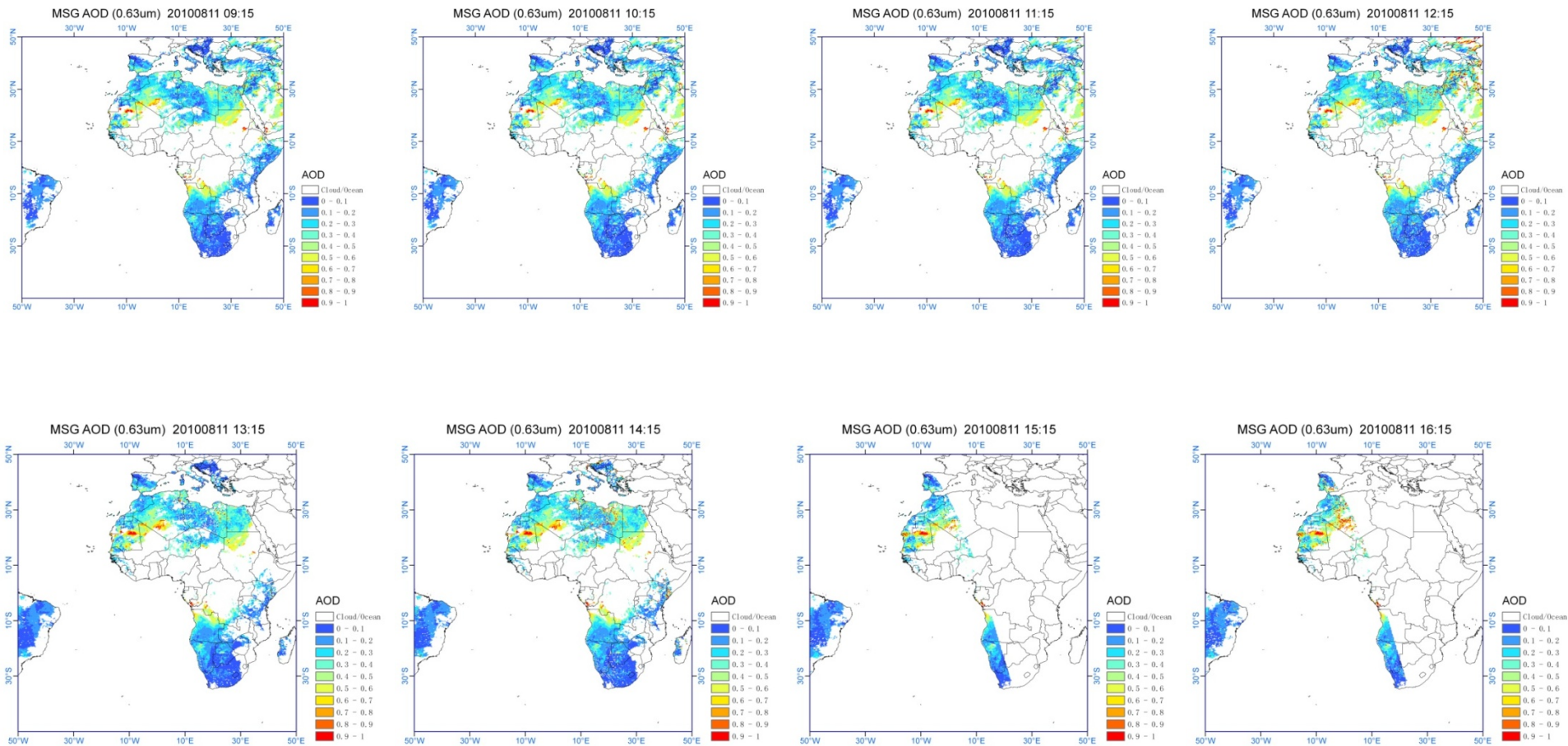
Mei, L., Xue, Y., de Leeuw, G., Holzer-Popp, T., Guang, J., Li, Y., Yang, L., Xu, H., Xu, X., Li, C., Wang, Y., Wu, C., Hou, T., He, X., Liu, J., Dong, J., and Chen, Z.: Retrieval of aerosol optical depth over land based on a time series technique using MSG/SEVIRI data, Atmos. Chem. Phys., 12, 9167-9185, doi:10.5194/acp-12-9167-2012, 2012.
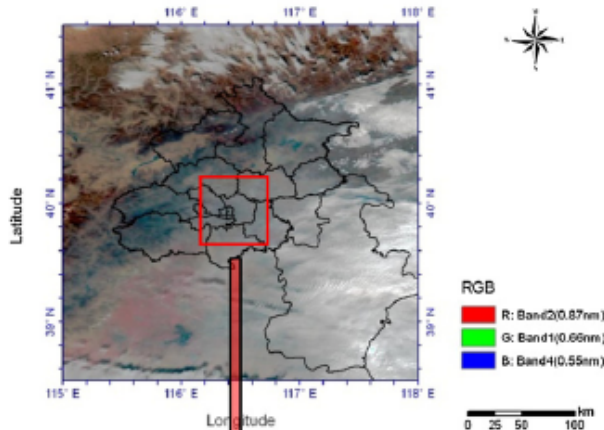
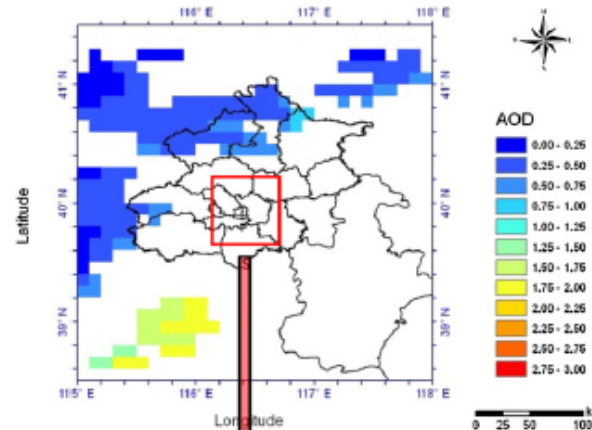www.ceode.cas.cn

Aerosol Types

AOD from Small Satellites

– Urban Air Pollution

Terra MODIS 500m x 500m RGB Image on April 5, 2010

a 500-m MODIS RGB image over Beijing areas

HJ-1 CCD RGB Image over Beijing City on April 5, 2010
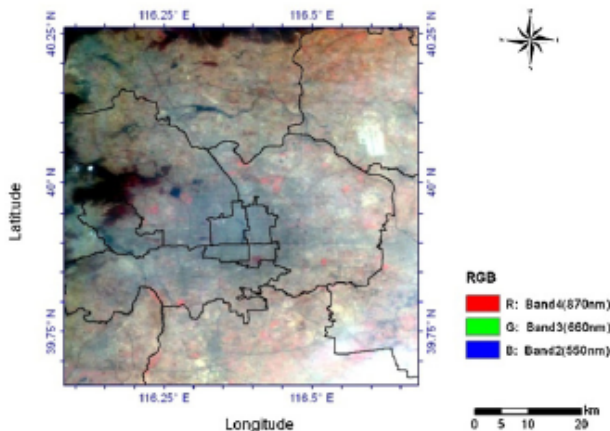
c HJ-1 CCD RGB image over Beijing City

MOD04_L2 10km x 10km AOD at 550 on April 5, 2010

b 10-km AOD from the MOD04_L2 product

HJ-1 CCD 100m x 100m AOD at 550nm over Beijing City on April 5, 2010
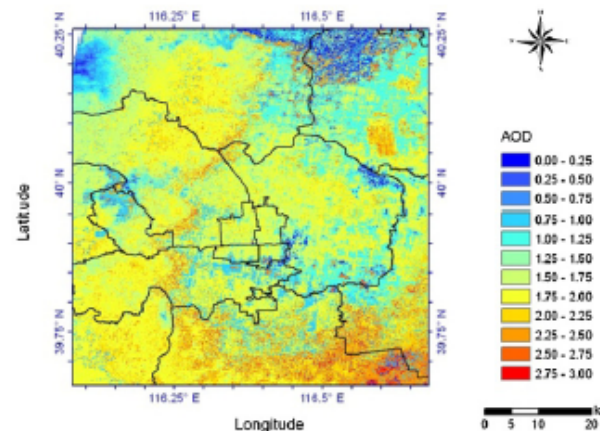
d 100-m AOD retrieved from the HJ-1 CCD Data

HJ-1A/1B CCD and Terra MODIS data synchronized with the ground-based measurements from March to June 2009 over Beijing area are collected for retrieval.

Yingjie Li, **Yong Xue**, Xingwei He, Jie Guang, 2012, High-Resolution Aerosol Remote Sensing Retrieval over Urban Areas by Synergetic use of HJ-1 CCD and MODIS Data. *Atmospheric Environment,* 46, 173-180. (DOI: 10.1016/ j.atmosenv.2011.10.002)

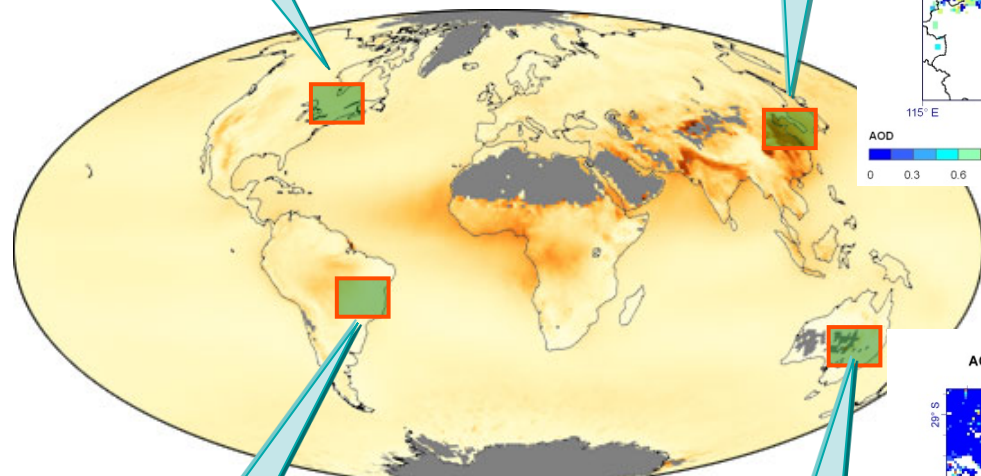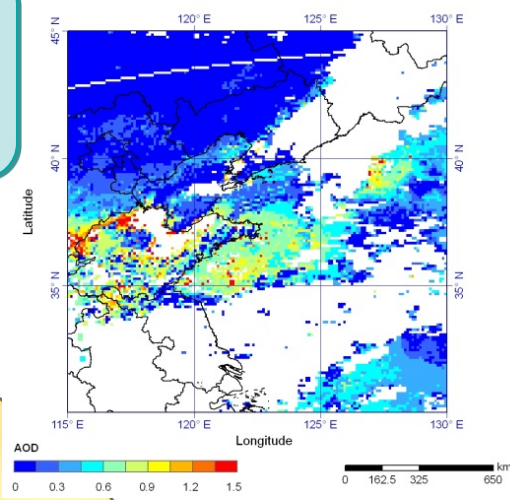# AOD For A-B-C-C Countries

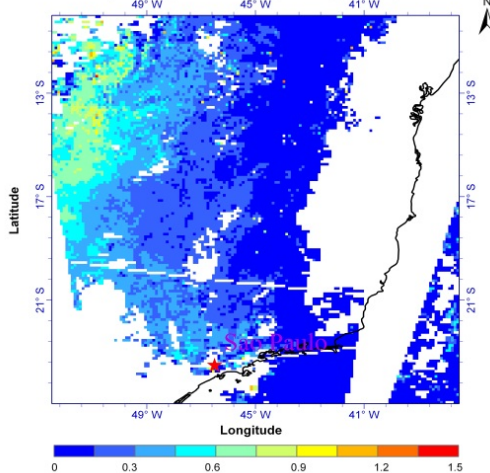AOD(550nm) _AQUA/MODIS_Toronto_2012_10_04
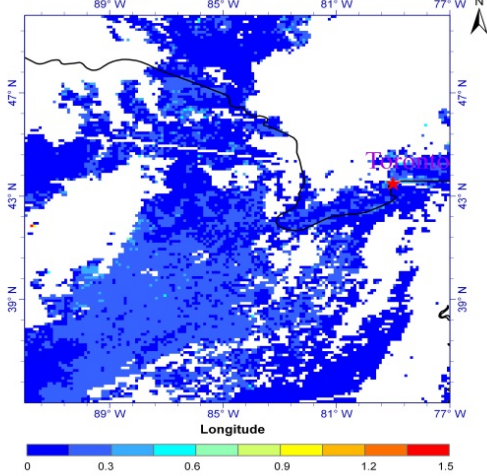
Toronto Canada

Beijing China

Aerosol_Optical_Depth(0.55um) AQUA_MODIS_2012_10_13

Sao Paulo Brazil

Sydney Australia

AOD(550nm) _AQUA/MODIS_St. Paul_2012_10_04

AOD(550nm) _AQUA/MODIS_Sydney_2012_10_15

Aerosol Optical Thickness

A-B-C-C Case Studies

AOD(550nm) _AQUA/MODIS_Sydney_2012_10_15

AOD(550nm) _AQUA/MODIS_St. Paul_2012_10_04

AOD(550nm) _AQUA/MODIS_Toronto_2012_10_04

Aerosol_Optical_Depth(0.55um) AQUA_MODIS_2012_10_13
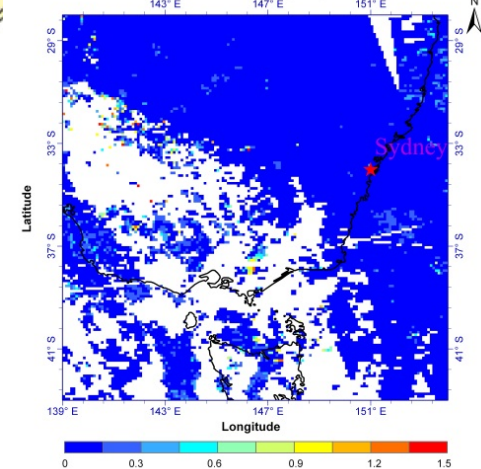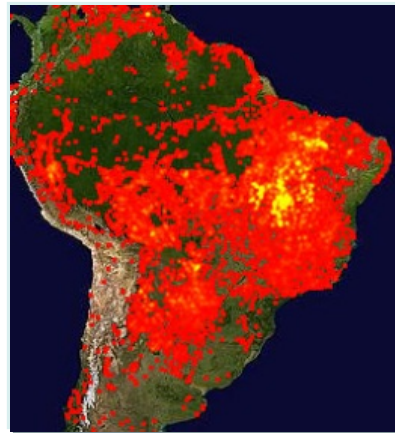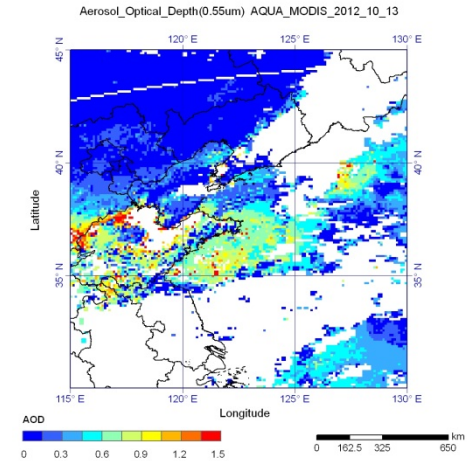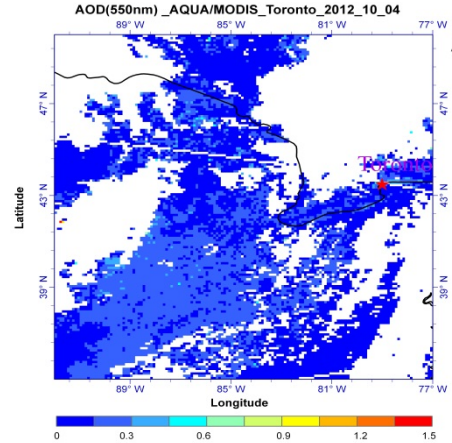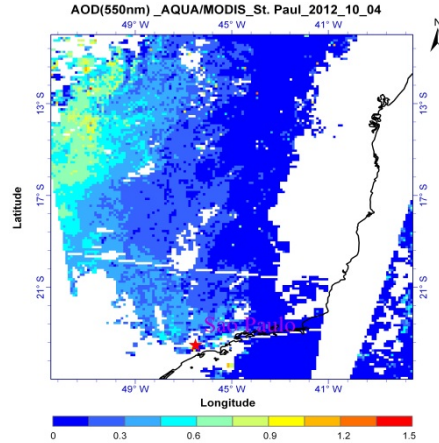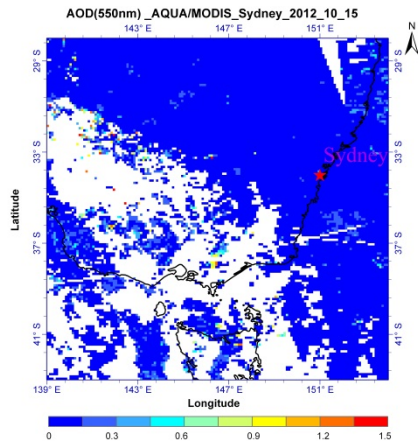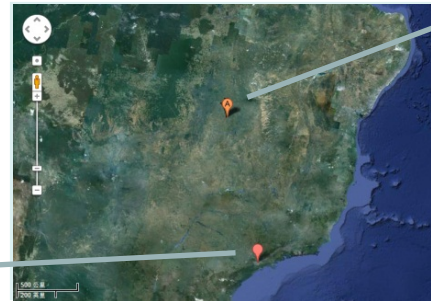
Period: 09/27/2012 - 10/06/2012
Color ranges from red where the fire count is low to yellow where number of fires is large.

Brasilia

Sao Paulo

Phase II …

- ABCC^E
  - European …

- A^{2}BCC
  - Arctic: By the late 1990s, the extent of sea ice had fallen to its lowest level for at least 1400 years. At the end of the summer 2012, only a quarter of the ...
  - and Antarctic

◆Goodbye grey skies, hello extra warming
  » Much of the uncertainty stems from clouds, whose effects climate models struggle to simulate.
  » High-level clouds trap heat, but those at low levels reflect sunlight and cool the planet. So depending on how they change, clouds could push temperatures up or down.
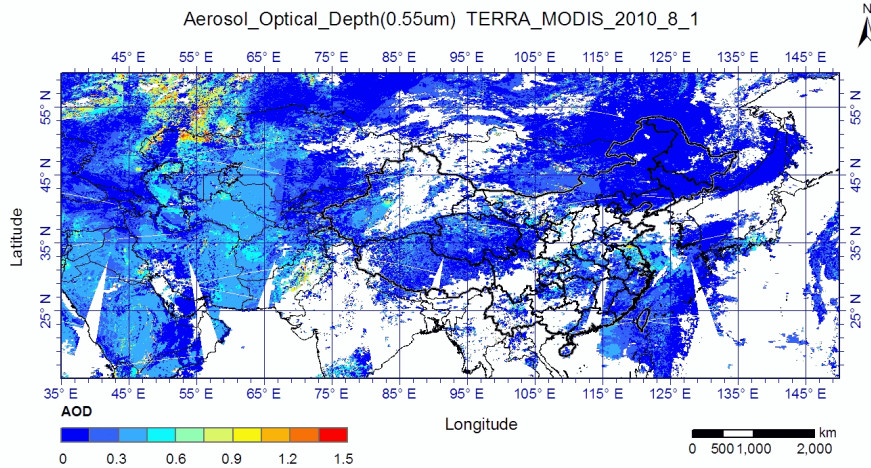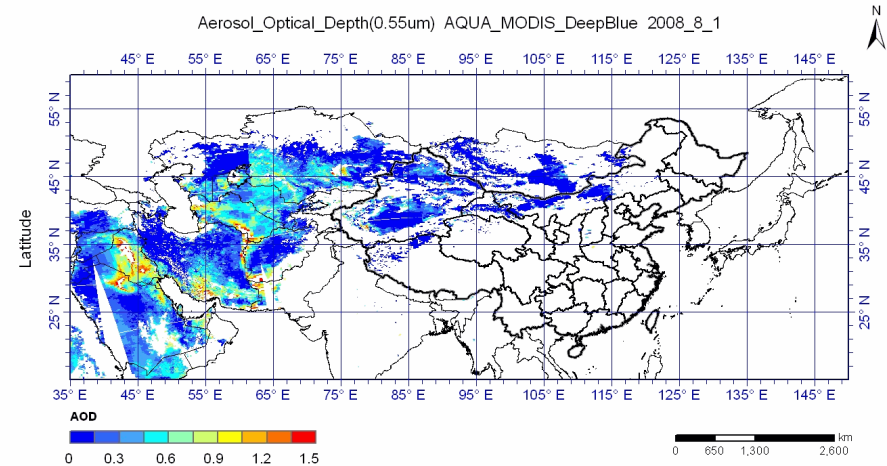
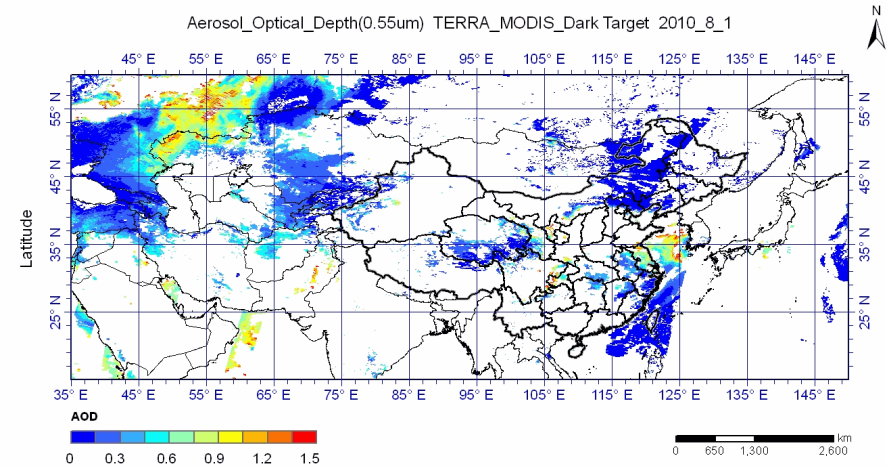# Thanks for your attention!

CEODE

China Collection 1.0

Aerosol_Optical_Depth(0.55um) TERRA_MODIS_2010_8_1

Spatial Resolution: 10km, 1km
Temporal Scale: from August 2002

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http://www.tgp.ac.cn

Aerosol_Optical_Depth(0.55um) AQUA_MODIS_DeepBlue 2008_8_1

Aerosol_Optical_Depth(0.55um) TERRA_MODIS_Dark Target 2010_8_1

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