A multi-platform system for understanding, monitoring and forecasting the impact of aerosol pollutants in South-East Asia

Santo V. Salinas[a]

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Collaborators: Ellsworth J. Welton[b], **Brent N. Holben**[b] **and Jun Wang**[c]

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CRISP atmospheric group

CRISP
National University of Singapore

- Started in 2007 with the set up of Singapore's first AERONET site at NUS. Also in the same year, the 7SEAS partnership with NASA and NRL as well as with regional countries starts.

- Year 2009 we started a partnership with MPLNET resulting on a semi-permanent LIDAR site at NUS.

- Year 2012 Creation of the Singapore NUS atmospheric super-site due to our participation in SEAC4RS 2012. In the same year, we also entered on a partnership with Univ. Wisconsin, resulting on the deployment of a Hyper-spectral high resolution lidar (HSRL).

- Year 2015: A MEWR/NEA funded project on "Strategic Studies of Singapore Atmospheric Environment PM2.5 in Singapore: Characteristics and Potential Health Impacts" have started. This project partners CEE, NERI, NUS (Chemistry, Anatomy) and CRISP.

- Year 2016: OSTIn/NRF/EDB funded project on "Regional Air Quality Monitoring and Forecasting Using Remote Sensing Satellites, Ground Instrumentation and Numerical Modeling" has started.

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Why did we propose such a project?

Trans-boundary haze (smoke)

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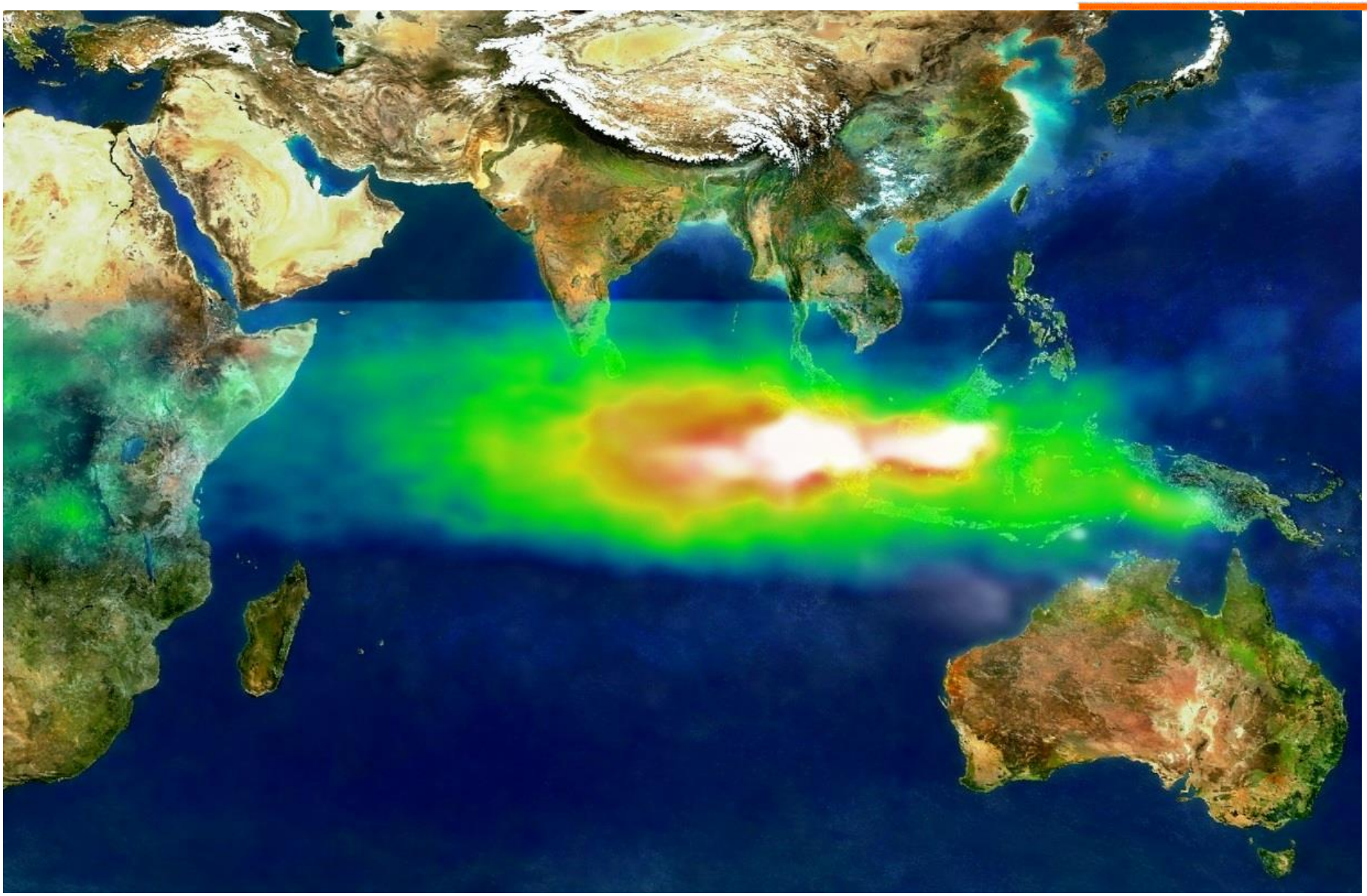

The June 2013 smoke episode

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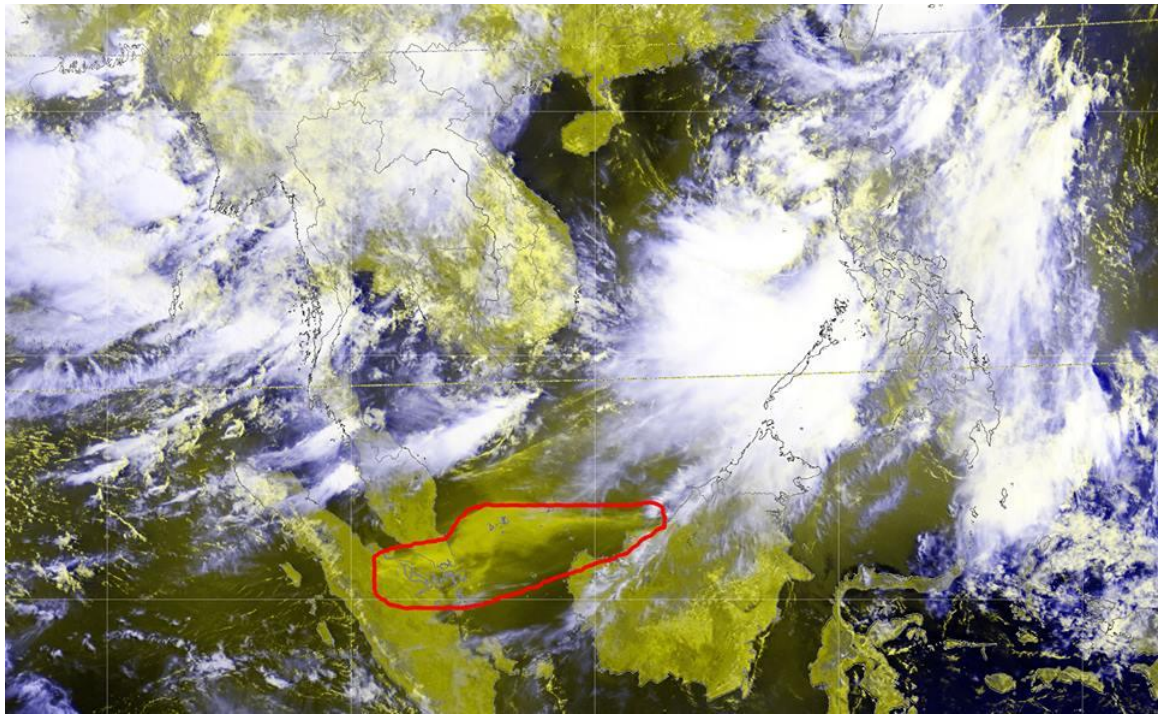

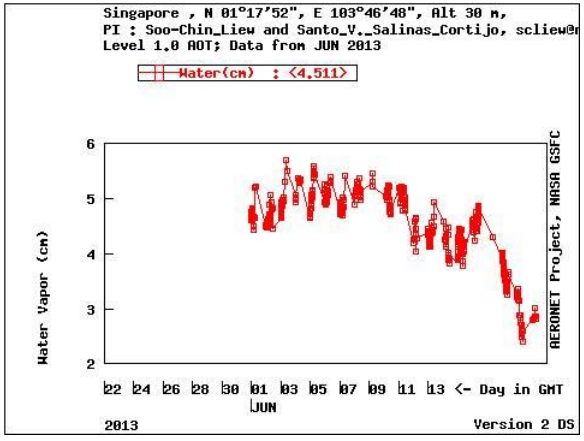

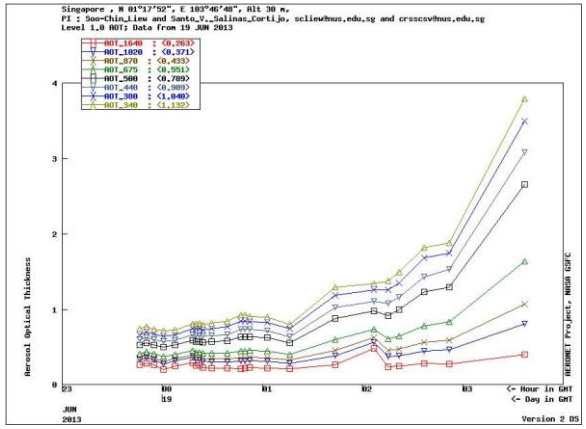

Fig. 1. Smoke episode June 19th to 22nd, 2013.

The June 2013 smoke episode

Fig. 1. Smoke episode June 19th to 22nd, 2013.

Operational objectives of the project

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- To develop, regional and country-wide monitoring and predictive capability of aerosol/particulate matter evolution and transport mechanisms especially during regional trans-boundary smoke events generated by biomass burning.
- Reduce uncertainty between satellite, model and in-situ ground measurements of aerosol/particulate matter.
- To develop a rapid and mobile platform for assessment of in-situ aerosol loadings, particulate matter concentration (PM2.5/10) and aerosol vertical distribution.
- To develop state-of-the-science numerical modelling capability for aerosol particle transport and evolution over the SEA region.
- To provide services in advanced air quality monitoring and prediction capabilities to local governments/agencies/private enterprises and regional stakeholders.

Sub-projects within the proposal

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- Satellite remote sensing:
  - Source identification/Thermal hot spot allocation.
  - Satellite derived aerosol physical and optical properties.
- In-situ ground measurements.
  - Photometric measurements (AERONET).
  - LIDAR vertical profiling(MPLNET).
  - Ambient particle sampling (nephelometer, PM2.5/10 sampling).
- Numerical modeling of aerosol/smoke transport.
  - IDEA-I/Hysplit Trajectory modeling.
  - WRF-Chem/GEOS-CHEM/CMAQ.
  - Others.

NUS/CRISP site of the Aerosol Robotic Network (AERONET, 2007)

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GODDARD SPACE FLIGHT CENTER | + Visit NASA.gov

AERONET
AEROSOL ROBOTIC NETWORK

+ AEROSOL OPTICAL DEPTH | + AEROSOL INVERSIONS | + SOLAR FLUX | + OCEAN COLOR | + MARITIME AEROSOL

+Home

Aerosol Optical Depth

+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
- DATA
+ LOGISTICS
+ NASA PROJECTS
+ OPERATIONS
+ PUBLICATIONS
+ SITE INFORMATION
+ STAFF
+ SYSTEM DESCRIPTION

AERONET DATA ACCESS
DATA SYNERGY TOOL
+ Data Display
AEROSOL OPTICAL DEPTH
+ Data Display

AERONET Data Display Interface | **Version 2 Direct Sun Algorithm**

Site: Singapore - Additional Site Information

DISCLAIMER	**AERONET Level 1.0. Real Time Data.** **The following AERONET data are unscreened and may not have final calibration applied**

The principal investigator(s) of the 'Singapore' site:
Soo-Chin Liew
Santo V. Salinas Cortijo
If you intend to use the following data please contact principal investigator(s) via e-mail:
scliew@nus.edu.sg
crsscsv@nus.edu.sg

Operational Time at 'Singapore' Site
1873 Days [5.132 Years]
Start Date: 01-JAN-2001; Latest Date: 18-NOV-2012

Total Processed Data [Years represent total data equivalent]
Level 1.0 AOD: 1706 Days [4.674 Years]
Level 1.5 AOD: 1505 Days [4.123 Years]
Level 2.0 AOD: 825 Days [2.260 Years]

Return to the World Map | Switch to Version 2 Inversions | Switch to Version 1 Direct Sun and Inversions

Data Display Controls

AERONET Data Type:
AOD
Water Vapor
440-870 Angstrom
SDA Fine/Coarse AOD
SDA Fine Mode Fraction

AOD Level (2012): (•) Level 1.0 ( ) Level 1.5
Data Format: (•) All points ( ) Daily averages
Triplet Error Bars (All Points Only): (•) Off ( ) On

Related Product Availability for Singapore (select each day below):
- Back Trajectory Analyses - Availability - More Information
- Show MPLNET Images - Availability - More Information
- Show TERRA-MODIS | AQUA-MODIS Rapid Response Images - Availability - More Information
- LandSat Image
- Visible Satellite Images (Check Availability) - More Information
- Infrared Satellite Images (Check Availability) - More Information

SELECT CHARTS FOR LARGER IMAGES

Choose year :	2006	2007	2008	2009	2010	2011	2012
Choose month of 2012 :	FEB	MAR	APR	MAY	JUN	JUL	AUG
	SEP	OCT	NOV				

Choose day of NOV 2012

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30						

NUS/CRISP site of the Micro Pulse Lidar NETwork (MPLNET, 2009)

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GODDARD SPACE FLIGHT CENTER

+ Sciences and Exploration Directorate
+ Earth Sciences Division
+ Laboratory for Atmospheres
+ Mesoscale Atmospheric Processes Homepage

The Micro Pulse Lidar Network

MPLNET

+ HOME | + DATA | + OPERATIONS | + INSTRUMENTS | + PUBLICATIONS | + PEOPLE

Data

+ SITES
+ PRODUCT INFO
+ DATA POLICY
+ DOWNLOADS

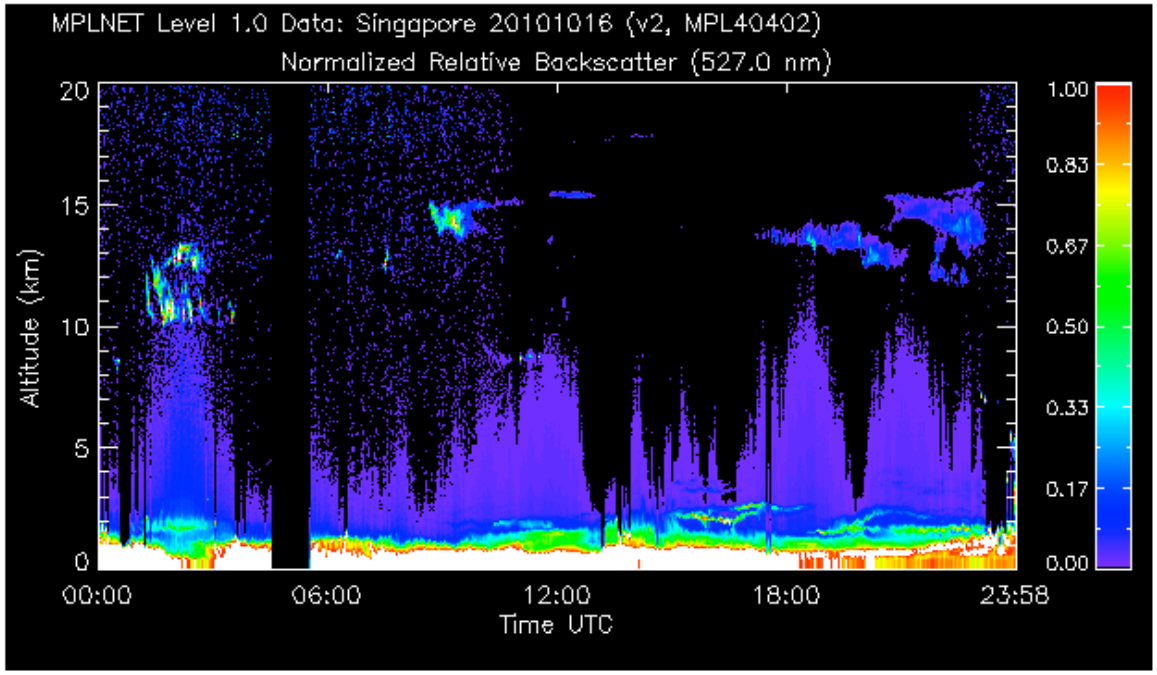
Singapore

Latitude: 1.29777
Longitude: 103.78000
Elevation: 0.0300 km

Principal Investigator: Jeff Reid
Onsite Contact: Chew Boon Ning

Email: PI & Contact

Site Description: View



Mobile sampling platform for local and regional campaigns

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MPL Lidar

3-Wavelenght Nephelometer

AERONET photometer

Portable PM2.5/10 particle sampler

Environmental Satellites : Terra/Aqua

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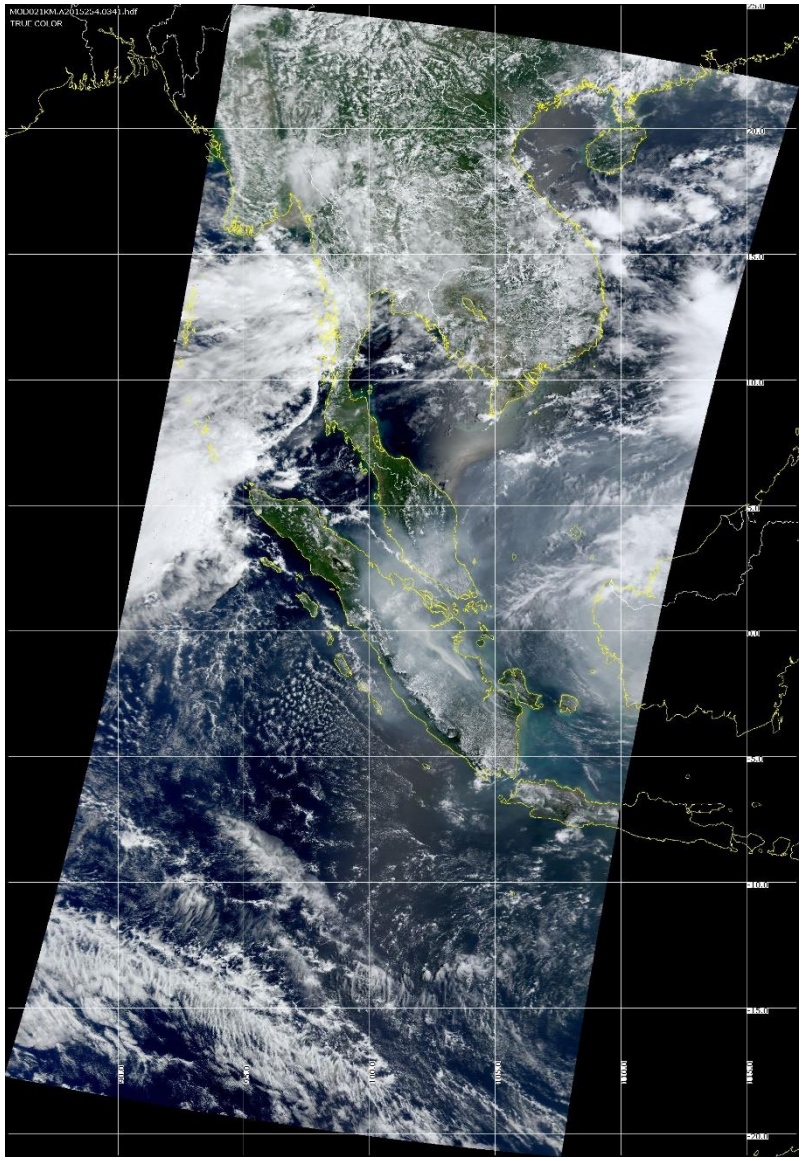
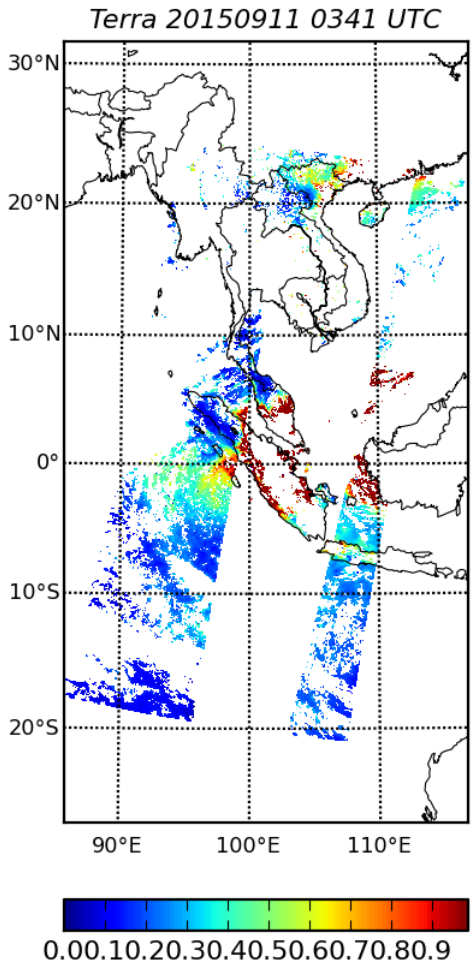
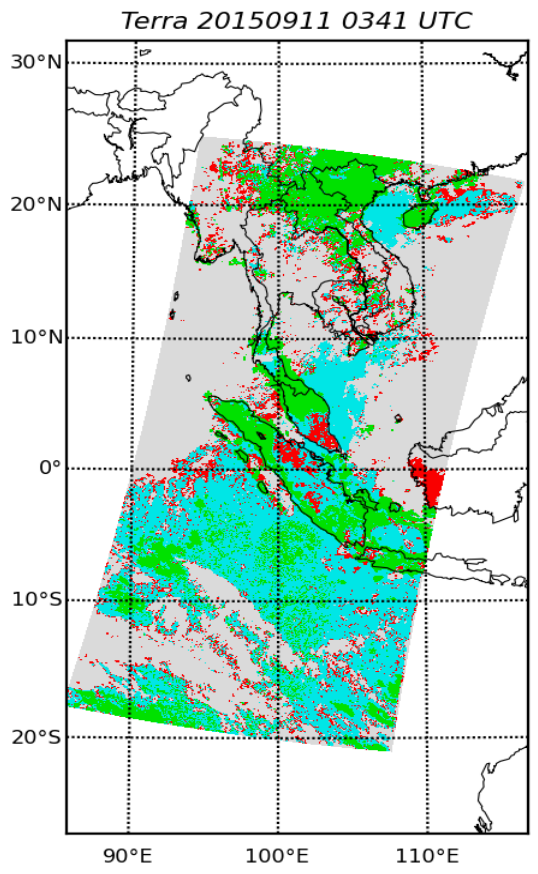


MODIS 3km Aerosol Optical Depth



MODIS Cloud Mask



Imagery from MODIS instrument on AQUA and TERRA satellites.

Potential of Himawari-8/9 geo-stationary Satellite.

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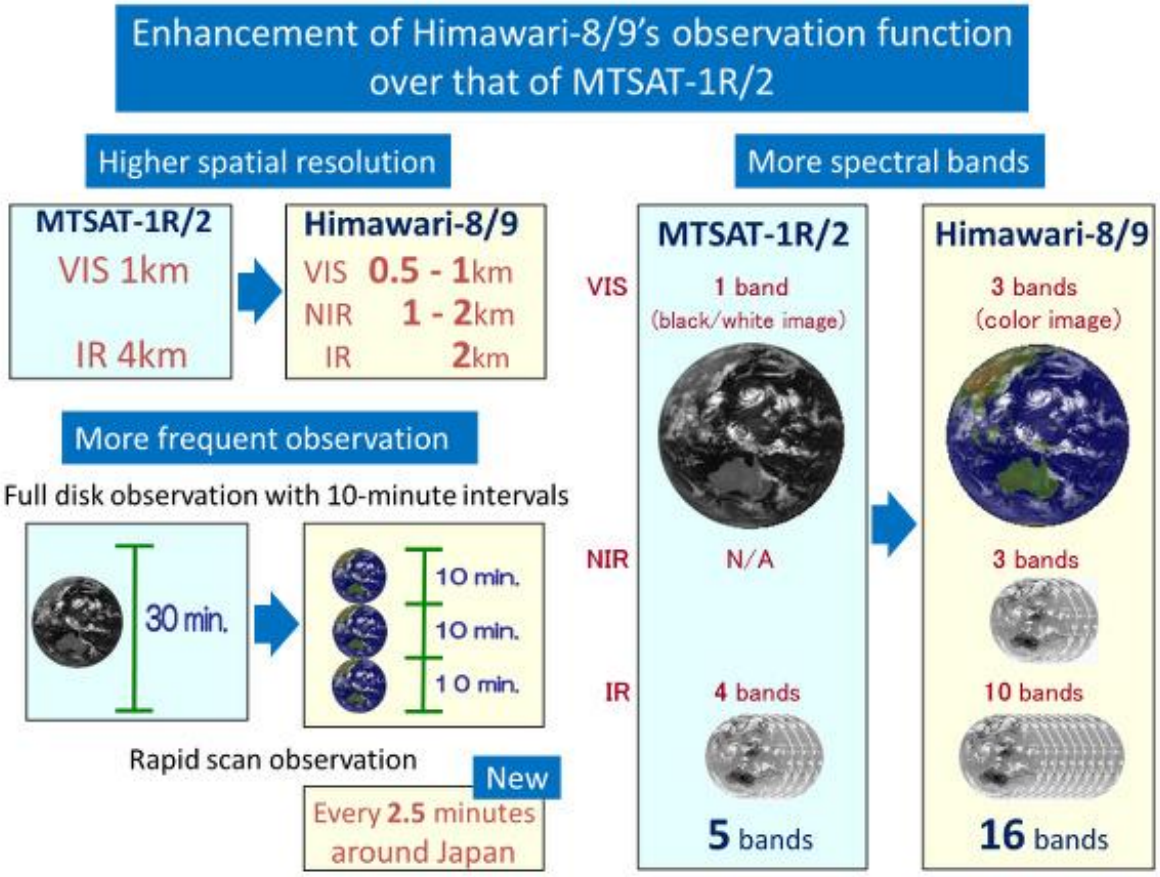
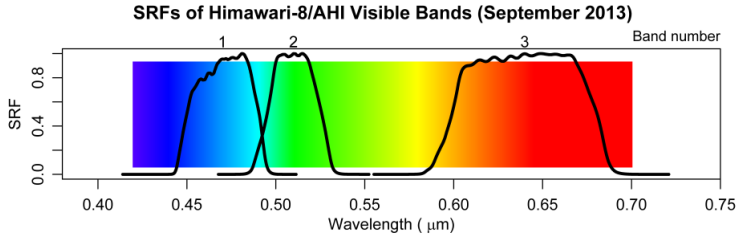
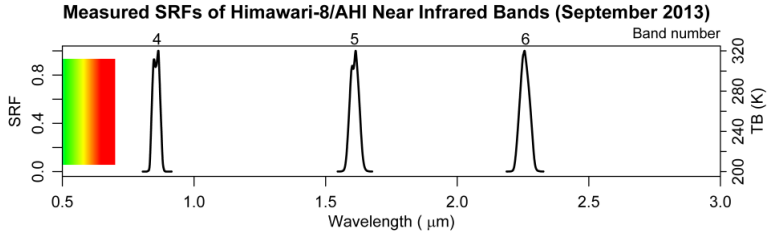
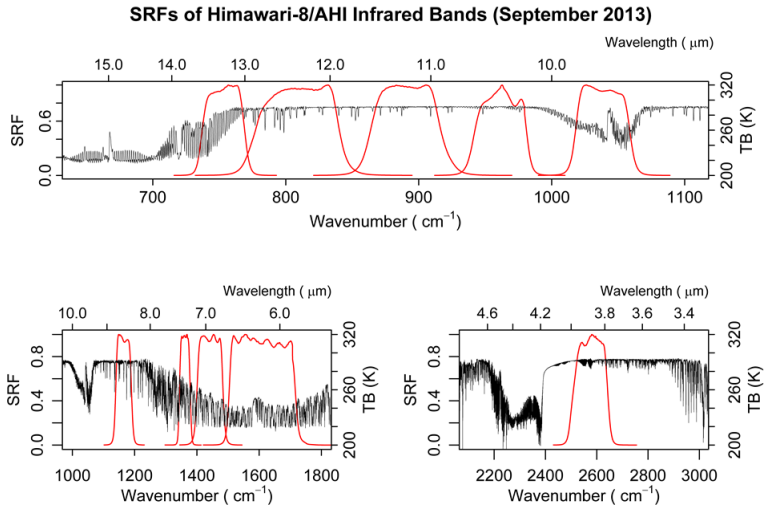
Besides MODIS/NPP we could use geostationary satellites like the newly launched Himawari-8/9!!!





RGB VALUES FOR VISIBLE WAVELENGTHS by Dan Bruton (http://www.physics.sfasu.edu/astro/color/spectra.html)





Centre for Remote Imaging, Sensing and Processing

NUS National University of Singapore

Forward aerosol trajectory modeling.

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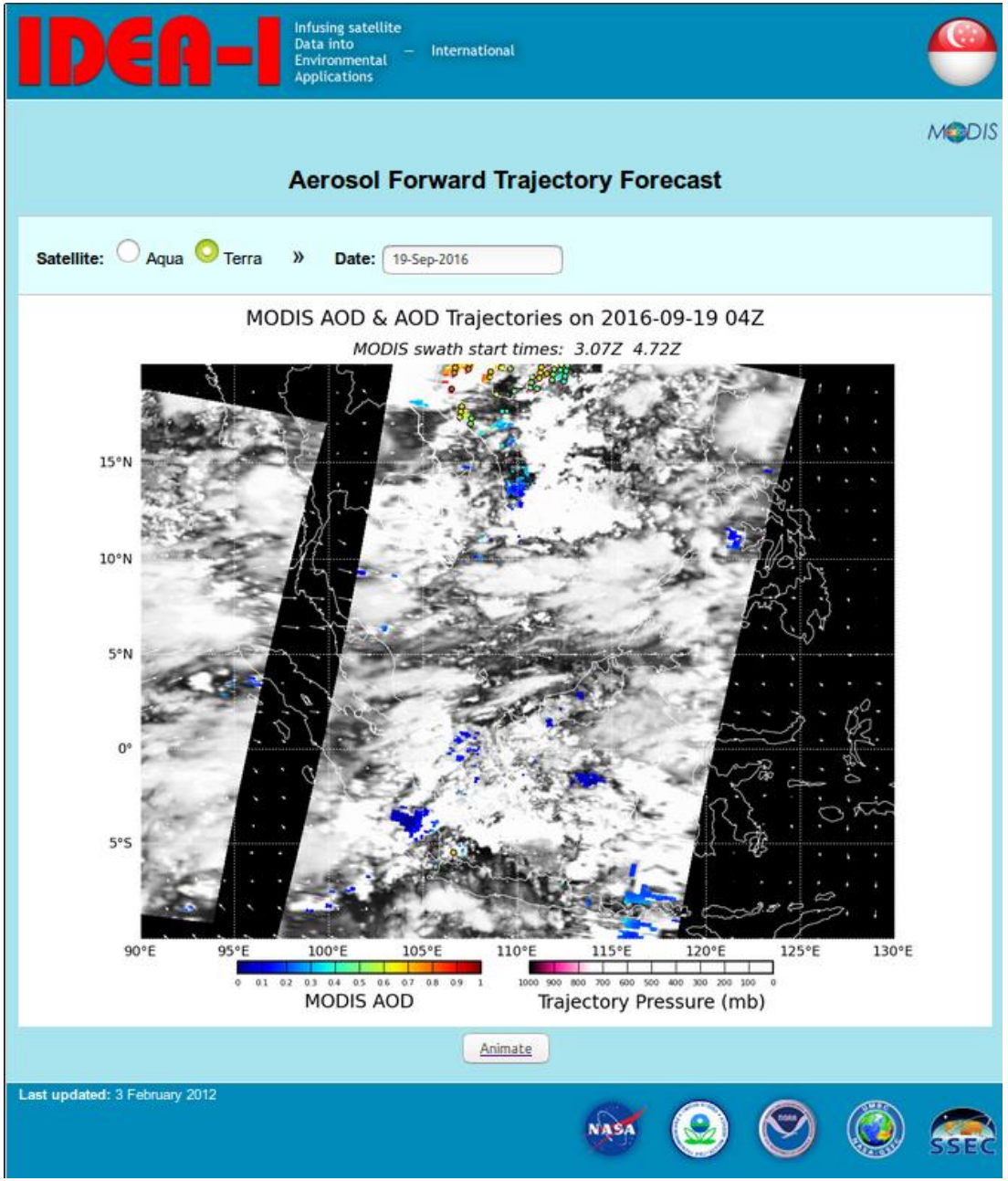


Forward aerosol trajectory modeling.

National University of Singapore

IMAPP MODIS Aerosol
Air Quality Forecast and Analysis
software package, IDEA-I software

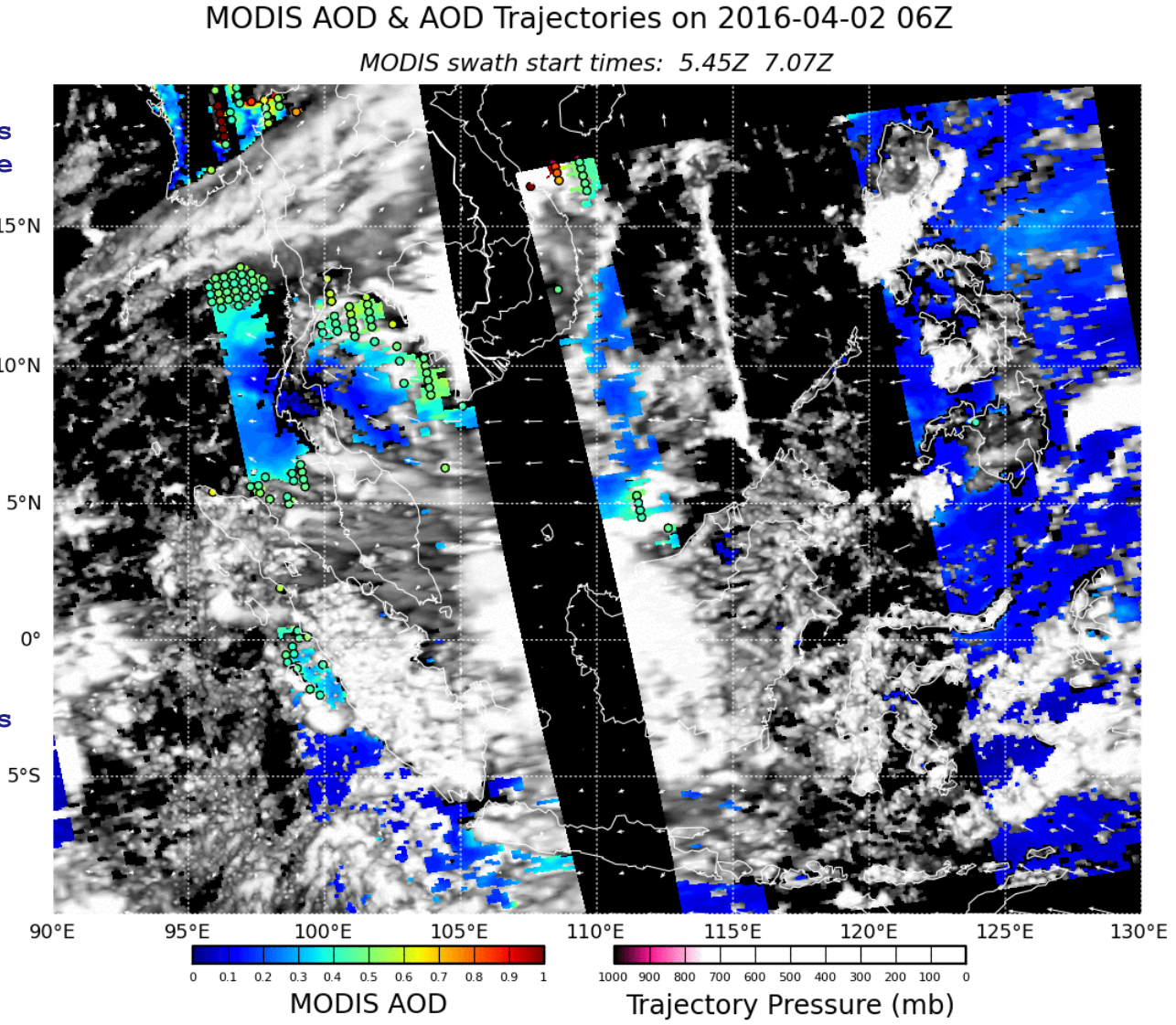
-) It supports direct broadcast users. It has a globally configurable scheme

-) Creates 48 hour 3 dimensional trajectory forecasts of aerosol pollution.

-) Terra and Aqua MODIS MOD04 Aerosol Optical Depth (AOD) retrievals are used to identify high aerosol loading.

-) A trajectory model is run to forecast the horizontal and vertical movement of the aerosols over the next 48 hours.

-) Winds are linearly interpolated in space and time from GFS forecasts which are stored at 3-hour intervals.



WRF-Chem modeling: 2013 smoke episode.

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Weather Research and Forecast (WRF) Model V. 3.6 with chemistry option.

WRF can generate atmospheric simulations using real data (observations, analyses) or idealized conditions

-) Major Haze episode: 18-24 June 2013. Simulation Period: 14-26 June 2013.

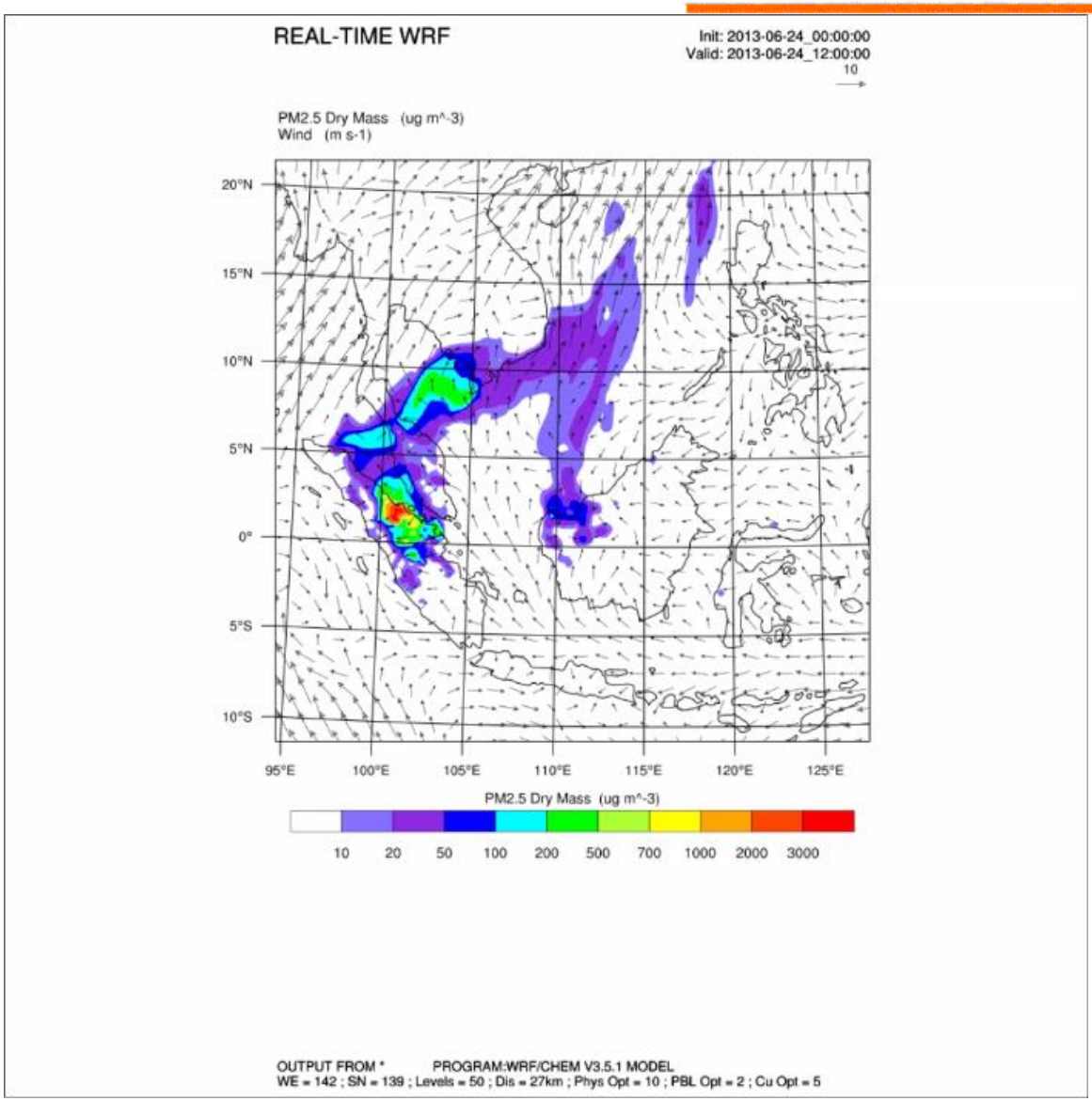
-) Domains: 2 (81km and 27km – so far simulation run with first domain as a test)

-) Vertical layers: 50

-) Global Analyses: NCEP-FNL

-) Source inventory: FLAMBE

-) 24 hours runs are restarted from previous day to account for change in daily emissions.



In a nutshell, our approach will need...

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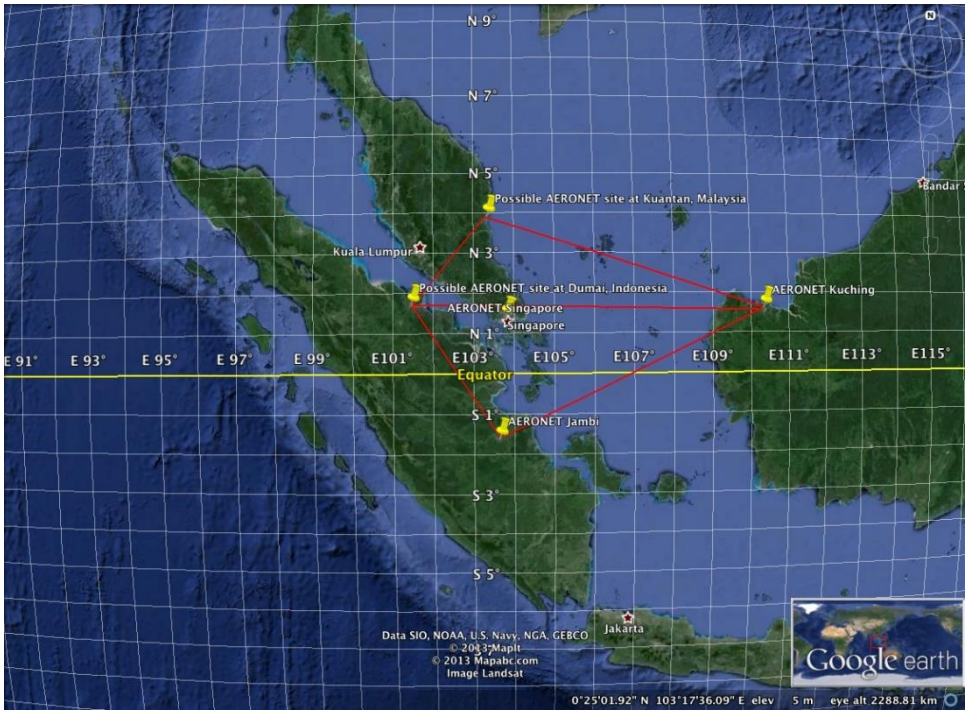
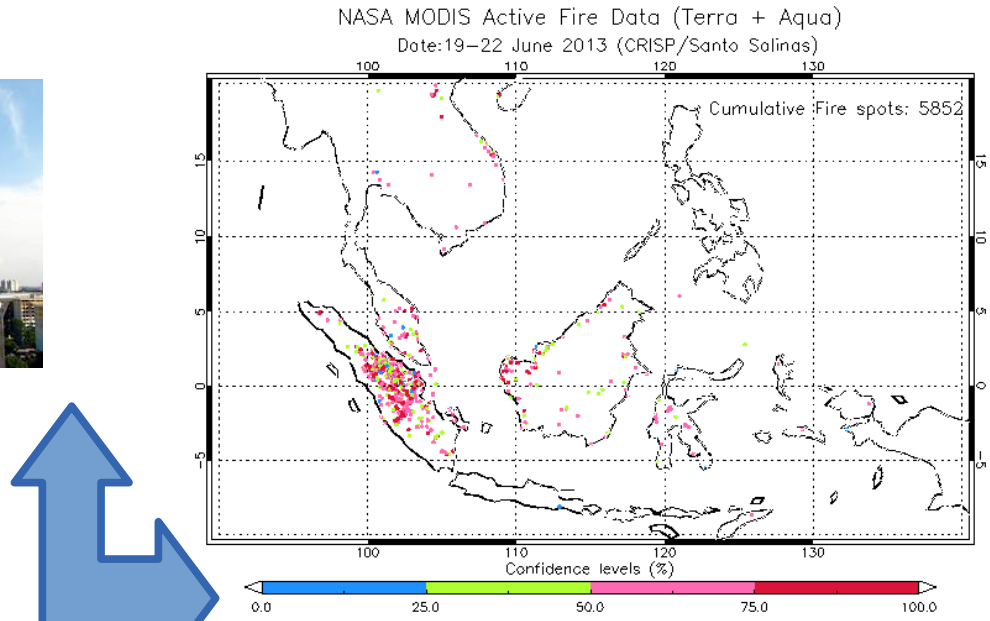
MODIS on Aqua and Terra

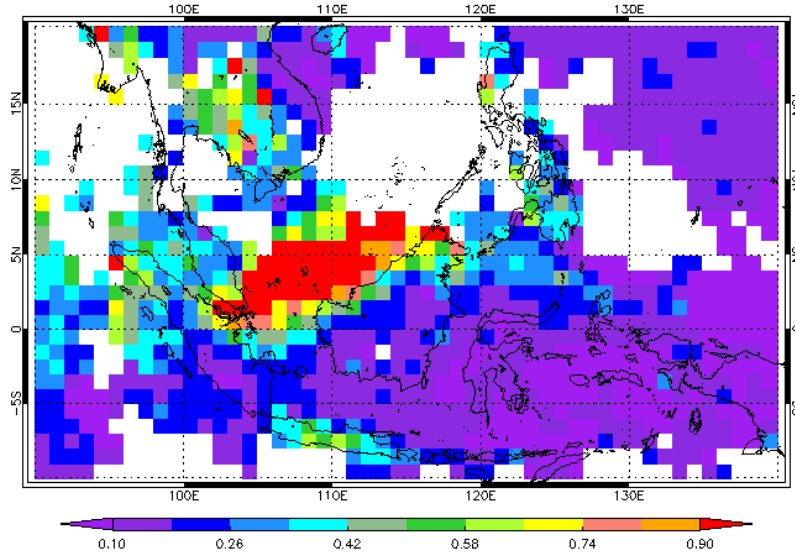
MPLNET

AERONET



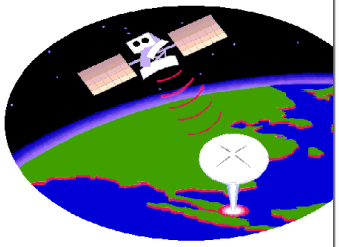
Local and regional ground campaigns

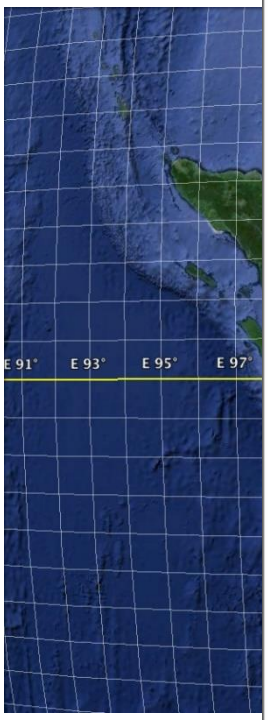




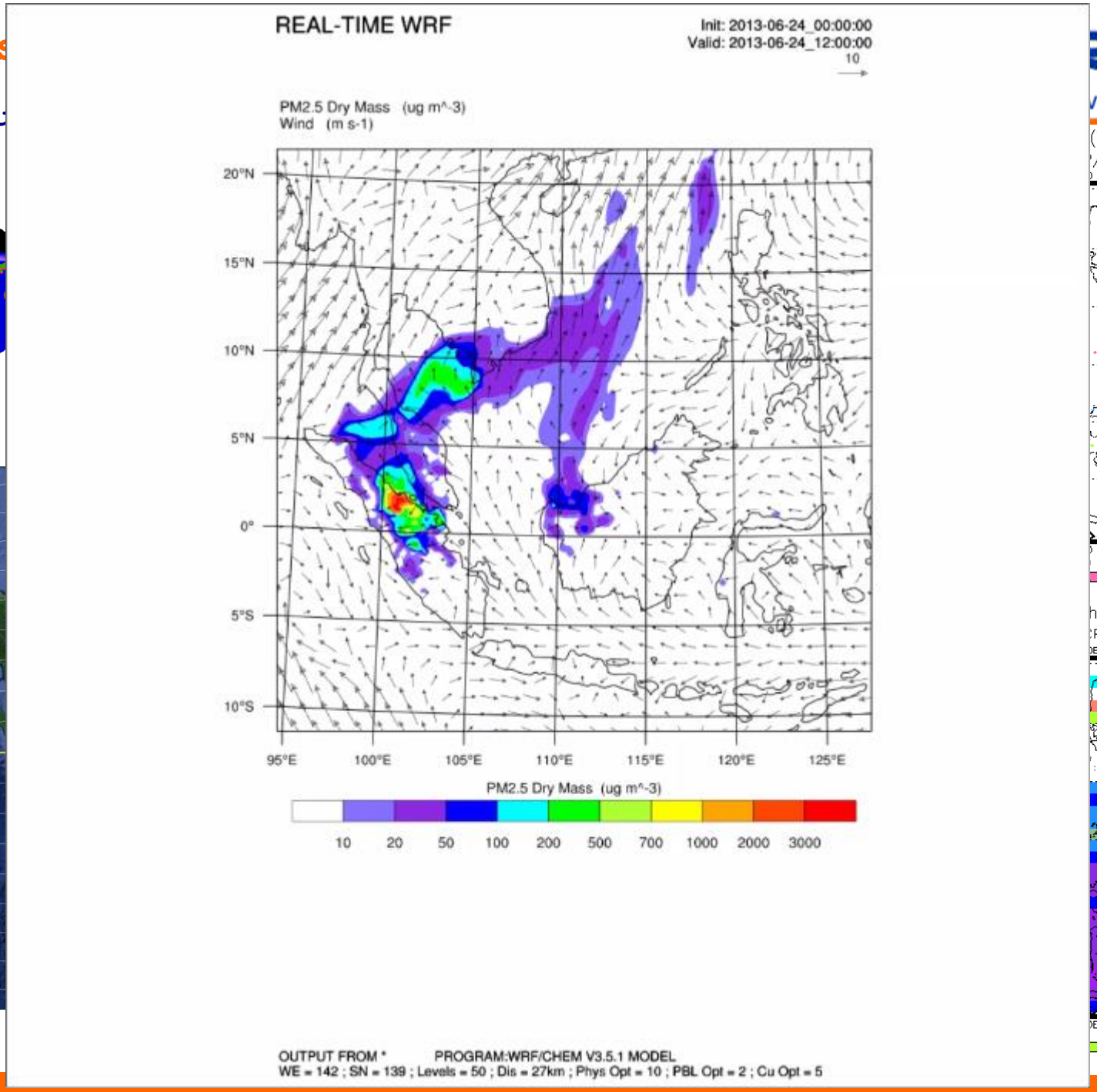
In a nuts

MODIS on Aqu
and Terra

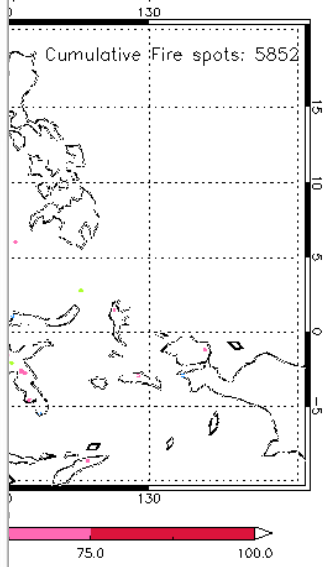




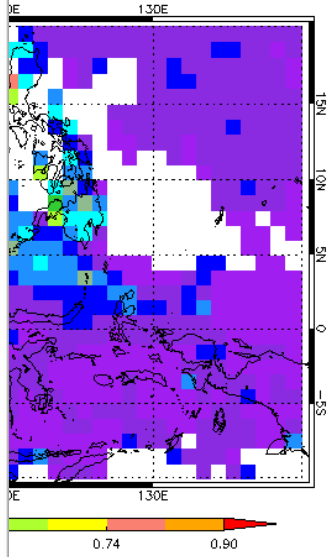
Local and



RISP
versity of Singapore
(Terra + Aqua)
/Santo Salinas)



h at 500nm [unitless]
RISP/Santo Salinas)



Summary

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- For severe pollution events, we propose a holistic approach that includes satellite, in-situ measurements and numerical modelling.
- Set up of a semi-mobile platform (photometer, lidar and PM2.5 samplers) deployed locally and regionally.
- Our aim is to reduce model and satellite uncertainty for the evolution and transport of trans-boundary smoke.
- To provide practical methods for in-situ, satellite and model based estimates of AOD and PM2.5.
- Enhancing our existing monitoring capabilities of in-situ and satellite remote sensing to provide forecasting via modelling.
- Scientific collaborations are welcome! We are looking for WRF/GEOS-Chem/CMAQ modellers, Anyone? Talk to us!

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The most recent trans-boundary smoke episode ...

The AUG-OCT 2015 smoke episode

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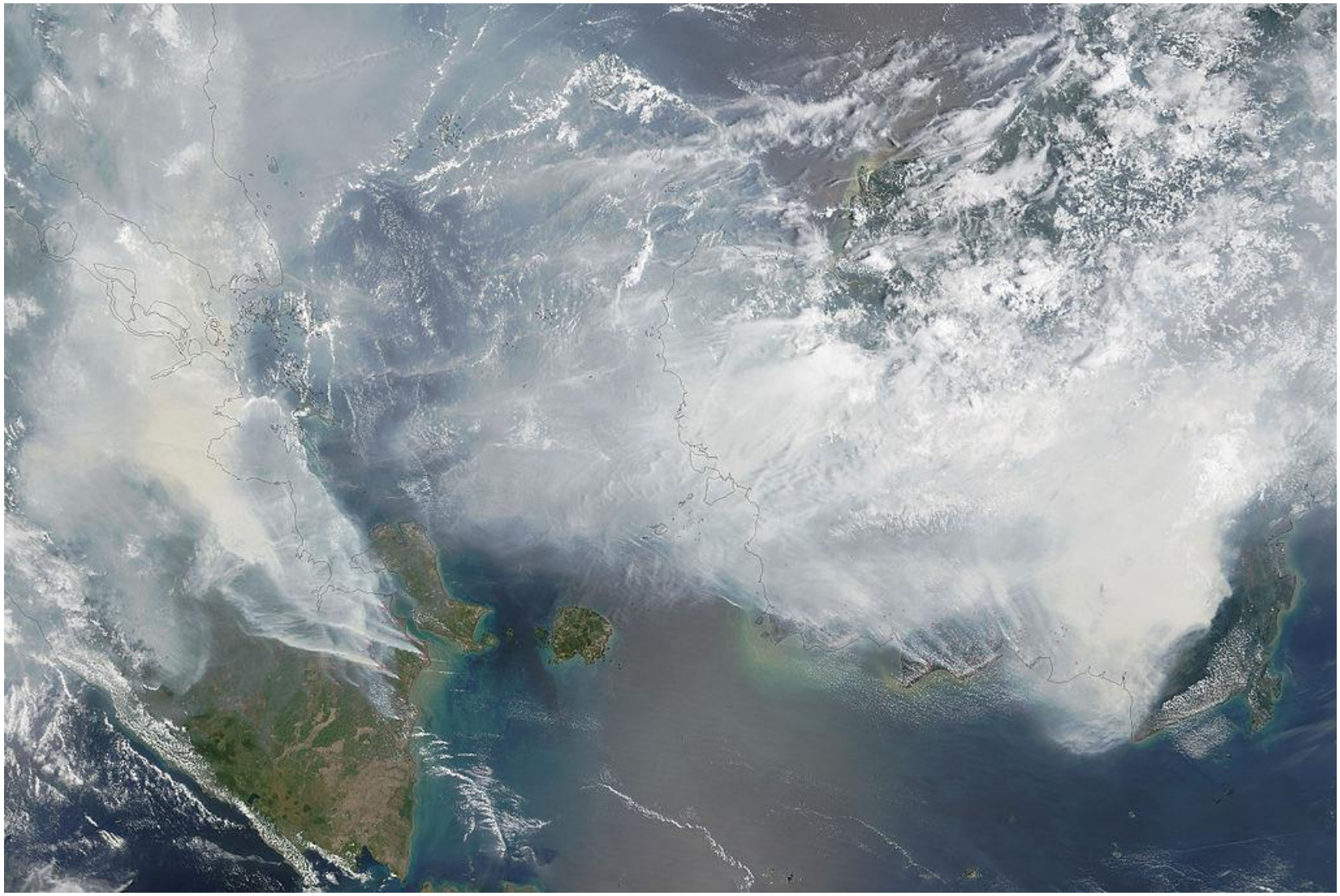

Fig. 1. Trans-boundary smoke recorded by Satellite. Image corresponds to 24th September

The AUG-OCT 2015 smoke episode

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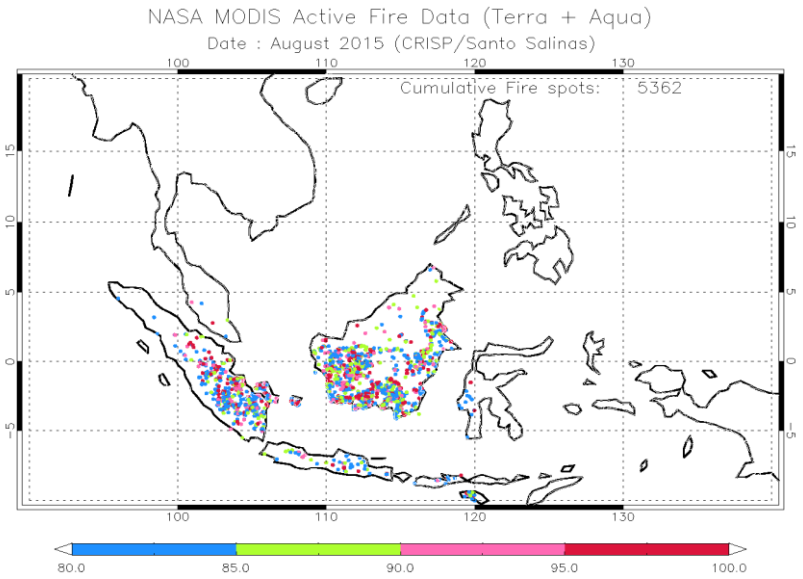

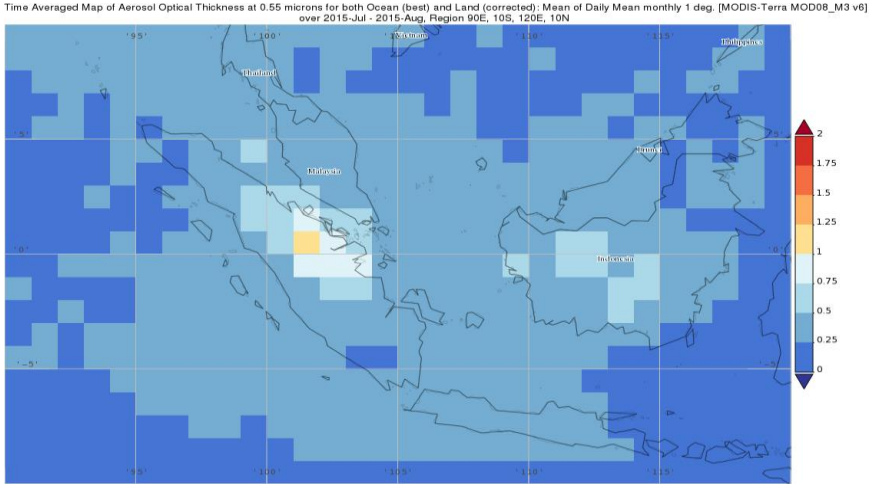

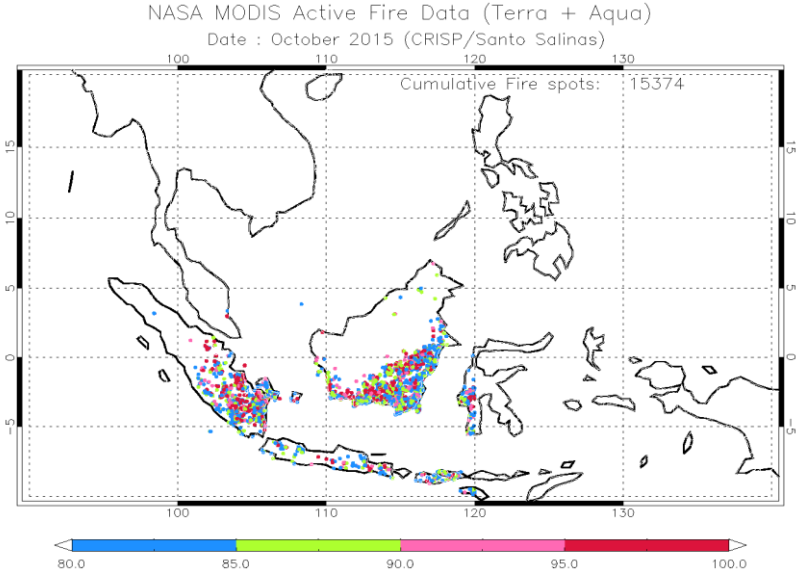

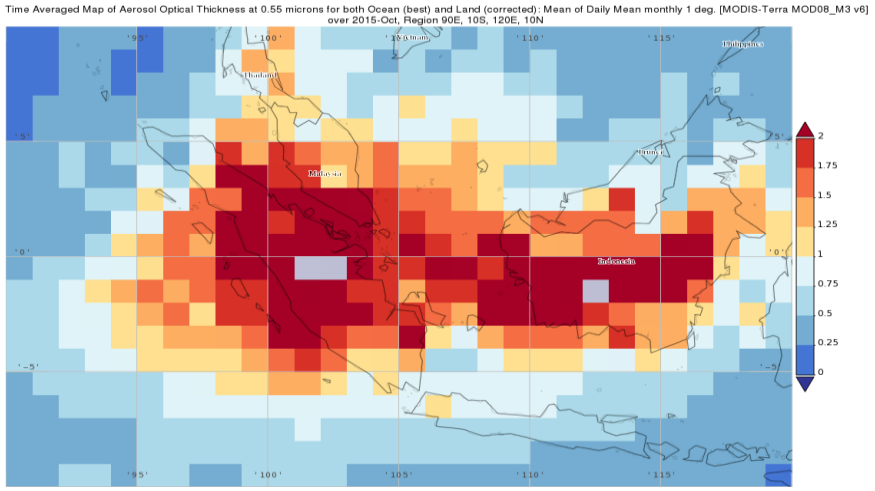

Fig. 2. Monthly fire spot count and cumulative aerosol optical depth as detected by the MODIS instrument on Aqua/Terra Satellites.

The AUG-OCT 2015 smoke episode

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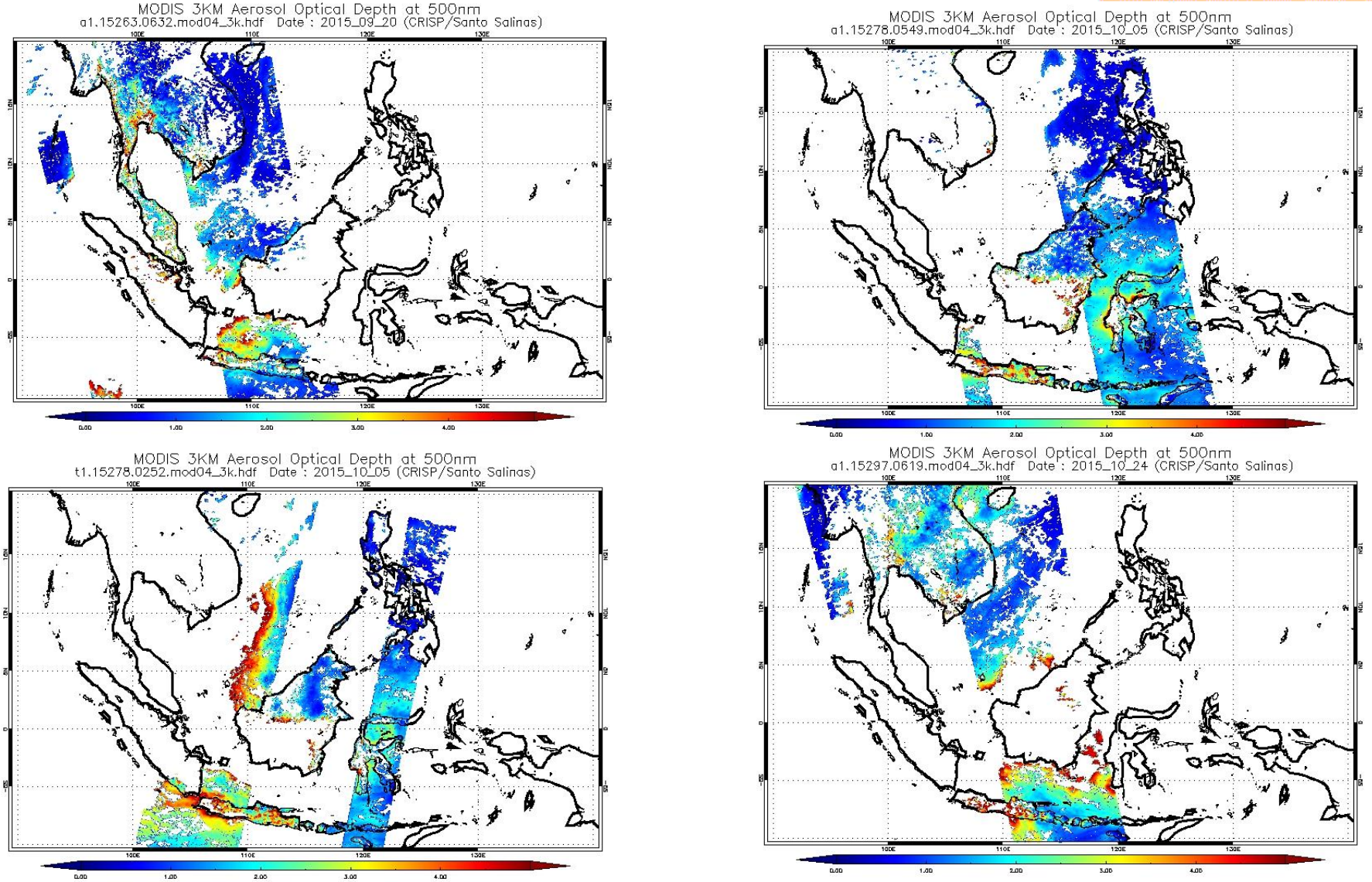

Fig. 3. Daily aerosol optical depth as detected by the MODIS instrument on Aqua/Terra Satellites.

AUG-OCT 2015 Photometer view

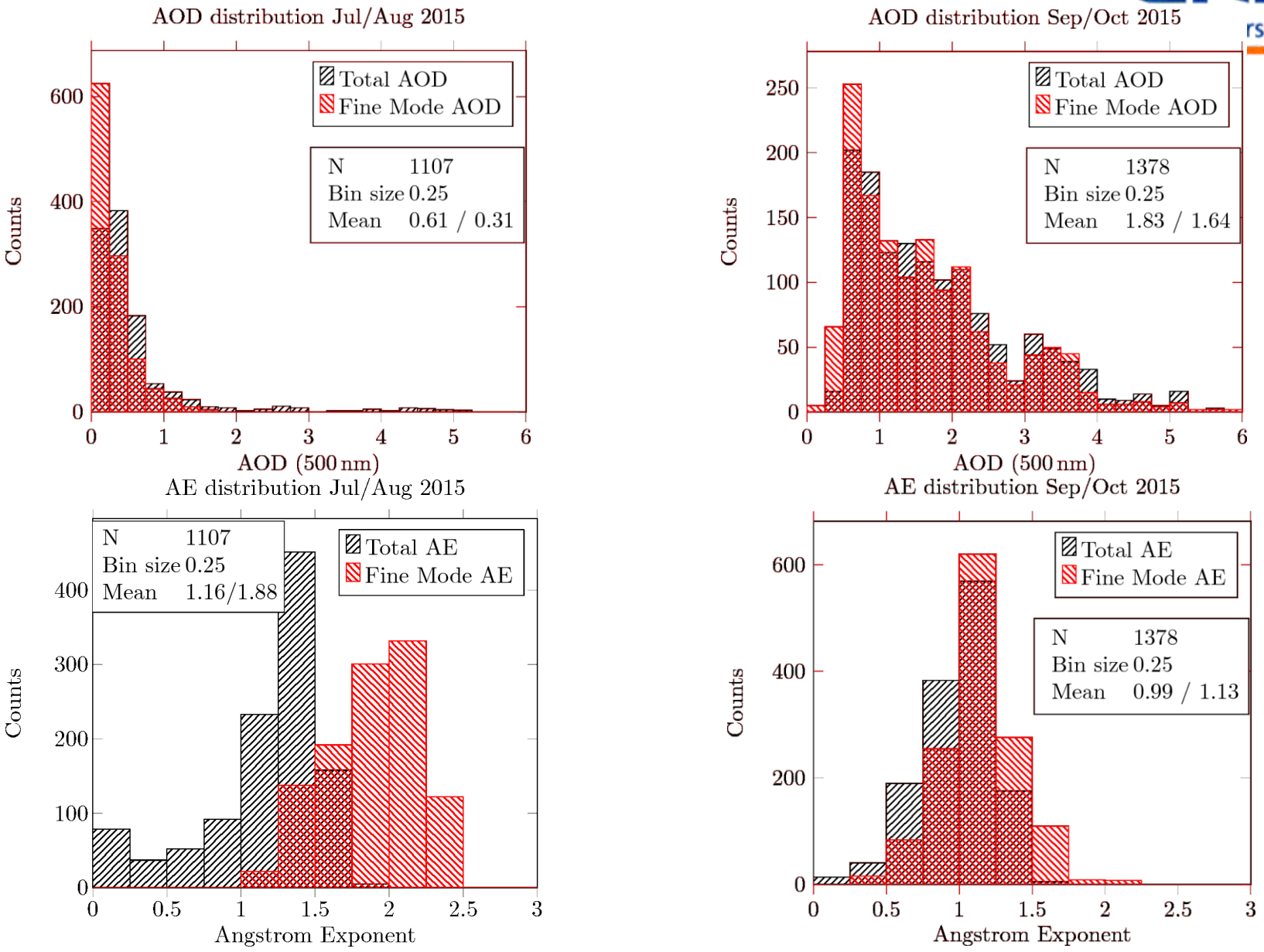

Fig. 4. Aerosol particle size classification and size distributions for Singapore.

AUG-OCT 2015 Photometer view

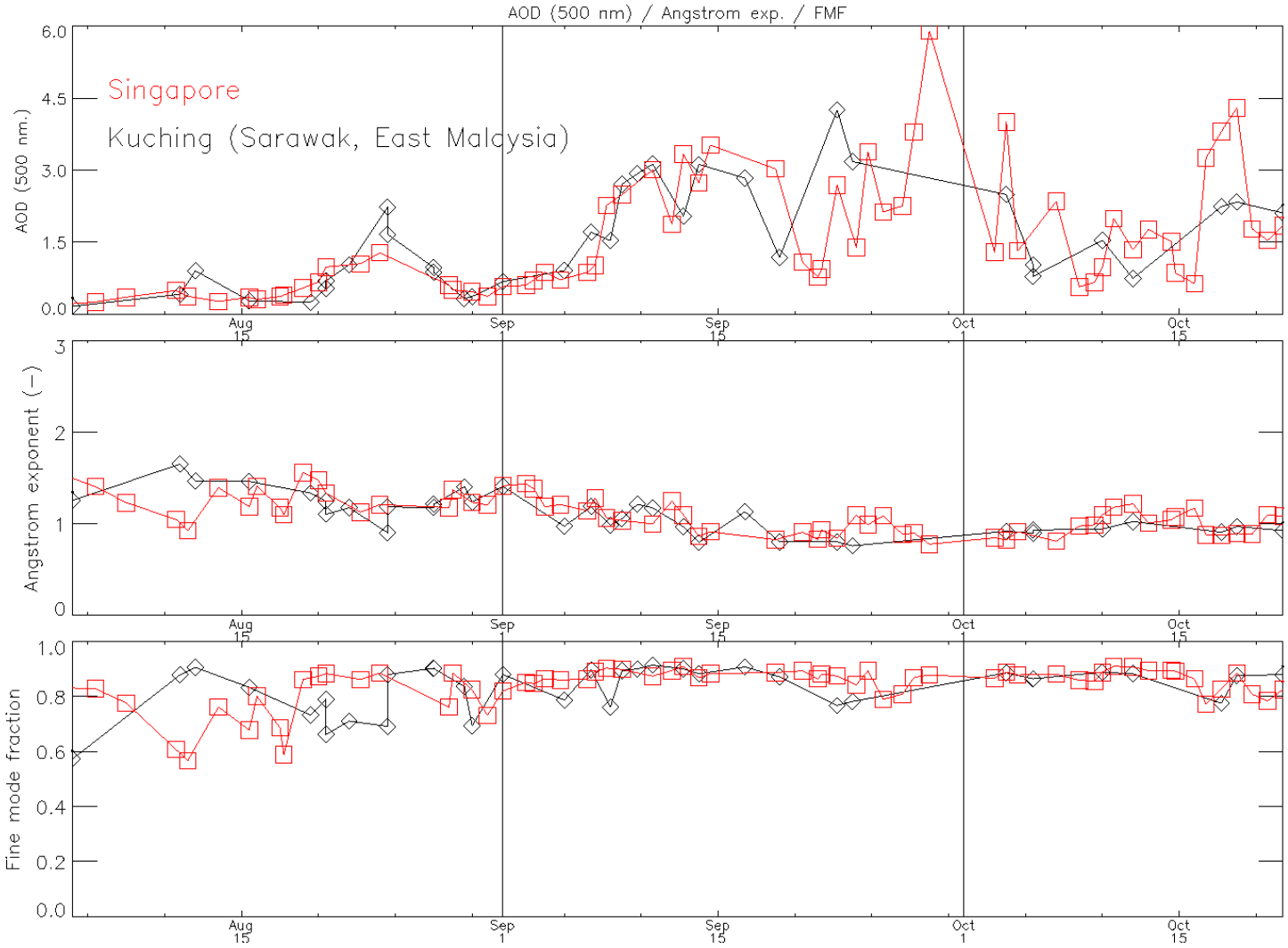

Fig. 5. Time series of daily averages of AOD, Angstrom exp. Number and fine mode fraction for both Singapore and Kuching city.

AUG-OCT 2015 PM2.5 vs AOD (fine mode)

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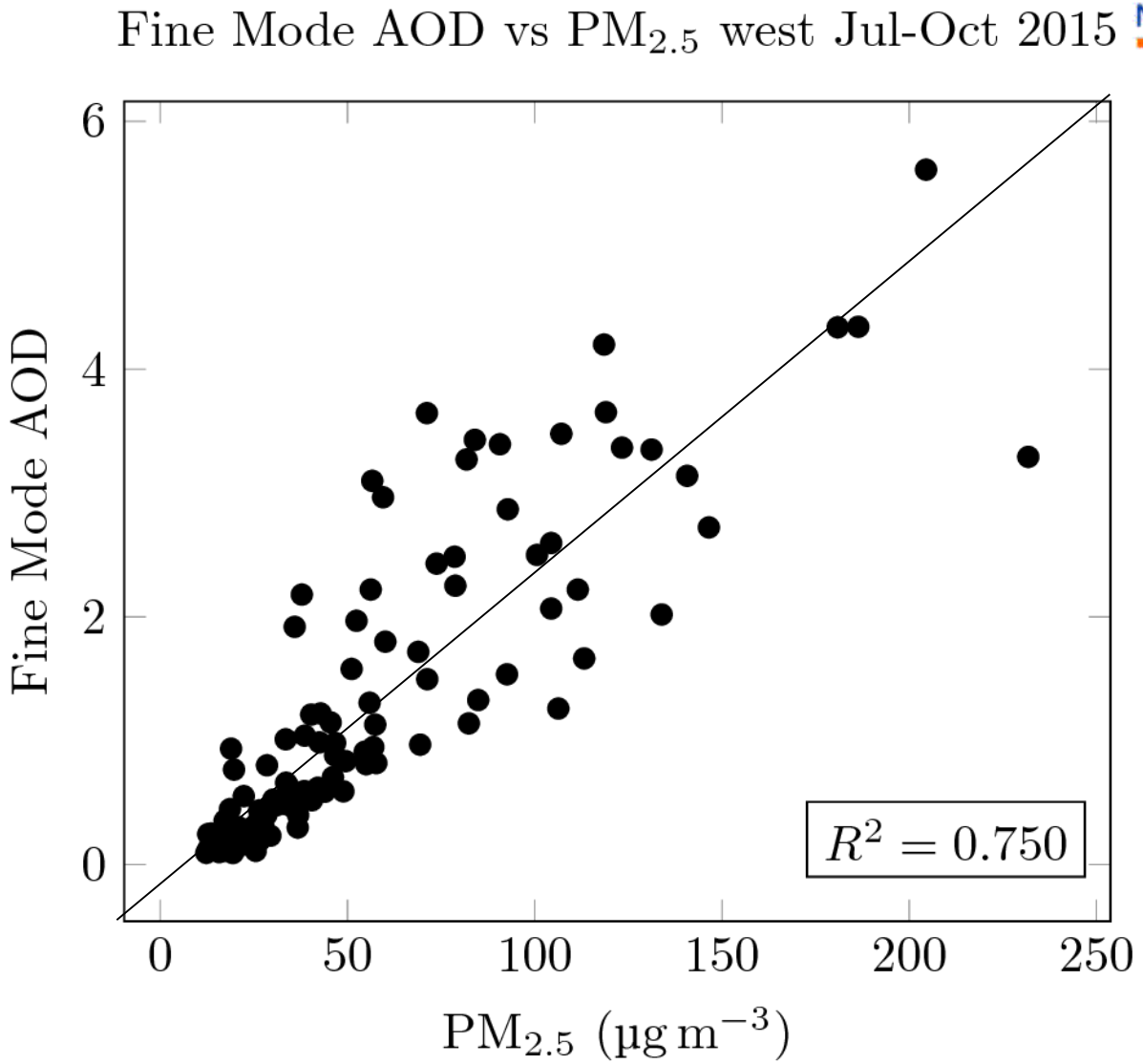

Fig. 6. Scatter plot of fine mode aerosol optical depth versus PM 2.5 for the months of July to October 2015 in Singapore..