Vietnam Academy of Science and Technology (VAST)
Institute of Geophysics (IGP)

Introduction to Aerosol-Related Research at IGP, VAST

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Outlines

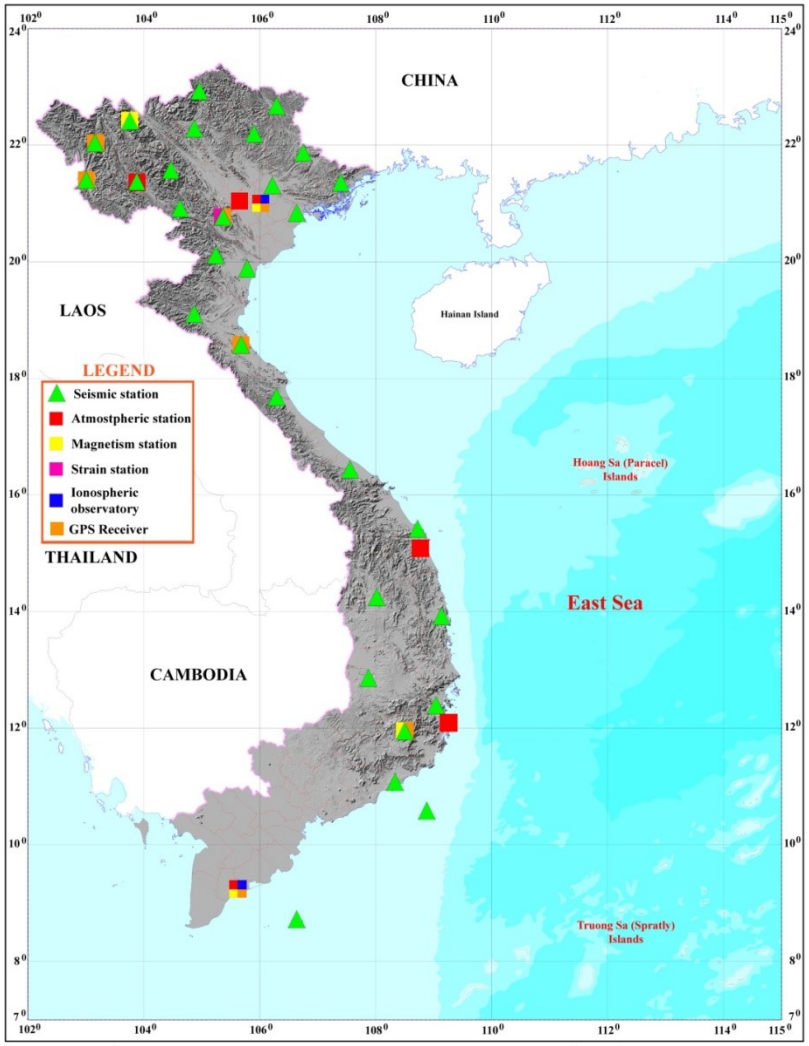
1. Introduction

2. Aerosol-Related Research Results

3. Possible connections to 7-SEAS in the near future

Introduction

IGP National Geophysical Station Network

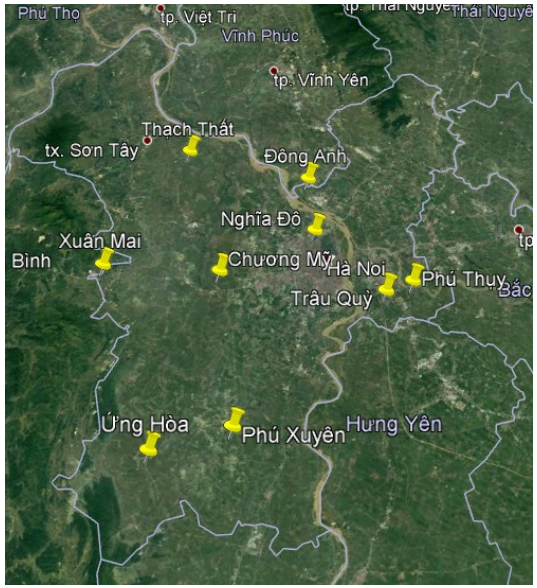


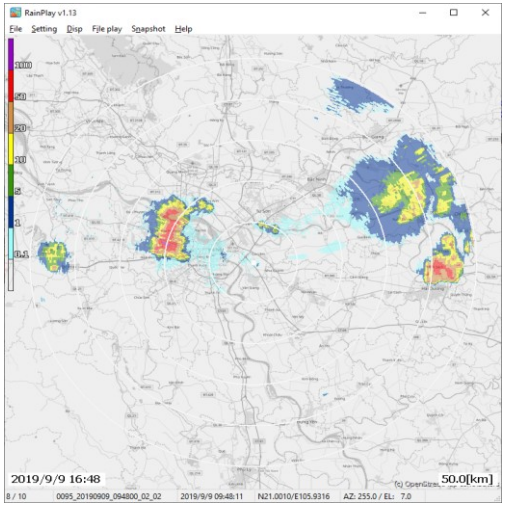
Climate in Vietnam

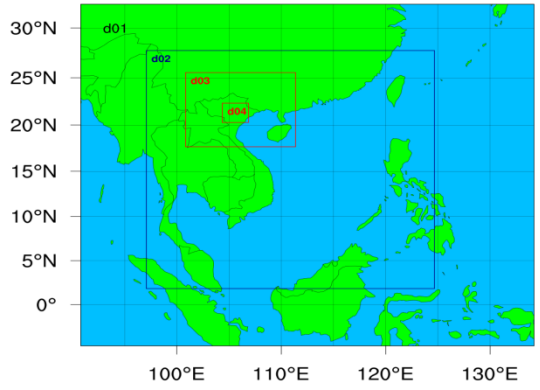
- Monsoon;
- Complicated Topography;
- Long Coast;
- Typhoons(8/years);
- Floods, droughts;
- 100 rainy days
- (1,500 to 2,000mm)
- Humidity (80%)
- The sunny hours (2,000)
- 100 kcal/cm2 in a year.
- 7 climatic zones
- (35 microclimatic zones)

Introduction

IGP Hanoi Atmospheric Station Network







Introduction

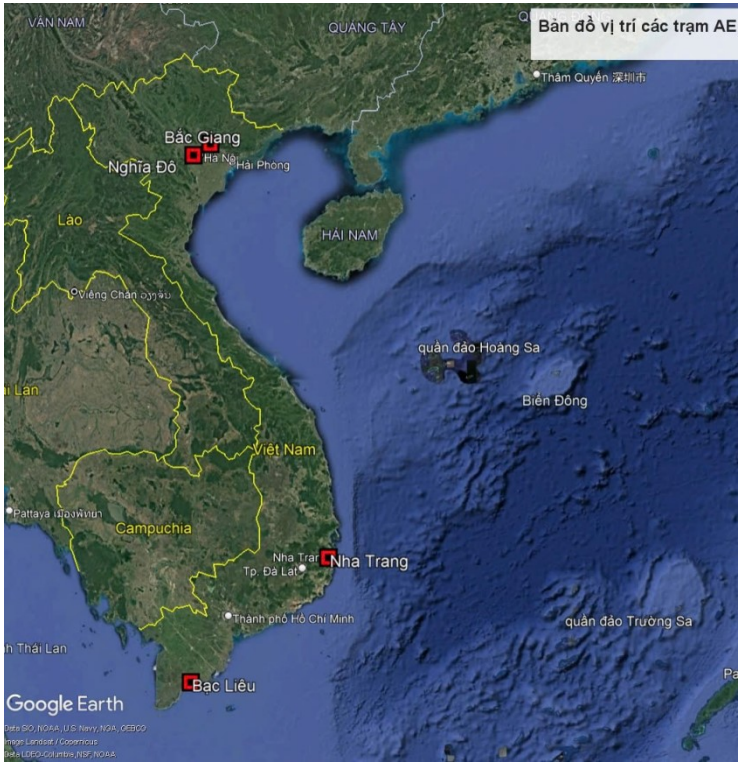
Introduction

- AErosol RObotic NETwork –AERONET (2003)
- Program to Study Pollution-Meteorology Feedbacks in Southeast Asia - 7 SEAS (2007)
- Micro-Pulse Lidar Network –MPLNET (2011)
- 7-SEAS/BASELInE (Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles and Interactions Experiment (2012)

AERONET DATA in Vietnam

Nghia Do station
(from 2010)

http://aeronet.gsfc.nasa.gov/



Bac Giang station
(2003-2009)

Bac Lieu station
(from 2003)

Nha Trang station
(2011-2014)

Comparison of AOD from MODIS and AERONET

Duration of observation at AERONET sites in Vietnam

Level 2.0

- Bac Giang: 634 days
- Nha Trang: 368 days
- Nghia Do: 253 days
- Bac Lieu: 759 days

The MODIS/Terra data:

Artist' view of the Terra spacecraft in orbit (image credit: NASA)

http://www2.hawaii.edu/~jmaurer/terra/

- Level 2.0 MODIS data (MOD_L2) from the Terra platform
- Spatial resolution of a 10x10km

Comparison of AOD from MODIS and AERONET

Methods

Calculate the MODIS data

- Retrieve MODIS AOD in a square box of 50 km x 50 km (5x5 pixels) centered over AERONET sites.

- Interpolate the AOD value of pixels to AERONET sites.

Calculate the AERONET data

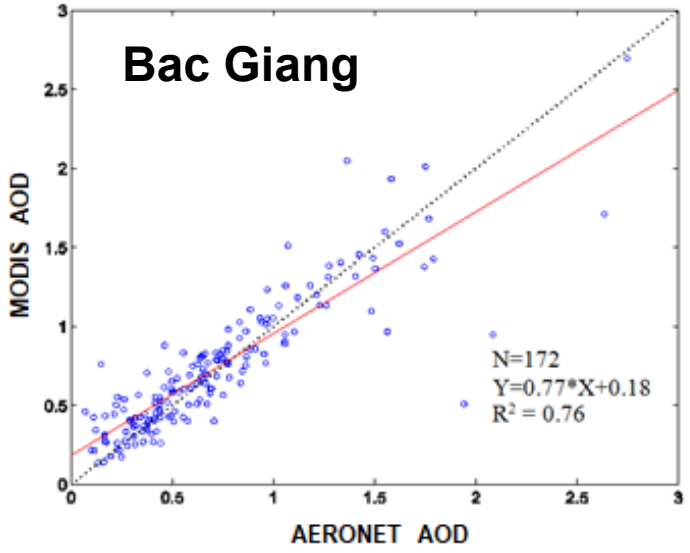
- Retrieve AERONET AOD within ±15 min of the MODIS overpass time

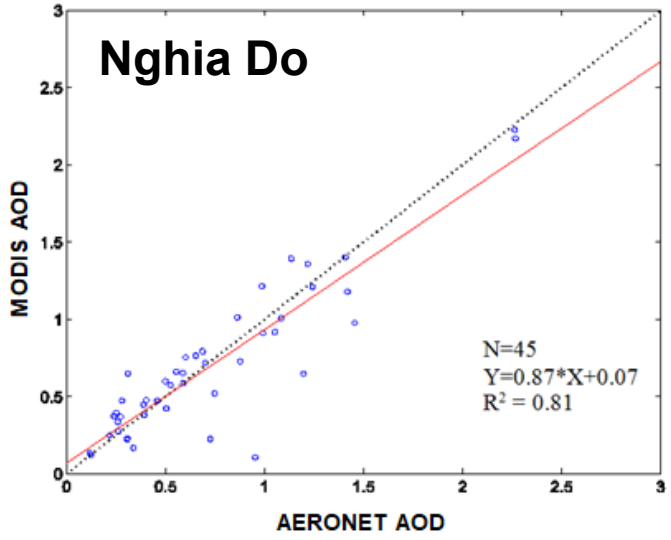
- Interpolate the AOD value at 0.55μm from the AOD value at 0.50μm *(Eck et al, 1999; Tripathi et al.*, 2005)

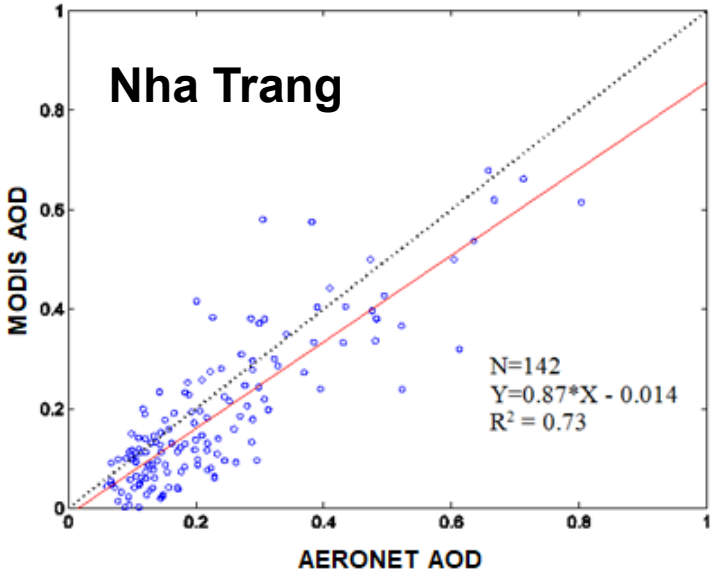
$$\tau_{0.55\,\mu m} = \frac{\tau_{0.5\,\mu m}}{e^{-\alpha_{0.44\,\mu m - 0.67\,\mu m} \ln \frac{0.5}{0.55}}}$$

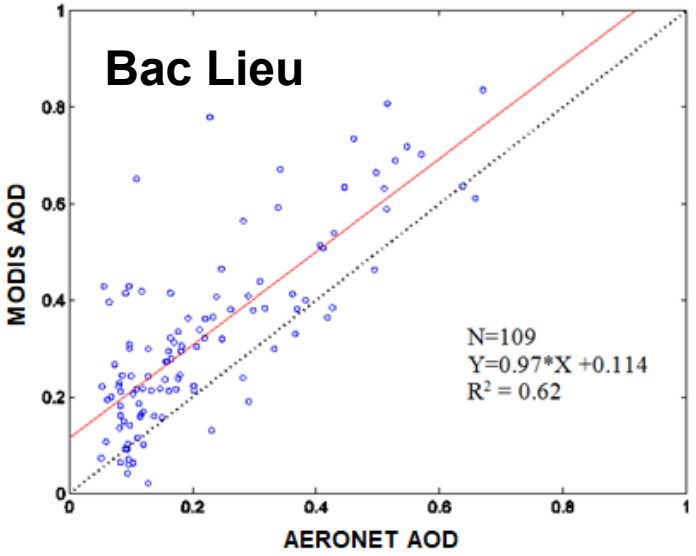
Comparison of AOD from MODIS and AERONET

Scatter plot between AOD derived from MODIS and AERONET









Comparison of AOD from MODIS and AERONET

Results of comparison of MODIS AOD and AERONET AOD over Vietnam show that:

1, There is a good agreement/ between MODIS and AERONET at Bac Giang with the mean absolute difference =0.09; Roots mean square error =0.23; Correlation coefficient = 0.87.

2, There is a good coincidence between MODIS and AERONET at Nghia Do with the mean absolute difference =0.13; Roots mean square error =0.22; Correlation coefficient = 0.90.

3, MODIS underestimate at Nha Trang station with the mean absolute difference =0.05; Roots mean square error =0.09; Correlation coefficient = 0.85.

4, MODIS overestimate at Bac Lieu with the mean absolute difference =0.11; Roots mean square error =0.16; Correlation coefficient = 0.79.

Data

- AOD from AERONET (AErosol RObotic NETwork)

  http://aeronet.gsfc.nasa.gov/data_menu.html

- AOD from MODIS (MODerate resolution Imaging Spectroradiometer)

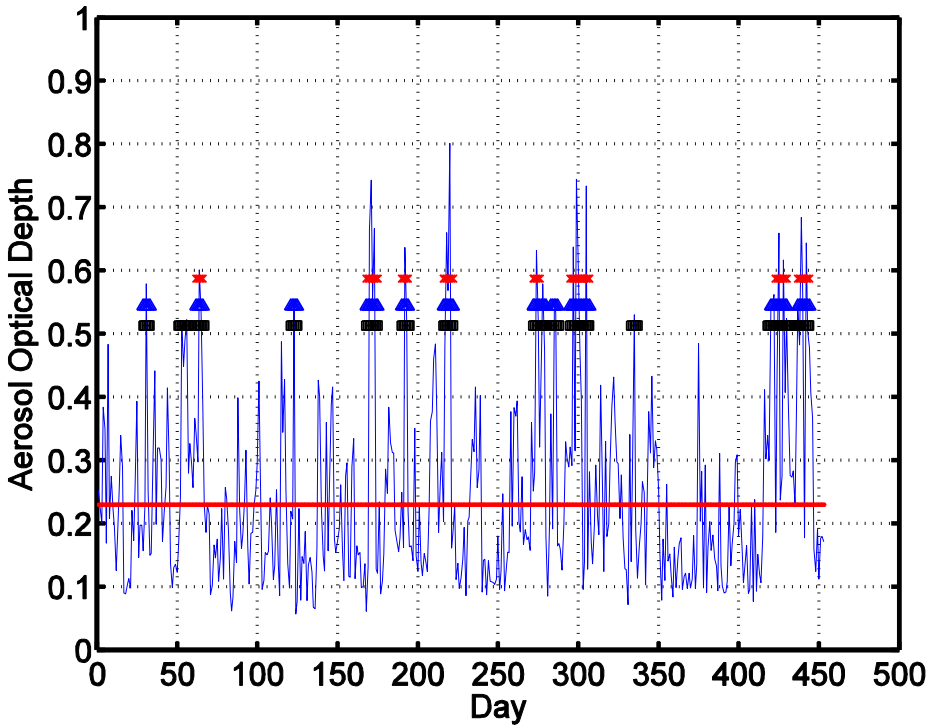
  ftp://windhoek.nascom.nasa.gov/pub/ridgway/daily_aod_binaries/

- Climate data from NCEP/DOE-2(the National Centers for Environmental Prediction/ Department of Energy – Reanalys 2)

  http://www.cdc.noaa.gov/cgi-bin/db_search/SearchMenus.pl

The Temporal Variability of AOD in Bac Lieu from AERONET Data

Variation of AOD in Bac Lieu (2003–2009)



- Mean = 0.23; Std = 0.14
- Positive Anomaly level 1 (PA1) = Mean+1.86*std= 0.51
- Positive Anomaly level 2 (PA2) = Mean+1.86*std= 0.54
- Positive Anomaly level 1= = Mean+1.86*std= 0.59

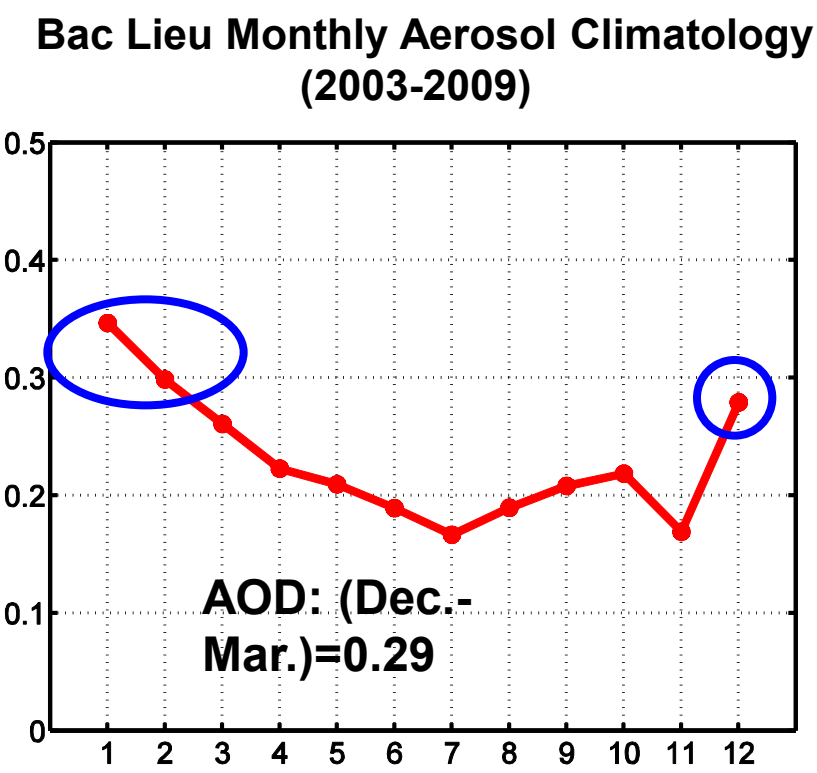
PA1 : total = 35,

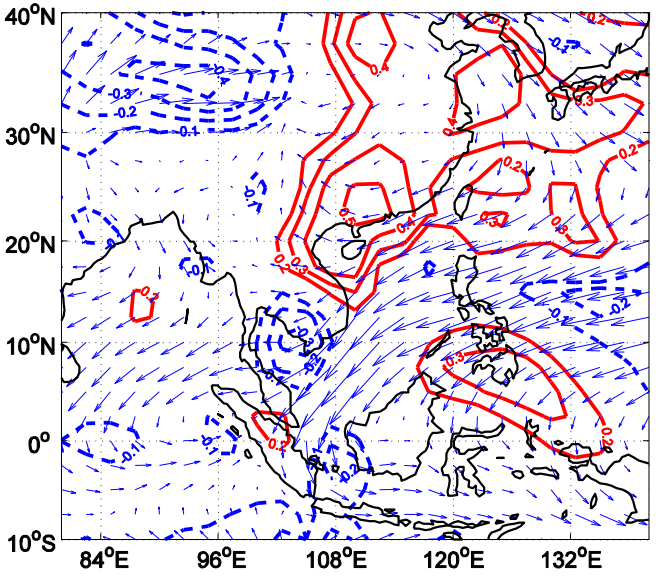
PA1 in (Dec.-Feb.) = 20.

=> Positive Anomaly of AOD at Bac Lieu appears in the middle of Winter (December, Juanary and Febrary)

THE VARIABILITY OF AOD OVER VIETNAM

The Temporal Variability of AOD in Bac Lieu from AERONET Data





Corr. : Wind and AOD

R_{max} = 0.5 in Southeastern China

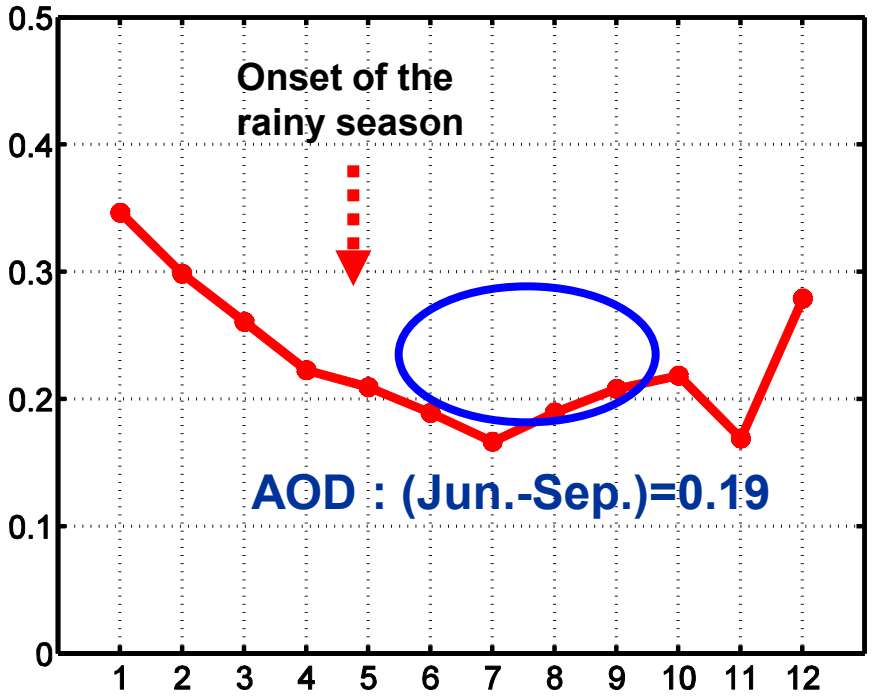
=> The variation of AOD in Bac is affected by the East Asia winter monsoon.

Pham X.T., Nguyen X.A. et al, 2012a

THE VARIABILITY OF AOD OVER VIETNAM

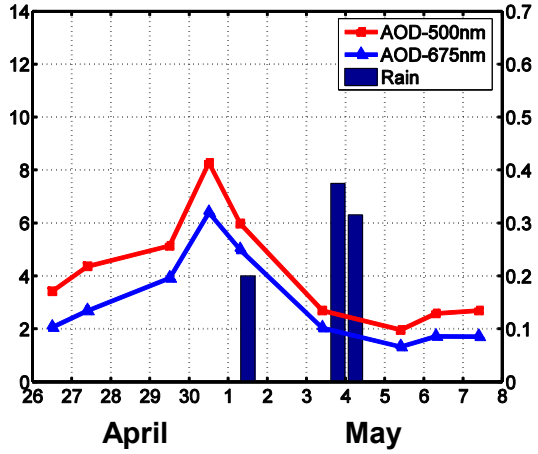
The Temporal Variability of AOD in Bac Lieu from AERONET Data

Bac Lieu Monthly Aerosol Climatology (2003-2009)

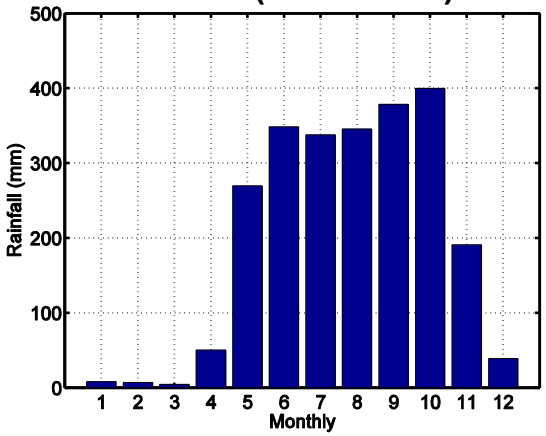


=> The difference of AOD_500nm in Bac Lieu between rainfall season (Jun. – Sep.) and dry season (Dec. – Mar.) is 0.1.

Onset of the rainy season in 2003



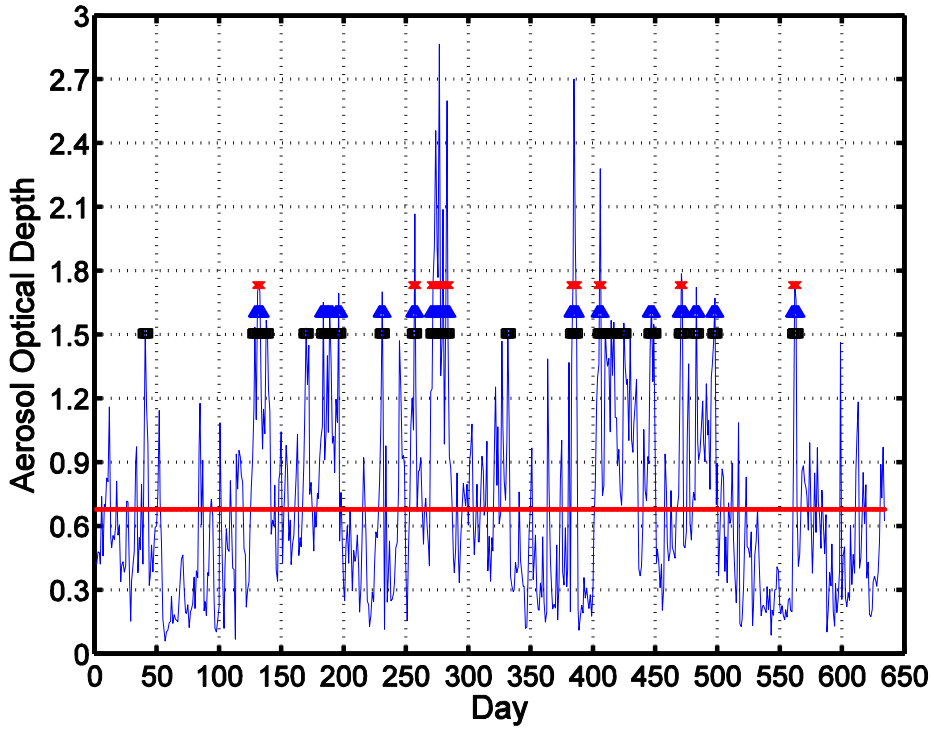
Bac Lieu Monthly Rainy Climatology (2003-2009)



Pham X.T., Nguyen X.A et al, 2011

The Temporal Variability of AOD in Bac Giang from AERONET Data

Variation of AOD in Bac Giang (2003–2009)



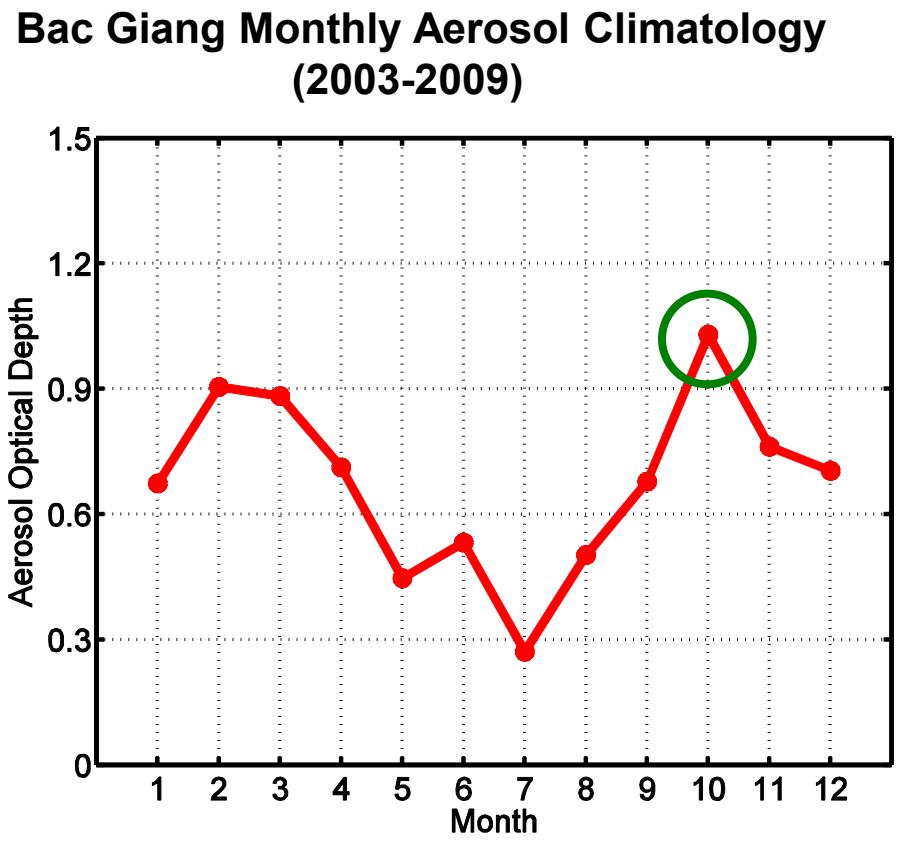
- Mean = 0.68; Std = 0.45
- Positive Anomaly level 1 (PA1) = Mean+1.86*std= 1.51
- Positive Anomaly level 2 (PA2) = Mean+1.86*std= 1.60
- Positive Anomaly level 1= = Mean+1.86*std= 1.73

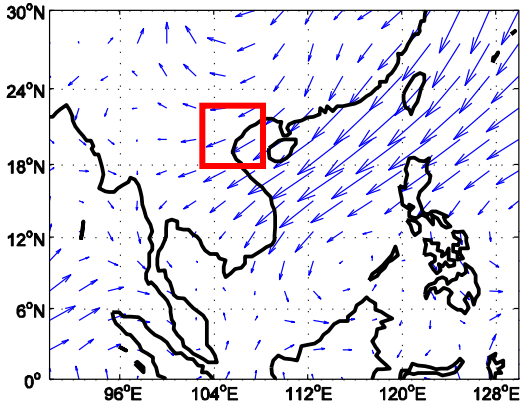
PA1: total = 38,

PA1 in (Oct.+Feb.+Mar.) = 18.

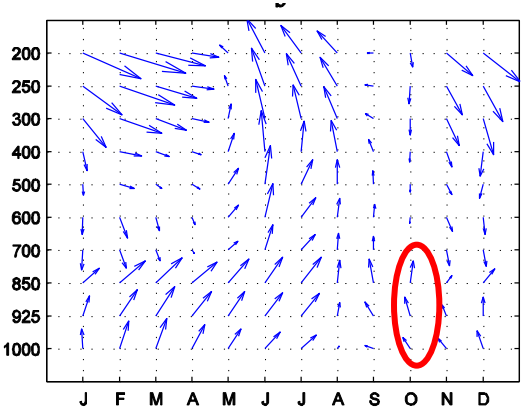
=> Positive Anomaly of AOD at Bac Giang appears in the early winter (October) and the last winter (February, March)

The Temporal Variability of AOD in Bac Giang from AERONET Data





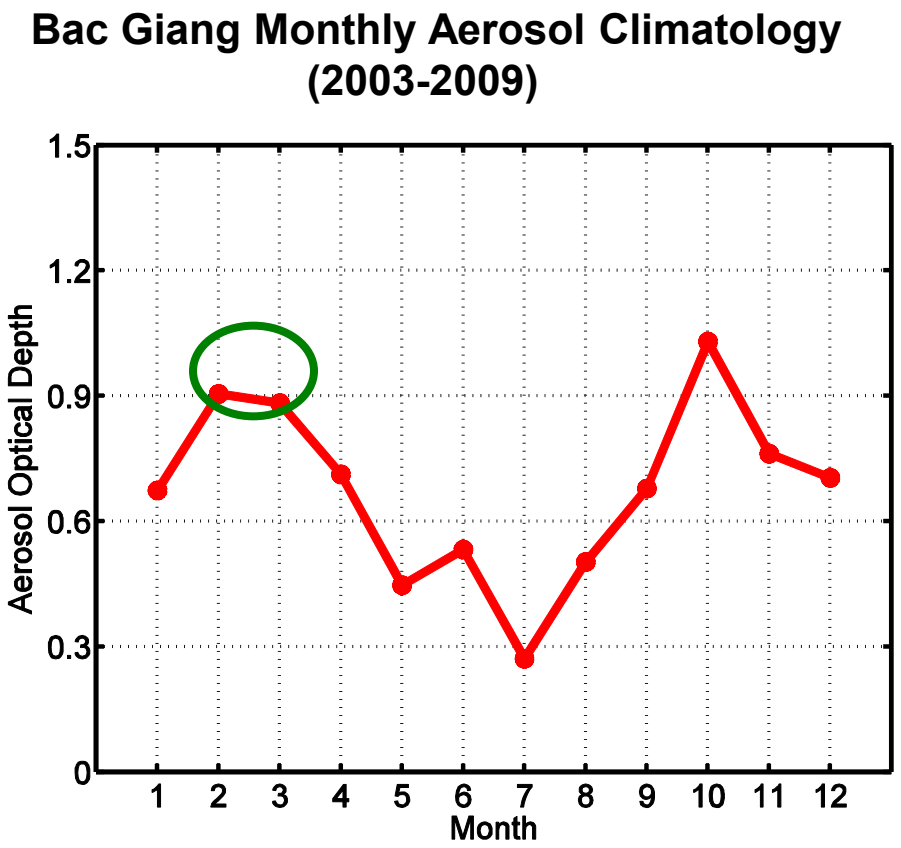
Wind at 1000hPa in Oct (2003-2009)



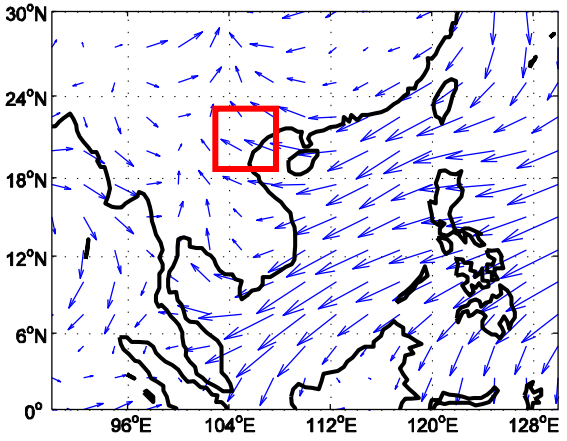
V & W wind in Northern Vietnam

THE VARIABILITY OF AOD OVER VIETNAM

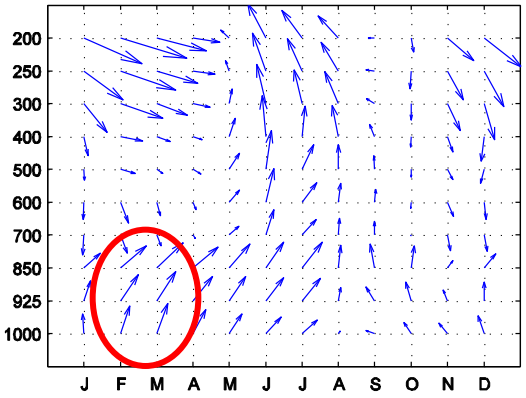
The Temporal Variability of AOD in Bac Giang from AERONET Data



=> The circulation creates favorable conditions for the accumulation of aerosol particles in Bac Giang



Wind at 1000hPa in Feb.-Mar. (2003-2009)

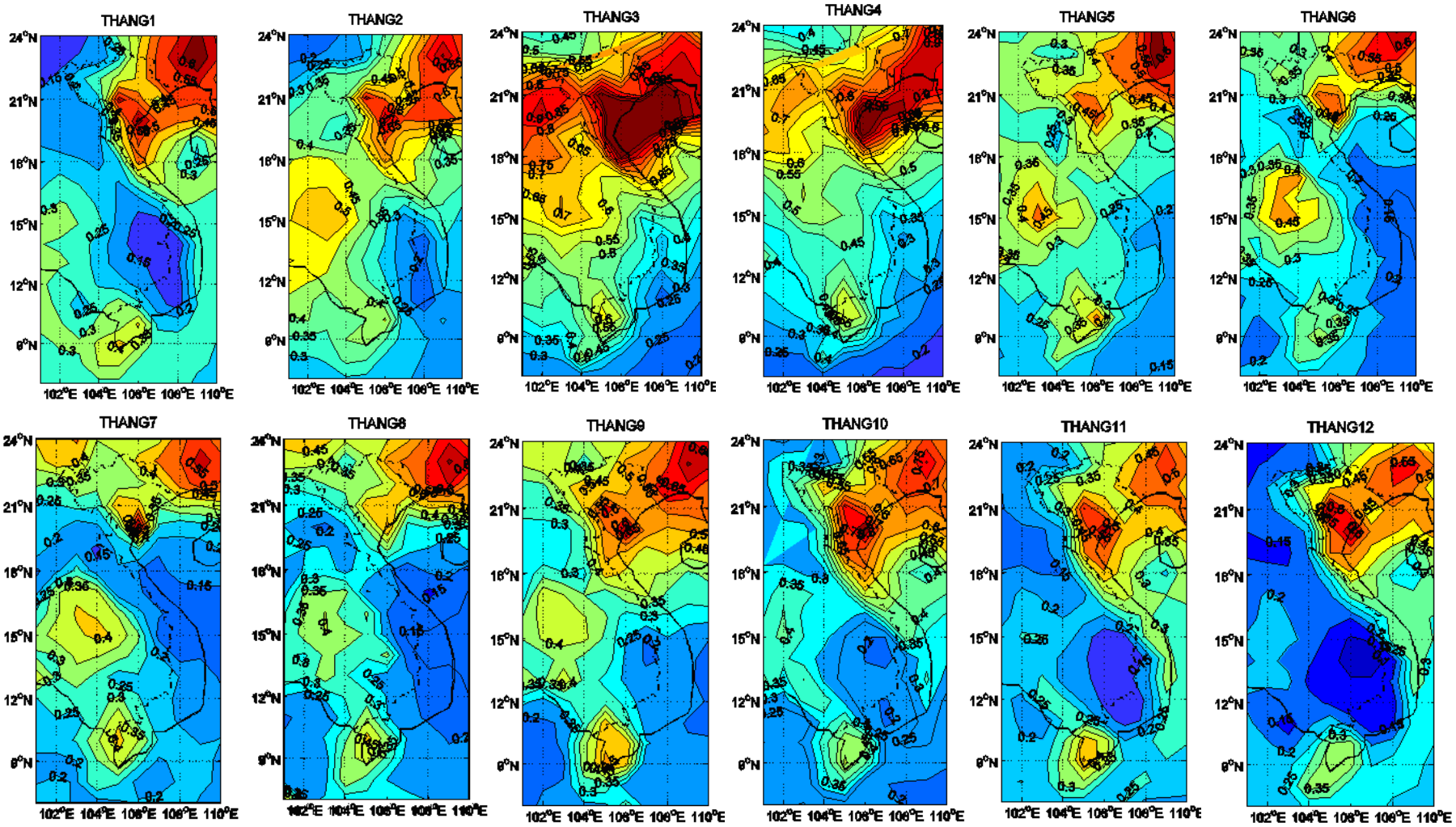


V & W wind in Northern Vietnam

THE VARIABILITY OF AOD OVER VIETNAM

The Spatial Variability of AOD from MODIS/Terra

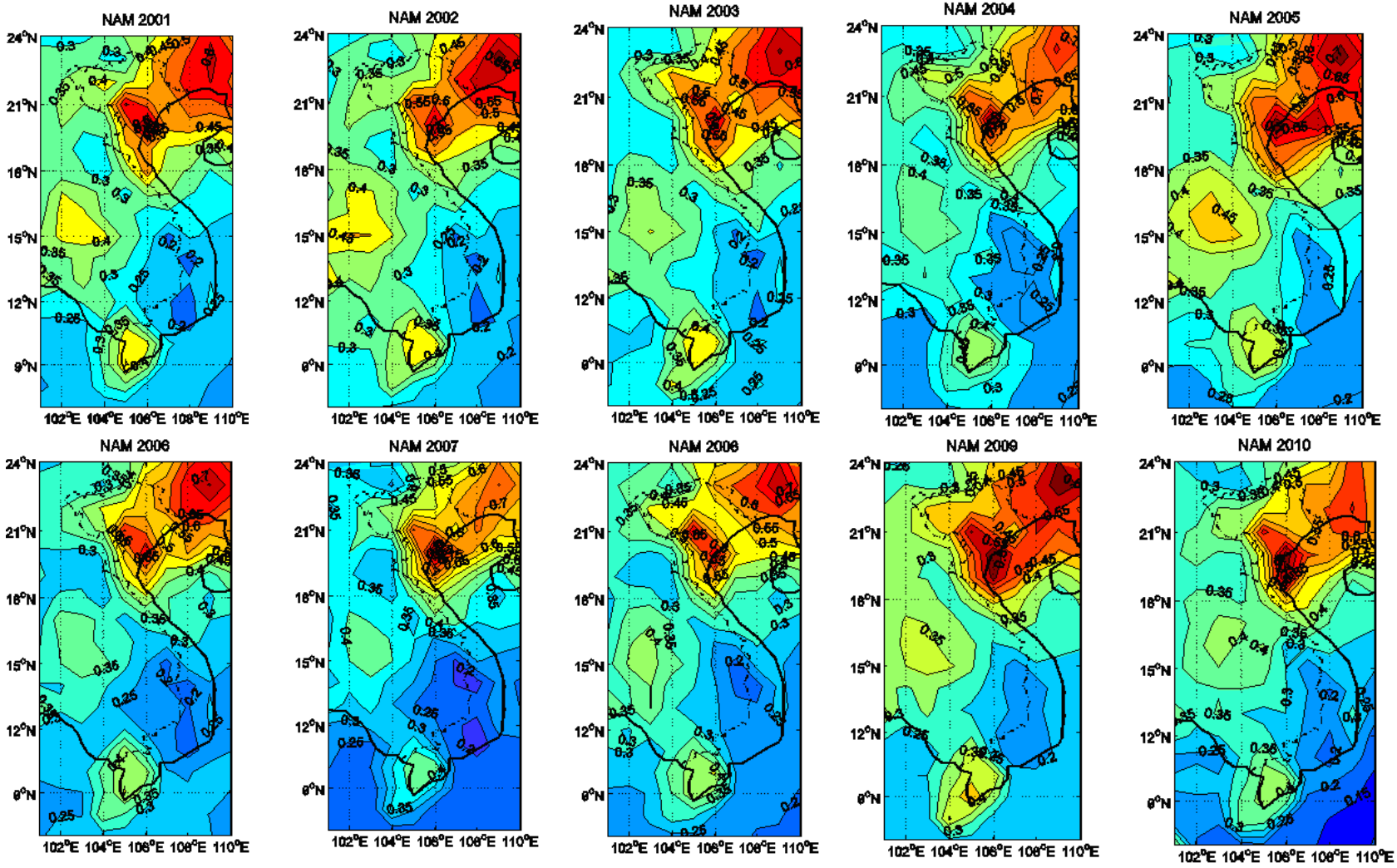
The monthly average of AOD (2001-2010)



THE VARIABILITY OF AOD OVER VIETNAM

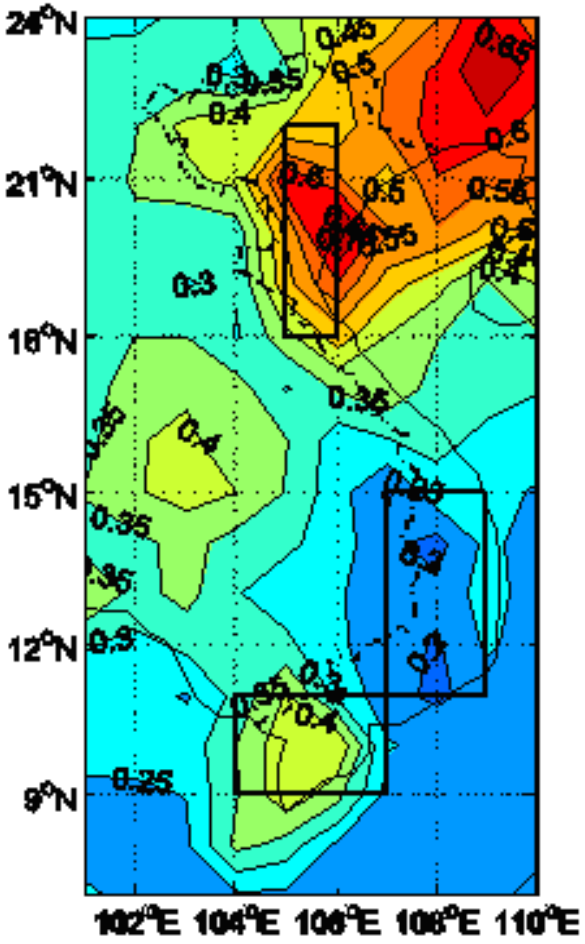
The Spatial Variability of AOD from MODIS/Terra

The annual average of AOD (2001-2010)



The Spatial Variability of AOD from MODIS/Terra

The average of AOD (2001-2010)



The territory of Viet Nam can be divided into 3 areas:

Northern Vietnam (18^{0}N-22^{0}N; 105^{0}E-106^{0}E)
Average Year : AOD from 0.47 to 0.62

Center Vietnam (11^{0}N - 15^{0}N; 107^{0}E - 109^{0}E)
Average Year : AOD from 0.23 to 0.30

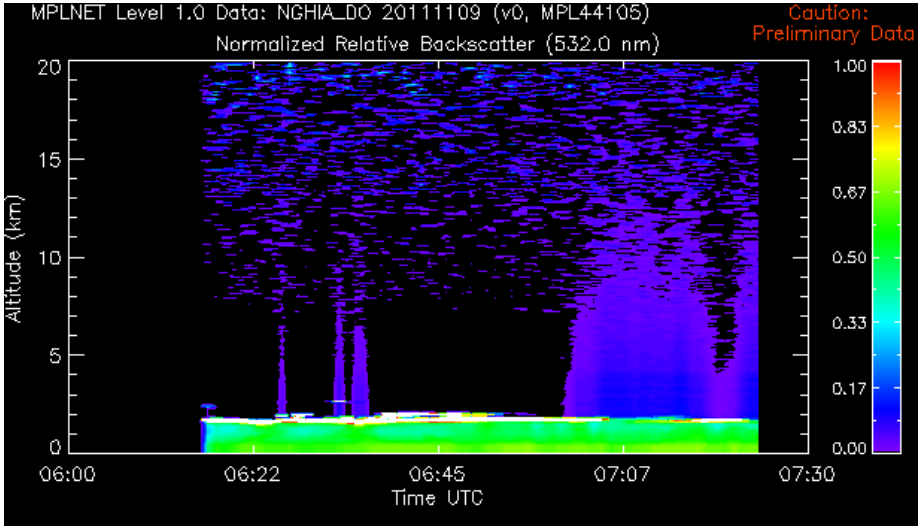
Southern Vietnam (9^{0}N- 11^{0}N; 104^{0}E-107^{0}E)
Average Year : AOD from 0.31 to 0.40

Nguyen X.A, Pham X.T., Do N.T, 2012b

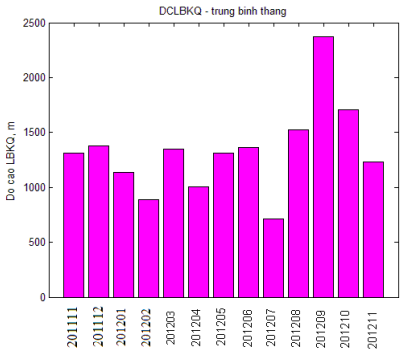
THE VARIABILITY OF AOD OVER VIETNAM

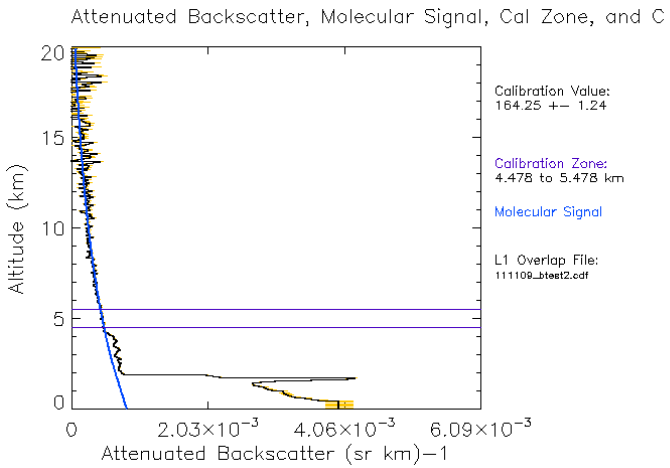
V.A.S.T

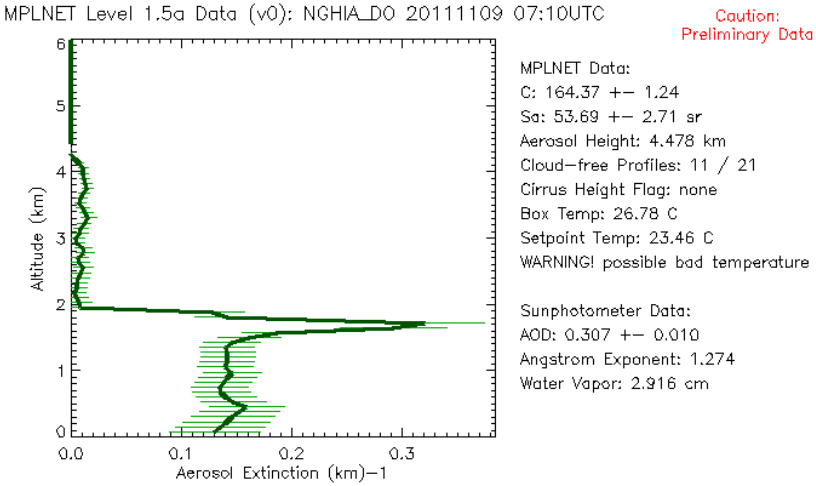
Hanoi MPLnet lidar station (Nov. 2011)



PBL Height in Hanoi







Remarks

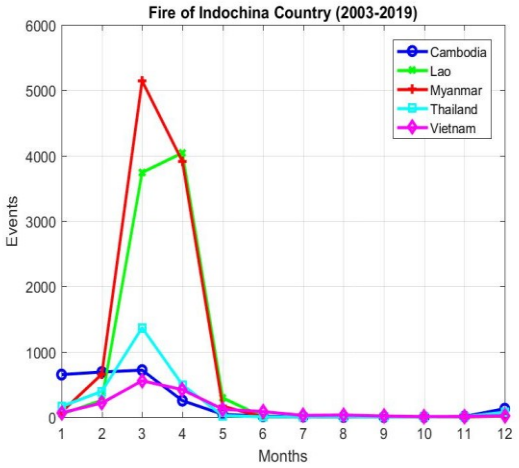
1. The temporal variability of AOD obtained from AERONET shows that, in Bac Giang and Bac Lieu, the average of AOD is 0.68 and 0.23 during 2003-2009, respectively. Cycle annual of AOD at Bac Giang shows a maximum in the early winter (October) and the last winter (February, March). In which, the highest values of AOD in Bac Lieu appear in the middle of winter (December, January and February).

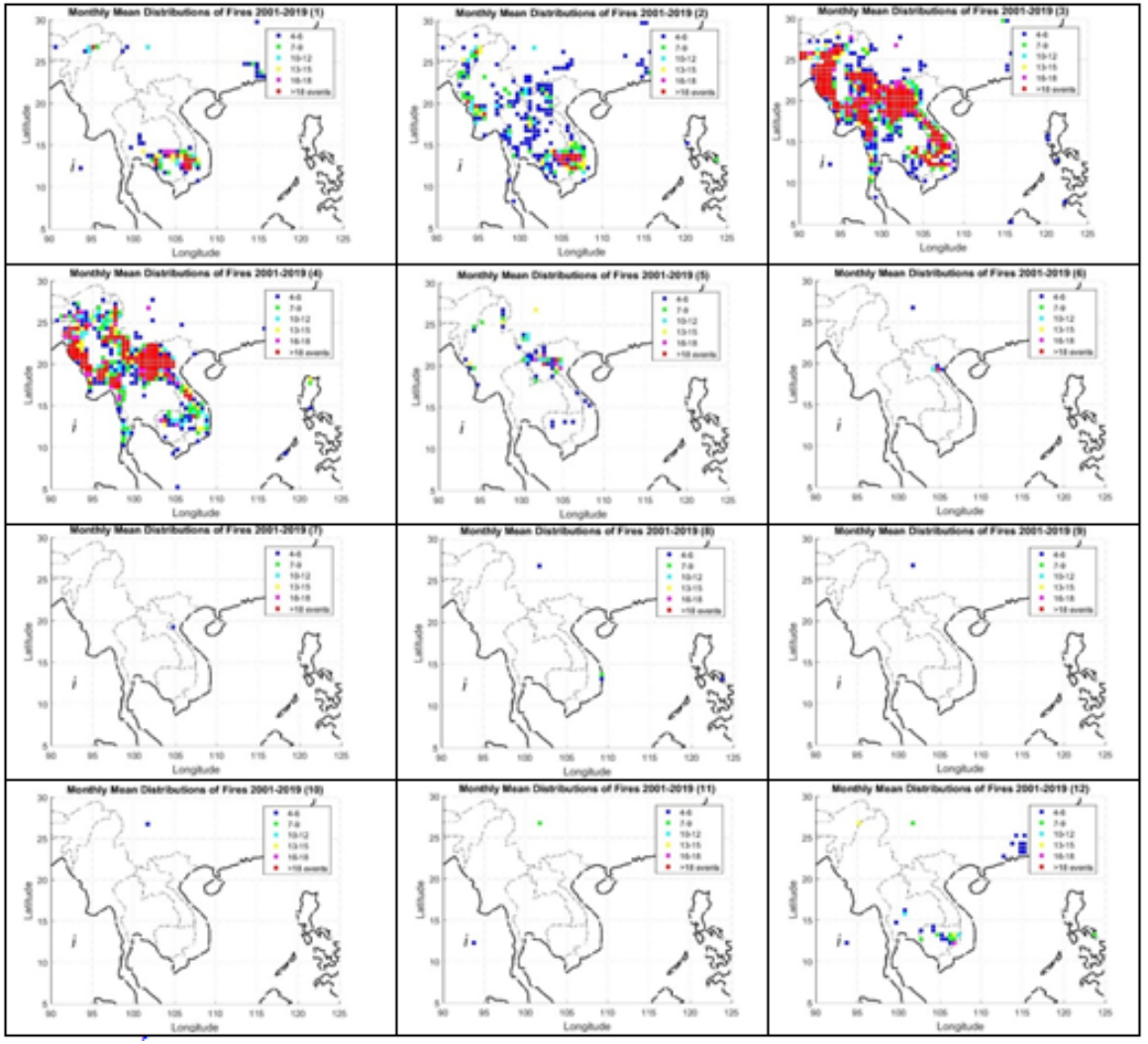
2. The winter monsoon circulations play an important role in the temporal variability of AOD in Bac Giang and Bac lieu.

3. The spatial variability of AOD derived from MODIS data shows that the territory of Viet Nam can be divided into 3 areas: Northern Vietnam, Center Vietnam and Southern Vietnam with the yearly AOD mean vary from 0.47 to 0.62, from 0.23 to 0.3, and from 0.31 to 0.40, respectively.

Effects of Fire Activity in Indochina on AOD in Hanoi

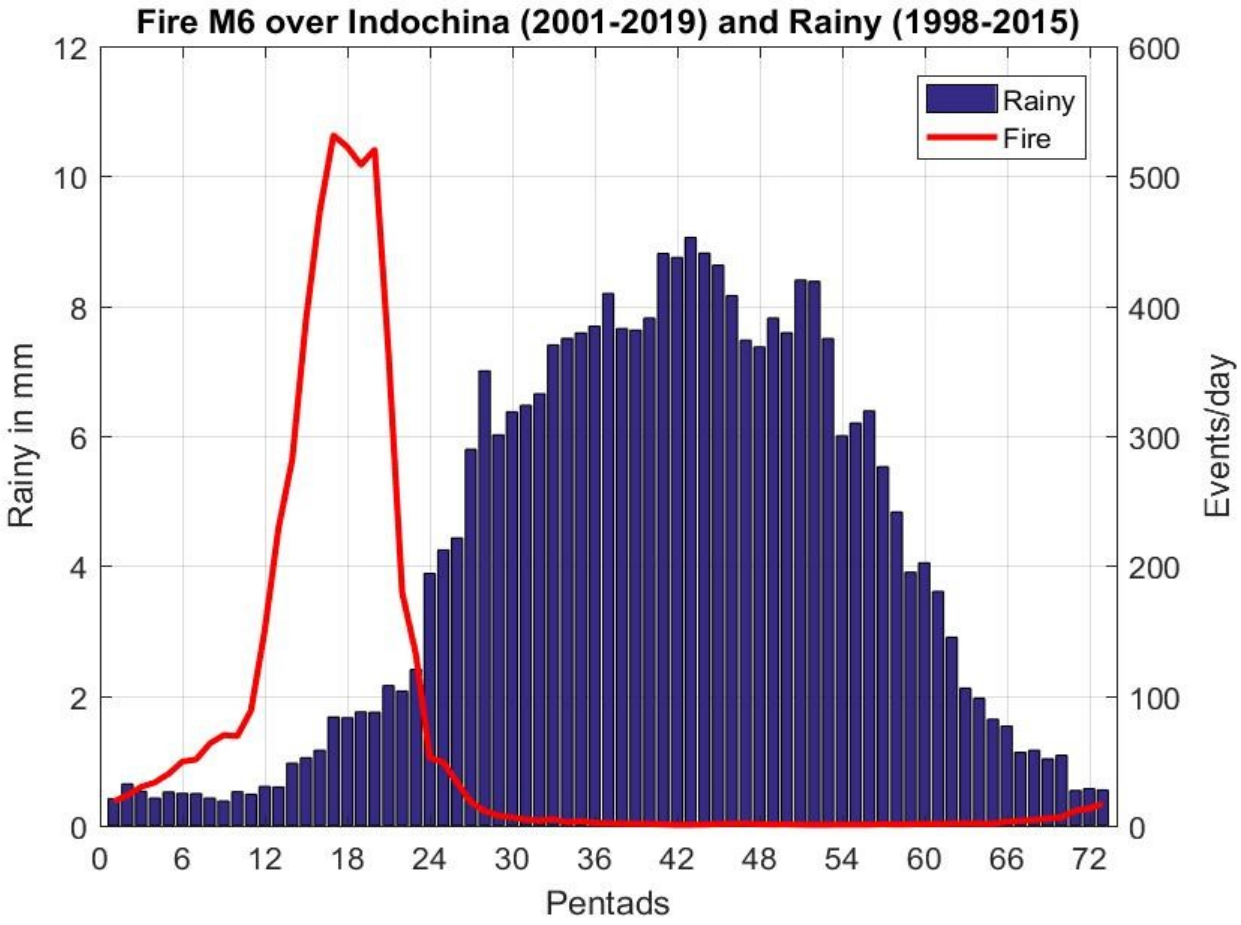
- Fire Activity in Indochina (2001-2019): https://firms2.modaps.eosdis.nasa.gov/active_fire/





Fire activity in Indochina

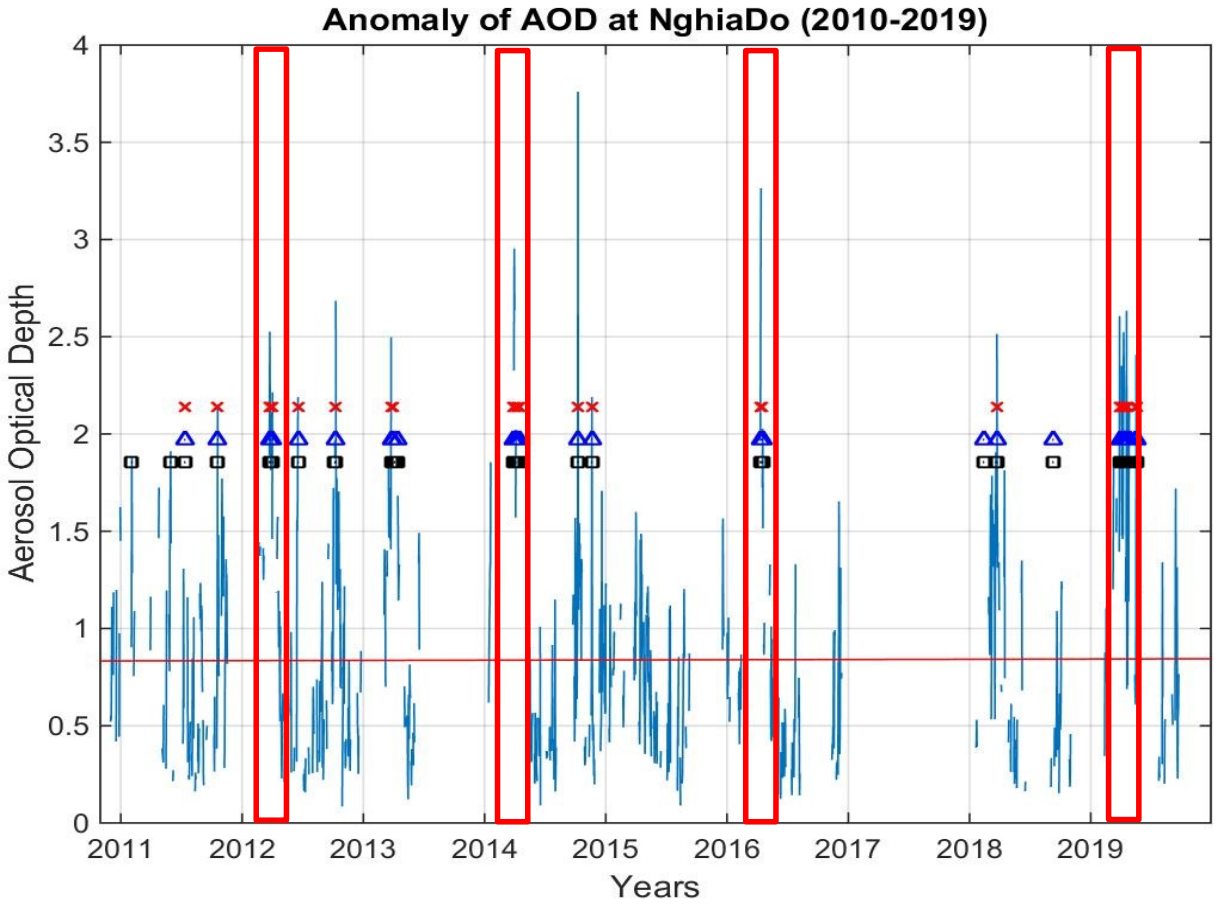
- Yearly evolution of fire activity and rainfall in Indochina (10°N-25°N; 90°E-110°E).



APHRODITE (Asian Precipitation - Highly Resolved Observational Data Integration Towards Evaluation) (http://www.chikyu.ac.jp/precip)

Aerosol Optical Depth in Hanoi

- Daily mean of AOD (500nm) in Hanoi (2010-2019).



The sign "■" indicates the high anomaly threshold type 1, "▲" the high anomaly threshold type 2, "✕" the high anomaly threshold type 3, the horizontal red line is the average value

- Existence of AOD anomalies:

http://aeronet.gsfc.nasa.gov/

24-27/3/2012

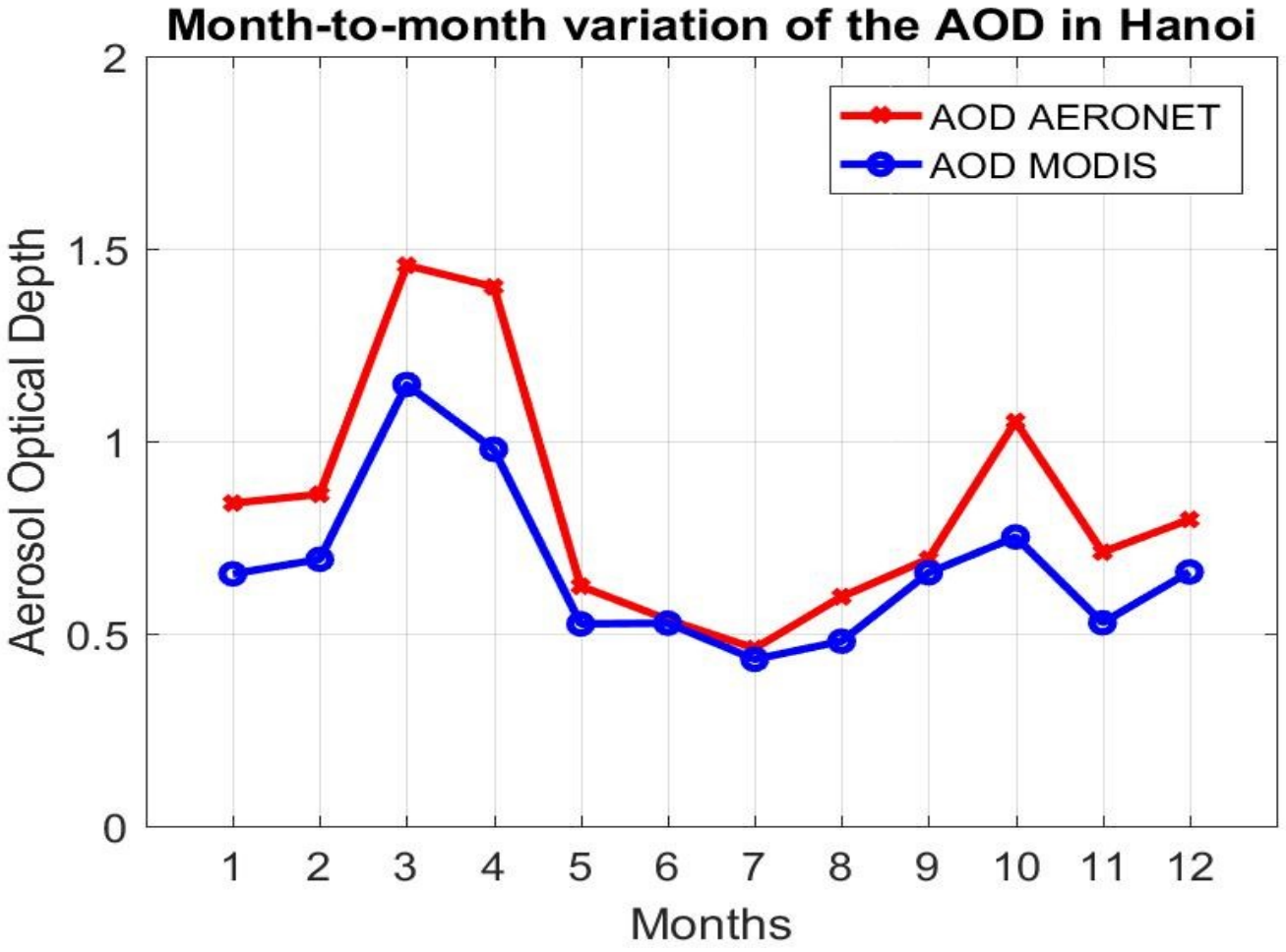
31/3-2/4/2014

12-14/4/2016

11-14/4/2019

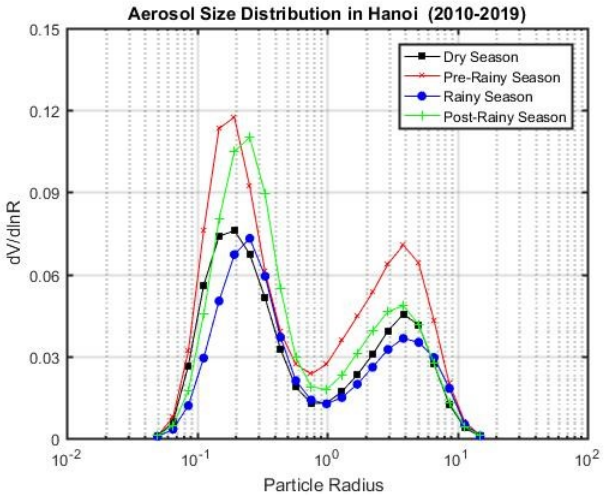
Aerosol Optical Depth in Hanoi

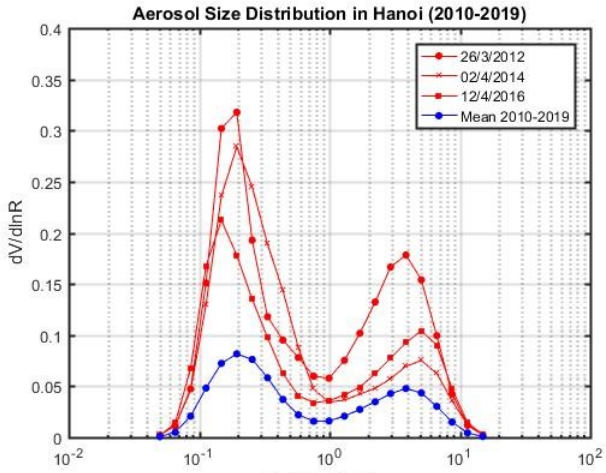
- Month-to-month variation of AOD in Hanoi (2010-2019): Maximum in March-April & October; Minimum in July & November.



Aerosol Optical Depth in Hanoi

- Size distribution of AOD (500nm) in Hanoi (2010-2019)





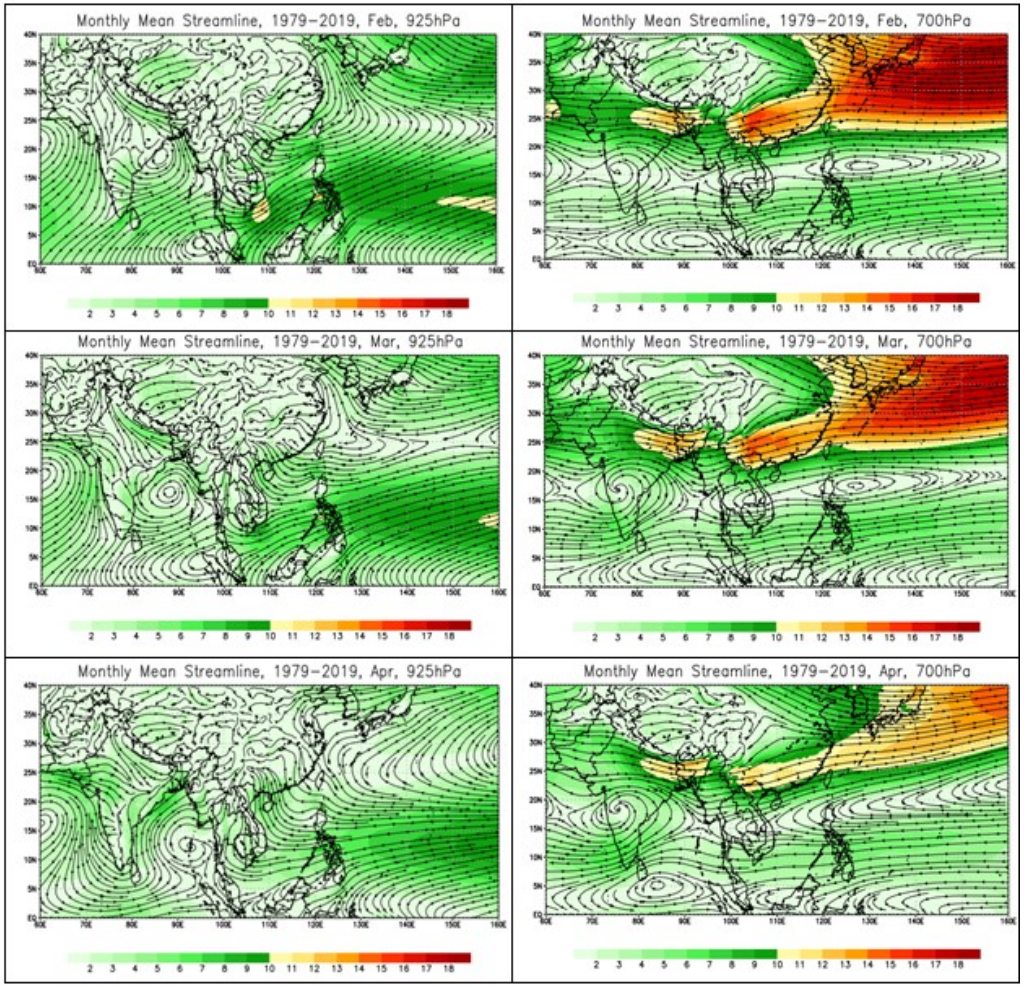
-Dry season (December, January, February),
-Pre-rainy season (March, April),
-Rainy season (June, July, August)
-and post-rainy season (October)

Day	Fine particle aerosol		Coarse particle aerosol	
	V_a ($\mu m^3/\mu m^2$)	R_a(μm)	V_c ($\mu m^3/\mu m^2$)	R_c (μm)
26/3/2012	0.318	0.1944	0.178	3.8575
02/4/2014	0.284	0.1944	0.075	5.0613
14/4/2016	0.276	0.1482	0.129	5.0613
Mean (2010-2019)	0.082	0.1944	0.048	3.8575

- The fine-particle aerosol on transition period is about 1.5 times higher than that of the dry and rainy seasons.

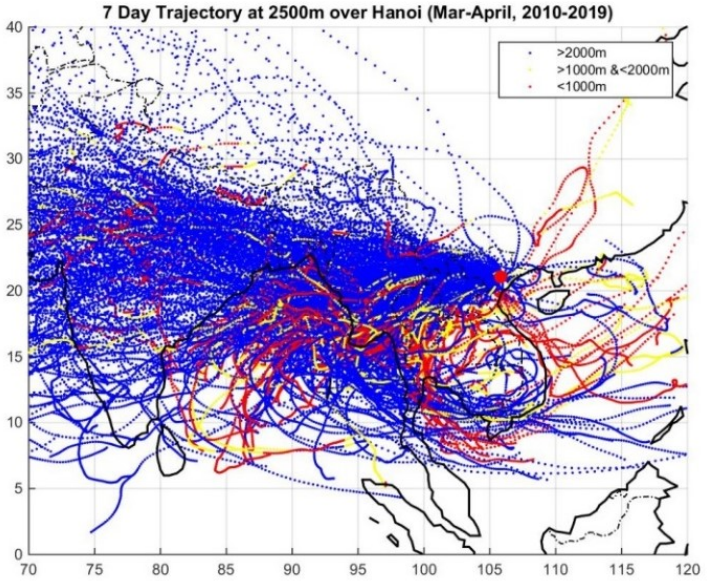
Effects of Fire Activity in Indochina on AOD in Hanoi

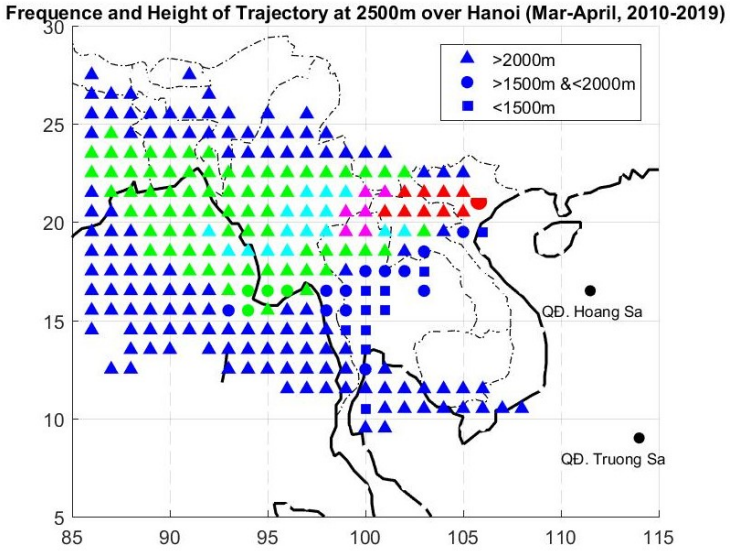
- Monthly mean streamline charts (for the period 1979-2019) of large-scale circulation in Asia-Pacific for 700 and 925hPa, in February, March, and April, respectively.



Effects of Fire Activity in Indochina on AOD in Hanoi

- Collection of 610 HYSPLIT lines through the height of 2500m at Hanoi station in March and April (2010-2019):





blue > 2000m,

yellow >1000m&<2000m,

red <1000m.

blue ~ 10-50 times;
green~51-100;

cyan ~ 101-150 times;

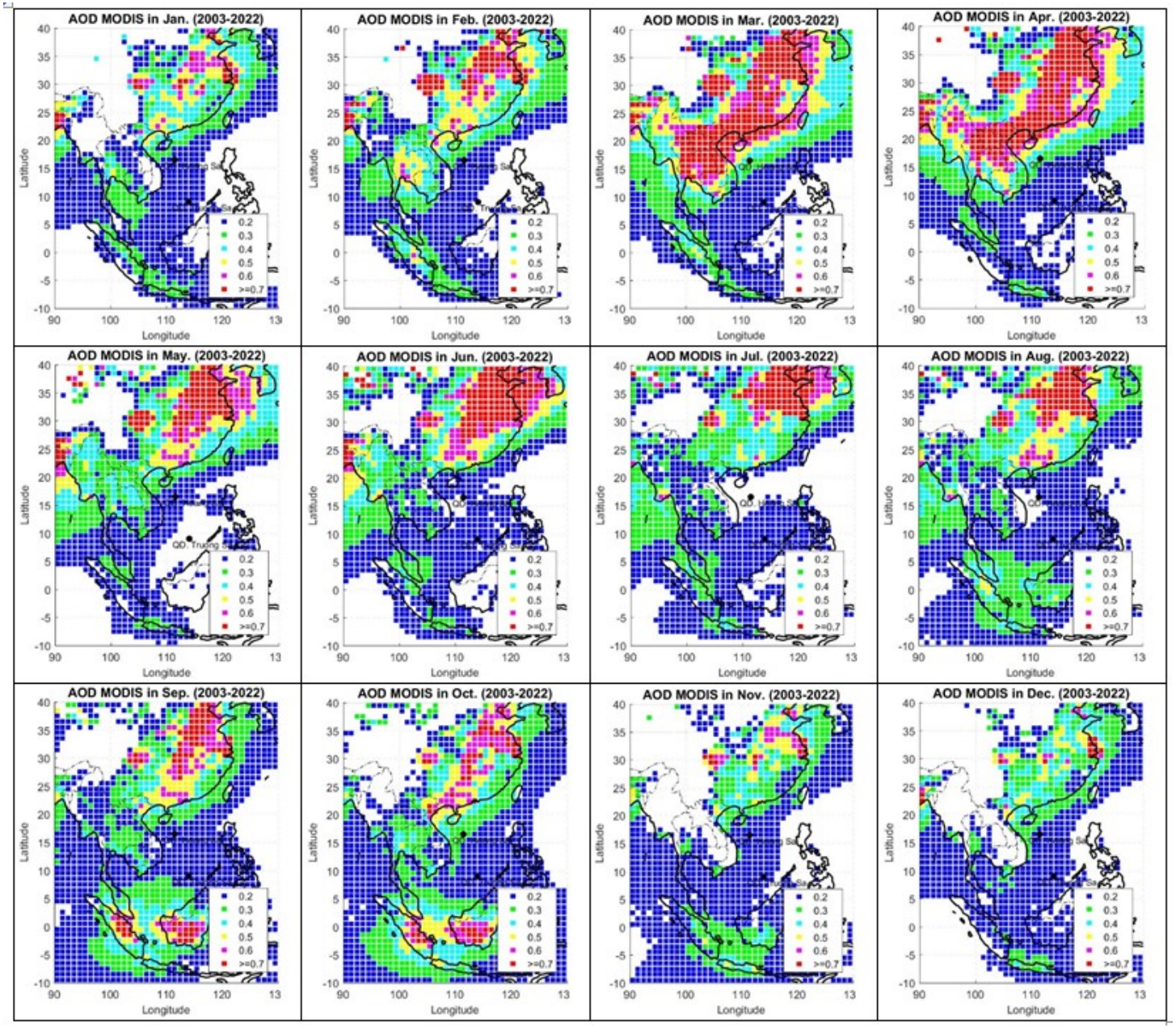
red >200 times.

▲>2000m,

●>1000&<2000m,

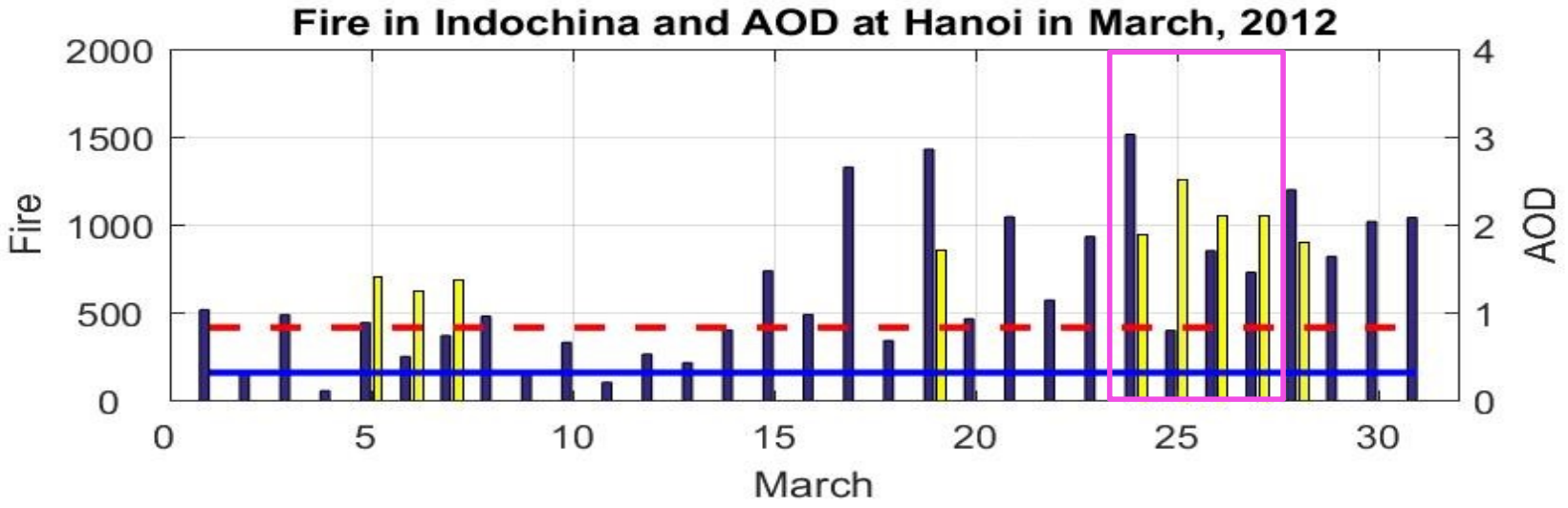
■<1000m.

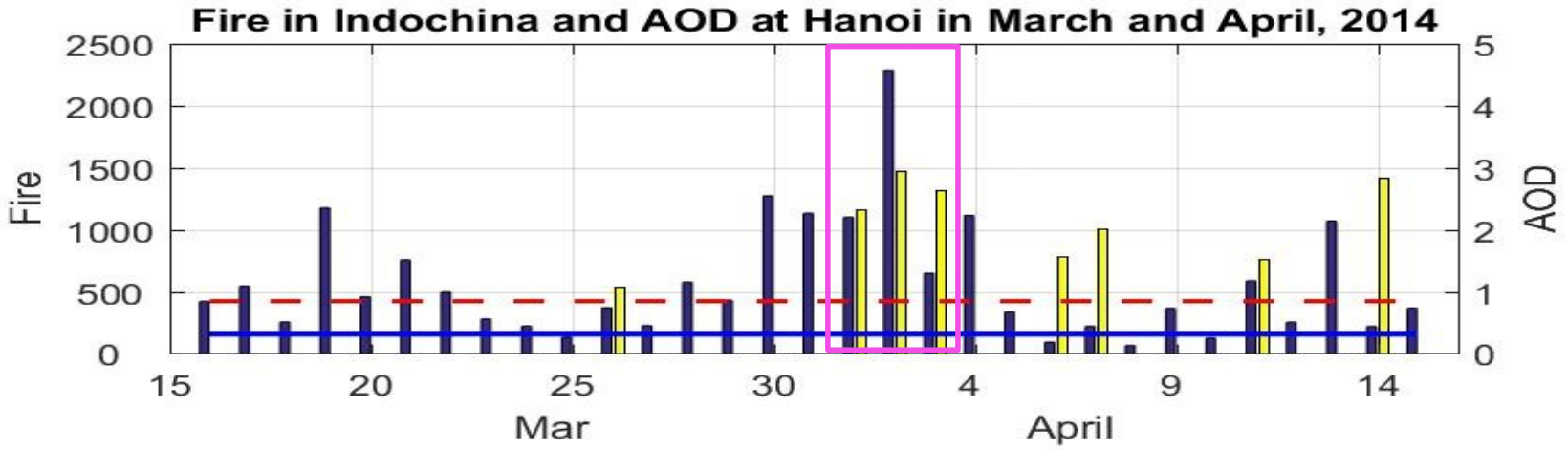
Monthly mean distribution of AOD (averaged for the period of 2003-2022) from MODIS data



Effects of Fire Activity in Indochina on AOD in Hanoi

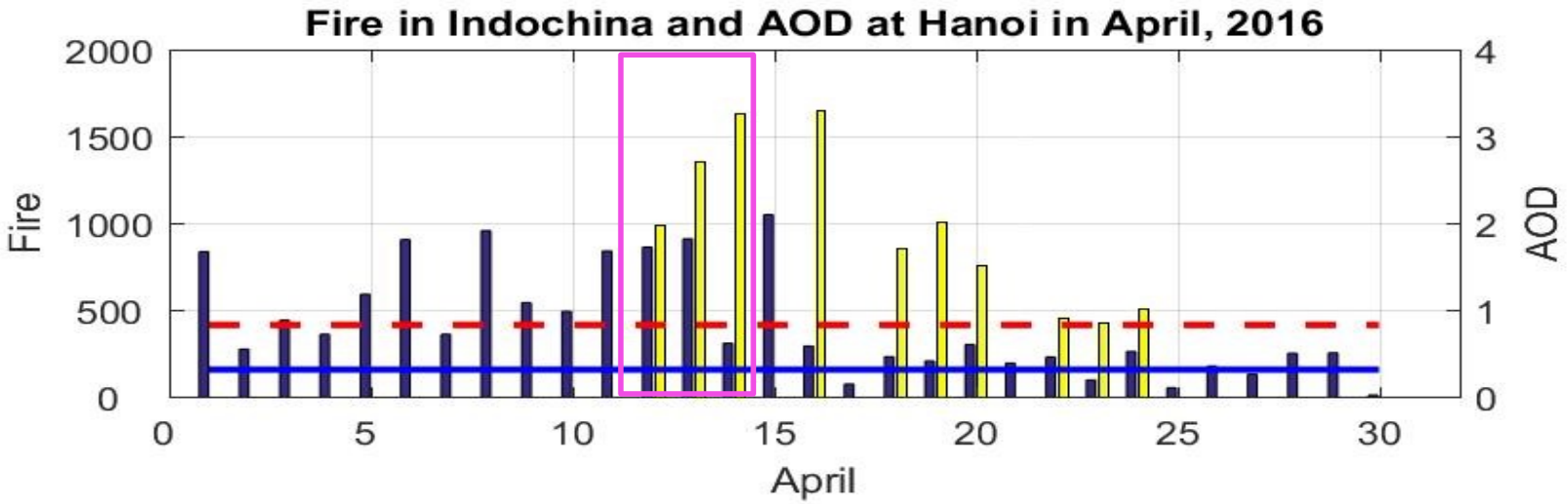
- Fire activity and AOD during anomalous days :

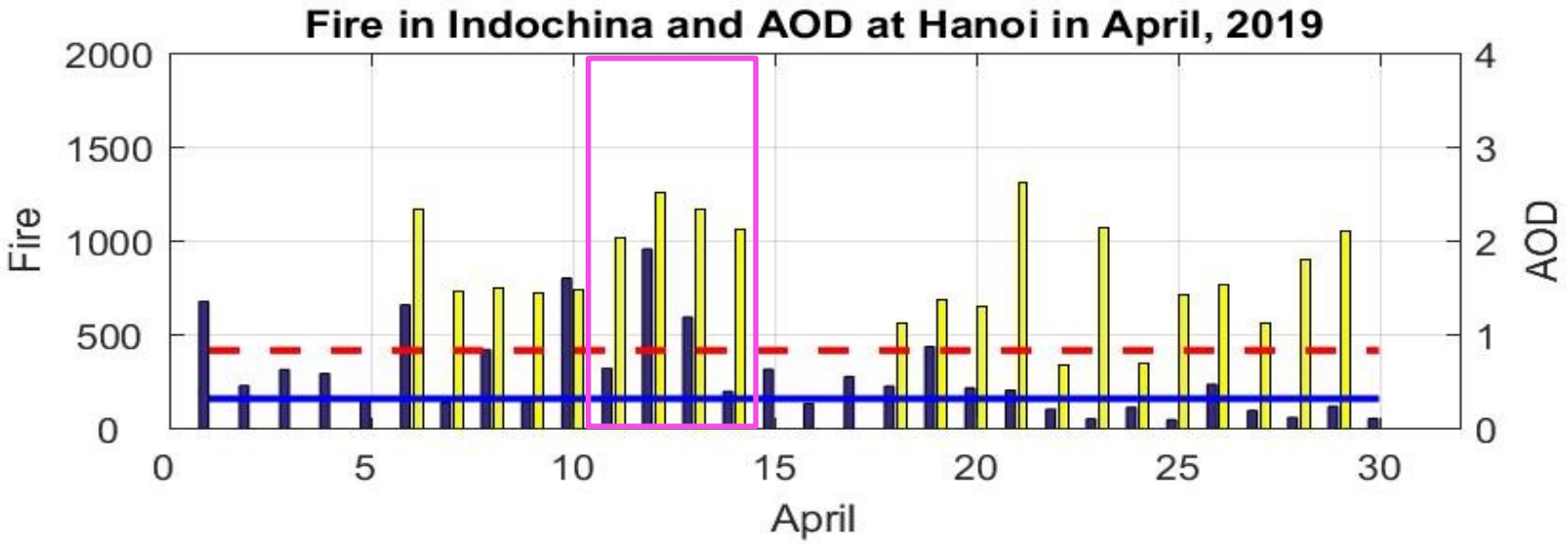




Effects of Fire Activity in Indochina on AOD in Hanoi

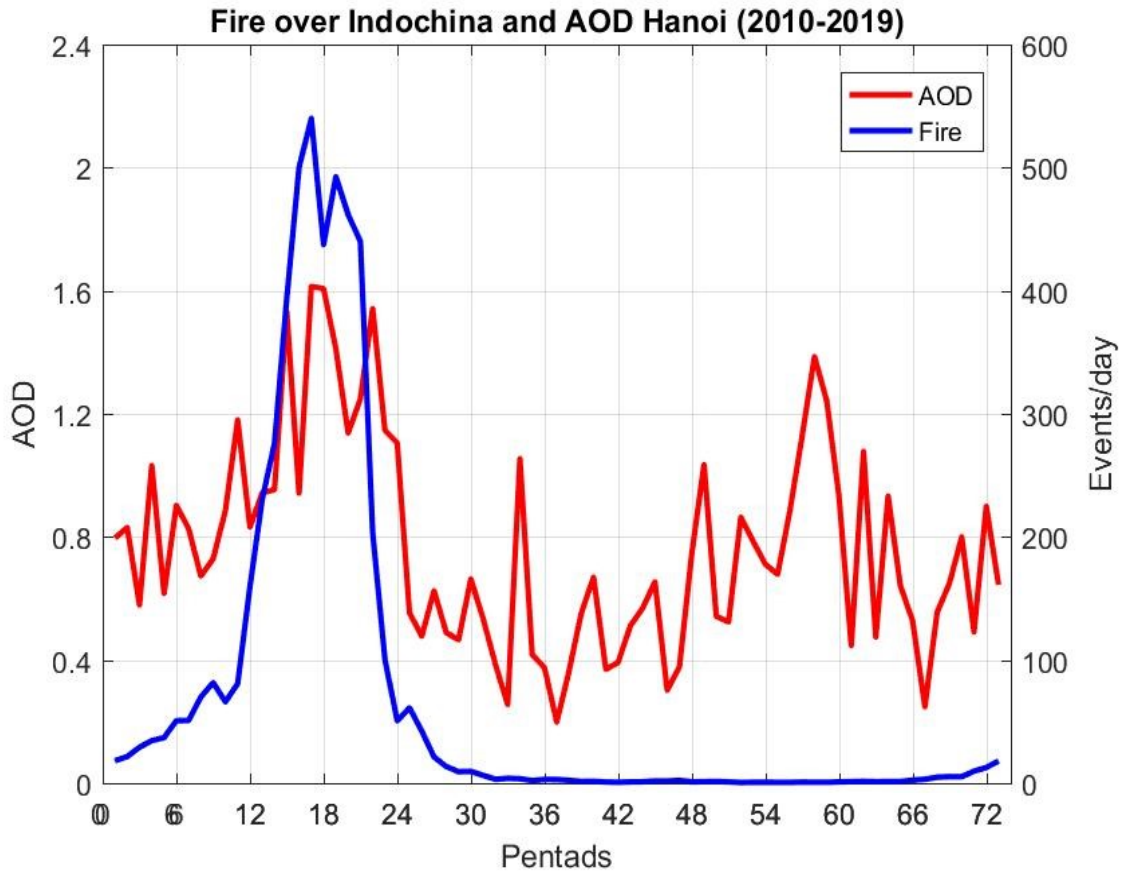
- Fire activity and AOD during anomalous days:





Effects of Fire Activity in Indochina on AOD in Hanoi

- Annual variation of fire activity in Indochina and AOD in Hanoi: Correlation R=0.64; For Jan.-April, R=0.76.

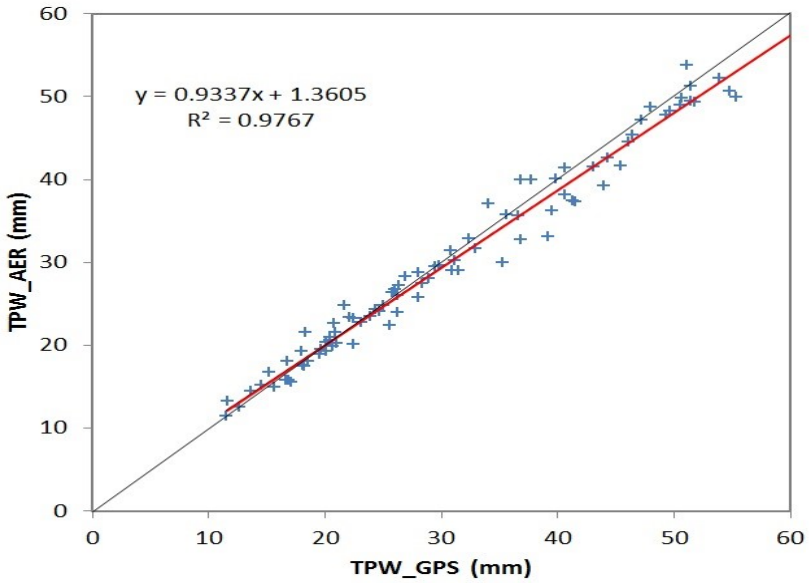


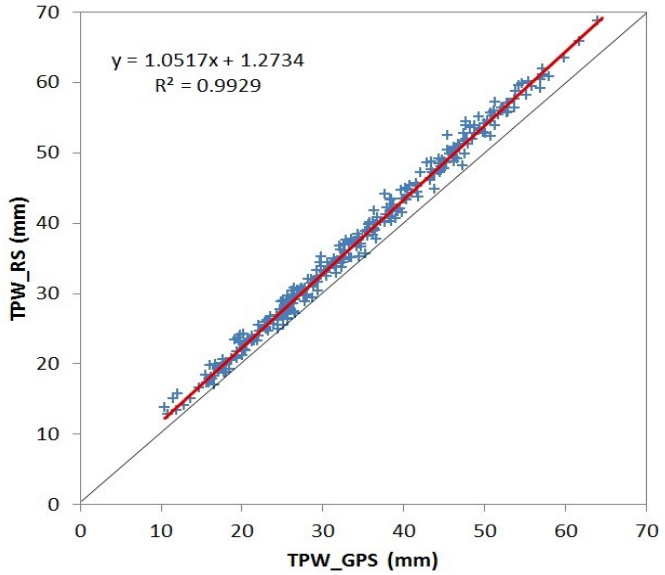
Remarks

- Fire activity in Indochina take place from December of one year to May of the next year with a maximum in March.
- During the period 2010-2019, Hanoi AERONET station recorded 4 AOD anomalies times, in 2012, 2014, 2016 and 2019.
- Atmospheric circulation plays an important role in transporting aerosols from biomass burning in Indochina to Hanoi.
- The biomass burning activity in Indochina is closely related to the AOD in Hanoi.

TPW from AERONET, radiosonde and GNSS data

Scatterplots of the average daily values of the estimated total precipitable water from GPS data (TPW_GPS), from AERONET data (TPW_AER) and from radiosonde data (TPW_RS) at Hanoi station.



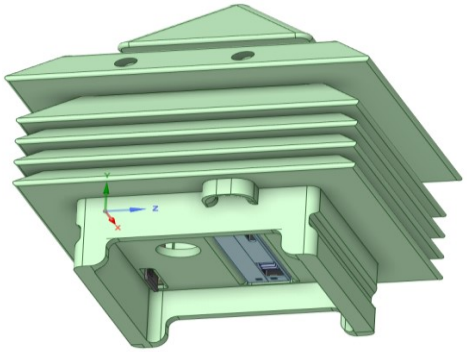


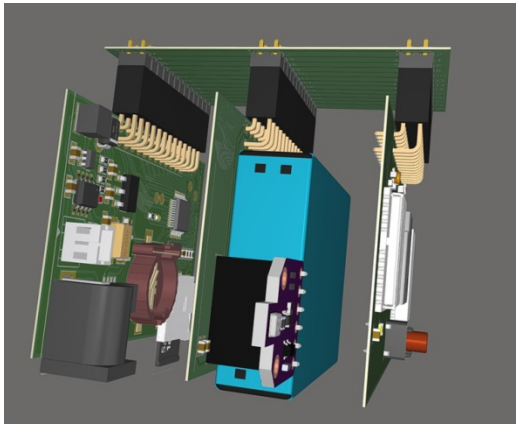
	ME (mm)	MAE (mm)	RMSE (mm)
TPW_GPS and TPW_AER	0.68	1.53	2.05
TPW_GPS and TPW_RS	-3.01	3.01	3.24

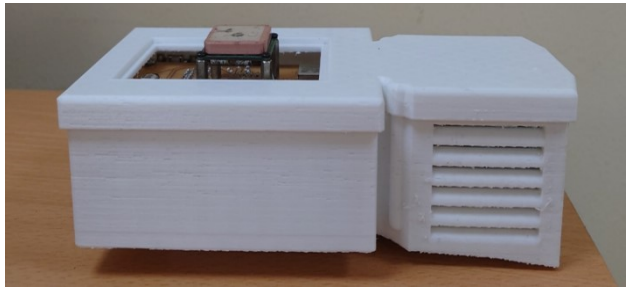
GPS data can be effectively employed to define the arrival of cold surges in the station area

P.L. Khuong, N.X. Anh, et. al. 2024

low-cost PM2.5 sensor-based monitoring device







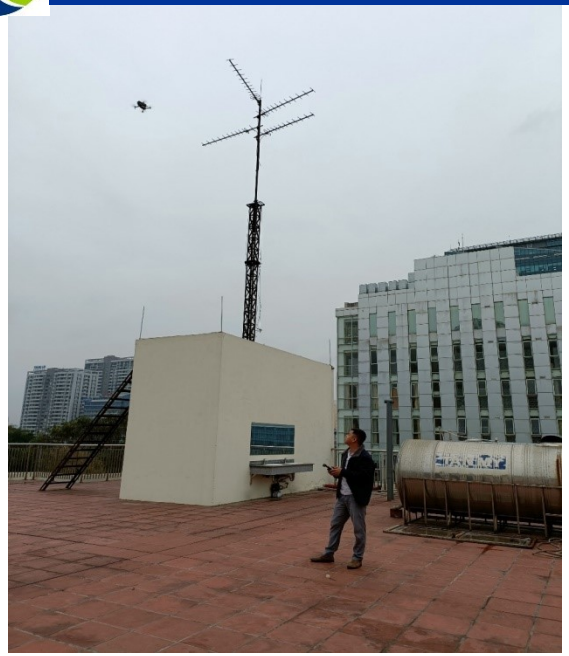
-Meteorological sensor: BME680
-Dust sensor: PMS7003
-GPS module: NEO6-M
-Microcontroller: STM32F103C8T6-RF
Lora 433MHz: Ra-02
-Wifi and bluetooth: ESP32 WROOM 32D-
Memory card: 16G

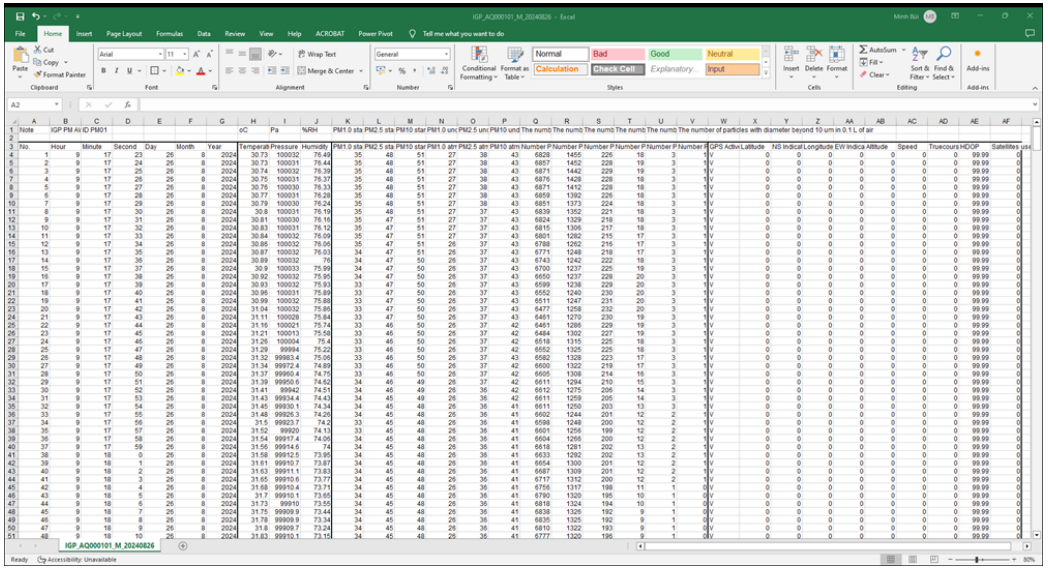
Specifications

- Update rate: 1Hz
- Battery: 3.7V – 1600mAh, operating time: 7 hours
- Data logger: SD card 8G, DRONE.CSV
- Size: Max 19cm x 8.5cm x 5.5cm
- Weight: 300g

Parameter	Value	Unit
Range of measurement	0.3 ~ 1.0 ; 1.0 ~ 2.5 ; 2.5 ~ 10	μm
Counting Efficiency	50%@0.3μm ; 98%@≥0.5μm	
Effective Range (PM2.5 standard)	0 ~ 500	μg/m³
Maximum Range (PM2.5 standard)	≥ 1000	μg/m³
Resolution	1	μg/m³
Maximum Consistency Error (PM2.5 standard data)	±10%@100 ~ 500μ g/m³ ±10μ g/m³@0 ~ 100μ g/m³	
Standard Volume	0.1	Litre(L)

low-cost PM2.5 sensor-based monitoring device

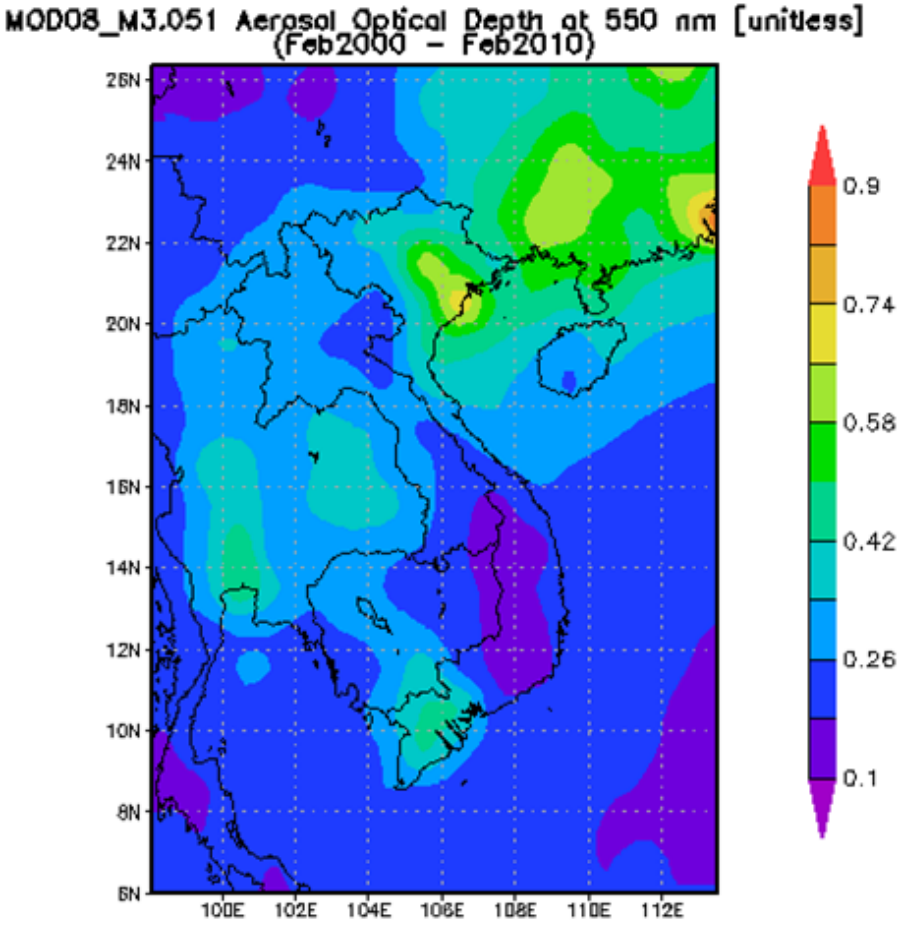




Number	int
Hour	int
Minute	int
Second	int
Day	int
Month	int
Year	int
Temperature	float
Pressure	float
Humidity	float
PM1.0 standard	int
PM2.5 standard	int
PM10 standard	int
PM1.0 atmospheric	int
PM2.5 atmospheric	int
PM10 atmospheric	int
Number PM0.3	int
Number PM0.5	int
Number PM1.0	int
Number PM2.5	int
Number PM5.0	int
Number PM10	int
GPSActiveStatus	char
Latitude	double
NS_Indicator	char
Longitude	double
EW_Indicator	char
Altitude	double
Speed	double
Truecourse	double
HDOP	double
SatellitesUsed	int

Possible connections to 7-SEAS

- AERONET sites (Hanoi, Baclieu)
- IOPs (Spring 2025) for aerosol related study: Collection of ground base related data (AERONET, meteo/air quality, GPS, UAV…) and remote sensing data.
- Data Analysis. Aerosol study (transport, vertical distribution, physical and chemical analysis)
- Research on aerosol impacts on weather, climate and environment.
- Weather forecast improvement for intense thunderstorms: emphasis on precipitation in Hanoi(2024-2026).



Thank you very much for your attention!