

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



Introduction to Aerosol-Related Research at IGP, VAST

N. X. Anh, P.X.Thanh, P. L. Khuong, N.N.Vinh, B.N.Minh IGP,VAST

Email: nxuananh05@gmail.com

ASAE,17-19 September 2024







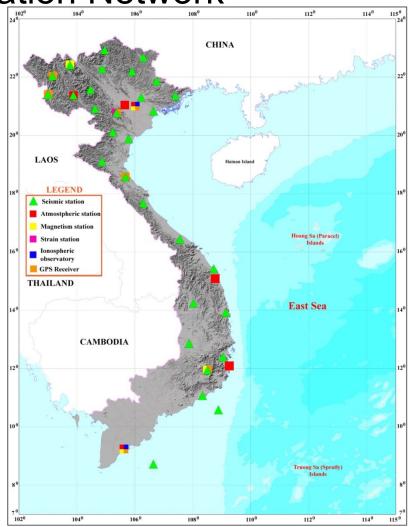
2. Aerosol-Related Research Results

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





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)



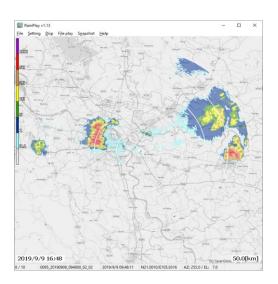


IGP Hanoi Atmospheric Station Network

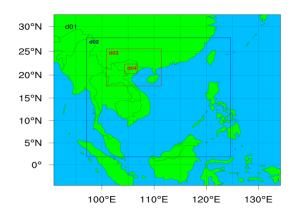




























- AErosol RObotic NETwork AERONET (2003)
- Program to Study Pollution-Meteorology Feedbacks in Southeast Asia -7 SEAS (2007)
- Micro-Pulse Lidar Network MPLNET (2011)
- 7-SEAS/BASELINE (Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles and Interactions Experiment (2012)



AERONET DATA in Vietnam

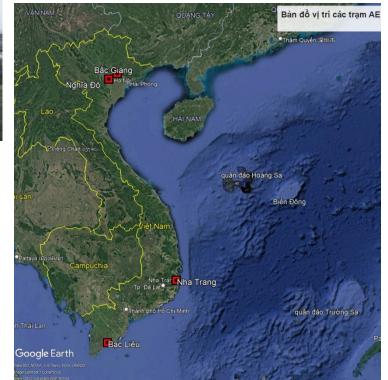




Nghia Do station (from 2010)



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





Bac Giang station (2003-2009)



Nha Trang station (2011-2014)

Bac Lieu station (from 2003)



Duration of observation at AERONET sites in Vietnam

Level 2.0

- Bac Giang: 634 days
- Nha Trang: 368 days

The MODIS/Terra data:

Artist' view of the Terra spacecraft in orbit (image credit: NASA) http://www2.hawaii.edu/~jmaurer/terra/

- Nghia Do: 253 days
- Bac Lieu: 759 days

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



V.A.S.T

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

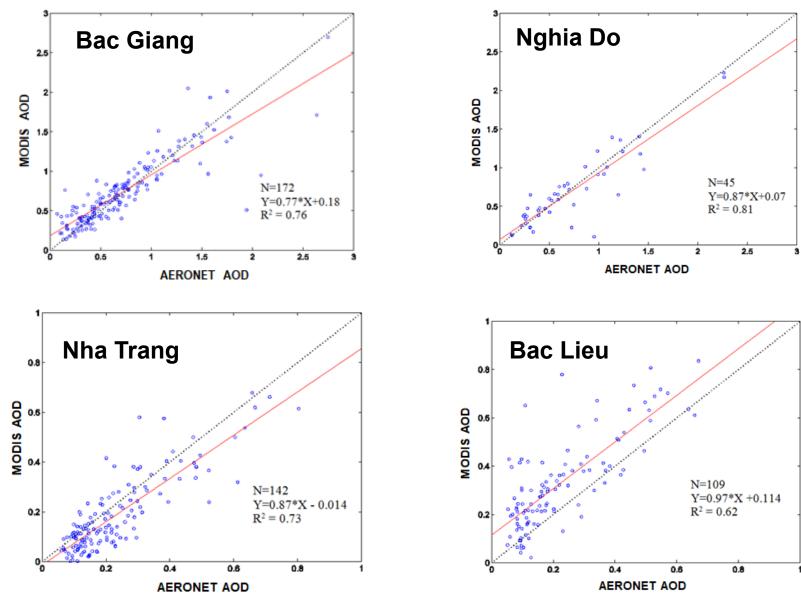
- Interpolate the AOD value at 0.55µm from the AOD value at 0.50µm *(Eck et al, 1999; Tripathi et al.*, 2005)

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

Comparison of AOD from MODIS and AERONET

V.A.S.T

Scatter plot between AOD derived 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.





• 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)

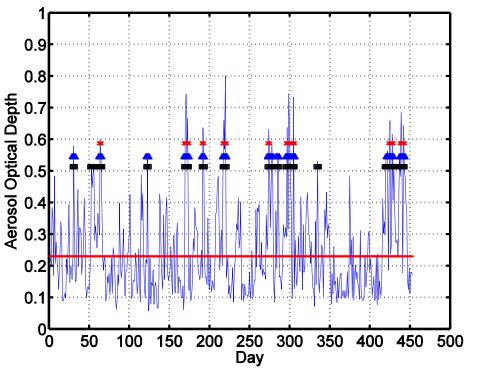
http://www.cdc.noaa.gov/cgi-bin/db_search/SearchMenus.pl





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,

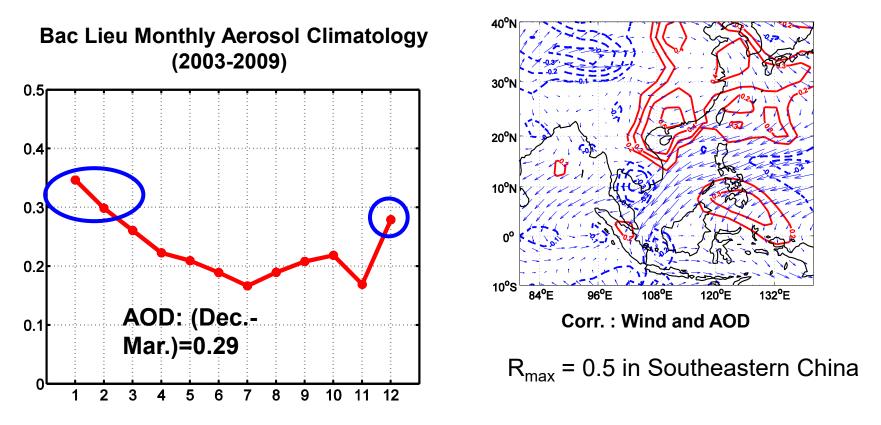
PA1 in (Dec.-Feb.) = 20.

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





The Temporal Variability of AOD in Bac Lieu from AERONET Data



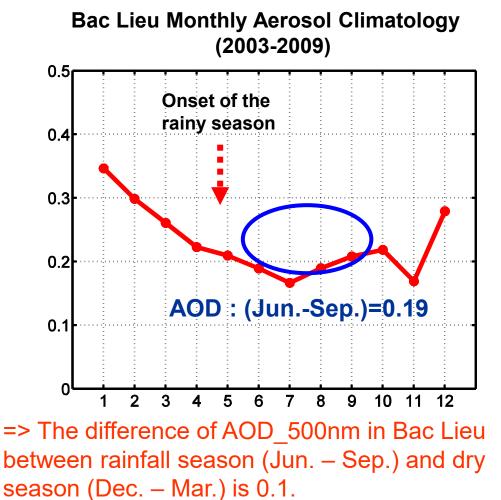
=> The variation of AOD in Bac is affected by the East Asia winter monsoon.

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

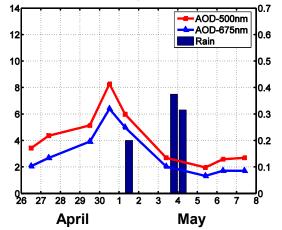




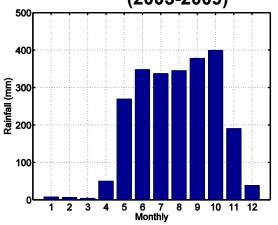
The Temporal Variability of AOD in Bac Lieu from AERONET Data



Onset of the rainy season in 2003



Bac Lieu Monthly Rainy Climatology (2003-2009)



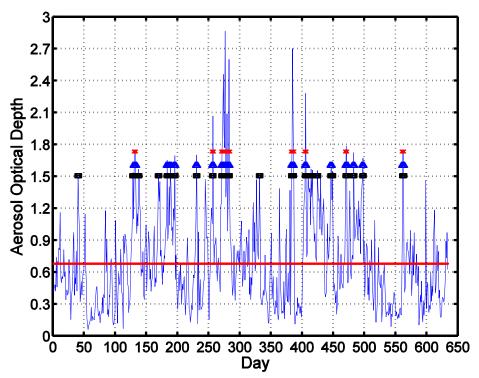
Pham X.T., Nguyen X.A et al, 2011





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,

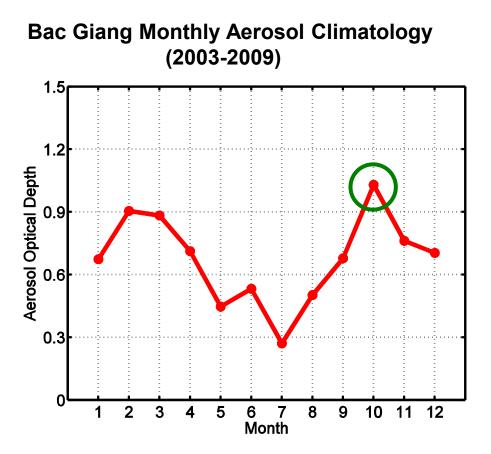
PA1 in (Oct.+Feb.+Mar.) = 18.

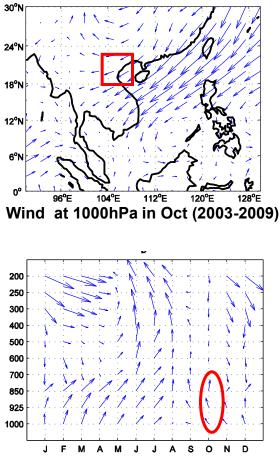
=> Positive Anomaly of AOD at Bac Giang appears in the early winter (October) and the last winter (February, March)





The Temporal Variability of AOD in Bac Giang from AERONET Data





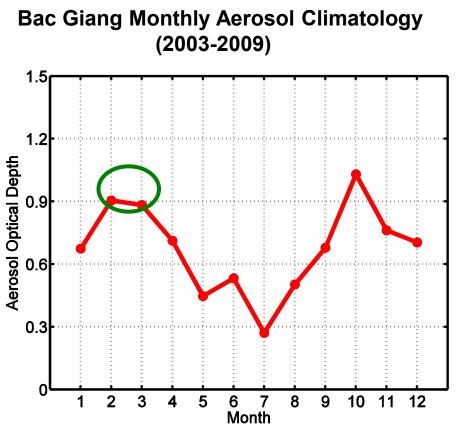
V & W wind in Northern Vietnam



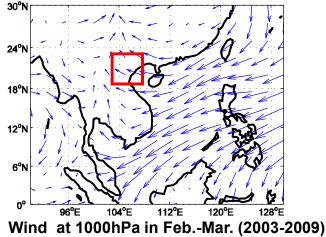


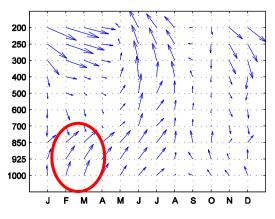
The Temporal Variability of AOD in Bac Giang from AERONET Data

E VARIABILITY OF AOD OVER V



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

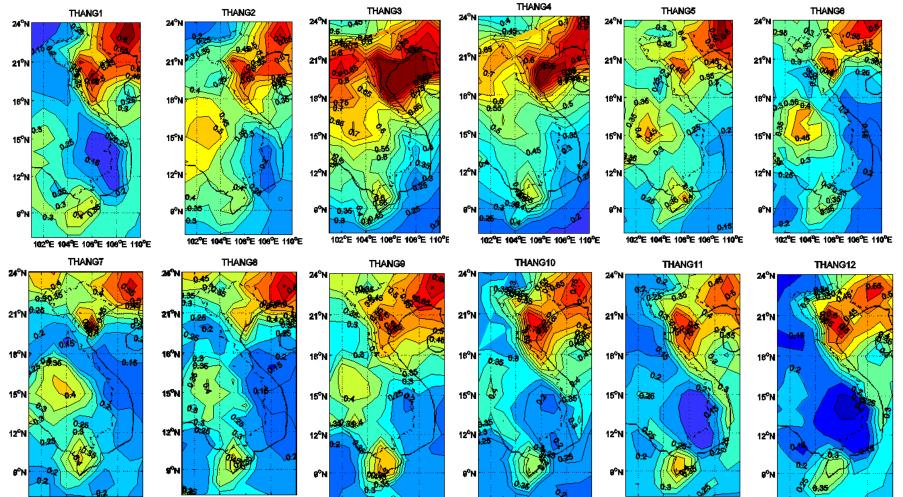




V & W wind in Northern Vietnam



The Spatial Variability of AOD from MODIS/Terra The monthly average of AOD (2001-2010)



102°E 104°E 106°E 106°E 110°E

102°E 104°E 106°E 106°E 110°E

104'E 106'E 106'E 110'E

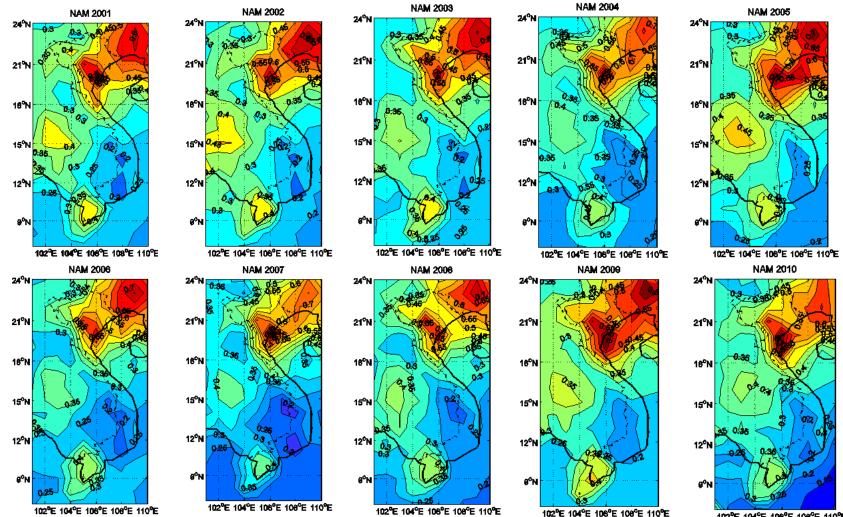
102°E 104°E 106°E 106°E 110°E

102°E 104°E 106°E 106°E 110°E

102°E 104°E 108°E 108°E 110°E



The Spatial Variability of AOD from MODIS/Terra The annual average of AOD (2001-2010)

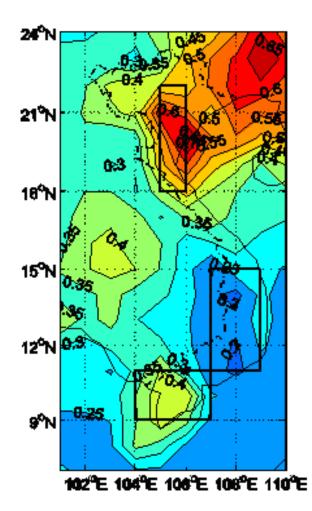


^{102°}E 104°E 106°E 108°E 110°E



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:

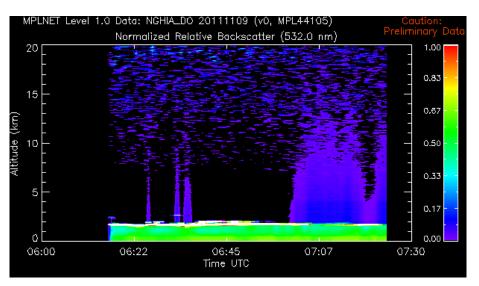
Northern Vietnam (18ºN-22ºN; 105ºE-106ºE) Average Year : AOD from 0.47 to 0.62

Center Vietnam (11^oN - 15^oN; 107^oE - 109^oE) Average Year : AOD from 0.23 to 0.30

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

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

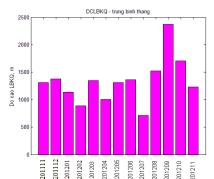
THE VARIABILITY OF AOD OVER VIET Hanoi MPLnet lidar station (Nov. 2011)

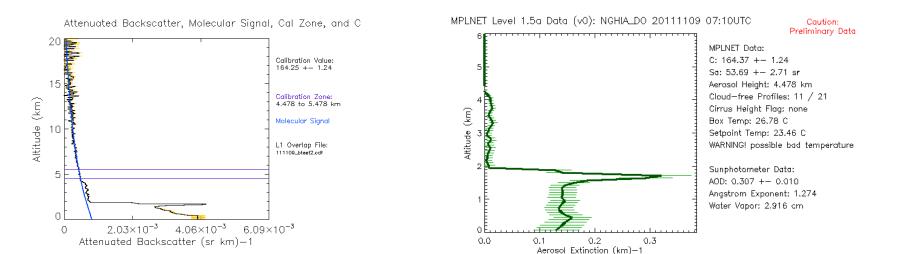


HOP



PBL Height in Hanoi









Remarks

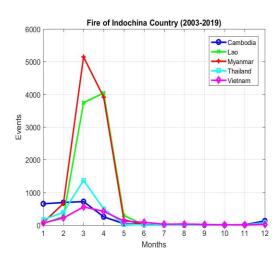
- 1. The temporal variability of AOD obtained from AERONET shows that, in Bac Giang and Bac Lieu, the average of AOD is 0.68 and 0.23 during 2003-2009, respectively. Cycle annual of AOD at Bac Giang shows a maximum in the early winter (October) and the last winter (February, March). In which, the highest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

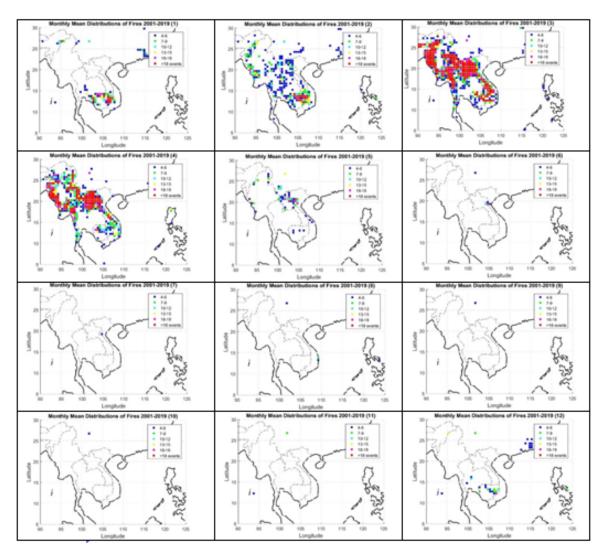


Effects of Fire Activity in Indochina on AOD in Hanoi



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

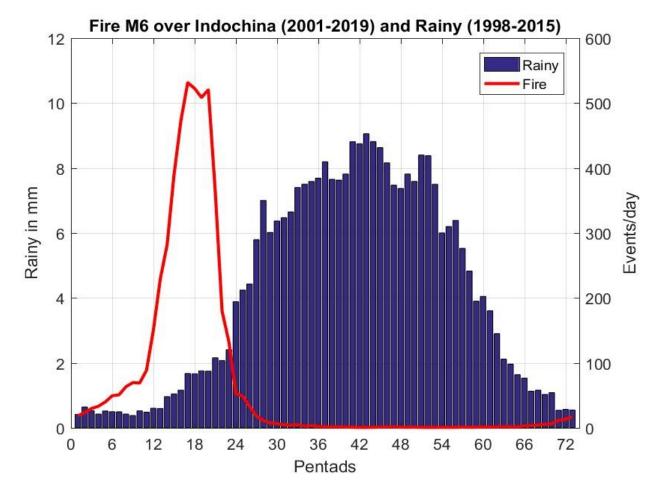








Yearly evolution of fire activity and rainfall in Indochina (10°N-25°N; 90°E-110°E).

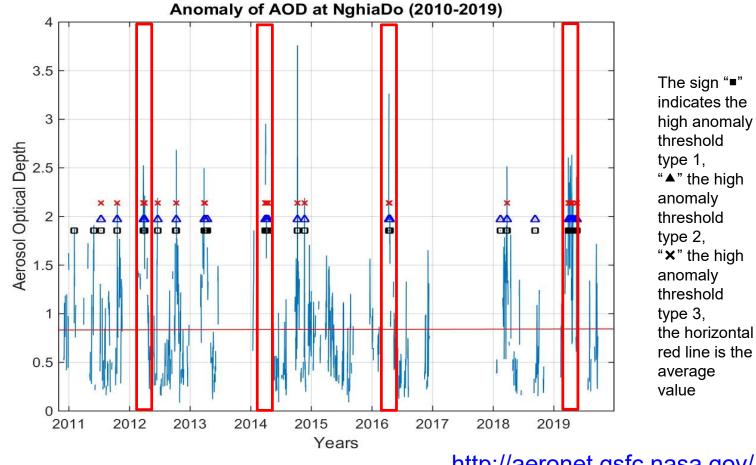


APHRODITE (Asian Precipitation - Highly Resolved Observational Data Integration Towards Evaluation) (<u>http://www.chikyu.ac.jp/precip</u>)



Aerosol Optical Depth in Hanoi

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



Existence of AOD anomalies:

24-27/3/2012 12-14/4/2016

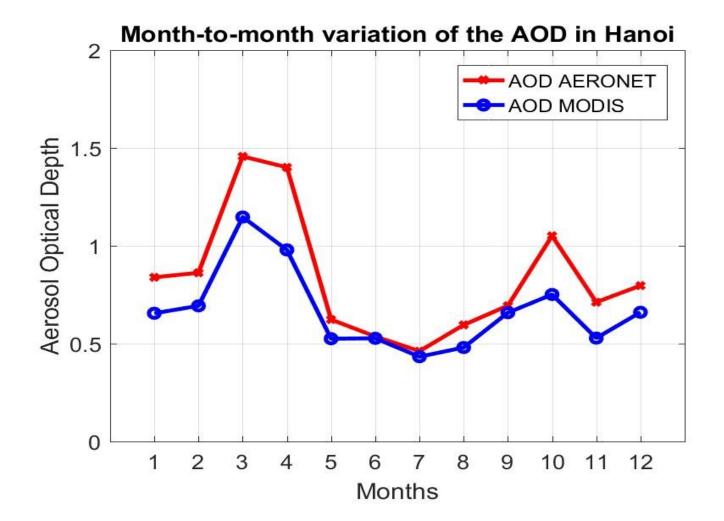
http://aeronet.gsfc.nasa.gov/

31/3-2/4/2014 11-14/4/2019





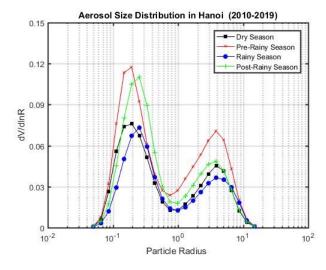
Month-to-month variation of AOD in Hanoi (2010-2019): Maximum in March-April & October; Minimum in July & November.



Aerosol Optical Depth in Hanoi

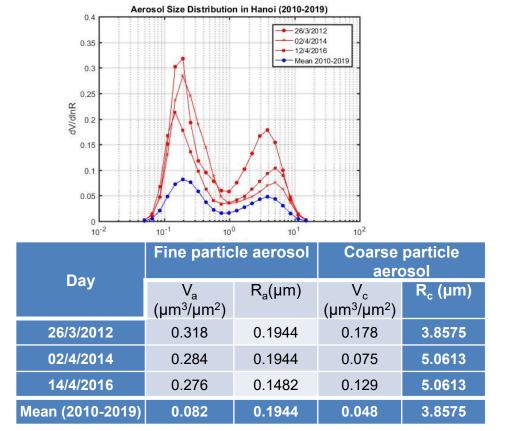


Size distribution of AOD (500nm) in Hanoi (2010-2019)



-Dry season (December, January, February),

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

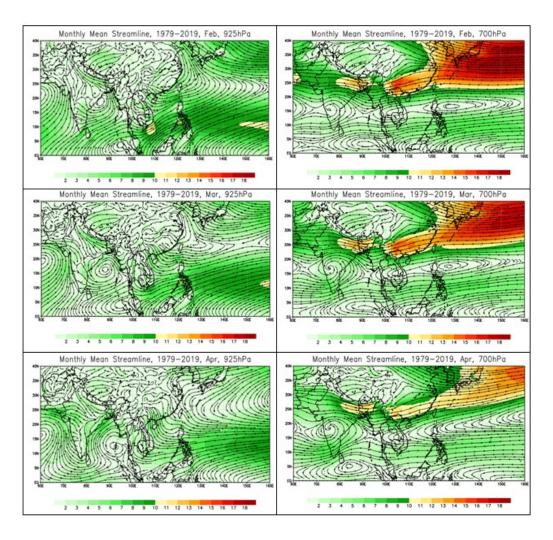


The fine-particle aerosol on transition period is about 1.5 times higher than that of the dry and rainy seasons.

Effects of Fire Activity in Indochina on AOD in Hanoi



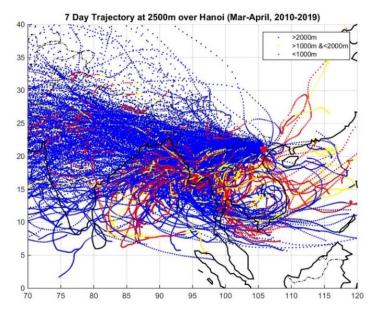
Monthly mean streamline charts (for the period 1979-2019) of large-scale circulation in Asia-Pacific for 700 and 925hPa, in February, March, and April, respectively.

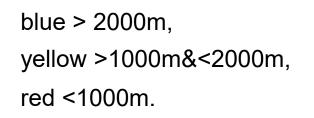


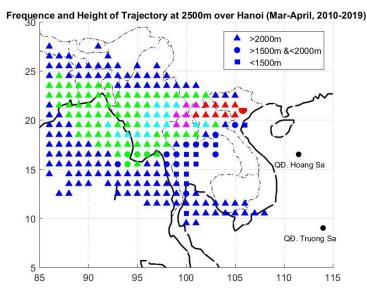
Effects of Fire Activity in Indochina on AOD in Hanoi



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



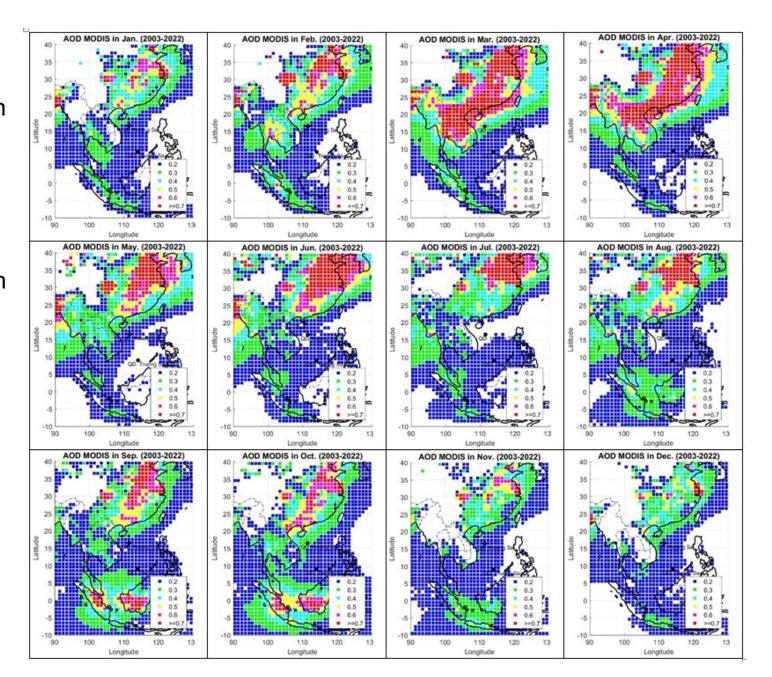




blue ~ 10-50 times; green~51-100; cyan ~ 101-150 times; red >200 times. ▲>2000m, ●>1000&<2000m,

∎<1000m.

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

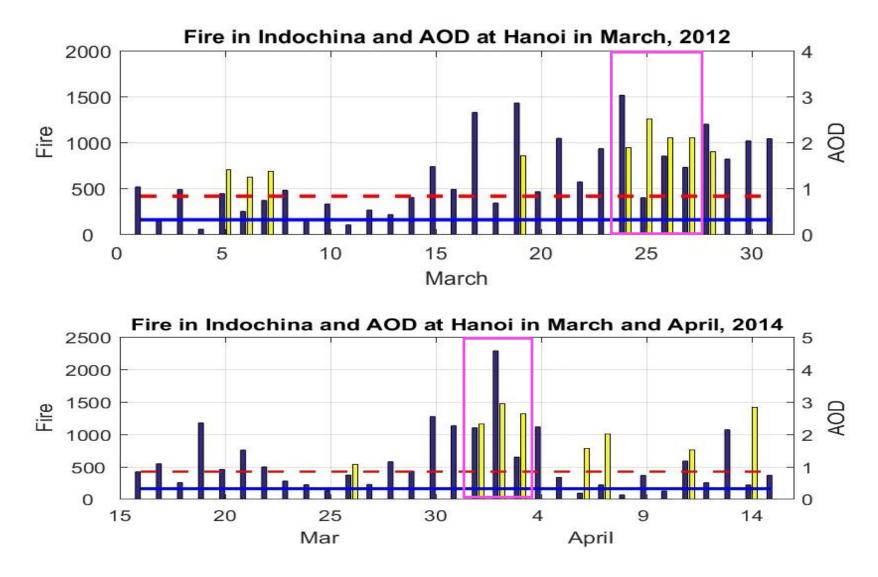




Fire activity and AOD during anomalous days :

JIEN VHI LY DIS

MIGP

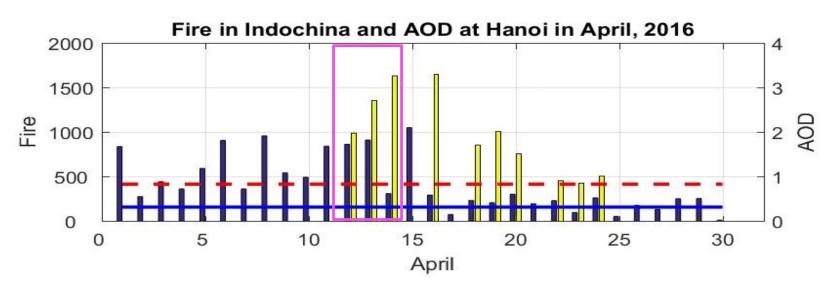


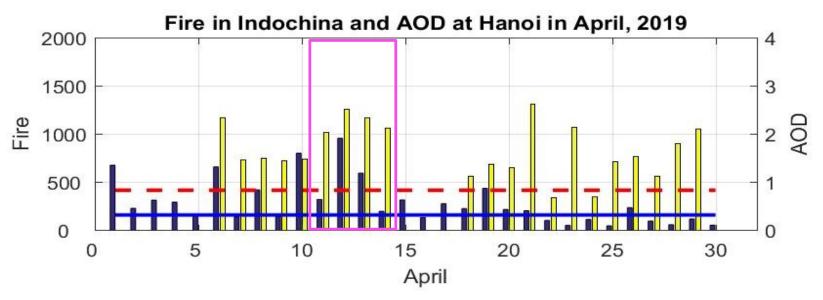


Fire activity and AOD during anomalous days:

VHI LP

MIGP

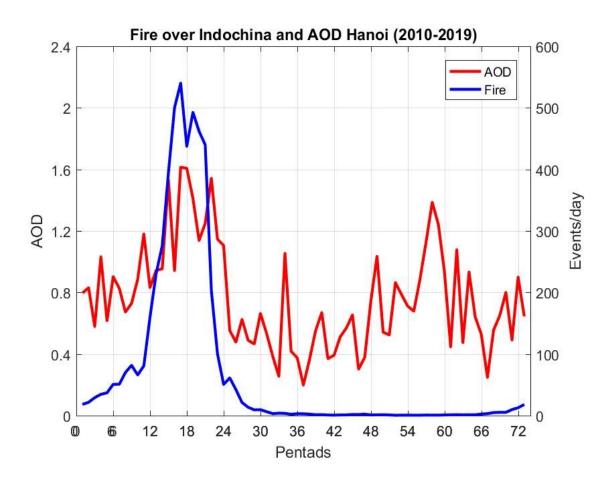




Effects of Fire Activity in Indochina on AOD in Hanoi



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

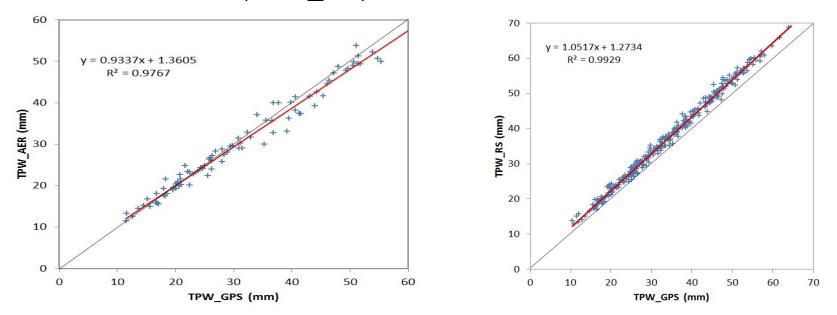




- Fire activity in Indochina take place from December of one year to May of the next year with a maximum in March.
- During the period 2010-2019, Hanoi AERONET station recorded 4 AOD anomalies times, in 2012, 2014, 2016 and 2019.
- Atmospheric circulation plays an important role in transporting aerosols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



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

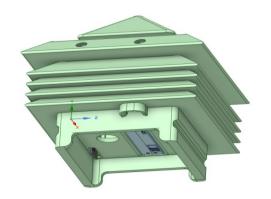
GPS data can be effectively employed to define the arrival of cold surges in the station area

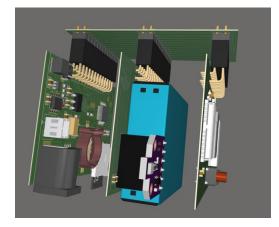
P.L. Khuong, N.X. Anh, et. al. 2024



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	<u>50%@0.3μm</u> ; 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	±10%@100 ~ 500μ g/m³	
(PM2.5 standard data)	±10µ g/m³@0 ~ 100µ g/m³	
Standard Volume	0.1	Litre(L)

low-cost PM2.5 sensor-based monitoring device







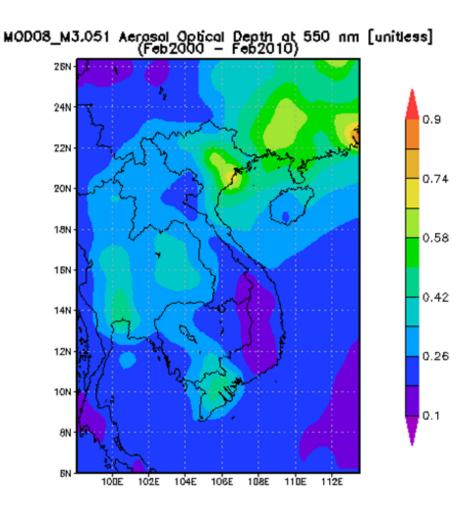
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17	9 17	39 3	8 8	2024	30.93	100032	75.93	33	47	50	26	37	43	6599	1238	229	20	3	1 V	Ő	0	Ő	ő	ŏ	ő	0 99.99	0
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- AERONET sites (Hanoi, Baclieu)
- IOPs (Spring 2025) for aerosol related study: Collection 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!