VERTICAL PROFILING OF AEROSOL TYPES OBSERVED ACROSS MONSOON SEASONS WITH A RAMAN LIDAR IN PENANG ISLAND, MALAYSIA

Presentation by:

Assoc Prof Dr. Lim Hwee San
School of Physics, Universiti Sains Malaysia (USM)
hslim@usm.my

Presentation Outline

- **INTRODUCTION**
- **STUDY AREA**
- **INSTRUMENTATION**
- **METHODOLOGY**
- **RESULTS AND DISCUSSION**
- **SUMMARY AND CONCLUSIONS**

INTRODUCTION

- Aerosols have attracted a substantial research interest over the last few decades.
- One reason is because aerosols are actively involved in global climate change.
- The National Aeronautics and Space Administration (NASA) Aerosol Robotic Network (AERONET) is a ground-based federated network of sun-photometers deployed all over the world since the 90's (http://aeronet.gsfc.nasa.gov).
- Various research endeavors have been conducted by synergizing the lidar measurements with the sunphotometer measurements.

INTRODUCTION

- However, results from this approach poorly resemble the actual atmospheric conditions, as only a single-valued, range-independent atmospheric parameter is obtained, such as the lidar ratio, while in fact, there might be several atmospheric layers that exist in the atmosphere.
- Therefore, the Raman lidar is preferred to study the actual atmospheric conditions as it resolves independently the extinction and backscattering coefficients, providing a direct measurement of the lidar ratio atmospheric profile, with respect to the single-wavelength elastic-backscatter lidar.

INTRODUCTION

- In this study, a Raman lidar was used to measure the range-dependent lidar ratio in Penang Island, Malaysia, and the corresponding aerosol types at various altitudes in the atmosphere were determined.
- In addition, the dominant aerosol types during different monsoon seasons were studied as well because this research was conducted from the end of the Northeast monsoon season until the beginning of the Southwest monsoon season.
- The Raman lidar findings are then validate with AERONET sun-photometer data and the aerosols radiative effect is evaluated with the Fu-Liou-Gu radiative transfer model.

STUDY AREA

- The lidar was setup on the roof top of the School of Physics, at the Universiti Sains Malaysia, Penang, Malaysia (5° 21′ 30.06″ N, 100° 18′ 8.1″ E, 51 m above mean sea level (AMSL).

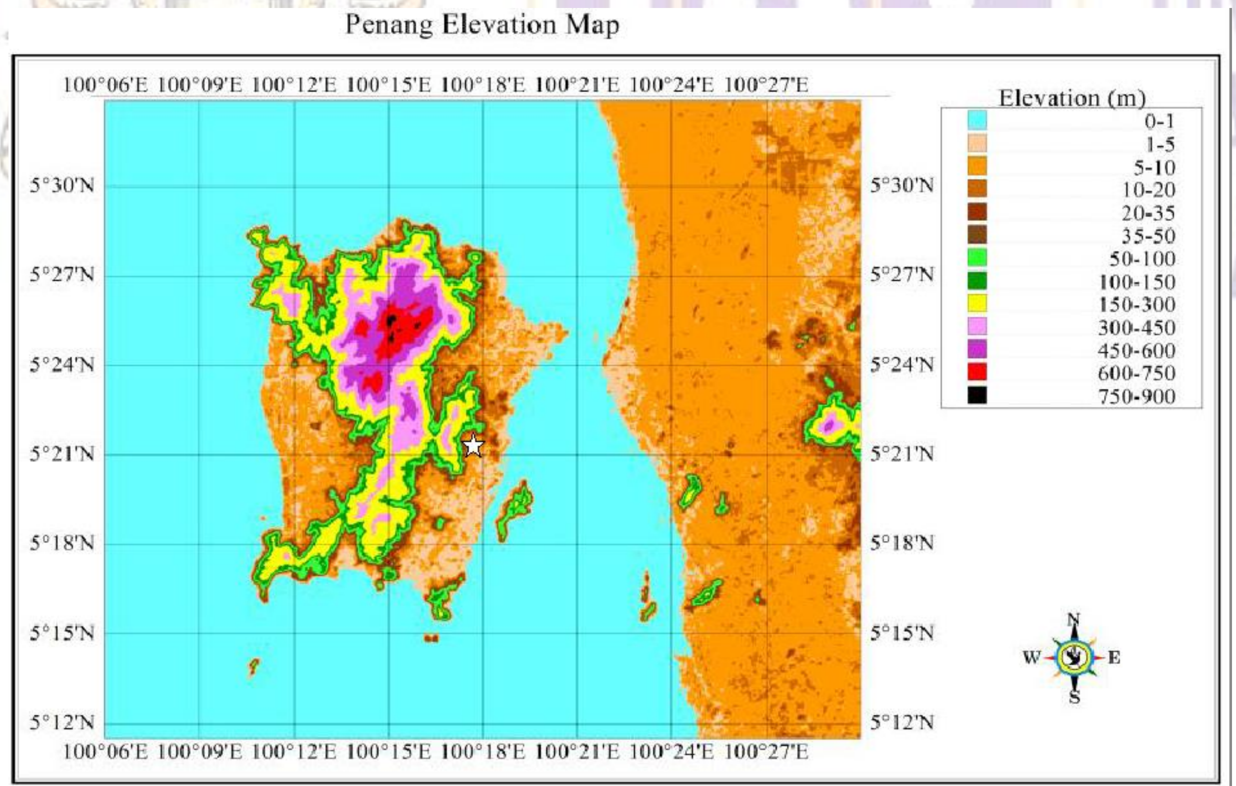

Fig. 1, a topographic map produced from the global digital elevation model (GDEM), shows the high-mountain and low-plain regions of Penang Island.

INSTRUMENTATION

- The Raman Lidar, model number ALS320-ESS-D200 used in this study, was manufactured by Raymetrics S.A. at Athens, Greece.
- The Raman lidar consists of a Nd:YAG tripled laser emitting pulsed radiation at 355 nm, with a repetition rate of 20 Hz.
- The outgoing laser pulse is collimated with a beam expander, which expands the beam diameter up to 10 times before sending it into the atmosphere.
- A 20-cm diameter Cassegrainian telescope was responsible for collecting the radiation backscattered from both atmospheric particles via elastic scattering and nitrogen gas via inelastic scattering through the vibrational-rotational Raman band of nitrogen at 387 nm.

INSTRUMENTATION

- Both the elastic and Raman lidar backscattered signals are separated by a dichroic mirror and interference filters.
- All of the signals, recorded with photomultiplier tubes in analogue and photon-counting mode, are stored at 1 min temporal resolution and 7.5 m spatial resolution, respectively.

METHODOLOGY

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RESULTS AND DISCUSSION

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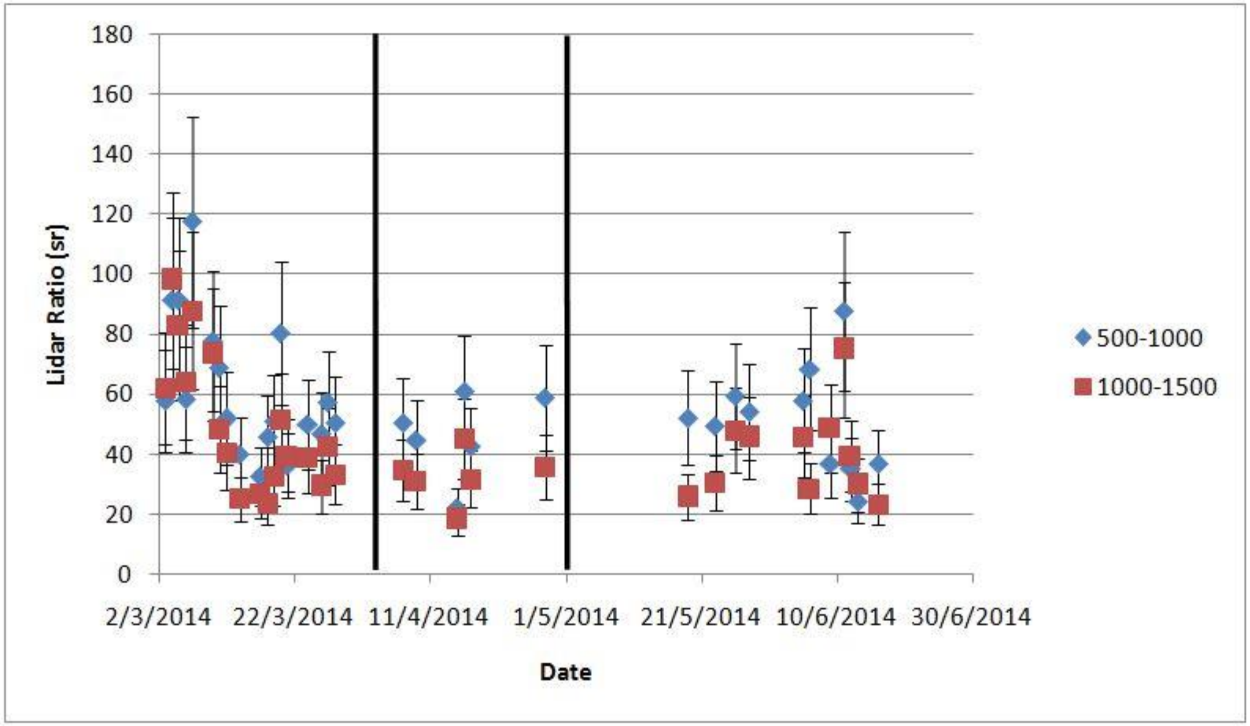
Range-dependent lidar ratio variation over the study period

- Fig. 2 show the mean lidar ratio over the 500-1000 m layer and 1000-1500 m layer.



RESULTS AND DISCUSSION

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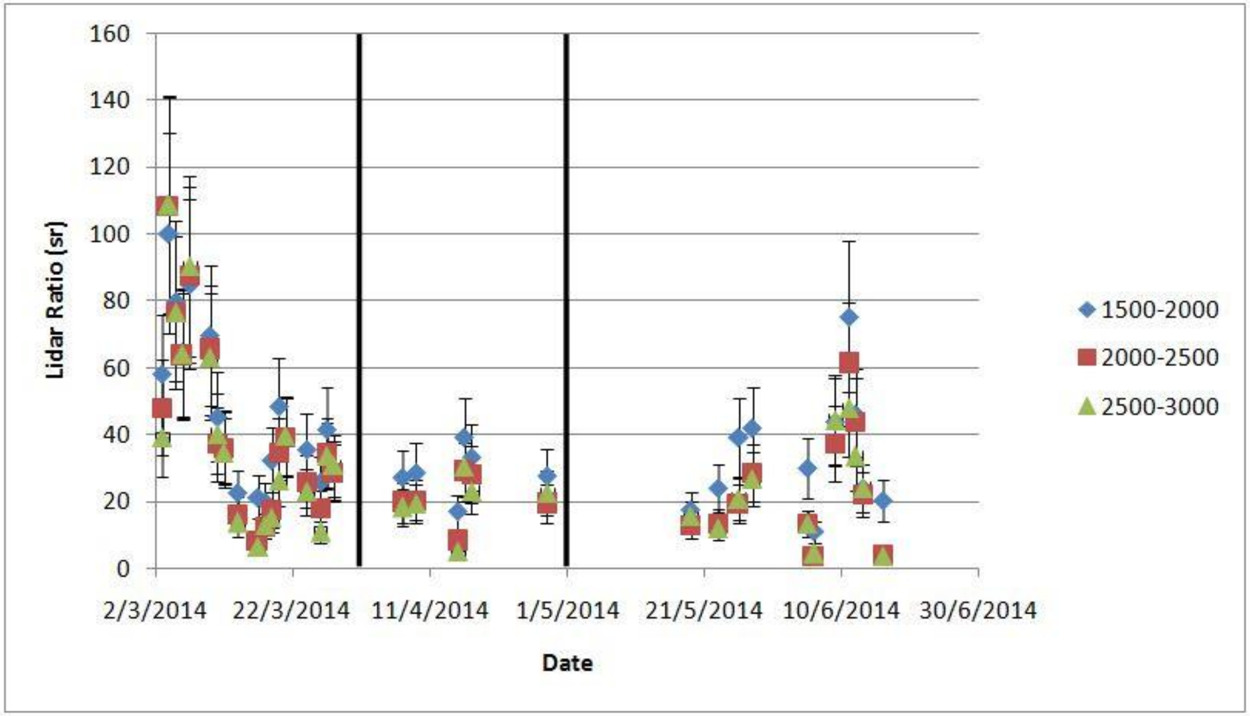
Range-dependent lidar ratio variation over the study period

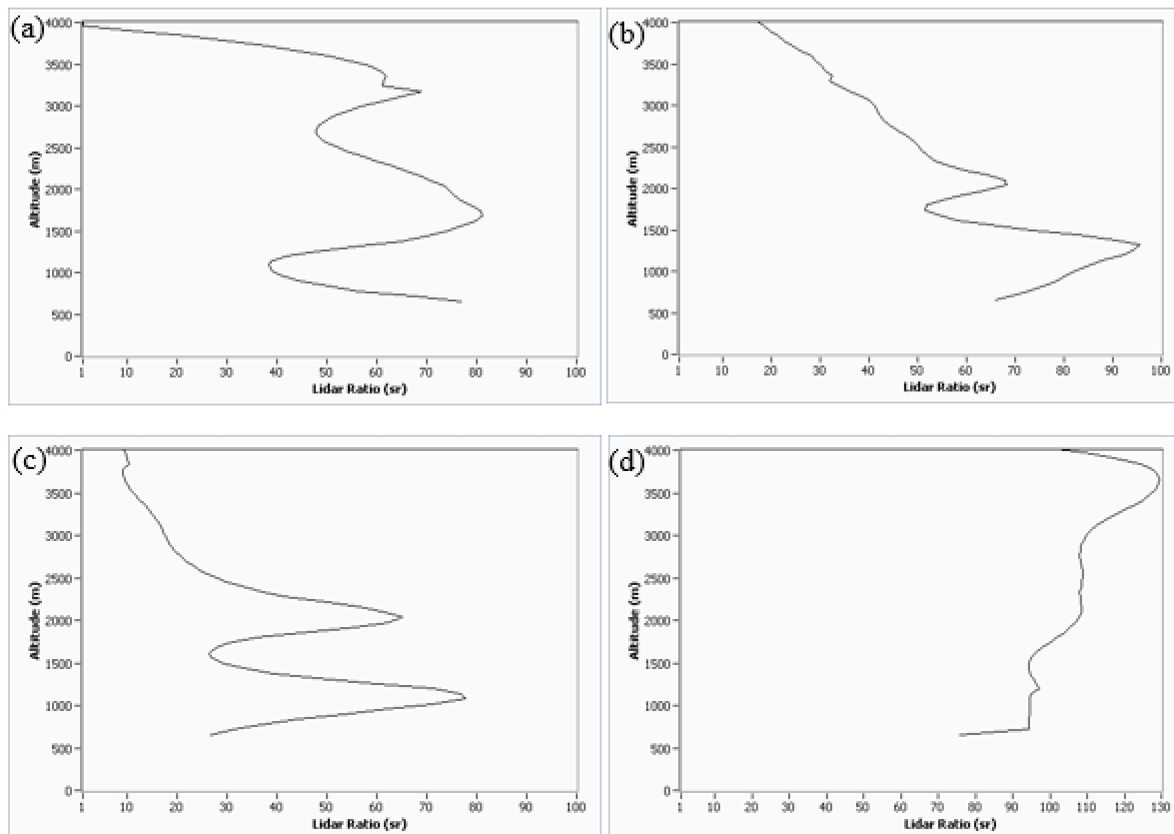
- Fig. 3 show the mean lidar ratio over the 1500-2000 m layer, 2000-2500 m layer and 2500-3000 m layer, with the black vertical lines marking the boundaries of different monsoon seasons.



RESULTS AND DISCUSSION

Raman Lidar Measurements of the March 2014 Haze Episode

- Fig. 4(a-d) shows the lidar ratio profile with increasing height for 3/3/2014 at 1200 UTC, 3/3/2014 at 1500 UTC, 3/3/2014 at 1800 UTC and 4/3/2014 at 1200 UTC, respectively.



RESULTS AND DISCUSSION

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Radiative Effects Of Background And Advected Aerosols

- The radiative effects of background and transported aerosols are evaluated with the FLG radiative transfer model.
- An accurate description of the model can be found in Lolli et al., 2016 and in Campbell et al., 2016.
- The FLG model evaluated the daily averaged radiative effect (calculated as the difference between aerosol and pristine condition cases) at surface for three different measured aerosol profiles:
  1. Background marine-polluted aerosols confined in the PBL (0-1000m)
  2. Same as 1), but with smoke advected aloft (1000-1500m)
  3. Entire column dominated by smoke (haze episode, 0-3000m)

RESULTS AND DISCUSSION

Radiative Effects Of Background And Advected Aerosols

The results are reported in Table 1

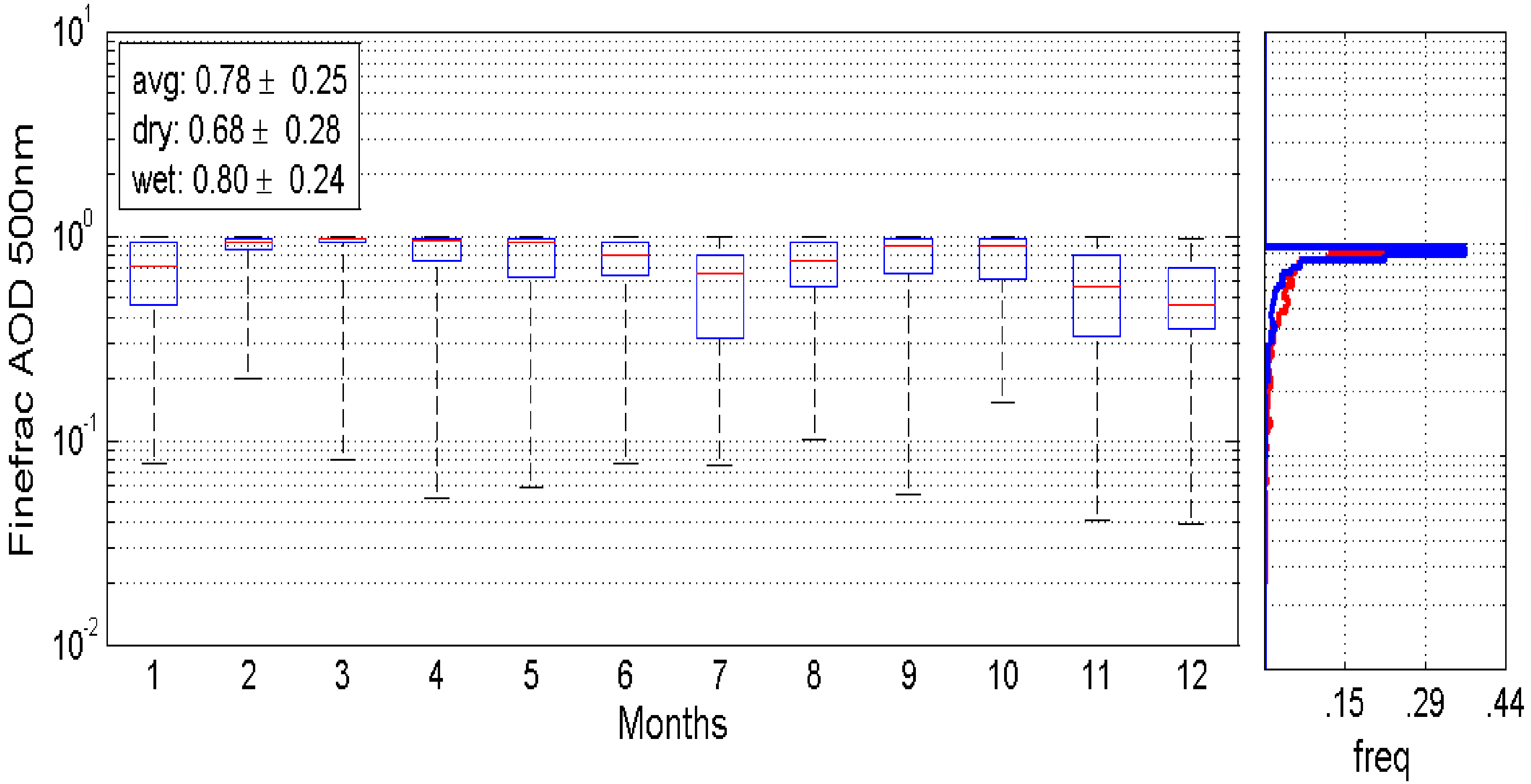
Table 1 FLG radiative model results for different aerosol configurations at surface

The shortwave component (SW) is order of magnitude bigger than outgoing infrared longwave component (LW). For haze conditions, the presence of thick biomass-burning aerosol layer can cool the surface of -113 W/m^2 in average.

Aerosol configuration	SFC Forcing (W/m^2)
1	-24
2	-66.2
3	-113

RESULTS AND DISCUSSION

Radiative Effects Of Background And Advected Aerosols



SUMMARY AND CONCLUSIONS

- In conclusion, the Raman lidar measurements found that background aerosols in Penang Island consist of marine and urban aerosols, with lidar ratio values ranging from approximately 20 ± 6 sr to 30 ± 9 sr and 30 ± 9 sr to 60 ± 18 sr, respectively.
- Additionally, wood burning aerosols (60 ± 18 sr to 80 ± 24 sr) and aged forest fire aerosols (80 ± 24 sr to 120 ± 36 sr) were present when pollution events occurred.
- Throughout the monsoon season, the background marine and urban aerosols were found during the study period, whereas wood burning and aged forest fire aerosols were found during early March 2014 (approaching the end of the Northeast monsoon season) and June 2014 (the beginning of the Southwest monsoon season).

SUMMARY AND CONCLUSIONS

- These pollution events consisting of smoke aerosols were found during periods of very hot and dry meteorological conditions, despite these periods occuring during the monsoon season.
- Therefore, the type of aerosol present over Penang is not related to the monsoon season, rather the meteorological conditions associated with biomass burning.
- Finally, the Raman lidar measurements during the haze episode showed that during the development phase of the haze episode, wood burning aerosols were dominant in the entire atmospheric column.
- When the haze began to subside, background urban aerosols were detected together with wood burning aerosols.

SUMMARY AND CONCLUSIONS

- After the haze subsided, wood burning aerosols were no longer detected in the atmosphere; however, aged forest fire aerosols were dominant in the entire atmospheric column.
- A few days were required before these aged forest fire aerosols completely dispersed from the atmosphere. Radiative transfer calculations put in evidence a strong cooling effect at surface of advected biomass-burning aerosol layers.
- However, this study is a localized study. Hence, the results only apply to Penang Island, not the general atmosphere in other region of the world.

THANK YOU

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Terima Kasih