能源及環境學院
SCHOOL OF ENERGY AND ENVIRONMENT

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Observational analysis of biomass burning impacts to Hong Kong

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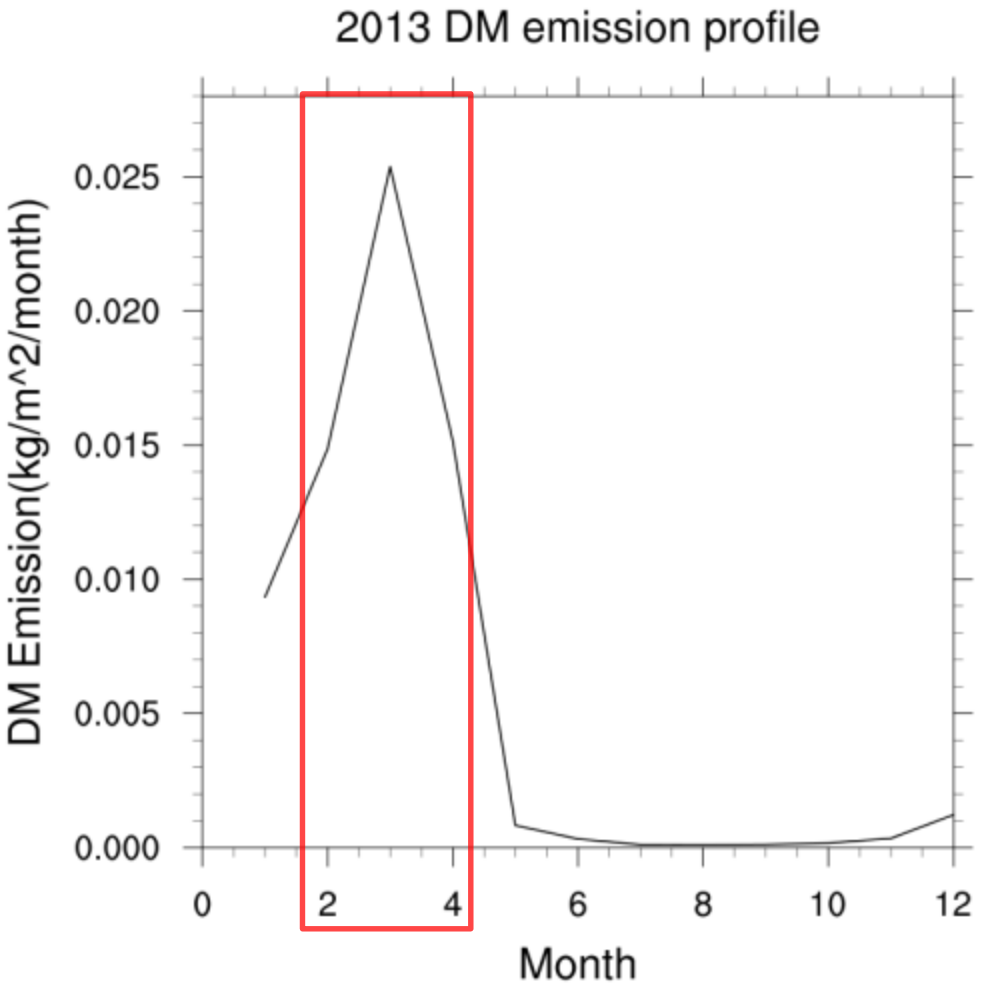
Introduction

Biomass burning:

- Forest, grassland, domestic and open burning
- Affect air quality, human health, visibility and global climate
- Global source of aerosol and trace gases
- Significant contribution of VOCs/PM/CO to the atmosphere

Source:http://news.stanford.edu/news/2014/july/images/14125-biomass_banner.jpg

Southeast Asia Burning Emissions)



(from Global Fire Emission Database)

- March and April are referred to the start of spring farming season in SEA peninsula (Pochanart *et al.*, 2001; Gadde *et al*., 2009)
- Annual profile of biomass burning dry matter (DM) emission in SEA
- **Peak at spring**
- Dry season: October to May

Hong Kong Situation

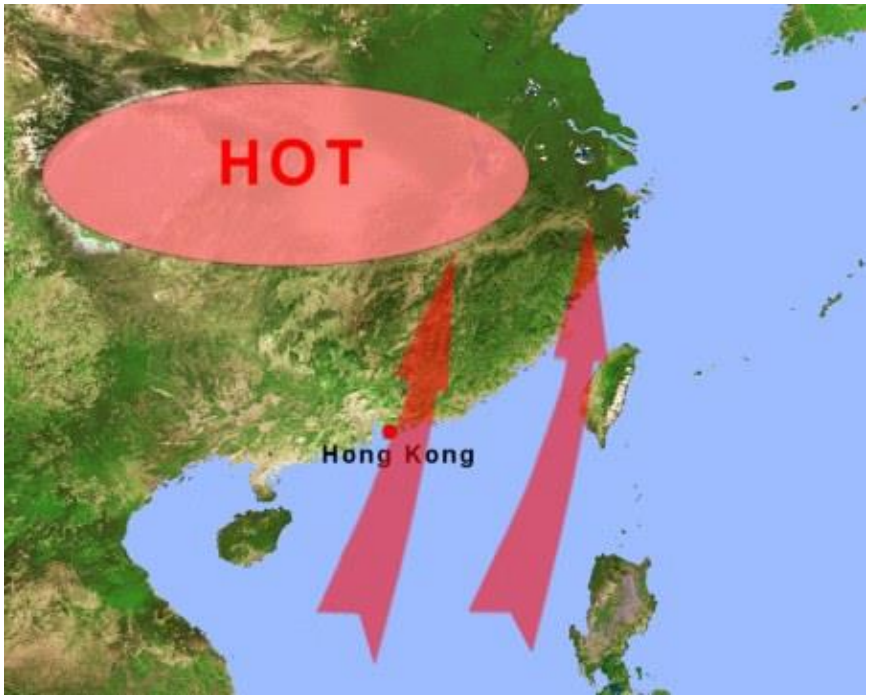
1. High pollutant concentrations in the spring

Examples from Tap Mun station:

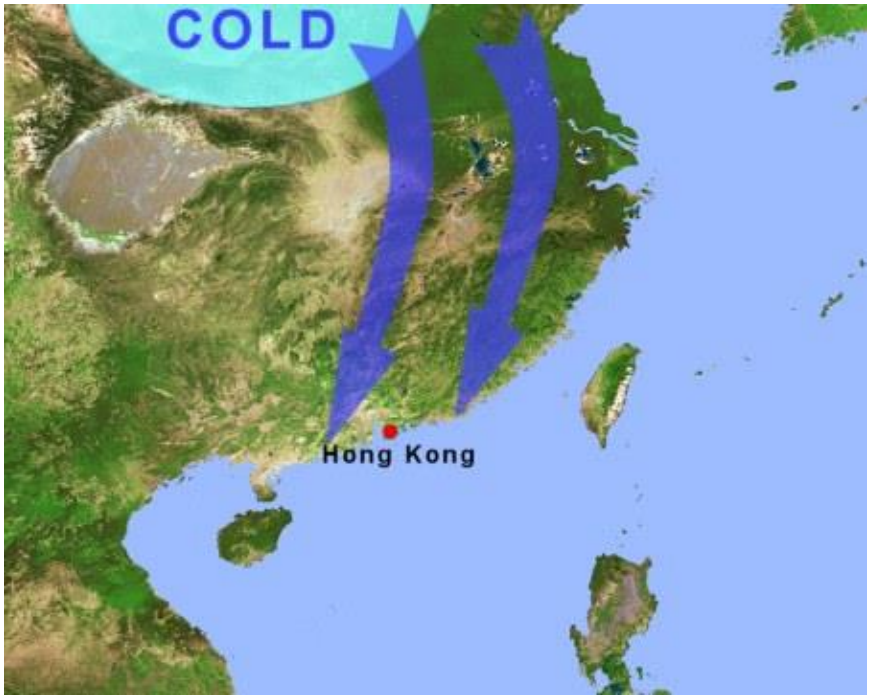
- O_3: 263 μg/m^3
- PM_{10}: 90 μg/m^3
- 17 incidents of “high” and 3 incidents of “very high” of Air Quality Health Index (AQHI) in April 2015

Seasonal change of wind pattern (South China Sea)

Summer Monsoon (SW):
bring clean maritime air to SCS



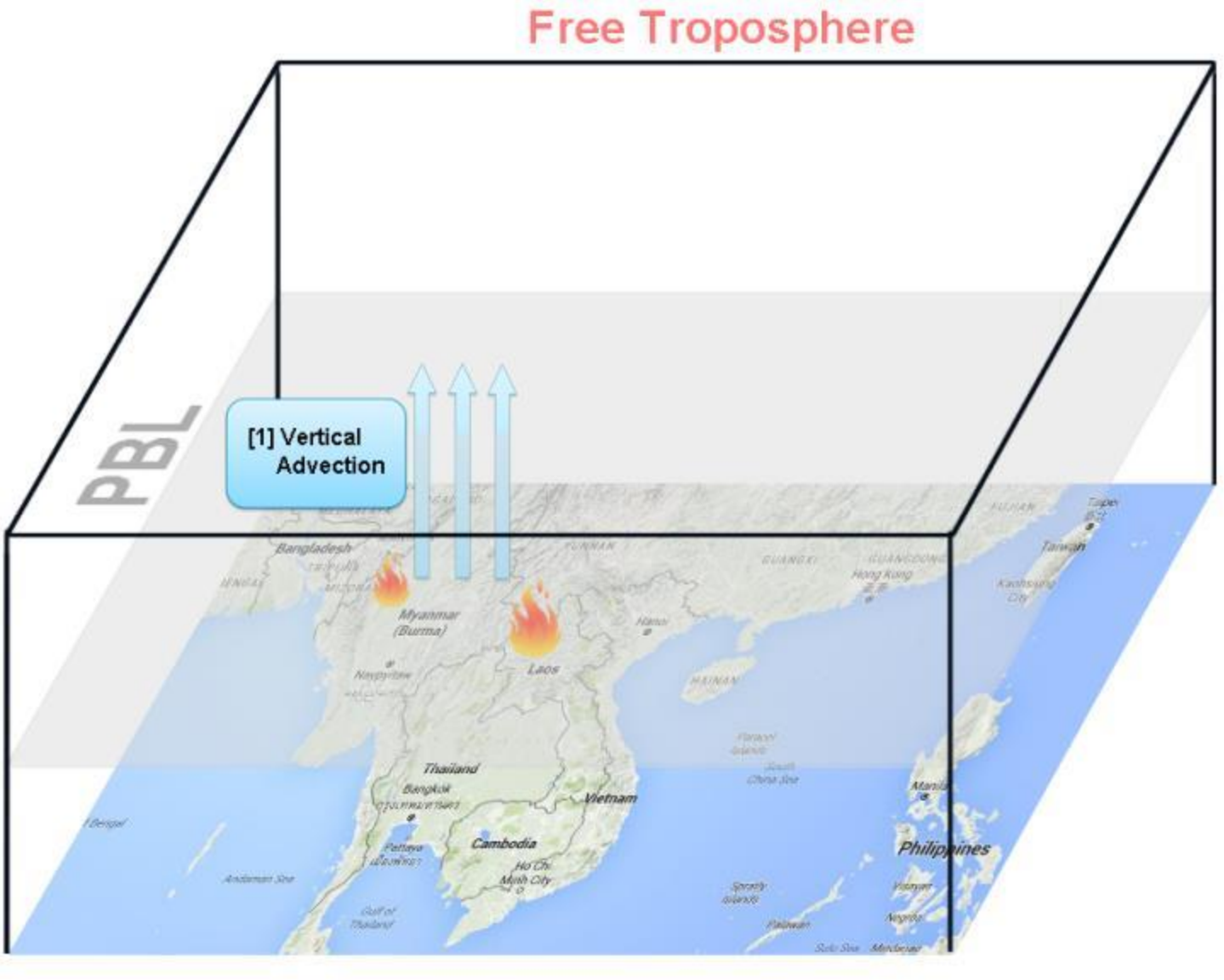
Winter Monsoon (NE):
bring industrial pollutants to SCS



Source: http://www.hko.gov.hk/blog/en/archives/00000071.htm

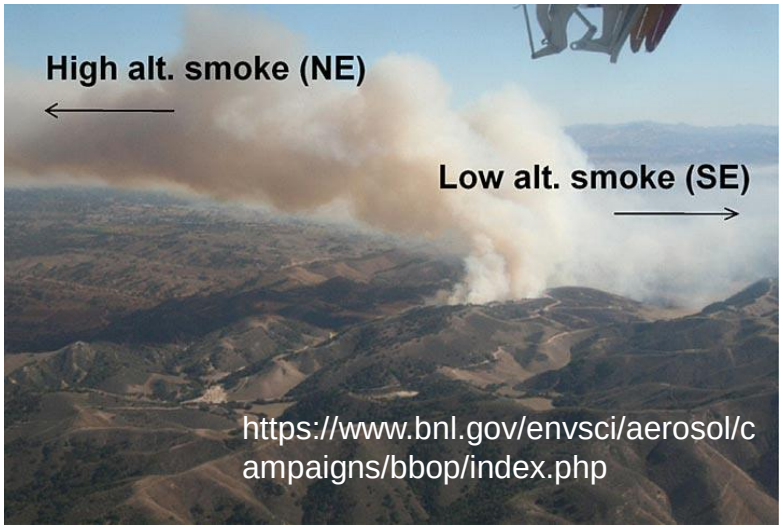
∴ Air pollution episodes mainly take place in winter

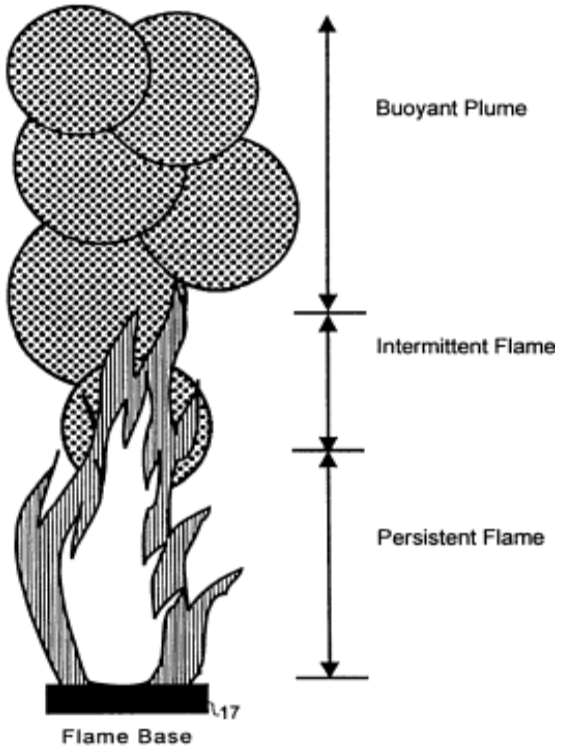
Transport Mechanism



[1] Vertical Advection

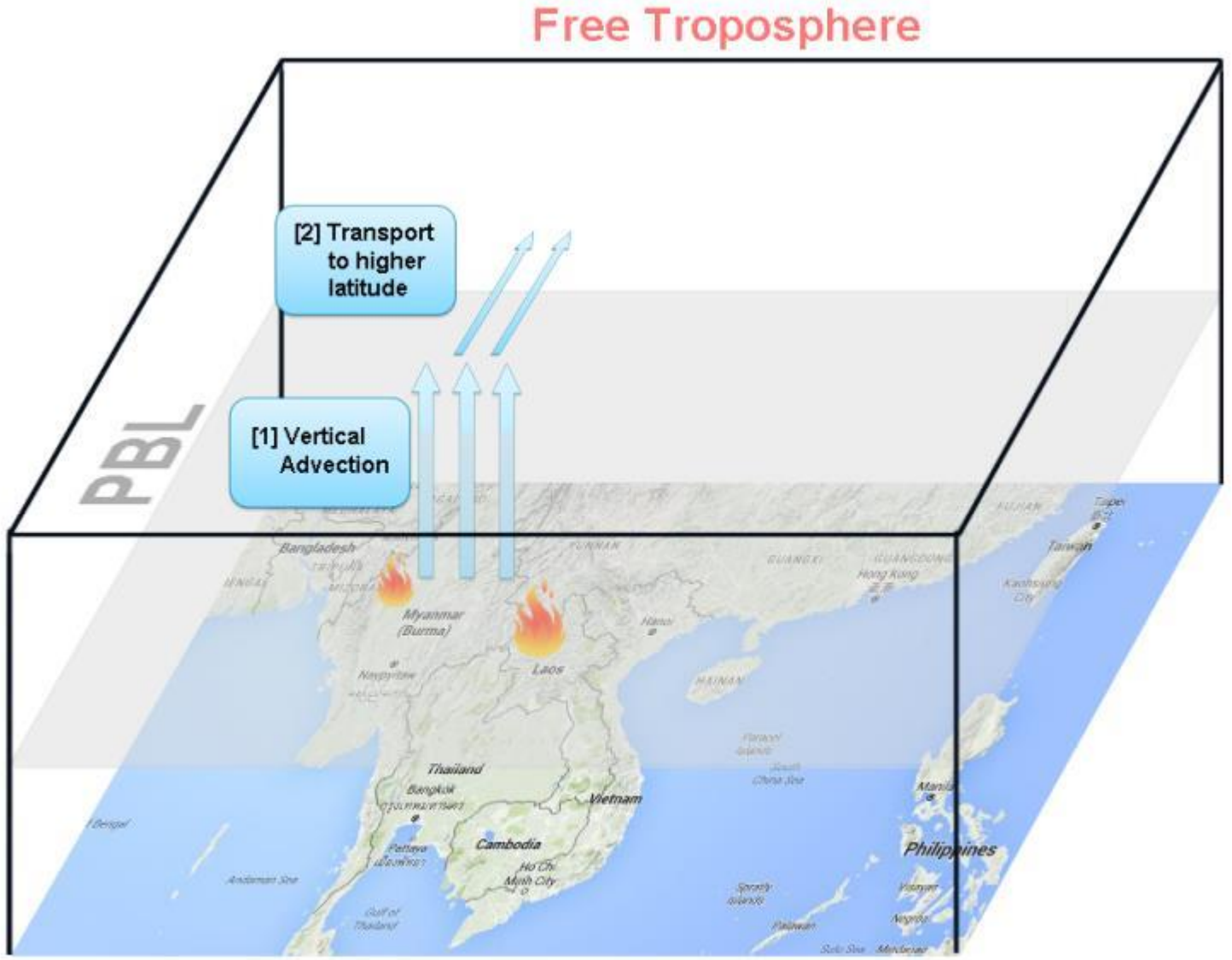
- **Fire buoyancy** - Height of emission plume = 2~5km
- ~40% **directly injected to the free troposphere** (Jian and Fu, 2013)
- Reach the free troposphere



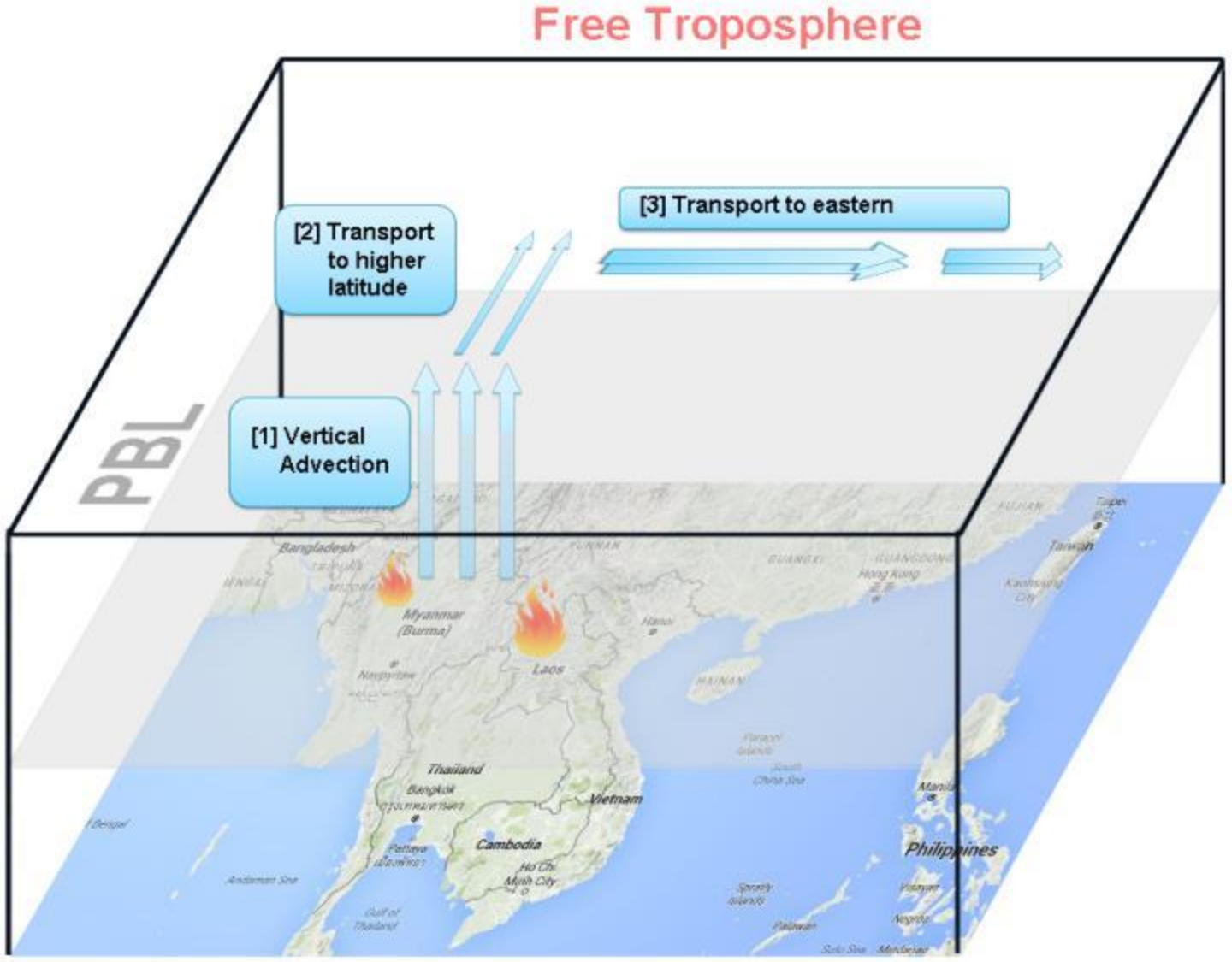


Source: http://patentimages.storage.googleapis.com/thumbnails/US6809743B2/US6809743-20041026-D00002.png

Transport Mechanism

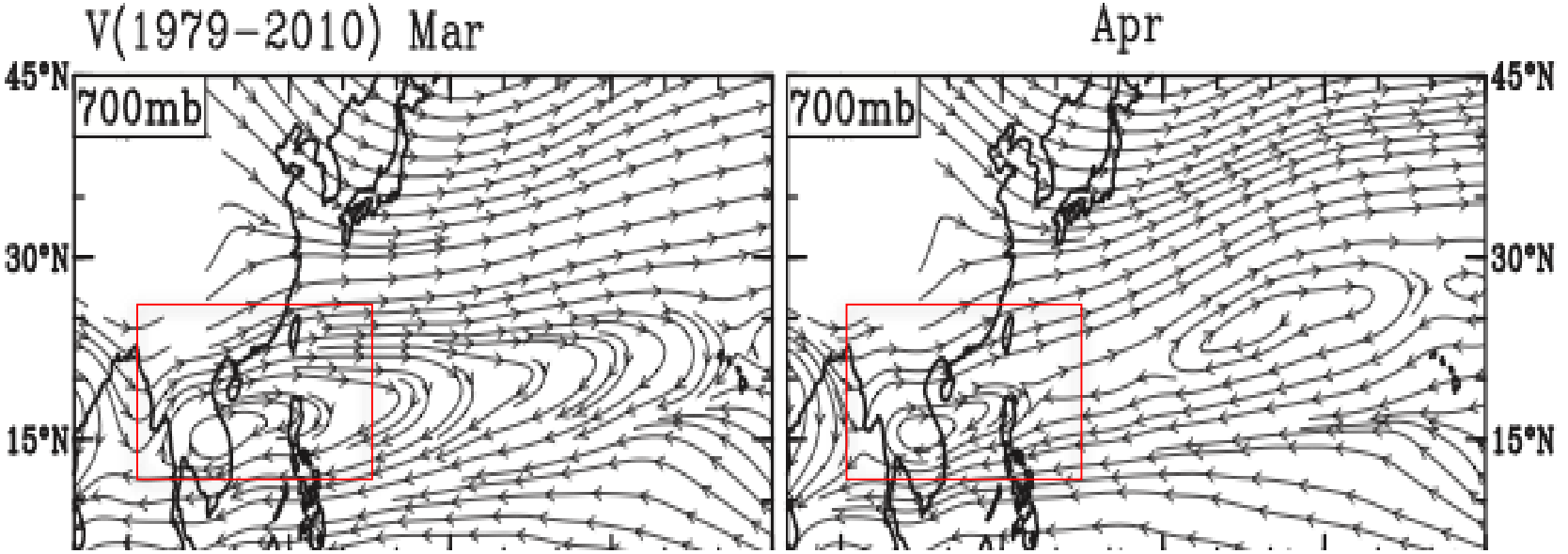


Transport Mechanism

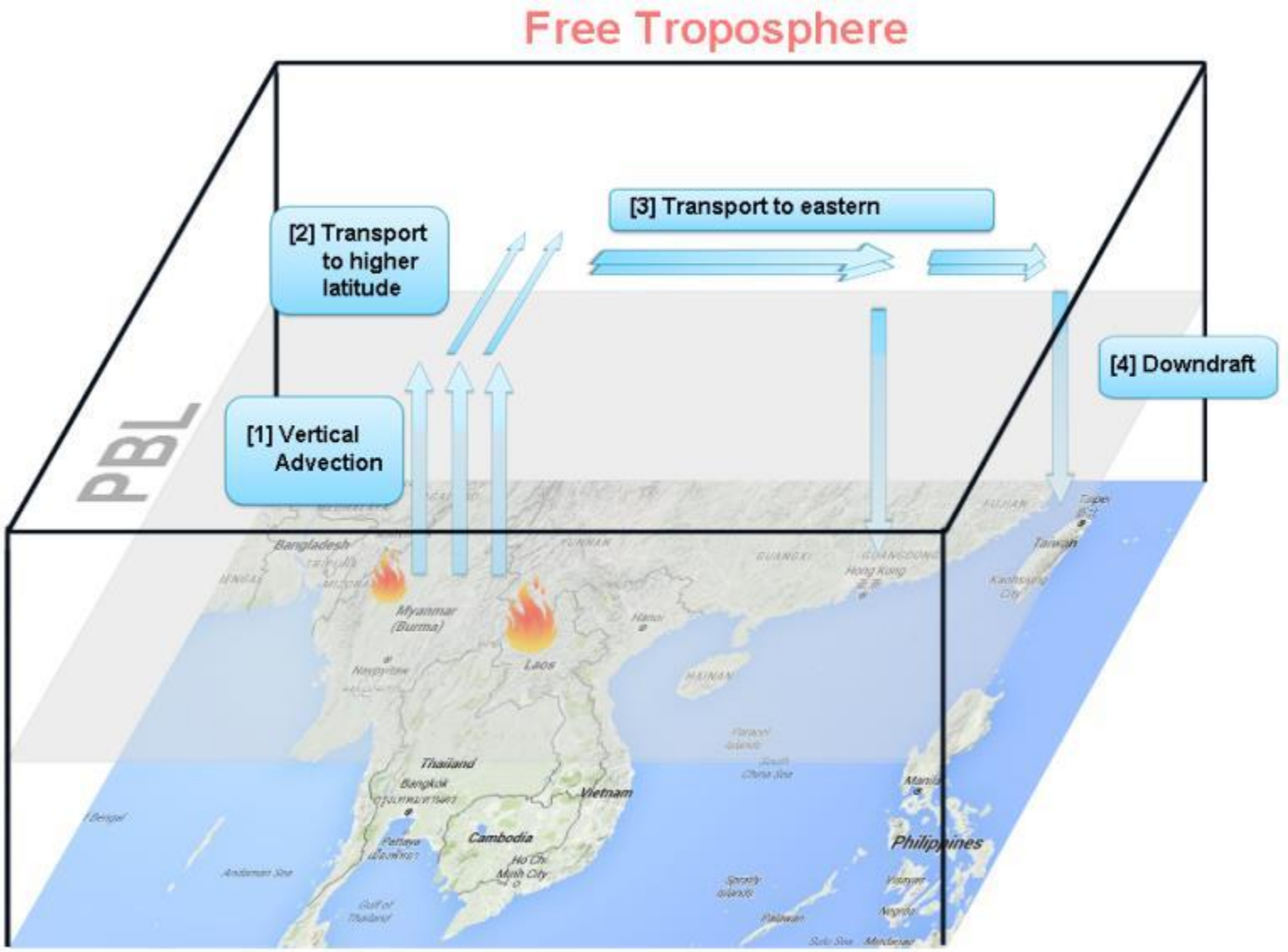


[2] Transport to Higher Latitude

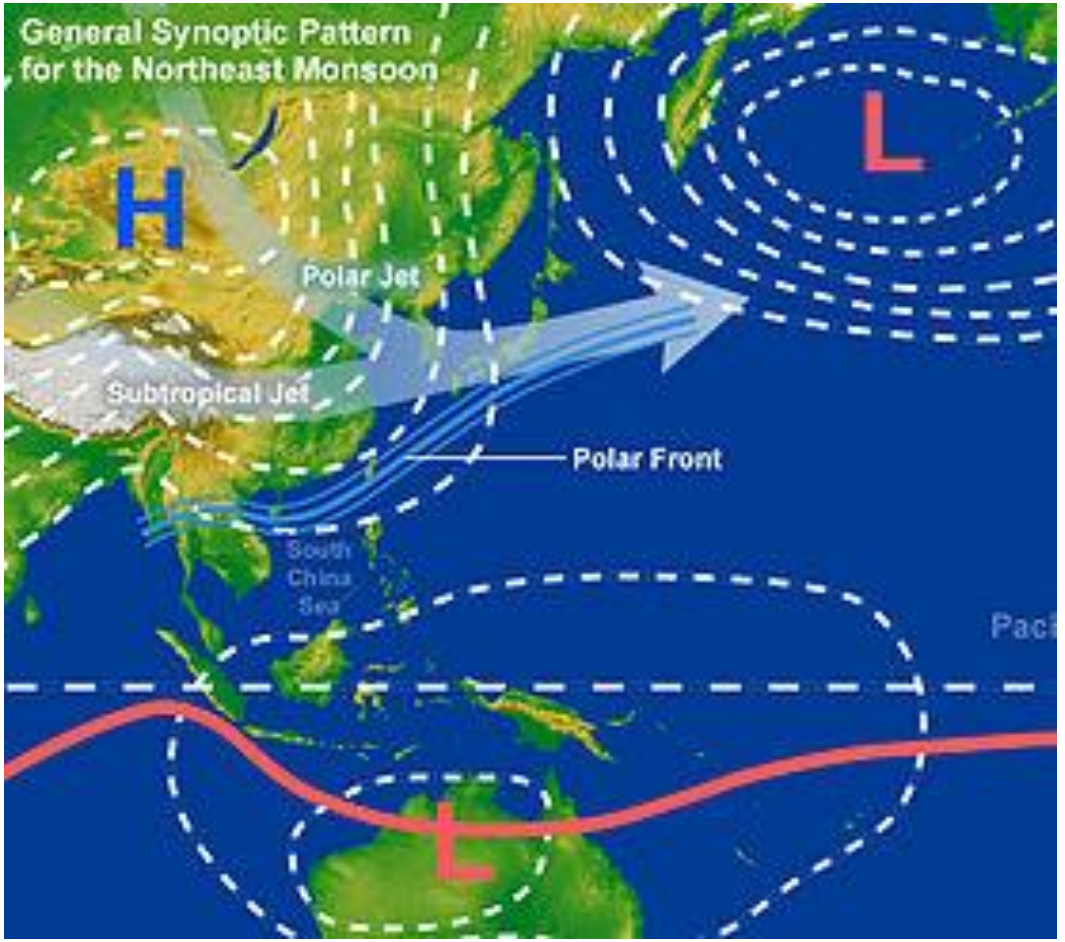
1. The southwesterly flow confluence boundary layer coupling with a well-organized **convergent center** at the Indochina peninsula in March and April
2. Encourage an **ascending motion** to form the upward branch at the burning region (Lin *et al*., 2013; Yen *et al*., 2013)
3. Pollutants were brought up to **higher latitude** regions



Transport Mechanism



[4] Downdraft to Surface



- Cold surge anticyclone: Southward cold air over northern provoke cold surge
- Cold surge and warm front meets
- Cold air slides under the warm air and bring biomass pollutants aloft to the surface of Hong Kong

Source: http://www.wxkph.info/#!ne-monsoon-and-cold-surges/czz9

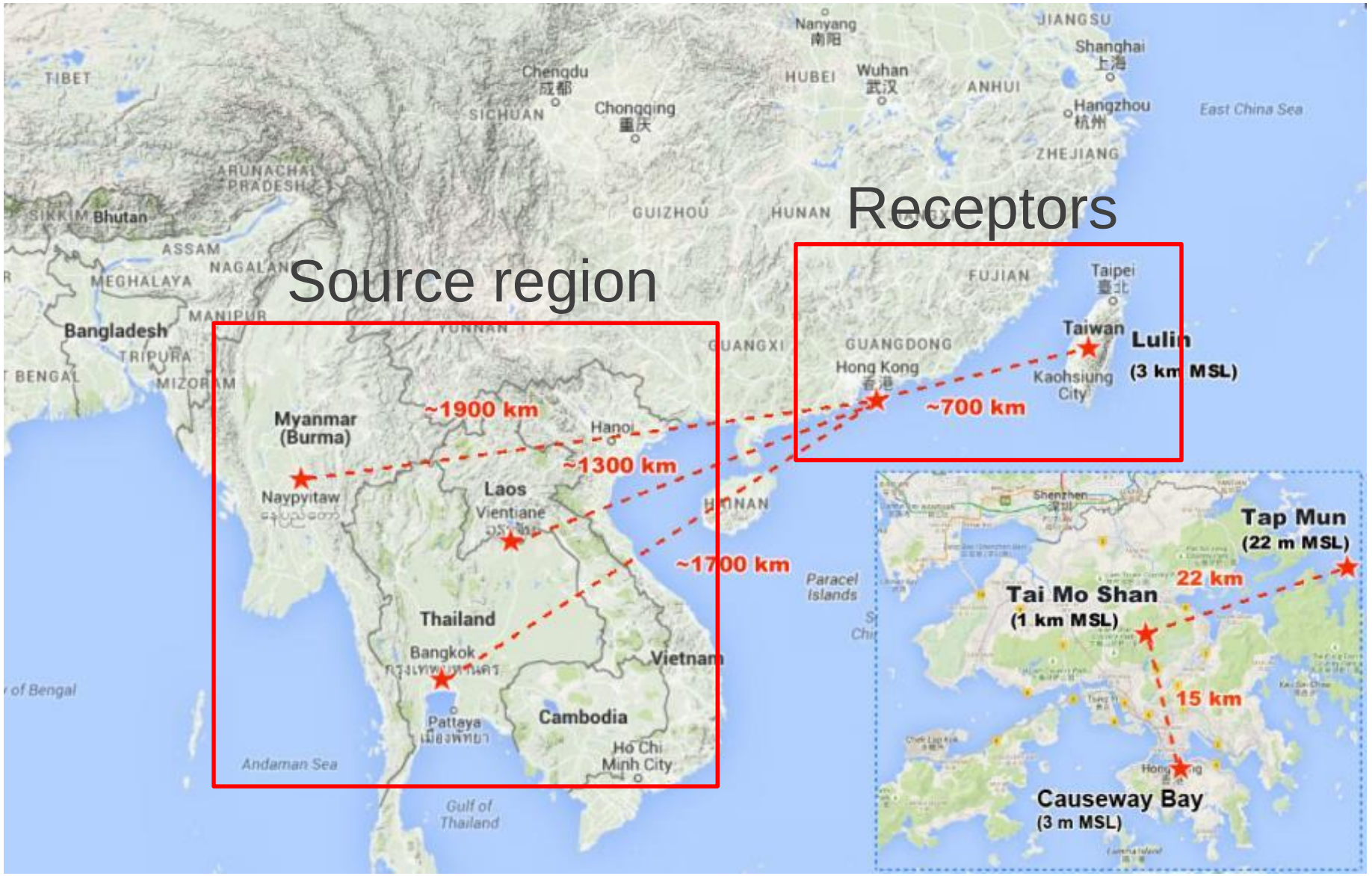
Study Analysis

Observation analysis/impact study

- Impacts on regional background pollution
- Study on Spring-time biomass burning events
- Impacts on local air quality at South China Seas

- Study period: **March – May 2012-2015**
  - O_3, CO, PM, NO_x, SO_2

Study Domain



Selected Stations

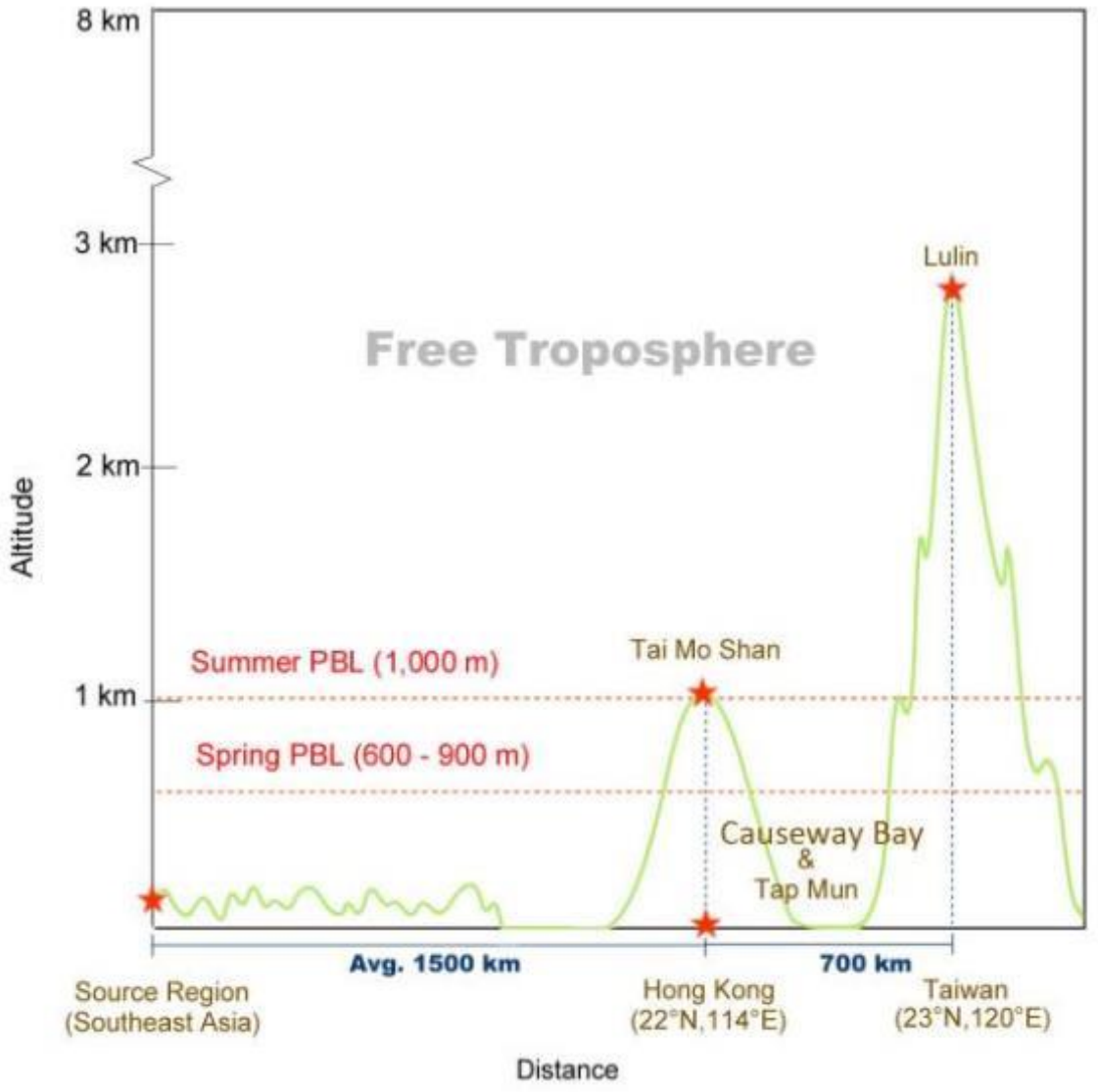
List of stations:

Hong Kong

- Tai Mo Shan
- Causeway Bay
- Tap Mun

Taiwan

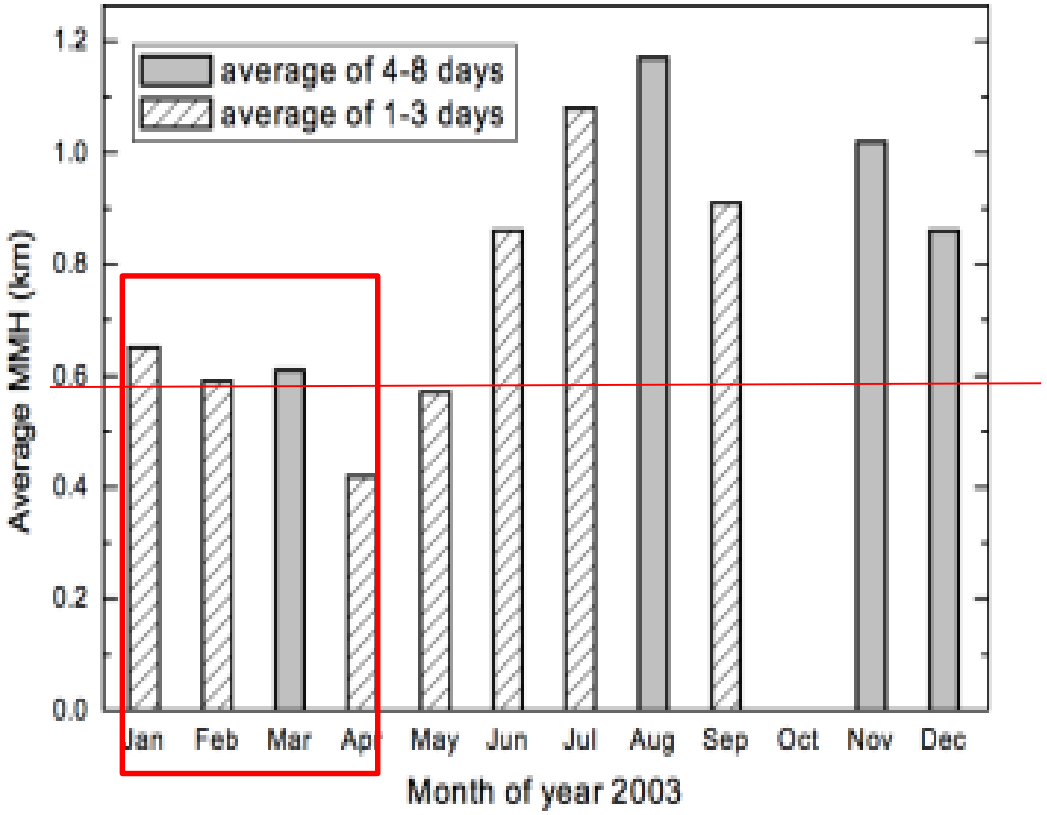
- Lulin



Hong Kong stations

[1] Tai Mo Shan Station

- ~1km MSL
- Spring-time PBL around 400-650 m, in most time less then 800m
- Well represent the air **above the PBL**
- Data available until 2015
- Equipment: O_3, CO, PM, NO_x, SO_2



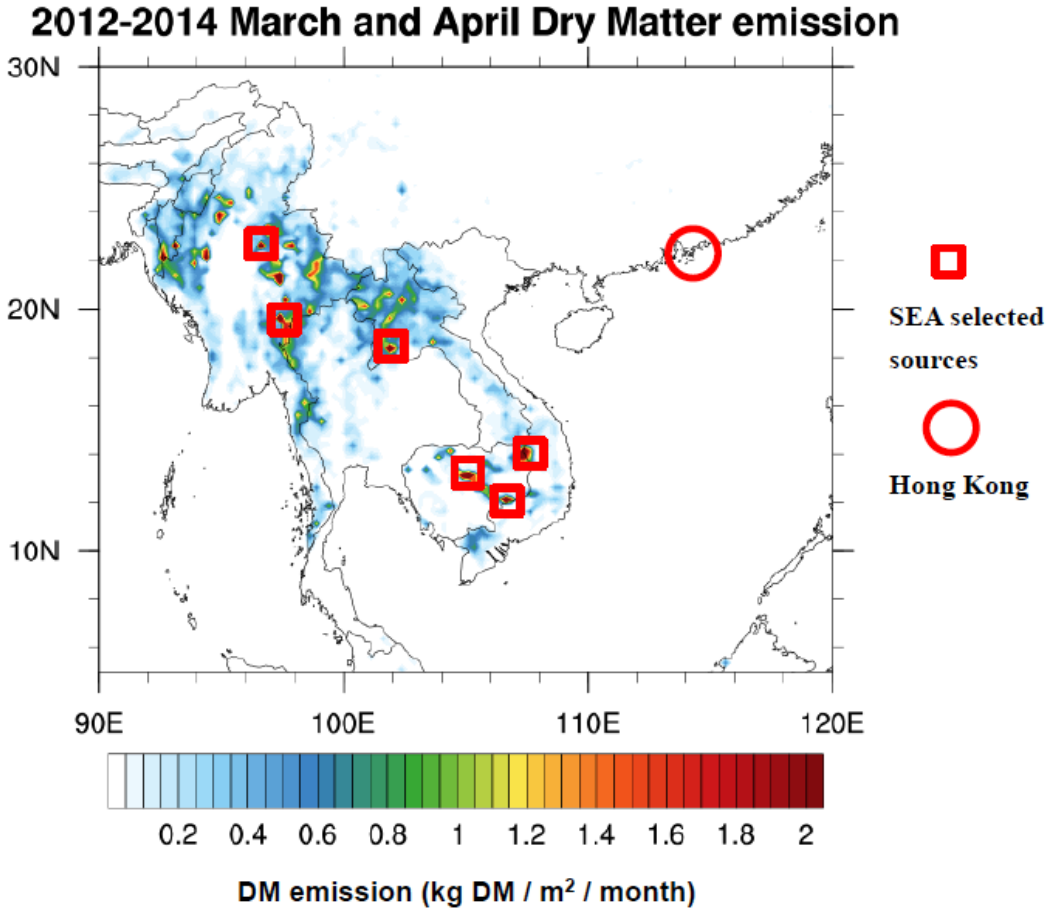
Results discussion

1. **Background contribution to SCS**
2. Event identification and its impact
3. Impacts of downdraft meteorological condition

[1] Background Contribution

- Identify source region
- Perform HYSPLIT particle dispersion model
  (1) With vertical mixing below 800m
  (2) Without vertical mixing or passing through HK domain
- Identify background enhancement through local monitoring data
  – Pure transport, regardless of SEA emissions

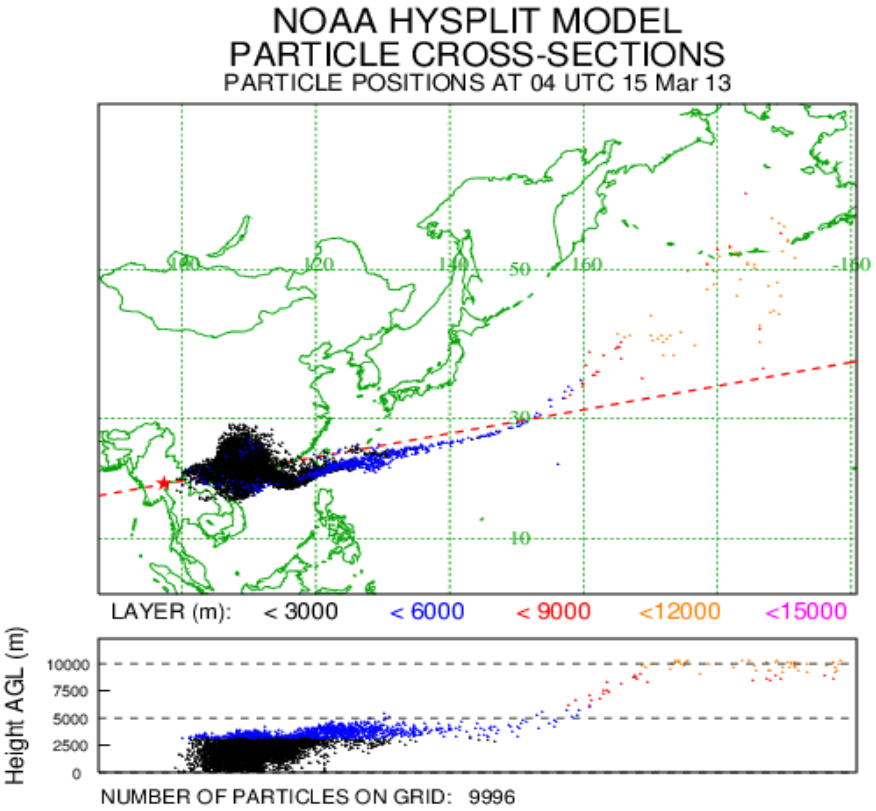
Identify source region



Statistics Dispersion	Magnitude (kg DM/m²/month)
Mean	0.135
Upper 5.0%	0.658
Upper 1.0%	**1.440**
Upper 0.1%	**2.911**

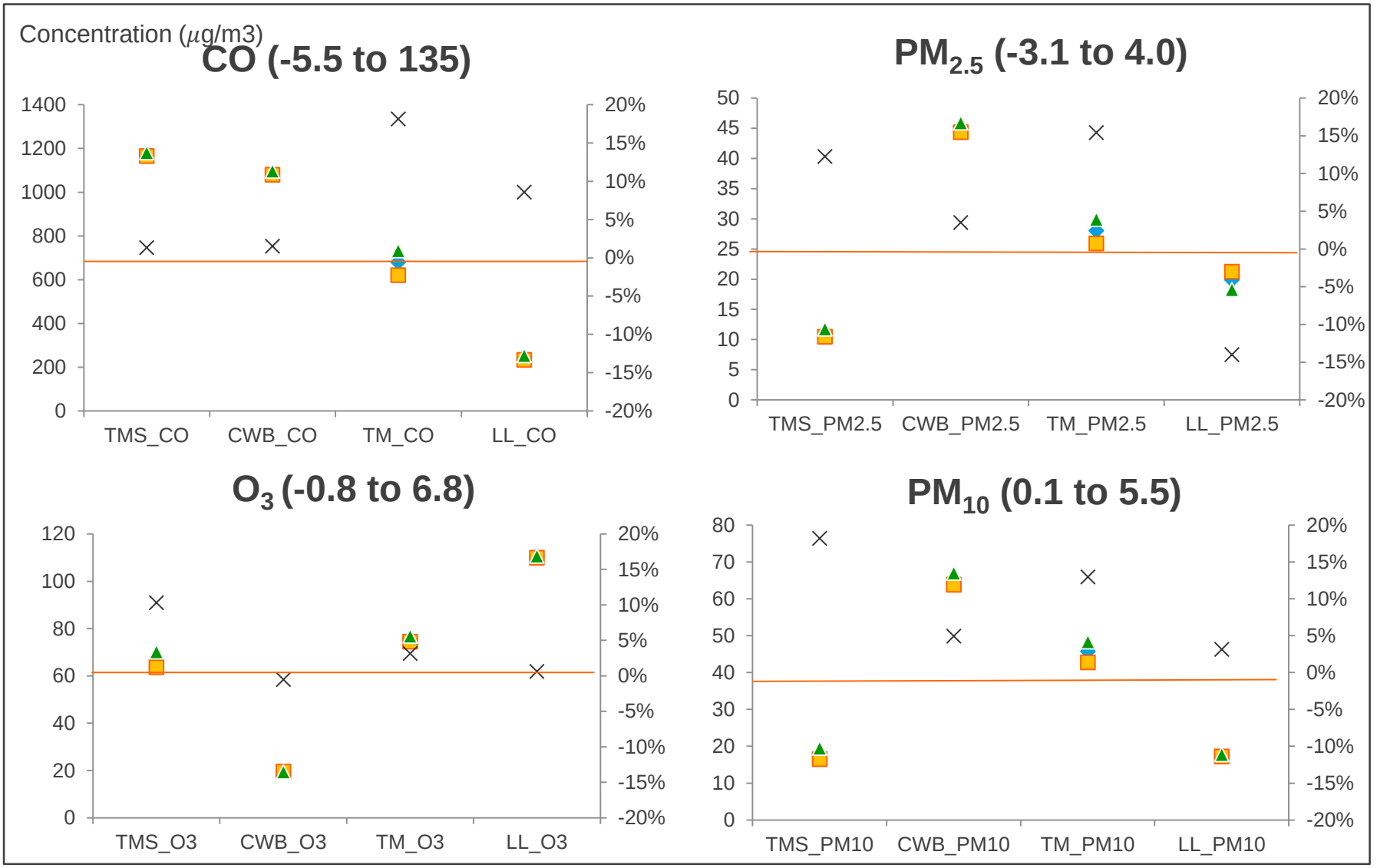
- Six locations are chosen by the Upper 1% of March and April DM sum

Perform HYSPLIT

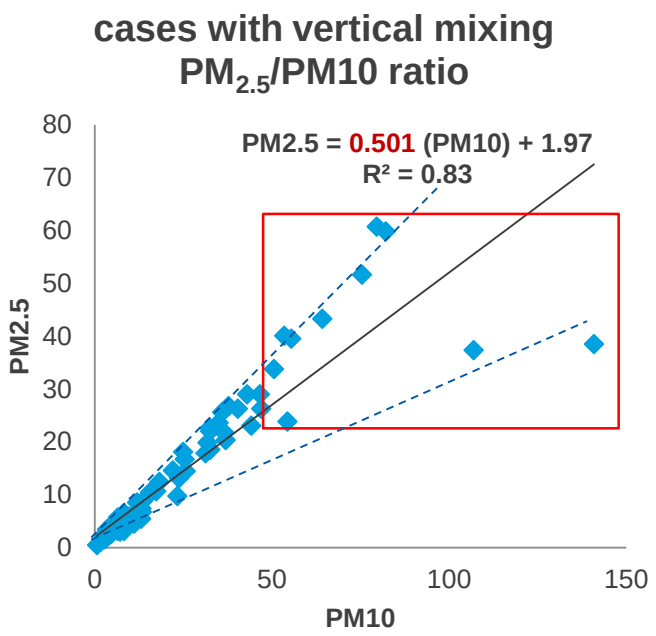


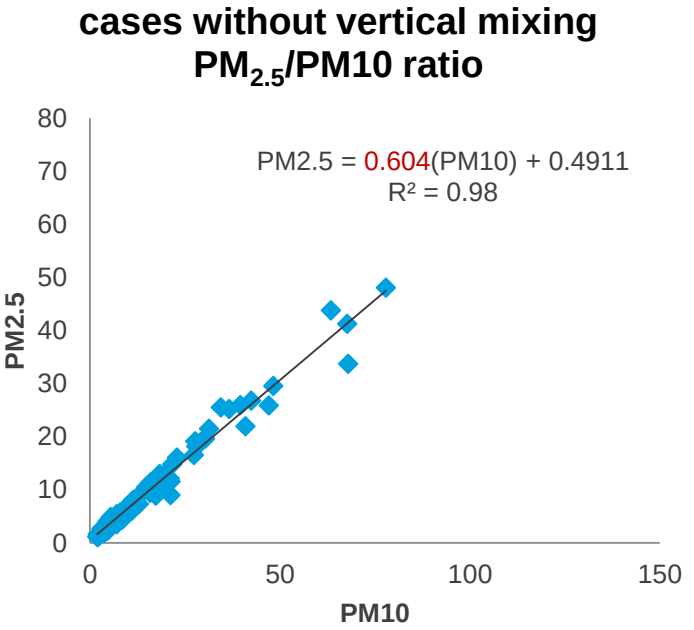
Year	Month	SEA emission arrival (%)
2012	March	45%
2012	April	50%
2013	March	45%
2013	April	30%
2014	March	39%
2014	April	70%

Background Contribution (μg/m³)



$\frac{\Delta PM_{2.5}}{\Delta PM_{10}}$ *ratio* (TMS)





- Represent the characteristics of the combustion sources
- Decreas of $\Delta PM_{2.5}/\Delta PM_{10}$ ratio
- Higher proportions of PM_{10} aerosols
- Contribution of different foreign sources in vertical mixing cases

Results discussion

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[2] Episodic event

Case Identification:

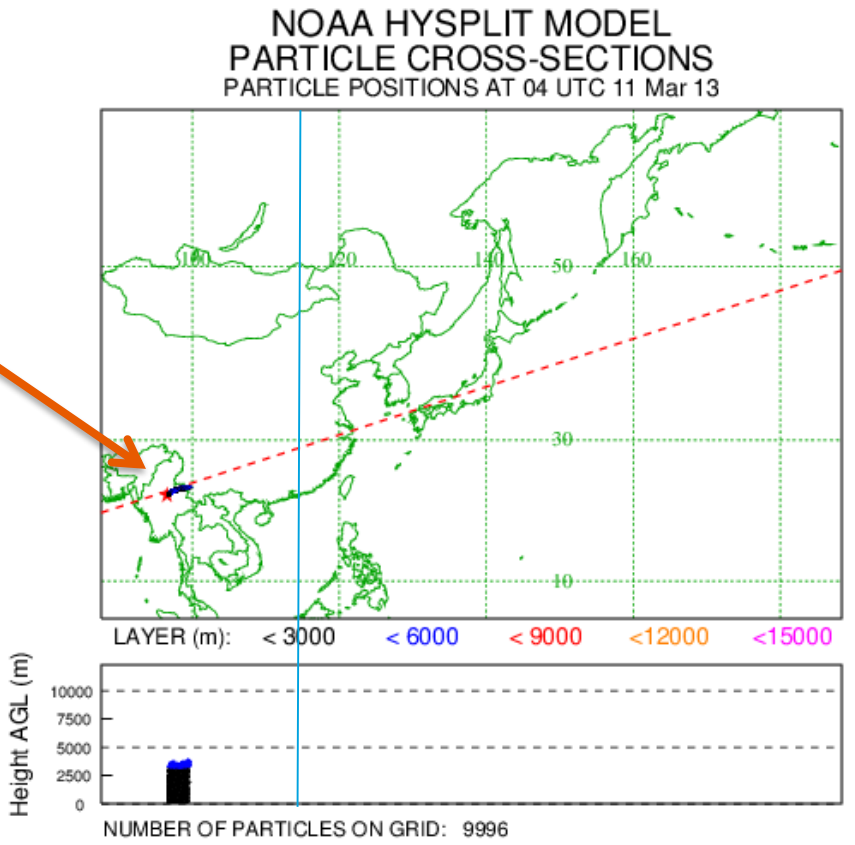
1. Particle dispersion starting from SEA pass over HK
2. Backward trajectory
3. HK meteorological conditions for downdraft
4. High level of fire emissions recorded at SEA areas

Example for Cases Identification (2013 March W3)

	SEA BB DM emissions (kg/day/m^2)	HK back trajectory	SEA pacticle dispersion	HK Meteor. Condition
	Greater than March and April lower quartile?	From SEA?	Arrice HK <800m?	Vertical mixing?
13/3/13	Y			Y
13/3/14	Y	Y	Y	Y
13/3/15	Y	Y	Y	Y
13/3/16	Y	Y		Y
13/3/17	Y		Y	
13/3/18	Y		Y	

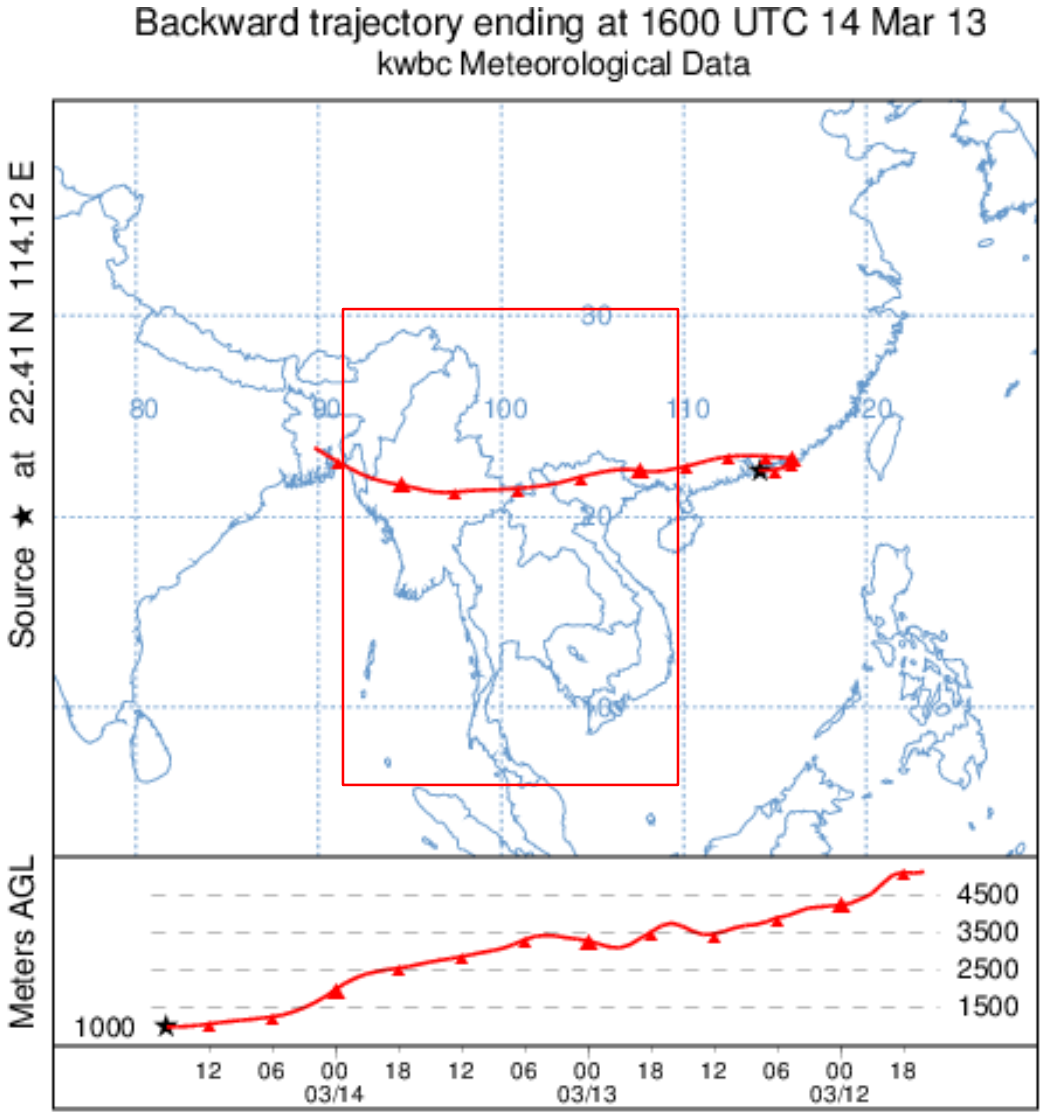
HYSPLIT

- From source
- Kyaukme, Myanmar, Burma (22.625, 96.625)

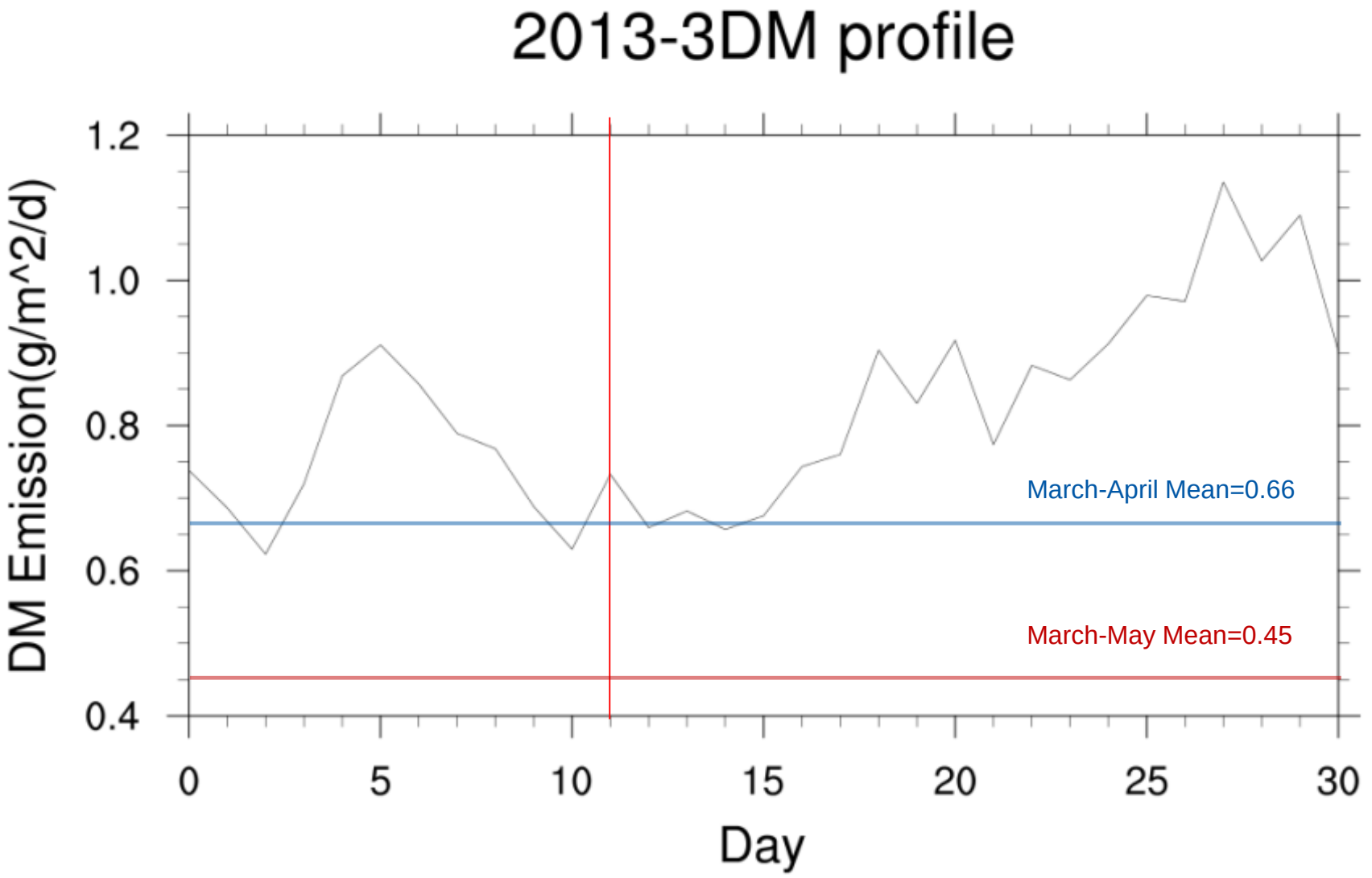


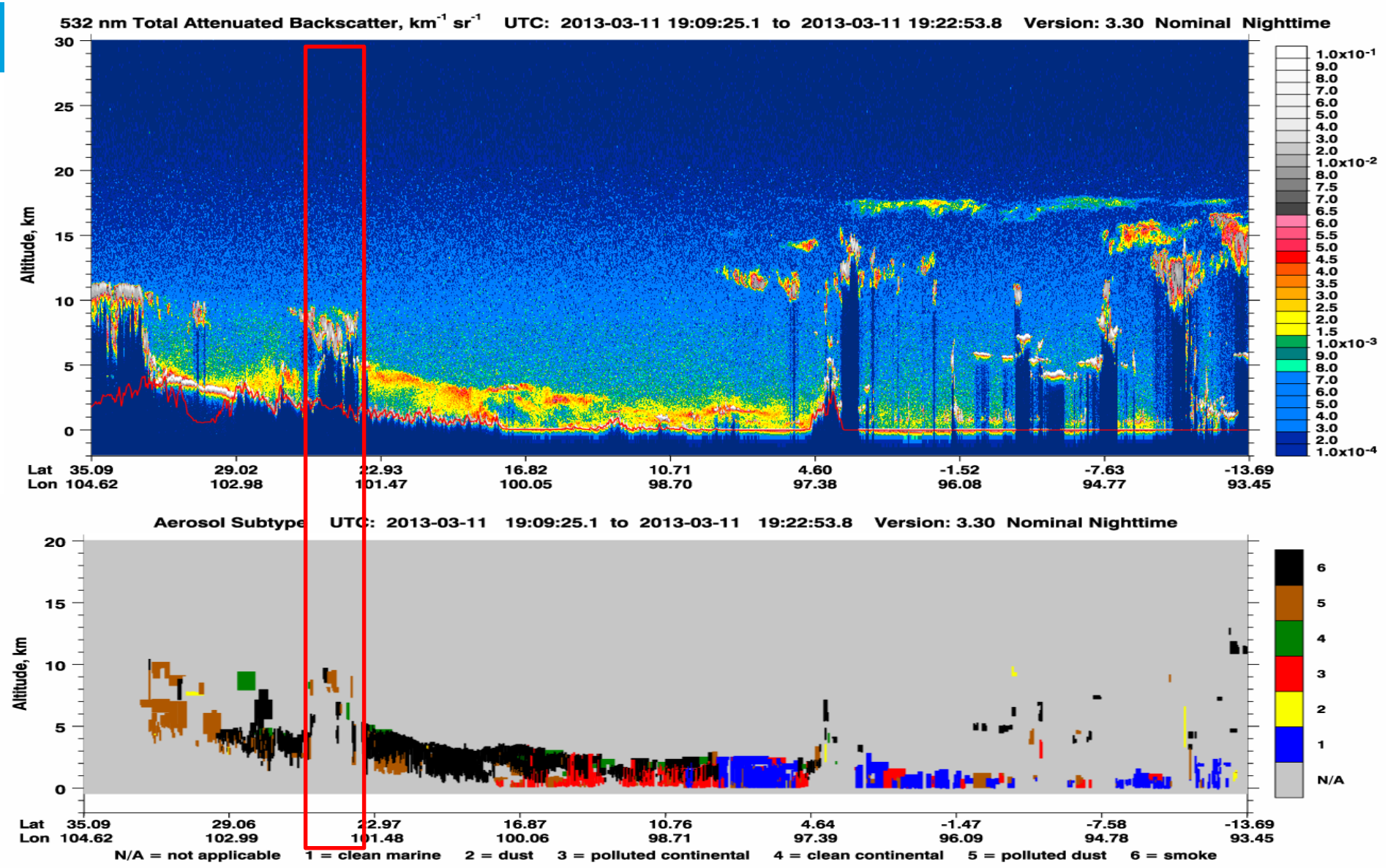
- Uplifted and transported northeastward
- Reached TW and started to descend to south
- Due to the subsidence as a result of the cold surge anticyclone

Backward Trajectory From HK



Southeast Asia Biomass Burning Emissions Profile

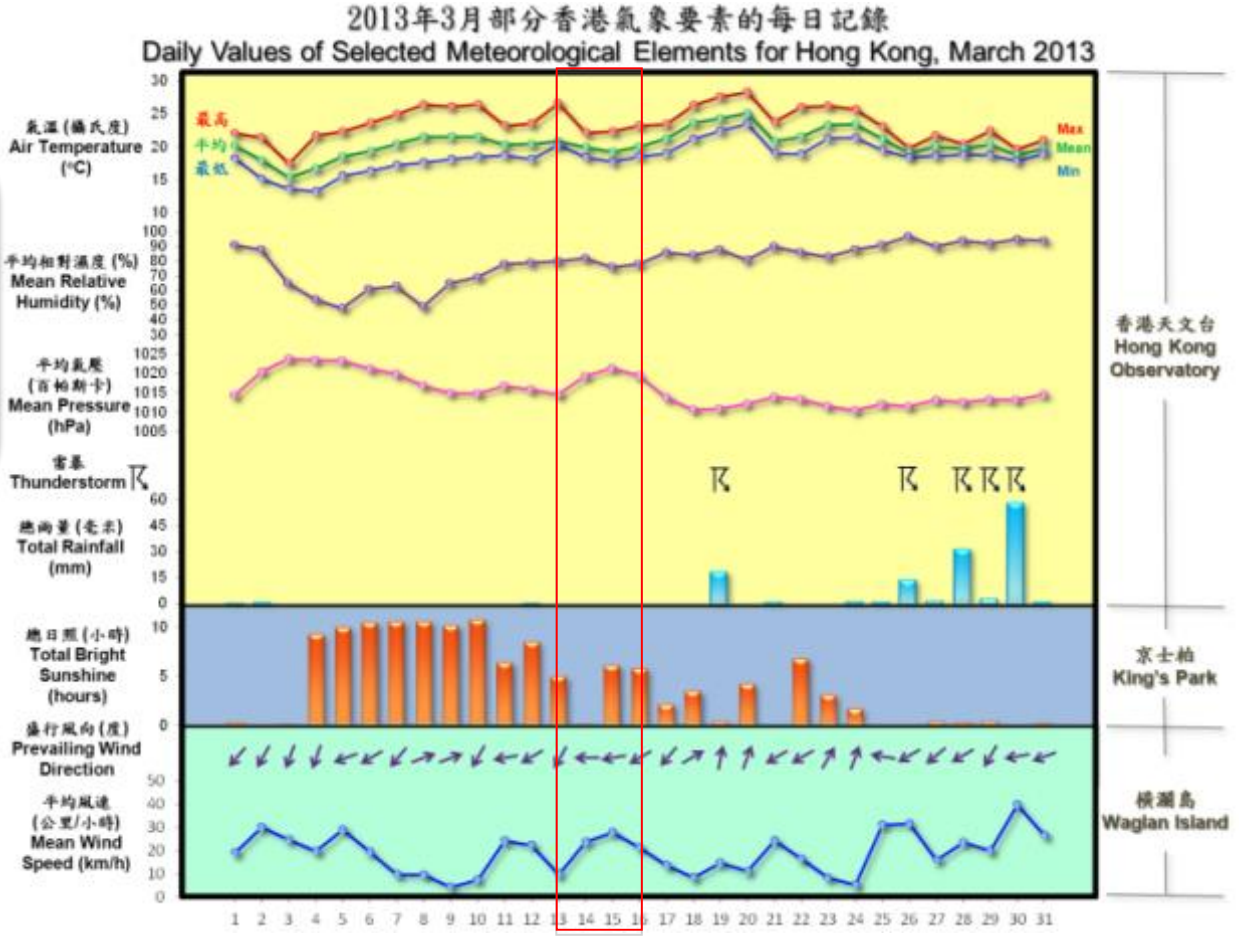



532 nm Total Attenuated Backscatter, km-1 sr-1 UTC: 2013-03-11 19:09:25.1 to 2013-03-11 19:22:53.8 Version: 3.30 Nominal Nighttime
Altitude, km
30
25
20
15
10
5
0
1.0x10-1
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0x10-2
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0x10-3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0x10-4
Lat 35.09 29.02 22.93 16.82 10.71 4.60 -1.52 -7.63 -13.69
Lon 104.62 102.98 101.47 100.05 98.70 97.38 96.08 94.77 93.45
Aerosol Subtype UTC: 2013-03-11 19:09:25.1 to 2013-03-11 19:22:53.8 Version: 3.30 Nominal Nighttime
Altitude, km
20
15
10
5
0
6
5
4
3
2
1
N/A
Lat 35.09 29.06 22.97 16.87 10.76 4.64 -1.47 -7.58 -13.69
Lon 104.62 102.99 101.48 100.06 98.71 97.39 96.09 94.78 93.45
N/A = not applicable 1 = clean marine 2 = dust 3 = polluted continental 4 = clean continental 5 = polluted dust 6 = smoke

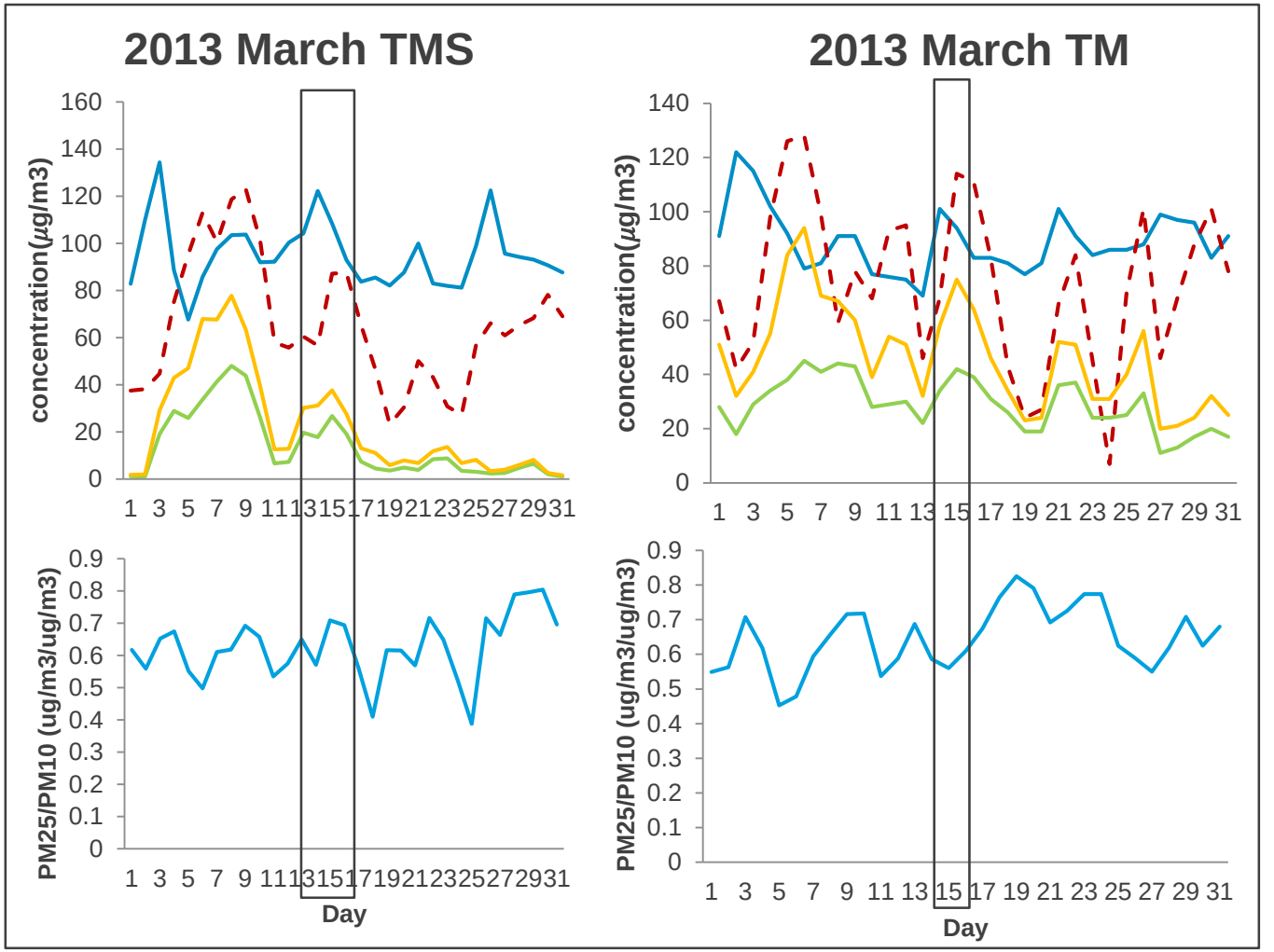
Hong Kong Meteorological Conditions

- Air mass **originated from the free atmosphere** was transported to the surface (cold, dry and higher speed)
  - Downdraft

- **Temperature declined**
- **Humidity dropped**
- **Wind speed increased**



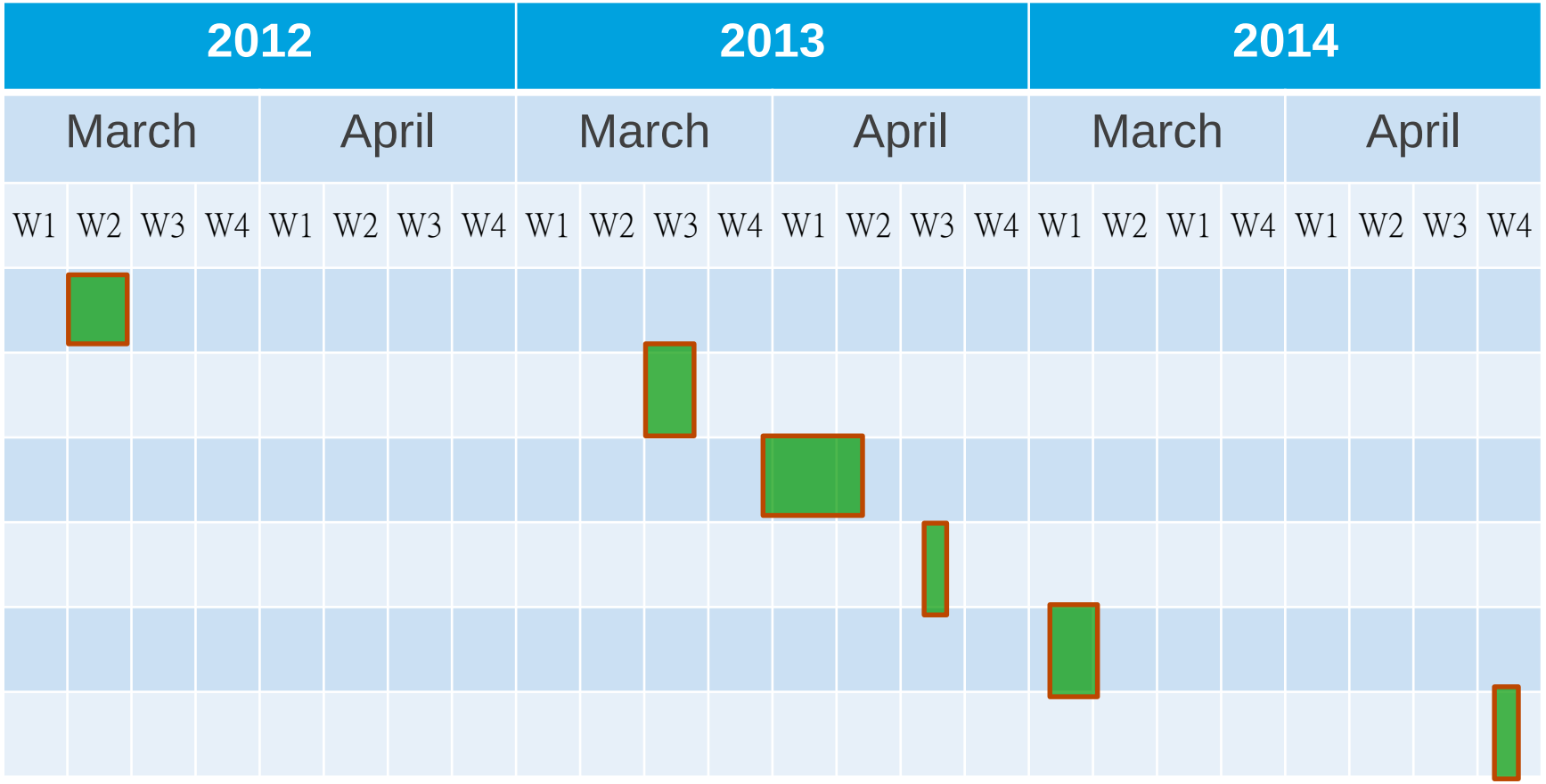
Effects of HK Air Quaity



- During episode period
- $CO, O_3, PM_{2.5}$ and PM_{10} increase
- $PM_{2.5}/PM_{10}$ ratio decrease

- Further study for other biomass burning emission tracer

Summary


2012
2013
2014
March
April
March
April
March
April
W1 W2 W3 W4 W1 W2 W3 W4 W1 W2 W3 W4 W1 W2 W3 W4 W1 W2 W1 W4 W1 W2 W3 W4

Results discussion

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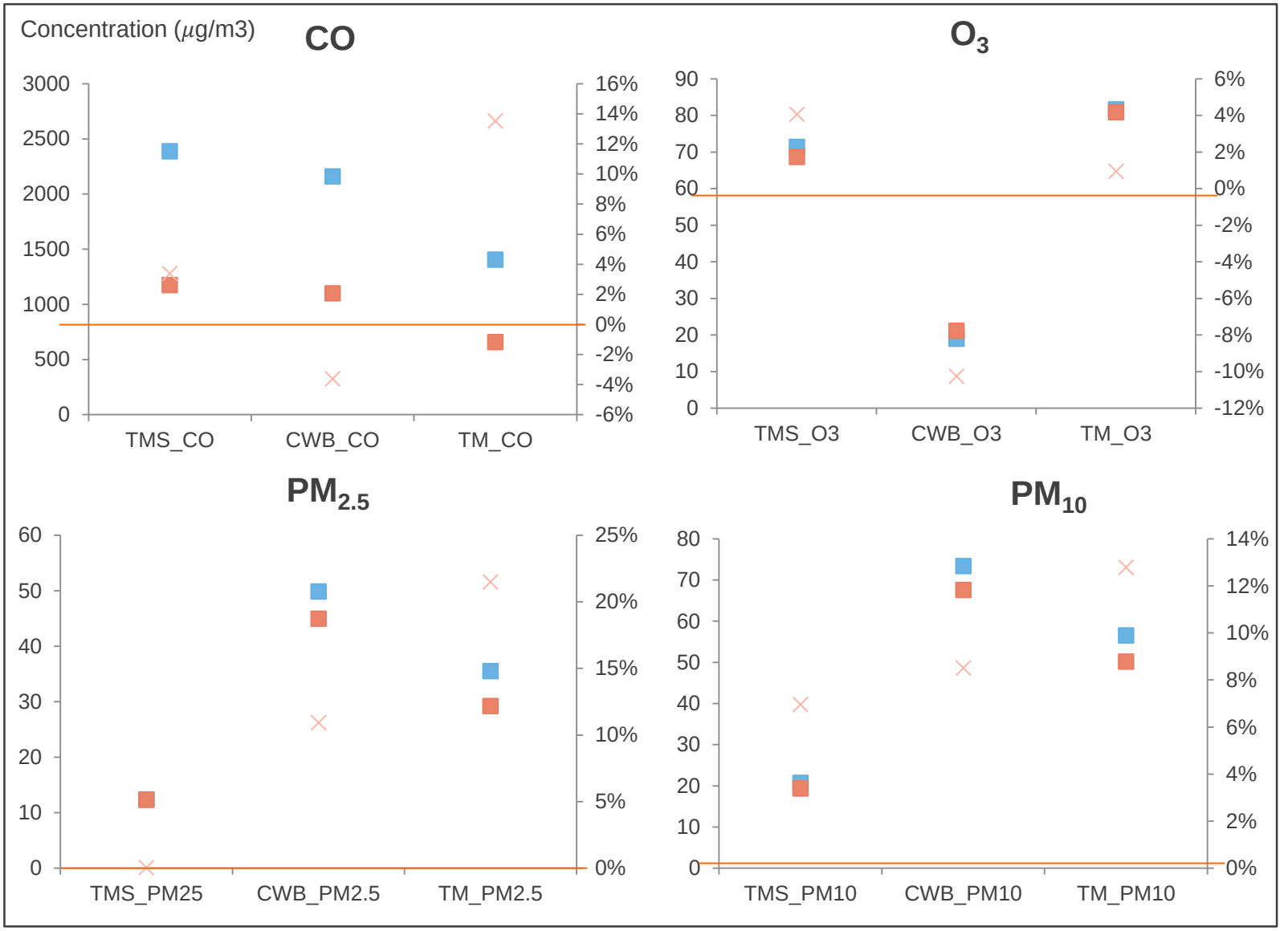
HK Local Air Pollution Enhancement by Downdraft



Summary

Concentration (μg/m3)

	TMS				CWB				TM			
	CO	O3	PM2.5	PM10	CO	O3	PM2.5	PM10	CO	O3	PM2.5	PM10
Background contribution	15.4	6.6	1.3	3.0	16.5	-0.1	1.6	3.1	112.6	2.3	4.0	5.6
Episodic event	243.3	21.1	9.5	15.7	28.1	5.3	8.5	19.9	184.3	17.6	11.0	22.5
Downdraft meteorological condition	39.7	2.8	0.0	1.3	-39.8	-2.2	4.9	5.8	88.9	0.8	6.3	6.4

Acknowledgement

- Environmental Conservation Funds
- Guy Carpenter Asia-Pacific Climate Impact Centre (GCACIC)
- Hong Kong Environmental Protection Department (Peter Louie)
- National Taiwan University (George Lin; Ming-Tung Chuang)

Thank you !

[3] Impacts of Meteorological Conditions

- Sorting with different groups by Hong Kong meteorological data (wind speed, temperature and humidity)

(1) With downdraft meteorological conditions

(2) Without downdraft meteorological conditions