Biomass burning in Southeast Asia from field studies to satellite data analysis And the SPRINTARS model

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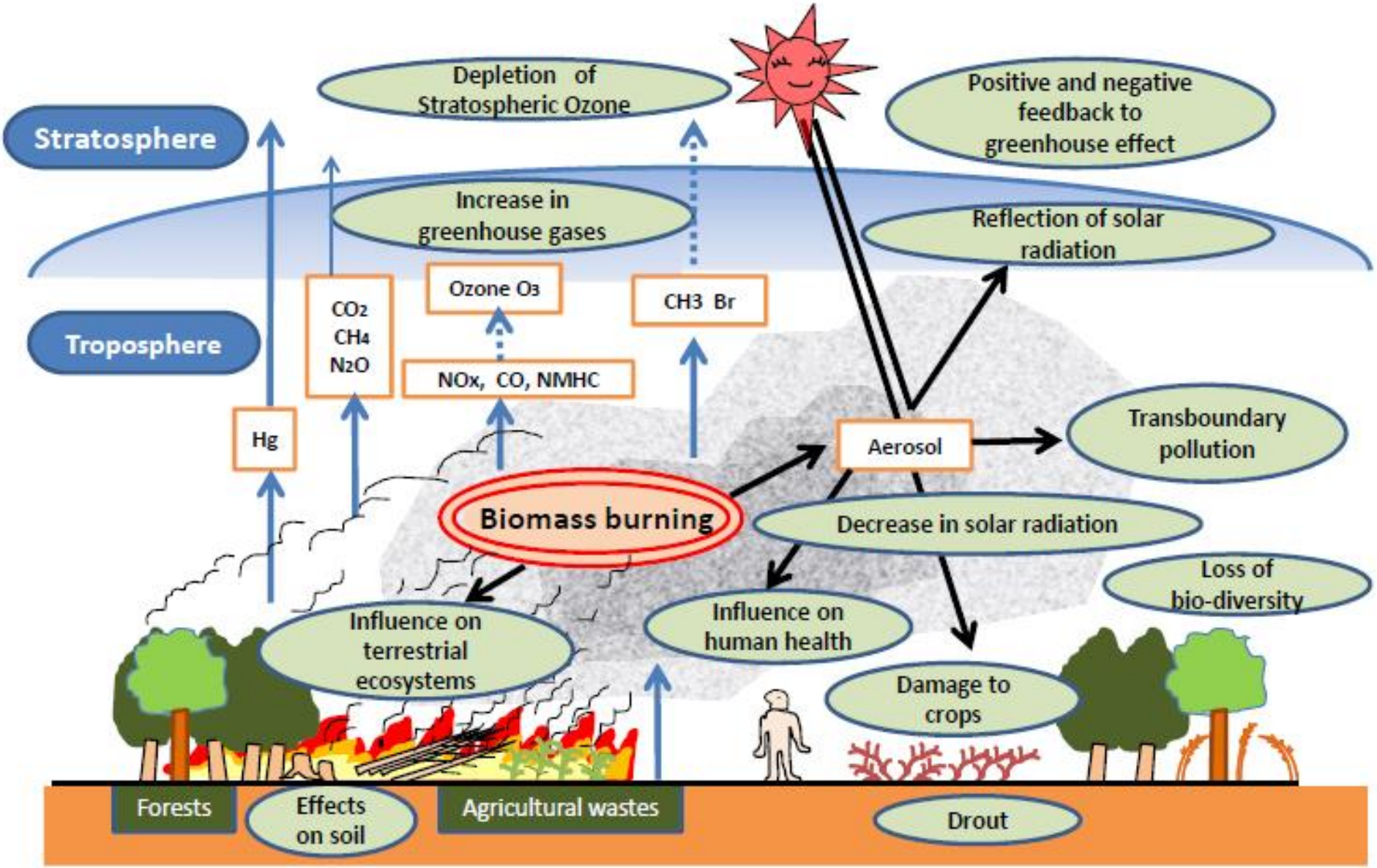
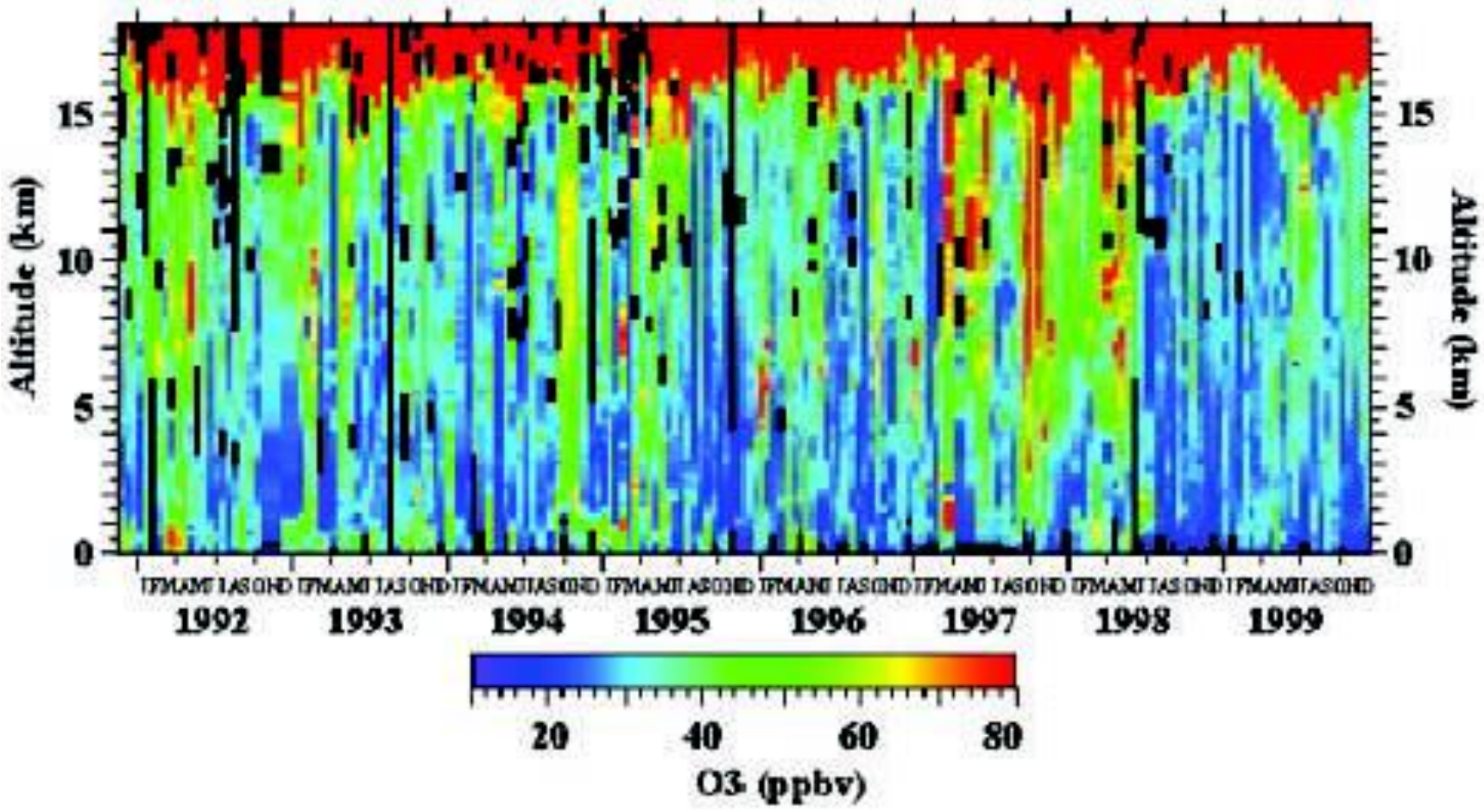


Impacts of biomass burning on local/regional/global environment

Collaborative study with Southeast and South Asia

Malaysian Meteorological Department (MMD): 1994-
(NASA: SHADOS program: with MMD)
Indonesia: BMG, BAU, 1995-
Drs. Nul Hayati, Murdiyarso, Saharjo
India: NPL, NRSA, 1995-
Drs. Mitra, Gupta, Badarinath, and Vadrevu
Singapore: National Environment Agency 1996-
Thailand: (DOA, JGSEE), Chulalongkorn Univ. 2006-

An intensive field study through one year is needed to understand a comprehensive picture on the effect of human activity Including LULC and BB on atmospheric environment.



Enhancement of tropospheric ozone influenced by the trans-boundary air pollution over KL, Malaysia (Yonemura et al, JGR, 2002)

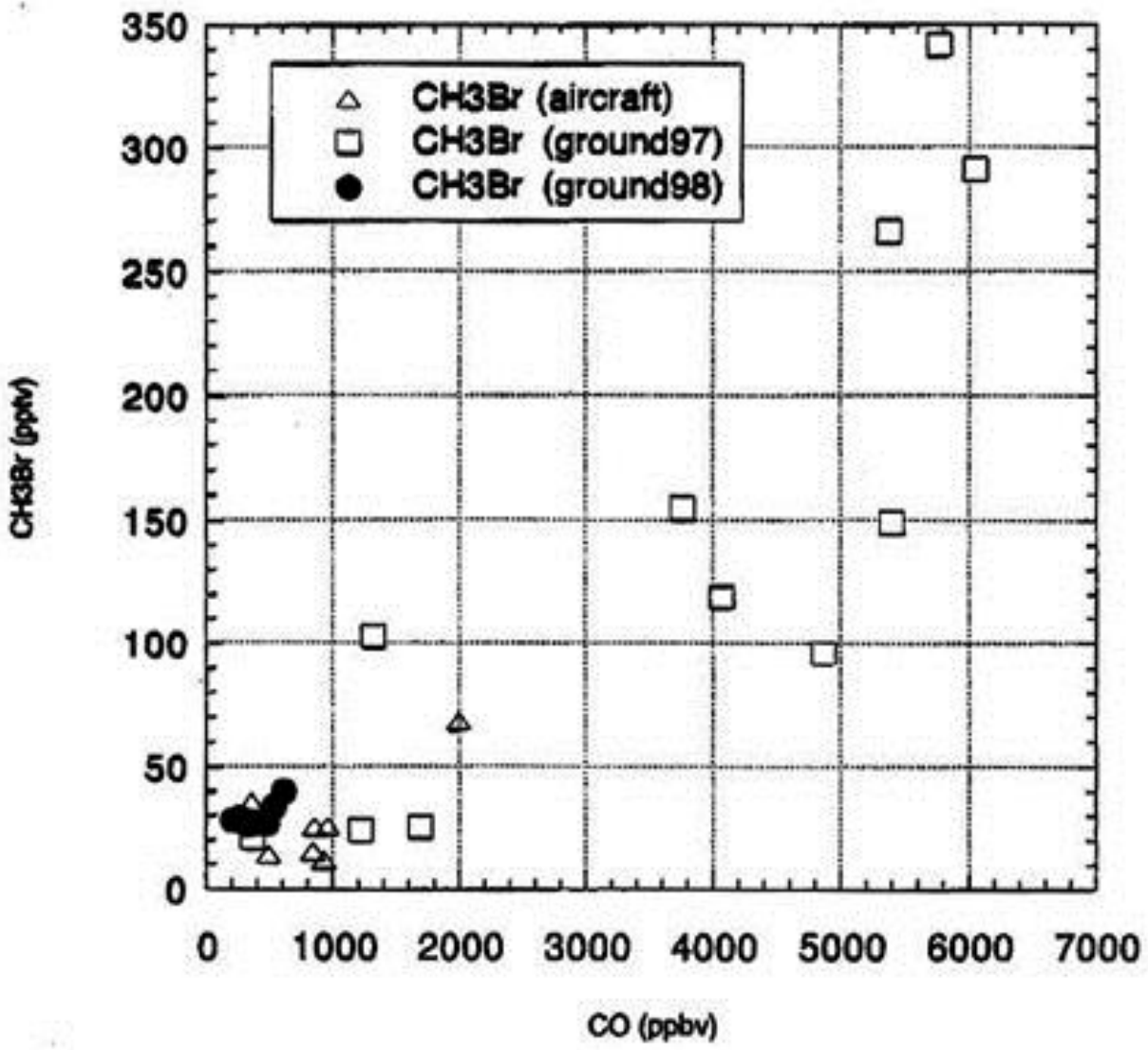


Fig. 8 Methyl bromide and CO concentrations by aircraft and ground measurements over/in Sumatra in 1997-1998 (Sudo, Yonemura, and Tsuruta, 2002)

Objectives of our study in Phimai, a SKYNET station

1. Chemical characterization of atmospheric aerosols at Phimai in rainy and dry seasons

2. AOT and single scattering albedo (SSAo) from optical measurements by skyradiometer

3. Single scattering albedo (SSAc) calculated from chemical compositions

4. Comparison of chemical/optical properties between the field study, and the SPRINTARS model and the CALIOP data

Monitoring stations for atmospheric aerosols by ABC, AERONET, and SKYNET in Asia.

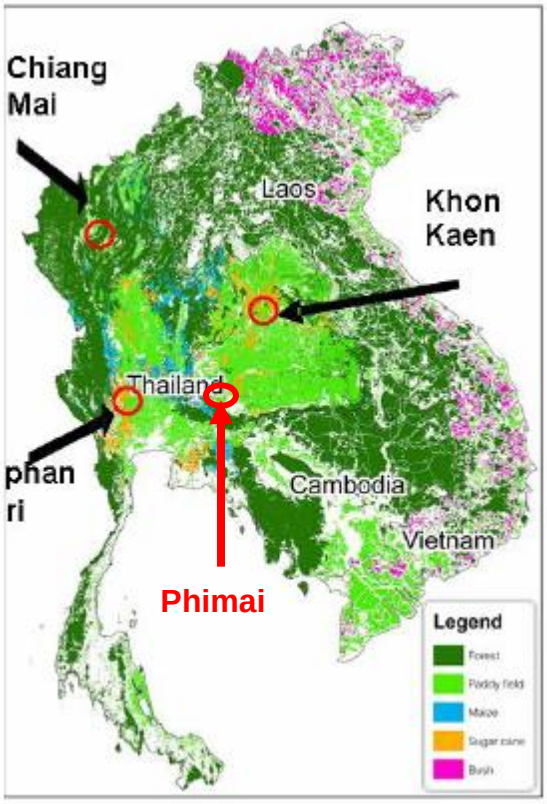
The station of Sri-Samrong and Amami-Oshima has moved to Phimai (since 2004) and Cape Hedo (since June 2005), respectively.

II. Atmospheric Aerosols at the Observatory of Atmospheric Research at Phimai (15.18° N, 102.57° E)

Sampling period

1. **June 2006-Feb. 2007**
2. **July 2007-July 2008**

A series of a half day sampling in the daytime and nighttime for three days was made twice in every month.



Measurements and analysis

Surface aerosol measurements

Sampling sites: Phimai, Thailand (15.18N,102.57E)

Sampling period: Jul. 2007-Aug. 2008

Aerosol sampler: Multi-nozzle cascade impact sampler with $PM_{1.0}$, $PM_{2.5}$ and PM_{10} impactor

Chemical analysis: Mass concentration

EC/OC (by optical/thermal analyser)

Water soluble ions (by IC)

Trace elements (by PIXE)

Optical measurements by Skyradiometer

Data analysis for: Aerosol optical thickness (AOT)

Single scattering albedo (SSA)

Angstrom exponent (AE)

Trace gases: CO and O3

Backward trajectory analysis:

HYSPLIT MODEL by NOAA

Satellite data analysis:

Hot spots of fires by MODIS (by Dr. Takeuchi)

Vertical distribution of aerosols/clouds by CALIOP

Vertical profile of aerosols:

LIDAR by NIES

Verical profiles of meteorological data (T,RH,WD,WS)

Radio sonde at Ubon Ratchathani 200km east of Phimai

Surface data:

Phimai Observatory:meteorological data(RH, T, WD, WS)

Soil chemical properties

Definition of wind patte

Dry season:

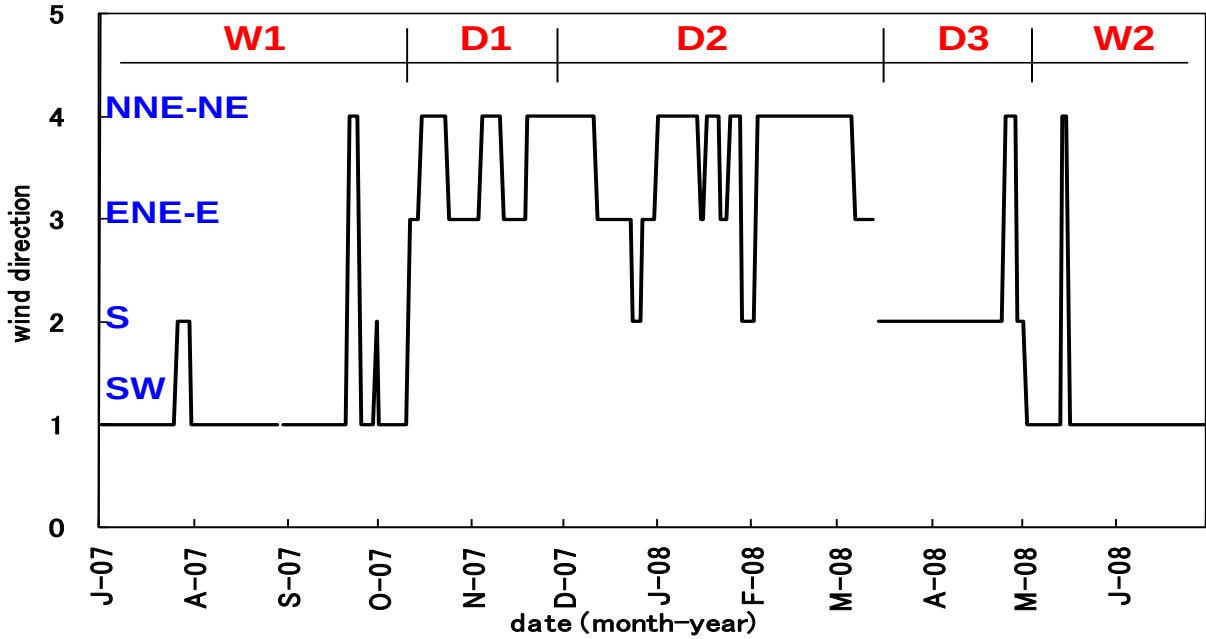
D1: northeasterly monsoon from East Asia or South China Sea

D2: Transition stage of D1 and D3

D3: From South China Sea

Rainy season:

W1, W2: southwesterly monsoon from Indian Ocean

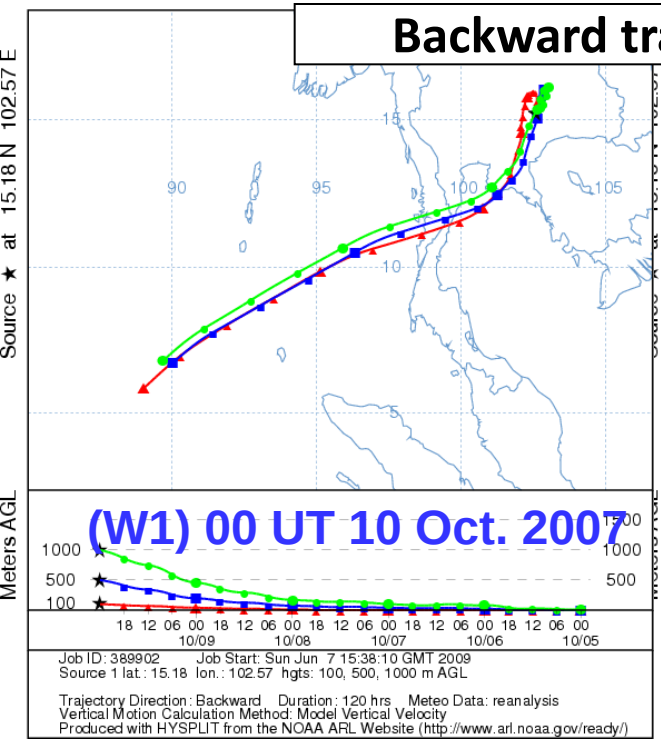


NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 10 Oct 07
CDC1 Meteorological Data

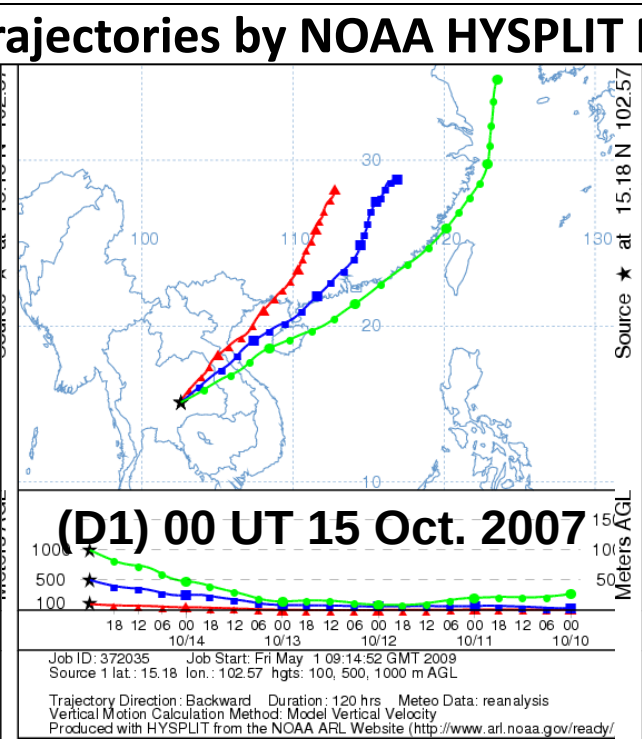
NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 15 Oct 07
CDC1 Meteorological Data

NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 20 Mar 08
CDC1 Meteorological Data

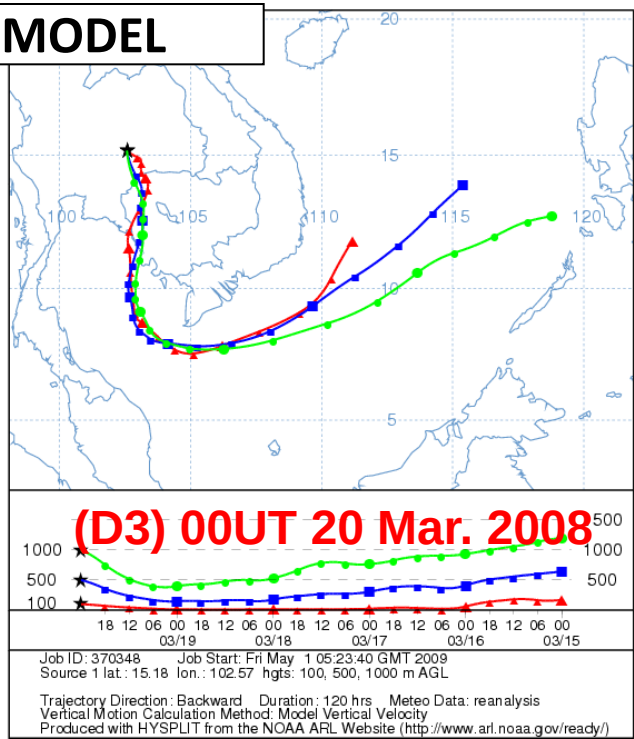
Backward trajectories by NOAA HYSPLIT MODEL



(W1) 00 UT 10 Oct. 2007



(D1) 00 UT 15 Oct. 2007



(D3) 00UT 20 Mar. 2008

Conclusion 1 : Chemical properties in Dry season,

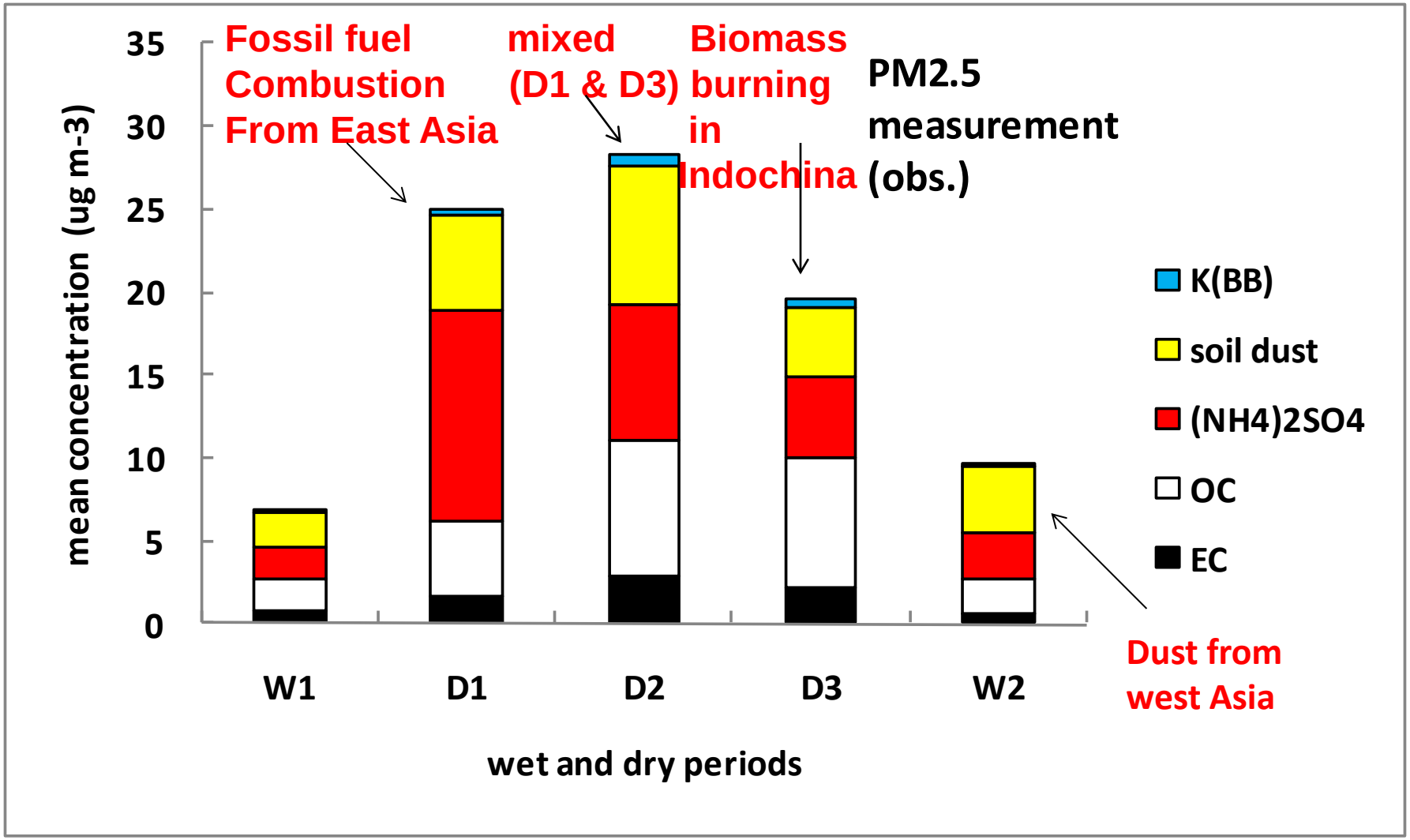
Analysing the ratio of nss-SO4/EC,

D1: Major source: Air pollutants from east Asia by NE monsoon,

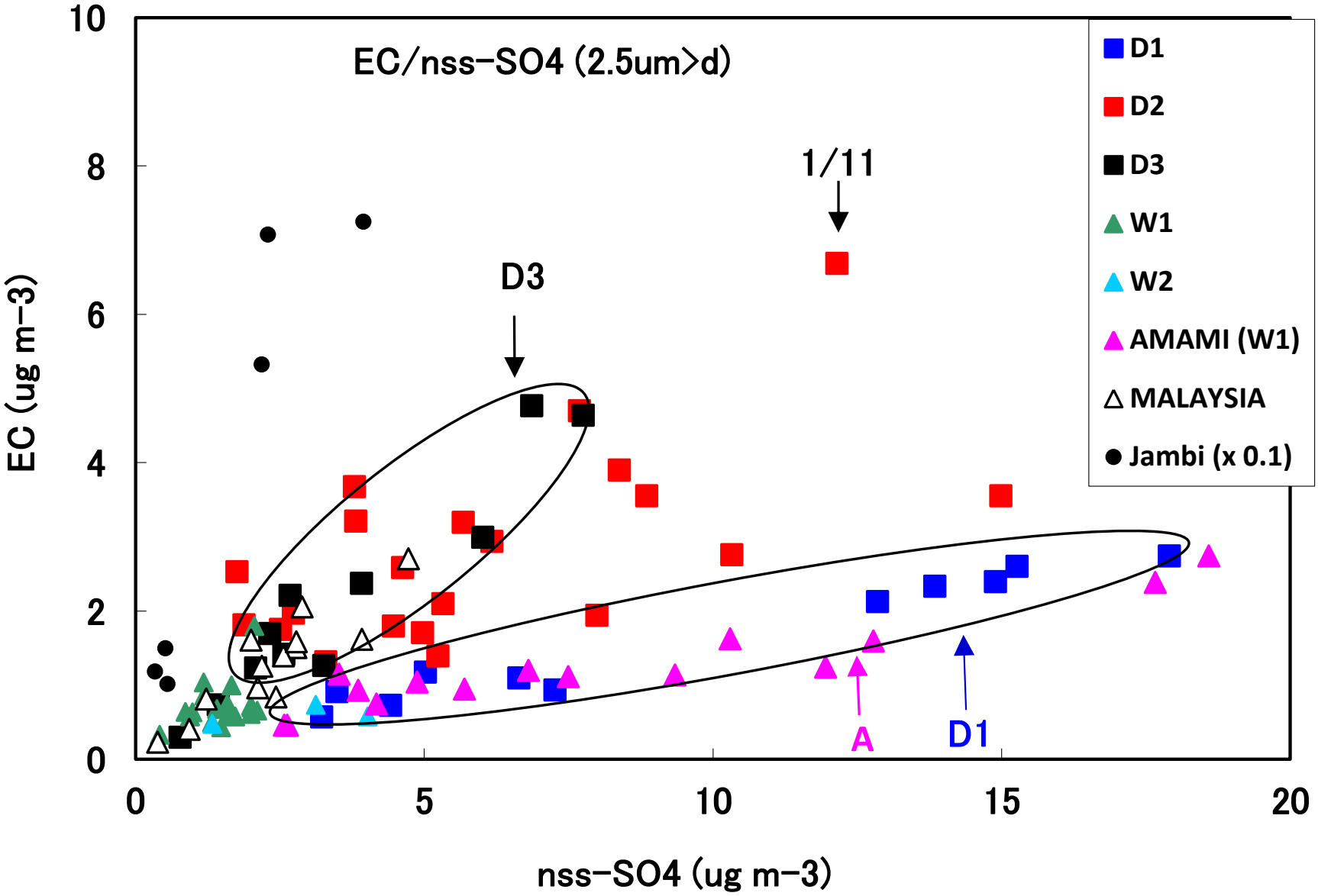
D3: Major source: Biomass burning from Indochina

D2: Transition stage between D1 and D3

Aerosols from severe biomass burning was frequently trapped in the lower boundary layer



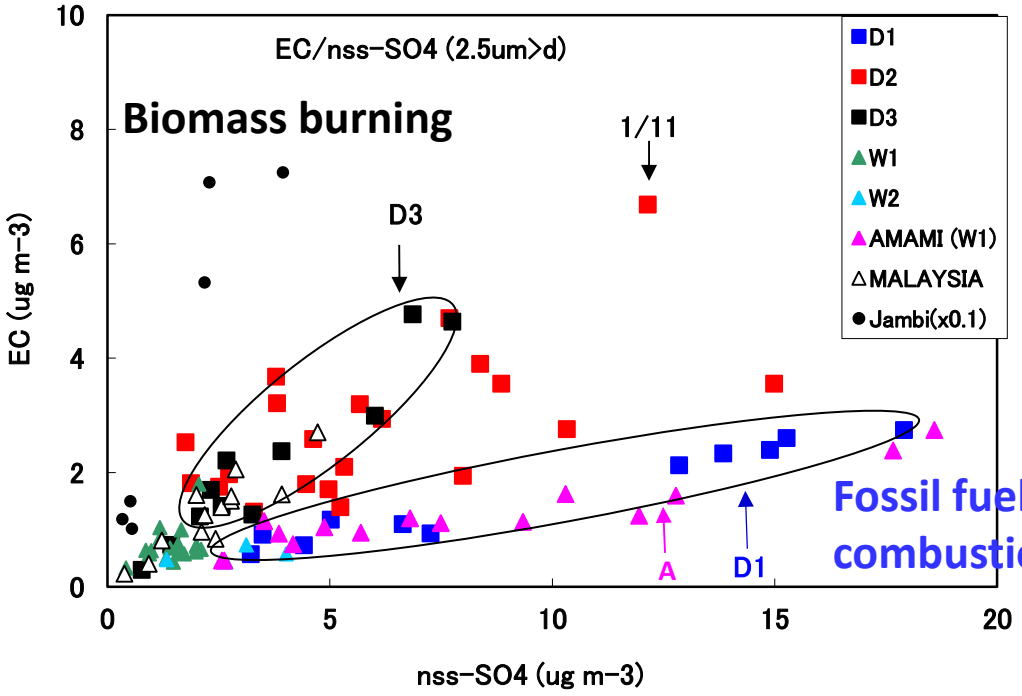
Time series of chemical composition in PM2.5 By the surface measurements



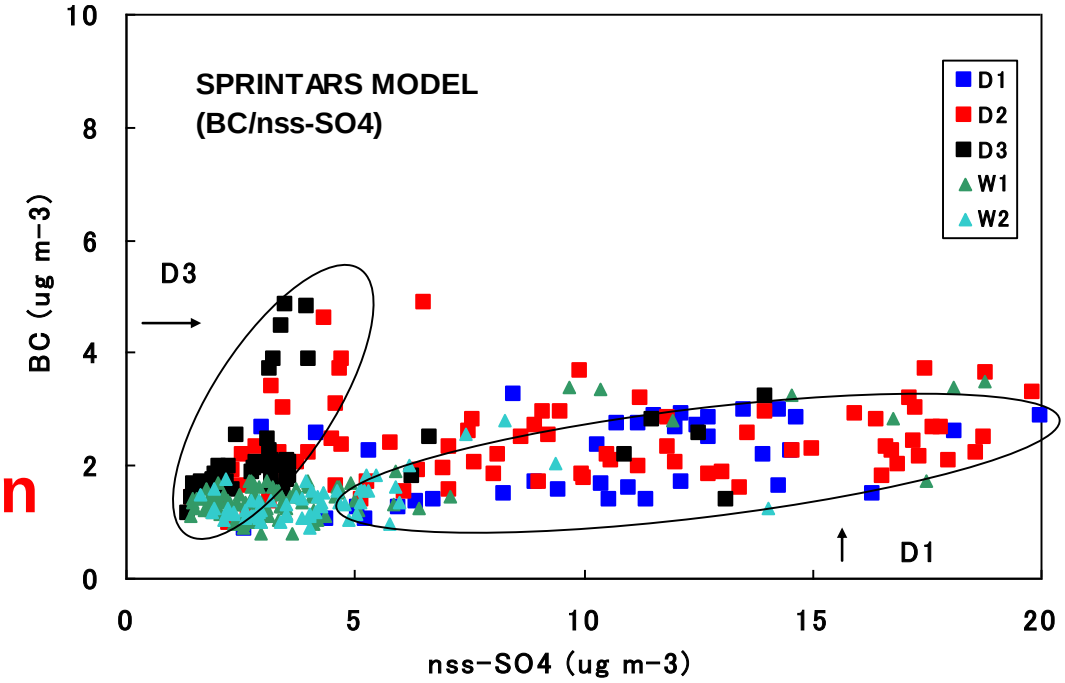
Scatter diagram between nss-SO4 and BC in PM2.5 from surface measurements (Phimai, Amami, Malaysia, Indonesia (Jambi))

Scatter diagram between nss-SO4 and BC(EC) in $PM_{2.5}$

Surface measurements



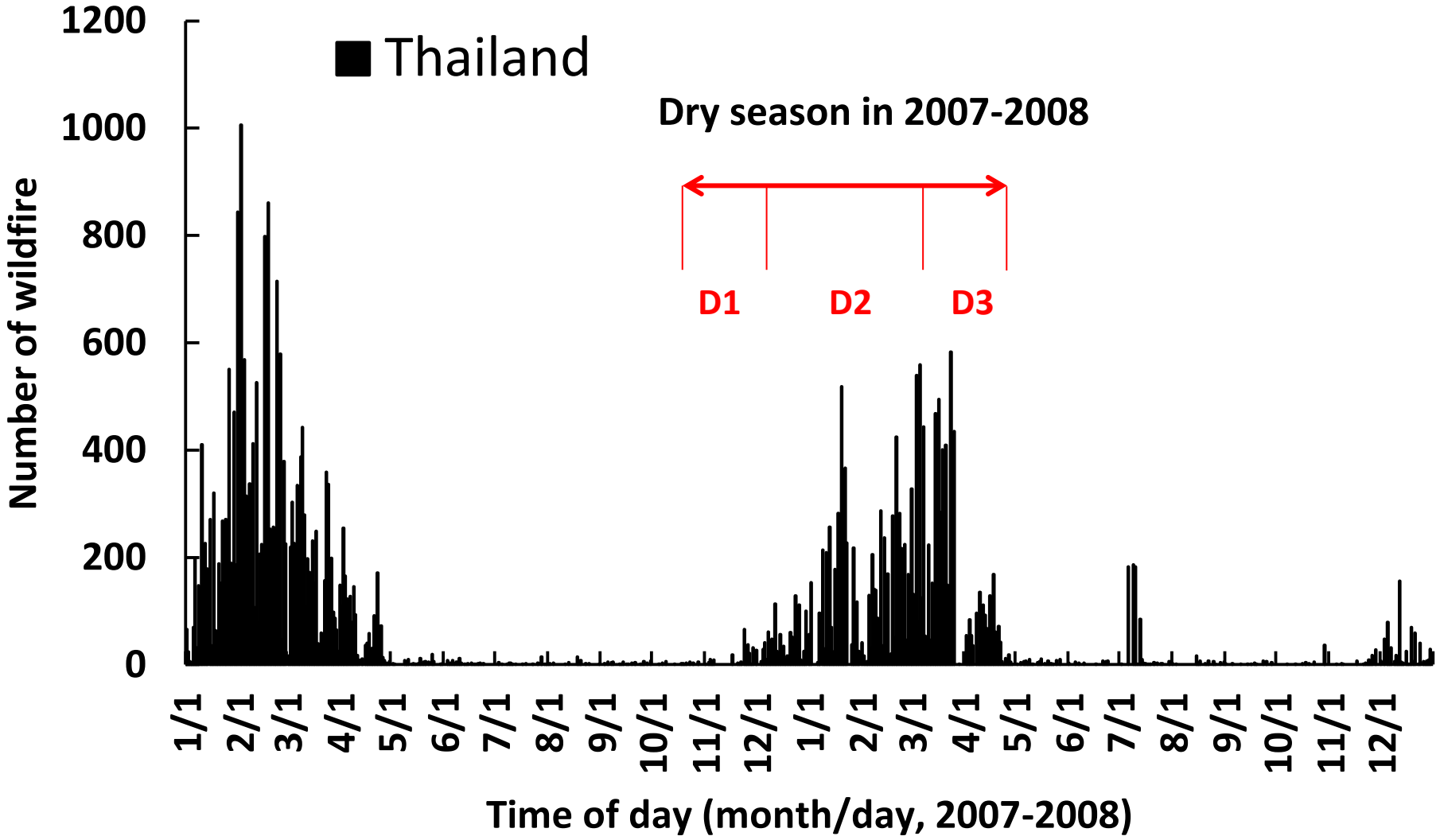
SPRINTARS model



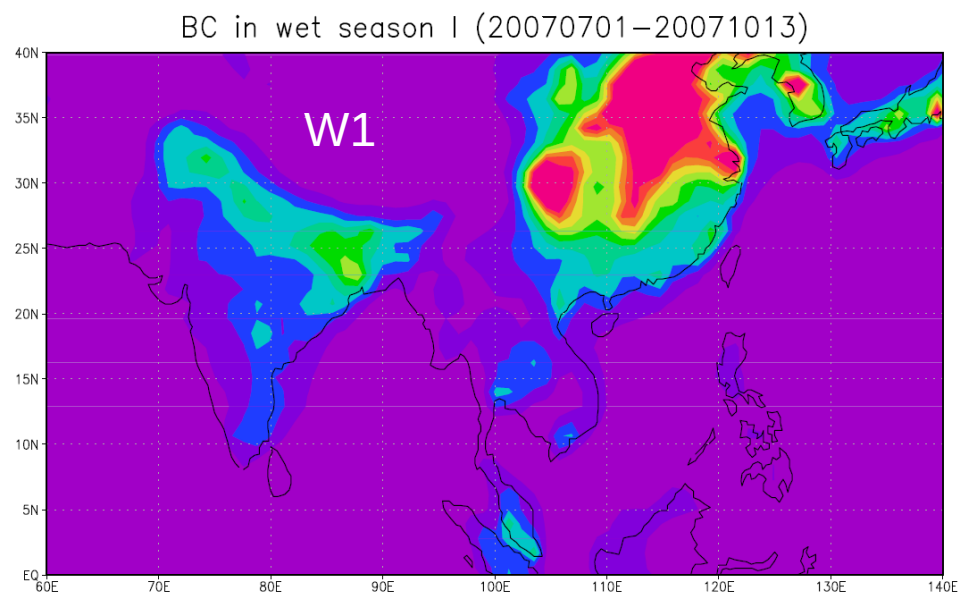
Large difference in BC(EC)/SO4 between D1 and D3 is well correlated between surface measurements and SPRINTARS.

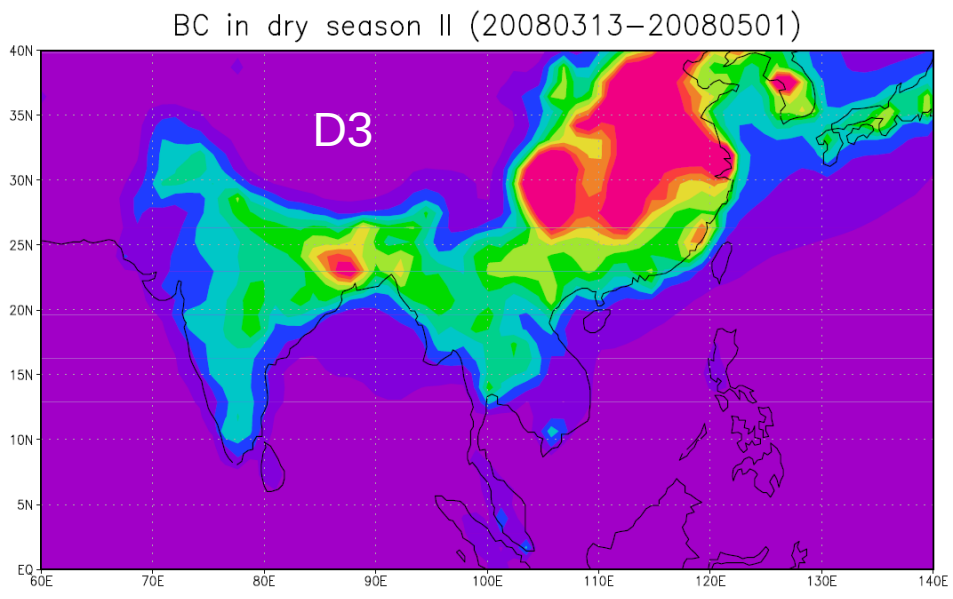
D1: fossil fuel combustion from East Asia

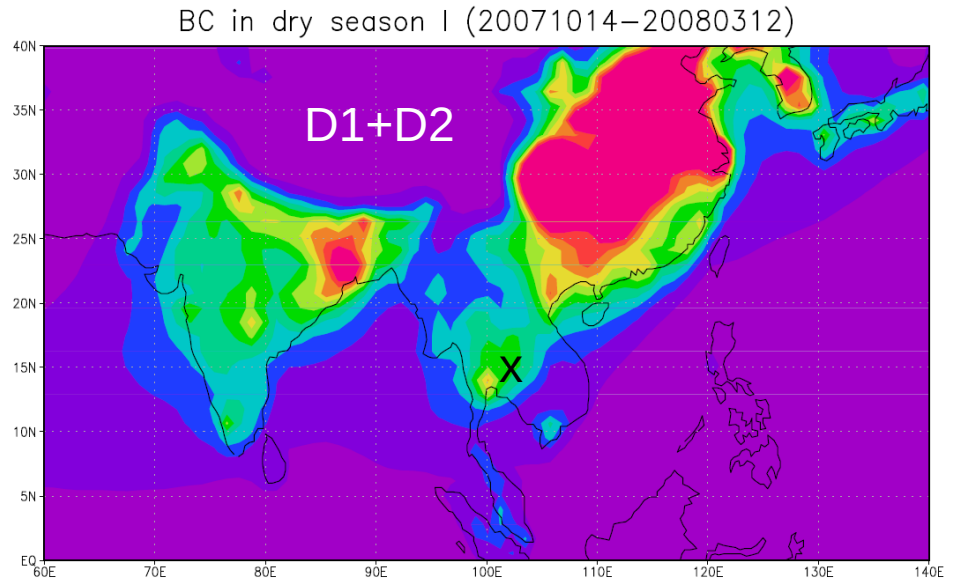
D3: biomass burning

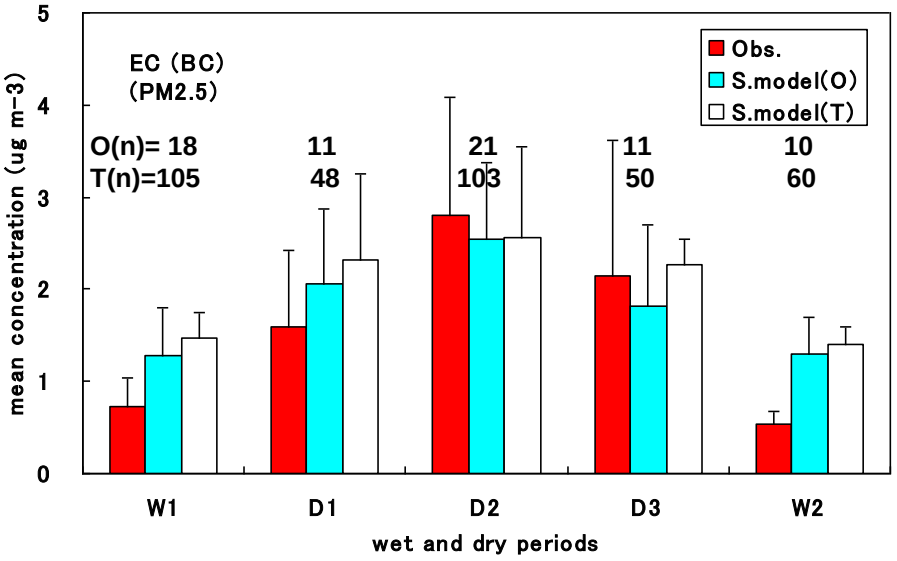


Number of wildfires from MODIS FireMAP During 2007-2008 (database from Prof. Takeuchi)

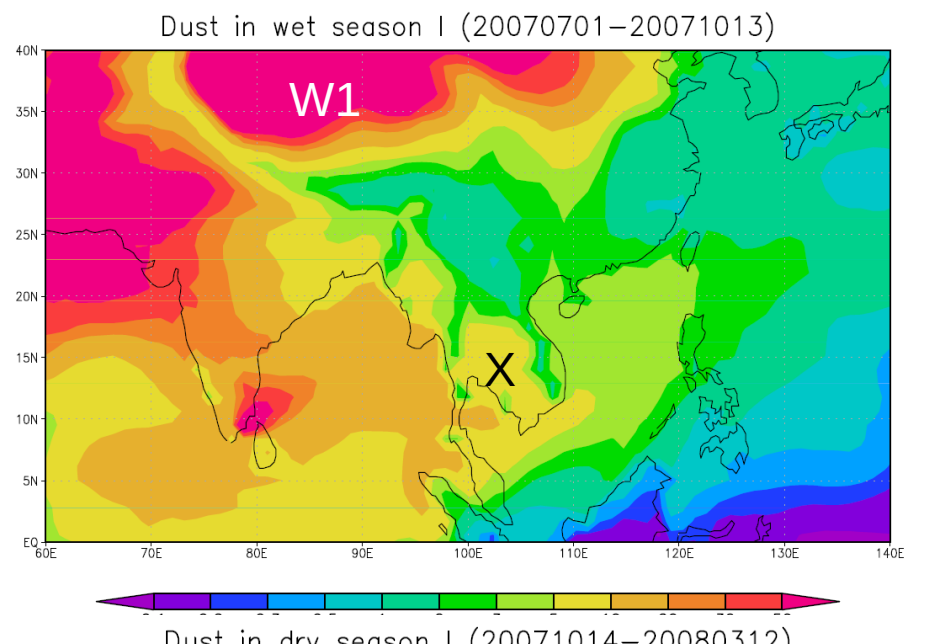


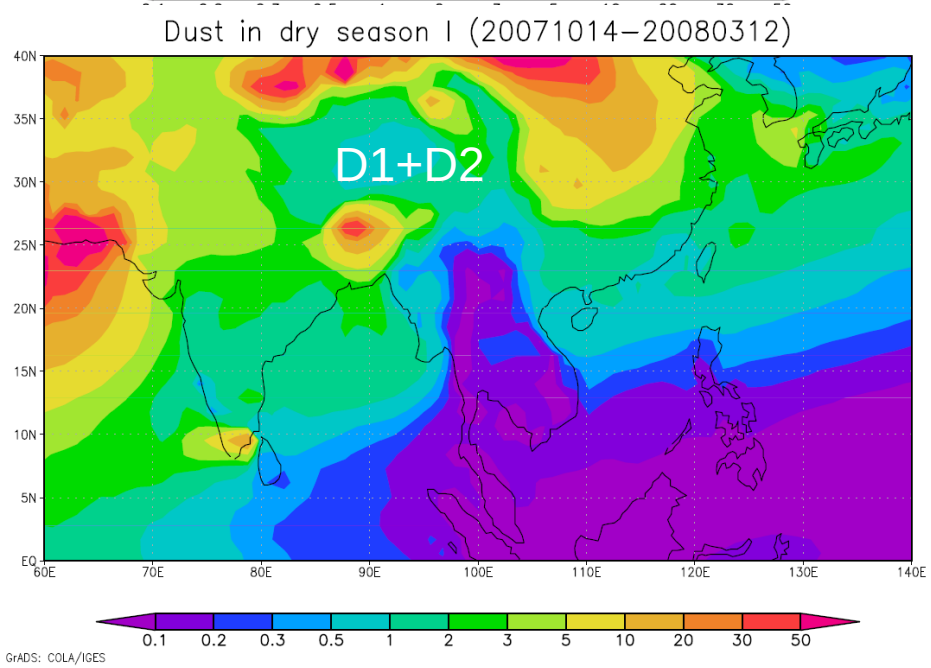


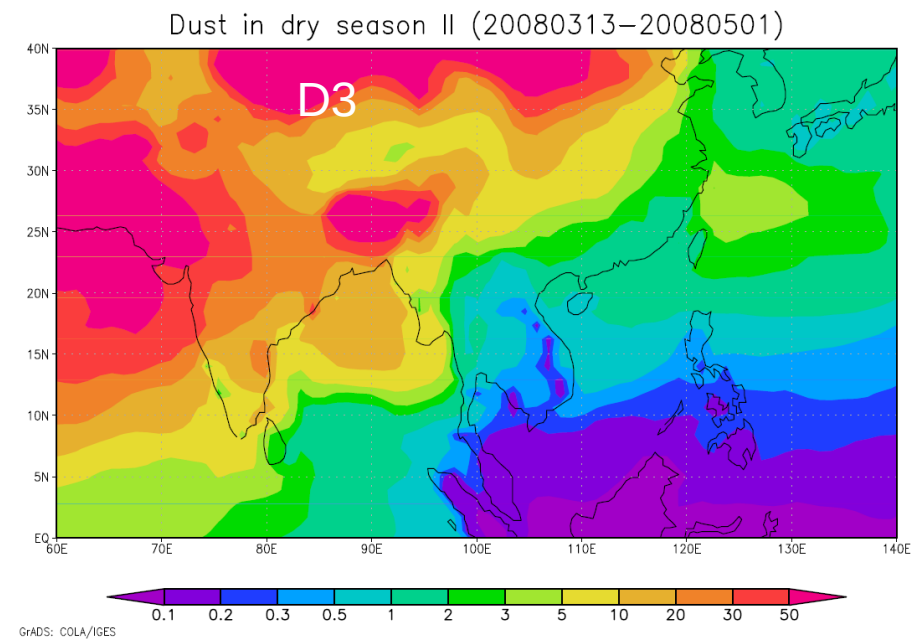


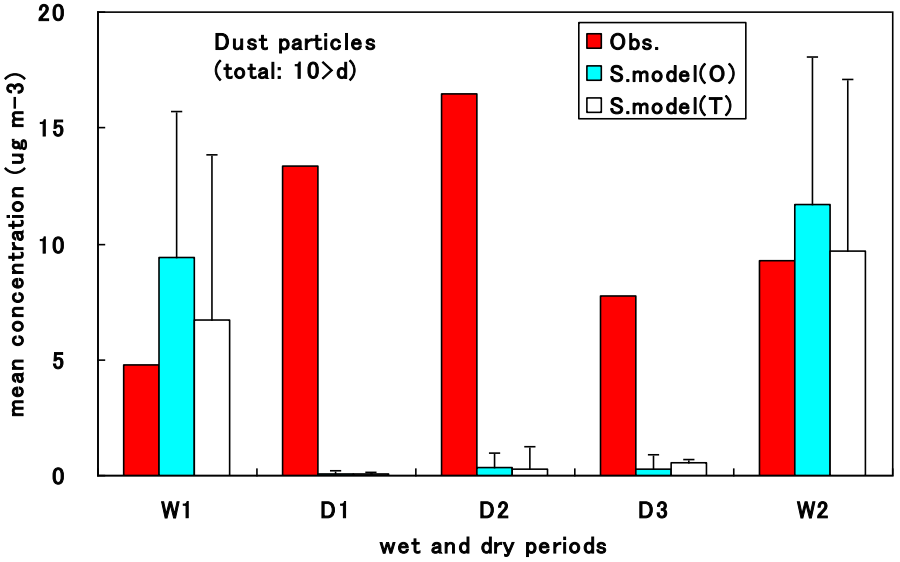


1. Spatial distribution of mean BC(EC) concentration in W1, DI(D1+D2), DII(D3) by SPRINTARS. Comparison of BC(EC) and OC between surface measurement and SPRINTARS in wet and dry periods is in good agreement.









4. Dusts: Large difference between the measurement and the model in the dry periods(SPRINTARS << Measurements)

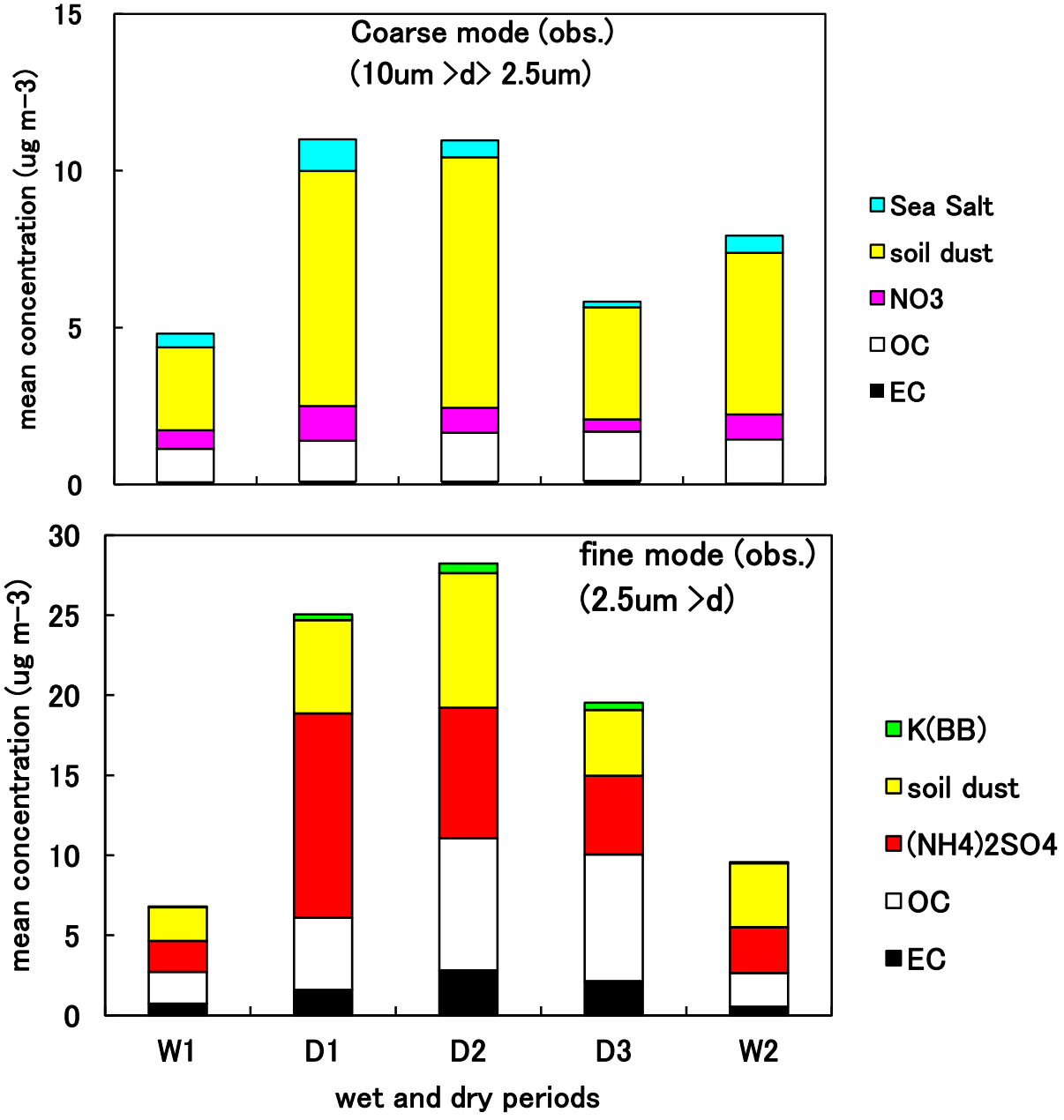
Conclusion 2 : Soil/mineral dusts

D1: direct transport from east Asia,
hardly from inner desert areas
D2: re-suspension of soil dusts in Indochina
D3: re-suspension of local soil dusts
caused by thermal plume
due to biomass burning in Indochina

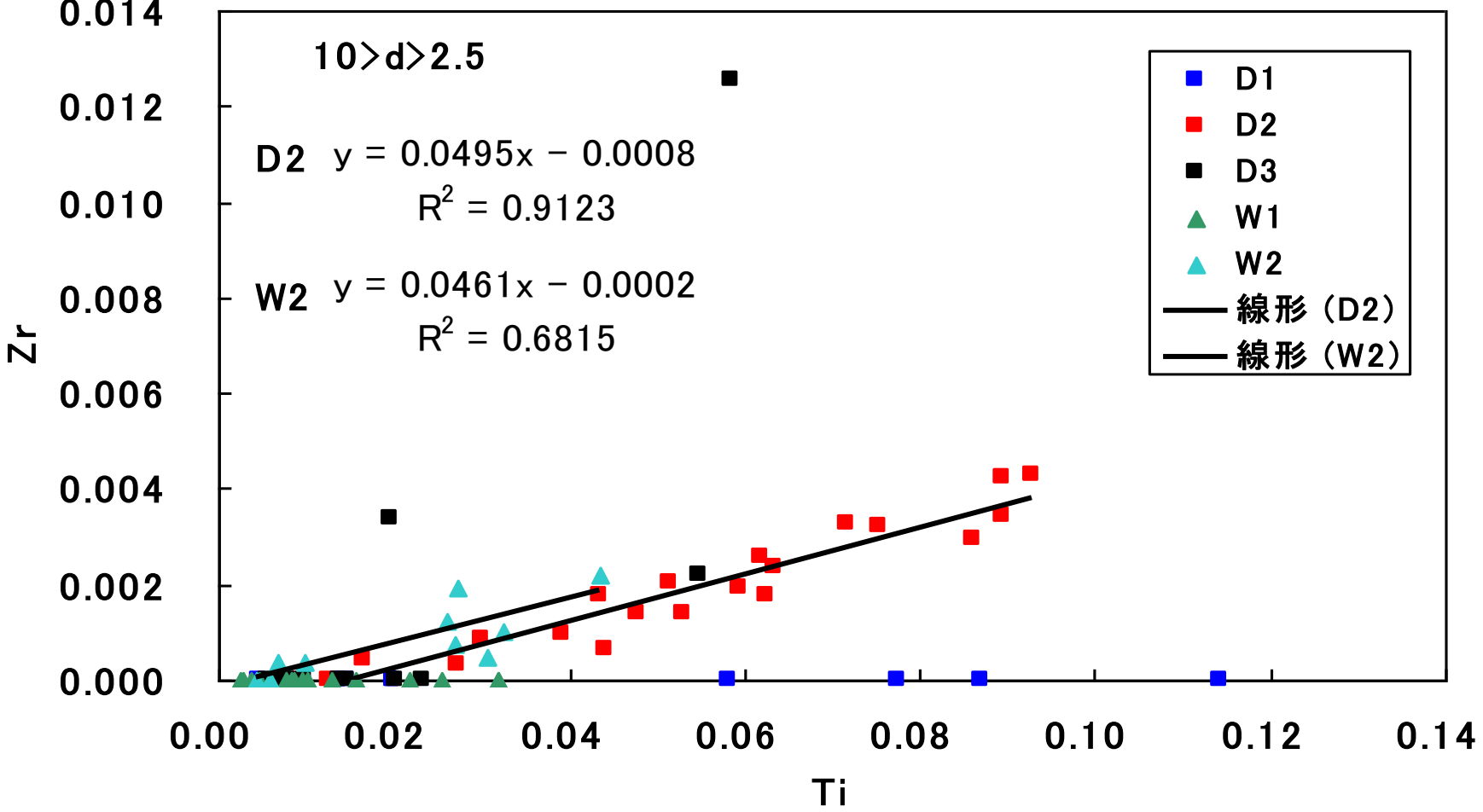
Wet season: Long range transport from west, possibly from the desert regions in west Asia

Coarse Particles →

PM2.5

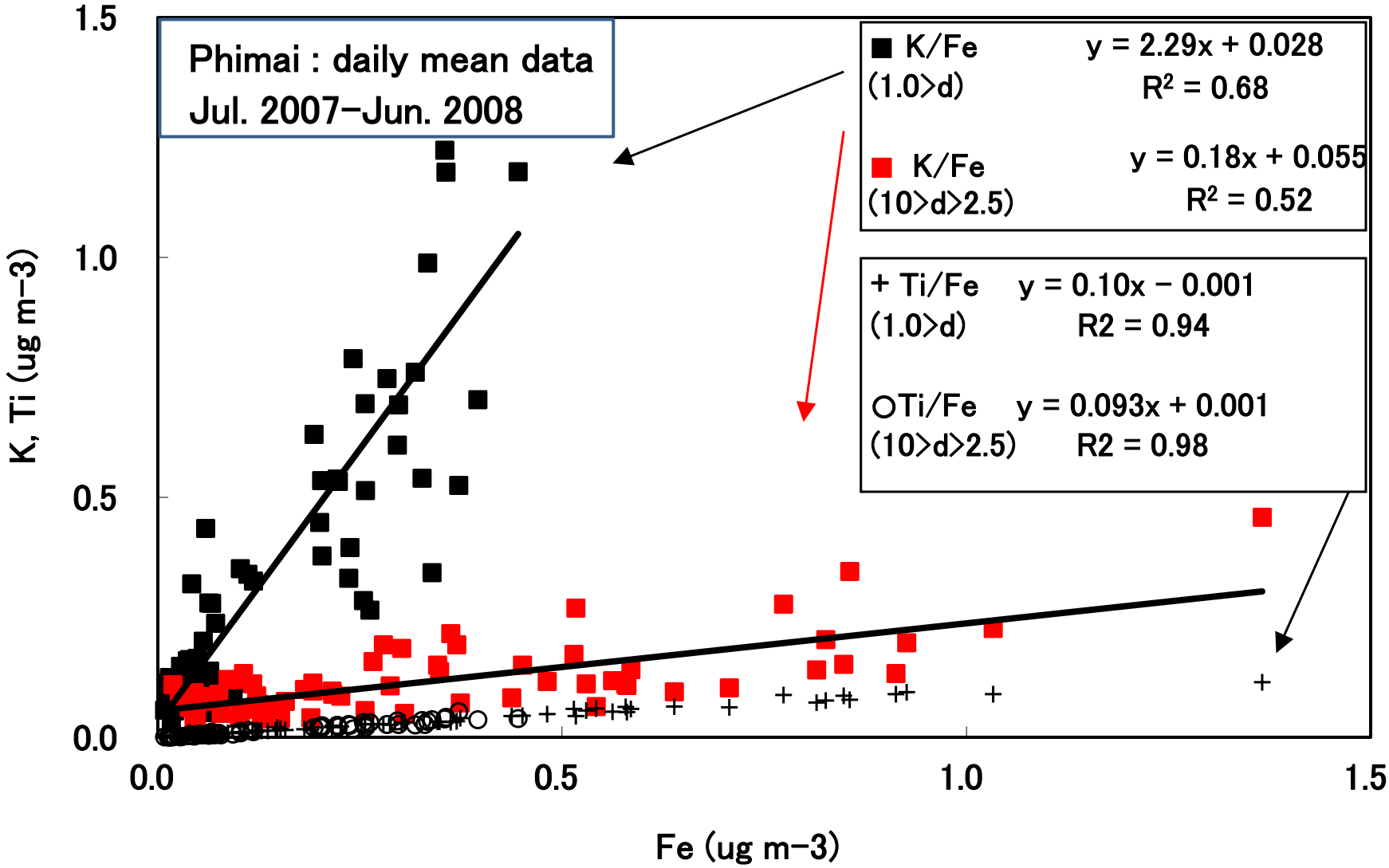


Mean chemical composition for fine and coarse particles in the wet and dry seasons



Zr has not been detected in atmospheric aerosols at Amami in spring time, And at Phimai in the D1 period when the surface wind was from east Asia. In contrast, Zr was detected in D2 and D3 periods, and it strongly suggests that, In the D1 period, soil was not dried well and biomass burning was not active.

In the D2 and D3 periods, however, soil became well dried and biomass burning very active, and local soil dust and re-suspended dust by biomass burning could strongly affect atmospheric aerosols at Phimai, in addition to that from east Asia in D2.



Relationship for K/Fe and Ti/Fe in coarse particles and $PM_{2.5}$ (July 2007- June 2008)

K: soil particles in coarse particles
biomass burning and bio-fuels in fine particles

20 June 2008

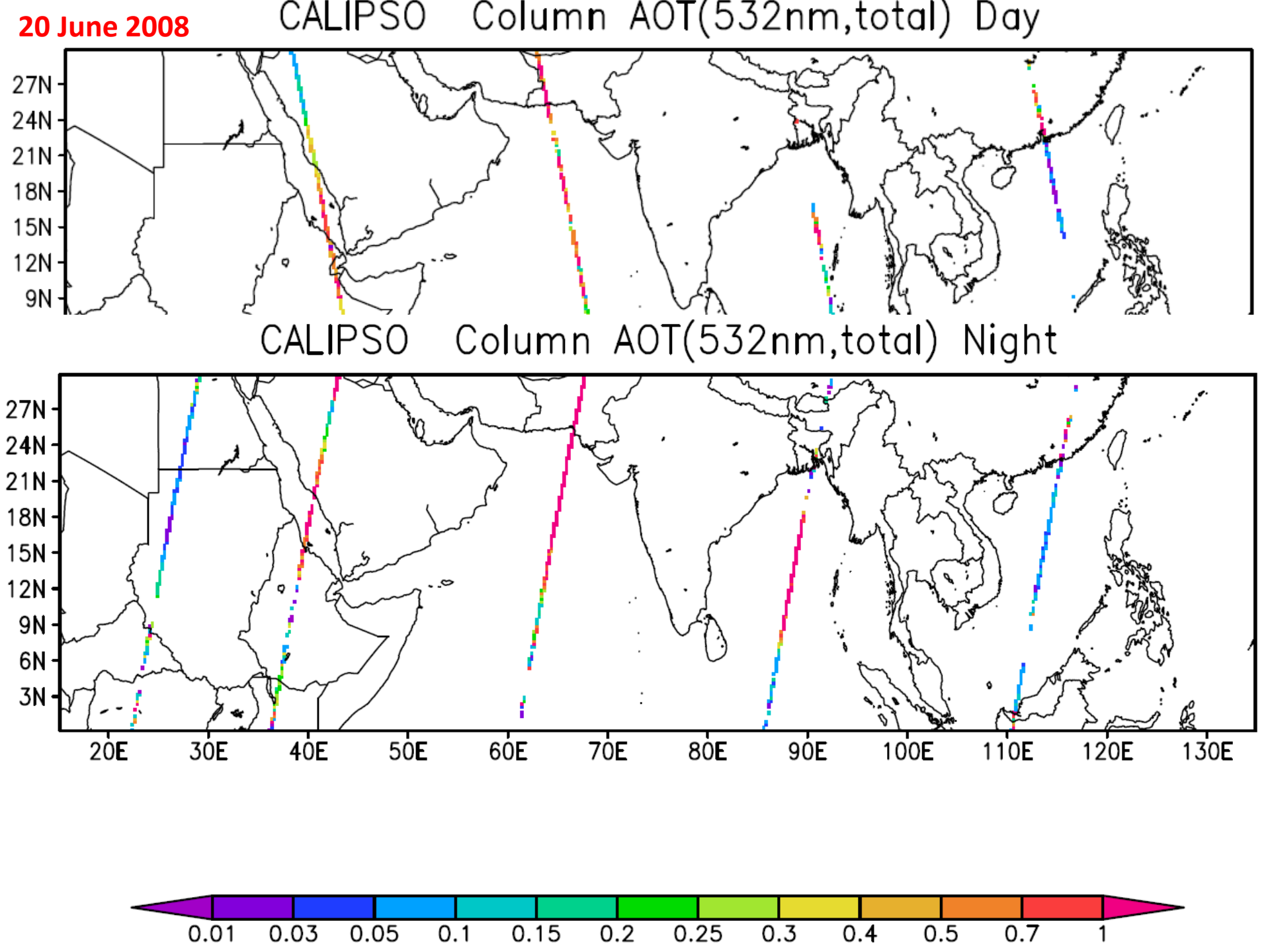
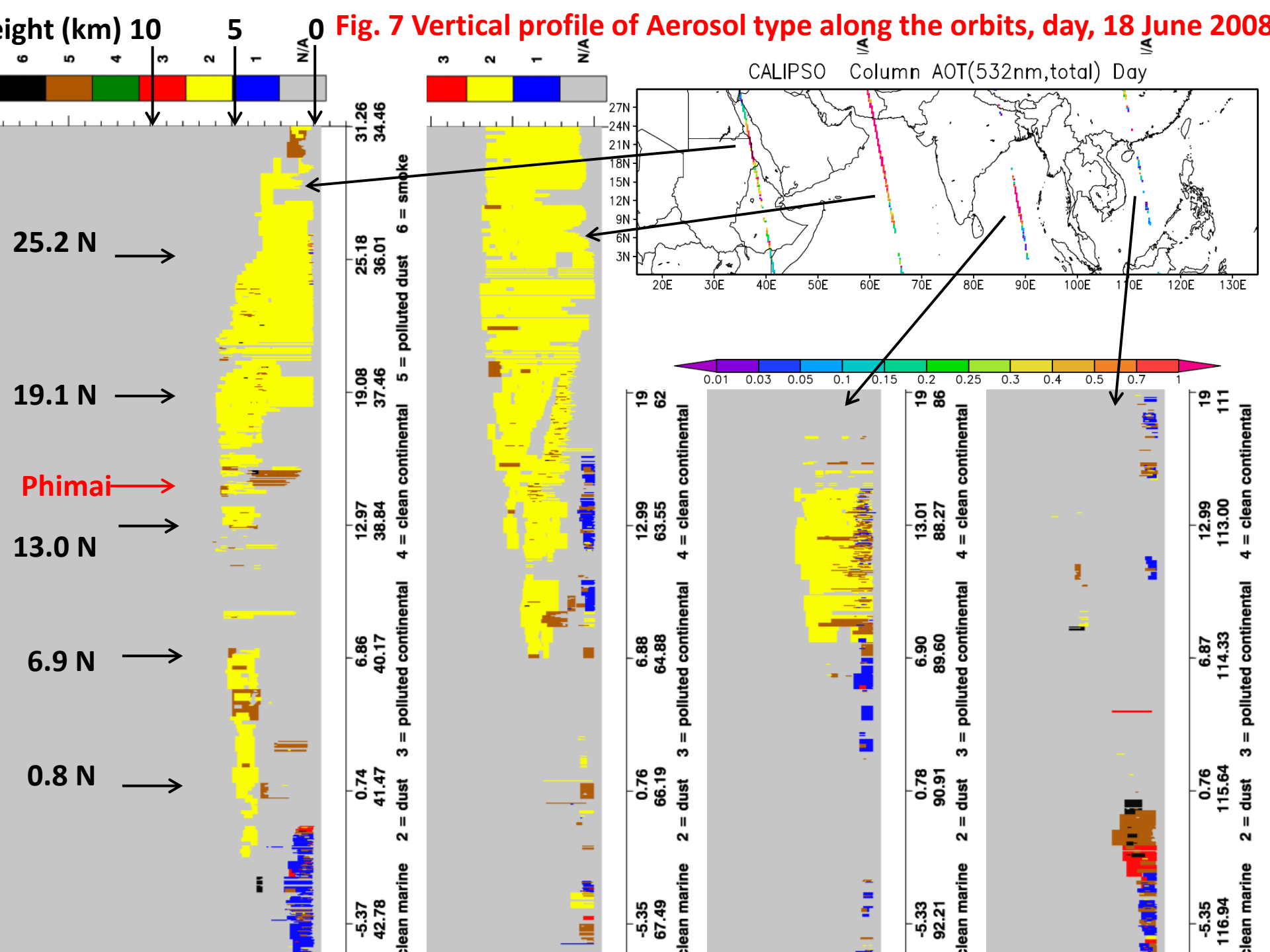

CALIPSO Column AOT(532nm,total) Day
27N
24N
21N
18N
15N
12N
9N
CALIPSO Column AOT(532nm,total) Night
27N
24N
21N
18N
15N
12N
9N
6N
3N
20E
30E
40E
50E
60E
70E
80E
90E
100E
110E
120E
130E
0.01
0.03
0.05
0.1
0.15
0.2
0.25
0.3
0.4
0.5
0.7
1

Fig. 7 Vertical profile of Aerosol type along the orbits, day, 18 June 2008



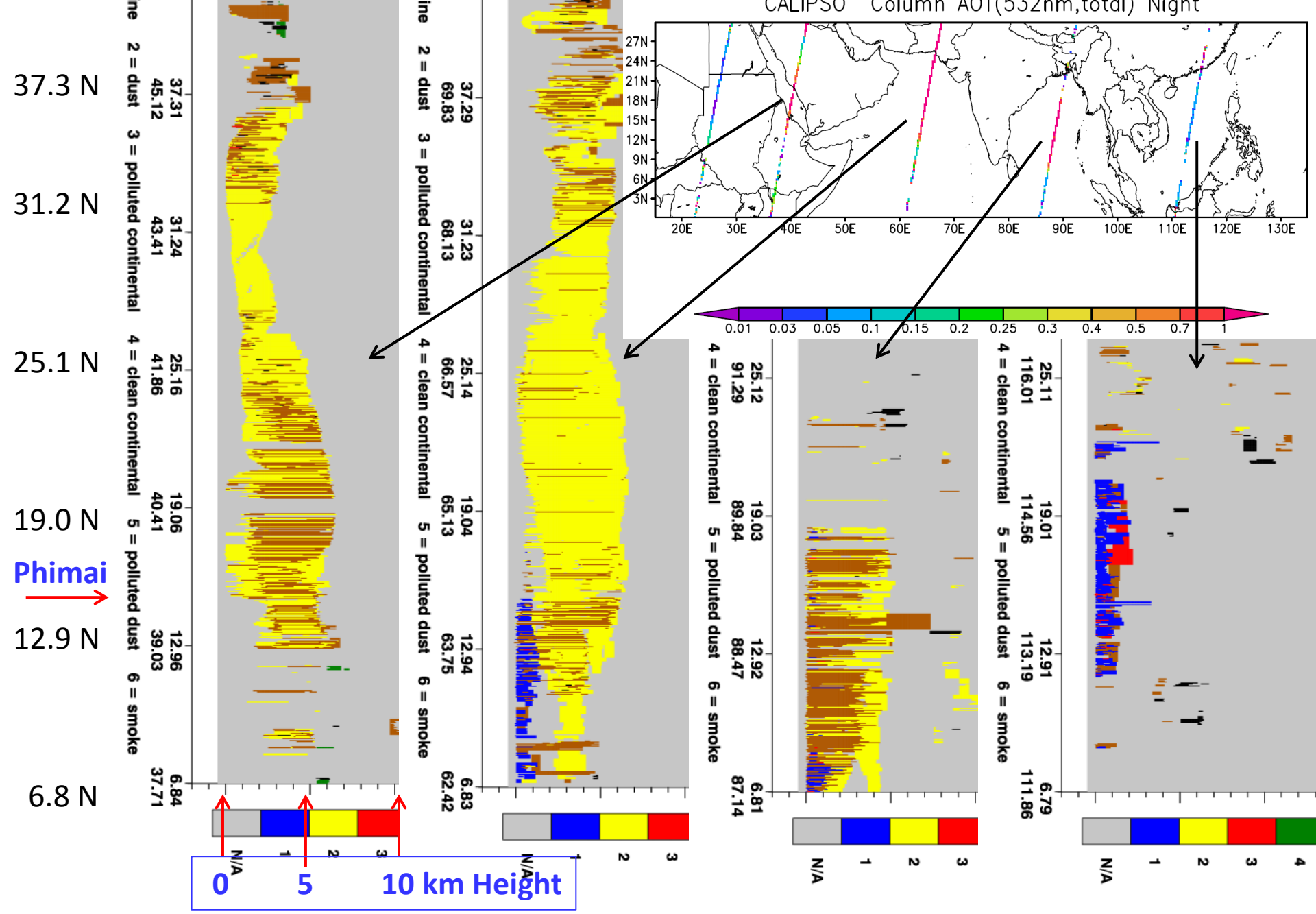
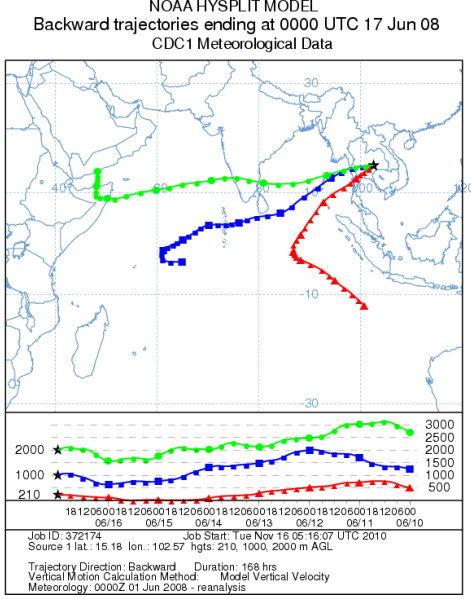
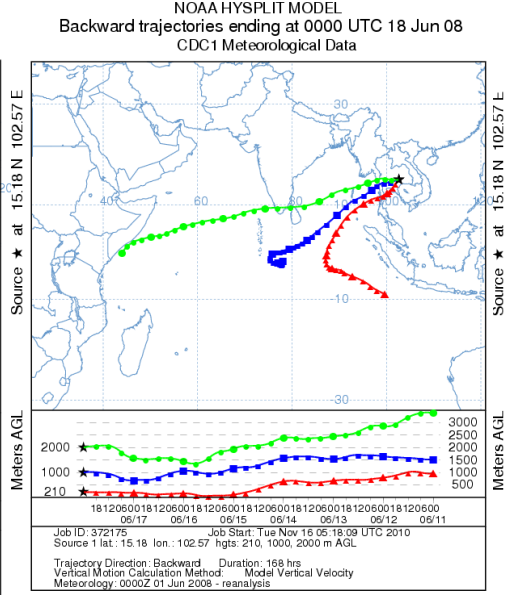
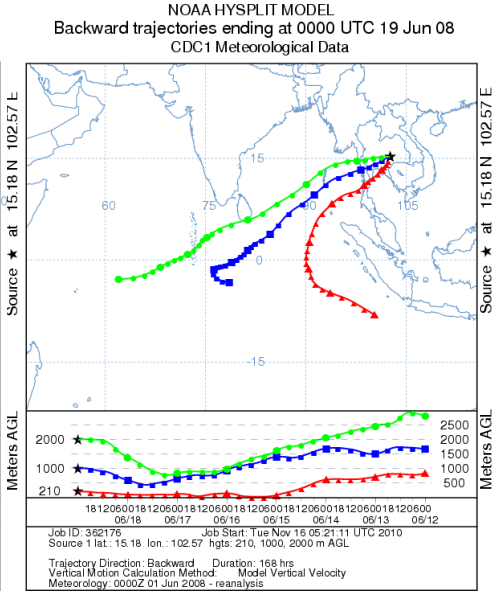
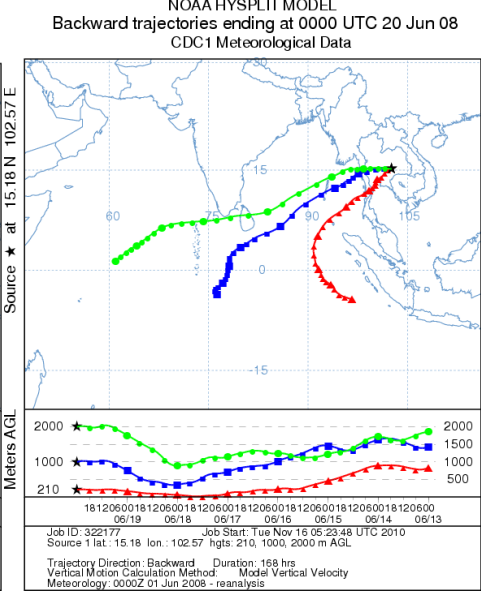


Fig. 8 Vertical profile of aerosol type along the orbit, night, 18 June 2008









17 June

210m, 1km, 2km

18 June

19 June

20 June

20 June

2,3,4km

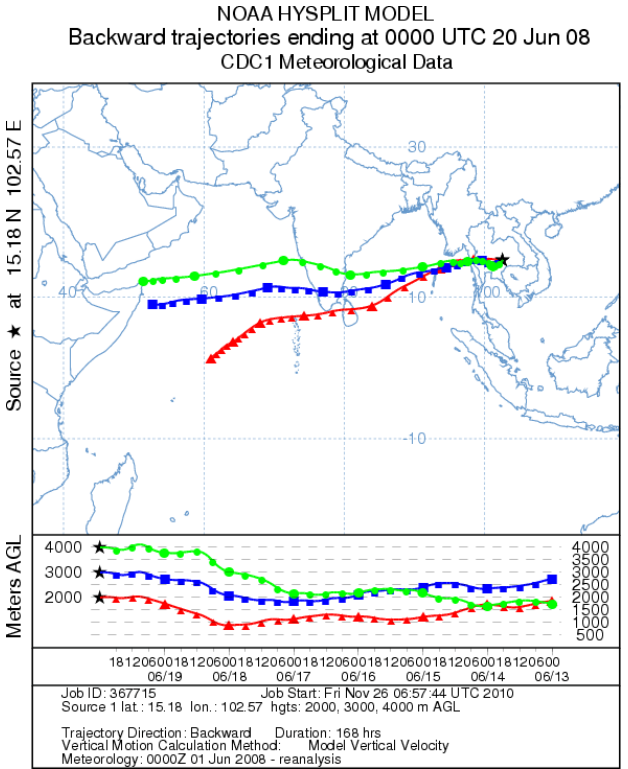


Fig. 10 Backward trajectory analysis of air masses arrived at Phimai on 17-20 June 2008, for a week By NOAA HYSPLIT MODEL

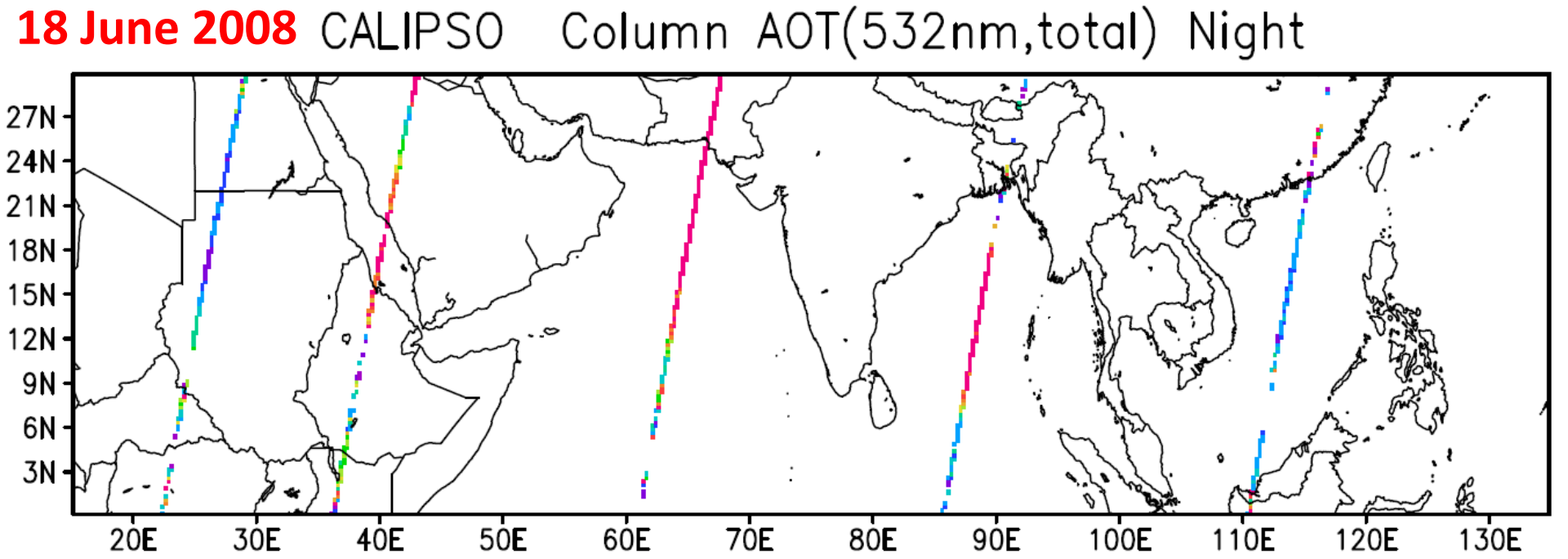
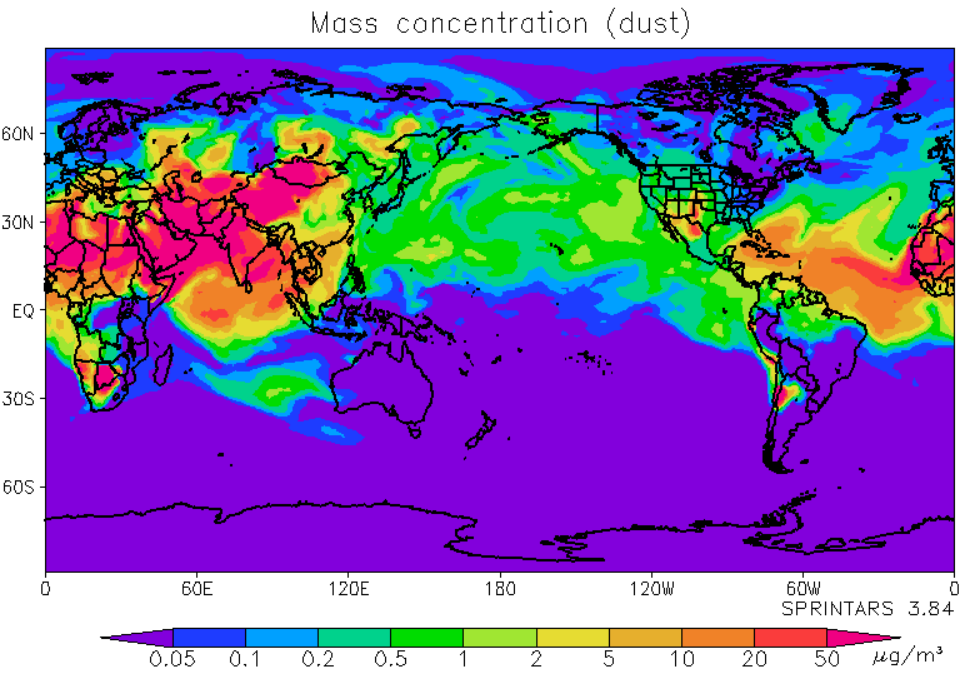
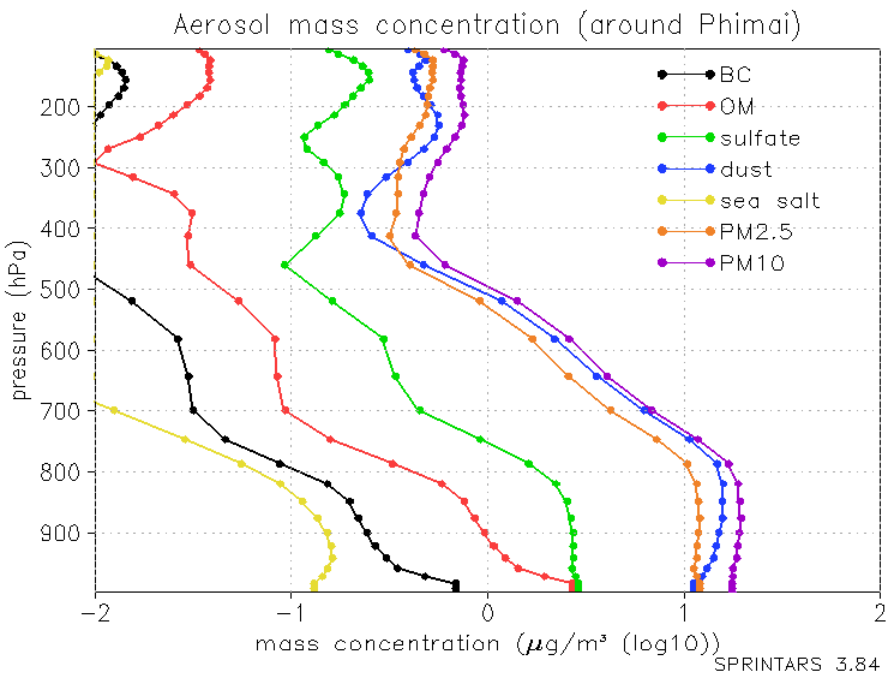


Fig. 9 Global and vertical aerosol distribution by SPRINTARS MODEL





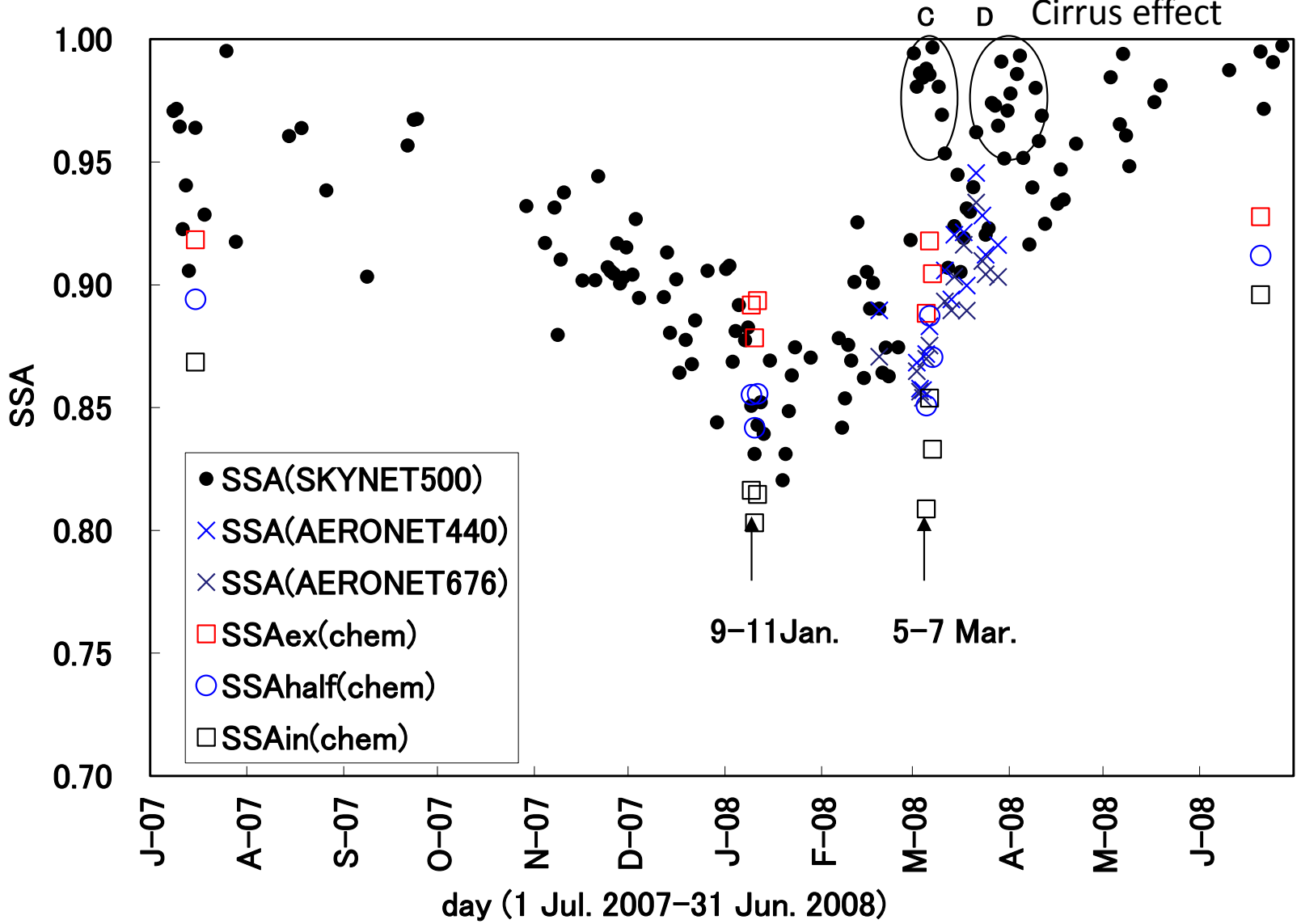
Conclusion 3: Optical properties

SSA: Clear seasonal variation with the minimum inD2

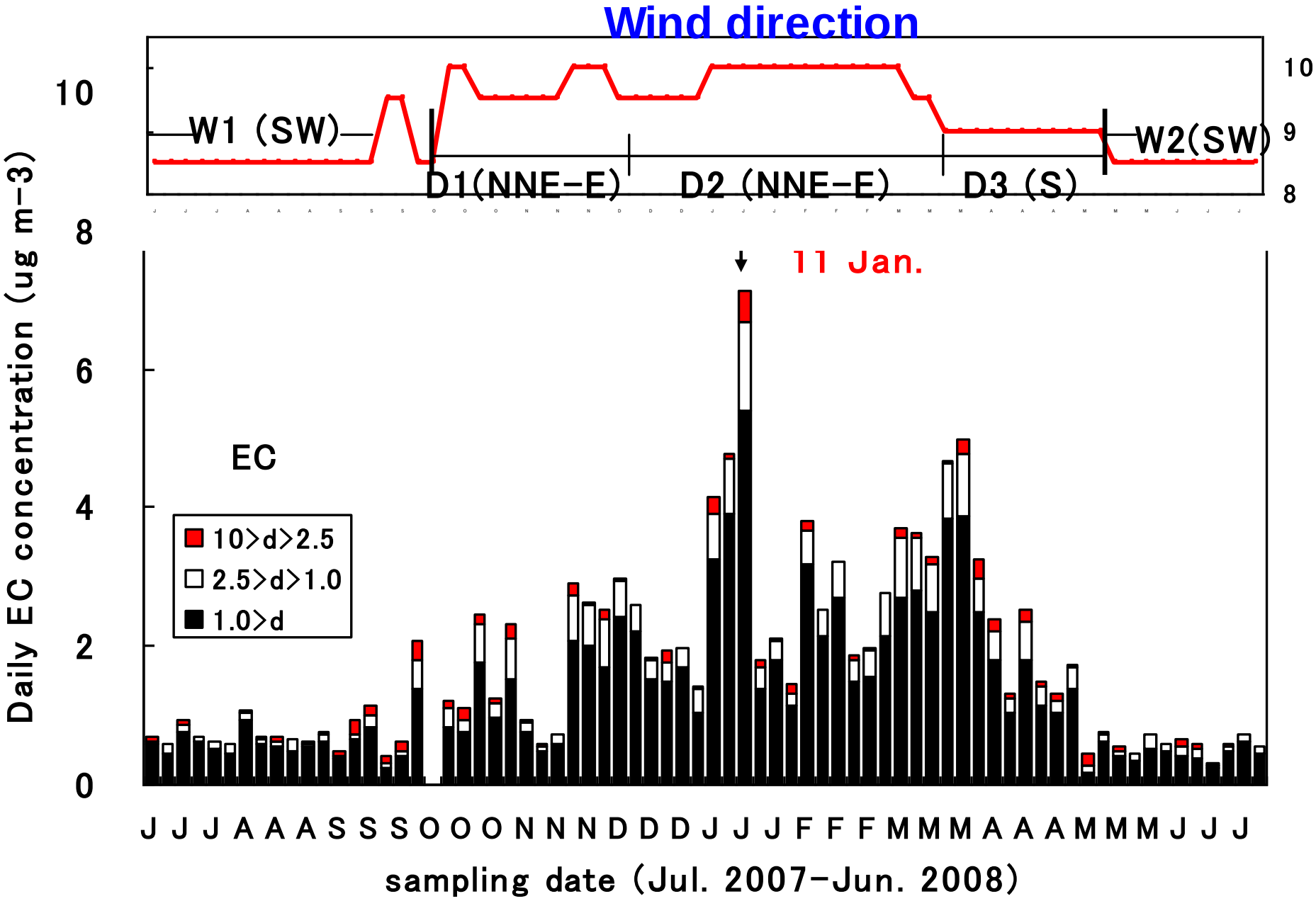
AOT: Highest in D3 possibly due to biomass burning

AOT and $PM_{2.5}$:
Positive correlation in D2 ,
and in D3, however, AOT was much higher than in D2.

A possible reason might be multi layers of aerosols, as shown in CALIOP data, due to biomass burning in Indochina or transport of polluted air masses from the west.

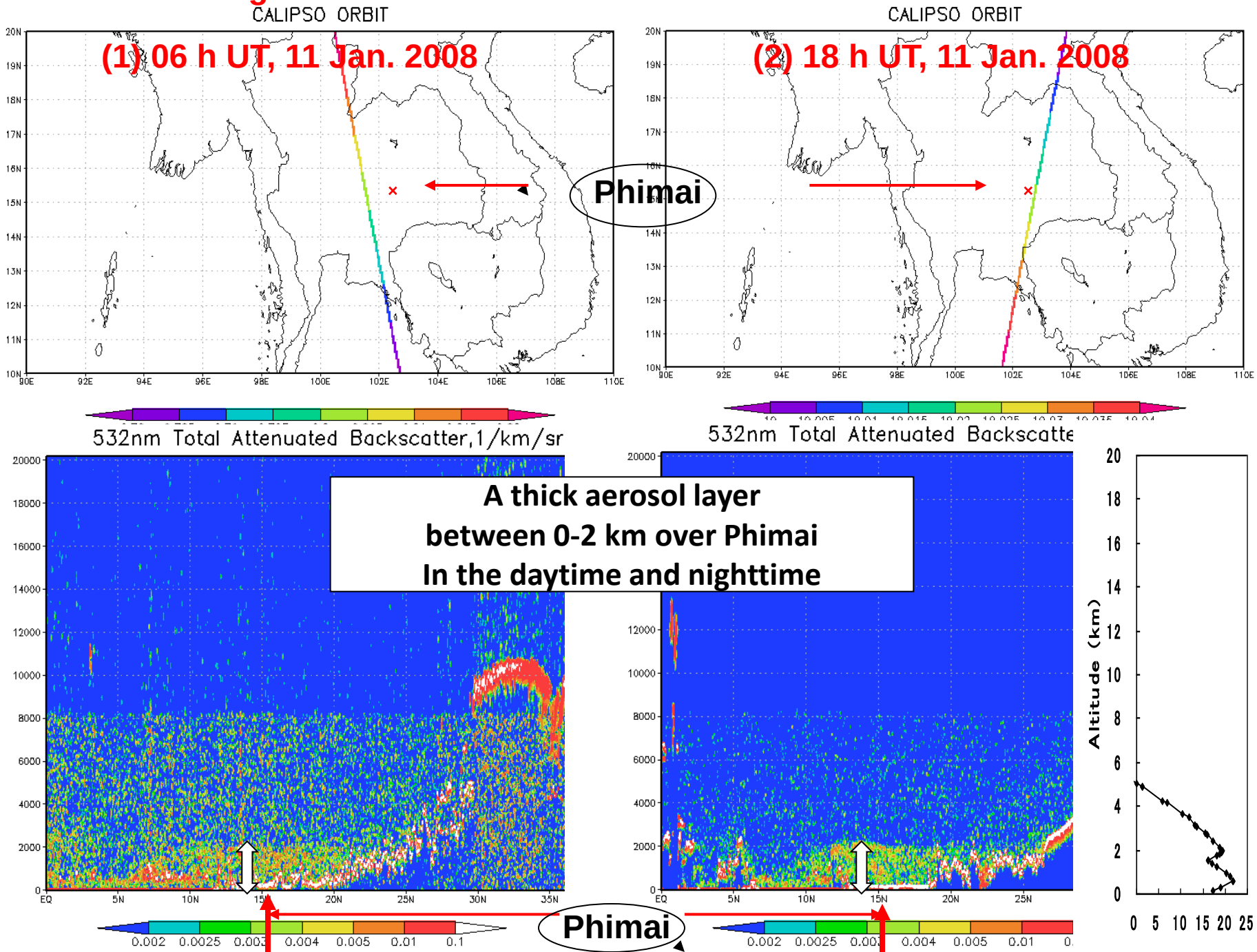


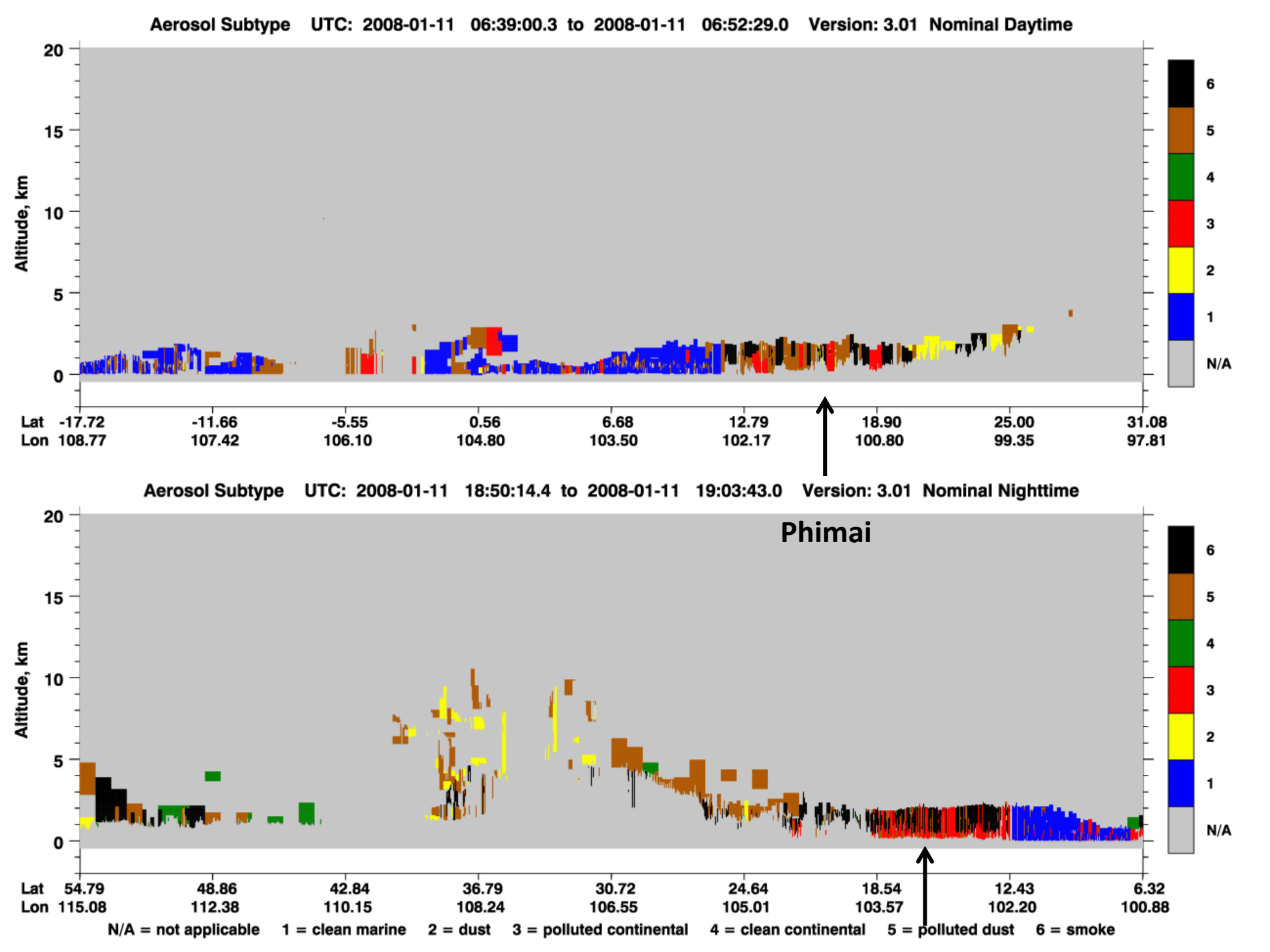
SSAo by skyradiometer and SSAc by surface chemical compositions, assuming external (ex), half internal (half), and internal mixture (in). SSAc is only calculated for several cases, because the size distribution of atmospheric aerosols are used at Amami, not Phimai.



Time series of EC concentration and wind direction

Fig. 14 Total attenuation backscatter from CALIOP




Aerosol Subtype UTC: 2008-01-11 06:39:00.3 to 2008-01-11 06:52:29.0 Version: 3.01 Nominal Daytime
Altitude, km
20
15
10
5
0
6
5
4
3
2
1
N/A
Lat -17.72 -11.66 -5.55 0.56 6.68 12.79 18.90 25.00 31.08
Lon 108.77 107.42 106.10 104.80 103.50 102.17 100.80 99.35 97.81
Aerosol Subtype UTC: 2008-01-11 18:50:14.4 to 2008-01-11 19:03:43.0 Version: 3.01 Nominal Nighttime
Phimai
Altitude, km
20
15
10
5
0
6
5
4
3
2
1
N/A
Lat 54.79 48.86 42.84 36.79 30.72 24.64 18.54 12.43 6.32
Lon 115.08 112.38 110.15 108.24 106.55 105.01 103.57 102.20 100.88
N/A = not applicable 1 = clean marine 2 = dust 3 = polluted continental 4 = clean continental 5 = polluted dust 6 = smoke

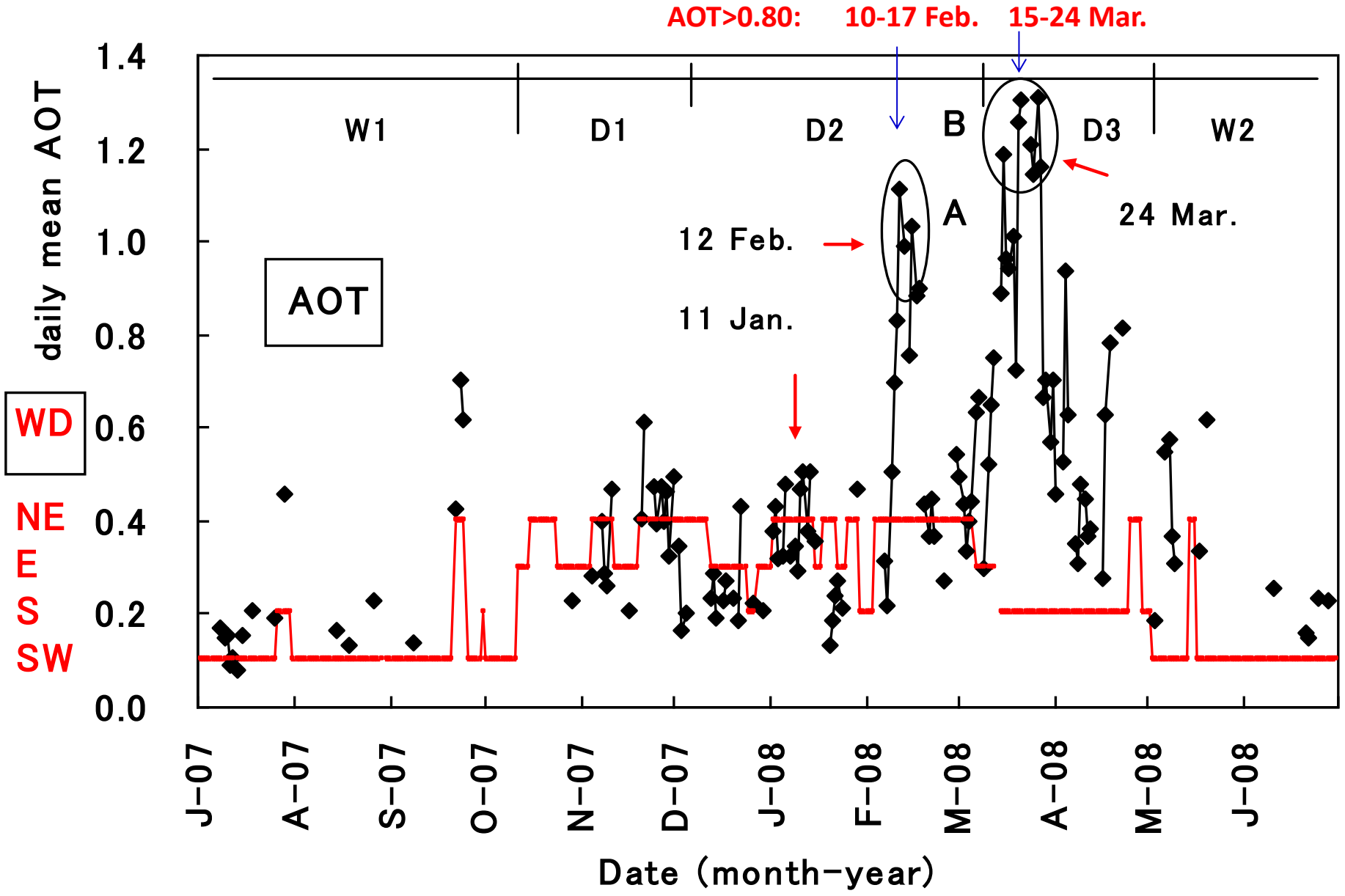
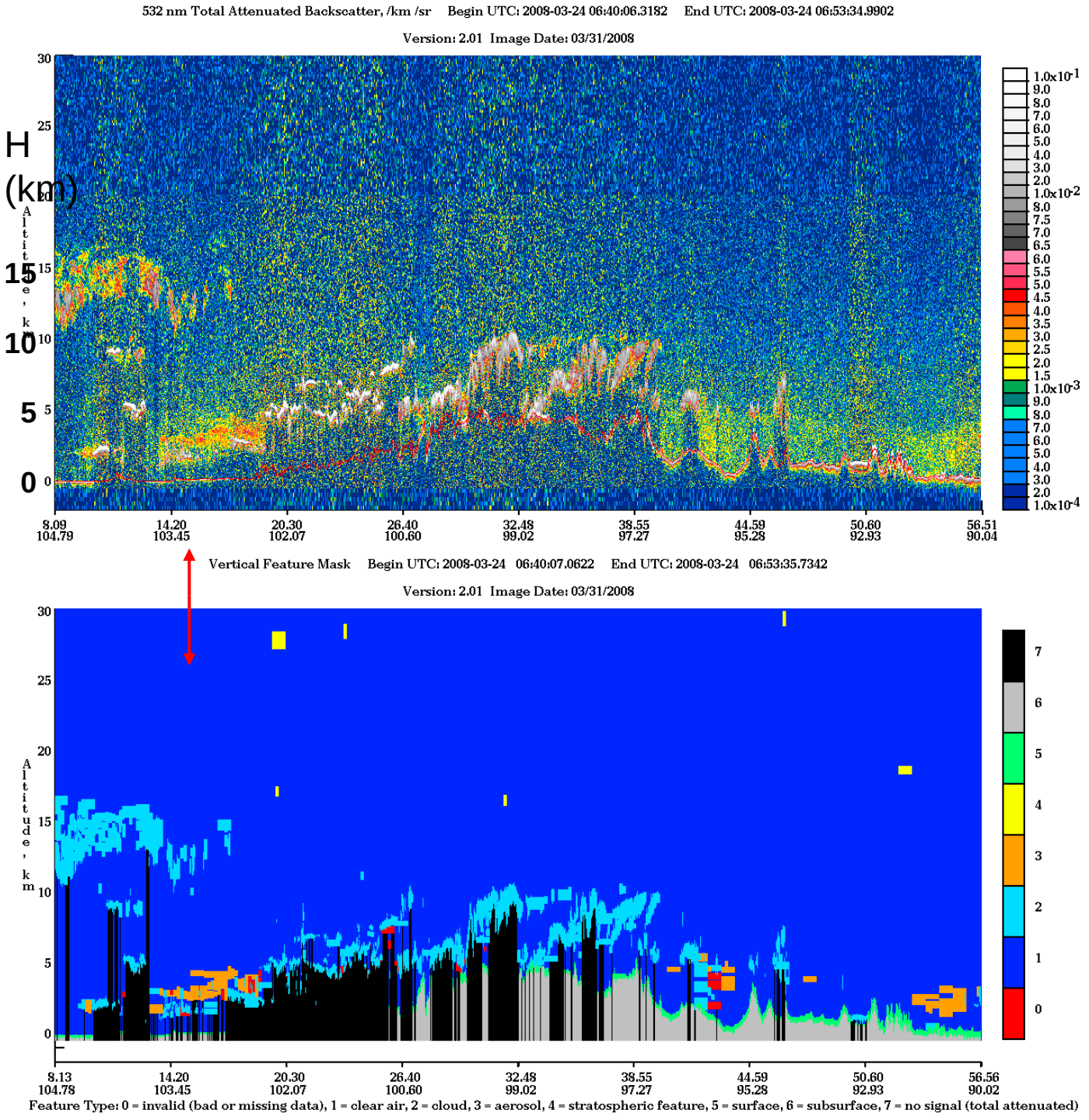


Fig. 11 Time series of Aerosol Optical Thickness (AOT, 500nm) and WD

Fig. 17

24 Mar. 2008
06h UT

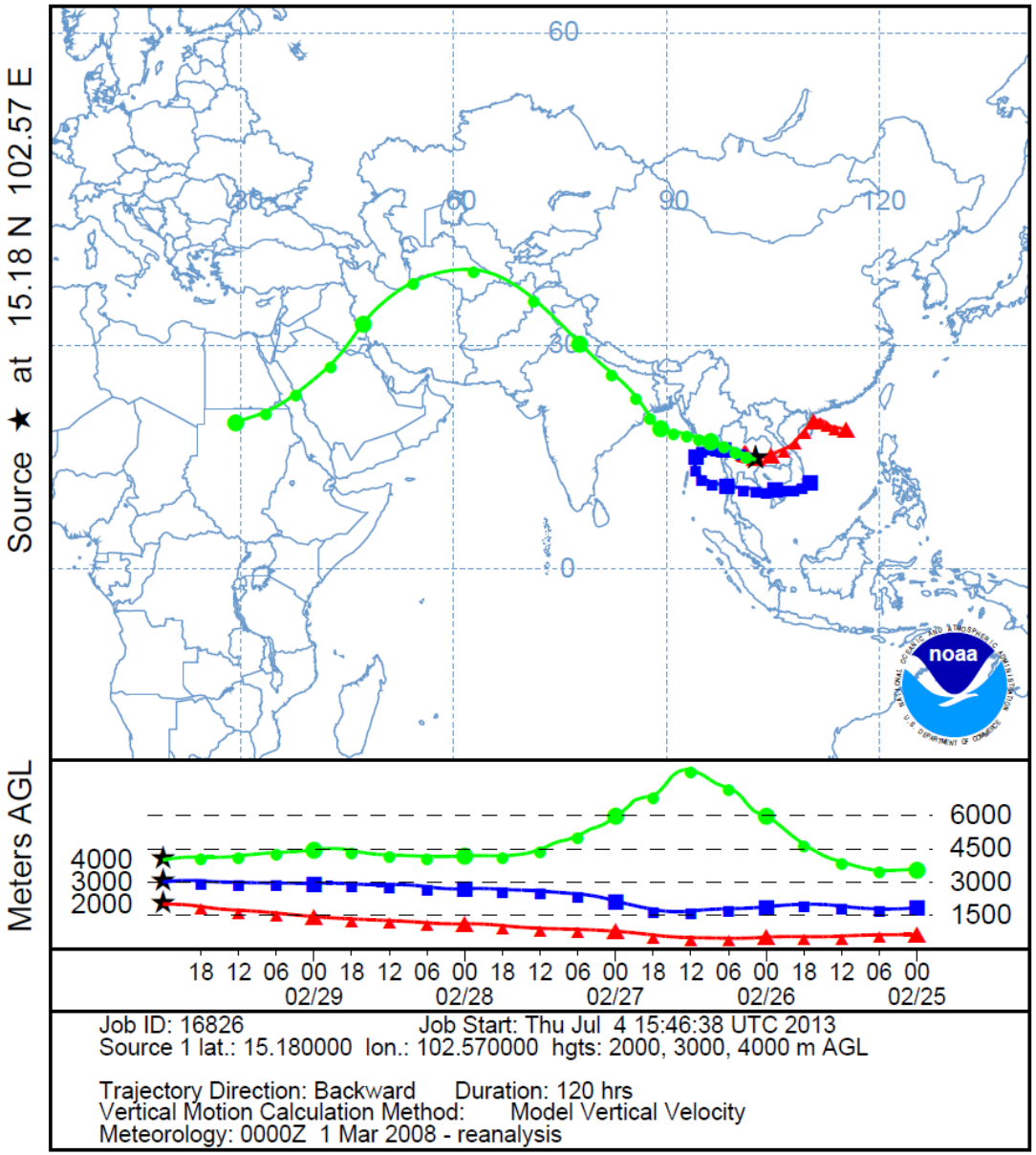
No surface measurement

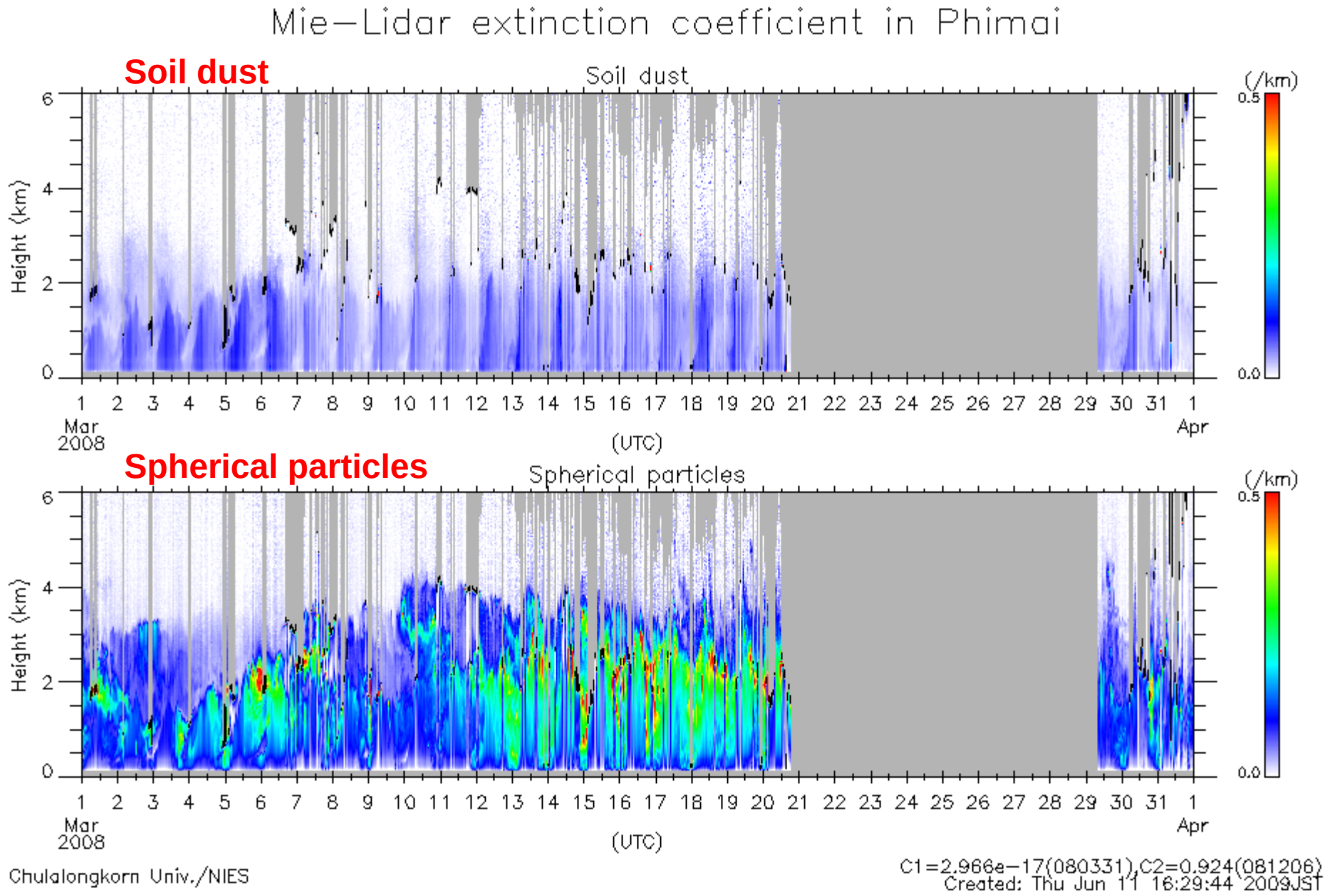


NOAA HYSPLIT MODEL

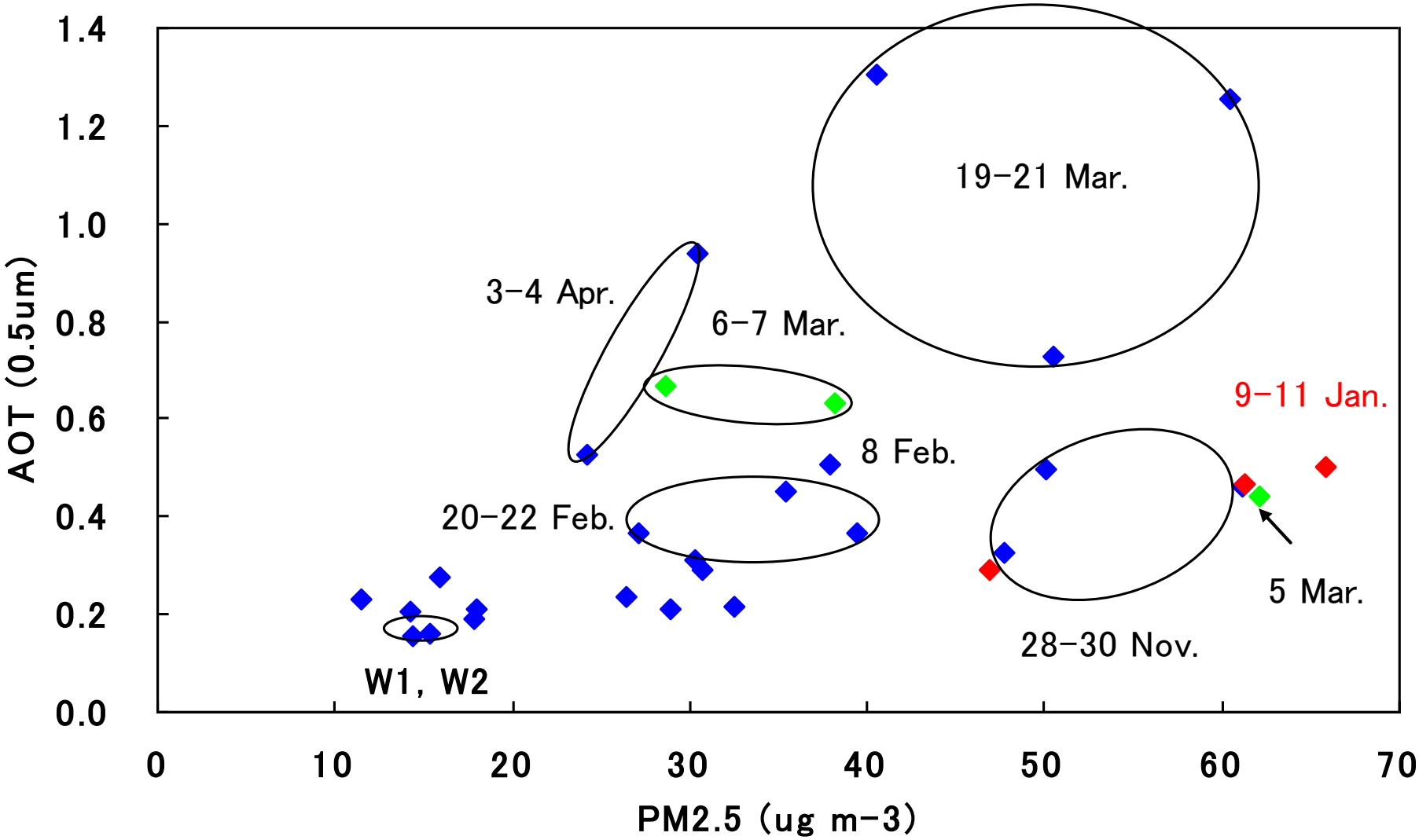
Backward trajectories ending at 0000 UTC 01 Mar 08

CDC1 Meteorological Data





Mie Lidar extinction coefficient over Phimai in March 2008



Scatter diagram between PM2.5 and AOT by skyradiometer in the days when both data were simultaneously measured.

AOT could be positively correlated with PM2.5 near the surface.

More comprehensive study among field measurements, satellite data analysis, and model simulation should be performed in future.

Thank you very much for your attention!!