Observation of Cloud Condensation Nuclei and aerosol in Northern Thailand

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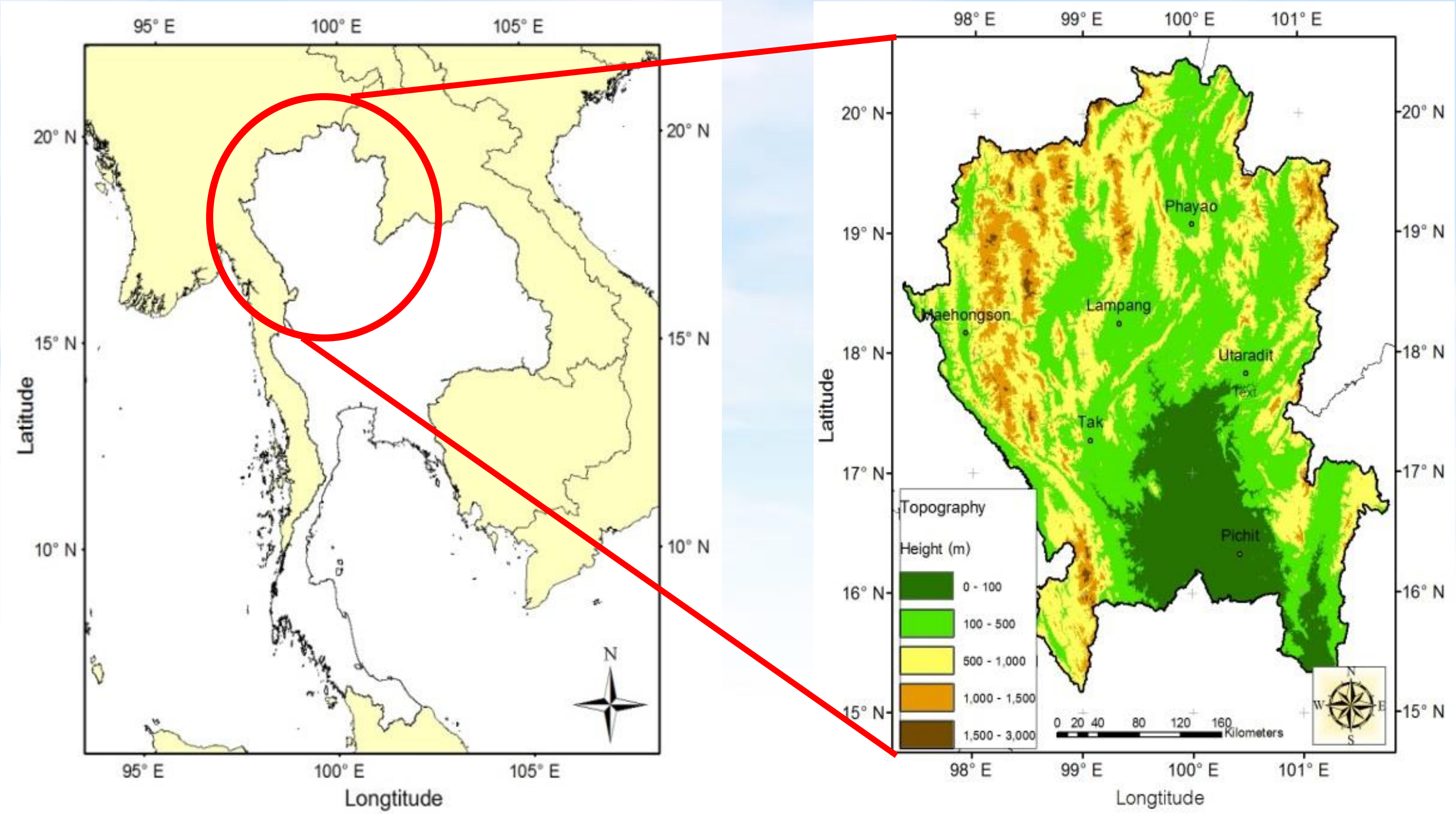
Introduction

Aerosols and cloud condensation nuclei play an important role in the clouds formations. Better understanding the influence of the typical aerosol observed during smoke period is important. The finding can be use for weather modification to perform rain enhancement to augment suitable hygroscopic nuclei to induce cloud formation when the weather condition is suitable such as relative humidity (RH >60%), etc.

Objective

To study the properties of aerosol and cloud condensation nuclei (CCN) during smoke situation (March to May) in northern Thailand.

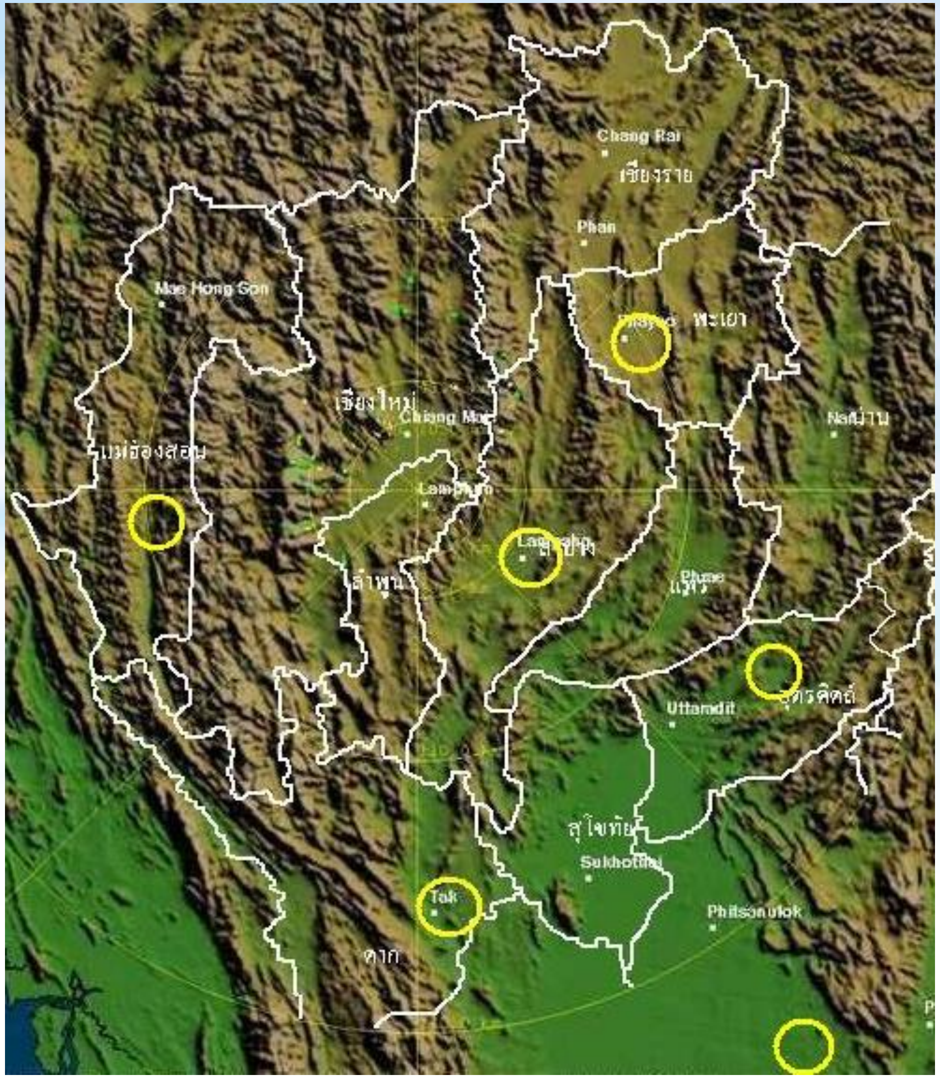
Data collection



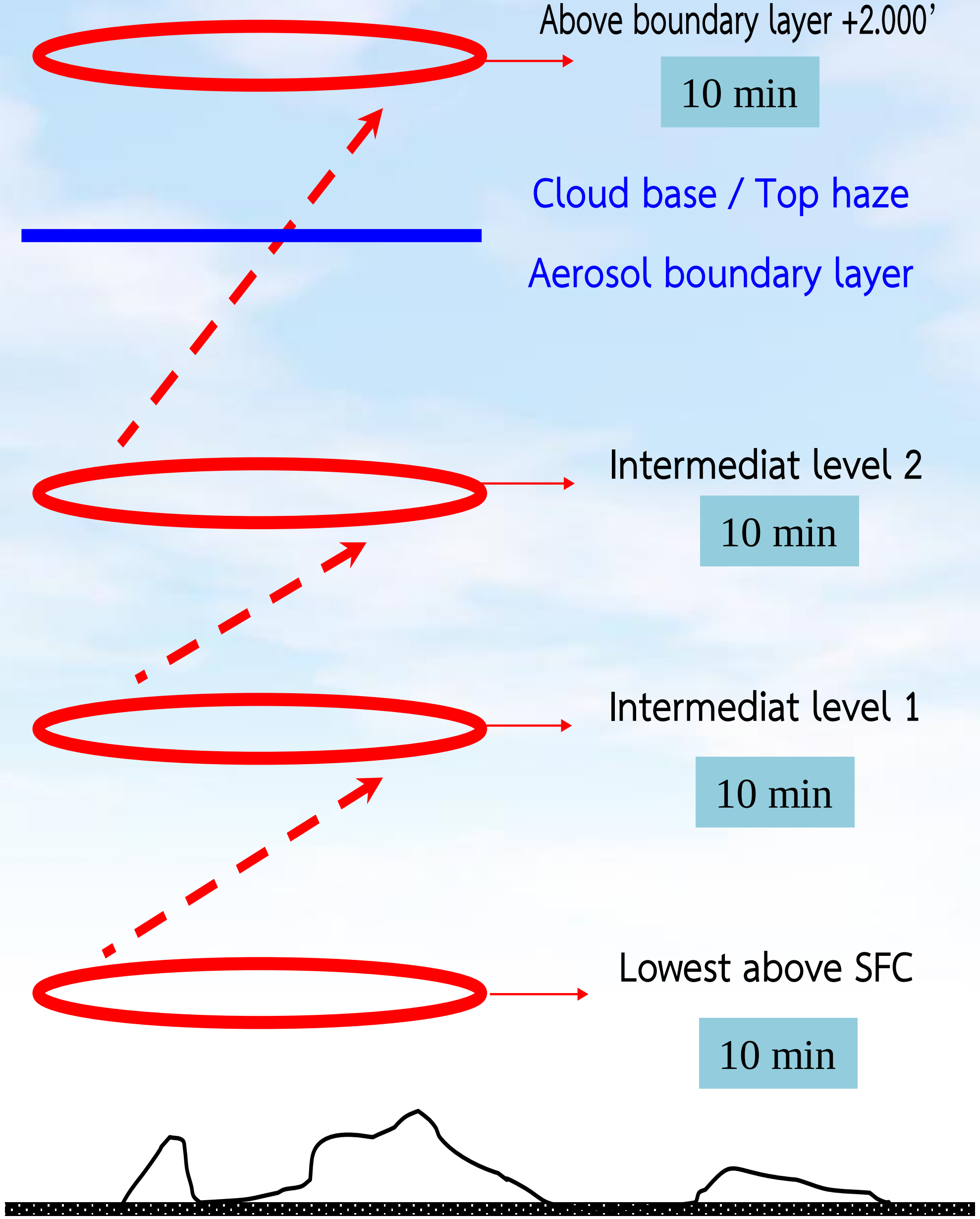
Data collection

1. Collected aerosol and cloud condensation nuclei concentration with constant super-saturation at 0.5% when ascending.
2. Collected aerosol and cloud condensation nuclei concentration with cycled supersaturation 0.2%, 0.5% and 0.8% respectively at 4 levels (900-1,200m/ 1,200-1,800m/ 1,800-2,800m/ 2,800-3,900m) to calculate Twomey's C and k parameters.
3. Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model from the Global Data Assimilation System (GDAS1) meteorological database.

Data collection



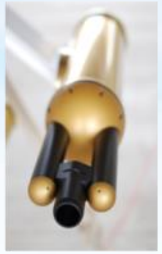
Aerosol profile



Cloud Physics Instruments

HVPS Probe
A High Volume Precipitation Spectrometer
Particle size 150-19,200 μm

PCASP
Passive Cavity Aerosol Spectrometer Probe
Aerosol size 0.1-3.0 μm



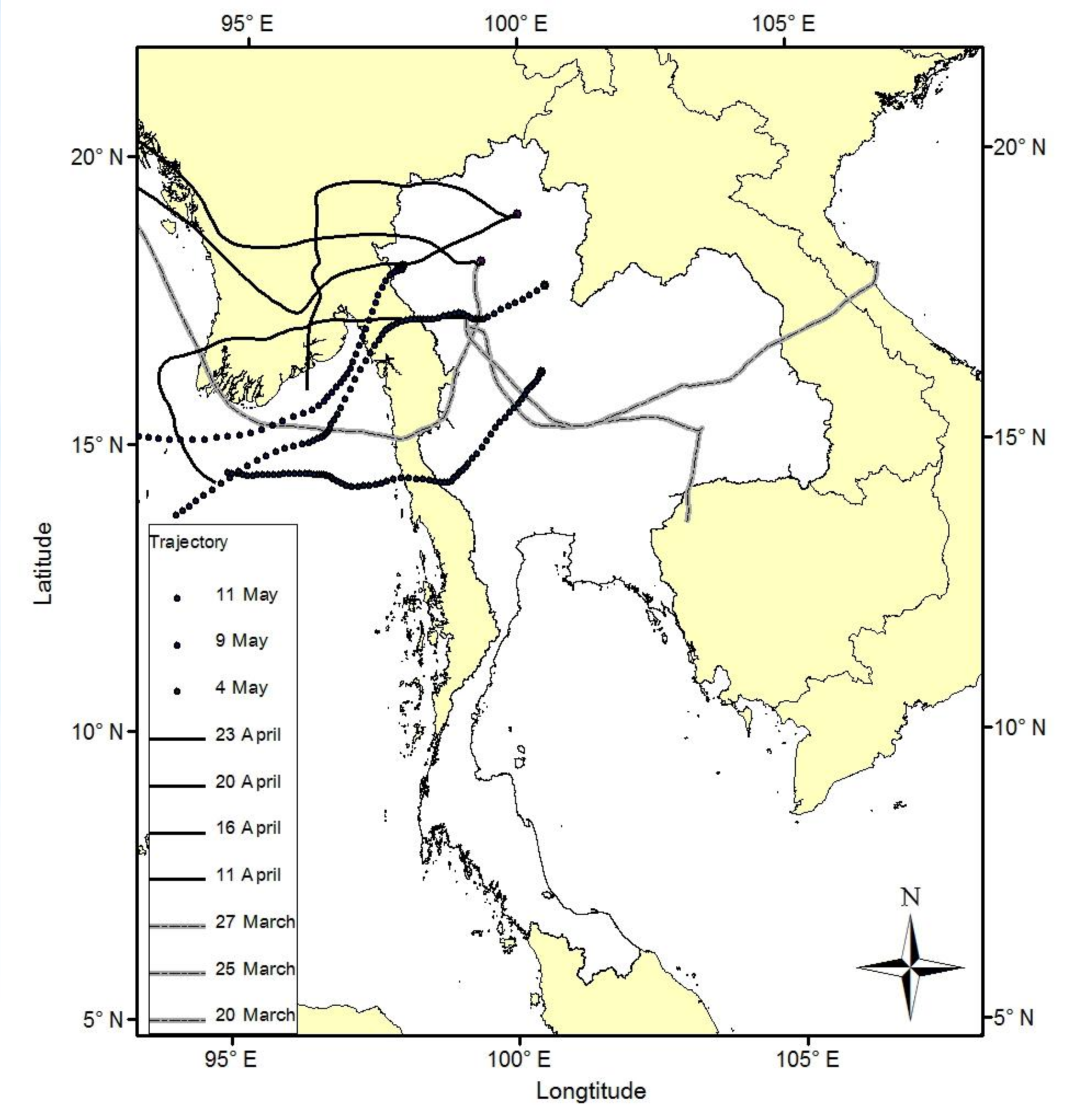
FFSSP
Fast Forward Scattering Spectrometer Probe
Particle size 1-50 μm

AIMMS Probe
Aircraft-Integrated Meteorological Measurement System
Temp., RH, Wind

CPI Probe
Cloud Particle Imager
resolution 2.3 μm/pixel

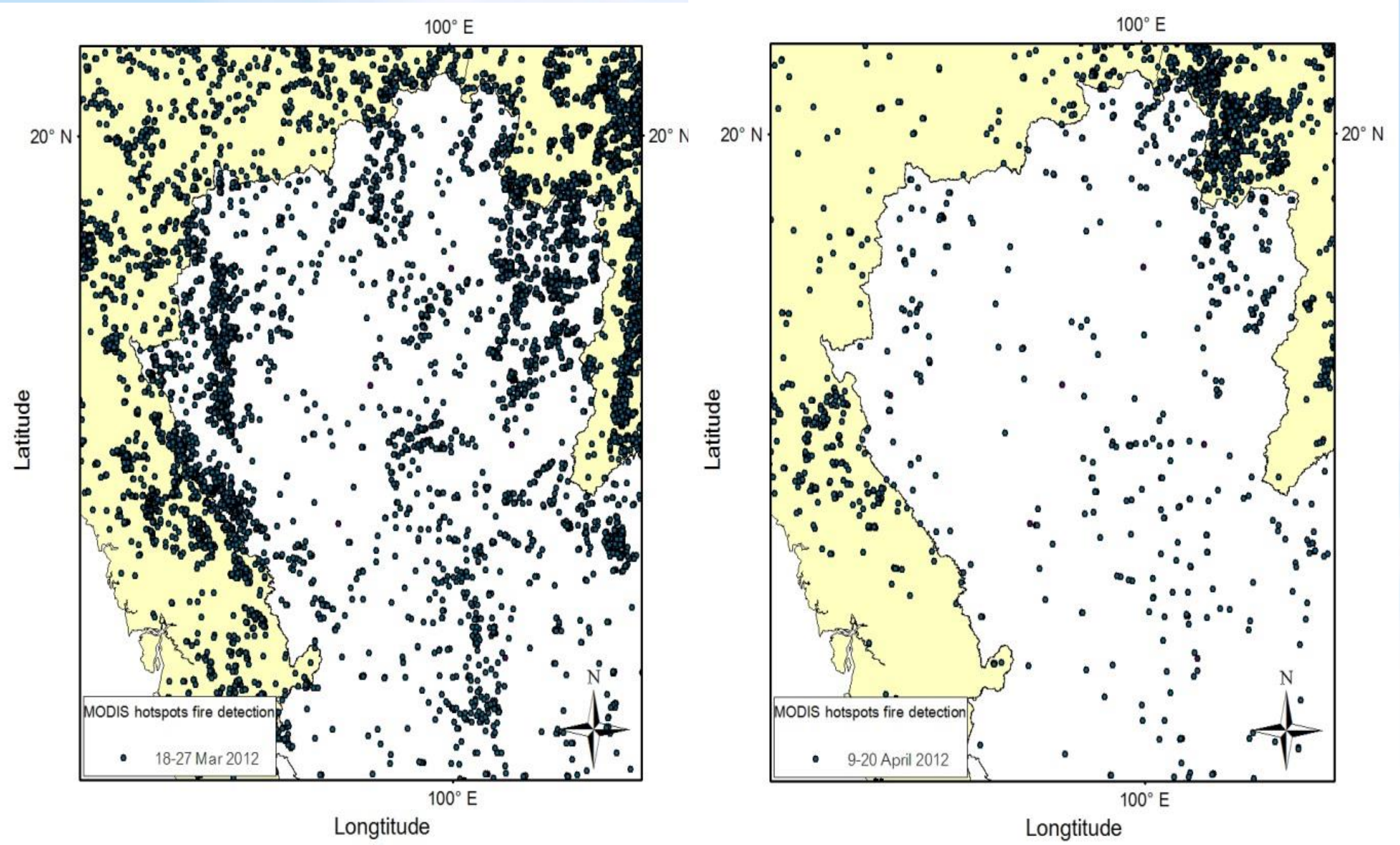
2D-S Probe
A Two Dimensional, Stereo, Particle Imaging
size 10 – 1280 μm
resolution 10 μm/pixel

Results



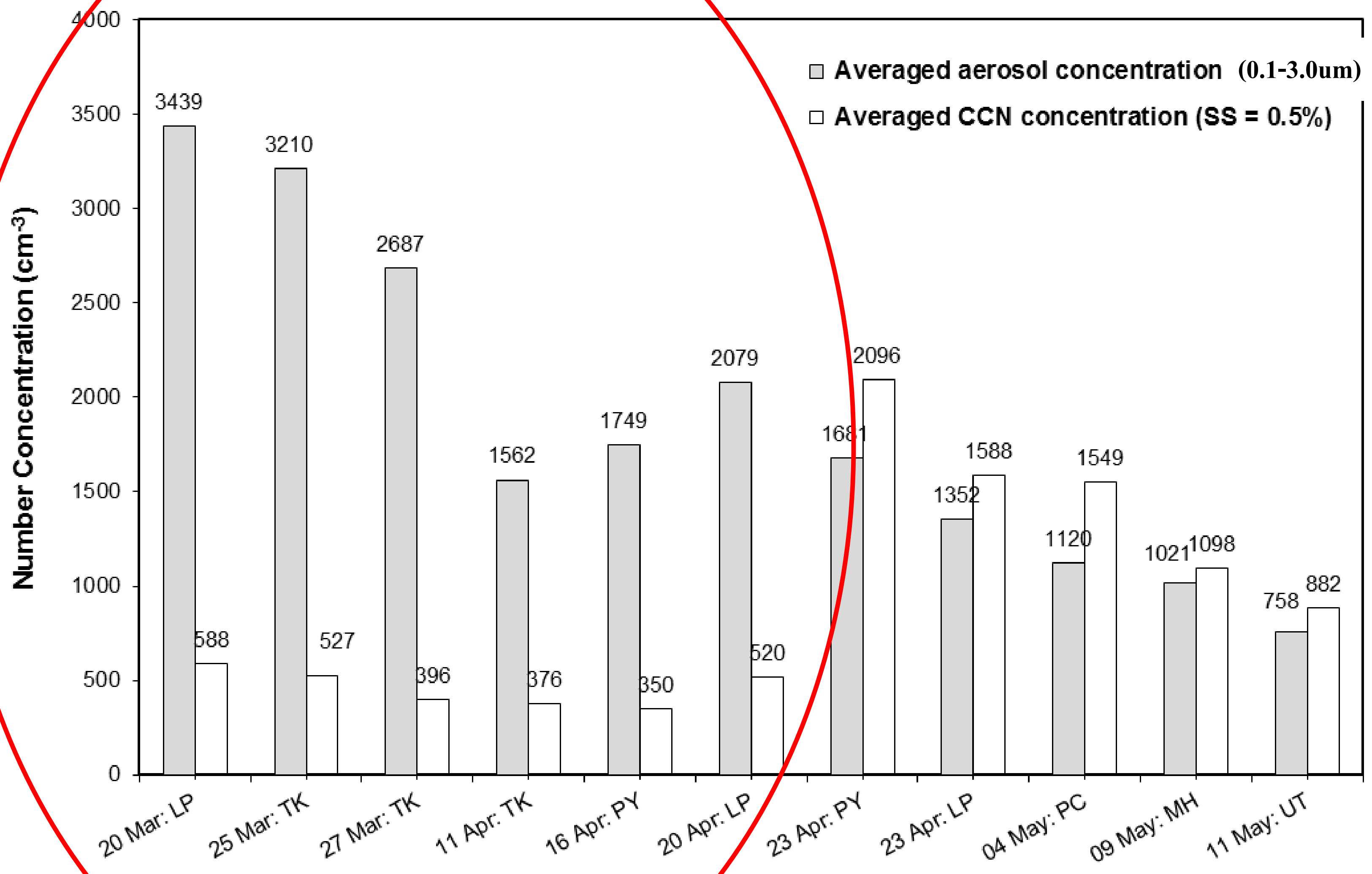
3 days back trajectories above ground level 1500 m

Results

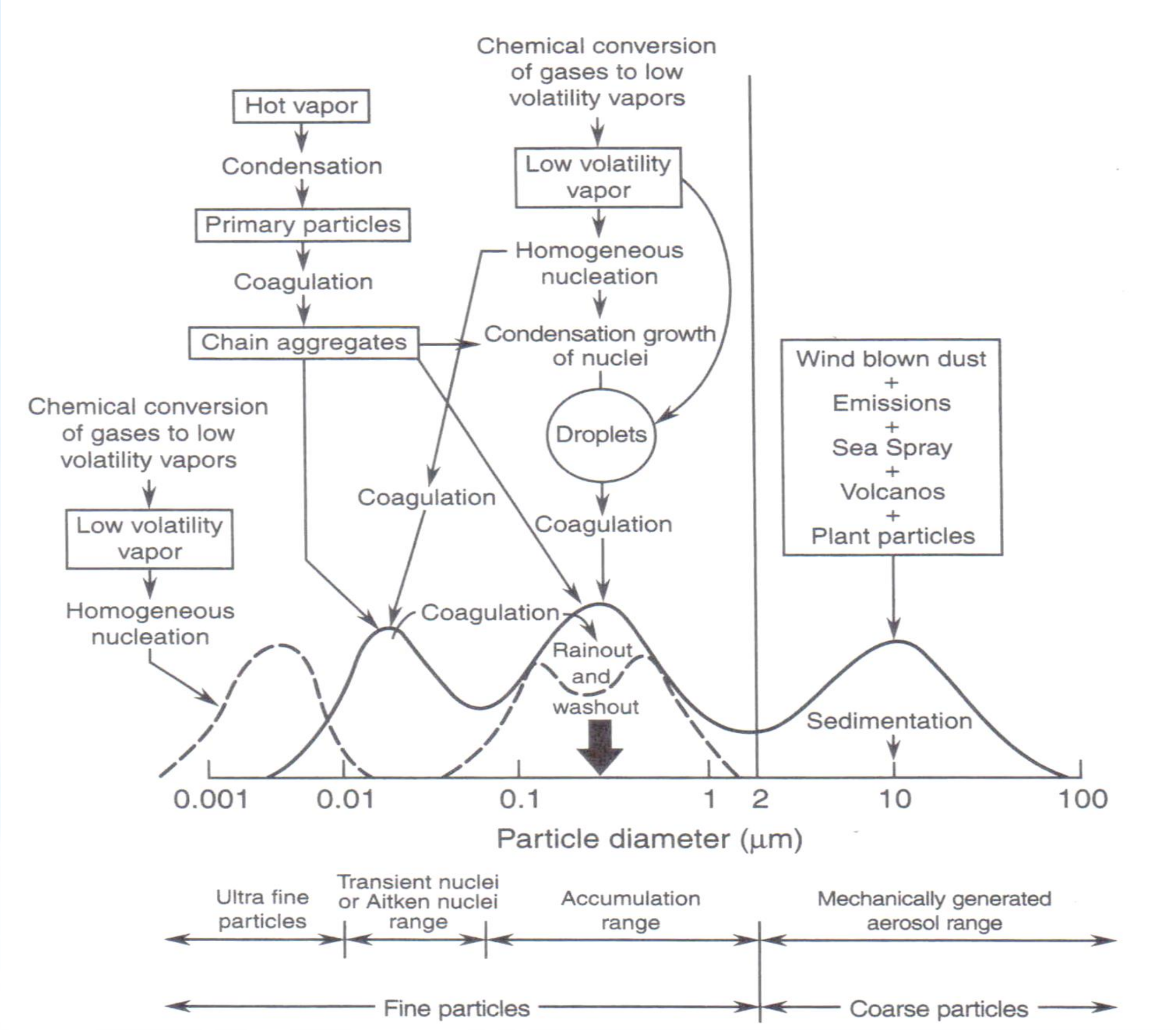


MODIS hotspots fire detection on March 18-27, 2012 (left) and on April 9-20, 2012 (right).

Results



Date and places: LP=Lampang, TK=Tak, PY=Payao, PC=Pichit, MH= Mae Hongson, UT=Utaradit



Aerosols size distribution and mechanism (Stier et el., 2008)

Cloud condensation nuclei

CCN Supersaturation cycles, Twomey (1959)

$$N_{CCN} = CS^k$$

When N_{CCN} is Total concentration of Cloud Condensation Nuclei (CCN)

S is Supersaturation

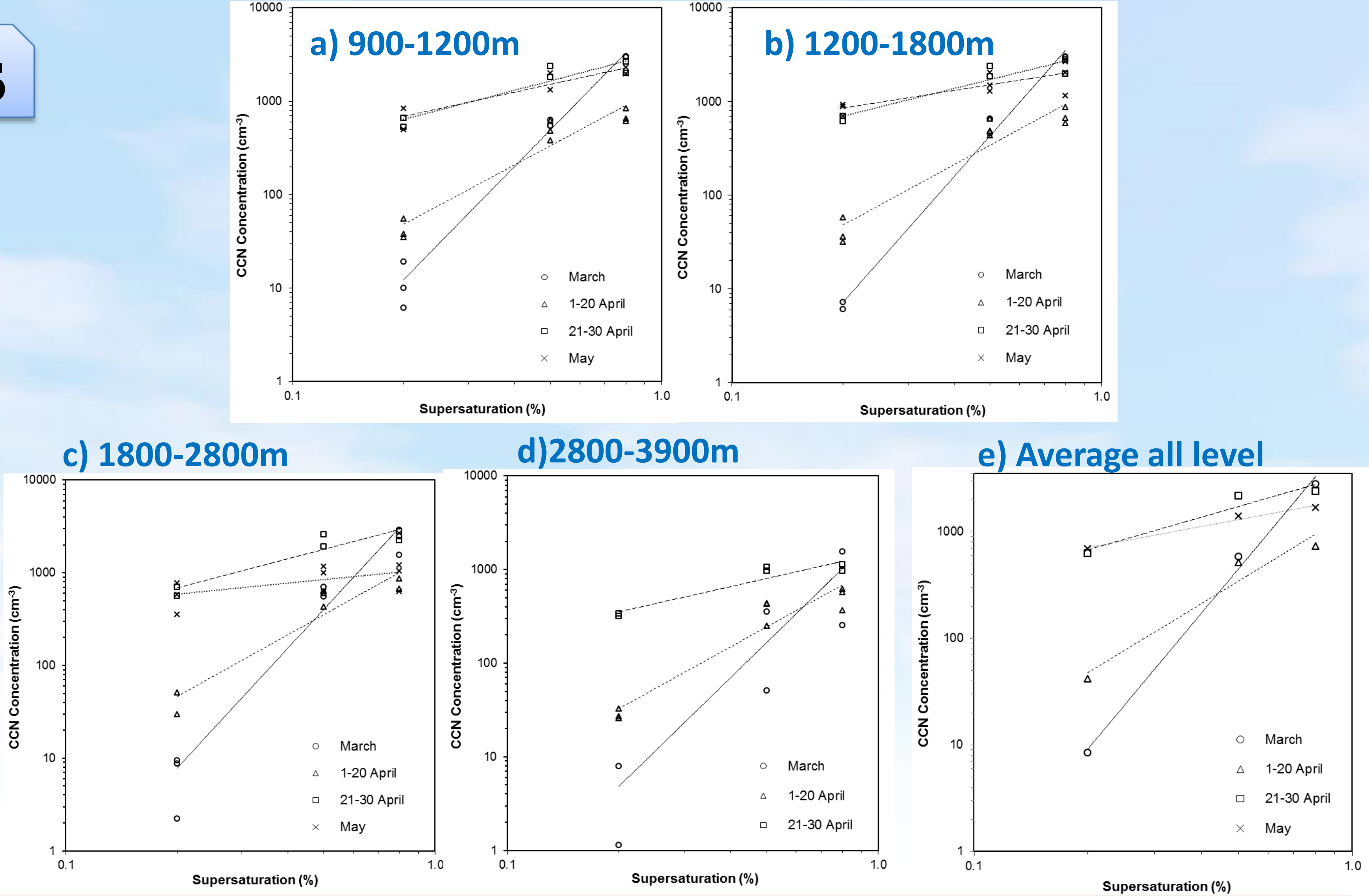
C is Constant, CCN concentration at S= 1%

k is slope index

table showed Twomey's C and k parameters

References	Maritime		Continental	
	C [cm^{-3}]	k	C [cm^{-3}]	k
R.R.Rogers, 1989	30-300	0.3-1.0	300-3,000	0.2-2.0
John M.Wallace and Peter V.Hobbs	100	N/A	1,000	N/A
G.Feingold et al,1997	100	0.5	1,000	1.0
Snider, J. R. et al. 2000	130-1300	0.4-1.1	N/A	N/A

Results



Logarithm averaged CCN concentration at (a) 900-1200 meter (b) 1200-1800 meter (c) 1800-2800 meter (d) 2800-3900 meter (e) Averaged all level within boundary layer

Results

Date	Province	C [cm^{-3}]	k
20-Mar-2012	Lampang	7,411	4.4
25-Mar-2012	Tak	6,217	3.8
27-Mar-2012	Tak	8,500	4.4
11-Apr-2012	Tak	1,298	2.2
16-Apr-2012	Phayao	1,318	2.2
20-Apr-2012	Lampang	1,651	2.1
23-Apr-2012	Phayao	3,445	1.0
23-Apr-2012	Lampang	2,548	1.0
04-May-2012	Pichit	2,580	0.7
09-May-2012	Maehongson	1,654	0.4
11-May-2012	Utaradit	1,567	0.7

Daily flight averaged C and k values within boundary layer over northern Thailand in summer season (March - May 2012) obtained from cycled supersaturation (0.2%, 0.5%, and 0.8%).

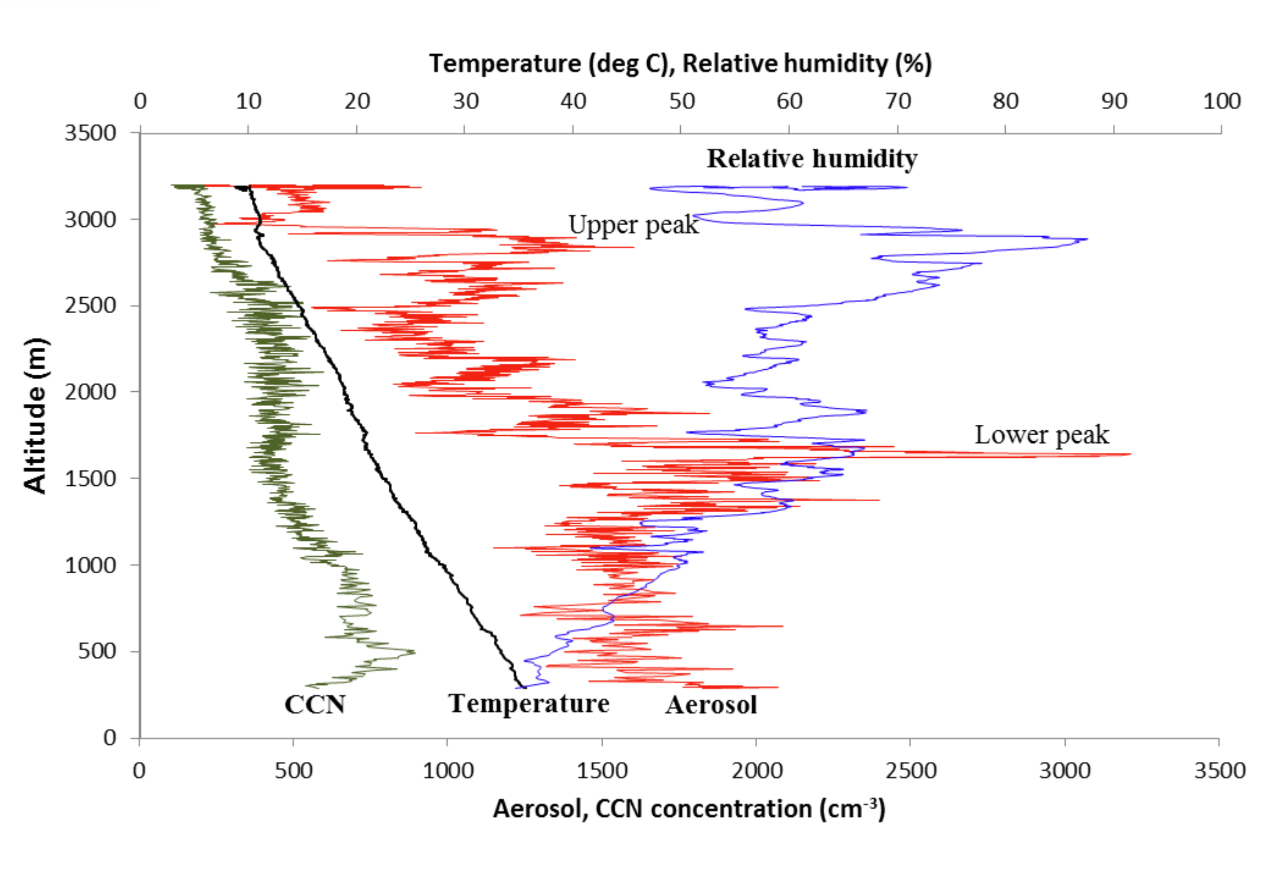
Results

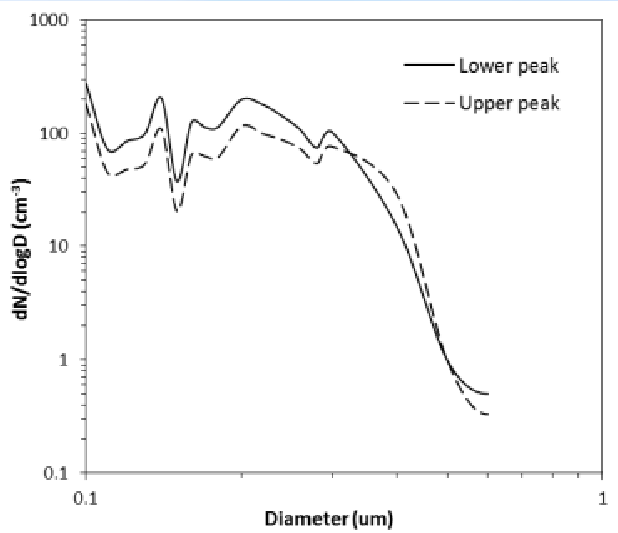
Cloud droplet spectra near cloud base observed in 2013

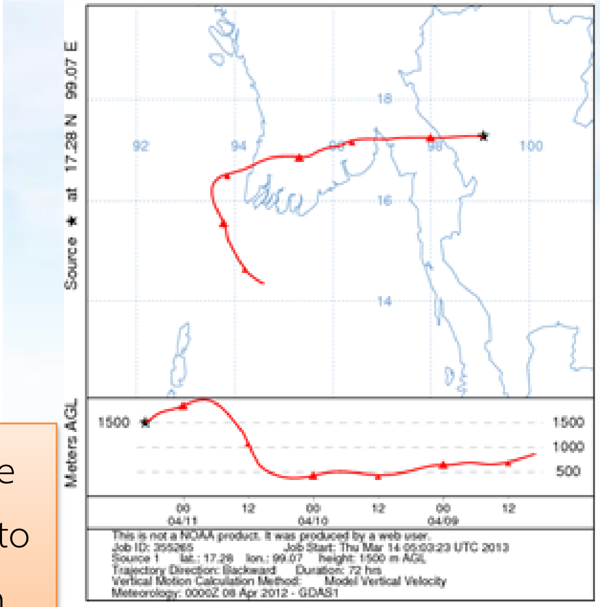
Date	Cloud ID	Max updraft (m/s)	Median diameter (um) Dp	Total CDN	CDN Conc at 7 um	CDN Conc at 9 um	CDN Con 11 um
2/4/2013	C1	2.9	7-25.5	278,097	78,394	75,252	62,602
	C2	0.3	7-28.5	573,719	121,659	115,761	108,370
4/4/2013	C1	-0.13	7-11	530,369	442,698	80,487	7,184
	C2	2.71	7-11	699,453	618,381	77,467	3,605
6/4/2013	C1	1.25	7-11	413,111	333,888	66,585	12,639
	C2	1.52	7-13	1,705,886	1,209,220	439,716	47,618
8/4/2013	C1	0.68	7-11	1,577,731	1,265,540	276,397	35,795
20/4/2013	C1	2.29	5.25-11	1,815,397	1,540,880	149,978	2,336
	C2	0.7	5.25-13	543,108	413,476	70,307	6,275
26/4/2013	C1	0.7	7-11	1,607,751	1,416,190	166,166	25,395
	C2	1.21	7-13	1,286,992	997,009	232,516	49,865
5/5/2013	C1	2.18	5.25-13	343,667	206,297	77,069	14,946
	C2	2.49	5.25-11	246,092	156,401	49,417	4,953
7/5/2013	C1	1.57	7-13	276,185	194,661	76,011	5,278
	C2	1.36	7-13	1,786,184	1,440,760	291,389	50,075
12/5/2013	C1	0.31	7-9	486,213	383,311	102,902	-
	C2	0.25	7-11	1,427,960	1,329,540	95,816	2,604

Results

Case study 11 April 2012







a) Vertical profile of aerosol, CCN concentrations (supersaturation 0.5%), temperature, and relative humidity in Tak province on April 11, 2012; b) Normalize aerosol size distributions corresponding to the distinct aerosol layers; c) Three-day back trajectory using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model showing the origin of air over Tak province

Conclusions

1. The data presented in this study give evidence that man-made sources aerosol such as biomass burning may have impacts on the evolution of precipitation processes from one region to the other and also on precipitation enhancement study. Evidence for this comes from observation of narrower cloud droplet spectra near cloud base forming in the environment of high CCN concentrations. The responses to seeding with hygroscopic material may differ depending on the natural background of aerosol and CCN concentrations. The results are consistent with previous study (Hudson et al., 1991; Kaufman and Nakajima, 1993). The impact of man-made sources of aerosol on clouds and precipitation should be study more.

Conclusions

2. Based on previous studies, related to hygroscopic seeding to enhance precipitation (Cooper et al., 1997; Reisin et al., 1996), one can speculate that the anthropogenic sources of aerosols and CCN could reduce the precipitation efficiency when aerosol particles are small and may negative impact the total precipitation especially from small to medium size cloud. However, when the aerosol are large and giant CCN are activated it could possibly enhance the precipitation efficiency. Further studies to evaluate these finding are essential.

3. The vertical distribution of aerosol and CCN concentration confirmed that temperature inversion highly influenced the vertically disperse of particles in the air.

Thank you

Cloud Physics Instruments

Index	Instrument Name	Description
1	Iso Inlet	Isokinetic Inlet - controlled by M300 and TAS
2	UHSAS	Aerosol measurement: Aerosol size distribution, 60-1000 nm
3	PCASP	Aerosol measurement: Aerosol size distribution, 100-3000 nm
4	FFSSP	Cloud measurement: Particle size distribution, 2-50 μm
5	2D-S	Cloud measurement: Particle size distribution, 10-1280 μm
6	HVPS	Cloud measurement: Particle size distribution, 150-19,200 μm
7	CPI	Cloud measurement: Particle size distribution, 10-2,400 μm
8	CCN	Aerosol measurement: CCN concentrations spectra at different supersaturations
9	AIMMS	Temperature, RH, winds, and Position data - Serial input to M300
10	Dewpoint	Dewpoint - analog input to M300
11	Total Temp	Total Temperature - analog input to M300
12	Icing	Icing Serial inputs to M300
13	Nevzorov	TWC and LWC - analog inputs to M300
14	ARINC	True Airspeed - input to M300
15	Video Cam	Video recording to Laptop