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APPENDIX I

THE OBSERVATORY FOR ATMOSPHERIC RADIATION RESEARCH AT SRI SAMRONG, SUKHOTHAI

THE OBSERVATORY FOR ATMOSPHERIC RADIATION RESEARCH SYSTEM

1 Introduction

The distribution of radioactive energy mechanism is complicated in the Asian monsoon region with the monsoon circulation caused by the ocean-land contrast at the continental scale. There are numerical simulations, for example, indicating that upper and lower level clouds play important but different roles in the energy flow on a

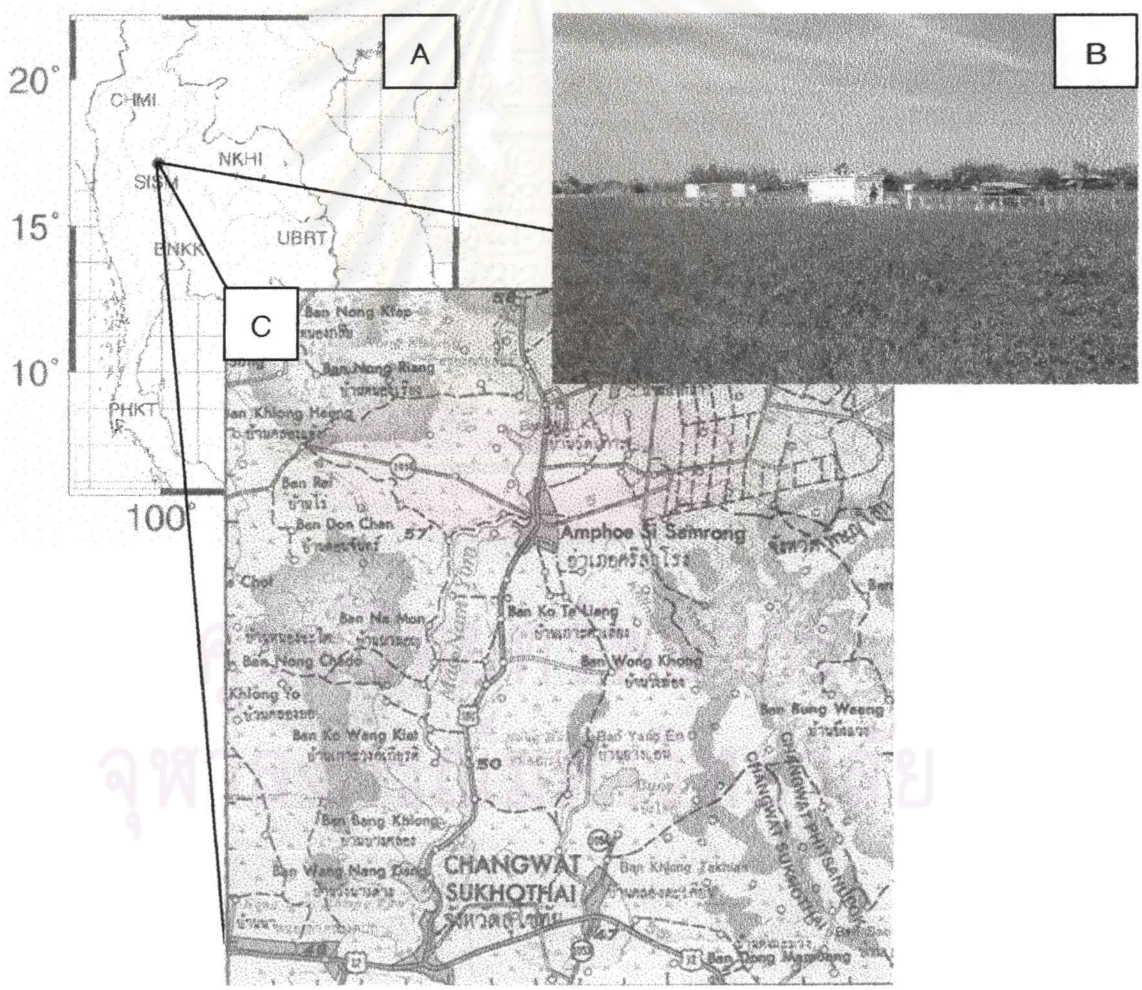


Figure 1 Amphoe Sri Samrong Location map (A) and The Observatory for Atmospheric Radiation Research (B) and topographic map (C)

continental scale. The effect of global warming due to greenhouse gas increase is especially large and sensitive budget structure over land areas. Therefore, to

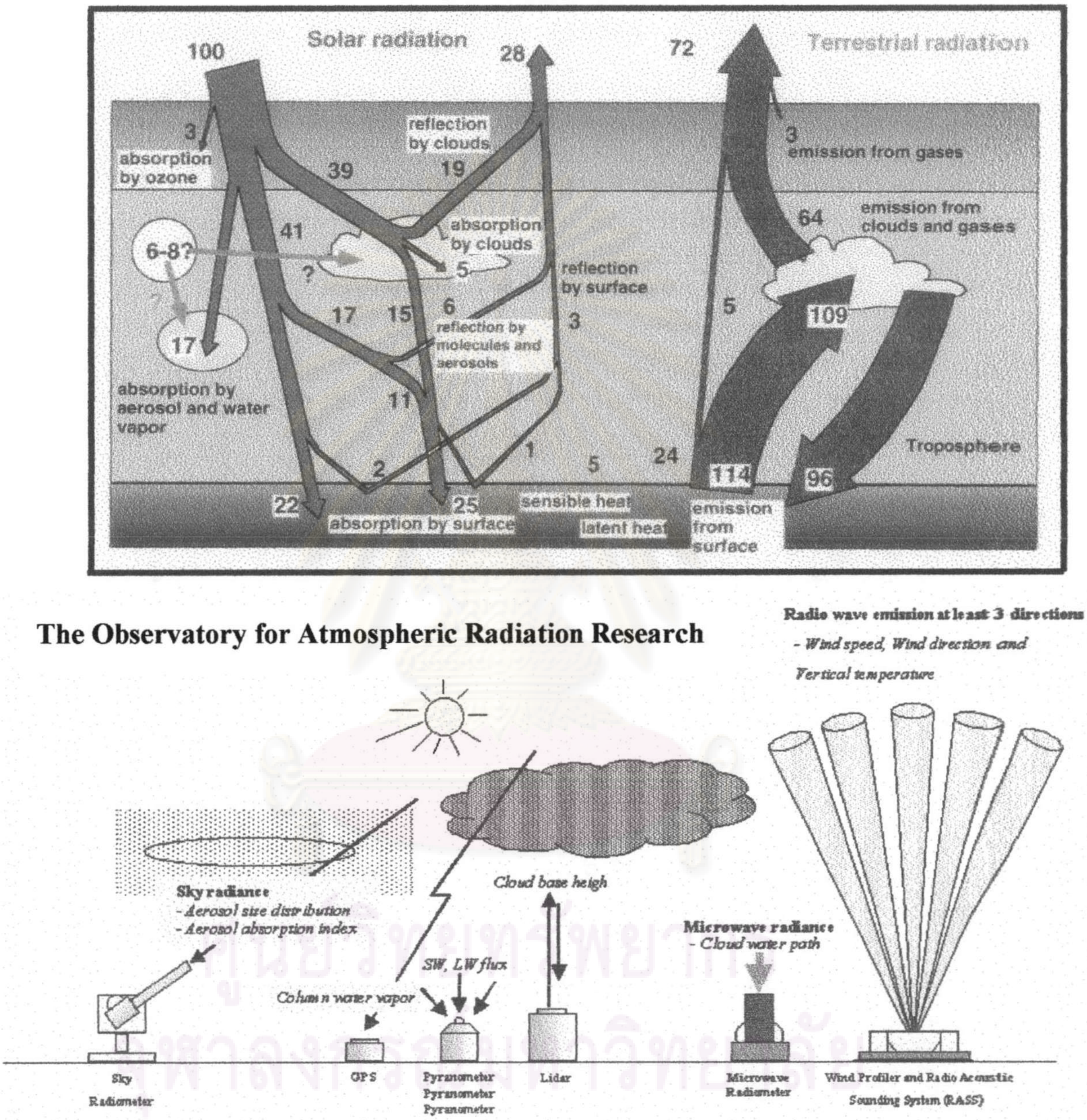


Figure 2.2 The relationship between atmospheric radiation budget (top) and the equipment's that installed at the Observatory for Atmospheric Radiation Research (down). The Observatory instruments compose of the radiative flux and related factor such as aerosol and cloud.

understand the climate formation of this region, it is important to study the effect of clouds, water vapor and surface conditions on the radiative budget of this region (Nakajima, et al., 1998). The high accuracy and temporal continuous instruments are need for radiative fluxes measurement and related ancillary quantities for this study. So, the Observatory for Atmospheric

Radiation Research was constructed in the corporation between Thai and Japanese scientists under GAME-T project. The Observatory was located at Sri Samrong, Sukhothai, Thailand about 700 km., north of Bangkok (See Fig.1)

2 Instrument Systems

Nakajima, et al., 1998 mention the major science objectives of the Radiation Activity as follow:

1. To understand the surface radiation budget distribution over Asian monsoon region.
2. To understand the role of cloud, aerosols, water vapor, and surface conditions in determining the budget regime of the earth-atmosphere system in the region.
3. To establish satellite remote sensing techniques for estimating surfaces radiation budget and optical properties of atmosphere and surface.

The Observatory contained some of equipments that can divide into 4 groups as below;

2.2.1. Water vapor observation group composed of Global Positioning System and Microwave radiometer or Water vapor radiometer.

2.2.2. Atmospheric radiation and surface meteorological component group composed of Upward and down looking pyranometers, down looking pyrgeometers, pyrheliometer, and automatic thermometer, barometer and anemometer.

2.2.3. Aerosol observation group, there are sky radiometer and lidar.

2.2.4. Wind Profiler

All of the instruments control by PC and working automatically. After the observation, data stored in the PC, download to computer server and transferred to the server at Chulalongkorn University and Center of Climate System Research (CCSR), university of Tokyo, respectively. The detail of instruments and data transfer express as below.

2.1. Water vapor observation group

Global Positioning System (GPS)

Introduction

GPS was originally designed as a navigational and in the field of geodetic positioning by detect signal from GPS satellite. The source of GPS signal propagation delay in the atmosphere composes of water vapor in troposphere and the other one is free electron in ionosphere. The propagation delay by free electron in the Ionosphere can remove by using 2 sufficient signal frequencies (L1 and L2) transmitted by the satellite. For propagation delay by water vapor, it becomes a signal in the field of meteorology.

Global Positioning System Network in Thailand

Remote sensing of atmospheric water vapor using the Global Positioning System in Thailand started in 1998 under GAME-T project up to 2001 by Prof. Teruyuki Kato from Earthquake Research Institute of University of Tokyo. GPS receivers have installed at TMD station at Bangkok (BNKK), Chaing Mai (CHMI), Ubon Ratchatani (UBRT), Sri Samrong (SISM) and Phuket (PHKT). On May 1998, the site at Phuket moved to

Nongkhai (NNKI) for a better distribution in East-West direction (Figure 3). GPS receivers utilize under GAME-T project were four Trimble 4000SSI and one Trimble 4000SSE (Figure 4 and Table 1). All of the session working all 24 hr, sampling data every 30 second, and 5 degree minimum elevation angle. Each session file automatically downloads from the receiver to PC 1 time in a day.

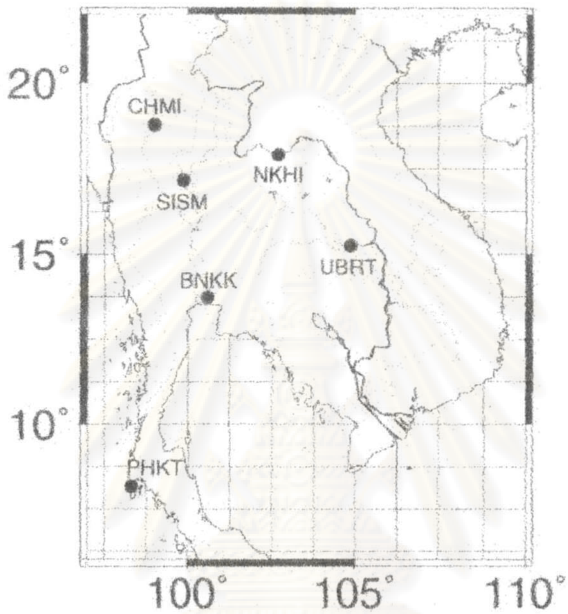


Figure 3 GPS sites observation in Thailand: Nakaegawa (1998)

Site	Code	Latitude (N)	Longitude (E)	Receiver
Chaing Mai	CHNI	18°40'0.5.96	098°58'21.54	Trimble 4000SSE
Nong Khai	NNKI	17°51'54.44	102°44'50.46	Trimble 4000SSi
Sri Samrong	SISM	17°09'40.43	099°51'42.26	Trimble 4000SSE
Ubon Ratchatani	UBRT	15°04'43.81	104°52'16.40	Trimble 4000SSi
Bangkok	BNKK	13°40'05.96	100°36'23.72	Trimble 4000SSi
Phuket	PHKT	08°06'18.12	098°18'28.57	Trimble 4000Ssi

Table 1 Detail of GPS receivers in Thailand from Nakaegawa et al., 1998

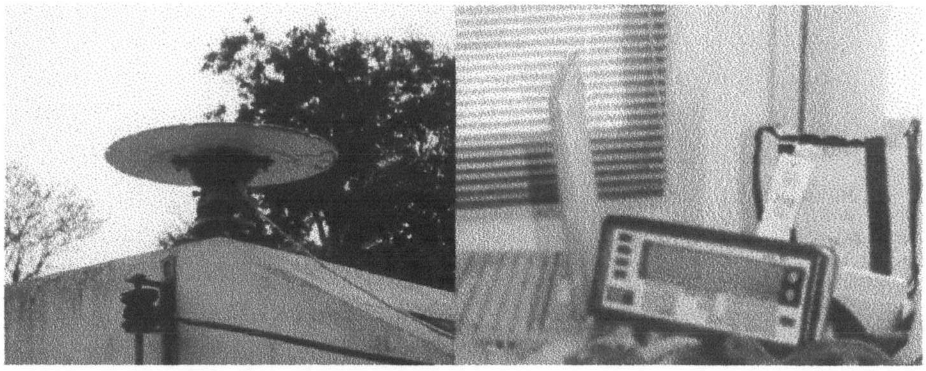


Figure 4 Dual frequency GPS receiver, Trimble 4000SSI (right) and antenna (left)

After finished project in 2000, all of the receivers, except that installed at Sri Samrong, brought back to Japan. In 2000, Frontier Observational Research System for Global Change (FORSGC) has established GPS site observation at Chaing Mai, Bangkok and Phuket almost the same with GAME-T project site by Dr. Wu Peiming (Figure 5). GPS receiver recorded the signal every 30 second and analyzes signal propagation delay every 5 minute.

Figure 5 GPS antenna, Dorne-Margolin antenna-plus-choke ring assemblies with a redome (left) and Ashtech version Z-Xtreme, GPS receiver set (right), that utilized under FORSGC project.

Microwave Radiometer

Microwave radiometer or water vapor radiometer is a device for water vapor and cloud liquid water observation by detecting microwaves in the atmosphere (Figure 6). This instrument detects electromagnetic waves at frequency 23.8 GHz for water vapor quantity observation and 31.4 GHz for cloud liquid observation. Water vapors emit electromagnetic waves at 22.235 GHz but Microwave Radiometer detects the signal at 23.8 GHz, called "hinge point", to reduce disturbance from atmospheric pressure. Cloud liquid water emits electro magnetic waves at frequency 31.4 GHz.

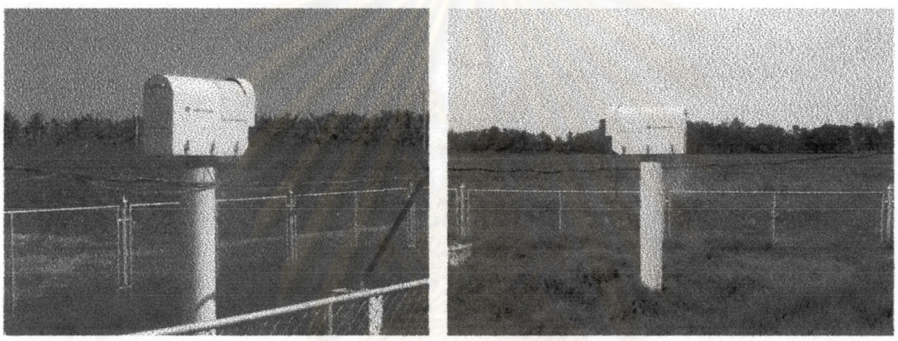


Figure 6 Microwave Radiometer or Water Vapor Radiometer

2.2. Atmospheric radiation and surface meteorological component group

SOLAC3 is a group of surface meteorological instruments that composed of 2 groups of instrument as below:

The radiometer

The radiative flux measure by radiometers there composed of *Pyranometer*, *Pyrgeometer* and *Pyrheliometer* to observed solar, terrestrial and, diffuse and direct radiation, respectively (Figure 7). Detail of radiometer express in Table 2.

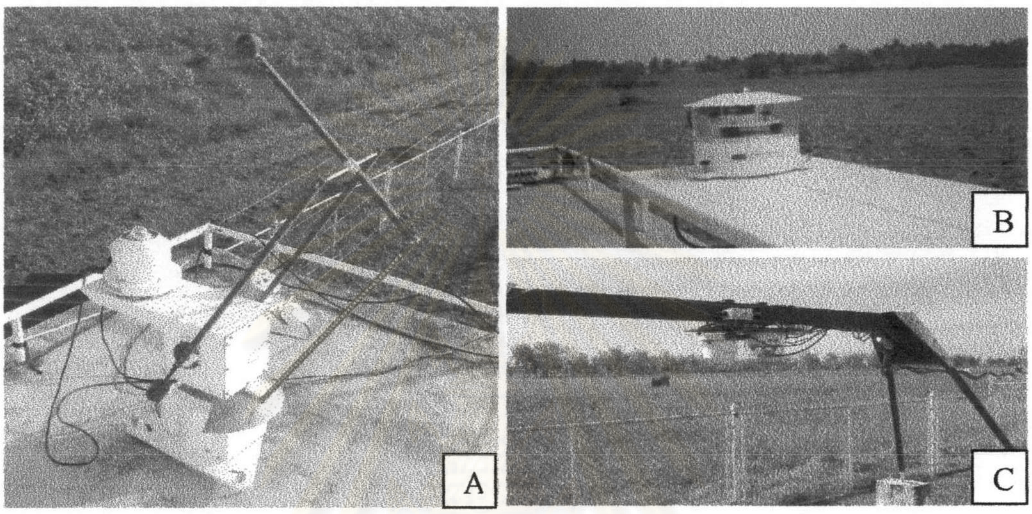


Figure 7 Radiative flux instrument system, (A) Pyrheliometer observed diffuse and direct radiations, (B) upward Pyranometer monitoring global solar radiation and (C) downward Pyranometer and Pyrgeometer detect reflects solar radiation and downward Pyrgeometer detect terrestrial radiation respectively.

Device	Application
Pyranometer	Global solar radiation over $0.3 \leq \lambda \leq 5.0$ μm.
Pyrheliometer	Direct beam solar radiation usually $0.3 \leq \lambda \leq 5.0$ μm.
Pyrgeometer	Longwave atmospheric radiation of $\lambda \geq 4.0$ μm.

Table 2 Detail of Radiometer instruments

Surface Meteorological Parameter measurement system

This system is composed of automatic thermometer, barometer and anemometer (Figure 8).

Figure 8 Top: Anemometer Middle left: Thermometer Middle right: Barometer

Data from all of instruments in SOLAC3 system contained in data logger and transfer to PC for SOLAC3 every 10 second. Each data in the PC is identified by the data code (Table 3).

code	kind of data	Unit
101	Pyranometer upward reflect data	Voltage
102	Pyrheliometer direct data	Voltage
103	Pyrgeometer downward thermopile data	Voltage
104	Pyrgeometer downward body thermistor data	Ohme
105	Pyrgeometer downward dome thermistor data	Ohme
106	Pyrgeometer upward thermopile data	Voltage
107	Pyrgeometer upward body thermistor data	Ohme
108	Pyrgeometer upward dome thermistor data	Ohme

109	Themperature data	Celsius Degree
110	Wind speed data	m/s
111	Wind direction data	Degree
112	Atmospheric pressure data	hPa
113	Humidity	%
114		

Table 3 SOLAC3 code

2.3. Aerosol observation group

Sky radiometer

Sky radiometer is used for measuring sky radiation in the solar aureole region at the wavelength of 315, 400, 500, 675, 870, 940 and 1020 nm. The measurements are carried out with the sky radiometer pointed along a conical surface with the same zenith angle of the sun (almucantar) from 0° to 160°. At the Observatory there are 2 kinds of Sky radiometers, *Sky radiometer* and i-Sky *radiometer* (Figure 2.8). i-Sky radiometer installs a filter to observed size of cloud and O_3.

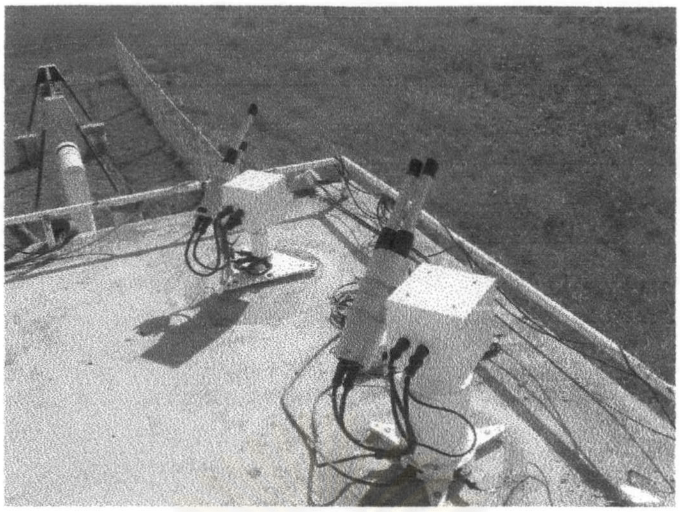


Figure 9 Sky radiometer (left) and I-Sky radiometer (right)

LIght Detection And Ragning (Lidar)

Detail of lidar expressed in CHAPTER 3 and lidar observation in the Observatory expressed in CHAPTER 3

2.4. Wind Profiler

Wind Profiler is equipment to observe air parcel movement by Doppler RAdio Detection And Ranging or Doppler RADAR technique (Figure 10). Wind Profiler emits pulse of radio wave to the atmosphere at least 3 direction to detect the air parcel movement, one normal to the earth surface and the other 4 directions about 15° from normal to the earth surface (Figure 10). While Wind Profiler emits radio waves, RASS emits sound to the atmosphere. Wind Profiler utilizes the time differences between radio waves and sound backscattered to the detector to evaluated vertical temperature.

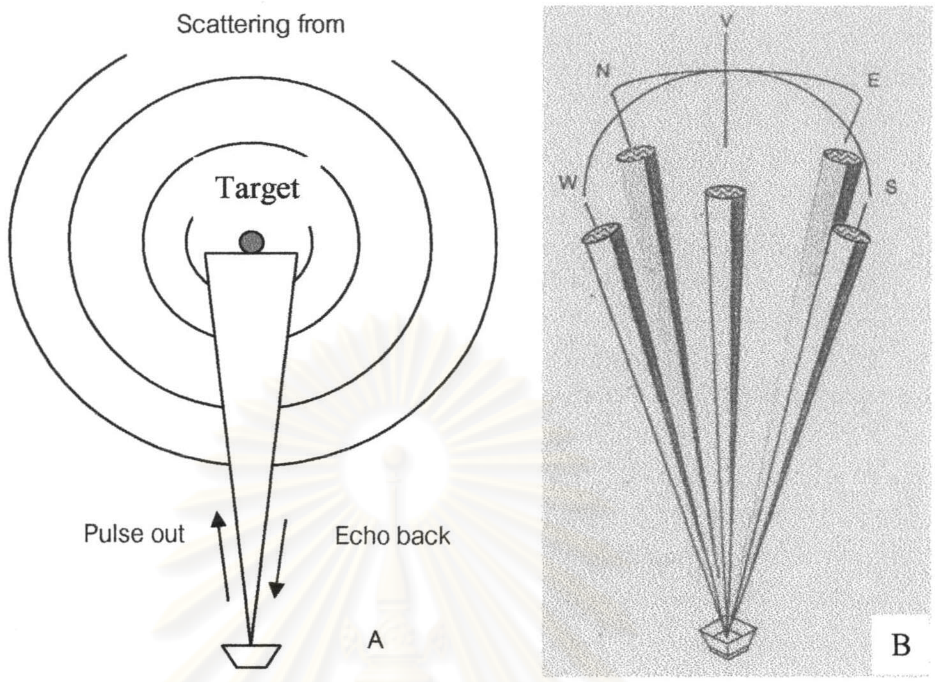
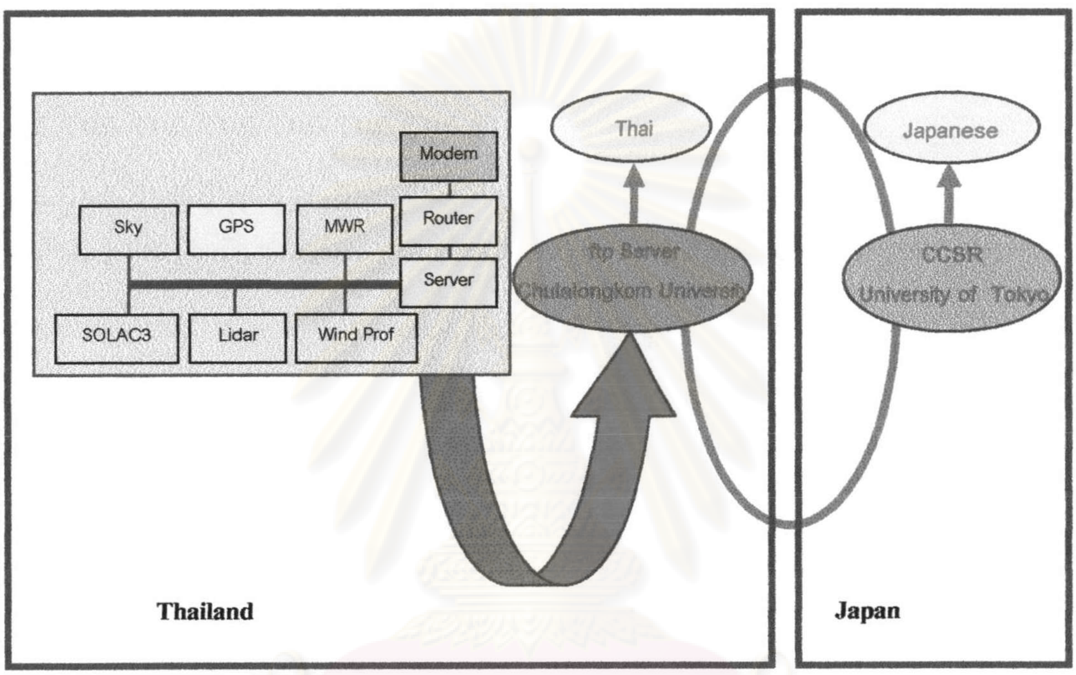


Figure 10 Principle of Wind Profiler, (A) RADAR technique and (B) Doppler RADAR technique

Figure 11 Wind Profiler and Sound Acoustic System (RASS)

3 Data transfer system at the Observatory

All of the PCs inside the observatory are linked with LAN system. Data stored in the PC are sent to server at Faculty of Science, Chulalongkorn University and Center for Climate System Research (CCSR) (Figure 12).



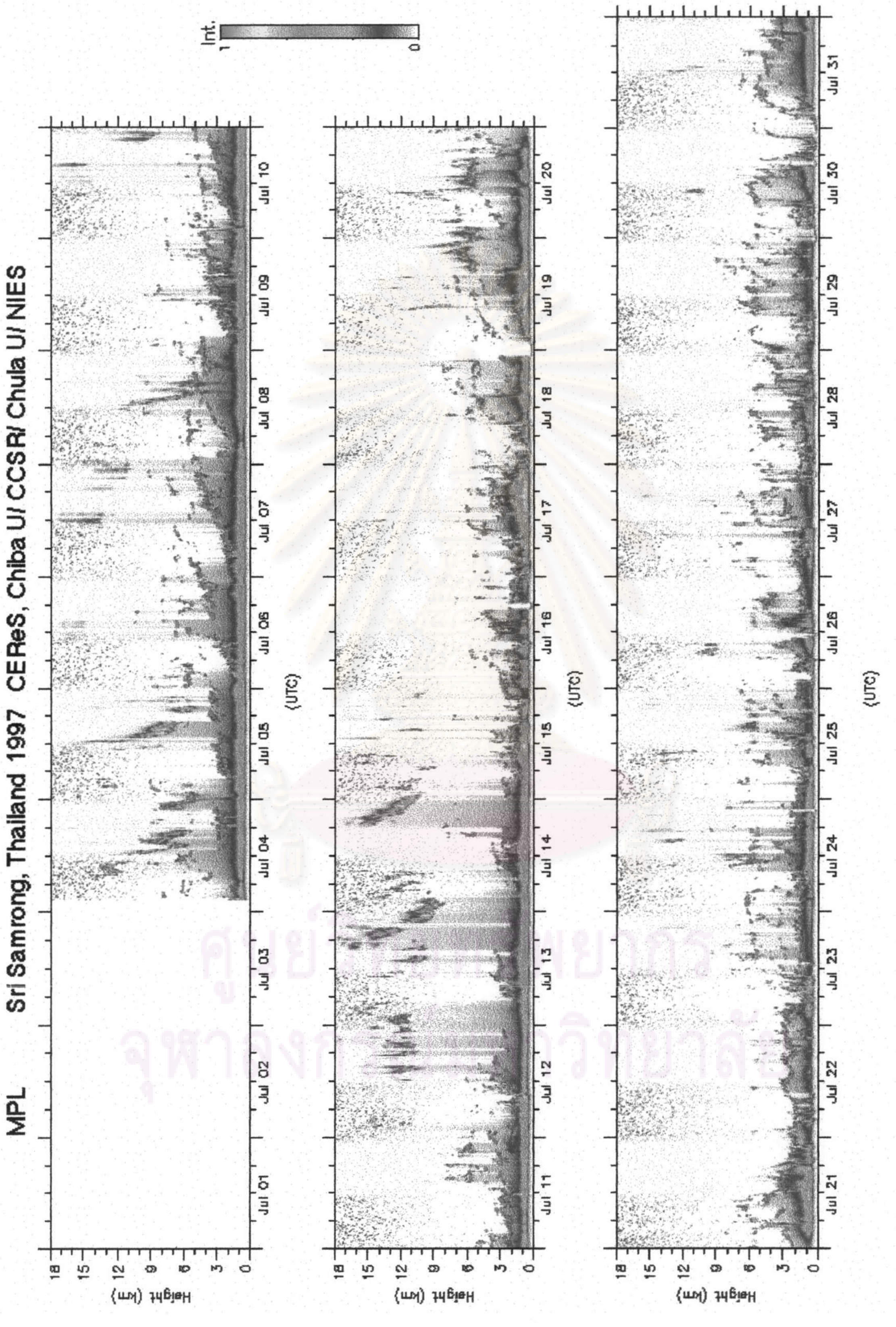
ftp.radiation.geo.sc.chula.ac.th

ftp.ccsr.cd0.skynet.thai

Figure 12 The Observatory's data transfer system

APPENDIX II

Monthly Lidar data during 1997-2002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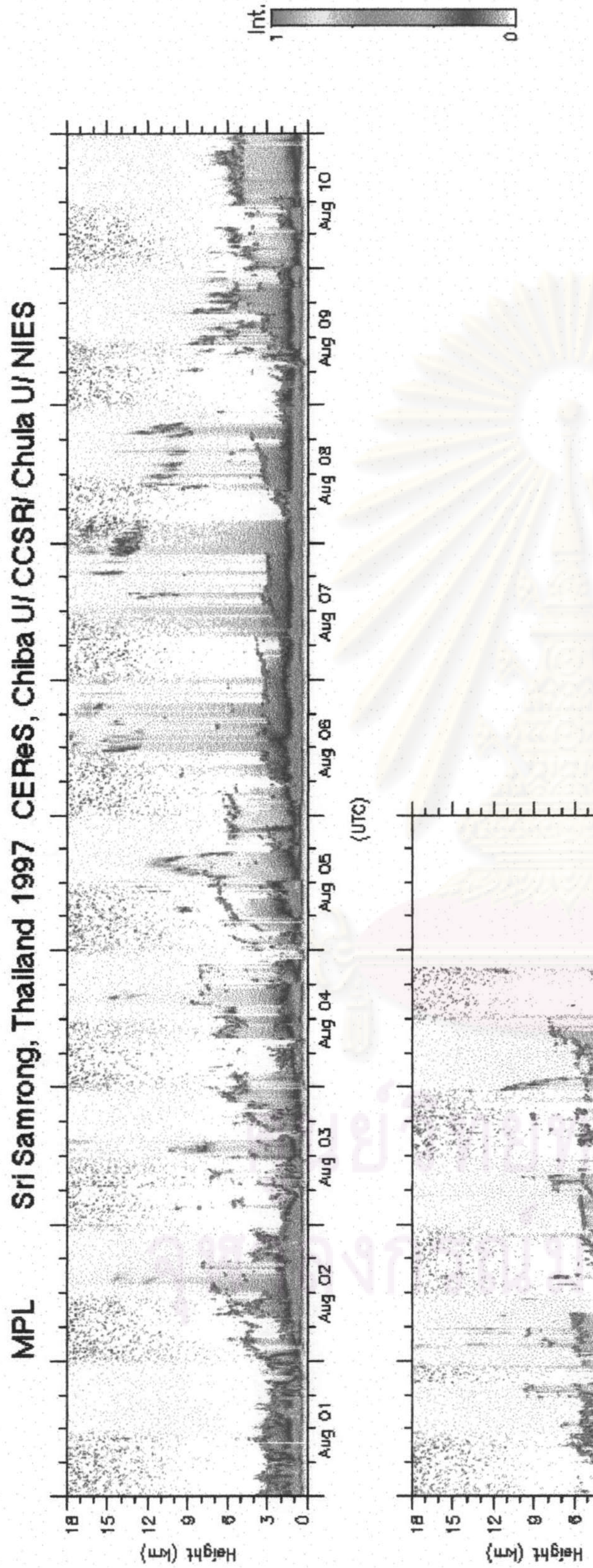
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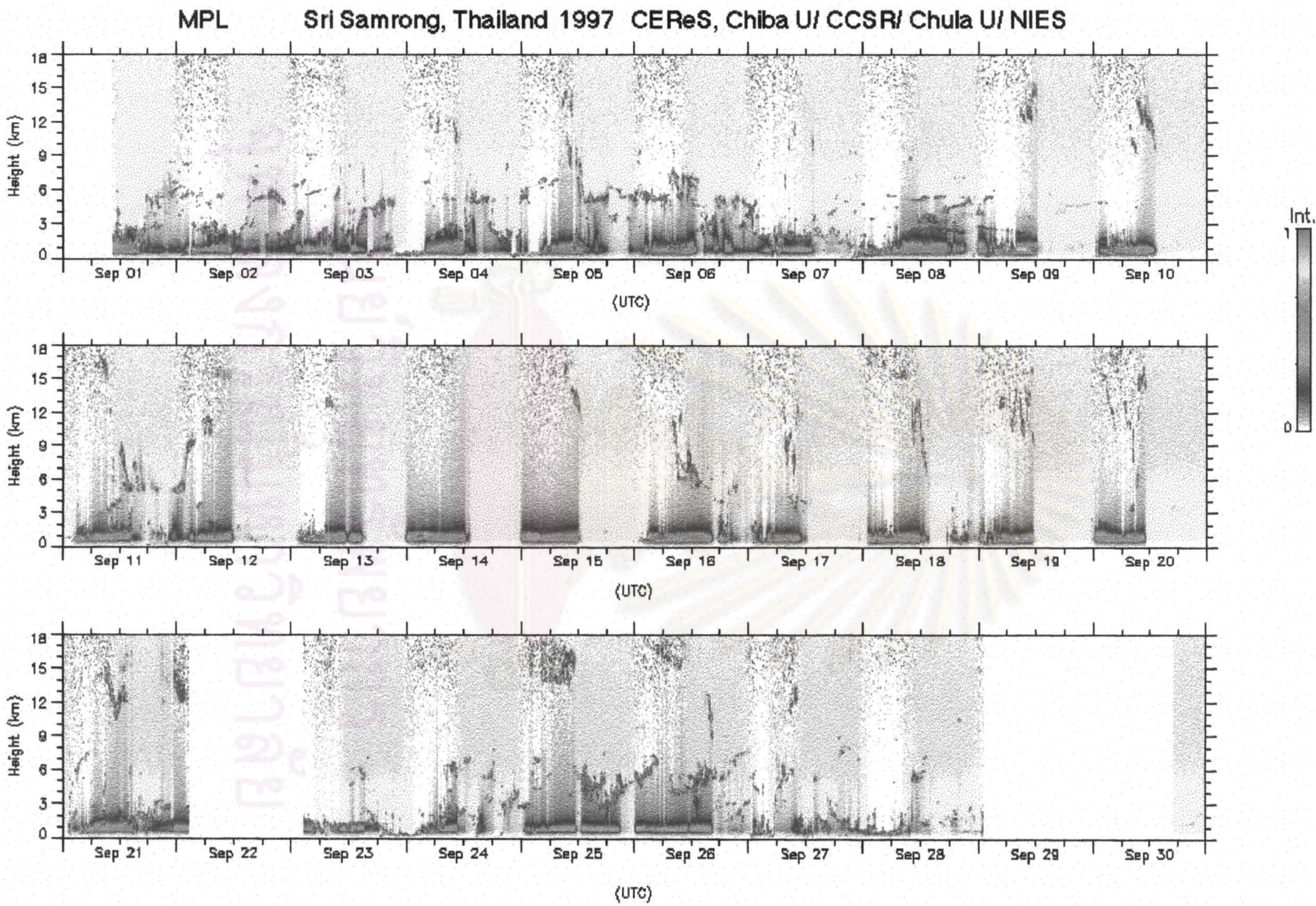
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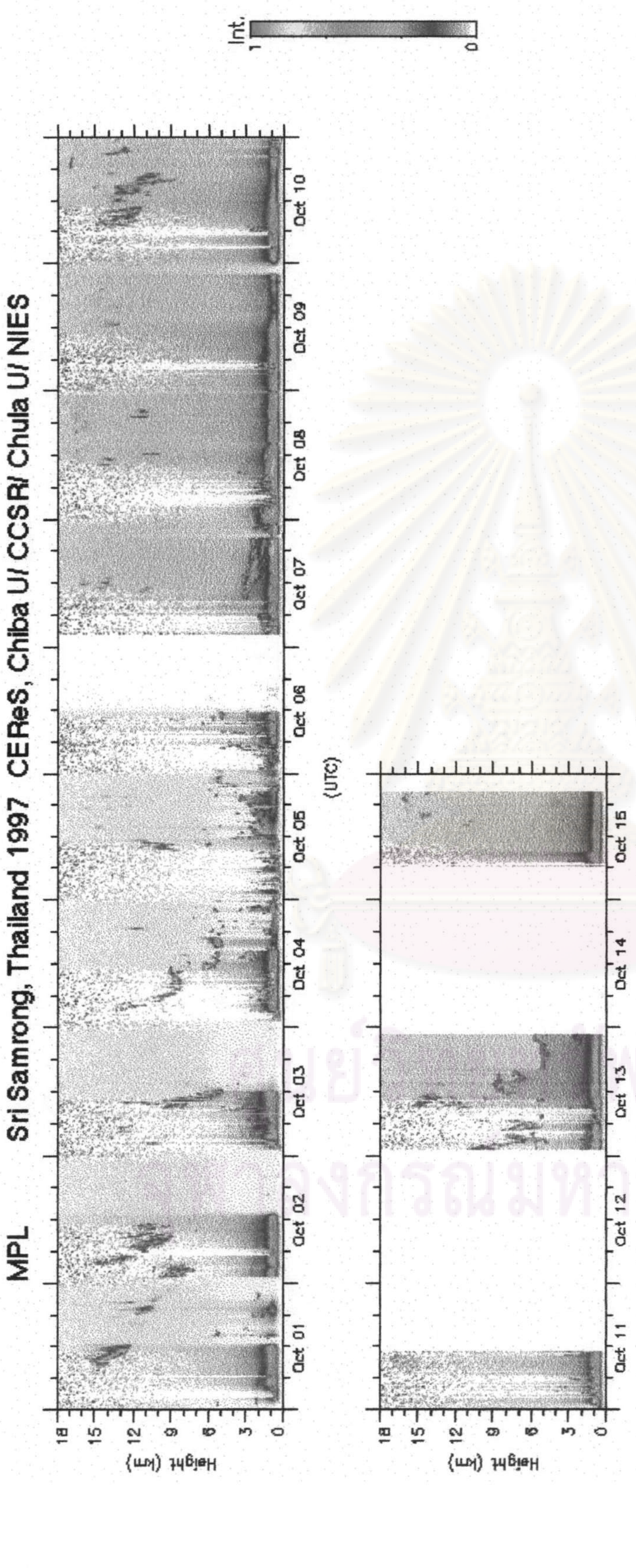
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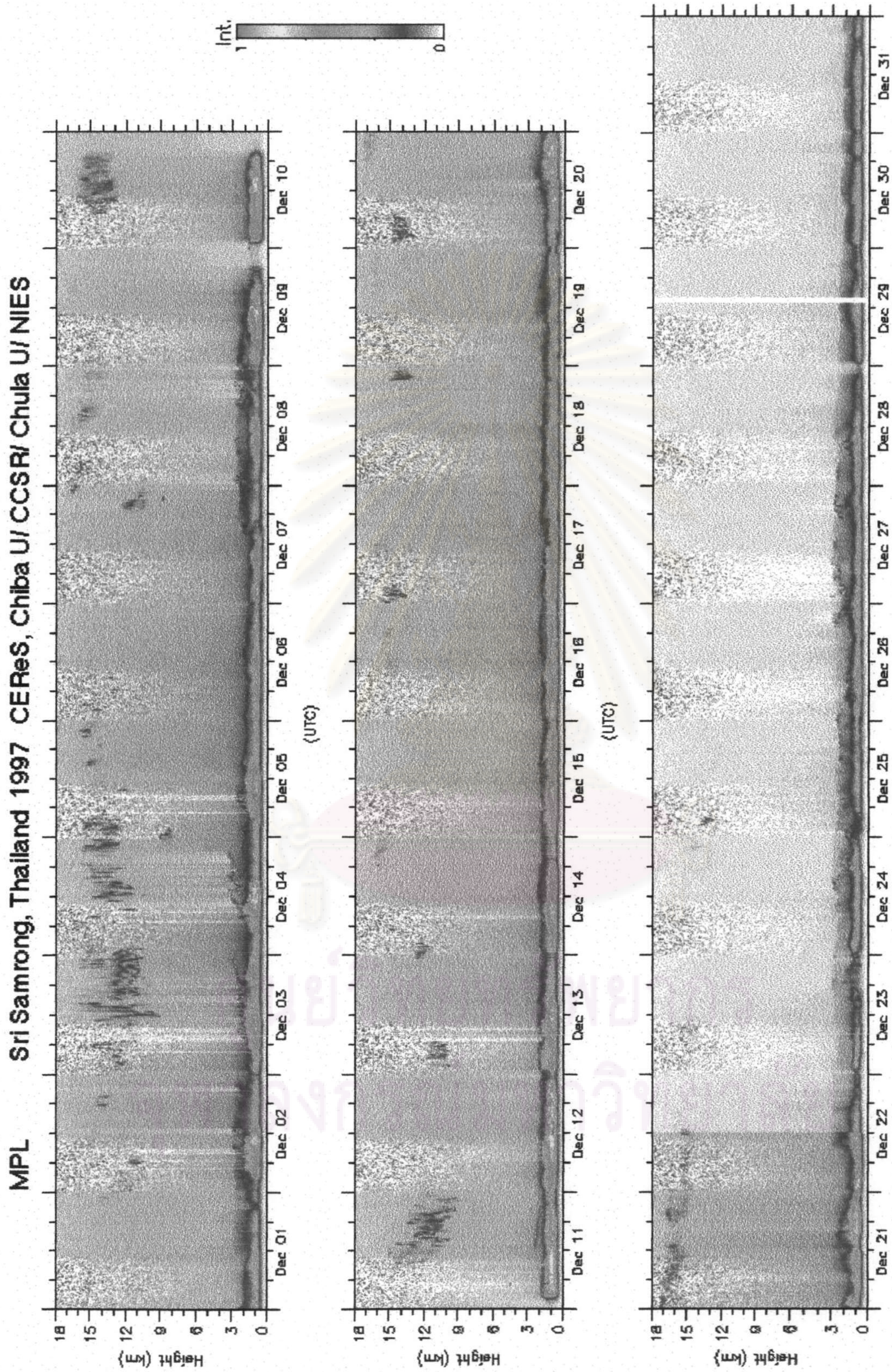
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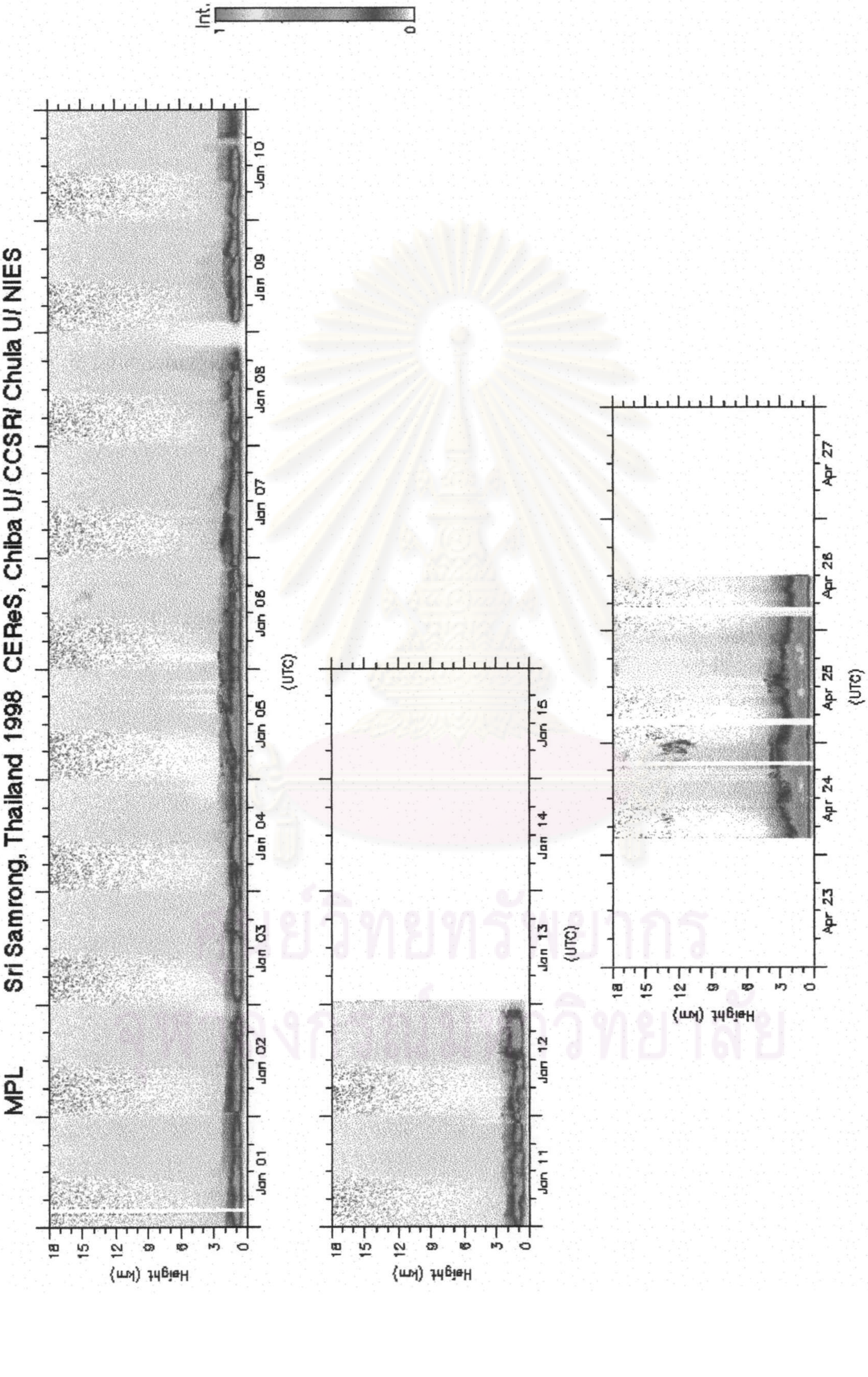
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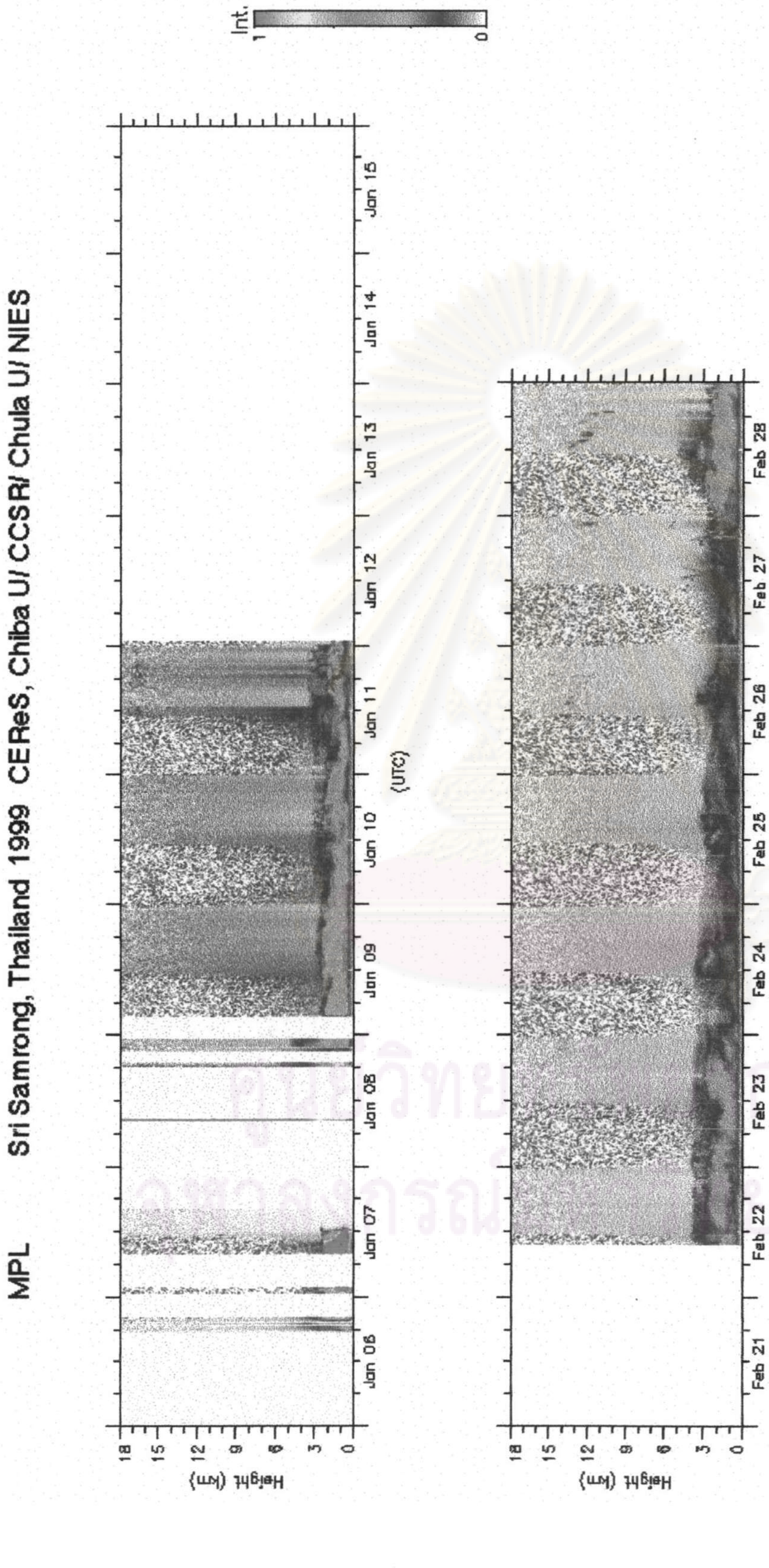
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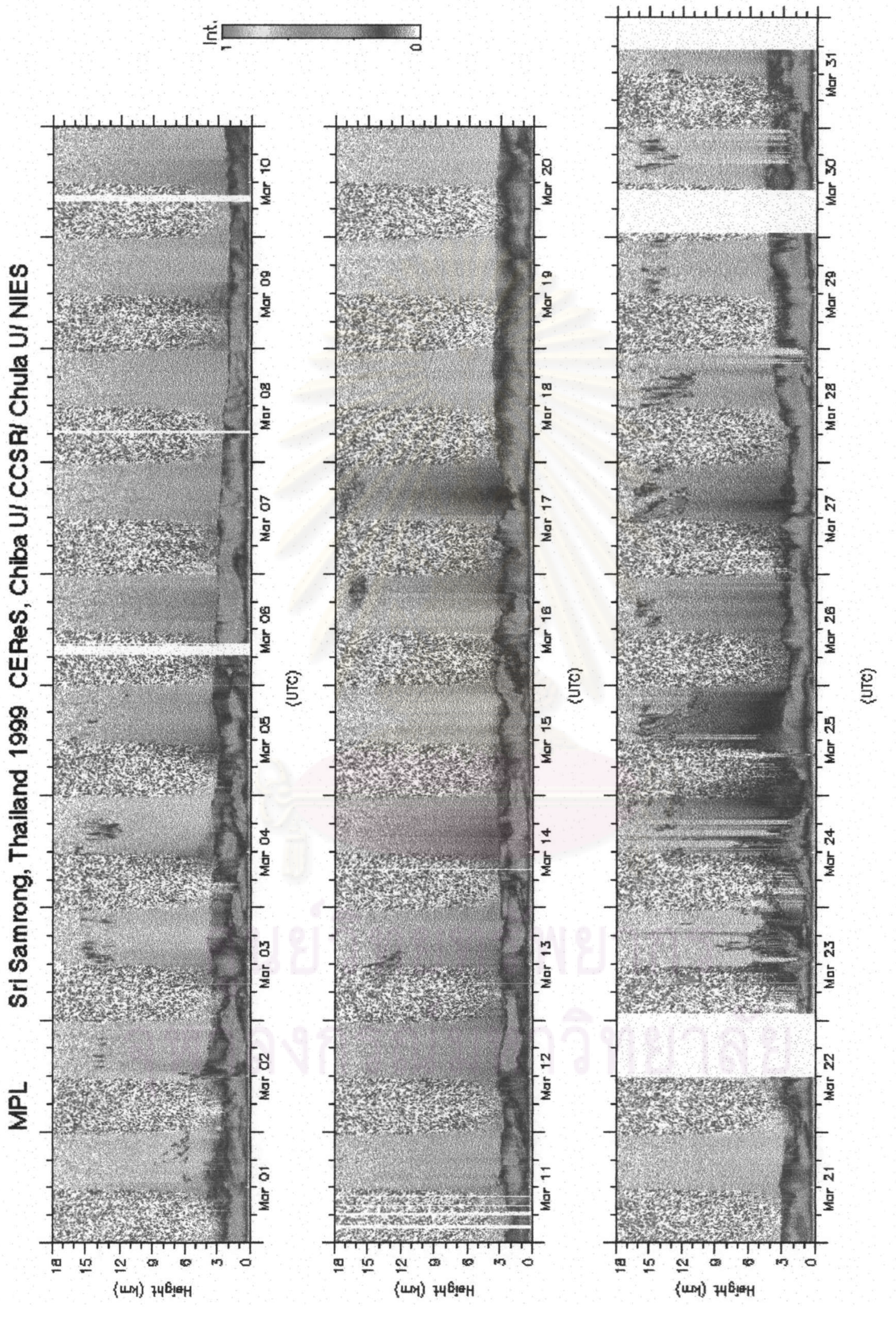
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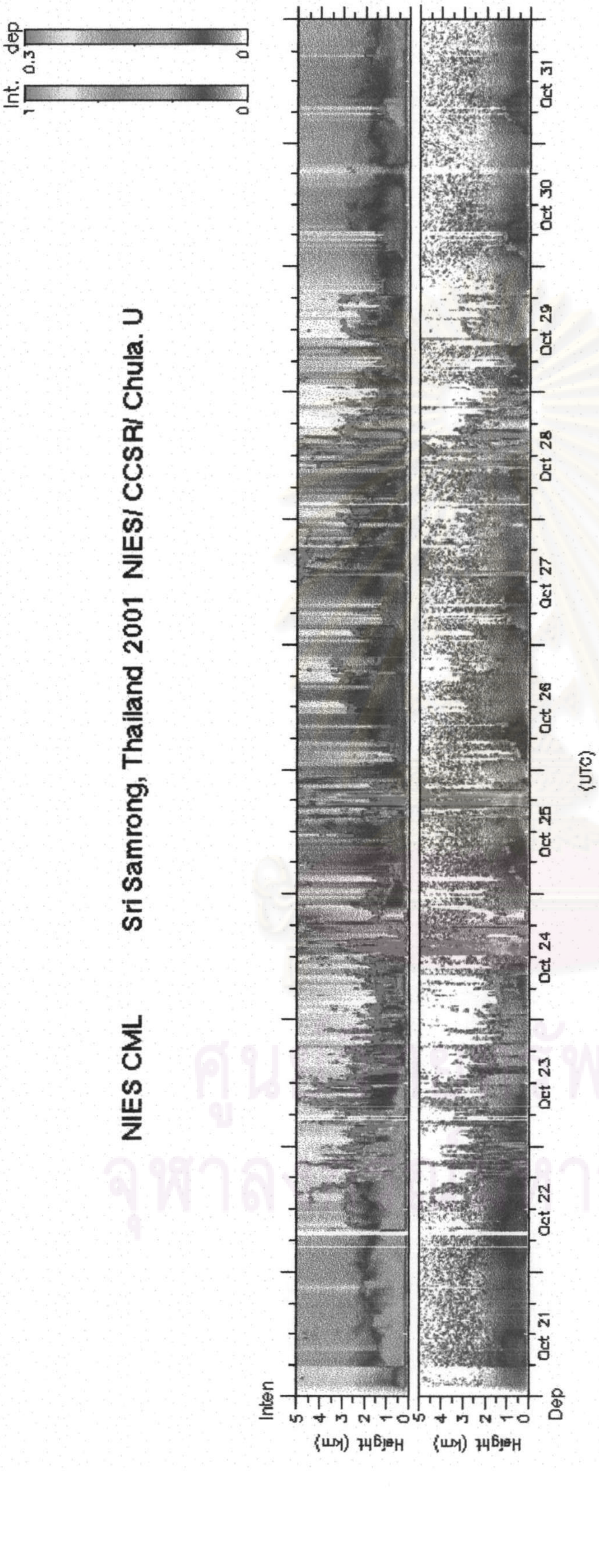
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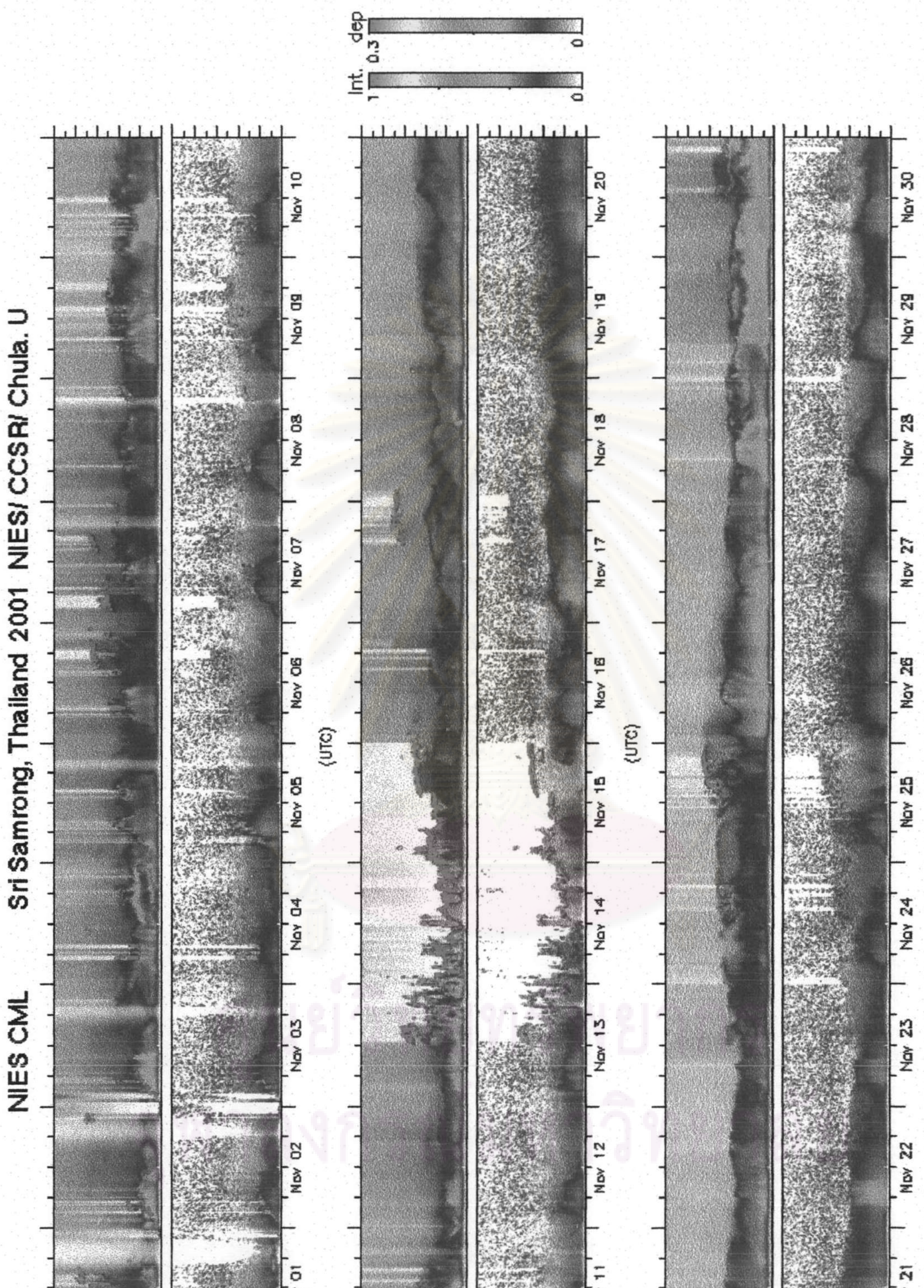
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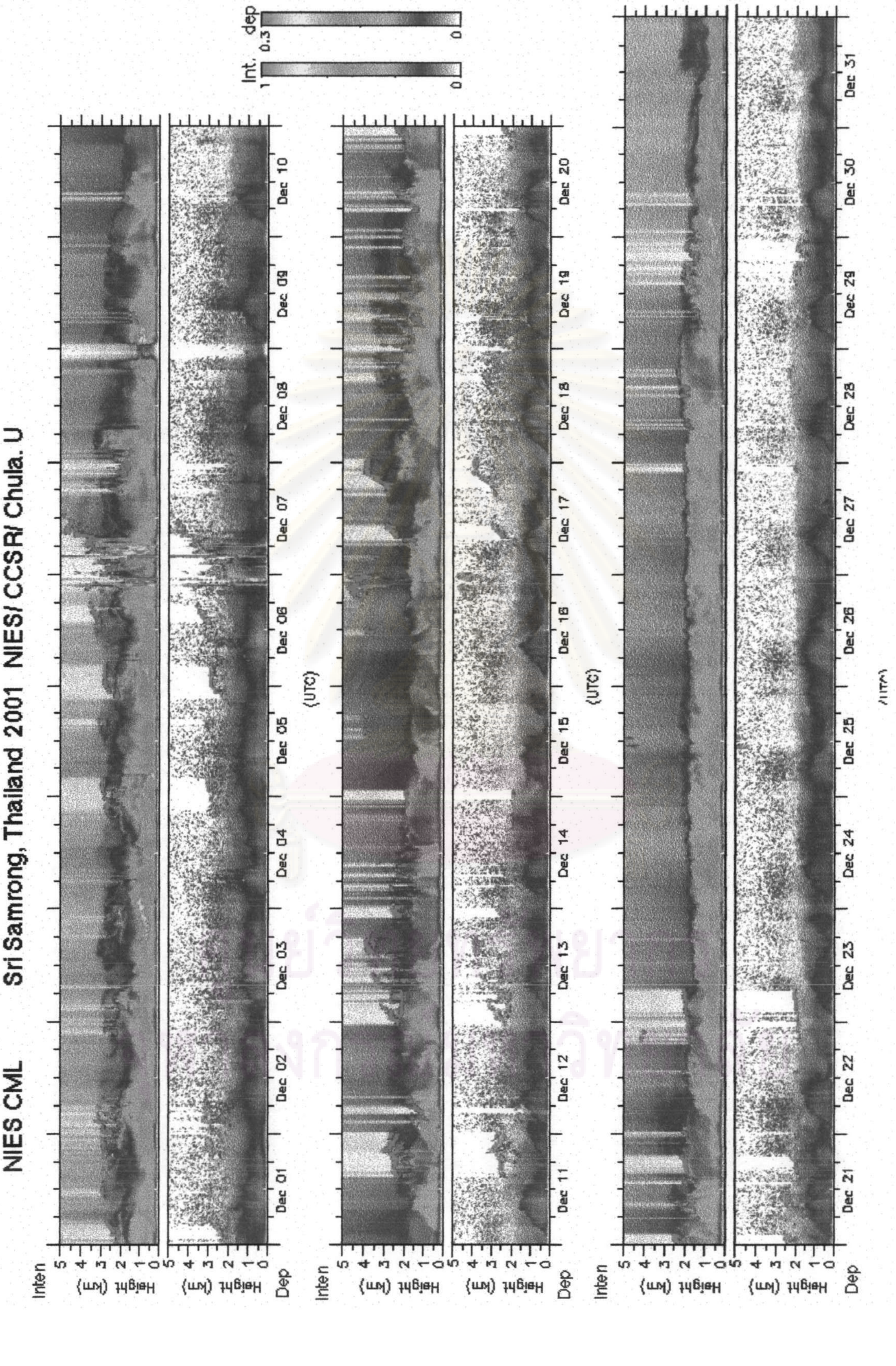

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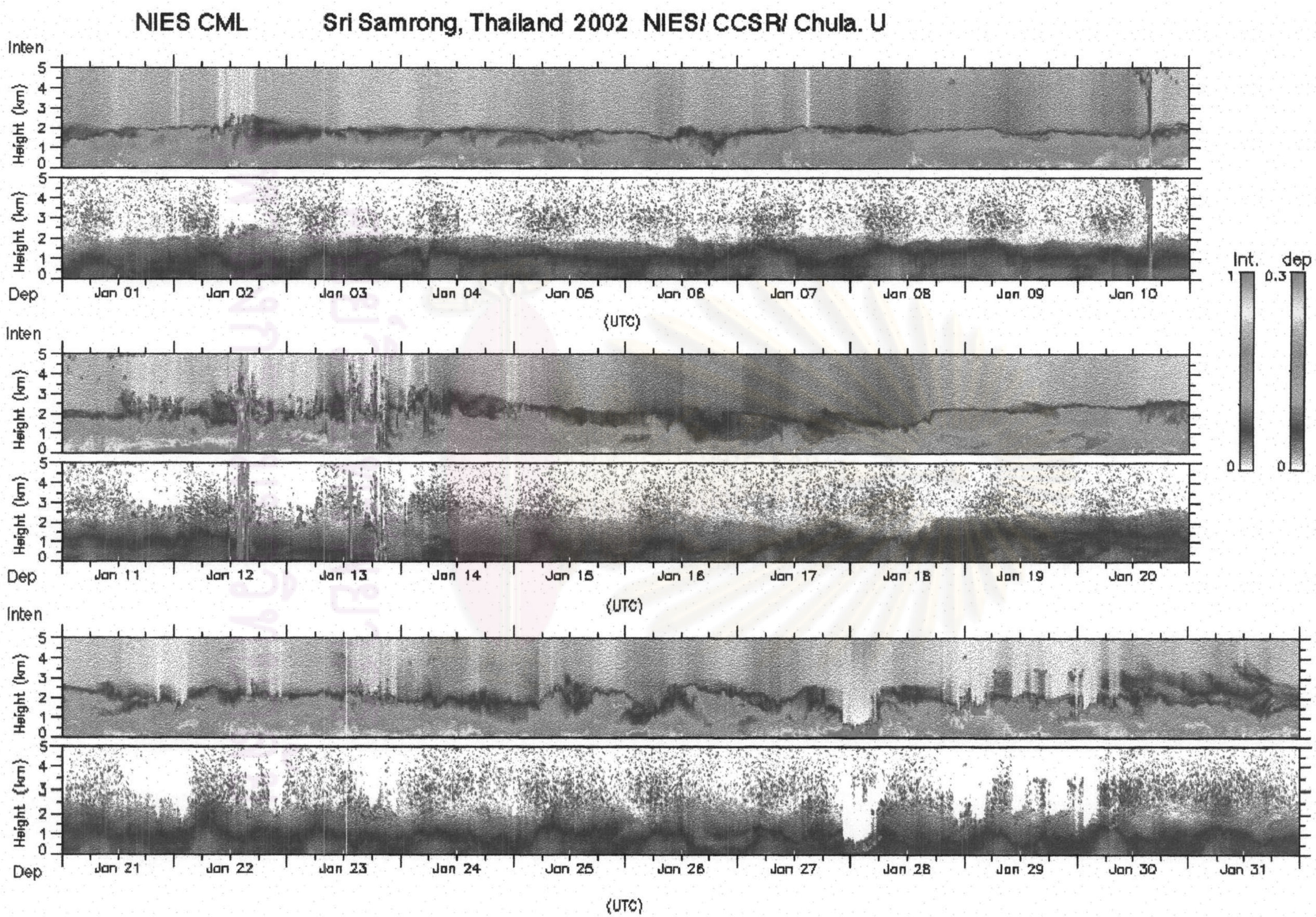
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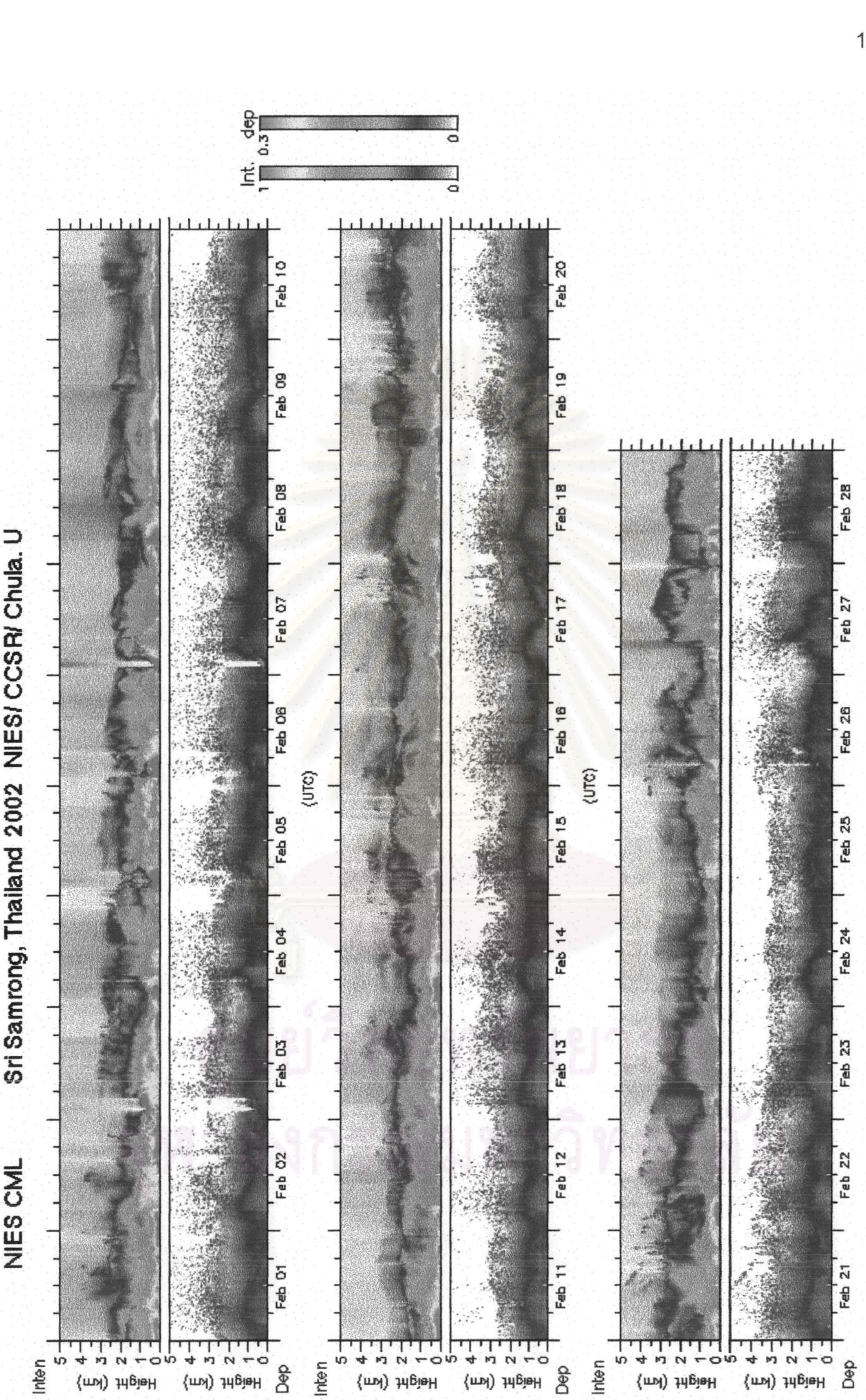
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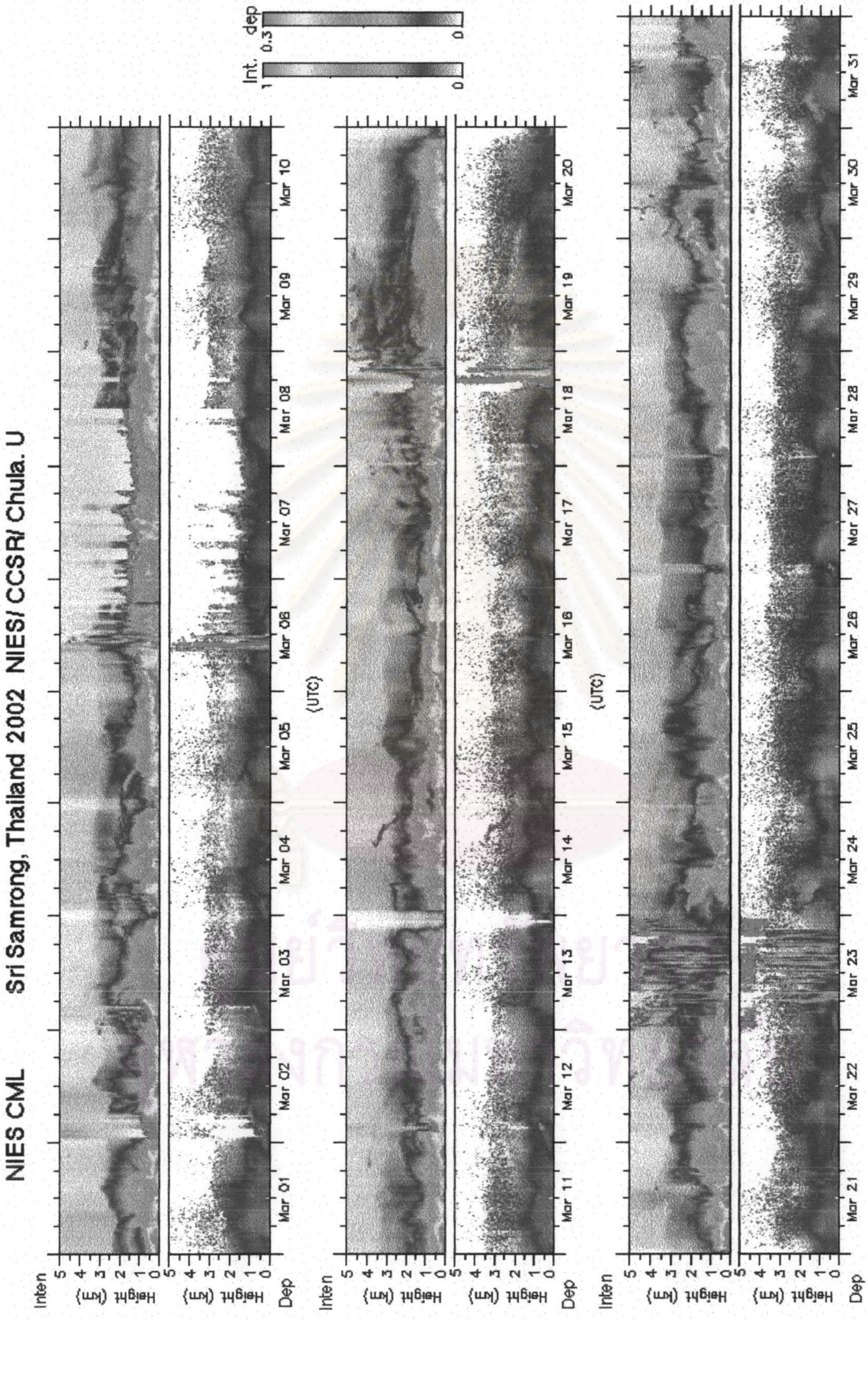
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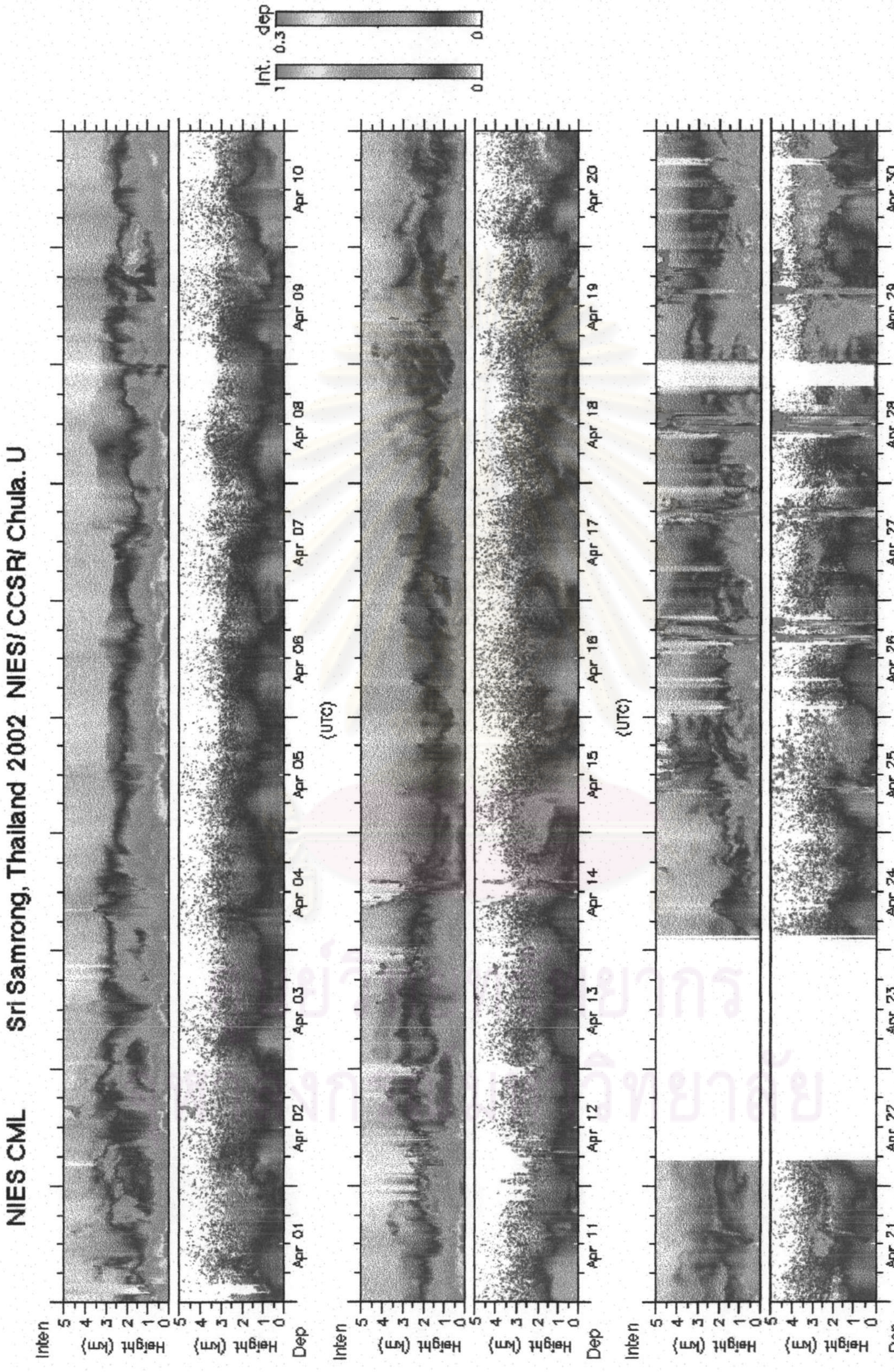
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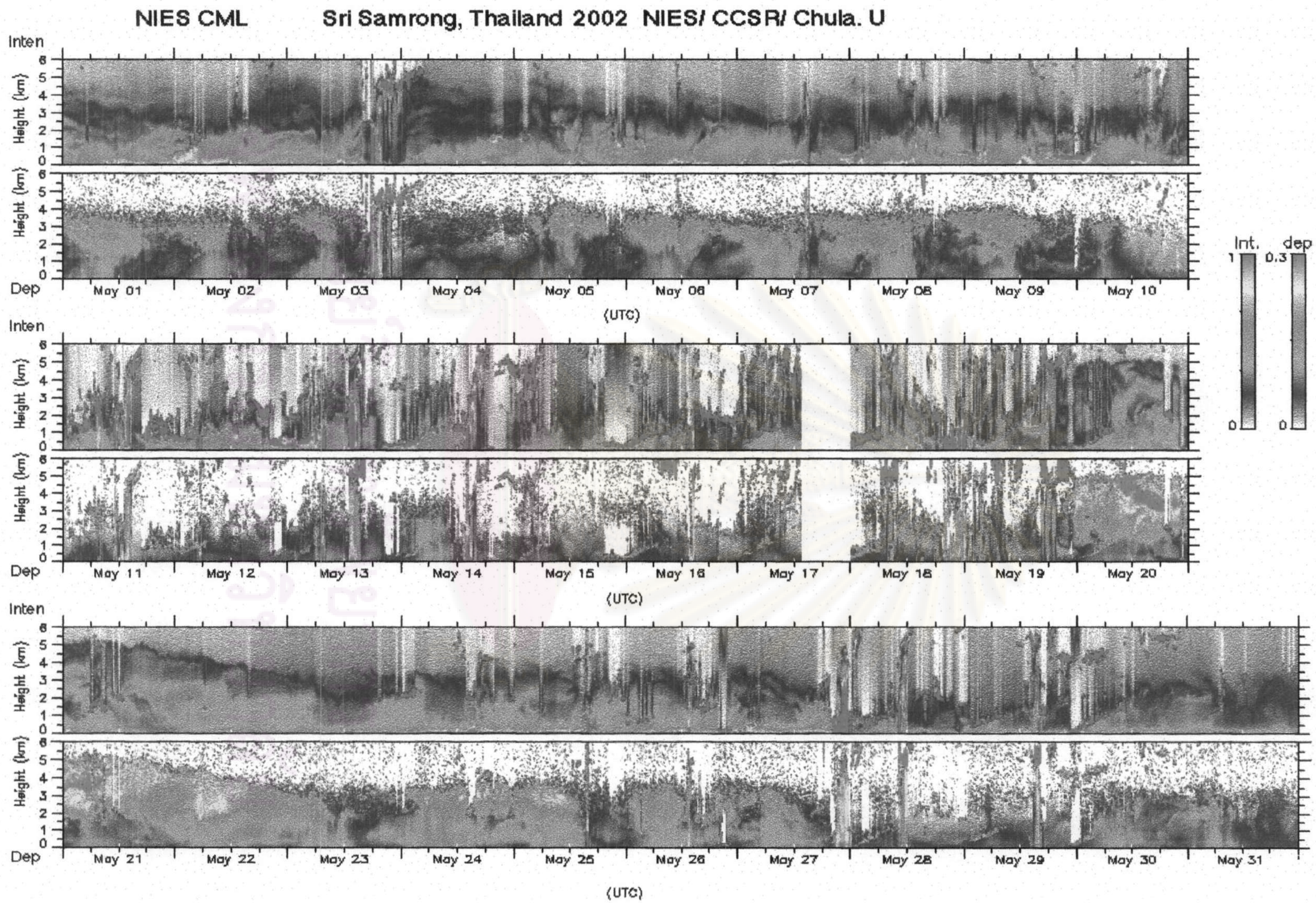
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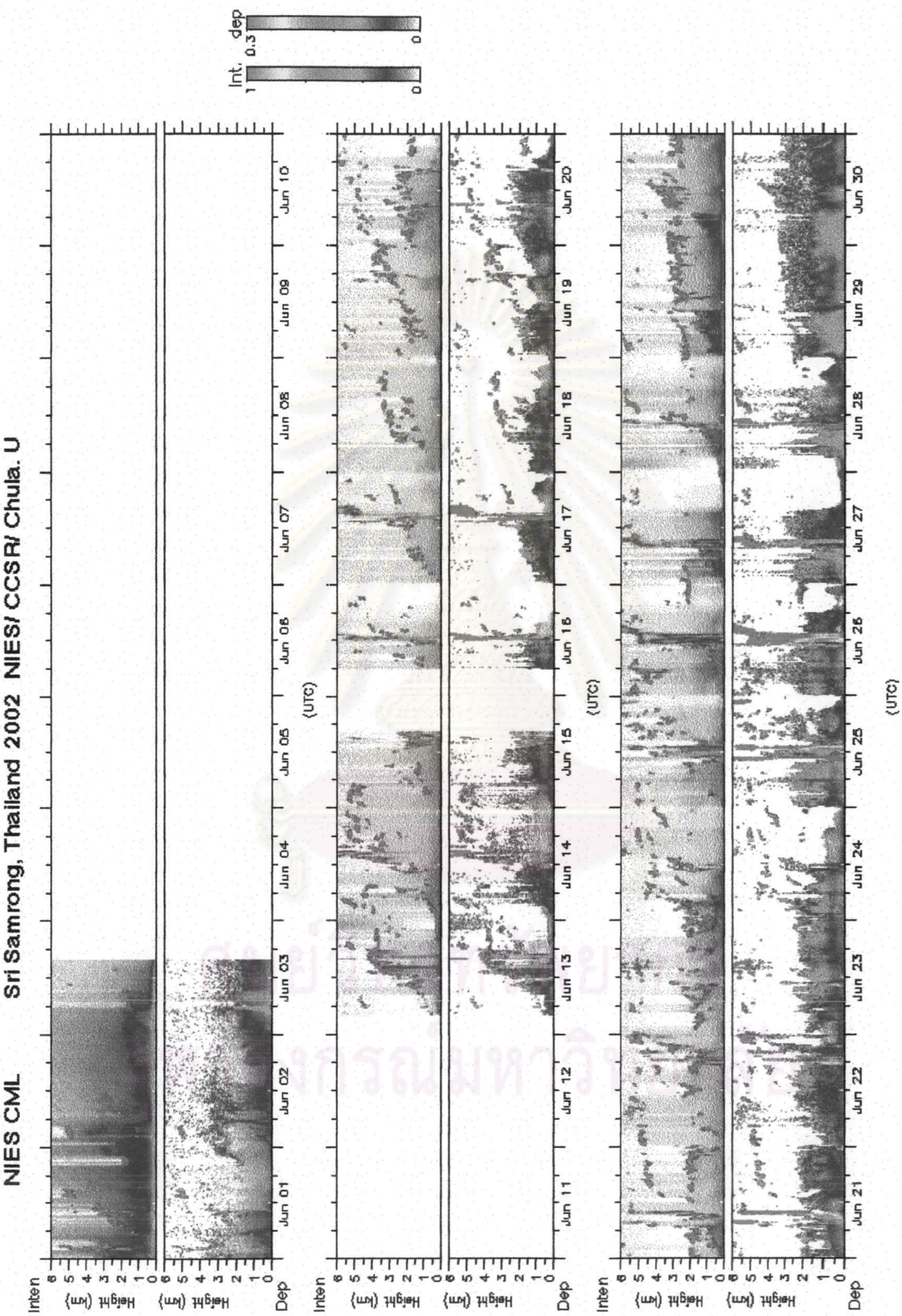
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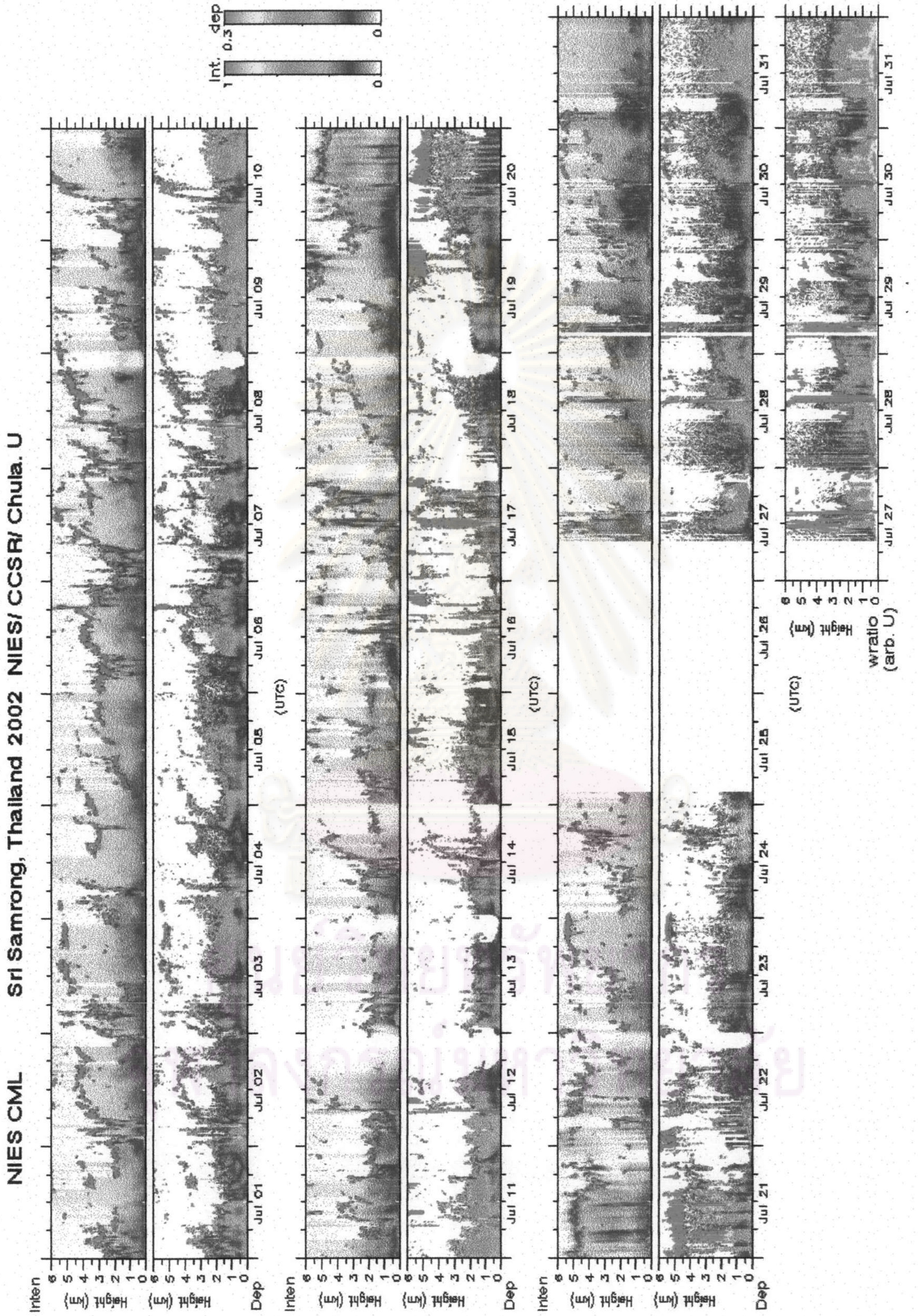
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Sri Samrong, Thailand 2002 NIES/ CCSR/ Chula. U
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NIES CML
Sri Samrong, Thailand 2002 NIES/ CCSR/ Chula. U
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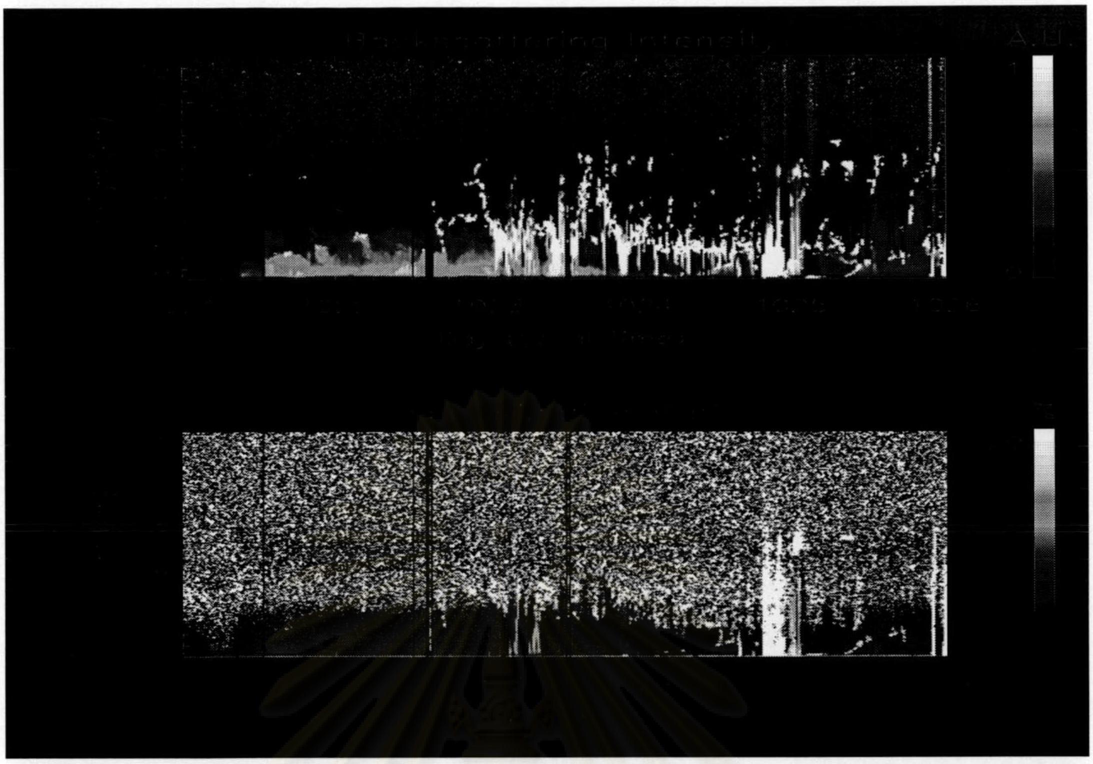
APPENDIX III

Backscattering Intensity and Depolarization Ratio data by Mie Scattering Lidar



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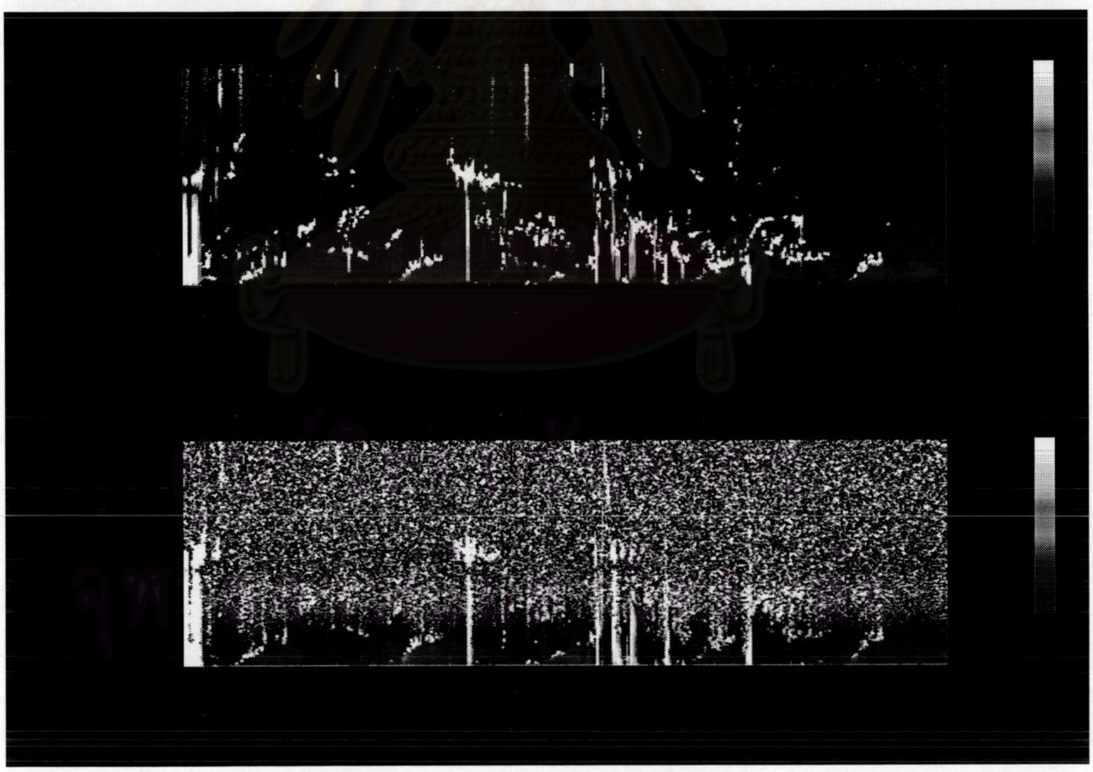
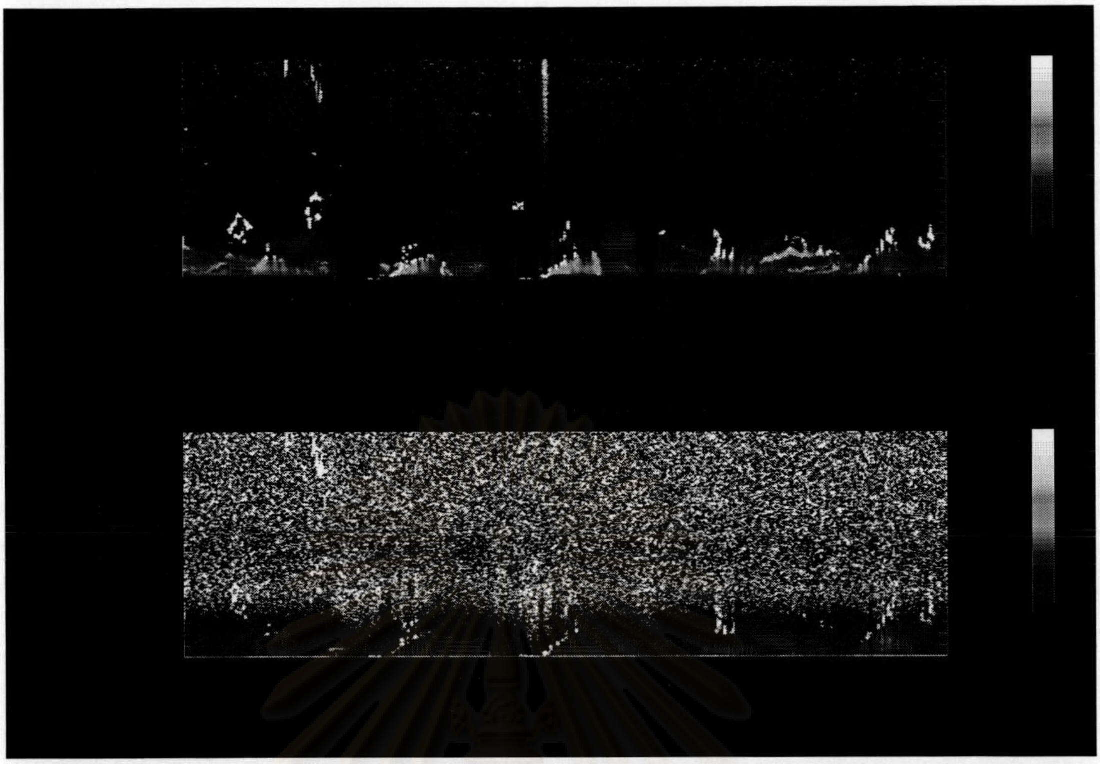
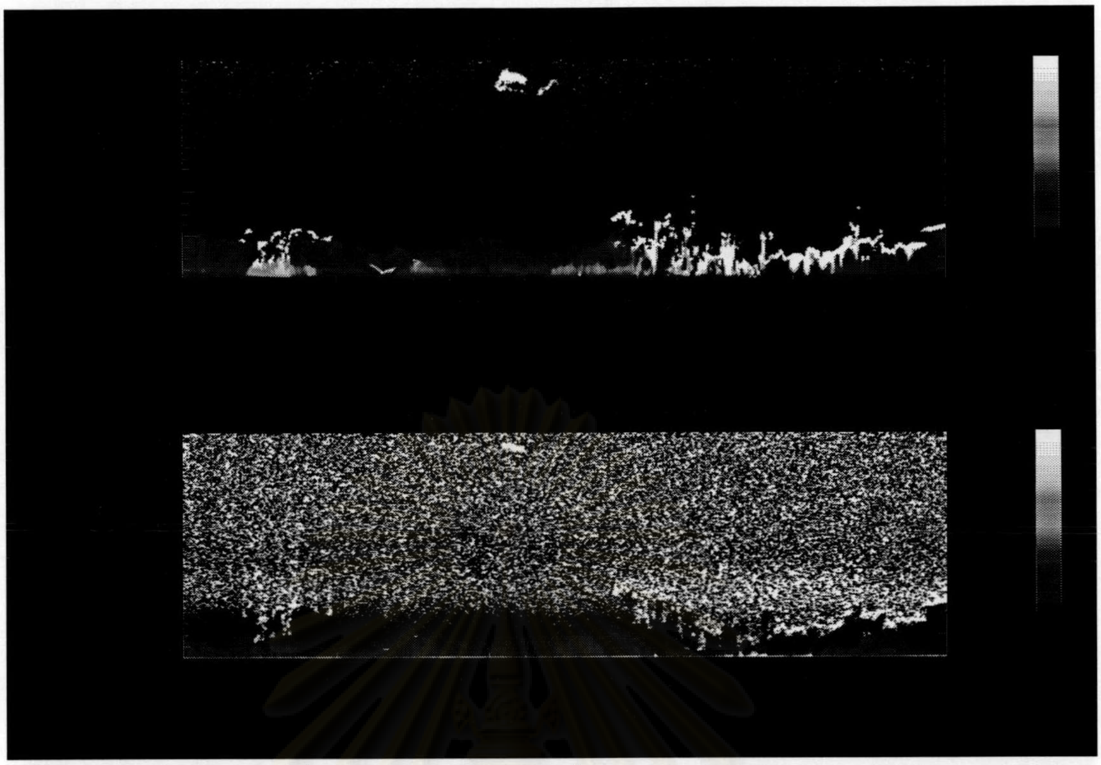


26th October 2001 – 30th October 2001



1st November 2001 – 5th November 2001

6th November 2001 – 10th November 2001

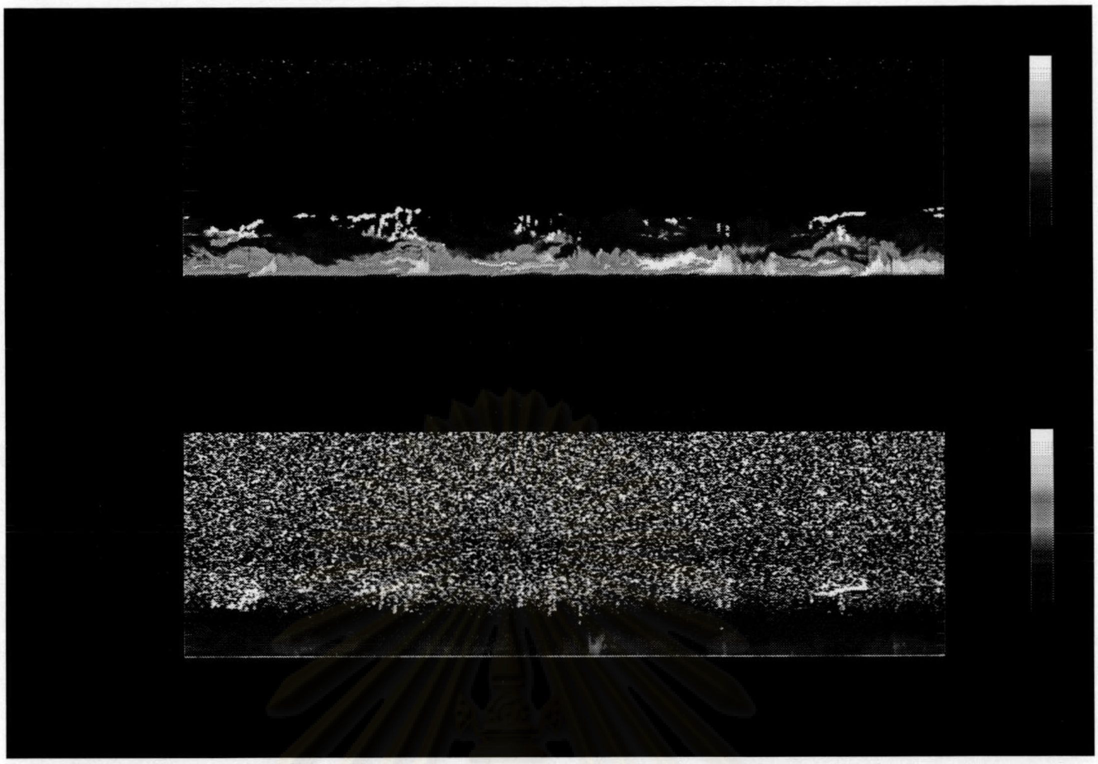


11th November 2001 – 15th November 2001

16th November 2001 – 20th November 2001

21st November 2001 – 25th November 2001

26th November 2001 – 30th November 2001



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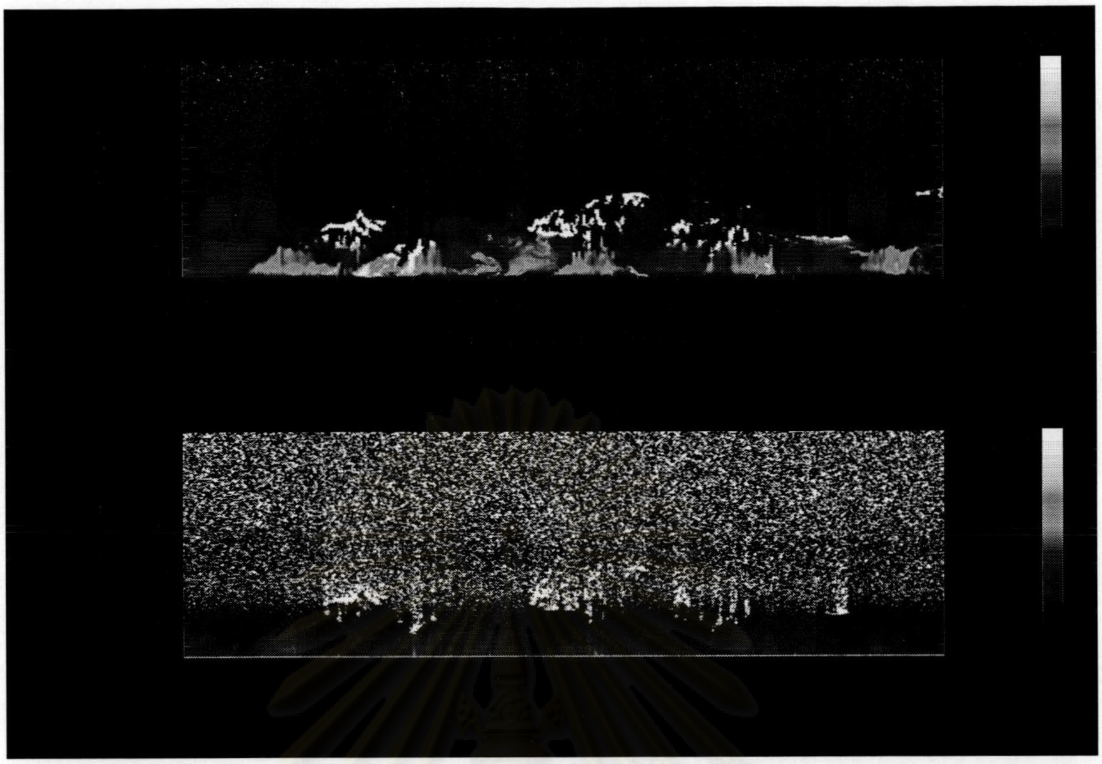

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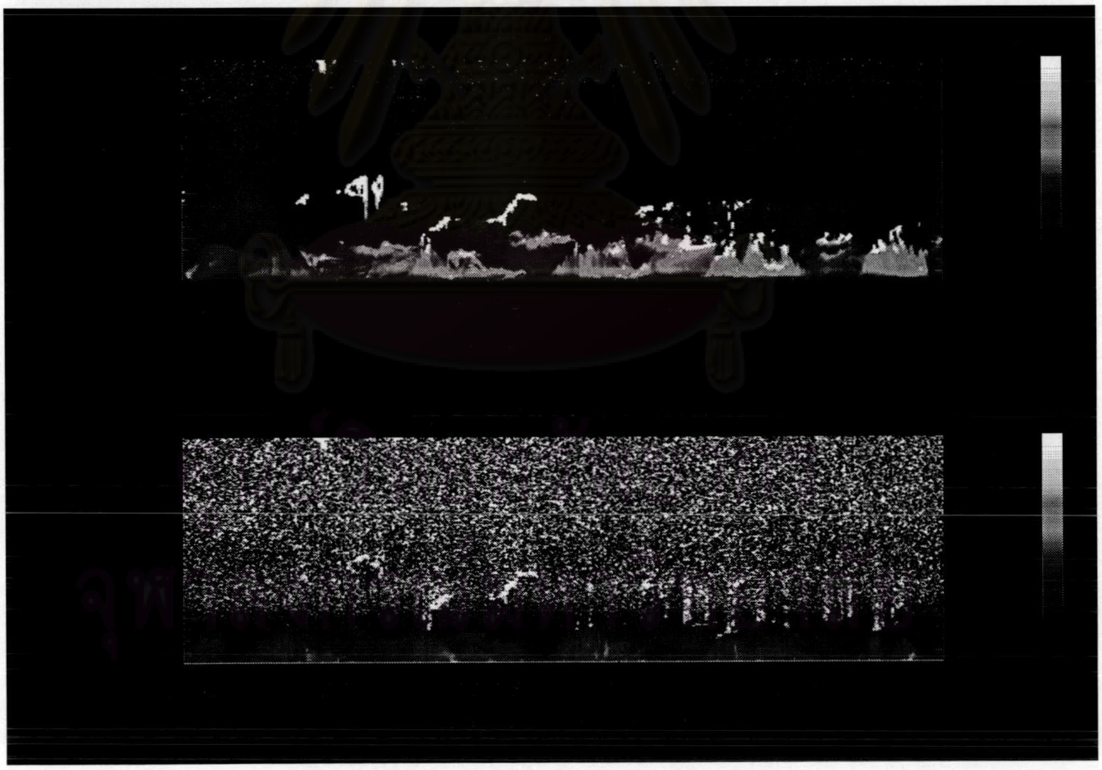

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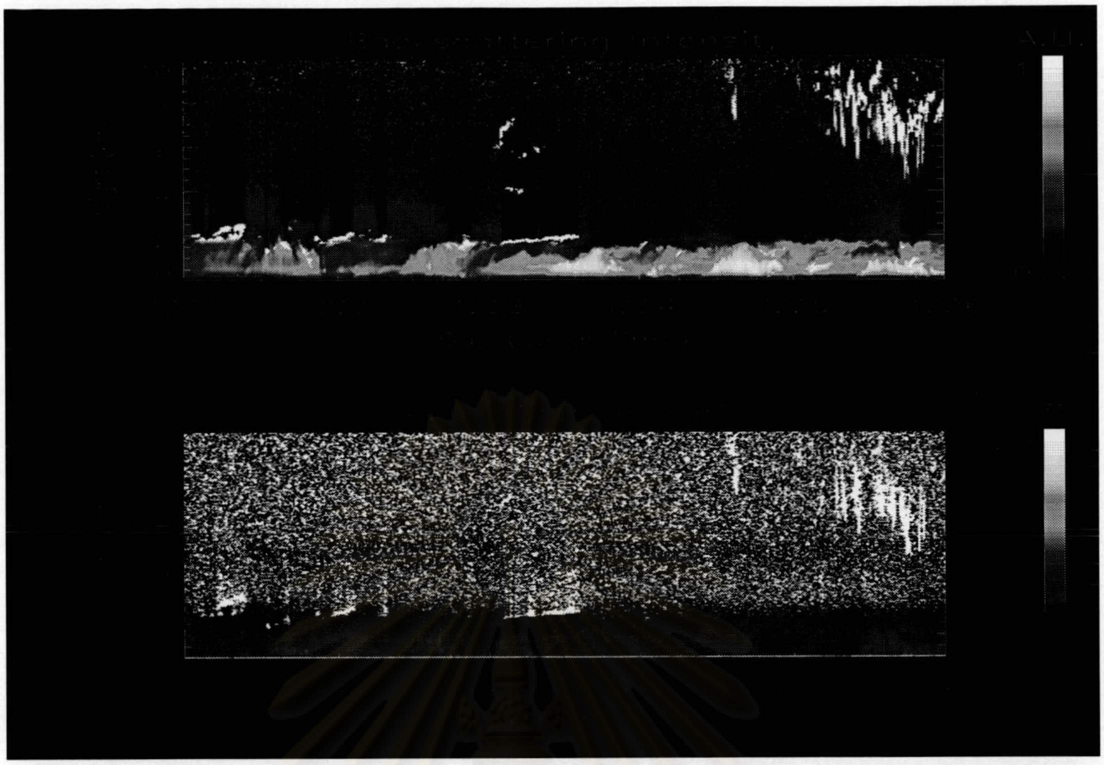

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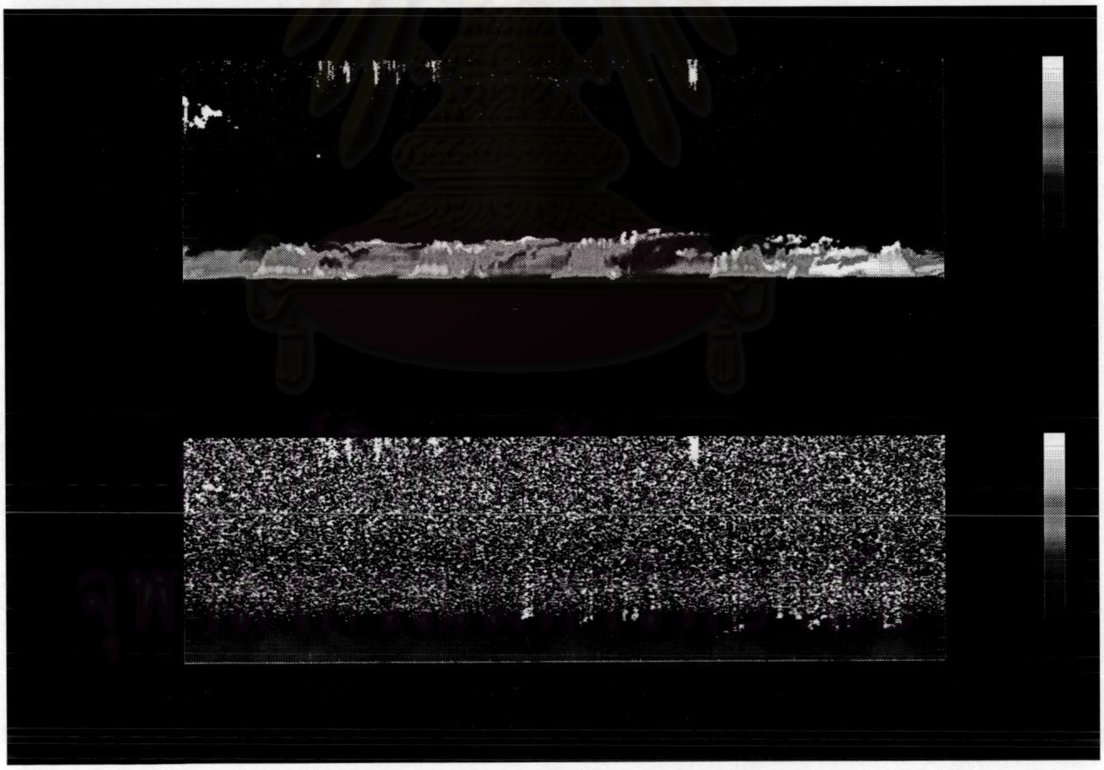

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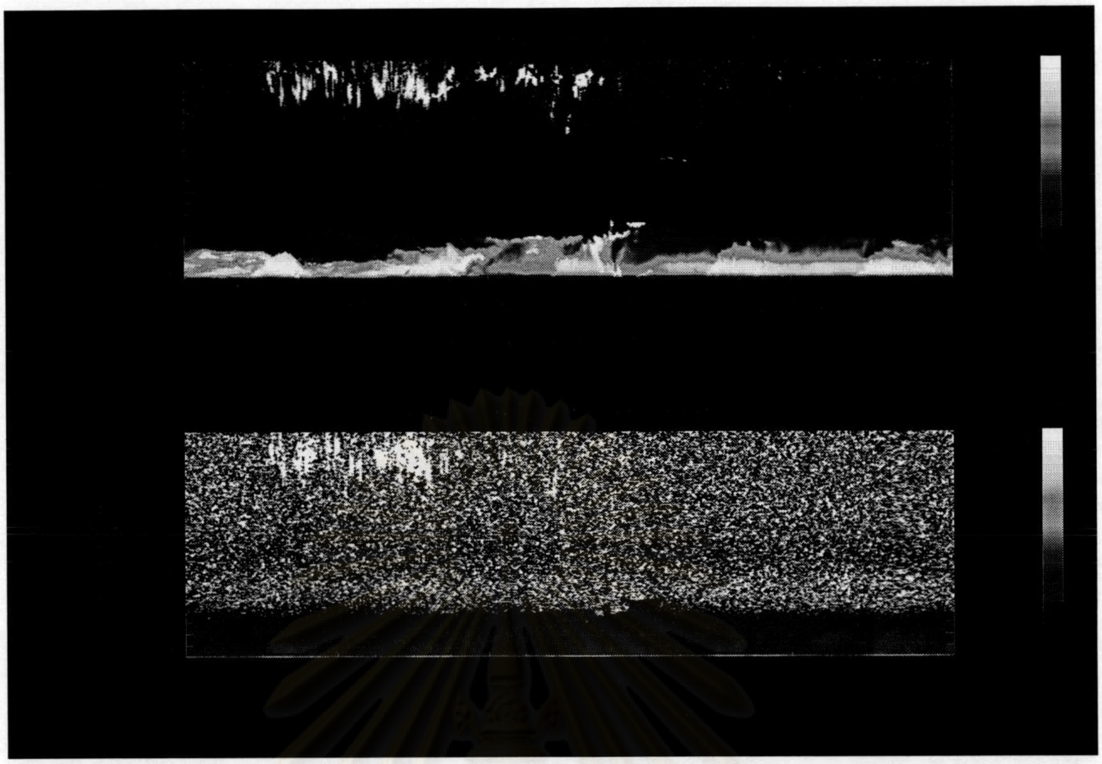

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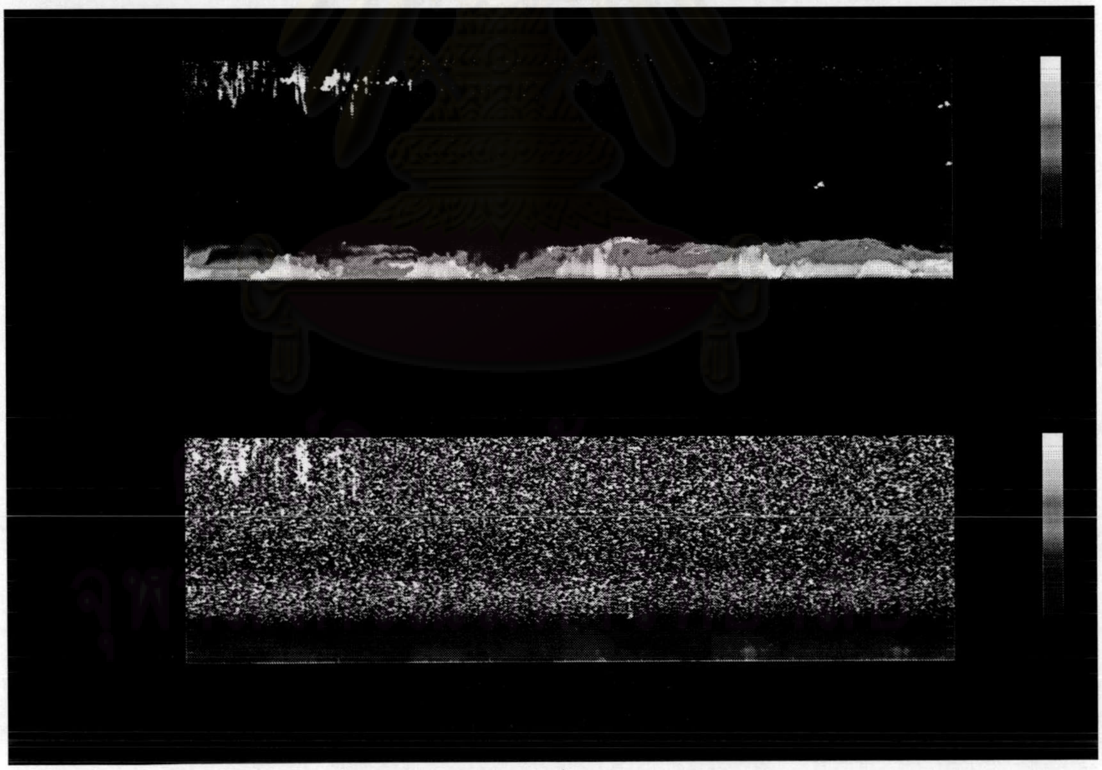

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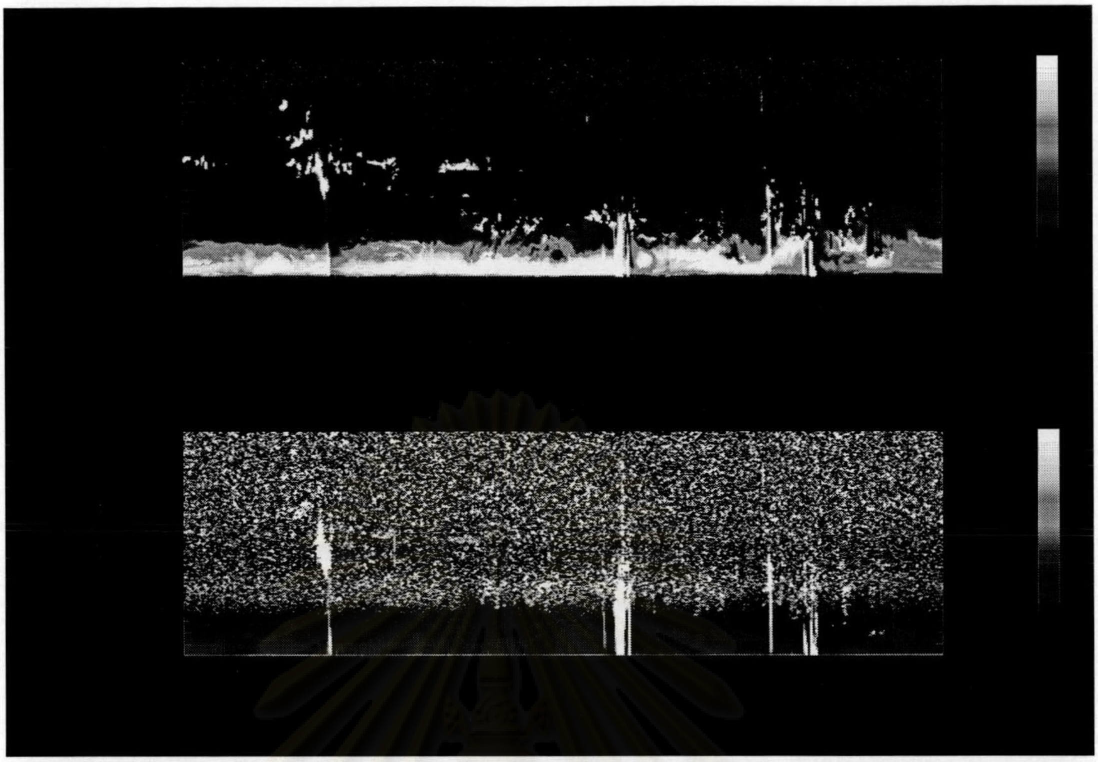

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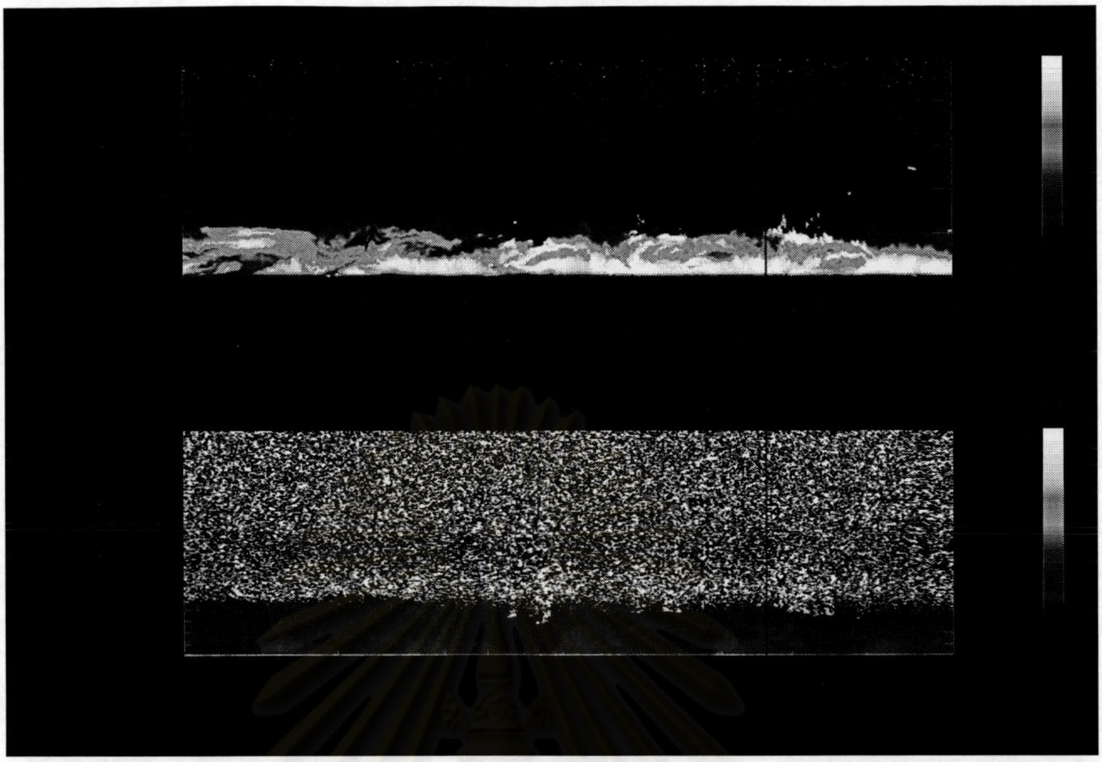
15^{th} January 2002 – 19^{th} January 2002



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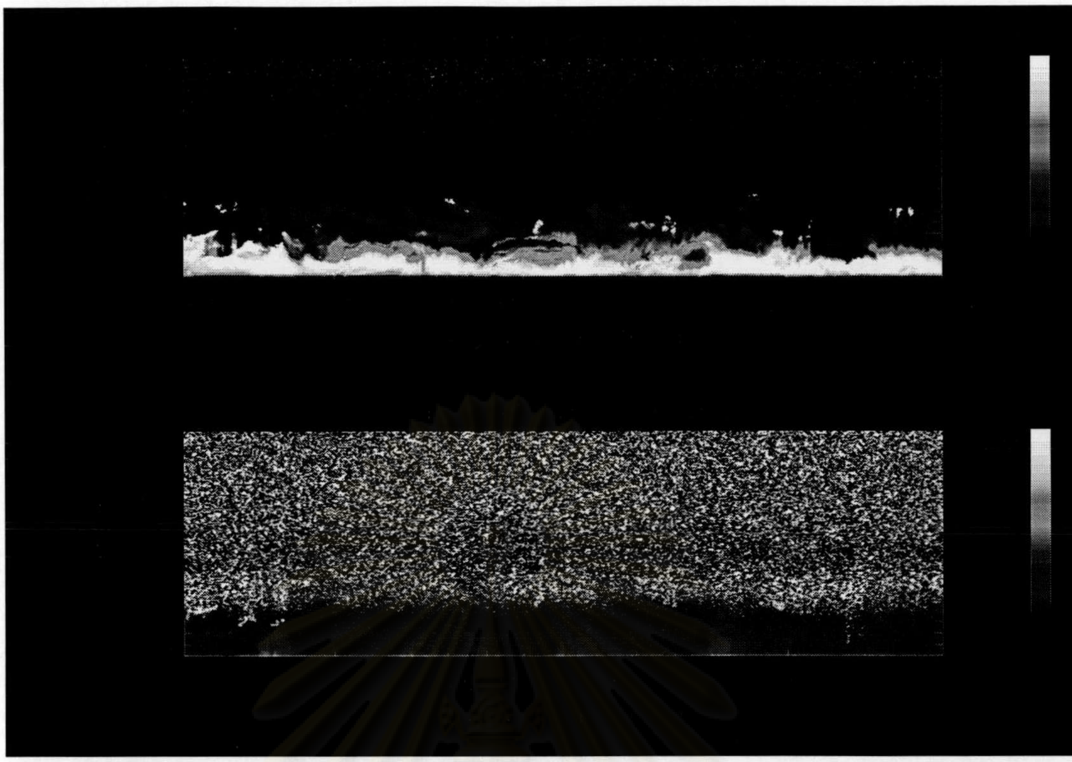
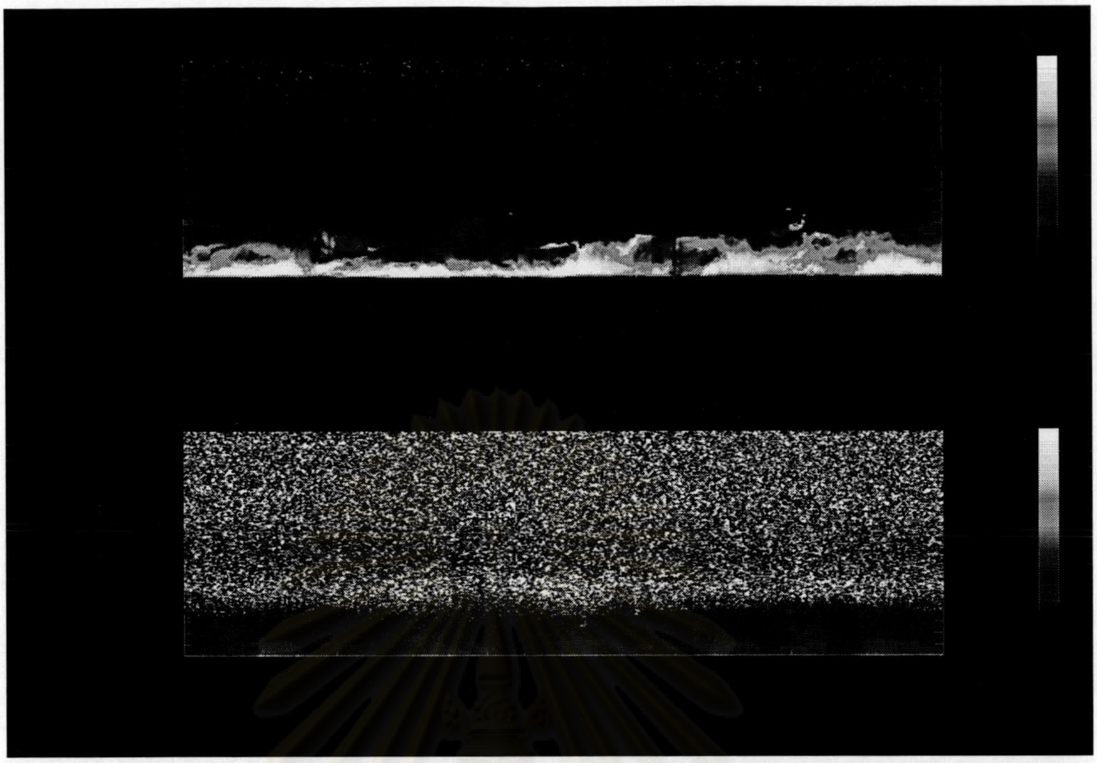
25th January 2002 – 29th January 2002



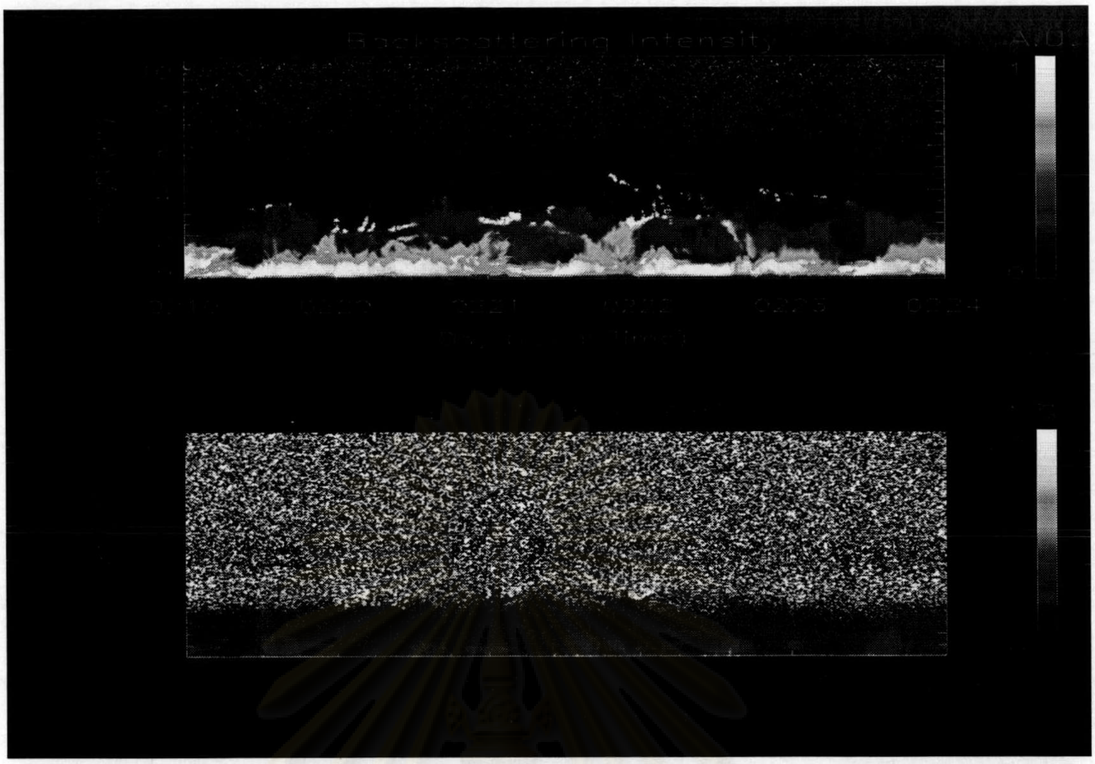
30th January 2002 – 3rd February 2002

4th February 2002 – 8th February 2002



9^{th} February 2002 – 13^{th} February 2002

14^{th} February 2002 – 18^{th} February 2002



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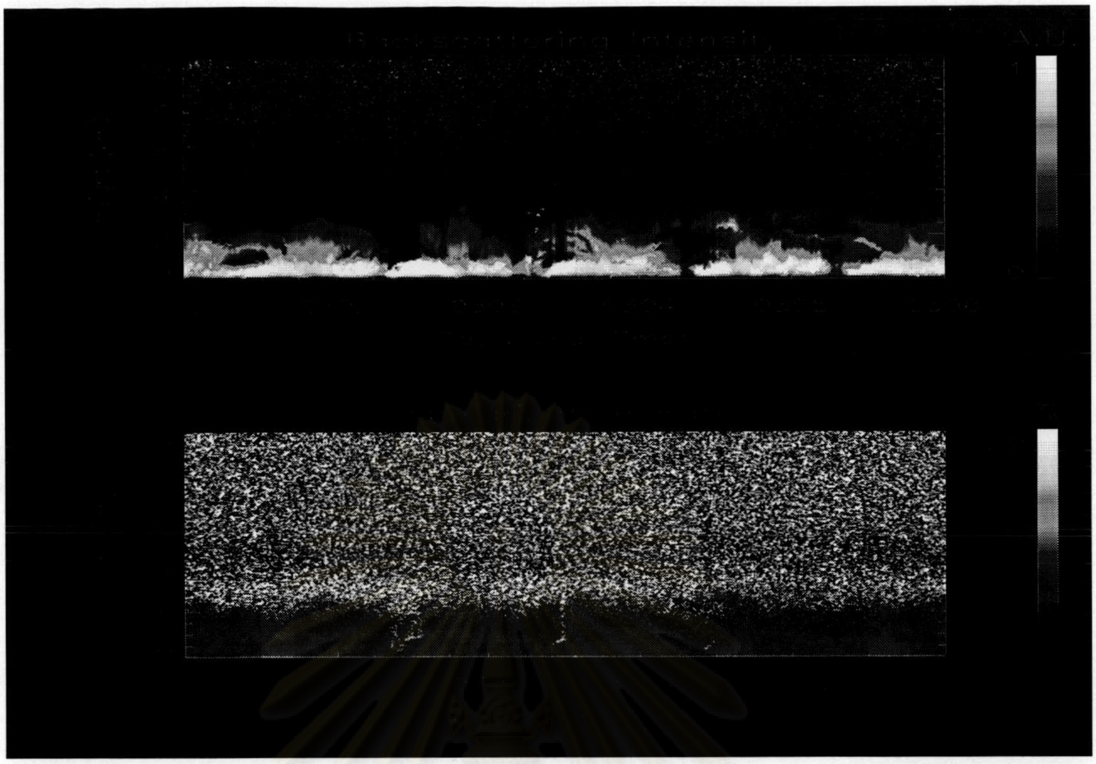
24th February 2002 – 28th February 2002



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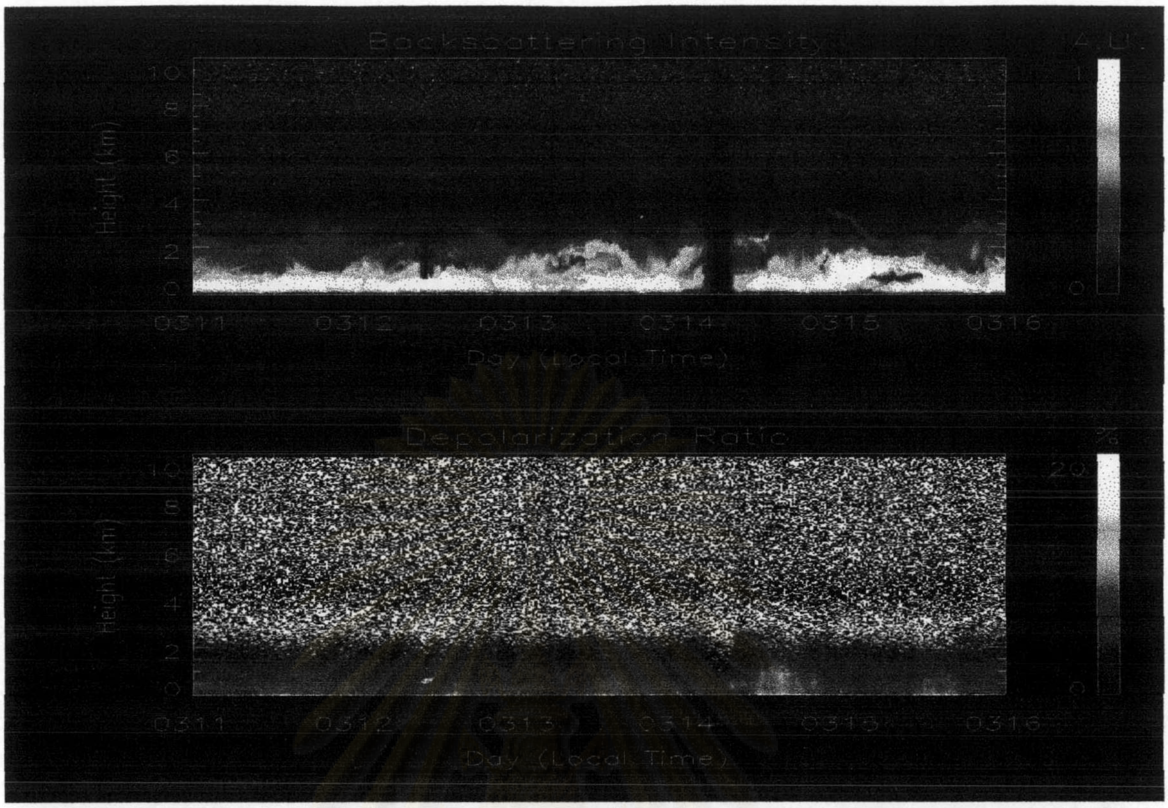
6^{th} March 2002 – 10^{th} March 2002



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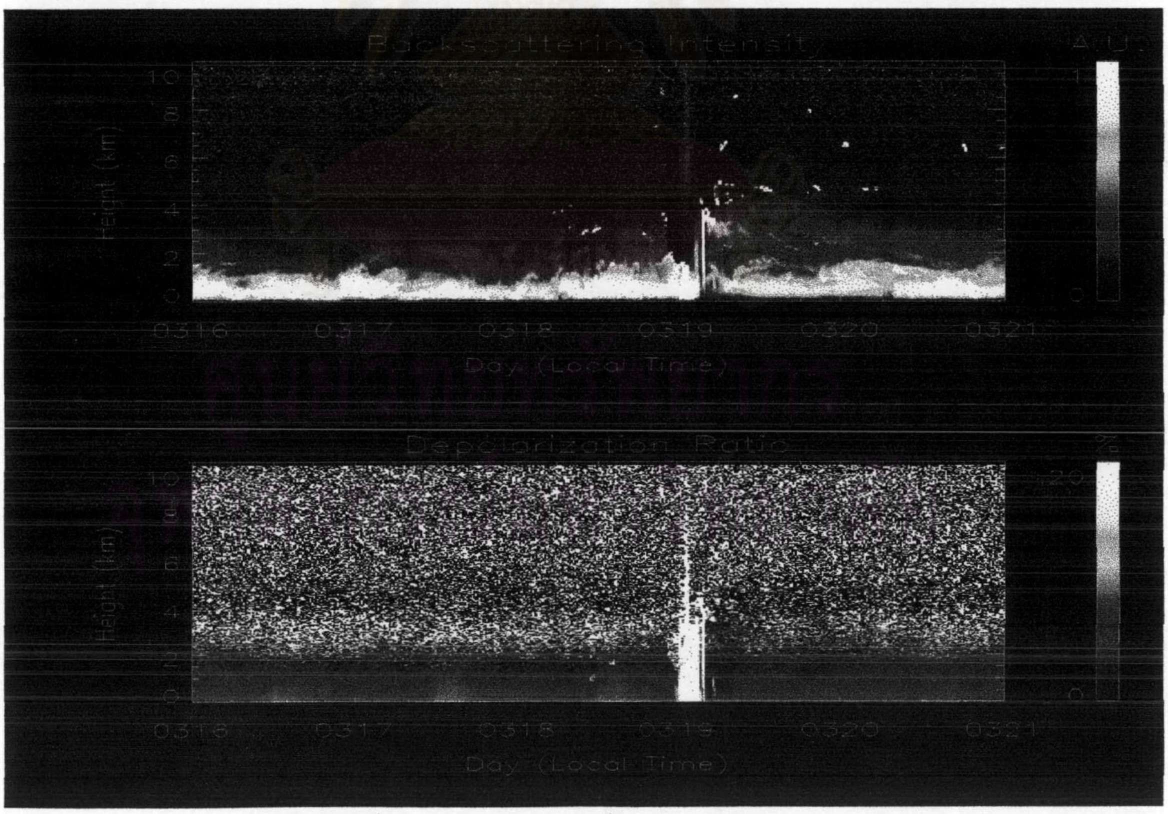

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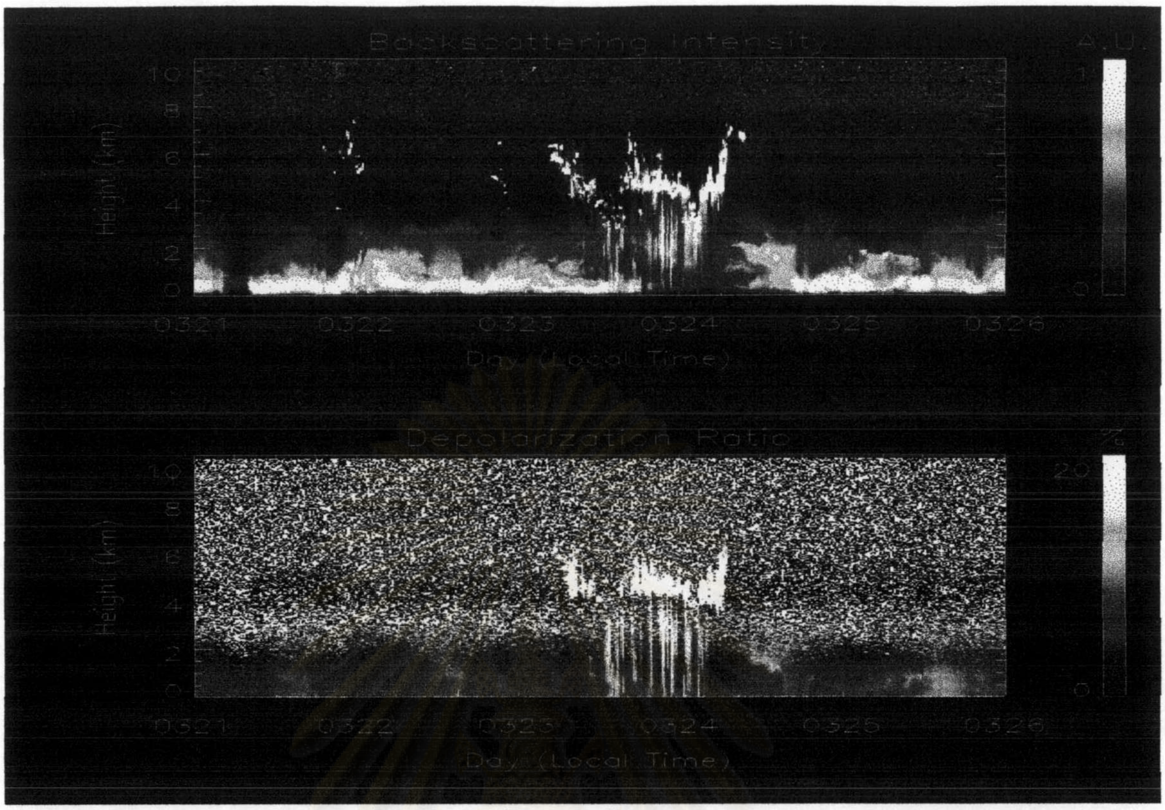

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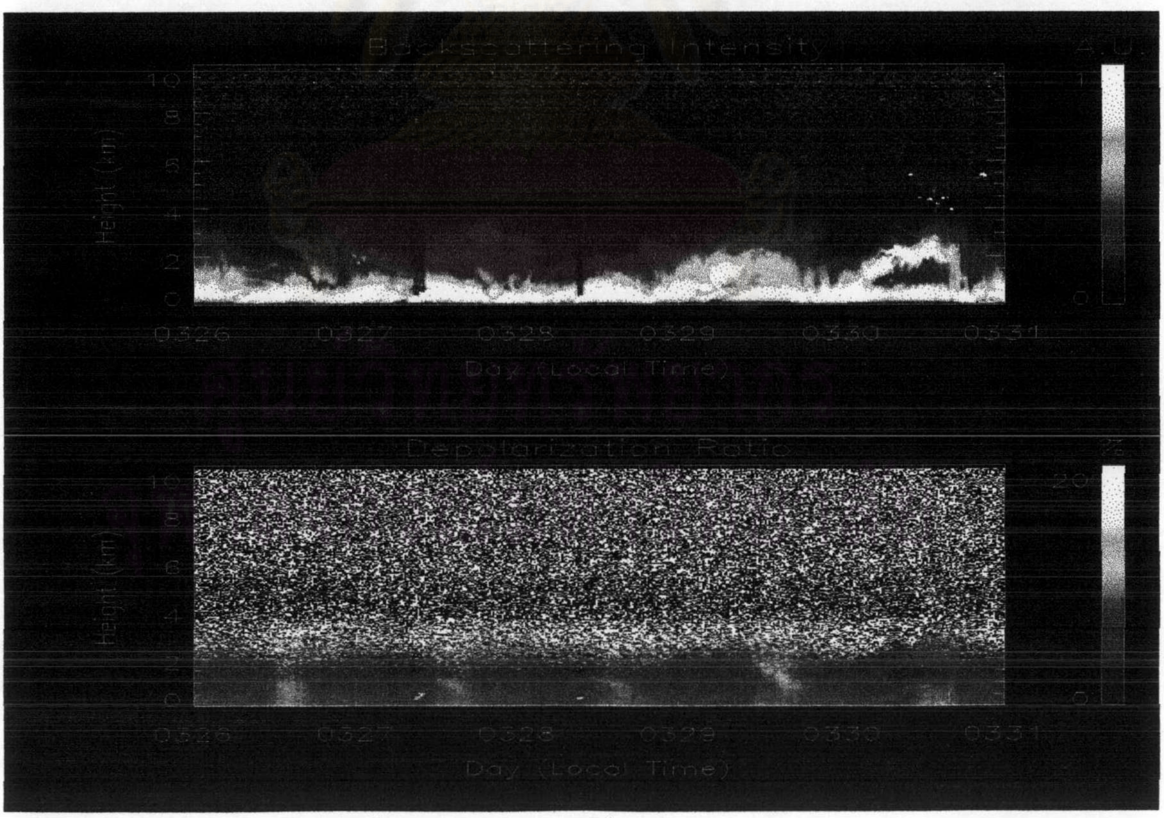

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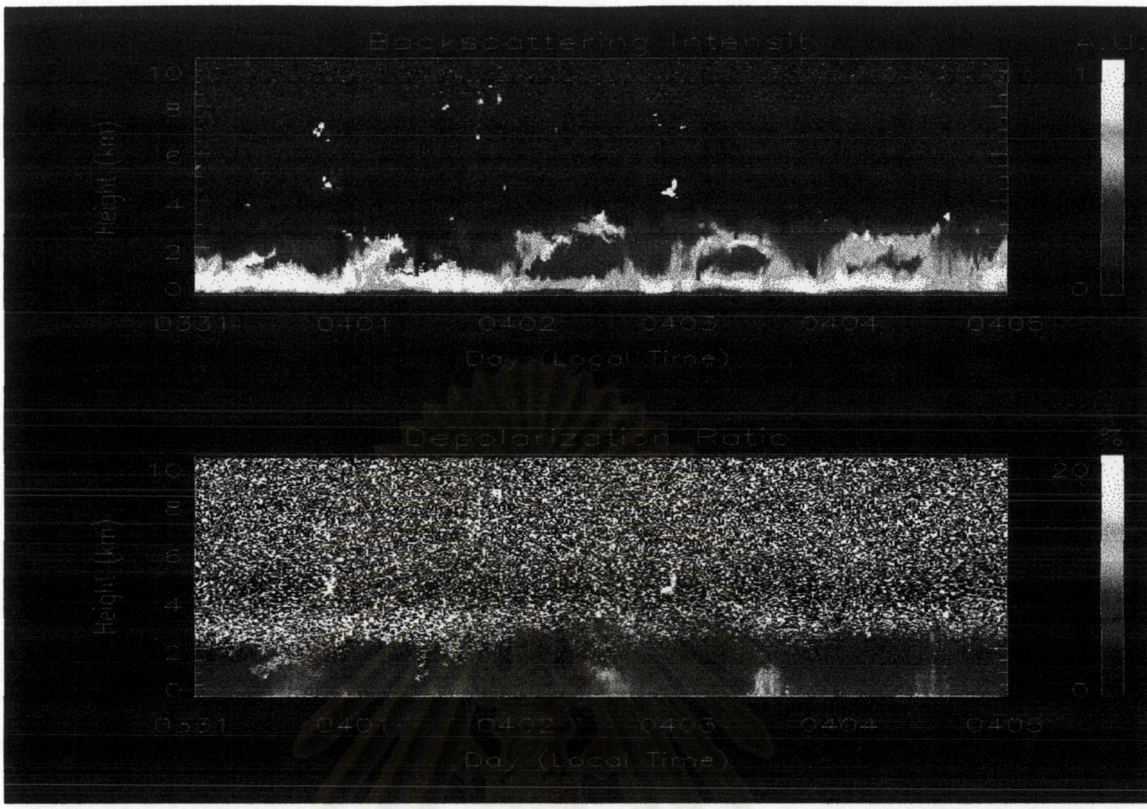
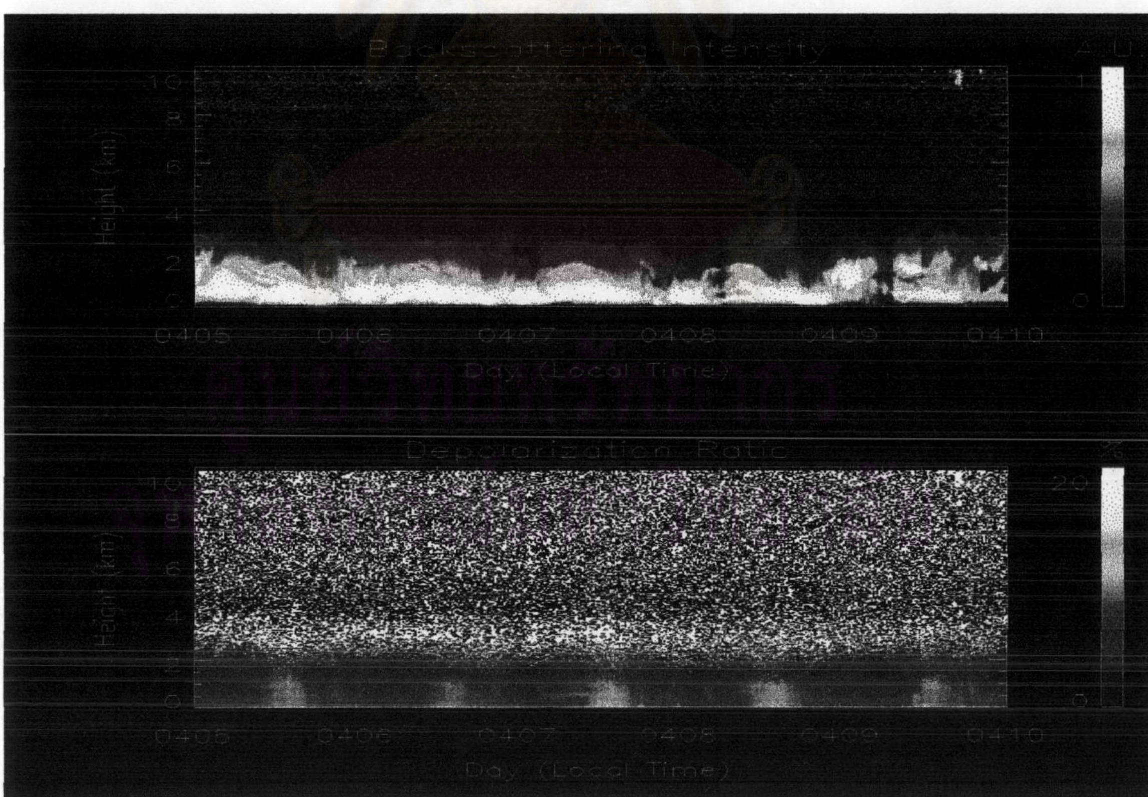


31st March 2002 – 4 April 2002



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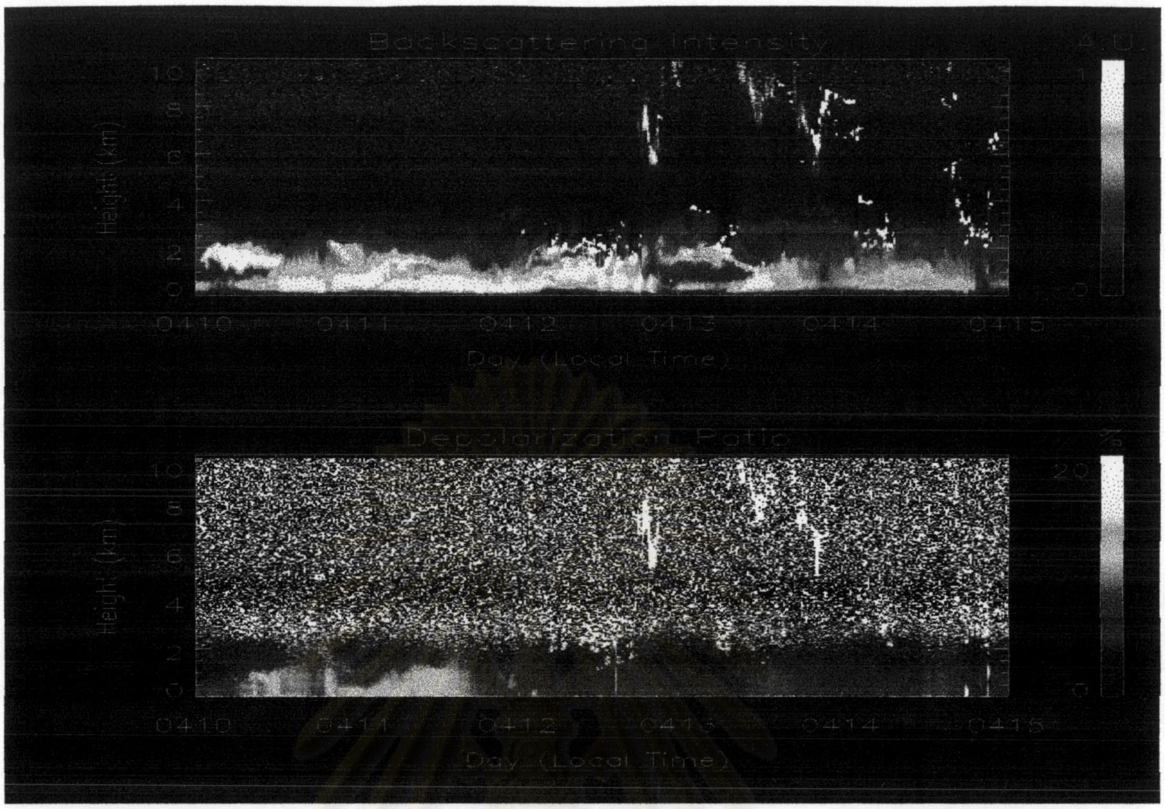

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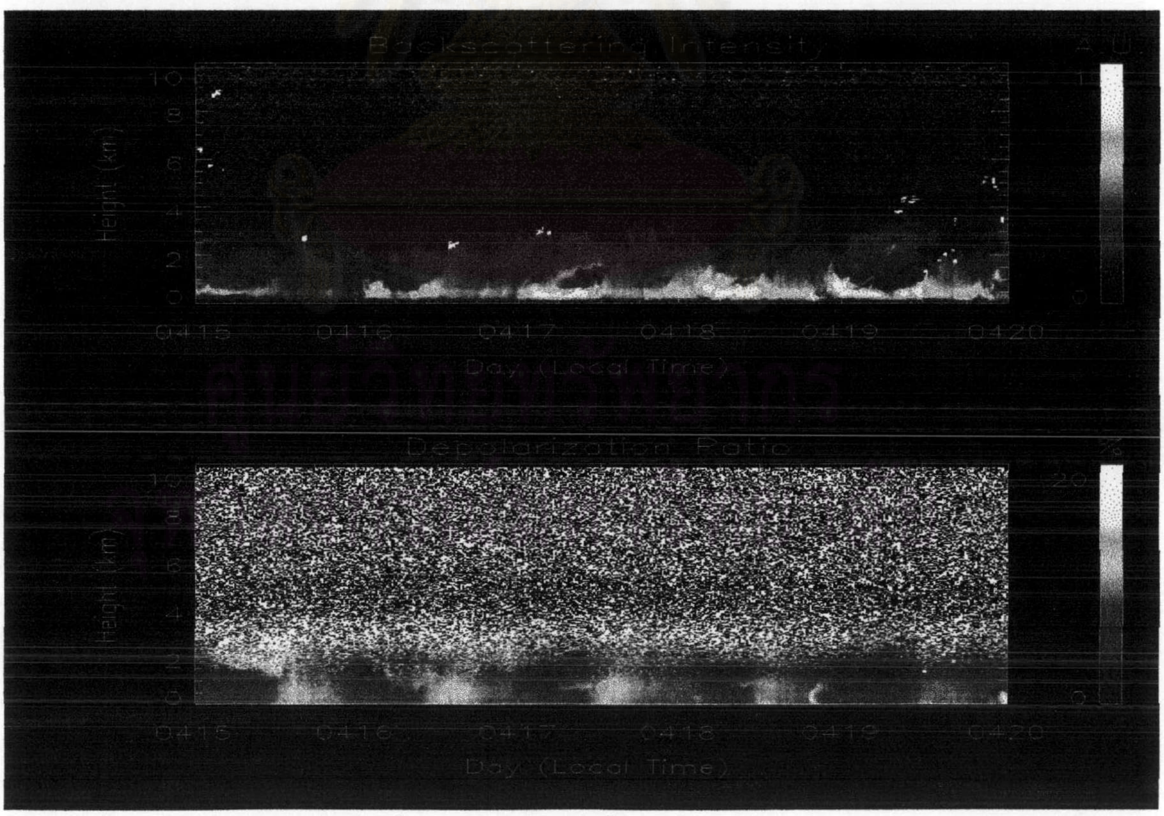

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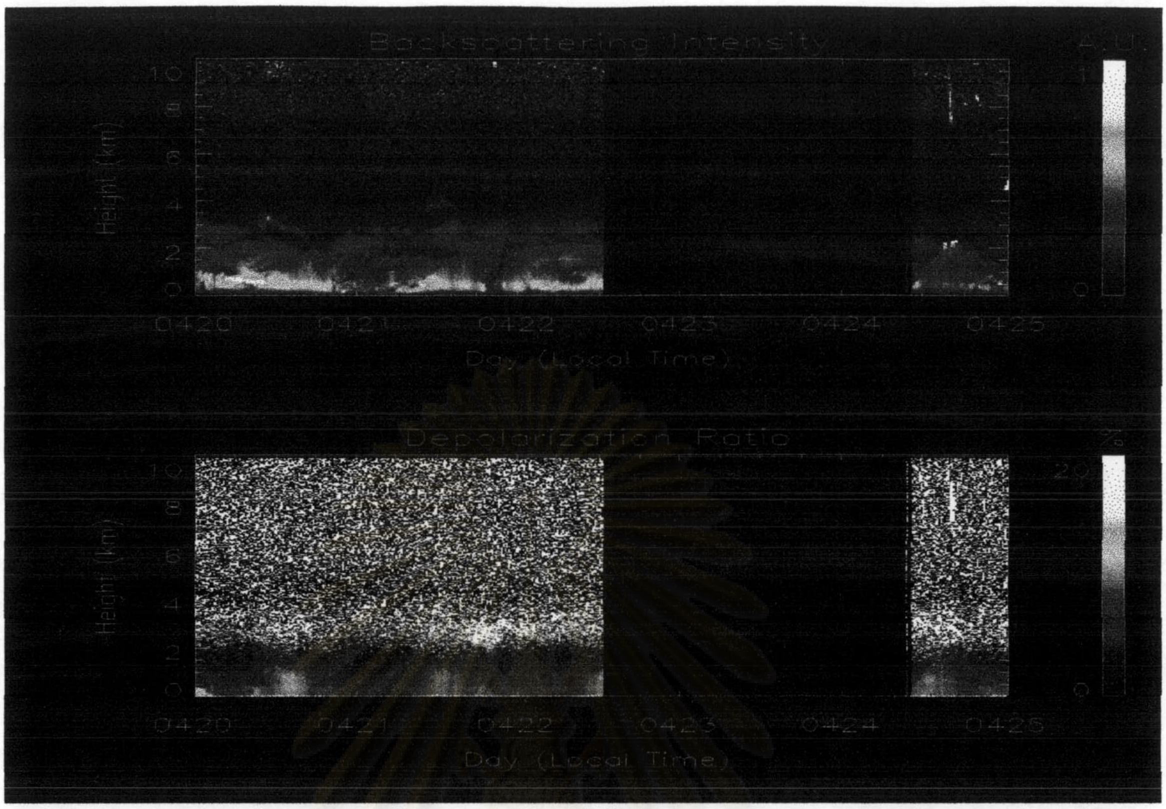

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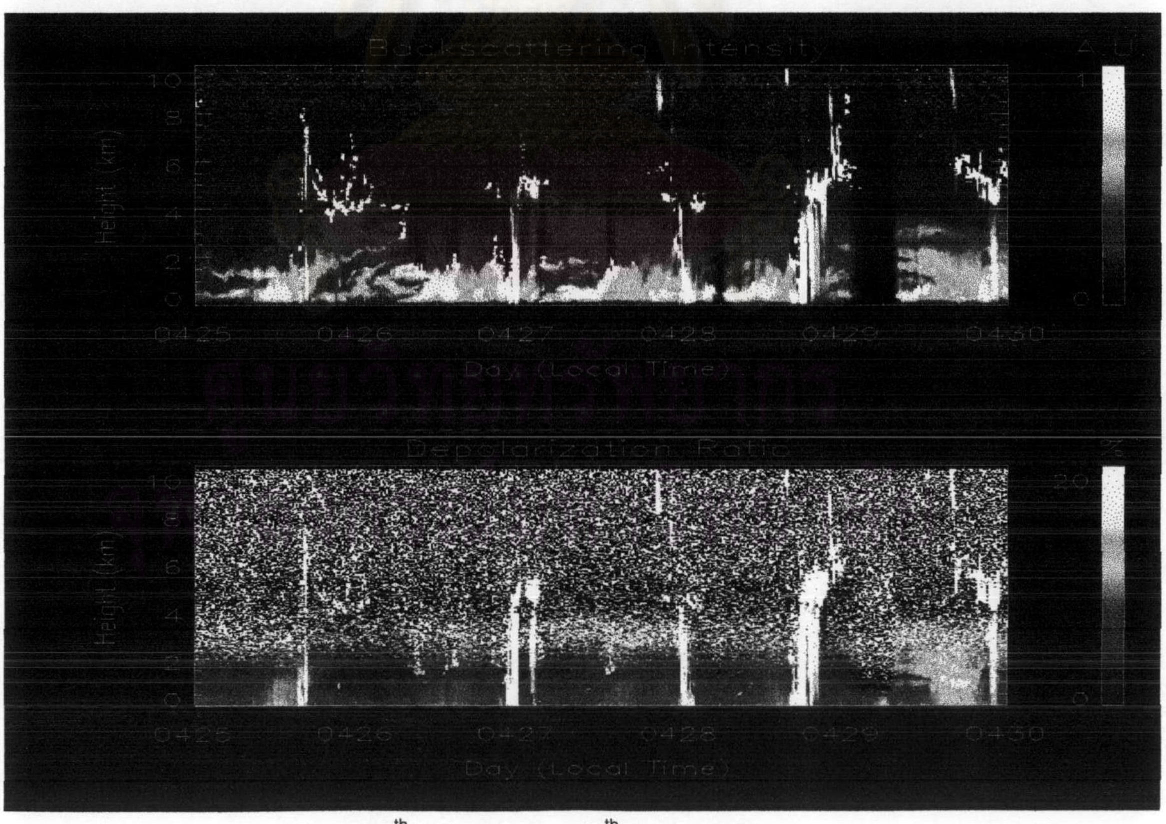

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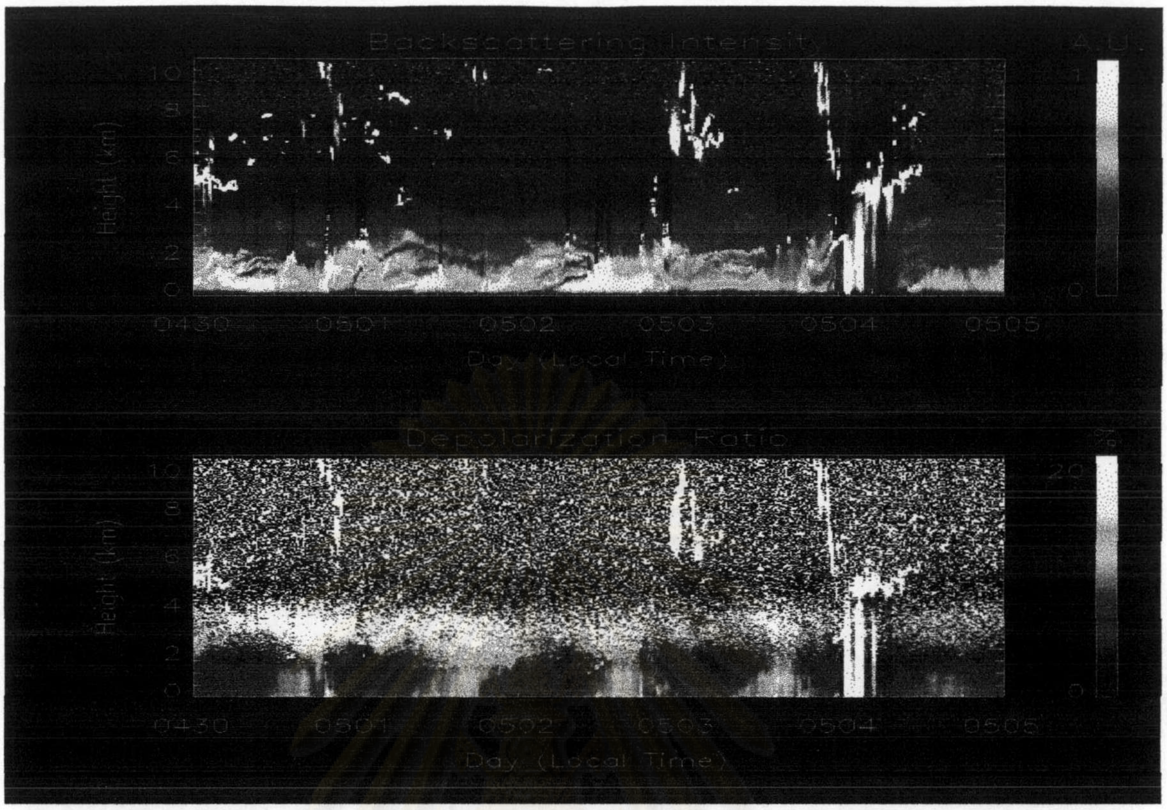

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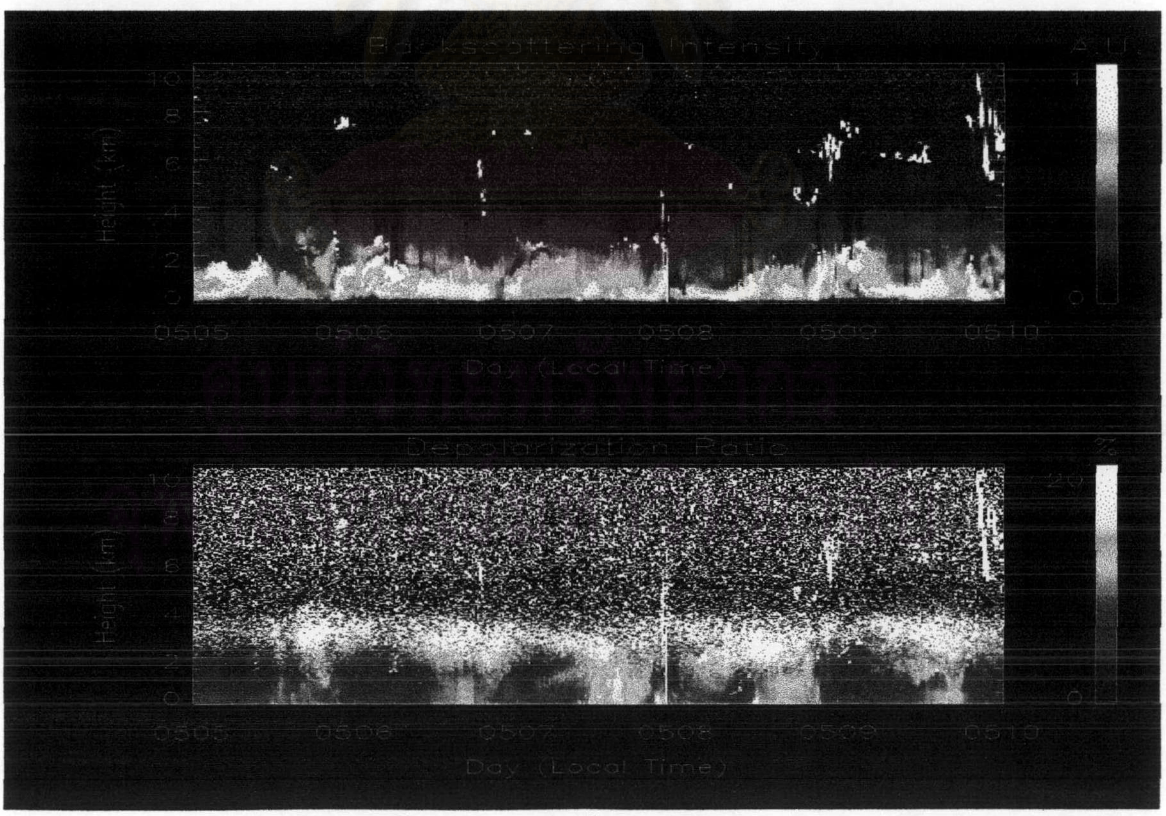

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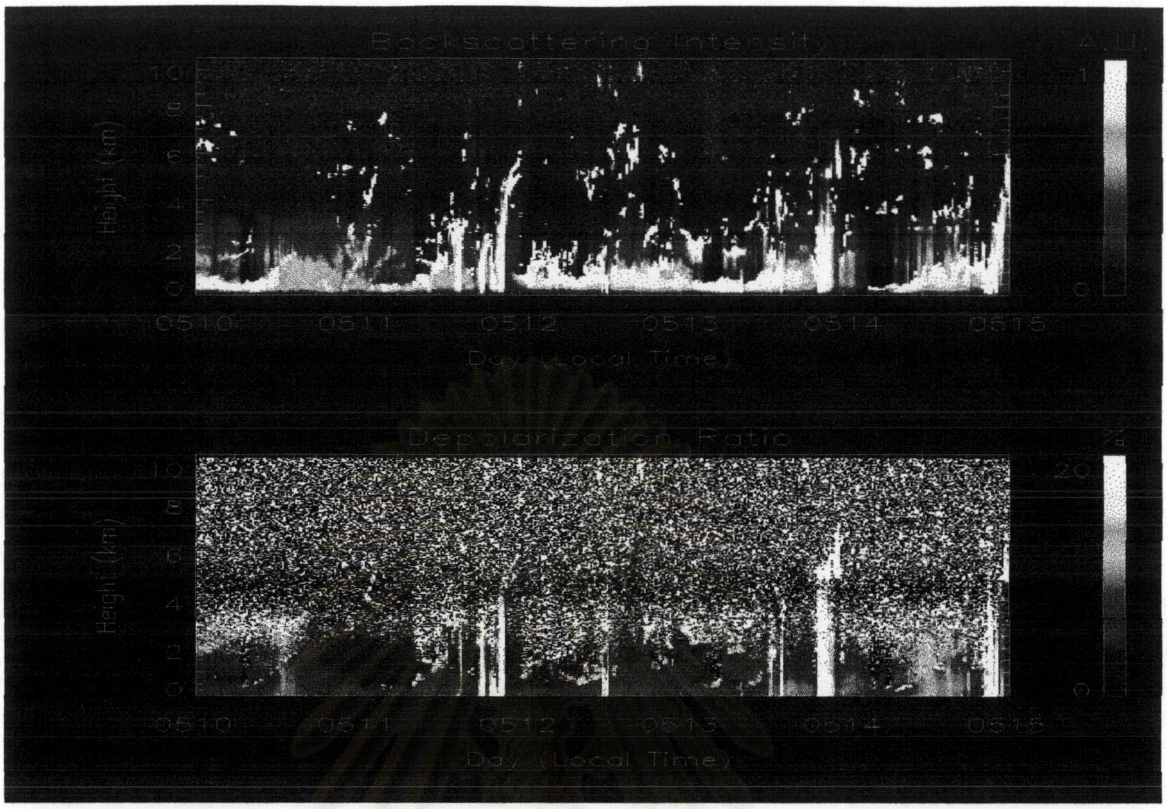

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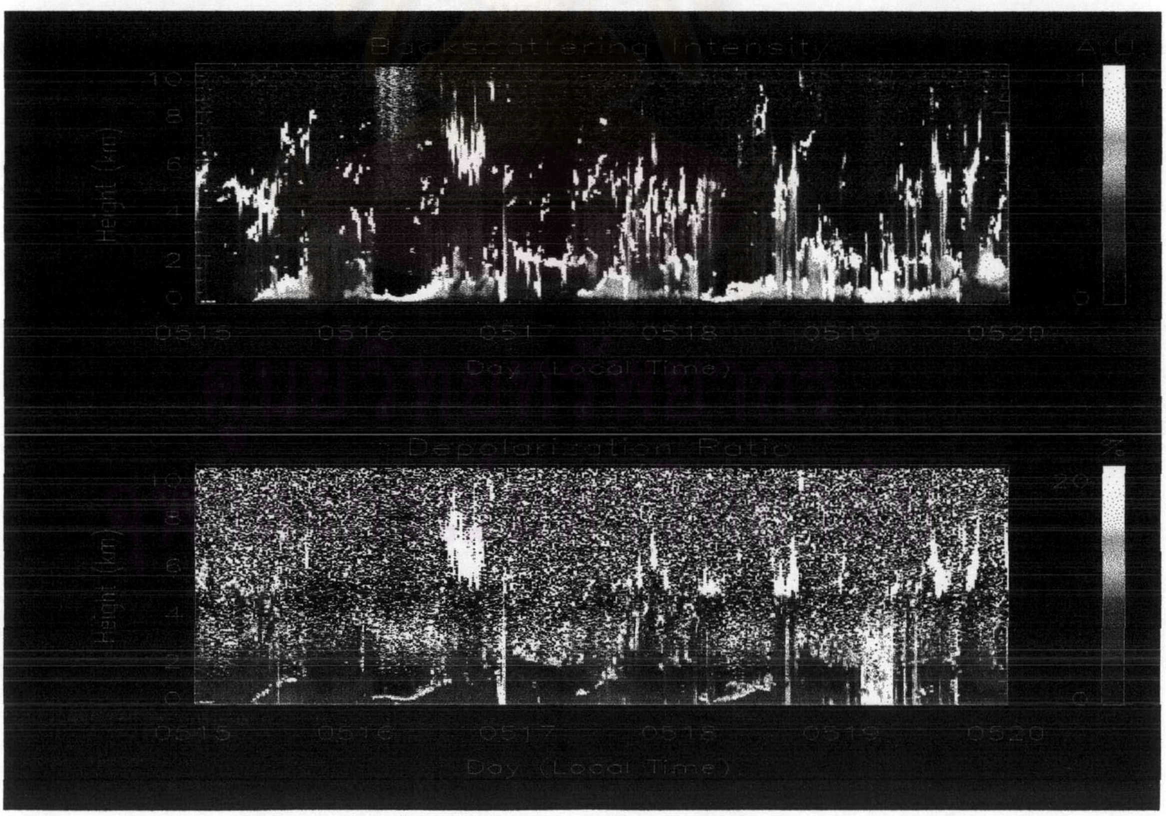

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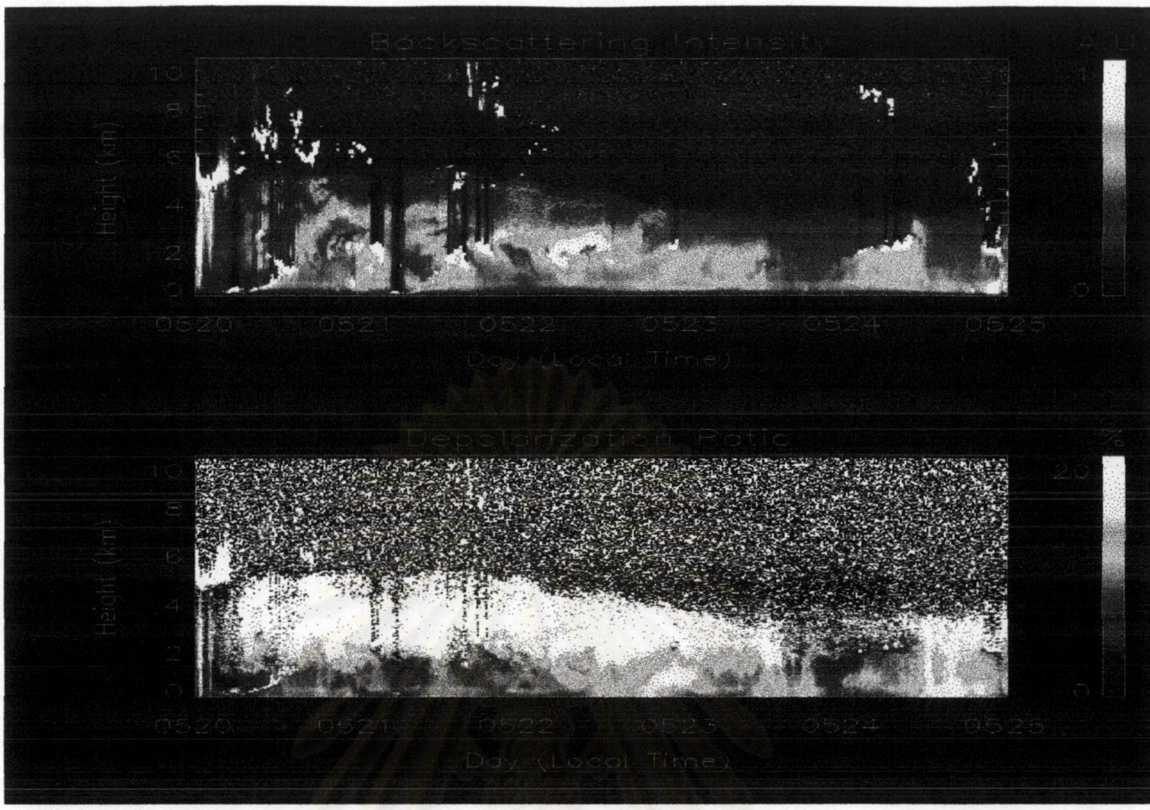

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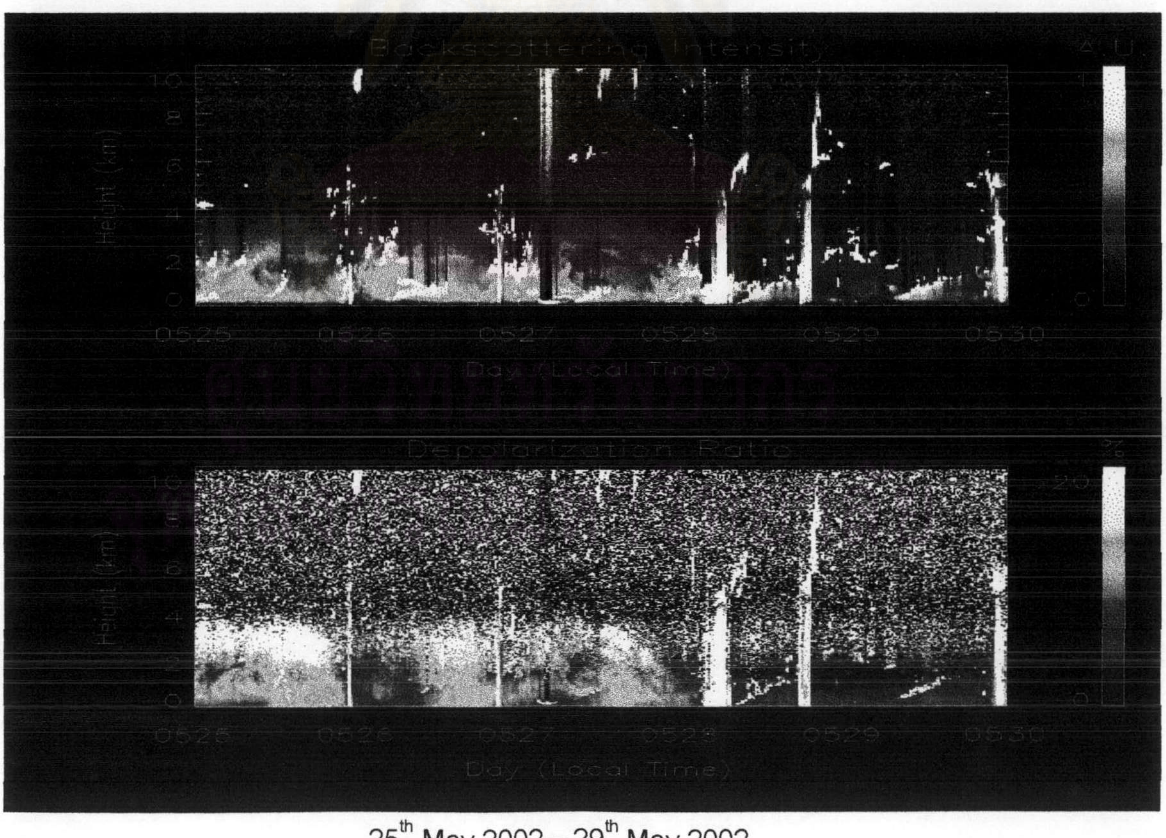

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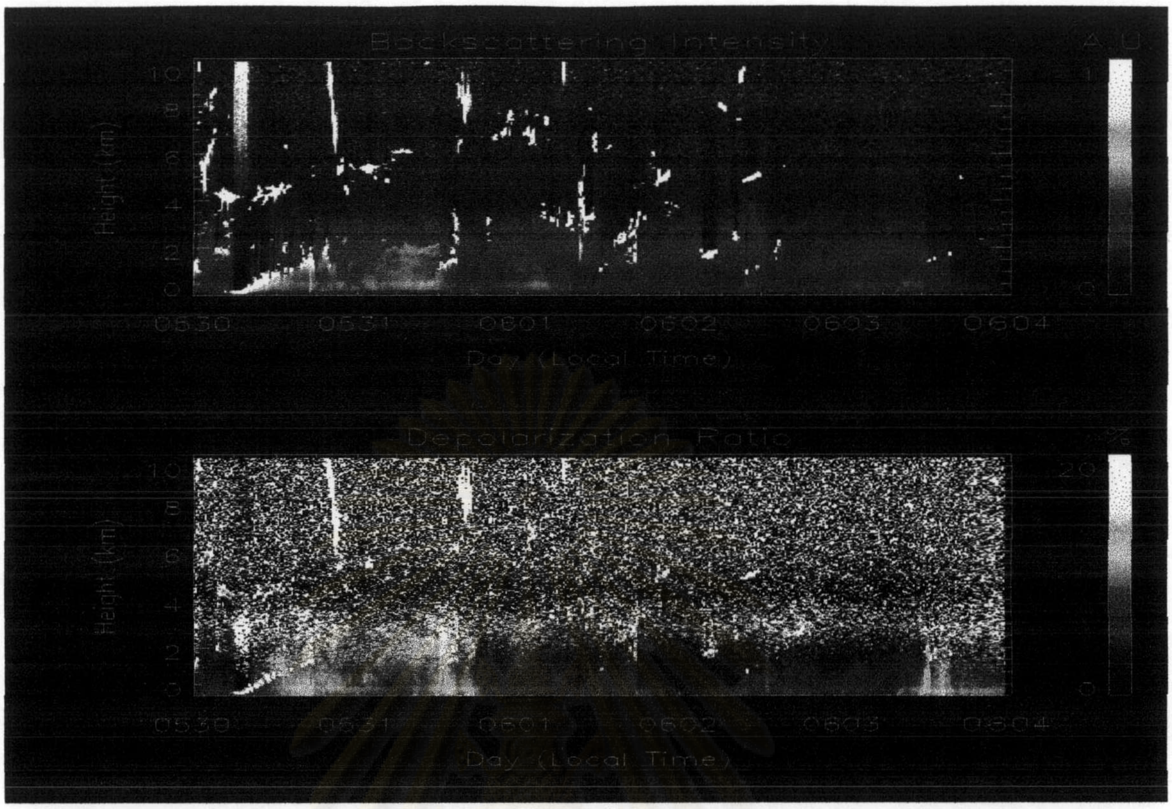
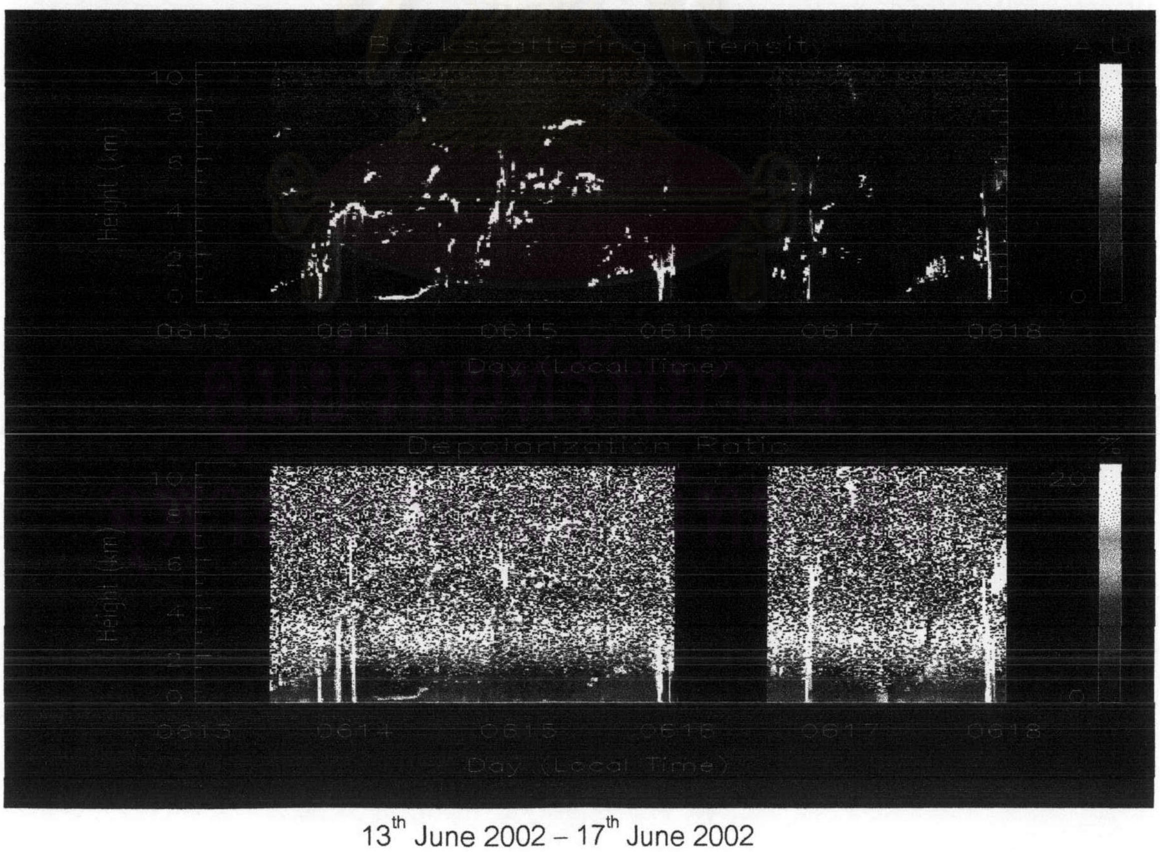


30th May 2002 – 3rd June 2002

4th June 2002 – 8th June 2002

8th June 2002 – 12th June 2002



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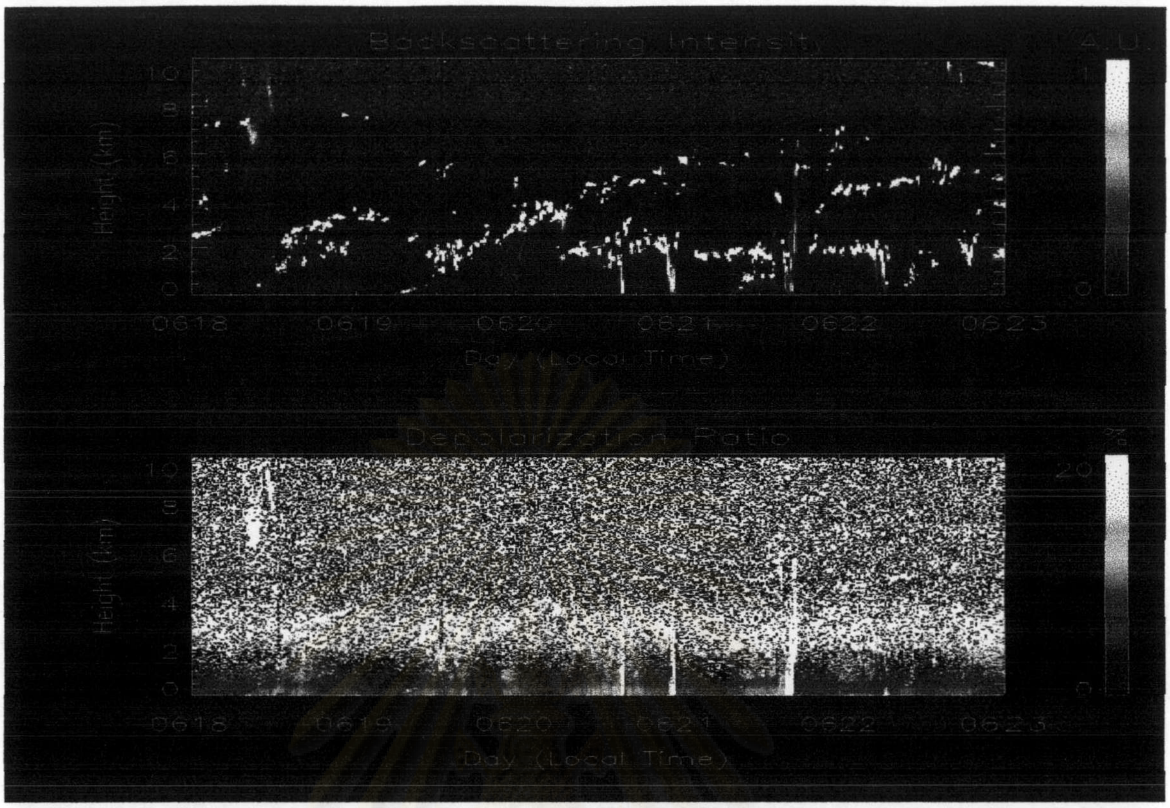

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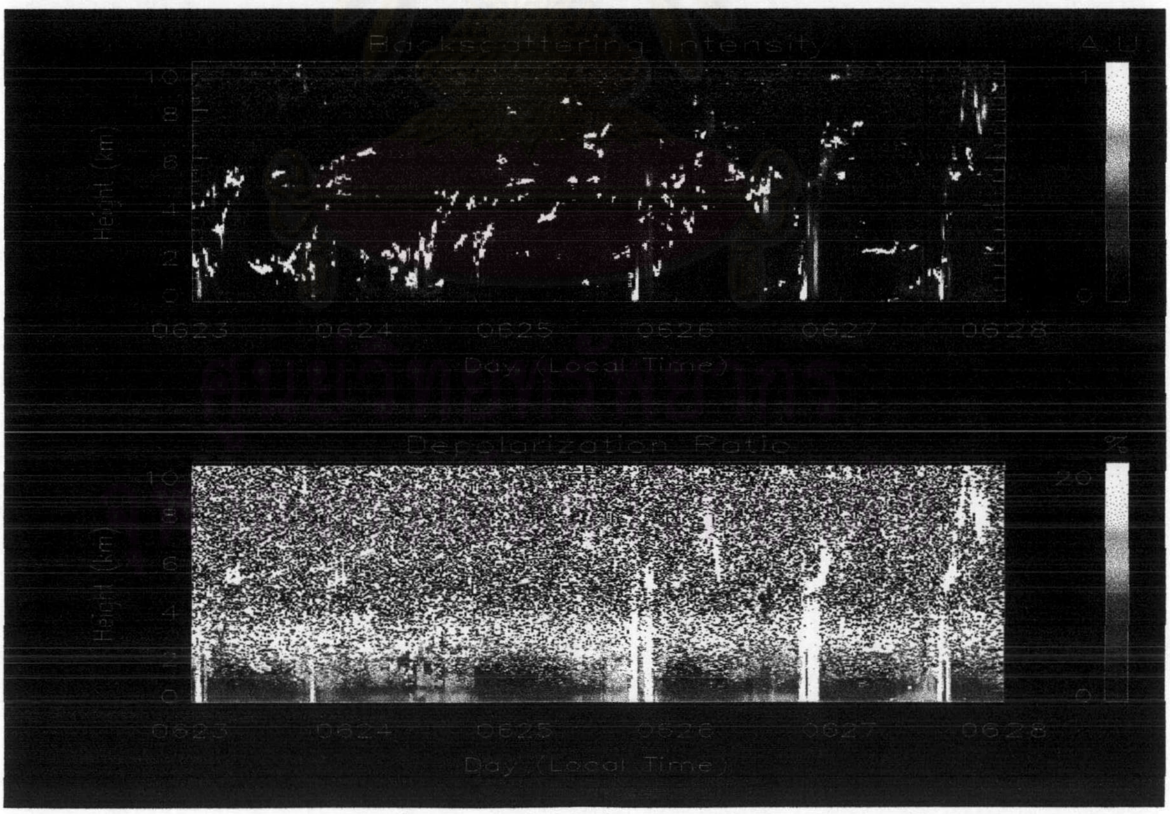

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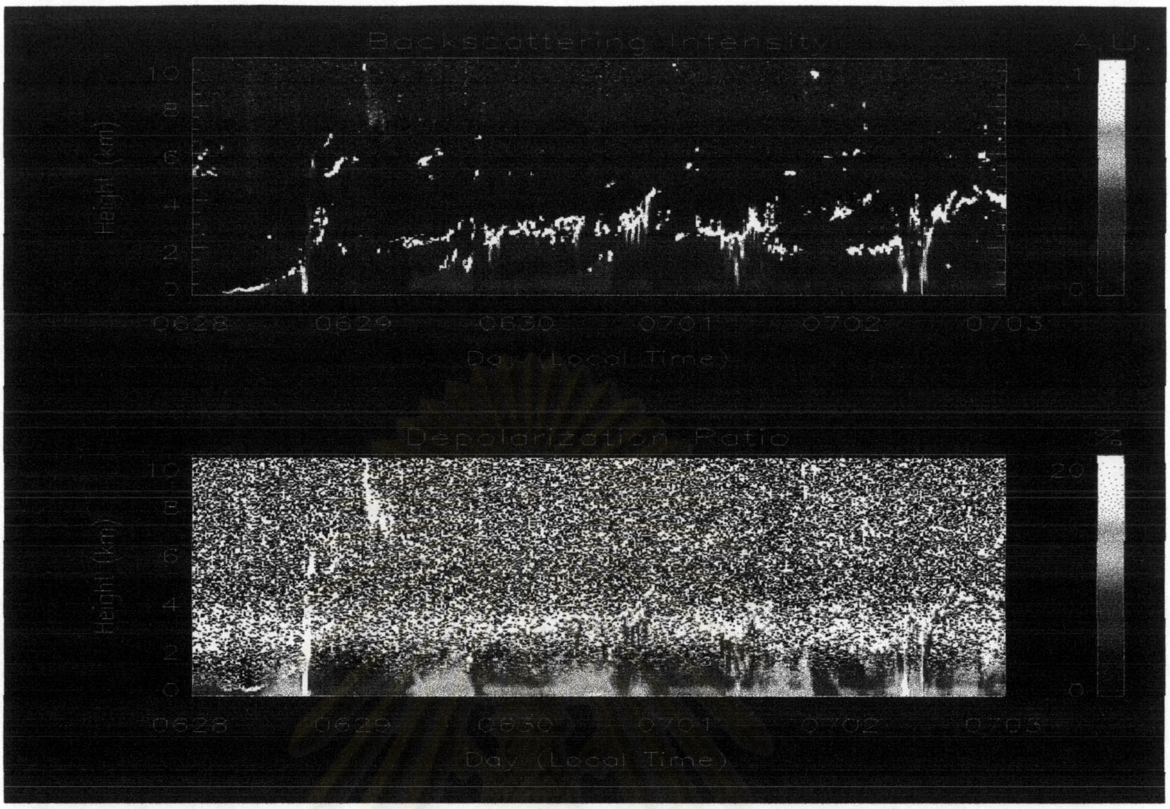

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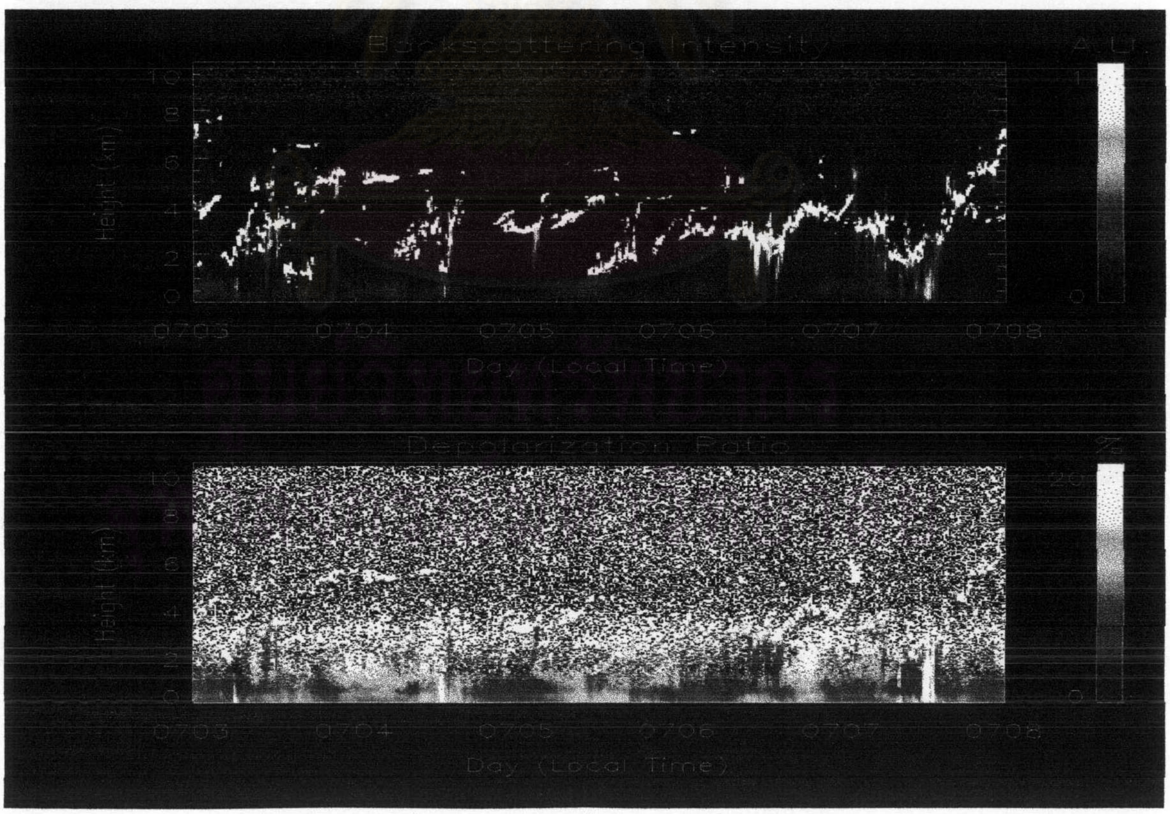

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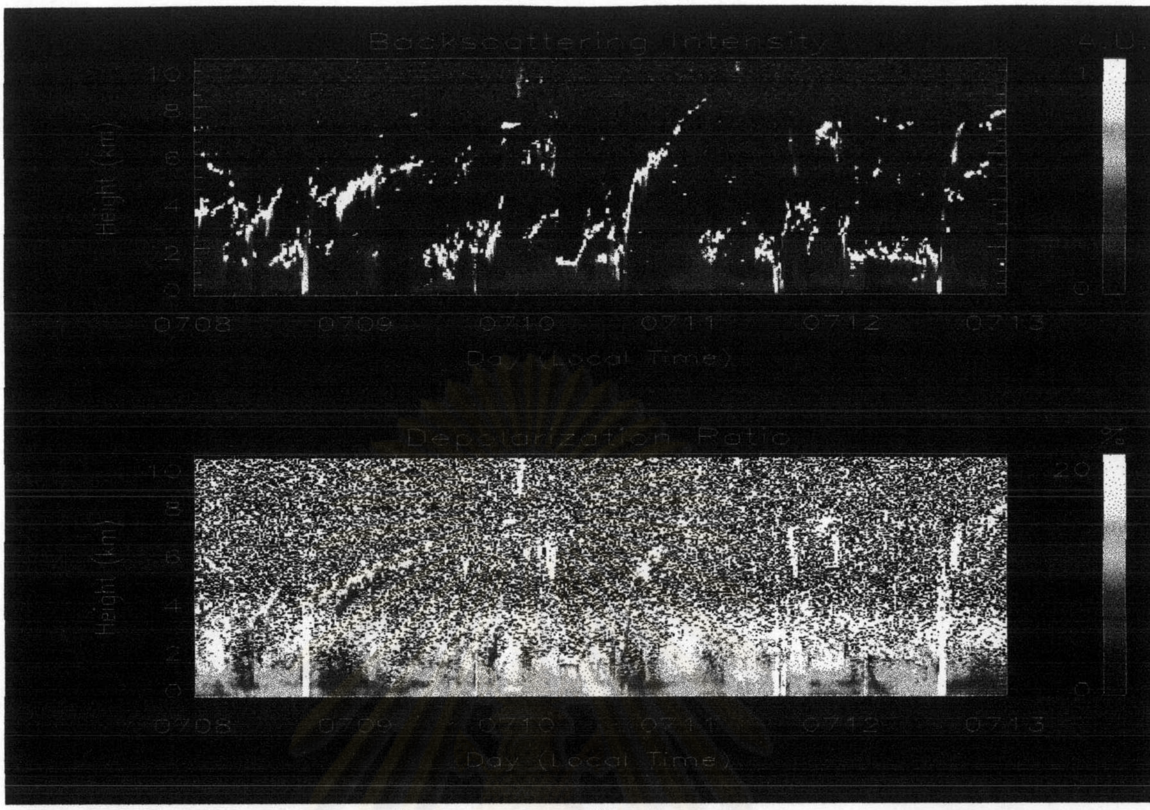
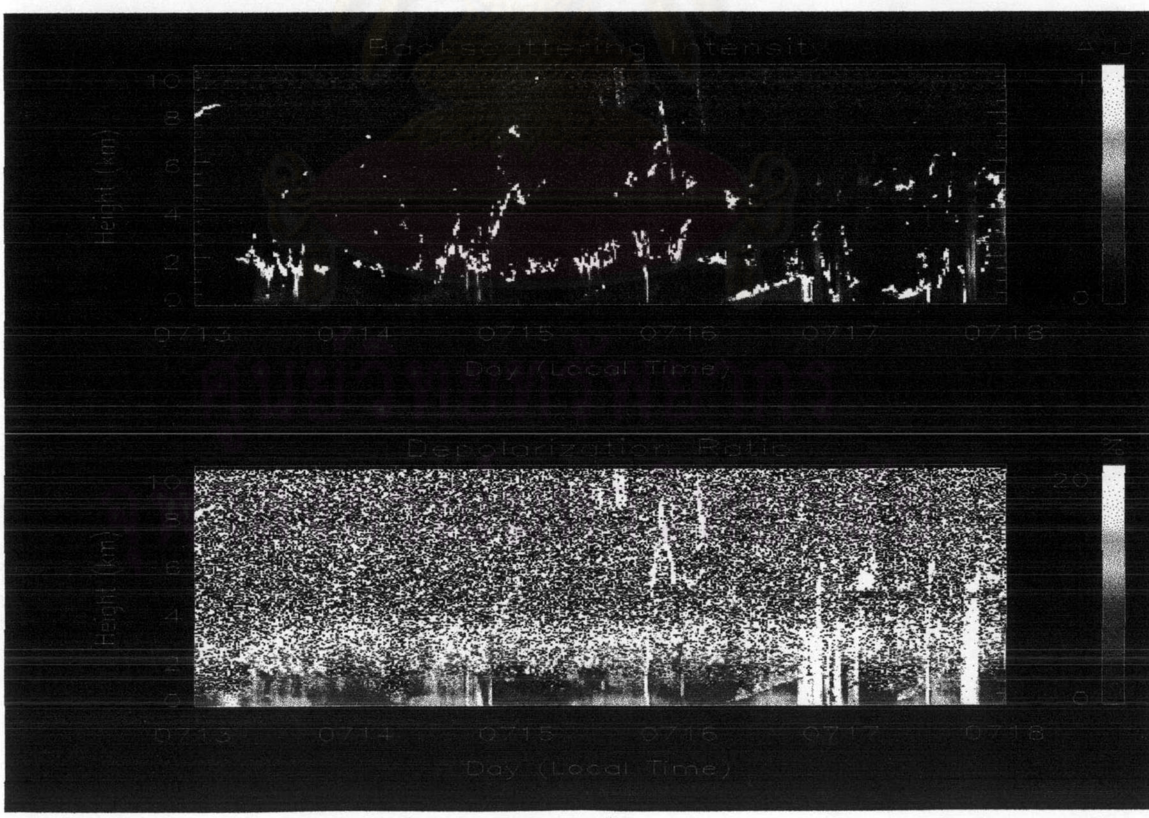


8th July 2002 – 12th July 2002



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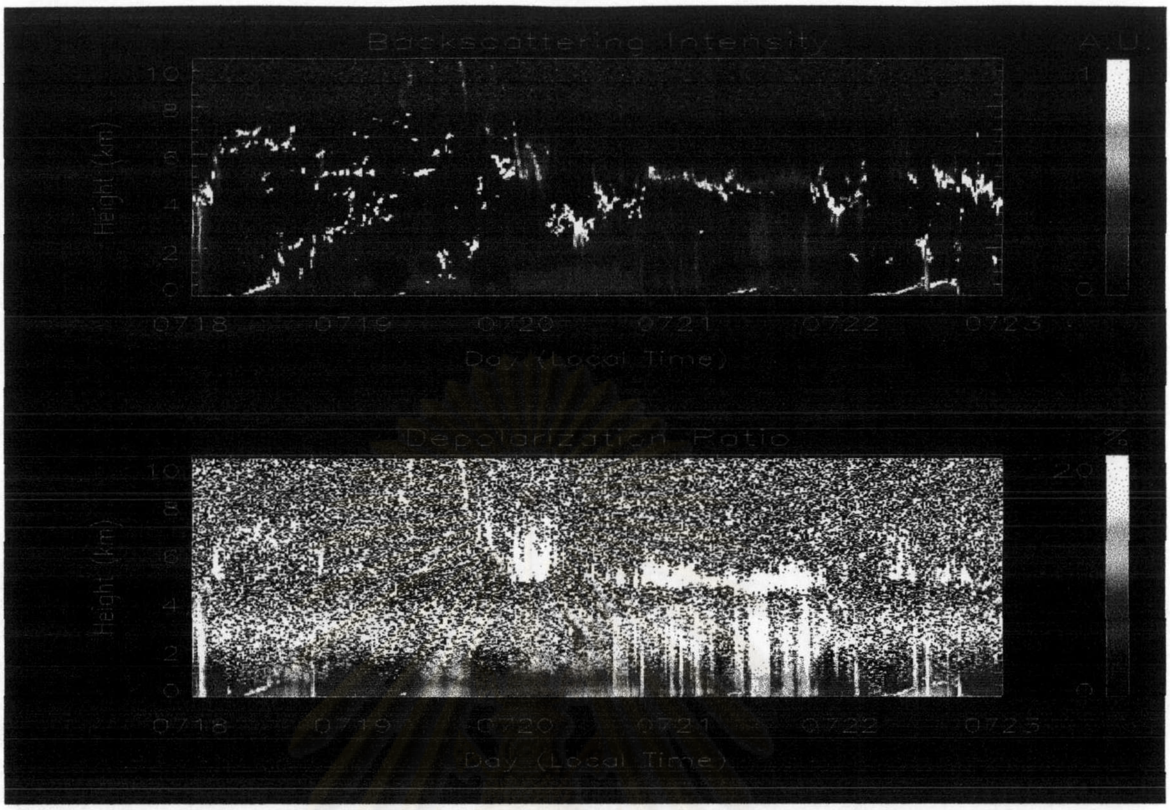
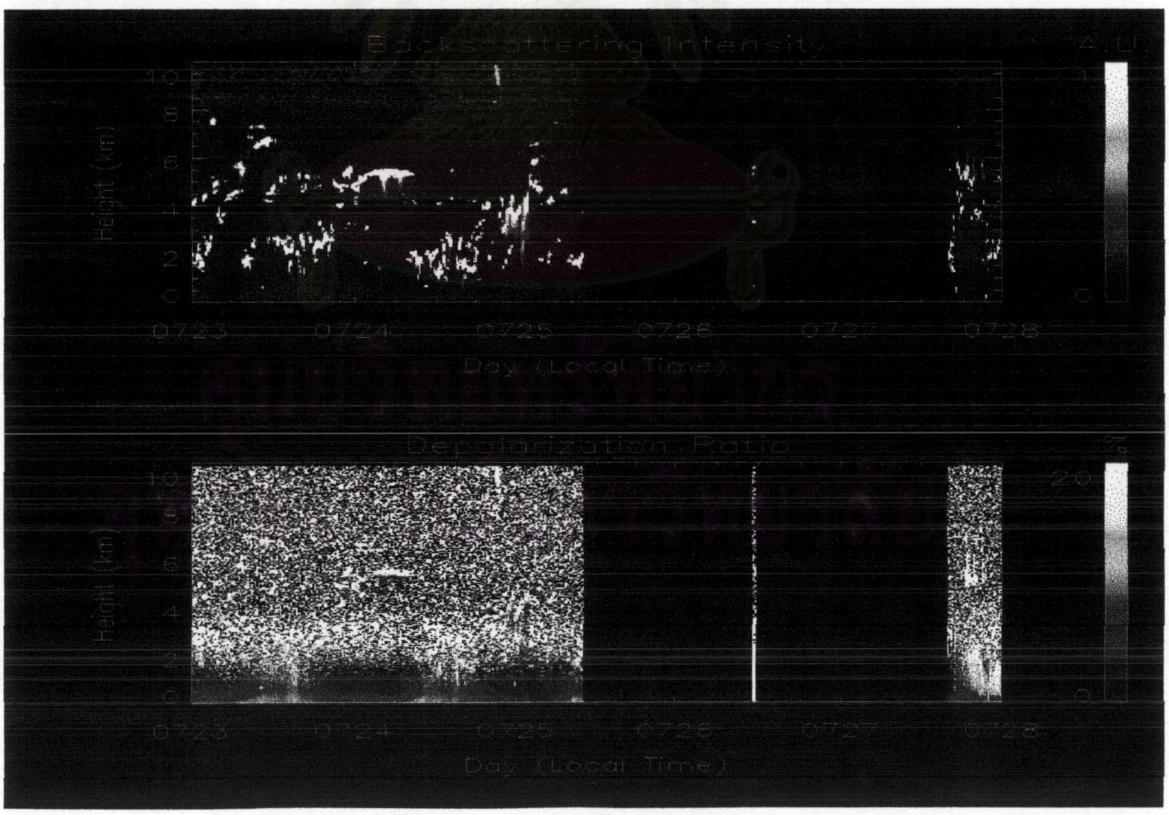
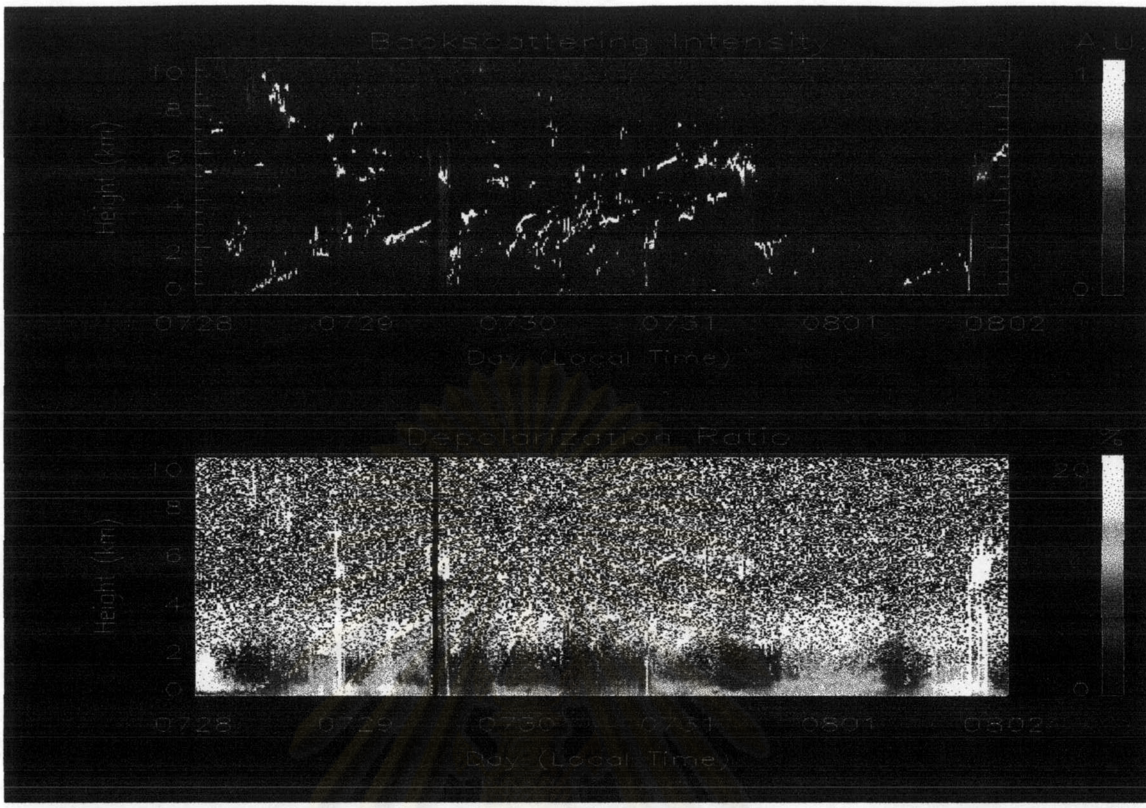


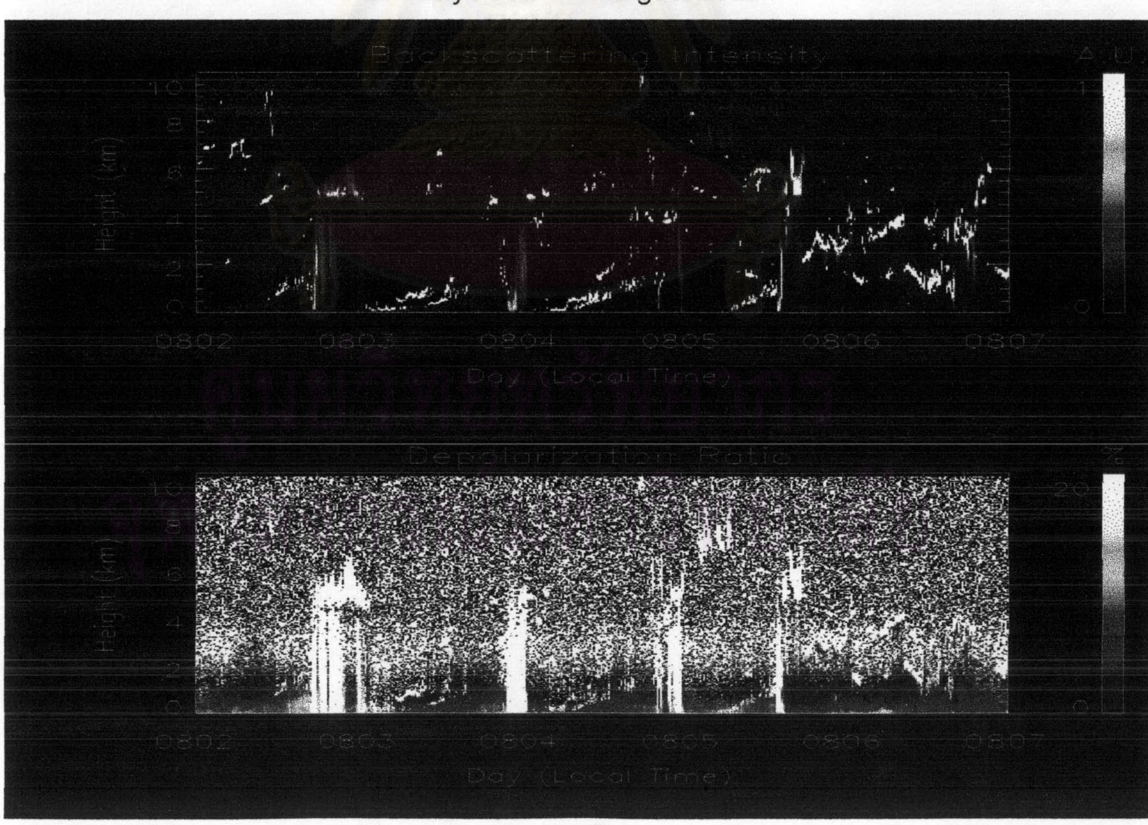
18th July 2002 – 22nd July 2002



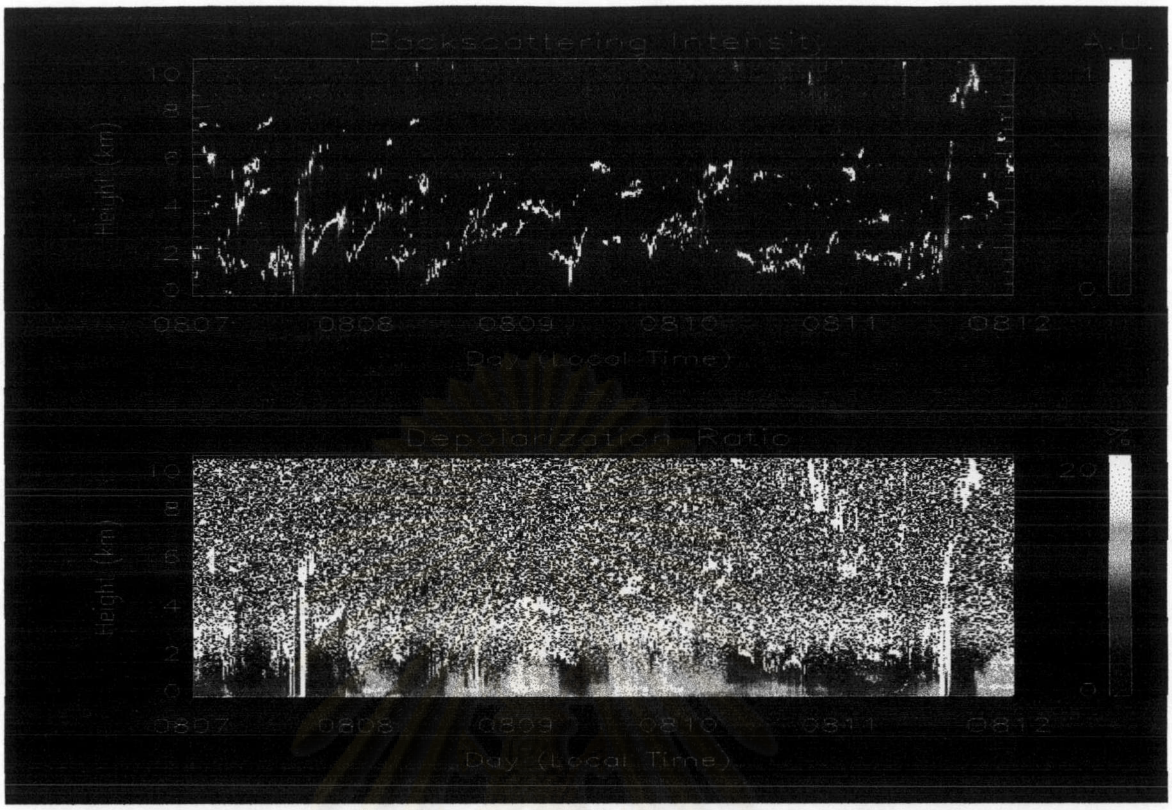
23rd July 2002 – 27th July 2002



28th July 2002 – 1st August 2002



2nd August 2002 – 6th August 2002



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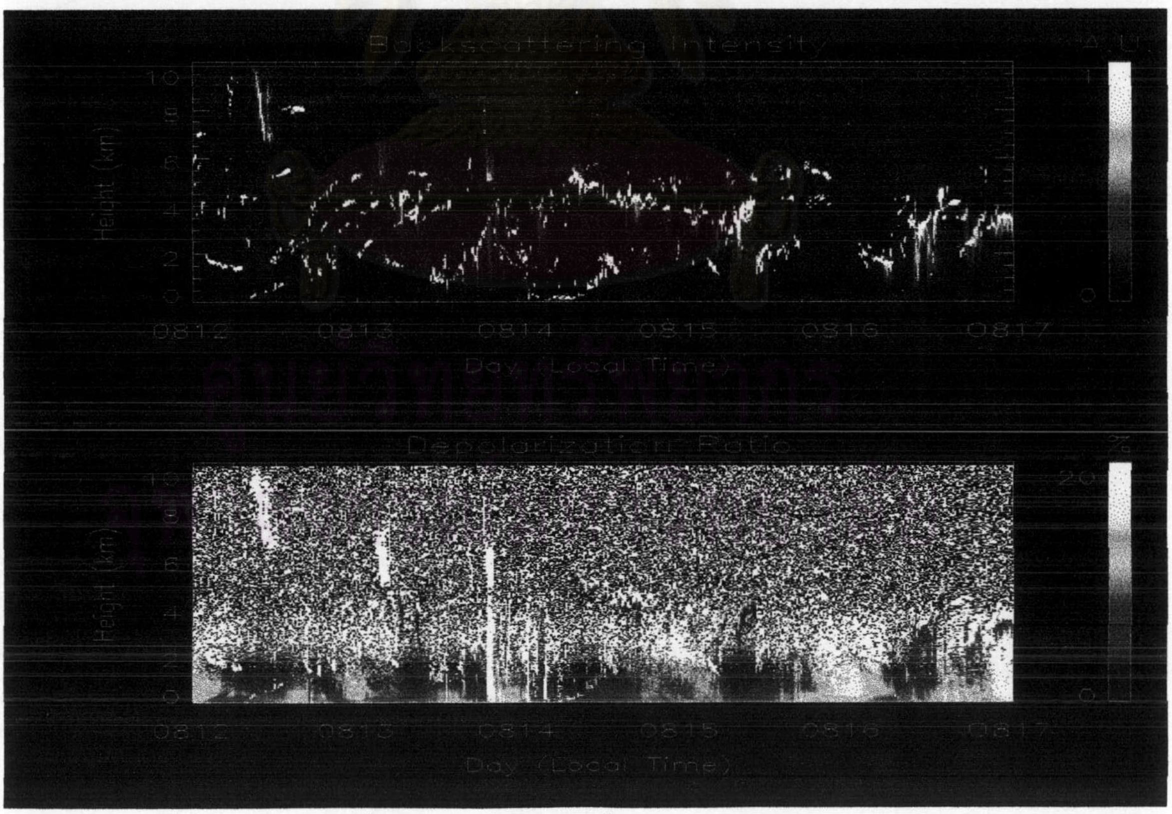

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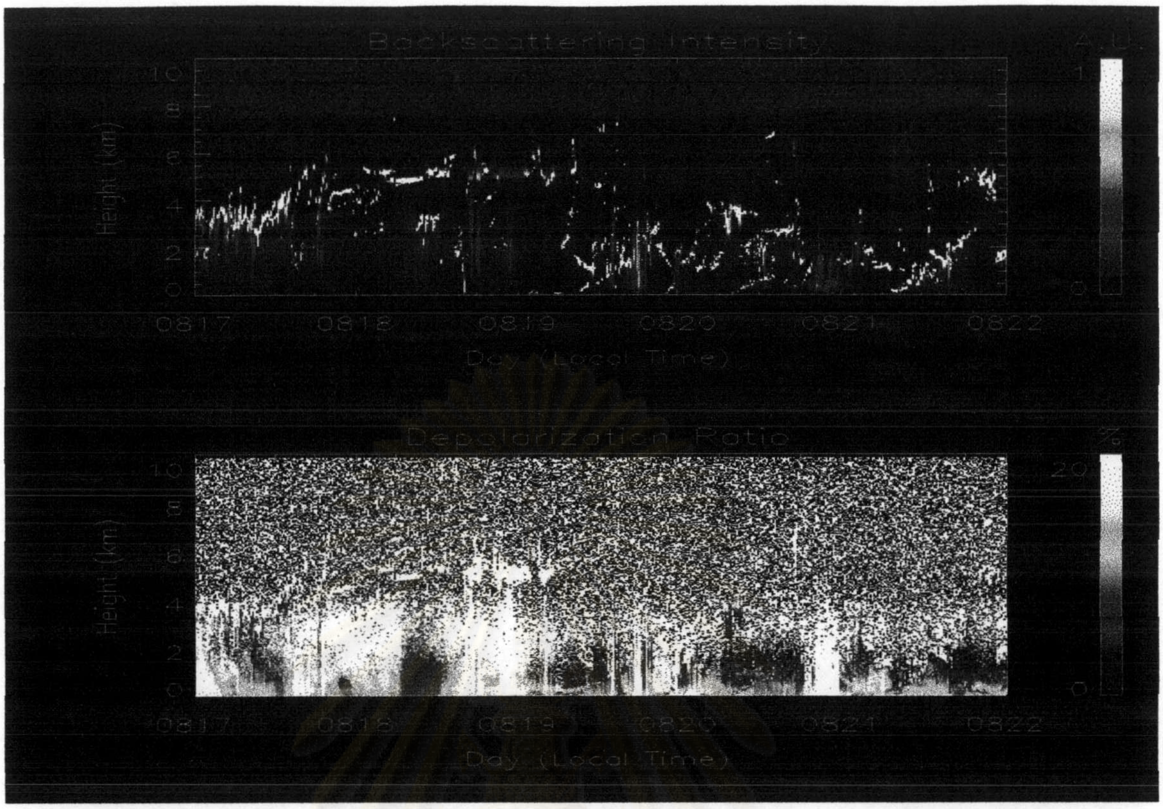
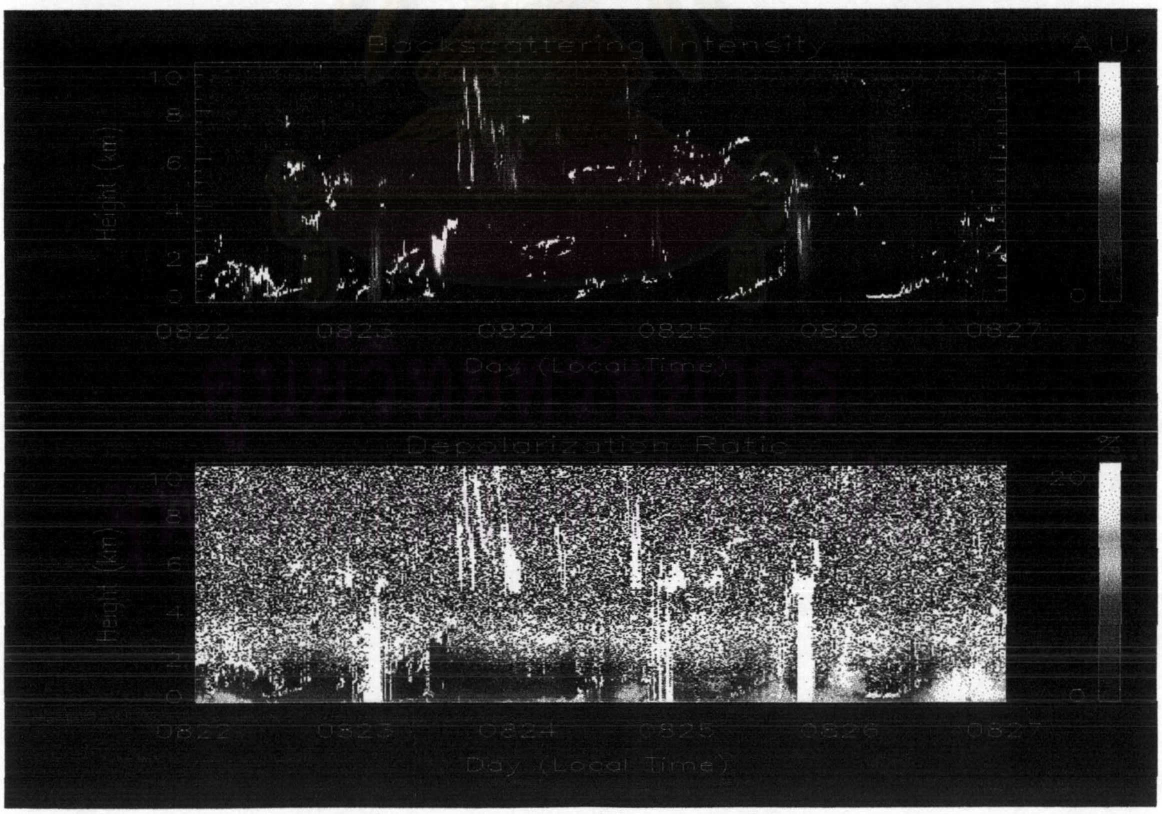


17th August 2002 – 21st August 2002



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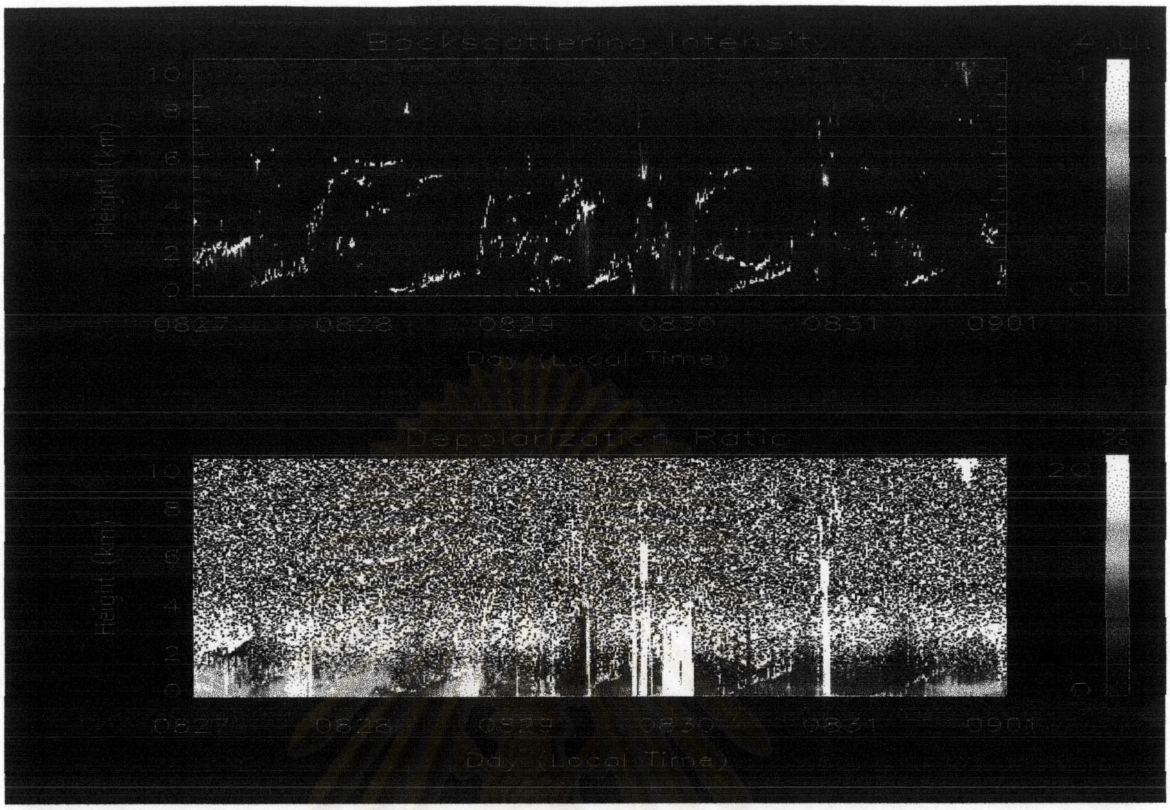

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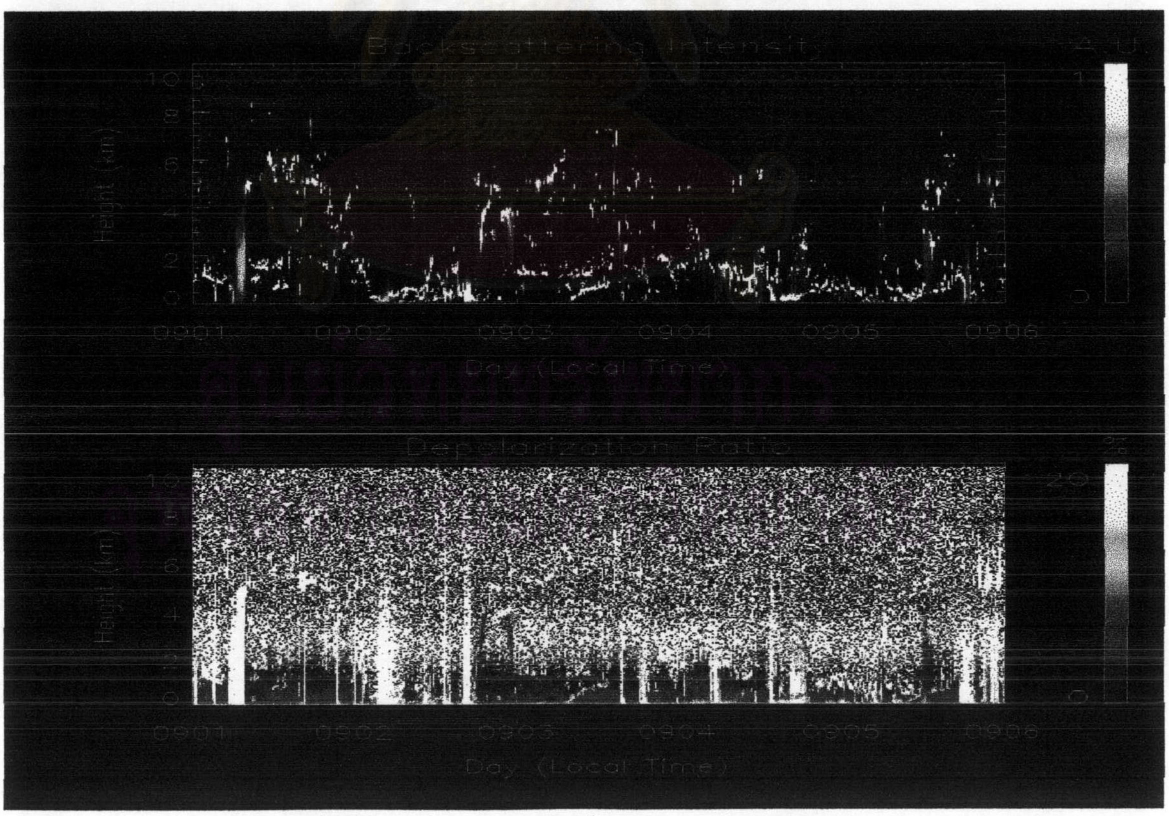

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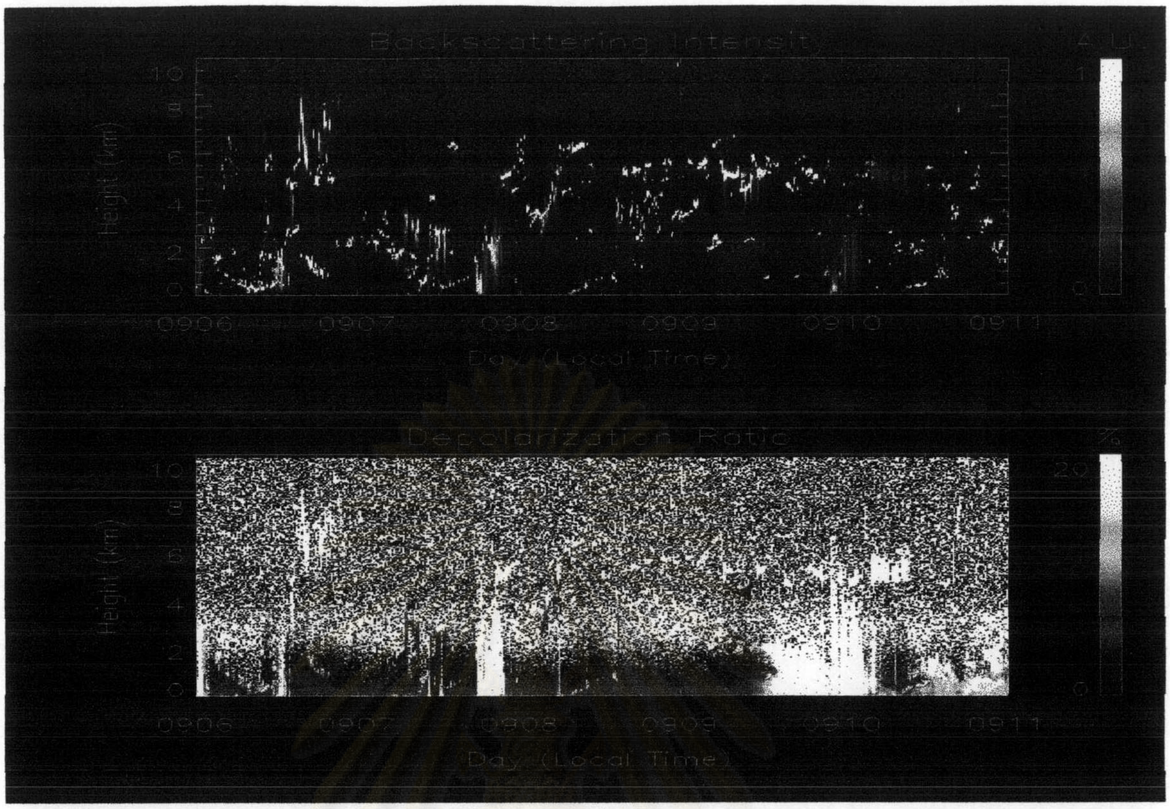
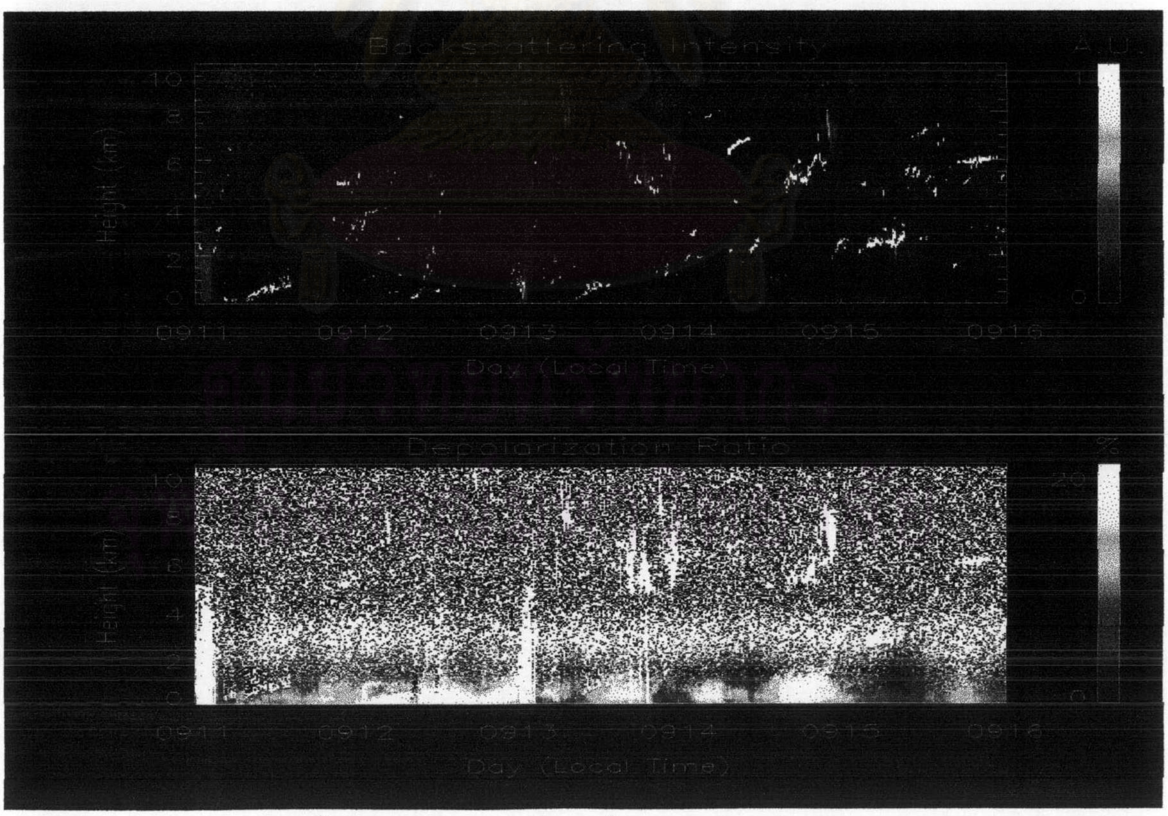


6th September 2002 – 10th September 2002



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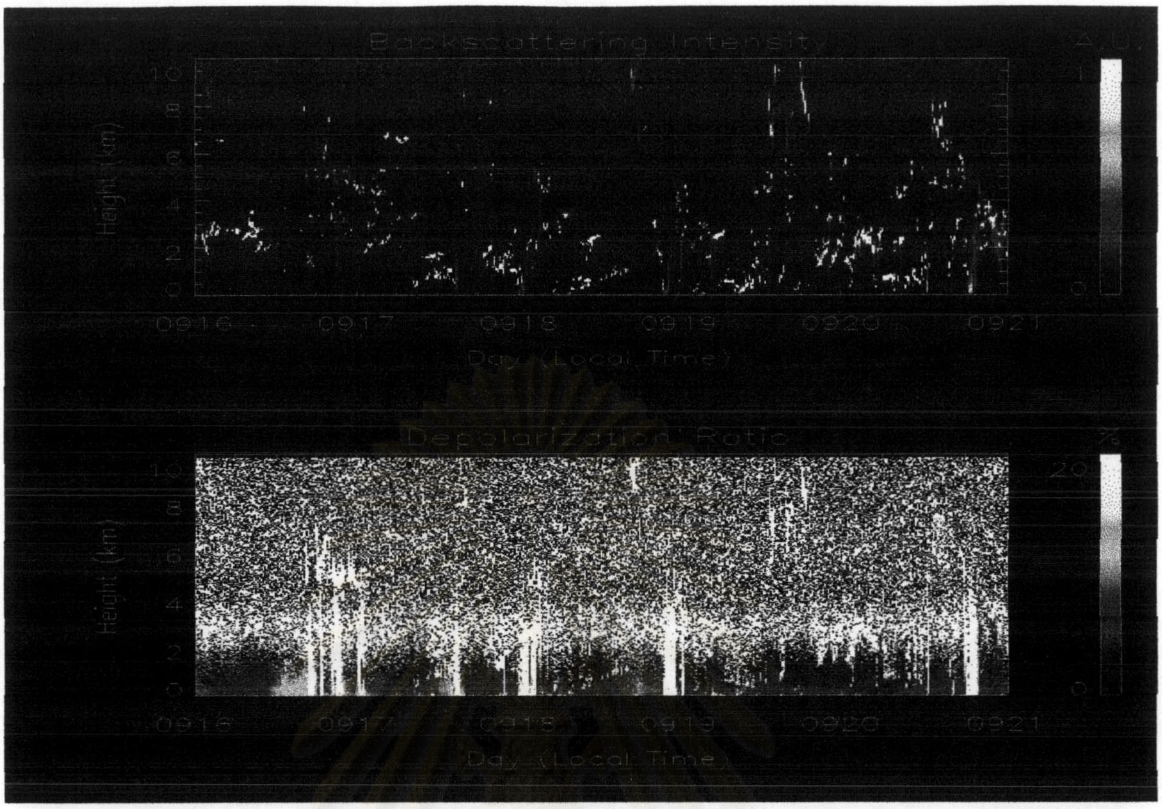

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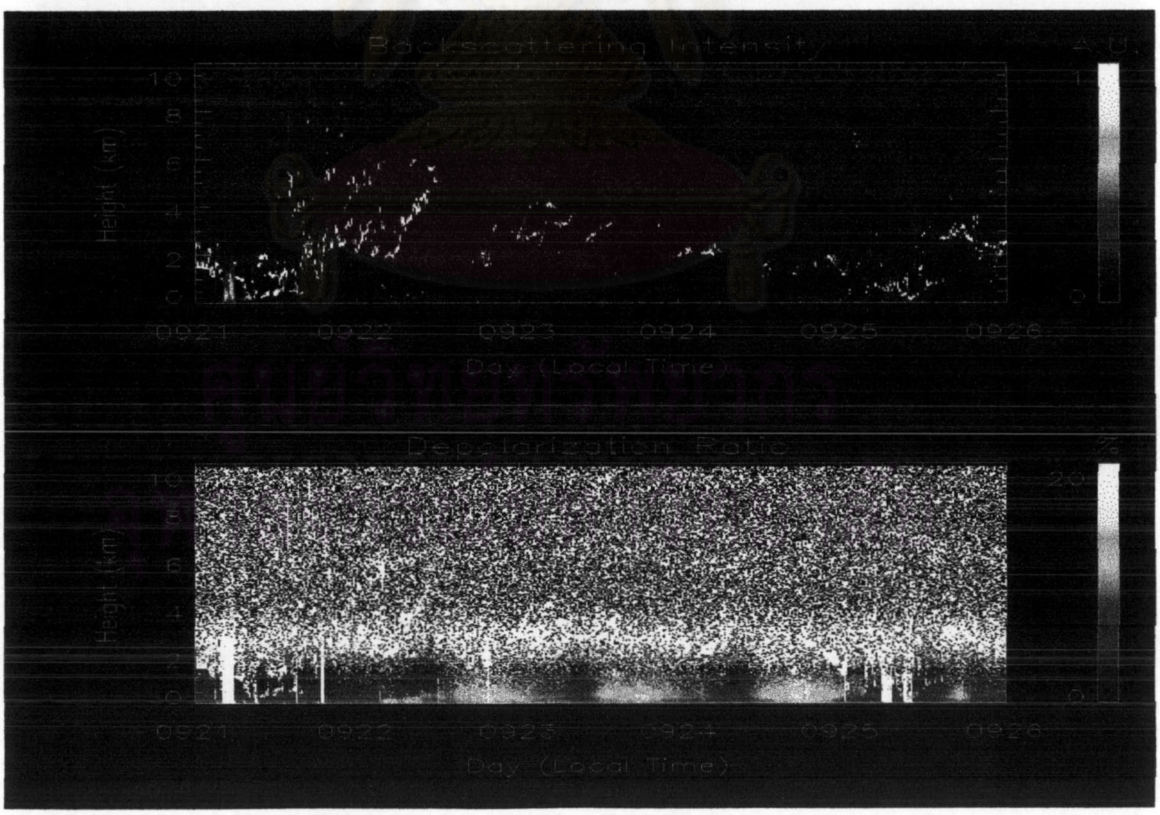
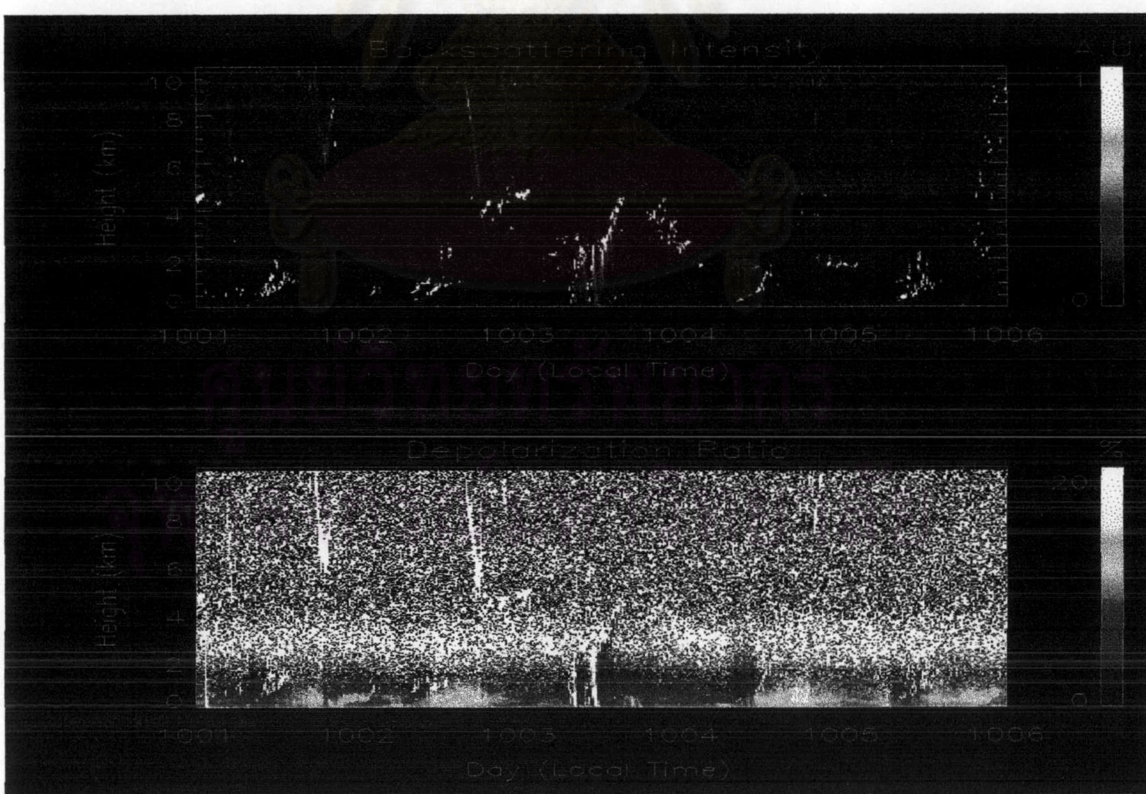


21st September 2002 – 25th September 2002

26th September 2002 – 30th September 2002



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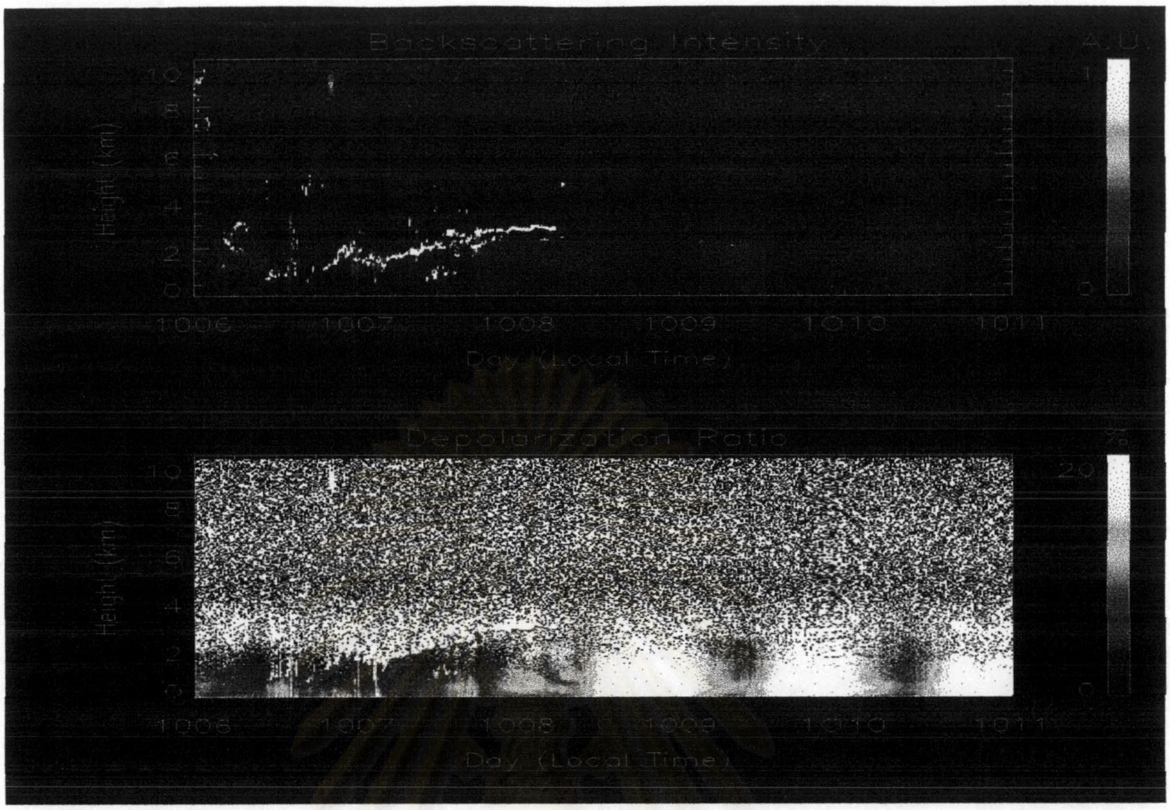
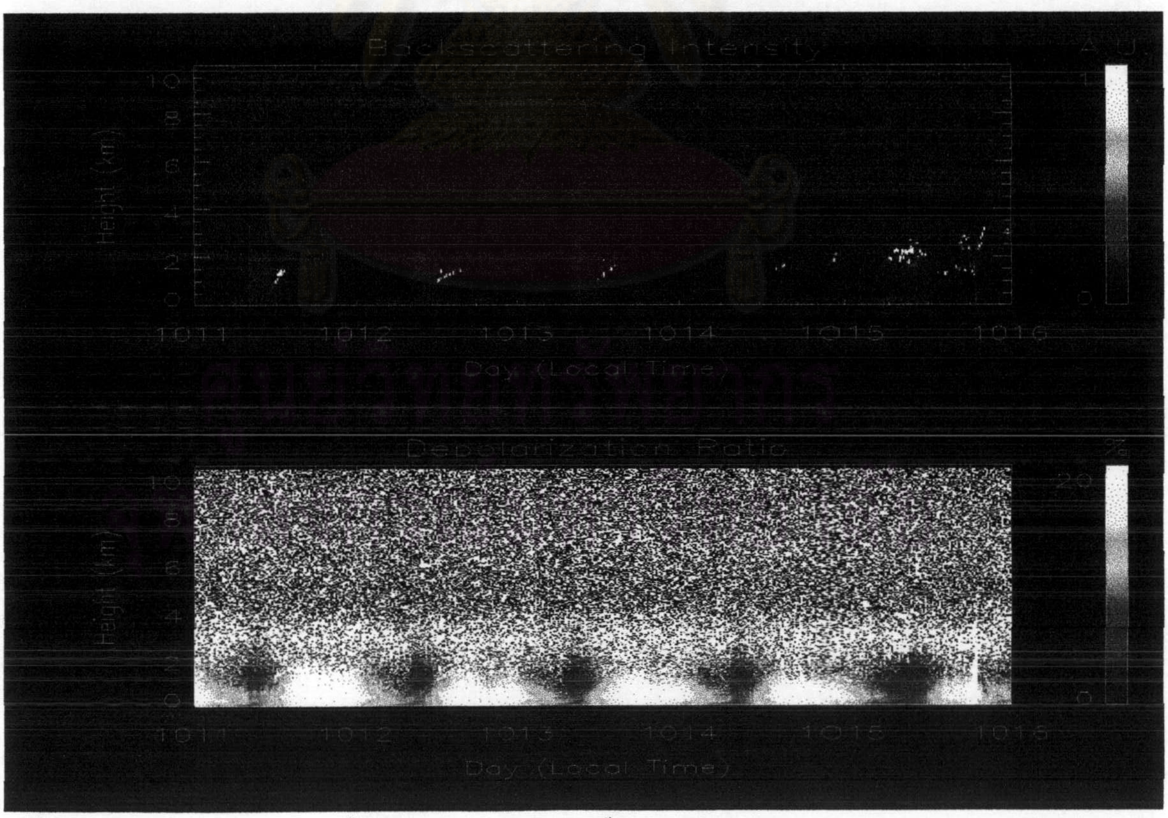


6th October 2002 – 10th October 2002



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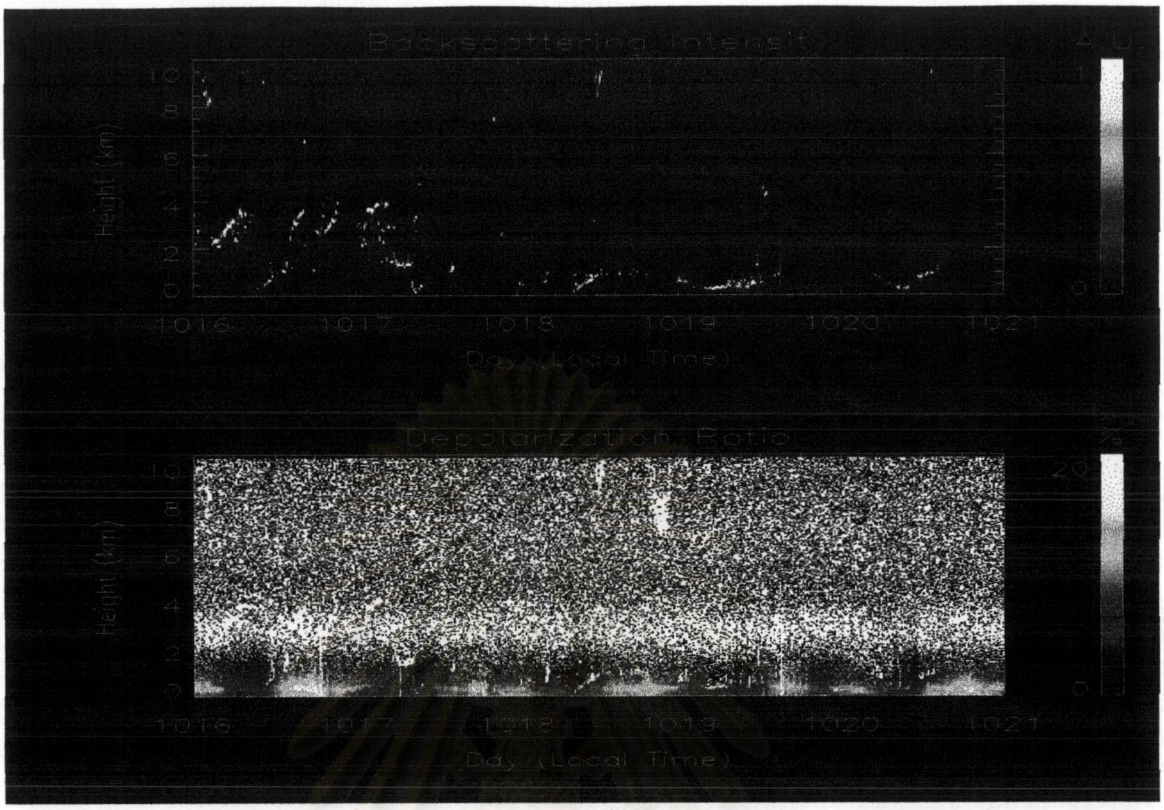
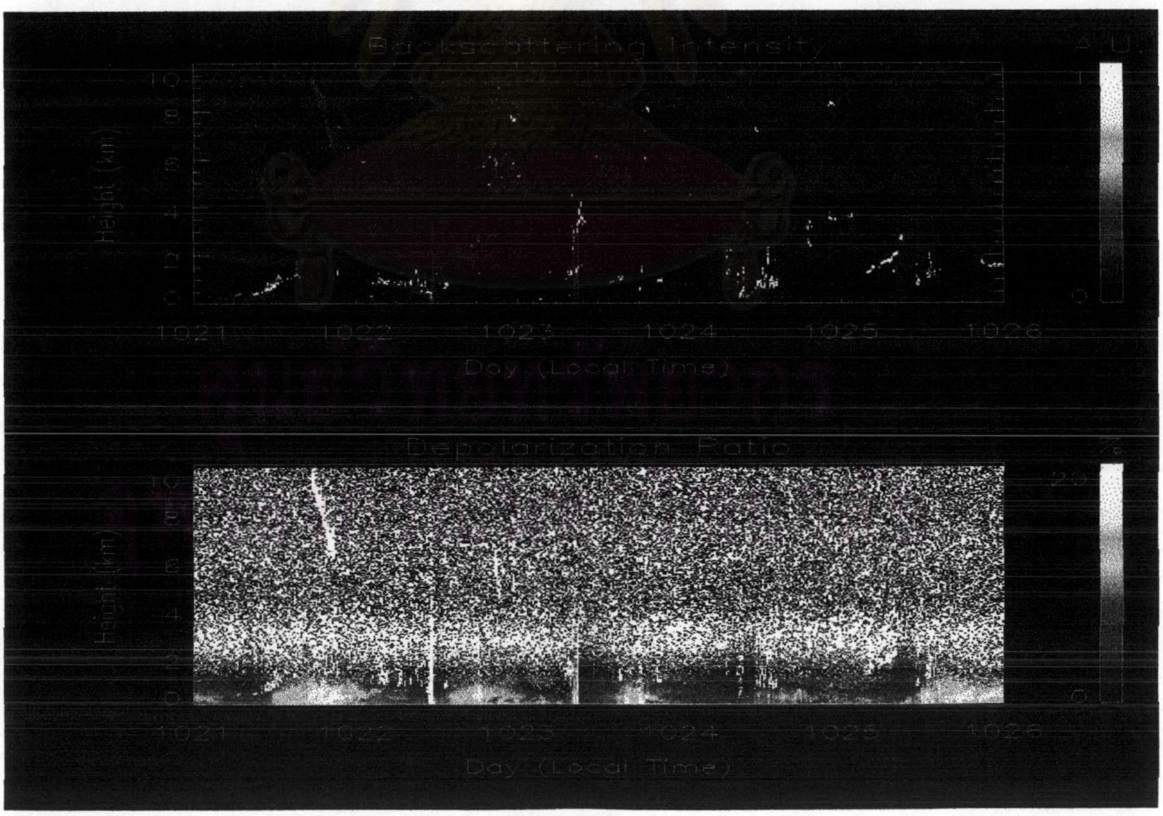
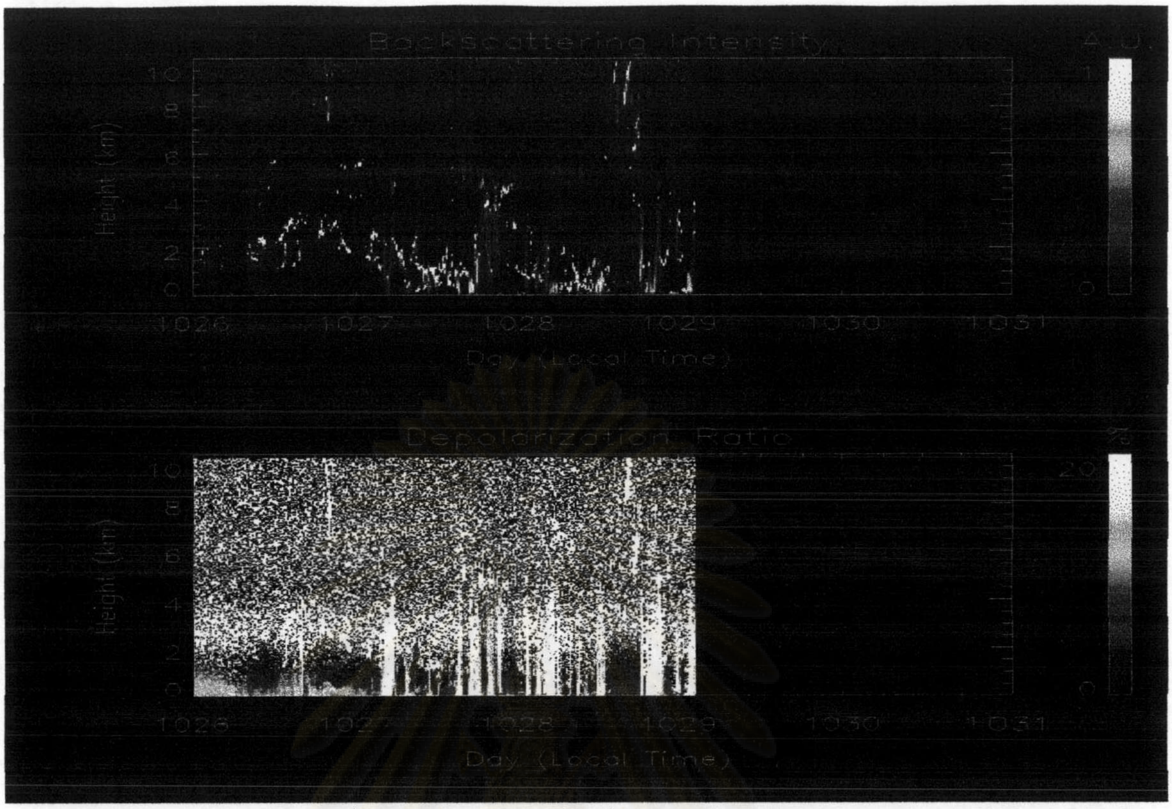


16th October 2002 – 20th October 2002

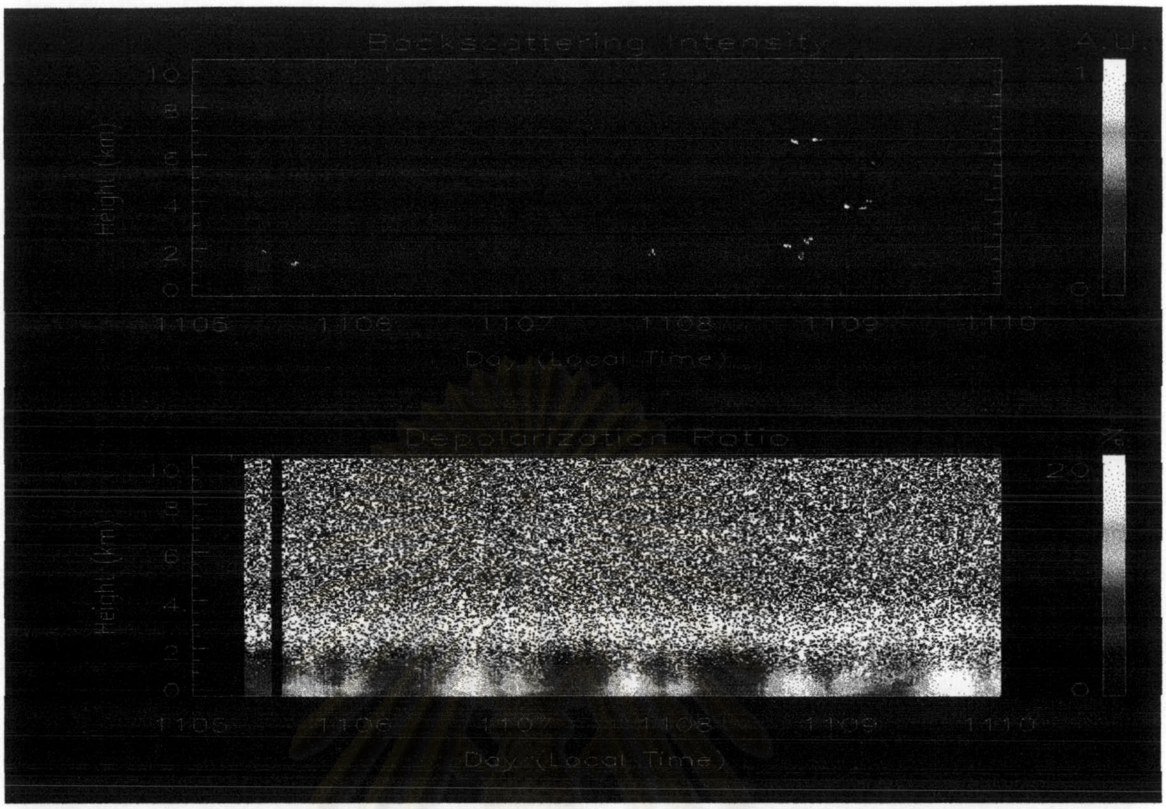


21st October 2002 – 25th October 2002

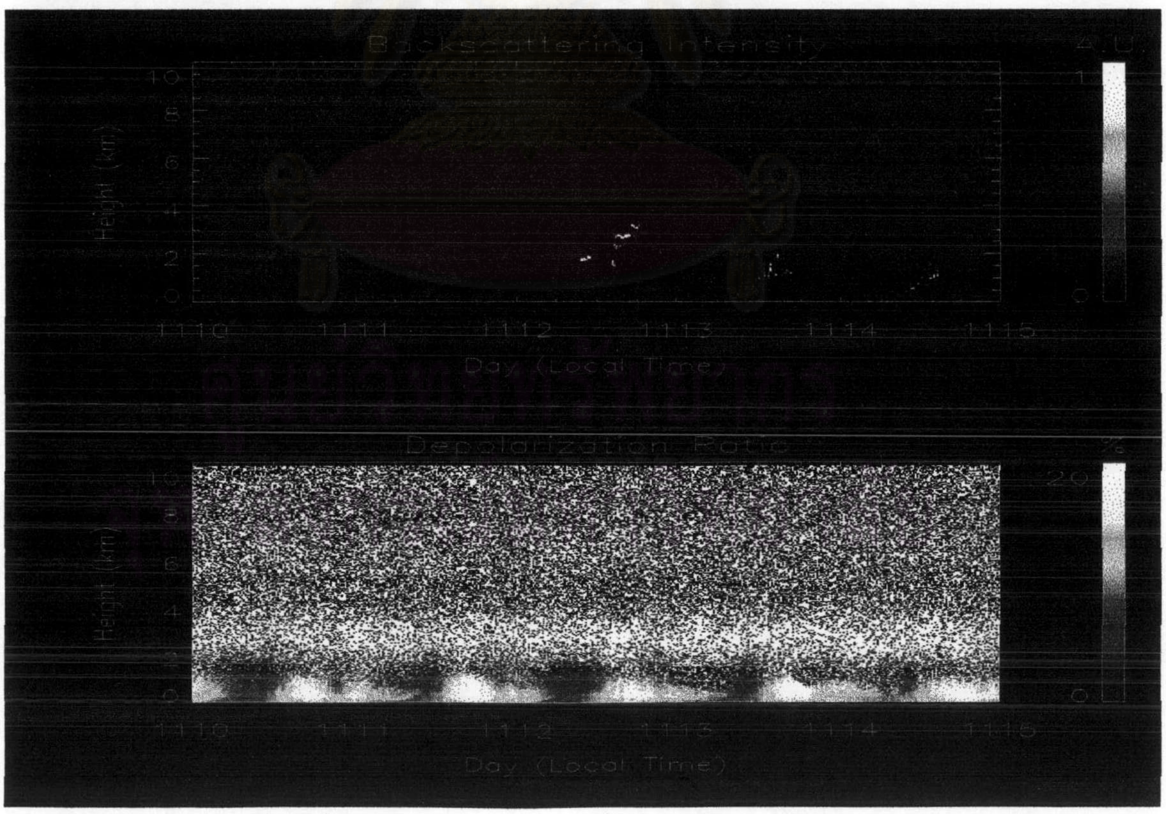


26th October 2002 – 30th October 2002

31st October 2002 – 4th November 2002



5th November 2002 – 9th November 2002



10th November 2002 – 14th November 2002