

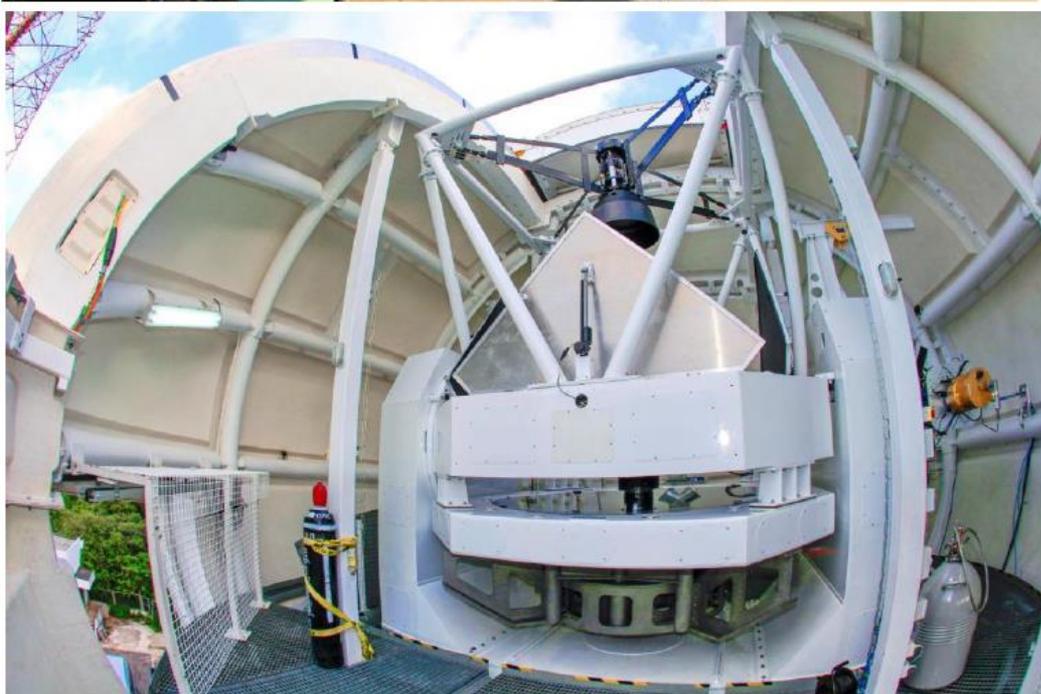


Atmospheric Characterization at TNO for Astronomy

“The atmosphere is an astronomer’s worst enemy.”

Ronald Macatangay (ronmcdo@gmail.com) and Somsawat Rattanasoon (Operations)
Atmospheric Research Unit, National Astronomical Research Institute of Thailand, Chiang Mai, Thailand

Jansawang Panomprai, Sauwaporn Pongpaisirikul, Porrawit Thaimai, Panpaka Suropan, Donduedee Sookjai, Thiranan Sonkaew, Ram Kesh Yadav, Raman Solanki, Pornisara Nuchvanichakul and Kyra Rumbaua



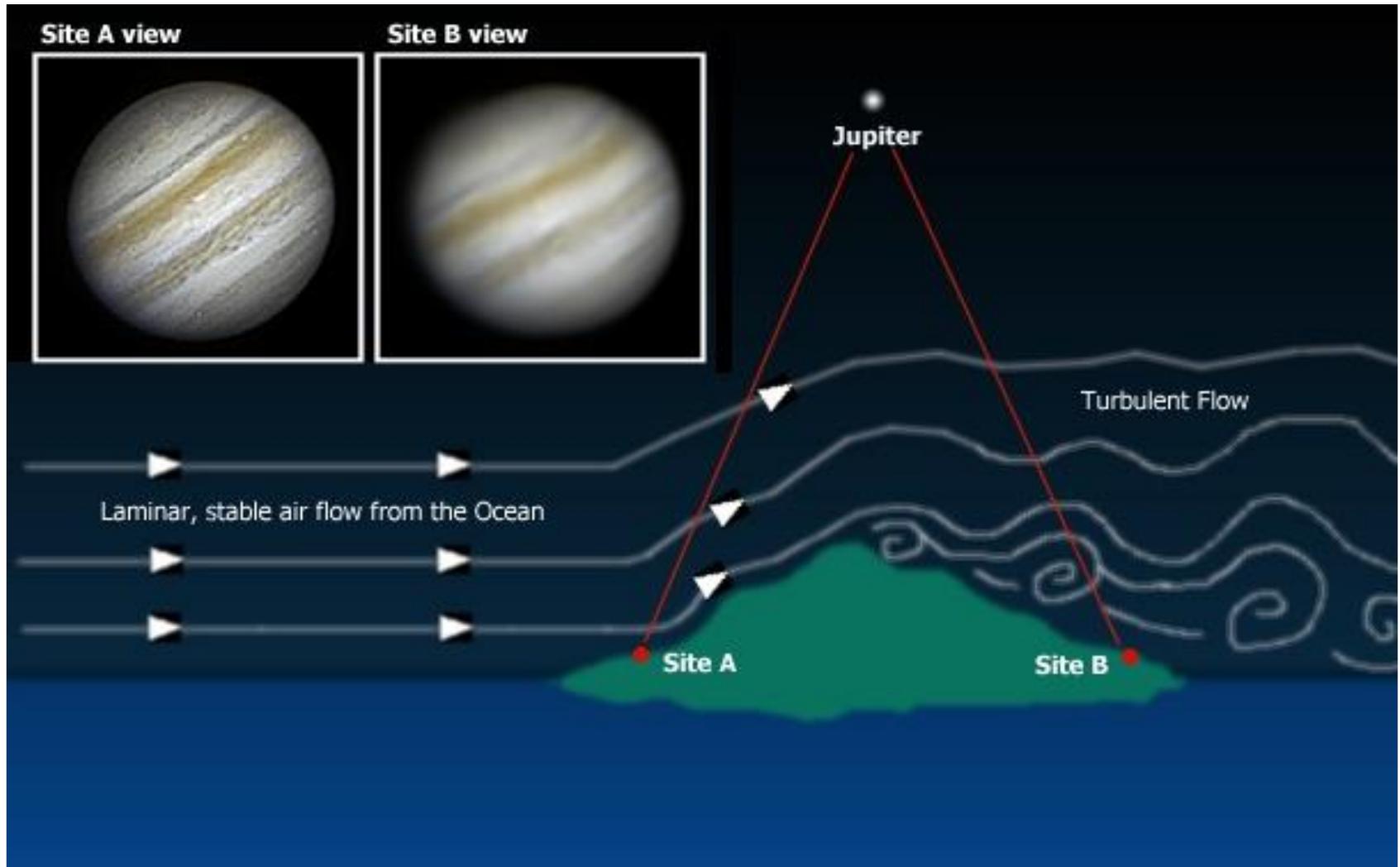
**Thai National Observatory,
2.4-m Thai National Telescope, TNT**

Outline

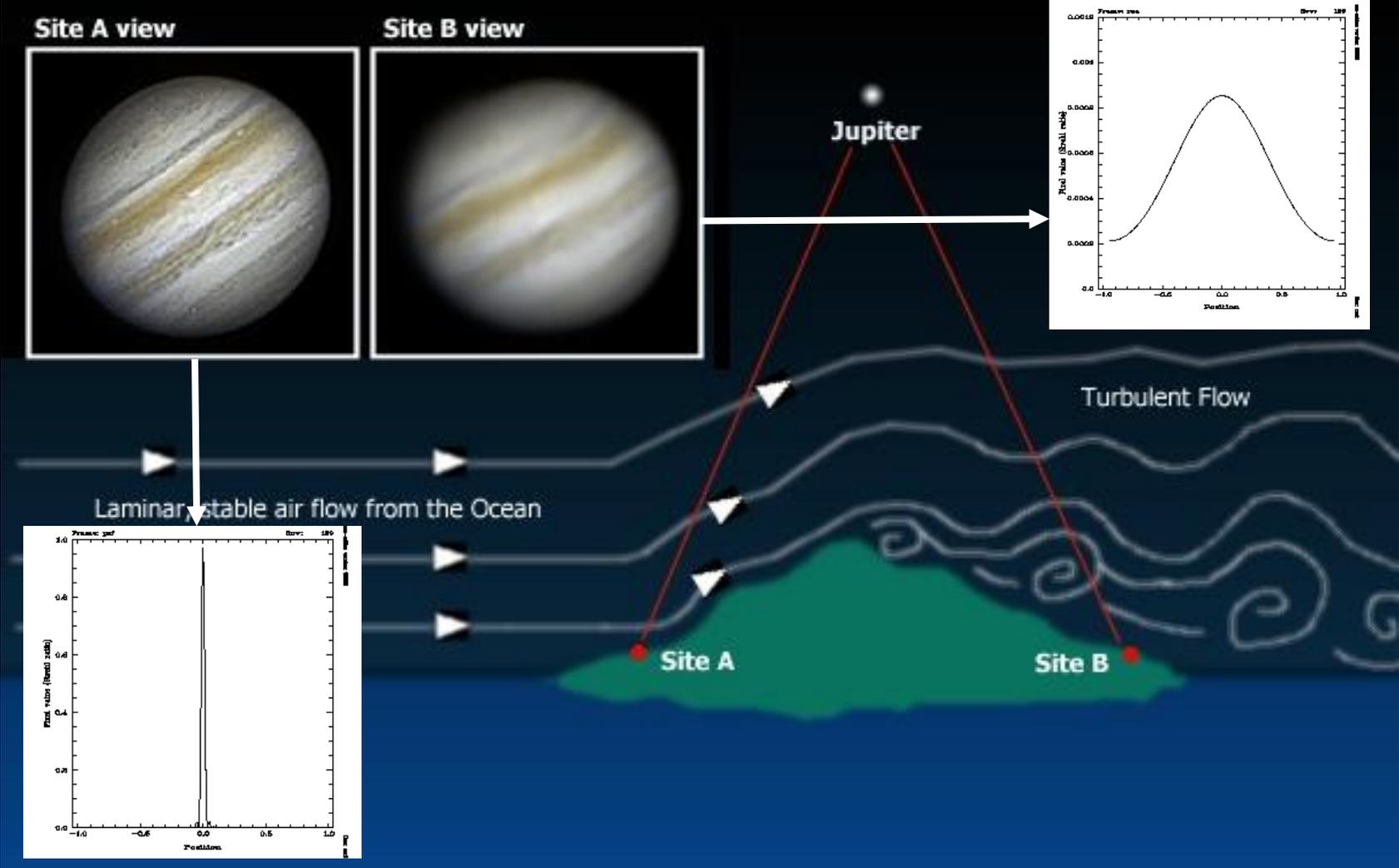
- Astronomical Seeing
- Atmospheric Extinction
- Aerosols
- Atmospheric Light Detection and Ranging (LiDAR)
- Potential Research Topics

Astronomical Seeing

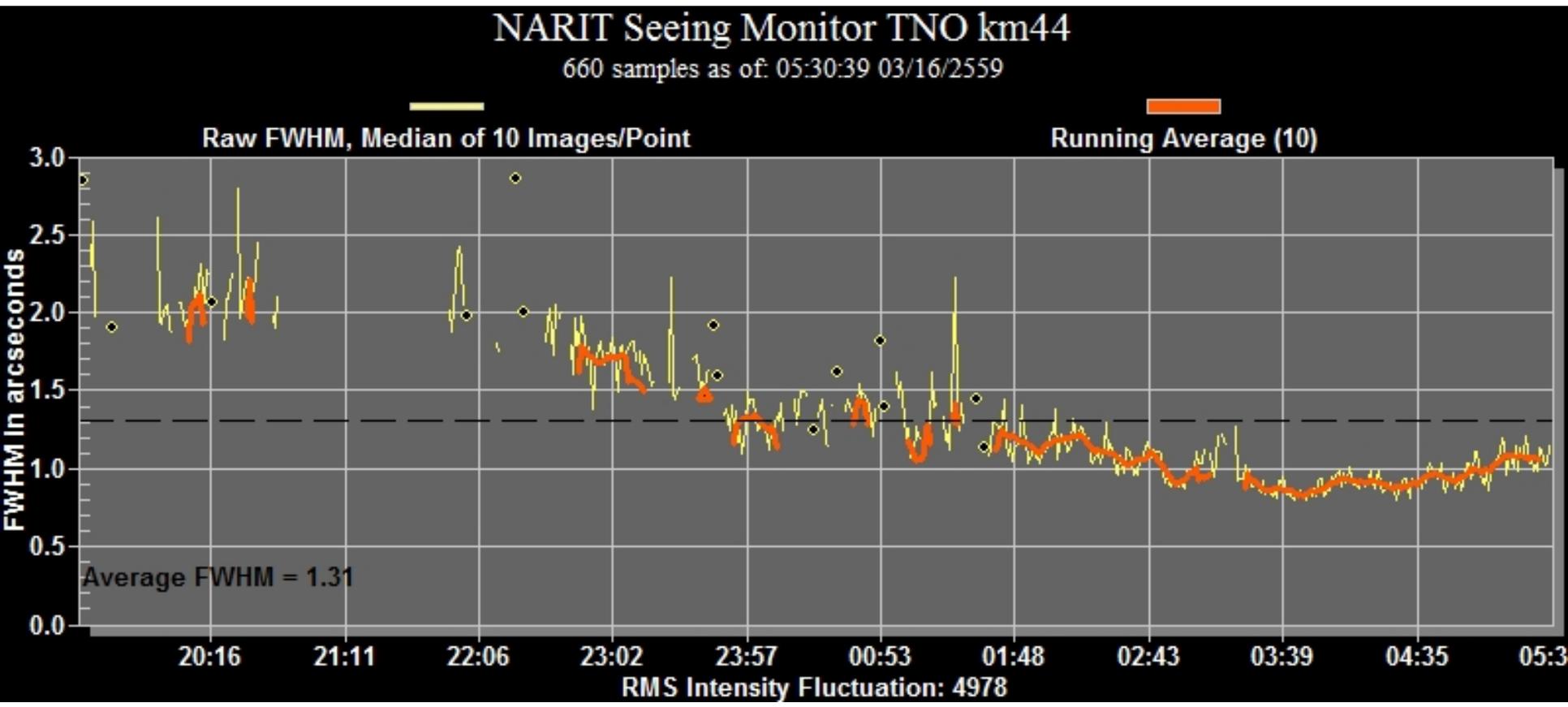
Air is responsible for poor *seeing* when it bends light chaotically, causing telescopic images to waver and smear. And it's responsible for poor transparency when it absorbs and scatters light, causing faint objects to appear even fainter than they really are.



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Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model

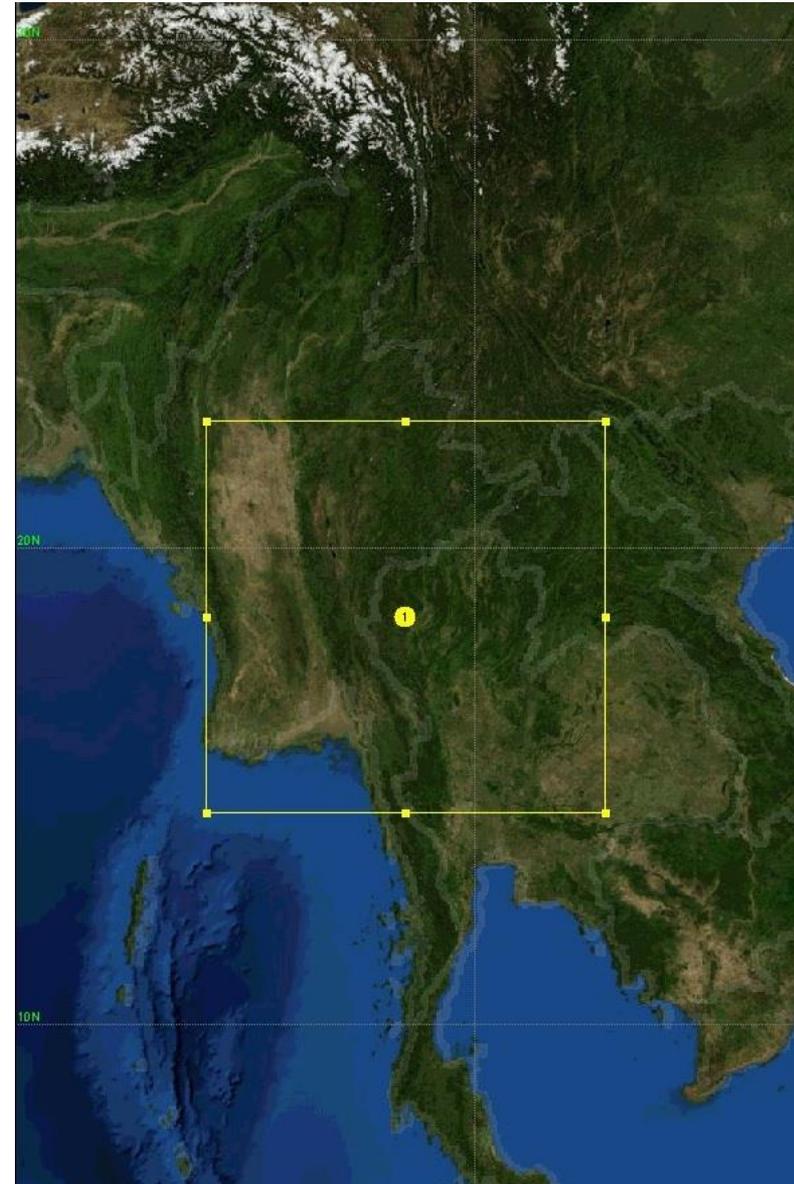
Model Setup

- (i) Initial / lateral boundary conditions from the NCEP Global Forecast System (GFS) 0.25 degree resolution
- (ii) A coarse grid, having a resolution of $\Delta x = \Delta y = 9$ km.
- (iii) 28 vertical levels, with a higher resolution in the surface layer $\Delta h_1 = 56.6$ m and $\Delta h_{28} = 1047$ m

The main parameters used for the simulation are as follows:

- (i) the microphysics scheme used is the Lin scheme ($mp_physics = 2$),
- (ii) the Rapid Radiative Transfer Model (RRTM) scheme is used for the long wave radiation ($ra_lw_physics = 1$),
- (iii) the Dudhia scheme is used for the short wave radiation ($ra_sw_physics = 1$),
- (iv) the Yonsei University scheme is used for the planetary boundary layer (PBL) ($bl_pbl_physics = 1$)
- (v) the 'simple diffusion' option is used to compute the diffusion ($diff_opt = 1$)

Model Domain

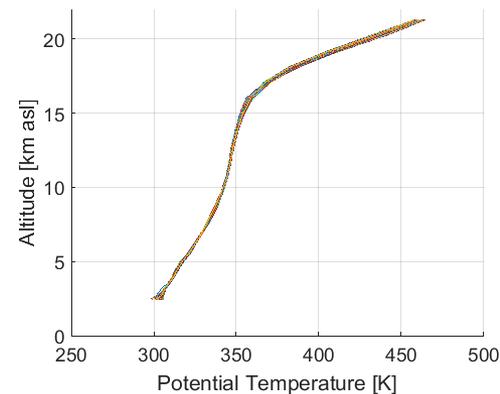
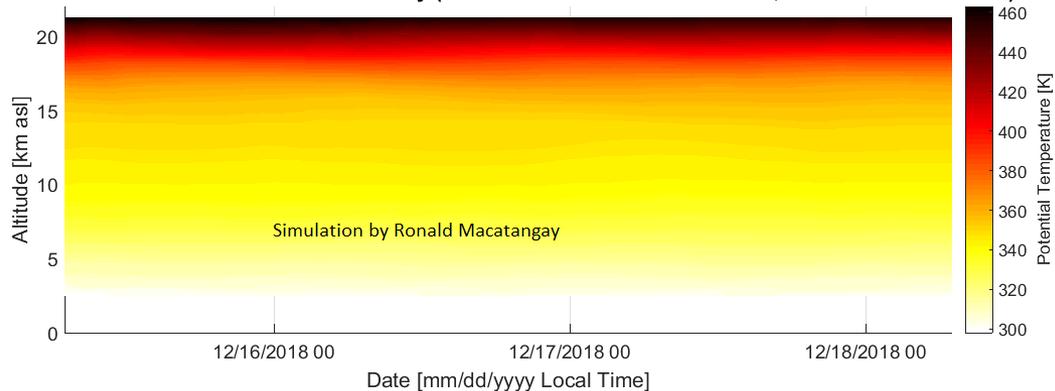


Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model

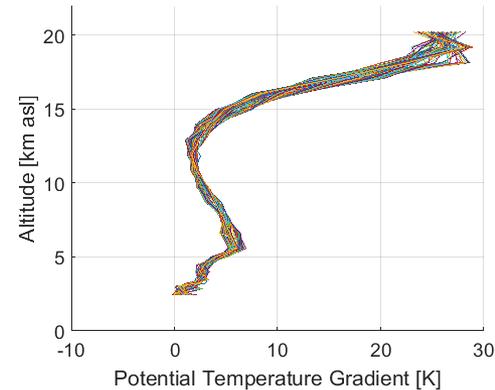
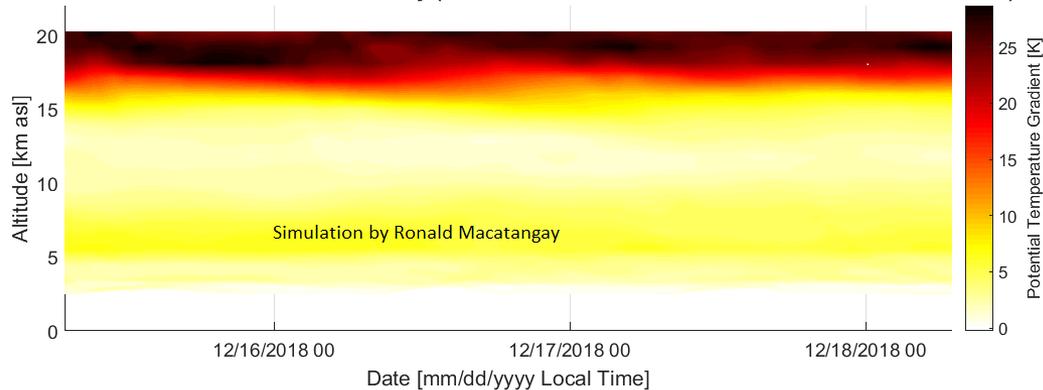
$$\chi(h) = \frac{d\bar{\theta}}{dz} \quad \text{gradient of the mean potential temperature}$$

Giordano et al. (MNRAS 2013)

Forecast for the Thai National Observatory (Model Initialized on December 15, 2018 07:00 Local Time)



Forecast for the Thai National Observatory (Model Initialized on December 15, 2018 07:00 Local Time)

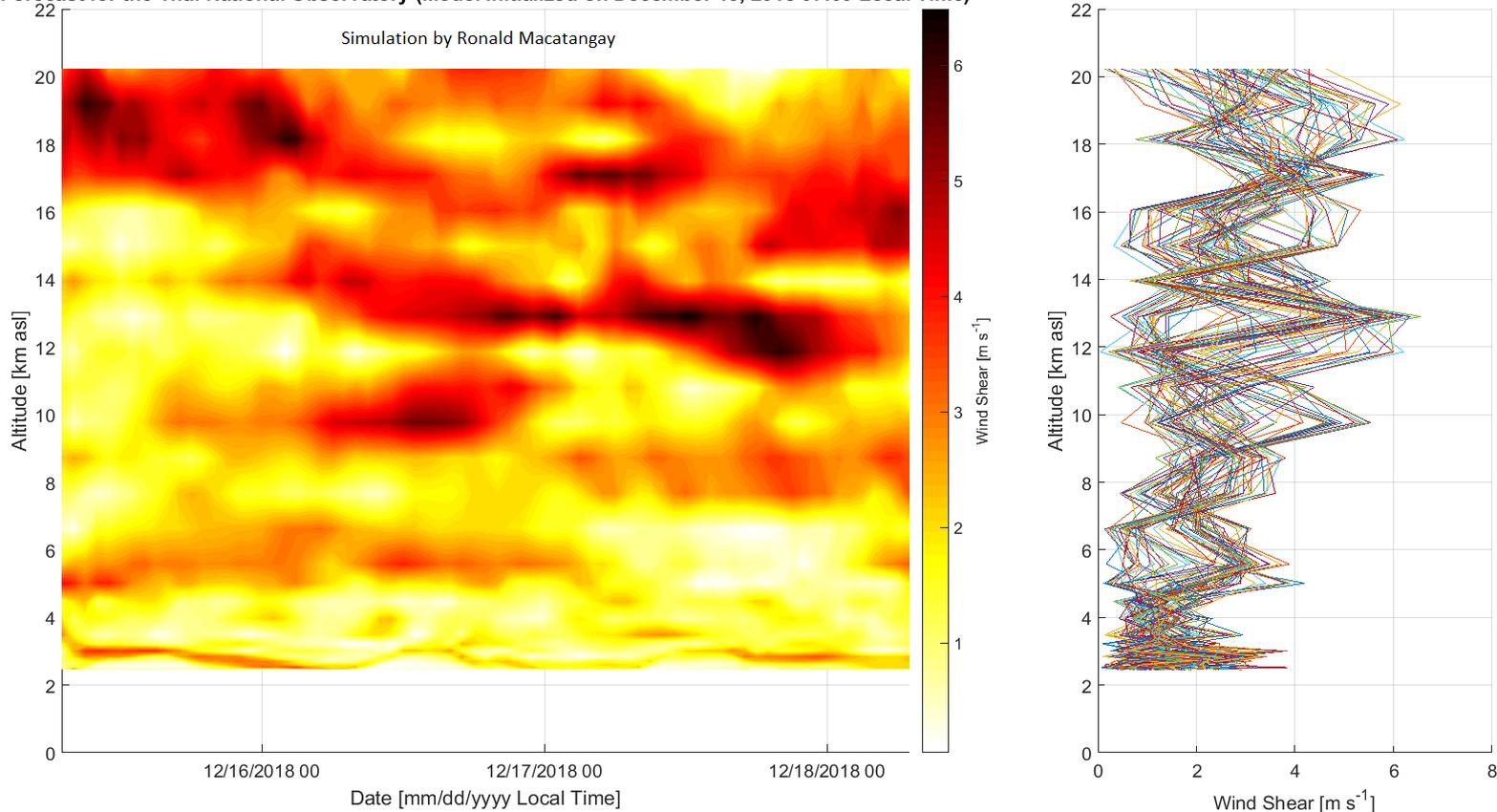


Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model

$$S(h) = \left[\left(\frac{dV_x}{dz} \right)^2 + \left(\frac{dV_y}{dz} \right)^2 \right]^{1/2} \quad \text{wind shear profile}$$

Giordano et al. (MNRAS 2013)

Forecast for the Thai National Observatory (Model Initialized on December 15, 2018 07:00 Local Time)



Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model

temperature structure vertical profile;

$$C_T^2(h) = \phi(h) \chi(h) S(h)^{1/2}$$

$\phi(h)$ parameter deduced from meteorological balloons

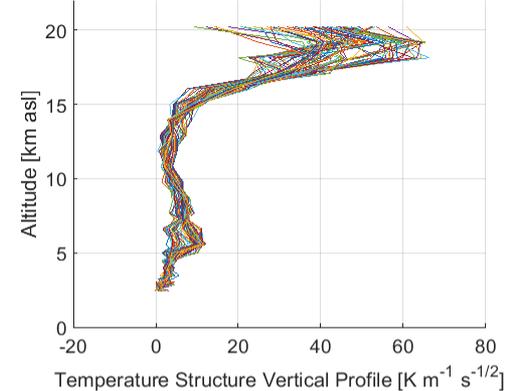
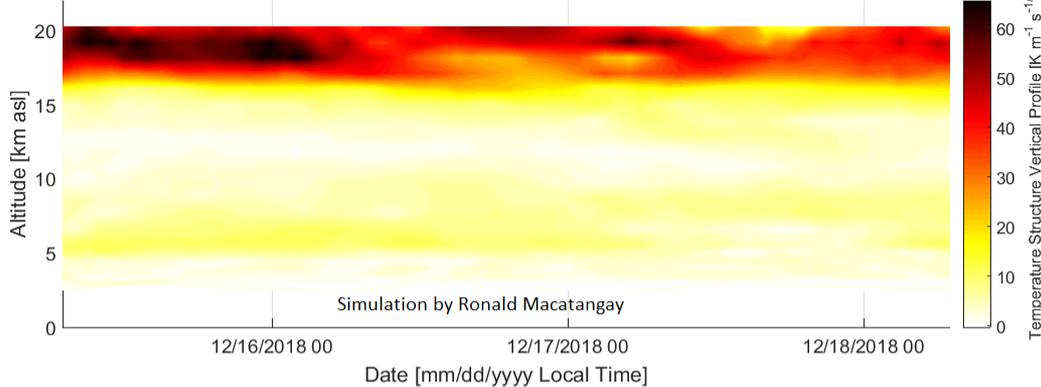
We don't have this. Bias correction needed.

refractive index vertical profile;

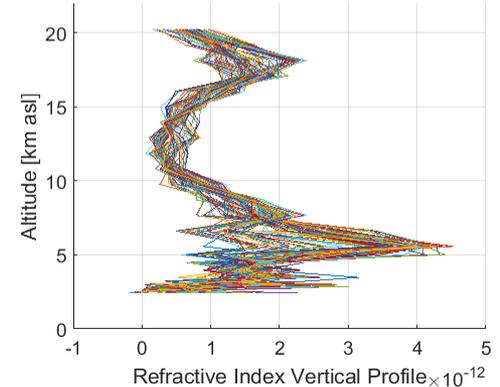
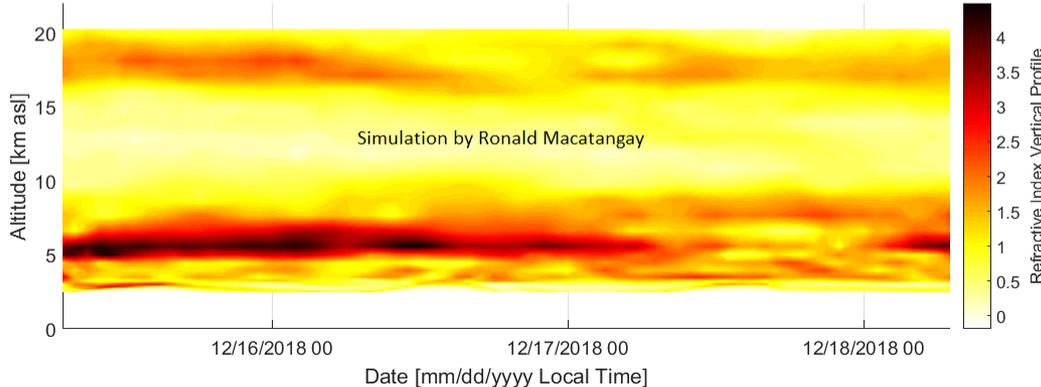
$$C_N^2(h) = \left(\frac{80 \times 10^{-6} P(h)}{T(h)^2} \right)^2 C_T(h)^2$$

Giordano et al. (MNRAS 2013)

Forecast for the Thai National Observatory (Model Initialized on December 15, 2018 07:00 Local Time)



Forecast for the Thai National Observatory (Model Initialized on December 15, 2018 07:00 Local Time)



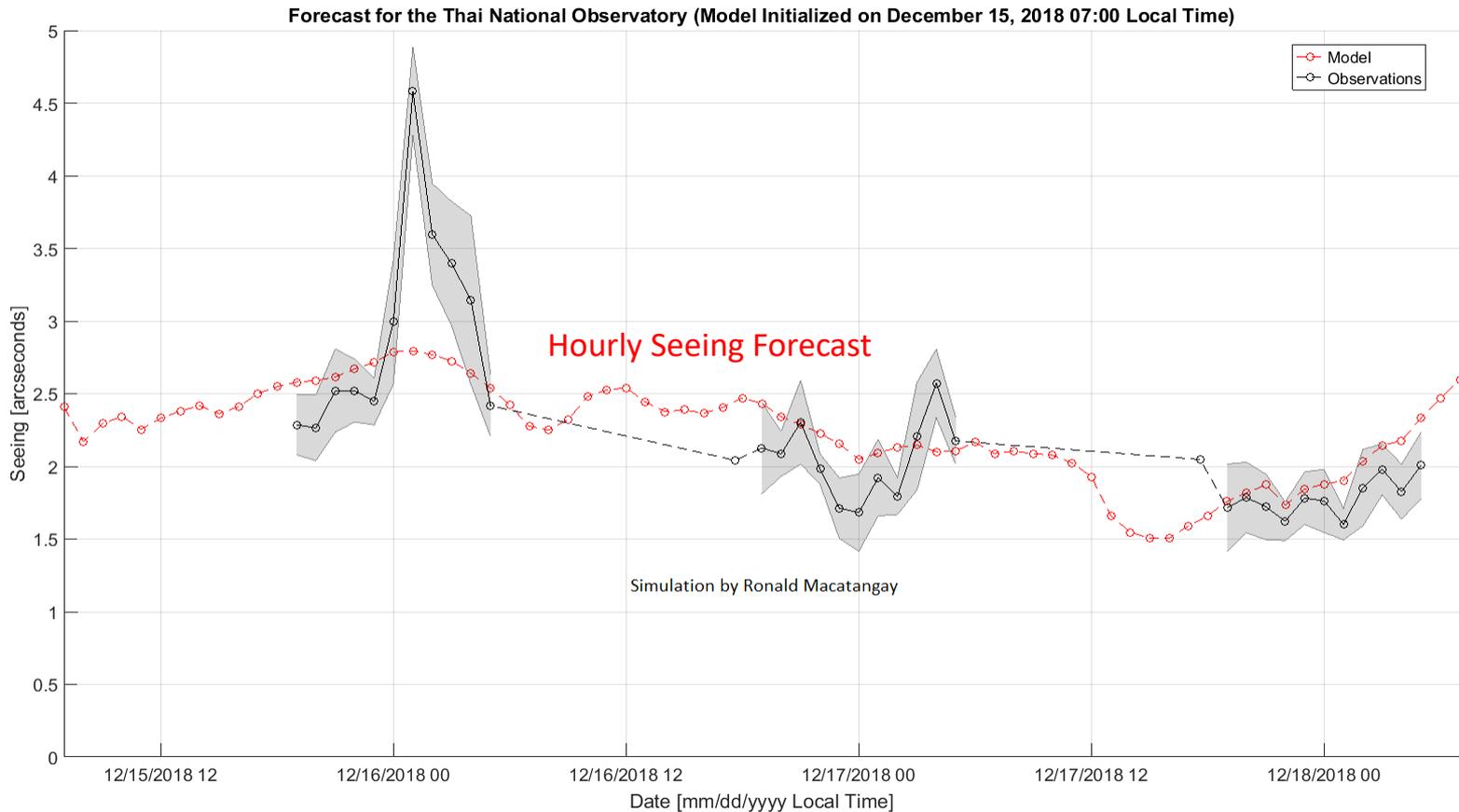
Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model

seeing

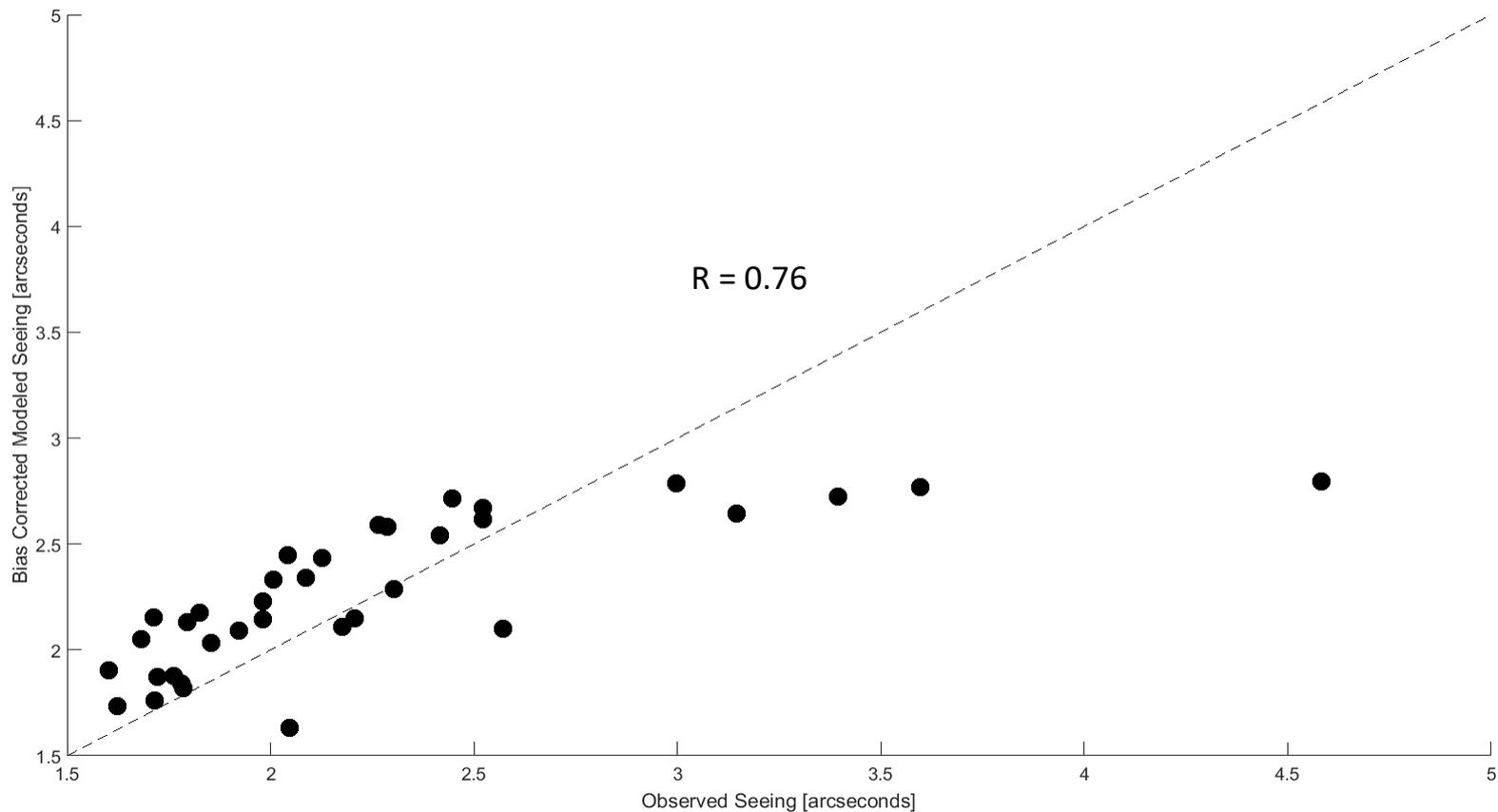
$$\epsilon_0 = 5.25\lambda^{-1/5} \left[\int_0^\infty C_N^2(z) dz \right]^{3/5} + C$$

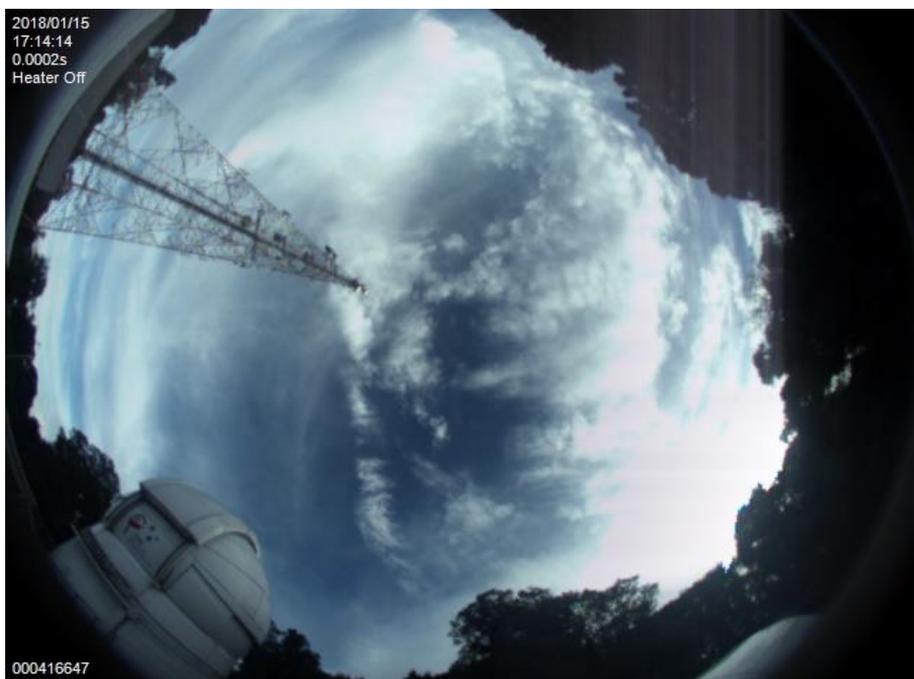
where C = bias correction
offset value
= -5.43 arc seconds
 $\lambda = 532 \text{ nm}$

Giordano et al. (MNRAS 2013)



Astronomical Seeing Forecast at TNO Using the Weather Research and Forecasting Model





All-Sky Camera at TNO

Cloud Cover

Development of a cloud detection method from whole-sky color images

Masanori Yabuki ^{a,*}, Masataka Shiobara ^{b,c}, Kimiko Nishinaka ^d, Makoto Kuji ^d

^a Research Institute for Sustainable Humanosphere, Kyoto University, Uji, Kyoto 611-0011, Japan

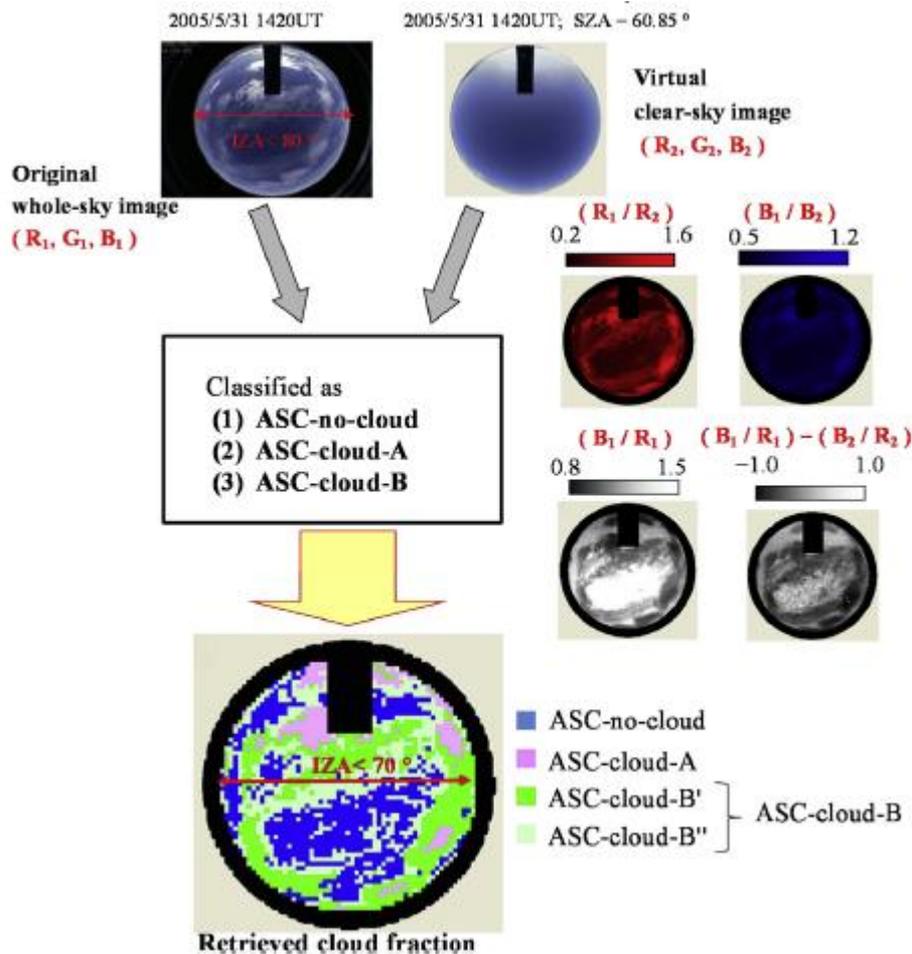
^b National Institute of Polar Research, Tachikawa Tokyo 190-8518, Japan

^c Department of Polar Science, The Graduate University for Advanced Studies, Tachikawa, Tokyo 190-8518, Japan

^d Nara Women's University, Nara, Nara 630-8506, Japan

Received 15 January 2014; revised 5 June 2014; accepted 18 July 2014

Available online 7 August 2014



Atmospheric Extinction

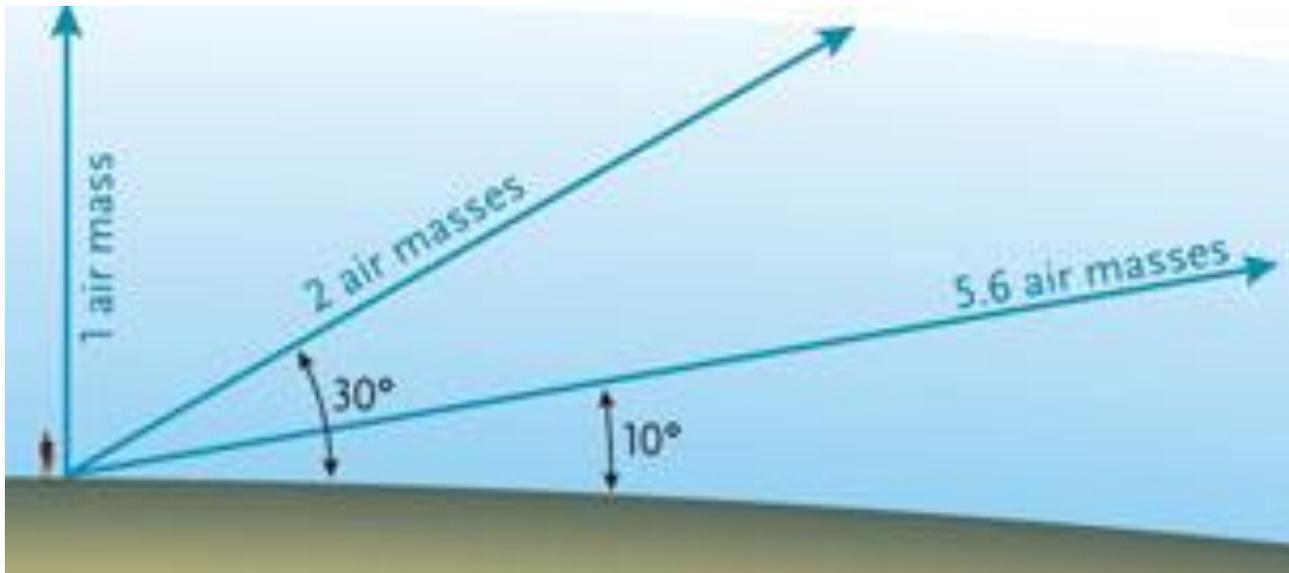
Astronomers who specialize in photometry need to compensate for *atmospheric extinction*: the reduction in a celestial object's apparent brightness when its light passes through the atmosphere.

This depends on three factors:

The *transparency* (clarity) of the air.

Your *elevation* above sea level.

The *altitude* (*celestial altitude*) above the horizon of your celestial target.



Extinction has two components:

absorption, where light is stopped cold in its tracks, and

scattering, where light is diffused away from its original source.

Thin fog scatters light, and smoke absorbs it.





Scattering is more harmful for astronomy, because it not only dims the object that you're observing, but also reduces contrast by brightening the background sky.

2019/03/22
22:29:41
32.0661s
Heater On



000070677

Scattering is more harmful for astronomy, because it not only dims the object that you're observing, but also reduces contrast by brightening the background sky.

สถาบันวิจัยดาราศาสตร์แห่งชาติ (องค์การมหาชน) เชิญร่วมงาน...

เสวนาดาราศาสตร์เอเชีย

เมืองฟ้ามืดเห็นดาว...กำลังจะเป็นเทรนด์ใหม่ Dark Sky Campaign

ถึงเวลา...เรียกหาความมืดของท้องฟ้าเพื่อโลกและดวงดาว



วันศุกร์ที่ 24 พฤศจิกายน 2560 | 16:00 - 19:30 น.

ณ ห้องสัมมนา อาคาร SMEs 2 ศูนย์ประชุมและแสดงสินค้านานาชาติ
เฉลิมพระเกียรติ 7 รอบ พระชนมพรรษา จังหวัดเชียงใหม่

**เริ่มลงทะเบียน 15.00 น. เป็นต้นไป

พบกับเรื่องราวที่น่าสนใจ อาทิ

- ทำไมมองไม่เห็นดวงดาวในเมืองใหญ่? หลายคนไม่เคยเห็นทางช้างเผือก?
- “มลภาวะทางแสง” ส่งผลกระทบต่อชีวิตมนุษย์และสัตว์อย่างไร?
- เป็นไปได้ไหม!? ไทยจะมีเขตอนุรักษ์ฟ้ามืดสากล (International Dark Sky Reserve)
- “เมืองฟ้ามืด” ส่งผลดีต่อการถ่ายภาพดาราศาสตร์อย่างไร?
- กิจกรรมรณรงค์ลดการใช้แสงสว่างในเขตชุมชนของต่างประเทศ

โดย...



Mr. Sze - Leung Cheung
ผู้ประสานงานบริการวิชาการนานาชาติ
สำนักงานบริหารวิชาการทางดาราศาสตร์
สหพันธ์ดาราศาสตร์สากล ประเทศไทย (IAU OAO)



บติพล ตั้งมติธรรม
ผู้เชี่ยวชาญด้านดาราศาสตร์



เจษฎา กิรติการัตน์
ผู้ประสานงานโครงการ Dark Sky Campaign ประเทศไทย



ชวนท่องเอกภพใน ท้องฟ้าจำลองเคลื่อนที่

Fulldome Digital s:UU Full HD DX4

ชวนชมดาว...เคล้าดนตรี

19.30 - 21.00 น.

(บริเวณลานกิจกรรมด้านหน้า)

- ดึงกล้องส่องดวงจันทร์ กระจุกดาวและกาแล็กซี
- แนะนำการดูดาวเบื้องต้นและการใช้แผนที่ดาว
ท่ามกลางสมทิวทัศน์เสียงดนตรีอันไพเราะ
จับลมลอดวงาน

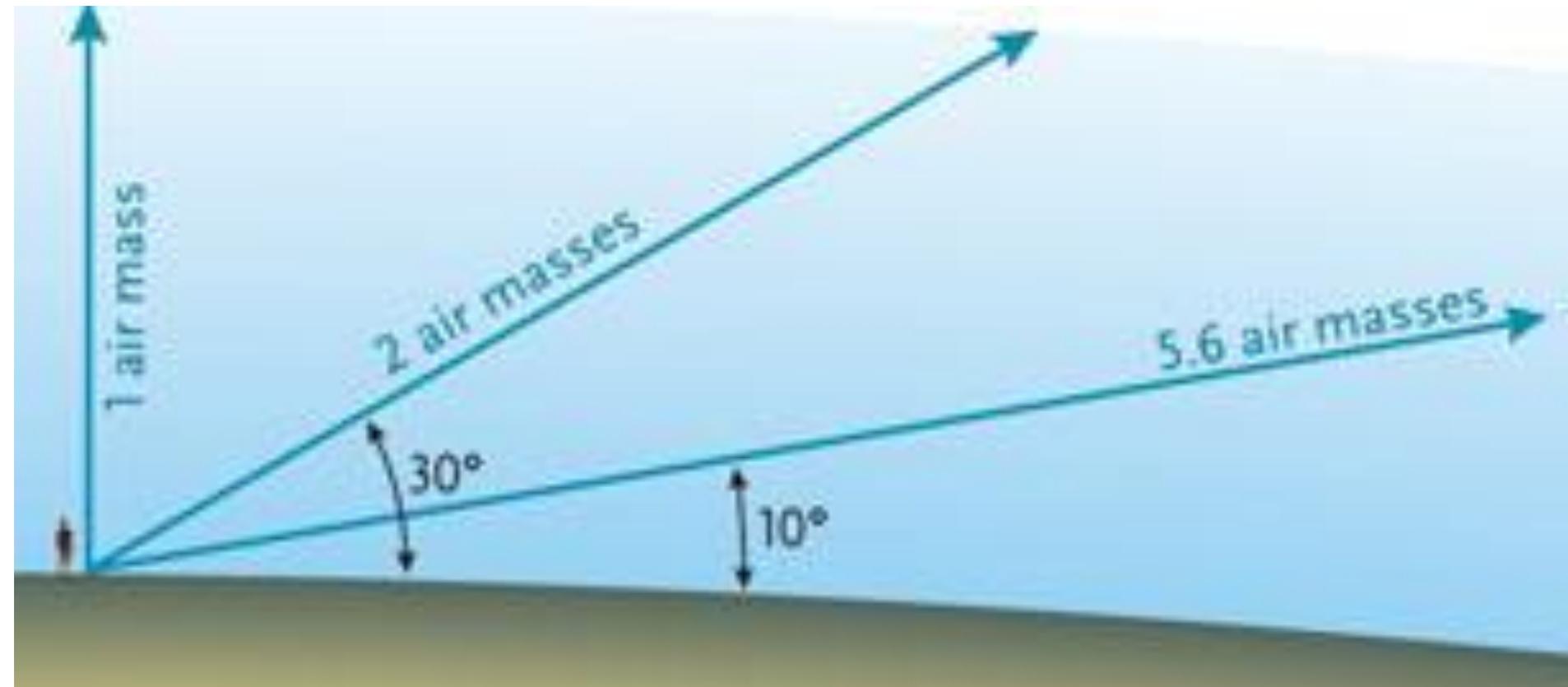


ฟรี! สำรองที่นั่งล่วงหน้าได้ที่

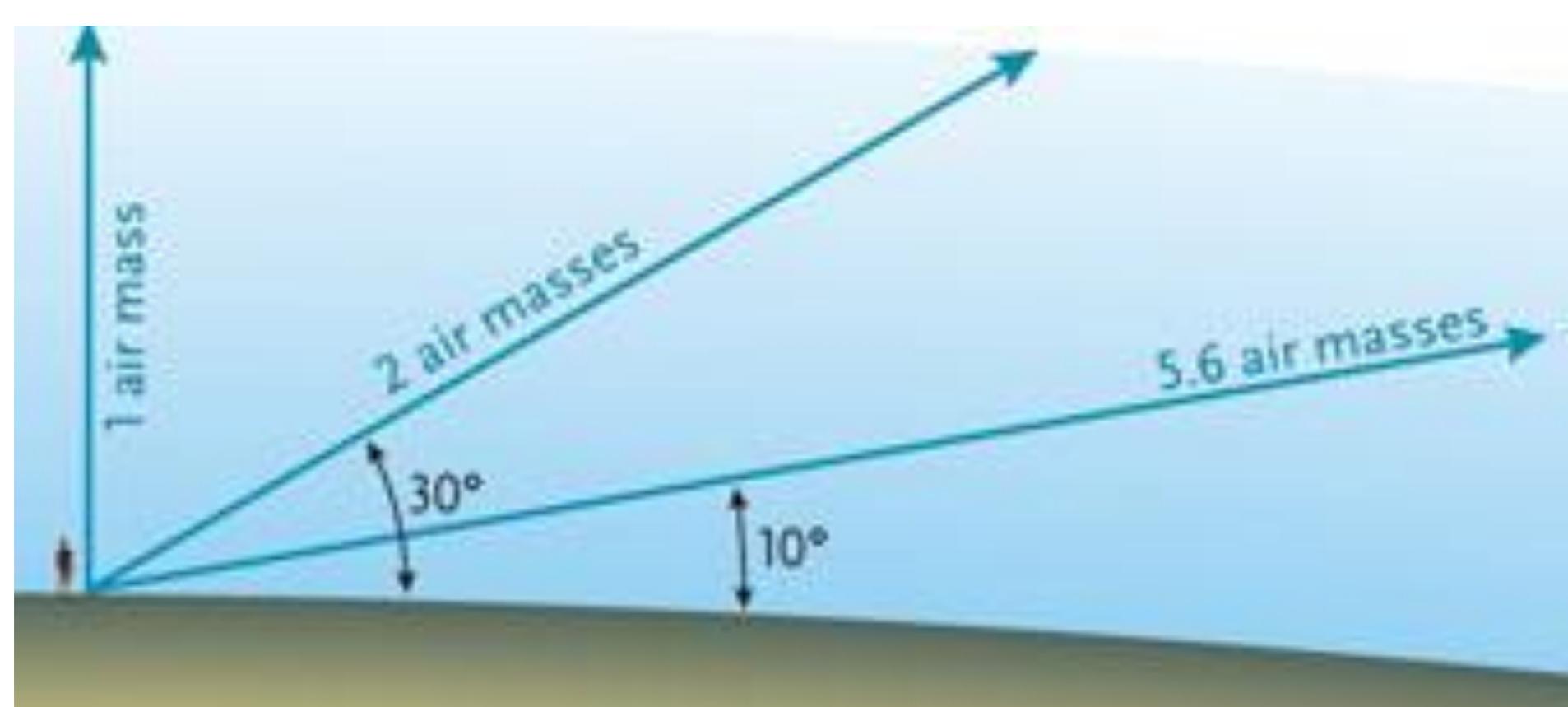
สอบถามเพิ่มเติม 053-121268-9 ต่อ 305, 081-764-8834 (คุณพิสิฏฐ)

The closer your target is to the horizon, the more air you have to look through, and the more degraded your view gets.

The amount of air directly overhead is called one *airmass*. (The actual amount of air in one airmass varies depending on your elevation above sea level.)



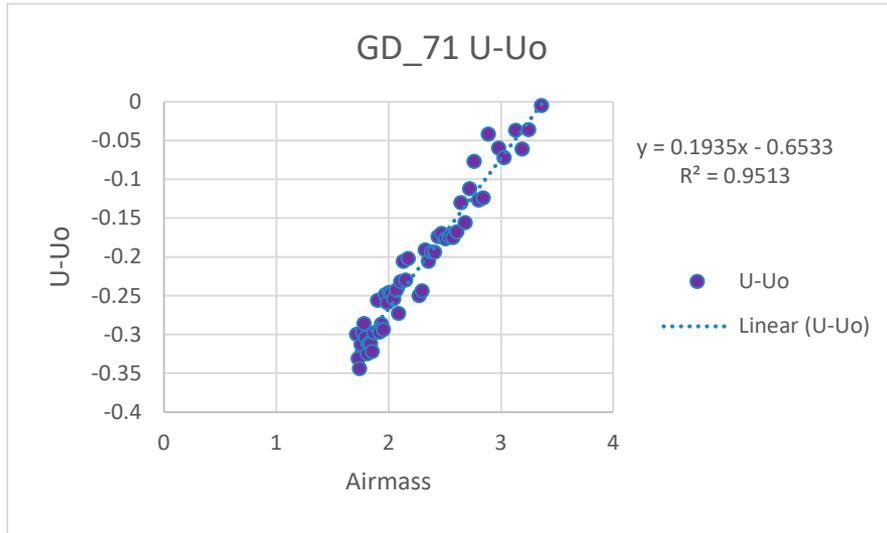
Extinction is usually measured in magnitudes per airmass. For instance, let's say that extinction is 0.16 magnitudes per airmass, the best it can ever get at sea level. Then a star overhead appears 0.16 magnitude fainter (86% as bright) as it really is, a star 30° above the horizon, with 2 airmasses to look through, appears 0.32 magnitude fainter, or 74% as bright, and a star 10° above the horizon appears 0.90 magnitude fainter, or just 44% as bright.



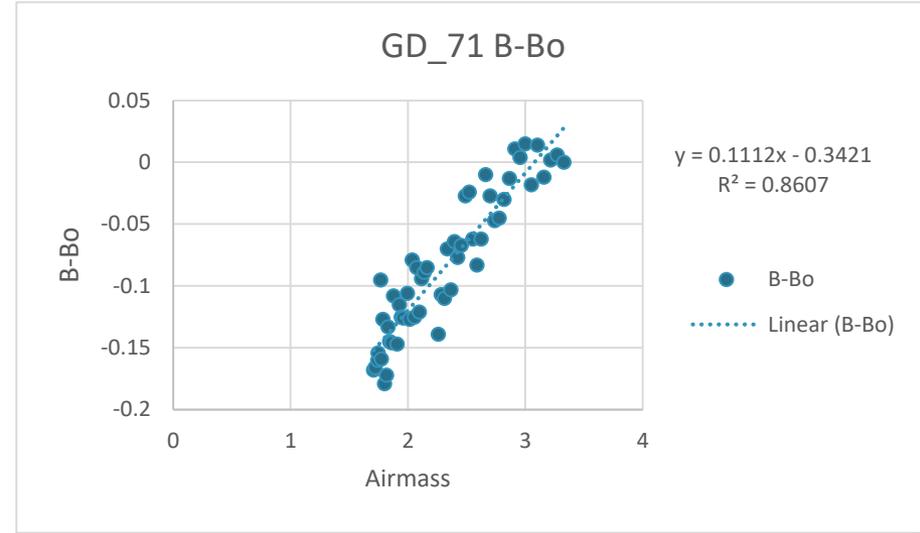
Measurement of Atmospheric Extinction at TNO Using the 2.4 m Telescope

Analysis by Jansawang Panomprai, Sauwaporn Pongpaisirikul, Porrawit Thaimai, Panpaka Suropan, Somsawat Rattanasoon, Donduedee Sookjai and Thiranan Sonkaew

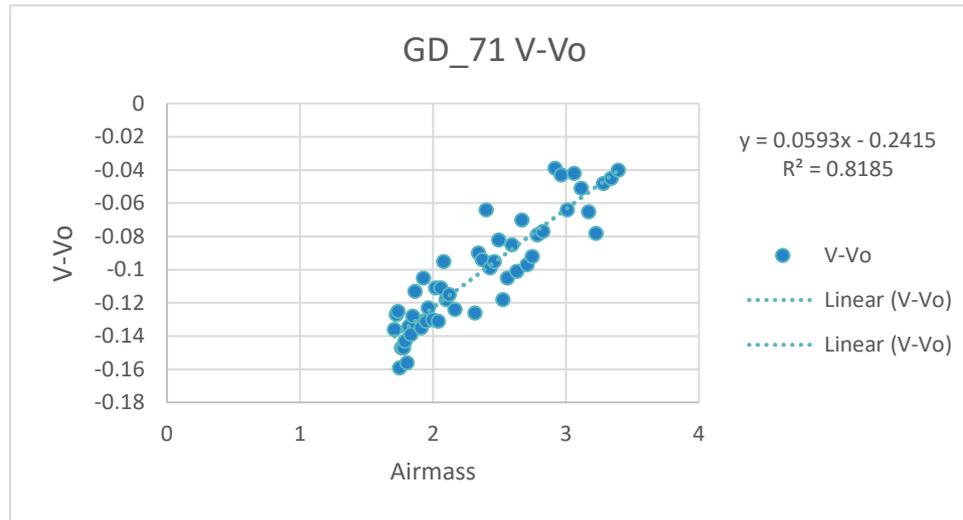
334 – 400 nm



389– 483 nm



501– 589 nm

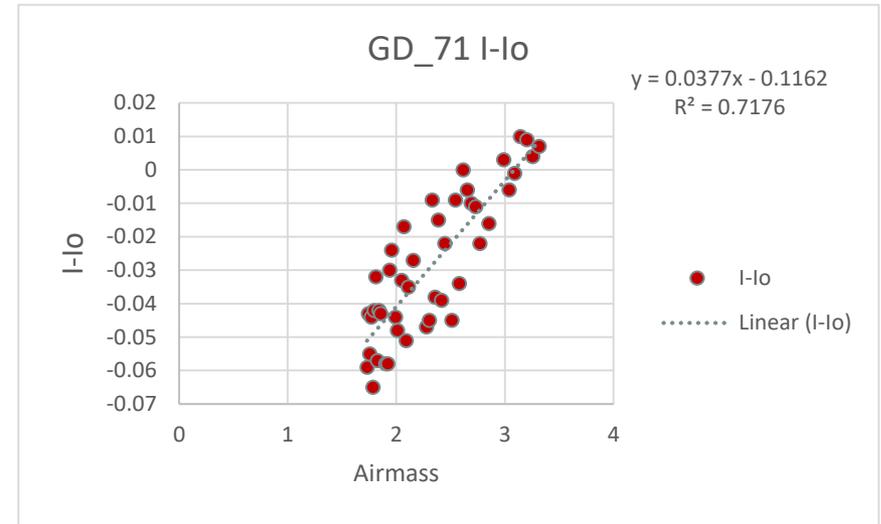
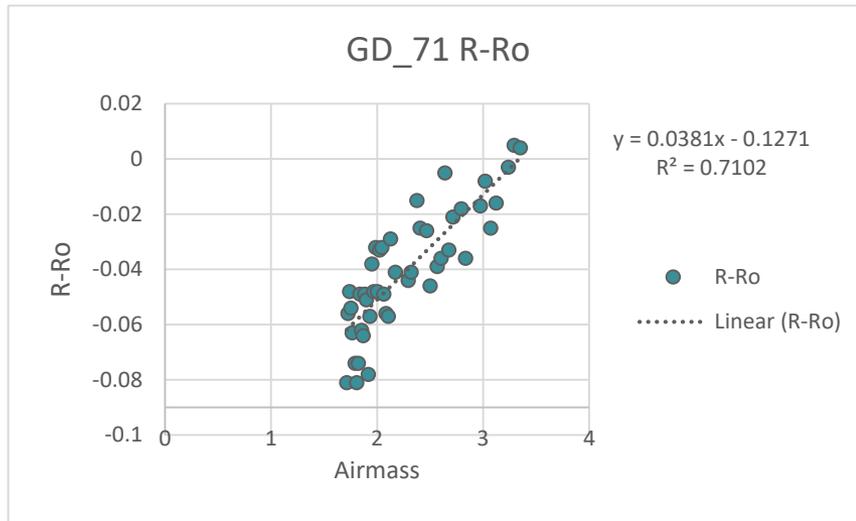


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569 – 707 nm

722.5 – 871.5 nm



Optical filter	Atmospheric Extinction	R^2
U	0.1935	0.9513
B	0.1112	0.8607
V	0.0593	0.8185
R	0.0381	0.7102
I	0.0377	0.7176

Aerosols

In practice, air is never perfectly clean. That's especially true in the summer, when natural pollutants such as dust and forest-fire smoke are at their worst, and humidity combines with emissions from power plants and motor vehicles to form smog. Generically, these pollutants are called *aerosols*: microscopic solid or liquid particles suspended in the atmosphere.

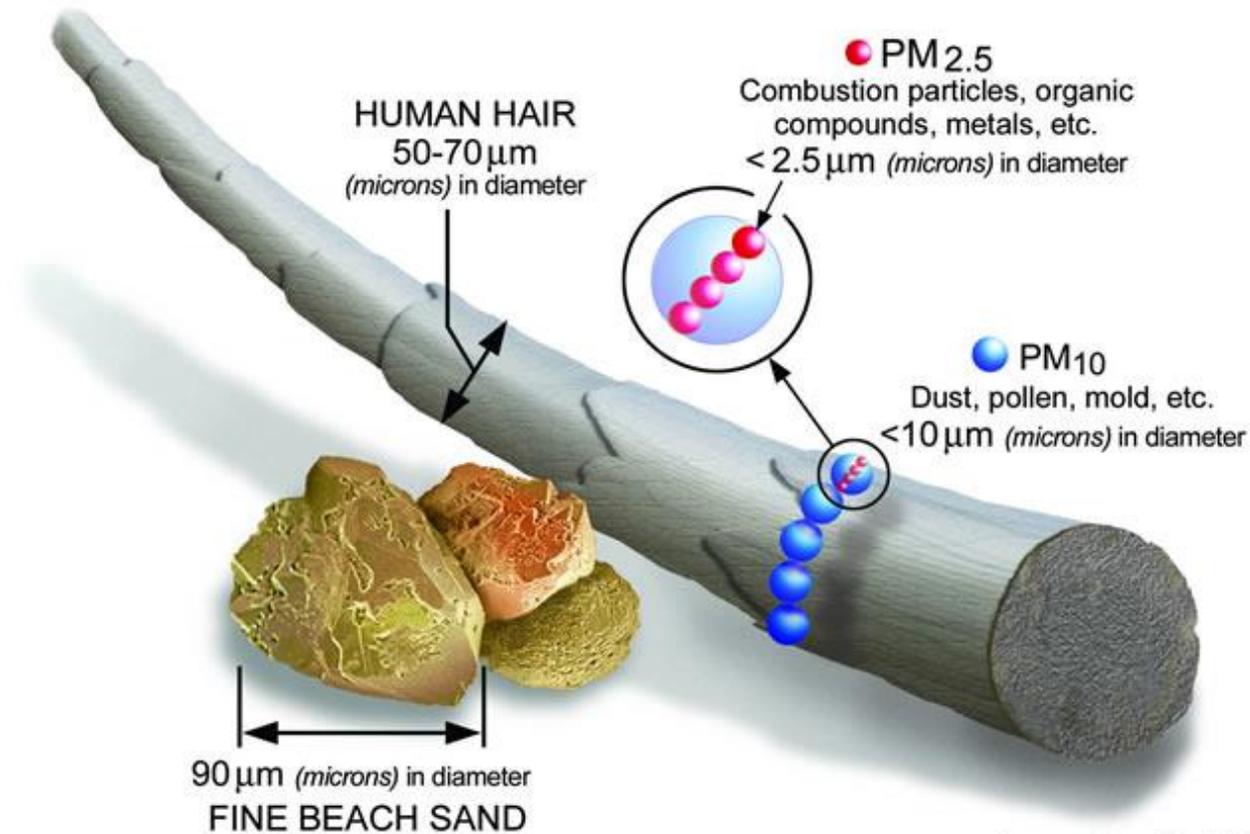
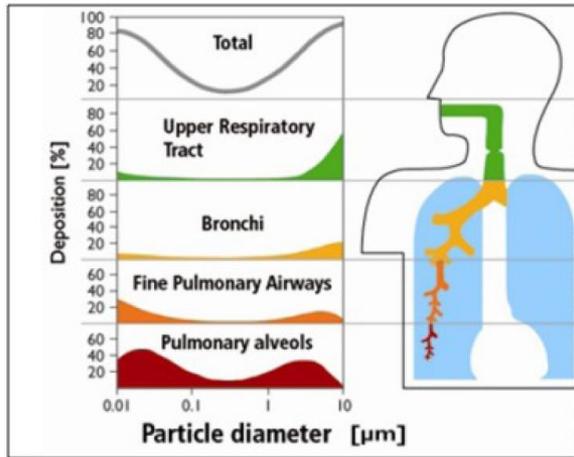
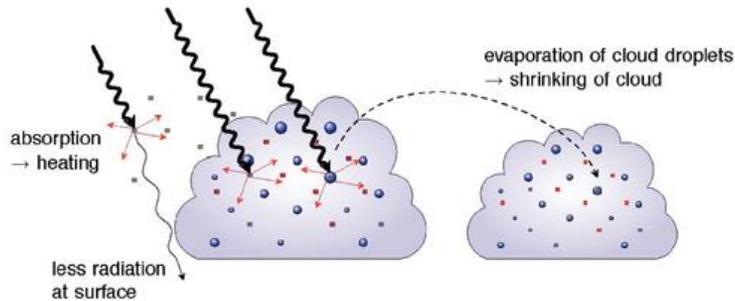


Image courtesy of the U.S. EPA

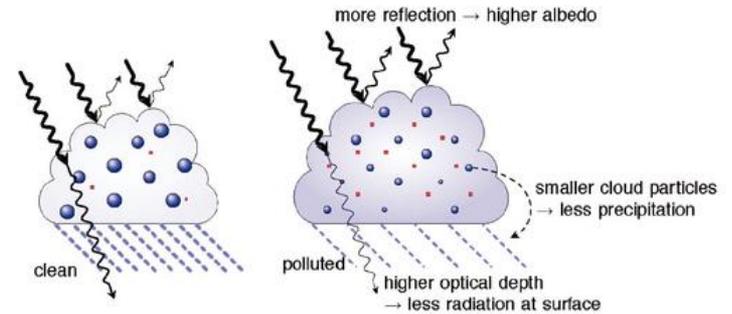
Health and Climate Effects



Semi-direct effect (positive radiative effect at TOA for soot inside clouds, negative for soot above clouds)

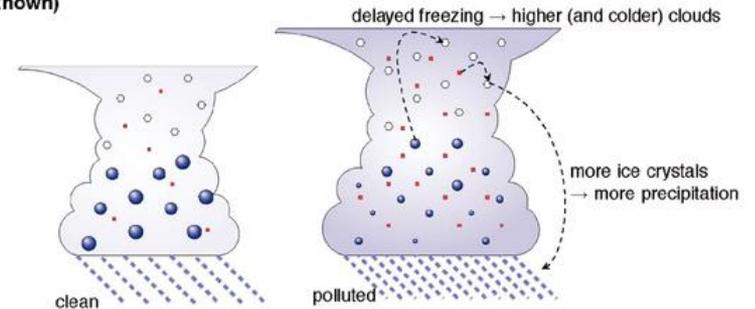


Cloud albedo and lifetime effect (negative radiative effect for warm clouds at TOA; less precipitation and less solar radiation at the surface)



Semi-direct effect (positive radiative effect at TOA for soot inside clouds, negative for soot above clouds)

Glaciation effect (positive radiative effect at TOA and more precipitation), thermodynamic effect (sign of radiative effect and change in precipitation not yet known)



Emitted compound

Resulting atmospheric drivers

Radiative forcing by emissions and drivers

Level of confidence

Emitted compound	Resulting atmospheric drivers	Radiative forcing by emissions and drivers	Level of confidence
Aerosols and precursors (Mineral dust, SO ₂ , NH ₃ , Organic carbon and Black carbon)	Mineral dust Sulphate Nitrate Organic carbon Black carbon		-0.27 [-0.77 to 0.23] H
	Cloud adjustments due to aerosols		-0.55 [-1.33 to -0.06] L

0

Reduction in visibility due to aerosols is called *aerosol optical depth* (AOD). Optical depth is the term used by atmospheric scientists for what astronomers call extinction. Both are usually measured on logarithmic scales, but optical depth uses "natural" logs with a base of e (roughly 2.718), while [astronomical magnitudes](#) are based on the fifth root of 100 (roughly 2.512). Multiply by 1.086 to convert optical depth to magnitudes.

The screenshot displays the NASA Worldview web application interface. The browser window title is "EOSDIS Worldview" and the URL is "https://worldview.earthdata.nasa.gov/?". The main map area shows a satellite view of Southeast Asia, with a semi-transparent overlay representing Aerosol Optical Depth (AOD). The AOD overlay is color-coded, with a legend in the sidebar showing a scale from <math>< 0,000</math> (dark blue) to 5,000 (dark red). The legend also includes the text "MODIS Combined Value-Added" and "Aerosol Optical Depth Terra and Aqua / MODIS".

The sidebar on the left contains several sections:

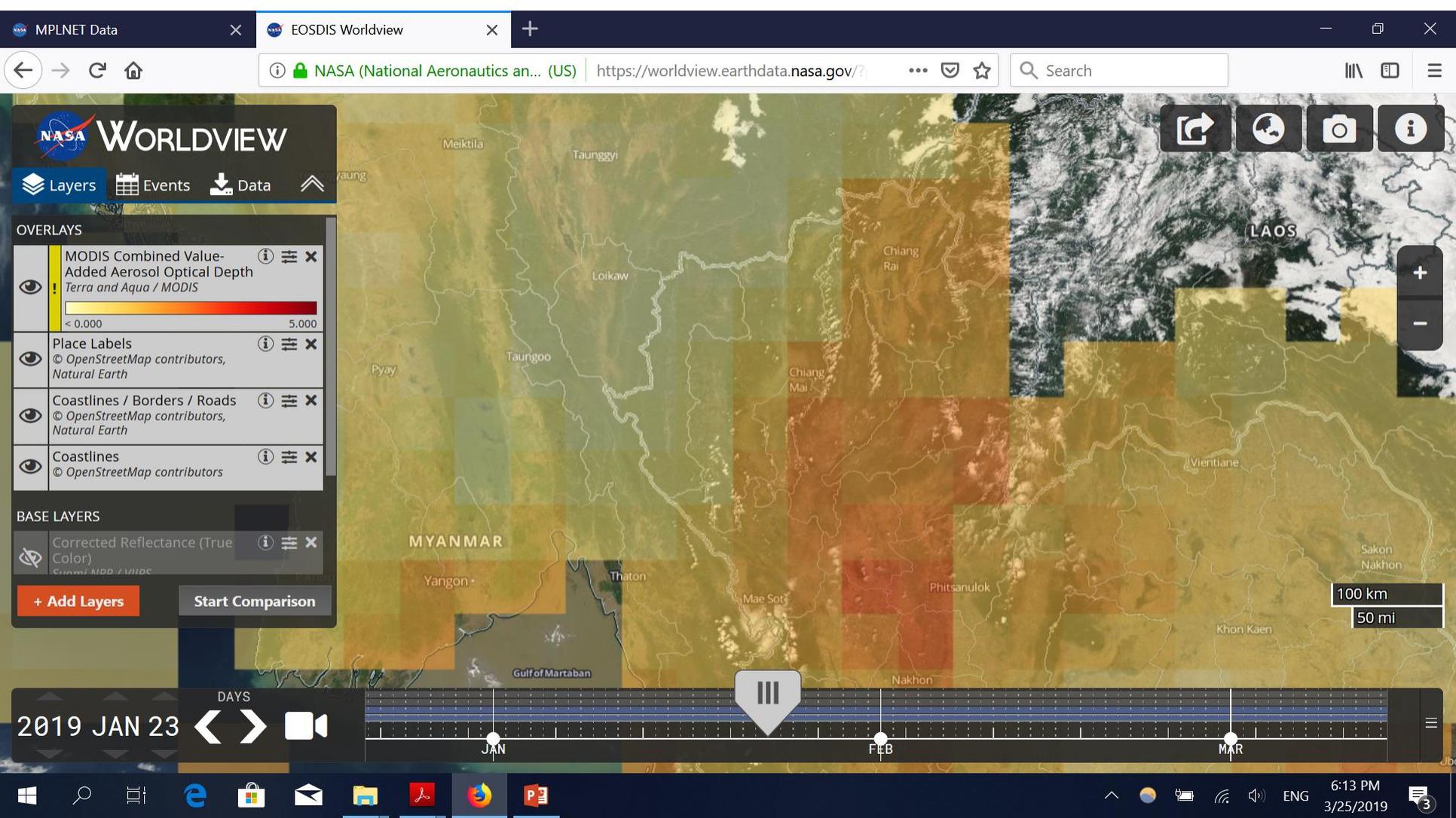
- OVERLAYS:**
 - MODIS Combined Value-Added (Aerosol Optical Depth) - Terra and Aqua / MODIS
 - Place Labels - © OpenStreetMap contributors, Natural Earth
 - Coastlines / Borders / Roads - © OpenStreetMap contributors, Natural Earth
 - Coastlines - © OpenStreetMap contributors
- BASE LAYERS:**
 - Corrected Reflectance (True Color) - Suomi NPP / VIIRS

At the bottom of the sidebar, there are buttons for "+ Add Layers" and "Start Comparison".

The bottom of the map features a timeline labeled "DAYS" with a date of "2019 JAN 23". The timeline shows a progression from January to March, with markers for "JAN", "FEB", and "MAR".

The Windows taskbar at the very bottom shows the system tray with the date "6:14 PM 3/25/2019" and the language "ENG".

Reduction in visibility due to aerosols is called *aerosol optical depth* (AOD). Optical depth is the term used by atmospheric scientists for what astronomers call extinction. Both are usually measured on logarithmic scales, but optical depth uses "natural" logs with a base of e (roughly 2.718), while [astronomical magnitudes](#) are based on the fifth root of 100 (roughly 2.512). Multiply by 1.086 to convert optical depth to magnitudes.



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The screenshot shows the NASA Worldview web application. The browser address bar displays the URL: <https://worldview.earthdata.nasa.gov/>. The main map area shows a satellite view of Southeast Asia, with a semi-transparent overlay representing Aerosol Optical Depth (AOD). The overlay is color-coded from yellow (low AOD) to red (high AOD). The map includes labels for countries like Myanmar and Laos, and cities such as Yangon, Chiang Mai, and Vientiane. A legend on the left side of the map, under the 'OVERLAYS' section, identifies the 'MODIS Combined Value-Added Aerosol Optical Depth' layer, showing a color scale from <math>< 0.000</math> to 5.000. Below the legend are options for 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines'. The 'BASE LAYERS' section shows 'Corrected Reflectance (True Color)'. At the bottom of the interface, there is a timeline slider set to '2019 MAR 23' and a scale bar indicating 100 km and 50 mi. The Windows taskbar is visible at the very bottom of the image.

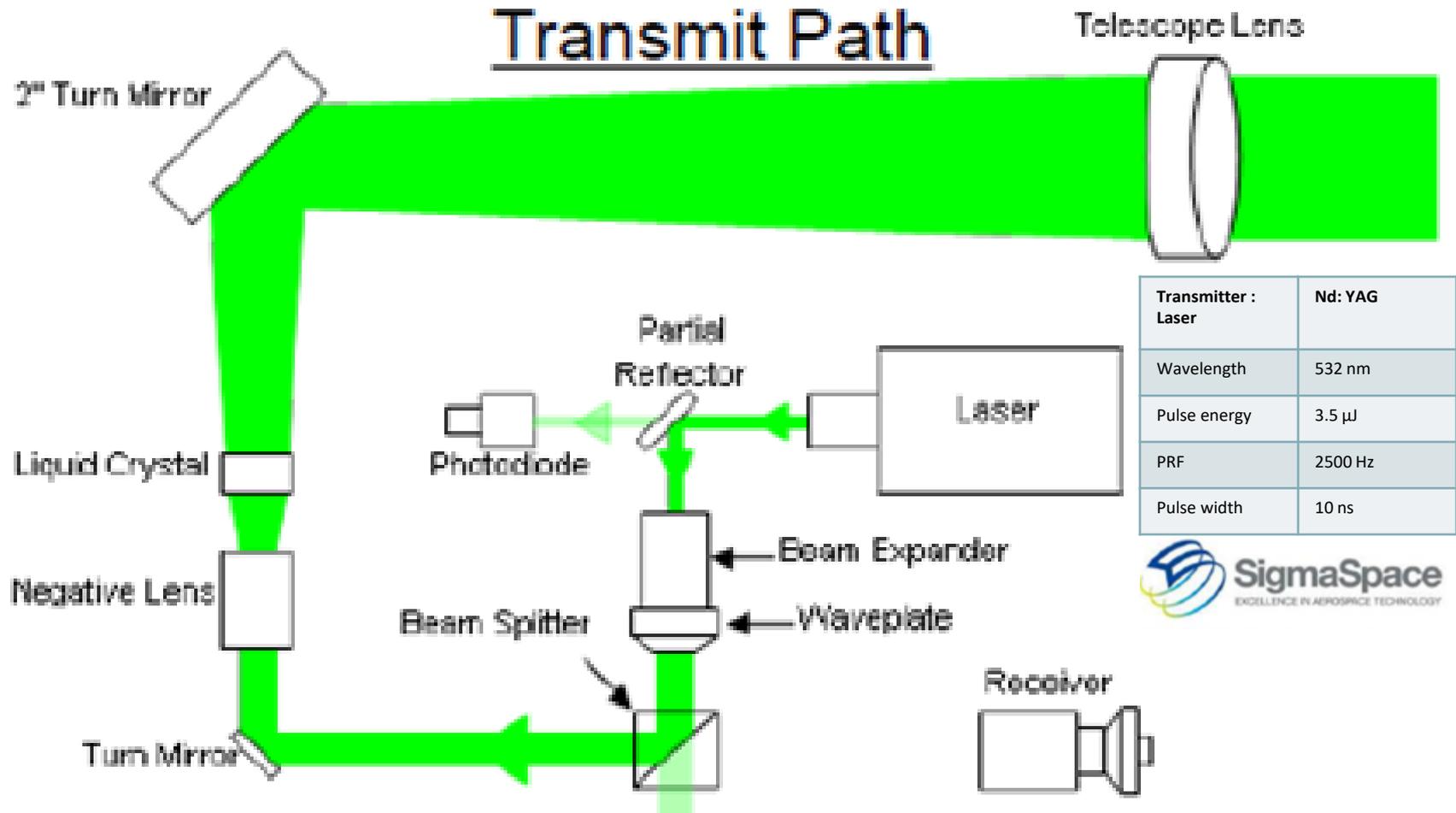
Reduction in visibility due to aerosols is called *aerosol optical depth* (AOD). Optical depth is the term used by atmospheric scientists for what astronomers call extinction. Both are usually measured on logarithmic scales, but optical depth uses "natural" logs with a base of e (roughly 2.718), while [astronomical magnitudes](#) are based on the fifth root of 100 (roughly 2.512). Multiply by 1.086 to convert optical depth to magnitudes.

The screenshot shows the NASA Worldview web application. The browser address bar displays the URL <https://worldview.earthdata.nasa.gov/>. The main map area shows a satellite-derived aerosol optical depth (AOD) map over Southeast Asia, with colors ranging from dark red (low AOD) to bright yellow (high AOD). The map includes labels for countries like Myanmar, Laos, and Thailand, and cities like Yangon, Vientiane, and Bangkok. The left sidebar contains the 'OVERLAYS' section, where the 'MODIS Combined Value-Added Aerosol Optical Depth' layer is selected. Below this, there are options for 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines'. The 'BASE LAYERS' section shows 'Corrected Reflectance (True Color)'. At the bottom, a timeline slider is set to '2019 MAR 23'. The Windows taskbar at the very bottom shows the system clock as 6:10 PM on 3/25/2019.

Atmospheric Light Detection and Ranging (LiDAR)

Light Detection and Ranging (LiDAR)

Principle, Components and Types of Atmospheric LiDAR Systems



Light Detection and Ranging (LiDAR)

Principle, Components and Types of Atmospheric LiDAR Systems

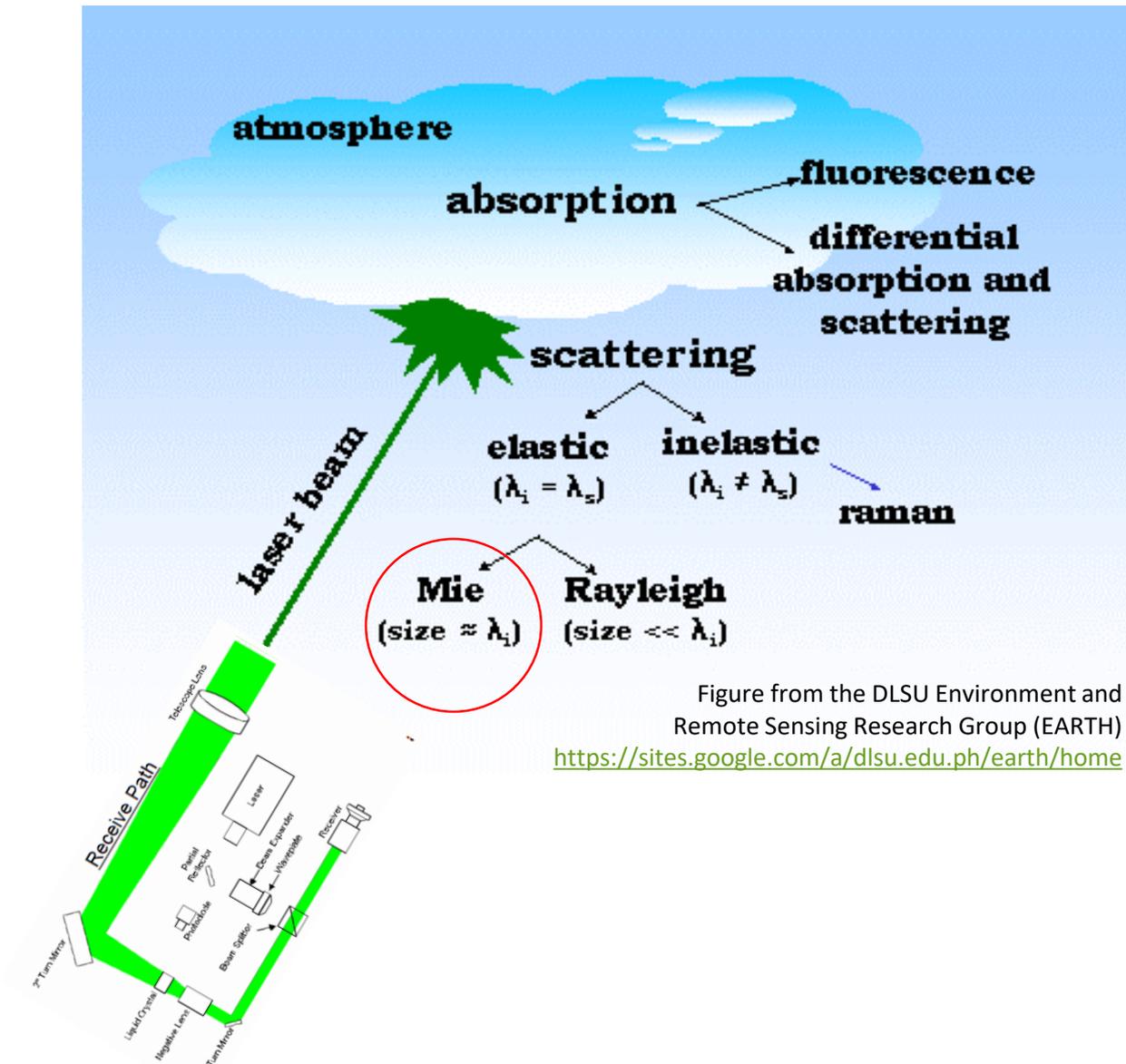
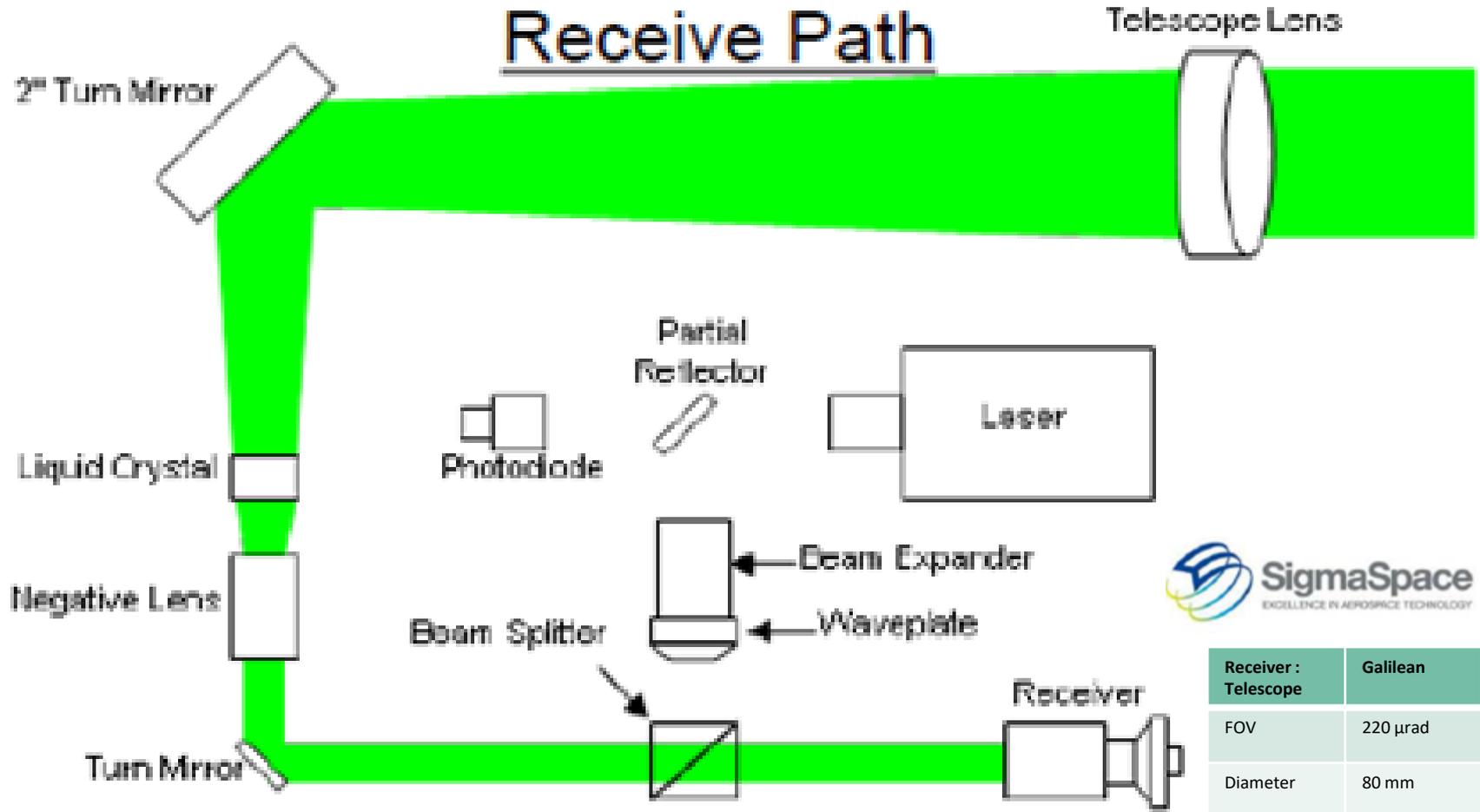


Figure from the DLSU Environment and Remote Sensing Research Group (EARTH)

<https://sites.google.com/a/dlsu.edu.ph/earth/home>

Light Detection and Ranging (LiDAR)

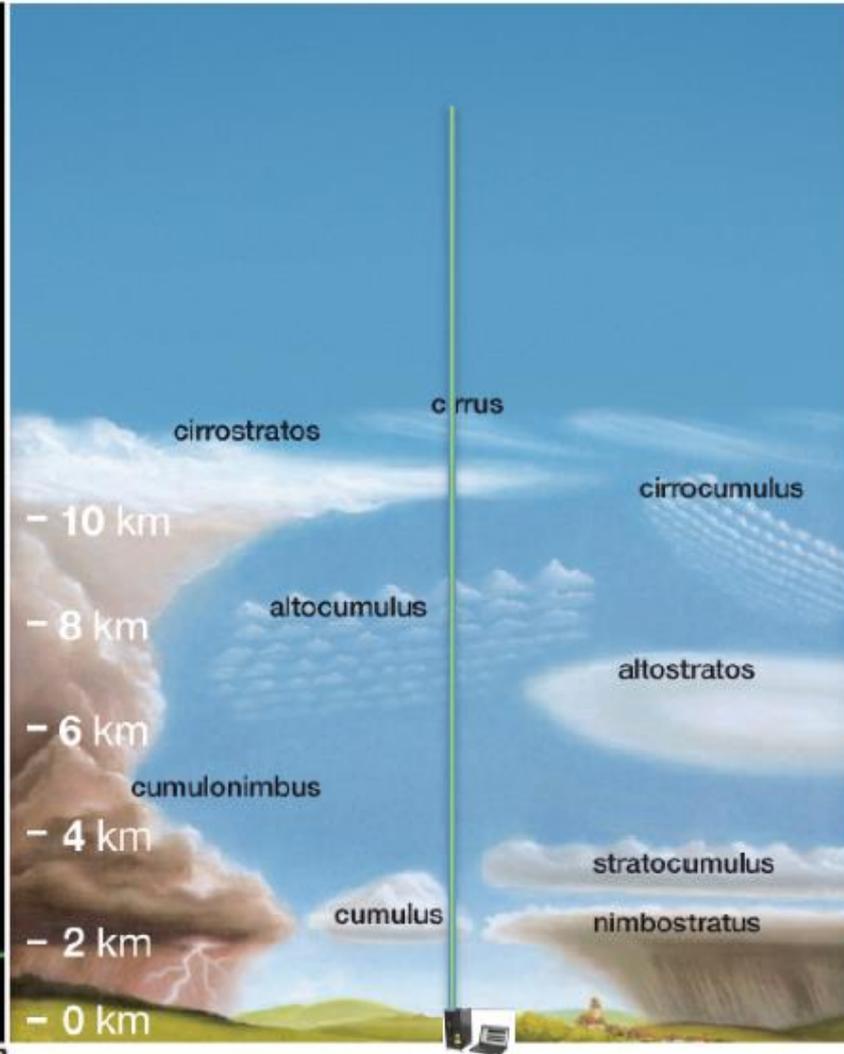
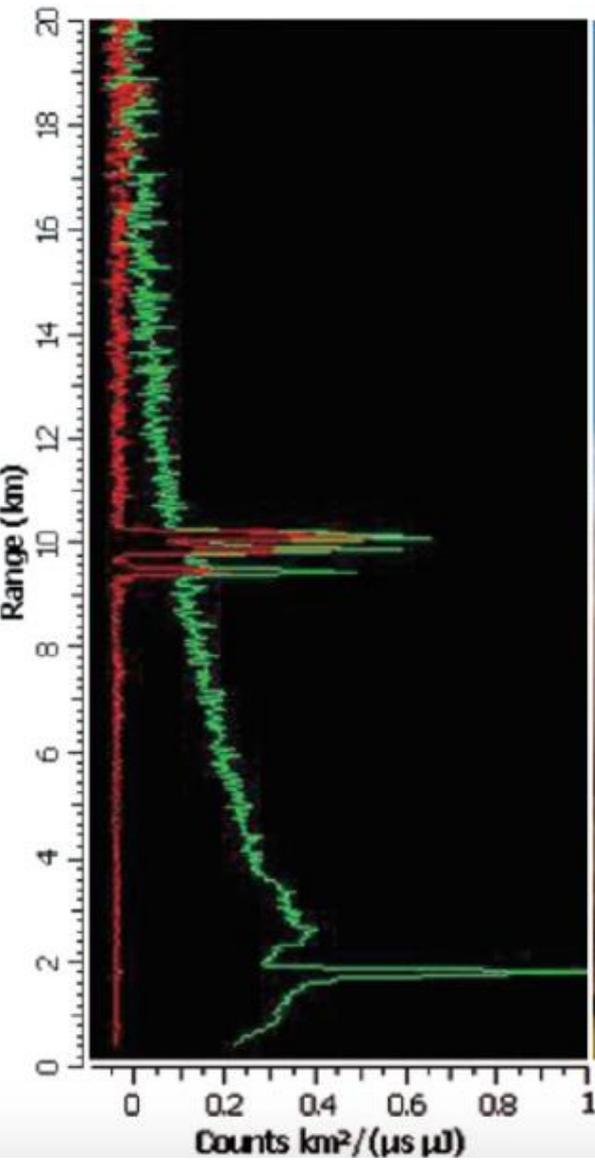
Principle, Components and Types of Atmospheric LiDAR Systems



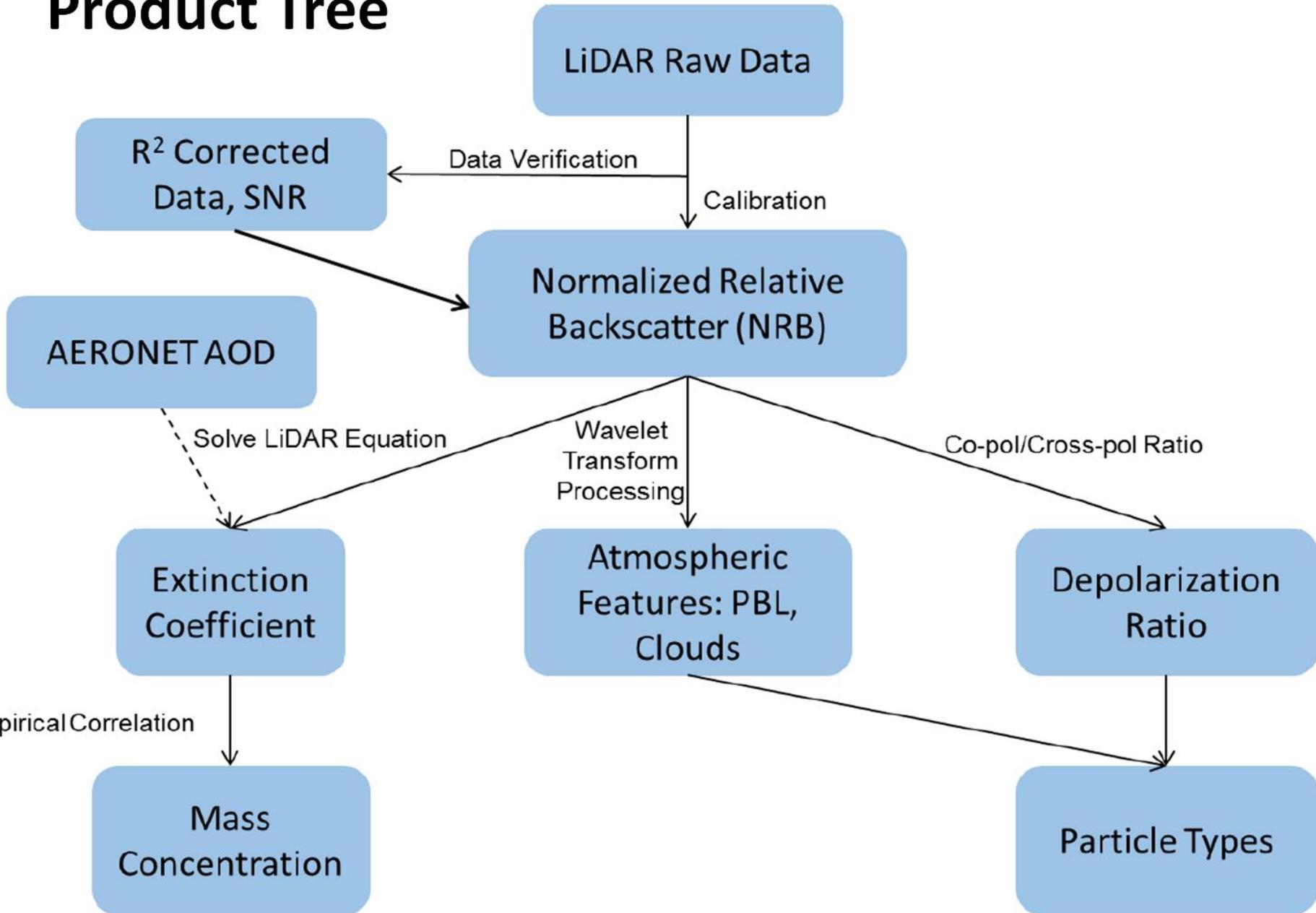
Receiver : Telescope	Galilean
FOV	220 μ rad
Diameter	80 mm

Detector efficiency	25 %
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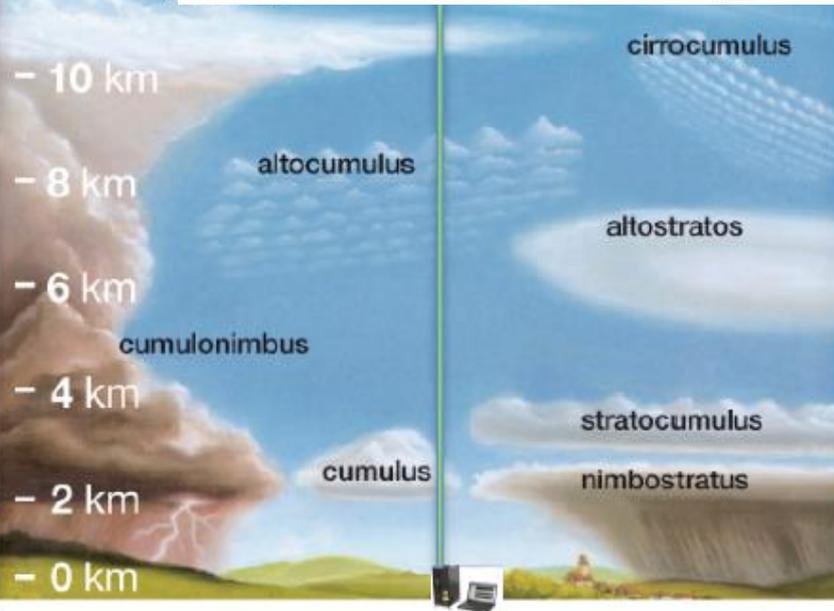
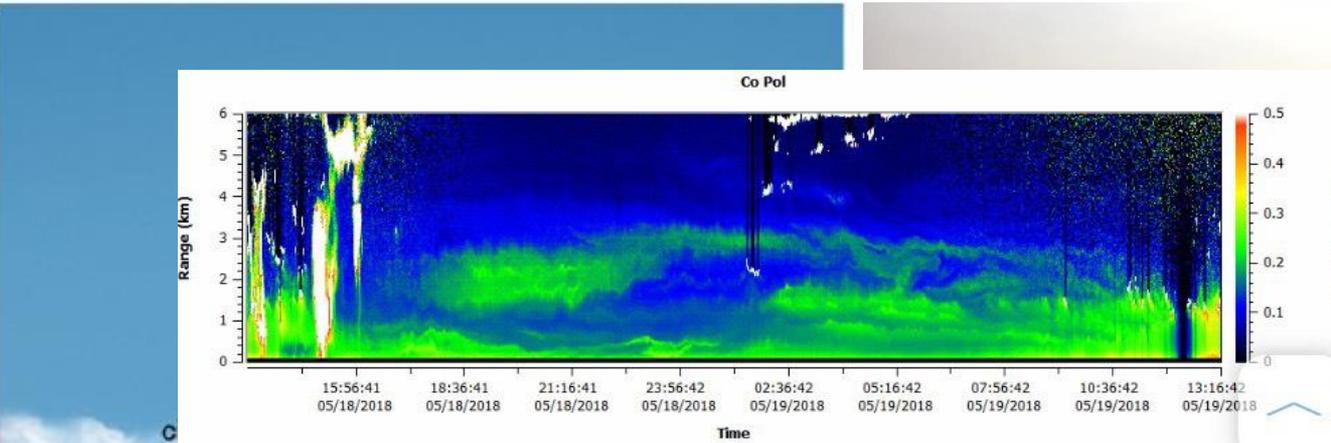
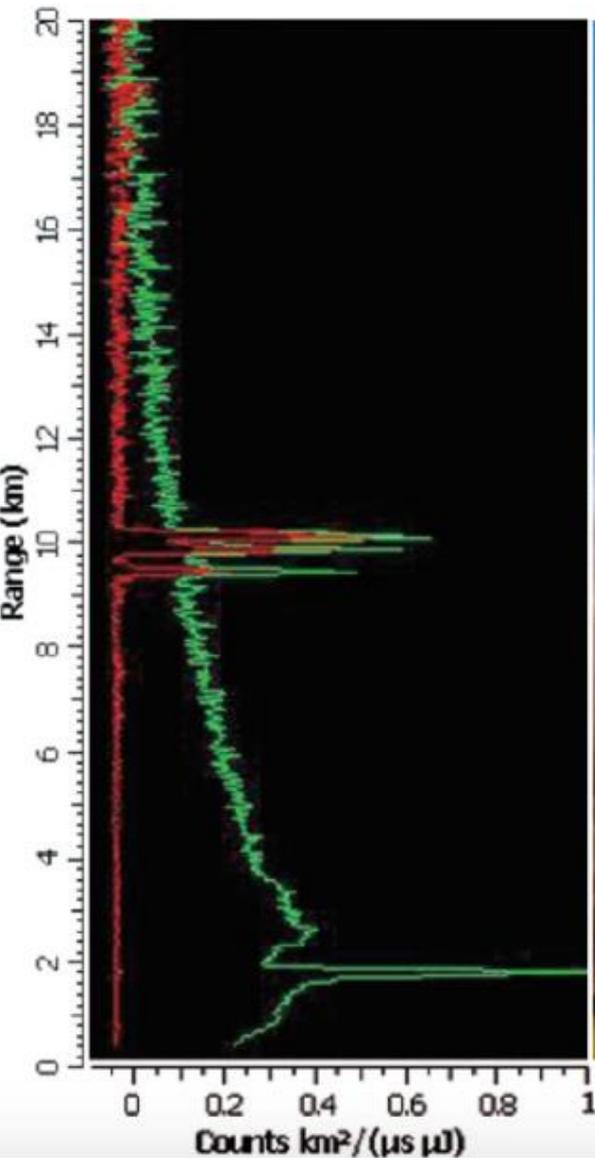
mini-Micropulse LiDAR Signals (Backscatter Signal)



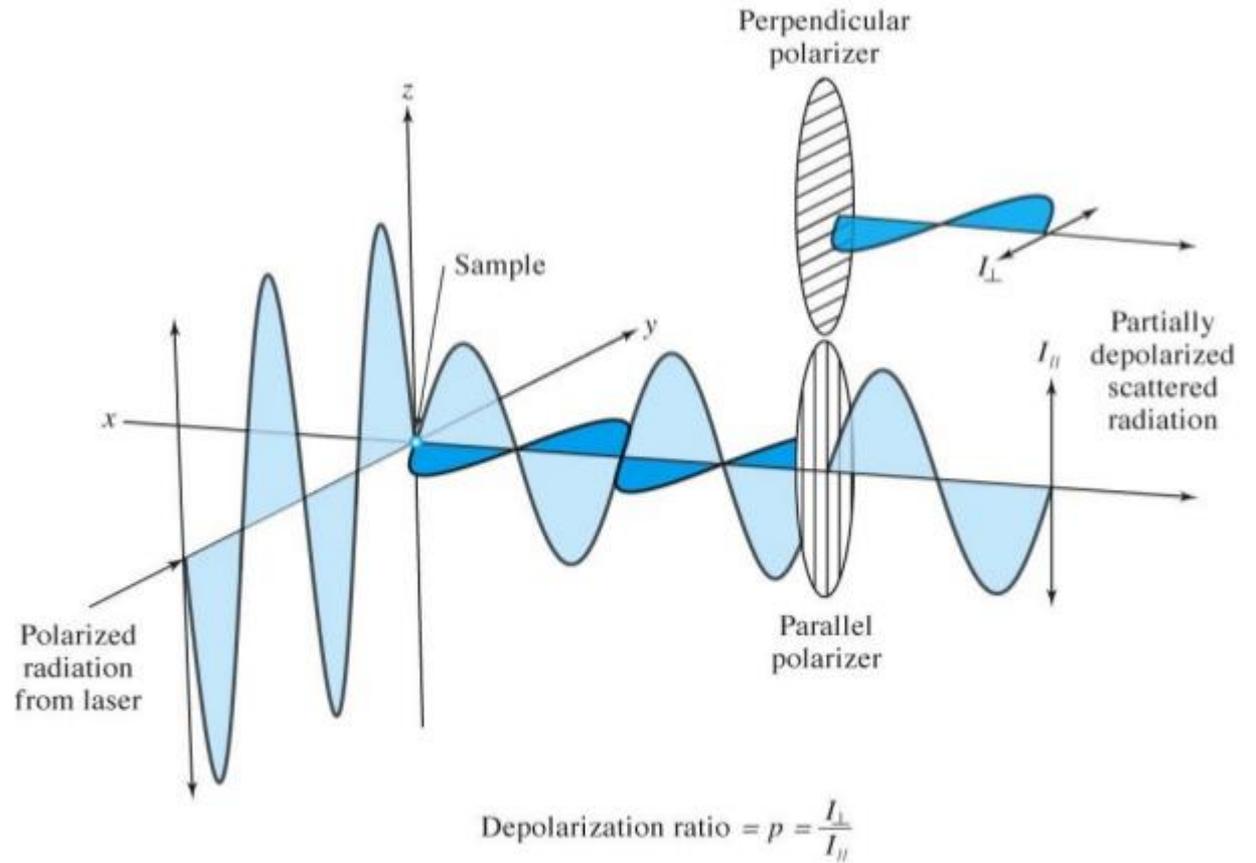
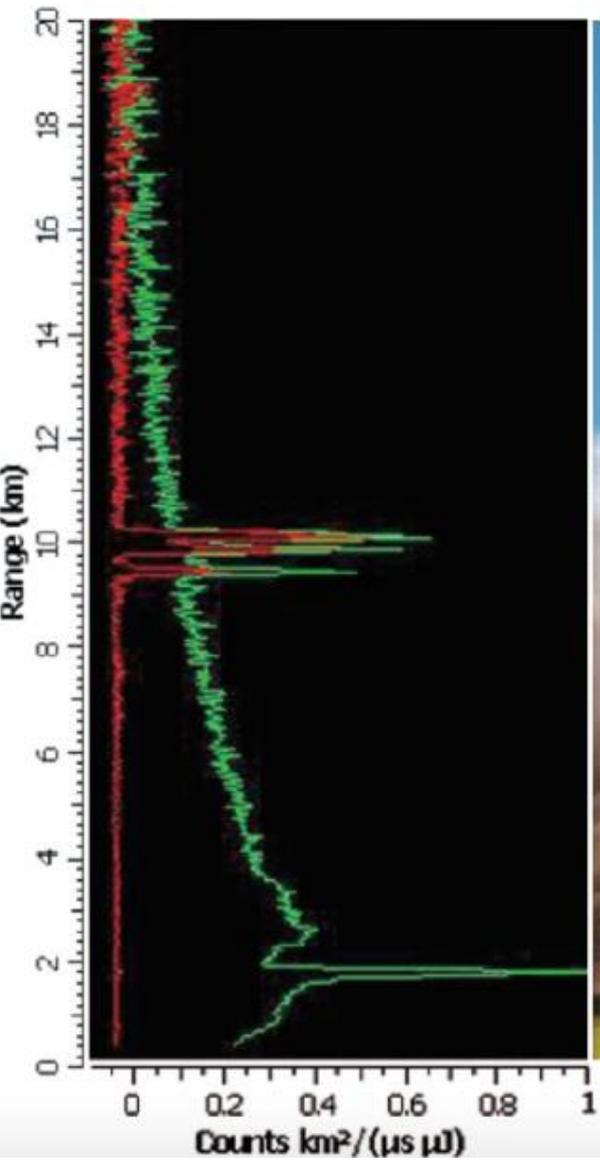
LiDAR Data Product Tree



Normalized Relative Backscatter (NRB)



Polarization

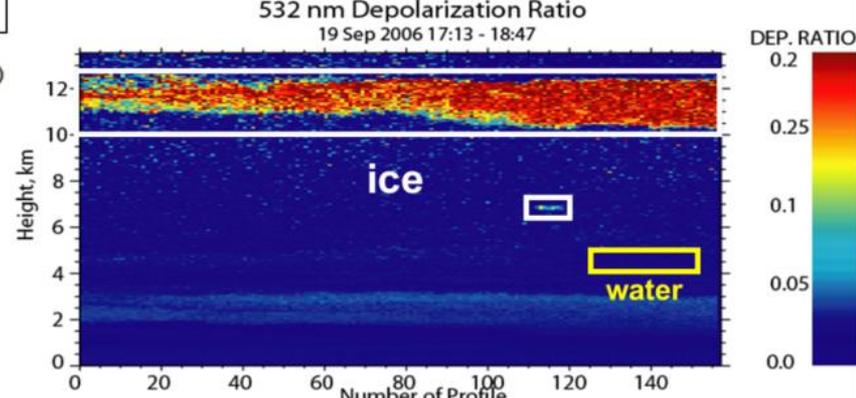
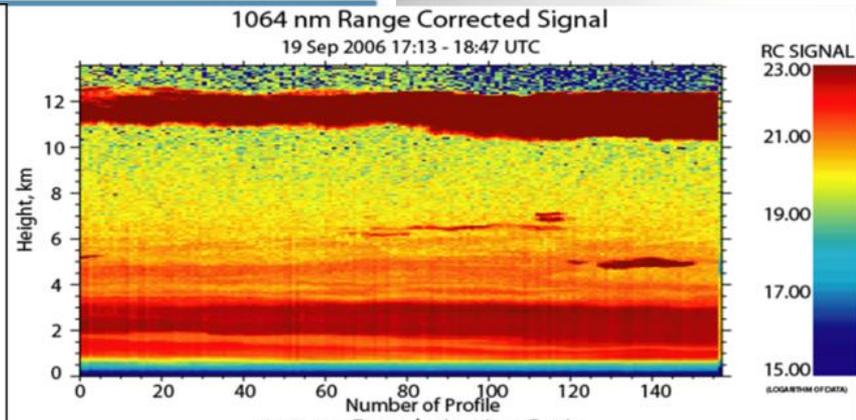
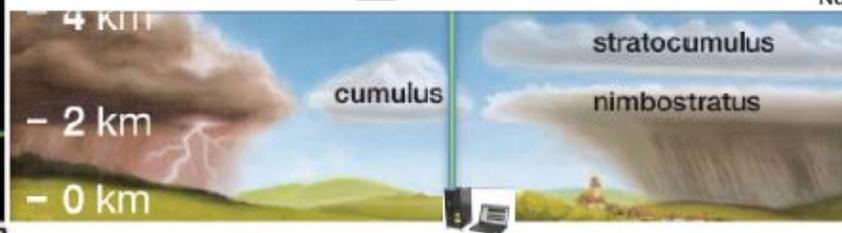
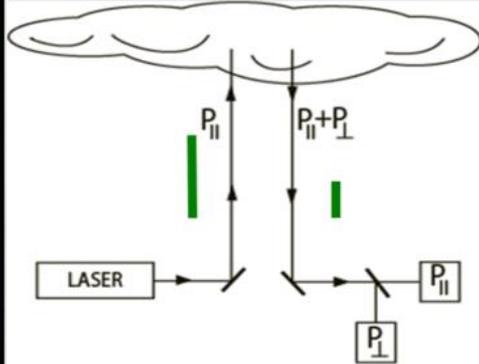
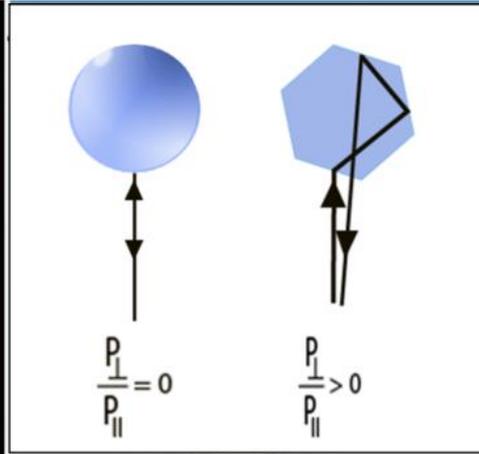
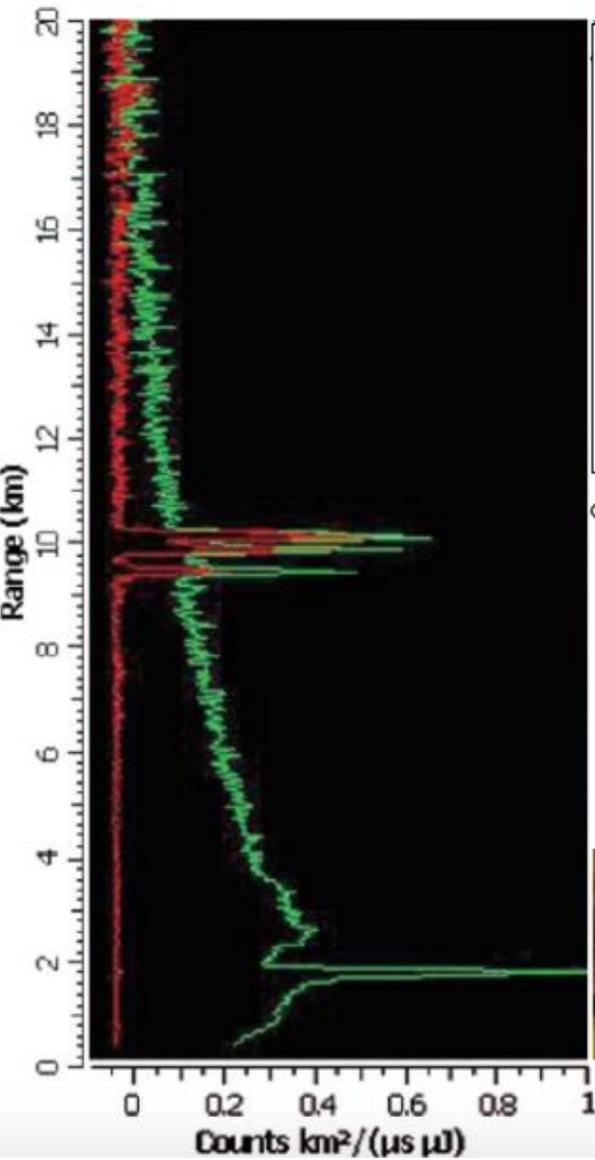


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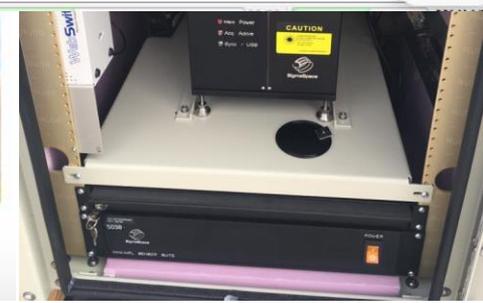
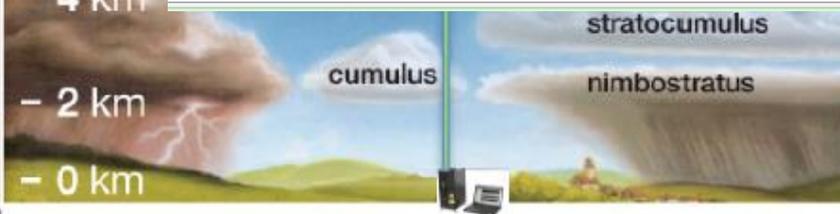
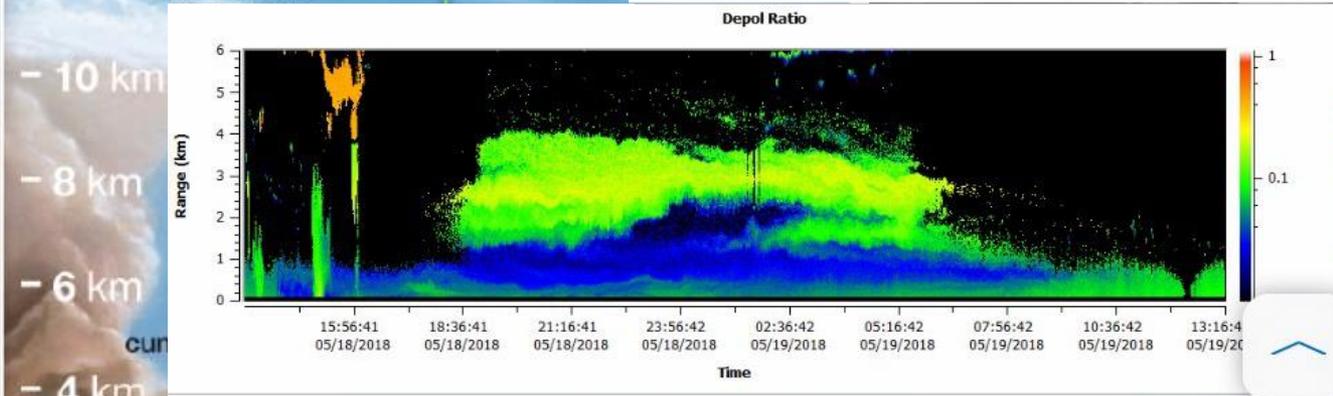
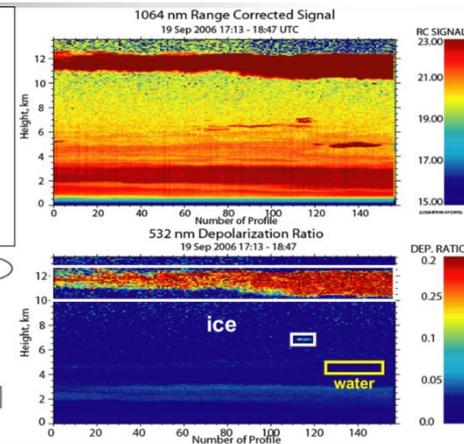
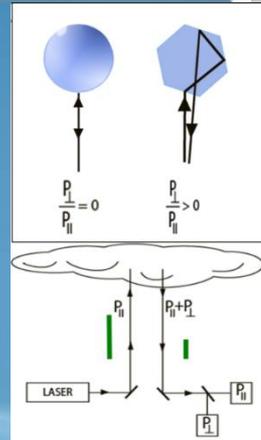
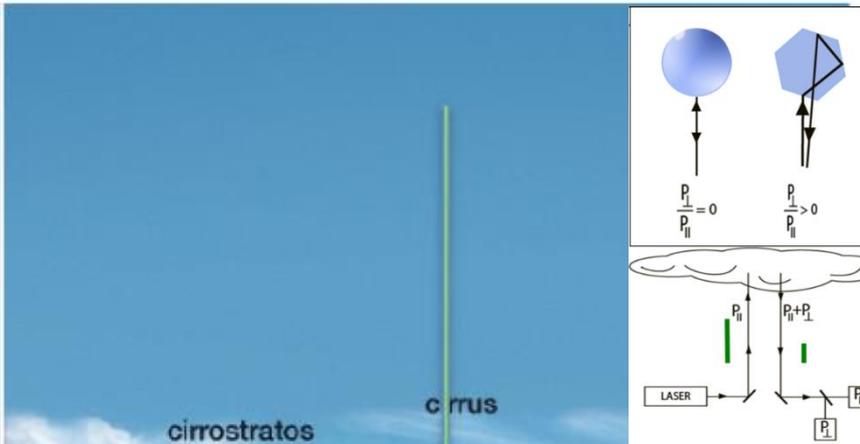
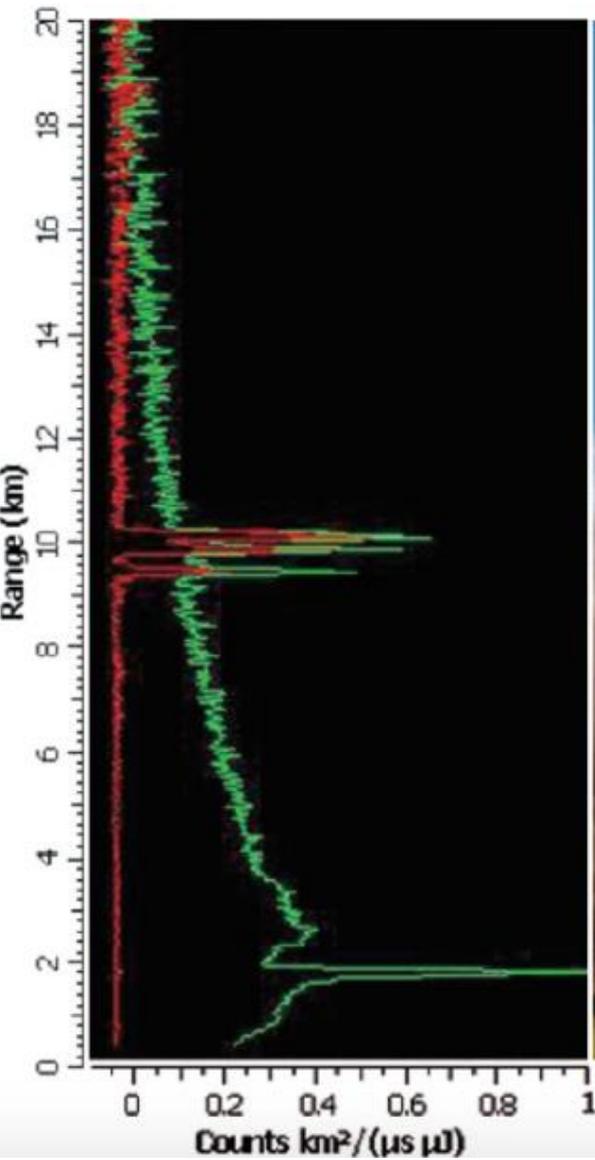
- 0 km



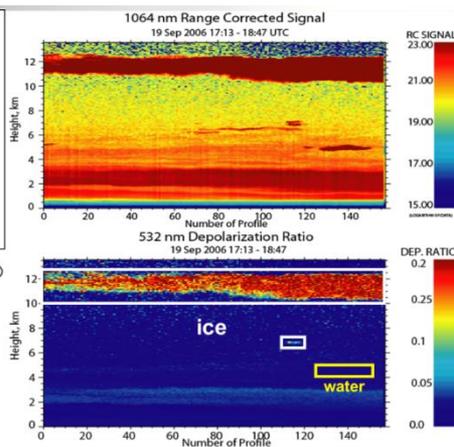
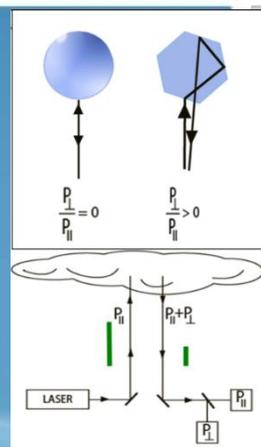
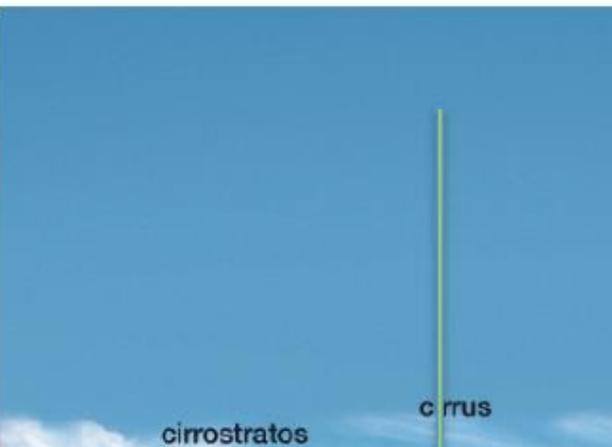
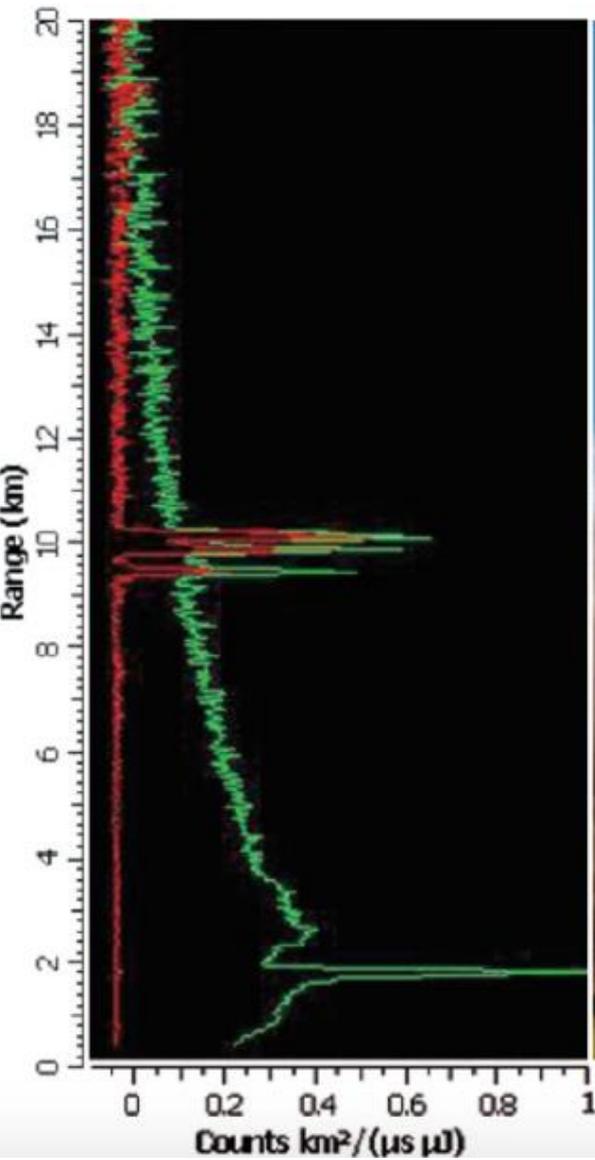
Depolarization



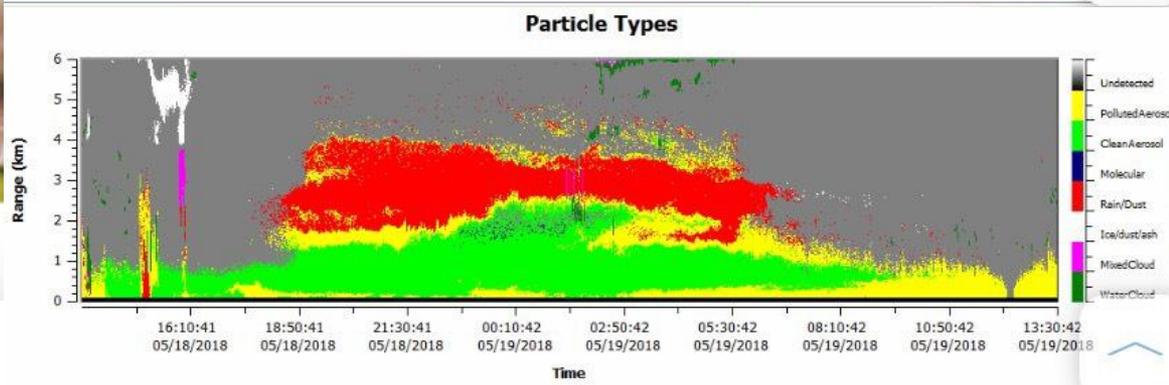
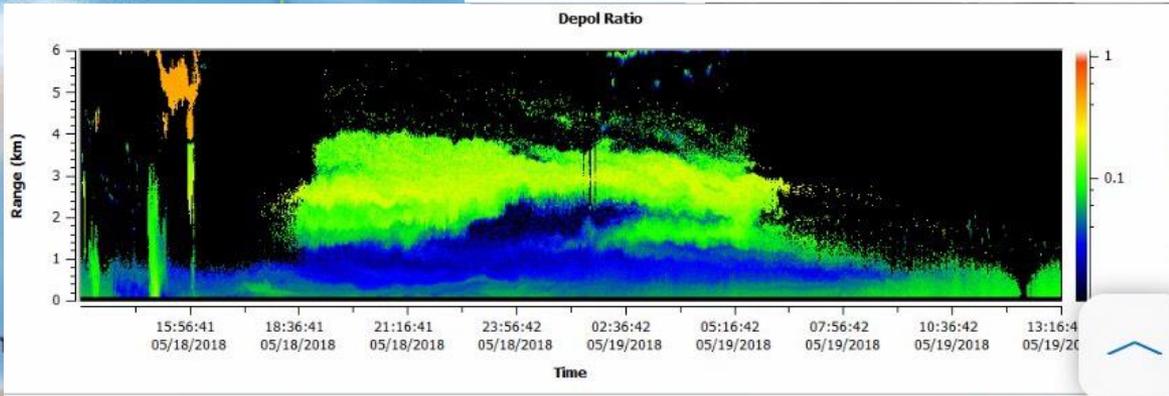
Depolarization Ratio



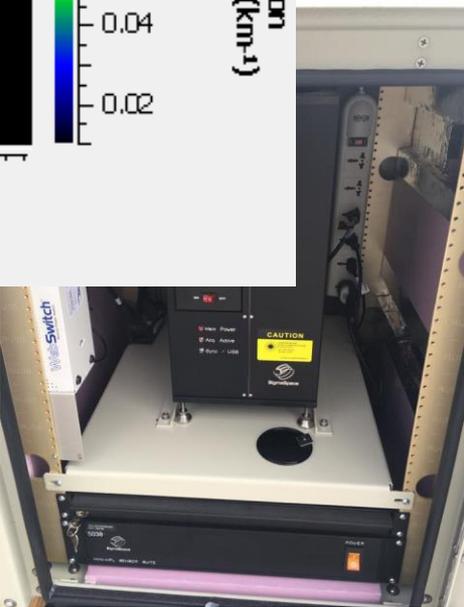
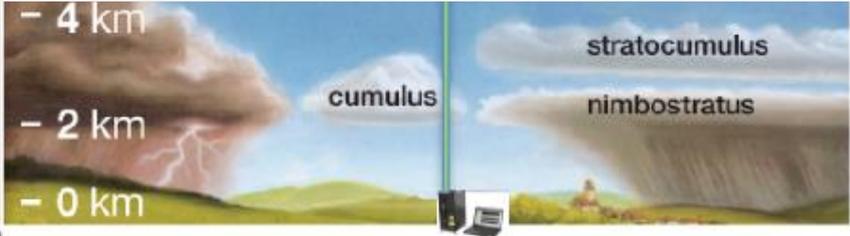
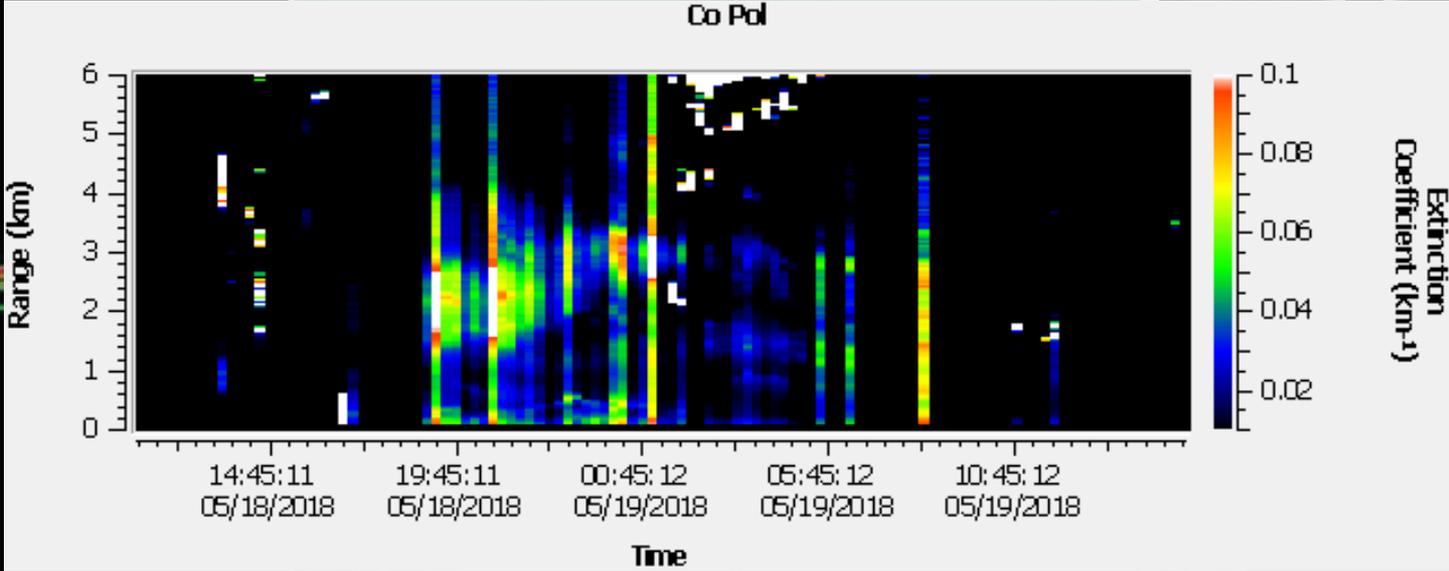
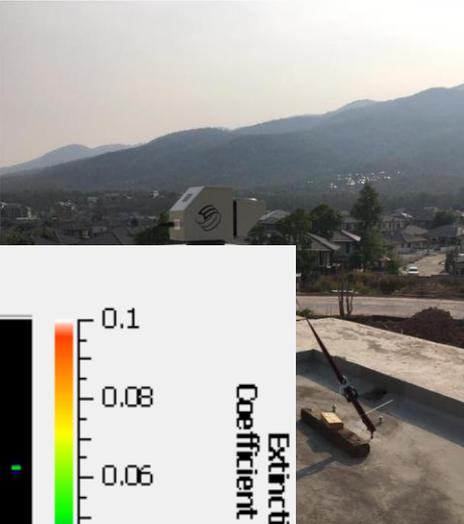
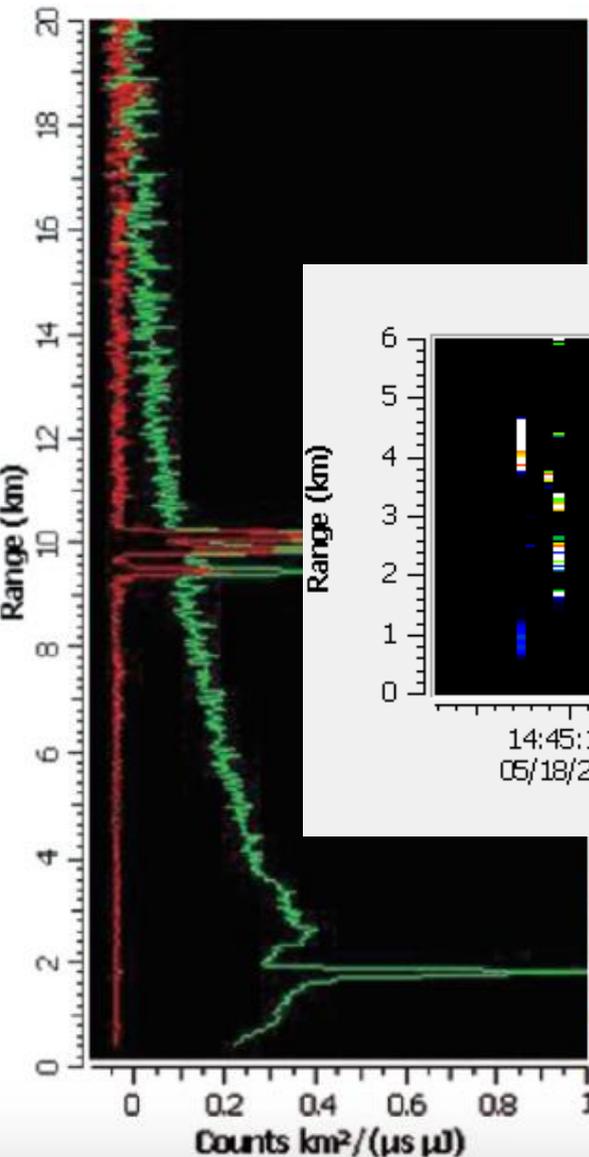
Depolarization Ratio to Particle Types (Aerosols and Cloud Phase)



– 10 km
– 8 km
– 6 km
– 4 km
– 2 km
– 0 km



Extinction Coefficient



Thank You
for
Your Attention!



Atmospheric Science

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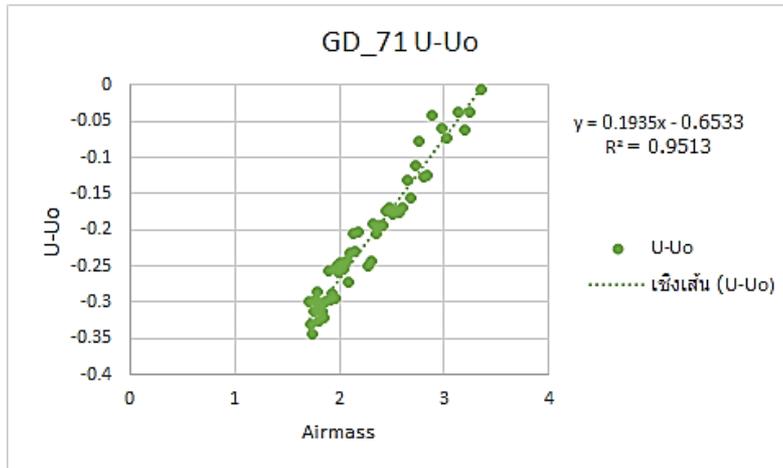
The Atmospheric Research Unit
of NARIT (ARUN) – ronmcdo@gmail.com



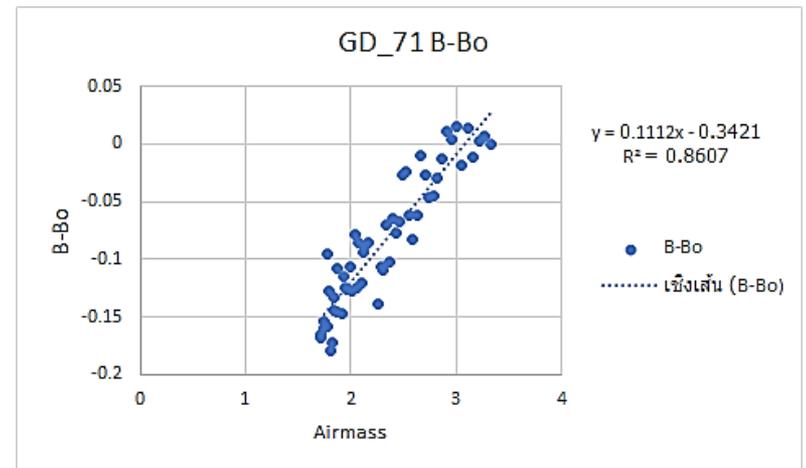
Measurement of Atmospheric Extinction at TNO Using the 2.4 m Telescope

Analysis by Jansawang Panomprai, Sauwaporn Pongpaisirikul, Porrawit Thaimai, Panpaka Suropan, Somsawat Rattanasoon, Donduedee Sookjai and Thiranan Sonkaew

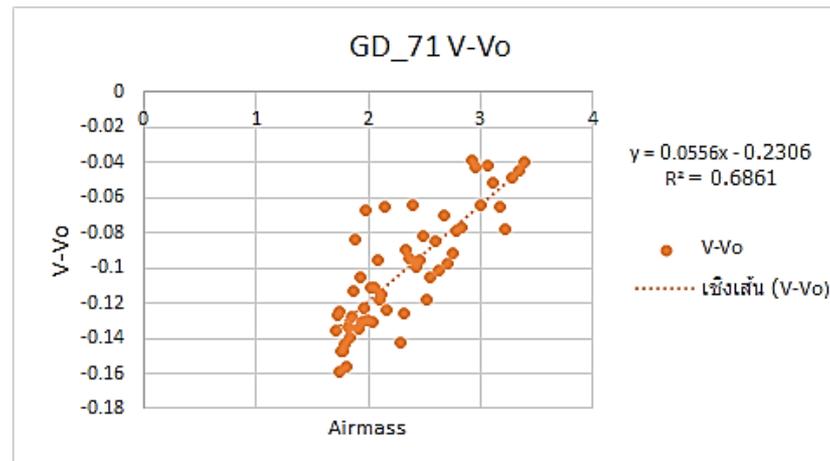
334 – 400 nm



389– 483 nm



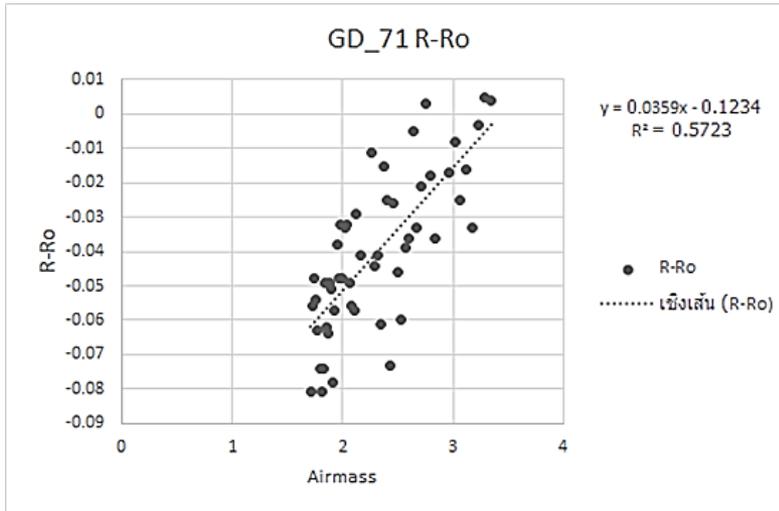
501– 589 nm



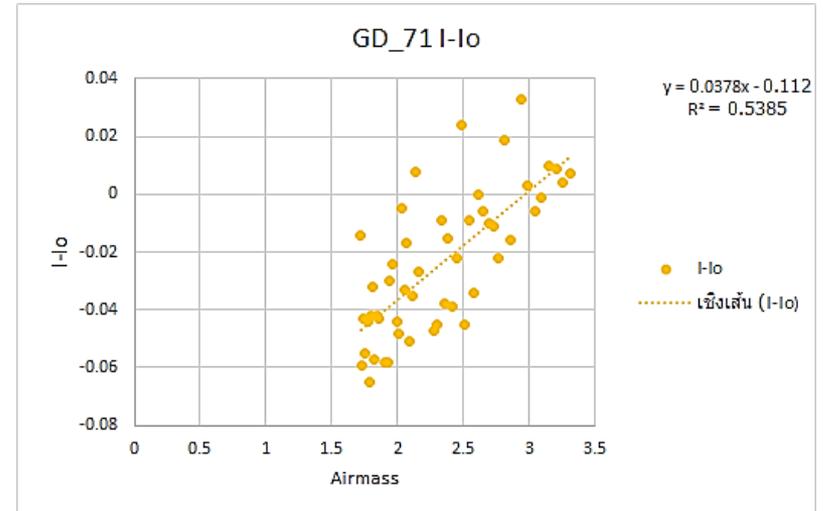
Measurement of Atmospheric Extinction at TNO Using the 2.4 m Telescope

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569 – 707 nm



722.5 – 871.5 nm



Optical filter	Atmospheric Extinction
U	0.1935
B	0.1112
V	0.0556
R	0.0359
I	0.0387