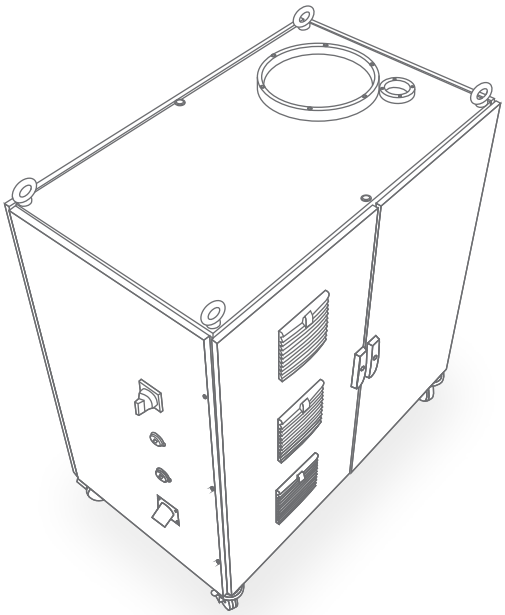
raymetrics
lidar systems

Customized LIDARs

Research | Pollution | Climate

Raman, Depolarization, Backscatter, DIAL



Raymetrics

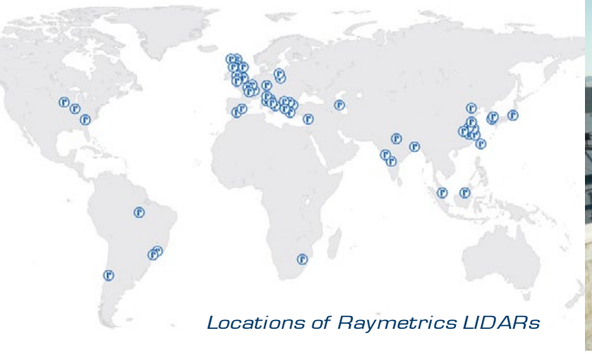
Introduction

Raymetrics was founded in 2002 with the aim of manufacturing the highest quality scientific instrumentation. The company designs, manufactures and delivers a range of advanced LIDAR systems for atmospheric measurement. Standard products include backscatter, depolarization and Raman LIDARs and LIDAR-related components such as specialist telescopes.

Through a global network of distributors, Raymetrics has LIDAR installations around the world including in the U.S.A., China, India, Europe, Southeast Asia, Africa and South America. Our client list includes such prestigious organizations as the Met Office (UK), Meteo France, the European Space Agency, CASER (run by Korean Met Agency) and the German Aerospace Centre (DLR).

Researchers remain a major part of the company's client base, but in recent years the market for atmospheric LIDARs has begun to expand. More than decade of development and use of our products in all kinds of environments has led to robust designs which are suitable for operational organizations such as meteorological agencies, aviation authorities, airports and more.

A background in LIDAR science has led to products which are compliant with all EARLINET (European LIDAR Network - key authority on LIDAR) requirements. The company is certified to standard ISO 9001:2008.



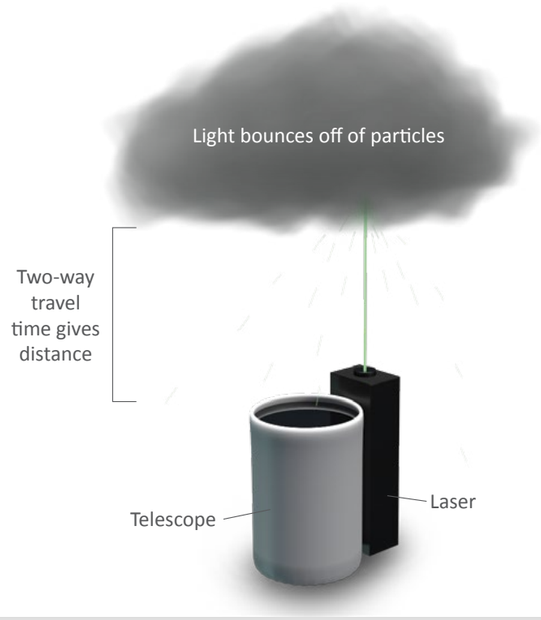
Locations of Raymetrics LIDARs

LIDAR Principle

A LIDAR works by emitting a laser beam into the atmosphere. The laser light is scattered by particles, with some "backscattered" to a telescope placed alongside the laser. Because the speed of light is known, the distance to the particle layers can be determined from the time taken for the light to return.

More advanced LIDARs can also take advantage of the properties of the returned light. From these, certain characteristics about the atmosphere can be determined, such as optical depth and particle identification (volcanic ash, smoke, marine aerosols, dust).

LIDARs plot every laser pulse individually. This means that energy per pulse is of the highest importance, since the more energy a laser pulse has, the further it will reach into the atmosphere before being scattered away. Stacking or integrating data can improve data quality but cannot do much for the range. This is why Raymetrics LIDARs use some of the most powerful industrial lasers on the market.



Products

Raymetrics has several products with fixed specifications, including an LR111-ESS-D200 model scanning LIDAR for applications including fog detection, visibility monitoring and plume monitoring; and an LR111-D300 model vertical LIDAR for meteorological applications including volcanic ash detection and Planetary Boundary Layer (PBL) studies. However we also offer our clients multiple options to modify their LIDARs according to requirements and budgets. Raymetrics produces LIDARs from within a standard range of components. Specifications which can be varied include:

- *Laser energy*
- *Telescope diameter*
- *Backscatter wavelengths (UV, Visible, IR)*
- *Cross-polarization wavelength options*
- *Nitrogen Raman options*
- *Water vapour Raman option (requires large telescope and high energy laser)*
- *Vertical or 3D scanning deployments*
- *Accessories*

Uses

- Volcanic Ash Detection
- Water Vapour (Humidity)
- Fog Detection
- Remote Visibility/Slant Visual Range
- PBL Depth
- Smoke Detection
- 3D Cloud Base
- Aerosol Discrimination
- Aerosol/Dust Layering
- Detection of Pollution Sources
- Water/Ice Cloud Determination
- Plume Tracking
- Backscatter Coefficient
- Colour Ratio
- Depolarization Ratio
- Extinction Coefficient
- Optical Depth
- Extinction-to-Backscatter Ratio

LIDARs

Backscatter/Raman/Depolarization

Choice of Laser Energy

- Emission at 355 nm:
  30, 60 or 90 mJ per pulse
- Emission at 532 nm:
  55, 130 or 200 mJ per pulse
- Emission at 1064nm:
  100, 200 or 330 mJ per pulse

Others available on request

Laser specs:
- Q-switch flashlamp-pumped Nd:YAG laser
- Repetition rate 20 Hz
- Energy stability <3%
- Pulse duration 5.5 - 9ns
- Divergence <1.5 mrad (reduced down to as little as 0.4 mrad after beam expansion)
- Flashlamp life >50 million shots

Powerful Lasers...

Choice of Telescope Size

- 200 mm
- 300 mm
- 400 mm

Custom sizes available on request

Telescope specs:
- Designed by Raymetrics specifically for LIDARs
- Carbonfibre tube/struts for stability
- Focal point inside telescope for reduced telescope size and greatly reduced obscuration from secondary mirror
- Optical quality glass with exceptional flatness (note: glass not used as lens, which introduces chromatic aberration)
- Enhanced aluminium (SiO2/TiO2) overcoat with up to 96% reflectivity
- Coatings tailored for wavelengths beyond visible range (UV and IR)

Large Telescopes...

Upgradable Systems...

Choice of Wavelengths

SPECTRUM	DETECTED	REQUIRED EMISSION	EYE-SAFETY
Ultraviolet	355 nm co-polar	355 nm	Eye-safe (at 30 mJ or 60 mJ)
	355 nm cross-polar	"	
	387 nm nitrogen Raman	"	
	408 nm water vapour Raman	"	NON-eye-safe
Visible (green)	532 nm co-polar	532 nm	
	532 nm cross-polar	"	
	607 nm nitrogen Raman	"	
Infra Red	1064 nm	1064nm	NON-eye-safe

Notes on Wavelengths:
- *Co-polar or backscatter wavelengths (355, 532, 1064 nm) provide distance to aerosols ("ranging"). Different wavelengths of light are scattered different amounts by particles of varying size. Detecting multiple wavelengths therefore allows a measure of relative particle size concentrations.*
- *Cross-polarization provides a measure of how spherical particles are. This can enable distinction of spherical water droplets from jagged ice in clouds and can enable volcanic ash to be distinguished from other particles (in combination with Raman).*
- *Nitrogen Raman provides a way of determining the LIDAR ratio more exactly, leading to more accurate results. It also allows for more particle properties to be determined (e.g. to identify volcanic ash, dust, smoke, etc).*
- *Water vapour Raman provides a measure of the water vapour (or humidity) in the atmosphere. This requires a powerful laser (60 or 90 mJ per pulse at 355 nm) and a larger telescope (300 or 400 mm) in order to capture the weak signal. Water vapour is currently only for use at night due to sunlight masking the signal.*

Deployment Options

"Vertical"
Raymetrics builds "vertical" LIDARs (note: levelling feet can be included which allow tilting up to around 5°).

Enclosure sizes vary from <1 m^2 up to 1.8 m x 1.6 m x 1.0 m (H x W x D). Enclosure size is dictated by telescope size, number of wavelengths detected and accessories required, as well as whether the system is for indoor or outdoor use.

Raymetrics can build LIDARs ready for future upgrades, such as by including a larger enclosure, a laser emitting at wavelengths which are not yet detected, etc.

Custom deployments are also available, such as vehicle-mounted systems.

3D Scanning
3D scanning options are also available. Scanning LIDARs can be supplied as single self-contained units or as two-unit models for easier transportation and added wavelength options (see images below).

3D Scanning Features

- 200mm telescope
- Q-switch Nd:YAG flashlamp-pumped laser
- Emission 30 mJ per pulse at 355 nm
- 10 X beam expansion
- Eye-safe emission (according to EU standard on laser safety EN60825-1: 2007)
- Detectable wavelength options:
  355 nm co-polar (required)
  355 nm cross-polar
  387 nm nitrogen Raman
- Full 3D rotation 360° (azimuth, 90° zenith)
- 200m overlap
- Range up to 10 - 15 km
- Environmental tolerance +5° to +35°C (climate control option available for extended range)

Modular Designs...

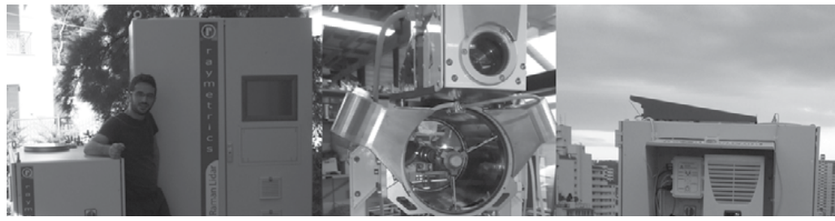
Accessories

Raymetrics offers a range of accessories, including:
- *Rain sensor with automatically closing hatch to protect windows from rain*
- *UPS with safe shutdown on power loss and automatic re-start upon power resumption*
- *Internal and external blowers for window condensation*
- *Double-walled enclosure with rain cover*
- *Camera for checking system functionality*
- *Temperature and humidity sensors*
- *Laser cooled with ethylene glycol (anti-freeze) for cold environments*
- *Full climate control (heater and cooler)*

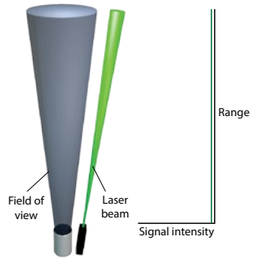
Hatch closed *Hatch open*

LIDARs

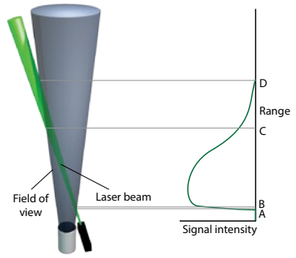
Backscatter/Raman/Depolarization



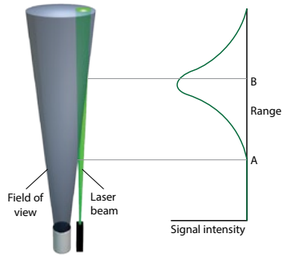
Remote Alignment



1. Misaligned LIDAR - easy to identify due to no signal



2. Misaligned LIDAR - difficult to identify, but far range compromised



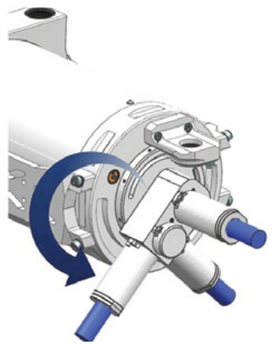
3. Properly aligned LIDAR

All LIDARs become misaligned over time. Misalignments can be difficult to identify, as shown in image 2 above. Some manufacturers use a large Field of View to combat this, but this introduces noise and reduces range. Raymetrics therefore gives the user the option to align the laser and telescope (or to increase FOV if required). Alignment can be achieved remotely through pico-motors which rotate reflecting mirrors to align the LIDAR. The motors can be controlled through Raymetrics software installed on a remote PC. Raymetrics LIDARs also come with equipment which allows the user to manually conduct the Telecover Test to check LIDAR fine alignment. All required software for alignment is supplied.

Depolarization Calculation

Raymetrics builds Wavelength Separation Units (WSUs) specifically designed to enable calculation of the depolarization constant. Calculation of this constant on site and at regular intervals, especially after the equipment has been moved, is extremely important . Even small errors in the constant can result in errors in the data greater than 100%!

Raymetrics LIDARS come with a WSU specially designed to perform EARLINET's +/-45° Test to calculate the depolarization constant. Because of the way the WSU is designed, Raymetrics can achieve close to 0.1% uncertainty in the depolarization ratio.

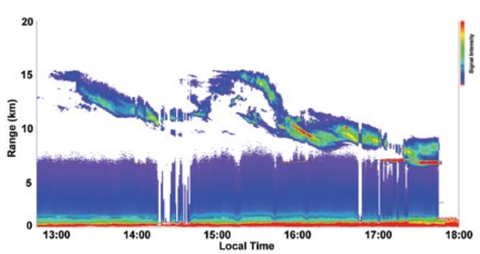


Raymetrics' rotating Wavelength Separation Unit (WSU) for depolarization constant calculation

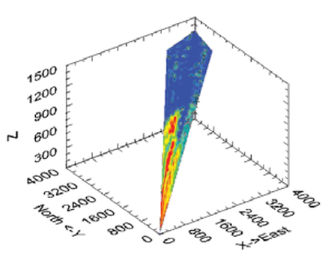
Expert Knowledge...

Software

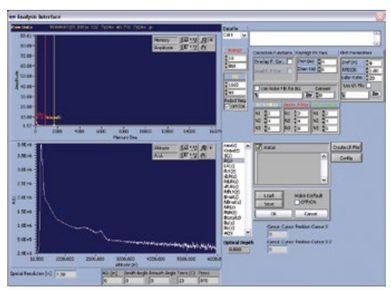
Raymetrics LIDARs come fully ready for use, with a full suite of software for instrument operation, diagnostics, data acquisition, data storage (database facility) and advanced data analysis and visualization. Software offers the capability to view data in real-time and to schedule measurements so that an operator is not required. Software comes pre-installed on the LIDAR's internal industrial grade PC and can be installed on additional external PCs. The internal PC allows for simple networking and remote operation.



Data can be viewed in real-time



Scan data can be viewed in 3D



Post-analysis interface

Key Features

Key features of a Raymetrics LIDAR include...

- Powerful yet robust industrial grade laser with high energy per pulse for better data quality and range
- Large custom-designed telescope specifically for LIDARs, increasing signal efficiency by up to 40% compared to off-the-shelf telescopes
- Up to 8 wavelengths detected including nitrogen Raman, water vapour Raman and Depolarization channels
- Advanced Wavelength Separation Unit with optional **remote +/- 45 degree calibration** at 355nm and 532nm
- Automated filter wheel option to allow for **remote signal optimization**
- Custom designed dichroic mirrors and optics which allow for **minimum attenuation** and **negligible phase shift at depolarization wavelengths**
- Opto-mechanical design guaranteeing **<2 degree angle of incidence** for each optical surface over the full effective measurement range
- Fully contained within a robust aluminium enclosure designed for housing electronics
- Optional accessories for outdoor use and storage - climate control, UPS, double-walled enclosure, humidity & temperature sensors, etc
- Complete software package provided as standard – including automated measurements, real-time views and advanced analysis
- Flexible networking options due to control by internal PC (even controllable over wifi, such as from a laptop, tablet, or mobile phone)
- Compliant with all EARLINET recommendations for LIDAR specifications

Fully Customized Designs

Customized DIAL Ozone LIDAR

Raymetrics builds most of its LIDARs from within a standard range of components. However the company also offers fully customized LIDAR designs from outside the standard component range.

This includes complete LIDAR stations with multiple emission sources (lasers) and multiple telescopes (e.g. for near and far field). It also includes customized vehicle-mounted systems.

As well as options from within the standard range of backscatter, depolarization and Raman type aerosol LIDARs, Raymetrics also builds custom Differential Absorption LIDARs (DIAL Systems). Currently these are only available for detecting ozone, however other gases may be available on request.

Raymetrics has a long history of designing customized systems. Other types of atmospheric LIDARs may also be available, including DIAL systems for other gases or LIDAR Induced Fluorescence (LIF) for detecting various gases and particles. Please contact us to discuss your LIDAR requirements.

Complete Solutions...

Why Raymetrics?

- EXPERIENCE: Raymetrics is probably the most experienced atmospheric LIDAR company in the world (in operation since 2002).
- GLOBAL BRAND: Clients come from all over the world, including Europe, North & South America, Africa, Asia & South East Asia.
- REASSURANCE: Our client list includes such prestigious organizations as Meteo France, the German Weather Service (DWD),European Space Agency, Dirección Meteorológica de Chile,German Aerospace Centre (DLR), National Environment Agency (Singapore), and the Met Office (UK), including networks of operational LIDARs and sales to many important research institutes.
- REPUTATION: Raymetrics has an excellent reputation among the LIDAR community.
- QUALITY: We use only high quality components provided by reputable suppliers. We provide specifications for all sub-components including manufacturer names. Blueprints and software source code are available to research clients on request.
- POWER: Raymetrics uses lasers with higher energies per pulse than most other manufacturers. This means the laser beam penetrates further into the atmosphere before being scattered away, resulting in better range and data quality.
- SIZE: Raymetrics designs optical systems including telescopes,which are larger than most other manufacturers', capturing more signal.
- MODULAR DESIGN: Raymetrics LIDARs are designed to be modular, allowing clients to customize and upgrade according to their needs.
- STANDARDS: Raymetrics LIDARs comply with all EARLINET (European LIDAR Network - global authority on LIDAR) requirements. This includes a depolarization unit capable of conducting the +/-45° test (for depolarization calibration constant calculation), tools for conducting the Telecover test for alignment checking, correction tools for daytime measurement and electronics & PMT performance tools.

Specifications

EMITTER	
Laser energy	Emission at 355 nm: 30, 60 or 90 mJ per pulse Emission at 532 nm: 55, 130 or 200 mJ per pulse Emission at 1064nm: 100, 200 or 330 mJ per pulse
Repetition rate	20 Hz
Beam Expansion	X5 to X10
Eye-safe	Some models (EU standard EN 60825-1: 2007)
Laser Class	IV
RECEIVER	
Size (primary mirror)	200, 300 or 400 mm
Field of view (FOV)	0.25 - 3 mrad (user adjustable)
Overlap	< 200 m (200 mm telescope) < 250 m (300 mm telescope) < 500 m (400 mm telescope)
DETECTION UNIT	
Detected Wavelength Options	***Emission at 355 nm:*** • 355 nm co-polar; 355 nm cross-polar; 387 nm nitrogen Raman, 408 nm water vapour Raman ***Emission at 532 nm:*** • 532 nm co-polar; 532 nm cross-polar; 607 nm nitrogen Raman ***Emission at 1064 nm:*** • 1064 nm
Spatial resolution	7.5 m (3.75 m available on request)
FWHM bandwidth	Approx. 0.5 nm per wavelength
Detection modes	Analogue and photon counting for near and far field
GENERAL	
Internal PC	Industrial grade PC running Windows
Software	Full suite of software supplied
Automation	Remotely operable with measurement scheduling for automation. Flashlamp changes required every 3-4 months on average with measurement scheduling program.
Enclosure	• Single-walled "indoor" models (weatherproof) • Double-walled aluminium alloy for better heat regulation for outdoor environments
Warranty	1 year as standard
Training	3 day installation and training course on site as standard
Accessories	• Climate control • Internal and external window blowers • Rain sensor + automatically closing hatch • UPS + automatic re-start after power loss • Antifreeze laser coolant for cold weather • Temp. & humidity sensors + external camera
ADDITIONAL	
Effective Range	Variable depending on specs, environmental conditions, integration times and wavelengths. In general up to 10-15 km with 200 mm telescope at 355 nm with 30 mJ laser and up to 20 km with 400 mm telescope at 355 nm and 90 mJ laser.
Environmental tolerance	• Indoor: +5 to +35 °C • Outdoor: -20 to +45 °C
Dimensions	Variable depending on specs <1.8 m x 1.5 m x 1.0 m (HxWxD)
Weight	100 to 300 kg
Power	110 - 240 V, 50 - 60 Hz (standard domestic power supply). Peak current 25 Amps.

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