DOWNLOAD PDF TECHNIQUES FOR LASER REMOTE SENSING OF THE ENVIRONMENT

Chapter 1 : Laser Spectroscopy for Atmospheric and Environmental Sensing

remote sensing techniques for monitoring environmental parameters. First, the principles and the basic performance of laser sensor systems are classified and compared.

FSLaRC March Remote sensing is any technique for measuring, observing or monitoring a process or object without physically touching the object under observation. Optical and radio elescopes, cameras, even eyesight, are types of remote sensing with which you are probably familiar. Because the remote sensing instrumentation is not in contact with the object being observed, remote sensing allows the monitor to: Avoid hazardous or difficult to reach regions, such as inside nuclear or chemical reactors, in biological hot spots, behind obstacles, inside smoke stacks, on the freeway, in the ocean depths, on mountain tops, in polar regions, on other planets, or on the sun. Measure a process without disturbance, such as monitoring flow around an aircraft model in a wind tunnel or measuring temperature during an experiment. Probe large volumes economically and quickly, such as providing global measurements of aerosols, air pollution, agriculture, human impact on the environment, ocean surface roughness, and large scale geographic features. Smooth local fluctuations by averaging over a large volume. Passive Remote Sensors There are two classes of remote sensors: Passive remote sensors do not include the energy source on which the measurement is based. The eye and optical telescopes are passive remote sensors: You cannot see at night if the room lights are not turned on. Active remote sensing instrumentation includes the energy source on which the measurement is based. RADAR is a widely known form of active remote sensing. In radar, the instrument emits a radio wave and senses the returned energy which is reflected from the target. Since the speed of radio waves and the time delay between emission and return are known, the distance to the target can be determined. Lidar Light Detection and Ranging is the optical analogue of radar. Lidars emit a concentrated light beam onto the target and measure the energy reflected back to the lidar receiver. Graphic above is pictorial of remote-sensing. The intensity or amount of reflected energy measured by the receiver provides the needed information about the target. With lidars, the light source is not a radio wave, but rather it is in the visible and adjacent ultraviolet and infrared regions of the electro-magnetic spectrum. The light source is generally a laser. Most of the remote sensors in use today are passive sensors: Unfortunately, passive remote sensors deployed on satellites only work when the sun is shining on the area under the satellite. Lidars Lidar comes in three major varieties: Range finders, like radar, emit a pulse of light and measure the time interval between when the pulse is emitted and when the reflected pulse is detected. Like radar, they are used to determine the distance to an object. Because of its much shorter wavelength, laser range finders are effective for much smaller targets. Dial lidar can be used to measure the temperature, density, and pressure of trace gases and aerosols in the atmosphere. The ratio of the on-line to off-line returned signal strength is related to the absorption characteristics which in turn depend on the temperature, density, and pressure of the target gas. You may already be familiar with the Doppler shift: Using a technique called heterodyning, the return signal is combined with another laser beam so the two interfere slightly, yielding a more easily measured radio wave in place of the two infrared light waves. The frequency of the radio wave will match the difference between the outgoing and incoming signals. A common application of Doppler radar in atmospheric remote sensing is to measure wind velocity, i. Wind velocity measurements have numerous military, civilian government, and commercial applications which include: By providing data for computer models, wind measurements allow better weather forecasting, including more accurate predictions of the paths of tropical storms and hurricanes. For all active atmospheric remote sensors, eye-safety is an absolute requirement. If visible wavelength laser energy is focused on the retina by the eye, concentrating the energy can lead to eye damage. In the infrared, energy is absorbed by the volume of the eye with the consequence that IR wavelength lasers that are as powerful as visible wavelength lasers do much less, if any, damage to the eye. For eye safety, lasers that operate outside the visible region of the electromagnetic spectrum are strongly preferred. For relativity long lifetimes and sufficient ruggedness to withstand the rigors of the space environment, diode pumped solid state lasers are preferred for space-based platforms. Image to left is the LASE logo. YAG laser, the "on" and "off" wavelengths are seperated by less than 70 picometers, a distance about 1,, times smaller than a human hair. The frequency of the Ti: The laser pulse pairs at a 5 Hz repetition rate are sequentially transmitted with about miscroseconds separation. The goals of the LITE mission were to validate key lidar technologies for spaceborne applications, to explore the applications of space lidar, to provide the first lidar science measurements of clouds and aerosols from space, and to gain operational experience which will benefit the development of future systems on free-flying satellite platforms. Image to right is the LITE logo. The LITE laser transmitter, the most powerful civilian laser ever flown in space, consists of two identical flashlamp-pumped, q-switched Nd: YAG lasers operating at a wavelength of 1. For experimental reasons, both lasers are not operated simultaneously. Doubling and tripling crystals provide simultaneous pulses at 0. ORACLE will provide real time, global remote sensing of stratospheric ozone which protects life on earth from harmful UV radiation from the sun. For the first time ever, Ti: YLF will generate narrowband UV energy. Further, although typical existing UV lasers have less than 0. SPARCLE will aim pulses of eye-safe laser light into the atmosphere and measure the light which is reflected back to it by dust and aerosols in the atmosphere. Using the optical heterodyne detection technique to measure the Doppler shifts in the return signals, wind velocities will be determined. Heterodyne detection involves the optical mixing of the lidar return with another laser operating at or near the lidar transmitter wavelength, with detection of the difference or beat frequency of the mixed signal. RSTB has designed and developed a two-micron diode-pumped Ho: The laser transmitter will deliver mJ pulses at 6 Hz pulse repetition frequency. The researchers at RSTB have recently demonstrated an all solid-state, room-temperature, two-micron laser system producing laser pulses of mJ at 10 Hz, an order of magnitude improvement over the previously developed solid-state 2 micron lasers. Using an ultra-stable micro-chip laser, as an injection seed for wavelength control,the output energy of the laser oscillator was mplified by adding four gain stages. The complete laser system was diode pumped. The output beam from the last amplifier stage had a pulse length of about nsec and a line width less than 1. Graphic to right wake vortex Lidar graphic. Aircraft vortices present a hazard to other aircraft. Given adequate time, a vortex will dissipate and another aircraft can safely travel through that airspace. Vortices do, however, limit how closely one aircraft can safely follow another, and hence, how much time must elapse between successive aircraft using a given airspace and runway. NASA LaRC is developing and demonstrating eyesafe pulsed coherent lidar systems for ground-based measurement of wake vortices in the airport terminal area. One system, based on a 2 micron wavelength, Hz pulse repetition frequency laser, has been deployed to three different airports resulting in a database of approximately aircraft landings. Potential commercial uses of these lasers include chemical sensing, llumination, surgical tools, dermatology, ophthamology, dentistry, and probes. By funding materials growth programs to significantly improve the quality of Ti: NASA also improved that old work-horse of the laser industry, Nd: Past laser research enabled NASA to develop lasers for the current generation of active remote sensors. For more details, visit the RSTB website.

Chapter 2 : Laser Remote Sensing for Environmental Monitoring - Lund University

The benefits of using laser remote sensing are discussed in the context of inspecting large and inaccessible South American areas of forest and crops. Laser remote sensing advances traditional radar technology with benefits of shorter wavelengths, less beam divergence and wavelength selectivity. These four main classes are, however, highly variable and transitional into each other. For example, pasture can be only grass or a mixture of grass, crops, soil, and slash. In the Amazon region, collecting the detailed vegetation data can be even more challenging because of the genetic variety observed even in same plant species. This paper deals with measurement techniques and issues pertinent to the remote sensing of finer vegetation data, by using laser induced fluorescence LIF , both differential and excitation-selective. The fluorescence time is short, close to a nanosecond. Plants also fluoresce in the presence of UV wavelengths nm from pigments other than chlorophyll a. Bands from nmnm can be used to locate paved surfaces and minerals such as iron in rocks and soil. Bands of nmnm show cellular arrangement and water content. Four kinds of chlorophyll exist a-d , with chlorophyll babsorption peak in the nm region. Leaf pigments of carotenoid, and anthocyanin are relevant in determining plant types. The presence of carotenoids appears at nm. Absorption by anthocyanin is within similar wavelengths of nm, both far shorter than the P chlorophyll peak. A dicot leaf can be composed of as many as six layers, i. The palisade tissue layer containing pigments and chlorophyll is densely packed allowing negligible scattering. In one photosystem, the chlorophyll amolecule P peaks as previously described. Both systems can occur within a plant simultaneously. Analysis can be made thus by measuring reflectance and transmittance integrated over a hemisphere at each wavelength. According to Yamada, by selecting wavelengths with large absorption coefficients, one loses accuracy at large chlorophyll contents and gets accuracy at small chlorophyll contents. Wide bandwidths usually reduce errors in the reflectance and transmittance measurements. Other possible laser wavelengths have been used, but for spaceborne lidar Nd: YAG currently offers the most developed technology. The nm wavelength is sufficiently long to be dominated by aerosol particle scattering in the lower troposphere, with poor noise properties from available APD detectors. The LIF method being reported in this paper, proposes to solve both problems by a combination of Synthetic-Aperture Radar SAR signal processing with differential fluorescence measurement. Analogous to SAR, the receptor is a bi-dimensional array of point detectors, connected in parallel in each row and with a computer controlled delay for each row to a series of summing units that coherently adds the light intensity collected in each point to a point further in time. The analogy to SAR is the effective increase of the detector antenna area, by signal processing. The spatial resolution is a trade-off between sensitivity and background noise and can be adjusted by adding together one or more detector lines in each row. The first step is being completed together with some sample measurements. The application of this technique can lead to better law-enforcement control of present issues such as illegal crop production and unlawful deforestation, as well as an improvement in agricultural planning and crop estimation. Ford, John et al. Presented at the 5th Thematic Conference: Yamada, Norihide et al.

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Chapter 3 : What is remote sensing?

Remote Sensing of Environment serves the Earth observation community with the publication of results on the theory, science, applications, and technology of remote sensing studies. Thoroughly interdisciplinary, RSE publishes on terrestrial, oceanic and atmospheric sensing.

Play media This video is about how Landsat was used to identify areas of conservation in the Democratic Republic of the Congo , and how it was used to help map an area called MLW in the north. Passive sensors gather radiation that is emitted or reflected by the object or surrounding areas. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples of passive remote sensors include film photography , infrared , charge-coupled devices , and radiometers. Active collection, on the other hand, emits energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. RADAR and LiDAR are examples of active remote sensing where the time delay between emission and return is measured, establishing the location, speed and direction of an object. Illustration of remote sensing Remote sensing makes it possible to collect data of dangerous or inaccessible areas. Remote sensing applications include monitoring deforestation in areas such as the Amazon Basin , glacial features in Arctic and Antarctic regions, and depth sounding of coastal and ocean depths. Military collection during the Cold War made use of stand-off collection of data about dangerous border areas. Remote sensing also replaces costly and slow data collection on the ground, ensuring in the process that areas or objects are not disturbed. Other uses include different areas of the earth sciences such as natural resource management , agricultural fields such as land usage and conservation, [6] [7] and national security and overhead, ground-based and stand-off collection on border areas. For a summary of major remote sensing satellite systems see the overview table. Applications of remote sensing[edit] Further information: Remote sensing geology and Remote sensing archaeology Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Other types of active collection includes plasmas in the ionosphere. Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so. By measuring the height and wavelength of ocean waves, the altimeters measure wind speeds and direction, and surface ocean currents and directions. Ultrasound acoustic and radar tide gauges measure sea level, tides and wave direction in coastal and offshore tide gauges. Light detection and ranging LIDAR is well known in examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology. Radiometers and photometers are the most common instrument in use, collecting reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors, followed by microwave, gamma ray and rarely, ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere. Spectropolarimetric Imaging has been reported to be useful for target tracking purposes by researchers at the U. They determined that manmade items possess polarimetric signatures that are not found in natural objects. These conclusions were drawn from the imaging of military trucks, like the Humvee , and trailers with their acousto-optic tunable filter dual hyperspectral and spectropolarimetric VNIR Spectropolarimetric Imager. These thematic mappers take images in multiple wavelengths of electro-magnetic radiation multi-spectral and are usually found on Earth observation satellites , including for example the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, detect invasive vegetation, deforestation, and examine the health of indigenous plants and crops, including entire farming regions or forests. Weather satellites are used in meteorology and climatology. Hyperspectral imaging produces an image where each pixel has full spectral information with imaging narrow spectral bands over a contiguous spectral range. Hyperspectral imagers are used in various applications including mineralogy, biology, defence, and environmental measurements. Within the scope of the combat against desertification , remote sensing allows researchers to follow up and monitor risk areas in the long term, to determine desertification factors, to support decision-makers in defining relevant measures of environmental management, and to assess their impacts. Overhead gravity data collection was first used in aerial submarine detection. Seismograms taken at different locations can locate and measure earthquakes after they occur by comparing the relative intensity and precise timings. Ultrasound sensors, that emit high frequency pulses and listening for echoes, used for detecting water waves and water level, as in tide gauges or for towing tanks. To coordinate a series of large-scale observations, most sensing systems depend on the following: High-end instruments now often use positional information from satellite navigation systems. The rotation and orientation is often provided within a degree or two with electronic compasses. Compasses can measure not just azimuth i. More exact orientations require gyroscopic-aided orientation , periodically realigned by different methods including navigation from stars or known benchmarks. Inverse problem Generally speaking, remote sensing works on the principle of the inverse problem. While the object or phenomenon of interest the state may not be directly measured, there exists some other variable that can be detected and measured the observation which may be related to the object of interest through a calculation. The common analogy given to describe this is trying to determine the type of animal from its footprints. For example, while it is impossible to directly measure temperatures in the upper atmosphere, it is possible to measure the spectral emissions from a known chemical species such as carbon dioxide in that region. The frequency of the emissions may then be related via thermodynamics to the temperature in that region. The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolutions. Spatial resolution The size of a pixel that is recorded in a raster image â€" typically pixels may correspond to square areas ranging in side length from 1 to 1, metres 3. Spectral resolution The wavelength of the different frequency bands recorded â€" usually, this is related to the number of frequency bands recorded by the platform. Current Landsat collection is that of seven bands, including several in the infrared spectrum, ranging from a spectral resolution of 0. The Hyperion sensor on Earth Observing-1 resolves bands from 0. Radiometric resolution The number of different intensities of radiation the sensor is able to distinguish. Typically, this ranges from 8 to 14 bits, corresponding to levels of the gray scale and up to 16, intensities or "shades" of colour, in each band. It also depends on the instrument noise. Temporal resolution The frequency of flyovers by the satellite or plane, and is only relevant in time-series studies or those requiring an averaged or mosaic image as in deforesting monitoring. Cloud cover over a given area or object makes it necessary to repeat the collection of said location. In order to create sensor-based maps, most remote sensing systems expect to extrapolate sensor data in relation to a reference point including distances between known points on the ground. This depends on the type of sensor used. For example, in conventional photographs, distances are accurate in the center of the image, with the distortion of measurements increasing the farther you get from the center. Another factor is that of the platen against which the film is pressed can cause severe errors when photographs are used to measure ground distances. The step in which this problem is resolved is called georeferencing , and involves computer-aided matching of points in the image typically 30 or more points per image which is extrapolated with the use of an established benchmark, "warping" the image to produce accurate spatial data. As of the early s, most satellite images are sold fully georeferenced. In addition, images may need to be radiometrically and atmospherically corrected. Radiometric correction Allows avoidance of radiometric errors and distortions. The illumination of objects on the Earth surface is uneven because of different properties of the relief. This factor is taken into account in the method of radiometric distortion correction. Topographic correction also called terrain correction In rugged mountains, as a result of terrain, the effective illumination of pixels varies considerably. In a remote sensing image, the pixel on the shady slope receives weak illumination and has a low radiance value, in contrast, the pixel on the sunny slope receives strong illumination and has a high radiance value. For the same object, the pixel radiance value on the shady slope will be different from that on the sunny slope. Additionally, different objects may have similar radiance values. These ambiguities seriously affected remote sensing image information extraction accuracy in mountainous areas. It became the main obstacle to further application of remote sensing images. The purpose of topographic correction is to eliminate this effect, recovering the true reflectivity or radiance of objects in horizontal conditions. It is the premise of quantitative remote sensing application. Atmospheric correction Elimination of atmospheric haze by rescaling each frequency band so that its minimum value usually realised in water bodies corresponds to a pixel value of 0. The digitizing of data also makes it possible to manipulate the data by changing gray-scale values. Interpretation is the critical process of making sense of the data. Image Analysis is the recently developed automated computer-aided application which is in increasing use. Object-Based Image Analysis OBIA is a sub-discipline of GIScience devoted to partitioning remote sensing RS imagery into meaningful image-objects, and assessing their characteristics through spatial, spectral and temporal scale. Old data from remote sensing is often valuable because it may provide the only long-term data for a large extent of geography. At the same time, the data is often complex to interpret, and bulky to store. Modern systems tend to store the data digitally, often with lossless compression. The difficulty with this approach is that the data is fragile, the format may be archaic, and the data may be easy to falsify. One of the best systems for archiving data series is as computer-generated machine-readable ultrafiche , usually in typefonts such as OCR-B , or as digitized half-tone images. Ultrafiches survive well in standard libraries, with lifetimes of several centuries. They can be created, copied, filed and retrieved by automated systems. They are about as compact as archival magnetic media, and yet can be read by human beings with minimal, standardized equipment. Data processing levels[edit] To facilitate the discussion of data processing in practice, several processing "levels" were first defined in by NASA as part of its Earth Observing System [17] and steadily adopted since then, both internally at NASA e. Level Description 0 Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts e. A Level 1 data record is the most fundamental i. Level 2 is the first level that is directly usable for most scientific applications; its value is much greater than the lower levels. Level 2 data sets tend to be less voluminous than Level 1 data because they have been reduced temporally, spatially, or spectrally. Level 3 data sets are generally smaller than lower level data sets and thus can be dealt with without incurring a great deal of data handling overhead. These data tend to be generally more useful for many applications. The regular spatial and temporal organization of Level 3 datasets makes it feasible to readily combine data from different sources. While these processing levels are particularly suitable for typical satellite data processing pipelines, other data level vocabularies have been defined and may be appropriate for more heterogeneous workflows. This section does not cite any sources. Please help improve this section by adding citations to reliable sources. 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Chapter 4 : Laser Remote Sensing â€“ Academy for Future Science

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Published online Dec Fiddler ,1 Israel Begashaw ,2 Matthew A. Mickens ,3,4 Michael S. Received Nov 18; Accepted Dec 2. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license http: This article has been cited by other articles in PMC. Abstract Lasers and laser spectroscopic techniques have been extensively used in several applications since their advent, and the subject has been reviewed extensively in the last several decades. This review is focused on three areas of laser spectroscopic applications in atmospheric and environmental sensing; namely laser-induced fluorescence LIF , cavity ring-down spectroscopy CRDS , and photoluminescence PL techniques used in the detection of solids, liquids, aerosols, trace gases, and volatile organic compounds VOCs. Introduction There are numerous traditional optical, gas chromatographic and mass spectrometric methods that have served extremely well in the detection of atmospheric and environmental trace gases, solid, and liquid compounds. However, promising new sensing and analytical measurement techniques based on laser spectroscopy have emerged and have been successfully used in numerous applications. There has been an exponential growth in the application of laser spectroscopic techniques in almost every area of pure and applied science. This interest has spurred recent developments in several novel technologies, such as diode and fiber lasers for the optical communications industry, diode-pumped solid-state lasers, etc. These advances, coupled with the reduced cost and complexity of laser systems, make such spectroscopic sources more universally available and user friendly to both established and new fields. These fields include monitoring air and water quality; industrial, traffic, and rural emissions; atmospheric chemistry; chemical analysis and process control; medical applications and cancer recognition; applications to national security and explosives detection; vegetation remote sensing; artwork characterization, etc. It is evident that use of lasers and laser spectroscopic techniques in atmospheric and environmental sensing continues to grow. This review selectively covers some of the applications of these techniques including laser-induced fluorescence LIF , cavity ring-down spectroscopy CRDS and photoluminescence techniques PL. The first section of the review covers recent development in the area of LIF that have bearing on environmental analysis. The LIF technique is used widely in research for a variety of analytical applications, from interrogation of plasma plumes in Laser Induced Breakdown Spectroscopy LIBS , to determination of cancerous tissues, to fluorescence spectroscopy of single molecules. LIF is one of the most sensitive approaches available for analytical purposes. The application of LIF techniques to the study of problems related to atmospheric and environmental sensing is reviewed. The CRDS section covers a brief summary of some of the common experimental schemes that have been used in various studies. Covering experimental setups is essential for CRDS, since it is a relatively new technique only about 20 years old and its application is expanding. The rest of the section is devoted to discussing the atmospheric and environmental applications of CRDS-based techniques. The discussions will focus on trace gas detection or analysis, biologically relevant trace gas sensing, isotope ratio measurements, and aerosol studies. Emphasis is placed on the solid state complexes, and the molecular interactions with volatile organic compounds VOCs that permit analyte recognition through observed changes in PL properties. This section reviews the numerous investigations that examine the photophysical properties of fluorophores that can potentially be employed as efficient chemosensors. Since the PL process has now become a routine spectroscopic technique, no effort is made in this review to describe the technical aspect of the methodology. Laser-induced Fluorescence Spectroscopy 2. Introduction Laser-induced fluorescence spectroscopy is based on the electronic excitation of an atom or molecule by laser irradiation. When the electron returns to a lower-lying energy level, the energy may be released in the form of a photon. This forms the basic principle of fluorescence. The LIF technique is well established, and theoretical, mathematical, and practical treatments of LIF are available in several books and review articles [1 - 4]. Therefore, those subjects will not be enumerated here. This section of the review covers laser-based fluorescence techniques that have bearing on environmental analysis. Many spectroscopic techniques are available for the analysis of a variety of systems, and the reader is directed to several reviews of other spectroscopic and spectrometric techniques not covered in this review [5 - 18]. Discussions of methods of quantitation, certified reference materials, sample preparation, and other topics are covered by a yearly review of atomic spectrometry techniques [5 - 9 , 16 , 17]. A recent review has been written concerning digestion procedures for soils, sediments, coal, and other materials [19]. A brief functional description of LIF-based techniques is first given, with references for more in-depth treatments. The subsection on solids covers the in situ analysis of sediments and minerals, environmental transport of thallium, arsenic analysis and speciation, and characterization of plant tissue. The subsection of liquids analysis focuses on in situ analysis of fresh water and seawater, as well as the utilization of sample substrates. The subsection concerning aerosols and gases focuses largely on single-particle analysis of aerosols and the measurement of OH, HO2, RO, and RO2 radicals. Review of the Technique 2. All methods have several things in common: Thought must be given to the sensitivity of the technique, but cost, size, and technical complexity also factor into design decisions. To achieve the lowest limit of detection LOD , the excitation and detection frequencies that produce the most intense emission are typically chosen. However, this may not always be the best method. Spectral interferences can hamper detection at some emission lines and not others. In other instances, LOD is not an issue, and linear dynamic range or measurement accuracy is more desirable. This is why experimental setups vary, not only due to the substrate, but the overall goal of the technique. The distinction between LEAFS and atomic fluorescence spectrometry AFS is that the atomic excited states are produced from a coherent laser source with a narrow frequency profile, rather than incoherent, broad-band light source. The advantages of LEAFS stem from the high degree of sensitivity and selectivity resulting from the selection of excitation frequency and fluorescence frequency [21 - 23]. Additionally, a degree of technical complexity is inherent in the system. A general schematic for LEAFS is depicted in Figure 1 , where laser irradiation should be tunable between and nm [25]. The resulting fluorescence is carefully selected and detected. Unlike typical LIF experiments, laser intensity in LEAFS is typically set slightly above the limit of saturation in order to reduce the absorption of fluoresced radiation by unexcited species and to minimize the effects of fluctuations in laser intensity [23]. The deleterious effects of non-linear phenomena are minimized, while minimizing self-absorption produces a typical linear dynamic range of 5â€”7 orders of magnitude.

Chapter 5 : Industrial Applications of Laser Remote Sensing

Remote Sensing Laser Spectroscopy Lidar System Lidar Signal Volcanic Plume These keywords were added by machine and not by the authors. This process is experimental and the keywords may be updated as the learning algorithm improves.

BibTeX Abstract This thesis studies the techniques of laser remote sensing and their applications in environmental monitoring, as documented in several published papers. The environment where the human being live is degrading with an accelerating speed. Quantitative monitoring characterizes the quality of the environment and offers possibilities to solve environmental problems. Laser remote sensing actively probes physical quantities with advantages of, e. Light detection and ranging LIDAR measures the backscattered light from remote targets using a short-pulsed laser. Three varieties of LIDAR techniques, based on a vehicle-carried laboratory, have been developed in the work within the thesis. Elastic LIDAR measures the elastic backscattering from the atmospheric aerosols, and has been used to comparatively study their vertical distribution above a Swedish rural area and a Chinese Magacity. Vertical measurements of two serious pollutants, atomic mercury and nitrogen monoxide, have been performed in the same Chinese city. Further, DIAL is also proved to be valid for remote gas analysis in multiple-scattering media. Fluorescence LIDAR can recognize the molecules contained in a remote target, through analyzing the laser-induced fluorescence fingerprint. Such a technique is employed in this thesis mainly for ecological studies, particularly for insect and bird monitoring. Promising performances have been revealed through feasibility tests and field experiments. Tunable diode laser absorption spectroscopy TDLAS attracts research attention for its compactness, cost-effectiveness, and high sensitivity. The signal-to-noise ratio of a TDLAS can be conventionally improved by applying modulation; while in the thesis, a different idea is proposed and demonstrated by operating the absorption spectroscopy on a zero light background. Proof-of-principle experiments are performed and considerations regarding real-world applications are discussed. Finally, fiber-optic remote sensing realizes the environmental monitoring by employing fiber-optic devices, e. Applications of these sensors are usually limited to temperature and stain monitoring. By using a methane catalyst which transfers the ambient methane into heat, FBG sensors become sensitive to methane. The sensitivity can be improved if the sensing FBG is interrogated by another reference grating having a matched spectrum. The multiplexing of such twin-grating-structure sensors is realized, and thus a distributed sensor network is possible to construct.

Chapter 6 : Remote Sensing | Special Issue : Lidar/Laser Scanning in Urban Environments

Laser remote sensing is a fast developing area of laser spectroscopy with numerous applications. Strengths and weaknesses of direct remote sensing, e.g. DIAL, LIDAR, and indirect sensing through fiber optics are discussed.

USA Preface This book covers industrial applications of laser remote sensing. Traditionally, laser remote sensing lidar has dealt with atmospheric measurement, with measurement ranges in the order of km. Therefore, lidar systems have been large in size and designed primarily for permanent installation and continuous measurement. However, for industrial applications, the system needs to be mobile or portable so that sensing could be performed at the necessary location at the necessary time, e. There exist several books on laser remote sensing, e. These books mainly cover atmospheric measurement. Recent lidar development has focused on satellite-borne lidar, whose aim is global monitoring of water vapor, ozone, CO2, wind, clouds, aerosols. On the other hand, a book on applications of laser remote sensing to closer ranges, in the order of m to tens of m, has not been previously published. These ranges require remote sensing because they are too large for in situ measurement using conventional sensors or sampling methods, but are too small for applying conventional lidar for atmospheric measurement. Laser remote sensing has several potential industrial applications in these closer measurement ranges, such as leak gas detection, pollutant detection, environment monitoring, wind profiling, and structural health monitoring. This book aims to provide some specific applications which may be useful to industry, as well as other applications such as marine environment monitoring, vegetation monitoring, and minor constituent monitoring, which are more oriented toward science, but may have applications to industry in the future. An overview of laser remote sensing and its applications to industry are presented in Chapter 1. Various kinds of lidar and measurable quantities are described. Conventional lidar design intended for atmospheric measurement does not allow sensing at very close range, because of insufficient overlap between the transmitted laser beam and the receiver field of view. In order to overcome the problem of insufficient overlap, new concepts on lidar design are under development for near field applications. The design of an in-line type lidar is covered in Chapter 2. Lasers have found increased use in industrial applications such as gas leak detection and pollutant detection. The most common technique used for gas leak detection is laser absorption spectroscopy, which is covered in Chapter 3. Another technique used for gas leak detection is Raman scattering, whose application to hydrogen gas leaks is covered in Chapter 4. Hydrogen is a gas species which cannot be detected by absorption, and this recently developed technology could find wide use with the increasing introduction of hydrogen energy. Pollutant detection using differential absorption lidar, e. Laser remote sensing has wide applications, which are not limited to detection of gases. The applications to the marine environment, such as bathymetry, oil spill detection, and water quality inspection are presented in Chapter 5. Application to vegetation monitoring is covered in Chapter 6. Laser-induced fluorescence from chrollophyl can provide useful information on vegetation growth. Laser sensing has also found use in safety and security. Although the death rate due to traffic accidents is declining every year owing to safer vehicles and better infrastructure, traffic accidents still rank at the top of the causes of accidental deaths. An example of the application of laser radar to traffic safety is covered in Chapter 7. The increase in use of renewable energy sources has led to a rapid increase in electricity generation using wind power. For optimal siting of windmills, profiling of local winds is necessary. The all-fiber laser Doppler lidar, which has recently been developed, has dramatically decreased the size and power consumption, so that portable wind profiling has become possible. This is covered in Chapter 8. An important social issue is the safety of infrastructure such as bridges and tunnels. The use of conventional ultrasound techniques is labor intensive, as it requires contact between the sensor and the object under testing. The application of laser ultrasound provides non-contact testing with a standoff distance of several meters. Recent developments in this field and application to inspection of concrete structures such as railway tunnels are covered in Chapter 9. This method provides the equivalent of Atomic Emission AE spectroscopy in a remote configuration. Since no sampling is necessary, the technology could be useful for minute concentration detection in hazardous environments. The affiliations of the authors of this book are distributed among academic institutions, private and government research institutes, and private companies. The distribution was chosen so that the content will vary from fundamental research to practical applications. Although laser remote sensing is especially suited to plasmas and combustion fields because of its ability to perform non-contact measurement, the applications to these areas are not covered in this book, because comprehensive texts already exist. The interested reader is requested to refer to these texts, such as K. The editors hope that this book be a useful addition to the technical library of researchers and engineers interested in laser sensing and its applications.

Chapter 7 : NASA - Remote Sensing and Lasers

The use of a laser heterodyne radiometer and fiber optics for remote sensing is studied. Future developments in the field of remote sensing, in particular the improvement of laser sources, the fabrication of compact remote sensing instruments, and space-borne applications for lidar, are considered.

Chapter 8 : Remote sensing - Wikipedia

Laser Remote Sensing provides an up-to-date, comprehensive review on LIDAR, focusing mainly on applications to current topics in atmospheric science. The scope of the book includes laser remote sensing of the atmosphere, including measurement of aerosols, water vapor, clouds, winds, trace constituents, and temperature.

Chapter 9 : Remote Sensing of Environment - Journal - Elsevier

Two RRS techniques have been compared. Here, we do such a comparison using two methods based on the detection and analysis of RS (RBS) spectra. Four methods are considered here for measuring the atmospheric temperature.