National Aeronautics and Space Administration

Environment

Interference Reduction Algorithm for Continuous Wave Lidar Return Data

State-of-the-art interference filtration for greater range and accuracy in continuous wave lidar systems

NASA's Langley Research Center has developed a waveform processing technique to eliminate signal noise resulting from sources of interference (scatterers) that can degrade continuous wave (CW) lidar return data. The algorithm was developed to enable CW lidar measurement of atmospheric gas concentrations as part of NASA's Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS) program, but can be used to test any chemical species such as poison gas or other trace elements in the atmosphere. The algorithm demonstrated reduction in interference resulting from thin cloud layers and other scatterers. The improvement holds the potential for significant advancement of CW lidar systems, which are less expensive, of simpler design, and can be operated at higher average power than pulsed lidar systems.

BENEFITS

- Lower hardware costs - performance enhancement of continuous wave (CW) lidar systems that can be up to 75% less expensive than pulsed systems.
- Ease of implementation - software-based wave form processing improves CW lidar signal quality with low implementation barriers.
- Reduced interference - eliminates channel interference and artifacts from lidar return signals.
- Improved resolution and range - algorithm enables more powerful CW lidar systems for greater signal-to-noise ratio
- Flexibility - algorithm may provide benefit to CW systems in a wide range of lidar applications.

technology solution

THE TECHNOLOGY

The NASA algorithm was developed to support the ASCENDS mission Laser Absorption Spectrometer (LAS) for carbon dioxide measurements in the mid-to-lower troposphere. The LAS is a satellite-based continuous wave lidar system capable of monitoring global variability of carbon dioxide concentration in the troposphere from space, with a measurement range of up to ~500 km (low earth orbit). The modulation algorithm (a filtered pseudo-noise code algorithm) is capable of eliminating cross-channel noise and interference by modulating the lidar return signal using a time shifting approach. Figures 1 and 2 below demonstrate these capabilities.

The technology builds on a strong remote sensing and lidar technology heritage at NASAs Langley Research Center. The algorithms are complete, have been verified as error-free by independent third parties, and flight tests aboard a Dassault HU-25C Guardian Falcon jet are scheduled for Fall of 2014. Lidar system specifications for the test bed include:

-- Three 17.7 cm telescopes
-- CW lidar system powered by three 10W erbium-doped fiber amplifiers to provide 30W average laser power
-- A low noise, high gain HgCdTe detector and cryocooler

The algorithms are mission ready and are available for licensure and implementation in a wide range of continuous wave lidar applications.

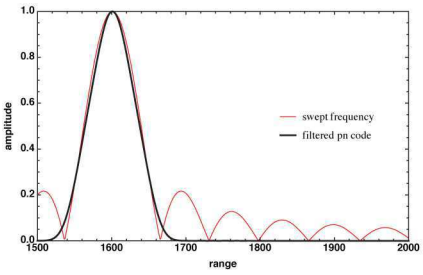

FIGURE 1: CW lidar pulse plot that compares the commonly used linear swept frequency modulation algorithm (red) with the new, improved NASA algorithm (black).

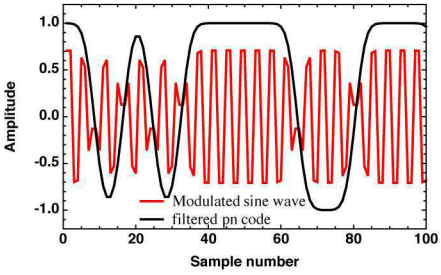

FIGURE 2: Modulated CW lidar return data. The time shifting pseudo noise code approach greatly simplifies CW lidar return signal processing.

APPLICATIONS

The technology has several potential applications:

- Gas sensing and detection
  -- Industrial emissions monitoring
  -- Pipeline leak detection
  -- Chemical spill response
  -- Weaponized gas detection
  -- Nuclear power plant monitoring
- Meteorology and atmospheric studies
  -- Carbon emission studies
  -- Wind farm surveying
- Mapping and range finding
  -- Surveying
  -- Digital terrain models
  -- Digital elevation models

PUBLICATIONS

Patent No: 8,605,262

Patent Pending

J. Campbell, B. Lin, and A. Nehrir, Advanced sine wave modulation of continuous wave laser system for atmospheric CO2 differential absorption measurements, Appl. Opt. Vol. 53, 816- 829 (2014) http://dx.doi.org/10.1364/AO.53.000816

More Information

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