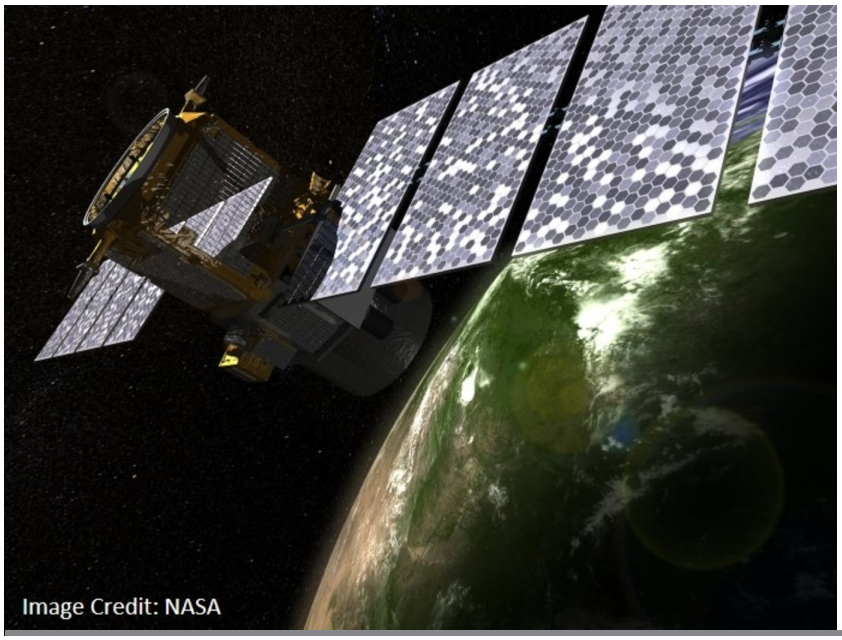

National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

Pulsed 2-Micron Laser Transmitter

For Coherent 3-D Doppler Wind Lidar Systems

Innovators at the NASA Langley Research Center (LaRC) have designed a Pulsed 2-Micron Laser Transmitter for Coherent 3-D Doppler Wind Lidar Systems. The design produces a compact, efficient, long-lifetime laser transmitter as needed for use in space, while also having potential applications as an airborne or ground-based wind measurement tool. The new laser transmitter leverages two-decades of research and development expertise at NASA LaRC in the field of 2-micron lasers, particularly those for coherent Doppler wind lidar remote sensing. The invention is a conductively cooled, highly efficient, pulsed 2-Micron Tm(Thulium):Fiber pumped Ho(Holmium):YAG laser transmitter that provides optimal atmospheric transmission for wind based measurements. This innovation provides a transformational improvement in weather forecasting by minimizing severe weather losses and offering better understanding of atmospheric and atmosphere-ocean processes, helping many investigations including climate change.

BENEFITS

- Enables wind speed measurements through cloud layer: this transmitter has the ability to measure wind speed under the cloud layer from space, an important missing data element in current weather models (about 60% of the Earth's surface is covered by clouds at any instant)
- Improved signal-to-noise ratio: the system achieves 200 pulses-per-second (pps), while current methods can only emit signals at 10 pps. Faster pulsing increases the likelihood that pulses can span clouds to gauge wind speed
- Compact and highly efficient: the transmitter uses a pumping frequency 10X closer to the output frequency than current methods, so much less input energy is wasted as heat. Current systems pass only 15% of the input power to output signals, while this new system passes over 95%, decreasing power and weight

THE TECHNOLOGY

The new NASA LaRC Pulsed 2-Micron Laser Transmitter for Coherent 3-D Doppler Wind Lidar Systems is an innovative concept and architecture based on a Tm:Fiber laser end-pumped Ho:YAG laser transmitter. This transmitter meets the requirements for space-based coherent Doppler wind lidar while reducing the mission failure risks. A key advantage of this YAG based transmitter technology includes the fact that the design is based on mature and low-risk space-qualified YAG host crystal. The transmitter operates at a 2096 nm wavelength using Ho:YAG, resulting in high atmospheric transmission (>99%), versus a transmitter operating at 2053 nm using co- doped Tm:Ho:LuLiF, which suffers limited transmission (90%) due to water vapor interference. In-band pumping through Tm:Fiber pump Ho:YAG architecture offers lower quantum defect from 1908 to 2096 nm (9.1%) compared to traditionally used co-doped Tm:Ho:LuLiF of 792 to 2051 nm (61%). The transmitter has an efficient pump compared to LuLF, since YAG has 27% higher pump absorption and 52% lower reabsorption of the emitted 2-micron, resulting in higher efficiency and lower heat load. Being isotropic, YAG is amenable for spatial-hole burning mitigation which supports linear cavity architecture without compromising injection seeding quality. This attribute is important in designing a compact, stable, high seeding efficiency laser. A folded linear cavity for long pulse (>200 ns), transform limited line-width (2.2 MHz) and high beam quality (M2 = 1.04) - the most critical parameters for coherent detection - are easier to achieve using YAG compared to LuLF. Lower heat load results in high repetition rate (>300 Hz) operation, which allows higher probability of wind measurements through broken clouds, off clouds, and below clouds, thus reducing errors and increasing science data product quantity and quality.

Artist's rendition of a pulsed coherent Doppler lidar system. Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Meteorology: airborne or ground-based or space-based wind measurement for weather forecasting
- Remote sensing: coherent 3-D Doppler wind lidar from satellites

PUBLICATIONS

Patent No: 11,340,337

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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