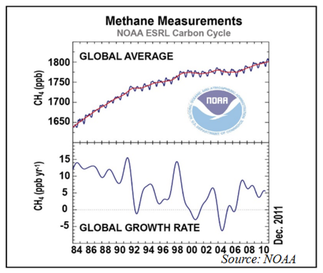
A Methane Lidar for Greenhouse Gas Measurements

Haris Riris[1], Kenji Numata[2] Stewart Wu[1], Randy Kawa[1]
[1]NASA-Goddard Space Flight Center, Greenbelt, MD, [2]UMD, College Park, MD,
Support: NASA, ESTO ACT, GSFC IRAD Programs Contact: Haris.Riris@gsfc.nasa.gov

➢ **The GSFC Integrated Path Differential Absorption (IPDA) lidar uses optical parametric technology and a sensitive detector to measure Differential Optical Depth (DOD) of CH_4 at 1651 nm. The technology can and has been used to measure CO_2, H_2O and CO in the near and mid-infrared.**

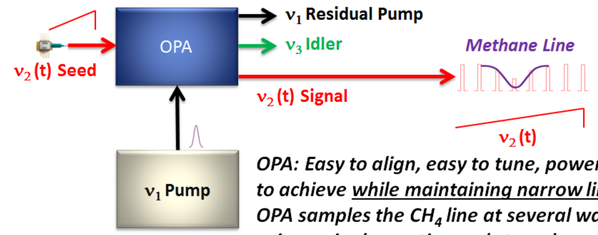
Why Methane?

- Earth Science Decadal Survey (NRC 2007):
  - *"Ideally, to close the carbon budget, methane should also be addressed, but the required technology is not now obvious. **If appropriate and cost-effective methane technology becomes available, methane capability should be added.**"* p. 207
- New Earth Science Decadal Survey is expected to call for CO_2/CH_4 measurements.
- *Large amounts of organic carbon are stored as CH_4 and CO_2 in the Arctic permafrost. Thawing Arctic permafrost soil, is a cause for concern as a rapid, positive greenhouse gas/climate feedback.*




Source: GISS

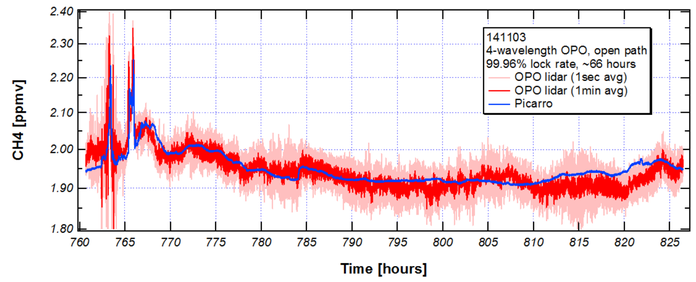
CH4 Transmitter Technology - OPA



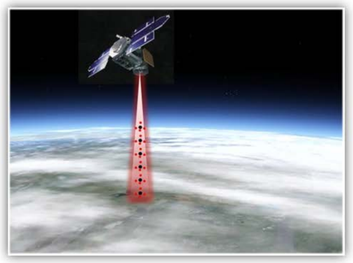
OPA: Easy to align, easy to tune, power scaling hard to achieve while maintaining narrow linewidth.
OPA samples the CH_4 line at several wavelengths using a single, continuously tuned seed laser

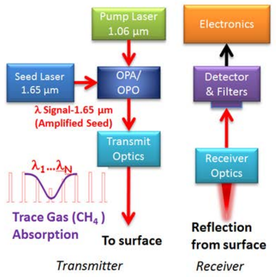
Open path result with 4 wavelength OPO

- Comparison with Picarro



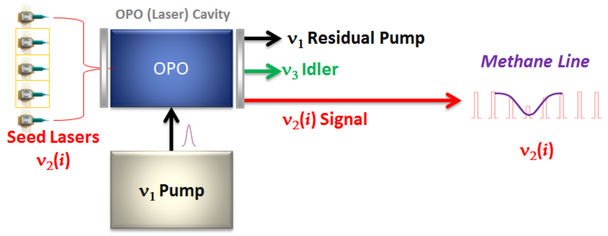
GSFC CH_4 Measurements





- **Need : Laser transmitter technology**
  - **3-5 µm for planetary**
  - **1.65 µm on Earth**
  - **Optical Parametric Generation (OPG) is the best solution currently available**

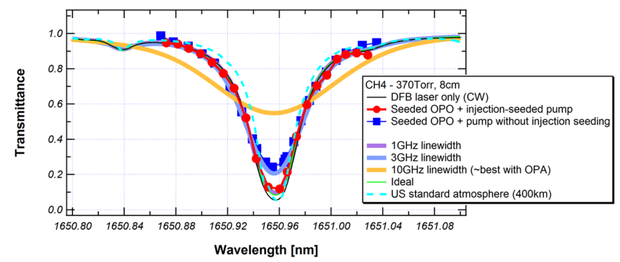
CH4 Transmitter Technology - OPO



OPO: Complicated to align and tune; power scaling easier to achieve while maintaining narrow linewidth.
OPO samples the CH_4 line at several discrete wavelengths using multiple seed lasers.
All lasers must be locked.

Linewidth estimation with CH_4 cell

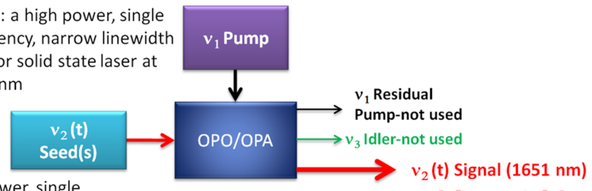
- Compared to simulated US standard atmosphere
  - **Red** is the result with OPO
  - **Orange** is close to the best with large pulse OPA



CH4 Laser Transmitter Components

Pump: a high power, single frequency, narrow linewidth fiber or solid state laser at 1064 nm

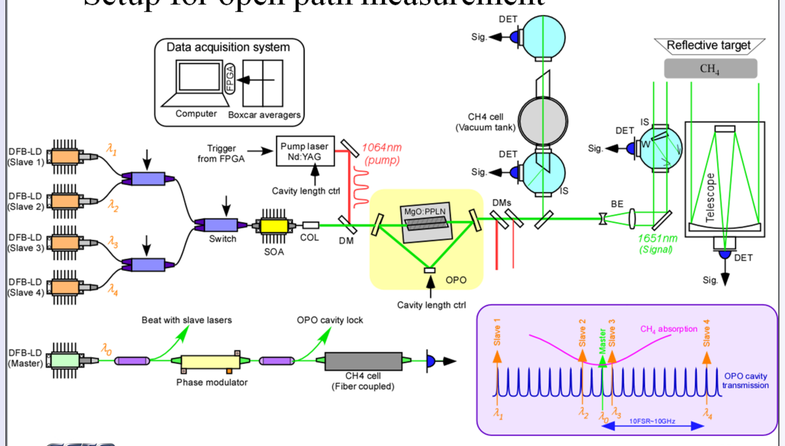
Seed: a low power, single frequency diode laser at 1651 nm.



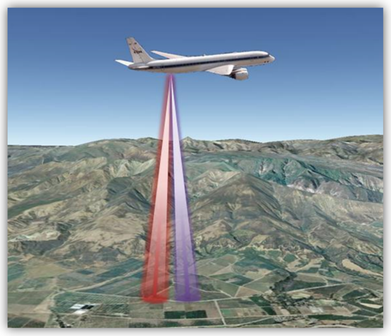
Optical Parametric Oscillator (OPO) or Optical Parametric Amplifier (OPA). A non-linear crystal that amplifies the seed laser to the energy needed for space (250-300 µJ) ***without*** degrading the spectral characteristics

4 wavelength OPO

- Setup for open path measurement



2015 Airborne Demonstration



- **Flight Test Methane LIDAR Instruments:**
  - **GSFC Methane Sounder**
  - **GSFC Picarro**
- **Conduct several test flights from NASA's Armstrong Science Aircraft Integration Facility (SAIF) in Palmdale, CA:**
  - 1 Engineering flight
  - 2-3 science flights
  - Approximately 12-15 hours of flight time in mostly in CA
- **Assess CH_4 LIDAR measurements over Western US**
- **Evaluate derivation of XCH_4 from LIDAR observations and compare with in-situ and calibrations sites whenever possible.**
- **Evaluate OPA and OPO performance**