Ocean subsurface studies from space-based lidar measurements

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Outline

• Space-based and Ground-based Lidar
• Overview of CALIPSO mission
• Ocean Subsurface results from space-based lidar
• Particulate Organic Carbon (POC) Results
Afternoon Constellation Evolution
A-train
Ground-based lidar-EARLINET

Earlinet Network

European Aerosol Research Lidar Network

25 stations

Naples station (40.833° N, 14.183° E, 118 m. asl)
Combing the ground-based and space-based lidar measurements

CALIPSO Mission Overview

**CALIPSO**: lidar measurements of aerosol and clouds

**Launched**: April 28, 2006

**Operational Achievements:**
- Long term measurements: CALIPSO collected more than 9 years of measurements so far;
- Observations during day/night and for all seasons
- Data publicly available
- CALIPSO Adds the Vertical Dimension
Lidar station of CALIPSO
30 degree off-nadir measurement for ocean subsurface studies- 2014 July 17 Night

Why pointing CALIPSO 30 degree off-nadir: avoid ocean surface backscatter

1. Direct demonstration of CALIPSO ocean subsurface signals in both co-polarization and cross-polarization to convince the community that CALIOP can measure phytoplankton backscatter
2. Direct measurements of depolarization ratios of phytoplankton backscatter to improve CALIOP estimate of phytoplankton backscatter and biomass estimate


subsurface

Total Attenuated Backscatter

Perpendicular Attenuated Backscatter

Total Attenuated Backscatter 1064

532nm Cross Polarization

Subsurface signal

1064nm Total
Zoom in to the lowest 1 km

532nm Total

1064nm Total

532nm Cross Polarization
Surface signals are much weaker than subsurface signals and can be corrected using 1064nm measurements.

- Red: subsurface signal in cross polarization
- Magenta: surface signal in cross polarization
- Blue: surface and subsurface in 532nm co-polarization
- Black and Green: surface signal in co-polarization
Ocean Subsurface results

**Results from CALIPSO**

- CALIPSO 2007 Day
- CALIPSO Sub-surface Backscatter: $\log_{10} \text{[Cross Polarization (1/sr)]}$

**Results from MODIS**

- Chlorophyll a concentration: $\log_{10} \text{(C)}$
- Particulate Organic Carbon: $\log_{10} \text{(POC)}$
Applications: Improving Phytoplankton Particulate Organic Carbon (POC) Estimate from CALIPSO

The 30 degree off-nadir measurement verifies the assumption about depolarization ratio

Behrenfeld, Hu, Hostetler, Dall'Olmo, Rodier, Hair, Trepte, GRL, 2013
27 May 2015

**Hacking a Climate Satellite to See Beneath the Ocean's Surface**

When NASA launched its CALIPSO spacecraft, the space agency did not intend to estimate phytoplankton populations.

References


Conclusion

1. CALIPSO satellite is tilted for one night-time orbit in July in order to measure phytoplankton backscatter at 30-degree off-nadir accurately.
2. Subsurface signals are clearly seen in both polarization channels of 532 nm (green) CALIOP measurements, where surface signals are one (co-polarization) and two (cross-polarization) orders of magnitudes weaker than subsurface signals.
3. Depolarization ratios of phytoplankton backscatter are measured from space for the first time.
4. The operation helps reduce uncertainty in global carbon biomass assessment using CALIPSO ocean subsurface optical measurements.