Statistics of MODIS radiances and CALIPSO backscatter in clear areas near clouds

Tamás Várnai[1,2] and Alexander Marshak[2]
[1] Univ. of Maryland, Baltimore County, JCET, [2]NASA GSFC, Laboratory for Atmospheres

Summary

- **MODIS radiances** reveal that 3-D radiative processes play an important role in creating enhanced clear sky radiances near clouds and need to be accounted for
  - The enhancements extend to more than 10 km away from clouds and are stronger near illuminated cloud sides than shadowy ones
  - The enhancements are stronger at shorter wavelengths and near optically thicker clouds, which confirms the hypothesis of "apparent bluing of aerosols"
- **CALIPSO lidar backscatter** shows that clouds are surrounded by a transition zone of enhanced particle content and size
  - The enhancements extend to more than 10 km away from clouds
  - The enhancements are strongest at low altitudes, slightly below the top of nearest clouds

Implications

- To avoid biases toward lower aerosol content and radiative forcing, studies on aerosol-cloud interactions and aerosol radiative forcing need to include the transition zone
- To avoid biases toward higher aerosol content and radiative forcing, it is important to account for 3-D effects in aerosol retrievals in the transition zone

Introduction

Several studies based on satellite data indicated enhanced clear-sky radiances near clouds.

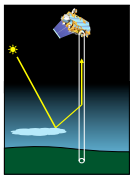
Possible causes

- Enhanced particle content (aerosol or undetected clouds)
- Instrument effects such as blurring
- 3-D radiative effects

Mechanism of 3-D effects

Cloud reflection increases the solar illumination of nearby clear columns.

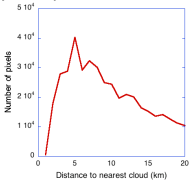
3-D effects are stronger at shorter wavelengths, where Rayleigh scattering is more effective in redirecting cloud-reflected photons toward MODIS.



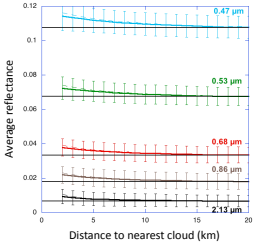
MODIS results

Dataset: MODIS Terra near-nadir data for Sept 14-29 over 8 years at NE Atlantic

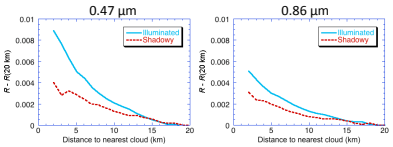
Many clear pixels lie close to clouds



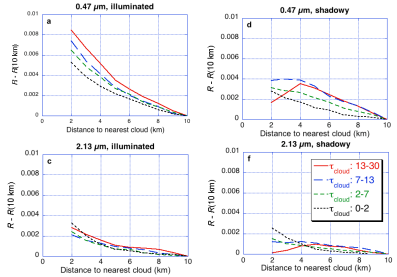
Clear-sky reflectances increase near clouds, especially at shorter wavelengths



As in 3-D simulations, the increase is larger near illuminated than shadowy cloud sides, especially at shorter wavelengths. (Outside actual shadows, 3-D effects cause enhancements even near shadowy cloud sides.)

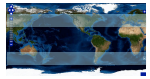


The increase is larger near thicker clouds, which cause stronger 3-D radiative enhancements as they reflect more sunlight toward nearby clear columns. Also, thicker clouds cast darker shadows.

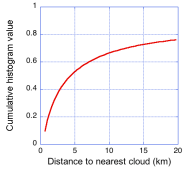


CALIPSO results

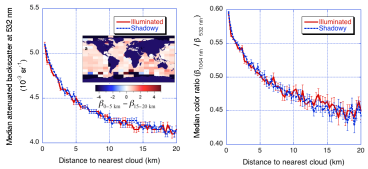
Following pioneering study of the Caribbean by Tackett and Di Girolamo, performed global study.
Dataset: CALIPSO data at mid-latitude & tropical oceans during Sept 15-Oct 14, 2008



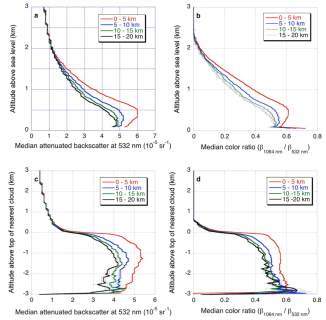
Most clear profiles lie close to clouds



Particle content and size increases near clouds over all oceans, and the increase is similar near illuminated and shadowy cloud sides.
(CALIPSO lidar backscatter is not influenced by 3-D effects.)



Enhancements are largest at low altitudes, near cloud top level. This is consistent with both cloud detrainment and aerosol swelling.



Enhancements near clouds and color ratios Higher than the value of 1/16 expected for clear air Indicates particle scattering even in columns where CALIPSO did detect any .aerosol layer