Lidar Surface Reflectivity Measurements (at 1.57 μm) from the CO_2 Sounder on the ASCENDS 2013 & 2014 Airborne campaigns

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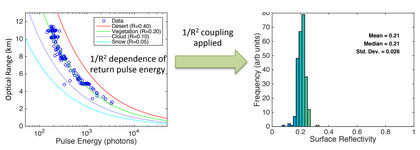
Importance of Reflectivity Measurements for ASCENDS mission

- Surface reflectivity varies by a factor of ~20, from 0.4 (desert) to 0.02 (dark snow) and depends on illumination source (sun/laser) and detection angles.
- Lidar return signal strength is crucial for S/N and precision
- Desired S/N impacts ASCENDS mission cost – via laser power and telescope size
- OSSEs studying contribution of ASCENDS to uncertainty reduction in global carbon budget depend on S/N
- Characterizing surface reflectivity specifically for lidar detection can improve mission planning and optimize cost.

Determining reflectivity

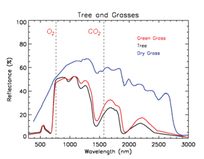
- Laser energy is fixed
- Return signal α r/R^2 (r=reflectivity, R=optical range). Hence, $1/R^2$ correction for return signal strength applied
- Off-line wavelengths (no absorption by CO2) used
- Absolute radiometric calibration done by assuming desert ≈ 0.4 (for example Railroad Valley, Nevada).
- ASCENDS 2013 campaign – Calibrated iris used with photon counting detector
- ASCENDS 2014 campaign – Analog detector
- Instrument was found to be radiometrically stable across both flight campaigns.



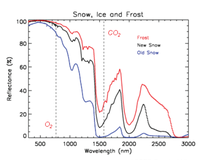
Surface Reflectivity from passive satellite instruments

Passive measurements are a good reference to compare lidar reflectivity against. Our reflectivity measurements for trees, cropland and snow match up well with passive measurements.

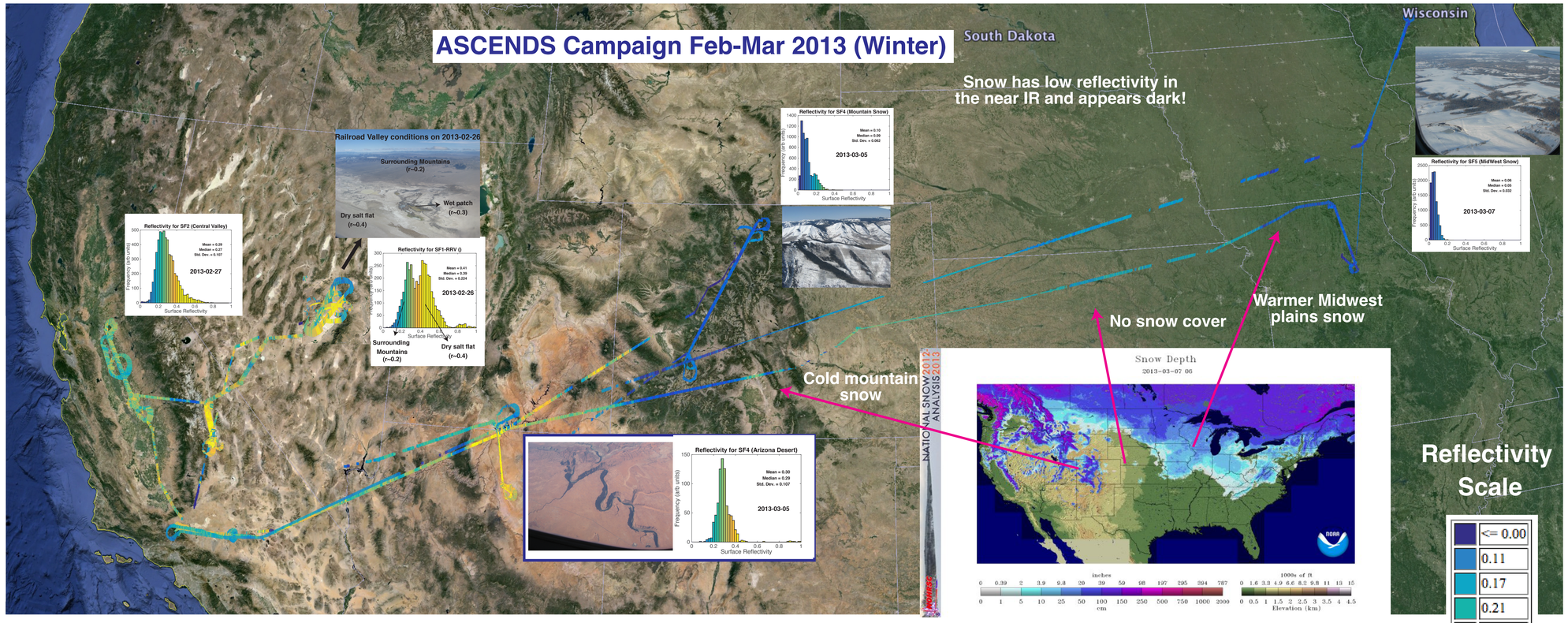
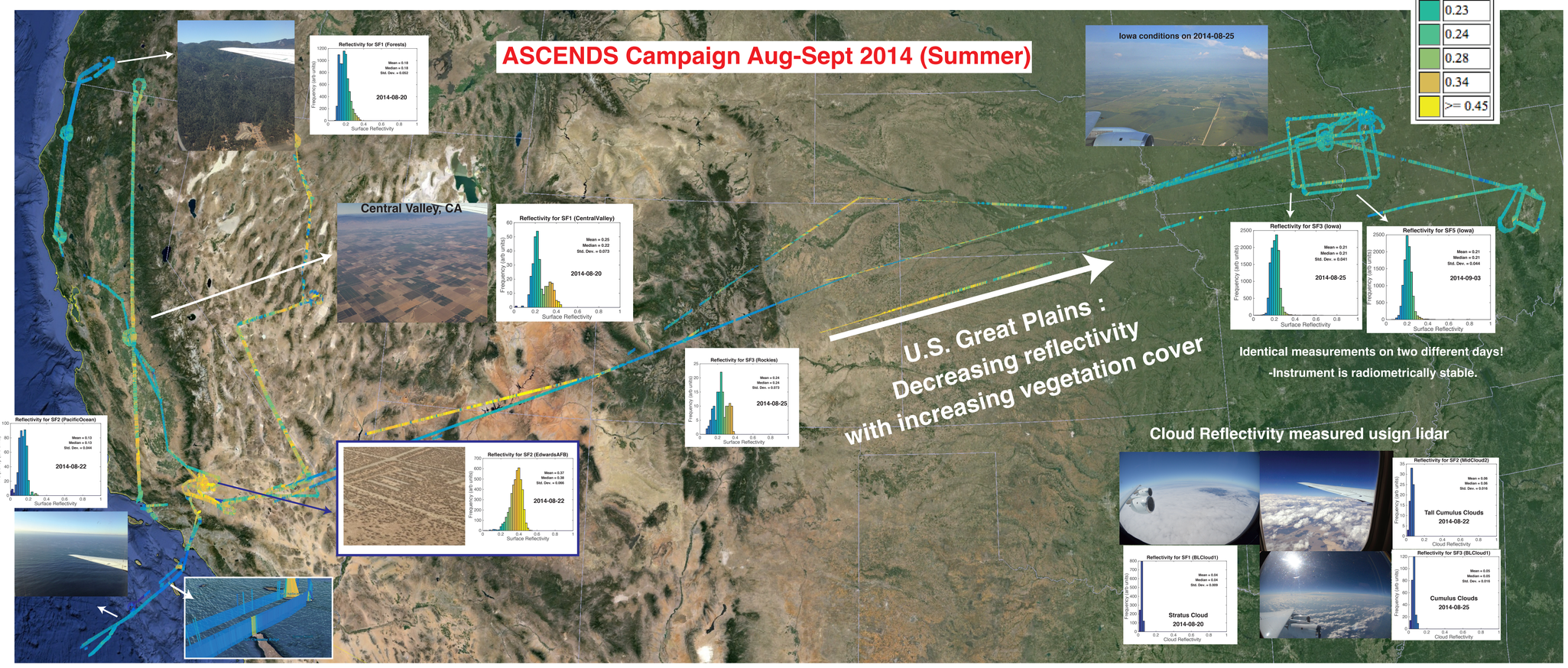
However, there are some differences due to the differences in the light source and scattering angles. For instance, multi-particle scattering from clouds illuminated by sunlight causes an effective reflectivity of ~0.9. This is not seen in lidar measurements (r<0.1) because of the point source illumination.



source: ASTER Spectral Library



source: ASTER Spectral Library

Summary of CO_2 Sounder reflectivity measurements from ASCENDS 2013 & 2014 Flight Campaigns

Surface	Reflectivity	Measurements
Desert	0.4 (established standard)	2014 SF2 Edwards AFB, CA 2013 SF1 Owens Valley, CA 2013 SF2 Railroad Valley, NV
Semi-desert	0.32	2014 SF2 Great Basin Range, NV
Desert/Cropland	0.25-0.35	2013 SF1 Central Valley, CA 2014 SF1 & SF4 Central Valley, CA
Cropland (winter)	0.30	2013 SF5 Great Plains CO/NE/IA
Mountain/Forests	0.25-0.30	2014 SF3 Rocky Mountains, CO 2014 SF4 Sierras, CA,
Cropland (summer)	0.20	2014 SF3 & SF5 Iowa
Forests	0.15-0.25	2014 SF1 N. California forests, CA
Ocean (normal incidence)	0.10-0.20	2014 SF2 Pacific Ocean
Ocean (slant incidence)	0-0.10	2014 SF2 Pacific Ocean
Snow (cold)	0.05-0.10	2013 SF4 Rockies, CO
Snow (warm)	0.02-0.10	2013 SF5 Midwest, IA/MO
Clouds	0.02-0.10	2014 SF1, SF2 & SF3