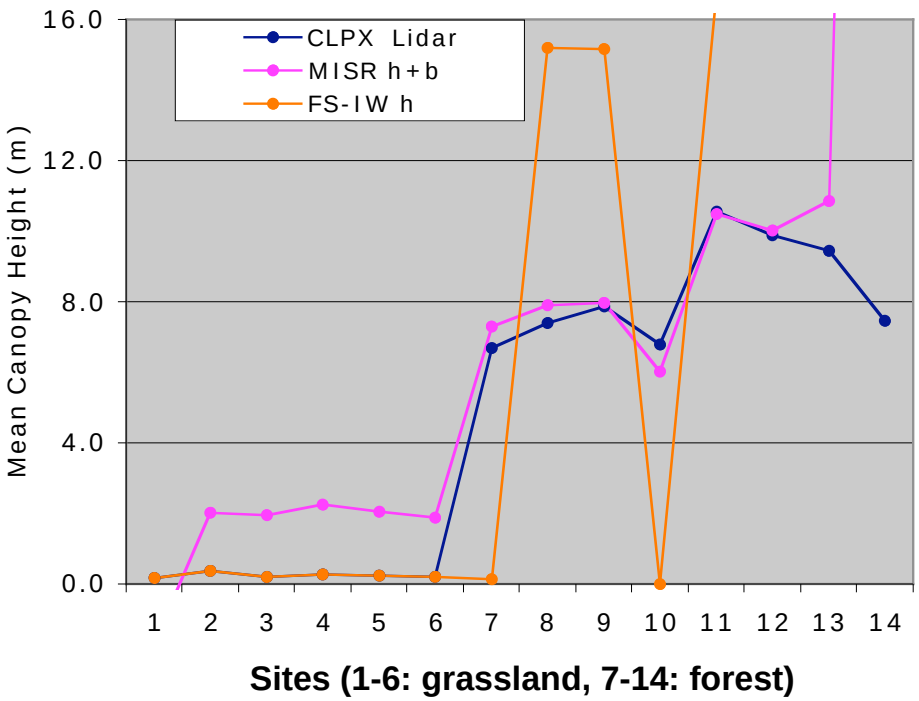
# Mapping Forest Canopy Height with MISR

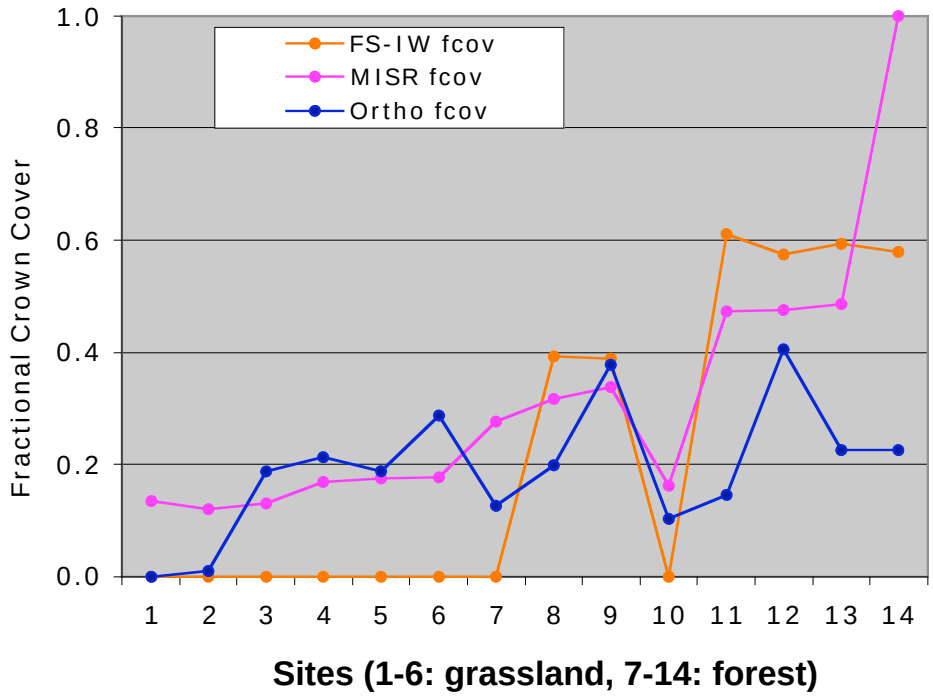
**We previously demonstrated a capability to obtain physically meaningful canopy structural parameters using data from MISR in a geometric-optical (GO) modeling framework. Assessments against U.S. Forest Service cover and height maps over ~200,000 km$^2$ in New Mexico and Arizona were encouraging (Chopping *et al.* 2008. Large area mapping of southwestern forest crown cover, canopy height, and biomass using the NASA Multiangle Imaging Spectro-Radiometer, *Remote Sensing of Environment* 112: 2051-2063).**

**Canopy height is required for estimating aboveground woody biomass, e.g., for quantifying loss and recovery from disturbance. The following slides show how MISR/GO retrievals perform with respect to lidar-derived canopy heights over forest in Colorado.**

**Contact: Mark Chopping (chopping@pegasus.montclair.edu)**

# MISR/GO (08/02) vs CLPX* lidar (09/03): Calibration Sites**



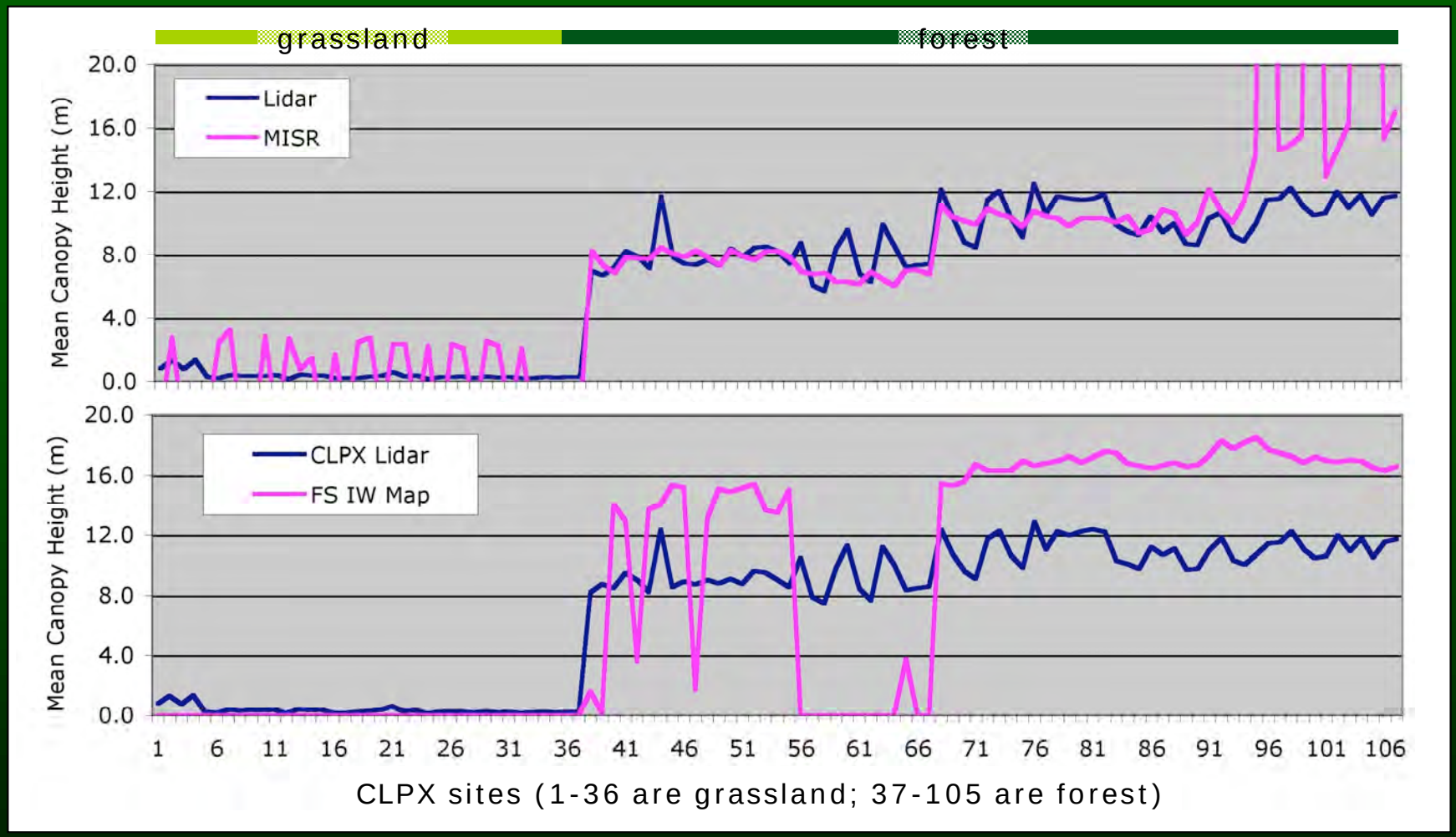




**MISR/GO height and crown cover retrievals are more accurate with respect to CLPX lidar and orthophoto-based crown cover estimates than Forest Service 2005 Interior West empirical estimates (based on MODIS VCF/VI, Forest Inventory Analysis, and many other variables). The lidar canopy height estimates were derived from ground and vegetation elevations obtained from a discrete return lidar survey with a spot spacing of ~2 meters.**

*** Cold Land Processes Experiment (http://www.nsidc.org/data/clpx/)**

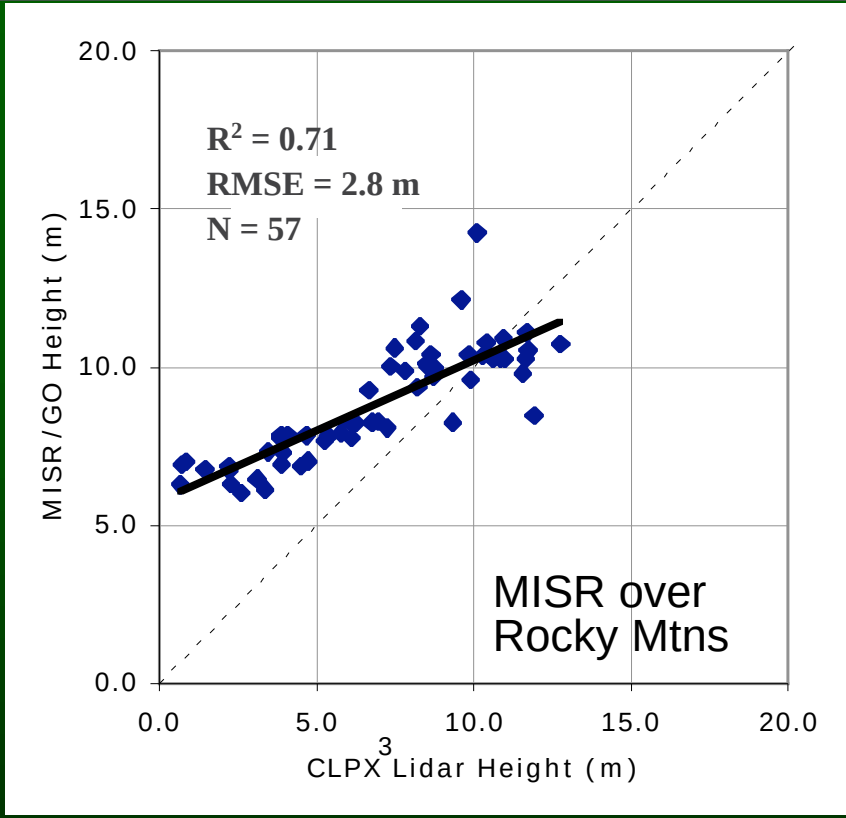
**** Sites used to extract background contributions for dynamic background prediction**

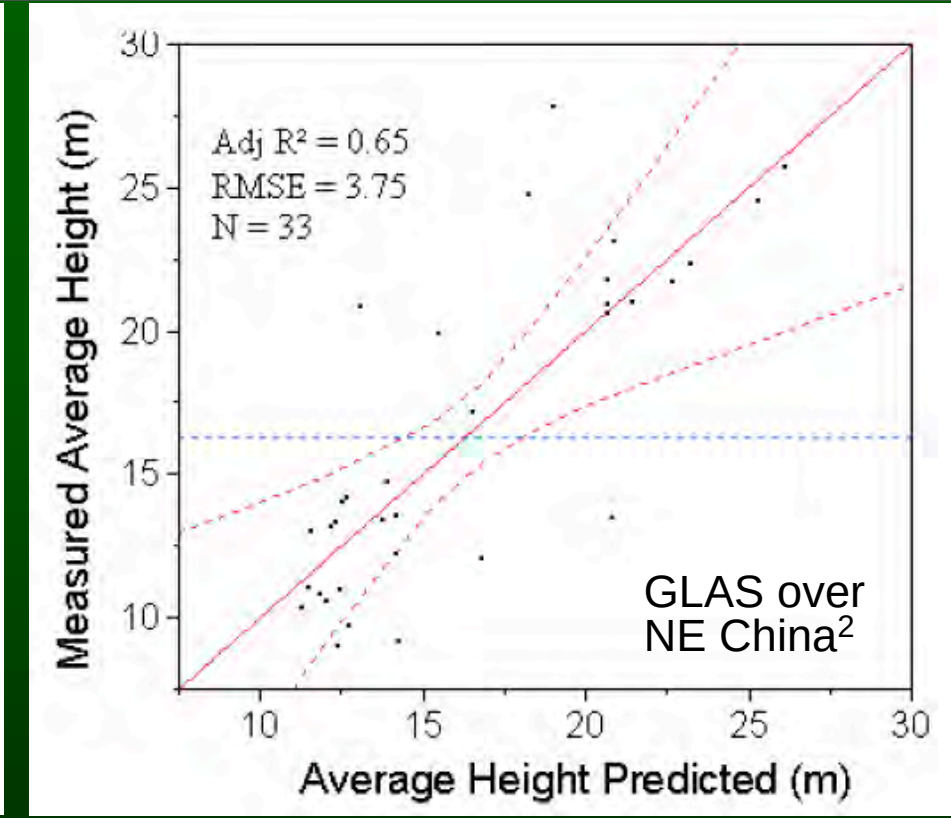
# MISR/GO (08/02) vs CLPX lidar (09/03) Heights: All Sites




**MISR/GO retrievals are more accurate vs CLPX lidar heights than Forest Service Interior West map empirical estimates. The FS Interior West map (for forest only) misses forest in sites 56-66. MISR/GO anomalies for sites 97-105 are easily screened out as crown cover >> 1.0 (#14 in previous slide).**

# MISR/GO Results vs GLAS[1] Results for Forest Height



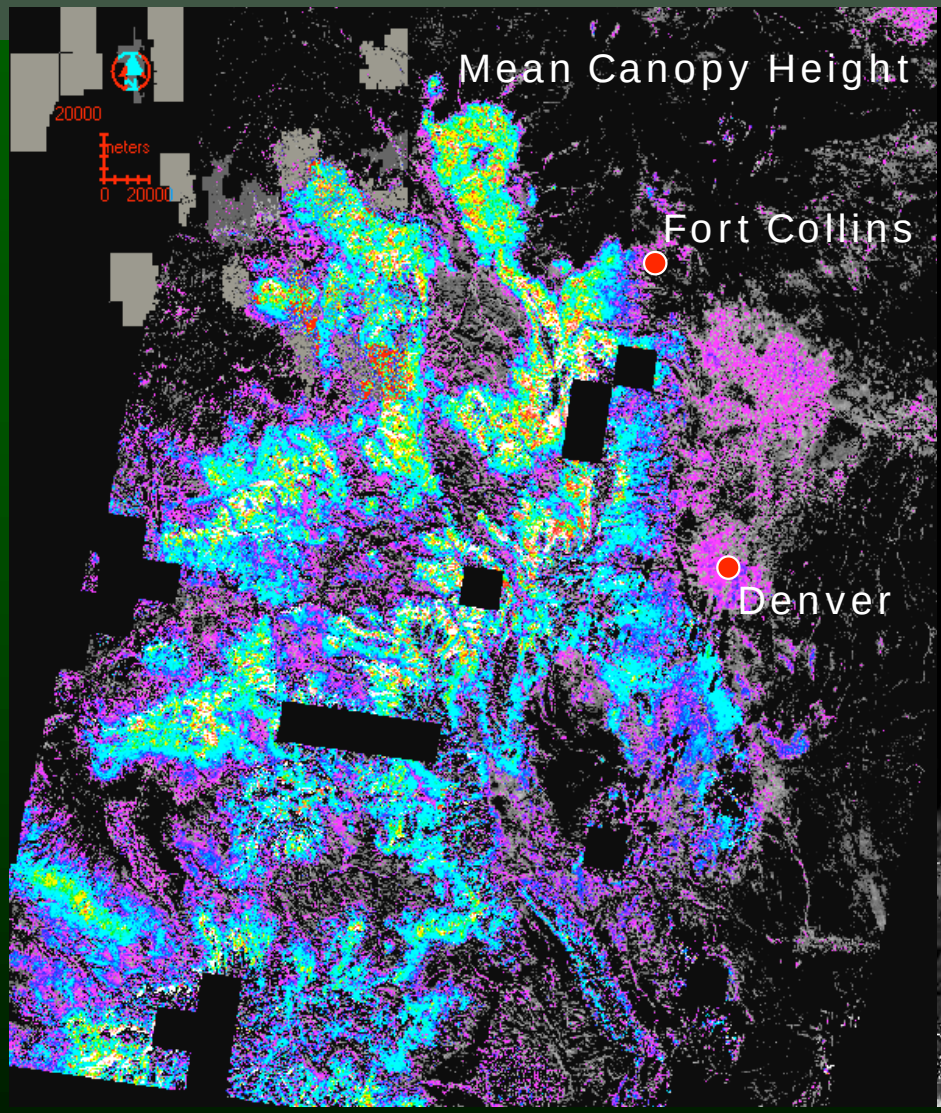

**Although not strictly comparable, this provides a first indication of respective performances. While the MISR/GO results show bias, waveform lidar height estimates from GLAS typically provide RMSEs of ~3-5 m (accuracy is impacted by topography and varying crown shape).**

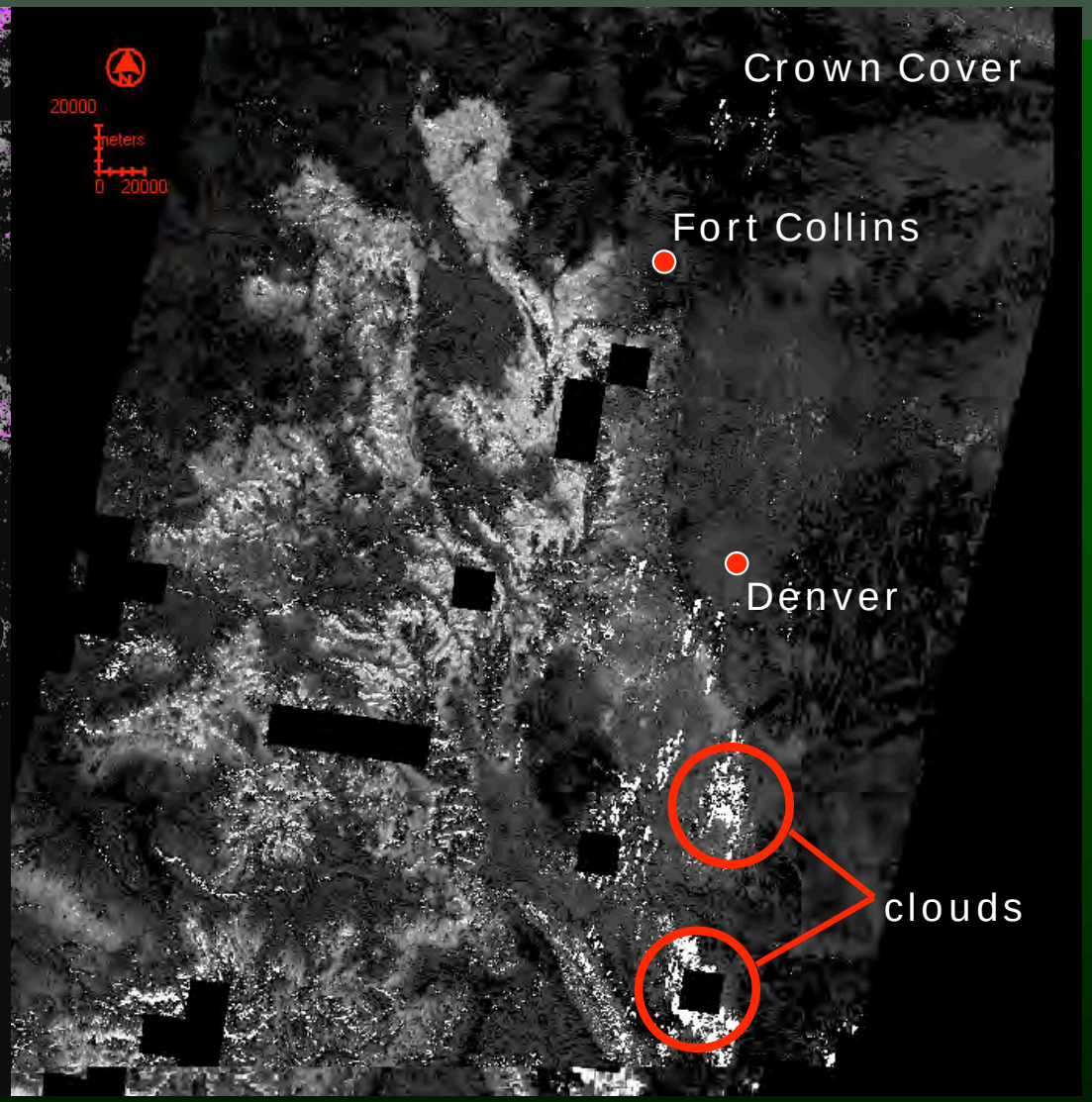
[1] Geoscience Laser Altimeter System on the ICESat platform.

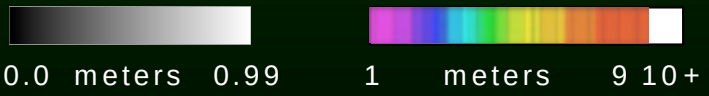
[2] Pang *et al*. 2008, Temperate forest height estimation performance using ICESat GLAS data from different observation periods, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* Vol. XXXVII, Part B7, Beijing 2008, 777-782.

[3] Cold Land Processes Experiment (http://www.nsidc.org/data/clpx/)

# Rocky Mountain MISR/GO 250 m Height & Crown Cover Maps





**Terra orbit 14073 (August 10, 2002). Rectangular areas show where surface retrievals failed; multi-pass compositing on min(inversion_RMSE) can provide wall-to-wall coverage because clouds and contrails result in higher model fitting error (not shown).**

# Mapping Forest Canopy Height with MISR: Summary

- Results are model-based, not empirical fits to data or trained (MISR retrievals are completely independent of the lidar data.)
- Good accuracy vs lidar height estimates: RMSE=2.8 m, $R^2$=0.71, N=57.
- Low sensitivity to topography; no corrections applied.
- Parsimonious: only red band data are required.
- Low cost: uses EOS MISR data; global record from 2000.
- Rapid: 200,000 $km^2$ @250 m in ~60 minutes, using modest facilities.
- The background contribution can/must be calibrated for varying conditions: only one coefficient set required for Rocky Mountain forest.
- Limitations: bias apparent; further work is required.
- Applications: 2000- baseline crown cover, canopy height, and aboveground biomass records in support of DESDynI; mapping distributions of aboveground woody carbon stocks over large areas; biomass loss and recovery from fire and other disturbance; mapping understory density; corrections for snow cover maps.

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# Mapping Forest Height with MISR: General Observations

- **Limitations: the method is unsuitable for closed canopies, i.e., tropical forest; separate calibrations may be needed for shrubs and forest.**
- **Can map low woody vegetation (shrubs) in addition to forest.**
- **The background estimate is an indicator of understory density.**
- **Model fitting RMSE is sensitive to clouds, even thin cirrus, allowing multi-pass minimum-error compositing to compensate for surface BRF retrieval failures and cloud and cloud shadow contamination. E.g., see the New Mexico/Arizona results in the next slide and Chopping *et al*. 2008. Large area mapping of southwestern forest crown cover, canopy height, and biomass using the NASA Multiangle Imaging Spectro-Radiometer, *Remote Sensing of Environment* 112: 2051-2063.**

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# MISR/GO vs USFS Map Heights: New Mexico/Arizona

| | Fractional crown cover (dimensionless) | Mean canopy height (meters) | Woody Biomass (tons acre$^{-1}$) | (Mg ha$^{-1}$) |
|---|---|---|---|---|
| Mean Relative Error (%) | 30 | 28 | 28 | - |
| Mean Absolute Error | 0.10 | 2.2 | 4.5 | 10.1 |
| Mean (MISR) | 0.48 | 10.3 | 21.8 | 49.0 |
| Mean (USFS) | 0.38 | 8.7 | 21.8 | 49.0 |
| Root Mean Square Error | 0.12 | 3.3 | 6.2 | 14.0 |
| $R^2$ | 0.78 | 0.69 | 0.81 | - |


N=576, random points, widely distributed. Results composited on minimum model fitting error and filtered for topographic shading.