



CERES Earthshine Simulation & Comparison to BBSO Result

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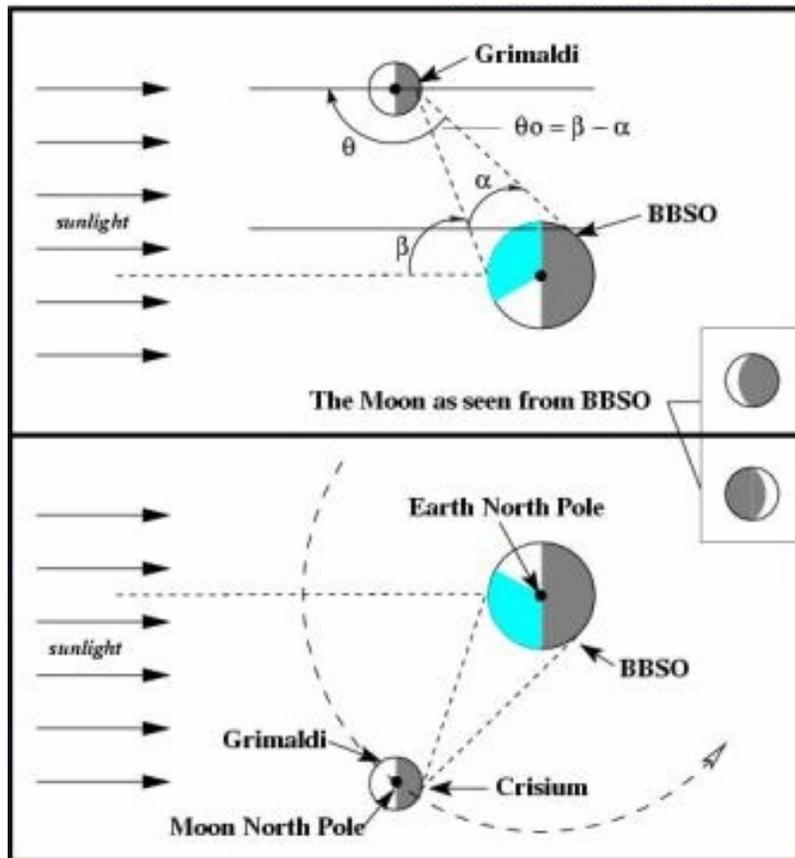
SAIC, Hampton, VA

N.G. Loeb

Hampton University, Hampton, VA

Inversion Group Meeting, May 2005, Princeton

Geometry of BBSO Measurements



DATASETS

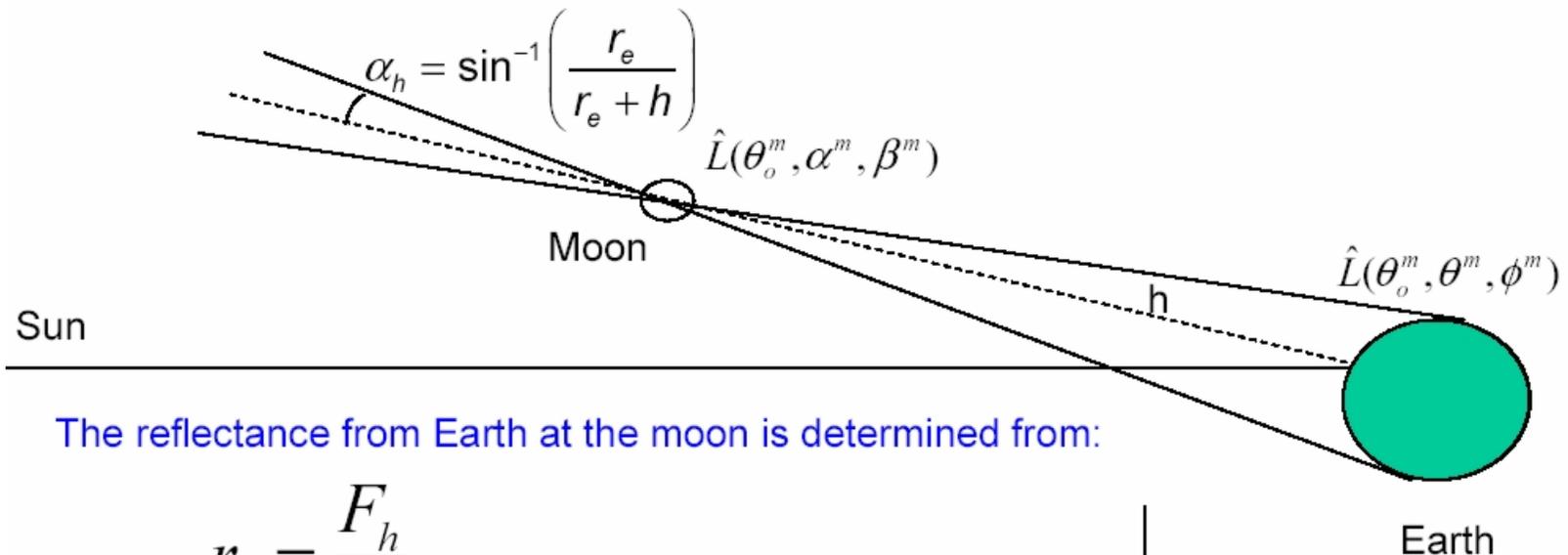
BBSO data:

- **353 nights from 01.2000 to 06.2004 ;**
- **Geometry & BBSO apparent reflectance (narrowband, 0.4 – 0.7 μm).**

Coincident MODIS/CERES data:

- **297 days from 03. 2000 to 11.2003 ;**
- **CERES apparent reflectance (broadband, 0.3 – 5 μm), daily mean cloud fraction, shortwave flux, local time difference and geometry.**
- **BBSO Sampling: 2000 - 33% , 2001 - 31%, 2002 - 21%, 2003 – 15% of total coincident data.**

CERES Earthshine Simulation



The reflectance from Earth at the moon is determined from:

$$r_h = \frac{F_h}{S_h}$$

$$F_h = \int_0^{2\pi} \int_0^{\alpha_h} \hat{L}(\theta_o^m, \alpha, \beta) \cos \alpha \sin \alpha d\alpha d\beta$$

$$S_h = \int_0^{2\pi} \int_0^{\alpha_h} \frac{\mu_o E_o}{\pi} \cos \alpha \sin \alpha d\alpha d\beta$$

$$\sin \alpha = \frac{r_e}{r_e + h} \sin \theta^m$$

h = Earth-moon dist

$$\beta = \phi$$

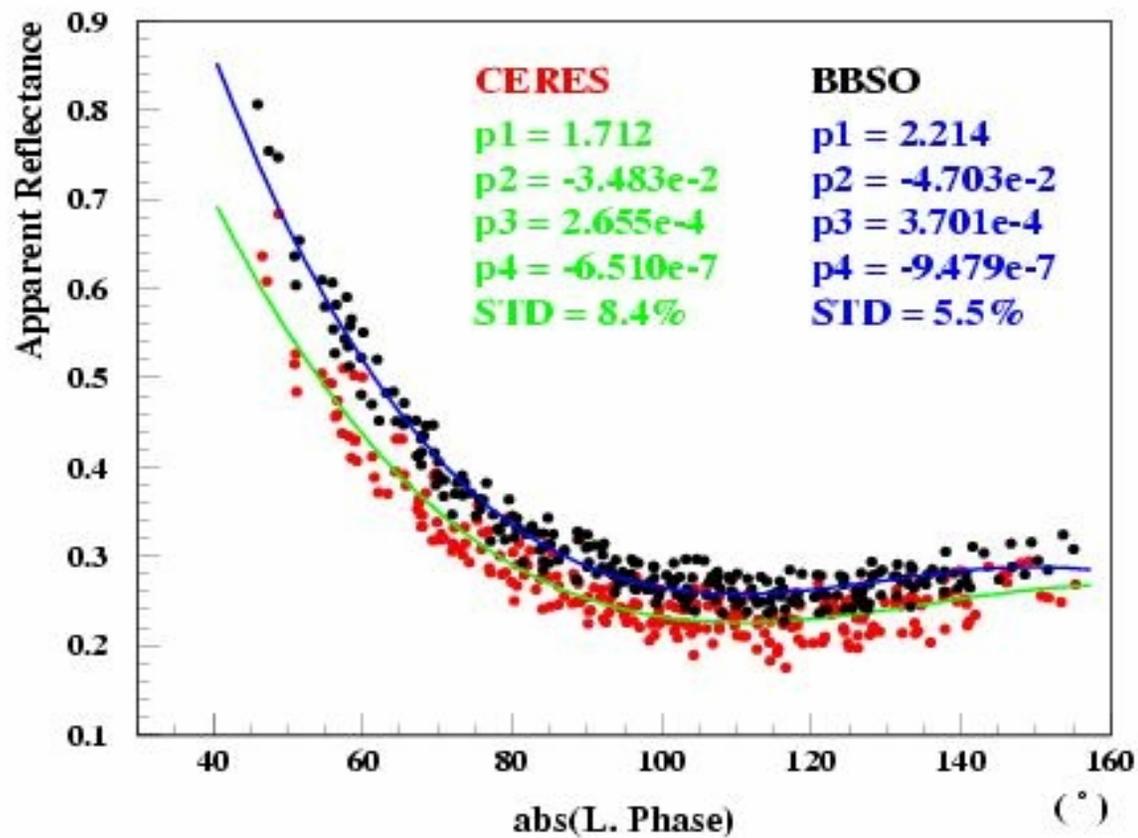
$$\mu_o = \cos(\theta_o^m)$$

$$E_o = 1365 \text{ W m}^{-2}$$

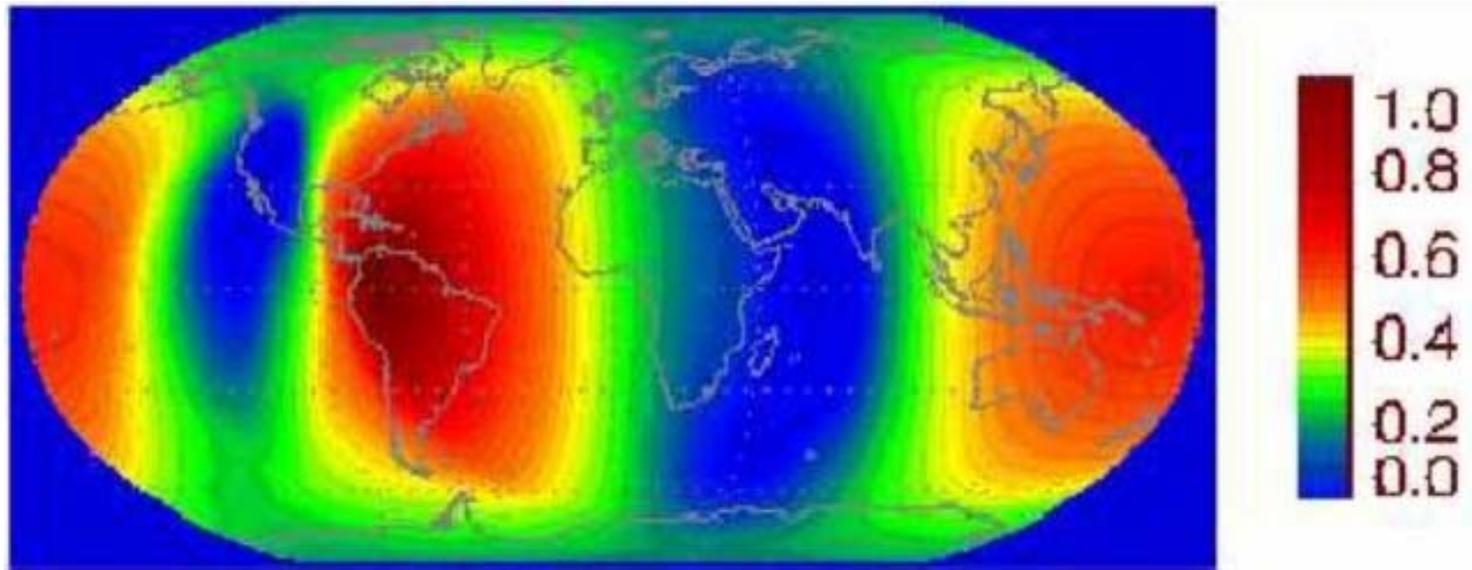
To determine above integrals, consider only regions that contribute to Earthshine.

Apparent Reflectance

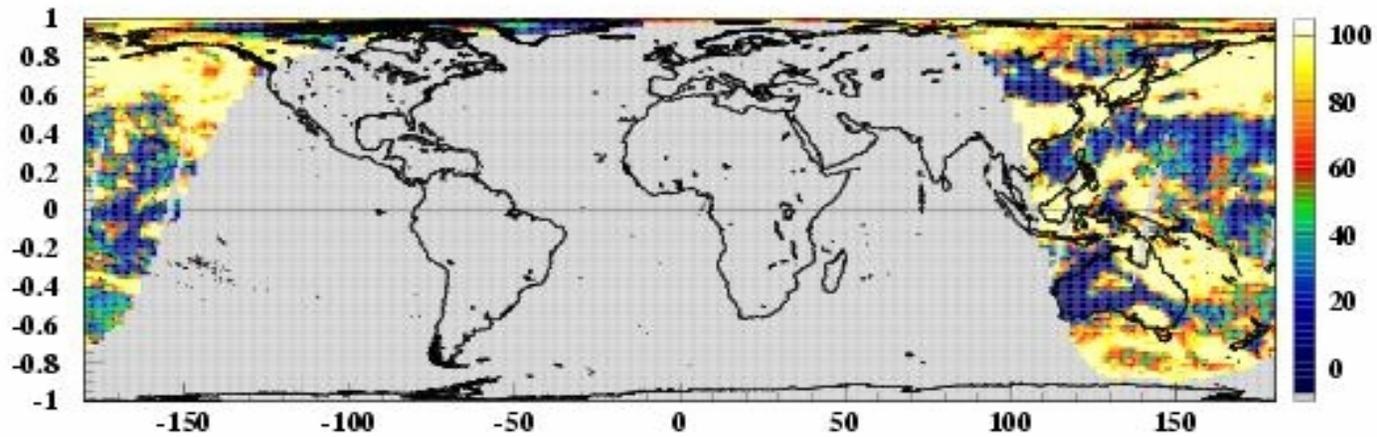
(266 nights with CERES cover > 90%)



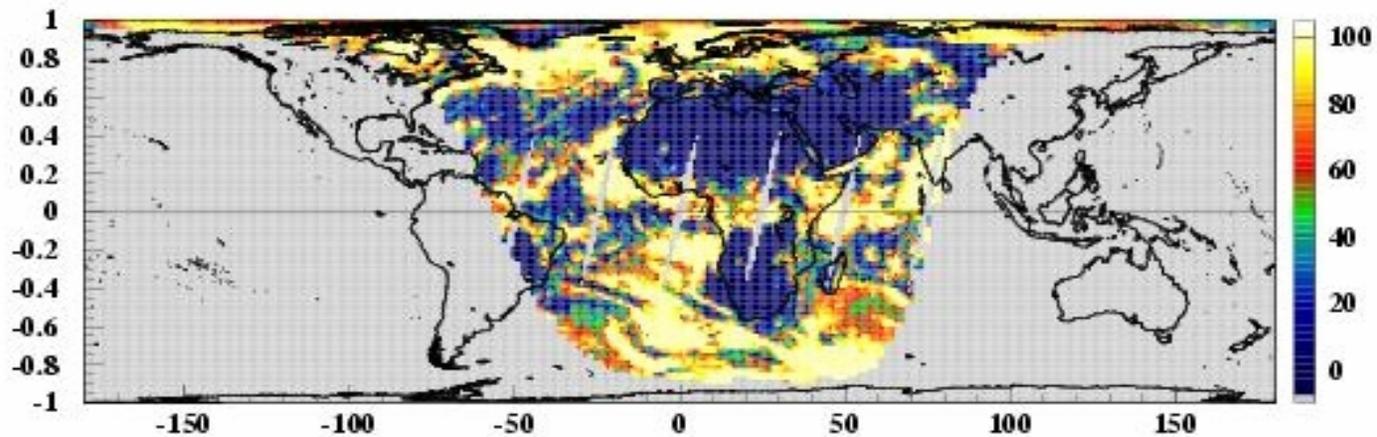
BBSO Regional Sampling



Large Lunar Phase Angle Cloud Fraction

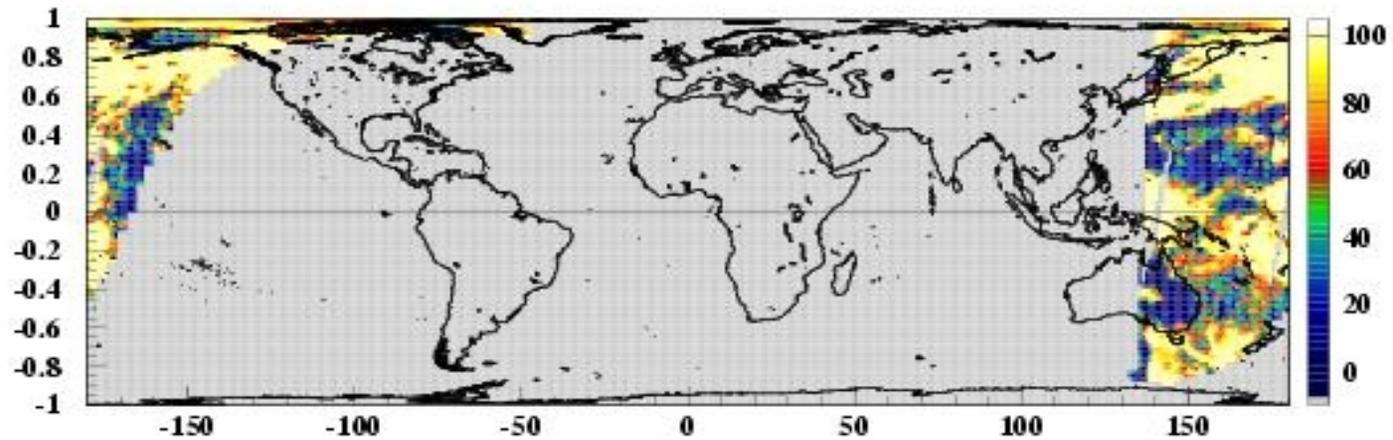


2000.06.08, lunar phase = -102°

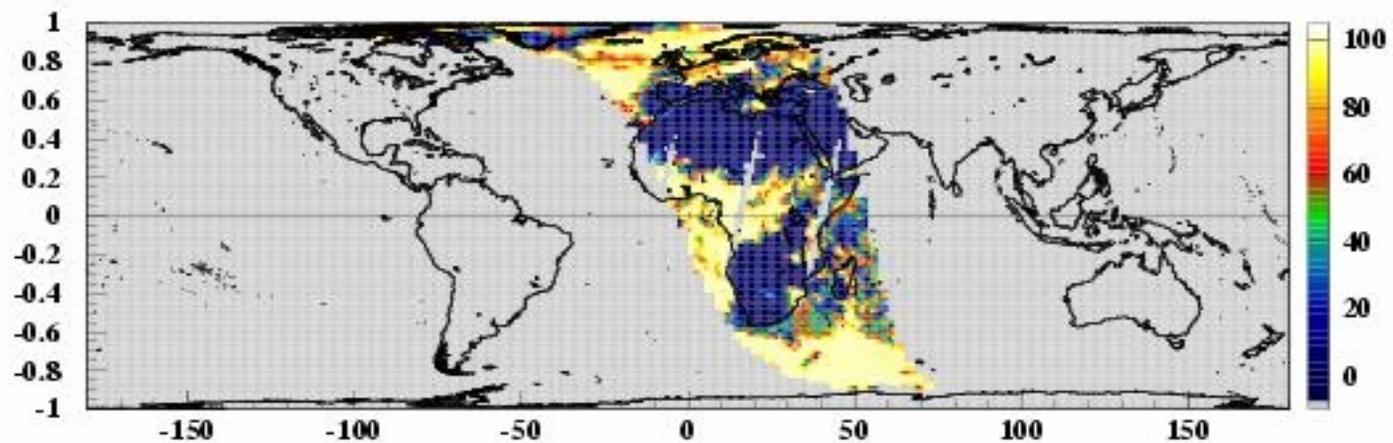


2000.06.28, lunar phase = 133°

Small Lunar Phase Angle Cloud Fraction



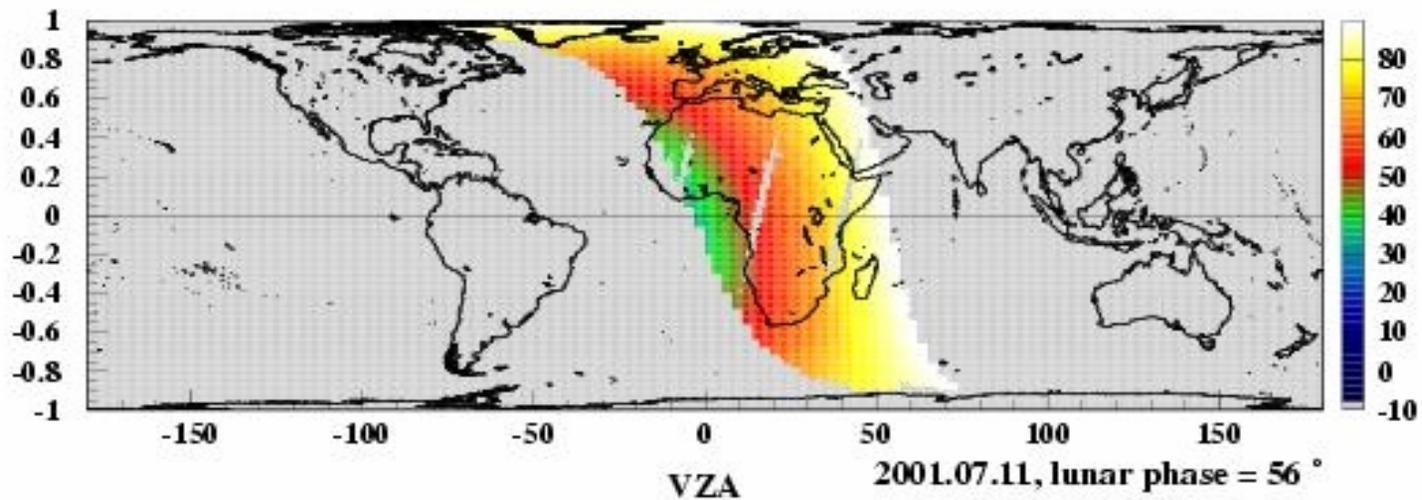
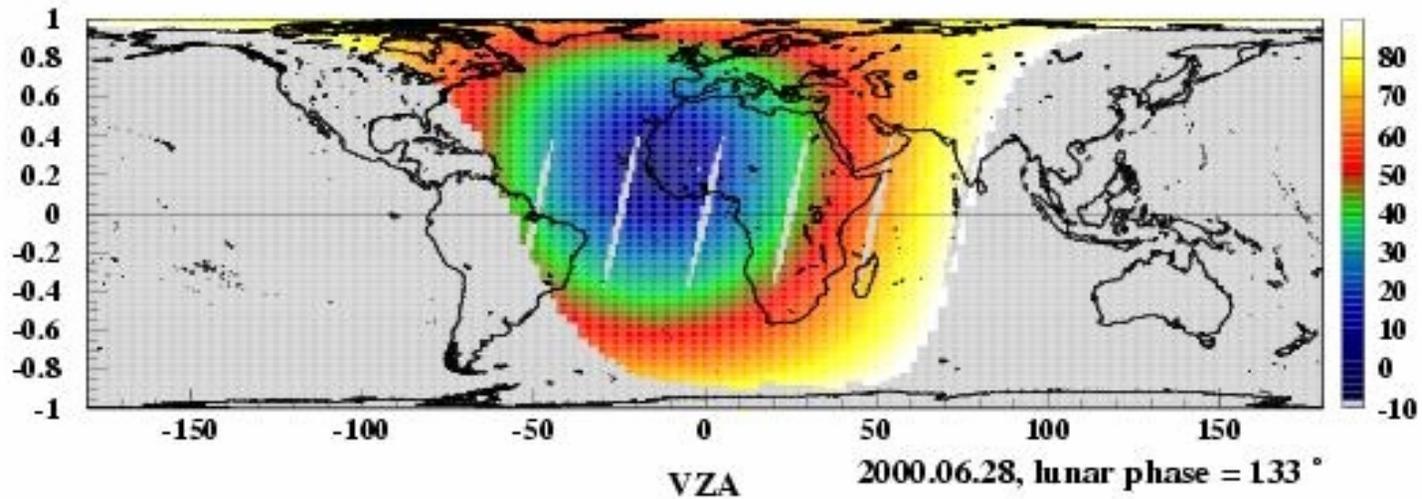
2001.06.02, lunar phase = -57°



2001.07.11, lunar phase = 56°

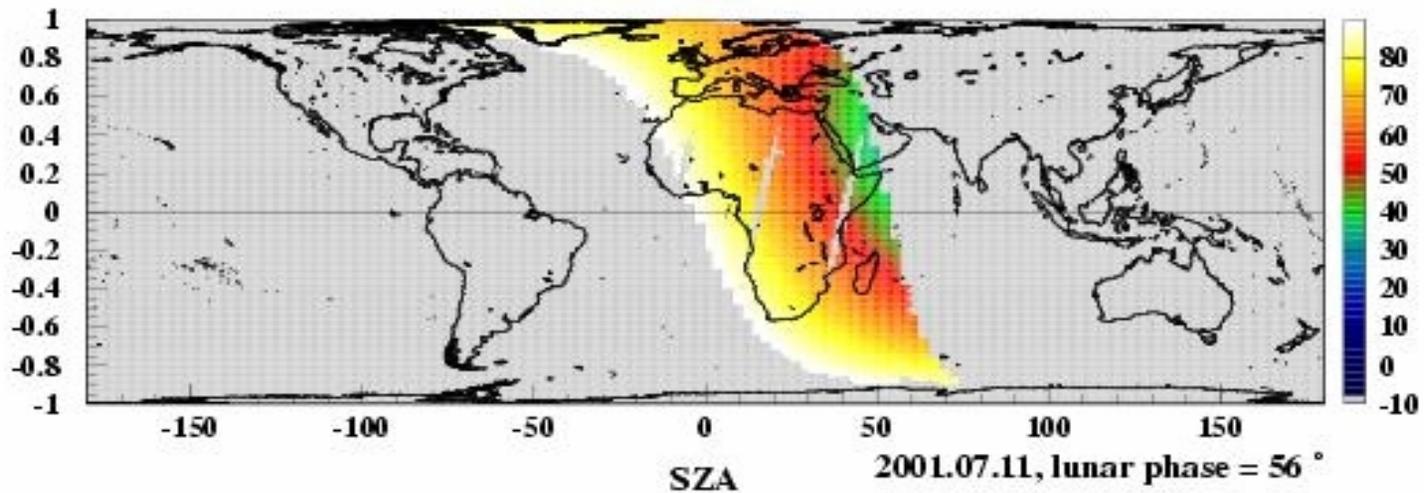
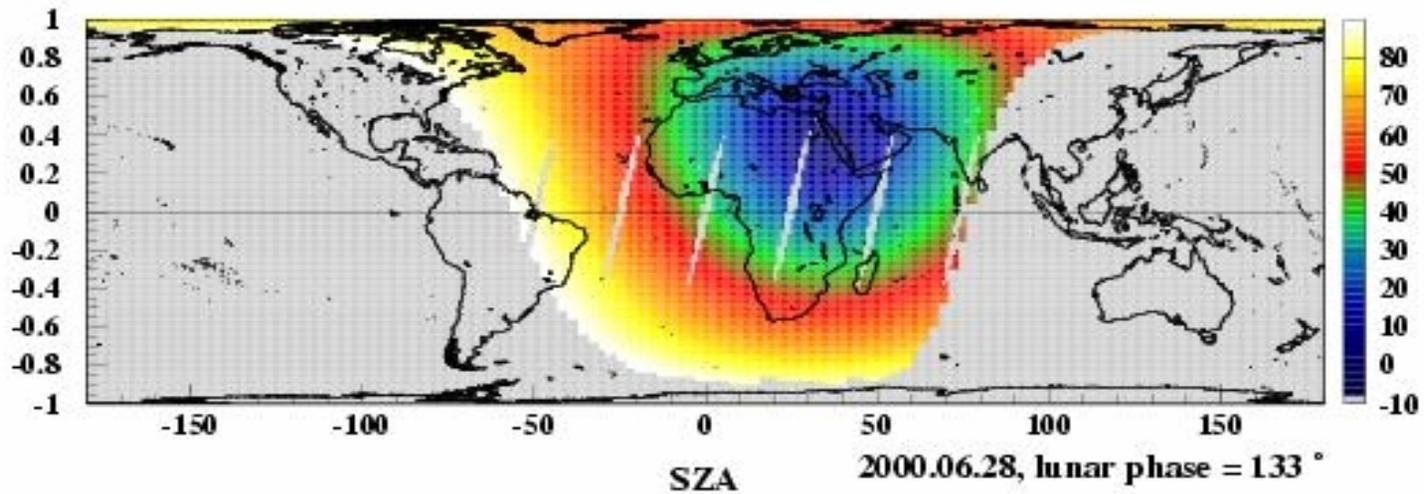
Earthshine Geometry

Mean VZA^m



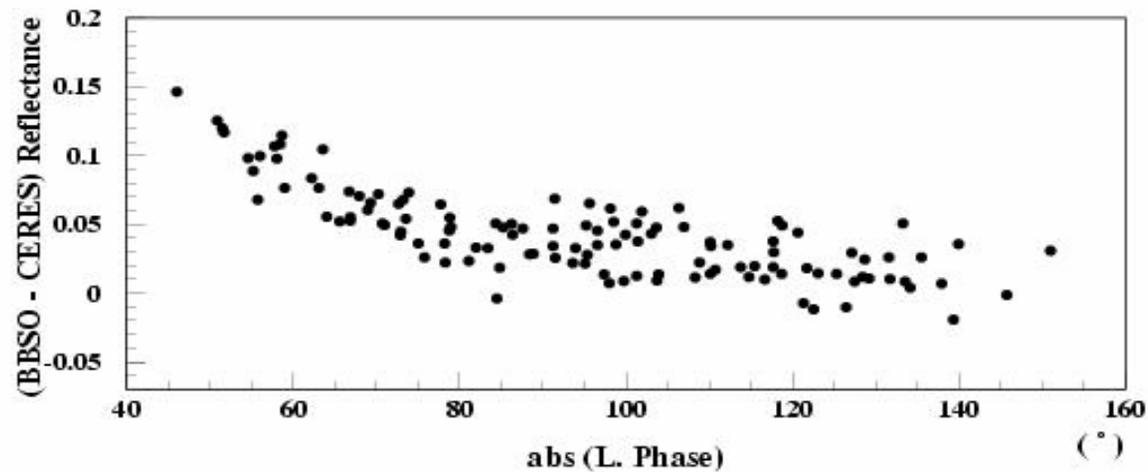
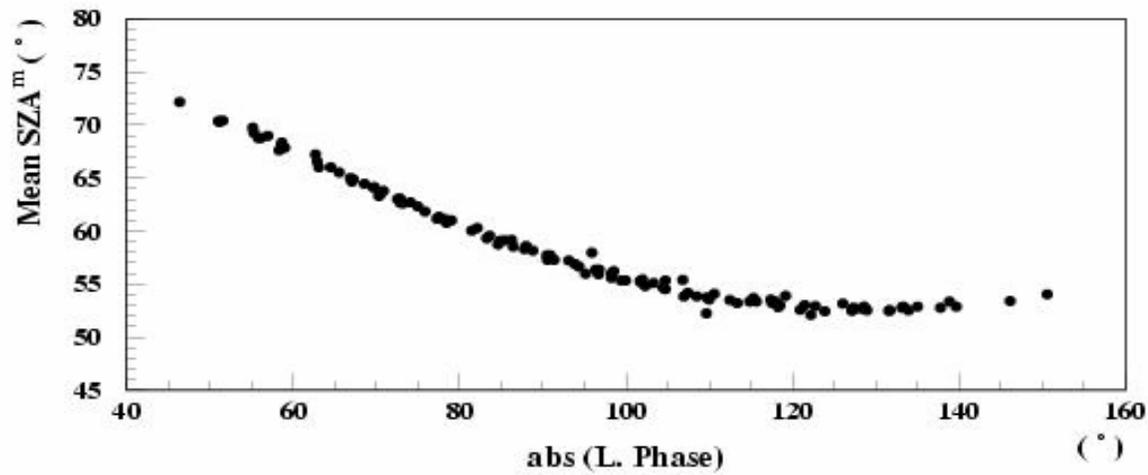
Earthshine Geometry

Mean SZA^m



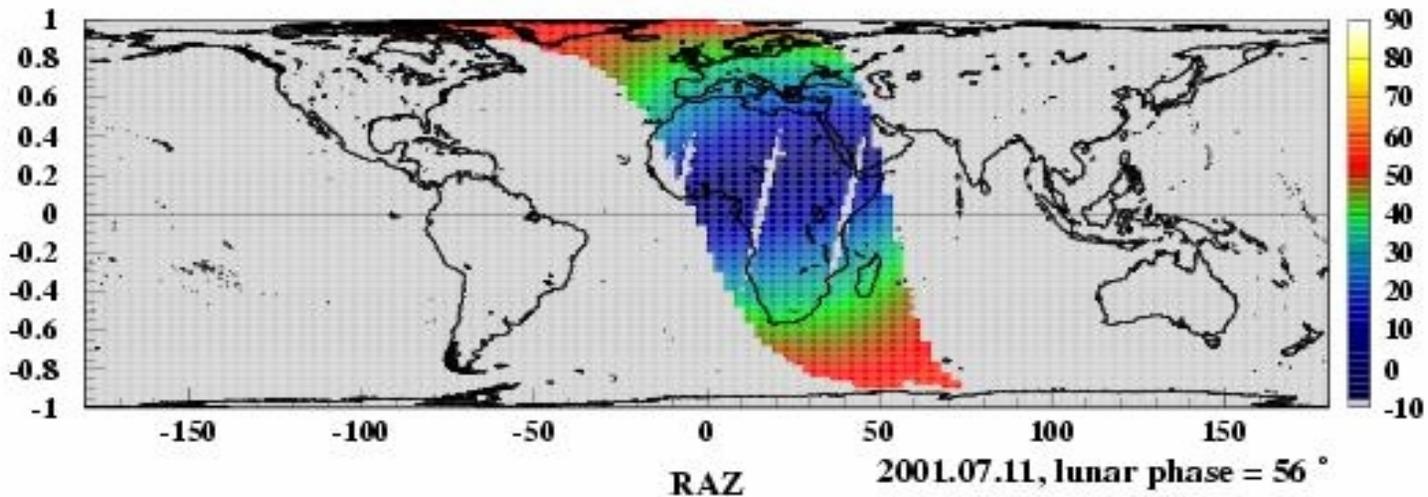
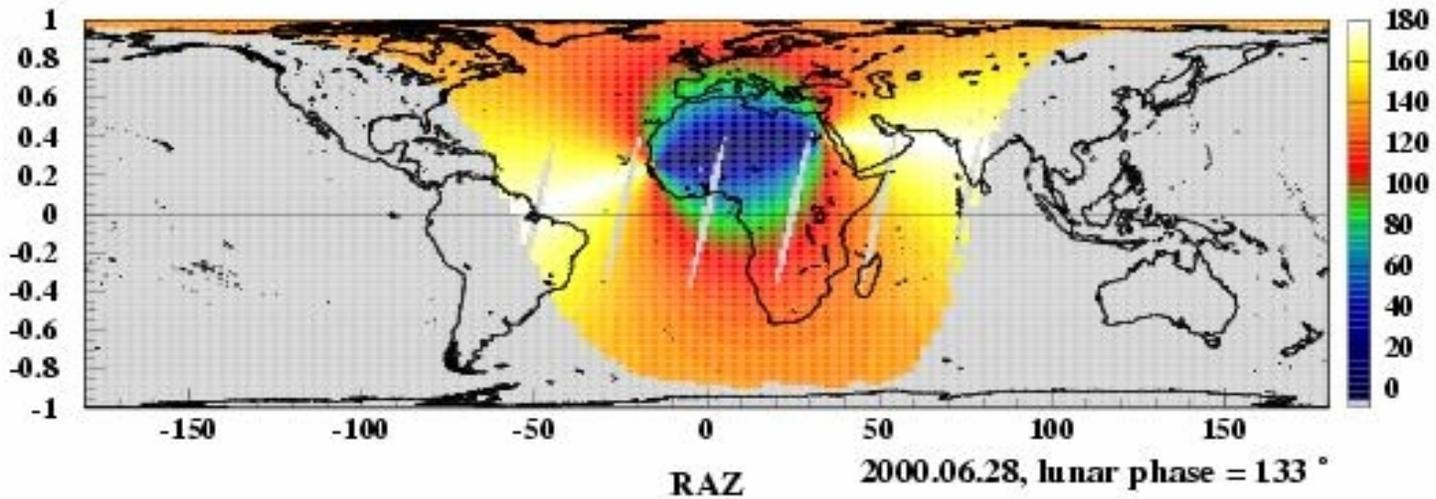
SAZ^m Dependence

(266 nights with CERES cover > 90%)

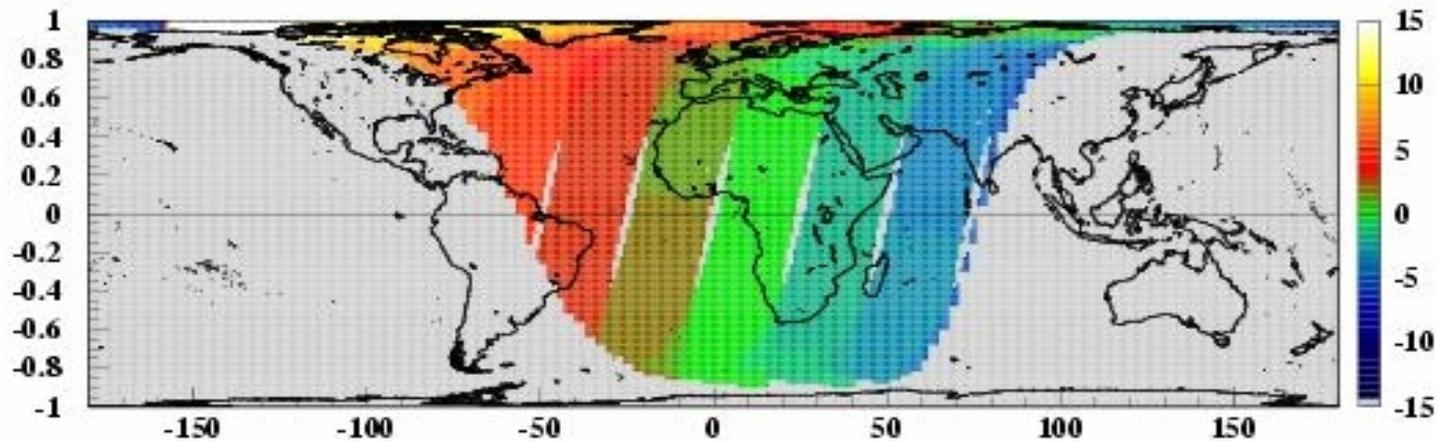


Earthshine Geometry

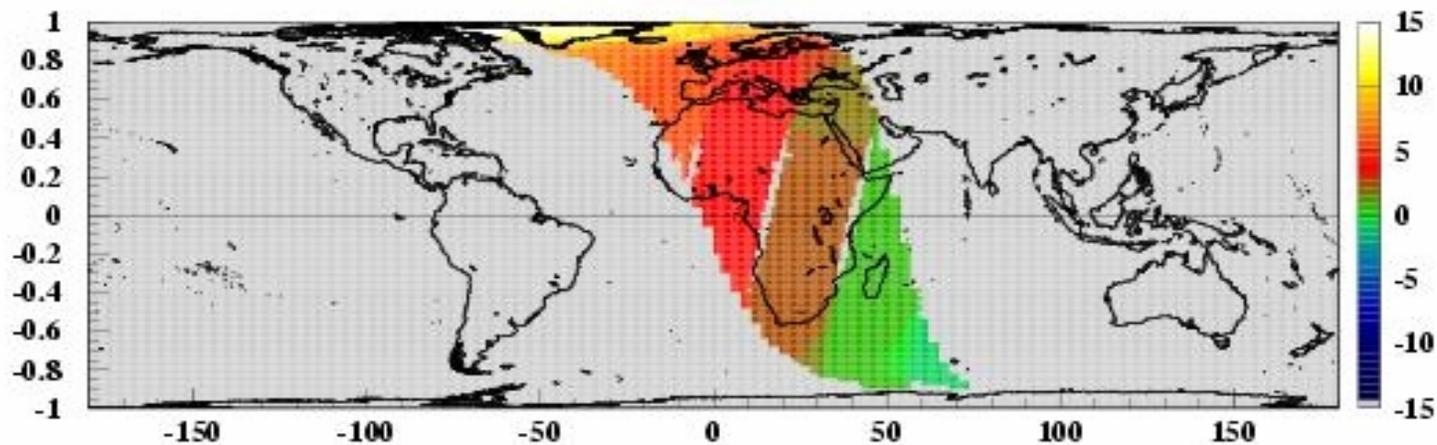
Mean RAZ^m



CERES/BBSO Local Time Difference



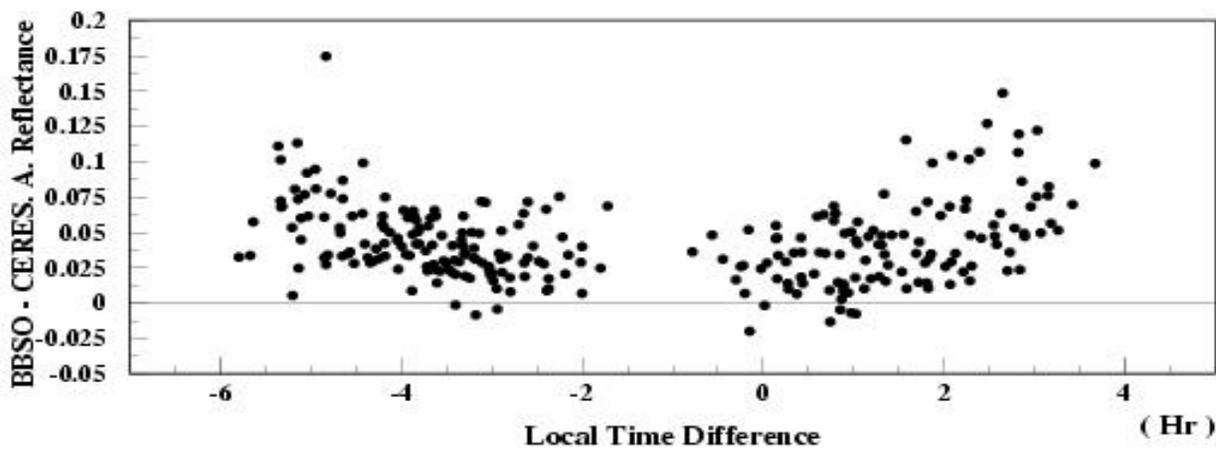
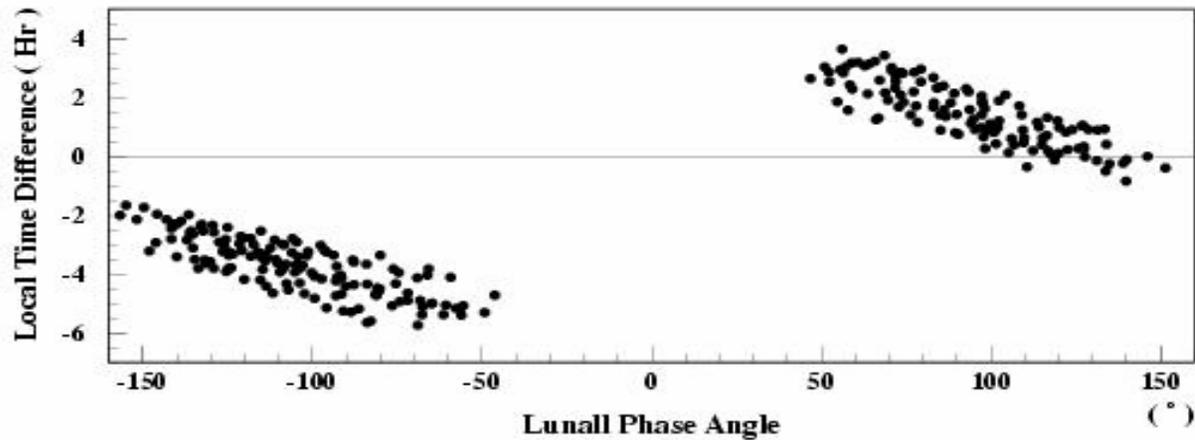
Local Time Difference, 2000.06.28, lunar phase = 133 °

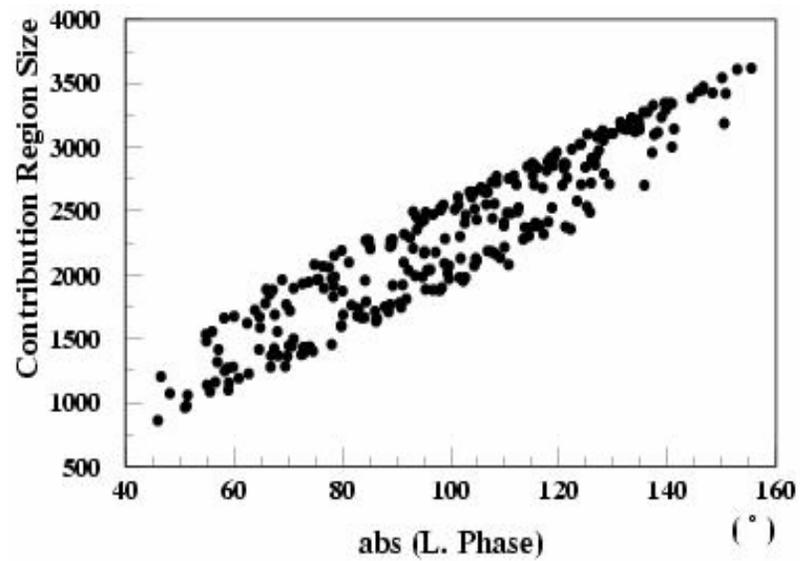


Local Time Difference, 2001.07.11, lunar phase = 56 °

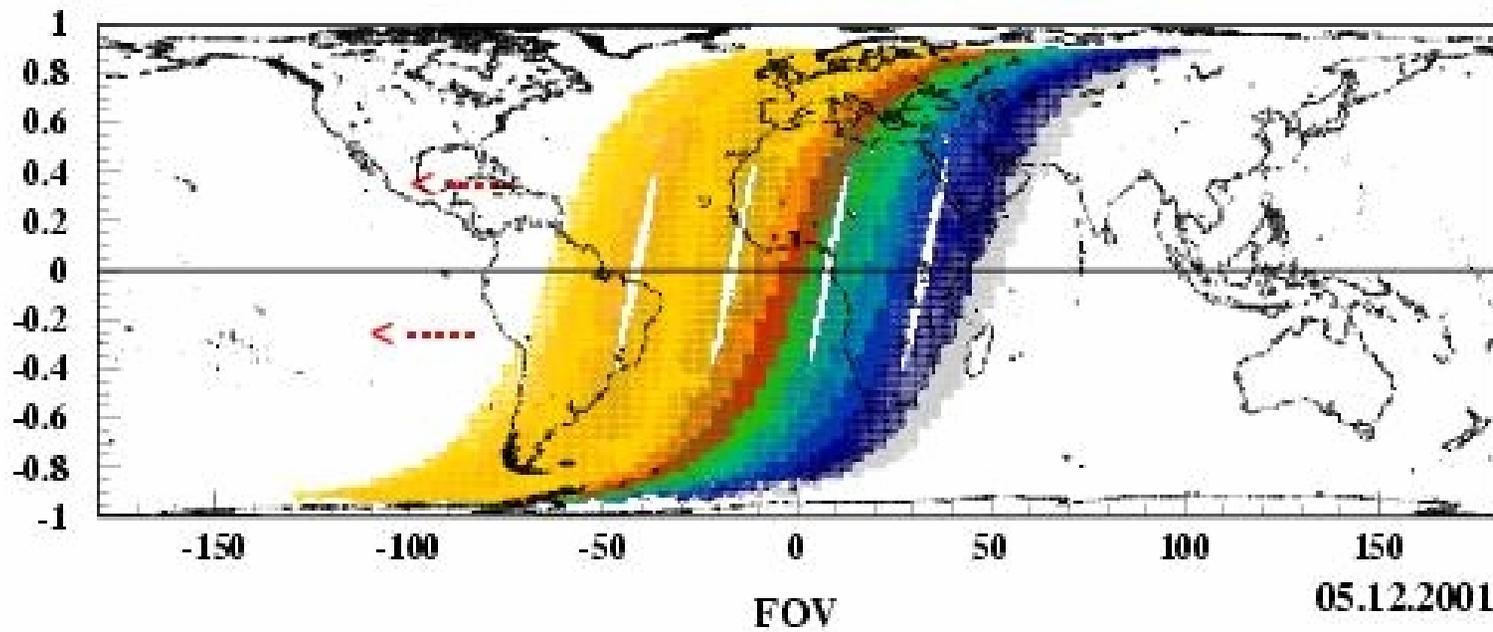
Local Time Difference

(266 nights with CERES cover > 90%)



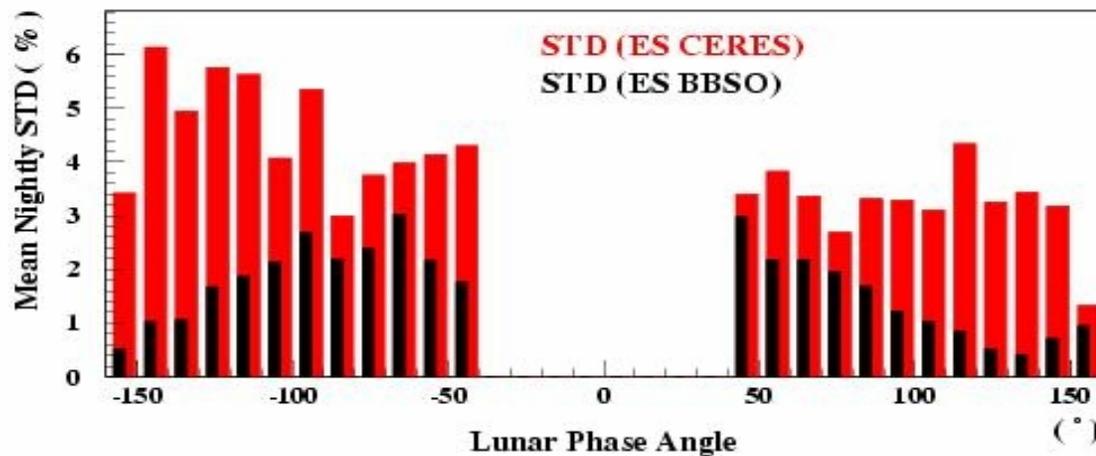
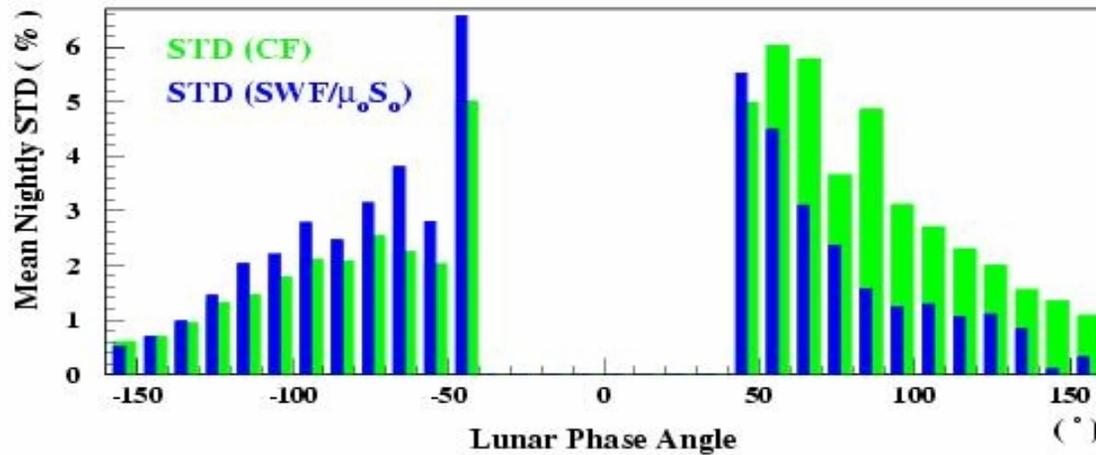


**Contribution
Spot Shift
(6.0 to 10.5 BBSO time)**



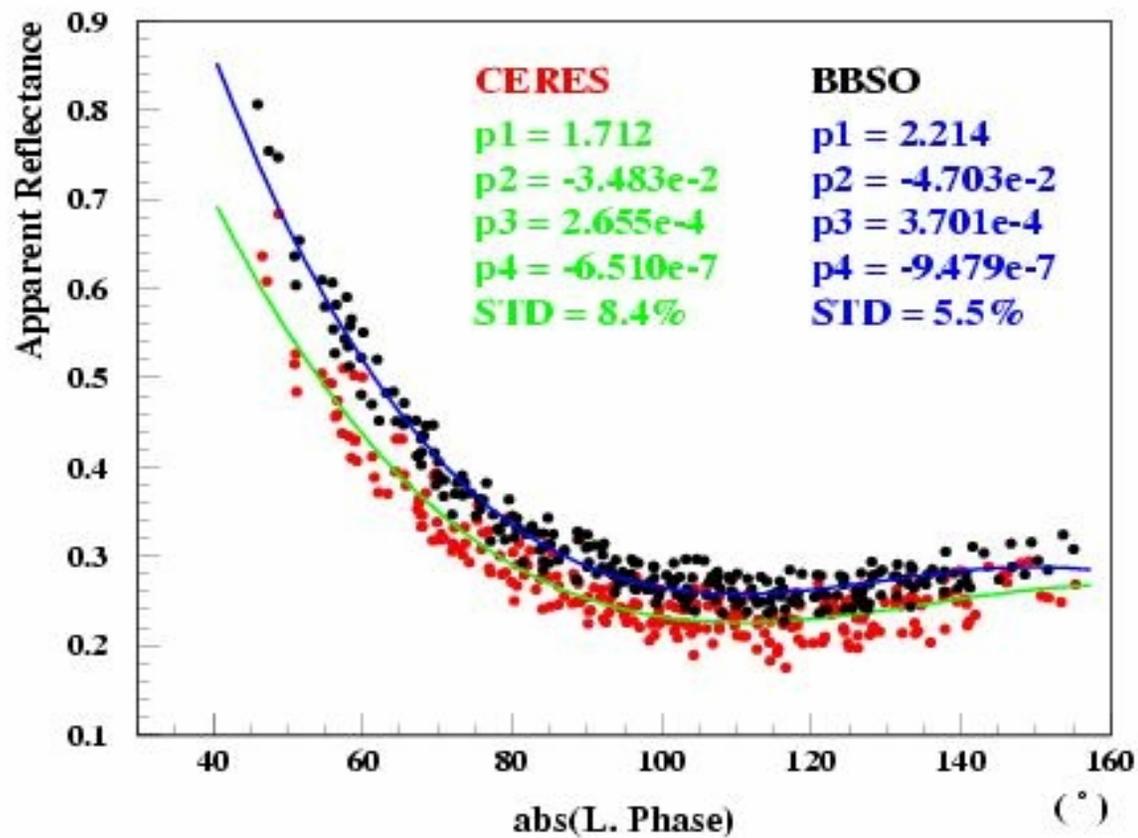
Spot Size Dependence

(266 nights with CERES cover > 90%)



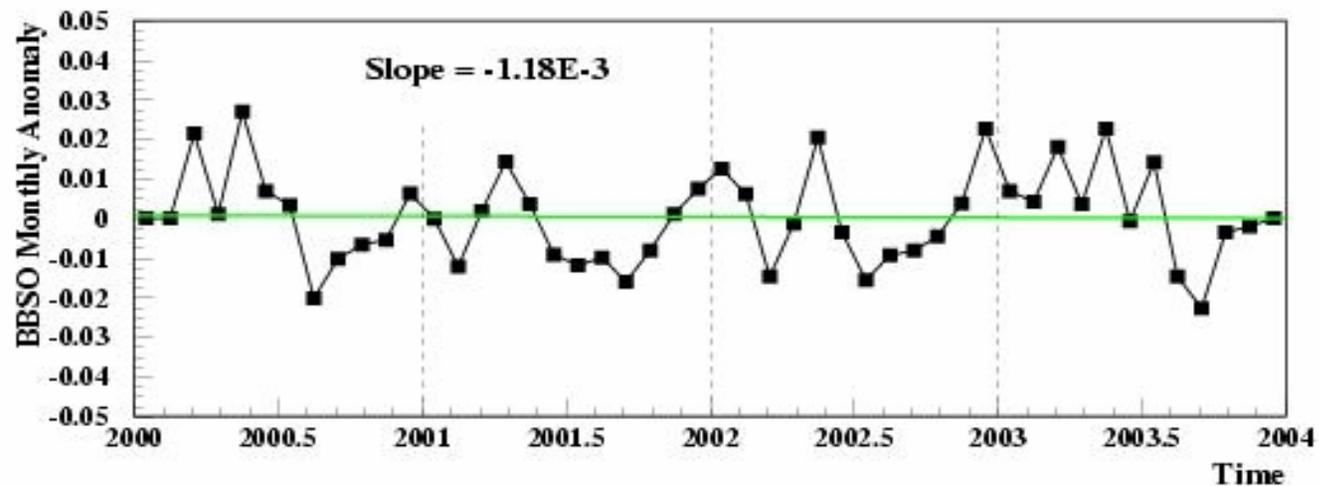
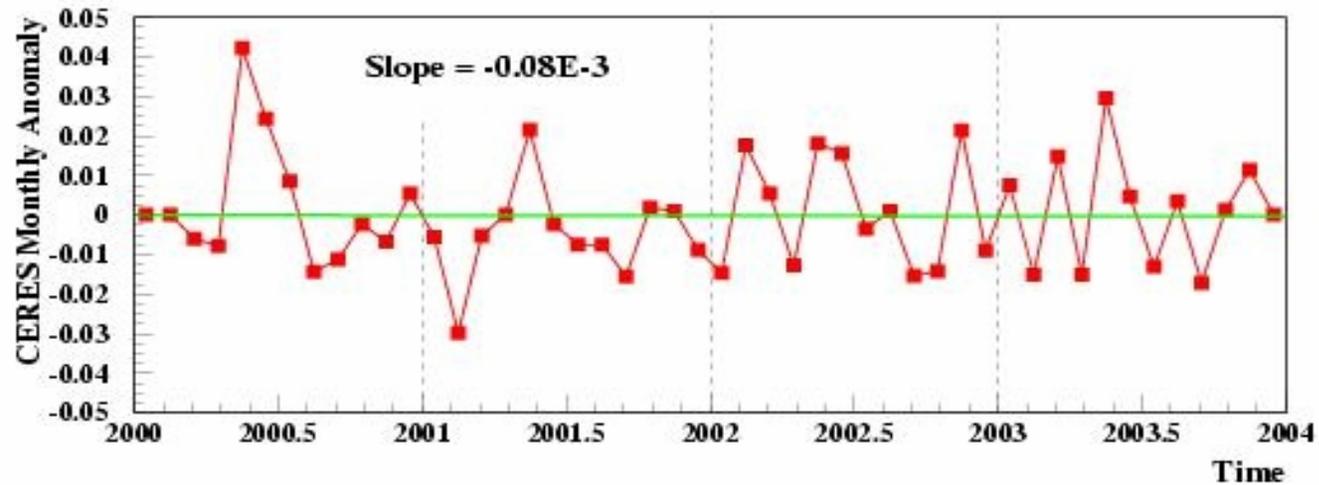
Apparent Reflectance

(266 nights with CERES cover > 90%)

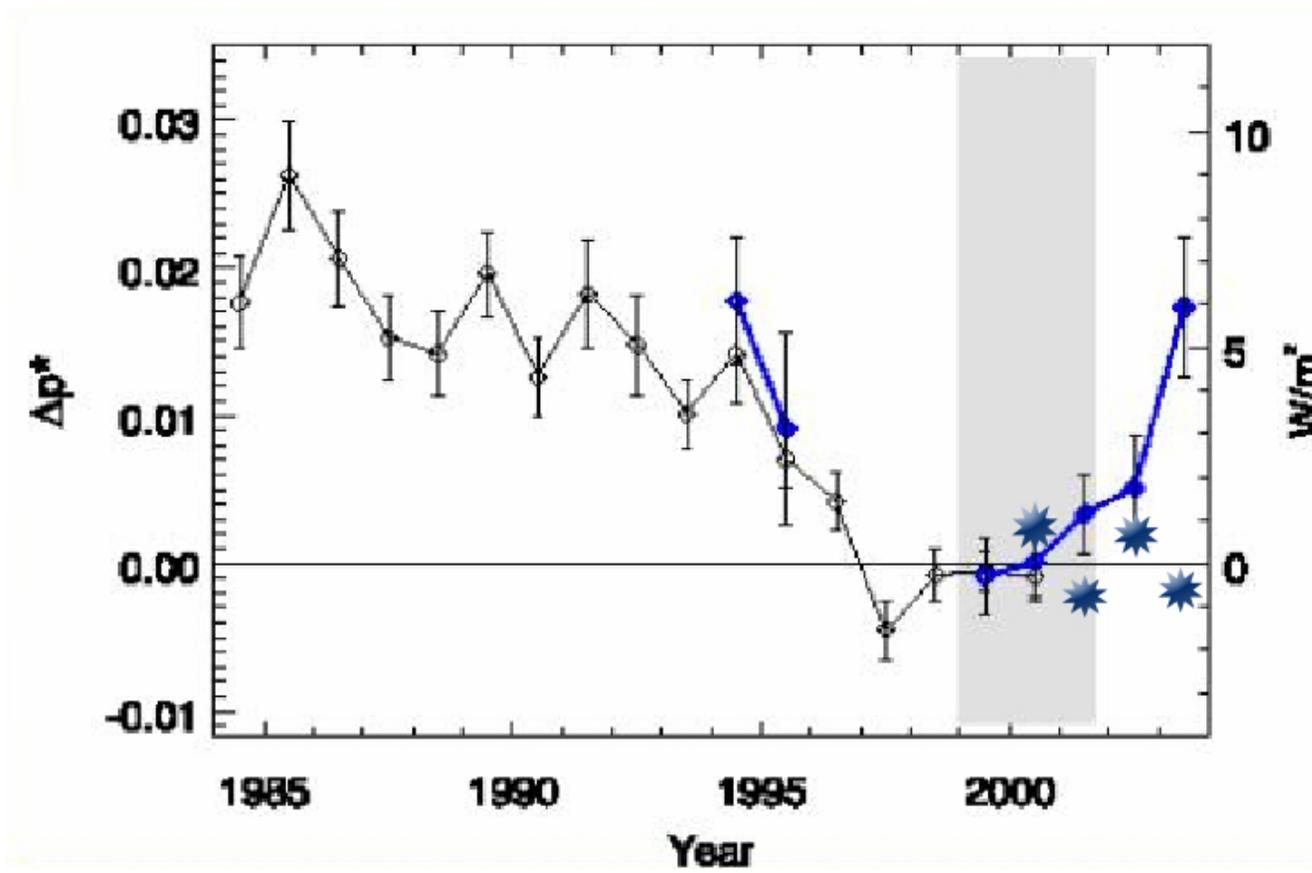


Apparent Reflectance Anomaly

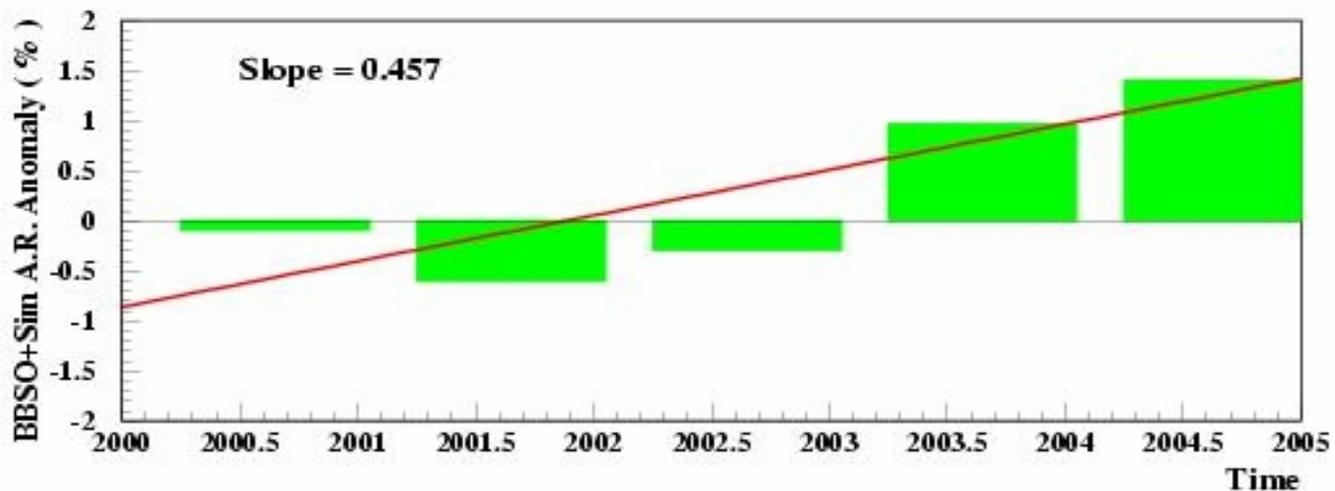
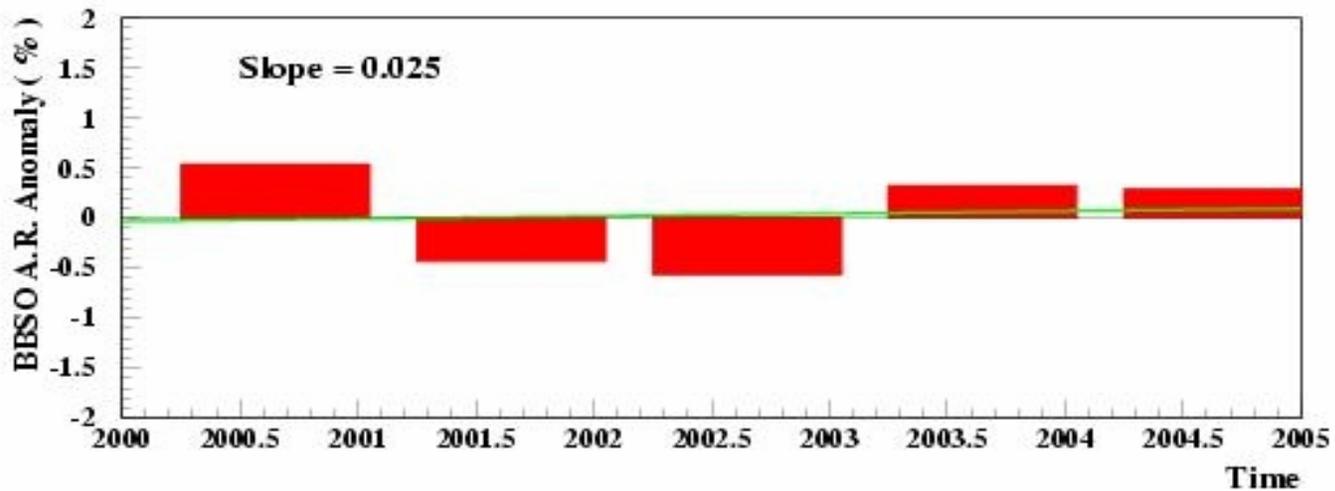
(266 nights, monthly mean)



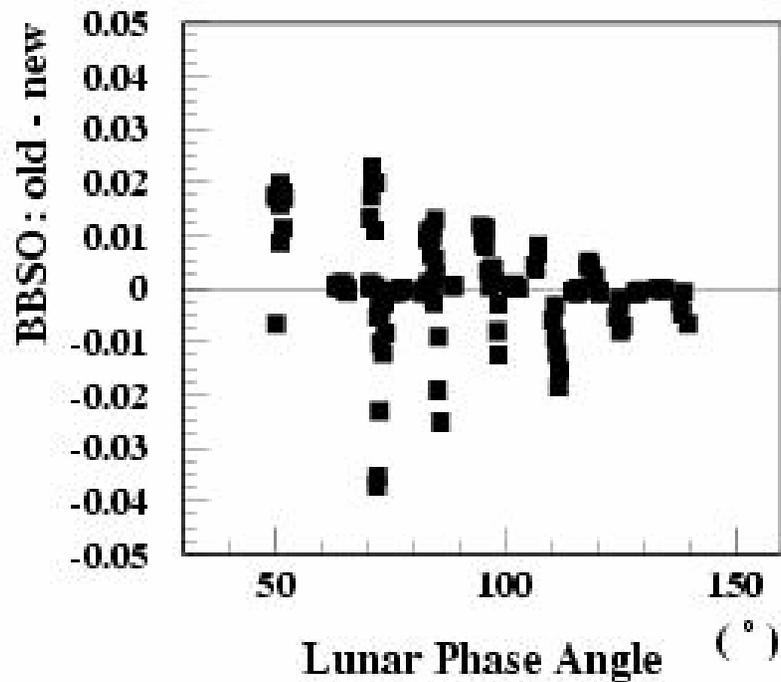
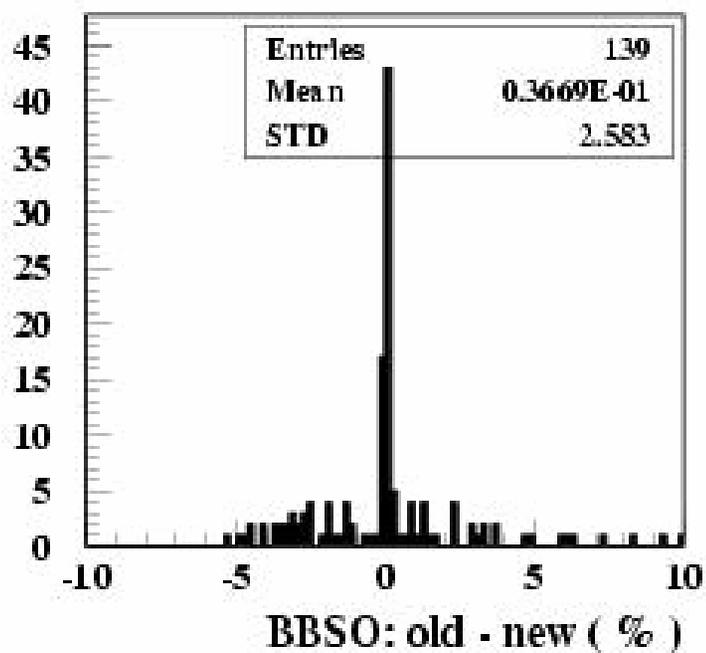
**BBSO (Science, v. 305, 2004)
& CERES Simulation (stars)**



BBSO Data (353 nights) and 2% Increase Simulation



Two Versions of BBSO Data



Summary

- ➡ **We do not see the trend in BBSO data (Why ?)**
- ➡ **We do not see the trend in the CERES Earthshine simulation. Consistent with CERES/Terra global albedo results.**
- ➡ **Comparison of CERES with BBSO are limited:**
 - **narrowband (BBSO) & broadband (CERES);**
 - **time difference cannot be ignored.**
 - **application of DM and ADMs twice, integration increase the errors in CERES simulation.**