Constraints on the Interannual Variation of Global and Regional Top-of-Atmosphere Radiation Budgets Inferred from MISR Measurements

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Background: basic climate theory (1)

1st fundamental equation of climate: albedo control

$$T_e = \left[S(1-\alpha) / 4\sigma \right]^{1/4}$$

planetary temperature 255 K

TSI ≈1365 W m^{-2}

planetary albedo ≈0.31

Background: basic climate theory (2)

2nd fundamental equation of climate:
vertical temperature control

$$T_s = T_e + \Gamma h_e$$

surface temperature 288 K

lapse rate 6.5 K km^{-1}

effective emission altitude ≈5.2 km

Background: 1st-Order Cloud effects

- shortwave: albedo
  - global shortwave cloud radiative forcing ≈50 W m^{-2}
  - 0.6 W m^{-2} $decade^{-1}$ ≈ 0.002 $decade^{-1}$ in global albedo
  - 1st-order changes due mainly to clouds, but also snow/ice
- longwave: greenhouse effect (sfc-TOA 'forcing')
  - ≈45% of total (adapted from Kiehl and Trenberth, BAMS 1997)
  - but this is instantaneous, not radiative-convective equilibrium
- longwave: effective height
  - for radiative-convective equilibrium, effective emission height is more important
  - 0.6 W m^{-2} $decade^{-1}$ ≈ +50 m $decade^{-1}$ in effective height

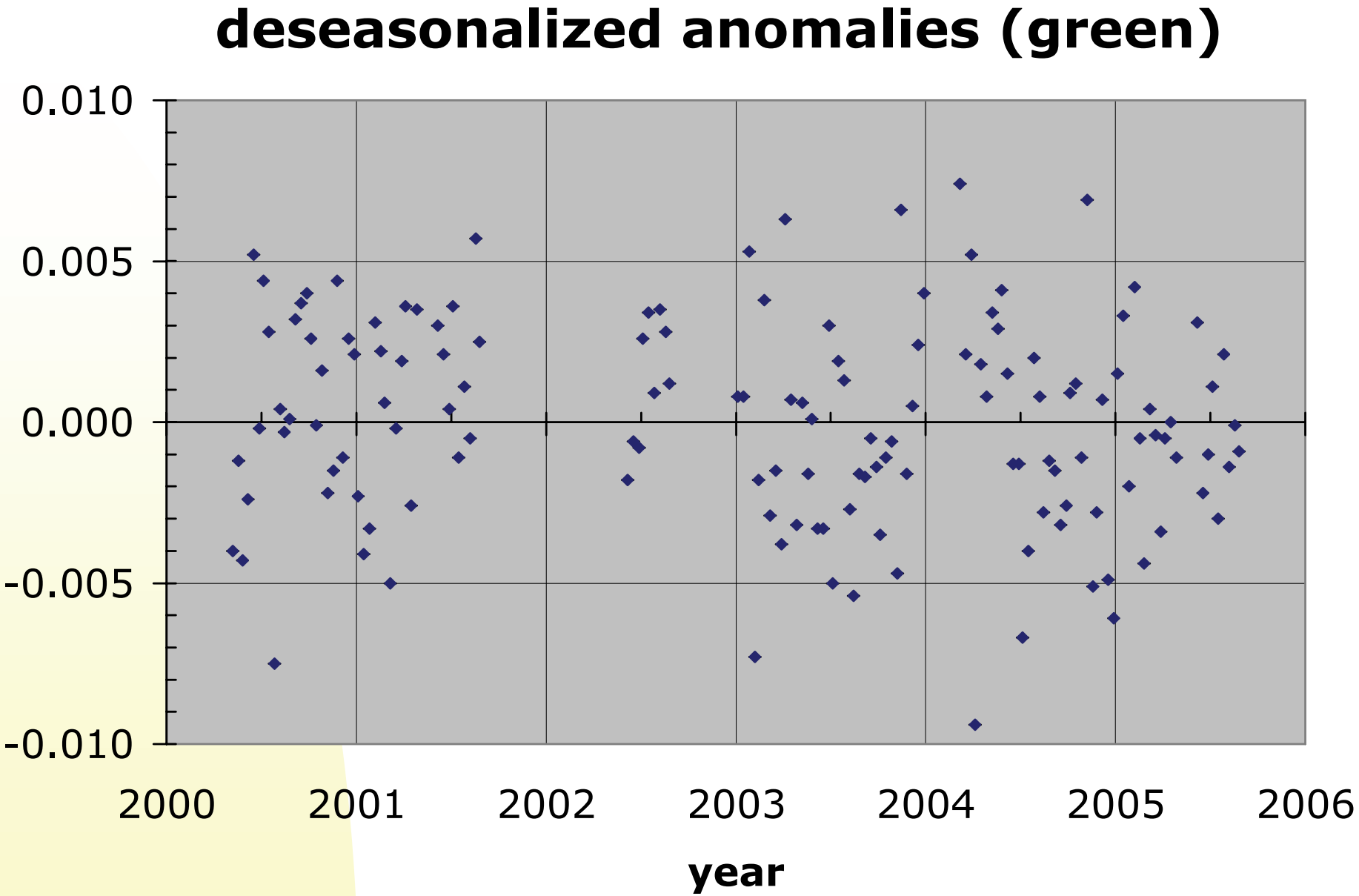
MISR: observation concept

- 9 view angles at Earth surface: +70.5° to –70.5°
- consistent climate data records from 5/2000 – present
- ‘expansive’ (30km-TOA) spectral albedo anomalies
  - onboard calibration ≈1% relative radiometric accuracy
- Effective height (RLRA) anomalies
  - geometrically derived: no calibration drift

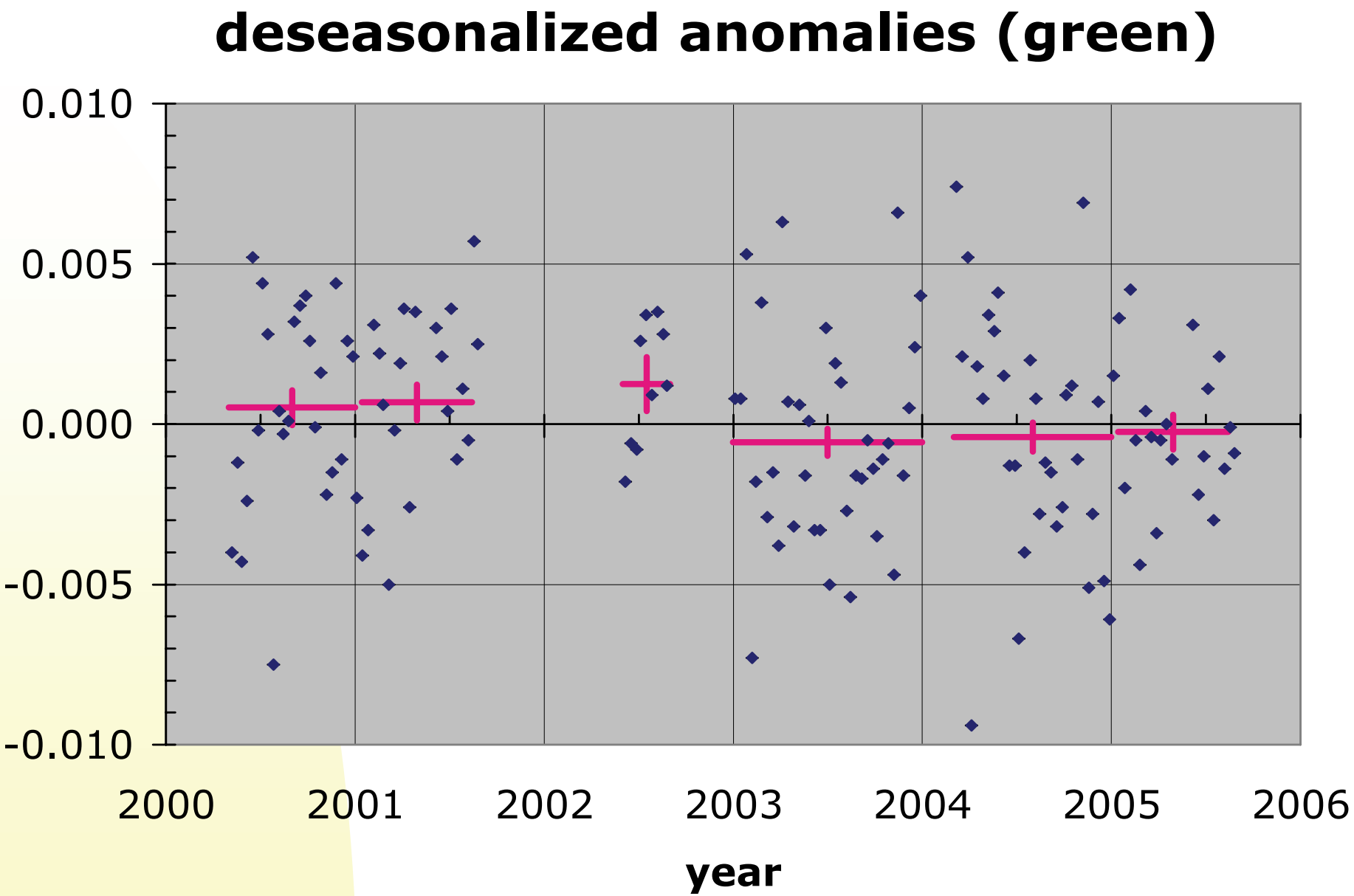
Terra: 10:30 am sun-synchronous

Global Average Anomalies

- 10-day deseasonalized samples
  - over 100 independent orbits per sample
  - energy-weighted for albedo
  - equal-area weighted
- 5/2000-4/2005 analyzed consistently for albedo and effective height
- recent data since 12/2005
  - preliminary, but may be interesting


deseasonalized anomalies (green)
0.010
0.005
0.000
-0.005
-0.010
2000
2001
2002
2003
2004
2005
2006
year

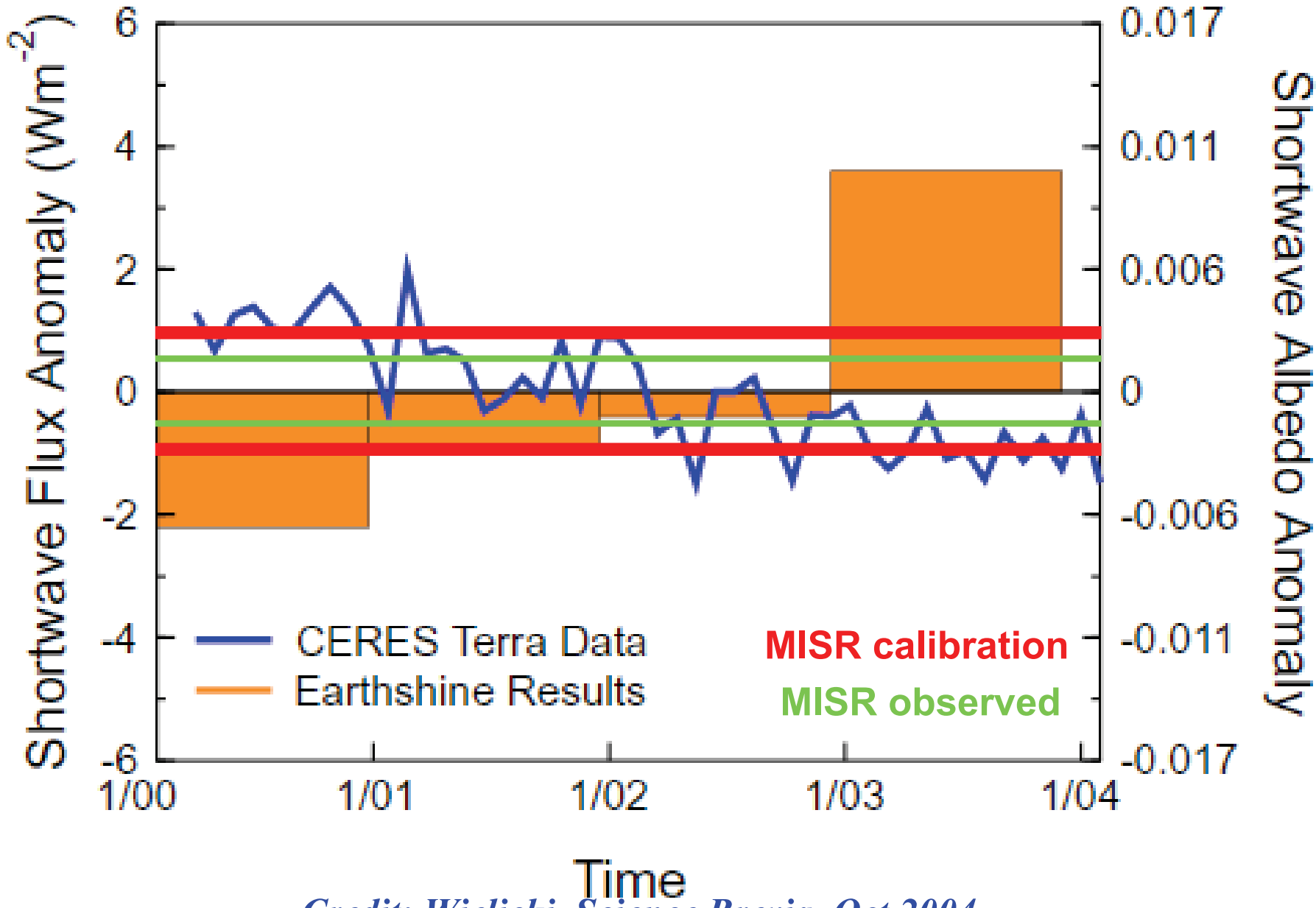
MISR expansive spectral albedo



Spectral Albedo Summary

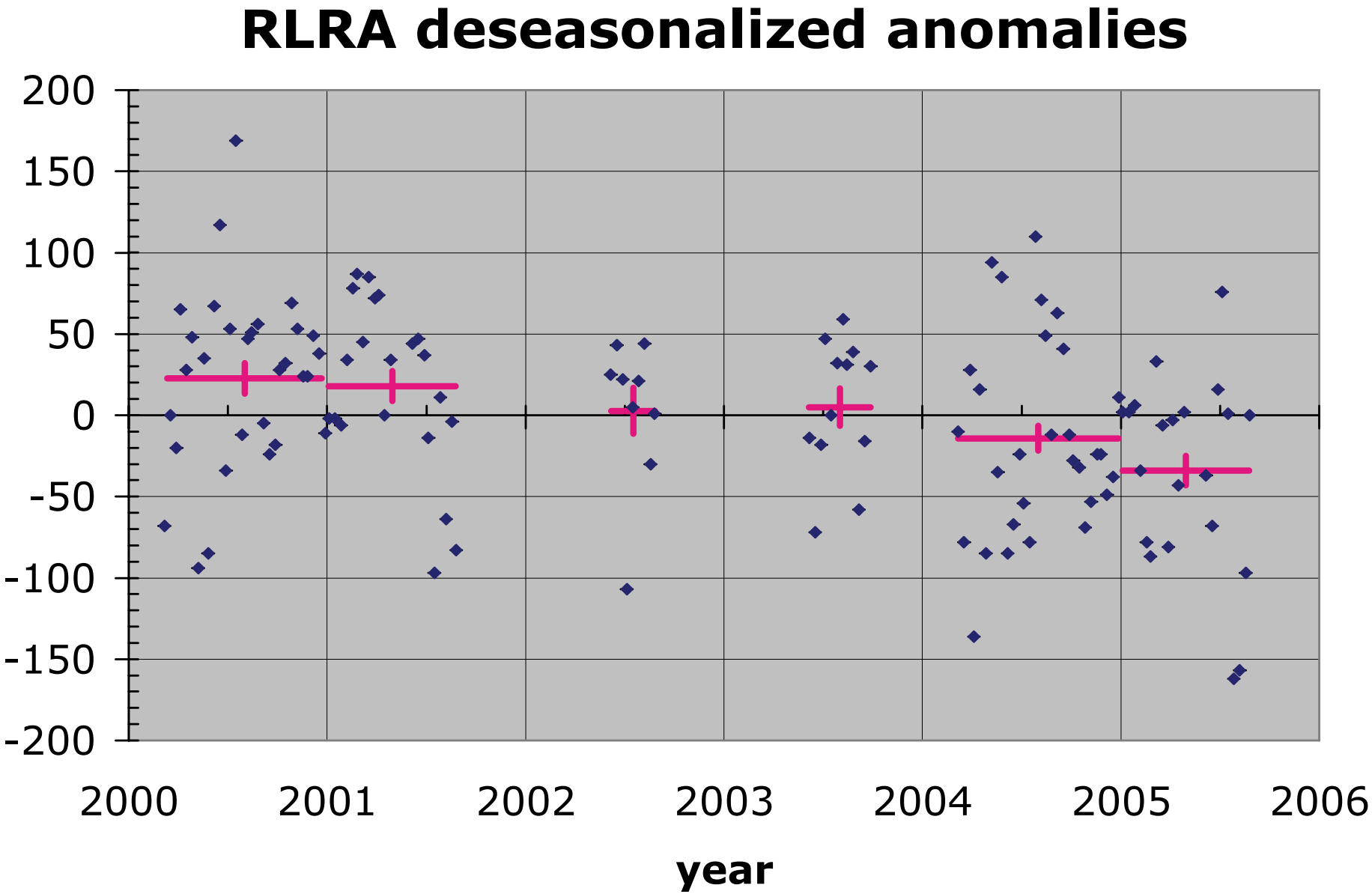
- all MISR spectral bands show similar anomalies, and are highly correlated with broadband shortwave anomalies
  - Sun et al, GRL (submitted 06) compares MISR and CERES directly
- observed interannual global albedo changes
  - <0.001 (0.3%)
- samping error (for 10:30 am only) at 1σ
  - 0.003 (10-day, global)
  - 0.0004 (12-month, global)
- overall difference 2005–2000
  - <0.2% ≈0.3 W m^{-2} (equivalent broadband)
  - this is << than radiometric uncertainty of 1%, or ≈±1 W m^{-2}

Earthshine Results versus CERES: 2000 to 2004



Credit: Wielicki, Science Brevia, Oct 2004


What about effective height changes?


RLRA deseasonalized anomalies
200
150
100
50
0
-50
-100
-150
-200
2000
2001
2002
2003
2004
2005
2006
year

Effective height summary

- absolute value is uncertain, but anomalies are accurate, with no radiometric uncertainty
- sampling uncertainty, 1σ
  - ±70 m for 10-day averages
  - ±11 m for 12-month averages
- observed interannual changes ≈ ±30 m globally
- overall difference 2005–2000
  - –44±11 m globally
  - +0.5 W m^{-2} (equivalent greenhouse effect)

summary 2000–2005

- main change observed is in effective height
  - and this is limited mainly by sampling error
- zonally, main difference is a reduced high cloud fraction in ITCZ
  - averages ≈ -70 m/yr at equatorial latitudes, over four years
  - weaker Hadley circulation?
- total cloud fraction, and albedo, show no observable interannual changes at global scale
  - albedo changes are technically limited by relative radiometric calibration
- However, preliminary results for 2006 appear to be rather different.