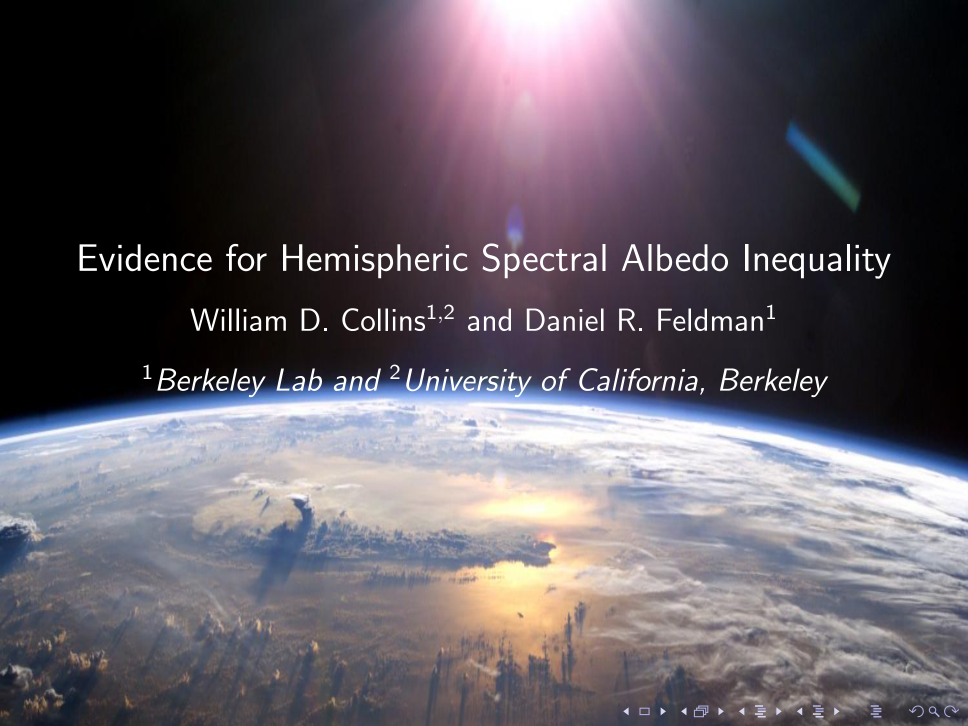
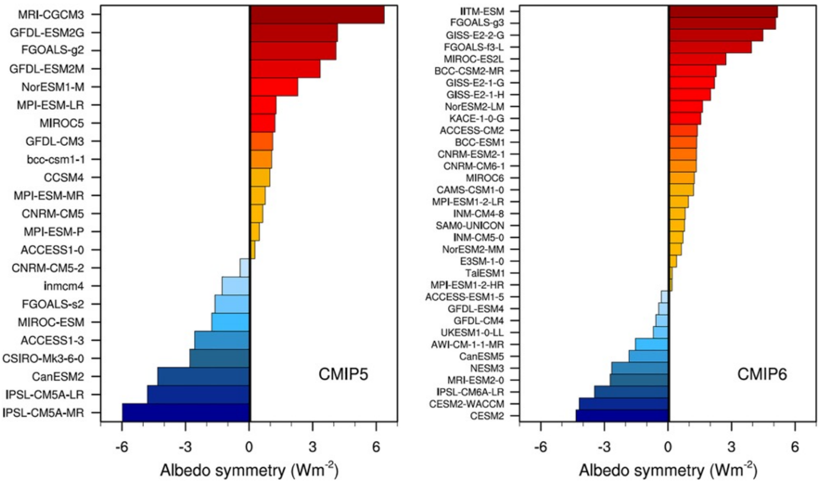


Evidence for Hemispheric Spectral Albedo Inequality

William D. Collins[1,2] and Daniel R. Feldman[1]

[1] *Berkeley Lab and* [2] *University of California, Berkeley*

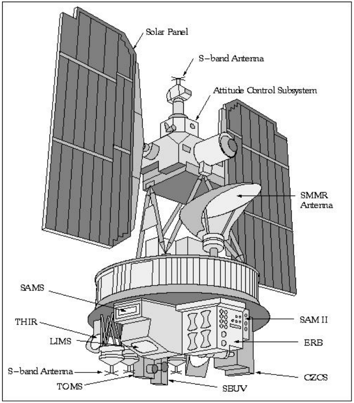
Earth's Reflected Shortwave Symmetry – not Seen in ESMs



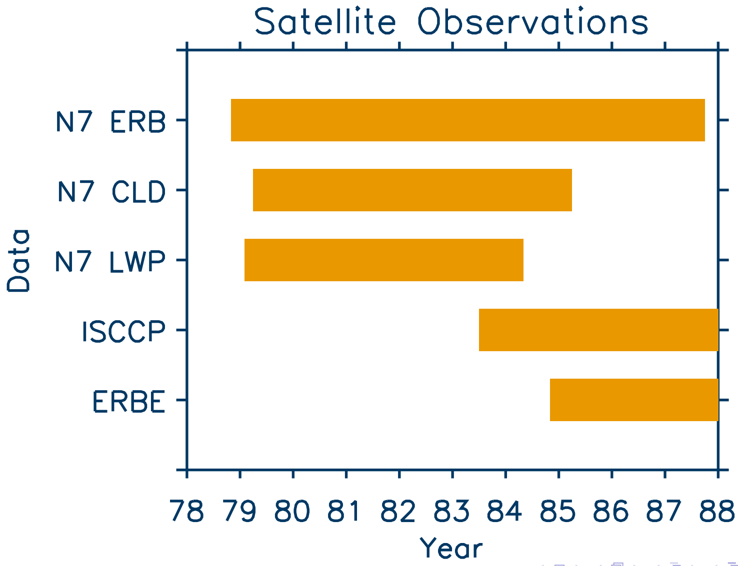
Nimbus-7 was last satellite with working near-IR broadband radiometers

Nimbus-7 Instrument Suite

- ERBS (Earth Radiation Budget Sensor)
- CZCS (Coastal-Zone Color Scanner)
- LIMS (Limb Infrared Monitoring of the Stratosphere)
- SAM II (Stratospheric Aerosol Measurement II)
- SAMS (Stratospheric and Mesopheric Sounder)
- SBUV (Solar Backscatter UV)
- SMMR (Scanning Multichannel Microwave Radiometer)
- THIR (Temperature-Humidity Infrared Radiometer)
- TOMS (Total Ozone Mapping Spectrometer)



Timeline of Data for Earth Radiation Budget studies



Relationship of Spectral to Broadband Albedos

The TOA broadband albedo in each hemisphere $i = NH, SH$ is:

$$R_i = f_v \, R_{v,i} + (1 - f_v) \, R_{n,i}$$

This can be written as:

$$\begin{aligned} R_i &= \frac{\Sigma R_{b,i}}{2} \left[1 + \frac{\Delta R_{b,i}}{\Sigma R_{b,i}} \, (2 \, f_v - 1) \right] \\ &= \frac{\Sigma R_{b,i}}{2} \, [s_i] \\ &= R_i \left[\frac{s_i}{s_i} \right] \end{aligned}$$

where

$$\begin{aligned} \Sigma R_{b,i} &= R_{v,i} + R_{n,i} \\ \Delta R_{b,i} &= R_{v,i} - R_{n,i} \\ s_i &= \left[1 + \frac{\Delta R_{b,i}}{\Sigma R_{b,i}} \, (2 \, f_v - 1) \right] \end{aligned}$$

Implications of Spectral Interhemispheric Differences

These results show that

$$R_{NH} \simeq R_{SH}$$

can be true even if

$$s_{NH} \neq s_{SH}$$

Let us write

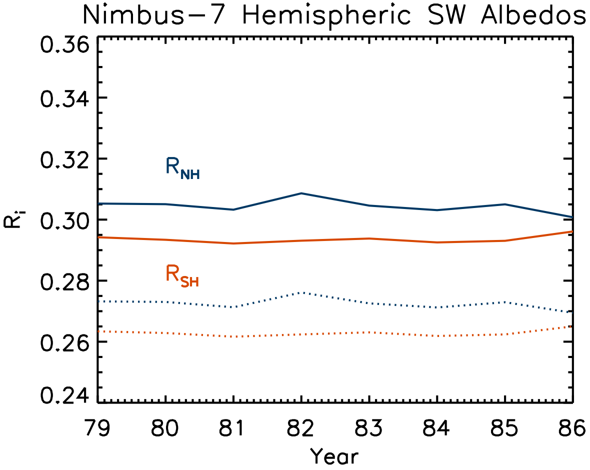
$$\begin{aligned} s_i &= [1 + r_i\,(2\,f_v - 1)] \\ r_i &= \frac{\Delta R_{b,i}}{\Sigma R_{b,i}} \end{aligned}$$

Note that

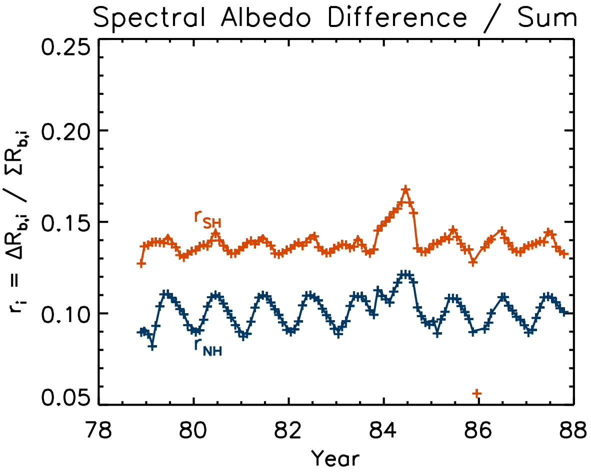
$$-1 \leq r_i \leq 1 \qquad r_i = \begin{cases} -1 \Rightarrow & R_{v,i} = 0 \Rightarrow \quad \text{max Surf. heating} \\ 1 \Rightarrow & R_{n,i} = 0 \Rightarrow \quad \text{max Atm. heating} \end{cases}$$

What does Nimbus-7 show?

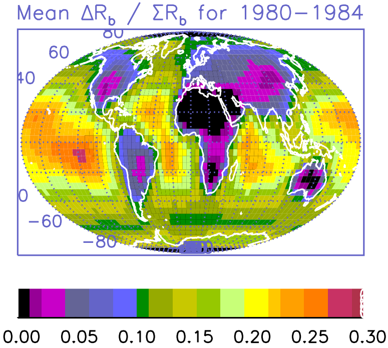
Nimbus-7 Hemispheric Shortwave Albedos

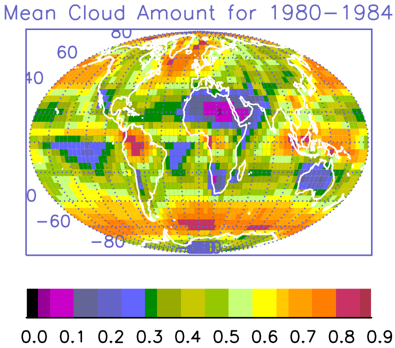


Spectral Albedo Difference / Sum

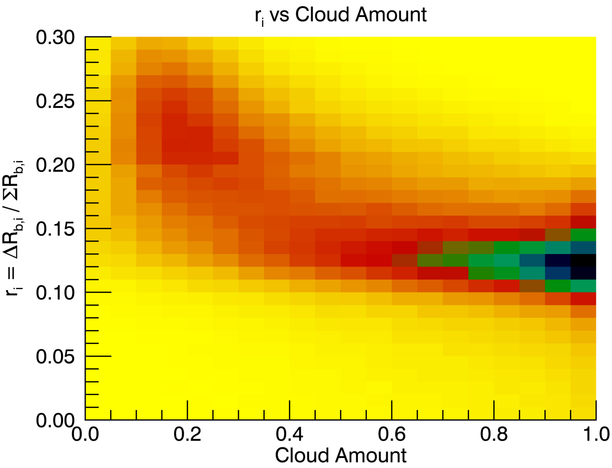


Time-Mean Spectral Albedo Difference / Sum & Cloud Amount

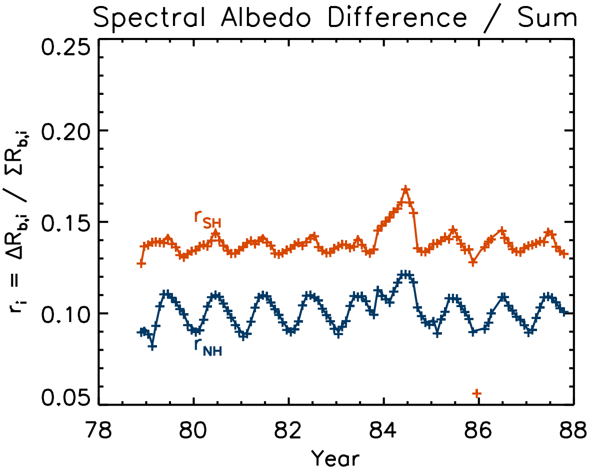




Daily Spectral Albedo Difference / Sum & Cloud Amount over Oceans

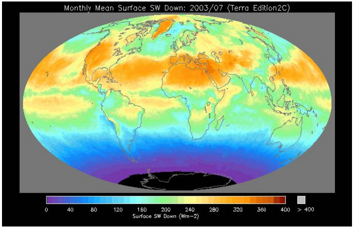


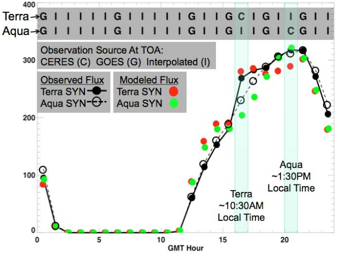
Can the Nimbus-7 Results be Tested with Recent Data?

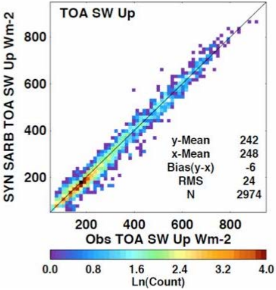


CERES SYN Product (2003–2021)

Global Hourly Gridded TOA BB, BB clear, and Spectral Fluxes:



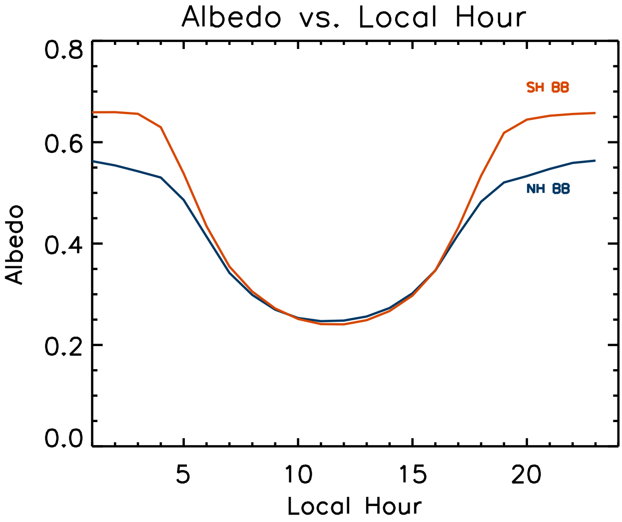




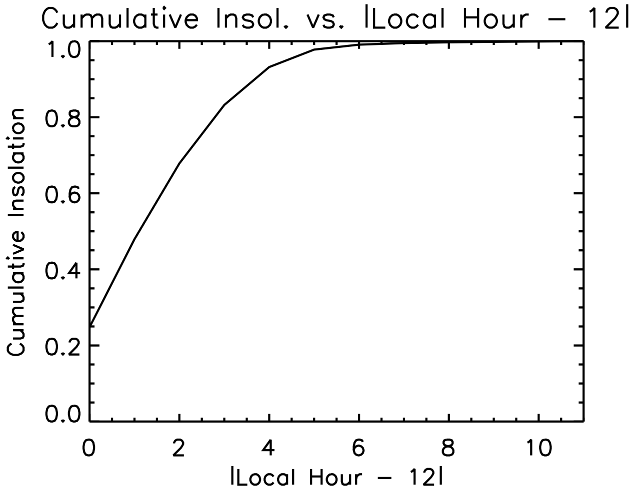
Hemispheric Albedos from CERES Products

Hemisphere	EBAF	SYN
NH	0.291	0.285
SH	0.291	0.285

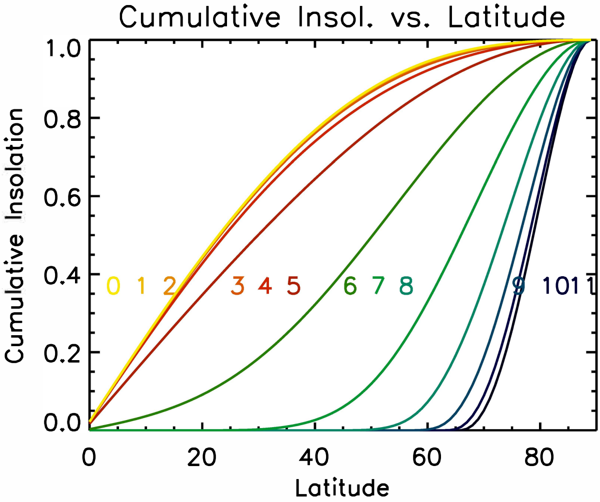
Variation of Hemispheric Albedo with Local Hour



Cumulative Insolation vs. Local Hr Range about Noon



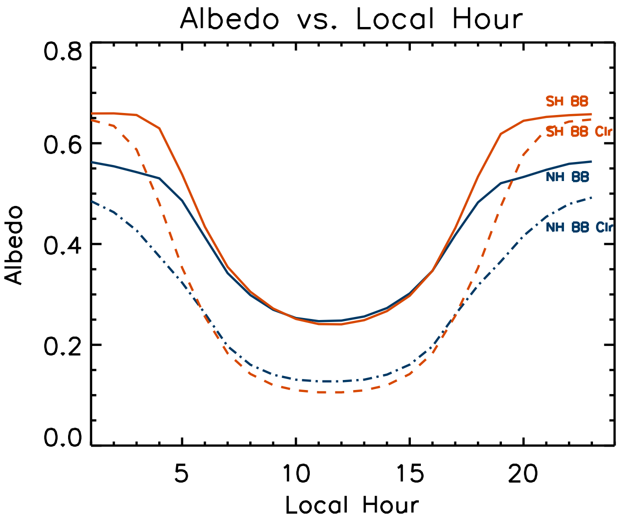
Cumulative Insolation by Local Hr vs Latitude



Hemispheric Albedos from CERES Products

Hemisphere	EBAF	SYN	Noon SYN	Nimbus-7
NH	0.291	0.285	0.247	0.304
SH	0.291	0.285	0.241	0.294

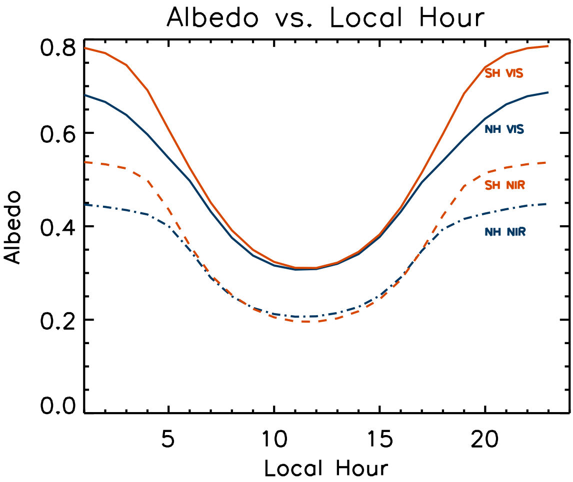
Variation of Clear-sky Hemispheric Albedo with Local Hour



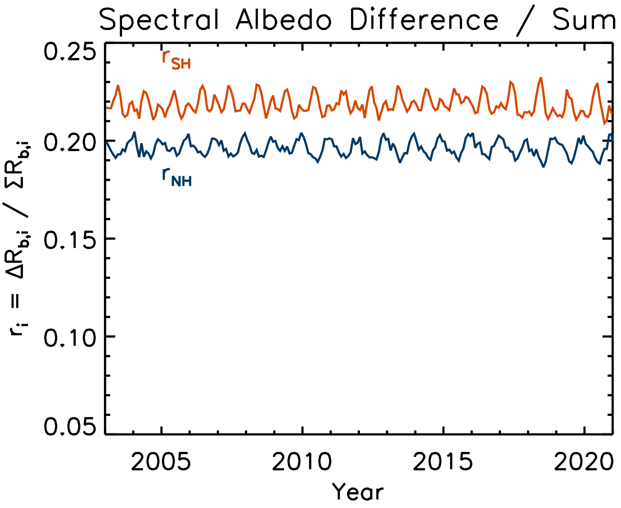
Hemispheric Albedos from CERES Products

Hemisphere	EBAF	SYN	Noon SYN	Spectral SYN
NH	0.291	0.285	0.247	0.292
SH	0.291	0.285	0.241	0.293

Variation of Spectral Hemispheric Albedo with Local Hour

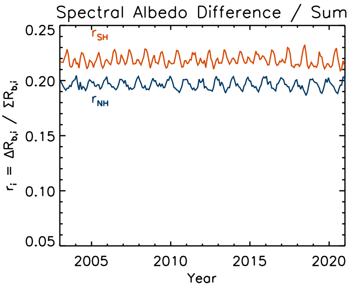


CERES SYN Spectral Albedo Difference / Sum

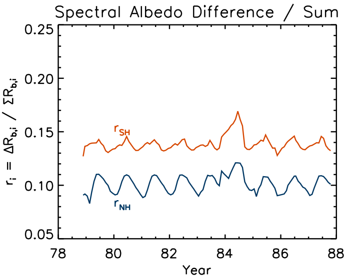


Comparison to Nimbus-7 Spectral Albedo Difference / Sum

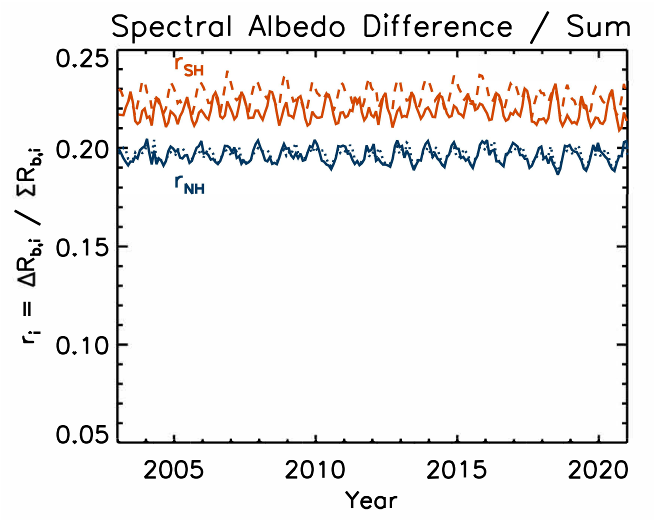
CERES SYN:



NIMBUS-7:



CERES SYN Spectral Albedo Diff. / Sum @ Local Noon



Open Issues

- What are the implications of these findings for possible mechanisms ($-$ve feedbacks) to maintain

$$R_{NH} \simeq R_{SH}$$

- Since $f_v = 0.497$, the spectral multipliers on R_i are insensitive to the spectral partitioning between visible and near-IR:

$$\frac{\partial s_i}{\partial r_i} = 2\, f_v - 1 \simeq 0$$

  What are the implications (if any)?

- The spectral factors are related to the albedo ratio $\mathcal{R}_i = R_{n,i}/R_{v,i}$ (Collins, 1998) by:

$$r_i = \frac{1 - \mathcal{R}_i}{1 + \mathcal{R}_i}$$

  This means r_i will differ between obs and models for cloudy conditions over oceans. What are the implications?