



Global Dimming and Brightening: An Opportunity for ARM

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Martin Wild and Connor Flynn**

International Workshop on Global Dimming and Brightening

- **10–14 February 2008**
- **Ein Gedi, Israel**
- **Hosted by Israel Science Foundation**
- **Meeting summary reported in EOS
(Martin Wild co-author)**

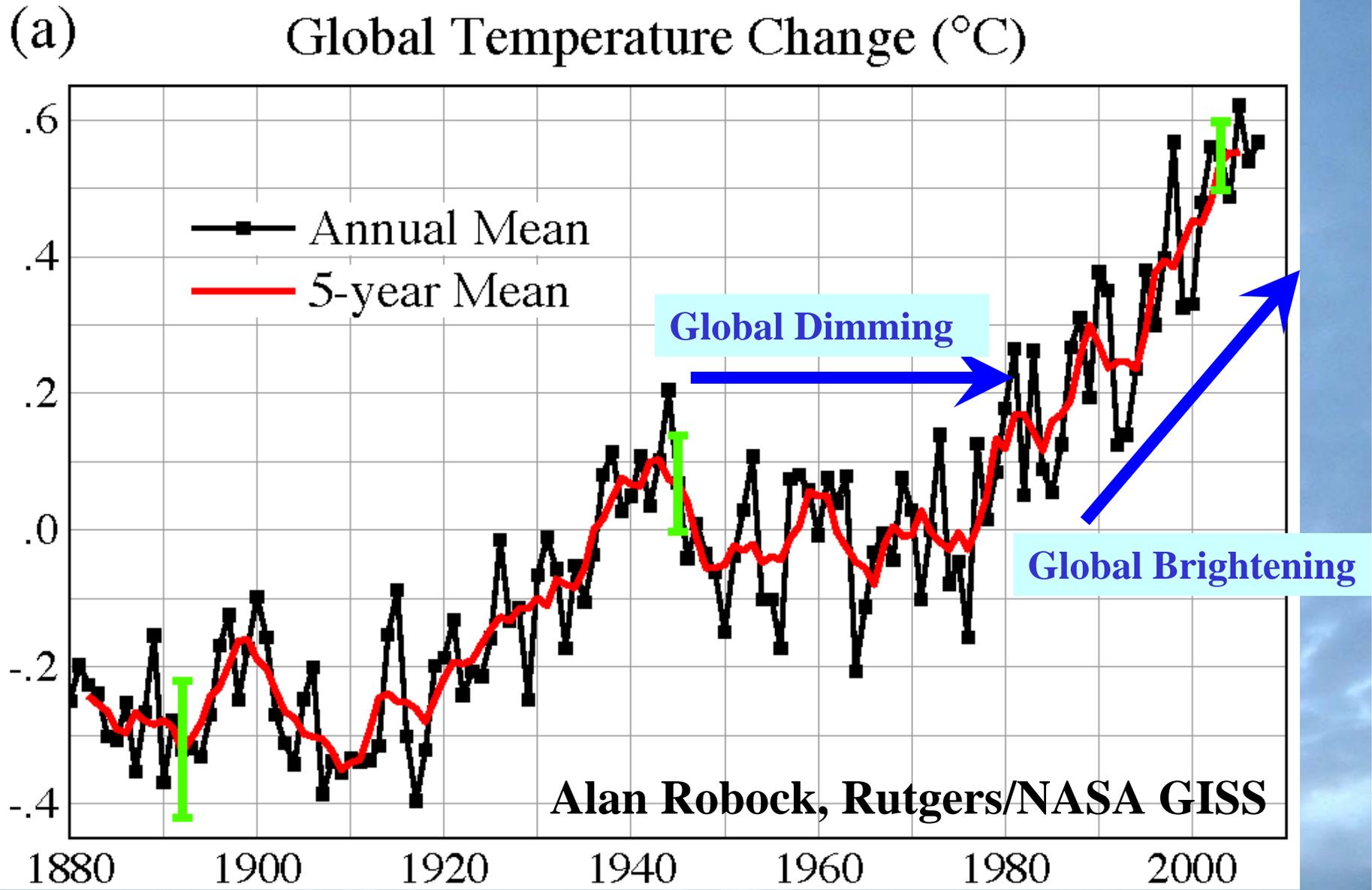
GDB Workshop Outcomes

- **Agree on the name “Global Dimming and Brightening”**
- **Define GDB as: “Decadal changes in downwelling solar radiation reaching the Earth’s surface.”**
- **Agree that it is a real phenomenon**
 - **Tendencies from SW, satellite, pan evaporation, earthshine, etc. all agree**
- **Now need to determine the causes of GDB**

GDB Workshop Outcomes

- **JGR Special Issue on Global Dimming and Brightening**
- **Papers currently in review**
- **Should hit print in about a year**

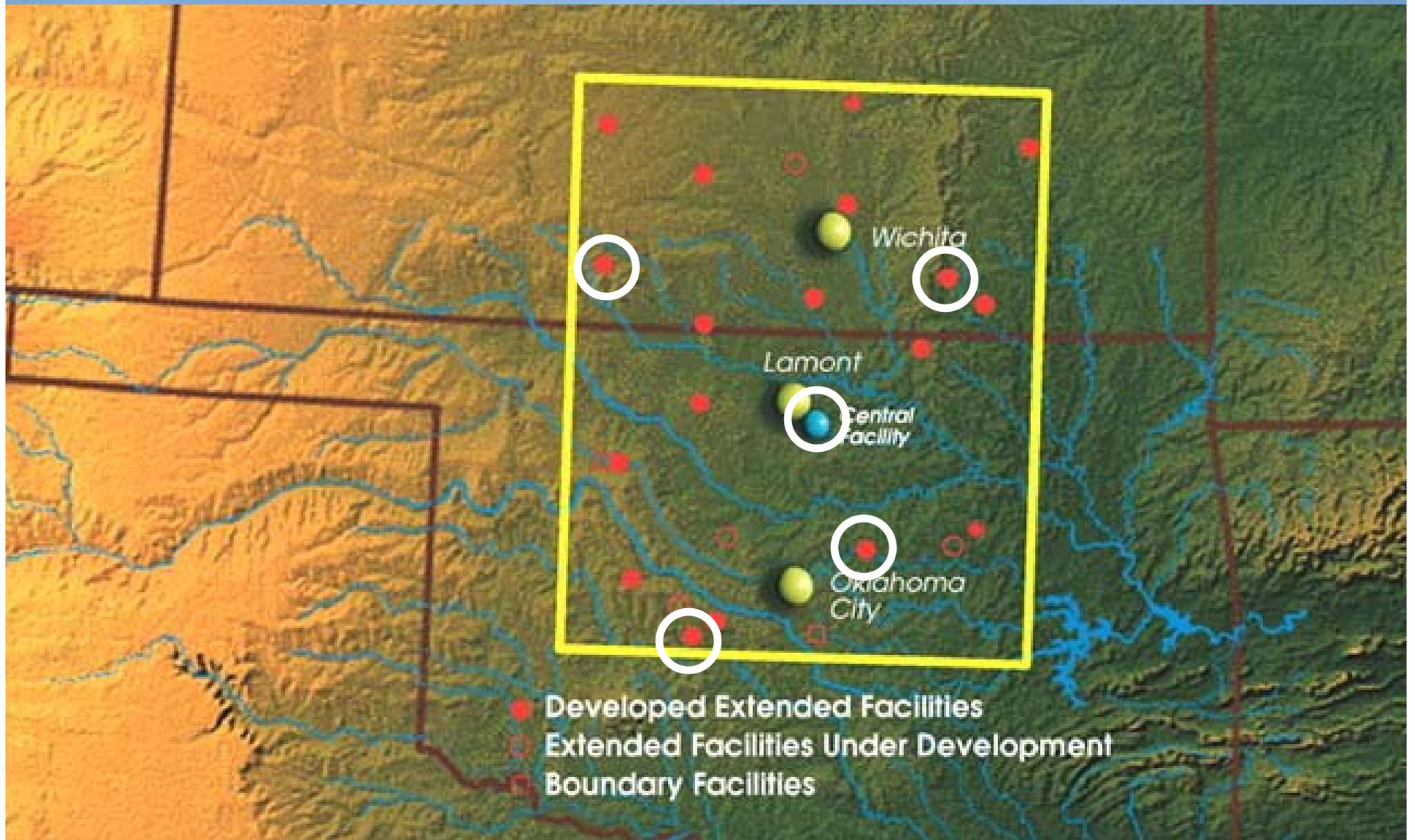
Climate Impact



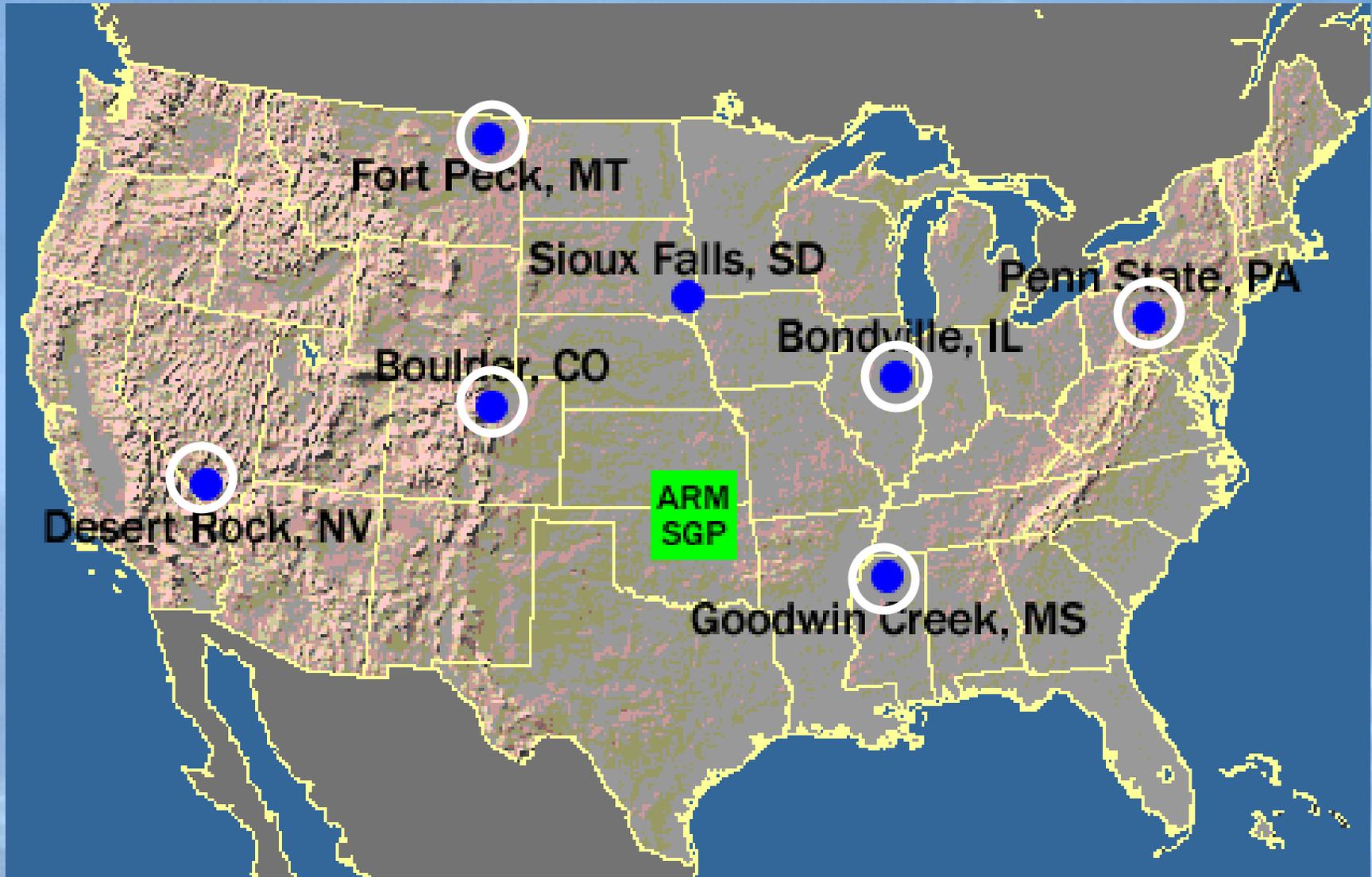
Causes of GDB

- **Clear-sky**
 - **Aerosol direct effect**
 - **Hydration effects (air traffic)?**
- **Clouds**
 - **Aerosol indirect and semi-direct effects**
 - **Greenhouse warming feedbacks?**
 - **Other (synoptic climate variability, etc.)**
- **Use Radiative Flux Analysis and ARM/SURFRAD/BSRN analyses**
 - **“read the tea leaves”**

ARM SGP Network



SURFRAD Network

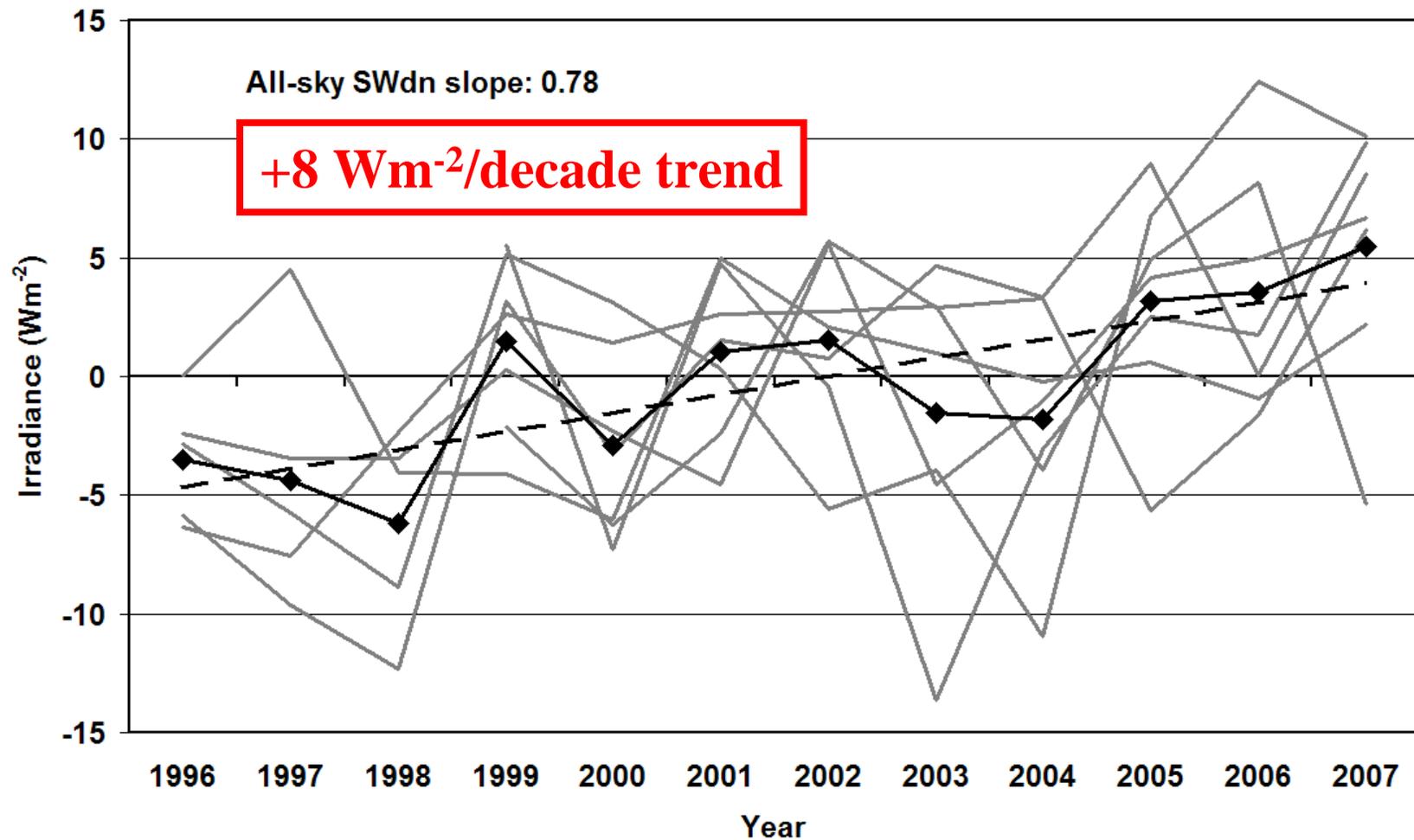


Long et al., JGR submitted

- **Data from 1996 – 2007**
 - **DRA and PSU start 1999**
- **All data tested using QCRad**
- **ARM SGP CF using BEFlux VAP**
- **Linear fits (slopes)**
- **Testing for statistical significance.**
 - **“Trend” if significant**
 - **“Tendency” if not**

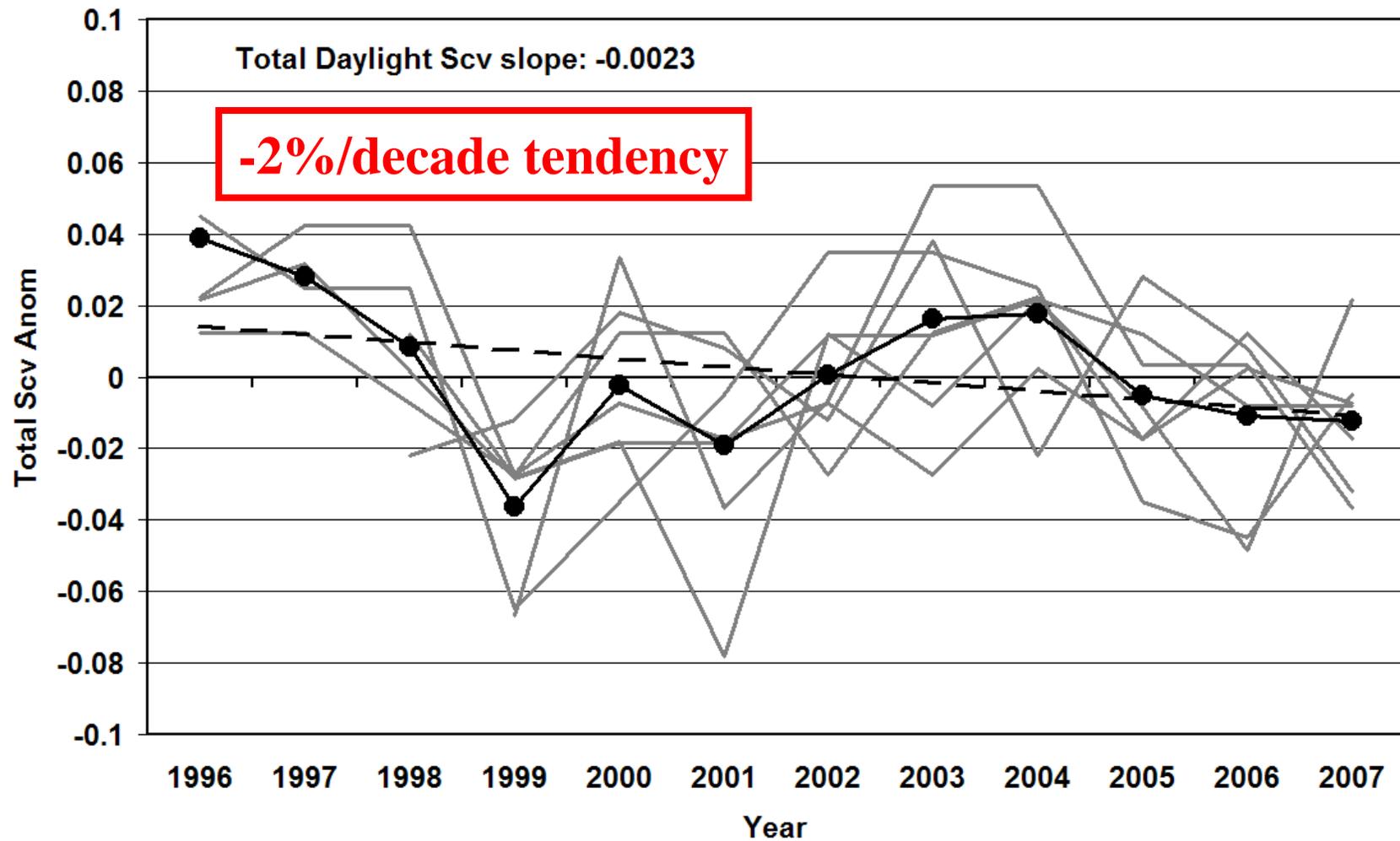
US Sites All-Sky SWdn

US Sites Yearly All-Sky SWdn Anomalies



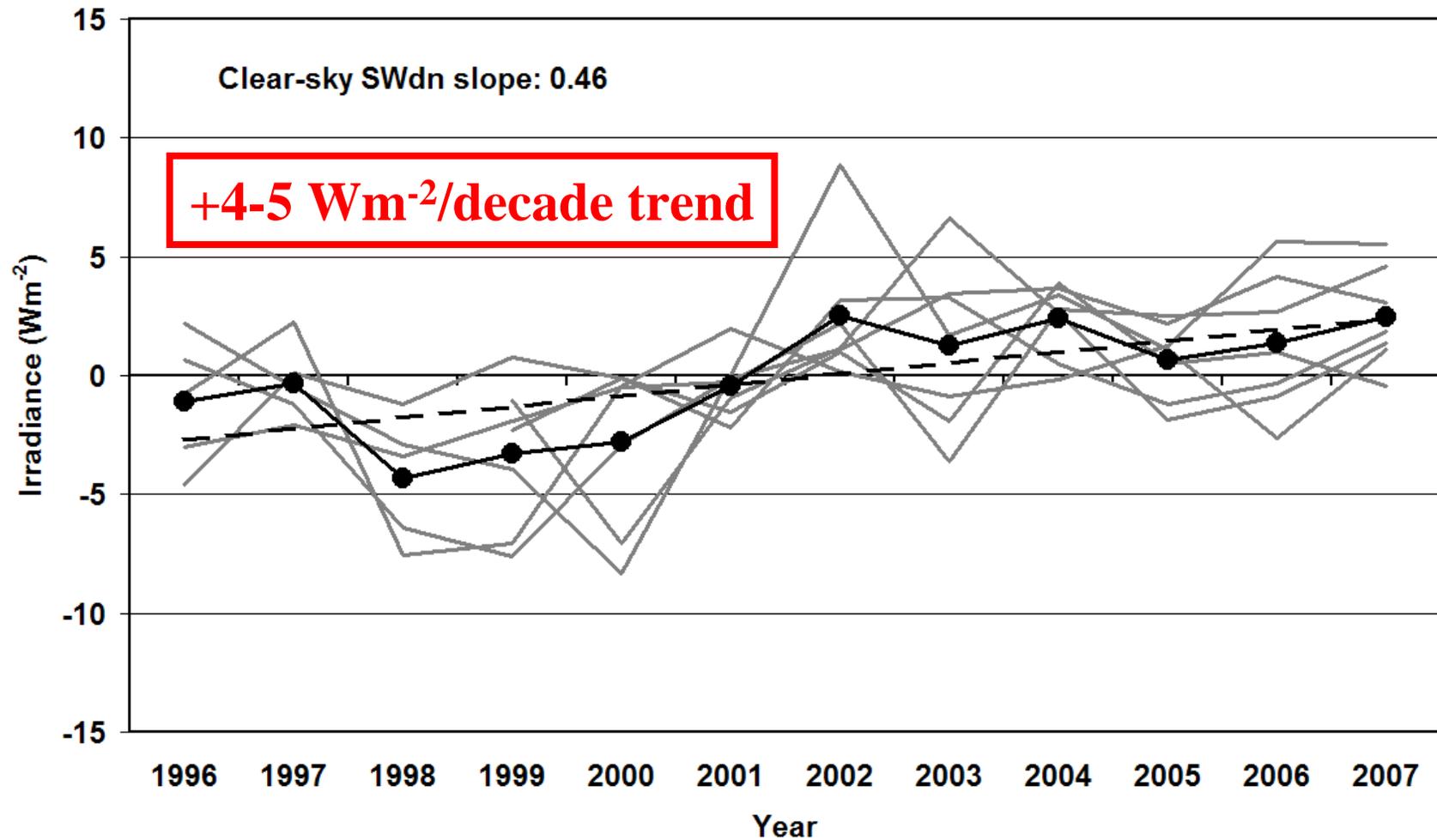
US Sites Daylight Sky Cover

US Sites Yearly Total Daylight Sky Cover Anomalies



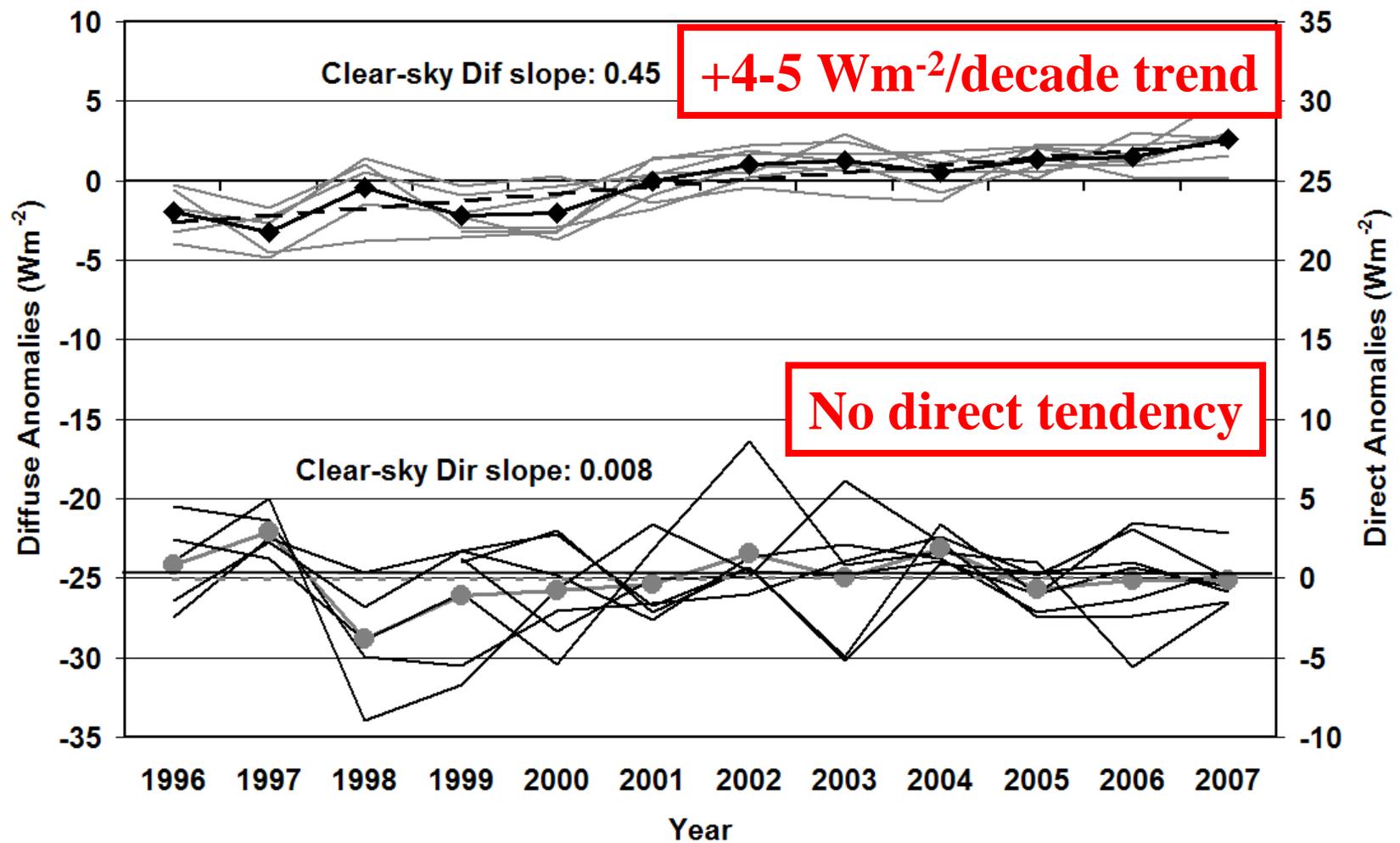
US Sites Clear-Sky SWdn

US Sites Yearly Clear-Sky SWdn Anomalies



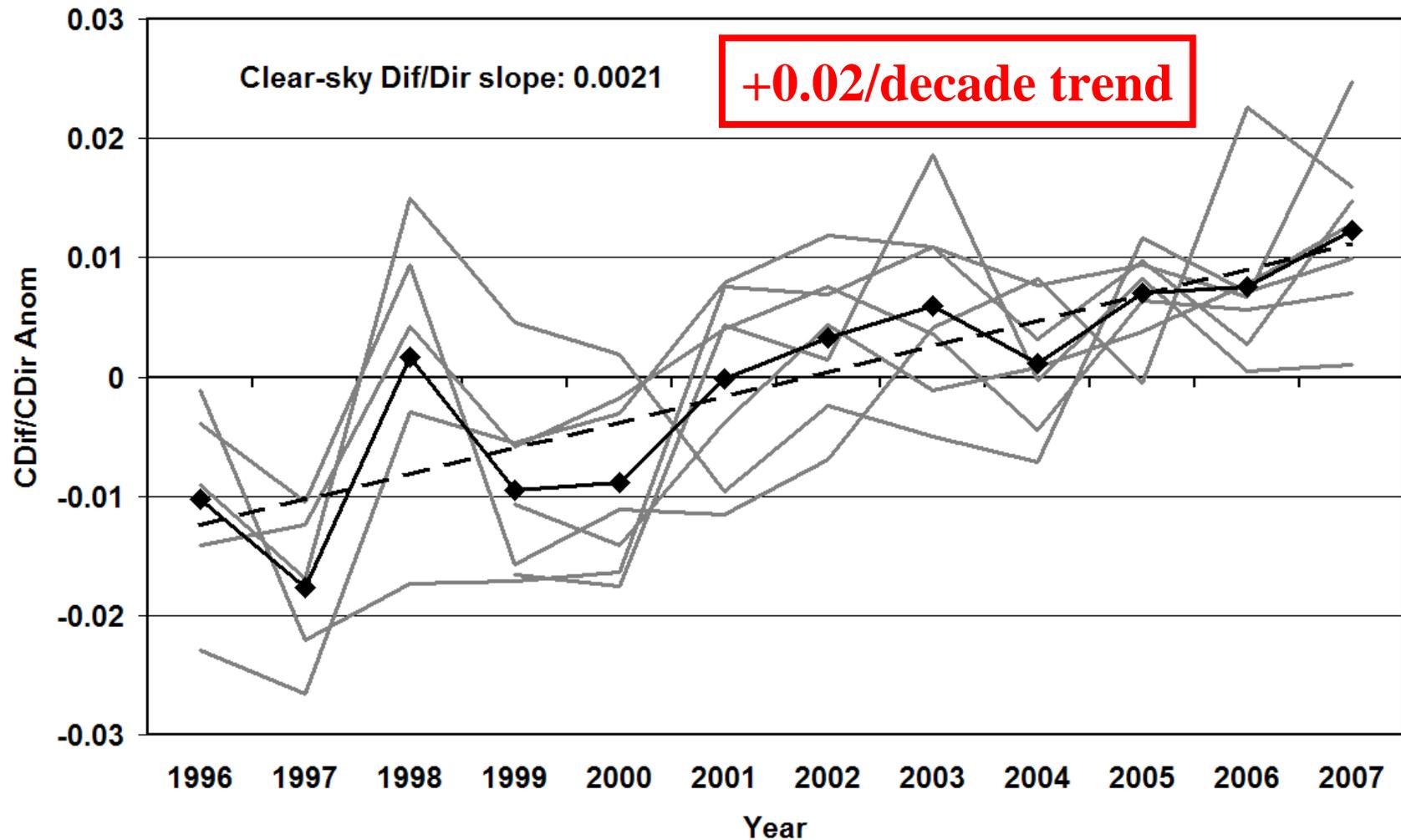
US Sites Clear-Sky SWdn

US Sites Yearly Clear-Sky Diffuse and Direct SW Anomalies



US Sites Clear-Sky Dif/Dir

US Sites Yearly Clear-sky Diffuse/Direct Ratio Anomalies



Western US, Riihimaki et al.

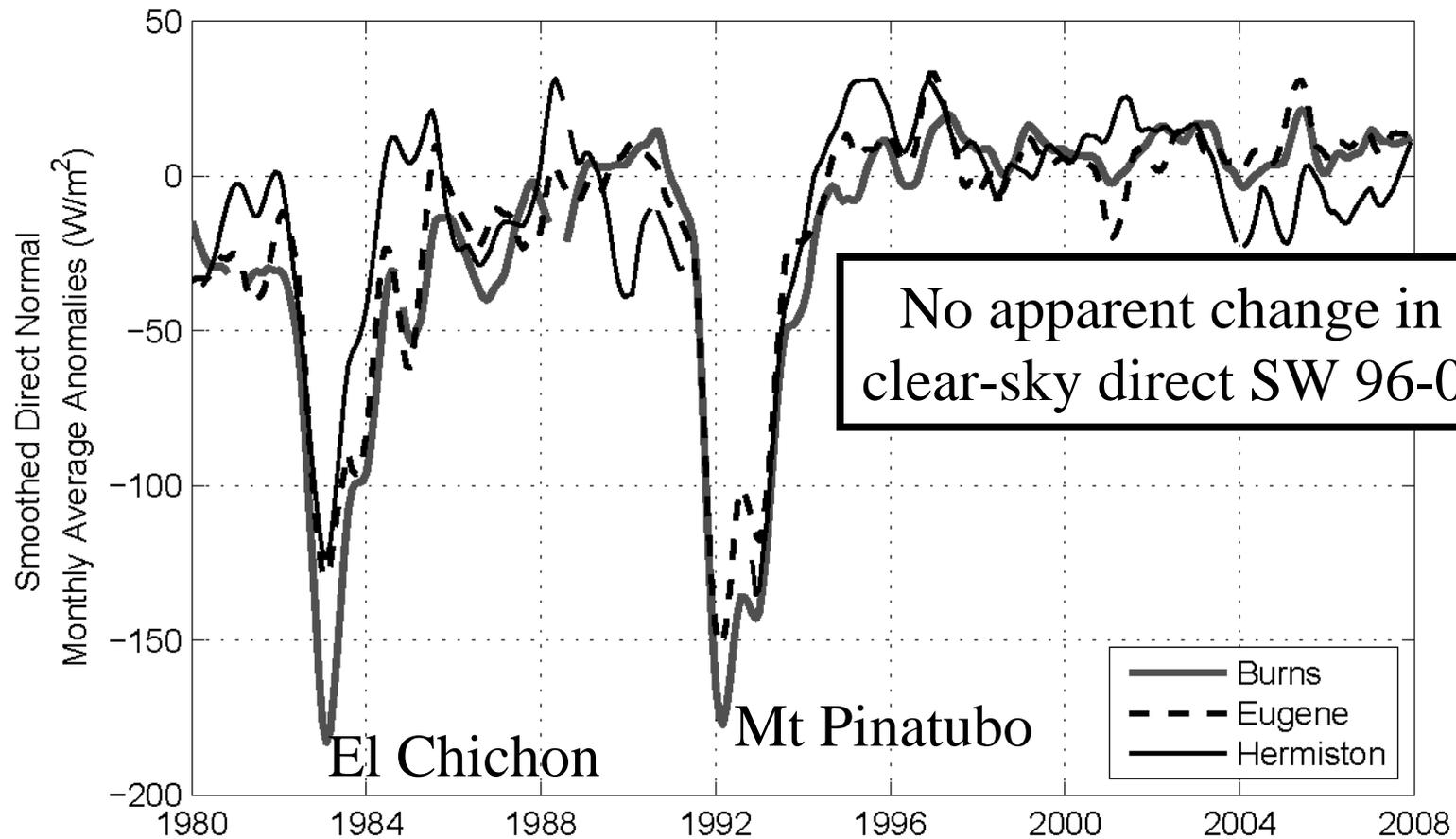


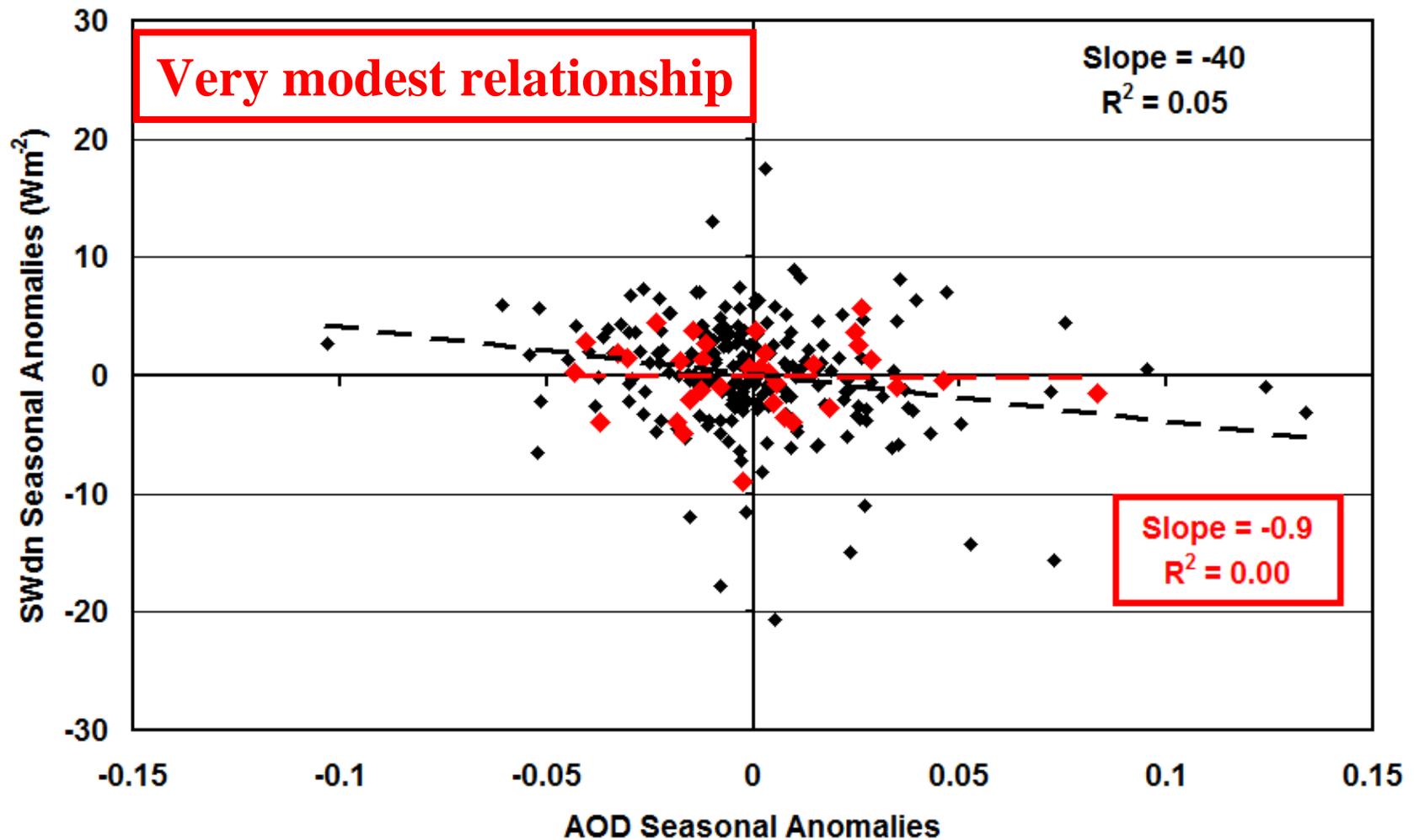
Figure 5. Monthly anomalies of clear-sky direct normal irradiance at zenith angles of 65–75° smoothed using a lowess filter with a 1-year span.

A puzzle...

- **Augustine et al. (2008, JGR) report 500 nm AOD decrease of -0.02 from 97-06**
- **But clear-sky SW increase is all in diffuse SW, no change in direct**
- **Dif/Dir ratio increase often associated with increase in atmospheric turbidity**
- **How do we define “clear sky”?**
- **Differences in FOV of NIP and aerosol instruments? [5.8° , $4-8^\circ$, 1.2°]**

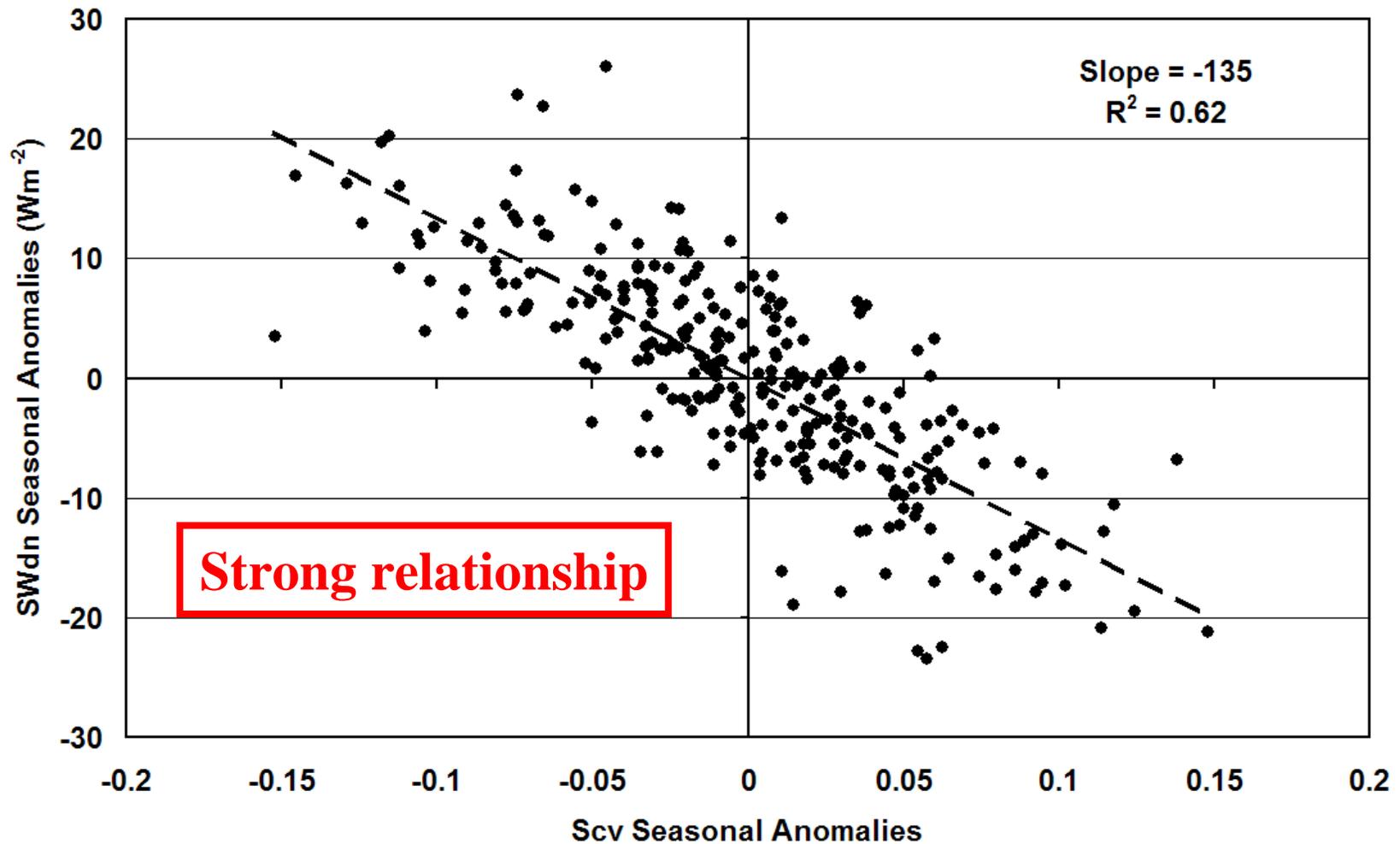
US Sites Clear-Sky AOD vs SWdn

US Sites Seasonal AOD vs Clear-sky SWdn Anomalies



US Sites All-Sky SCV vs SWdn

US Sites Seasonal Sky Cover vs All-sky SWdn Anomalies



Other Regions SWdn, Wild et al.

	1990s	2000-2005
USA		
Central America		
Europe		
China/Mongolia		
Japan		
Korea		
India		
Antarctica		

US Summary

- **All-sky increase of 8 Wm^{-2} /decade is far greater than the Wild et al. (2008) wide spread estimate of 2 Wm^{-2} /decade for 1986-2000**
- **Also more than twice the 2-3 Wm^{-2} /decade increase in downward surface longwave radiation during the same time period**
- **Only half of the US increase occurs under clear-skies, an increase in diffuse SW**
- **But weak at best relationship to AOD changes**
- **Strong relationship to cloud amount changes**

Summary

- **Global Brightening is still widespread, except for places like India and China which are injecting massive amounts of pollution aerosol**
- **Less coherent and pronounced than in the 1990s**
- **But while variety and balance of individual causes is great, they work to create a brightening almost everywhere**
- **This suggests some overall principle at work, whose details play out differently in different regimes, requires local and regional explanations**

ARM Role

- **GDB is real, it is significant, it is not being well represented in the GCMs**
- **Its cause has a major cloud component**
 - **And is regional in details**
- **ARM is best suited to study these cloud (and aerosol) causes**
- **GDB is a “research gorilla” looming on horizon of community awareness**
- **ARM can not only hop on the GDB bandwagon, I really believe that ARM can lead the parade!**