On the Diagnosis of Radiative Feedback in the Presence of Unknown Radiative Forcing

-or -

Theoretical & Observational Evidence that Cloud Feedbacks could be Negative, Not Positive

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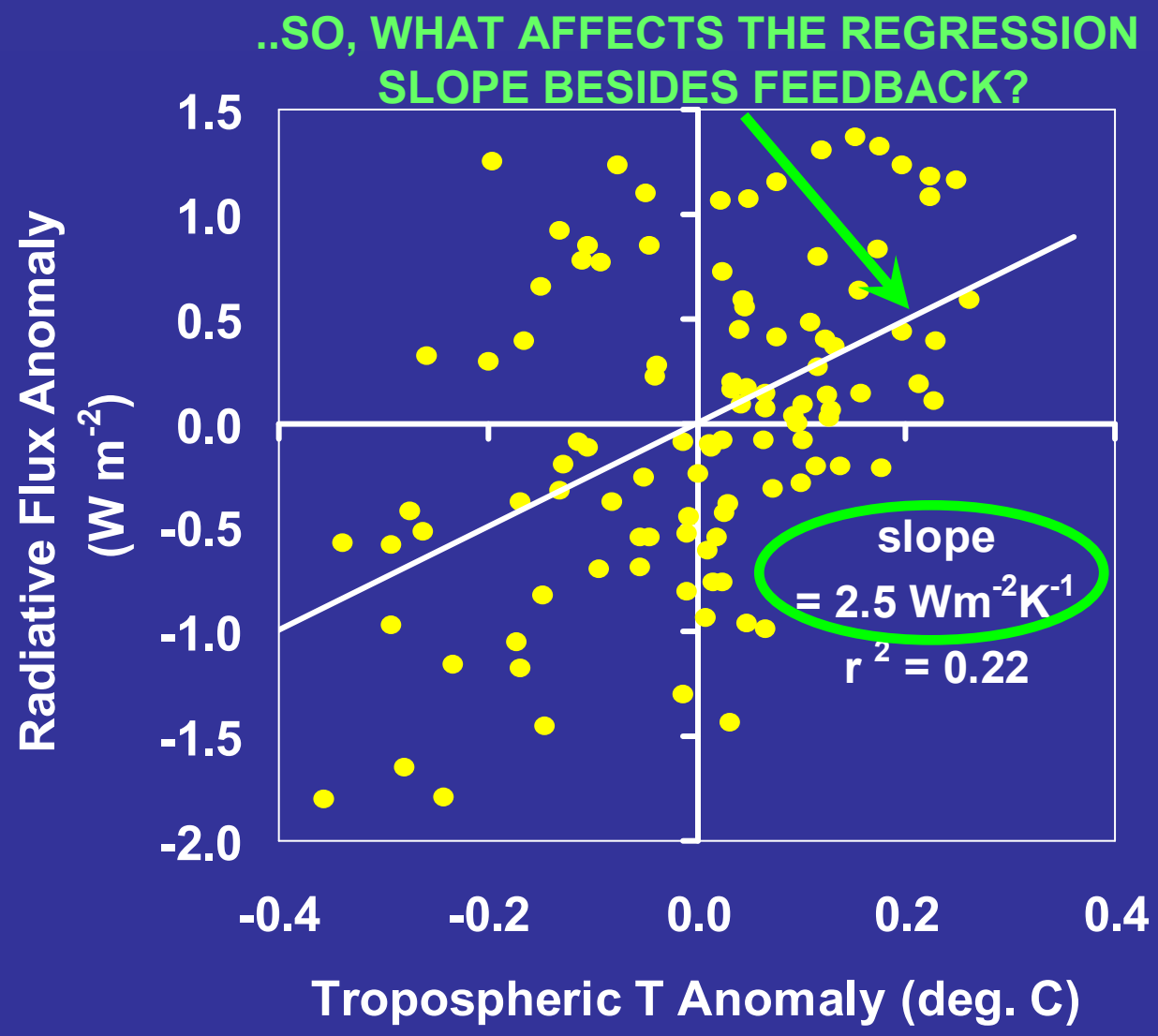
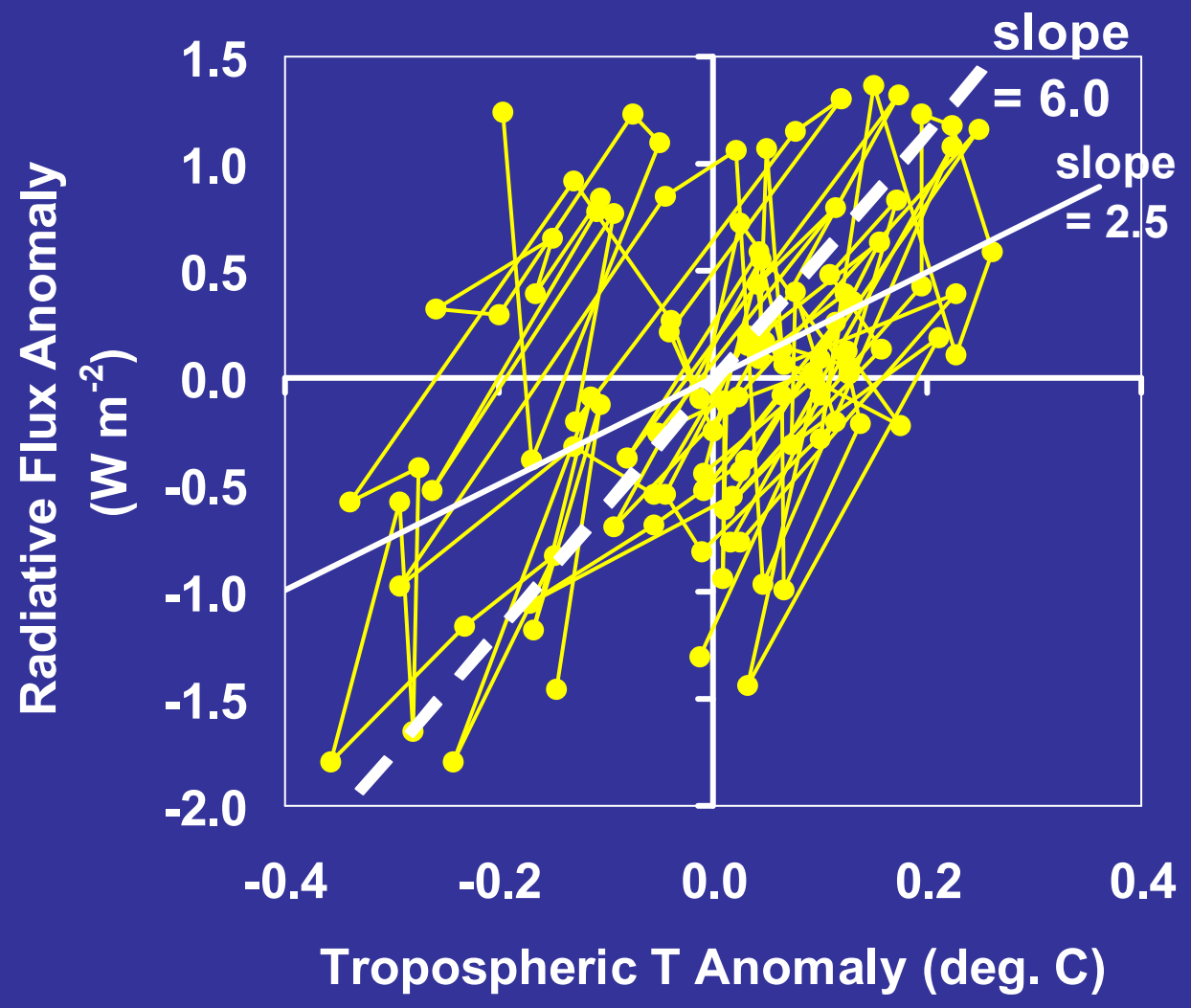
Rad. Flux vs. Temperature plots used to estimate feedbacks usually show Strong Decorrelation…

Monthly Global
Terra Satellite
CERES ES-4 LW+SW
vs UAH MT (Aqua AMSU)
(Mar. 2000 – Dec. 2008)



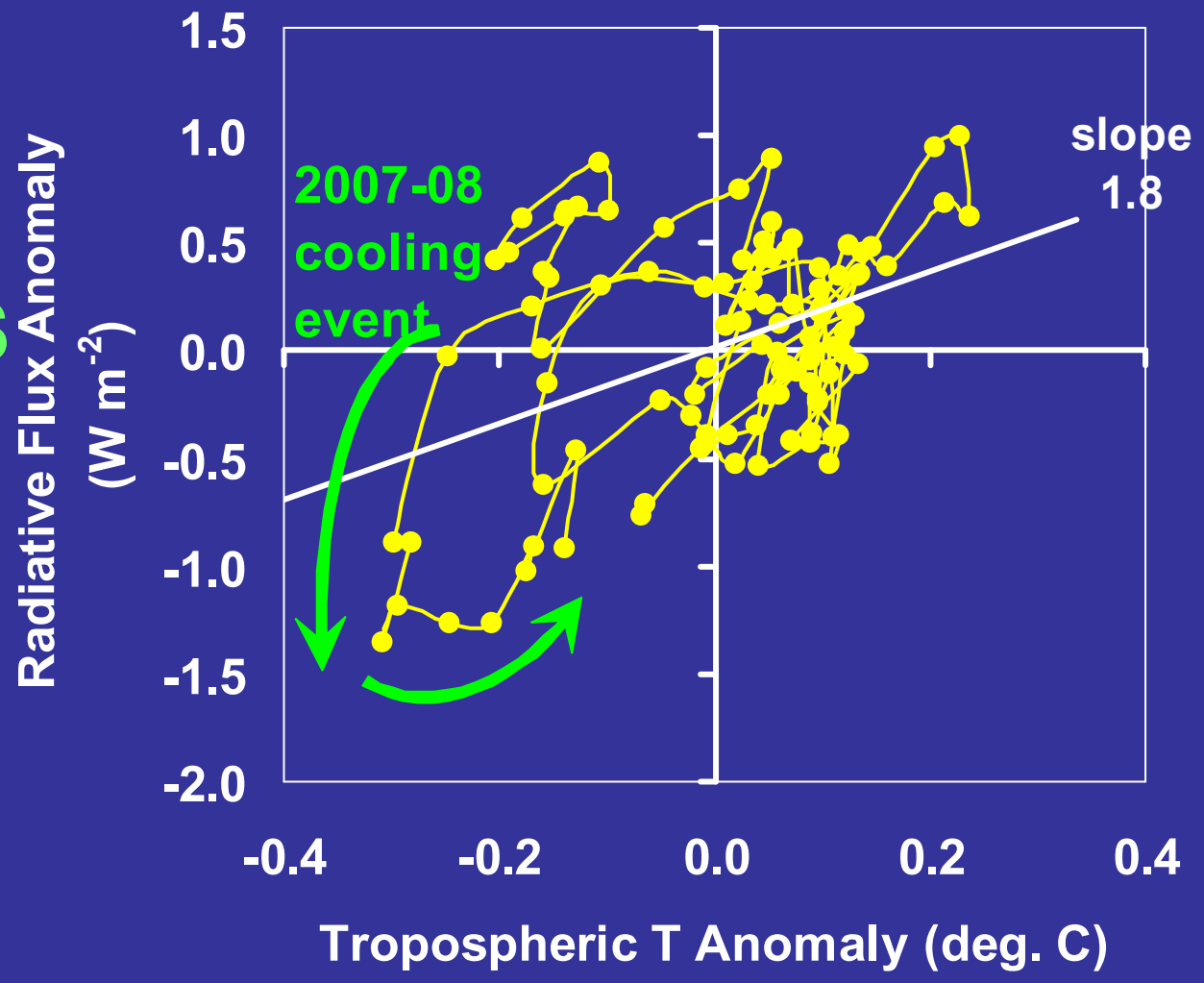
…but PHASE SPACE plotting reveals <u>linear striations</u> with a preferential slope…

DO THESE LINEAR STRIATIONS HAVE ANYTHING TO DO WITH FEEDBACK?



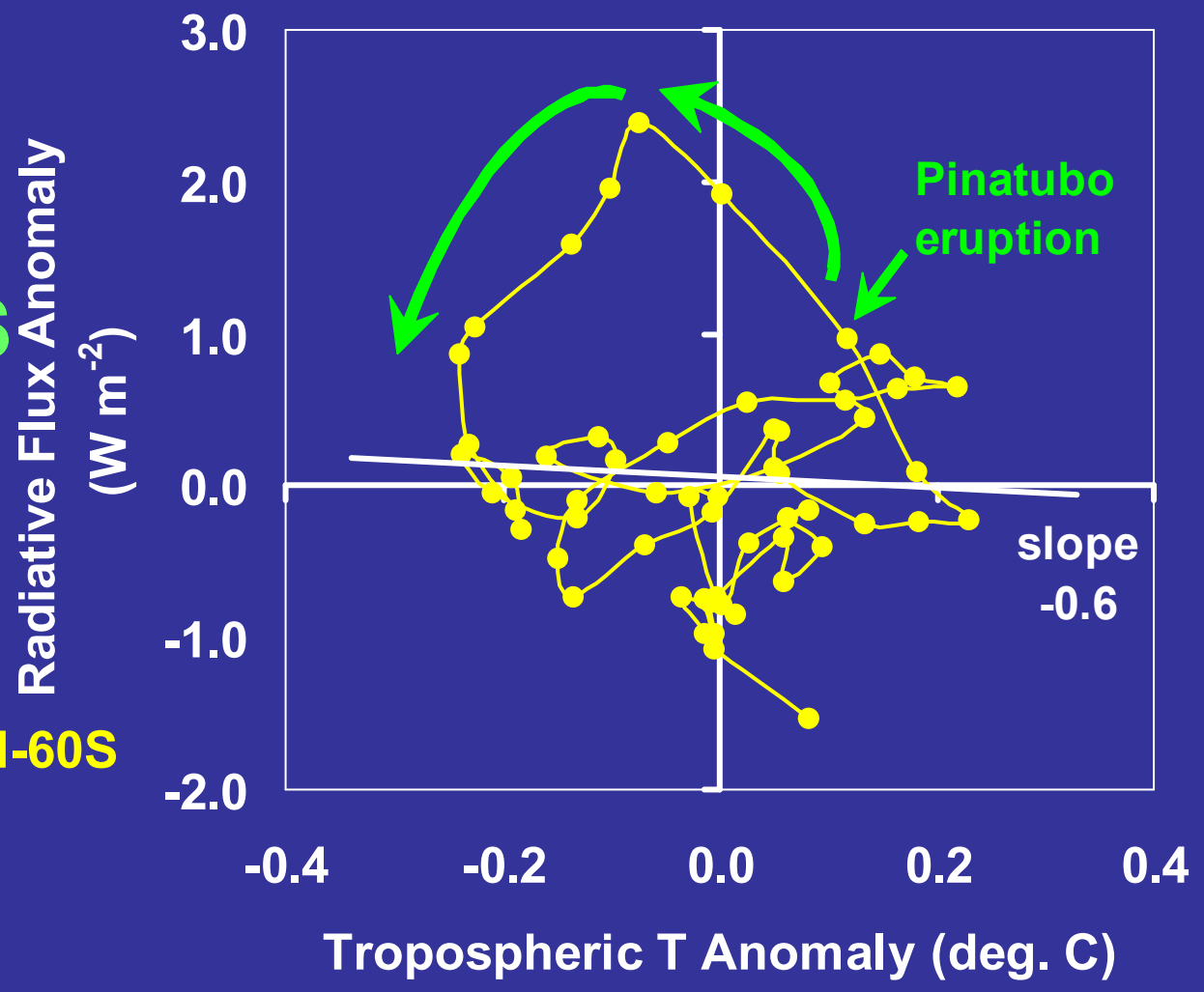
…& low-pass filtering reveals Looping Patterns…

WHAT CAUSES LOOPING?



& older ERBS data shows similar looping pattern after 1991 Pinatubo eruption.

WHAT CAUSES LOOPING?



72-day "Seasons", 60N-60S
ERBS Satellite
ERBE LW+SW
vs UAH MT
(1985-1999)

Linear & Looping Features Easily Explained with a Simple Model of Climate Variability:

(Spencer & Braswell, 2008 *J. Climate* [thanks to Isaac Held, *pers. comm.*])

Bulk heat Capacity (mixed layer depth)

CERES measures a combination of these 3 (NOT just feedback)

$$C_p(d\Delta T/dt) = f(t) + N(t) + S(t) - \lambda\Delta T$$

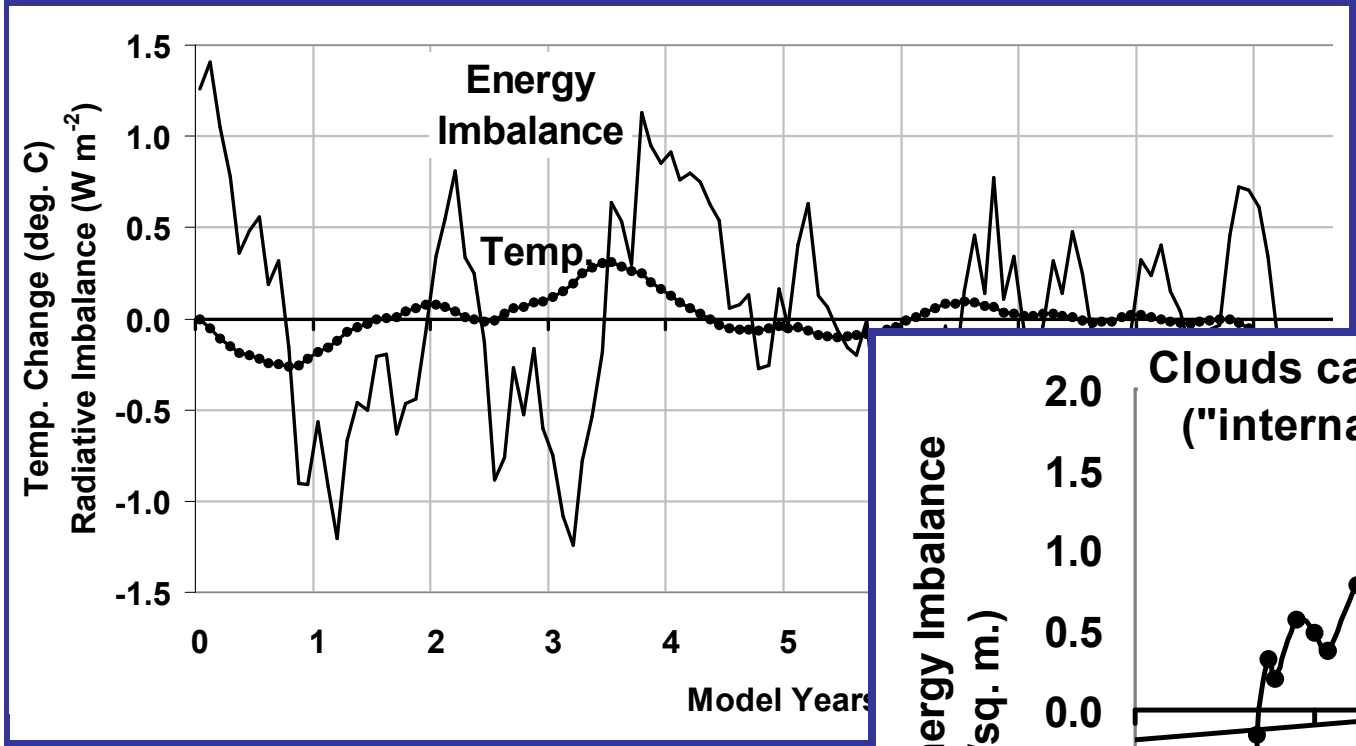
external radiative forcings (anthro.; volcanoes; solar)

internal radiative forcings (non-FB vars. in clouds, mostly)

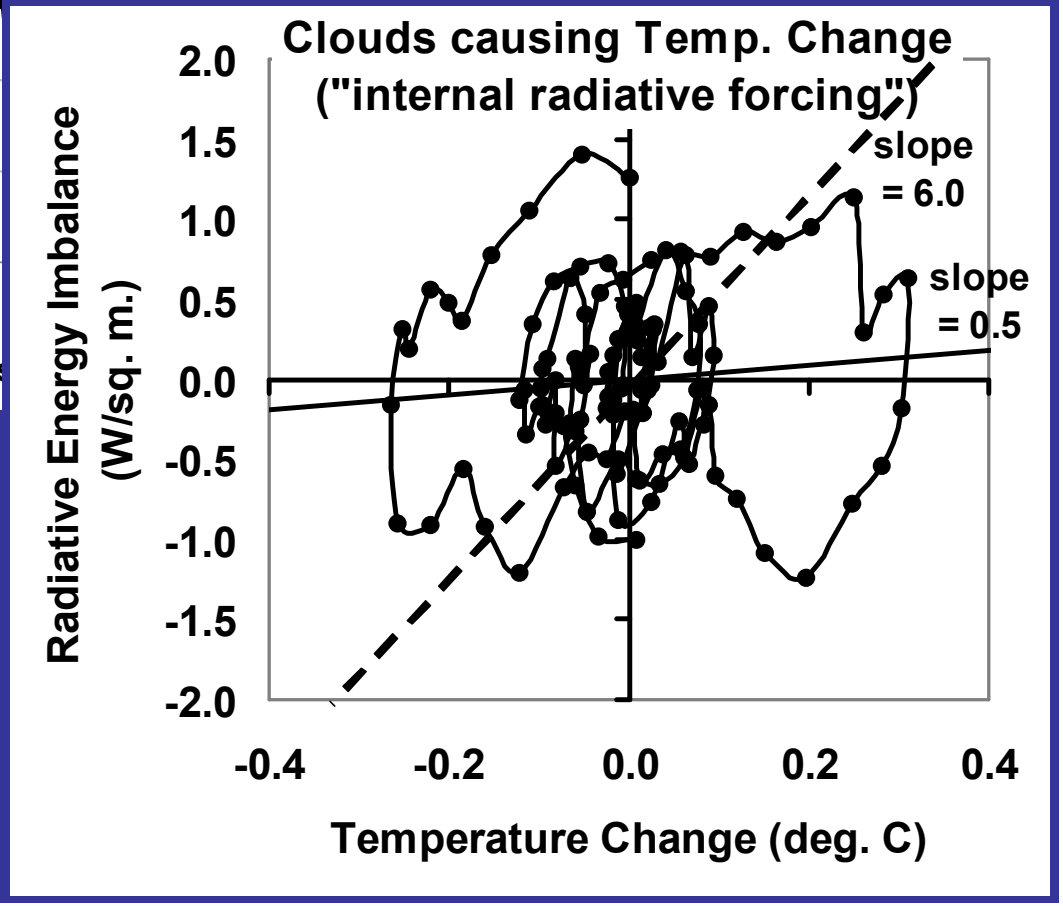
internal NON-radiative forcings (vars. in ocean => Atmos. heat flux)

Feedback

Non-fb Cloud Vars. (*N* =“internal rad. forcing”) Cause LOOPING PATTERNS…



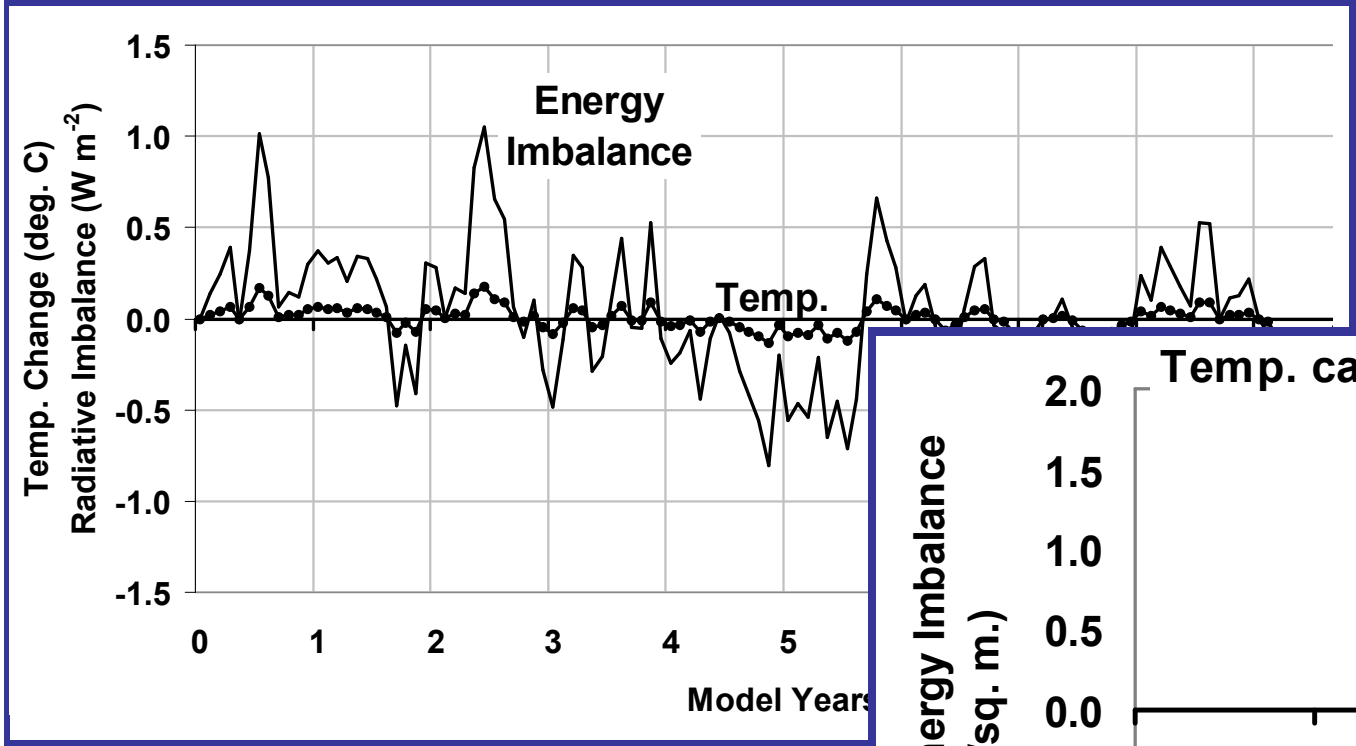
LOOPING PATTERNS



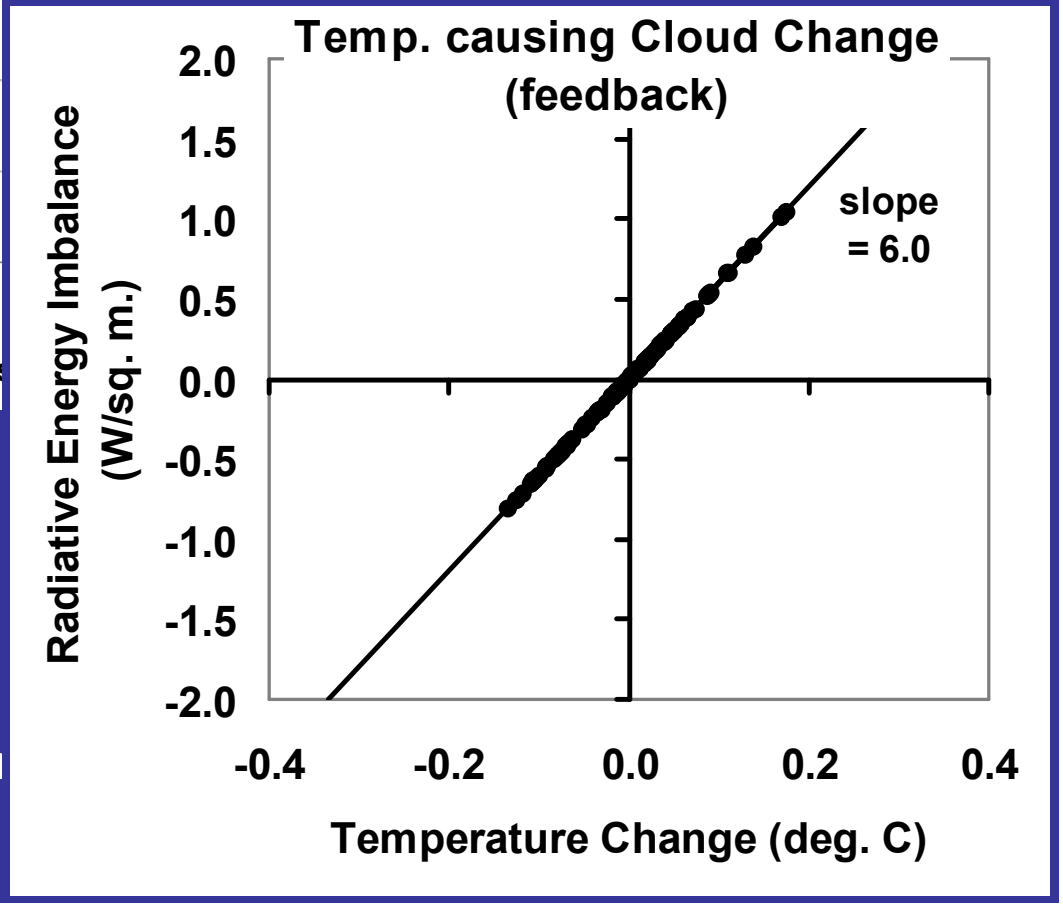
Model parameters

15 m mixed layer;
λ = 6 W m^{-2} K^{-1};
1 month time step;
forced with low-pass filtered random cloud variations (“N” term)

Feedback Upon non-Rad. Forcing of Temp. (*S*) causes LINEAR STRIATIONS.



LINEAR PATTERN



Model parameters

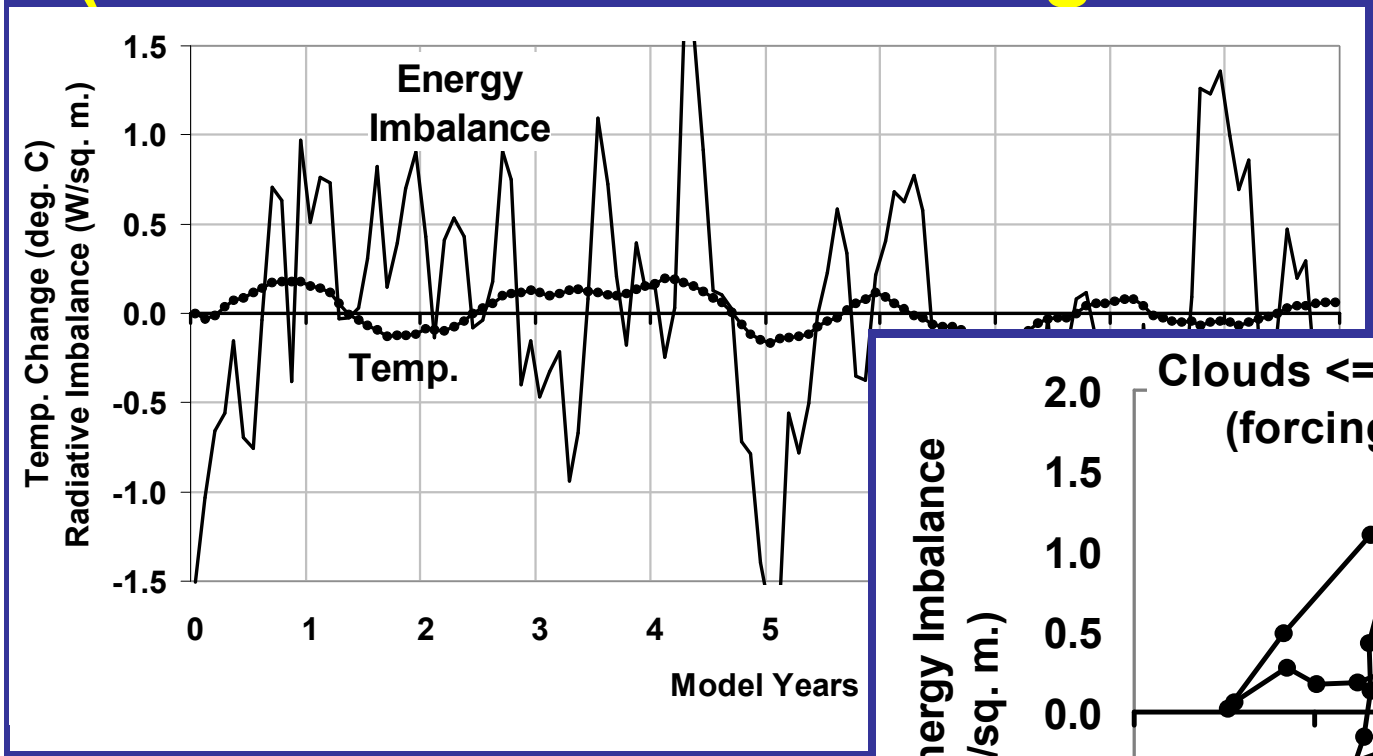
15 m mixed layer;

$\lambda = 6\ W\ m^{-2}\ K^{-1}$;

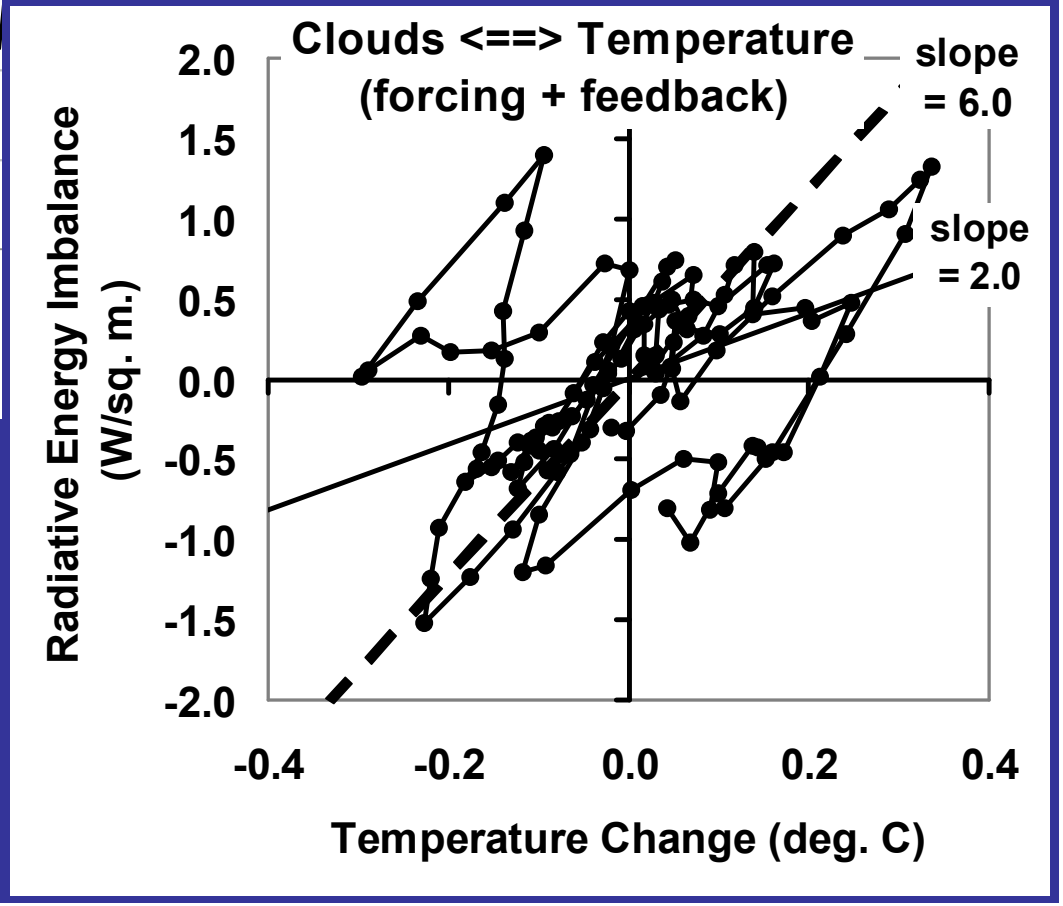
1 month time step;

forced with low-pass filtered random temp. variations ("S" term e.g. chgs. in convective heat flux)

BOTH Forcings Combined (internal radiative forcing + non-rad. forcing)



LINEAR & LOOPING PATTERNS



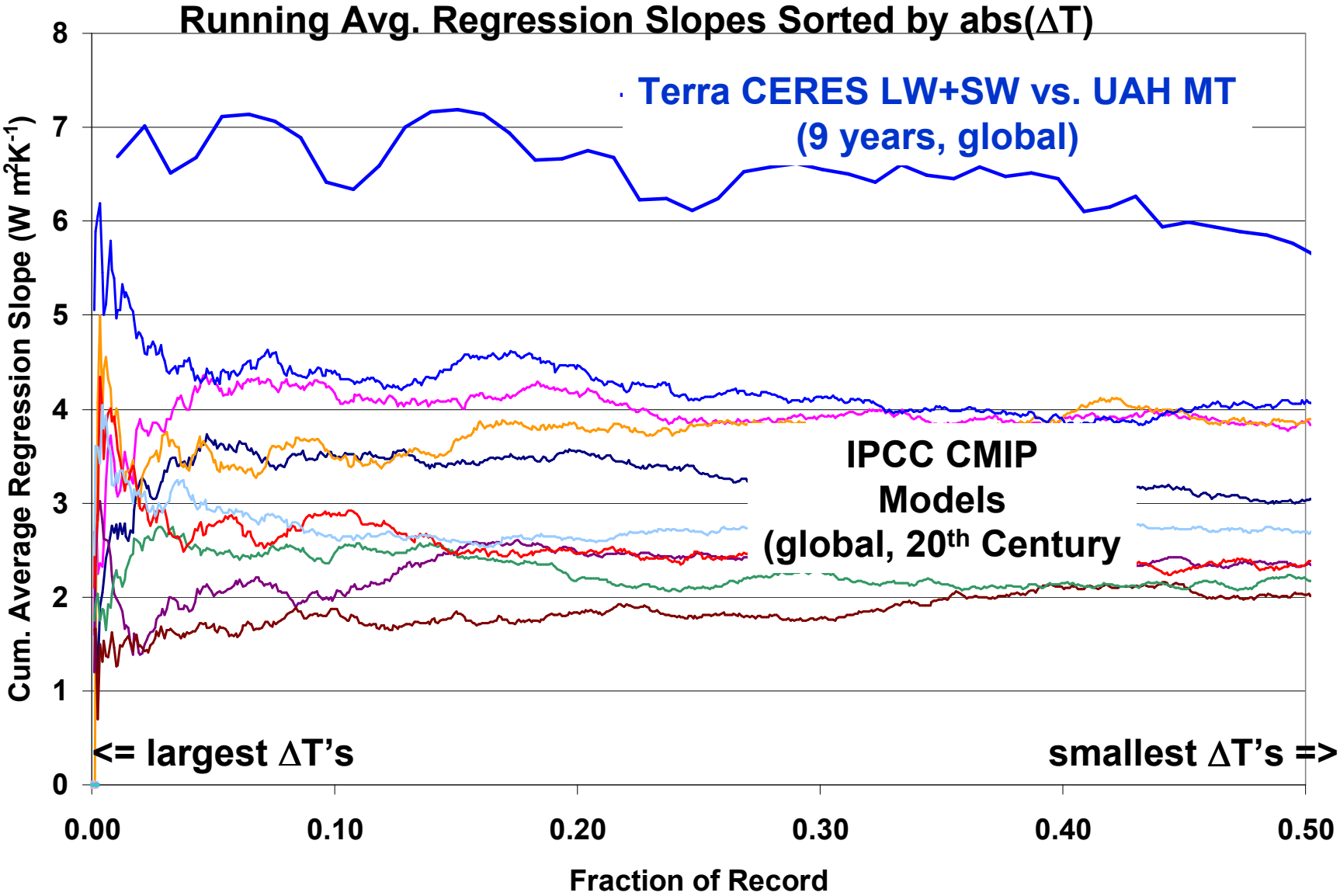
Model parameters

15 m mixed layer;
$\lambda = 6\ W\ m^{-2}\ K^{-1}$;
1 month time step;
forced with low-pass filtered random cloud & T variations ("N" & "S" terms)

Implications for Satellite Diagnosis of Feedbacks

- Feedback diagnosis MUST account for internal radiative forcing
  - Feedback can NOT be measured in response to unknown time-varying radiative forcing of any kind
- Ignoring internal radiative forcing leads to Feedback Parameter Diagnoses that are:
  - Variable (leading to additional uncertainty)
  - Biased Low (usually…depends on length of record)
- Conceptually, this is a "cause vs. effect" issue: CLOUDS <==> TEMPERATURE

IPCC CMIP Model Behavior vs. Satellite: evidence of negative cloud feedback?



Backup Slides

WHY TROPOSPHERIC TEMPERATURE RATHER THAN SURFACE TEMPERATURE?

At ~1 month time resolution, Aqua CERES Radiative Flux Anomalies are more closely correlated with <u>tropospheric temperature</u> than with <u>sea surface temperature</u> (SST, from Aqua AMSR-E)