Low Cost, Low Risk Use of Improved Calibration Techniques to Detect Cloud Climate Feedback Within One Decade of the Present

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Exelis Geo-spatial Systems

CALCON 2012

Talk Structure

Cloud Climate Feedback Uncertainty

- *Causes largest range of GCM predictions – need observations to validate*

Detecting Trends in Climate Data Records (CDRs)

- *Statistics of natural variability*
- *Instrument Calibration Error Effects for Terra*

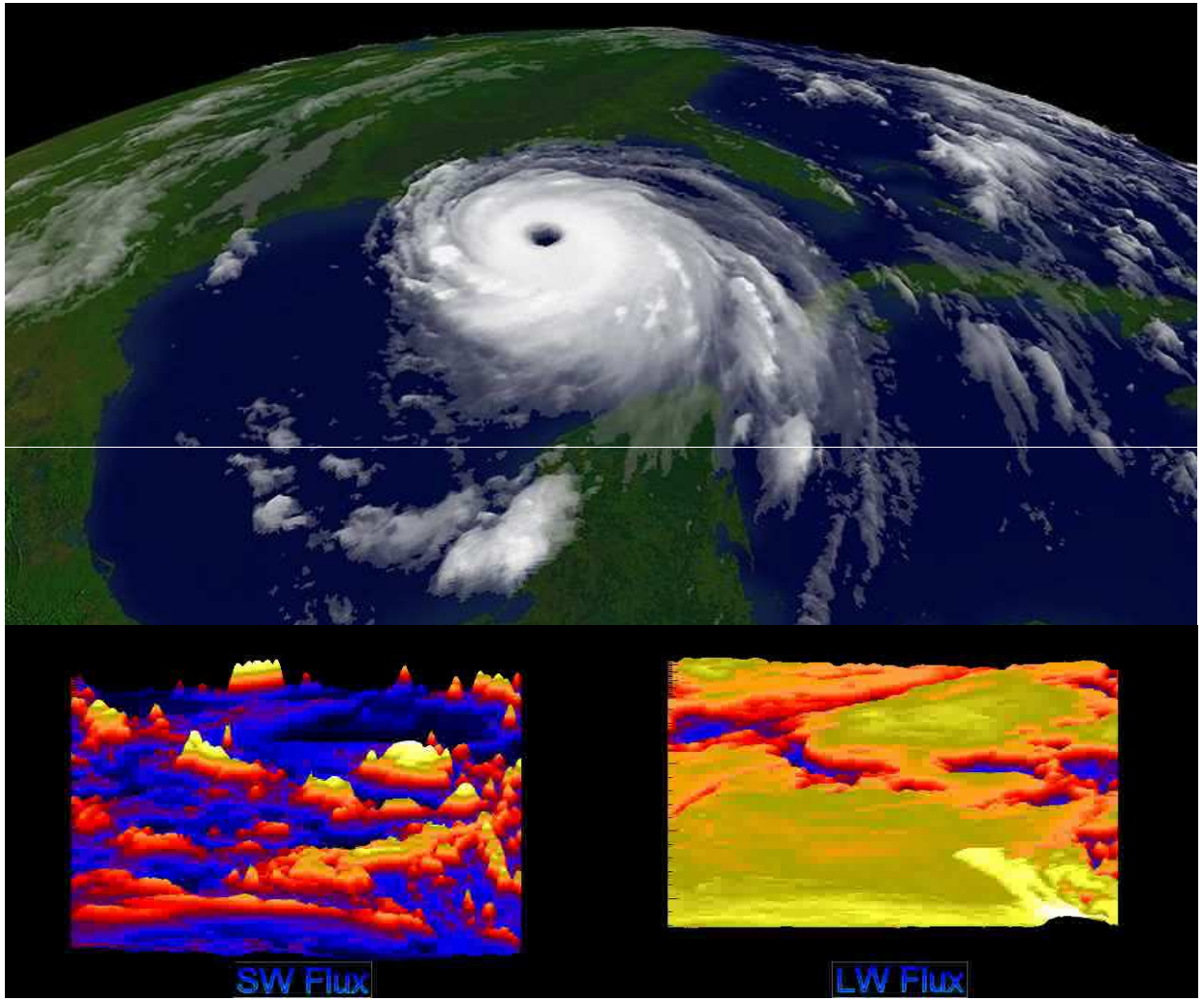
Improved Terra CDR Calibration using the Moon

- *Accounting for non-ideal instrument FOV for Lunar disc*
- *Estimate of improvement to Terra CDRs using Moon*

Conclusions and Future Studies

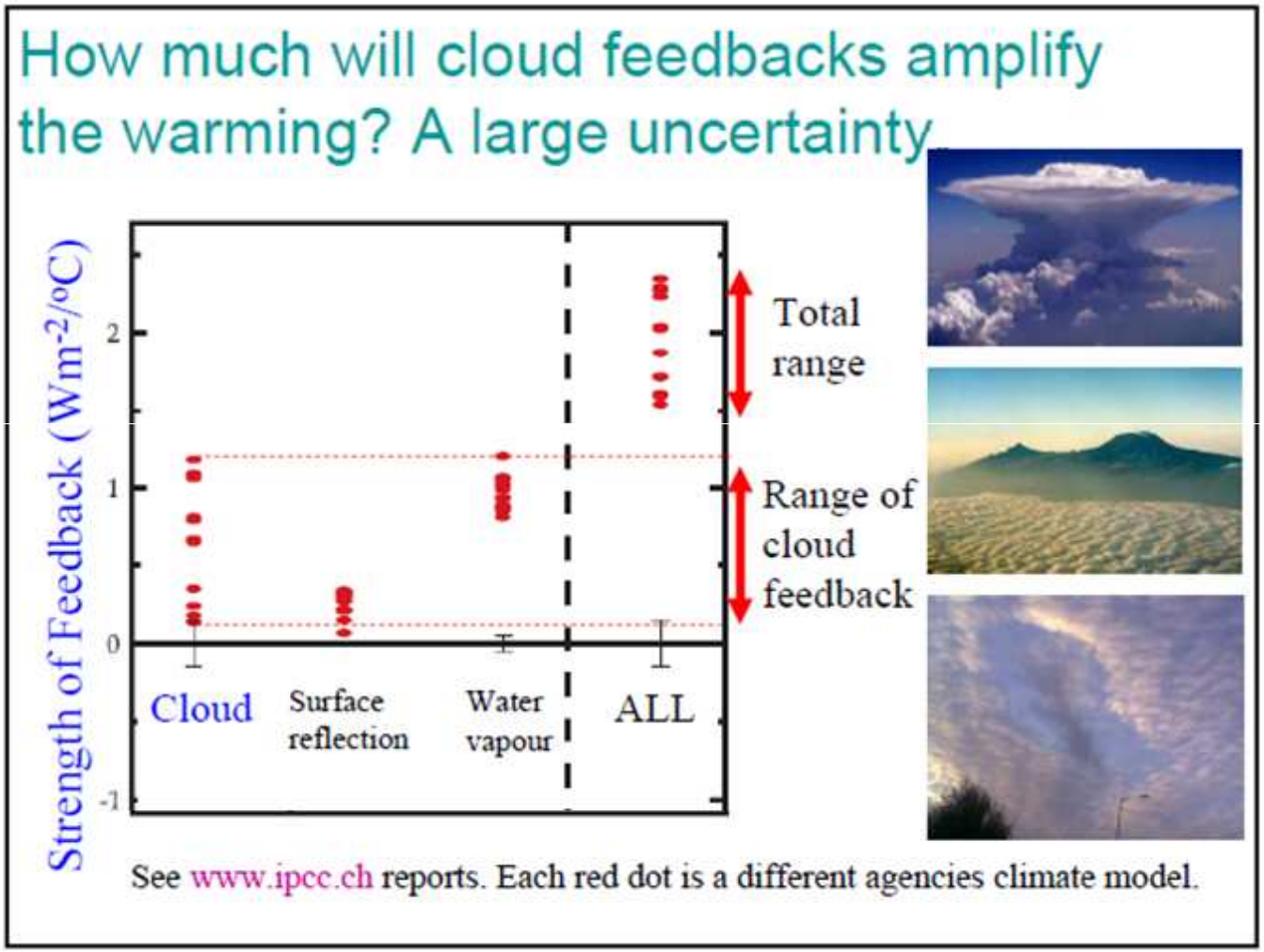
Instruments measure reflected short wave (SW) sunlight and emitted long wave (LW) thermal output from Earth & clouds for climate

Clouds reflect Sunlight (SW)



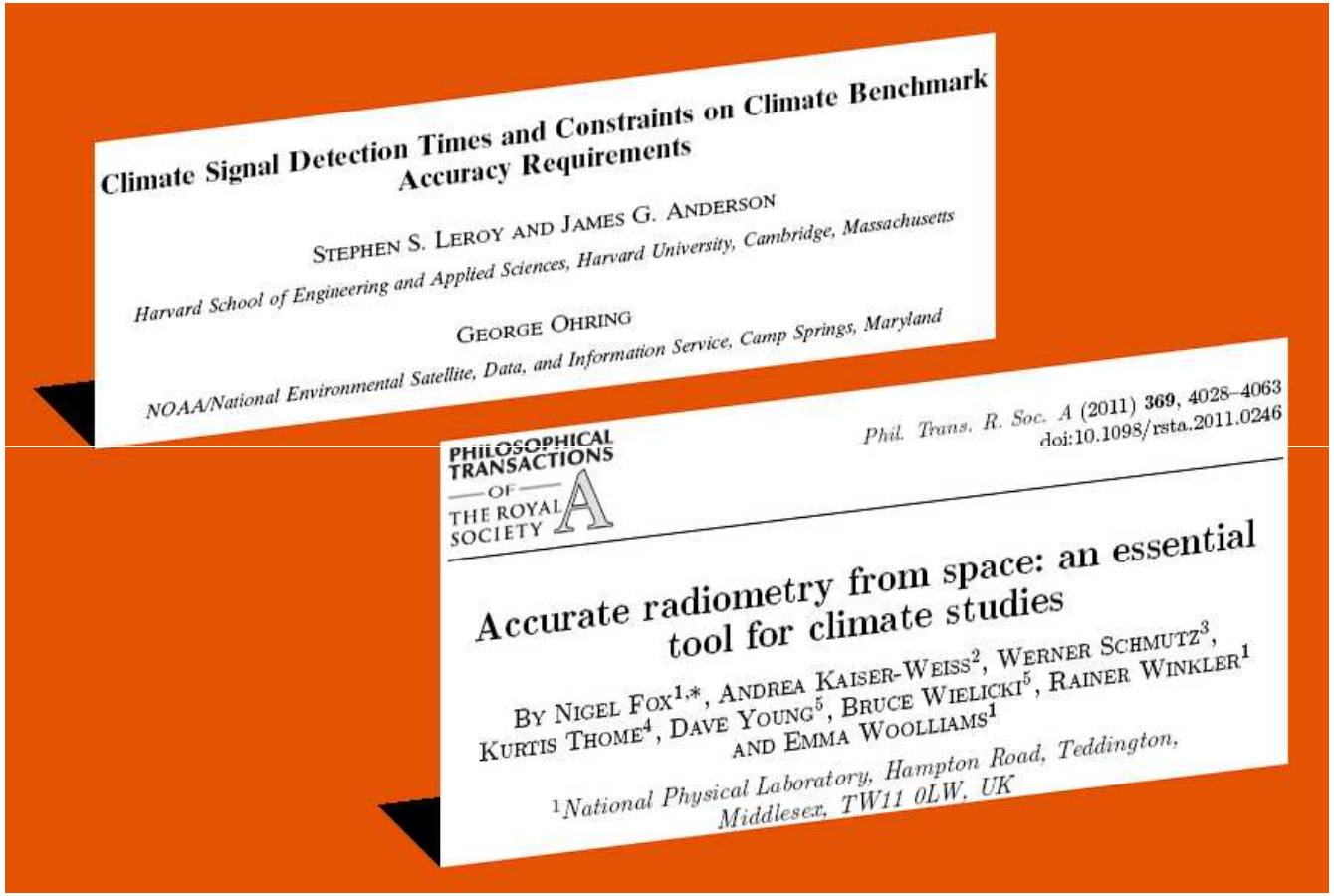
but trap outgoing Infra-Red (LW)

Cloud Climate Feedbacks are the cause of most uncertainly in predicting climate change and hence future increases in extreme weather



The size of cloud climate feedback uncertainty is so large that even its polarity is in question. Will clouds amplify or reduce the rate of climate change? To predict extreme weather in the 2020's, we need to know.

Caution is needed in looking for trends in Climate Data Records due to natural variability and instrument calibration accuracies



Climate Signal Detection Times and Constraints on Climate Benchmark Accuracy Requirements

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A

Phil. Trans. R. Soc. A (2011) **369**, 4028–4063
doi:10.1098/rsta.2011.0246

Accurate radiometry from space: an essential tool for climate studies

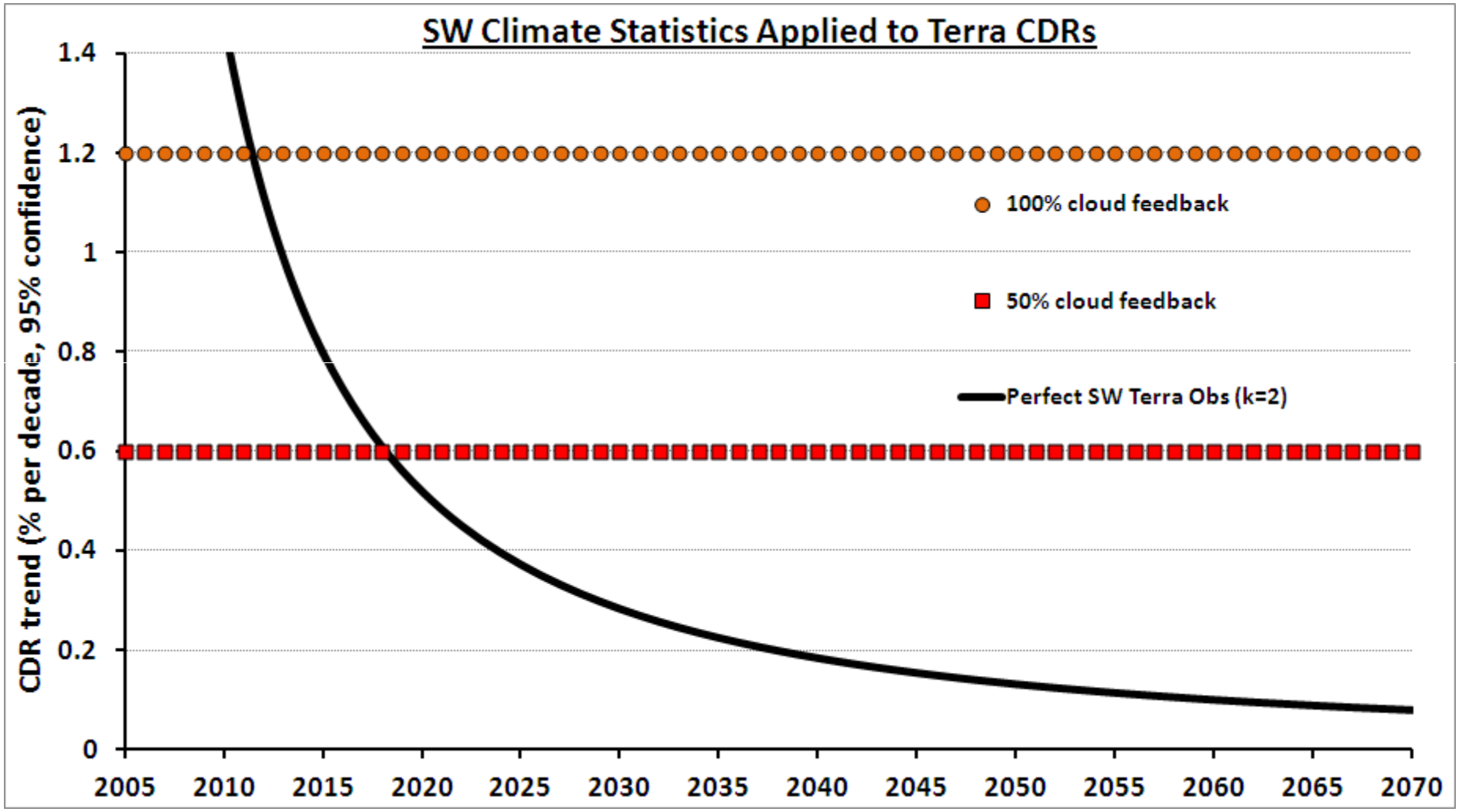
BY NIGEL FOX[1,*], ANDREA KAISER-WEISS[2], WERNER SCHMUTZ[3], KURTIS THOME[4], DAVE YOUNG[5], BRUCE WIELICKI[5], RAINER WINKLER[1] AND EMMA WOOLLIAMS[1]

[1]*National Physical Laboratory, Hampton Road, Teddington, Middlesex, TW11 0LW, UK*

The papers on the left helped define the methodology for climate signal detection. Specifically the size of cloud feedbacks and current instrument accuracies were quantified.

$$\langle (\delta m)^2 \rangle \simeq 12 (\Delta t)^{-3} (\sigma_{\mathrm{var}}^2 \tau_{\mathrm{var}} + \sigma_{\mathrm{meas}}^2 \tau_{\mathrm{meas}}),$$

Such work set the target sizes for SW cloud climate feedback signals and estimated size of trend detectable for perfect vs. real observations



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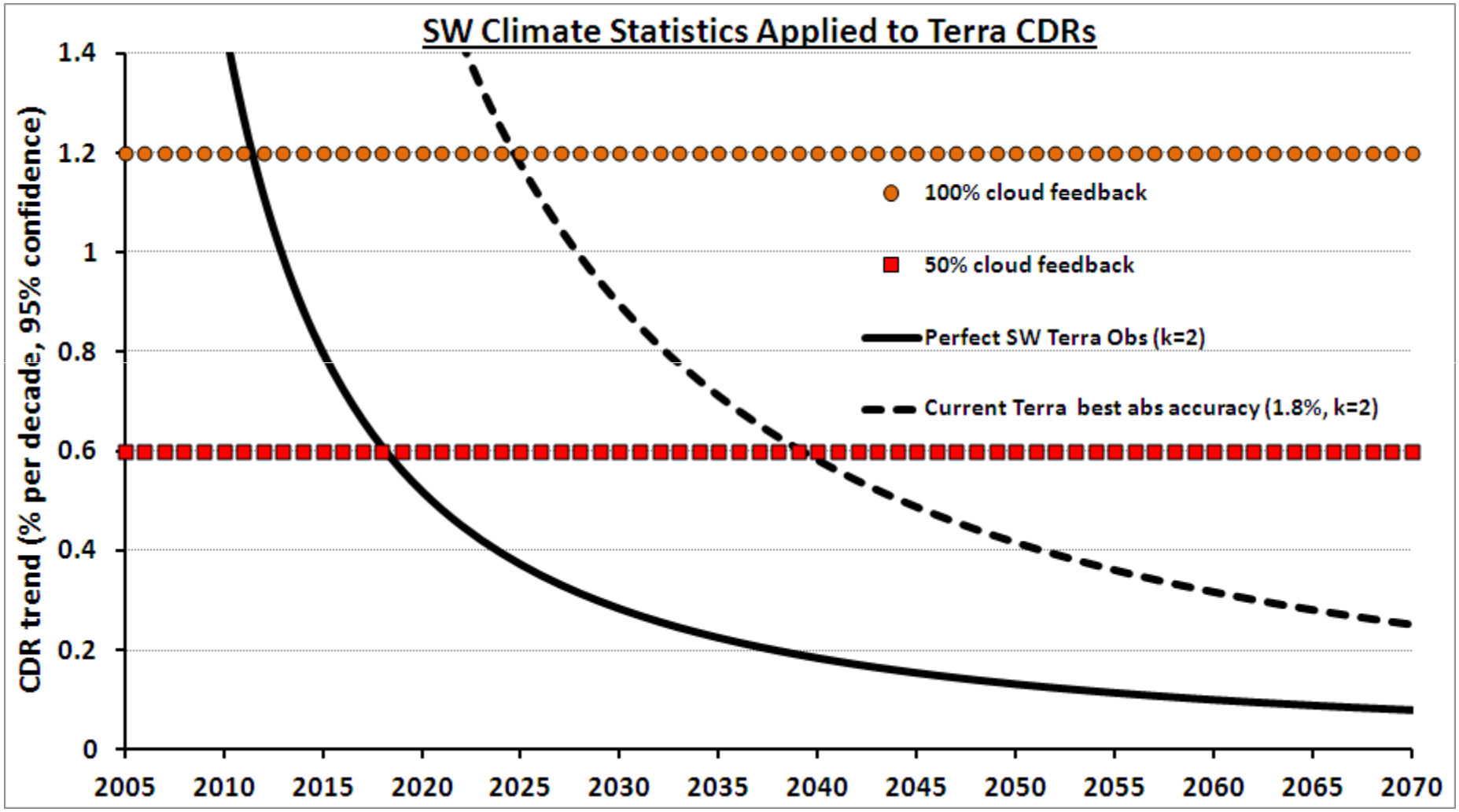

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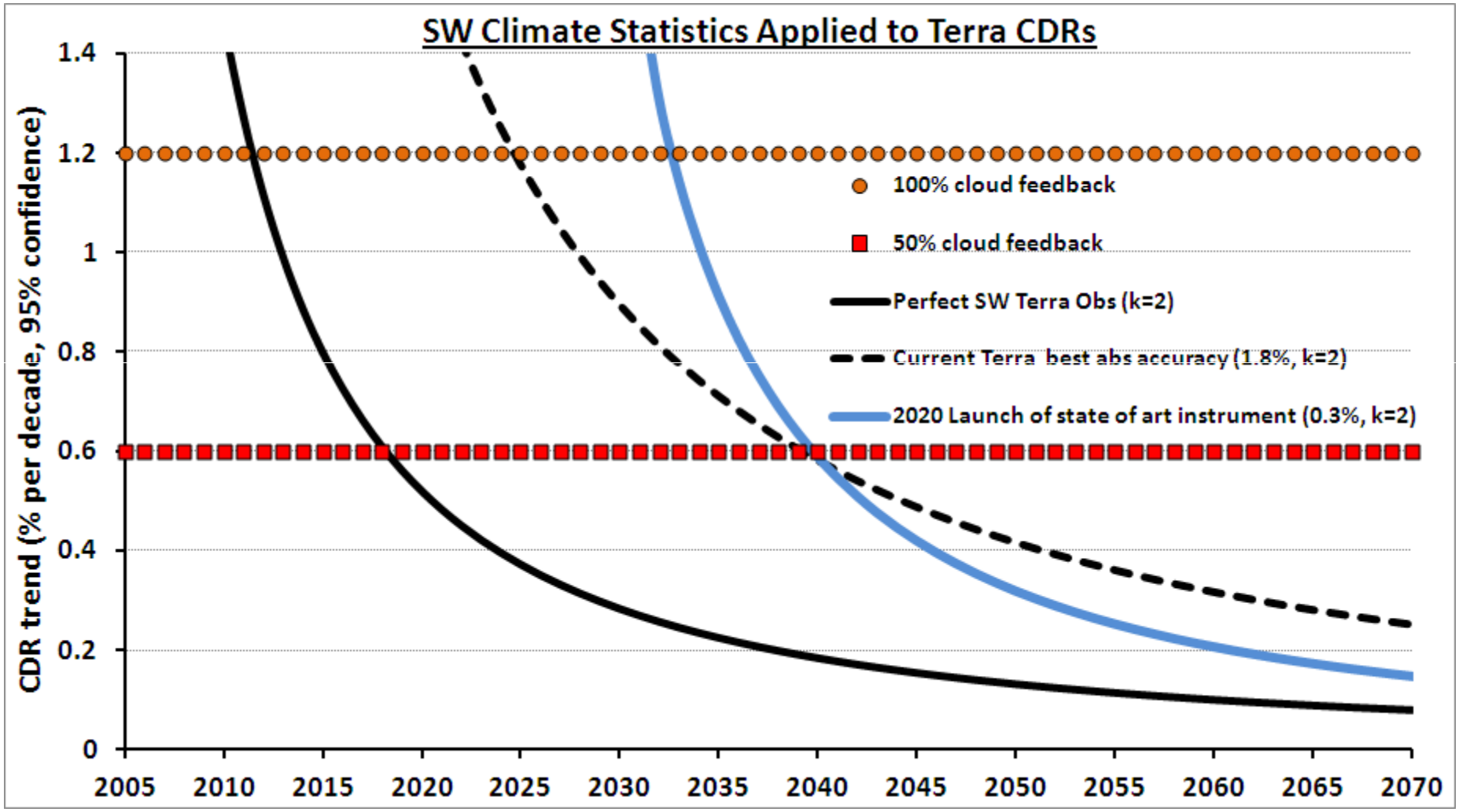
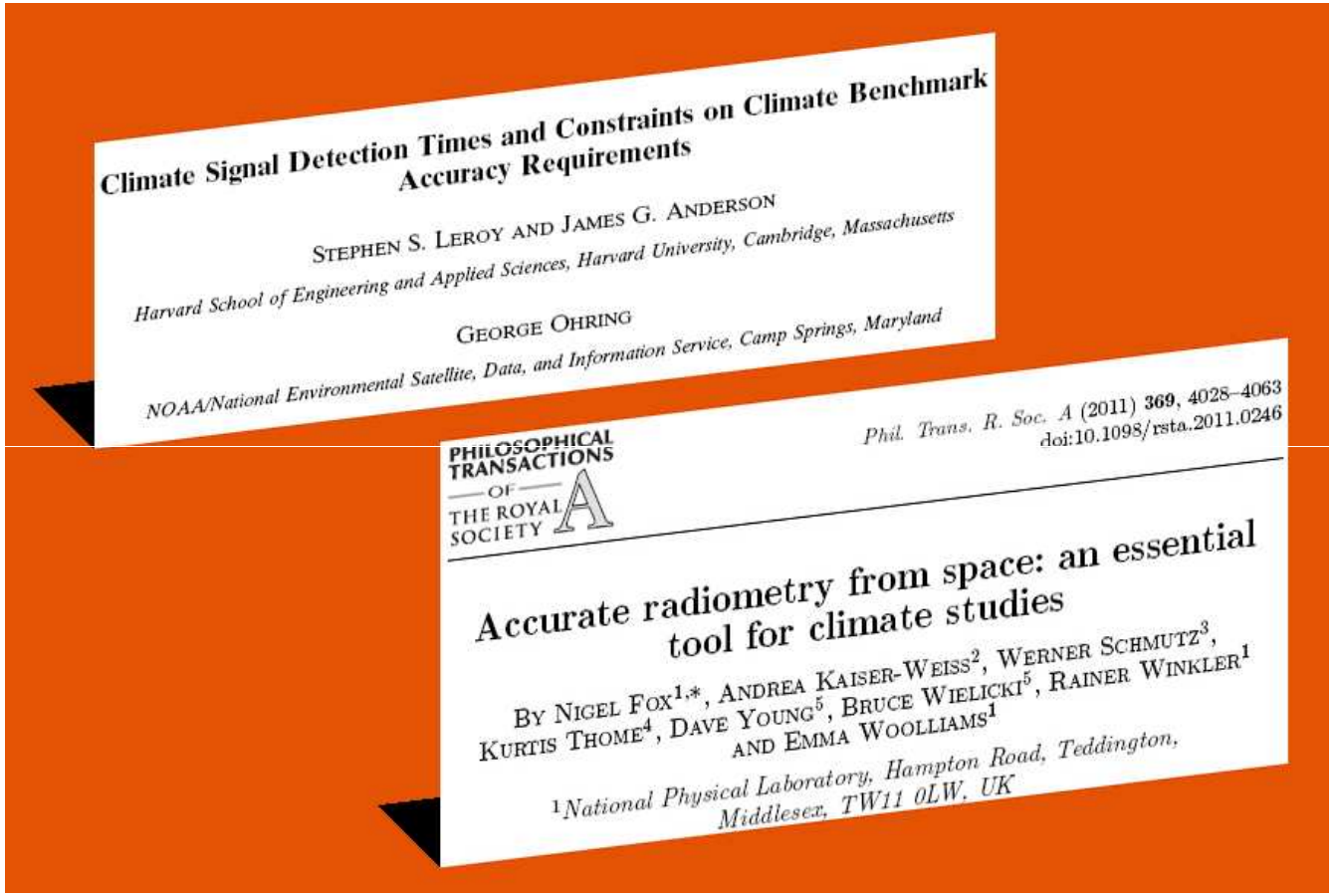


Previous work made the following assumption:



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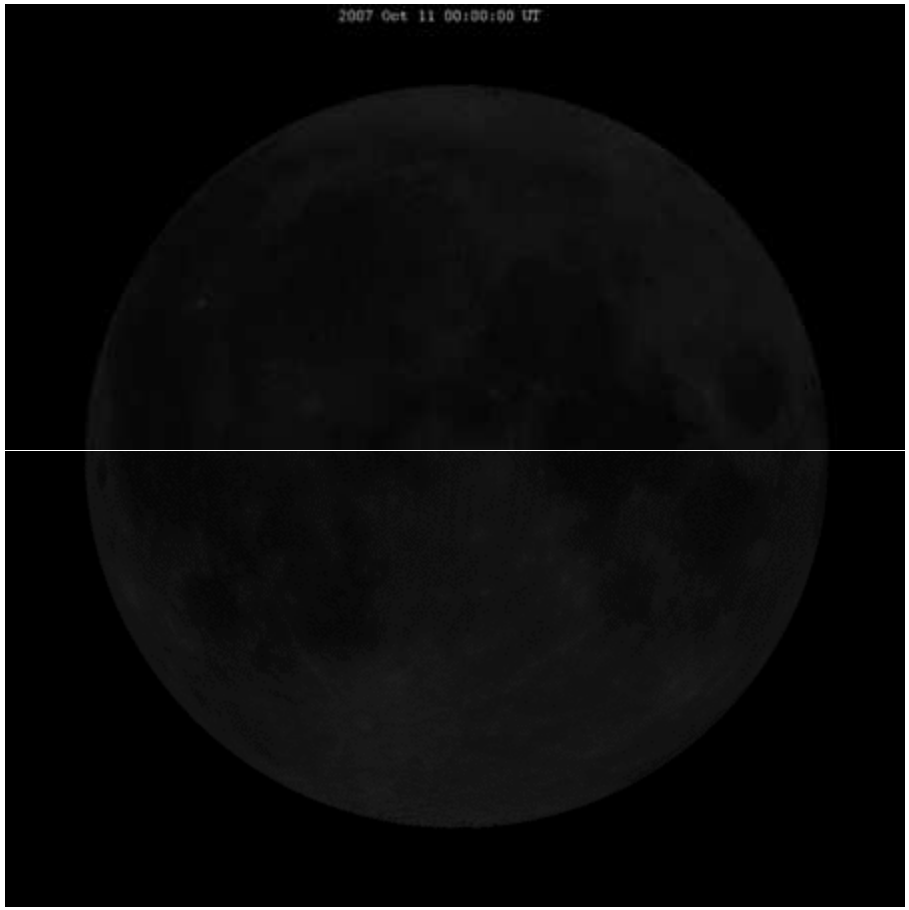
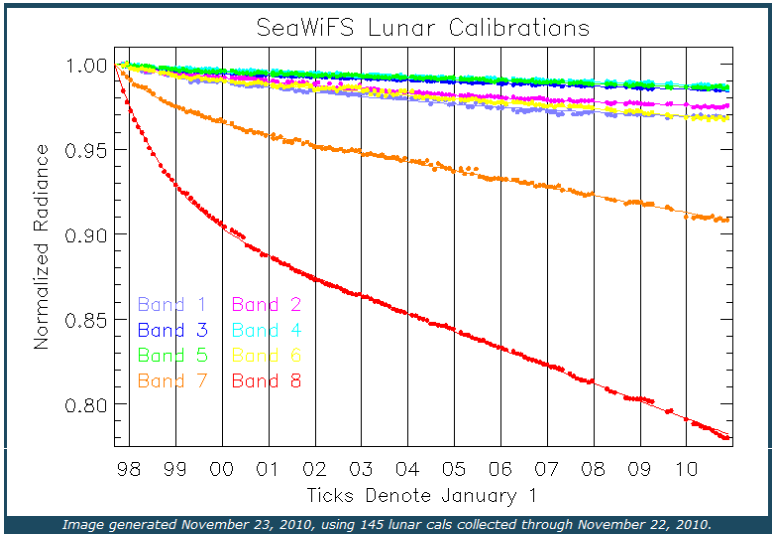
$$\langle (\delta m)^2 \rangle \simeq 12 (\Delta t)^{-3} (\sigma^2_{\mathrm{var}} \tau_{\mathrm{var}} + \sigma^2_{\mathrm{meas}} \tau_{\mathrm{meas}}),$$

"It is impossible to demonstrate experimentally that the residual difference between the truth and measurement remains constant over an instrument's lifetime"

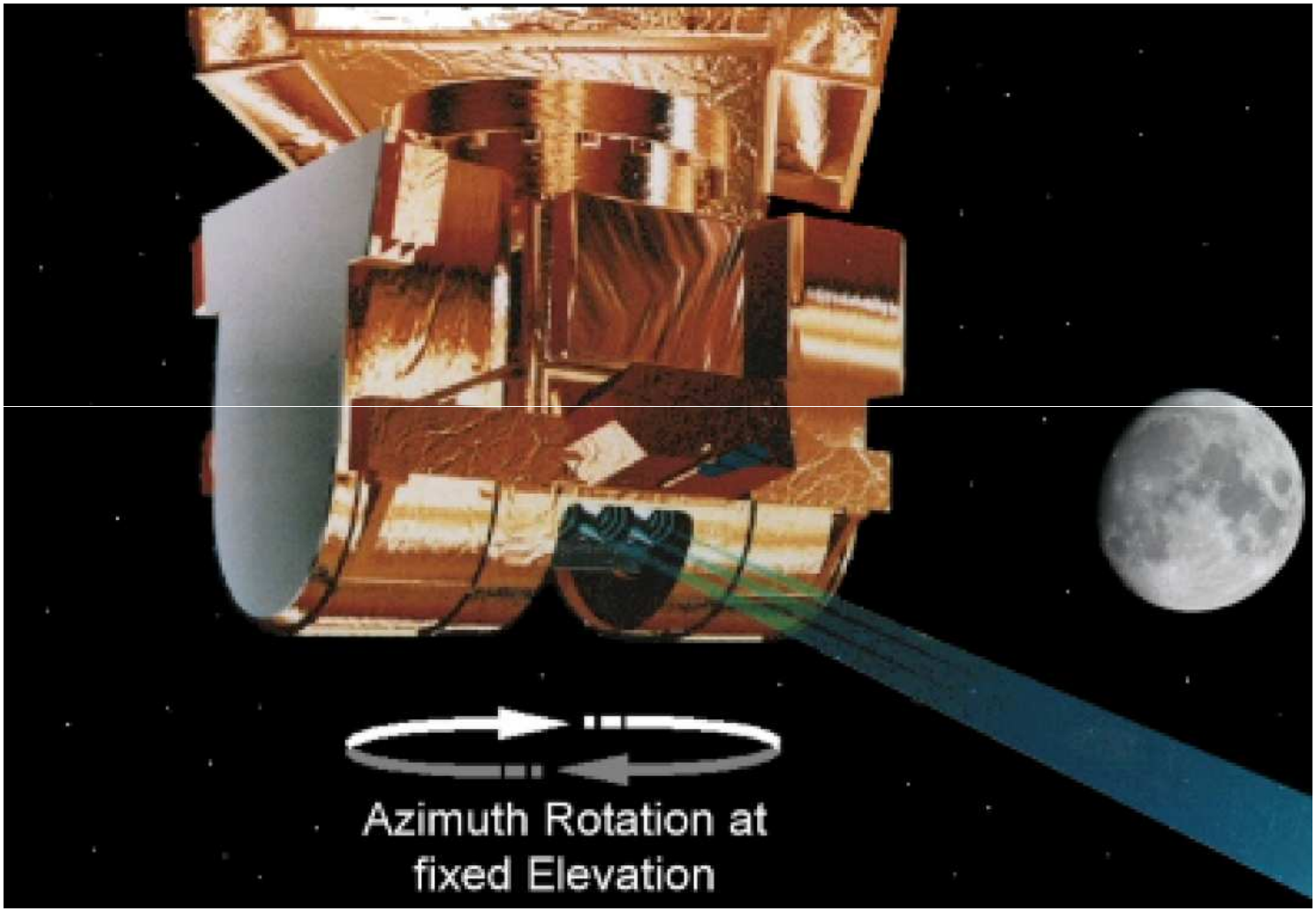
Lunar Calibration? The most stable instrument in-flight is SeaWIFS using the Moon





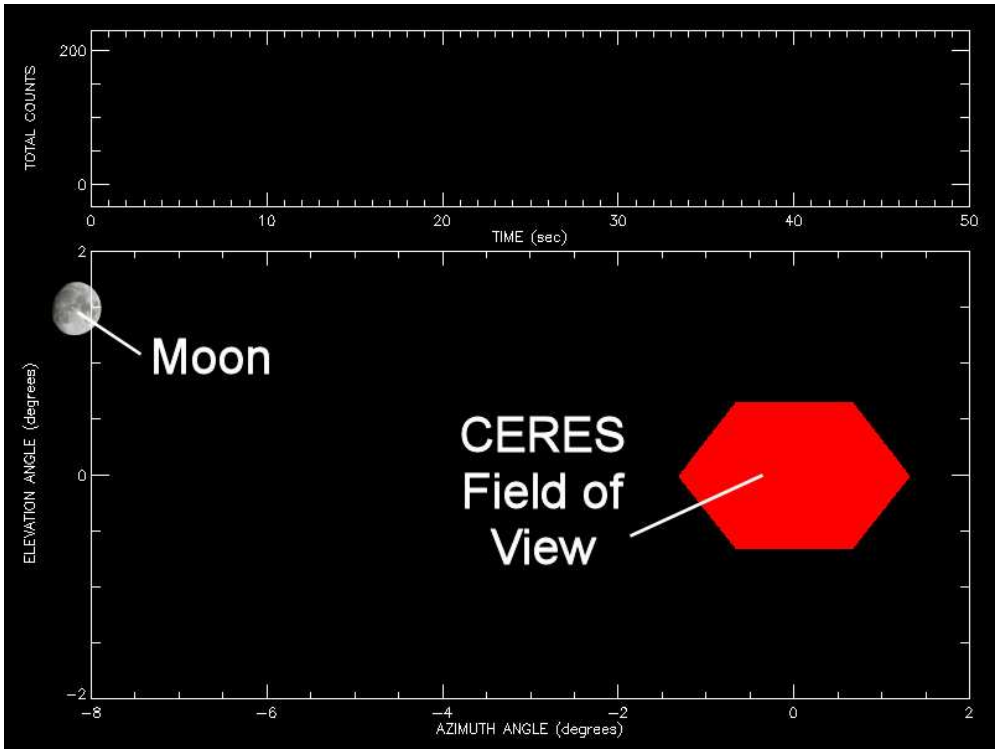
The instrument SeaWIFS uses the Moon to track changes in its solar wavelength calibration to 0.1%/decade

Can we use the Moon to improve existing Terra CDRs from Clouds and the Earth's Radiant Energy System (CERES)?

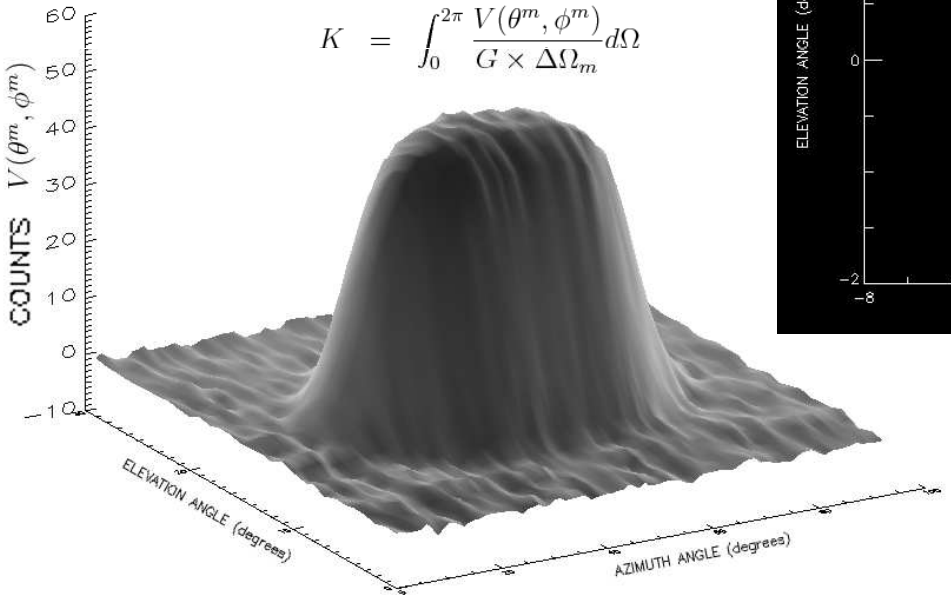


ITT EXELIS also has developed concepts on use of existing lunar scans to detect instrument changes

The challenge faced was that since the Moon is far away; it appears too small for its “climate” to be measured by an CERES instrument as is done for the Earth



$$K = \int_0^{2\pi} \frac{V(\theta^m, \phi^m)}{G \times \Delta\Omega_m} d\Omega$$



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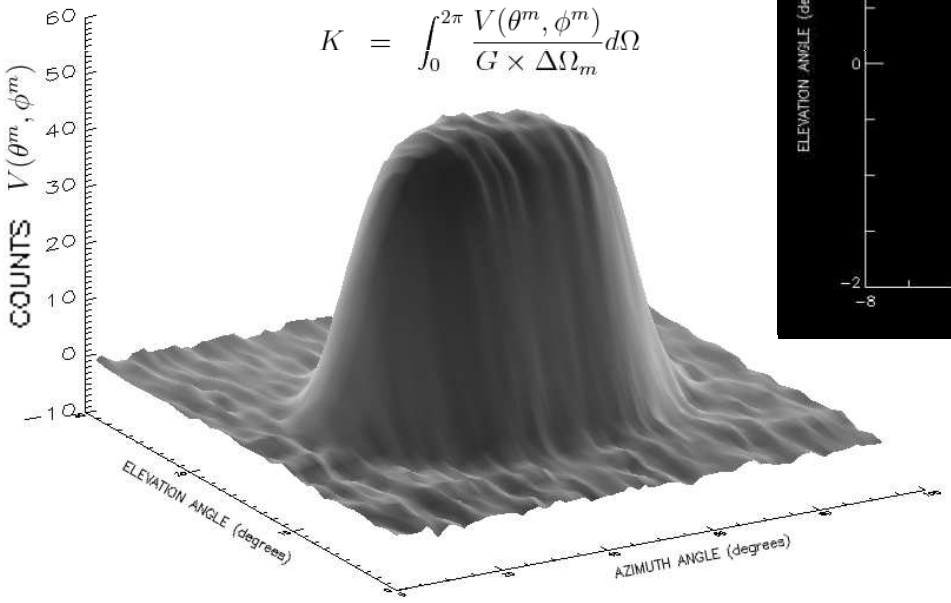
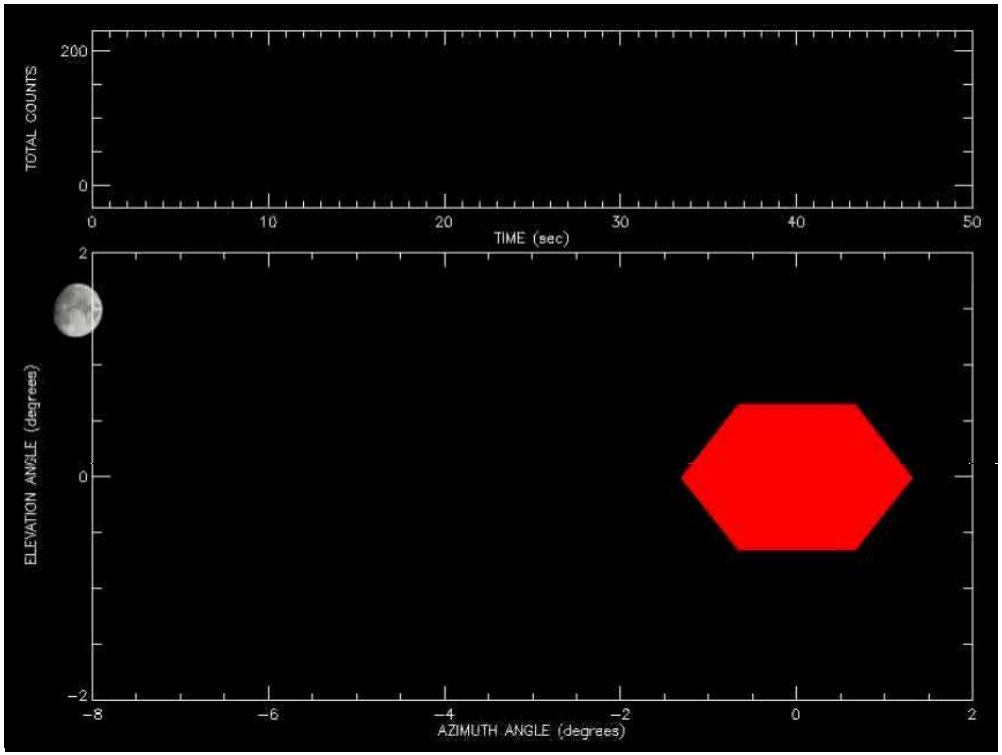
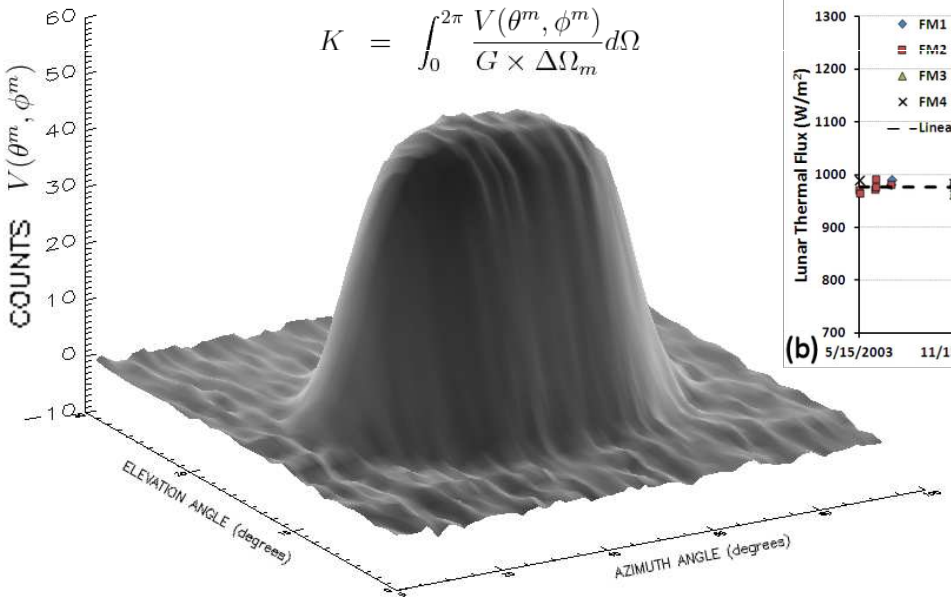


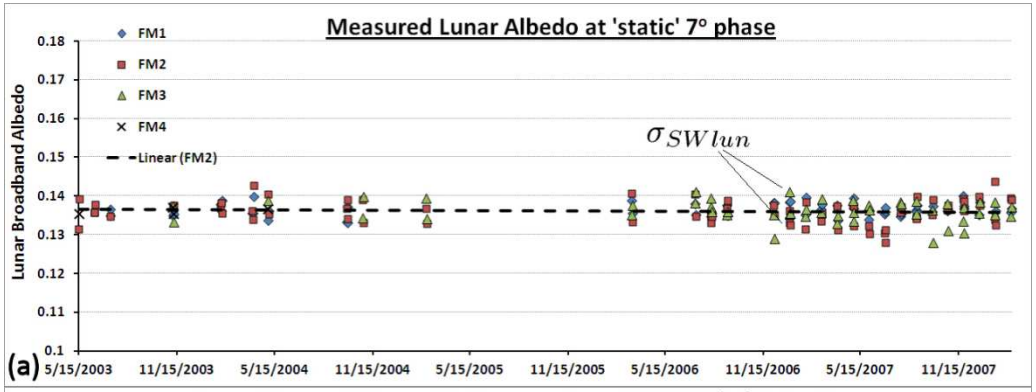


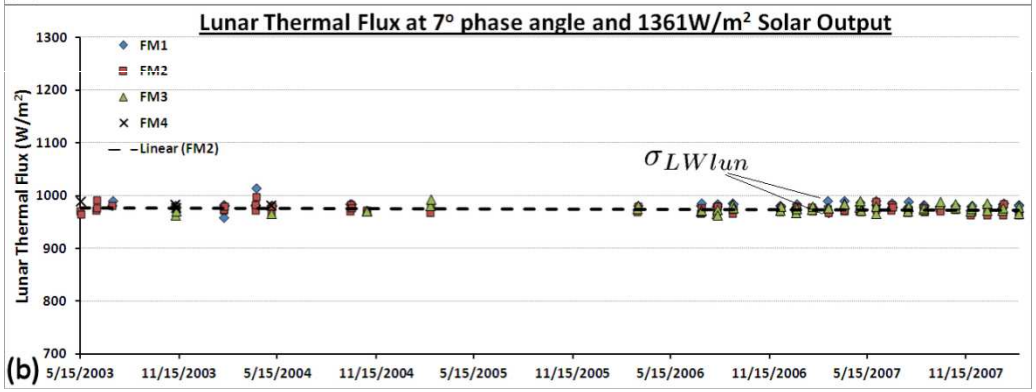
EXELIS developed a new way of measuring the Moon’s climate from Earth’s orbit using raster scan data

If you measure Earth's climate changing with the same instrument that measures no change in the Moon you have confidence it is Earth, not your instrument changing

Look for trends in Lunar albedo and surface IR emissivity since they cannot change

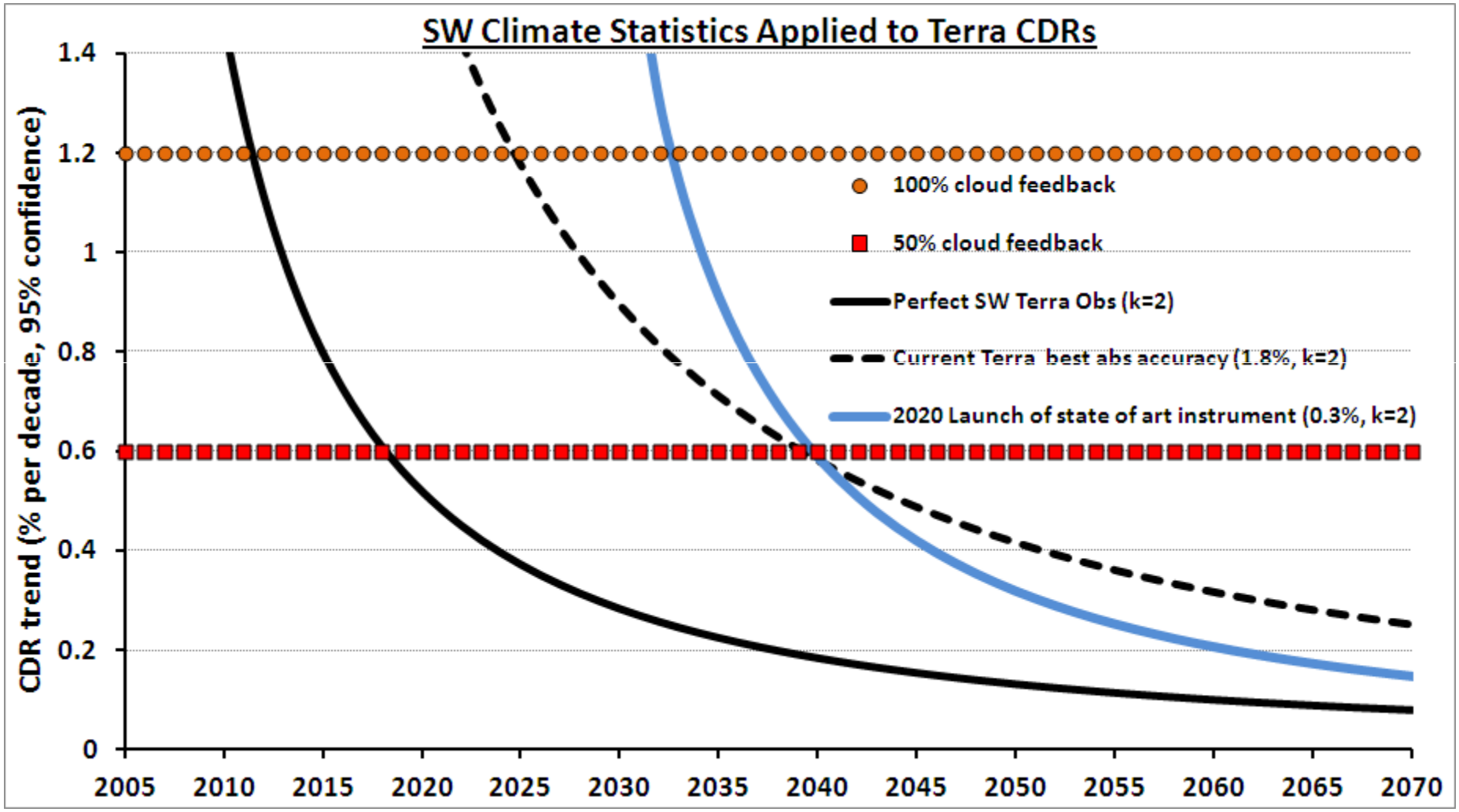




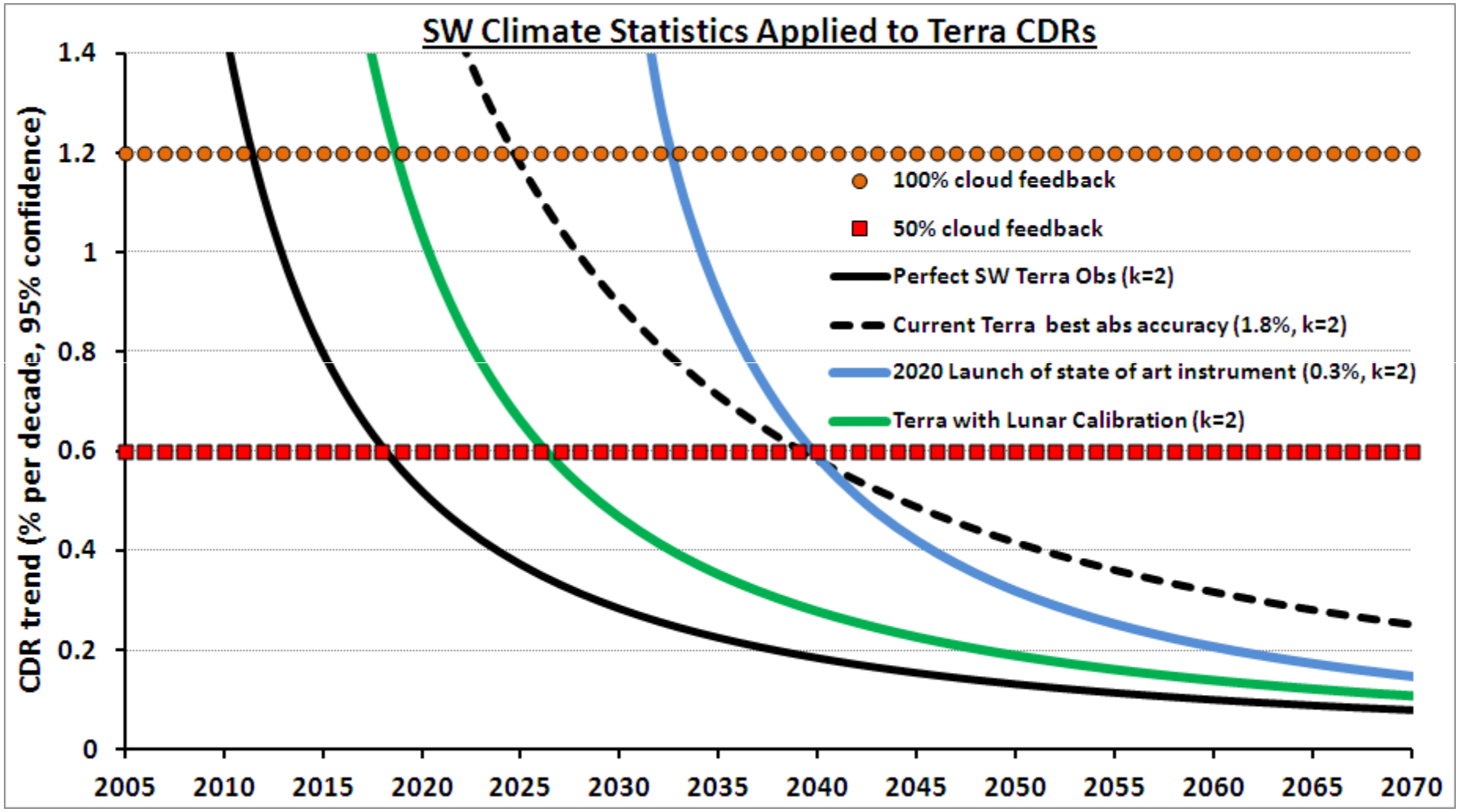


Any such trends **have to be due to your instrument changing**

Use established theory to estimate size of trends detectable in CDRs beginning with Terra – Aqua – NPP – JPSS using lunar calibration



Use established theory to estimate size of trends detectable in CDRs beginning with Terra – Aqua – NPP – JPSS using lunar calibration



Talk Summary & Conclusions

- Large uncertainty about climate change comes from the way Clouds are simulated in GCMs
- Need to use measurements from CDRs to validate GCM simulations of cloud climate feedback
- However existing CDRs have trends due to the instrument, rather than Earth's climate changing
- Exelis technique measures the Moon's "constant climate" with Terra – track instrument changes
- Current data suggest the size of GCM predicted cloud climate feedback signals will become detectable within one decade
- Future plans – CrIS Lunar Calibration?

Questions? Note that Exelis Cross-track Infra-red Sounder (CrIS) on NPP can also see the Moon 100 times per year