



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Radiative Surface Forcing from CH₄ at the North Slope of Alaska and Southern Great Plains Sites

Daniel Feldman¹

Bill Collins¹, Jon Gero², Dave Turner³, Sebastien Biraud¹, Eli Mlawer⁴, Margaret Torn¹

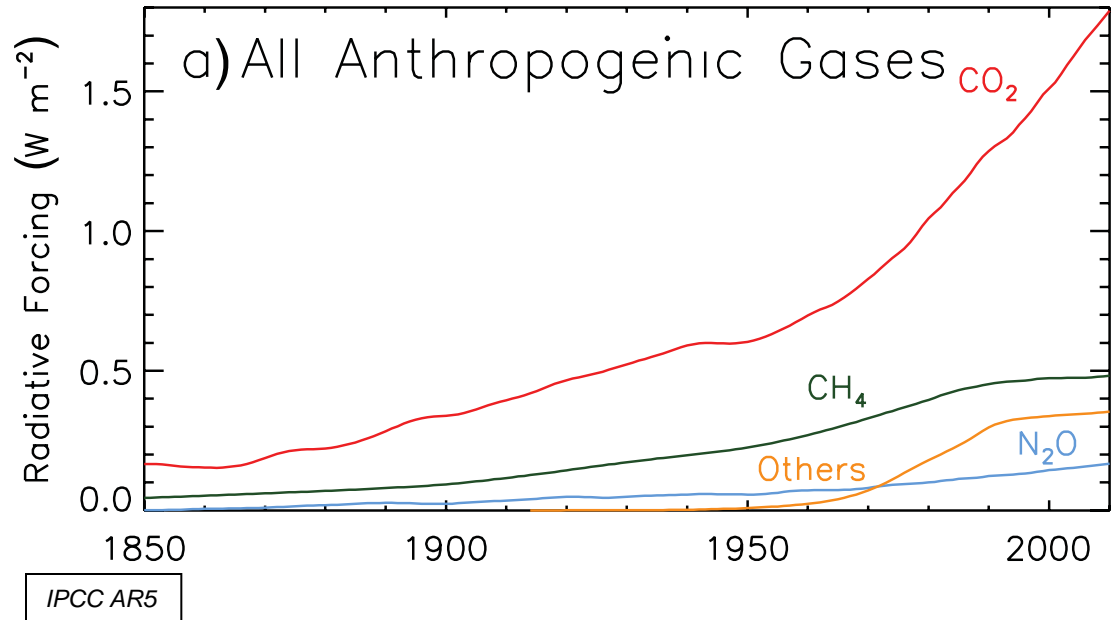
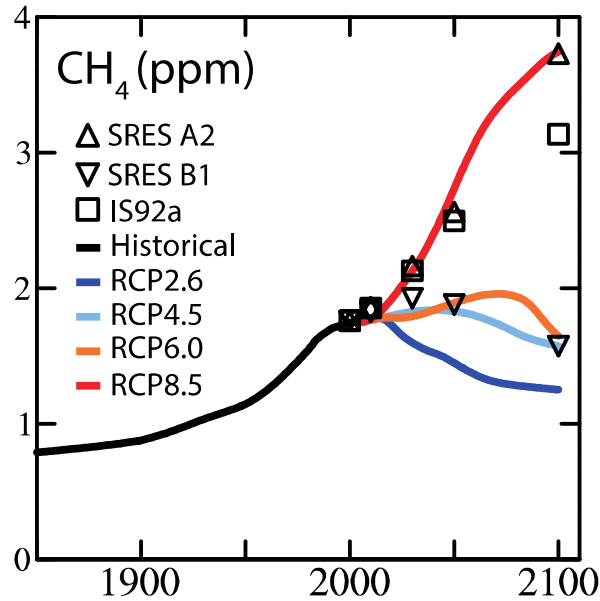
ASR/ARM PI Meeting

March 18, 2015

- ¹ Lawrence Berkeley National Laboratory, Earth Sciences Division
- ² University of Wisconsin, Space Sciences and Engineering Center
- ³ NOAA Severe Storms Laboratory
- ⁴ Atmospheric and Environmental Research



CH₄ Concentrations and Forcing

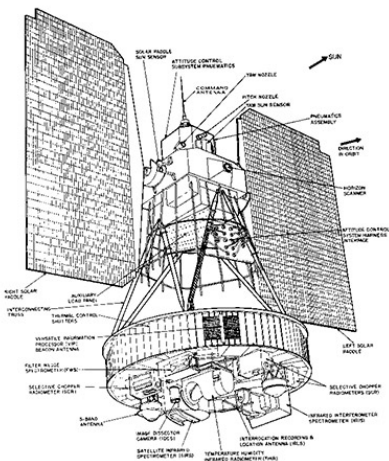


- While the concentrations are observed, these forcings are strictly modeled.
- Can we observe climate forcing?

1st Detection of WMGHG Forcing

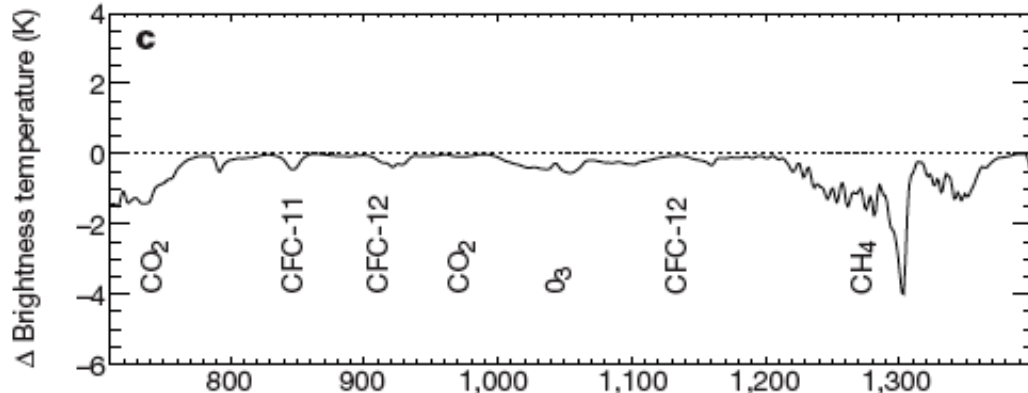
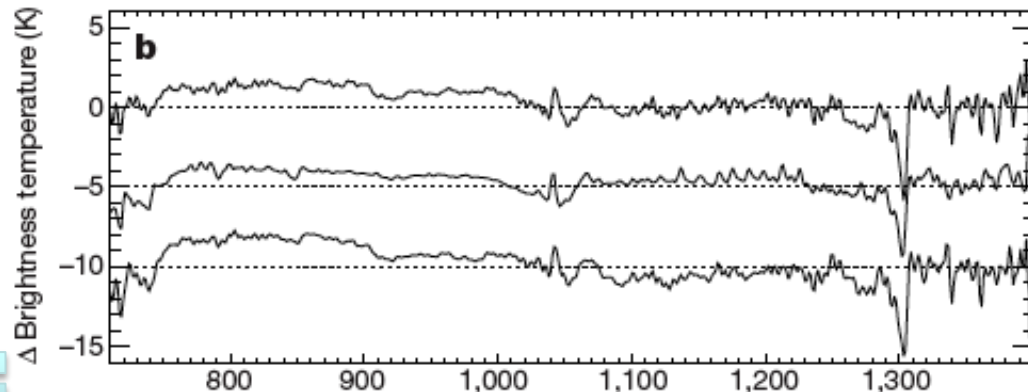


minus



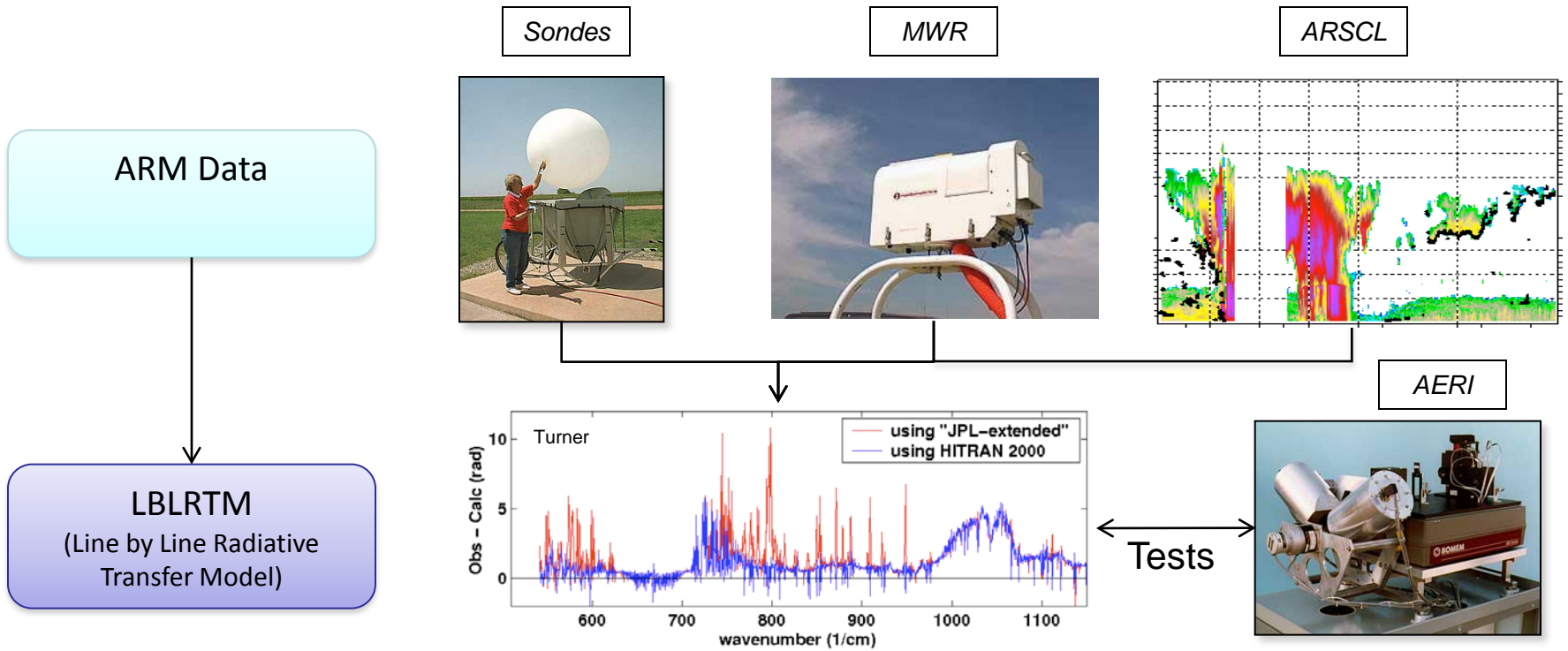
Nimbus-4, 1970

Reduced Emission to Space from Enhanced Greenhouse



Wavenumber (cm⁻¹)

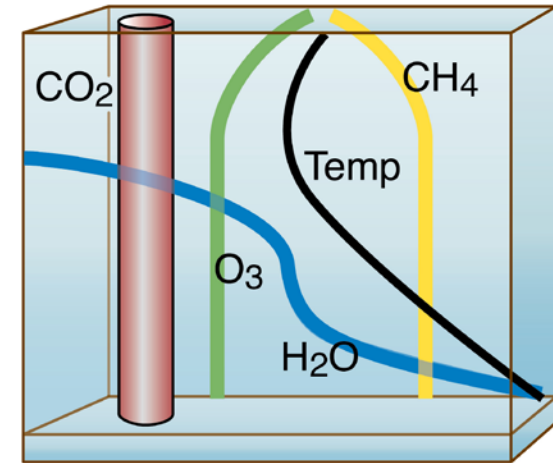
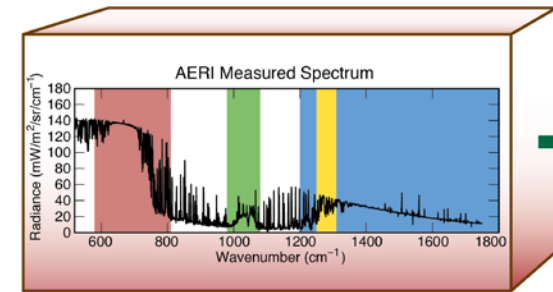
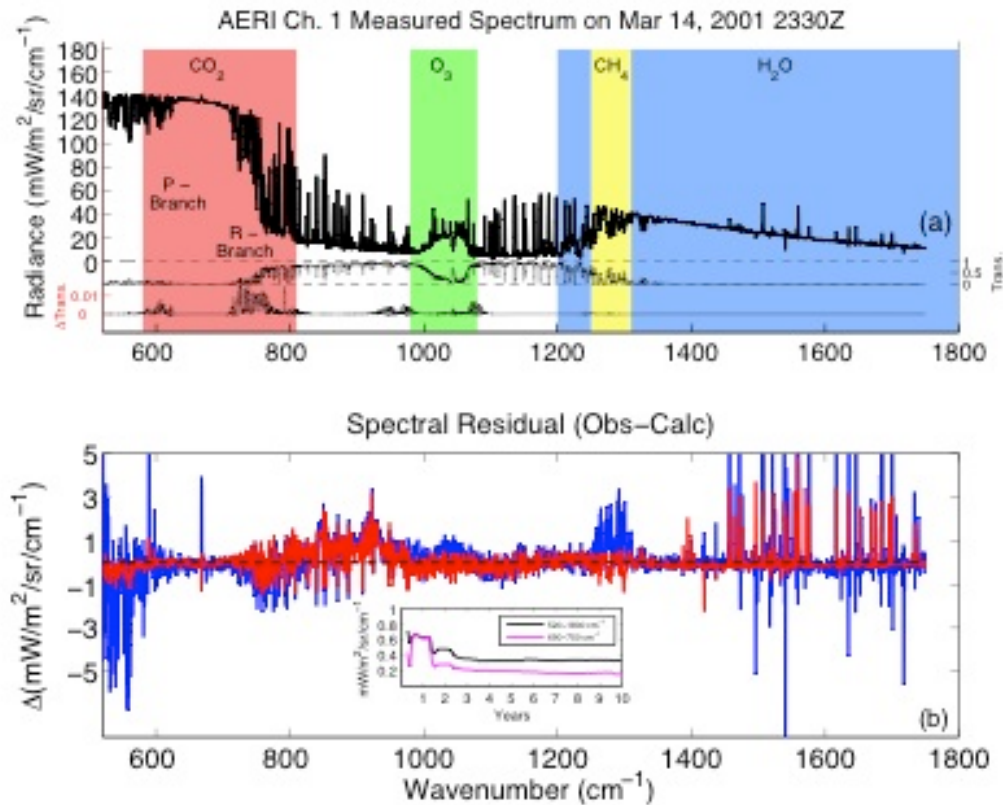
Schema for our Forcing Calculations



Feldman et al, Nature, 2015

Measurements of CO₂ Surface Forcing

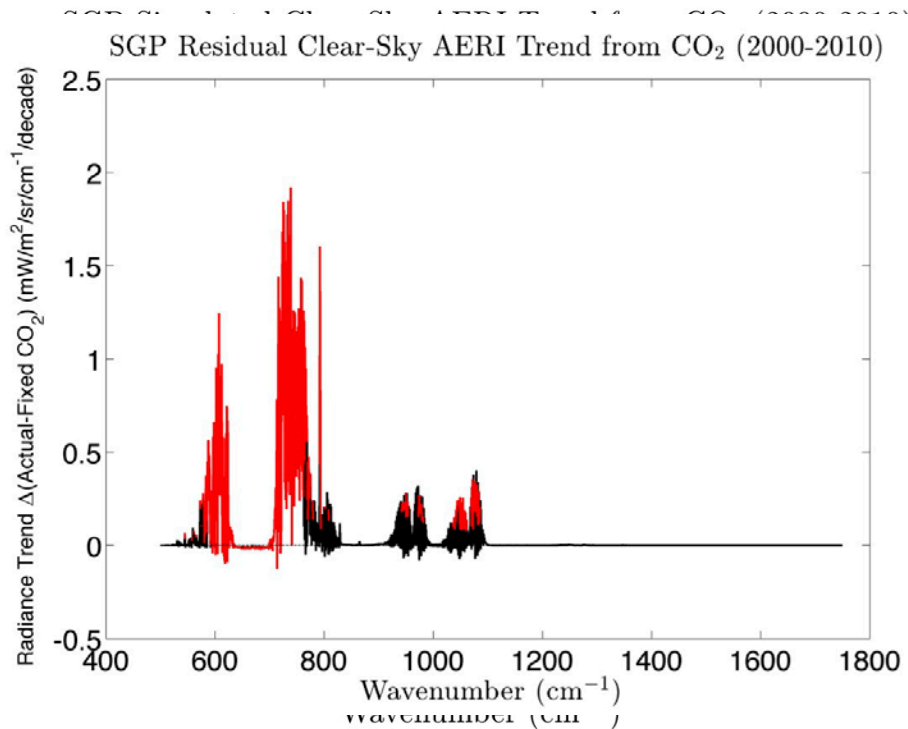
- ARM facilities at NSA and SGP contain numerous datastreams that enable the detection of the change in the surface energy budget due to rising CO₂.



Feldman et al, Nature, 2015

Spectroscopic Separation

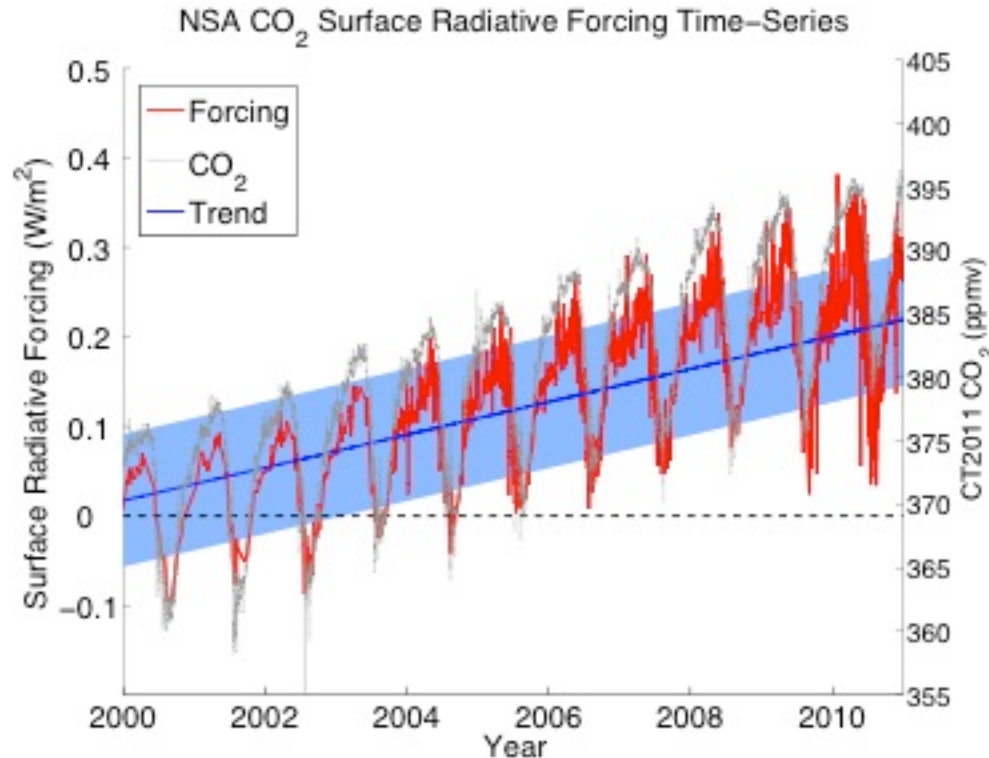
- Necessary to control for thermodynamic structure of the atmosphere through RAOBs.
- CO₂ absorption features are separable and appear in the measurements.



Feldman et al, Nature, 2015

CO₂ Surface Forcing Time-Series

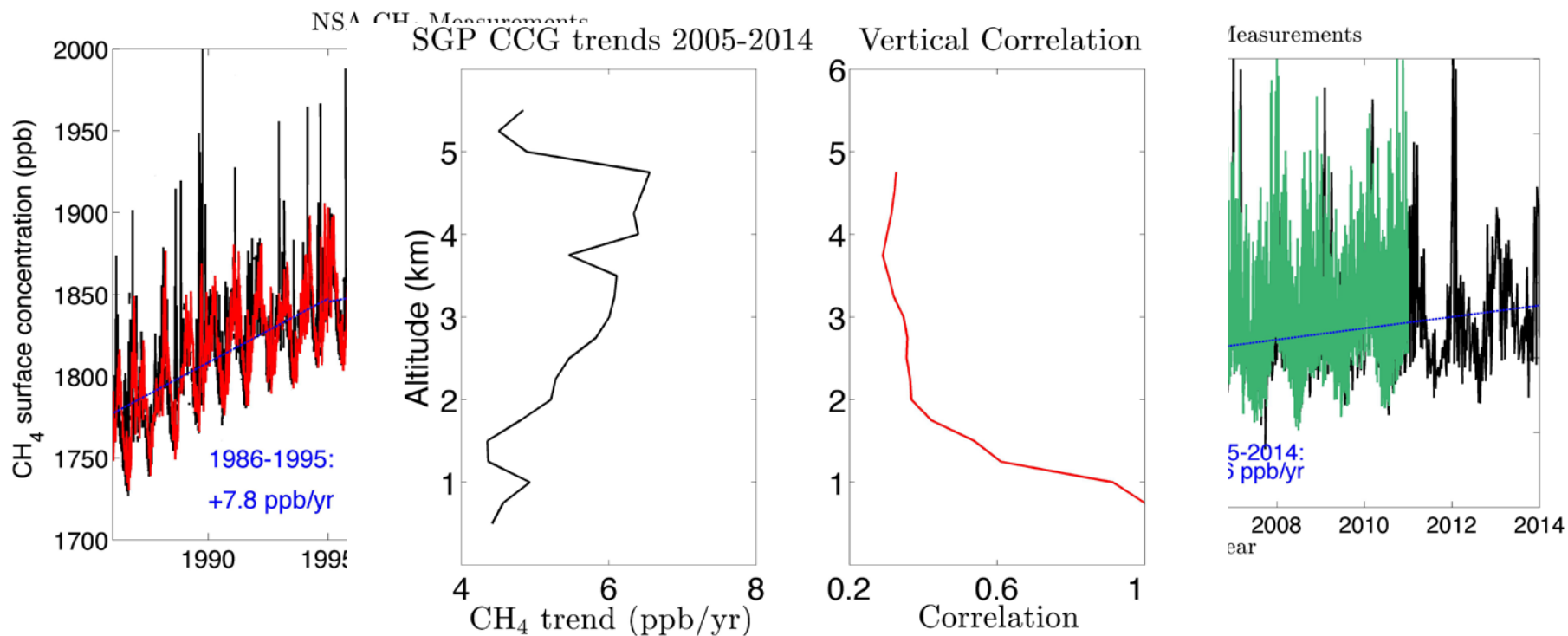
- We track systematic differences between AERI residuals (obs – calc, fixed CO₂) between 2000 and 2010.
- Time-series at two sites reveal positive slopes $\sim 0.2 \text{ W/m}^2/\text{decade}$.
- Seasonal cycle $\sim 0.5 \text{ W/m}^2$. Diurnal, synoptic, and seasonal features.
- Observational demonstration of CO₂'s greenhouse effect in action.



Feldman et al, Nature, 2015

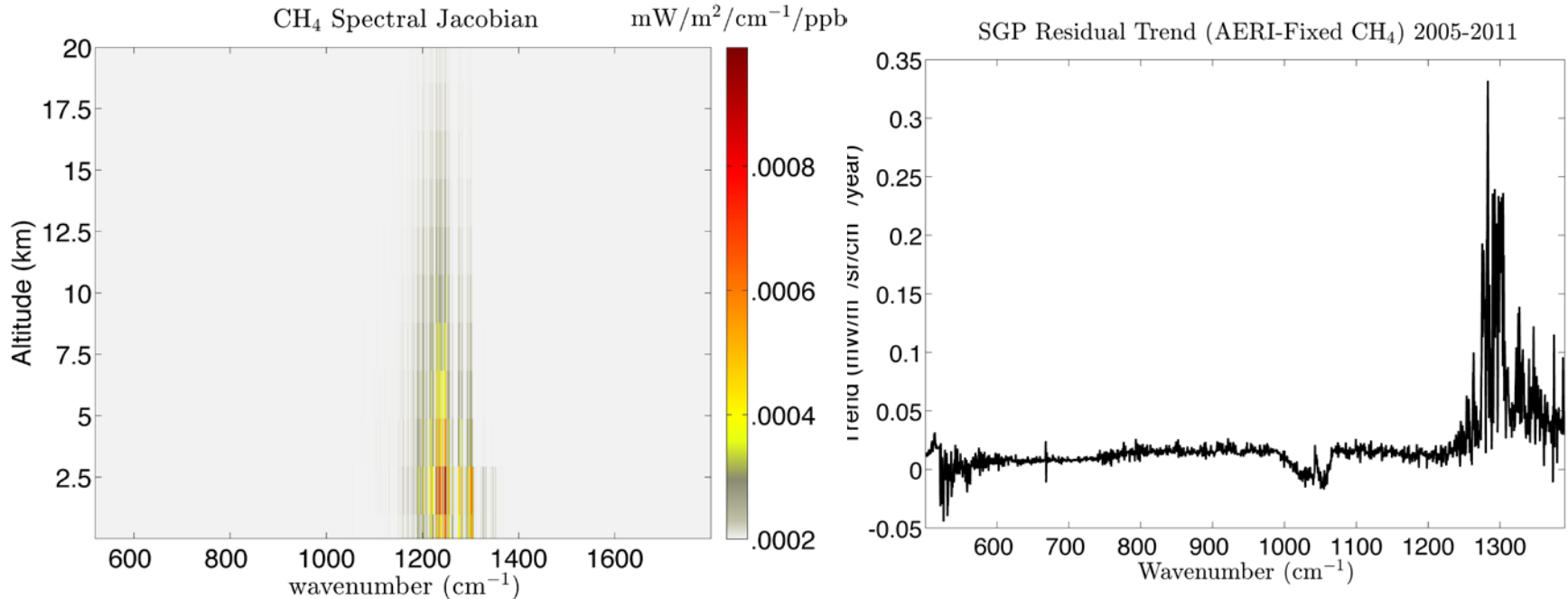
CH₄ Concentrations

- The hiatus in increasing atmospheric CH₄ ended ~2005. Measurements at NSA and SGP indicate this.
- Measured profiles of CH₄ also indicate trends in CH₄, but low vertical correlation.



Trends in AERI Radiances – Fixed CH₄

- CH₄ has a prominent absorption feature at 1311 cm⁻¹. Using the same approach as for CO₂, we can derive a time-series of forcing from CH₄.

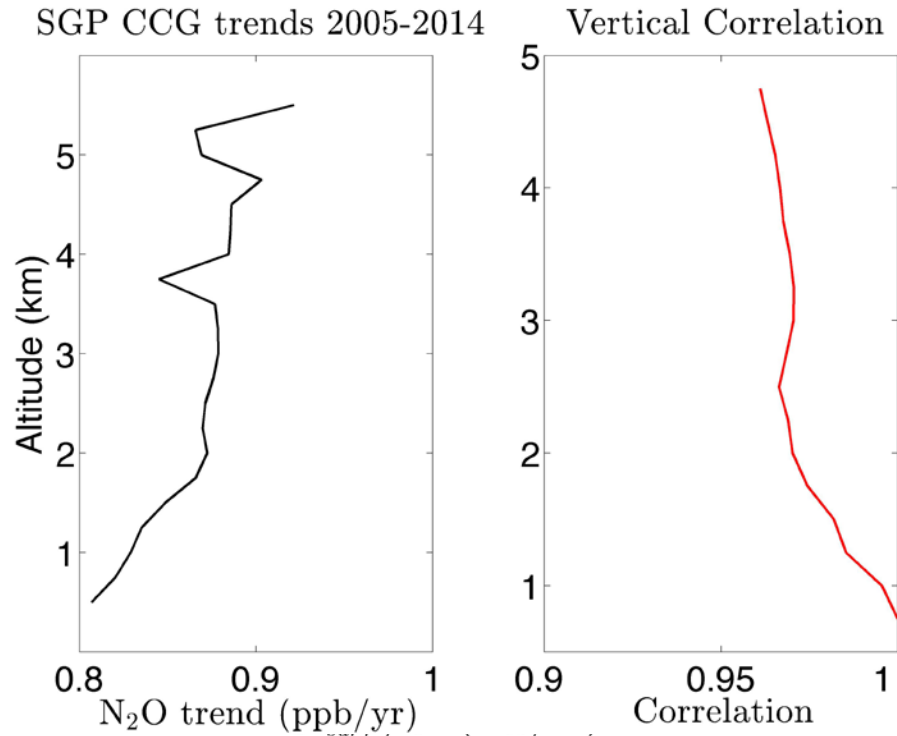


Difference between AERI and model spectra with fixed CH₄ reveals:

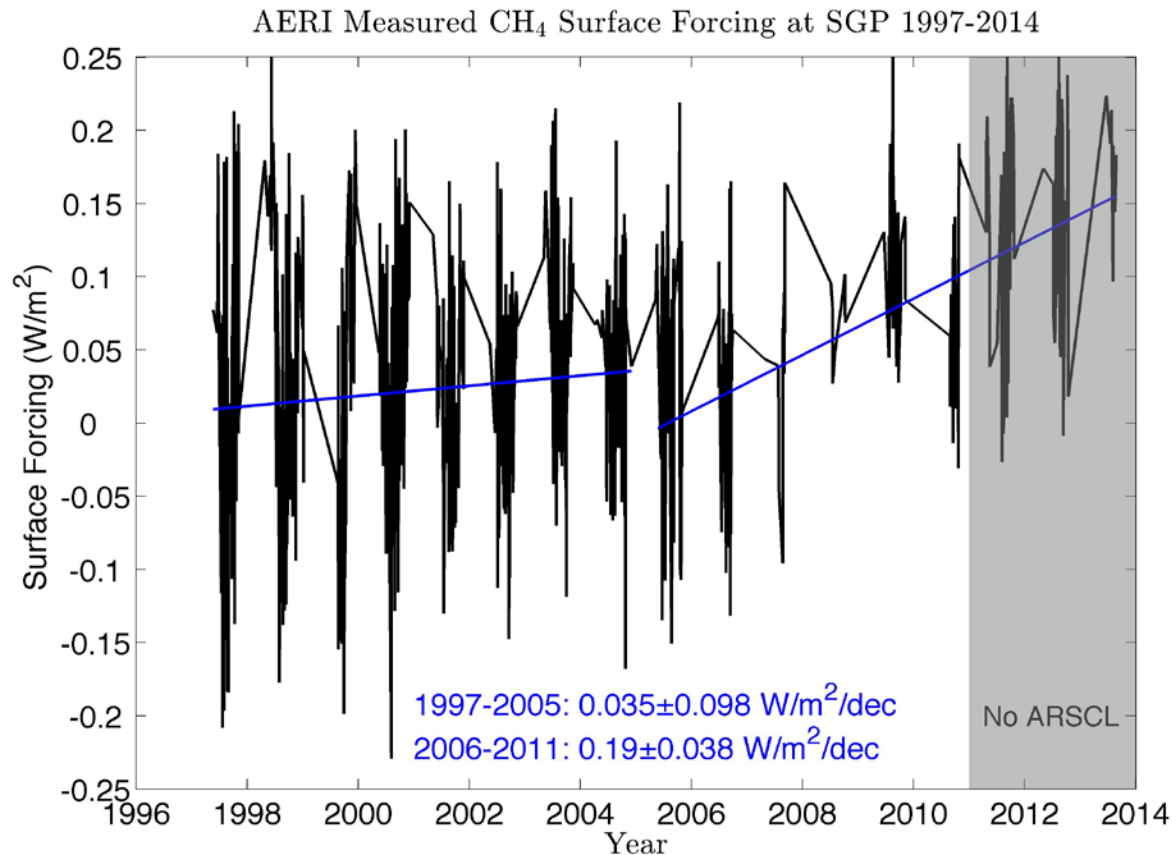
- Large secular trend in increased atmospheric emission in 1200-1350 cm⁻¹.
- Minor features outside of 1200-1350 cm⁻¹.

Challenges for CH₄ Forcing

- CH₄ band is very sensitive to T and H₂O.
- N₂O and CH₄ features overlap.
 - But observations indicate N₂O uncorrelated with, and rising more slowly than, CH₄.



1st Detection of CH₄ Surface Forcing

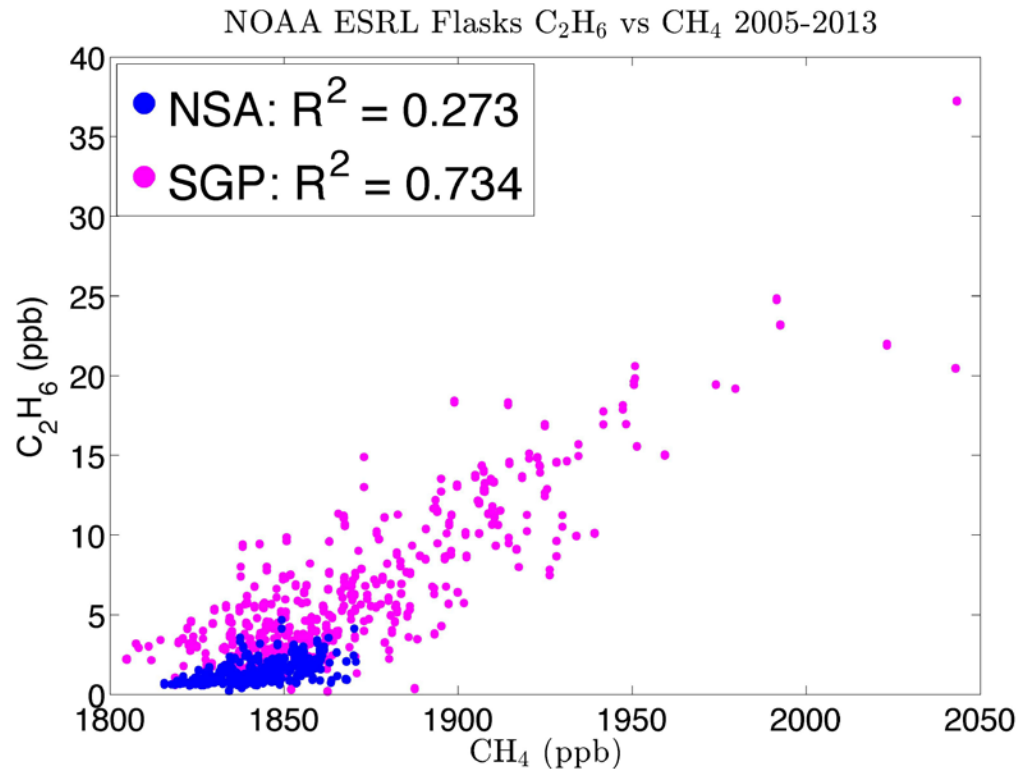


Observational Determination of:

- Time series of radiative forcing by CH₄: Signals of “hiatus” and recent rise.
- Quantification of impact of CH₄ on the Earth’s surface energy budget.
- Determination of the radiative signal from seasonal cycle.

Anthropogenic Forcing

- Coincidental measurements of C_2H_6 and CH_4 indicate that spikes in surface CH_4 are generally due to anthropogenic activities, likely from a nearby source.



Conclusions

- The ARM data record is sufficiently long to quantify spectral signatures of anthropogenic forcing.
- We have used this record to quantify trends in surface radiation from recent changes in methane concentrations, with high-frequency spikes likely from anthropogenic activity.
- Trends: $0.19 \pm 0.04 \text{ Wm}^{-2} / \text{decade}$
at the Southern Great Plains site.

Acknowledgements:

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