Radiative feedbacks in 1D-RCE

Lukas Kluft, Sally Dacie, Stefan A. Buehler, Hauke Schmidt, and Bjorn Stevens

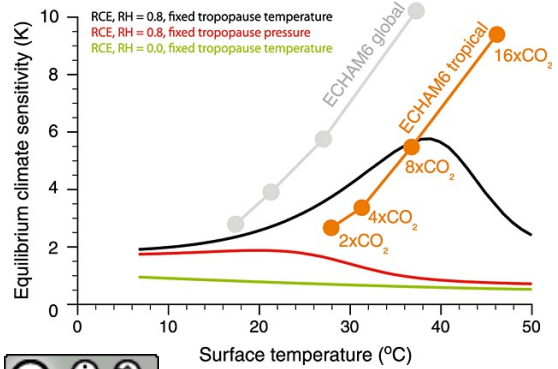
IMPRS-ESM, Hamburg
Max-Planck-Institut für Meteorologie, Hamburg
CEN, Universität Hamburg

Except where otherwise noted, this work is licensed under a *Creative Commons Attribution 4.0 International License*

The state

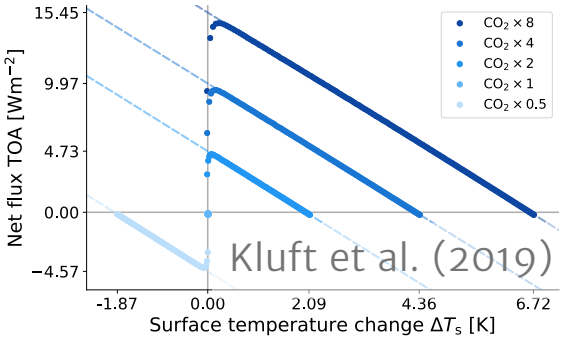
State-dependent climate feedback

- Quantifying the temperature dependence of the climate feedback parameter
- Meraner et al. (2013) find a strong dependence for RCE-like model (black curve)
- Romps (2020) confirms the qualitative behaviour in high-resolution simulations
- Only a small state-dependence of the climate feedback in Kluft et al. (2019)



CC BY NC

Meraner et al. (2013)

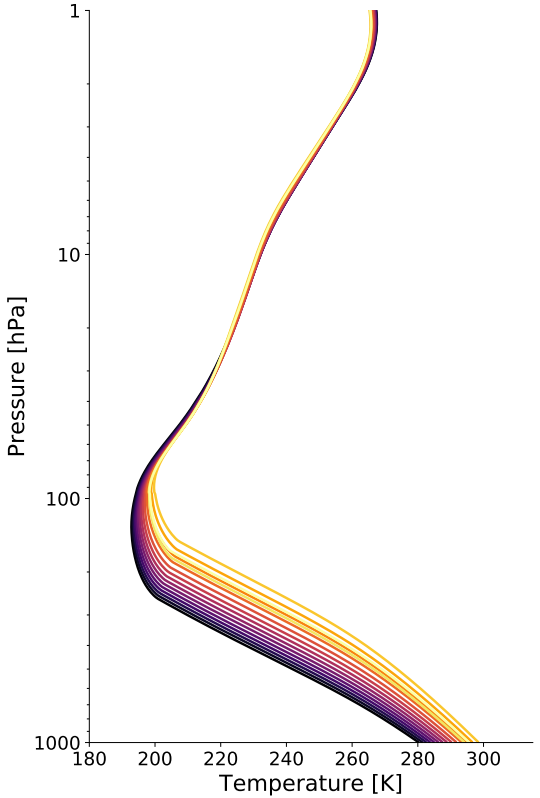


Kluft et al. (2019)

How to change the climate?

How to adjust the state?

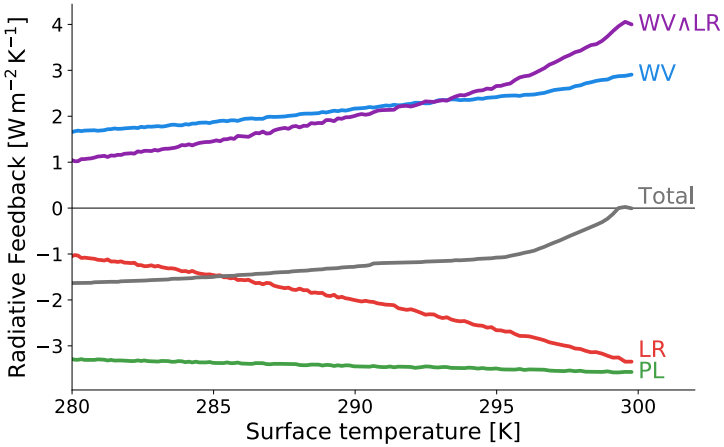
- Adjusting the boundary conditions to sample surface temperatures:
  - Solar constant
    Affects stratospheric temperature
  - Relative humidity
    Reduces water vapour feedback
  - Fixed surface temperature
    Unable to quantify radiative forcing
- **Introduce a surface heat sink**



Temperature profiles for different values of the surface heat sink

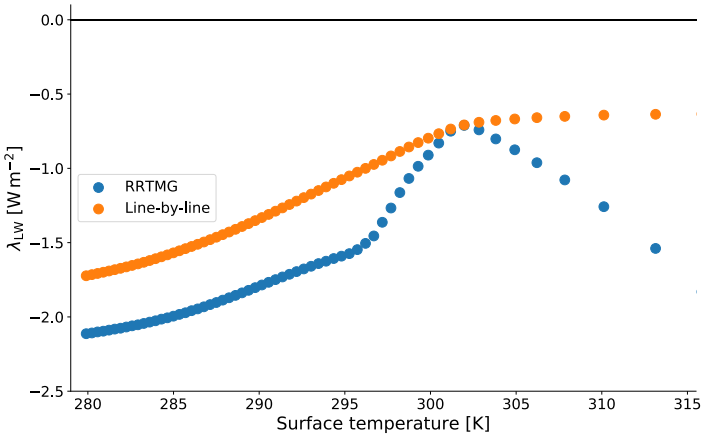
Decomposed feedbacks

- The 1D-RCE model Konrad is run with T_S between 280 and 300 K
- We find a robust state-dependence of the total climate feedback
- Decompose feedbacks by turning their mechanism on/off
- The increase is driven by a strengthening of the water-vapour feedback [in agreement with Meraner et al. (2013)]



Is it a feature or a bug?

- RRTMG is optimised for a reasonable set of atmospheric conditions
- The tropical model configuration reaches these boundaries
  - Water vapour amount (80% RH)
  - Tropopause height above 100 hPa
- Koll and Cronin (2018) find a closing of the atmospheric window for surface temperatures around 300 K



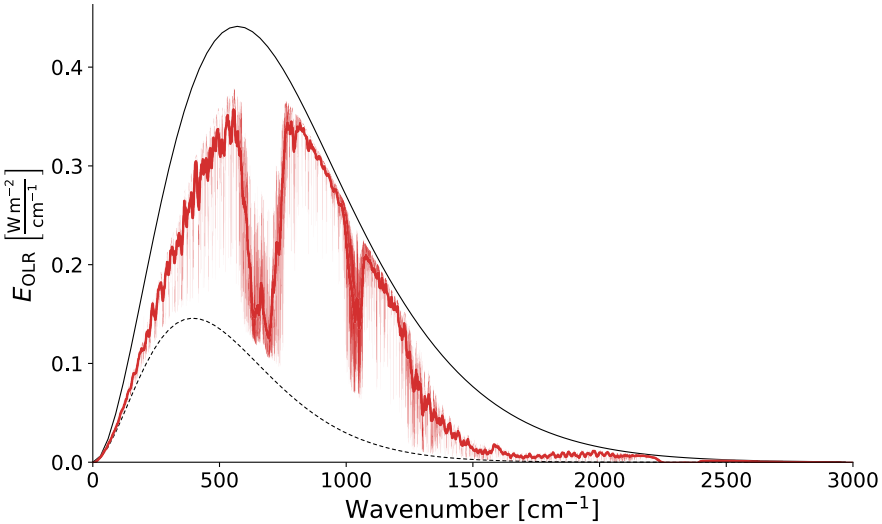
Comparison of RRTMG radiative feedbacks with offline line-by-line simulations

High-resolution* modelling

*radiative transfer

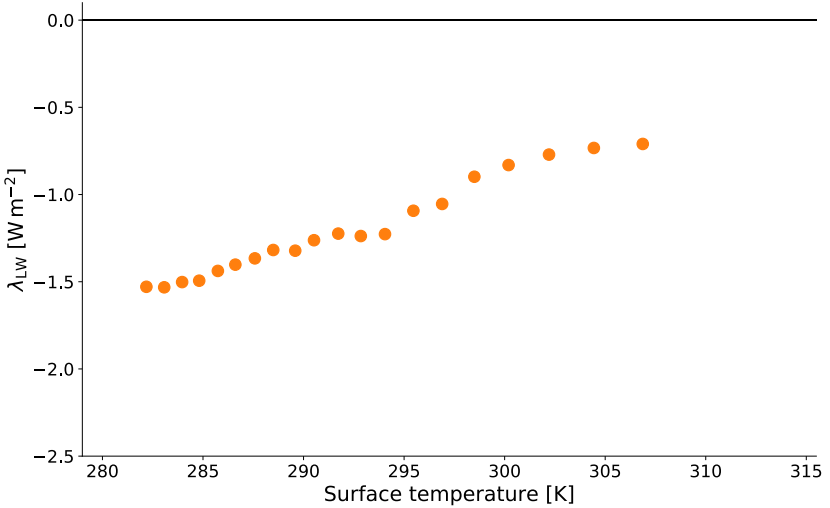
Line-by-line longwave radiation

- Replace RRTMG LW with the line-by-line model ARTS
- 30,000 frequencies between 1 and 3000 cm^{-1}
- 128 pressure levels
- Shift the ozone profile together with the expanding troposphere
- Keep RRTMG for the shortwave component (possible inconsistencies)



Preliminary results

- 1D-RCE with on-the-fly line-by-line radiative transfer
- Robust state-dependence of the total climate feedback
- Weaker (or no) temperature dependence above 300 K surface temperature
  [in agreement with a conceptual by Ingram (2010)]



- **Be careful when using fast radiation schemes in extreme climates**