Instantaneous radiative forcing (IRF)

Net TOA or tropopause irradiance difference between a pair of radiative transfer simulations, one including the forcing agent in question and one without (Hansen et al., 1981). If performed online in an ESM, this is known as a "double [radiation] call" (Chung & Soden, 2015).

Solar | Thermal   TOA

ΔF Tropopause

z T

Stratospherically adjusted radiative forcing (SARF)

TOA

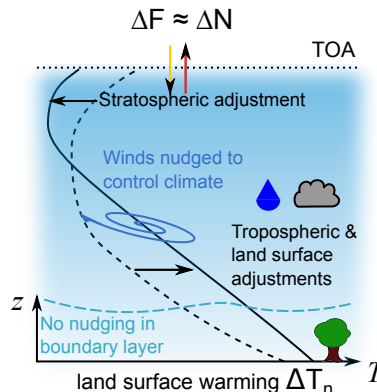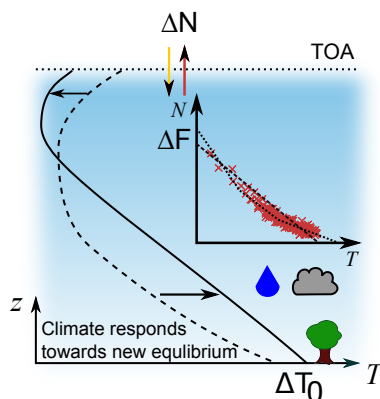Stratospheric adjustment

ΔF Tropopause

z T
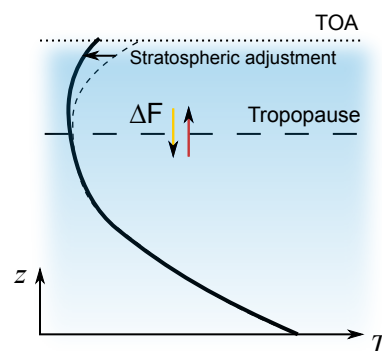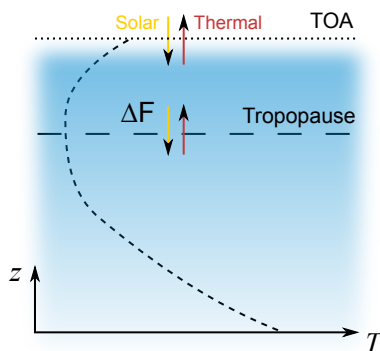
Tropopause irradiance difference between a pair of offline radiative transfer simulations, one including the forcing agent in question and one without, allowing for the stratospheric temperature to adjust to a new equilibrium iteratively (Fels et al., 1980)

Effective radiative forcing (ERF)

Regression method

ΔN

TOA

N

ΔF

T

z

Climate responds towards new equilibrium

ΔT_0 T

Coupled ocean-atmosphere model simulation following an abrupt forcing perturbation. Regression of ΔN versus ΔT for each year of simulation. ERF is the intercept of ΔN at $\Delta T = 0$ (Gregory et al., 2004). An improvement considers non-constancy of climate feedback (Fredriksen et al., 2021).

Fixed sea-surface temperatures with nudged circulation

$\Delta F \approx \Delta N$

TOA

Stratospheric adjustment

Winds nudged to control climate

Tropospheric & land surface adjustments

z

No nudging in boundary layer
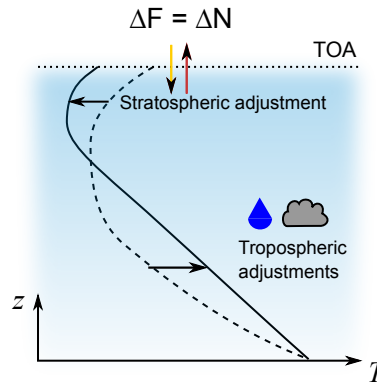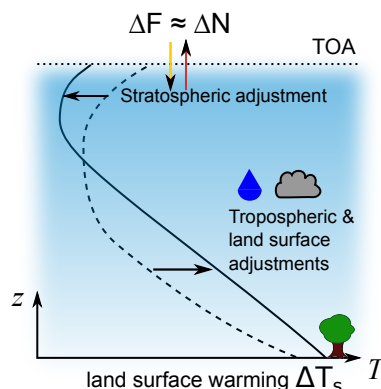
land surface warming ΔT_n T

Difference between two atmosphere-only model simulations with climatological sea-surface temperatures and sea-ice, one including the forcing agent in question and one without, with winds "nudged" towards a reference climatology in both simulations (Kooperman et al., 2012).

Fixed sea-surface temperature method

$\Delta F \approx \Delta N$

TOA

Stratospheric adjustment

Tropospheric & land surface adjustments

z

land surface warming ΔT_s T

Difference between two atmosphere-only model simulations with prescribed sea-surface temperatures and sea-ice, one including the forcing agent in question and one without (Hansen et al., 2005). Land surface is allowed to freely respond.

Fixed sea- and land-surface temperature method

$\Delta F = \Delta N$

TOA

Stratospheric adjustment

Tropospheric adjustments

z T

Difference between two atmosphere-only model simulations with prescribed surface temperatures, one including the forcing agent in question and one without (Shine et al., 2003).