

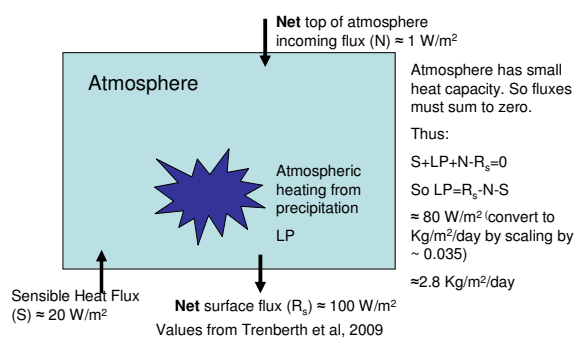
Global energy and global precipitation or Why doesn't precipitation increase as Clausius-Clapeyron?

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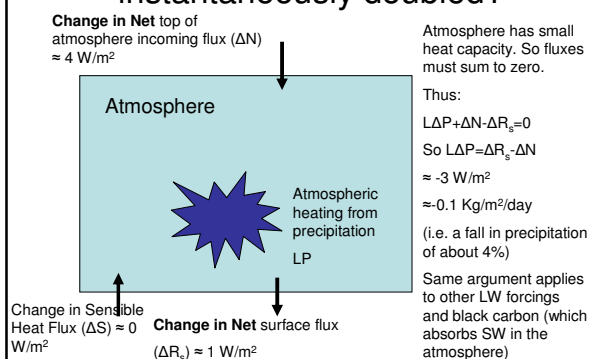
Clausius-Clapeyron

- Models (and observations) suggest that atmospheric relative humidity stays constant.
- This implies that atmospheric water vapour increases at about 6.5%/K.
- Naively might expect precipitation to increase at the same rate.
- Rest of this brief talk is to show you why this is not so. (and also to illustrate the power of thinking about Energy).

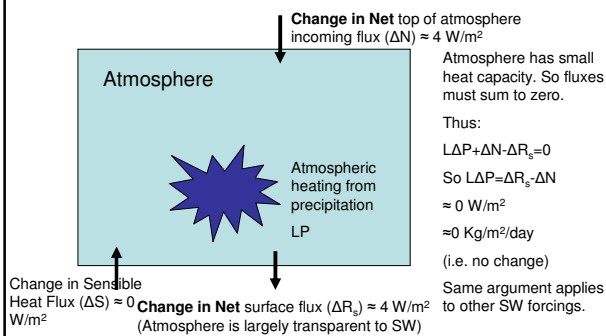
Energy budget of the Atmosphere (big terms)



What happens when CO2 is instantaneously doubled?



What happens when TSI is instantaneously increased by 4 W/m^2 ?



Impact of temperature changes

- But changing the net top of atmosphere flux causes the surface temperature to change.
- Simple model is to assume that $S + R_s$ scale linearly with surface temperature.
- From a range of climate models this is about $3 \text{ W/m}^2/\text{K}$ corresponding to a precip. change of about 4%/K.
- Key are the fluxes of heat from the surface into the atmosphere.

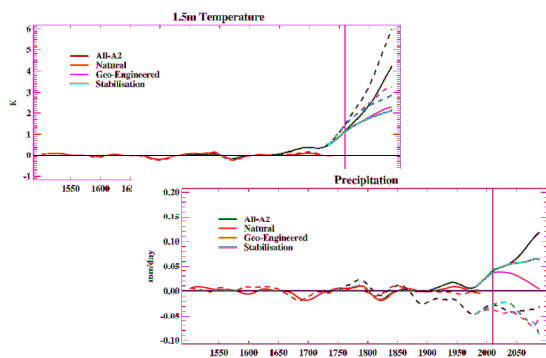
CO₂ and Precipitation

- So putting these things together.
- 1) Doubling CO₂ causes precipitation to fall by about 4%
- 2) Each 1K increase in temperature causes an increase in precipitation by about 4%.
- IPCC Climate Sensitivity range 2-4.5 K gives change in global mean precipitation of 4%-14%. (if your range is different compute the impact).

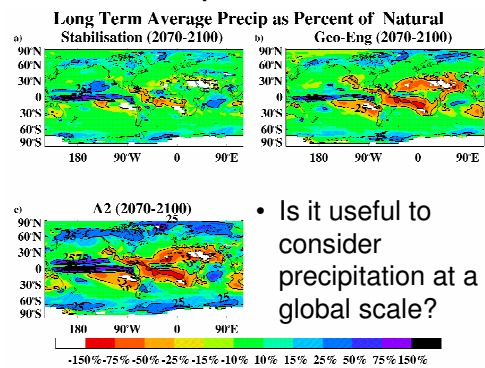
Geo-engineering through solar radiation management

- Aim of Geo-engineering is to balance forcing from Greenhouse gases by increasing albedo of earth.
- Imagine a case where CO₂ increases and is balanced by an increase in Stratospheric aerosol to balance the forcing.
- Then no change in temperature so no increase in atmospheric heating from that.
- But increasing CO₂ then causes a FALL in precipitation.
- So say we stabilise at 4xpre-industrial (1120 ppm) but use geo-engineering (-8 W/m²) to keep the temperature change to zero.
- Then have -8% reduction in precipitation from CO₂ and no increase in temperature.

Geo-Engineering



Precipitation



- Is it useful to consider precipitation at a global scale?

Useful papers

- Allen and Ingram, 2002 (Nature)
- Lambert and Allan, 2009 (J. Climate)