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Invited lecture

Radiation, the fundamental driver of climate and climate change

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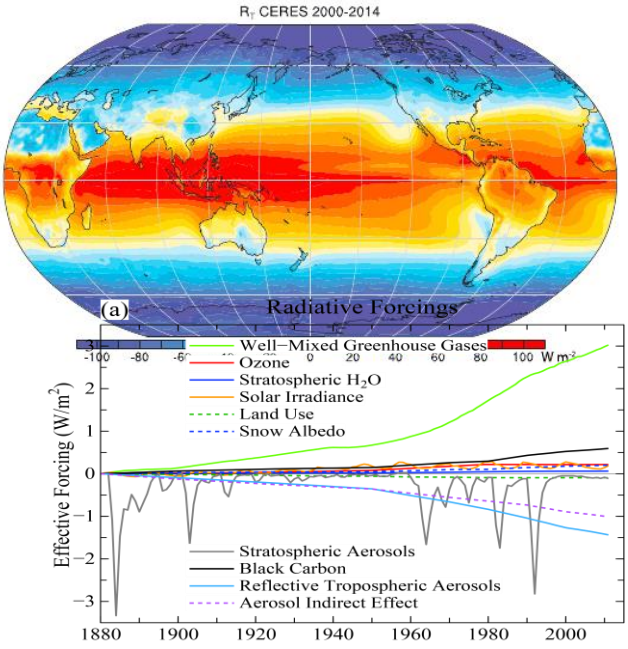
The two main terms in the Earth's energy balance are the absorption of solar radiation, which warms the Earth, and the emission of radiation, which cools it. Over fairly long time constants (tens to hundreds of years), the Earth's temperature adjusts so that these two terms compensate each other. Any change in one of these terms alters this quasi-equilibrium, resulting in a change in the Earth's temperature and therefore in its climate. As the absorption of solar radiation is not uniform over the Earth's surface, the radiation also influences the spatial distribution of the energy balance, which is positive in the equatorial regions and negative in the polar regions. This difference induces energy transport and thus circulation of the atmosphere and the ocean. Thus, energy exchange by radiation is one of the key drivers of climate.

After introducing these general concepts that provide a simplified global overview, I will present how human activities have modified these radiative exchanges and thus perturbed the climate in recent decades. I will emphasise the increase in the greenhouse effect due to the increase in CO2. Although its calculation is no longer a problem today, this effect is nevertheless complex and often poorly understood. I will present an analysis based on the concept of emission altitude, which allows us to grasp important elements of this complexity and to understand some paradoxes. Finally, I will conclude by mentioning other anthropogenic disturbances, the notion of radiative forcings which allows us to compare their amplitude, as well as some current research avenues on radiation issues.

Annual mean radiative budget at the top of the atmosphere. Positive values mean radiation warm the Earth. *[Trenbert & Fatsulo, 2017]*



Time evolution of individual radiative forcing at the tropopause (W/m^2) *[Miller et al. (2021)]*

References:

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