International Water Resources Association

Water Vapor: The Heat-Trapping GHG & Its Relationship to Global Water Resources

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Takeaways From This Presentation

Although not widely discussed, **water vapor is responsible for 41 - 67% of the heat trapped in our atmosphere**

CO2 & Methane accounts for another ~ 45% of the trapped heat

As the earth warms, the rate of evaporation and the amount of water vapor in the air both increase. Because water vapor is a greenhouse gas, this is causing further warming

For most latitudes, **global warming is reducing recharge to aquifers, which supplies almost ½ of the water consumed**

Composition of the Earth's Atmosphere

- The majority of the Earth's atmosphere is composed of a mixture of only a few gases-

  nitrogen, oxygen, and argon;

Combined, **these three gases comprise more than 99.5% of all the gas molecules in the atmosphere**

These gases exhibit almost no effect on warming the earth and its atmosphere since **they do not absorb visible or infrared radiation**

Water Vapor Traps More Heat Than Other GHGs

- **Only a portion of the remaining 0.5% is comprised of the heat-trapping GHGs, i.e., 0.43%:**

- Water vapor is the most important greenhouse gas overall, being responsible for 41–67% of the greenhouse effect, **but its global concentrations are not directly affected by human activity** (NOAA Carbon Cycle Greenhouse Gases Group 2024).

- **carbon dioxide (the second most important GHG**), methane, nitrous oxide, sulfur hexafluoride, & ozone are the main heat-trapping GHGs

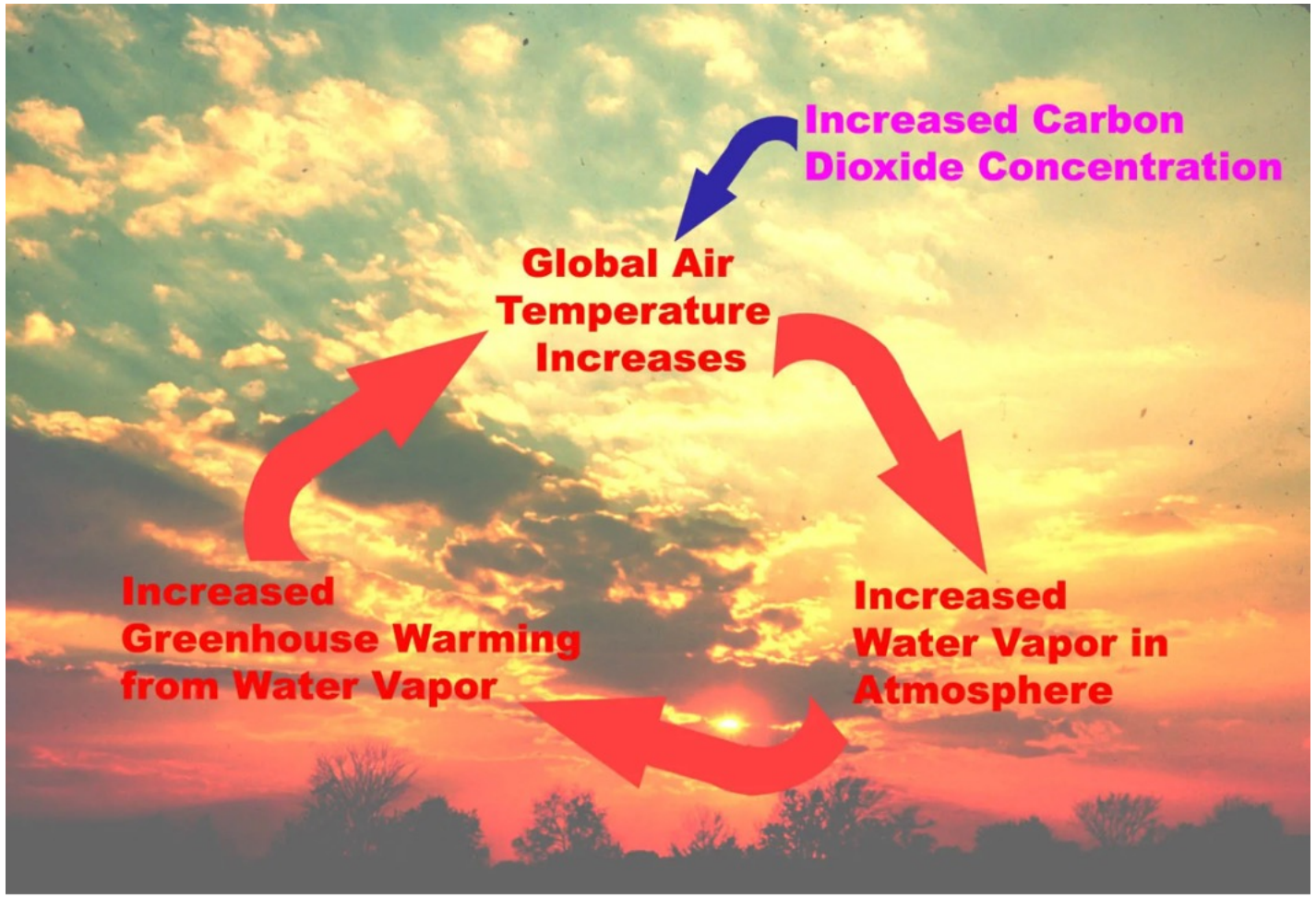
- Stated another way: **These GHGs contain the infrared radiation emitted by the Earth**

Water Vapor Traps More Heat Than Other GHGs

As the earth warms, the rate of evaporation and the amount of water vapor in the air both increase. Because water vapor is a greenhouse gas, this leads to further warming.

Water Vapor Increases as Temperatures Rise

(image from NASA website 8/28/24)



Everything is Heating Up

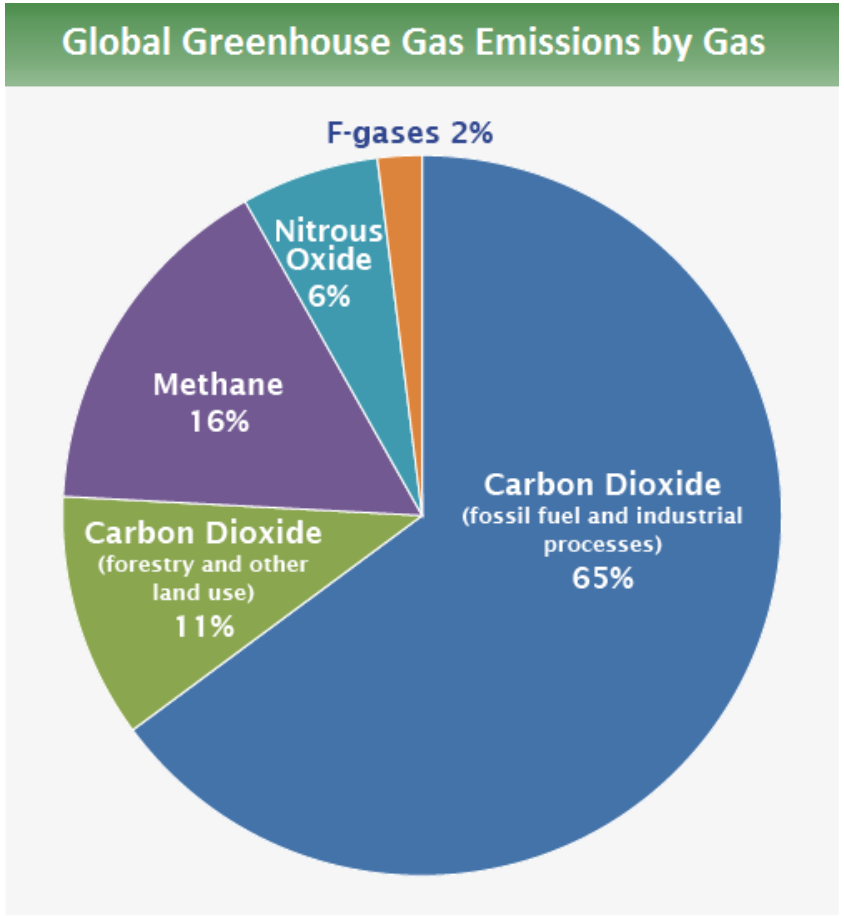
Greenhouse gas concentrations, the global temperature across land and the ocean, global sea level and ocean heat content all reached record highs in 2023, according to the 34th annual State of the Climate report

Total GHG Emissions in 2023 were 40.7B Tons

(Image from I*riedlingstein et al. 2023 Global Carbon Budget 2023. Earth System Science Data)*

This is the highest annual GHG total on record (Global Carbon Project, 12/5/23)

Carbon Dioxide & Methane are the 2 Largest Man-Made Heat Trapping GHGs



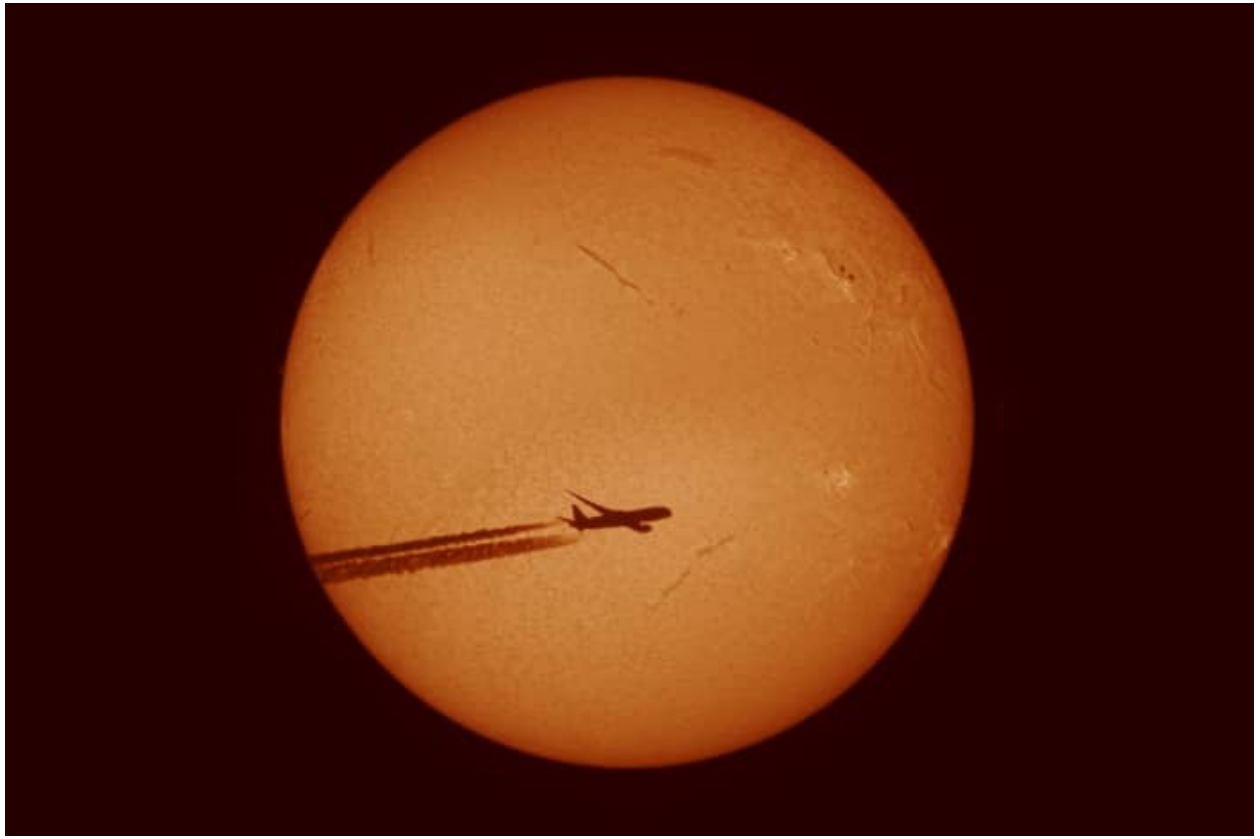
Water Vapor & Methane Trap Most of the Heat

Water vapor is the most important greenhouse gas overall, being responsible for 41–67% of the heat-trapping effect, or greenhouse effect

Methane is responsible for almost ½ (~45%) of the heat-trapping effect

Methane can trap 80 times as much heat as carbon dioxide in the first 20 years after its release into the atmosphere, before it is chemically broken down (IPCC).

Jet Condensation Trails



Jet Condensation Trails Form From Water Vapor

- Condensation trails, or “contrails” form when water vapor condenses around jet engine pollutants

- A report published in 2022 by the Intergovernmental Panel on Climate Change said that clouds formed from contrails account for about 57% of aviation’s global-warming impact.

Water Vapor's Adverse Effects on Global Water Resources

Water vapor, the most abundant heat-trapping GHG, traps about ½ (41 – 67%) of all the heat trapped by the various GHGs (CO_2 and CH_4 are the next biggest heat trappers)

As the oceans & ambient air heat up, we have less storms but the storms are more intense and result in more runoff and less recharge to the aquifers.

(There are arid areas where it has been shown that monsoonal rains can provide significant recharge to the aquifers if sufficiently permeable soils overlie the aquifers; however, for most latitudes and soil columns, recharge will decrease due to heating caused by GHG buildup.)

Water Vapor's Adverse Effects on Global Water Resources

More intense monsoonal rains increases the incidence of flooding, which causes property damage, loss of life, and the spread of pollutants outside of watercourses in floodplains and low-lying urban areas, where they leach into underlying groundwater supplies

More intense monsoonal rains overload municipal wastewater treatment plants (WWTPs), which causes uncontrolled releases of pollutants

Water Vapor's Adverse Effects on Global Water Resources
Global Warming Increases Seawater Intrusion Risk

- Rising sea levels from climate change coupled with the lowering of freshwater levels in drinking water wells results in **seawater intrusion** into coastal aquifers, rendering drinking water unsuitable for consumption due to high chloride concentrations.

- In some areas, climate change will cause drought, which will also increase the negative impact of seawater intrusion on coastal groundwater resources.

Water Vapor's Adverse Effects on Global Water Resources

Aside from the more intense monsoonal rains in most latitudes, some regions will experience prolonged drought

Prolonged drought decreases recharge to aquifers, which globally supplies almost half of all consumed water

Drought also leads to major fires, as has recently occurred on a large scale in Australia and Northern California

Summary

Although not as widely discussed, water vapor is responsible for 41 - 67% of the heat trapped in our atmosphere

CO2 & Methane accounts for another ~ 45% of the trapped heat

As the earth warms, the rate of evaporation and the amount of water vapor in the air both increase. Because water vapor is a greenhouse gas, this is causing further warming

For most latitudes, global warming is reducing recharge to aquifers, which supplies almost ½ of the water consumed

Questions?

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