The Latest Climate Science
Good News for Irish Agriculture!

Dublin, November 14, 2023

W. A. van Wijngaarden
York University, Toronto, Canada

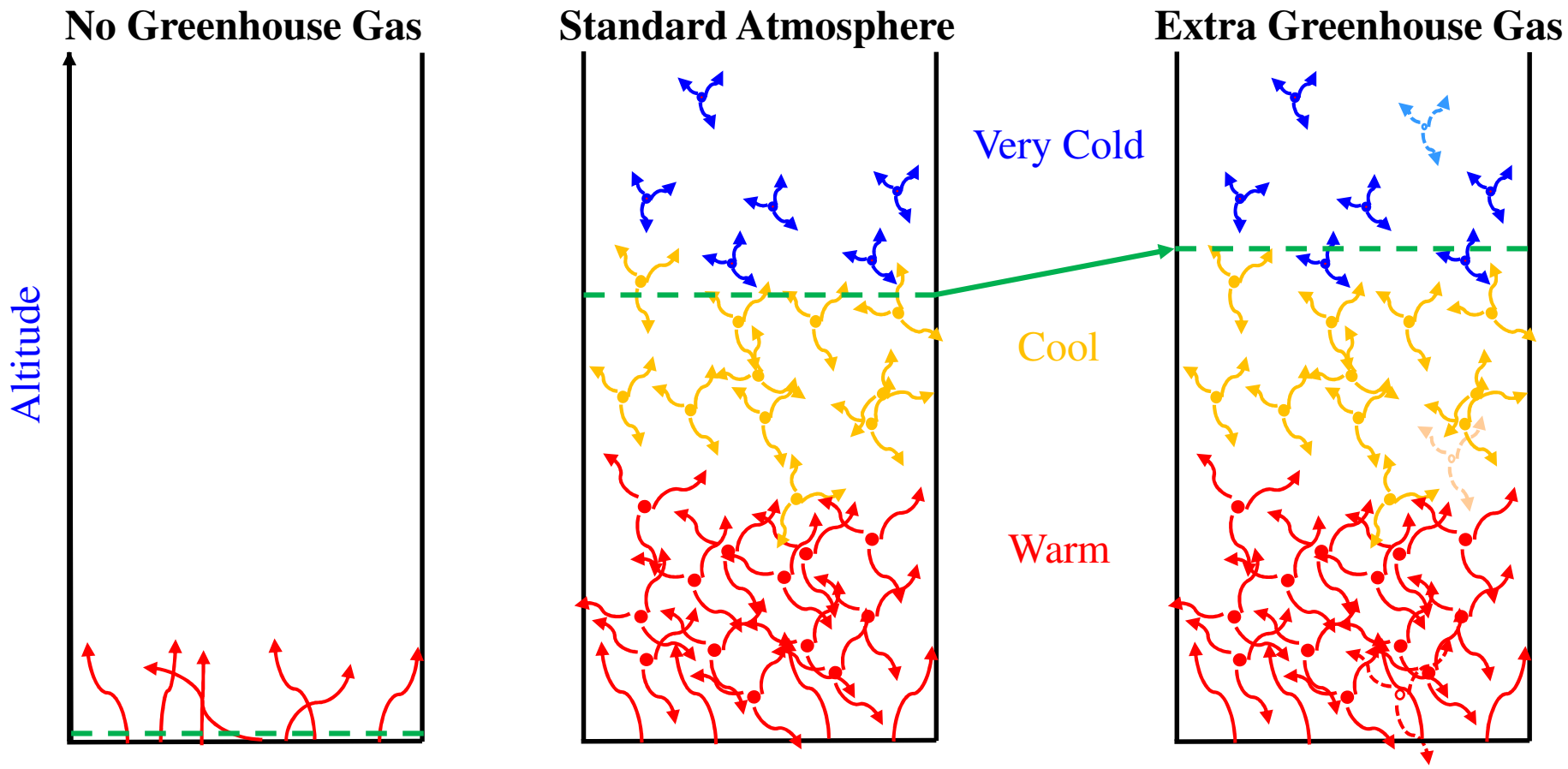
www.wvanwijngaarden.info.yorku.ca

Greenhouse Gas Molecules

WvW & WH, *Greenhouse Gas Primer,* Atmos. & Oceanic Phys, "arXiv: 2303.00808v1 (2023)

- Earth's surface & atmosphere radiates heat or infrared radiation.
- Greenhouse gases such as H_2O, CO_2, O_3, N_2O & CH_4 transmit sunlight but absorb various infrared colours.
- Our work calculates transmission of infrared radiation through atmosphere to outer space.

What is Greenhouse Effect?



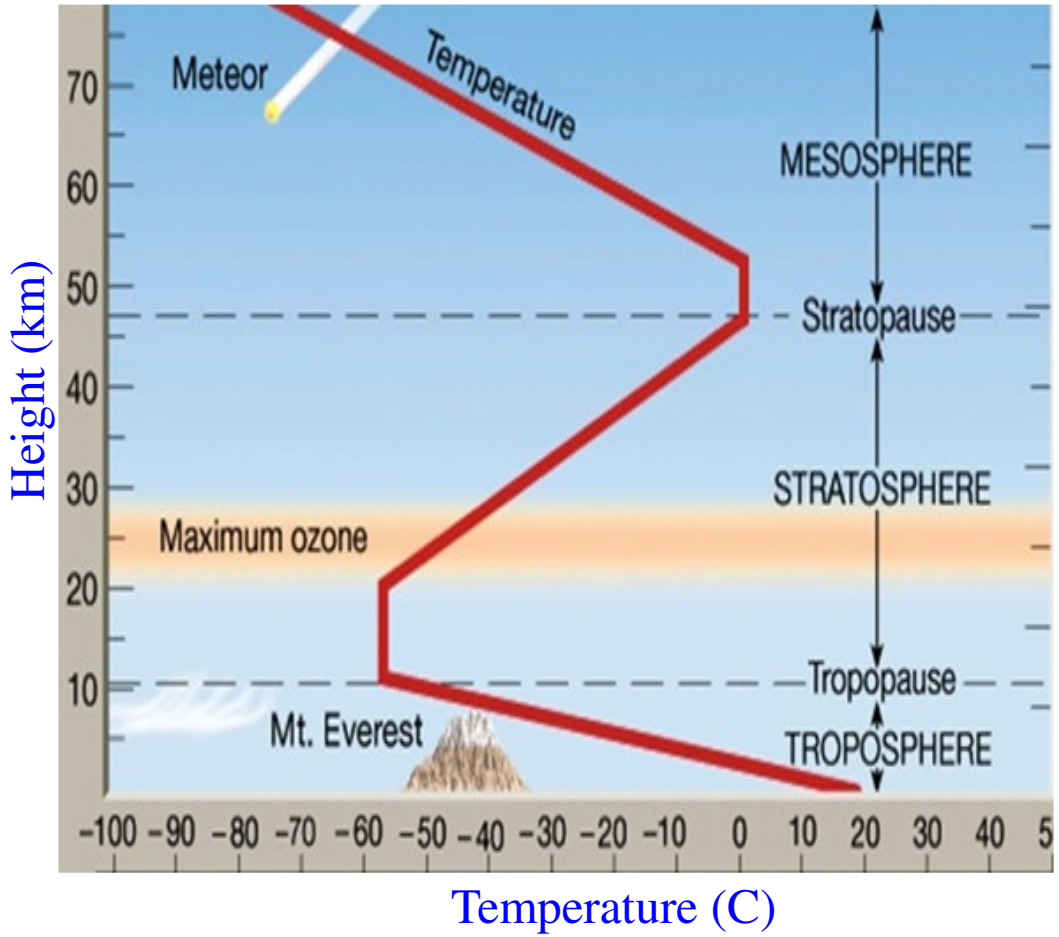
- Surface temperature = -20 C with no atmosphere
- Heat from surface escapes to space given by dashed green line

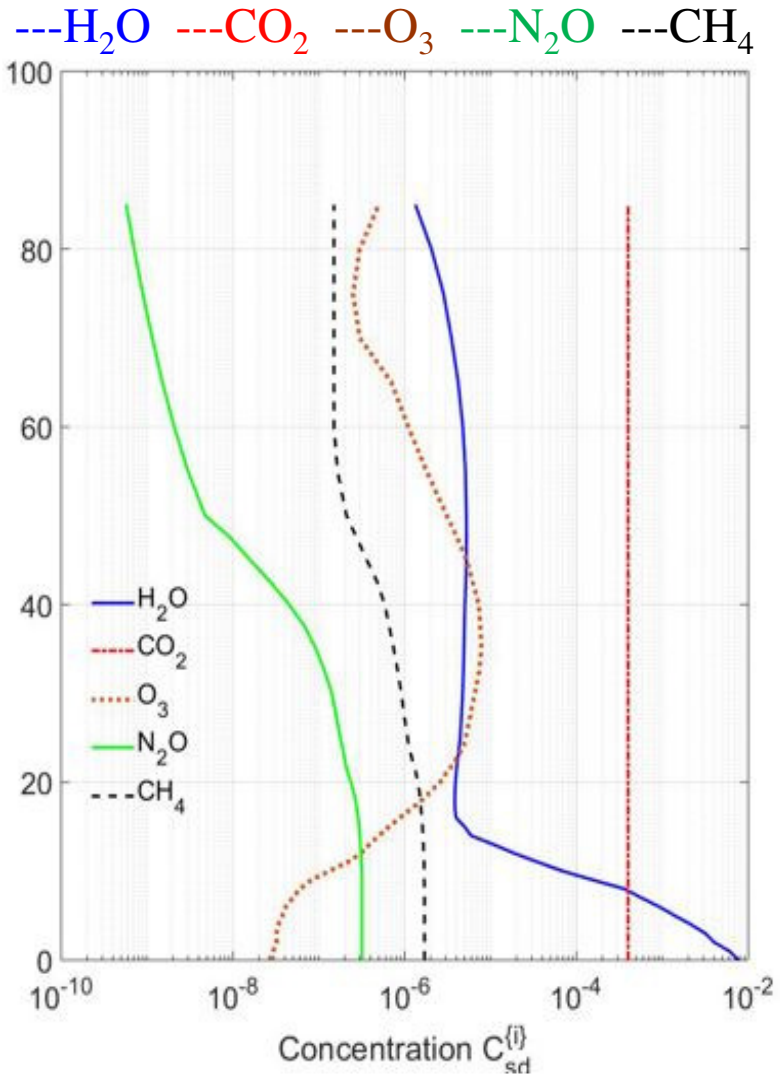
- Greenhouse gas absorb heat & radiate in all directions causing surface to warm
- Heat escapes to space at altitude where gas density is too low for absorption

- More greenhouse gas raises escape altitude
- Higher molecules are colder & radiate less heat to space
- Radiative Forcing = Incoming Solar Energy – Radiated Heat causes greenhouse warming

Atmosphere

G. Anderson et al, Air Force Geophys. Lab., Mass. (1986)



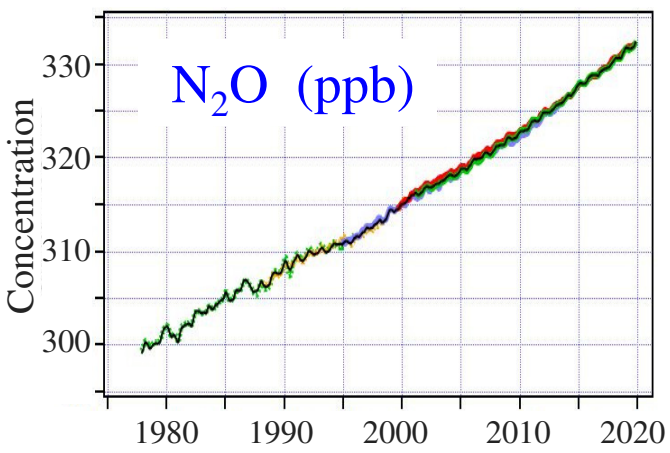


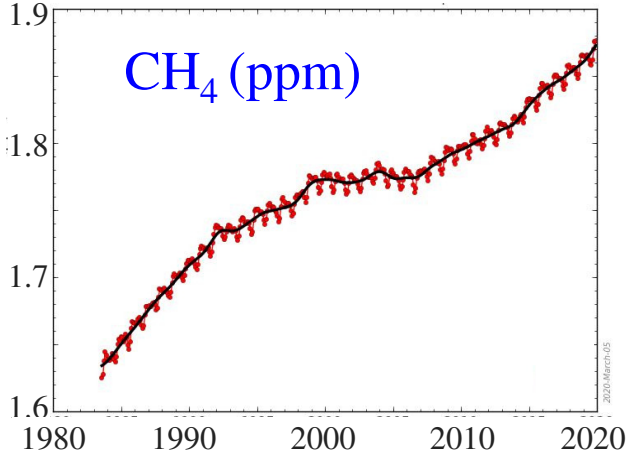
Surface Concentrations (ppm): $H_2O = 7750$, $CO_2 = 400$, $N_2O = 0.32$

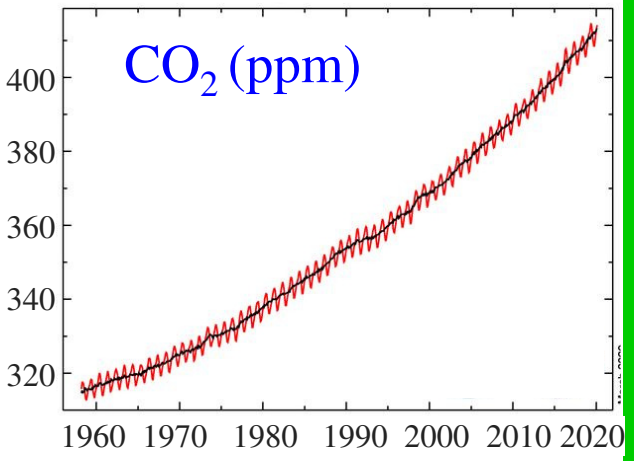
$CH_4 = 1.8$, $O_3 = 7.8$ at 35 km

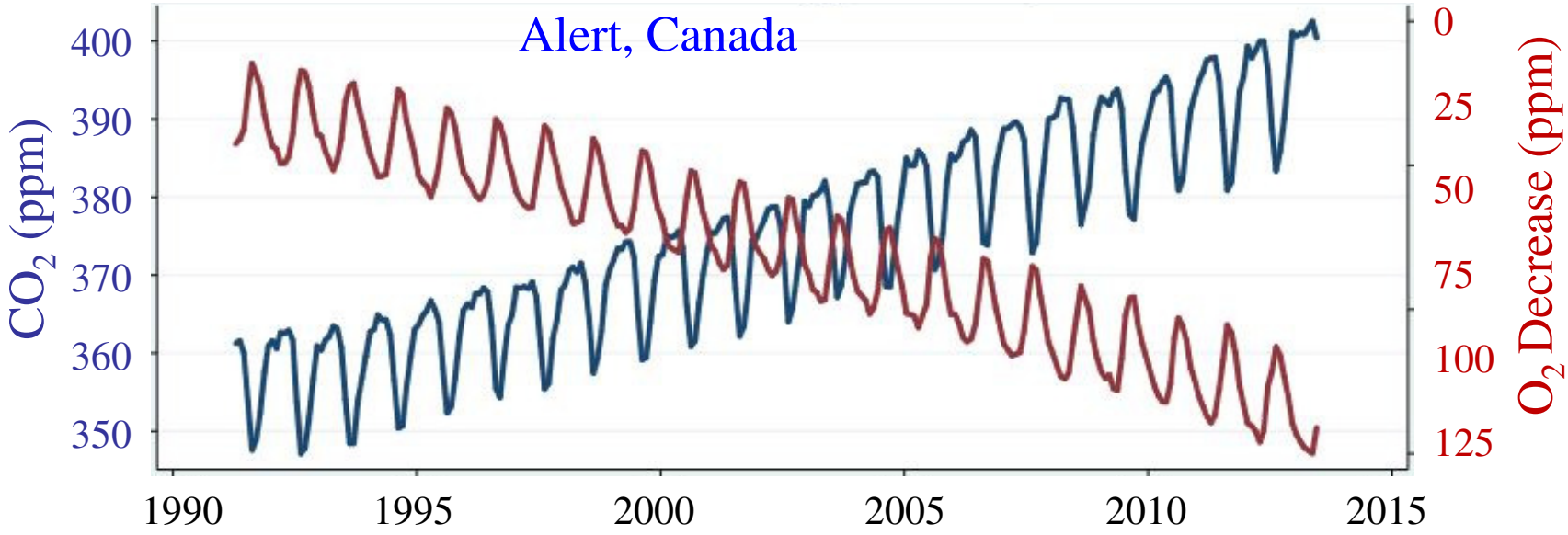
Increase in Greenhouse Gases

www.esrl.noaa.gov and scrippso2.ucsd.edu







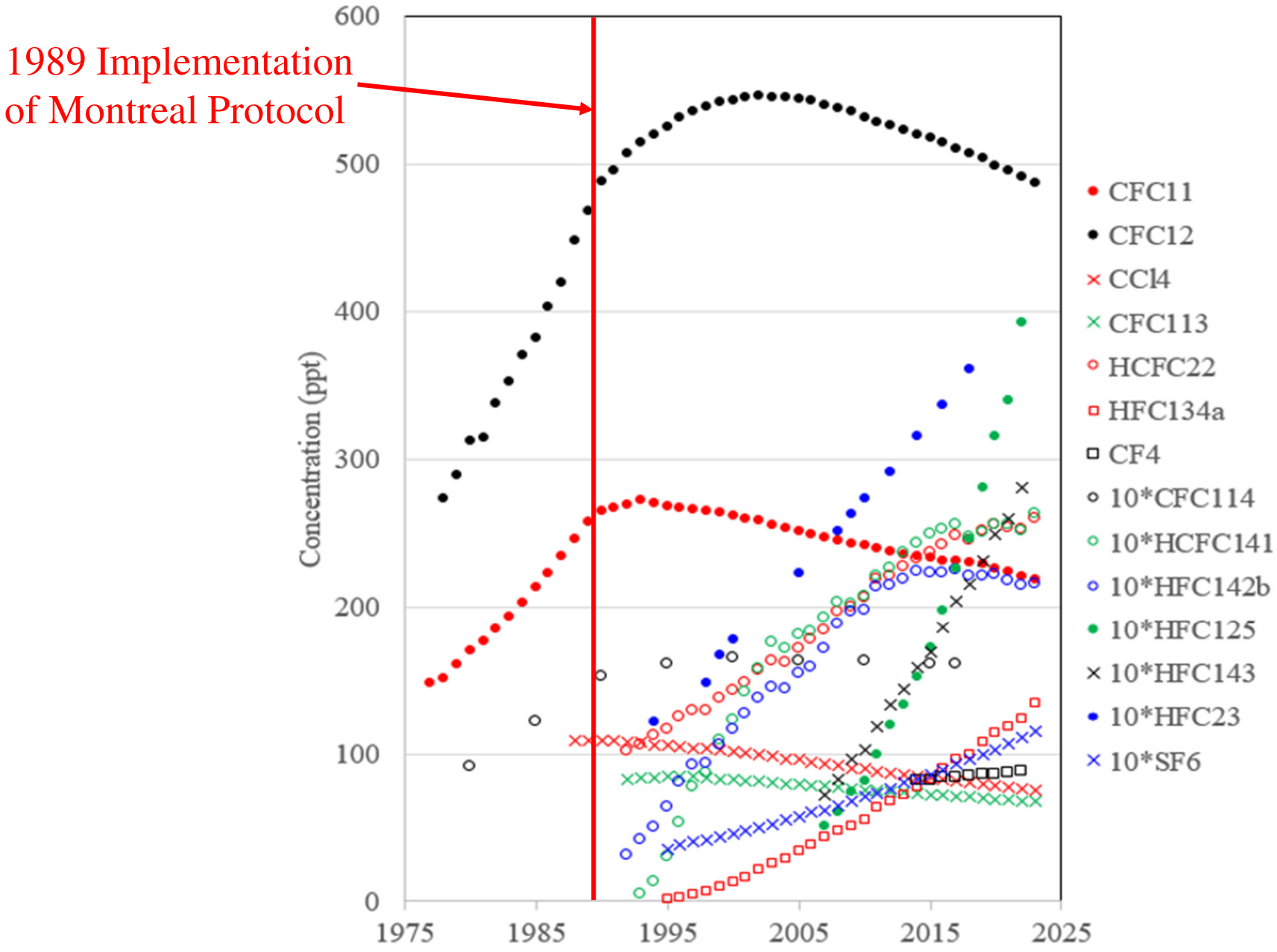


1991 – 2013: O_2 Decrease ~ 90 ppm > CO_2 Increase ~ 36 ppm

$\Rightarrow$ Significant CO_2 goes into oceans

Increase in Halogenated Greenhouse Gases

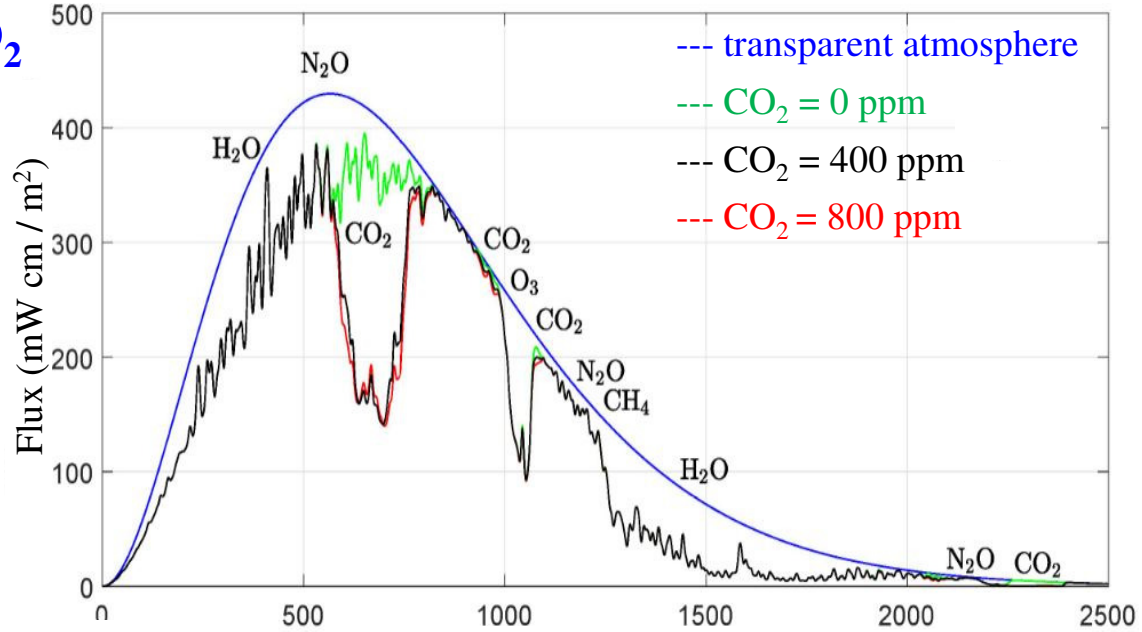
WvW & WH, *Inst. Clear Sky Rad. Forcings of Halogenated Gases*, Atmos. & Oceanic. Phys. arXiv: 2306.13642 (2023)



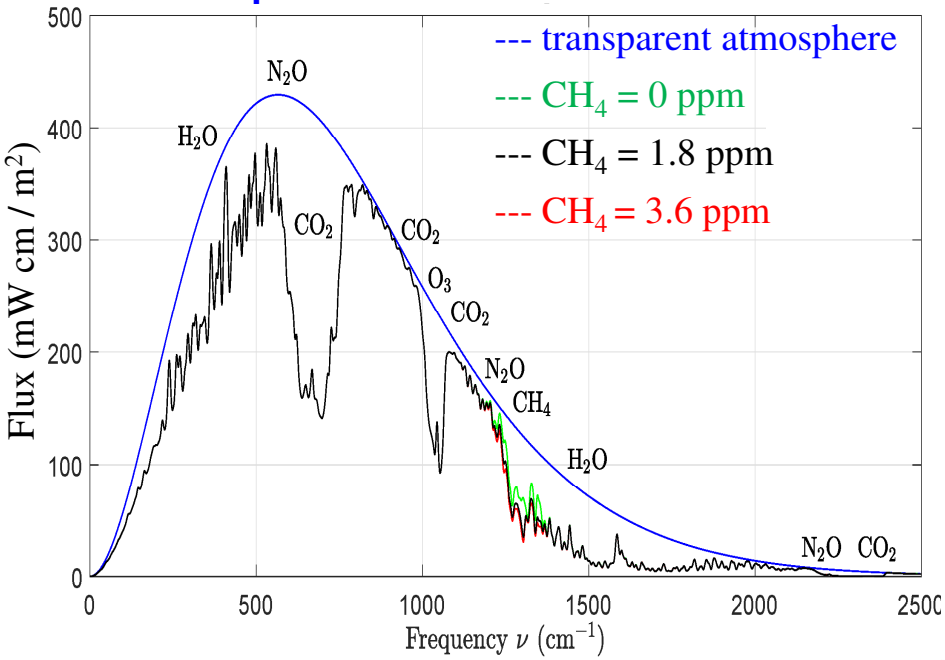
Top of Atmosphere Flux

WvW & WH, Atmos. & Oceanic Phys. arXiv: 2006.03098 (2020)

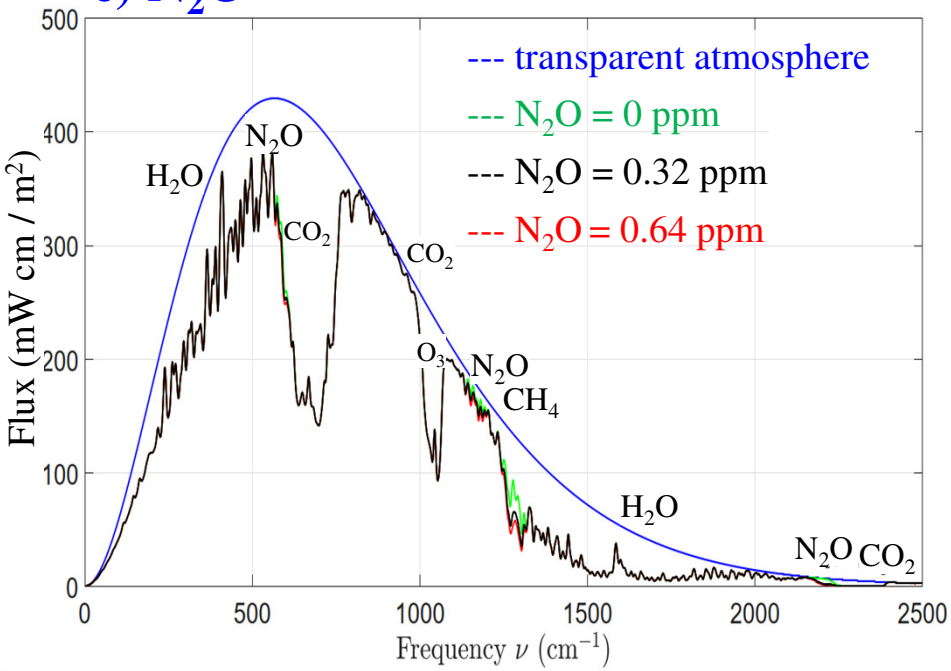
a) CO_2



b) CH_4



c) N_2O

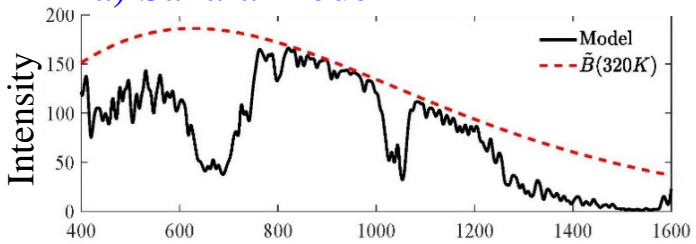


CLEAR SKY Model Comparison to Observations

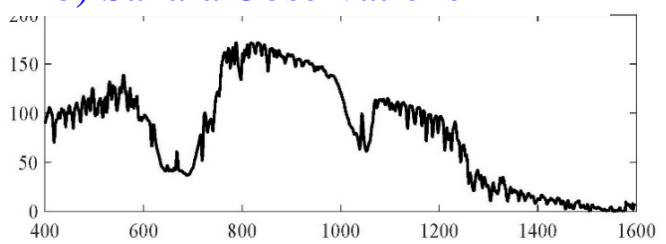
a) Satellite Upwelling

b) Surface Downwelling

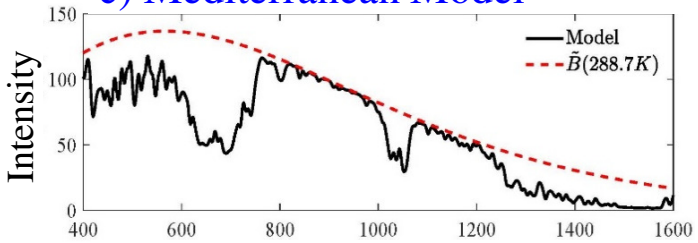
a) Sahara Model



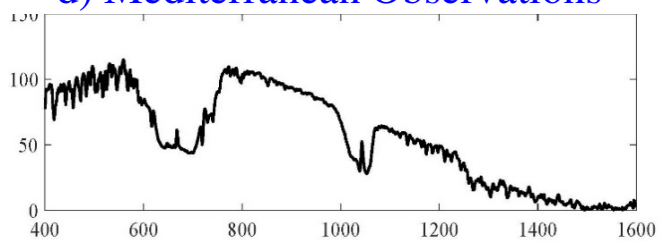
b) Sahara Observations



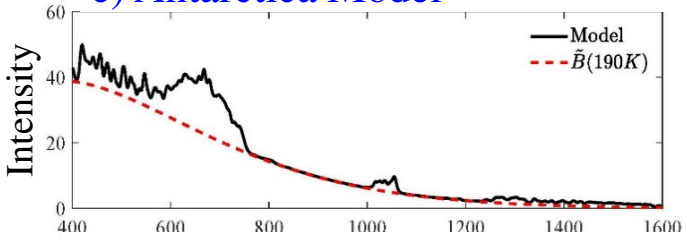
c) Mediterranean Model



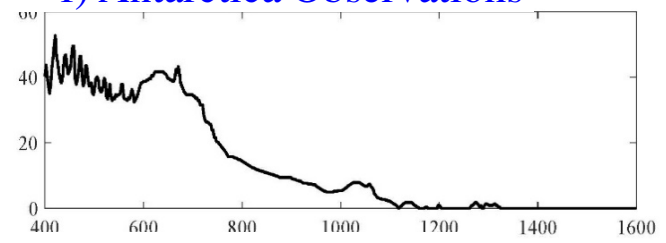
d) Mediterranean Observations



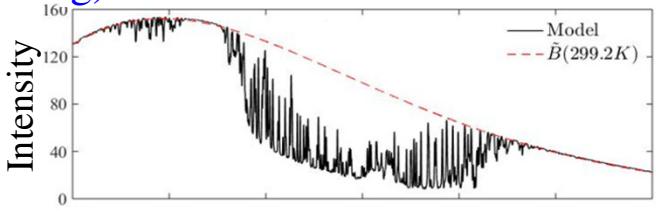
e) Antarctica Model



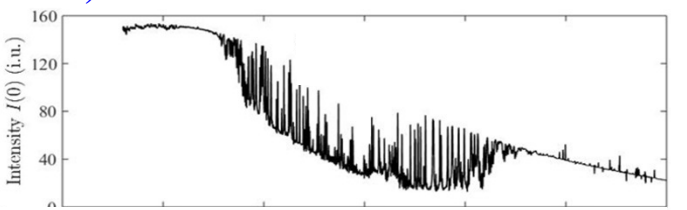
f) Antarctica Observations



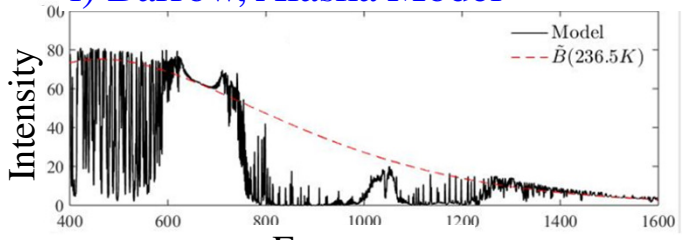
g) Nauru Model



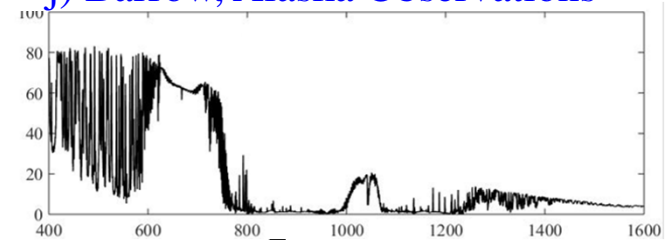
h) Nauru Observations



i) Barrow, Alaska Model

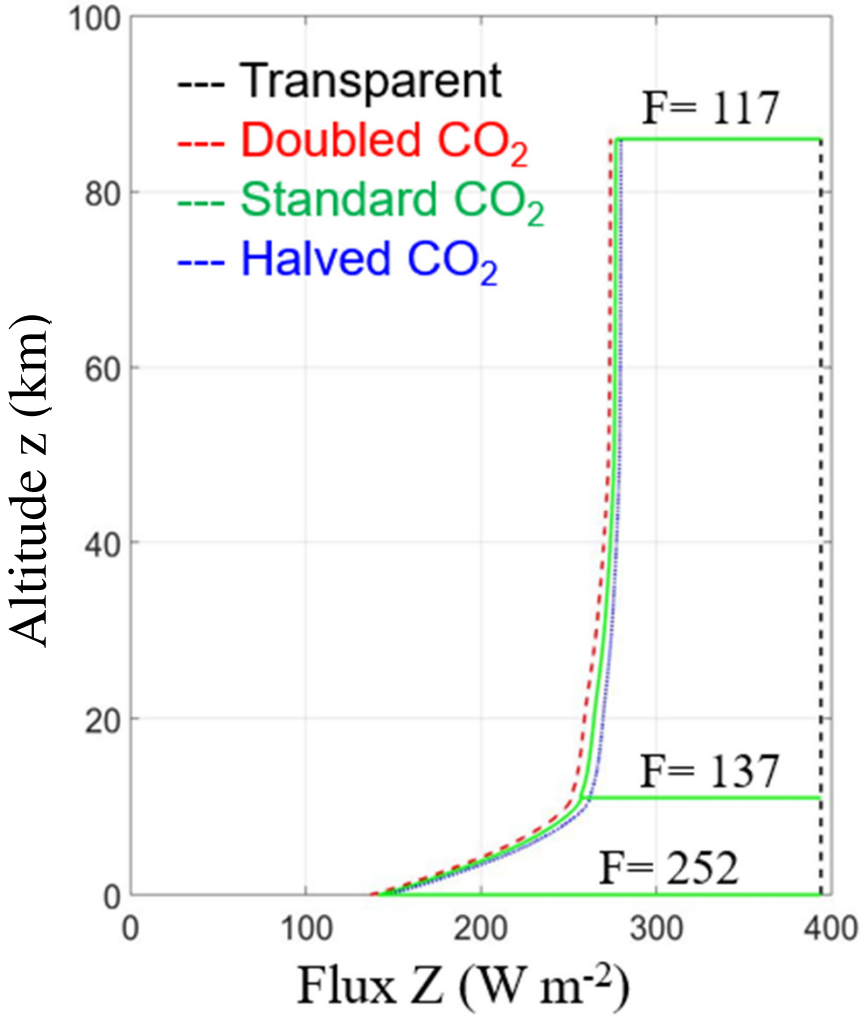


j) Barrow, Alaska Observations



Frequency Integrated Flux vs. Altitude

WvW & WH, Atmos. & Oceanic Phys arXiv: 200603098 (2020)



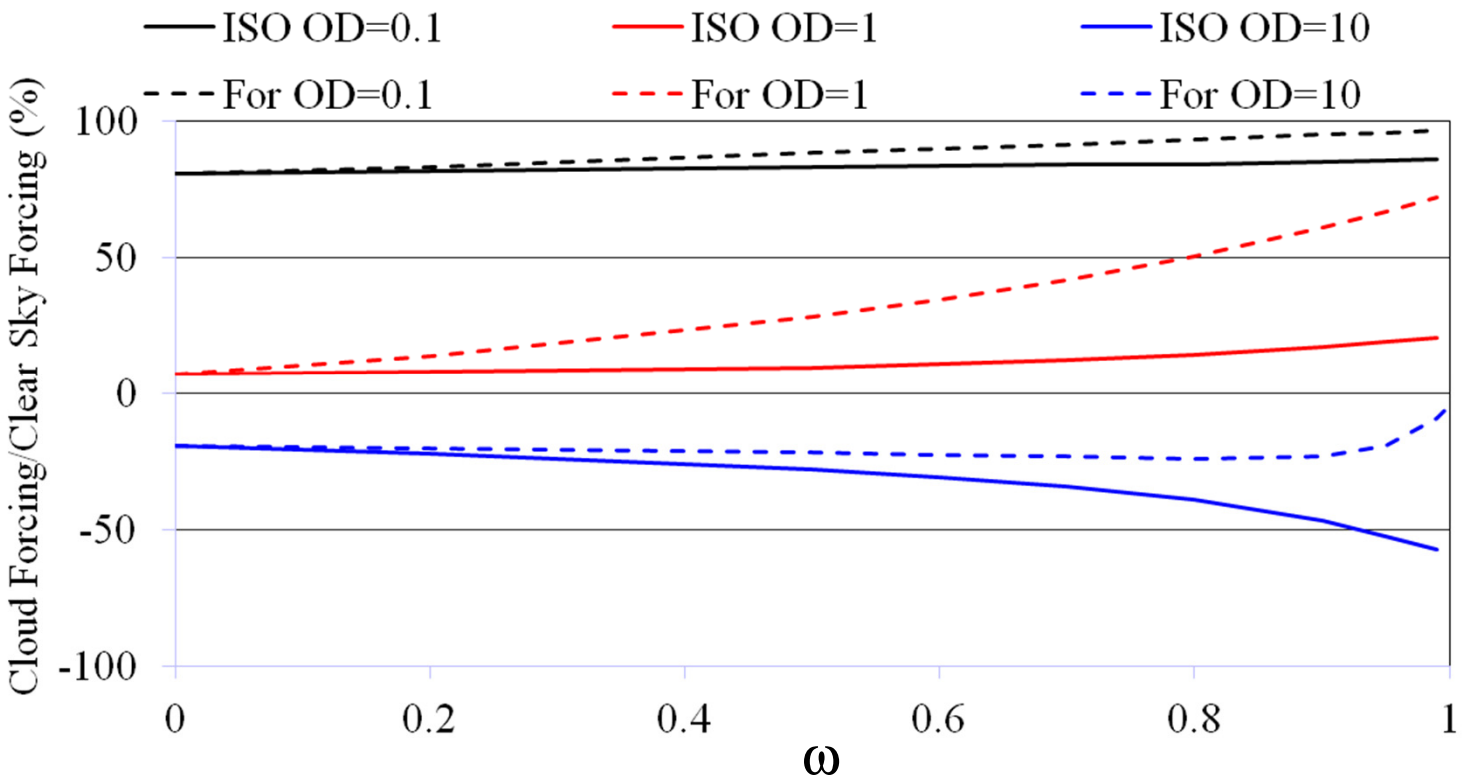
Greenhouse Gas Increase	Forcing (W/m^2)	
	Collins*	This Work
+6% H_2O	1.1	0.7
2 x CO_2	2.8	3.0
2 x N_2O	1.2	1.1
2 X CH_4	0.6	0.7
+10% O_3		0.3

*W. Collins et al, J. Geophys. Res. **111**, D14317 (2006)

Forcing = Flux(CO_2) – Flux (2*CO_2)
= 3.0 W / m^2

Preliminary Work: Effect of Cloud Layer at 11 km on TOA Forcing due to Doubling CO_2

- Cloud layer with optical depth (OD) scatters with single scattering albedo (ω)
- Scattering is isotropic (ISO) or strongly in forward (FOR) directions



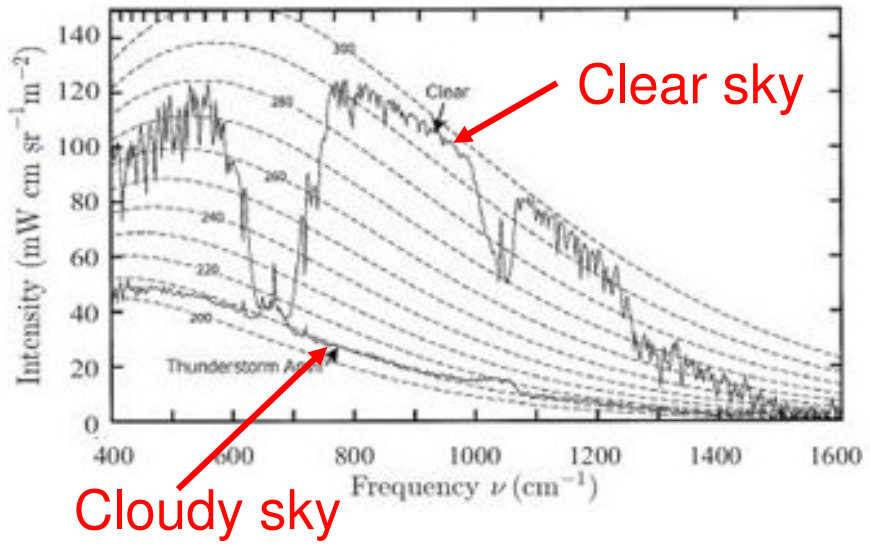
Clouds significantly reduce greenhouse gas forcing.

Forcing is negative for thick high altitude cloud!

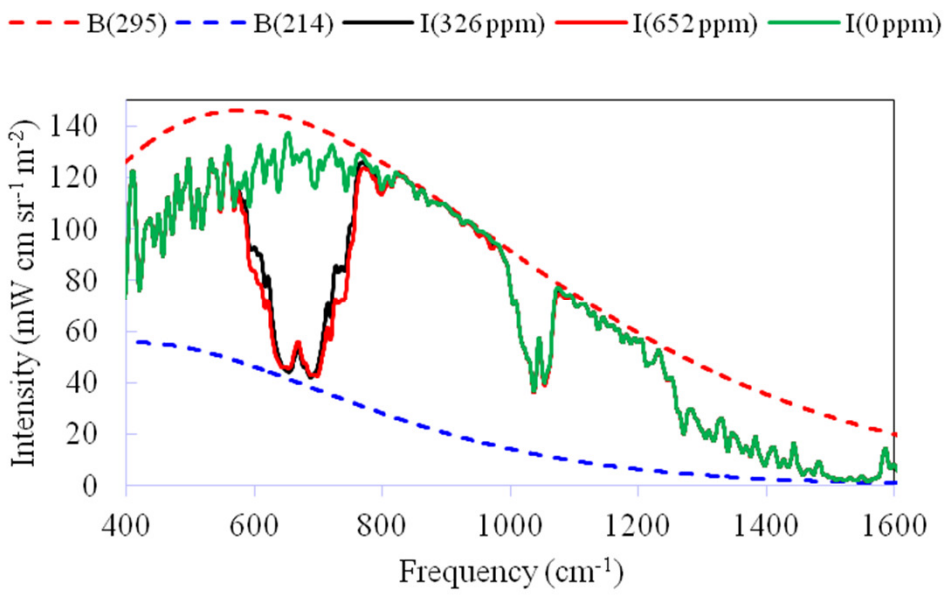
Effect of Thick Clouds – Western Pacific

WvW & W. Happer, *2n-Stream Therm. Emis. from Clo*uds, Atmos. & Oceanic Phys. arXiv: 2301.08129 (2023)

a) Nimbus Satellite Observations Western Pacific

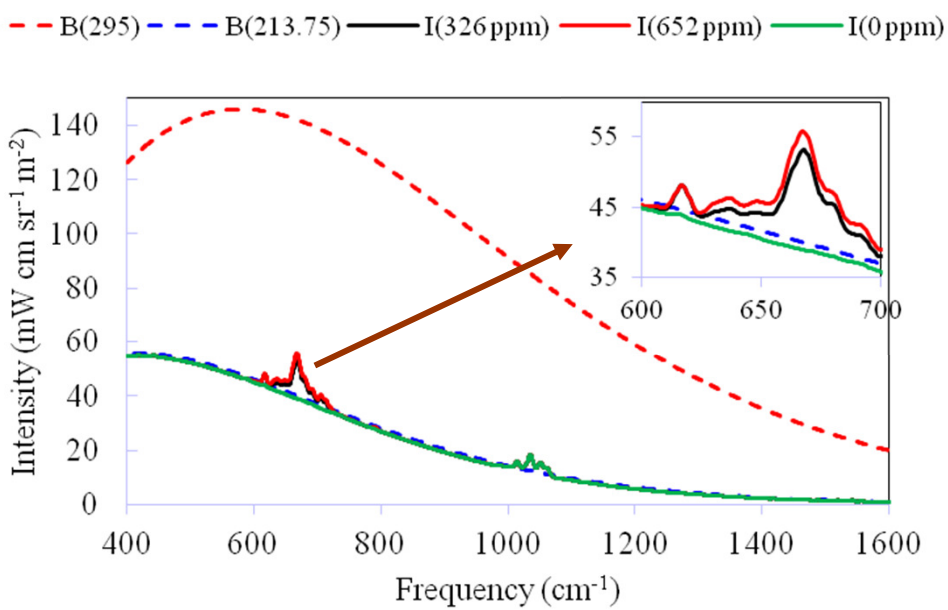


b) Clear Sky Model



Clear Sky 2 x CO_2 Forcing = +3.15 W/m^2

c) Clouds at 11-13 km, Opt. Depth = 20



Cloudy Sky 2 x CO_2 Forcing = -0.58 W/m^2

Clouds & Climate Change

- Clouds cover about 70% of Earth
- Climate effect highly uncertain & reason why IPCC warming estimate due to CO_2 doubling not improved

IPCC Report	Climate Sensitivity (C)
1990	1.5 - 4.5
1996	1.5 – 4.5
2001	1.5 – 4.5
2007	2.0 – 4.5
2014	1.5 – 4.5
2021	2.5 – 4.0

- Radiative forcing due to doubling CO_2 = 3 W/m^2 about 1% of heat flux to space. This could be compensated for by small changes in cloud thickness, altitude etc.

Le Chatelier: When system at equilibrium subjected to change in concentration, temperature, volume or pressure, system changes to new equilibrium & this change partly counteracts applied change.

Global Warming Potential

C. de Lange, J. Ferguson, WH & WvW, *Nitrous Oxide & Climate*, *Atmos & Oceanic Phys* arXiv 2211.15780 (2022)

Introduced by IPCC in attempt to show warming of greenhouse gas relative to CO_2.

$$GWP_i(T) = \frac{P_i / m_i}{P_{CO2} / m_{CO2}} \frac{\theta_i(T)}{\theta_{CO2}(T)} \quad \text{where } \theta_i = \int_0^T e^{-t/\tau_i}\, dt$$

P_i = **clear sky** forcing in W/m^2 divided by column density # molecules/m^2 of gas i

m_i = mass of molecule i

τ_i = atmospheric lifetime of molecule i

Gas	$\frac{P_i}{P_{CO2}}$	m_i (amu)	τ_i (yr)	This Work			IPCC 2022	
				GWP(0)	GWP(20)	GWP(100)	GWP(20)	GWP(100)
CO_2	1	44	**	1	1	1	1	1
CH_4	31	16	12	85.5	53.9	19.2	83 ± 26*	30 ± 11*
N_2O	233	44	109	233	279	290	273 ± 118	273 ± 130

**Multiple lifetimes due to various CO_2 removal processes

*Includes indirect effects of CH_4 oxidizing products CO_2 & H_2O

Greenhouse Gas Contribution to 21st Century Warming

WvW & WH, *Instantaneous Clear Sky Rad. Forcings of Halogenated Gases*",
Atmos. & Oceanic Phys, arXiv: 4971146 (2023)

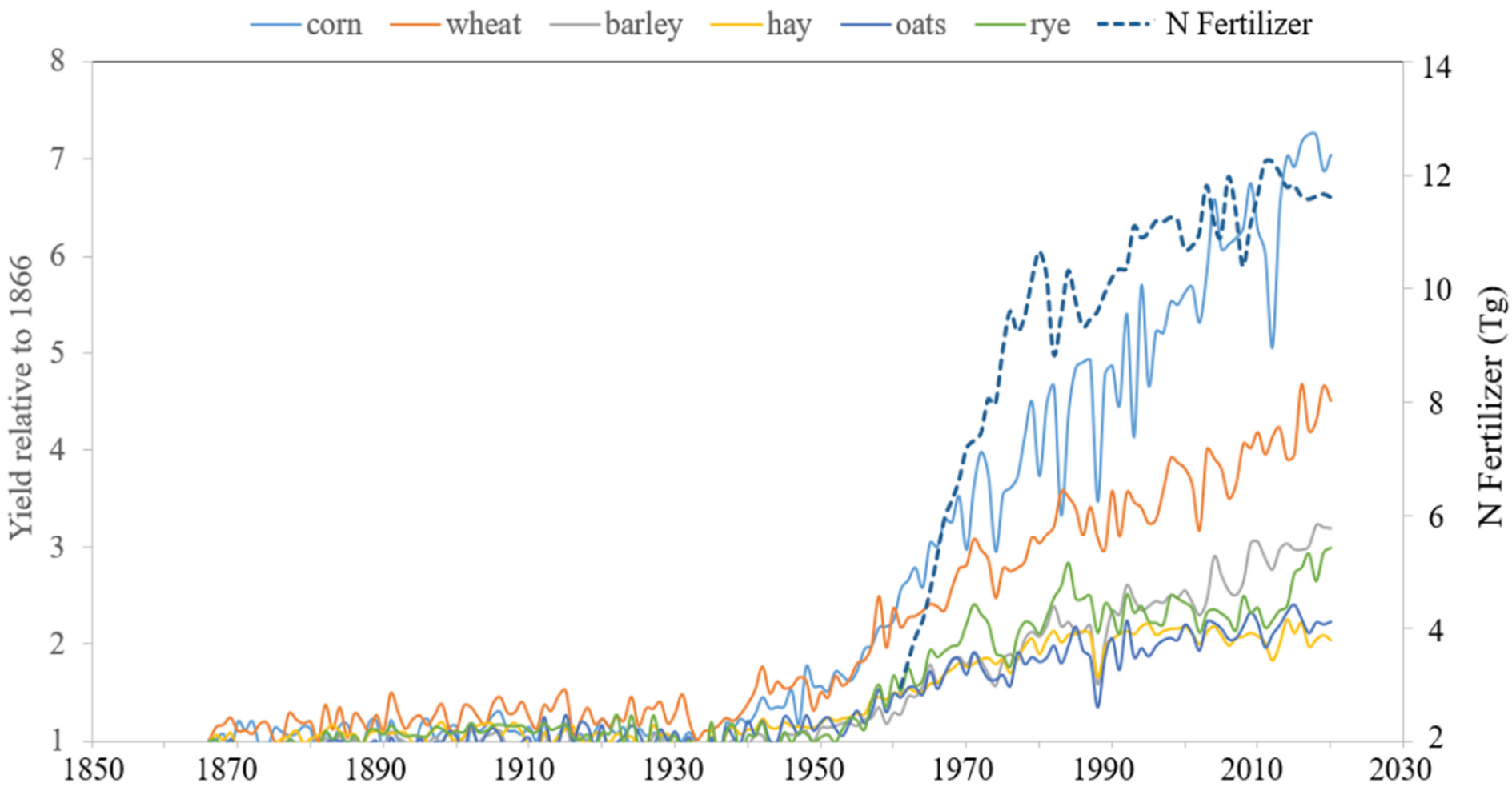
Assumptions

1. Greenhouse gas increase at observed 2000-2020 rates
2. Same warming in 21st century as in 20th century ~ 1 K/century
3. All warming due to greenhouse gas increase
   i.e. Neglect all other effects such as warming due to end of Little Ice Age
4. Greenhouse gas warming proportional to its **clear sky** forcing increase

Gas i	$\mathbf{C^i}$ (ppm)	$\frac{dC^i/dt}{dC^{CO2}/dt}$	$\frac{\boldsymbol{P_i}}{\boldsymbol{P_{CO2}}}$	$\frac{\partial \boldsymbol{T^i}}{\partial \boldsymbol{t}}$ (K/Century)
CO_2	410	1	1	0.834
CH_4	1.9	$\frac{1}{312}$	31	0.083
N_2O	0.34	$\frac{1}{3125}$	233	0.062
Halogenated Gases				0.021
				$\sum_i \frac{\partial T^i}{\partial t} = 1.0$

Effect of N Fertilizer on Crop Yield

US Crop Yields www.nass.usda.gov/Publications/Todays_Reports/croptr19

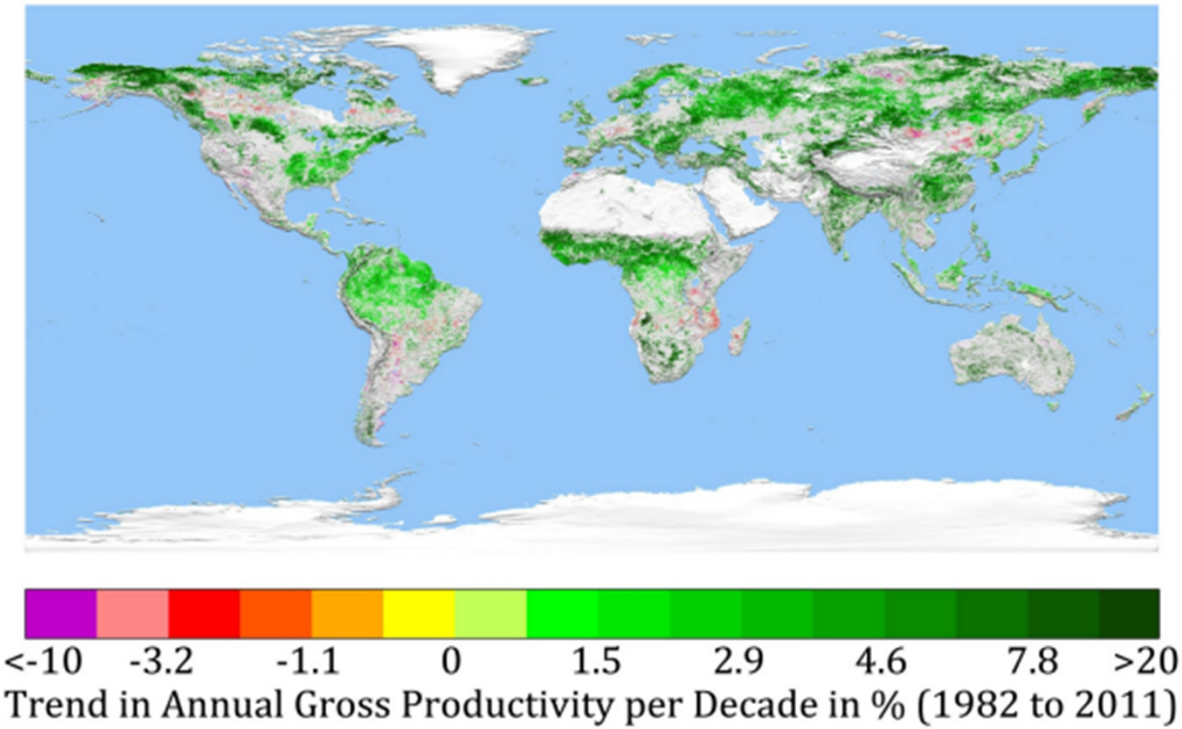


Outlawing fertilizer use to stop atmospheric N_2O increase threatens world food supply and reduces temperature rise by < 0.1 C per century!

Vegetative Response

- Increased growth may reduce rate of CO_2 increase
  C. Idso, Energy & Env. **12**, No. 4, 287 (2001)

Greening Earth: Spatial Patterns



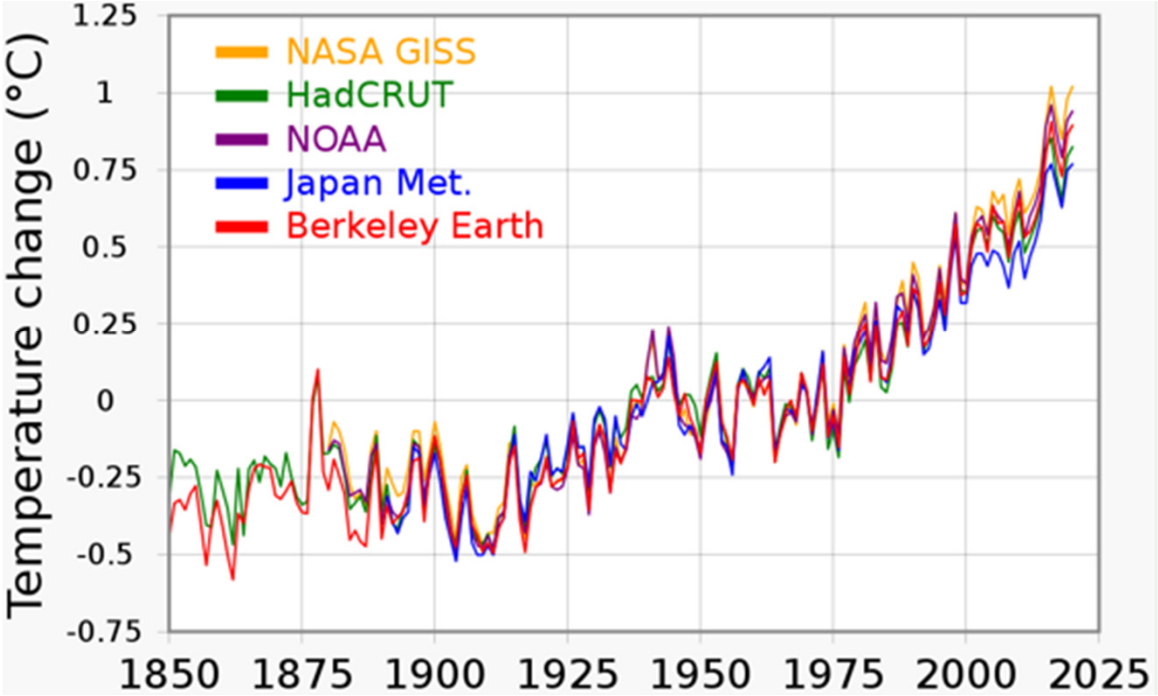
- More CO_2
  $\Rightarrow$ smaller stomata reducing water loss

$\Rightarrow$ easier for plants to grow in arid regions
Z. Zhu et al, Nature Climate Change **7**, 791 (2016)

Global Average Surface Temperature

Warming $\Delta T = S \, Log_2 \, C/C_o$ where $C = CO_2$ concentration at time t

C_o = original CO_2 concentration



Interval	ΔT_{obs} (C)	CO_2 (ppm)	S_{calc} (C)	$S_{IPCC\ 2021}$(C)
1905 - 1940	0.5	298 - 311	8	3
1940 – 1980	0	311 – 339	0	
1980 – 2000	0.5	339 – 370	4	
2000 – 2016	0	370 - 404	0	

- Global Climate Models failed to predict 2000 – 2016 hiatus.
- There is more going on than just CO_2!

Conclusions

- Extrapolating observed warming of 1 C since 1850 to 21st century & using clear sky forcings which are higher than when cloud effects are considered gives:

Gas	Global Warming C / Century	Irish Emissions Fraction	Irish Warming C/Century
CO_2	0.83	1.1×10^{-3}	9.0×10^{-4}
CH_4	0.08	1.6×10^{-3}	1.3×10^{-4}
N_2O	0.06	1.9×10^{-3}	1.2×10^{-4}
Total Warming	**1.0**		**0.0012**

- Evidence doesn't support hysteria about: droughts/floods, polar ice/glacier retreat, sea level rise, ocean acidification, forest fires etc.
  - WvW, *Impact of Changing Greenhouse Gas Conc. on Ontario's Climate*, Atmos. & Oceanic Phys arXiv: 2305.05500 (2023) wvanwijngaarden.info.yorku.ca
  - *US Farmers Defy a Scorching Summer to Grow Record Crop*, climatedepot.com

- Outlawing fertilizers negligibly affects climate & endangers global food supply
- Beware of unintended consequences. eg. Replacing food produced efficiently by Irish farmers with that grown in Brazil will destroy Amazonian rainforest
- World not close to climate crisis in < 10 or even 100 years