End-Permian Mass Extinction

AOSC 680

Ross Salawitch

Class Web Sites:
http://www2.atmos.umd.edu/~rjs/class/fall2024
https://umd.instructure.com/courses/1367293

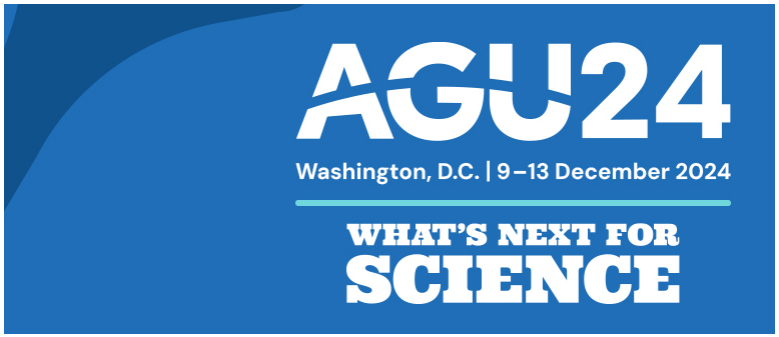
https://en.wikipedia.org/wiki/Siberian_Traps

Lecture 23

20 November 2024

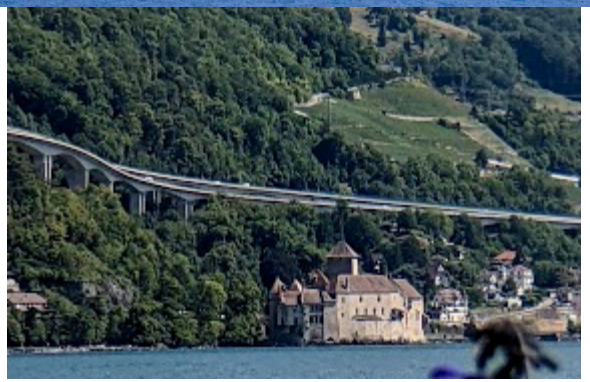
Announcement

11/21	The End-Permian Mass Extinction	**Chapter 4** of *Ends of the World*, Brannen to be handed out in class 38 pages	AT 23	Lecture 23: **Sam**			
11/26	The End-Ordovician Mass Extinction	**Chapter 2** of *Ends of the World*, Brannen to be handed out in class 44 pages	AT 24	Lecture 24: **Kyle**			
12/03 **We will need to start early or go late**	Student Presentations, Day 1		No AT	Presentations students 1 to 7	Each Presentation is 12 minutes, with 3 mins for discussion. 7 x 15 = 105 minutes Paper due 4 Dec, 11:59 pm		
12/05 **We will need to start early or go late**	Student Presentations, Day 2		No AT	Presentations students 8 to 14	Each Presentation is 12 minutes, with 3 mins for discussion. 7 x 15 = 105 minutes Paper due Dec 6, 11:59 pm		



Last Day of Classes	December 9 (Monday)
Reading Day	December 10 (Tuesday)
Final Exams	December 11-17 (Wednesday-Tuesday)

Castle



Darkness

Darkness

I had a dream, which was not all a dream.
The bright sun was extinguish'd, and the stars
Did wander darkling in the eternal space,
Rayless, and pathless, and the icy earth

Happy were those who dwelt within the eye
Of the volcanos, and their mountain-torch:
A fearful hope was all the world contain'd;
Forests were set on fire--but hour by hour
They fell and faded--and the crackling trunks

All earth was but one thought--and that was death

https://allpoetry.com/poem/8511087-Darkness-by-George-Gordon-Byron
https://en.wikipedia.org/wiki/Lord_Byron

Einstein Tower

The **Einstein Tower** (German: *Einsteinturm*) is an astrophysical observatory in the Albert Einstein Science Park in Potsdam, Germany built by architect Erich Mendelsohn.[3] It was built on the summit of the Potsdam *Telegraphenberg* to house a solar telescope designed by the astronomer Erwin Finlay-Freundlich. The telescope supports experiments and observations to validate (or disprove) Albert Einstein's relativity theory.

https://en.wikipedia.org/wiki/Einstein_Tower

Stones From Six Continents

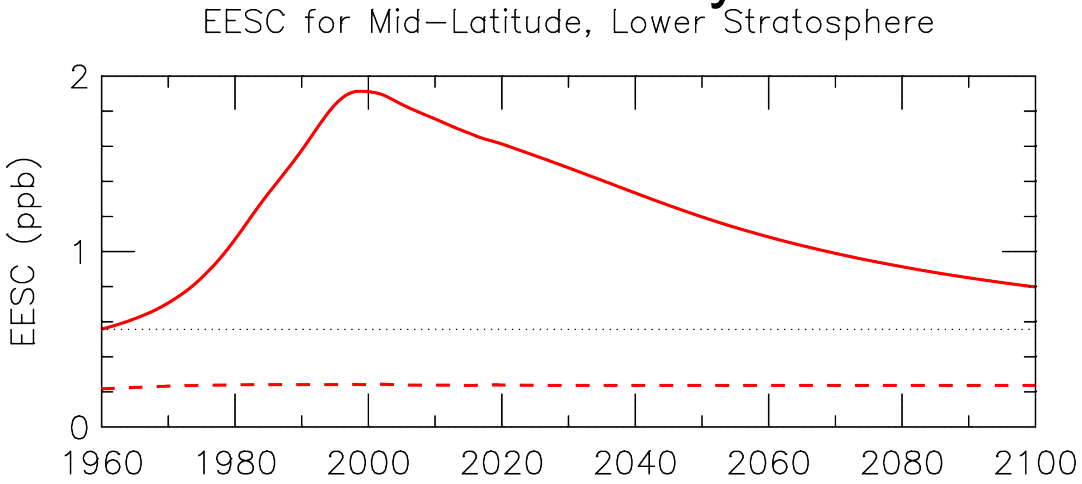
Montreal Protocol

chemicals showed the ozone layer almost disappearing from the planet entirely by the 2060s, an unimaginable situation that would have doubled UV radiation at the planet's surface and spawned a global wave of lethal mutations and cancers.

International negotiations managed to stave off the prospect of life-threatening radiation by midcentury, but the effort to stanch the hemorrhage of greenhouse gases into the atmosphere has been woefully inadequate, despite similarly alarming computer model simulations of business as usual. This is because the halocarbons covered under the Montreal Protocol (some of the same chemicals that would have boiled out of Russia at the End-Permian) are a rather niche group of industrial chemicals, amenable to global regulation and replaceable by a slew of viable, market-ready alternatives. By contrast, the entire global economy is based on the combustion of fossil fuels, which, unnervingly, might have been the most important component of the End-Permian guillotine. Burning coal, oil, and gas has underwritten the very flourishing of humanity since the Industrial Revolution.

Peter Brannen, *The Ends Of The World*

Recovery of the Ozone Layer



EESC for mid-latitude, lower stratospheric air based on direct atmospheric observation of halogens up to 2022 and future projections that include estimates of emissions from **banks**, **feedstock use**, plus the **lifetime** for removal of each halocarbon, as given in **Table 6-4, WMO/UNEP 2018**

EESC: Equivalent Effective Stratospheric Chlorine
Metric that reflects stratospheric chlorine & bromine concentrations due to decomposition of ozone depleting substances (ODSs) such as CFCs, halons, etc.

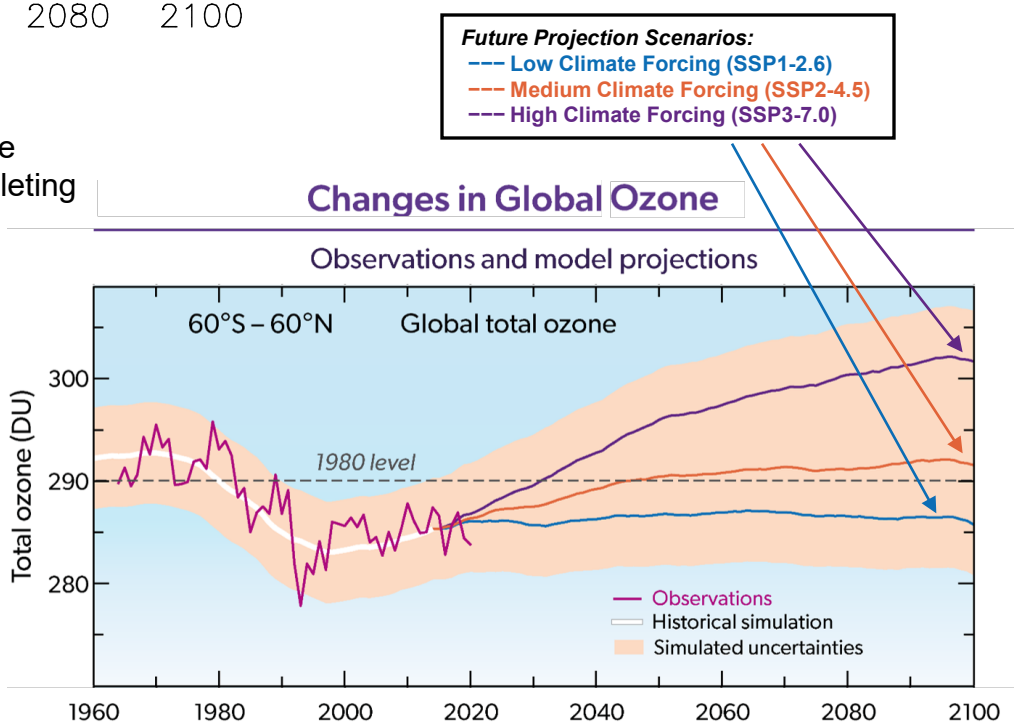


Fig Q20-1, WMO/UNEP Twenty QAs Ozone

Montreal Protocol

Q18 Are Montreal Protocol controls of ozone-depleting substances also helping protect Earth's climate?

Yes. Many ozone-depleting substances (ODSs) are also potent greenhouse gases that contribute to global warming when they accumulate in the atmosphere. Montreal Protocol controls have led to a substantial reduction in the emissions of ODSs over the last two decades. These reductions, while protecting the ozone layer, have the additional benefit of reducing the human contribution to climate change. Without Montreal Protocol controls, the global warming due to ODSs could now be nearly three times the present value. With the 2016 Kigali Amendment to the Montreal Protocol, climate protection was extended to include controls on HFCs, which do not deplete ozone but contribute to global warming (see Q19).

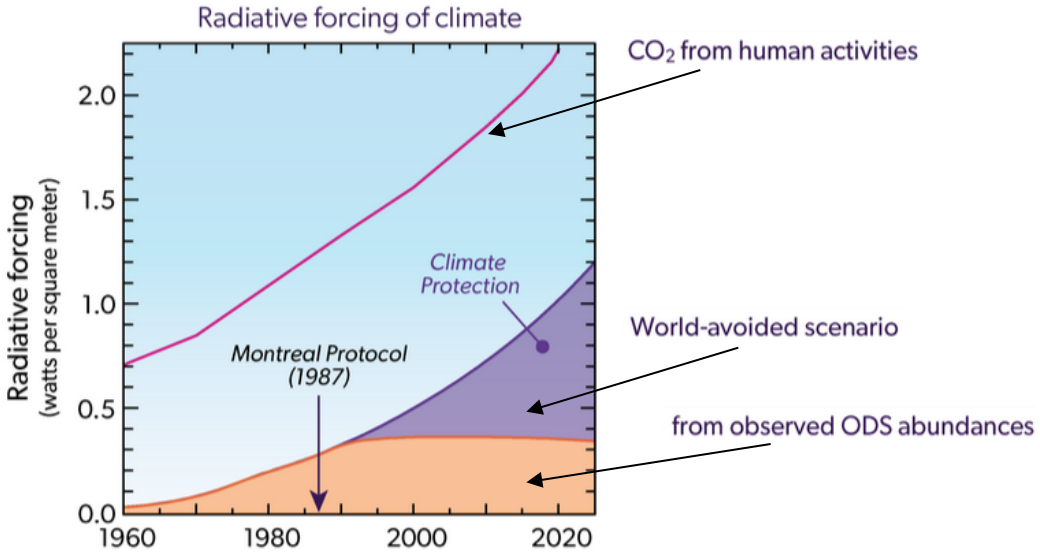


Fig Q18-1, WMO/UNEP Twenty QAs Ozone

https://csl.noaa.gov/assessments/ozone/2022/twentyquestions/#section-v

End-Permian Ozone Layer

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A

Phil. Trans. R. Soc. A (2007) **365**, 1843–1866
doi:10.1098/rsta.2007.2046
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DAVID J. BEERLING[1,*], MICHAEL HARFOOT[2], BARRY LOMAX[1] AND JOHN A. PYLE[2,3]

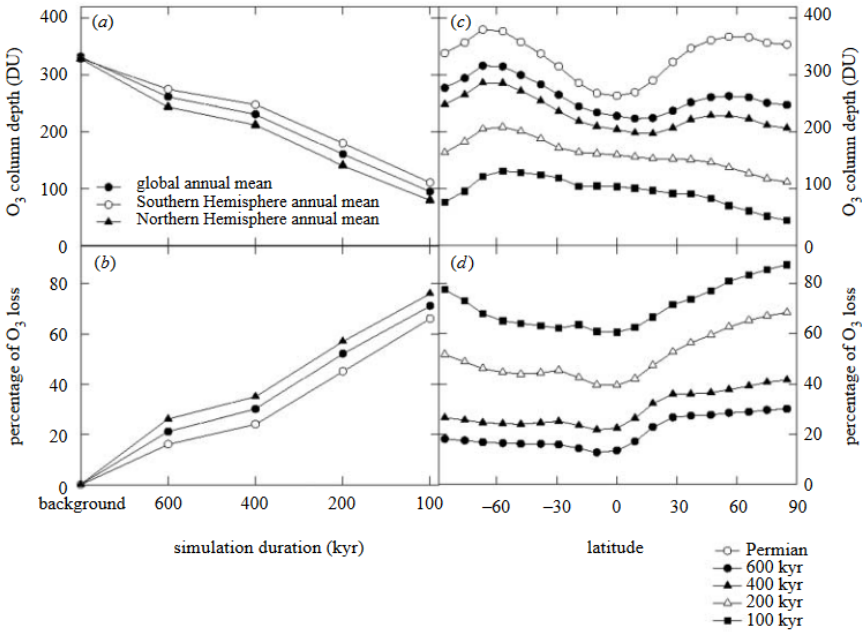

Figure 3. Changes in annual mean O_3 column depth (DU and percentage loss) due to HCl release from the Siberian Traps and CH_3Cl release from the heating of coals and rocks combined (run 4) as a function of (*a*,*b*) the duration of the main eruptive phase (background, 100, 200, 400 and 600 kyr) and (*c*,*d*) expressed as a function of latitude. Du, Dobson units.

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We calculated the resulting increases in UV-B fluxes arising from O_3 depletion for experiments in run 4 (Siberian Traps and CH_3Cl release from coals and dispersed organic matter combined) to determine if they might be sufficient to destabilize plant genomes based on experimental evidence.

Genomic stability is assessed by measuring changes in the frequency of homologous recombination (HR) of DNA in somatic tissue, a central mechanism of DNA repair that confers protection against the deleterious effects of UV-B radiation (Schuermann *et al.* 2005). HR frequency is assessed by resolving HR events within individual cells using transgenic plants carrying a visible 'reporter' gene that switches from an inactive to an active state whenever a DNA rearrangement occurs and causes them to stain blue.

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In summary, UV-B fluxes ranged from 30 to 60 $(\mathrm{kJ\,m^{-2}\,d^{-1}})_{\mathrm{BE}}$ throughout the growing season for the 600–400 kyr simulations and 50–100 $(\mathrm{kJ\,m^{-2}\,d^{-1}})_{\mathrm{BE}}$ for the 100–200 kyr simulations. Current experimental evidence suggests that these ranges are sufficient to trigger instabilities in plant genomes, especially if sustained over tens of thousands of years. Experimental studies, for example, indicate that HR frequency increased substantially in *Arabidopsis thaliana* and *Nicotiana tabacum* when the daily UV-B dose rose from a control 'background' value from 2.3 $(\mathrm{kJ\,m^{-2}\,d^{-1}})_{\mathrm{BE}}$ to 6.6 $(\mathrm{kJ\,m^{-2}\,d^{-1}})_{\mathrm{BE}}$ (Ries *et al.* 2000). Further experiments increasing the daily flux up to 27.1 $(\mathrm{kJ\,m^{-2}\,d^{-1}})_{\mathrm{BE}}$ produced much higher HR frequencies—14 times in *Arabidopsis* and 7 times in tobacco. Furthermore, the genomic instability of *Arabidopsis* increased with each generation; second generation progeny plants had HR rates two to five times higher than those of their parents when exposed to the same UV-B dosage. This suggests that UV-B fluxes induce mutations in reproductive (germ) cells (i.e. was heritable), and highlights the possibility of long-term cumulative effects of exposure to moderately high UV radiation.

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