

CERES/ERSST Comparison

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CERES variable name convention

CERES uses a very consistent sign convention:

- **Incoming solar** = solar_mon (positive **downward**)
- **Reflected shortwave** = toa_sw_* (positive **upward**)
- **Emitted longwave** = toa_lw_* (positive **upward**)

So:

$$\text{TOA net} = +\text{SW}_{\text{in}} - \text{SW}_{\text{out}} - \text{LW}_{\text{out}}$$

TOA SW: positive **upward** (outgoing to space)

Surface SW:

Downwelling SW (sfc_sw_down) is **positive downward**

Upwelling SW (sfc_sw_up) is **positive upward**

Net SW at surface is positive downward and computed as

$$\text{sfc_net_sw} = \text{sfc_sw_down} - \text{sfc_sw_up}$$

So:

If the surface reflects a lot → sfc_sw_up is large → sfc_net_sw becomes **smaller**

If the surface absorbs more → sfc_net_sw becomes **larger**

Variable	Meaning	Sign
sfc_sw_down	Incoming solar at surface	+ downward
sfc_sw_up	Reflected solar	+ upward
sfc_net_sw	Net SW = down - up	+ downward

Prefix	Meaning	Direction of +
solar_*	Incoming solar	Downward
toa_sw_*	Reflected shortwave	Upward
toa_lw_*	Emitted longwave	Upward
net	Net flux	Downward positive

👉 **One subtlety: the _c suffix**

The _c means:

- **Clear-sky for cloud-free portions of the grid cell,**
- Not the hypothetical “clear-sky if clouds were removed” used in some radiative kernels.

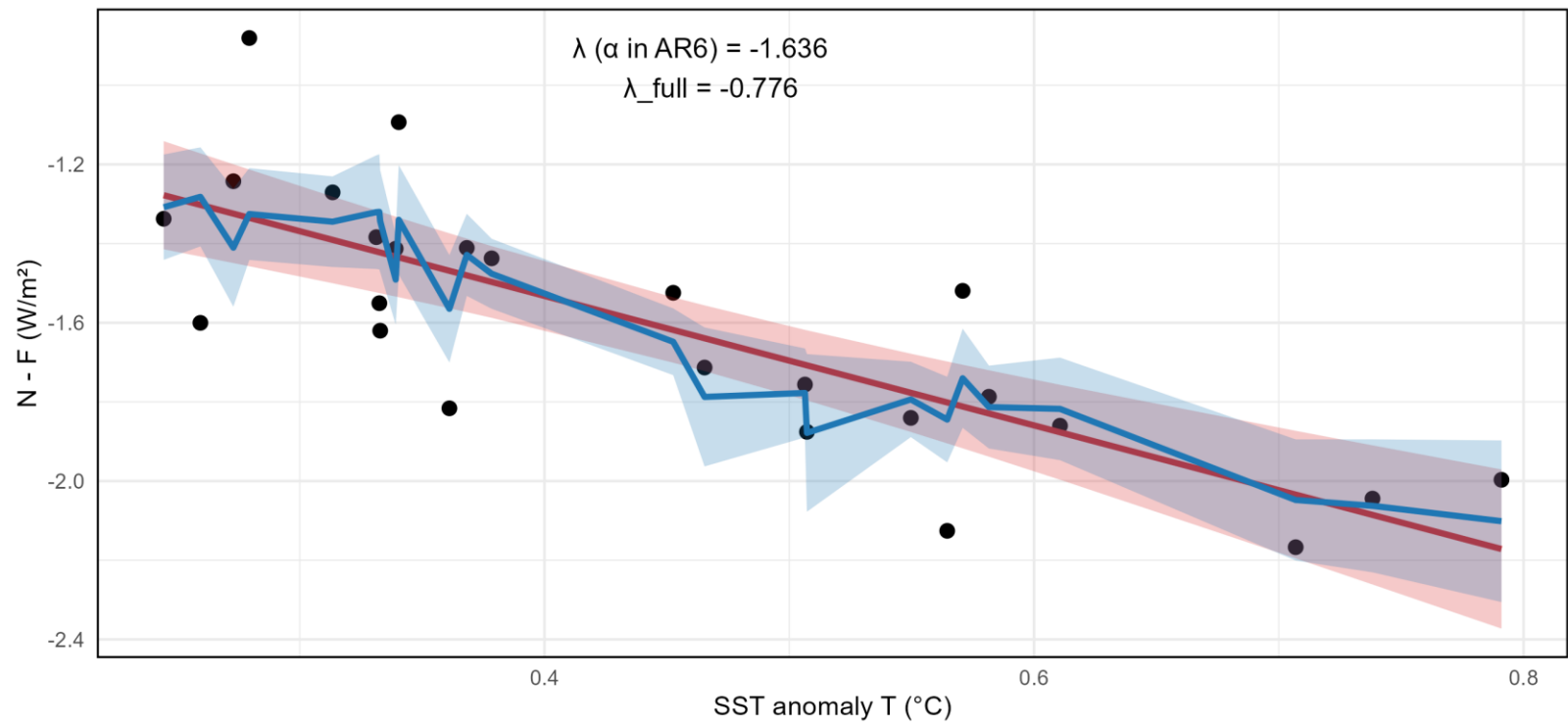
CERES has two clear-sky flavors:

- **_clr_c_ → clear-sky for cloud-free areas only**
- **_clr_t_ → clear-sky for the entire grid cell, using cloud-clearing algorithms**

Variable	Meaning	Sign
sfc_sw_down	Solar down	+ downward
sfc_sw_up	Reflected SW	+ upward
sfc_net_sw	SW down - up	+ downward
sfc_lw_down	Atmospheric LW down	+ downward
sfc_lw_up	Surface-emitted LW	+ upward
sfc_net_lw	LW down - up	+ downward

Net downward TOA flux = SW_in – SW_out – LW_out,: **TOA_net_all_mon** = solar_mon – toa_sw_all_mon – toa_lw_all_mon

AR6-Constrained vs Floating CERES–Forster Regression (with Confidence Bands)



Using Forster F values.
 AR6 constrained: $N - F = \lambda$
 AR6 $F = -3.93$, $ECS = F/\lambda = -3.93/-1.64 = 2.4 \text{ } ^\circ\text{C}/2\text{xCO}_2$
 Myhre/AR5 $F = 3.7$, $ECS = F/\lambda = -3.7/-1.64 = 2.26 \text{ } ^\circ\text{C}/2\text{xCO}_2$
 vWH $F=3$, $ECS = F/\lambda = -3.0/-1.64 = 1.83 \text{ } ^\circ\text{C}/2\text{xCO}_2$

Model — AR6 constrained (α) — Floating model (λ_{full}) Confidence band — AR6 constrained (α) — Floating model (λ_{full})

“AR6-constrained” forces the system to obey the AR6 energy-balance identity: $N = F + \lambda T$. It regresses N_{minus_F} against T (m_g). $N = TOA_Net_all_mon$.
 The floating regression allows the coefficient on F to float and regresses N against $F+T$ (m_full).

The λ s are different, the $m_g \lambda = -1.636$ and the full regression (m_full) $\lambda = -0.776$.

m_g assumes $N = F + \lambda T$ is exactly true and gives the straight line and a constant slope that is the “climate feedback parameter.”

Significance: **Their λ values differ because the AR6 identity does not hold exactly in CERES–Forster data.** The difference is statistically significant and physically meaningful.

The error in the CERES measurements, the short period of data (25 years), and the small change in SST combine to make the estimate of ECS with this dataset problematic.

Anomaly sensitivity versus the rolling slope

Anomaly Sensitivity

Anomaly sensitivity is defined as:

$$\frac{X'(t)}{SST'(t)}$$

This is a *pointwise ratio* of two noisy annual anomalies.

- SST anomalies vary only by **~0.5 °C** over 2001–2025.
- In several years, SST' is from the 1961-1990 mean and never close to **zero**
- TOA_net yearly anomalies vary by **~0.8 W/m²**.

$$\frac{X'}{SST'} SST' \approx 0$$

CERES anomalies are dominated by interannual variability.

Rolling slope

The rolling slope is a regression slope estimate:

$$\beta(t) = \text{slope of } X'(t \pm 2) \text{ vs } SST'(t \pm 2)$$

This is a *local linear regression*, not a ratio.

A regression slope is stable because:

It uses 5 years of data.

It minimizes squared error.

It is not sensitive to SST' being near zero in any single year.

This is why your rolling slope is smooth and physically reasonable.

The SST anomalies never get close to zero (minimum $\approx 0.279 \text{ °C}$), the wild swings in the anomaly-sensitivity series **cannot** be explained by divide-by-zero behavior. That means the instability is coming from a *different* source.

The reason is subtle and it matters for interpreting CERES.

The key insight

Even when SST' never approaches zero, the ratio

$$\frac{X'(t)}{SST'(t)}$$

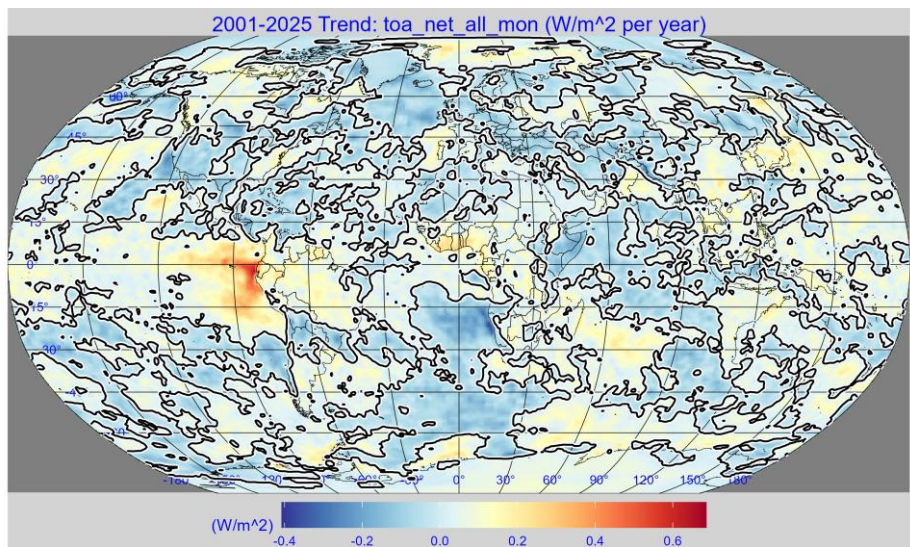
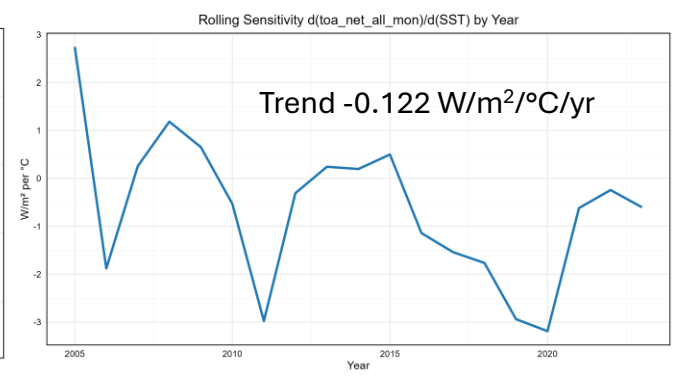
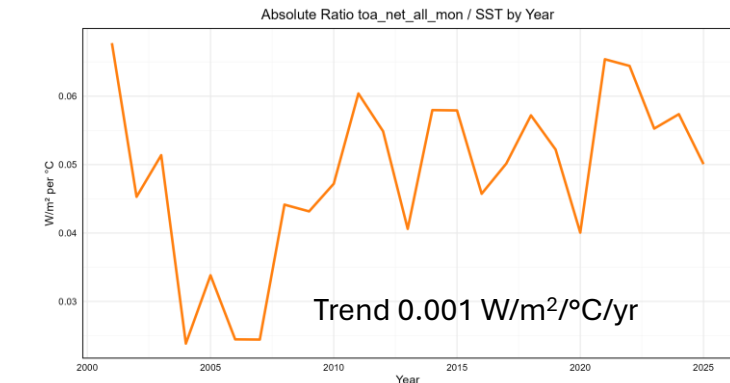
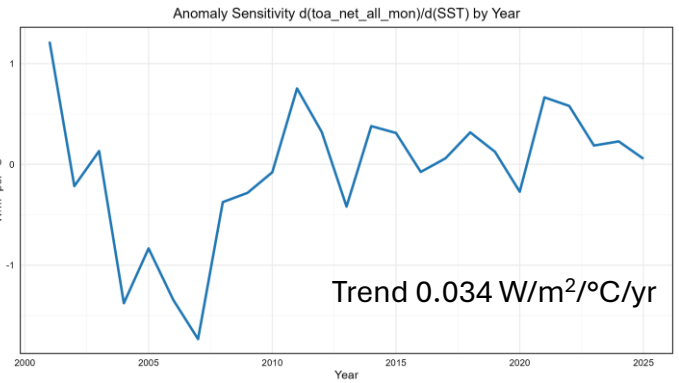
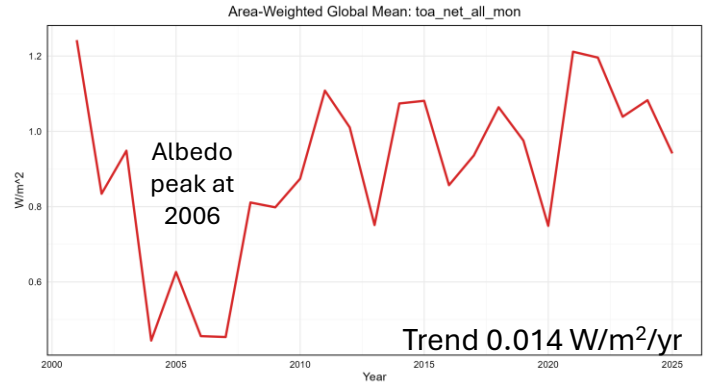
is still **mathematically unstable** whenever:

1. **SST' varies over a very small range**, and
2. **X' varies over a much larger range**, and
3. **the anomalies are not linearly related year-to-year**.

All three are true in your CERES + SST dataset.

This is why the anomaly-sensitivity curve is noisy even though SST' never crosses zero.

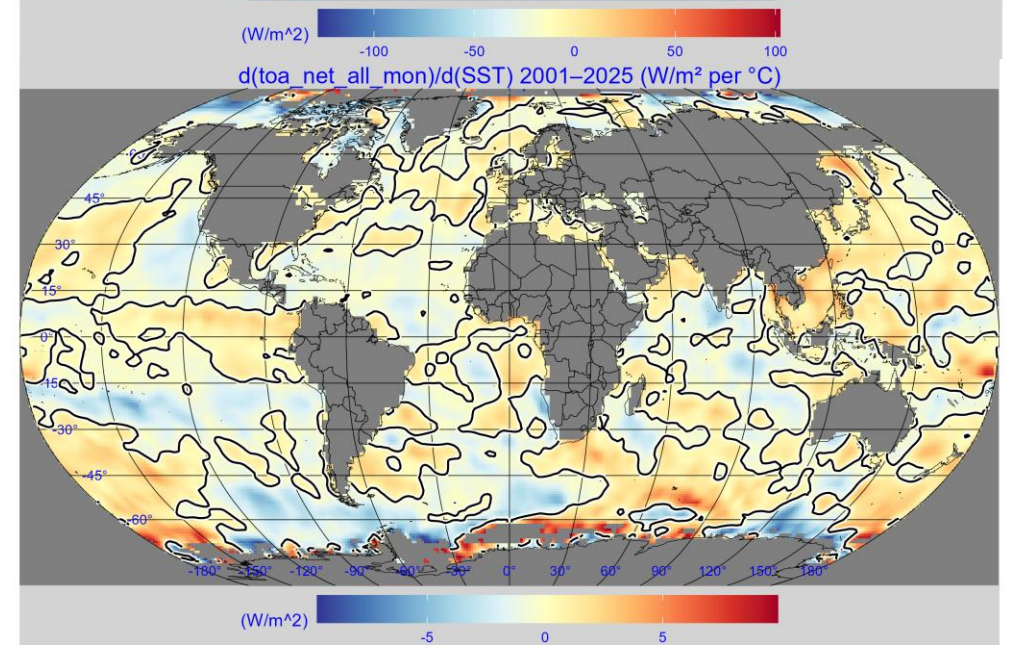
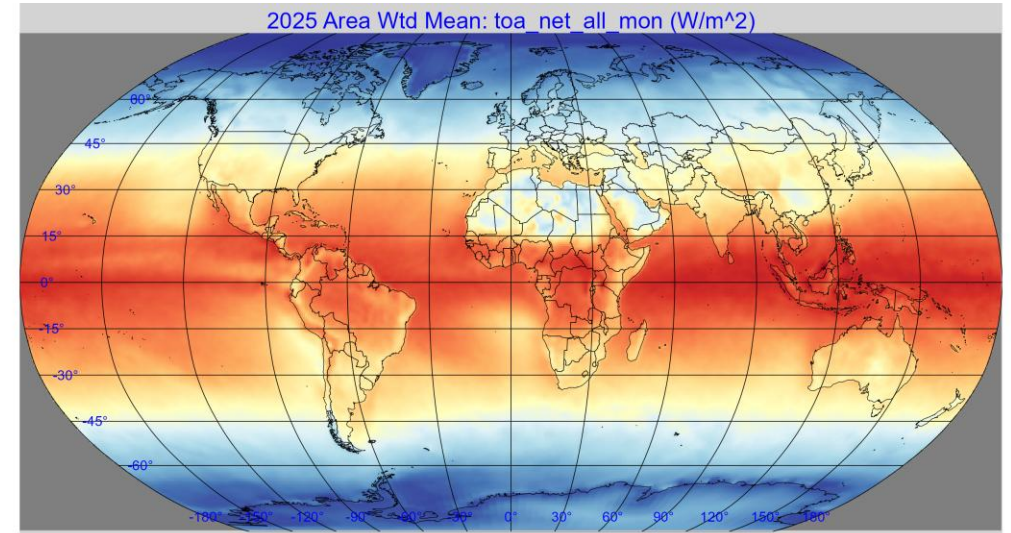
Net downward TOA flux = $SW_{in} - SW_{out} - LW_{out}$,: **TOA_net_all_mon** = solar_mon - toa_sw_all_mon - toa_lw_all_mon



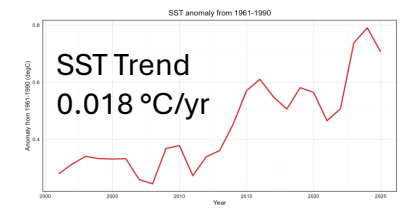
The global slope for this variable is 0.532 **W/m²/°C**. This is the 2001–2025 change for **TOA_net_all** for each 1°C change in global-mean SST.

With many important assumptions ECS can be computed from this data, and it equals 2.26 (see slide 3).

Positive values are downward, that is the surface gaining energy, negative is the surface losing energy.



Net downward total flux is increasing, but the rolling slope suggests that surface energy loss is increasing per °C SST. The two ratios say the opposite, but the rolling slope is a better indicator.



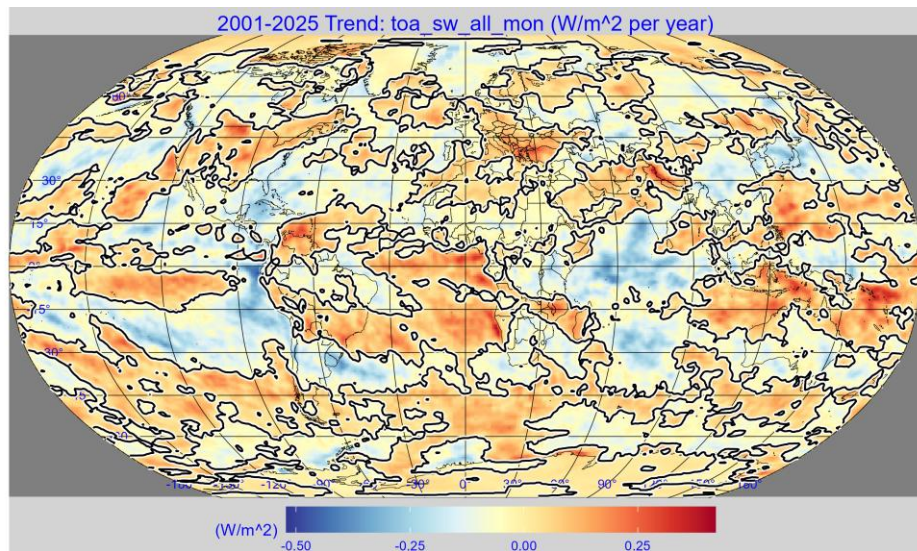
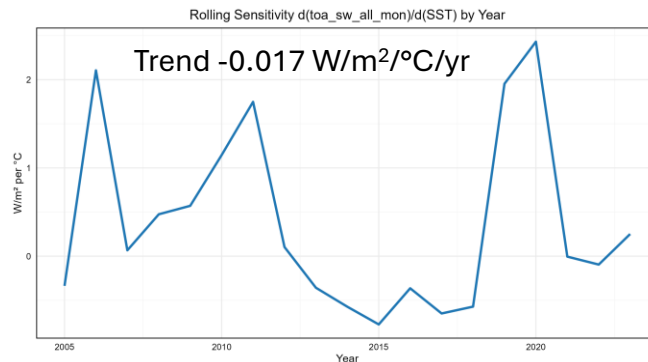
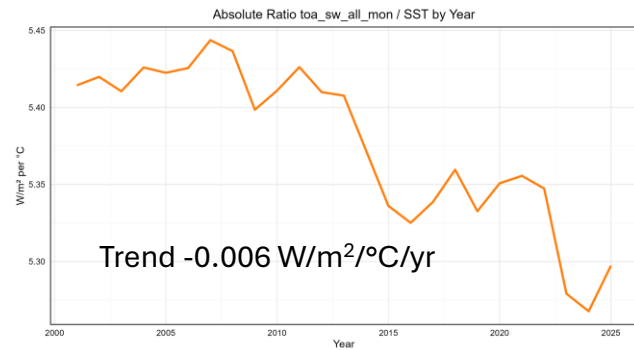
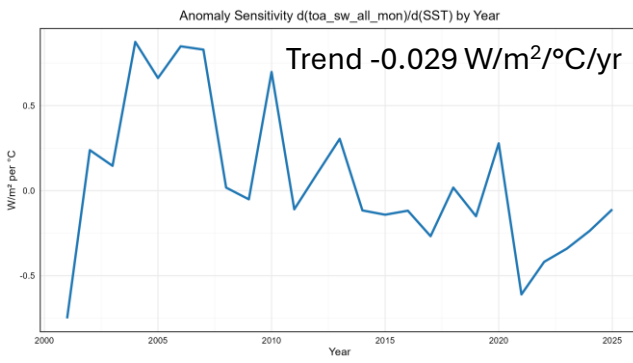
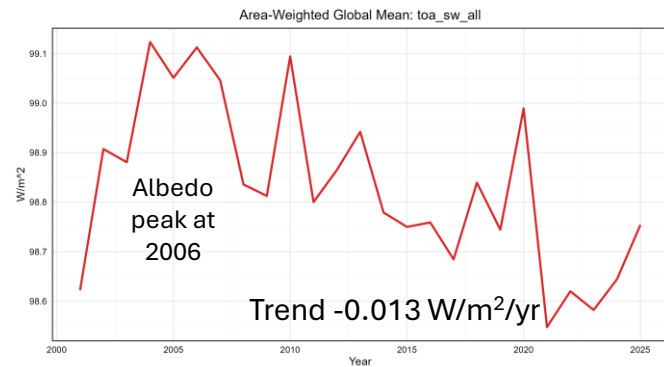
$$\text{TOA_net_all_mon} = \text{solar_mon} - \text{toa_sw_all_mon} - \text{toa_lw_all_mon}$$

(W/m²)

Year	wtd global mean	abs ratio	anom sens	global slope	sst clim mean	toa net all anom	sst anom 1961-90	solar_mon	toa_sw_all	toa_lw_all	solar-sw-lw
2001	1.234	0.068	1.218	0.532	17.935	0.340	0.279	340.201	98.622	240.348	1.230
2002	0.827	0.045	-0.216	0.532	17.935	-0.068	0.313	340.196	98.907	240.467	0.822
2003	0.939	0.051	0.132	0.532	17.935	0.045	0.340	340.181	98.881	240.364	0.936
2004	0.435	0.024	-1.378	0.532	17.935	-0.459	0.333	340.180	99.123	240.625	0.432
2005	0.618	0.034	-0.834	0.532	17.935	-0.276	0.331	340.187	99.051	240.522	0.614
2006	0.447	0.024	-1.346	0.532	17.935	-0.447	0.333	340.190	99.113	240.634	0.444
2007	0.444	0.024	-1.734	0.532	17.935	-0.450	0.259	340.202	99.046	240.715	0.441
2008	0.803	0.044	-0.375	0.532	17.935	-0.092	0.244	340.201	98.836	240.566	0.799
2009	0.790	0.043	-0.283	0.532	17.935	-0.104	0.368	340.173	98.812	240.575	0.786
2010	0.864	0.047	-0.078	0.532	17.935	-0.030	0.378	340.216	99.094	240.260	0.862
2011	1.100	0.060	0.753	0.532	17.935	0.206	0.273	340.209	98.800	240.313	1.096
2012	1.003	0.055	0.321	0.532	17.935	0.109	0.339	340.206	98.865	240.343	0.998
2013	0.743	0.041	-0.419	0.532	17.935	-0.151	0.361	340.217	98.942	240.536	0.739
2014	1.066	0.058	0.380	0.532	17.935	0.172	0.453	340.204	98.779	240.363	1.062
2015	1.072	0.058	0.311	0.532	17.935	0.178	0.571	340.226	98.750	240.407	1.069
2016	0.848	0.046	-0.075	0.532	17.935	-0.046	0.611	340.225	98.759	240.622	0.845
2017	0.927	0.050	0.060	0.532	17.935	0.033	0.550	340.232	98.684	240.624	0.923
2018	1.055	0.057	0.317	0.532	17.935	0.161	0.506	340.221	98.839	240.330	1.052
2019	0.967	0.052	0.125	0.532	17.935	0.072	0.582	340.215	98.744	240.508	0.963
2020	0.741	0.040	-0.271	0.532	17.935	-0.153	0.565	340.228	98.989	240.502	0.736
2021	1.203	0.065	0.665	0.532	17.935	0.309	0.465	340.211	98.548	240.464	1.199
2022	1.188	0.064	0.580	0.532	17.935	0.294	0.507	340.214	98.620	240.410	1.184
2023	1.032	0.055	0.187	0.532	17.935	0.138	0.738	340.205	98.582	240.596	1.027
2024	1.074	0.057	0.228	0.532	17.935	0.180	0.791	340.212	98.644	240.497	1.070
2025	0.933	0.050	0.056	0.532	17.935	0.039	0.707	340.206	98.754	240.523	0.929
min	0.435	0.024	-1.734	0.532	17.935	-0.459	0.244				0.432
max	1.234	0.068	1.218	0.532	17.935	0.340	0.791				1.230
average	0.894	0.049	-0.067	0.532	17.935	0.000	0.448				0.890
max-min	0.799	0.044	2.952	0.000	0.000	0.799	0.547				0.798

← Close match →

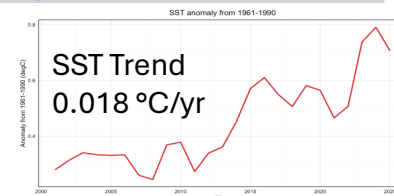
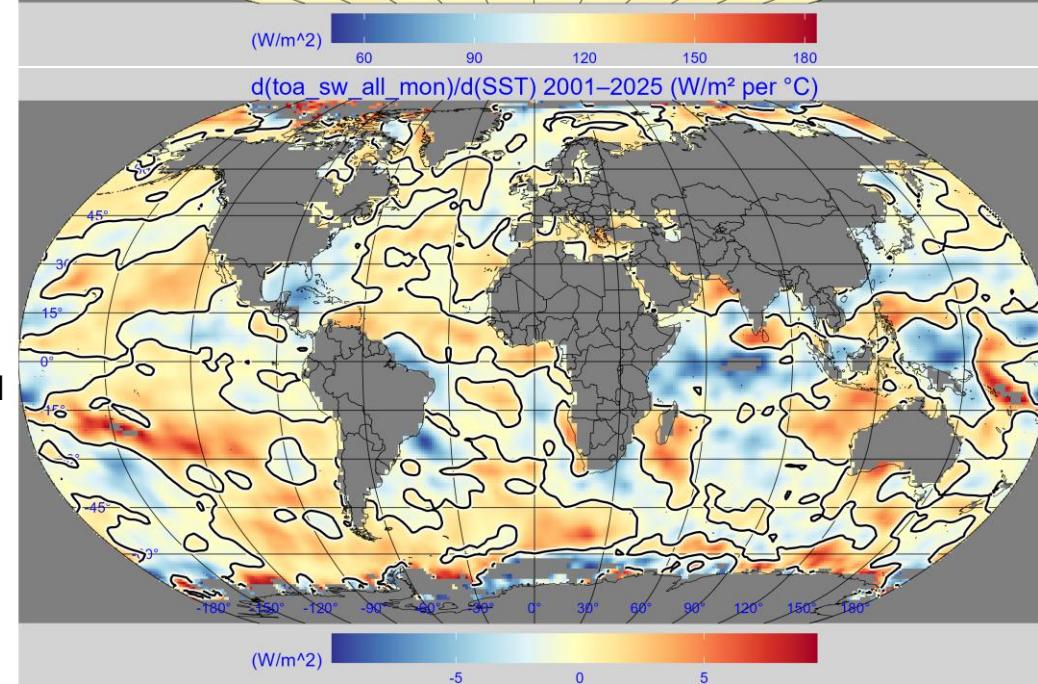
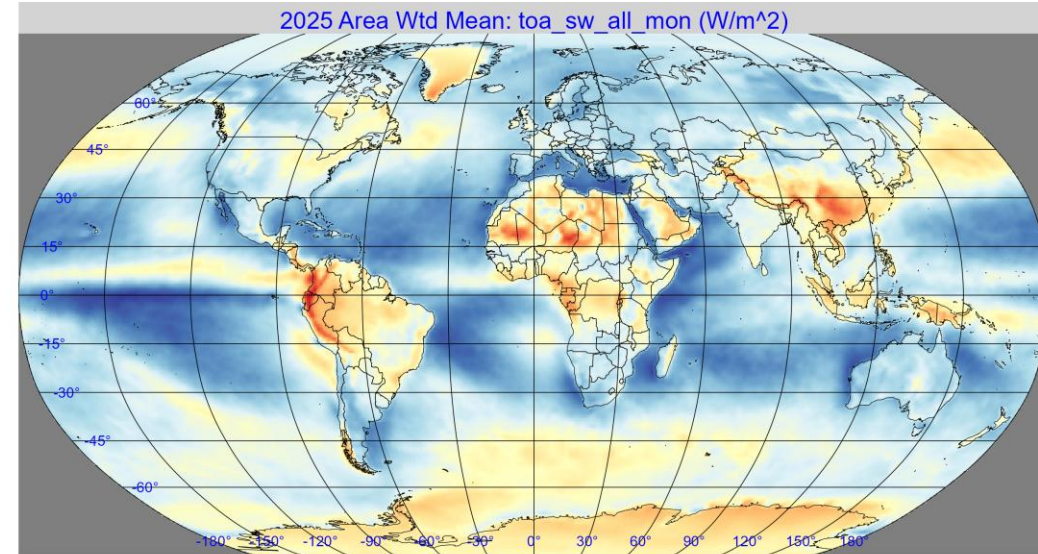
TOA Reflected Outgoing SW flux all sky: toa_sw_all_mon



The global slope for this variable is $-0.575 \text{ W/m}^2/^\circ\text{C}$. This is the total SW reflected radiation.

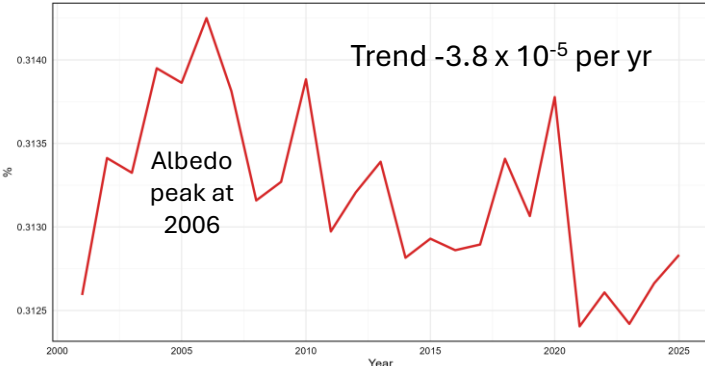
It is decreasing overall and as a function of SST, especially since ~2005.

Shows a distinct maximum between 2004 & 2007.



TOA Outgoing SW flux all sky **Albedo**: toa_sw_all_mon

Area-Weighted Global Mean: albedo_toa_sw_all

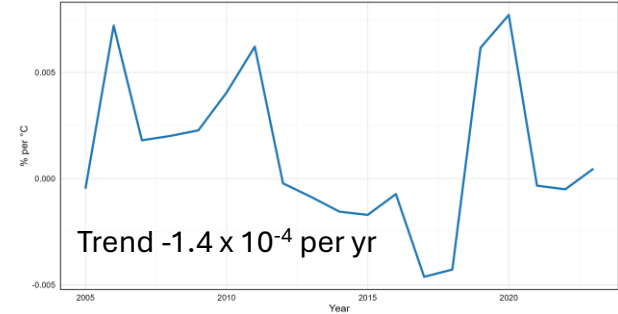


The global slope for this variable is -1.6×10^{-3} per $^{\circ}\text{C}$.

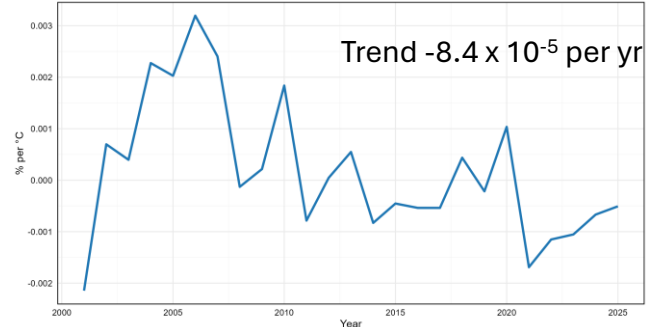
All-sky albedo has trended down past 25 years, especially since 2005. It has also trended down per $^{\circ}\text{C}$ SST.

Albedo = $\text{toa_sw_all}/\text{solar_mon}$

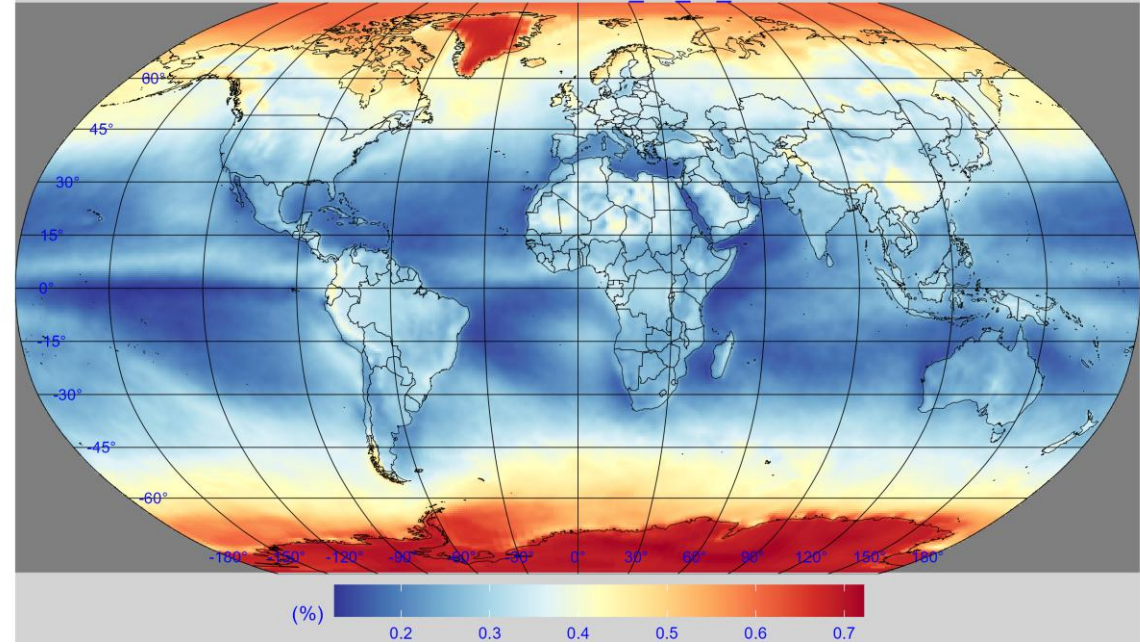
Rolling Sensitivity $d(\text{albedo_toa_sw_all_mon})/d(\text{SST})$ by Year



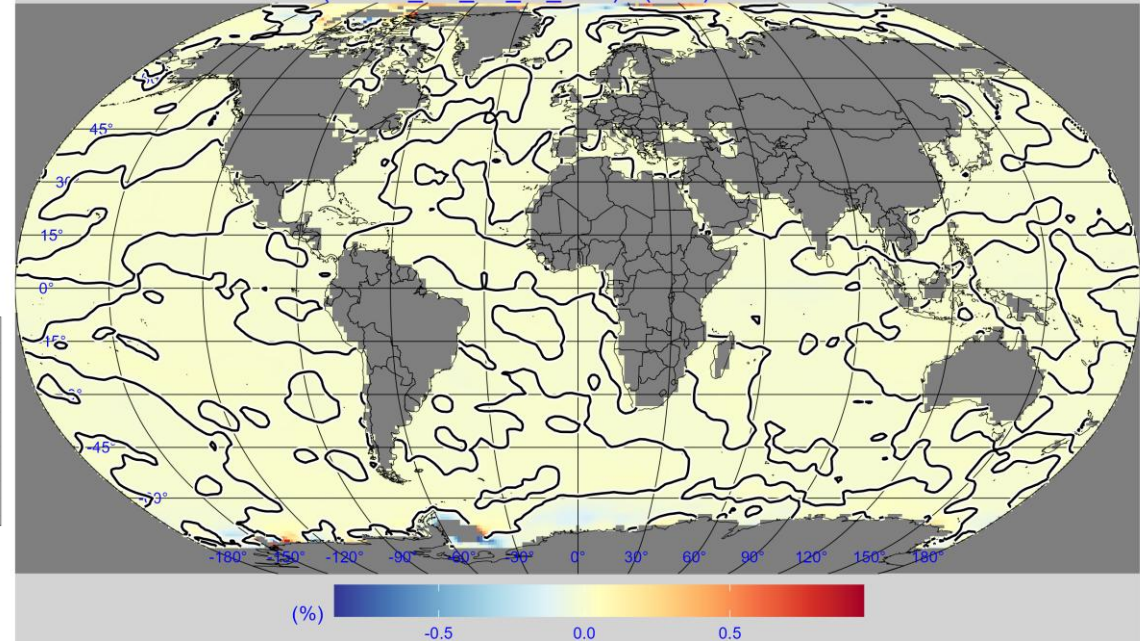
Anomaly Sensitivity $d(\text{albedo_toa_sw_all_mon})/d(\text{SST})$ by Year



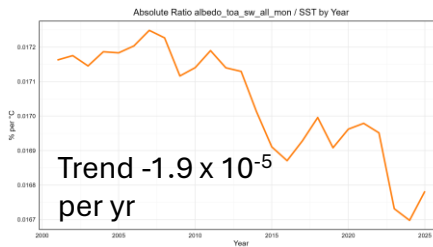
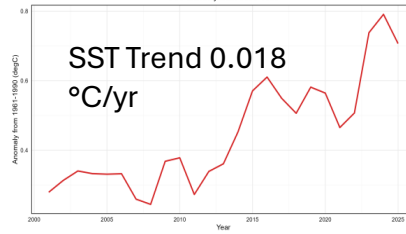
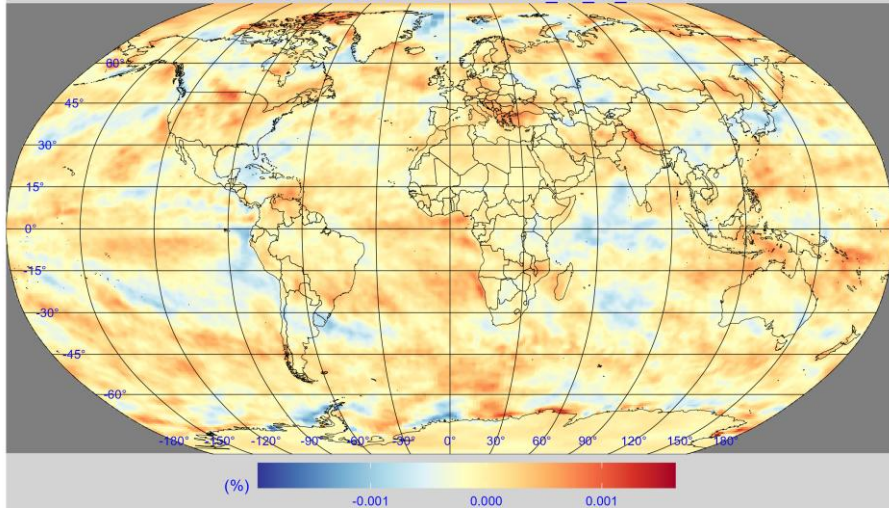
2025 TOA Albedo: toa_sw_all_mon



$d(\text{albedo_toa_sw_all_mon})/d(\text{SST})$ 2001-2025



2001-2025 TOA Albedo Trend: toa_sw_all_mon



Albedo

Programming Method

Read both variables from the same EBAF file (or consistent files):

toa_sw_all_mon (W m^{-2} , up)

solar_mon (or equivalent incoming SW, W m^{-2} , down)

Compute albedo per grid cell:

$$\alpha_{\text{clr}} = \frac{\text{toa_sw_all_mon}}{\text{solar_mon}}$$

Mask low-sun conditions:

Where solar_mon is very small (e.g. polar night), set albedo to NA to avoid huge ratios.

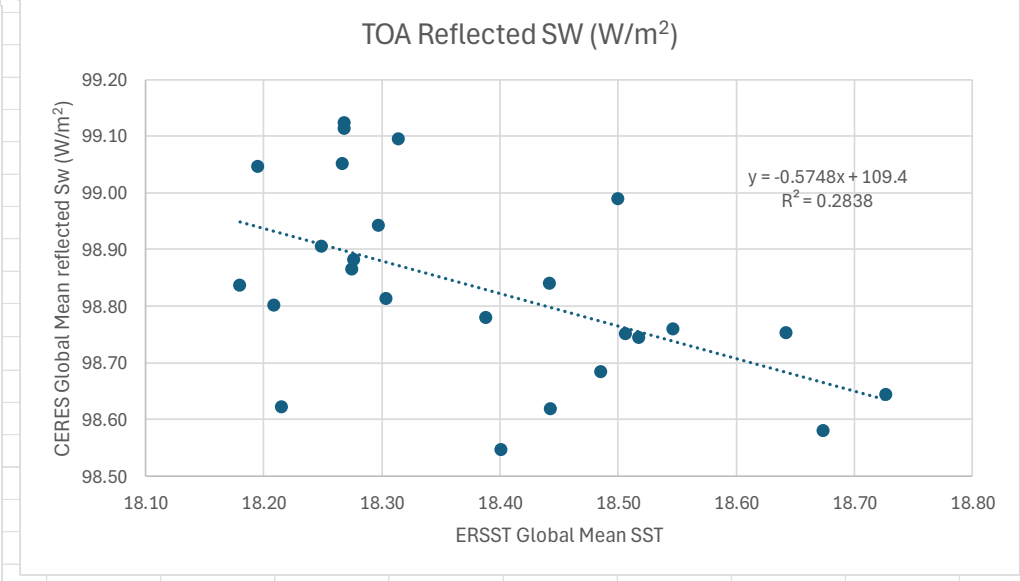
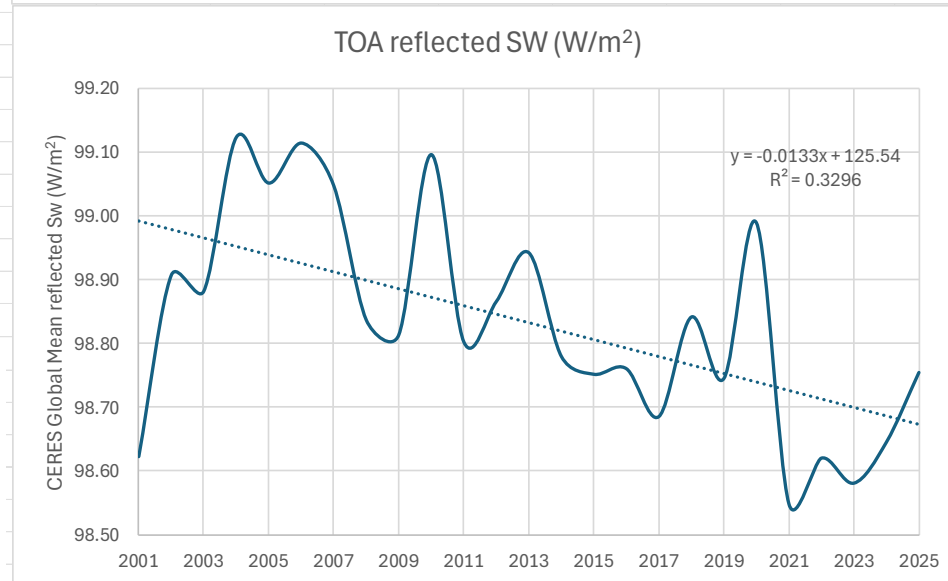
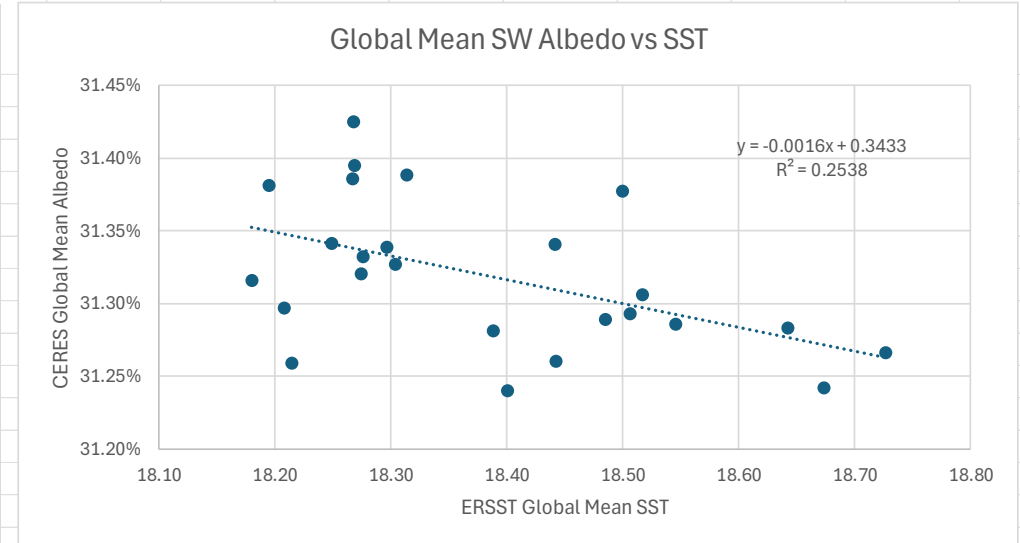
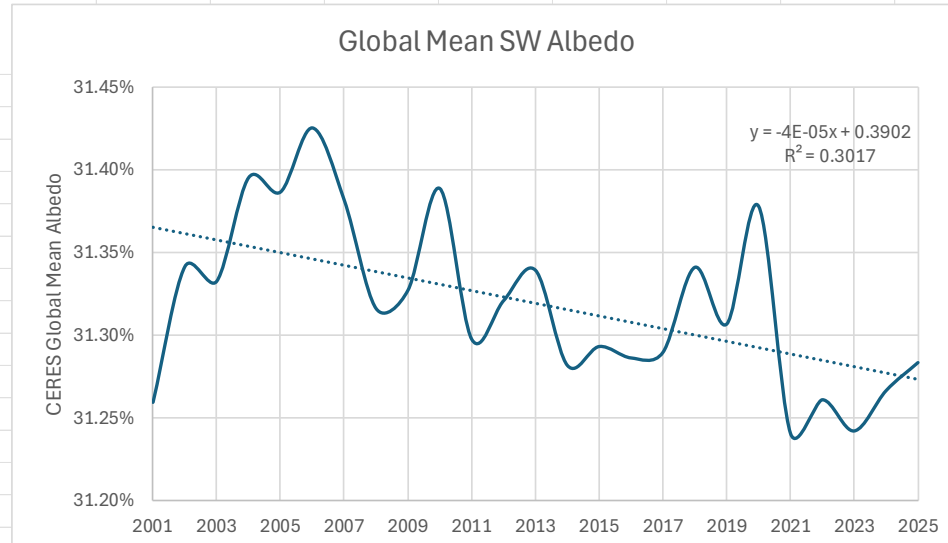
This method computed the “CERES albedo”, which is different from the conventional albedo. The conventional albedo is:

$$\text{Total_reflected/total_in_from_sun}$$

Which is problematic since the sun’s position in the sky is constantly changing and the surface facing the sun is always changing. The “CERES sun” is constant, eliminating one of the factors. The CERES albedo (~31%) is higher than the conventional albedo (~29%), but it is a function of changes in the surface and not the daily, seasonal, and yearly changes in the position of the sun.

Albedo versus SST and by year

year	Global Mean SST	Global Mean SW Albedo	TOA reflected SW (W/m ²)
2001	18.21	31.26%	98.62
2002	18.25	31.34%	98.91
2003	18.28	31.33%	98.88
2004	18.27	31.39%	99.12
2005	18.27	31.39%	99.05
2006	18.27	31.43%	99.11
2007	18.19	31.38%	99.05
2008	18.18	31.32%	98.84
2009	18.30	31.33%	98.81
2010	18.31	31.39%	99.10
2011	18.21	31.30%	98.80
2012	18.27	31.32%	98.87
2013	18.30	31.34%	98.94
2014	18.39	31.28%	98.78
2015	18.51	31.29%	98.75
2016	18.55	31.29%	98.76
2017	18.49	31.29%	98.68
2018	18.44	31.34%	98.84
2019	18.52	31.31%	98.74
2020	18.50	31.38%	98.99
2021	18.40	31.24%	98.55
2022	18.44	31.26%	98.62
2023	18.67	31.24%	98.58
2024	18.73	31.27%	98.64
2025	18.64	31.28%	98.75



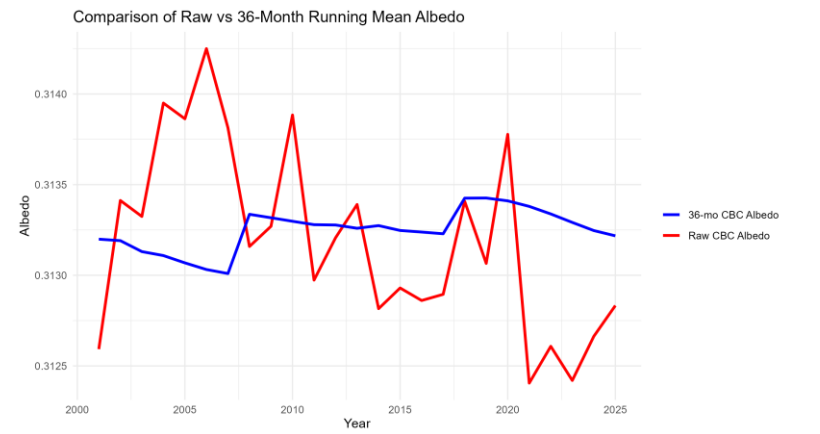
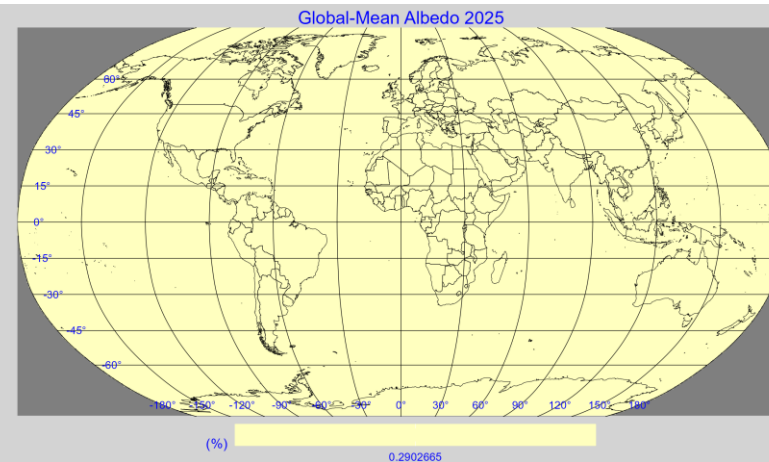
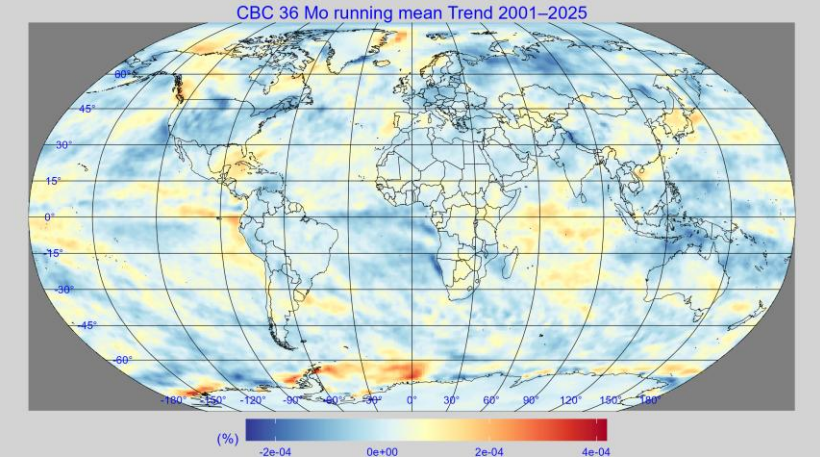
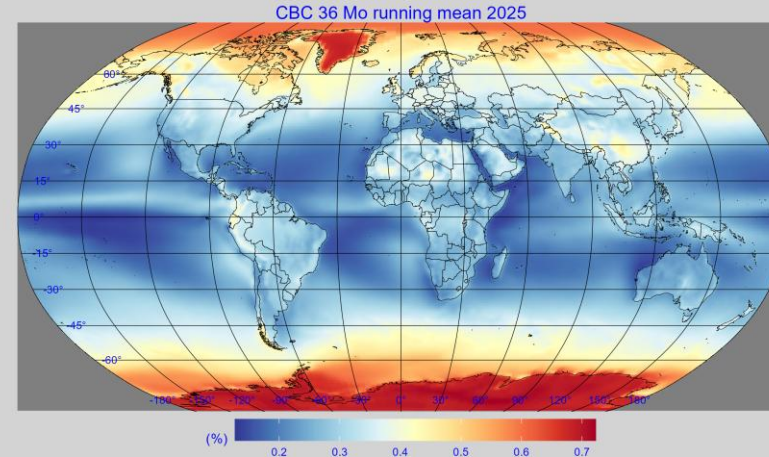
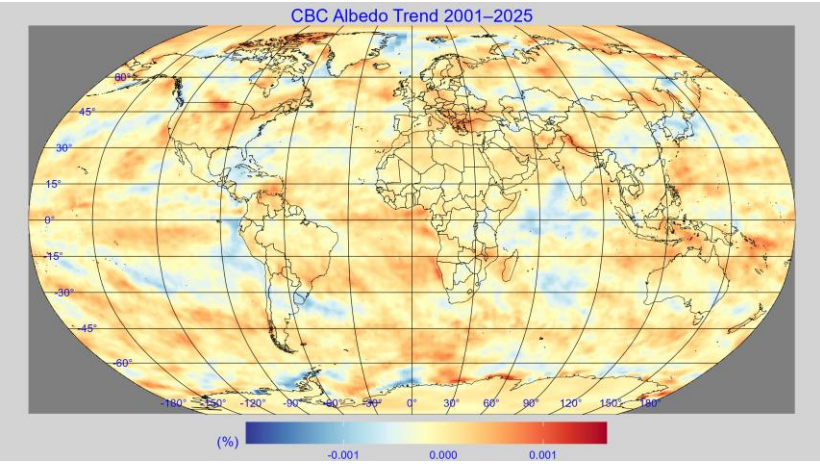
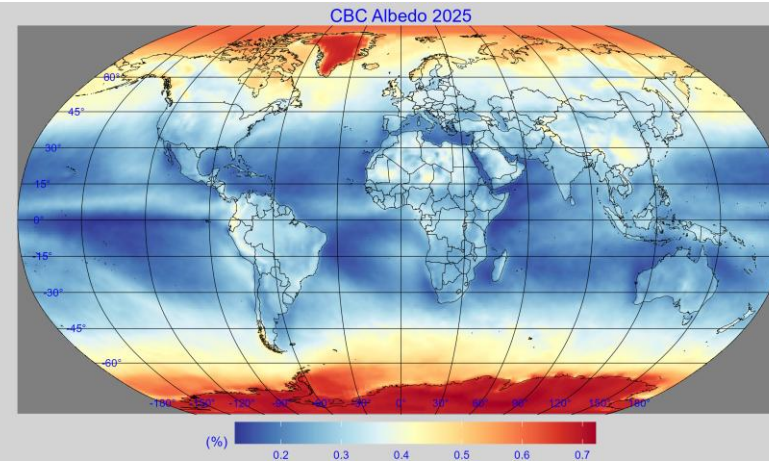
Albedo is clearly decreasing from 2001-2025, it is also decreasing as SST goes up. SST goes up about 0.5°C and albedo decreases about 0.35 W/m² or from 31.35% to 31.27%

“cbc albedo” The area weighted cell-by-cell area-weighted global mean albedo

“cbc rm36 albedo” The area-weighted cell-by-cell 36-month running area-weighted global mean albedo

“conventional gm albedo” The area-weighted global means of toa_sw_all and solar_mon converted into a single global mean

year	toa sw all	solar mon	cbc albedo	cbc rm36 albedo	conventional gm albedo
2001	98.622	340.213	31.26%	31.32%	28.99%
2002	98.907	340.208	31.34%	31.32%	29.07%
2003	98.881	340.193	31.33%	31.31%	29.07%
2004	99.123	340.193	31.39%	31.31%	29.14%
2005	99.051	340.199	31.39%	31.31%	29.12%
2006	99.113	340.203	31.43%	31.30%	29.13%
2007	99.046	340.215	31.38%	31.30%	29.11%
2008	98.836	340.213	31.32%	31.33%	29.05%
2009	98.812	340.186	31.33%	31.33%	29.05%
2010	99.094	340.228	31.39%	31.33%	29.13%
2011	98.800	340.221	31.30%	31.33%	29.04%
2012	98.865	340.219	31.32%	31.33%	29.06%
2013	98.942	340.229	31.34%	31.33%	29.08%
2014	98.779	340.217	31.28%	31.33%	29.03%
2015	98.750	340.238	31.29%	31.32%	29.02%
2016	98.759	340.238	31.29%	31.32%	29.03%
2017	98.684	340.244	31.29%	31.32%	29.00%
2018	98.839	340.233	31.34%	31.34%	29.05%
2019	98.744	340.227	31.31%	31.34%	29.02%
2020	98.989	340.240	31.38%	31.34%	29.09%
2021	98.548	340.224	31.24%	31.34%	28.97%
2022	98.620	340.226	31.26%	31.33%	28.99%
2023	98.582	340.217	31.24%	31.33%	28.98%
2024	98.644	340.225	31.27%	31.32%	28.99%
2025	98.754	340.218	31.28%	31.32%	29.03%



Comparing Δ albedo to Δ CO₂ from 2005-2025

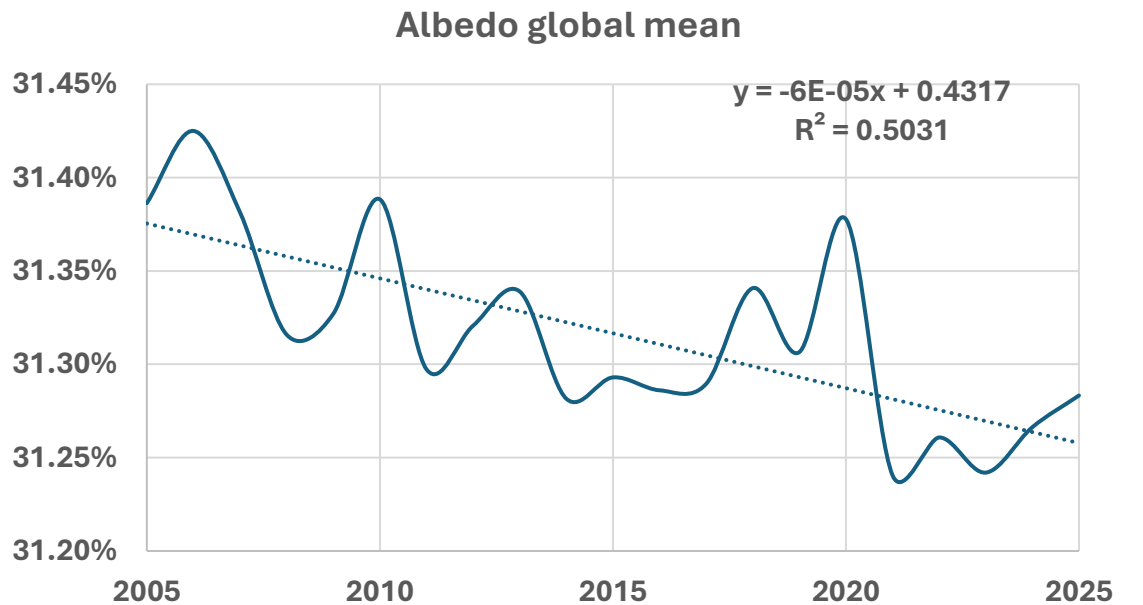
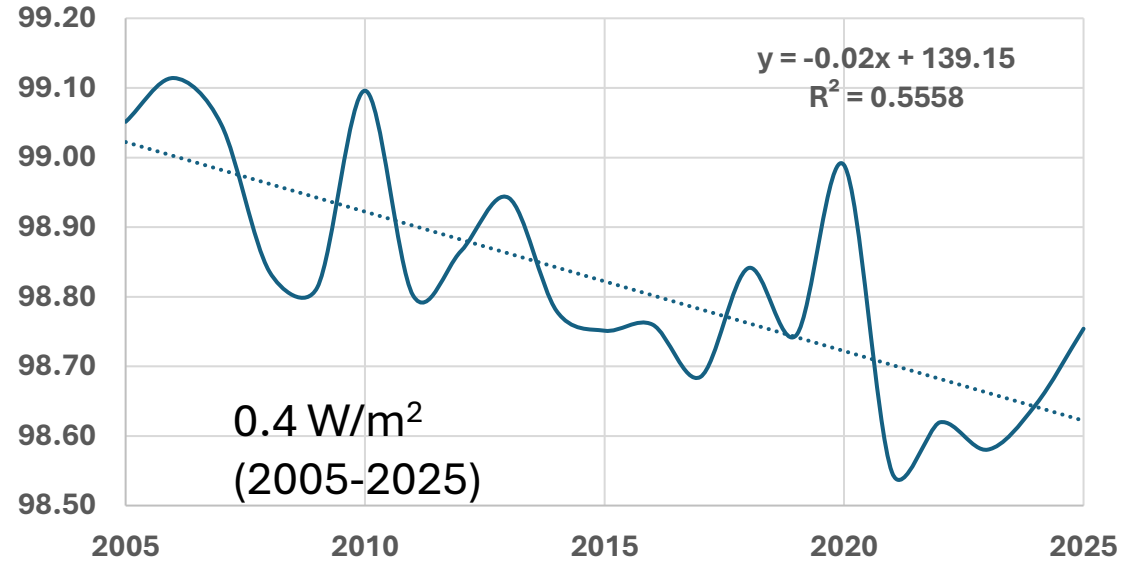
toa sw all

Global mean values CERES toa_sw_all							
year	CERES toa sw all	ERSST v5 SST gm	Absolute Ratio	anomaly sensitivity	global slope	5-yr Rolling slope	Albedo global mean
2001	98.62	18.21	5.41	-0.75	-0.57		31.26%
2002	98.91	18.25	5.42	0.24	-0.57		31.34%
2003	98.88	18.28	5.41	0.15	-0.57		31.33%
2004	99.12	18.27	5.43	0.87	-0.57		31.39%
2005	99.05	18.27	5.42	0.66	-0.57	-0.34	31.39%
2006	99.11	18.27	5.43	0.85	-0.57	2.11	31.43%
2007	99.05	18.19	5.44	0.83	-0.57	0.07	31.38%
2008	98.84	18.18	5.44	0.02	-0.57	0.47	31.32%
2009	98.81	18.30	5.40	-0.05	-0.57	0.57	31.33%
2010	99.10	18.31	5.41	0.70	-0.57	1.15	31.39%
2011	98.80	18.21	5.43	-0.11	-0.57	1.75	31.30%
2012	98.87	18.27	5.41	0.10	-0.57	0.10	31.32%
2013	98.94	18.30	5.41	0.30	-0.57	-0.36	31.34%
2014	98.78	18.39	5.37	-0.12	-0.57	-0.57	31.28%
2015	98.75	18.51	5.34	-0.14	-0.57	-0.77	31.29%
2016	98.76	18.55	5.33	-0.12	-0.57	-0.36	31.29%
2017	98.68	18.49	5.34	-0.27	-0.57	-0.65	31.29%
2018	98.84	18.44	5.36	0.02	-0.57	-0.57	31.34%
2019	98.74	18.52	5.33	-0.15	-0.57	1.95	31.31%
2020	98.99	18.50	5.35	0.28	-0.57	2.43	31.38%
2021	98.55	18.40	5.36	-0.61	-0.57	-0.01	31.24%
2022	98.62	18.44	5.35	-0.42	-0.57	-0.10	31.26%
2023	98.58	18.67	5.28	-0.34	-0.57	0.25	31.24%
2024	98.64	18.73	5.27	-0.24	-0.57		31.27%
2025	98.75	18.64	5.30	-0.11	-0.57		31.28%
Means	98.83	18.38	5.38	0.06	-0.57	0.37	31.32%

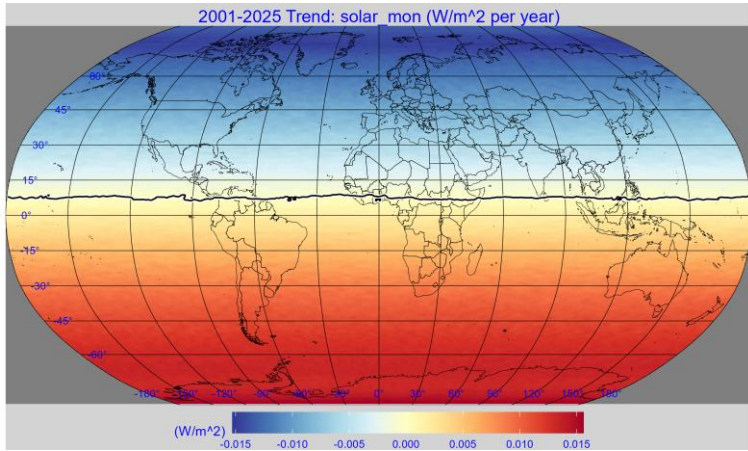
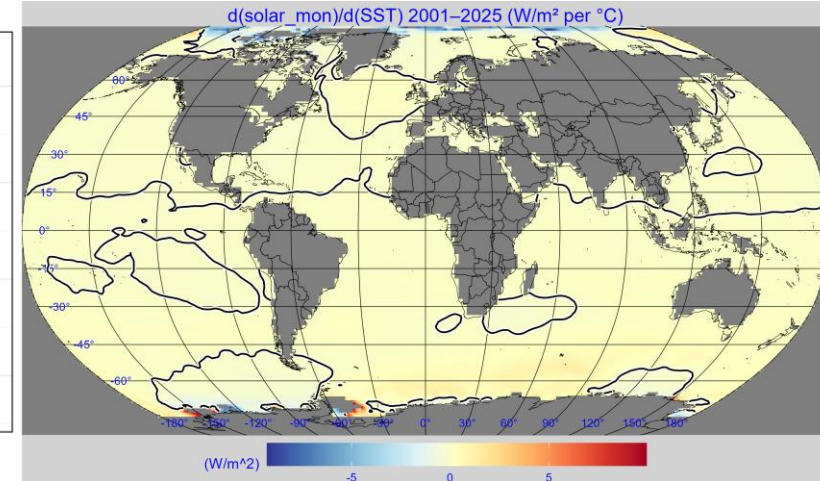
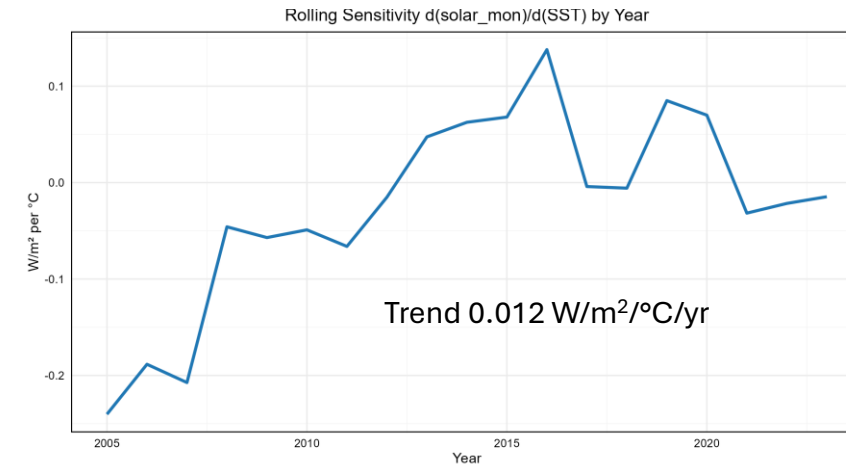
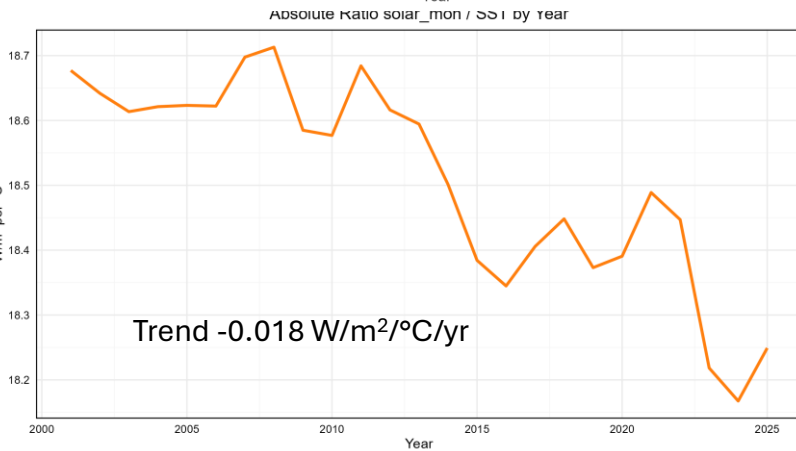
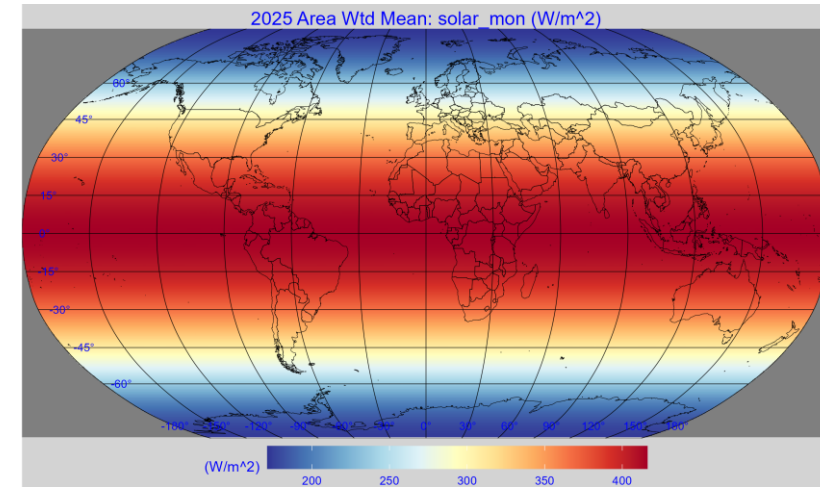
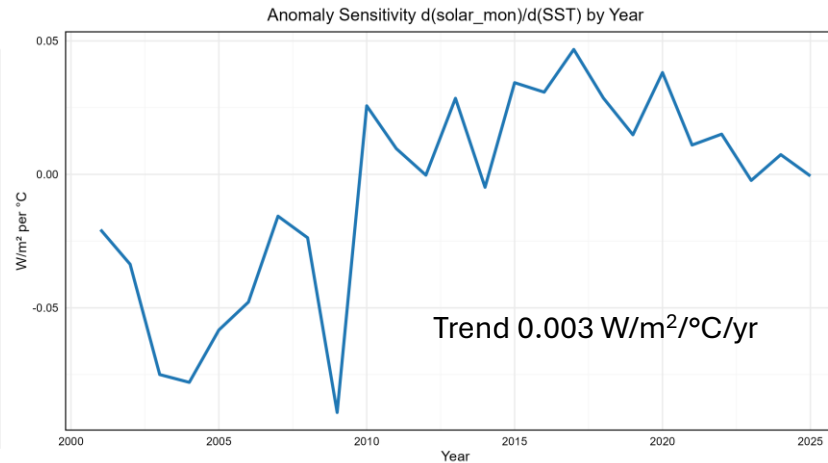
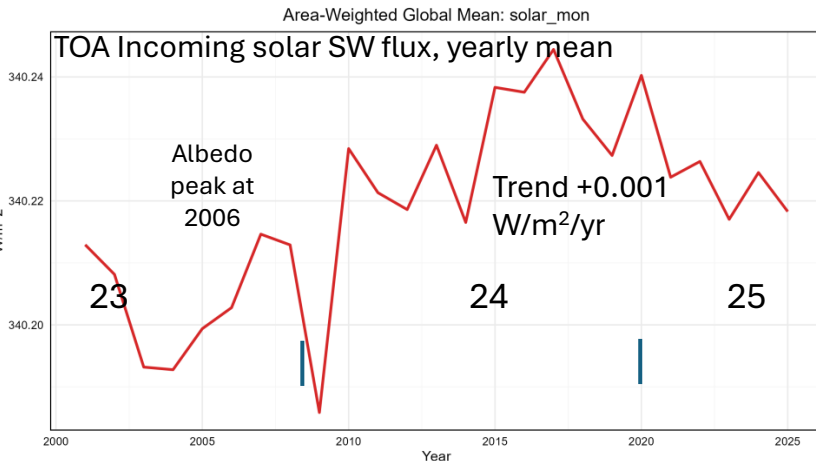
ΔF (2xCO ₂)	3.7	W/m ²
CO ₂ 2005	380	ppm
CO ₂ 2025	427.4	ppm
Diff	47.4	ppm
% 2x	12.47%	of 2xCO ₂
Forcing	0.46	W/m ²

Δ Albedo	-0.42	W/m ²
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Albedo peaks just after 2005. Expected CO₂ forcing (Myhre/AR5 = 3.7), 2005-2025, is 0.46, versus 0.42 from the decrease in albedo.

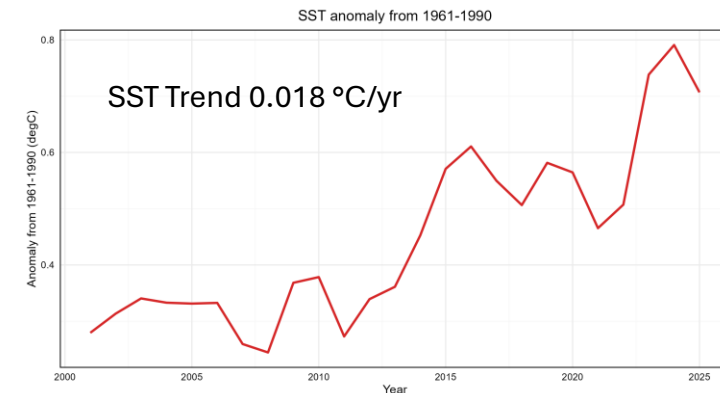


Incoming solar SW flux: solar_mon



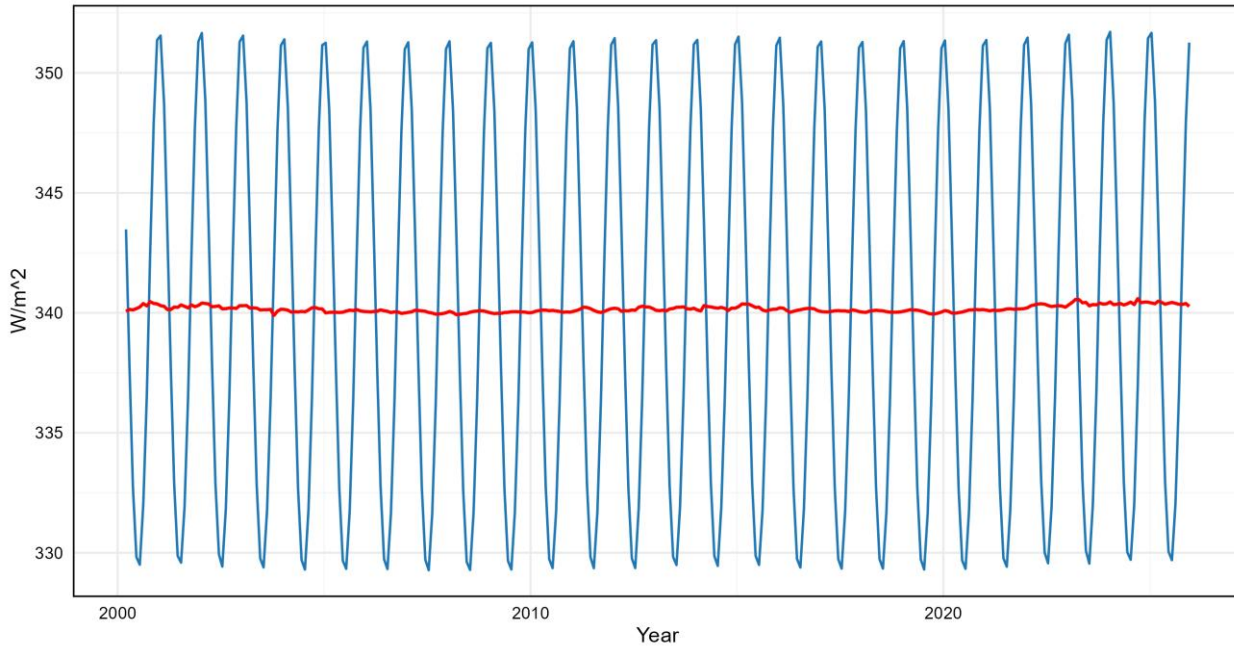
The global slope for this variable is **0.049 W/m²/°C**. These are all calendar year averages and for the global mean this creates some distortion. But it is clear that for this period, at least on a yearly average, incoming SW flux is increasing, and it is increasing per °C SST.

Southern Hemisphere is receiving more solar SW. The warming per degree is also greater near Antarctica.

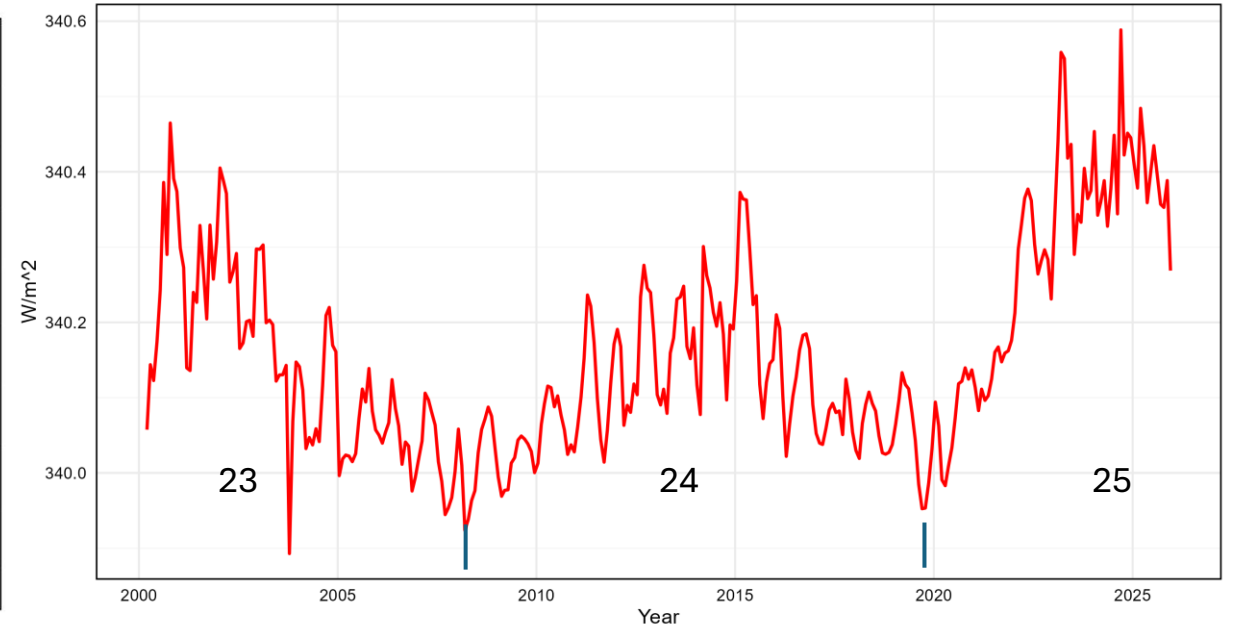


Monthly average and yearly average solar_mon plots

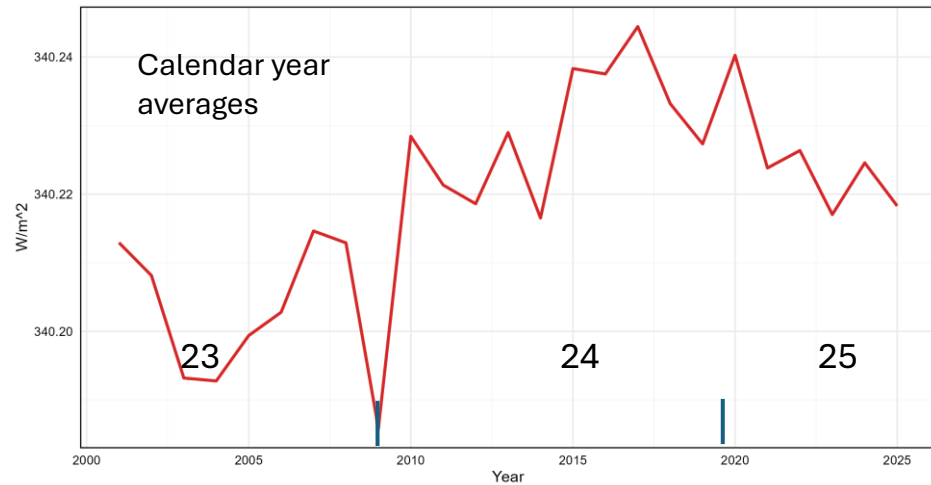
Monthly Incoming Solar Flux (blue) and Extracted Solar Cycle (red)



Monthly Incoming Solar Flux anomaly



Area-Weighted Global Mean: solar_mon



Key points:

✓ From 2001-2025 the underlying solar SW input is increasing about 0.025 W/m^2 the increase begins at the beginning of solar cycle 24. Overall, the linear increase in solar input from March 2008 to December 2025 is 0.78 W/m^2 , using the CERES EBAF monthly data (the blue line). The per month increase is 0.0037 W/m^2 and there are 214 months.

✓ The solar cycle signal is tiny

✓ The orbital annual cycle is huge

✓ The visibility of the solar cycle depends on where the averaging window begins and ends

The solar magnetic cycle is only $\sim \pm 0.6 \text{ W/m}^2$ globally averaged or 15x smaller than the orbital cycle. The solar cycles remains in the plot on the left, but its amplitude is reduced by the calendar yearly averages and distorted.

Date	Solar SW global mean	month	year	climatic mean for the month	solar cycle anomaly
3/15/2000	343.479	3	2000	343.5807	-0.10168
4/15/2000	337.7557	4	2000	337.771	-0.01536
5/15/2000	332.7595	5	2000	332.7959	-0.03646
6/15/2000	329.8189	6	2000	329.8039	0.01504
7/15/2000	329.4992	7	2000	329.4154	0.083846
8/15/2000	332.0301	8	2000	331.8034	0.226674
9/15/2000	336.5469	9	2000	336.4159	0.130971
10/15/2000	342.5341	10	2000	342.2285	0.305632
11/15/2000	347.9328	11	2000	347.701	0.231846
12/15/2000	351.3688	12	2000	351.1542	0.21455
1/15/2001	351.5576	1	2001	351.4178	0.139804
2/15/2001	348.6925	2	2001	348.5789	0.113607
3/15/2001	343.5611	3	2001	343.5807	-0.0196
4/15/2001	337.7479	4	2001	337.771	-0.02316
5/15/2001	332.8766	5	2001	332.7959	0.080664

R code

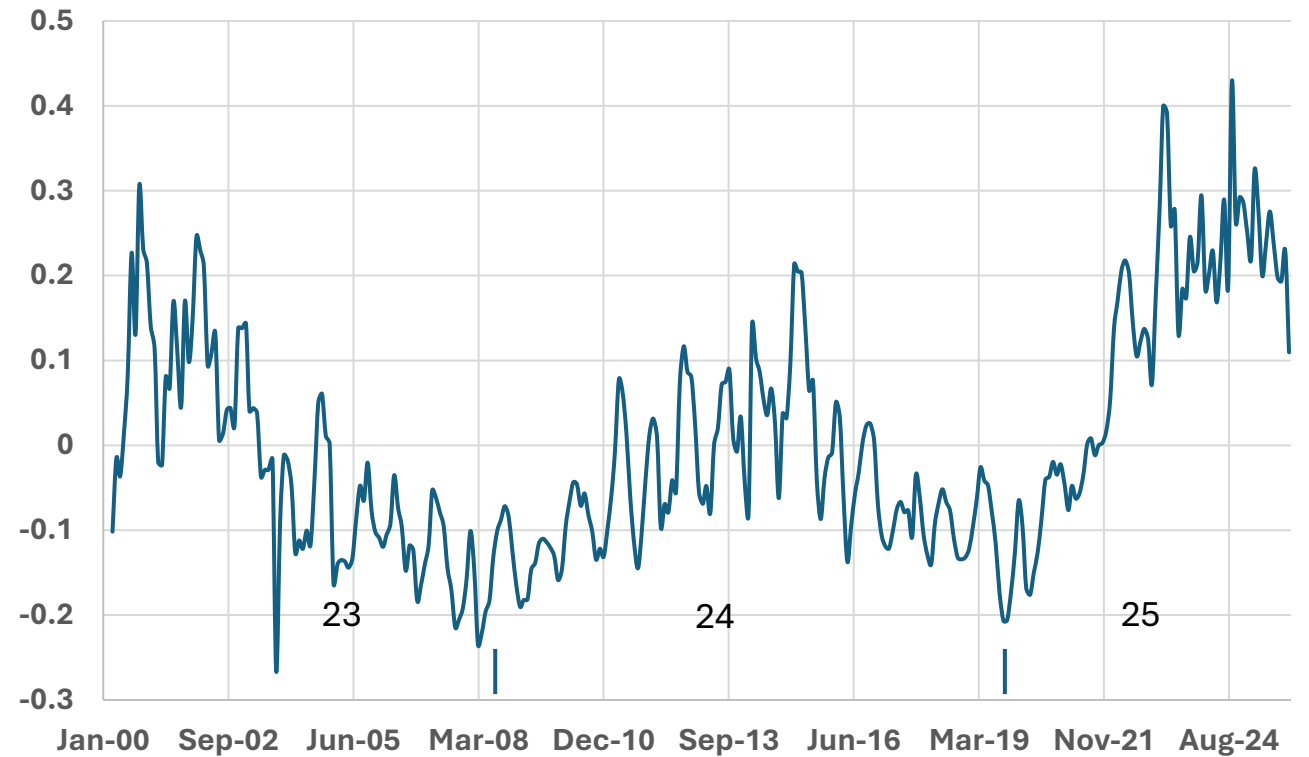
```
# Add month and year columns
solar_monthly_ts <- solar_monthly_ts |>
mutate(
  month = lubridate::month(date),
  year = lubridate::year(date)
)

# Compute monthly climatology (2001–2025)
solar_clim <- solar_monthly_ts |>
group_by(month) |>
summarise(clim_mean = mean(mean, na.rm = TRUE))

# Merge and compute anomaly (removes orbital cycle)
# Compute anom: actual monthly mean – long-term average
# Need to extract the weak solar cycle from the signal
solar_anom <- solar_monthly_ts |>
left_join(solar_clim, by = "month") |>
mutate(anom = mean - clim_mean) # subtract the expected value

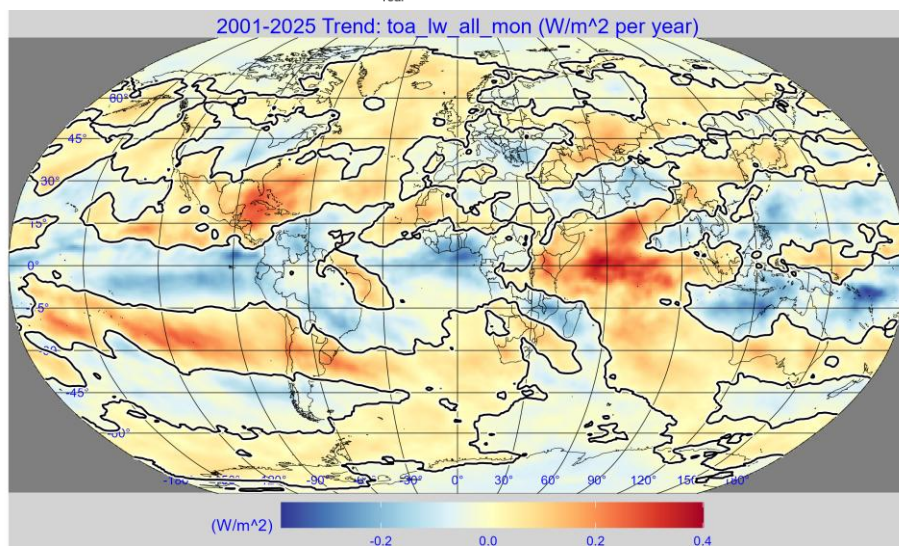
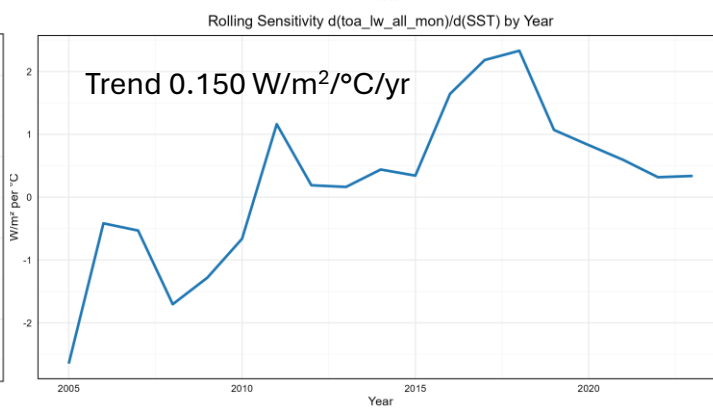
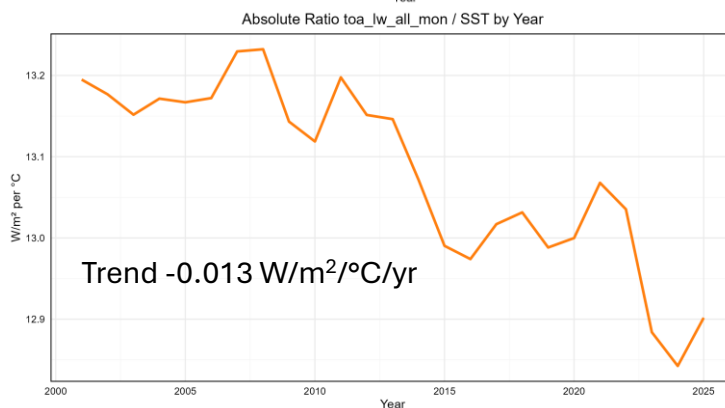
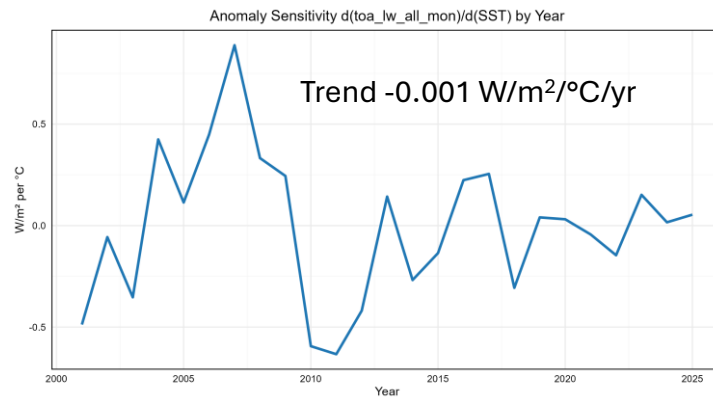
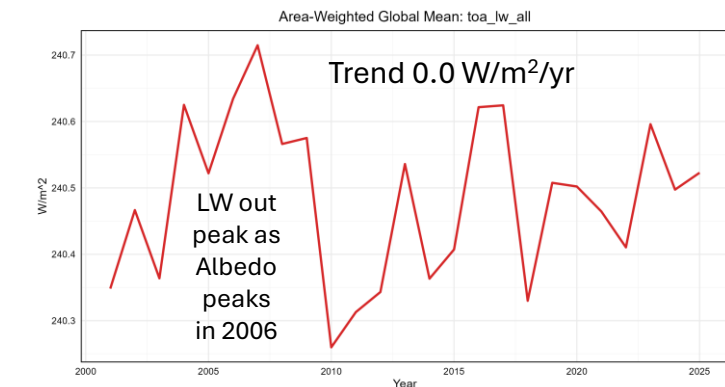
write_csv(solar_anom,
paste0("spreadsheets/", "solar_anom_monthly_2000_2025.csv"))
```

Solar Cycle Anomaly



To extract the weak solar cycle signal from the yearly noise we must compute an average value for each month of the year and then subtract this “expected” monthly value from each month. This allows the solar cycle to be seen

TOA Outgoing LW flux all sky: toa_lw_all_mon

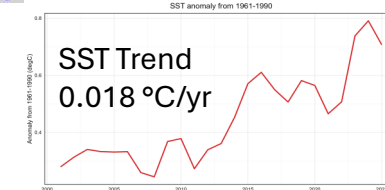
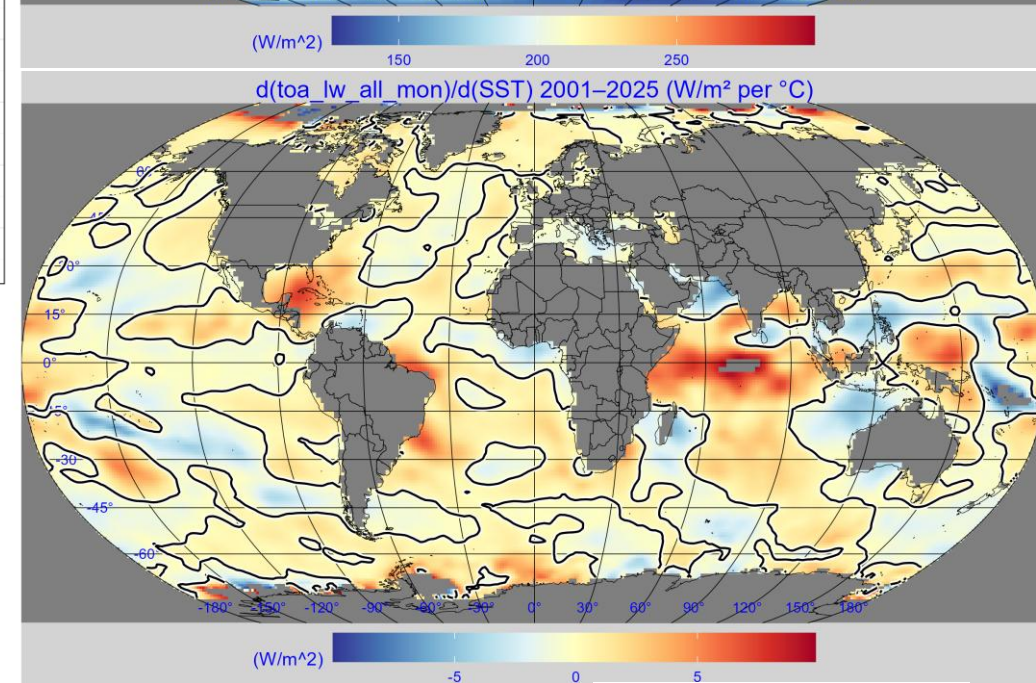
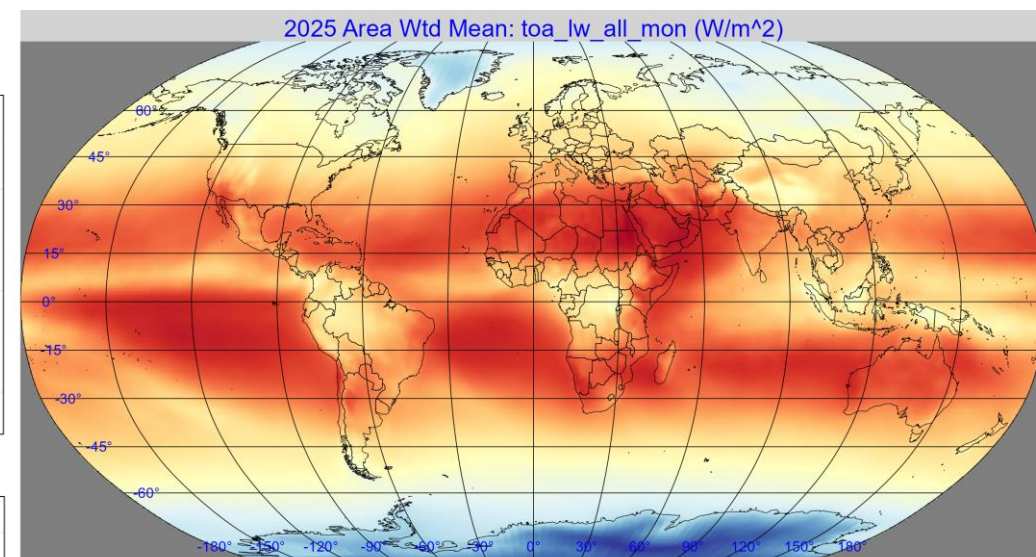


The global slope for this variable is 0.092 W/m²/°C.

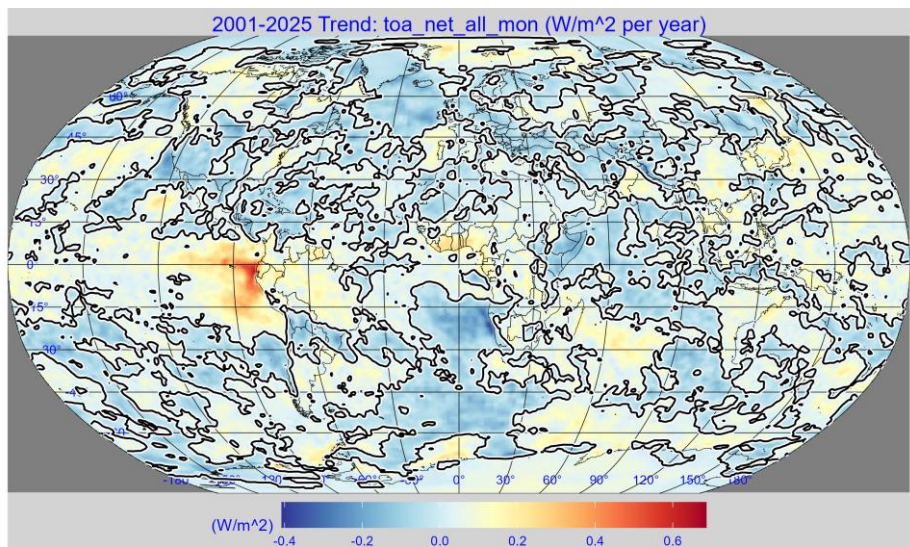
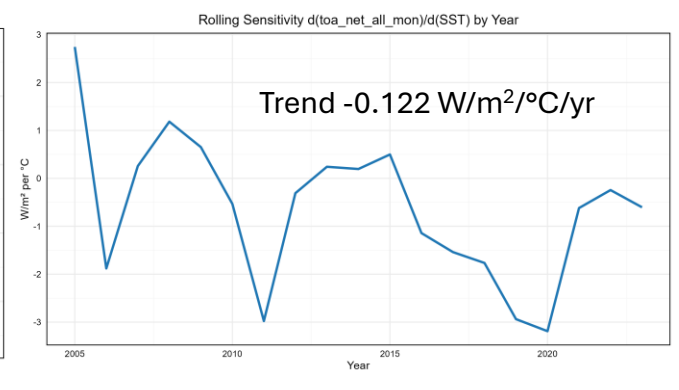
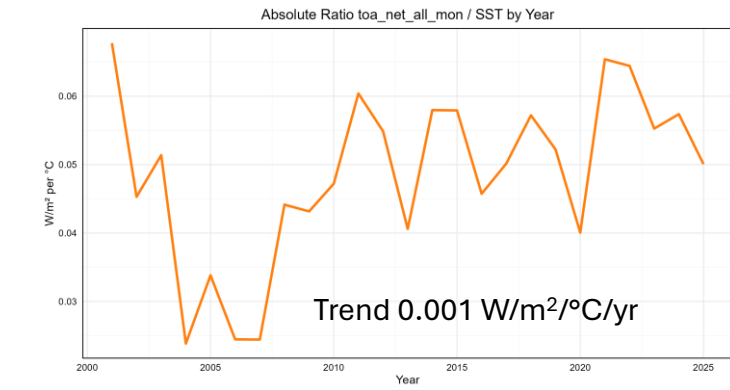
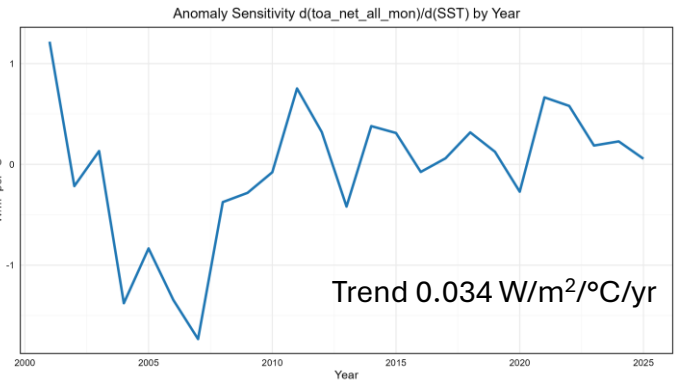
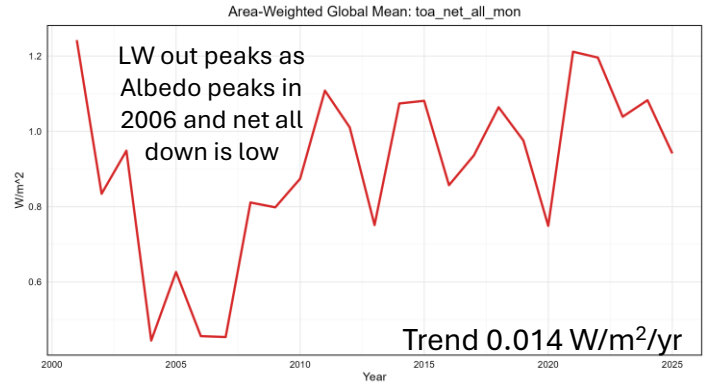
Outgoing LW is flat. The change per degree C SST is up slightly on the rolling slope, but very erratic relative to SST.

The trends in the Indian Ocean and Caribbean are notable. So is the cooling trend along the equator in the Pacific and Atlantic.

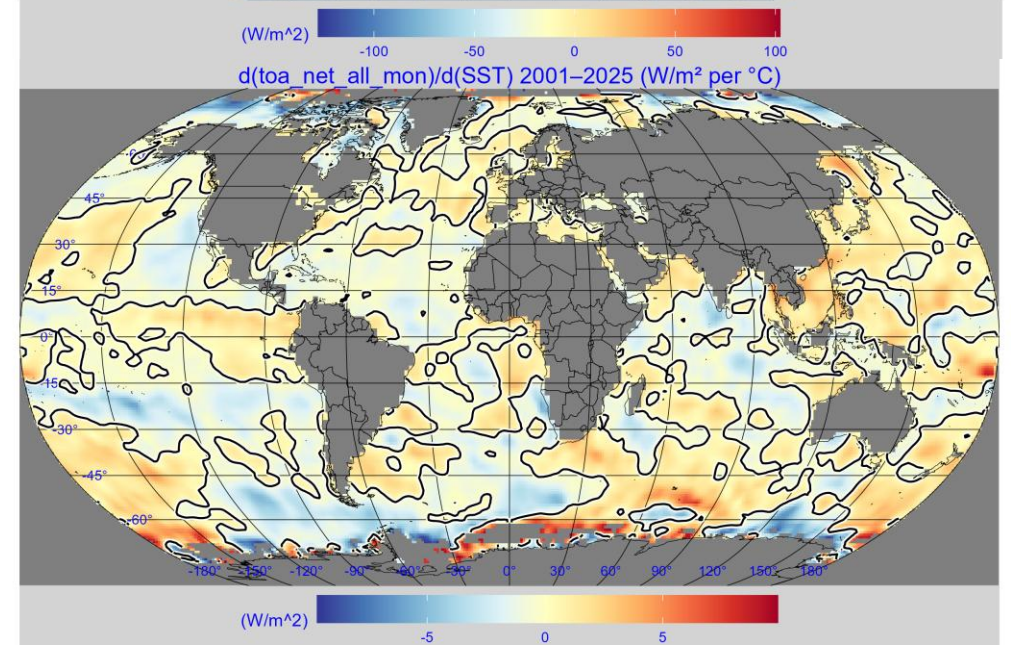
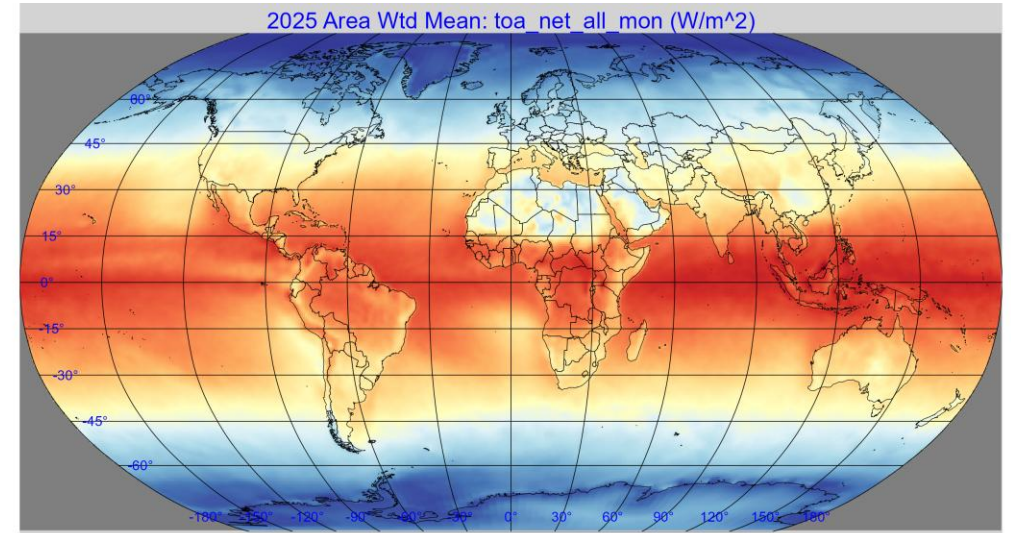
Interesting that LW outgoing (emitted) peaks as albedo peaks.



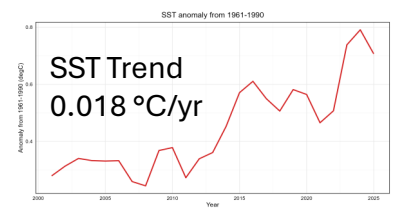
Net downward TOA flux = $SW_{in} - SW_{out} - LW_{out}$,: **TOA_net_all_mon** = solar_mon - toa_sw_all_mon - toa_lw_all_mon



The global slope for this variable is 0.532 **W/m²/°C**. With many important assumptions ECS can be computed from this data, and it equals 2.26. The regression slope (1.64) with this variable is $-\beta$, which = λ so ECS = $3.7/1.64 = 2.26^{\circ}\text{C}$, where 3.7 is the assumed CO₂ doubling forcing from AR5/Myher. The 2005 anomaly suggests that albedo dominates toa_net_all.



Net downward total flux is increasing. However, the 5-yr rolling slope (W/m²/°C/yr) is decreasing.

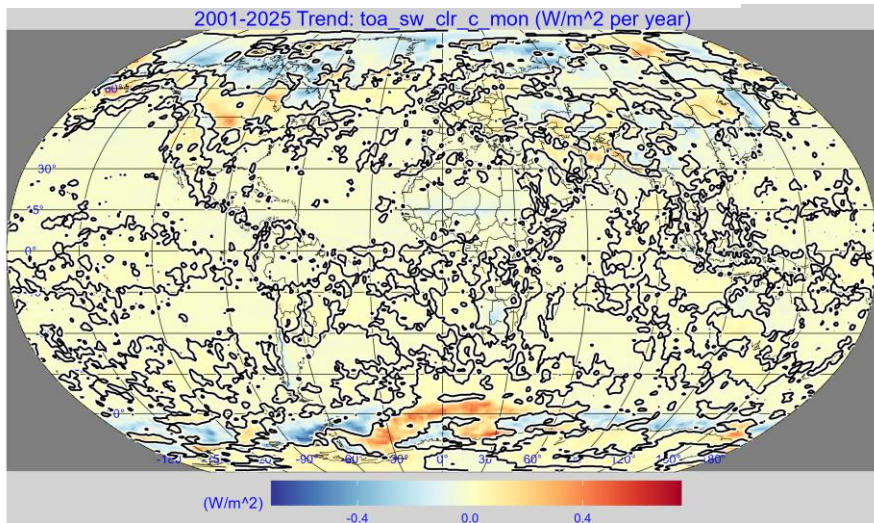
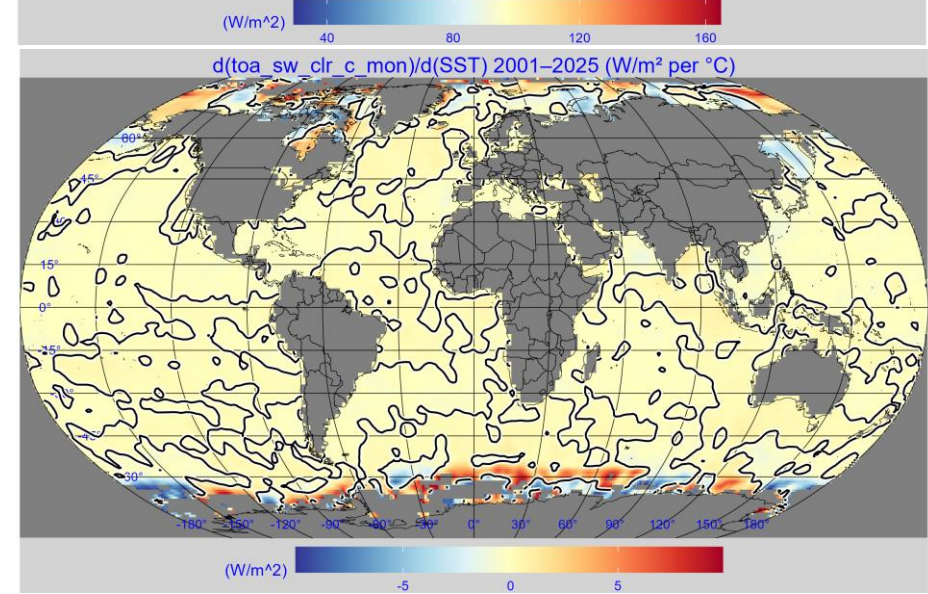
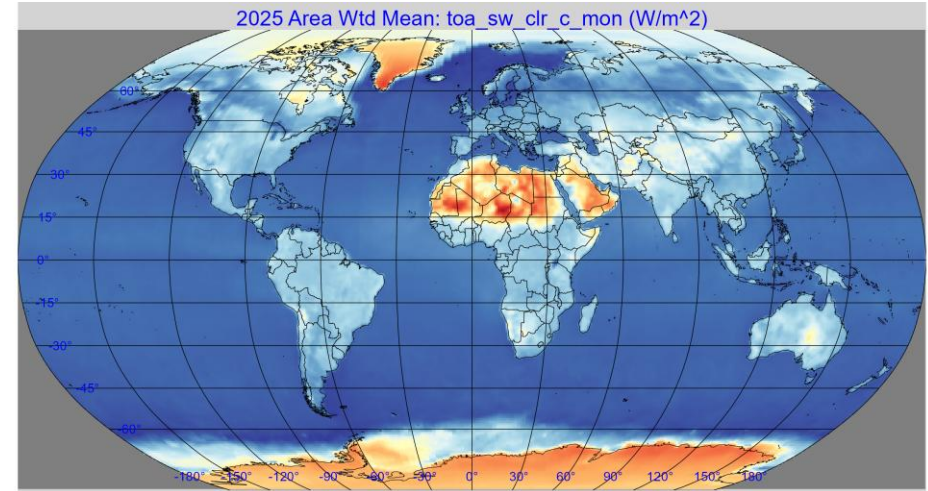
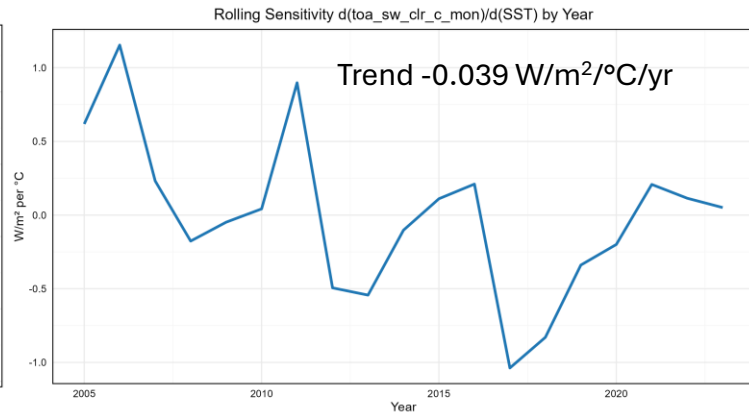
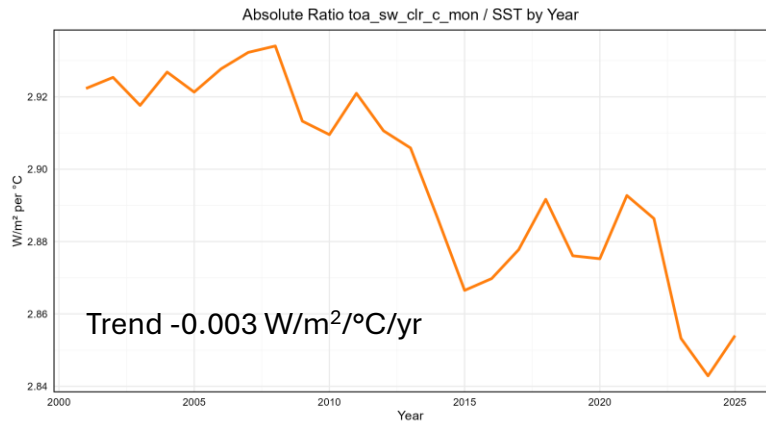
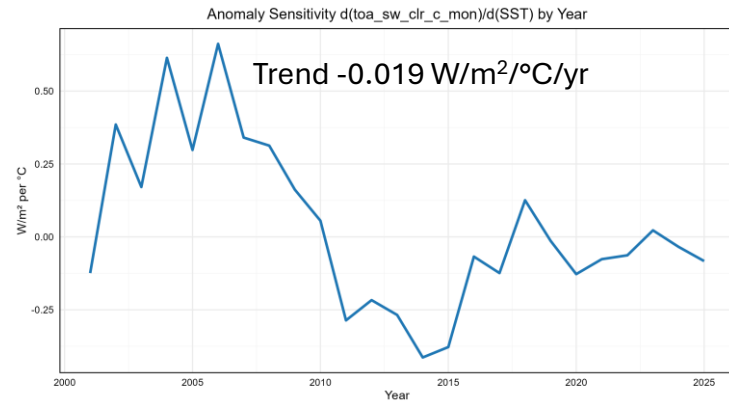
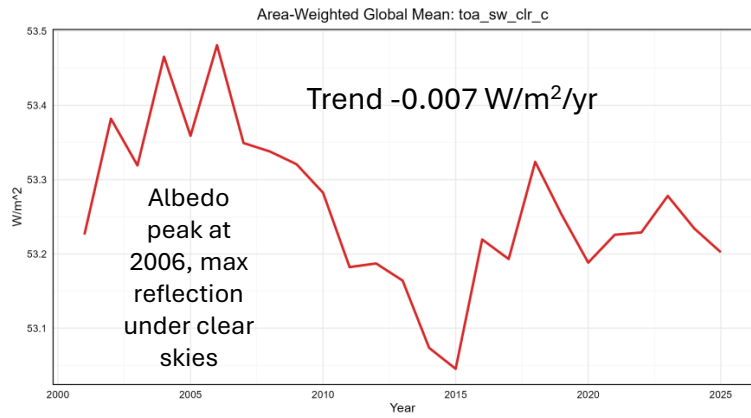


year	toa_net_all	solar-toa_sw-toa-lw	toa_sw_all	toa_lw_all	solar_mon
2001	1.234	1.234	98.622	240.344	340.2005
2002	0.827	0.827	98.907	240.463	340.1958
2003	0.939	0.939	98.882	240.360	340.1808
2004	0.435	0.436	99.123	240.622	340.1804
2005	0.618	0.618	99.051	240.518	340.187
2006	0.447	0.447	99.114	240.629	340.1904
2007	0.444	0.444	99.047	240.711	340.2023
2008	0.803	0.803	98.836	240.562	340.2005
2009	0.790	0.790	98.813	240.570	340.1735
2010	0.864	0.864	99.096	240.256	340.216
2011	1.100	1.100	98.802	240.307	340.209
2012	1.003	1.003	98.865	240.338	340.2062
2013	0.743	0.743	98.942	240.532	340.2166
2014	1.066	1.066	98.779	240.359	340.2041
2015	1.072	1.072	98.751	240.403	340.2259
2016	0.848	0.848	98.760	240.617	340.2251
2017	0.927	0.927	98.685	240.620	340.2321
2018	1.055	1.055	98.841	240.325	340.2208
2019	0.967	0.967	98.745	240.504	340.215
2020	0.741	0.741	98.989	240.498	340.2279
2021	1.203	1.204	98.548	240.460	340.2114
2022	1.188	1.188	98.620	240.406	340.214
2023	1.032	1.032	98.580	240.592	340.2047
2024	1.074	1.074	98.645	240.493	340.2122
2025	0.933	0.933	98.754	240.518	340.2059
Means	0.894	0.894	98.832	240.480	340.206

Cross check works out

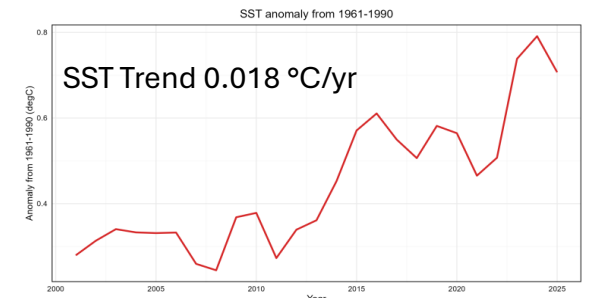
$$\text{Toa_net_all} = \text{solar_mon} - \text{toa_sw_all} - \text{toa_lw_all}$$

TOA SW outgoing (+=up) flux clear sky: toa_sw_clr_c_mon



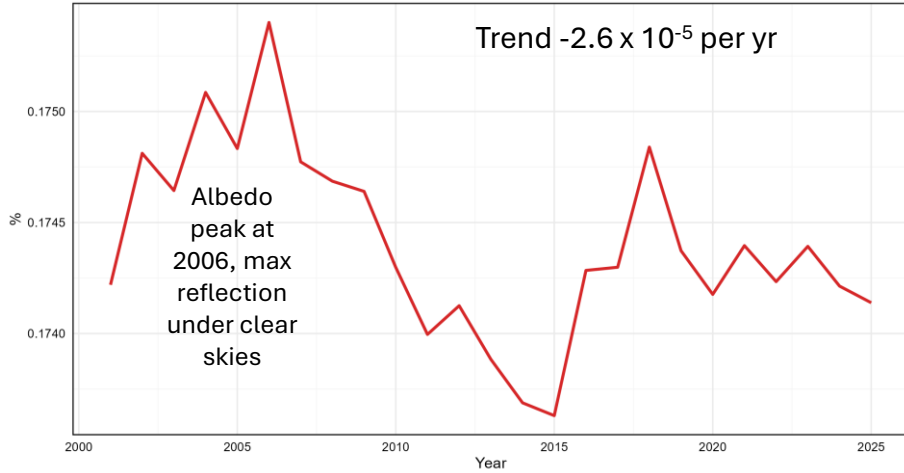
The global slope for this variable is **-0.259 W/m²/°C**.

This is reflected sw for the clear portion of the cell. It is clearly declining during the period. Clear sky albedo is increasing in the albedo peak.



TOA Outgoing SW flux clear sky **Albedo**: toa_sw_clr_c_mon

Area-Weighted Global Mean: albedo_toa_sw_clr_c



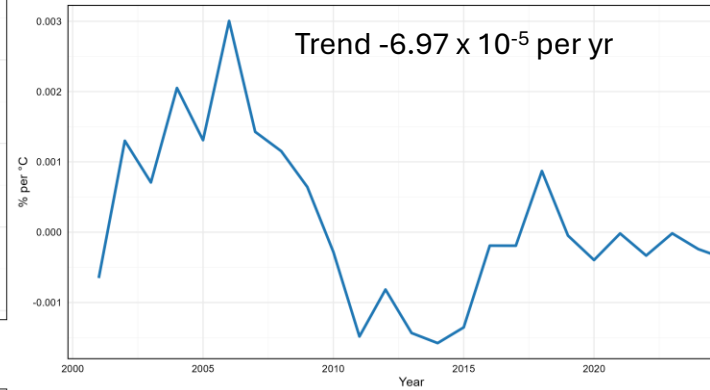
The global slope for this variable is -9.5×10^{-4} per $^{\circ}\text{C}$: This is the 2001–2025 change for the all-sky clear portion of the cell albedo for each 1°C change in global-mean SST.

The albedo peak is very well defined under clear skies, suggesting clouds make little difference. It is also well defined as a function SST.

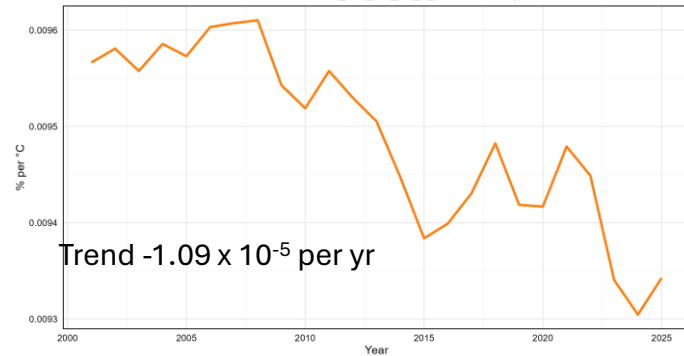
Rolling Sensitivity $d(\text{albedo_toa_sw_clr_c_mon})/d(\text{SST})$ by Year



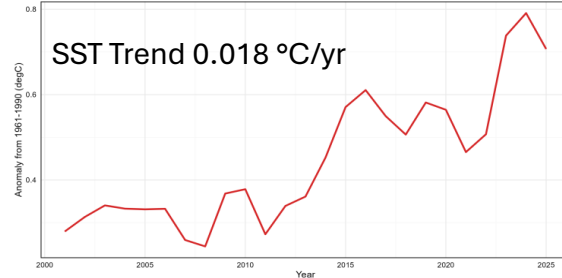
Anomaly Sensitivity $d(\text{albedo_toa_sw_clr_c_mon})/d(\text{SST})$ by Year



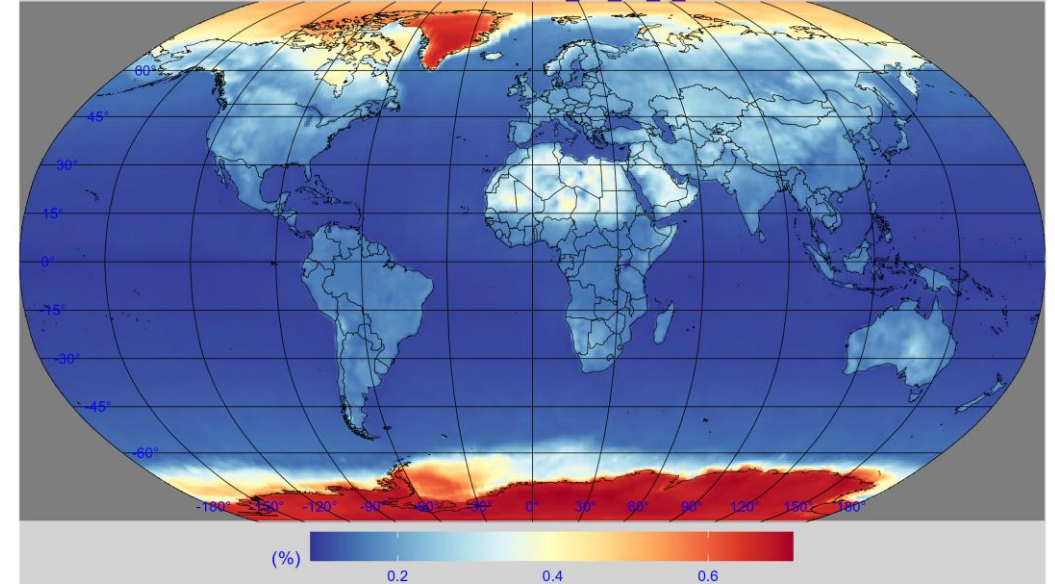
Absolute Ratio $\text{albedo_toa_sw_clr_c_mon} / \text{SST}$ by Year



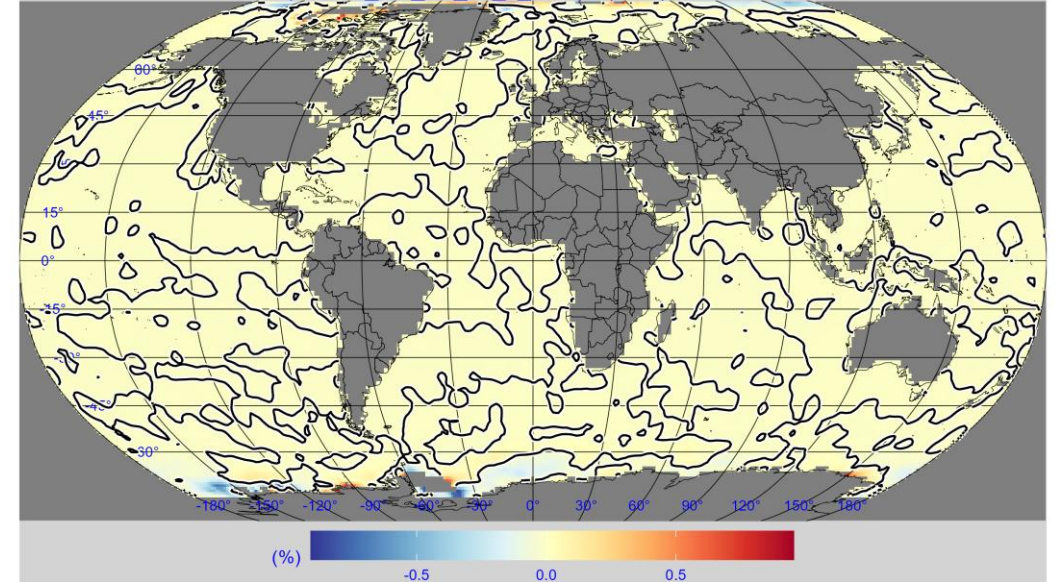
SST anomaly from 1961-1990



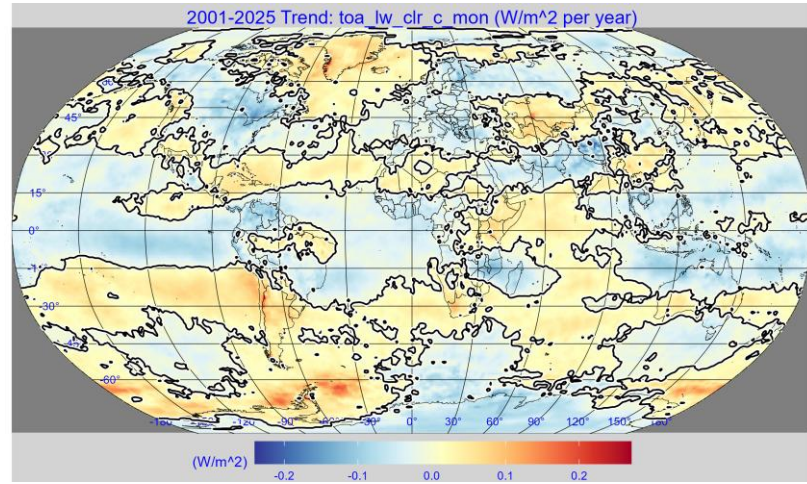
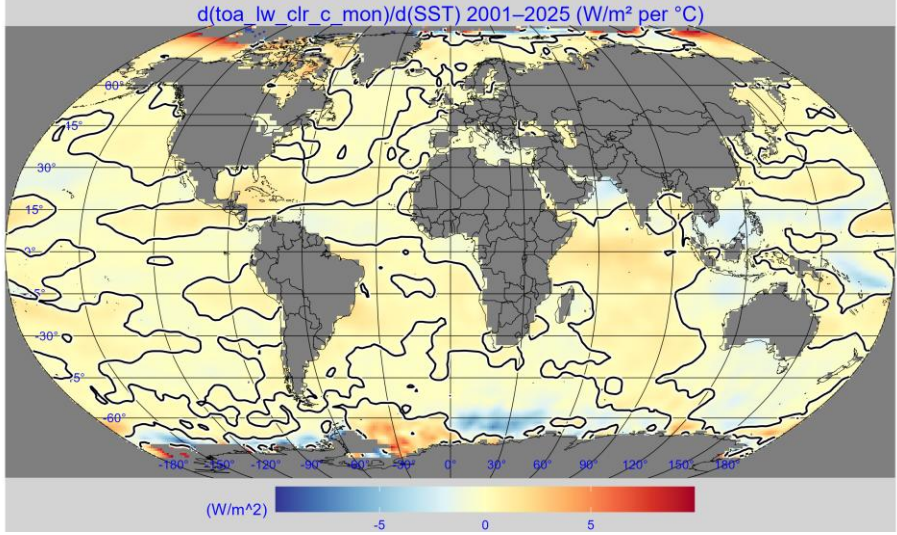
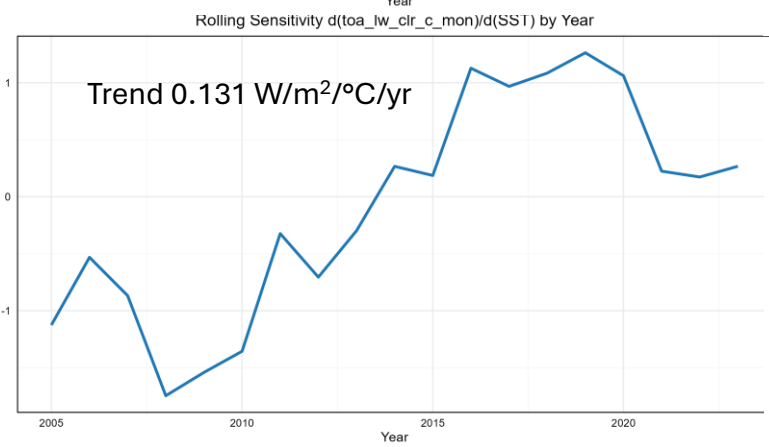
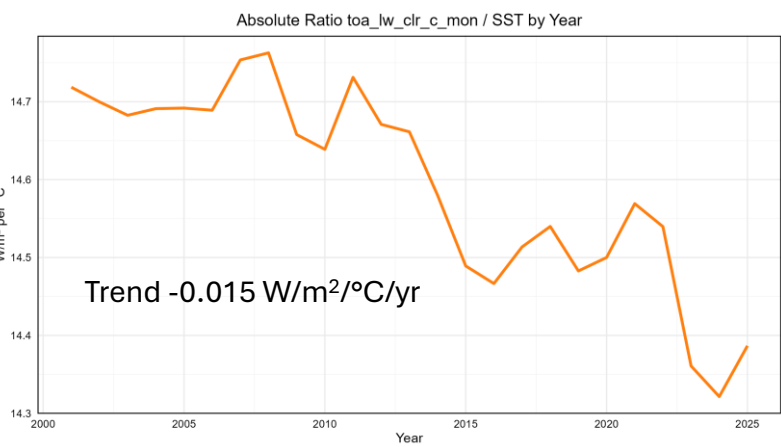
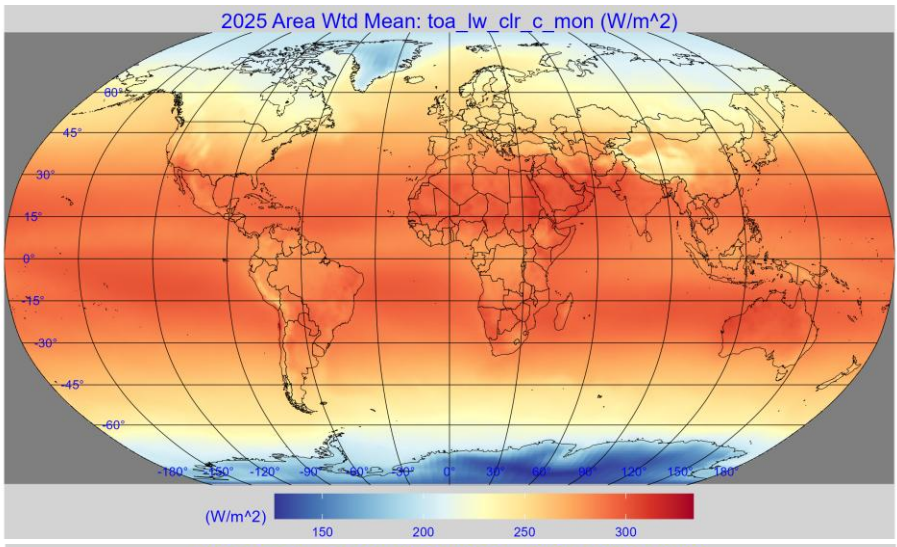
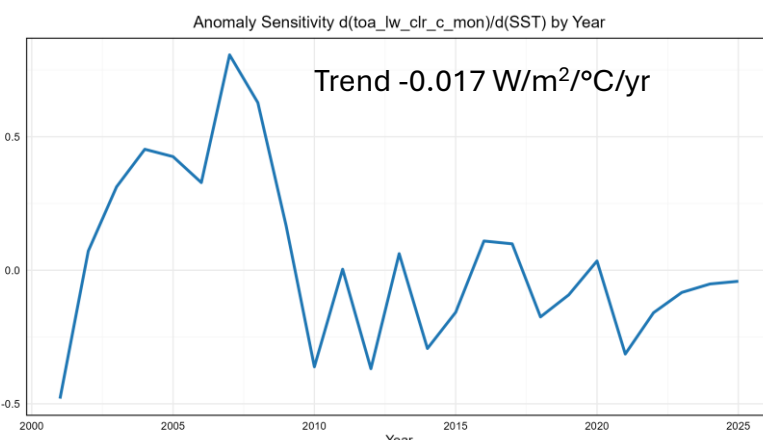
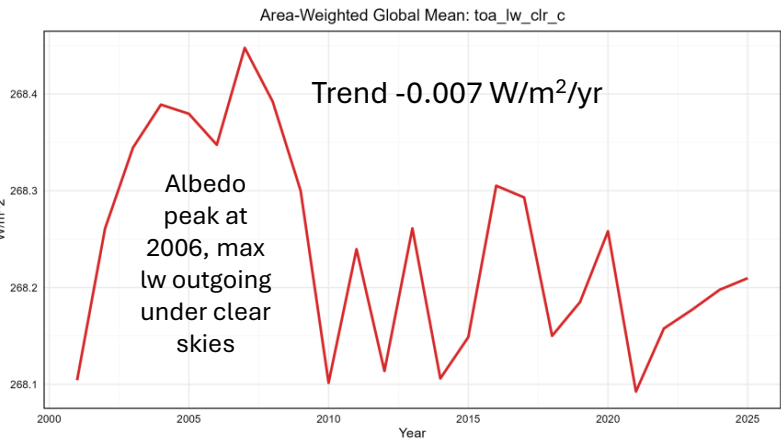
2025 TOA Albedo: toa_sw_clr_c_mon



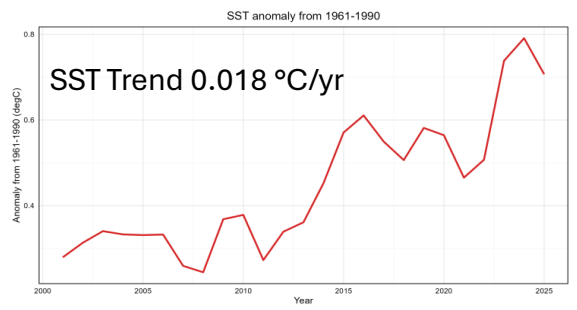
$d(\text{albedo_toa_sw_clr_c_mon})/d(\text{SST})$ 2001–2025



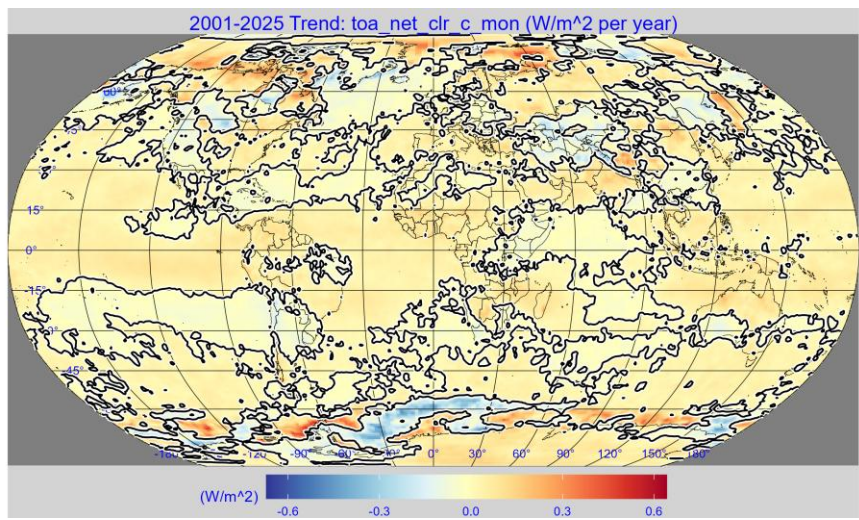
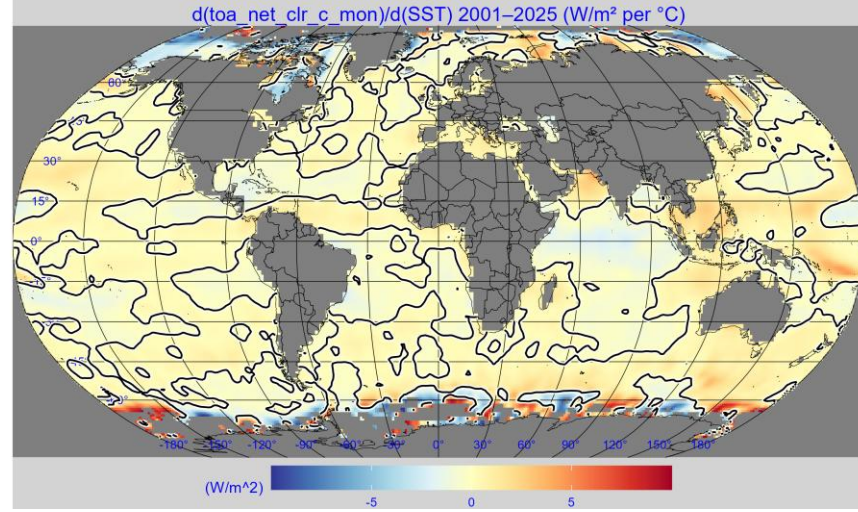
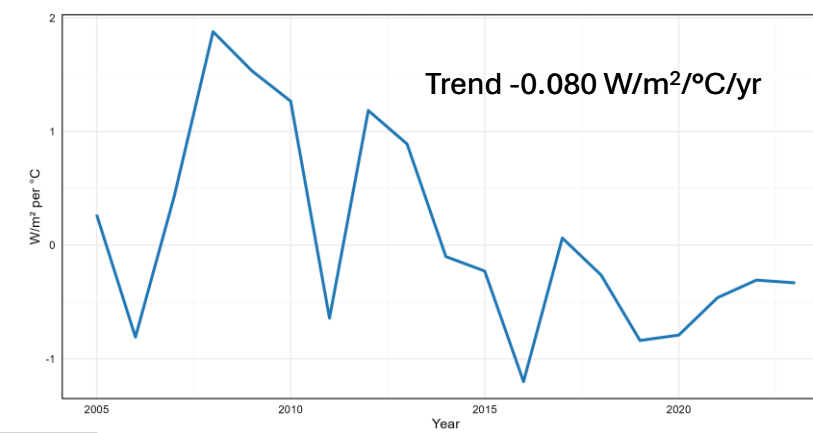
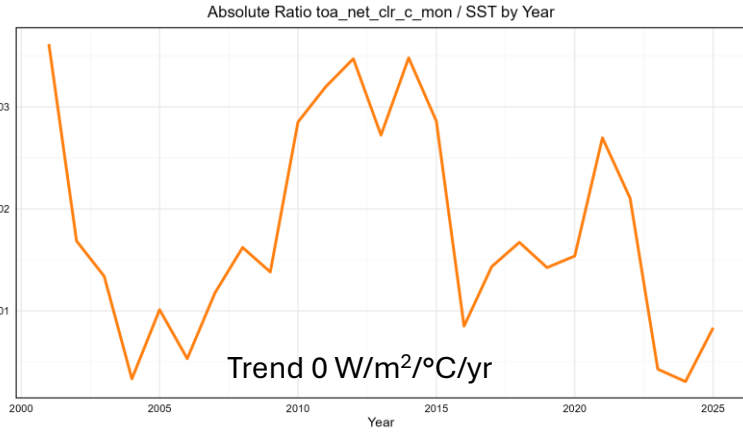
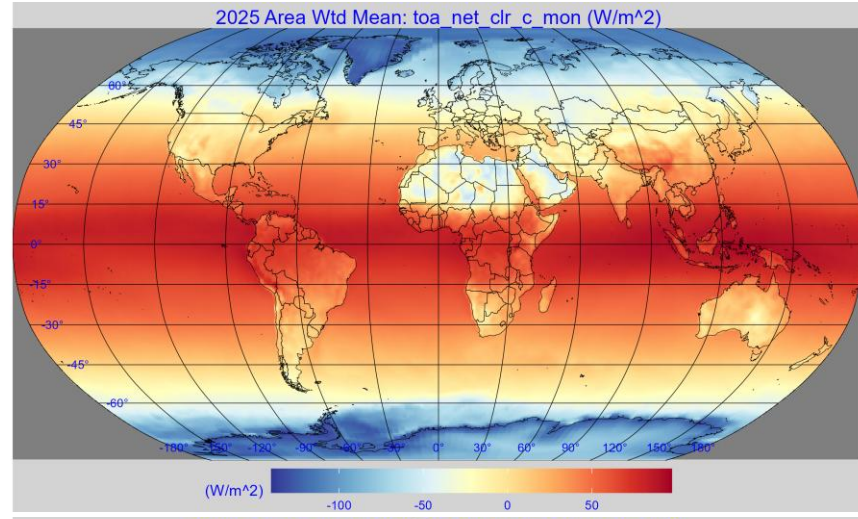
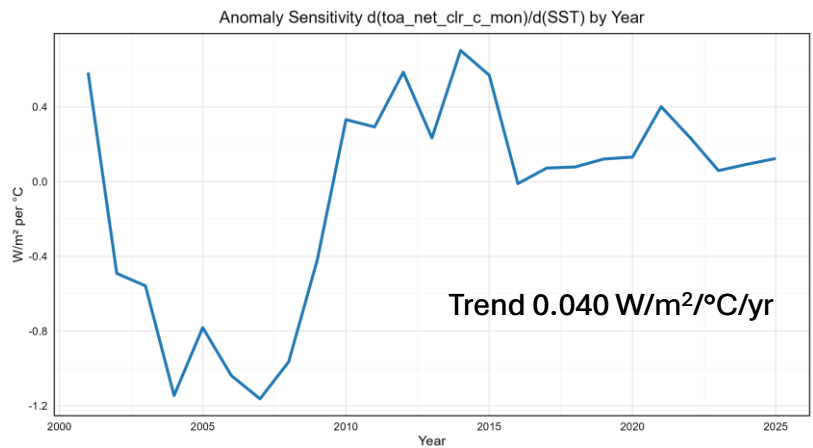
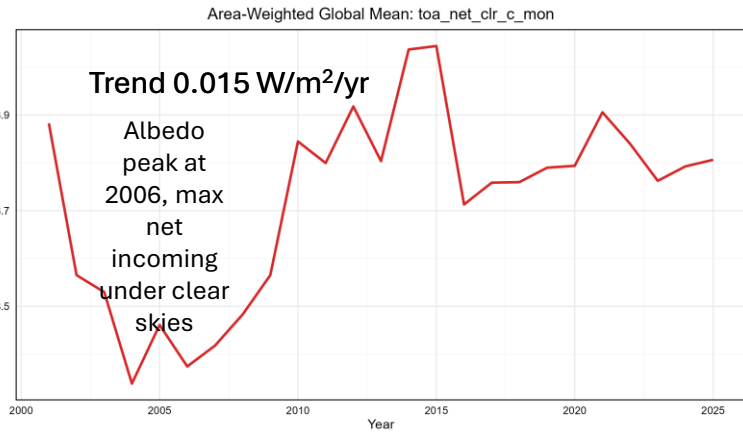
TOA LW Clear sky outgoing (+=up) flux clear sky only: toa_lw_clr_c_mon



The global slope for this variable is **-0.243 W/m²/°C**. The albedo peak coincides with maximum outgoing (emitted) LW.

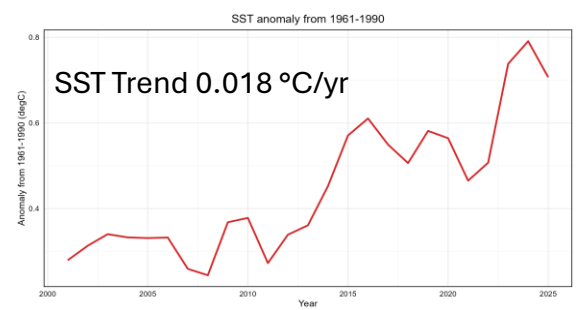


TOA net Clear sky incoming (+=down) flux clear sky only: toa_net_clr_c_mon



The global slope for this variable is 0.551 W/m²/°C.

Toa_net_* is always positive down and equal to solar_mon - sw_clr_c - lw_clr_c. The upper left graph confirms that total outward radiation is minimal at the albedo peak under clear skies.

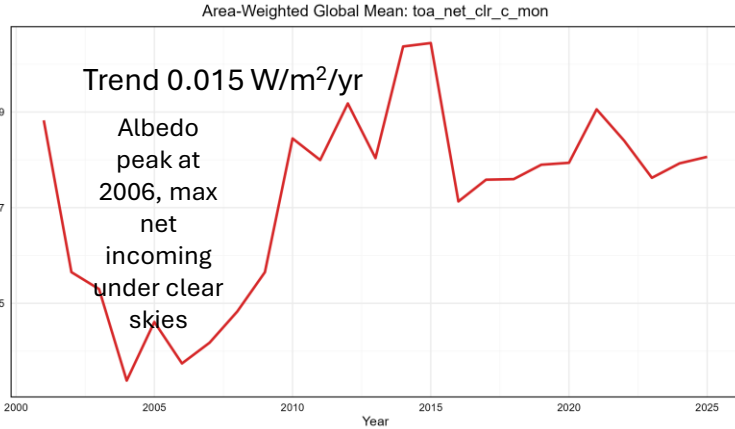


Sign Check for toa_net_clr_c

$$\text{Toa_net_clr_c} = \text{solar_mon} - \text{toa_sw_clr_c} - \text{toa_lw_clr_c}$$

It is net downward flux under clear skies

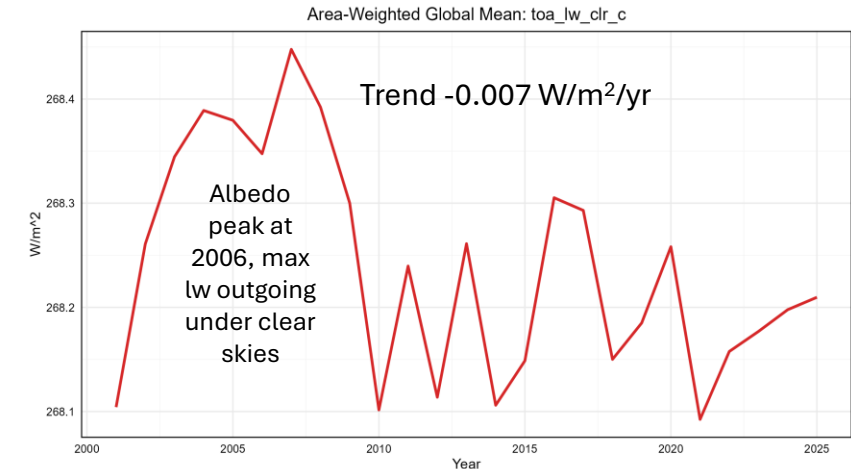
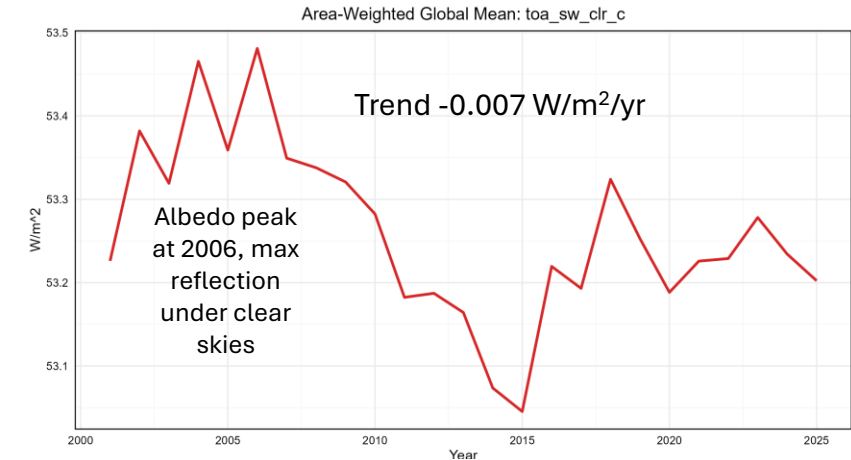
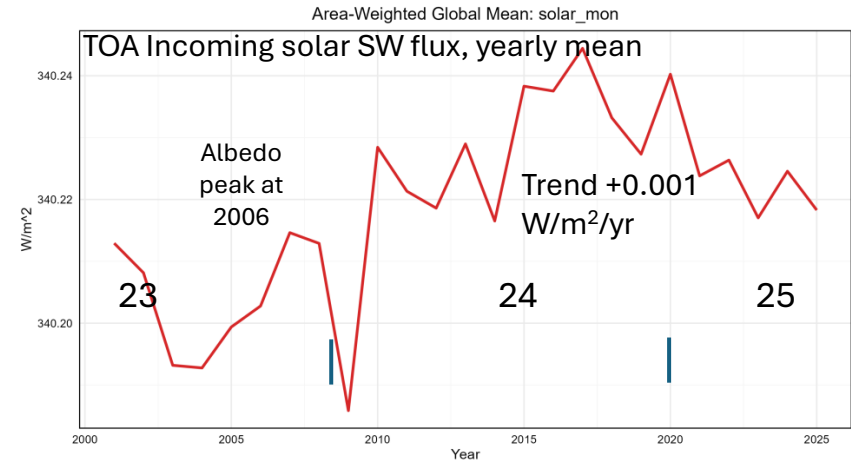
At the albedo peak, the outward total radiation flux is minimal at the albedo peak under clear skies.



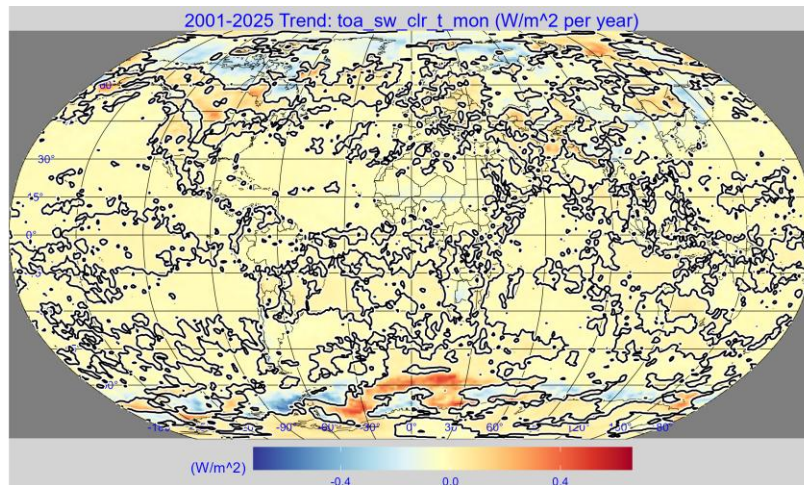
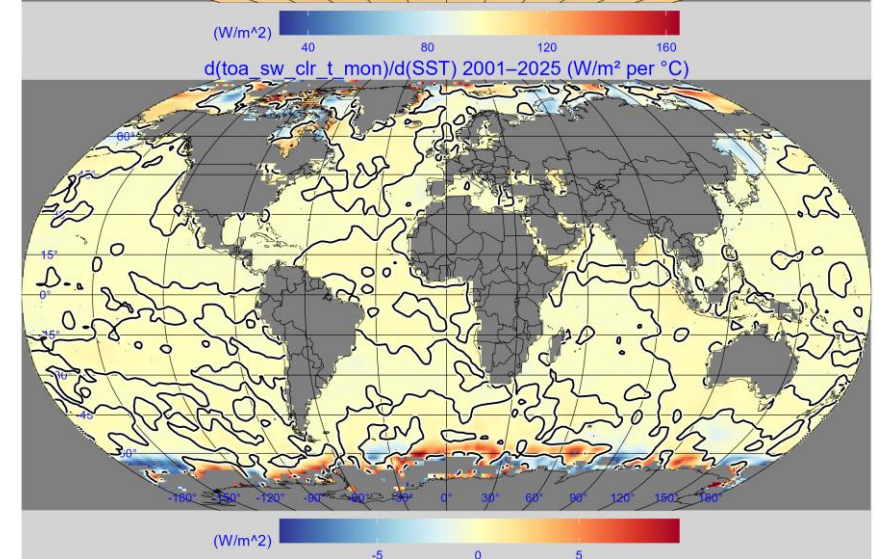
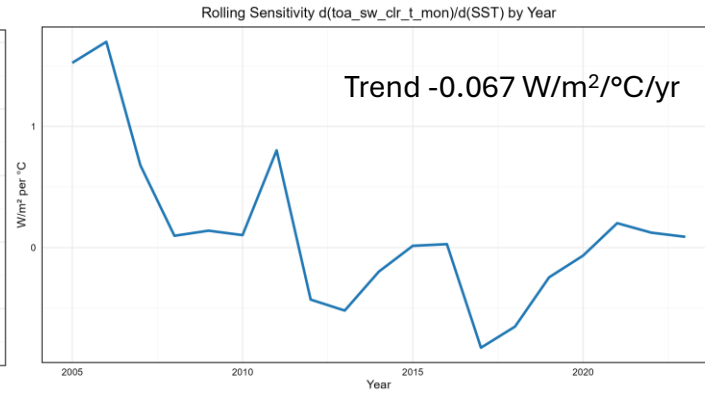
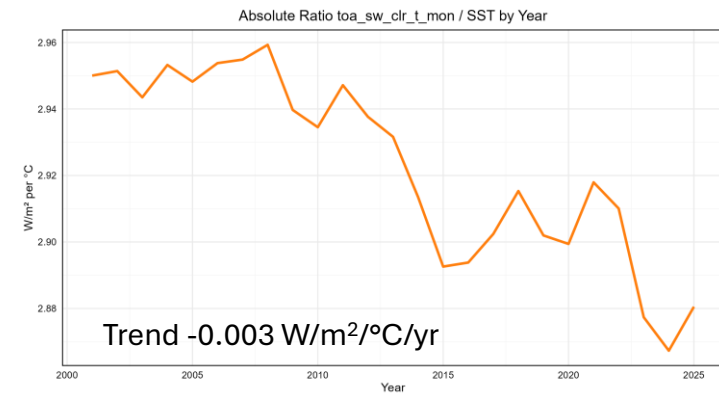
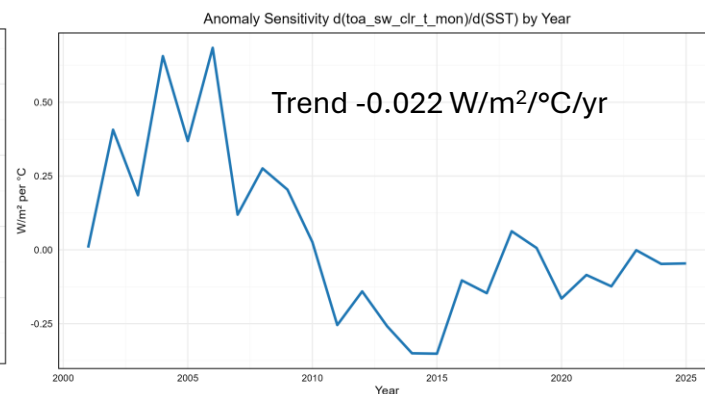
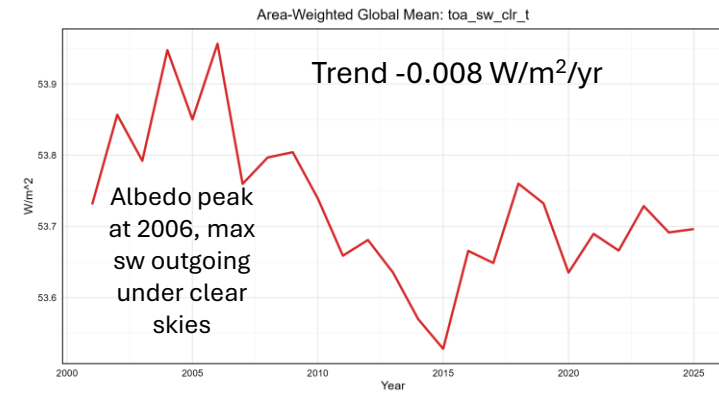
Area Wtd Mean Global clear skies net radiation sign check						
	Net down	Outgoing SW	Outgoing LW	incoming	net down solar-SW-LW	
year	toa_net_clr_c	toa_sw_clr_c	toa_LW_clr_c	solar_mon		
2001	18.874	53.230	268.097	340.201	18.874	
2002	18.556	53.385	268.254	340.196	18.557	
2003	18.521	53.322	268.338	340.181	18.520	
2004	18.329	53.469	268.382	340.180	18.329	
2005	18.452	53.363	268.373	340.187	18.451	
2006	18.365	53.484	268.341	340.190	18.365	
2007	18.409	53.353	268.441	340.202	18.409	
2008	18.475	53.341	268.385	340.201	18.475	
2009	18.557	53.324	268.293	340.173	18.556	
2010	18.836	53.285	268.095	340.216	18.836	
2011	18.790	53.186	268.233	340.209	18.790	
2012	18.909	53.191	268.107	340.206	18.909	
2013	18.795	53.168	268.254	340.217	18.795	
2014	19.028	53.077	268.099	340.204	19.028	
2015	19.036	53.049	268.142	340.226	19.035	
2016	18.704	53.223	268.299	340.225	18.704	
2017	18.750	53.196	268.286	340.232	18.750	
2018	18.750	53.328	268.143	340.221	18.750	
2019	18.781	53.256	268.178	340.215	18.781	
2020	18.784	53.192	268.251	340.228	18.784	
2021	18.897	53.229	268.086	340.211	18.897	
2022	18.831	53.232	268.151	340.214	18.831	
2023	18.754	53.281	268.170	340.205	18.753	
2024	18.784	53.237	268.191	340.212	18.784	
2025	18.798	53.206	268.202	340.206	18.798	

Comparison of anomalies in W/m²						
	Net down	Outgoing SW	Outgoing LW	incoming	net down solar-SW-LW	
year	toa_net_clr_c	toa_sw_clr_c	toa_LW_clr_c	solar_mon		
2001 - 2004	0.544	-0.239	-0.285	0.020	0.544	
diff max-min	0.706	0.436	0.355	0.059	-0.732	
Total LW+SW		0.791				

At least in terms of W/m², the small change in solar_mon is not causing the albedo peak.

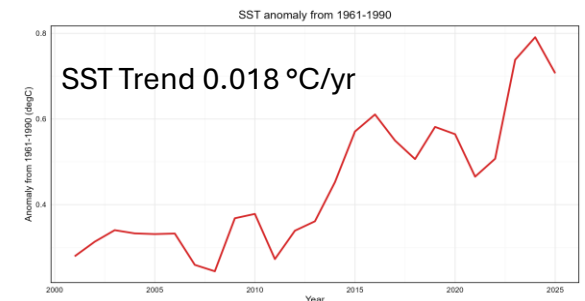


TOA sw reflected clear sky outgoing (+=down) flux clear sky only: toa_sw_clr_t_mon

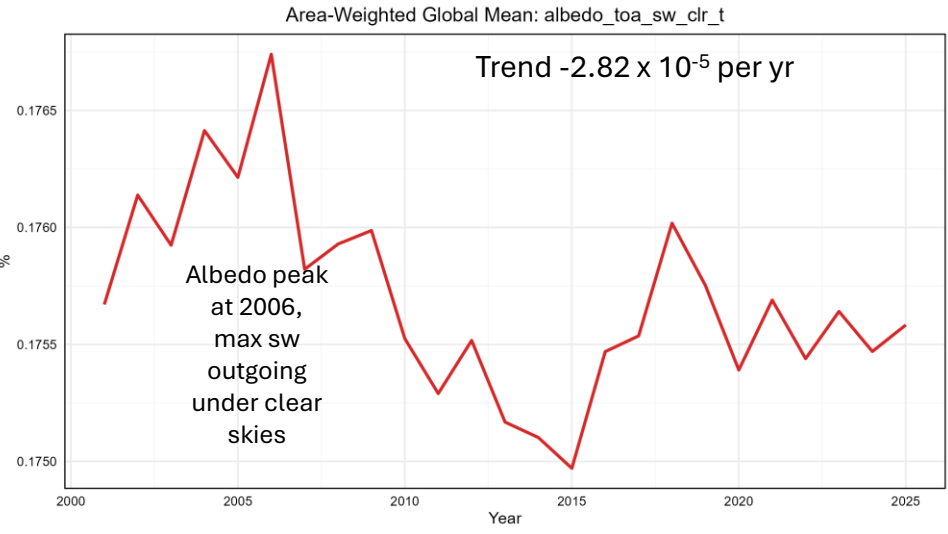


The global slope for this variable is $-0.284 \text{ W/m}^2/^\circ\text{C}$: This is the 2001-2025 change for toa_sw_clr_t_mon for each 1°C change in global-mean SST.

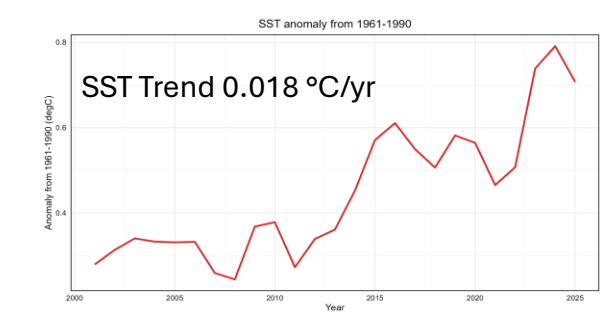
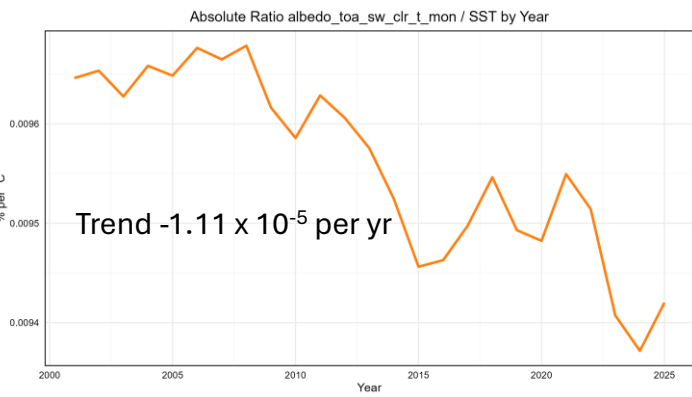
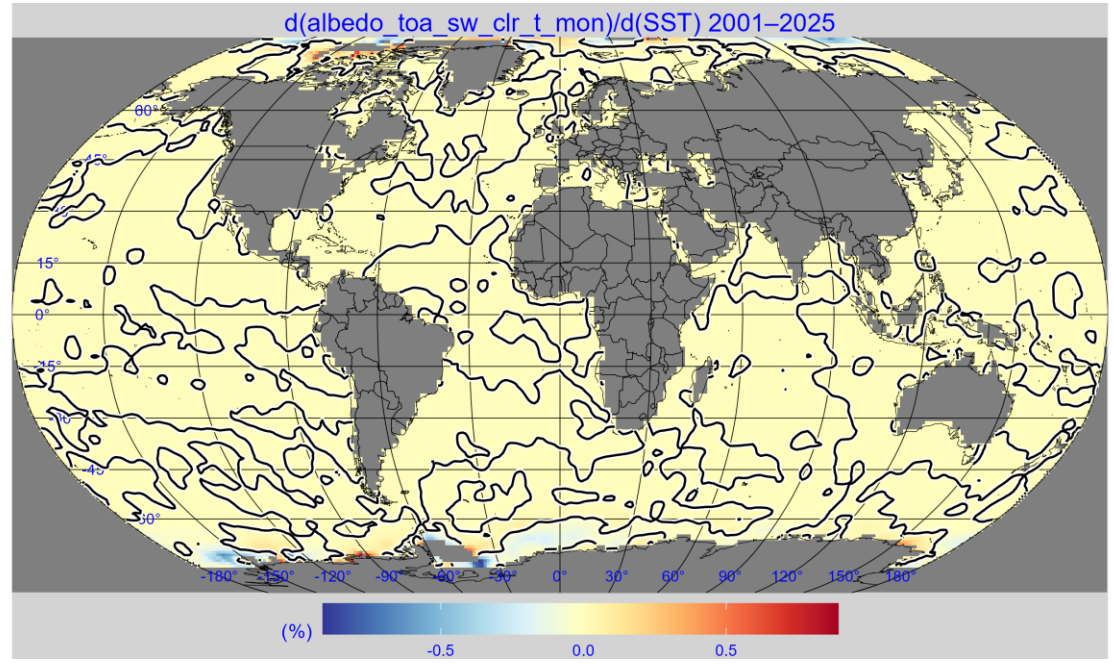
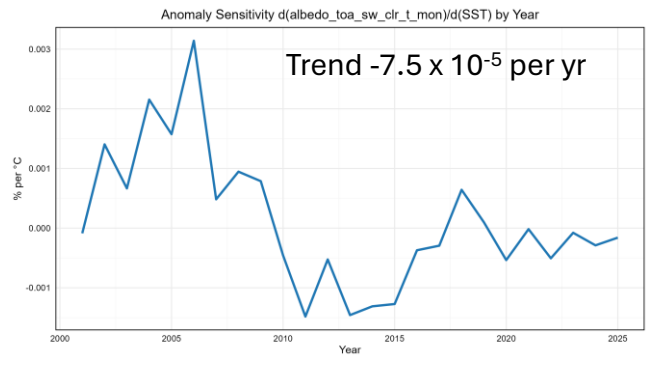
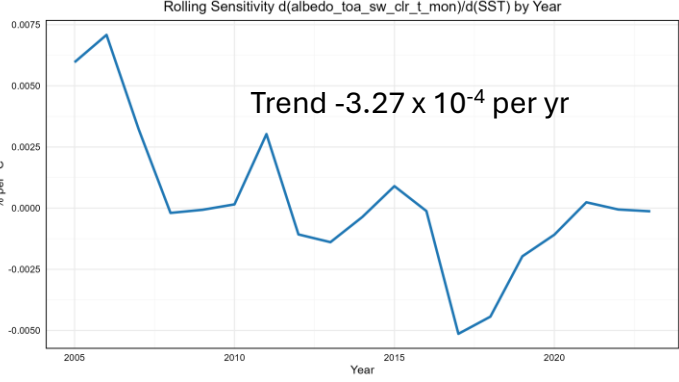
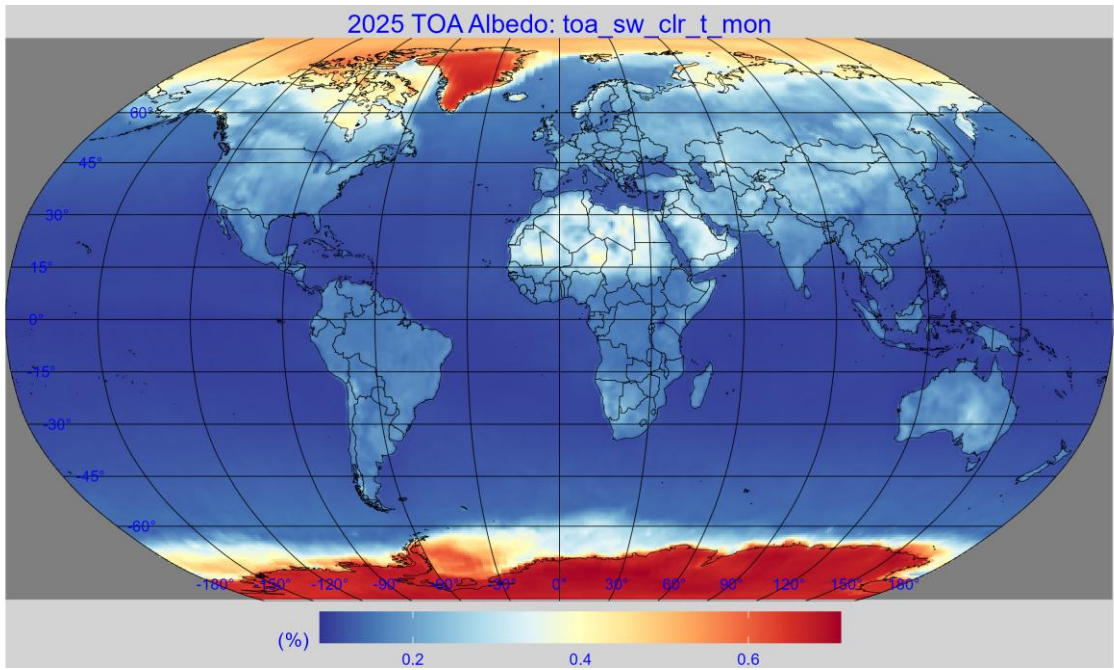
This is the calculated clear sky reflected sw for the total cell.



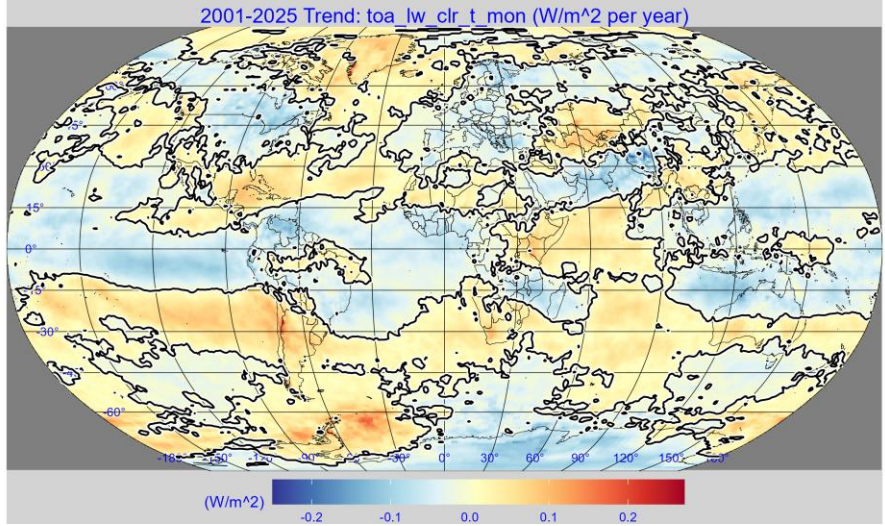
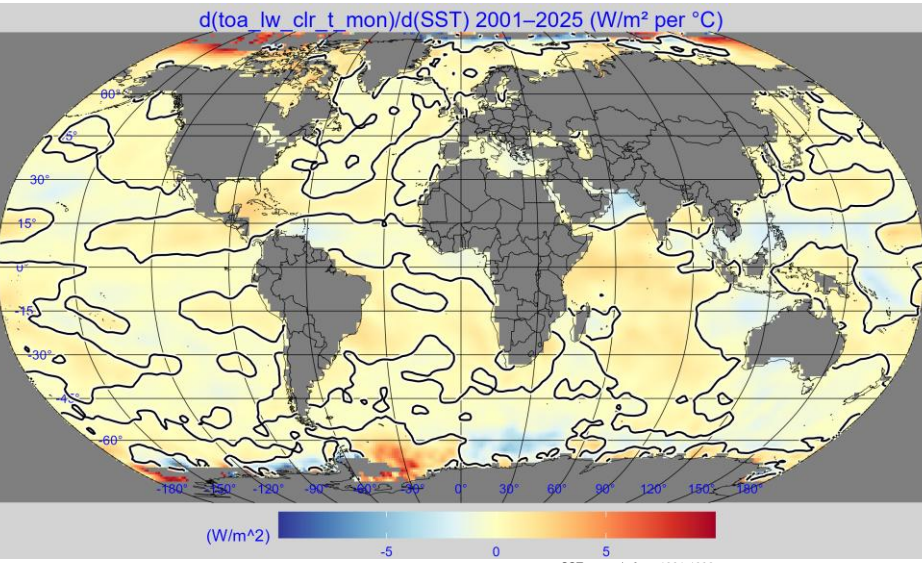
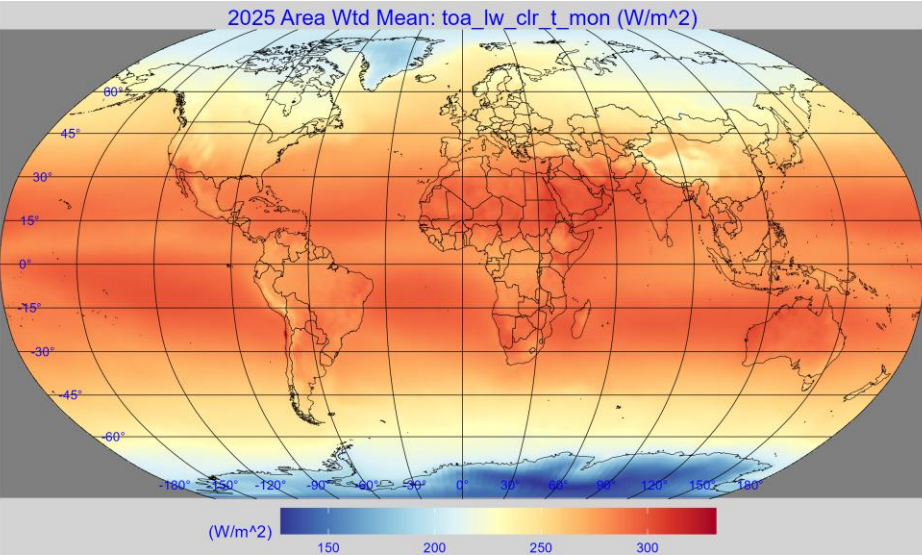
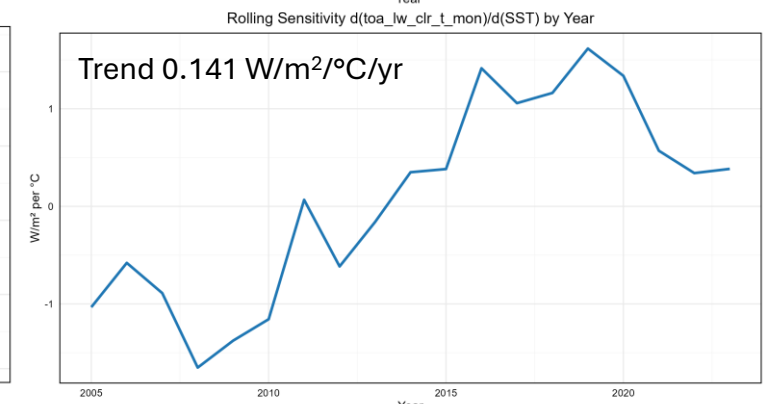
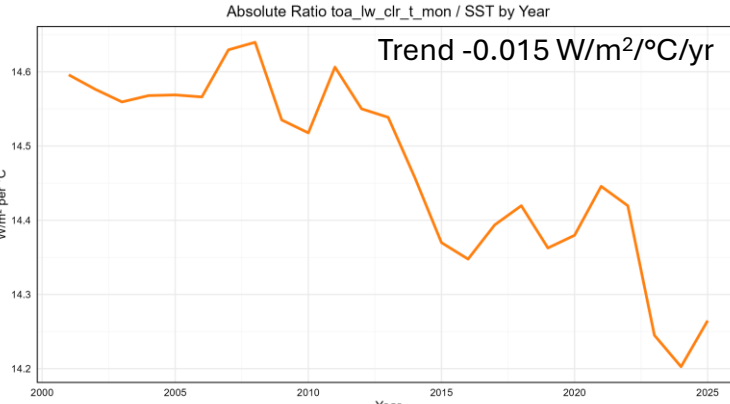
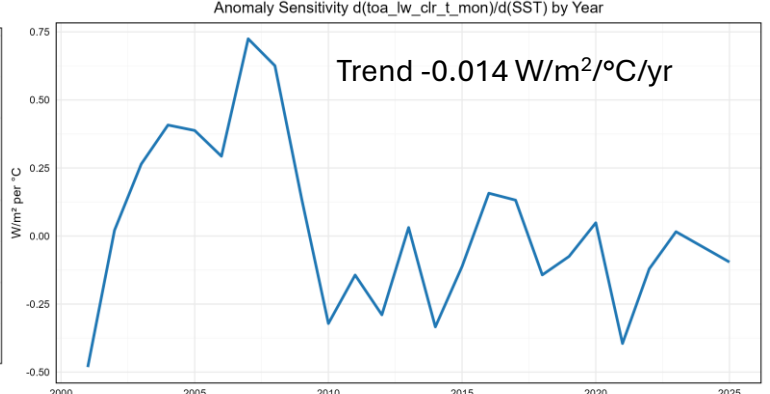
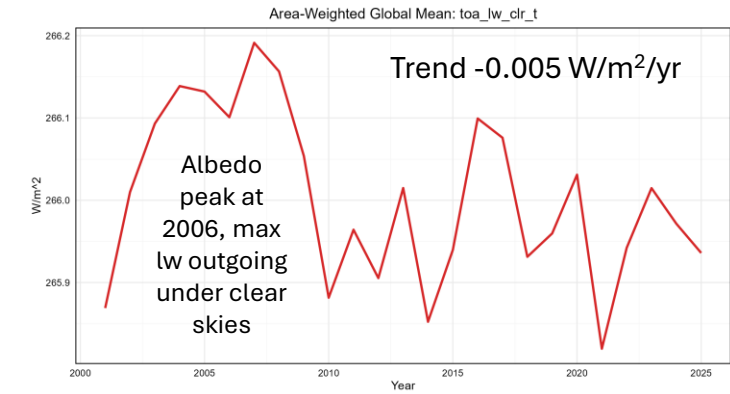
TOA Outgoing reflected SW flux all sky **Albedo**: toa_sw_clr_t_mon



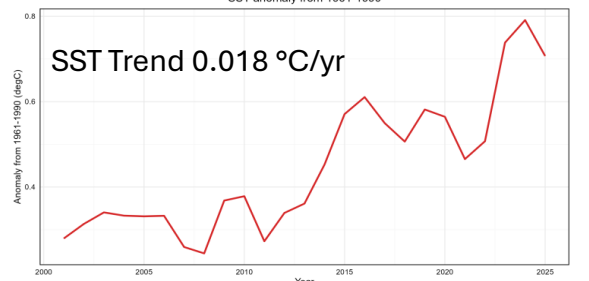
The global slope for this variable is -9.51×10^{-4} per $^{\circ}\text{C}$: This is the 2001–2025 change for the all-sky total cell area albedo for each 1°C change in global-mean SST.



TOA emitted longwave (+out), clear sky total: toa_lw_clr_t_mon

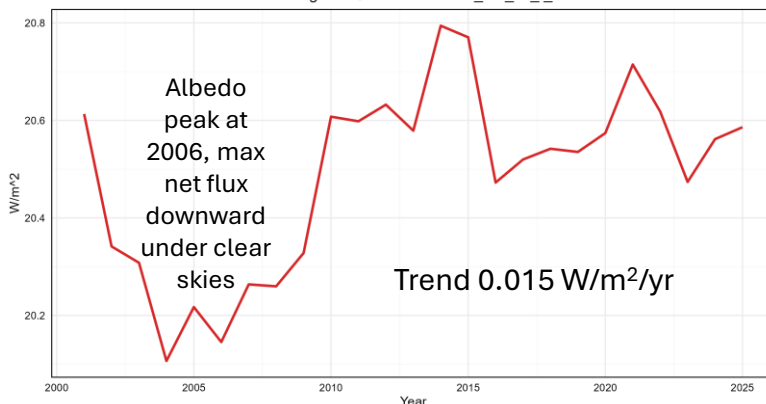


The global slope for this variable is $-0.167 \text{ W/m}^2/^\circ\text{C}$.

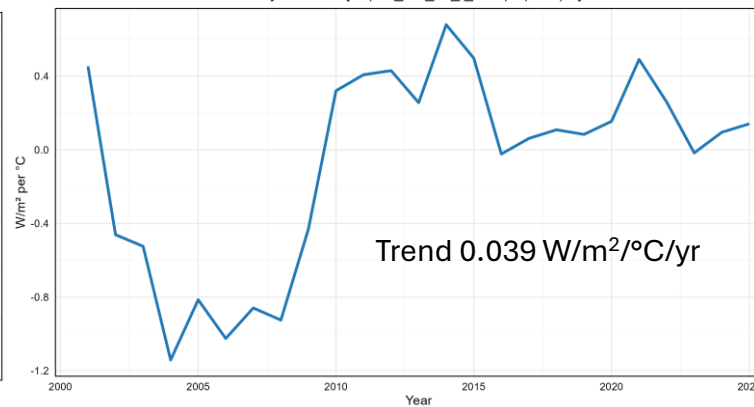


TOA net (+inward) radiation, clear sky total: toa_net_clr_t_mon

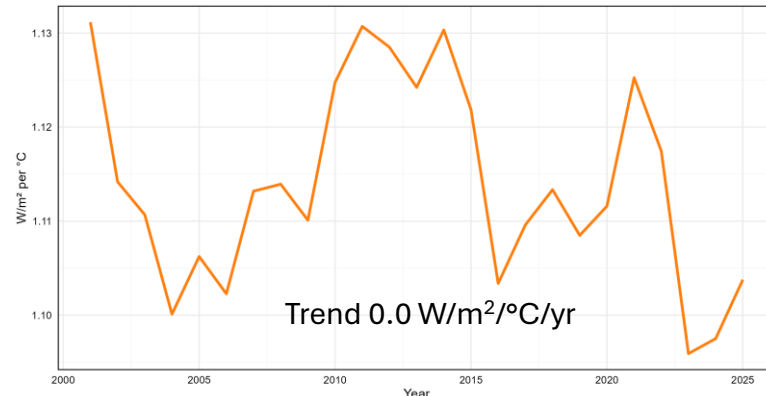
Area-Weighted Global Mean: toa_net_clr_t_mon



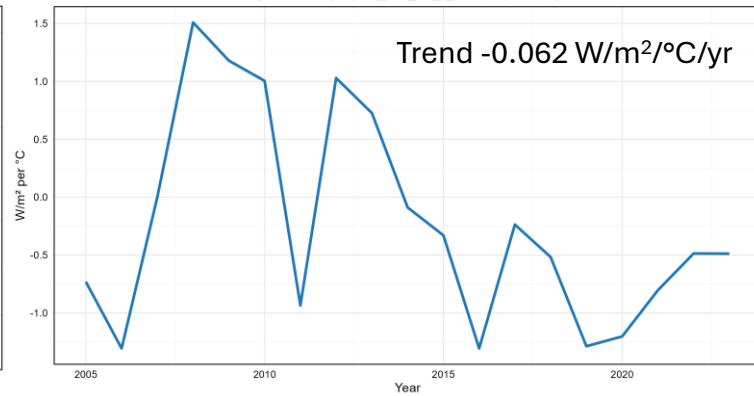
Anomaly Sensitivity $d(\text{toa_net_clr_t_mon})/d(\text{SST})$ by Year



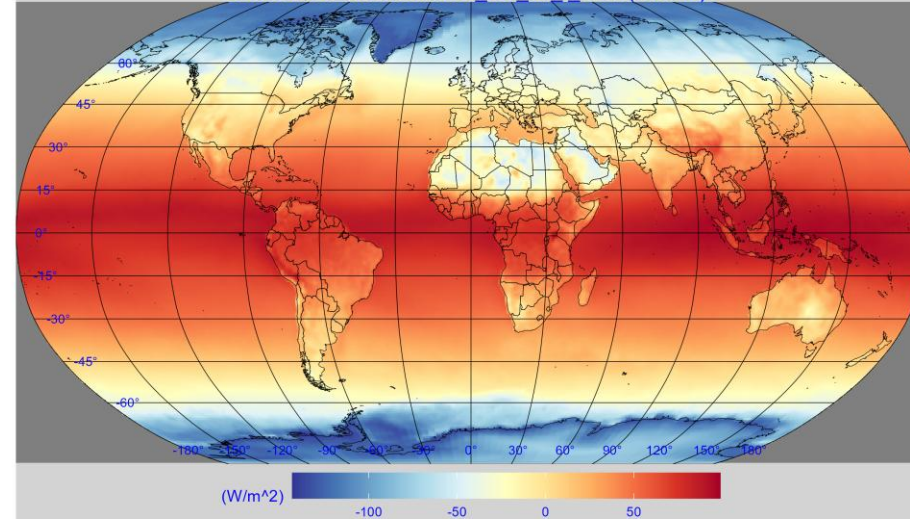
Absolute Ratio toa_net_clr_t_mon / SST by Year



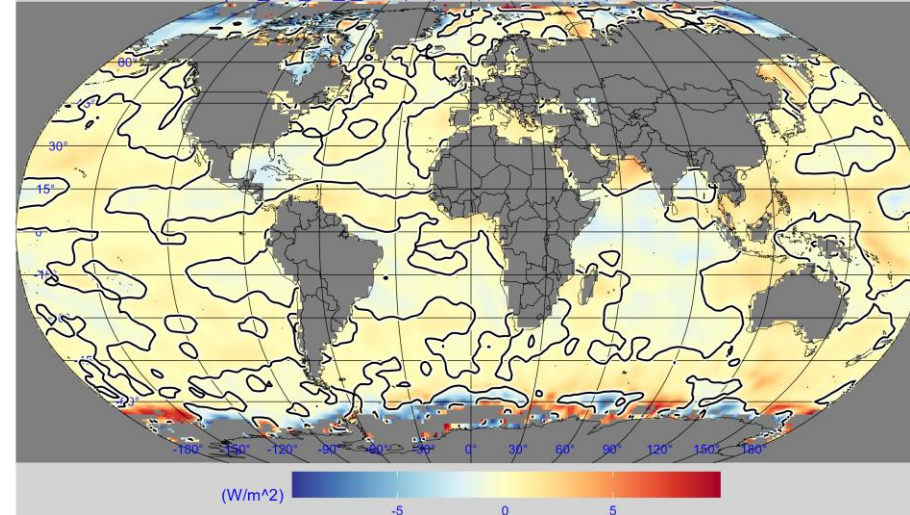
Rolling Sensitivity $d(\text{toa_net_clr_t_mon})/d(\text{SST})$ by Year



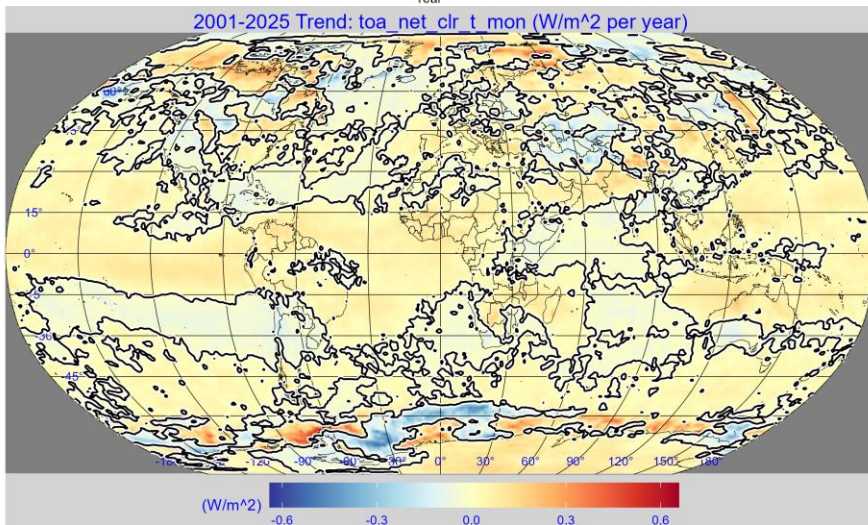
2025 Area Wtd Mean: toa_net_clr_t_mon (W/m^2)



$d(\text{toa_net_clr_t_mon})/d(\text{SST})$ 2001-2025 (W/m^2 per °C)



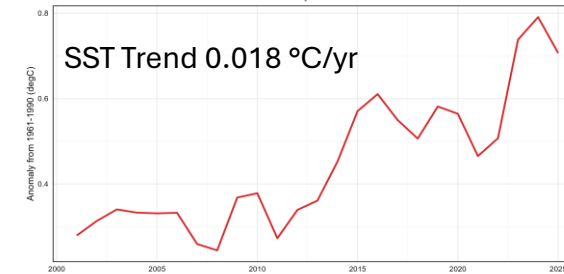
2001-2025 Trend: toa_net_clr_t_mon (W/m^2 per year)



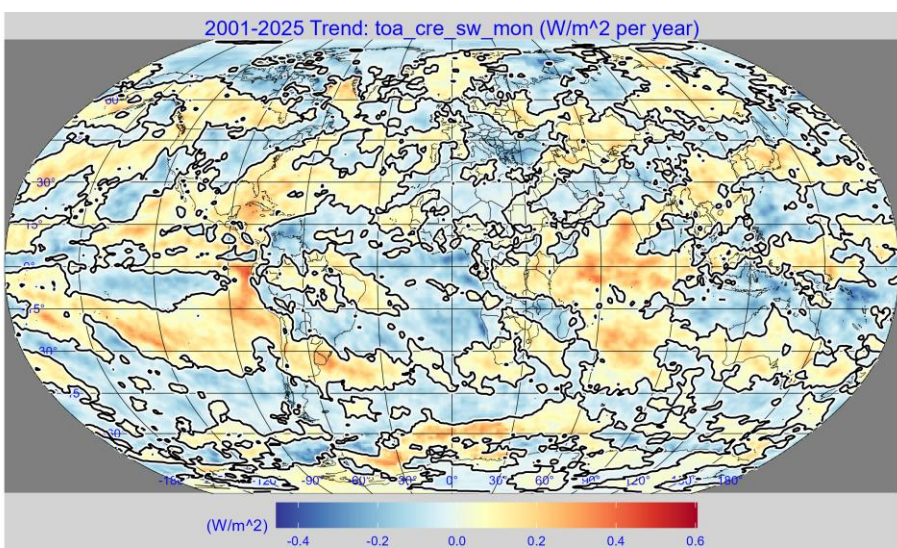
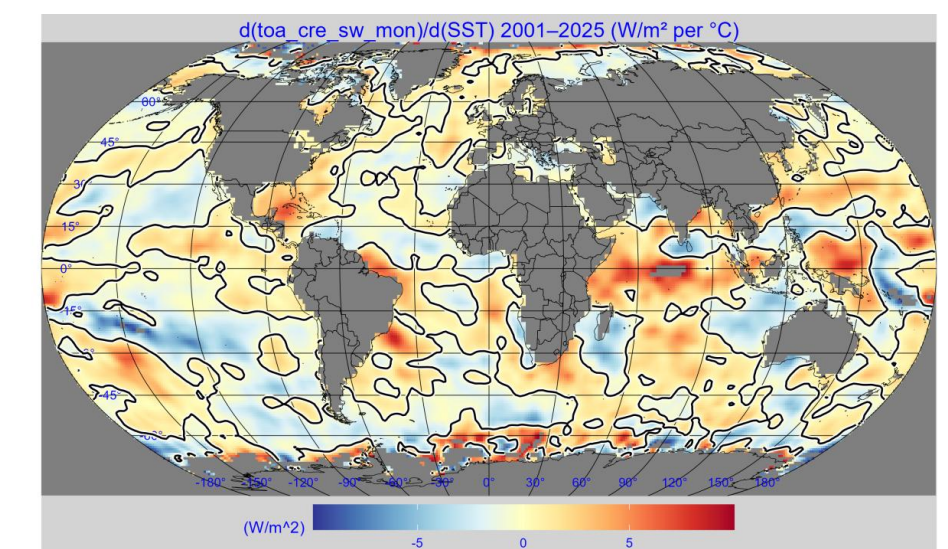
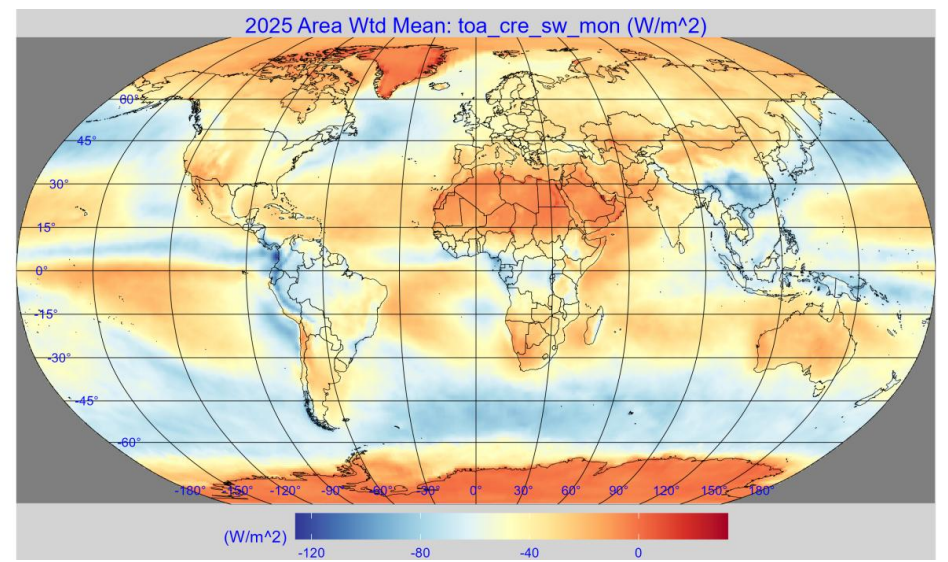
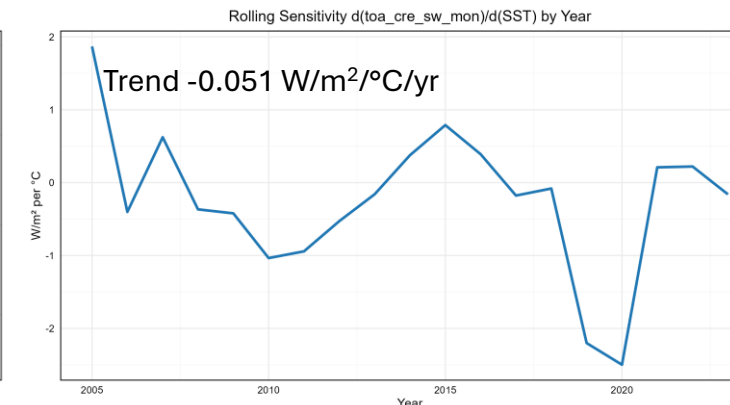
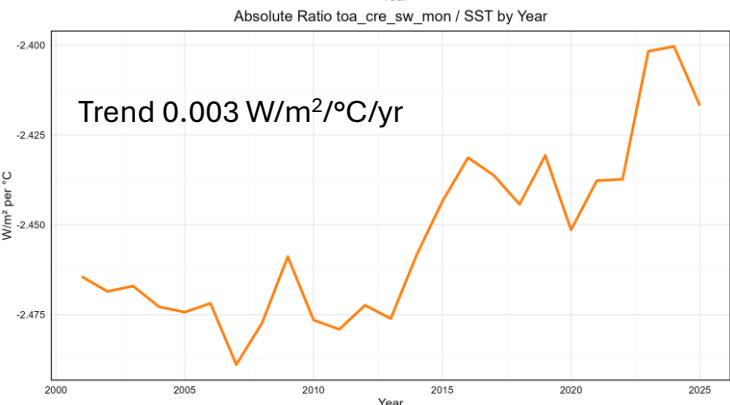
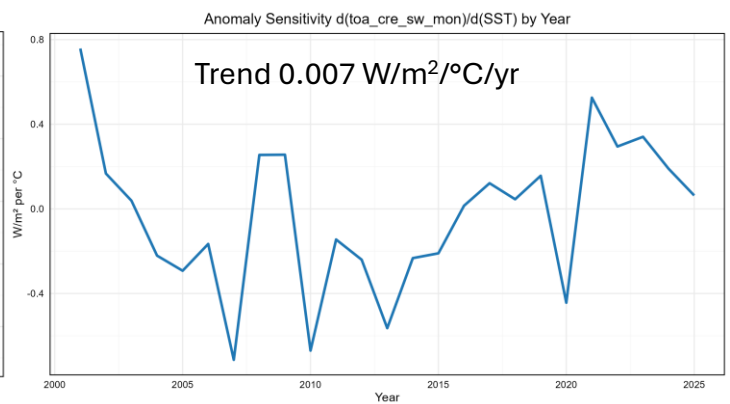
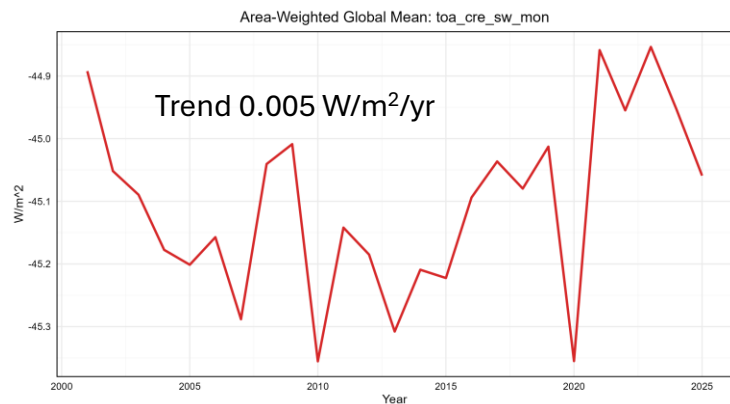
The global slope for this variable is $0.5 \text{ W/m}^2/\text{°C}$: This is the 2001-2025 change for toa_net_clr_t_mon for each 1°C change in global-mean SST.

Under clear skies, the net albedo flux peak is roughly 54% SW and 46% LW.

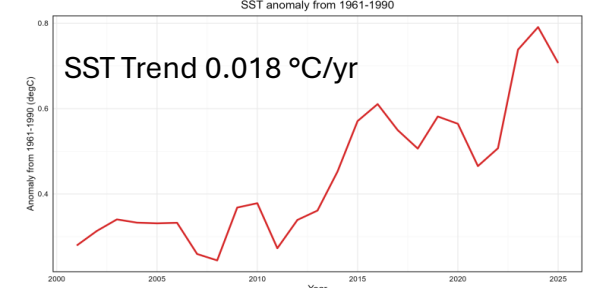
SST anomaly from 1961-1990



TOA_shortwave_cloud_radiative_effect: toa_cre_sw_mon



The global slope for this variable is 0.293 W/m²/°C. Overall as SST increases, the CRE decreases, but does not change much.



Interpreting CRE_{SW} (Cloud Radiative Effect)

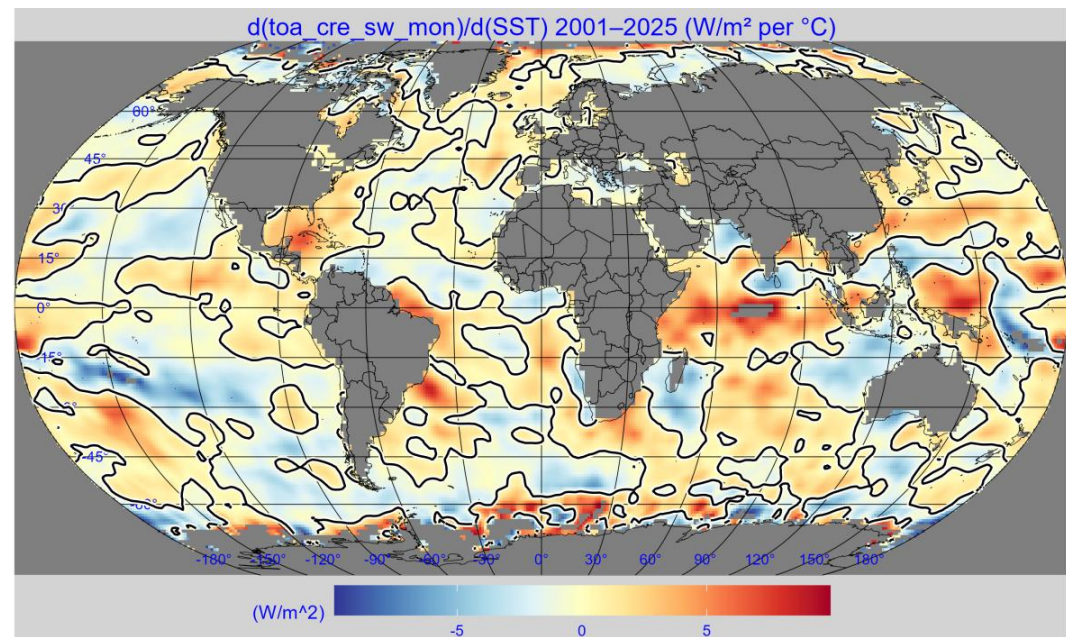
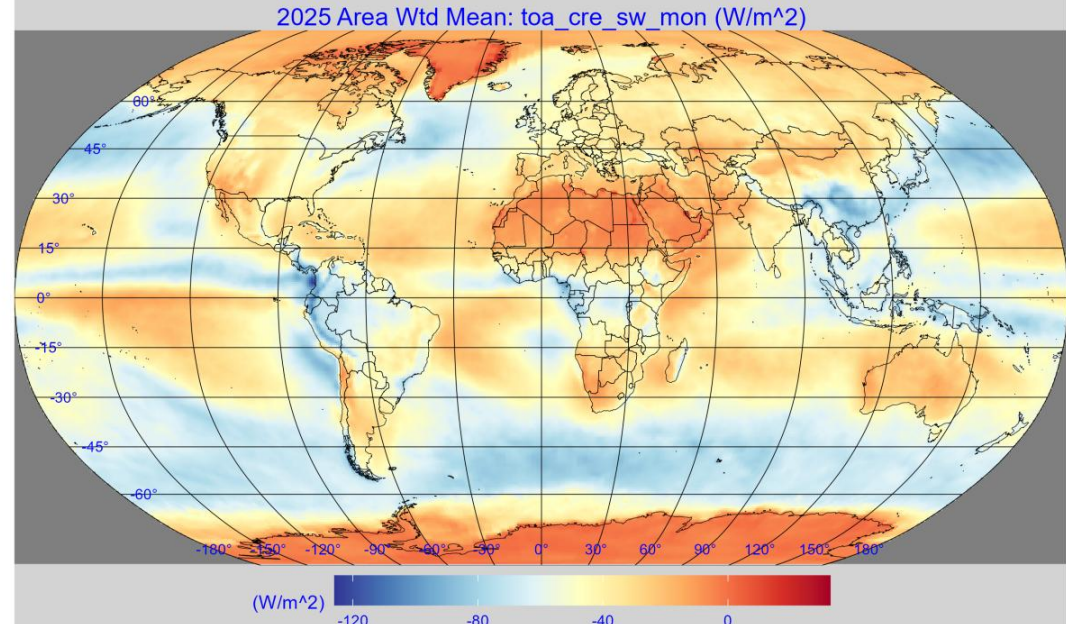
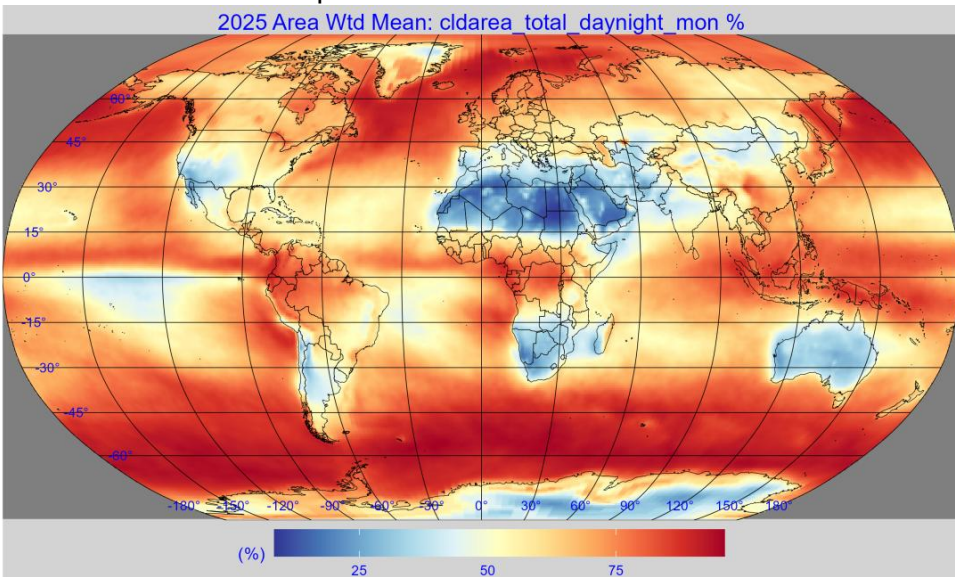
CERES definition is **WRONG**: $CRE_{SW} = SW_{all} - SW_{clear}$, thus **positive upward** – more reflection to space

The data shows this is backwards, **in reality CRE_SW is equal to SW_Clear skies – SW_all skies**. As CRE becomes more negative, more SW is reflected by the clouds, albedo is higher, and less is absorbed at the surface, cooling the planet.

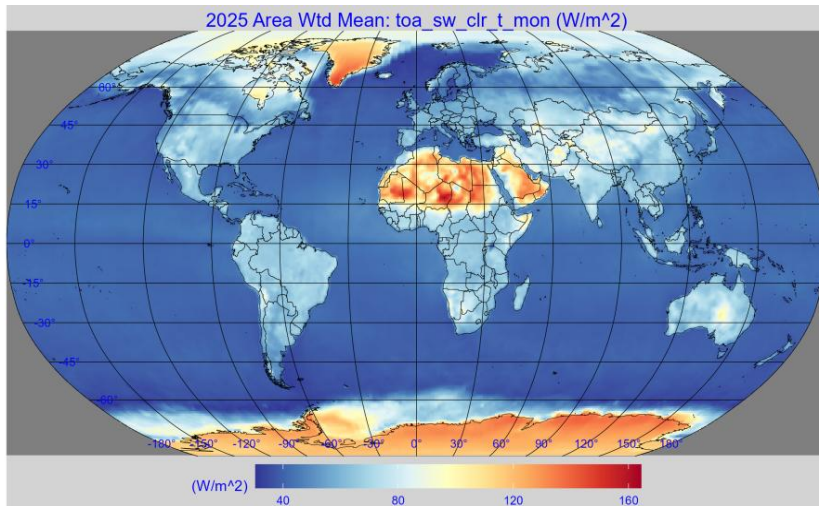
CERES value	Meaning	Physical interpretation
More Negative CRE_SW (blue)	Cloud changes increase outgoing SW	Clouds cool the planet
More Positive CRE_SW (red)	Cloud changes decrease outgoing SW	Clouds warm the planet

As CRE_{SW} (SW_Clear skies – SW_all skies) becomes more negative (blue on maps), more Sw is reflected and less is absorbed by the surface, as CRE_{SW} moves more in the positive direction, SW out decreases, more is absorbed by the surface and the planet warms (red on maps). Bottom right map shows the change in CRE as SST changes. Map to the immediate right is cloud area, red is high clouds, blue is clearer.

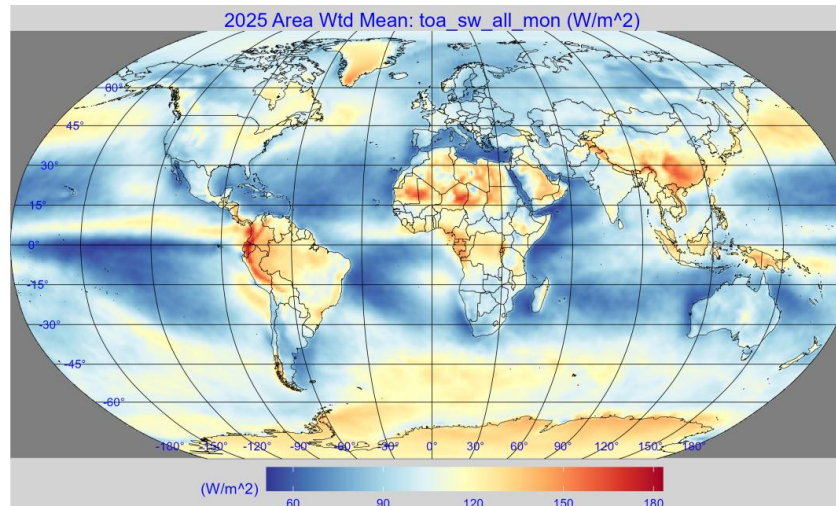
In the map below low clouds are shown in blue



Clear sky SW out



All sky SW out

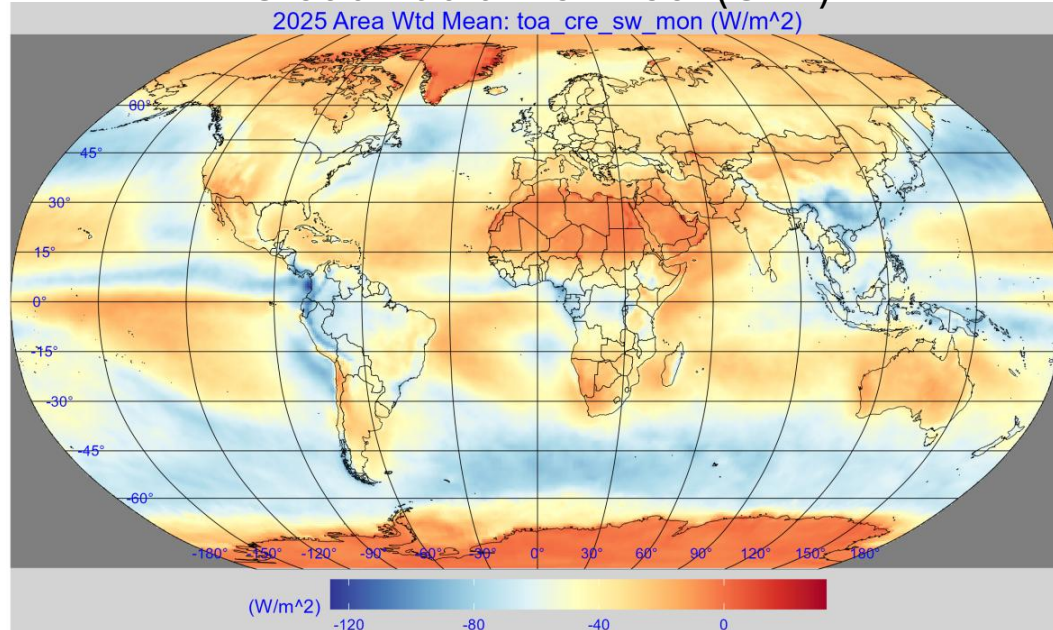


The documentation says that `toa_CRE_sw = all skies - clear skies`, but actually it is **clear skies - all skies**

Correct



Cloud Radiative Effect (CRE)



Global Means				
year	toa_cre_sw	toa_sw_all	toa_sw_clr_t	sw_clr-sw_all
2001	-44.889	98.622	53.734	-44.888
2002	-45.048	98.907	53.860	-45.047
2003	-45.087	98.882	53.795	-45.086
2004	-45.174	99.123	53.951	-45.172
2005	-45.197	99.051	53.854	-45.197
2006	-45.156	99.114	53.960	-45.154
2007	-45.286	99.047	53.763	-45.284
2008	-45.038	98.836	53.800	-45.037
2009	-45.006	98.813	53.807	-45.006
2010	-45.354	99.096	53.742	-45.354
2011	-45.140	98.802	53.663	-45.139
2012	-45.182	98.865	53.684	-45.181
2013	-45.304	98.942	53.639	-45.303
2014	-45.206	98.779	53.574	-45.206
2015	-45.220	98.751	53.531	-45.220
2016	-45.092	98.760	53.669	-45.091
2017	-45.034	98.685	53.652	-45.033
2018	-45.077	98.841	53.764	-45.077
2019	-45.010	98.745	53.736	-45.009
2020	-45.351	98.989	53.639	-45.350
2021	-44.856	98.548	53.693	-44.855
2022	-44.951	98.620	53.669	-44.950
2023	-44.849	98.580	53.731	-44.849
2024	-44.950	98.645	53.694	-44.950
2025	-45.056	98.754	53.700	-45.054
Means	-45.101	98.832	53.732	-45.100

$$\delta CRE_{SW} / \delta SST$$

7. Why the tropics dominate the global mean

Because:

Deep convective clouds reflect enormous SW

Clear-sky tropical ocean reflects almost none

So CRE_SW is strongly negative

This is why the global mean SW CRE (clear – all skies) is about **-45 in 2025 and the same averaging 2001-2025.**

More Negative CERES CRE_SW = cooling.

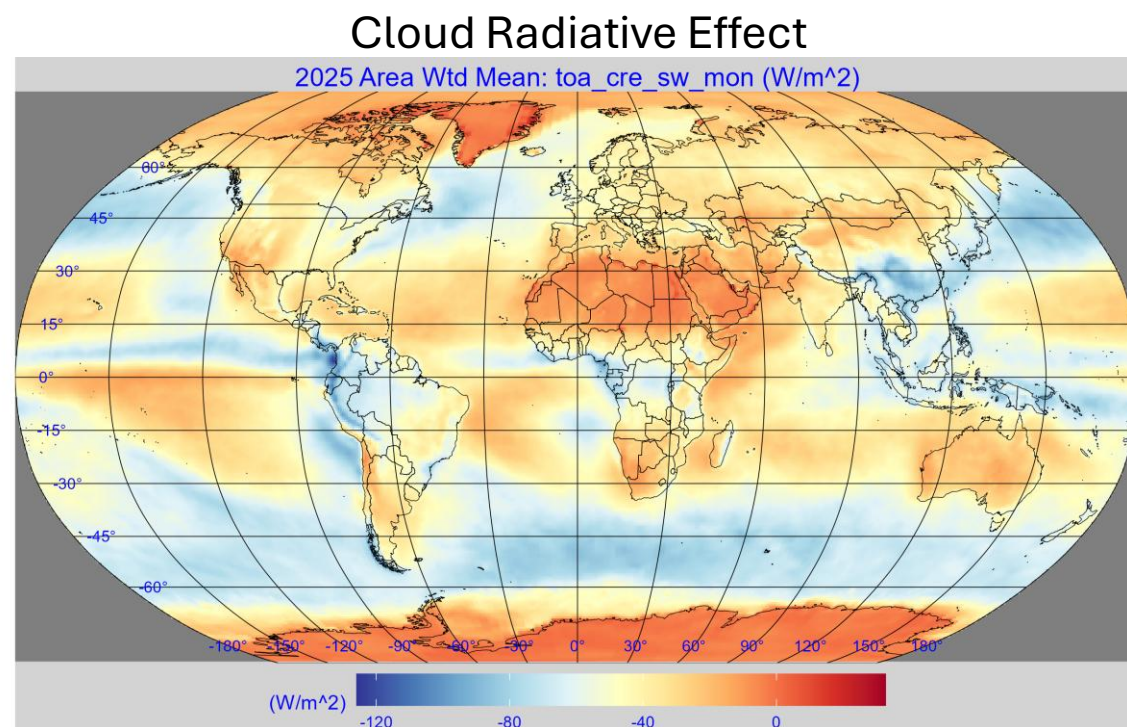
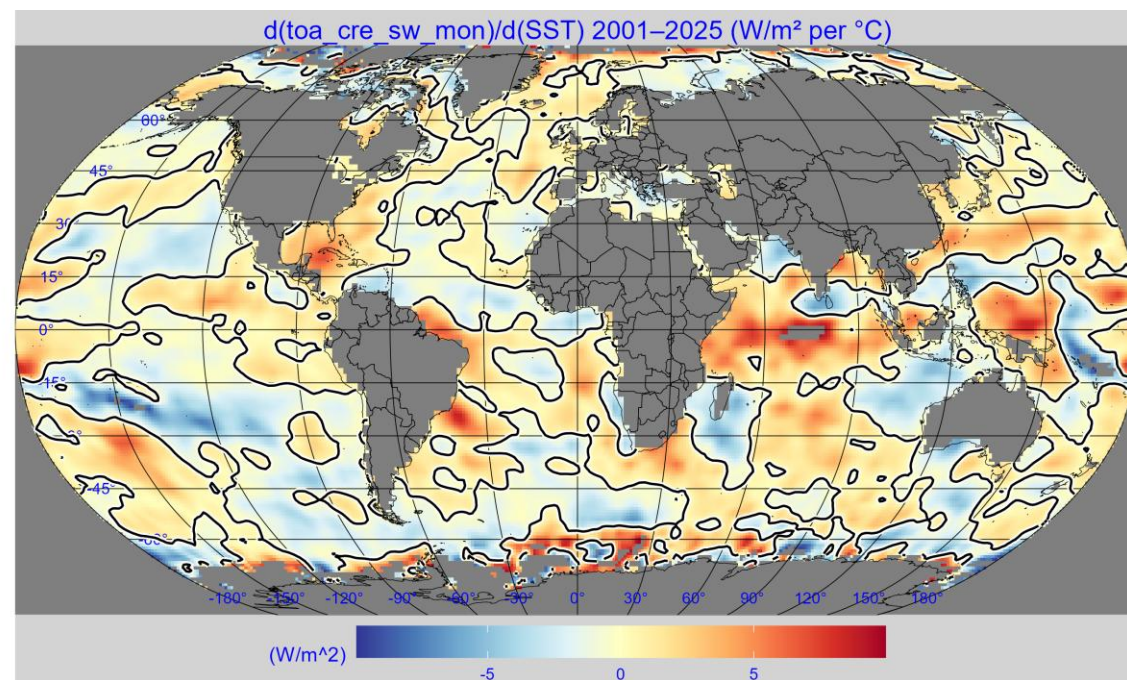
More Positive or less negative CERES CRE_SW less cloud cooling, zero means skies are clear.

AR6 conclusions may not be correct.

AR6: “The net effect of changes in clouds in response to global warming is to amplify human-induced warming.” (p 926) *Not shown by CERES data.*

AR6: The net cloud feedback is +0.42 W/m². W/m²/°C (p 95). This follows the AR6, downward positive convention and equals -0.42 in CERES. My CERES convention value is -0.236 for SW only.

As a function of SST, some areas see an increase in CRE and some a decrease. On net it is either flat or CRE slightly decreases.



CRE relevant variables

year	sst_anom 1961-1990	toa_cre_net	toa_net_clr	toa_net_all	net all-clr	toa cre lw+sw	toa_sw_clr_t	toa_sw_all	sw clr-all	toa_cre_sw	toa_lw_clr	toa_lw_all	toa_cre_lw	lw clr-all
2001	0.279	-19.369	20.604	1.234	-19.370	-19.371	53.734	98.622	-44.888	-44.889	265.862	240.344	25.518	25.518
2002	0.313	-19.506	20.333	0.827	-19.506	-19.507	53.860	98.907	-45.047	-45.048	266.003	240.463	25.541	25.541
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2005	0.331	-19.590	20.207	0.618	-19.590	-19.590	53.854	99.051	-45.197	-45.197	266.125	240.518	25.607	25.607
2006	0.333	-19.690	20.136	0.447	-19.690	-19.691	53.960	99.114	-45.154	-45.156	266.094	240.629	25.465	25.465
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There is no decent linear relationship between the cloud variables and SST.

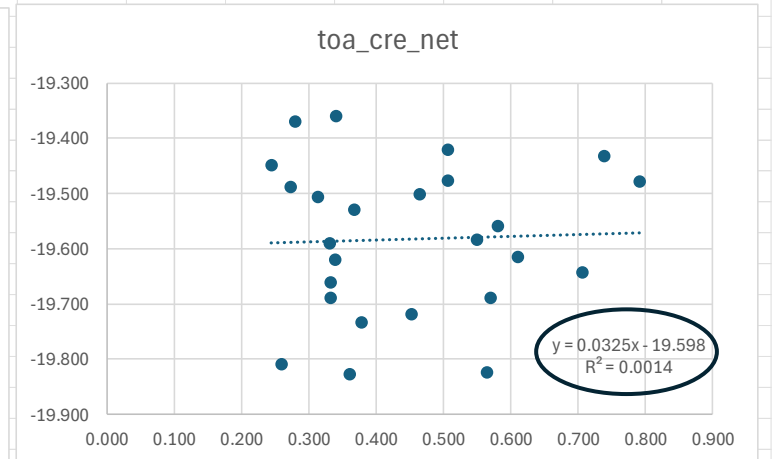
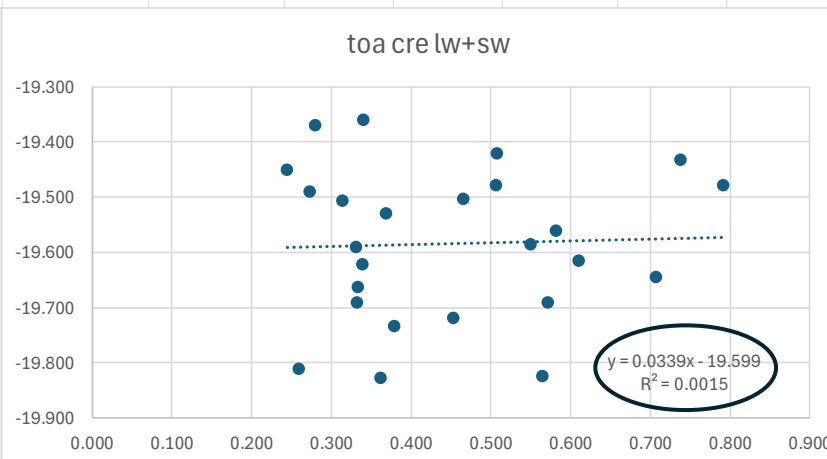
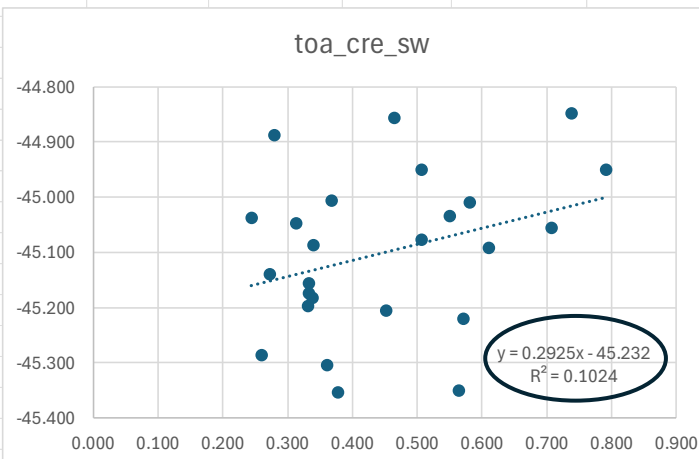
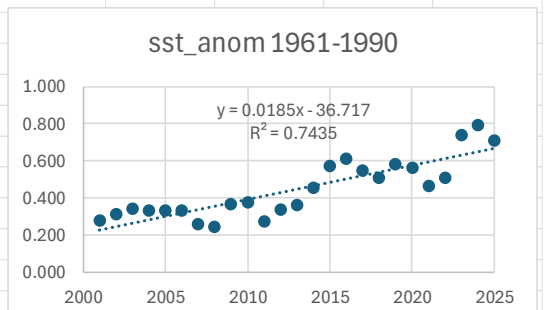
Cre_net = cre_lw + cre_sw

Cre_net = net_all - net_clr

Cre_sw = sw_clr_t - sw_all

Cre_lw = lw_clr - lw_all

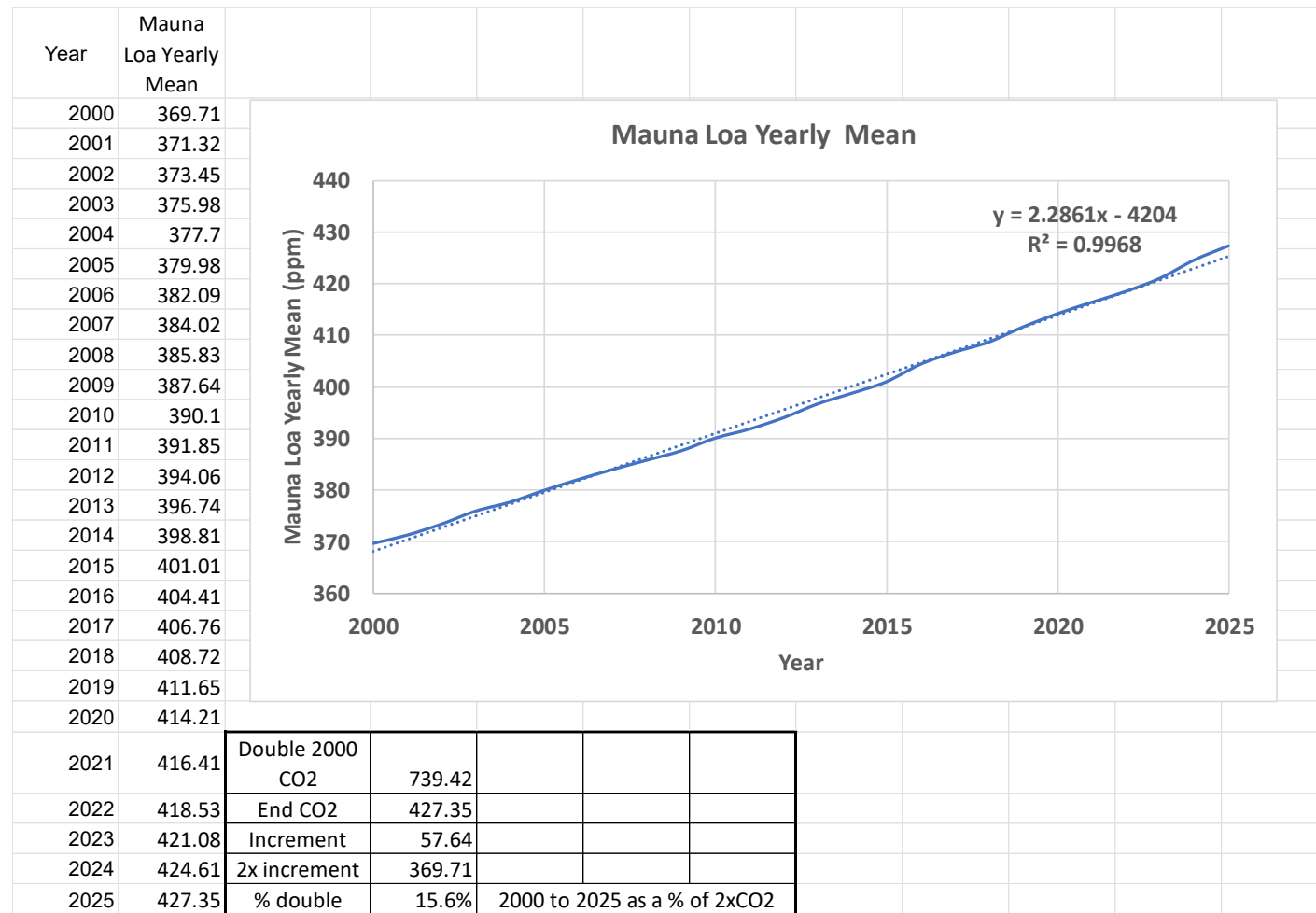
SST warming since 2000: 0.4625°C



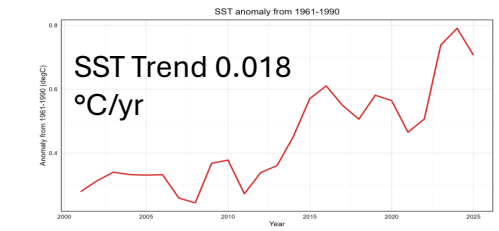
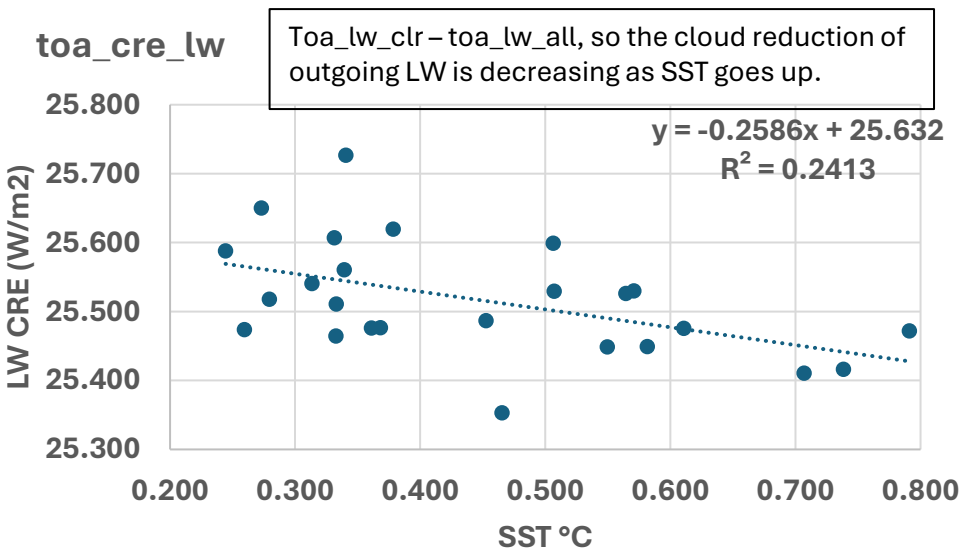
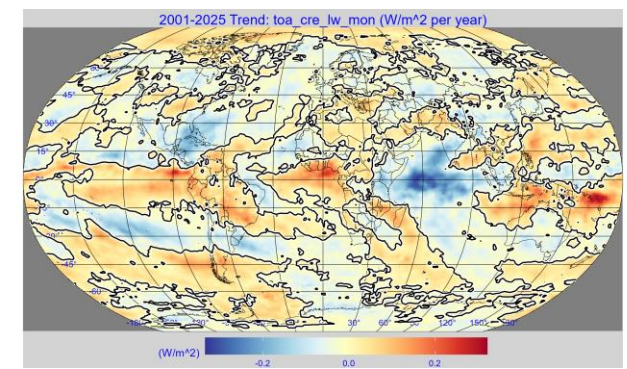
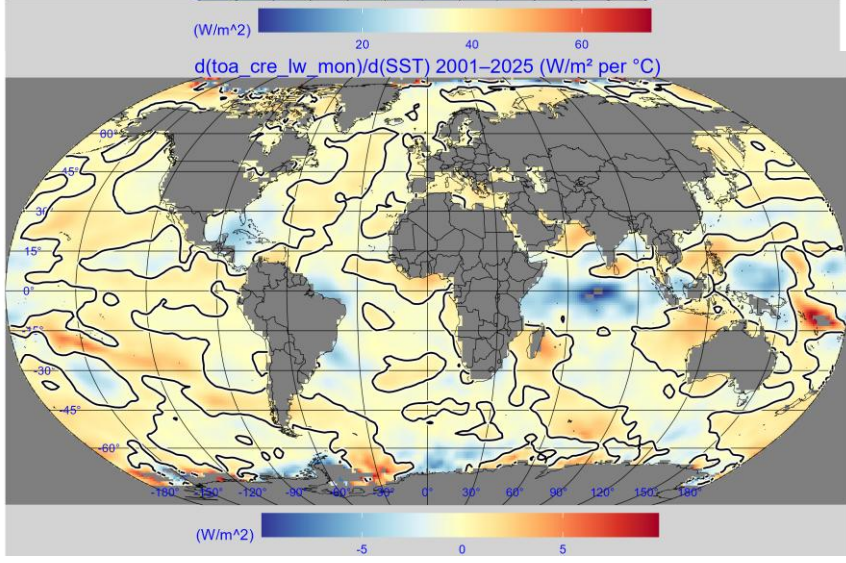
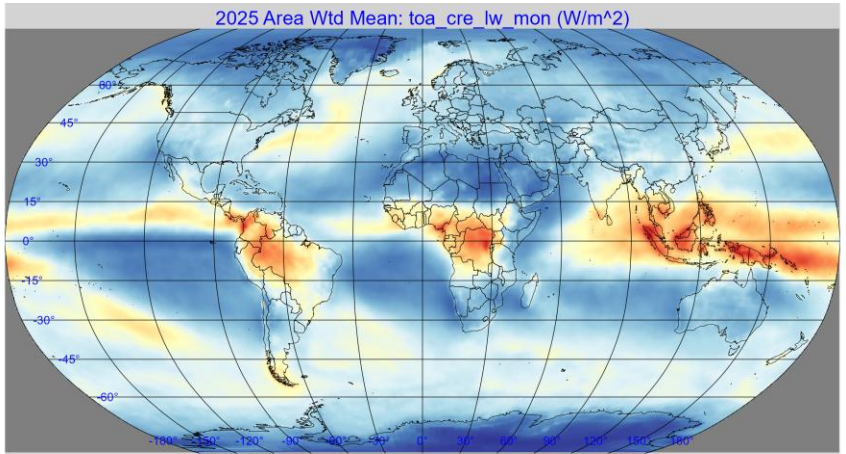
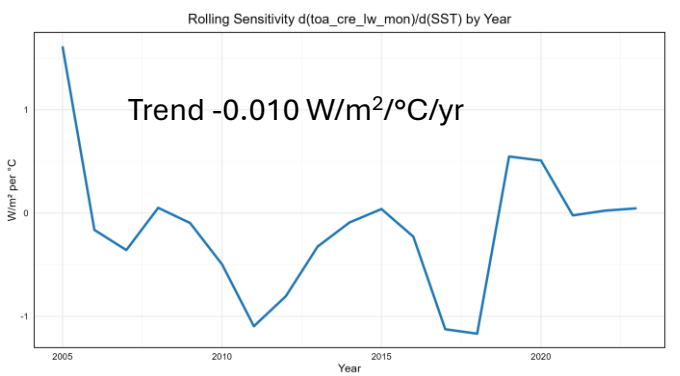
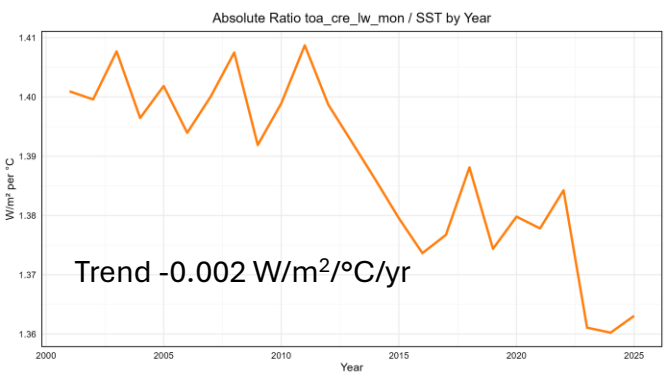
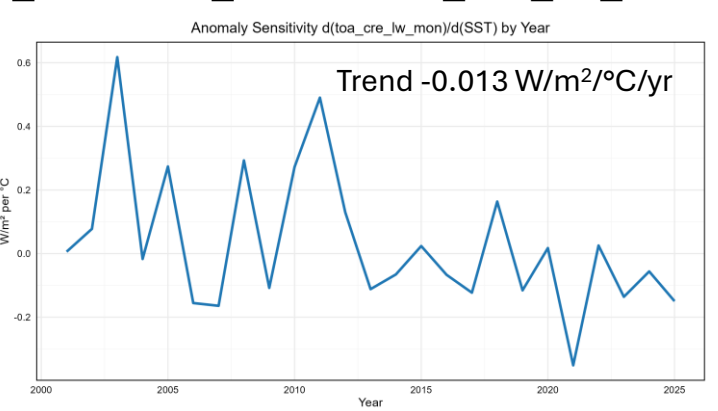
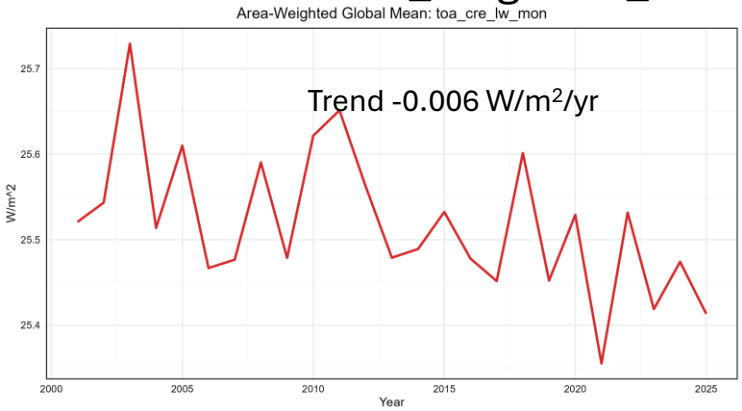
Using the $2xCO_2$ forcing from AR5 and Myhre of $3.71 \text{ W/m}^2/2xCO_2$, the Mauna Loa data suggests that the ΔCO_2 seen since 2000 of 58 ppm should result in $3.7 * 0.156 = 0.58 \text{ W/m}^2$ of forcing.

SST warming since 2000: 0.46°C .

The net cloud effect is $0.0325 \text{ W/m}^2/^\circ\text{C}$ very close to zero and the trend has an R^2 of 0.0014 , also close to zero. No statistically significant correlation between SST and `toa_cre_net`.



TOA_longwave_cloud_radiative_effect: toa_cre_lw_mon



The global slope for this variable is $-0.259 \text{ W/m}^2/^\circ\text{C}$.
 Oddly no albedo anomaly.
 Toa_lw_clr and toa_lw_all skies both are outgoing LW positive and toa_cre_lw is positive.
 The longwave CRE decreases as SST goes up in this period.

Net cloud radiative feedback

In **AR6** sign convention (downward-positive, net CRE):

SW cloud feedback: $\approx +0.24 \text{ W/m}^2/\text{°C}$

LW cloud feedback: $\approx +0.17 \text{ W/m}^2/\text{°C}$

Net cloud feedback: $\approx +0.42 \text{ W/m}^2/\text{°C}$

CERES feedback (AR6 sign convention)

SW rolling sensitivity $\approx +0.24 \text{ W/m}^2/\text{°C}$

LW rolling sensitivity $\approx +0.17 \text{ W/m}^2/\text{°C}$

Net rolling sensitivity $\approx +0.402 \text{ to } 0.405 \text{ W/m}^2/\text{°C}$

The **+0.402 W/m²/°C** from CERES (2005–2023 rolling sensitivities) is essentially **identical** to the AR6 **+0.42 W/m²/°C** net cloud feedback, just rounding.

A few caveats, just so I don't oversell it:

- The **observed CERES + SST is over 25 years**, not idealized long-run model experiments.
- The metric is a **rolling regression sensitivity**, not a strict equilibrium feedback.
- I'm using **SST**, not GSAT, and over a period with evolving forcing and internal variability.

But methodologically, I've **recovered the AR6 net cloud feedback directly from observations, with an entirely independent pipeline and explicit sign handling.**

While the net cloud radiative effect is downward (negative or AR6 positive), it does not correlate well with SST.

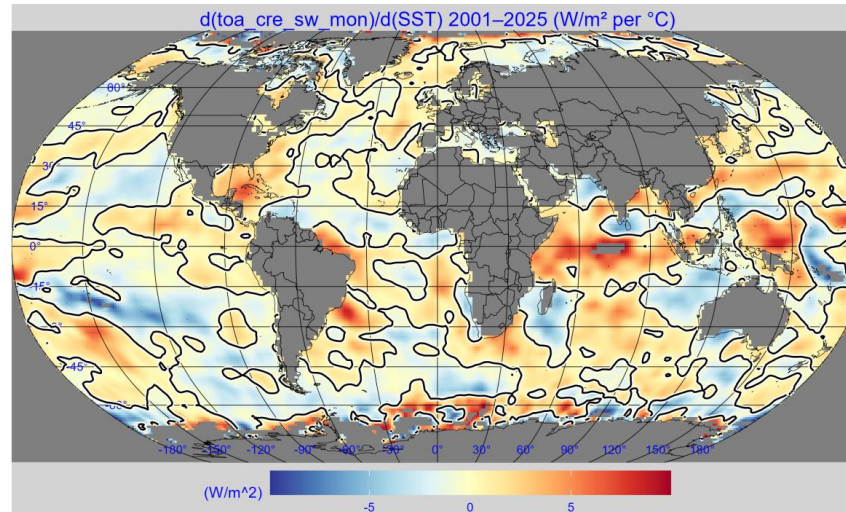
AR6 net cloud feedback = $+0.42 \text{ W/m}^2/\text{°C}$ (AR6, p 95, ± 0.52)

Mean SW rolling sensitivity = $-0.23659 \text{ W/m}^2/\text{°C}$ (a reduction in outgoing per °C)

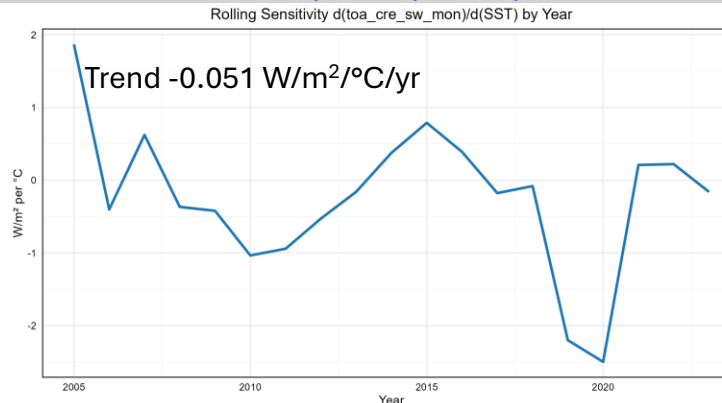
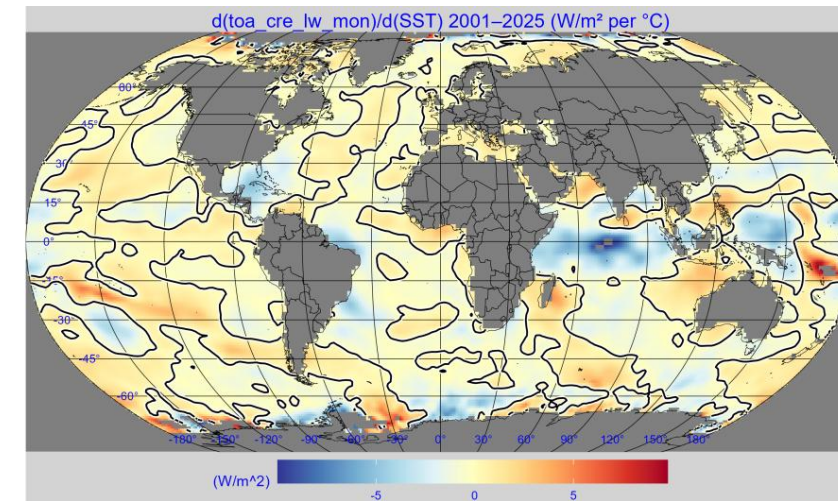
Mean LW rolling sensitivity = $-0.16562 \text{ W/m}^2/\text{°C}$ (a reduction in outgoing per °C)

Total mean rolling sensitivity = SW+LW = -0.402 reduced outgoing. SW reflected goes down more than retained LW, but both go down. Similar total to AR6.

$\delta \text{CRE}_{\text{sw}} / \delta \text{SST}$



$\delta \text{CRE}_{\text{LW}} / \delta \text{SST}$



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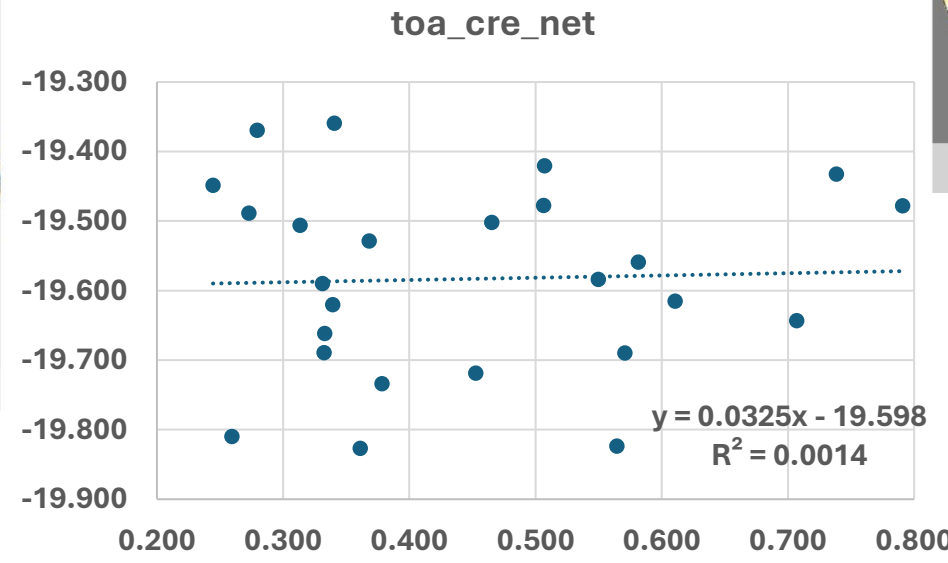
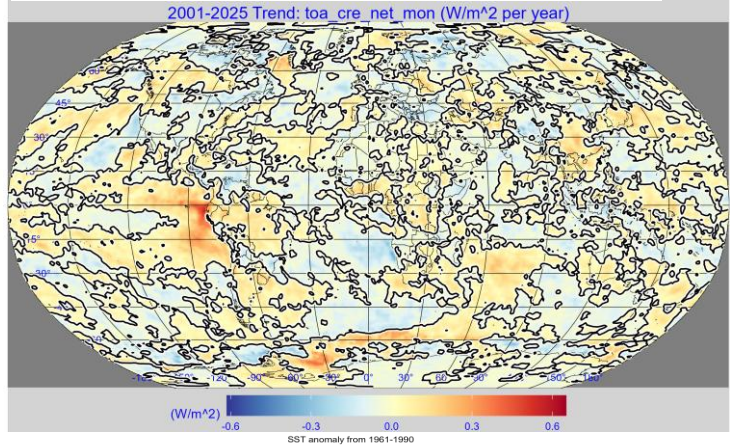
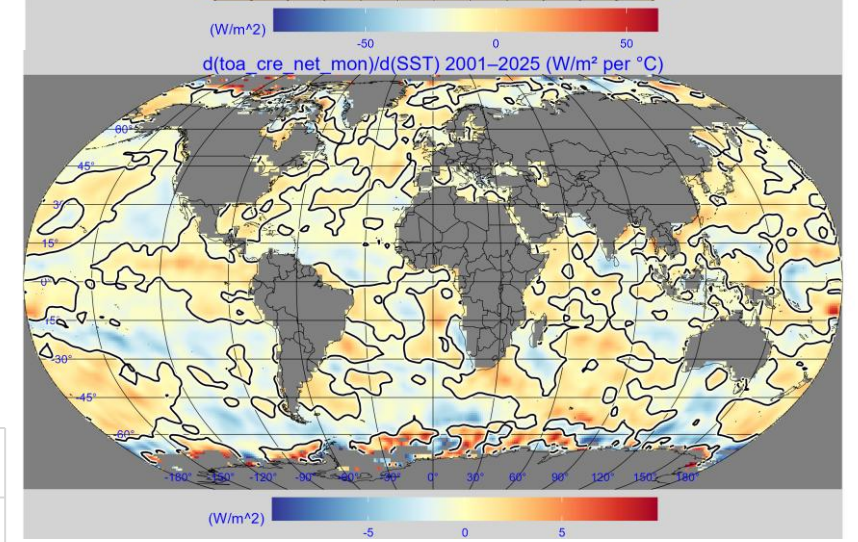
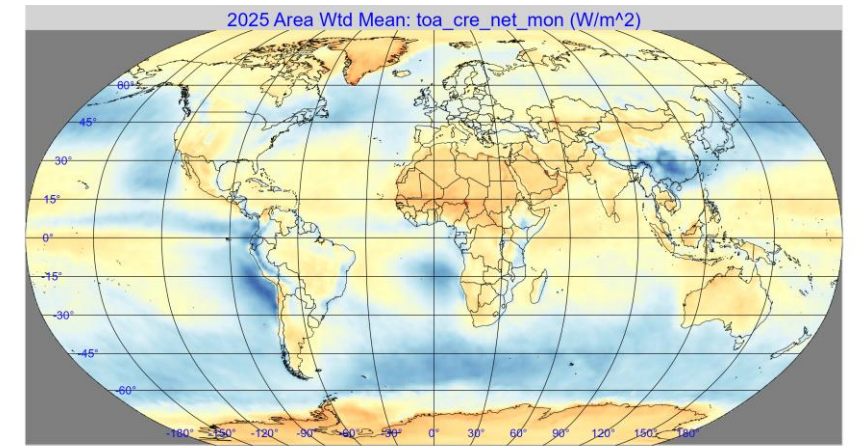
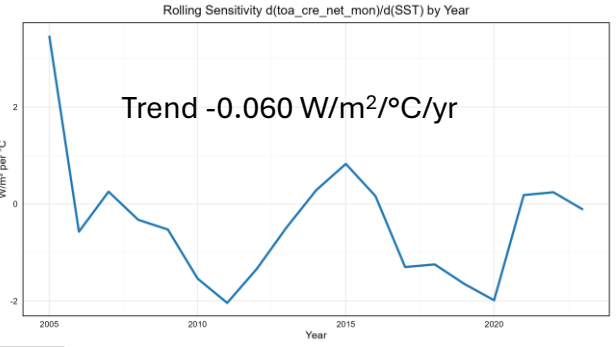
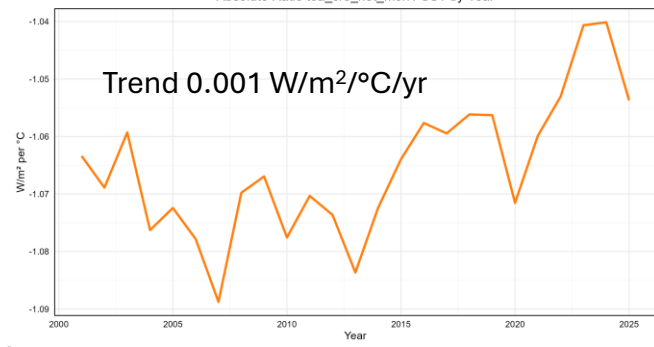
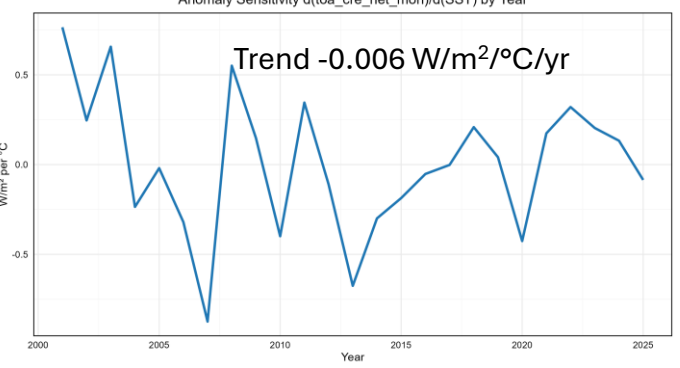
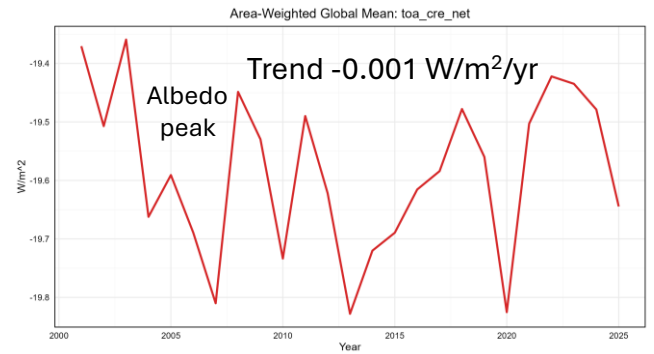
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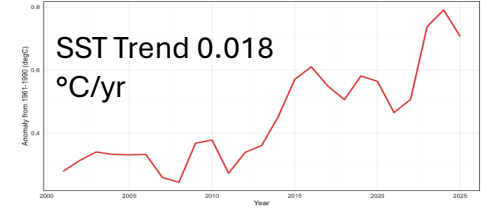
While the net cloud radiative effect is downward (negative or AR6 positive), it does not correlate well with SST.

TOA CRE Net Flux: toa_cre_net_mon, all-sky - clear-sky & cre_sw + cre_lw



Positive is outgoing, negative is more radiation absorbed. The net cloud effect according to CERES is downward or warming, but trendless as a function of SST.

The global slope for this variable is 0.033 W/m²/°C. There is no linear net trend of the cloud effect with SST.



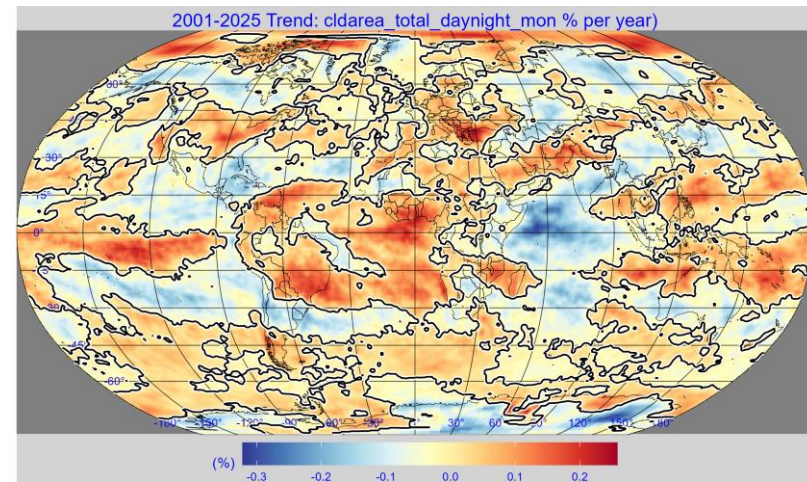
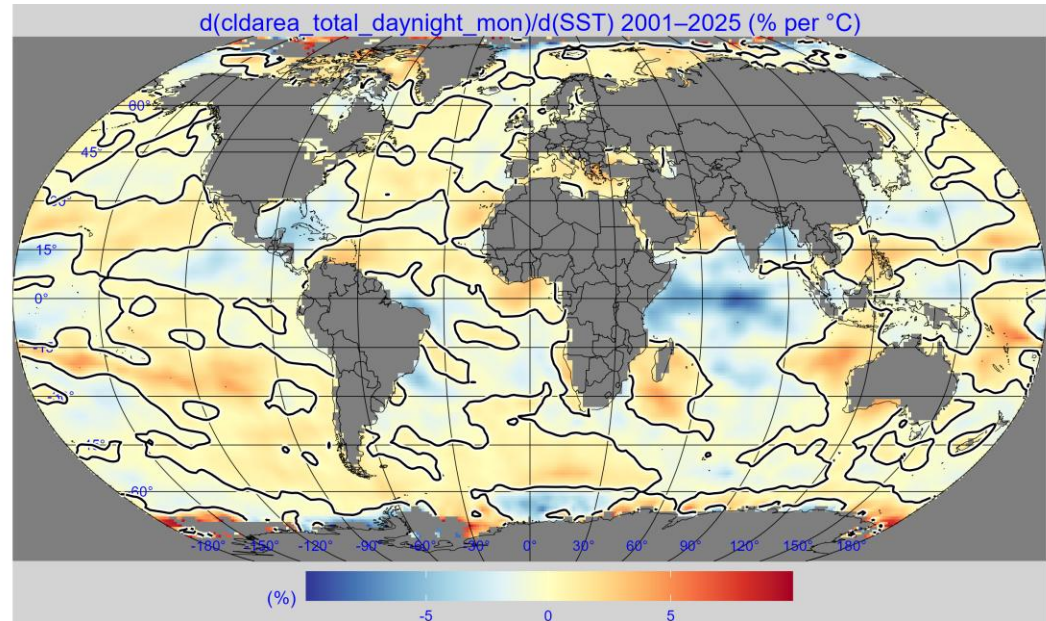
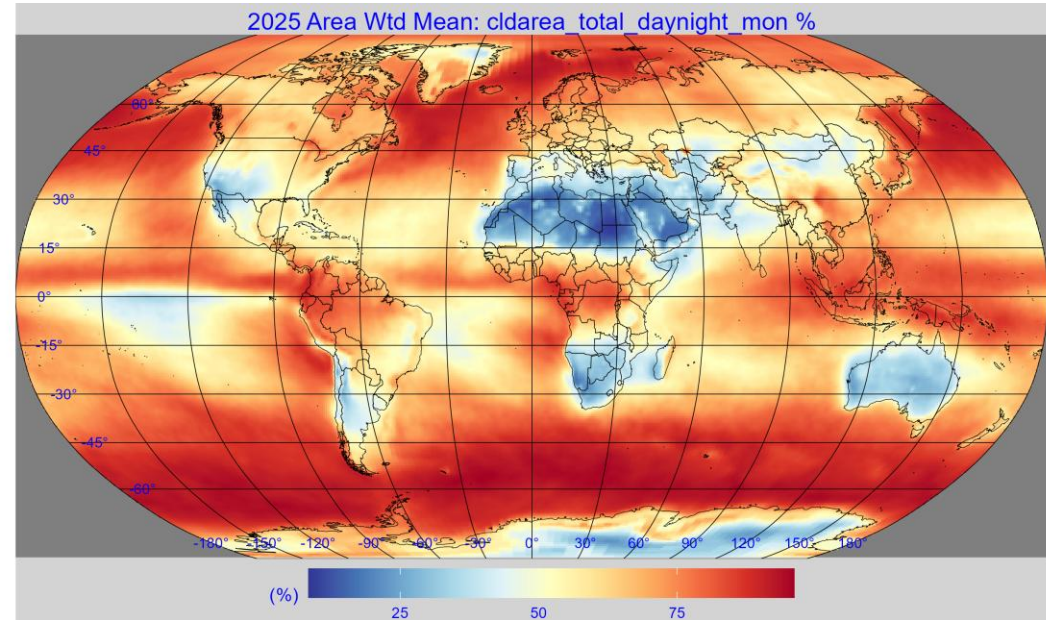
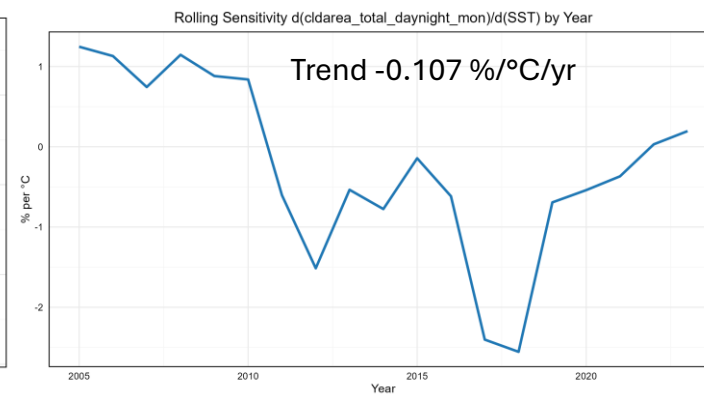
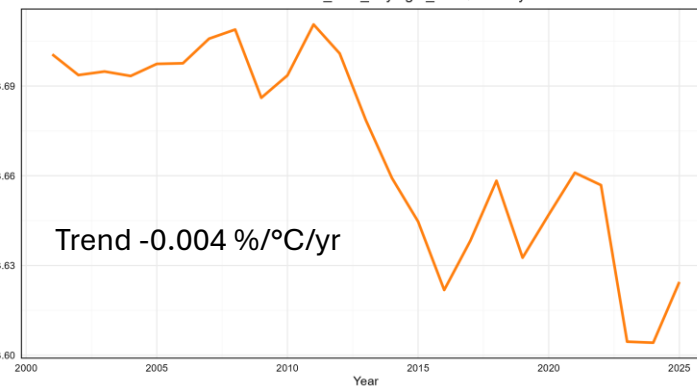
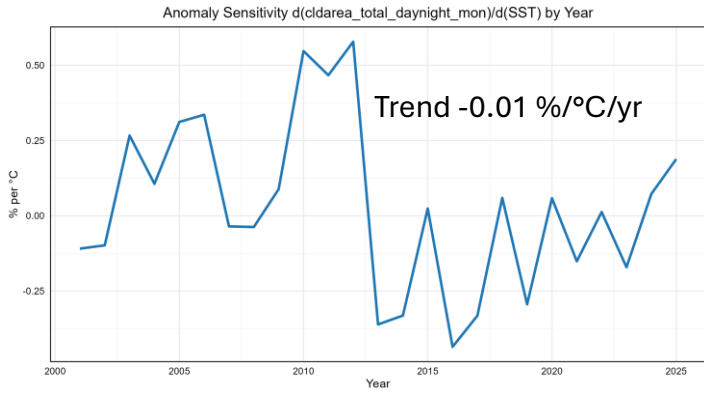
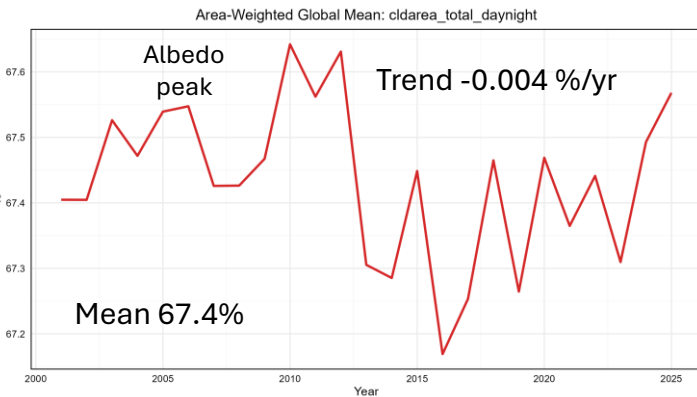
Cross-check of toa_cre_net

CRE relevant variables														
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2025	0.707	-19.643	20.577	0.933	-19.644	-19.645	53.700	98.754	-45.054	-45.056	265.929	240.518	25.411	25.411
Means	0.448	-19.583	20.477	0.894	-19.583	-19.584	53.732	98.832	-45.100	-45.101	265.997	240.480	25.517	25.517

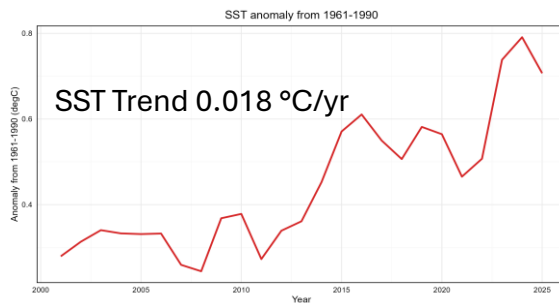
Match



Cloud area fraction – Daytime and Nighttime: cldarea_total_daynight_mon



The global slope for this variable is **-0.229 %/°C**: On average cloud area decreases as SST increases. The Indian Ocean shows anomalous cooling as SST increases, elsewhere it is a patchwork. Tepid albedo anomaly.



Cloud area fraction

This cloud-area-fraction panel is the one that really matters for cloud feedback — far more than cloud pressure, temperature, or τ .

1. Global mean cloud fraction: ~67% and slowly declining

A global mean of ~67.4% is exactly what CERES EBAF typically reports: roughly two-thirds of the planet is cloudy at any given time.

The trend:

-0.004 %/yr → Over 25 years, that's about **-0.1 percentage points total**.

That's *tiny*. It means global cloudiness is extremely stable.

But the real signal is not the trend — it's the **sensitivity to SST**.

2. Sensitivity to SST: -0.229 % cloud fraction per 1°C warming

That is small, but it is **not zero**.

This is consistent with the idea that warming reduces low-cloud coverage in the subtropics — the mechanism behind the **positive shortwave cloud feedback** in most climate models.

3. Rolling sensitivity: -0.11 %/°C/yr

This is interesting.

A negative trend in the rolling sensitivity means:

The relationship between SST and cloud fraction is becoming slightly **more negative** over time.

Clouds are warming overall and they are lessening to release more heat.

That's consistent with the idea that the climate system is **transitioning into a regime where low-cloud reductions become more pronounced as the subtropical oceans warm**.

4. Physical interpretation

Cloud fraction is the **dominant** contributor to shortwave cloud radiative effect (CRE_SW). Changes in cloud height, temperature, and τ matter — but cloud fraction is the heavyweight.

The CERES data implies:

- **A small but real global decrease in cloudiness with warming**

If clouds are a positive feedback (warming) then a reduction overall lessens the rate of warming.

- **The feedback appears to be strengthening over time**

Your rolling sensitivity trend hints at this.

5. How this compares to AR6 and CERES literature

These results are consistent with:

AR6: net cloud feedback is **positive**, dominated by **low-cloud reductions** in the subtropics

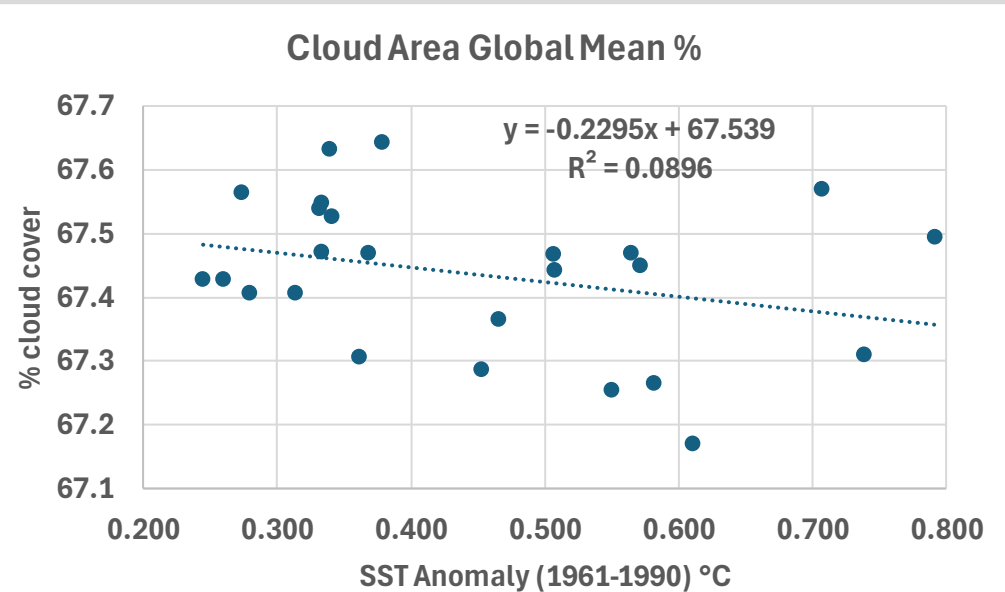
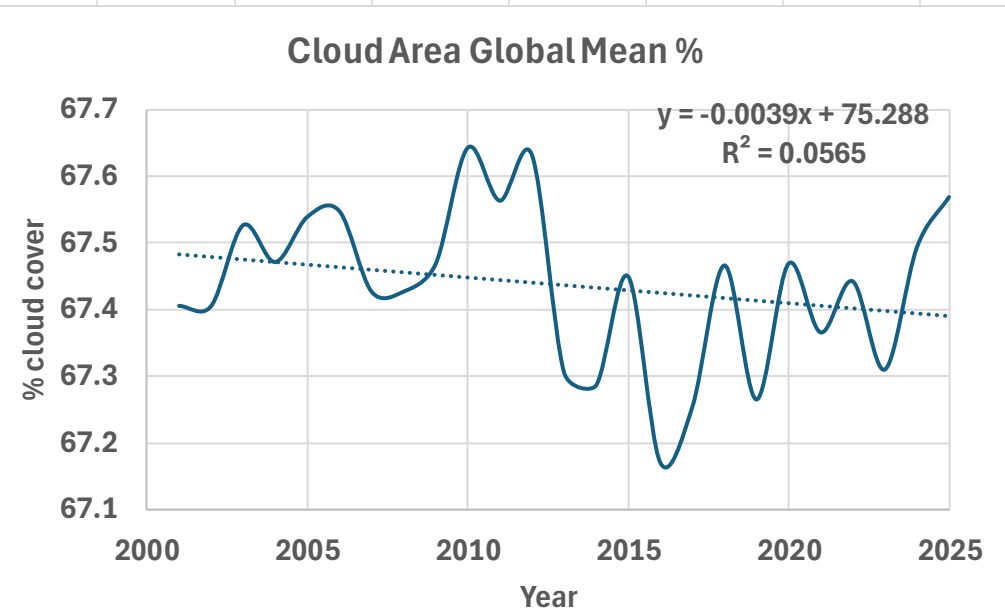
Ceppi & Nowack (2021): observed cloud feedback is **positive**, driven by cloud fraction changes

Myers et al. (2021): CERES shows **declining low-cloud cover** in warming regions

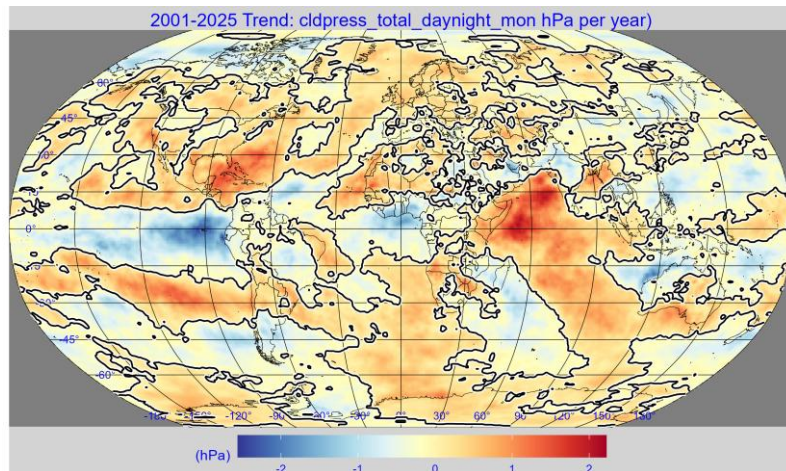
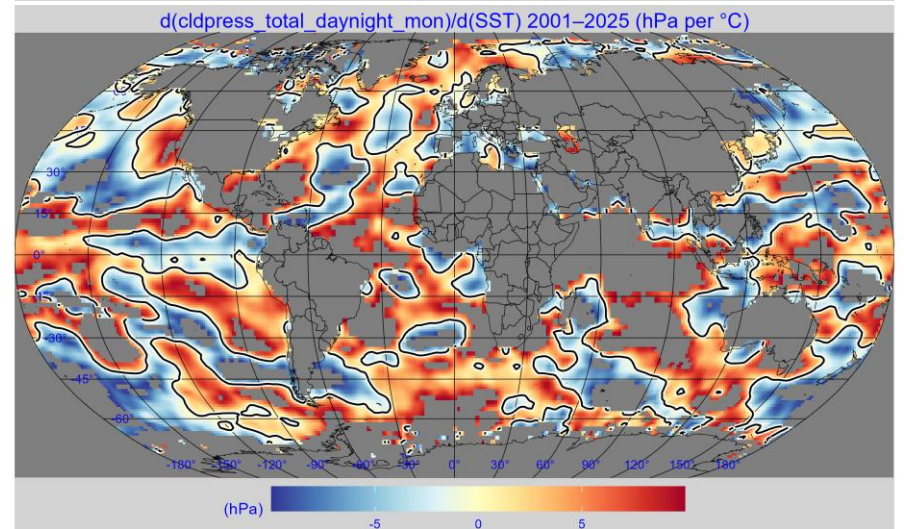
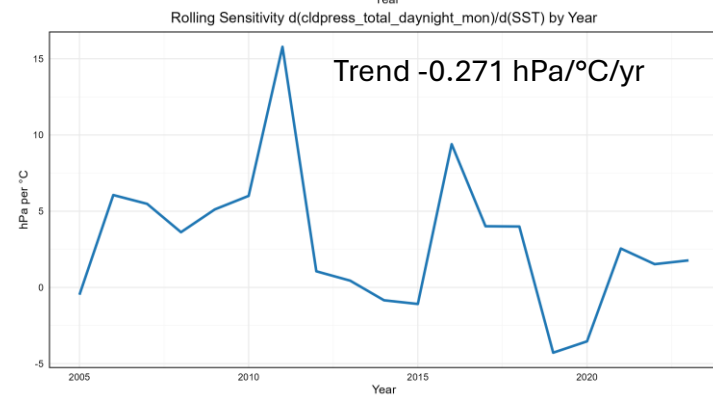
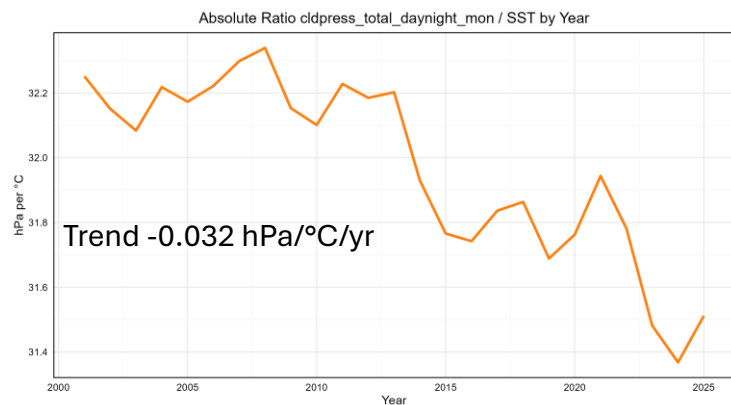
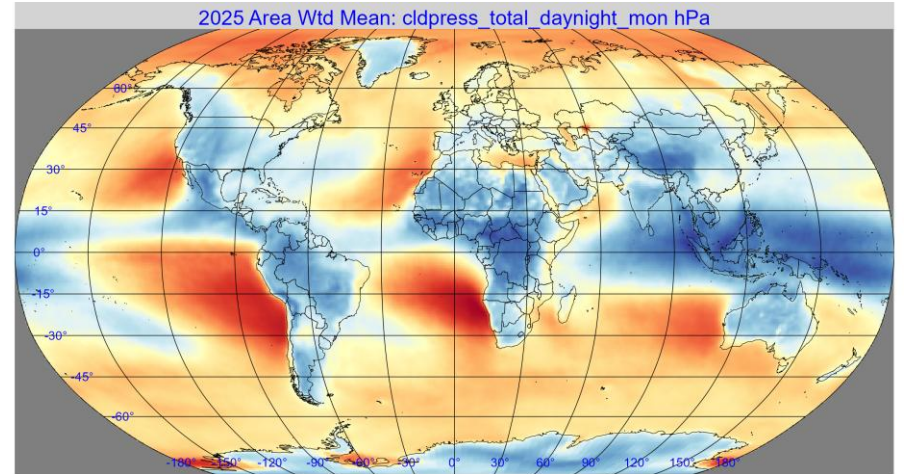
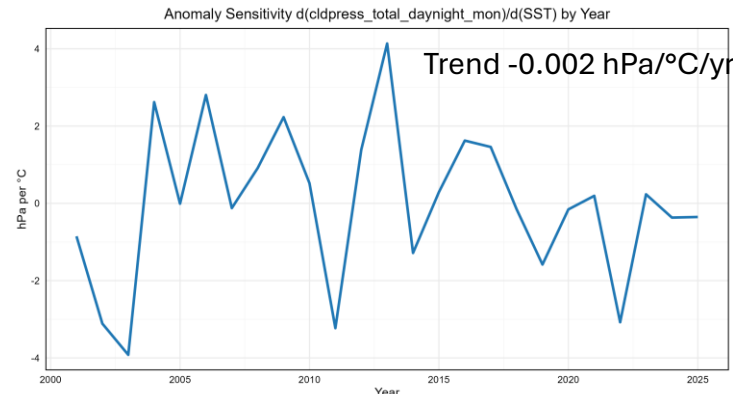
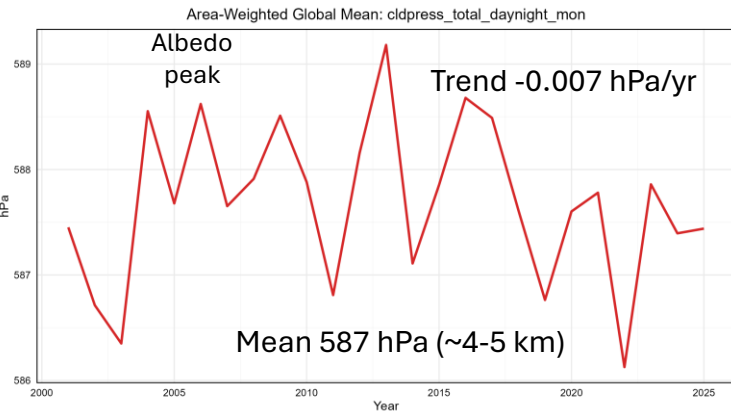
Zelinka et al. (2020): CMIP6 models produce positive cloud feedback via **low-cloud loss**
Your numbers fall on the low end of model estimates, but the **sign** and **pattern** match.

Cloud Area in %

year	sst_anom 1961-1990	Cloud Area Global Mean %	absolute ratio %/°C	anomaly sensitivity %/°C	global slope %/°C	5-yr rolling slope %/°C
2001	0.279	67.40595	3.700596	-0.10942	-0.22946	
2002	0.313	67.40571	3.693678	-0.09832	-0.22946	
2003	0.340	67.52721	3.694867	0.266385	-0.22946	
2004	0.333	67.47182	3.693366	0.106053	-0.22946	
2005	0.331	67.53972	3.697406	0.311522	-0.22946	1.246857
2006	0.333	67.54809	3.697611	0.335517	-0.22946	1.130296
2007	0.259	67.42733	3.705835	-0.03543	-0.22946	0.744348
2008	0.244	67.42735	3.708889	-0.03754	-0.22946	1.145852
2009	0.368	67.46904	3.686077	0.088299	-0.22946	0.881629
2010	0.378	67.64359	3.693565	0.547205	-0.22946	0.838465
2011	0.273	67.56392	3.710592	0.466842	-0.22946	-0.60388
2012	0.339	67.63265	3.700888	0.578205	-0.22946	-1.51378
2013	0.361	67.30606	3.678601	-0.36126	-0.22946	-0.53609
2014	0.453	67.28637	3.659235	-0.33175	-0.22946	-0.77628
2015	0.571	67.45014	3.644705	0.023861	-0.22946	-0.14366
2016	0.611	67.17053	3.621813	-0.43562	-0.22946	-0.61643
2017	0.550	67.25403	3.638269	-0.33201	-0.22946	-2.40308
2018	0.506	67.46664	3.658332	0.059477	-0.22946	-2.55538
2019	0.582	67.26528	3.632612	-0.29446	-0.22946	-0.69294
2020	0.565	67.46944	3.646993	0.058313	-0.22946	-0.54043
2021	0.465	67.36604	3.66102	-0.15144	-0.22946	-0.3685
2022	0.507	67.44277	3.656879	0.012323	-0.22946	0.030602
2023	0.738	67.31021	3.604531	-0.17109	-0.22946	0.195107
2024	0.791	67.49373	3.604188	0.072323	-0.22946	
2025	0.707	67.56942	3.624504	0.188007	-0.22946	
mean	0.448	67.43652	3.668602	0.03024	-0.22946	-0.23881



Cloud Effective pressure – Daytime and Nighttime: cldpress_total_daynight_mon



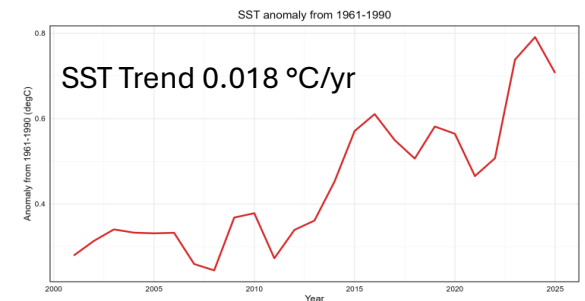
The global slope for this variable is **-0.202 hPa/°C**: This is the 2001–2025 cloud pressure change for each 1°C change in global-mean SST.

On average clouds rise (lower pressure) as SST goes up, but the trend is highly variable and small.

Cloud effective pressure is a satellite-retrieved proxy for **cloud top height**.

Gaps in the $dX/dSST$ map are due to bad regressions, usually due to no change over the period.

There is a trend of decreasing pressure along the equator, except in the Indian Ocean.



1. Cloud Effective Pressure (hPa)

What it is: Cloud effective pressure is a satellite-retrieved proxy for **cloud top height**. Lower pressure → higher cloud tops. Higher pressure → lower cloud tops.

The global mean: ~587 hPa, which corresponds to **~4-5 km (global mean 4.5 km) altitude** (mid-troposphere).

Results show

- **Trend:** -0.007 hPa/yr (very slight and insignificant decrease)
- **Sensitivity to SST:** **-0.20 hPa/°C** (global slope)
- **Interpretation:**
 - As SST warms, cloud tops rise *slightly*.
 - The magnitude is small — consistent with the idea that cloud-top height is fairly stable globally.

Physical significance

Cloud-top height affects **longwave radiation**:

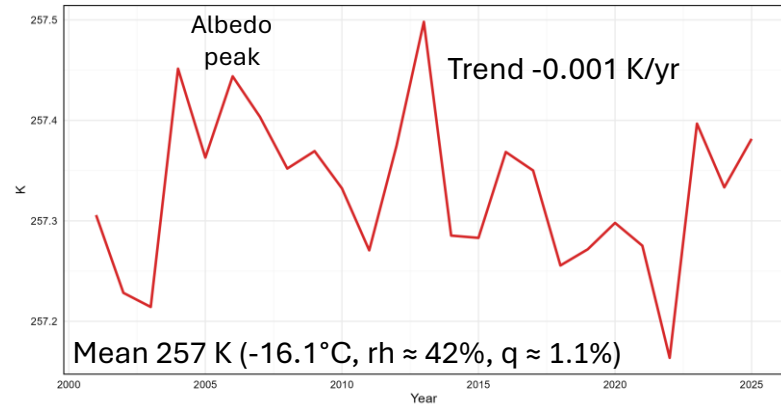
- **Higher clouds → colder tops → stronger greenhouse effect** (positive LW feedback).
- **Lower clouds → warmer tops → weaker greenhouse effect.**

This result (slightly rising cloud tops with warming) is consistent with a **weak positive LW cloud-height feedback**, similar to what CMIP models and CERES-based studies report.

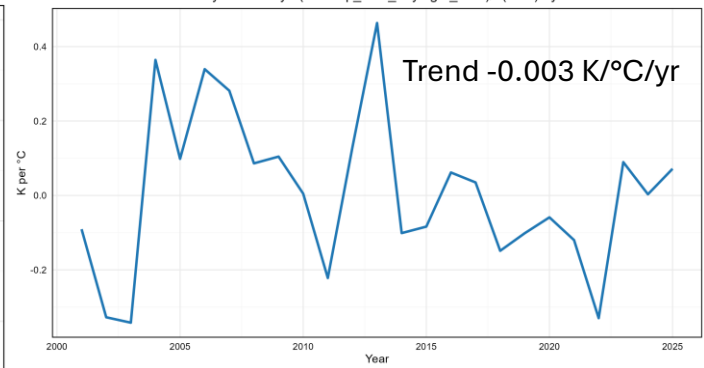
But the magnitude is small — meaning cloud-top height is *not* a dominant contributor to net cloud feedback.

Cloud Effective Temperature – Daytime and Nighttime: $\text{cldtemp_total_daynight_mon}$

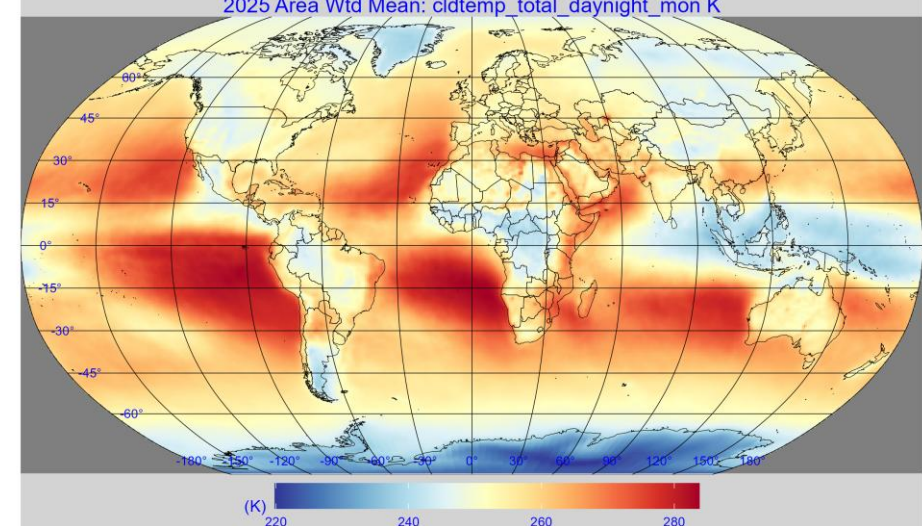
Area-Weighted Global Mean: $\text{cldtemp_total_daynight_mon}$



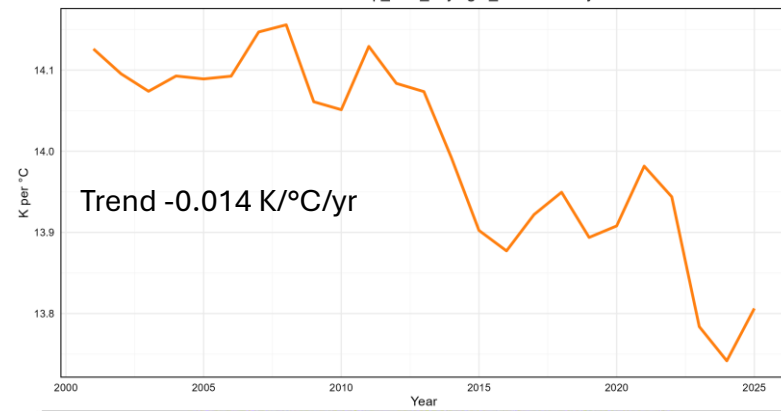
Anomaly Sensitivity $d(\text{cldtemp_total_daynight_mon})/d(\text{SST})$ by Year



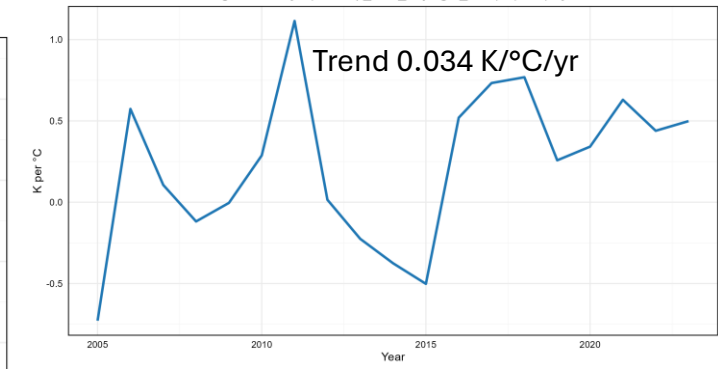
2025 Area Wtd Mean: $\text{cldtemp_total_daynight_mon}$ K



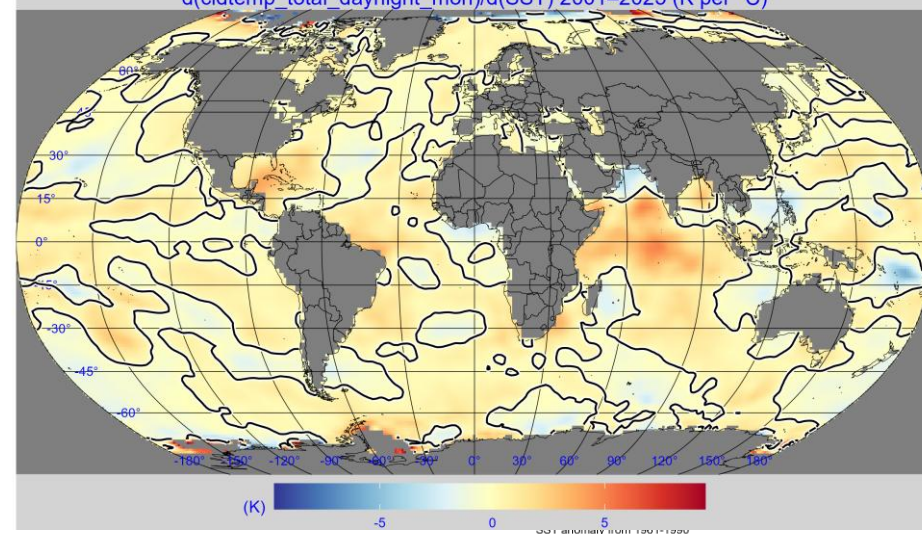
Absolute Ratio $\text{cldtemp_total_daynight_mon} / \text{SST}$ by Year



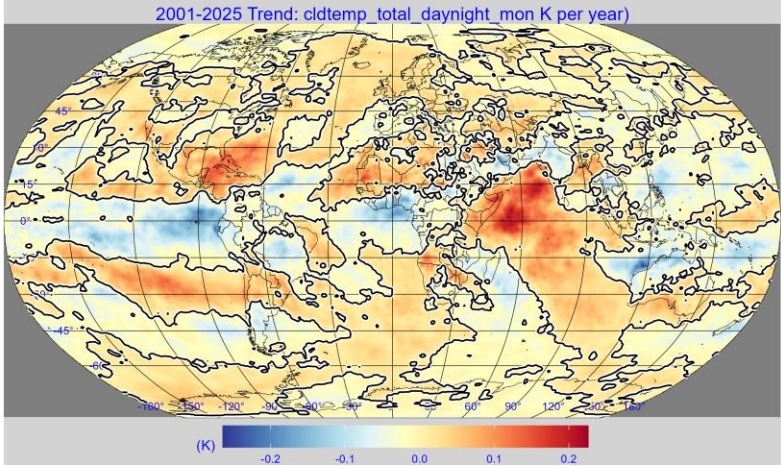
Rolling Sensitivity $d(\text{cldtemp_total_daynight_mon})/d(\text{SST})$ by Year



$d(\text{cldtemp_total_daynight_mon})/d(\text{SST})$ 2001–2025 (K per °C)

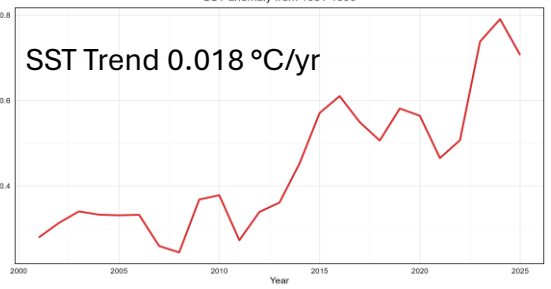


2001–2025 Trend: $\text{cldtemp_total_daynight_mon}$ K per year



The global slope for this variable is **-0.037 K/°C**: This is the 2001–2025 cloud temperature change for each 1°C change in global-mean SST.

While the global slope suggests cloud tops are cooling the rolling slope suggests the opposite, best interpretations is that cloud top temperatures are steady.



2. Cloud Effective Temperature (K)

What it is: The radiative temperature of the cloud top, retrieved from IR channels. It is tightly tied to cloud-top pressure but not identical (depends on lapse rate and cloud type).

Your global mean: 257 K (−16.1°C) This is exactly what you expect for mid-tropospheric clouds.

 **What your results show**

Trend: ~0 K/yr (essentially flat)

Low and conflicting sensitivity to SST.

Interpretation:

Cloud-top temperatures are *extremely stable* globally.

 **Physical significance**

Cloud-top temperature controls **outgoing longwave radiation (OLR):**

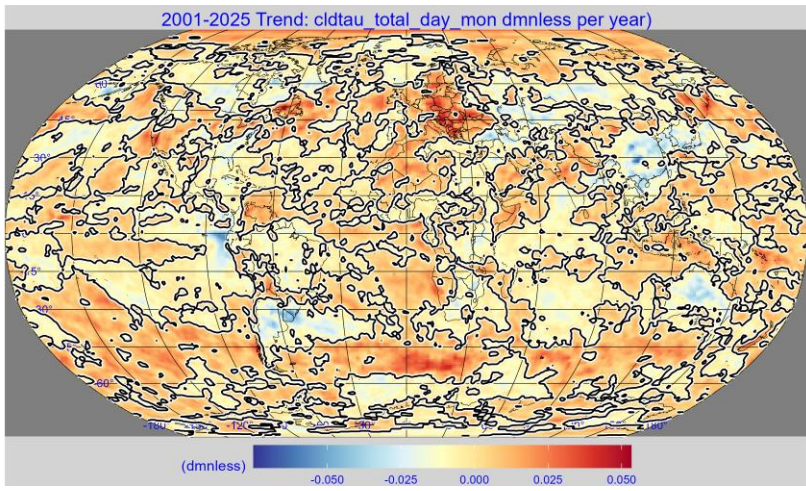
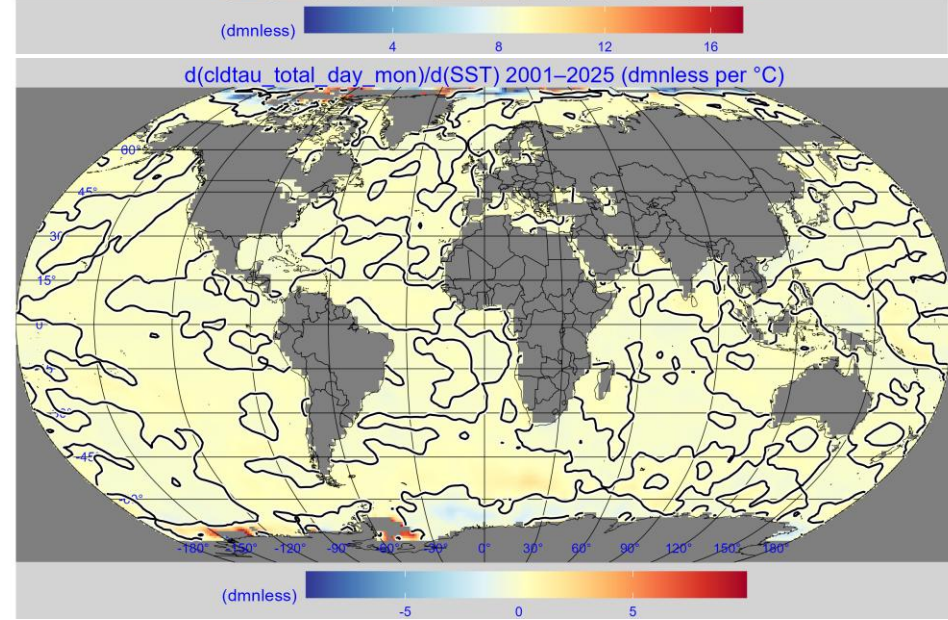
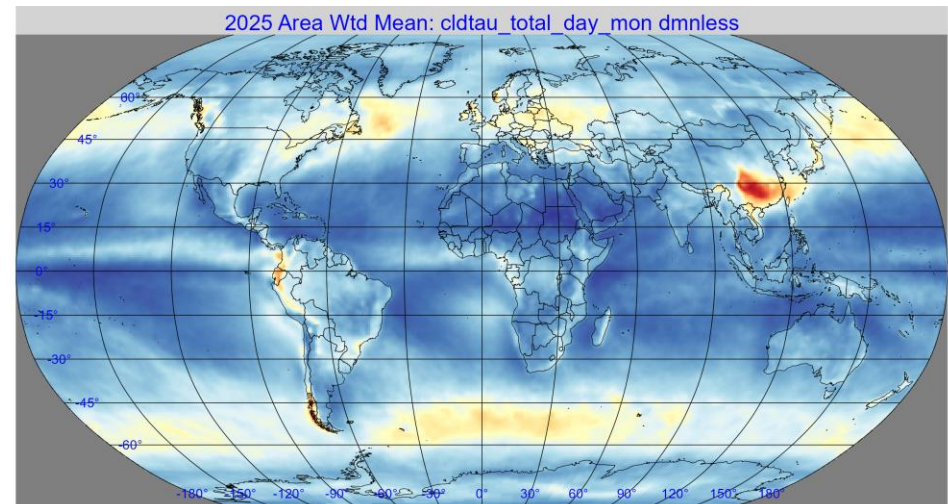
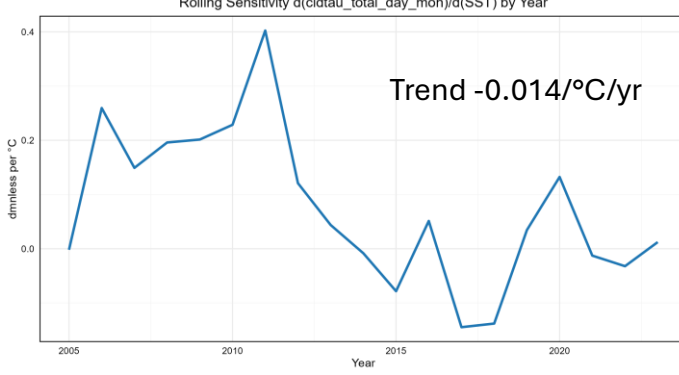
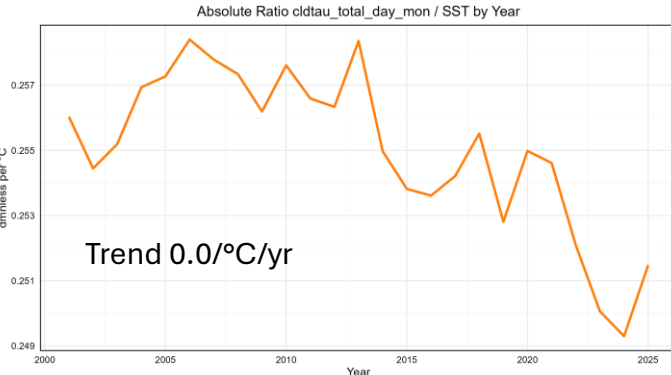
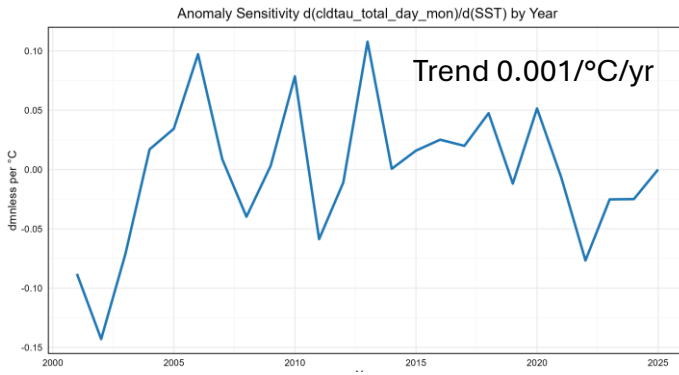
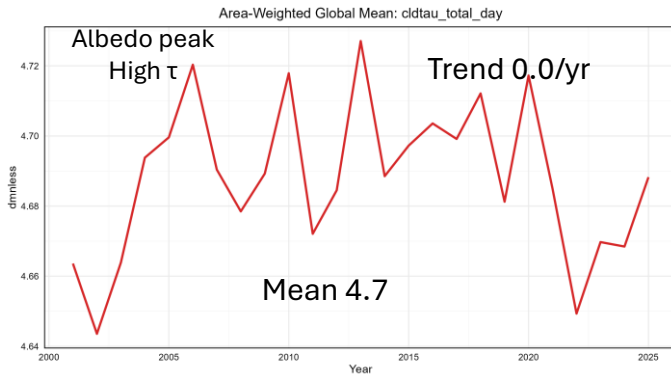
Colder cloud tops → less OLR → warming effect

Warmer cloud tops → more OLR → cooling effect

The CERES data suggests a steady temperature with respect to SST—effectively neutral.

This is consistent with CERES literature: cloud-top temperature is one of the *least* sensitive cloud properties.

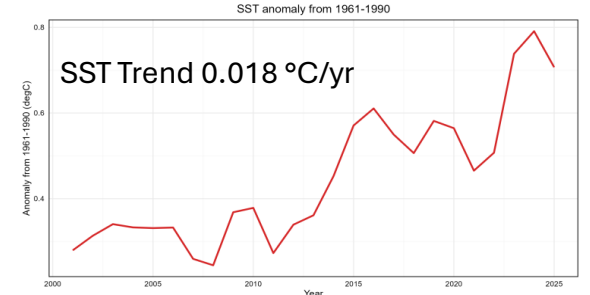
Cloud Visible Optical Depth (dimensionless) – Daytime: cldtau_total_day



The global slope for this variable is 0.001 /°C. The trend of this variable is near zero overall and as a function of SST.

No significant albedo peak anomaly.

Basically, this value is steady.



Cloud tau and cloud characteristics according to CERES

Cloud Visible Optical Depth (τ)

What it is: A measure of cloud thickness and reflectivity.
 Higher τ \rightarrow brighter clouds \rightarrow more reflected sunlight \rightarrow cooling.
 Lower τ \rightarrow dimmer clouds \rightarrow warming.

The global mean: $\tau \approx 4.7$ (typical for global cloud cover).

What it means

- **Trend:** $\sim 0/\text{yr}$ (flat)
- **Sensitivity to SST:** ≈ 0
- **Interpretation:**
 - Cloud optical depth is remarkably stable.
 - No global brightening or dimming trend.
 - No systematic change with SST.

Physical significance

Optical depth is the **dominant driver** of shortwave cloud radiative effect (CRE_SW). If τ were decreasing globally, that would imply a strong positive cloud feedback.

τ is flat \rightarrow no global SW optical-depth feedback.

This is consistent with the fact that global CRE_SW trends in CERES are small and dominated by regional patterns (e.g., subtropical stratocumulus decks).

Overall interpretation

CERES EBAF shows that global cloud properties (height, temperature, optical depth) are remarkably stable from 2001–2025.

The small CERES sensitivities imply:

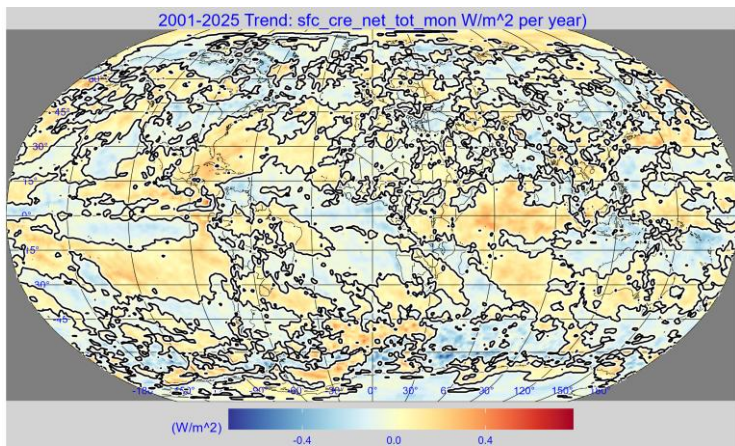
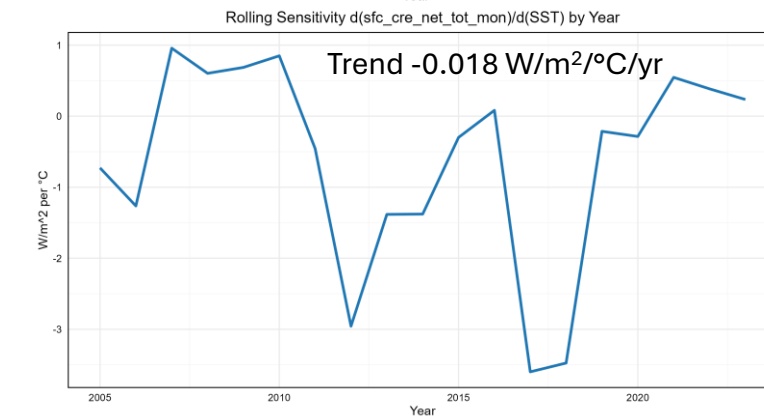
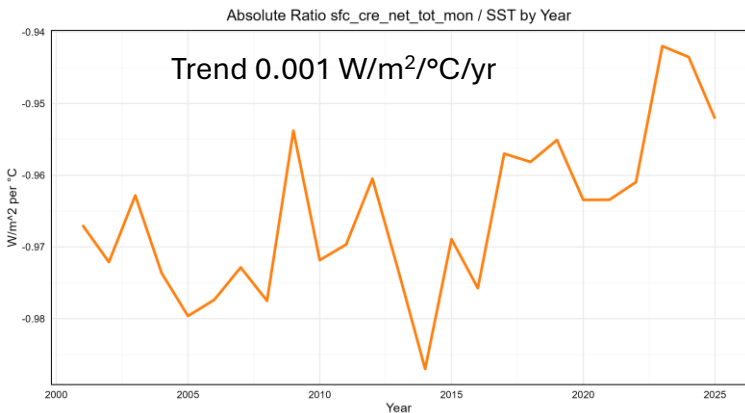
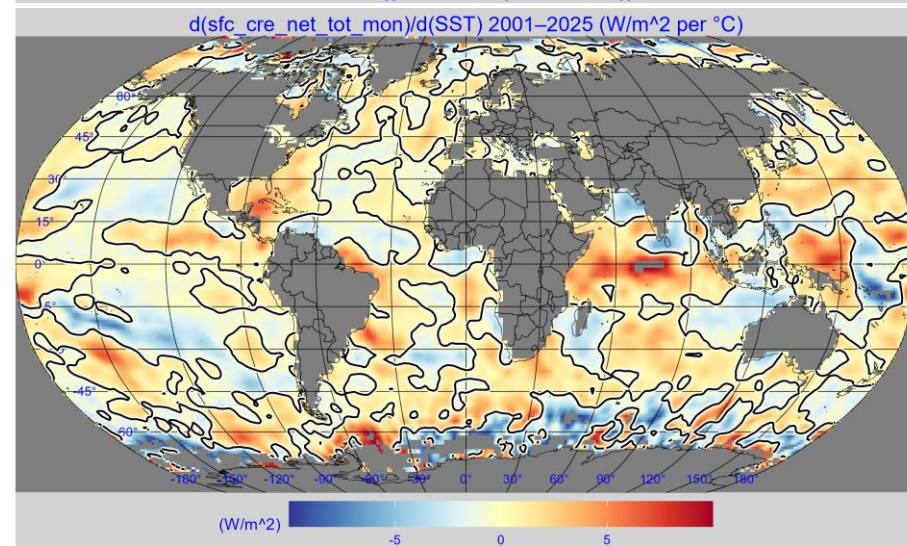
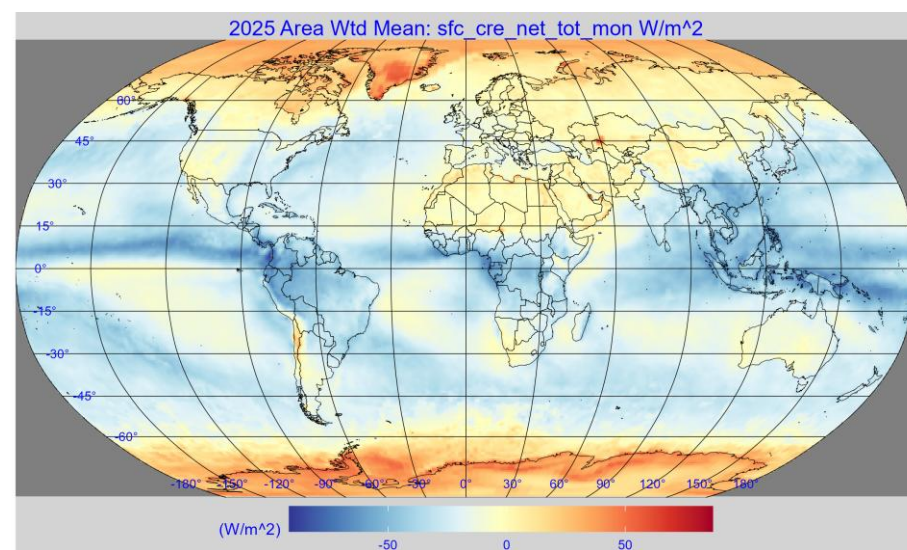
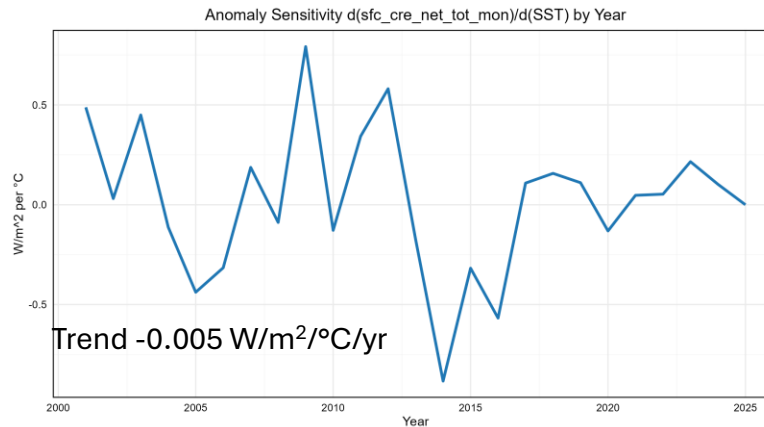
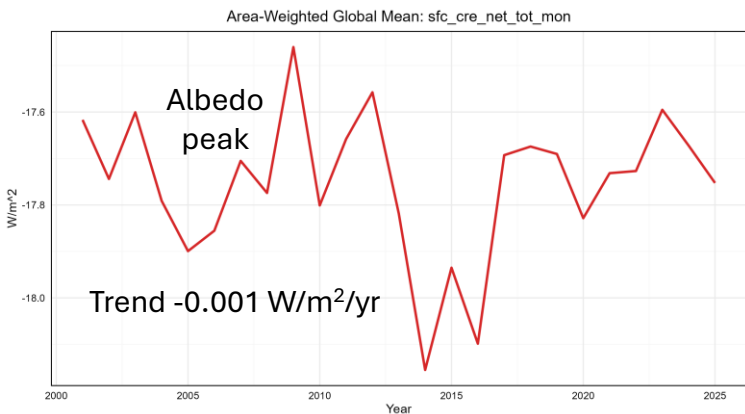
- **Cloud feedbacks are real but weak** in the global mean. They are probably statistically insignificant
- **Regional patterns dominate** (e.g., tropics vs. subtropics).
- The large cloud feedbacks in climate models come mostly from **cloud fraction** and **cloud phase**, not from τ , height, or temperature.

CERES weakly supports the AR6 assessment that **net cloud feedback is small positive**, driven mainly by:

- Decreasing low-cloud fraction in subtropics
- Increasing high-cloud altitude in convective regions
- Cloud microphysical changes (phase shifts)

Variable	What it controls	CERES result	Implication
Cloud pressure	Cloud-top height	Slight rise with SST	Weak positive LW feedback
Cloud temperature	Cloud-top emission	Nearly constant	LW feedback \sim neutral
Cloud optical depth (τ)	Cloud reflectivity	Flat	SW feedback \sim neutral

Surface CRE Net Total Flux – all sky-clear sky: sfc_cre_net_tot_mon

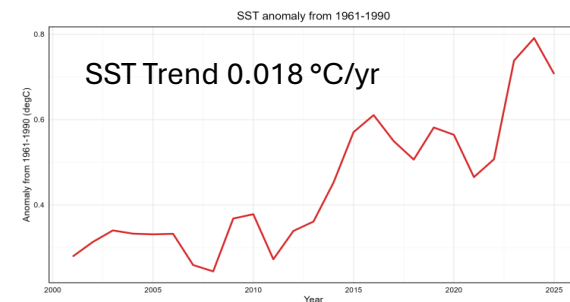


The global slope for this variable is -0.098 W/m²/°C. Calculated as all-sky flux minus clear-sky (for total region) flux or equivalently as sfc_cre_net_lw+sfc_cre_net_sw

sfc_cre_net_tot_mon is the net total downward flux due to clouds, it is a negative number due to the CERES surface sign convention (“cre_net” positive means the surface gains energy and negative means it is losing energy, negative is upward flux or the surface is losing energy, confusing I know).

Positive sfc_cre_net_tot: Clouds increase the net downward energy at the surface→ clouds warm the surface (LW effect dominates). Negative sfc_cre_net_tot clouds decrease the net downward energy at the surface→ clouds cool the surface (SW shading dominates).

Although this is supposed to be net SW + net LW down to the surface, it is off by 1.5 W/m² as shown in the next slide.



sfc_cre_net_tot & sfc_cre_net_sw

Problematic Variables																					
cre_net_sw + cre_net_lw does not equal sfc_cre_net_tot							net_lw_all - net_lw_clr_t does equal sfc_cre_net_lw as it should							net_sw_all - net_sw_clr_t does not equal sfc_cre_net_sw							
year	sfc_cre_net_tot_mon		sfc_cre_net_sw_mo		sfc_cre_net_lw_mo		Sum	sfc_net_lw_all_mon		sfc_net_lw_clr_t_mo		sfc_cre_net_lw_mo		Diff	sfc_net_sw_all_mon		sfc_net_sw_clr_t_m		sfc_cre_net_sw_mo		Diff
	gm	Num_nulls	gm	Num_nulls	gm	Num_nulls		gm	Num_nulls	gm	Num_nulls	gm	Num_nulls		gm	Num_nulls	gm	Num_nulls	gm	Num_nulls	
2001	-17.6169	1	-47.365	0	28.381	0	-18.984	-52.217	0	-80.598	0	28.381	0	28.381	163.891	0	211.367	0	-47.365	0	-47.476
2002	-17.744	0	-47.489	0	28.299	0	-19.190	-52.313	0	-80.613	0	28.299	0	28.299	163.577	0	211.178	0	-47.489	0	-47.601
2003	-17.6006	0	-47.557	0	28.379	0	-19.179	-52.230	0	-80.608	0	28.379	0	28.379	163.622	0	211.279	0	-47.557	0	-47.657
2004	-17.791	0	-47.643	0	28.388	0	-19.255	-52.031	0	-80.418	0	28.388	0	28.388	163.255	0	211.001	0	-47.643	0	-47.745
2005	-17.8993	0	-47.658	0	28.363	0	-19.295	-52.060	0	-80.423	0	28.363	0	28.363	163.418	0	211.194	0	-47.658	0	-47.777
2006	-17.8554	1	-47.697	0	28.457	0	-19.240	-52.272	0	-80.729	0	28.457	0	28.457	163.436	0	211.221	0	-47.697	0	-47.785
2007	-17.7051	1	-47.792	0	28.454	0	-19.338	-52.400	0	-80.854	0	28.454	0	28.454	163.502	0	211.402	0	-47.792	0	-47.900
2008	-17.7742	1	-47.509	0	28.343	0	-19.167	-52.457	0	-80.800	0	28.343	0	28.343	163.769	0	211.367	0	-47.509	0	-47.598
2009	-17.4603	1	-47.475	0	28.471	0	-19.004	-52.244	0	-80.715	0	28.471	0	28.471	163.706	0	211.273	0	-47.475	0	-47.567
2010	-17.801	0	-47.820	0	28.534	0	-19.285	-52.033	0	-80.567	0	28.534	0	28.534	163.346	0	211.233	0	-47.820	0	-47.887
2011	-17.6582	1	-47.588	0	28.353	0	-19.235	-52.182	0	-80.535	0	28.353	0	28.352	163.778	0	211.485	0	-47.588	0	-47.707
2012	-17.5576	1	-47.708	0	28.524	0	-19.184	-52.080	0	-80.604	0	28.524	0	28.524	163.646	0	211.470	0	-47.708	0	-47.824
2013	-17.8186	0	-47.821	0	28.440	0	-19.382	-52.244	0	-80.683	0	28.440	0	28.440	163.684	0	211.624	0	-47.821	0	-47.940
2014	-18.155	0	-47.706	0	28.181	0	-19.525	-52.380	0	-80.560	0	28.181	0	28.180	163.826	0	211.646	0	-47.706	0	-47.820
2015	-17.935	0	-47.767	0	28.276	0	-19.490	-52.362	0	-80.638	0	28.276	0	28.276	163.981	0	211.842	0	-47.767	0	-47.861
2016	-18.0985	1	-47.610	0	28.172	0	-19.438	-52.530	0	-80.702	0	28.172	0	28.172	163.872	0	211.597	0	-47.610	0	-47.725
2017	-17.6929	0	-47.547	0	28.346	0	-19.202	-52.408	0	-80.753	0	28.346	0	28.346	164.036	0	211.710	0	-47.547	0	-47.674
2018	-17.6743	0	-47.608	0	28.546	0	-19.061	-52.207	0	-80.753	0	28.546	0	28.546	163.719	0	211.432	0	-47.608	0	-47.713
2019	-17.6903	0	-47.473	0	28.322	0	-19.150	-52.488	0	-80.809	0	28.322	0	28.322	163.920	0	211.477	0	-47.473	0	-47.558
2020	-17.8285	0	-47.880	0	28.473	0	-19.408	-52.311	0	-80.784	0	28.473	0	28.473	163.595	0	211.594	0	-47.880	0	-47.998
2021	-17.7316	0	-47.311	0	28.238	0	-19.072	-52.445	0	-80.683	0	28.238	0	28.238	164.095	0	211.495	0	-47.311	0	-47.399
2022	-17.727	0	-47.387	0	28.318	0	-19.069	-52.284	0	-80.601	0	28.318	0	28.318	163.923	0	211.407	0	-47.387	0	-47.484
2023	-17.5952	1	-47.297	0	28.269	0	-19.027	-52.298	0	-80.567	0	28.269	0	28.269	163.891	0	211.295	0	-47.297	0	-47.404
2024	-17.6723	0	-47.427	0	28.314	0	-19.113	-52.236	0	-80.550	0	28.314	0	28.314	163.836	0	211.375	0	-47.427	0	-47.540
2025	-17.7526	1	-47.562	0	28.319	0	-19.243	-52.115	0	-80.434	0	28.319	0	28.319	163.678	0	211.347	0	-47.562	0	-47.669

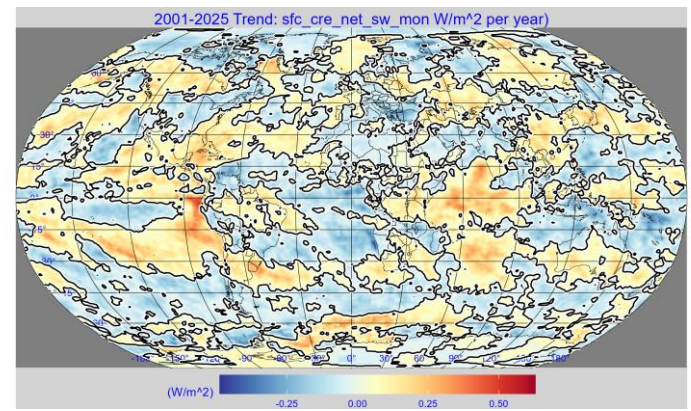
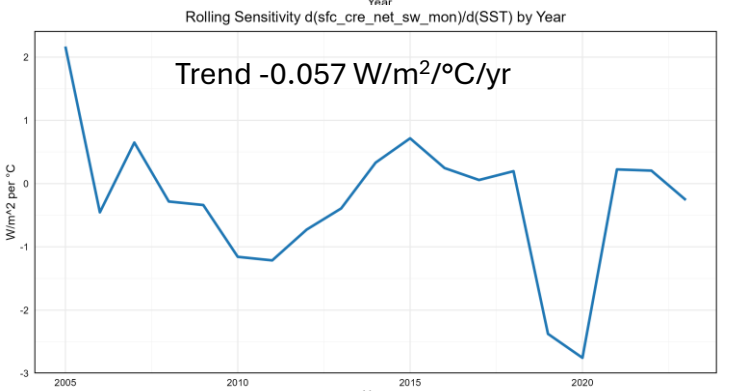
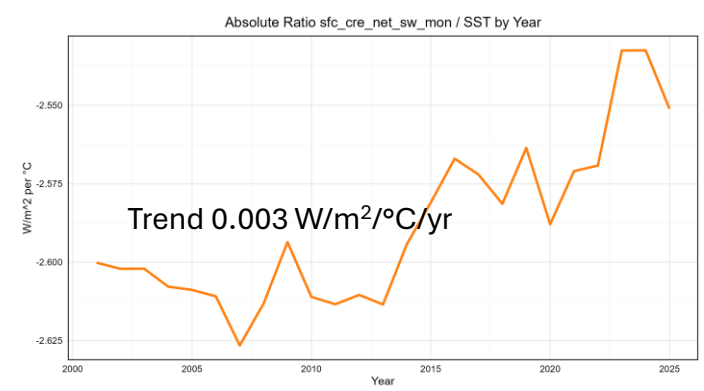
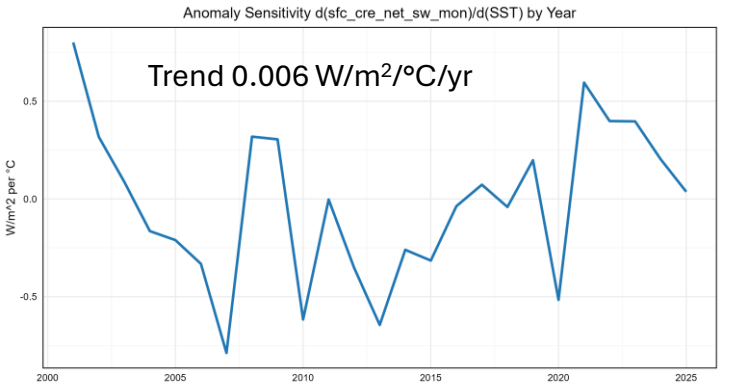
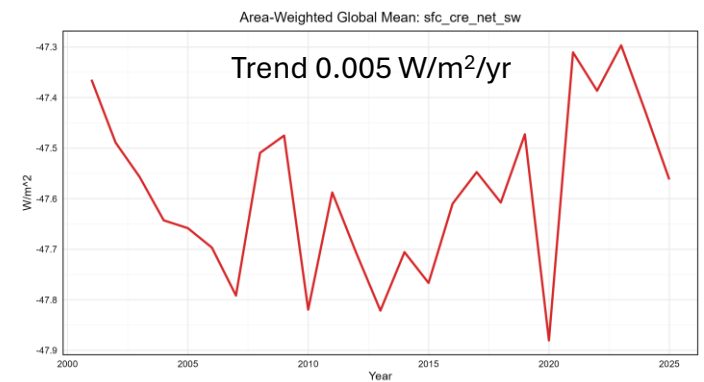
Should be =

Are =

Should be =

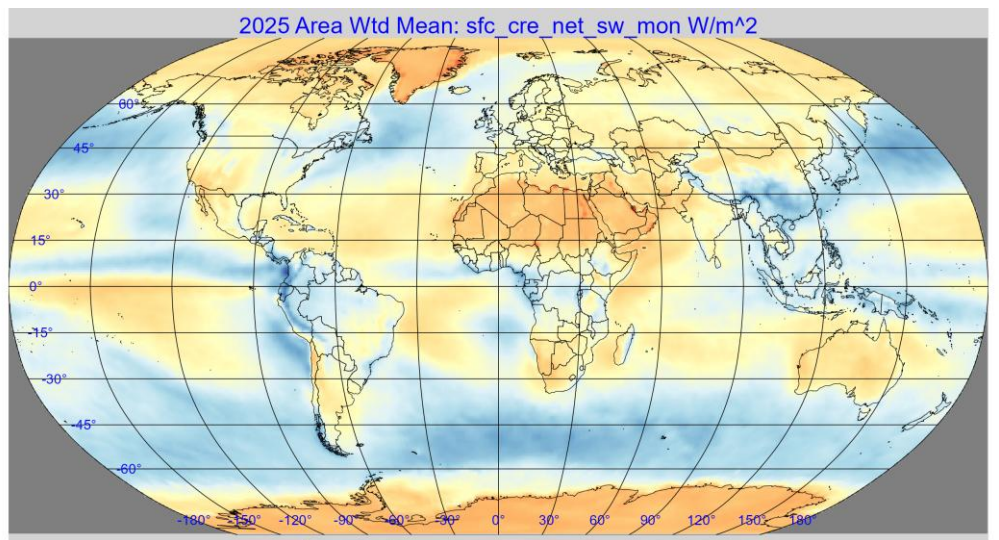


Surface CRE Net downward SW Flux – all sky-clear sky: sfc_cre_net_sw

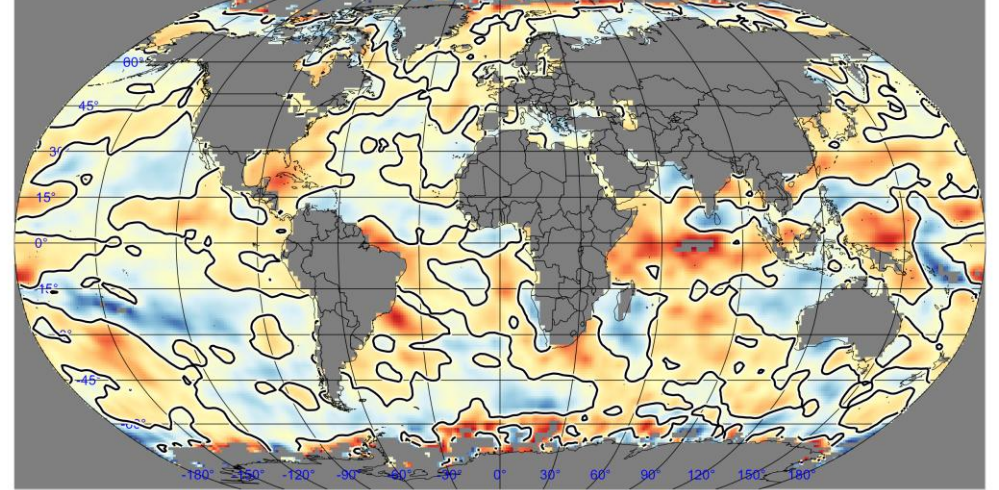


Surface Net downward SW Flux due to clouds, All sky – Clear sky (for total cell). The value is negative, meaning clouds block SW. The global slope for this variable is 0.265 **W/m²/°C**. The direction of this variable as a function of SST is ambiguous and the mean has no definitive trend. The SW cloud effect is flat.

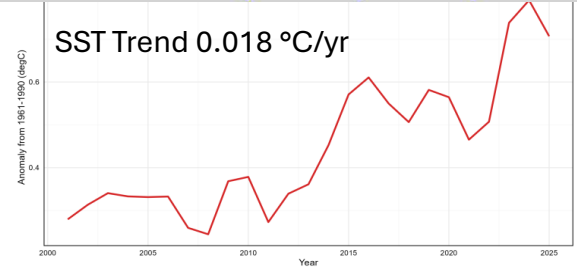
Calculated as all-sky SW flux minus clear-sky SW flux. But the number off, as seen in the next slide. Positive values mean surface gains energy/ absorbs SW energy due to clouds, negative (the norm) means the opposite.



(W/m²)
d(sfc_cre_net_sw_mon)/d(SST) 2001–2025 (W/m² per °C)



(W/m²)



Don't Match



Don't Match



sfc cre net sw

year	sfc cre net tot	sfc_cre_net_lw + sfc_cre_net_sw	sfc cre net lw	sfc cre net sw	net_sw_all - net_sw_clr_t	sfc net sw clr_t	sfc net sw all
2001	-17.61	-18.98	28.38	-47.36	-47.47	211.35	163.88
2002	-17.74	-19.18	28.30	-47.49	-47.60	211.17	163.57
2003	-17.60	-19.17	28.38	-47.56	-47.65	211.27	163.61
2004	-17.79	-19.25	28.39	-47.64	-47.74	210.99	163.25
2005	-17.89	-19.29	28.37	-47.65	-47.77	211.18	163.41
2006	-17.85	-19.24	28.46	-47.70	-47.78	211.21	163.43
2007	-17.70	-19.33	28.46	-47.79	-47.90	211.39	163.49
2008	-17.77	-19.16	28.34	-47.51	-47.60	211.35	163.76
2009	-17.46	-19.00	28.47	-47.47	-47.56	211.26	163.70
2010	-17.80	-19.28	28.54	-47.82	-47.89	211.22	163.34
2011	-17.66	-19.23	28.36	-47.59	-47.71	211.47	163.77
2012	-17.55	-19.18	28.53	-47.70	-47.82	211.46	163.64
2013	-17.81	-19.38	28.44	-47.82	-47.94	211.61	163.68
2014	-18.15	-19.52	28.18	-47.70	-47.82	211.63	163.82
2015	-17.93	-19.49	28.28	-47.77	-47.86	211.83	163.97
2016	-18.10	-19.43	28.17	-47.61	-47.72	211.59	163.86
2017	-17.69	-19.20	28.35	-47.55	-47.67	211.70	164.03
2018	-17.67	-19.06	28.55	-47.61	-47.71	211.42	163.71
2019	-17.69	-19.15	28.32	-47.47	-47.56	211.47	163.91
2020	-17.82	-19.40	28.47	-47.88	-47.99	211.58	163.59
2021	-17.73	-19.07	28.24	-47.31	-47.40	211.48	164.09
2022	-17.72	-19.06	28.32	-47.38	-47.48	211.40	163.91
2023	-17.59	-19.02	28.27	-47.29	-47.40	211.28	163.88
2024	-17.67	-19.11	28.32	-47.42	-47.54	211.36	163.83
2025	-17.75	-19.24	28.32	-47.56	-47.67	211.33	163.67

The documentation:

NC_FLOAT sfc_cre_net_sw_mon(lon, lat, time) ;

NC_CHAR sfc_cre_net_sw_mon:long_name = "Surface Cloud Radiative Effects Net Shortwave Flux, (uses Clear-Sky for total region), Monthly Means" ;

NC_CHAR sfc_cre_net_sw_mon:standard_name = "Surface CRE Net Shortwave Flux" ;

NC_CHAR sfc_cre_net_sw_mon:CF_name = "none" ;

NC_CHAR sfc_cre_net_sw_mon:comment = "Calculated as all-sky flux minus clear-sky (for total region) flux." ;

NC_CHAR sfc_cre_net_sw_mon:units = "W m-2" ;

NC_CHAR sfc_cre_net_sw_mon:valid_min = " -300.000" ;

NC_CHAR sfc_cre_net_sw_mon:valid_max = " 100.000" ;

NC_FLOAT sfc_cre_net_sw_mon:_FillValue = -999 ;

Cross Checking Problems

cre_net_sw + cre_net_lw does not equal sfc_cre_net_tot

net_lw_all - net_lw_clr_t does equal sfc_cre_net_lw as it should.

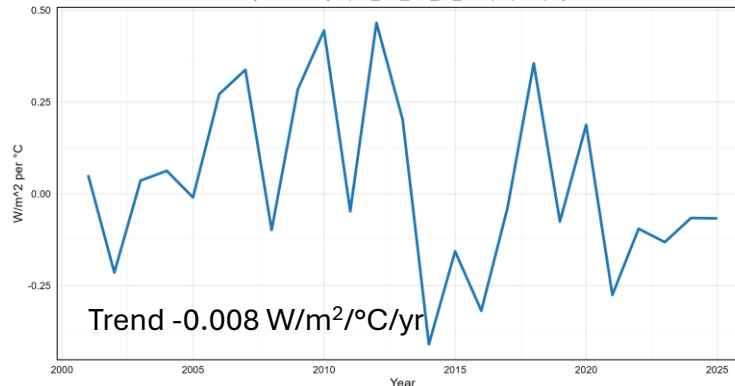
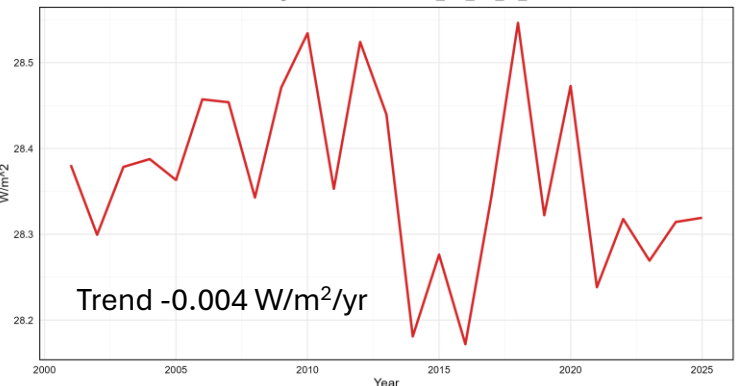
But, net_sw_all - net_sw_clr_t does not equal sfc_cre_net_sw and by a different amount than the difference between cre_net_sw + cre_net_lw and sfc_cre_net_tot.

There is a problem.

Surface CRE Net LW Flux – all sky-clear sky: sfc_cre_net_lw_mon

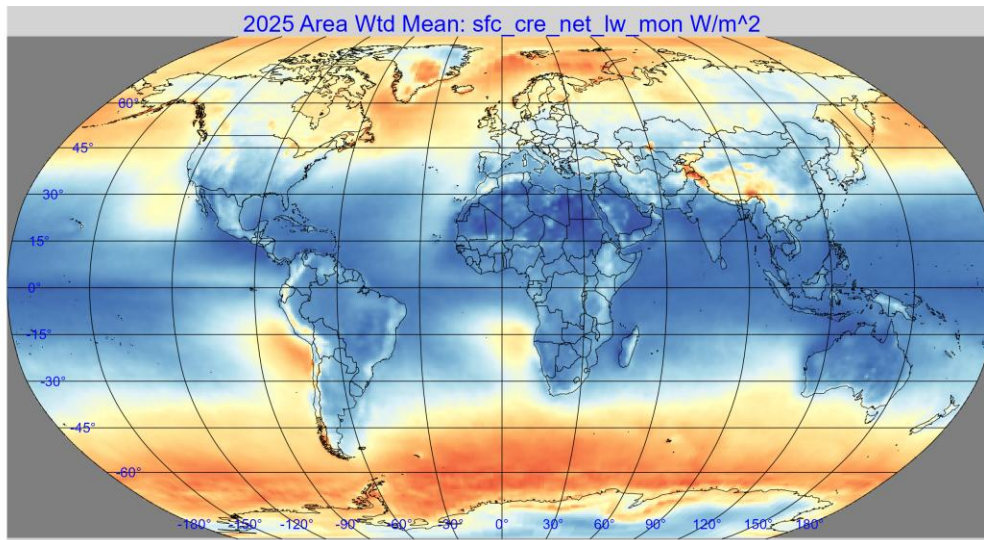
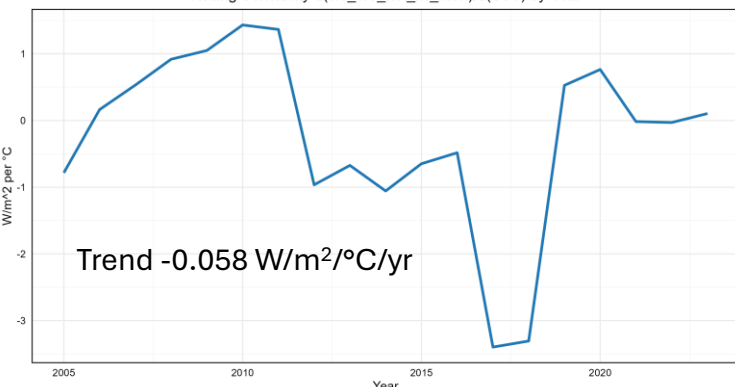
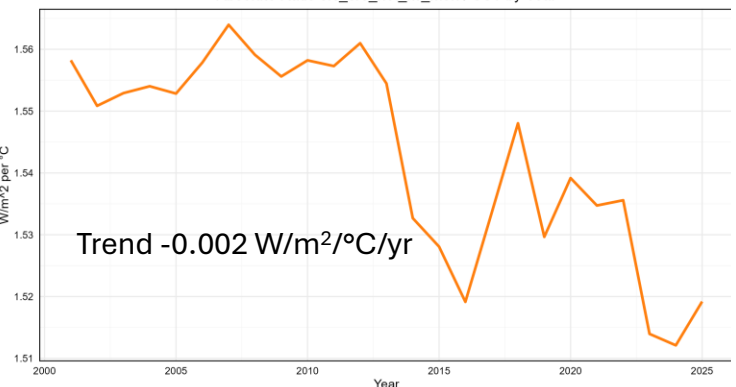
Area-Weighted Global Mean: sfc_cre_net_lw_mon

Anomaly Sensitivity $d(\text{sfc_cre_net_lw_mon})/d(\text{SST})$ by Year

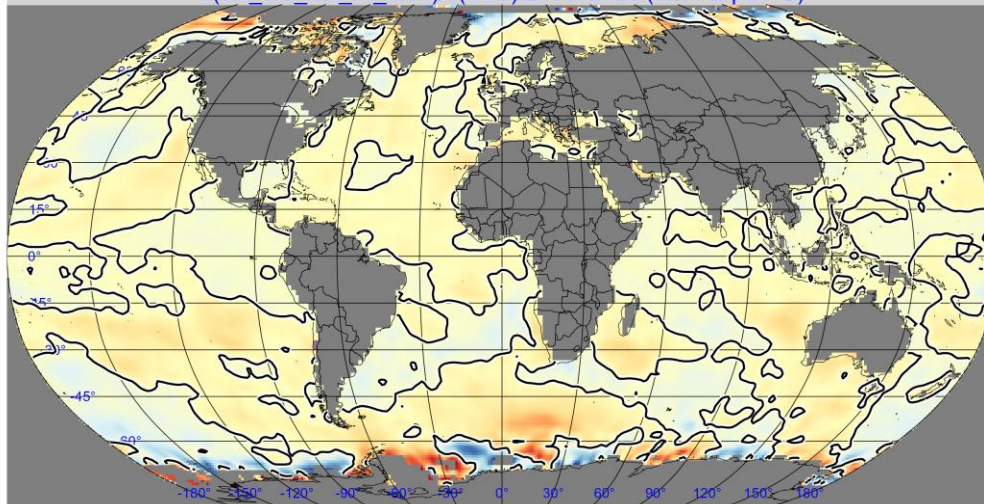


Absolute Ratio sfc_cre_net_lw_mon / SST by Year

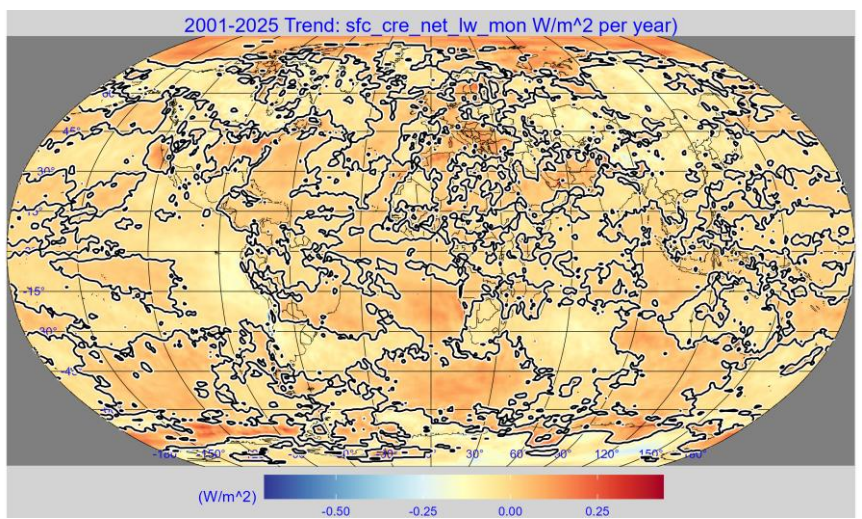
Rolling Sensitivity $d(\text{sfc_cre_net_lw_mon})/d(\text{SST})$ by Year



(W/m^2)
20 40 60 80



(W/m^2)
-5 0 5



The global slope for this variable is **-0.255 W/m²/°C**:
Calculated as all-sky flux minus clear-sky (for total region) flux. This one checks out, see next slide.

Net downward longwave flux from clouds. **Positive sfc_cre_net_lw** → clouds **increase** net downward LW at the surface (this is the usual case: clouds act like a blanket and warm the surface). **Negative sfc_cre_net_lw** → clouds **decrease** net downward LW (rare; requires very cold cloud tops over a warm surface).



sfc cre net lw				
year	sfc cre net lw	sfc net lw clr_t	sfc net lw all	net all-net lw clr_t
2001	28.38288	-80.5968	-52.2139	28.38288
2002	28.30142	-80.6121	-52.3107	28.30142
2003	28.3809	-80.6079	-52.227	28.38093
2004	28.3895	-80.418	-52.0285	28.3895
2005	28.36538	-80.4228	-52.0574	28.36538
2006	28.45895	-80.7289	-52.2699	28.45895
2007	28.4563	-80.8536	-52.3976	28.45604
2008	28.34453	-80.7989	-52.4543	28.34453
2009	28.47345	-80.7145	-52.241	28.47345
2010	28.53698	-80.5667	-52.0297	28.53698
2011	28.35571	-80.5345	-52.1794	28.35511
2012	28.52662	-80.6033	-52.0767	28.52662
2013	28.44151	-80.6823	-52.2408	28.44151
2014	28.18315	-80.5595	-52.3769	28.18256
2015	28.27904	-80.6374	-52.359	28.27845
2016	28.17415	-80.7009	-52.527	28.1739
2017	28.34773	-80.7526	-52.4048	28.34773
2018	28.54867	-80.7524	-52.2037	28.54867
2019	28.32469	-80.809	-52.485	28.32399
2020	28.4747	-80.7832	-52.3085	28.4747
2021	28.2404	-80.6823	-52.4419	28.2404
2022	28.32029	-80.6009	-52.2806	28.32029
2023	28.27144	-80.5663	-52.2949	28.27144
2024	28.31647	-80.5499	-52.2334	28.31647
2025	28.32136	-80.4338	-52.1124	28.32136

This one works as documented

```
NC_FLOAT sfc_cre_net_lw_mon(lon, lat, time) ;
```

```
NC_CHAR sfc_cre_net_lw_mon:long_name = "Surface Cloud Radiative Effects Net Longwave Flux, (uses Clear-Sky for total region), Monthly Means" ;
```

```
NC_CHAR sfc_cre_net_lw_mon:standard_name = "Surface CRE Net Longwave Flux" ;
```

```
NC_CHAR sfc_cre_net_lw_mon:CF_name = "none" ;
```

```
NC_CHAR sfc_cre_net_lw_mon:comment = "Calculated as all-sky flux minus clear-sky (for total region) flux." ;
```

```
NC_CHAR sfc_cre_net_lw_mon:units = "W m-2" ;
```

```
NC_CHAR sfc_cre_net_lw_mon:valid_min = "-100.000" ;
```

```
NC_CHAR sfc_cre_net_lw_mon:valid_max = "300.000" ;
```

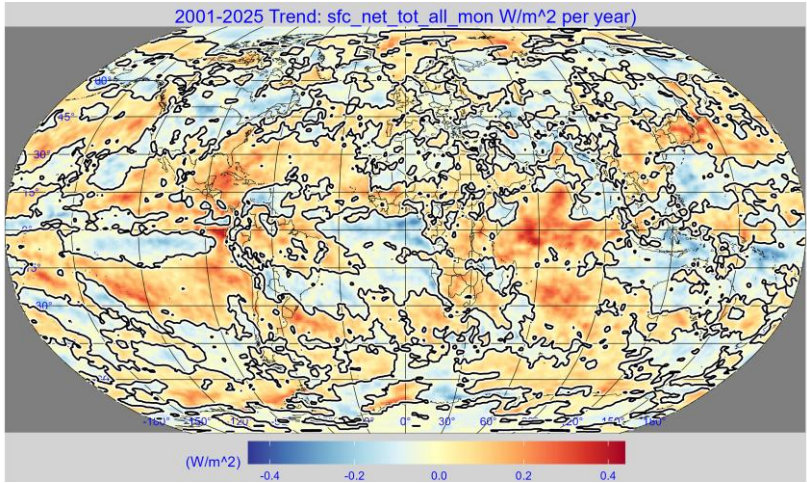
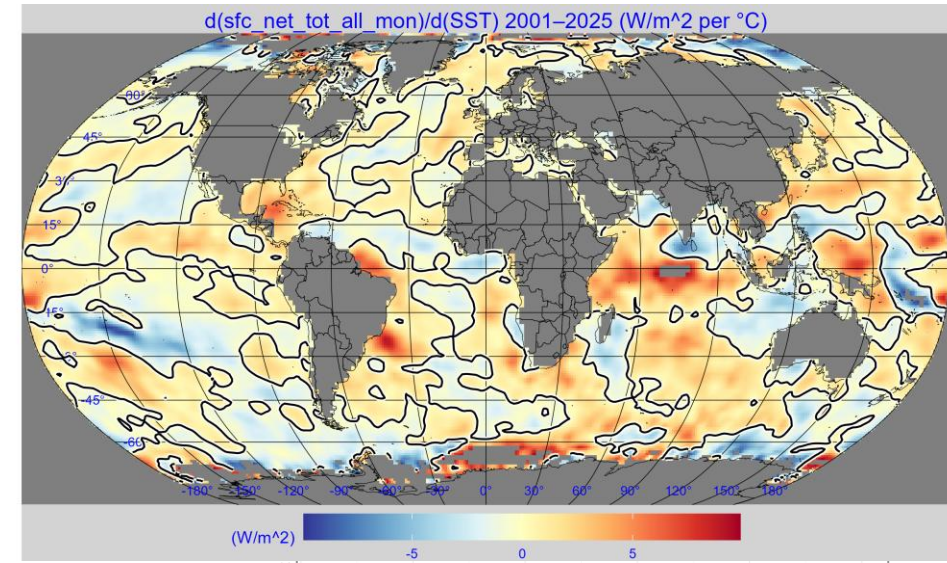
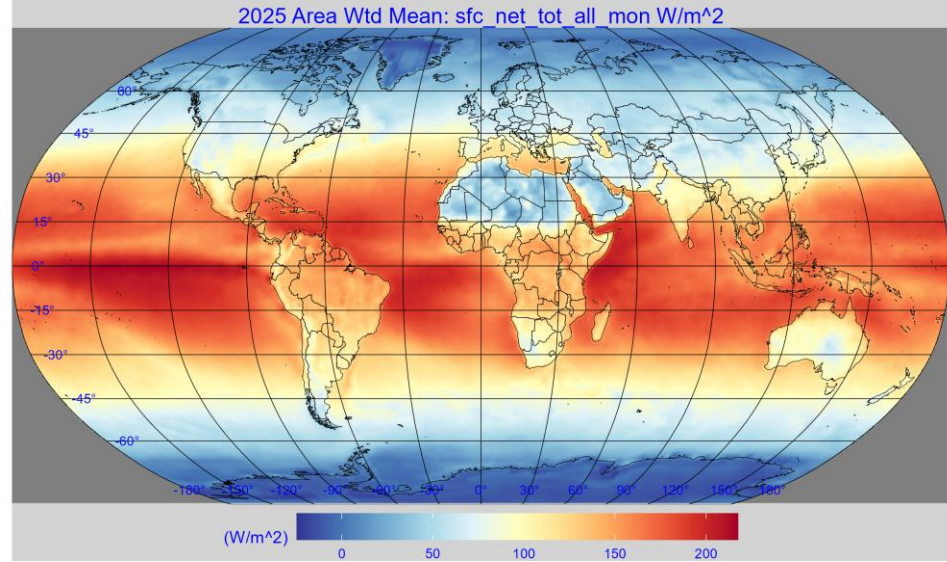
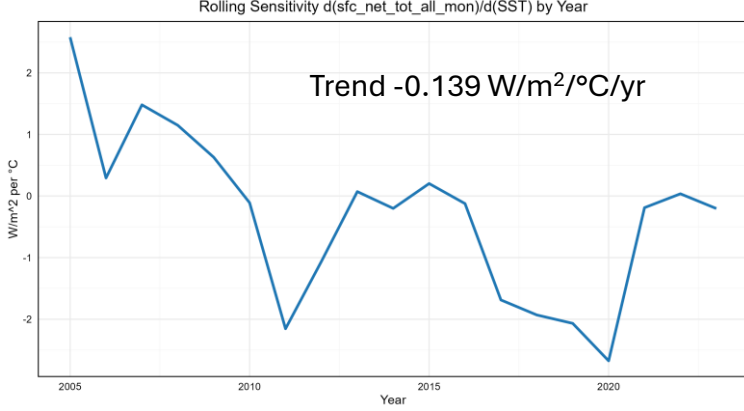
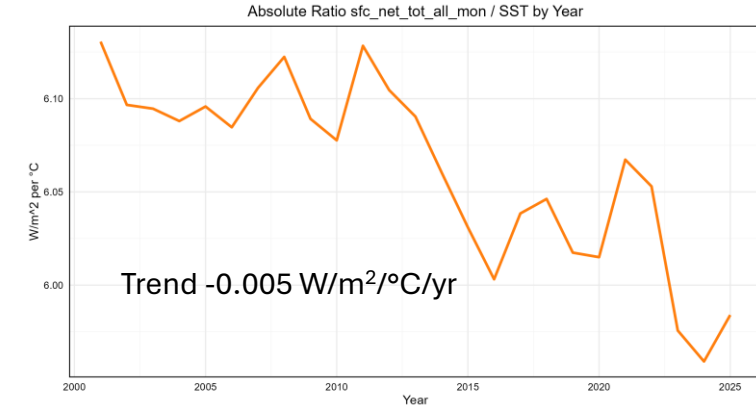
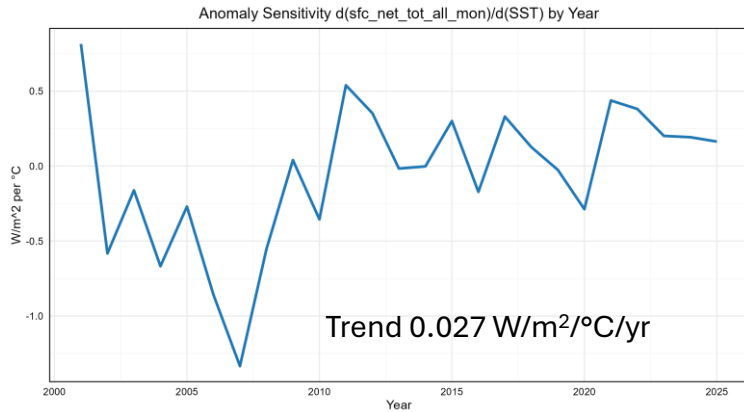
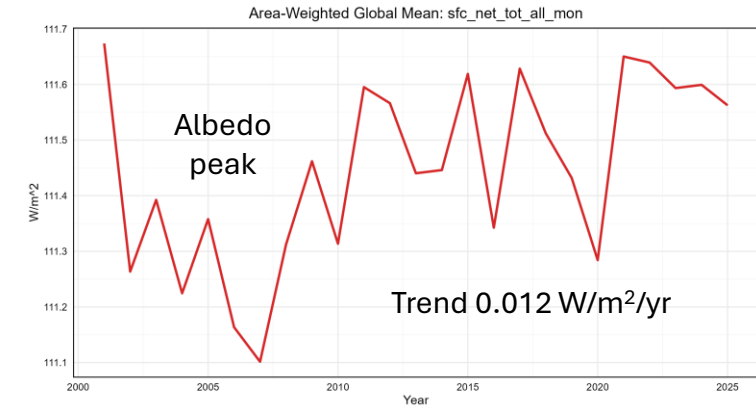
```
NC_FLOAT sfc_cre_net_lw_mon:_FillValue = -999 ;
```

Note the following:

$$\text{Sfc_cre_net_lw} = \text{sfc_net_lw_all} - \text{sfc_net_lw_clr_t} = -52.27 - (-80.64) = \sim 28.37$$

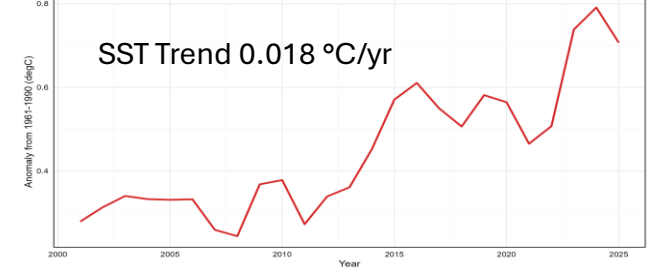
Both sfc_net_lw_all and sfc_net_lw_clr_t are negative, meaning they are radiation out and cooling the surface, clear skies output is larger, so clouds (on net) warm the surface in longwave radiation.

Surface net downward radiative flux = net_SW + net_LW: sfc_net_tot_all



The global slope for this variable is 0.452 W/m²/°C. Sfc_net_tot = (sw_down - sw_up) + (lw_down - lw_up)

Sfc_net_tot also = net_lw_all + net_sw_all



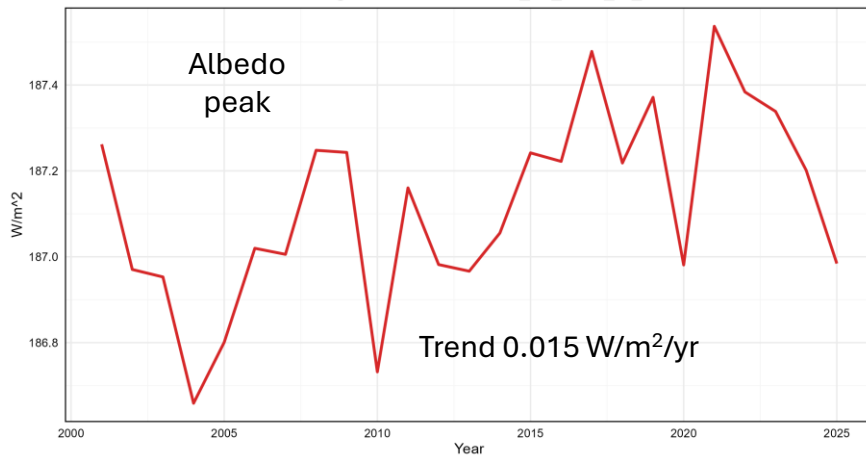
sfc_net_tot_all

All ways of calculating sfc_net_tot_all work fine

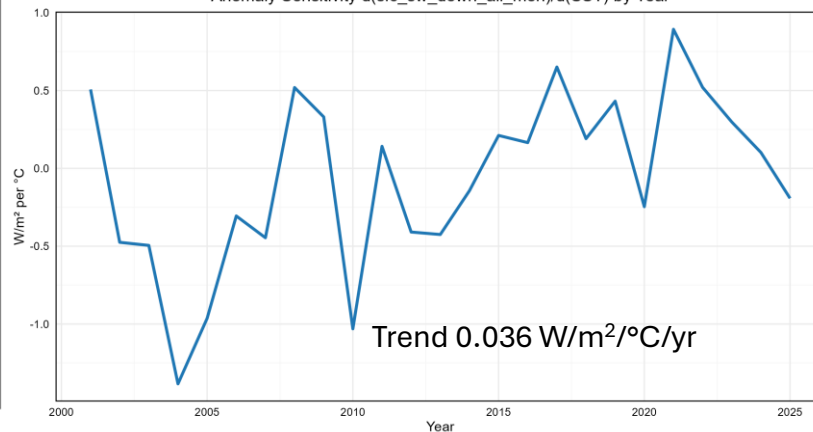
sfc net tot all									
year	sfc net tot all	sw_down-sw_up + lw_down-lw_up	net_lw_all + net_sw_all	sfc lw down all	sfc lw up all	sfc sw up all	sfc sw down all	sfc net lw all	sfc net sw all
2001	111.6679	111.6679	111.6679	346.5771	398.791	23.37465	187.2565	-52.2139	163.8818
2002	111.2578	111.2578	111.2578	346.4094	398.7201	23.39741	186.9659	-52.3107	163.5685
2003	111.3853	111.3853	111.38531	346.6486	398.8755	23.33401	186.9463	-52.227	163.6123
2004	111.2182	111.2182	111.21817	346.7451	398.7736	23.40735	186.654	-52.0285	163.2466
2005	111.3509	111.3509	111.35091	346.8588	398.9162	23.38729	186.7956	-52.0574	163.4083
2006	111.1552	111.1552	111.15521	346.5884	398.8583	23.58796	187.0131	-52.2699	163.4251
2007	111.0944	111.0944	111.09442	346.6906	399.0882	23.50715	186.9992	-52.3976	163.492
2008	111.305	111.305	111.30497	346.4257	398.8801	23.48239	187.2417	-52.4543	163.7593
2009	111.4552	111.4552	111.45517	346.6404	398.8814	23.54024	187.2365	-52.241	163.6962
2010	111.306	111.306	111.30598	346.634	398.6637	23.38899	186.7247	-52.0297	163.3357
2011	111.5875	111.5875	111.58748	346.6516	398.831	23.38659	187.1534	-52.1794	163.7668
2012	111.56	111.56	111.55998	346.8801	398.9568	23.33936	186.976	-52.0767	163.6367
2013	111.4344	111.4344	111.43441	346.4632	398.7041	23.28607	186.9613	-52.2408	163.6752
2014	111.4395	111.4395	111.43948	346.401	398.7779	23.23341	187.0498	-52.3769	163.8164
2015	111.6119	111.6119	111.61189	346.3048	398.6638	23.26458	187.2355	-52.359	163.9709
2016	111.3354	111.3354	111.33544	346.2254	398.7524	23.35336	187.2158	-52.527	163.8624
2017	111.6218	111.6218	111.6218	346.2976	398.7024	23.446	187.4726	-52.4048	164.0266
2018	111.5043	111.5043	111.50434	346.4766	398.6804	23.50329	187.2114	-52.2037	163.7081
2019	111.4255	111.4255	111.42548	346.379	398.864	23.45535	187.3659	-52.485	163.9105
2020	111.2781	111.2781	111.27809	346.6788	398.9873	23.3891	186.9757	-52.3085	163.5866
2021	111.6439	111.6439	111.64394	346.4951	398.937	23.44466	187.5305	-52.4419	164.0859
2022	111.6335	111.6335	111.63352	346.7367	399.0173	23.46455	187.3787	-52.2806	163.9141
2023	111.589	111.589	111.589	346.755	399.0499	23.45097	187.3349	-52.2949	163.8839
2024	111.5928	111.5928	111.59278	346.7961	399.0295	23.36953	187.1957	-52.2334	163.8262
2025	111.556	111.556	111.556	346.9551	399.0675	23.31025	186.9786	-52.1124	163.6684

Surface shortwave Flux Down - All-Sky: sfc_sw_down_all_mon

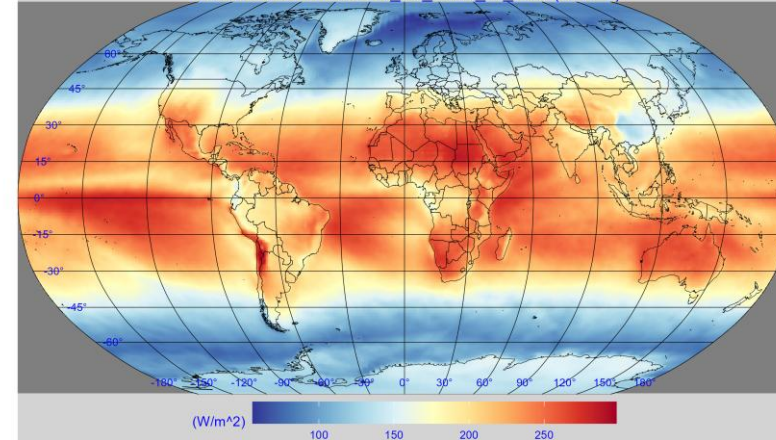
Area-Weighted Global Mean: sfc_sw_down_all_mon



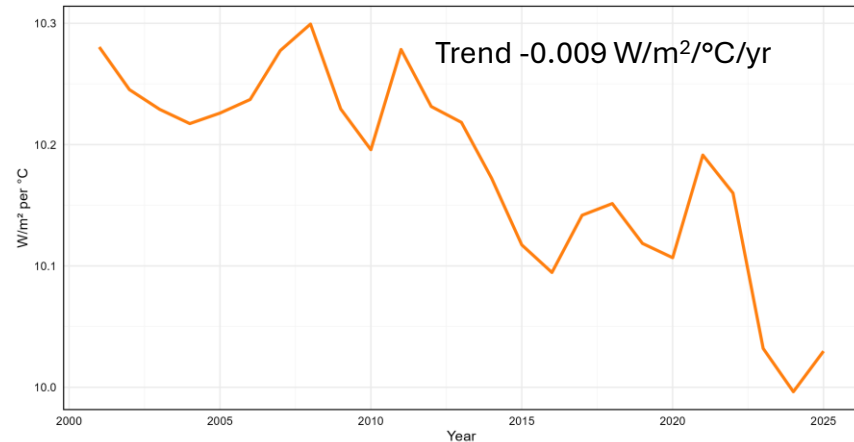
Anomaly Sensitivity $d(\text{sfc_sw_down_all_mon})/d(\text{SST})$ by Year



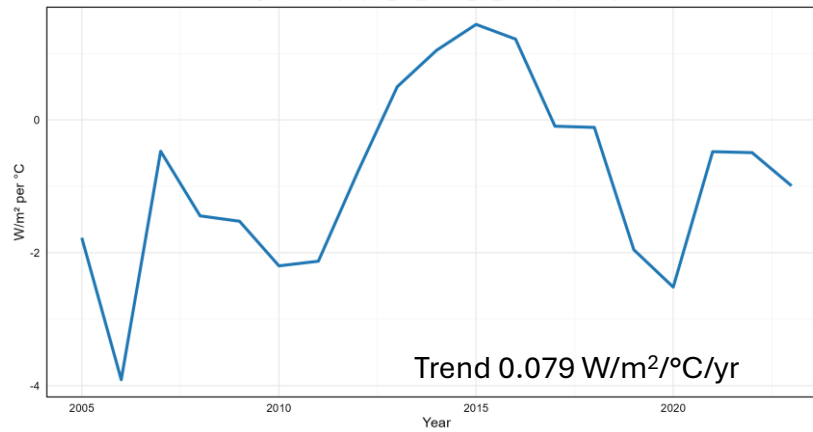
2025 Area Wtd Mean: sfc_sw_down_all_mon (W/m^2)



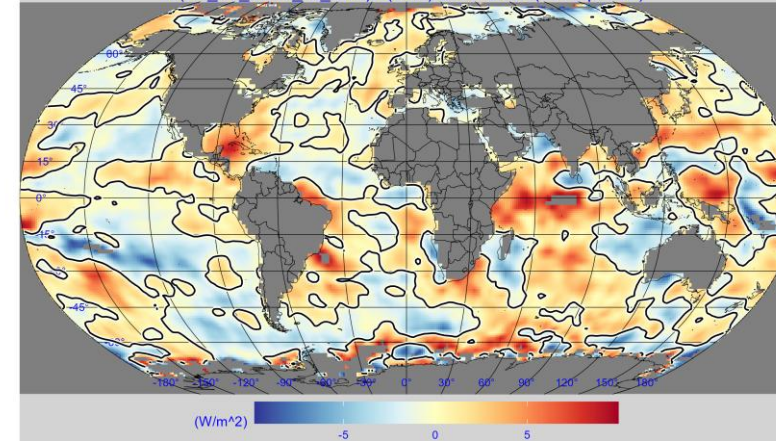
Absolute Ratio $\text{sfc_sw_down_all_mon} / \text{SSI}$ by year



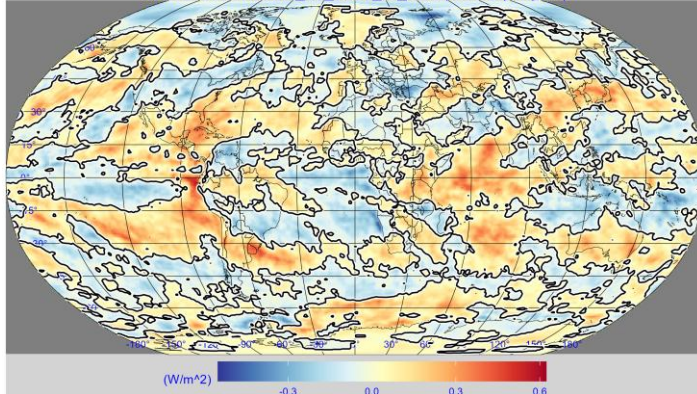
Rolling Sensitivity $d(\text{sfc_sw_down_all_mon})/d(\text{SST})$ by Year



$d(\text{sfc_sw_down_all_mon})/d(\text{SST})$ 2001-2025 (W/m^2 per $^\circ\text{C}$)

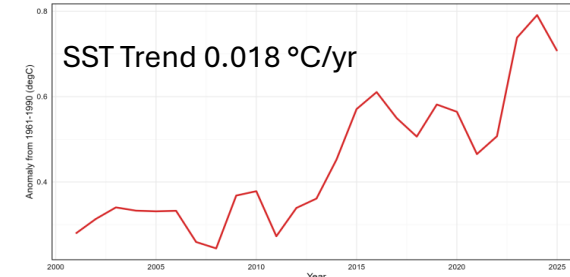


2001-2025 Trend: sfc_sw_down_all_mon (W/m^2 per year)

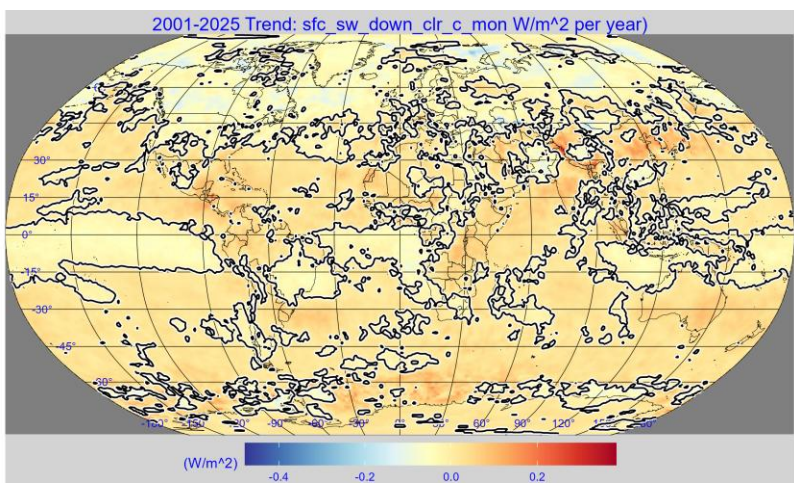
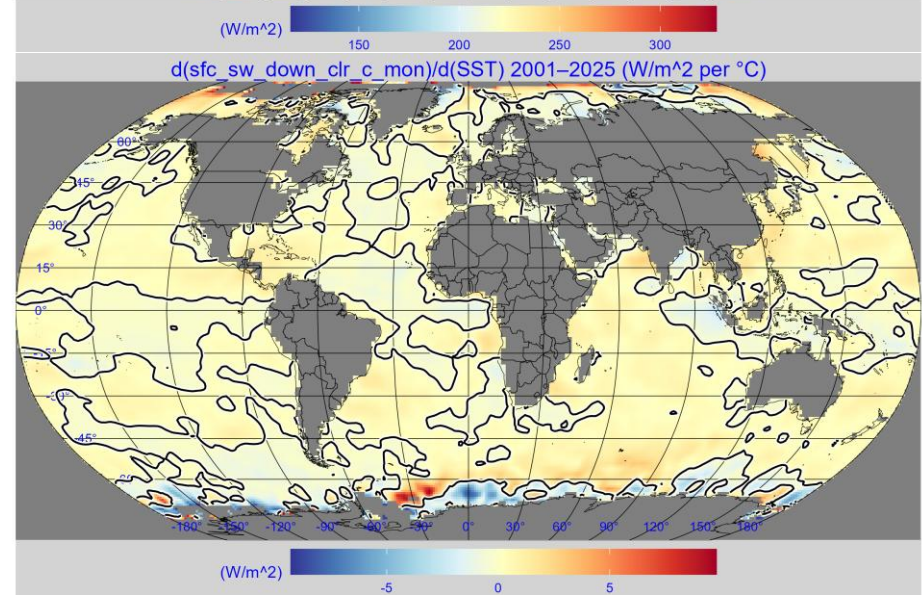
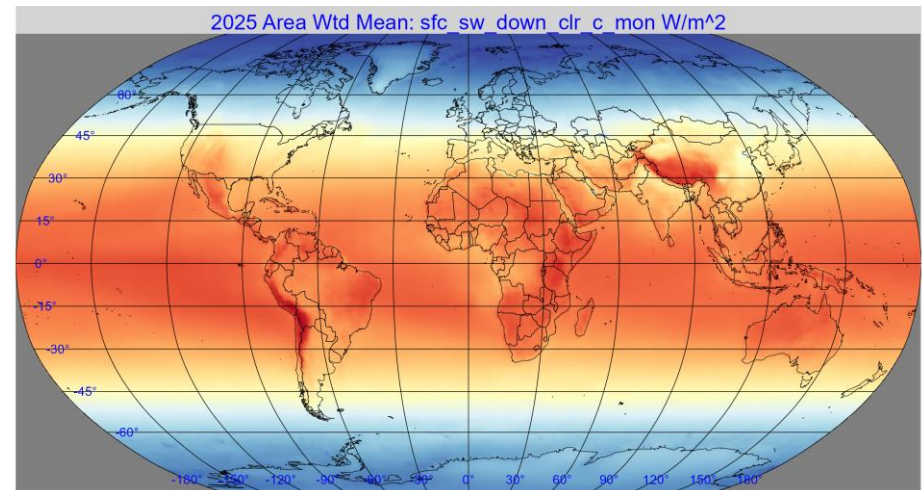
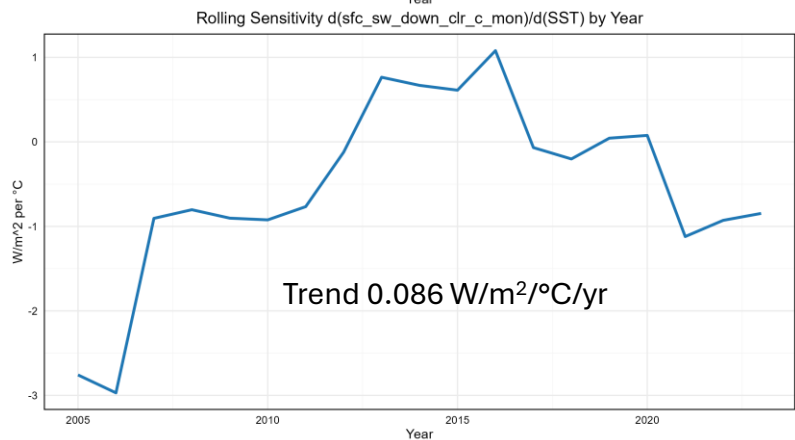
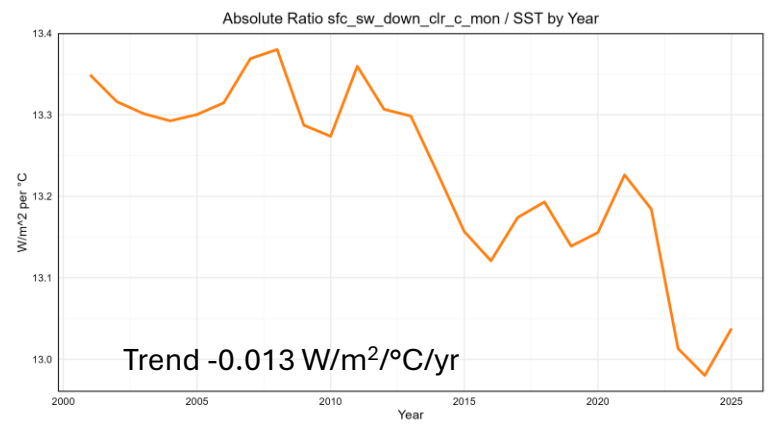
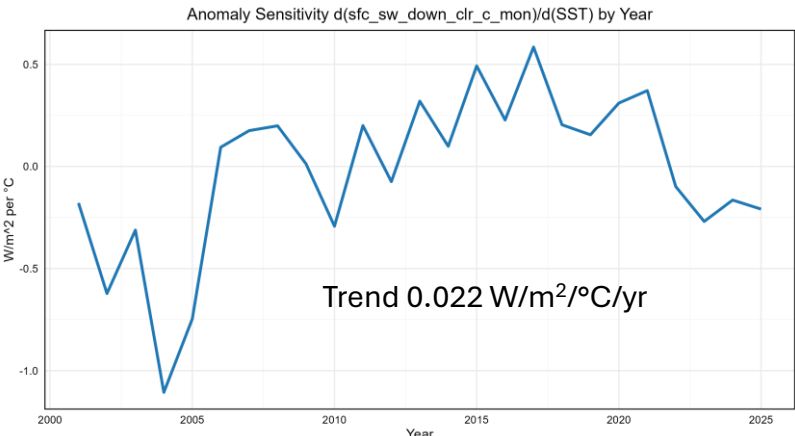
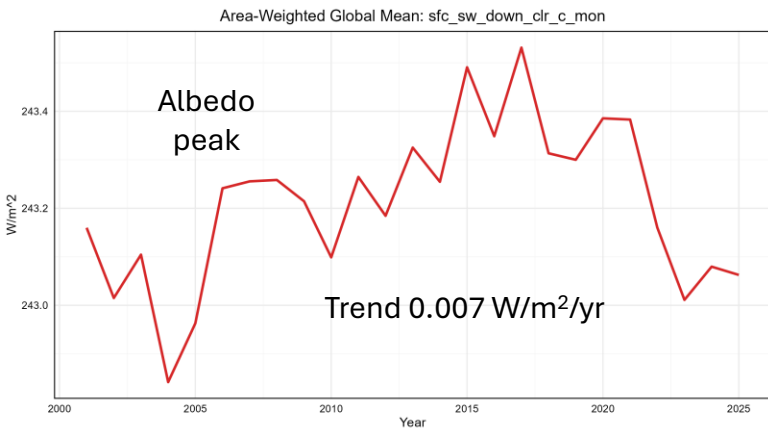


The global slope for this variable is $0.538 \text{ W/m}^2/^\circ\text{C}$. Negative albedo anomaly as expected, less SW down and absorbed at the surface.

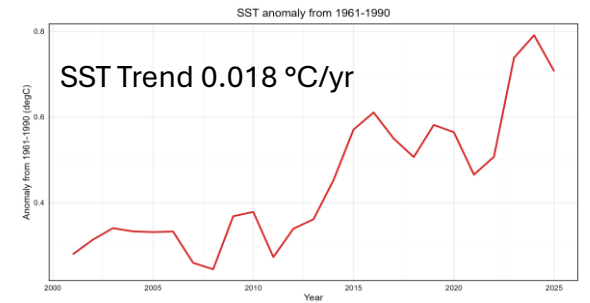
SST anomaly from 1961-1990



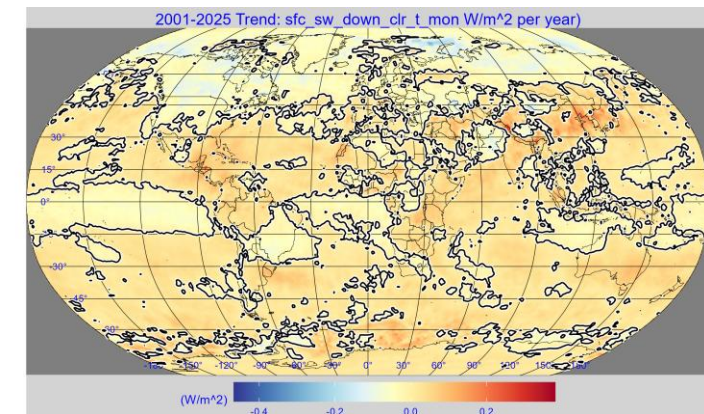
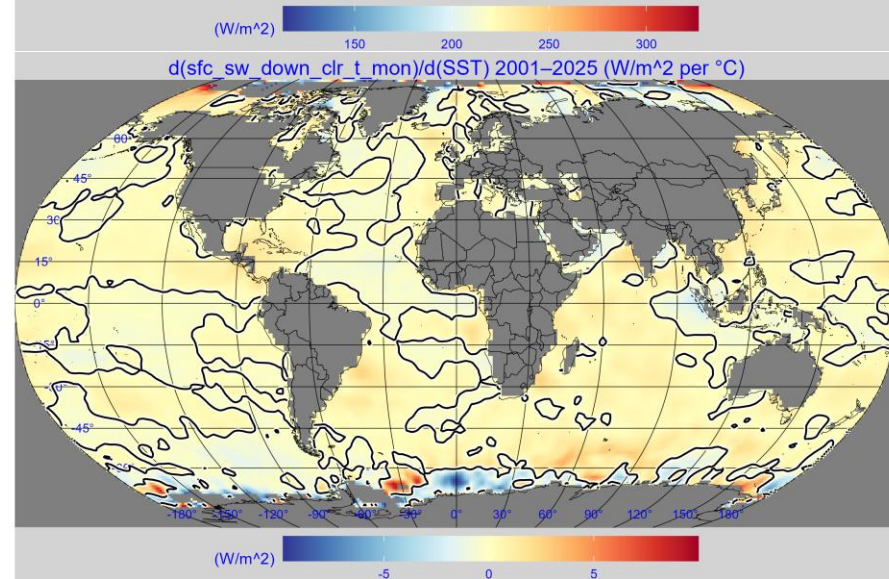
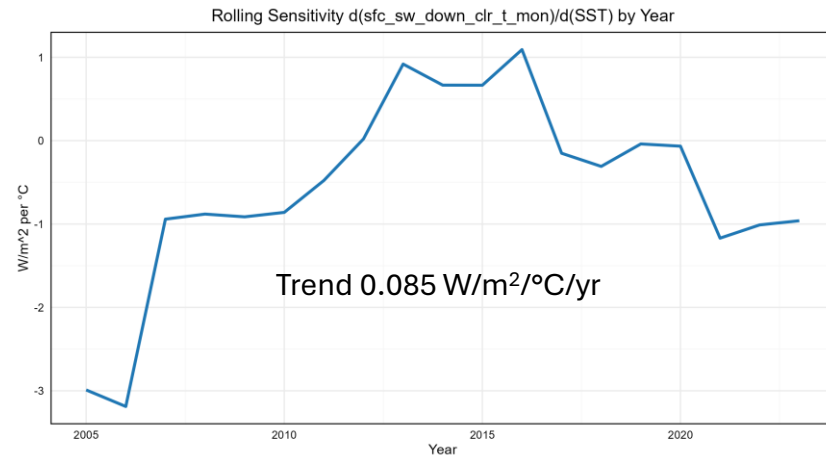
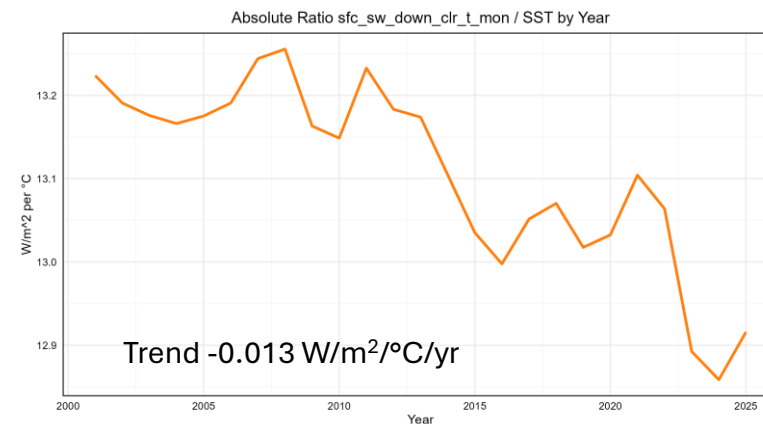
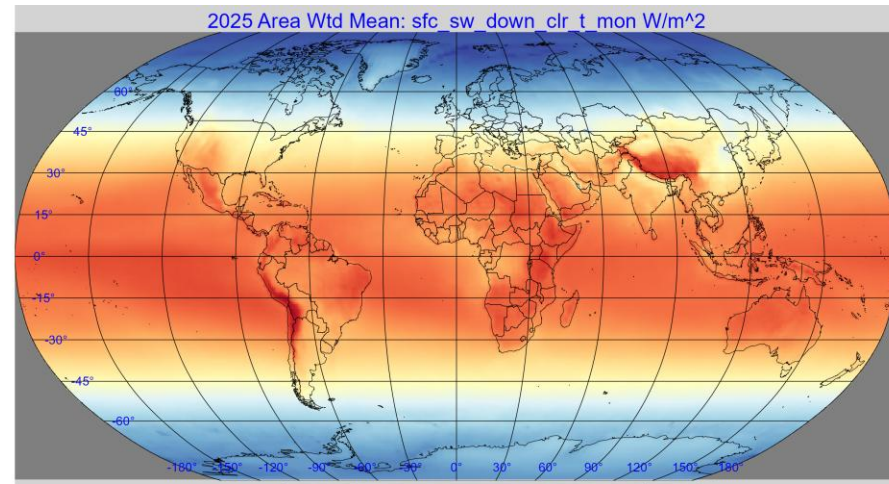
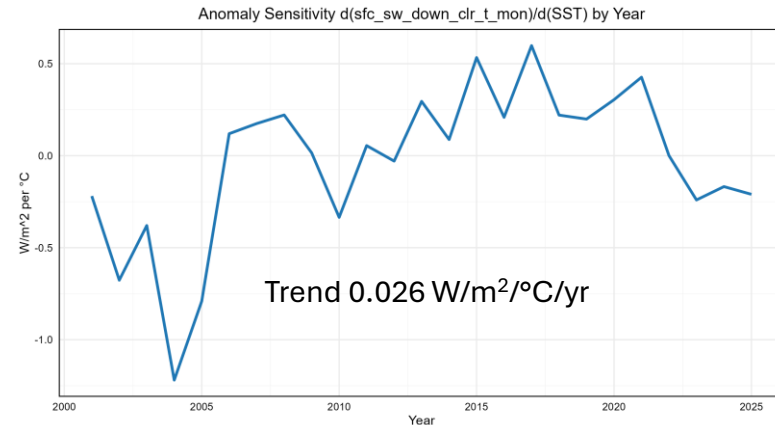
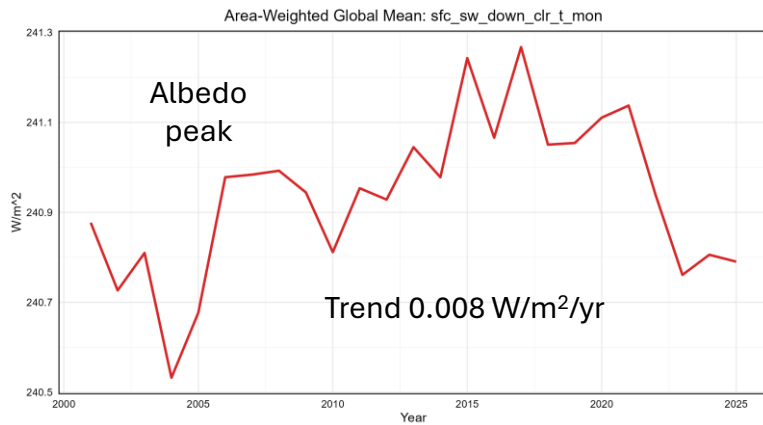
Surface shortwave Flux Down – Clear skies: sfc_sw_down_clr_c



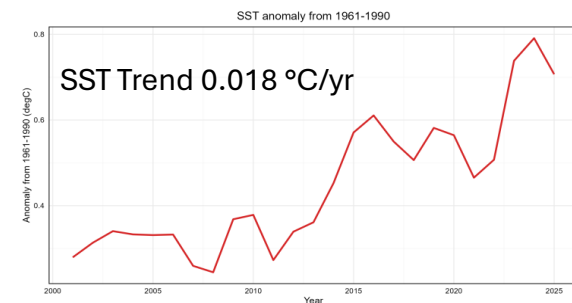
The global slope for this variable is -0.124 **W/m²/°C**. Albedo peak is down and short, even under clear skies.



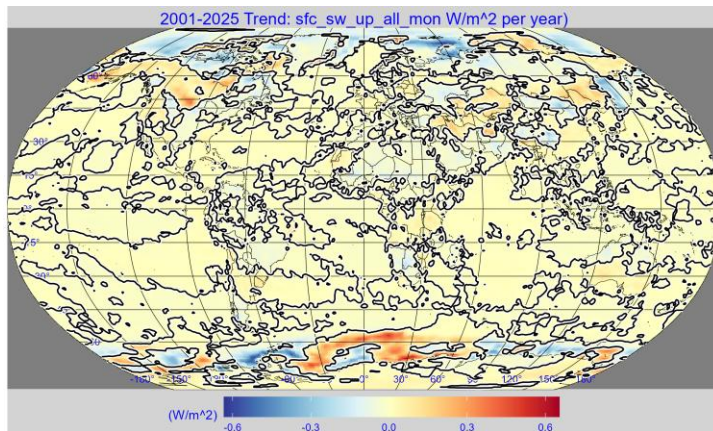
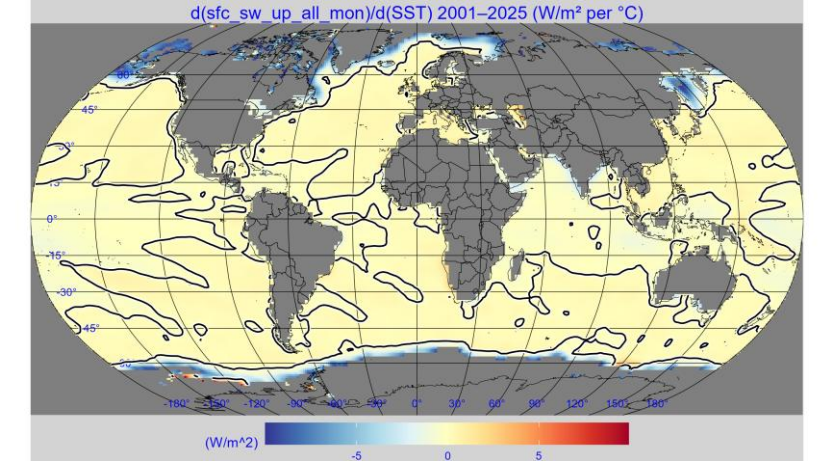
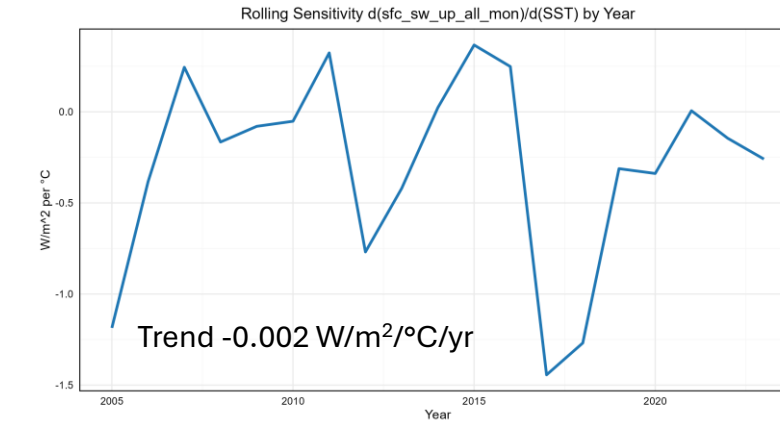
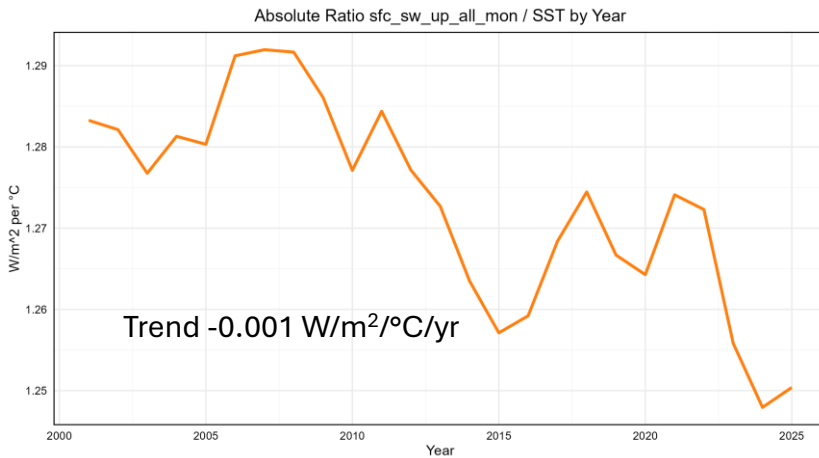
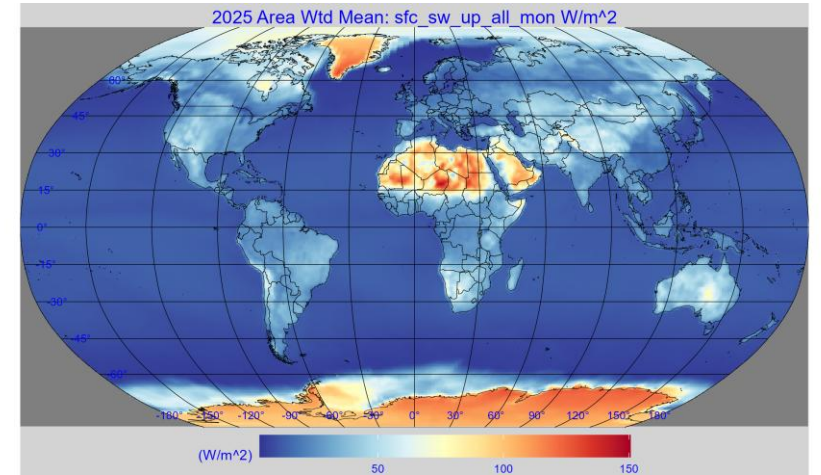
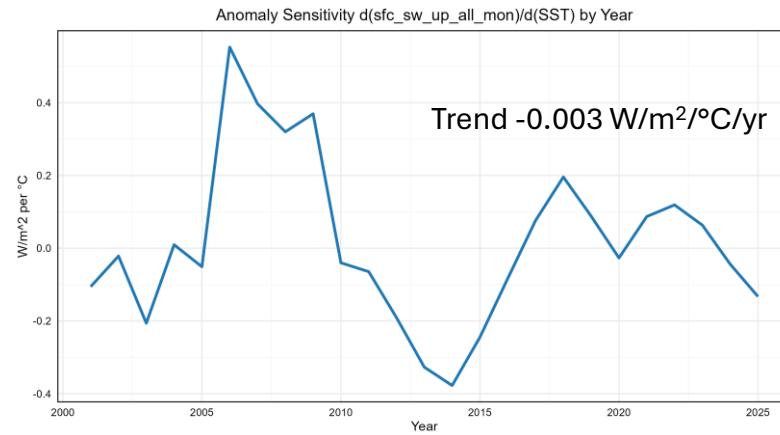
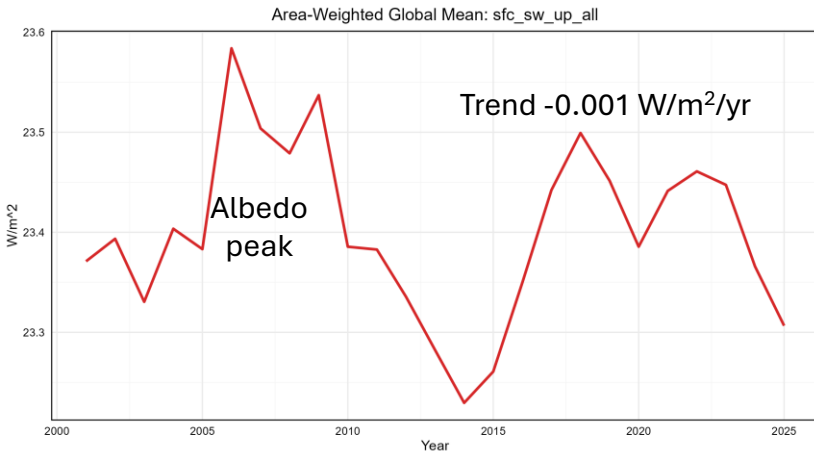
Surface shortwave Flux Down – Clear skies - all cell: sfc_sw_down_clr_t



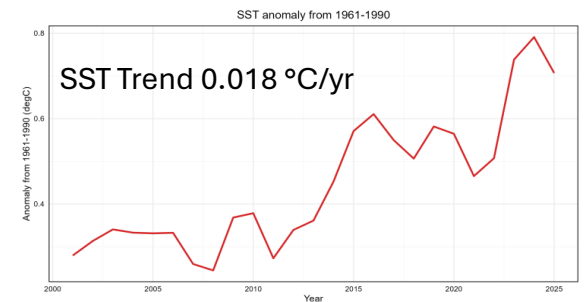
The global slope for this variable is -0.177 W/m²/°C. Negative albedo peak as expected.



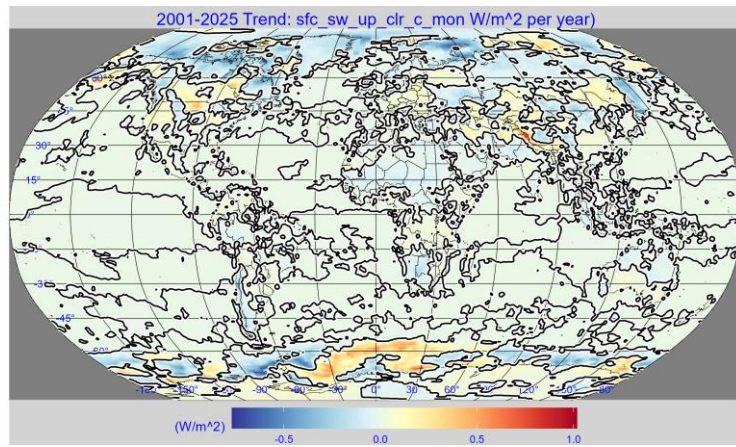
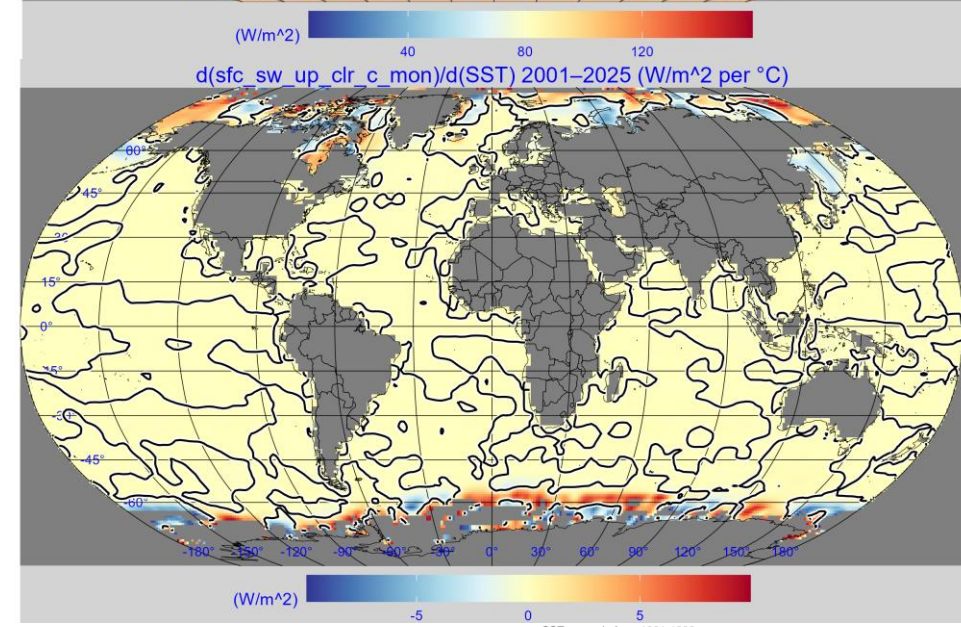
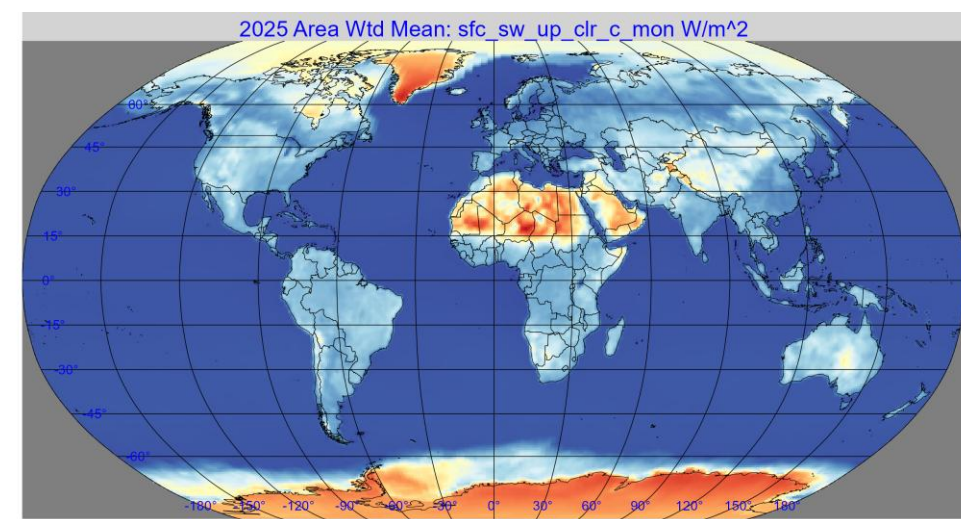
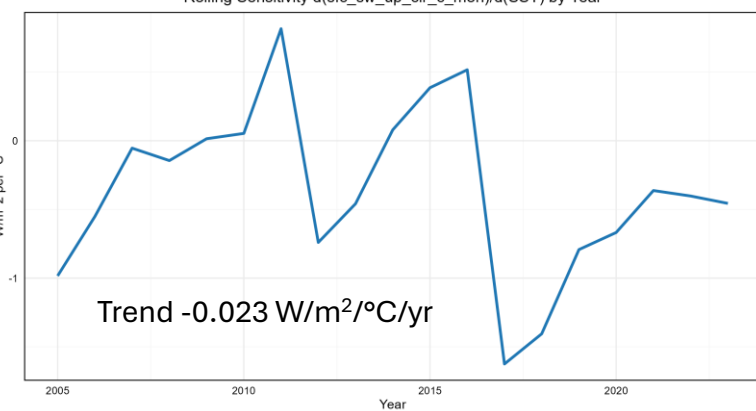
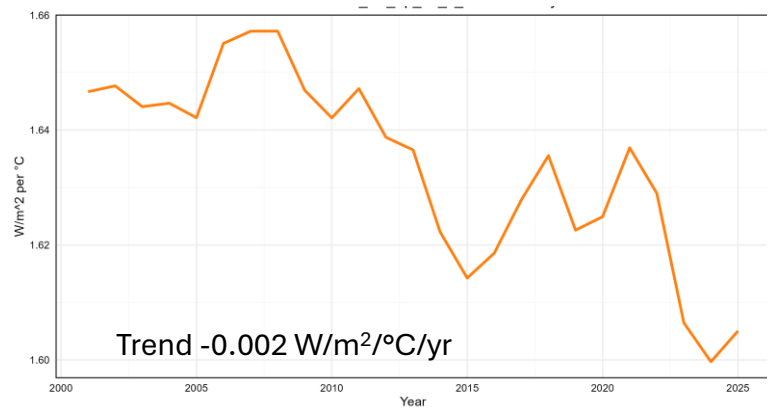
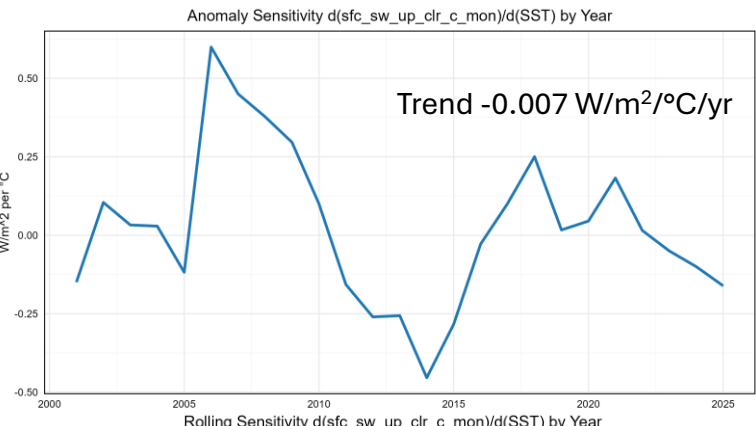
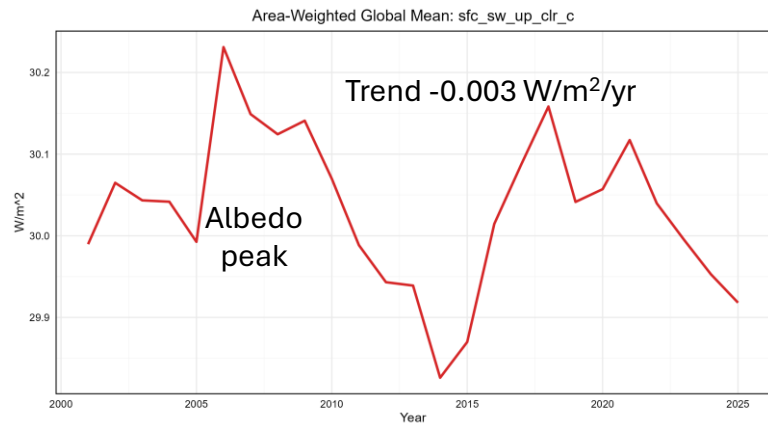
Surface shortwave Flux Up - All-Sky: sfc_sw_up_all_mon



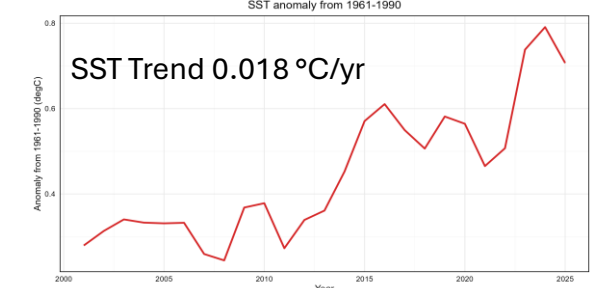
The global slope for this variable is $-0.101 \text{ W/m}^2/^\circ\text{C}$. This is surface SW reflected up in all skies and the albedo peak is dramatic. The albedo peak may not be due to clouds, but a surface event. Extreme trends, both positive and negative occur in the higher latitudes.



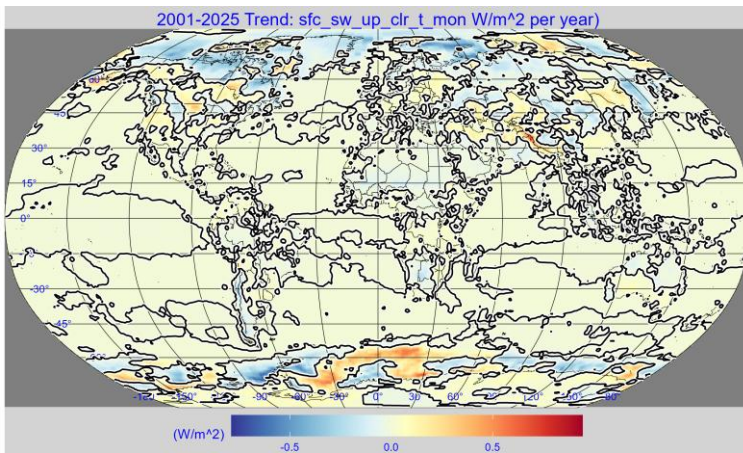
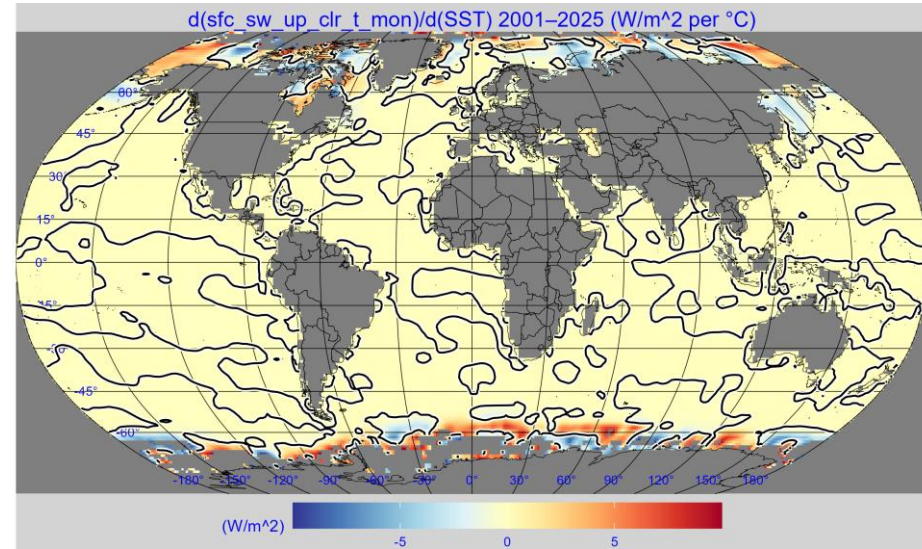
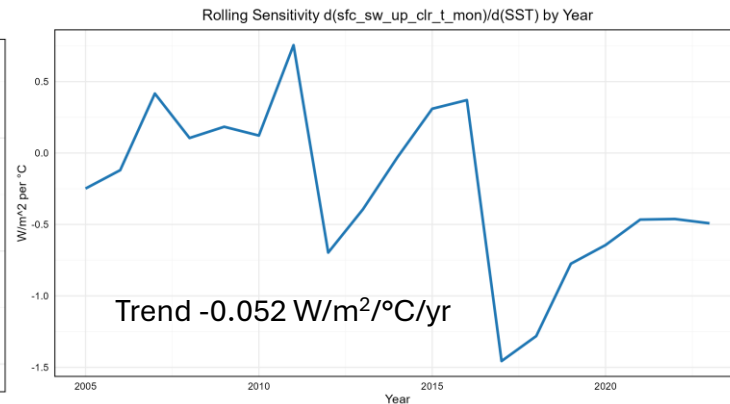
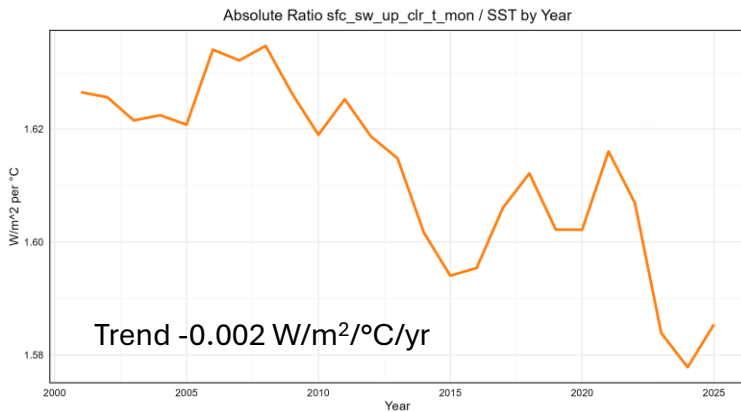
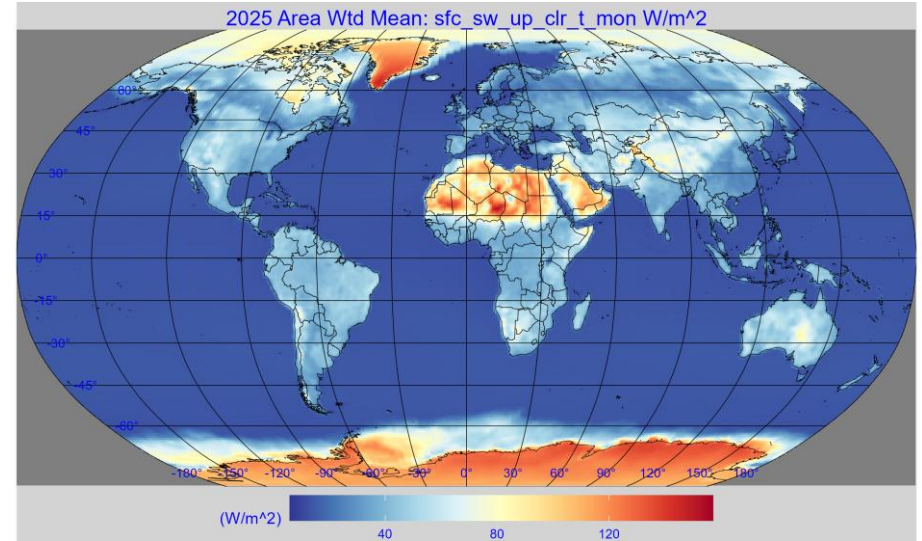
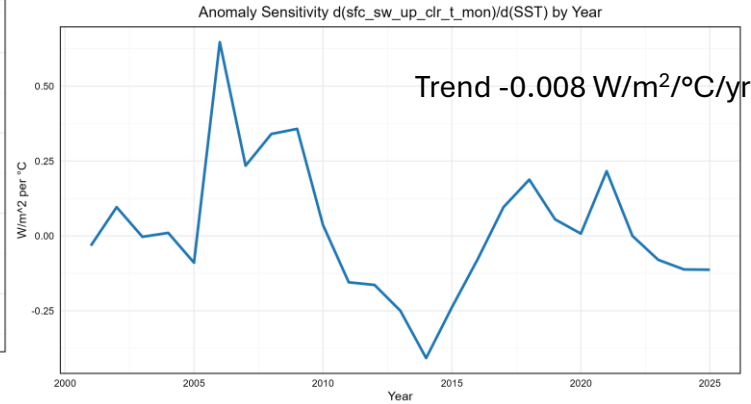
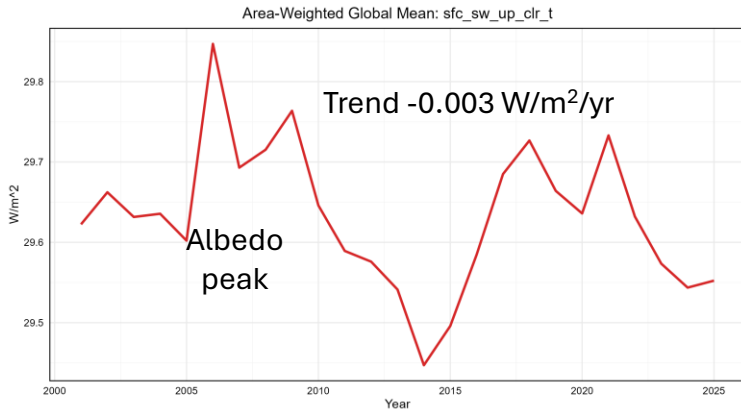
Surface shortwave Flux Up – clear skies: sfc_sw_up_clr_c



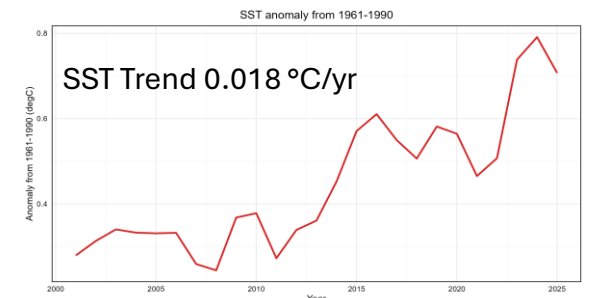
The global slope for this variable is $-0.196 \text{ W/m}^2/^\circ\text{C}$. SW reflected upward from the surface under clear skies. Strong albedo peak with no clouds.



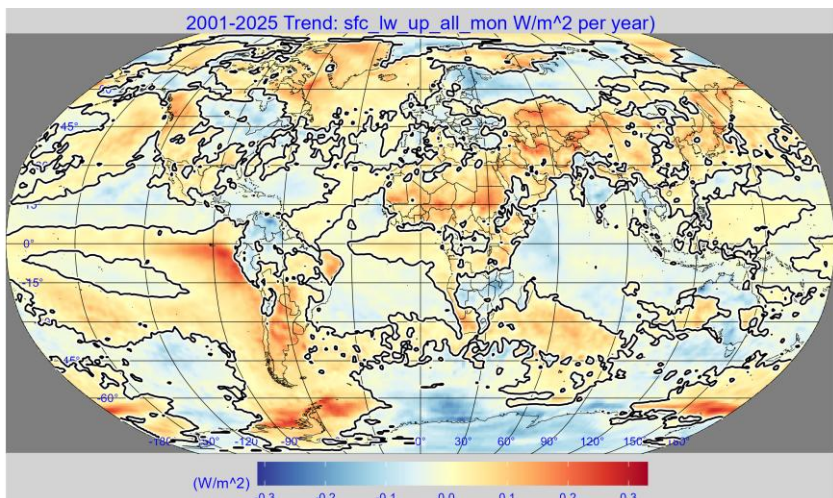
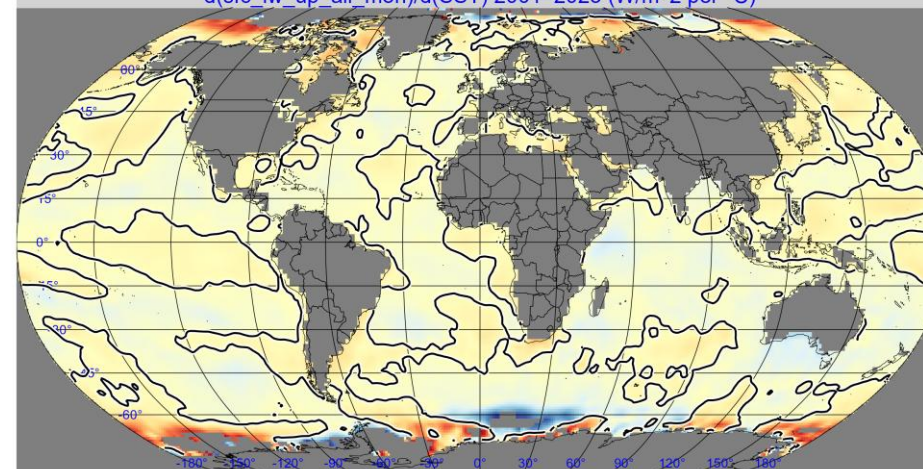
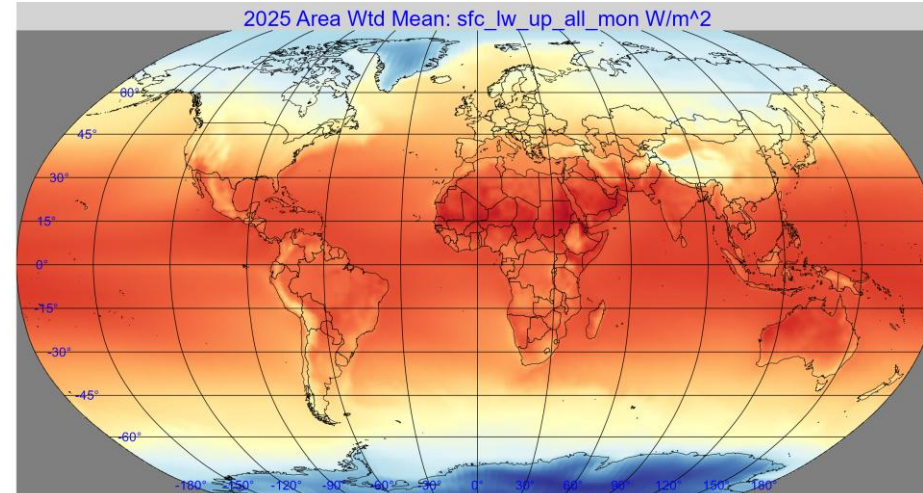
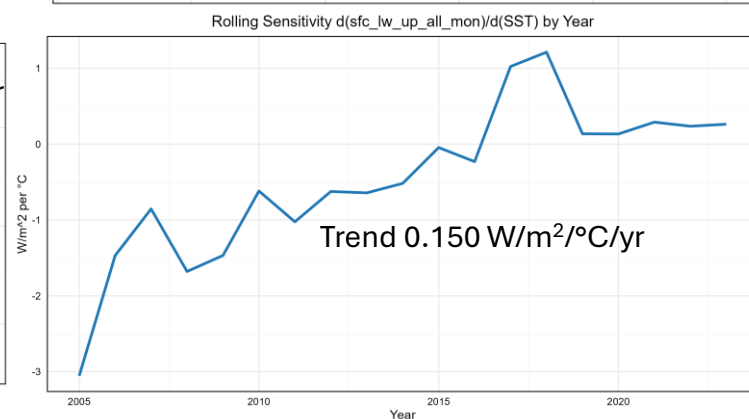
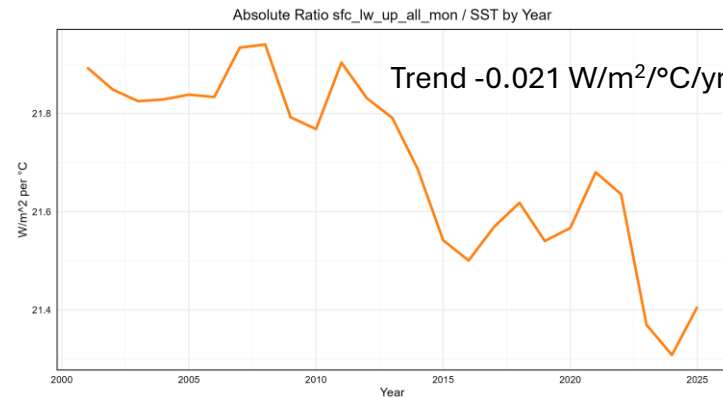
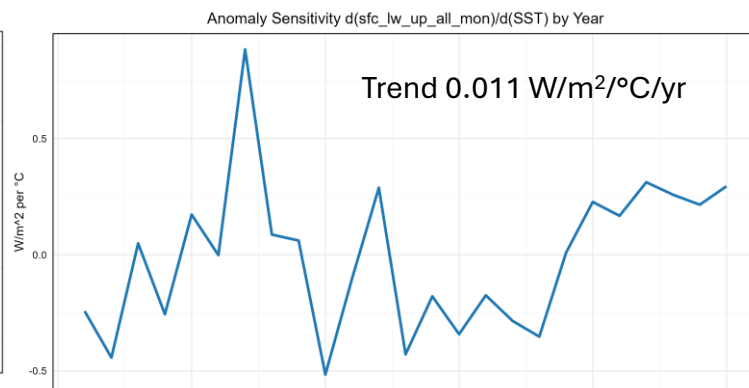
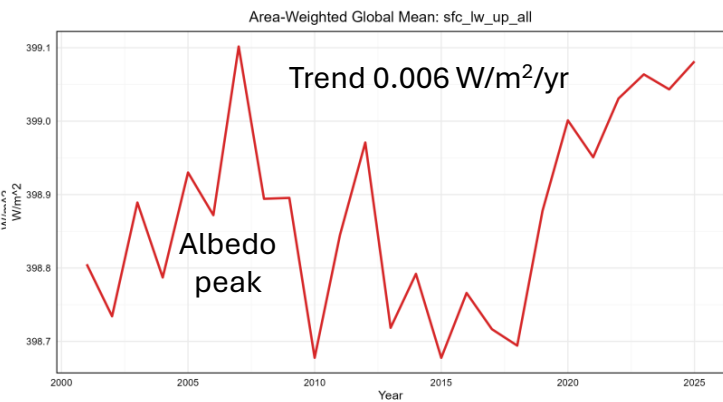
Surface shortwave Flux Up – clear skies: sfc_sw_up_clr_t



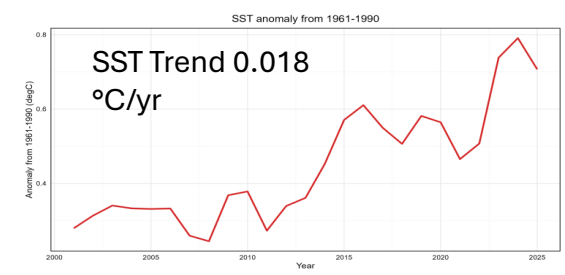
The global slope for this variable is **-0.199 W/m²/°C**. Strong albedo peak with no clouds. Strongest trends are in the higher latitudes.



Surface upwelling longwave radiation (all-sky): sfc_lw_up_all_mon

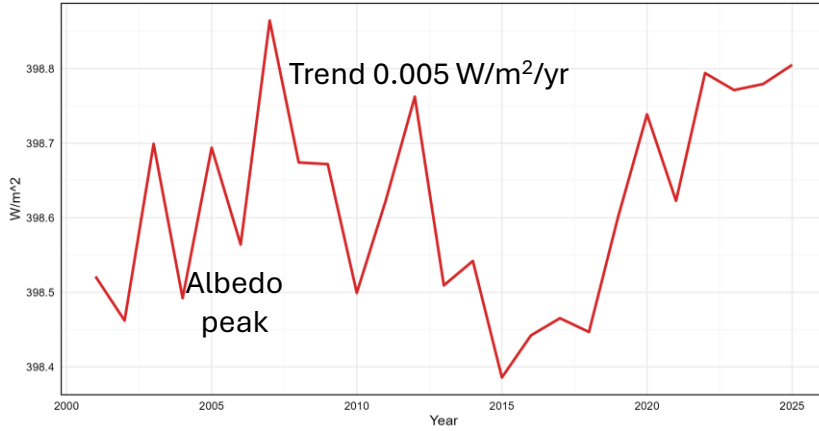


The global slope for this variable is 0.218 W/m²/°C. Strong albedo peak even in lw? LW increases as a function of warming SSTs as expected.

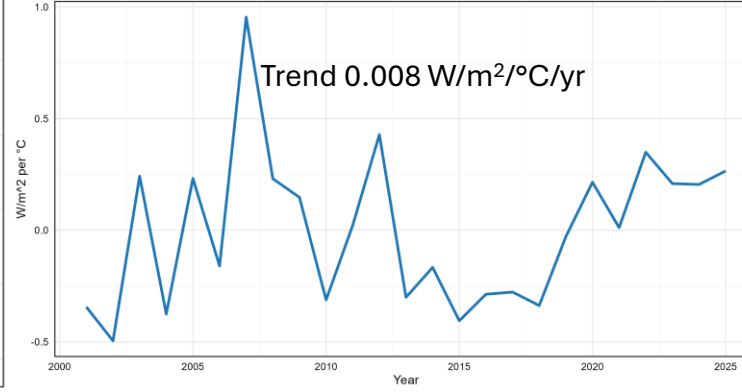


Surface upwelling longwave radiation (clear-sky): sfc_lw_up_clr_c

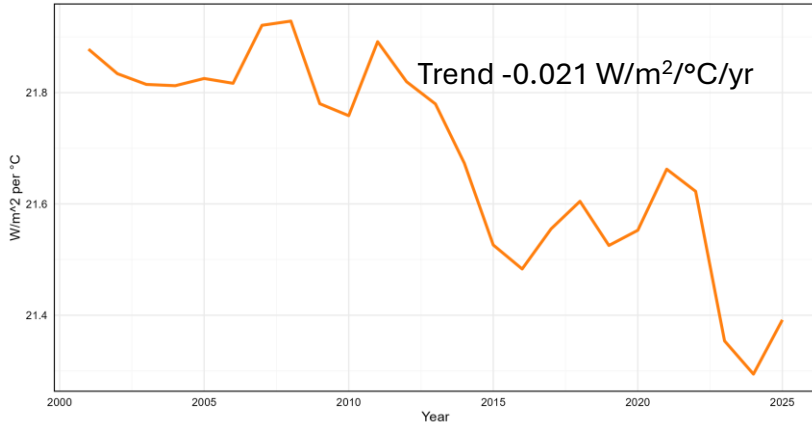
Area-Weighted Global Mean: sfc_lw_up_clr_c_mon



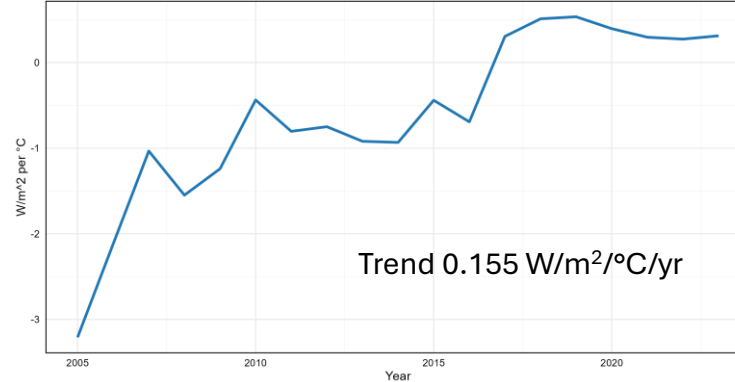
Anomaly Sensitivity $d(\text{sfc_lw_up_clr_c_mon})/d(\text{SST})$ by Year



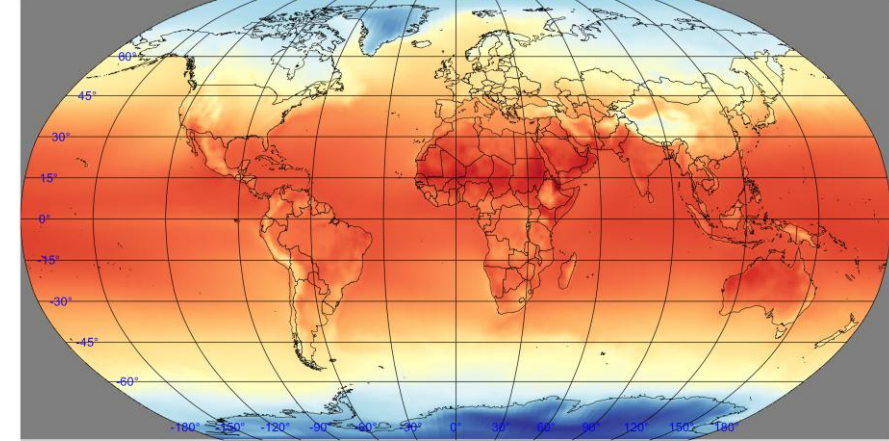
Absolute Ratio sfc_lw_up_clr_c_mon / SST by Year



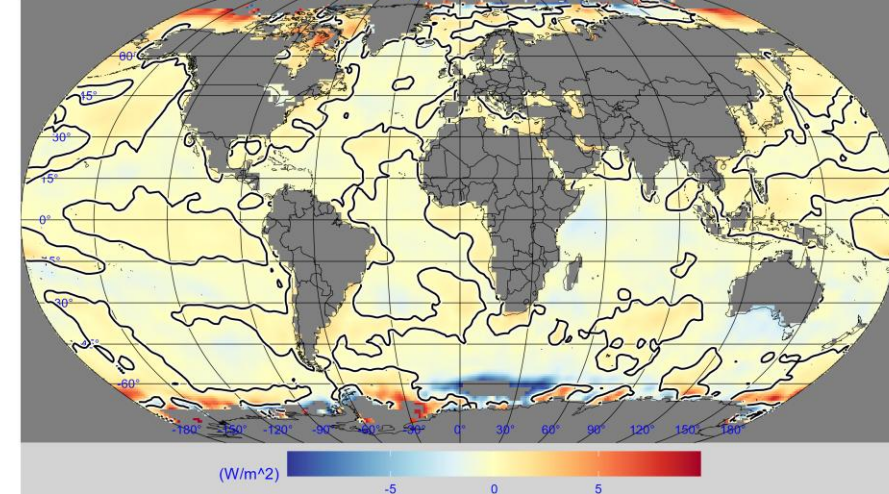
Rolling Sensitivity $d(\text{sfc_lw_up_clr_c_mon})/d(\text{SST})$ by Year



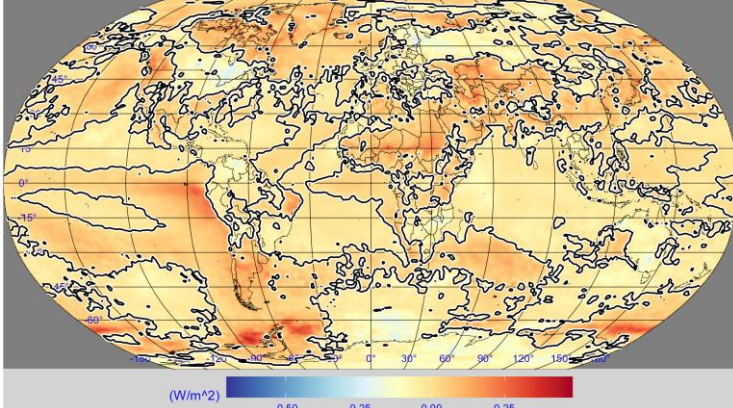
2025 Area Wtd Mean: sfc_lw_up_clr_c_mon W/m^2



$d(\text{sfc_lw_up_clr_c_mon})/d(\text{SST})$ 2001-2025 (W/m^2 per °C)

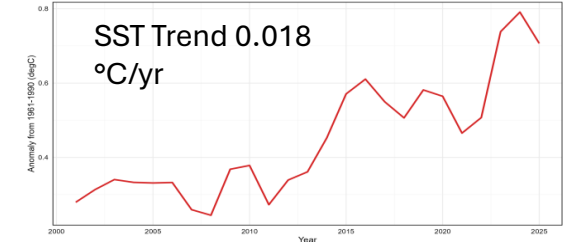


2001-2025 Trend: sfc_lw_up_clr_c_mon W/m^2 per year



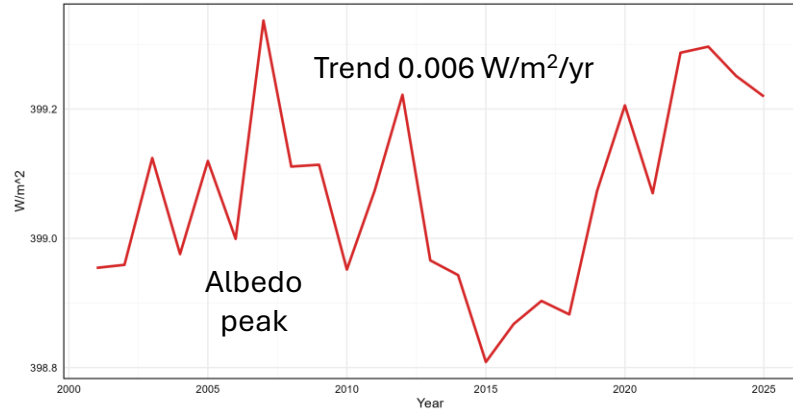
The global slope for this variable is **0.112 W/m²/°C**. Under clear skies we still see a peak in the albedo years. LW emissions increase as SST goes up as expected.

SST anomaly from 1961-1990

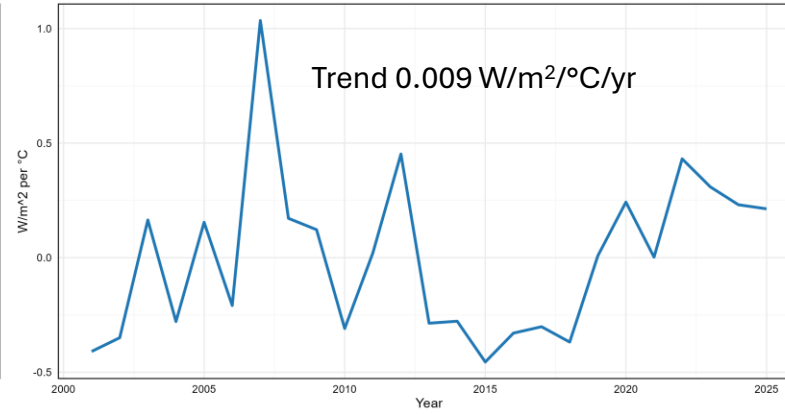


Surface upwelling longwave radiation (clear-sky): sfc_lw_up_clr_t

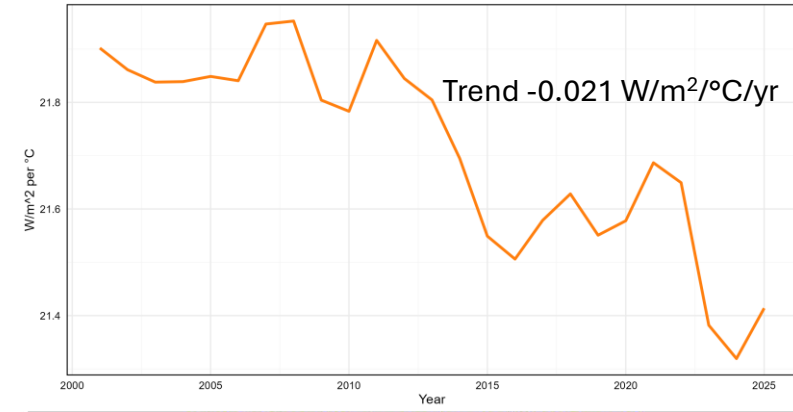
Area-Weighted Global Mean: sfc_lw_up_clr_t_mon



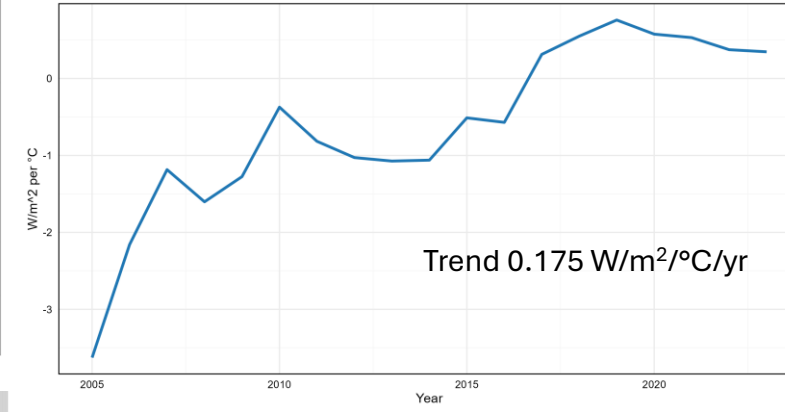
Anomaly Sensitivity d(sfc_lw_up_clr_t_mon)/d(SST) by Year



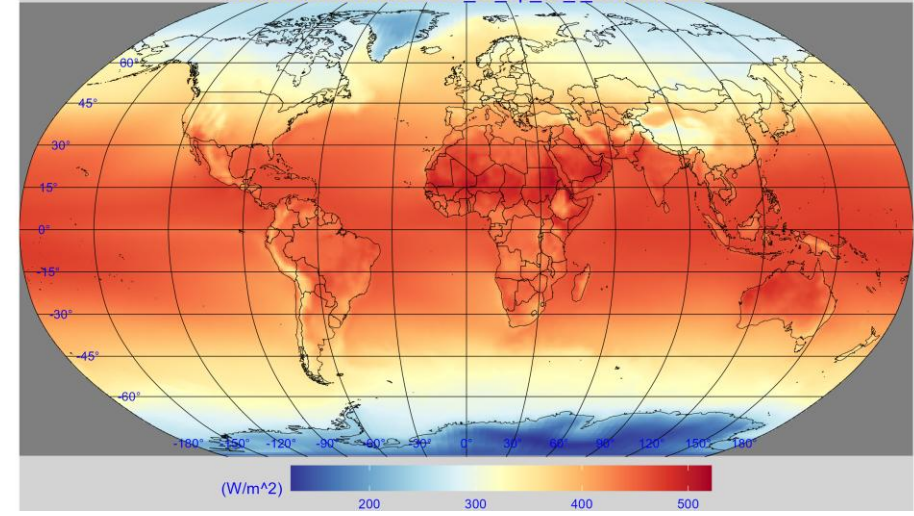
Absolute Ratio sfc_lw_up_clr_t_mon / SST by Year



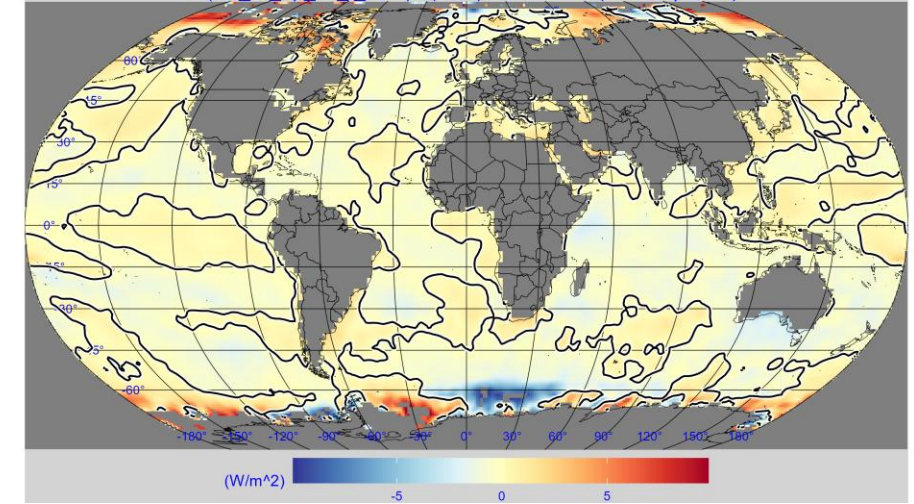
Rolling Sensitivity d(sfc_lw_up_clr_t_mon)/d(SST) by Year



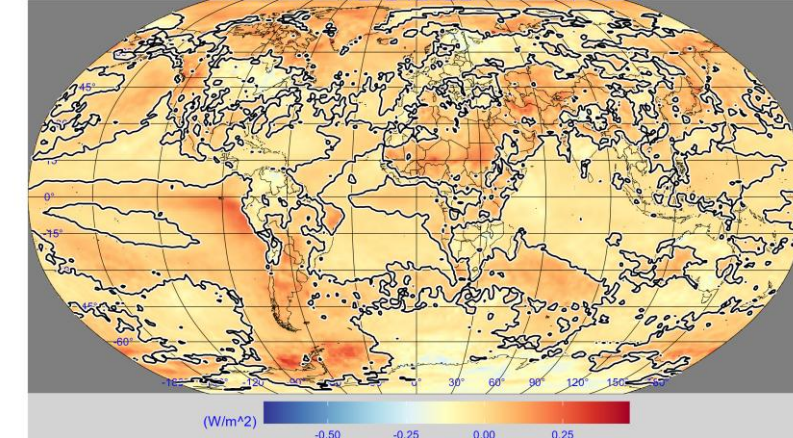
2025 Area Wtd Mean: sfc_lw_up_clr_t_mon W/m^2



d(sfc_lw_up_clr_t_mon)/d(SST) 2001-2025 (W/m^2 per °C)

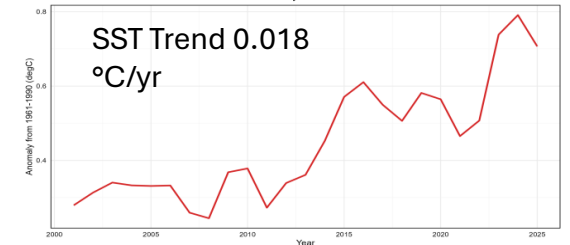


2001-2025 Trend: sfc_lw_up_clr_t_mon W/m^2 per year

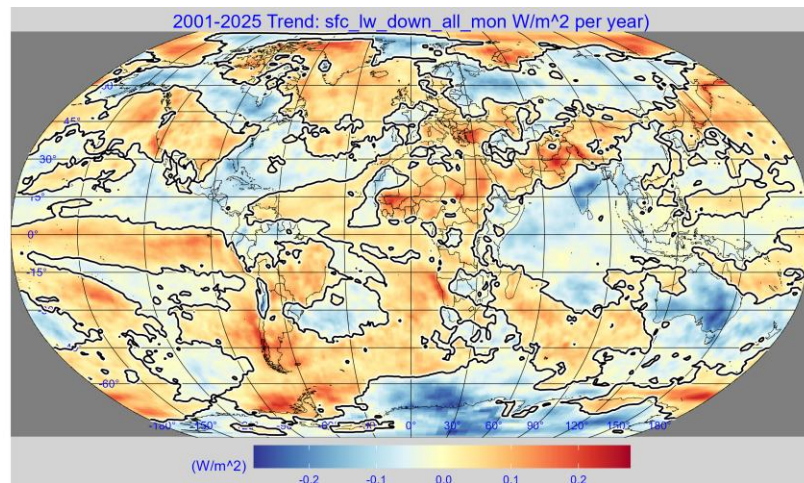
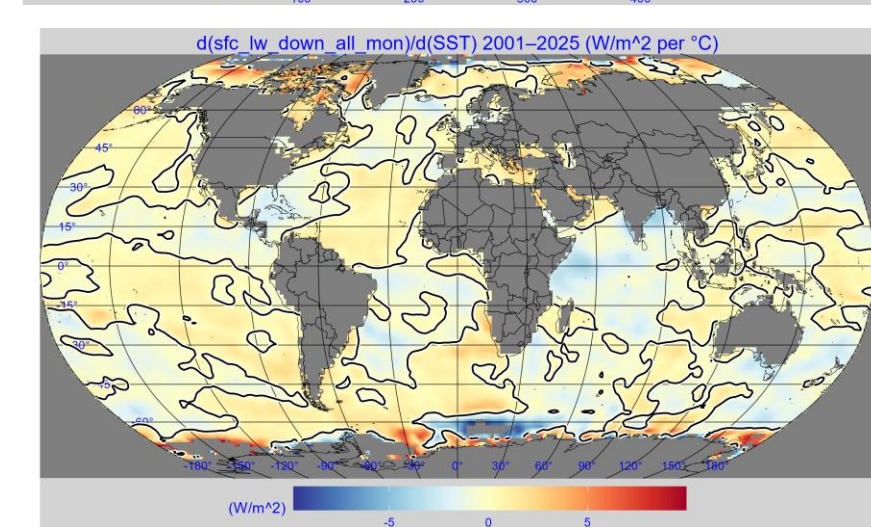
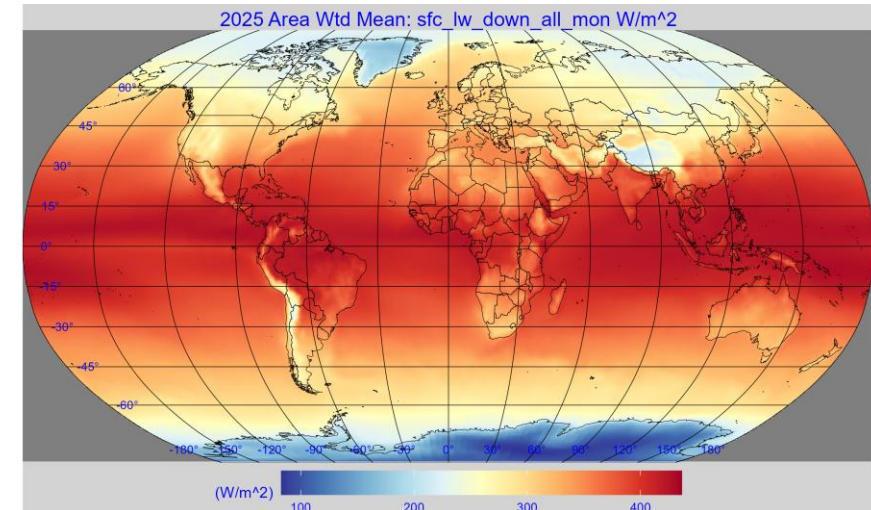
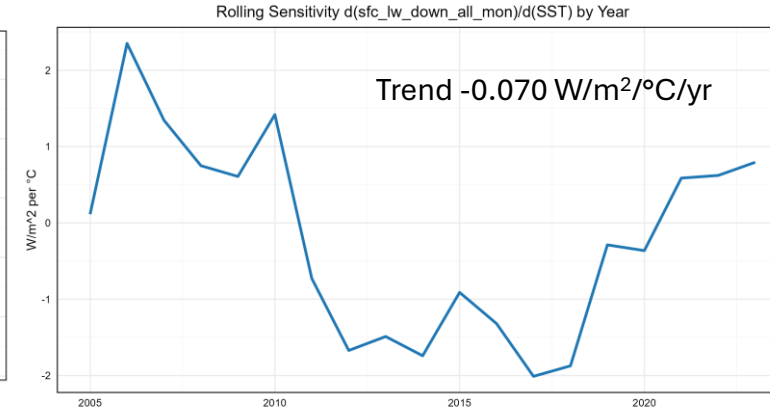
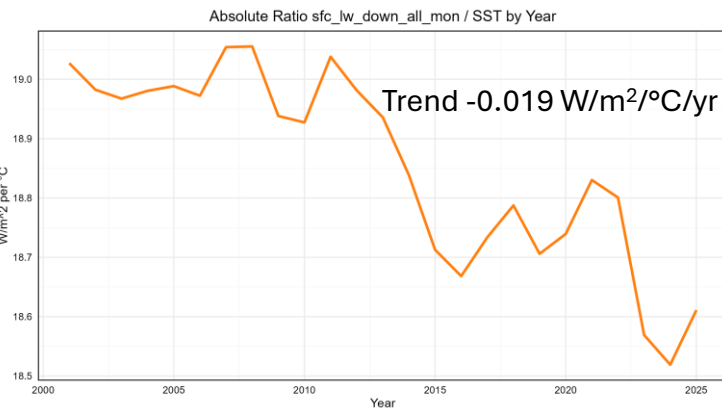
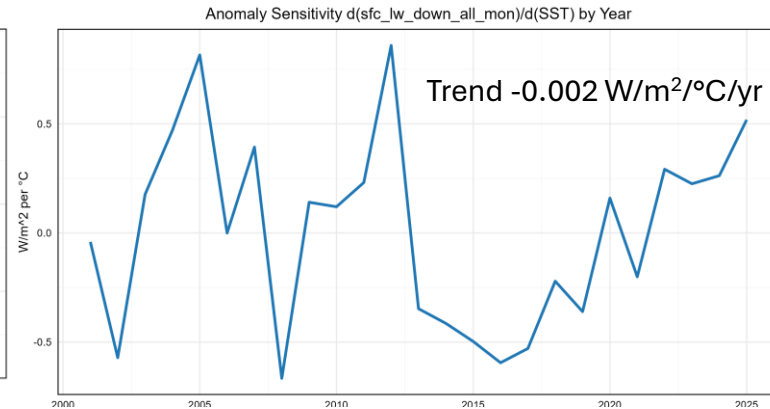
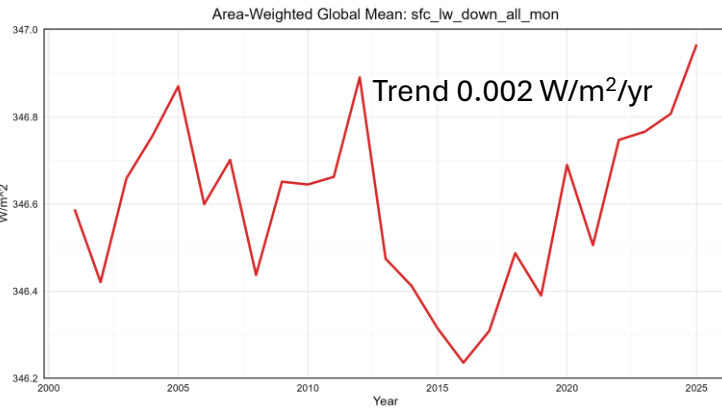


The global slope for this variable is 0.137 W/m²/°C. LW increasing as SSTs go up.

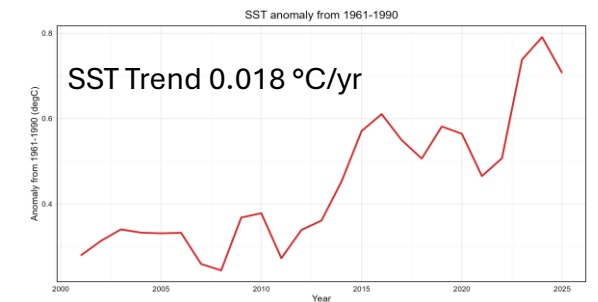
SST anomaly from 1961-1990



Surface Longwave Flux Down - All-Sky: sfc_lw_down_all_mon

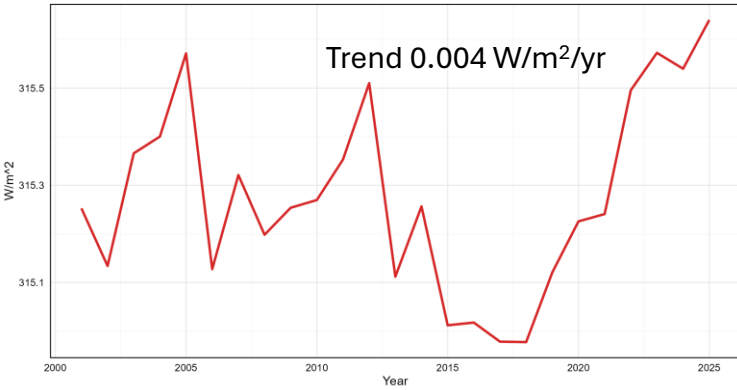


The global slope for this variable is **0.030 W/m²/°C**. All longwave down generally flat. LW down as a function of SST decreasing as cloud area decreases, makes sense.

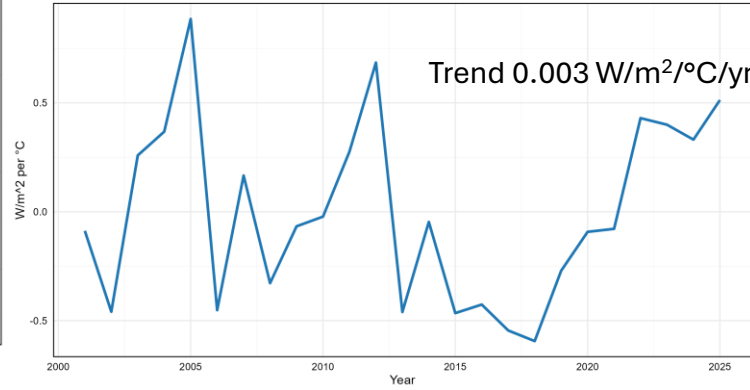


Surface Longwave Flux Down - Clear-Sky: sfc_lw_down_clr_c

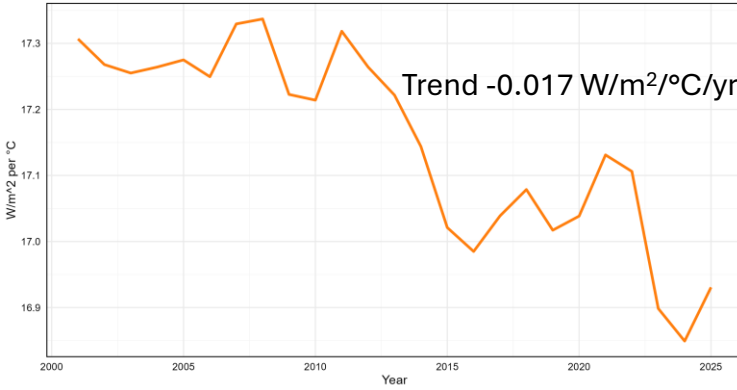
Area-Weighted Global Mean: sfc_lw_down_clr_c_mon



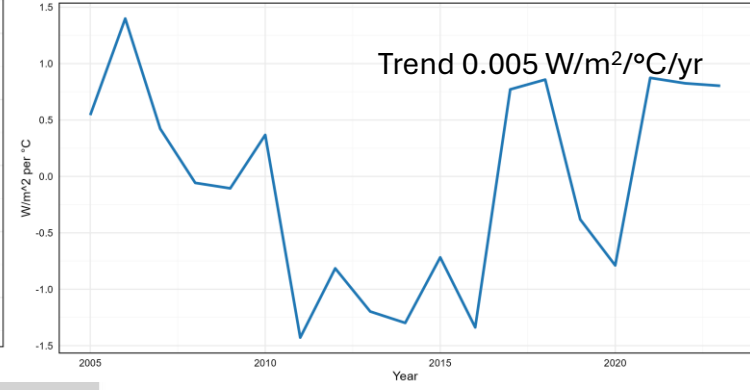
Anomaly Sensitivity d(sfc_lw_down_clr_c_mon)/d(SST) by Year



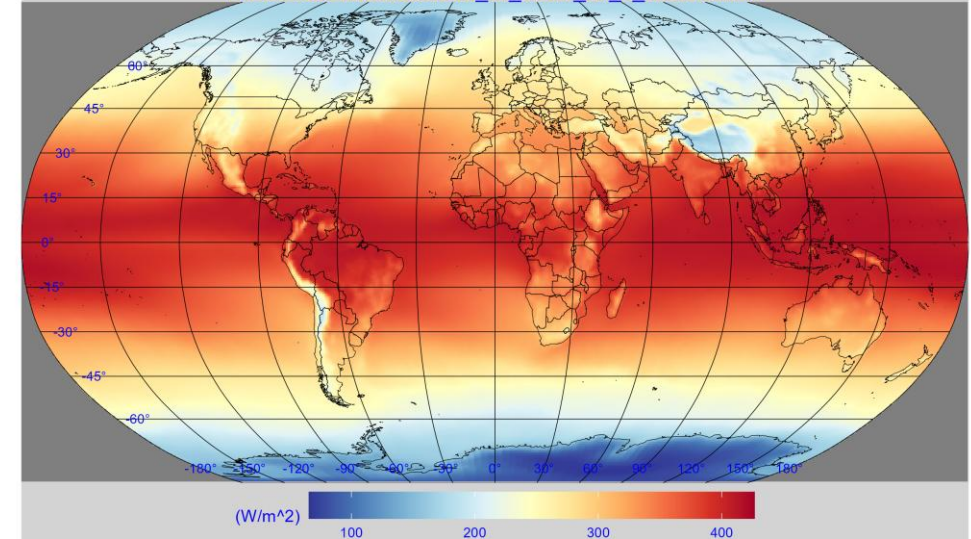
Absolute Ratio sfc_lw_down_clr_c_mon / SST by Year



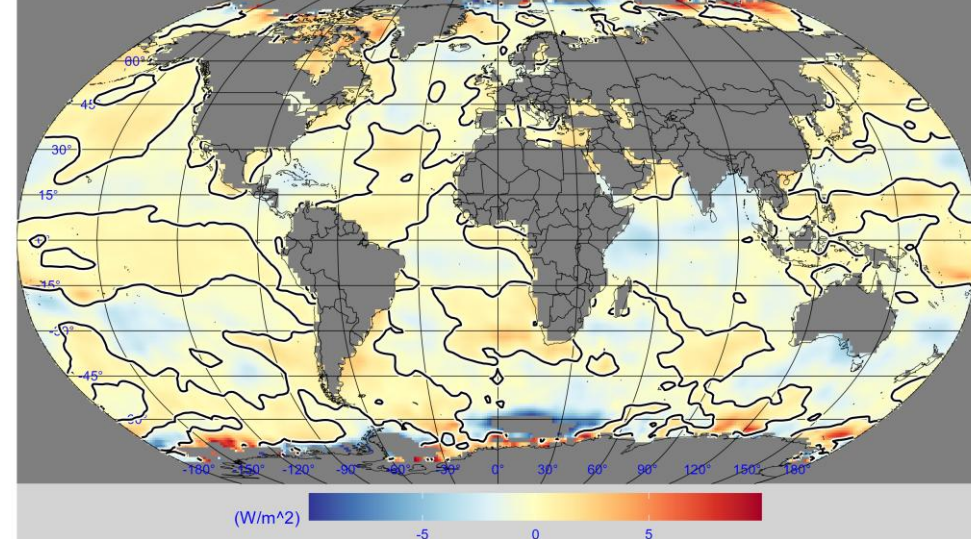
Rolling Sensitivity d(sfc_lw_down_clr_c_mon)/d(SST) by Year



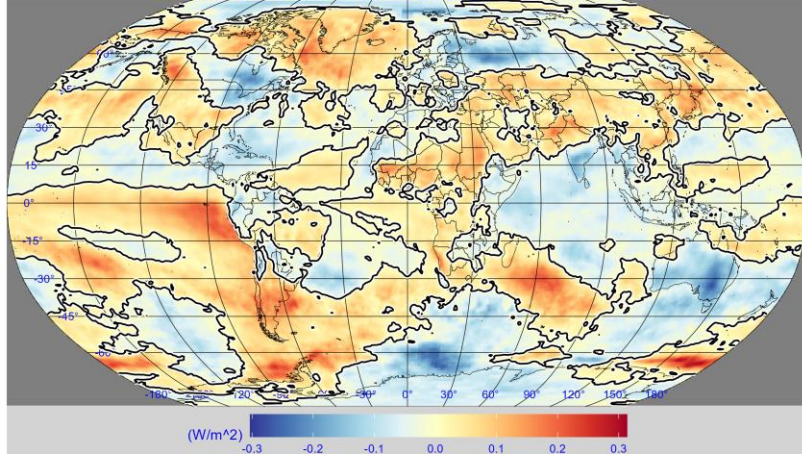
2025 Area Wtd Mean: sfc_lw_down_clr_c_mon W/m^2



d(sfc_lw_down_clr_c_mon)/d(SST) 2001-2025 (W/m^2 per °C)

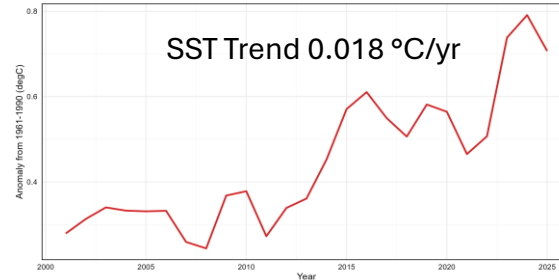


2001-2025 Trend: sfc_lw_down_clr_c_mon W/m^2 per year



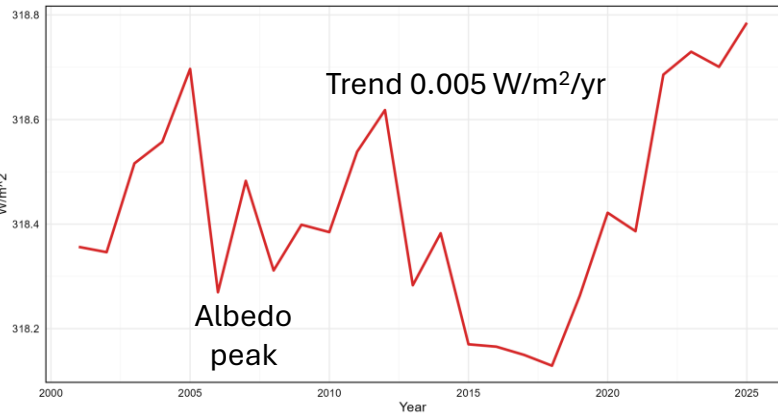
The global slope for this variable is **0.17 W/m²/°C**. Under clear skies, lw down is pretty flat.

SST anomaly from 1961-1990

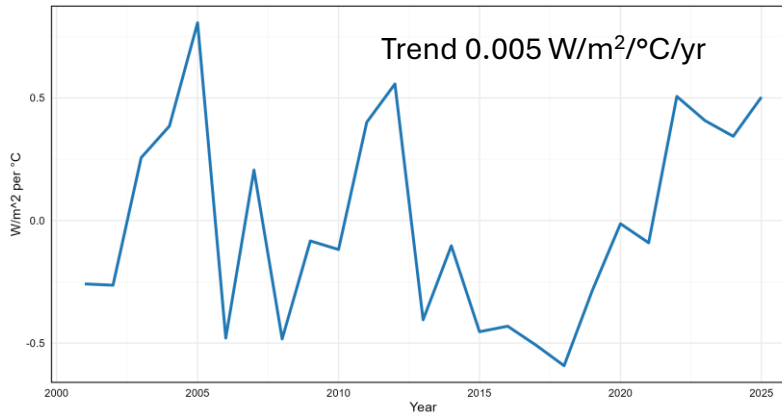


Surface Longwave Flux Down - Clear-Sky: sfc_lw_down_clr_t

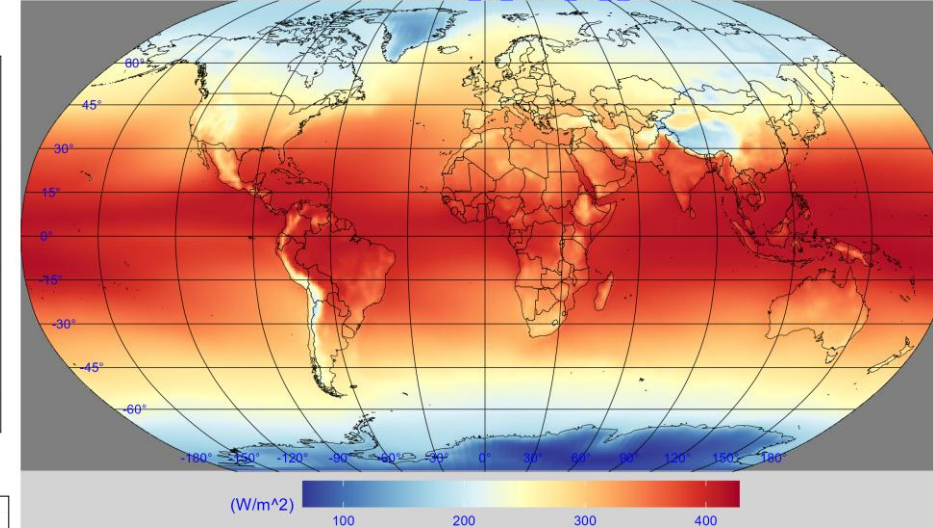
Area-Weighted Global Mean: sfc_lw_down_clr_t_mon



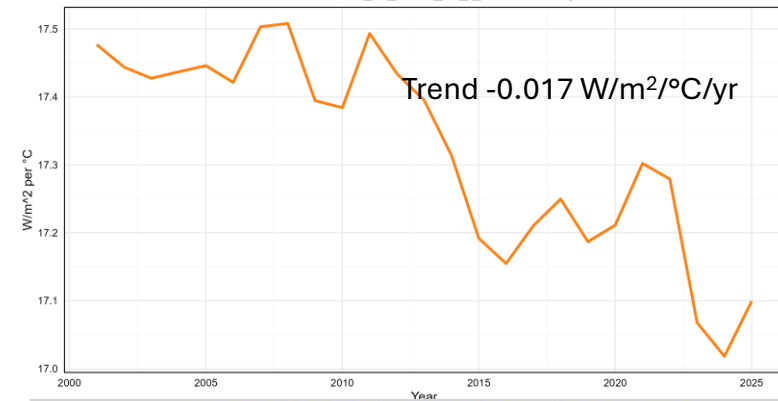
Anomaly Sensitivity d(sfc_lw_down_clr_t_mon)/d(SST) by Year



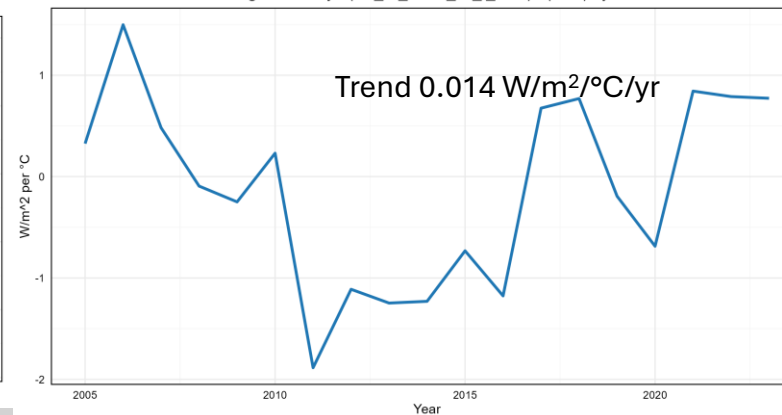
2025 Area Wtd Mean: sfc_lw_down_clr_t_mon W/m^2



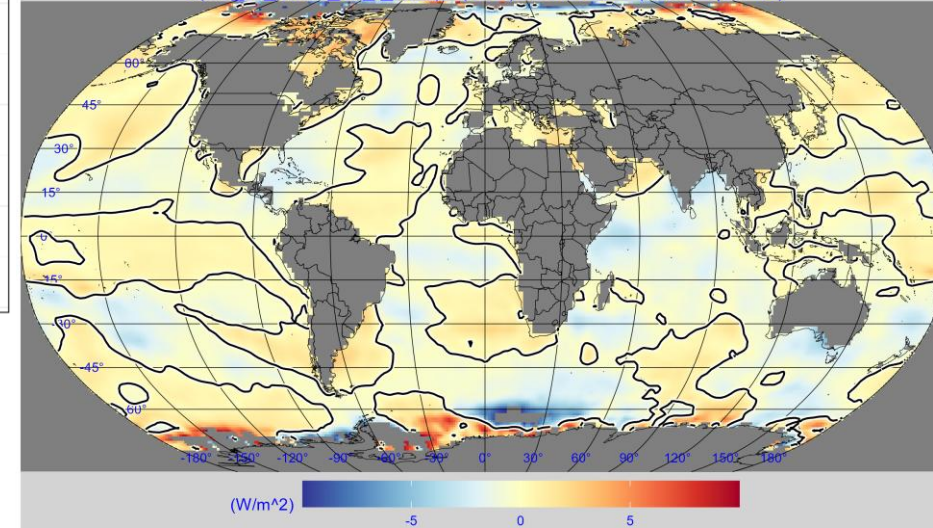
Absolute Ratio sfc_lw_down_clr_t_mon / SST by Year



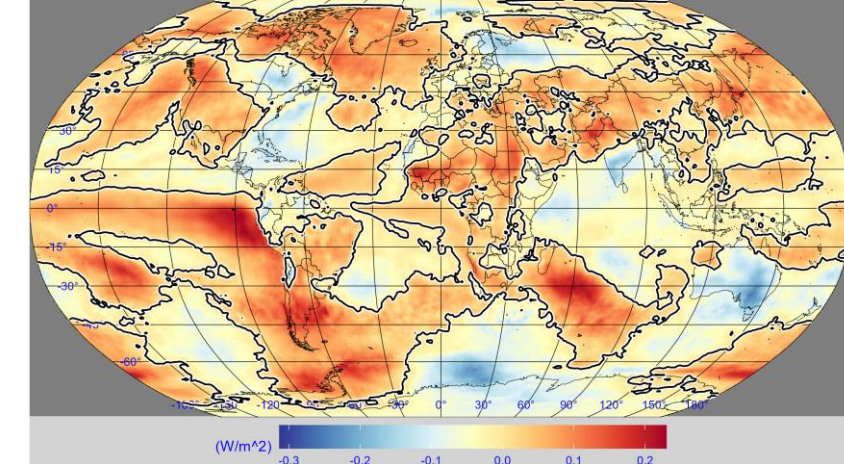
Rolling Sensitivity d(sfc_lw_down_clr_t_mon)/d(SST) by Year



d(sfc_lw_down_clr_t_mon)/d(SST) 2001-2025 (W/m^2 per °C)

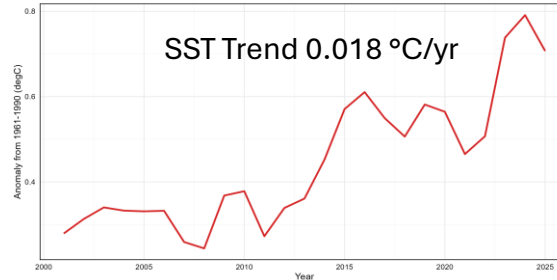


2001-2025 Trend: sfc_lw_down_clr_t_mon W/m^2 per year



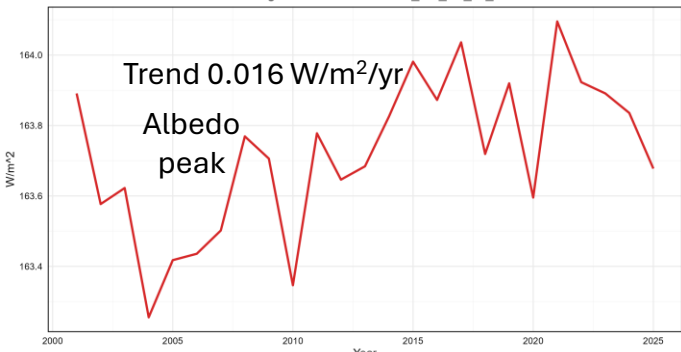
The global slope for this variable is **0.205 W/m²/°C**. Pretty flat on average and as a function of SST.

SST anomaly from 1961-1990

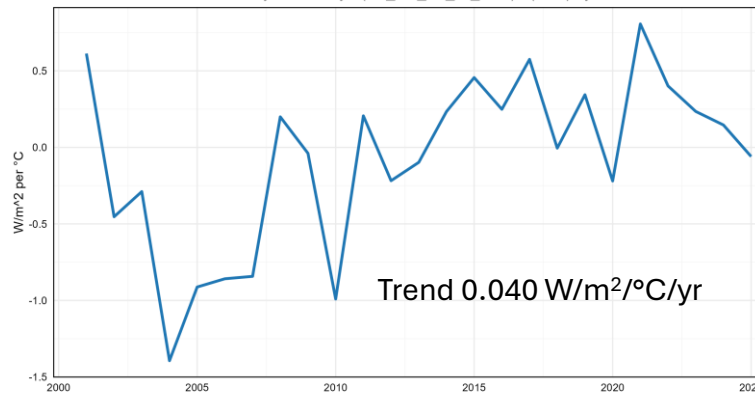


Surface net downward SW flux all sky: sfc_net_sw_all_mon

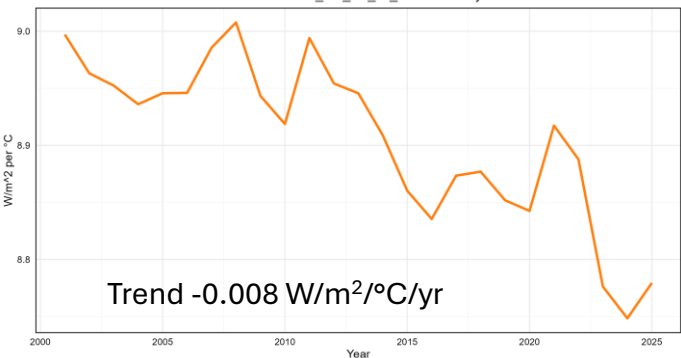
Area-Weighted Global Mean: sfc_net_sw_all_mon



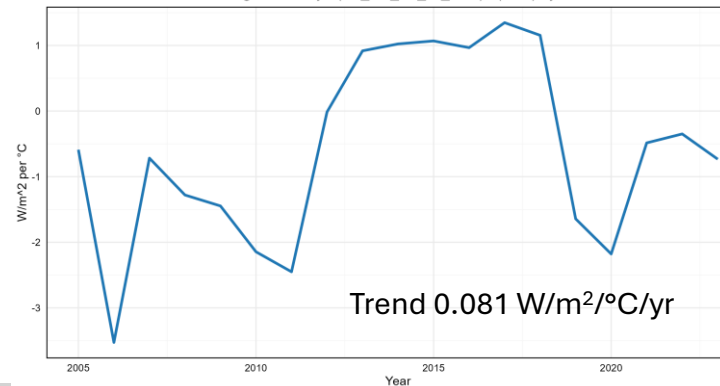
Anomaly Sensitivity d(sfc_net_sw_all_mon)/d(SST) by Year



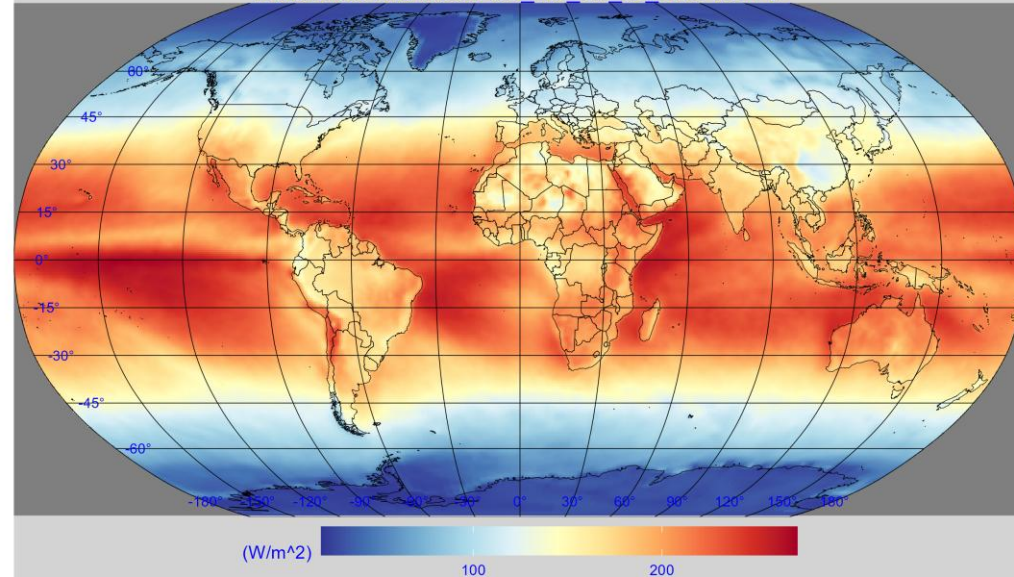
Absolute Ratio sfc_net_sw_all_mon / SST by Year



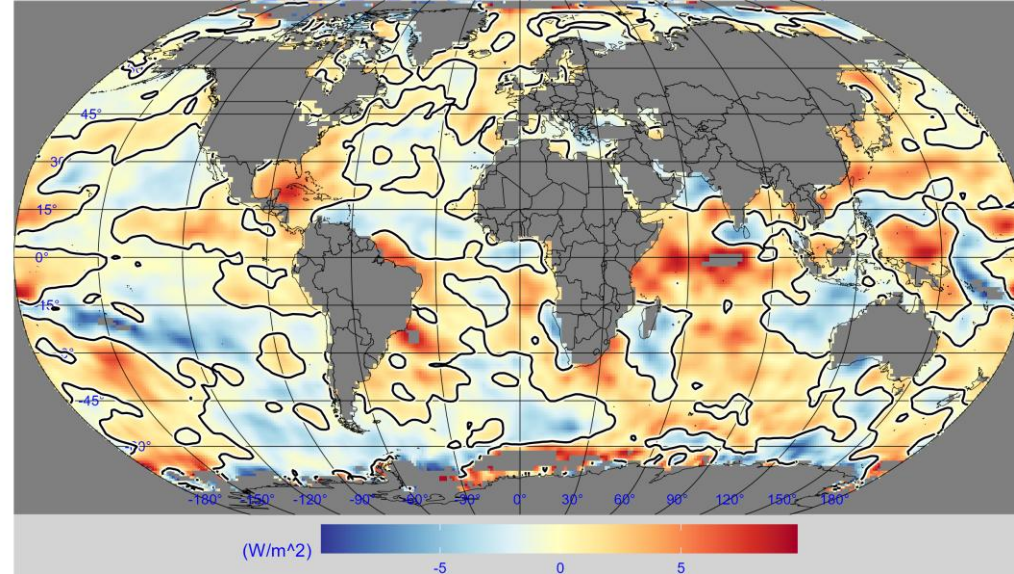
Rolling Sensitivity d(sfc_net_sw_all_mon)/d(SST) by Year



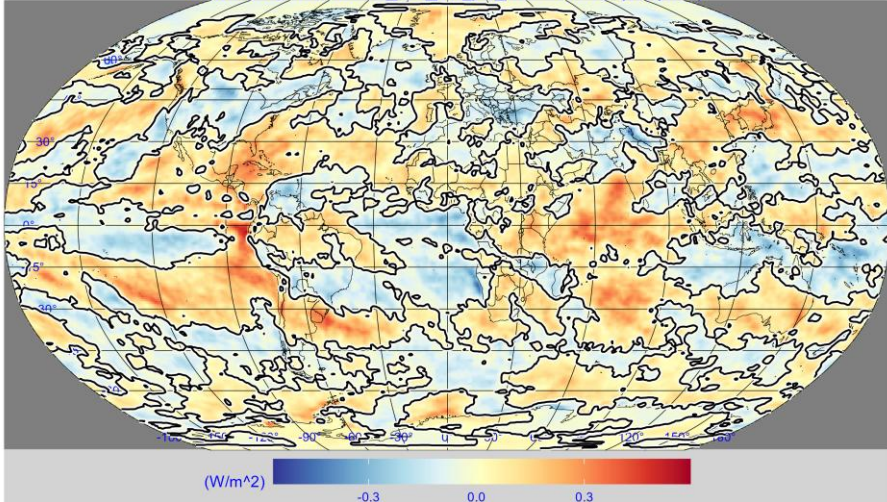
2025 Area Wtd Mean: sfc_net_sw_all_mon W/m^2



d(sfc_net_sw_all_mon)/d(SST) 2001–2025 (W/m^2 per °C)

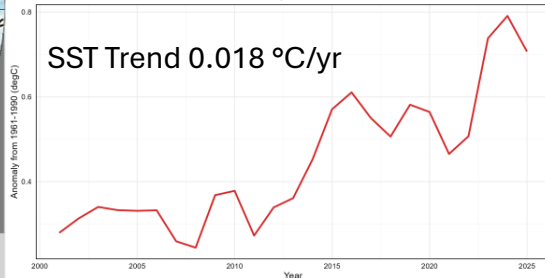


2001-2025 Trend: sfc_net_sw_all_mon W/m^2 per year

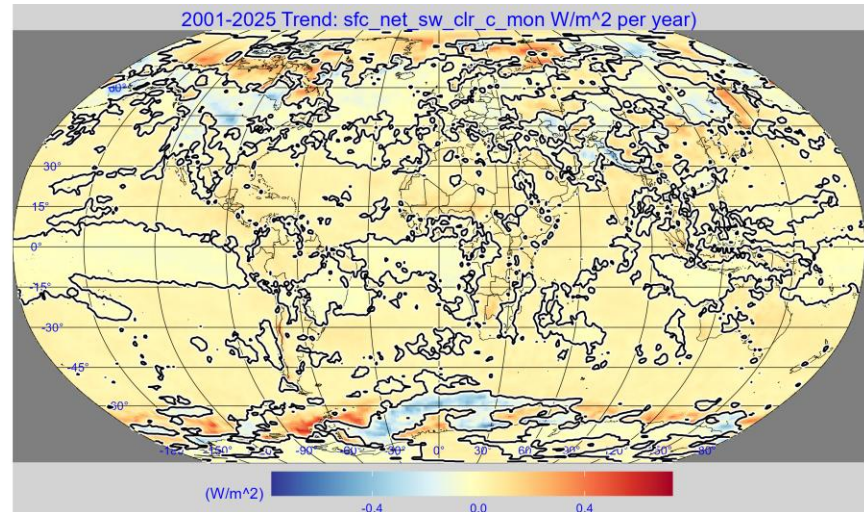
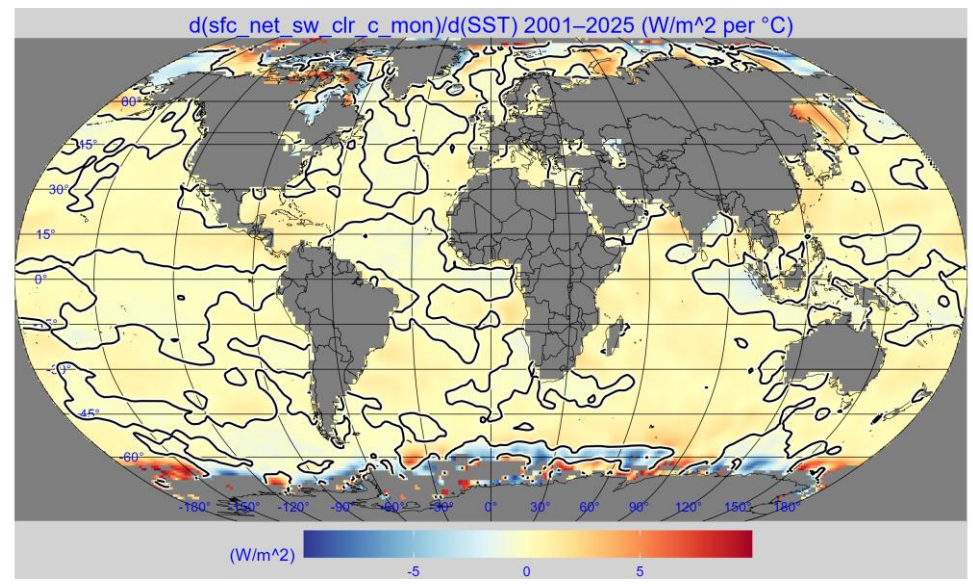
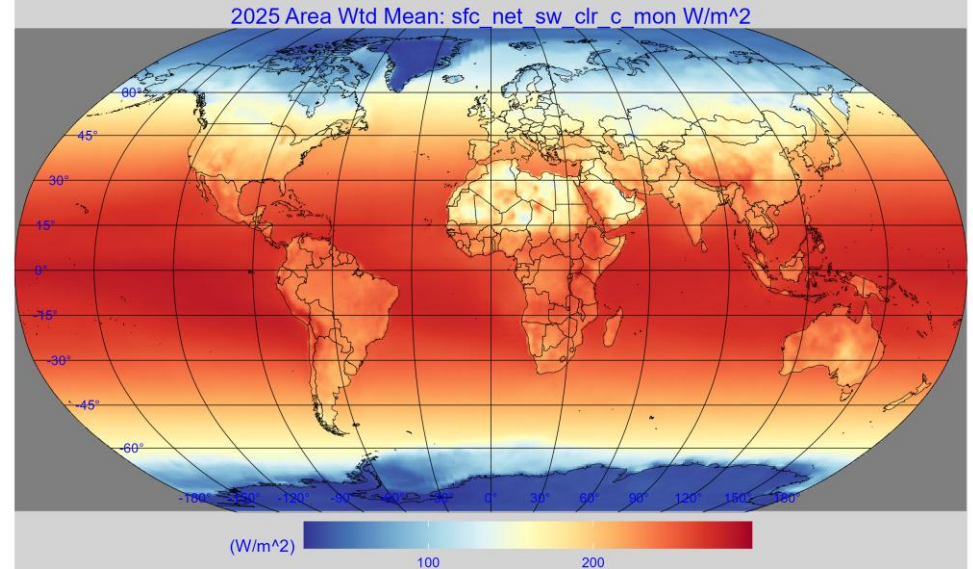
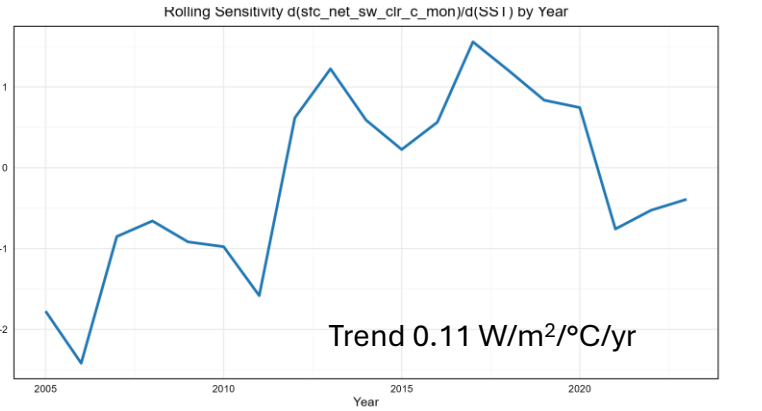
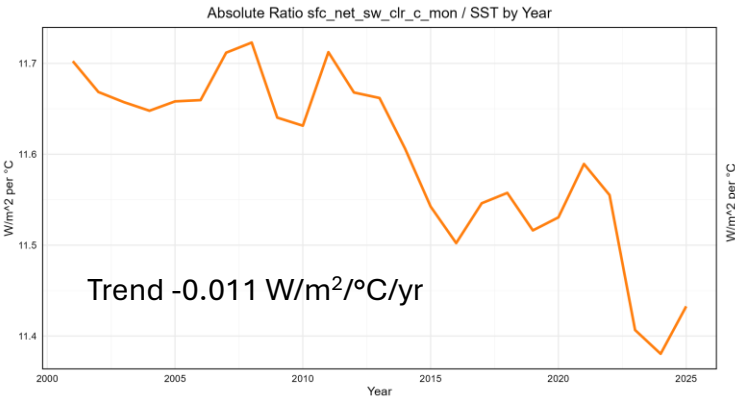
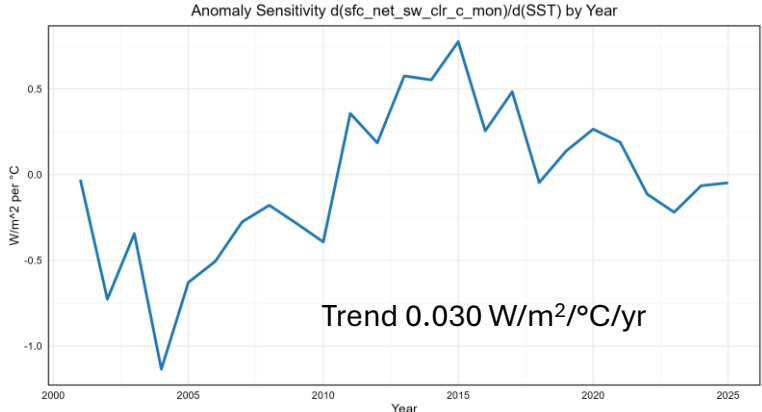
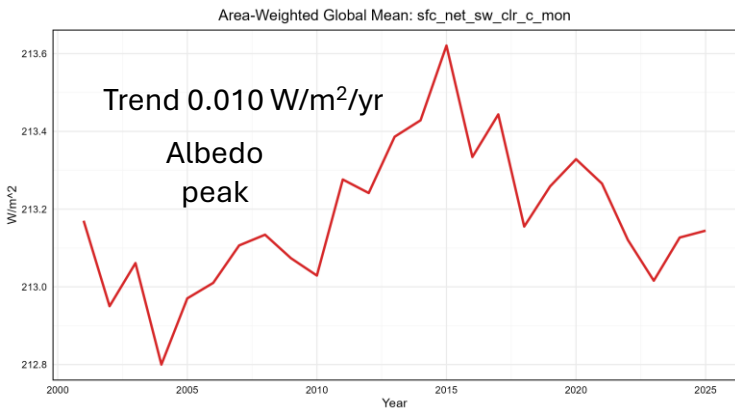


The global slope for this variable is 0.64 W/m²/°C. Increasing trend, negative albedo peak.

SST anomaly from 1961-1990

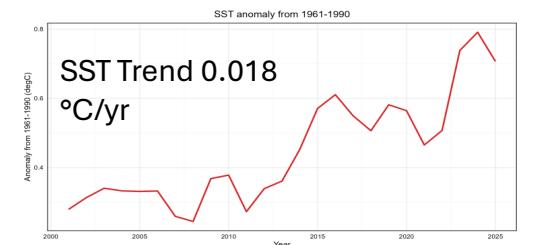


Surface net downward SW flux Clear sky: sfc_net_sw_clr_c



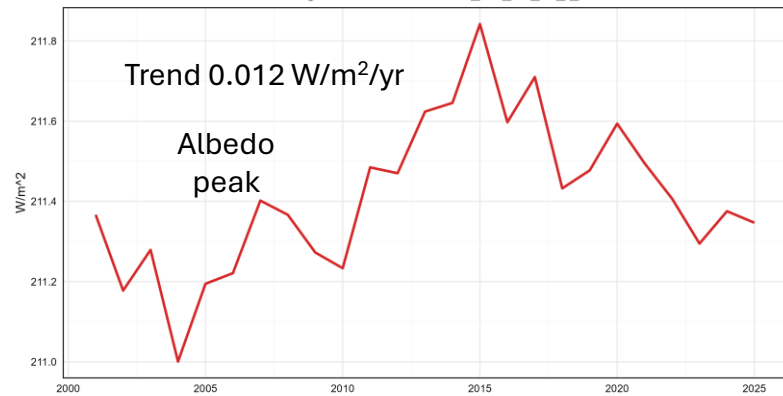
The global slope for this variable is 0.32 W/m²/°C. Increasing with decreasing albedo.

Note:
 $sfc_net_sw_clr_c$
 $= sfc_sw_down_clr_c - sfc_sw_up_clr_c$

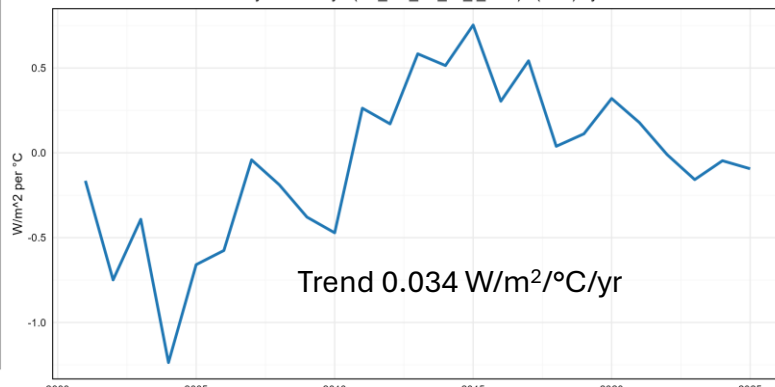


Surface net downward SW flux Clear sky: sfc_net_sw_clr_t

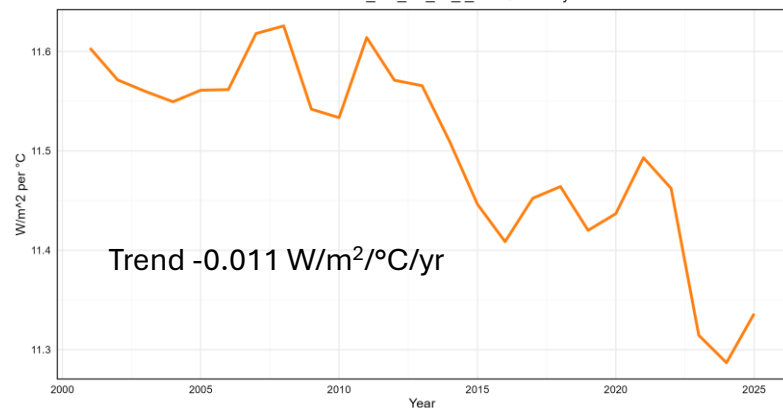
Area-Weighted Global Mean: sfc_net_sw_clr_t_mon



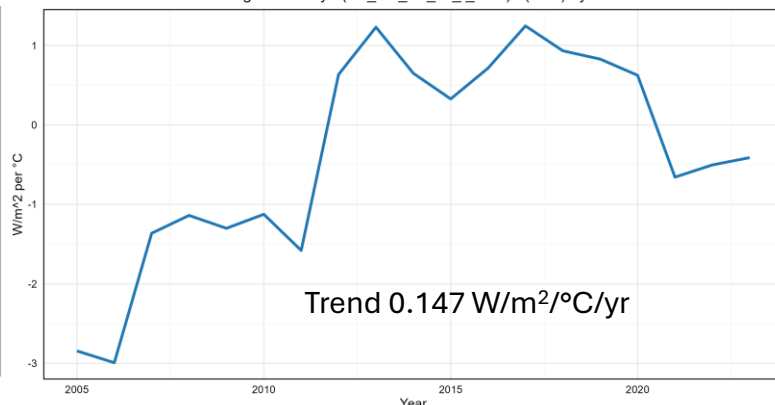
Anomaly Sensitivity d(sfc_net_sw_clr_t_mon)/d(SST) by Year



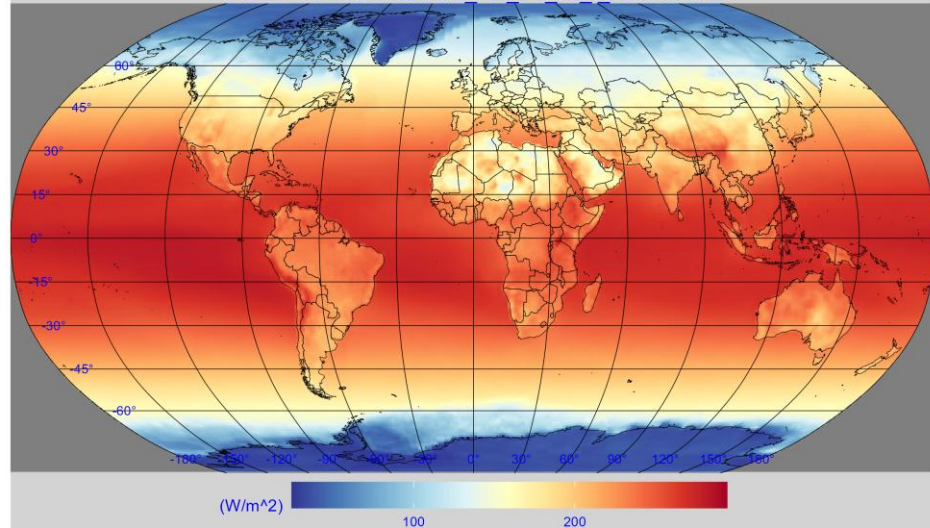
Absolute Ratio sfc_net_sw_clr_t_mon / SST by Year



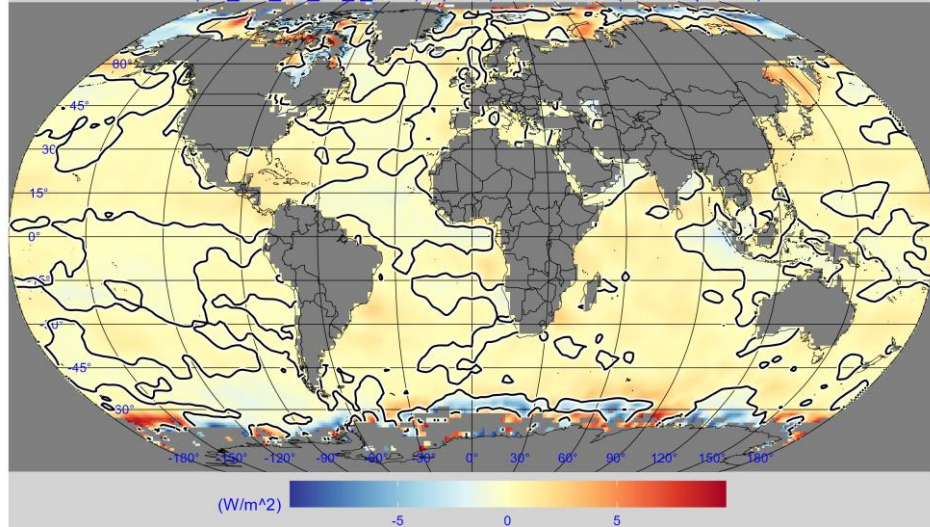
Rolling Sensitivity d(sfc_net_sw_clr_t_mon)/d(SST) by Year



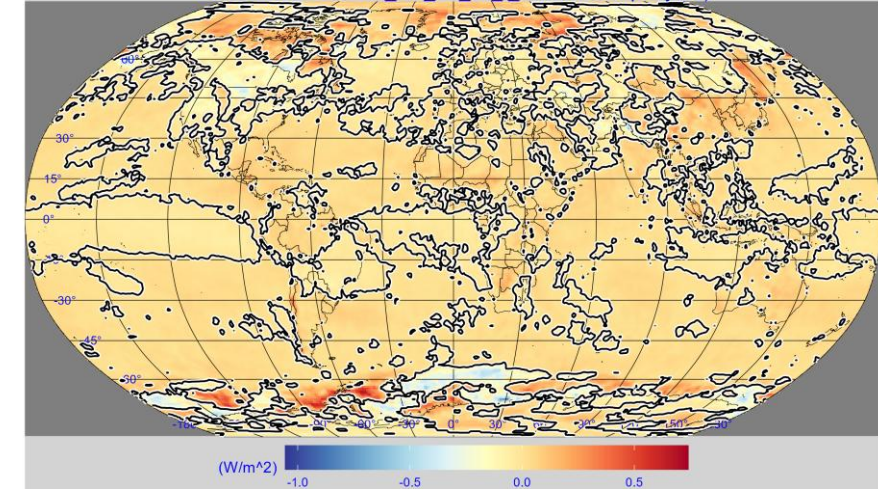
2025 Area Wtd Mean: sfc_net_sw_clr_t_mon W/m^2



d(sfc_net_sw_clr_t_mon)/d(SST) 2001-2025 (W/m^2 per °C)



2001-2025 Trend: sfc_net_sw_clr_t_mon W/m^2 per year



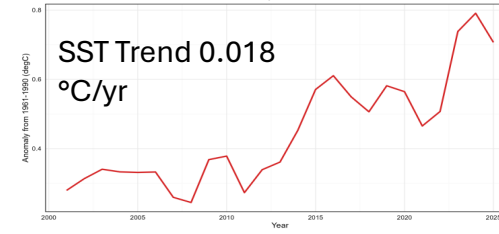
The global slope for this variable is 0.385 **W/m²/°C**. Increasing with decreasing albedo.

Note:

$$\text{sfc_net_sw_clr_t} = \text{sfc_sw_down_clr_t} - \text{sfc_sw_up_clr_t}$$

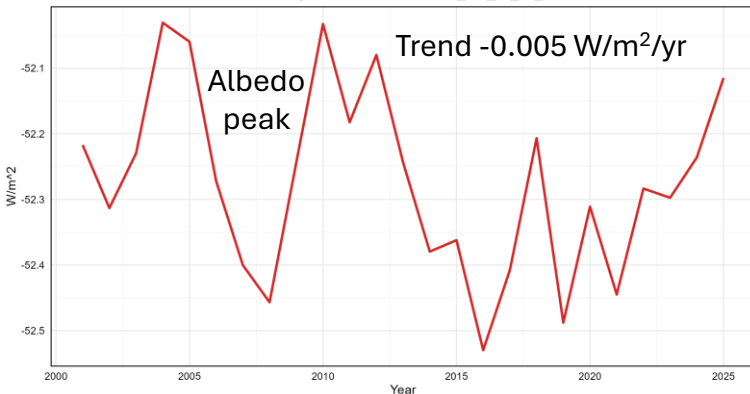
Positive is energy gained at the surface, net is downward.

SST anomaly from 1961-1990

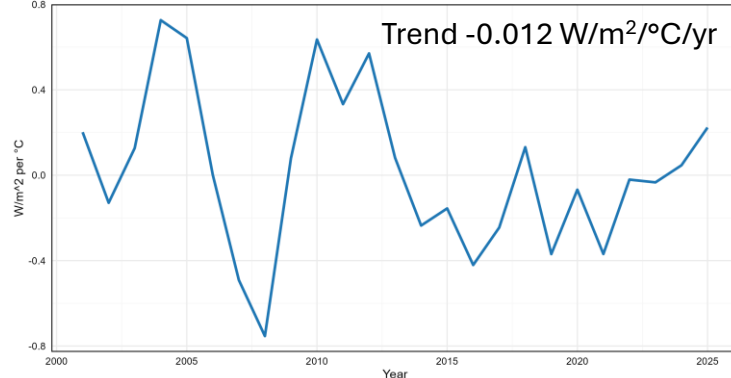


Surface net downward LW flux all sky: sfc_net_lw_all_mon

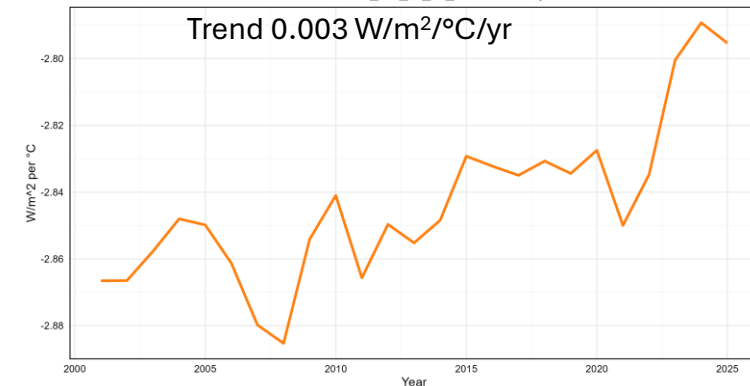
Area-Weighted Global Mean: sfc_net_lw_all_mon



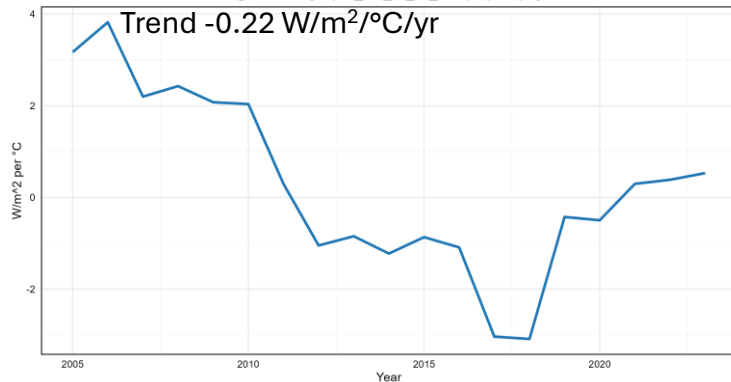
Anomaly Sensitivity d(sfc_net_lw_all_mon)/d(SST) by Year



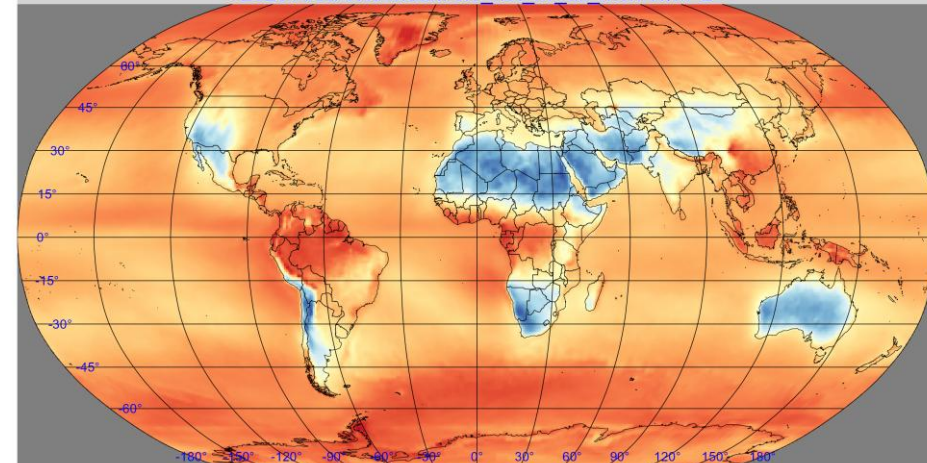
Absolute Ratio sfc_net_lw_all_mon / SST by Year



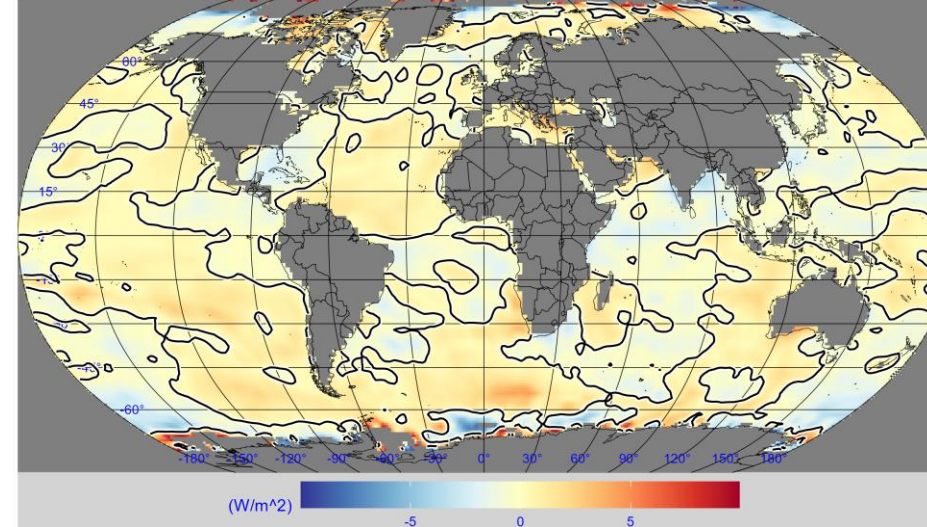
Rolling Sensitivity d(sfc_net_lw_all_mon)/d(SST) by Year



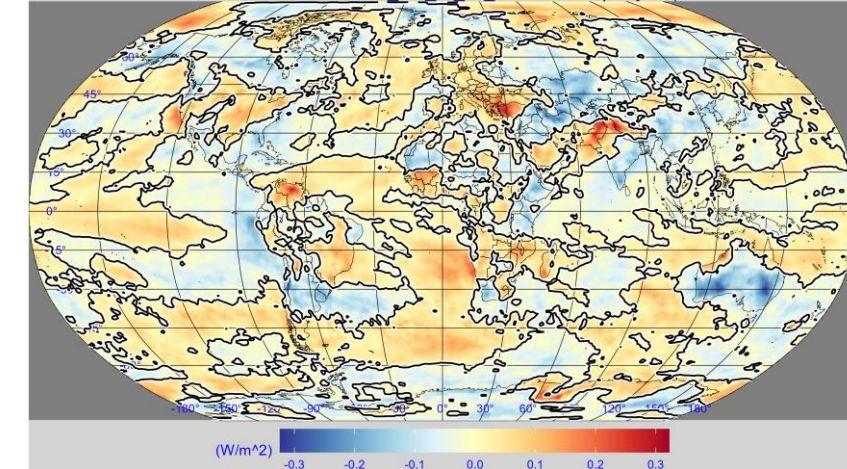
2025 Area Wtd Mean: sfc_net_lw_all_mon W/m^2



d(sfc_net_lw_all_mon)/d(SST) 2001-2025 (W/m^2 per °C)

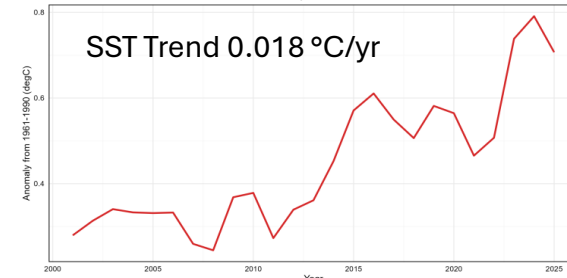


2001-2025 Trend: sfc_net_lw_all_mon W/m^2 per year

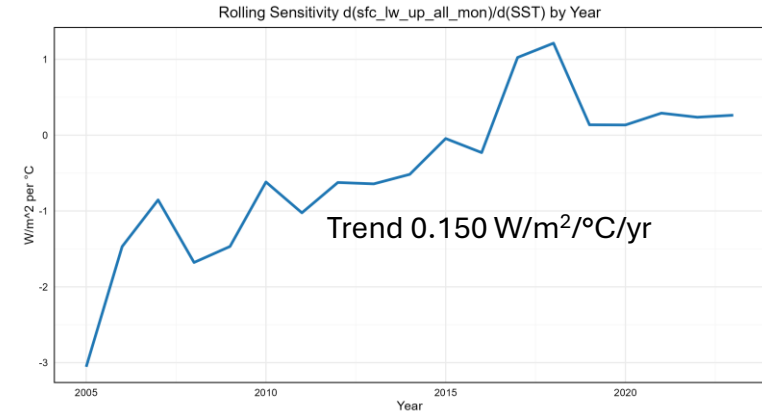
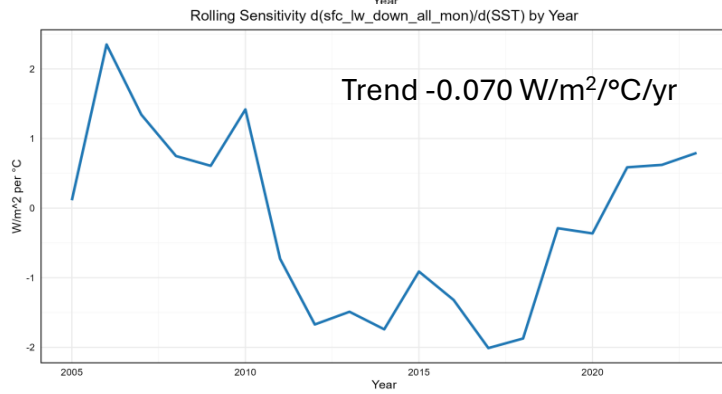
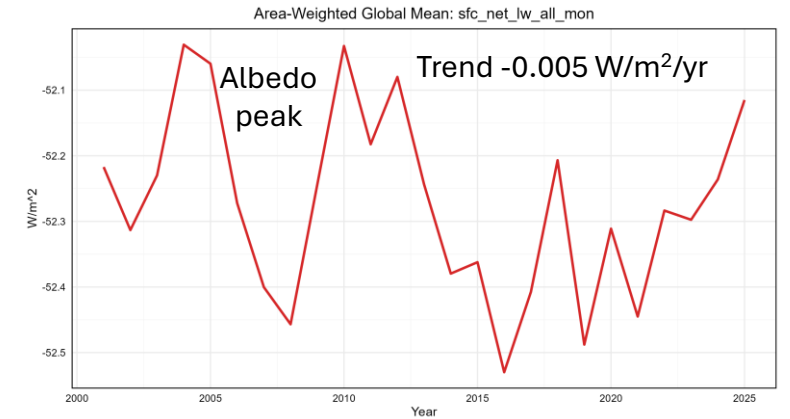
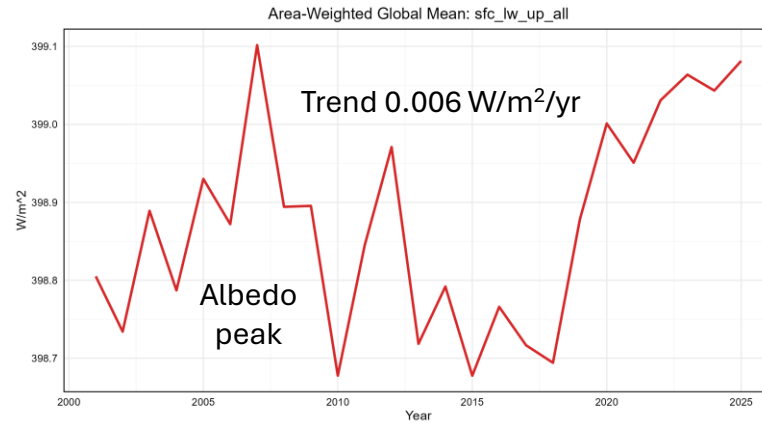
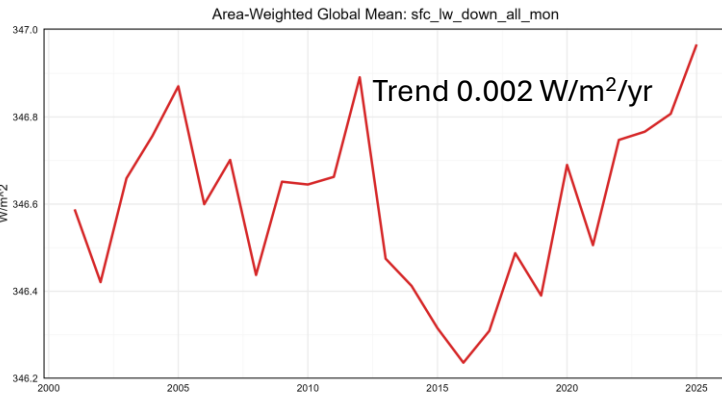


The global slope for this variable is **-0.188 W/m²/°C**. Equals down-up. Negative albedo peak, mean is flat, as a function of SST downward trend. Positive is energy gained at the surface, net is downward.

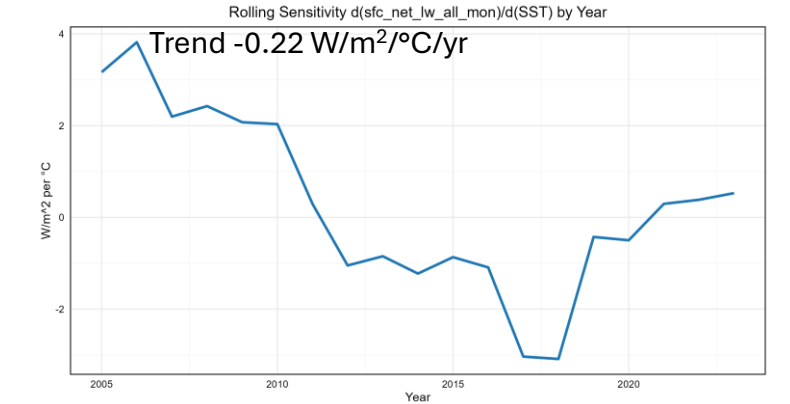
SST anomaly from 1961-1990



Sfc_net_lw_all

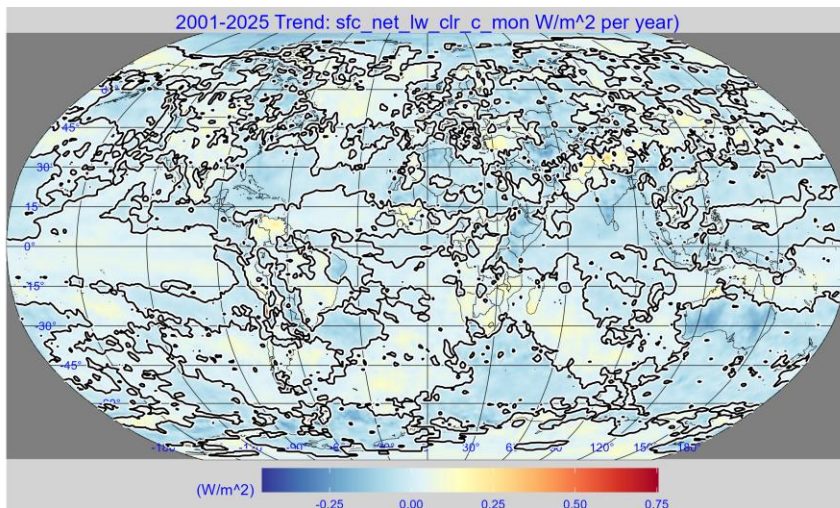
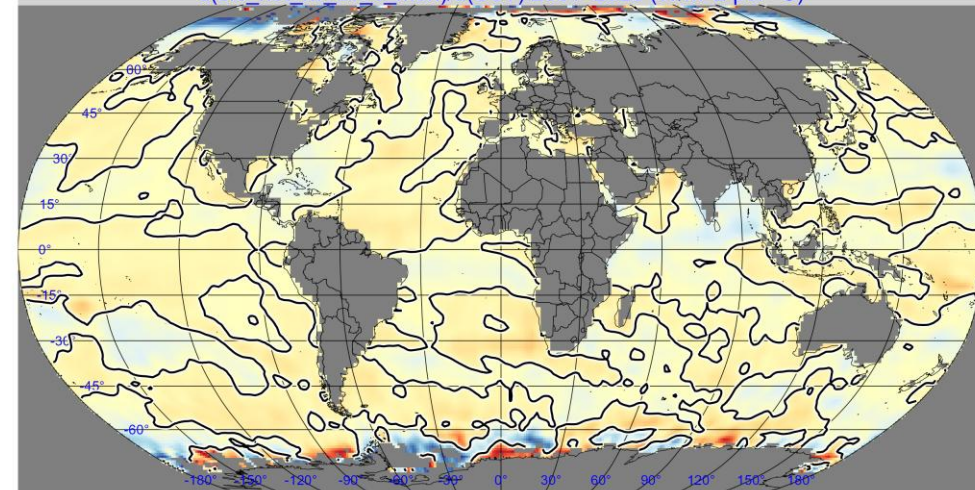
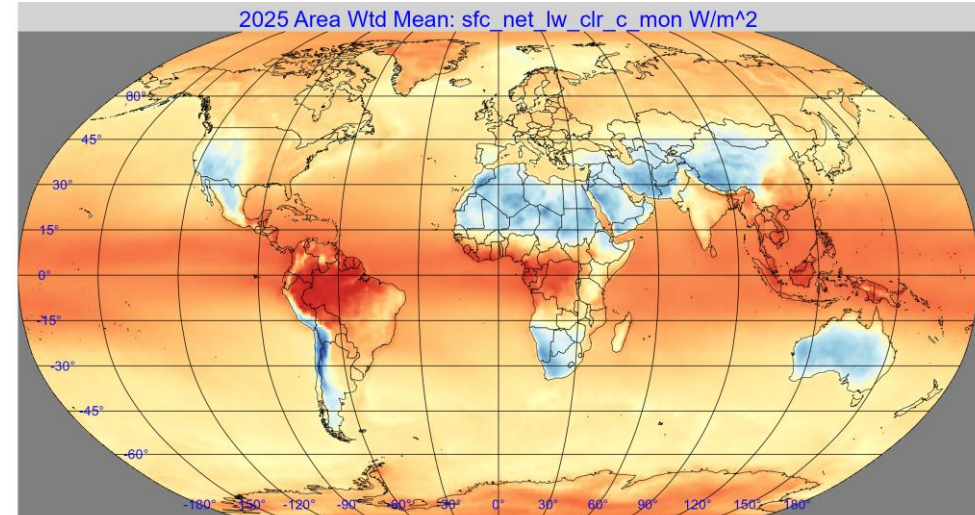
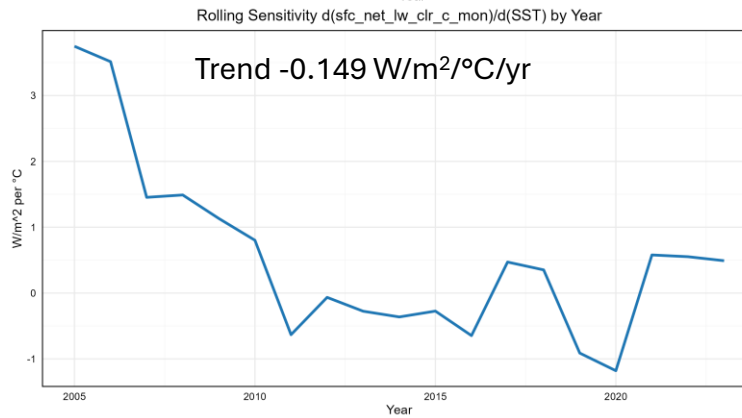
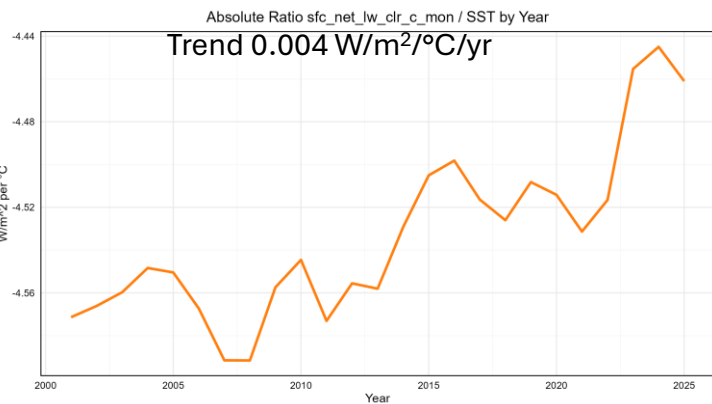
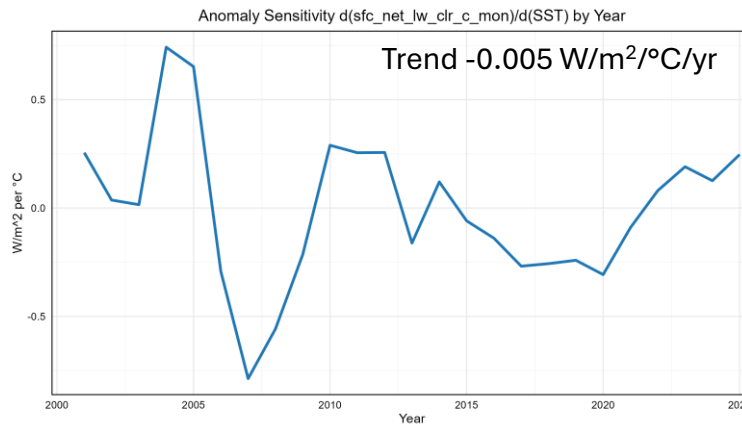
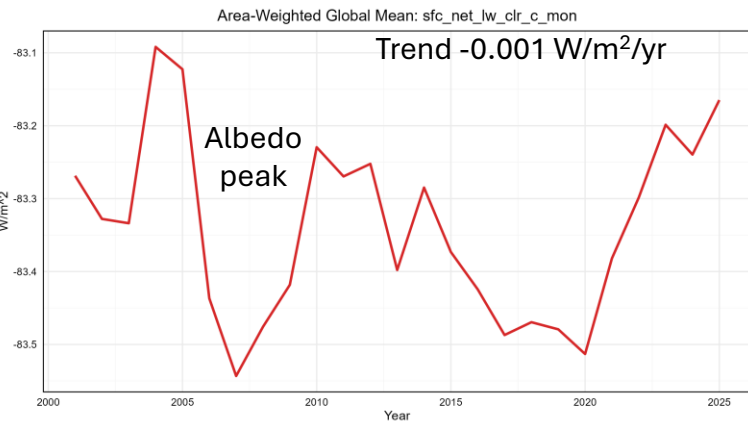


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Positive is energy gained at the surface, net is downward.

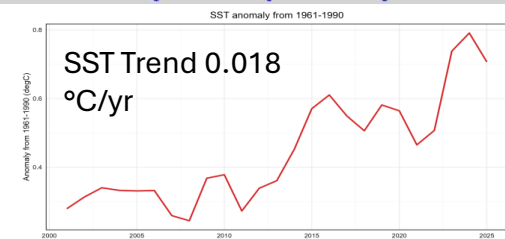
Surface net downward LW flux clear sky: sfc_net_lw_clr_c



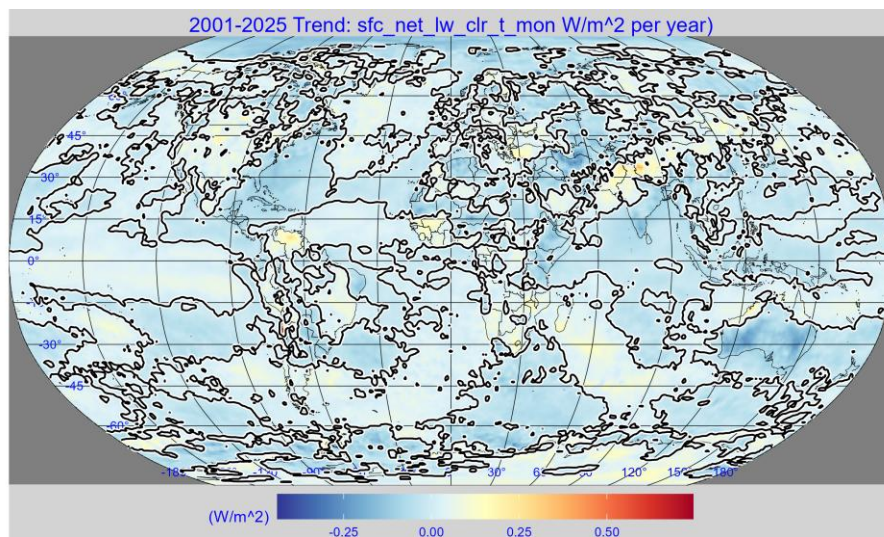
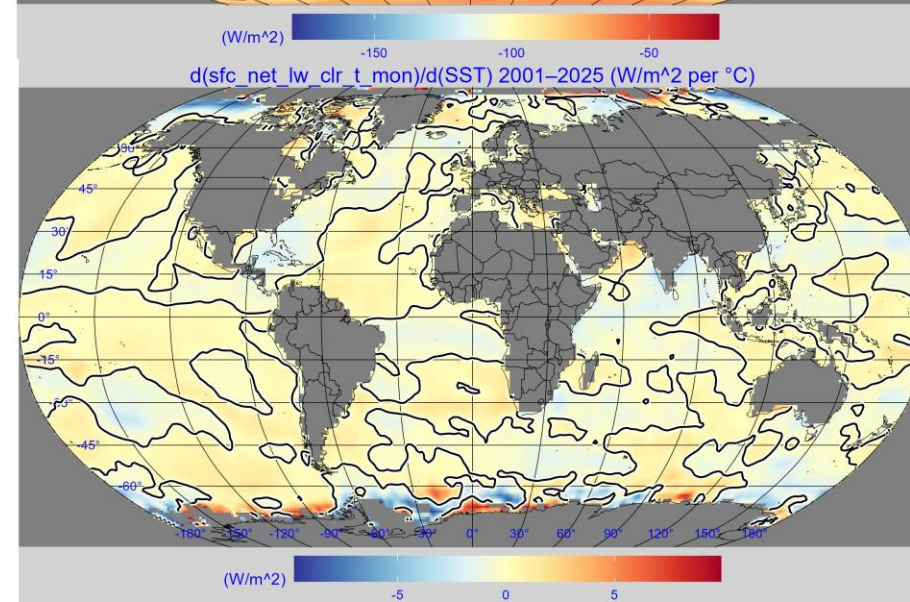
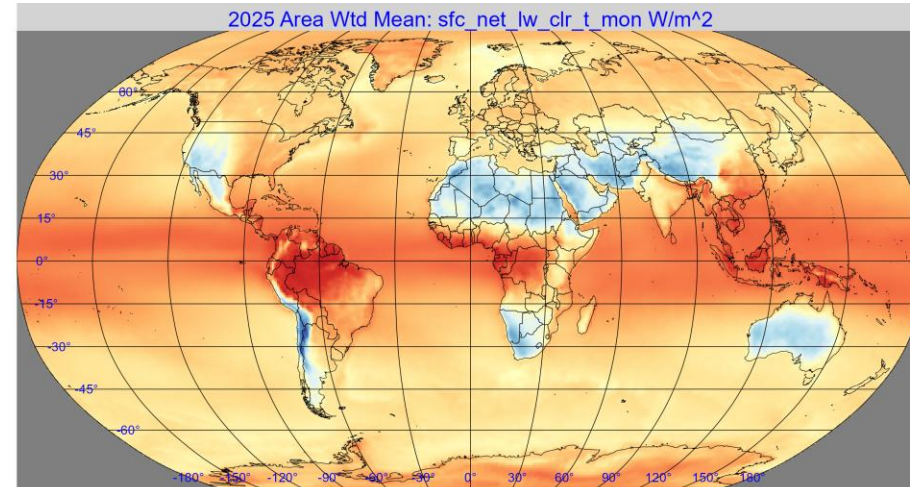
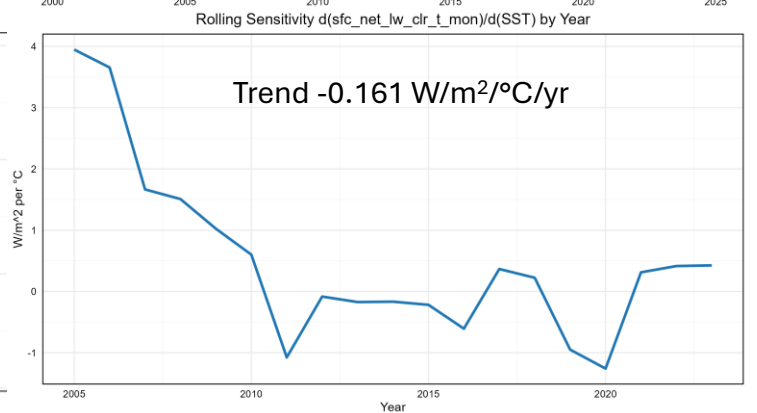
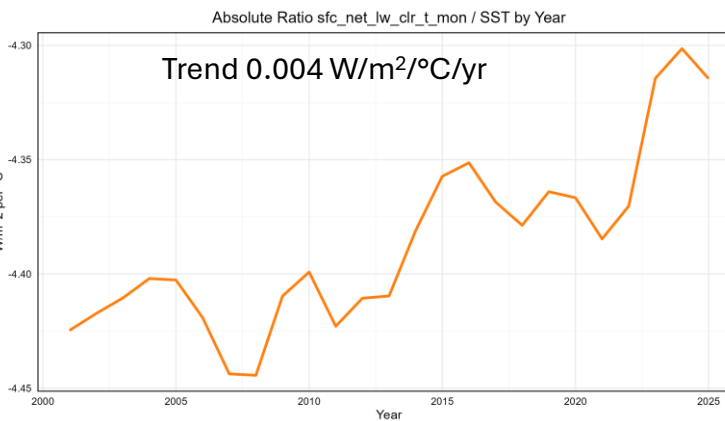
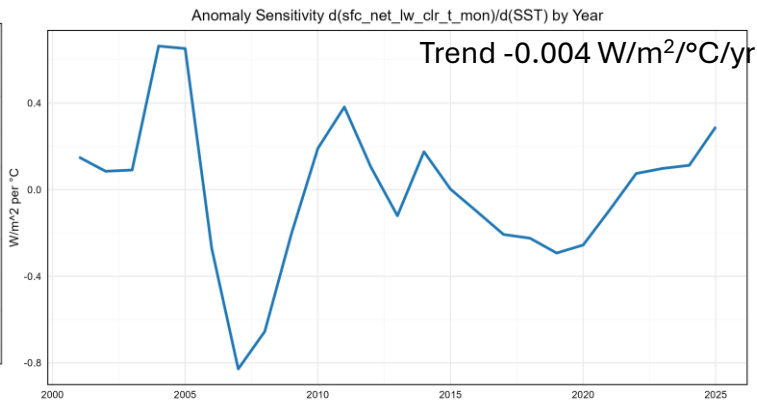
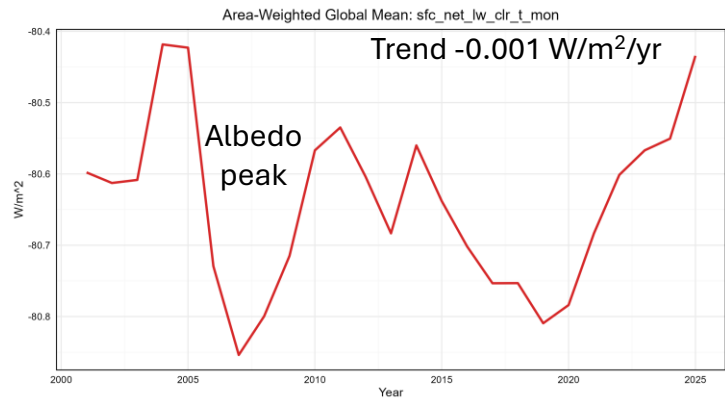
The global slope for this variable is 0.058 **W/m²/°C**: This is the 2001-2025 change for sfc_net_lw_clr_c for each 1°C change in global-mean SST.

"sfc_net_lw" =
"sfc_lw_down" - "sfc_lw_up"

Positive is energy gained at the surface, net is downward.



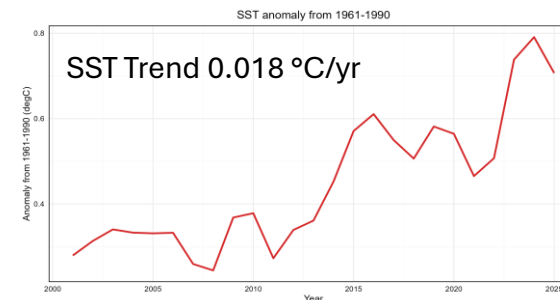
Surface net downward LW flux clear sky: sfc_net_lw_clr_t



The global slope for this variable is 0.068 **W/m²/°C**: This is the 2001-2025 change for sfc_net_lw_clr_t for each 1°C change in global-mean SST.

"sfc_net_lw" =
"sfc_lw_down" - "sfc_lw_up"

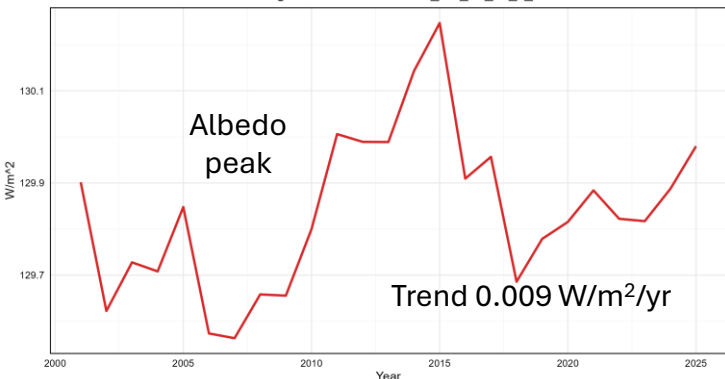
Positive is energy gained at the surface, net is downward.



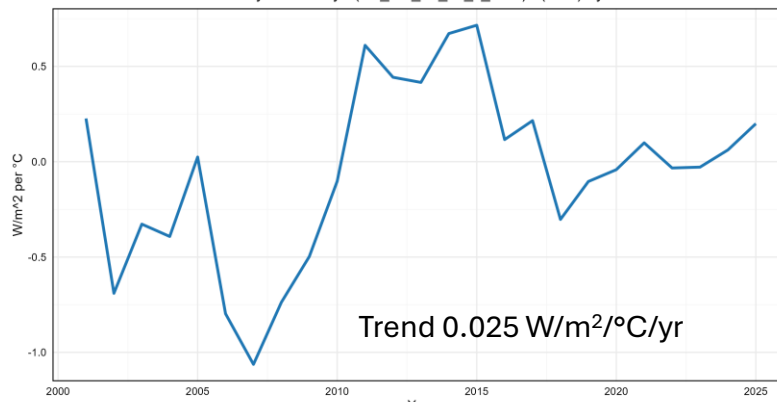
sfc_net_lw_clr_t check				
year	sfc net lw clr_t	sfc net lw clr_t	sfc lw up clr_t	sfc lw down clr_t
2001	-80.597	-80.597	398.940	318.343
2002	-80.612	-80.612	398.945	318.333
2003	-80.608	-80.608	399.111	318.503
2004	-80.418	-80.418	398.962	318.544
2005	-80.423	-80.423	399.106	318.683
2006	-80.729	-80.729	398.985	318.256
2007	-80.854	-80.854	399.323	318.469
2008	-80.799	-80.799	399.097	318.298
2009	-80.714	-80.714	399.100	318.385
2010	-80.567	-80.567	398.938	318.371
2011	-80.534	-80.535	399.060	318.525
2012	-80.603	-80.603	399.208	318.605
2013	-80.682	-80.682	398.951	318.269
2014	-80.559	-80.560	398.929	318.369
2015	-80.637	-80.638	398.795	318.157
2016	-80.701	-80.701	398.854	318.152
2017	-80.753	-80.753	398.889	318.136
2018	-80.752	-80.752	398.868	318.116
2019	-80.809	-80.810	399.059	318.249
2020	-80.783	-80.783	399.191	318.408
2021	-80.682	-80.682	399.056	318.373
2022	-80.601	-80.601	399.273	318.672
2023	-80.566	-80.566	399.283	318.716
2024	-80.550	-80.550	399.237	318.687
2025	-80.434	-80.434	399.205	318.772
Mean	-80.639	-80.639		

Surface net down radiative flux = net_SW + net_LW: sfc_net_tot_clr_c

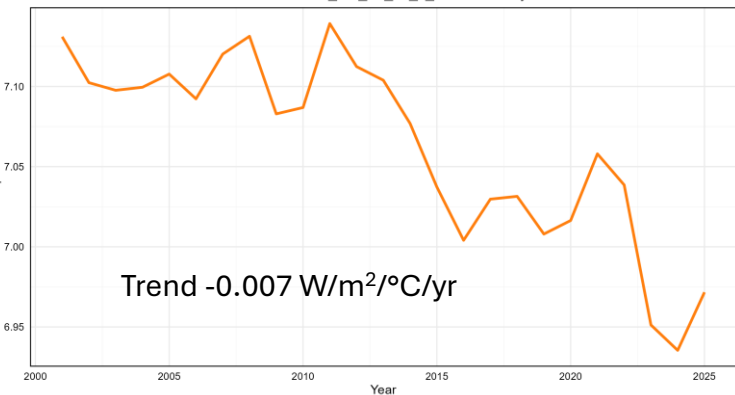
Area-Weighted Global Mean: sfc_net_tot_clr_c_mon



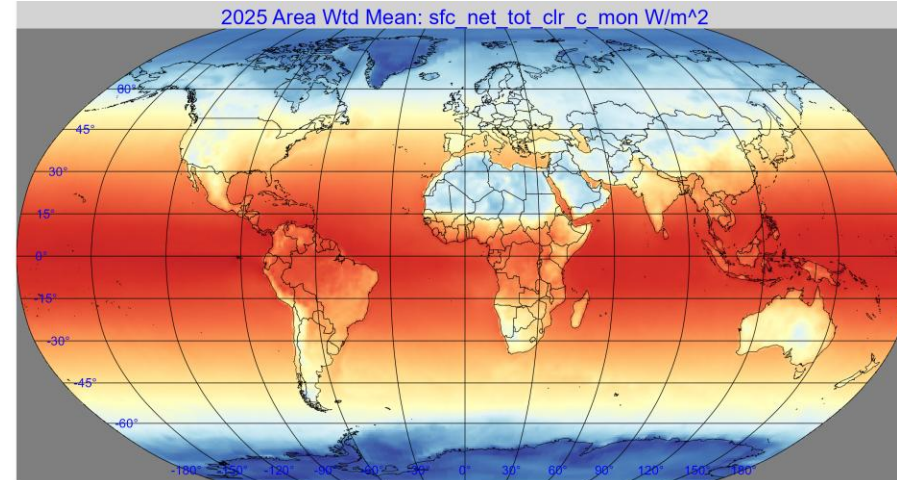
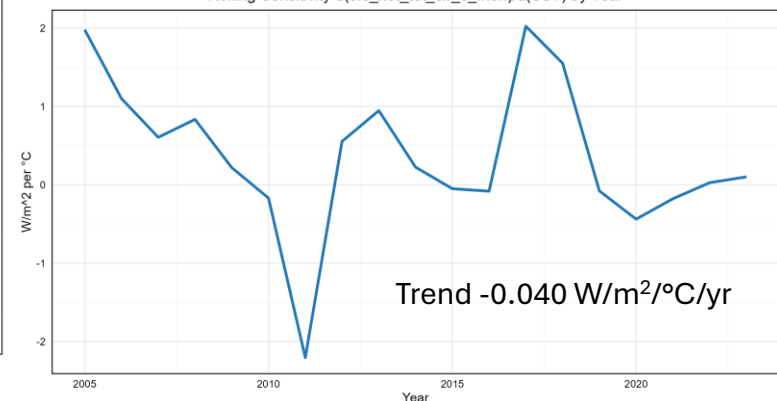
Anomaly Sensitivity $d(\text{sfc_net_tot_clr_c_mon})/d(\text{SST})$ by Year



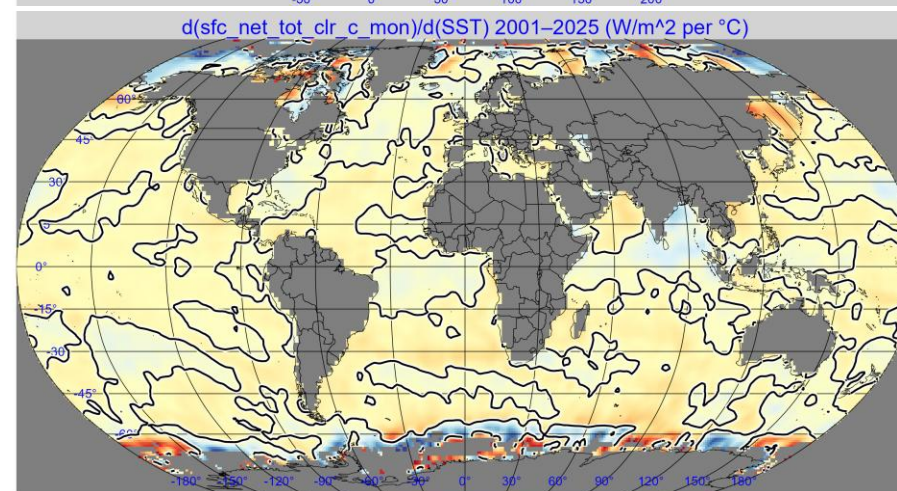
Absolute Ratio $\text{sfc_net_tot_clr_c_mon} / \text{SST}$ by Year



Rolling Sensitivity $d(\text{sfc_net_tot_clr_c_mon})/d(\text{SST})$ by Year

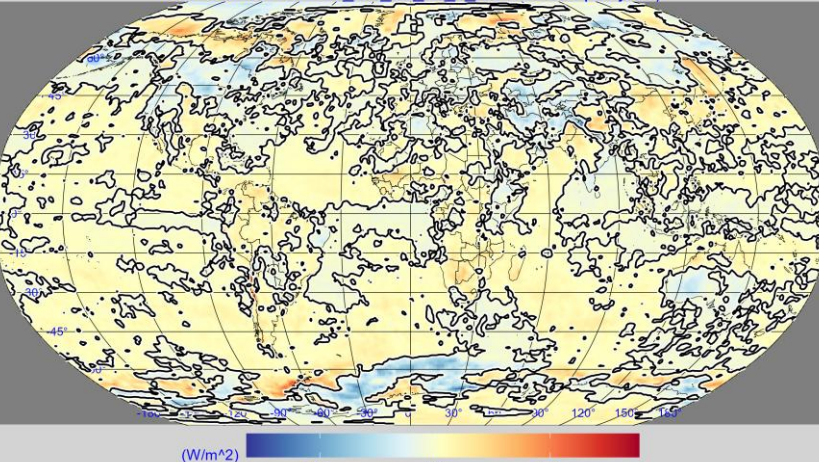


(W/m²)



(W/m²)

2001-2025 Trend: sfc_net_tot_clr_c_mon W/m^2 per year



(W/m²)

Surface Net Total Flux, Clear-Sky (for cloud-free areas of region) conditions. The global slope for this variable is **0.377 W/m²/°C**.

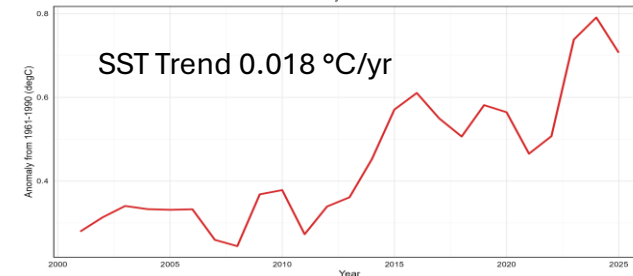
Surface net downward radiative flux assuming clear sky.

Net_lw_all + net_sw_all to the surface

Also:

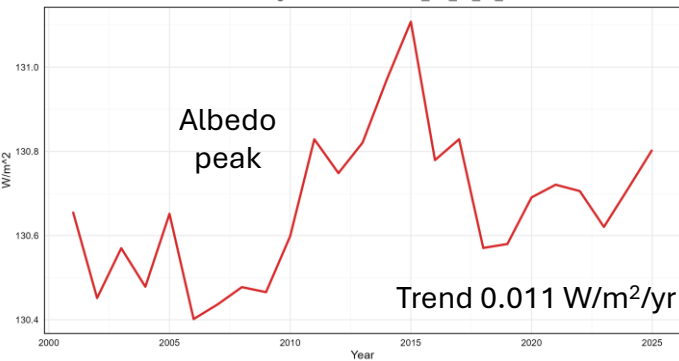
sw_down-sw_up + lw_down-lw_up

SST anomaly from 1961-1990

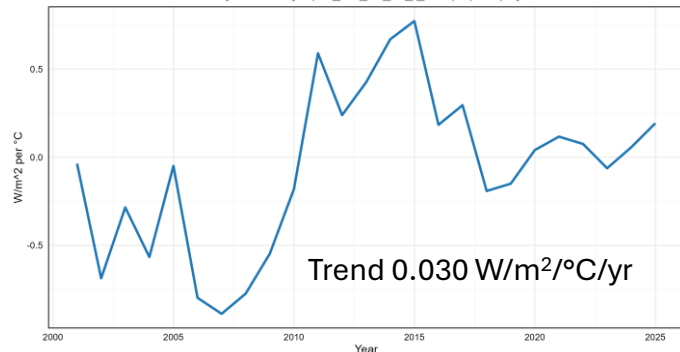


Surface net down radiative flux = net_SW + net_LW: sfc_net_tot_clr_t

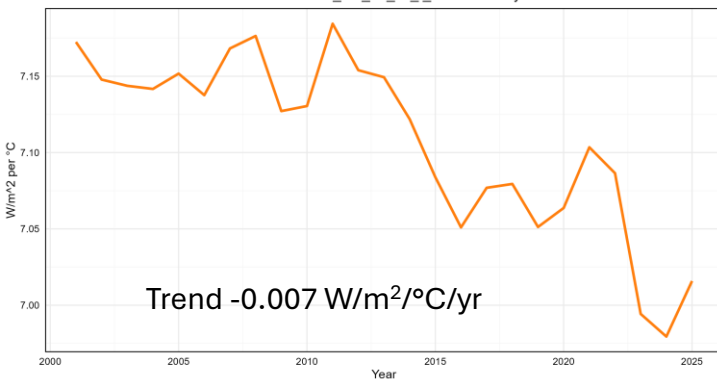
Area-Weighted Global Mean: sfc_net_tot_clr_t



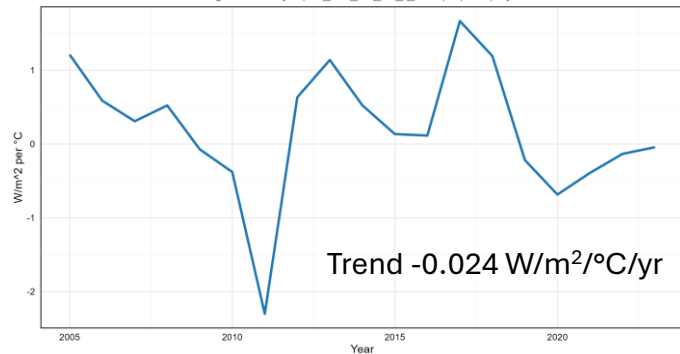
Anomaly Sensitivity d(sfc_net_tot_clr_t_mon)/d(SST) by Year



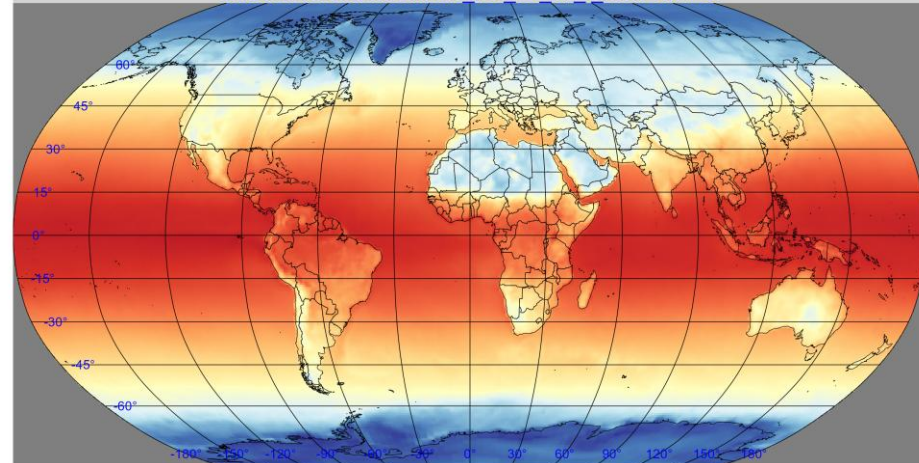
Absolute Ratio sfc_net_tot_clr_t_mon / SST by Year



Rolling Sensitivity d(sfc_net_tot_clr_t_mon)/d(SST) by Year

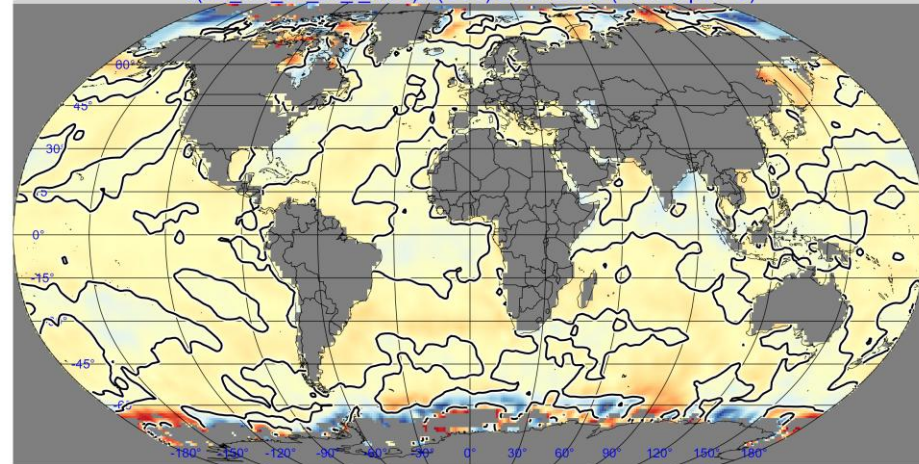


2025 Area Wtd Mean: sfc_net_tot_clr_t_mon W/m^2



(W/m^2)

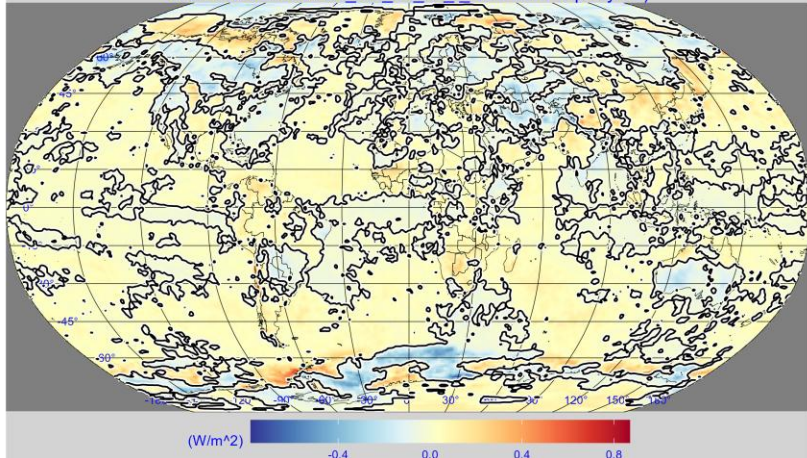
d(sfc_net_tot_clr_t_mon)/d(SST) 2001-2025 (W/m^2 per °C)



(W/m^2)

SST Trend 0.018 °C/yr

2001-2025 Trend: sfc_net_tot_clr_t_mon W/m^2 per year



Surface Net Total Flux, Clear-Sky (for total cell) conditions. The global slope for this variable is 0.443 **W/m²/°C**.

Surface net downward radiative_flux assuming clear sky.

Net_lw_all + net_sw_all to the surface
Also:
sw_down-sw_up + lw_down-lw_up

