

Trends of UV Radiation in Antarctica

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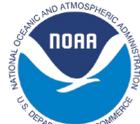
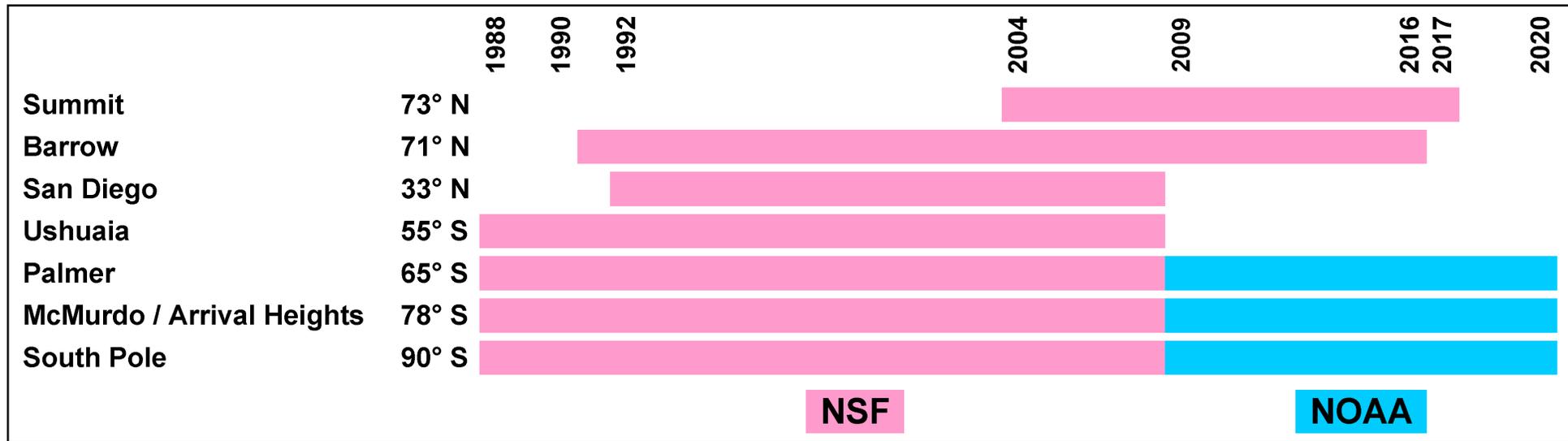


Outline

- History of observations
- Instrumentation and data products
- Success of Montreal Protocol in curbing UV
- Corrections for drifts in calibrations
- New trend estimates
- Conclusions



History and Milestones



Websites

NSF Polar UV Monitoring Network

**National Science Foundation
Polar Programs UV Monitoring
Network**
Maintained by Biospherical Instruments Inc.

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BSI Home

June 11, 2020

The network has been reorganized in 2009. Please read this document to learn about these important changes.

Welcome to the NSF Polar UV Monitoring Network Web Site

The National Science Foundation (NSF) Ultraviolet (UV) Monitoring Network was established in 1987 by the NSF Division of Polar Programs in response to serious ozone depletion reported in Antarctica. Biospherical Instruments installed the first instruments in 1988. Observations were extended to the Arctic and are now part of NSF's Arctic Observing Network. The project is providing data to researchers studying the effects of ozone depletion on terrestrial and marine biological systems. Data are also used for the validation of satellite observations and for the verification of models describing the transfer of radiation through the atmosphere. Instruments are part of the **Network for the Detection of Atmospheric Composition Change (NDACC)**.

<http://uv.biospherical.com>

Data up to 2008

NOAA Antarctic UV Monitoring Network

**Earth System Research Laboratory
Global Monitoring Division**

Global Monitoring Division About Research Products Outreach Information Sitemap Intranet

NOAA Antarctic UV Monitoring Network
Thu, 11 Jun 2020 22:36:10 UTC - DOY [163]

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ARO Building at South Pole

McMurdo UV Index
Latest UV Index: 7 at NA

Palmer UV Index
Latest UV Index: 0.00 at 20:59

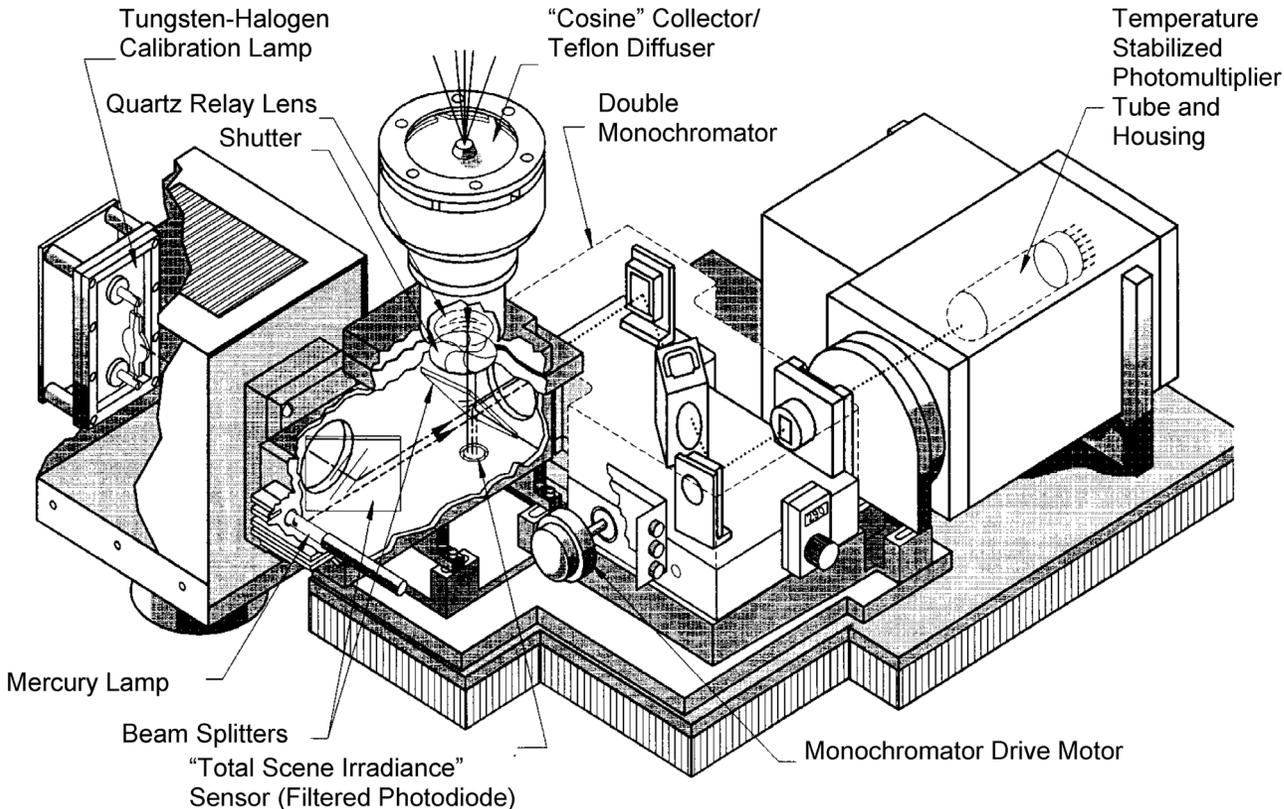
<https://www.esrl.noaa.gov/gmd/grad/antuv/>

Data from 2009



Instrumentation / Data Products

SUV-100 scanning spectroradiometer



Data Products

- Global spectral irradiance ("power per area and per wavelength") between 280 and 600 nm
- Biologically effective radiation levels (UV Index, Vitamin D synthesis, UV-B, UV-A)
- Total ozone
- Cloud optical depth
- Effective surface albedo
- Modeled spectra
- Actinic flux and photolysis rates
[$O_3 \rightarrow O(^1D) + O_2$; $NO_2 \rightarrow NO + O(^3P)$]
- Ozone profiles (vertical distribution of ozone)



Success of Montreal Protocol in Curbing UV Radiation

www.nature.com/scientificreports

**SCIENTIFIC
REPORTS**

nature research

Success of Montreal Protocol Demonstrated by Comparing High- Quality UV Measurements with “World Avoided” Calculations from Two Chemistry-Climate Models

Richard McKenzie¹, Gernar Bernhard², Ben Liley¹, Patrick Disterhoft^{3,4}, Steve Rhodes⁵,
Alkiviadis Bais⁶, Olaf Morgenstern^{1,7}, Paul Newman⁸, Luke Oman⁸, Colette Brogniez⁹ &
Stana Simic¹⁰

McKenzie, R., G. Bernhard, B. Liley, P. Disterhoft, S. Rhodes, A. Bais, O. Morgenstern, P. Newman, L. Oman, C. Brogniez and S. Simic (2019). Success of Montreal Protocol demonstrated by comparing high-quality UV Measurements with “World Avoided” calculations from two chemistry-climate models, *Scientific Reports*, 9, 12332, doi: <https://doi.org/10.1038/s41598-019-48625-z>.

Method:

Compare high-quality UV Index measurements at 17 sites with UV Index data that were:

- calculated from total ozone measurements;
- estimated from a chemistry-climate models (CCM) that represent “**World Expected**” scenario;
- estimated from CCMs that represent the “**World Avoided**” scenario.

World Expected: Emissions of ozone-depleting substances are curbed in compliance with Montreal Protocol

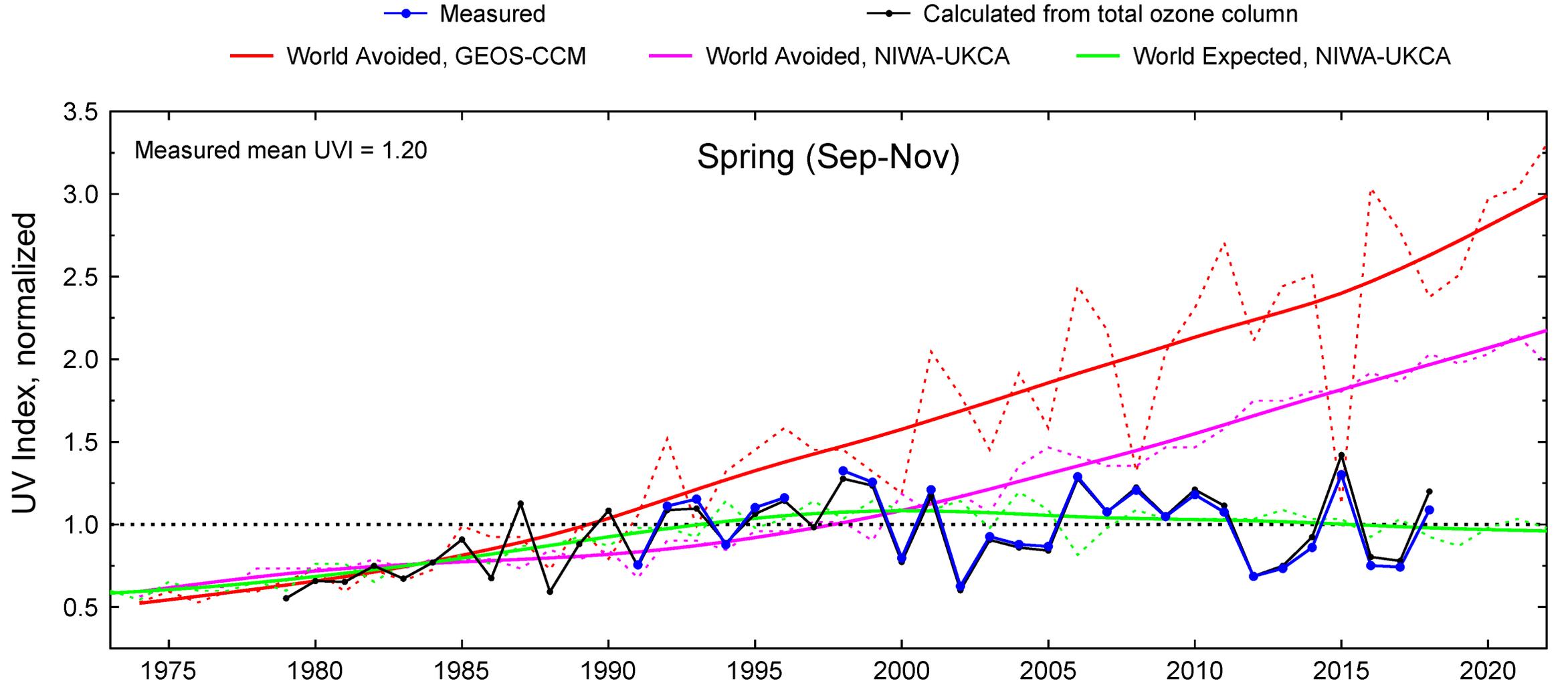
World Avoided: Emissions of ozone-depleting substances continue to rise unabated without being controlled by the Montreal Protocol

Rationale:

➔ Good agreement between measurements and World Expected simulations would give credibility to the World Avoided projections.



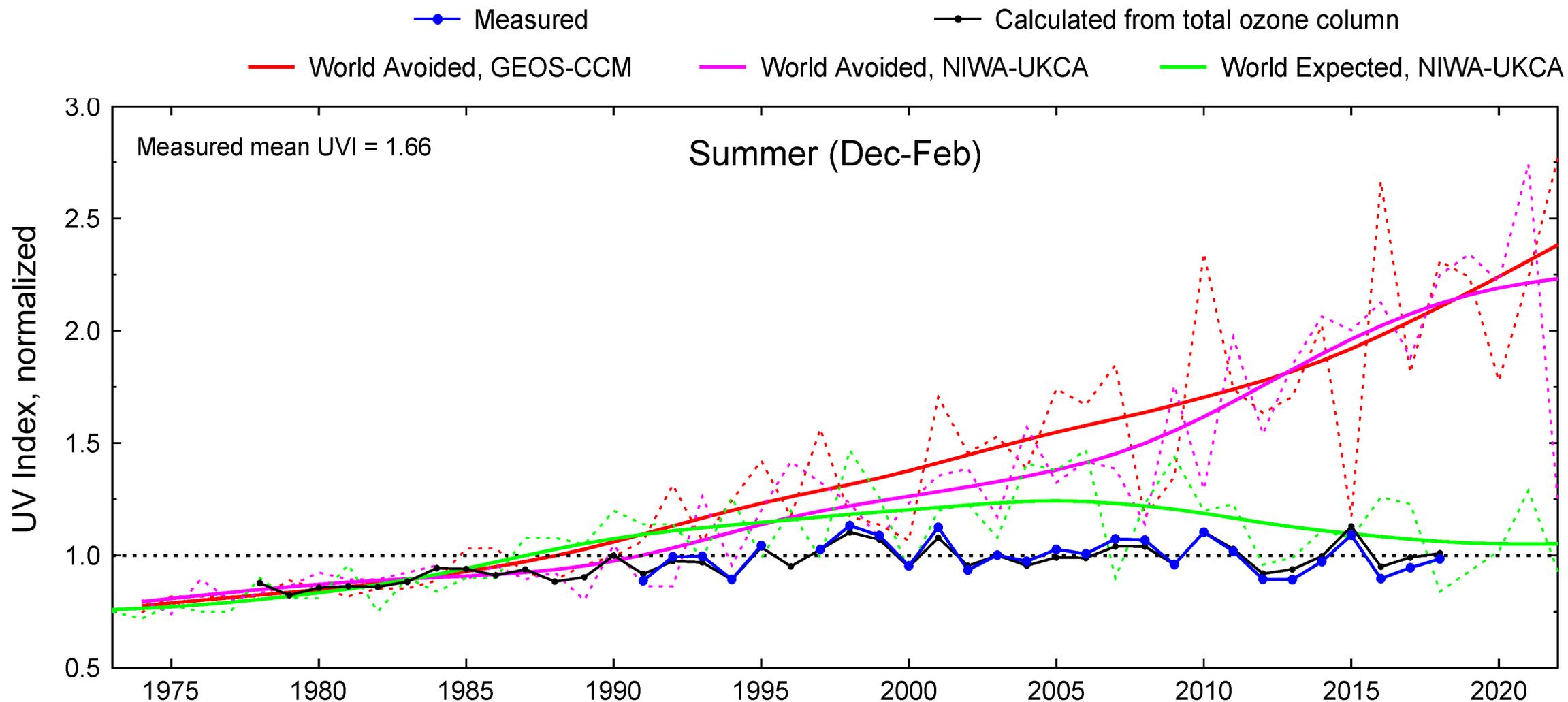
UV Measurements and Projections for South Pole, Spring



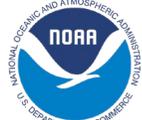
Part of Supplement of McKenzie et al. (2019), doi: <https://doi.org/10.1038/s41598-019-48625-z>.



UV Measurements and Projections for South Pole, Summer



Part of Supplement of McKenzie et al. (2019), doi: <https://doi.org/10.1038/s41598-019-48625-z>.



Decadal UV Index Trends since 1996, Spring

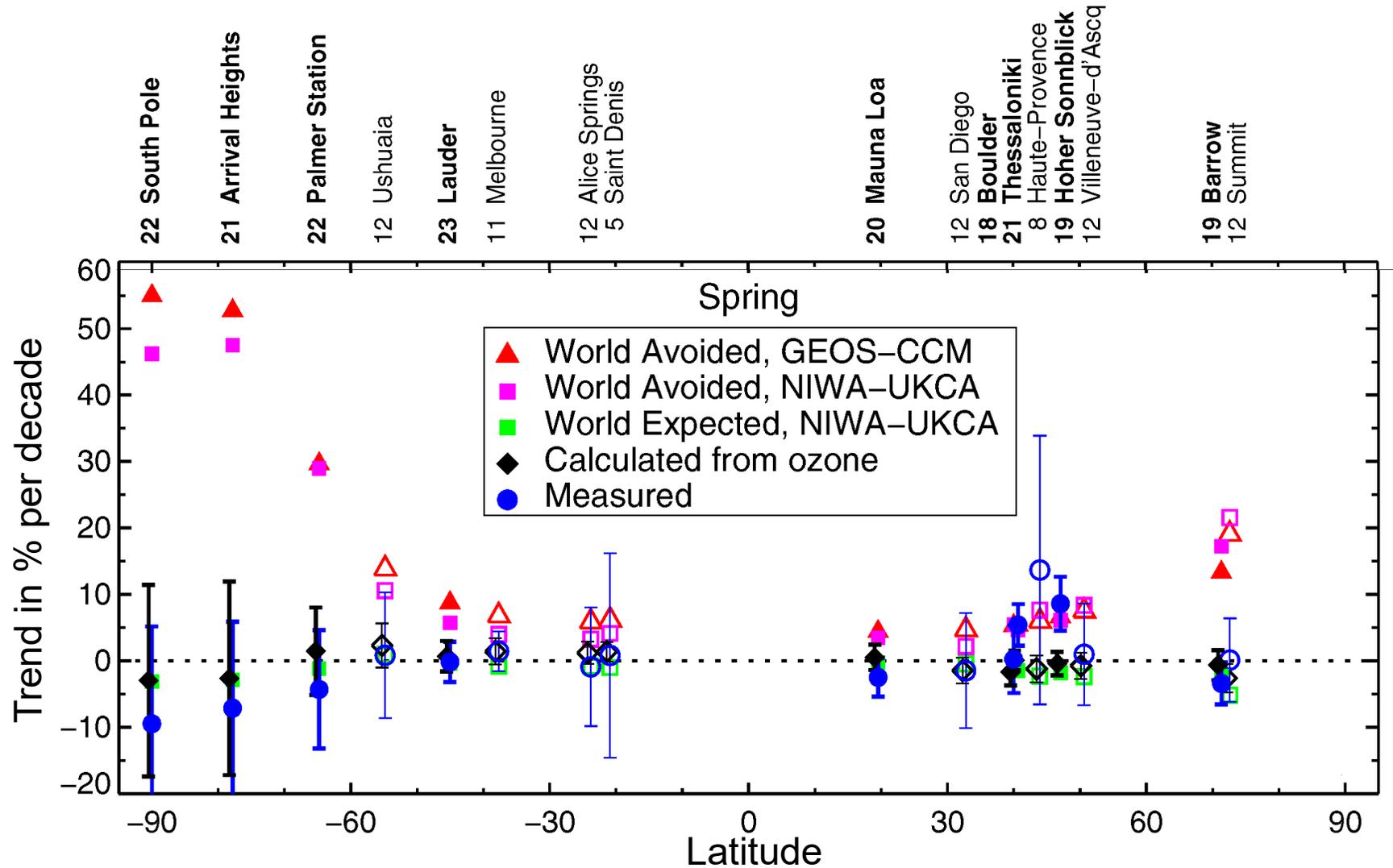
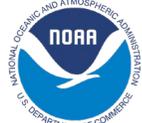
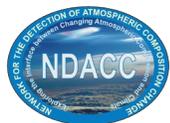


Figure 6 of McKenzie et al. (2019), doi: <https://doi.org/10.1038/s41598-019-48625-z>.



Decadal UV Index Trends since 1996, Summer

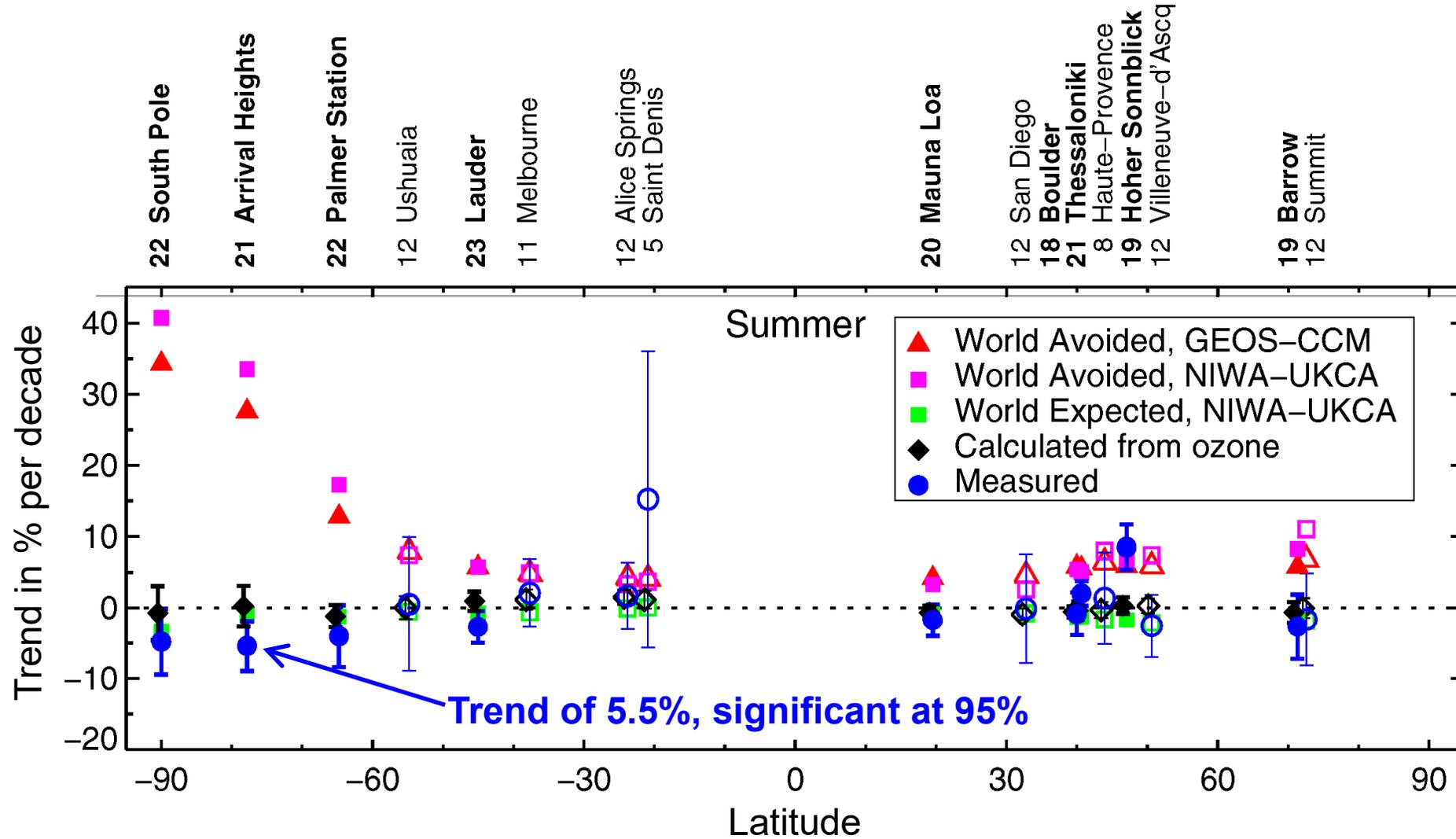


Figure 6 of McKenzie et al. (2019), doi: <https://doi.org/10.1038/s41598-019-48625-z>.



Drift of Calibrations?

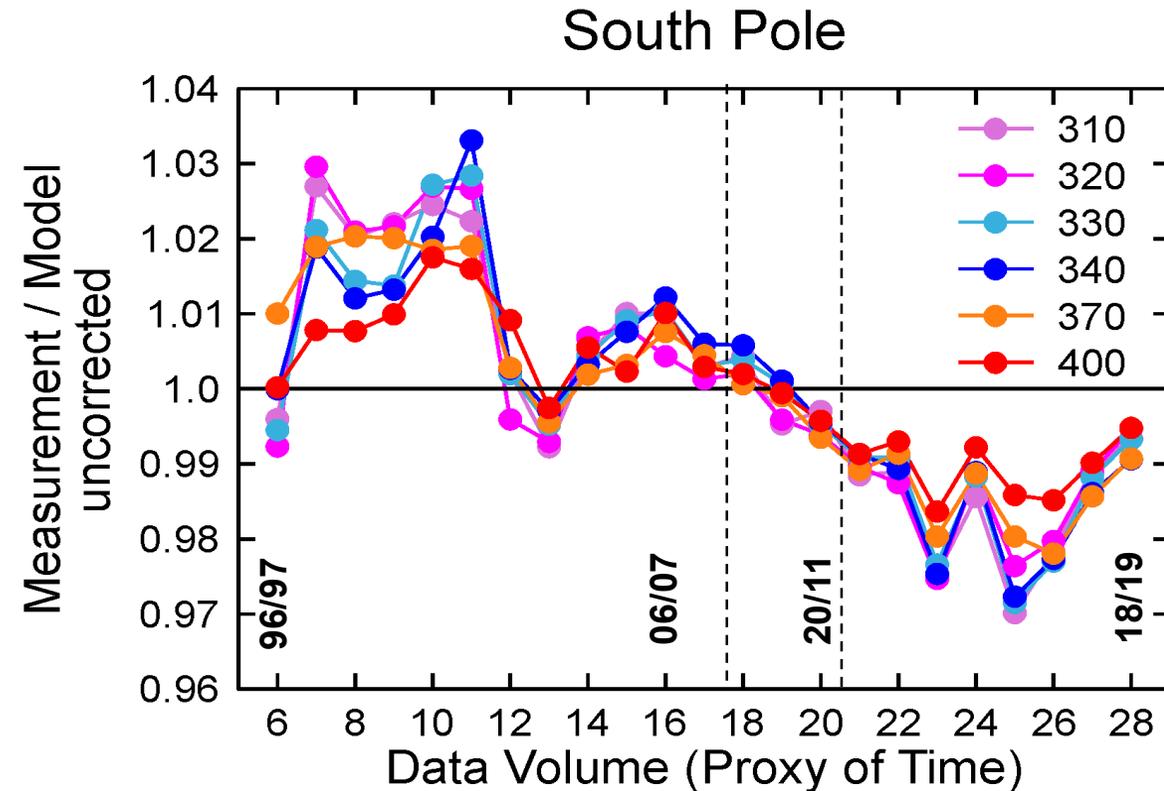
Caveat stated in *McKenzie et al. (2019)* paper:

“We also note that measurements at South Pole, Arrival Heights and Palmer Station are potentially affected by long-term drifts of approximately 1% per decade, which are associated with hardware modifications and changes in calibration standards.”

Ratio of measured and modeled clear sky irradiance is decreasing since ~2006/2007

- Each data point is median of measurement / model of clear sky spectra for each Data Volume
- Model: libRadtran/UVSPEC radiative transfer model
- Model considers: total ozone, ozone profiles, pressure
- Surface albedo and aerosols are fixed

➔ **Decrease in ratio could be explained by drift in calibrations or changes in albedo and aerosols**

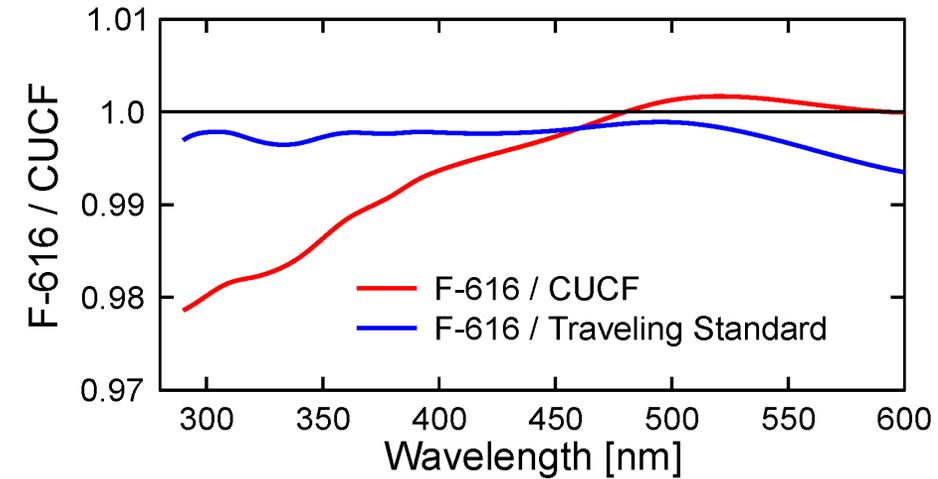
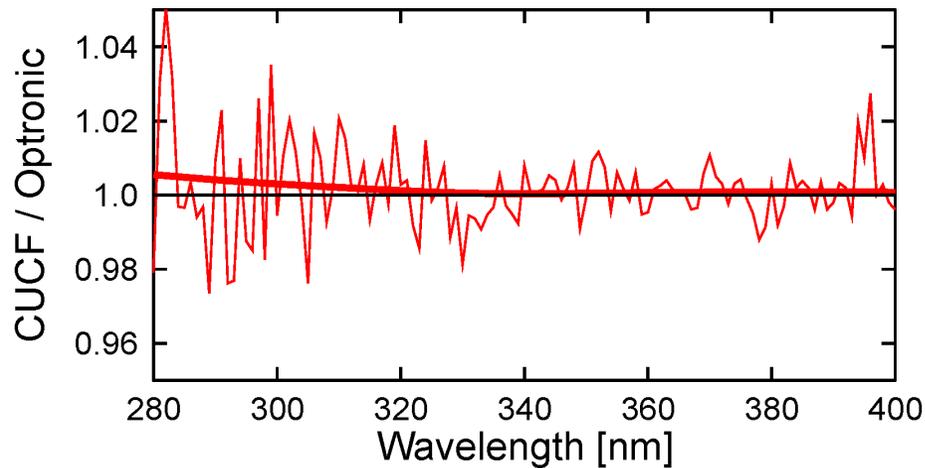


Change in Calibration Scale

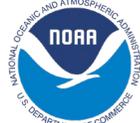
Primary Scale of Spectral Irradiance over time



FEL Lamp



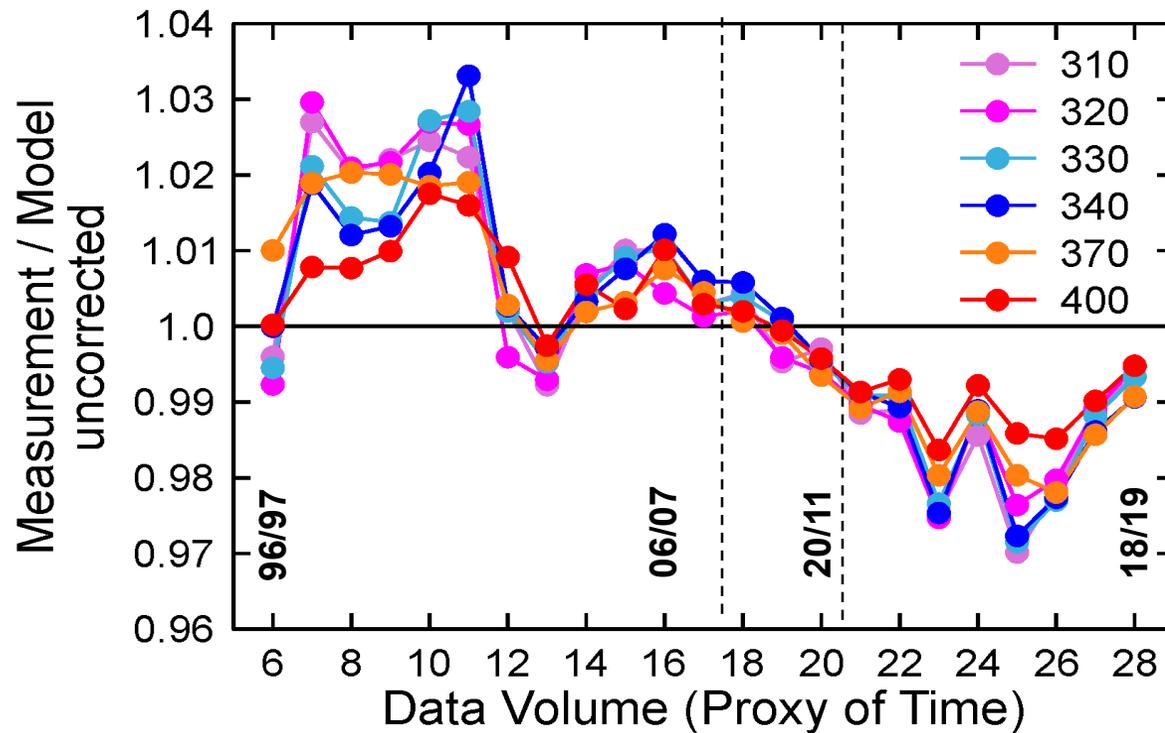
➔ UV Index with F-616 is low by 1.7%



Effect of Correction of Irradiance Scale

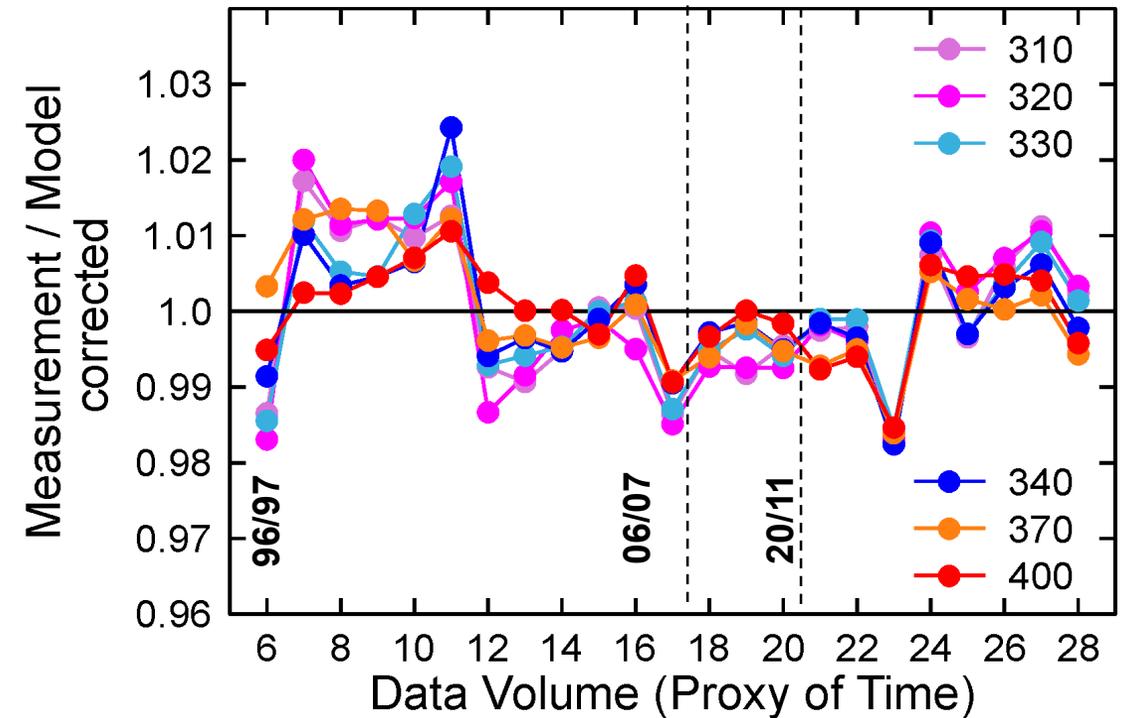
Uncorrected

South Pole

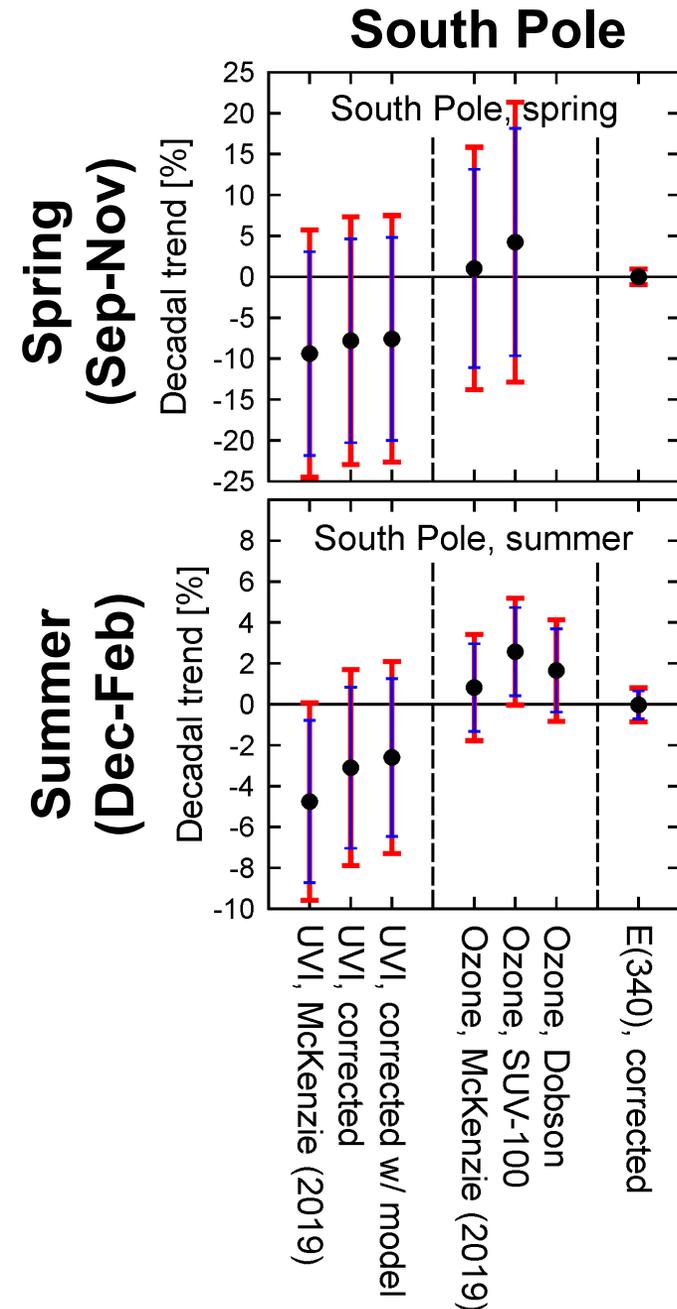


Corrected

South Pole



Trends, recalculated

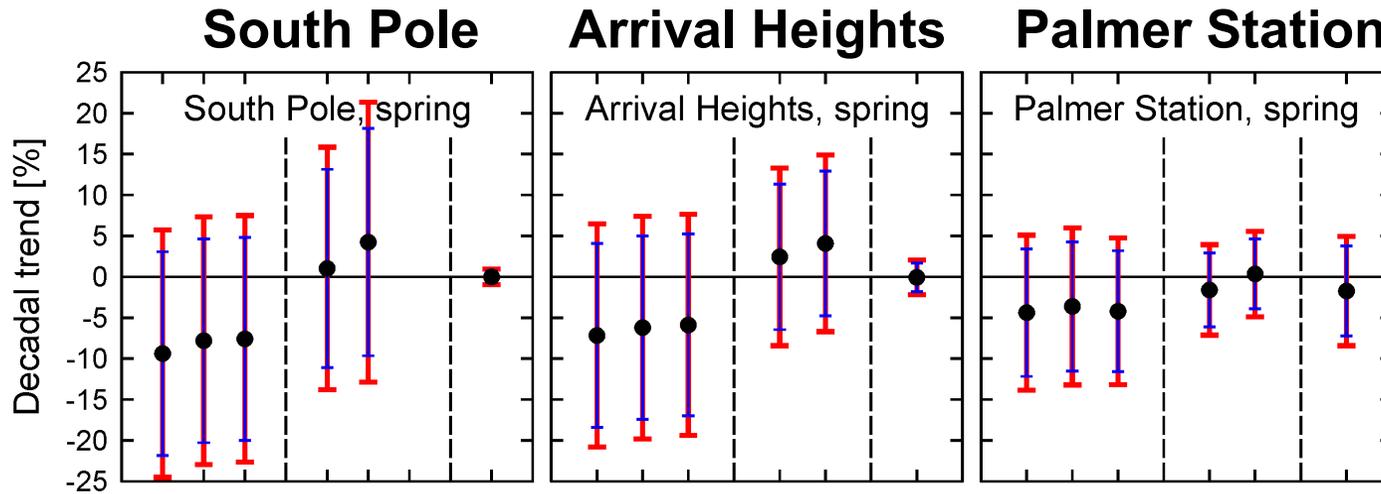


Explanation of datasets

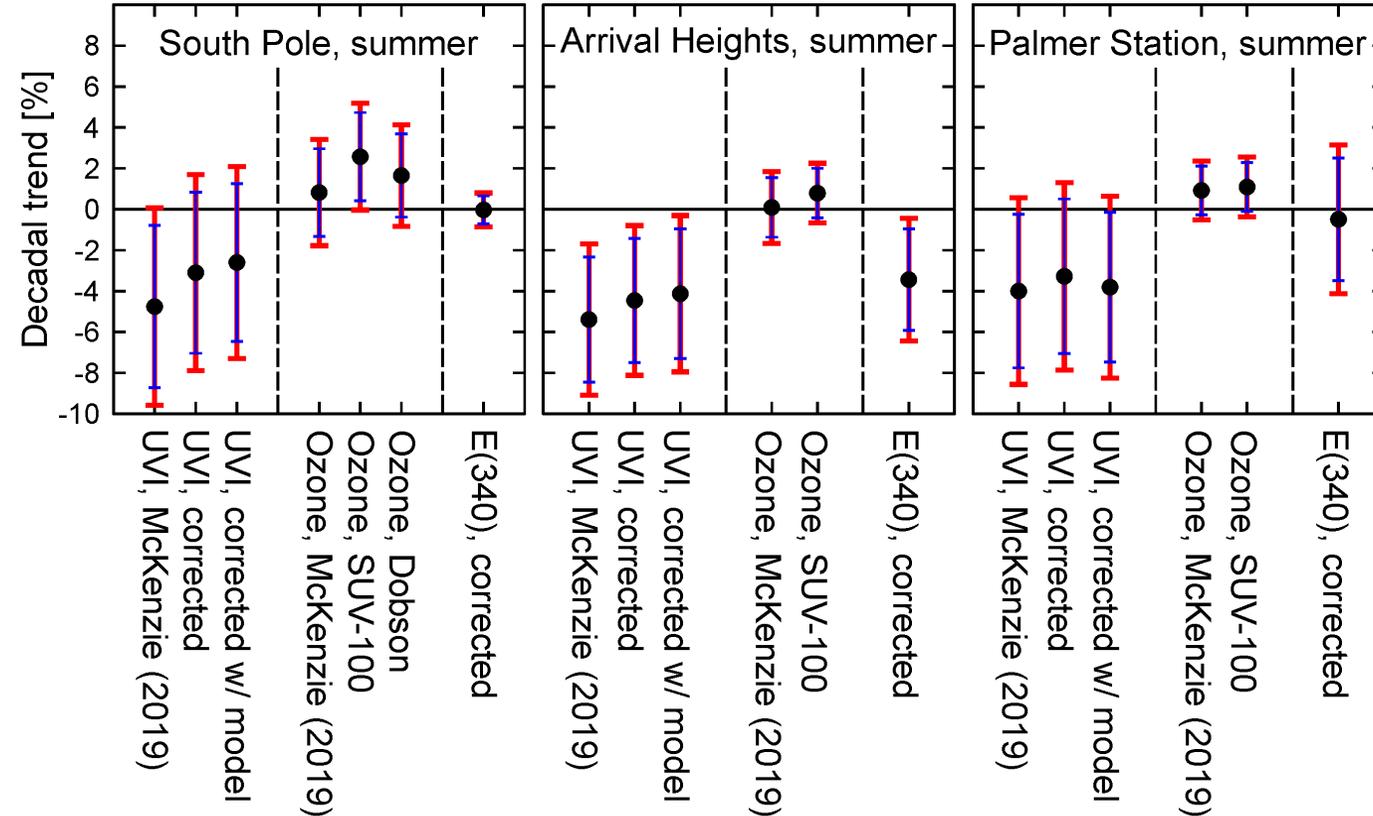
- UVI, McKenzie (2019)
Trend in UV Index as published by McKenzie et al. (2019)
- UVI, corrected
Trend in UV Index, corrected for drift in calibration scale
- UVI, corrected w/ model
Trend in UV Index, corrected using RT model
- Ozone, McKenzie (2019) :
Trend in total ozone data used by McKenzie et al. (2019)
- Ozone, SUV-100:
Trend in total ozone measured by SUV-100 radiometer
- Ozone, SUV-Dobson:
Trend in total ozone measured by Dobson at South Pole
- E(340), corrected:
Trend in spectral irradiance at 340 nm, corrected for drift in calibration scale

Trends, recalculated

Spring
(Sep-Nov)



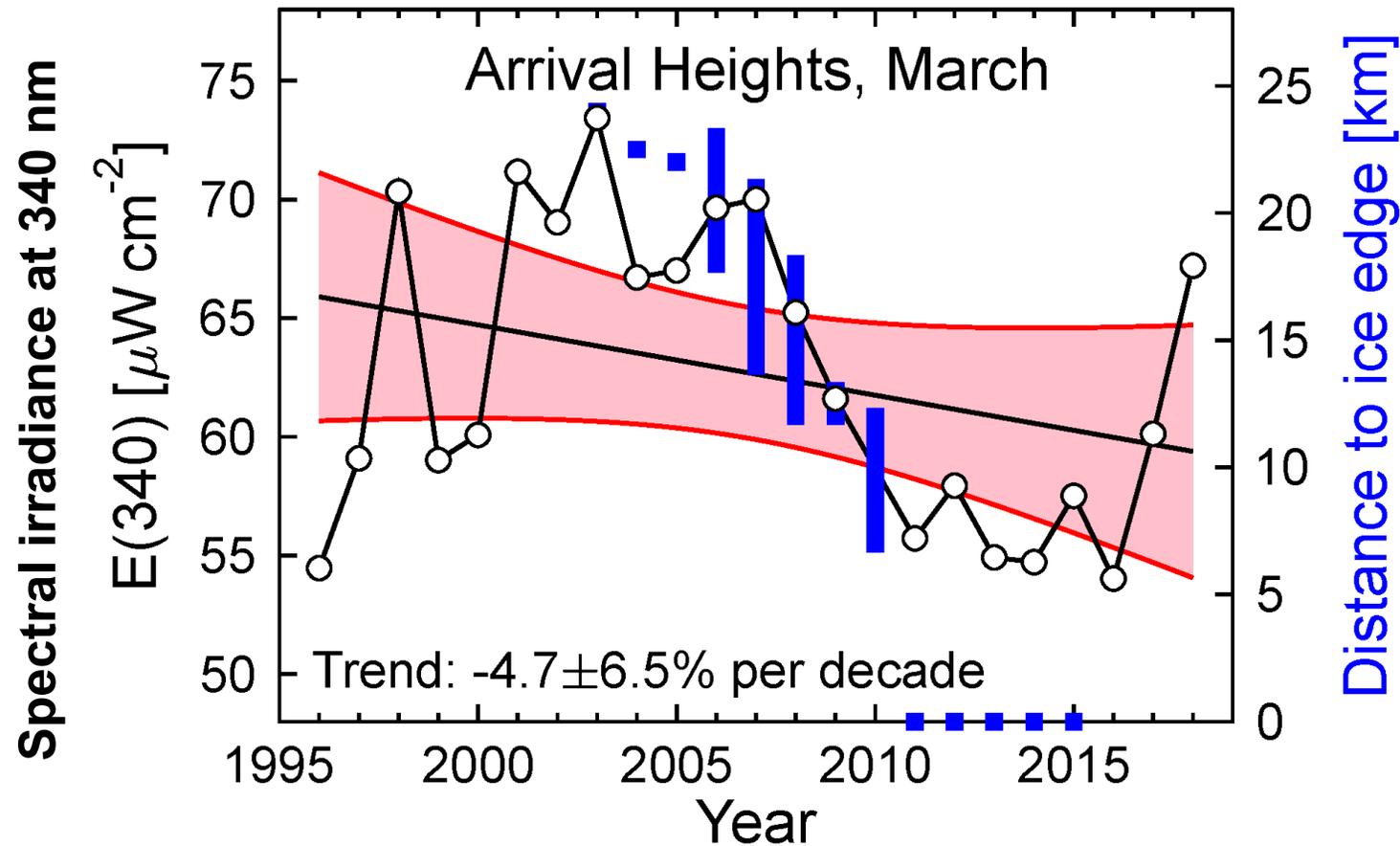
Summer
(Dec-Feb)



Explanation of datasets

- UVI, McKenzie (2019)
Trend in UV Index as published by McKenzie et al. (2019)
- UVI, corrected
Trend in UV Index, corrected for drift in calibration scale
- UVI, corrected w/ model
Trend in UV Index, corrected using RT model
- Ozone, McKenzie (2019) :
Trend in total ozone data used by McKenzie et al. (2019)
- Ozone, SUV-100:
Trend in total ozone measured by SUV-100 radiometer
- Ozone, SUV-Dobson:
Trend in total ozone measured by Dobson at South Pole
- E(340), corrected:
Trend in spectral irradiance at 340 nm, corrected for drift in calibration scale

Effect of Fast Sea Ice on UV Irradiance at Arrival Heights



Distance to ice edge was inferred from Figure 3 of Kim, S., B. Saenz, J. Scanniello, K. Daly, D. and Ainley (2018). Local climatology of fast ice in McMurdo Sound, Antarctica. *Antarctic Science*, 30(2), pp.125-142, doi: 10.1017/S0954102017000578.



Effect of Small Ozone Hole in Spring 2019 on Trends

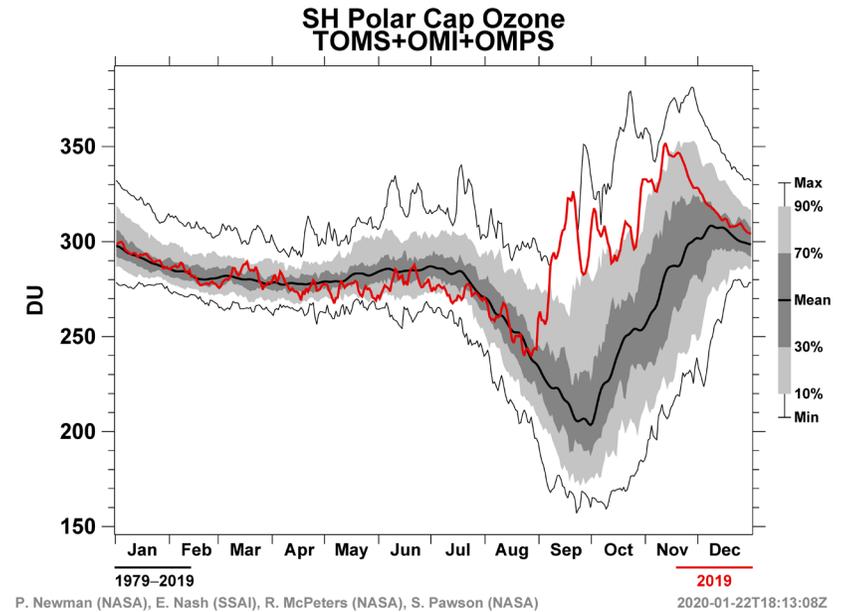


Monday, October 21, 2019

2019 ozone hole smallest on record

Warmth in polar stratosphere limited depletion

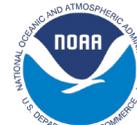
<https://research.noaa.gov/article/ArtMID/587/ArticleID/2566/2019-ozone-hole-smallest-on-record>



<https://ozonewatch.gsfc.nasa.gov>

Decadal Trends, corrected for drift in calibration scale

	Season	Decadal Trend for period discussed by <i>McKenzie et al.</i> (2019)	Decadal Trend for 1996 – 2019/2020
South Pole	Spring	-7.8% ± 15.1%	-10.4% ± 14.4%
	Summer	-3.1% ± 4.7%	-3.5% ± 4.1%
Arrival Heights	Spring	-6.2% ± 13.6%	-7.8% ± 12.1%
	Summer	-4.5% ± 3.7%	-3.9% ± 2.8%



Conclusions

- Results confirmed the study by *McKenzie et al.* (2019) that UV Indices at the three Antarctic sites have been decreasing between 1996 and 2018, but trends for most months are not yet statistically significant.
- Decadal UV Index trends calculated from data corrected for drifts in calibrations are 0.7% – 1.7% smaller than those reported by *McKenzie et al.* (2019).
- For spring (September – November), statistically significant reductions in the UV Index have not yet been detected at any site because the ozone hole leads to large UV Index variability. It will likely take many more years until ozone recovery can be detected in UV data for spring.
- Trends in the UV Index are generally most significant for January and February.
 - At South Pole, significant decadal trends of -4.1% and -3.2% exist for January and February. These negative trends may be partly explained by positive trends in total ozone.
 - At Arrival Heights, a significant decadal trend of -4.5% is observed for summer. It can be explained with a significant upward trend in total ozone of 1.7% per decade for January plus the effect of changes in fast ice covering McMurdo Sound.
- Trends in the UV Index at Palmer station were generally not significant.

