Ultraviolet radiation in the Arctic: an update

Highlights of AON project “Ultraviolet Radiation in the Arctic: 2012-2015” and previous projects

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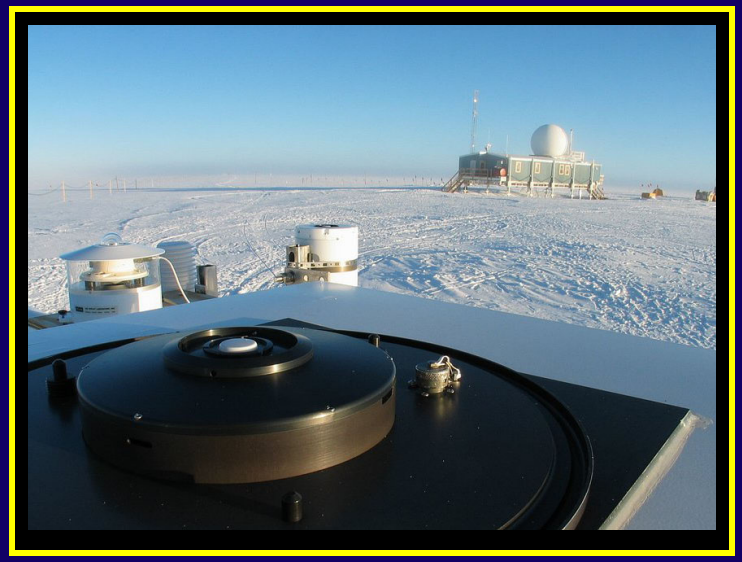
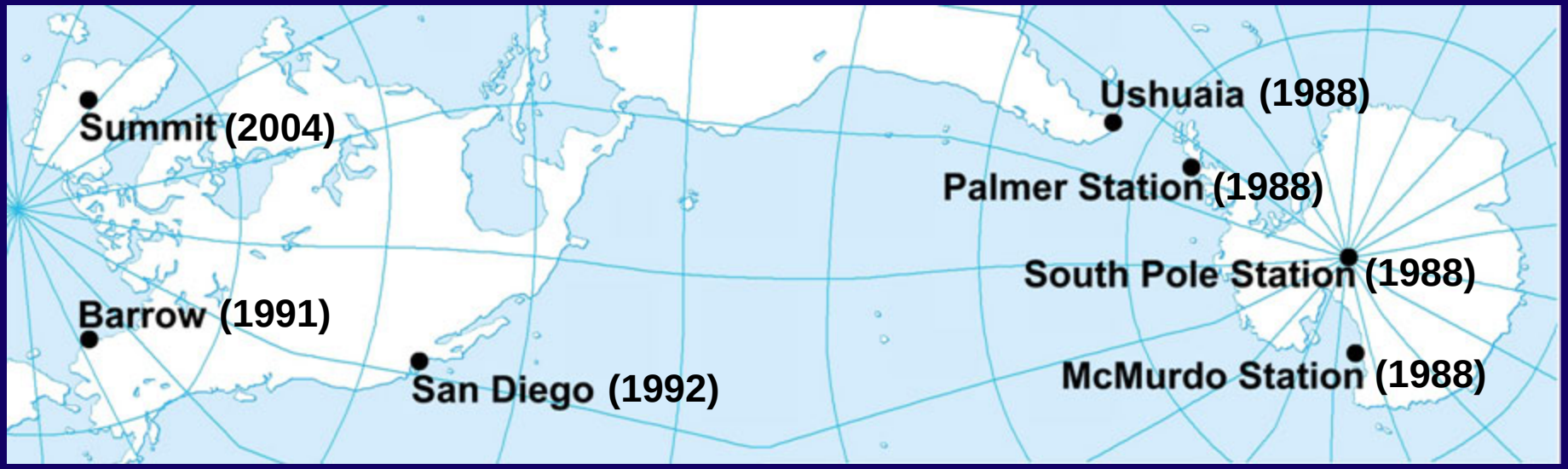


- History
- Instruments
- Data
- Recent results
- Emerging science

History

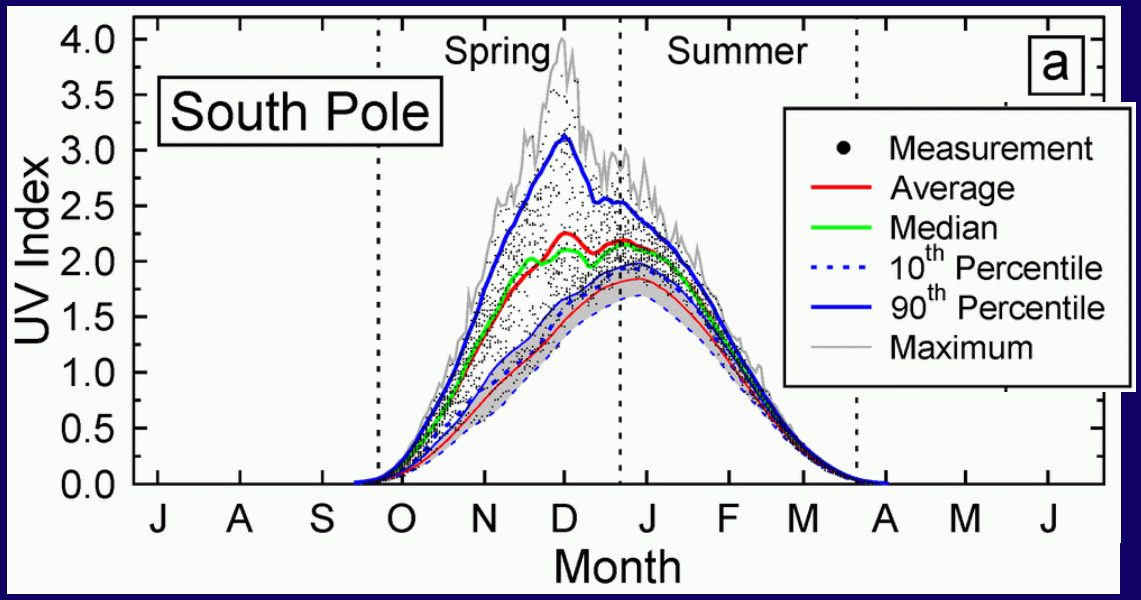


1988: Establishment of the "NSF Office of Polar Programs Ultraviolet Spectral Irradiance Monitoring Network" (UVSIMN)

2009: Barrow and Summit become part of NSF's Arctic Observing Network; McMurdo, Palmer and South Pole Stations become part of NOAA's Antarctic UV Monitoring Network

- Climate Data Records of > 25 years

Example from the South Pole



Bernhard, G., C. R. Booth, and J. C. Ehramjian (2010). Climatology of Ultraviolet Radiation at High Latitudes Derived from Measurements of the National Science Foundation's Ultraviolet Spectral Irradiance Monitoring Network, in: *UV Radiation in Global Climate Change: Measurements, Modeling and Effects on Ecosystems*, edited by W. Gao, D. L. Schmoldt, and J. R. Slusser, 544 pp., Tsinghua University Press, Beijing and Springer, New York, ISBN 978-3-642-03312-4.

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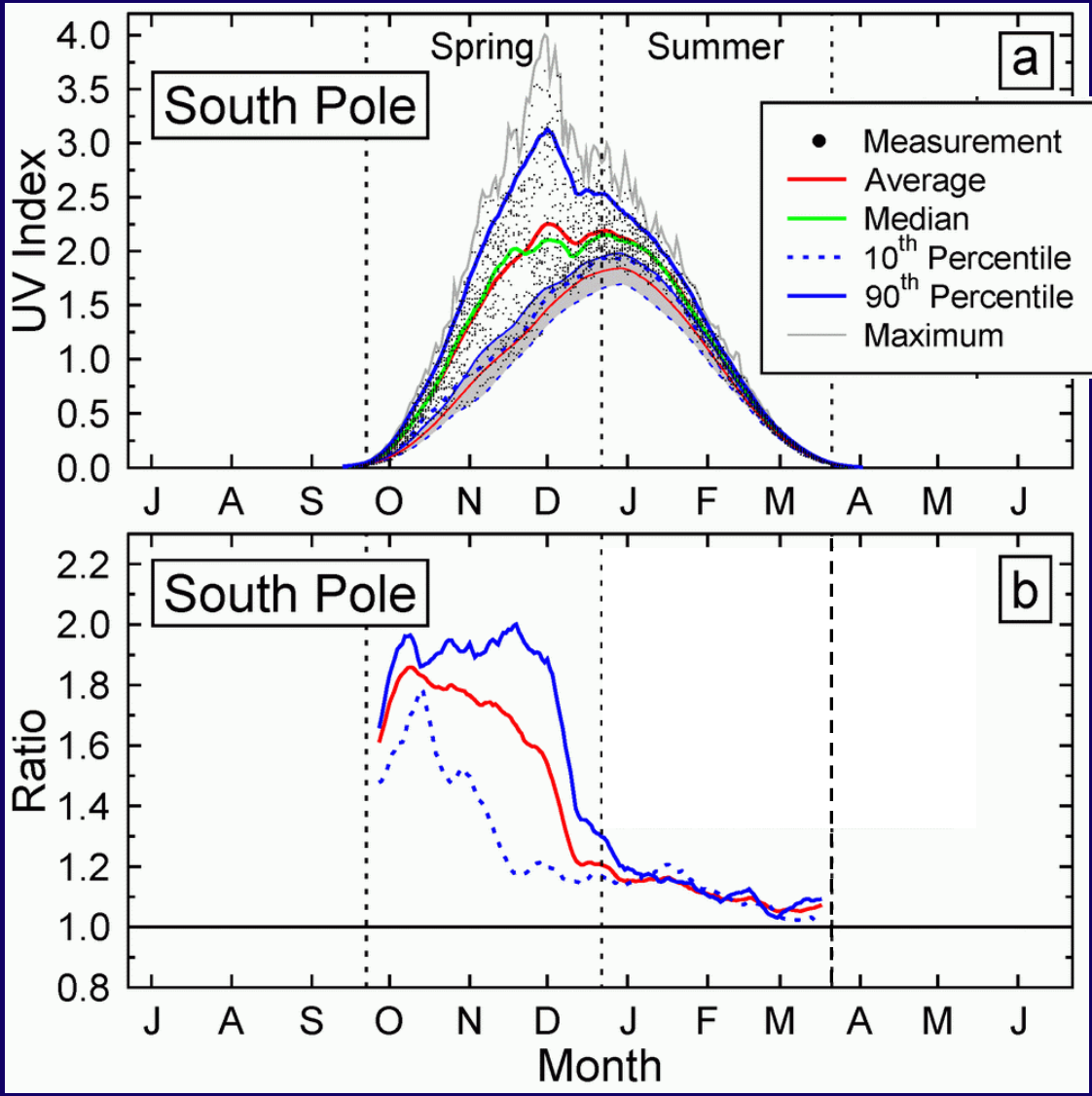

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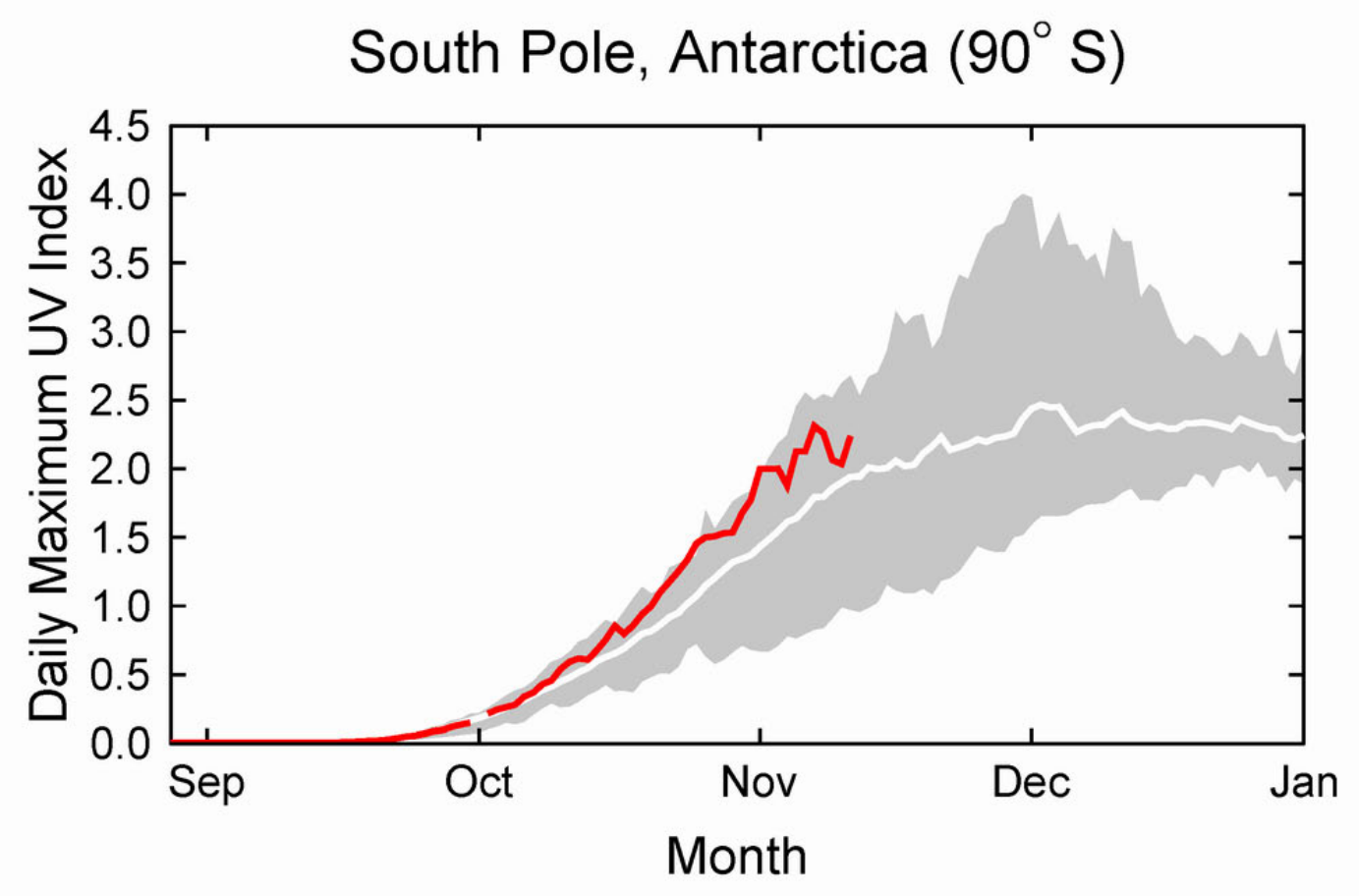
Latest measurements from the South Pole

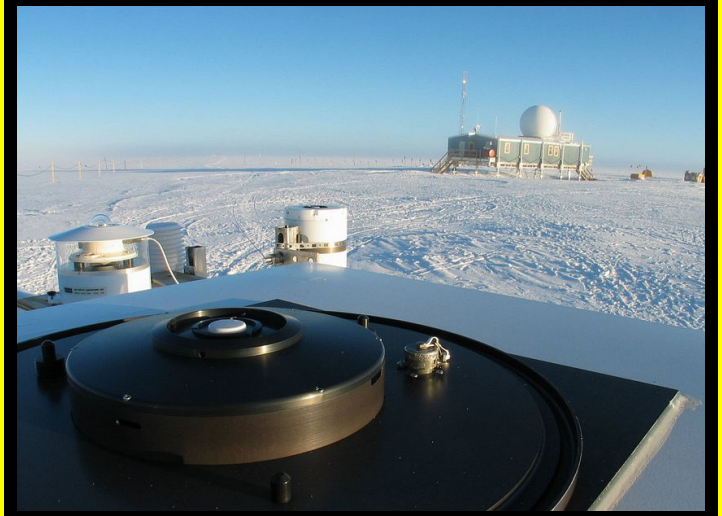


UV Index data from 2009 - 2015 were provided by the NOAA Antarctic UV Monitoring Network.
Measurements before 2009 are from the NSF Polar UV Monitoring Network.

Instruments

Summit

SUV-150B spectroradiometer



- Global spectral irradiance between 280 and 600 nm
- 0.63 nm resolution

Barrow

SUV-100 spectroradiometer

- Global spectral irradiance between 280 and 600 nm
- 1 nm resolution

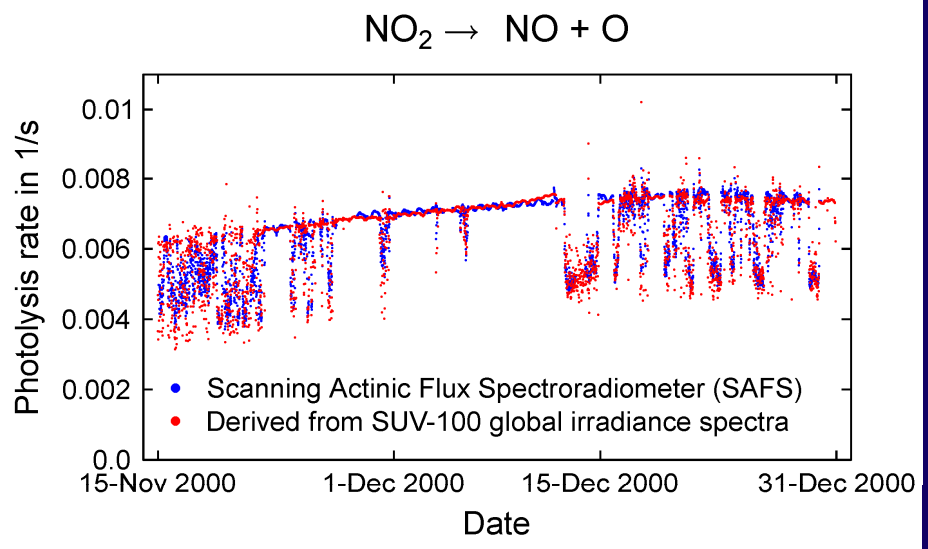
Data

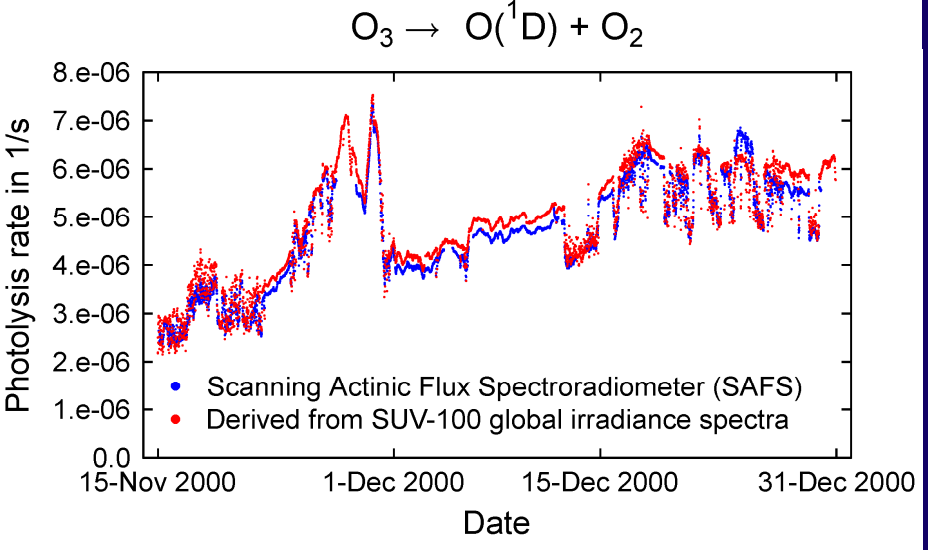
- Global spectral irradiance
- Biologically effective radiation levels (UV Index, Vitamin D, UV-B, UV-A, etc.)
- Total ozone
- Cloud optical depth
- Effective surface albedo
- Actinic flux and photolysis rates [$O_3 \rightarrow O(^1D) + O_2$; $NO_2 \rightarrow NO + O(^3P)$]
- Modeled spectra
- NEW: Ozone profiles (vertical distribution of ozone)

Data available at:

- ✓ ACADIS (https://www.aoncadis.org)
- ✓ Our website (http://UV.biospherical.com)
- ✓ NDACC Data Host Facility (http://www.ndacc.org)
- ✓ World Ozone and UV Data Center (http://woudc.org)

Validation of Photolysis Rates





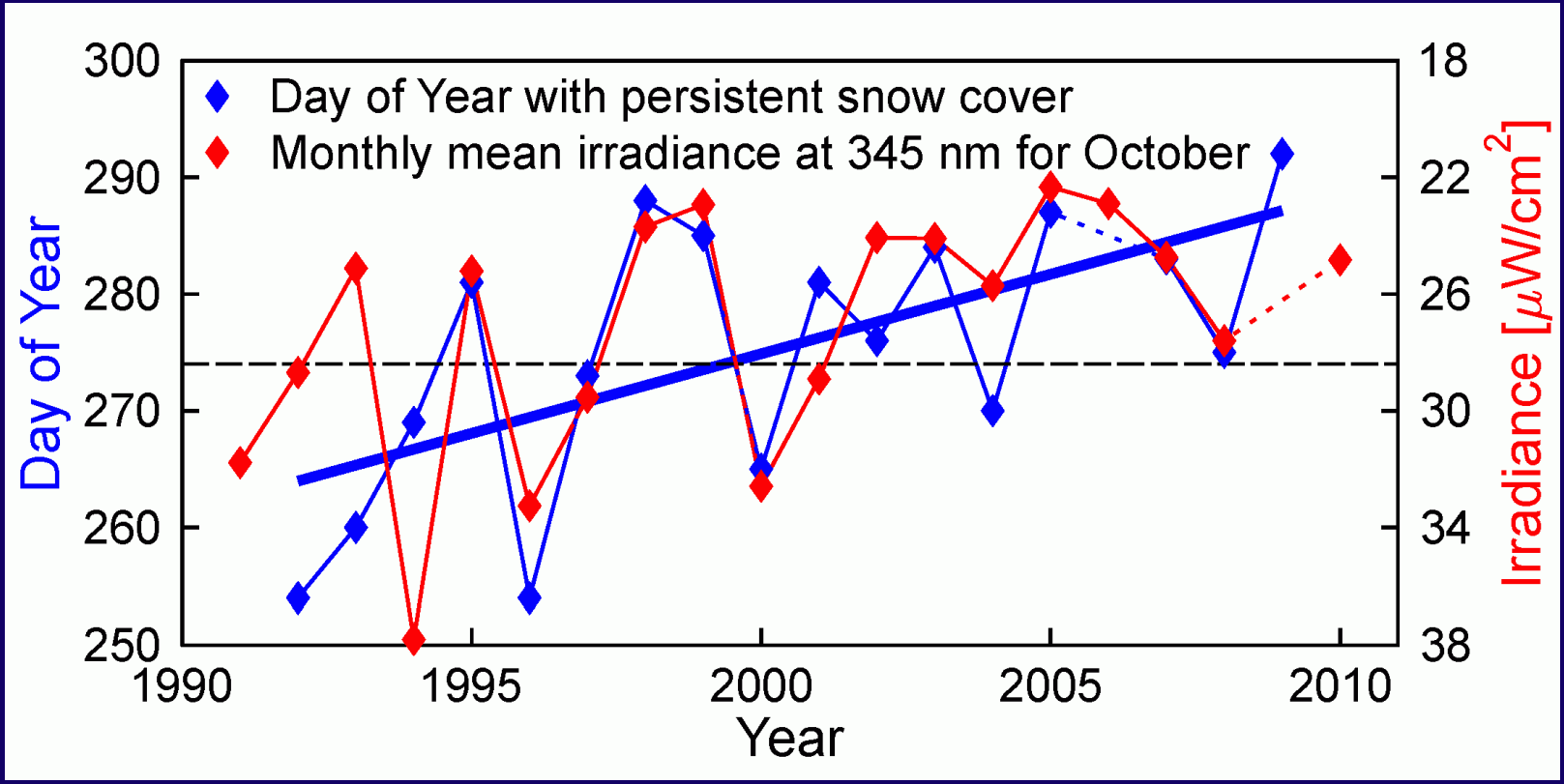
SAFS data were received from Gao Chen, NASA Langley Research Center, and are from the "Sulfur Chemistry in the Antarctic Troposphere" (ISCAT 2000) project that took place at the South Pole in November / December 2000:

Davis, D. D., and 30 co-authors An overview of ISCAT 2000. Atmospheric Environment, 38(32), 5363-5373.

The SAFS instrument is described in:
Lefer, B. L., Cinquini, S. H. L., & Shetter, R. E. (2001). Photolysis frequency measurements at the South Pole during. Geophysical research letters, 28(19), 3637-3640.

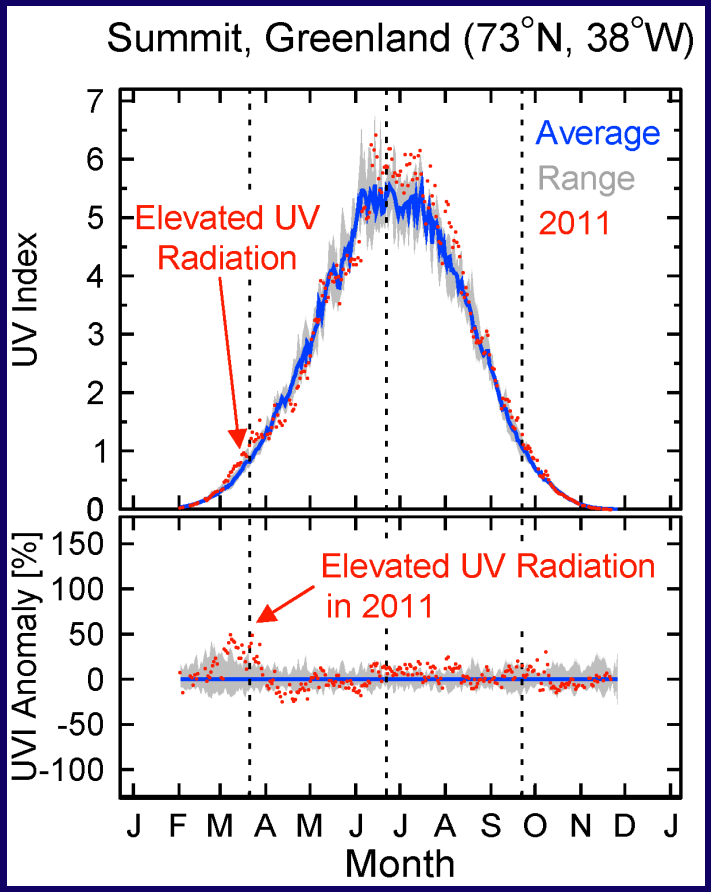
SUV-100 spectra are from the Version 2 data edition.

Recent results:
Change of UV Irradiance at Barrow



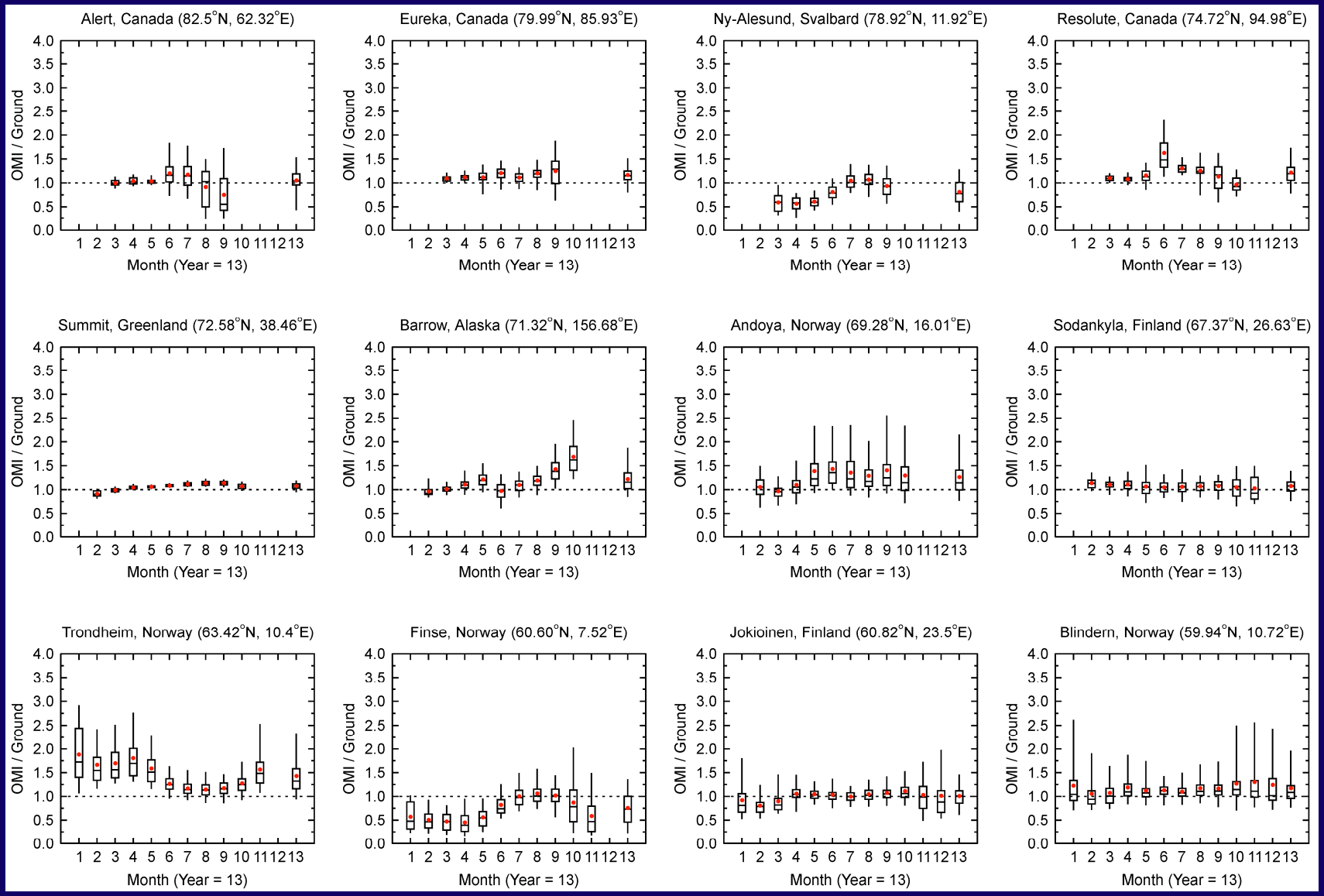
Bernhard, G., (2011). Trends of solar ultraviolet irradiance at Barrow, Alaska, and the effect of measurement uncertainties on trend detection, *Atmos. Chem. Phys*., *11*, 13,029-13,045.

Recent results:
Elevated UV radiation during 2011 Arctic “ozone hole”



Bernhard, G., A. Dahlback, V. Fioletov, A. Heikkilä, B. Johnsen, T. Koskela, K. Lakkala, and T. M. Svendby. (2013). High levels of ultraviolet radiation observed by ground-based instruments below the 2011 Arctic ozone hole, *Atmos. Chem. Phys.,13*, 10,573-10,590.

Recent results: Satellite validation



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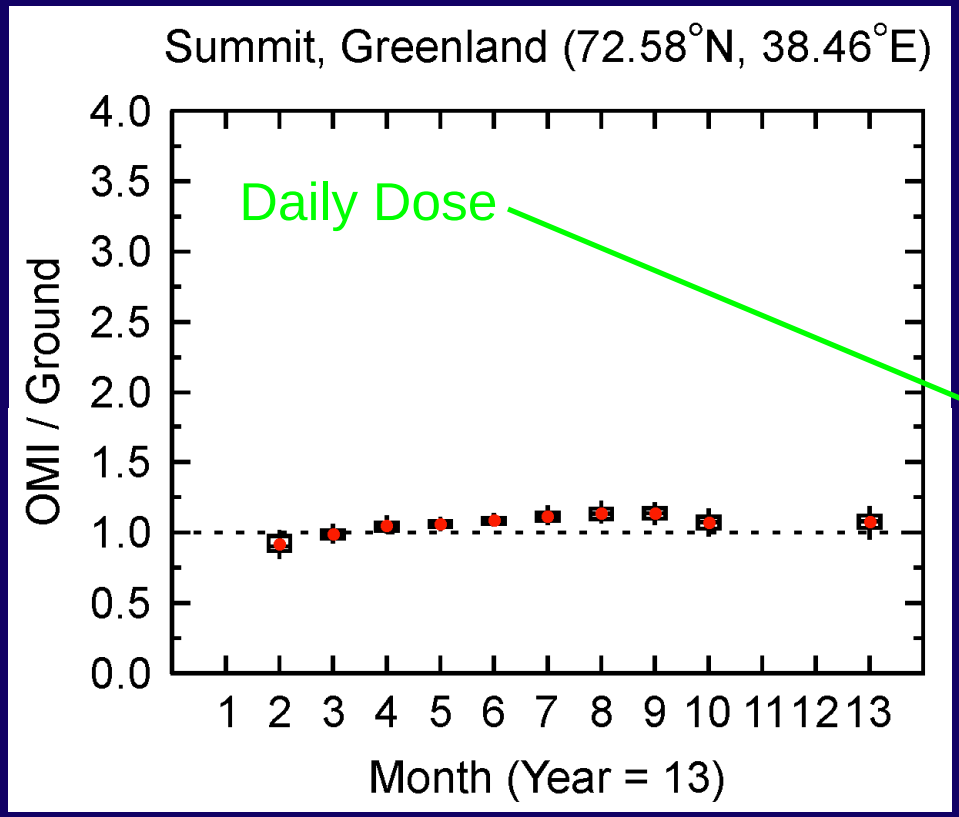
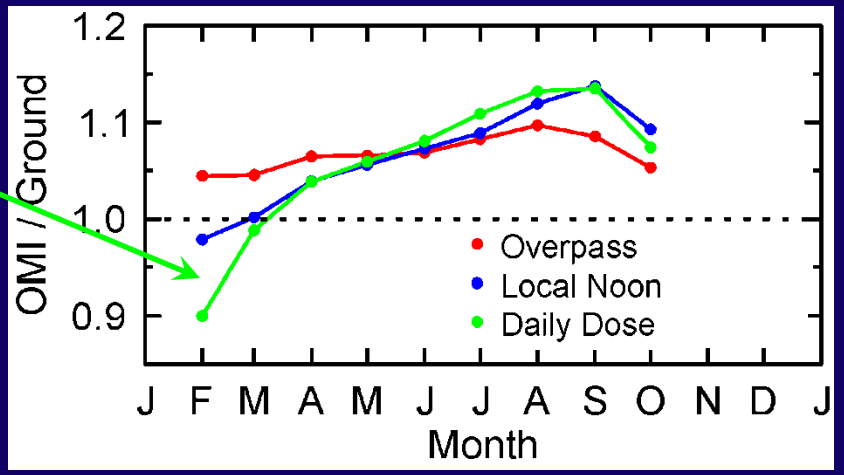
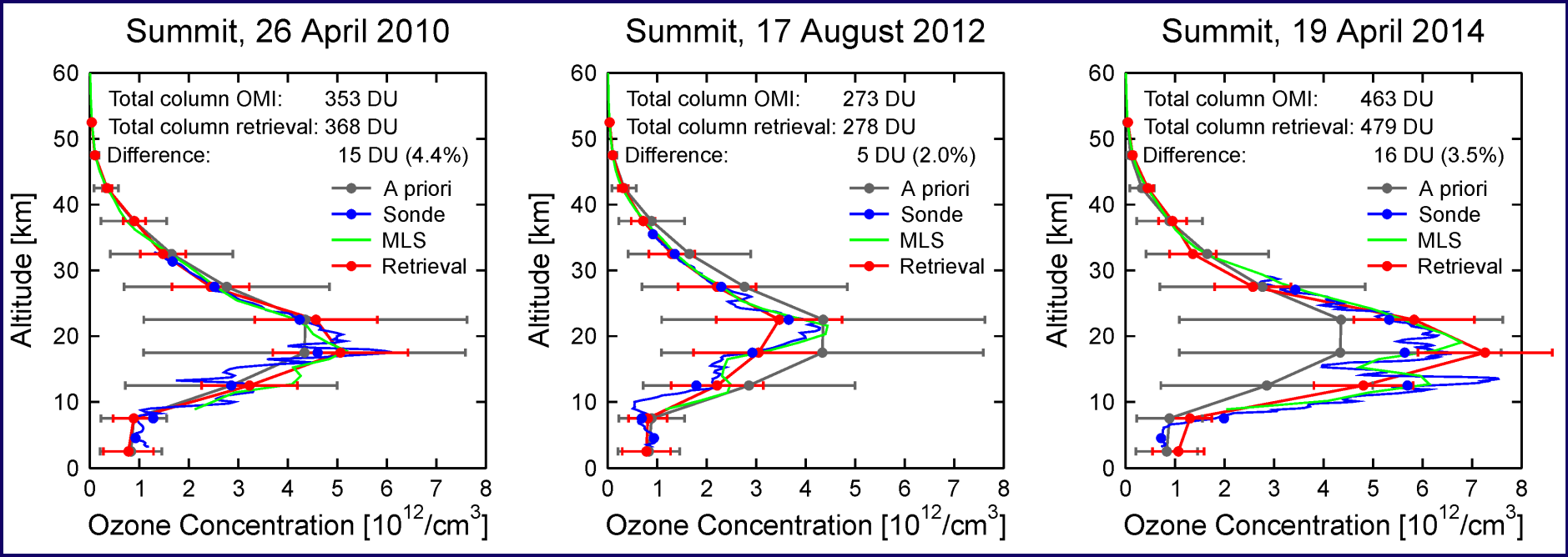




Bernhard, G., A. Arola, A. Dahlback, V. Fioletov, A. Heikkilä, B. Johnsen, T. Koskela, K. Lakkala, T. Svendby, and J. Tamminen. (2015). Comparison of OMI UV observations with ground-based measurements at high northern latitudes, *Atmos. Chem. Phys.*, *15*, 7391-7412.

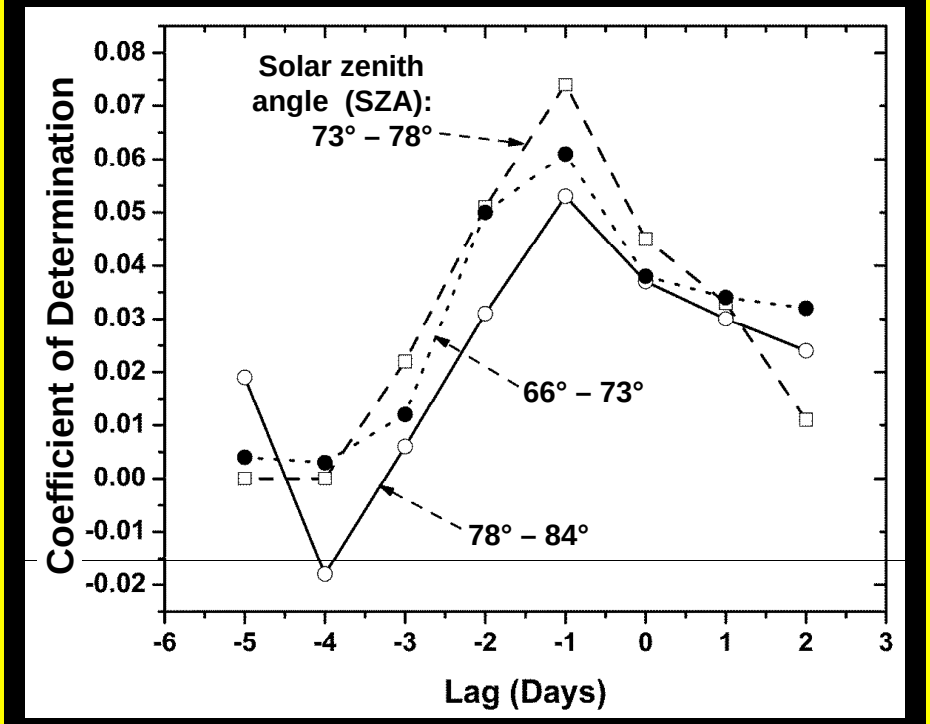
Emerging science:
Umkehr profiles



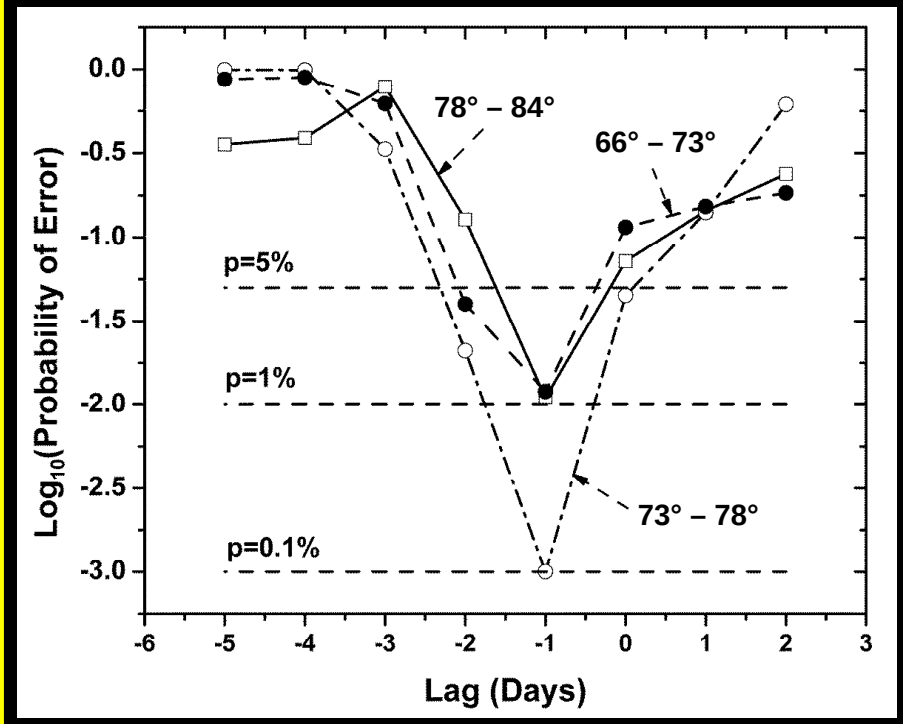
G. Bernhard and I. Petropavlovskikh, Retrieving vertical ozone profiles from measurements of spectral global irradiance, manuscript in preparation.

Emerging science:

Link between geomagnetic activity and atmospheric transmission



Correlation of daily-mean atmospheric transmission with the planetary Ap magnetic index for Ap-values lagged from 5 days before to 2 days after the irradiance ratios.



Probabilities that correlations between daily-mean atmospheric transmission and the planetary Ap index arise by chance.

John E. Frederick, Atmospheric Opacity over Summit, Greenland: Possible Links to Magnetic Activity on Short Time Scales, submitted to *Journal of Atmospheric and Solar-Terrestrial Physics.*

Conclusions ("take-home points")

- A 25 year long Climate Data Record of UV radiation at Barrow is available.
- The 2011 “Arctic ozone hole” led to large increases in UV radiation, and such events may reoccur in the future.
- Estimates of surface UV radiation from space is subject to large (>50%) uncertainties.
- Changes in climate (e.g., snow cover; cloudiness) will drive future UV levels in the Arctic. Ground-based measurements are necessary to quantify these changes in UV radiation.
- Changes in the Earth’s magnetic field have a measurable effect on UV and visible irradiance at Summit and this effect may need consideration in climate models.