

# Modeling Ozone Depletion - TOMS Data (NASA) for Latitude Bands

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# What is/where is TOMS (NASA)?

It is *now* at **ozoneaq**

<http://ozoneaq.gsfc.nasa.gov/>



<http://npp.gsfc.nasa.gov/omps.html>

**Suomi NPP is NASA's next Earth-observing research satellite.**

**Whats in a name: Why Suomi-NPP?** NASA renamed NPP in honor of the late Verner E. Suomi, U. of Wisconsin, recognized widely as "the father of satellite meteorology."

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

Ozone Hole Watch

Images, data, and information for the Southern Hemisphere

Ozone Maps Meteorology Ozone Facts Multimedia Education

# Sample of ozoneaq site



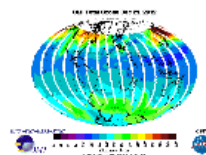
- + Home
- Ozone and Air Quality**
- + Measurements
- + Instruments
- + **Multimedia**
- + Tools
- + News Archive
- + FAQ
- + Documentation
- + Discussion
- + Quality Assessment
- + Known Issues
- + Ozone Hole

## What's New?

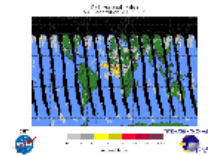
[The new OMPS instrument web site.](#)  
We're still in beta, but take a look!

[New Instrument to Measure Ozone and Other Atmospheric Constituents in Orbit](#)

[Ozone Monitoring Instrument problem](#)



Latest OMI Ozone image

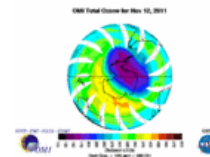


Latest OMI Aerosol image

At this website we provide the results and ongoing data studies for the study of ozone and other gases, aerosols, radiances, and ultraviolet radiation, and what has been learned about atmospheric pollution and air quality from the international science missions making these measurements.

Over 30 years ago scientists first realized that man-made CFCs being released into the atmosphere could destroy large amounts of ozone in the stratosphere through a previously unrecognized catalytic reaction. In recognition of the importance of understanding such atmospheric perturbations, Congress directed NASA in June 1975 to "develop and carry out a comprehensive program of research,

## Spotlight




South Pole ozone hole, 11/02/11 to 12/31/11, as seen by OMI.

## What would you like to look at?

- [Ozone](#)
- [Aerosol](#)
- [Erythemat UV](#)
- [Radiative Cloud Fraction](#)
- [Tropospheric Ozone](#)
- [Ozone Profile](#)
- [Clouds](#)
- [Aerosol Optical Properties](#)
- [SO<sub>2</sub>](#)
  - [NO<sub>2</sub> \(OMI\)](#)
  - [HCHO \(OMI\)](#)
  - [BrO \(OMI\)](#)
  - [OCIO \(OMI\)](#)
  - [Instrument Info](#)

Note: Not all products may be available at this time.


# Sample of Suomi NPP site



National Aeronautics and Space Administration  
Goddard Space Flight Center

[GO](#)

[Flight Projects](#) | [Sciences and Exploration](#)




## Suomi NPP


Suomi National Polar-orbiting Partnership


[About the Mission](#) | [Science and Data](#) | [Ground Operations](#) | [Education and Outreach](#)

### Suomi NPP

- Home
- Mission Details
- Newsroom
- Spacecraft & Instruments
  - Spacecraft Details
- VIIRS
- CrIS
- ATMS
- OMPS**
- CERES
- Gallery
- Meet the Team

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 Like us on Facebook

 See our Flickr Gallery

### Ozone Mapper Profiler Suite (OMPS)

#### OMPS Continues More Than 30 Years of Ozone Data

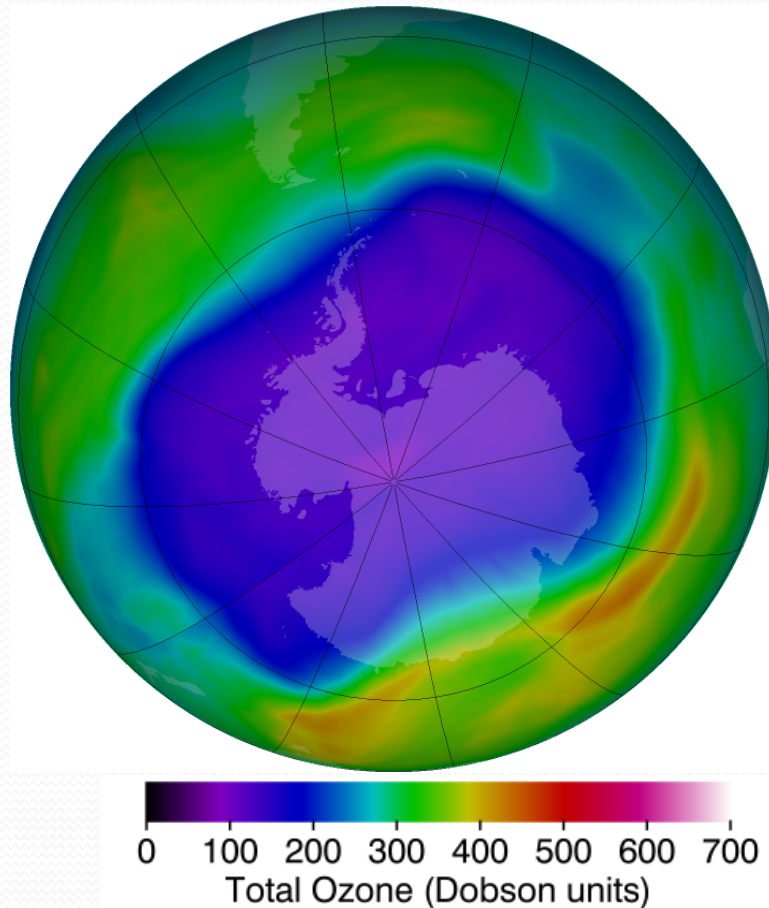
OMPS data will contribute to observing the recovery of the ozone layer in the coming years. The image shows the thickness of the Earth's ozone layer on January 27th from 1982 to 2012. This atmospheric layer protects Earth from dangerous levels of solar ultraviolet radiation.

[+ go to feature](#)

OMPS, an advanced suite of three hyperspectral instruments, extends the 25-plus year total-ozone and ozone-profile records. These records are used by ozone-assessment researchers and policy makers to track the health of the ozone layer. The improved vertical resolution of OMPS data products allows for better testing and monitoring of the complex chemistry involved in ozone destruction near the troposphere. OMPS products, when combined with cloud predictions, also help produce better ultraviolet index forecasts.

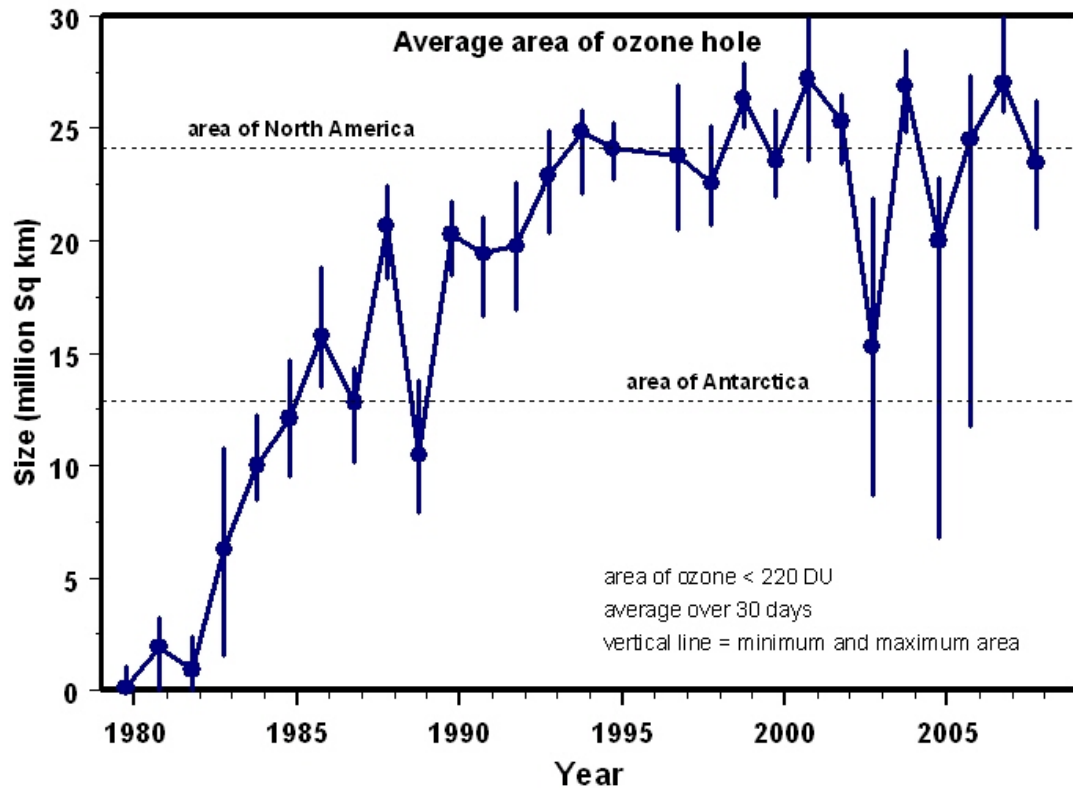
- + **Mass:** 68 kilograms
- + **Average Power:** 108 Watts
- + **Vendor:** Ball Aerospace and Technologies Corp. (BATC), Boulder, CO
- + **OMS Sensor Leads:** Scott Janz (Goddard Space Flight Center), Glen Jaross (SSAI)
- + **Purpose:** To measure the global distribution of O<sub>3</sub> (Ozone) in the stratosphere

From a student favorite site: Ozone Hole Watch  
The largest ozone hole: 24 September 2006.



# another favorite:

## annual ozone hole area



# Where it all began



- Developed : 331,613 - *Integrated Math and Science for Teachers*
  - NASA-NOVA grant.
  - Integrated mathematics, science, and technology
    - pre-service elementary and middle, in-service high school teachers
  - Goals:
    - Strengthen math and science content knowledge
    - Develop understanding of interconnections between math and science
    - Provide experience with innovative teaching strategies
    - Integrate technology to enhance learning and improve instruction
    - Strengthen integration of national science and mathematics standards
    - Use data from NASA Strategic Enterprises to enhance learning
  - Team taught by: Robert Boram, Physical Science; Karen Lafferty, Education; Daniel Seth, Math Sciences

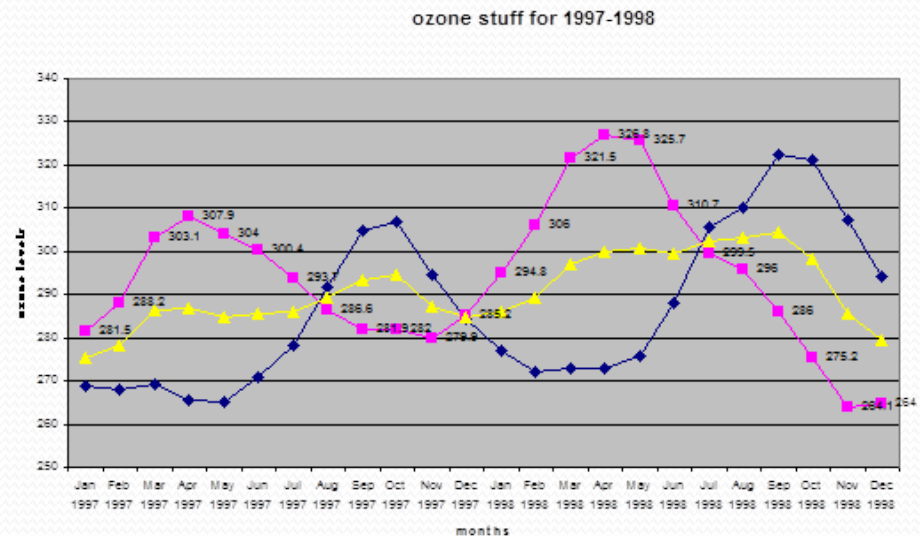


# Classroom Integration - WTAMU

- Courses where Ozone data is integrated. Students make predictions and discuss relevance to their lives and the future of the planet.
  - College algebra – regression : linear functions from real data
  - Math for liberal arts – linear regression models of real data
  - Linear algebra (least squares theory – generalized inverse)
- Future course integrations :
  - Elementary/engineering statistics (get data, analyze it and test regression models)
  - linear algebra lab (get data, develop ozone level models for cities around the world and/or ozone hole area models)
  - Integrated math and science for teachers – collect data and develop models, by groups, for latitude bands

# In-Class Pre-Project to retrieve and plot TOMS data.

- Get ozone data from TOMS (*Total Ozone Mapping Spectrometer instruments*)
- Plot ozone levels for two years for different latitude bands.
- 1997-1998 monthly ozone averages latitude bands:
  - -35 to -30
  - +30 to +35
  - averaged levels



		Jan 1997	Feb 1997	Mar 1997	Apr 1997	May 1997	Jun 1997	Jul 1997	Aug 1997
-35	-30	268.9	267.9	269.4	265.4	265.3	271	278.2	291.6
30	35	281.5	288.2	303.1	307.9	304	300.4	293.7	286.6
average		275.2	278.05	286.25	286.65	284.65	285.7	285.95	289.1

# Ozone Project with NASA TOMS Data

- ***Project goals:***

- Model change in ozone layer over past several years.
- Develop equations modeling annual ozone levels of latitude bands around the earth.
- Predict future ozone levels and climatological changes.

- ***Group Activity:***

- Each group is assigned a latitude band around the earth.
- Determine scatter plots: years vs. average ozone levels, determine least squares regression models, use model equations to predict future ozone levels of the latitude band.
- Collect models for other latitude bands from other groups.

# Ozone Project with NASA TOMS Data

- ***Technology:***

- Ozone data was collected from TOMS ozone data archives

( <http://toms.gsfc.nasa.gov/> ).

- EXCEL - process data, make scatter plots, determine regression model equations
- EXCEL and the TI-83 graphing calculator - make predictions, evaluate the model equations for future time values, in years.

- ***Latitude bands:***

- -70 through -50; -50 through -30; -30 through -10;
- -10 through +10; +10 through +30; +30 through +50;
- and +50 through +70

# Sample Annually Averaged Student Data Set

## NASA TOMS – Latitude band: 50-70

Years	Average
1979	369.2342
1980	371.7791
1981	366.2628
1982	372.6907
1983	356.0907
1984	363.5233
1985	362.3605
1986	355.9326
1987	345.0379
1988	358.9581
1989	359.6186
1990	352.1116
1991	361.9395
1992	347.3927
1993	334.004
1994	358.4429
1996	310.1813
1997	347.2225
1998	366.2214
1999	360.8683
2000	356.1

# Student Displayed Projects

## Math\_Sci 331

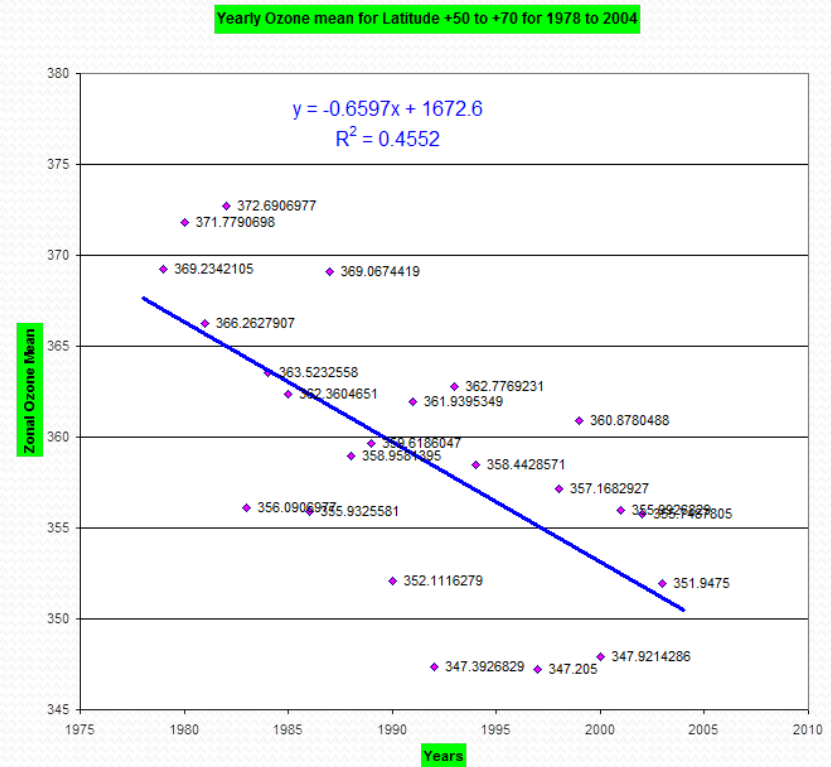
- Ozone Project power point: Bays, Deopke, Roark
- Ozone Project poster: -30 to -10 group
- Ozone Project power point: -10 to +10 group

# Group Projects – Math\_Sci 631

- Latitude Band: +50 to +70
- Model:  $y = -0.6597x + 1672.6$ 
  - R squared value: 0.4552
- Group comments:
  - Between 2009 to 2024, model shows little change in ozone levels. Studies conducted recently by the EPA suggest the opposite is true for this prediction. They have found evidence that the ozone layer is getting thinner in this band.

## • Prediction of Future Ozone Levels

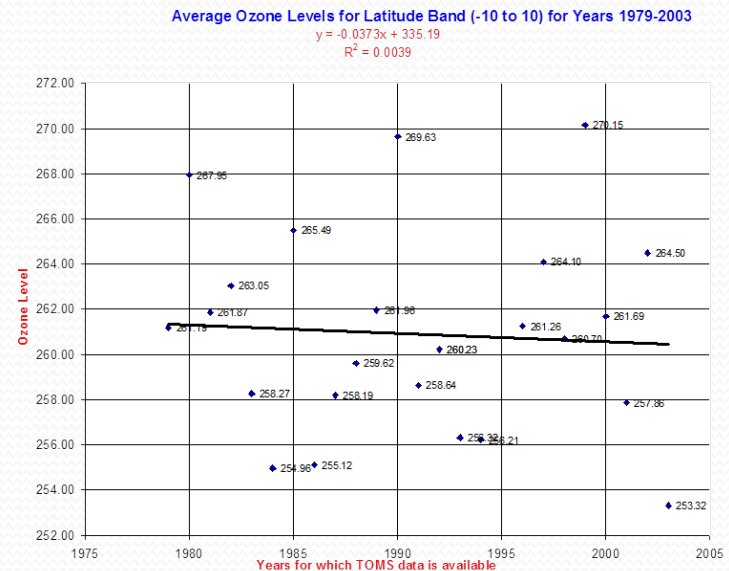
Year	Ozone layer
2009	347.2627
2014	343.9642
2024	337.3672
2054	317.5762
2104	284.5912



# Group Projects – Math\_Sci 631

- Latitude Band: -10 to 10
- Model:  $y = -0.0373x + 335.19$ 
  - R squared value: 0.0039
- Group comments:
  - R value of 0.0039 means that our data has not been modeled very well by our regression equation.
- **Prediction of Future Ozone Levels**

Year	Ozone Level
2009	260.2543
2019	259.8813
2029	259.5083
2054	258.5758
2104	256.7108





# Acknowledgements

- "The data used in this effort were acquired as part of the activities of NASA's Science Mission Directorate, and are archived and distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC)."
- Robert Boram, Department of Physical Sciences, Morehead State University, and I developed the course wherein this material was initially put together. The effort was funded under the NASA NOVA program.

# References

- **ozoneaq** : <http://ozoneaq.gsfc.nasa.gov/>
- **Suomi NPP is NASA's next Earth-observing research satellite** : <http://npp.gsfc.nasa.gov/omps.html>
- **Ozone Hole Watch** : <http://ozonewatch.gsfc.nasa.gov/>
- **TOMS The Total Ozone Mapping Spectrometer (TOMS)** : <http://mirador.gsfc.nasa.gov/cgi-bin/mirador/presentNavigation.pl?tree=project&project=TOMS>
- **Goddard Earth Sciences Data and Information Services Center; Ozone: OVERVIEW** : <http://disc.sci.gsfc.nasa.gov/ozone>