Use of Satellite-Derived Air Pollution Observations to Provide Insight into the Relationship Between Population, Long-Range Transport, and Climate

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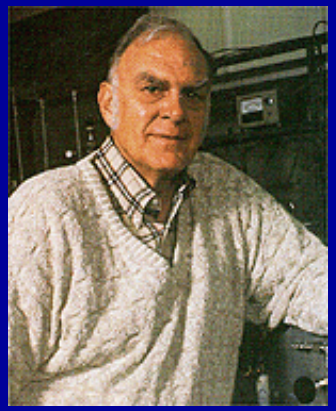
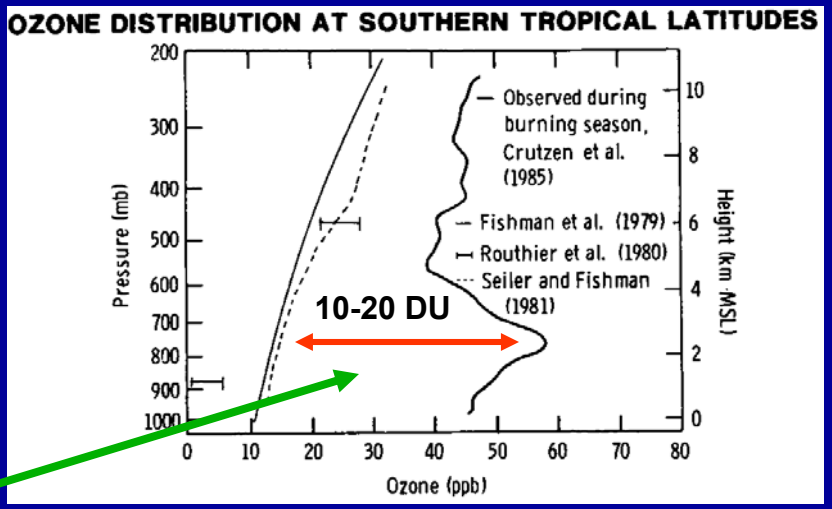
The Origin of Using Satellite Data to Study Tropospheric Ozone Can be Linked to Nobel-Prize Winning Research

from Nobel Prize press release:

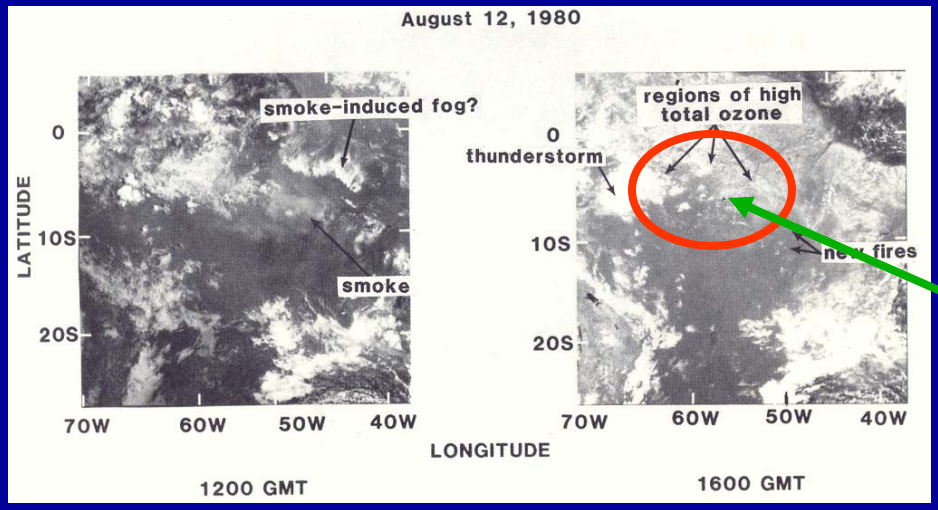
The Royal Swedish Academy of Sciences has decided to award the 1995 Nobel Prize in Chemistry to
Paul Crutzen, Mario Molina and **F. Sherwood Rowland**
for their work in atmospheric chemistry, particularly concerning **the formation** and decomposition **of ozone**.



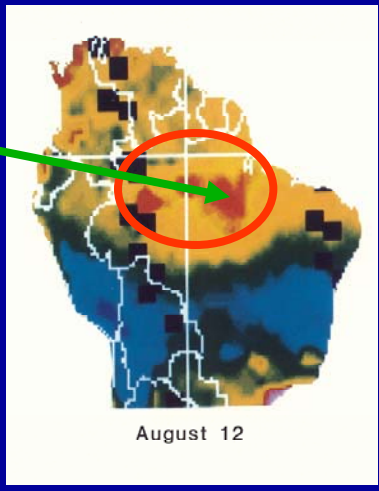
Crutzen made the first comprehensive measurements of trace gases where tropical biomass burning was occurring and found considerably higher concentrations than what had been published previously



Can the 10-20 DU enhancement be identified with TOMS total ozone measurements?

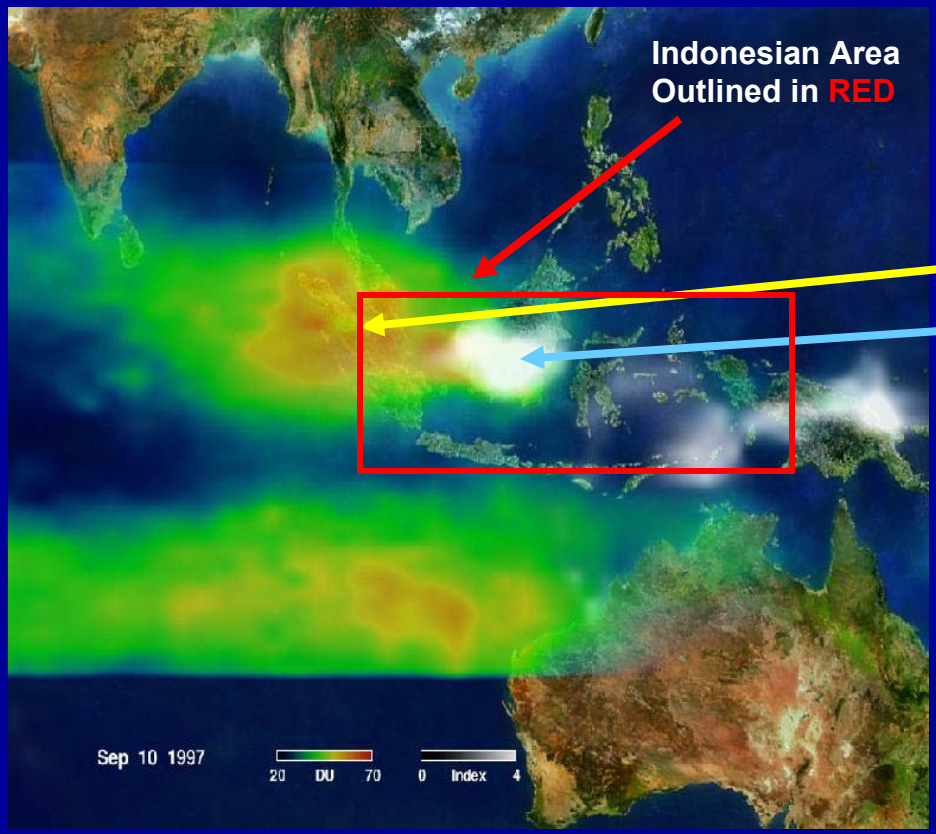


Enhanced **Total Ozone** Observed in Conjunction with **Biomass Burning** in 1980 Episode



(from Fishman, Minnis & Reichle, *JGR* , **91**, 1986)

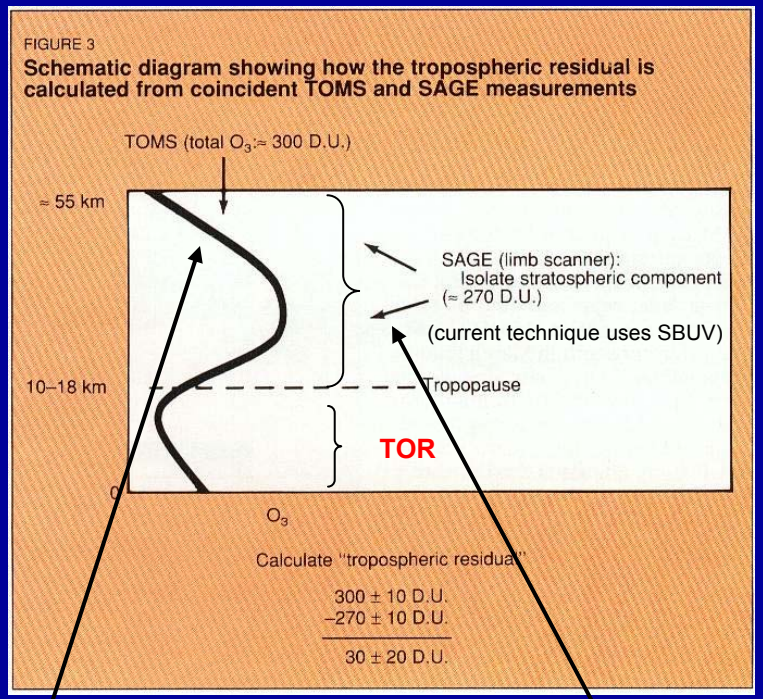
Widespread Burning in Indonesia in 1997 Observed by TOMS



- TOMS data were used to identify ozone* pollution (colors) and smoke (gray) in the tropics
- Burning was determined to be related to ENSO (Thompson et al., 2001)

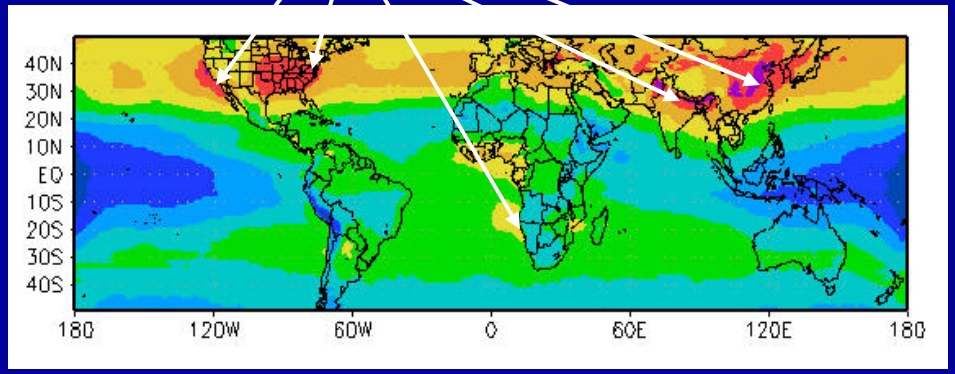
*Ozone Data Product Generated by Separating Stratosphere from Troposphere

Global Distribution of Tropospheric Ozone Residual (TOR) Identifies Several Regions of Enhanced Photochemical Smog

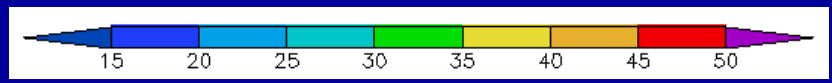


TOR Technique:
TOMS Total O3 – SCO (from SBUV)

Regional "Hotspots" of Tropospheric Ozone



Dobson Units (DU)

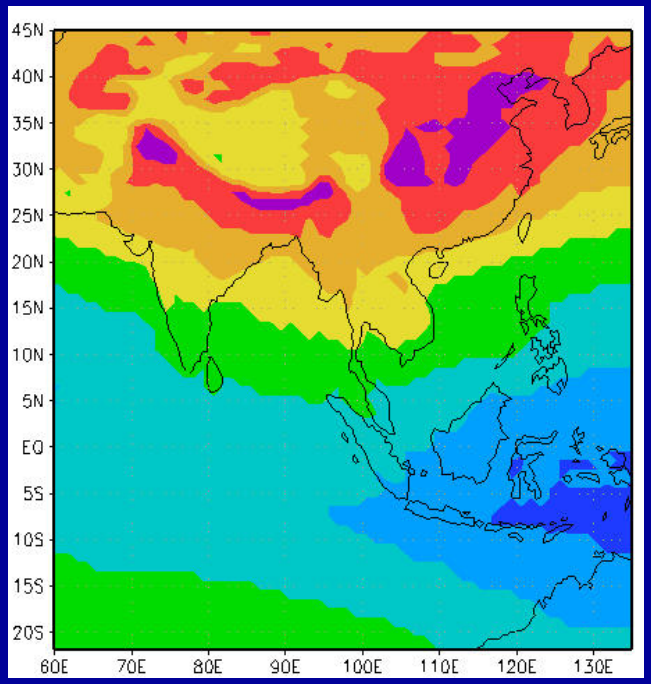


Tropospheric Ozone Residual (TOR) JJA 1979-2000

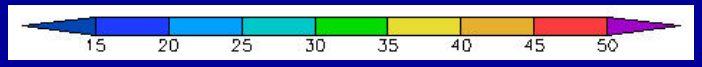
(From Fishman et al., 2003)

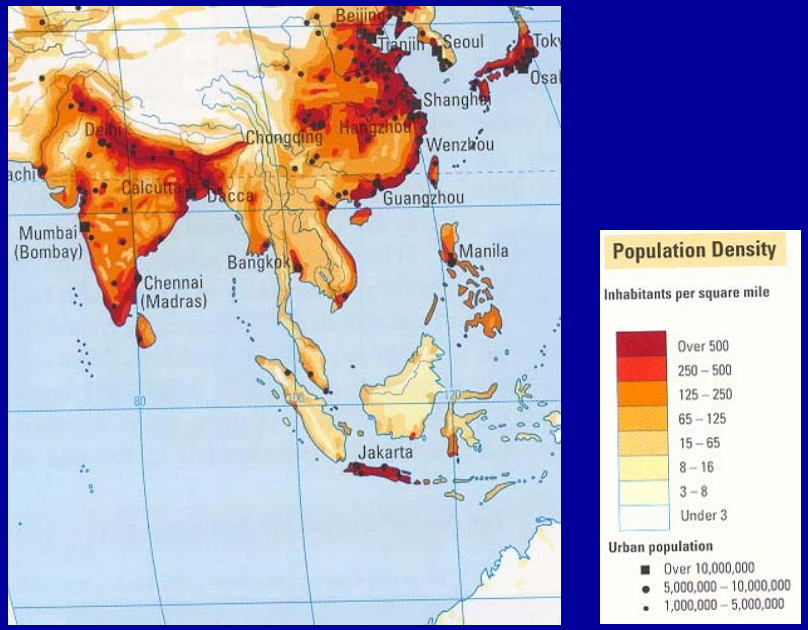
Asian Air Pollution and El Niño

Population and Ozone Pollution Strongly Correlated in India and China



Summer Climatological Tropospheric Ozone

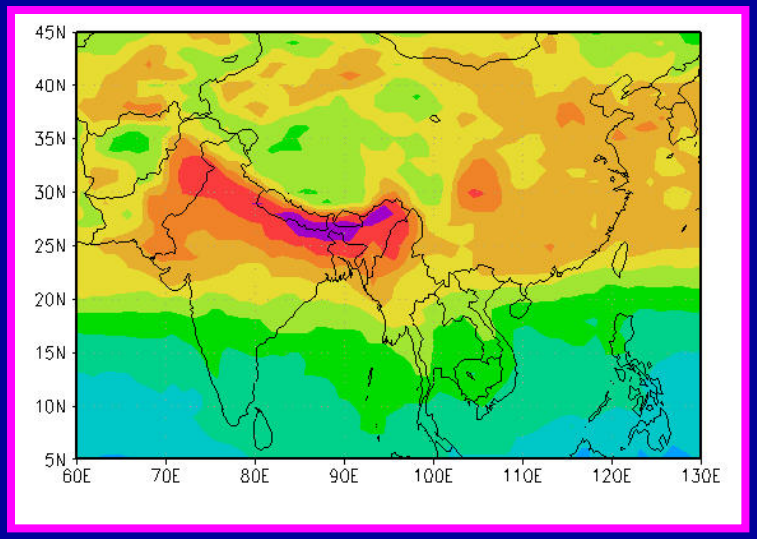




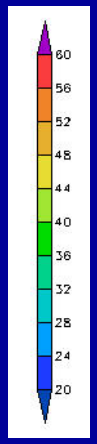
Population Density

Asian Pollution Event Stronger than Historic 1988 Eastern United States Episode

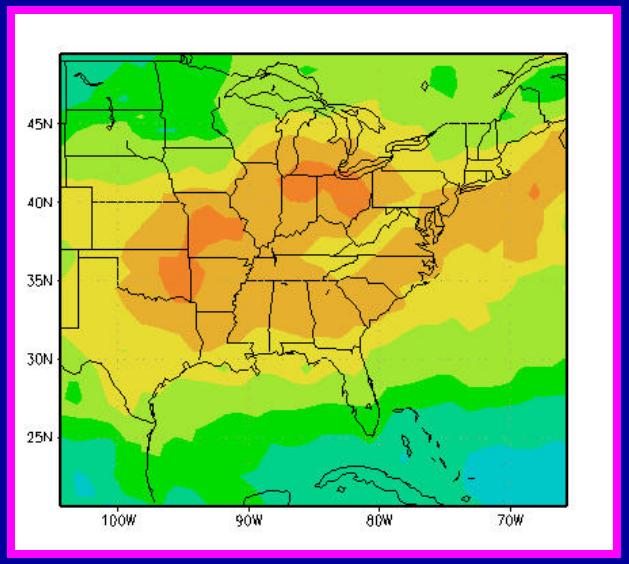
Monthly Depictions



TOR June 1982

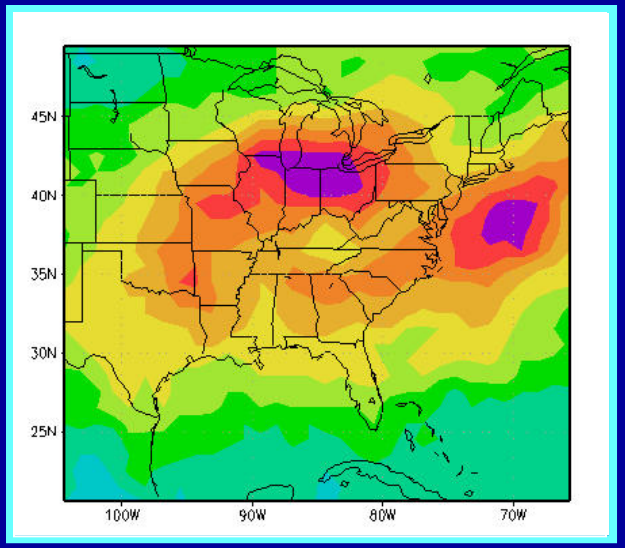


Dobson Units (DU)

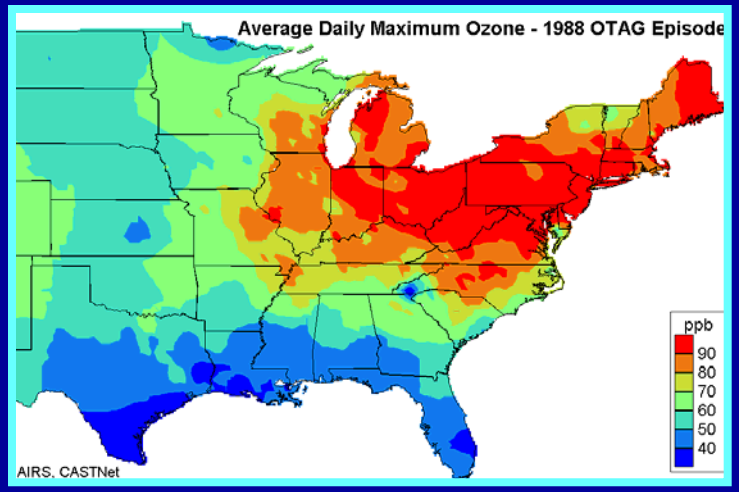


TOR July 1988

Episodic Depictions

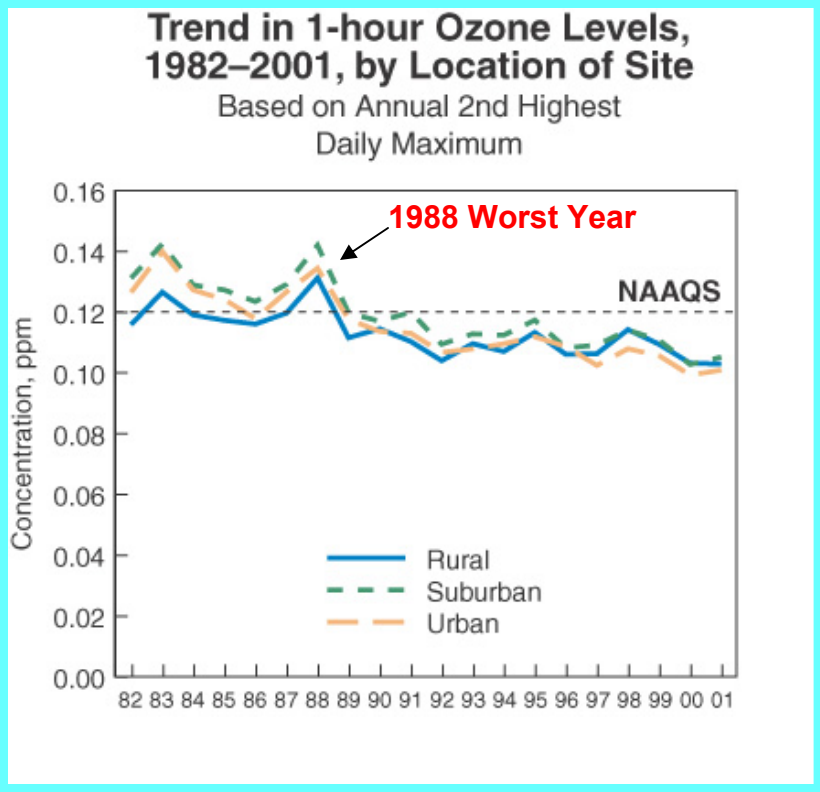


TOR July 3-15 1988

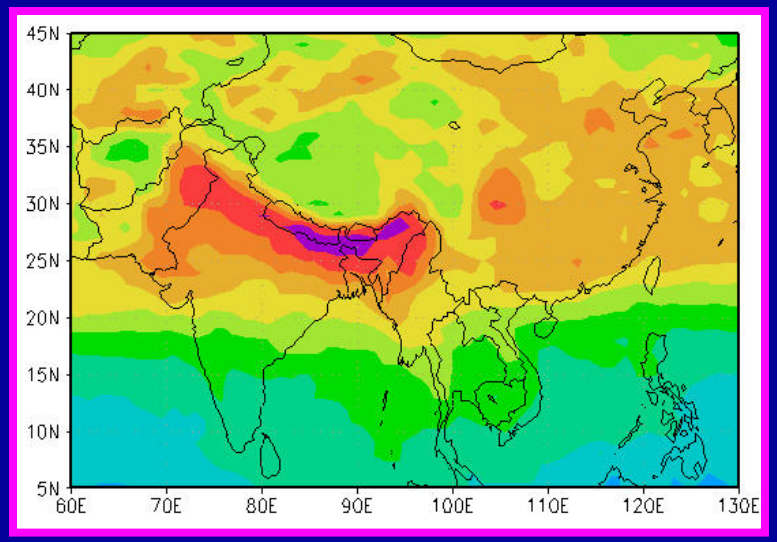


Surface O_3 July 3-15 1988

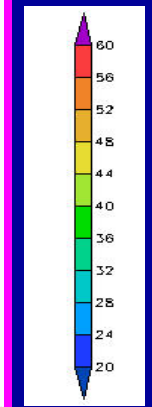
U.S. Surface Ozone Levels 1982-2001



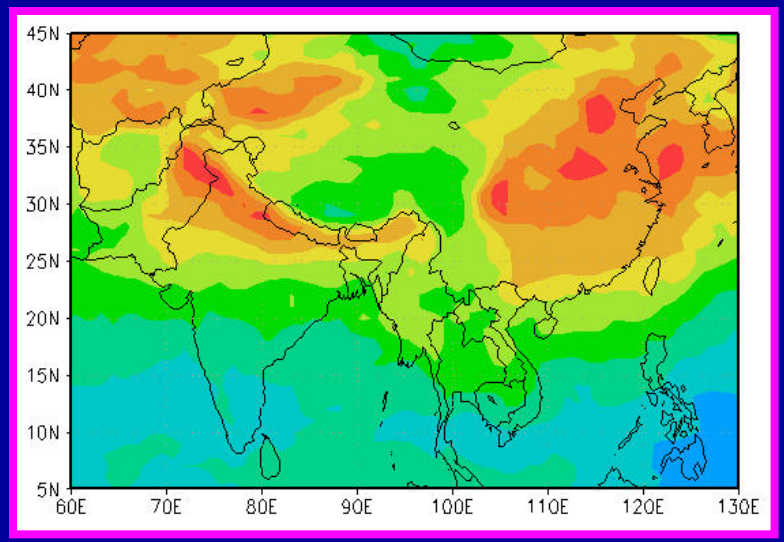
Interannual Variability Linked to El Niño – Southern Oscillation



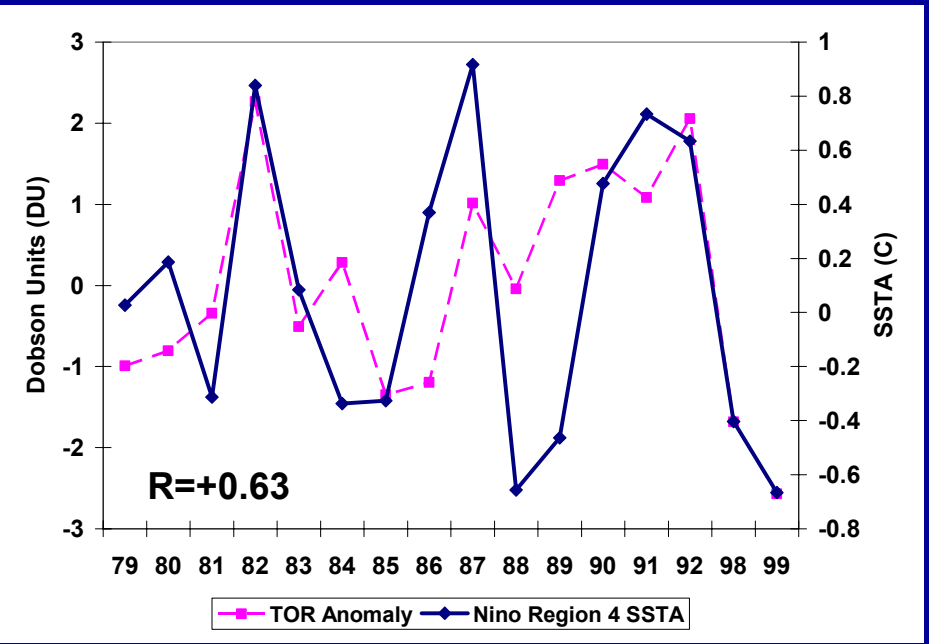
June 1982 - Strong El Niño Year

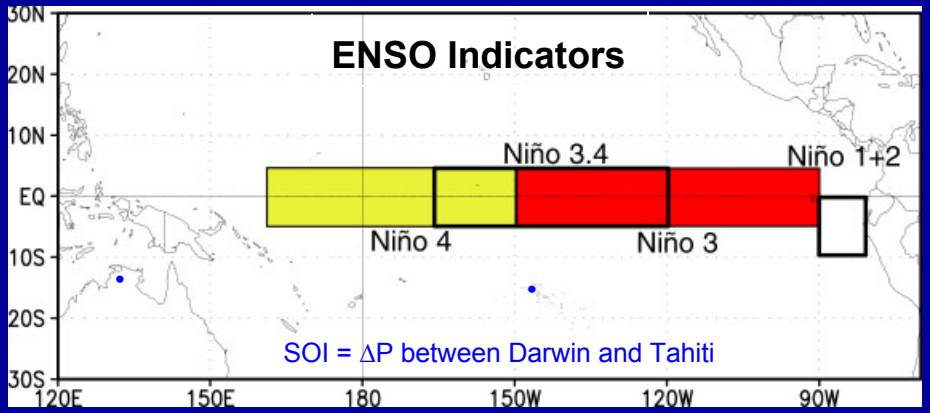


Dobson Units (DU)



June 1999 - Strong La Niña Year





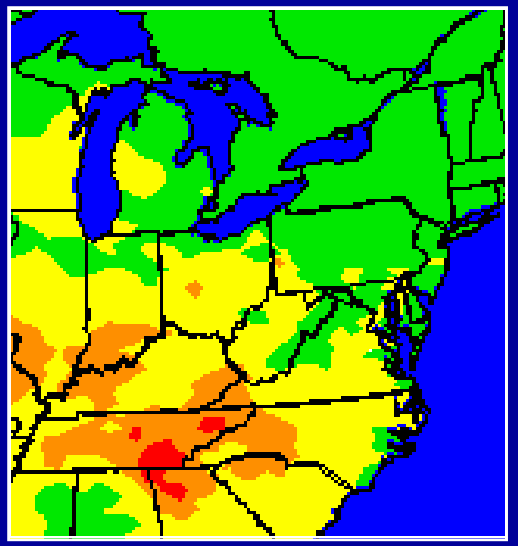
Other definitions include Sea Surface Temperature Anomalies (SSTA) in various regions of the Pacific:

Niño 1+2: Off coast of Ecuador; Niño 3: Eastern Pacific; Niño 4: Western Pacific; Niño 3.4: Central Pacific

Air Quality Forecasts Utilizing MODIS Satellite Observations

The National Air Quality Goal

August 9, **2012**

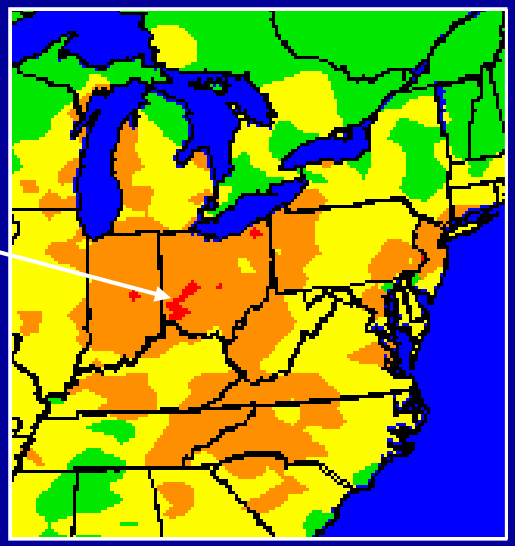


Air Quality Index (AQI): Ozone		
Index Values	Levels of Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100*	Moderate	Unusually sensitive people should consider limiting prolonged outdoor exertion.
101 - 150	Unhealthy for Sensitive Groups	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
151 - 200	Unhealthy	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.
201 - 300	Very Unhealthy	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
301 - 500	Hazardous	Everyone should avoid all outdoor exertion.

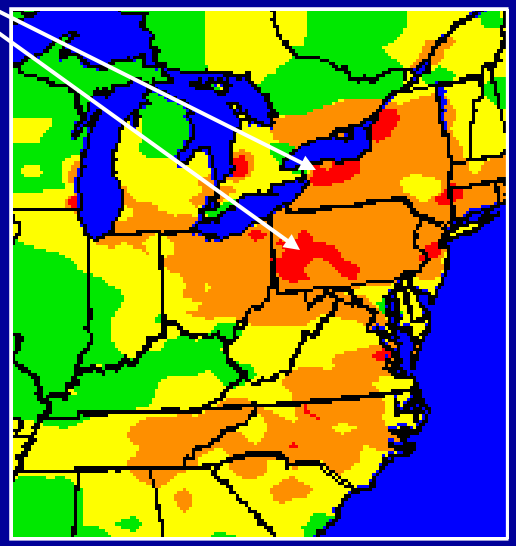
With Data from August 9:

Can we predict **unhealthy O_3**

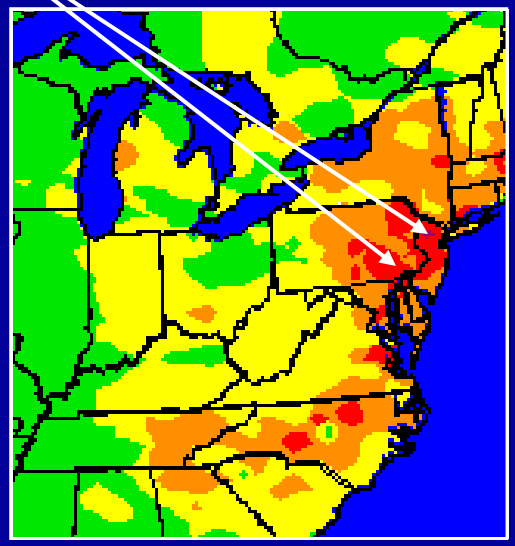
- in Cincinnati on the 10th?
- in Pittsburgh and Buffalo on the 11th?
- in Philadelphia and New Jersey on the 12th?



August 10

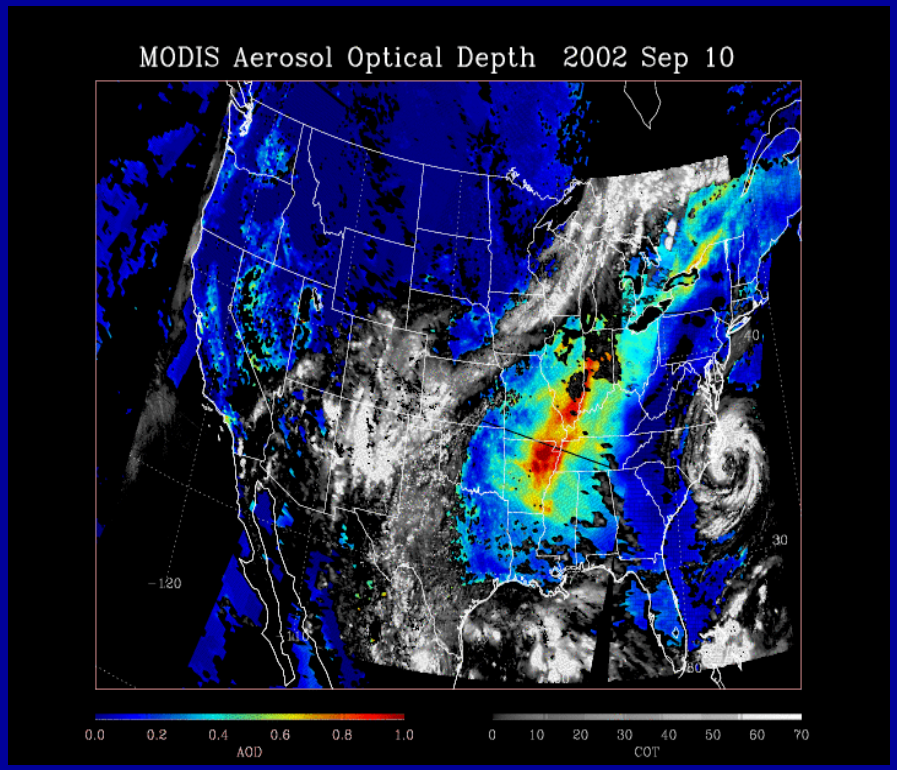


August 11



August 12

Aerosol Forecasts Using MODIS Data:
First Use of Satellite Data to Predict PM2.5 Air Quality



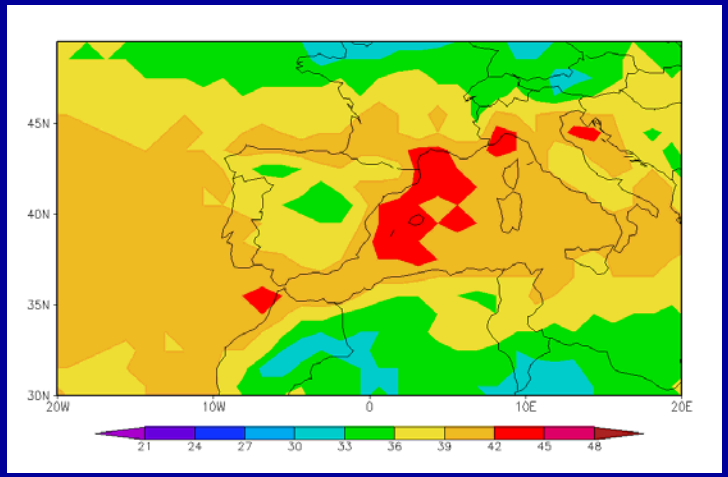
- Comparison of NASA satellite data (MODIS aerosol products) with EPA AIRNow ground network data.
- "Data-fusion" products prototyped for use in EPA Air Quality Index forecasts (utilizing MODIS aerosol optical depth and cloud optical thickness, hourly PM2.5 measurements, wind fields, air parcel trajectories)
- Application to September 2003 Wildfire Season
- Eventual Goal: Synoptic Air Quality Forecasts of Tropospheric Ozone

What Happens to the Ozone Produced in the Eastern United States?

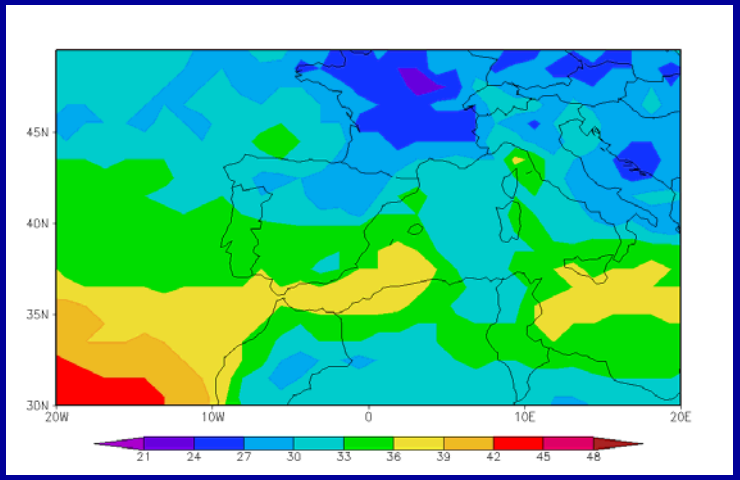
A Study of the Intercontinental Transport of Tropospheric Ozone from the Eastern U.S. to Western Europe

Springtime TOR Variability Over North Atlantic Linked to Transport Patterns Modulated by the North Atlantic Oscillation (NAO)

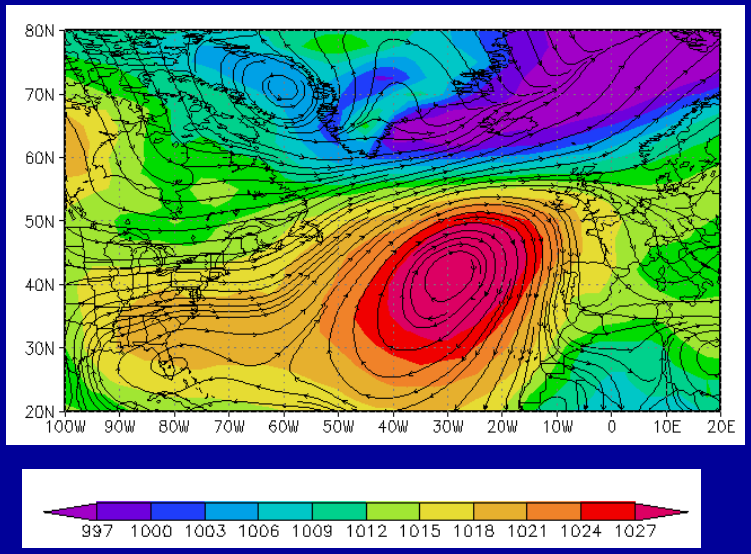
Spring 1990 – Positive NAO



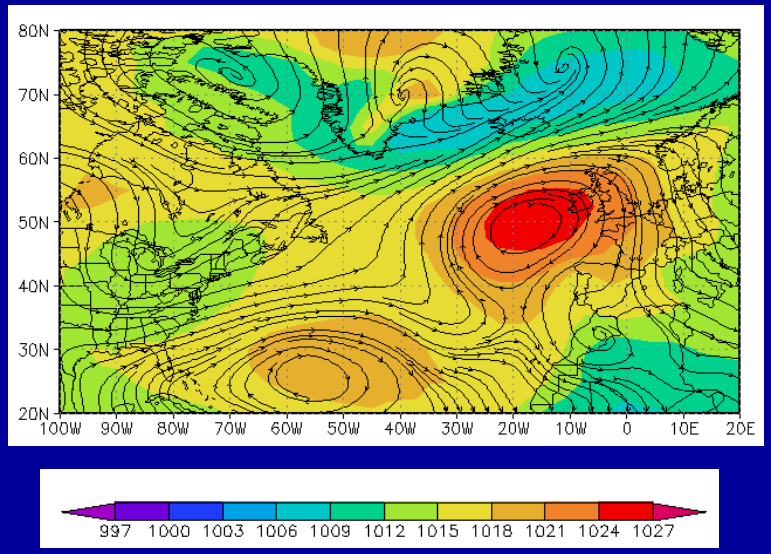
Spring 1980 – Negative NAO



Seasonal TOR Depictions



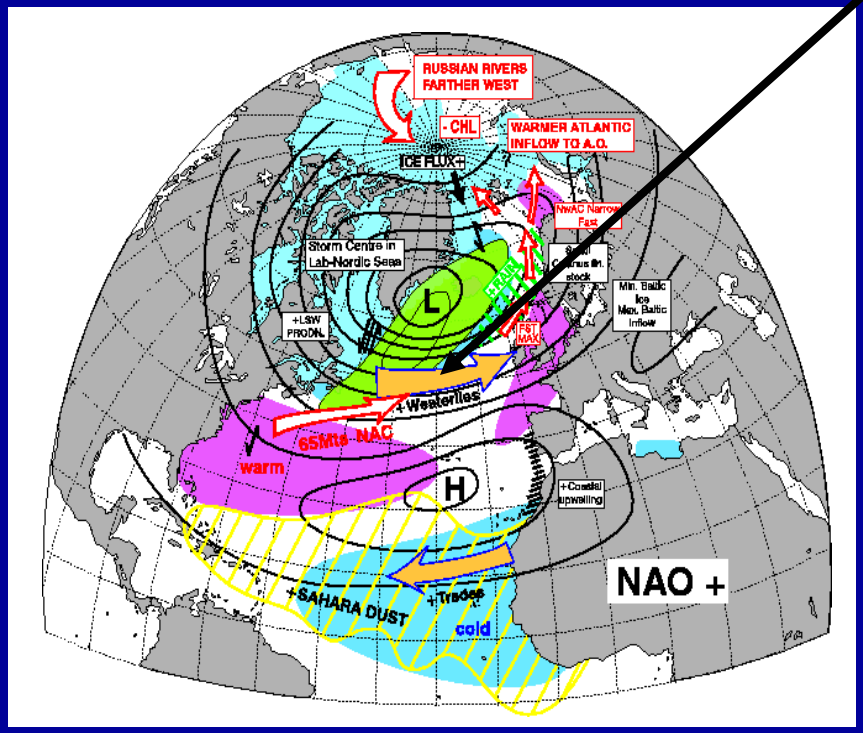
Seasonal Surface Pressure and 850mb Wind Depictions

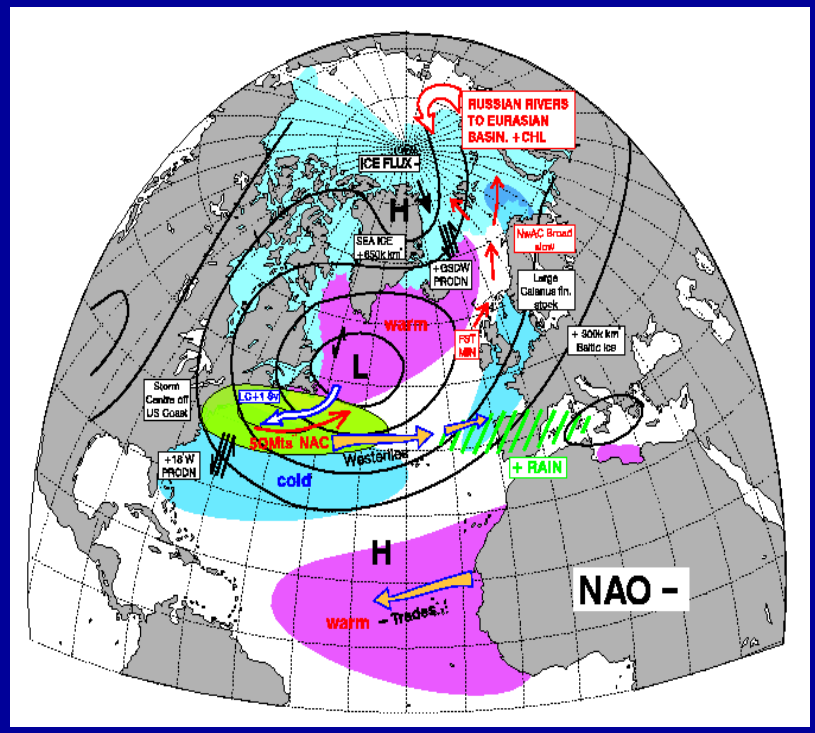


(From Creilson et al., 2003)

Phase of the North Atlantic Oscillation Controls Transport Strength and Speed

Transport Processes Stronger during Positive Phase



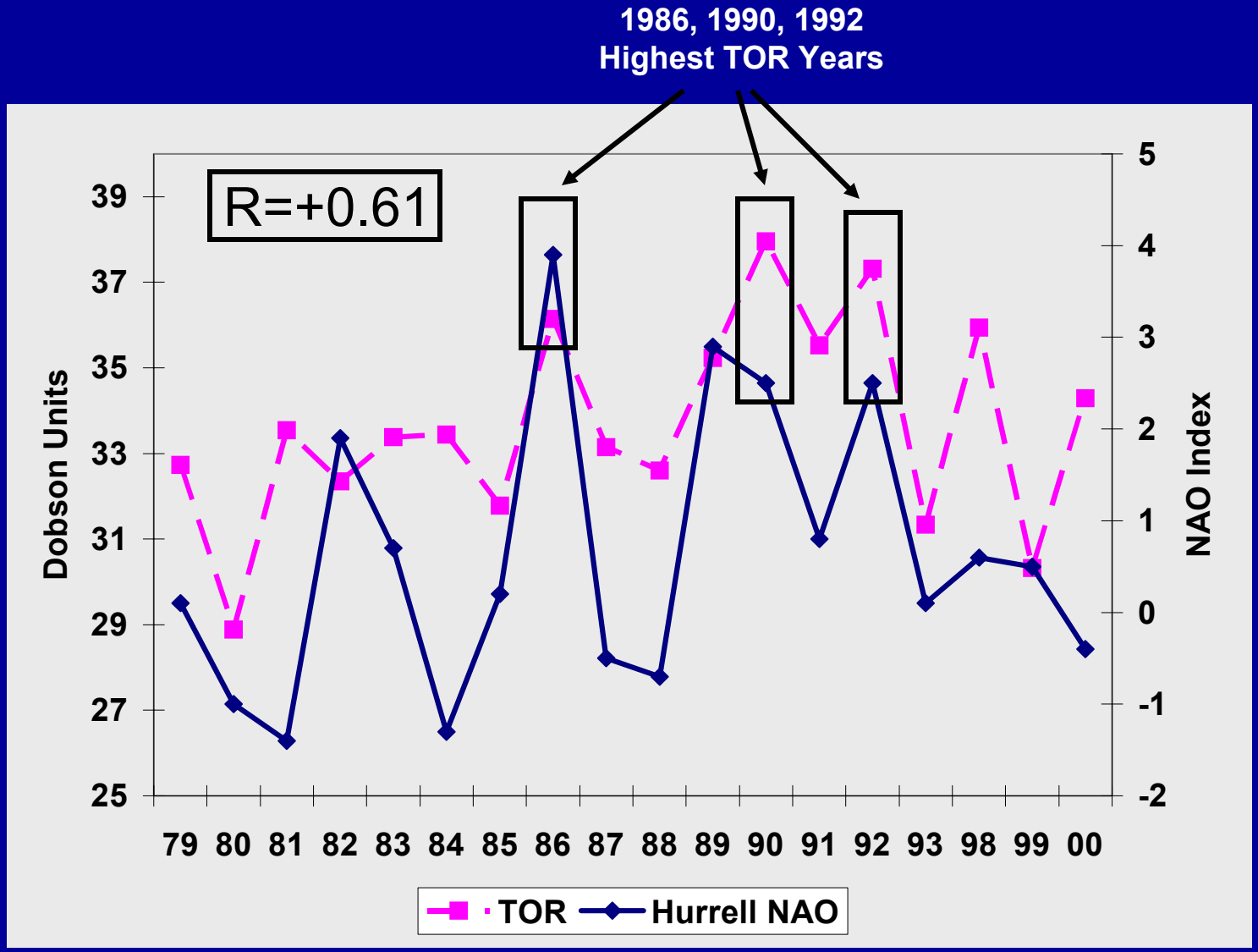


Positive Phase of the NAO

Negative Phase of the NAO

(From Creilson et al., 2003)

Interannual Variability of Western Europe Springtime TOR and Spring NAO Index



(From Creilson et al., 2003)

SUMMARY

- Pioneering Research into Tropospheric Ozone Leads to Discovery of Tropospheric Signal in TOMS
  - 20 Years of Tropospheric Ozone (TOR) Data now available at http://asd-www.larc.nasa.gov/TOR/data.html
- Strong Correlation between Asian Pollution and Population
  - Asian pollution event stronger than historic U.S. episode
  - Interannual Variability over India Linked to Phase of ENSO
- First Glimpse into Synoptic Scale Forecasts of Air Quality
  - http://idea-aqi.larc.nasa.gov
- Pollution Transport across North Atlantic Linked to NAO