An Investigation of Interannual Variability of Ozone over Africa Determined from Satellite Measurements

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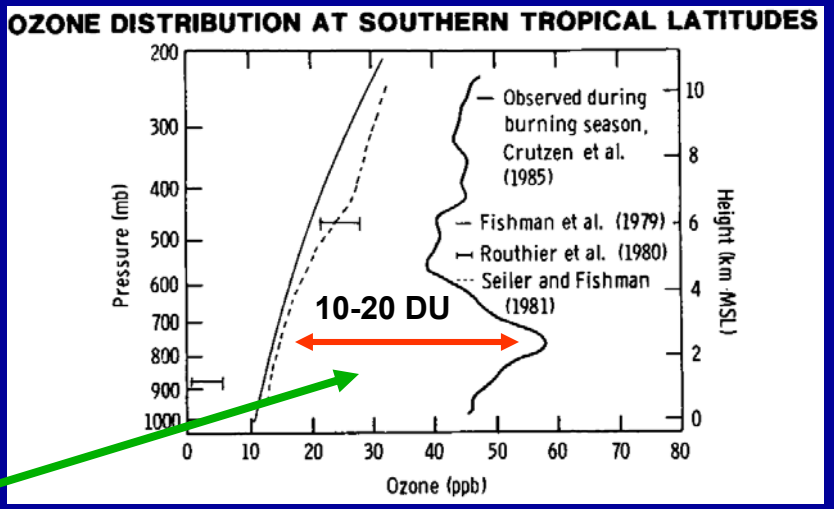
AGU 2004 Spring Meeting
Montreal, Quebec Canada
May 18, 2004

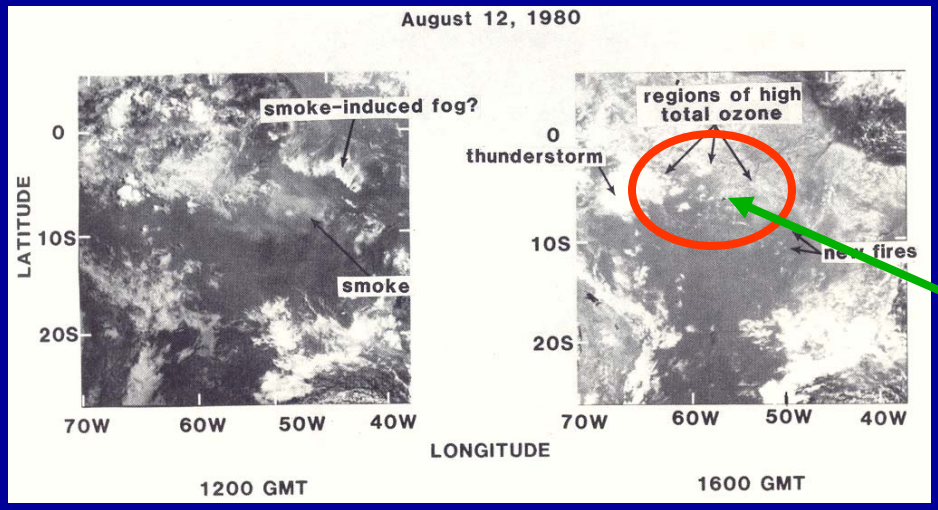
Road Map

- History Behind Use of Satellites to Study Tropospheric Air Pollution
- Tropospheric Ozone Residual (TOR) Methodology and Climatology (Fishman et al., 2003)
- Previous Studies:
  - Intercontinental Transport of Tropospheric Ozone (Creilson et al., 2003)
  - Interannual Variability of Tropospheric Ozone over India and Asia
- Current Study: Interannual and Seasonal Variability of Tropospheric Ozone over West Africa and its Relationship to Climate Indices (NAO and ENSO)

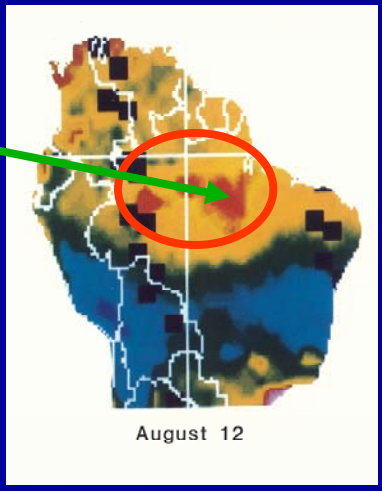
In the late 70's, Paul Crutzen led a team of NCAR scientists that made comprehensive measurements of trace gases where tropical biomass burning was occurring and found considerably higher concentrations than what had been published previously



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

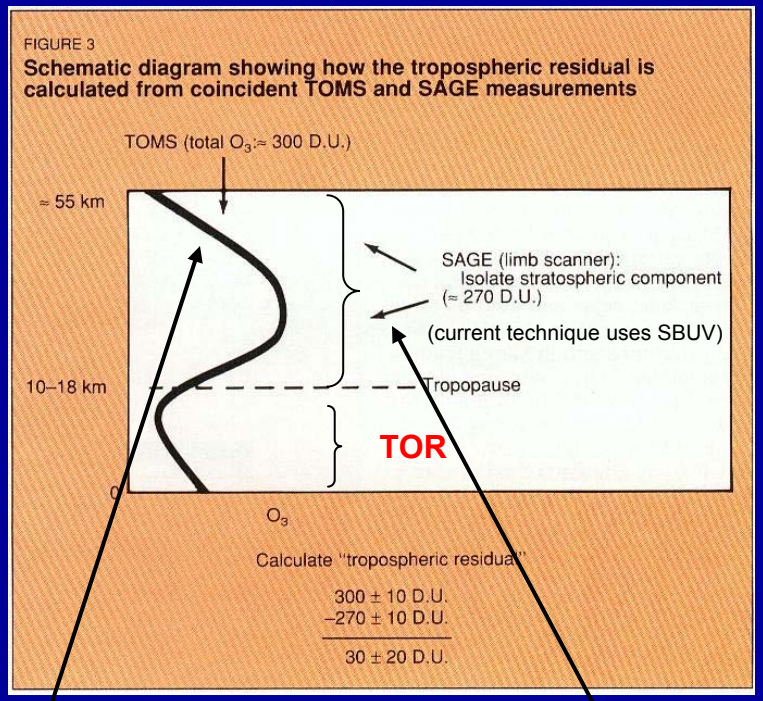


Enhanced **Total Ozone** Observed in Conjunction with **Biomass Burning** in 1980 Episode



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

Separate Stratosphere from Troposphere to Compute Tropospheric Ozone Residual (TOR)

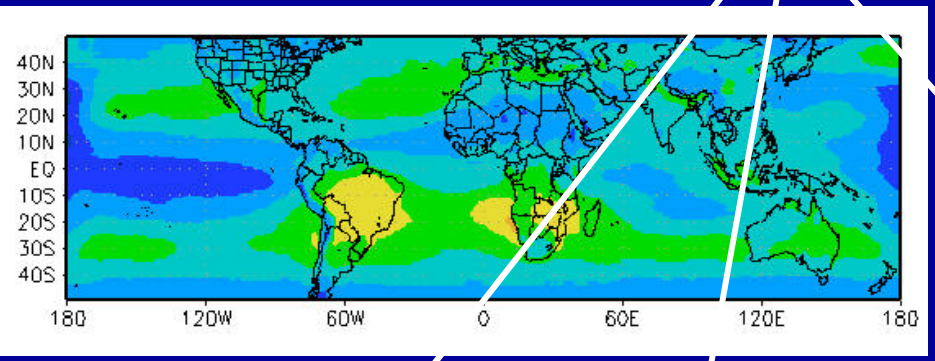


TOR Technique:
TOMS Total O3 – SCO (from SBUV)

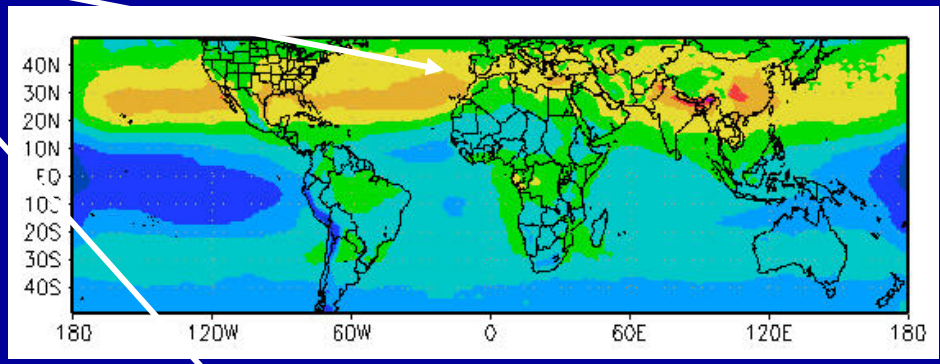
Global Distribution of Tropospheric Ozone Residual (TOR) Identifies Several Regions of Enhanced Photochemical Smog

(Climatological TOR: 1979-2000)

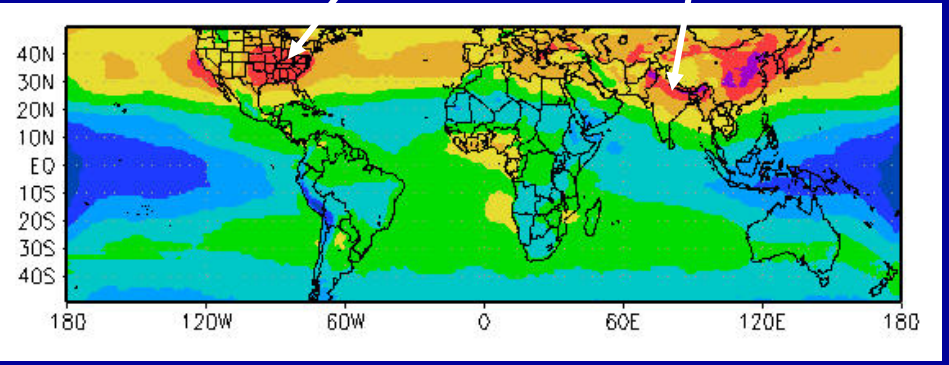
Regional "Hotspots" of Tropospheric Ozone



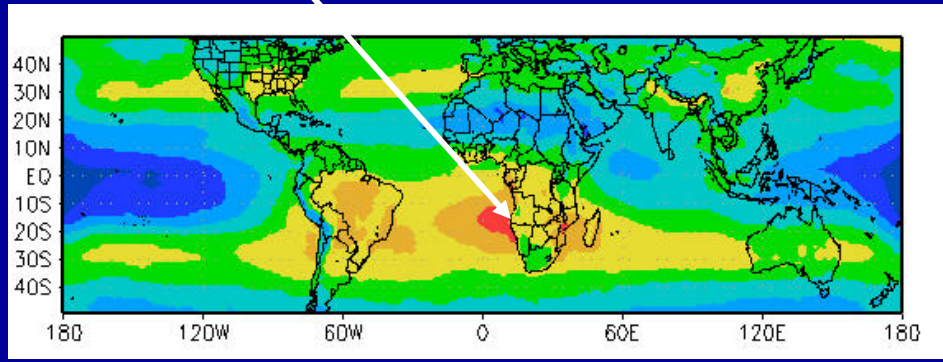
December - February



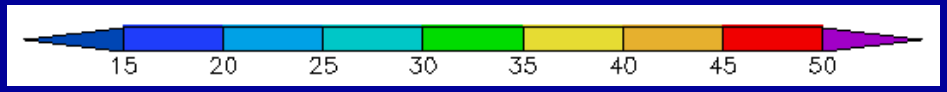
March - May



June - August



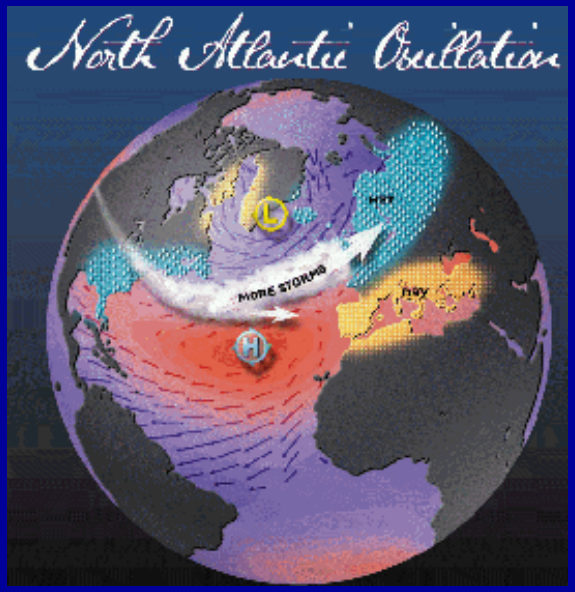
September - November



Dobson Units (DU)

(From Fishman et al., 2003)

Previous Studies have shown Strong Relationship between TOR over Western Europe and the North Atlantic Oscillation…



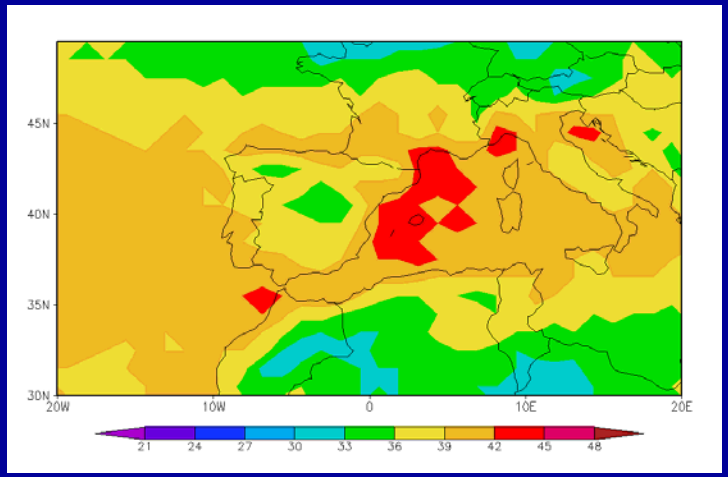
Positive NAO

Negative NAO

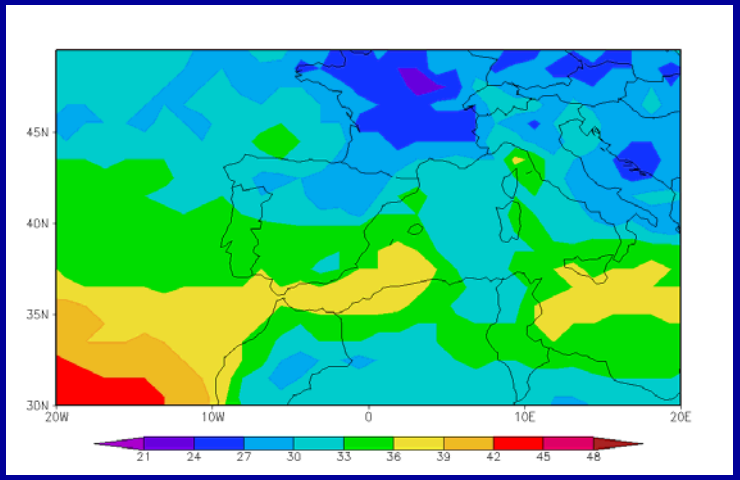
(From Creilson et al., 2003)

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

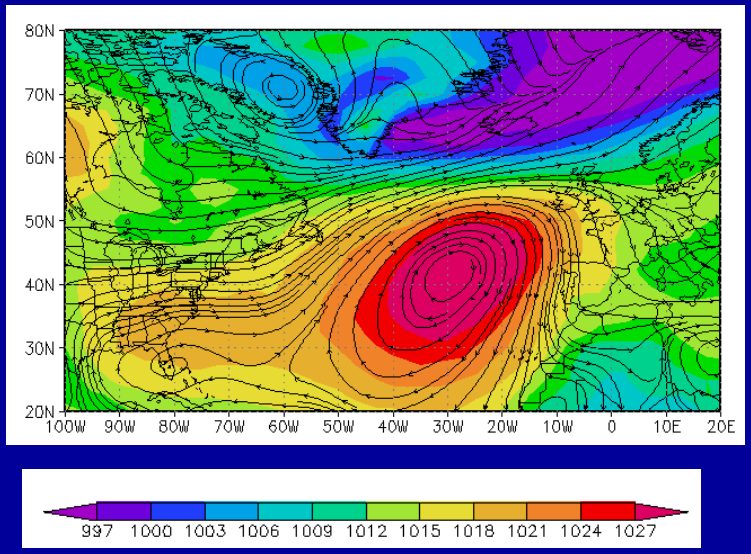
Spring 1990 – Positive NAO



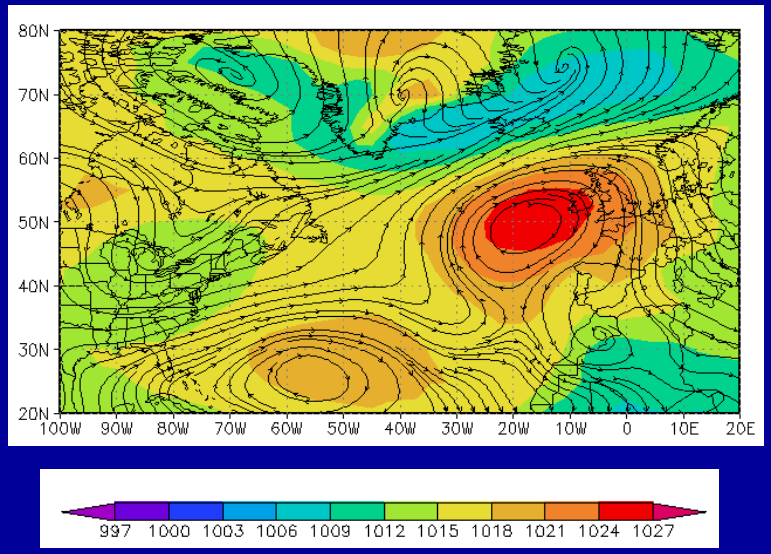
Spring 1980 – Negative NAO



Seasonal TOR Depictions

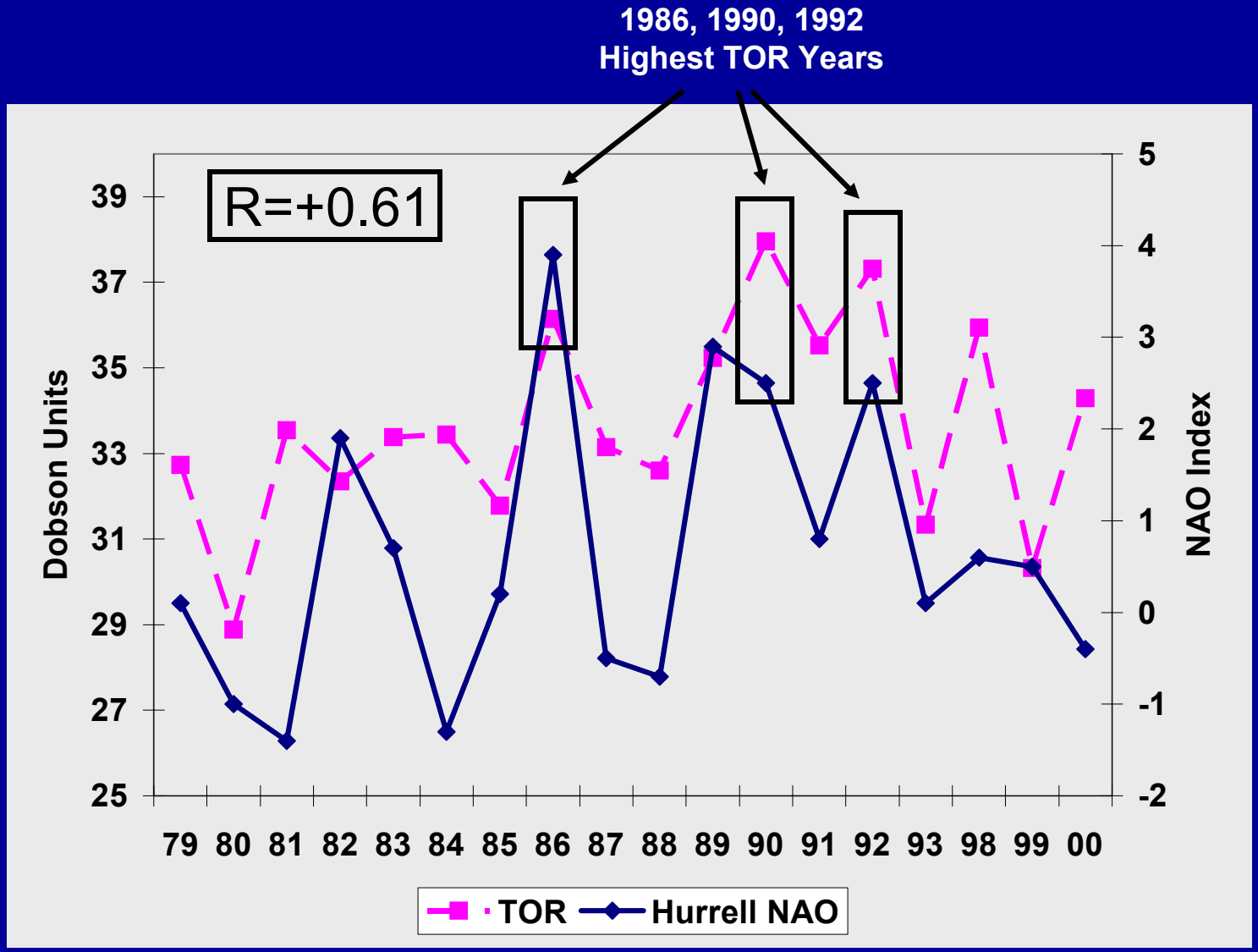


Seasonal Surface Pressure and 850mb Wind Depictions



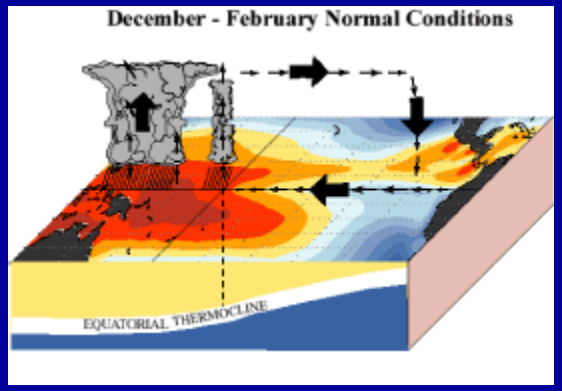
(From Creilson et al., 2003)

Interannual Variability of Western Europe Springtime TOR and Spring NAO Index

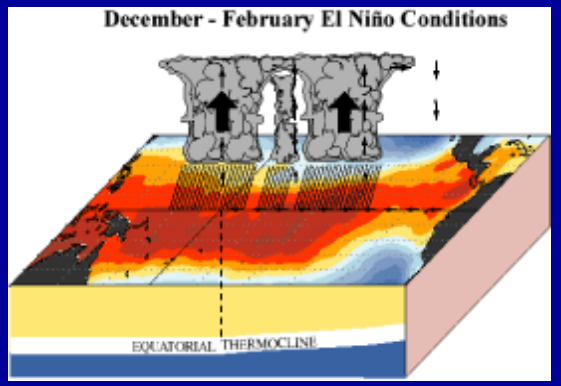


(From Creilson et al., 2003)

…as well as between Ozone Pollution over Northern India and both Population & Phase of ENSO

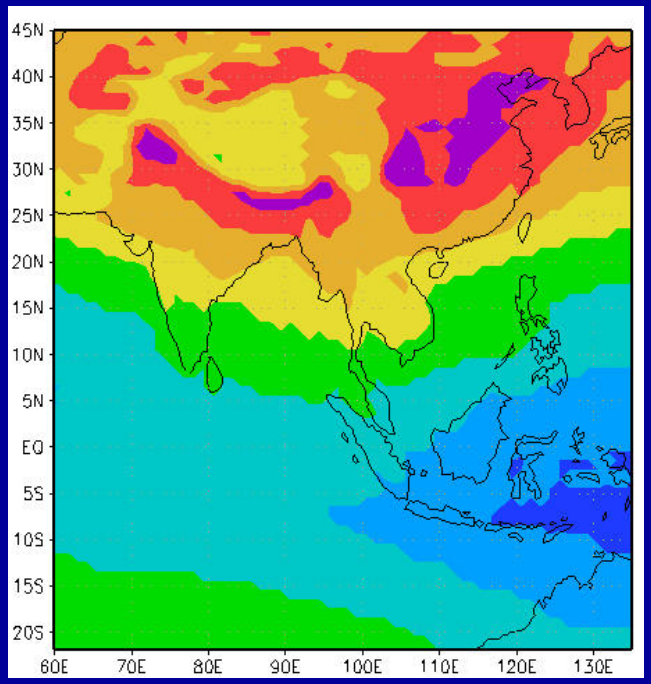


Normal Conditions

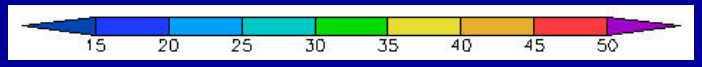


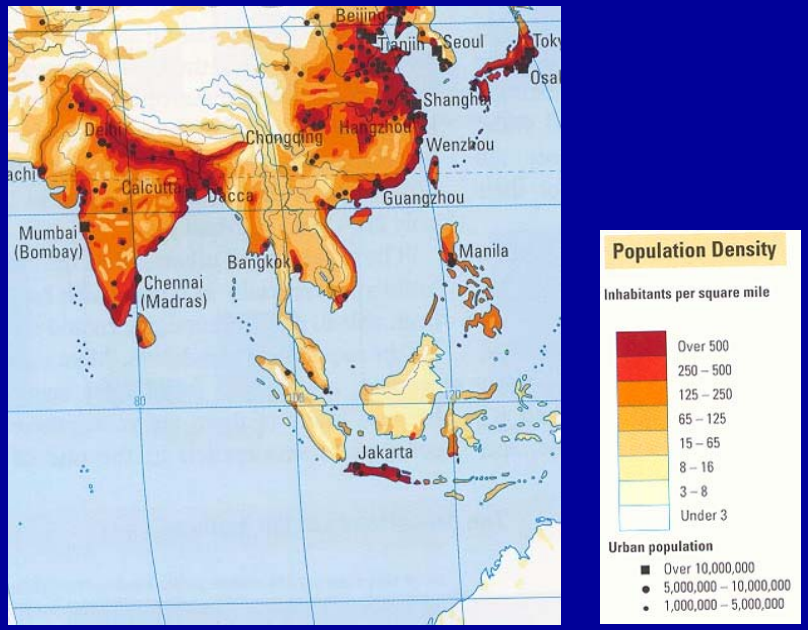
Typical El Niño

Population and Ozone Pollution Strongly Correlated in India and China



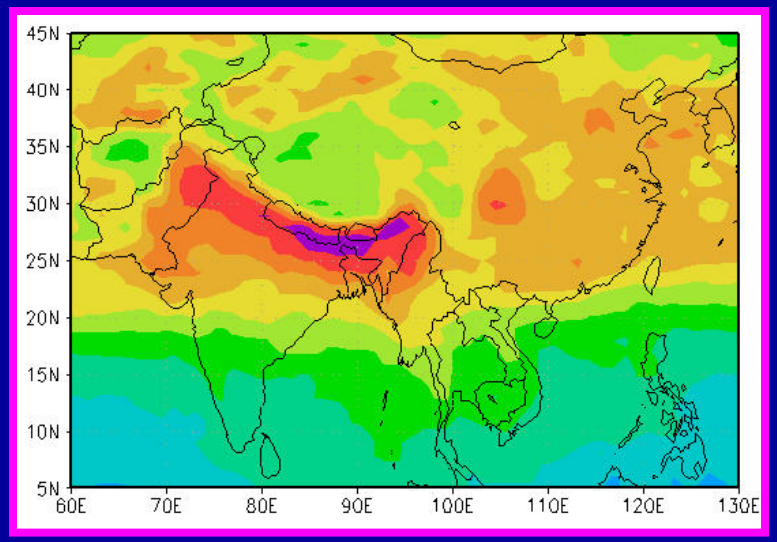
Summer Climatological Tropospheric Ozone



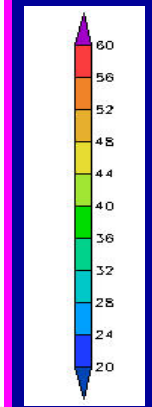


Population Density

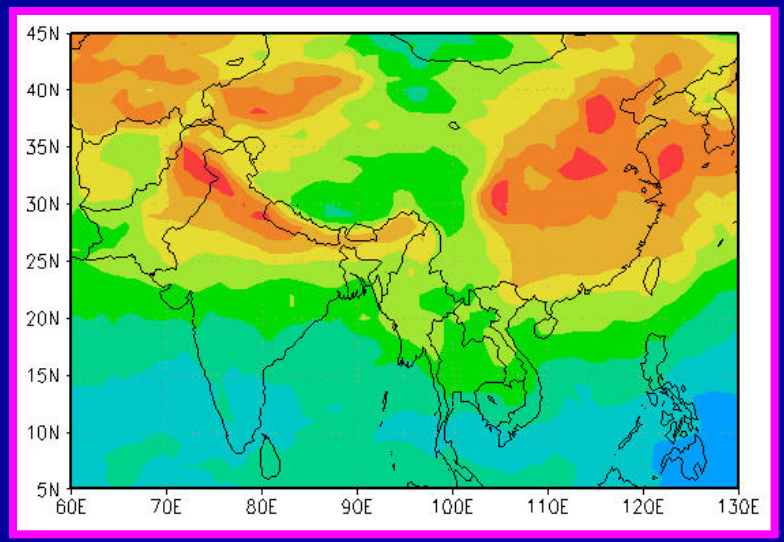
Interannual Variability Linked to El Niño – Southern Oscillation



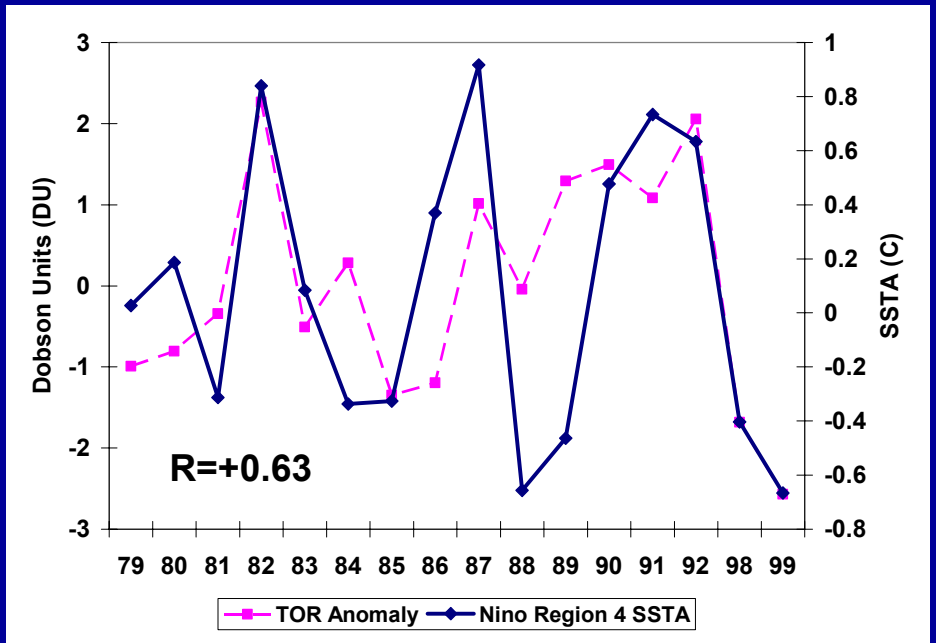
June 1982 - Strong El Niño Year



Dobson Units (DU)



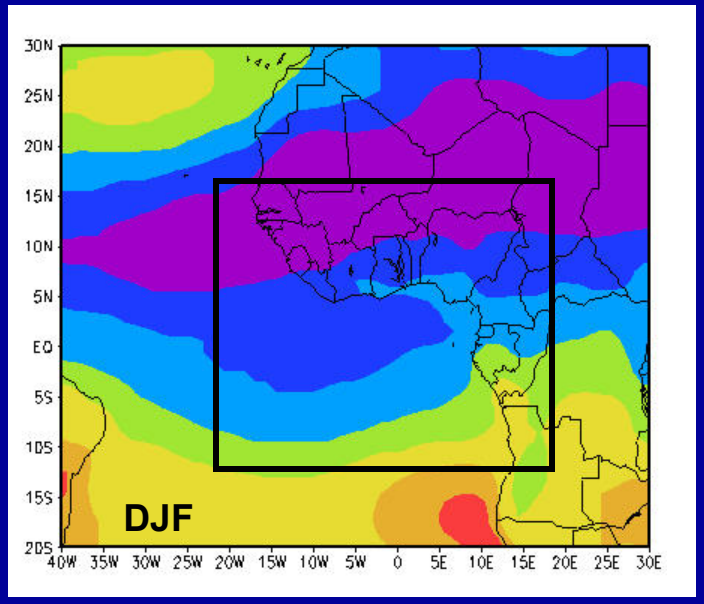
June 1999 - Strong La Niña Year

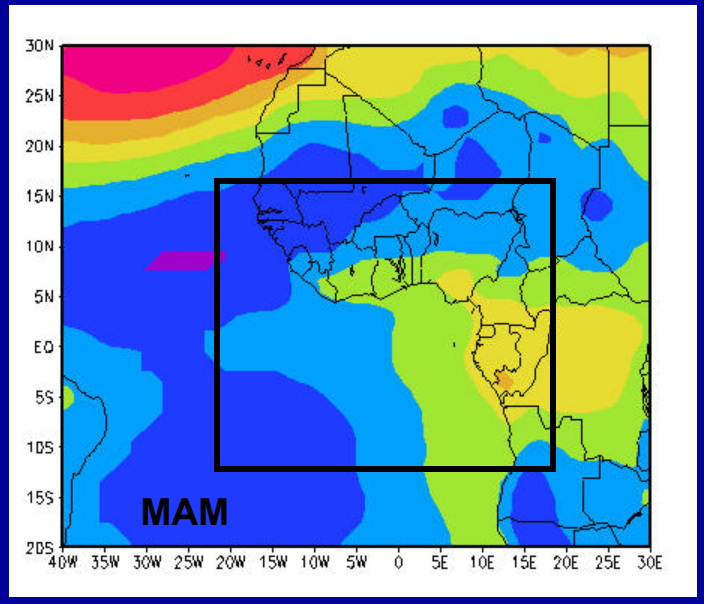


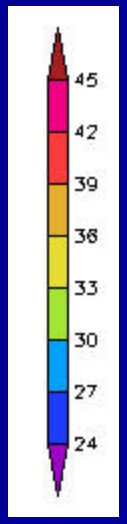
We also see Significant Interannual and Seasonal Variability over Regions of West Africa

Region of Interest

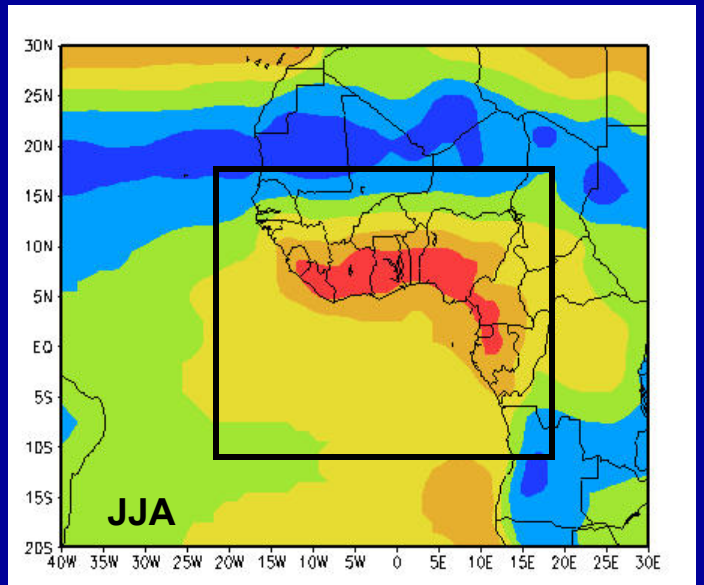
Seasonal Depictions of Climatological West African Tropospheric Ozone Residual

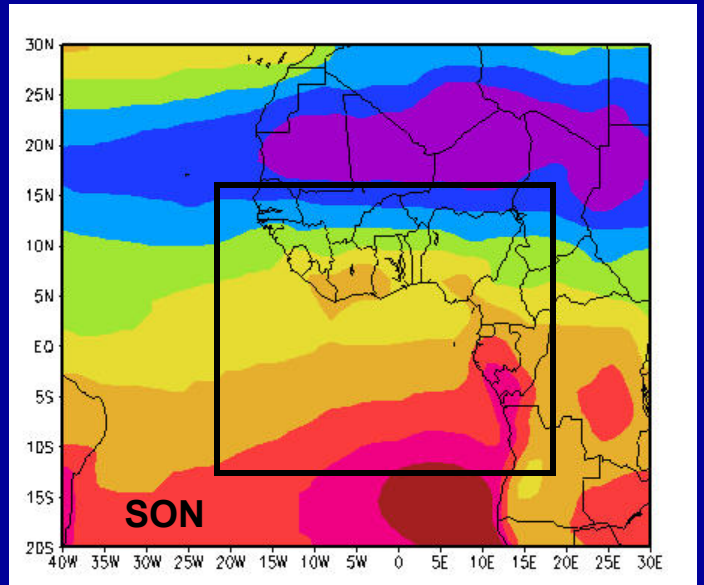






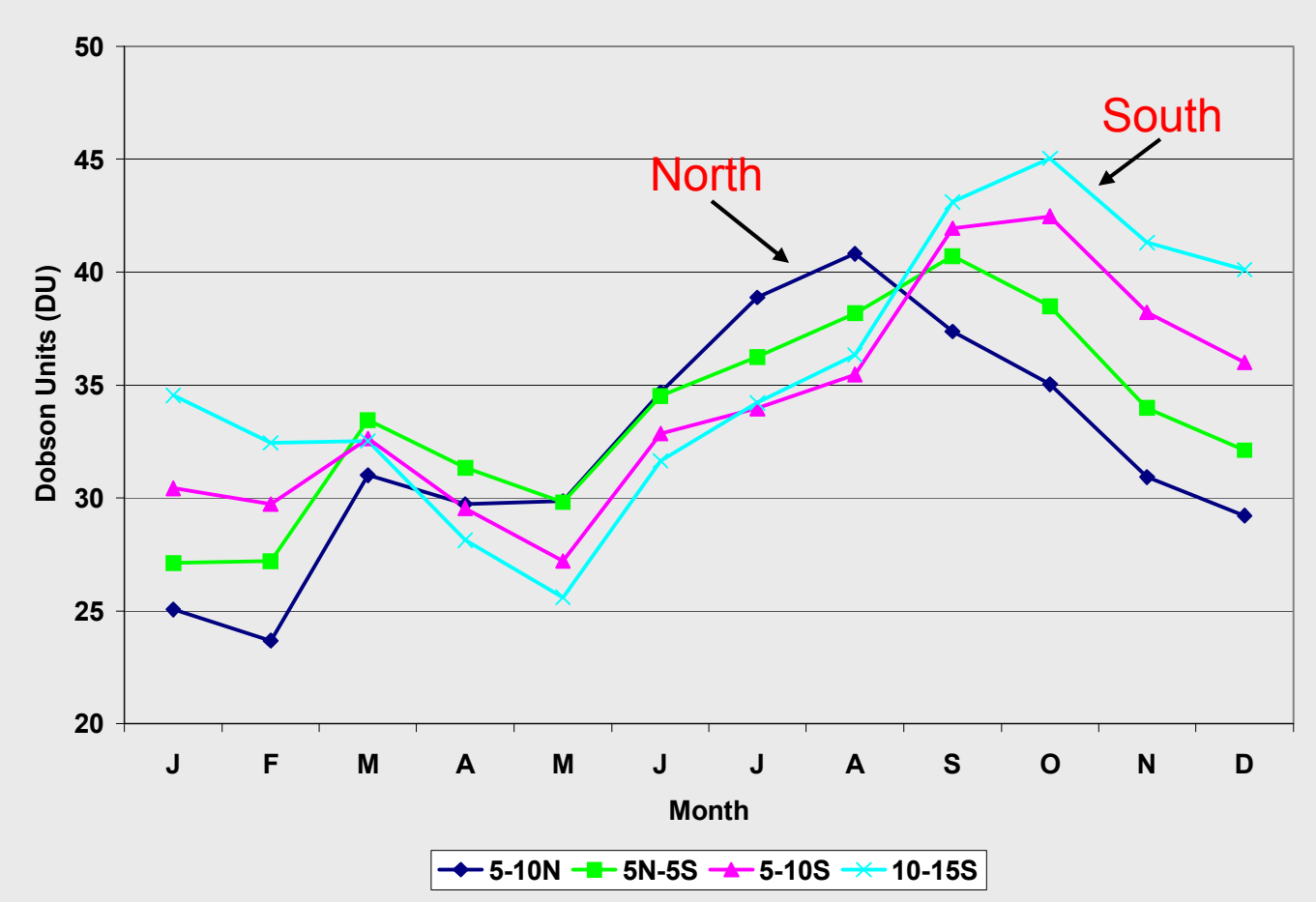
Dobson Units





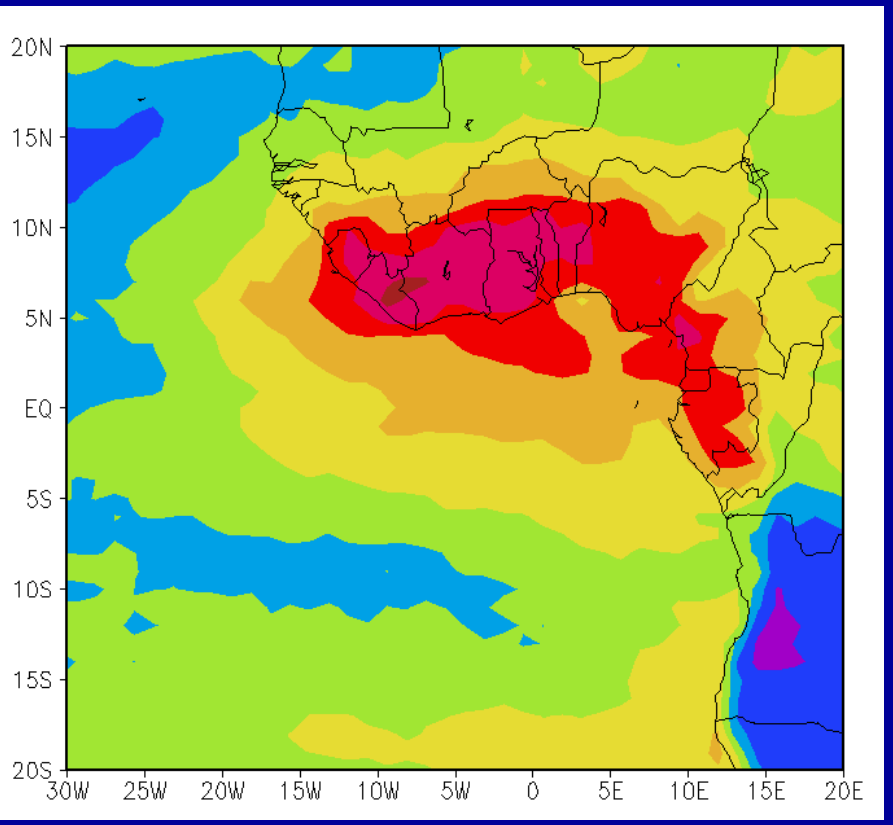
West Africa Monthly TOR Climatology
20W to 20E

North to South Seasonal Migration Of TOR Evident

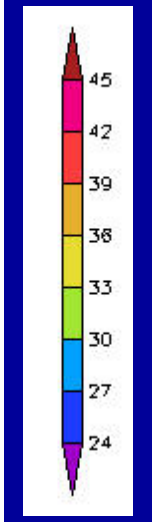


Significant TOR Interannual Variability Evident between North and South of the ITCZ: Potential Linkage to Phase of the El Niño

North-South TOR: June 1982

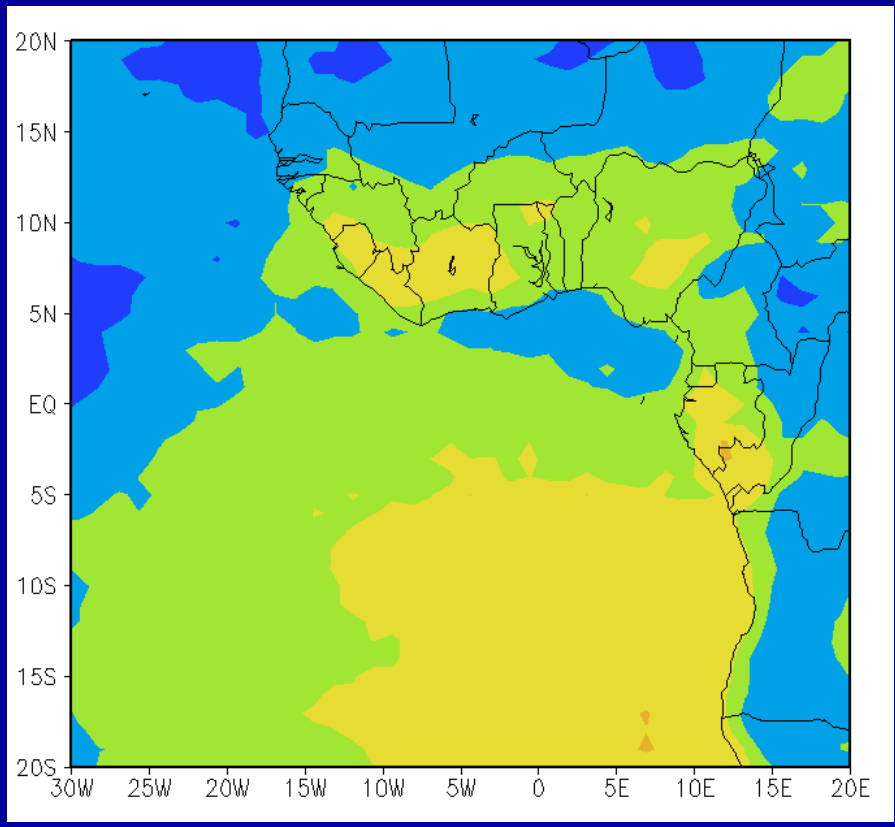


Strong El Niño



Dobson Units

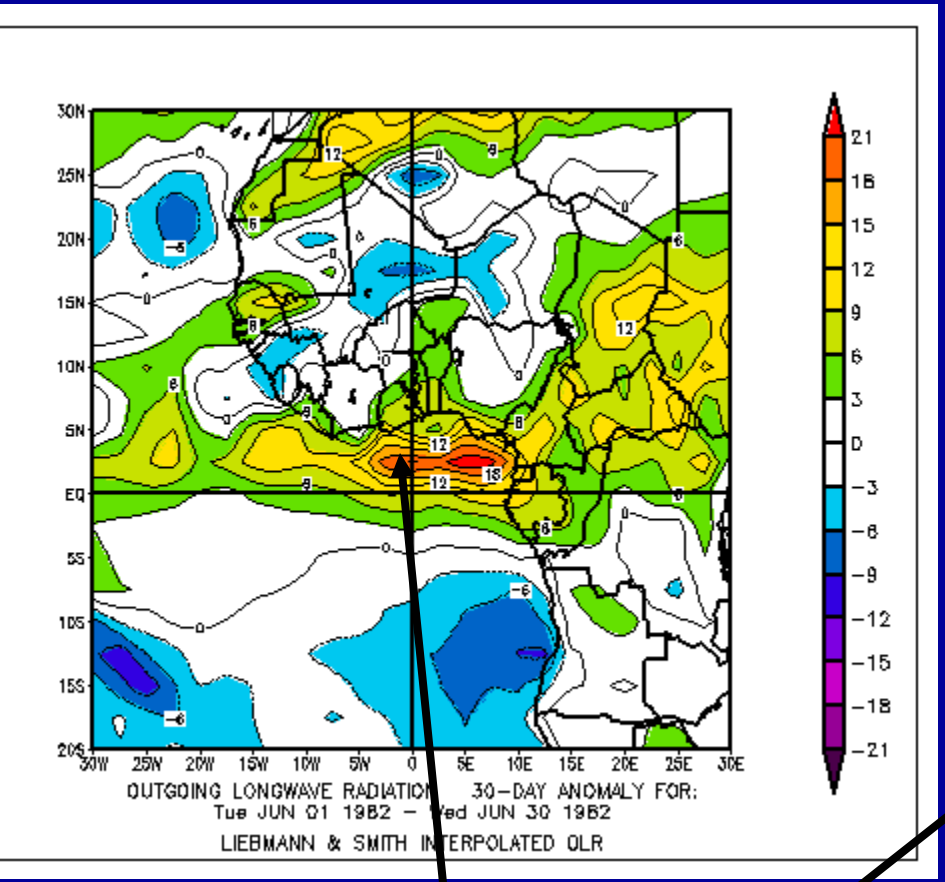
North-South TOR: June 1984



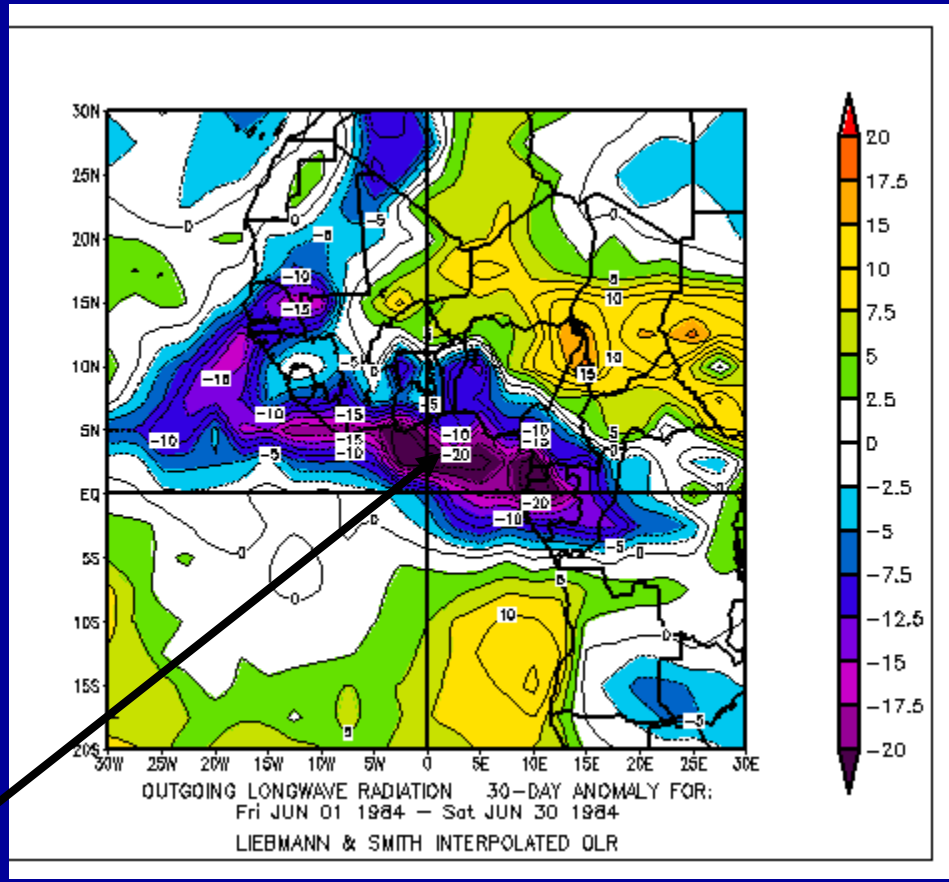
Strong La Niña

Strong Difference Seen in Outgoing Longwave Radiation Between June of 1982 (El Niño) and June of 1984 (La Niña)

ORL – June 1982

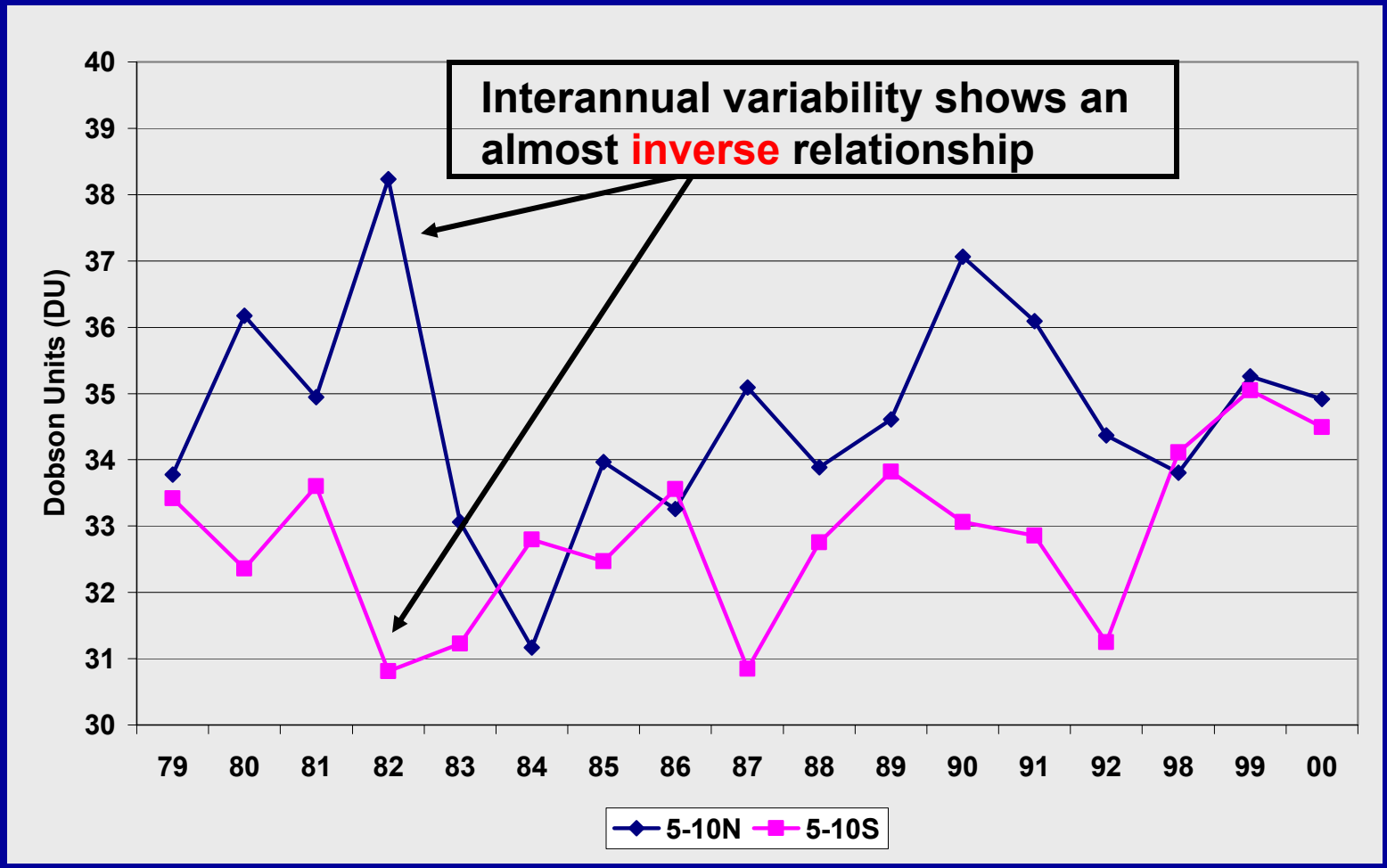


ORL – June 1984

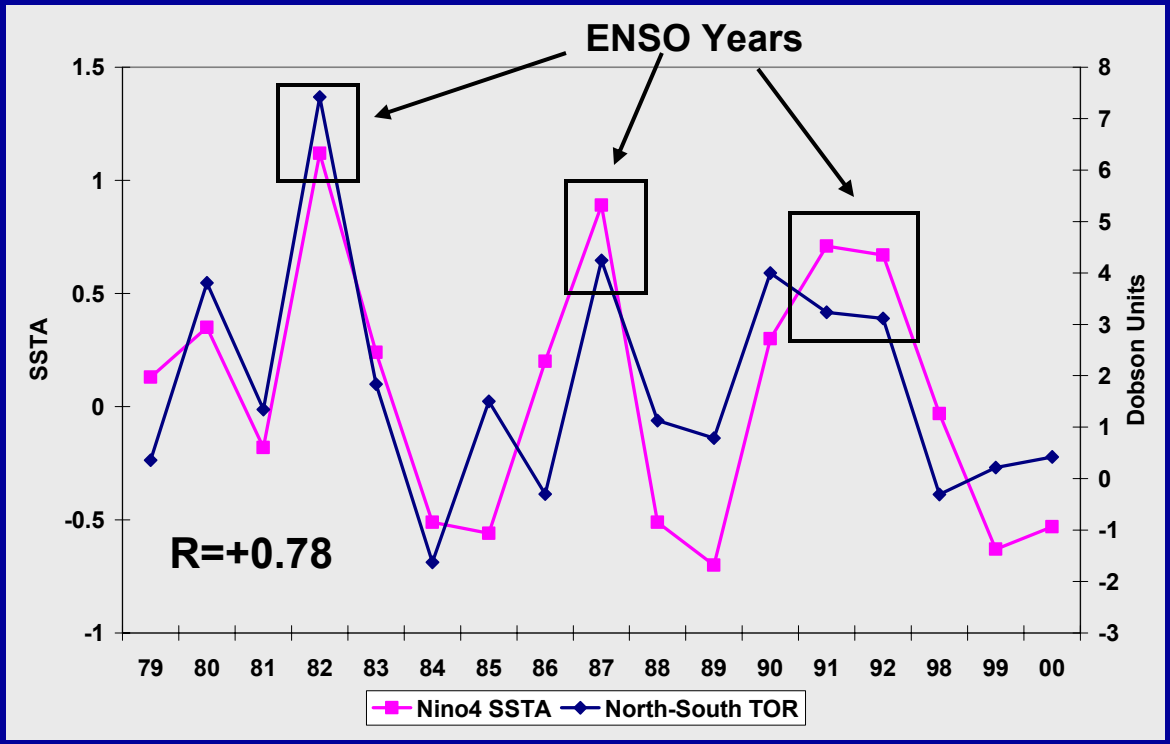


Positive Versus Negative Anomaly over the Same Region

West Africa June TOR for 5-10N and 5-10S

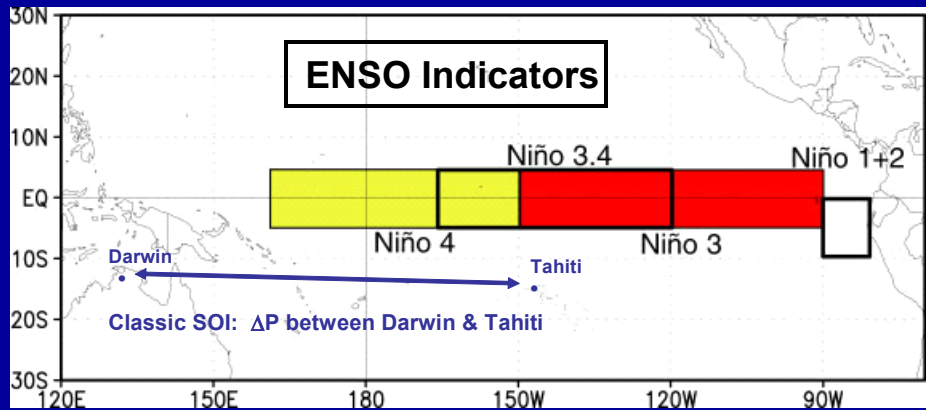


North-South (5N-5S) June TOR Differential Versus Nino Region 4 SSTA: Strong Correlation Evident



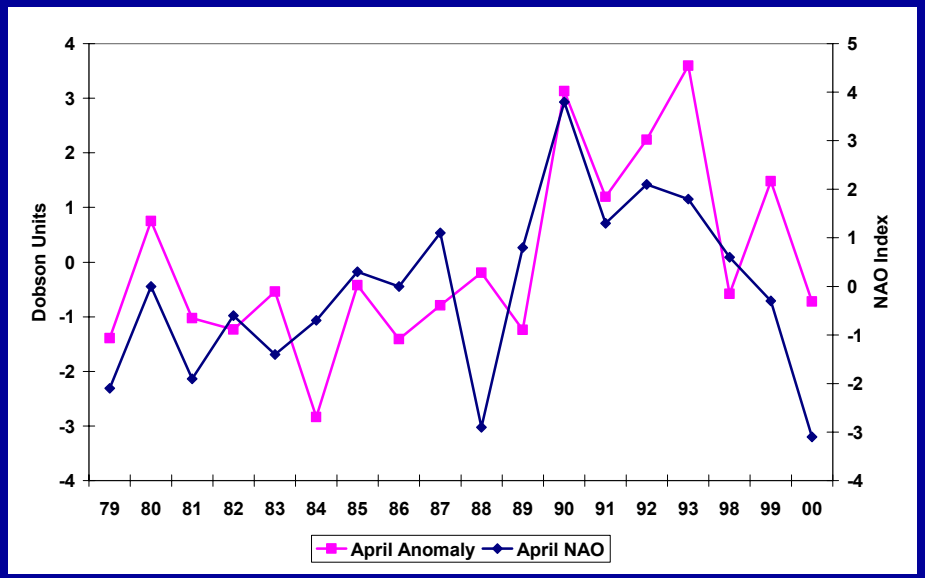
Other definitions include Sea Surface Temperature Anomalies (SSTA) in various regions of the Pacific:

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

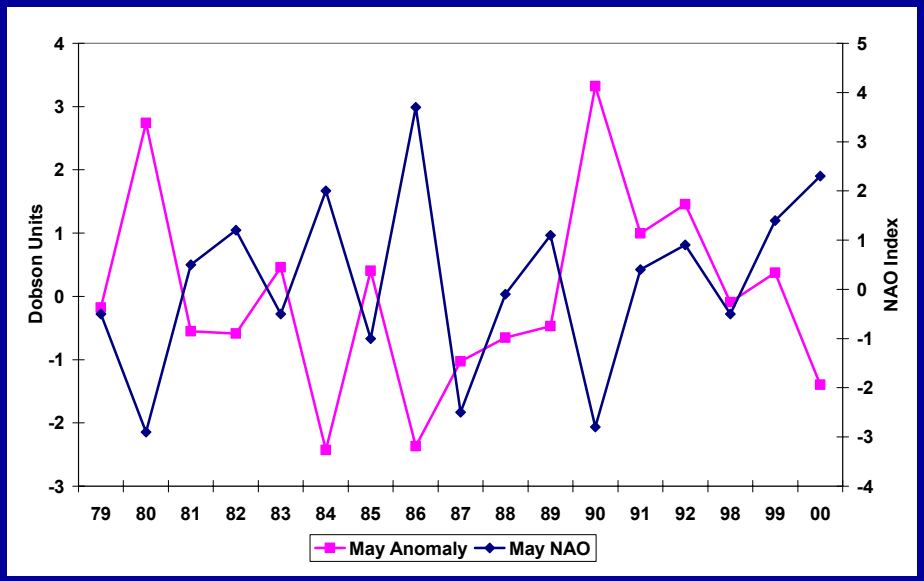


Consecutive Month Interannual Variability (5N-5S) Shows Strong Relationship With Different Phases of the North Atlantic Oscillation: Potential ITCZ-NAO Connection

April



May



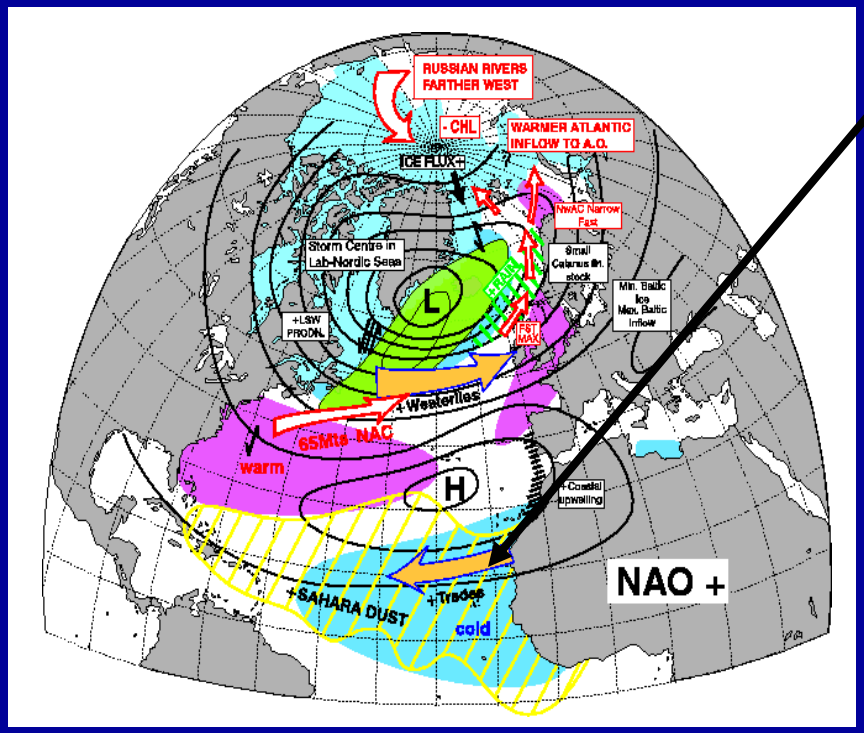
R=+0.63

R=-0.70

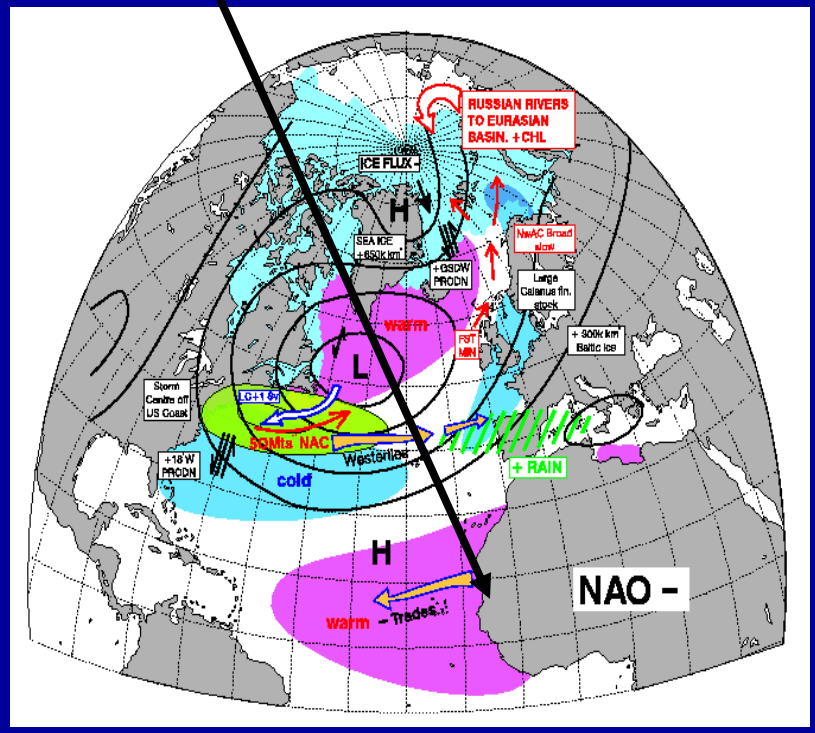
Inverse Relationship

Phase of the North Atlantic Oscillation Controls Transport Strength, Speed, and Direction

Differing effects between Positive and Negative Phase



Positive Phase of the NAO



Negative Phase of the NAO

SUMMARY

- Pioneering Research into Tropospheric Ozone Led 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
- Previous Work Has Shown both Regional Utility and Interannual Variability of TOR Dataset
- Current Study Spotlights Strong Relationships between West African Pollution and **BOTH** the NAO and ENSO
  - April TOR-NAO: R=+0.63; May TOR-NAO: R=-0.70
  - June TOR-ENSO: R=+0.78
- Further Investigation Utilizing GCM Needed to Help Explain Significant Dual Coupled Climate-TOR Relationships