WORLD OZONE SYMPOSIUM 7/2000 #49

Tropical tropospheric ozone: A multi-satellite view from TOMS and other instruments

Anne M Thompson
NASA/GSFC/Code 916, Greenbelt, MD 20771 USA

Robert D Hudson, Hua Guo
Dept of Meteorology, U Maryland, College Park, MD 20742 USA

Jacquelyn C Witte, Tom L Kucsera
EITI at NASA/GSFC/Code 916, Greenbelt, MD 20771 USA

Matthew G Seybold
Dept of Marine, Atmospheric and Earth Sciences, No Carolina State Univ., Raleigh, NC USA

Abstract. New tropospheric ozone and aerosol products from the TOMS (Total Ozone Mapping Spectrometer) satellite instrument can resolve episodic pollution events in the tropics and interannual and seasonal variability. Modified-residual (MR) Nimbus 7 tropical tropospheric ozone (TTO), two maps/month (1979-1992, 1-deg. latitude x 2-deg. longitude) within the region in which total ozone displays a tropical wave-one pattern [maximum 20S to 20N; Thompson and Hudson, 1999], are available in digital form at http://metosrv2.umd.edu/~tropo. Also available are preliminary 1996-1999 MR-TTO maps based on real-time Earth-Probe (EP)/TOMS observations. Examples of applications are given.

1. Tropical Ozone and Smoke Aerosol Seasonality

Modified-residual TTO and smoke aerosol time-series from Nimbus 7/TOMS (1979-1992) are used to evaluate seasonal patterns and trends in the tropics in the 1980's [Thompson and Hudson, 1999; Herman et al, 1997]. Regions considered were the south Atlantic, southern Africa, Brazil, the eastern Pacific and the Indonesian- Malaysian-New Guinea area. No significant trends in tropospheric ozone were found over these areas from 1980-1990, as seen in Figure 1, depicting Indonesian TTO. The deseasonalized mean, the dashed line, with 26.6 DU in 1980, has a trend = -0.14 DU/yr, not significant at the 2-sigma level. Indonesian TTO displays two peaks in an annual cycle, one in May associated with SE Asian biomass burning, the second, in November, more likely caused by large-scale dynanmics and/or transport of ozone and ozone precursors from African and Australian burning.

Another factor contributing to high TTO in October-November may be lightning NO which leads to ozone formation [Martin et al., 2000]. Lightning activity is observed with satellite data from the OTD (Optical Transient Detector) and TRMM (Tropical Rainfall Measuring Mission) satellite Lightning Imaging Sounder. High-ozone peaks over the south tropical Atlantic, for example, were traced back to lightning activity over southern Africa during the *R/V R H Brown* Aerosols99 cruise [Thompson et al., 2000].

2. High-Resolution Views of Biomass Burning

The Nimbus 7 record captures the 1982-1983 ENSO (El Niño-Southern Oscillation) in a feature of > 40 DU in Figure 1. More intense ENSO-induced biomass fires of 1997-1998, viewed by Earth-Probe TOMS are detected as an extended period of high TTO (solid line, Figure 2). The low smoke aerosol signal (dashed line, Figure 2) during April-May 1998 suggests that Indonesian TTO is due to transport of ozone and ozone precursors. However, burning over Kalimantan and Sumatra accelerated in late August 1997 and ozone formed rapidly over Indonesia, with peaks in mid-September and October (Figure 2). In late November 1997 smoke and tropospheric ozone levels dropped to more typical levels. By August 1998 TTO was below 20 DU, similar to August 1996. Smoke aerosol in the region encompassing Indonesia remained low throughout 1998 except for the February-March period.

Nine-day averaged TOMS tropospheric ozone over Indonesia in the latter part of the local fires (mid-

November 1997) appears in Figure 3. An air parcel (trajectory) model is initialized from three Indian Ocean locations. Relatively high ozone (40-50 DU, near Sumatra, Singapore and Malaysia) originated from regions with fires in central Indonesia and New Guinea. At 12S, 110E, lower ozone (20-30 DU) originated over a less polluted central Indian Ocean.

Acknowledgments. This work was supported by NASA ACMAP. TOMS aerosol data are available by ftp from <toms.gsfc.nasa.gov> and tropospheric ozone data from <http://metosrv2.umd.edu/~tropo>.

References

Herman, J. R., et al., Global distribution of UV-absorbing aerosols from Nimbus 7/TOMSdata, *J. Geophys. Res.*, **102**, 16911-16922, 1997.

Martin, R. V., et al., Detection of a lightning influence on tropical tropospheric ozone, *Geophys. Res., Lett.*, **27**, 1639-1642, 2000.

Thompson, A. M. and R. D. Hudson, Tropical tropospheric ozone (TTO) maps from Nimbus 7 and Earth-Probe TOMS by the modified-residual method: Evaluation with sondes, ENSO signals and trends from Atlantic regional time series, *J. Geophys. Res.*, **104**, 26961-26975, 1999.

Thompson, A. M., et al., Shipboard and satellite views of a tropical Atlantic tropospheric ozone maximum and wave-one in January-February 1999, *Geophys. Res., Lett.*, in press, 2000.

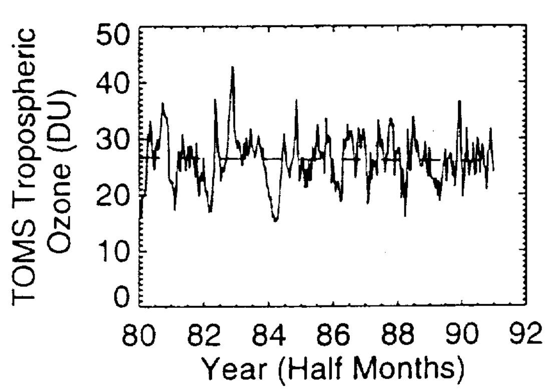

Figure 1. Time-series of tropospheric ozone from Nimbus 7/TOMS by the modified-residual method, 1980-1990, with data averaged from 0-12S, 80-110E, covering western Indonesia, Singapore and Malaysia. Dashed line represents trend (a not statistically significant loss) deduced from a model fit to deseasonalized TTO data. Mean is 26.6 DU.

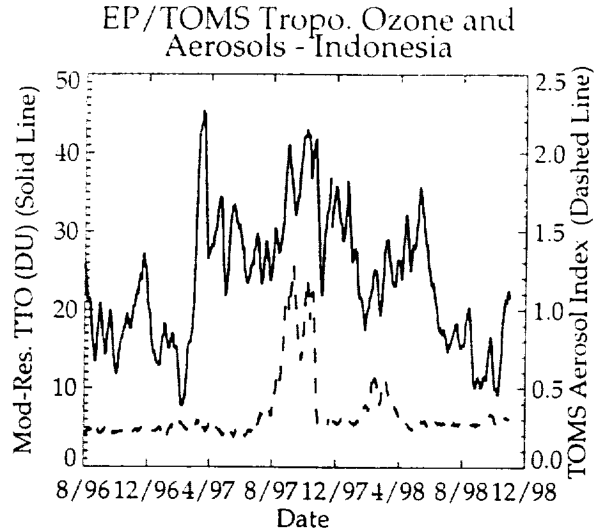

Figure 2. Time-series of tropospheric ozone (solid line) and smoke aerosol index (dashed line) over the Indonesian area (5N-14S, 95-120E) from the Earth Probe/TOMS record.

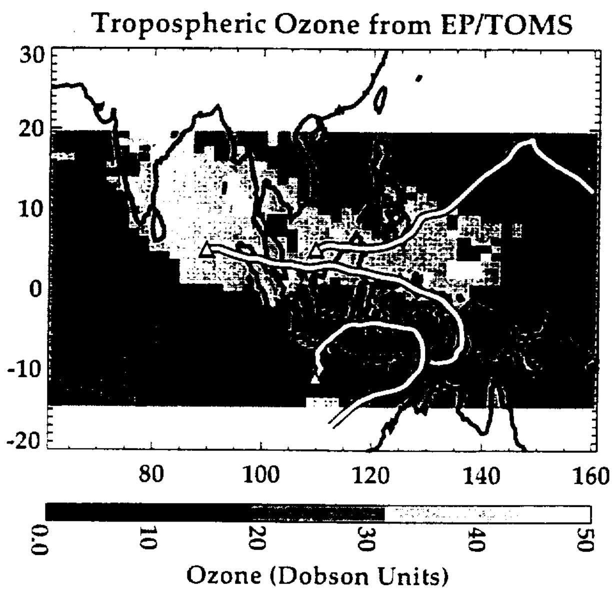

Figure 3. Nine-day averaged TTO from EP/TOMS for the period 971108-971116. Superimposed 10-day back trajectories initialized at 971116 for three locations: 12S, 110E; 4N, 110E; 4N, 90E.

QUAD Ozone Symposium 7/2000 #499

Tropical tropospheric ozone: A multi-satellite view from TOMS and other instruments

Anne M Thompson
NASA/GSFC/Code 916, Greenbelt, MD 20771 USA

Robert D Hudson, Hua Guo
Dept of Meteorology, U Maryland, College Park, MD 20742 USA

Jacquelyn C Witte, Tom L Kucsera
EITI at NASA/GSFC/Code 916, Greenbelt, MD 20771 USA

Matthew G Seybold
Dept of Marine, Atmospheric and Earth Sciences, No Carolina State Univ., Raleigh, NC USA

Abstract. New tropospheric ozone and aerosol products from the TOMS (Total Ozone Mapping Spectrometer) satellite instrument can resolve episodic pollution events in the tropics and interannual and seasonal variability. Modified-residual (MR) Nimbus 7 tropical tropospheric ozone (TTO), two maps/month (1979-1992, 1-deg. latitude x 2-deg. longitude) within the region in which total ozone displays a tropical wave-one pattern [maximum 20S to 20N; Thompson and Hudson, 1999], are available in digital form at http://metosrv2.umd.edu/~tropo. Also available are preliminary 1996-1999 MR-TTO maps based on real-time Earth-Probe (EP)/TOMS observations. Examples of applications are given.

1. Tropical Ozone and Smoke Aerosol Seasonality

Modified-residual TTO and smoke aerosol time-series from Nimbus 7/TOMS (1979-1992) are used to evaluate seasonal patterns and trends in the tropics in the 1980's [Thompson and Hudson, 1999; Herman et al, 1997]. Regions considered were the south Atlantic, southern Africa, Brazil, the eastern Pacific and the Indonesian- Malaysian-New Guinea area. No significant trends in tropospheric ozone were found over these areas from 1980-1990, as seen in Figure 1, depicting Indonesian TTO. The deseasonalized mean, the dashed line, with 26.6 DU in 1980, has a trend = -0.14 DU/yr, not significant at the 2-sigma level. Indonesian TTO displays two peaks in an annual cycle, one in May associated with SE Asian biomass burning, the second, in November, more likely caused by large-scale dynamnics and/or transport of ozone and ozone precursors from African and Australian burning.

Another factor contributing to high TTO in October-November may be lightning NO which leads to ozone formation [Martin et al., 2000]. Lightning activity is observed with satellite data from the OTD (Optical Transient Detector) and TRMM (Tropical Rainfall Measuring Mission) satellite Lightning Imaging Sounder. High-ozone peaks over the south tropical Atlantic, for example, were traced back to lightning activity over southern Africa during the *R/V R H Brown* Aerosols99 cruise [Thompson et al., 2000].

2. High-Resolution Views of Biomass Burning

The Nimbus 7 record captures the 1982-1983 ENSO (El Niño-Southern Oscillation) in a feature of > 40 DU in Figure 1. More intense ENSO-induced biomass fires of 1997-1998, viewed by Earth-Probe TOMS are detected as an extended period of high TTO (solid line, Figure 2). The low smoke aerosol signal (dashed line, Figure 2) during April-May 1998 suggests that Indonesian TTO is due to transport of ozone and ozone precursors. However, burning over Kalimantan and Sumatra accelerated in late August 1997 and ozone formed rapidly over Indonesia, with peaks in mid-September and October (Figure 2). In late November 1997 smoke and tropospheric ozone levels dropped to more typical levels. By August 1998 TTO was below 20 DU, similar to August 1996. Smoke aerosol in the region encompassing Indonesia remained low throughout 1998 except for the February-March period.

Nine-day averaged TOMS tropospheric ozone over Indonesia in the latter part of the local fires (mid-

November 1997) appears in Figure 3. An air parcel (trajectory) model is initialized from three Indian Ocean locations. Relatively high ozone (40-50 DU, near Sumatra, Singapore and Malaysia) originated from regions with fires in central Indonesia and New Guinea. At 12S, 110E, lower ozone (20-30 DU) originated over a less polluted central Indian Ocean.

Acknowledgments. This work was supported by NASA ACMAP. TOMS aerosol data are available by ftp from <toms.gsfc.nasa.gov> and tropospheric ozone data from <http://metosrv2.umd.edu/~tropo>.

References

Herman, J. R., et al., Global distribution of UV-absorbing aerosols from Nimbus 7/TOMSdata, *J. Geophys. Res.*, **102**, 16911-16922, 1997.

Martin, R. V., et al., Detection of a lightning influence on tropical tropospheric ozone, *Geophys. Res., Lett.*, **27**, 1639-1642, 2000.

Thompson, A. M. and R. D. Hudson, Tropical tropospheric ozone (TTO) maps from Nimbus 7 and Earth-Probe TOMS by the modified-residual method: Evaluation with sondes, ENSO signals and trends from Atlantic regional time series, *J. Geophys. Res.*, **104**, 26961-26975, 1999.

Thompson, A. M., et al., Shipboard and satellite views of a tropical Atlantic tropospheric ozone maximum and wave-one in January-February 1999, *Geophys. Res., Lett.*, in press, 2000.

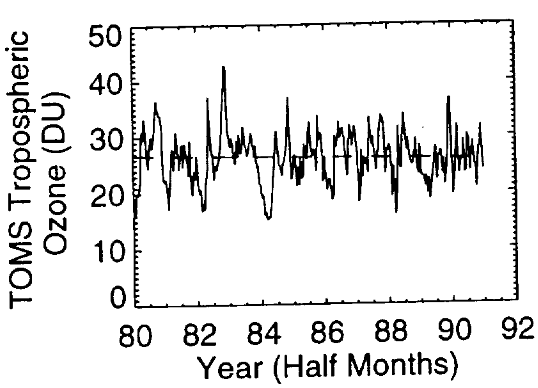

Figure 1. Time-series of tropospheric ozone from Nimbus 7/ TOMS by the modified-residual method, 1980-1990, with data averaged from 0-12S, 80-110E, covering western Indonesia, Singapore and Malaysia. Dashed line represents trend (a not statistically significant loss) deduced from a model fit to deseasonalized TTO data. Mean is 26.6 DU.

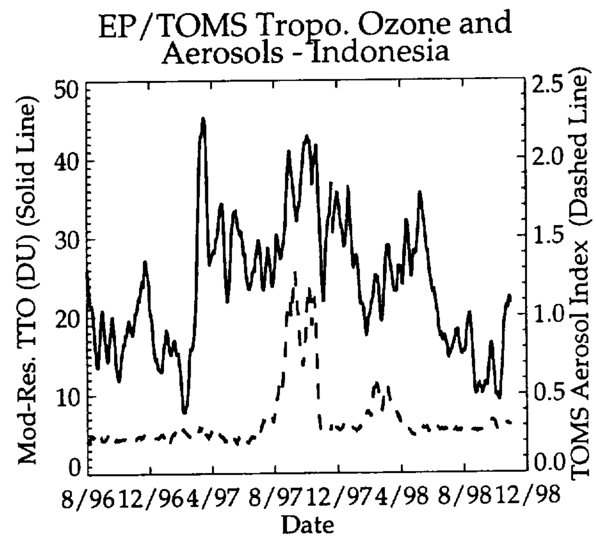

Figure 2. Time-series of tropospheric ozone (solid line) and smoke aerosol index (dashed line) over the Indonesian area (5N-14S, 95-120E) from the Earth Probe/TOMS record.

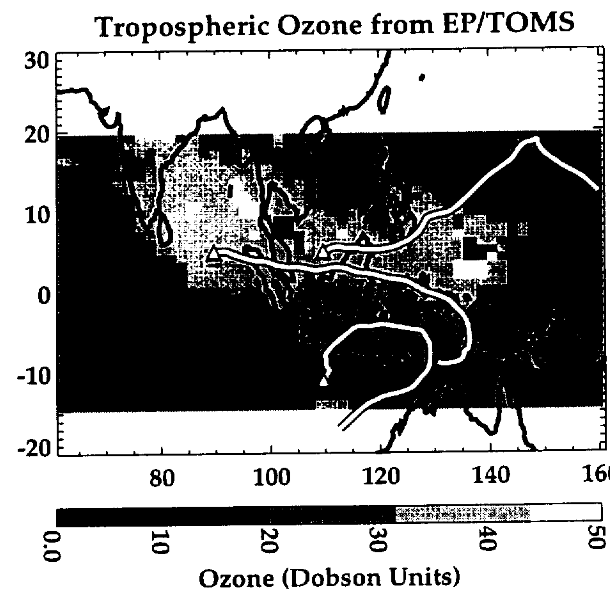

Figure 3. Nine-day averaged TTO from EP/TOMS for the period 971108-971116. Superimposed 10-day back trajectories initialized at 971116 for three locations: 12S, 110E; 4N, 110E; 4N, 90E.