INDONESIA

INTRODUCTION

Atmospheric structure of Indonesia is expected very complicated because of it's dynamically effect. Strong convection significantly influences the composition of the atmosphere. This phenomenon is mainly driven by solar insolation.
Minor constituents that affect the atmospheric dynamics and thermal distributions are found in abundance. Particularly Indonesian Maritime Continent is the region where trace gas distributions in the troposphere is strongly influenced by deep convection, frequent lightning and biomass burning. Quantitative studies of these processes have been very limited so far in this region because of the lack of simultaneous measurements of key species.

OBSERVATIONAL ACTIVITIES

National Institute of Aeronautics and Space (LAPAN) works in collaboration with other National Institutions: NASA, NOAA, NASDA and Japanese University perform ozone measurements.

Surface ozone measurement

Surface Ozone measurement conducted at 4 Locations, Bandung, Watukosek, Biak and Pontianak. The surface ozone monitor used in this observation is Dylec model 1006-AHJ and model 1150, produced under a license of Dasibi Inc. The air containing the ozone is pumped into sample cell where the measurement is done by using ultraviolet absorption technique. The result is represented in units of ppbv with the resolution of 1 ppbv and recorded on a strip chart or sent directly to PC that is operated as data logger. The cycle time of measurement is about 12 seconds (Anonym, 1985). This instrument was operated automatically 24 hours every day .
The measurements are conducted in Bandung (6.9 ^{o}S, 107.5 ^{o}E) West Java, 740 m asl, representing polluted city. Biak (1^{o} S,136 ^{o}E) Papua, 50 m asl, representing unpolluted area. Pontianak (0.05 ^{o}N ,109.33 °E), West Kalimantan, representing unpolluted area that sometimes influenced by pollution comes from biomass burning / forest fire. Watukosek (7.5^{o}S, 112.6^{o}E), East Java, 50 m asl representing growing urban area

Column measurements of ozone and other gases/variables relevant to ozone loss

Brewer spectrophotometer MK-IV (#94) operated at Watukosek (1994-2000) data send to NASDA. After 2000 Watukosek Brewer spectrophotometer not operated.
In 1996, LAPAN install Brewer spectrophotometer MK-IV (#116) in Bandung, operated until 1998. In 2006 re operated after calibrated assistance by MWO in September 2006.

Profile measurements of ozone and other gases/variables relevant to ozone loss

Balloon-borne measurements take place at Watukosek, East Java (7.5°S, 112.6°E, 51 m a.s.l).
Ozonesondes Since 1998, the Watukosek ozonesonde station was officially accepted into the Southern Hemisphere Additional OZonesondes (SHADOZ) network. Weekly ozonesonde soundings have been conducted on a weekly basis, using ECC ozonesondes. Ozonosondes launches are a collaboration between NASA/NOAA. Kyoto University and the Hokkaido University, Japan

Vertical ozone measurement is conducted regularly at Watukosek by using balloon borne equipment. The system is set up of an airborne system - ozonesonde payload type RSII-KC79D provided by Meisei Co., ground observation system tracking telemetry signal automatically and data processing system (also data acquisition system) based on personal computer. The important ozonesonde unit is made up of an ozone detector and the dedicated electronics. Ozone data which is converted into audio signal is sent sequentially

with meteorological signals information, i.e. temperature, pressure and references (Anonym, 1979). This payloads were carried aloft using meteorological hydrogen filled rubber balloon (usually 3000 grams) and a protective parachute.
Ozone detector is based on Komhyr's carbon iodine ozone-sensor. The operating principle is based on the reaction of ozone to a potassium iodide solution wherein free iodine is liberated. The liberated iodine is measured quantitatively by a coulometrical method (Kobayashi and Toyama, 1966). According to Kobayashi, error of the measurement is estimated to be within $\pm$ 2%.

Water Vapor Measurements
Since 2001, together with ozone soundings also water vapor soundings have been taken place. Soundings have been conducted annually (usually in December or January) using cryogenic chilled-mirror hygrometers that are flown in combination with ozonesondes. Water vapor soundings are a collaboration between Kyoto University, Hokkaido University and CIRES-University of Colorado/NASA/NOAA.

UV measurements
The UV measurements are performed by LAPAN, located at Bandung and Watukosek.

Broadband measurements

Narrowband filter instruments
Bandung and Watukosek station is used to measure UV. The UV Sensor measures UV-B irradiances of the UV spectrum (280 nm - 315 nm).
Spectroradiometers

Calibration activities
Pre-launch calibration takes place in a regular basis. Vaisala is calibrated at NOAA/CIRESUniversity of Colorado/NASA.
Brewer instrument was installed by LAPAN in Bandung (Brewer spectrophotometer MK-IV #116). The instrument was installed in early 1995 and last visited in 2001, but had been out of service for the past 4-5 years. The instrument was found to need a new power supply, micro-board and UV filter in front of photomultiplier tube to get it back into service. This calibration was completed in September 2006 at LAPAN site in Bandung, Indonesia by Ken Lamb, (IOS) with support from the Vienna Convention Trust Fund through the World Meteorological Organization (WMO).

RESULTS FROM OBSERVATIONS AND ANALYSIS

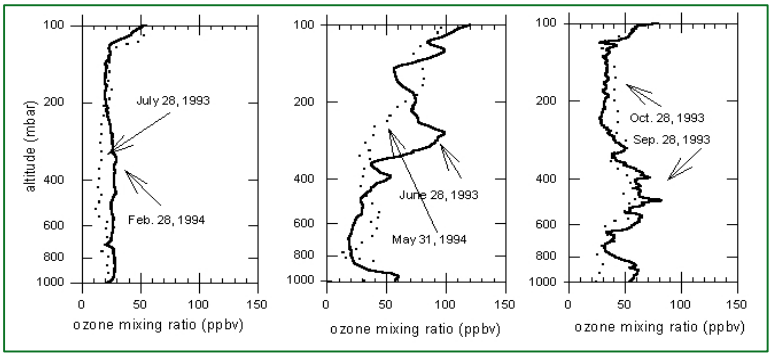

Fig.1. Typical profiles of ozone concentration observed at Watukosek (Komala, N. et al, 1996)

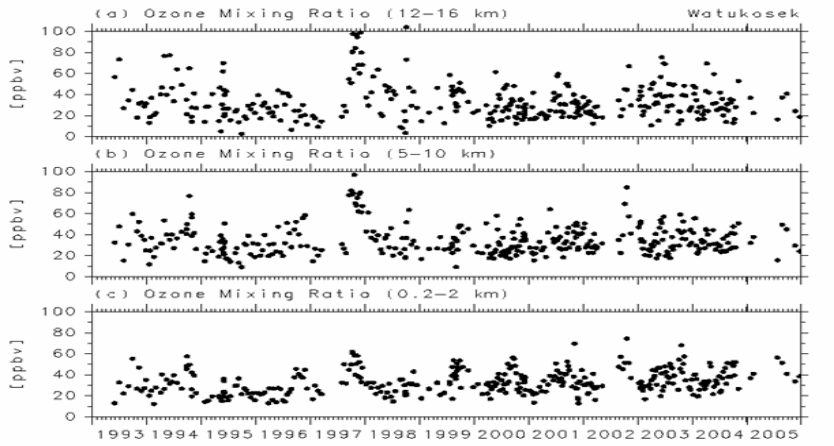

Fig.2. Mixing ratio of ozone at Watukosek at three layers (0.2-2km), (5-10 km) anf (12-16 km) which shows peak at 1994,1997 and also shows peak at 2002.

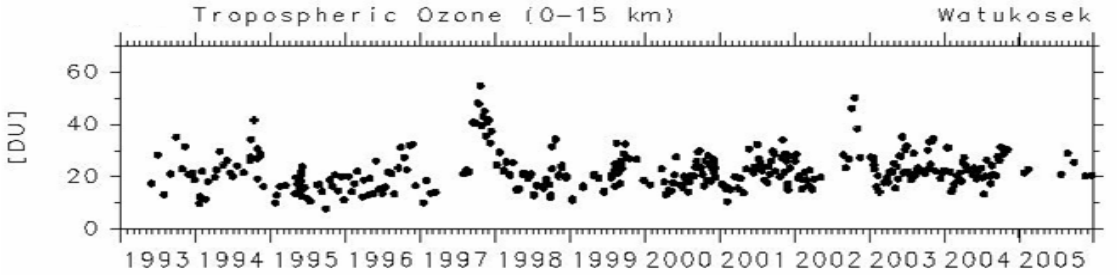

Fig 3. The time series of tropospheric column ozone shows an interesting peak in 1994, 1997 and late 2002. The peak value is comparable to those of the 1994 and 1997 events.

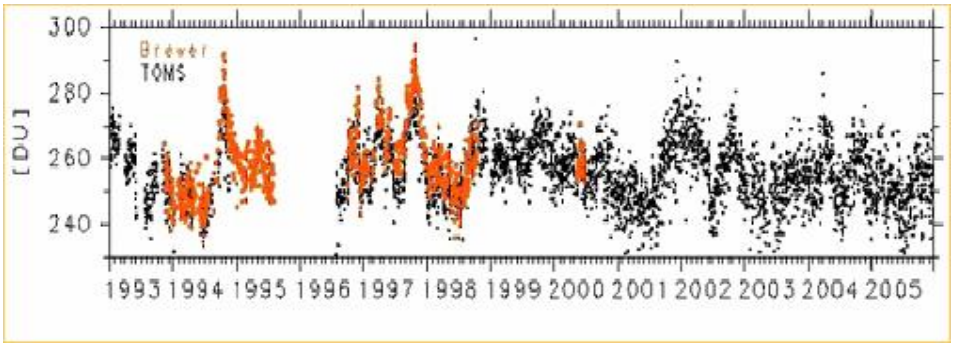

Fig 4. Watukosek Brewer Spectrophotometer #92 data (red dot) compared with TOMS data. Late 1994 and late 1997 show higher total ozone due to the longer dry season and forest fire effect from Sumatra and Kalimantan.

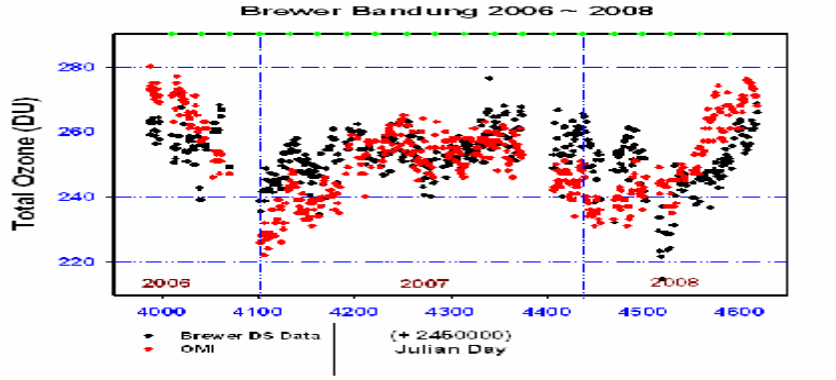

Fig 5. The red circle is total ozone by OMI, and black circle is direct-sun Brewer #116, Simultaneous measurement between direct-sun Brewer #116 and OMI gives different value of total ozone column over Bandung.

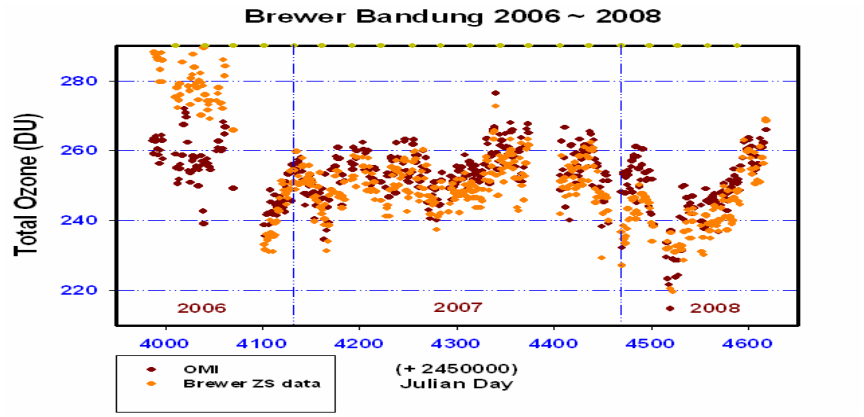

Fig 6. Comparison of total ozone between zenith-sky Brewer 116 and OMI data. The zenith-sky total ozone is represented by orange circle, whereas OMI data is represented by brown circle..

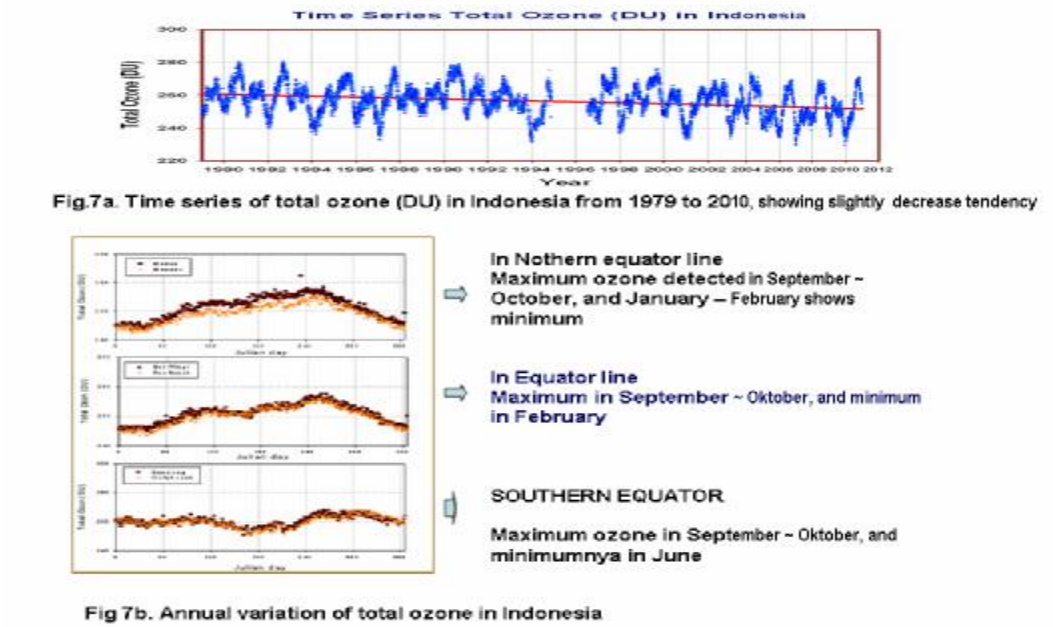

Fig 7. The trend of long term ozone in Indonesian region derived from SBUV, TOMS and OMI AURA (7a) and annual variation of total ozone in Indonesia (7b).

UV measurements

The UV measurements are performed by LAPAN, located at Bandung and Watukosek. The UV Sensor measures UV-B irradiances of the UV spectrum in the wavelength of 280 nm ~ 315 nm. The UV Index measurement also conducted in Bandung by using AWS (Automatic Weather Station).

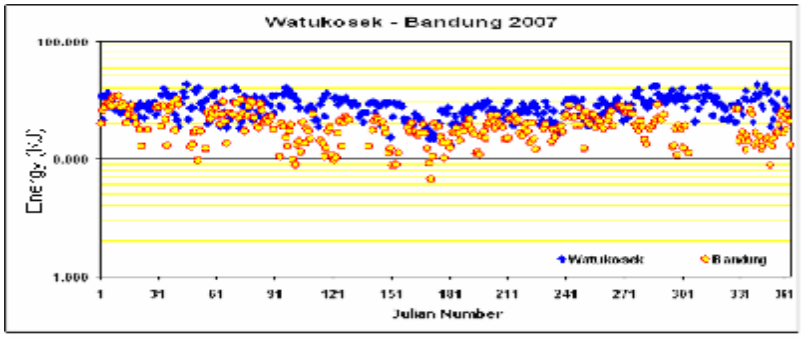

Figure 8, Daily UV energy at Watukosek and Bandung in 2007

In Indonesia, UV index levels are normally extreme, as shown in time series of UV Index derived from OMI_AURA data in 2004-2010. Range of UV index in Indonesia usually in between 8 to 15.

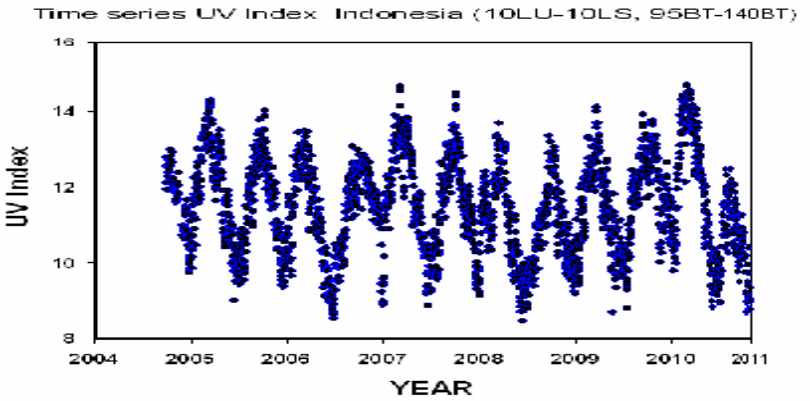

Figure 9, Time series of UV index in Indonesian region in the period of 2004-2010 derived from OMI AURA data.

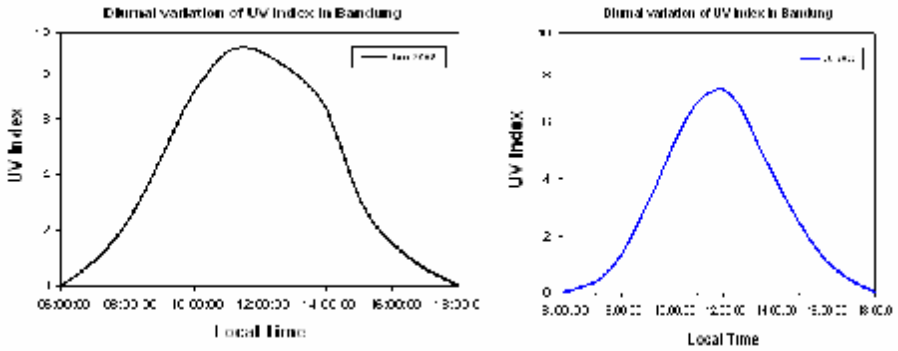

Fig 10. Comparison of the diurnal variation of UV index in Bandung on January and July 2008.

UV index levels in Bandung on January (wet season) show higher compare to July (dry season). Peak of UV index in January show 9 and in July only show 7.

THEORY, MODELLING, AND OTHER RESEARCH

The Ozone Standard Profile was constructed by using the long term observation data of the ozonesonde launchings from Watukosek (surface ~ 20 km). This Watukosek standard profile is used to validate Watukosek ozone profile based on MOZART (Model of Ozone And Related Tracers) output.

There is on-going research on the relationship between ozone, UV radiation and climate with the goal of improving modeling.

DISSEMINATION OF RESULTS

Data reporting

The ozone profile data collected in Watukosek is sent to Hokkaido University, Sapporo, Japan. The data from Hokkaido University is then transferred to the SHADOZ (Southern Hemispheric Additional OZonesondes) archives data: http://croc.gsfc.nasa.gov/shadoz/java.html.

Bandung Brewer Spectrophotometer data is sent to WOUDC, Canada, ftp://ftp.tor.ec.gc.ca

Information to the public

Vertical ozone profile data is made available after every launch on the SHADOZ website for the scientific community.

Relevant scientific papers

- Vömel, H., J. E. Barnes, R. N. Forno, M. Fujiwara, F. Hasebe, S. Iwasaki, R. Kivi, N. Komala, E. Kyrö, T. Leblanc, B. Morel, S.-Y.Ogino, W. G. Read, S. C. Ryan, S. Saraspriya, H. Selkirk, M. Shiotani, J. Valverde Canossa, and D. N. Whiteman (2007), **Validation of Aura Microwave Limb Sounder water vapor by balloon-borne Cryogenic Frost point Hygrometer measurements**, *Journal of Geophysical Research, 112*, D24S37, doi:10.1029/2007JD008698.
- Hasebe, F., M. Fujiwara, N. Nishi, M. Shiotani, H. Vömel, S. Oltmans, H. Takashima, S. Saraspriya, N. Komala, and Y. Inai (2007), **In situ observations of dehydrated air parcels advected horizontally in the Tropical Tropopause Layer of the western Pacific**, *Atmospheric Chemistry and Physics, 7*, 803-813
- Fujiwara, M., Y. Tomikawa, K. Kita, Y. Kondo, N. Komala, S. Saraspriya, T. Manik, A. Suripto, S. Kawakami, T. Ogawa, E. Kelana, B. Suhardi, S. W. B. Harijono, M. Kudsy, T. Sribimawati, and M. D. Yamanaka (2003), **Ozonesonde observations in the Indonesian maritime continent: A case study on ozone rich layer in the equatorial upper troposphere**, *Atmospheric Environment, 37*, Issue 3, 353-362.
- Fujiwara, M., K. Kita, T. Ogawa, S. Kawakami, T. Sano, N. Komala, S. Saraspriya, and A. Suripto (2000), **Seasonal variation of tropospheric ozone in Indonesia revealed by 5-year ground-based observations** , *Journal of Geophysical Research, 105*, No. D2, 1879-1888.
- Fujiwara, M., K. Kita, S. Kawakami, T. Ogawa, N. Komala, S. Saraspriya, and A. Suripto (1999), **Tropospheric ozone enhancements during the Indonesian forest fire events in 1994 and in 1997 as revealed by ground-based observations**, *Geophysical Research Letters, 26*, No. 16, 2417-2420.
- Fujiwara, M., K. Kita, T. Ogawa, N. Komala, S. Saraspriya, A. Suripto, and T. Sano (1998), **Total ozone enhancement in September and October 1994 in Indonesia**, in *Atmospheric Ozone*, Vol. 1, (Proceedings of the XVIII Quadrennial Ozone Symposium, L'Aquila, Italy, September 12-21, 1996), edited by R. D. Bojkov and G. Visconti, pp. 363-366.
- Komala, N., S. Saraspriya, K. Kita, and T. Ogawa, **Tropospheric ozone behavior observed in Indonesia**, *Atmospheric Environment, 30, 1851-1856, 1996.*

PROJECTS AND COLLABORATION

The major international collaborations are with Hokkaido University, Kyoto University, CIRES-University of Colorado-NOAA/NASA.

LAPAN has participated in projects:

- Southern Hemisphere ADditional OZonosondes, SHADOZ, financed by NASA, from 01.01.1998 - not yet defined.
- Sounding of Ozone and Water vapor at Equatorial Region (SOWER), financed by Hokkaido University, Kyoto University, CIRES-University of Colorado-NOAA/NASA, from: 01.01.2004 – not yet defined, Through this project we launch regularly ozone and water vapor sondes at Biak (campaign is conducted every January).

FUTURE PLANS

These following activities are planned for the future:

- Continue monitoring vertical ozone profiles under the SHADOZ program,
- Ozone Climatology,
- Continue Monitoring of the water vapor profiles in Biak under SOWER program,
- Continuing and improve the Surface ozone measurements,
- To improve dissemination of the data to the Indonesian community by establishing LAPAN's own web page.

NEEDS AND RECOMMENDATION

- We need financial support for travelling to attend the meetings, seminars and workshops abroad.
- We recommend to start with an UV network in Indonesia (measurement of UV index). Collaboration research concerning the impact of higher UV-B radiation and depletion of the ozone layer in Indonesia are also needed as a consequence of the equatorial region country.
- Assistance for calibration and maintenance of the instrumentations are needed since they can not be done by Indonesia due to the lack of spare parts and expertise.

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