SOURCES CONTRIBUTING TO TROPOSPHERIC OZONE PRODUCTION OVER SOUTHERN AFRICA AND THE ADJACENT INDIAN OCEAN ISLANDS

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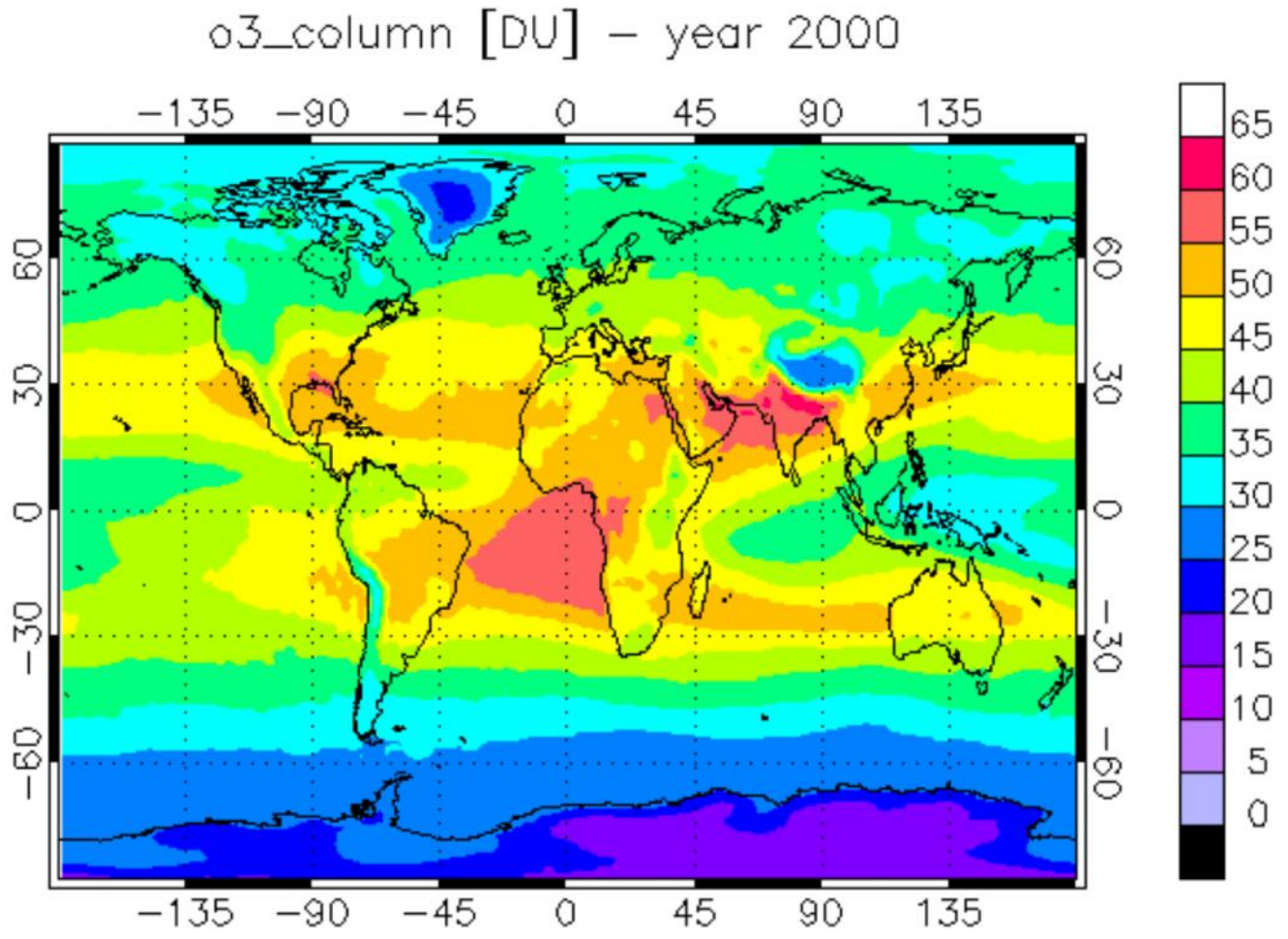
Outline

1. Background
   - Key research question
2. Tropospheric ozone sources categories;
   - Stratospheric Tropospheric Exchange (STE);
   - Biomass burning emissions (BB);
   - Anthropogenic emission (AE)s;
   - Biogenic emissions(BE);
   - Lightning emissions (LE);
   - Sinks and ozone budget
3. Effects of TO sources on climate
4. Summary
5. References

Background

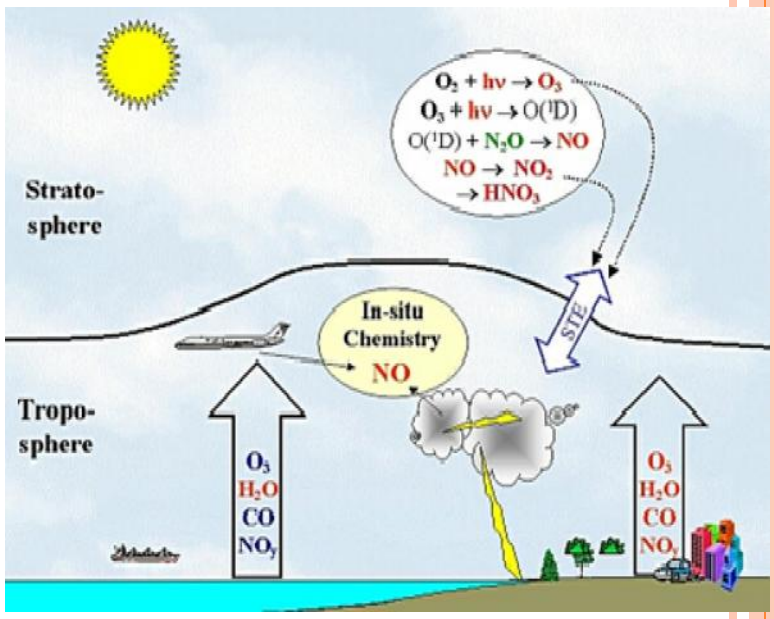
Why studying tropospheric ozone over SAAIOI?

- Secondary pollutant and greenhouse gas;
- O_3 poorly documented over the region;
- Elevated concentrations observed since the last 2 decades of the 20th century over SAAICI;
- Negative impacts on humans and the environment;
- SAAIC vulnerable to climate change;
- Studies useful to understand trends, validate previous ground based and remote sensing data and predict the future due to climate change.

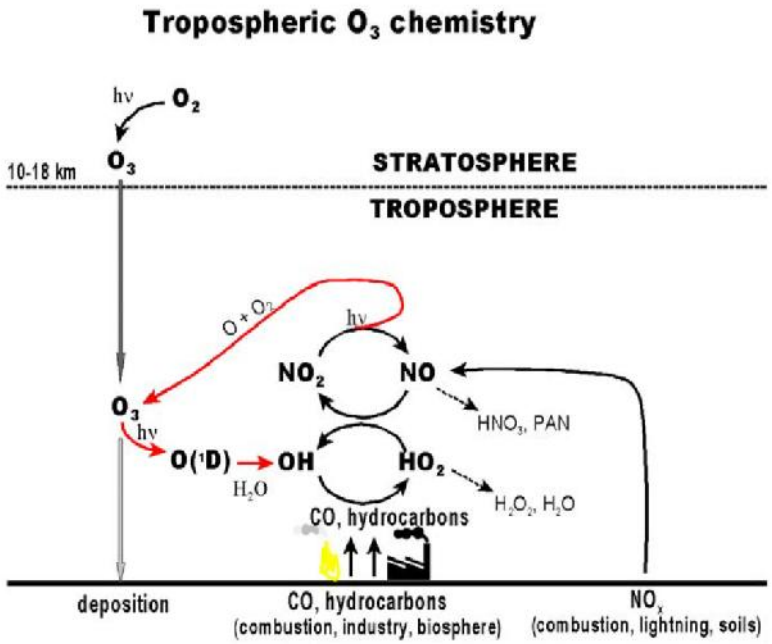

o3_column [DU] – year 2000
−135 −90 −45 0 45 90 135
60 30 0 −30 −60
65 60 55 50 45 40 35 30 25 20 15 10 5 0

Tropospheric ozone sources categories

- Stratospheric Tropospheric Exchange (O_3 intrusion)
- Photochemical formation (oxidation of precursors and sunlight)

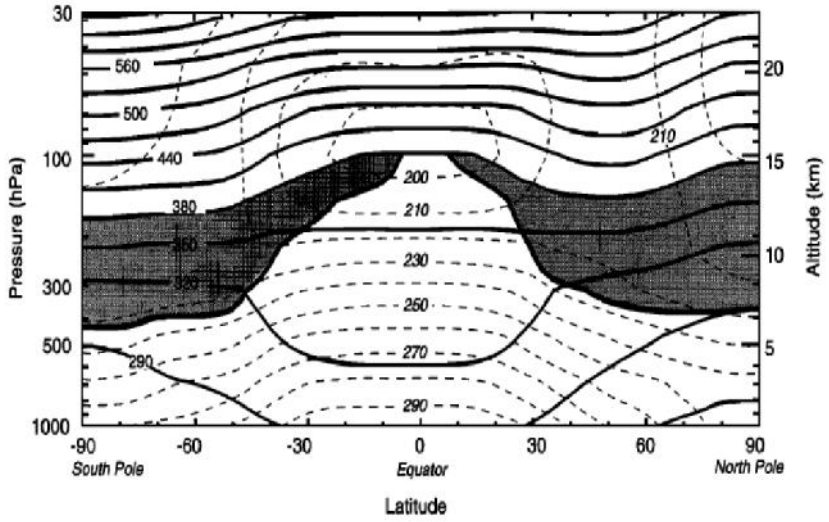


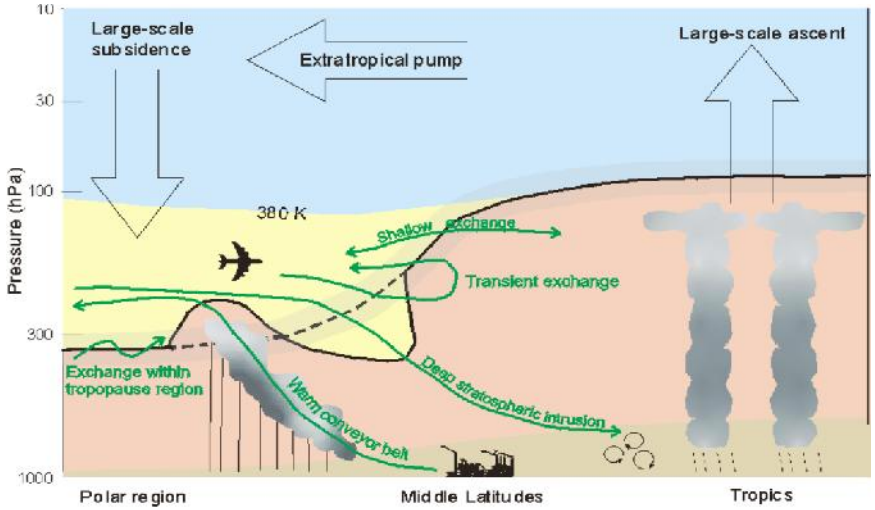
Source: http://www.fz- juelich.de/icgi/mozaic/background



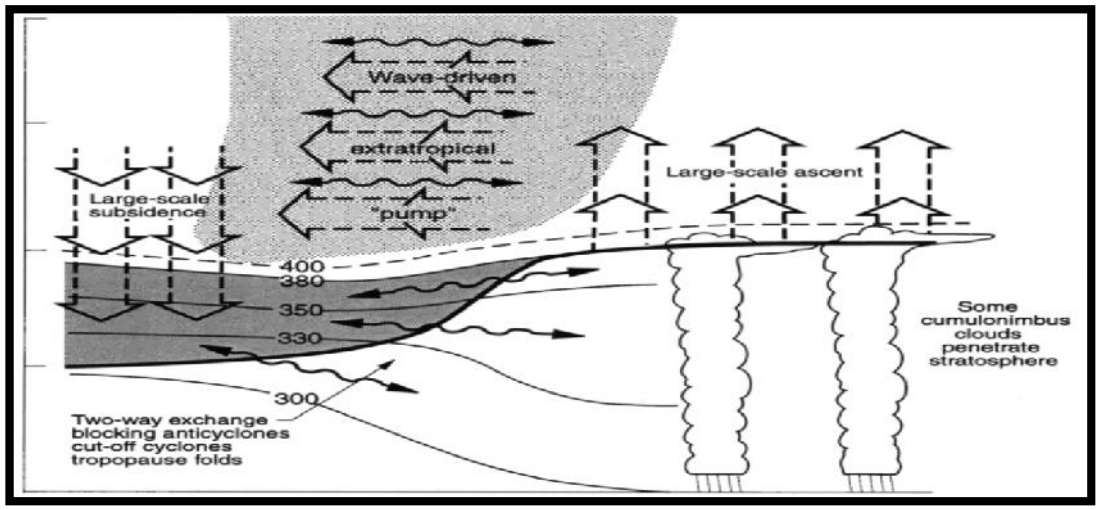
Sources: http://faculty.washington.edu/jaegle/558/ozone_NOx.pdf

Stratospheric Tropospheric Exchange (STE)





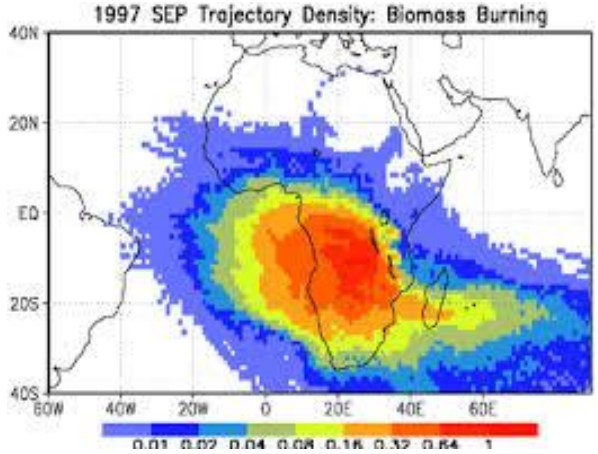
Dynamical aspect of STE



Sources: Holton *et al*. (1995).

Biomass Burning emissions (BB);

- Main traditional energy source
- Secular cultural practice for agriculture and pastoral activities
- A response to socio-economic pressures of the ever increasing population in developing world particularly in African continent



- A significant source of radiative species (aerosols, CO_2, nitrogen oxides (NOx = NO + NO_2), (CO)
- Africa = leading source of air pollution from biomass burning (Hao and Liu,1994)

- Average of 30 to 50% of the total amount of vegetation burned globally each year in Africa; an estimated $1.3x10^6$ tons of dry biomass burned per year (Delmas *et al.* 1991);

- Satellites and ground based measurements show ozone enhancement over SAAIOI region (Seiler and Cruzen, 1980; Cruzen and Andrea, 1990) during burning season;

- International research bodies STARE, TRACE-A and SAFARI 2000, SHADOZ, MOZAIC…etc, confirm BB role on photochemical formation of ozone;

- Contradiction with the above findings led to the use of three-dimensional (3-D) atmospheric chemistry and transport models (CTMs);

- Photochemical O_3 formation from BB may be less important than indicated (Lelieveld and Dentener, 2000; Marufu *et al*. 2000; Moxim and Levy, 2000);

- BB contribution to ozone formation is smaller when compared to the effects from lightning and transport in the troposphere (Ziemke *et al.* 2009);

- No research on the spatial and temporal distribution of BB to comprehend its contribution to TO_3 over SAAIOI (Wai *et al.* 2013).

- Analyse of remote sensing and ground based measurements (1994-2005) to comprehend BB trends and contribution to TO_3.

Anthropogenic emissions

- Human activities (energy-use in industry, transportation, mining, construction, and in the household (Aghedo *et al*. 2007

- Southern Hemisphere emissions contribute to 10 to 20% of the total column ozone (TCO)

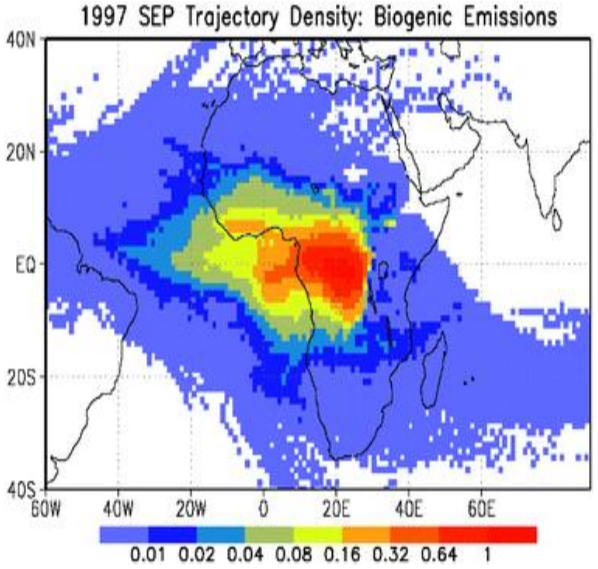
- Southern African region, the fastest growing region with regard to human population and urbanisation,

- Anthropogenic emissions set to increase as the needs of energy for households, transportation and industrialisation (UNEP 1999)

- Most countries in southern Africa lack or have inadequate air quality standards (UNEP 1999) to control anthropogenic emissions from mobile and stationary sources;

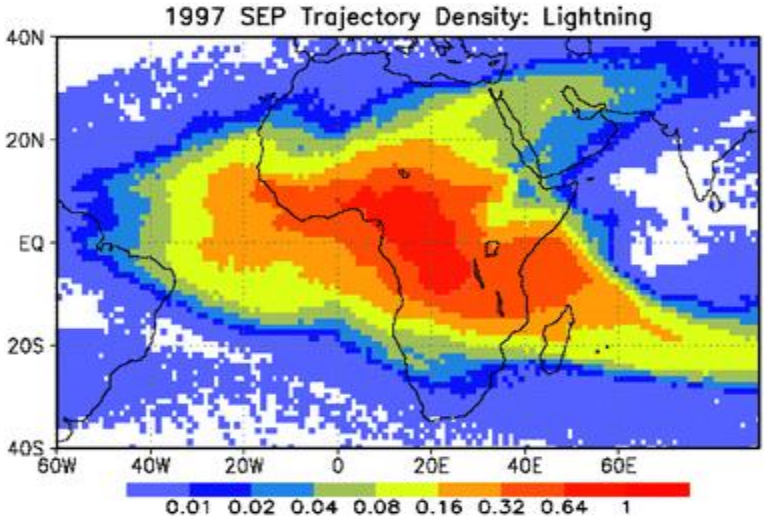
- Much of tropospheric ozone observed at Irene is due to urban and industrial pollution from Gauteng (11 large coal power plants with 34 GW generating capacity (Diab *et al.*2004)).

BIOGENIC EMISSIONS



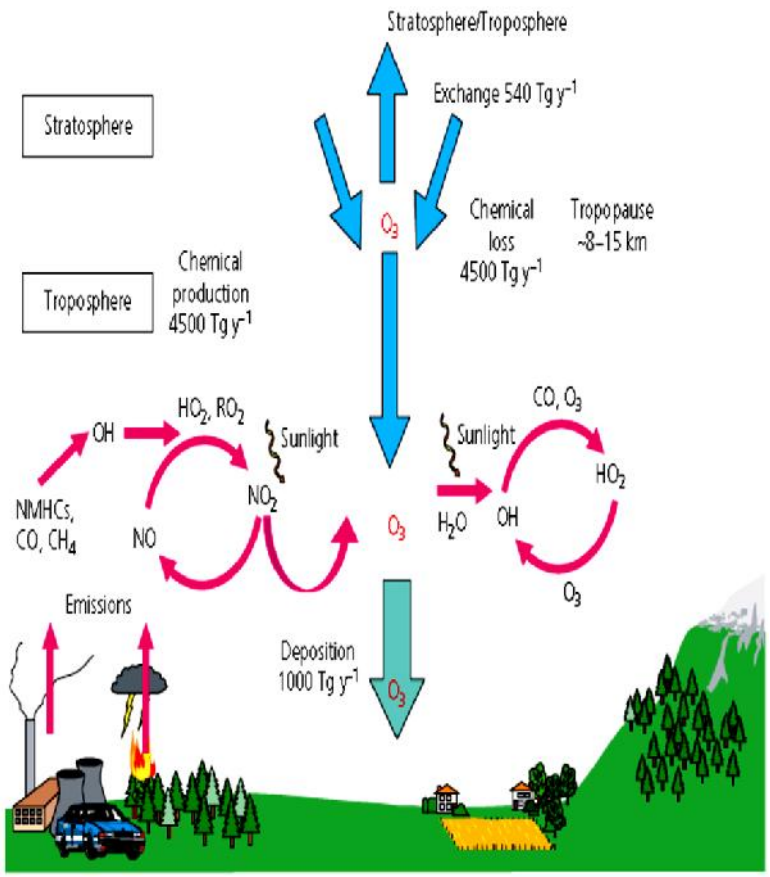
- Emissions from biological metabolic processes on land and in the Oceans (USEPA, 2005). VOCs, $NO_{2,}$ CO, $CH_{4;}$
- Significantly contribute to atmospheric chemistry both at a global and regional scale (Otter and Scholes, 2005);
- Isoprene is the most dominant biogenic species (Guenther *et al.* 2006);
- Tropical and subtropical savannahs key source regions of global soil biogenic $NO_{x,}$ due to high T° and their wide geographic coverage;
- Future changes in environmental conditions may increase biogenic emission rates significantly (Pyle *et al.* 2007).

Lightning



- Sources of NO_x in the middle to upper troposphere (Pickering *et al*. 1998; Otto *et al*. 2010) ;
- Not well understood; radiative forcing for tropospheric ozone formation as a greenhouse gas is still uncertain (Yuan *et al*. 2012).
- Long lifetime of NOx in the upper troposphere especially in the tropics could be the cause of dominant features in tropical tropospheric ozone distributions
- Aerosols concentration and mesoscale convective systems play a considerable role on the formation of tropospheric ozone

Sinks contributing to the tropospheric ozone budget



Ozone production and destruction in the atmosphere
Sources: Royal Society 2008.

- **Photolysis**

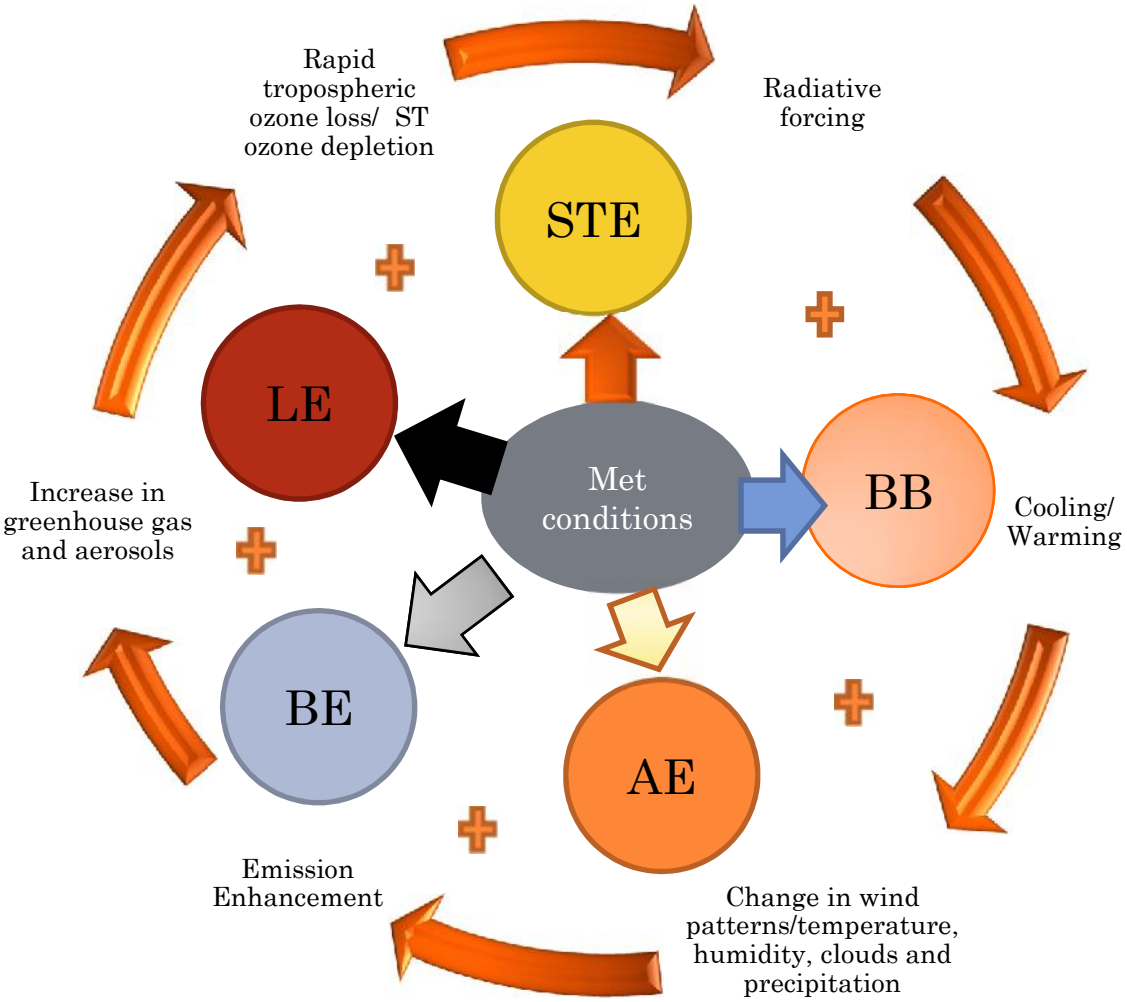
$$O_3 + h\nu\ (\lambda < 320\ \text{nm}) \rightarrow O_2 + (O^*)$$

$$(O^*) + H_2O \rightarrow OH + OH$$

- **HO2/OH catalyzed destruction**

- **Surface deposition (dry and wet)**

Effects of sources contributing to ozone formation on climate



Summary

- STE, BB, BE, AE, LE are the main contributing source of tropospheric ozone in the SAAIOI;
- Natural sources depend on meteorological factors;
- Impact on human health and natural environment;
- SAAIOC is vulnerable to climate change;
- Investigation on the trend and distribution and variability of the source and meteorological factors need to be investigated;
- Legislation needed to mitigate future impacts of ozone on humans and general environment.


THANK YOU