Tropospheric ozone columns retrievals from SCIAMACHY limb-nadir matching observations

Ebojie Felix*, Christian von Savigny, Annette Ladstätter-Weißenmayer, Alexei Rozanov, Mark Weber, Stefan Bötel, Kai-Uwe Eichmann, Nabiz Rahpoe, Heinrich Bovensmann, John P. Burrows

Universität Bremen

esa

Institute of Environmental Physics/Remote Sensing, University of Bremen, Bremen, Germany

*email: felix@iup.physik.uni-bremen.de)

iup

SCIAMACHY

1) Introduction and aim

Ozone in the troposphere is of great importance to the environment. It is a surface pollutant, an effective greenhouse gas and a precursor of hydroxyl (OH) radical, which regulates the chemical lifetime of various chemical species in the troposphere. The increase in tropospheric ozone is of great concern and therefore require careful monitoring.

Satellite instruments such as the Scanning Imaging Absorption spectroMeter for Atmospheric CartograpHY (SCIAMACHY) can be used to monitor tropospheric ozone globally. However, the retrieval process is difficult because of the presence of tropospheric clouds and stratospheric ozone columns which accounts on average for 90% of the total ozone columns. The first approach to derive global tropospheric ozone from satellite measurements involved subtracting the stratospheric ozone columns measured in the limb geometry from the total ozone column measured independently in the nadir view (Fishman and Larsen, 1987) This technique has undergone several modifications over the years and in fact, a similar approach is applied here but in our analysis the stratospheric ozone columns and the total ozone columns information are obtained from the same satellite instrument (SCIAMACHY) through the limb-nadir matching (LNM) technique. This retrieval technique has the potential of leading to reduction in retrieval error as the information from the limb and nadir views are obtain from close air masses. The LNM observation of SCIAMACHY is also expected to characterize stratospheric in-homogeneity and provide an improved understanding of the monitoring of global tropospheric ozone. To validate our results, we used the ozonesondes instruments which is an in-situ measurements as this is expected to be a better reference since it does not need any information on apriori that is mainly needed in satellite retrievals. Also included in the comparison plots are the tropospheric ozone measurements from other satellite instruments.

2) Schematics of SCIAMACHY limb-nadir matching observations

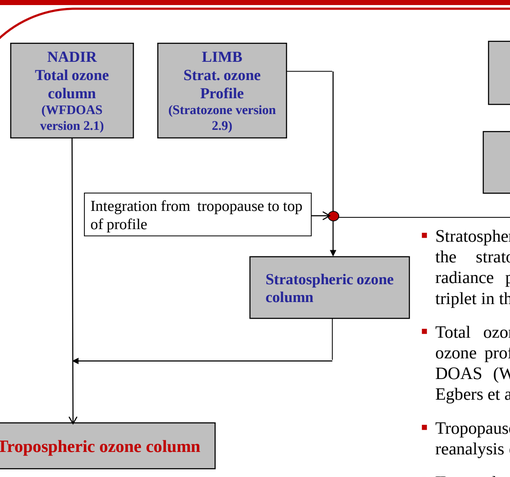
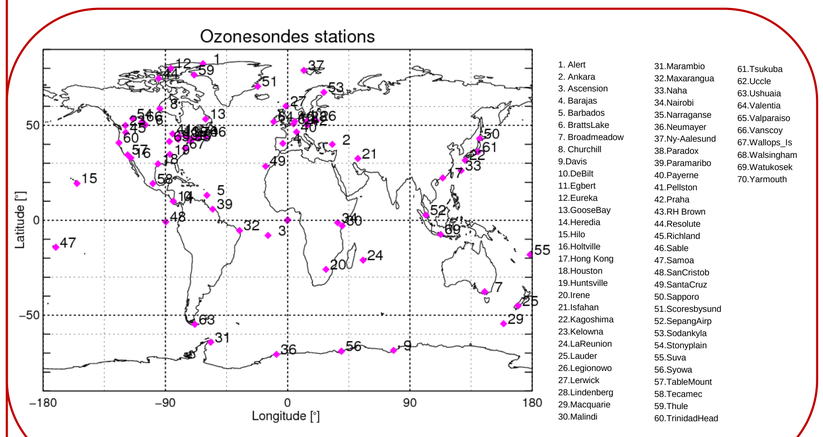


Figure 1: Illustration of the limb-nadir matching technique

- Stratospheric ozone columns derived from the stratospheric ozone profiles using radiance profiles in ultraviolet and ozone triplet in the visible (Sonkaew et al., 2009)
- Total ozone columns derived from nadir ozone profiles using the weighting function DOAS (WFDOAS) techniques (Coldewey-Egbers et al., 2005)
- Tropopause height determined from ECMWF reanalysis data
- Tropospheric ozone column is obtained by subtracting the stratospheric ozone columns from the total ozone columns

3) In-situ measurements: Ozonesondes stations



1. Alert
2. Ankara
3. Ascension
4. Barajas
5. Barbados
6. BrattsLake
7. Broadmeadow
8. Churchill
9.Davis
10.DeBilt
11.Egbert
12.Eureka
13.GooseBay
14.Heredia
15.Hilo
16.Holtville
17.Hong Kong
18.Houston
19.Huntsville
20.Irene
21.Isfahan
22.Kagoshima
23.Kelowna
24.LaReunion
25.Lauder
26.Legionowo
27.Lerwick
28.Lindenberg
29.Macquarie
30.Malindi
31.Marambio
32.Maxarangua
33.Naha
34.Nairobi
35.Narragansе
36.Neumayer
37.Ny-Aalesund
38.Paradox
39.Paramaribo
40.Payerne
41.Pellston
42.Praha
43.RH Brown
44.Resolute
45.Richland
46.Sable
47.Samoa
48.SanCristob
49.SantaCruz
50.Sapporo
51.Scoresbysund
52.SepangAirp
53.Sodankyla
54.Stonyplain
55.Suva
56.Syowa
57.TableMount
58.Tecamec
59.Thule
60.TrinidadHead
61.Tsukuba
62.Uccle
63.Ushuaia
64.Valentia
65.Valparaiso
66.Vanscoy
67.Wallops_Is
68.Walsingham
69.Watukosek
70.Yarmouth

Figure 2: global plots of ozonesondes stations

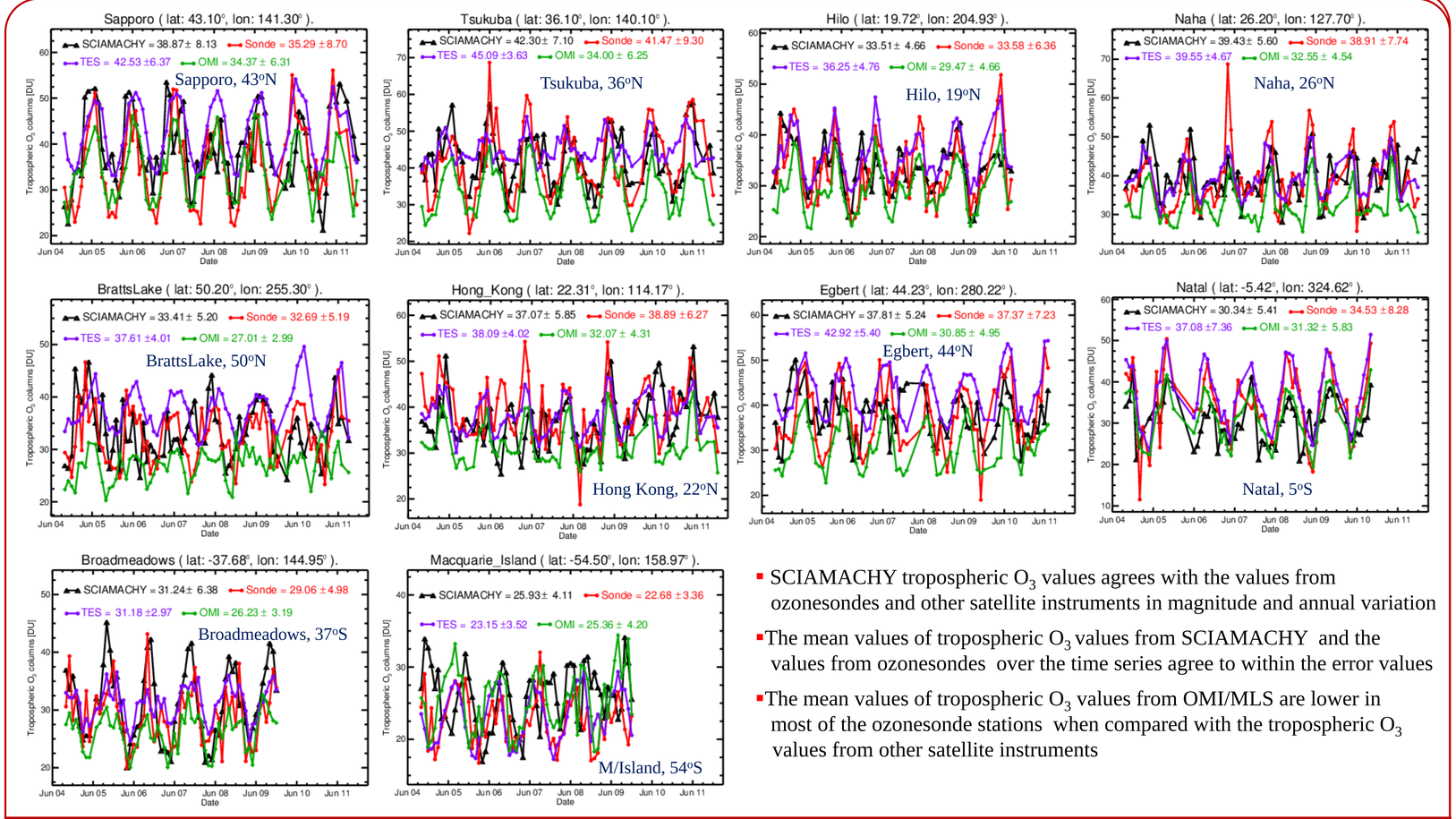
6) Possible error sources

- Ozonesondes measurements correspond to advected measurements along trajectory paths
- Satellite measurements provide averages over large regions
- Retrieval of tropospheric ozone from satellite instruments require information on the a-priori and different satellite instruments may use different a-priori information
- The retrieval algorithm from the different satellite instruments may be different. Also cloud treatment may be different
- Error in stratospheric ozone column from the different error parameters may lead to large bias in tropospheric ozone column

7) Summary and conclusions

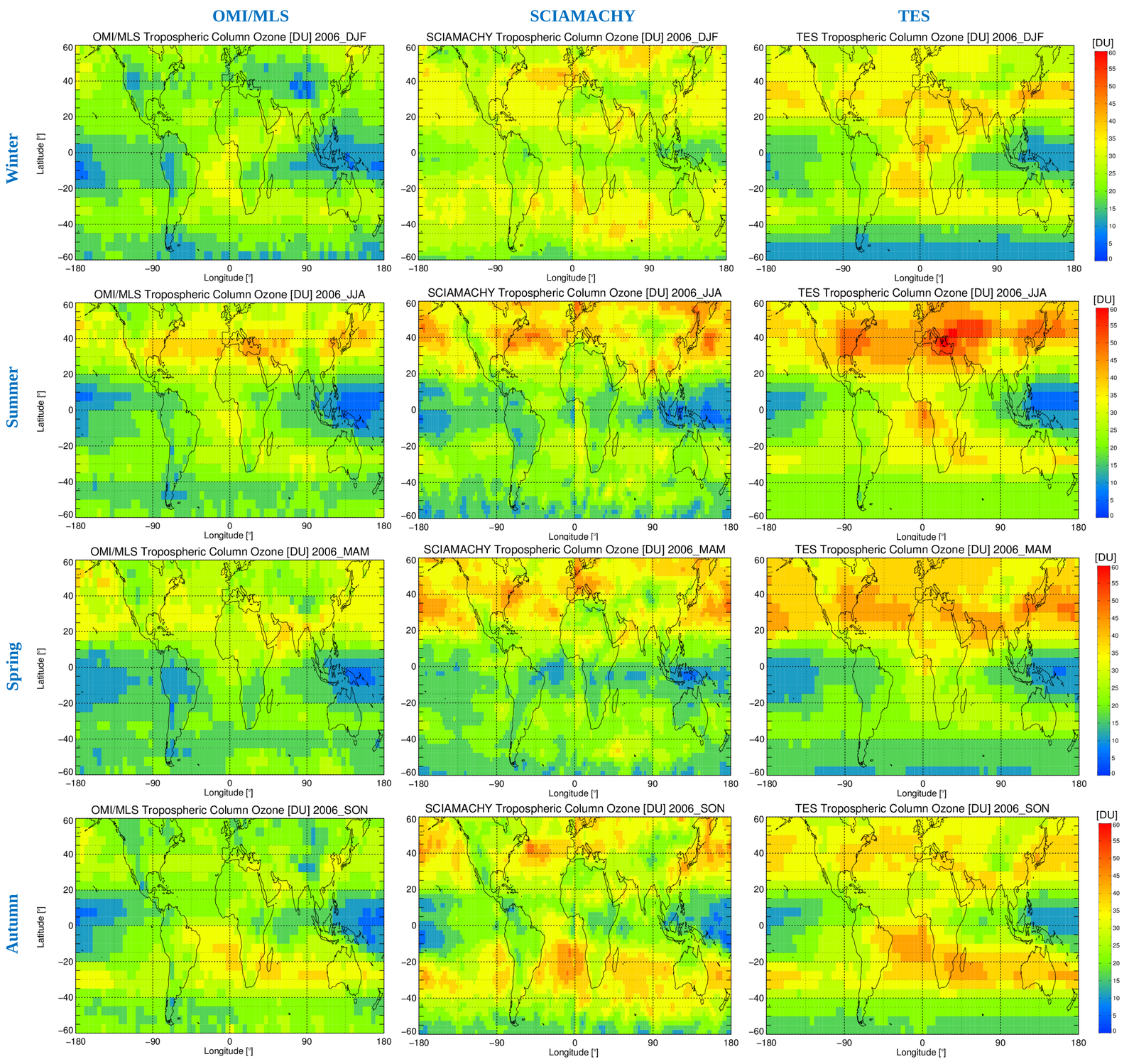
- Comparison of collocated SCIAMACHY, ozonesondes, TES and OMI/MLS data show good correlation with the occurrence of tropospheric ozone precursors
- There is strong evidence of seasonal cycle mostly at the northern mid latitudes
- Intercomparison with ozonesondes provide absolute validation of the satellite instruments, but this is limited by the sparseness of the ozonesondes data
- Observed differences with the ozonesonde instruments are within the estimated errors
- Direct intercomparison of measurements from different satellite instruments is prone to errors as the different satellite instruments have different sensitivity. The retrieval and cloud treatment algorithms may be different
- Comparison of collocated SCIAMACHY, TES and OMI/MLS data for the year 2006 show similar geographic and pollution features as well as seasonal variability but with slight difference in magnitude

4) Tropospheric ozone from SCIAMACHY, TES, OMI and ozonesondes



- SCIAMACHY tropospheric O_3 values agrees with the values from ozonesondes and other satellite instruments in magnitude and annual variation
- The mean values of tropospheric O_3 values from SCIAMACHY and the values from ozonesondes over the time series agree to within the error values
- The mean values of tropospheric O_3 values from OMI/MLS are lower in most of the ozonesonde stations when compared with the tropospheric O_3 values from other satellite instruments

5) Global distribution of tropospheric ozone from OMI/MLS, SCIAMACHY and TES



- Tropospheric O_3 values from SCIAMACHY show maximum values at northern mid-latitudes in spring-summer due to anthropogenic pollution. These pollution features are also captured by the other satellite instruments but OMI/MLS values are lower than the values from other satellite instruments
- Enhanced Tropospheric O_3 values in northern autumn at the southern mid-latitudes due to the presence of O_3 precursors is detected by SCIAMACHY as well as other satellite instruments
- SCIAMACHY tropospheric O_3 values in the tropical regions are high as a result of seasonal biomass burning. This is also captured by the other satellite instrument, although at slightly different amplitudes
- SCIAMACHY shows minimum values of tropospheric O_3 over tropical oceans due to chemical ozone loss
- The high-ozone feature over the southern tropical Atlantic mostly during northern winter-autumn is enhanced by a persistent recirculation of ozone pollution in an anticyclonic high pressure system over southern Africa

Acknowledgement

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