Investigation of the fine-scale structure of tropospheric nitrogen dioxide columns over Tokyo by combining SCIAMACHY measurements with MERIS cloud coverage data

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Introduction

The retrieval of tropospheric NO_2 from satellite

- measures total slant column (SC) densities (stratospheric + tropospheric)
- tropospheric SC is obtained by subtracting stratospheric SC from total SC

Here, we use the high-resolution MERIS cloud data to redistribute the tropospheric NO_2 retrieved and derived from SCIAMACHY on a sub-pixel level to the cloud-free MERIS pixels over the hot-spot Tokyo.

Assumptions:

- *Most of the NO_2 pollution is below clouds*
- *NO_2 signal comes from only cloud-free parts of the region.*

MERIS and SCIAMACHY instruments

- both are on Envisat
- SCIAMACHY provides NO_2 data; the size of its pixel is about 30km x 60km
- MERIS provides cloud data using the MICROS algorithm; the size of its pixel is about 1km x 1km
- They perform measurements at the same time over the same location
- MERIS has wider swath, therefore, SCIAMACHY pixel is masked completely
- SCIAMACHY also provides cloud data in the same resolution as NO_2 data using an intensity criterion

Algorithm

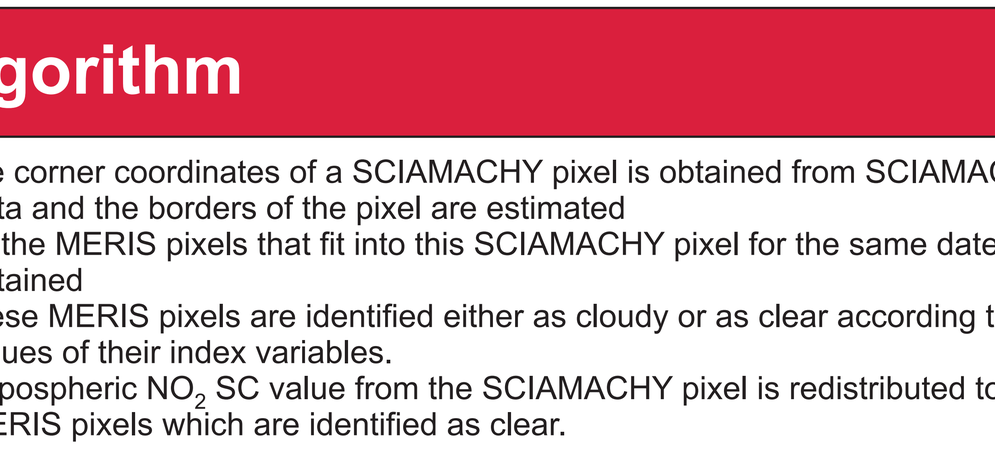
- the corner coordinates of a SCIAMACHY pixel is obtained from SCIAMACHY data and the borders of the pixel are estimated
- all the MERIS pixels that fit into this SCIAMACHY pixel for the same date are obtained
- these MERIS pixels are identified either as cloudy or as clear according to the values of their index variables.
- tropospheric NO_2 SC value from the SCIAMACHY pixel is redistributed to those MERIS pixels which are identified as clear.

The following formula is used to make corrections to the tropospheric SC densities by taking into account clouds:

$$SC'_{NO_2} = \frac{N_{cloudy} + N_{clear}}{N_{clear}} \times SC_{NO_2}$$

where N_{clear} , N_{cloudy} are the numbers of cloudy and cloud-free MERIS pixels respectively, SC_{NO2} is the NO_2 slant column value, and SC'_{NO2} is the corrected NO_2. This value is then attributed to each cloud-free MERIS pixel.

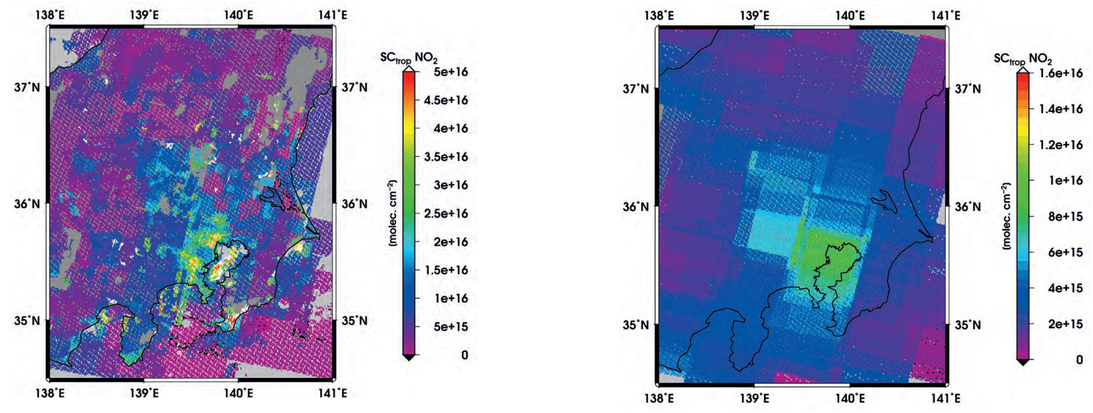
Cloud data: MERIS and SCIAMACHY



MERIS cloud data (left) and SCIAMACHY cloud data (right) for 24/08/2009, illustrating the difference in resolution

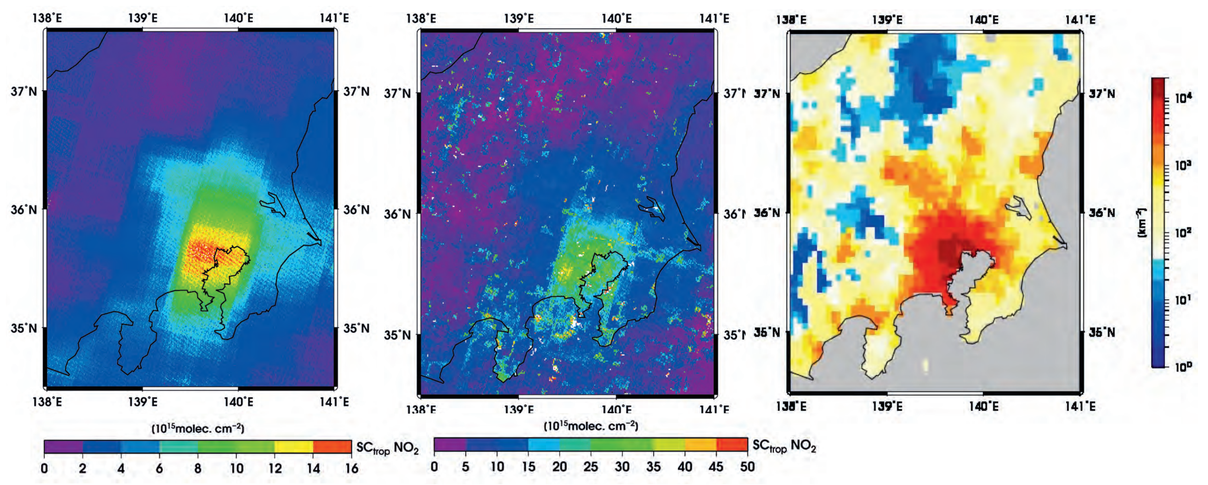
MERIS captures cloud structures on a much finer scale.

Tropospheric NO_2 over Tokyo



Tropospheric NO_2 mean SC densities by using MERIS cloud data (left, see Algorithm) and SCIAMACHY cloud data (right, only cloud-free measurements) for August 2009

Population Density comparison



Averaged troposheric NO_2 from SCIAMACHY cloud data (left), from MERIS cloud data (middle) for 2009, and population density over Tokyo region (right)

MERIS cloud data gives results more like the population density data (sqaure shaped).

Results / Conclusions

- MERIS provides much more detailed cloud coverage information than SCIAMACHY (about 1000 times better resolved).
- Tropospheric NO_2 obtained by using SCIAMACHY cloud data is about 3 times smaller than the tropospheric NO_2 obtained by using MERIS cloud data under our assumptions
- Obtaining spatial structures of NO_2 emissions at scales smaller than a SCIAMACHY pixel becomes possible if the results are averaged over long periods (month or year).
- The results have a good correlation with population density over Tokyo region.

References

- MERIS. Retrieved December 25, 2010 from http://envisat.esa.int/instruments/meris/
- Gottwald, M. et. al. (2006) SCIAMACHY
- P. Wang. et. al. (2004) FRESCO+: an improved O2 A-band cloud retrieval algorithm for tropospheric trace gas retrievals
- Remote Sensing. Retrieved January 4, 2011, from http://www.iup.uni-bremen.de/E-Learning/at2-els NO2/index.htm
- SEDAC, Gridded population of the world. Retrieved January 21, 2011 from http://sedac.ciesin.columbia.edu/gpw

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