Tropospheric ozone from IASI


LISA, CNRS / Univ. Paris-12 & Paris-7, Créteil, France

* IMK-ASF, FZK / KIT, Karlsruhe, Germany

** now at EADS Astrium, Friedrichshafen, Germany

ESA Atmospheric Science Conference
Barcelona, September 7-11, 2009


Outline

1) Motivation of this study

2) Approach

3) First results (summer 2007 over Europe)

4) Validation using O$_3$ sondes (world-wide)

5) Comparison with tropospheric models (GEMS)

6) Chinese megacities (Beijing, Shanghai, Hongkong)

7) Conclusions and outlook
Motivation of this study

- tropospheric O3:
  - key species in tropospheric chemistry
  - important greenhouse gas and climate parameter

- air quality forecast is based on surface networks

- problems: lack of spatial coverage, vertical extension

- IASI: high spatial coverage, good vertical sensitivity
Approach for retrieval of trop. O3

- IASI L1 data through the ETHER database (France)
- RTM: KOPRA and associated retrieval code (KOPRAFIT)
- Filtering for clouds (surface temperature, baseline)
- Temperature profiles using CO$_2$ bands (instead of L2 data)
- Altitude-dependent regularization (Tikhonov-Philips)
- Details: Eremenko et al., GRL 35, L18805, 2008
Vertical resolution and DOFs

43.94°N / 16.15°E
Tsurf=37.5°C
DOF(0-6km)=0.68
DOF(7-12km)=0.60

40.06°N / 14.67°W
Tsurf=12.2°C
DOF(0-6km)=0.57
DOF(7-12km)=0.63
First results: heatwave in summer 2007

- $O_3$ column 0-6 km, sliding average over 5 days
Tropospheric ozone distributions over Europe during the heat wave in July 2007 observed from infrared nadir spectra recorded by IASI

M. Eremenko,1 G. Dufour,1 G. Foret,1 C. Keim,1 J. Orphal,1 M. Beekmann,1 G. Bergametti,1 and J.-M. Flaud1

Received 27 May 2008; revised 17 July 2008; accepted 5 August 2008; published 23 September 2008.

[1] First partial tropospheric ozone columns (0–6 km) derived from radiances observed by the IASI instrument aboard the MetOp-A platform over Europe during summer 2007 are presented. They were retrieved using an altitude-dependent regularization method. Comparison with measurements from balloon sondes shows excellent agreement. Space-borne observations show large lower tropospheric ozone amounts over South-Eastern Europe during the heat wave period, which are also displayed by simulations with a regional chemistry-transport model CHIMERE. Citation: Eremenko, M., G. Dufour, G. Foret, C. Keim, J. Orphal, M. Beekmann, G. Bergametti, and J.-M. Flaud (2008), Tropospheric ozone distributions over Europe during the heat wave in July 2007 observed from infrared nadir spectra recorded by IASI, Geophys. Res. Lett., 35, L18805, doi:10.1029/2008GL034803.

[4] Here, we present first results of tropospheric O3 measured with the Infrared Atmospheric Sounding Interferometer (IASI) launched in October 2006 onboard the satellite MetOp-A. The used retrieval method allows separating the tropospheric O3 columns into two semi-independent columns and demonstrates the potential of IASI to measure the lower tropospheric O3 variability. The IASI observations used here focus on the heat wave in July 2007 over Europe. These observations are compared to O3 balloon sonde measurements and to predictions from the CHIMERE model for validation and interpretation.

2. The IASI Instrument

[5] The IASI instrument [Clerbaux et al., 2007] is an operational meteorological instrument. In addition to temperature and humidity profiles and cloud information, providing partial distributions of O3 is one of the objectives.
Validation using ozone sondes

- focus: mid-latitudes
- coincidence criteria
  - spatial: ± 100 km
  - temporal 12 hours
- different vertical resolution → smoothing sonde profiles
- comparisons with scientific and operational products
- details: *Keim et al.*, ACPD 9, 11441, 2009
Validation using ozone sondes

- details: Keim et al., ACPD 9, 11441, 2009
Validation using ozone sondes

Atmos. Chem. Phys. Discuss., 9, 11441–11479, 2009
www.atmos-chem-phys-discuss.net/9/11441/2009/
© Author(s) 2009. This work is distributed under
the Creative Commons Attribution 3.0 License.

This discussion paper is/has been under review for the journal Atmospheric Chemistry
and Physics (ACP). Please refer to the corresponding final paper in ACP if available.

Tropospheric ozone from IASI:
comparison of different inversion
algorithms and validation with ozone
sondes in the northern middle latitudes

C. Keim¹,* , M. Eremenko¹, J. Orphal¹, G. Dufour¹, J.-M. Flaud¹, M. Höpfner²,
A. Boynard³, C. Clerbaux³, S. Payan⁴, P.-F. Coheur⁵, D. Hurtmans⁵, H. Claude⁶,
H. Dier⁷, B. Johnson⁸, H. Kelder⁹, R. Kivi¹⁰, T. Koide¹¹, M. López Bartolomé¹²,
K. Lambkin¹³, D. Moore¹⁴, F. J. Schmidlin¹⁵, and R. Stübi¹⁶

◆ details: Keim et al., ACPD 9, 11441, 2009
Comparison with GEMS-RAQ simulations

- Use IASI tropospheric O3 observations for evaluation of GEMS-RAQ simulations, in particular for free troposphere

- Specific questions to be answered:
  - Are the spatial structures of tropospheric O3 columns well reproduced by CTMs and consistent with IASI?
  - Importance of the boundary conditions?
  - Can we relate differences in free troposphere O3 between models to differences in surface O3?

- Details: Dufour et al., ACPD, 2009
IASI and simulated 0-6km O3 columns
Tropospheric O3 over Chinese megacities
Monthly mean spatial distribution of trop. O3

Large O3 amounts consistent with highest population density
Monthly variations of tropospheric O3

- good agreement with trop. O3 climatology
- general observation: maximum in late spring
- Beijing: clear decrease starting in early summer
- Shanghai and Hong Kong: summer minimum, second maximum in fall
- influence of meteorology (Monsoon) and regional emissions/photochemistry
Conclusions

- tropospheric O3 is retrieved from IASI with good quality

- validation with O3 sondes shows good agreement
  - bias < 5%
  - variability consistent with O3 climatology

- comparison with photochemical models (GEMS)

- Chinese megacities: Beijing, Shanghai, Hong Kong
  - seasonal variations: Asian summer monsoon
  - regional variations: air quality monitoring

- important demonstration for future projects (e.g. GEO)