8-years time evolution of stratospheric HNO3 columns: investigation of the drivers of variability and of the link to O3

G. Ronsmans, B. Langerock, C. Wespes, M. De Mazière, D. Hurtmans, Cathy Clerbaux, Pierre-François Coheur

To cite this version:


HAL Id: insu-01369321
https://hal-insu.archives-ouvertes.fr/insu-01369321
Submitted on 20 Sep 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Introduction

Nitric acid (HNO₃) is one of the main species involved in the stratospheric ozone cycles. Until recently, the distribution of HNO₃ in the stratosphere was available only from limb-sounding instruments, such as MLS, MIPAS or ACE-FTS. The IASI nadir looking thermal infrared instrument is now providing HNO₃ concentration distributions with unprecedented spatial and temporal sampling since 2007. Here, we briefly review the IASI observational capabilities for HNO₃ (in terms of vertical sensitivity and errors) and show the results of a validation exercise made through a comparison with ground-based FTIR measurements.

We also provide an analysis of the time evolution of HNO₃ concentrations from IASI measurements since the end of 2007, through global distributions as well as latitudinal time series of HNO₃ columns. The first results of a multivariate regression analysis are shown in order to highlight the various factors responsible for HNO₃ spatial and temporal variability. The capabilities of the IASI instrument also allows for a joint analysis between HNO₃ and O₃ evolutions throughout the years, also briefly described hereafter.

FORLI-HNO₃

- Fast Optimal Retrieval on Layers for IASI = near-real time processing chain, at ULB
- Retrieval range: 850-1800 cm⁻¹; Retrieval scheme: Optimal Estimation Method (Rudgers, 2000)
- Inversion on 41 layers, with a single a priori profile and covariance matrix
- Data kept if: DOFS > 0.9
- RMS of the spectral residual < 3×10⁻8 W m⁻² sr⁻¹ m⁻¹
- Cloud coverage < 25%.
- See Hurtmans et al. (2012) for detailed information

Validation

Choice of 6 stations, all part of the NDACC network
- Re-gridding and smoothing of the FTIR vertical profiles (bottom left figure) give good agreement with IASI profiles
- Comparison of FTIR and IASI time series (bottom right figure): Retrieval columns (0-35 km) of both datasets are within the error range of one another
- Differences between FTIR and IASI data (F-I) vary between -30 and 30%
- Mean of differences (bias) = 4.0 %
- IASI slightly overestimates concentrations compared with FTIR
- Standard deviation ≈ 9.7 %
- Bias > std • differences not significant, compared to variability

Spatial & temporal distributions

- Seasonal variations
- Influence of the annual cycle
- Influence of the latitude bands

Multivariate regressions

- Good correlation between fit & observations (R=0.74-0.92) except for tropical latitudes (R=0.42)
- Dominance of the annual cycle (B-D circ.) in the regression
- Large influence also of stratospheric T₁

HNO₃-O₃ time series

- Systematic drop of HNO₃ columns when stratospheric T₁'s reach the PSs's formation threshold
- Lowest columns when lowest T₁
- At the lowest HNO₃, stratospheric column: start of decrease in O₃ stratospheric column (delay of a few weeks)

Conclusions & ongoing works

- The IASI instrument shows a good sensitivity to the HNO₃ vertical profile, with its maximum in the stratosphere
- The validation with the FTIR profiles suggests good performances of IASI overall, with a mean bias of 30.5 %
- The seasonal variations observed are relevant and are in agreement with chemical and dynamical processes in the atmosphere, and more specifically the stratosphere
- Multivariate regressions allow fitting the HNO₃ time evolution; some unexplained residuals deserve more attention
- The co-located IASI measurements allow for a HNO₃/O₃ co-analysis
- Improvement of the regression model to reduce the residuals
- Implementation of a chemistry-climate model to apprehend climate variables and their effects on [HNO₃]
- Focus on the polar regions and their specific dynamics and chemistry

References

Urban et al., Nitric acid in the stratosphere based on IASI observations from 2005 to 2009 – Part II: IASI climatology, Atmos. Chem. Phys., 9, 7031– 7048, 2009
Wespes et al., Global distributions of nitric acid from IASI/MetOp-A measurements, Atmos. Chem. Phys., 9, 7949-7962, 2009-2010

Contact

For information or IASI HNO₃ data request:
gronsmann@ulb.ac.be