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Synergetic use of IASI and TROPOMI for generating a tropospheric methane profile product

Matthias Schneider[1] and the Synergetic IASI+TROPOMI CH4 product generation and validation team[*]

[1]Karlsruhe Institute of Technology, IMK-ASF, Eggenstein-Leopoldshafen, Germany (matthias.schneider@kit.edu)

[*]A full list of authors appears at the end of the abstract

We present a method for the synergetic use of IASI (Infrared Atmospheric Sounding Interferometer) profile and TROPOMI (TROPOspheric Monitoring Instrument) total column data products. Our method uses the output of the individual retrievals and consists of linear algebra a posteriori calculations (i.e. calculation after the individual retrievals). We show that this approach is largely equivalent to applying the spectra of the different sensors together in a single retrieval procedure, but with the substantial advantage of being usable together with different individual retrieval processors, of being very time efficient, and of directly benefiting from the high quality and most recent improvements of the individual retrieval processors.

For demonstrating the method, we focus on atmospheric methane (CH_4) and use IASI profile products generated by the processor MUSICA (MUlti-platform remote Sensing of Isotopologues for the investigation of the Cycle of Atmospheric water). We perform a theoretical evaluation and show that the a posteriori combination method yields total column averaged CH_4 products (XCH_4) that have the same good sensitivity as the respective TROPOMI products and upper tropospheric and lower stratospheric (UTLS) CH_4 profile data with the same good sensitivity as the IASI product. In addition, the combined product offers sensitivity for the tropospheric partial column, which is not provided by the individual TROPOMI nor the individual IASI product. The theoretically predicted synergetic effects are verified by comparisons to CH_4 reference data obtained from collocated XCH_4 measurements at five globally distributed TCCON (Total Carbon Column Observing Network) stations, CH_4 profile measurements made by 24 individual AirCore soundings, and lower tropospheric CH_4 data derived from continuous observations made at two nearby Global Atmospheric Watch (GAW) mountain stations. The comparisons clearly demonstrate that the combined product can reliably detect XCH_4 signals and allows to distinguish between tropospheric and UTLS CH_4 partial column averaged mixing ratios, which is not possible by the individual TROPOMI and IASI products. We find indications of a weak positive bias of +1.7% +/- 1.2% of the combined lower tropospheric data product with respect to the references. For the UTLS CH_4 partial columns we find no significant bias and a scatter with respect to the references of below 1%. We also briefly demonstrate the possibility of generating a combined IASI + TROPOMI water vapour isotopologue ratio product (HDO/H_2O), which allows the detection of boundary layer HDO/H_2O ratios independently from free tropospheric ratios.

The approach has the particular attraction, that IASI and TROPOMI successor instruments will be jointly aboard the upcoming Metop Second Generation satellites (guaranteeing observations from the 2020s to the 2040s). There will be several 100,000 globally distributed and perfectly collocated observations (over land) of IASI and TROPOMI successor instruments per day, for which combined products can be generated in a computationally very efficient way.

Synergetic IASI+TROPOMI CH4 product generation and validation team: Matthias Schneider, Benjamin Ertl, Christopher Diekmann, Farahnaz Khosrawi, Amelie N. Röhling, Frank Hase, Omaira E. García, Eliezer Sepúlveda, Alba Lorente, Jochen Landgraf, Huilin Chen, Rigel Kivi, Thomas Laemmel, Michel Ramonet, Cyril Crevoisier, Martin Steinbacher, Frank Meinhardt, Voltaire A. Velazco, Nicholas M. Deutscher, David Griffith, David F. Pollard, Hartmut Bösch, Tim Trent, Harald Sodemann