**Introduction**

- Spectrometer SCIAMACHY onboard ENVISAT
- Wavelength range: 8 channels ranging from UV/VIS to NIR
- Two main observation geometries:
  - Nadir mode: observing the atmospheric volume directly under the instrument
  - Limb mode: the instrument looks at the edge of the atmosphere
- Limb–nadir matching: the same atmospheric volume is first observed in limb and about 7 minutes later in nadir geometry

**Basic Principle**

The basic idea of the limb–nadir matching algorithm is to use limb profile data to calculate a stratospheric column, and to subtract this intermediate result from a total column obtained from nadir measurement data.

**Processor Integration**

The limb–nadir matching algorithm needs limb profiles and nadir slant columns of the full orbit as input. Therefore it is implemented as a processing step that starts after the limb and nadir retrievals.

**Algorithm Input/Output**

- **Input**:
  - Limb NO₂
  - Radiative transfer calculations
  - Ozone profile
  - ECMWF tropopause height DB
  - TOMS albedo climatology
  - NO₂ limb–nadir offset DB

- **Output**:
  - Tropospheric vertical column
  - Tropospheric slant column
  - Fitting output flag
  - Limb geolocation
  - Radiative transfer calculations

**Algorithm Flowchart**

1. **Integrating limb stratospheric profiles.** Stratospheric slant columns are computed by integration of partial columns from limb profiles.
2. **Interpolating limb stratospheric slant columns to the nadir grid.** As limb profiles are sparse compared to nadir measurements, the limb stratospheric vertical columns need to be interpolated to the positions of the nadir pixels. This is done by associating the limb columns with their four line of sight (LOS) angles, e.g. 25°, 8°, 10°, 27°, and by performing a 2-dimensional interpolation to the nadir geolocations based on their LOS angles and latitudes. Note that only the descending parts of the orbits and forward scans are used.
3. **Applying stratospheric AMF.** AMF_strat are computed by the radiative transfer model LURDT using the climatology of the Halogen Occultation Experiment (HALOE) stratospheric NO₂ profiles. They are applied to convert limb stratospheric vertical columns \( VCD_{strat} \) on the nadir grid into stratospheric slant columns.
4. **Subtracting offset between nadir total slant column and stratospheric slant column on nadir grid.** Experience shows that small but significant offsets exist between the slant columns from limb \( SC_{limb} \) and nadir slant columns \( SC_{corr} \) even over clean regions, and that these offsets vary with latitude and season. This is the result of systematic errors in one or both data products. Since the tropospheric column in less polluted regions is very sensitive to the stratospheric correction, these offsets need to be accounted for. In order to do this, a data base of daily difference offsets \( offset = SC_{corr} - SC_{limb} \)

**Detailed Processing (continued)**

5. Subtracting limb stratospheric slant columns from total slant column. The tropospheric slant column is computed as the difference between the nadir NO₂ total slant column and the stratospheric slant column:

\[ SC_{trop} = SC_{corr} - SC_{limb} \]

6. Adding Pacific background to tropospheric slant column. Applying the aforementioned offset to the retrieved \( SC_{trop} \) is assumed that there are no significant tropospheric quantities of NO₂ in the reference sector. Therefore \( SC_{trop} \) obtained in the previous step must be corrected for the tropospheric NO₂ background levels:

\[ SC_{trop} = SC_{trop} + SC_{AMF}_{corr}(month, latitude) \]

Climatological NO₂ data derived from the Oslo chemistry–transport model simulations [5] are used for this purpose as \( SC_{AMF}_{corr} \).

7. Applying tropospheric AMF. Tropospheric vertical columns are derived from the tropospheric slant columns by division with the air mass factor \( VC_{AMF} = SC_{corr}/AMF_{trop} \) and \( VC_{AMF} \) are read from a look-up table used in the operational processing of the GOME-2 data [4] and depend on five parameters including the viewing geometry. After several interpolation and accumulation operations, taking NO₂ profiles from MOZART climatology into account, \( AMF_{trop} \) is calculated from these block AMFs.

**Verification Results**

- **Verification data set: total of 216 orbits**
- **Reference data from scientific NO₂ products provided by**:
  - IUP (Institute of Environmental Physics, University of Bremen) [1, 2]
  - ECMWF Tropopause Detection & Mapping Service [5]
  - Scatterplots of tropospheric NO₂ VCDs

**Outlook**

- **Operational limb–nadir matching is programmed in a generic way**
- **Suitable for further tropospheric trace gas retrievals (BrO, O₃)**

**References**


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