Aerosol optical property retrieval from visible and infrared: sensitivity analysis.

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ABSTRACT: A sensitivity analysis of a radiative transfer model for the retrieval of aerosol properties from satellite measurements will be presented. The model includes both visible and infrared components and will be used in conjunction with the SEVIRI (Spinning Enhanced Visible and Infra-red Imager) instrument on board of Meteosat Second Generation. This work is based on the ORAC aerosol retrieval algorithm, developed at Oxford University and Rutherford Appleton Laboratories for the visible and near infrared channels, with the extension to the two SEVIRI infrared channels centered at 10.8 and 12.1 micron. The forward model values of atmospheric scattering, absorption and emission are calculated by DISORT (Direct Ordnary Radiative Transfer) radiative transfer code. The forward model uses an aerosol database of macroscopic optical properties computed from published aerosol microphysical properties. The aerosol parameters retrieved are: aerosol optical depth (at 550nm) and effective radius. We show that the IR channels are sensitive to the scattering and absorption of aerosol. This information will be of particular interest when monitoring aerosol events, such as desert dust or a volcanic eruption. The application to SEVIRI is particularly interesting as it enables us to follow the aerosol evolution in time.

Oxford-RAL retrieval of Aerosol and Clouds (ORAC)

The Oxford-RAL retrieval of Aerosol and Clouds (ORAC) scheme was developed to determine aerosol properties from satellite borne radiometers such as SEVIRI and ATSR (Aerosol Total散射 Radiometer) instruments. The ORAC forward model is sensitive to aerosol size, chemical composition, and shape, as these characteristics determine aerosol optical properties. The addition of the 2 infrared channels will add sensitivity to aerosol vertical distribution and surface temperature.

Forward Model Computation scheme

**Optimal Estimation Approach (Rodger 2000)**

- \( y = F(x) + e \)
- \( y \) is the measurement vector, \( x \) the state vector, \( F \) forward model, \( e \) measurement measurement error

**Linearity**

For the purpose of assessing information content and to perform an error analysis it is necessary to linearize the forward model around some reference state vector \( x_0 \):

\[ y(x_0) = \{F(x) | x = x_0 \} + \{e | x = x_0 \} \]

- \( y \) are the simulated SEVIRI reflectances and brightness temperatures
- \( x_0 \) are:
  - \( AOD \) - aerosol optical depth at 550nm
  - \( Reff \) - effective radius (between 0.01 and 10 um)
  - \( Ts \) - surface temperature
  - \( H \) - aerosol layer height

**Retrieval Model**

State vector is \( x \). The cost function is given by:

\[ J = (y - y(x)) \cdot Sa \cdot (y - y(x)) \]

This quantities determine of model radiance on the state vector from the observation and the departures of the state from prior knowledge:

\[ Sa \cdot (y - y(x)) \]

**Sensitivity Analysis**

- The solution state vector which minimizes the cost function is: \( \hat{x} \)
- \( \hat{x} = (A^{-1} \cdot Sa)^{-1} \cdot Sa \cdot e + A^{-1} \cdot Sa \cdot y \)

**SEVIRI AOD**

Monthly average AOD at 550nm from SEVIRI measurements at 10.8 and 12.1 micron. The standard deviation of AOD at 10.8 and 12.1 micron is 0.01 and 0.02 respectively.

**SEVIRI AOD (preliminary result)**

Case study:

**Detailed Results**

Aerosol optical properties are retrieved from satellite measurements at 550nm.

**AEROSOL OPTICAL PROPERTIES**

- Scattering coefficient normalized to extinction at 550nm
- Extinction coefficient normalized to extinction at 550nm

**REFERENCES**


**ERROR ANALYSIS**

- Random errors for different scenarios as a function of effective radius considering all the 5 channels (VIS-NIR) and only the 3 VIS-NIR channels
- \( S_x \) = errors on the state vector after adding measurements to the a priori error

**INFORMATION CONTENT**

- \( C_y \) = correlation coefficient

**FUTURE WORK AND ANALYSIS IMPROVEMENTS**

- Implementation of SEVIRI to ORAC
- Evaluation of aerosol retrieval performance

**CONCLUSION**

- Aerosol retrieval error is dominated by errors from the state vector
- AOD and effective radius are retrieved with more accuracy than surface temperature and surface pressure
-\( \Delta \) is the relative difference

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