Aerosol Remote Sensing from PARASOL and the A-Train

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PARASOL

• Project managed by CNES
  – Principal Investigator Didier Tanré (CNRS-LOA)
  – Project scientist Anne Lifermann (CNES)

• Heritage from the POLDER series
  • POLDER-1/ADEOS-1: nov. 96-june 97
  • POLDER-2/ADEOS-2: apr.-oct. 03

• PARASOL (POLDER-3) launched in Dec. 2004 on a micro-satellite of the Myriad series
  – Start of scientific operation in March 2005
  – 1 year and 8 month of data, Availability is 87.8%
Principle of observation

- The directionality and the polarization degree of the reflectances are measured at the TOA.
  - Use of a rotating filter wheel carrying 15 filters and polarizers
  - Spectral range from 0.440 µm and 1.04 µm
  - Imaging of the Earth with a two-dimensional CCD detector array (pixel size 5.3 x 6.2 km) and a wide field-of-view optics (swath 1600 km cross-track and 2100 km along track)

Up to 16 different viewing angles for a satellite overpass
Principle of inversion

• A look-up table approach
  – Over land: polarized radiances @670 and 865 nm
    • Modeled BPDF
    • Fine mode AOT
  – Over ocean: total and polarized radiances @670 and 865 nm
    • Total aot, f-aot, size, nonsphericity, refractive index
    • Information content depends on the range of scattering angle available
Information content. Ocean

From Herman et al. 2005
Global Aerosol Optical thickness - ocean
(@ 865 nm, monthly mean May 2005)
Fine Mode AOT Land & Ocean
(03/2005-02/2006)
Validation versus Sun photometer observations. Ocean

Agreement within 0.04 @865nm

(Goloub et al., 2006)
Validation versus Sun photometer observations. Land

F-AOT (<0.6 µm)

F-AOT (<0.35 µm)

Courtesy of J.-L. Deuzé, LOA
Application to ground PM2.5 monitoring

- Direct comparison of ground PM2.5 and F-AOT (POLDER-2 data) over France (28 stations, 1974 points)
- Threshold of AOT=0.17 at 440 nm corresponds to EPA “moderate” AQC (daily concentration above 15.5 µg/m³)

Kacelenenbogen et al., ACPD, 2006
Research Products
Dust height scale from PO$_2$

Theoretical accuracy of the retrieval as a function of the AOT

<table>
<thead>
<tr>
<th>$\delta$$_{aero}$</th>
<th>$\Delta$Z$_{a}$ (km)</th>
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<td>0.1</td>
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<td>0.6</td>
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Dubuisson et al., to be written, 2006
PARASOL

Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
The third dimension

August, 10th 2006
PARASOL AOT, CALIOP att. Backscatt. Coef. 532nm

AOT color scale 0.0-0.8
A-Train synergy

• Different ways of combining data
  – Comparison/ validation of products or hypothesis
    • AOT, F-AOT (Parasol-Modis)
    • Cloud mask (Parasol-Modis-Caliop)
    • PO2, Rayleigh pressure (Parasol-Caliop-Omi)
    • Intercomparison of retrieval methods
MODIS-PARASOL

13 March 2006
Tanré et al., 2006

Total AOT
MODIS-PARASOL

13 March 2006

Accumulation AOT
A-Train synergy

• Different ways of combining data
  – *Comparison/ validation of products or hypothesis*
    • AOT, F-AOT *(Parasol-Modis)*
    • Cloud mask *(Parasol-Modis-Caliop)*
    • PO2, Rayleigh pressure *(Parasol-Caliop-Omi)*
    • *Intercomparison of retrieval methods*
  – New joined algorithms
    • Parasol-MODIS SWIR information
    • Lidar aerosol retrieval constrained by radiometer observations
Benefices of combining PARASOL-Calipso Lidar

- Lidar extinction profiles retrievals depends on the choice of the lidar ratio
  - Lidar ratio depends on aerosol type, size, shape that can be assessed (column) by PARASOL
Non sphericity

- Simulation of lidar ratio and Angstrom exponent for a bimodal size distribution using sphere and spheroid (Dubovik et al., 2006)
- Coarse mode median radii 1, 2, 5 µm; fine mode median radii 0.12, 0.14, 0.2 µm
- Various value of the lidar ratio for a given Ang. Expon.
- Non-spherical coarse particle have higher lidar ratio than spherical ones
Benefices of combining PARASOL-Calipso Lidar

- **Lidar extinction profiles retrievals depends on the choice lidar ratio**
  - *Lidar ratio depends on aerosol type, size, shape that can be assessed (column) by PARASOL*

- Development of new products by adding more constrains in the retrieval
  - Vertical profiles of extinction of total and fine fraction and effective radius
  - Method developed and applied to MODIS-Airborne lidar observations (Kaufman et al., IEEE 2003; GRL, 2003; Léon et al., JGR, 2003, Waquet et al., JGR, 2005)
  - Application to PARASOL at work
    - Data processed at the Parasol L2 reference grid
PARASOL-CALIOP joined retrieval

• Basis (Daytime/cloud-free/ocean)
  – Use every possible combination of 1 fine and 1 coarse mode from the PARASOL set of models for a given fraction of non-spherical coarse particles
  – Use the ratio between 532 and 1064 nm lidar derived extinction coef. to adjust the respective contribution of the fine and coarse mode
  – Vertical integration of candidate profiles
  – Selected profiles matched best the Parasol inversion (within the accuracy of the Parasol retrieval)
Conclusions

- PARASOL fully operational within A-train

- Unique polarization capabilities that provides information on particles type
  - Fine mode fraction, N-sphericity

- Various possibility of simple or advanced combination with A-Train observations
  - Passive-passive combination
  - Passive-active combination