Remote Sensing of Clouds and Aerosols from POLDER
Recent Development in the A-Train Framework and Perspectives for New Mission Concept

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OUTLINE

Context
Contribution from POLDER/Parasol
Multi-sensor Analysis
Perspective

Hurricane Ileana - 23 August 2006
Remote Sensing of Clouds and Aerosols from POLDER in the A-Train

HISE/OSA - Feb. 2007 - Santa Fe

Context & Instrumental Background

– CNES/LOA instrument, Parasol launched Dec. 2004
  • ~ 705 km polar orbits, ascending (13:30 a.m.)
– Sensor Characteristics
  • 10 spectral bands ranging from 0.443 to 1.020 µm
  • 3 polarised channels
  • Wide FOV CCD Camera with 1800 km swath width
  • +/- 43 degrees cross track
  • +/- 51 degrees along track
  • Multidirectionnal observations (up to 16 directions)
  • Spatial resolution: 6x7 km
  • No onboard calibration system - Inflight vicarious calibration:
    – 2-3% absolute calibration accuracy
    – 1% interband – 0.1% interpixel over clouds
Contribution of POLDER/PARASOL to the A-Train

Almost 2 years of POLDER3/Parasol data already available
POLDER3/Parasol Products availability

Data available since March 2005.

Level1: calibrated georeferenced data
Level2: daily products – one file per orbit swath
Level3: monthly products
Joint Atmosphere product (selected daily and monthly products)

Data processed with collection 2 algorithms (heritage from POLDER1 and POLDER2 mission)

POLDER L1 data and products together with MODIS/Aqua, Caliop, IIR, ... available online from the ICARE data center

http://www.icare.univ-lille1.fr/
Cloud spherical albedo is retrieved under up to 16 directions
Directional product provided at $\lambda = 670$nm (land) and 865 nm (ocean)
Contribution of POLDER/Parasol to the A-Train
Benefits from multiangle observations: Application for aerosols

Over Ocean « Cases 1-2-3 »

δ, δ_Acc, r_Acc, m_Acc, α

δ, δ_Acc, α

(Herman et al., J.G.R. 2005)

δ, δ_Acc, r_Acc, m_Acc, m_coarse, α

NSI = δ_{ns}/(δ_{cs} + δ_{cns})
Contribution of POLDER/Parasol to the A-Train
Benefits from polarization observations: Application for clouds

Cloud Phase

Cloud microphysics

Riedi et al

Bréon, Chepfer et al
**Contribution of POLDER/Parasol to the A-Train**

Benefits from polarization observations: Application for aerosols

Discrimination between spherical and non-spherical aerosols

\[ \delta = 0.13 \quad \alpha = 0.56 \]
\[ \text{cf} = 0.49 \quad \text{cc} = 0.51 \quad \text{rf} = 0.19 \, \mu m \]

\[ \delta = 0.15 \quad \alpha = 0.49 \]
\[ \text{cf} = 0.26 \quad \text{cns} = 0.74 \quad \text{rf} = 0.15 \, \mu m \]

Deuzé, Herman et al
Altitude of the aerosol top layer from PARASOL (Derived for $\tau_{490} > 0.5$)

Gérard, Deuzé, Herman et al
Potential Synergy for Clouds

Cloud detection
Cloud detection can be tricky under many circumstances (heavy aerosol loading, glint, bright surfaces: desert, snow/ice)

Cloud layers height
Deriving multiple cloud top pressure (O2, Rayleigh, CO2 slicing, H2O) to detect multilayer clouds and better describe vertical structure

Cloud thermodynamic phase
Combination of information on particle shape and absorption properties help

Improved cloud retrievals
ex: Using Size retrieval from MODIS to improve multidirectionnal OT retrievals from POLDER

Cloud Heterogeneities
Using MODIS 250m information to understand angular behavior in POLDER measurements and separate 3D effect from subpixel heterogeneities
Cloud layers height
Deriving multiple cloud top pressure (O2, Rayleigh, CO2 slicing) to detect multilayer clouds and better describe vertical structure

Basis
We do expect differences in pressure due to resp. sensitivities and we also expect increasing differences in case of multilayer situations

O2: Oxygen band differential absorption  (Vanbauce et al)
Rayleigh: Polarization Rayleigh Scattering absorption
CO2: CO2 Slicing (IR)
Cloud layers height

Cloud Top Pressure retrieval from O2

(Vanbauce et al)
Cloud layers height

Cloud Top Pressure retrieval from O2
Cloud layers height

Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.
Cloud layers height

Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.
Cloud layers height

Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.

April

August

Active fire detection (Rapid Response System)
Aerosols over clouds: a case study

18 August 2006
Aerosols over clouds: a case study
Aerosols over clouds: a case study

18 August 2006
Example: aerosols over cloud

Usually with single layer: $O_2 > \text{Rayleigh} > \text{CO2}$ with small differences

And here we have: $O_2 > \text{CO2} >> \text{Rayleigh}$ due to presence of aerosol in the upper layer
Example: aerosols over cloud

*LIDAR Alt from 5km Cloud Layer product
Example: aerosols over cloud
Cloud thermodynamic phase
Combination of information on particle shape and absorption properties

Basis

Polarization
mostly single scattering
sensitive to particle shape
Top of cloud but see through it if very thin

SWIR
Differential Water/Ice Absorption
sensitive to particle size
Some depth in the cloud

Thermal IR
Diff. Water/Ice,
also sensitive to surf. emissivity, H2O
Some depth in the cloud except thin cirrus

Cirrus ? Thin ?

H2O ?

Water ? Mixed ?

Surface spectral albedo ?
Cloud thermodynamic phase

Case study:

Hurricane Ileana
23 August 2006
Cloud thermodynamic phase

Hurricane Ileana - 23 August 2006
Cloud thermodynamic phase

SWIR over VIS ratio
(MODIS bands 2 and 7)

BTD 8 – 11 microns
Cloud thermodynamic phase
Combination of information on particle shape and absorption properties help

- **ICE**
- **UNKNOWN**
- **LIQUID**

POLARIZATION  SWIR/VIS Ratio  IR Bispectral
Cloud thermodynamic phase

Results from the combined POLDER/MODIS phase algorithm
Cloud thermodynamic phase

CALIOP

CLOUDSAT

LIDAR*
O2
Rayleigh
CO2 / IR
Cloud thermodynamic phase
Perspective for New Mission

Lessons learned:

Multiangle measurements applications suffer from non simultaneous acquisition (stereo height retrieval)

Algorithm can prove difficult to design when the range of scattering angle can vary significantly

Microphysical properties retrievals of clouds and aerosols requires a good sampling of the BPDF / BRDF

Observation and analysis of clouds 3D structure could benefit from simultaneous observation of both their bright and dark side.
CLOUD REMOTE SENSING SCIENCE QUIZZ

What is the difference between LIFE and CLOUDS?

LIFE: Always look on the bright side of life ...
(From Bryan's Life)

CLOUDS: Better look at both the bright and dark side of clouds
(From Marshak's Talk)
Perspective for New Mission

ORIGINAL POLDER vs TWIN VIEW CONCEPT
Perspective for New Mission

ORIGINAL POLDER vs TWIN VIEW CONCEPT
Summary

PARASOL/MODIS combination is a real opportunity to improve many existing parameters and can help design a next generation sensor.

PARASOL/MODIS open perspectives to extend the active sensors observation to the full swath, increasing statistics.

PARASOL/MODIS offer a test suite for definition of future cloud/aerosol missions.

2 years of POLDER3/Parasol data are available through the ICARE data center: [http://www.icare.univ-lille1.fr/](http://www.icare.univ-lille1.fr/)
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