What did we learn from POLDER and MODIS that can be used for SGLI / GCOM-C?

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Context and Motivation

Our proposed contribution to SGLI/GCOM is on remote sensing of the following parameters using combination of multiangle, multispectral and polarimetric measurements from SGLI based on POLDER/MODIS experience:

- **cloud thermodynamic phase** retrieval from polarimetric, shortwave infrared and thermal infrared measurements
- **cloud vertical structure** from exploitation of multiangle measurements in the O2 Aband and analysis of Rayleigh scattering polarisation signal
- **ice cloud microphysical properties** from multispectral (visible, near infrared) and polarimetric measurements
- **aerosols properties retrievals over clouds** from multispectral (visible, near infrared) and polarimetric measurements

Contribution of LOA to SGLI / GCOM-C project intended at providing the necessary understanding and experience to get the best out of SGLI sensor.
Optical Thickness, Effective Radius Retrievals

Optical Thickness, Effective Radius Retrievals

Which cloud phase should we use?

If ice cloud → which microphysical properties?

What are the corresponding optical properties?

Particle size and habit distribution?

How do we extend retrievals when additional channels are available?
POLDER vs MODIS Optical thickness

(a) POL–ice MOD–ice
Total Number: 2.74E+07

(b) POL–ice MOD–liq
Total Number: 5.93E+05

(c) POL–liq MOD–ice
Total Number: 1.20E+07

(d) POL–liq MOD–liq
Total Number: 2.74E+07

POLDER vs MODIS  Scaled Optical thickness: \( \tau^* = (1-g) \tau \)
Science rationale: model ice crystal properties

From Zhang et al, 2009 (ACP)

Fig. 7. The ratio of (a) $\tau_c^{\text{IHM}} / \tau_c^{\text{Baum05}}$ and (b) $P_{11}^{\text{Baum05}} / P_{11}^{\text{IHM}}$ as a function of scattering angle.
Phase functions of pristine or heterogeneous particles are very different:

- Pristine (smooth) hexagonal particles tend to produce marked angular features in the phase function which remain in observed distribution of angular reflectance.

- Features vanish when surfaces are roughened or heterogeneities are introduced.

Angular reflectance features act as fingerprints of particle shapes.
Testing cloud models from multiangle observation


Numerically created Voronoi aggregates for a model of irregular ice particles. (from Ishimoto et al – 2012 - Fig 3.)

From Fig 8 - Ishimoto et al – 2012

From Fig 10 Ishimoto et al – 2012
RESULTS OF SAD TEST FOR IHM AND Roughened GHM

IHM : Inhomogeneous Hexagonal Model (Labonnote et al)
GHM : Generalized Habit Mixture (Baum et al, Yang et al)
RESULTS OF SAD TEST FOR IHM AND VORONOI AGGREGATE

IHM

VORONOI AGGREGATE

Normalized relative spherical albedo difference

Number of pixels (directions) involved

Scattering Angle
RESULTS OF SAD TEST FOR GHM AND VORONOI AGGREGATE

VORONOI AGGREGATE

MODERATE ROUGH GHM
RESULTS OF SAD TEST FOR VORONOI AGGREGATE

CRYSTAL SIZE IMPACT?

VERY SMALL
(higher Qext and g)

LARGE
Information content analysis for cloud retrieval using multispectral polarization observation

- Motivation: Retrieve more information on cloud properties beyond \((\text{Tau},\text{Reff})\) → access to vertical profile of cloud properties
- Goal: build a retrieval algorithm based on optimal estimation technique for SGLI and 3MI
- Approach: extend bispectral retrieval of cloud properties to use all information available from SGLI and then 3MI
- Methodology: perform an information content analysis to define accessible parameters from multispectral polarized observation
Information content analysis for cloud retrieval using multispectral polarization observation

We evaluate degree of freedom (DOF) for a given observation and state vector. If DOF > 0.5 parameter can be retrieved from the given observation vector.

We first analyze single view measurements using 2 channels and compared with and without polarisation.

Analysis if performed for all accessible geometries → representation in polar diagram with sun geometry fixed.
Retrieval of Tau, Reff and Veff (state vector)
Tau=10, re=10, ve=0.02, sza=30
Wv=0.670 (1 channel observation vector)
Retrieval of Tau, Reff and Veff (state vector)

\[ \text{Tau}=10, \text{re}=10, \text{ve}=0.02, \text{sza}=30 \]

\[ Wv=0.670 \] (1 channel observation vector)
Retrieval of $\tau$, $r_{\text{eff}}$ and $v_{\text{eff}}$ (state vector)
$\tau=10$, $r_{\text{eff}}=10$, $v_{\text{eff}}=0.02$, $\text{sza}=30$
$W_v=2.2$ micron (1 channel observation vector)

**Total reflectance**

**Polarized reflectance**
Retrieval of Tau, Reff and Veff (state vector)

\( \text{Tau} = 10, \text{re} = 10, \text{ve} = 0.02, \text{sza} = 30 \)

\( Wv = 2.2 \text{ micron} \) (1 channel observation vector)
Retrieval of Tau, Reff and Veff (state vector)

Tau=10, re=10, ve=0.02, sza=30
Wv=0.670 and 2.2 micron (2 channels observation vector)
Retrieval of Tau, Reff and Veff (state vector)

Tau=10, re=10, ve=0.02, sza=30
Wv=0.670 and 2.2 micron (2 channels observation vector)
Retrieval of Tau, Reff and Veff (state vector)

Tau=10, re=10, sza=30
Wv=0.670 and 2.2 micron (2 channels observation vector)

Polarized AND total reflectance : Veff =0.15

Polarized AND total reflectance : Veff =0.02
Conclusions

- We are testing the proposed SGLI ice models libraries by means of SAD test:
  - Preliminary results look very encouraging: Voronoi aggregate models perform very similarly to currently best IHM or GHM models
  - Will finalize the analysis: perform full comparison with GHM models for all sizes and also test polarization consistency

- We have started investigating retrieval of cloud properties using single view 2 channels polarized and total reflectance observations:
  - Preliminary results show that $V_{eff}$ might be accessible depending on observation configuration and value
  - will continue analysis based on dual view geometry (SGLI)