

Effective particle shape retrieval from dual satellite observations

H. Chepfer, P. Minnis, L. Nguyen
 La boratoire de Météorologie Dynamique, IPSL, France
 NASA Langley Research Center, USA

Objective

Cirrus clouds:
 20% of the Earth / Radiative impact ?

Strong link :
 radiation / microphysics
 (ice crystal size, shape, orientation in space)

Particle shape :
 - Complex / variable
 - Albedo change : 30%

Requirement :
 knowledge of the shape temporal and spatial
 variability

Method

Observations of one cloud parcel under 2 directions:
 dual-satellite measurements GOES, NOAA, TRMM,
 EOS, ...

Satellite 1 : direction of observation: $165 < \Theta < 178$ deg.

Satellite 2 : direction of observation: $30 < \Theta < 170$ deg.

For both satellites :
 - temporal resolution : variable -
 - spatial resolution : 1 to 8 km
 - $\lambda = 650$ nm

Theoretical tools: Reflectance computations

Radiative transfer :

- doubling/adding (De Haan et al. 1987)
- plane-parallel approximation
- molecules + cloud
- surface albedo : 3 % for sea
 12 % for land

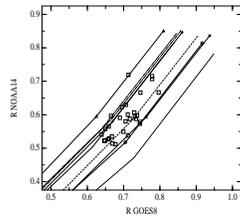
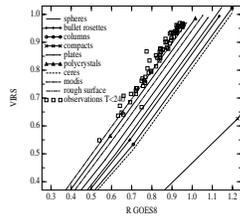
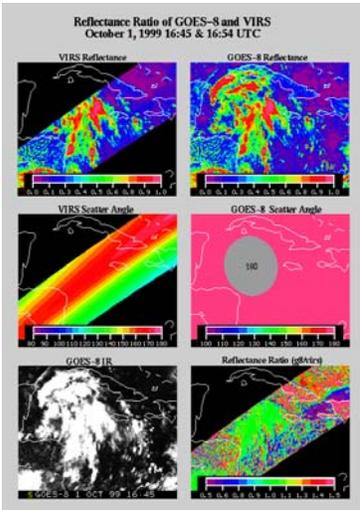
Optical properties ...

a priori choice of 14 phase functions

- 3 ceros
- 3 modis
- 1 isccp
- 1 rough surface crystal
- 4 simple crystals : column, plate, compact, bullet-rosette
- 2 liquid spheres : 6 and 8 μ m

=> $0.70 < g < 0.95$

Exemple of Application

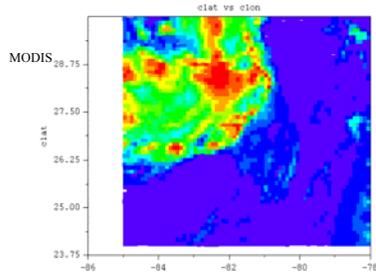


Date	Time	θ	Location	View 1	View 2
dd mm	UTC			θ	θ
GR / VIRS (time difference = 9 min)					
01 10	1650	20	18 N - 80 W	20 178 179	20 150 170
GR / NOAA (time difference = 15 min)					
27 08 00	2050	63.5 - 66	33 N - 66 W	40 111 124	52 178 166
G10 / G1 (max time difference = 2 min)					
31 10 99	1700	52.5	36 N - 96 W	58 106 119	47 167 169
G10 / G1 (max time difference = 15 min)					
10 03 00	1630	47.5	35 N - 85 W	59 80 104	46 170 173
17 03 00	1630	43.5	Oklahoma	59 90 110	16 179 178
11 03 00	1600	52	40 N - 89 W	58 102 118	46 170 173
16 03 00	1630	48	Illinois USA	66 89 103	48 169 171
17 03 00	1630	45.5	Illinois USA	66 98 111	48 179 176
12 03 00	1630	47	43 N - 94 W	59 292 118	24 111 123
16 03 00	1630	53	Iowa, USA	64 90 104	53 170 171
17 03 00	1630	49.5	Illinois USA	64 99 111	53 179 176
13 03 00	1630	46.5	34 N - 104 W	59 299 118	58 112 122
17 03 00	1630	46.5	USA	53 97 114	50 171 170
14 03 00	1600	50	31 N - 96 W	55 68 97	46 163 166
16 03 00	1630	45	Texas, USA	56 75 101	75 171 170
17 03 00	1630	40	Texas, USA	57 84 106	43 179 173
G10 / G1 (max time difference = 15 min)					
26 08 00	1622	40 - 45	8 N - 108 W	33 11 107	40 162 167
27 08 00	1622	37 - 41	Pacific Ocean	32 10 115	40 162 169
28 08 00	1622	29 - 33	Pacific Ocean	37 13 114	36 161 169
28 08 00	1622	36.5 -	12 N - 97 W	38 24 107	37 168 167
28 08 00	1652	40	Pacific Ocean	36 17 114	38 162 169

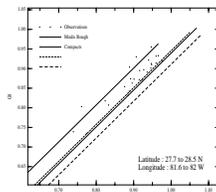
Date	Time	Class	A	B	C	D	30-45	45-60	60-75	75-90
01 10 99	* 1645	o								x
31 10 99	1700		o							x
10 03 00	1630		o	o						x
17 03 00	1700		o	o						x
17 03 00	1730		o	o						x
11 03 00	* 1600		o	o	o					x
11 03 00	* 1630		o	o	o					x
11 03 00	* 1700		o	o	o					x
12 03 00	1600		o	o	o					x
12 03 00	1630		o	o	o					x
12 03 00	1700		o	o	o					x
13 03 00	1600		o	o	o					x
13 03 00	1700		o	o	o					x
14 03 00	1600		o	o	o					x
14 03 00	1630		o	o	o					x
14 03 00	1630		o	o	o					x
14 03 00	1700		o	o	o					x
26 08 00	1622	o	o	o	o					x
26 08 00	1652	o	o	o	o					x
27 08 00	1622	o	o	o	o					x
27 08 00	1652	o	o	o	o					x
27 08 00	2050	o	o	o	o					x
28 08 00	1652	o	o	o	o					x
05 09 00	* 2055	o	o	o	o					x

Class A : isccp, modis-rough, plates
 Class B : 3 modis, bullet rosettes
 Class C : ceros-nov, ceros-contrails,
 ceros-big, columns, compacts
 Class D : liquid spheres

Application to Crystal-FACE case : 13 of July



GOES : 1602 GMT
 MODIS : 1603 GMT
 Spatial resolution: 0.1°
 $\theta_s = 23^\circ$
 GOES : $\theta_v = 33^\circ$, $\phi_v = 115^\circ$
 MODIS : $\theta_v = 23^\circ$, $\phi_v = 177^\circ$



Interest of the method:

- good phase determination (except at $\Theta = 60$ and 140)
- phase function discrimination possible
- most of the time: shape retrieval

Limitations of the method:

- satellites inter-calibration
- cloud heterogeneities (σ_T):
 plane-// approximation
 thin diff. between satellites
- optically thin clouds: knowledge of surface

Future work on CRYSTAL-FACE

Study of several ice cloud cases with good collocation and viewing geometries between MODIS and GOES :
 July 5, 6, 15, 16, 20, 22-25, 29

Comparisons with complementary particles shape retrieval:
 In-situ
 Lidar depolarization
 Polder airborne