SENSITIVITY OF AMV HA METHODS TO CLOUD PROPERTIES USING SIMULATED MSG RADIANCES.

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General context

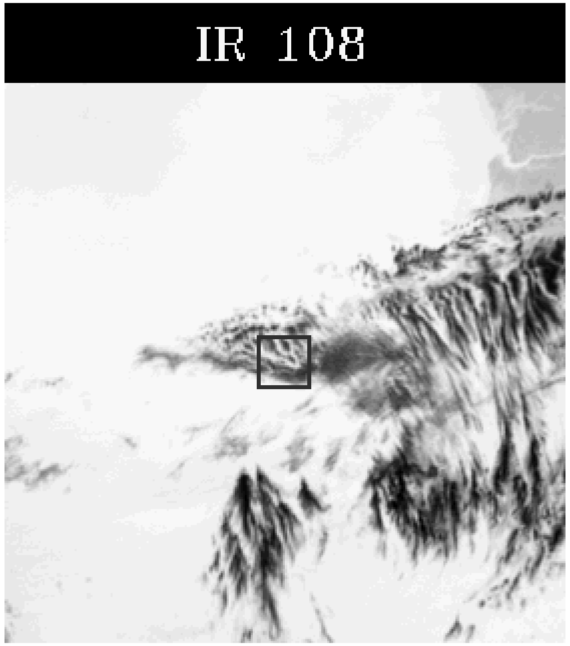
- Operational extraction of Atmospheric Motion Vectors from satellite images (AMV product: speed, direction, altitude, QI)

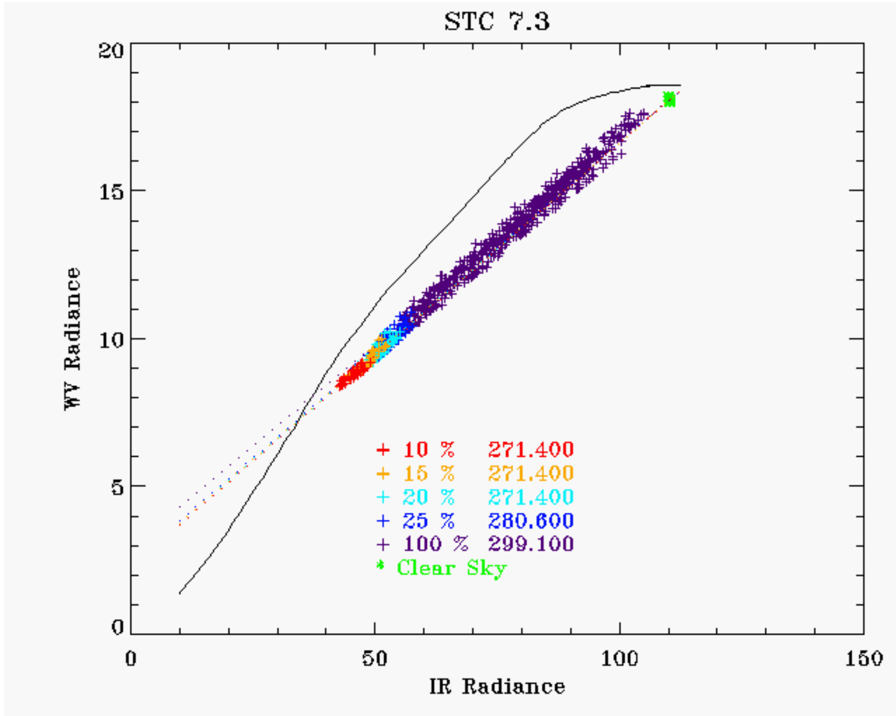
- AMVs are daily assimilated in forecast models

- Main problem is to set the correct altitude to detected AMVs.

- For semi-transparent clouds, STC and CO_2 slicing methods are used to estimate the pressure.

STC method


IR 108


STC 7.3
WV Radiance
IR Radiance
0
5
10
15
20
0
50
100
150
+ 10 % 271.400
+ 15 % 271.400
+ 20 % 271.400
+ 25 % 280.600
+ 100 % 299.100
* Clear Sky

CO2 Slicing Method

$$\frac{R_{cf}(CO_2)-R_{cd}(CO_2)}{R_{cf}(IR\nu)-R_{cd}(IR\nu)}=\frac{\varepsilon(CO_2)}{\varepsilon(IR\nu)}\frac{\left[R_{suf}(CO_2)-R_{bcd}(CO_2,P_c)\right]}{\left[R_{suf}(IR\nu)-R_{bcd}(IR\nu,P_c)\right]}$$

R_{cd} : Measured cloudy radiance

R_{cf} : Measured cloud free radiance

R_{bcd} : Calculated Planck blackbody radiance for a cloud at level P_c

R_{suf} : Calculated clear air radiance

ε : Emissivities

$$\varepsilon(CO_2)\cong\varepsilon(IR\nu)$$

Best fit

P_c

Several problems for the validation

- Few in situ measurements (RadObs).

- CTH of ST clouds also depend on instrument characteristics.

- Comparison against other collocated satellite measurements is sometimes difficult to analyse. The other instrument is assumed to be the true reference but may have different characteristics.

Objective of this study

Question:

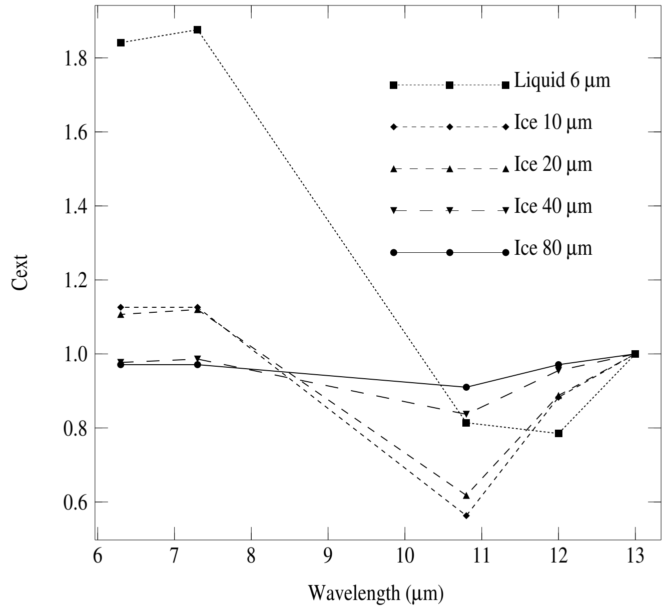
How can we test the intrinsic performances of CO_2 and STC methods as function of several atmospheric parameters.

Answer:

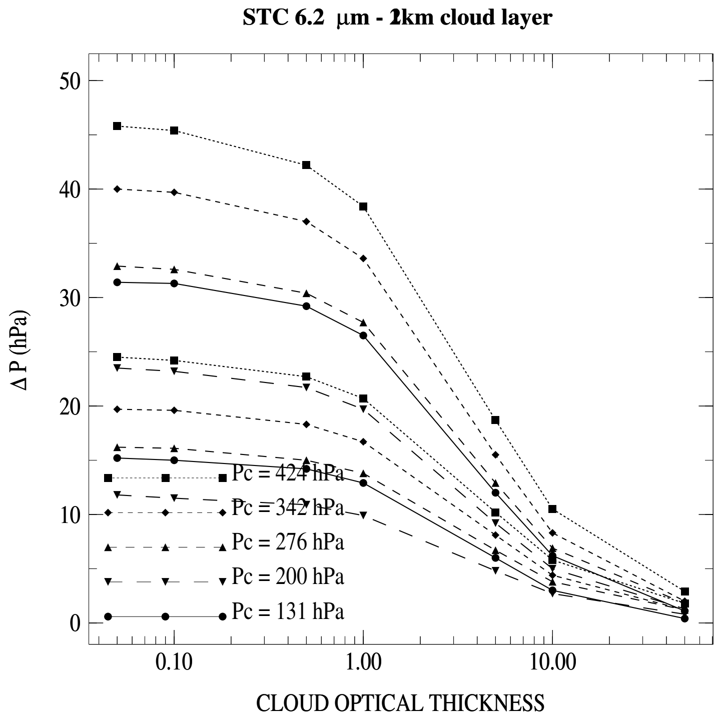
Using simulated data, for which CTH is accurately known.

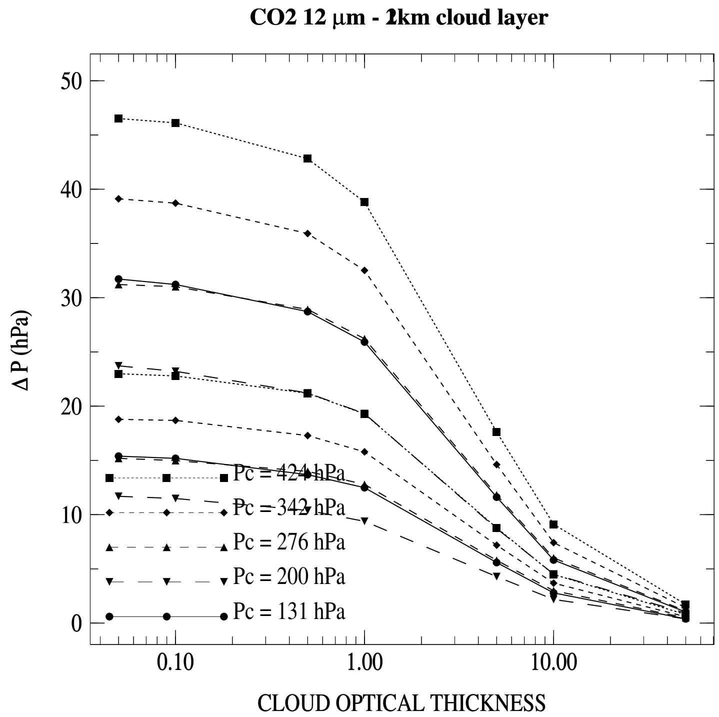
FASDOM simulations

Inputs	Cases
Atmospheric profiles	Mid-Latitude (4), Tropical (4)
Clouds	Grey (no spectral variation) , Liquid (6 µm), 4 Crystal (10, 20, 40 and 80 µm)
Cloud optical thickness	0.2, 0.5, 1, 2, 4, 8, 16, 32 and 100 at 13 µm
Cloud top pressure	11 cloud top heights, from 525 hPa to 162 hPa
View angle	θ = 0, 45 and 60°



Grey clouds (no spectral variation)
Sensitivity to cloud thickness



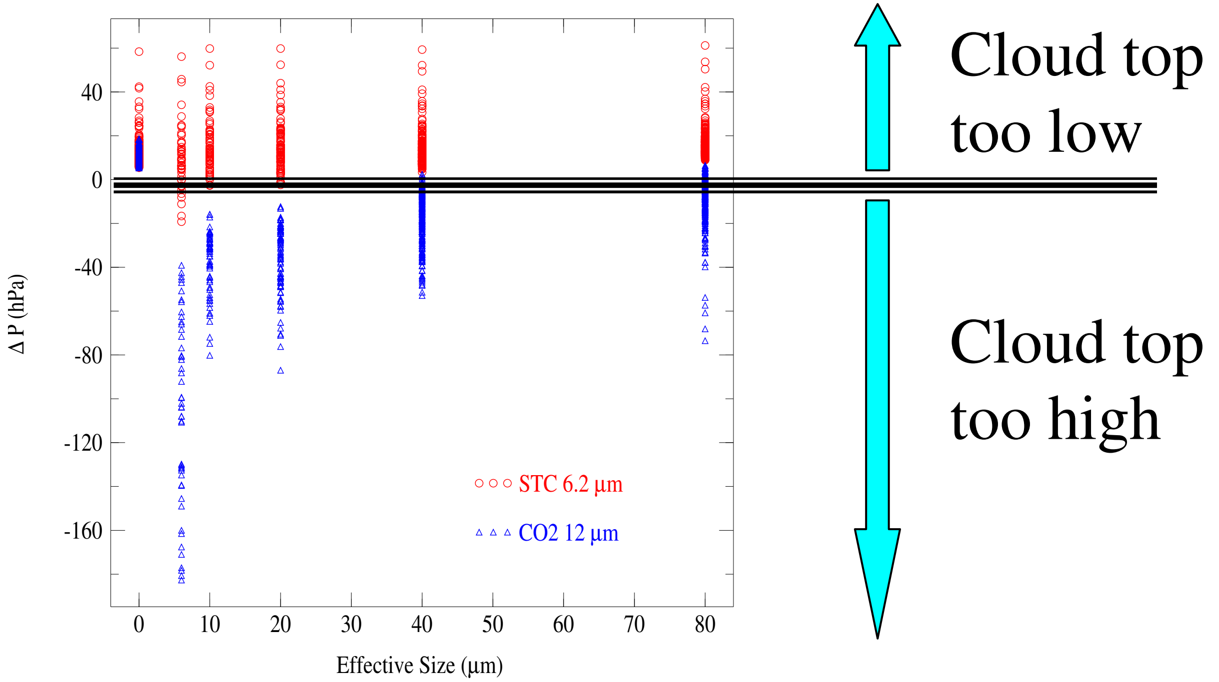


$\Delta P = P(\text{retrieved}) - P(\text{simulation})$

Grey clouds

Pressure levels (hPa)	STC Method			CO2 method		
	STD (hPa)	Bias (hPa)	Succes rate (%)	STD (hPa)	Bias (hPa)	Succes rate (%)
471	24	16	68	11	8	100
423	16	12	95	9	7	100
380	10	8	100	8	6	100
342	8	6	100	7	5	100
307	7	6	100	7	5	100
276	7	5	100	6	4	100
247	7	5	100	6	4	100
222	6	4	100	5	4	100
200	5	4	100	4	3	100
162	8	6	100	8	6	100
131	6	5	100	6	4	100
106	5	4	100	5	4	100

More realistic liquid cloud
Sensitivity to size particles



$\Delta P = P(\text{retrieved}) - P(\text{simulation})$

Ice clouds

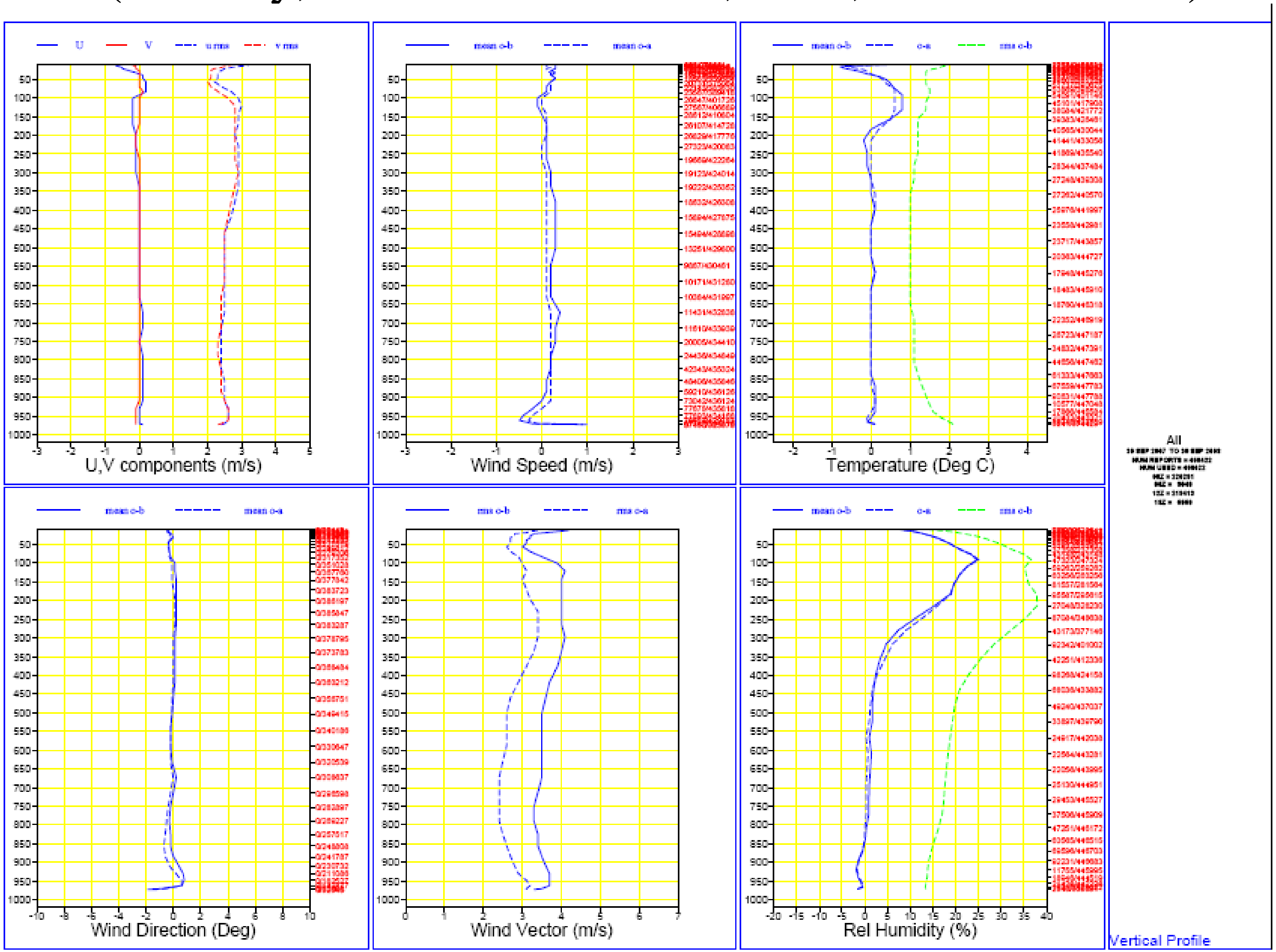
Pressure levels (hPa)	STC Method			CO2 method		
	STD (hPa)	Bias (hPa)	Succes rate (%)	STD (hPa)	Bias (hPa)	Succes rate (%)
471	21	14	65	49	-26	99
423	20	12	94	47	-24	98
380	17	6	99	48	-24	98
342	9	6	100	37	-20	99
307	14	4	100	38	-22	98
276	7	2	100	36	-23	98
247	9	1	100	32	-19	96
222	7	0	100	27	-16	94
200	12	-1	99	26	-16	91
162	10	3	98	15	-9	86
131	23	2	96	9	-5	70
106	6	4	56	1	1	8

Ice clouds (<20 μm)

Pressure levels (hPa)	STC Method			CO_2 method		
	STD (hPa)	Bias (hPa)	Succes rate (%)	STD (hPa)	Bias (hPa)	Succes rate (%)
471	20	10	66	72	-45	98
423	19	7	94	69	-41	97
380	22	2	99	68	-40	96
342	7	2	100	52	-35	98
307	24	2	100	51	-37	96
276	7	-3	100	48	-35	95
247	8	-4	100	41	-28	92
222	10	-4	100	36	-25	89
200	16	-8	99	33	-24	85
162	11	-1	97	18	-13	77
131	25	1	91	10	-8	55
106	3	2	22	-	-	0

Comparison radiosondes and a global NWP model

(courtesy, Parrett and Rawlins, 2009, UK Met Office)



0.5 K perturbation in temperature profile, grey clouds

Cloud pressure Levels (hPa)	δ	DP_{pert} (hPa) STC6.2	DP_{pert} (hPa) STC7.3	DP_{pert} (hPa) CO10.8	DP_{pert} (hPa) CO12.0
424.	0.25	-66.	-34.	-22.	-26.
	0.50	-36.	-16.	-10.	-12.
	1.00	-16.	-6.	-4.	-5.
	2.00	-4.	-2.	-1.	-1.
342.	0.25	-44.	-28.	-12.	-16.
	0.50	-19.	-12.	-5.	-7.
	1.00	-7.	-4.	-2.	-3.
	2.00	-2.	-1.	-1.	-1.
276.	0.25	-49.	-38.	-12.	-17.
	0.50	-23.	-16.	-5.	-7.
	1.00	-8.	-6.	-2.	-3.
	2.00	-2.	-2.	-1.	-1.
223.	0.25	-51.	-32.	-7.	-11.
	0.50	-19.	-16.	-3.	-5.
	1.00	-7.	-6.	-1.	-2.
	2.00	-2.	-2.	0.	-1.
162.	0.25	-29.	-32.	-5.	-10.
	0.50	-24.	-15.	-2.	-6.
	1.00	-10.	-10.	-1.	-2.
	2.00	-3.	-3.	0.	-1.
106.	0.25	-	-.	-1.	-2.
	0.50	-10	-10.	-1.	-4.

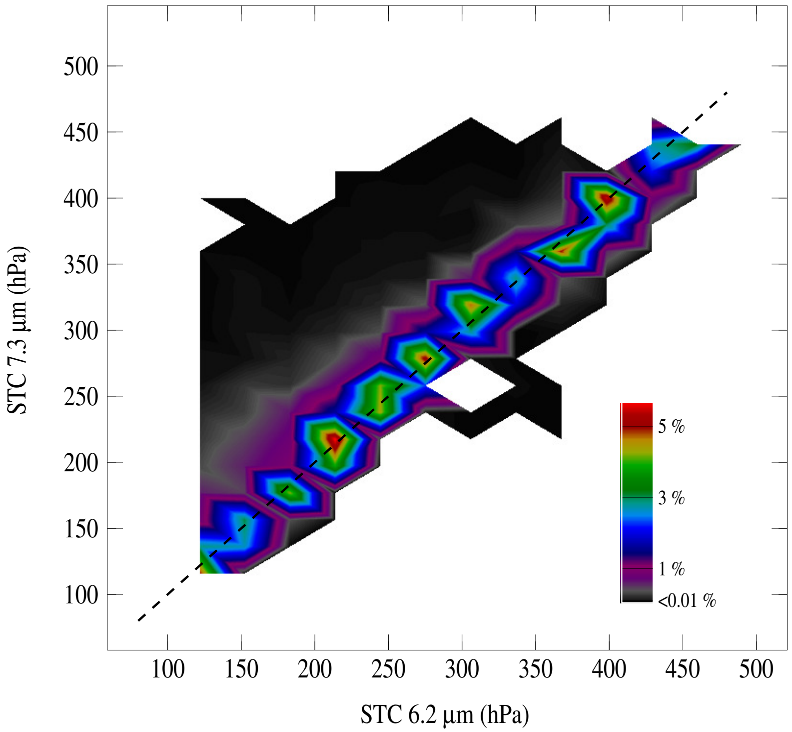
10% perturbation in humidity profile, grey clouds

Cloud pressure Levels (hPa)	δ	ΔP_{pert} (hPa) STC6.2	ΔP_{pert} (hPa) STC7.3	ΔP_{pert} (hPa) CO10.8	ΔP_{pert} (hPa) CO12.0
424.	0.25	250.	83.	57.	46.
	0.50	116.	34.	25.	20.
	1.00	29.	13.	10.	8.
	2.00	5.	3.	3.	2.
342.	0.25	68.	57.	37.	27.
	0.50	27.	26.	16.	11.
	1.00	10.	10.	6.	4.
	2.00	3.	3.	2.	1.
276.	0.25	60.	65.	35.	24.
	0.50	29.	33.	16.	11.
	1.00	13.	14.	7.	4.
	2.00	3.	4.	2.	1.
223.	0.25	71.	77.	34.	19.
	0.50	30.	35.	13.	8.
	1.00	11.	14.	5.	3.
	2.00	3.	4.	1.	1.
162.	0.25	66.	80.	26.	17.
	0.50	31.	42.	13.	8.
	1.00	14.	20.	6.	4.
	2.00	5.	7.	2.	1.
106.	0.25	71.	103.	28.	19.
	0.50	35.	58.	13.	7.

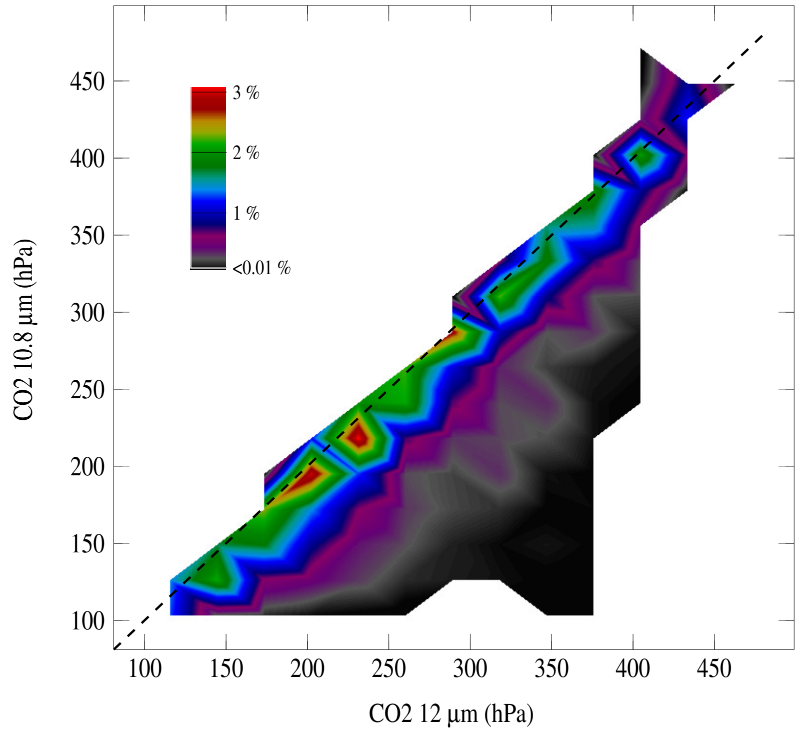
10% error on clear sky radiance, grey clouds

Cloud pressure Levels (hPa)	δ	ΔP_{pert} (hPa) STC6.2	ΔP_{pert} (hPa) STC7.3	ΔP_{pert} (hPa) CO10.8	ΔP_{pert} (hPa) CO12.0
424.	0.25	97.	97.	-	-
	0.50	68.	48.	62.	62.
	1.00	34.	16.	27.	27.
	2.00	11.	7.	10.	9.
342.	0.25	130.	111.	-	-
	0.50	56.	26.	65.	64.
	1.00	15.	11.	23.	22.
	2.00	7.	5.	9.	8.
276.	0.25	151.	73.	157.	157.
	0.50	33.	22.	65.	63.
	1.00	15.	11.	26.	25.
	2.00	7.	6.	11.	11.
223.	0.25	135.	67.	198.	196.
	0.50	40.	28.	78.	76.
	1.00	17.	10.	36.	35.
	2.00	7.	5.	11.	11.
162.	0.25	122.	61.	246.	241.
	0.50	45.	23.	96.	93.
	1.00	22.	14.	39.	38.
	2.00	12.	9.	17.	17.
106.	0.25	111.	58.	306.	299.
	0.50	45.	30.	114.	112.

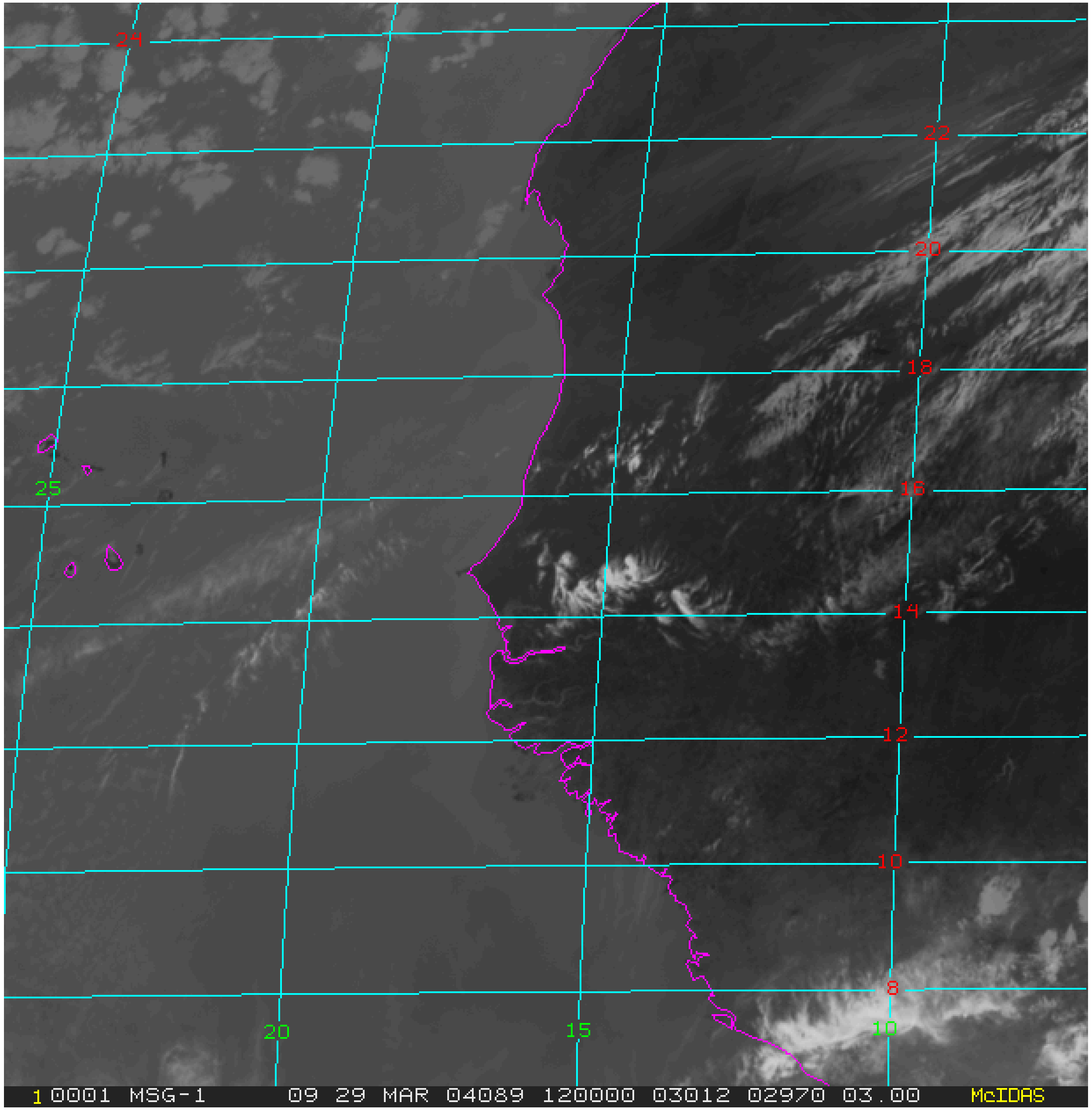
Comparison of different configurations of the same method



STC



CO2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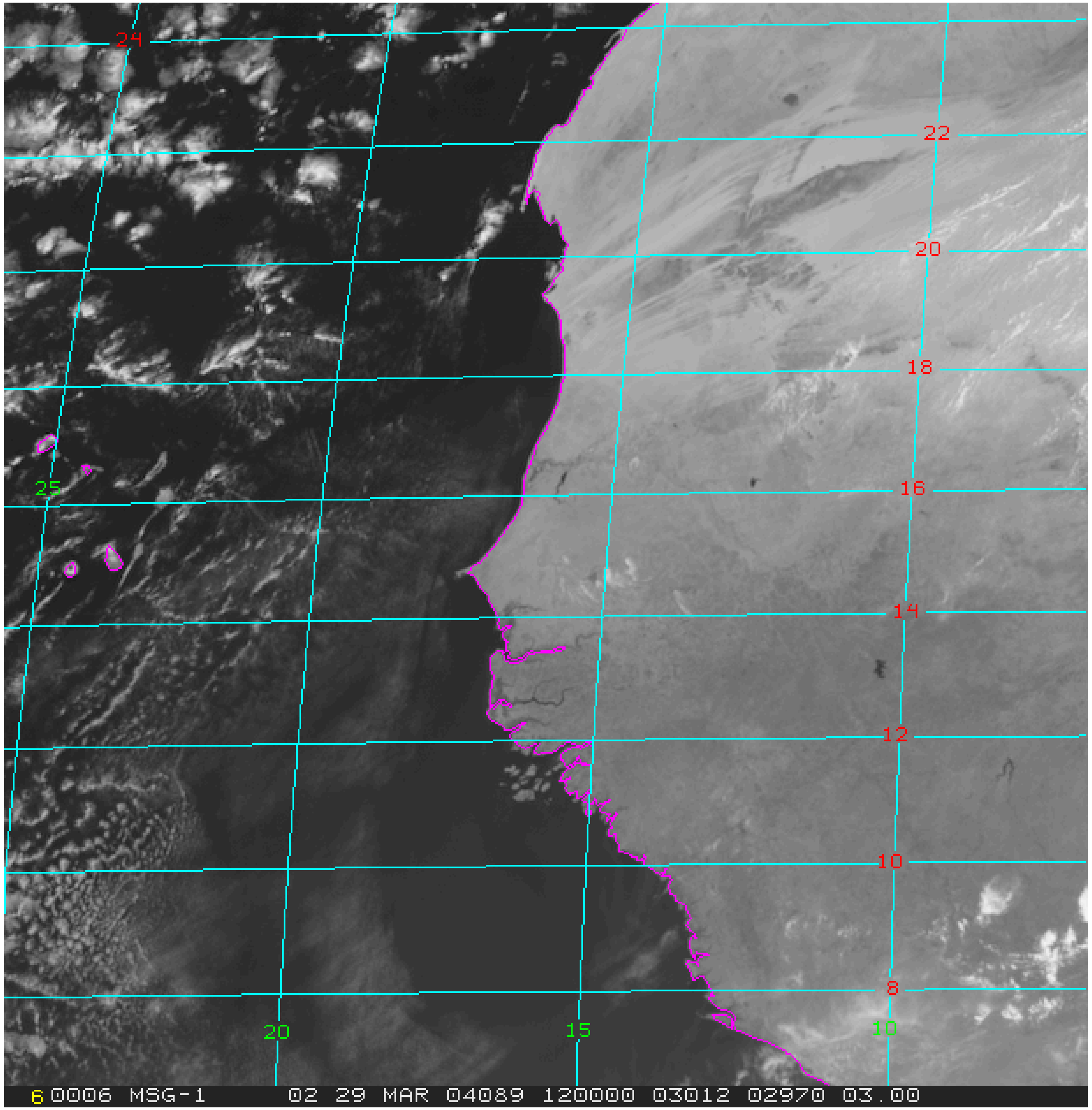

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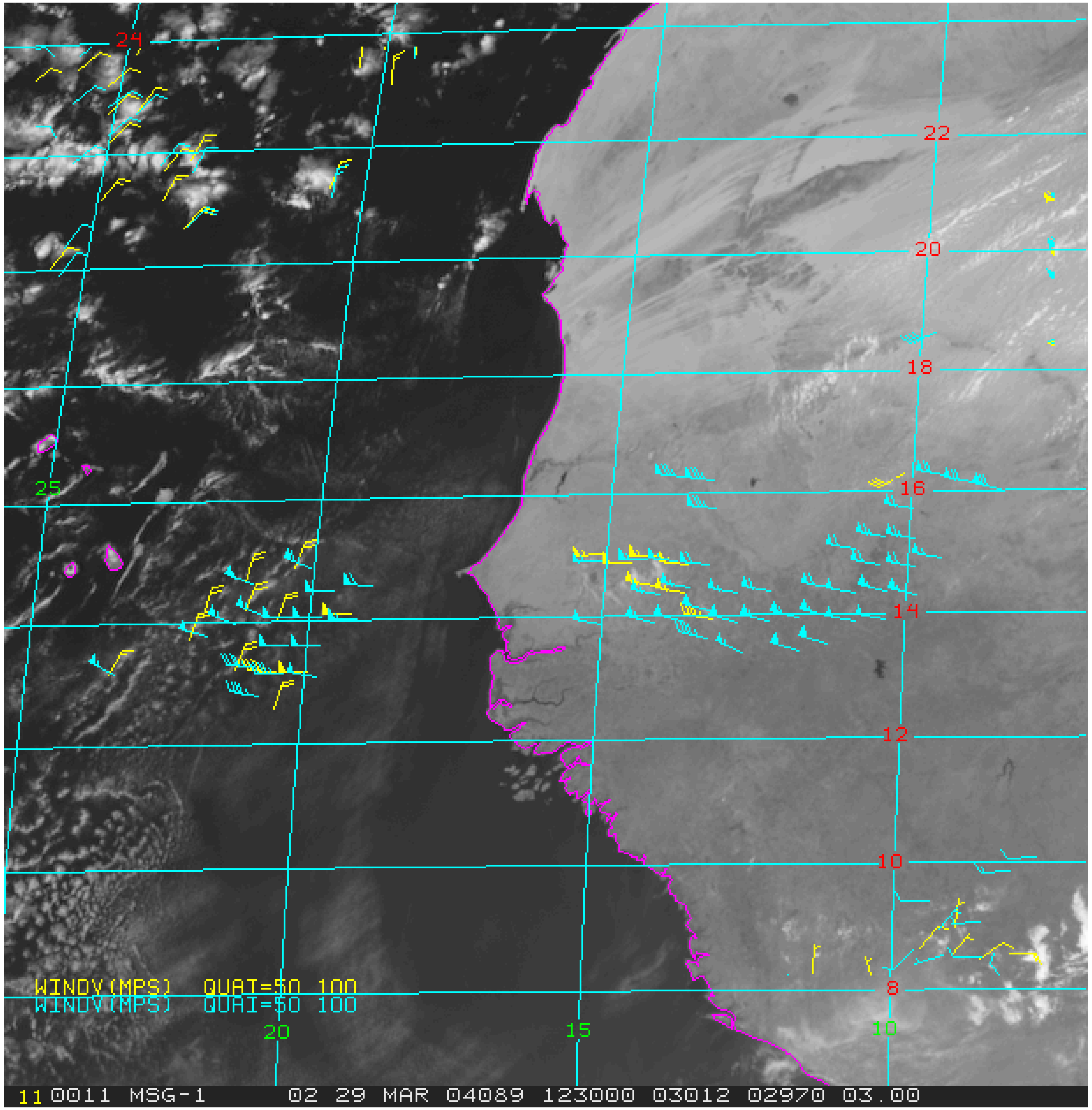

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WINDV(MPS) QUAT=50 100
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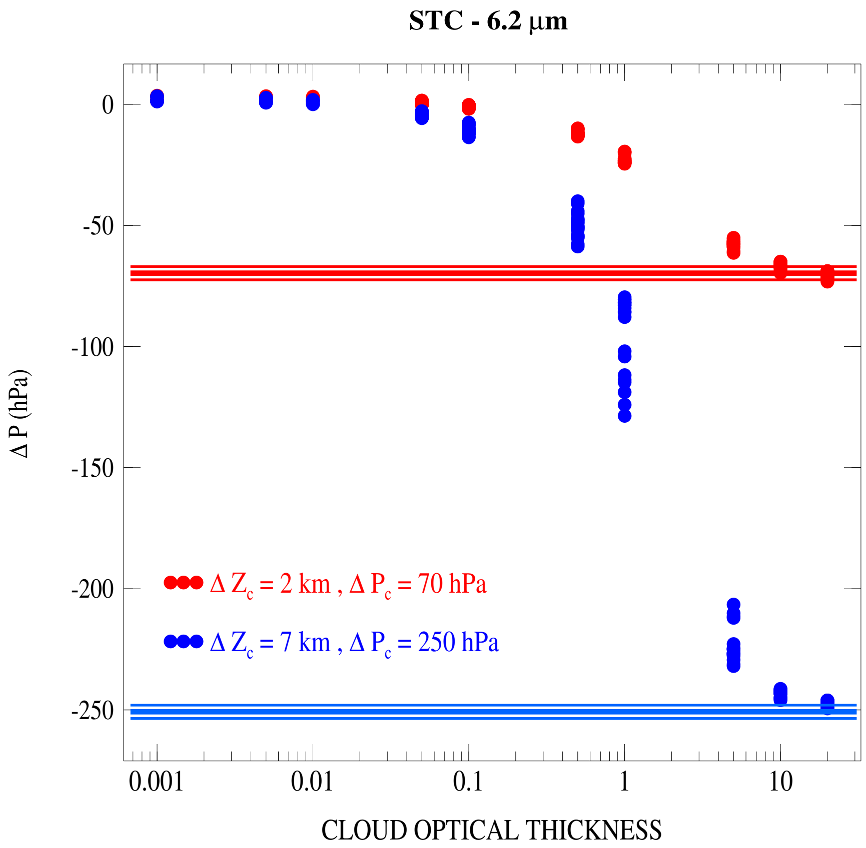
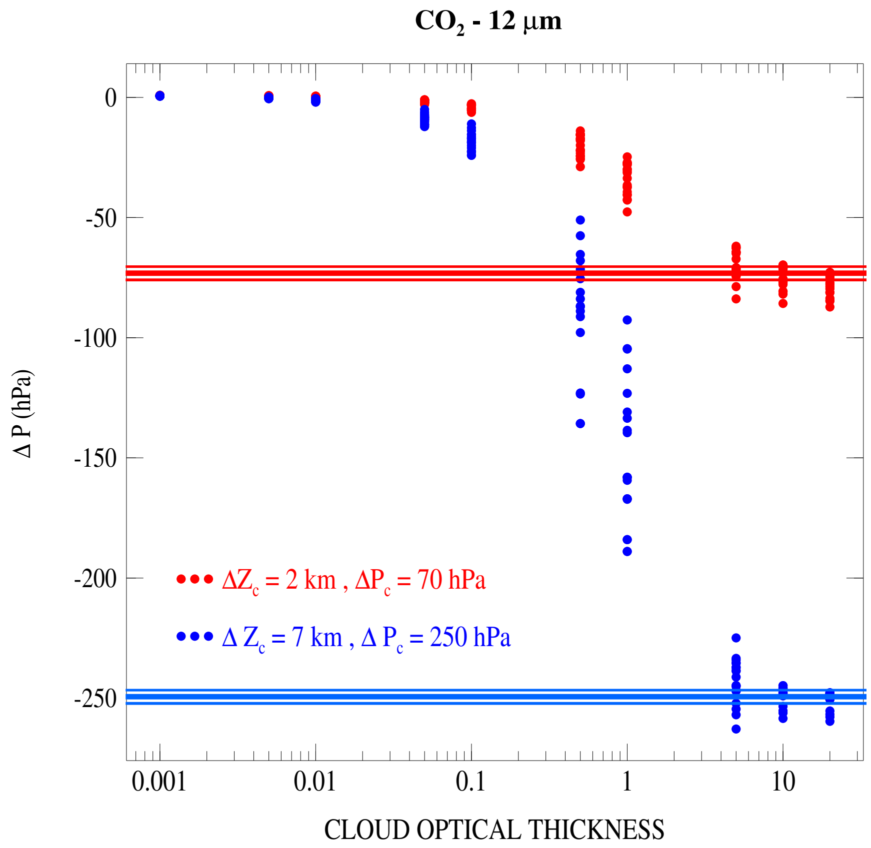
Multilayer Situations





ΔP = P(retrieved) – P(low cloud)

Conclusion

- STC and CO2 methods retrieve correct pressure within few hPa in ideal thick case

- Methods are very sensitive to several atmospheric parameters, and performances are really poor for thin clouds.

- STC generally more accurate and more robust for grey clouds, but more sensitive to natural noise coming from geophysical data.

- CO2 slicing depends on the cloud microphysics

- Multilayer situations can not be treated using such methods.

THANKS

Paper accepted at JAMC:

Borde, R. and Ph. Dubuisson, 'Sensitivity of Atmospheric Motion Vectors Height Assignment methods to semi-transparent cloud properties using simulated Meteosat-8 radiances'*, to be published at JAMC, 2010.*