



CO₂ Slicing Method for IASI

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- ❑ IASI algorithms ← recommended methods from ISSWG
 - ❑ Cloud detection within IFOV → profile retrievals
 - ❑ CTP retrieval ← CO₂ slicing method (Smith and Frey, 1990)
- Prototyping Processing Facility for IASI L2 products (MET division)
 - Implement methods, optimise algorithms & coefficients
- Input:
 - ECMWF (or ATOVS) co-located profiles & T_{skin}
 - IASI L1 radiance, surface emissivity, RTIASI-4, auxiliary file (list of channels)
- Output:
 - CTP and CFR → iterative profile retrieval

Algorithm

CO₂ channel selection

Validation



Algorithm

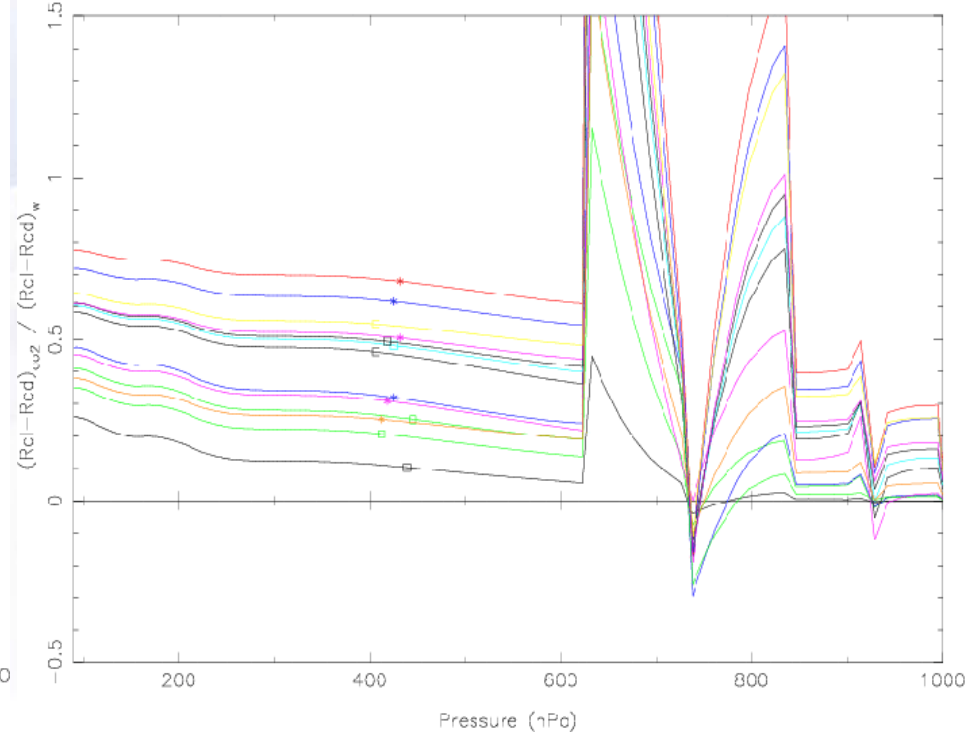
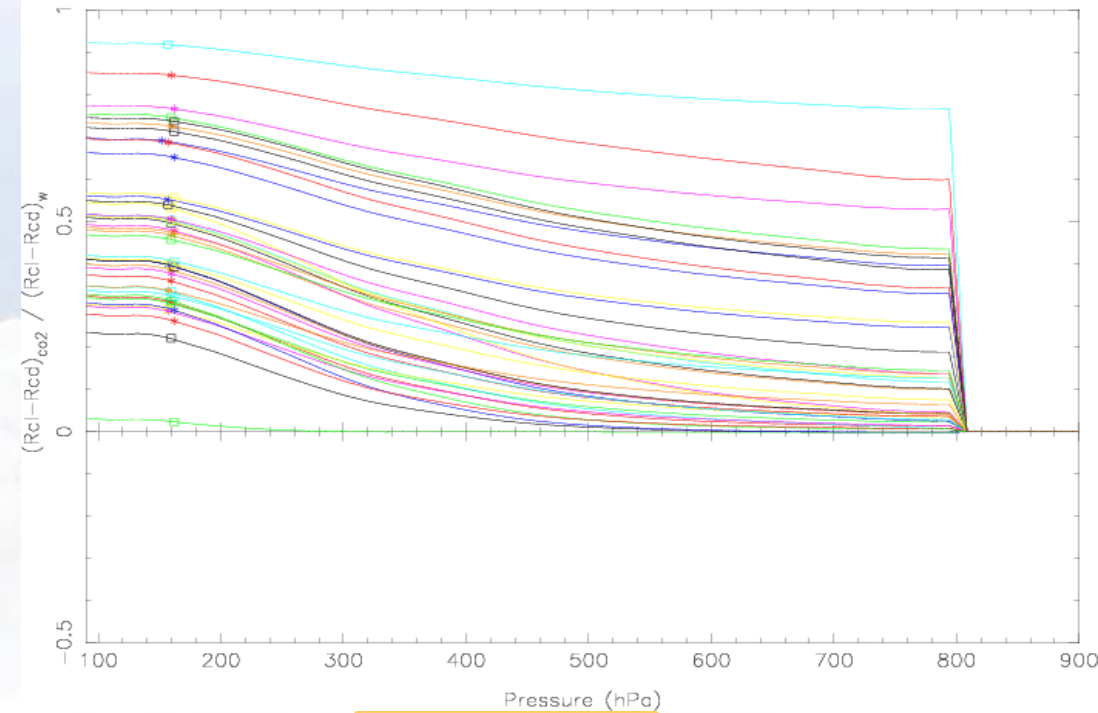
$$x_{k,n} = \frac{R_k^{\text{clear}} - R_k^{\text{cloudy}}}{R_{\text{ref}}^{\text{clear}} - R_{\text{ref}}^{\text{cloudy}}} - \frac{R_k^{\text{clear}} - R_k^{\text{B}}(p_n)}{R_{\text{ref}}^{\text{clear}} - R_{\text{ref}}^{\text{B}}(p_n)}$$

$$P_k = P(\min(|x_{k,n}|))$$

$$P_c = \frac{\sum_{k=1}^M w_k^2 P_k}{\sum_{k=1}^M w_k^2}$$

case 24087, chns 41, lat=24.11, land, Ts=27.3 C, Ps=794.7 Pc=155.4 Err=4.4 RMS=2.1hPa

case 3, chns 13, lct=89.14, water, Ts=-35.1 C, Ps=994.9 Pc=416.4 Err=8.1 RMS=12.1hPa



Algorithm

CO₂ channel selection

Validation



Algorithm implementation

❖ Non noisy radiance

$$(R_w^{\text{cloudy}} \geq R_w^B(p_{\text{suf}})) \quad R_{k,\text{ref}} \geq \text{SNR} * \text{NE}\delta E_{k,\text{ref}} \quad \text{with} \quad \text{SNR} = 3$$

$$(R_{\text{ref}}^{\text{clear}} - R_{\text{ref}}^{\text{cloudy}}) \geq \text{SNR} * \sqrt{2} \text{NE}\delta E_{\text{ref}} \quad \text{and} \quad (R_k^{\text{clear}} - R_k^{\text{cloudy}}) \geq \text{SNR} * \sqrt{2} \text{NE}\delta E_k$$

○ Search profile for inversions below 500 hPa (flag levels p_i)

✓ Flag levels p_n with noisy cloud signal $R_{\text{ref}}(p_n) \rightarrow$ skip levels p_n, p_i

• Retrieve cloud top pressure P_k with a single CO_2 channel

Calculate effective C_{fk} using the window channel \rightarrow exclude channel k if C_{fk} outside $(0,1]$

□ CTP histogram from single channel retrievals

☺ Retrieved P_c as in Smith and Frey $\leftarrow P_k$ in most populated class

➤ If inversion exists and $P_c > 600$ hPa \rightarrow use P_k below inversion basis only

▪ Effective cloud fraction $C_f \leftarrow P_c$ and window channel

➤ P_c and C_f delivered if $C_f > 10\%$

(Other results for quality control: P_k rms, ΔP_k , δP_c from $\text{NE}\delta R$ and T error, Number of channels used)

Algorithm

CO_2 channel selection

Validation



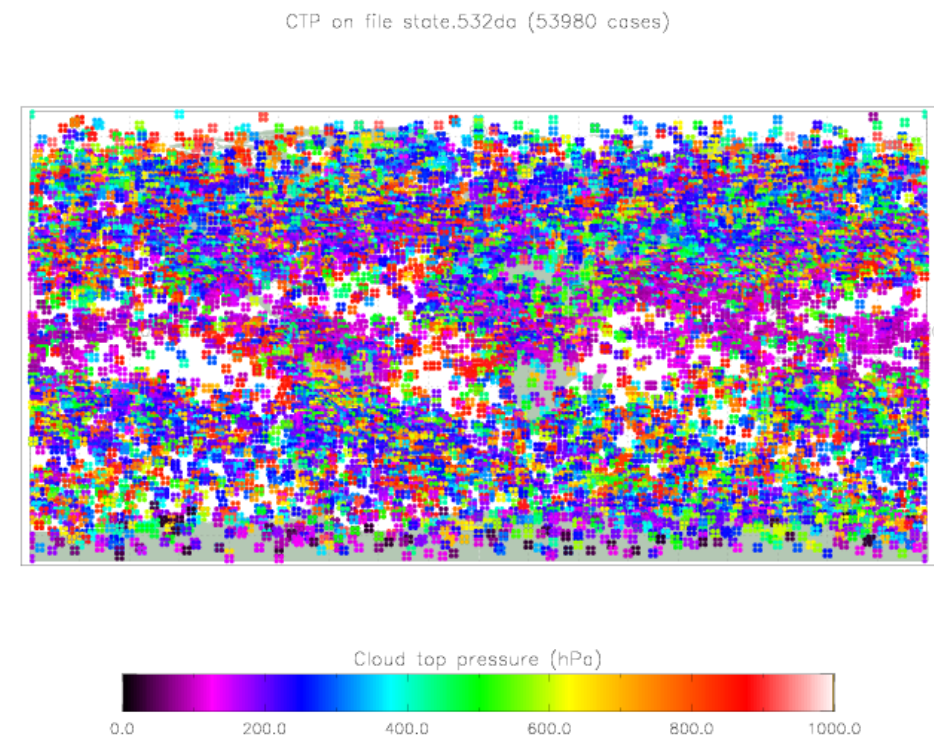
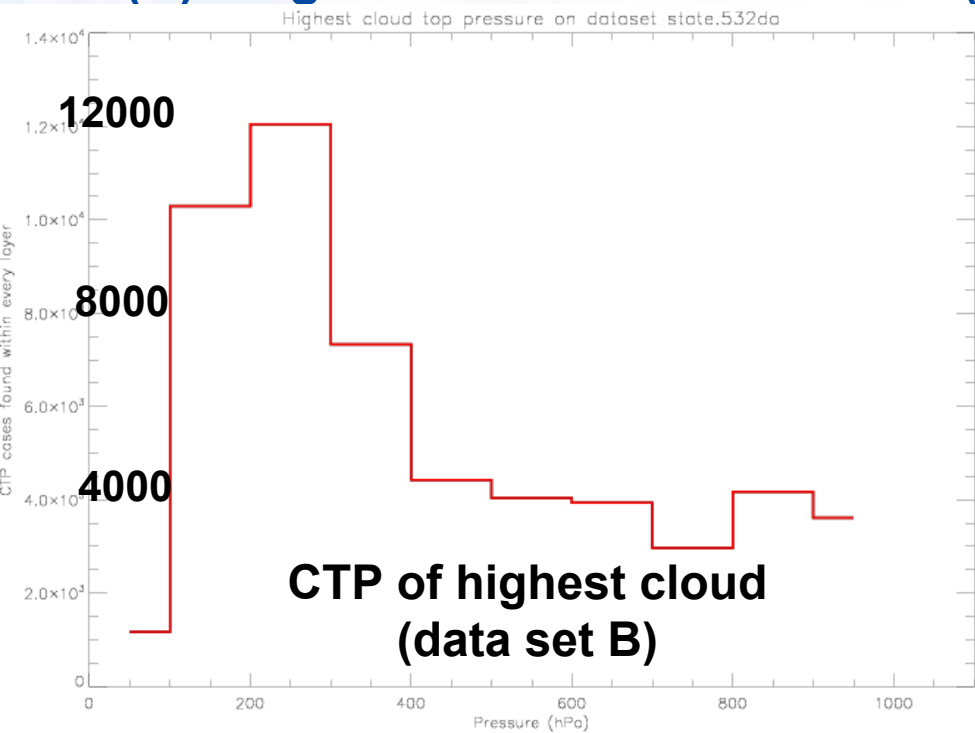


CO₂ channel selection (1)

window: 990.50 cm⁻¹ (11.10494 μm) **reference:** 796.75 cm⁻¹ (12.55099 μm)

Retrievals of 53980 scenarios (RTIASI) → **41** CO₂ channels (707.50 – 756.00 cm⁻¹)

- Two global data sets (all cloud fractions, surface types, day/night, seasons)
(A) single level black clouds and (B) multilevel, water/ice clouds, 6 types



Algorithm

CO₂ channel selection

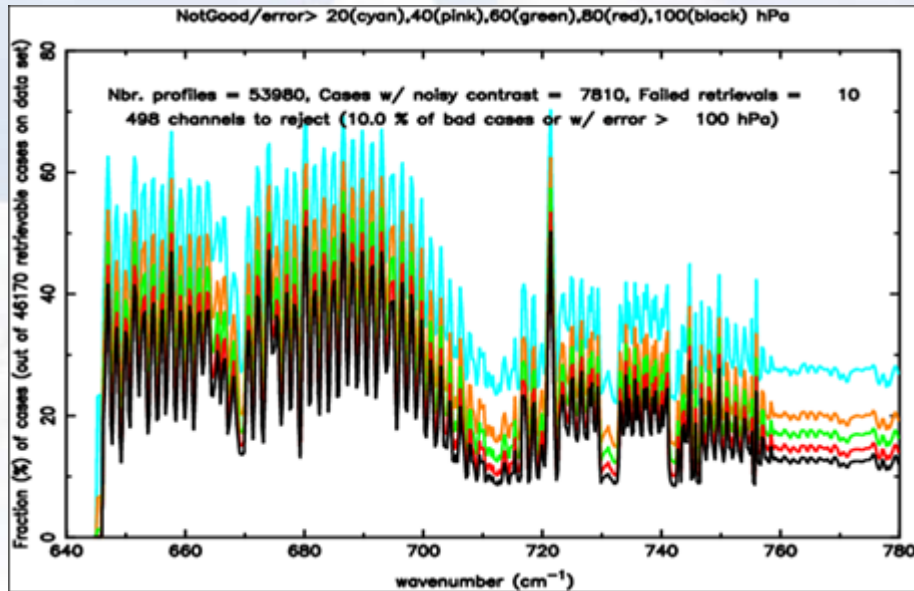
Validation





CO₂ channel selection (2)

- Retrievals with single channel $k \leftarrow 545$ IASI frequencies (645.0 to 781.0 cm⁻¹)
- Significance of channel k : $Q\%$ scenarios $\{k \text{ NOT used OR error} \geq \text{critical } E\}$
- Given a critical error E_n identify (among 545 channels) the set M_{ni} of channels with a pre-defined Q_i and find the set S_{ni} of scenarios left with no channels
- ☺ $\{E_n < 100 \text{ hPa}, S_{ni} \leq 1\%\} \leftrightarrow Q_i = 10\% \Rightarrow$ exclude 498 (A) [264 (B) channels]



...	40 hPa	60 hPa	80 hPa	100 hPa
5.0%	542	539	539	539 excld.
	7778	1945	1945	1945 non-expl.
	16.85	4.21	4.21	4.21 %
10.0%	539	539	539	498 excld.
	1945	1945	1945	56 non-expl.
	4.21	4.21	4.21	0.12 %

Algorithm

CO₂ channel selection

Validation





CO₂ channel selection (3)

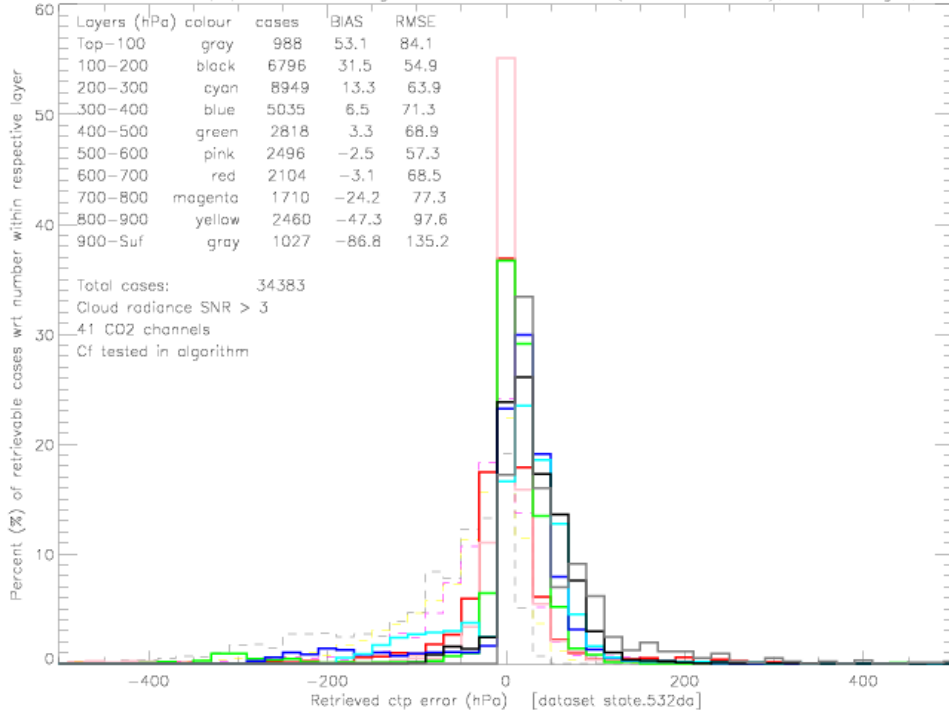
➤ Statistics of retrievals (data set B) using 41 or 281 CO₂ channels

41 chs: 34383
281 chs: 35848

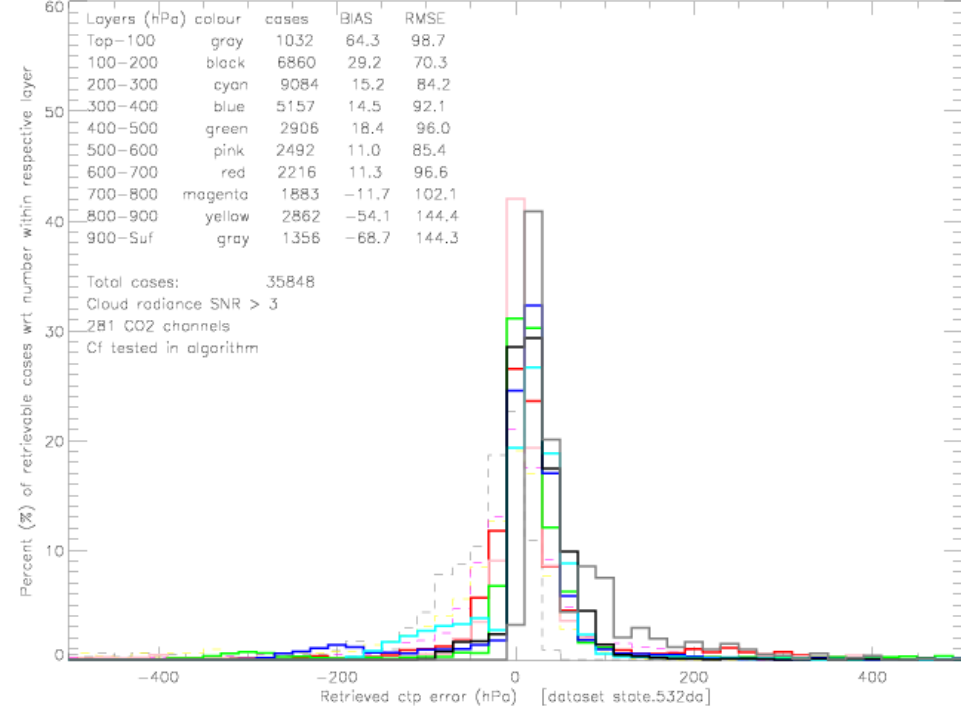
Layer (100, 400] hPa
20780 12.5 61.8
21101 19.6 68.9

Layer (400, 800] hPa
9128 -0.4 67.6
9496 8.8 94.3

Retrieved cloud top pressure wrt highest cloud within IFOV (0.0 ≤ Fc < 1.0), StatusFlag: 0, 5-13



Retrieved cloud top pressure wrt highest cloud within IFOV (0.0 ≤ Fc < 1.0), StatusFlag: 0, 5-13



Algorithm

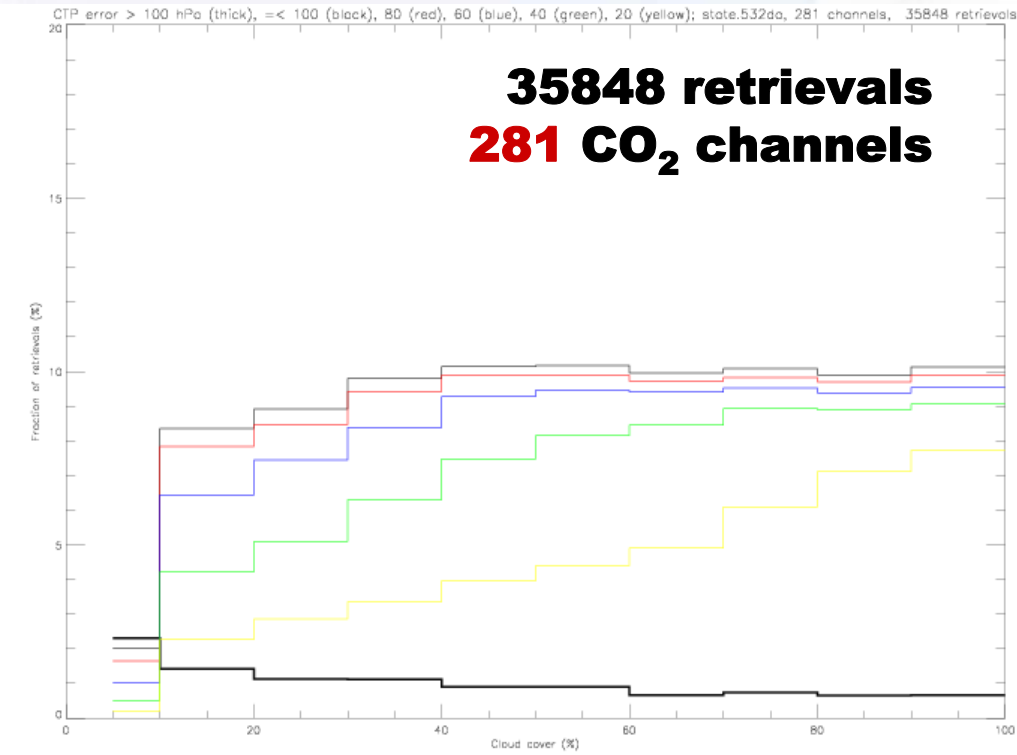
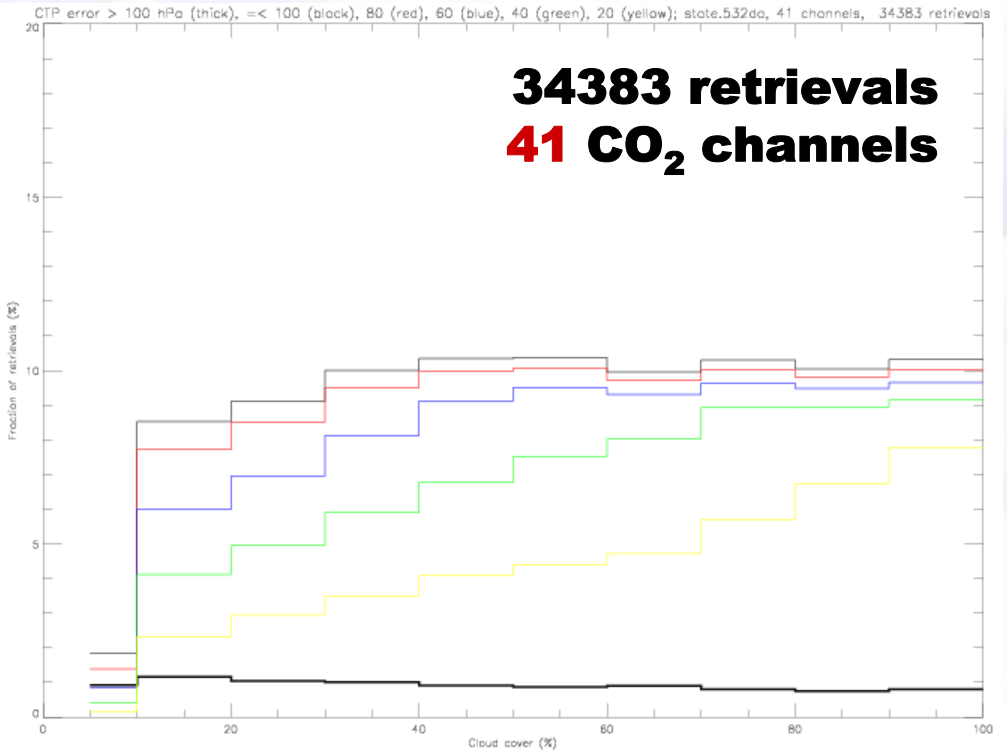
CO₂ channel selection

Validation



CO₂ channel selection (4)

Frequency (%) of retrievals vs. cloud cover of highest cloud (data set with multilevel water/ice clouds, six types)



Algorithm

CO₂ channel selection

Validation



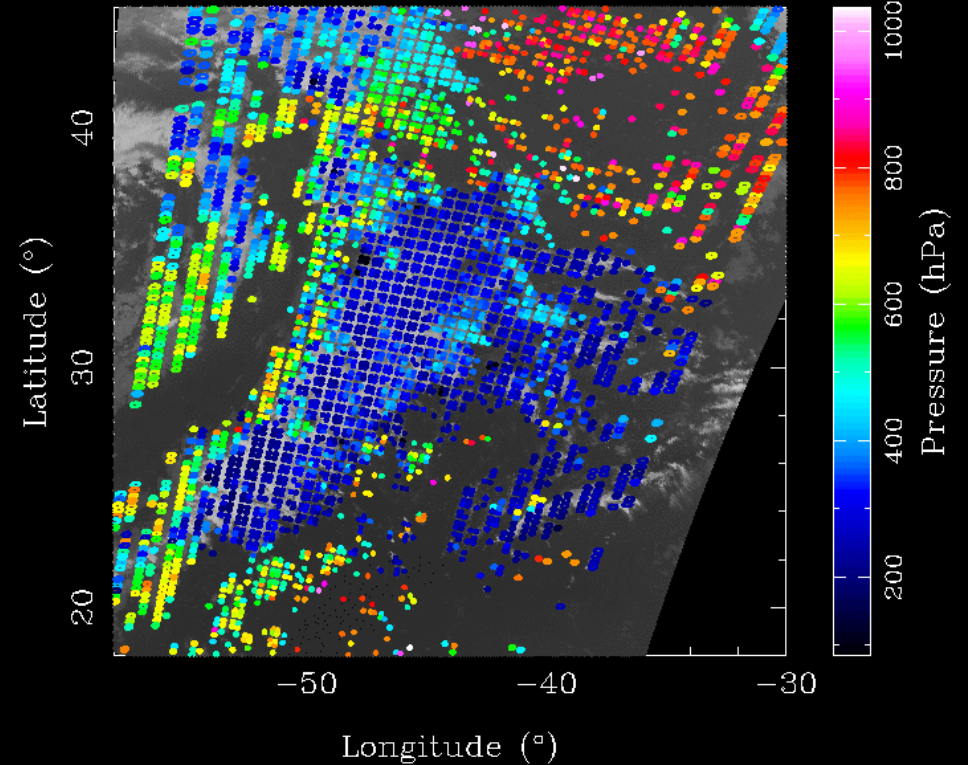
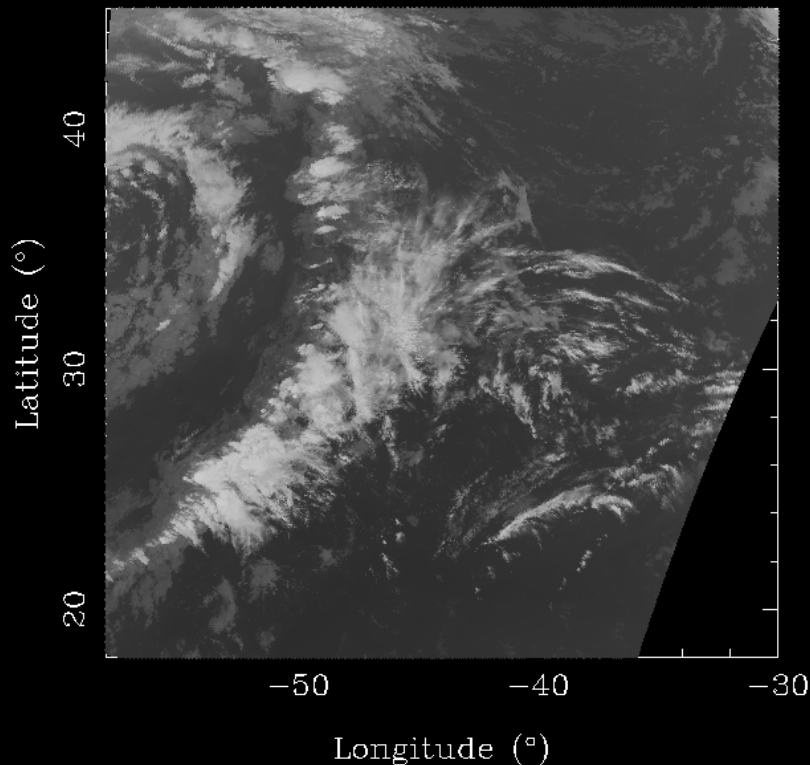


Validation (1a)

Consistency with AVHRR images: frontal system & post frontal convection (north Atlantic)

AVHRR/10.8 Cold front [IASI 20070418124454Z

AVHRR/10.8, CTP IASI 20070418124454Z



Algorithm

CO₂ channel selection

Validation

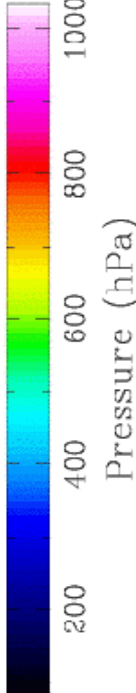
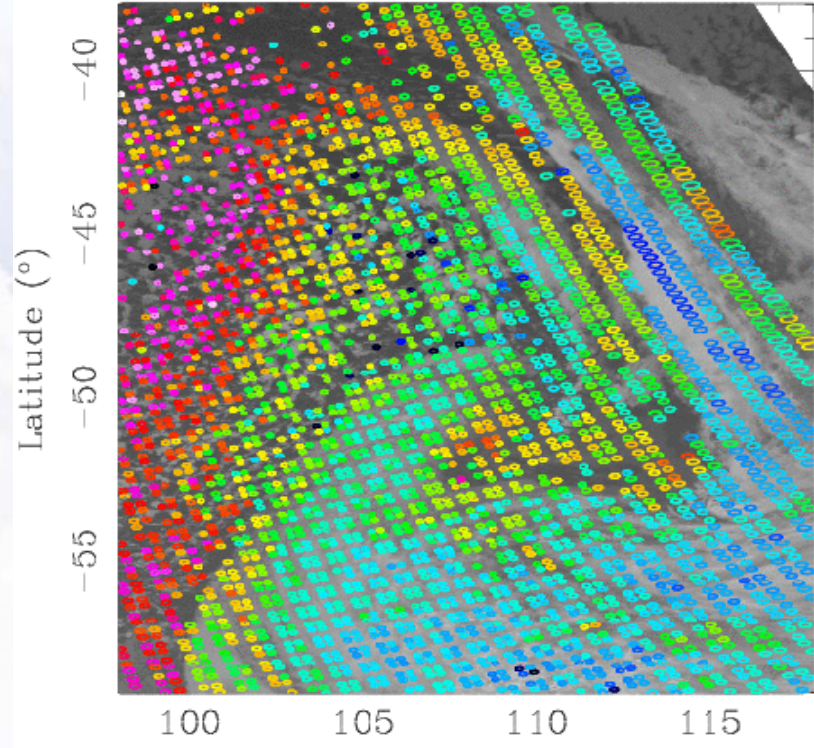
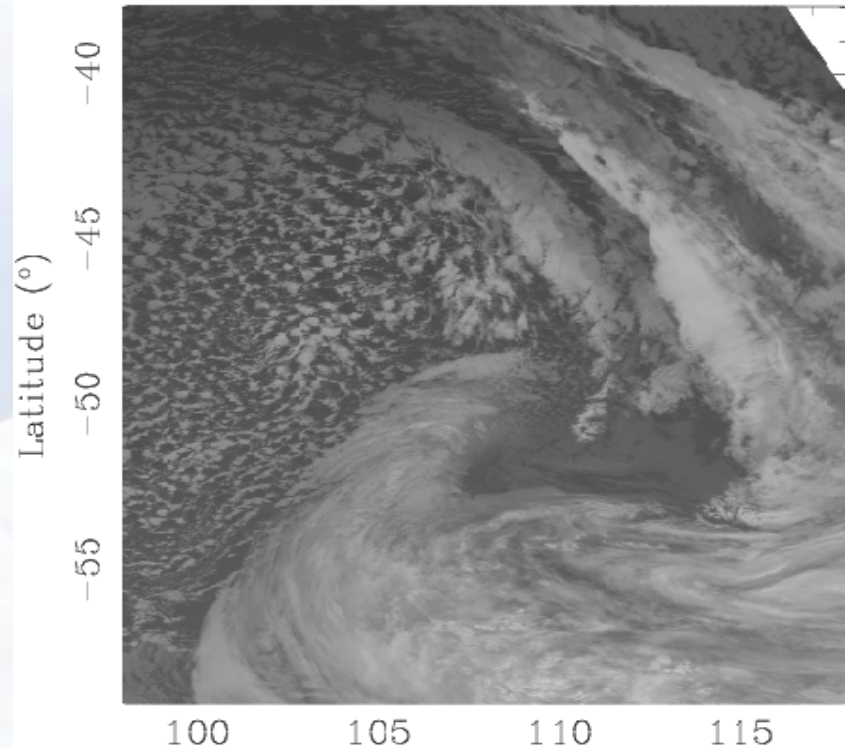


Validation (1b)

Consistency with AVHRR images: frontal system (western south Pacific)

AVHRR/10.8, IASI 20070418142358Z

AVHRR/10.8, CTP IASI 20070418142358Z



Longitude (°)

Longitude (°)

Algorithm

CO₂ channel selection

Validation



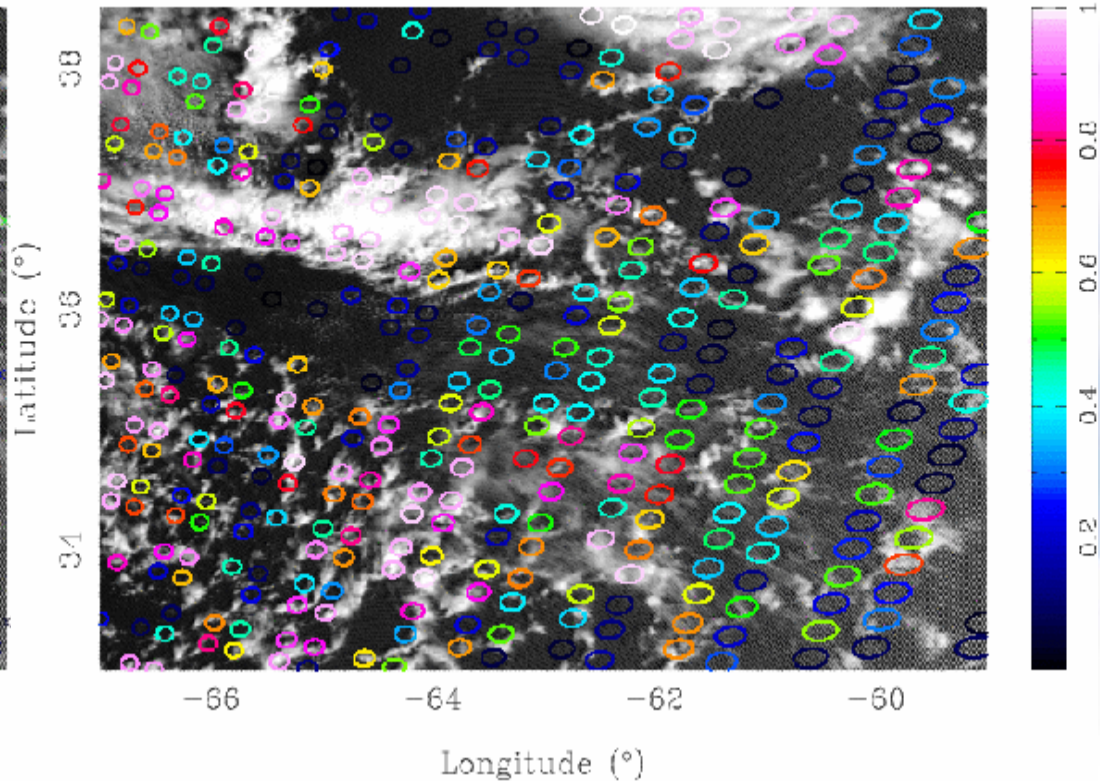
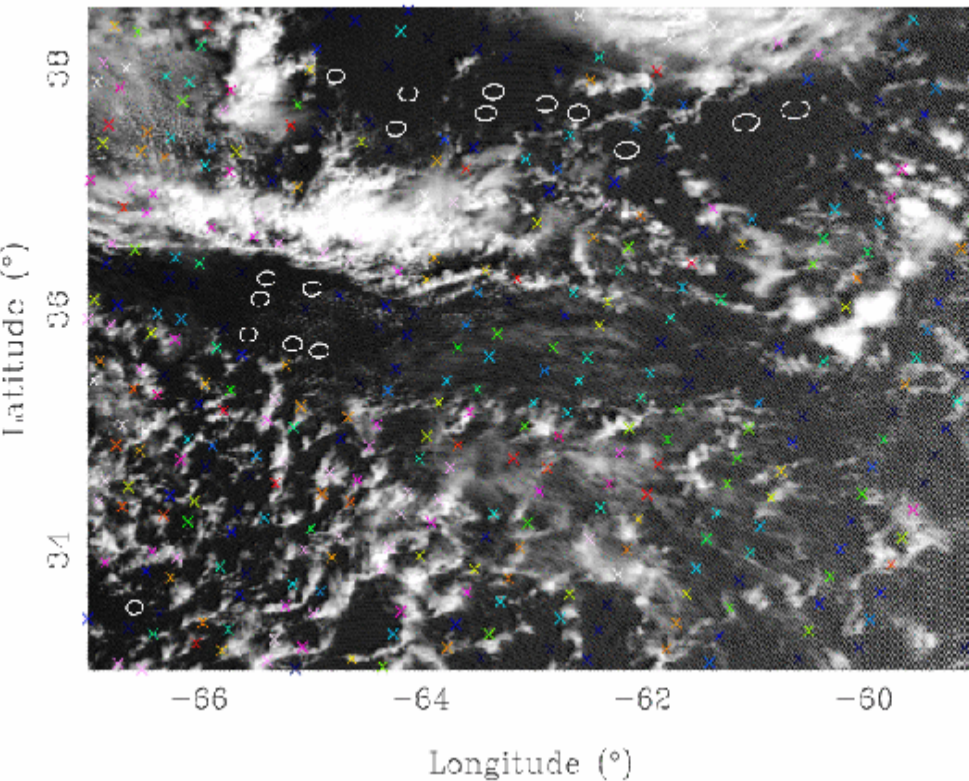
Validation (1c)

Consistency with AVHRR images:

post frontal squall-line and cumulus clouds organised as open cells (western north Atlantic)

AVHRR/0.6, CLR and CFR IASI 20070418142358Z

AVHRR/0.6, CFR IASI 20070418142358Z



Algorithm

CO₂ channel selection

Validation



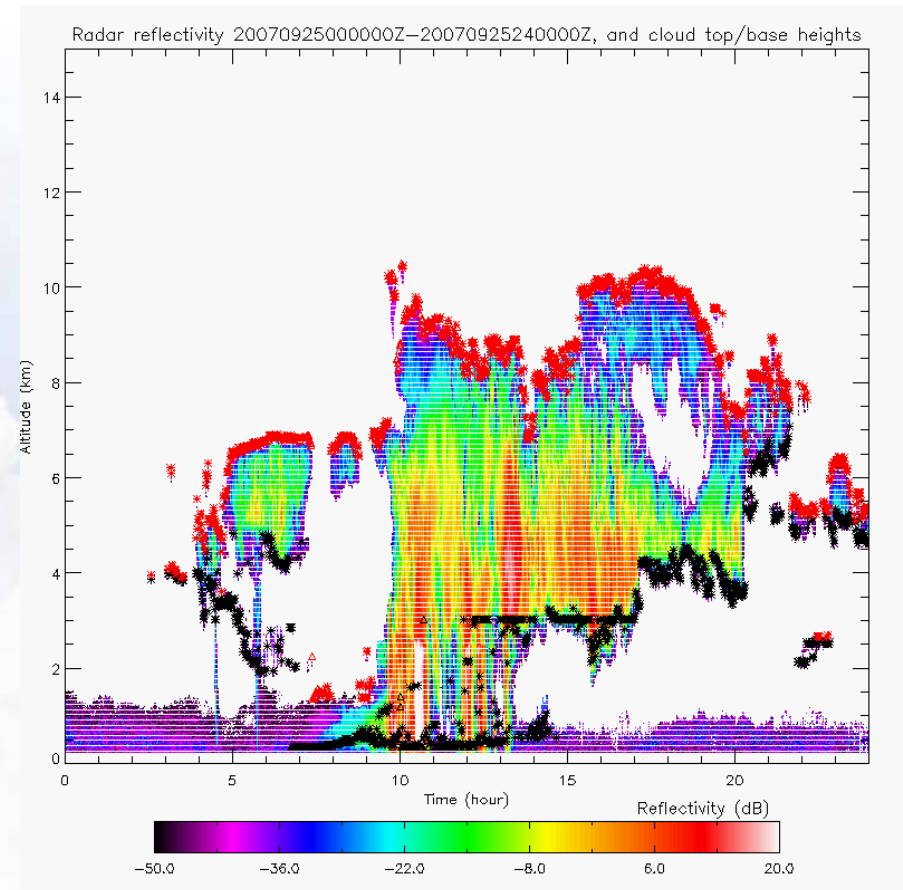
Validation (2)

Metop sounding campaign Lindenberg Observatory (near Berlin) Jun-Aug (+Sep) 2007

180 overpasses (~9 AM, ~8 PM) with IASI data
Co-located ECMWF forecasts (profiles, T_{skin})
Co-located surface emissivity (as in PPF)

Cloud data: type & CFR (overpass time) + CTP
Observer (Jun-Aug) and AVHRR images
Cloud radar (1 min-integrated) reflectivity + Sounding

CTP from radar measurements (zenith):
CTP = **mode of radar samples**
within a sampling time interval
(200-400 hPa wind) / 7 km (~ IFOV radius)



Algorithm

CO₂ channel selection

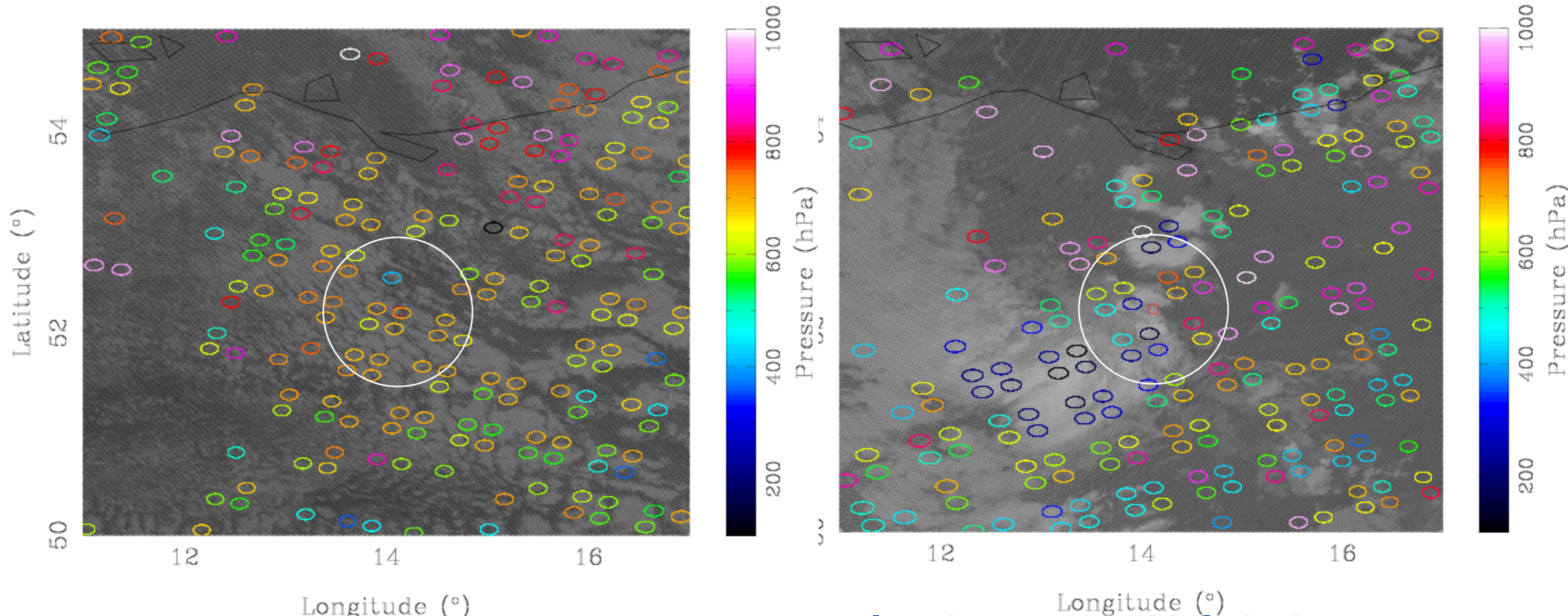
Validation



Validation (3)

Mean of retrieved CTP (and CFR) within IASI IFOVS up to 7 km of Lindenberg 50 km of Lindenberg if CTP in $[P_R-100, P_R+100]$

AVHRR/10.8, ARL CTP IASI CO2 slicing, overpass_20070915092208 10.8, ARL CTP IASI CO2 slicing, overpass_20070904193731



Algorithm CO₂ channel selection

Validation





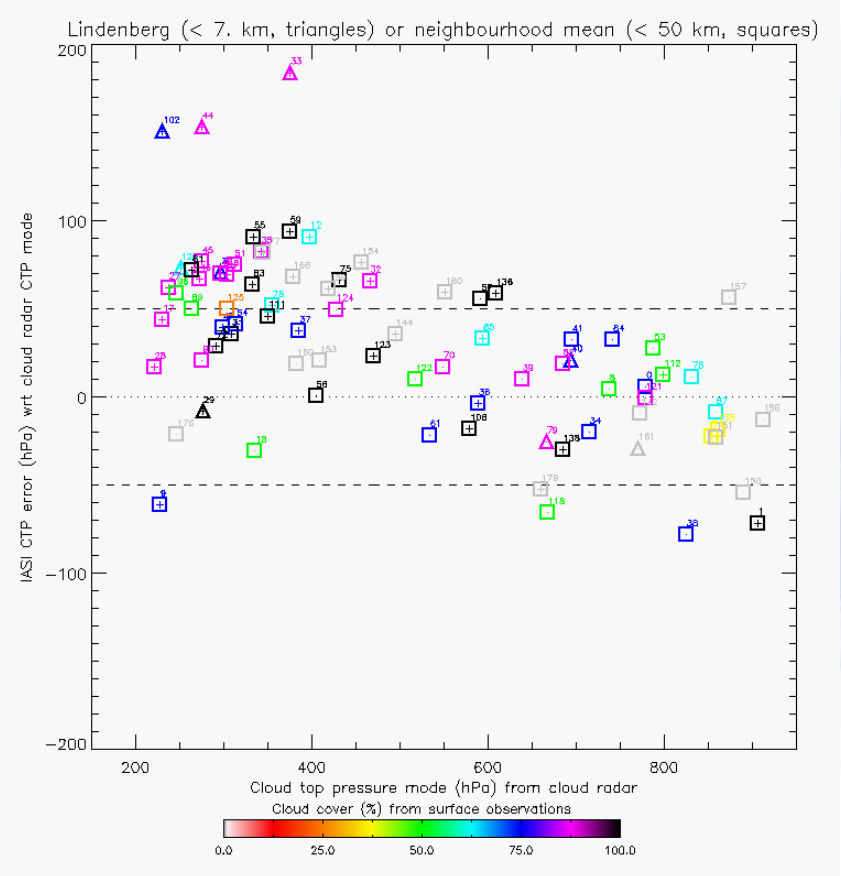
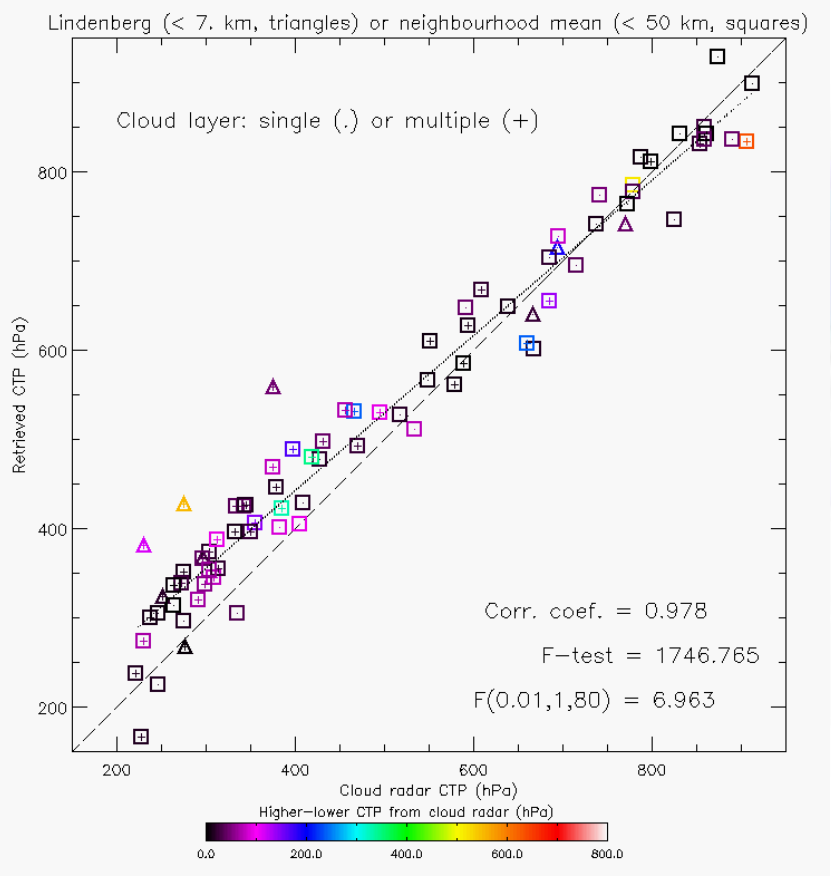
Retrieved cloud top pressure error Validation (4)

All 82 cases:

bias = 29.4 hPa std = 49.2 hPa

72 cases (CFR > 40%):

25.1 45.9





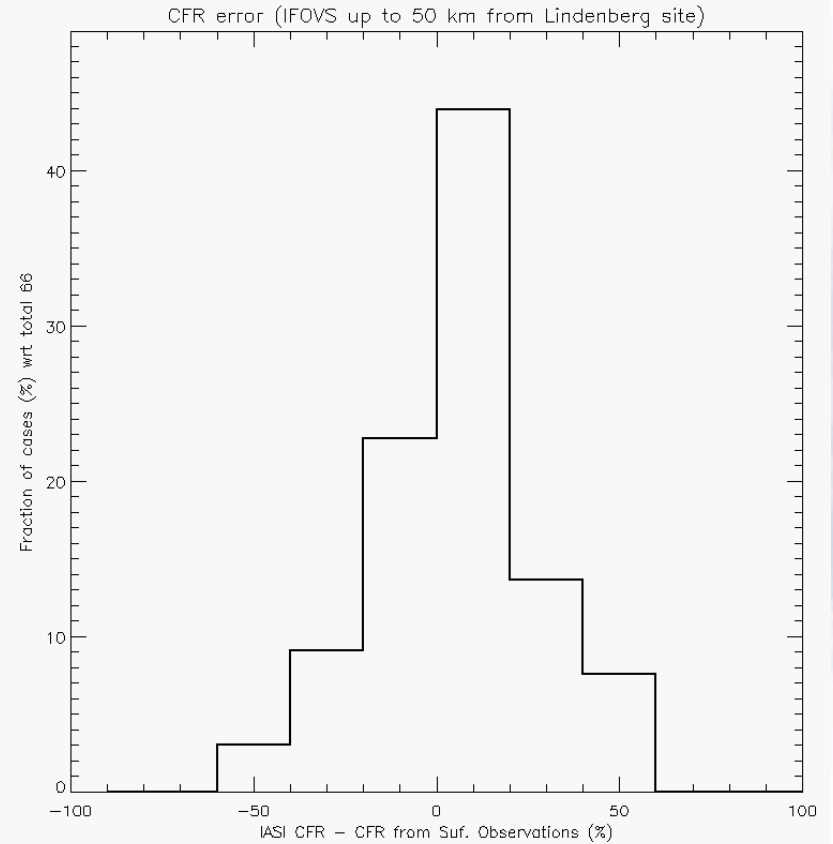
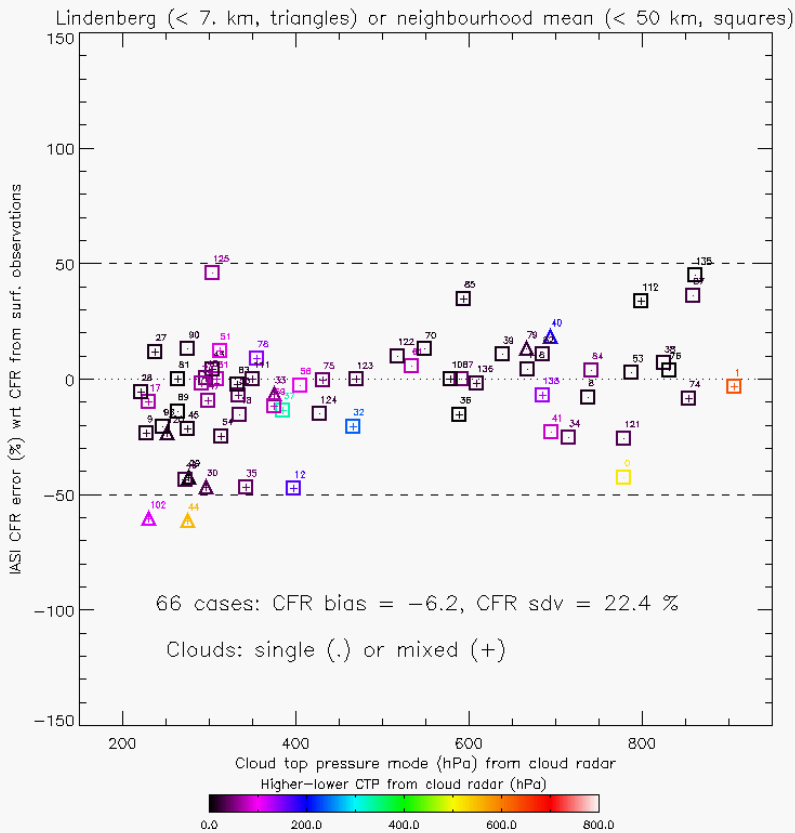
Retrieved cloud cover error Validation (5)

66 cases (Jun-Aug):

CFR bias = - 6.2%

CFR std = 22.4%

(with respect to cloud cover reported by the observer)



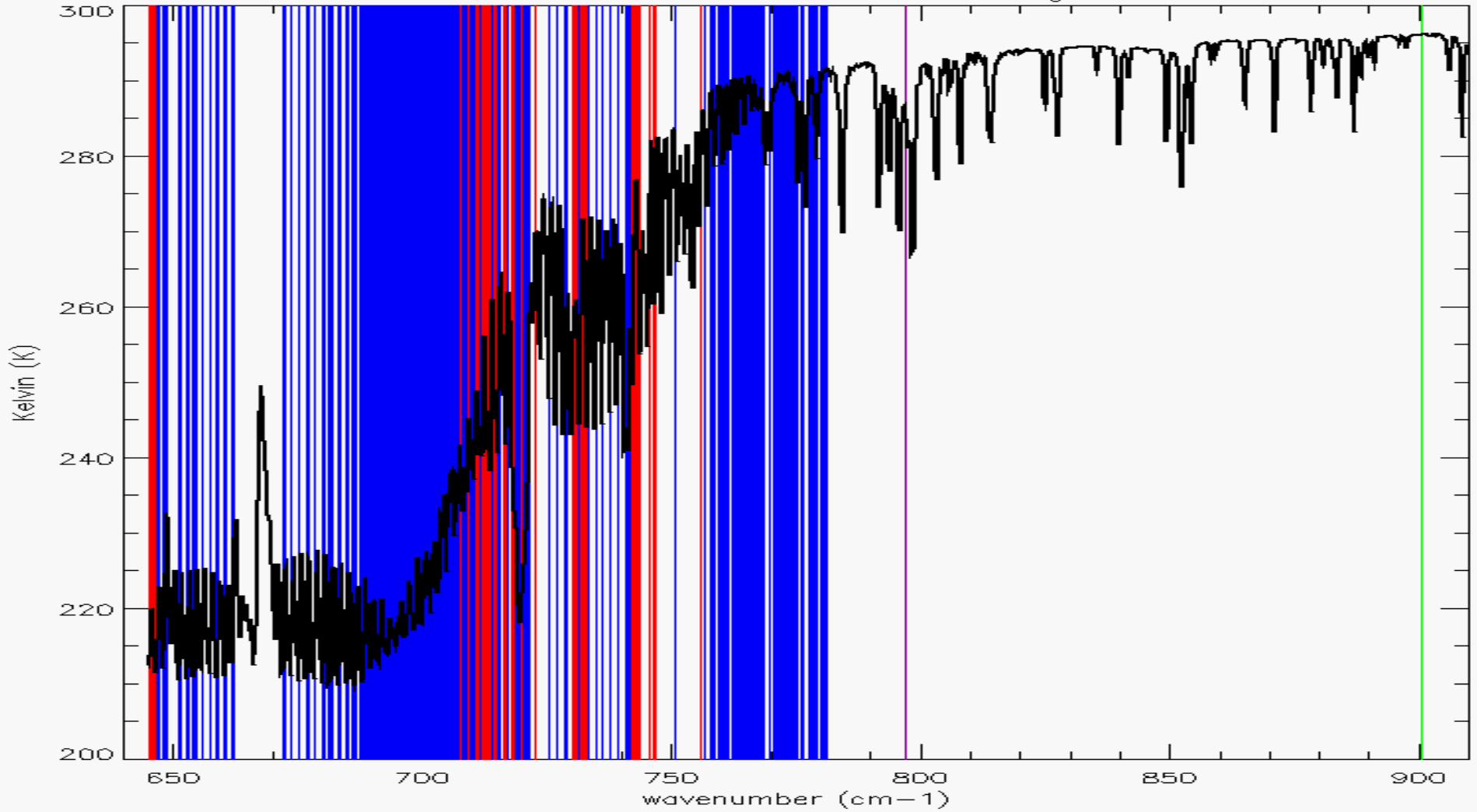


Thank you



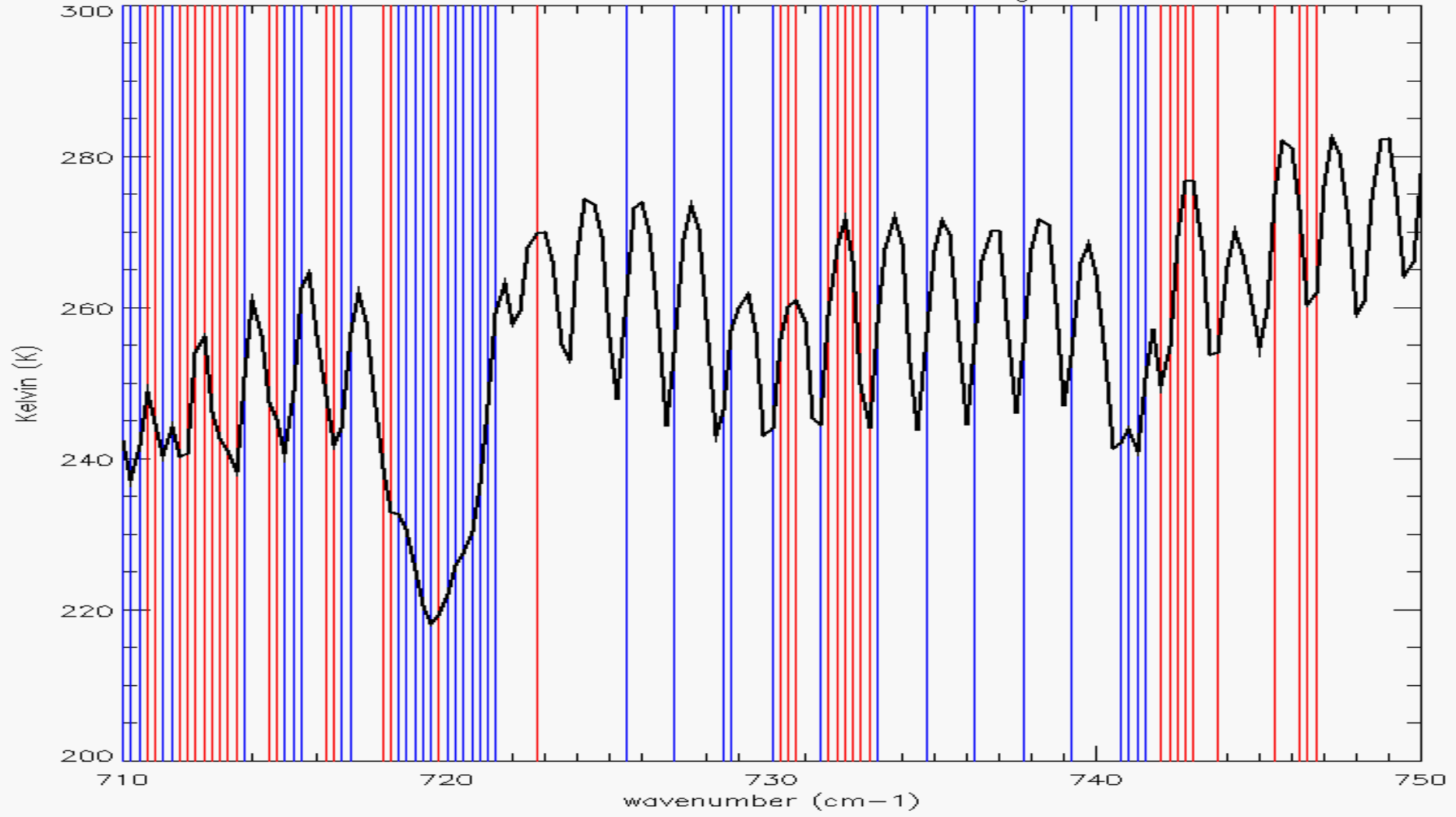


Wavenumbers for CO2 slicing





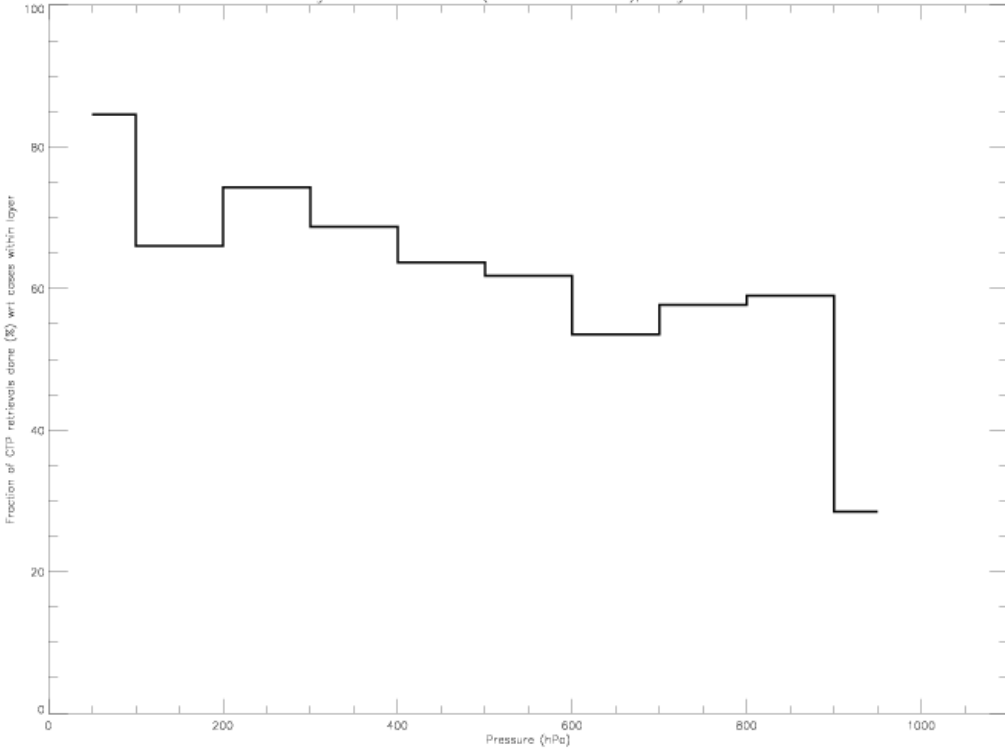
Wavenumbers for CO2 slicing



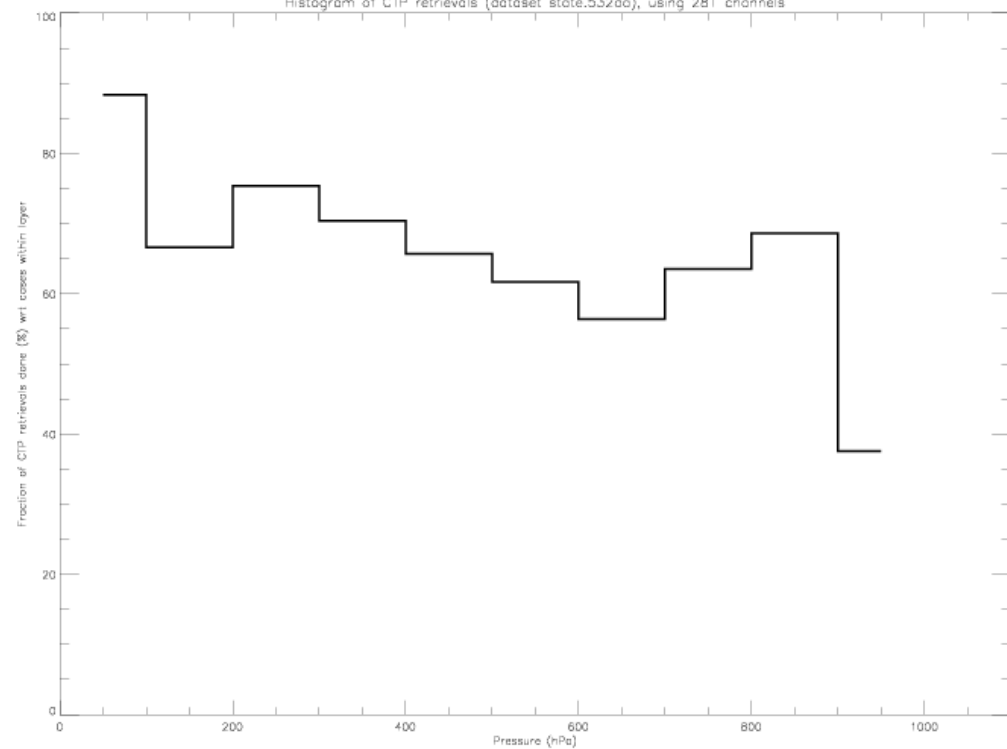


Relative frequency (%) of retrievals (10 layers)

Histogram of CTP retrievals (dataset state.532da), using 41 channels

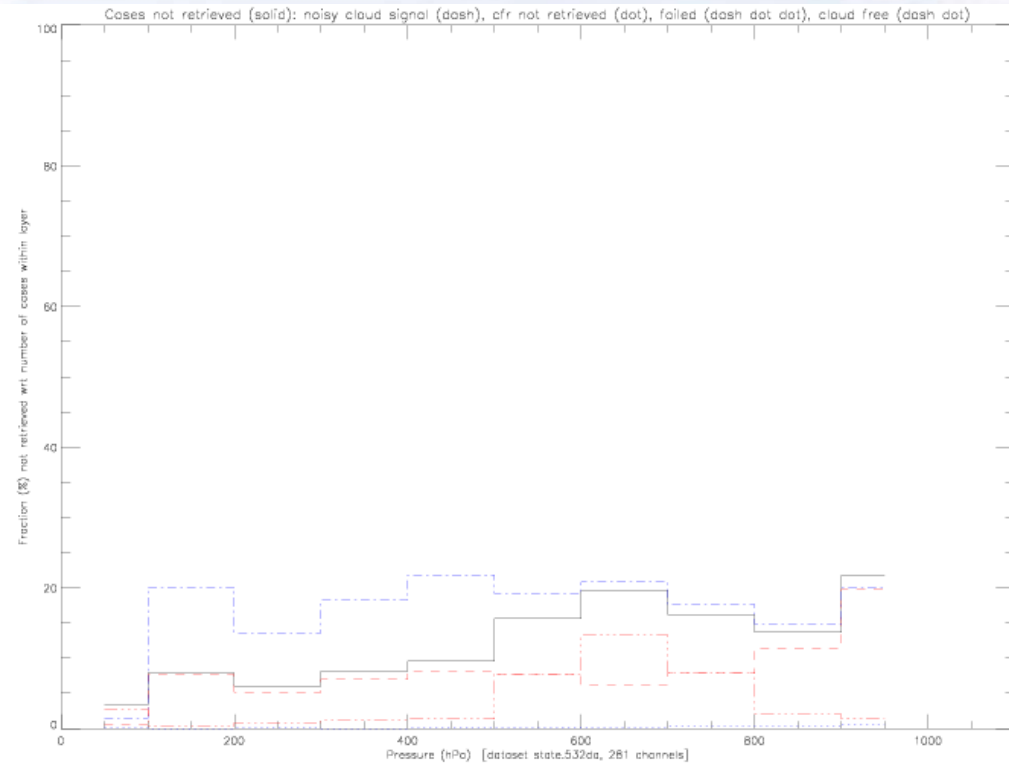
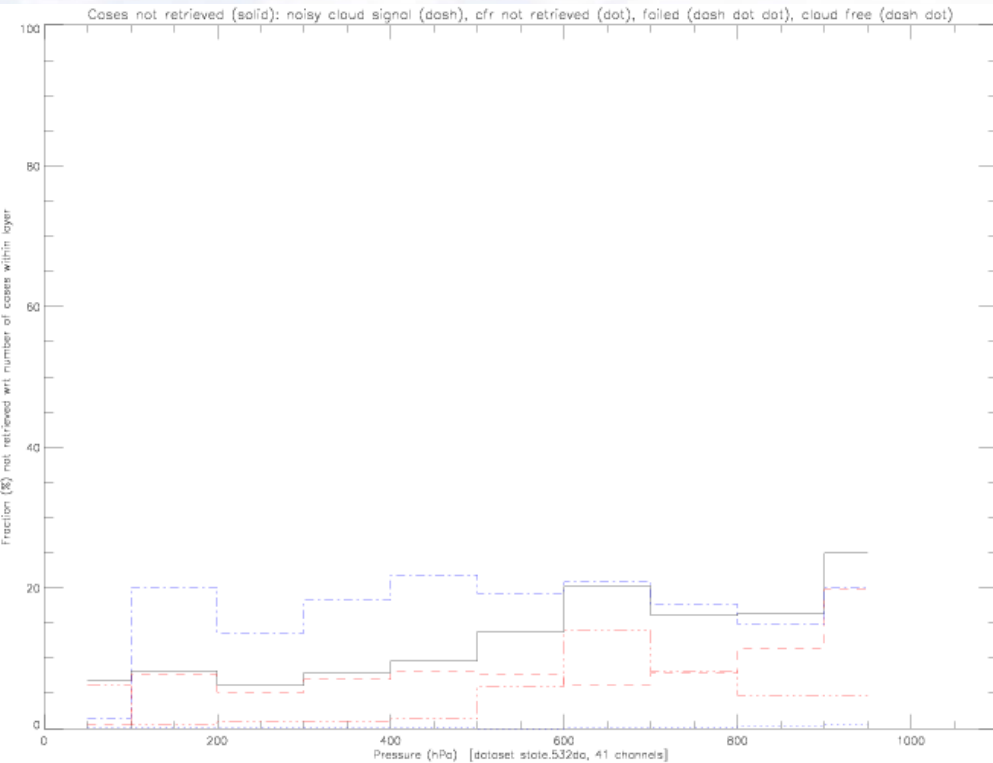


Histogram of CTP retrievals (dataset state.532da), using 281 channels





Relative frequency (%) of non-retrieved cases





Cloud fraction: cyan[0-0.2),pink[0.2-0.4),blue[0.4-0.6),green[0.6-0.8),red[0.8-1]

