CO_2 Slicing Method for IASI

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Introduction

- IASI algorithms ← recommended methods from ISSWG
  - Cloud detection within IFOV →profile retrievals
  - CTP retrieval ← CO_2 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

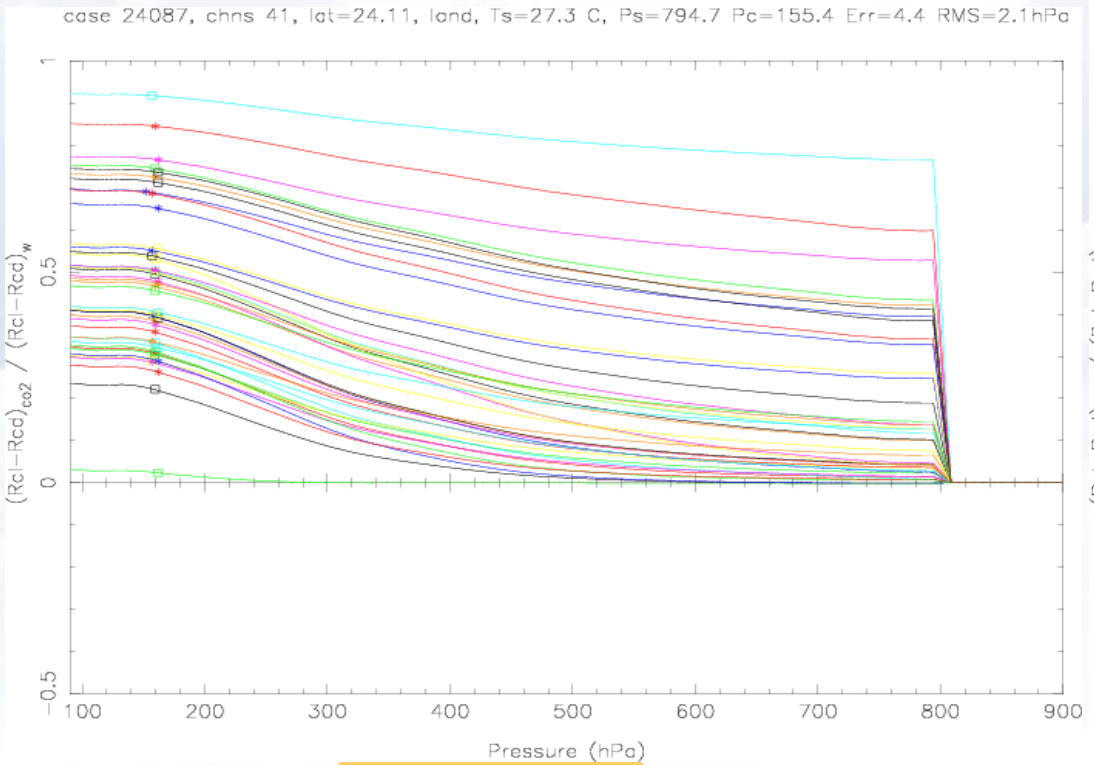
Algorithm CO_2 channel selection Validation

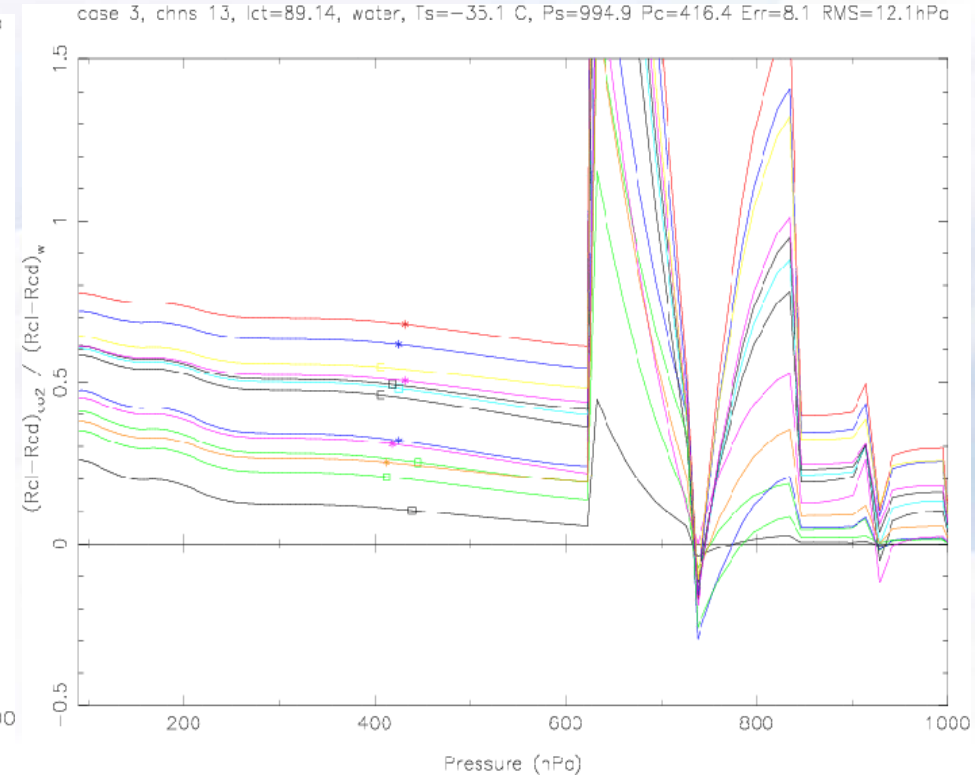
Algorithm

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

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

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





Algorithm **CO_2 channel selection** **Validation**

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Algorithm implementation

❖Non noisy radiance

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

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

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

✓Flag levels p_n with noisy cloud signal $R_{ref}(p_n)$ → 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 → exclude channel k if C_{fk} outside (0,1]

❑ CTP histogram from single channel retrievals

☺ Retrieved P_c as in Smith and Frey ← P_k in most populated class

- **If inversion exists and P_c> 600 hPa → use P_k below inversion basis only**

▪ Effective cloud fraction C_f ← P_c and window channel

- **P_c and C_f delivered if C_f > 10%**

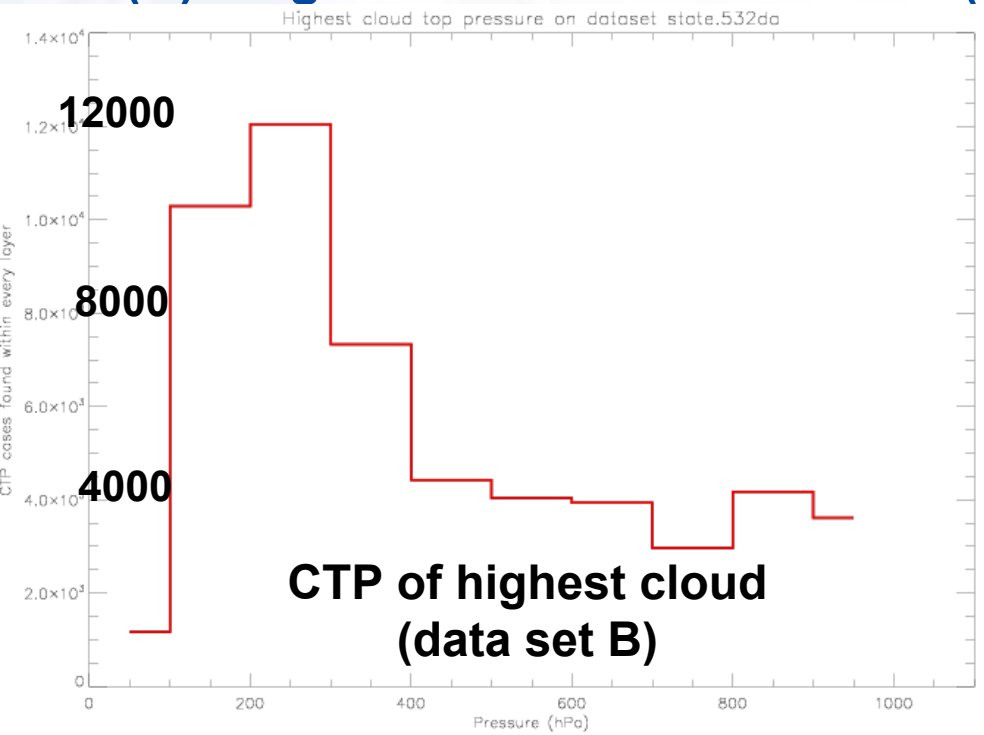
(Other results for quality control: P_k rms, ΔP_k , δP_c from NEδR and T error , Number of channels used)

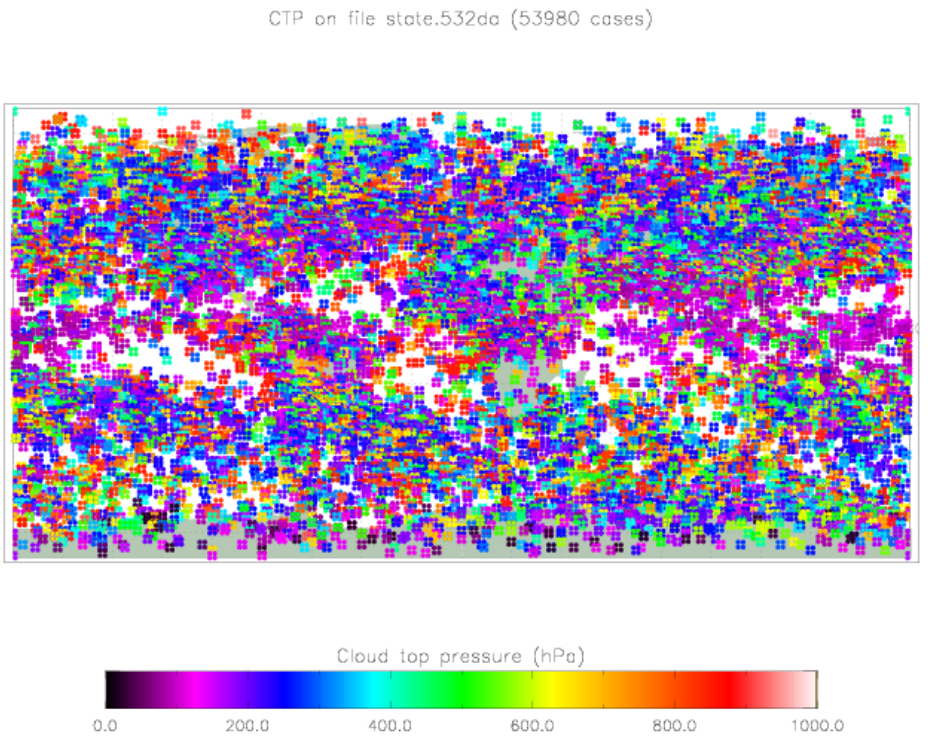
CO_2 channel selection (1)

window: 990.50 cm^{-1} (11.10494 µm) reference: 796.75 cm^{-1}(12.55099 µm)

Retrievals of 53980 scenarios (RTIASI) → 41 CO_2 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





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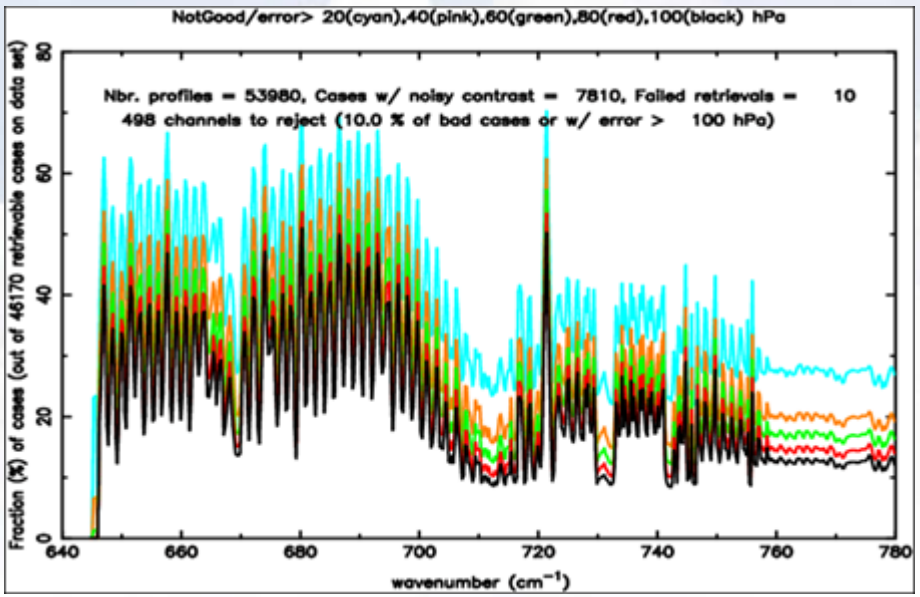
CO_2 channel selection (2)

- Retrievals with single channel **k** ← 545 IASI frequencies (645.0 to 781.0 cm^{-1})
- Significance of channel **k**: Q% scenarios {**k** NOT used OR error ≥ 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 hPa, S_{ni} ≤ 1%} <> Q_i = 10% => exclude 498 (A) [264 (B) channels]

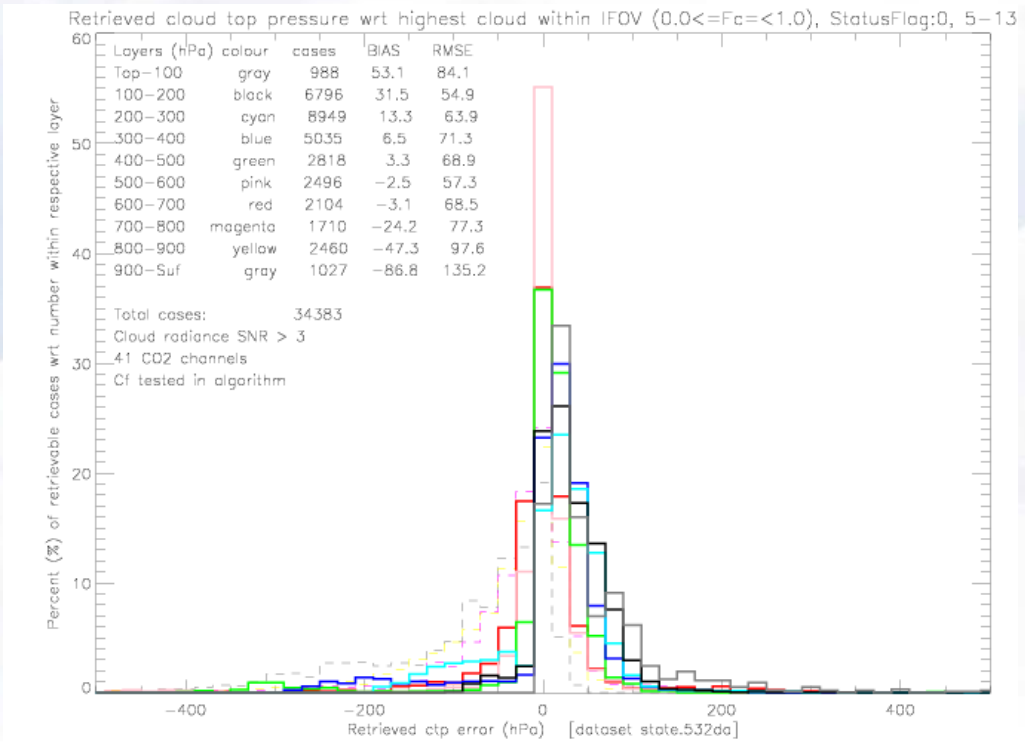


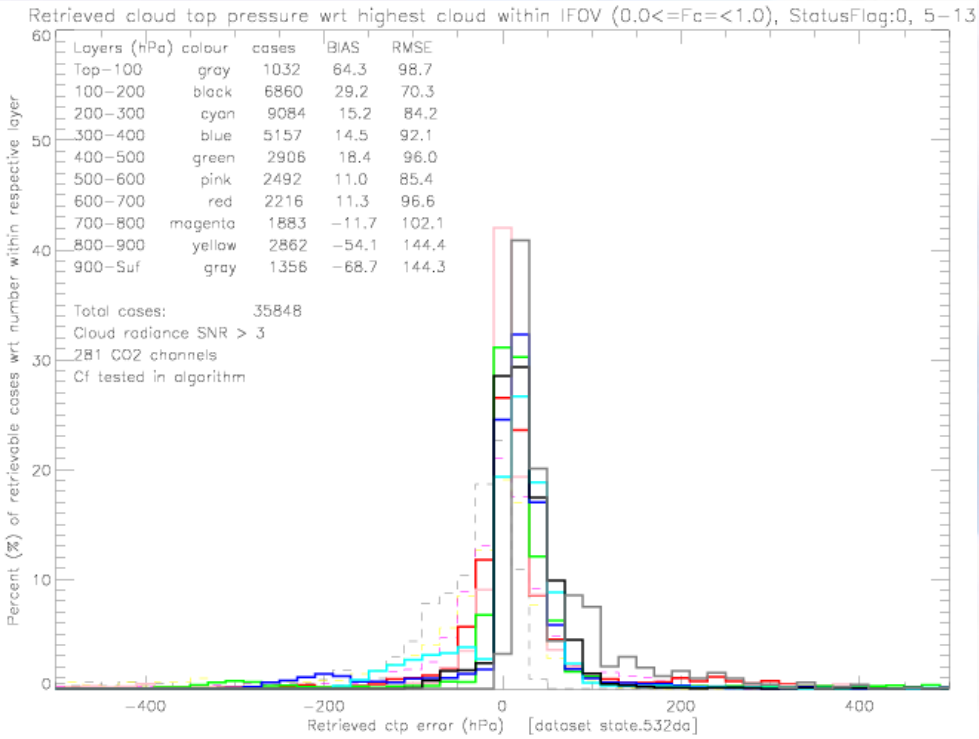
…	40 hPa	60 hPa	80 hPa	**100 hPa**
5.0%	542	539	539	539 excld.
	7778	1945	1945	1945 non-expl.
	16.85	4.21	4.21	4.21 %
10.0%	539	539	539	**498** excld.
	1945	1945	1945	56 non-expl.
	4.21	4.21	4.21	**0.12 %**

CO_2 channel selection (3)

- **Statistics of retrievals (data set B) using 41 or 281 CO_2 channels**

	Layer (100, 400] hPa			Layer (400, 800] hPa		
41 chs: 34383	**20780**	**12.5**	**61.8**	**9128**	**-0.4**	**67.6**
281 chs: 35848	**21101**	**19.6**	**68.9**	**9496**	**8.8**	**94.3**





Algorithm **CO_2 channel selection** **Validation**

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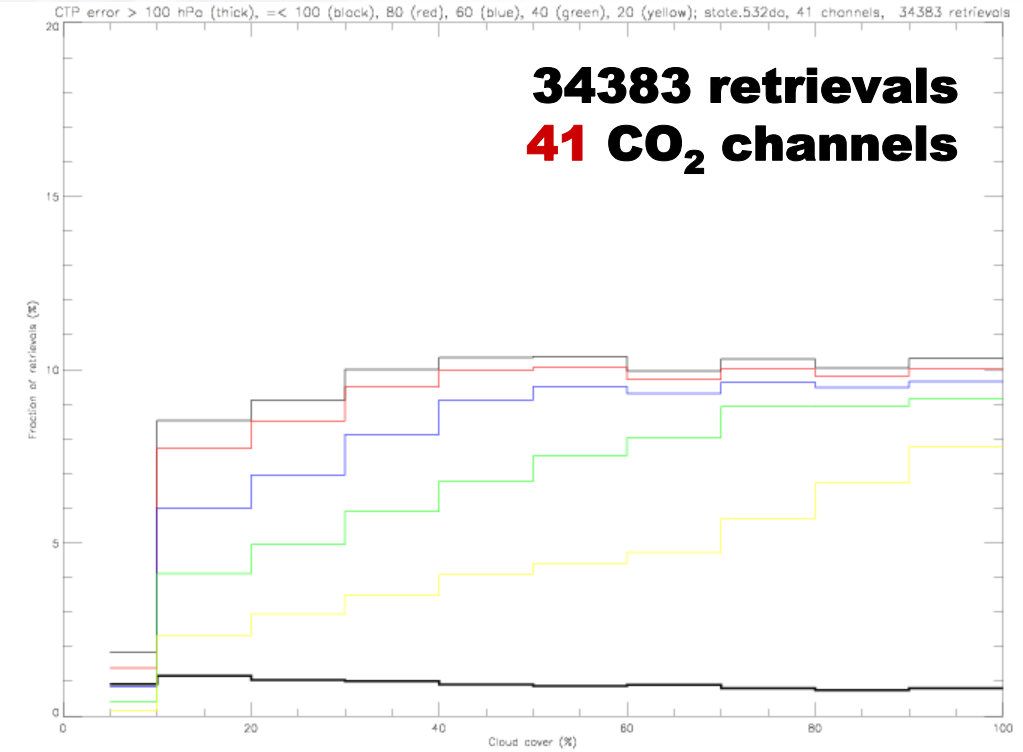
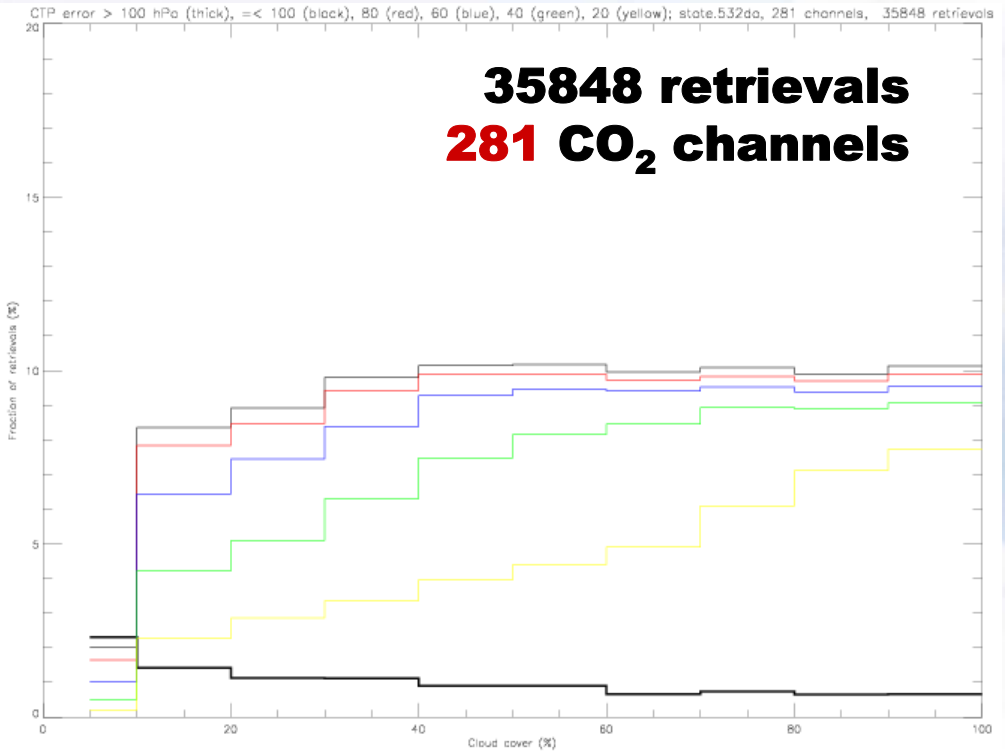
CO_2 channel selection (4)

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





Algorithm | CO_2 channel selection | Validation

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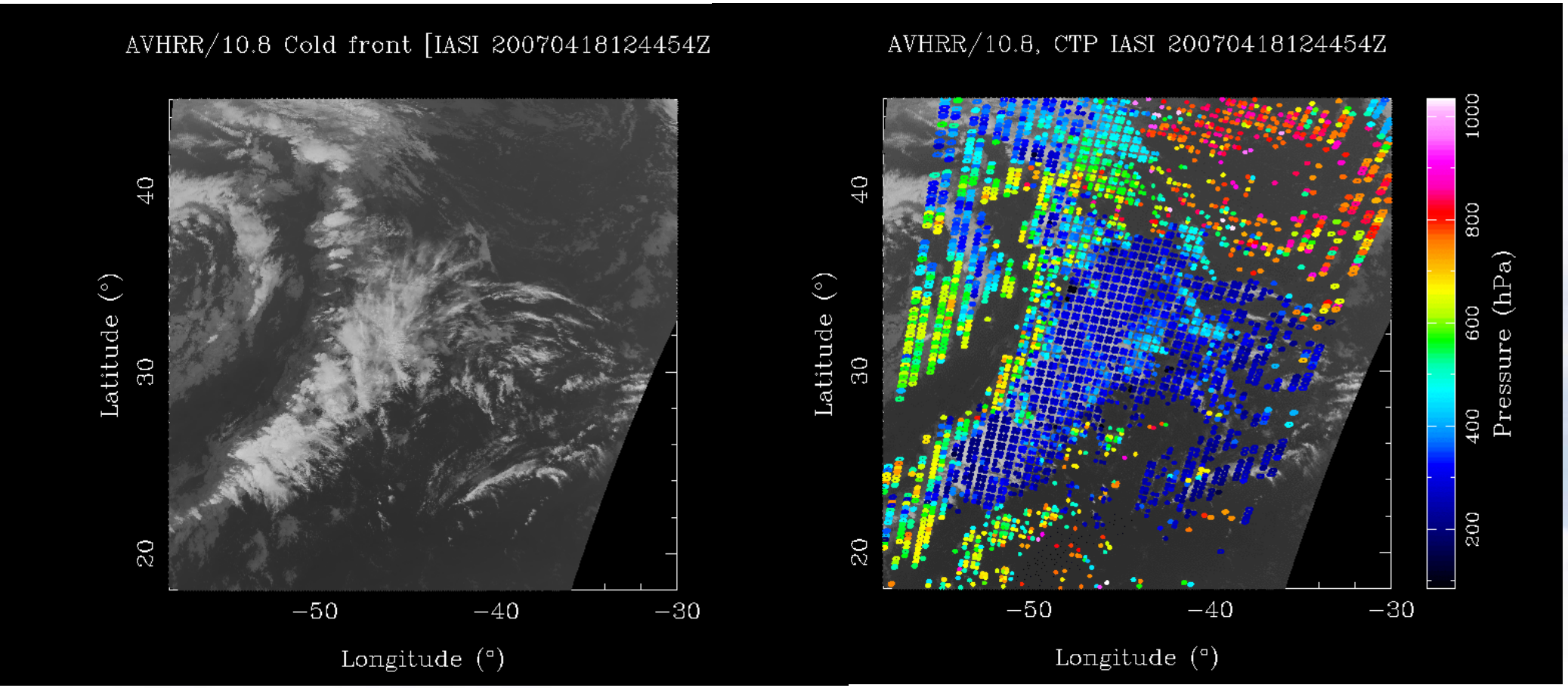
Validation (1a)

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



Algorithm **CO_2 channel selection** **Validation**

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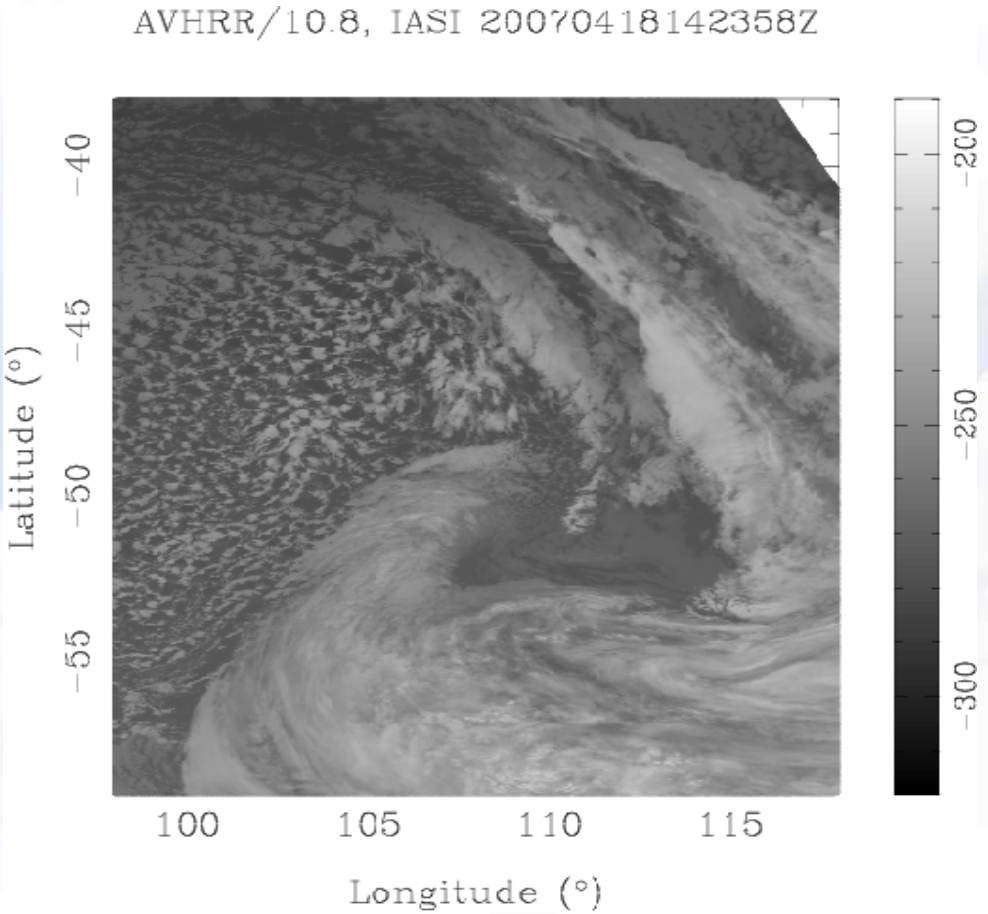
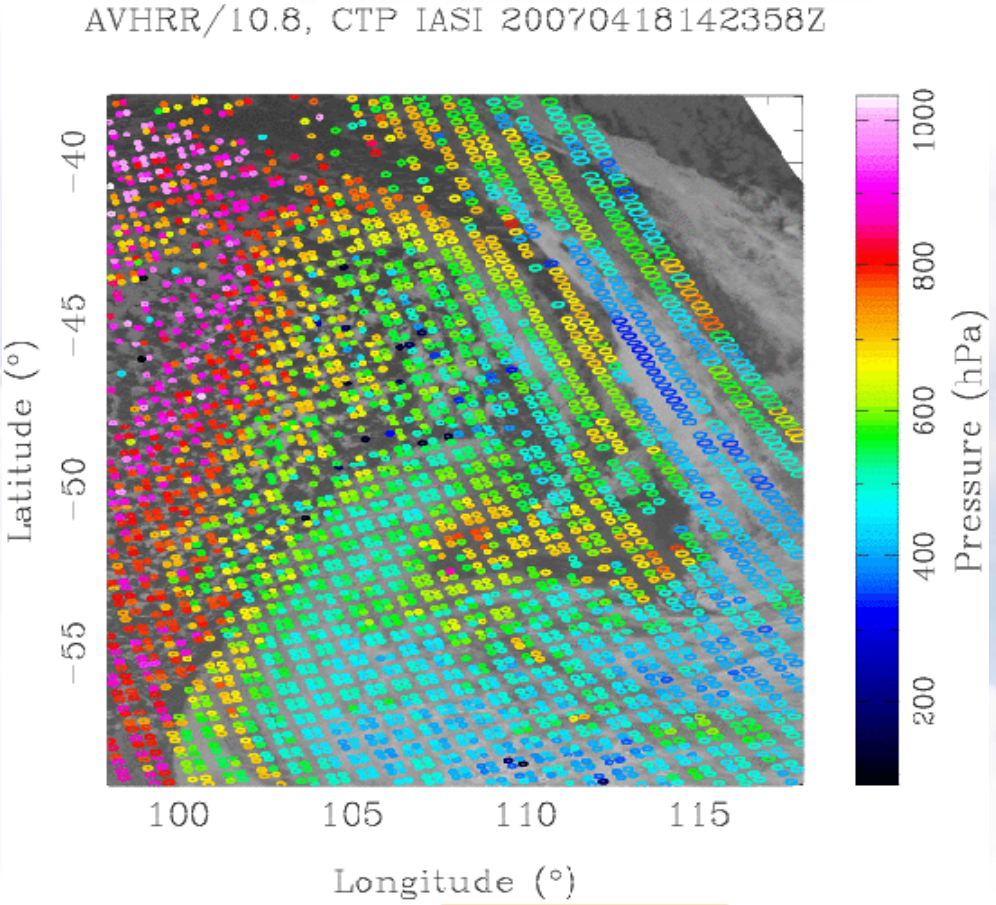
Consistency with AVHRR images: frontal system (western south Pacific)





Algorithm **CO_2 channel selection** **Validation**

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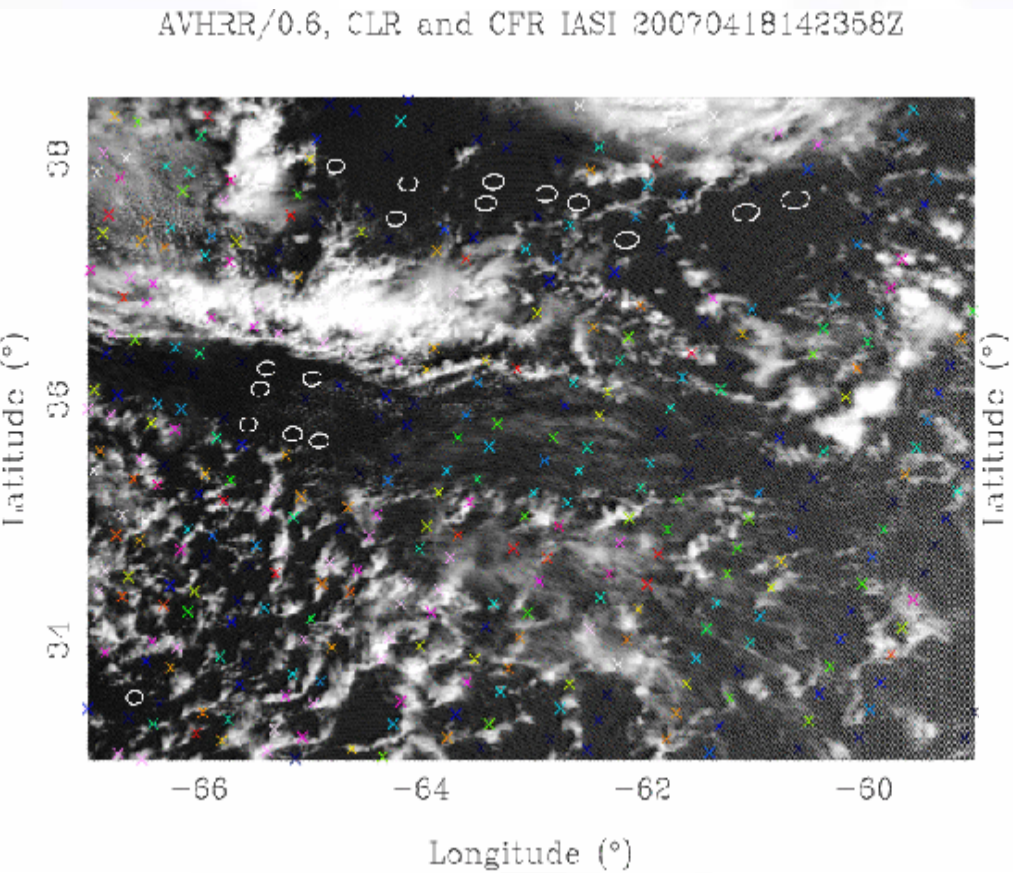
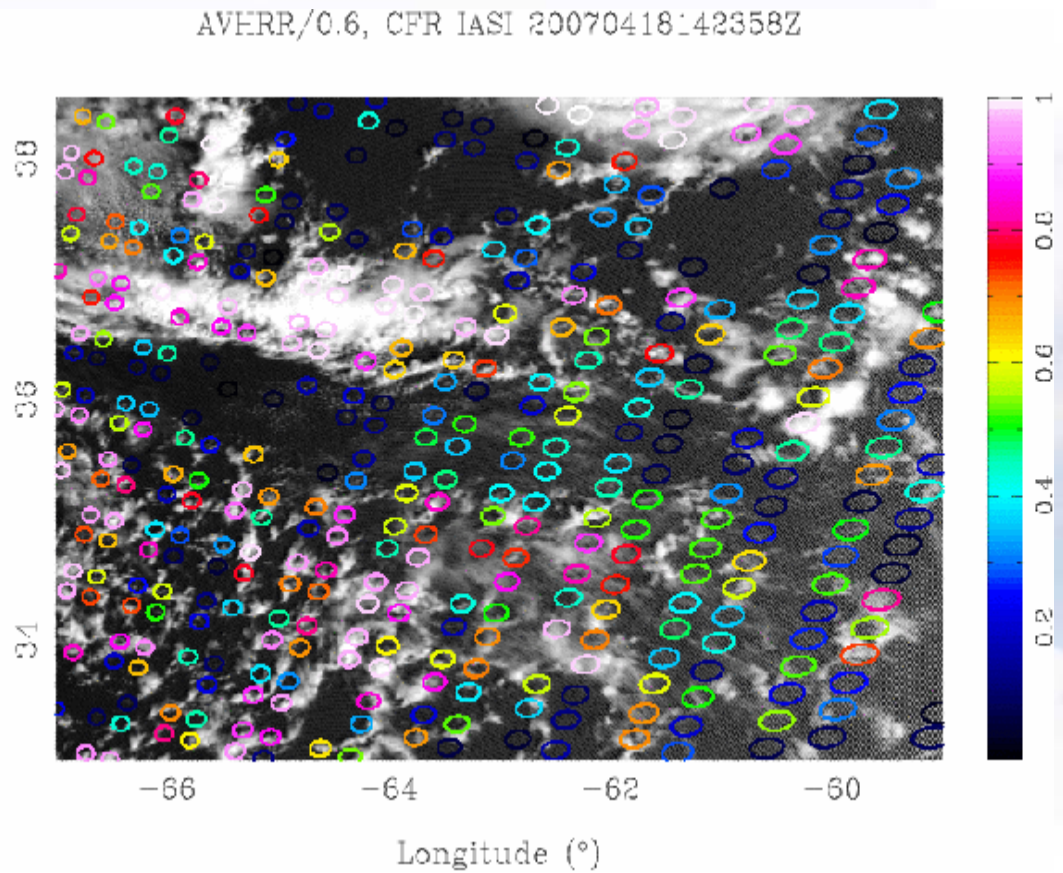
Validation (1c)

Consistency with AVHRR images:

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





Algorithm **CO_2 channel selection** **Validation**

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Validation (2)

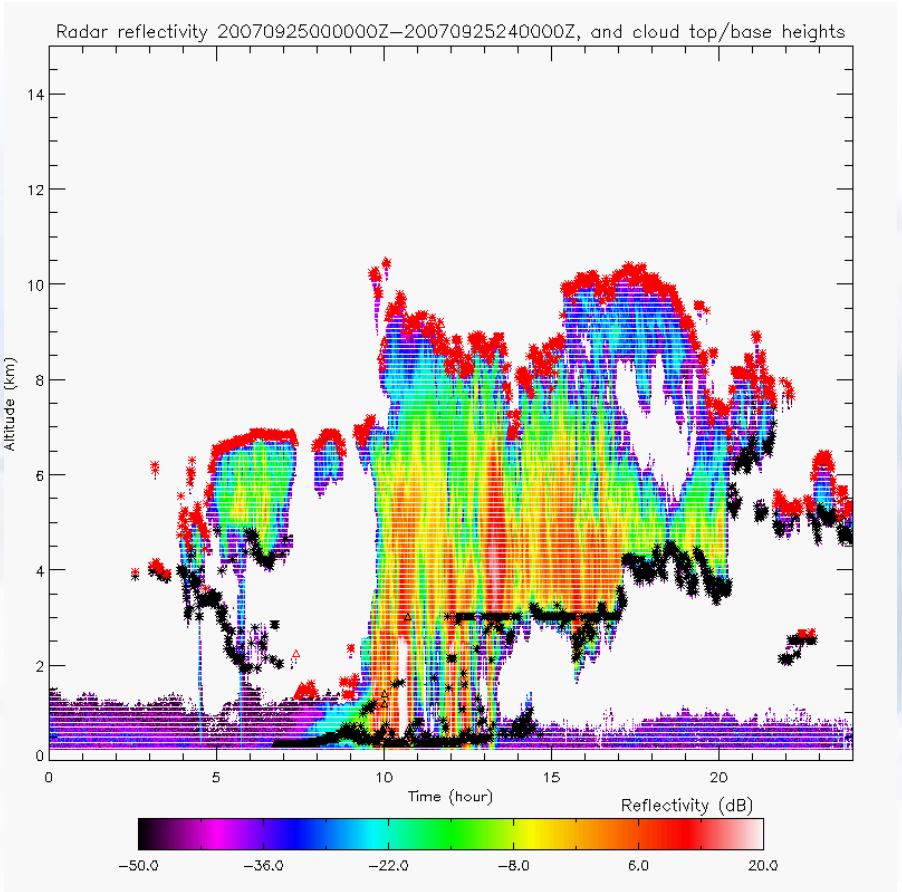
Metop sounding campaign

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 CO_2 channel selection Validation

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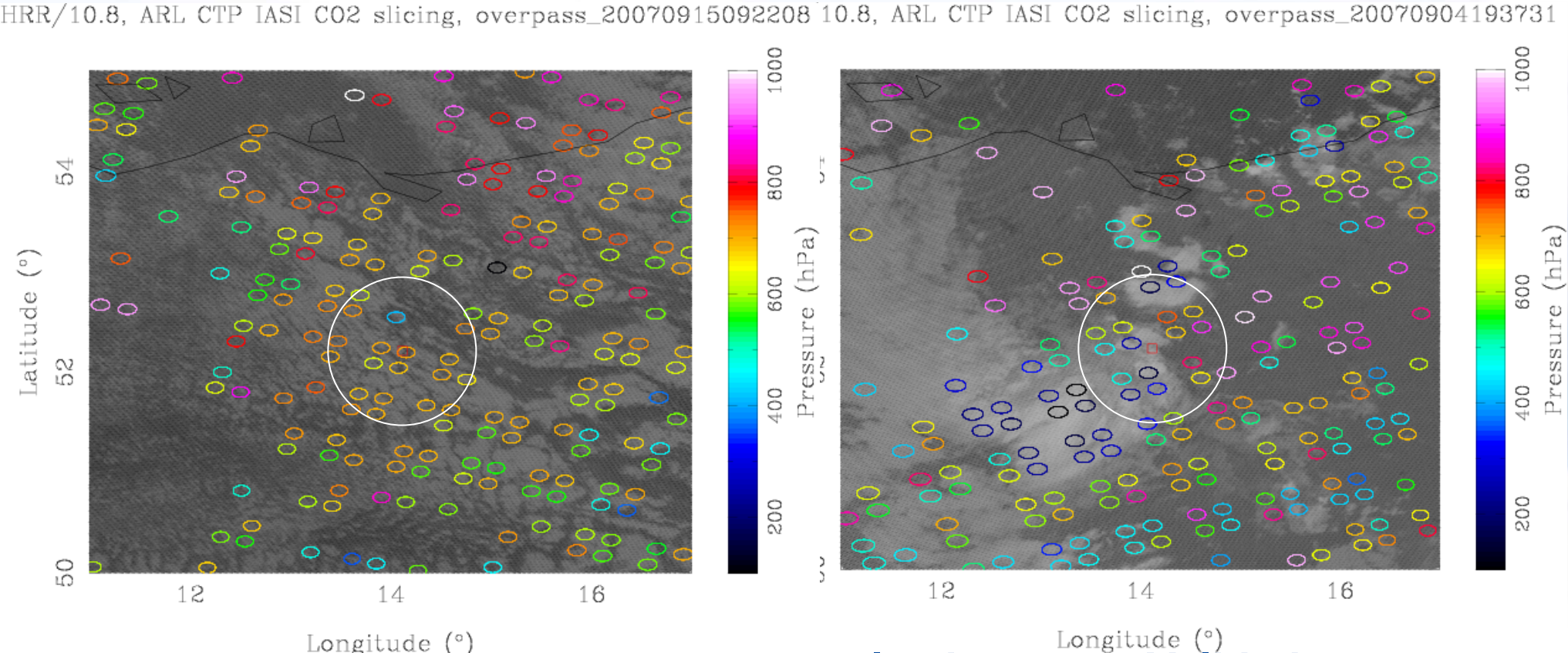
Validation (3)

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]



Algorithm CO_2 channel selection **Validation**

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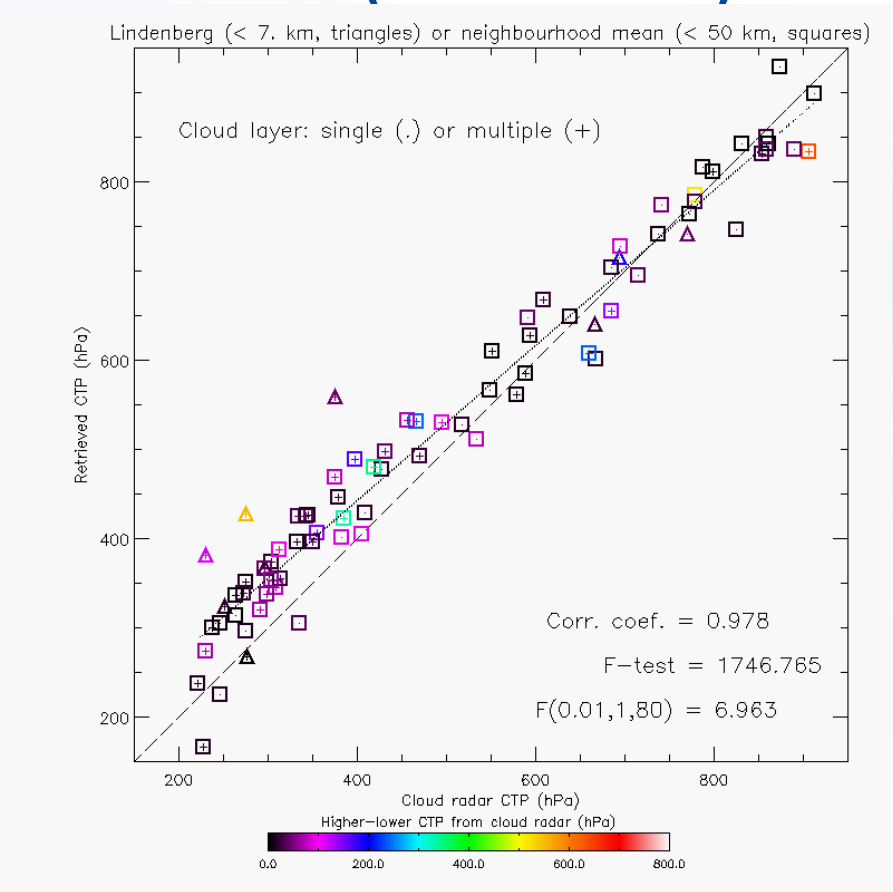
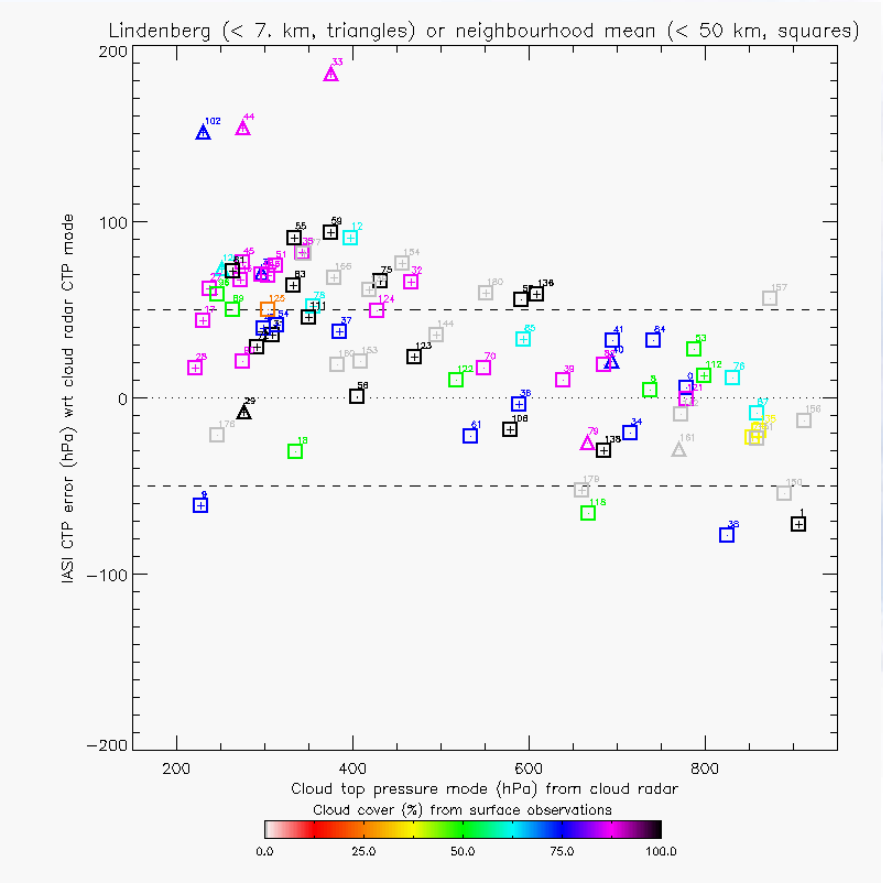
Retrieved cloud top pressure error Validation (4)

All 82 cases: bias = 29.4 hPa std = 49.2 hPa

72 cases (CFR > 40%): 25.1 45.9

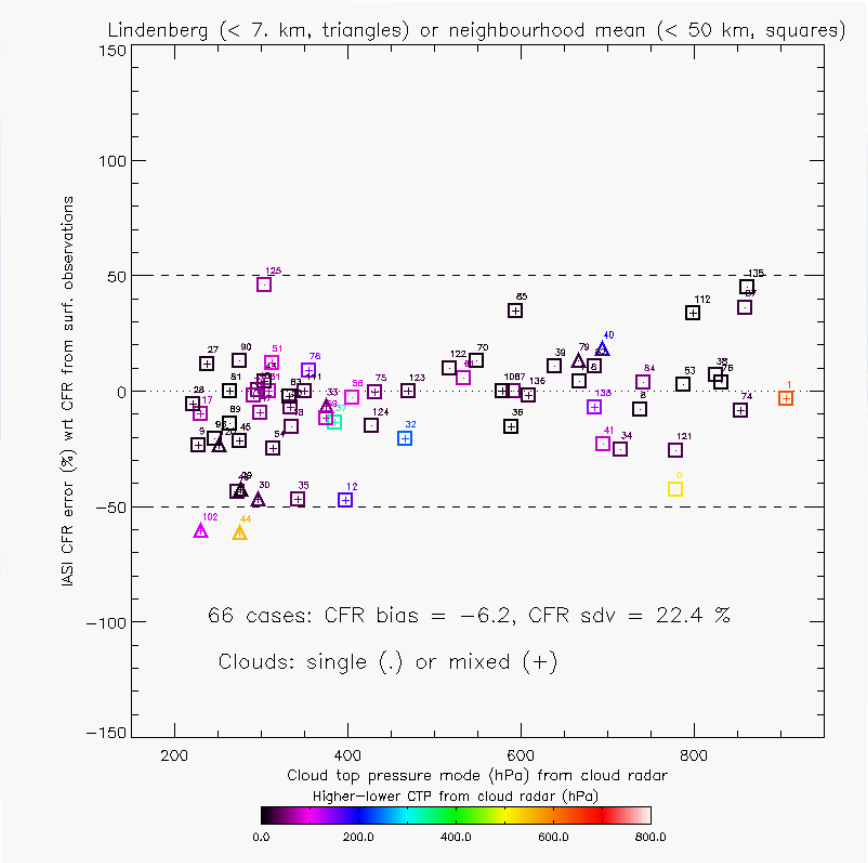


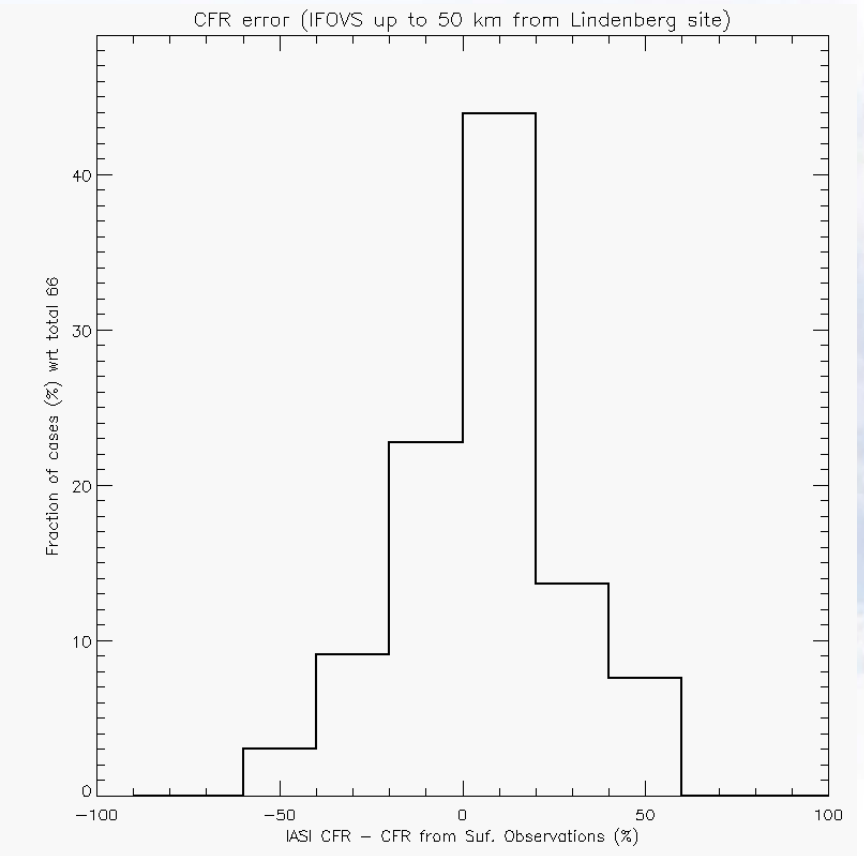


Retrieved cloud cover error Validation (5)

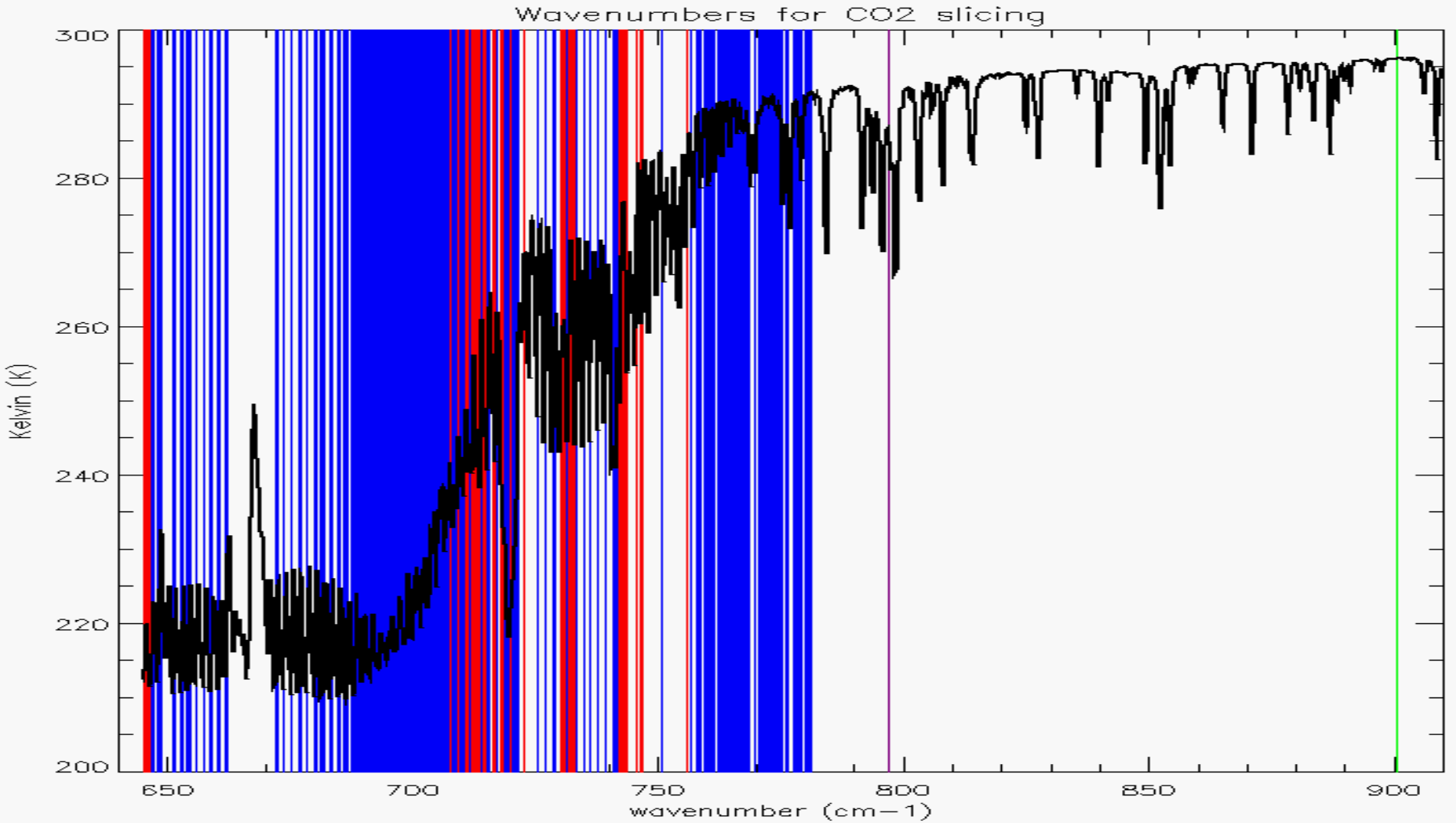
66 cases (Jun-Aug): CFR bias = - 6.2% CFR std = 22.4%

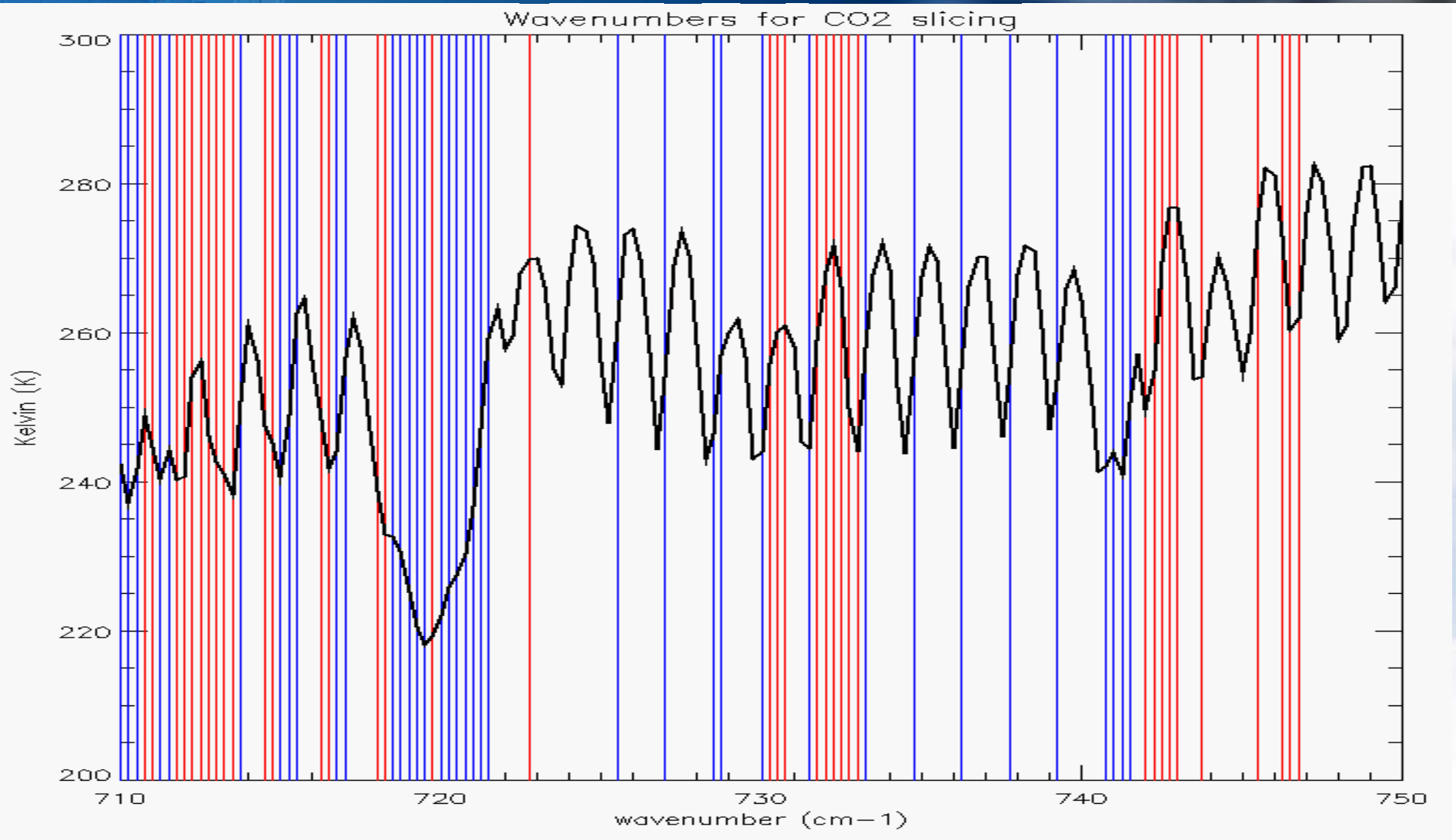
(with respect to cloud cover reported by the observer)



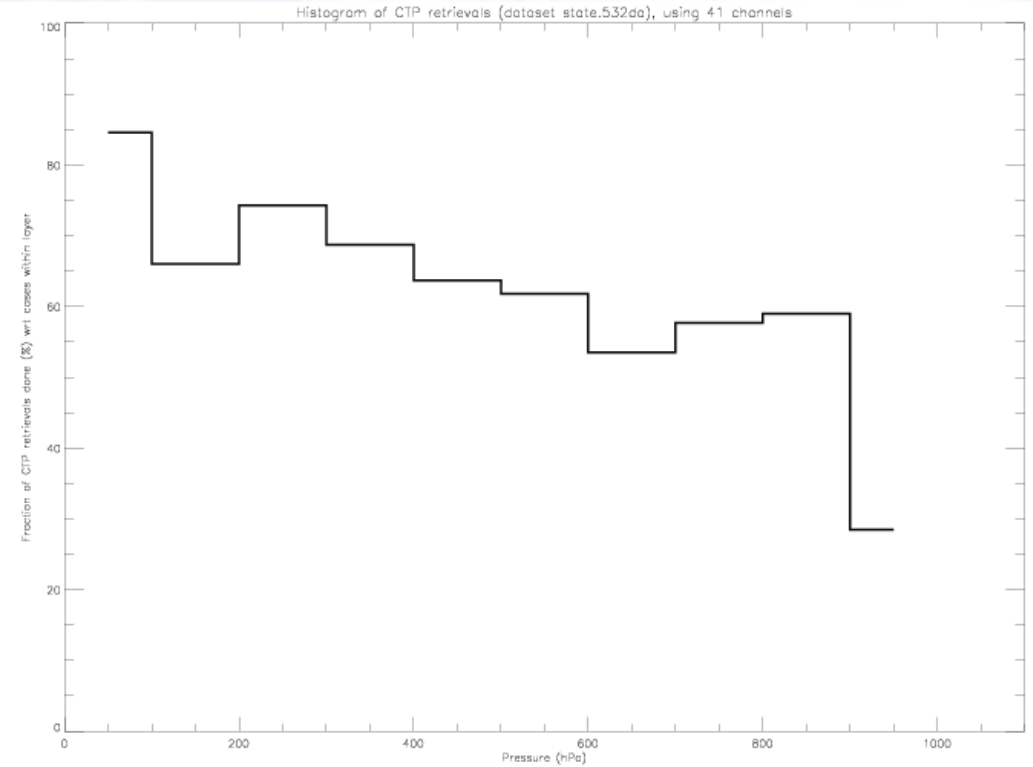


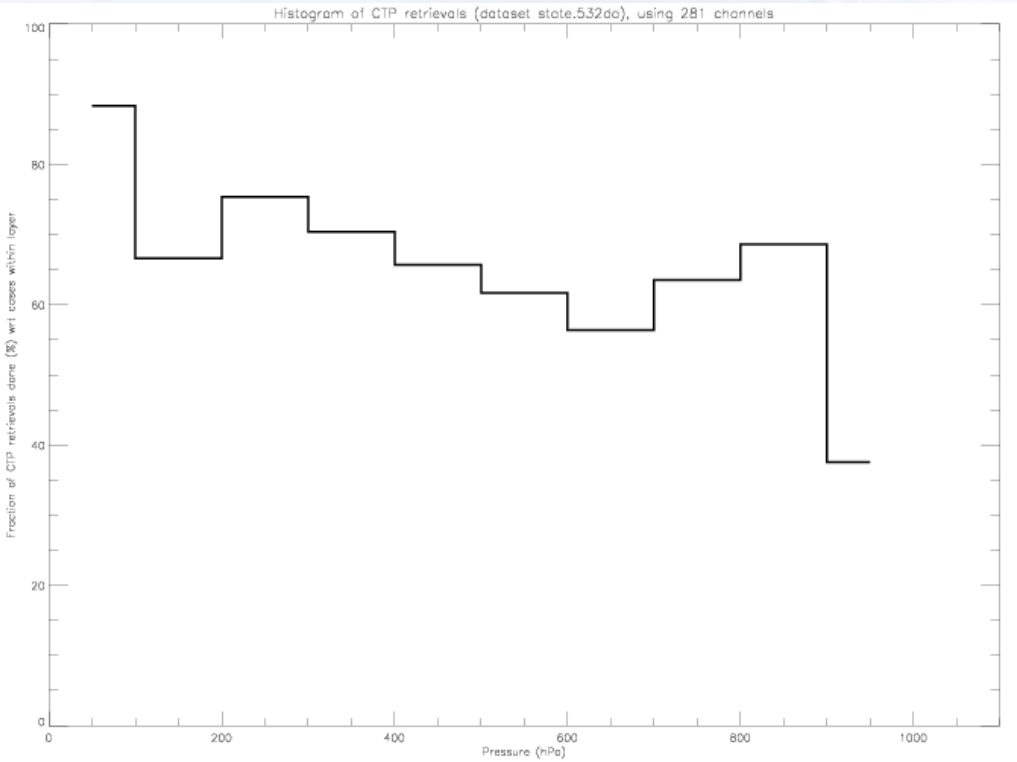
Thank you


Wavenumbers for CO2 slicing
Kelvin (K)
300
280
260
240
220
200
650
700
750
800
850
900
wavenumber (cm−1)


Wavenumbers for CO2 slicing
300
280
260
240
220
200
Kelvin (K)
710
720
730
740
750
wavenumber (cm−1)

Relative frequency (%) of retrievals (10 layers)





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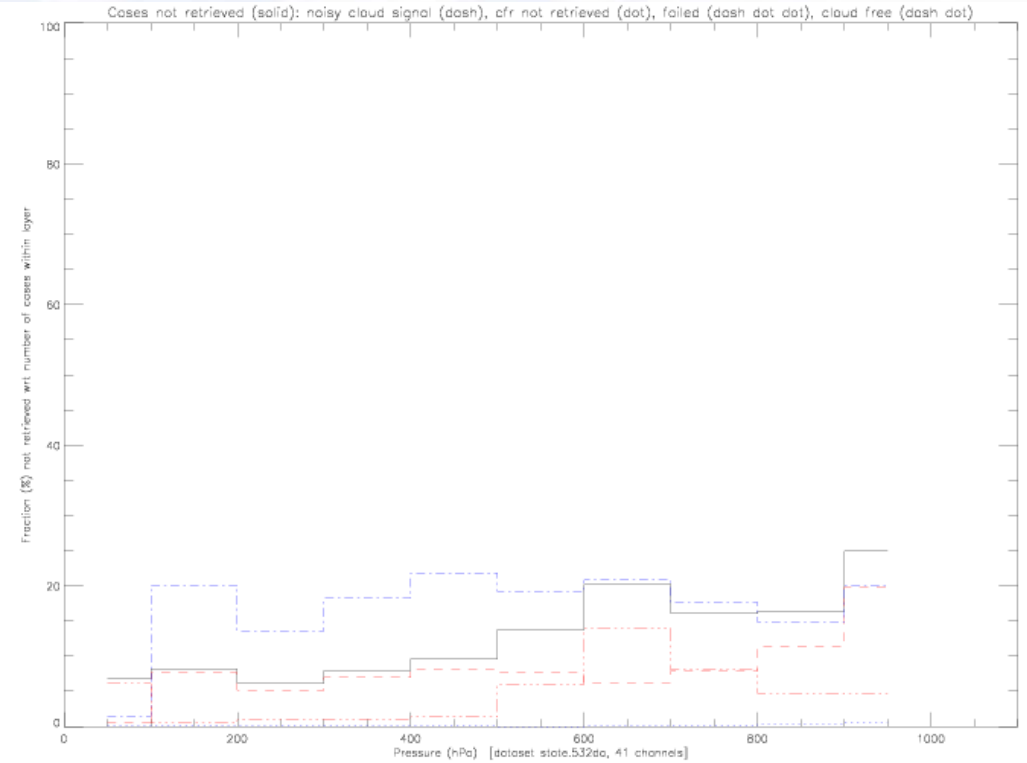
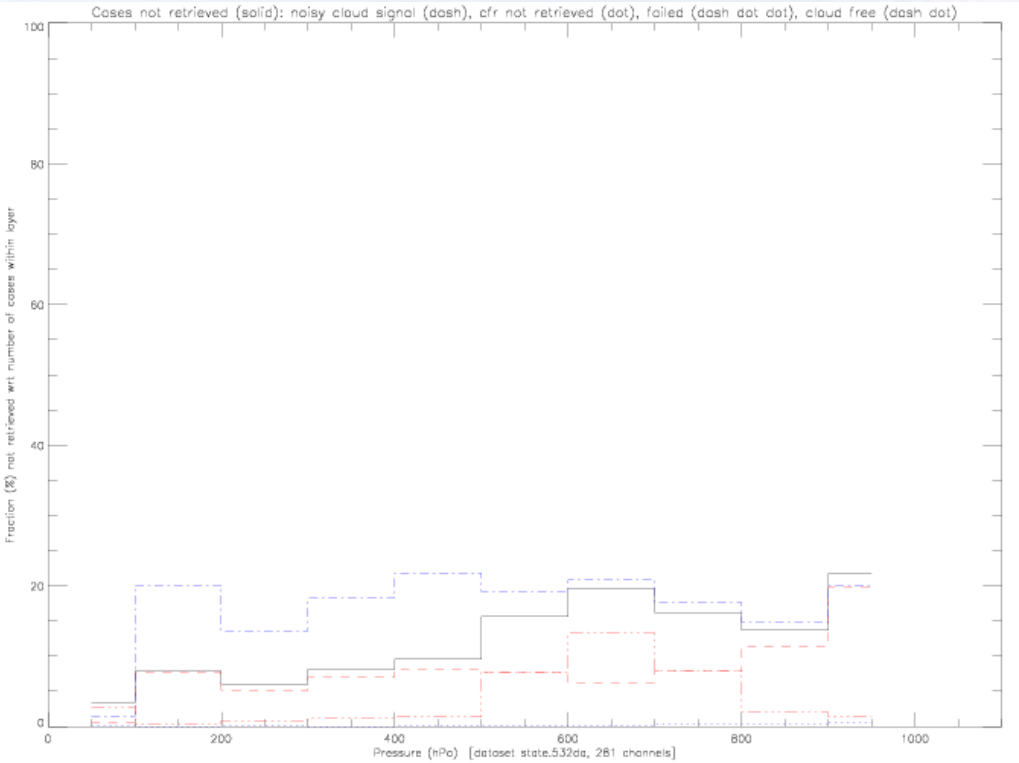
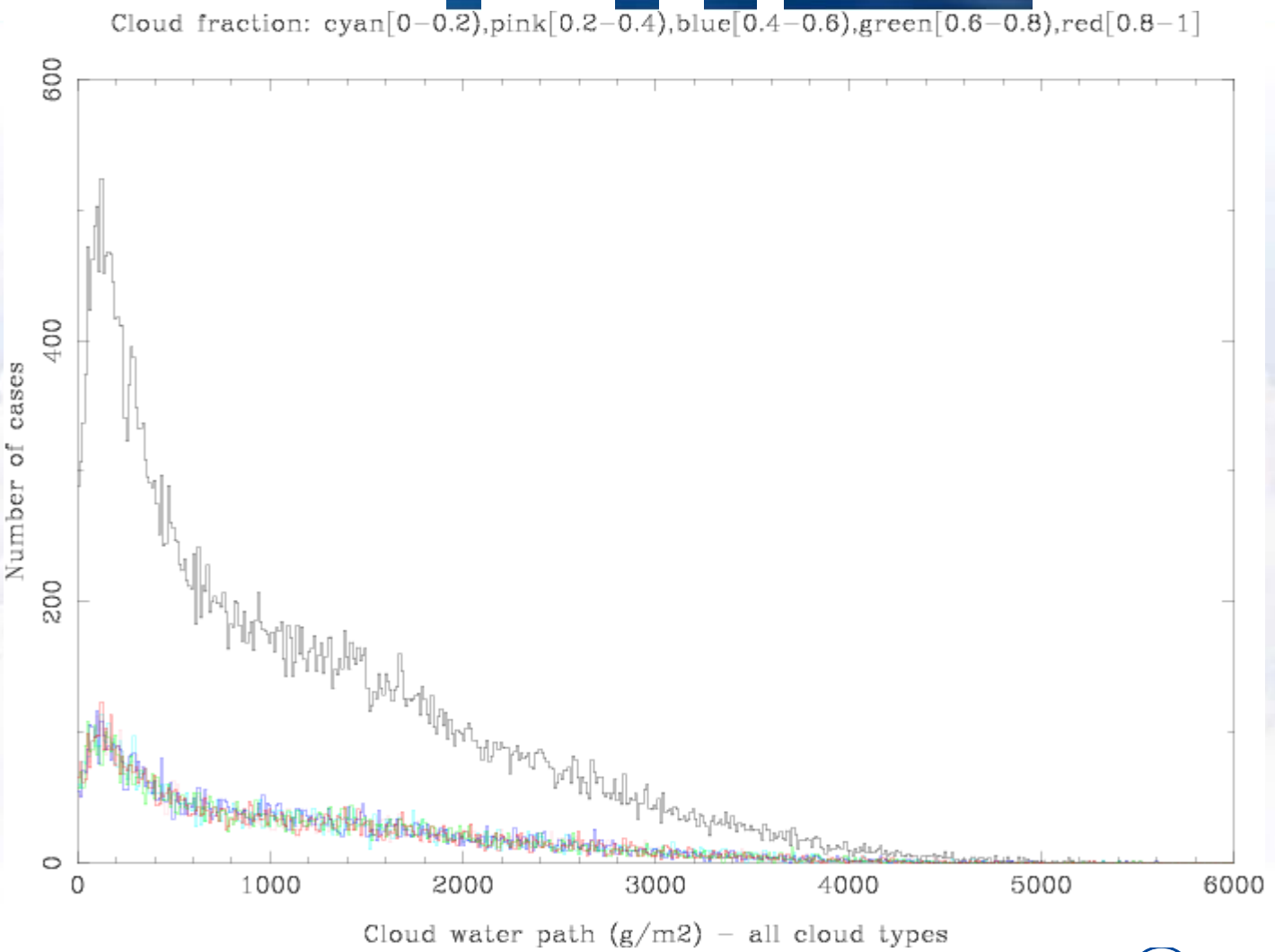
Relative frequency (%) of non-retrieved cases






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]
Number of cases
0
200
400
600
0
1000
2000
3000
4000
5000
6000
Cloud water path (g/m2) – all cloud types

International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.