Residual & Error Correlation (REC) Analysis

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- Residual: difference between measured and fitted spectra after L2 retrieval.
  - Ideally, just noise
  - In practice, contain spectral signatures of a variety of sources of error either in the retrieval forward model or the measurement.

- REC analysis is a statistical correlation between residual spectra and the spectral signatures of potential error sources.

$\Rightarrow$ Rapid indication of where problems might occur, but does not replace the need for examining residuals by eye.

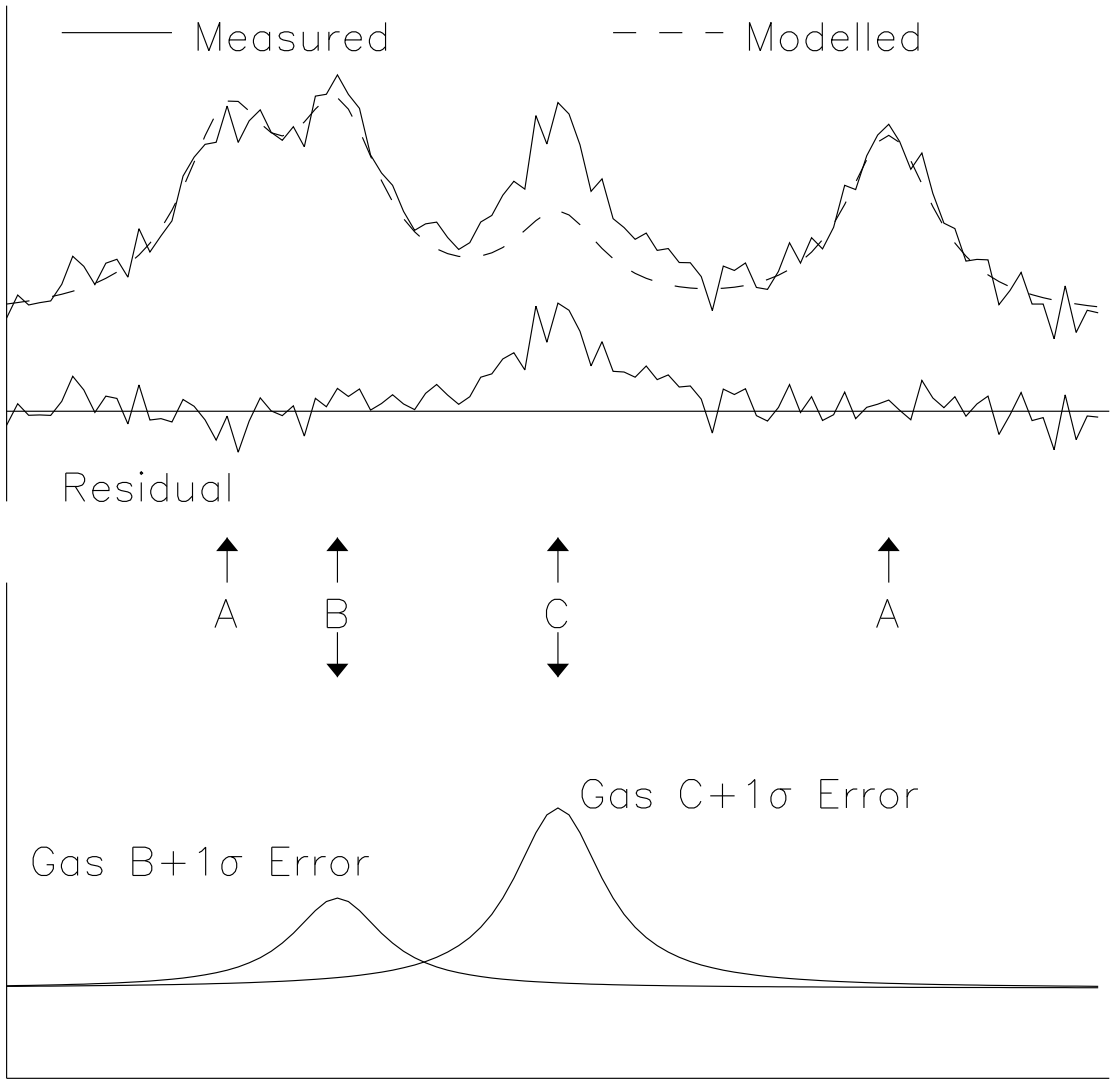
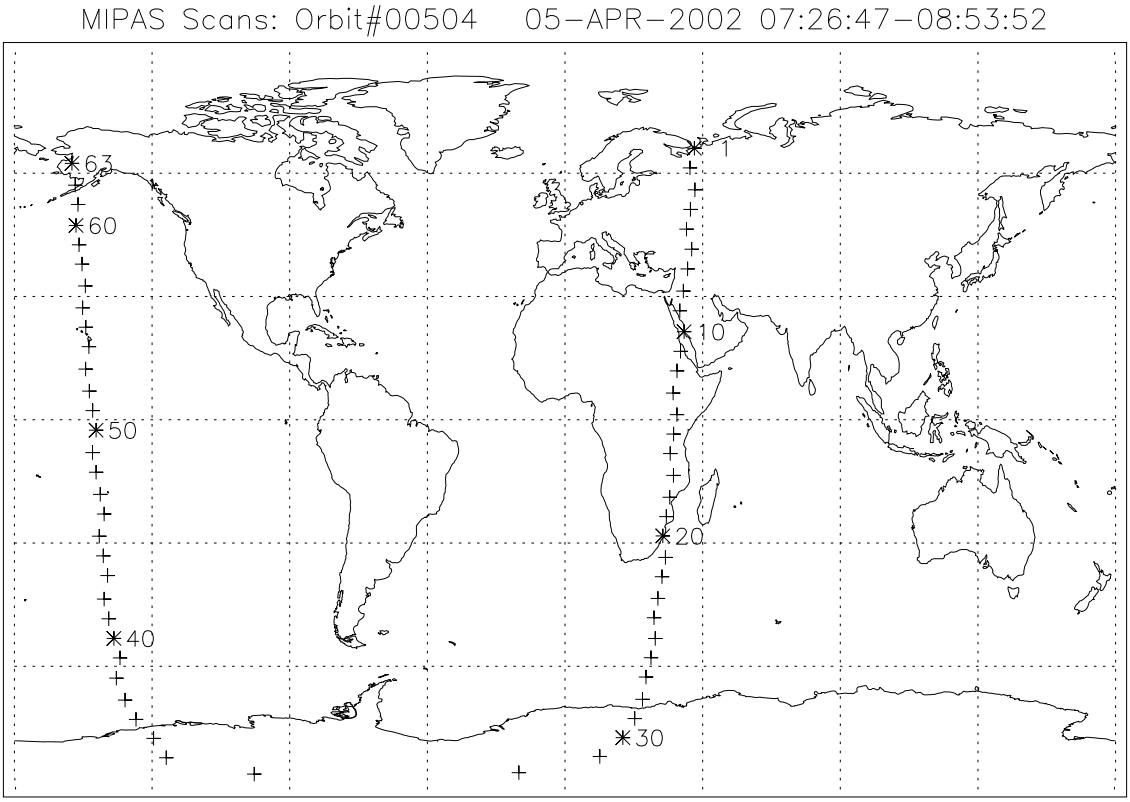


Diagram showing the principle of REC analysis. In a microwindow for retrieving gas A there are also lines of two foreign gases B, C. The lower plot shows the expected residual errors if gases B and C are perturbed by a climatological 1 σ from their nominal values. A correlation between these error spectra and the residual would suggest that gas C was underestimated by approximately 0.5σ in the forward model.

- Applied to MIPAS Orbit#504 (5th April, 2002)



- Residuals in orbit 504 are grouped in 39 subsets (averages over 1–8 profiles) $\times$ (pT + 6 species).

- Here we have simply analysed a weighted average of all residuals for all species.

Results (1)

Error	Fit	Uncertainty
o3	−0.21	0.00
no2	0.06	0.00
hno3	−0.28	0.00
so2	0.05	0.00
ch4	0.06	0.00
n2o	0.07	0.00
co2mix	0.48	0.00
h2o_12	−0.10	0.00
nonlte	0.22	0.00
h2o_st	−0.23	0.00
nh3	−0.54	0.01
hcn	0.07	0.01
n2o5	0.81	0.01
pre	0.45	0.01
clono2	2.31	0.01
cof2	3.90	0.02
f12	6.17	0.03
co2	−0.66	0.04
ccl4	1.37	0.04
hocl	2.27	0.05
ocs	5.23	0.08

- Most retrieved species show small residual signatures
- Non-LTE and CO_2 line mixing effects not as large as expected (should have Fit$\simeq$1)
- Several minor species underestimated (ClONO2, COF2, CFC-12 ...)

Results (2)

shift	12	15	18	21	24	27	30	33	36	39	42	47	52	60	68
A -----															
PT__0039								-31	-24	-24	-23	-26			
PT__0001							-9	-7	-9	-9	-10	-11	-13	-14	-14
PT__0037						-6	-5	-6	-3						
PT__0017						-16	-11	-14	-8	-6	-7	-12	-16	-23	-3
PT__0038				-8	-8	-7	-8								
PT__0004		-9	-8	-8	-7	-8									
O3__0030				-9	-6	-5	-7	-8							
PT__0006		-12	-9	-9	-9										
O3__0026			-3	-9	-8	-10	-10								
O3__0022			1	-8	-8										
O3__0021	-3	-6	-6	-8	-8	-9	-10	-11	-11	-11	-12	-13	-18	-25	
PT__0002	0	-4	-6	-7	-8	-8	-8	-8							
H2O_0002	-10	-14	-11												
HNO30001	2	-3	-6	-6	-8	-12	-16	-16	-23	-23	-25				
HNO30006	0	-4	-4	-5	-7	-9	-13	-14	-15	-17	4				
AB -----															
O3__0013													-6	-3	
O3__0012			18	-1	-1	-3	-3	-4	-4	-5	-6	-10	-11	-53	
O3__0001	2	0	0	-1	-2	-2	-3	-3	-4	-4	-5	-6	-9	-14	
N2O_0025	-2	-6	7	0	1	-2									
CH4_0007		3													
B -----															
CH4_0012	10	6	3	2	1	0	0	0	0	0	-1	-6	-13	-12	
CH4_0013	3	-3	-2	1	2	2	1								
N2O_0004	8	3	6	5	2	0	-1								
N2O_0001	-1	2	3	2	1	0	-2	-3	-3	-2	-2	-6			
CH4_0001	2	2	2	3	4	3	2	1	1	0	0	-1	-5	-8	
C -----															
NO2_0001					9	10	9	9	8	8	8	7			
NO2_0003					10	10	9	8	7	8	11	9			
H2O_0010					16	19	18	21	22						
NO2_0013					13	12	12								
CH4_0021		37	26	21	26	26	35	41	52	69	128	310	202****		
H2O_0007						22	16	16	17	15	13	7	4	2	
H2O_0001		12	12	12	12	12	12	12	12	12	12	9	7	4	
D -----															
PT__0021	45			30	23	26	14	29	16	5	24	34	7	.	

- Also fit 0th, 1st and 2nd order derivatives of expected spectrum to residuals ('gain', 'shift' and 'deriv2') for each microwindow/sweep.

- Residuals suggest a spectral shift ~ -0.001 cm^{-1} in A-band MWs (=10 units) $+0.001$ cm^{-1} in D-band MWs

- Also suggest shift $\sim +0.001$ cm^{-1} with decreasing altitude.

- Problem indicated with MW CH4_0021 (C-band, 1626.5–1626.775 cm^{-1}). This is a back-up MW, used in 13/62 retrievals.

```
gain      12  15  18  21  24  27  30  33  36  39  42  47  52  60  68
CH4_0021    -313-191 -93  29 144 315 381 698 823 802********4260

shift     12  15  18  21  24  27  30  33  36  39  42  47  52  60  68
CH4_0021      37  26  21  26  26  35  41  52  69 128 310 202****

deriv2    12  15  18  21  24  27  30  33  36  39  42  47  52  60  68
CH4_0021      24  15  10   3   2   3   2   2  21  37 240 282-791
```