Synergistic Retrieval and Complete Data Fusion applied to FORUM and IASI-NG Simulated Measurements

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We compare two alternative approaches to determine atmospheric and surface state parameters (temperature, H_2O, O_3 and surface temperature and emissivity) by exploiting simultaneously both FORUM (Far-Infrared Outgoing Radiation Understanding and Monitoring) and IASI-NG (Infrared Atmospheric Sounding Interferometer – New Generation) simulated measurements:

- the **Synergistic retrieval (SR).** The SR product is obtained fitting simultaneously the radiances acquired by the two instruments with the forward model simulations;
- the **Complete Data Fusion (CDF),** an a posteriori method that uses the results of the individual retrievals (vmr, CMs and AKMs) to provide an optimized final product (enhanced vertical sensitivity, reduced total error).

We carry out two sets of test retrievals emulating an idealized situation in which both FORUM and IASI-NG measure, with perfect matching and with a mismatch in time and space, for 900 times, the same portion of the Antarctic Plateau surface covered by coarse snow

SOUNDERS

	Instruments	
Characteristics	**IASI-NG**	**FORUM**
Spectral coverage	**645- 2760** cm^{-1}	**100-1600** cm^{-1}
Spectral sampling	**0.125** cm^{-1}	**0.36** cm^{-1}
Spectral resolution	**0.25** cm^{-1}	**0.5** cm^{-1}
Measurement mode	Step and stare (azimuth scanning)	Step and stare (no azimuth scanning)
Ground pixel (diameter at nadir)	**12 km**	**15 km**
Satellite	On board two sun-synchronous polar orbiting satellites in loose formation (MetOp-SG-1A for IASI-NG)	

SYNTETHIC OBSERVATIONS

TEST SETTINGS		INDIVIDUAL RETRIEVAL		SYNERGYSTIC METHODS	
		FORUM	IASI-NG	SR	CDF
Test		Assumptions to generate synthetic observations			
No mismatch (900 cases) $x_1=x_2$	State vector x_i	• x_1 **(for T,Ts,H2O,O3)** true state vectors obtained applying a stochastic perturbation to their reference value X_0 consistent with $S_M/2$ diagonal values. • $E_{S,i}$ generated from the snow emissivity profile of Huang et al 2016			Input state vectors: $\hat{x}_1$ and $\hat{x}_2$
	A priori x_a	• x_{ai} **(for T,Ts,H2O,O3)** a priori state vector obtained applying a random perturbation to their reference value X_0 consistent with S_a • $E_{s,ai}$ a priori=0.99 constant			S_a
	Errors CMs used in the retrieval	S_{y1}	S_{y2}	S_{y1} and S_{y2}	S_f
	Retrieved $\hat{x}_i$	$\hat{x}_1$	$\hat{x}_2$	$\hat{x}_{sr}$	$\hat{x}_f$
mismatch (900 cases) $x_1 \neq x_2$	State vector x_i	Simulated as in 'no mismatch' case but with $x_1 \neq x_2$			Input state vectors: $\hat{x}_{1,msm}$ and $\hat{x}_{2,msm}$
	A priori x_a	Simulated as in 'no mismatch' case			S_a
	Errors CM used in the retrieval	Sy_1	Sy_2	$S_{sr,msm}$ (S'_{y2} for IASI-NG)	$S_{f,msm}$ ($S'_{n,2}$ for IASI-NG)
	Retrieved $\hat{x}_{i,msm}$	$\hat{x}_{1,msm}$	$\hat{x}_{2,msm}$	$\hat{x}_{sr,msm}$	$\hat{x}_{f,msm}$

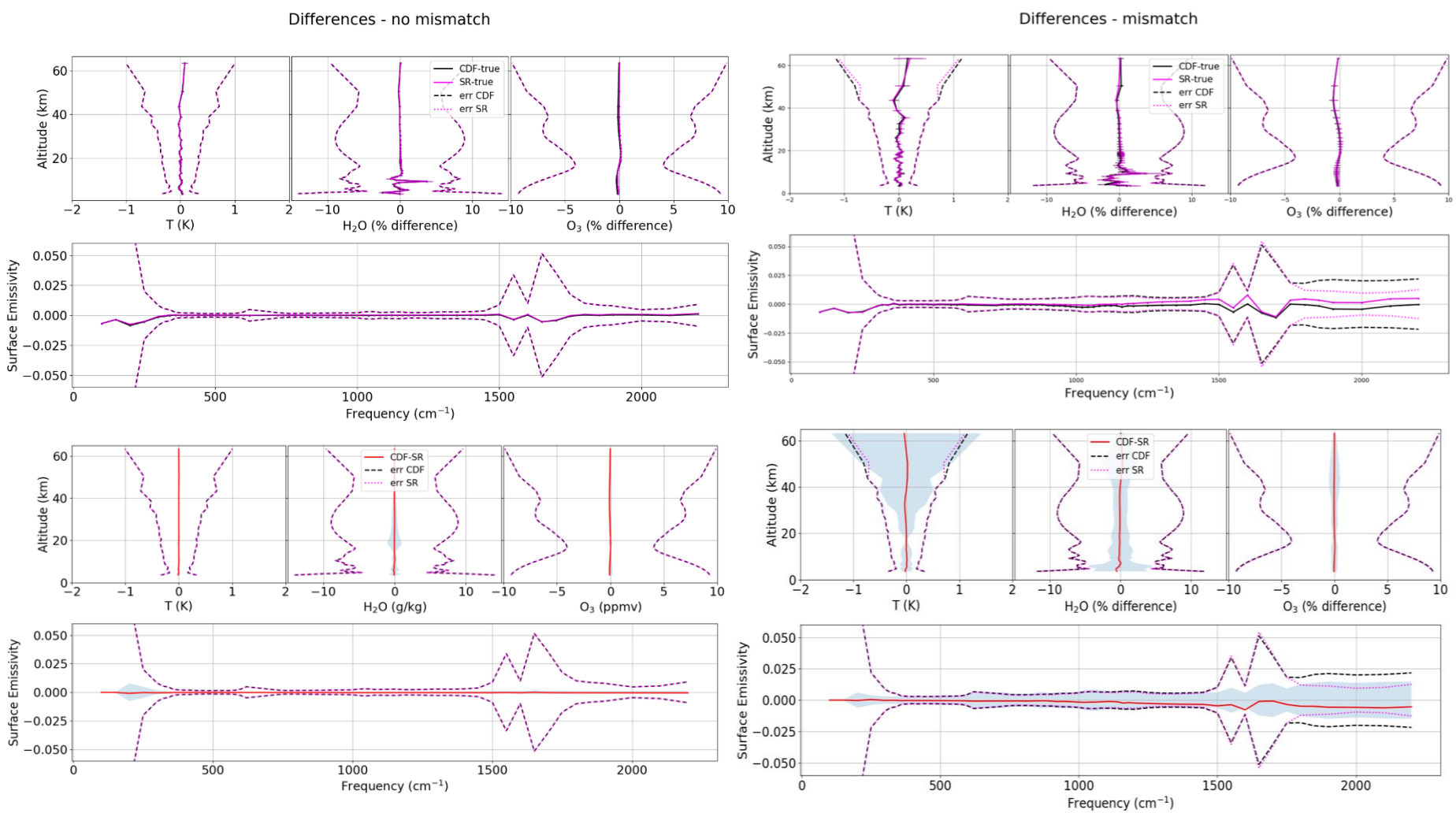
RESULTS

For T, H_2O, O_3 and surface emissivity profiles, we evaluate:

- the average differences between CDF/SR products and the true values (top) with the standard error of the average differences (error bars) ;

- the average differences between CDF and SR products (bottom) with the standard deviation of the average differences (shaded areas)

The dashed lines represent the CDF and SR average total errors.



CONCLUSIONS

We found that:

- in case of perfectly matching measurements, SR and CDF actually provide results that differ by less than 1/10 of their associated noise retrieval error;
- in case of a realistic mismatch between the measurements, the two methods provide more different results, the differences, however, are still within the retrieval error;
- the differences between SR and CDF results are mainly due to the different treatments of the mismatch in the two methods and not to the non-linearities of the problem.