

ABSTRACT

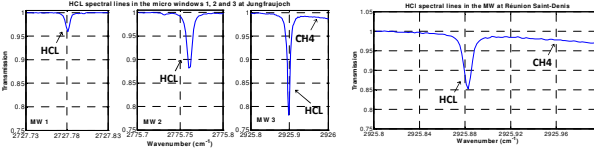
The Fourier Transform Infra Red (FTIR) remote measurements of atmospheric constituents at the observatories at Saint-Denis (20.90° N, 55.48° E, 50 m a.s.l., Île de la Réunion) and Jungfraujoch (46.55° N, 7.98° E, 3580 m a.s.l., Switzerland) are affiliated to the Network for the Detection of Atmospheric Composition Change (NDACC). The responsible scientists deliver retrieved vertical concentration profiles of constituents that are important players in the stratospheric ozone cycle, on a regular, rapid delivery basis to the EDMOM data center, and – once consolidated – to the NDACC database. For the users of the data and in particular for trend analyses, it is important that errors and uncertainties associated to these data are well characterized. In this poster we therefore present a preliminary study of the comparison of errors on retrieved vertical concentration profiles of HCl and HF (up to 100 km altitude) between Saint-Denis and Jungfraujoch. Both HCl and HF originate from photolysis of organic Cl- and F-containing source gases (e.g. CFCs and HCFCs) in the stratosphere. These reservoir species are used as indicators for the amount of emitted organic precursor gases. At both stations, we have used the same retrieval algorithm, namely SFIT2 v3.92 developed jointly at the NASA Langley Research Center, the National Center for Atmospheric Research (NCAR) and the National Institute of Water and Atmosphere Research (NIWA) at Lauder, New Zealand, and error evaluation tools developed at the Belgian Institute for Space Aeronomy (BIRA-IASB). The error components investigated in this study are: smoothing, noise, model parameters, temperature, spectroscopy (in particular the pressure broadening and intensity), interfering species and solar zenith angle (SZA) error. We will determine if the characteristics of the sites in terms of altitude, geographic locations and atmospheric conditions produce significant differences in the error budgets for the retrieved HCl and HF vertical profiles.

HCl-RETRIEVAL RESULTS

Jungfraujoch (JUN)	
MW1	2727.73 – 2727.83 cm ⁻¹
MW2	2775.70 – 2775.80 cm ⁻¹
MW3	2925.80 – 2926.00 cm ⁻¹
Interfering molecules	CH ₄ , O ₃ , N ₂ O, NO ₂
A priori profiles	WACCM

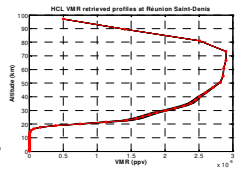
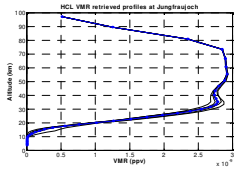
Réunion Saint-Denis (RSD)	
MW	2925.80 – 2926.00 cm ⁻¹
Interfering molecules	CH ₄
A priori profiles	WACCM

For the purpose of comparing the calculated error budgets, 6 spectra were selected with distinct solar zenith angles (SZA) for Jungfraujoch (JUN) (in the period 03-2007 – 11-2007) and for Réunion Saint-Denis (RSD) (in the period 06-2007 – 10-2007).



Station	Spectra	SZA	VCA-HCl	DOFS	RMS
JUN	R07923AE.MOY	47.238°	3.1032E+15 molecules cm ⁻²	2.45	0.083
RSD	07629002.Shh	47.36°	2.2152E+15 molecules cm ⁻²	1.34	0.075

At RSD only MW3 can be used to retrieve HCl profiles, the HCl line in the other MW1 and MW2 cannot be discerned because of the high H₂O vapour concentration close to sea level and close to the sea. At JUN, a higher DOFS was found than at RSD because of (1) a higher HCl concentration and (2) the much smaller H₂O vapour concentration.



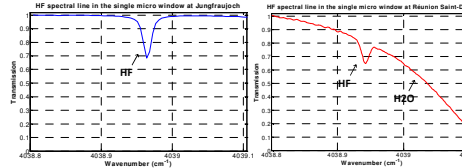
- The updated HITRAN 2004 spectroscopic database was used in both cases.
- All a priori profiles were calculated using the Whole-Atmosphere Community Climate Model (WACCM). WACCM has recently been adopted by the NDACC-RWG community for it's a priori's in order to have a common origin.

HF-RETRIEVAL RESULTS

JUN	
MW	4038.800 – 4039.105 cm ⁻¹
Interfering molecules	H ₂ O, HDO, CH ₄
HF a priori profile	ACE (2004 – 2009)
Interfering molecules a priori profiles	WACCM

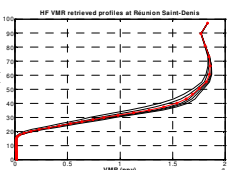
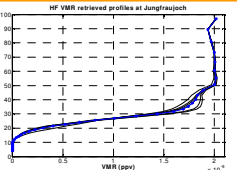
RSD	
MW	4038.800 – 4039.105 cm ⁻¹
Interfering molecules	H ₂ O
HF a priori profile	ACE (2004 – 2009)
Interfering molecules a priori profiles	WACCM

Also here for the purpose of comparing the calculated error budgets, 5 and 6 spectra were selected with distinct solar zenith angles (SZA) for Jungfraujoch (in the period 03-2007 – 11-2007) and for Réunion Saint-Denis (in the period 06-2007 – 10-2007), respectively.



Station	Spectra	SZA	VCA-HF	DOFS	RMS
JUN	R07312JL.MOY	50.031°	1.0092E+15 molecules cm ⁻²	1.96	0.11
RSD	07629008.Shf	50.793°	1.4051E+15 molecules cm ⁻²	2.24	0.43

At RSD H₂O vapour is a prominent interfering molecule in the HF MW, where as at JUN almost no H₂O vapour can be discerned in the same MW. Because of the high H₂O vapour concentration and H₂O profile variability at RSD, a much higher error budget contribution is expected at RSD than at JUN.

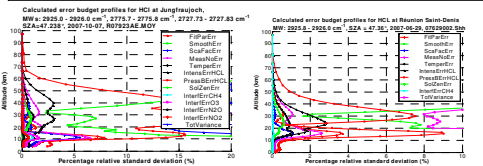


- The updated HITRAN 2004 spectroscopic database was used in both cases.
- The a priori profiles for the interfering molecules were calculated using the Whole-Atmosphere Community Climate Model (WACCM).
- The HF a priori profile was calculated using ACE data.

HCl-ERROR BUDGETS

Station	Spectra	SmoothErr	RetNoErr	TempErr	IntensErr	PressBErr	SoZenErr	InterErrCH4	InterErrO3	InterErrN2O	InterErrNO2	TotalErr
JUN	R07923AE.MOY	0.88 %	0.46 %	2.04 %	13.59 %	2.04 %	0.12 %	0.15 %	0.02 %	0.02 %	-	13.82 %
RSD	07629002.Shh	2.11 %	0.43 %	0.63 %	1.91 %	2.11 %	0.41 %	0.02 %	-	-	-	3.69 %

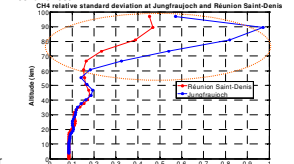
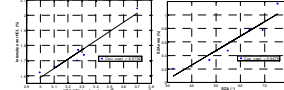
Errors in target HCl total VCA due to the source parameters



The spectral intensity and pressure broadening uncertainties of the HCl were taken from the HITRAN 2004 updated data base.

All errors due to interfering molecules in the micro windows are calculated using WACCM a priori covariances.

Error budgets were calculated using the theory described in Rodgers (inverse methods for atmospheric sounding), assuming a linear relationship between the concerned error source (parameters) covariance and the corresponding error covariance of the target profile.



The smoothing error at RSD is about twice compared to the one at JUN. This is due to the reduced sensitivity (see figure) at RSD (i.e. also lower DOFS) than at JUN in an altitude range [10 – 20 km] where the HCl profile is still contributing, and to a higher standard deviation at RSD for this altitude range.

A linear relationship was found between the error contribution on the total VCA and the VCA due to intensity uncertainty of HCl. (see figure).

The higher CH₄ interfering error at JUN is most probably due to the higher variance above 60 km compared to the CH₄ variance at RSD (see figure).

The temperature standard deviations at JUN and RSD (see figure) were taken from NCEP. The higher temperature error at RSD is due to the higher variance in the altitude range [20 – 30 km] and corresponding relatively high sensitivity of the HCl profile with respect to temperature variations in this altitude range (i.e. gain matrix x temperature weighting function matrix).

The pressure broadening error was found to be much higher at JUN than at RSD. In fact, the broadening error at JUN approximates the one from RSD when dropping MW1 and MW2. Dropping the latter MWs only slightly (= 0.1) decreases the DOFS.

At JUN, a clear linear trend can be observed between the errors of the interfering molecules CH₄, O₃, N₂O, NO₂, and their VCA.

The source SZA error was estimated at 0.2°. A linear relationship was found between the error contribution on the total VCA and the VCA due to the uncertainty in the SZA (see figure).

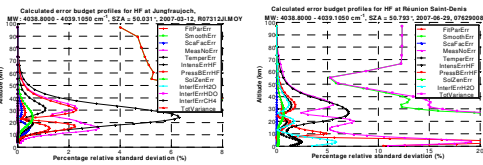
The large pressure broadening error at JUN is to a great extent reflected in the total error. However, the total error becomes similar (3.2%) to the total error at RSD when using the same single MW around 2925.9 cm⁻¹.

The retrieval noise error was calculated using the RMS from the difference between the observed and calculated spectra (in the MWs)

HF-ERROR BUDGETS

Station	Spectra	SmoothErr	FitParErr	RetNoErr	TempErr	IntensErr	PressBErr	SolZenErr	InterErrH2O	InterErrHDO	InterErrCH4	TotalErr
JUN	R07312JL.MOY	1.66 %	0.04 %	0.45 %	0.32 %	4.43 %	0.18 %	0.42 %	0.007 %	0.001 %	0.003 %	4.79 %
RSD	07629002.Shh	3.90 %	0.47 %	3.33 %	0.95 %	4.05 %	0.23 %	0.36 %	2.00 %	-	-	6.93 %

Errors in target HF total VCA due to the source parameters



Because of the higher noise level (i.e. RMS values) in the RSD spectra than in the JUN analogues, the retrieval noise error is expected to be larger.

At RSD (50 m a.s.l.) the H₂O vapour concentration is much higher (VCA-H₂O = 8.4121E+22 molecules cm⁻² at RSD and VCA-H₂O = 2.1120E+21 molecules cm⁻² at JUN, i.e., a factor of about 40) and more variable than at JUN (3580 m a.s.l.). This is reflected in the error budget due to the interfering H₂O molecule in the spectra (MW). Between 0 and 15 km, the H₂O vapour variability is much higher at RSD (see figure), and combined with the high sensitivity in this range (see figure), the H₂O vapour interfering error is expected to be much larger than at JUN (see table).

The HF error budgets were calculated in exactly the same way as the HCl error budgets.

As for the HCl case, the temperature error is also expected to be larger due to the higher variability in the temperature profile below 30 km and the higher sensitivity compared to JUN.

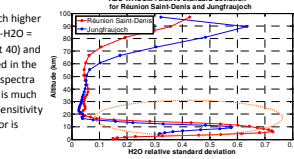
The intensity and pressure broadening errors are quite similar for RSD and JUN, which is also expected because exactly the same spectral line is targeted.

Both the HF a priori profile and the HF relative standard deviation profile were calculated using ACE data. The a priori profiles and covariances of the interfering molecules were calculated using WACCM relative standard deviation from ACE at Jungfraujoch and Réunion Saint-Denis.

As observed in the HCl case, also here a linear relationship was found between the intensity error and the VCA of HF.

At RSD (50 m a.s.l.) the H₂O vapour concentration is much higher (VCA-H₂O = 8.4121E+22 molecules cm⁻² at RSD and VCA-H₂O = 2.1120E+21 molecules cm⁻² at JUN, i.e., a factor of about 40) and more variable than at JUN (3580 m a.s.l.). This is reflected in the error budget due to the interfering H₂O molecule in the spectra (MW). Between 0 and 15 km, the H₂O vapour variability is much higher at RSD (see figure), and combined with the high sensitivity in this range (see figure), the H₂O vapour interfering error is expected to be much larger than at JUN (see table).

The smoothing error at RSD is larger than at JUN because of the larger standard deviation (see figure) especially in the most sensitive altitude range [15 – 40 km] (see figure)



At RSD, no other interfering molecules than H₂O is taken into account in the retrievals and error calculation since H₂O vapour is the dominating interfering molecule in the MW that, to a large extent, masks the other molecules HDO and CH₄.

CONCLUSIONS

The characteristics of the two FTIR observation sites, Jungfraujoch and Réunion Saint-Denis, with respect to the strong difference in the H₂O vapour concentration and its variability, was clearly observed in their corresponding HF target profile error and HF total VCA error.

A clear difference was observed in the error due to the uncertainty in the pressure broadening coefficient of HCl at Jungfraujoch when taking additional HCl micro windows (i.e., around 2727.78 cm⁻¹ and 2775.75 cm⁻¹) into account than the common micro window at Jungfraujoch and Réunion Saint-Denis at around 2925.9 cm⁻¹.