CFC-11, CFC-12 and HCFC-22 retrievals at Eureka, Nunavut, Canada

aka Progress on validation of ACE-FTS CFC-11, CFC-12 and HCFC-22 products

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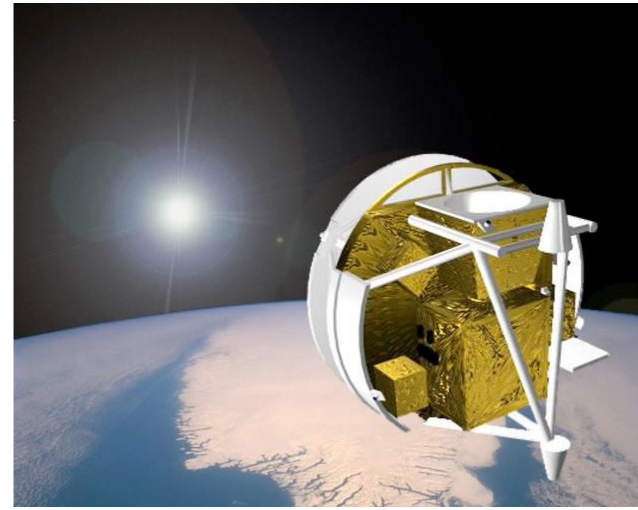
Motivation

This works details our progress on the validation of ACE-FTS CFC-11 (CCl_3F), CFC-12 (CCl_2F_2), and HCFC-22 ($CHClF_2$) measurements.

- Why is it important to monitor chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)?
  - significant contributors to anthropogenic ozone depletion
    - photodissociation of CFCs and HCFCs in stratosphere release chlorine radical → catalytic destruction of O3
  - high Global Warming Potentials (GWP)(IPCC, 2013)
    - high radiative efficiency and long lifetimes
    - contributes to the Earth's radiation budget

- ACE-FTS
  - primary instrument on SCISAT-1
  - high-resolution (0.02 cm^{-1}) infrared (750-4400 cm^{-1}) Fourier Transform Spectrometer
  - non-linear least-squares fitting approach (ACE-FTSv3.5)



- Satellite solar occultation measurements, such as those from ACE-FTS, are well suited for monitoring these long-lived species
  - Also used to derive atmospheric lifetimes (Brown et al., 2013, Minschwamer et al., 2013, Hoffman et al., 2014…) and trends (Rinsland et al, 2005)
- Quality of satellite measurements must be assessed through validation with other data sources
  - Ground-based FTIR have proven to be particularly useful for this satellite data validation.

Previous Validation Efforts for ACE-FTS CFC-11, CFC-12 and HCFC-22

- CFC-11 and CFC-12: First tackled in Mahieu et al., 2008 using atmospheric balloon measurements (FIRS-2 & Mark IV)
- Worked continued by F. Kolonjari and E. Mahieu and their collaborators to validate measurements using ground-based FTIR measurements (presented at AGU general meeting, 2013)
- HCFC-22 measurements recently compared with MIPAS retrievals. (Chirkov et al., 2015)

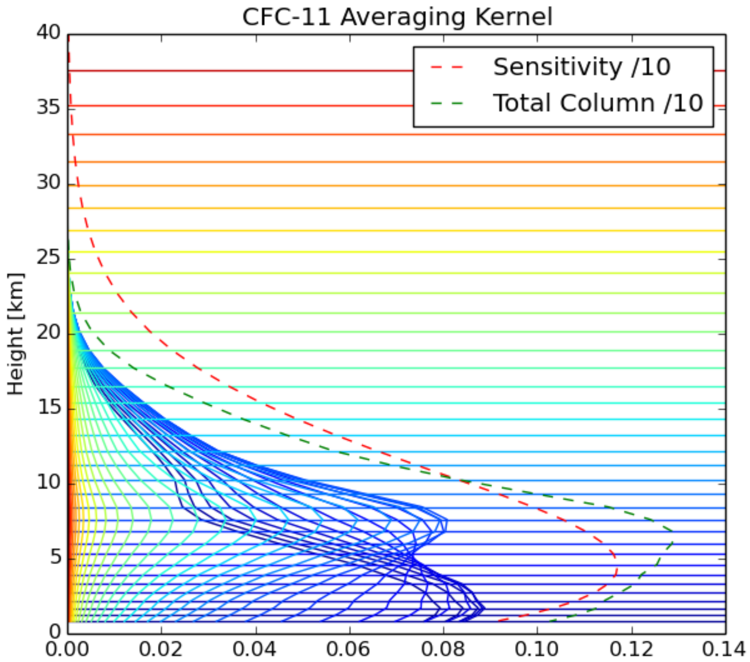
Eureka Retrievals

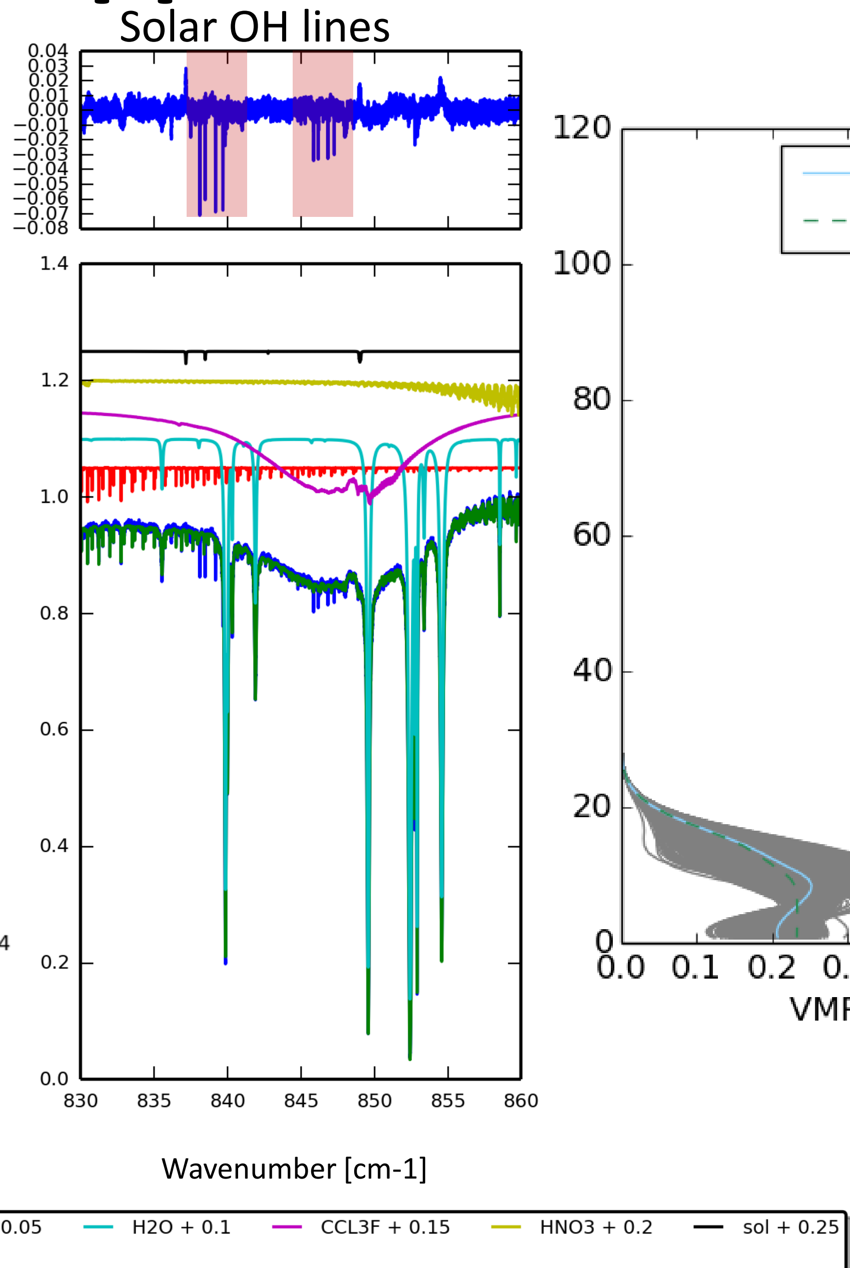
- 80.05N, 86.42W, 610 masl
- Bruker 125 HR with resolution of 0.035 cm^{-1}
- July 2006-present
  - 2012-2013 measurements on campaign basis
- Retrievals:
  - SFIT4 with WACCM 6, calculating SNR for micro windows on a measurement by measurement basis.

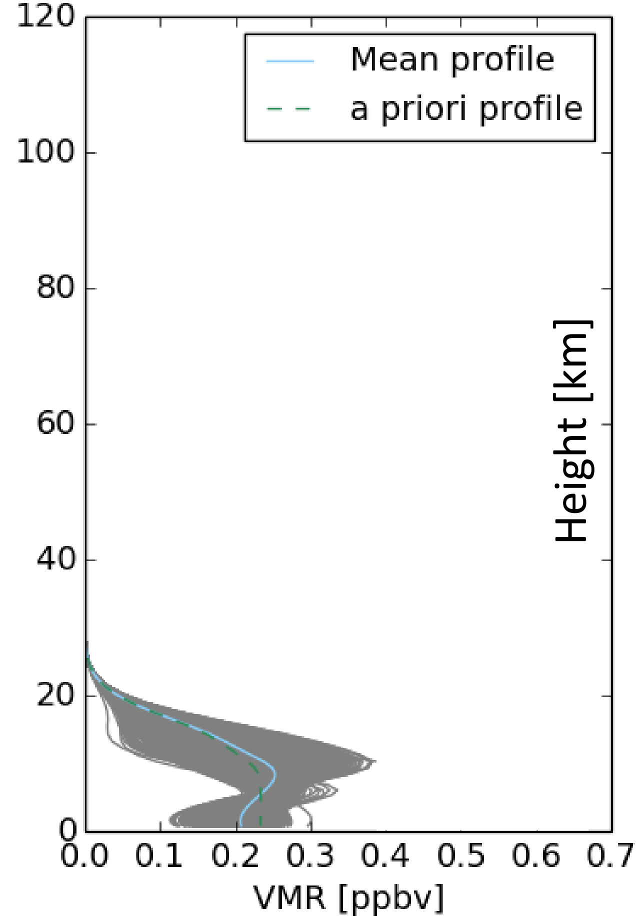
Species	Micro window	Sa	DOFS	
CFC-11	830 - 860 cm^{-1}	0.15	1.0 – 2.5	H_2O, O_3 as profile
CFC-12	920.1 - 923.5 cm^{-1}	0.10	1.0 – 2.5	H_2O as profile
HCFC-22	828.75-829.4 cm^{-1}	0.40	1.0 – 2.5	H_2O, O_3 as profile

Retrieval Approach: CFC-11

ACE-FTS measurements are sensitive between 6 - 30 km

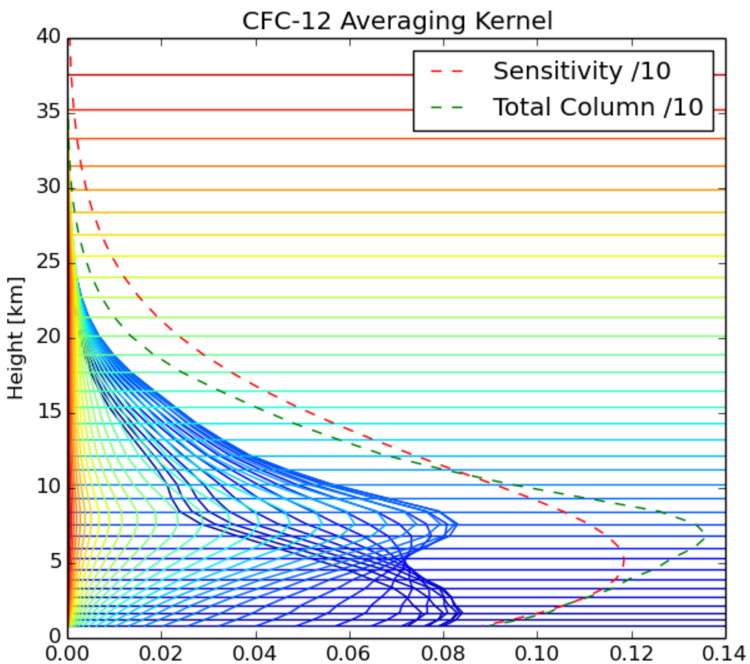


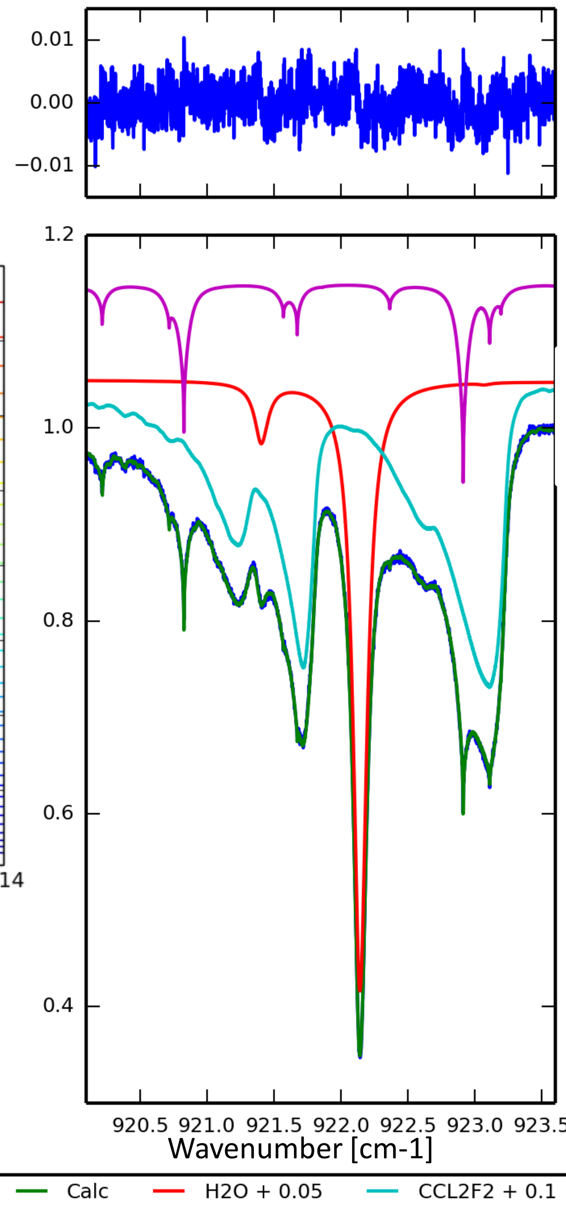


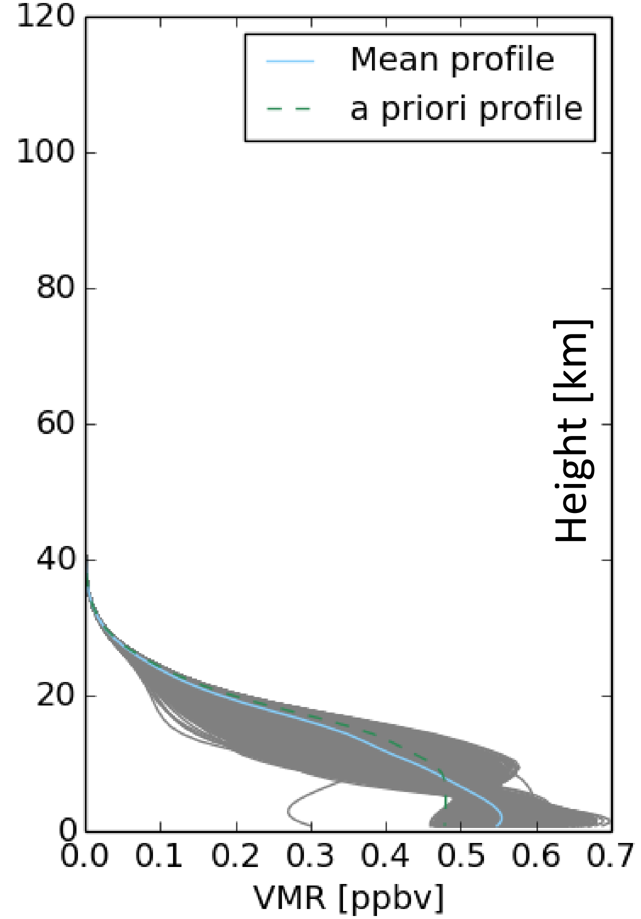


Retrieval Approach: CFC-12

ACE-FTS measurements are sensitive between 6 - 30 km

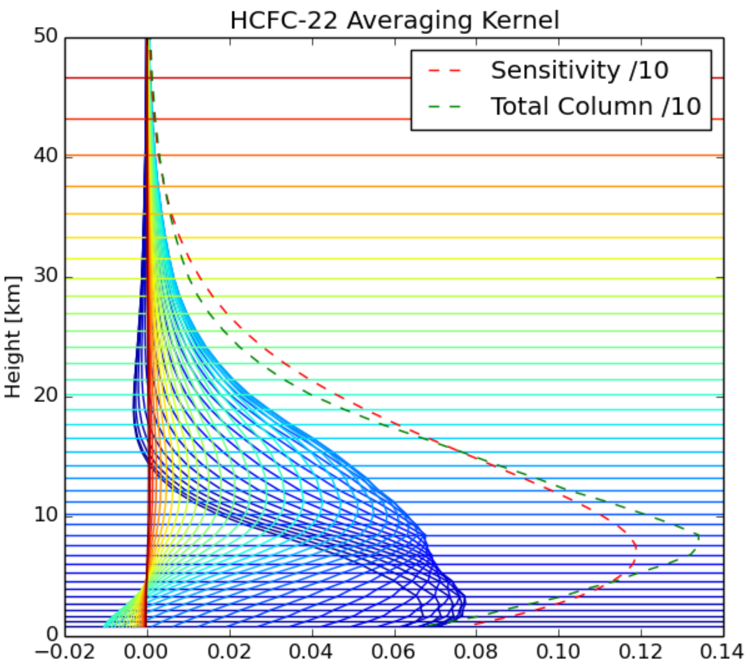


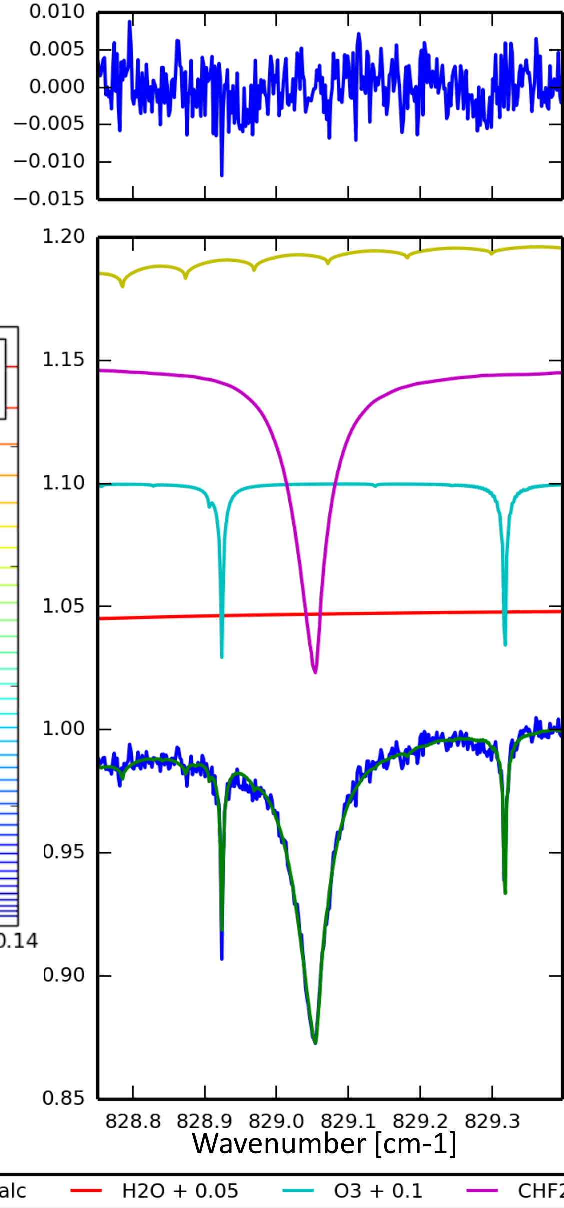


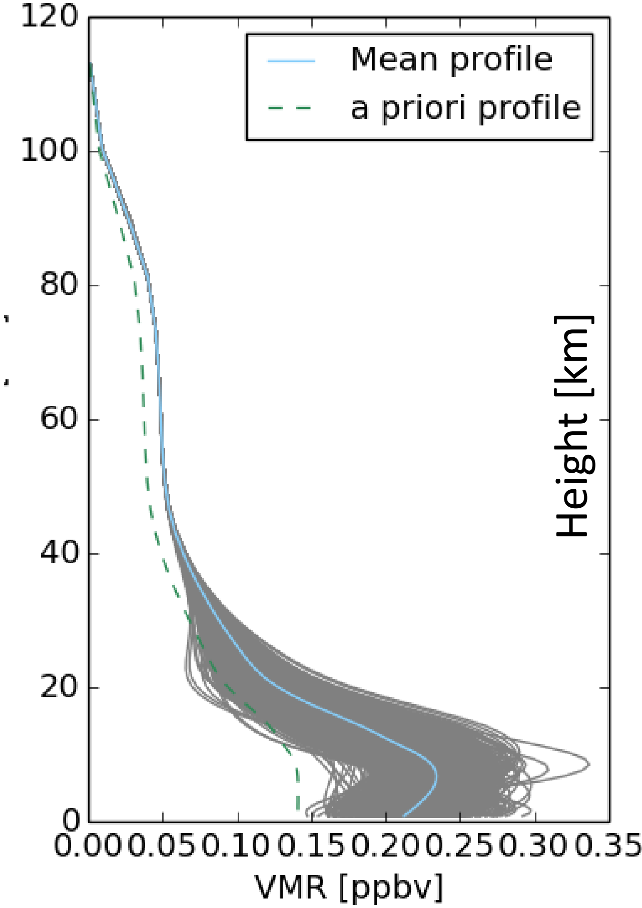


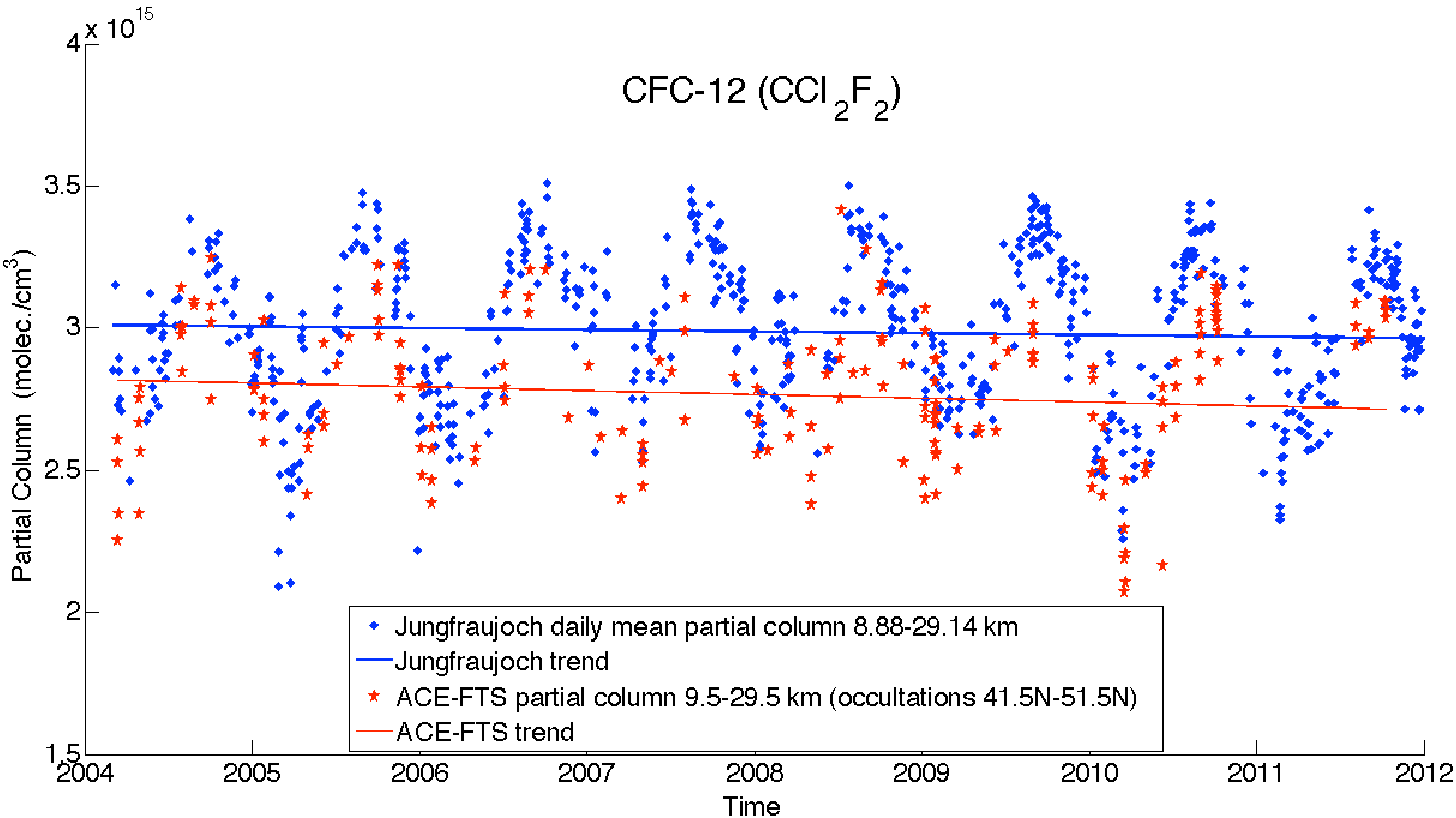
Retrieval Approach: HCFC-22

ACE-FTS measurements are sensitive between 6 - 30 km



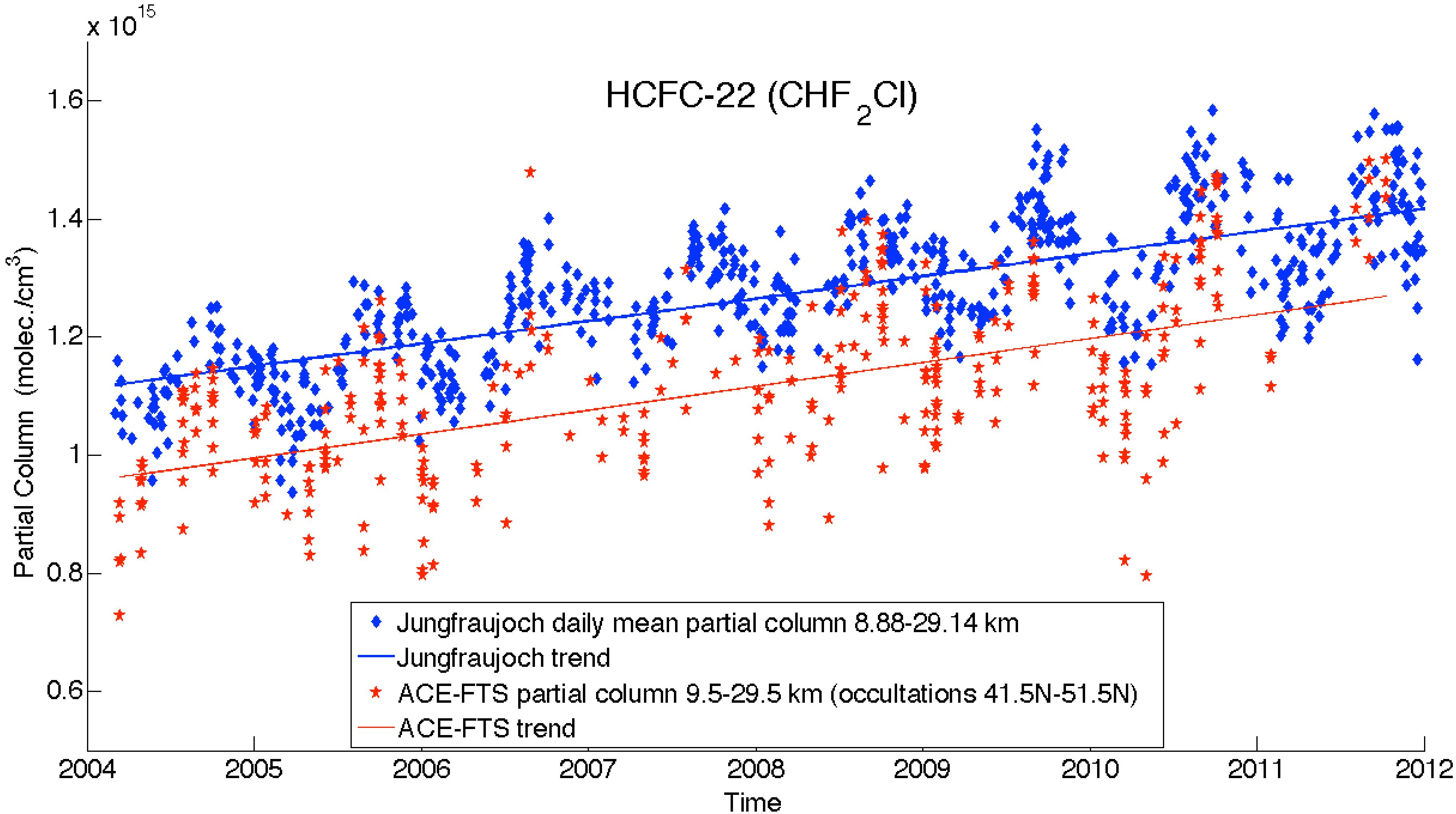






ACE-FTS	Jungfraujoch
-1.35 +/- 0.67 x 10^{13} molec./cm^3	-5.97 +/- 2.96 x 10^{12} molec./cm^3
-0.43 +/- 0.21 % $year^{-1}$	-0.21 +/- 0.10 % $year^{-1}$

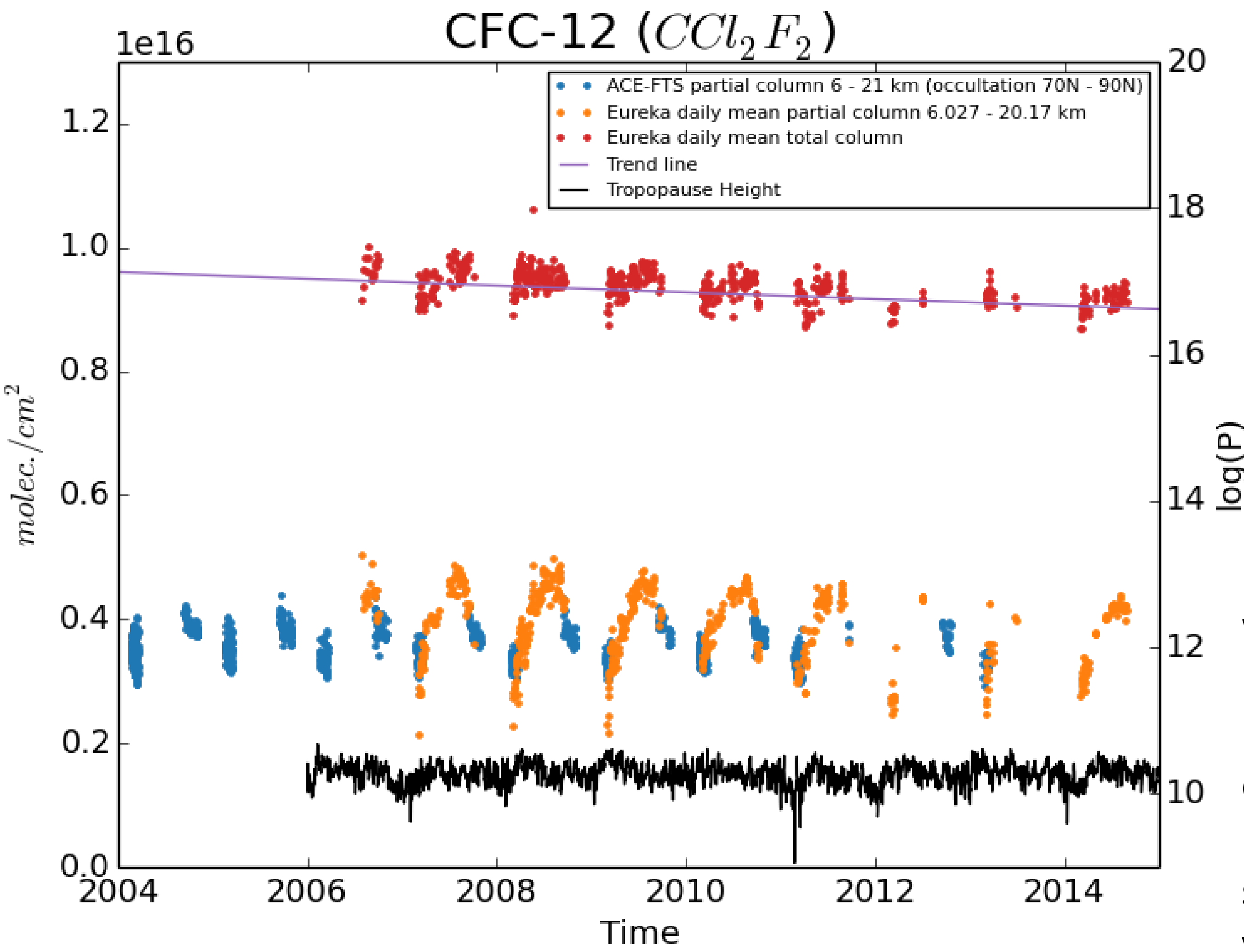
Kolonjari et al., Validation of ACE-FTS measurements of CFC-11, CFC-12, and HCFC-22 using ground-based FTIR spectrometers, AGU 2013.



ACE-FTS	Jungfraujoch
4.05 +/- 2.02 x 10^{13} molec./cm^2	3.81 +/- 1.91 10^{13} molec./cm^2
3.52 +/- 1.76 % $year^{-1}$	3.56 +/- 1.78 % $year^{-1}$

Kolonjari et al., Validation of ACE-FTS measurements of CFC-11, CFC-12, and HCFC-22 using ground-based FTIR spectrometers, AGU 2013.

Eureka CFC-12



Total Column
-0.58 % year^{-1}

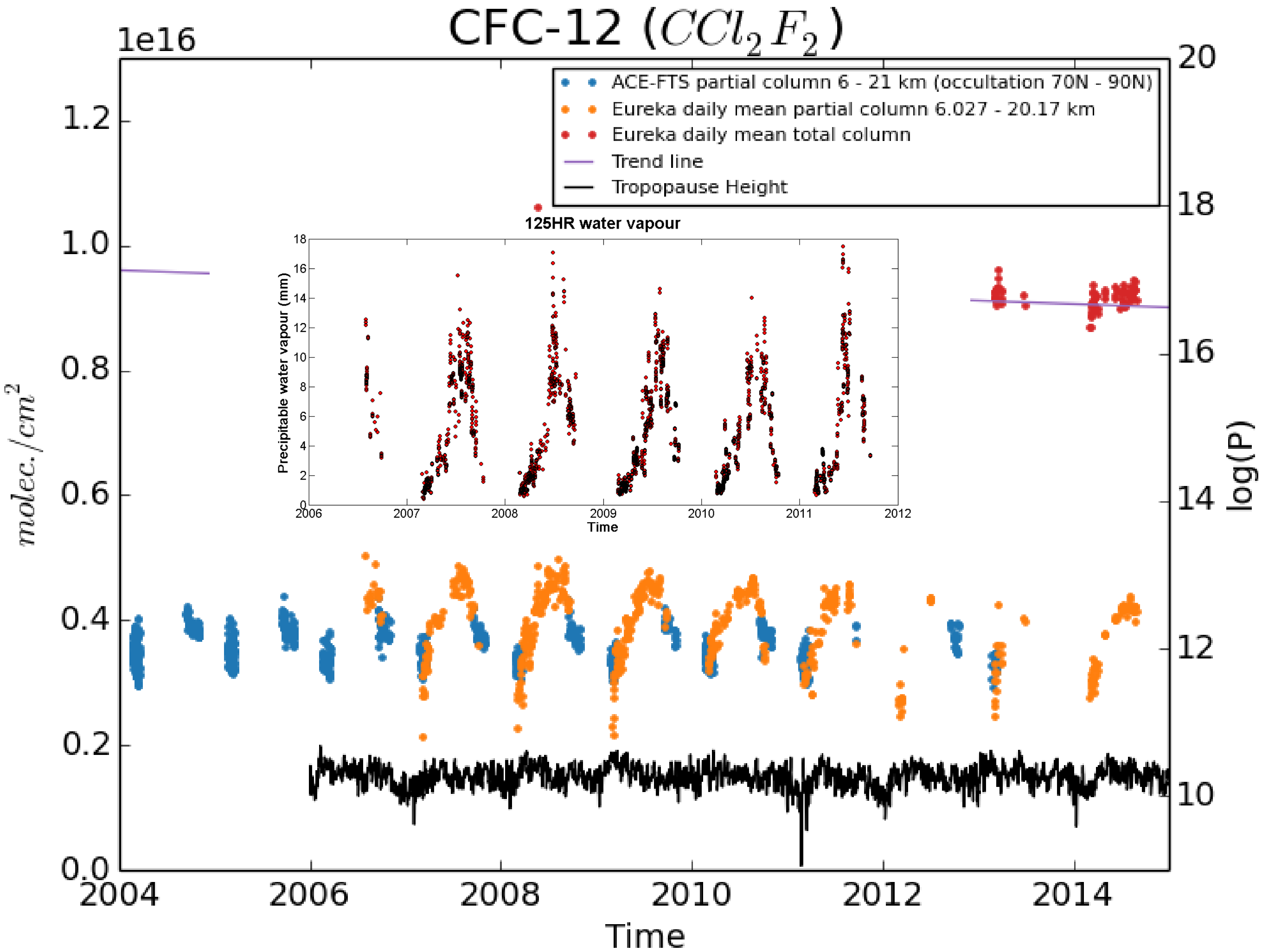
Jungfraujoch (2000-2014)*
$-(0.54 \pm 0.03)$ % year^{-1}

in situ (2004-2010)*
$-(0.39 \pm 0.05)$ % year^{-1}

In Rinsland et al., 2012 it was suggested that the 'seasonal cycle' in CCl_4 may be caused by changes in tropopause height or impact of the strong variation of water vapor

*Mahieu et al, Halogenated source gases measured by FTIR at the Jungfraujoch station: updated trends and new target species, EGU2015. In situ measurements adapted from WMO-2014

Eureka CFC-12



Total Column
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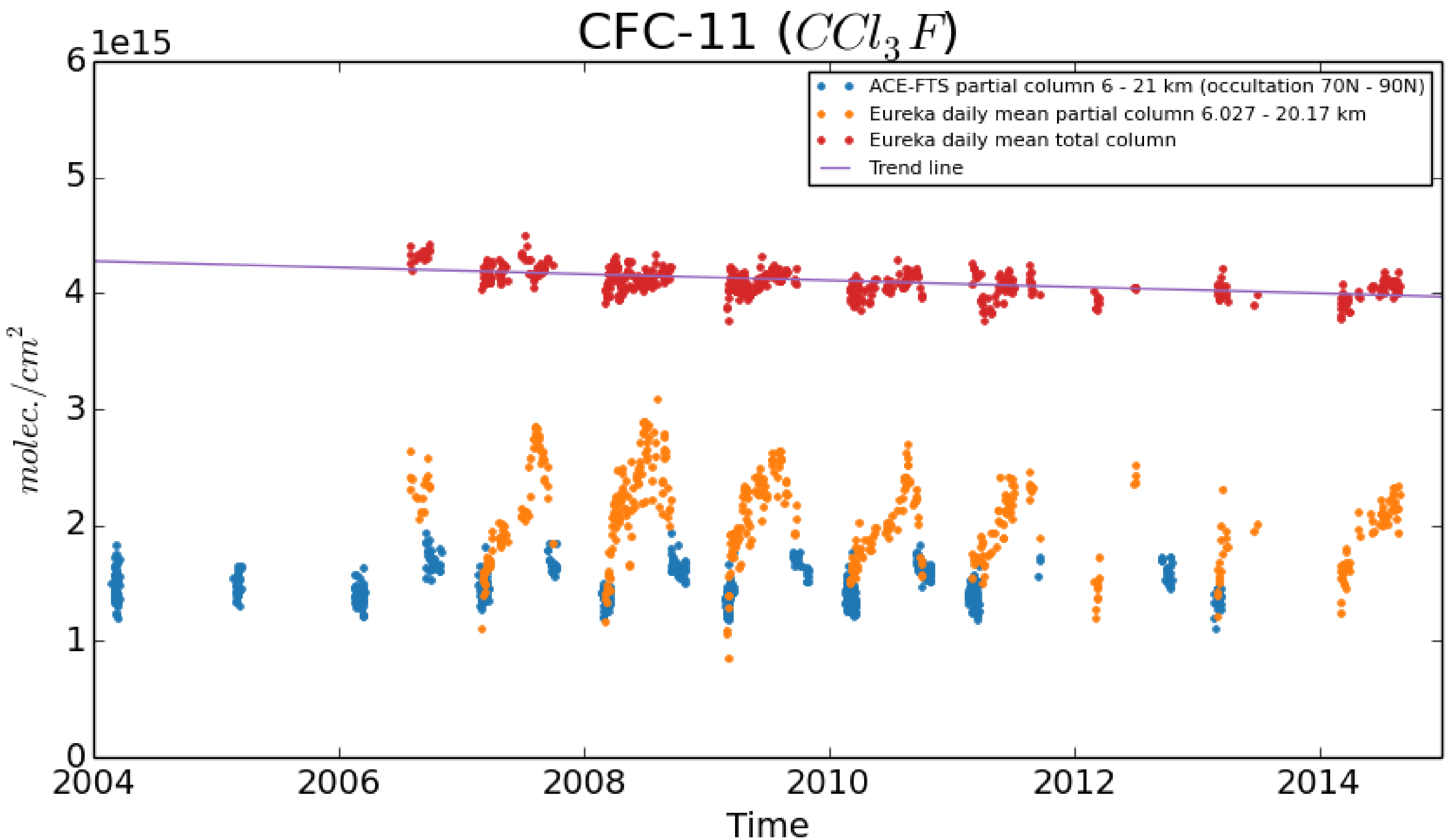
Jungfraujoch (2000-2014)*
-(0.54 ± 0.03) % year^{-1}

in situ (2004-2010)*
-(0.39 ± 0.05) % year^{-1}

MUSICA water vapour retrievals

*Mahieu et al, Halogenated source gases measured by FTIR at the Jungfraujoch station: updated trends and new target species, EGU2015. In situ measurements adapted from WMO-2014.

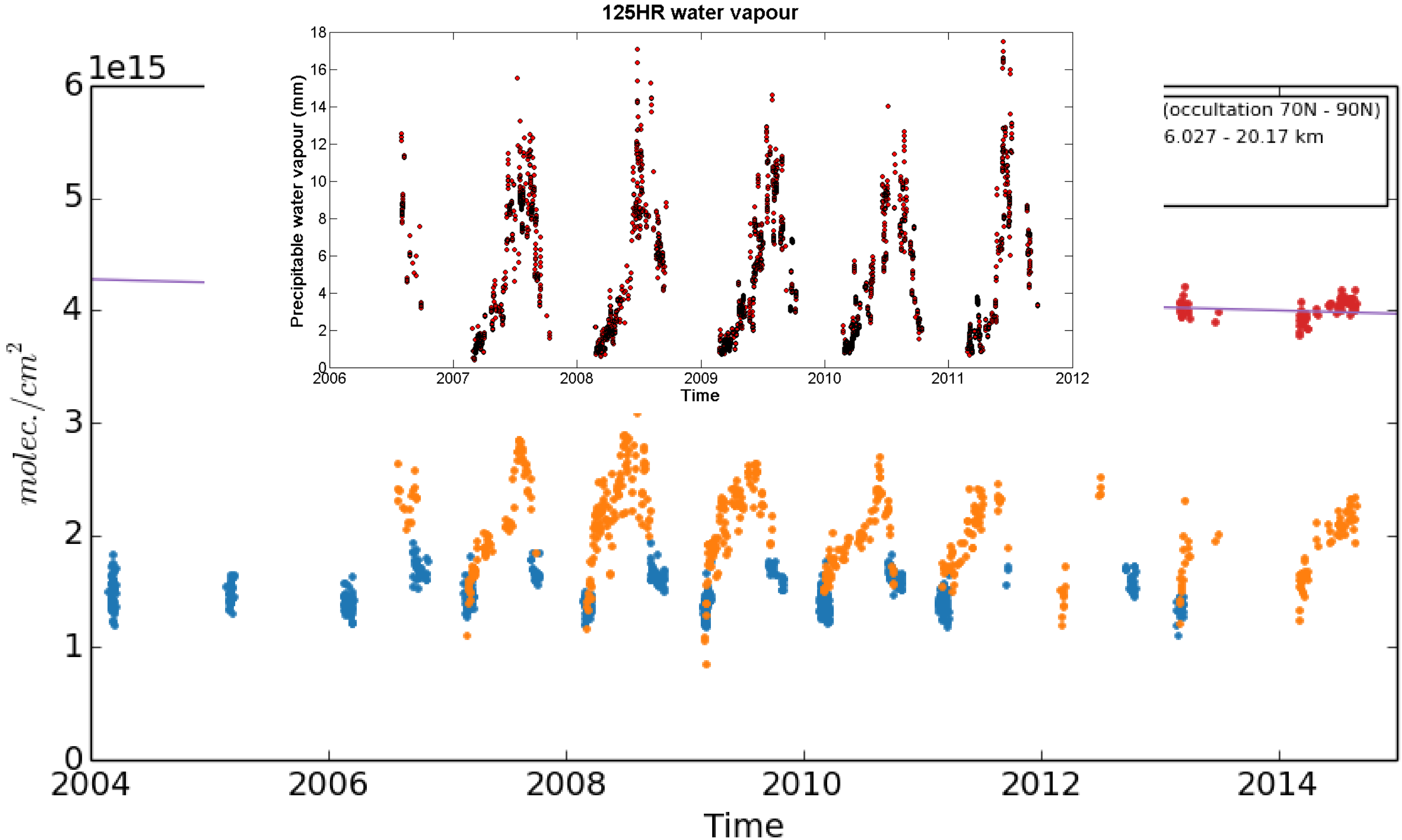
Eureka CFC-11



Total Column	Jungfraujoch (2000-2014)*	in situ (2004-2010)*
-0.66 % $year^{-1}$	-(0.94 ± 0.03) % $year^{-1}$	-(0.82 ± 0.09) % $year^{-1}$

*Mahieu et al, Halogenated source gases measured by FTIR at the Jungfraujoch station: updated trends and new target species, EGU2015. In situ measurements adapted from WMO-2014.

Eureka CFC-11



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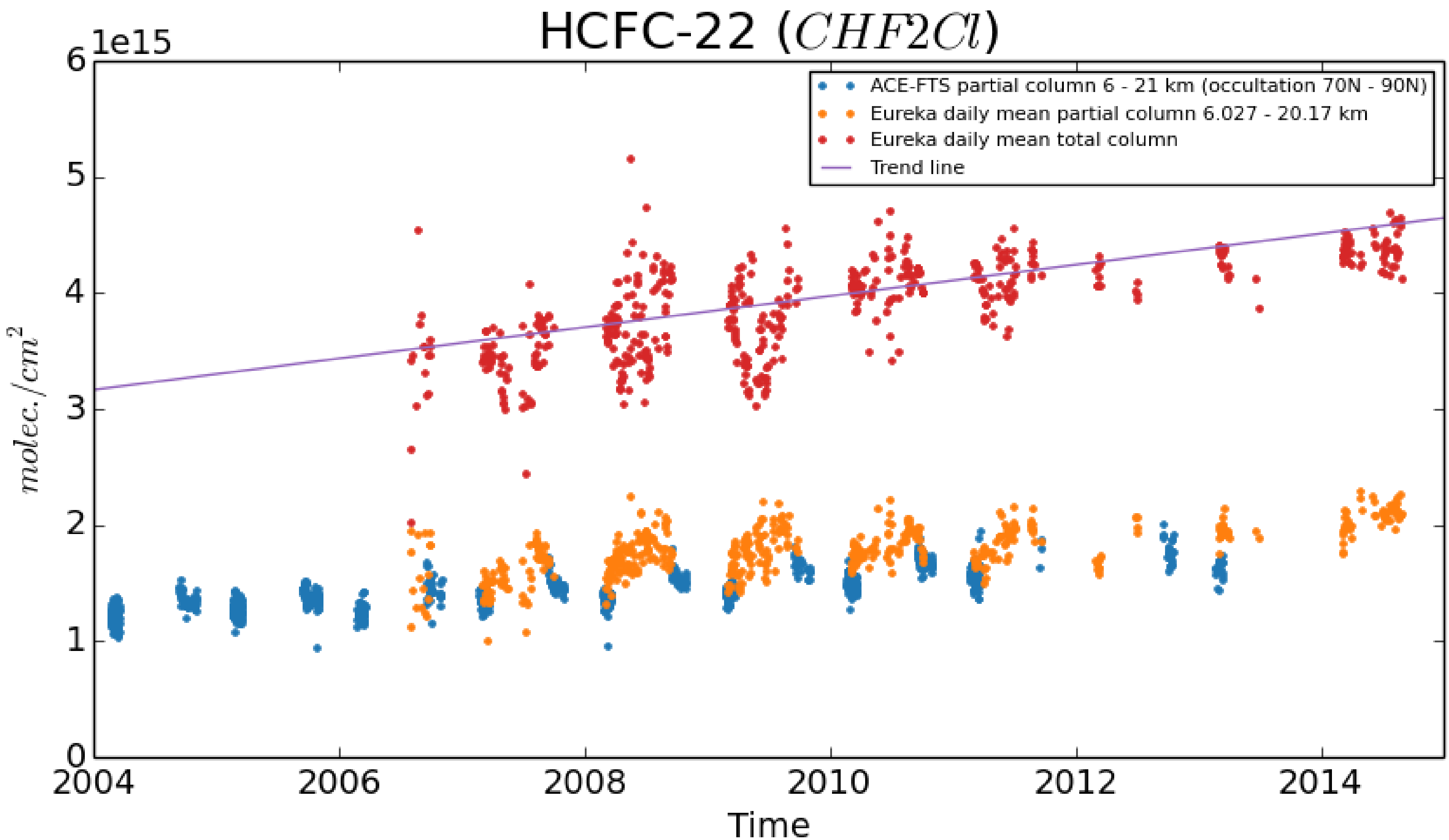
Eureka HCFC-22



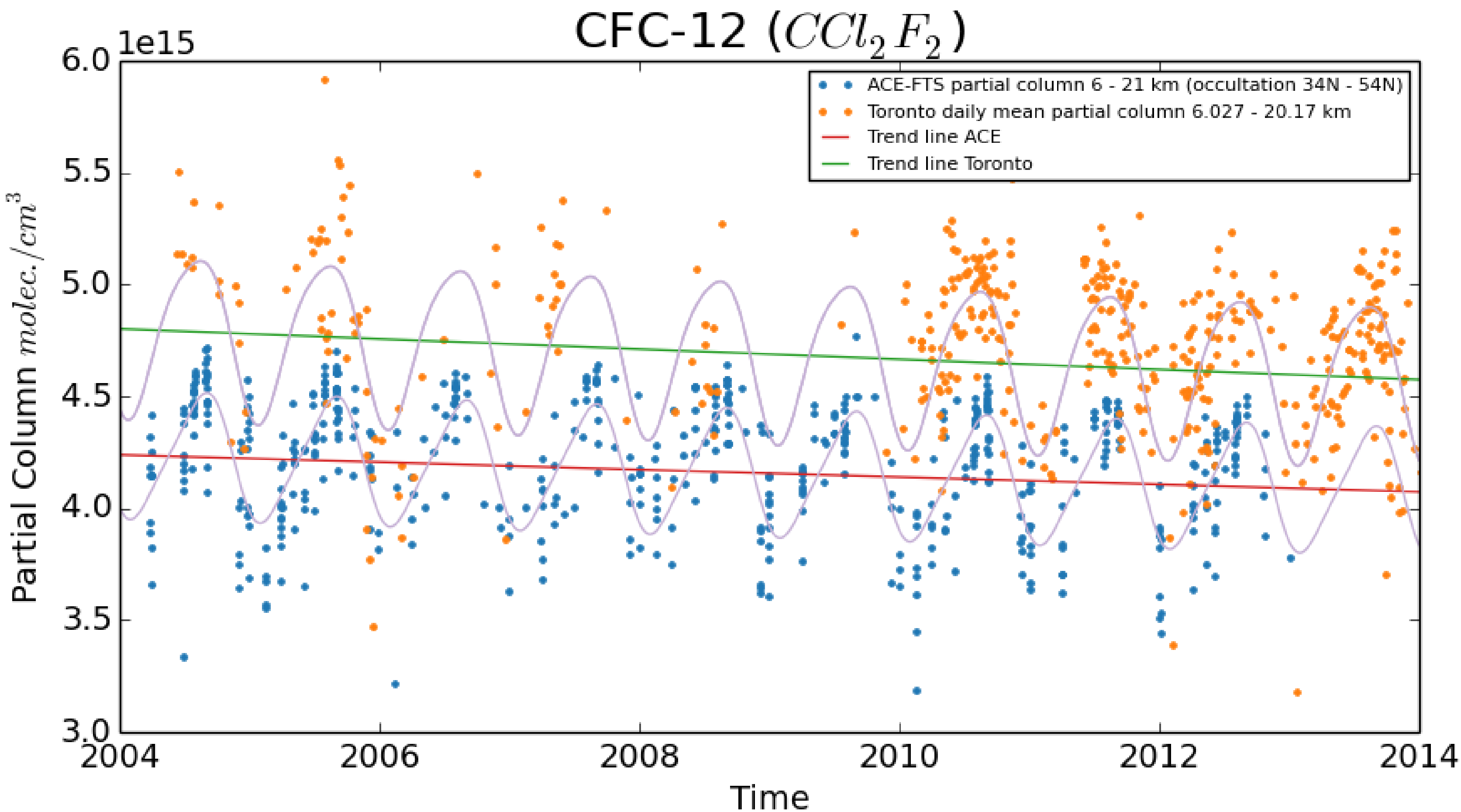
Total Column	Jungfraujoch (2000-2014)*	in situ (2004-2010)*
+3.8 % year^{-1}	+(4.16 ± 0.05) % year^{-1}	+(4.48 ± 0.06) % year^{-1}

*Mahieu et al, Halogenated source gases measured by FTIR at the Jungfraujoch station: updated trends and new target species, EGU2015. In situ measurements adapted from WMO-2014

Future Work

- Resolve solar line issue for CFC-11
- Investigate variability and finalize retrieval strategies for Eureka measurements
- Assess potential for CFC-11, CFC-12 and HCFC-22 retrievals from Toronto measurements
- Refine validation efforts
- Extend the validation to more sites

Toronto CFC-12



- Original plan
  - Jungfraujoch (University of Liege)
  - Poker Flat (NICT Bruker)
  - Toronto (University of Toronto)
  - Eureka: CANDAC Bruker and PARIS-IR (University of Toronto)