First HFC-134a retrievals and analysis of long-term trends from FTIR solar spectra above the Jungfraujoch station

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HFC-134a

- 1,1,1,2-Tetrafluoroethane (CH_2FCF_3)
- Kigali amendment (2016)
- Replaced CFC-12 as preferred refrigerant
- Most abundant HFC in the atmosphere
- Largest contributor to the radiative forcing due to HFCs (44% of 44.1 ± 0.6 mW m^{-2} in 2020)
- Principal atmospheric sink: reaction with OH → TFA & wet deposition

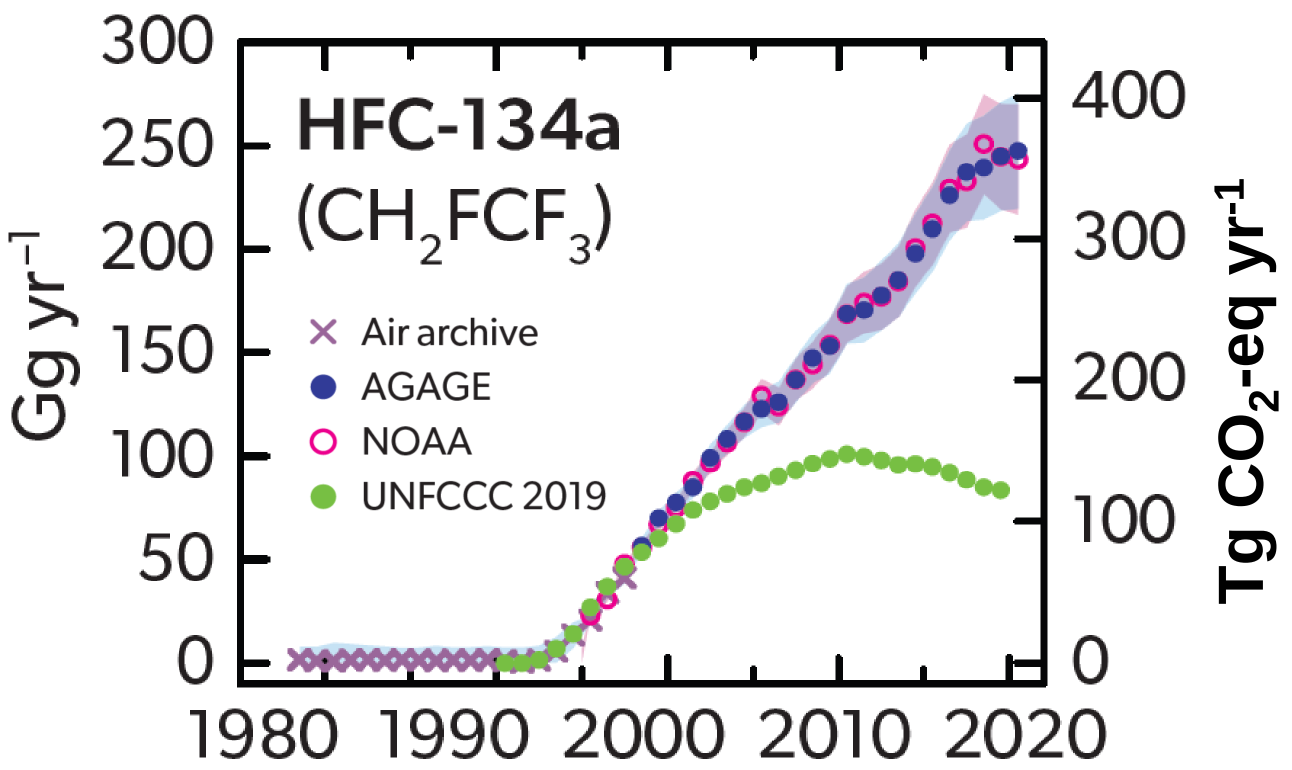
Table 2-1. Lifetimes, the 100-year time horizon GWP, and main applications of the HFCs with the highest atmospheric abundances.

Name	Formula	Lifetime (yr)	GWP-100	Main Applications
HFC-134a	CH_2FCF_3	14	1470	• Refrigerant for mobile and for domestic refrigerators/freezers • Blend component for stationary air-conditioning and commercial refrigeration • Propellant for pharmaceutical aerosols and for industrial aerosols • Blowing agent

Source: WMO, Scientific Assessment of Ozone Depletion, 2022

Tropo: 14.3 yr
Strato: 267 yr
Source: Harrison et al., 2021

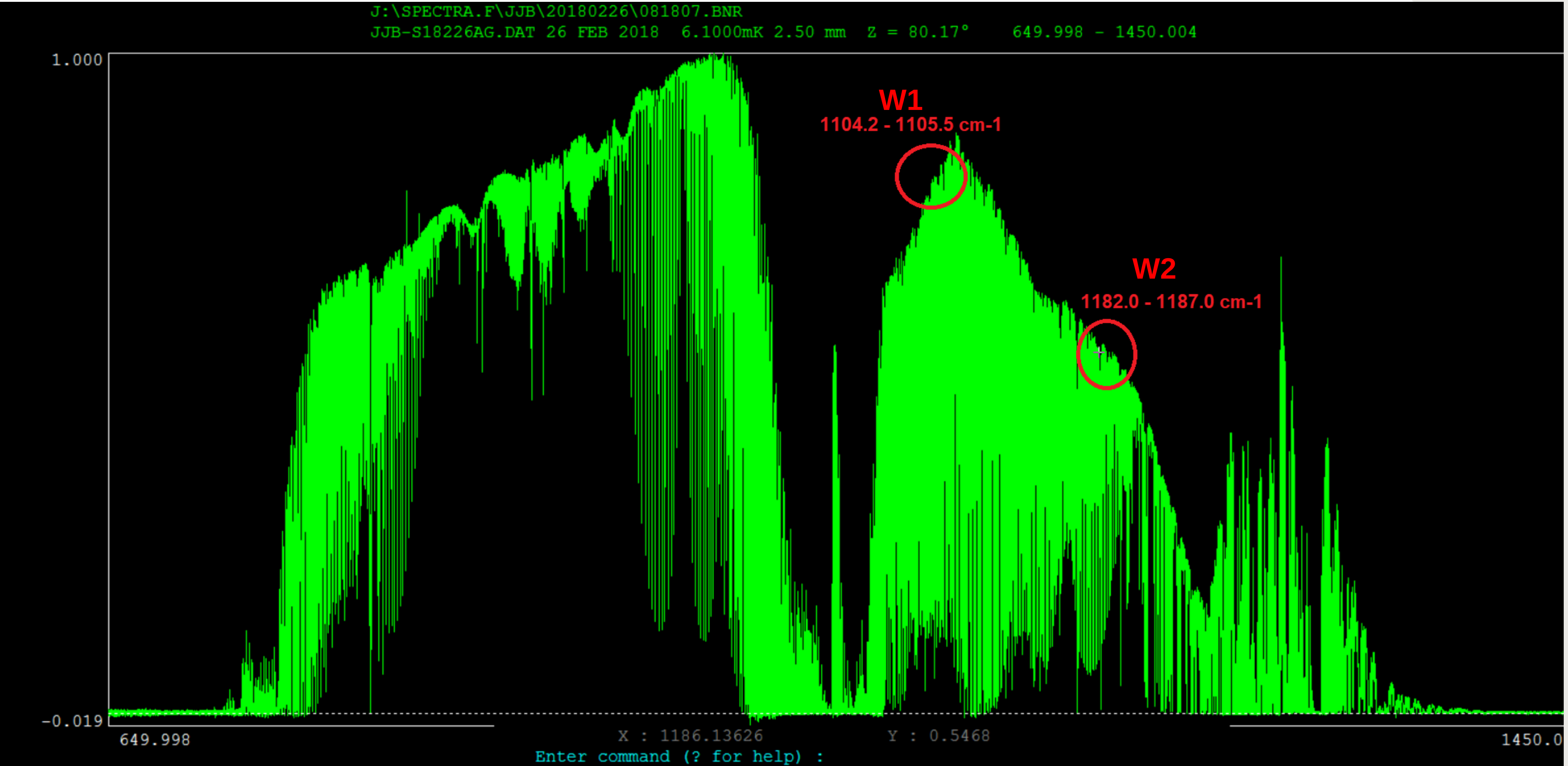
Global emissions



Adapted from Figure 2-2. WMO, Scientific Assessment of Ozone Depletion, 2022

FTIR SOLAR SPECTRA ABOVE JUNGFRAUJOCH STATION

Spectral windows

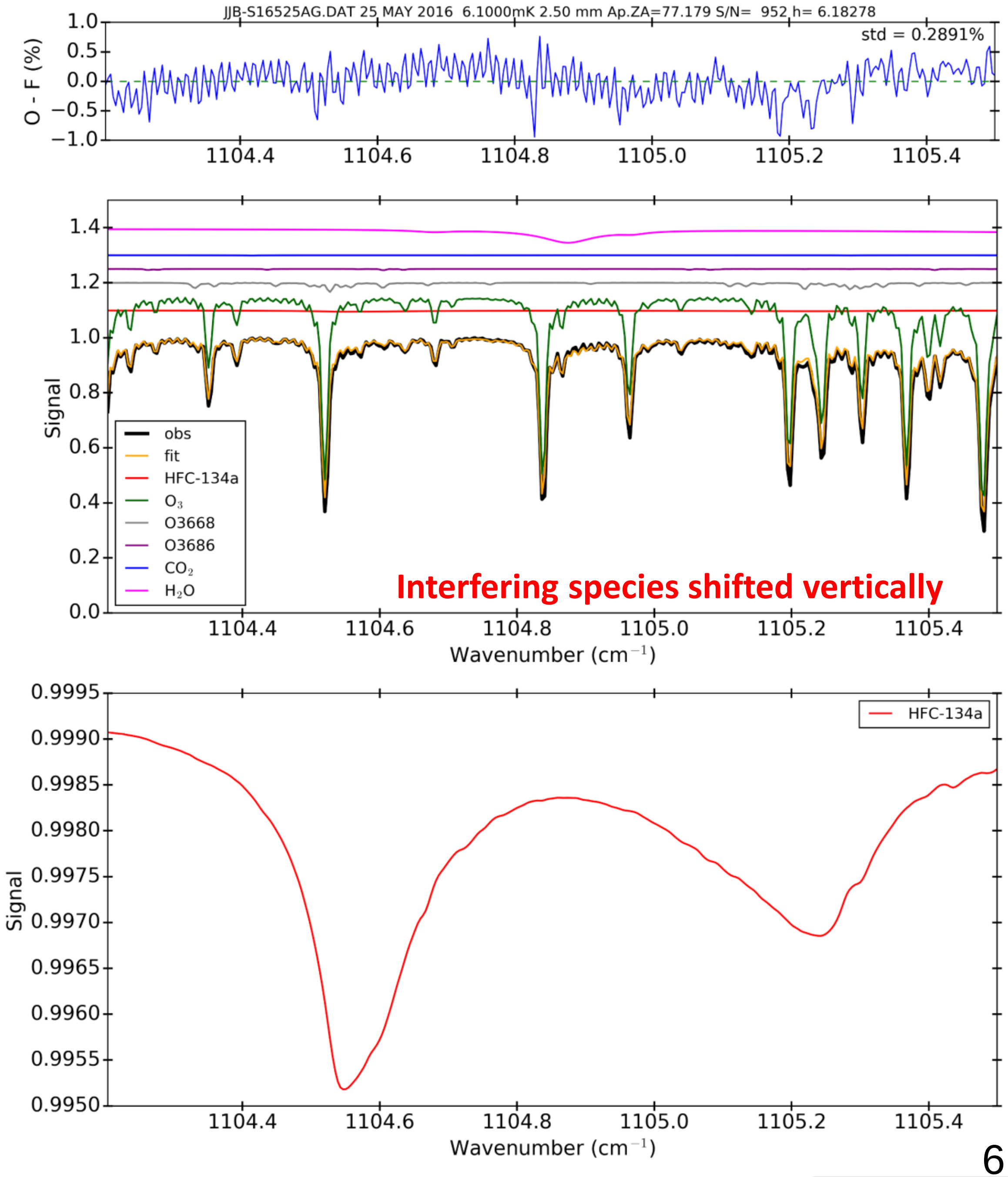


Retrieval strategy

- Bruker IFS-120HR (spectral resolution = $0.0061\ \mathrm{cm}^{-1}$; OPD = $82\ \mathrm{cm}$)
- SFIT-4 v1.0.18
- 41 layers (from 3.58 km to 120 km; thicknesses increase gradually from 0.65 km to 15 km)
- SZA: 60° – 85°
- Interfering species: H_2O, ~~N_2O~~, CO_2, O_3, O3668, O3686, ~~O3667~~
- Spectroscopic parameters:
  - Interfering species: HITRAN2020 (+ATM2020 for H_2O)
  - PLLs from G. C. Toon, including HFC-134a
- Tikhonov regularization
- A priori HFC-134a profiles: ACE-FTS L2 v4.0 2006 VMR (Harrison et al., 2021)
- Time series from 2000 to 2022

W1 = [1104.2 – 1105.5] cm^{-1}

	DOFS	RMS (%)	H_2O tot col $(\mathrm{molec.\,cm^{-2}})$
Mean	1.009	0.32	6.82×10^{21}
Median	1.003	0.29	5.40×10^{21}
S16525AG 25 May 2016	1.002	0.29	7.33×10^{21}



Error budget

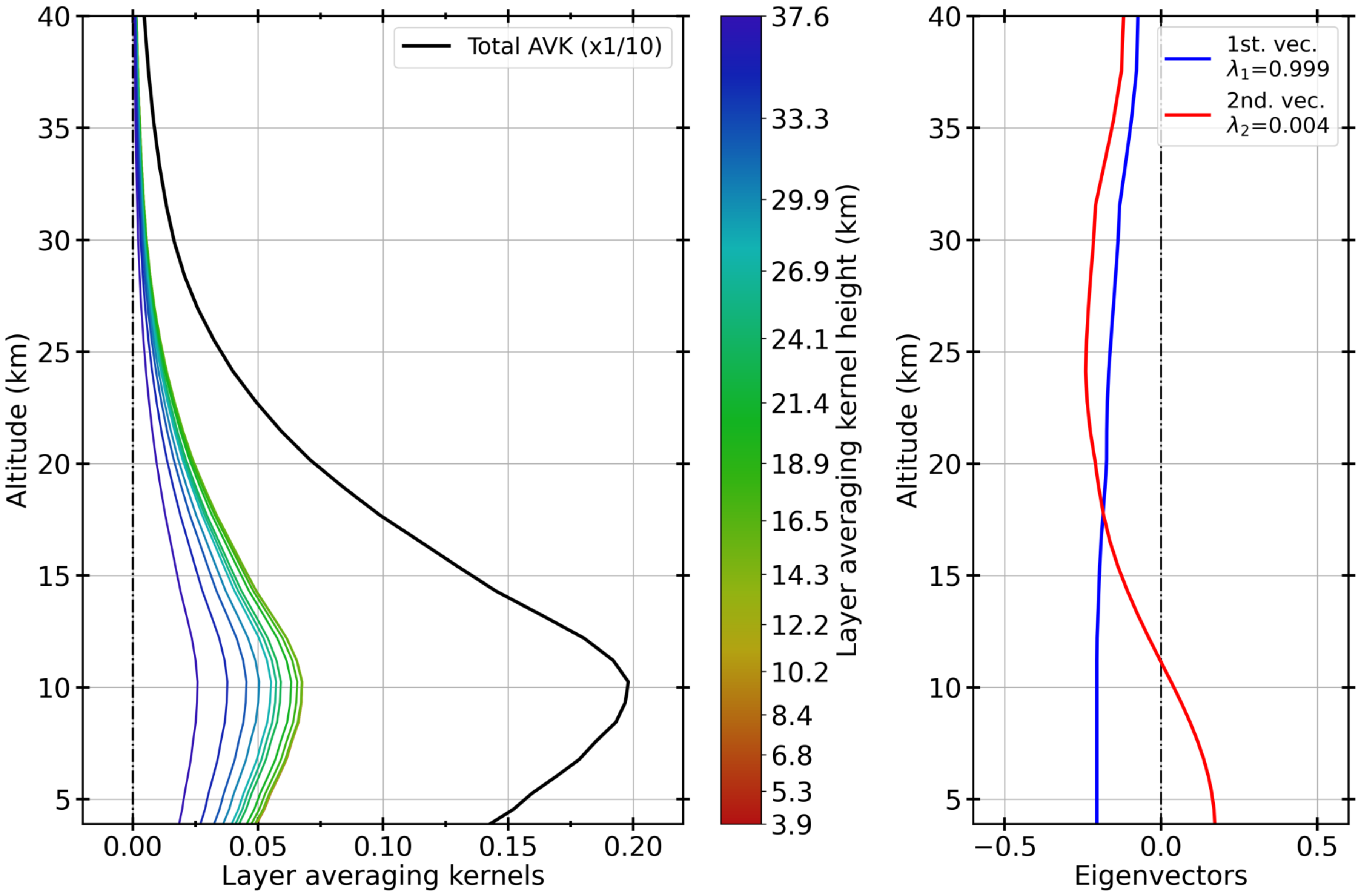
(2008)

Error type and source	Relative uncertainty (%)
Measurement	8.2
Temperature	2.9
SZA	0.3
Interfering species	3.2
Smoothing	1.8
Retrieval parameters	0.2
Total random	**9.4**

Error type and source	Relative uncertainty (%)
HFC-134a line intensity	4.9
Temperature	4.4
SZA	0.1
Total systematic	**6.8**

In progress…

Averaging Kernels and eigenvectors
(2007 – 2009)



OTHER DATASETS FOR VALIDATION

TOMCAT/SLIMCAT model simulations

- Global 3-D CTM
- Abundances of trace gases
- Winds and temperatures: ERA-Interim
- 2.8° × 2.8° horizontal resolution
- Input values: NOAA global mean surface VMR
- Simulations for Jungfraujoch site
- 2000 – 2018

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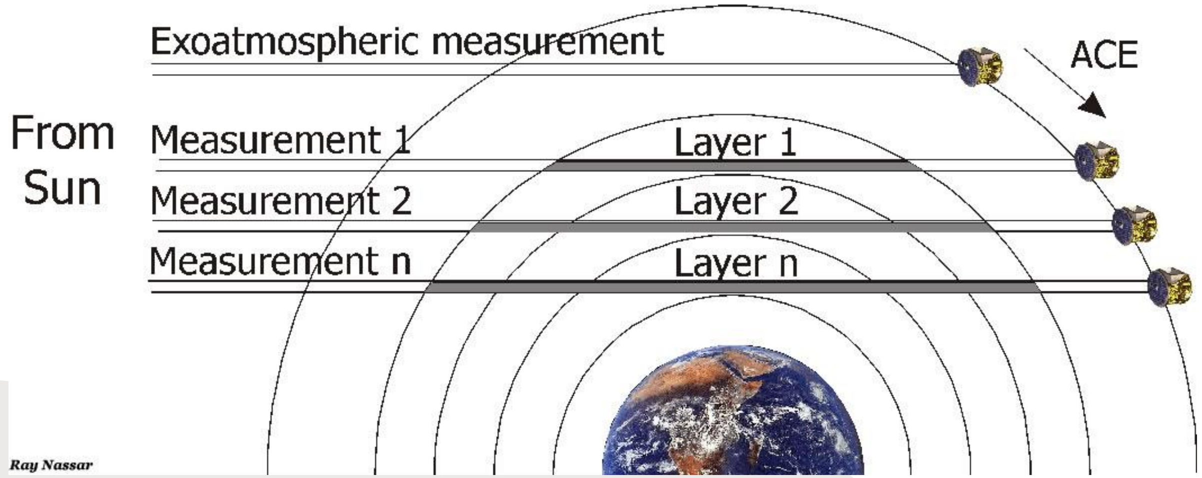
ACE-FTS satellite data

- FTS (750 – 4400 cm^{-1})
- Solar occultations
- Spectral resolution: 0.02 cm^{-1}
- ACE-FTS L2 v5.1 VMR retrievals
- 2004 – 2022



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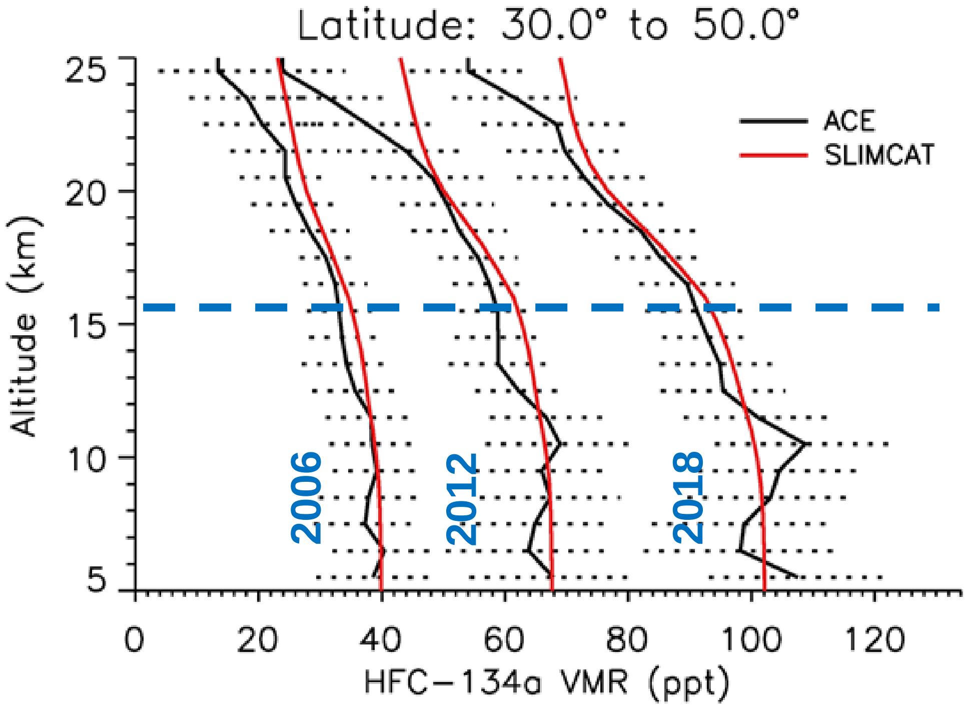
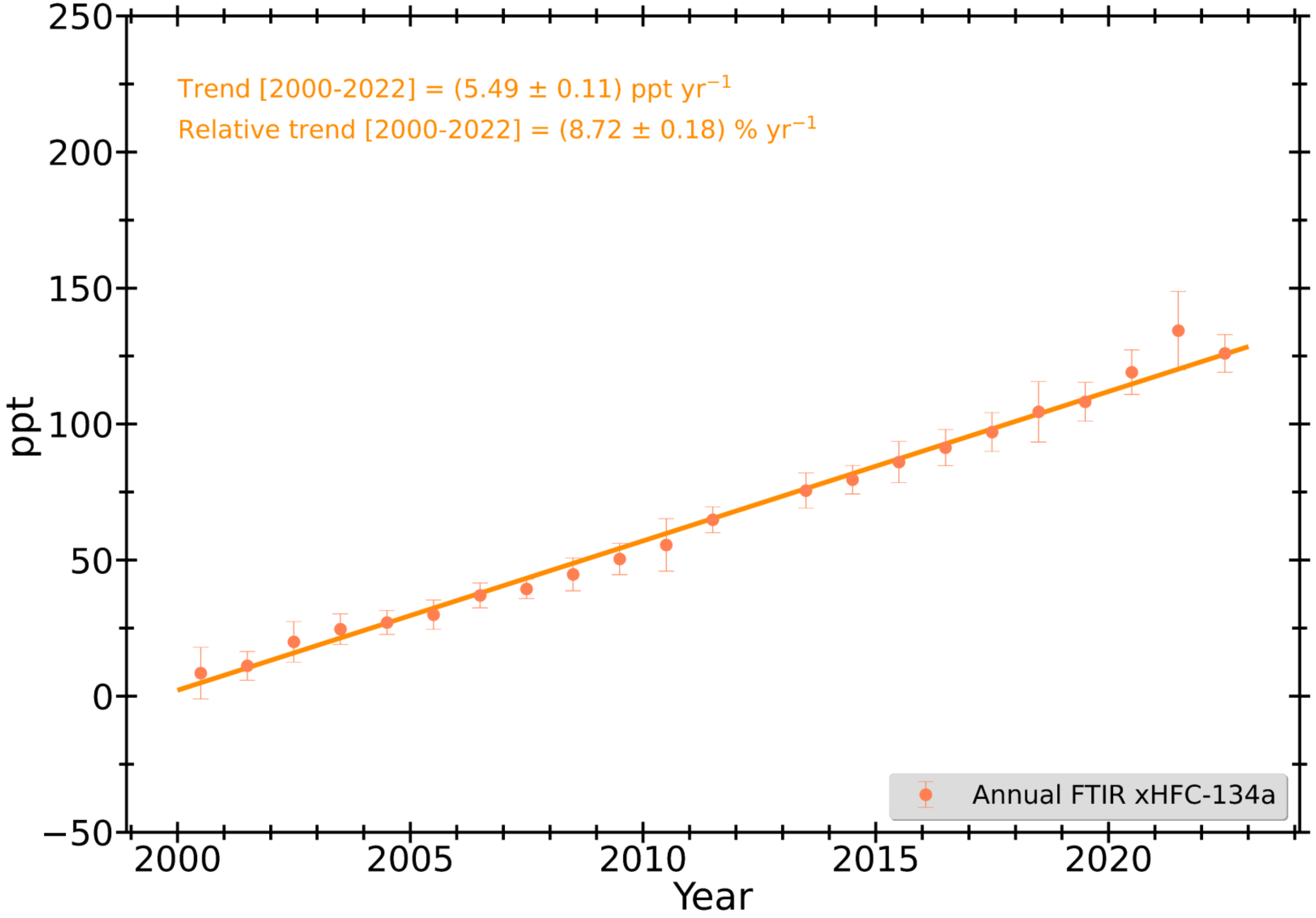


Source: Harrison et al., 2021

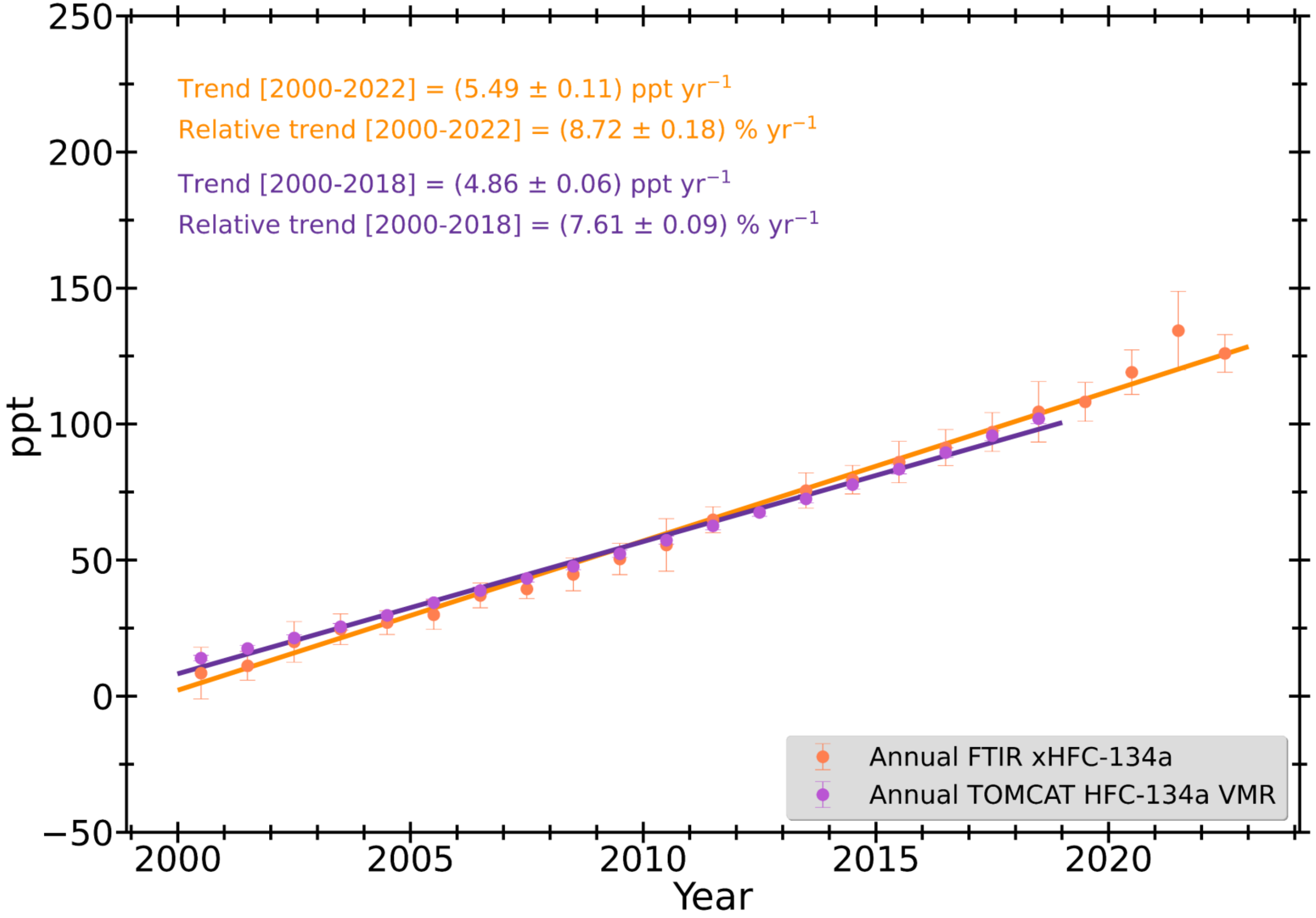
RESULTS

HFC-134a long-term trends

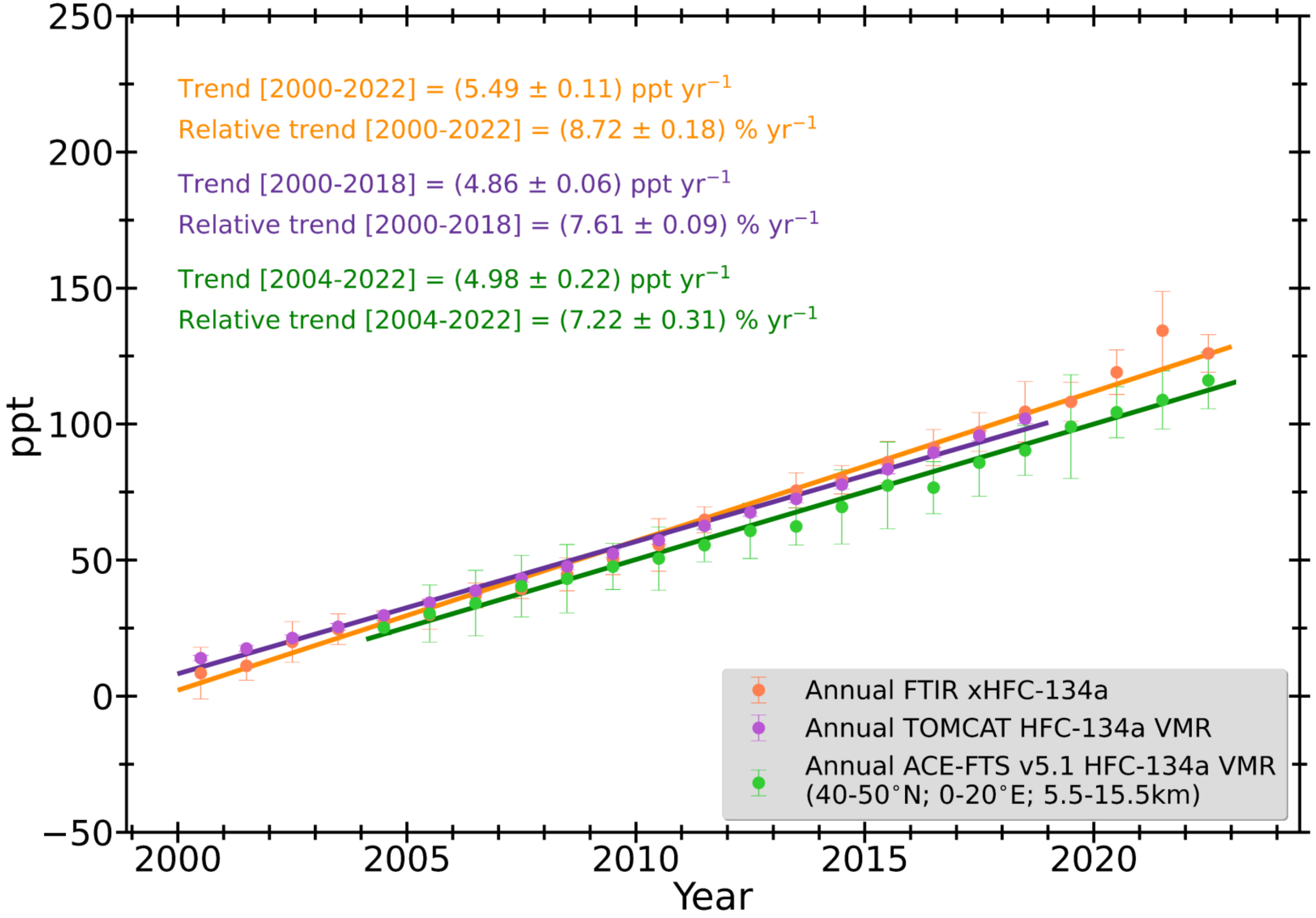
HFC-134a long-term trends



HFC-134a long-term trends



HFC-134a long-term trends



HFC-134a long-term trends

[2004 – 2018]

Dataset	Trend (ppt/yr)	Relative trend (%/yr)
xHFC-134a JFJ	5.56 ± 0.14	8.86 ± 0.23
TOMCAT VMR	5.10 ± 0.05	8.02 ± 0.08
ACE-FTS VMR	4.62 ± 0.32	8.00 ± 0.56

Conclusions and prospects

- First HFC-134a retrievals from ground-based FTIR observations
- Trend ≈ 8% yr^{-1}
- Consistent with other time series

- Retrievals before 2000
- 2 different spectral windows in the W1 (1104.2 – 1105.5 cm^{-1})
- Obtain more information from W2 (1182.0 – 1187.0 cm^{-1})
- Other interfering species

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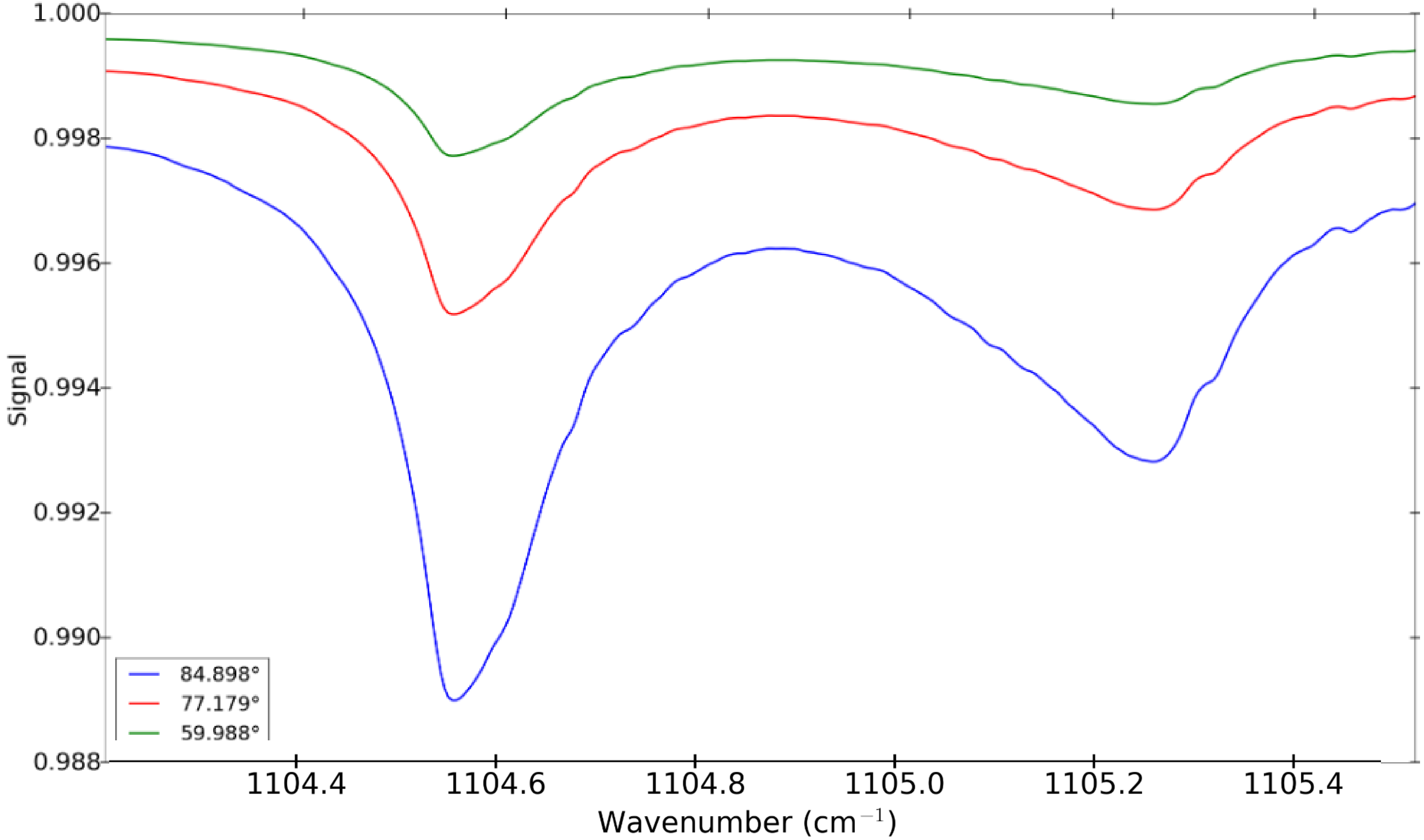
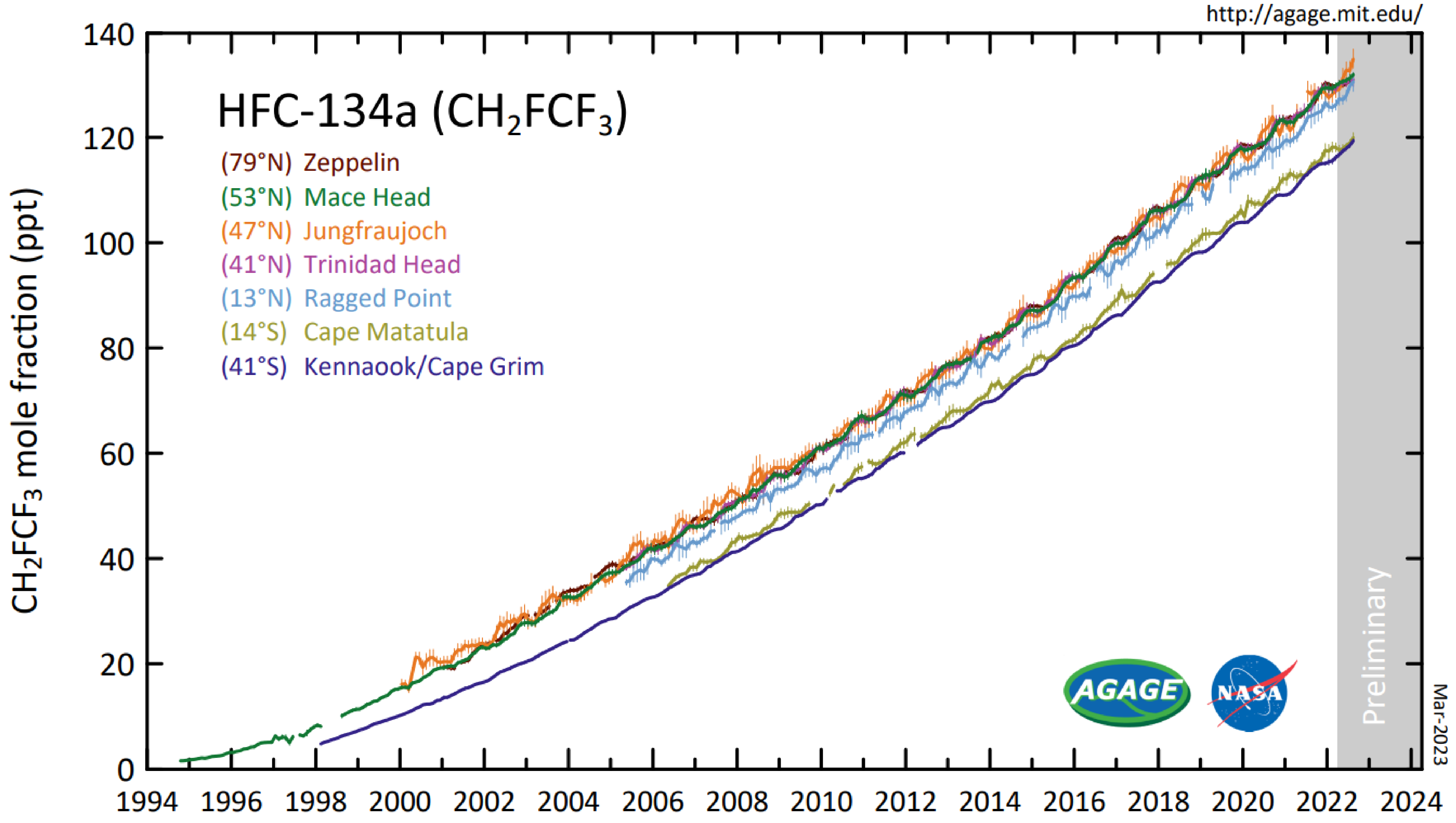
16/05/2003

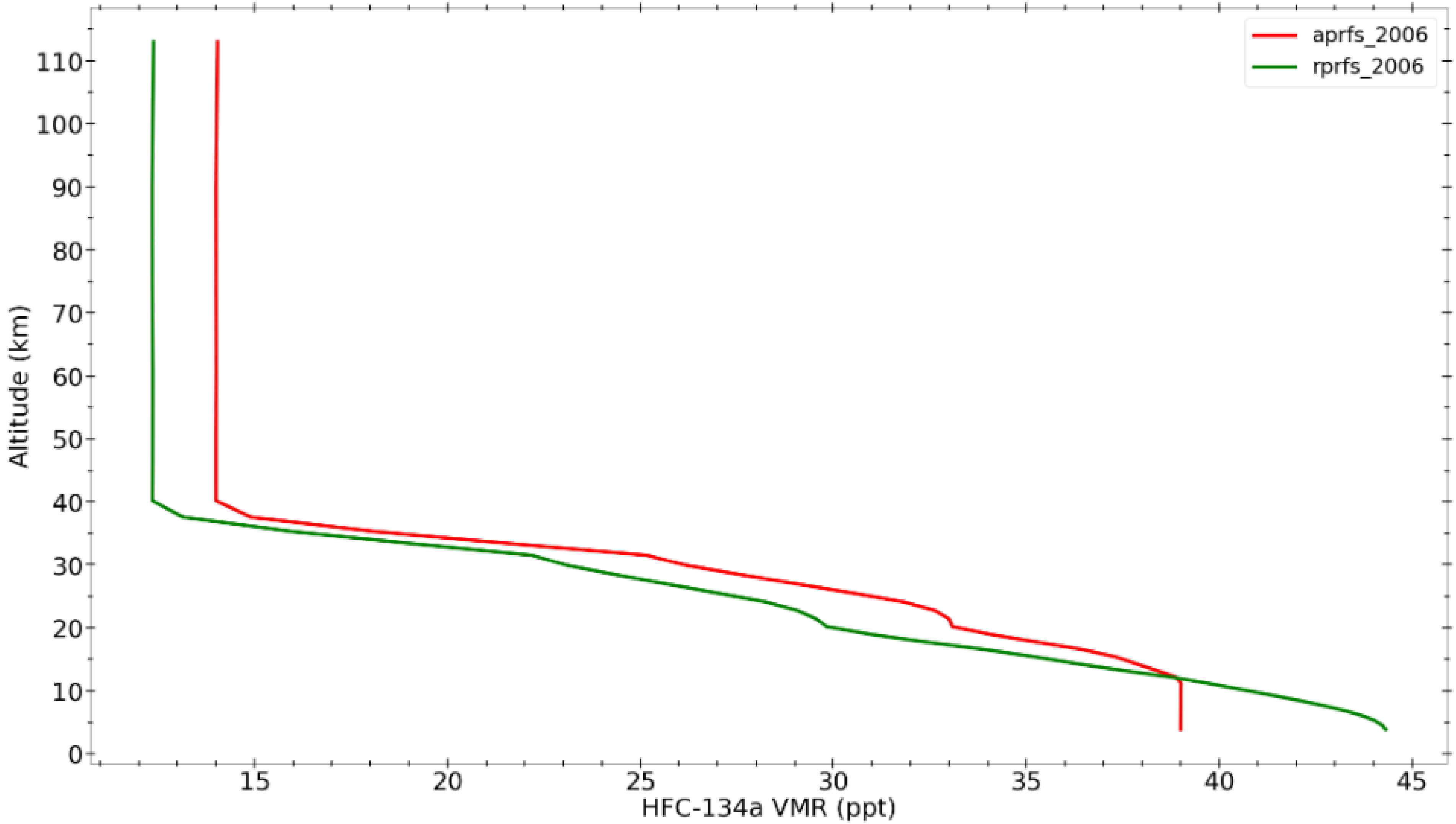
25/05/2016

15/03/2007

Influence of the SZA on the depth of the HFC-134a signal




http://agage.mit.edu/
HFC-134a (CH_2FCF_3)
(79°N) Zeppelin
(53°N) Mace Head
(47°N) Jungfraujoch
(41°N) Trinidad Head
(13°N) Ragged Point
(14°S) Cape Matatula
(41°S) Kennaook/Cape Grim
CH_2FCF_3 mole fraction (ppt)
0
20
40
60
80
100
120
140
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Preliminary
Mar-2023
AGAGE
NASA


aprfs_2006
rprfs_2006
Altitude (km)
HFC-134a VMR (ppt)
0
10
20
30
40
50
60
70
80
90
100
110
15
20
25
30
35
40
45