Comparison of IASI CH_4 retrievals based on ASIMUT and RTTOV

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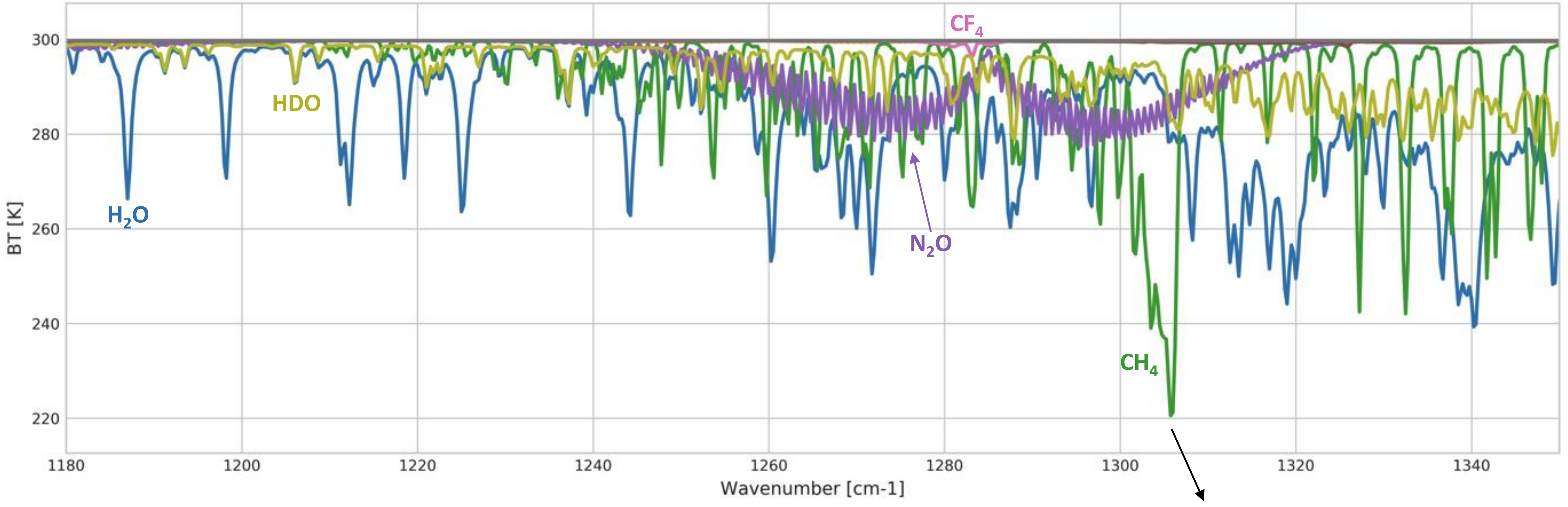
Overview

- Methane in the thermal infrared with IASI
- An overview of ASIMUT & RTTOV
- Comparison of RTM simulations
- Comparing ASIMUT and RTTOV retrievals
  - Temperature retrieval
  - CH_4 Line-Mixing
  - RTM
- Very Preliminary comparison with in-situ data

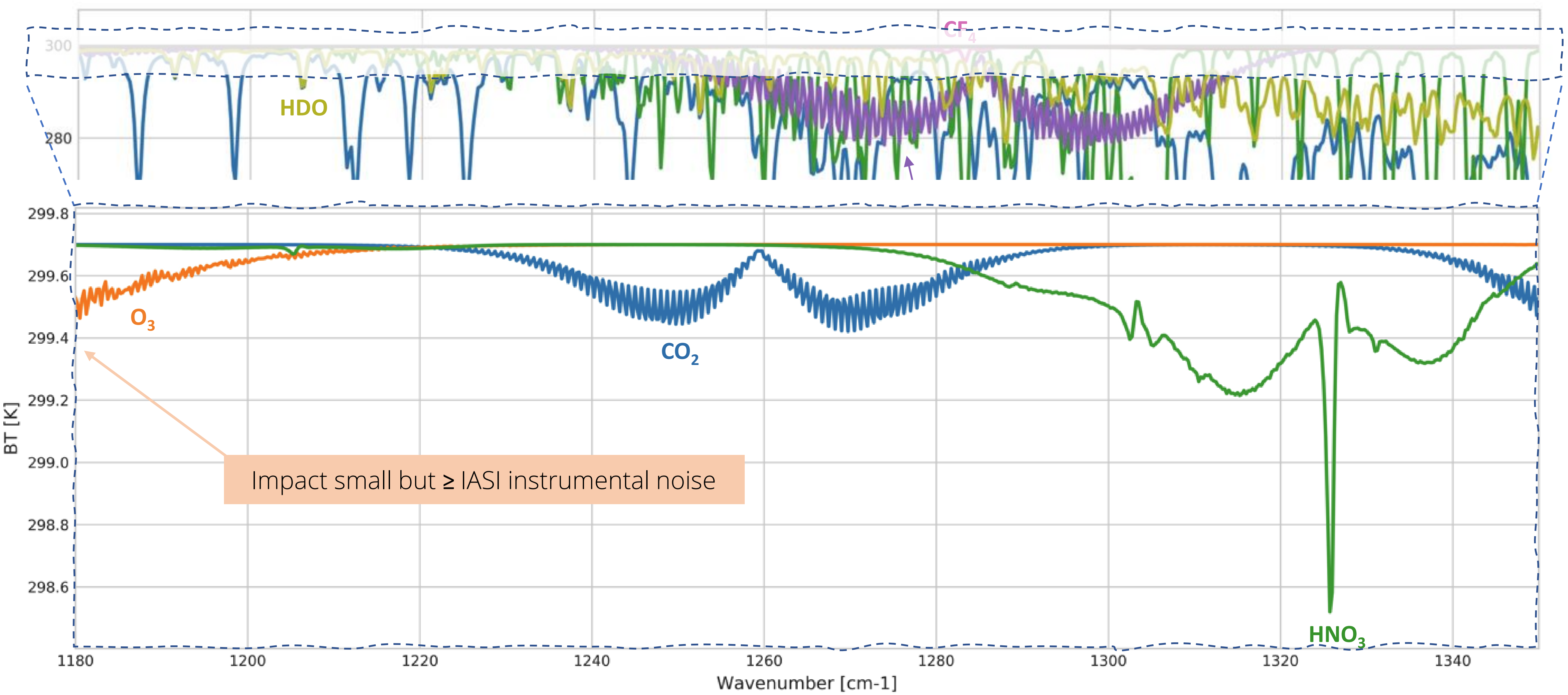
Retrieval of methane in the TIR

Top-of-Atmosphere BT contributions from different species



CH_4 Q-branch in ν_4 band where line-mixing is important

Retrieval of methane in the TIR



Radiative Transfer and Inverse Models | ASIMUT & RTTOV

RTM

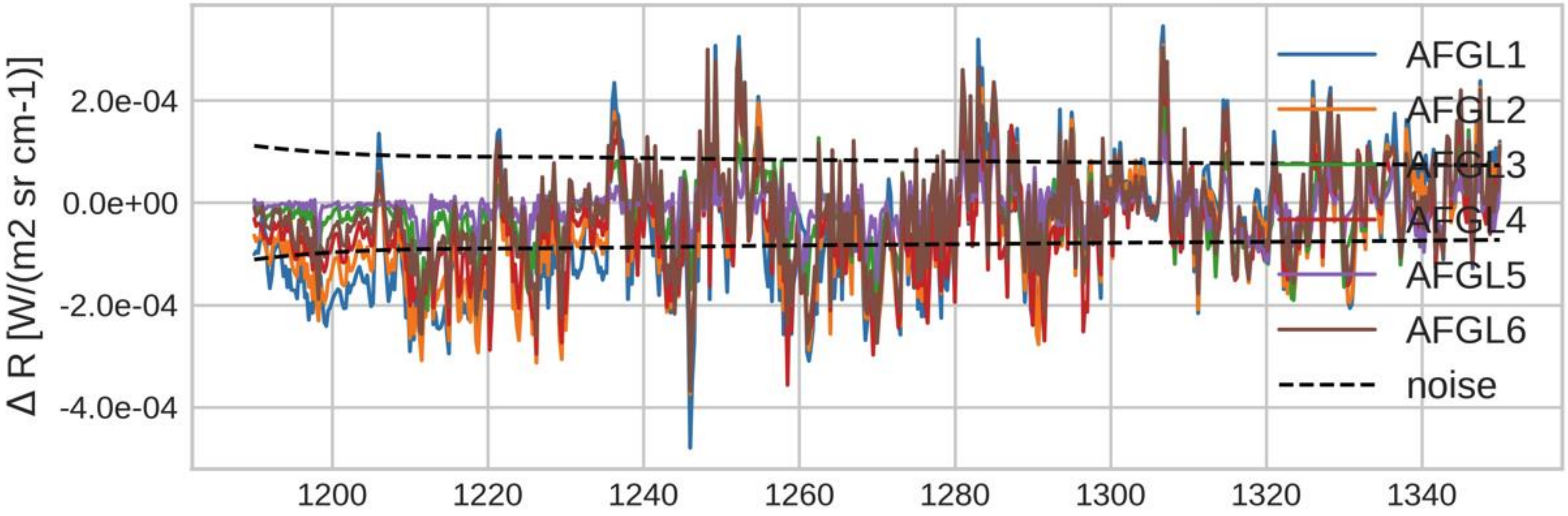
	ASIMUT	RTTOV
RTM	Full line-by-line (LBL) optical depth (OD) can be computed « in stream »	Coefficient files pre-computed using LBLRTM v12.2
Spectroscopic data base	HITRAN 2020 but large flexibility	LBLRTMv12.2/AER 3.2
H_2O Continuum	MTCKD 3.4	MTCKD 2.5.2
Fixed species considered	Flexible	O2, NO, NO2, HNO3, OCS, N2, CCL4, CFC-11, CFC-12, CFC-14, NH3, OH, HF, HCl, HBr, HI, ClO, H2CO, HOCl, HCN, CH3Cl, H2O2, C2H2, C2H6
LUT	Can be generated for LBL species and for cross-section species, but not for continuum User specified (P,T) grid	Coefficient files for visible and infrared. ->Temperature, H2O and O3 profiles sampled from the ECMWF reanalysis fields (Chevallier et al., 2006), -> For variable trace gas profiles: Copernicus Atmosphere Model reanalysis fields were used
Spectral sampling step	Defined by the user	Variable with RTM layering (LBLRTM strategy)
Layering	Defined by the user	Based on 101 levels, but can be provided by the user
CH4 Line-Mixing	Yes (based on Tran et al., 2006)	Based on AER line-coupling (different approach)

Inversion

		ASIMUT	RTTOV
Retrieval Method		OEM	OEM
Retrieved parameters	**Surface**	T_{surf} e(s) and albedo can be fitted	T_{surf}
	T profile	Presently fixed, upcoming retrieved T profile	Can be retrieved
	Species	Flexible	T, H_2O, O_3, CO_2, CH_4, N_2O, CO, SO_2
	species	Flexible	H_2O, N_2O, CO, CH_4

Comparison of RTMs for atmospheres (AFGL)

RTTOV - ASIMUT

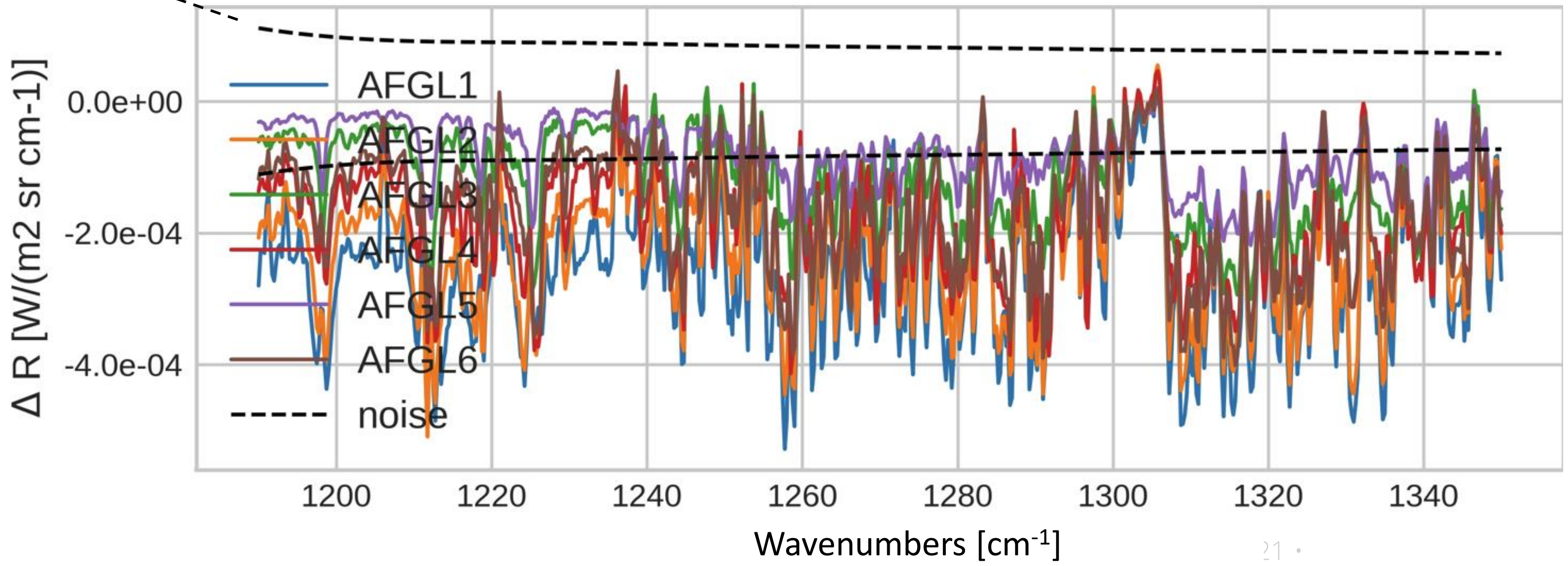


Atmospheres

- Tropical
- Midlatitude summer
- Midlatitude winter
- Subarctic summer
- Subarctic winter
- US Standard

IASI instrumental noise (CNES)

RTTOV - σ-IASI (UniBas)



→ Differences between RTMs are larger than the instrumental noise

Comparison Study | Introduction

Impact of RTM	→ ASIMUT, RTTOV
impact of state vector	→ T retrieval
impact of regularization	→ Tikhonov ~~vs pure OEM~~
impact of spectroscopy	→ CH_4 line-mixing

Data

- ~700 Clear-sky IASI Observations (METOP-A) near Hawaii (January 2016)
- PCC-based radiances (lower noise)

Retrieval set-up

- Temperature and H_2O from EUMETSAT (IASI L2)
- Extended spectral domain with useful information on CH_4, surface, perturbing species, avoiding too strong contribution of H_2O
- Species considered in ASIMUT retrieval the state vector : CH_4, N_2O, H_2O, HDO, CF_4, HNO_3, O_3, CO_2
- Species considered in RTTOV retrieval the state vector: CH_4, N_2O, H_2O (and T in some case)

Retrieval versions

RTTOV

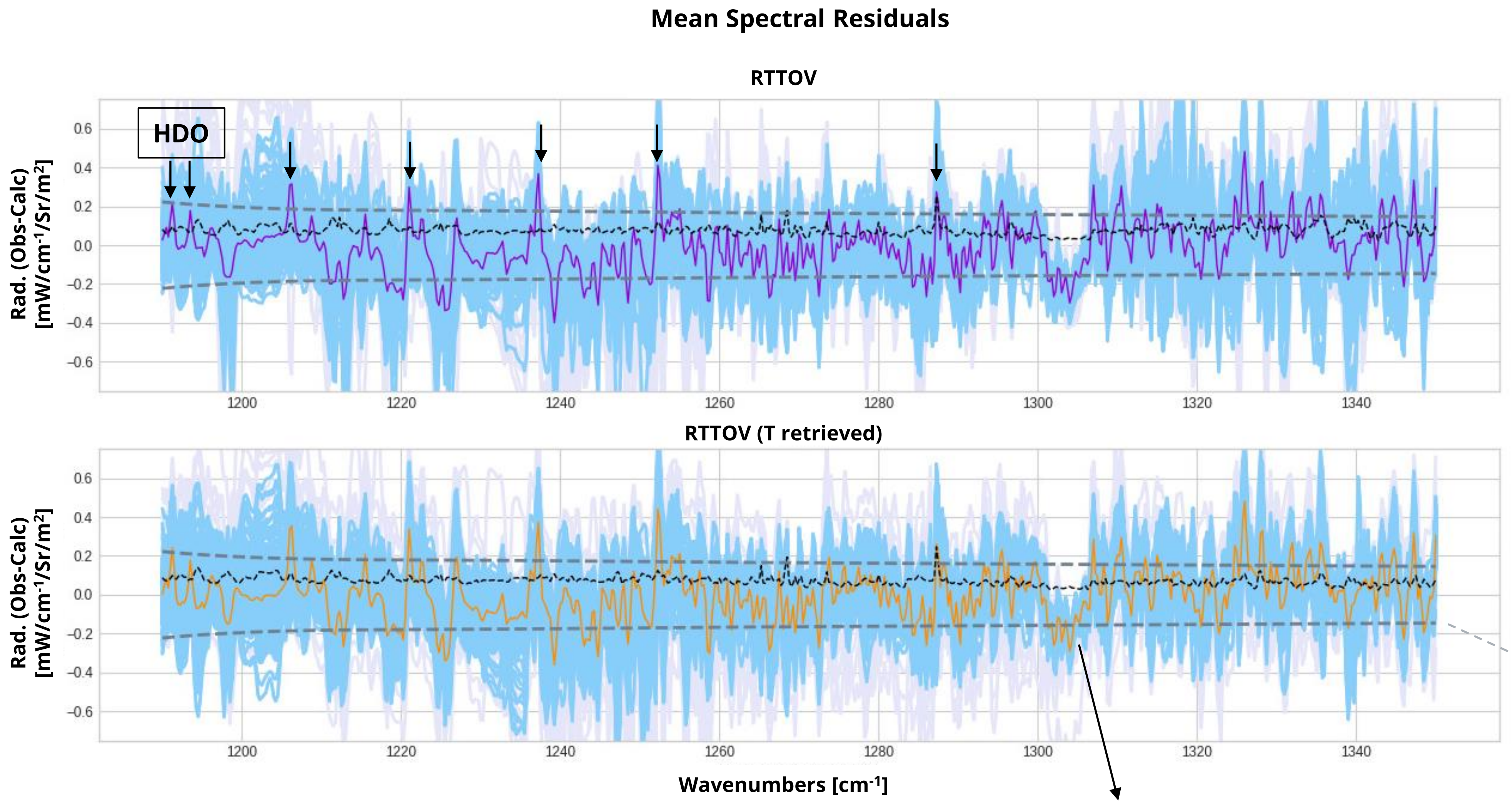
- CH_4, N_2O, H_2O
- CH_4, N_2O, H_2O, T

ASIMUT

- "standard" CH_4 spectroscopy
- CH_4 including Line-Mixing effects

Comparison | RTTOV

→ Testing the impact of adding the temperature profile to the state vector



Version	χ^2
standard	1.01
T retrieved	0.968

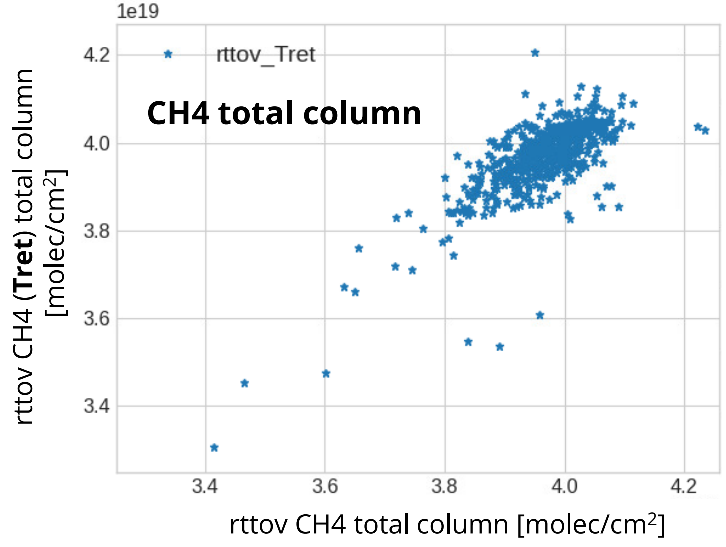
Version	CH4 DOFs
standard	1.9
T retrieved	1.3

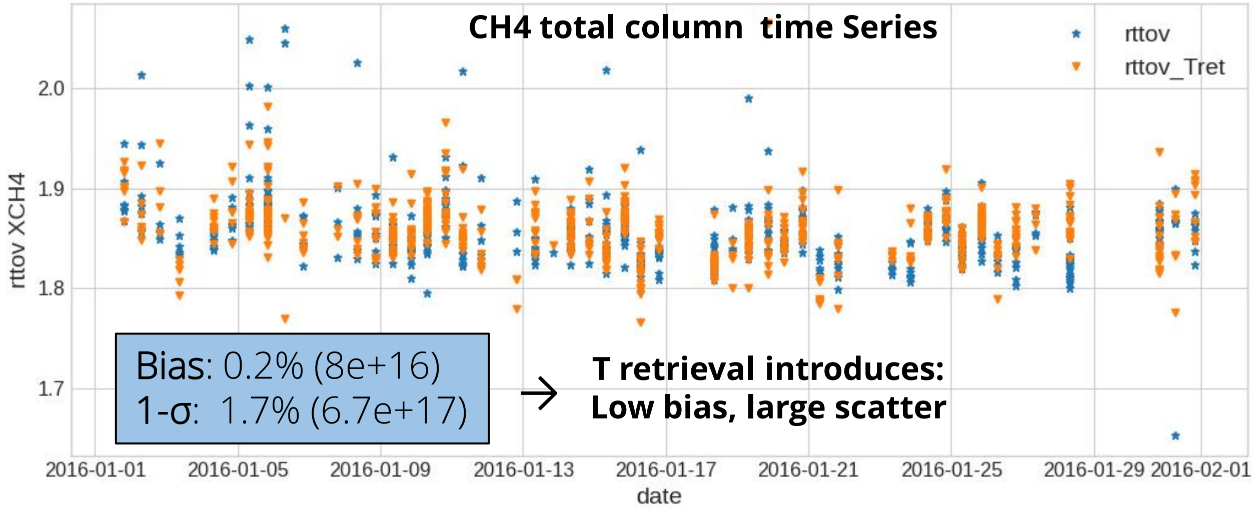
Instrumental noise (CNES) inflated by a factor of 2

CH_4 Q-branch improved residuals

Comparison | RTTOV

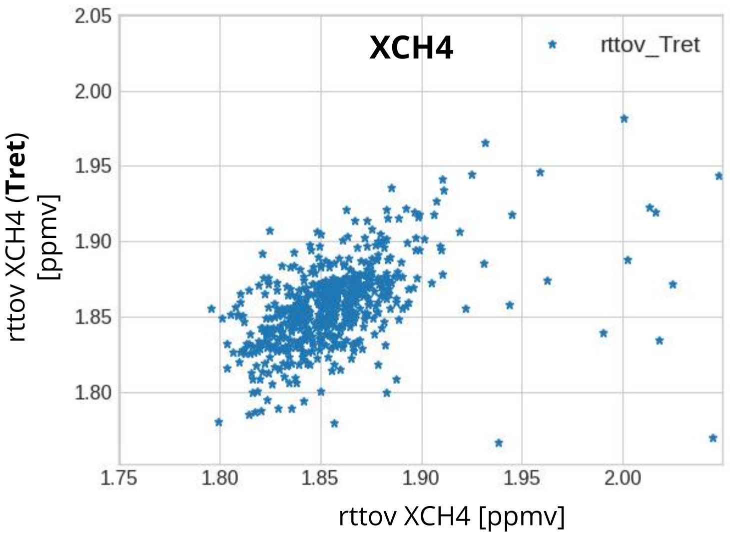
→ Testing the impact of adding the temperature profile to the state vector

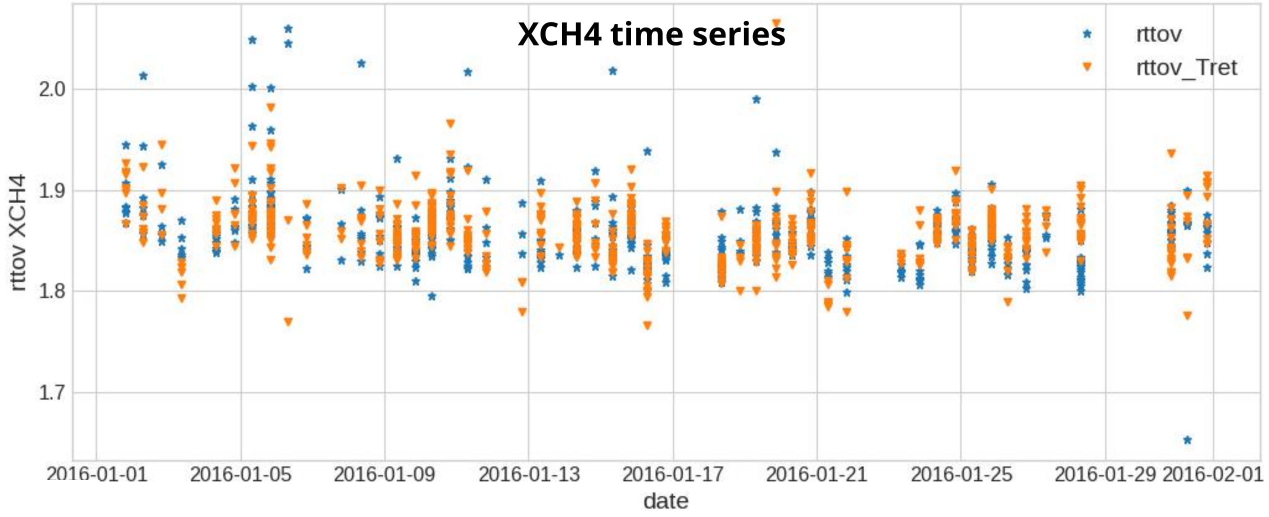




Bias: 0.2% (8e+16)
1-σ: 1.7% (6.7e+17)

→ **T retrieval introduces: Low bias, large scatter**

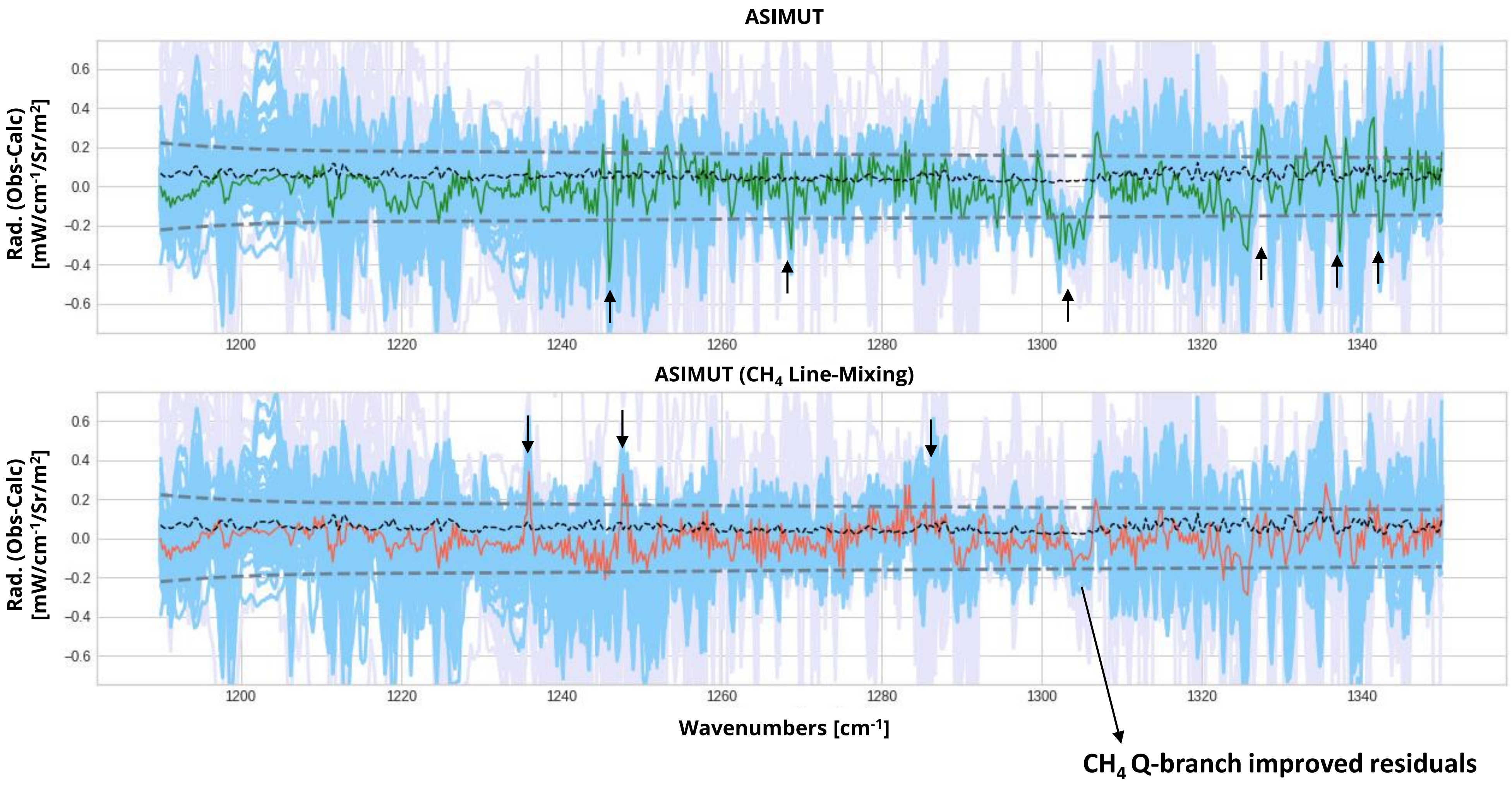




Comparison | ASIMUT

→ Testing the impact of adding Line-Mixing effects to methane

Mean Spectral Residuals

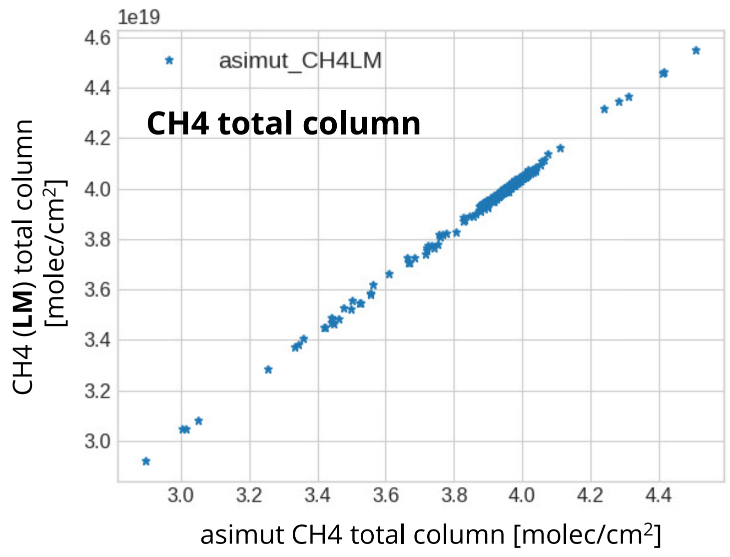


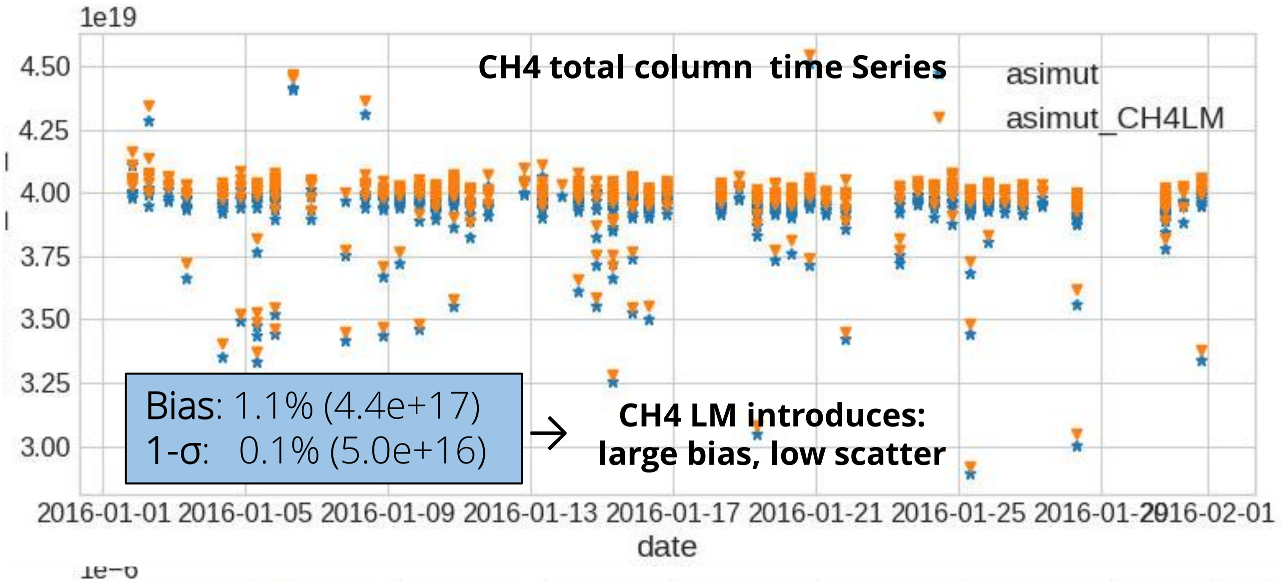
Version	χ^2
ASIMUT	0.684
CH_4 LM	0.371

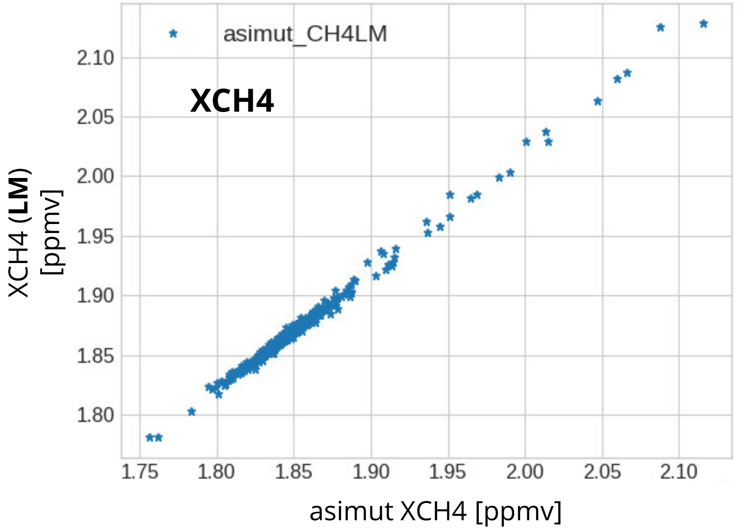
Version	DOFs
ASIMUT	2.1
CH_4 LM	2.1

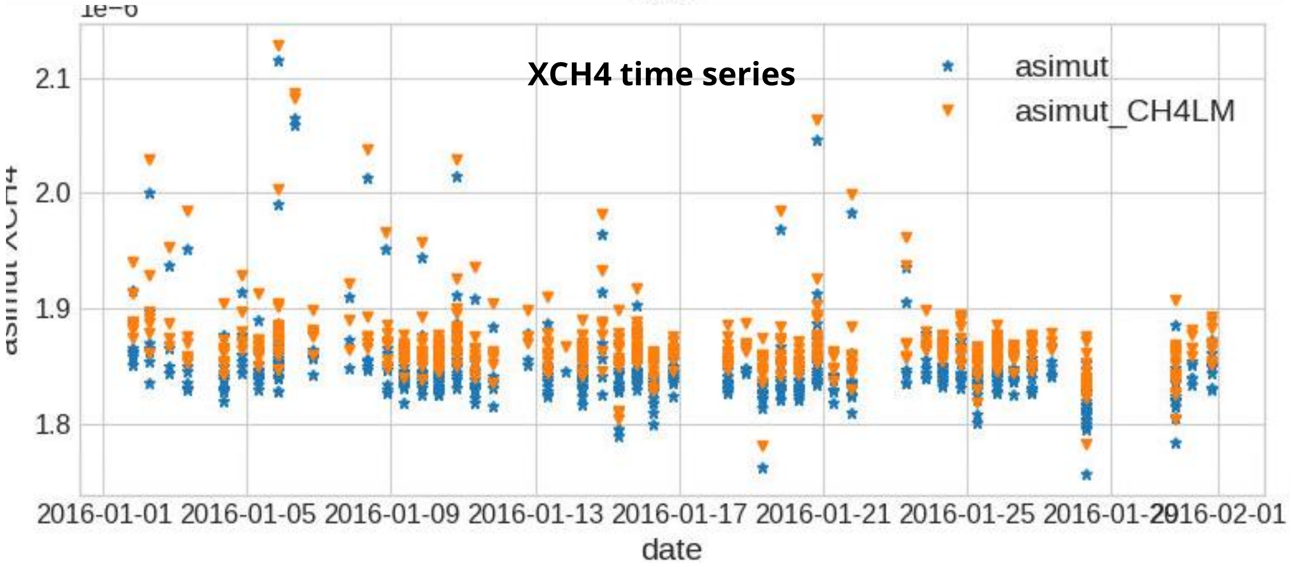
Comparison | ASIMUT

→ Testing the impact of adding Line-Mixing effects to methane





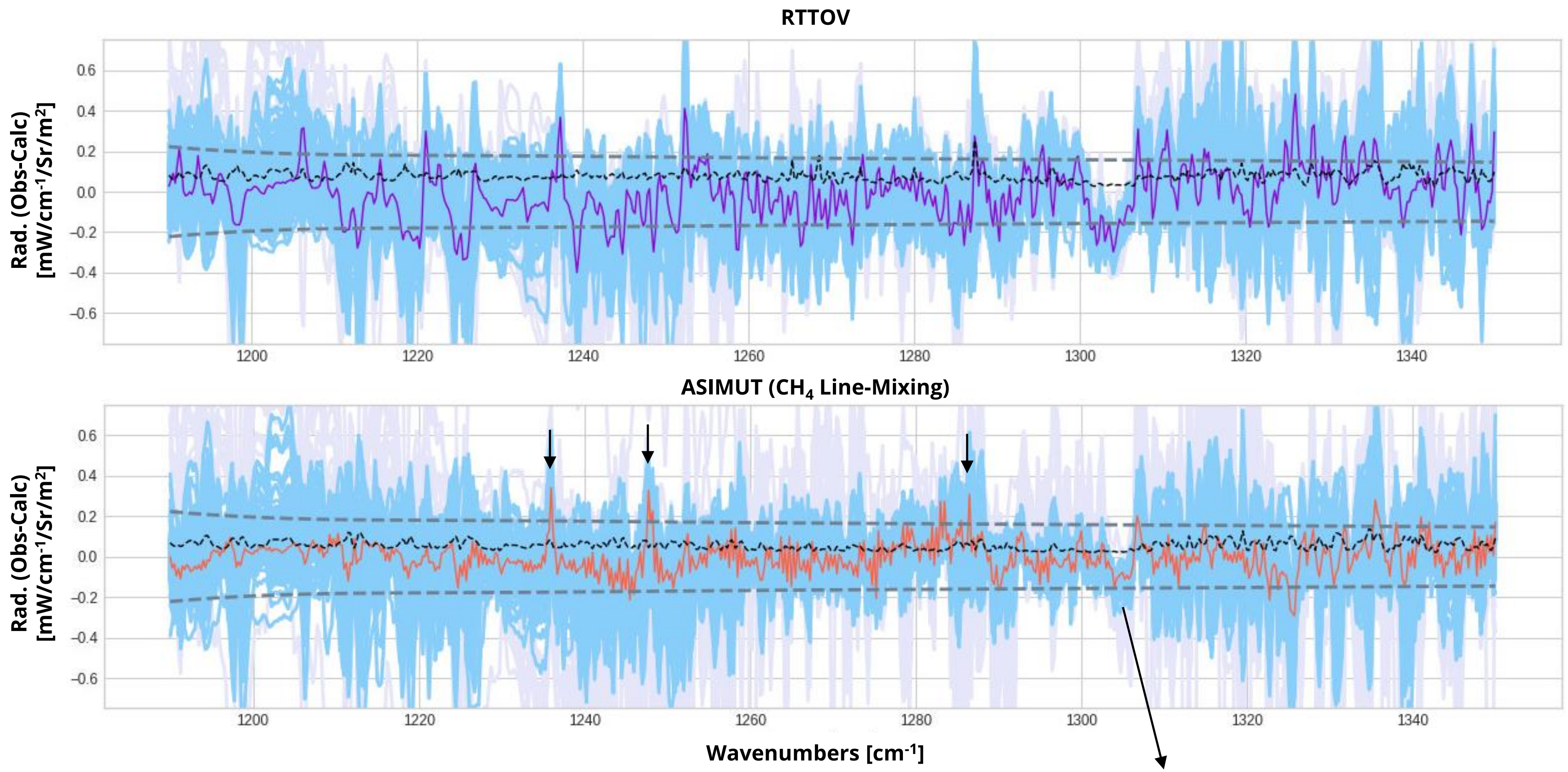




Comparison | ASIMUT (with LM) vs RTTOV

→ Testing the impact of RTM

Mean Spectral Residuals

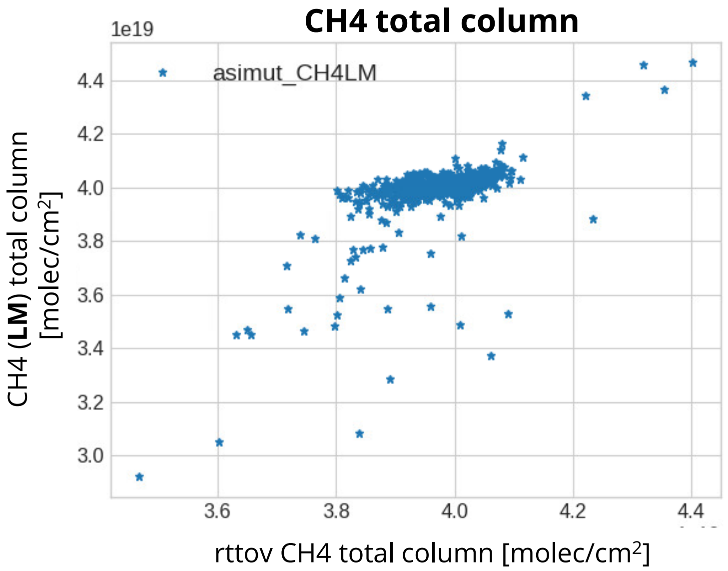


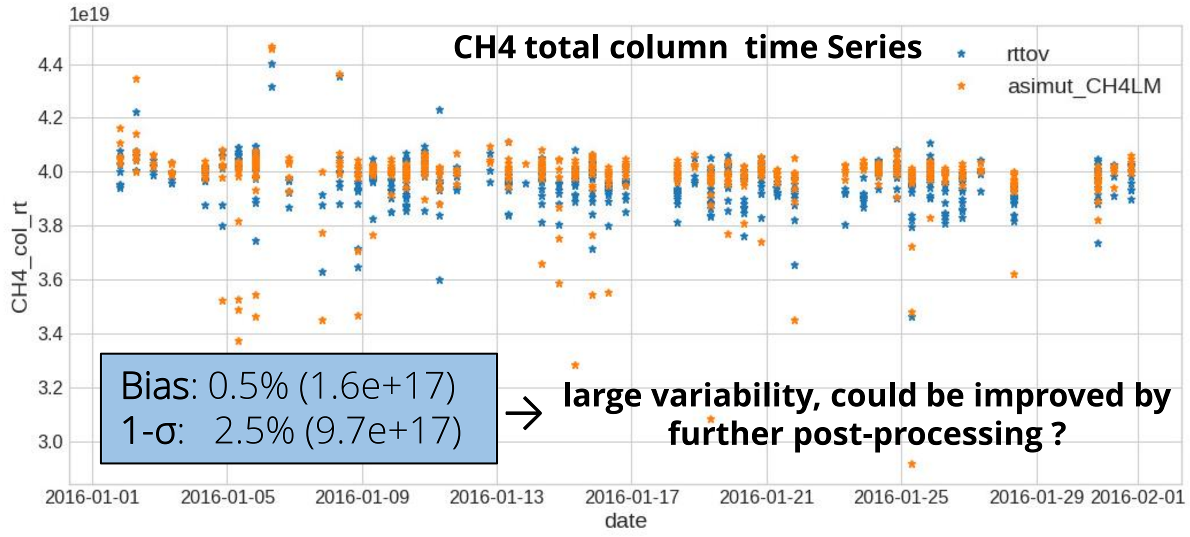
CH_4 Q-branch improved residuals

Version	χ^2	DOFs
RTTOV	1.01	1.9
CH_4 LM	0.371	2.1

Comparison | ASIMUT (with LM) vs RTTOV

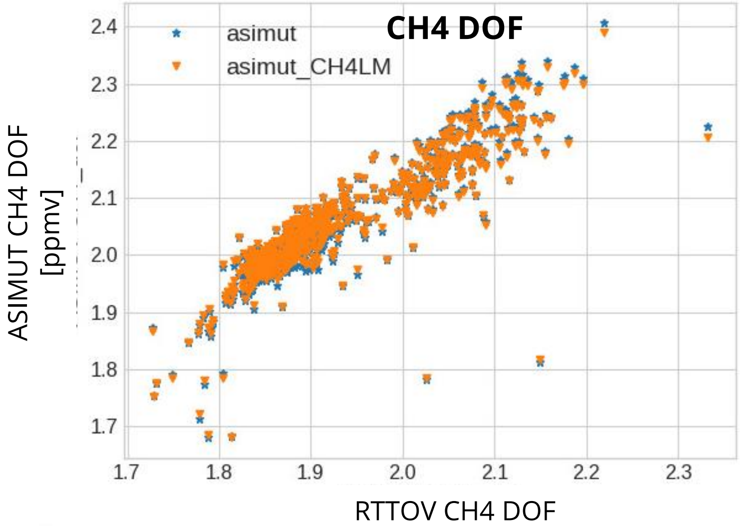
→ Testing the impact of RTM

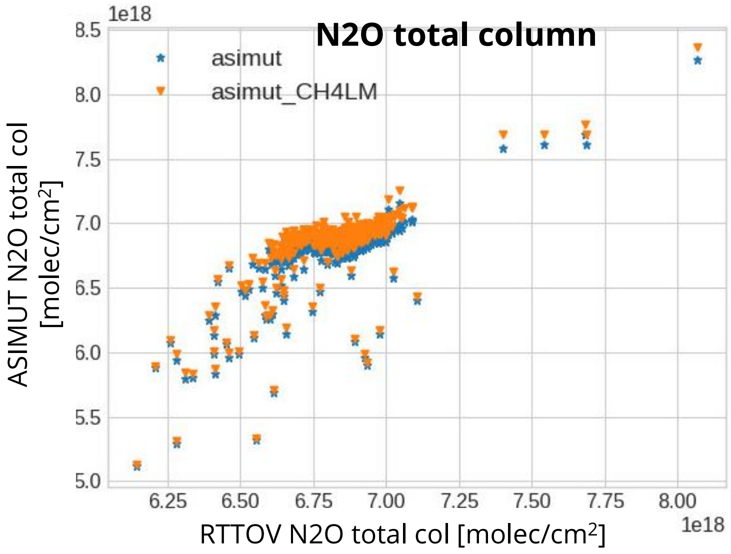


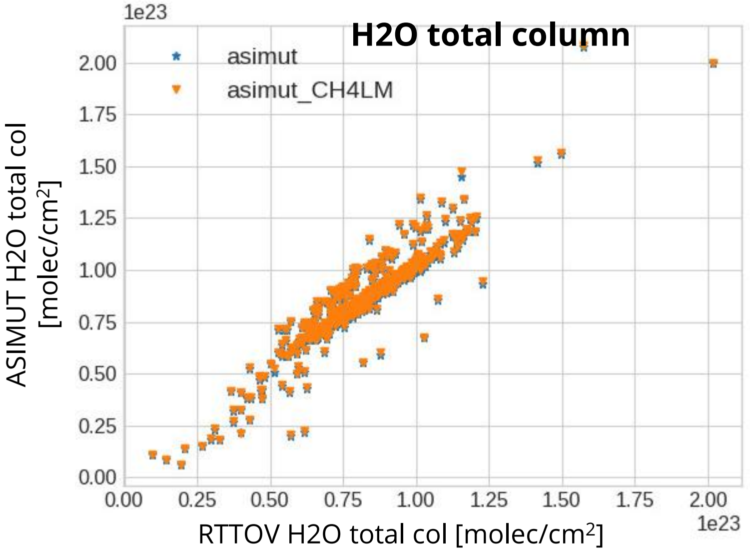


Bias: 0.5% (1.6e+17)
1-σ: 2.5% (9.7e+17)

→ **large variability, could be improved by further post-processing ?**





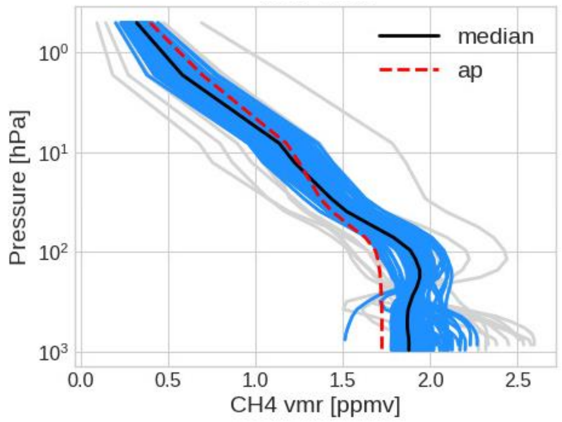


Comparison | ASIMUT (with LM) vs RTTOV

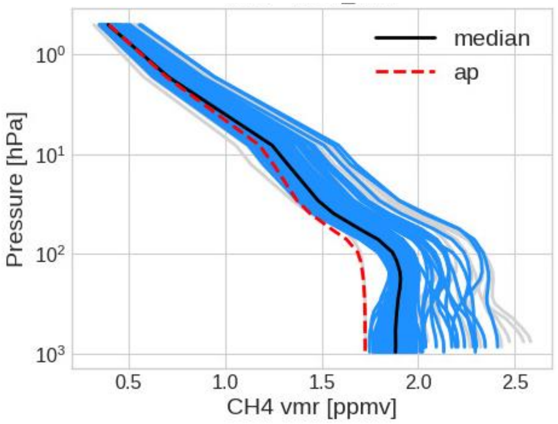
→ Testing the impact of RTM

Median CH_4 profiles over Hawaii (01/2016)

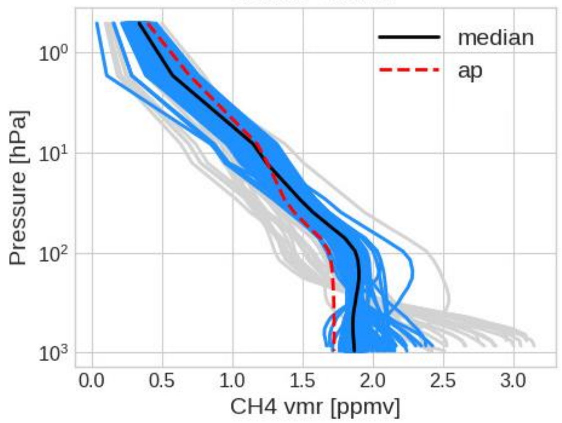
RTTOV



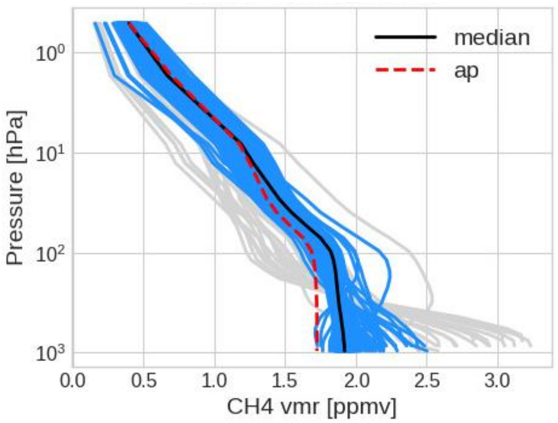
RTTOV (Tret)



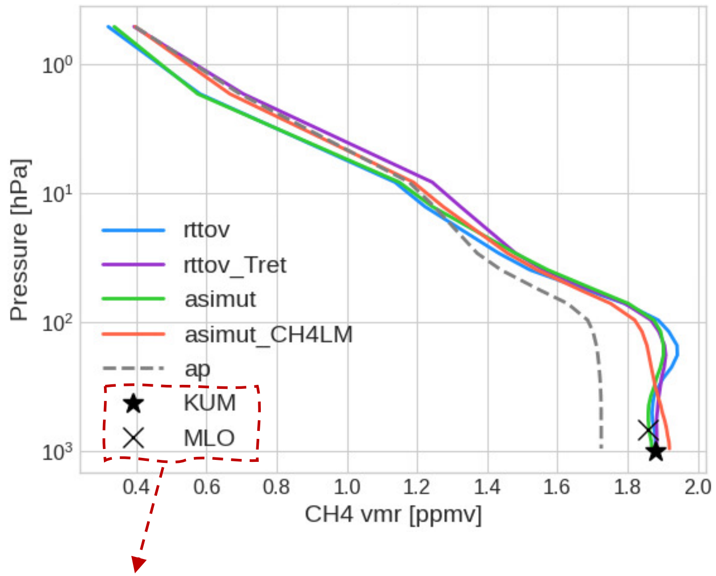
ASIMUT



ASIMUT CH4LM



Median CH_4 profiles over Hawaii (01/2016)



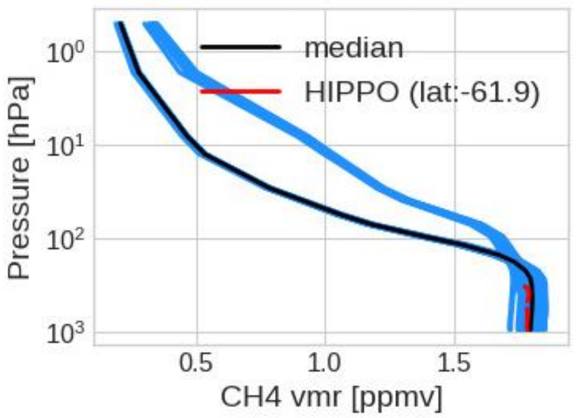
Flask measurements Mauna Loa, Kumukahi

Comparison | ASIMUT (with LM) vs RTTOV

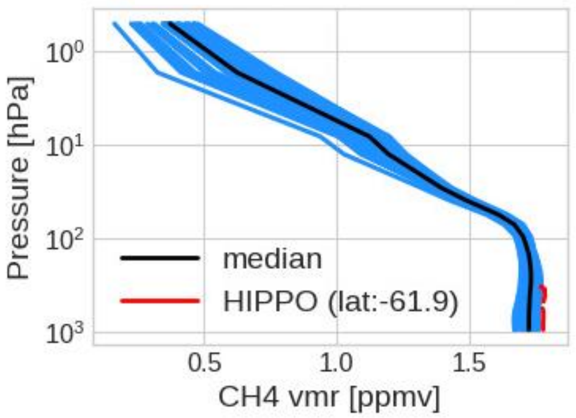
→ Testing the impact of RTM

Median CH_4 profiles HIPPO campaign (High Latitudes)

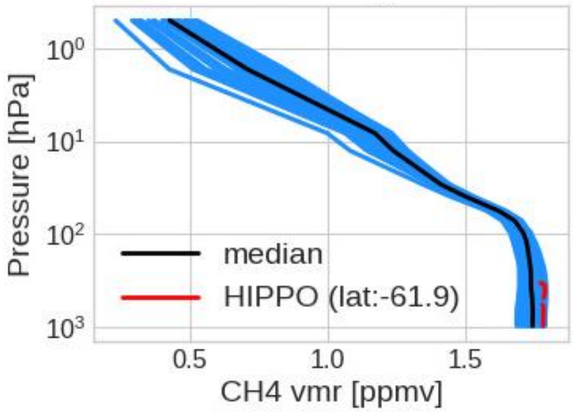
RTTOV



ASIMUT

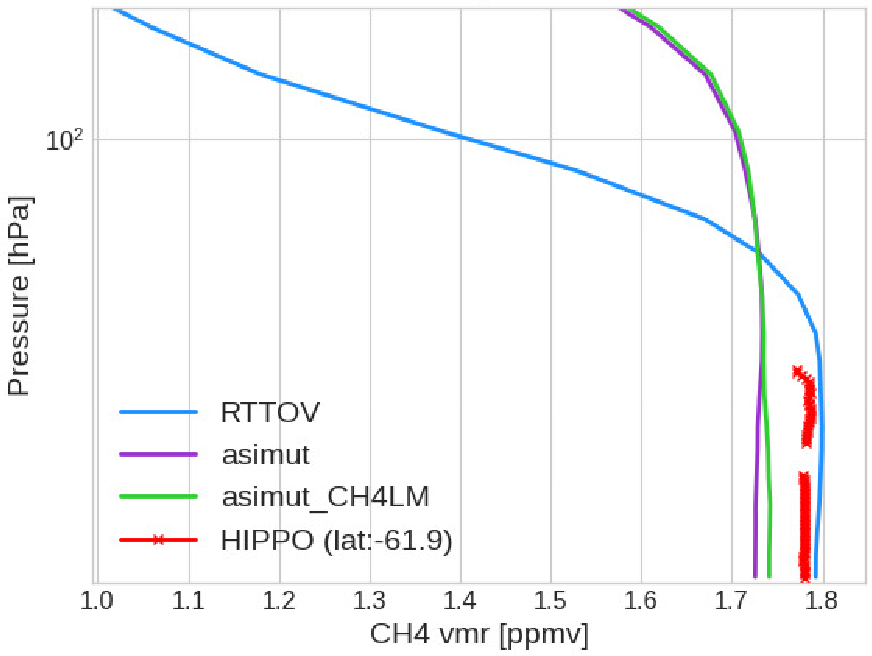


ASIMUT CH4LM



Unfortunately, the wrong a priori (Mauna Loa) was selected for ASIMUT

Median CH_4 profiles HIPPO campaign (20110830)



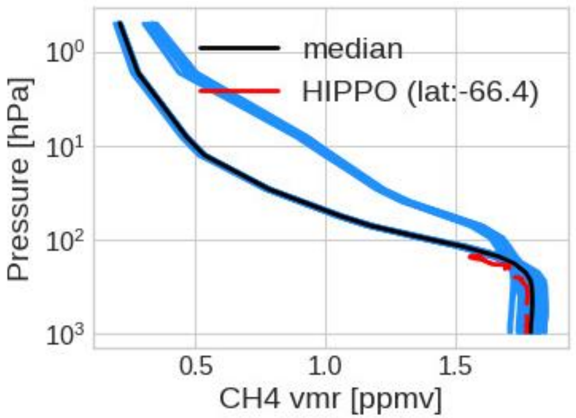
Preliminary work!

Comparison | ASIMUT (with LM) vs RTTOV

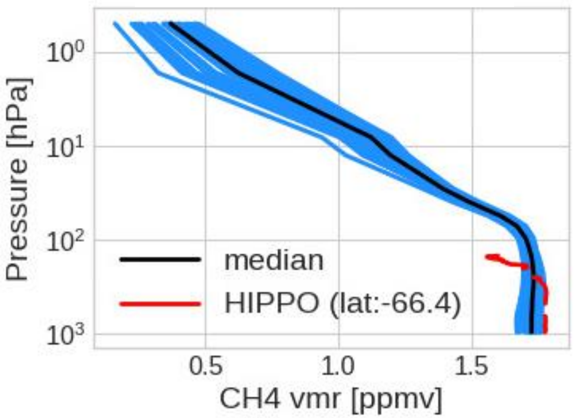
→ Testing the impact of RTM

Median CH_4 profiles HIPPO campaign (High Latitudes)

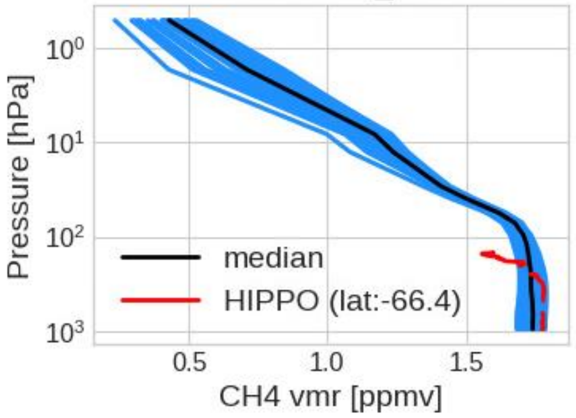
RTTOV



ASIMUT



ASIMUT CH4LM



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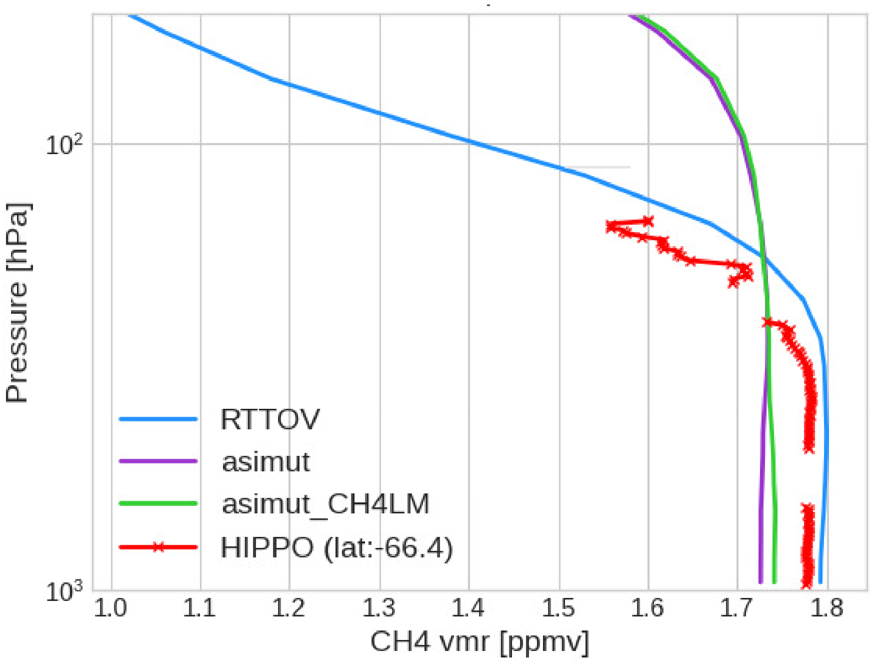
Median CH_4 profiles HIPPO campaign (20110830)



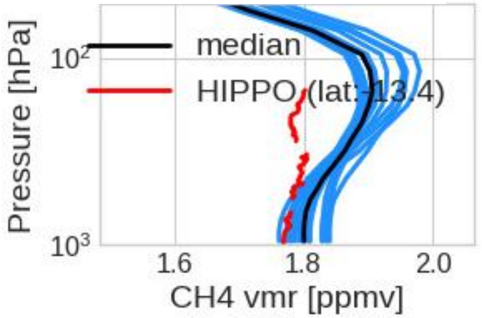
Preliminary work!

Comparison | ASIMUT (with LM) vs RTTOV

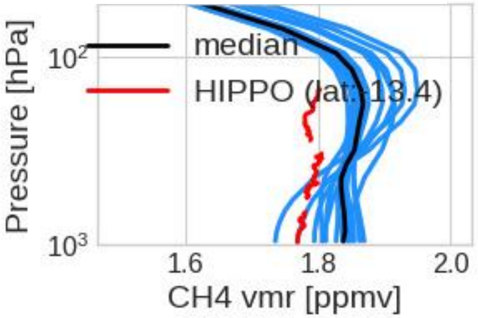
→ Testing the impact of RTM

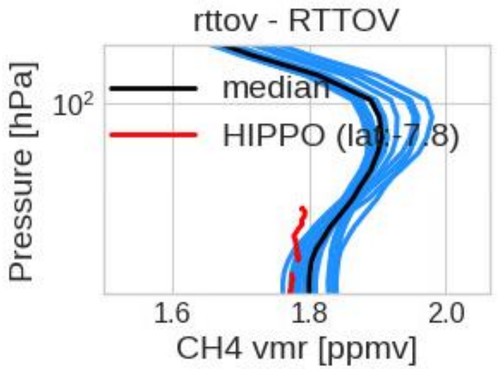
Median CH_4 profiles HIPPO campaign (Tropics)

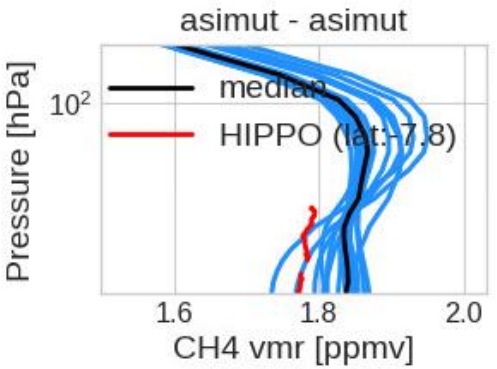
RTTOV



ASIMUT







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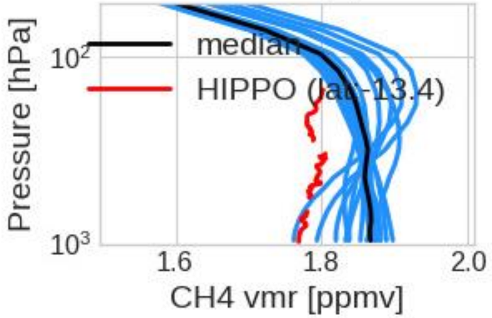

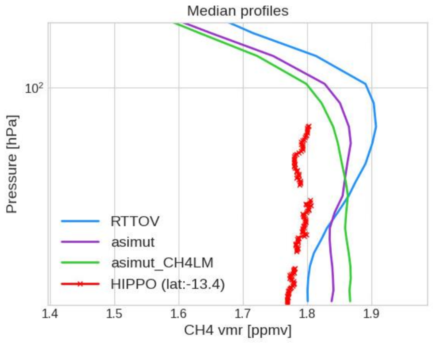

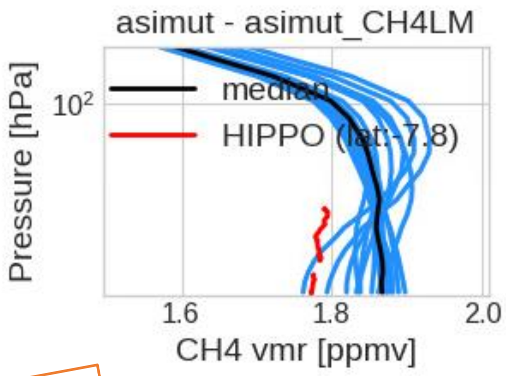

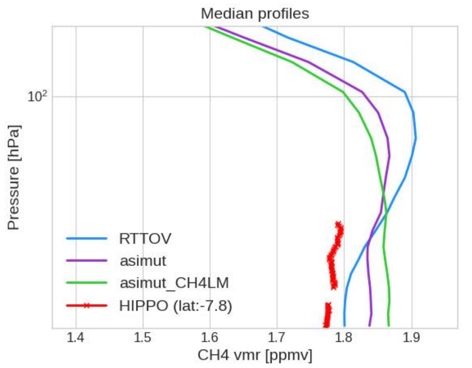

Preliminary work!

Conclusions

RTM simulations with ASIMUT and RTTOV

- Different RTMs simulations show spectral residuals larger than the instrumental errors for well-defined atmospheres
  - RTTOV is fast and user-friendly
  - Asimut is more flexible in terms of spectroscopy and retrieved species

Temperature retrieval in the state vector

- No appreciable change to spectral residuals
- Small change in mean CH_4 column (0.2%) but larger variability (1.7%)

CH_4 Line mixing

- Taking the CH4 line-mixing into account reduces the spectral residuals, especially in the Q-branch
- Significant increase of mean CH_4 column (1.1%) but small variability (0.1%) -> a constant shift

ASIMUT vs RTTOV

- Generally good agreement between both retrievals
- ASIMUT CH_4 columns are larger than RTTOV by 0.5% with a 1-σ spread of 2.5% (which might be improved by proper post-processing)
- Very preliminary comparison with in-situ measurements seem promising

THANK YOU!

MORE INFO?

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