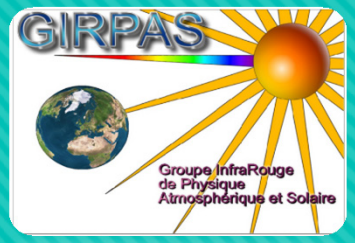
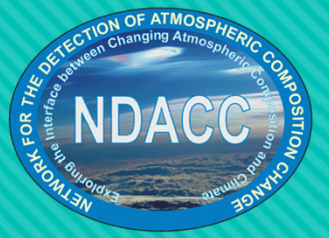




Investigation of the consistency of the recent CH_4 increase derived from NDACC-FTIR, ACE-FTS and GEOS-Chem

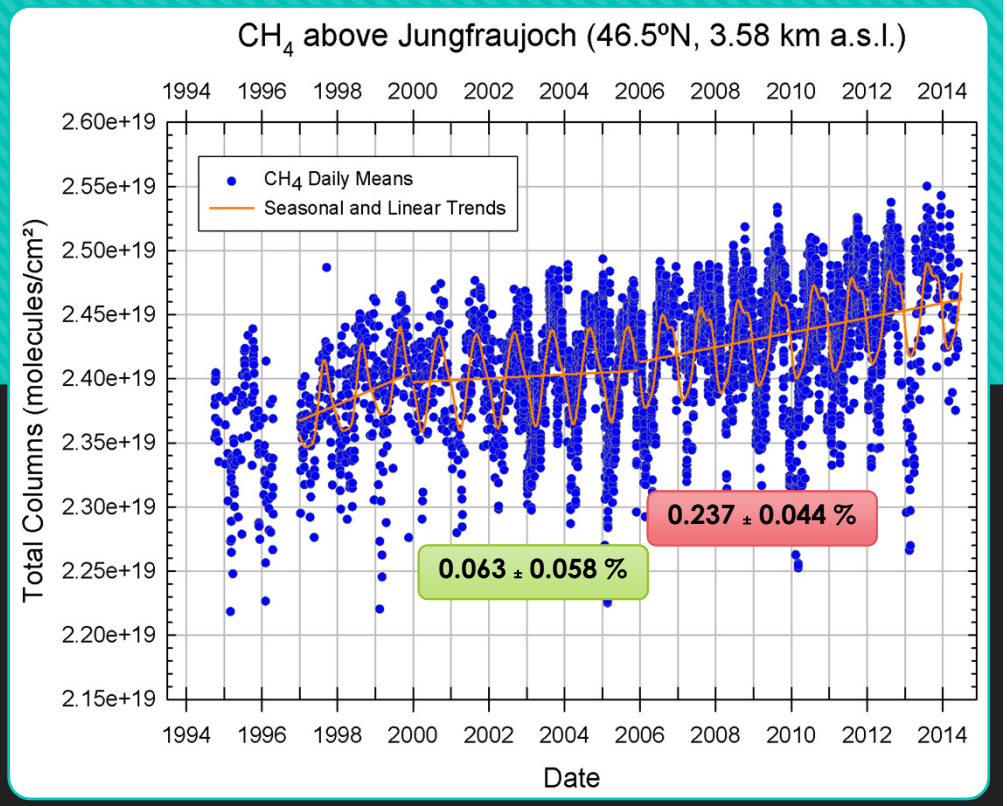
W. Bader, S. Conway, K. Strong, I. Murata, D. Smale, A. Turner, P. Bernath, E. Buzan, B. Bovy, B. Franco, B. Lejeune and E. Mahieu

Ongoing work…

Methane changes

- Second anthropogenic greenhouse gas
- Global Warming Potential : 25 (100-yr horizon)
- ~1/5 of the increase in radiative forcing by human-linked greenhouse gases since 1750 is due to methane [*Nisbet et al.*, 2014]
- 1824 ppb : new high of +260% wrt pre-industrial levels (1750)
- Non monotonic behaviour

CH_4 : Last 15 years



- 2000-2005/2006 : stable
  - reduced global fossil-fuel-related emissions (Chen and Prinn, 2006)
  - compensation between ↑ anthropogenic emissions and ↓ wetland emissions
  - significant to small changes in OH concentrations
- The need "For a proper closure of the methane budget and the development of realistic future climate scenarios, methane emissions during this stabilization period should be understood and precisely quantified" *Pison et al., 2013*
- From 2005-2006 : new increase → Why ?

CH_4 increase as reported

- A positive anomaly of CH_4 emissions from natural wetlands (2007-2008)
  - 25% from boreal regions
  - 75% from tropical natural wetlands
  - related to positive anomalies of temperature and of precipitation
  - Hypothesis : inter-annual variability
- Large increase of fossil fuel emissions
- Biomass burning contribution insignificant : no large CO anomaly
- No evidence of strongly increased emissions as a reaction to climate change
  - From melting permafrost
  - From marine hydrates
- Source attribution to the increase → ?

GEOS-CHEM Model Simulation

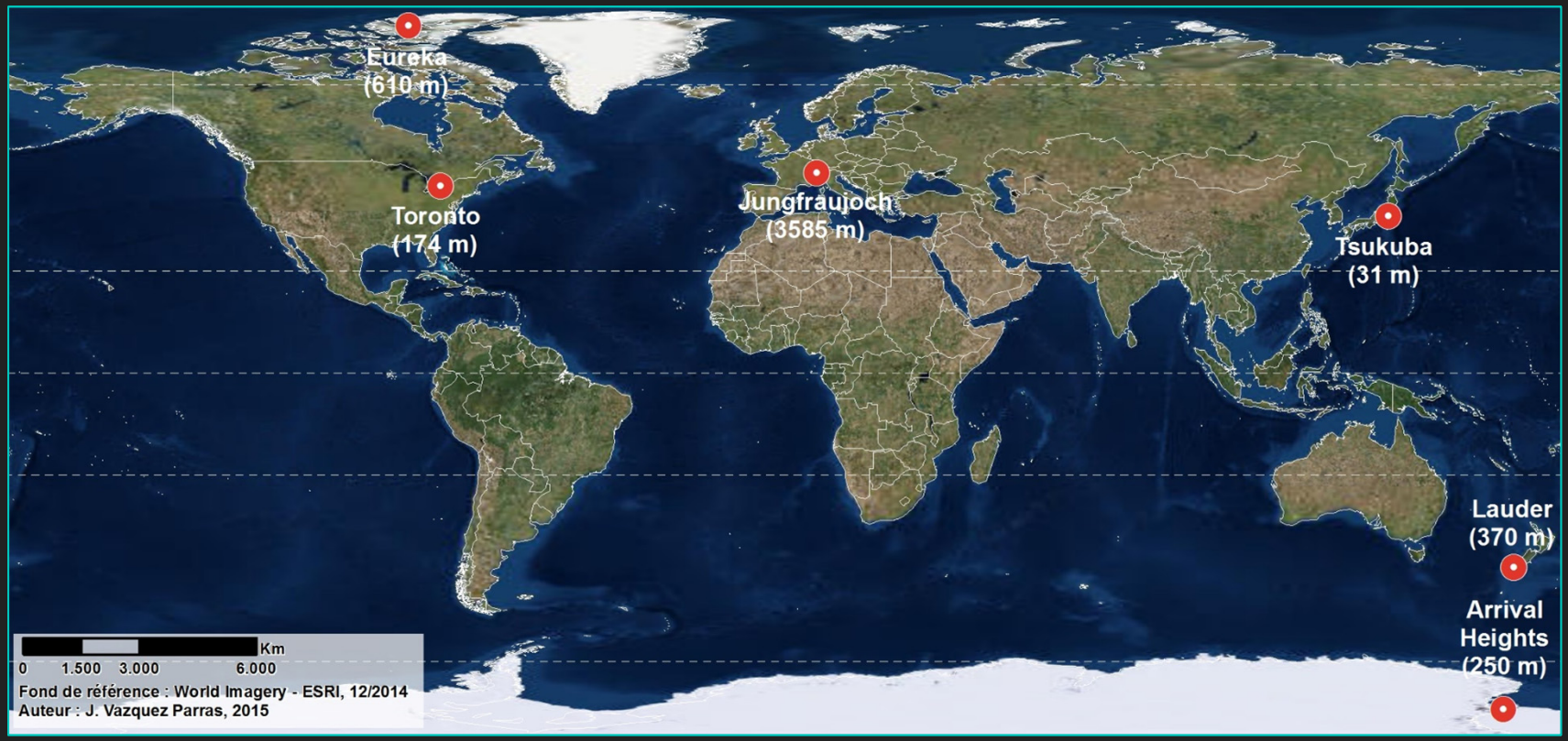
Tracers
1- Total
2- Gas and oil
3- Coal
4- Livestock
5- Waste management
6- Biofuels
7- Rice cultures
8- Biomass burning
9- Wetlands
10- Other natural
11- Other anthropogenic
12- Soil absorption

- ✓ GEOS-CHEM MODEL V9-02
- ✓ Chemical Transport Model
- ✓ 2X2.5 & 47 vertical levels
- ✓ Time step : 3 hours
- ✓ GEOS5 (2005-2013/05)
- ✓ GFED3
- ✓ EDGAR v4.2 (2004-2008)
- ✓ OH_v5-07-08
- ✓ K. Wecht et al., 2014

- ✓ Each tracer represents the contribution of each source to the simulated total column of methane

NDACC FTIR Sites

1 Eureka (80 °N, 86 °W)
2 Jungfraujoch (46 °N, 8 °E)
3 Toronto (44 °N, 79 °W)
4 Tsukuba (36 °N, 140 °E)
5 Lauder (45 °S, 169 °E)
6 Arrival Heights (77 °S, 166 °E)



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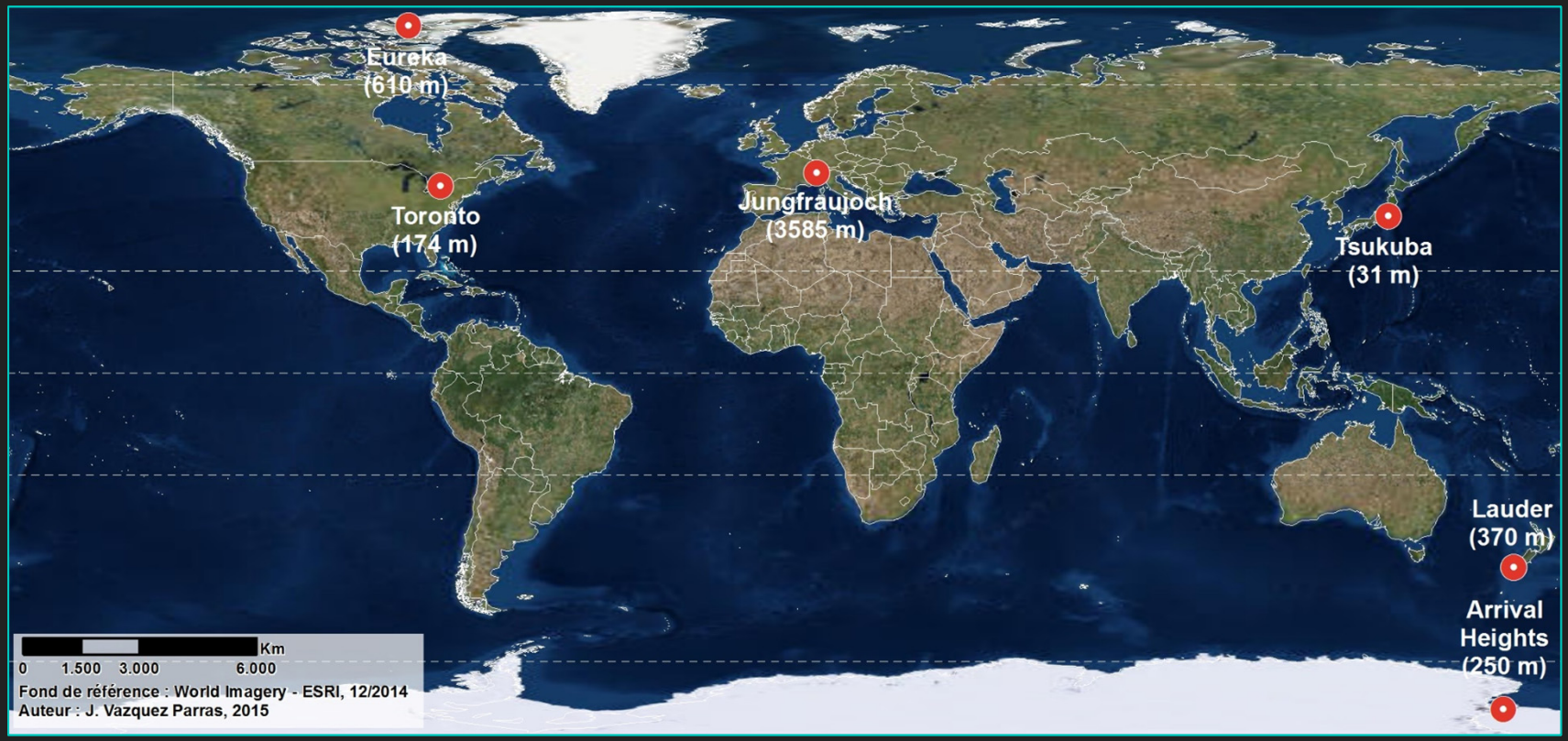


Does GEOS-CHEM reproduces well the observed CH_4 changes ?

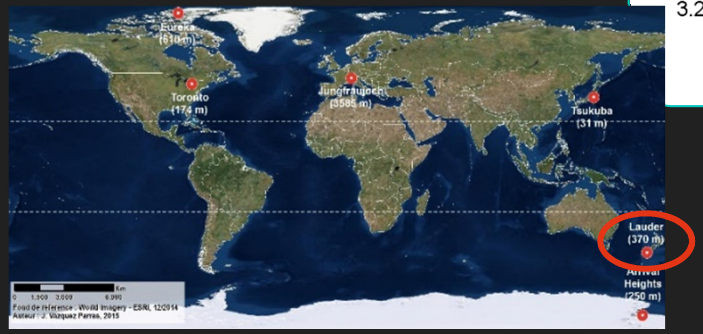
Processing of GEOS-CHEM data

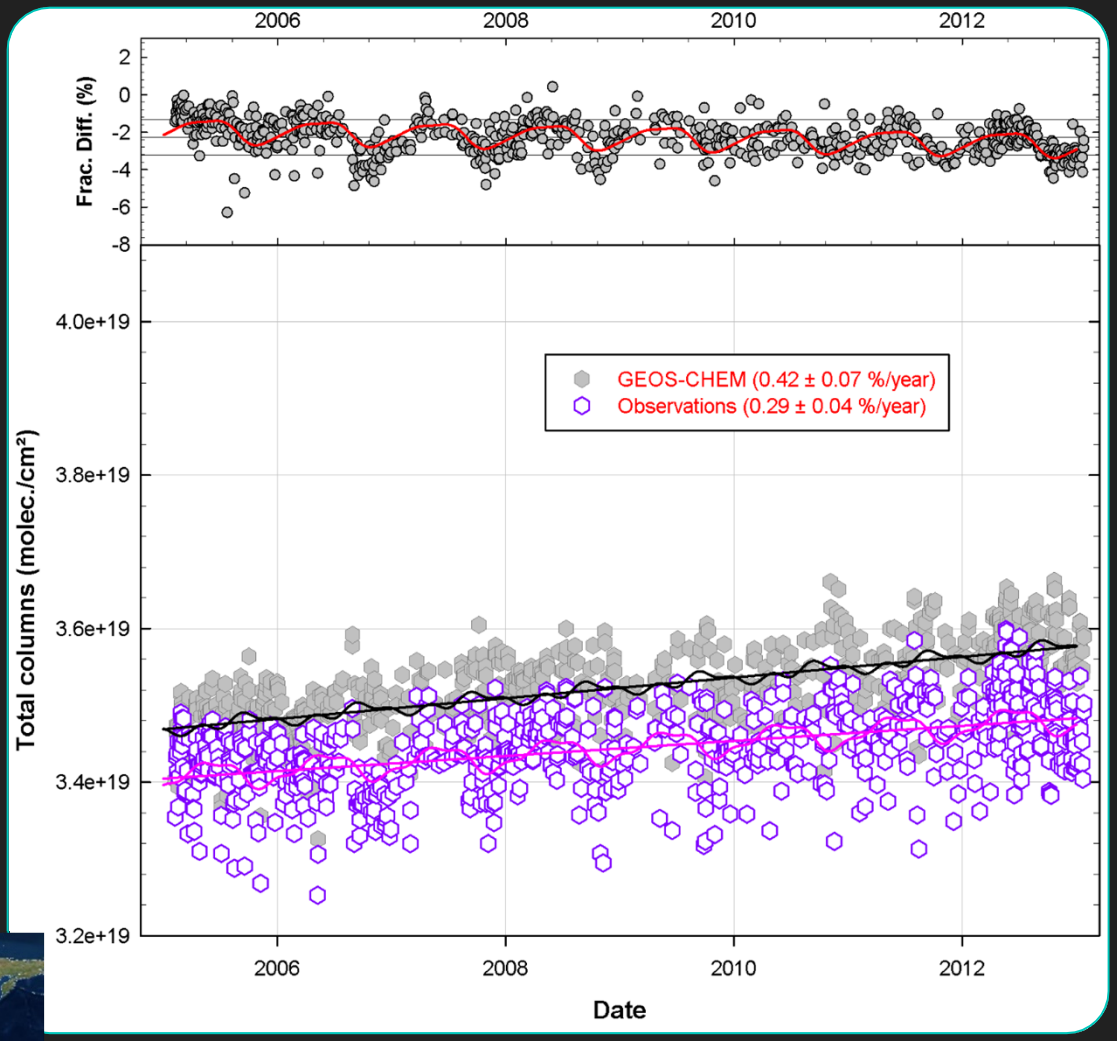
- Nearest-neighbour interpolation to match ground-based instrument coordinates
- Conservative regridding scheme to the grid used in the FTIR retrieval (specific to each station)
- Smoothing of GEOS-CHEM data by the respective averaging kernels
- Changes calculation with a bootstrap resampling method that includes linear fit + Fourier series
- Comparison only for days when observation is available

FTIR vs GEOS-CHEM CH_4 total columns

Lauder CH_4 daily means

Bias within the systematic error of the retrieved CH_4 total column





Total column changes not in agreement

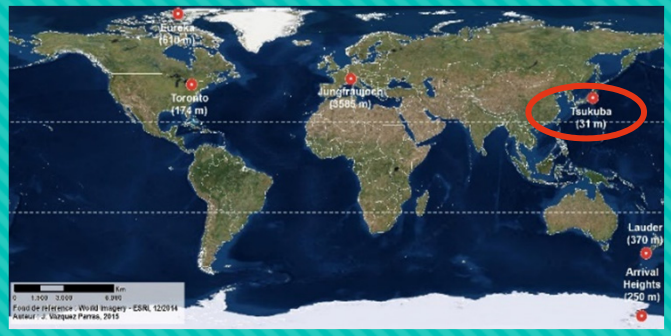
GC : 0.42 ± 0.07 %/year

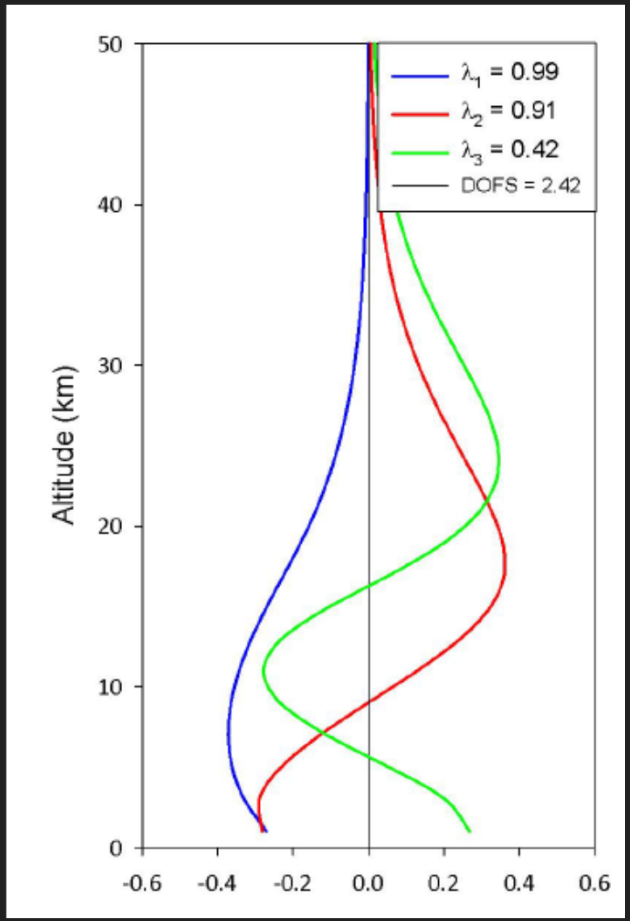
FTS : 0.29 ± 0.04 %/year

GEOS-CHEM known issues

- EDGAR emission inventory
  - Spatial patterns
  - Increase in Chinese CH_4 emissions from coal after 2002 not supported by surface aircraft or satellite observations
  - Best inventory available
- Simplistic stratosphere (first order-loss)

FTIR vs GEOS-CHEM



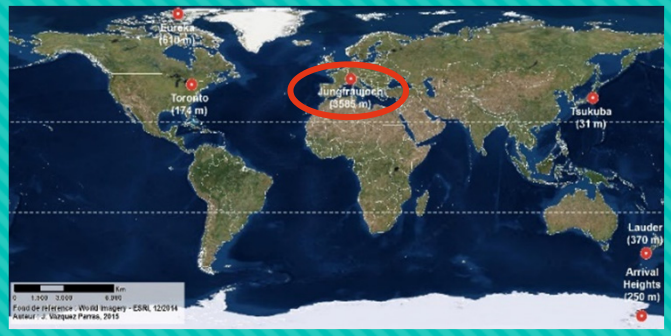


Information content allows us to retrieve two partial columns

Tropospheric (0.03 - 10 km) & Stratospheric (10 - 30 km)

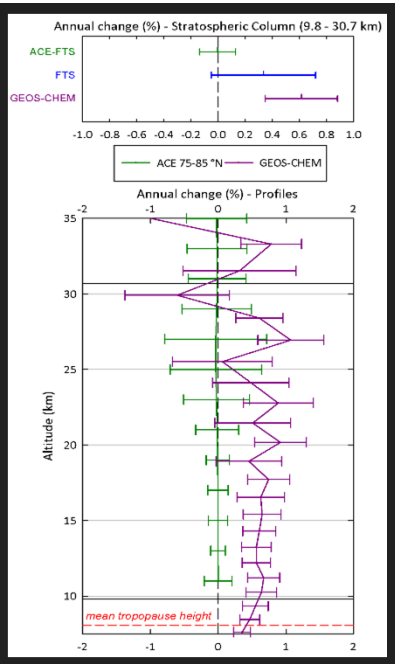
(Tsukuba station)

FTIR vs GEOS-CHEM

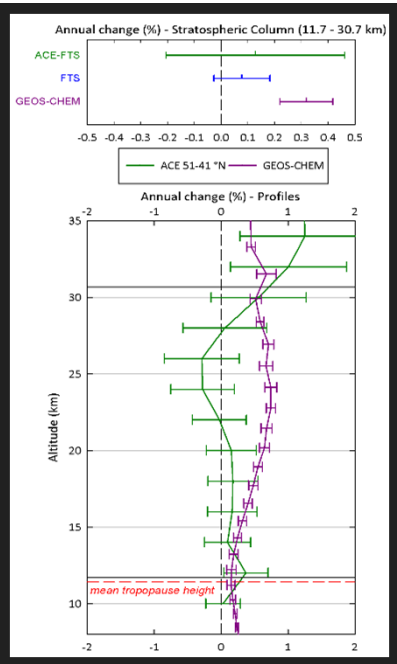


Investigation on CH_4 increase for partial columns according to FTIR and GEOS-CHEM (Jungfraujoch site)

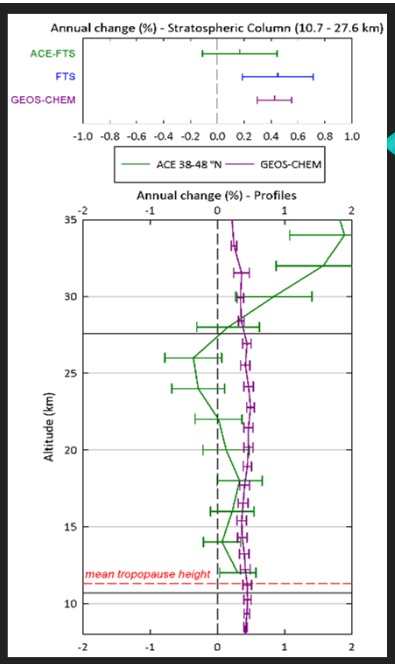
Annual change (%/year)		
Column	Observations	GEOS-CHEM
Total	0.18 ± 0.04	0.28 ± 0.03
Tropospheric	0.22 ± 0. 03	0.27 ± 0.02
Stratospheric	0.08 ± 0.11	0.32 ± 0.09



Eureka



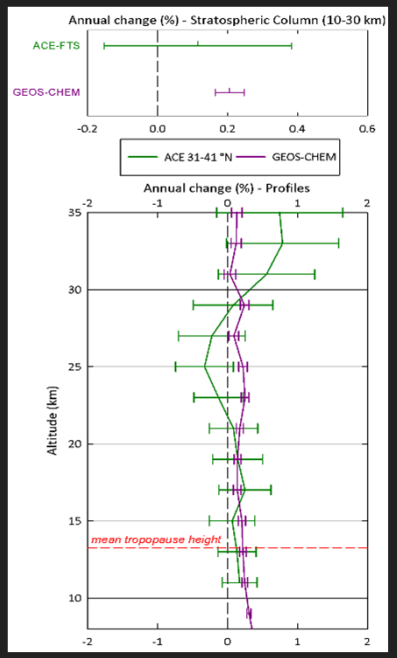
Jungfraujoch



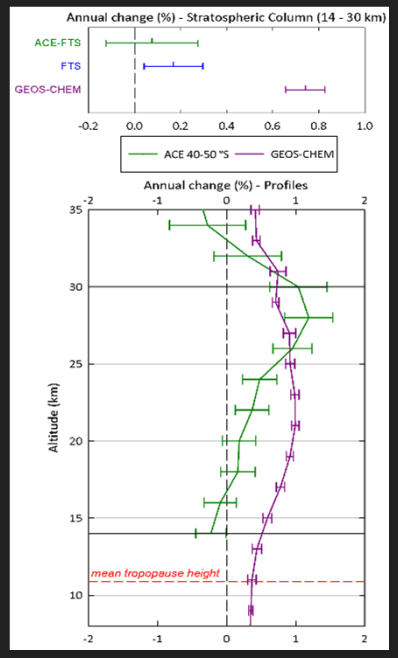
Toronto

CH_4 changes in the stratosphere

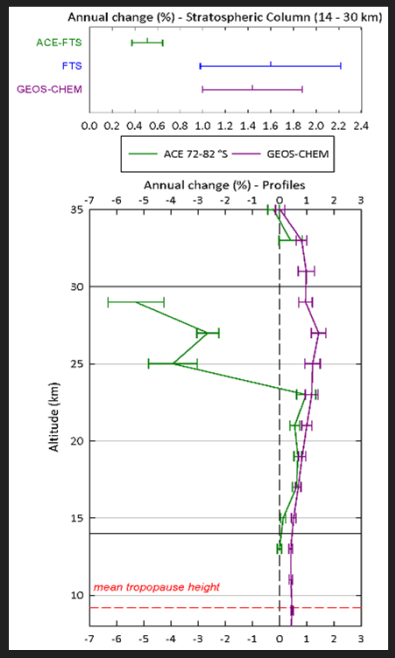
FTIR vs ACE-FTS vs GEOS-CHEM



Tsukuba



Lauder



Arrival Heights

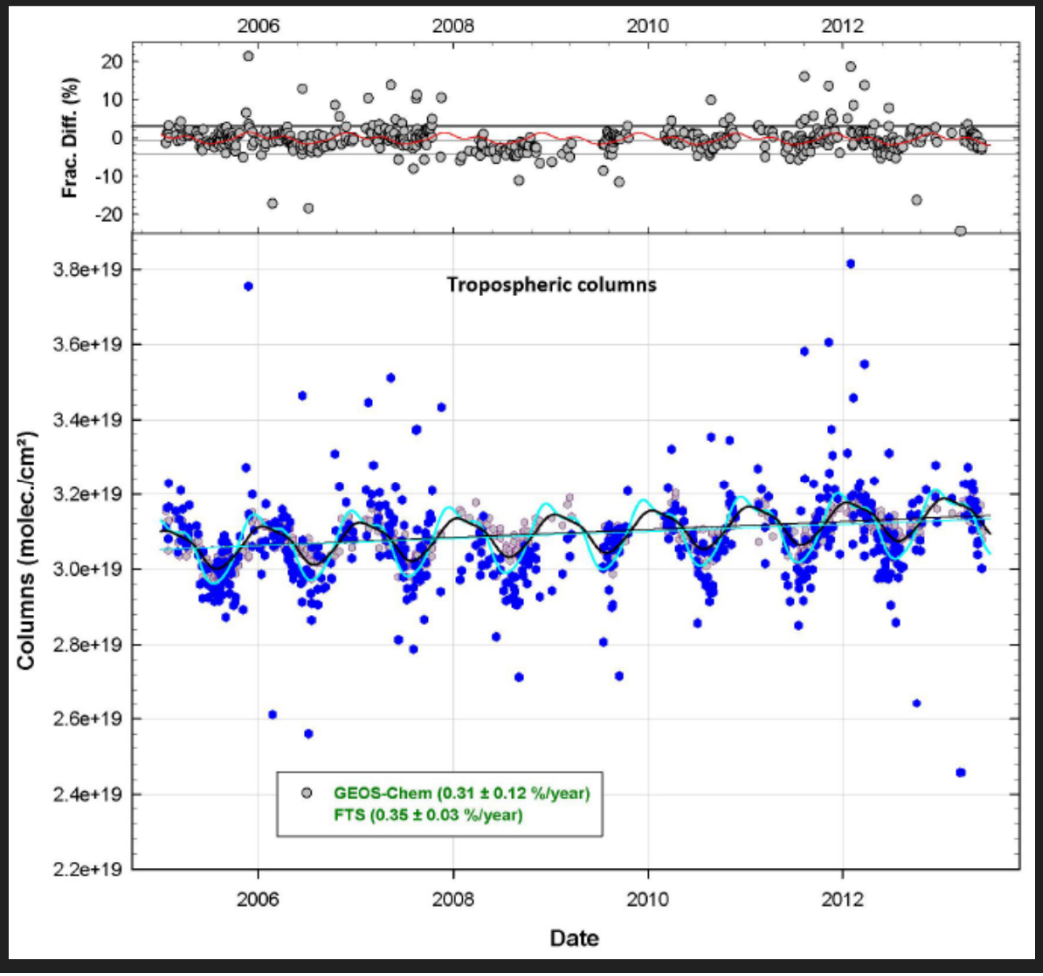
ACE-FTS
→ no changes (AHTS)

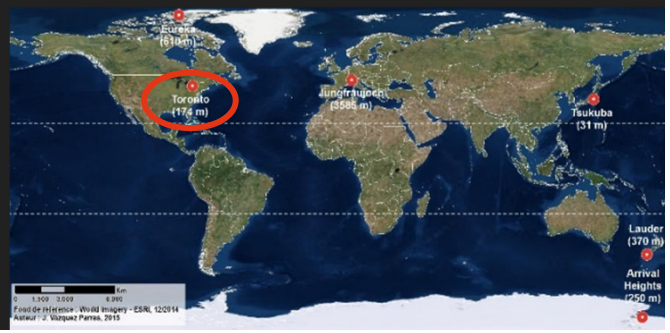
GEOS-Chem
→ overestimat° changes

FTIR
→ lower or no change (Toronto & AHTS)

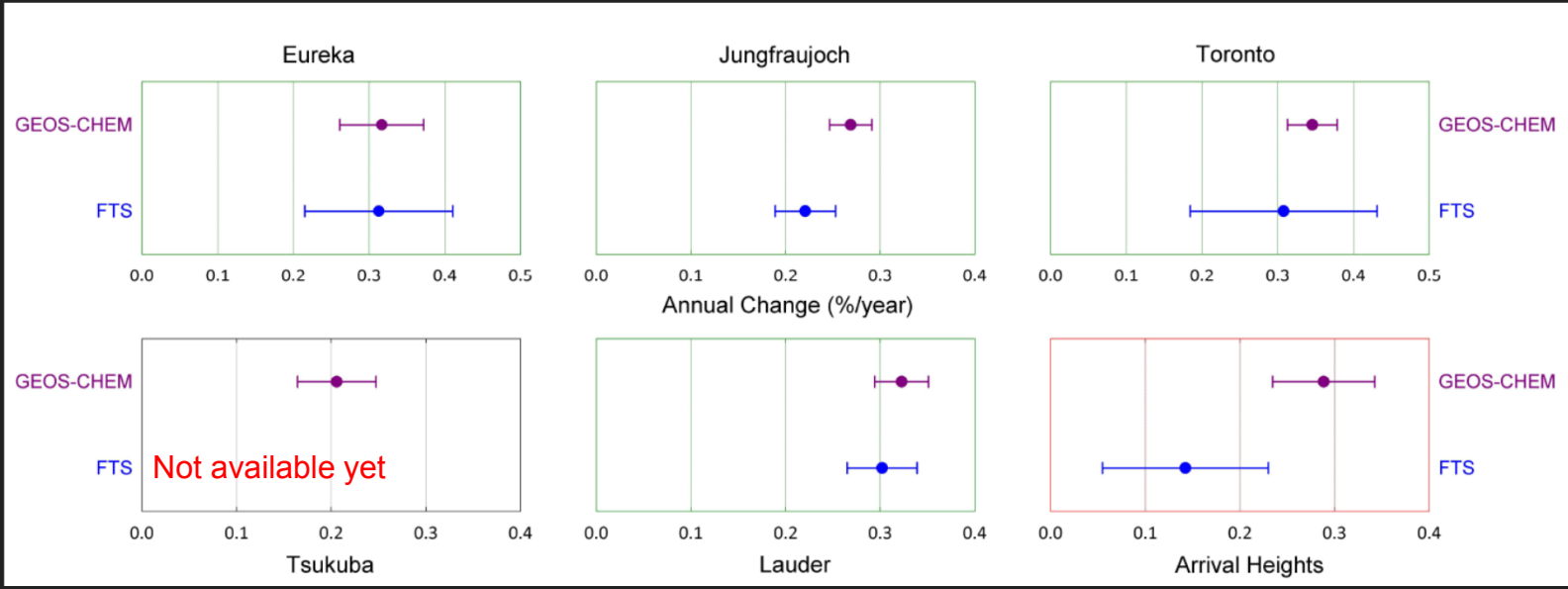
Stratospheric CH_4 : unresolved

Tropospheric methane : time series





Tropospheric methane : Annual change



Tropospheric methane changes as simulated by GEOS-CHEM are in agreement with the FTIR ground-based measurements

Conclusions

- Tagged simulation enables a source identification of the recent methane increase
- Vertical bias between FTIR observations and GEOS-CHEM simulation
- Focus on tropospheric methane

Next steps…

- Changes computation for Tsukuba
- Include comparisons of tropospheric methane measured by in situ observations
- Once vertical bias between FTIR and GC characterized, move on with the tracer analysis of the simulation