

Measurement of greenhouse gases and other climate relevant species using in-situ and FTIR remote sensing at Ile de La Réunion

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Belgium ICOS Meeting, Gemboux, 2017-10-20

Ile de La Réunion (21° S, 55° E)

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A unique atmospheric observatory situated in the Indian Ocean, about 700 km east of Madagascar and 170 km southwest of Mauritius providing the background state. In addition, we see the influence of biomass burning in Madagascar, South Africa and South America

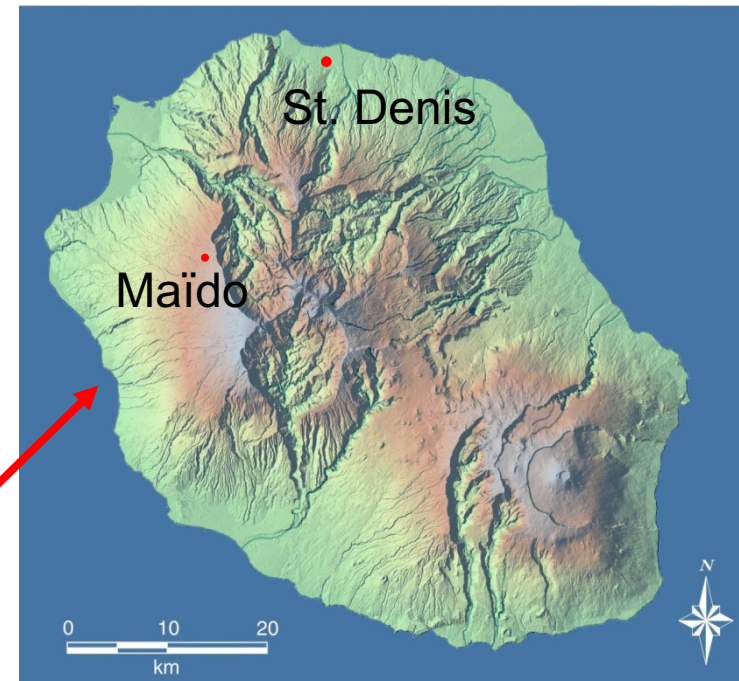
One of the very few atmospheric observation stations providing both in-situ and remote sensing greenhouse gas (GHG) data for atmospheric components in the southern hemisphere

Two dedicated sites – St. Denis (83 m.a.s.l) and Maïdo (2154 m.a.s.l)



Google Earth

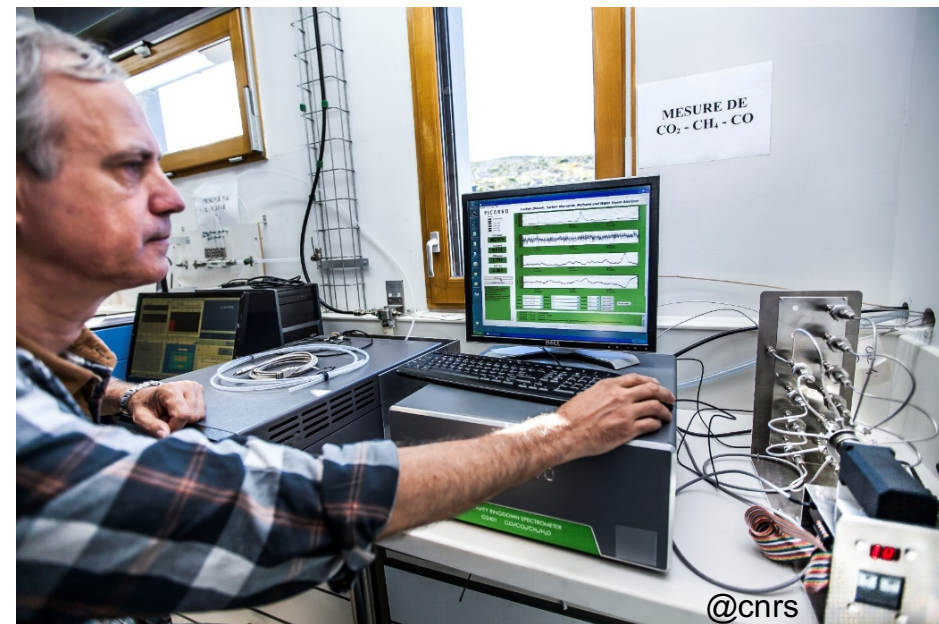
Ile de la Réunion



Instrumentation at St. Denis and Maïdo

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Site	St. Denis			Maïdo	
Altitude	83 m a.s.l			2154 m a.s.l	
Location	-20.9014 N, 55.4848 E			-21.0796 N, 55.3841 E	
Instrument	FTIR IFS 120M	FTIR IFS 125HR	PICARRO G1301	FTIR IFS 125HR	PICARRO G2401
Time coverage	Oct. 2002 – Nov. 2011	Sep. 2011 -	Aug. 2010 -	Mar. 2013 -	Jan. 2014 -
Network	NDACC (MIR)	TCCON (NIR)	French atmospheric monitoring network	NDACC (MIR)	ICOS application



Picarro in-situ instrument

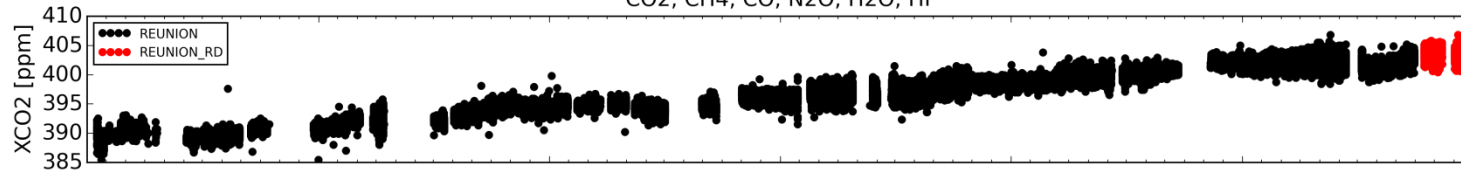


FTIR spectrometer – Bruker IFS 125HR

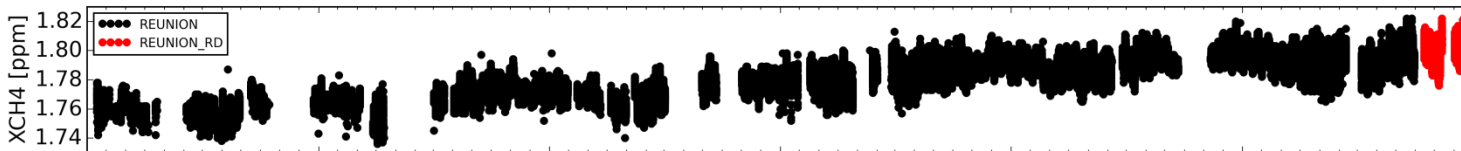
St. Denis TCCON time series of GHGs (CO₂, CH₄, CO)

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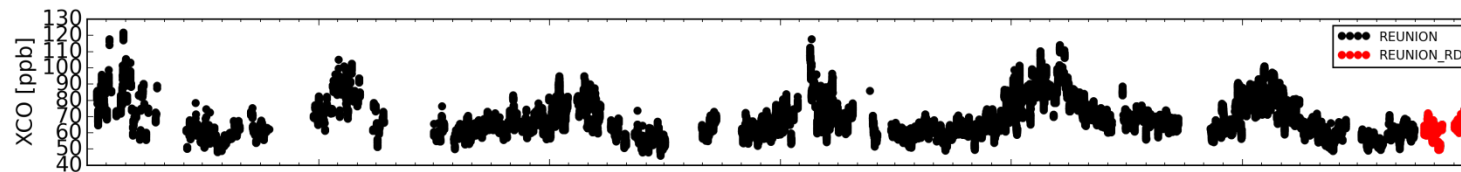
CO₂, CH₄, CO, N₂O, H₂O, HF



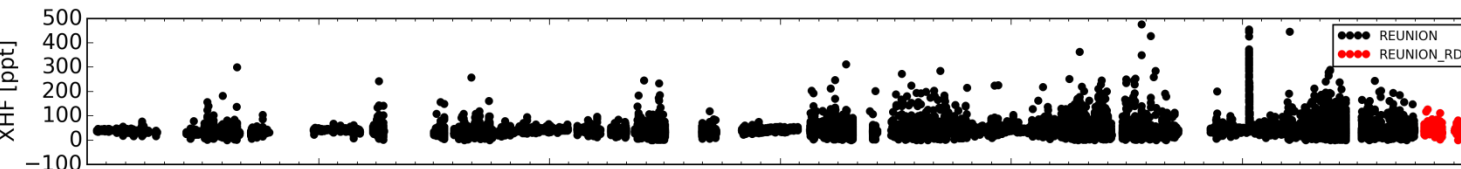
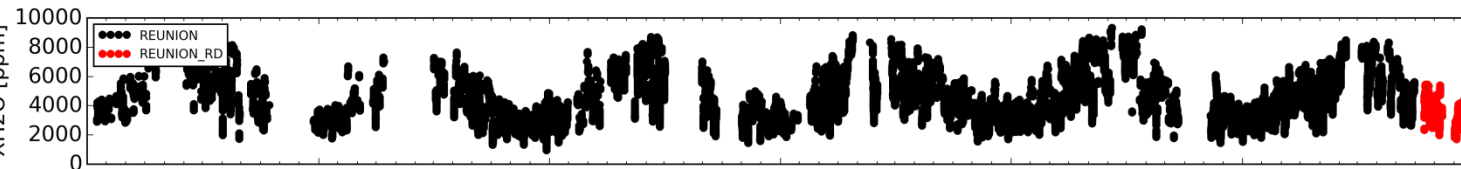
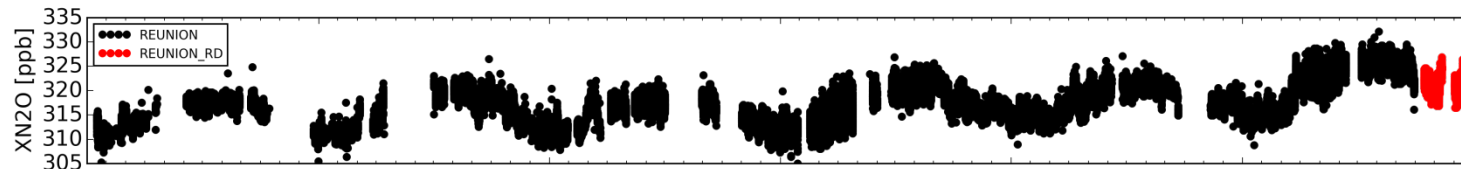
Time series of few selected GHG



Completed 5 years of TCCON measurements



Data available on TCCON public database 3 months after the measurements

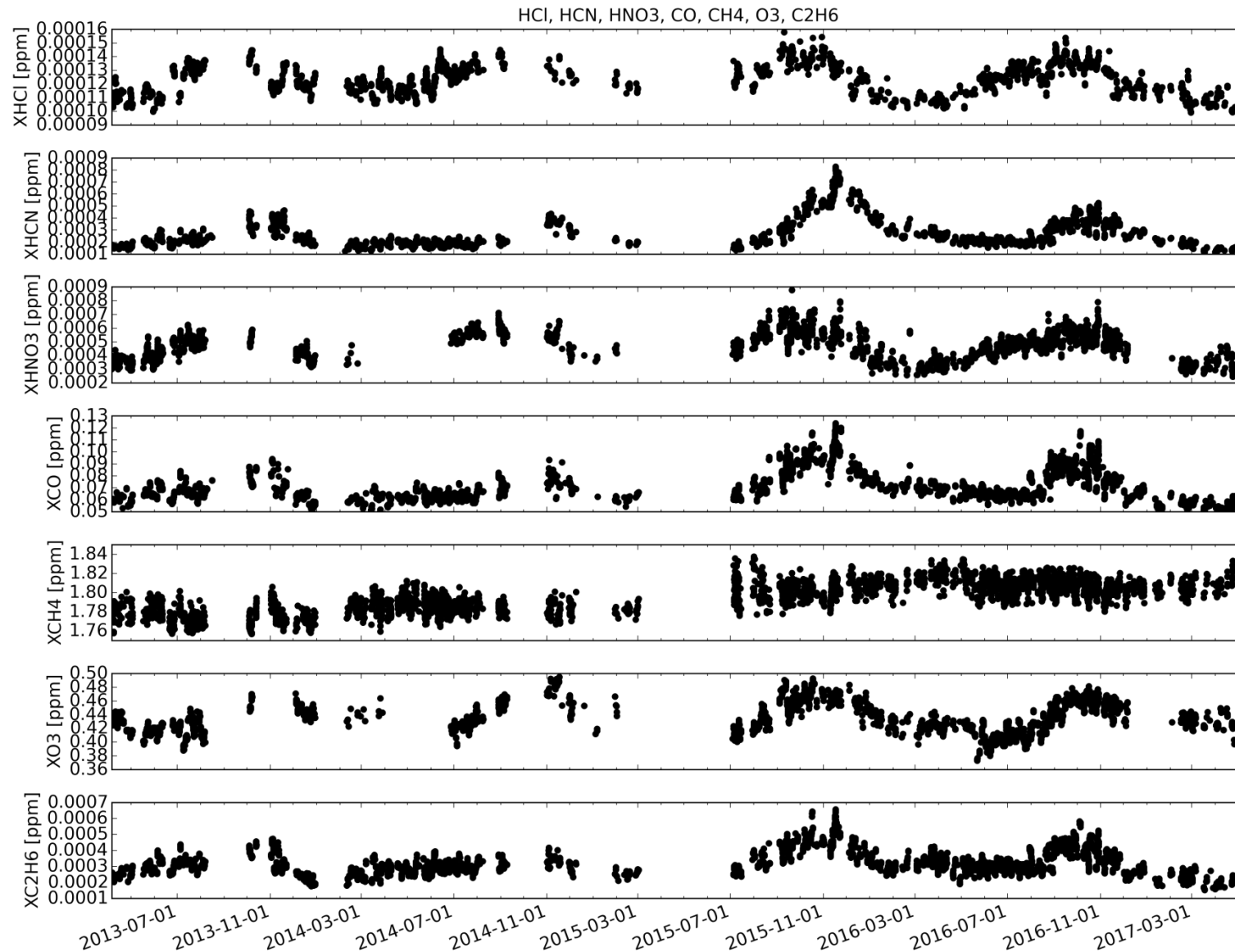


2011-09-01 2012-09-01 2013-09-01 2014-09-01 2015-09-01 2016-09-01 2017-09-01

Visualize our data here: <http://infrared-data.aeronomie.be/>

Maïdo NDACC time series (HNO_3 , HCl , CH_4 , CO , O_3 , C_2H_6)

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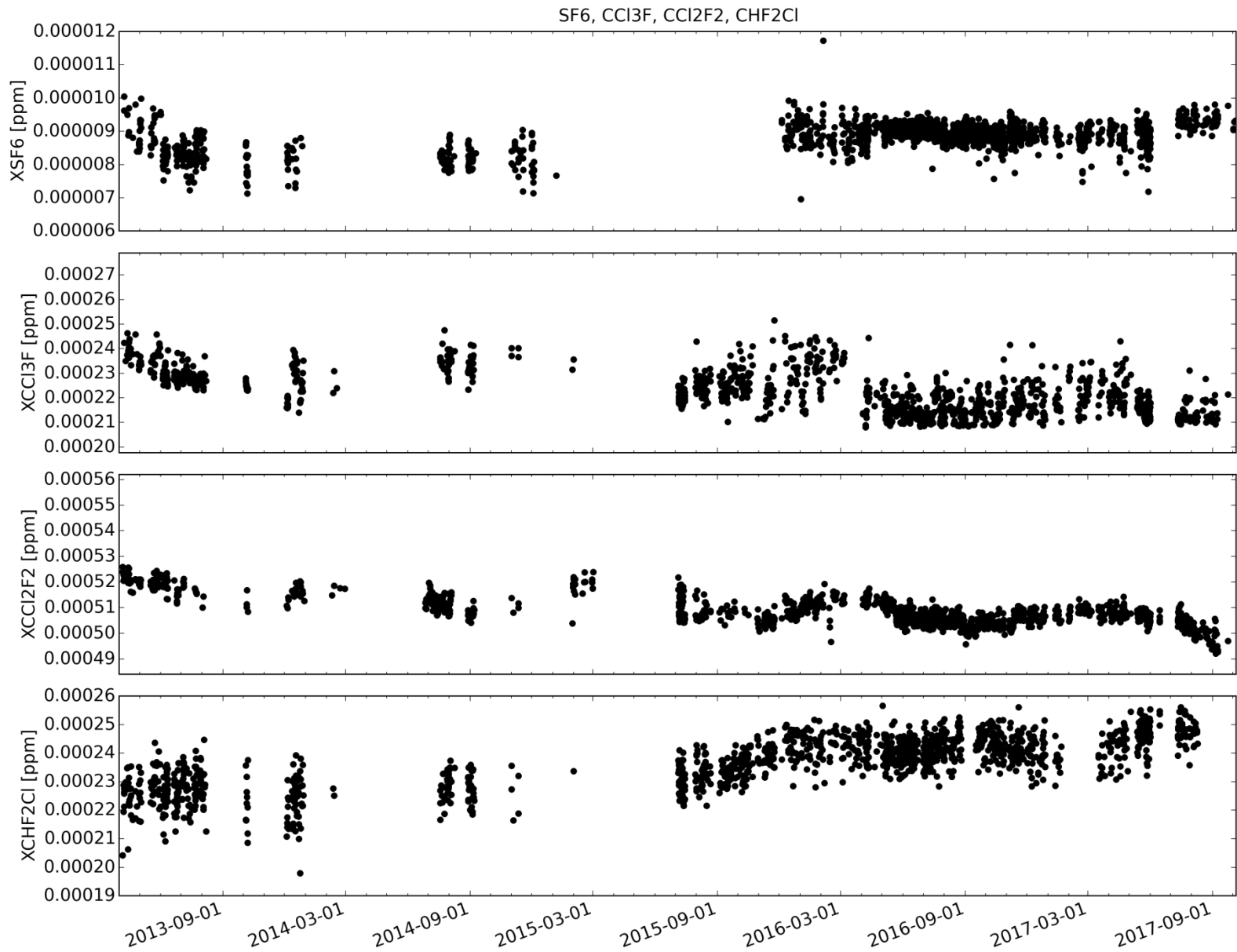


Time series of a few selected gases

Available on the NDACC database

Maïdo NDACC time series (SF₆, CFC-11, CFC-12, HCFC-22)

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Inter-comparisons CO₂, CH₄, CO between in-situ and FTIR measurements

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Site	St. Denis		Maïdo	
Altitude	83 m a.s.l		2154 m a.s.l	
Instrument	FTIR IFS 125HR	PICARRO G1301	FTIR IFS 125HR	PICARRO G2401
Details	Total column	Surface	Profile	Surface
Network	TCCON (NIR)	French atmospheric monitoring network	NDACC (MIR)	ICOS application
Species and Measurement Uncertainties	CO ₂ : 0.2% CH ₄ : 0.5% CO: 1.2%	CO ₂ : 0.05% CH ₄ : 0.05% No CO	No CO ₂ CH ₄ : 3.5±1.5%* CO: 2.5±1.0%*	CO ₂ : 0.05% CH ₄ : 0.05% CO: 3.0%

Calibration: ICOS → WMO; TCCON → WMO ; NDACC not yet

*For the NDACC retrieval uncertainty, it is separated into two components (systematic ± random).

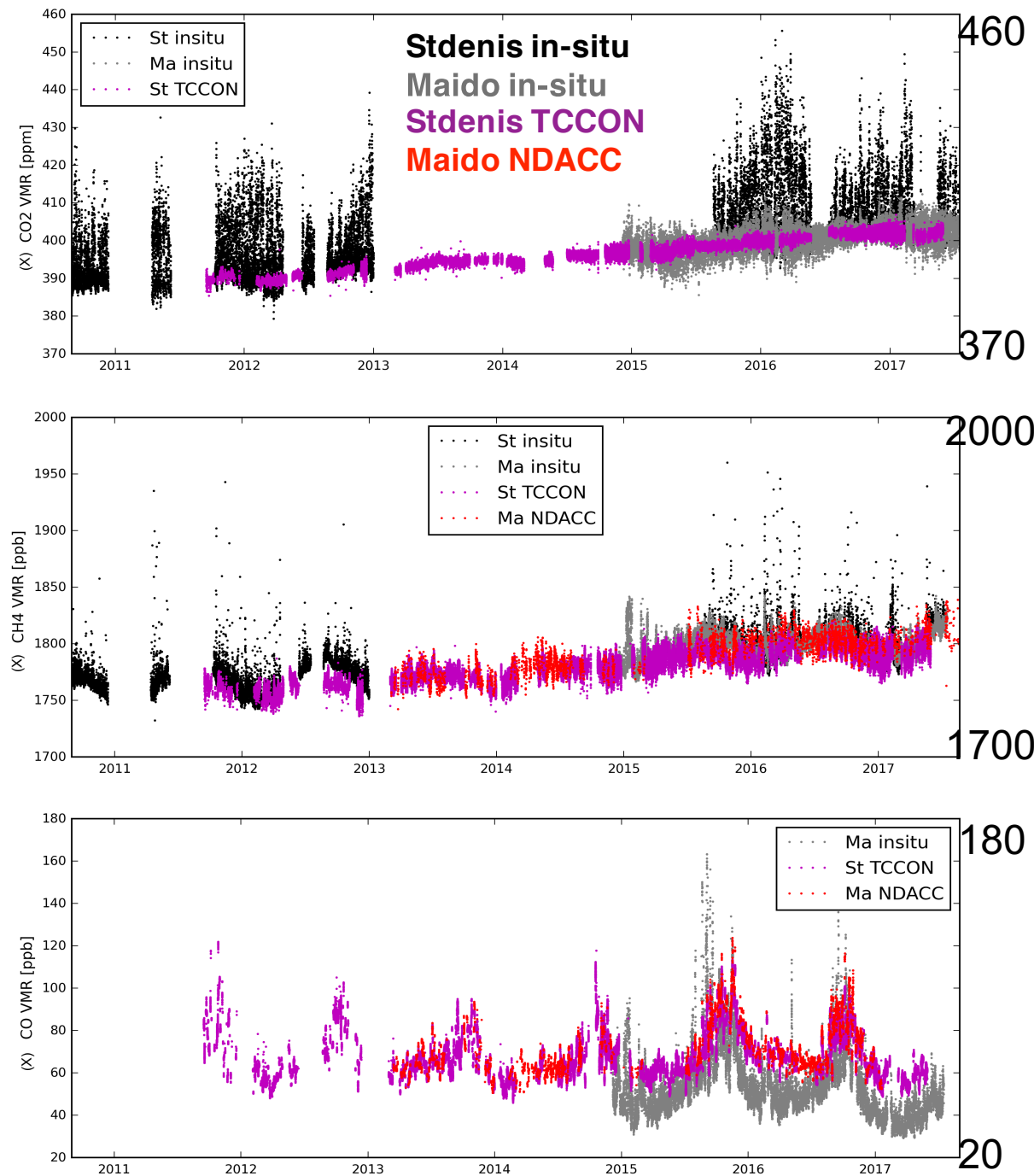


Time series

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE

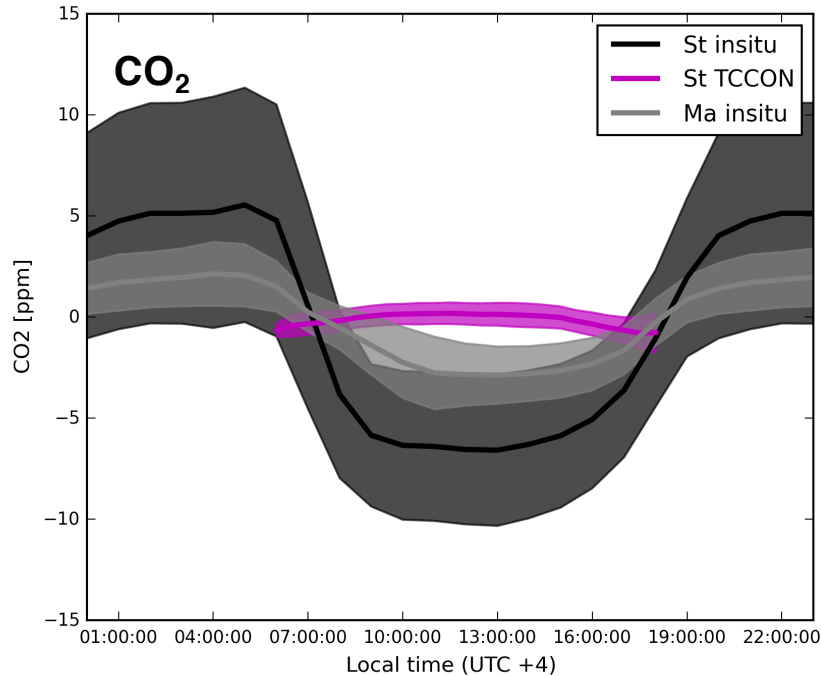
For FTIR retrievals, we use the dry-air column-averaged mole fraction of target gas (X_{gas})

$$X_{gas} = TC_{gas} / TC_{air}^{dry}$$

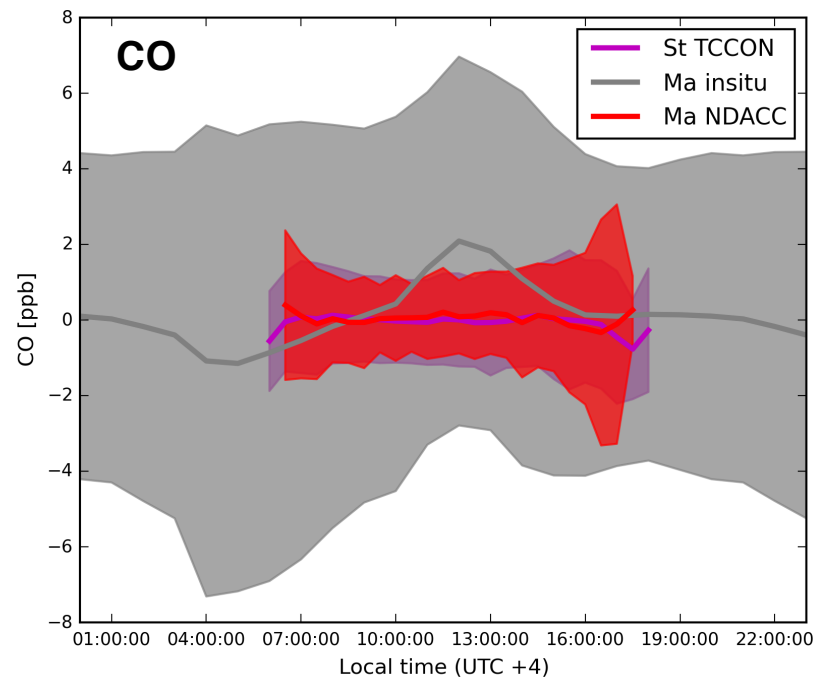
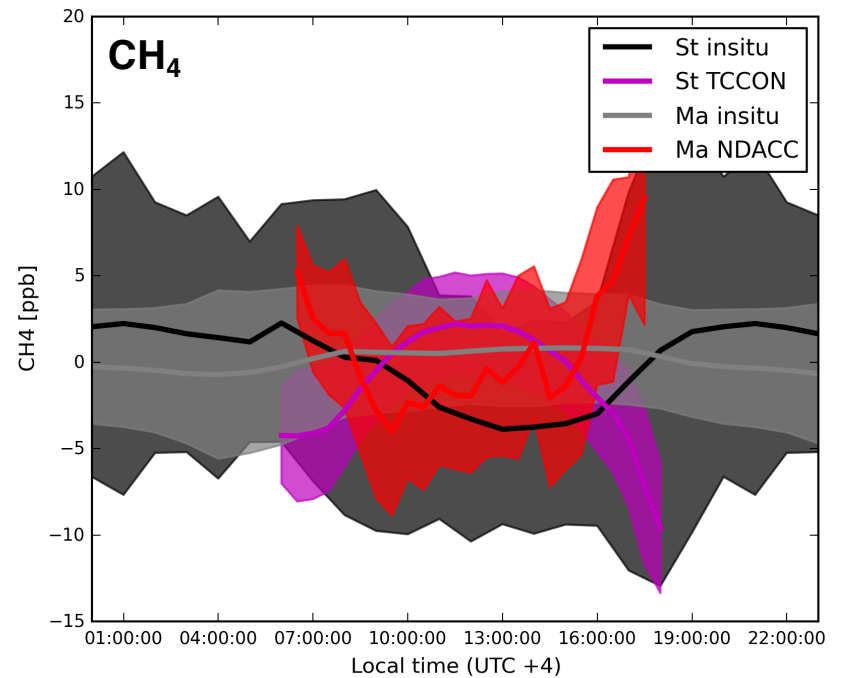


Diurnal variations

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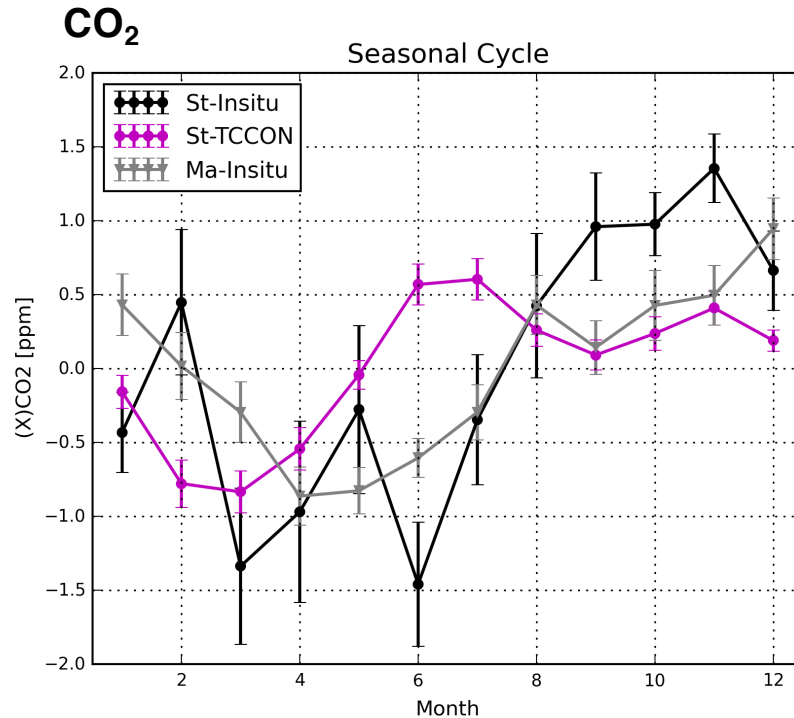


- CO₂: PBL dependent
- CH₄: not clear
- CO: small / no diurnal variation

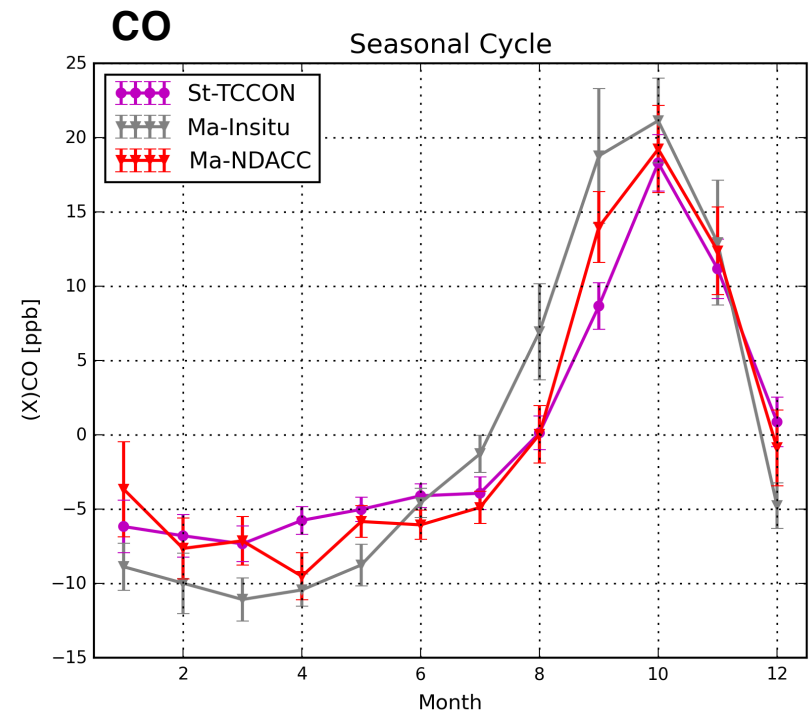
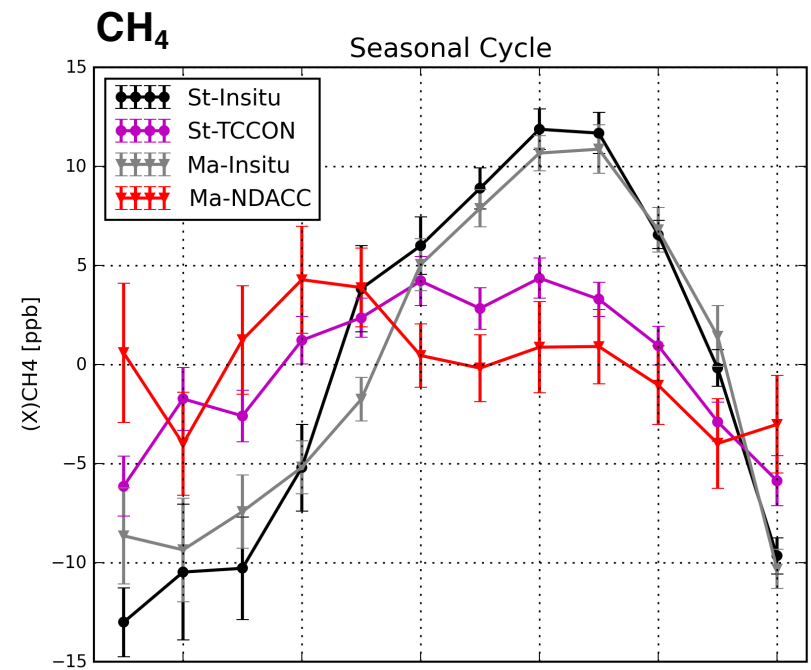


Seasonal cycles

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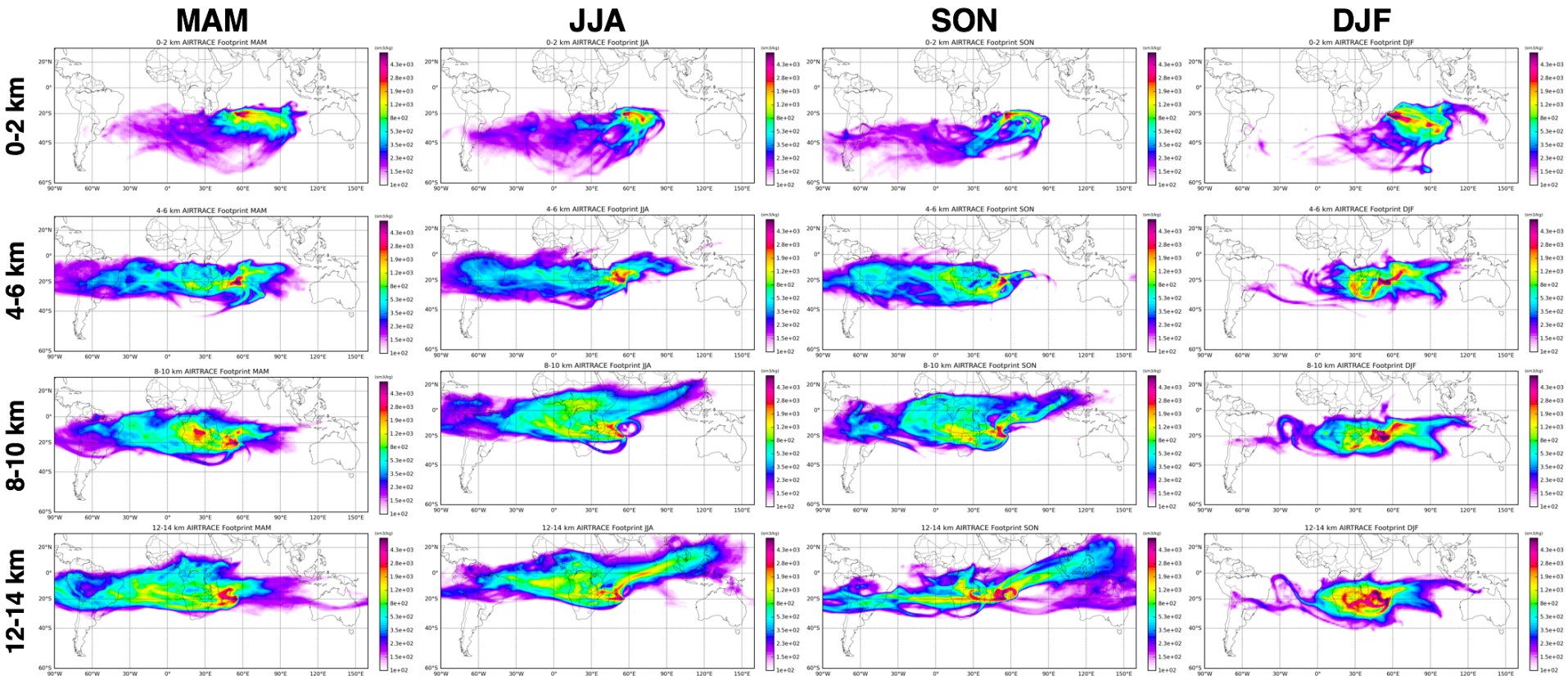


- CO₂: respiration & photosynthesis
- CH₄: OH variation & vertical transport
- CO: Biomass burning & OH variation



Airmass transport at Réunion Island

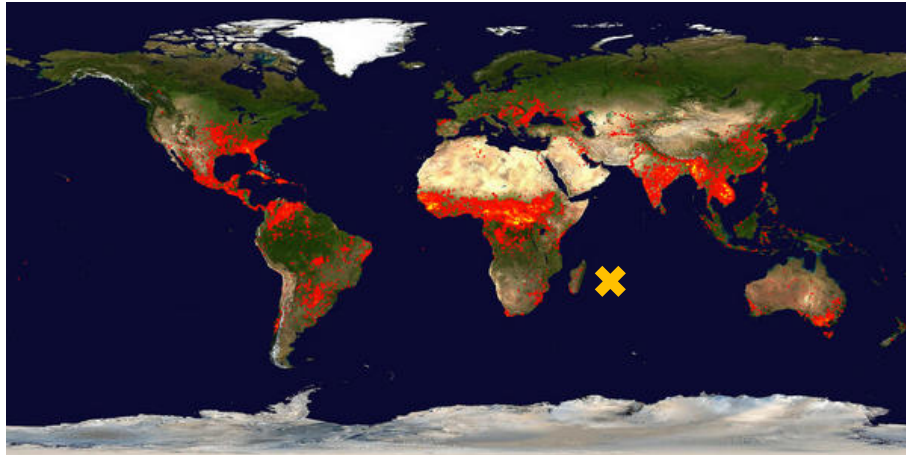
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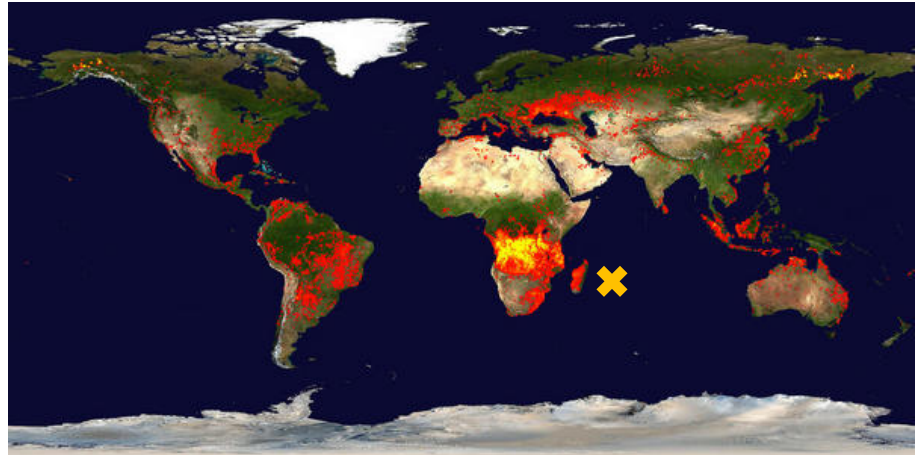
Air mass source of different altitude in the troposphere above Réunion Island in 2007-2011 simulated with FLEXPART v9.02 (20 days' backward running).

Global fire map

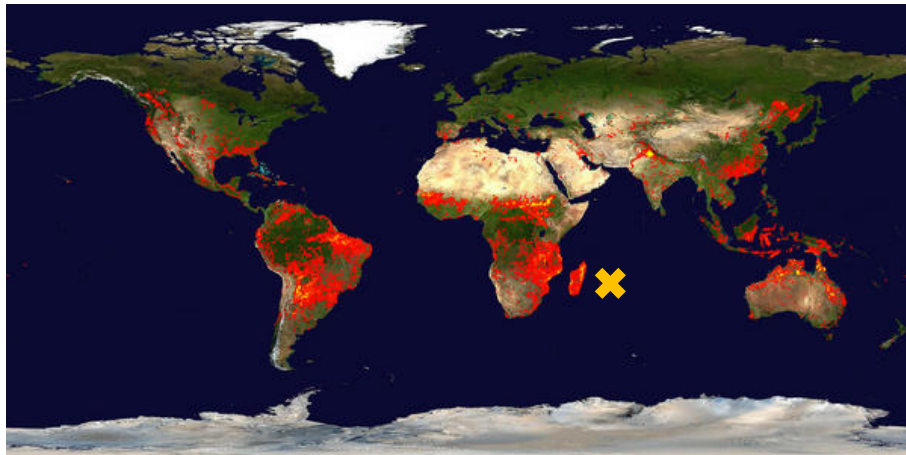
MAM



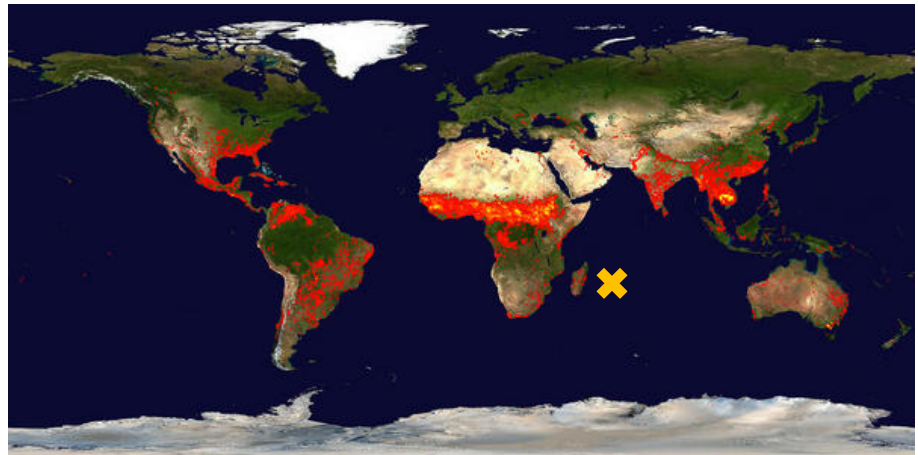
JJA



SON



DJF



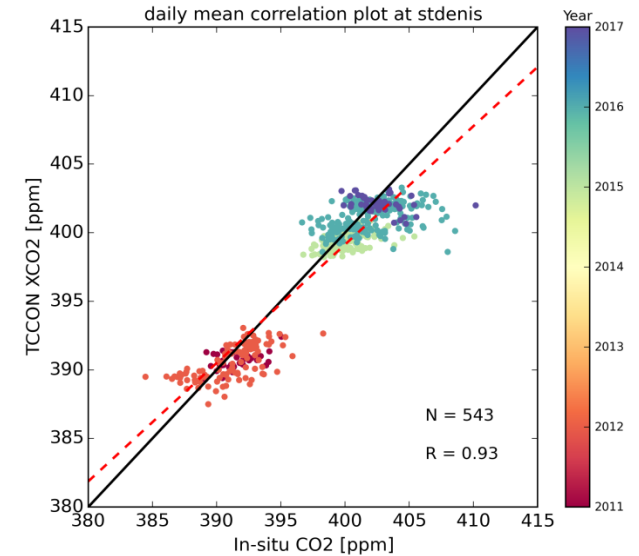
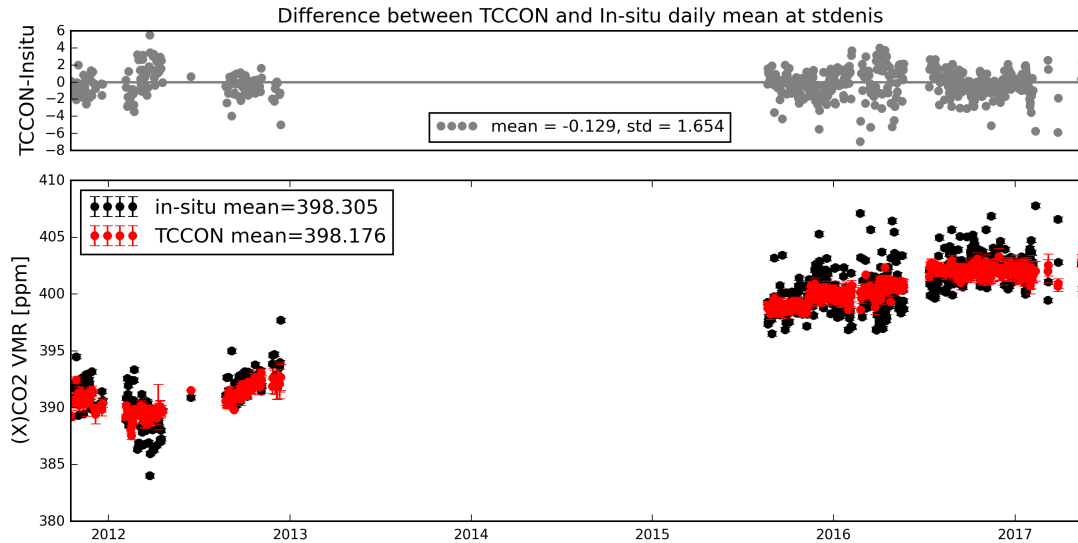
✕ Réunion Island

<https://lance.modaps.eosdis.nasa.gov/>

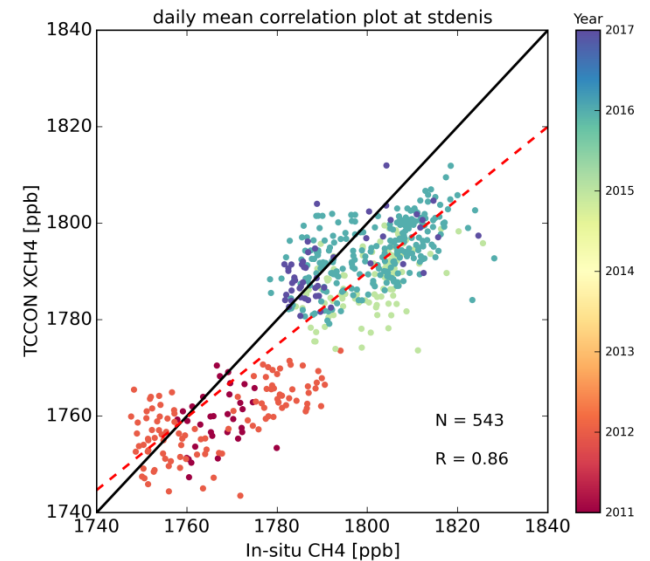
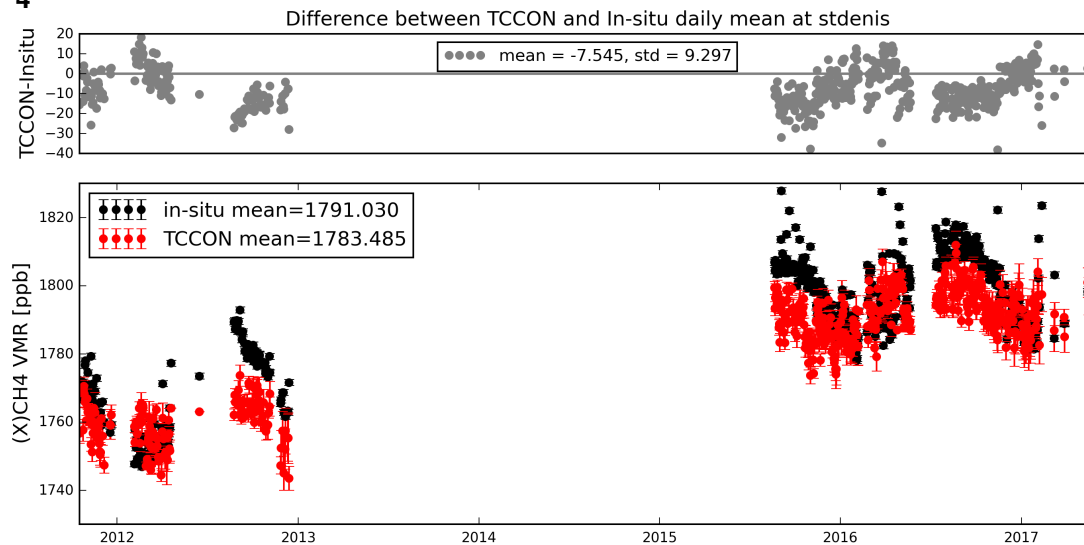
Inter-comparisons at St. Denis (TCCON vs in-situ)

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CO₂



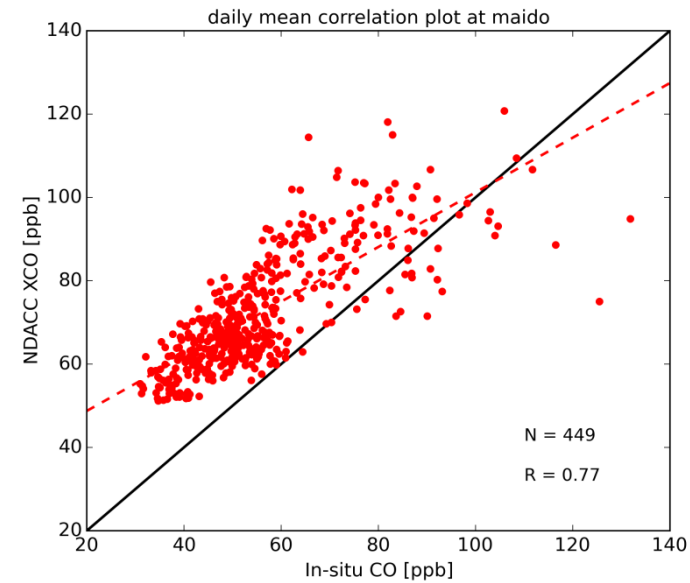
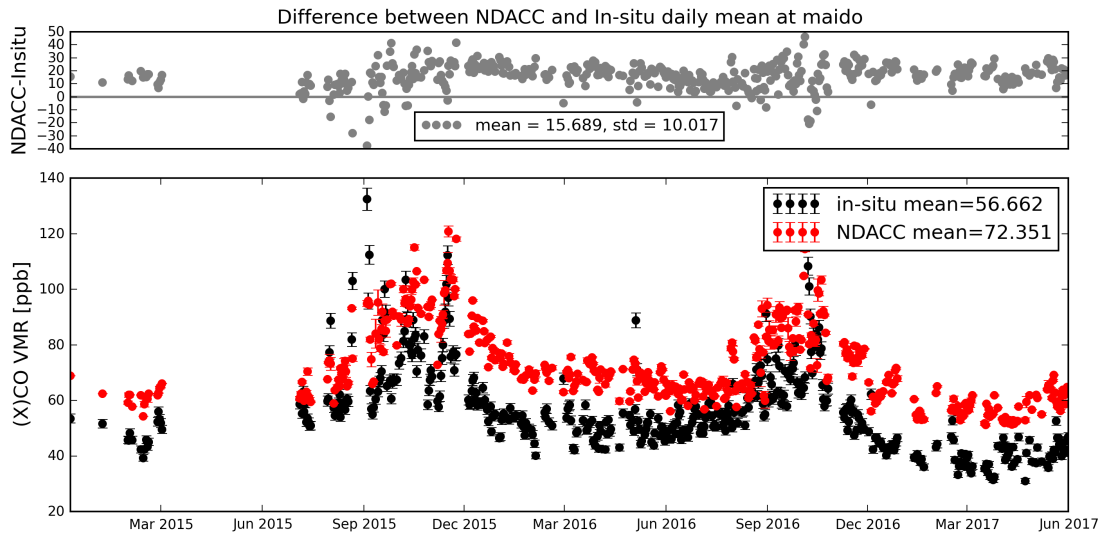
CH₄



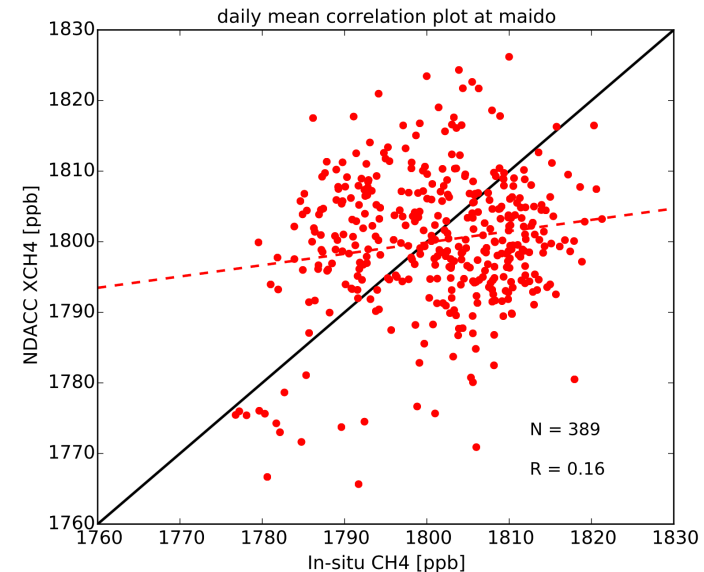
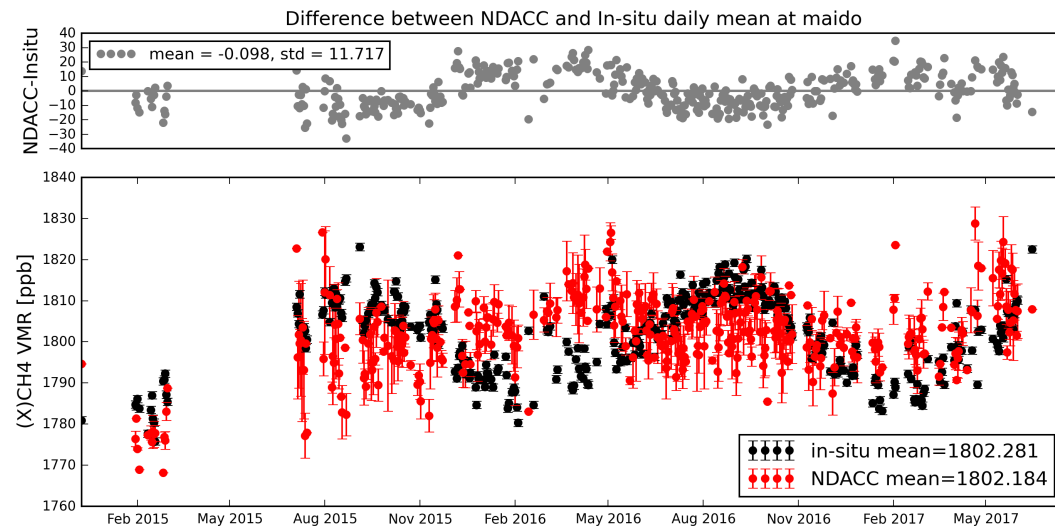
Inter-comparisons at Maïdo (NDACC vs in-situ)

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CO



CH₄



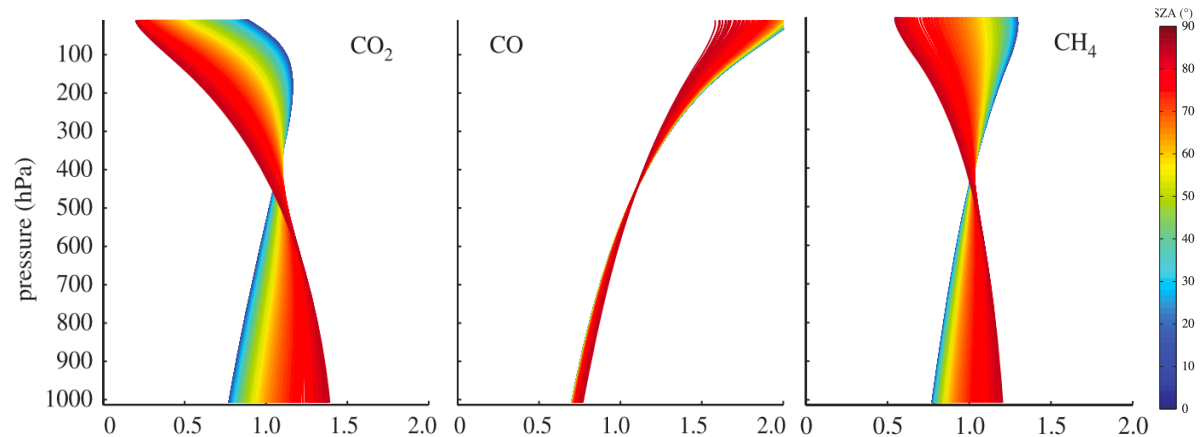
Why the CH₄ seasonal cycles from in-situ and FTIR measurements are different?

FTIR vertical sensitivity

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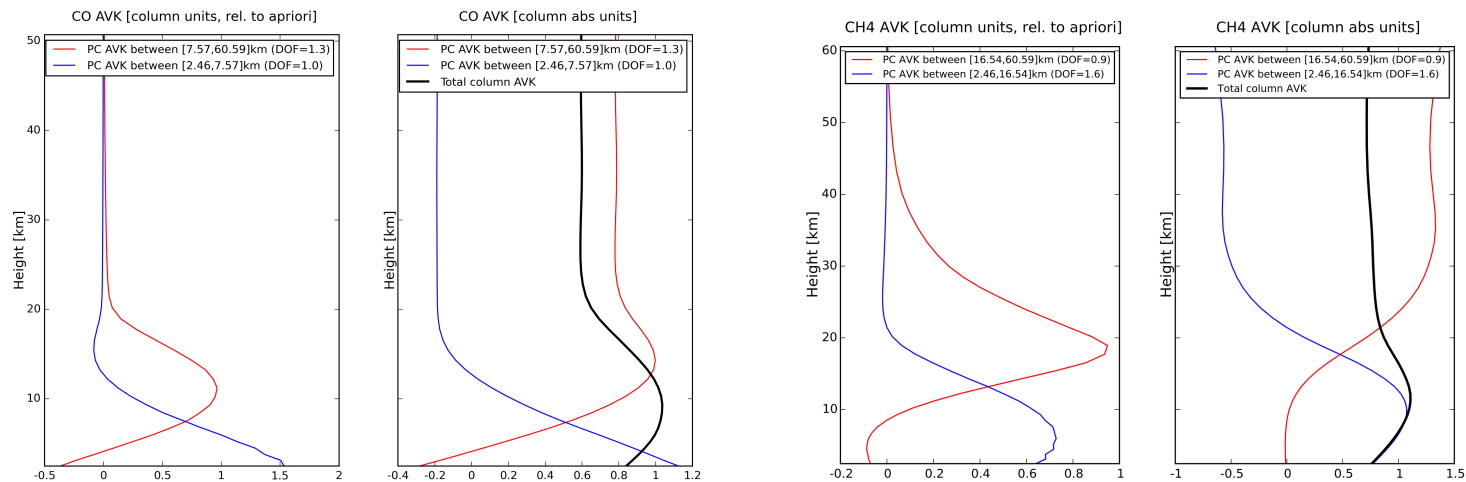
TCCON

CO₂: the whole troposphere
 CO: mid-upper troposphere
 CH₄: the whole troposphere and stratosphere



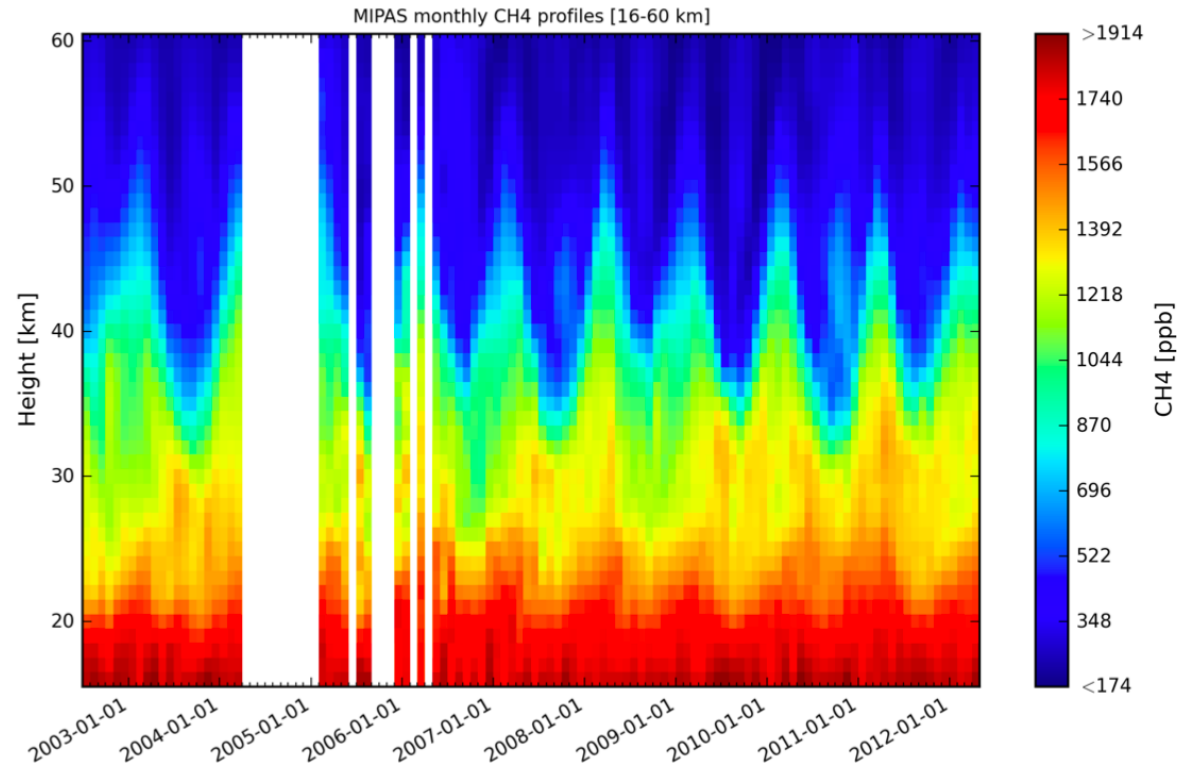
NDACC

CO: the whole troposphere and lower stratosphere
 CH₄: mid-upper troposphere and the lower-middle stratosphere

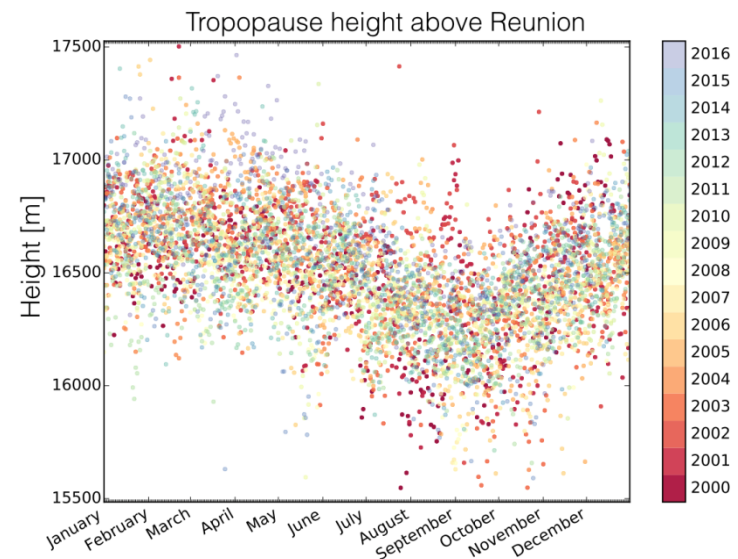


MIPAS CH₄ vertical profiles [16-60 km]

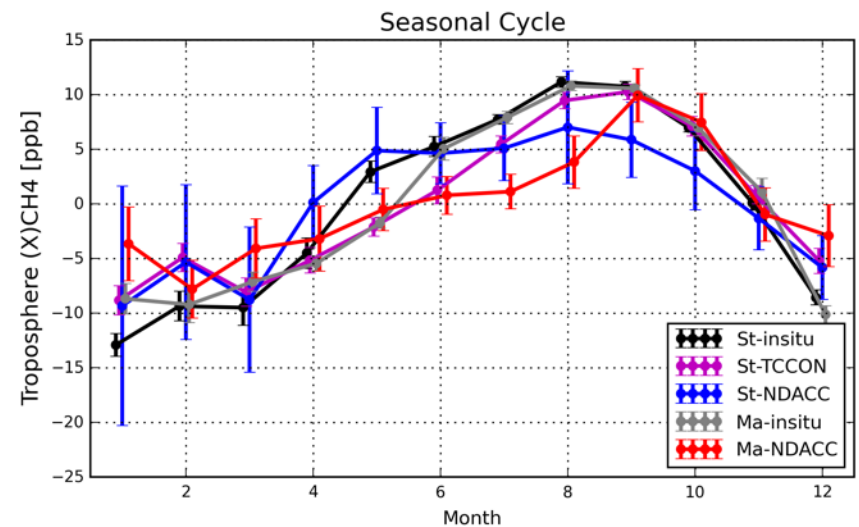
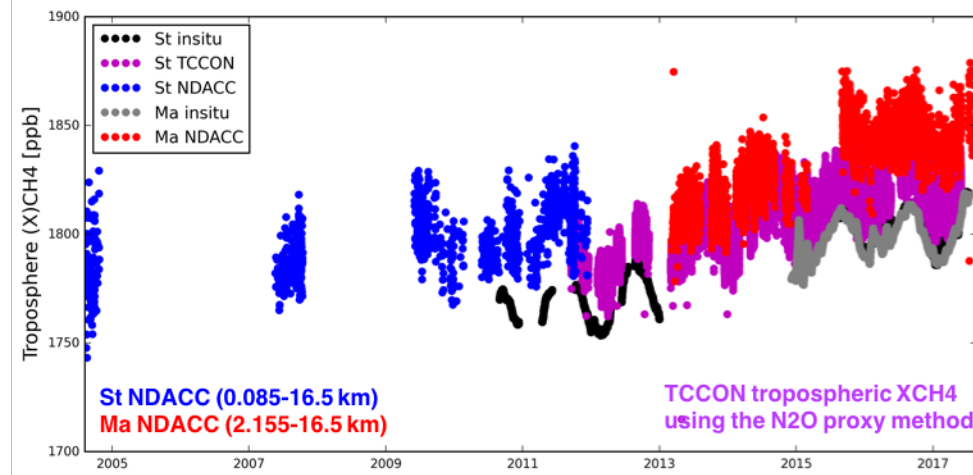
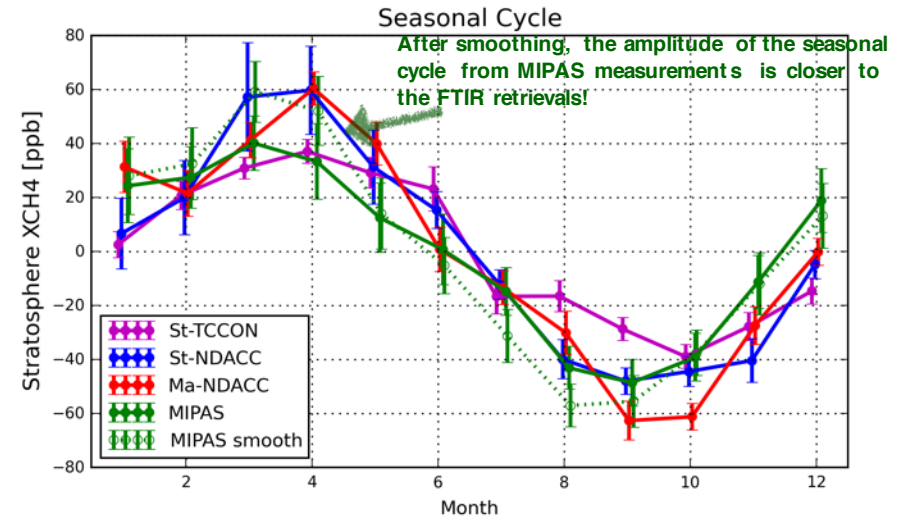
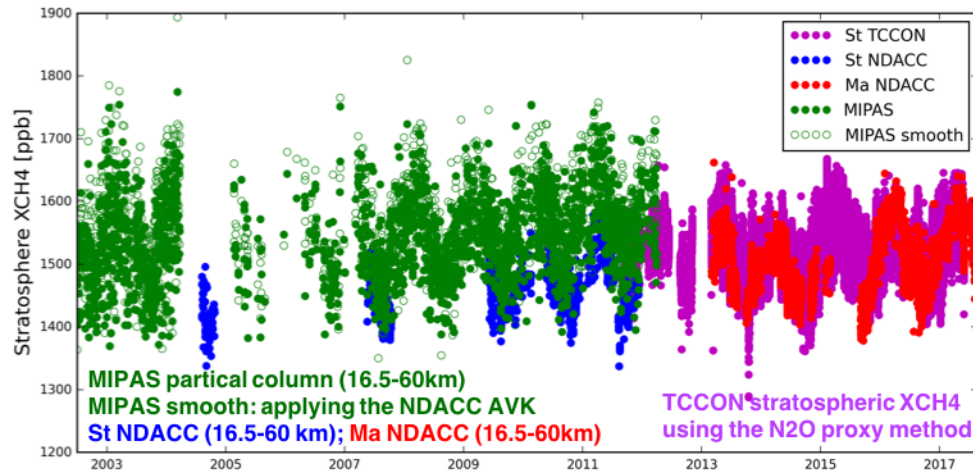
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CH₄ monthly profiles above Reunion Island (± 3 lat ± 5 lon) between 16 and 60 km from MIPAS observations in 2002-2012



Different CH₄ seasonal cycles in the stratosphere and troposphere



- Stratospheric CH₄: vertical transport
- Tropospheric CH₄: OH variation

Conclusions

- ❑ Long term measurements of surface and total column CO_2 , CH_4 and CO concentrations at Reunion Island (Indian Ocean).
- ❑ TCCON CO_2 total columns have a good sensitivity to the troposphere.
- ❑ CO spikes (both surface and total column) in September-November corresponding to the biomass burning in Africa and South American.
- ❑ TCCON and NDACC CH_4 total columns have a good sensitivity to the troposphere, and also to the stratosphere. CH_4 different seasonal cycles are observed in the troposphere and stratosphere.

Thank you for your attention

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