Seven years of measurements of atmospheric methane at the Chacaltaya GAW regional station

Marcos Andrade[1], **Laura Ticona[1]**, Michel Ramonet[2], Olivier Laurent[2], Paolo Laj[3,4,5], Fernando Velarde[1], Isabel Moreno[1], Rene Gutierrez[1], Ricardo Forno[1] and Luis Blacutt[1]

[1]Laboratory for Atmospheric Physics, Institute for Physics Research, Universidad Mayor de San Andrés, La Paz, Bolivia
[2]Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France
[3]Univ. Grenoble-Alpes, CNRS, IRD, Grenoble-INP, IGE, 38000 Grenoble, France
[4]Institute of Atmospheric Sciences and Climate, National Research Council of Italy, Bologna, Italy
[5]Institute for Atmospheric and Earth System Research, University of Helsinki, Helsinki, Finland

***contact**: lticona@chacaltaya.edu.bo

INTRODUCTION

Methane (CH4) is the second most important greenhouse gas behind carbon dioxide due to its radiative properties and it is the most abundant greenhouse gas in the atmosphere after water vapor and carbon dioxide. Its effects on climate and atmospheric chemistry are reasons of concern over its growth rate, even more in tropical regions such as the Amazon.
An improved understanding of the emissions, distribution, and trends of atmospheric methane are essential for taking the right actions in the future.

OBJECTIVES

- Characterize and interpret daily, monthly and seasonal behavior of the methane concentrations observed at the Chacaltaya (CHC) GAW station in the period 2014-2021.
- Quantify the dominant regional methane sources through analysis of satellite products and backtrajectories based on reanalysis data.

MEASUREMENT SITE

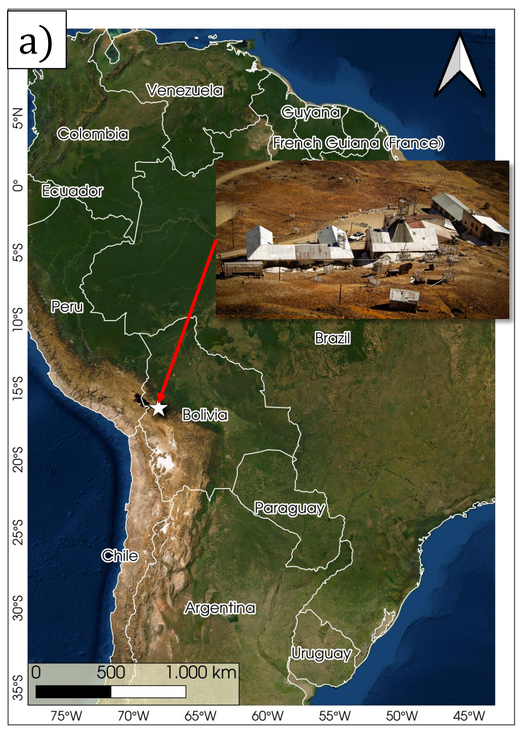
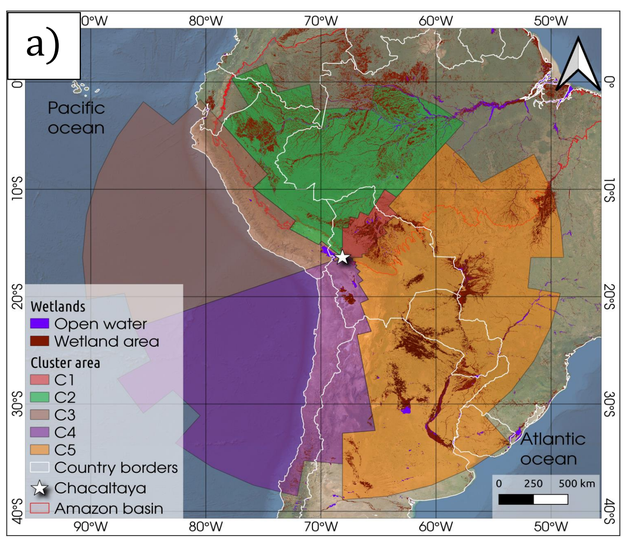


Figure 1. Location of Chacaltaya (CHC) GAW regional station in the South American continent.

Measurements of methane concentrations have been made at the CHC Global Atmosphere Watch (GAW) regional station (5240 m a.s.l.) located in the Bolivian Andes since 2014 to date.
During this period, two high-precision Picarro-CRDS analyzers were used at the station. They were regularly calibrated with internationally certified gases (WMO X2004A) via the Laboratory for Sciences of Climate and Environment (LSCE) primary scale. The site has a privileged location not only because of its altitude but also because it can sample air masses arriving from the near Altiplano, a sizeable high-altitude plateau (~3 800 m a.s.l.); the Amazon to the north, the Pacific Ocean, and the growing metropolitan area of La Paz/El Alto (~2 million of inhabitants) located around 15 Km to the south.

PREVALENT PATHWAYS OF AIR MASSES ARRIVING TO CHACALTAYA



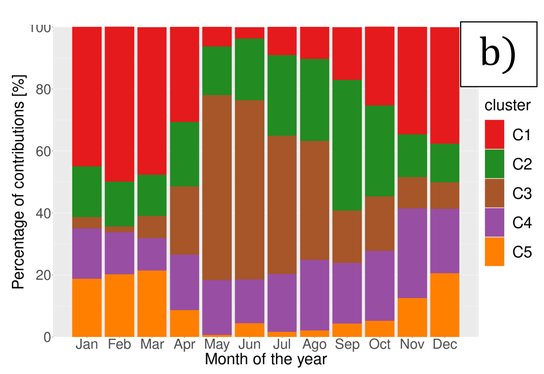


Figure 2. a) Air mass cluster definition centered on CHC (white star). The five prevalent clusters of mass air origin were obtained following the method in Chauvigné et al. (2019) b) Monthly variation, in percentage, of the contribution of each cluster.

In order to identify prevalent pathways of air masses at a regional scale, we use a set of 96 hours of air mass HYSPLIT back-trajectories calculated for every hour from the CHC station for 2014 - 2021. The input meteorological fields were obtained from ERA5 (~30 Km horizontal resolution). The air mass classification was obtained by applying k-means clustering analysis to the temporal signatures of geographic cells over a log-polar grid (Chauvigné et al., 2019).
Cluster **C1** encompasses most of the Amazonian wetlands of Bolivia, known as the "Llanos de Moxos" (150 000 Km^2), located between the eastern Andes and the Brazilian shield. **C2** encloses the northern region of the central Amazon basin. **C3** and **C4** cover the northwest and south region of the Altiplano, respectively. Finally, **C5** includes the "Dry Chaco" region shared by Bolivia and Paraguay, in addition to the Pantanal wetland at the eastern border with Brazil.
The main contributors during the wet season (Dec, Jan, Feb & Mar) are clusters C1 and C2 (Amazon), whereas C3 (Altiplano) is the main contributor throughout the dry season (May, Jun, Jul & Aug).

DAILY, SEASONAL AND INTERANNUAL METHANE CYCLES

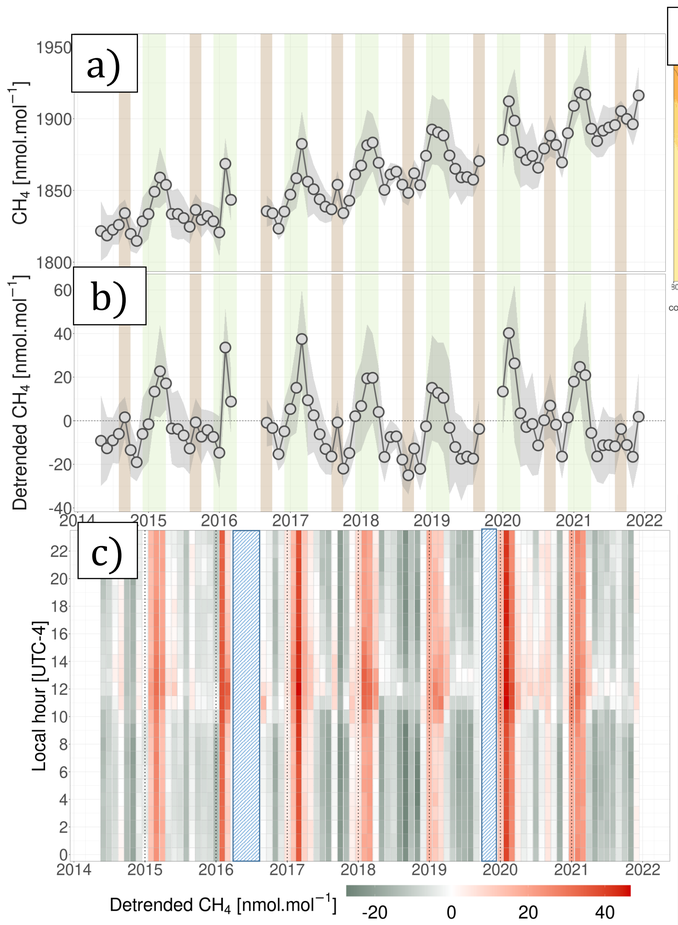


Figure 3. Interannual monthly time series of atmospheric methane at CHC. It should be noted that data were collected regularly during the COVID lockdown. Brown and green shaded areas highlight the dry and wet season, respectively ***a)** series without removing the trend, **b)** detrended series, **c)** heat map from detrended values*

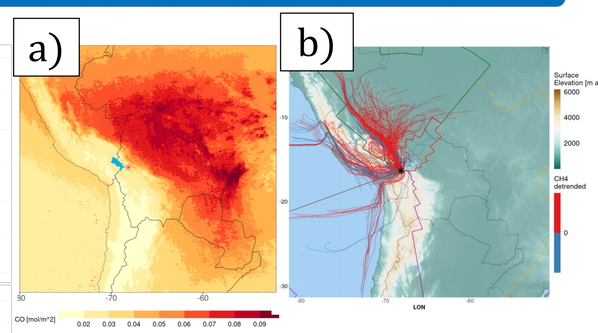


***Figure 4. a)** Vertical integrated CO column density, obtained from TROPOMI, averaged for September 2020, **b)** Back-trajectories for the same month.*

South America has the world largest relative area (>20%) covered by a great variety of wetlands (Kandus et al., 2017). Natural wetlands are the primary potential sources and drivers of methane emissions in the region, producing a clear interannual cycle (Figure 3). Biomass burning is the second contributor to methane concentrations observed at CHC. Although most of the fires occur along the so called 'arc of deforestation in Brazil', in the southern part of the Amazon rainforest during the dry season (Tunnicliffe et al., 2020), methane (and other products) are transported to the Andes under the right meteorological conditions.

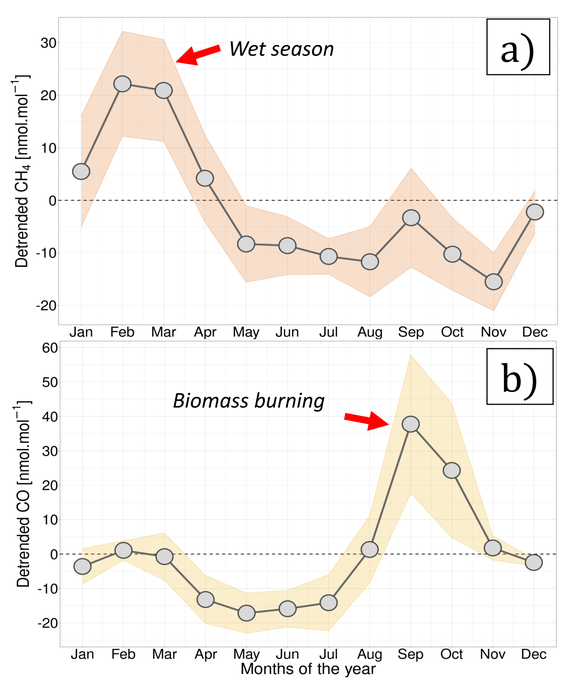


*Figure 5. Seasonal cycles for concentrations of **a)** methane and **b)** carbon monoxide. Mean values in solid gray lines. Shadow areas denote one standard deviation. Data corresponding to local contamination (8h - 18h LT) were excluded from the calculations. Both figures are based on detrended data.*

In terms of seasonal cycle (Figure 5a), two peaks are observed. The first one, and the most important, occurs in Feb-Mar, at the end of the rainy season. It is probably related to the flooded areas in the lowlands due to runoff from the Andes.
A secondary peak occurs at the heart of the biomass burning season, September, which also coincides with the largest peak observed in the carbon monoxide concentration mean monthly values (figure 5b).

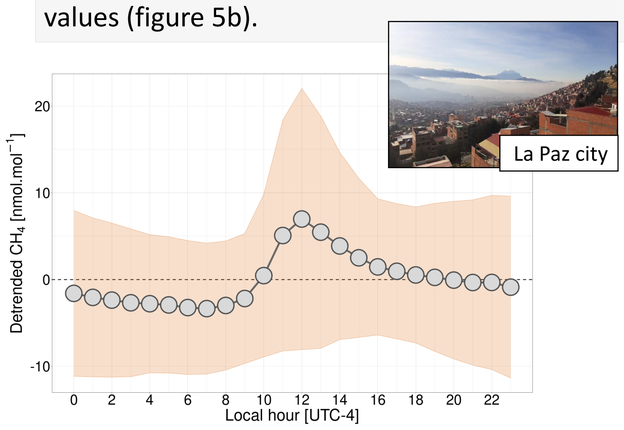


Figure 6. Diurnal cycle of methane measurements obtained from detrended values. The peak observed between 8 and 18 hours corresponds to the period when air masses from the metropolitan area typically arrive to the station.

CONCLUSIONS

- The contribution from the metropolitan area to the measurements in CHC are observed (8 -18h LT)
- The maximum of methane is observed during the wet season.
- There is a secondary maximum during the biomass burning season.
- In both cases, methane sources seem to be in the lowlands.
- Long-range transport, under the right meteorological conditions, plays a major role in the observed concentrations at CHC.

REFERENCES

Chauvigne, A., Aliaga, D., Sellegri, K., Montoux, N., Krejci, R., Mocnik, G., Moreno, I., Müller, T., Pandolfi, M., Velarde, F., Weinhold, K., Ginot, P., Wiedensohler, A., Andrade, M., & Laj, P. (2019). Biomass burning and urban emission impacts in the Andes Cordillera region based on in situ measurements from the Chacaltaya observatory, Bolivia (5240a.s.l.). *Atmospheric Chemistry and Physics*, *19*(23), 14805–14824. https://doi.org/10.5194/ACP-19-14805-2019

Kandus, P., Minotti, P. G., Morandeira, N. S., Grimson, R., González Trilla, G., González, E. B., ... & Gayol, M. P. (2018). Remote sensing of wetlands in South America: status and challenges. International Journal of Remote Sensing, 39(4), 993-1016

Tunnicliffe, R. L., Ganesan, A. L., Parker, R. J., Boesch, H., Gedney, N., Poulter, B., Zhang, Z., Lavrič, J. V, Walter, D., Rigby, M., Henne, S., Young, D., & O'doherty, S. (2020). Quantifying sources of Brazil's CH 4 emissions between 2010 and 2018 from satellite data. Atmos. Chem. Phys, 20, 13041–13067. https://doi.org/10.5194/acp-20-13041-2020