The ANR COoL-AMmetropolis project : towards establishing virtuous scenarios for reducing greenhouse gas emissions of the Aix-Marseille-Provence metropolis (France)

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CONTEXT : Cities and their industrial infrastructures are estimated to emit more than 70% of global fossil fuel CO_2 emissions (Seto et al, 2014). Furthermore, methane sources are not well known at the regional/urban/industrial site scales. The Aix-Marseille metropolis is located in the south-east of France in the SUD-PACA region. It is supposed to emit about 15% of national fossil fuel CO_2 emissions (i.e. 10.4 MtC/yr, source : ATMOSUD) and about 4.6% of national anthropogenic CH4 emissions (i.e. 2.65 MteqCO2, source : ATMOSUD) . Its emissions are delivered at a fine scale (1h, 1x1 km²) by the regional air quality monitoring agency ATMOSUD, but these emissions have never been assessed independently. Our project aims at assessing independently the ATMOSUD CO_2 and CH_4 emissions inventory using top-down approaches in order to reducing its uncertainties and to helping local and regional stakeholders to take efficient emissions mitigation actions towards reaching carbon neutrality in 2050 or earlier. We organize regular seminars with stakeholders to discuss about our results and to improve with them the definition of virtuous and realistic scenarios. We will model these scenarios at the fine scale using the MESO-NH national meteorological model coupled with the ISBA-A-gs vegetation model and the TEB urban canopy model.

OBJECTIVES :

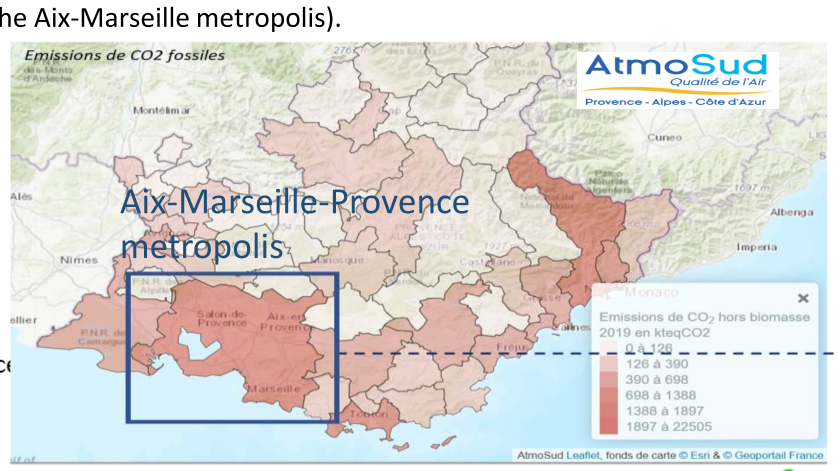
- ✓**Assessing and improving current emission inventory estimates of the Aix-Marseille-Provence metropolis** through atmospheric observation-based approaches.
- ✓**Developing a high resolved CO_2 modeling framework based on the MESO-NH model** including emission inventory estimates and a dynamic modeling tool of CO_2 emissions from buildings, to model atmospheric CO_2 urban plumes.
- ✓**Assessing the performances of the modeling framework** by comparing meteorological, boundary layer height and CO_2 measurements with the modeled fields.
- ✓**Defining vertuous CO_2 emissions mitigation scenarios** together with local stakeholders and socio-economic actors taking into account current environmental laws and sobriety approaches, at the horizon 2030 and 2050.
- ✓**Modeling these scenarios by emission sectors at high resolution on the AMP metropolis** (including e.g. building isolation, air conditioning mitigation, greener mobility)

FOCUS OF THIS POSTER : Here we present results on atmospheric CO_2 variability and source apportionment in the area of the Aix-Marseille-Provence metropolis, France.

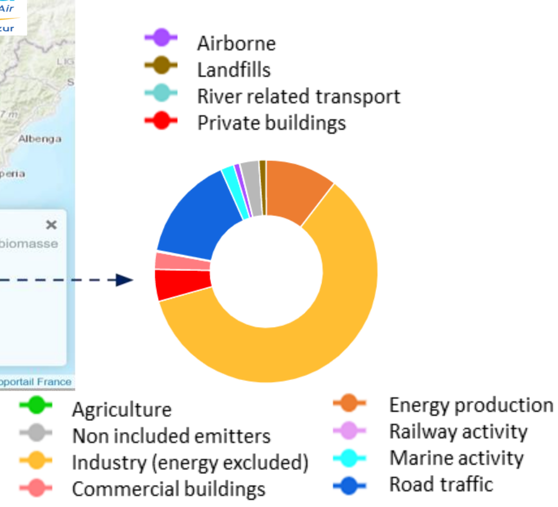
REGIONAL AND METROPOLITAN CO2 EMISSIONS :

According to ATMOSUD inventory, 96% of anthropogenic emissions from Aix-Marseille-Provence metropolis come from the burning of fossil fuels (mostly from the industry sector, as there is a very large industrial complex in the west part of the Aix-Marseille metropolis).

The SUD-PACA region and Aix-Marseille-Provence metropolis



FFCO2 emissions of the SUD-PACA region

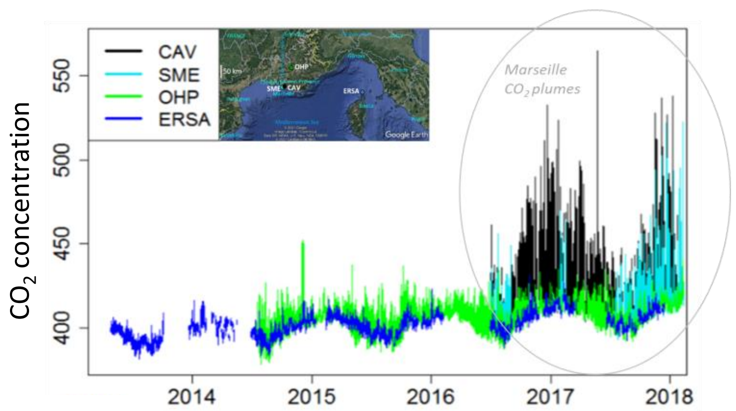


REGIONAL ATMOSPHERIC CO2 AND CH4 NETWORK :

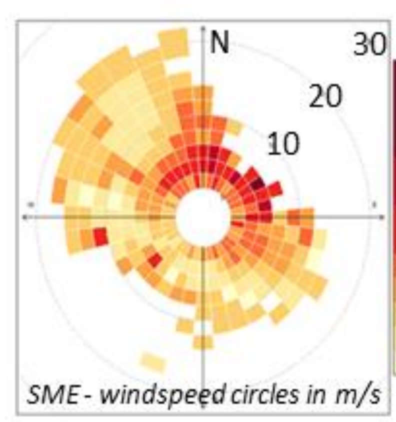
We developed an atmospheric CO_2 and CH_4 observation network in and around the Aix-Marseille-Provence metropolis made of 6 sites equiped of CRDS analyzers calibrated on the WMO-2007 scale. The data precision and accuracy is <0,1 ppm.

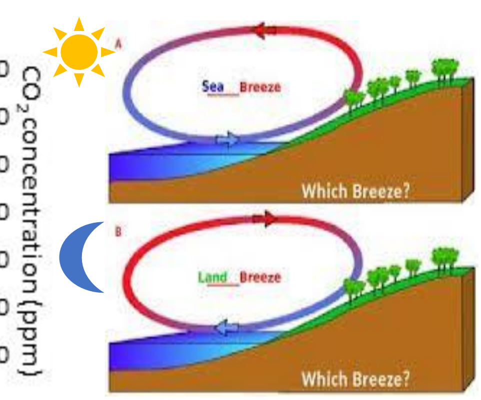
OHP : Observatoire de Haute Provence (rural)
PDB : Port-de-Bouc (industriel)
MRS : Marseille-Longchamp (urbain)
SME : Station Marine d'Endoume (côtier urbain)
FBL : Fontblanche (forestier)
ERSA : Cap Corse (côtier)

VARIABILITY OF ATMOSPHERIC CO_2 : *Xueref-Remy et al, 2022, in subm.*



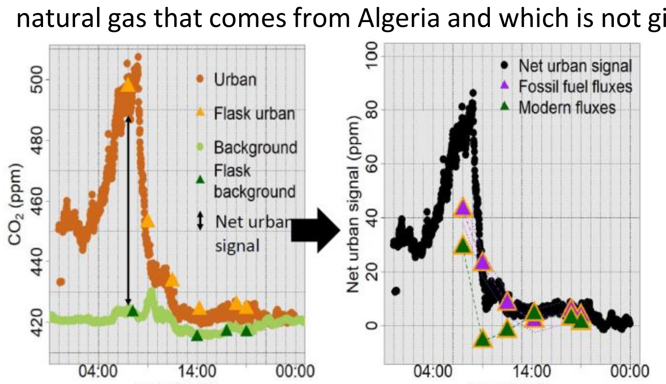
At both ICOS remote sites (ERSA and OHP), atmospheric CO_2 shows a clear seasonal cycle of about 10 ppm of amplitude and an annual increase of about 2.7 ppm almost as in Mauna Loa, Hawaii. Large spikes of CO_2 are found in Marseille (CAV), especially in winter (higher emissions from heating and lower boundary layer height) and at low wind speed (accumulation of emissions on the city), giving rise to a CO_2 urban dome/plume. At the urban coastal site (SME), the coastal breezes regime controls the CO_2 variability with higher CO_2 concentrations for airmasses coming from land and passing over the city in a shallow boundary layer (land breezes, at night) than for those coming from the sea (sea breezes, daytime).



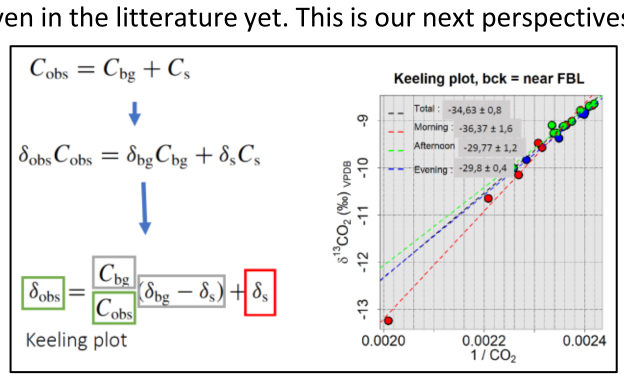


ATMOSPHERIC CO_2 SOURCES APPORTIONMENT: *Lelandais, Xueref-Remy et al, EGU 2022*

To assess the role of fossil fuel combustion vs modern sources on the urban CO_2 plume of Marseille, we performed a ^{14}C in CO_2 analysis in the winter 2020 at the CAV site, which shows that at the maximum of the morning traffic peak, about 87% of atmospheric CO_2 comes from the combustion of fossil fuel sources. We also carried on a ^{13}C analysis in atmospheric CO_2 which gives a source signature of -44 permil at the maximum of the morning traffic peak. Although in the litterature this value is close to the signature of natural gas, we can not conclude in our case year as we need to measure the signature of local natural gas that comes from Algeria and which is not given in the litterature yet. This is our next perspectives, with the characterization of the signatures of the main local 13C sources (wood, grasses, oil…).



% of CO2ff the urban plume	
Morning	: 58 (44-87)
14h	: 20.4
Evening	: 46.71



$\delta^{13}Cs = a * \delta^{13}Cff + b * \delta^{13}Cmodern$

$\delta^{13}Cs = X * \delta^{13}Cff + (1- X) * \delta^{13}Cmodern$

X% of CO2ff
Morning : 58 (44-87)
14h : 20.4
Evening : 46.71

-24‰ δ13Cbio

Technics	Keeling plot		
period	Morning	14h	Evening
δ13Cs	-36,07	-27,74	-29,8
δ13Cff (δ13Cs corrected)	-44,53	-42,28	-36,41

Reference	d13C traffic (permil)	d13C liq (permil)	d13C gas (permil)	d13C solid (permil)	d13C bio (permil)	d13Cs (permil)	d13Cff (permil)
Venturi et al 2021	-27	-28.9	-44			-27 to -36	
Clark and Thorne 2003 Widory and Javoy 2003 Pang et al 2016	-32 to -27		-44 to -37	-24.8			
Venturi et al 2020	-27				-26.5 -20	-26 / -22 jul -30.6 / -25.5 oct -36.4 / -30.4 nov-dec	
Gorcka and lewicka 2013 Zimnoch et al 2009	-27		-40/-42		-26.5 -20	-27.6 / -25.7	
Lopez et al 2013		-26,5	-41	-24.1	-24.7		-36.1 / -36.2

References : Lelandais, Xueref-Remy et al (2022), EGU conference, Vienna, Austria. Seto et al (2014) eds. Cambridge, UK and New York, NY: Cambridge University Press. Xueref-Remy et al (2022), Atm. Env., in subm.