ChArMEx/TRANSEMED: Urban atmospheric pollution from emission evaluation to health impact assessment in the Eastern Mediterranean.

Agnes Borbon[1]*, Th. Salameh[2], A. Waked[2], S. Sauvage[2], C. Afif[3], N. Locoge[2], F. Oztürk[4], B. Cetin[5], B. Thera[1] , M. Keles[3], S. Alfaro[6], A. Wheida [7], S. Hassan [7], J. Sciare[8]

Presented by François Dulac, LSCE, France (ChArMEx coordinator) on behalf of A. Borbon

[1] LaMP, OPGC, CNRS, France
[2] IMT Lille Douai, SAGE, France
[3] EMMA, USJ, Lebanon
[4] Abant Izzet Baysal University, Turkey
[5] Gebze Technical University, Turkey
[6] LISA, CNRS, France,
[7] NRC, Egypt
[8] Cyprus Institute, Cyprus

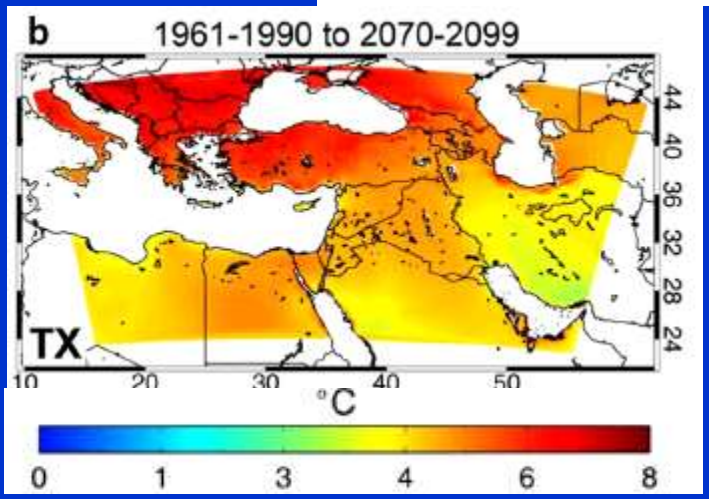
* a.borbon@opgc.univ-bpclermont.fr

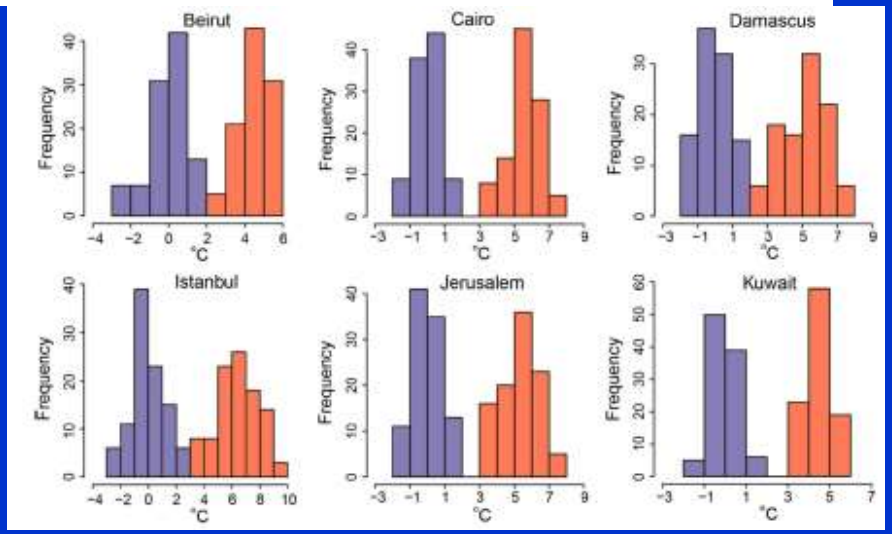
Why East Med ?

- **Highly sensitive environment under considerable pressures**

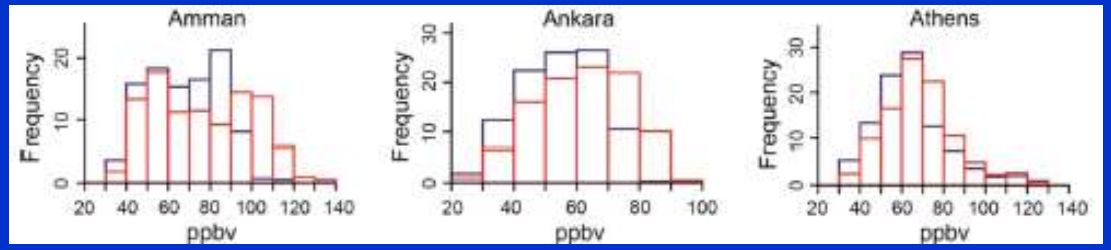
EM as **a hot spot of climate change : much stronger** warming than in other regions (Lelieveld et al., 2009, 2012, 2014)

Modelled max daytime temperature 1961-1990 2070-2099





EM as a hot spot of poor air quality (Pozzer et al., 2012)



Calculated surface ozone distribution
2005 2050

Increased respiratory diseases and premature mortality (Lelieveld et al. 2013)

Emissions : a key compounding factor

Regional : increasing of atmos. pollutant load in urban areas

NO_2 column

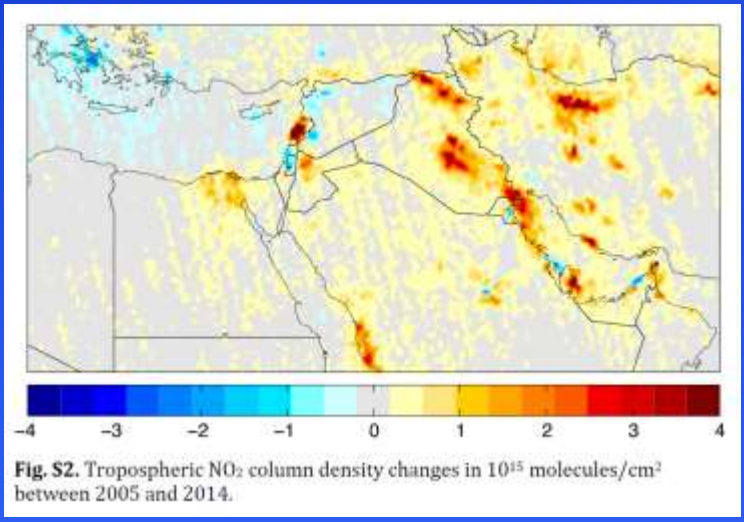
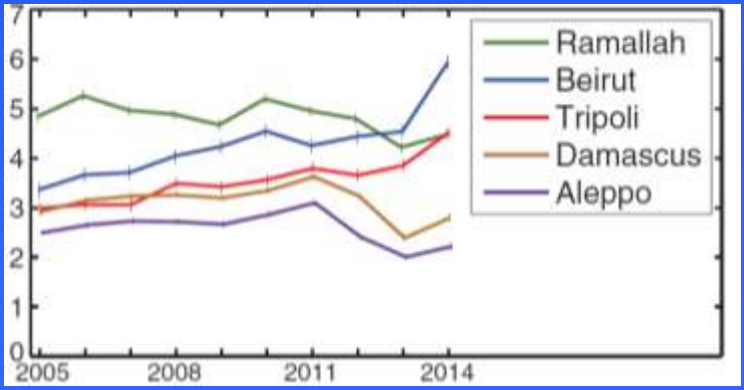
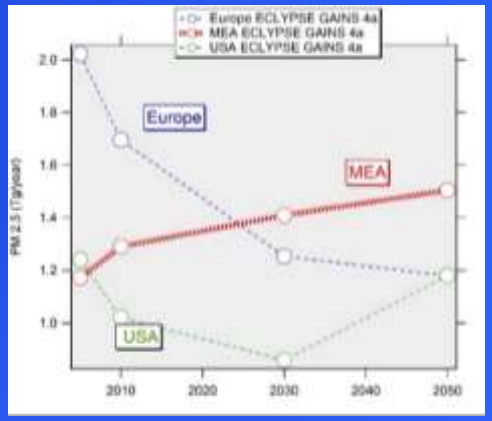


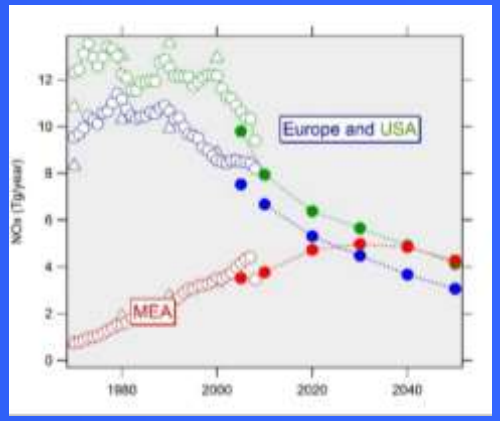
Fig. S2. Tropospheric NO_2 column density changes in 10^{15} molecules/cm^2 between 2005 and 2014.

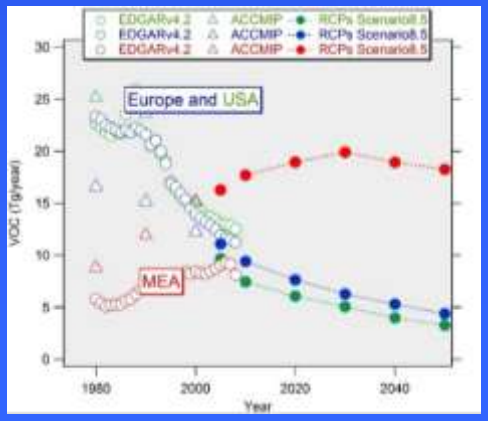


Lelieveld et al., 2015

Global : emissions from Middle-East (MEA) as significant or even higher than the rest of the world







Salameh et al., 2017

TRANSEMED : TRANSport Emissions and Mitigation in the East meDiterranean

Assessing the state of atmospheric anthropogenic pollution at urban and EMB scales at present and for the next decades

Objective 1

Urban atmospheric composition and evaluation of anthropogenic emission inventories

Objective 2

Evaluation of the present impact of anthropogenic emissions on air quality

Perspective

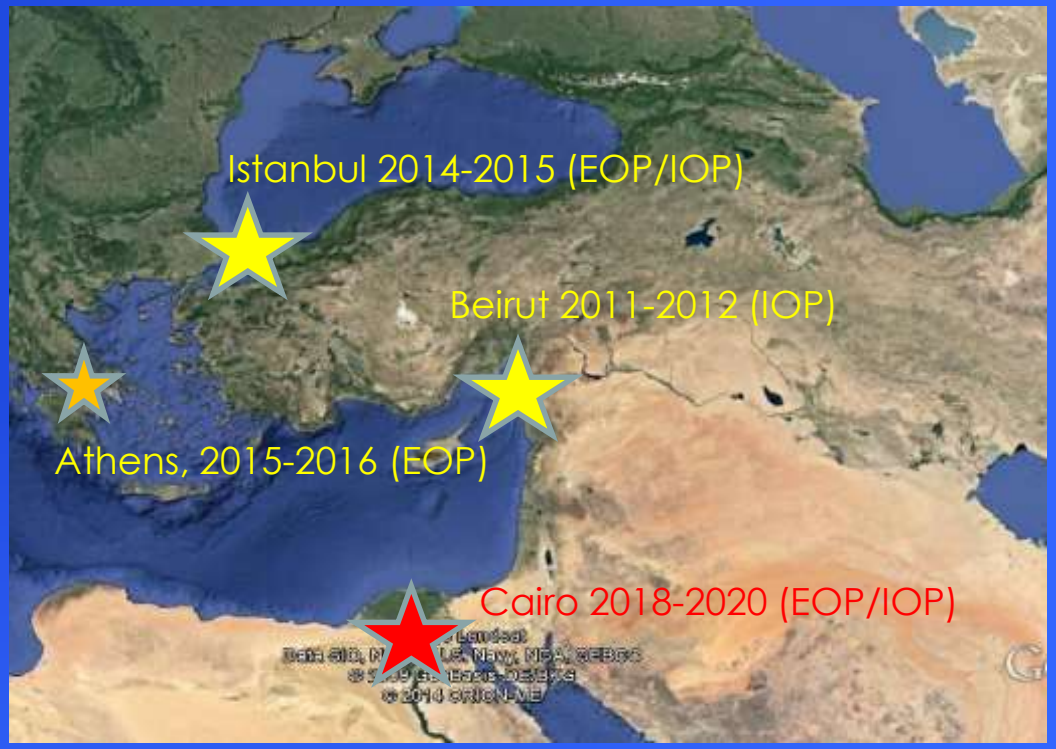
Creating region-specific mitigation scenarios in a changing climate

Strategy

Year round monitoring (EOP) and intensive field campaigns (IOP) at urban background sites and near sources

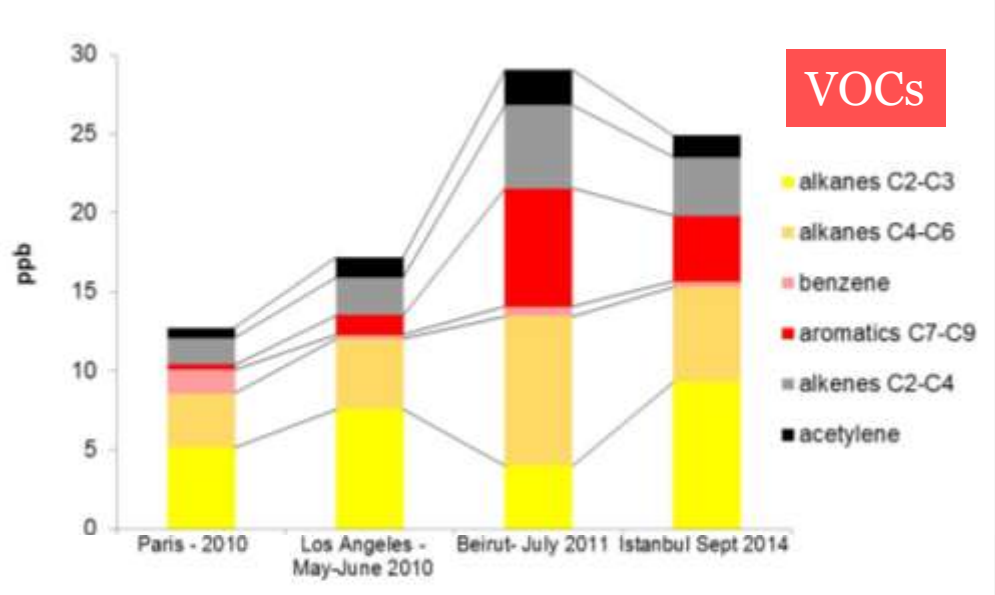
Source-receptor approach : Emission Ratios, Positive Matrix Factorization (PMF)

Emission inventories evaluation (local and global with downscaling)



- **Air Quality Parameters : NO/NO_2/Nox, Ozone, CO**
- **Organics in both gas and particulate phases : more than 60 VOC (GCFID, PTRMS and active tubes), primary and secondary organic aerosol tracers, OC/EC; PAH**
- **Trace metals, ions**
- **Meteorological parameters, NO_2 photolysis frequency**

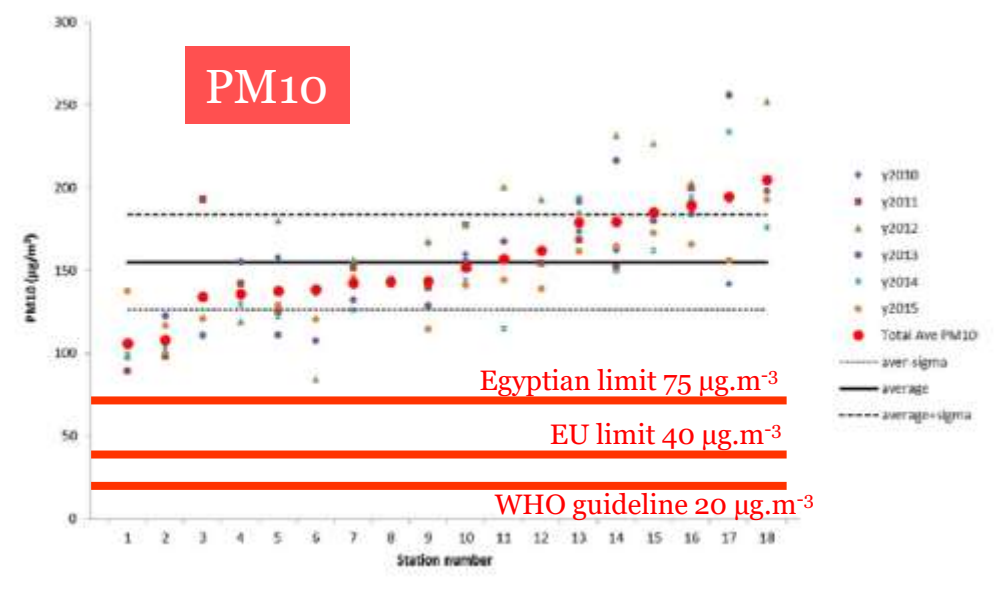
High levels of pollution



VOC atmospheric composition

Higher levels of VOC observed (factor of ~2), especially for the unburned fossil fuel fraction (C4-C6 alkanes and aromatics).

Salameh et al., Environ. Chem., 2015
Borbon et al., 2016 , and in prep. for ACP



PM_{10} in Cairo 2010-2015 at 18 stations

155 µg.m^{-3} on average >> AQ guidelines

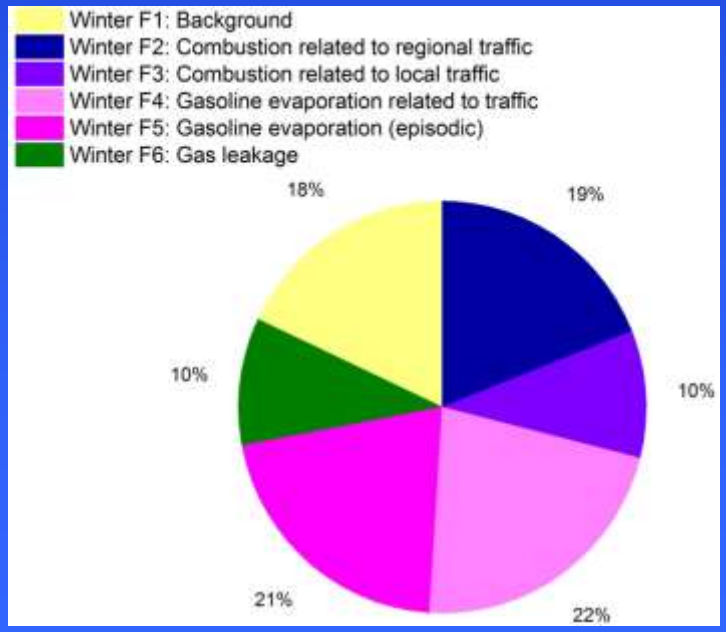
Wheida et al., Environ. Res., 2018

Importance of traffic emissions ?

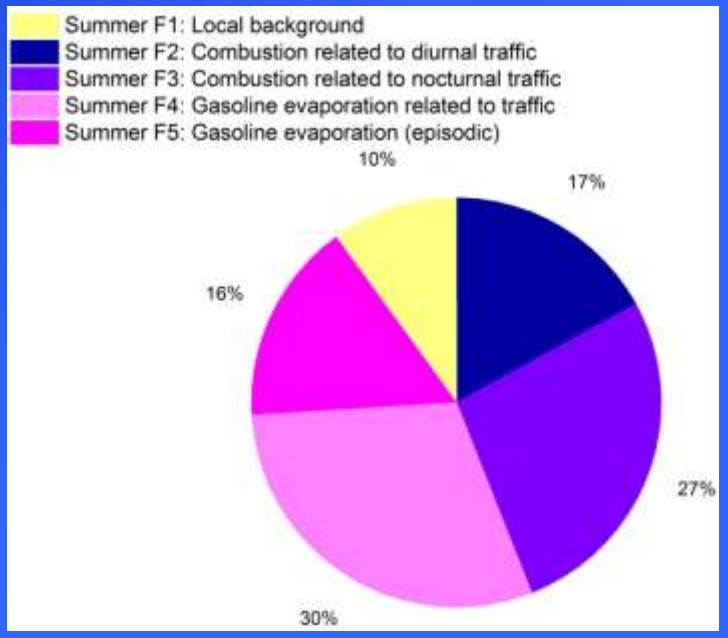
- **PMF analysis of VOCs in Beirut :**
- **Traffic (exhaust + evaporation) dominates observed VOC concentrations :**

51% in winter **76% in summer**

Contributions in winter 2011



Contributions in summer 2011

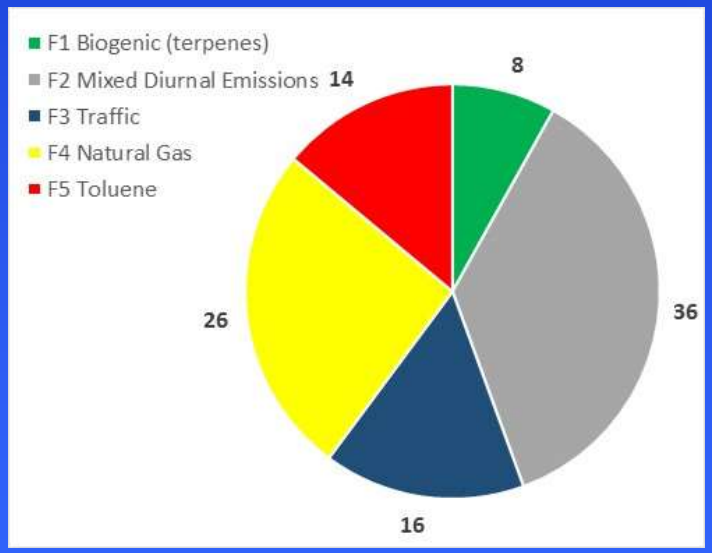


Salameh et al., ACP, 2016

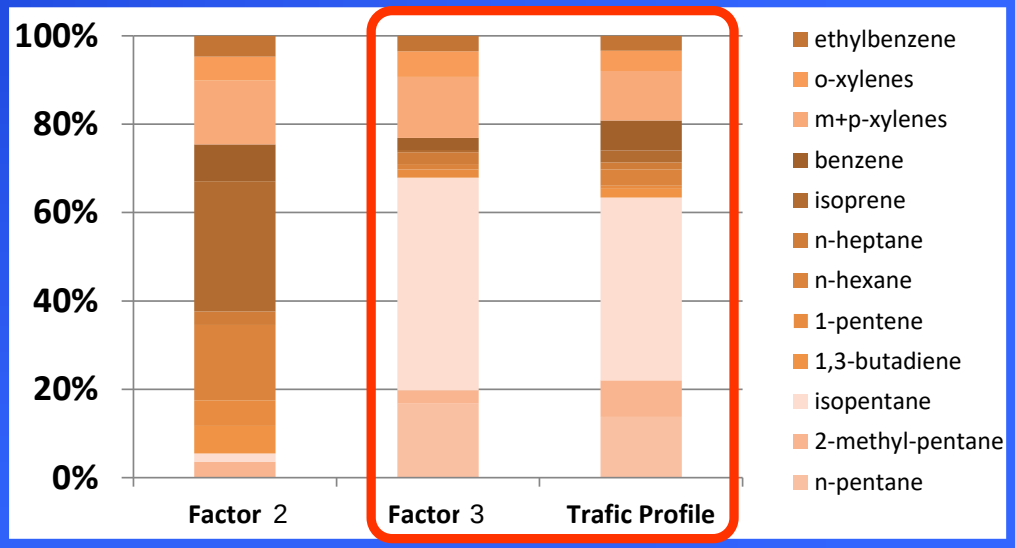
Importance of traffic emissions ?

- **PMF analysis of VOCs in Istanbul**
- **Traffic (exhaust + evaporation) is not dominant : 16%**

Contributions in %



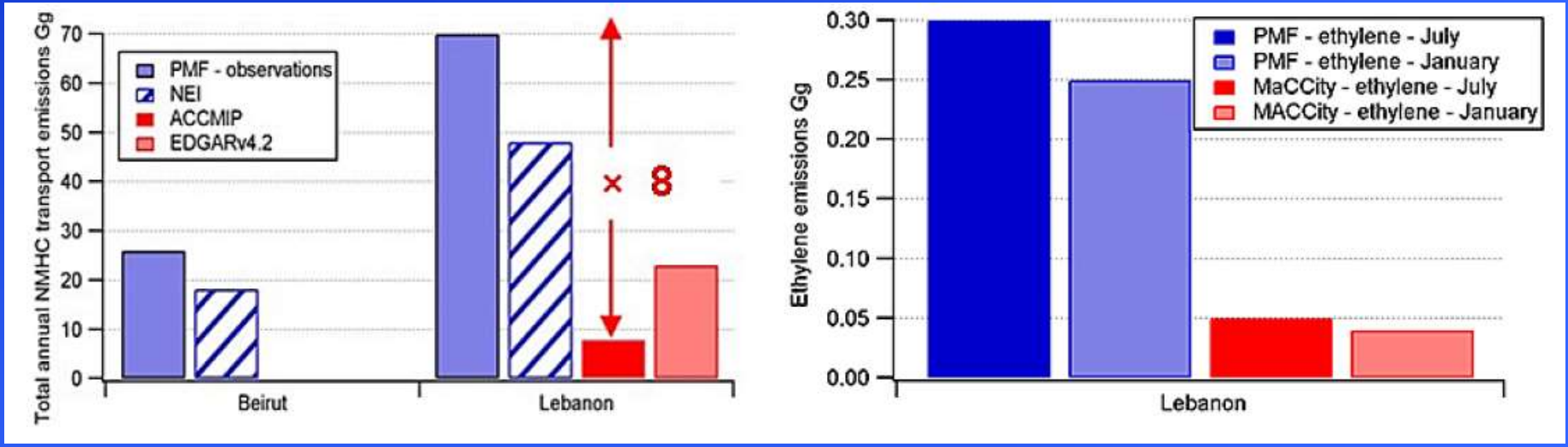
Traffic factor composition ≈ Traffic composition



Thera, Borbon et al., 2018, in prep for ACP

Uncertainties on global emission inventories

PMF results provide useful constraints to evaluate emission inventories (local and global) for the transport sector in particular



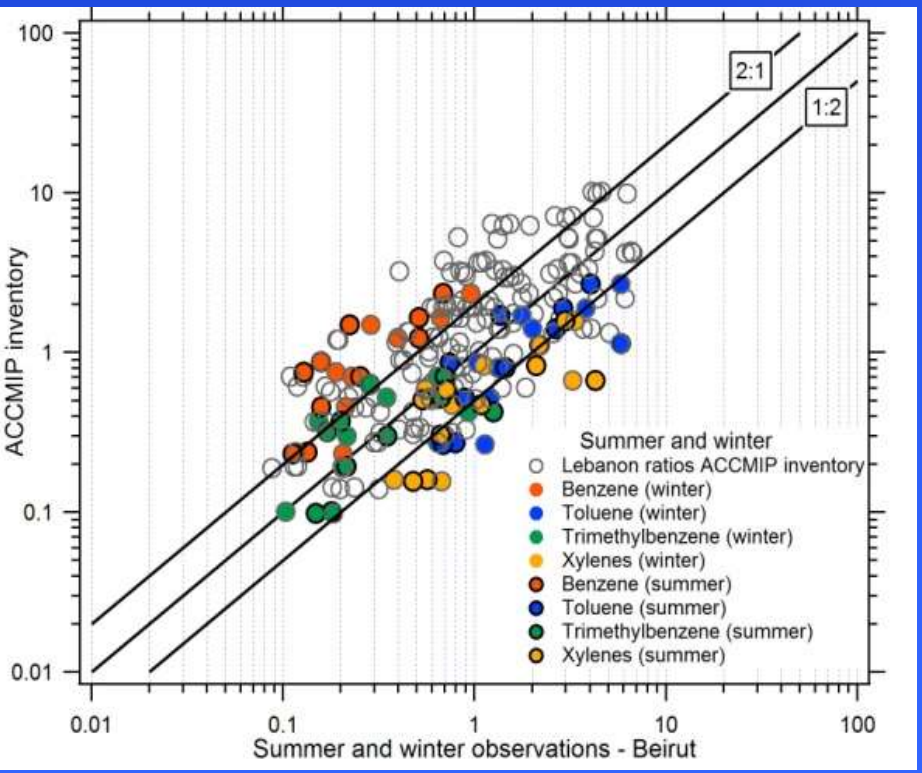
Salameh et al., 2016, Atmos. Chem. Phys.

- **Consistency between the local emission inventory (NEI) for Beirut and PMF results**
- **However global emission inventories downscaled to Lebanon underestimate by a factor of ~8 the total annual VOC emissions for the transport sector**
- **For an individual VOC like ethylene the underestimation is of the same order of magnitude**

Uncertainties on global emission inventories

- **Emission Ratios provide useful constraints to evaluate individual VOC emission inventories (local and global)**

Inventory of emission ratios (ppb ppb^{-1})
(ACCMIP vs. Observations,
All anthropogenic sectors for Lebanon)



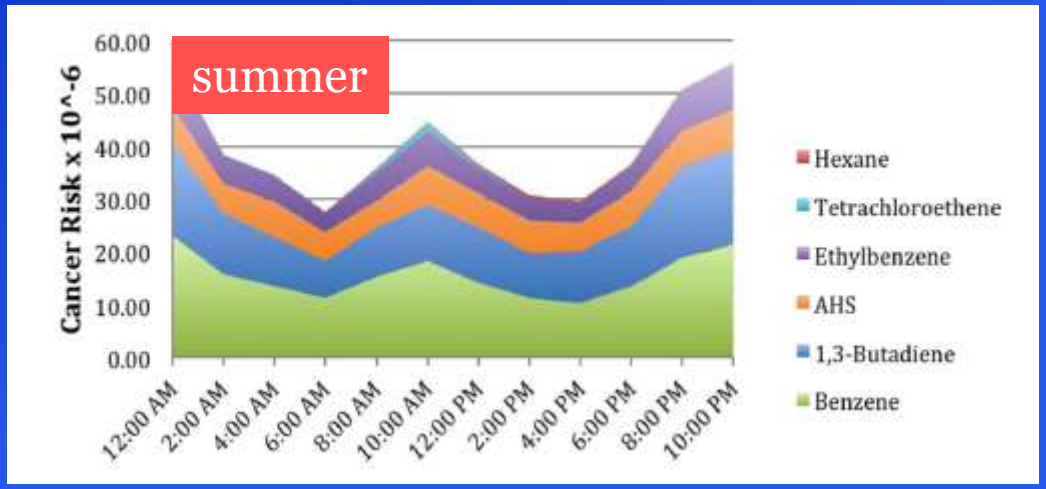
Almost all VOC known as SOA and ozone precursors are well represented within a factor of 2

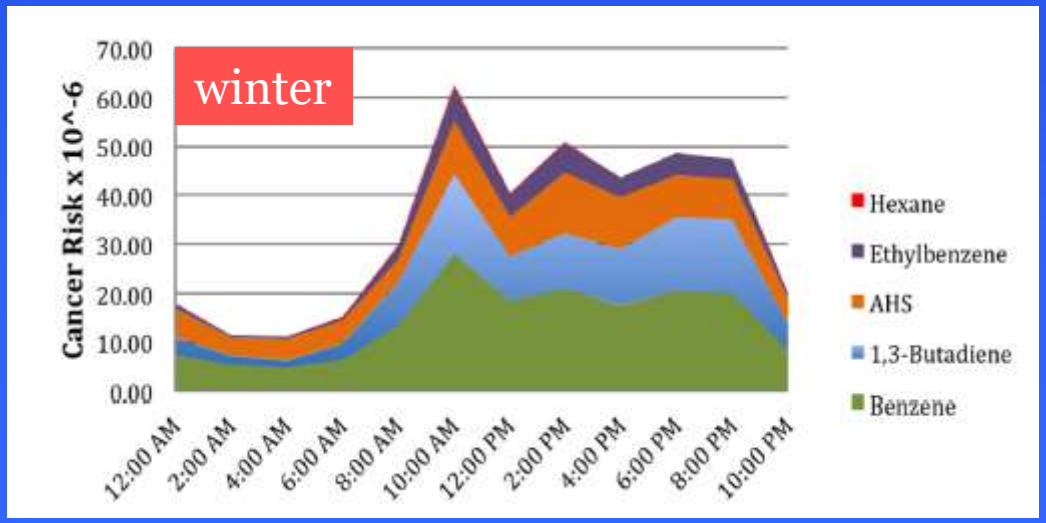
Some exceptions : benzene and xylenes are respectively over- and under-estimated in the ACCMIP global emission inventory

Salameh et al., 2017, Atmos. Chem. Phys.

Health impacts : cancer risk patterns in Beirut

- **From ECOCEM field campaigns and carcinogenic VOCs**





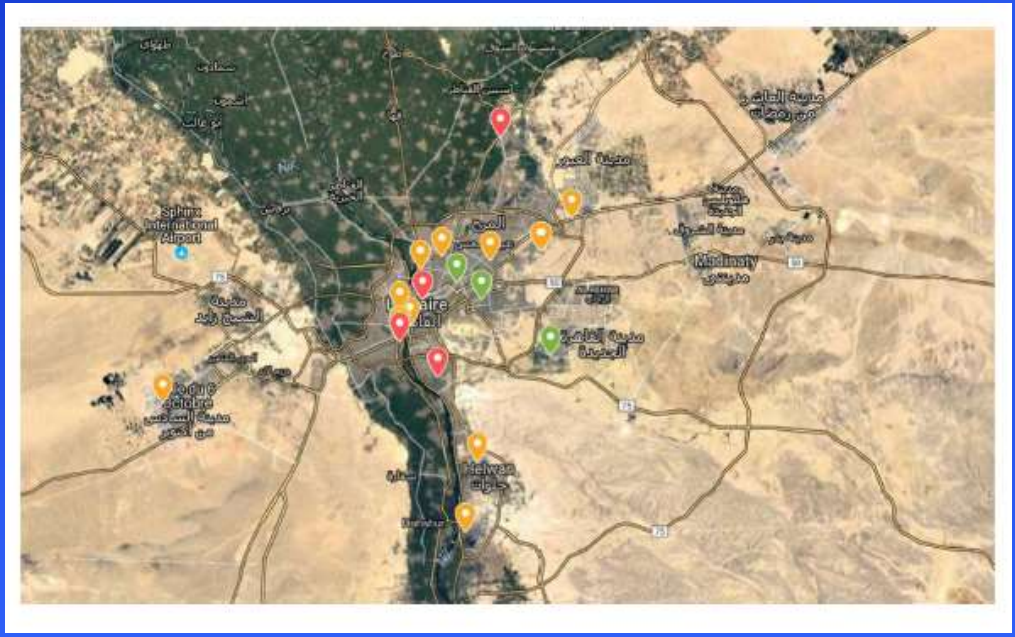
Diurnal evolution of the cancer risk patterns

The cumulative cancer risk >> the USEPA acceptable level (10^{-6}) by 30-40-fold, with benzene and 1,3-butadiene as the highest risk contributors PM2.5 attributable average mortality fraction is estimated to be 7.8-10%.

Daini et al., 2017, Environ. Sc. Poll. Res.

Health impacts : long-term exposure in Cairo

- From Air Quality Network data (18 stations): NO2, PM, ozone
- Years 2000 to 2015



Estimation of the excess mortality by the Relative Risk (RR) and Integrated Risk assessment (WMO, 2013)

Test of the effect of the different concentration/response functions (CRF)

In the population older than 30 years, 11% (±3%) of the non-accidental mortality is due to PM2.5

8% is due to NO2

Wheida et al., Environ. Res., 2018

Conclusions

- Very detailed database under construction since 2010 for major urban areas of the East Med, especially for VOCs (>60 species) and PM composition (trace metals, ions, PAH, EC/OC, organic tracers)
- High levels of pollution
- Seasonal differences and from one urban centre to the other : traffic emissions do not systematically dominate
- Observations are useful constraints for source-apportionment studies
- Uncertainties on global and regional emission inventories for VOC : high in absolute amount (underestimation) but reasonable regarding VOC speciation
- First health impact assessments for Beirut and Cairo from observations

Perspectives

- Spatial scale extension : Athens (on-going) and Cairo (POLCAIR project with 1^{+}-yr EOP : 2018-2019 / IOP October 2019)
- *To be developed and discussed: Evaluation of the future impact of anthropogenic emissions on air quality and human health in a changing climate by creating region-specific mitigation scenarios*






Teşekkür شكر

Thank you

Merci σας ευχαριστώ

Contact: a.borbon@opgc.univ-bpclermont.fr