

Effect of VOC emissions from vegetation on air quality in Berlin during a heat wave

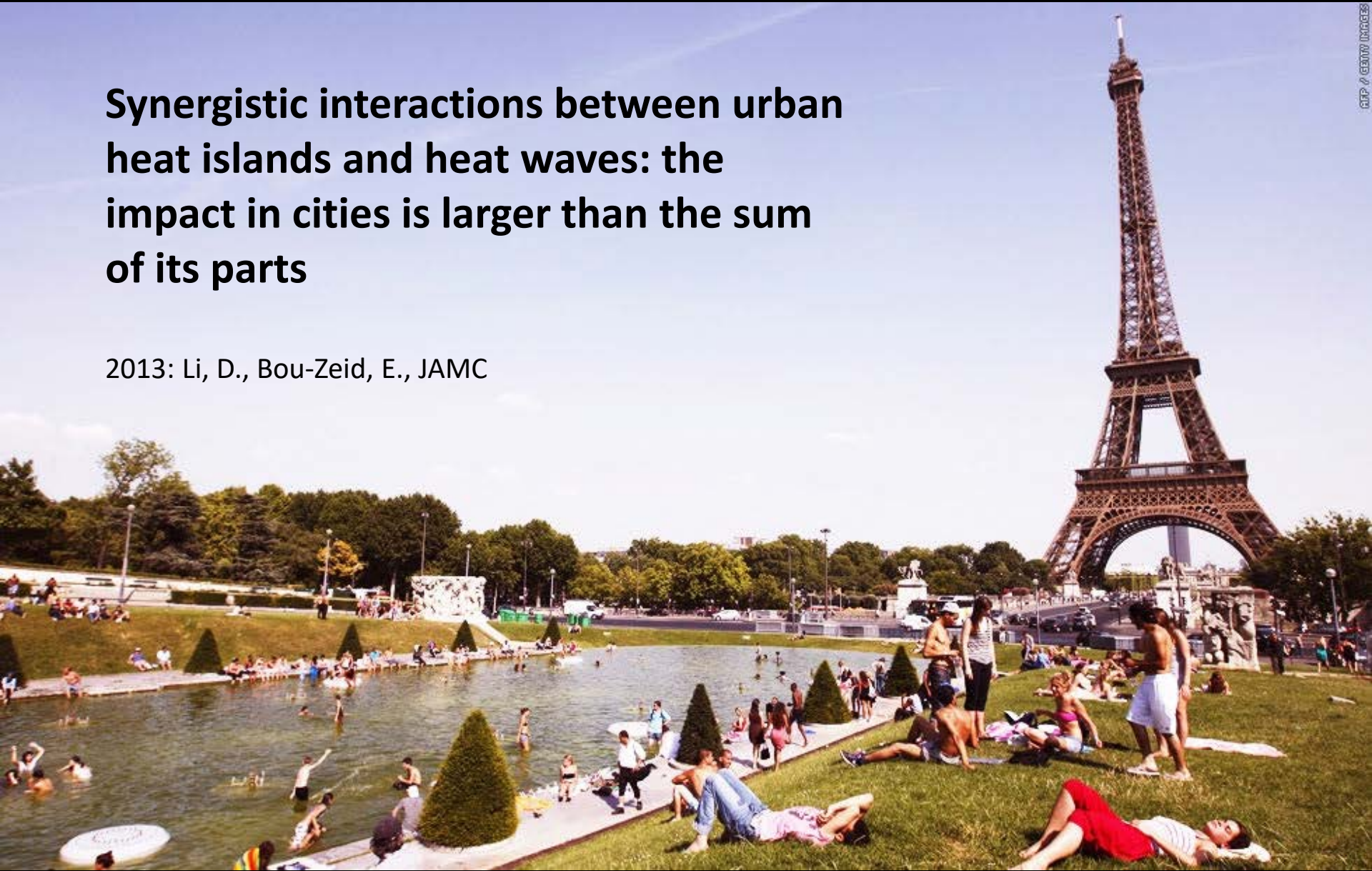
Galina Churkina, Friderike Kuik, Boris Bonn, Axel Lauer, Rüdiger Grote,
Karolina Tomiak, Tim Butler

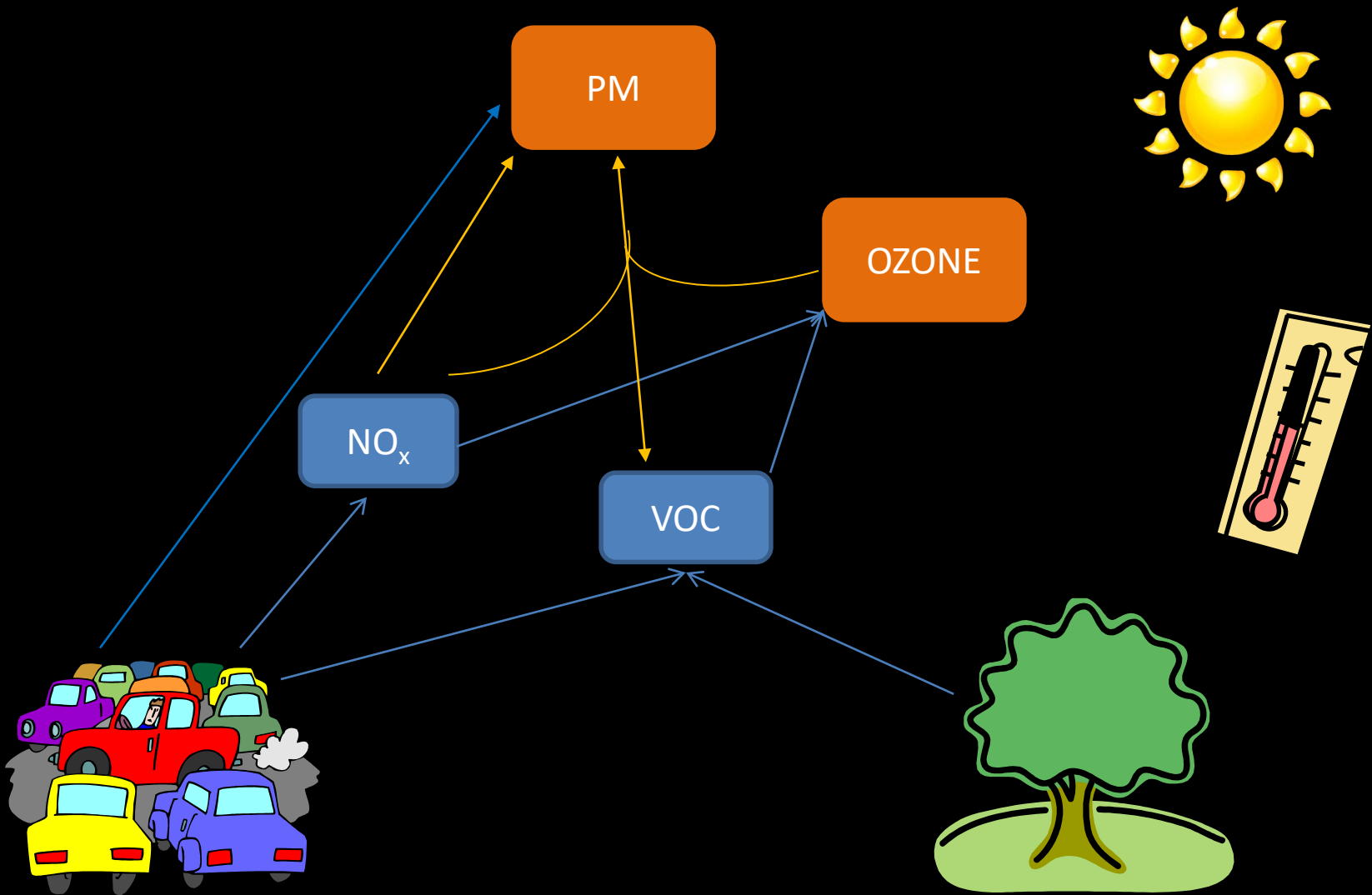
Technical Support: Jörn Quedenau, Ciaron Linstead, WRF-Help



Synergistic interactions between urban heat islands and heat waves: the impact in cities is larger than the sum of its parts

2013: Li, D., Bou-Zeid, E., JAMC

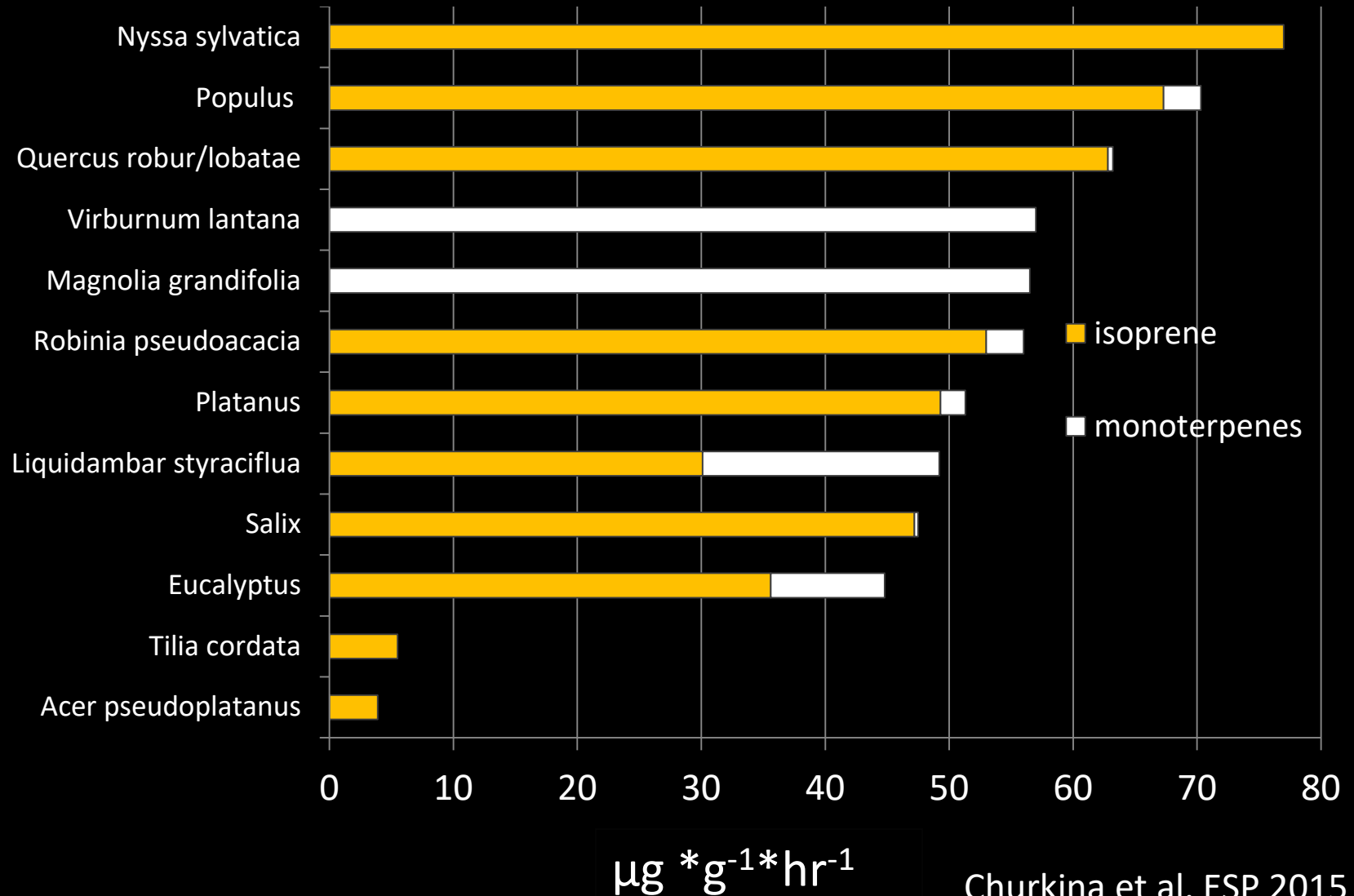




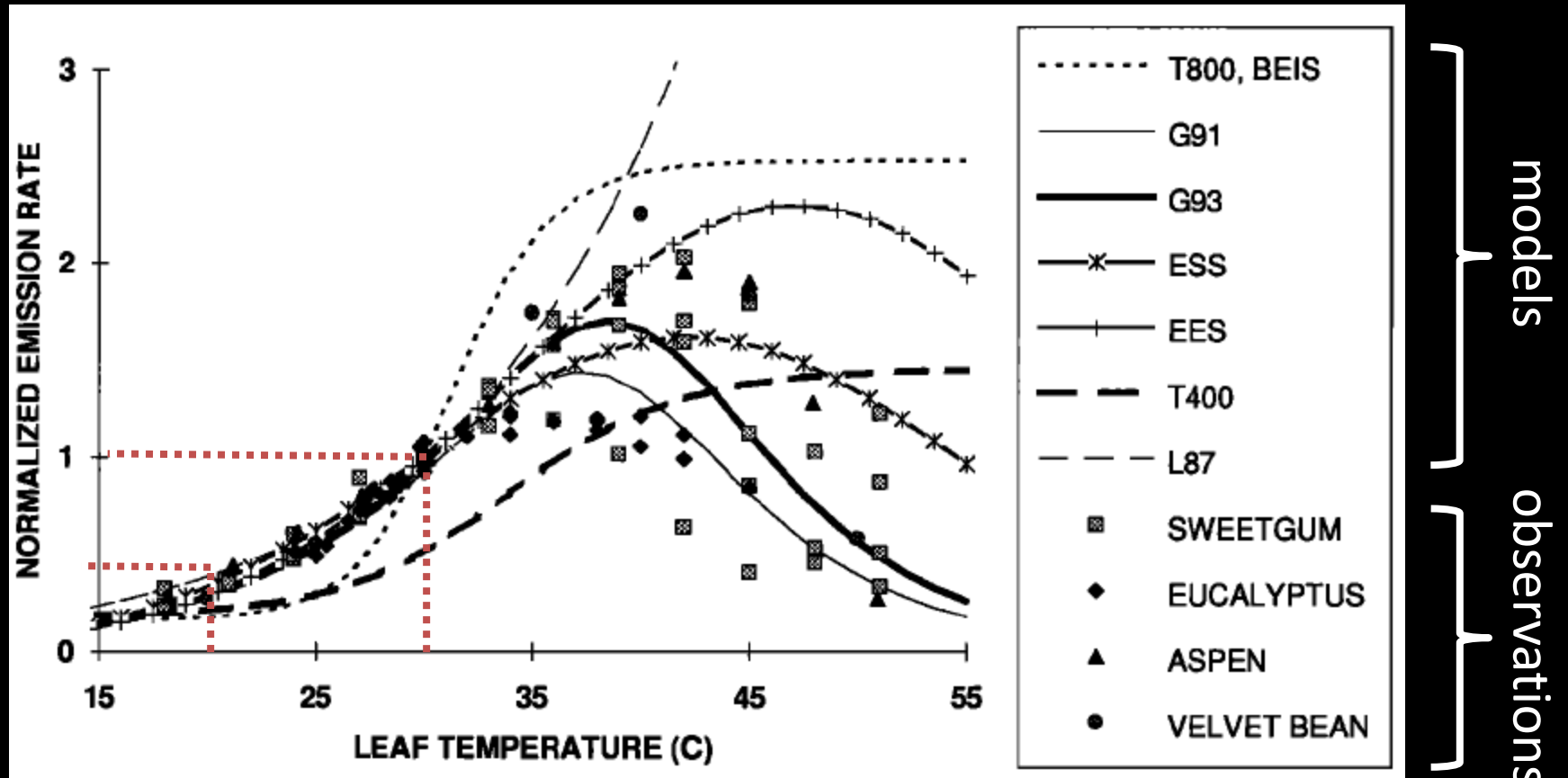
PM -particulate matter

VOC -volatile organic compounds

Selected popular urban trees and their average VOC emissions rates

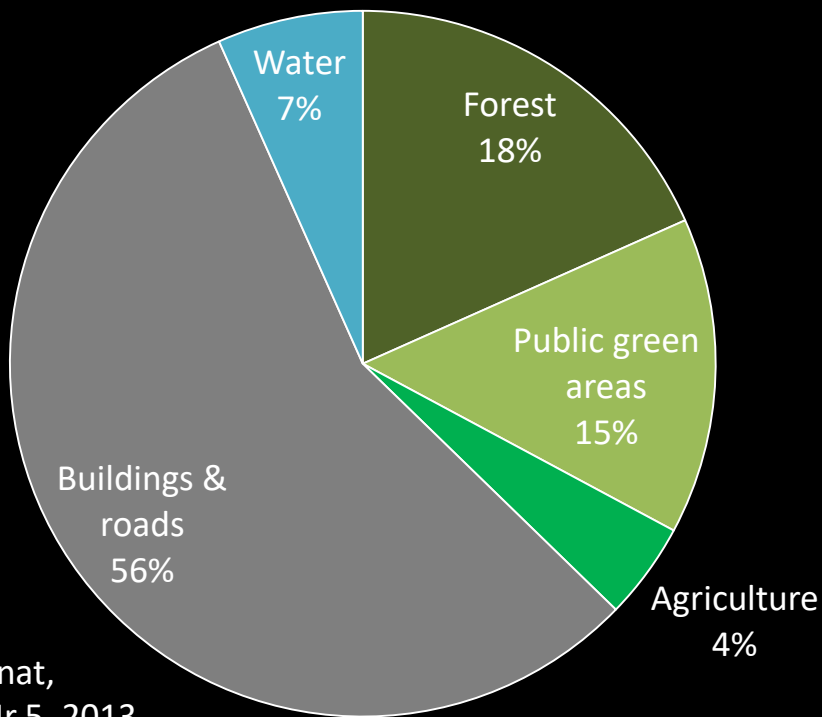


Temperature is an important driver of VOC emissions from vegetation



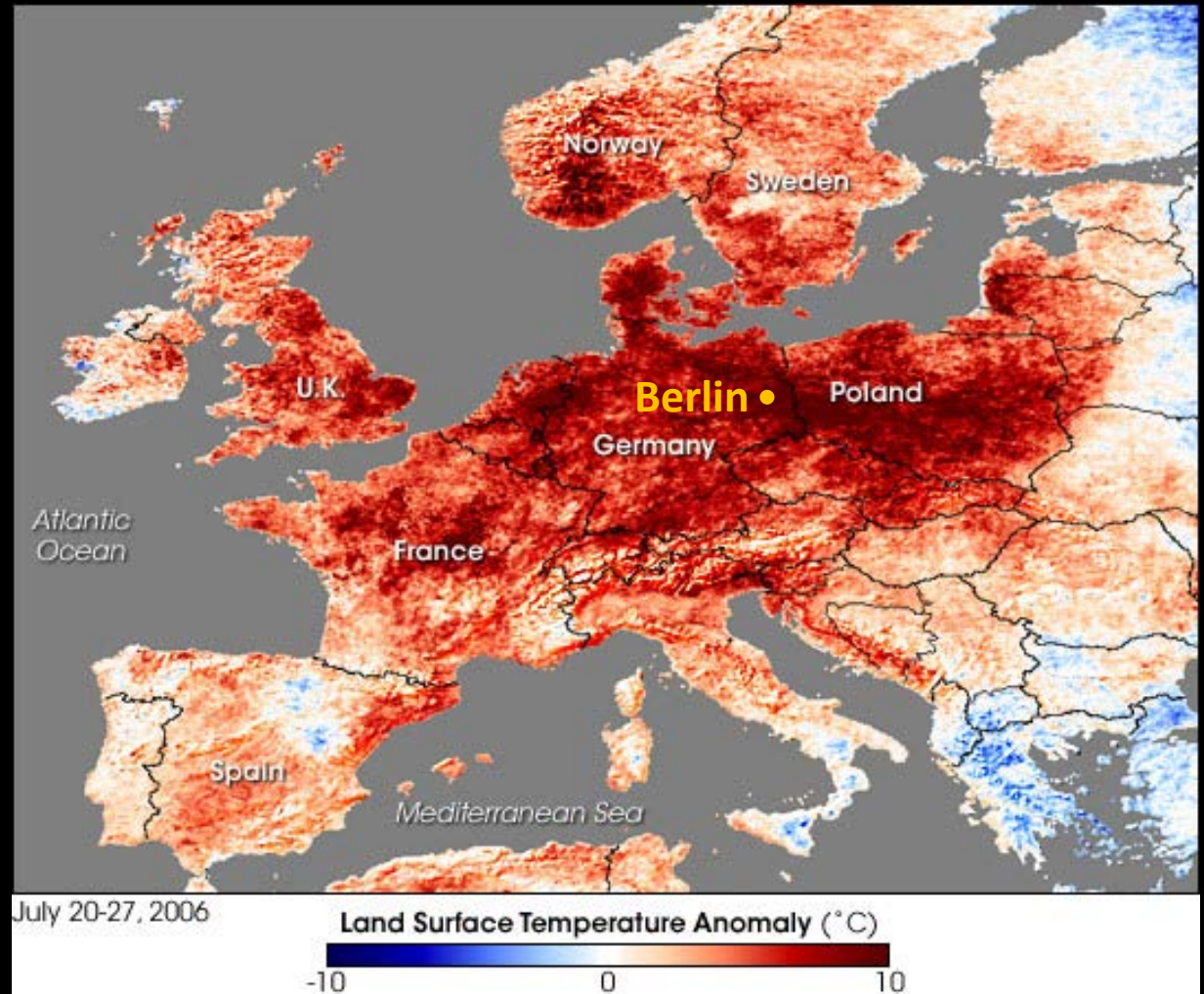
Objective

To estimate the effect of **VOCs** emitted from urban vegetation on the **ground-level ozone and PM concentrations** in summer and especially during heat wave period



Berlin is a
green city

Heat Wave July 10-30 2006

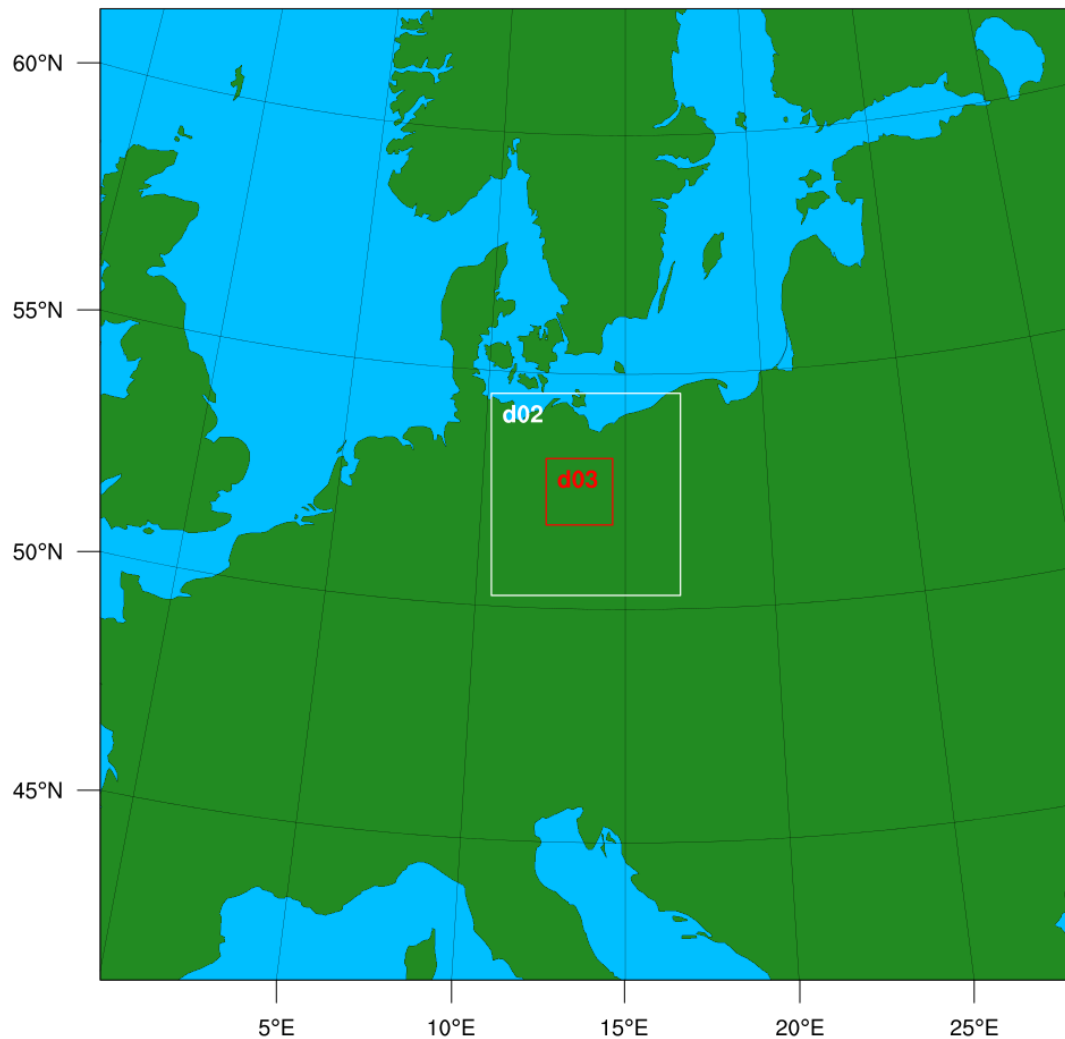


Methods


- **Weather Research and Forecasting Model** with coupled atmospheric chemistry (WRF-Chem 3.7.1) and biogenic VOC emissions module (MEGAN 2.0)
- **Site observations** of temperature, wind, PBL, ozone, PM, NO_x, VOCs (field campaign 2014)

Model Setup

- 3 domains:
 - 15 km, 5 km, 1 km
- 35 eta levels up to 50 hPa
- Boundary conditions
 - ECMWF reanalysis data
- Anthropogenic emissions
 - MACC
- Biogenic VOC emissions
 - MEGAN 2.04



Model Simulations: summers of 2006 & 2014

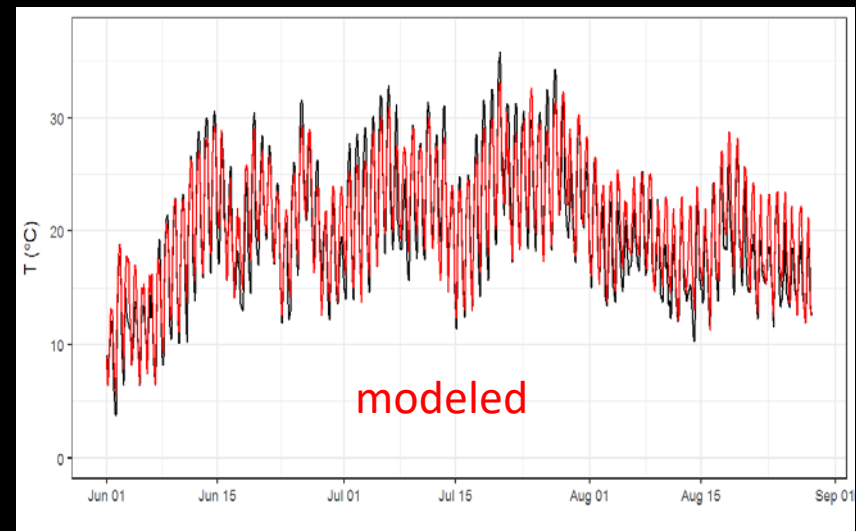


Abbreviation of Model Simulation	Anthropogenic Emissions	Biogenic Emissions	MEGAN Input Data
ANTH	included	none	none
ANTH+BIO	included	included	original
ANTH+BIO _m	included	included	modified

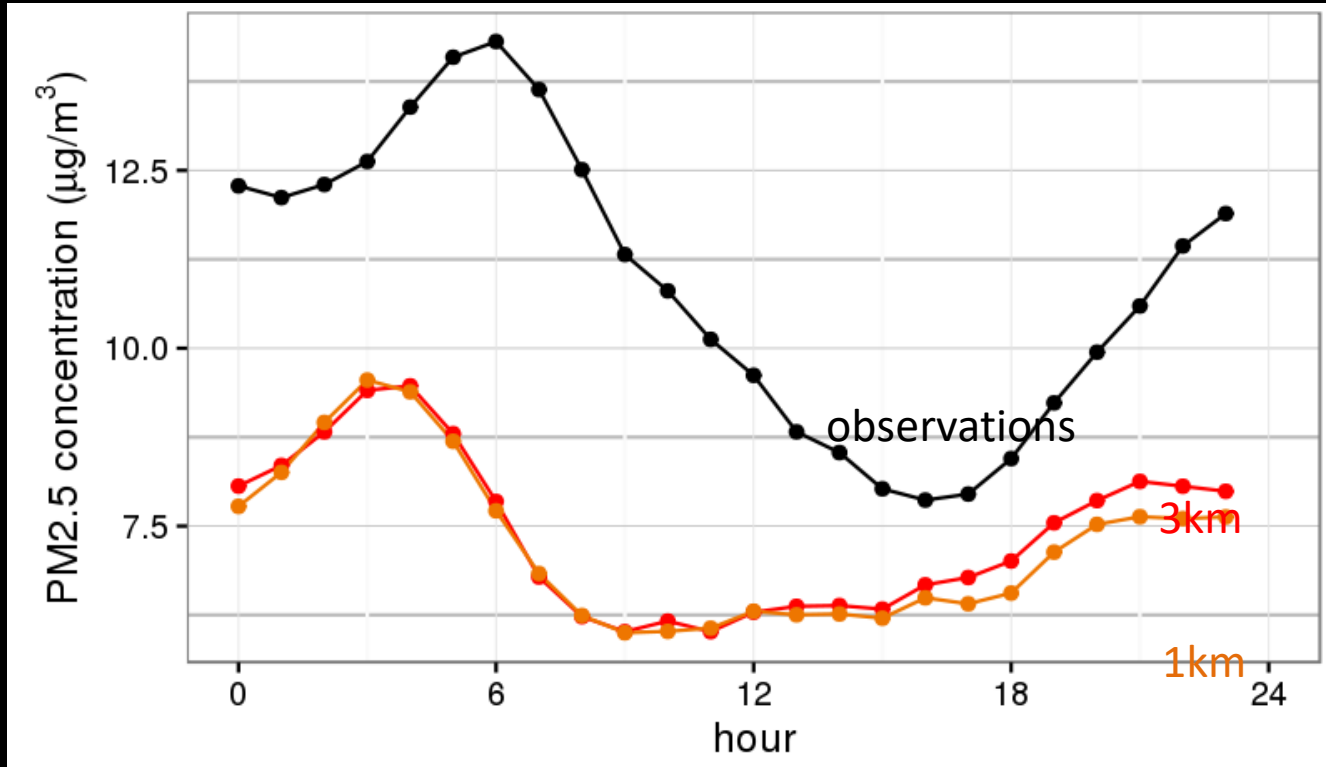
Observed temperatures and ozone were ...

- well represented on average
- peaks were underestimated

2 m temperatures averaged over six measurement stations in Berlin-Brandenburg Metropolitan area in 2006

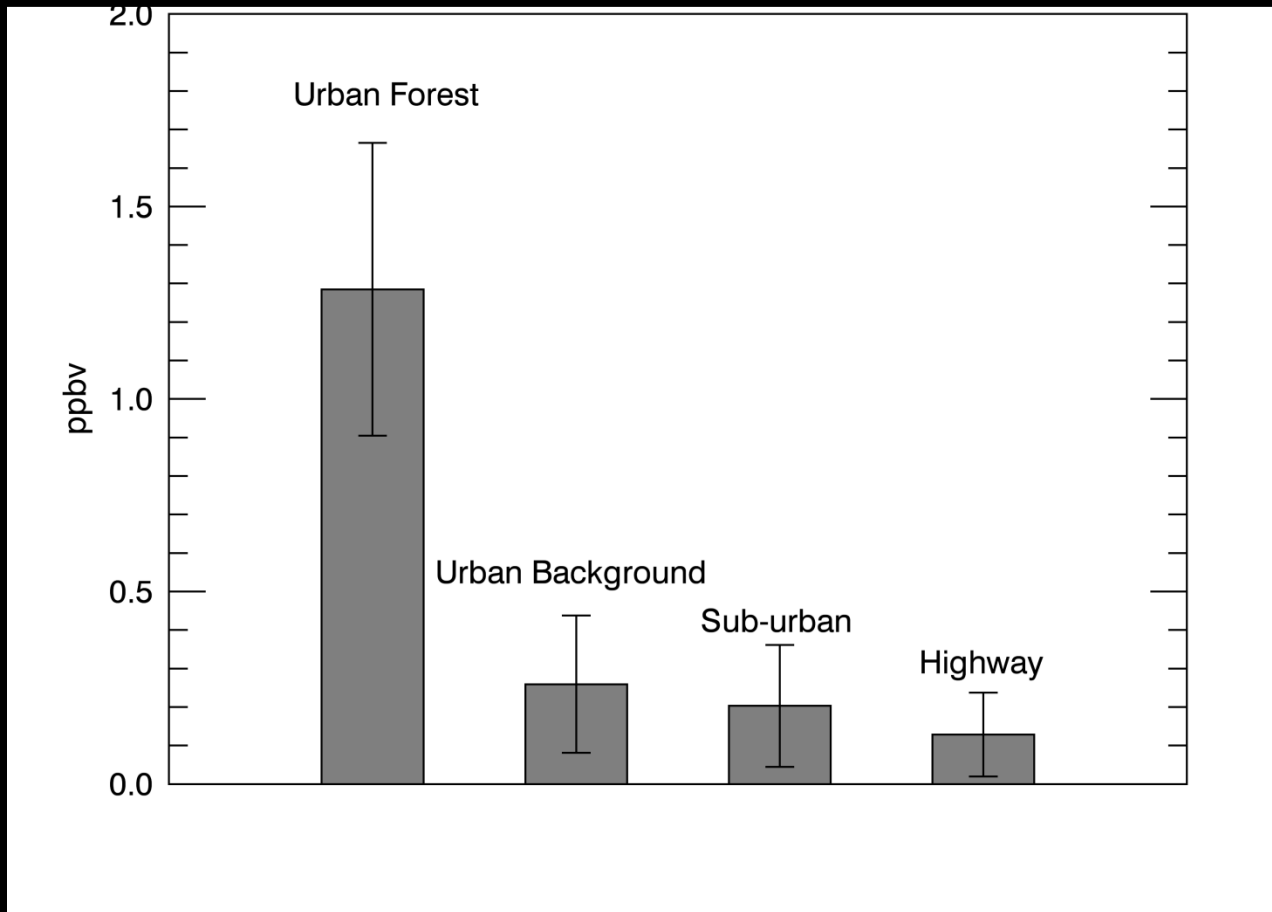


PM was greatly overestimated

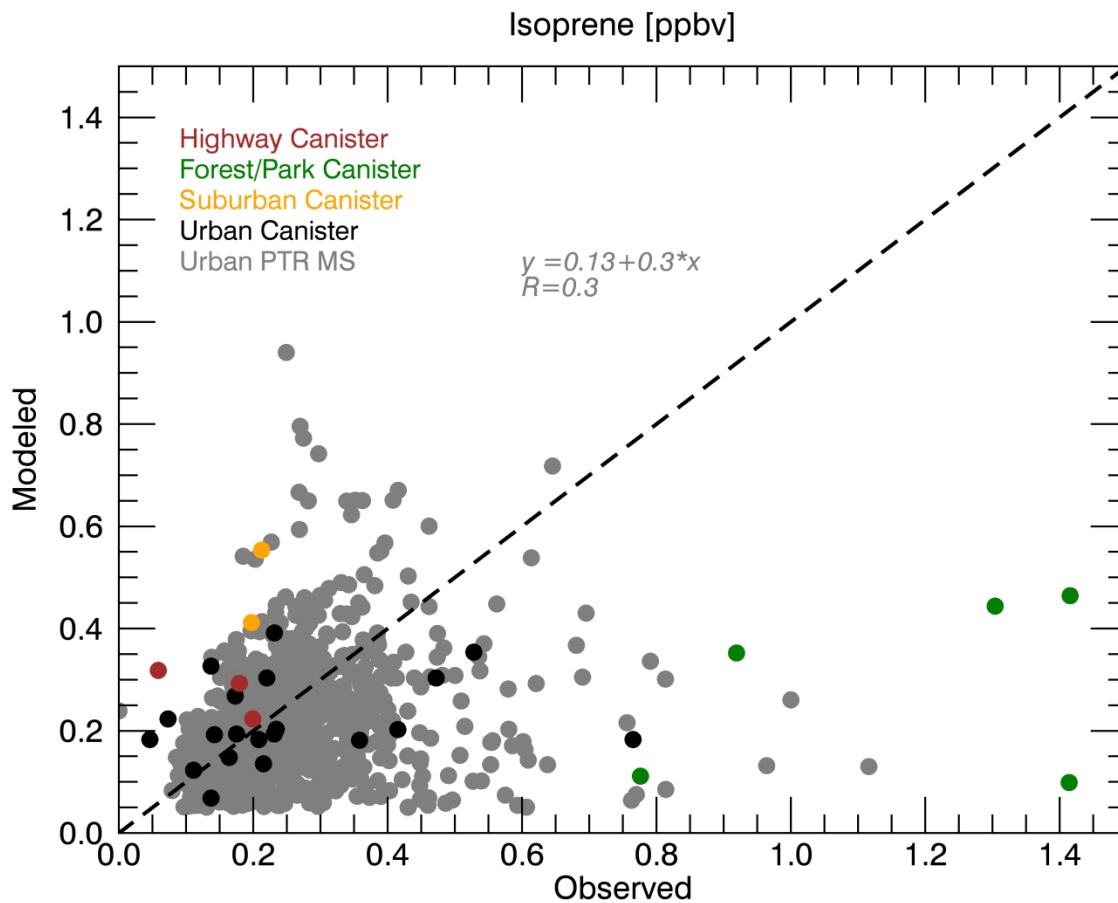


Surface PM_{2.5} average diurnal cycle (median) for Potsdam in summer 2014

Observed Isoprene



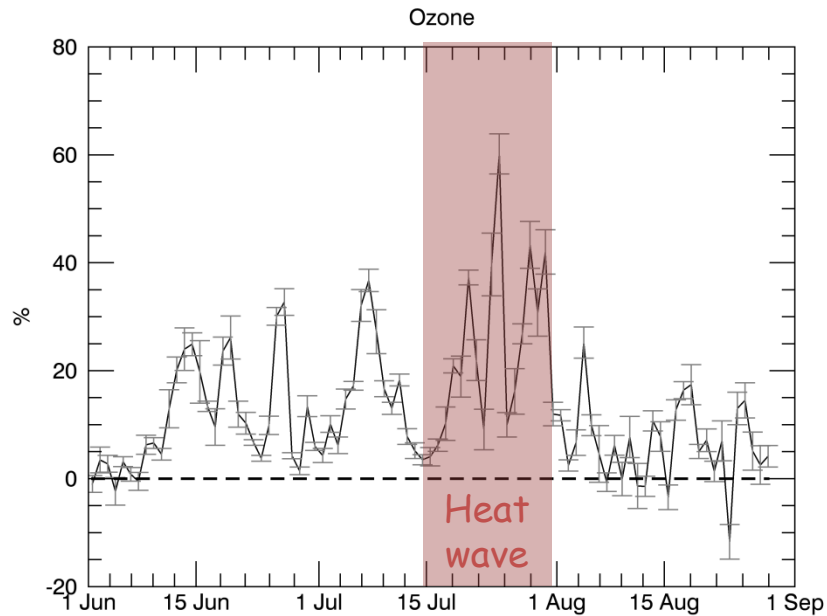
Isoprene Observed & Modeled



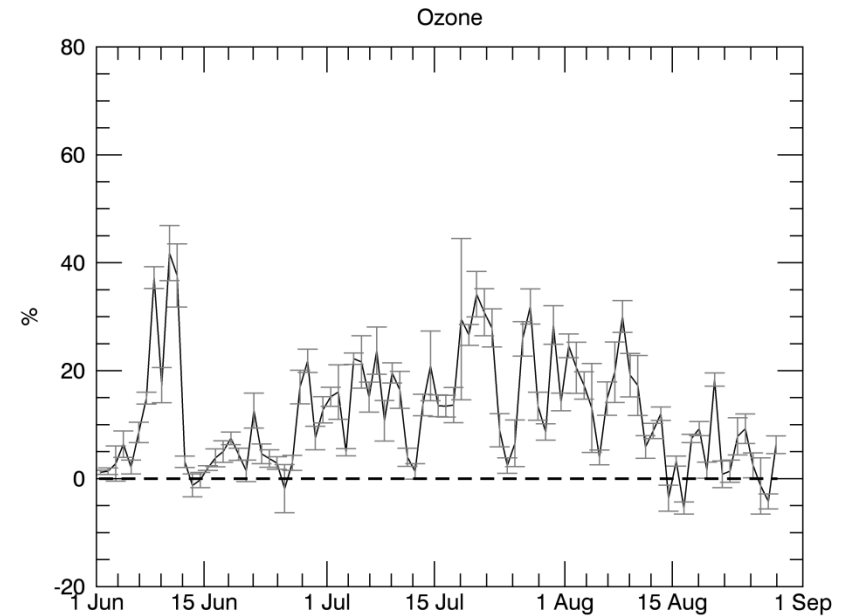
Urban background
station in the center of
Berlin

Contribution of VOCs from Vegetation to Ozone

2006



2014



$$Impact_{ozone} = \frac{OZONE_{ANTH+BIO} - OZONE_{ANTH}}{OZONE_{ANTH}} * 100\%$$

Conclusions

- The contribution of VOC from vegetation to ozone levels in Berlin:
 - ~ 9-11 % on average in June and August
 - ~ 17-20% on average in July
 - ~ 60% during the heat wave
- WRF-Chem is not able to simulate PM and associated effect of BVOC on PM formation
- WRF-Chem has limited ability to simulate isoprene mixing ratios over urban forests
 - Mismatch between model and measurement spatial resolutions (1x1 km grid versus point)
 - Urban vegetation is poorly represented in MEGAN (leaf area index, emission factors)

More about vegetation and air quality in Berlin:

- Churkina G, Kuik F, Bonn B, Lauer A, Grote R, Tomiak K, Butler T, Effect of VOC emissions from vegetation on air quality in Berlin during a heatwave, *Env. Sci. and Technology*, in revision.
- Bonn B. et al, BAERLIN2014 - The influence of land surface types on and the horizontal heterogeneity of air pollutant levels in Berlin. *Atmos. Chem. Phys. Discuss.* **2016**, 2016, (16), 7785-7811.
- Kuik, F et al, Air quality modelling in the Berlin-Brandenburg region using WRF-Chem v3.7.1: sensitivity to resolution of model grid and input data. *Geosci. Model Dev. Discuss.* **2016**, 1-46.