Institute for Advanced Sustainability Studies (IASS)

HEAT WAVES, URBAN VEGETATION, AND AIR POLLUTION

Galina Churkina[1], Rüdiger Grote[2], Boris Bonn[1], Tim Butler[1]

[1] IASS, Potsdam, Germany, [2] Institute of Meteorology and Climate Research Atmospheric Environmental Research, KIT, Karlsruhe, Germany

1. Background

Urban greening – expansion of green space, planting more trees, development of rooftop gardens.

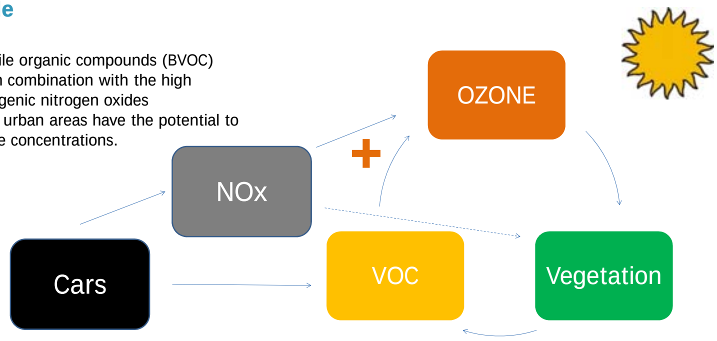
The growing momentum to increase the amount of green space in urban areas such as various "Million Trees" campaigns brings many benefits to urban dwellers: reduction of summer temperatures, additional recreational opportunities, and storm water control

The **potential downsides** of urban greening are ignored by urban planners.

Heat waves amplify emissions of BVOC and lead to health risk for urbanites: overheating and inhaling ozone.

Potential downside

Emissions of biogenic volatile organic compounds (BVOC) from popular urban trees in combination with the high concentrations of anthropogenic nitrogen oxides ($NOx=NO+NO_2$) typical for urban areas have the potential to increase ground-level ozone concentrations.



2. Scientific objectives and …

Here we investigate how global change induced heat waves affect emissions of volatile organic compounds (VOC) from urban vegetation and corresponding ground-level ozone levels.

… their practical relevance

Provide recommendations to city officials for urban greening strategies that ensure the limiting effect on ground–level ozone while providing other benefits such as carbon storage/sequestration and cooling in summer.

3. Methods

Modeling

- Regional climate and air chemistry models: WRF-Chem [1] with dynamic BVOC emissions within CLM land surface scheme [2].
- First case study is Berlin, Germany, with green space covering 36% of its area.
- Different greening scenarios: planting trees/shrubs/grasses, expanding green areas, etc.

Observations

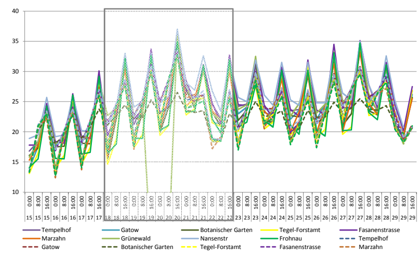
BÄRLIN – 2014 (*B*erlin *A*ir quality *R*esearch: *L*ocal and long range *I*mpact of anthropogenic and *N*atural hydrocarbons) measurement campaign:

- Meteorological variables: temperature, precipitation, air humidity, radiation (Berlin Senat)
- Ozon, NOx, benzene, toluene, PM10, CO (Berlin Senat)
- Anthropogenic and biogenic VOCs and their oxidation products (IASS Frankfurt M. University) [4]
- Soot, carbon isotopes (IASS)
- Aerosol particle chemical composition (Duisburg Technical University)
- Aerosol size distribution (Technical University Berlin, Umweltbundesamt)
- Atmospheric structure and boundary layer height (Karlsruhe Institute for Technology, Garmisch-Partenkirchen).

4. Preliminary Results

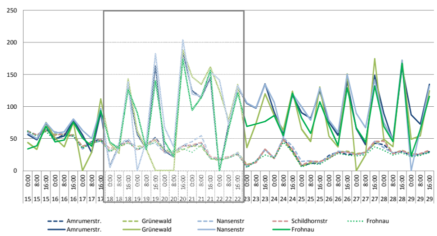
How good are the simulated variables over Berlin – Potsdam area?

Observed and Simulated Temperatures (deg C)



Observed data are from Free University and BLUME network
Simulated data are from WRF-CHEM for July 15-29, 2006

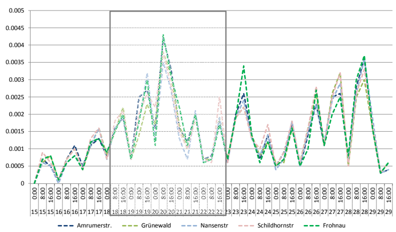
Observed and Simulated Ozone (µg/m³)



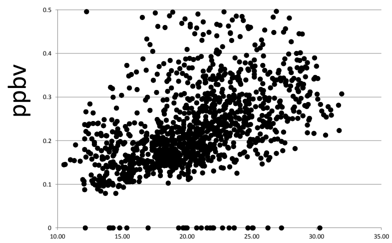
Simulated data are from WRF-CHEM for July 15-29, 2006

Temperature is an important driver of isoprene emissions

Simulated Isoprene (ppmv)



Simulated data are from WRF-CHEM for July 15-29, 2006



12 June-11 August 2014, Berlin, Germany
Temperature from BLUME network (Berlin Senat),
Isoprene from PTR-MS measurements (IASS)

References

[1] Skamarock WC & Klemp JB (2008) A time-split nonhydrostatic atmospheric model for weather research and forecasting applications. J. Comput. Phys., 227, 3465–3485.
[2] Grote R, Morfopoulus C, Niinemets Ü, Sun Z, Keenan T, Pacifico F, Butler T (in press), A fully integrated isoprenoid emissions model coupling emissions to photosynthetic Characteristics, Plant, Cell & Environment.
[3] Butler TM, Lawrence MG, Taraborrelli D, Lelieveld J (2011) Multi-day ozone production potential of volatile organic compounds calculated with a tagging approach. Atmos. Environ. 45:4082-4090.
[4] Bourtsoukidis E, Bonn B, Dittmann A, Hakola H, Hellén H, Jacobi S (2012) Ozone stress as a driving force of sesquiterpene emissions: a suggested parameterisation. Biogeosciences 9:4337-4352.
[5] Churkina G, Grote R, Butler T, Lawrence M (in review) Urban Nature: A Warning. Environmental Science and Policy.

The IASS is sponsored by

Sponsored by the Federal Ministry of Education and Research

FONA Research for Sustainable Development BMBF

LAND BRANDENBURG Ministerium für Wissenschaft, Forschung und Kultur