Urban Multi-scale Environmental Predictor

An integrated tool for urban climatology and climate sensitive planning applications

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Background

- Communication between the research community and practitioners/planners/stakeholders is a challenge
- Planners use/want maps
- Planners want/need to investigate issues occurring at different scales

Background

- Urban climate influenced by processes at a range of different scales.
- Appropriate scale based on application.
- Important to couple and understand the different scale dependent processes.



Göteborg, Sweden

Frankfurt am Main, Germany



Overview of UMEP

- Consists of a coupled modelling system which combines "state of the art" 1D and 2D models.
- System contained within UMEP is designed to run from the street canyon to city scale (10⁰-10⁵ m).
- Restructuring of program code necessary



THE SOLWEIG MODEL (Solar and LongWave Environmental Irradiance Geometry) (Lindberg et al. 2008 and Lindberg & Grimmond 2011)

- Simulates spatial variations of 3D radiation fluxes and T_{mrt} in complex urban settings
- T_{mrt} derived by modelling shortwave and longwave radiation fluxes
- Sky view factor and shadow patterns are a central elements when estimating the fluxes

Mean radiant temperature $(T_{mrt}) = A$ sum of all shortwave and longwave radiation fluxes to which the human body is exposed.



Digital Surface Model, Göteborg (Sweden)



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SUEWS (Surface Urban Energy and Water Balance Scheme)

(e.g. Grimmond and Oke 1991, Grimmond et al. 1991, Offerle et al. 2003, Loridan et al. 2010, Järvi et al.

2011, Järvi et al. 2014)

- SUEWS simulates urban energy and water balances using information on surface cover and basic meteorology
- Several sub-models for *Q**, ΔQ_s, Q_F, I_e
- *Q_H* is estimated as a residual
- Surface divided into seven interacting surface types
- Latest version: v2015a
 beta (Ward et al. 2015)



LUCY (Large scale Urban Consumption of energY model) (Allen et al. 2010, Lindberg et al. 2013)

- LUCY simulates all components of anthropogenic heat flux (Q_F) from global to neighborhood scale.
- It can be applied to any part of the world.
- LUCY operates at multiple scales specified by input data. Data could be replaced and refined based on application.
- Forcing data includes population, energy consumption, traffic numbers and air temp.









The Modelling system – existing coupling

BLUEWS (Boundary Surface Urban Energy and Water Balance Scheme)

(Onomura et al. 2014)



 A convective boundary model is coupled to the SUEWS scheme to estimate daytime temperature and humidity based on the surface energy fluxes





The CBL modelling scheme (Cleugh and Grimmond, 2001)

The Modelling system – planned coupling BLUEWS



- Intra urban nighttime T_a cooling rate scheme will be included in BLUEWS.
- Scheme based on empirical relations using weather parameters and urban geometry.
- Can be used to obtain initial parameters for the daytime CBL scheme



Conceptual cooling rate model (Holmer et al. 2007)

The Modelling system – planned coupling

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- Air temperature and humidity is used as forcing input to SOLWEIG
- SOLWEIG output will be used to improve outgoing igodolradiation fluxes used in SUEWS/BLUEWS

Sun/shade patterns 1130, 3 June. Barbican London





The Modelling system – planned coupling



- Air temperature will be forced into LUCY
- LUCY will be able to provide more detailed information on anthropogenic heat flux to the modelling system
- New features will be included in the Q_F modelling e.g. detailed traffic information and/or agent based modelling



Anthropogenic heat flux (Q_F) in Hong Kong using high resolution population data (Yogeswaran, 2014)

The interface (API)

UMEP will be widely accessable to researchers and practitioners

- Graphical User Interface needed
- GIS-based approach needed
- Many types of formats and data information need to be processed
- Interface needed for pre- and post processing
- Interface will provide users with tips, recommendations and documentation



The interface (API)

Instead of starting from the beginning QGIS will be used as API/GIS



The QGIS GUI, version 2.10

The interface (API)



QGIS makes is possible to:

- make use of all the mapping capabilities within the API (e.g. OGR/GDAL)
- make use of all the geoprocessing capabilities within the API (e.g. GRASS, SAGA)
- extend the API by developing new components (as plugins and core plugins)
- be OS independent
- Quantum GIS founded: 2002. QGIS: an official project of OSGeo (osgeo.org).
- Provides a growing number of capabilities provided by core functions and plugins.
- Can visualize, manage, edit, analyze data, and compose printable maps.



The Plugin manager in QGIS 2.4

The UMEP plugin

The UMEP plugin consist of three separate parts:

Pre-processor

- Input data preparation
- Grid generation for sub-grid modelling
- Simple weather generator to produce example input data
- Generation of general morphology info such as sky view factor, PAI, FAI, H/W-ratios etc.

Processor

- Execution of the actual modelling system
- Models can run separately or coupled
- Models can be run with the focus on time, space or in combination

Post-processor

- Possibilities to visualize output data
- Map generation (QGIS)
- Averaging and statistical analysis of output data

UMEP (beta version 0.1) together with installation instruction and a test dataset is available from the UMEP repository: <u>https://bitbucket.org/fredrik_ucg/umep</u> (64-bit Windows)















🤨 Suews Simple





Invitation to participate

- The **open source** concept of UMEP makes it possible for everyone to contribute.
- Contribute:
 - as a USER report issues and suggest improvements
 - as a DEVELOPER- fix bugs, general improvement, develop new tools
 - to the DOCUMETATION– write manuals, TODOs
 - Contribute to data management

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Summary

- Concept of UMEP (Urban Multi-scale Environmental Predictor), an integrated tool for urban climatology and climate sensitive planning applications is presented.
- Tool consists of a coupled modelling system which combines "state of the art" 1D and 2D models related to the processes essential for scale independent urban climate estimations
- UMEP is available as a plugin in QGIS, which is an OSGIS API
- Invitation to participate in an open source project

Thank you