Workshop LCSRNet

Transition towards low carbon societies in a changing world

Paris, 13-14 October 2011

Numerical Tools for Low-Carbon Urban Development Studies

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Introduction

- **Urban Population**
  - **50% of world**
  - **75% in Europe!**
- **Urban areas**
  - **2.5% of land**
  - **10% of available soil in Europe**

Introduction

- **Urban consumption**
  - **75% of the total energy (summer peak)**
- **Anthropogenic Carbon Emissions**
  - **90% from cities with 80% from**
    - **human respiration**
    - **domestic heating and cooling**
    - **aviation**
    - **automobiles**

Introduction

The city:

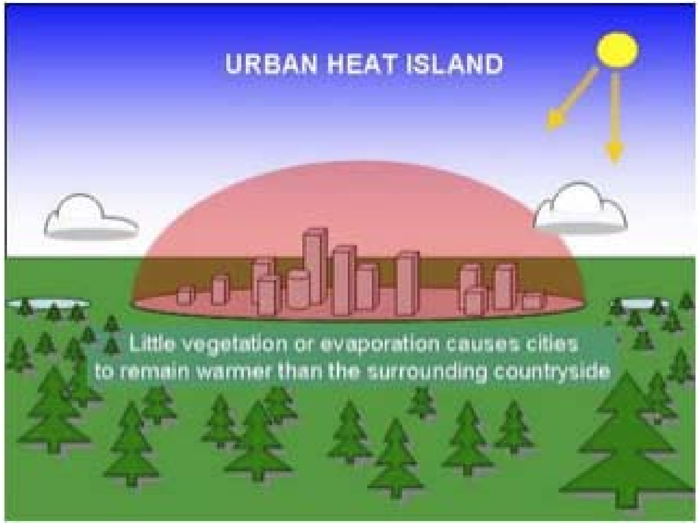
- **is a dynamic system,**
- **considered as a *living organism***
- **exchanging energy and matter (CO_2 and H_2O)**
- **exhibits Urban Metabolism.**

Cities modify

air temperature

Humidity

Wind circulation



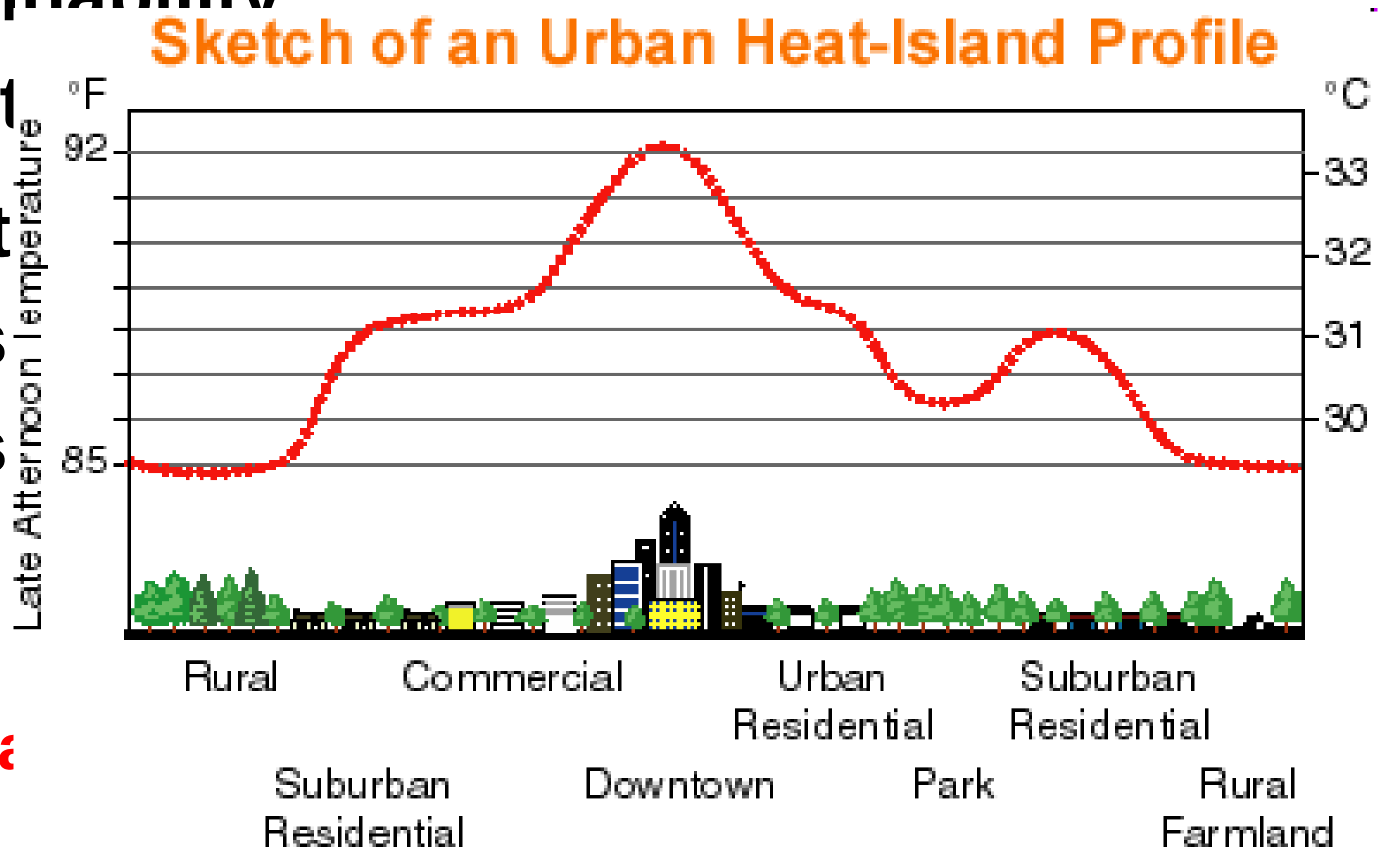
Introduction

Urban Metabolism:

Related issues

1) Urban fluxes impact
   a. Sustainability
   b. Climat
2) Future st
   a. Flows
   b. Flows

Urban heat island phenomena



What is needed?

- Knowledge:
  - Impact of climate change
  - Surface fluxes (e.g., heat and CO_2)
- Action:
  - Monitor “state of art” of urban fluxes
  - Predict future urban fluxes
  - Integrate
    - weather,
    - climate
    - socio-economic scenarios

Research

- **Objectives:**
  - **suitable tools**
  - **quantitative indicators**
- **Goals:**
  - **support urban planning**
  - **support urba**
  - **sustainable m**

Who benefits?

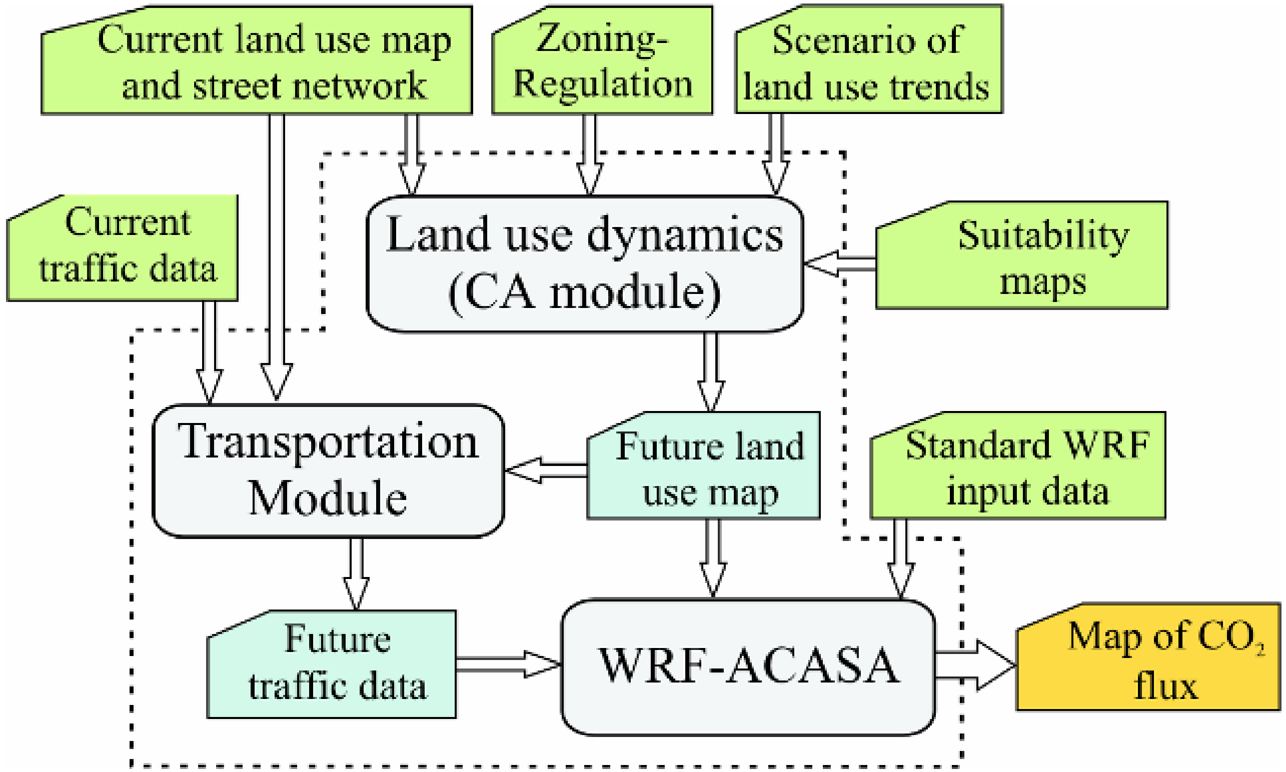
- Environmental agencies
- Energy agencies
- Health agencies
- Traffic management agencies
- Municipality
- Urban developers and planners
- Private companies

Modelling system

Urban drivers to be considered

- Demography
- Future land use allocation
- Socio-economic development
- Economic growth
- Modified transportation load
- Climate scenarios

Modelling system



1. **Constrained Cellular Automata** (urban land-use dynamics simulation)
2. **Transportation model** (variation of the transportation network load)
3. **ACASA** (Advanced Canopy-Atmosphere-Soil Algorithm) (microscale flux calculations)
4. **WRF** mesoscale weather model

Coupled land-use change – transportation model

Spatial dynamic model for simulating future urban development

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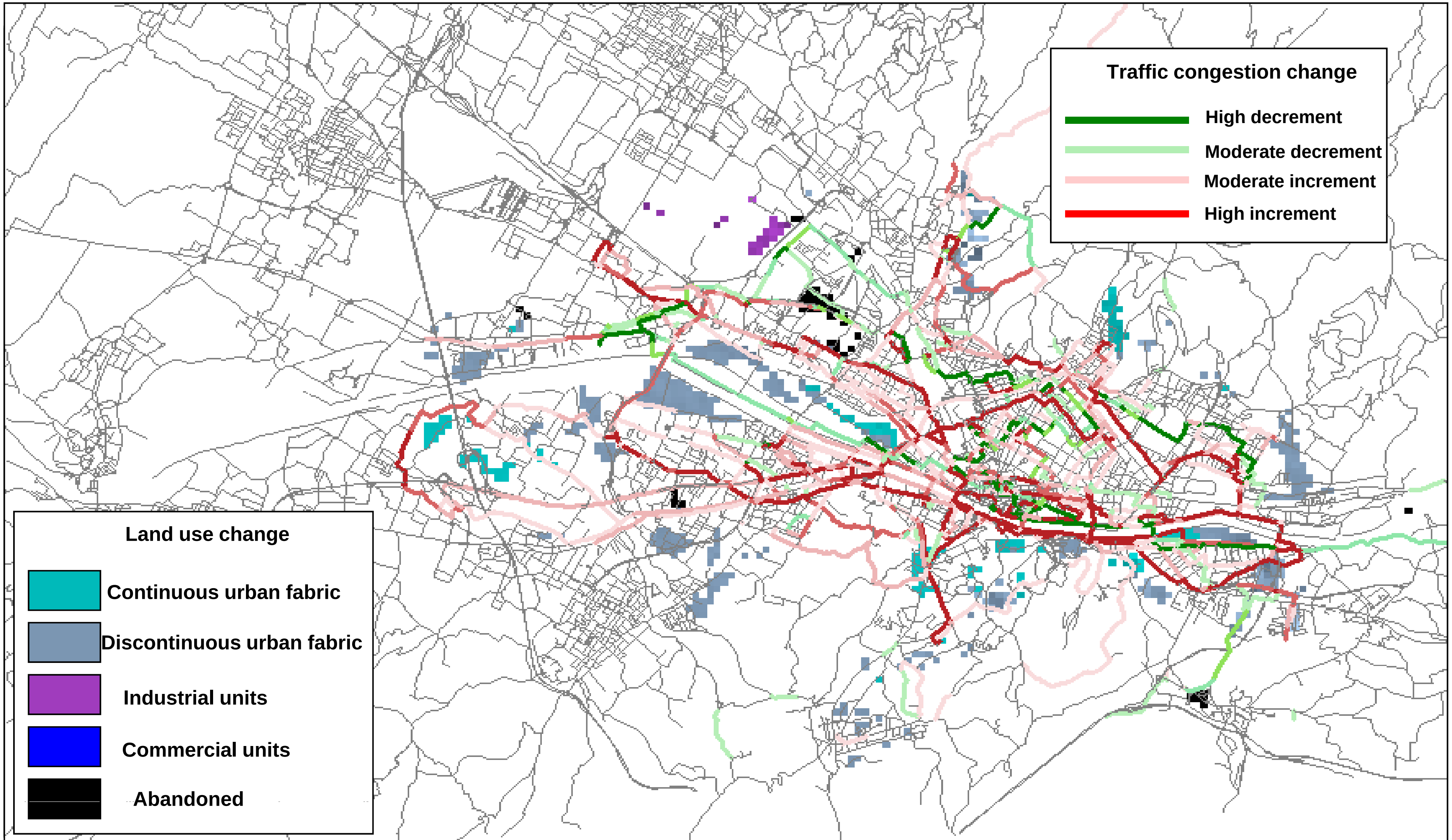
Transportation model for estimating the traffic load related to the future land use scenarios

Spatialized emission inventory

Future land use and traffic load projections

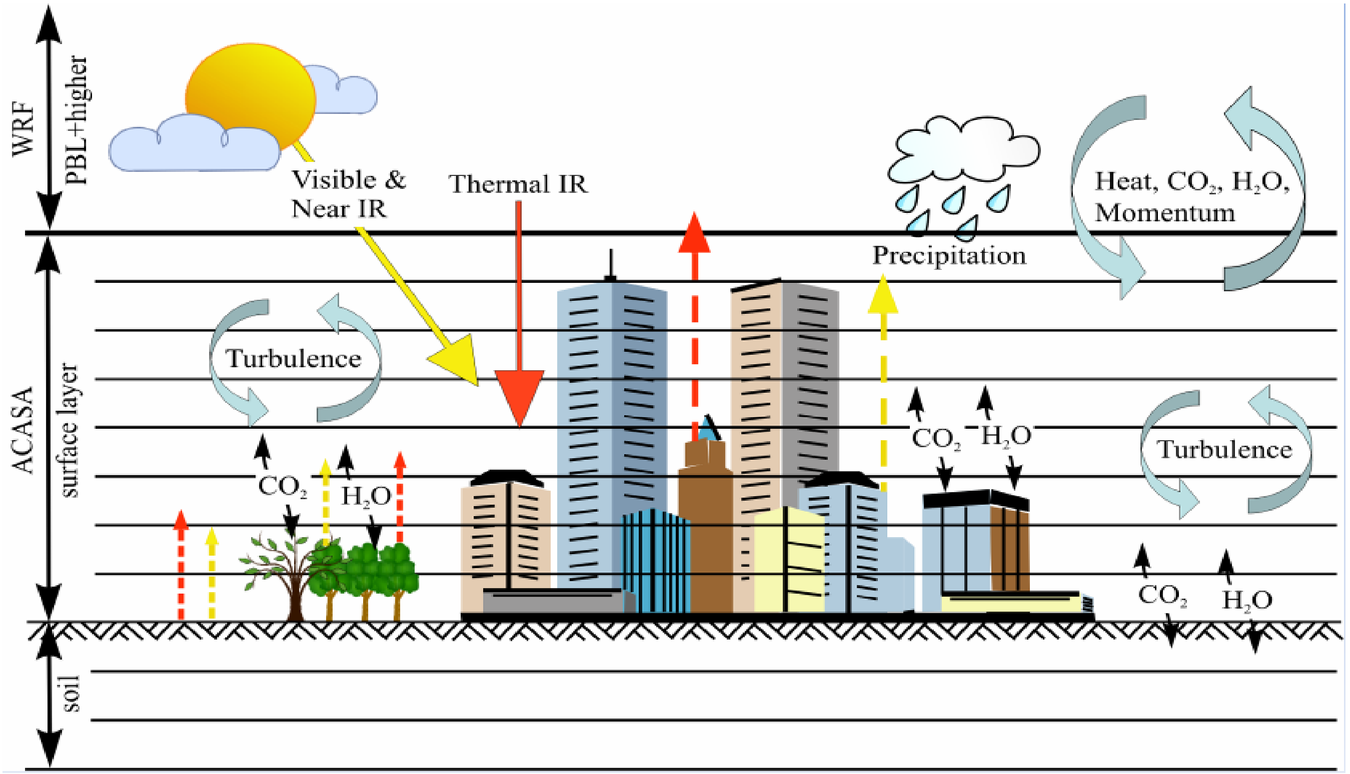


Florence, Italy

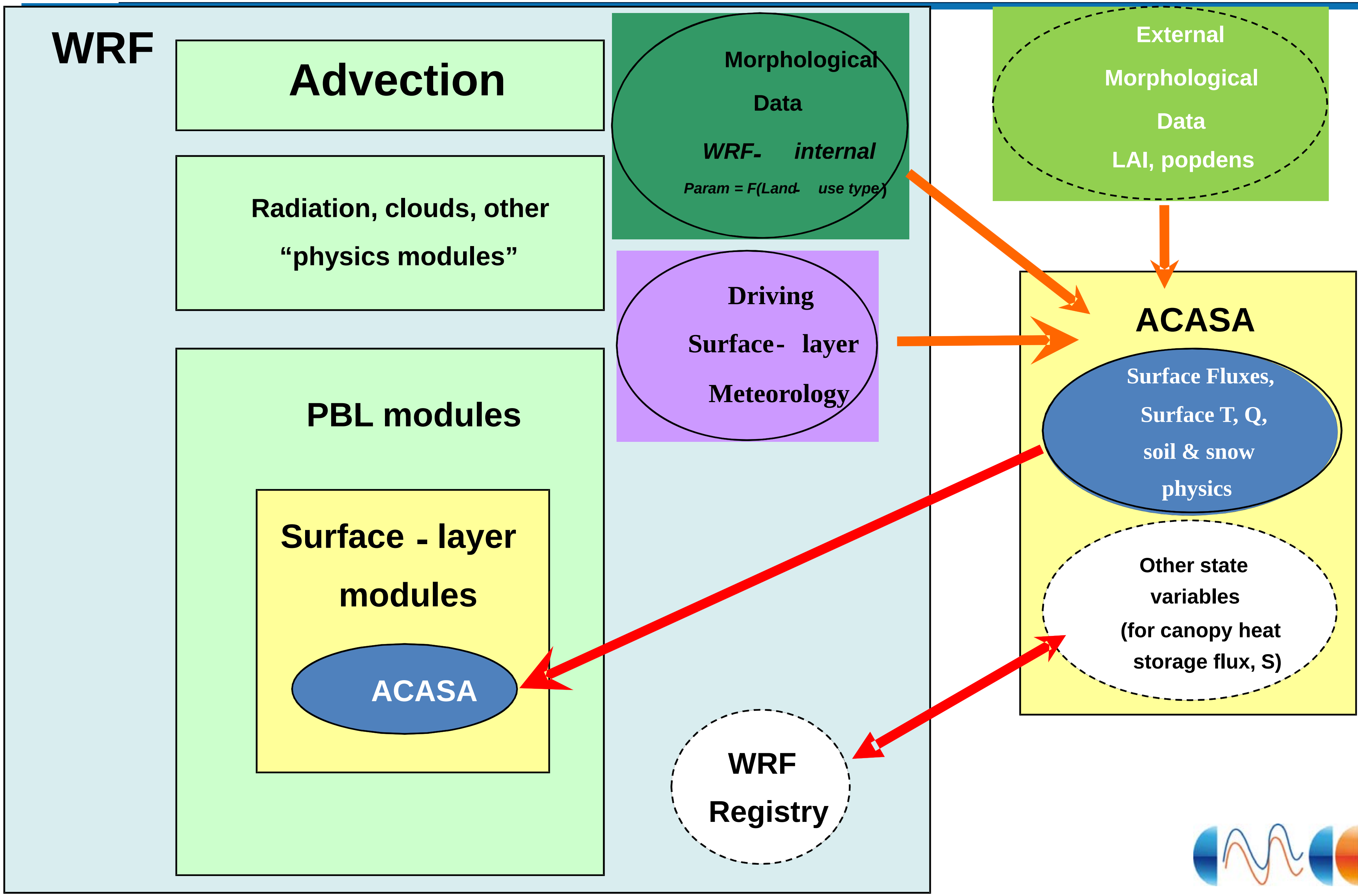
WRF-ACASA coupled model

Land use change and traffic congestion data are used by WRF-ACASA to produce high detailed ***CO_2 flux maps*** (e.g. hourly/daily/monthly-averaged values)

ACASA consists of an algorithm for determining the exchanges of energy, mass and momentum between the atmosphere and the land surface. These exchanges have a range of temporal and spatial scales.



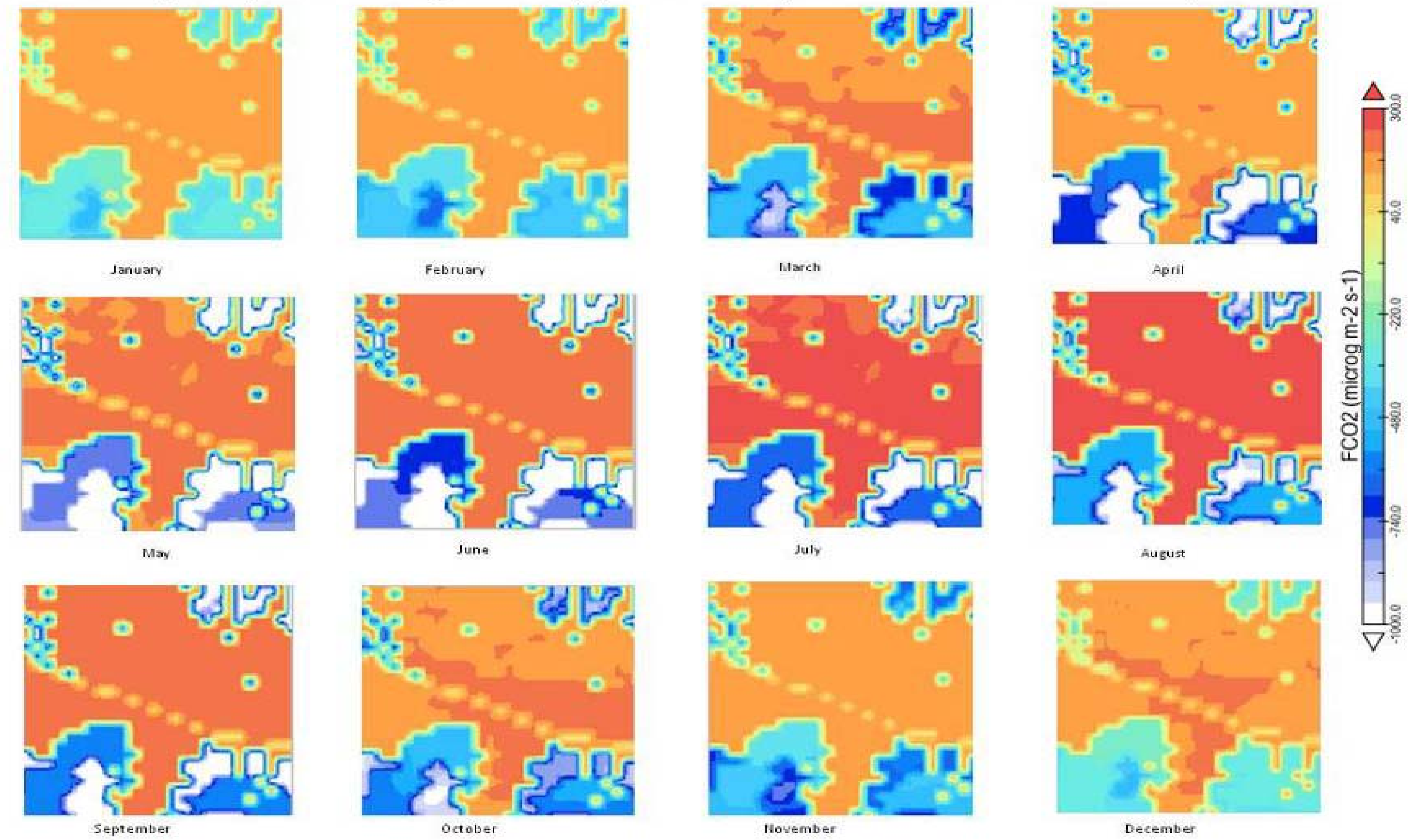
WRF-ACASA coupled model



WRF-ACASA – Florence baseline scenarios

Monthly CO_2 flux depending on vegetation growth, anthropogenic sources, and land use baseline scenario

5 – Monthly Composite-Average Midday (12:00 PM LT) Carbon Dioxide Flux Density



Jan.-Apr.

May-Aug.

Sep.-Dec.

WRF-ACASA- alternatives scenarios

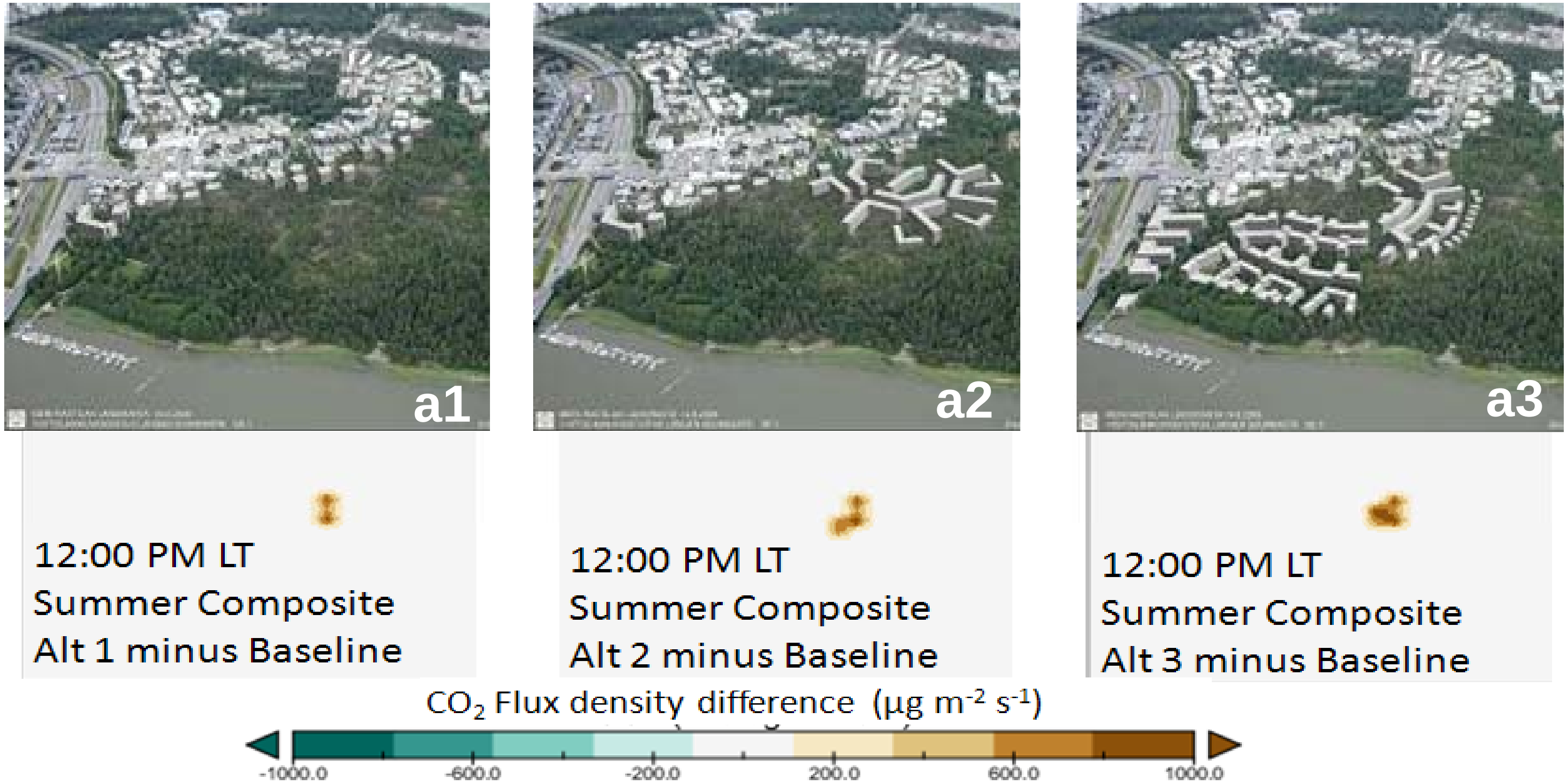
- **Simulates the impact of planning alternatives on energy and mass fluxes**

- **Evaluates impact of changes in land use**

Support planners to evaluate the impact and to work towards sustainable development

WRF-ACASA- Helsinki alternatives scenarios

2008



- **FCO_2>0 for most hours and most of the year, which agrees with building intensity.**
- **More photosynthesis; especially in spring and summer**
- **Differences are less pronounced during the winter.**

Conclusions

A modelling system was developed to assess the impact of changes and planning alternatives using the main drivers of the urban environment

Useful tools

1) **ACASA and WRF-ACASA**
   - Knowledge on urban response to climate change
   - Helps with future planning alternative scenarios
2) **CA (land-use) module**
3) **Transporatation model**

Output provides support to planners to make sustainable development choices