

Assessment of evaporative water loss from Dutch cities

Cor Jacobs¹⁾, Jan Elbers¹⁾, Reinder Brolsma²⁾, Oscar Hartogensis³⁾,
Eddy Moors¹⁾ and Bert van Hove^{3,4)}

¹⁾Wageningen UR Alterra, Climate Change and Adaptive Land and Water Management

²⁾Deltares

³⁾Wageningen University, Meteorology and Air Quality

⁴⁾Wageningen University, Earth System Science



Evaporation is...

- The link between the energy and water budgets
- The link between heat mitigation and water management
- Crucial in ground water management
- Contributing to specific problems, such as
 - salt intrusion in coastal areas
 - decay of wooden foundations
- **Virtually unknown for Dutch cities**



www.paalrot.info

Main Questions

- How much water evaporates from Dutch cities, notably during the summer half-year (April-September)?
- Can we estimate evaporation from routine weather data?

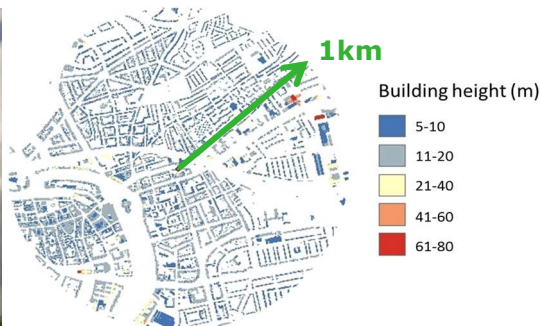


Photograph by Wiebke Klemm
(Wageningen University, Landscape Architecture)



1) Direct observations in Arnhem (EC)

(www.climateXchange.nl; www.geog.ubc.ca/urbanflux)

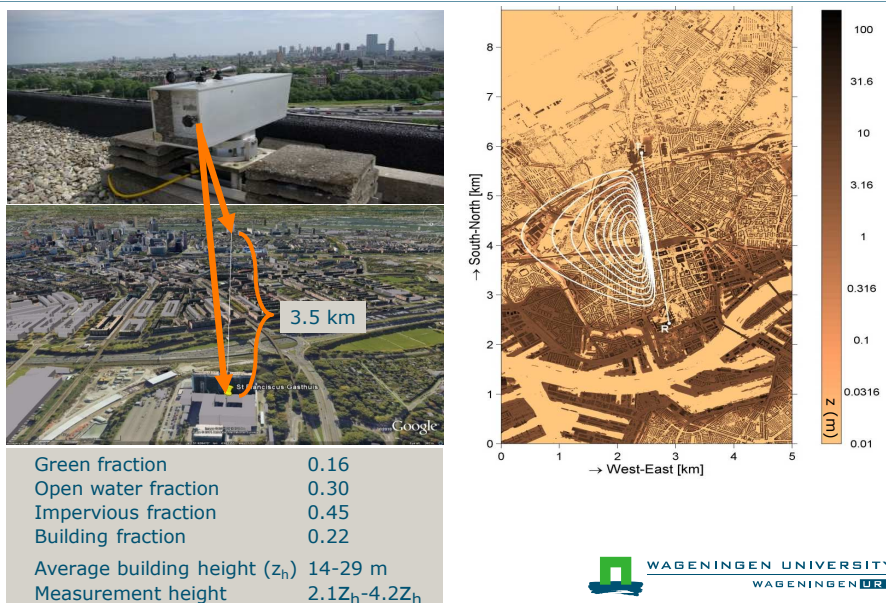


Green fraction	0.12
Open water fraction	0.01
Impervious fraction	0.84
Building fraction	0.39

Average building height (z_h)	11 m
Measurement height	$2.1z_h$



2) Indirect observations in Rotterdam (scinty)

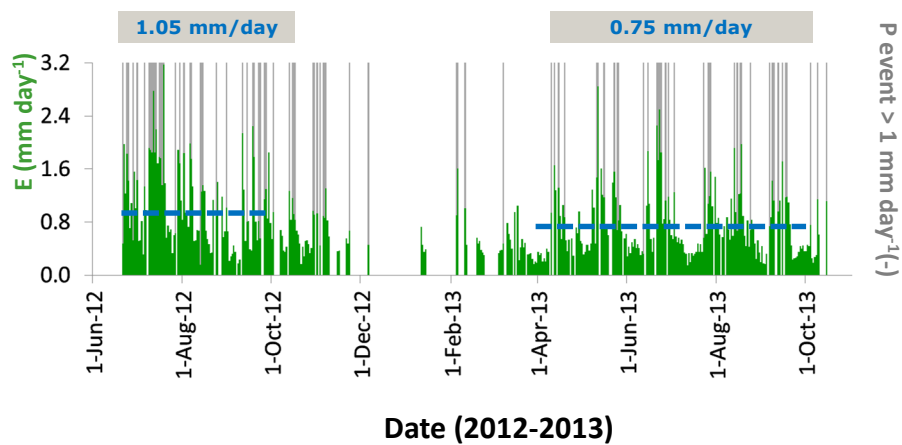


3) Sap flow of trees in Rotterdam (sap flow)

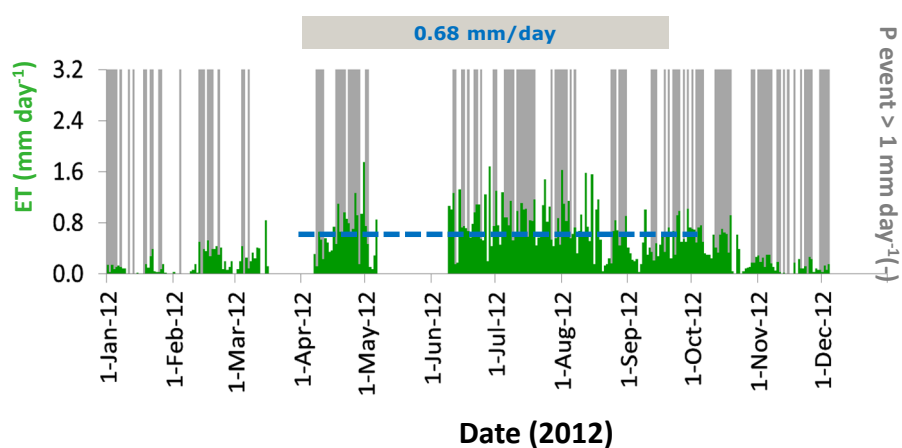


Object	Species	Stem diameter (cm)	Sapwood area (cm ²)
Berk 1	Common lime (<i>Tilia × europaea</i>)	29	528
Berk 2	Common lime (<i>Tilia × europaea</i>)	31	578
Park 1	Ash (<i>Fraxinus excelsior</i> L.)	45	930
Park 2	Common lime (<i>Tilia × europaea</i>)	38	754
Park 3	Common lime (<i>Tilia × europaea</i>)	44	905

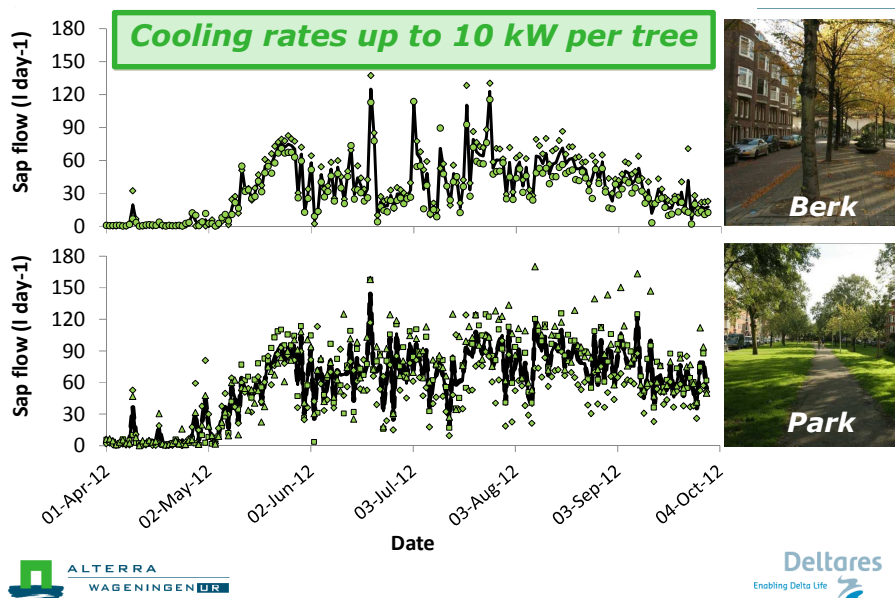
Observed evaporation in Arnhem (EC)



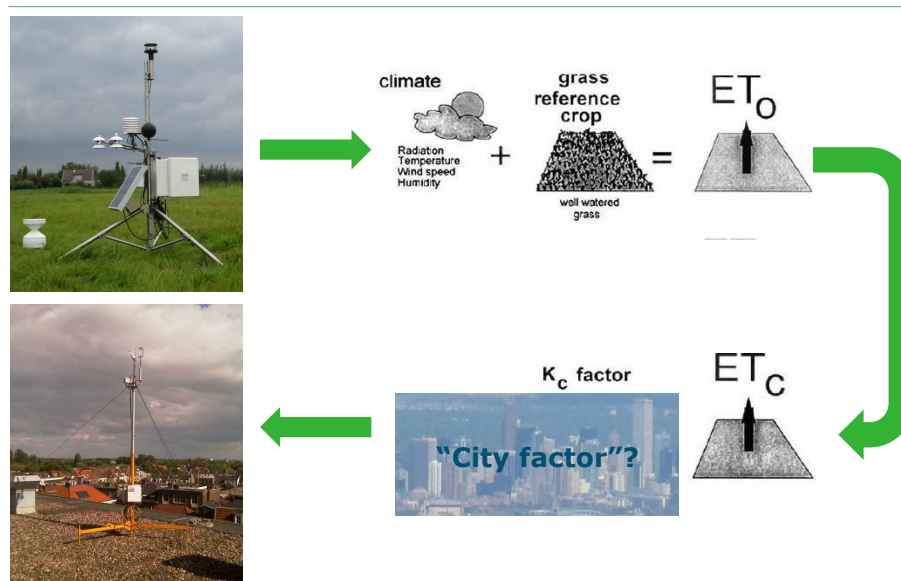
Observed evaporation in Rotterdam (scinty)



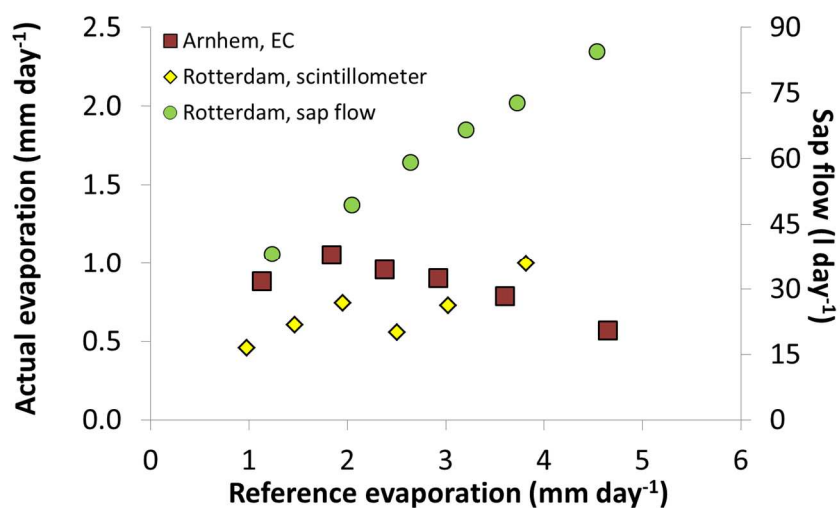
Observed daily sap flow in Rotterdam



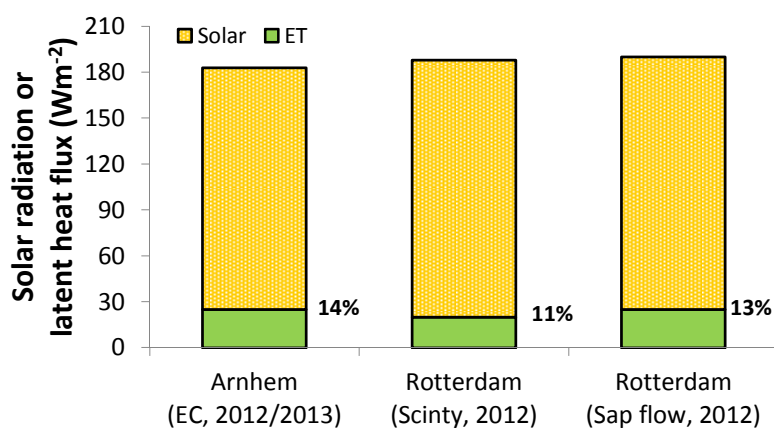
Urban evaporation from routine weather data?



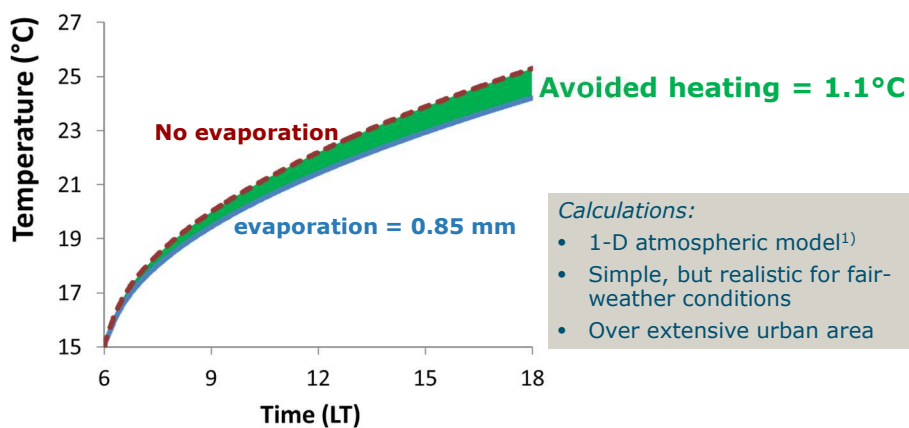
Actual versus reference evaporation (Apr-Sep)



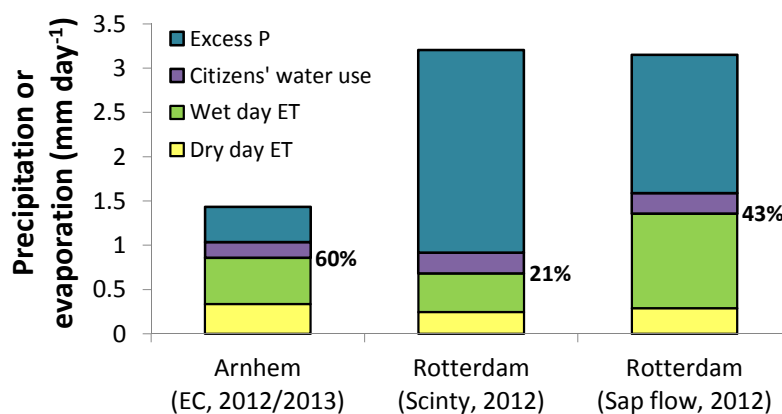
Evaporation as a component of the energy budget (April-September)



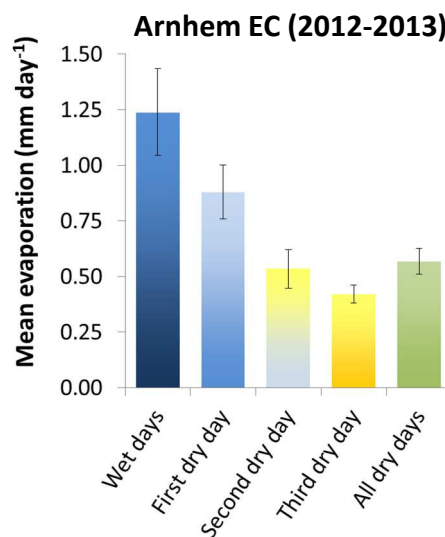
Avoided heating by evaporation: a first-order estimate



Evaporation as a component of the water budget (April-September)

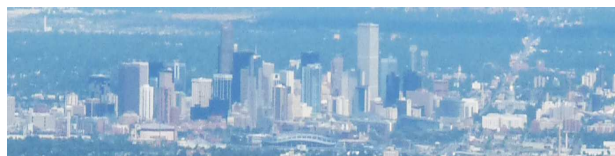


Drying of wet spots on flat roofs?



Main conclusions

- Summer ET in Arnhem and Rotterdam:
typically ~0.5 - 1 mm/day:
 - Contribution to city cooling
 - Water loss 20% - 60% of precipitation
 - Important role of interception reservoir/storage (flat roofs?)
- Tree transpiration can be important locally, but represents a relatively small water loss at the city scale
- Estimation of urban evaporation from routine weather observations needs further investigation



Thank you for your attention!

This research has been funded by the **Knowledge for Climate** program, co-financed by the Dutch Ministry of Infrastructure and the Environment. It was also part of the **KBIV 'Sustainable spatial development of ecosystems, landscapes, seas and regions'**, funded by the Dutch Ministry of Economic Affairs, Agriculture and Innovation, and carried out by Wageningen University and Research Centre.



Rijksoverheid

