SEMI-MECHANISTIC MODELING OF PESTICIDE WASHOFF FROM CONCRETE SURFACES

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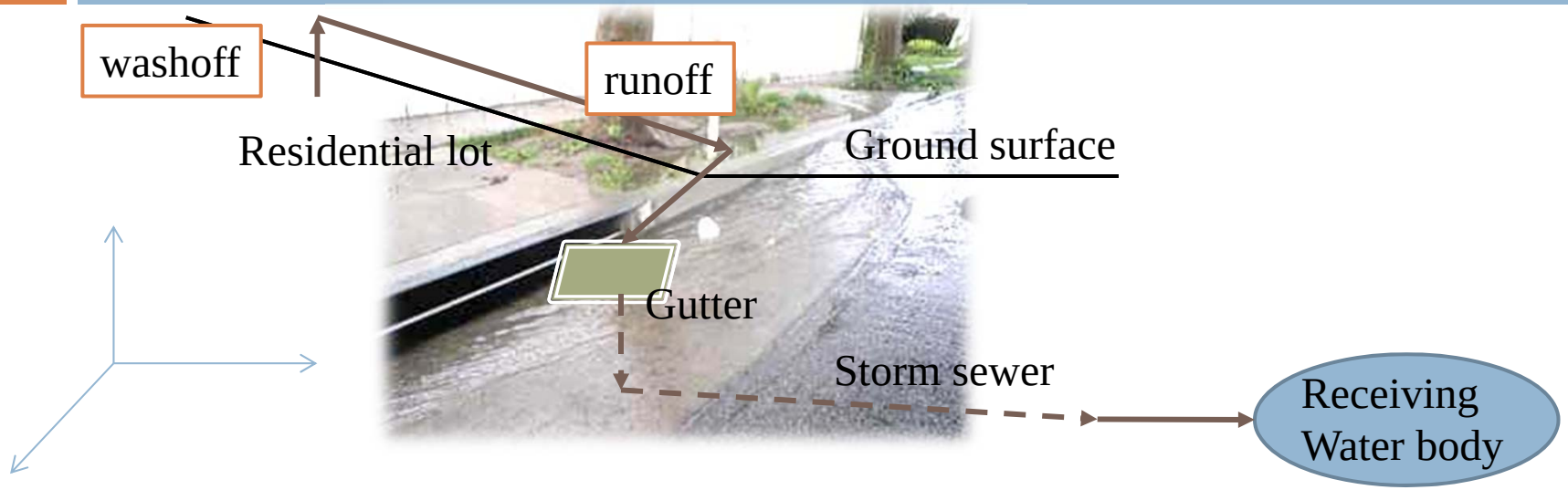
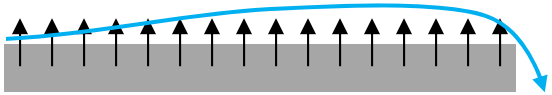
Research needs



Pesticide process	Potential model	Model status
Washoff: impervious surfaces		No model
Washoff: pervious surfaces	Soil extraction and erosion	Developed
Runoff: overland flow and concentrated flow	Field models	Partially developed
Runoff: conveyance system of storm sewer	Storm water management model (SWMM)	Developed
Runoff: open channel flow	Watershed models	Developed

Pesticide washoff experiments

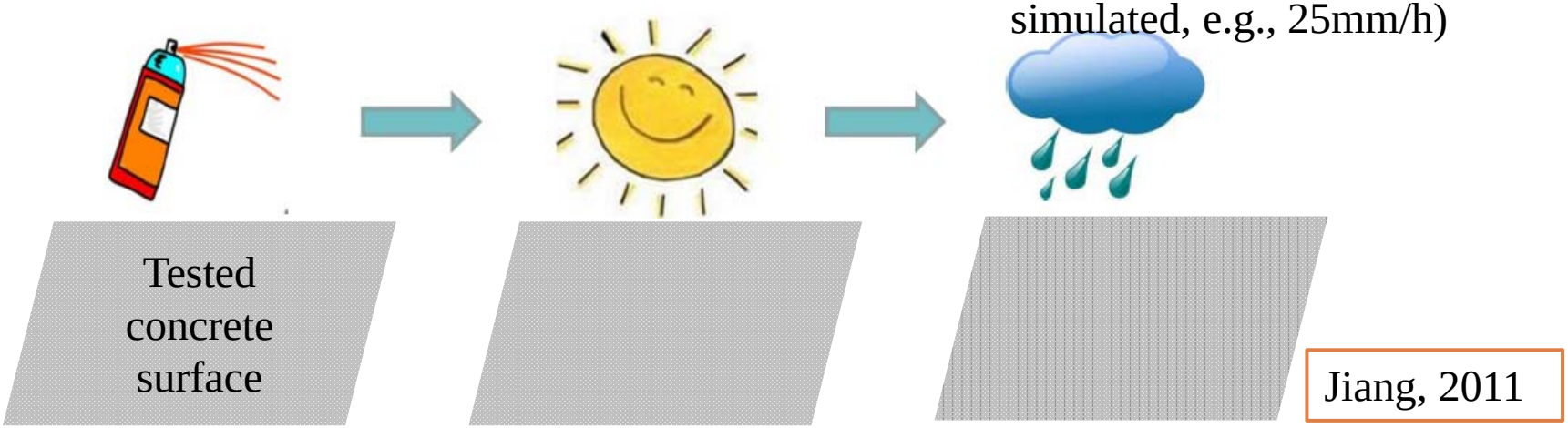


Tested concrete surfaces
(40cm*60cm or 80*80cm),
uniformly treated with pesticide

Application

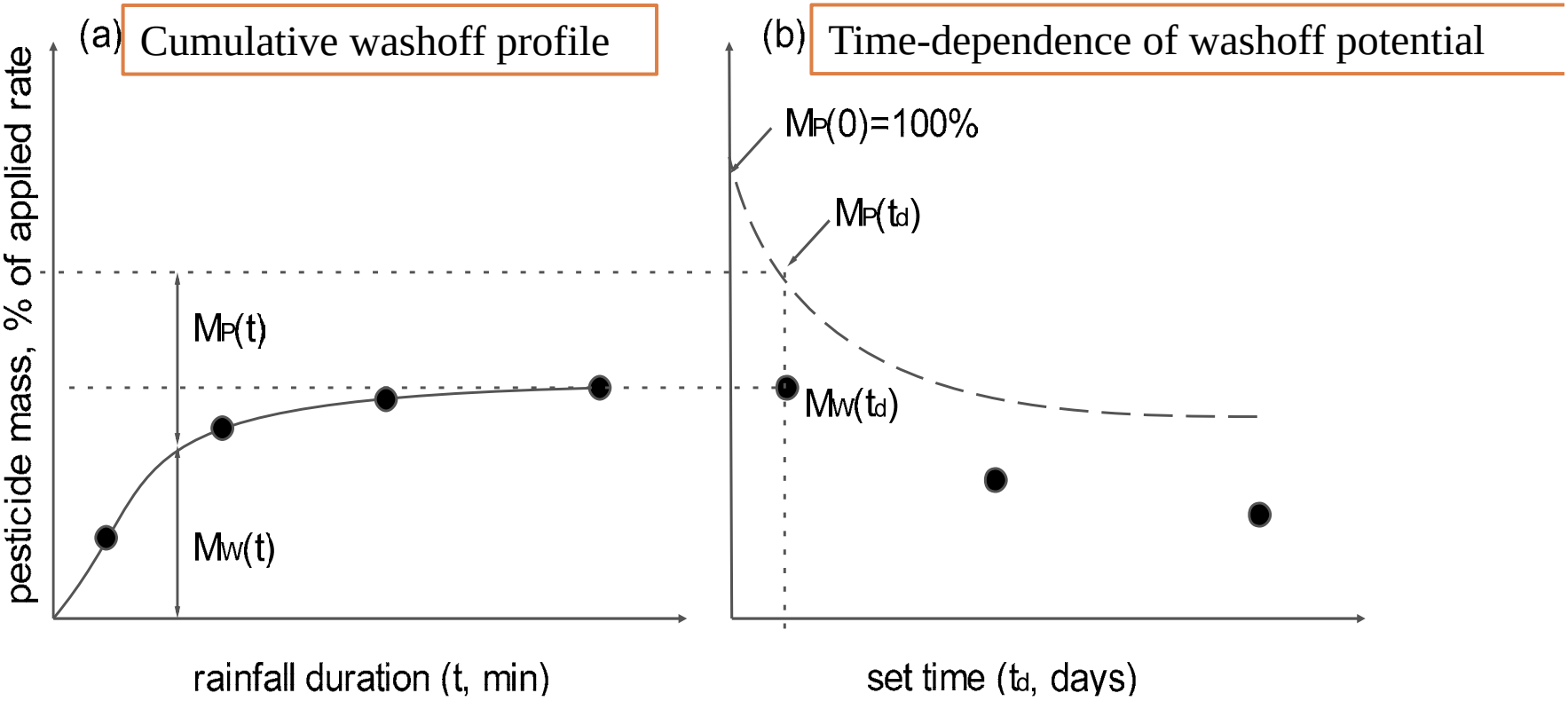
Dry period (set time)

Rainfall (natural or simulated, e.g., 25mm/h)



Jiang, 2011

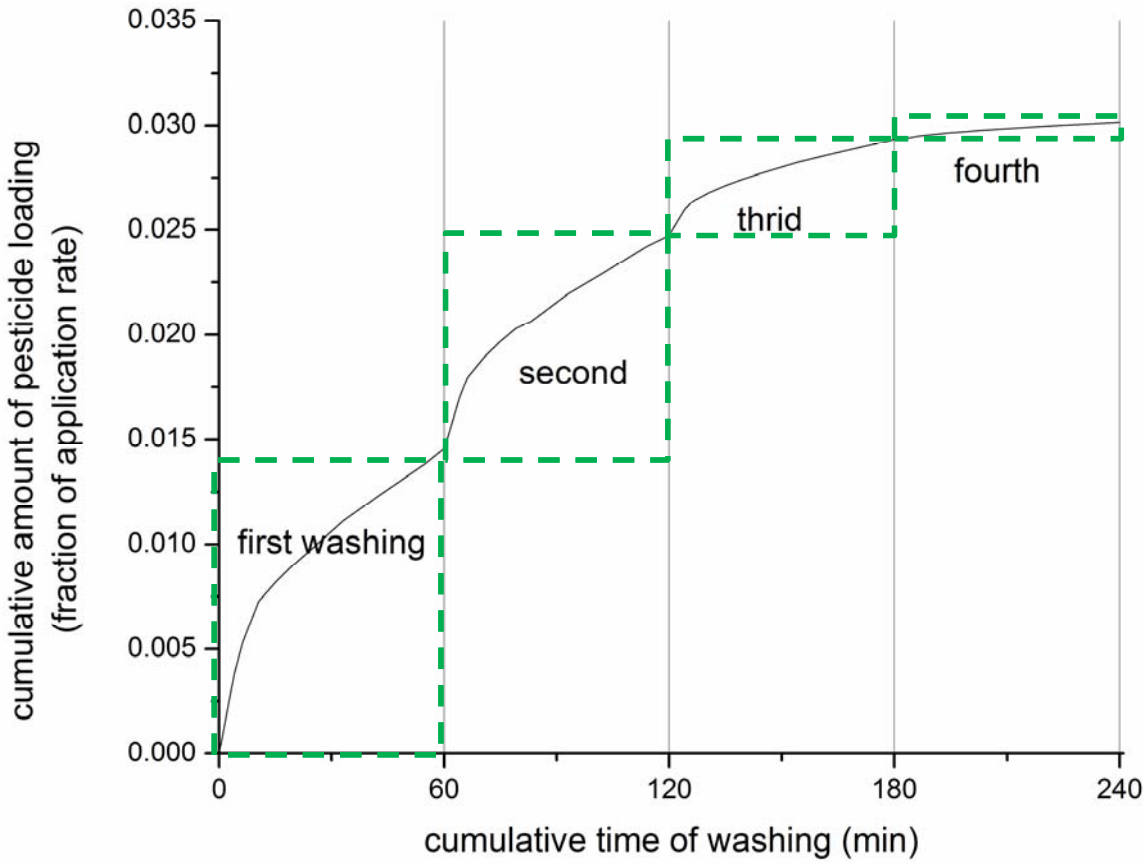
Pesticide washoff experiments



- Two systems of time: td (dry period), t (rainfall duration)
- $M_P(td)$: washoff potential (a theoretical value of mass available for washing)
- $M_W(t)$: measured washoff mass under experiment settings

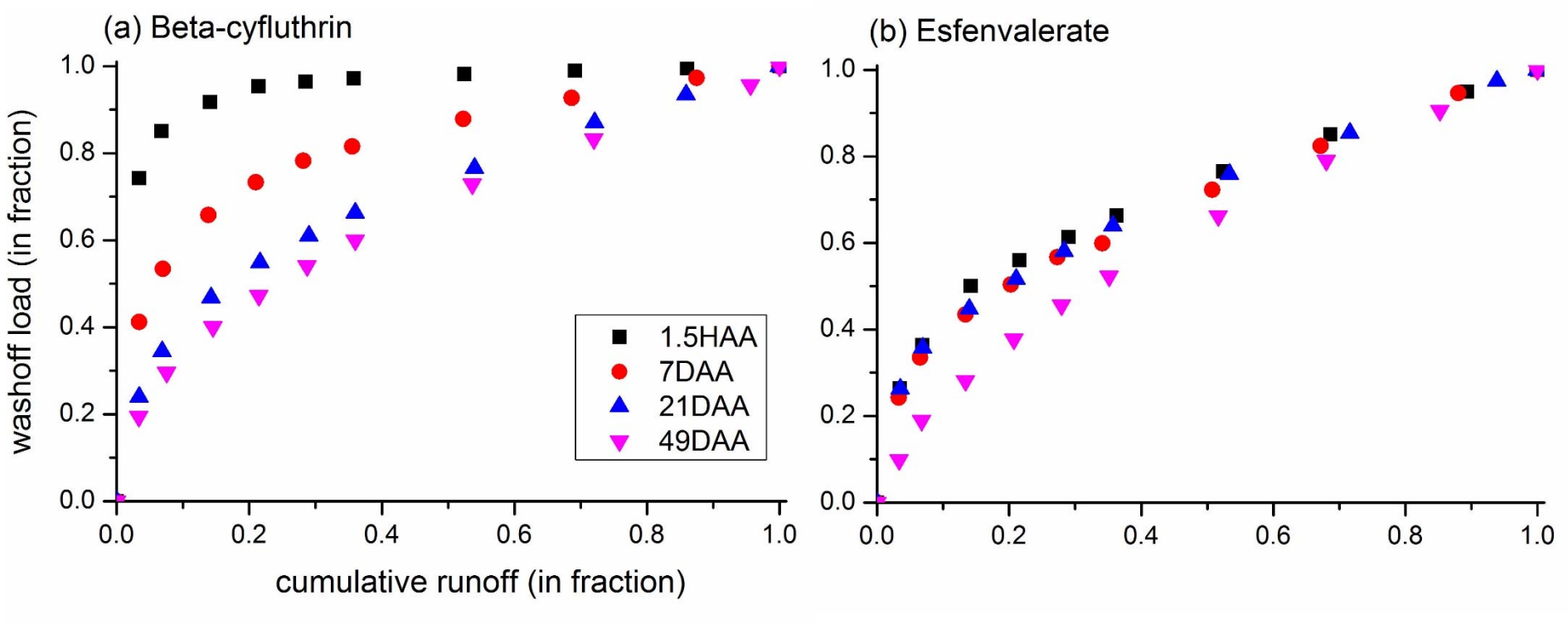
Repeated rainfall events

Cumulative washoff profile



Normalized washoff profile

Data from
Jorgenson and Young, 2010



Data sources

- CDPR supported studies
  - Jorgenson and Young, 2010, ES&T, 44(13): 4951-7
  - Thuyet et al., 2012, Sci Total Environ, 414(1): 515-24
  - Jiang et al., 2012, Water Res, 46(3): 645-52
  - Unpublished data from UC Davis collaborators

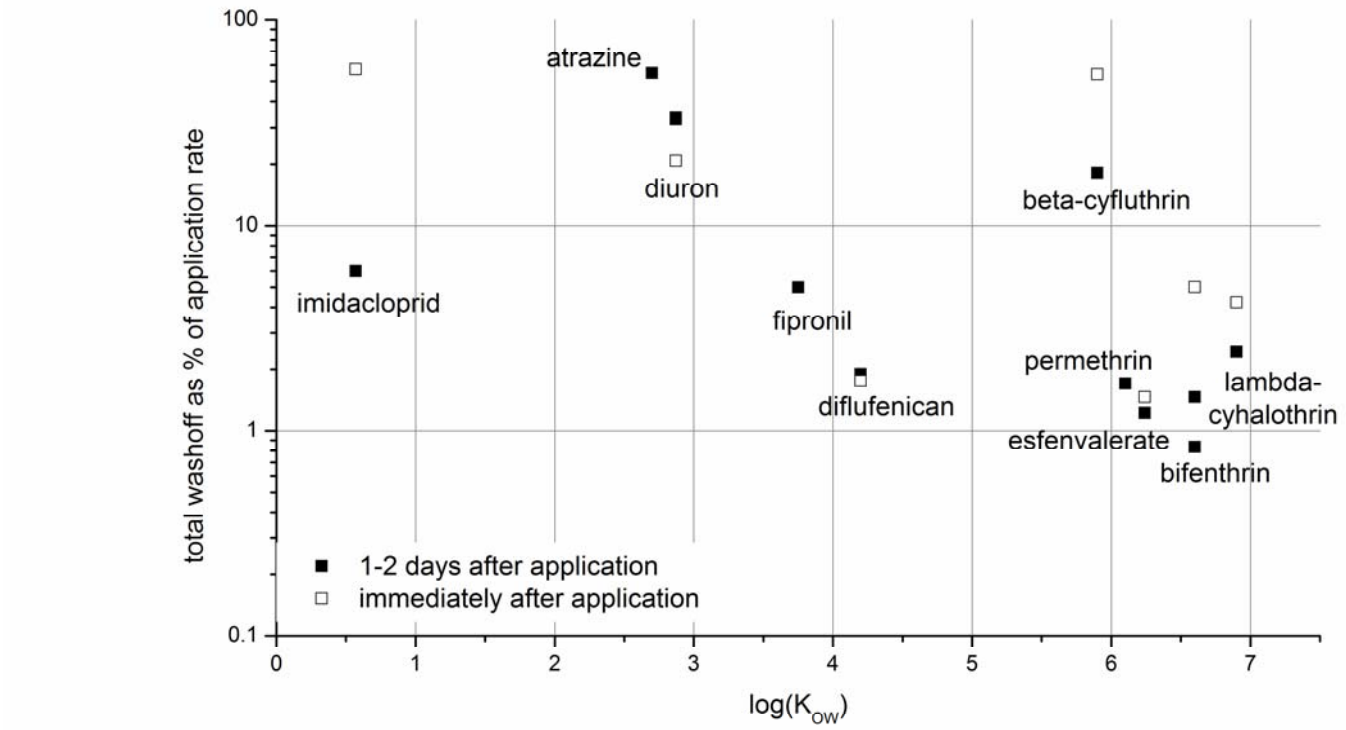
  - Insecticides: bifenthrin, beta-cyfluthrin, carbaryl, esfenvalerate, fipronil, imidacloprid, lambda-cyhalothrin, permethrin, and malathion

Data sources

- CDPR supported studies
- Keywords: pesticide, washoff, impervious surface (except for wall/facade)
- Additional studies for general data review
  - Shepherd and Heather, 1999, Cranfield Univ, UK
  - Ramwell, 2005, Pest Manag Sci, 61(2), 144-50
  - Spanoghe et al., 2005, Pest Manag Sci, 61(8), 793-8

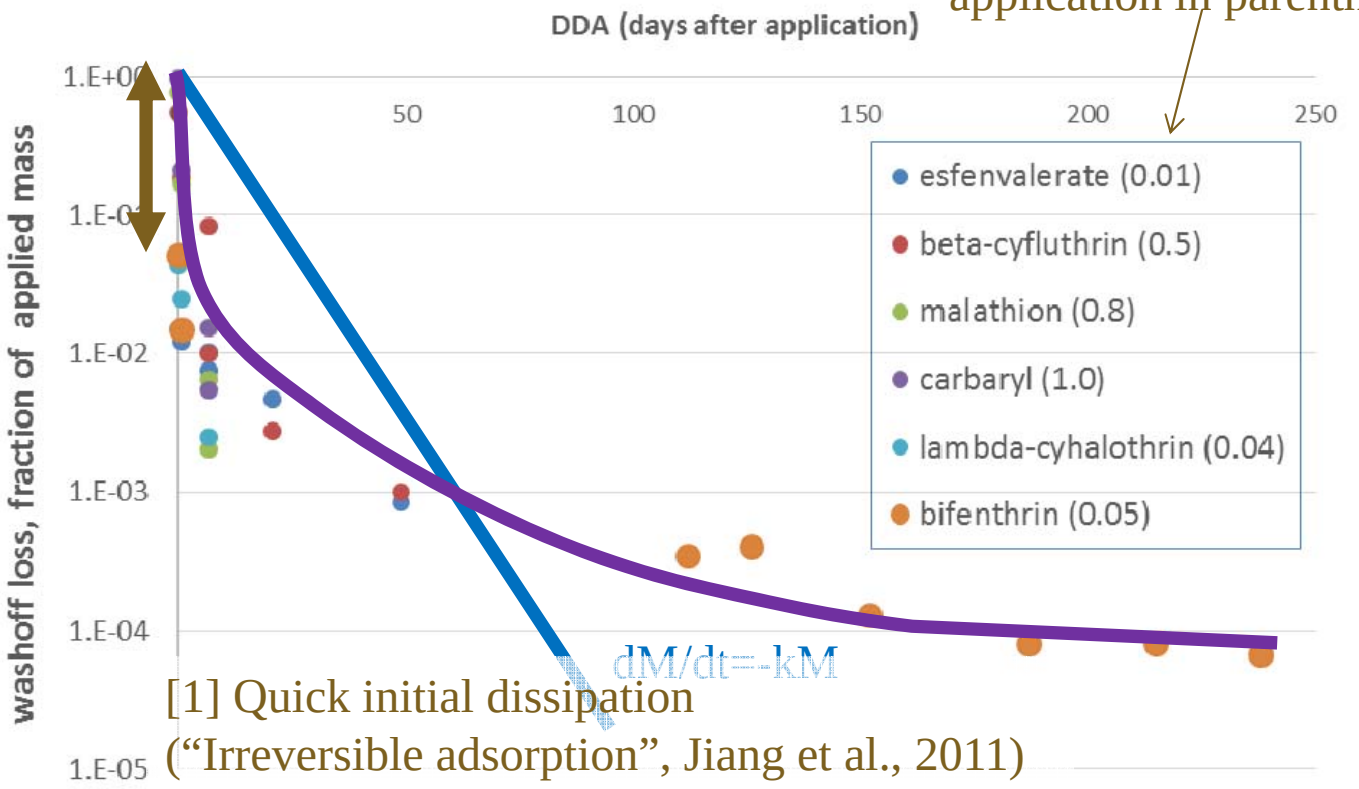
Data analysis and implications

- Weak association between washoff loads and physicochemical properties



Data analysis and implications

- Washoff potential



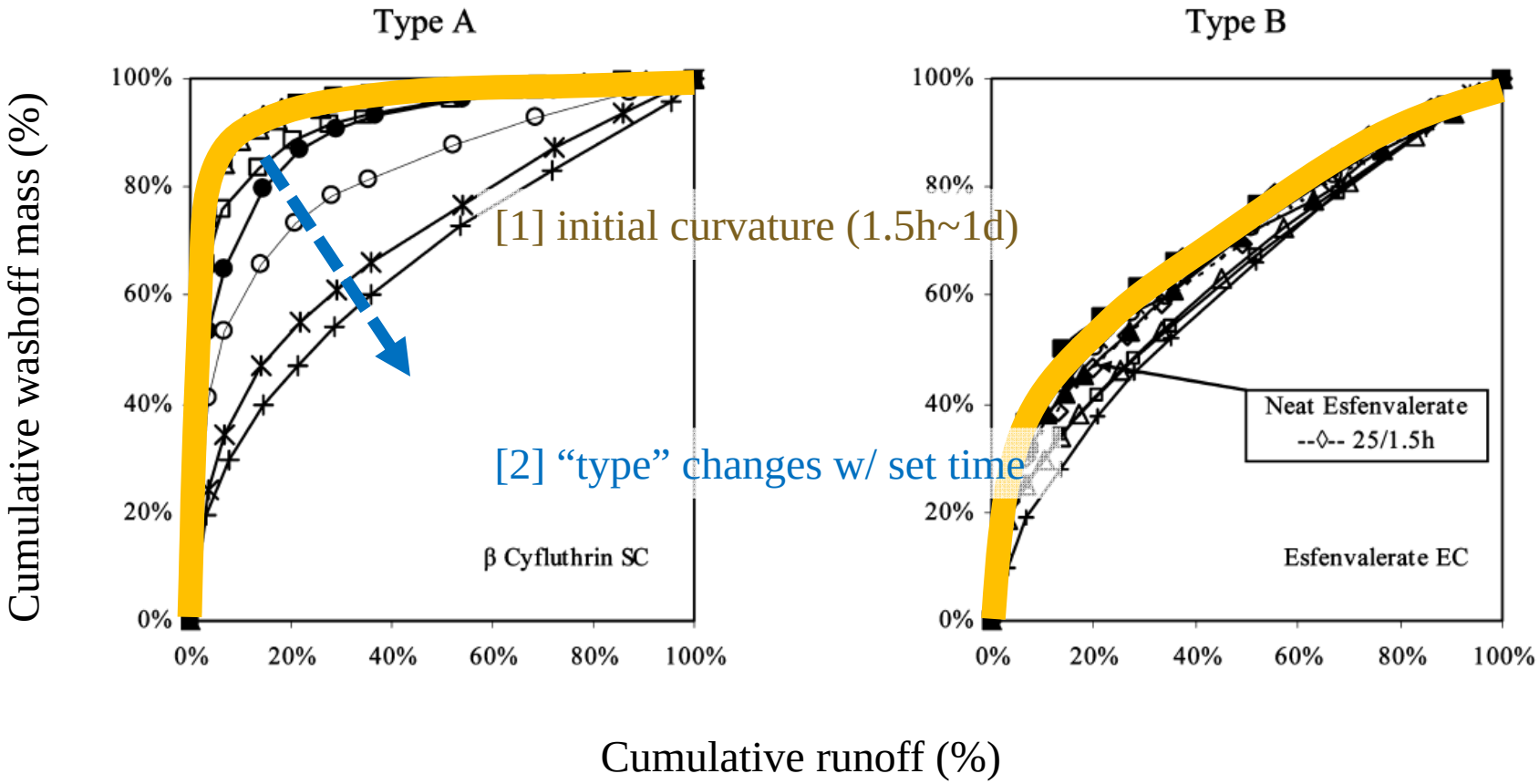
[1] Quick initial dissipation ("Irreversible adsorption", Jiang et al., 2011)

[2] Decreasing rate constant of dissipation: dM/dt=-K(td)M

Data analysis and implications

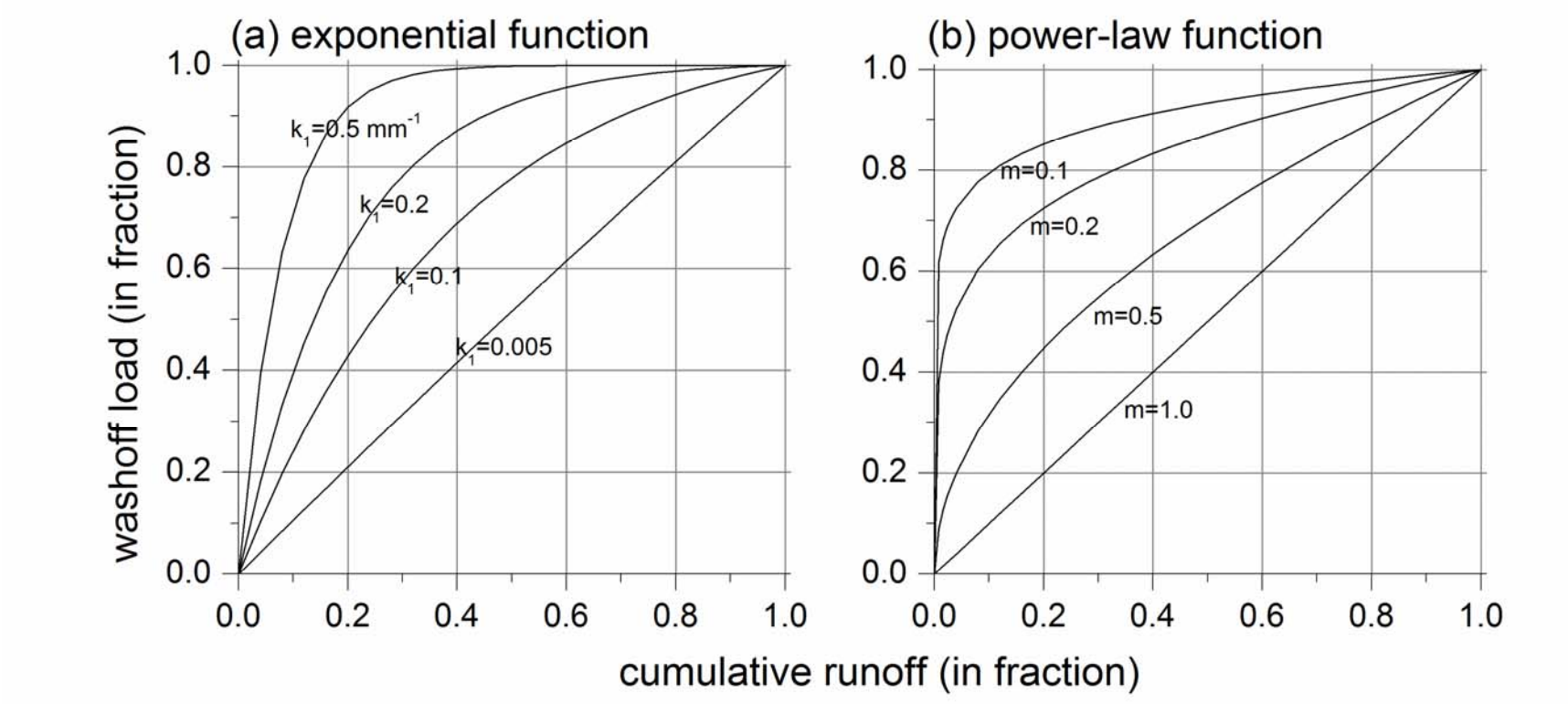
- Washoff profile

Jorgenson and Young, 2010



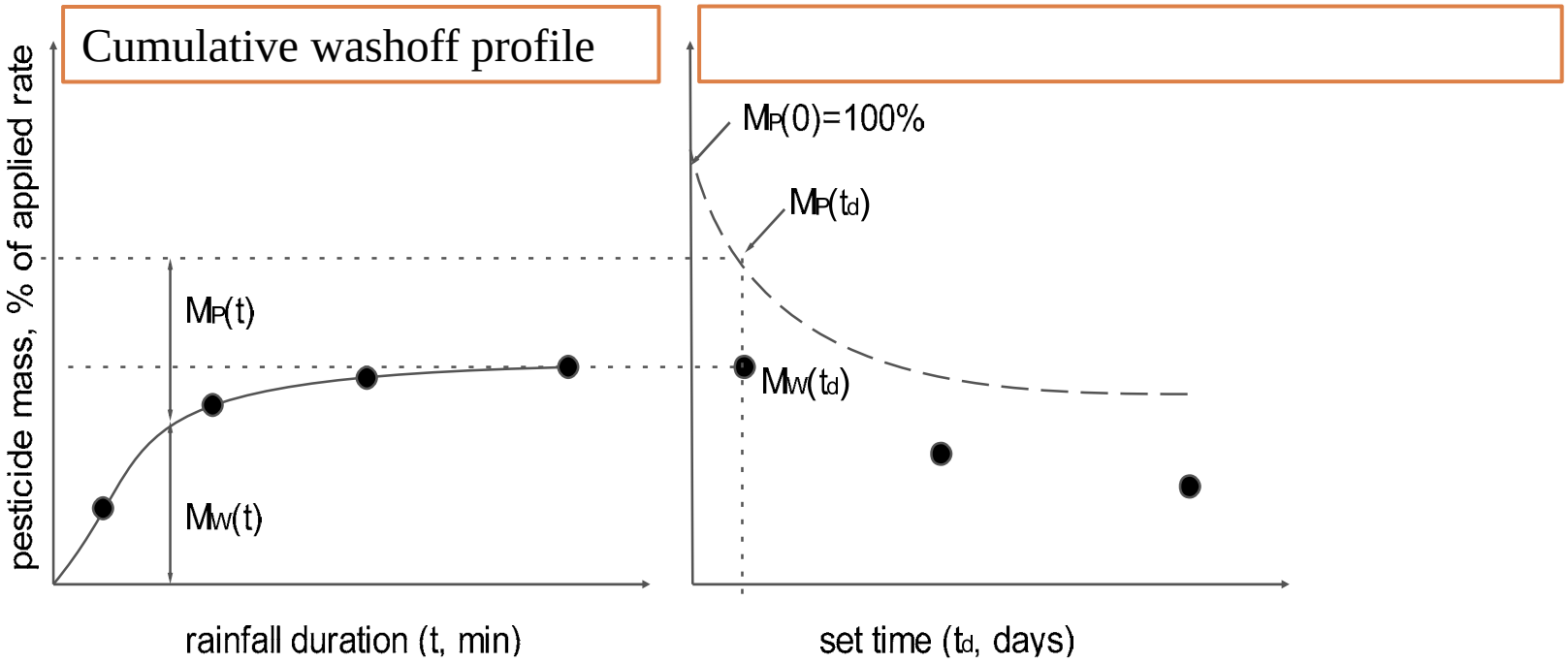
Data analysis and implications

- Washoff profile



Model development

- Washoff potential: First-order kinetics with time-variable dissipation rate constant
- Washoff profile: 1D diffusion equation with time-variable effective diffusivity



Model development

- Washoff potential: First-order kinetics with time-variable dissipation rate constant
  - Initial rate constant, K(0)
  - Time-dependence: $K(t_d)=K(0)*M_P(t_d)$
- Washoff profile: 1D diffusion equation with time-variable effective diffusivity
  - Initial effective diffusivity: D(0)
  - Time-dependence: $D(t)=D(0)*t^{[1- s *M_P(t_d)]}$

Model development

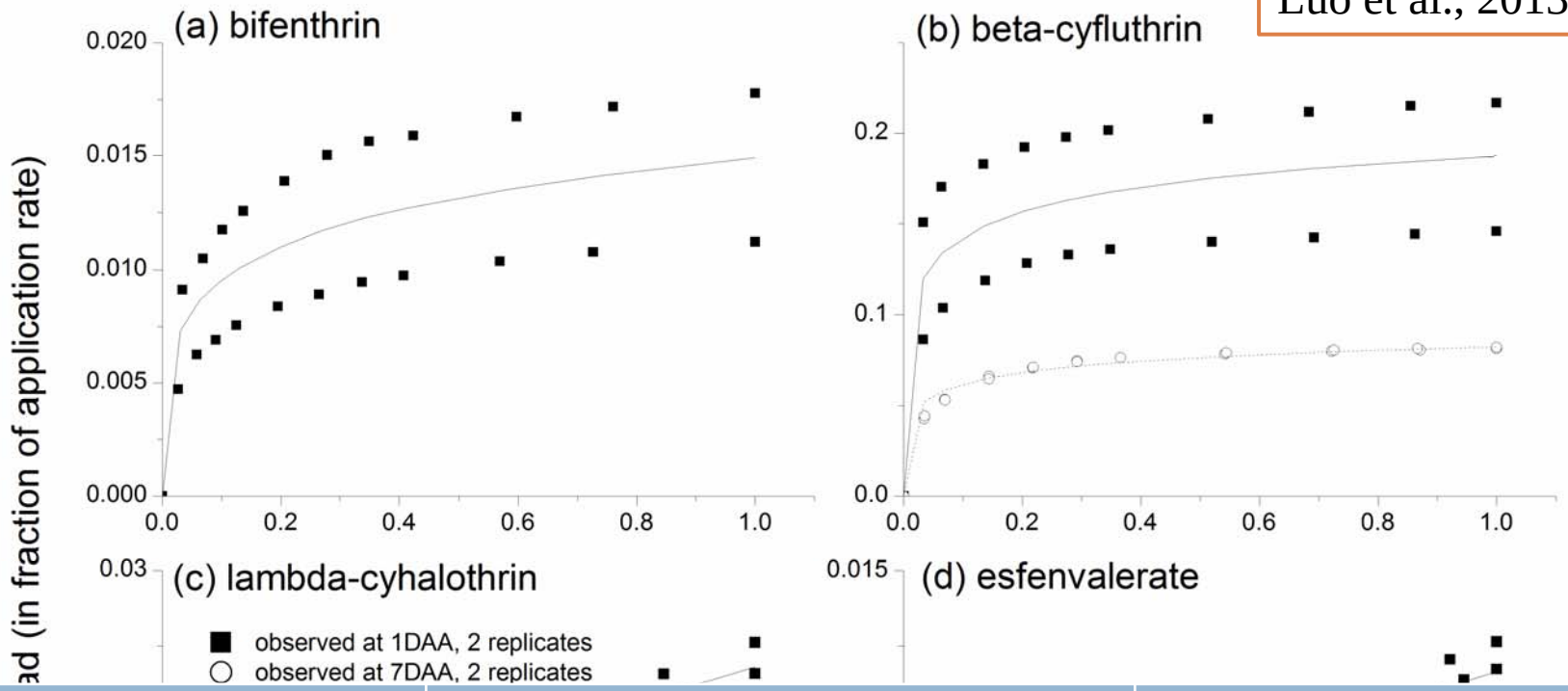
- Washoff potential: First-order kinetics with time-variable dissipation rate constant
- Washoff profile: 1D diffusion equation with time-variable effective diffusivity
- New parameters
  - Persistence (K, s^{-1}): rate constant for washoff potential
  - Transferability (D, s^{-1}): effective diffusivity
  - Shape factor (s, unitless): time-dependence of D
  - Values specific to a product (not AI) AND a set of environmental configurations

Model applications

- Insecticides: bifenthrin, beta-cyfluthrin, carbaryl, esfenvalerate, fipronil, imidacloprid, lambda-cyhalothrin, permethrin, and malathion ($\log K_{OW}$=0.6~6.9)
- Settings: >100 selected rainfall events (@25mm/h for 1h), under single and/or repeated (1~7 times) rainfall events with set time of 1.5h~238d after application.

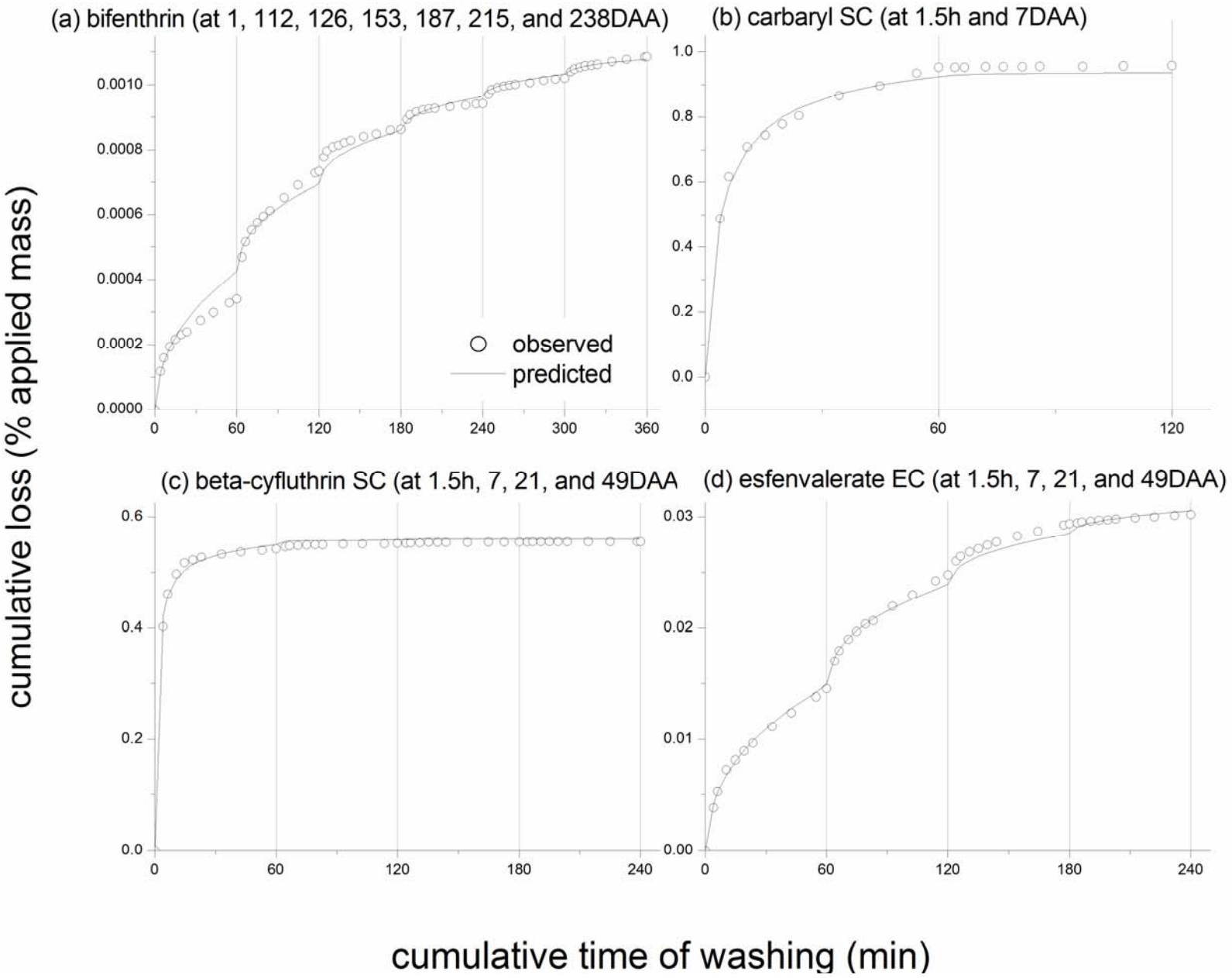
Modeling results, first flush

Luo et al., 2013



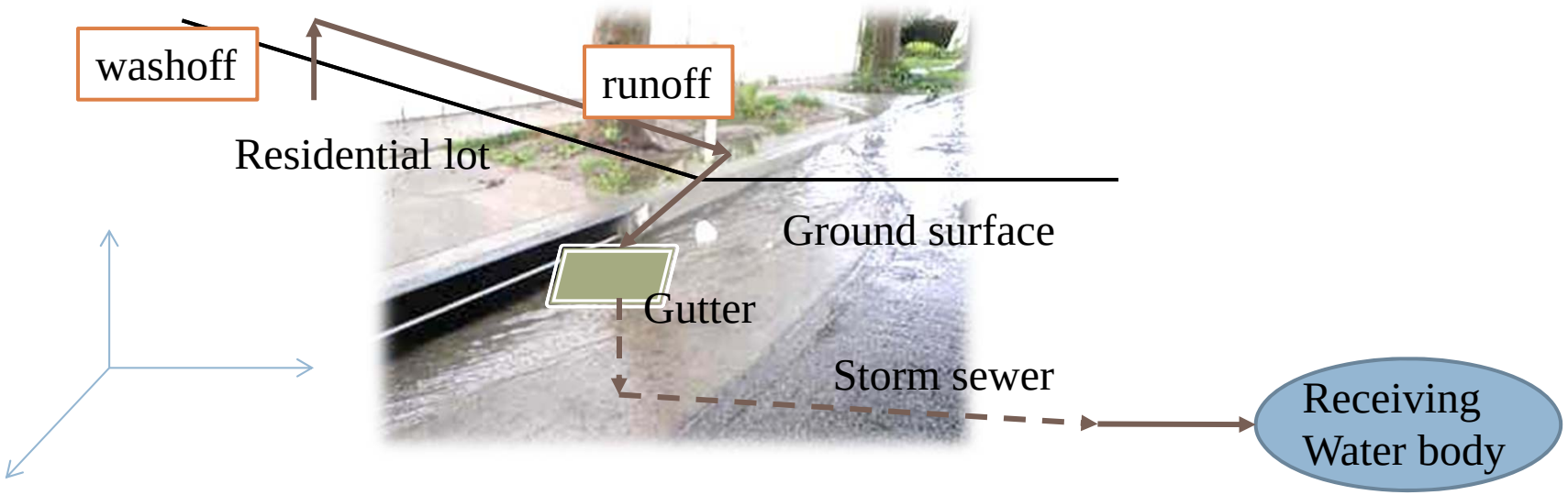
Products	Model parameters			Model performance	
	D(0)	K(0)	s	%RMSE	NS
bifenthrin	5.65E-07	0.601	0.451	0.027	0.998
beta-cyfluthrin	1.04E-04	0.694	0.436	0.069	0.994
lambda-cyhalothrin	8.31E-07	1.487	0.107	0.099	0.989
esfenvalerate	4.53E-08	0.070	0.052	0.085	0.980

Modeling results, repeated rainfall



Next steps

- Incorporation with runoff models
- The role of particles
- Physical interpretation of parameter values



Acknowledgements & Ref's

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- Published experimental data
  - Jorgenson and Young, 2010, ES&T, 44(13): 4951-7
  - Thuyet et al., 2012, Sci Total Environ, 414(1): 515-24
  - Jiang et al., 2012, Water Res, 46(3): 645-52
- Published modeling work
  - Luo et al., 2013, Water Res, 47(9): 3163-72

THANKS

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