Accuracy of Pedestrian and Traffic Flow Models
Meaningful Quantifications

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Celebrating 50 Years of Traffic Flow Theory — Portland, Oregon, 2014

Background

How good is a traffic/pedestrian flow model?

Observations

- reality
- experiment

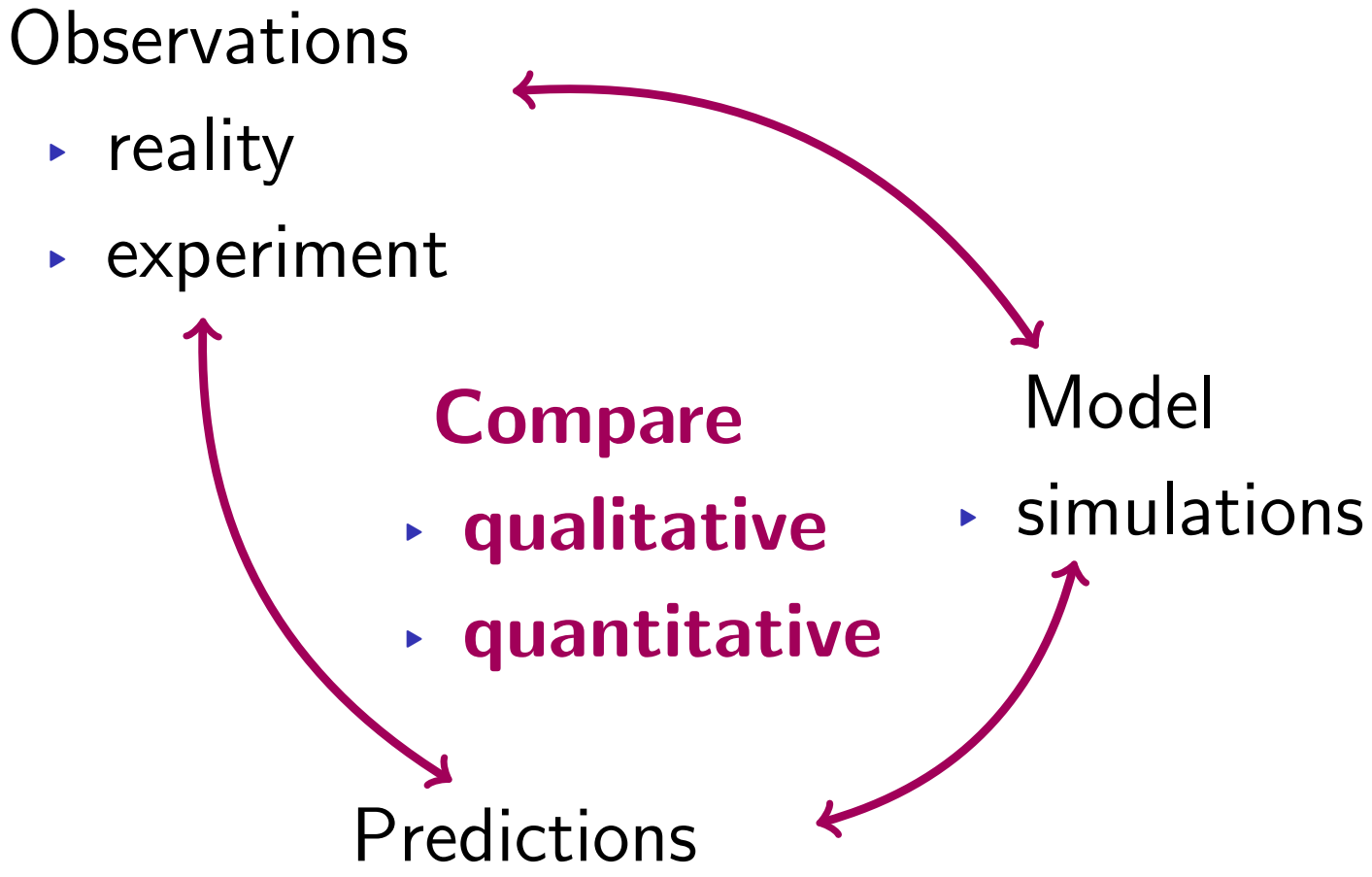
Model

- simulations

Predictions

Background

How good is a traffic/pedestrian flow model?



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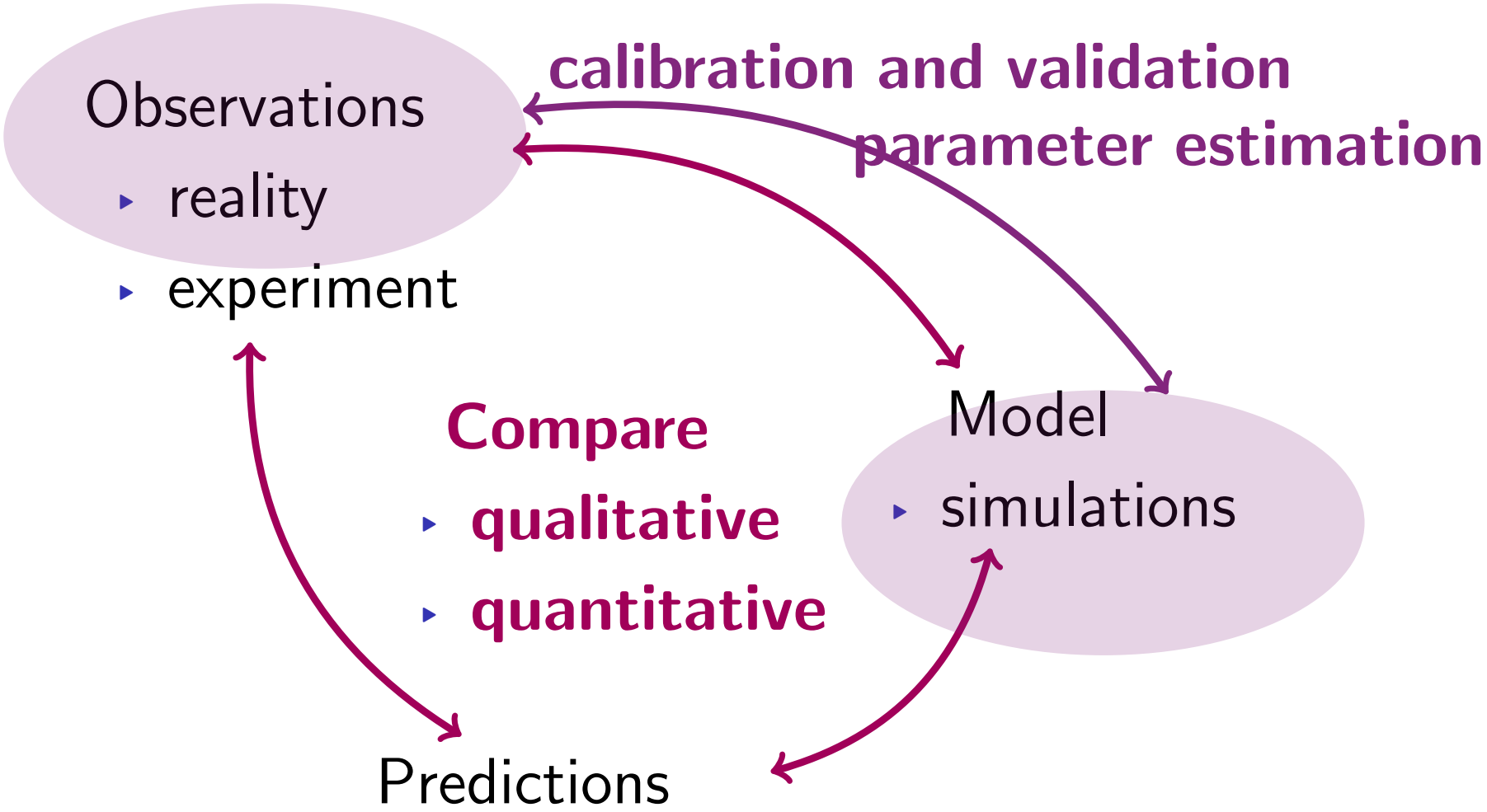


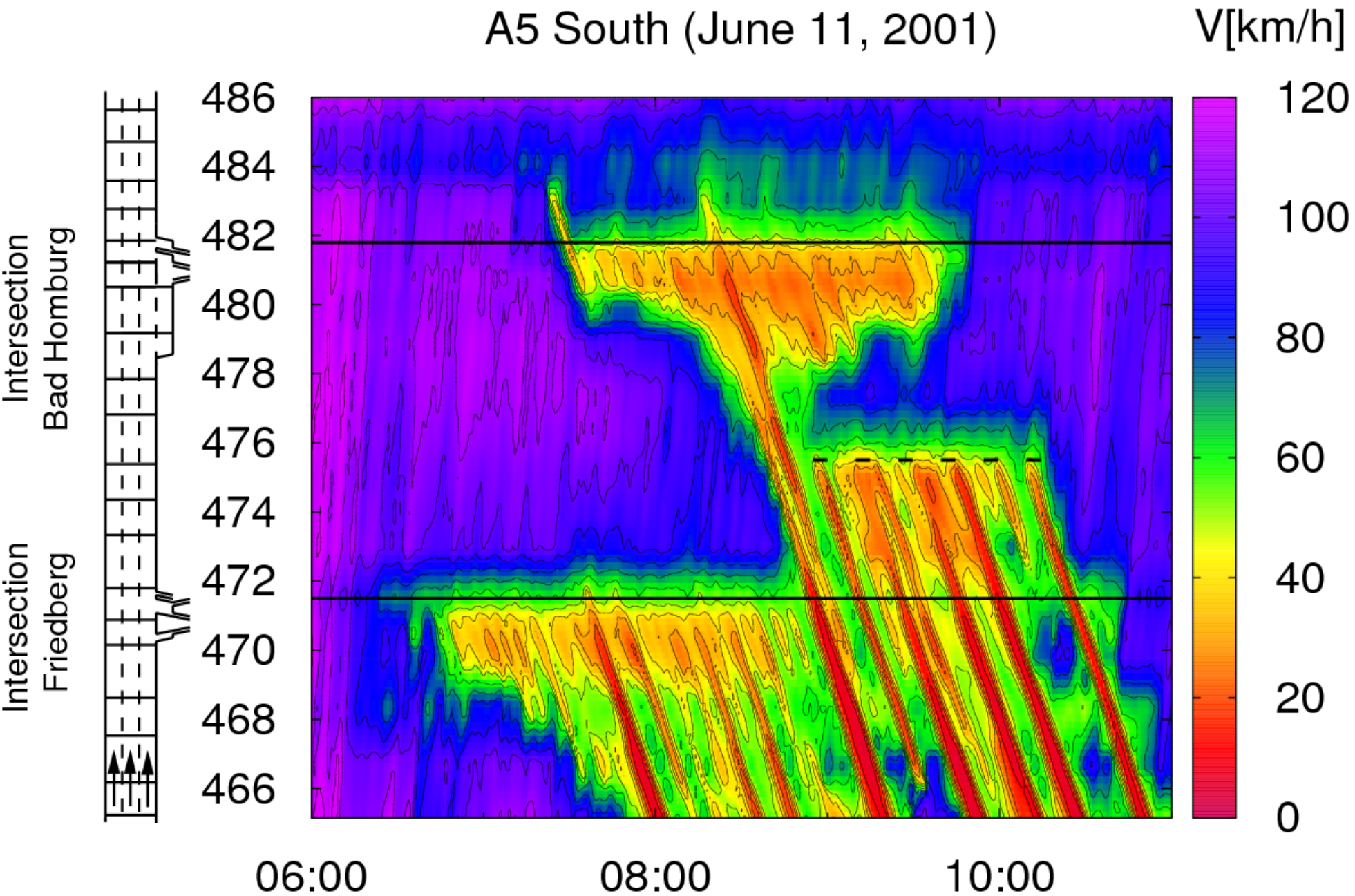
Accuracy measures review

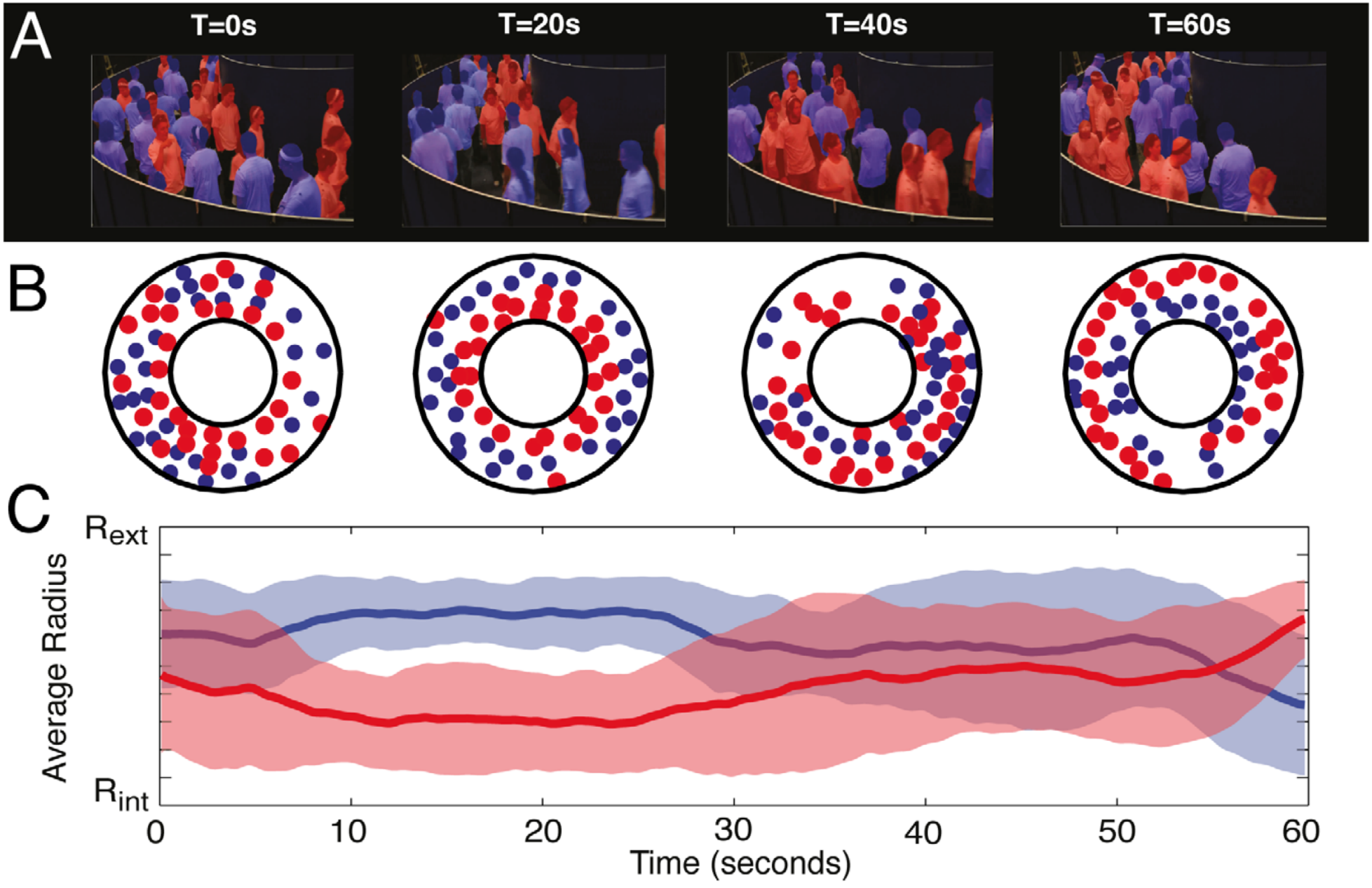
- Goodness of Fit of speed, spacing, density, flow
  - (Root Mean) Squared (Normalized) Error, Mean (Absolute) (Normalized) Error,
  - GEH statistic
  - Correlation Coefficient
  - Theil's Bias/Variance/Covariance Proportion, Theil's Inequality Coefficient
- Likelihood
- Total flux, time spent, evacuation time

Usually do not take into account specific features

Shock waves

source: www.traffic-states.com

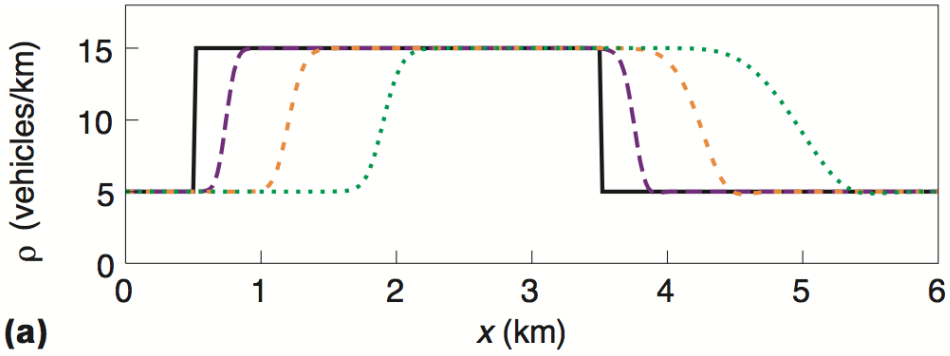


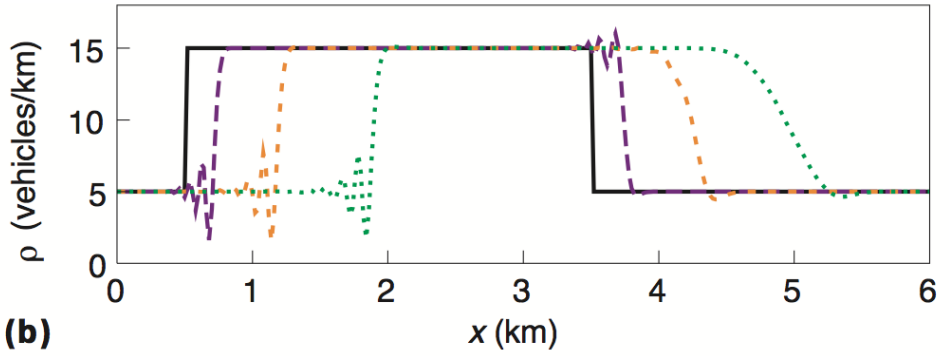


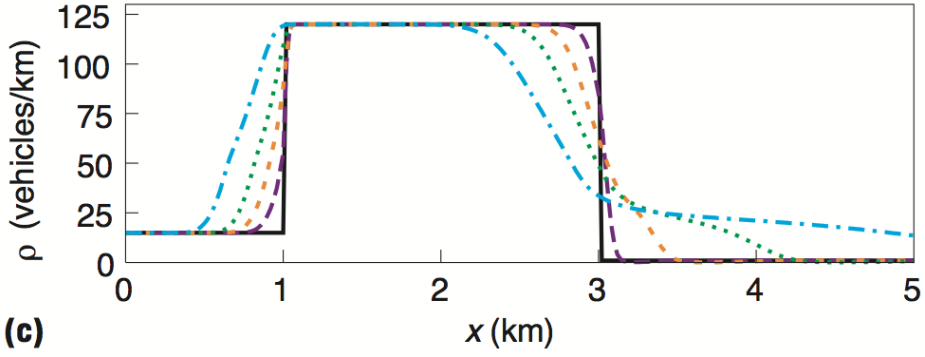
Lane formation

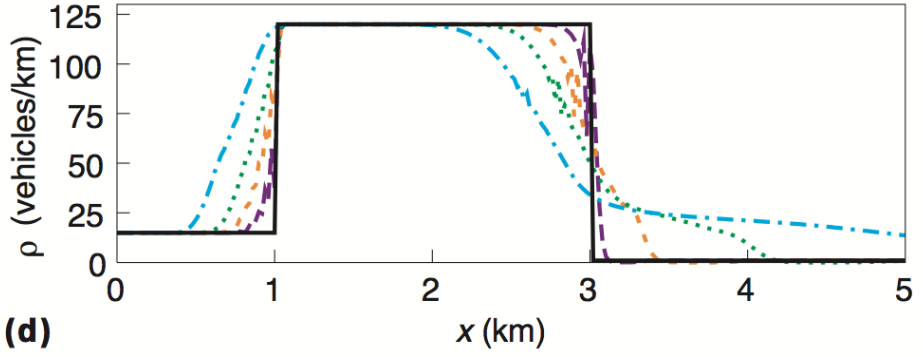
source: Moussaïd (2012)

Turbulence









Numerical simulations

source: Helbing & Treiber (1999)

Contribution: new accuracy measures

- Allow focus on certain feature of flow instead of averaging
- Gives insight into type of error
- $\Rightarrow$ Insight into how to improve accuracy

Outline

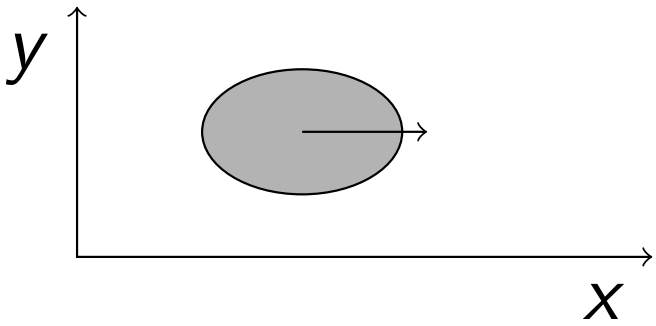
Introduction

New accuracy measures

Test cases
- Traffic congestion simulation
- Bi-directional pedestrian flow modelling

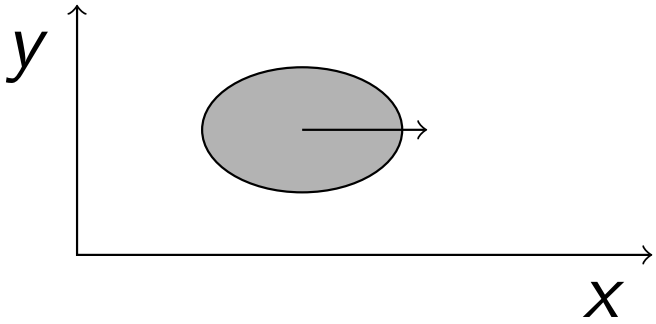
Conclusion & outlook

New accuracy measures



Exact

New accuracy measures



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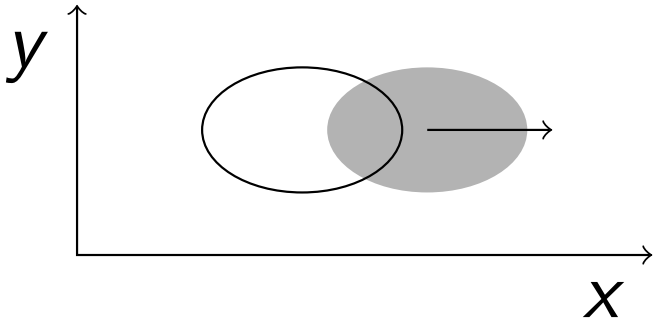
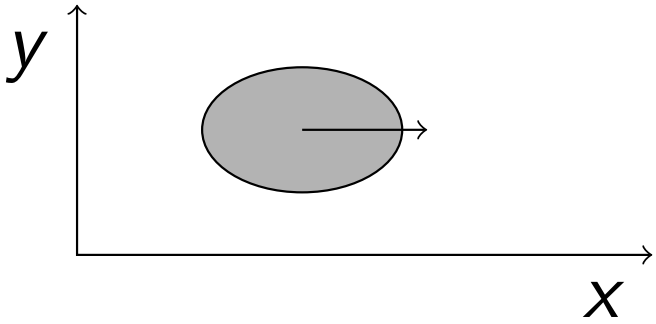


Phase error

Is location of high/low density/speed area correct?

New accuracy measures



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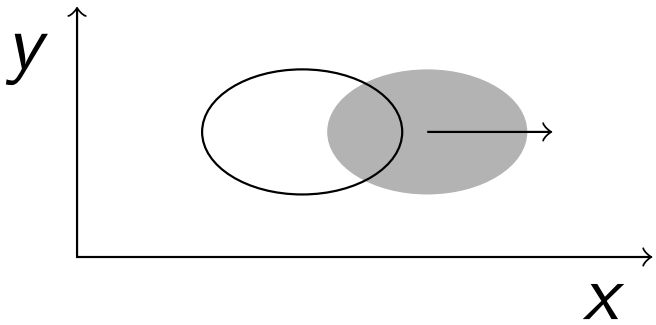

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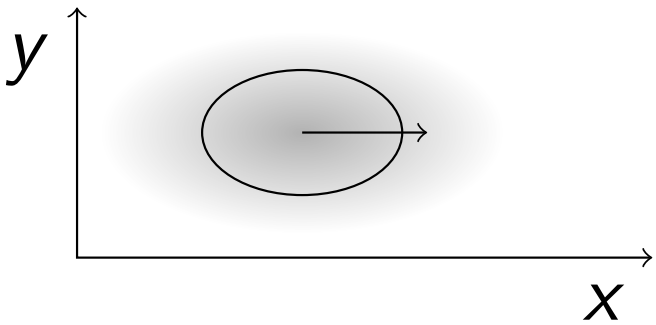


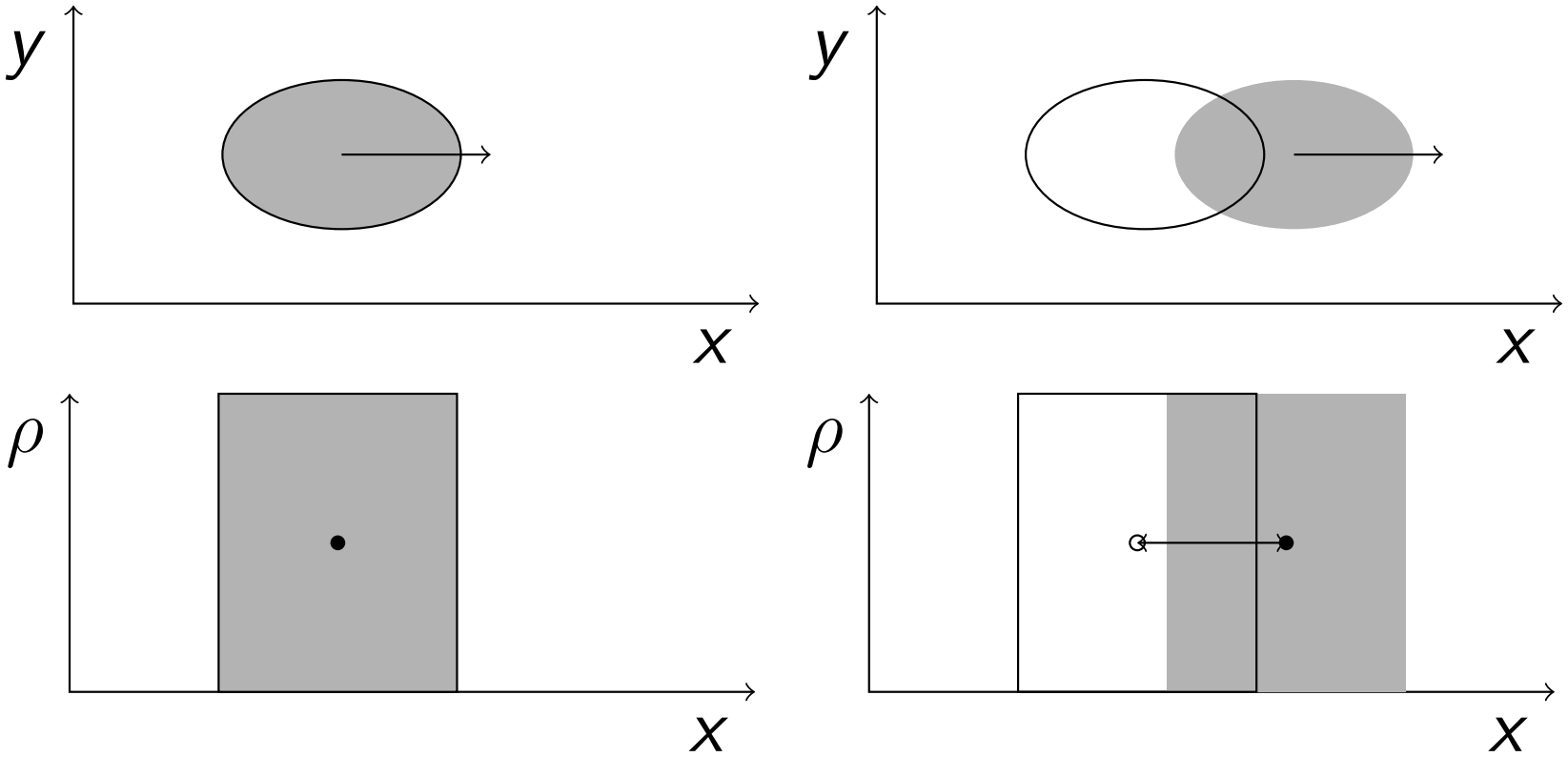
Diffusion error

Do sharp transitions between high/low density/velocity areas stay sharp?

From concept to quantification

Centre of mass for phase error

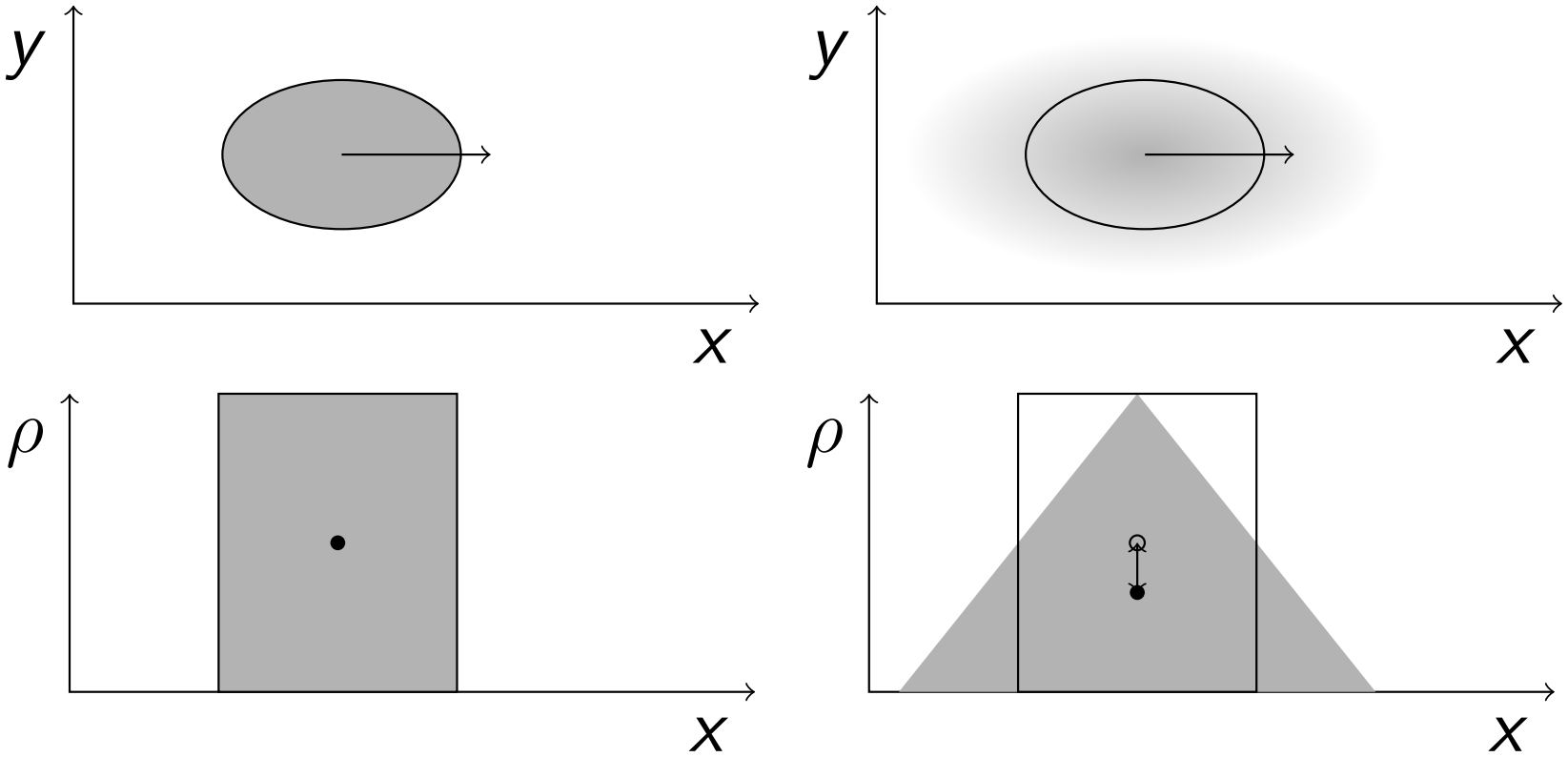
- In x- and y-direction
- Large difference $\Rightarrow$ large phase error



From concept to quantification

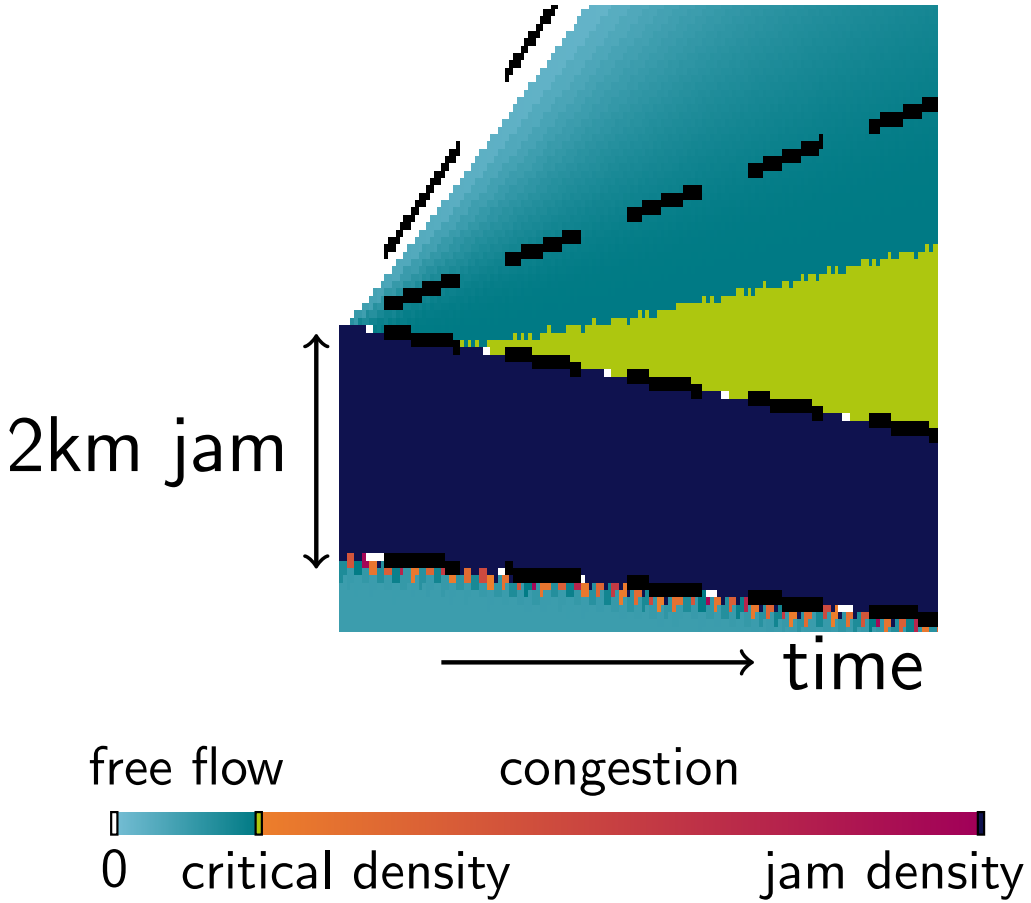
Centre of mass for diffusion error

- In density- (or speed-) direction
- Large difference ⇒ large diffusion error



Test case 1: Traffic congestion simulation

Exact solution of LWR model ⇔ simulation results



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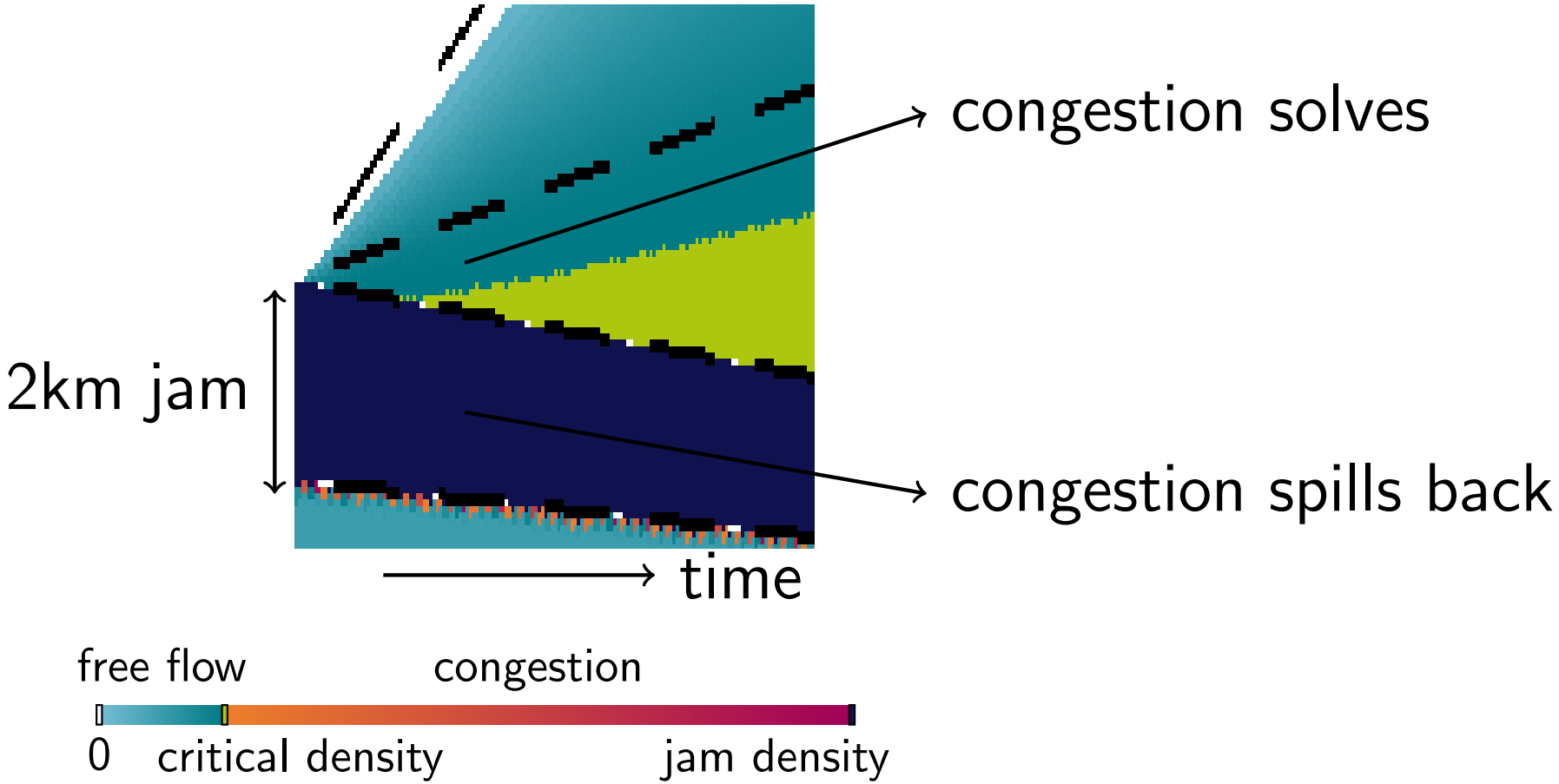
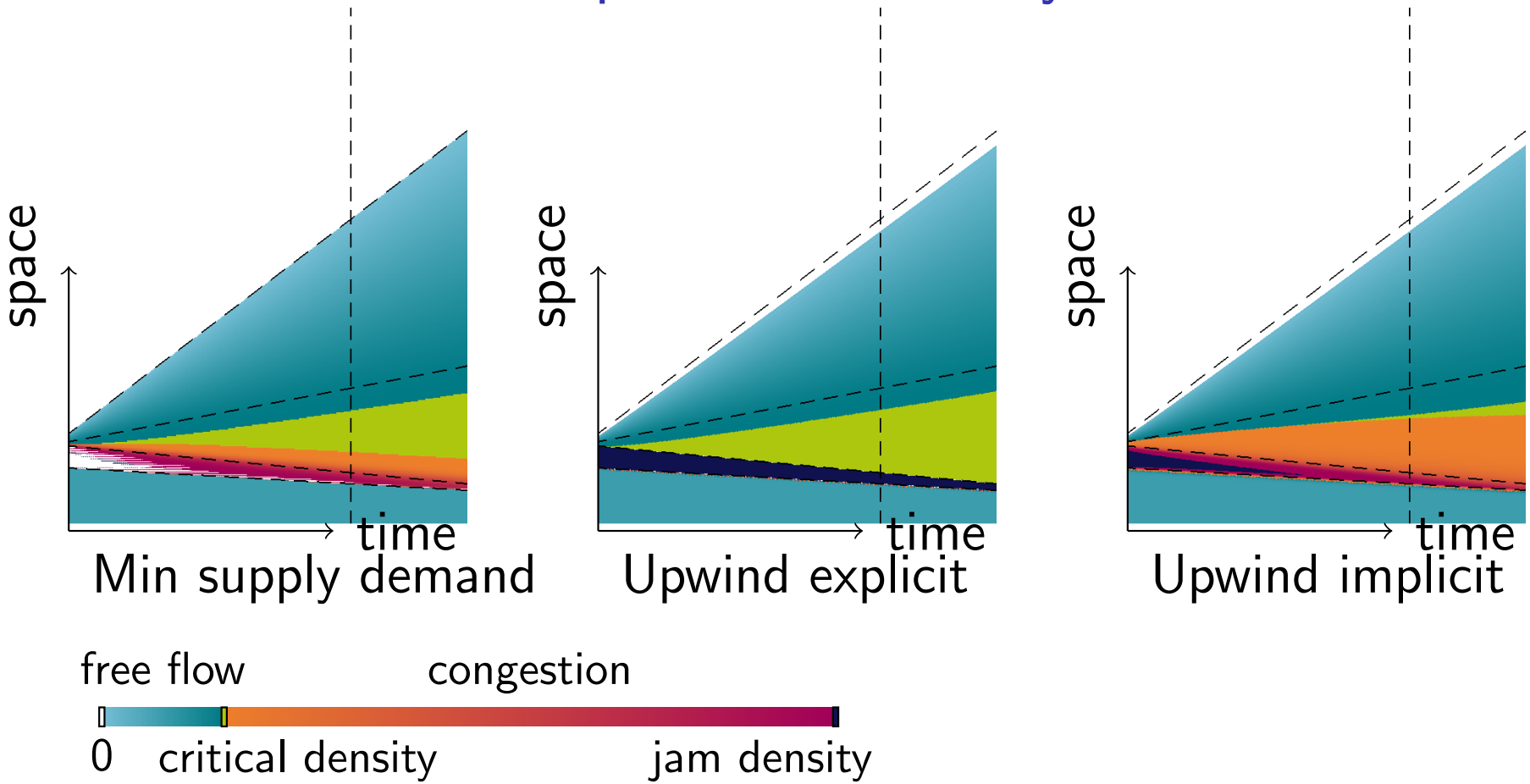
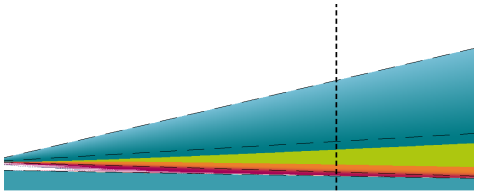


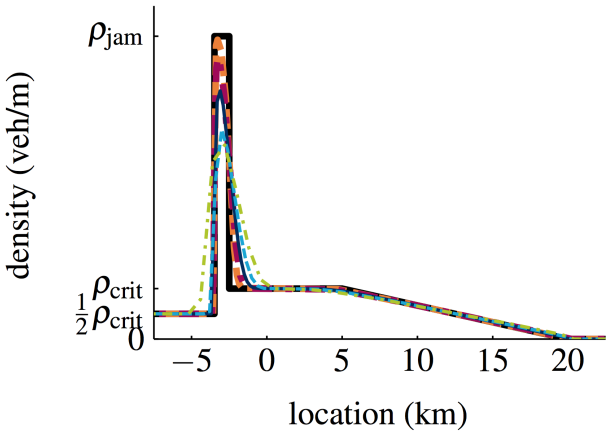
Solve with different numerical methods

Numerical solutions: space time density

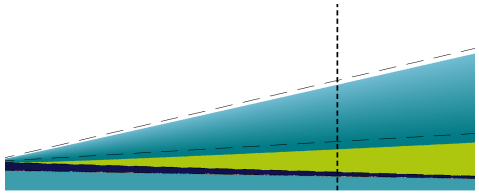


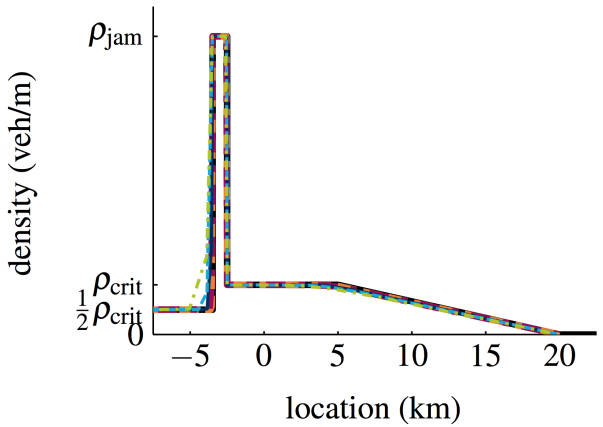
Numerical solutions: density cross section $t = 600$ s



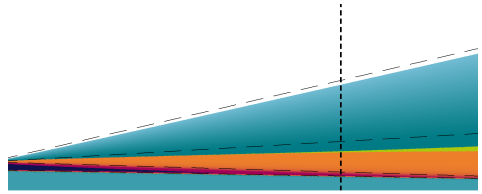


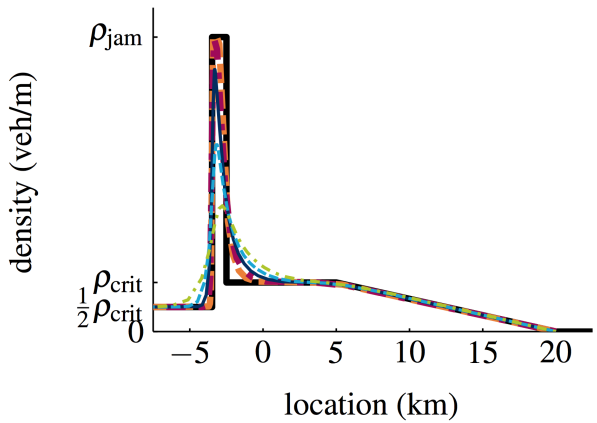
Min supply demand





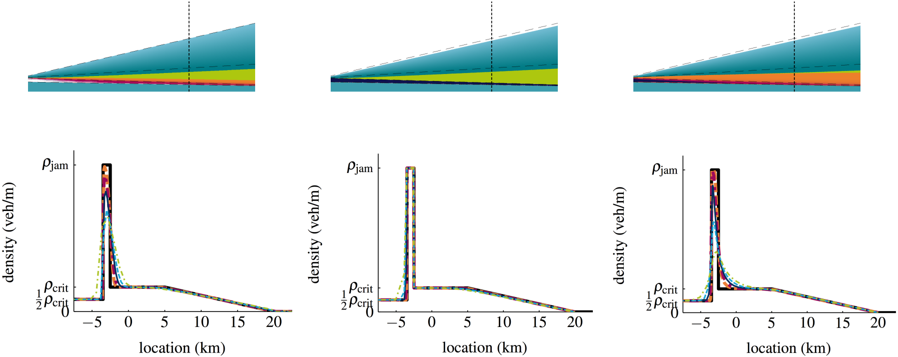
Upwind explicit





Upwind implicit

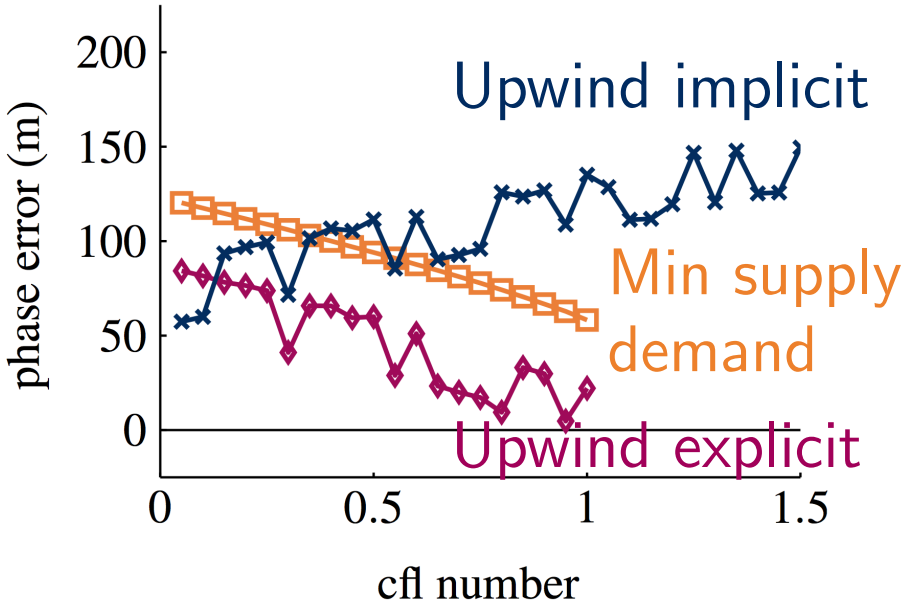
Numerical solutions: density cross section $t = 600$ s



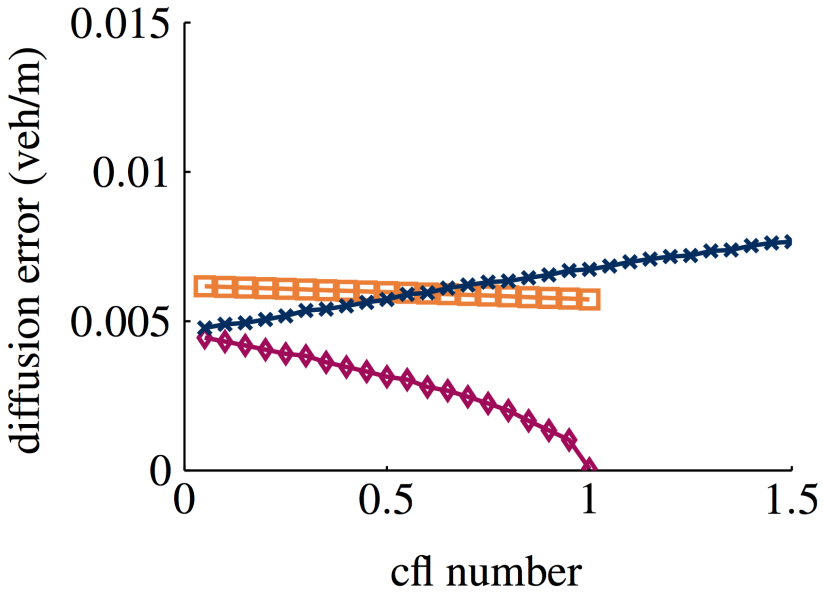
Min supply demand | Upwind explicit | Upwind implicit

Centre of mass ⇒ phase & diffusion error

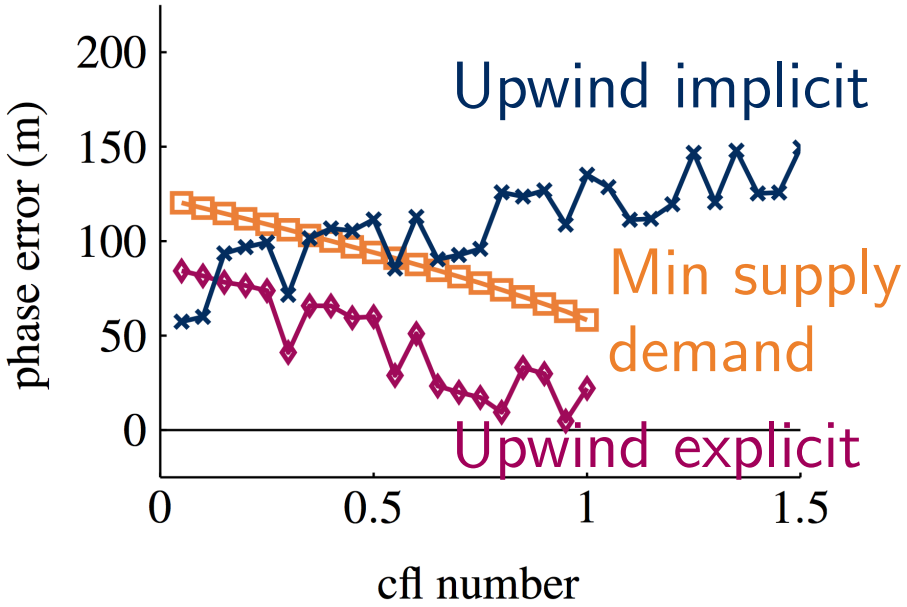
Phase error



Diffusion error



Phase error



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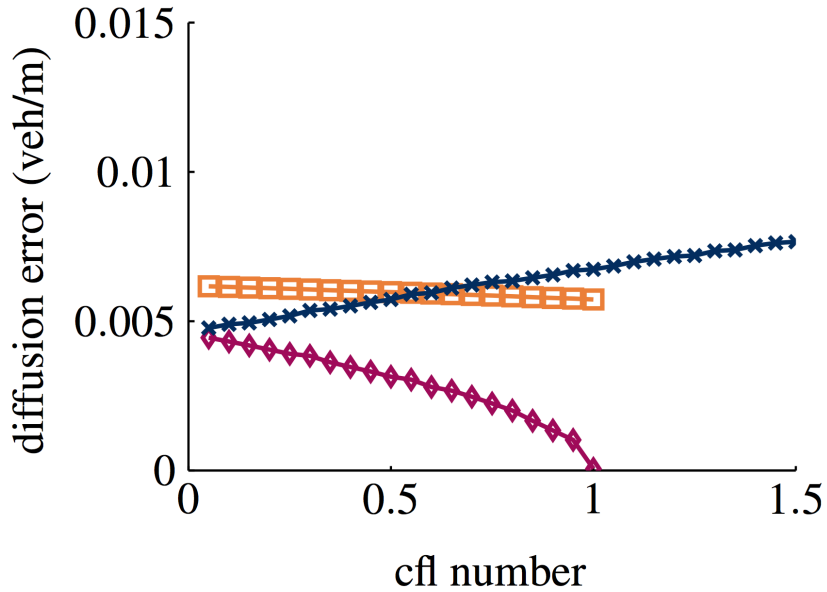


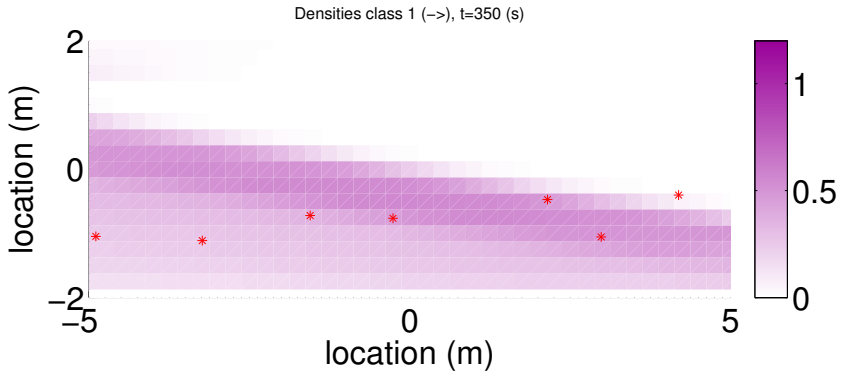
Results help selecting appropriate numerical method

- Small time steps: upwind is best
- Big time steps: use implicit, but at cost of phase error

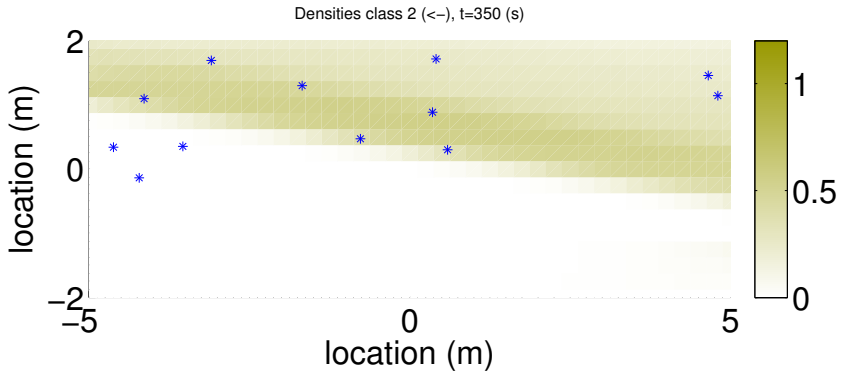
Test case 2: Bi-directional pedestrian flow modelling

Experimental data ⇔ model

class 1 →



class 2 ←



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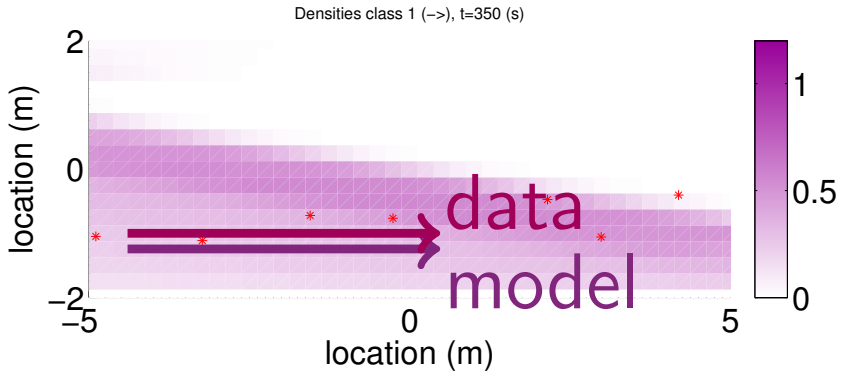

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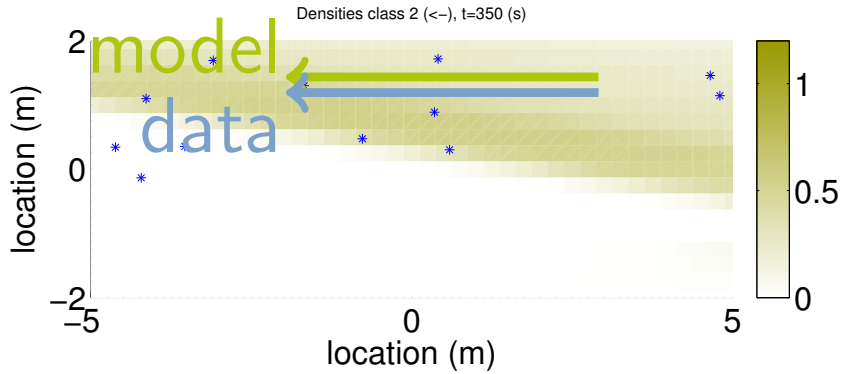

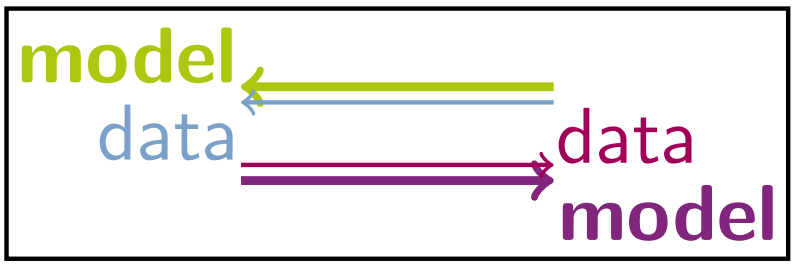

Continuum flow model

2 parameters for avoidance

$\beta_u = 0.8$, $\beta_o = 2.3$ (set 1)

Test case 2: Bi-directional pedestrian flow modelling

Experimental data ⇔ model

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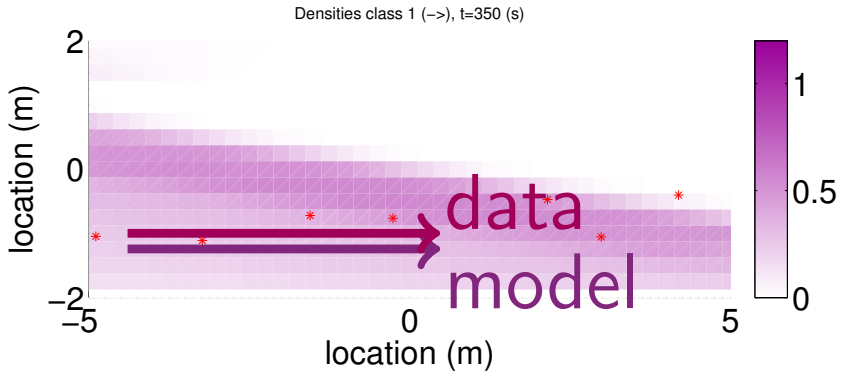

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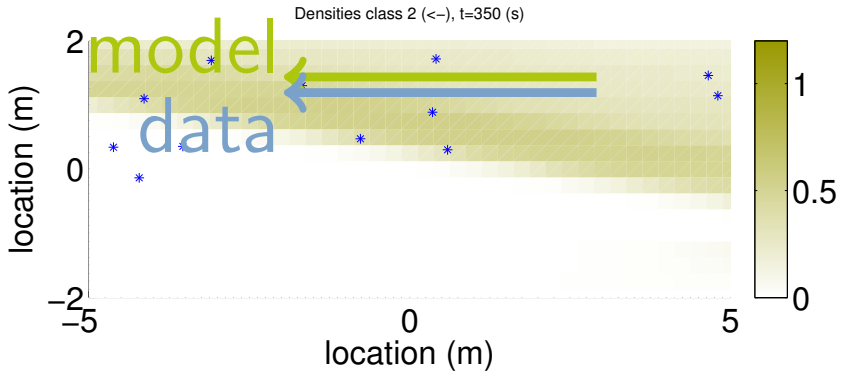

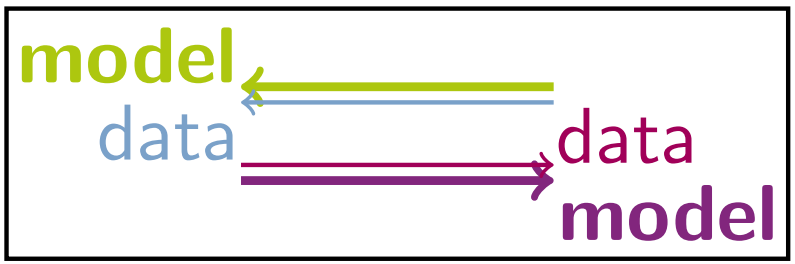

Continuum flow model

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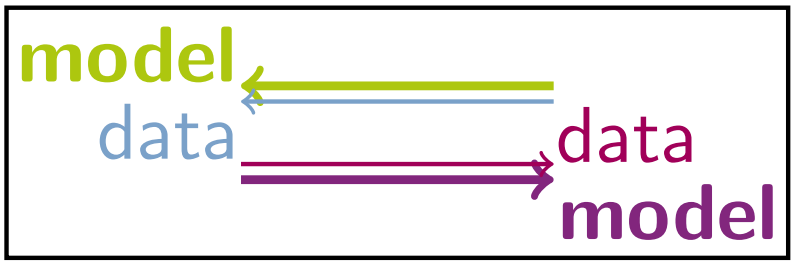
Test with other parameter settings

Experimental data $\Leftrightarrow$ model with different parameter settings



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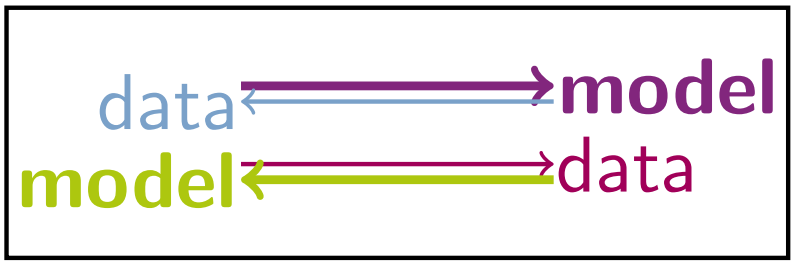
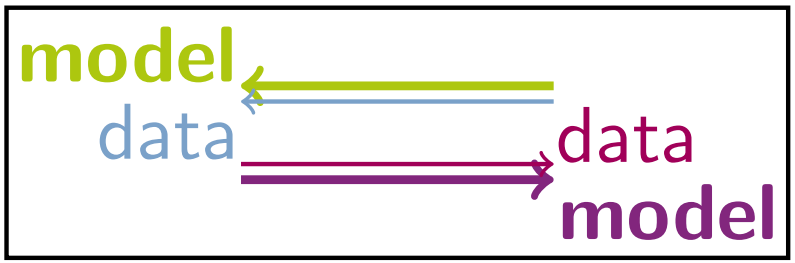
almost perfect



$\beta_u = 0.7$, $\beta_o = 1.36$ (set 2)
lanes swapped

$\beta_u = 0.63$, $\beta_o = 0.63$ (set 3)
no lanes

Experimental data $\Leftrightarrow$ model with different parameter settings



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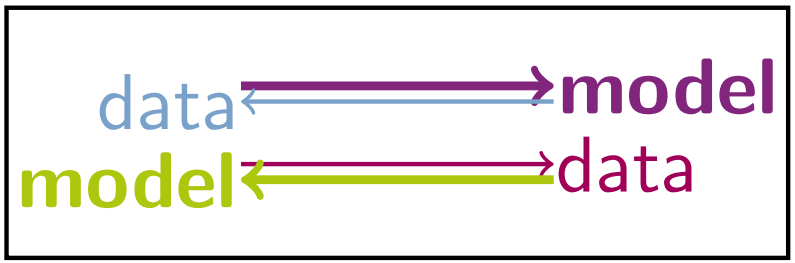

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Parameters are calibrated for total flux

Results

No difference for parameter settings according to:

- MAE & RMSE of class specific speed
- Diffusion error
- Total flux

Results

No difference for parameter settings according to:

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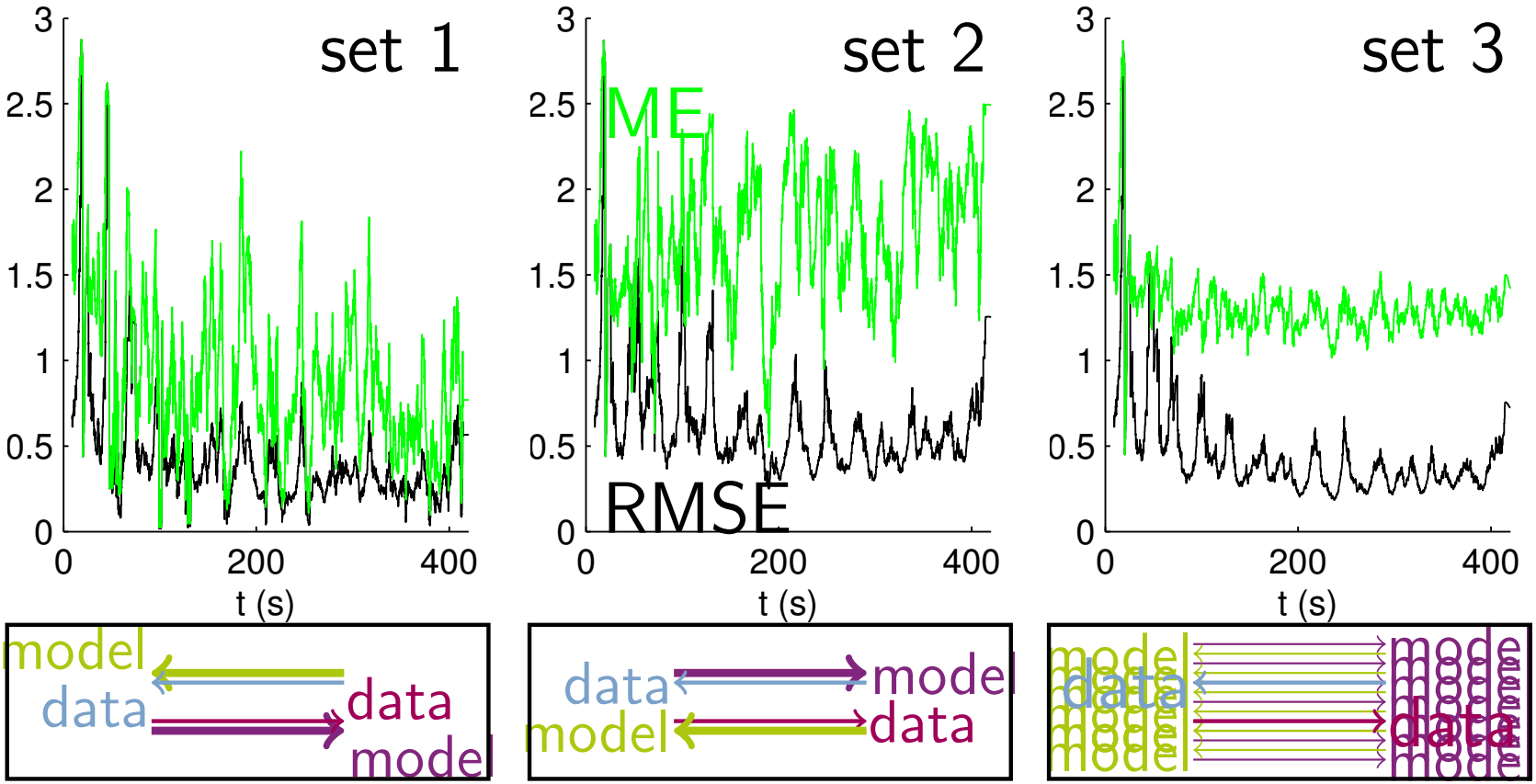
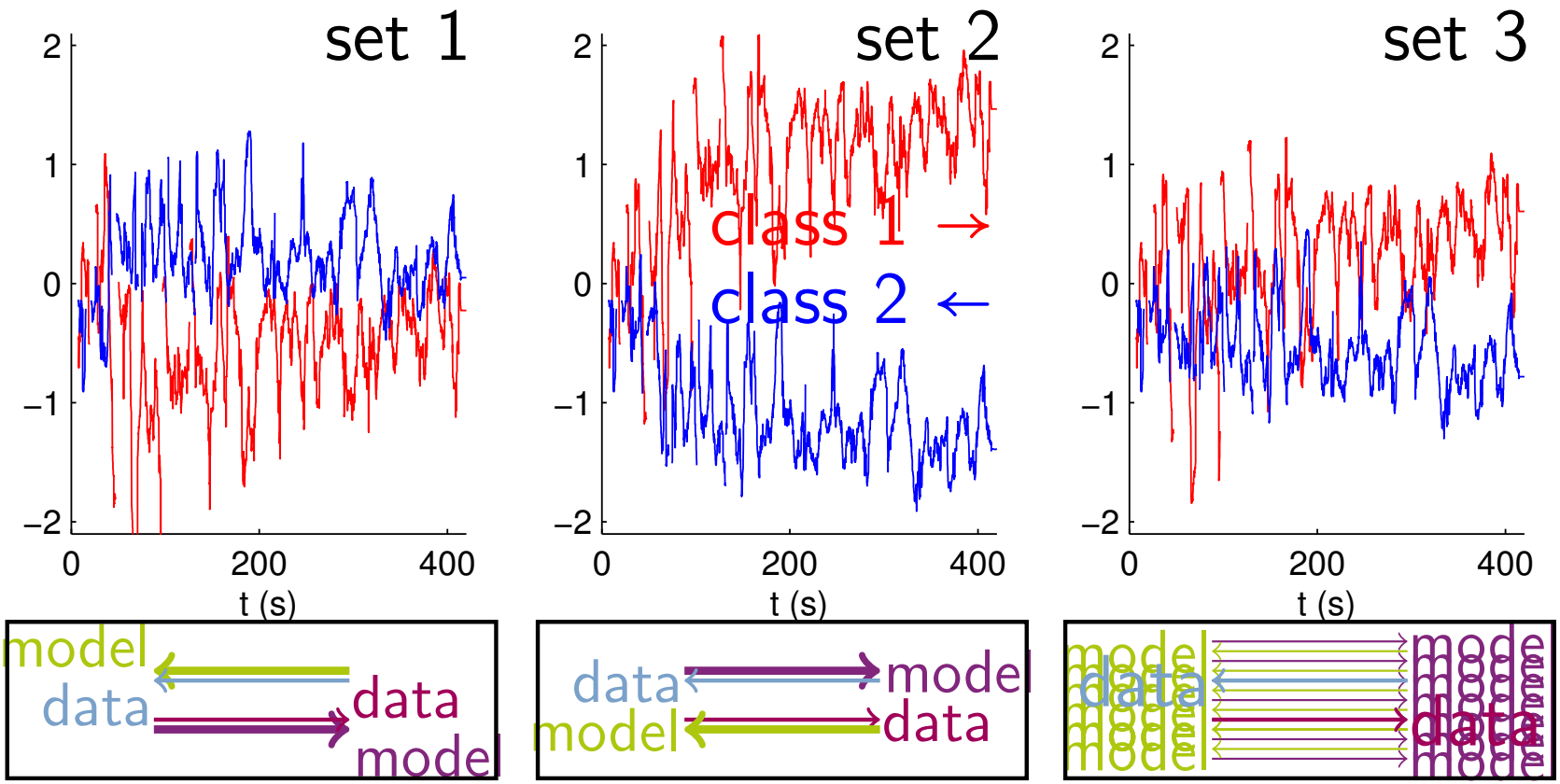
But: ME & RMSE of v_x and phase error show set 1 is best

Results ME & RMSE of v_x



- Set 1 best

Results Phase error y-direction



- Set 1 best
- Large phase error for set 2

Conclusion & outlook

- Phase error and diffusion error
- Applications
  - Road traffic & pedestrian flow. Future: NFD?
  - Comparing data vs model, model vs simulation, ...
  - Parameter estimation or assessment of model/simulation method
- Distinguish between different outcomes → interpretation needed:
- Phase error sometimes ok, sometimes not
- Insight into possible improvements

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- Phase error sometimes ok, sometimes not
- Insight into possible improvements
- Future research:
  - Larger networks with many features?
  - Include time

Thanks!

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