



UDRIVE

European Naturalistic
Driving Study

Preliminary results

Content: preliminary results

- Personal driving style I
 - Headway
- Driving conditions
 - congestion/other road-users
 - road infrastructure
- Personal driving style II
 - Speed choice, braking, gear shifting

Goal:

- give an idea of the content of the data
- illustrate work-flow of the analysis
- preliminary, so no final conclusions yet

Personal driving style

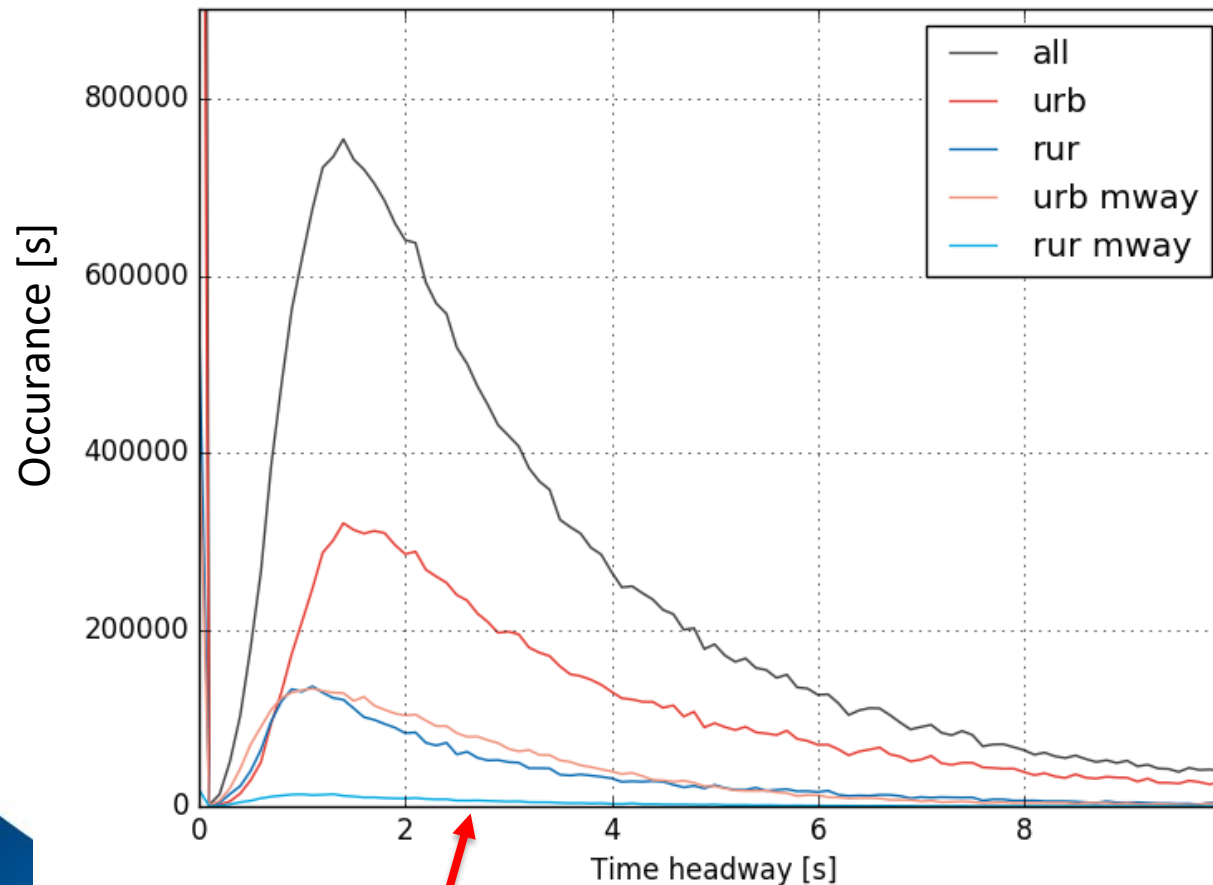
- Velocity, acceleration per driver, and resulting braking
- Headway at different velocities
- Average velocity at various speed limits
- Engine speed (gear shifting behaviour)

- All analysed for the various driving conditions
 - Free-flow or average flow
 - Different road types
 - Road infrastructure (curve, intersection)

Personal style remains when all external causes are excluded

Personal driving style: headway

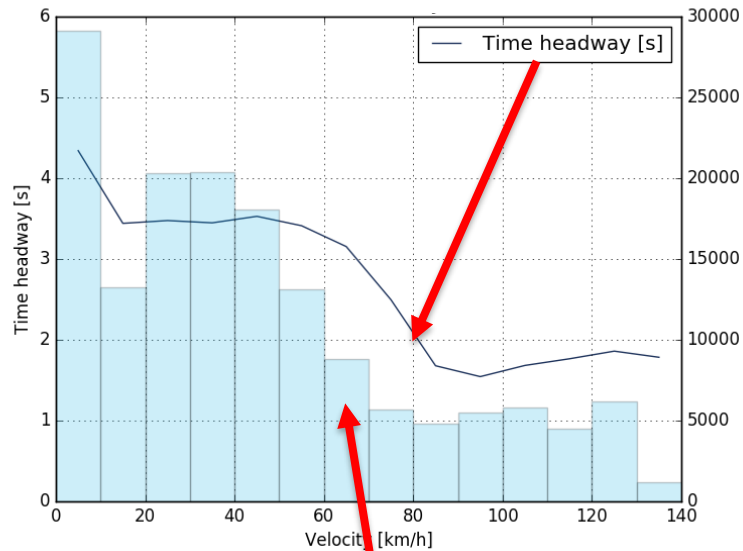
- Time headway lies mostly below 2 seconds



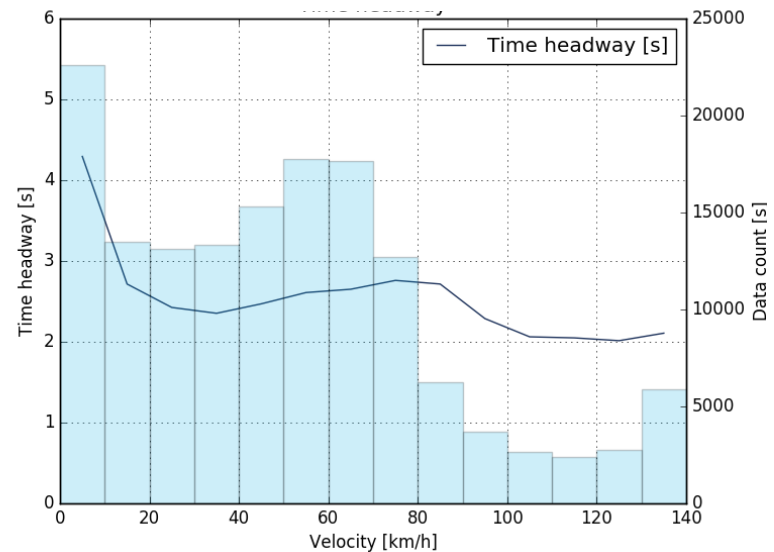
Longer average headway at rural motorway

Personal driving style: headway

- Every driver has a personal average headway



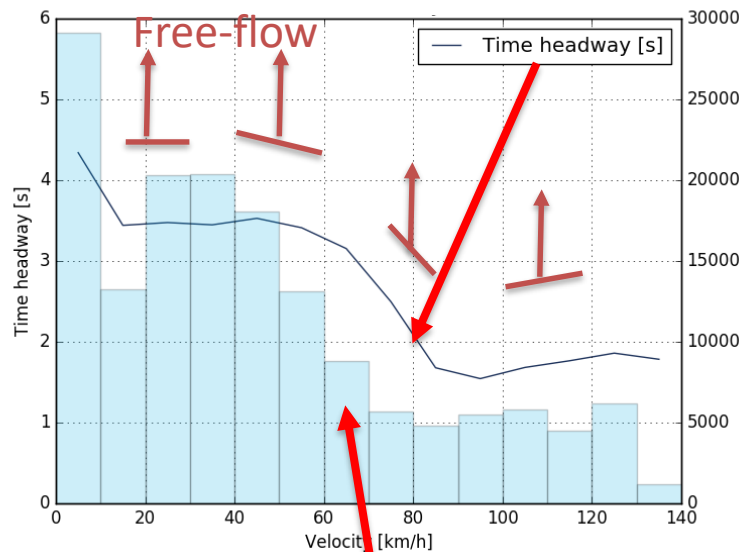
Time spent in this velocity bin



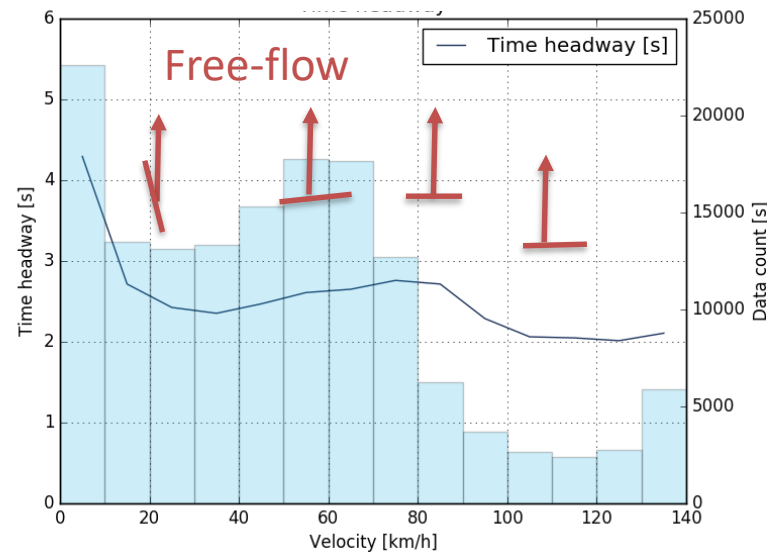
Personal driving style: headway

- Every driver has a personal average headway
- Define free-flow for each driver as:

$$\text{headway}_{\text{velocity bin}} > \text{avg headway}_{\text{velocity bin}} + 1 \text{ second}$$



Time spent in this velocity bin



Personal driving style

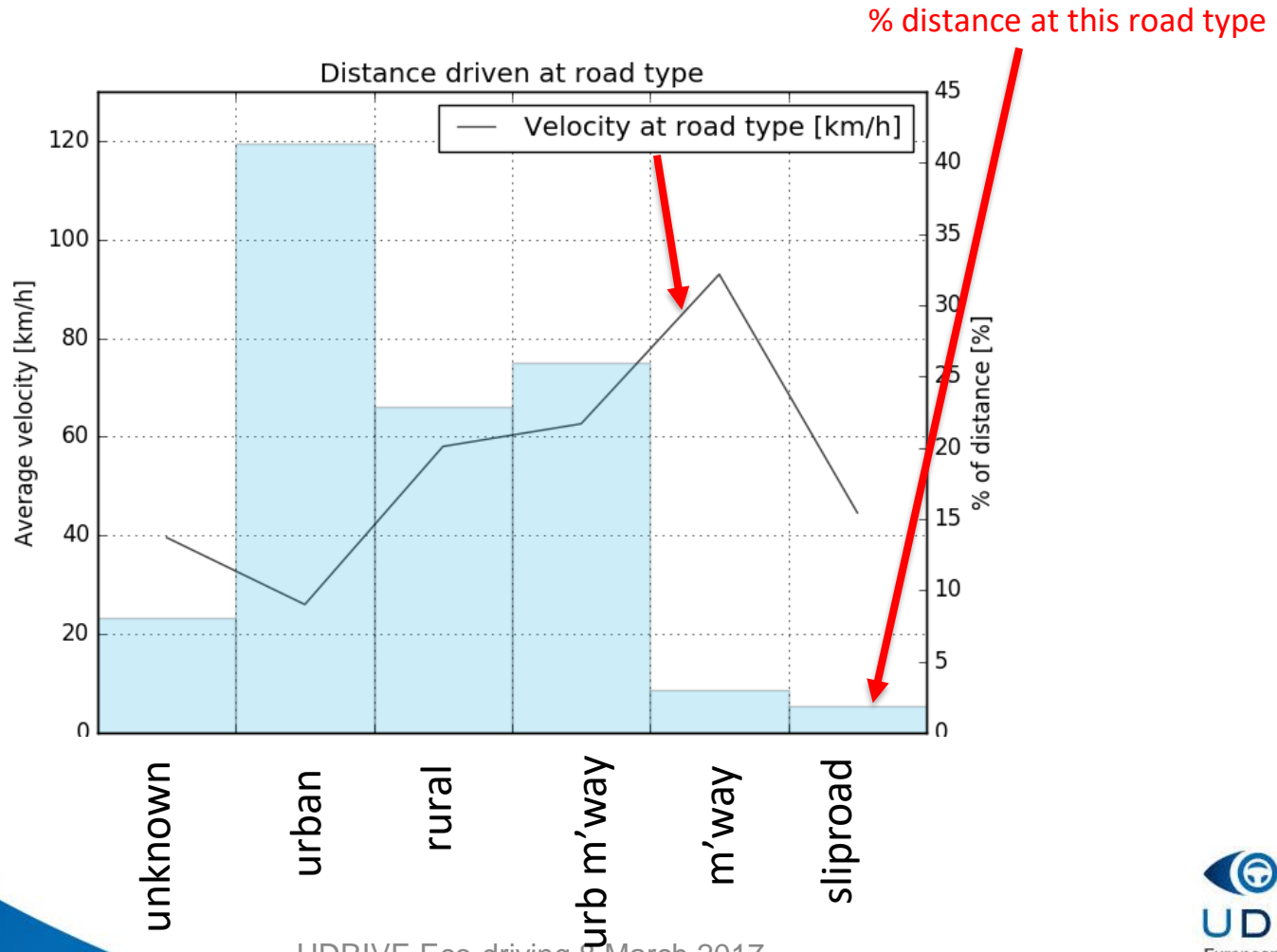
- Velocity, acceleration per driver, and resulting braking
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 - Different road types
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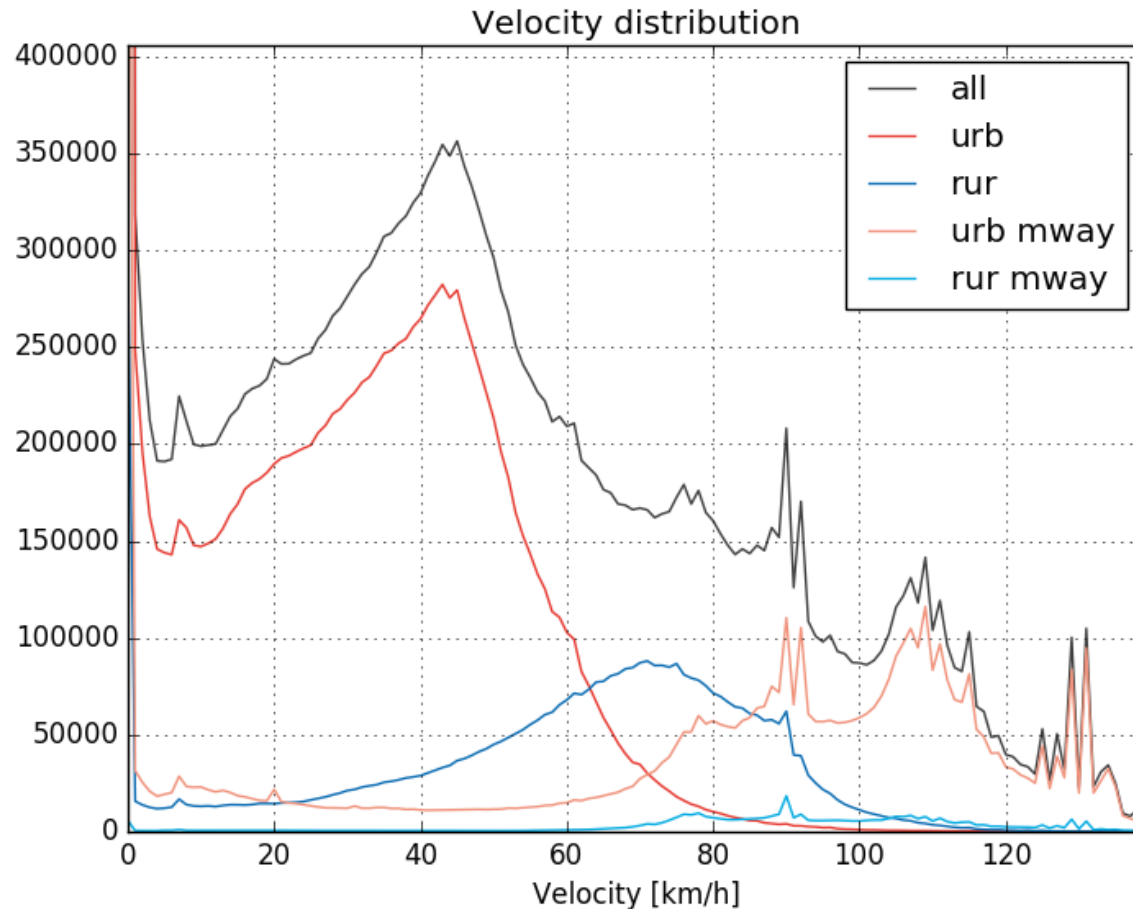
Personal style remains when all external causes are excluded

Driving conditions

- % kilometers made on different road types

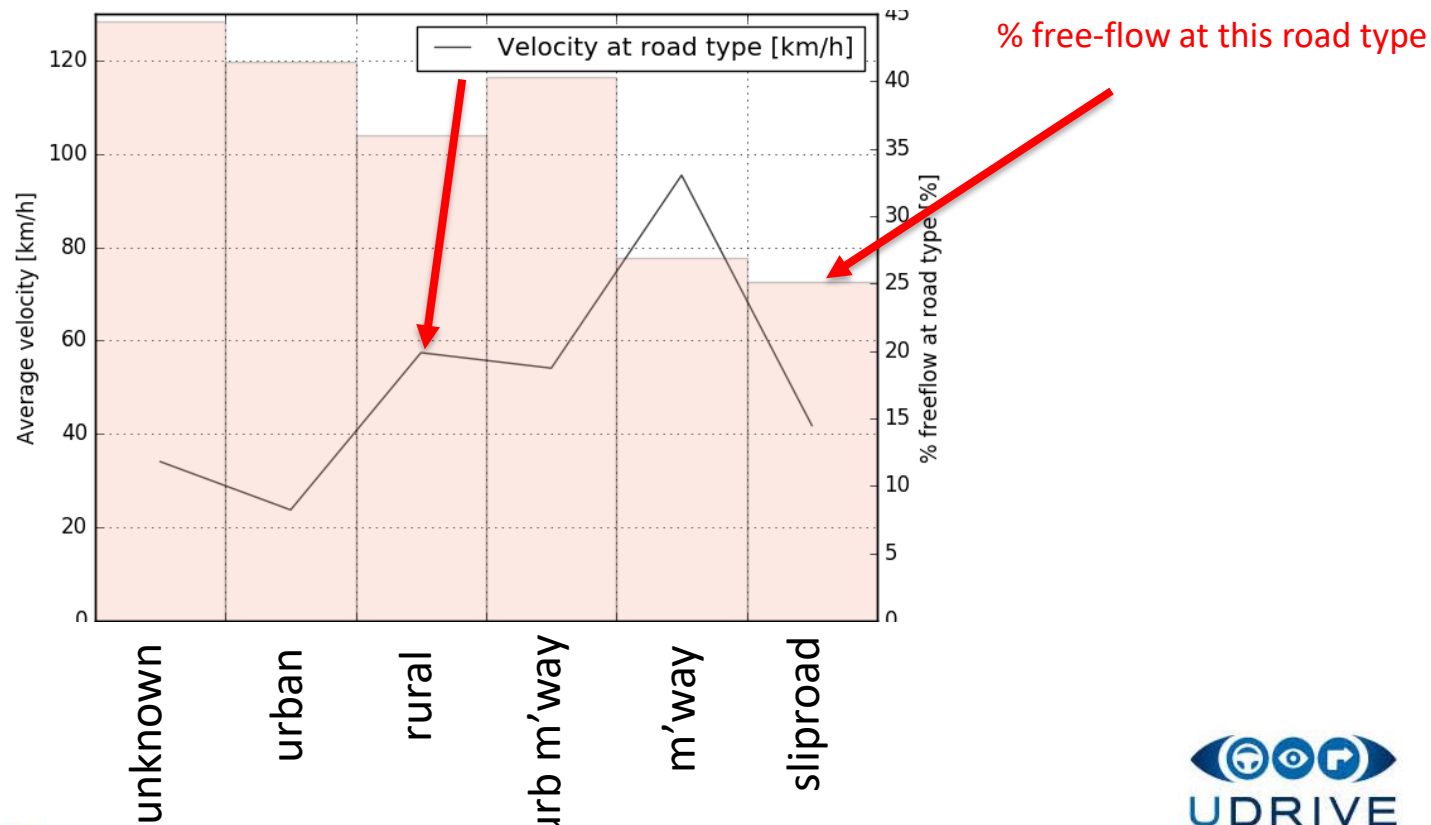


Driving conditions on different road types



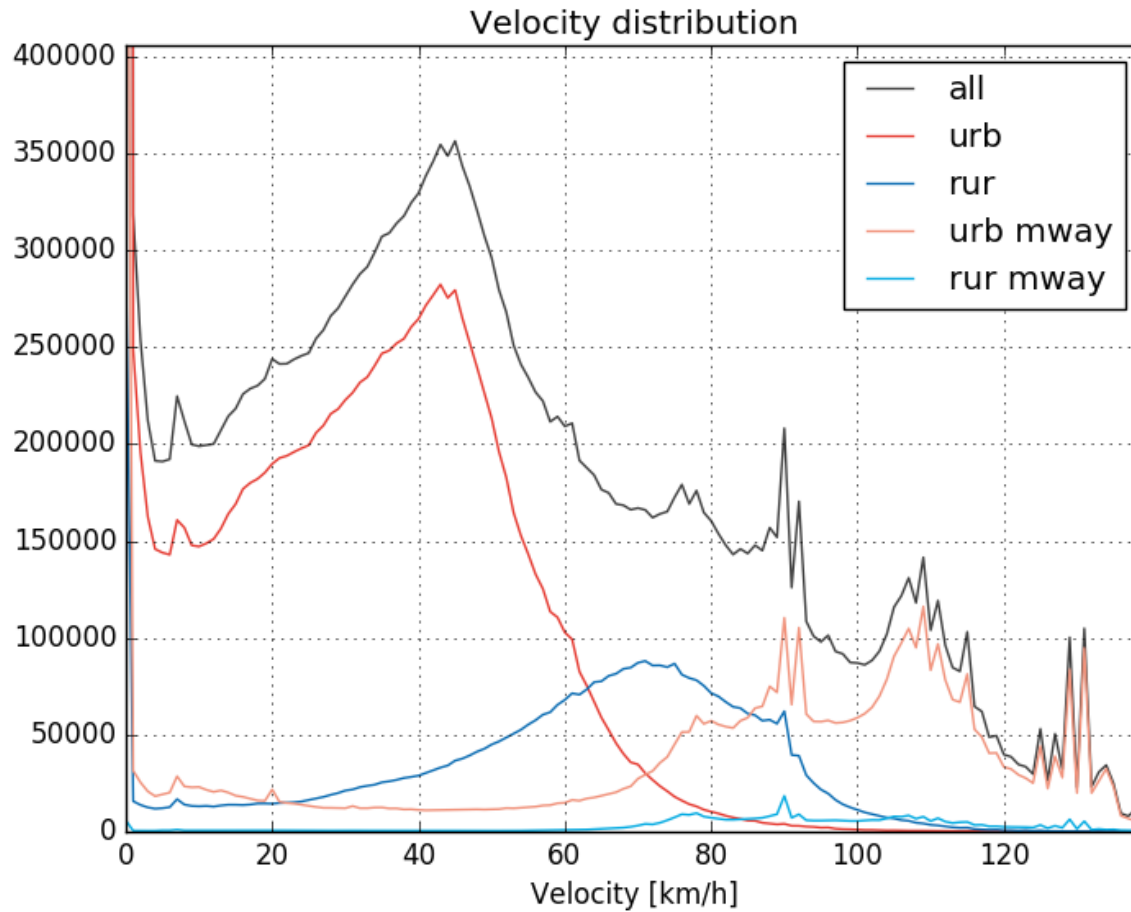
Driving conditions on different road types

- % time in average flow and in free-flow conditions
 - Free-flow: $\text{headway}_{\text{velocity bin}} > \text{avg headway}_{\text{velocity bin}} + 1 \text{ second}$
- Between 25-45 % freeflow

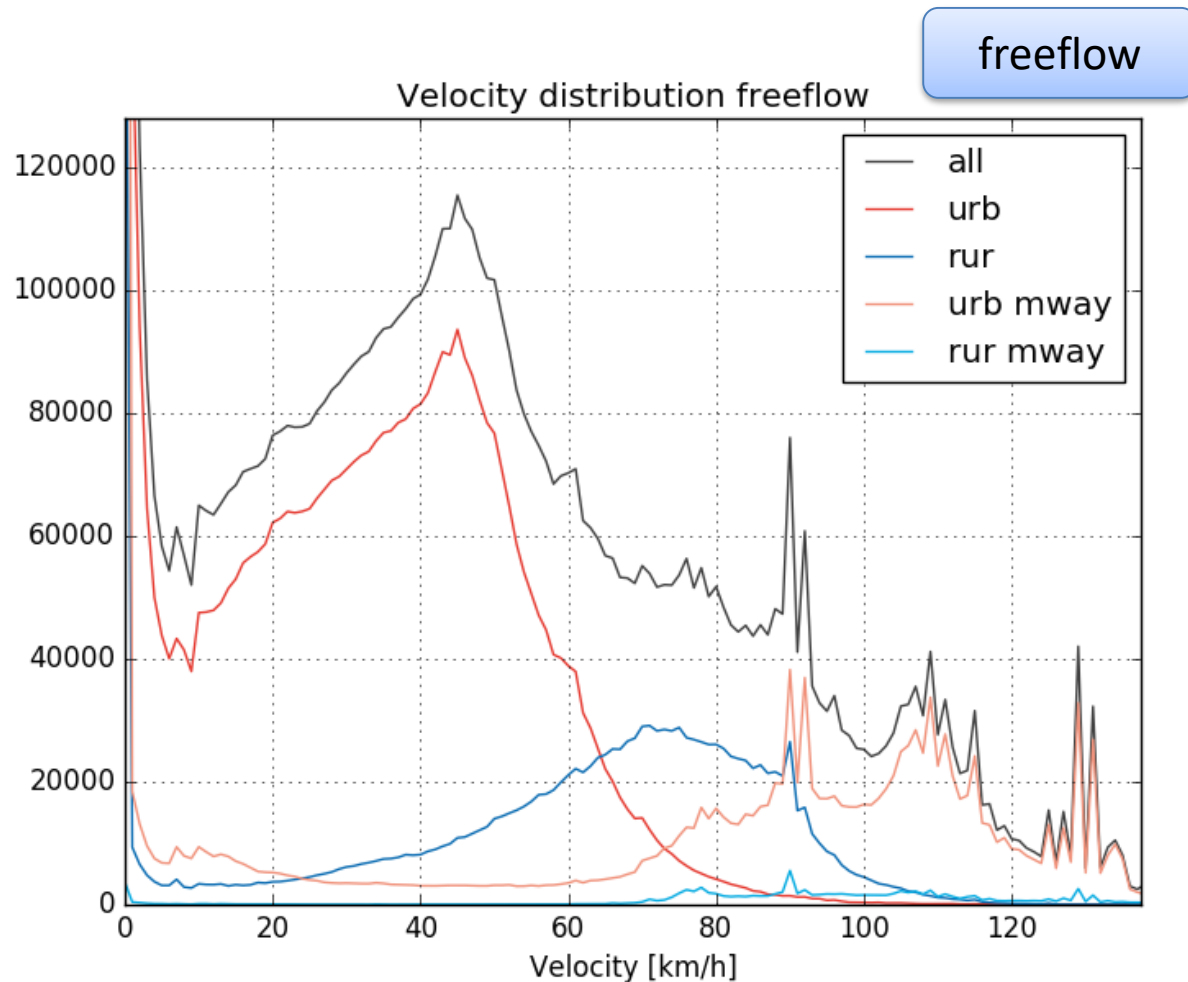


Driving conditions on different road types

Repeated slide



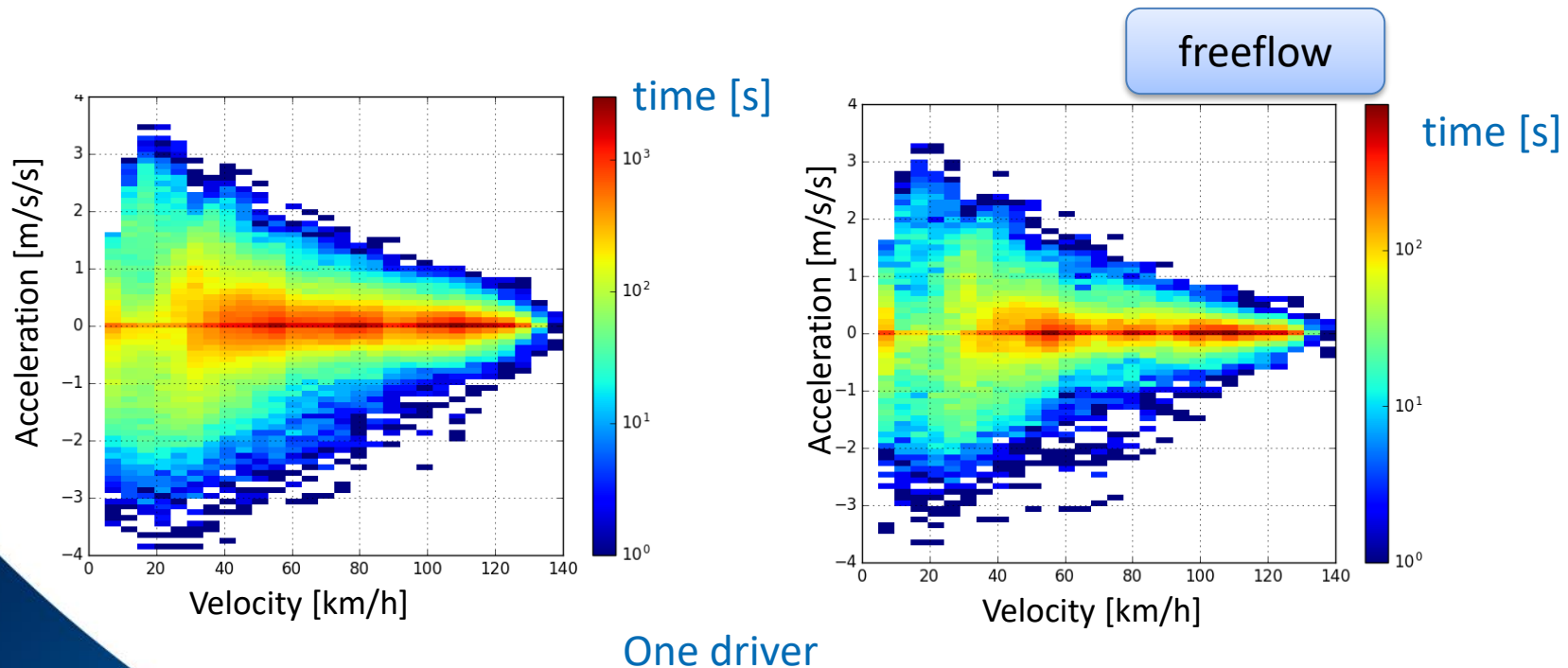
Driving conditions on different road types



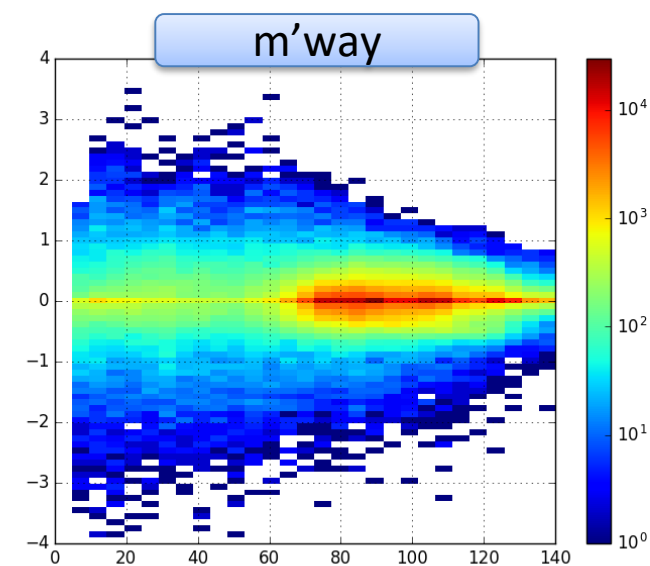
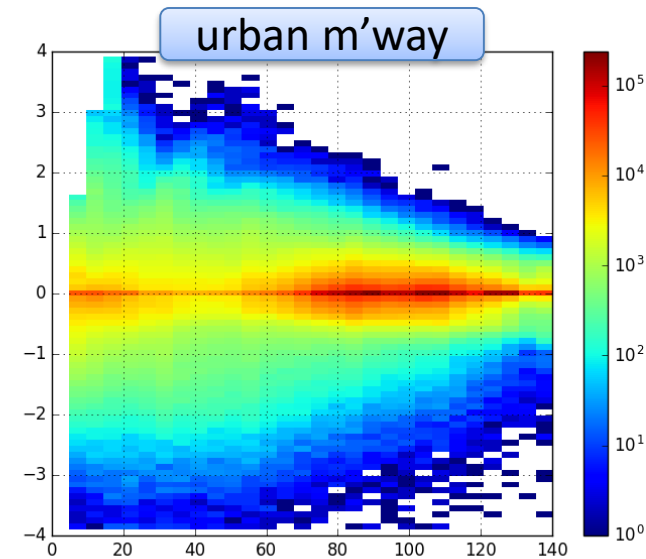
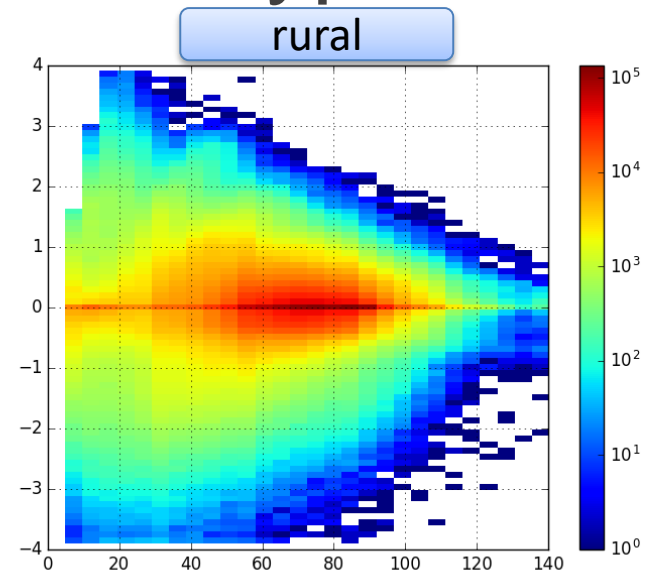
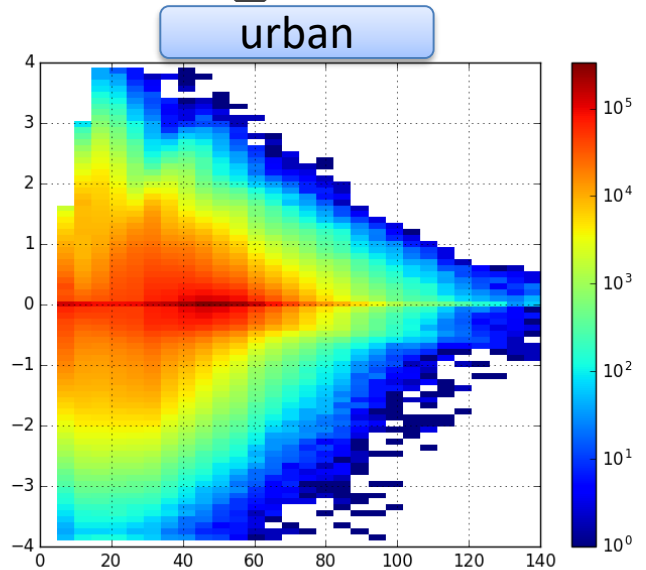
Personal driving style: velocity/acceleration

- v-a distribution per driver determines emissions

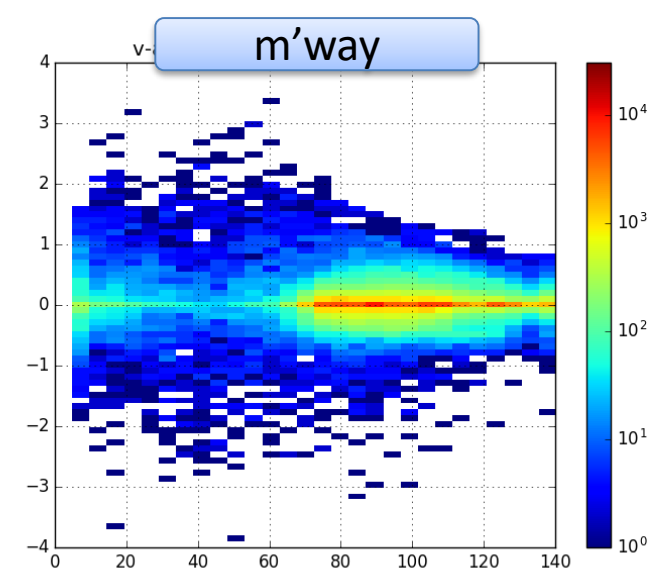
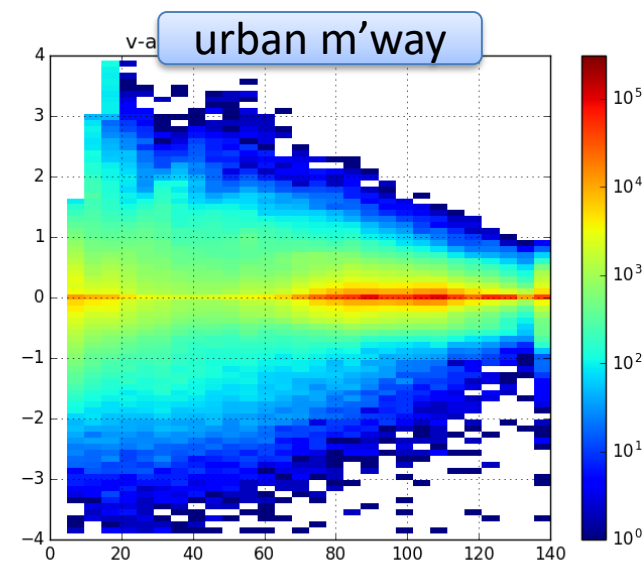
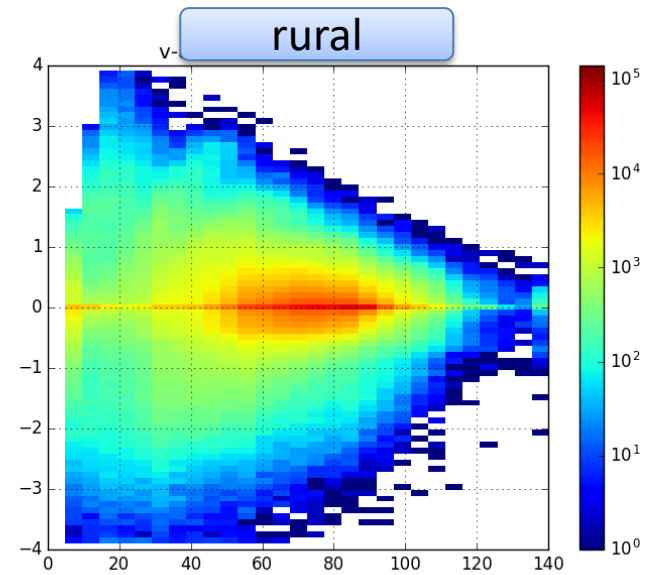
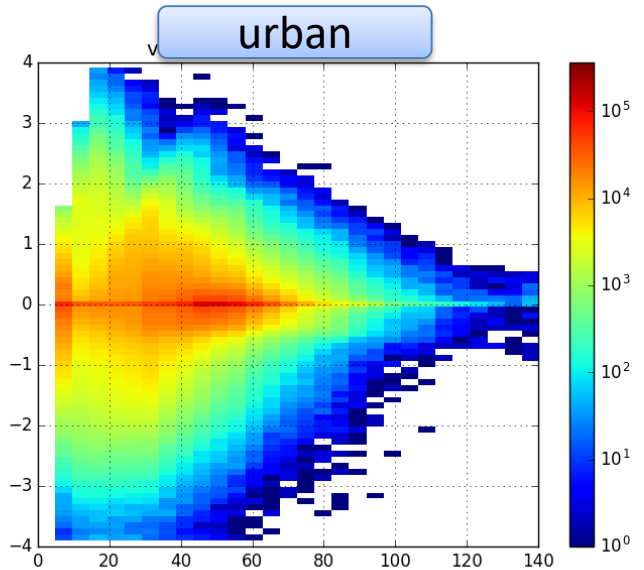
$$\text{CO}_2 \text{ [g]} = \text{time [s]} * \text{CO}_2 \text{ [g/s]}$$



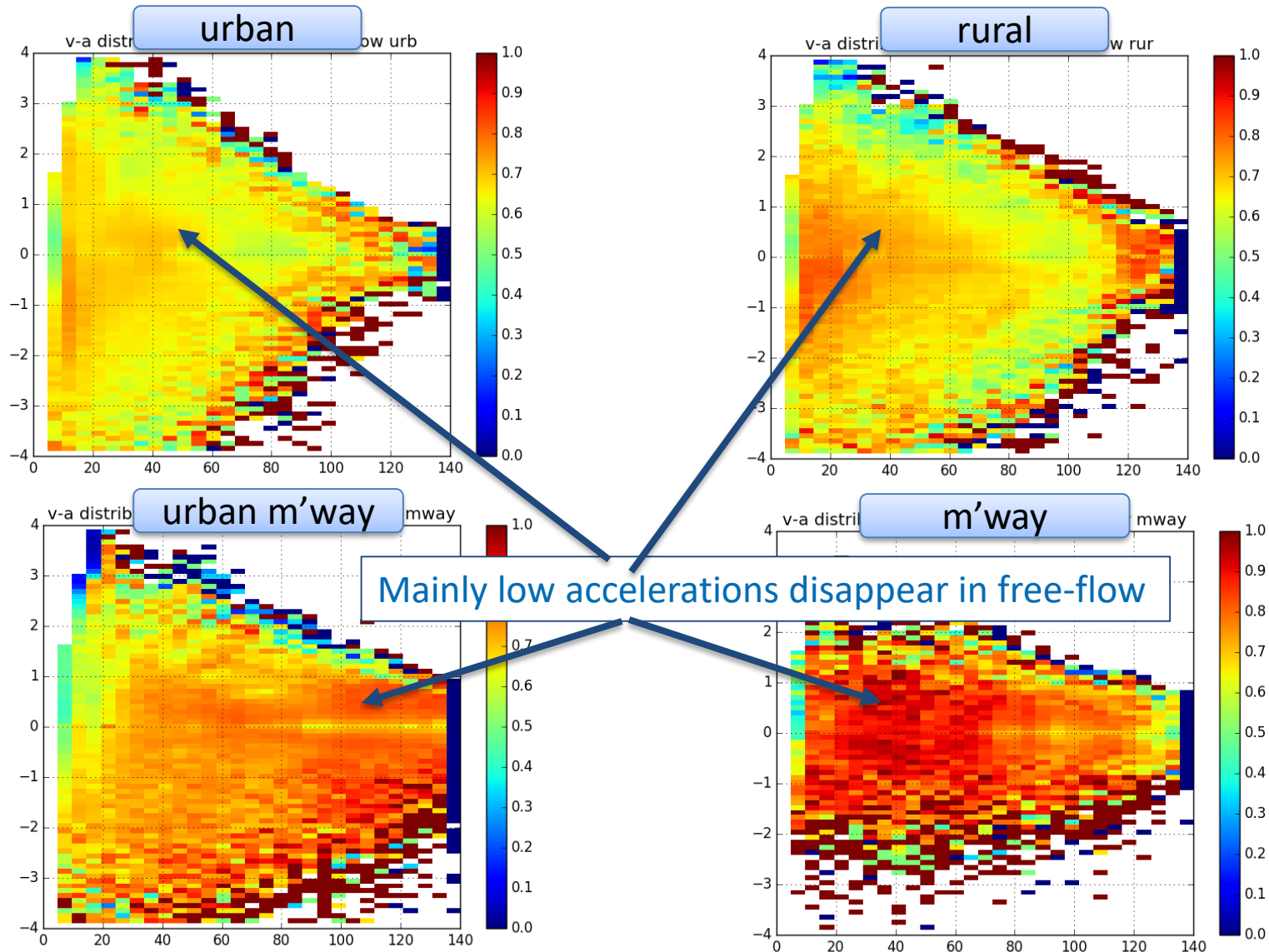
Driving conditions on road types



Driving conditions on road types: free-flow



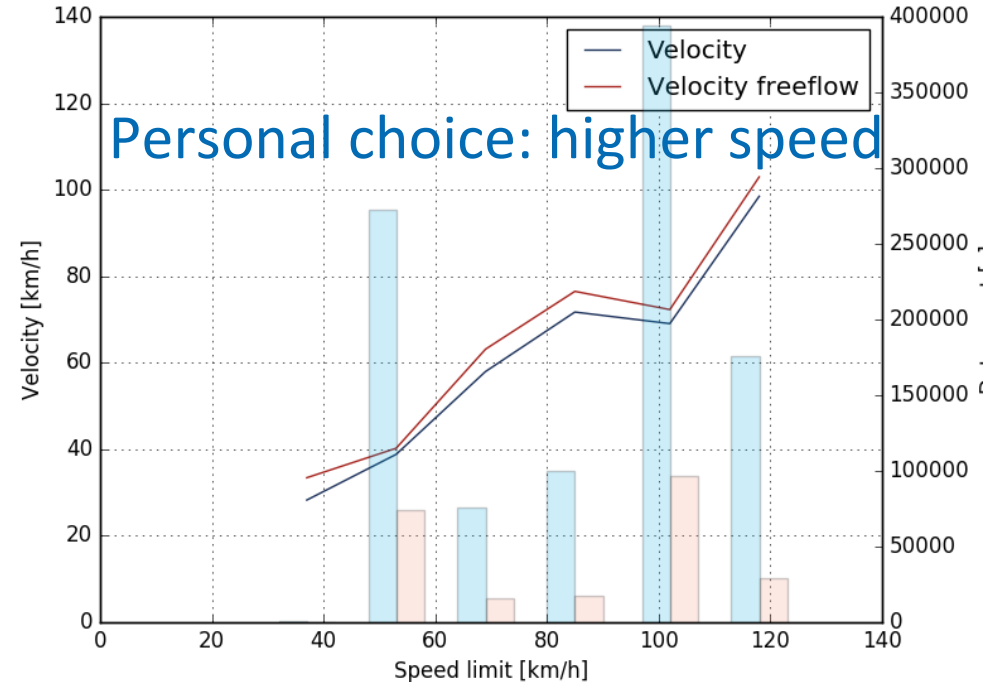
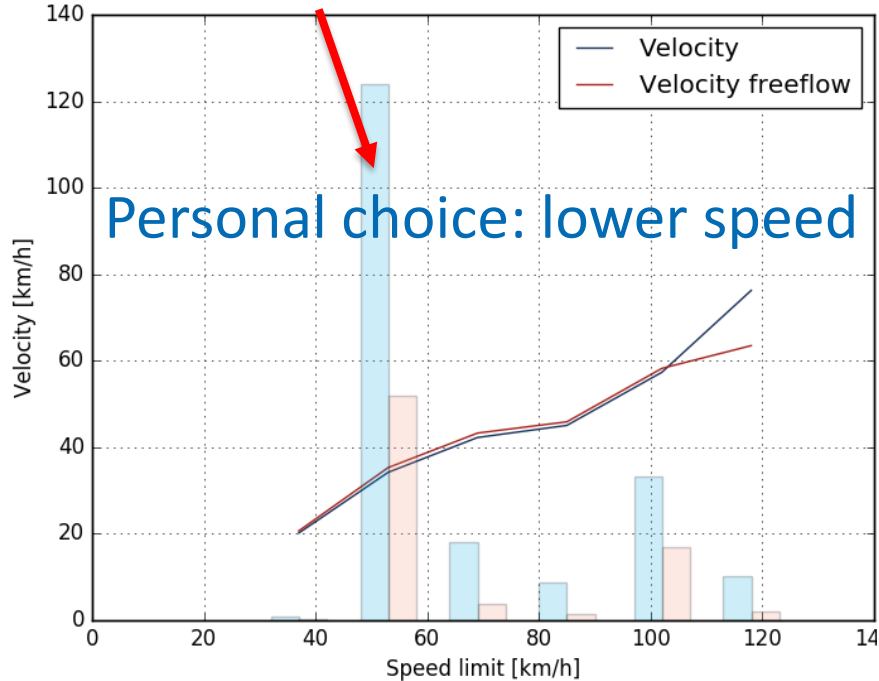
Difference between free-flow and total



Personal driving style: velocity

- How do drivers deviate from speed limit in normal traffic and free-flow?

Time spent at this speed limit



Personal driving style: braking

- Assumption: more headway means less braking
- Average headway for a given velocity bin:

$$\langle HW(v) \rangle = \frac{1}{N} \sum_{v_{low} < v < v_{high}} HW_v$$

- Braking: faster deceleration than the driving resistance

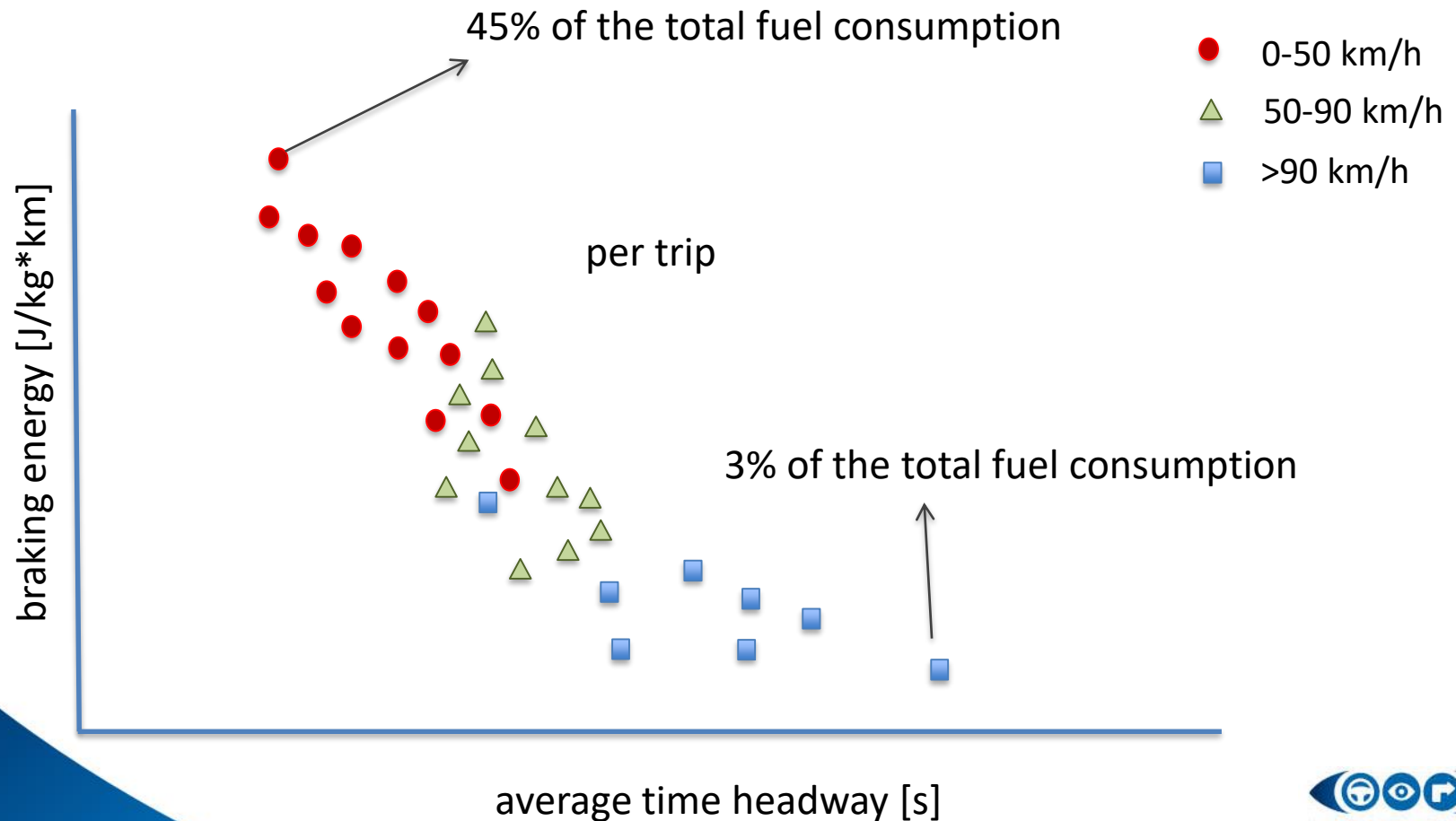
$$a_{resist} \left[\frac{m}{s^2} \right] = 0.098 \times slope[\%] - 0.11 - 0.3 \times \left(\frac{v \left[\frac{km}{h} \right]}{100} \right)^2$$

- Total energy per kilogram (J/kg*km) lost in braking:

$$E_{braking} \left[\frac{J}{kg} km \right] = - \frac{1}{dist} \times \sum_{a < a_{resist}} (a - a_{resist}) \times \frac{v \left[\frac{km}{h} \right]}{3.6}$$

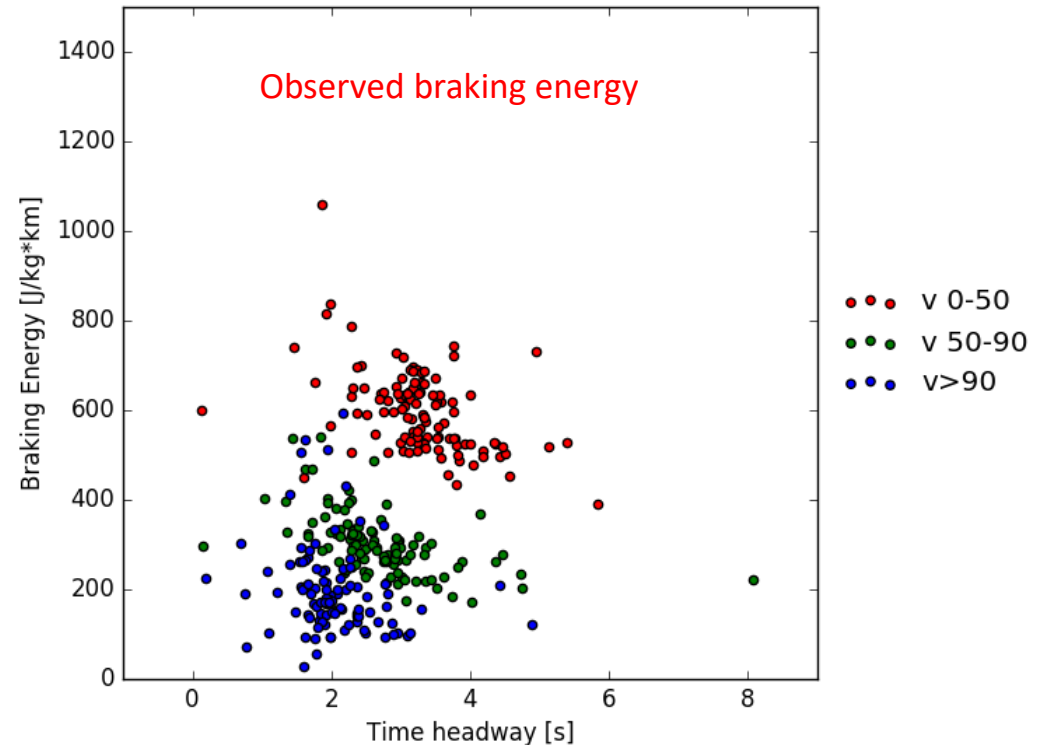
Personal driving style: braking

Expected braking energy (in total $\sim 400 \text{ J/kg*km}$)



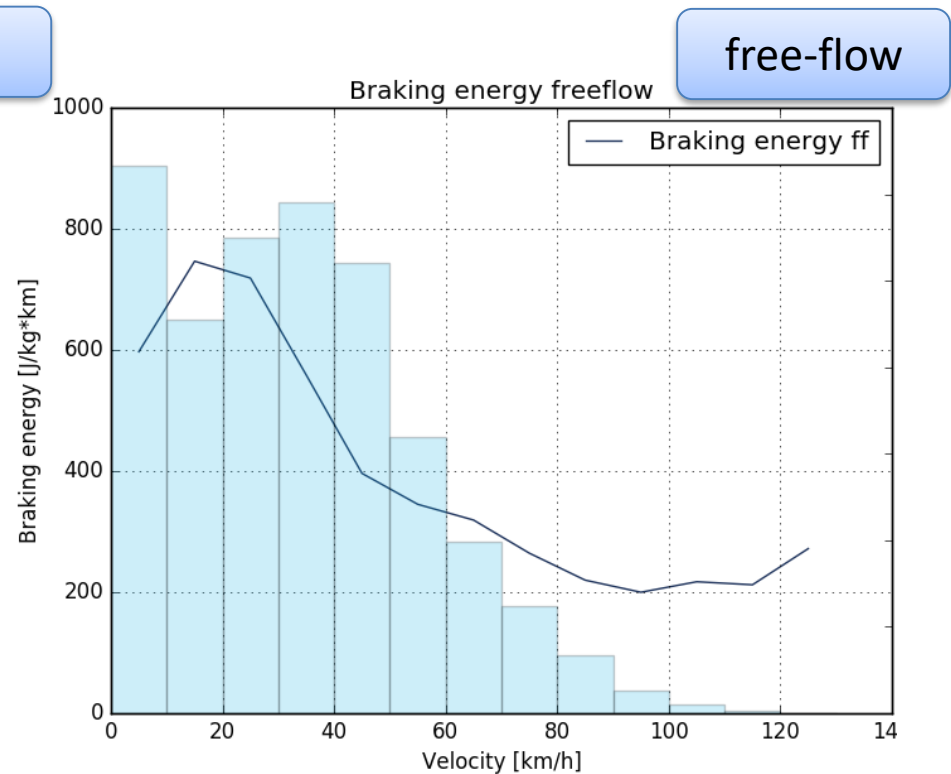
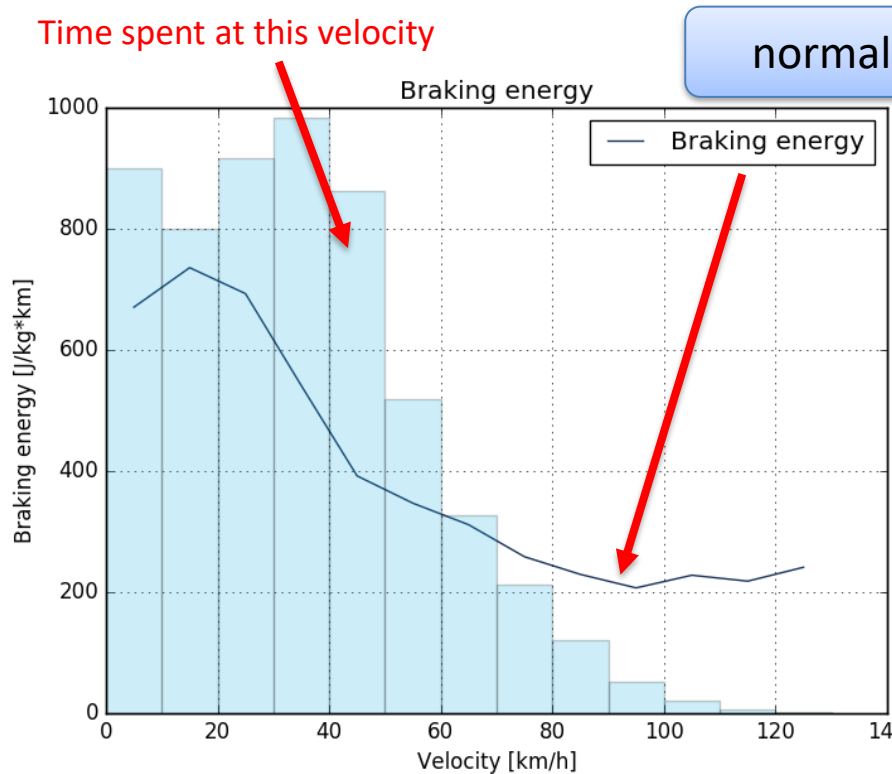
Personal driving style: braking

- Braking energy decreases with increasing velocity
- Headway decreases with increasing velocity



Personal driving style: braking

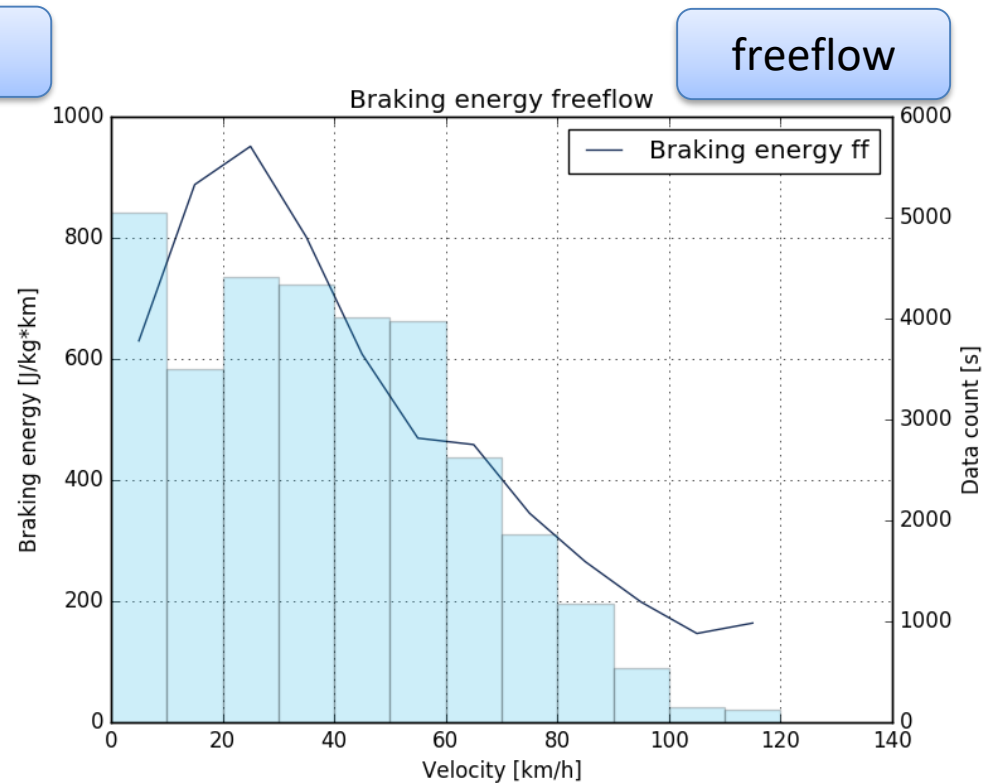
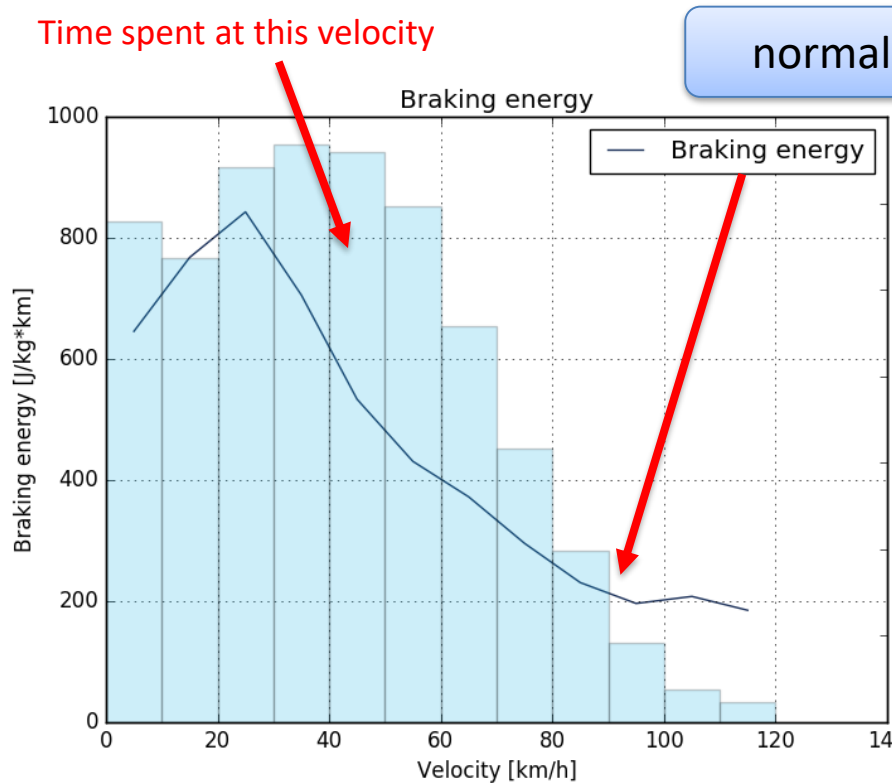
Time spent at this velocity



Average of all drivers

Personal driving style: braking

Time spent at this velocity

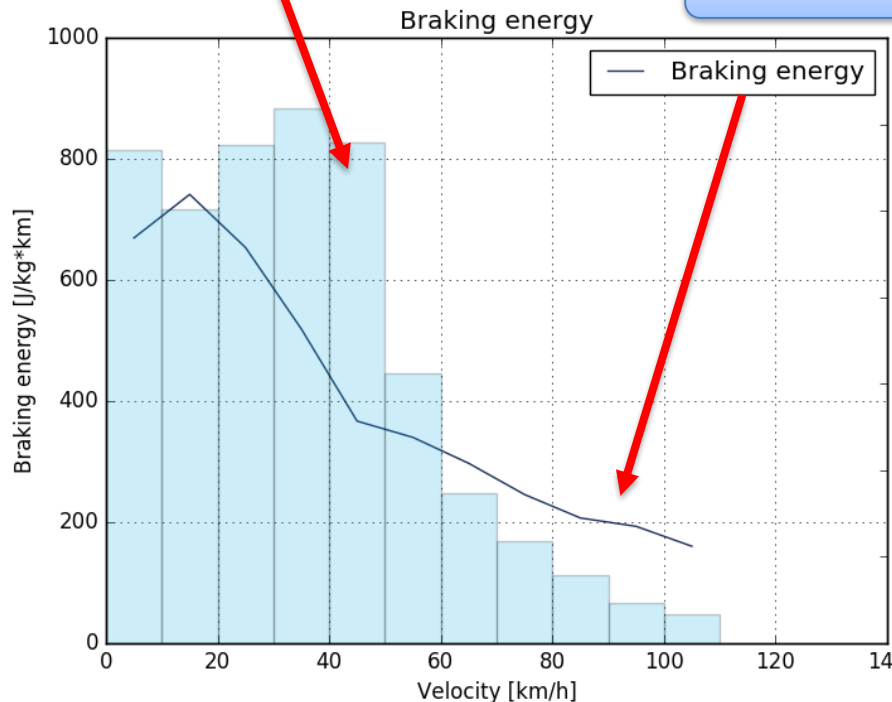


A driver who brakes more in free-flow

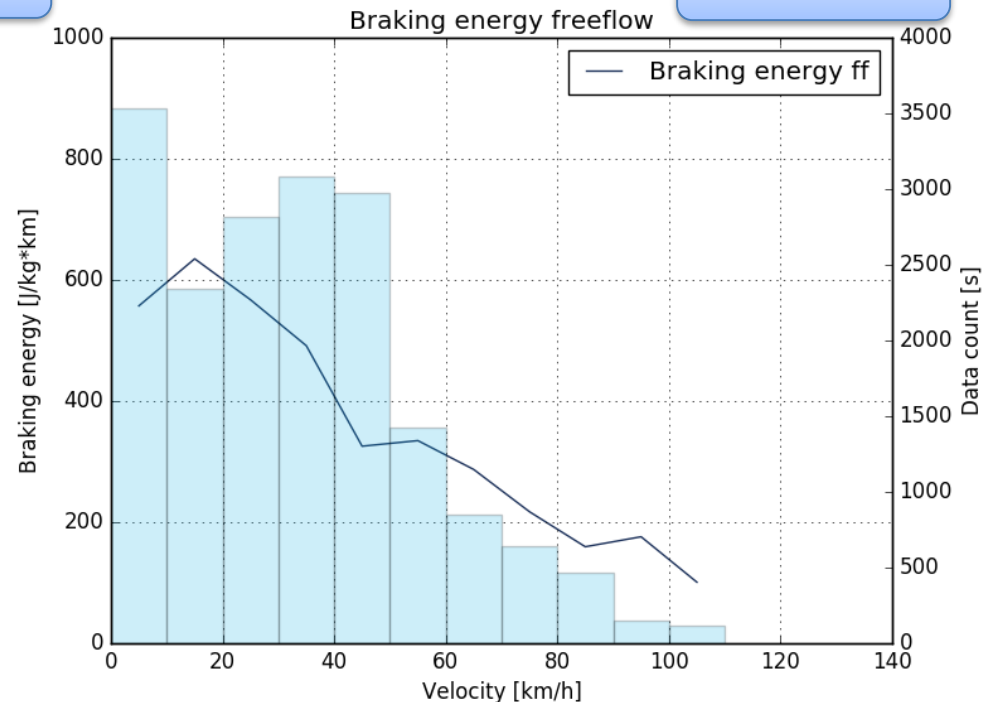
Personal driving style: braking

Time spent at this velocity

normal



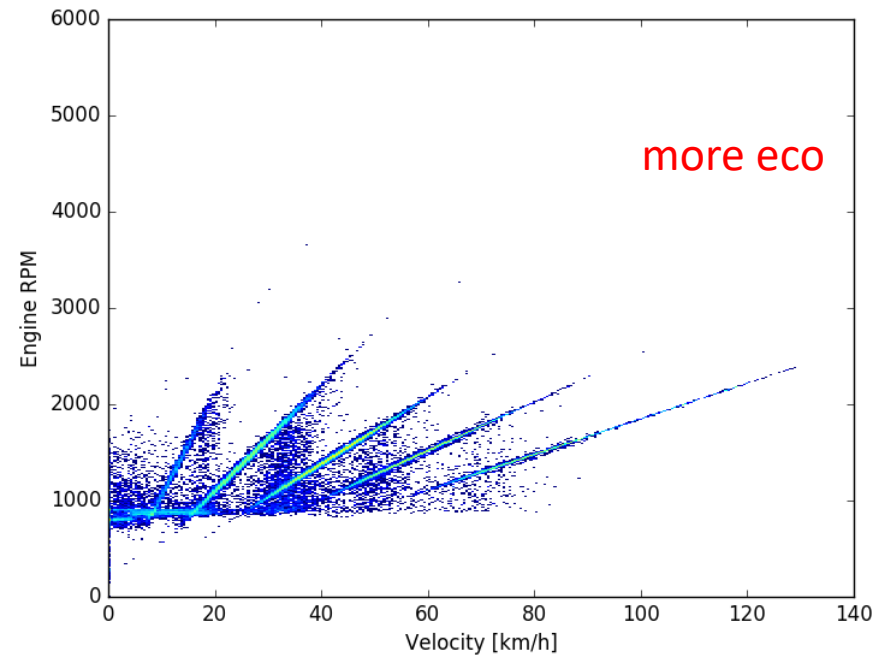
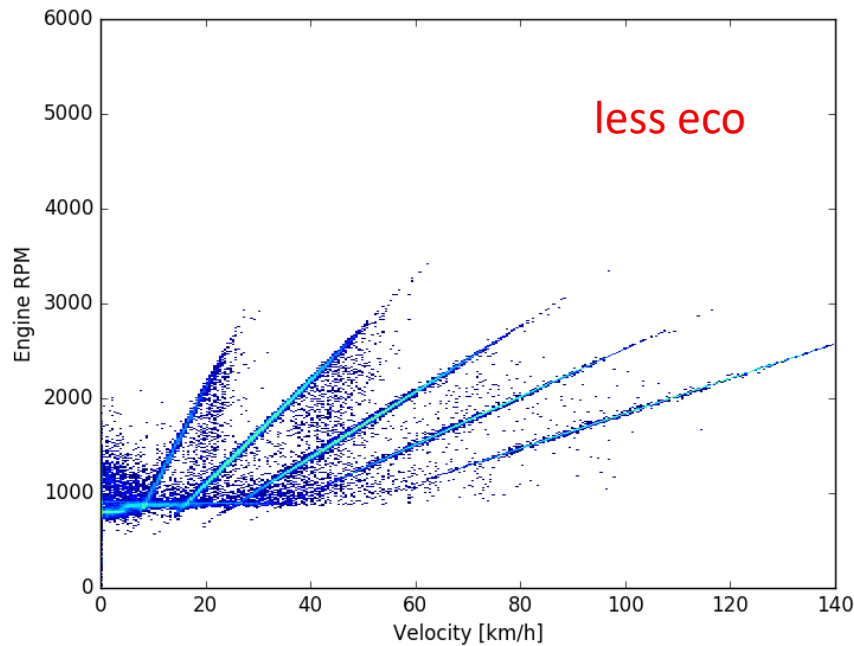
freeflow



A driver who brakes less in free-flow

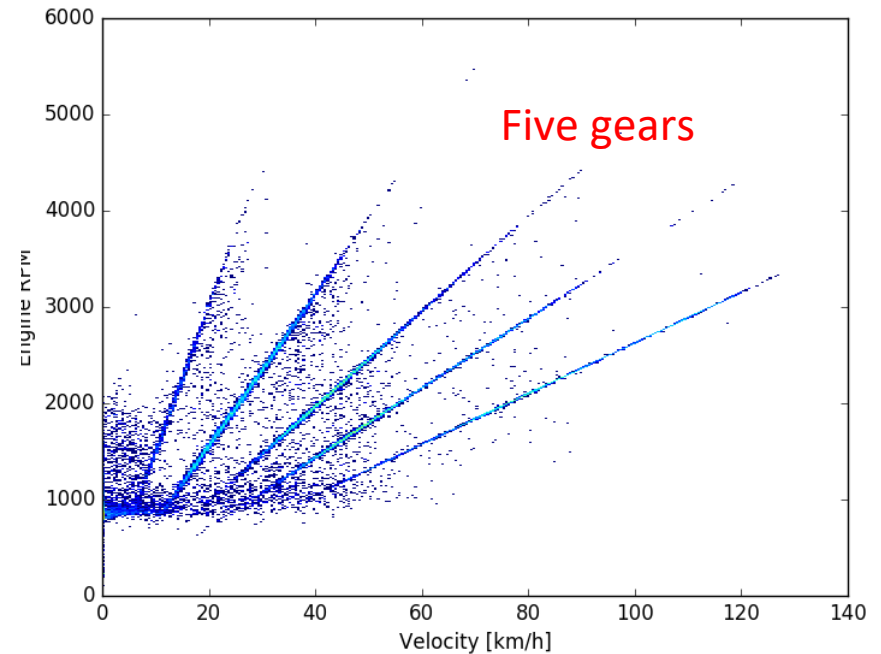
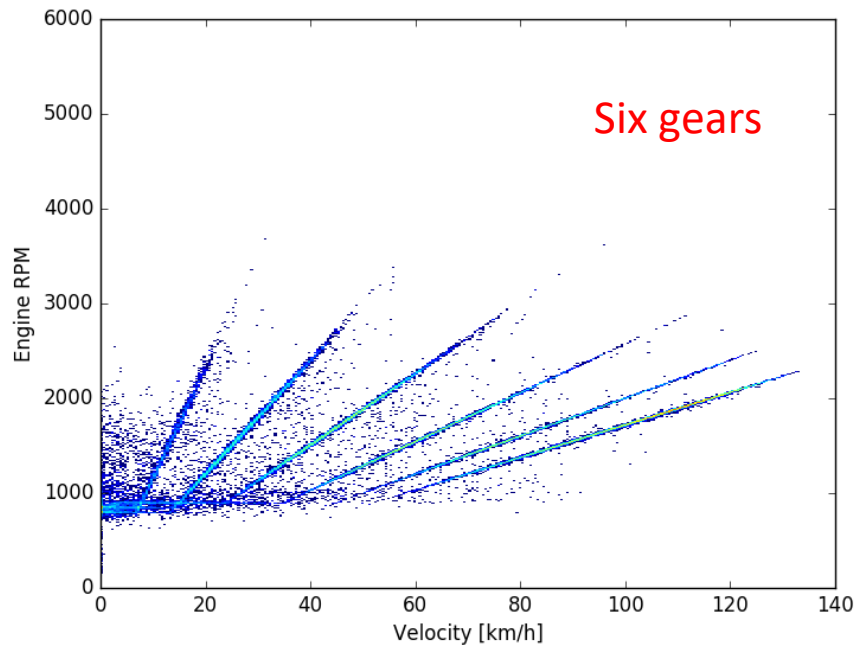
Personal driving style: gear shifting

- Gear shift around 2000-2500 RPM is eco



Personal driving style: gear shifting

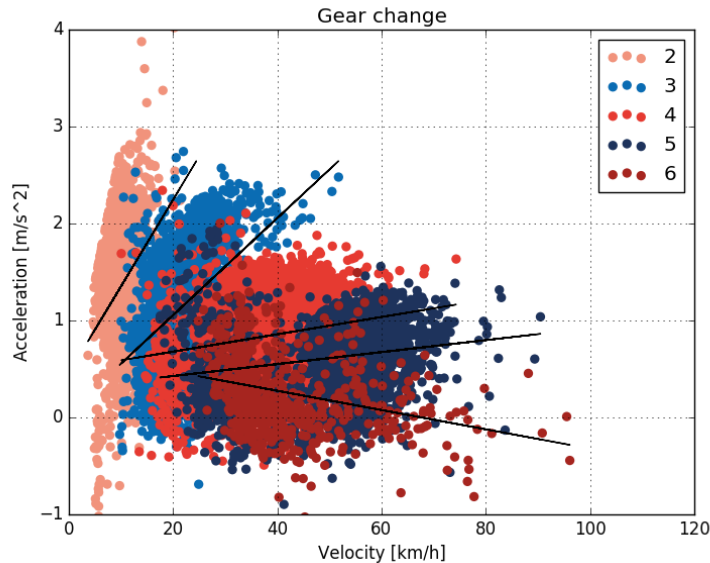
- Need more input on vehicle type (fuel, rated power)



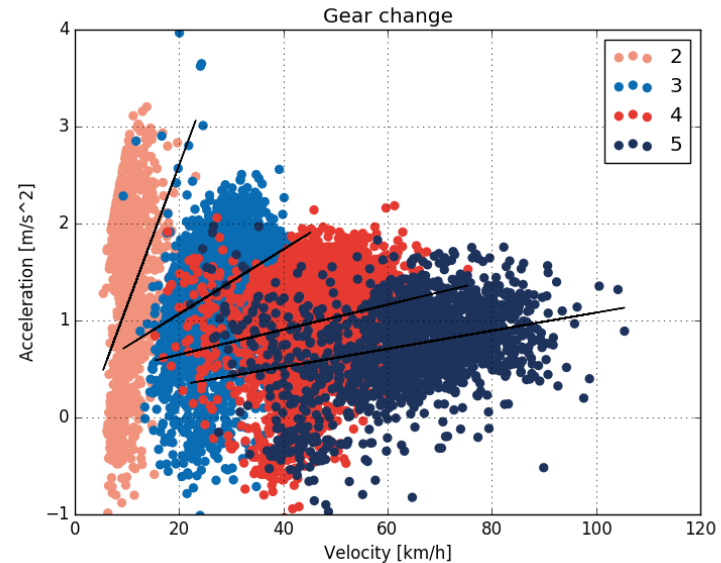
Personal driving style: gear shifting

- Determine gear shift moment from rpm/velocity
- Plot acceleration and velocity just before gear shift

Six gears,
automatic transmission?

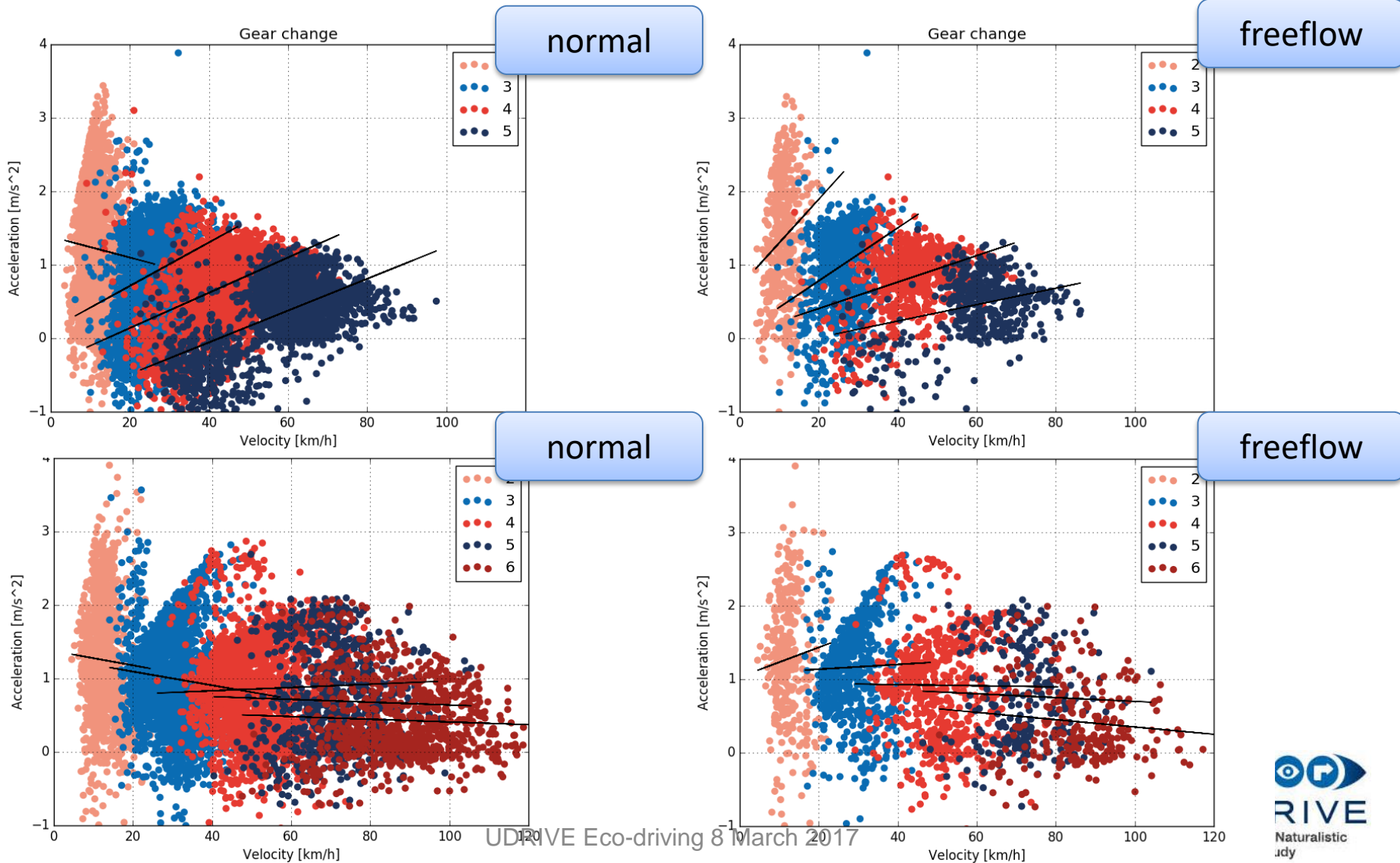


Five gears, less eco



Personal driving style: gear shifting

- Different behaviour between normal and free-flow



Eco-driving score and potential

- Disentangle **driving conditions** and personal **driving style**
- Determine **'average'** driving style
 - % time on roadtype
 - Average velocities and accelerations (per speed limit, at roadtype, before curve, ...)
 - Gear shifting moment
 - Braking energy
 - Headway
- Determine **residual** of each driver with respect to average
- Find **common characteristics** of driver groups
- Estimate **room for improvement** by eco-driving measures

Q&A

UDRIVE Eco-driving 8 March 2017



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European Naturalistic
Driving Study

Conclusions

Preliminary conclusions

preliminary

- Get a good overview of naturalistic driving
- Disentangling conditions and driving style is not trivial
- Drivers brake harder at low speeds
- Most drivers have less moderate accelerations in free-flow
- Gear change behaviour is a clear indicator of driving style
- Eco-driving is a characteristic of certain drivers
 - Large differences in driving style between drivers
 - For some drivers, free-flow conditions improve behaviour, for others not

Planned activities

- Velocity / braking before curves (together with TNO Soesterberg)
- Road conditions besides road type and headway (e.g. traffic light, intersection)
- Quantify personal driving style into eco-driving scores
- Compute residuals of each driver to the average
- Cluster drivers by eco-driving score
- Cluster drivers by characteristics (country, gender, ...)
- Provide input to WP 4.2.4 (everyday driving) for correlation with safe driving, through characteristics per drivers. Use the clustering of drivers from WP 4.2.4

REGISTRATION OPEN!

Final event

The UDRIVE Experience

June 7, 2017

6th International Symposium

Naturalistic Driving Research

June 8 – 9, 2017

More information?

<http://ndrsymposium.com>

Q&A

Thank you for your attention