**Working paper number WLTP-DHC-03-04**


# Comparison of different European databases with respect to road category and time periods (on peak, off peak, weekend)

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# Introduction


- **The methodology to develop the WLTP drive cycle requires the collection of in-use driving behaviour data and statistical information about the mileage for the following road categories and time periods within each road category:**

  1. **Urban,**
  2. **Rural,**
  3. **Motorway,**

  a) **On peak,**
  b) **Off peak,**
  c) **Weekend.**

# Introduction


- 2 different databases were analysed in order to determine the influence of time period and road category on the driving behaviour data.
- The following databases were used:
  1. in-use data from Switzerland (CH),
  2. in-use data from Belgium (BE),
  3. In-use data from Berlin (DE, urban only).
  - All CH and BE data is customer data, that means that routes and time periods were not predefined or influenced by third parties.
  - The DE data was derived by a mid size car floating with the traffic.

# Influence of time periods


- **Table 1 shows for the different databases average speeds and stop percentages separated in road categories and time periods.**
- **Figures 1 to 3 show the corresponding vehicle speed distribution curves. Figures 4 and 5 show the short trip duration and stop phase duration distributions for the road category “urban”. Figure 6 shows the RPA values of the short trips vs average speed for the different time periods and urban.**
- **Only some cases reflect the expected trend. The differences between the time periods are smaller than the differences between locations/databases. Even the RPA values show a high overlap between the time periods.**

# Influence of time periods


| Region | road cat | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|---|
| BE | motorway | on peak | 83.4 | 2.7% | 85.7 | 42.6% |
| BE | motorway | off peak | 101.9 | 1.5% | 103.4 | 43.6% |
| BE | motorway | weekend | 105.6 | 3.3% | 109.3 | 13.9% |
| BE | rural | on peak | 45.5 | 11.8% | 51.6 | 45.7% |
| BE | rural | off peak | 45.6 | 10.6% | 51.0 | 28.1% |
| BE | rural | weekend | 48.6 | 8.4% | 53.0 | 26.2% |
| BE | urban | on peak | 30.7 | 14.8% | 36.0 | 49.5% |
| BE | urban | off peak | 26.9 | 17.7% | 32.7 | 28.8% |
| BE | urban | weekend | 24.9 | 20.6% | 31.3 | 21.7% |
| CH | motorway | on peak | 90.8 | 2.8% | 93.4 | 47.0% |
| CH | motorway | off peak | 98.9 | 1.6% | 100.5 | 41.5% |
| CH | motorway | weekend | 98.0 | 1.7% | 99.6 | 11.5% |
| CH | rural | on peak | 46.1 | 9.8% | 51.0 | 45.3% |
| CH | rural | off peak | 43.0 | 13.9% | 49.9 | 44.2% |
| CH | rural | weekend | 40.3 | 15.7% | 47.8 | 10.5% |
| CH | urban | on peak | 22.0 | 30.5% | 31.7 | 32.2% |
| CH | urban | off peak | 24.0 | 27.9% | 33.3 | 52.4% |
| CH | urban | weekend | 25.7 | 26.1% | 34.8 | 15.4% |
| DE | urban | on peak | 16.6 | 34.9% | 25.5 | 23.1% |
| DE | urban | off peak | 25.4 | 23.9% | 33.4 | 54.2% |
| DE | urban | weekend | 27.7 | 23.2% | 36.1 | 22.7% |

Table 1

# Vehicle speed distributions

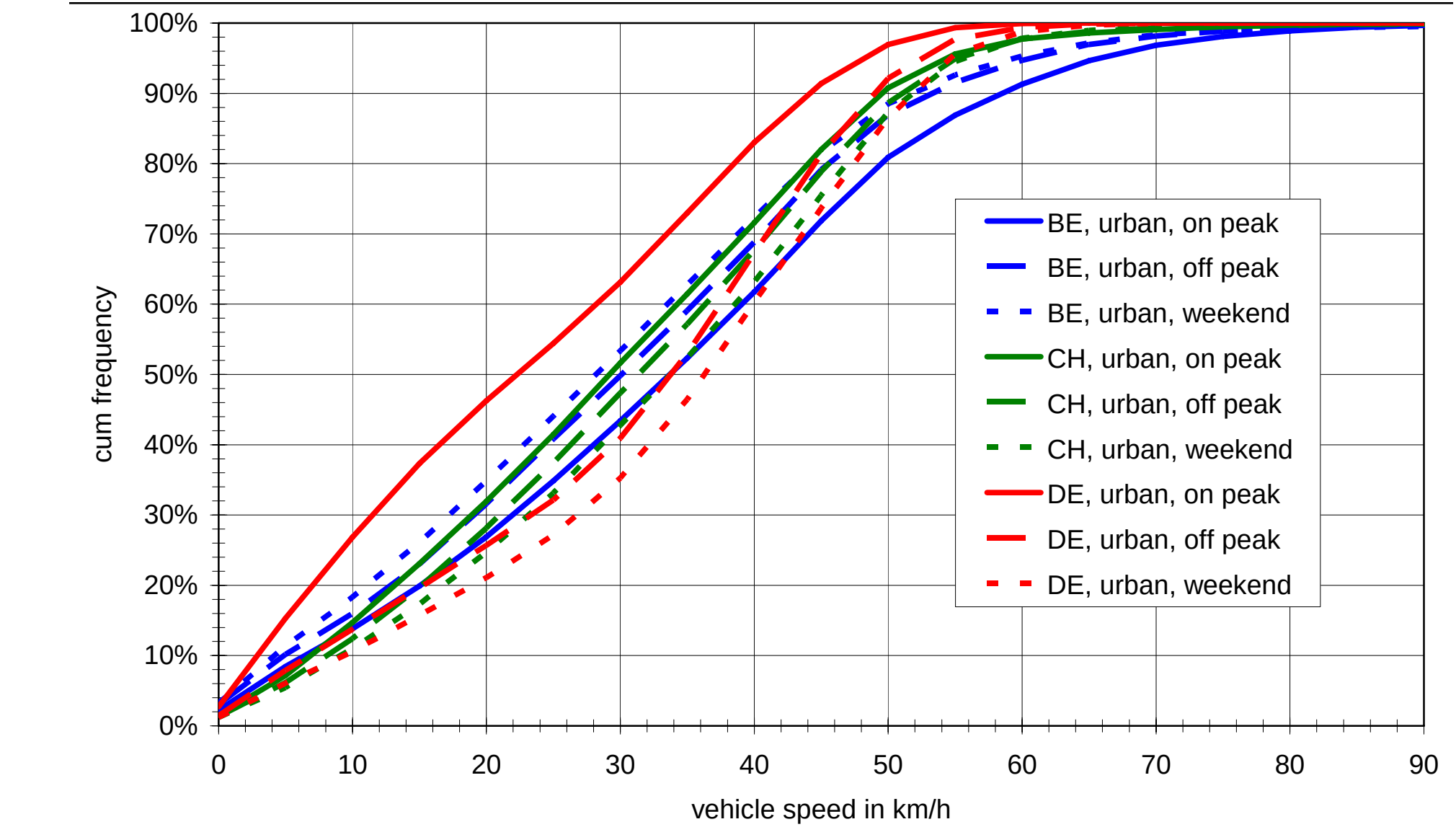


Figure 1

# Vehicle speed distributions

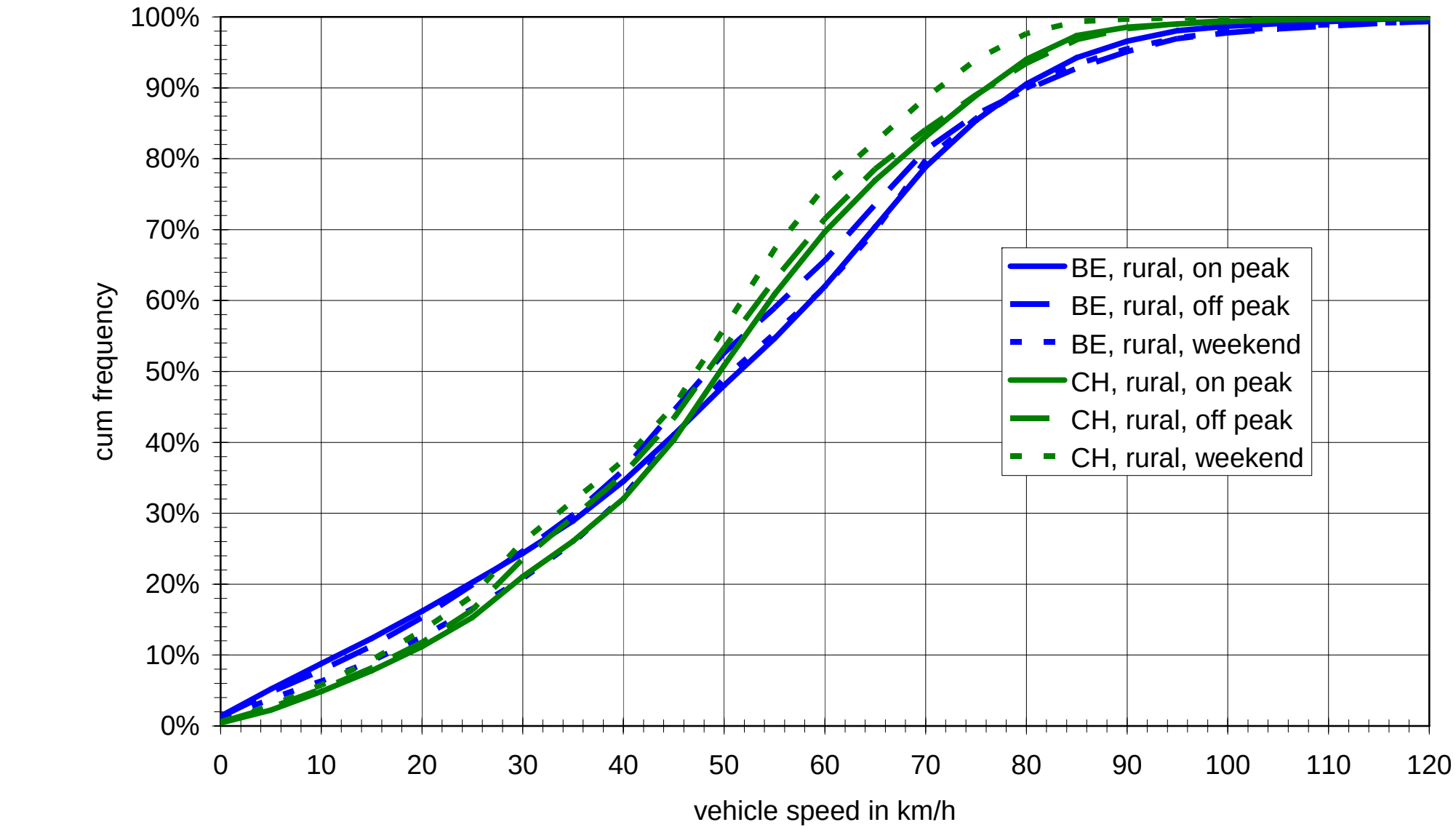


Figure 2

# Vehicle speed distributions

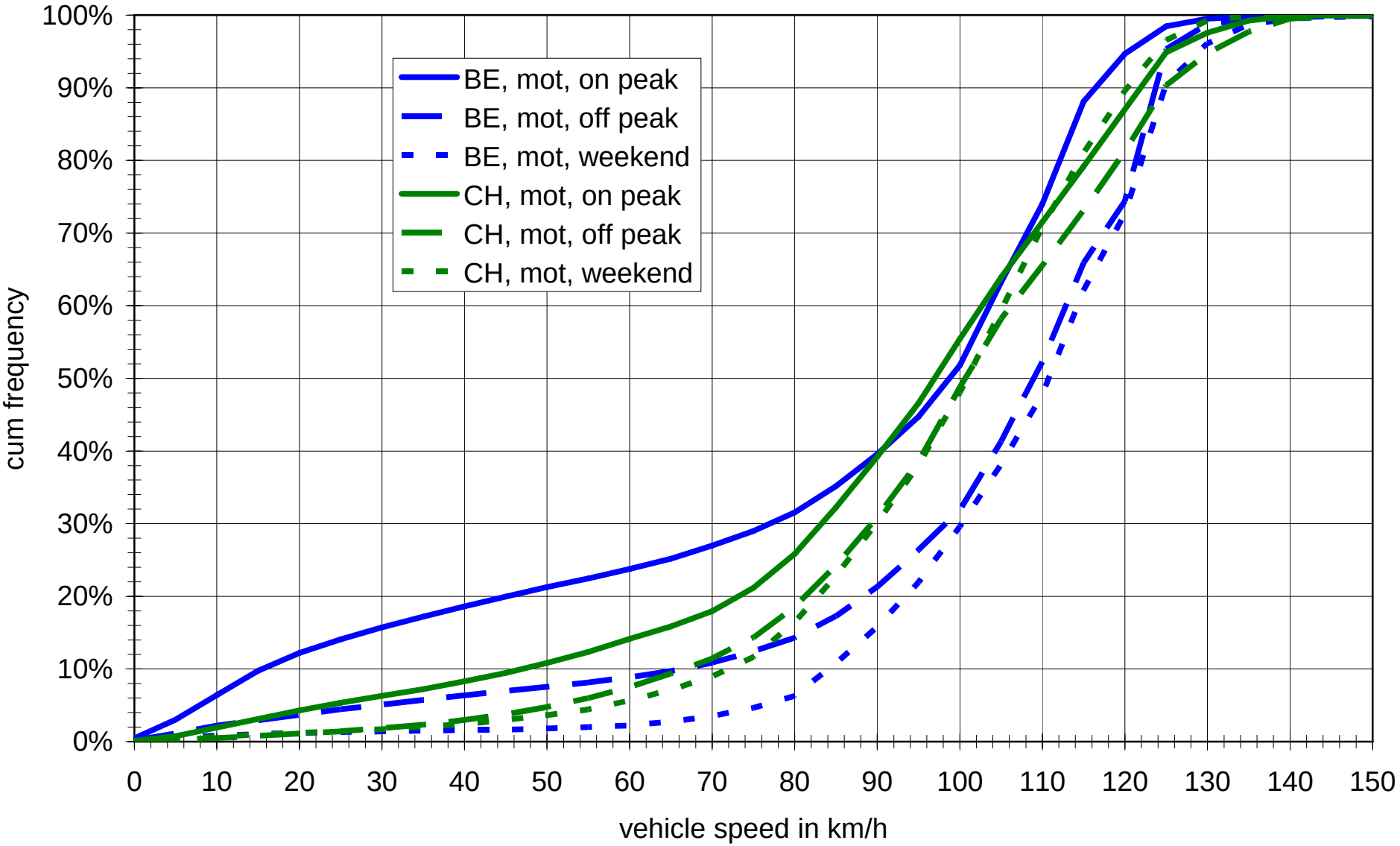


Figure 3

# Short trip duration distributions

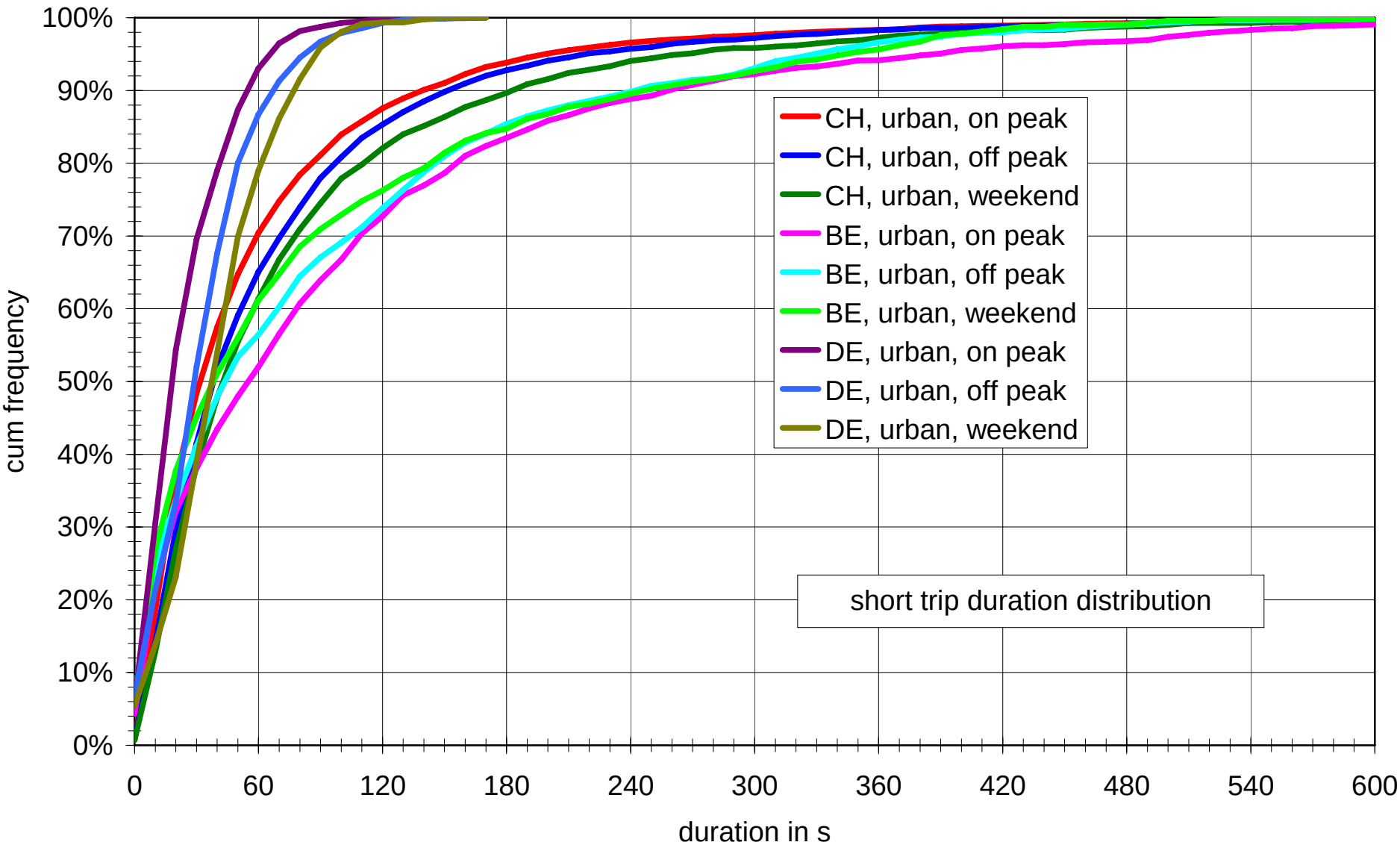


Figure 4

# Stop phase duration distributions

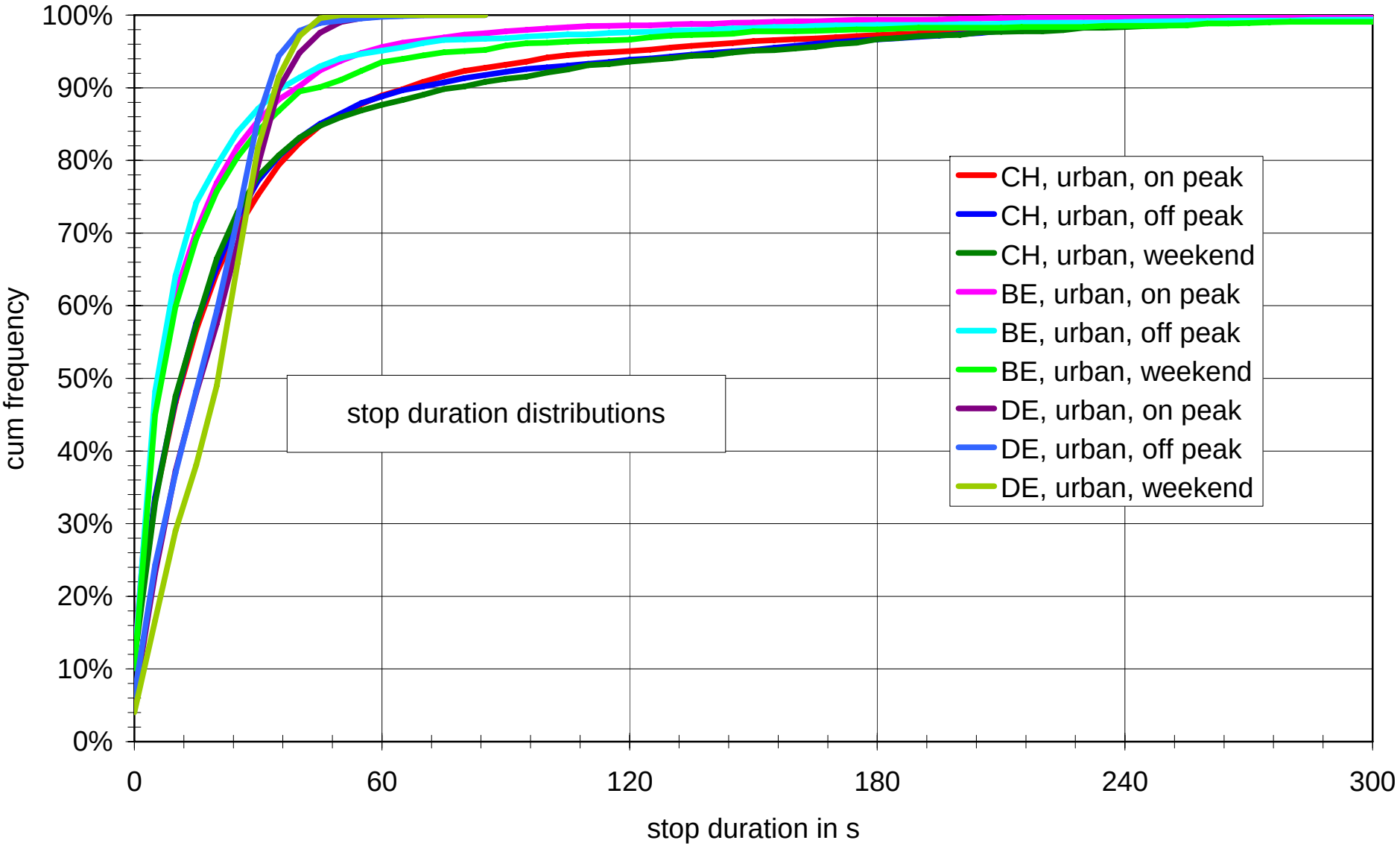


Figure 5

# RPA versus average speed

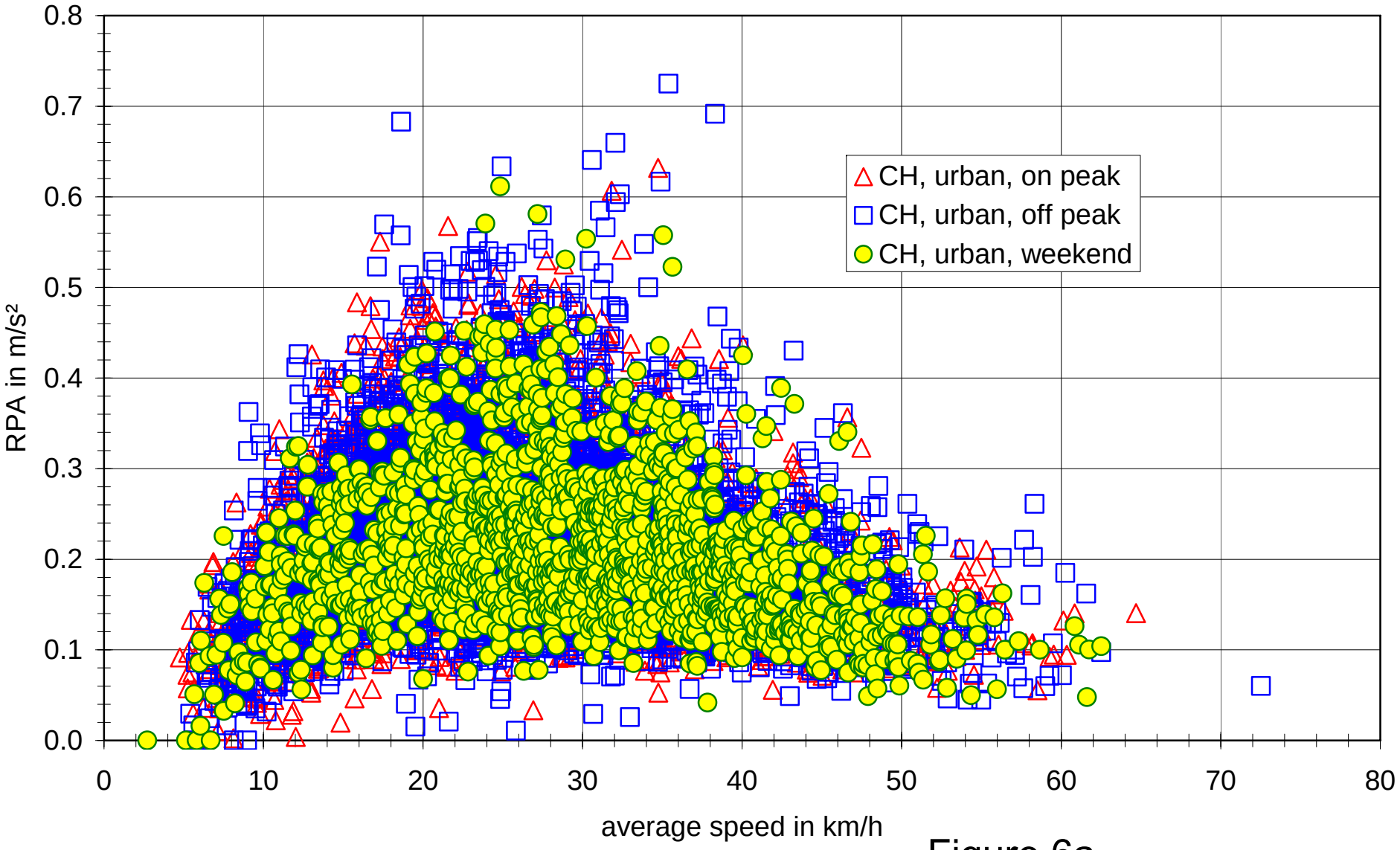


Figure 6a

# RPA versus average speed

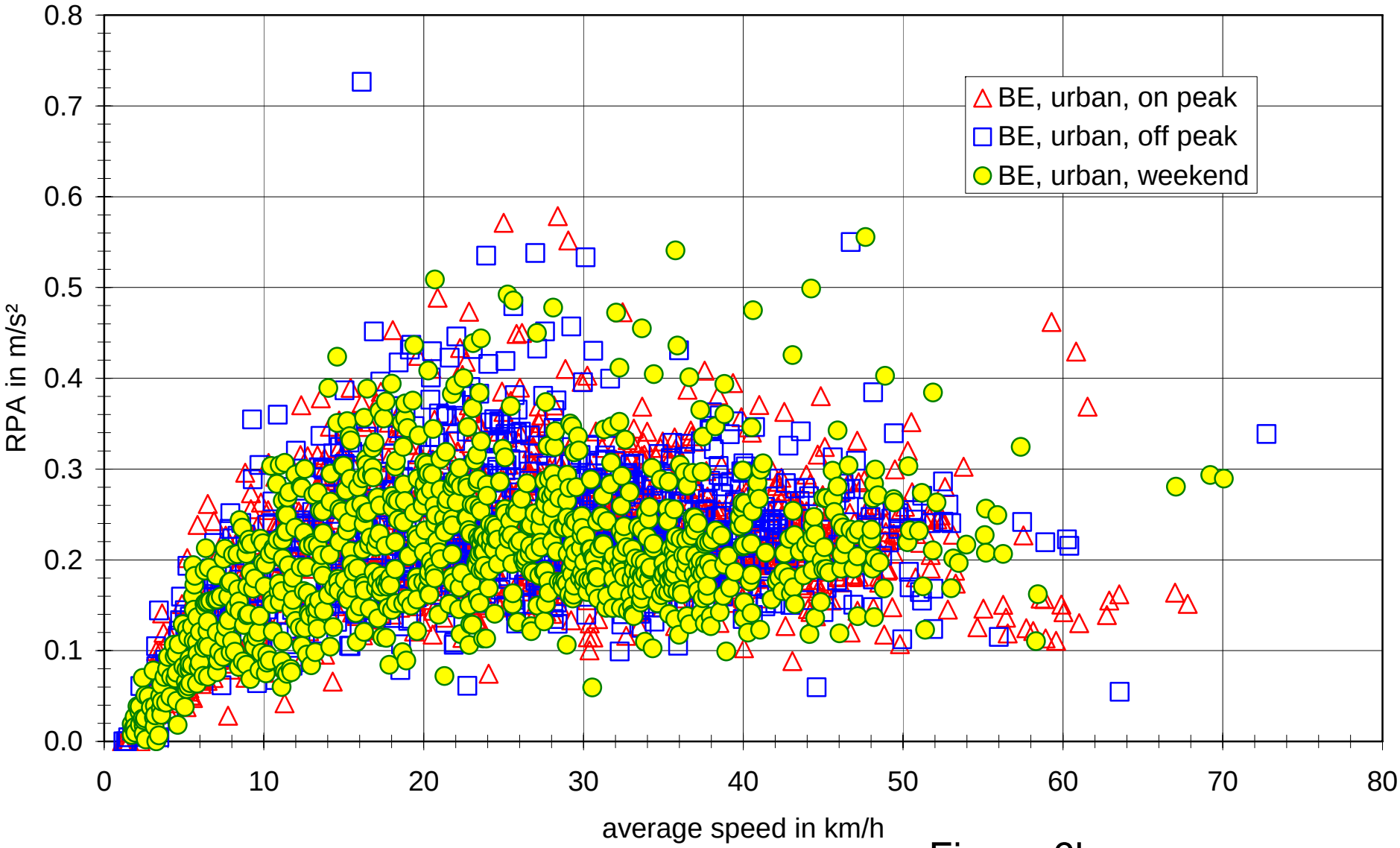


Figure 6b

# RPA versus average speed

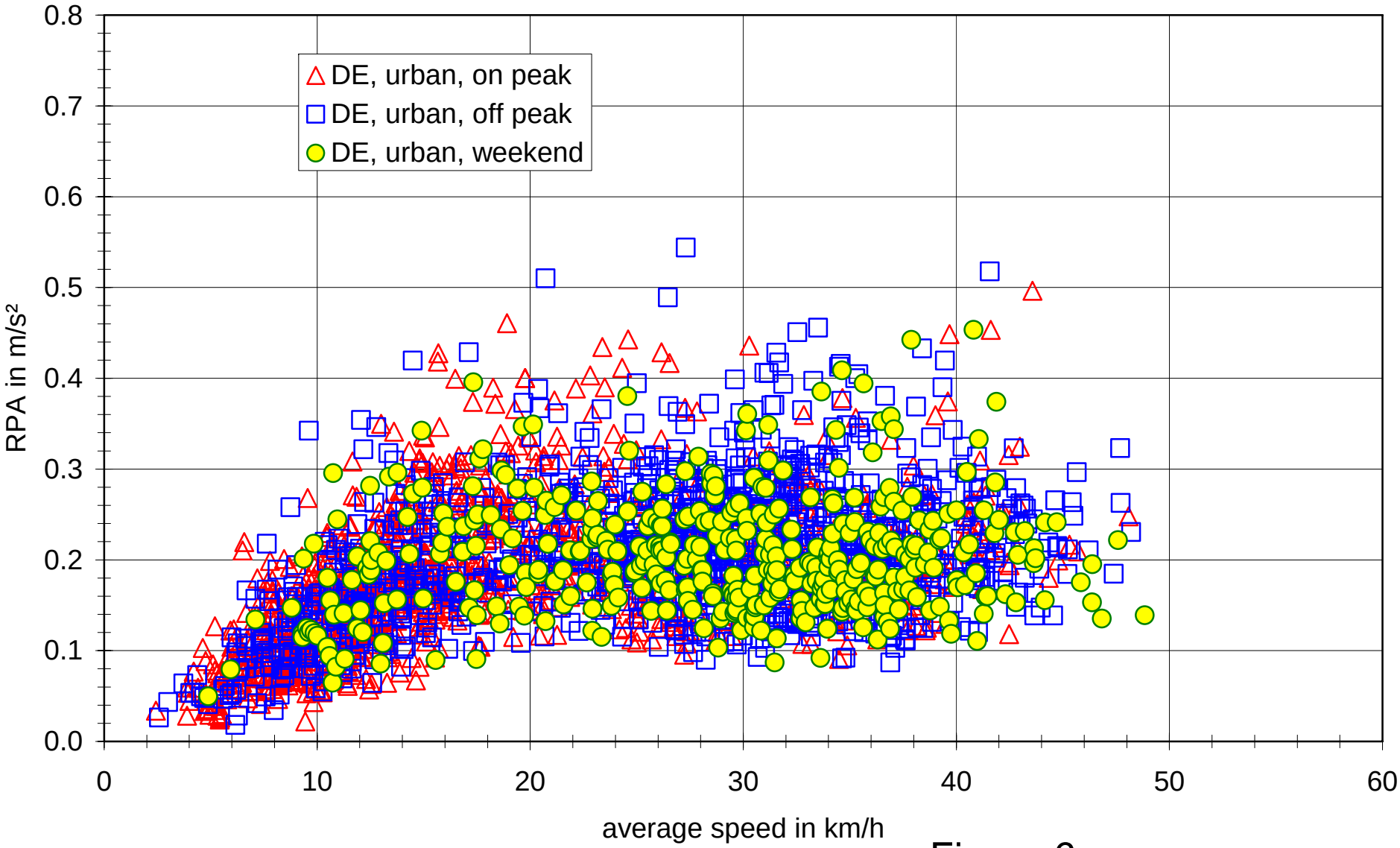


Figure 6c

# Influence of time periods


- The Belgium data could be separated into different cities/regions.
- Table 2 shows the average speeds and stop percentages for different cities/regions.
- Figure 7 shows the vehicle speed distribution curves for some cities separated for the 3 time periods. Figure 8 shows the vehicle speed distributions for the several cities/regions for the time period “on peak”. Figure 9 shows the short trip duration distributions for the road category “urban”.
- The differences between the cities/regions are much higher than the differences between the time periods.

# Influence of time periods


| City/region | road cat | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|---|
| Bocholt-Kaulille | motorway | on peak | 108.6 | 0.0% | 108.6 | 10.1% |
| Bocholt-Kaulille | motorway | off peak | 93.0 | 1.1% | 94.0 | 75.0% |
| Bocholt-Kaulille | motorway | weekend | 109.4 | 0.6% | 110.1 | 14.9% |
| Bocholt-Kaulille | rural | on peak | 54.5 | 6.8% | 58.5 | 58.4% |
| Bocholt-Kaulille | rural | off peak | 53.3 | 7.7% | 57.7 | 21.3% |
| Bocholt-Kaulille | rural | weekend | 58.2 | 4.6% | 61.0 | 20.2% |
| Bocholt-Kaulille | urban | on peak | 25.8 | 17.4% | 31.2 | 52.4% |
| Bocholt-Kaulille | urban | off peak | 23.3 | 22.6% | 30.1 | 26.3% |
| Bocholt-Kaulille | urban | weekend | 28.3 | 13.6% | 32.7 | 21.3% |
| Brugge | motorway | on peak | 99.1 | 1.3% | 100.3 | 58.9% |
| Brugge | motorway | off peak | 110.0 | 0.2% | 110.2 | 36.2% |
| Brugge | motorway | weekend | 110.7 | 0.8% | 111.5 | 4.9% |
| Brugge | rural | on peak | 45.0 | 9.5% | 49.8 | 40.9% |
| Brugge | rural | off peak | 41.5 | 12.5% | 47.4 | 38.8% |
| Brugge | rural | weekend | 50.3 | 6.7% | 53.9 | 20.2% |
| Brugge | urban | on peak | 27.7 | 19.7% | 34.5 | 38.7% |
| Brugge | urban | off peak | 28.8 | 15.0% | 33.8 | 41.3% |
| Brugge | urban | weekend | 30.4 | 15.7% | 36.1 | 19.9% |

Table 2a

# Influence of time periods


| City/region | road cat | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|---|
| Brussels region | motorway | on peak | 65.3 | 4.5% | 68.3 | 55.4% |
| Brussels region | motorway | off peak | 96.1 | 2.0% | 98.1 | 25.5% |
| Brussels region | motorway | weekend | 99.6 | 4.3% | 104.1 | 19.0% |
| Brussels region | rural | on peak | 29.0 | 28.1% | 40.3 | 41.2% |
| Brussels region | rural | off peak | 38.8 | 15.7% | 46.0 | 29.8% |
| Brussels region | rural | weekend | 40.6 | 13.7% | 47.1 | 29.0% |
| Brussels region | urban | on peak | 38.4 | 5.8% | 40.8 | 68.4% |
| Brussels region | urban | off peak | 29.3 | 14.2% | 34.2 | 15.3% |
| Brussels region | urban | weekend | 26.7 | 16.2% | 31.9 | 16.3% |
| Gent | motorway | on peak | 74.6 | 3.6% | 77.4 | 55.8% |
| Gent | motorway | off peak | 88.9 | 1.9% | 90.7 | 34.7% |
| Gent | motorway | weekend | 100.5 | 3.2% | 103.8 | 9.5% |
| Gent | rural | on peak | 30.7 | 18.9% | 37.9 | 32.2% |
| Gent | rural | off peak | 35.6 | 15.3% | 42.0 | 33.9% |
| Gent | rural | weekend | 33.1 | 18.7% | 40.7 | 33.9% |
| Gent | urban | on peak | 19.7 | 16.8% | 23.7 | 37.7% |
| Gent | urban | off peak | 23.1 | 10.3% | 25.7 | 35.0% |
| Gent | urban | weekend | 18.0 | 18.9% | 22.2 | 27.4% |

Table 2b

# Influence of time periods


| City/region | road cat | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|---|
| Leuven region | motorway | on peak | 88.3 | 3.9% | 91.9 | 34.5% |
| Leuven region | motorway | off peak | 112.2 | 0.0% | 112.2 | 60.8% |
| Leuven region | motorway | weekend | 116.5 | 0.0% | 116.5 | 4.7% |
| Leuven region | rural | on peak | 39.2 | 12.9% | 45.1 | 46.1% |
| Leuven region | rural | off peak | 46.8 | 12.9% | 53.8 | 42.1% |
| Leuven region | rural | weekend | 42.9 | 14.5% | 50.2 | 11.8% |
| Leuven region | urban | on peak | 26.1 | 9.4% | 28.8 | 53.5% |
| Leuven region | urban | off peak | 31.2 | 6.5% | 33.4 | 32.3% |
| Leuven region | urban | weekend | 28.8 | 8.8% | 31.6 | 14.2% |
| Lommel | rural | on peak | 56.2 | 9.7% | 62.2 | 70.0% |
| Lommel | rural | off peak | 53.9 | 8.0% | 58.6 | 12.5% |
| Lommel | rural | weekend | 52.7 | 9.3% | 58.1 | 17.5% |
| Lommel | urban | on peak | 35.4 | 9.6% | 39.2 | 63.6% |
| Lommel | urban | off peak | 33.3 | 9.6% | 36.8 | 16.6% |
| Lommel | urban | weekend | 32.0 | 12.8% | 36.7 | 19.8% |

Table 2c

# Influence of time periods


| City/region | road cat | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|---|
| Nieuwerkerken | motorway | on peak | 86.6 | 12.1% | 98.5 | 2.0% |
| Nieuwerkerken | motorway | off peak | 106.5 | 1.9% | 108.6 | 83.7% |
| Nieuwerkerken | motorway | weekend | 99.4 | 8.0% | 108.1 | 14.3% |
| Nieuwerkerken | rural | on peak | 38.8 | 11.0% | 43.6 | 9.8% |
| Nieuwerkerken | rural | off peak | 46.5 | 7.5% | 50.3 | 54.4% |
| Nieuwerkerken | rural | weekend | 43.6 | 10.5% | 48.7 | 35.8% |
| Nieuwerkerken | urban | on peak | 15.9 | 43.5% | 28.2 | 9.7% |
| Nieuwerkerken | urban | off peak | 25.6 | 20.1% | 32.0 | 58.0% |
| Nieuwerkerken | urban | weekend | 17.3 | 38.5% | 28.1 | 32.3% |
| Tervuren | motorway | on peak | 104.5 | 0.4% | 104.9 | 54.2% |
| Tervuren | motorway | off peak | 116.1 | 0.0% | 116.1 | 9.3% |
| Tervuren | motorway | weekend | 116.5 | 0.1% | 116.5 | 36.5% |
| Tervuren | rural | on peak | 39.5 | 14.4% | 46.2 | 52.3% |
| Tervuren | rural | off peak | 44.9 | 11.1% | 50.5 | 21.9% |
| Tervuren | rural | weekend | 47.1 | 9.2% | 51.9 | 25.8% |
| Tervuren | urban | on peak | 32.8 | 12.4% | 37.5 | 51.8% |
| Tervuren | urban | off peak | 33.2 | 10.4% | 37.1 | 21.7% |
| Tervuren | urban | weekend | 36.3 | 7.3% | 39.1 | 26.4% |

Table 2d

# Vehicle speed distributions

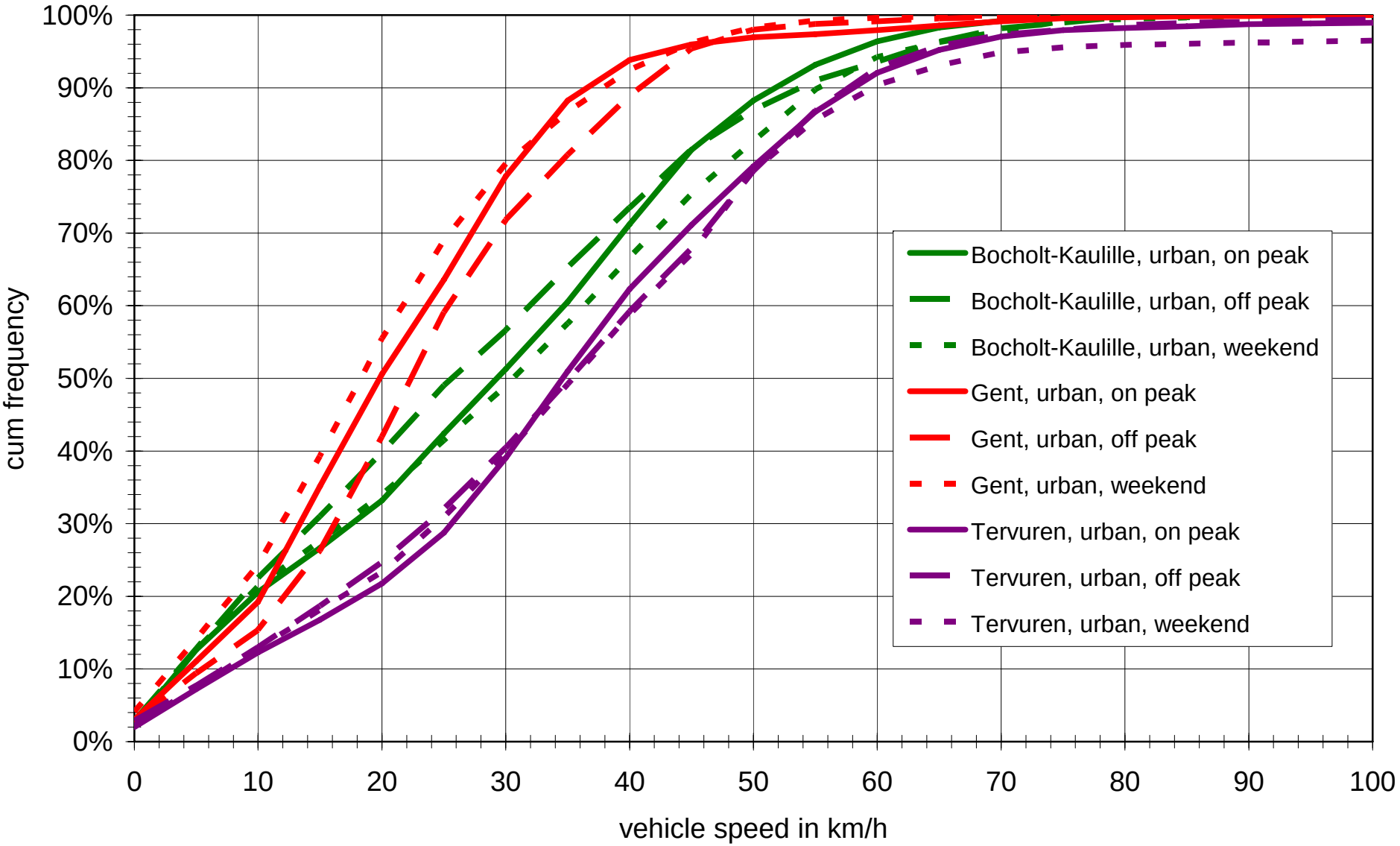


Figure 7

# Vehicle speed distributions

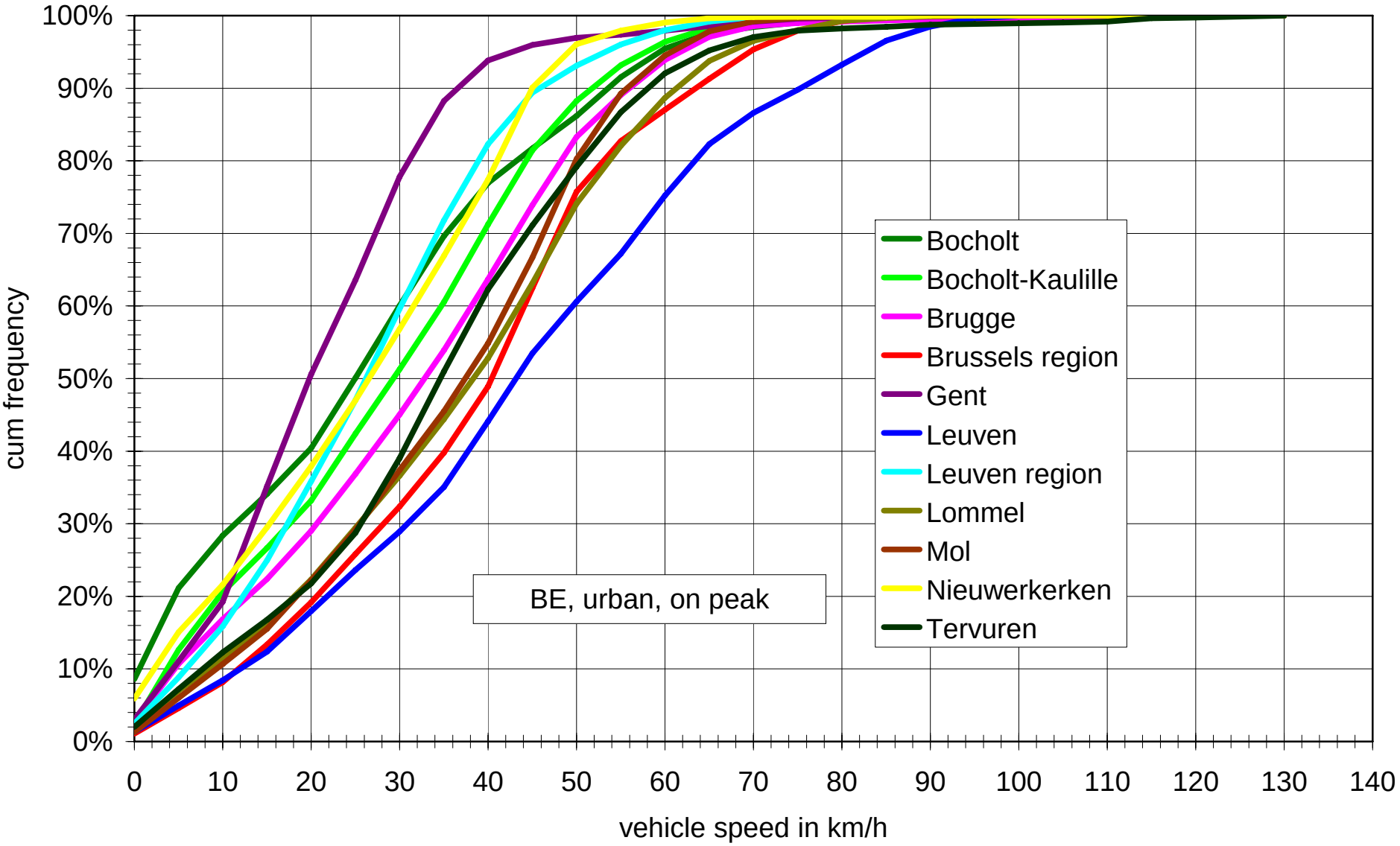


Figure 8a

# Vehicle speed distributions

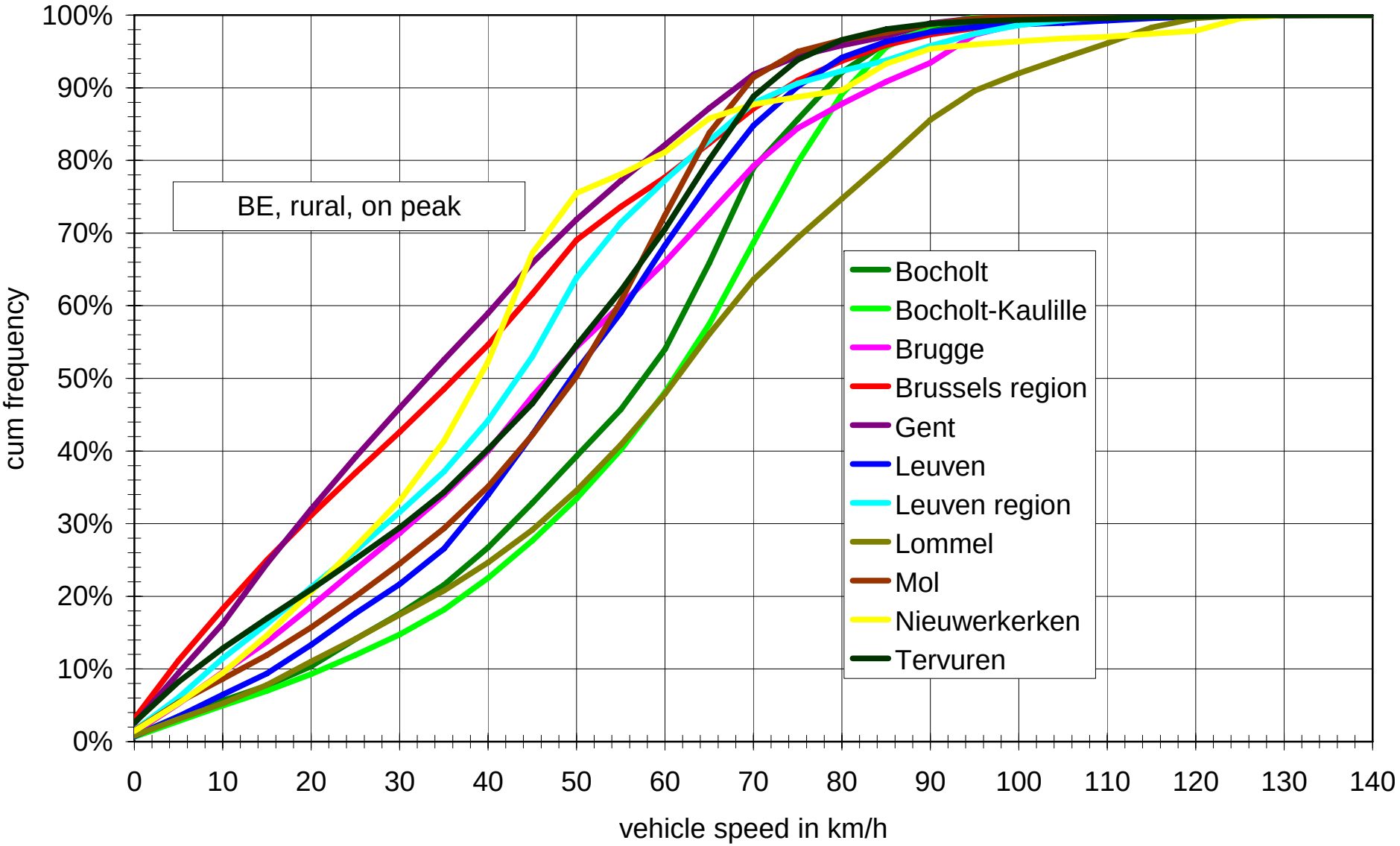


Figure 8b

# Vehicle speed distributions

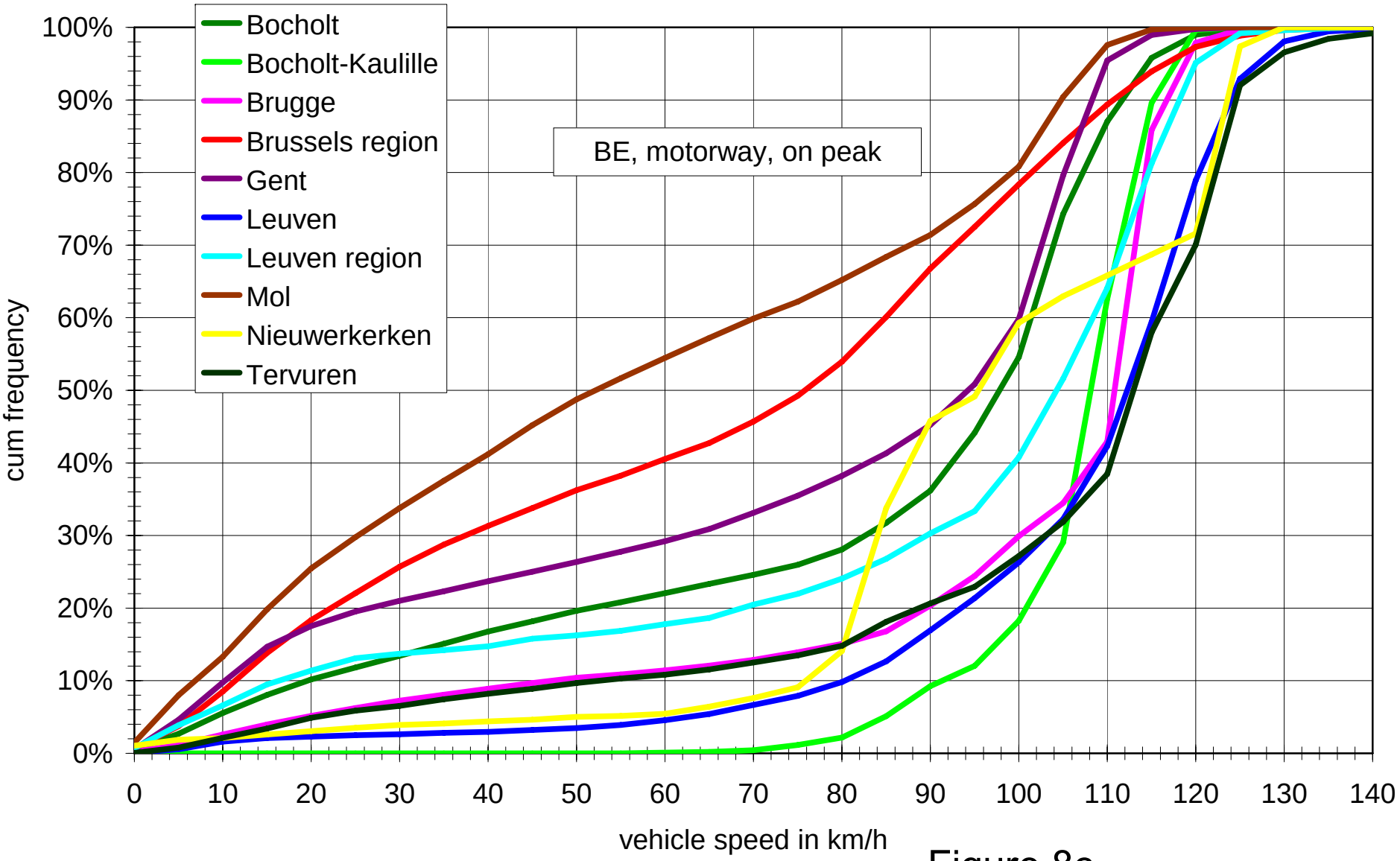


Figure 8c

# Short trip duration distributions

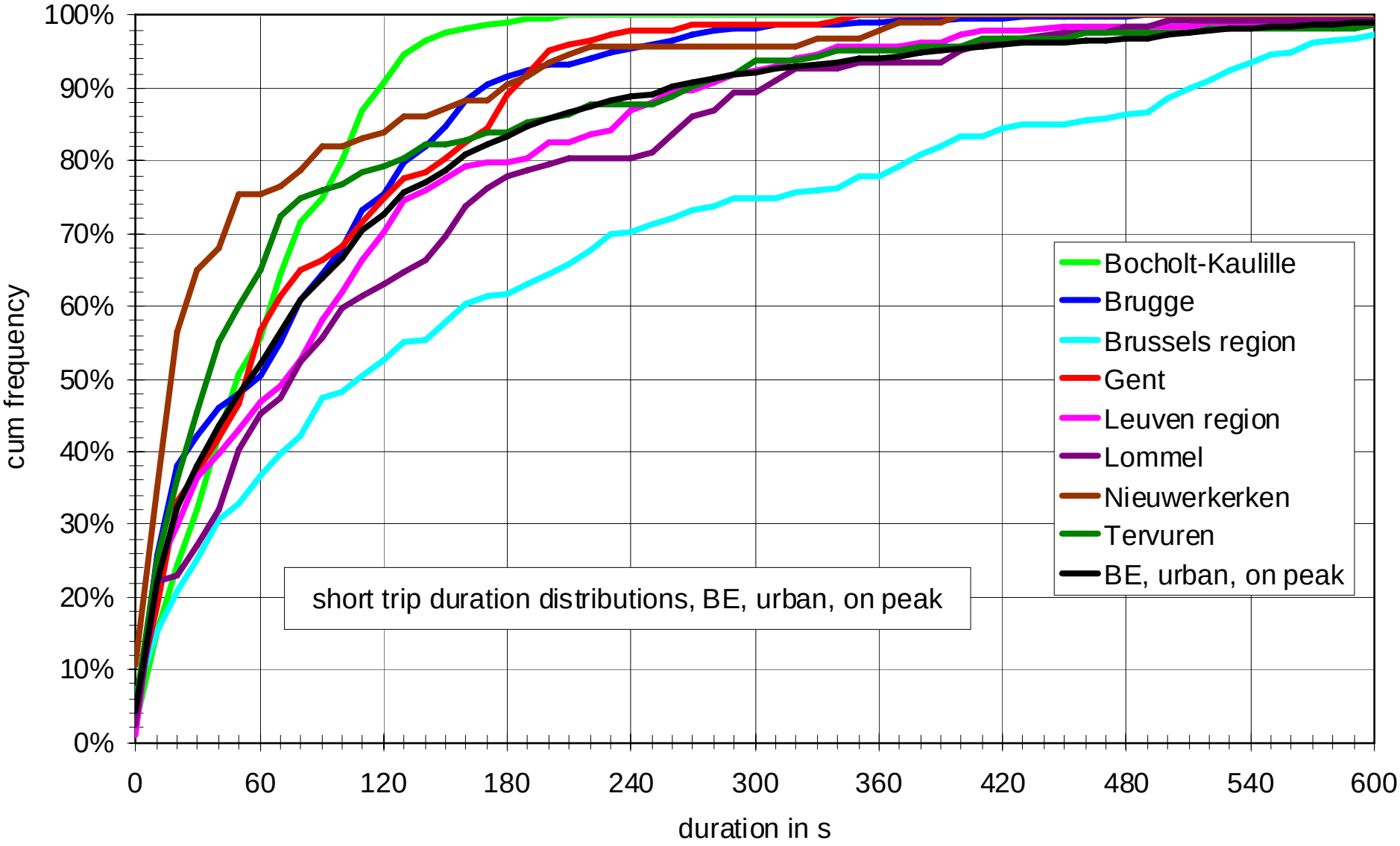


Figure 9a

# Short trip duration distributions

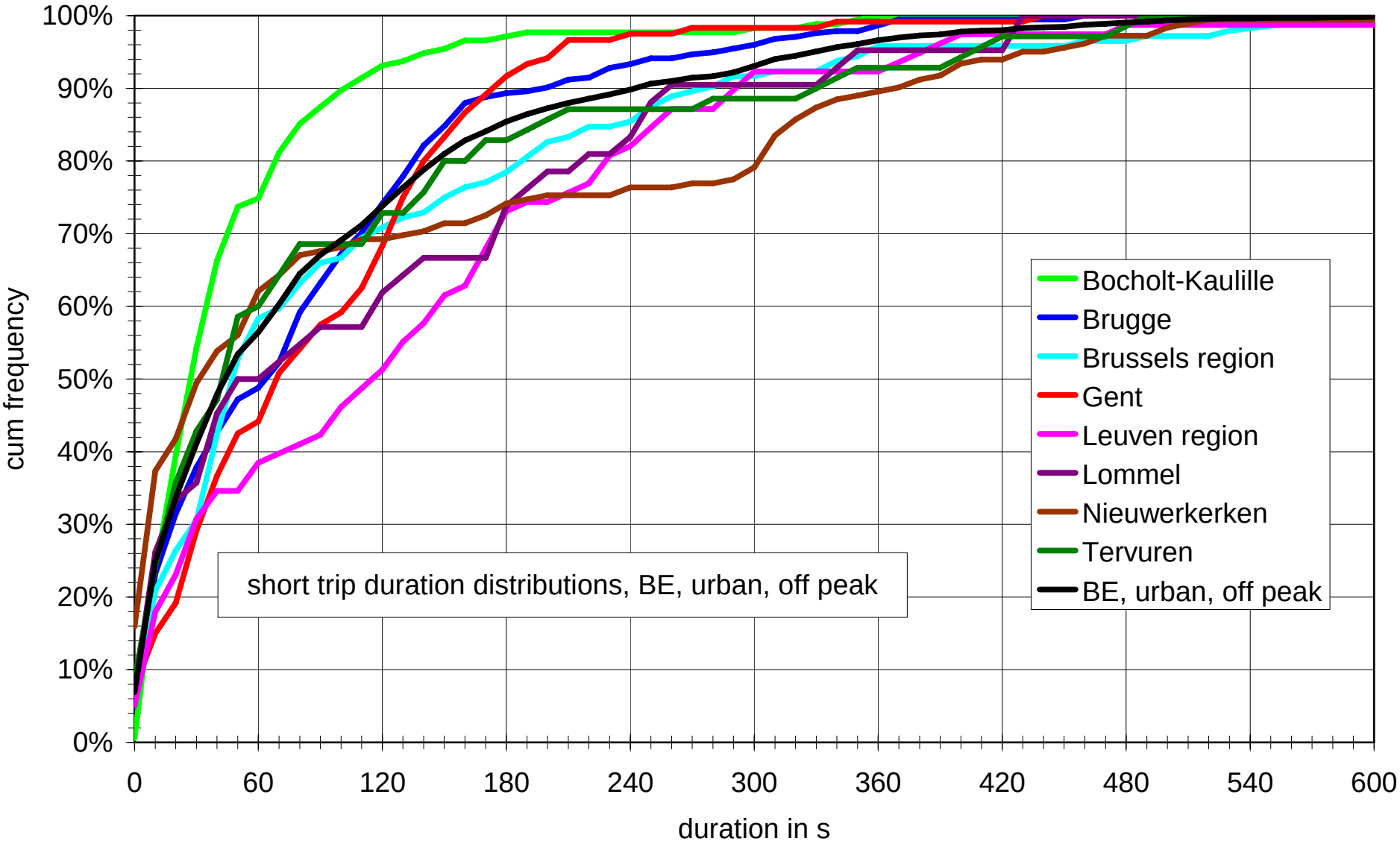


Figure 9b

# Short trip duration distributions

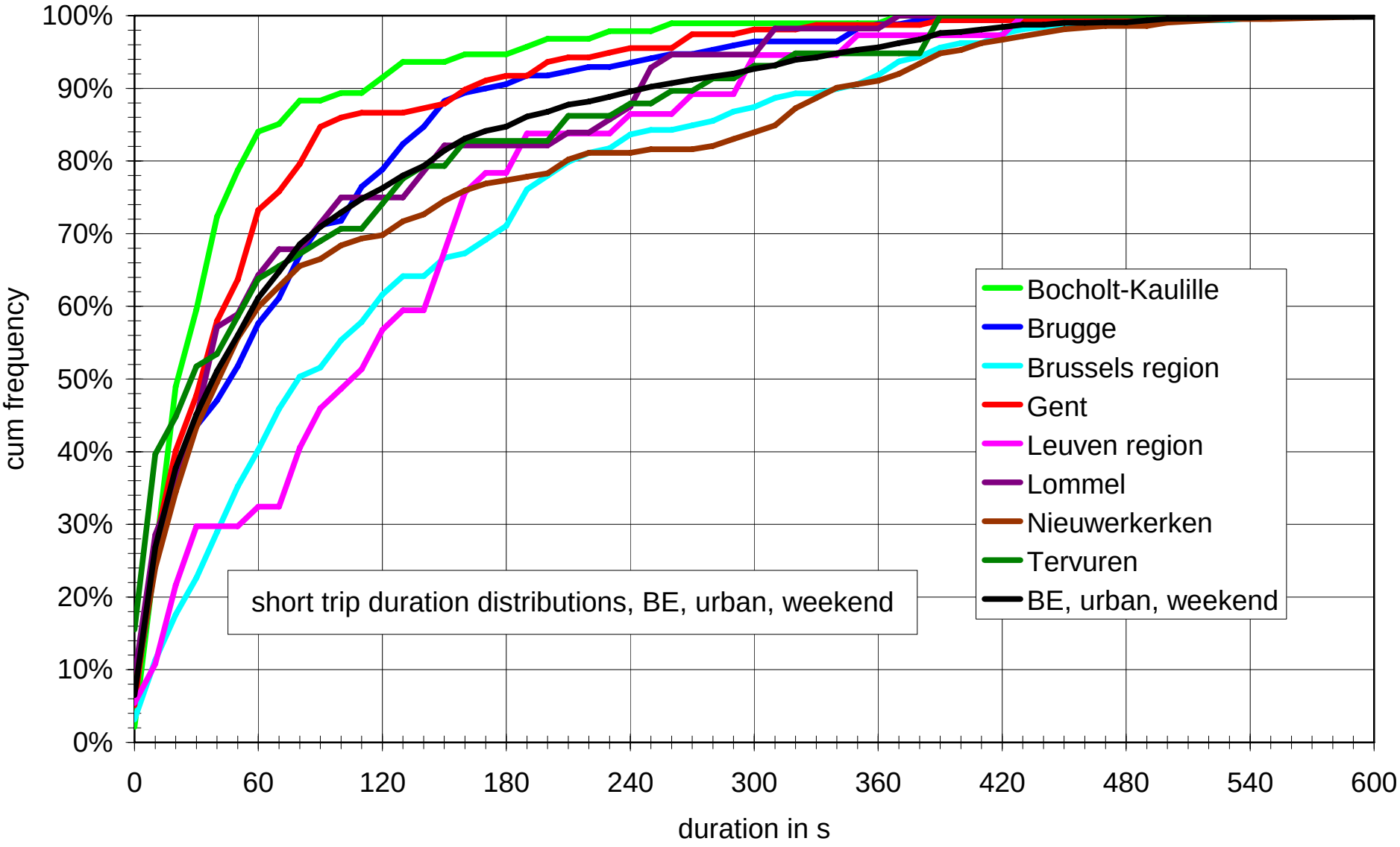


Figure 9c

# Influence of time periods


- The Swiss data could be separated into roads with different speed limits.
- Table 3 shows the average speeds and stop percentages for different cities/regions.
- Figure 10 shows the vehicle speed distribution curves for some speed limits separated for the 3 time periods.
- The influence of the time period is small compared to other influencing parameters.

# Influence of time periods


| speed limit in km/h | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|
| 30 | on peak | 14.3 | 39.6% | 23.6 | 32.8% |
| 30 | off peak | 12.9 | 44.5% | 23.3 | 47.3% |
| 30 | weekend | 14.7 | 43.8% | 26.2 | 19.8% |
| 40 | on peak | 20.1 | 29.1% | 28.3 | 34.2% |
| 40 | off peak | 18.9 | 32.6% | 28.1 | 51.9% |
| 40 | weekend | 20.6 | 27.3% | 28.3 | 13.9% |
| 50 | on peak | 25.7 | 26.1% | 34.8 | 34.2% |
| 50 | off peak | 27.5 | 22.5% | 35.5 | 51.5% |
| 50 | weekend | 29.4 | 20.5% | 36.9 | 14.3% |
| 60 | on peak | 32.2 | 20.7% | 40.6 | 34.8% |
| 60 | off peak | 35.4 | 19.1% | 43.7 | 49.8% |
| 60 | weekend | 36.2 | 19.1% | 44.8 | 15.4% |

Table 3a

# Influence of time periods


| speed limit in km/h | Period | v_ave in km/h | stop percentage | v_ave without stops in km/h | mileage distribution in database |
|---|---|---|---|---|---|
| 70 | on peak | 56.0 | 6.6% | 59.9 | 45.0% |
| 70 | off peak | 56.6 | 5.1% | 59.6 | 44.2% |
| 70 | weekend | 56.9 | 1.3% | 57.7 | 10.8% |
| 80 | on peak | 61.3 | 5.3% | 64.8 | 47.0% |
| 80 | off peak | 71.1 | 2.4% | 72.9 | 42.9% |
| 80 | weekend | 73.6 | 0.3% | 73.9 | 10.1% |
| 100 | on peak | 90.6 | 1.3% | 91.8 | 44.9% |
| 100 | off peak | 98.0 | 0.7% | 98.6 | 43.9% |
| 100 | weekend | 99.8 | 0.1% | 99.9 | 11.2% |
| 120 | on peak | 103.3 | 0.5% | 103.8 | 48.3% |
| 120 | off peak | 111.6 | 0.2% | 111.9 | 40.1% |
| 120 | weekend | 107.2 | 0.4% | 107.7 | 11.6% |

Table 3b

# Vehicle speed distributions

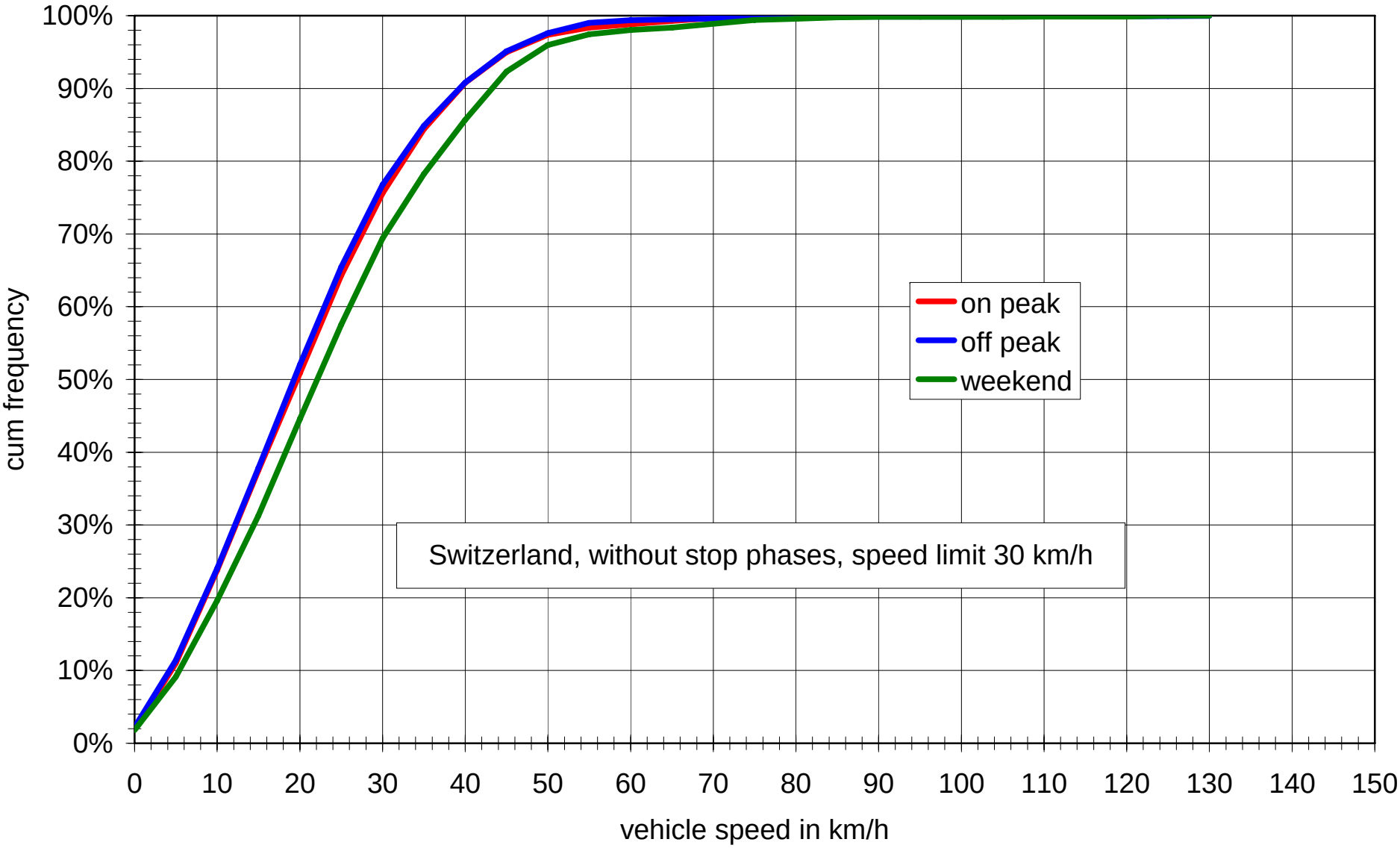


Figure 10a

# Vehicle speed distributions

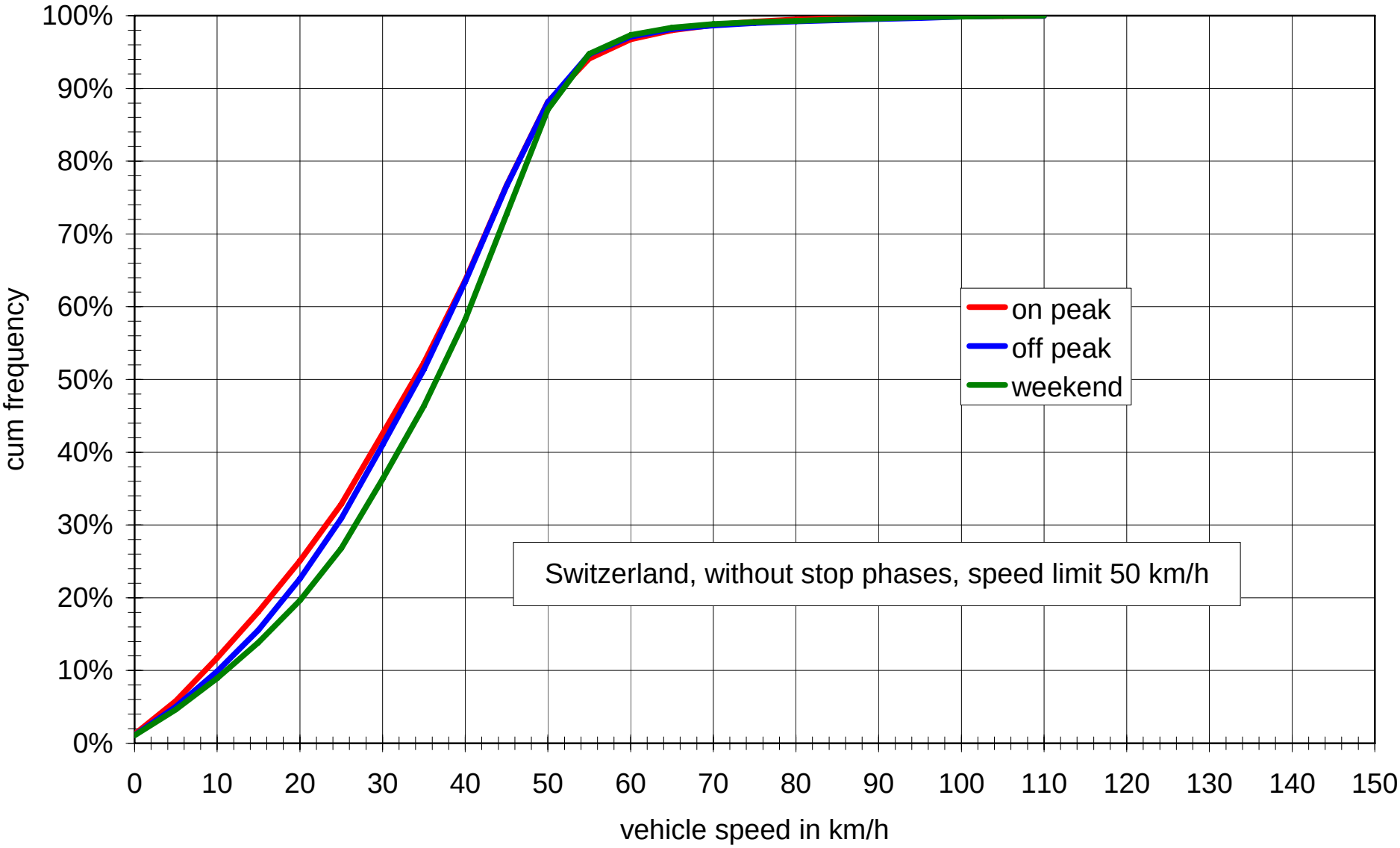


Figure 10b

# Vehicle speed distributions

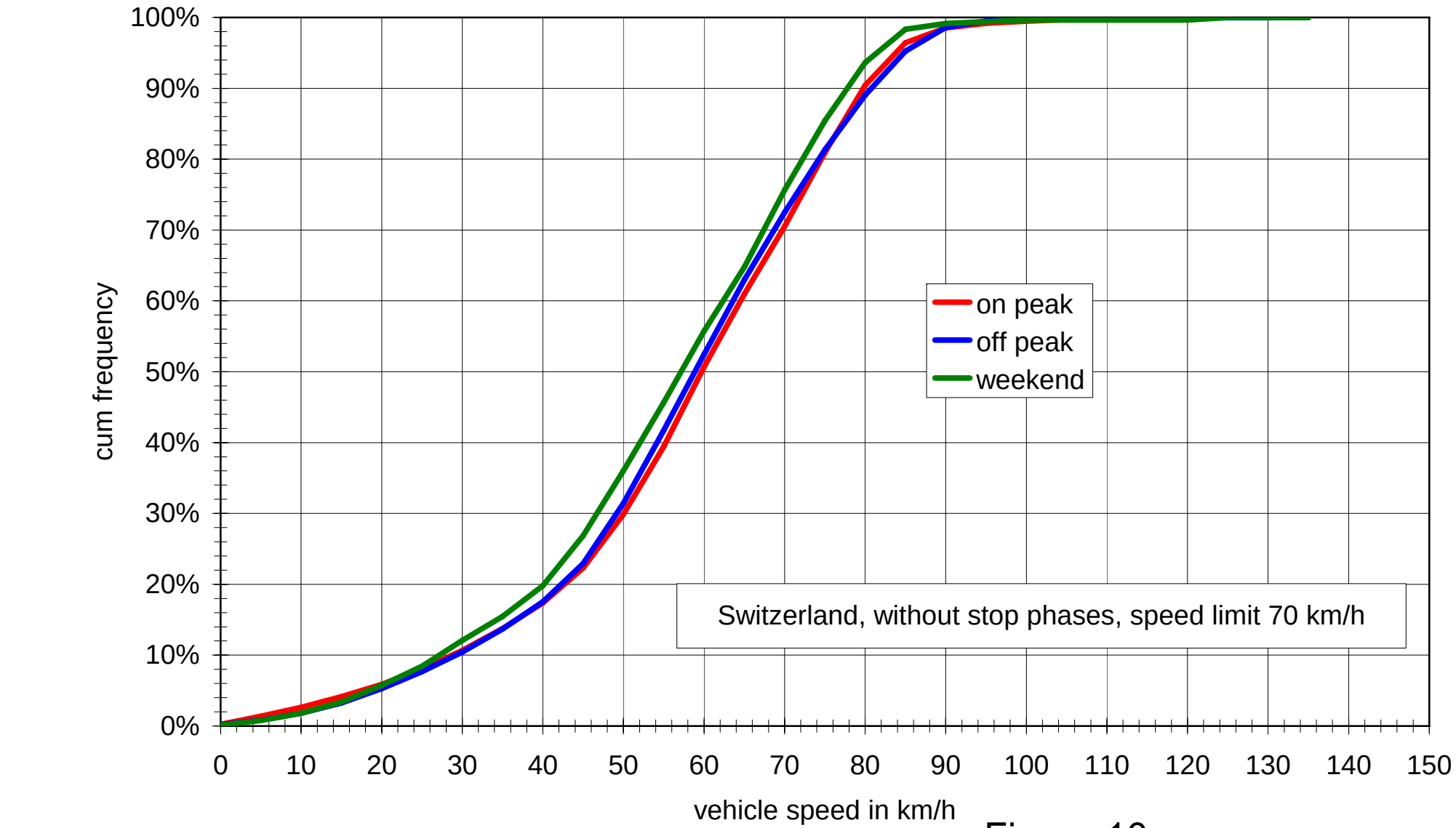


Figure 10c

# Vehicle speed distributions

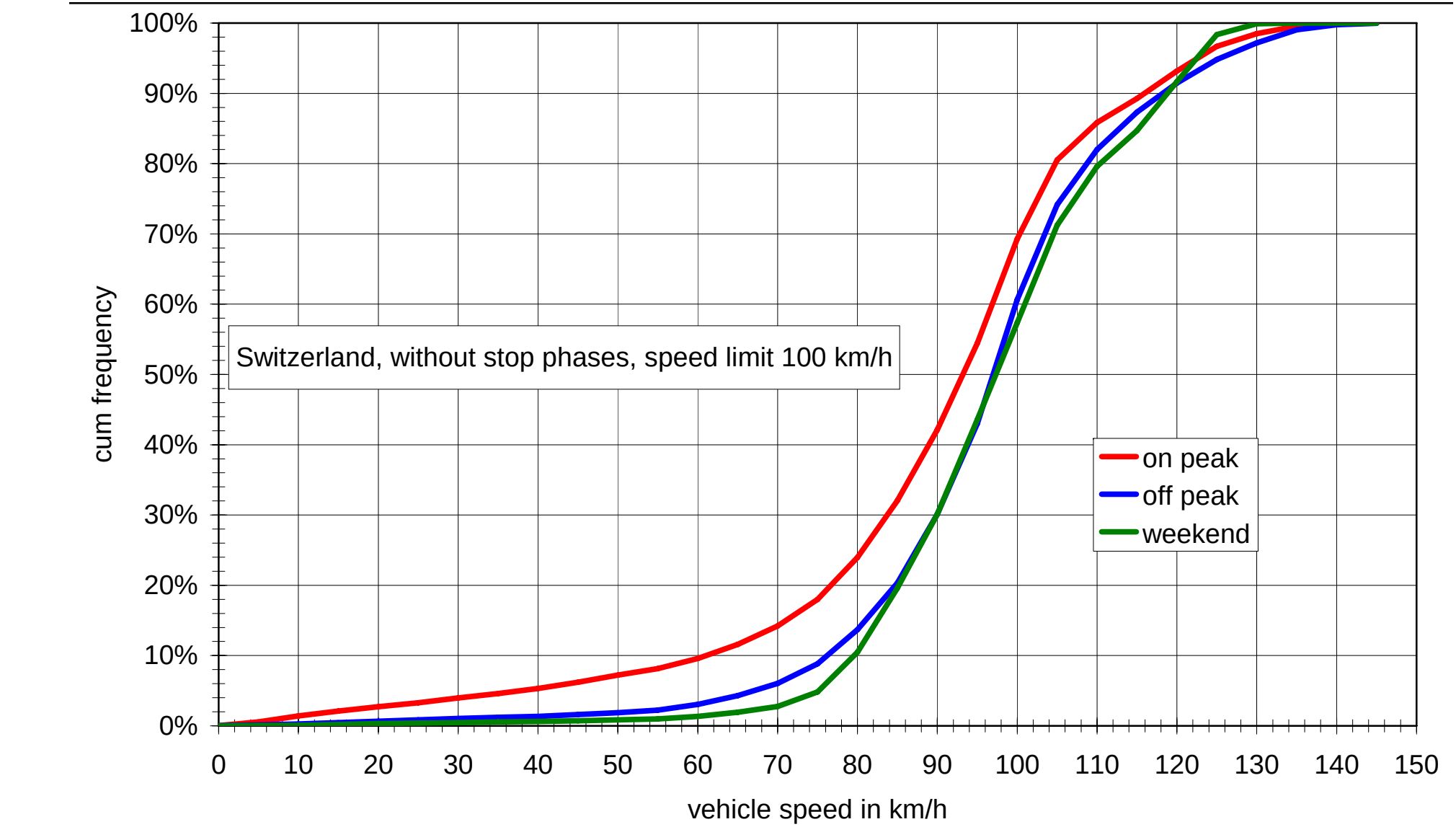


Figure 10d

# Vehicle speed distributions

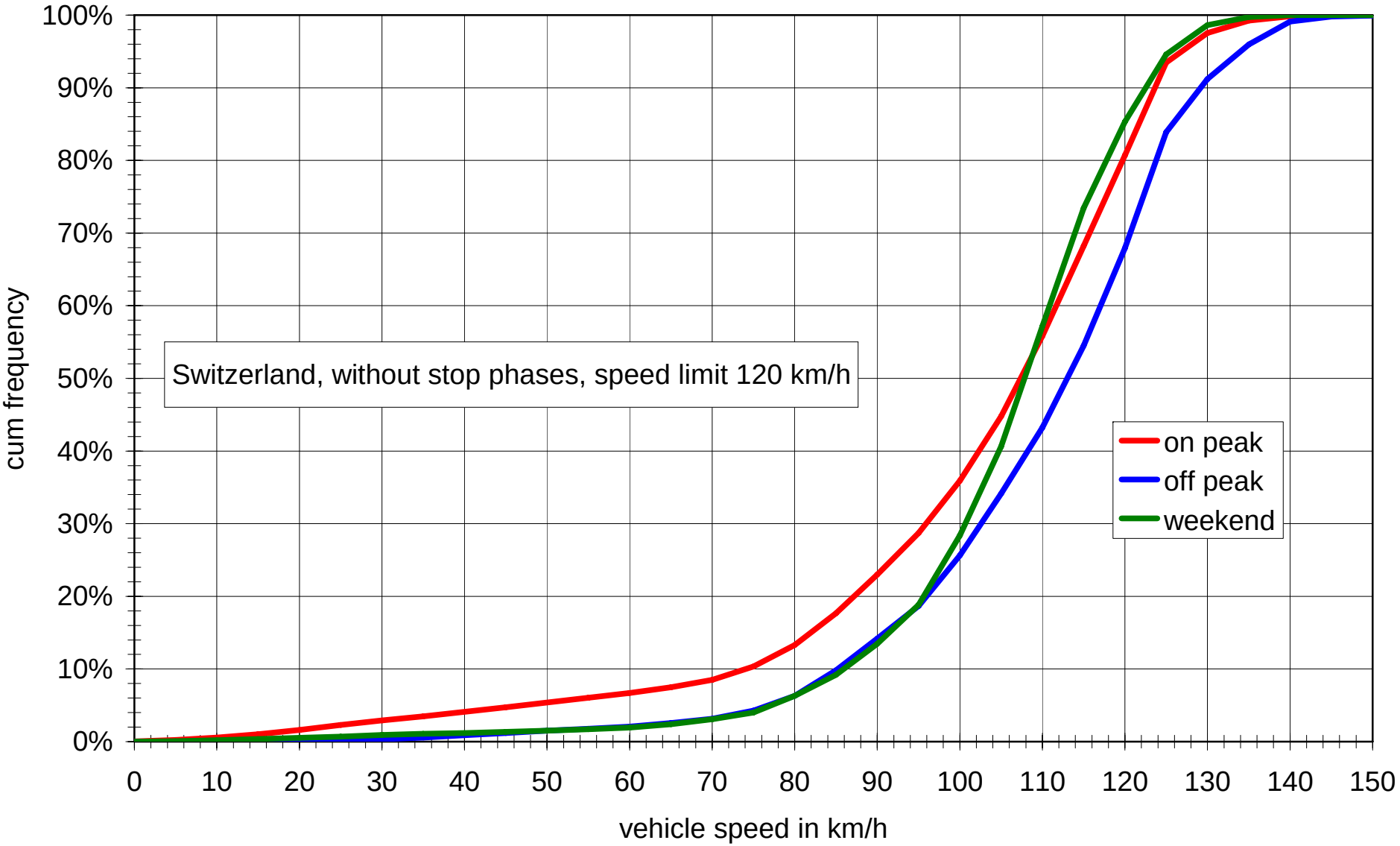


Figure 10e

# Road categories


- The second part of this presentation is dedicated to road categorization.
- The Belgium and Swiss databases contained the road category as classification parameter. For the German database this was only partly the case. The non classified parts were classified on the basis of the speed pattern design.
- There might be a risk that the categorization for different databases is based on different criteria.
- Furthermore, the main problem is caused by the fact that the road category can vary during one short trip.

# Road categories


- **The average short trip durations and distances are significantly different between the Swiss and Belgium database (see table 4).**
- **The Swiss motorway and rural short trips are significantly longer than the Belgium short trips. For urban it is the other way round.**
- **The average short trip duration values for motorway could be misinterpreted. 436 s for the BE database seems to be appropriate for a cycle length of 600 s.**
- **But this average value has nearly no shares in the database. Due to the high amount of congestion, 50% of the short trips are 200 s or shorter. 20% are 900 s or longer.**

# Short trips and road categories


| road category | average short trip duration in s | |
|---|---|---|
| | CH | BE |
| motorway | 718 | 436 |
| rural | 335 | 160 |
| urban | 70 | 96 |
| | average short trip distance in m | |
| | CH | BE |
| motorway | 18462 | 10276 |
| rural | 5964 | 2239 |
| urban | 650 | 898 |

Table 4

# Road categories


- **Table 5 shows the categorization of the short trips with respect to the number of road categories per trip.**
- **About 50%/70% of the short trips in the Belgium/Swiss database are dedicated to one road category only.**

# Short trips and road categories


| | short trip category | number | percentage |
|---|---|---|---|
| **BE** | short trips with 3 road categories | 2210 | 10.5% |
| | short trips with 2 road categories | 7857 | 37.2% |
| | short trips with 1 road category | 11070 | 52.4% |
| | total number of short trips | **21137** | **100.0%** |
| **CH** | short trips with 3 road categories | 914 | 6.0% |
| | short trips with 2 road categories | 3394 | 22.3% |
| | short trips with 1 road category | 10918 | 71.7% |
| | total number of short trips | **15226** | **100.0%** |

Table 5

# Road categories


- As already mentioned, the Swiss data can be categorized to speed limits.
- Table 6 shows the categorization with respect to the number of different speed limits per short trip.
- Less than 50% of the short trips are dedicated to one speed limit only.
- This is important, because the speed limit is one of the most important parameter for the vehicle speed pattern (see figure 10).
- Figure 11 shows the RPA values vs average speed of short trips separated for the number of speed limits per trip. Above 60 km/h nearly all trips consist of parts with different speed limits.

# Short trips and road categories


| | short trip category | number | percentage |
|---|---|---|---|
| **CH** | short trips with 9 speed limits | 2 | 0.0% |
| | short trips with 8 speed limits | 36 | 0.2% |
| | short trips with 7 speed limits | 98 | 0.6% |
| | short trips with 6 speed limits | 245 | 1.6% |
| | short trips with 5 speed limits | 395 | 2.6% |
| | short trips with 4 speed limits | 714 | 4.7% |
| | short trips with 3 speed limits | 1857 | 12.2% |
| | short trips with 2 speed limits | 4490 | 29.5% |
| | short trips with 1 speed limit | 7389 | 48.5% |
| | total number of short trips | **15226** | **100.0%** |

Table 6

# RPA versus average speed

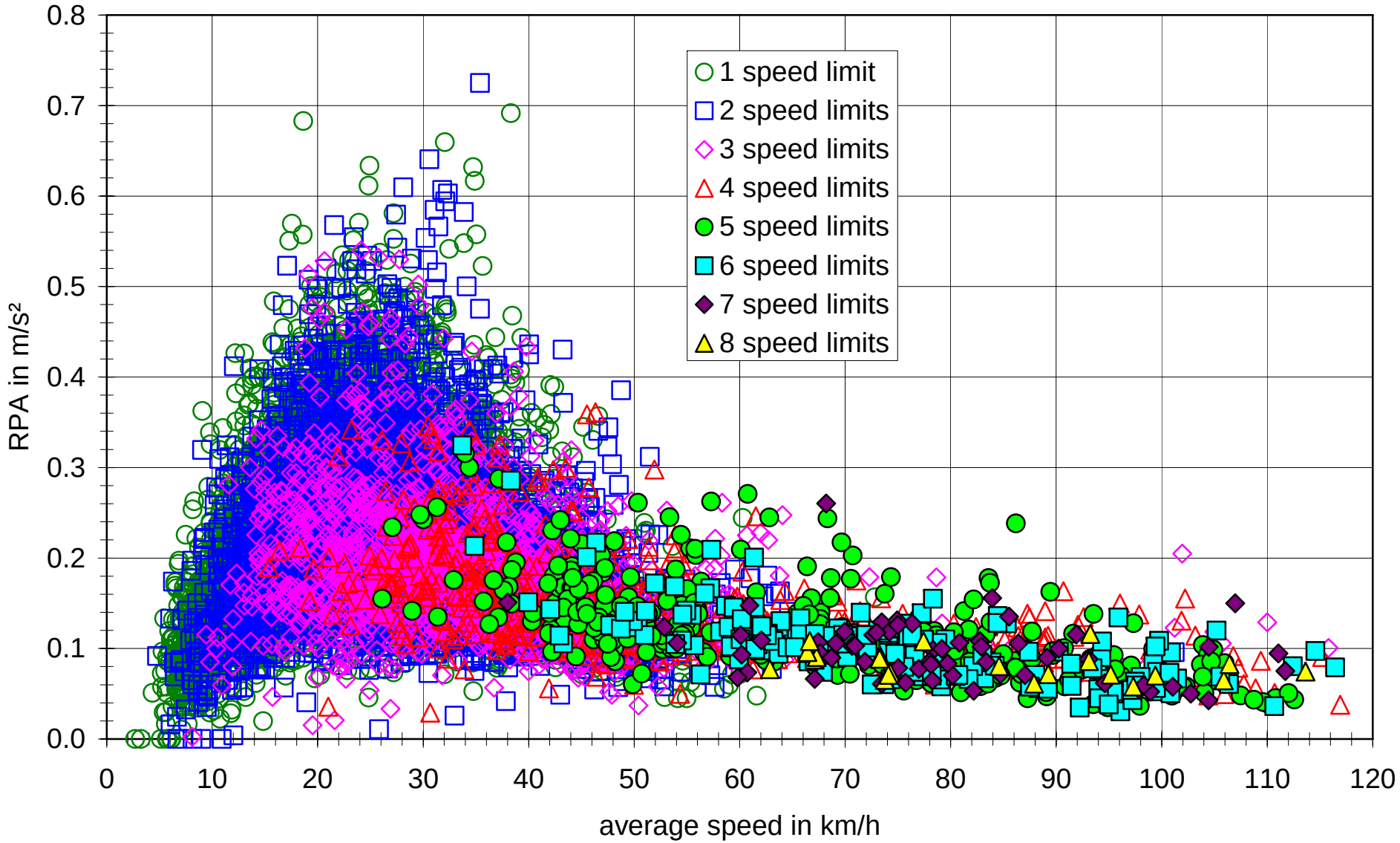


Figure 11

# Road categories


- Figure 12 shows the vehicle speed distributions of the BE, CH and DE databases.
- The smallest differences can be found for the urban parts. For the rural parts the BE and CH distributions are close together, while the DE distribution has significantly higher speeds.
- Differences in speed limits for rural roads (BE: 90 km/h, CH: 80/100 km/h, DE: 100 km/h) could be one reason.
- Another explanation is related to the classification approach. The Swiss road categorization is area based rather than speed limit based, the German categorization is speed limit based.

# Road categories


- **If the Swiss categorization would also be based on speed limit, the rural distribution curve would be shifted to significantly higher speeds, while the distribution curves for urban and motorway would be changed nearly insignificant (see figure 13).**
- **The differences in the motorway distributions reflect the differences in speed limit (BE and CH: 120 km/h, DE: no general speed limit).**
- **The differences between the BE and CH motorway distributions in the speed range below 80 km/h reflect the fact that the BE distribution contains much more congestions than the Ch distribution (see figure 14).**

# Vehicle speed distributions

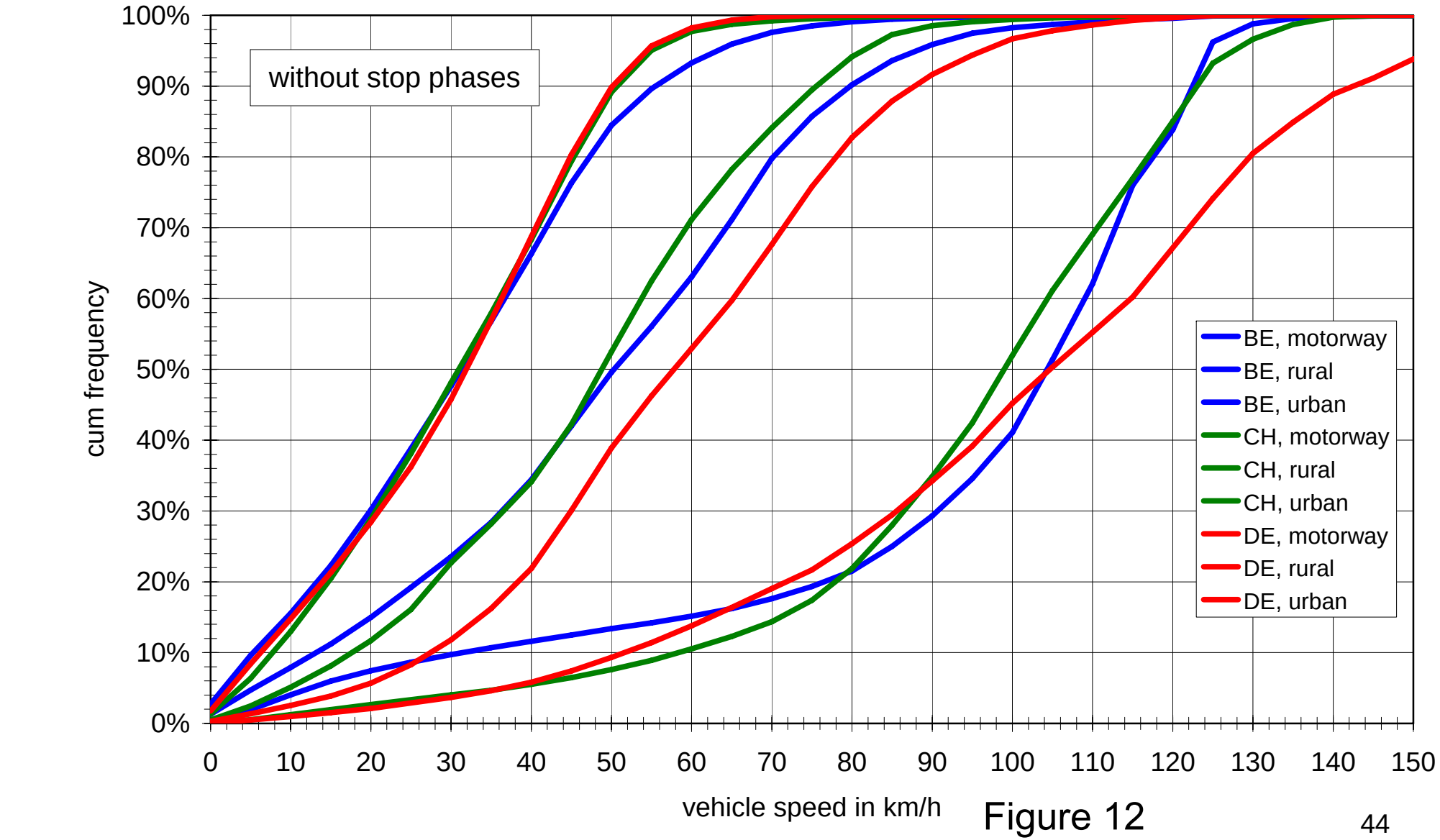


Figure 12

# Vehicle speed distributions

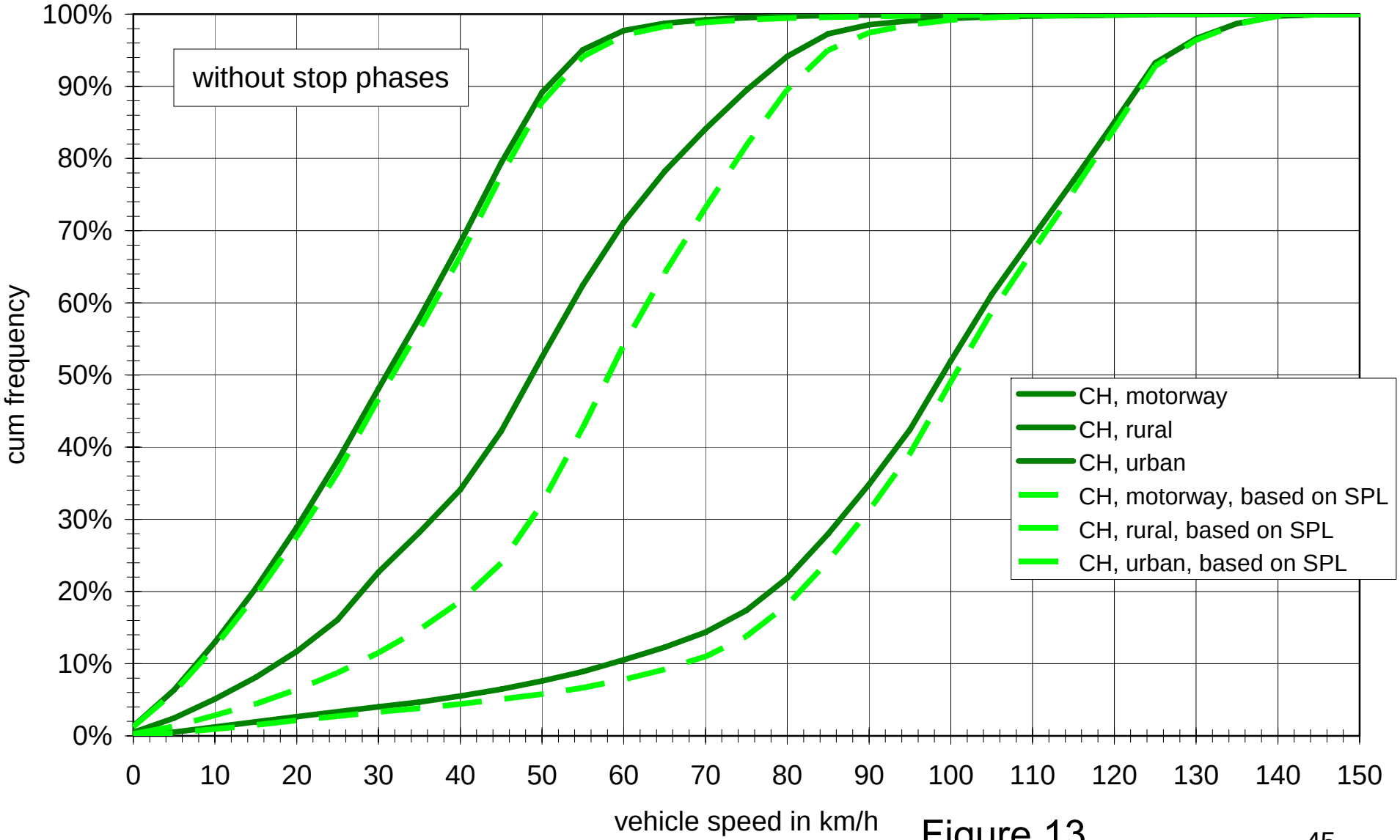


Figure 13

# RPA versus average speed

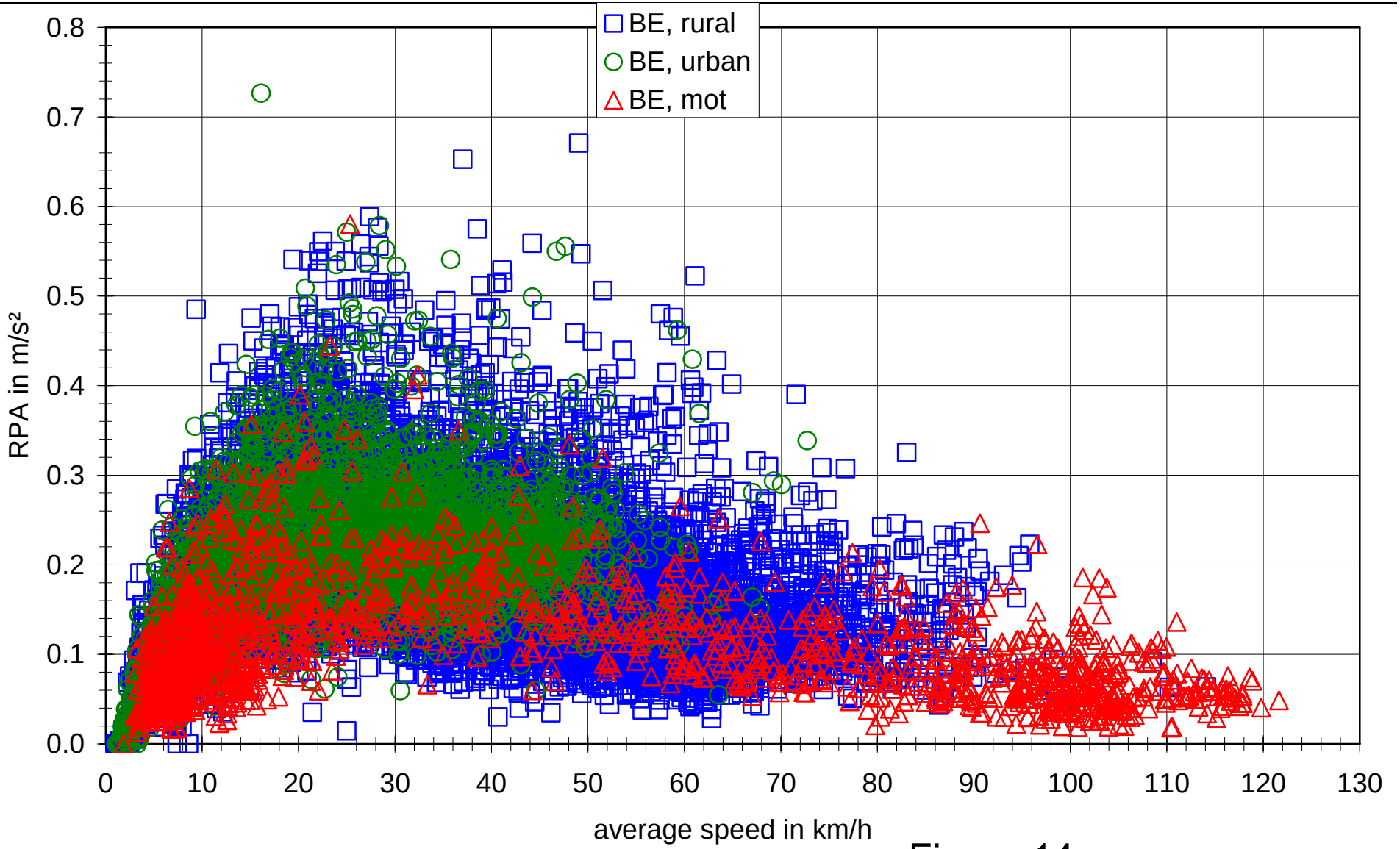


Figure 14a

# RPA versus average speed

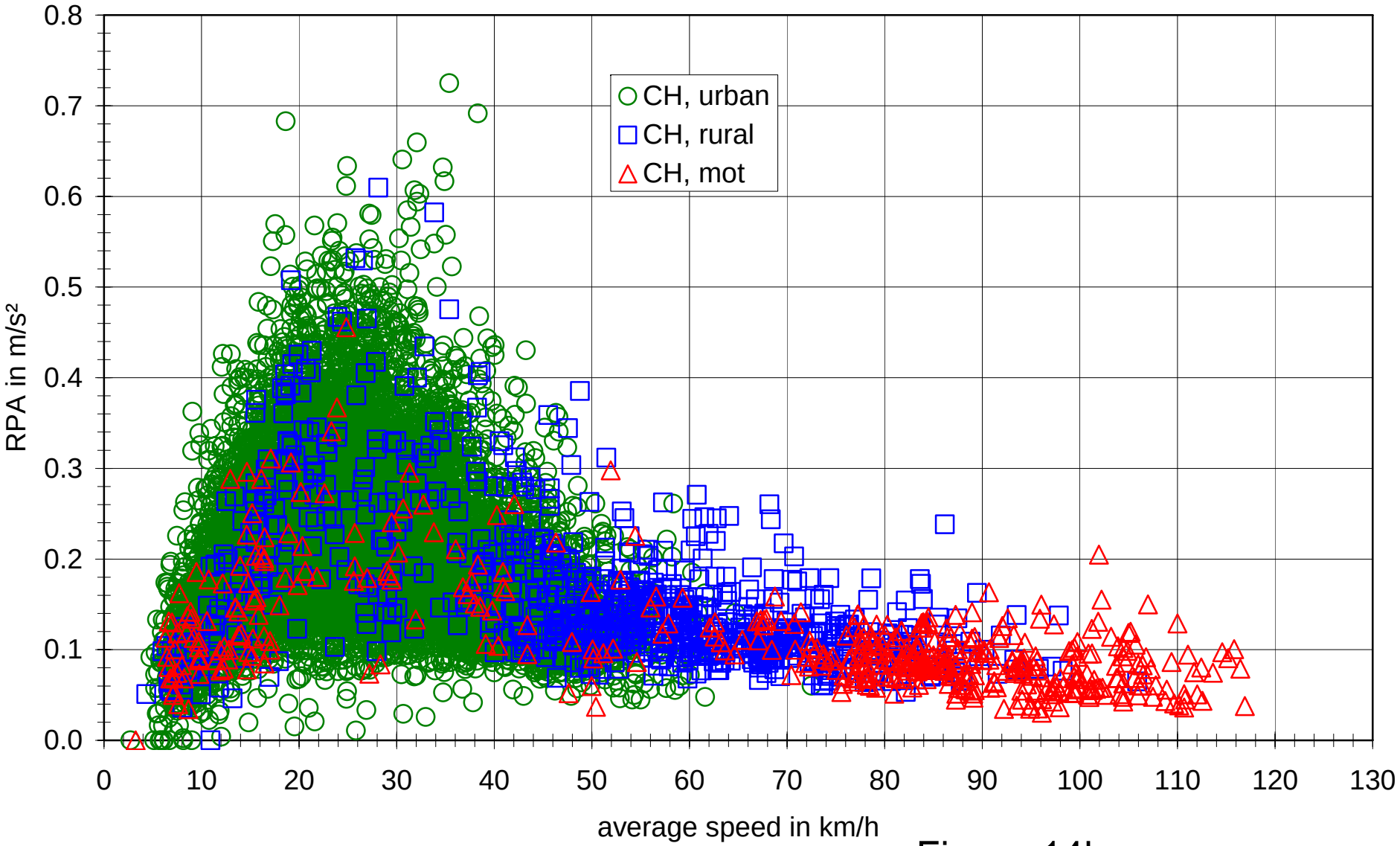


Figure 14b

# Vehicle speed categories


- In order to overcome the problems outlined in the previous pages the Japanese colleagues propose to replace “urban”, “rural” and “motorway” by “low”, “medium” and “high” speed ranges and base the categorization on the maximum speed of the short trips.
- This approach can be supported in principle, but it needs to be assessed where the appropriate borderlines would be for Europe and whether v_max is sufficient as discriminator.
- In order to enable a first assessment, v_max was plotted versus v_ave for the BE and Ch databases (see figure 15)

# Max. speed versus average speed

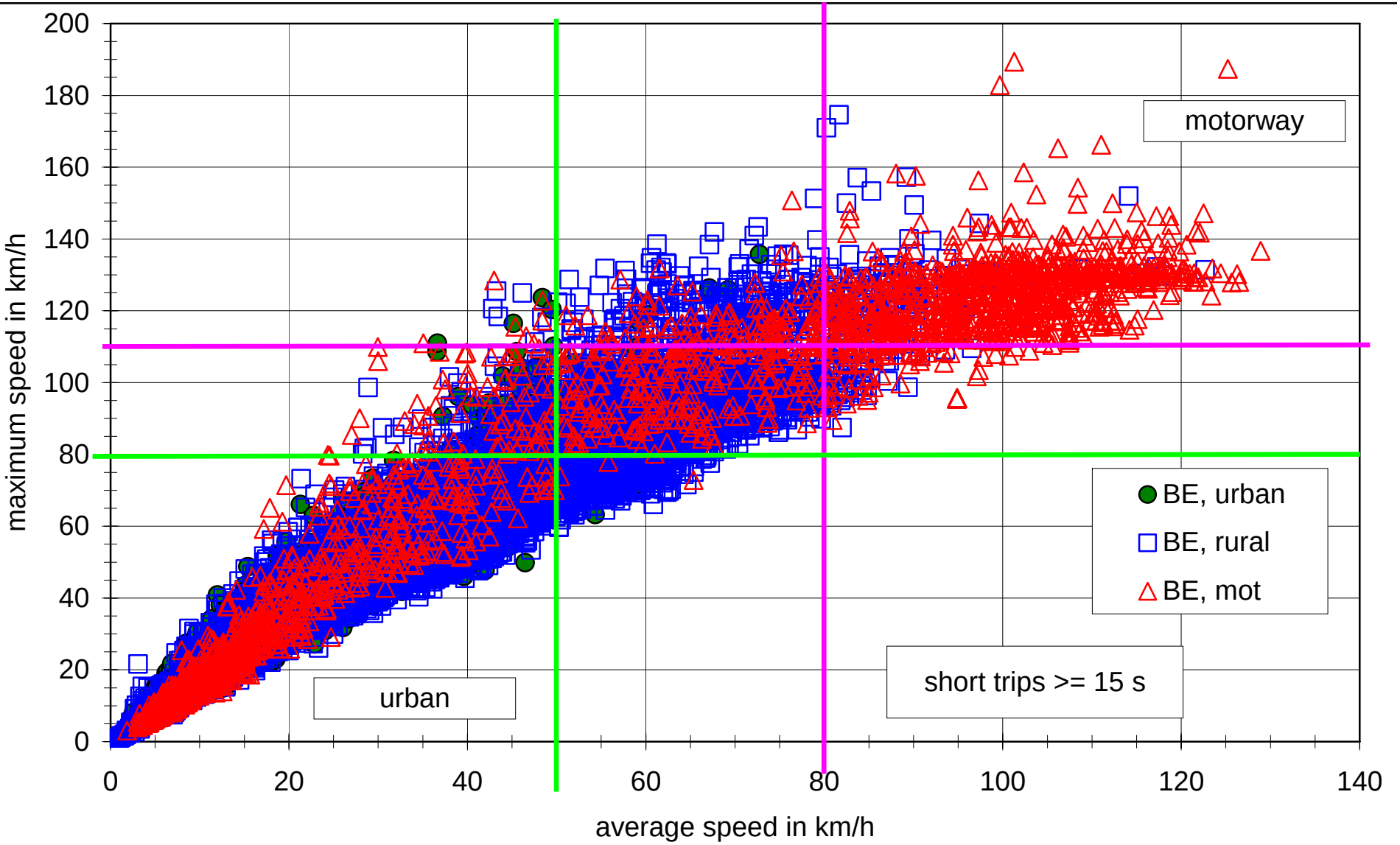


Figure 15a

# Max. speed versus average speed

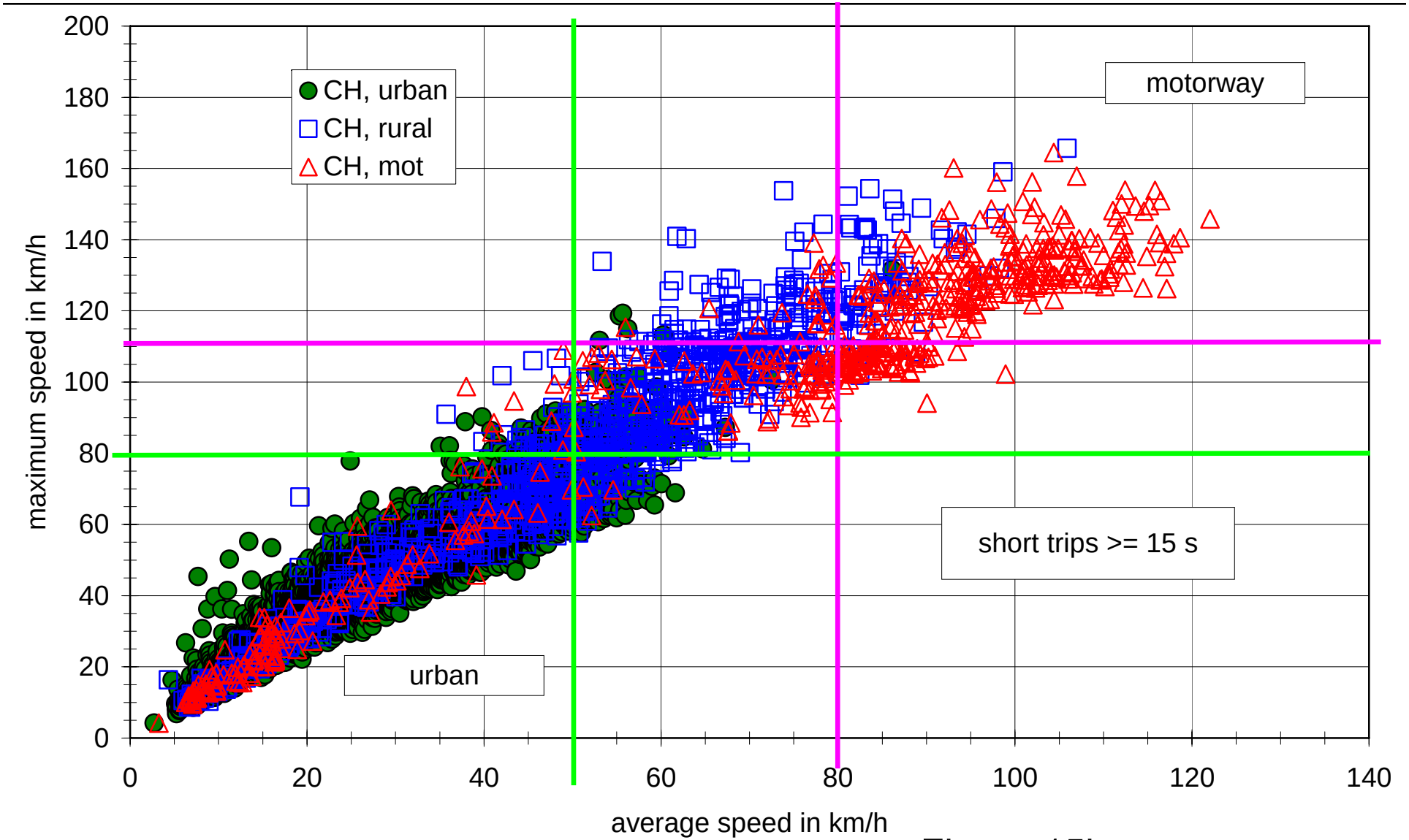


Figure 15b

# Vehicle speed categories


- A first calculation was performed using a combination of v_max and v_ave borderlines.
- In addition 2 scenarios were calculated based on v_max borderlines only.
- In figure 16 the results are compared to the original distributions.
- The combined scenario and the v_max scenario with 70 km/h and 110 km/h borderlines lead to good agreement with the original distributions for urban and motorway, but shift the rural distribution to higher speeds.

# Vehicle speed categories


- **The v_max scenario with 60 km/h and 100 km/h borderlines lead to good agreement with the original distributions for rural but shifts the distributions for urban and motorway to significantly lower speeds.**
- **The v_max scenario with 70 km/h and 110 km/h borderlines could be an acceptable compromise.**

# Vehicle speed distributions

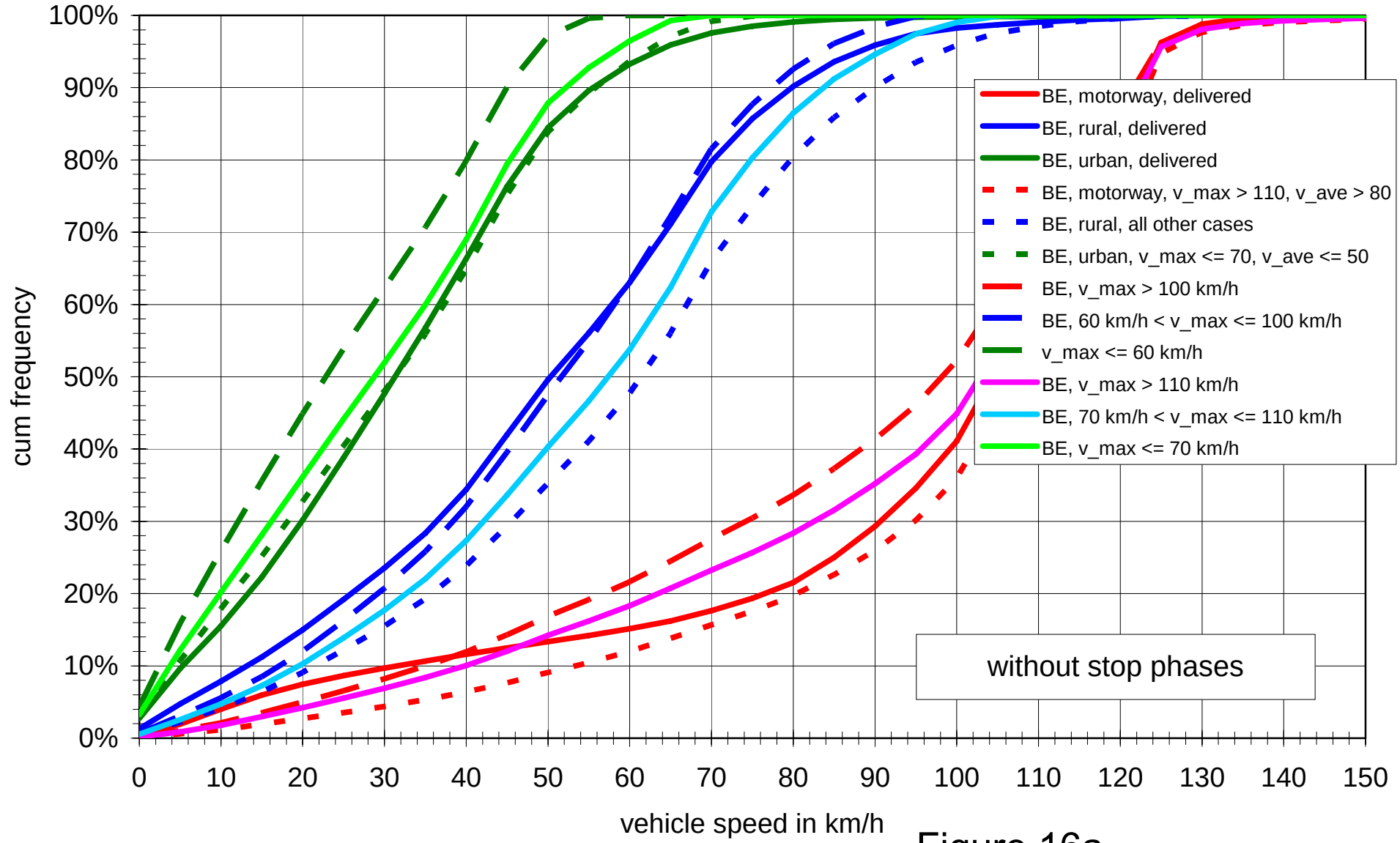


Figure 16a

# Vehicle speed distributions

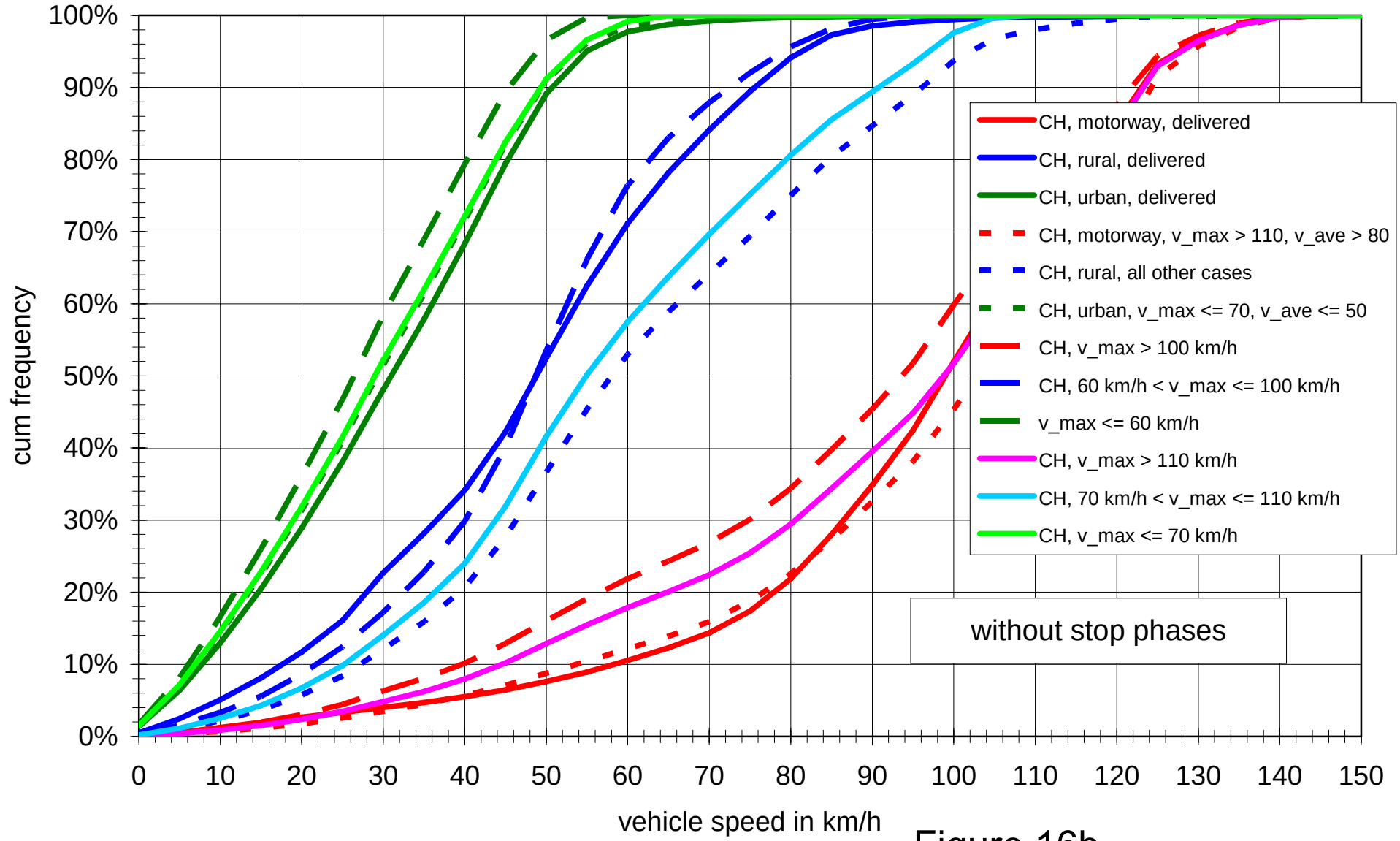


Figure 16b

# Vehicle speed categories


- **Figure 15 shows that the maximum speed of 120 km/h on motorways is exceeded by a significant number of short trips in Belgium as well as in Switzerland.**
- **For the Swiss database could be checked whether tis is also the case for rural and urban roads, since the speed limit is known.**
- **Figure 17 shows the results for speed limits between 30 km/h and 120 km/h.**
- **The time percentages for a transgression of the speed limit varies between 10% and 30%. The lowest rates were found for speed limits between 40 and 60 km/h, the highest for rural roads and motorways.**

# Vehicle speed distributions

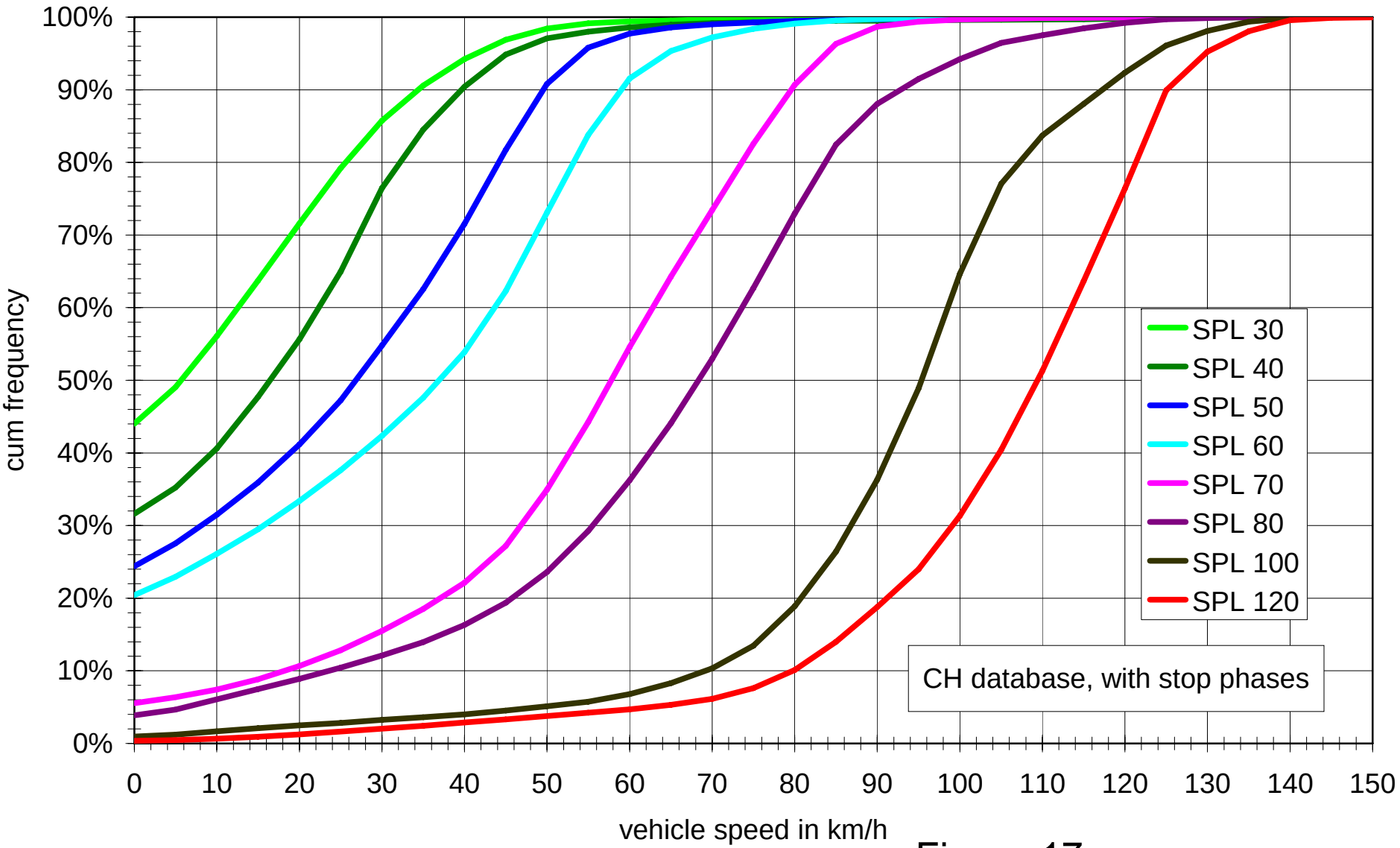


Figure 17a

# Vehicle speed distributions

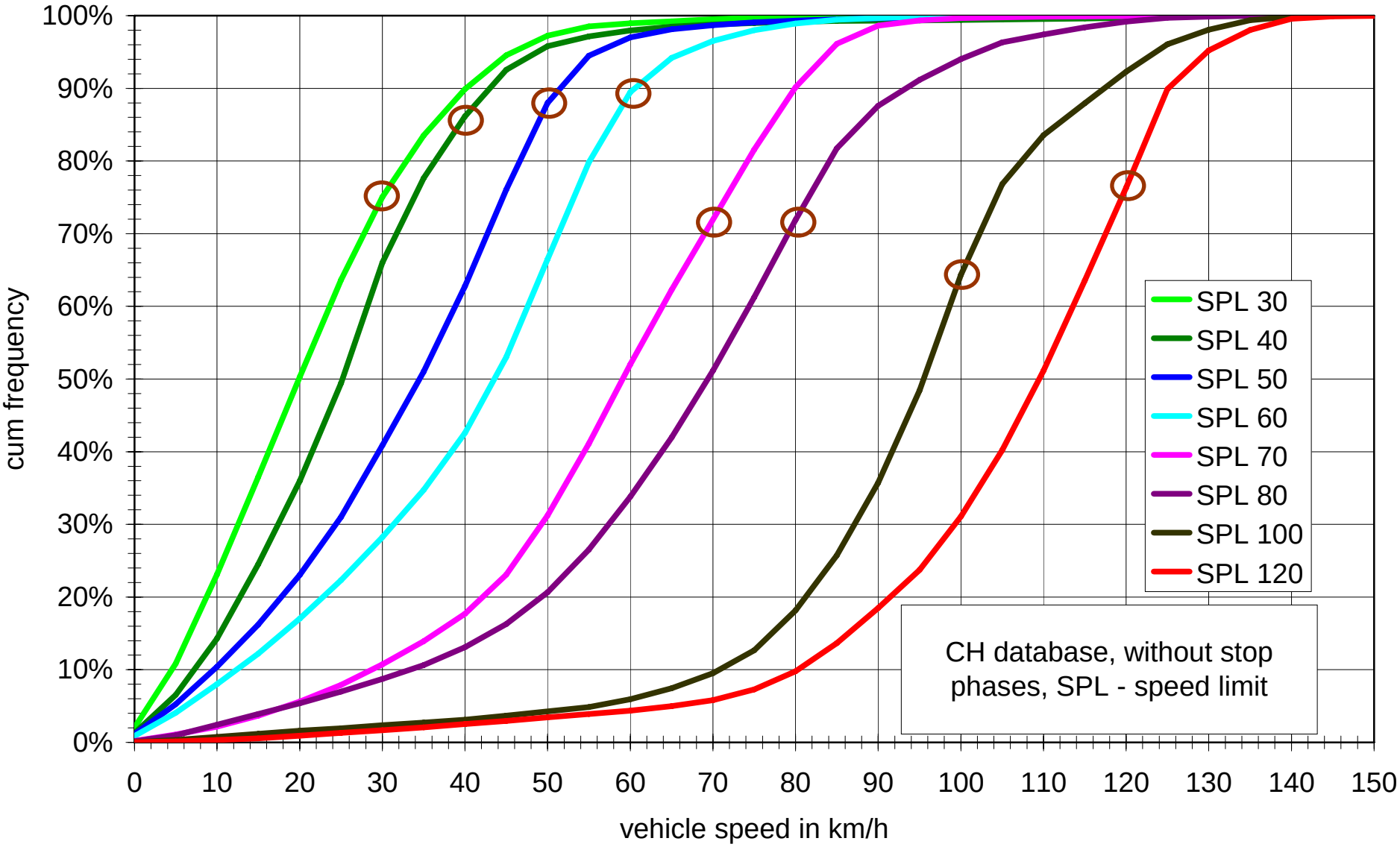


Figure 17b

# Conclusions


- **Concerning the time periods “on peak”, “off peak” and “weekend” the differences in vehicle speed distributions as well as short trip and stop phase duration distributions are smaller than the differences between locations/databases or cities/regions within one country.**
- **Even the RPA values show a high overlap between the time periods.**
- **The Belgium data shows that “off peak” in one city/region could be “on peak” in another city/region and vice versa.**

# Conclusions


- **Furthermore, since it is difficult to get reliable statistical mileage data for the different time periods and since there is sufficient overlap between the time periods with respect to the dynamics of the short trips, it is recommended to skip this parameter.**
- **Regarding the road categorization the problems are outlined and the Japanese proposal for an alternative categorization based on the maximum speed of the short trips was assessed.**
- **The v_max scenario with 70 km/h and 110 km/h borderlines was found to be an acceptable compromise for European data.**

# Conclusions


- **The Swiss data enabled an assessment of the compliance rate with speed limits.**
- **The time percentages for a transgression of the speed limit varies between 10% and 30% of the driving time. The lowest rates were found for speed limits between 40 and 60 km/h, the highest for rural roads and motorways.**
- **An analysis of in-use driving behaviour data from the US and China, whose results cannot be presented yet, confirm/support the above stated conclusions.**