Data analysis and modelling at SBB

Eress Forum
June 13th, 2018
Rome

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a) Temperature
b) Height difference (potential energy)
c) Train weight
d) Length of train run
e) Speed
f) Precipitation
g) Traction type
h) Wind speed
i) Characteristics of line (topology)
j) Traffic situation
k) Other

*traction type: vehicles with equal driving dynamics characteristics.

What do you consider the three most relevant factors for energy consumption?

Traction type

Train category

Weight

Train run length

Height difference

Wh/gtkm per traction type* and train category

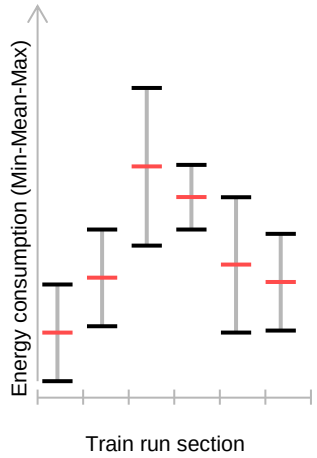
gross ton kilometers (gtkm)

height coefficient

Model

– will calculate substitute and validation values individually per train run

Energy consumption per section



Analysis of metering data allows improved modelling of energy consumption.

Traction type

Train category

Weight

Train run length

Height difference

Wh/gtkm per traction type* and train category

gross ton kilometers (gtkm)

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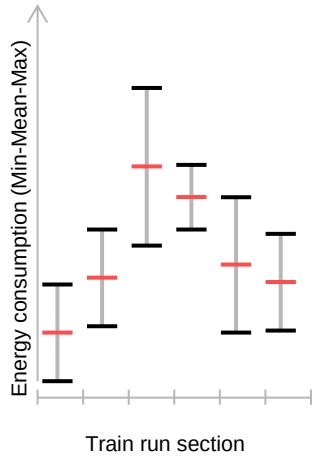
Energy consumption per section

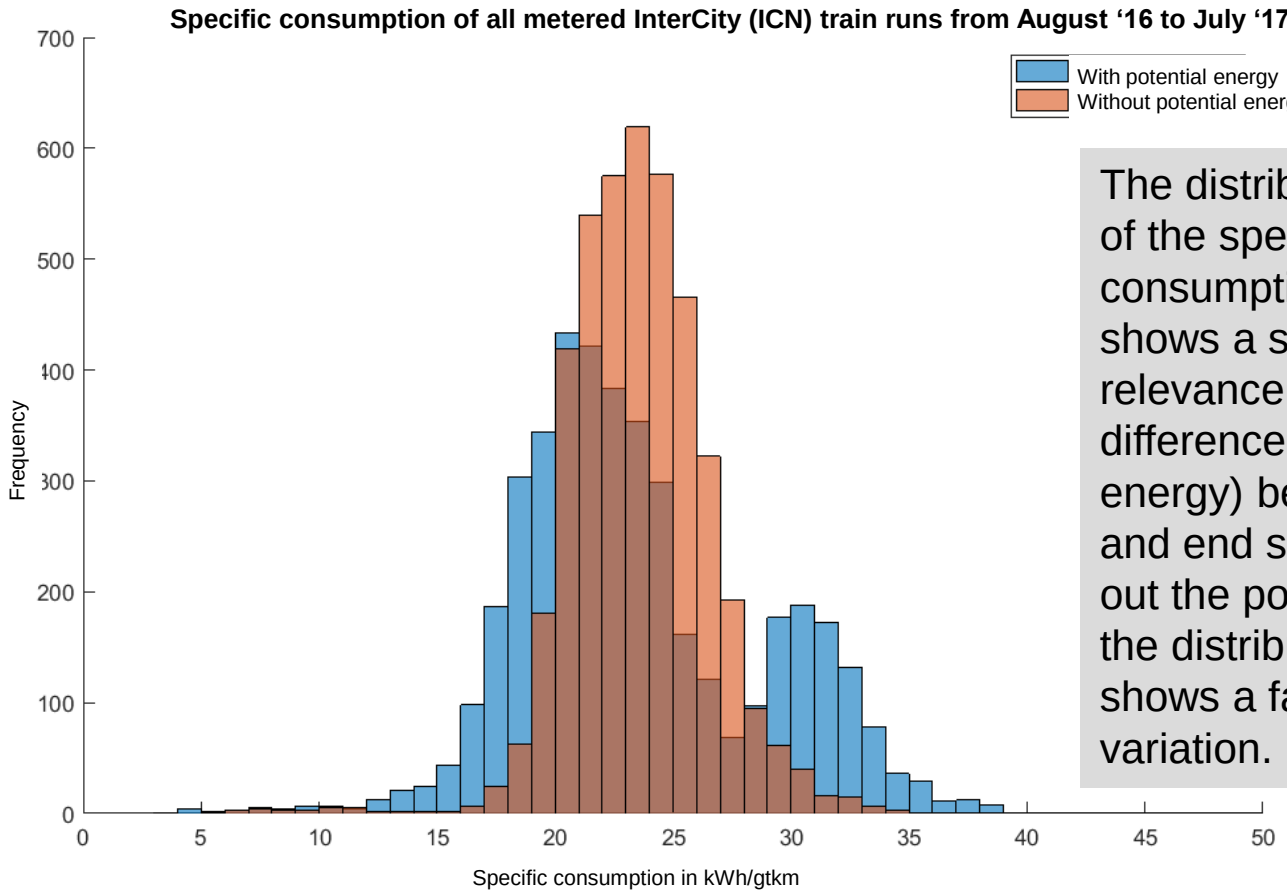


Temperature

Line Charac-teristics

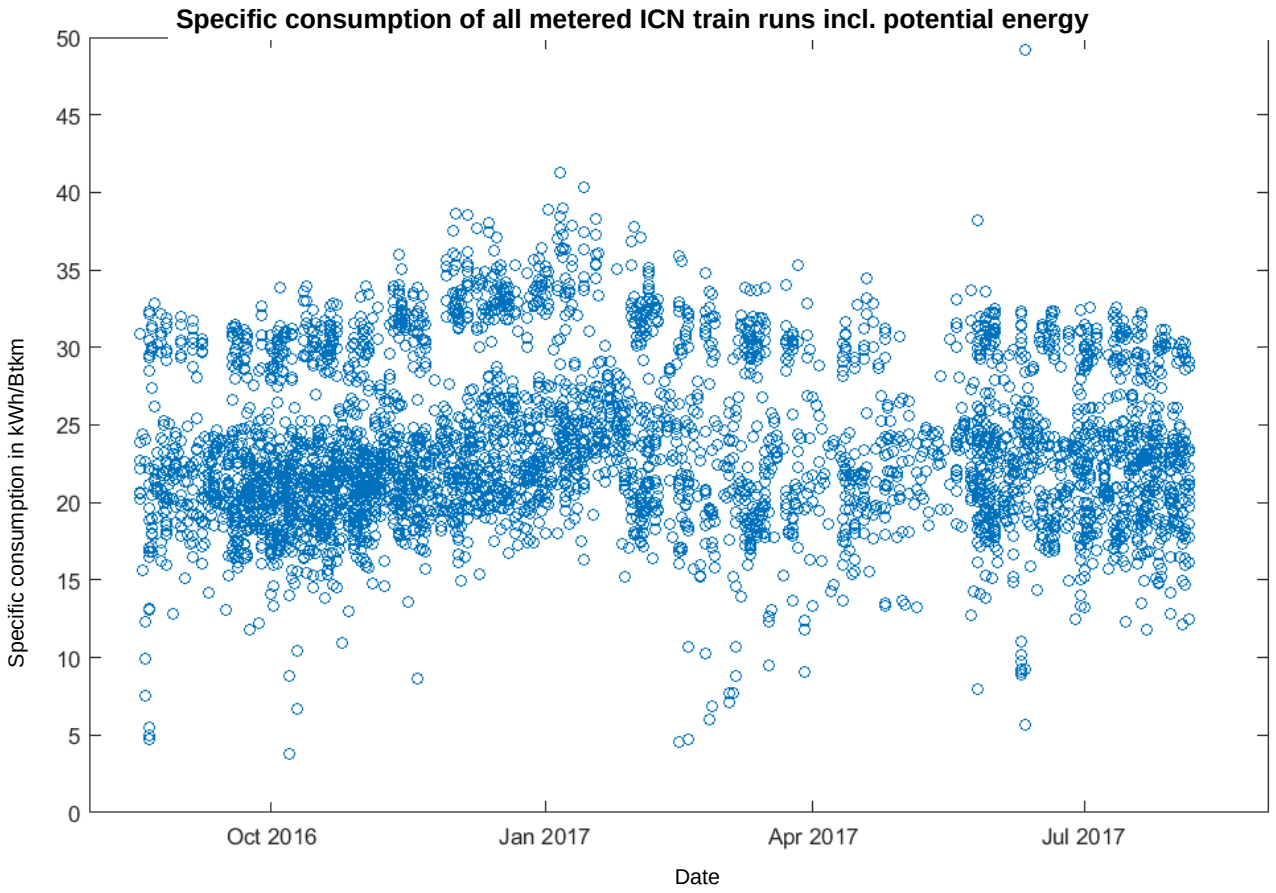
Precipitation

More factors might be added in future.



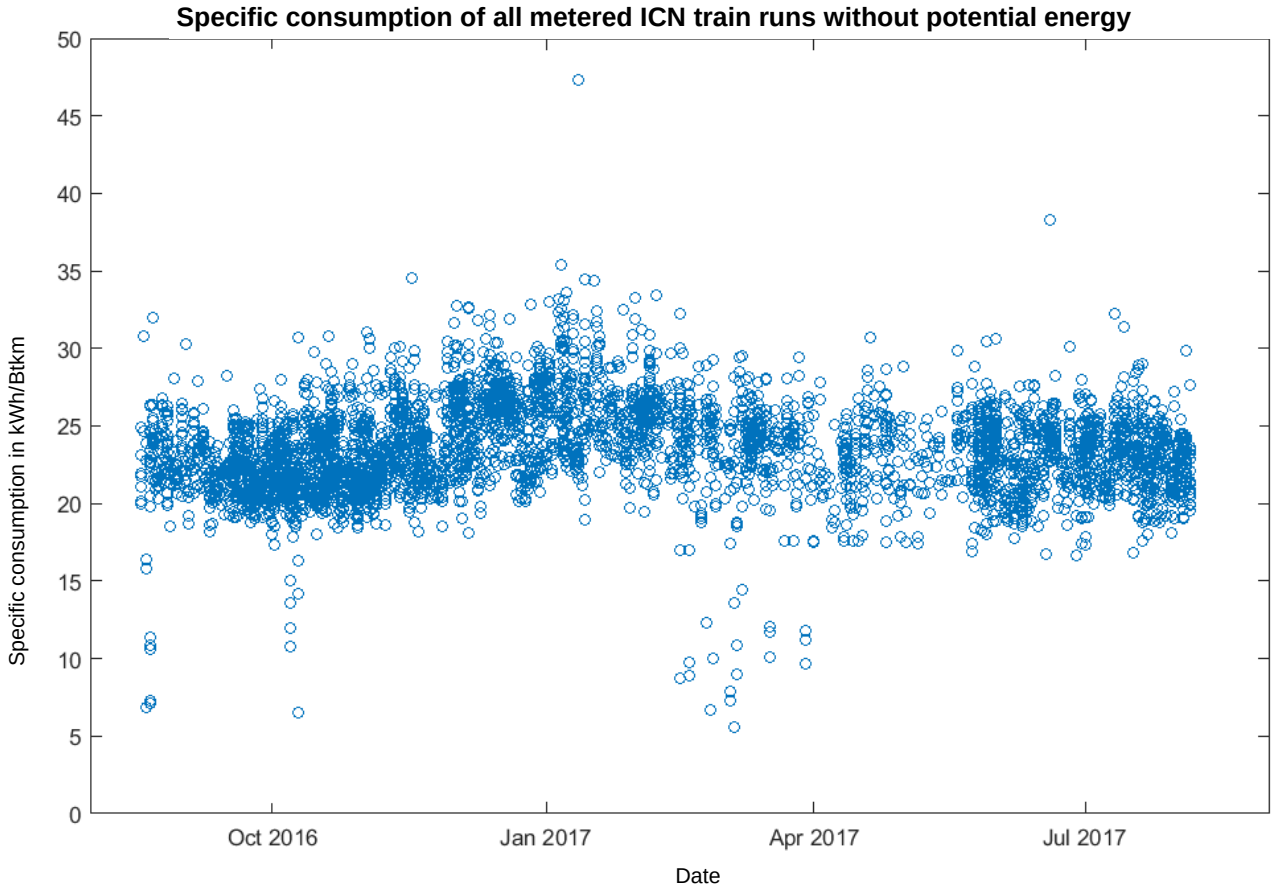
The distribution of the specific consumption values shows a strong relevance of the height difference (potential energy) between start and end station. Taking out the potential energy the distribution shows a far smaller variation.

Height difference between start and end station has significant influence on energy consumption.



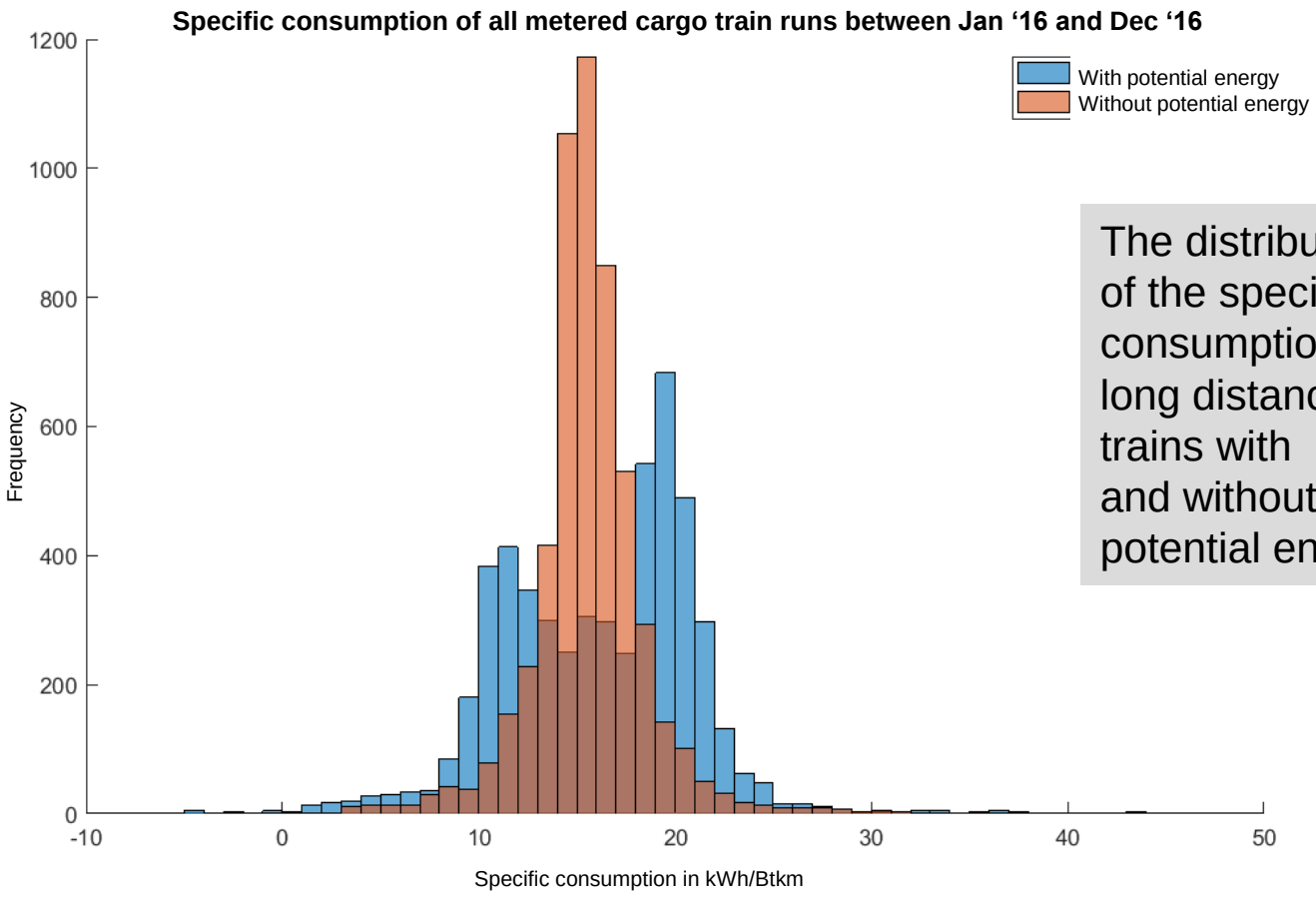
Pattern over time of the specific consumption incl. potential energy. The two «bands» are caused by the potential energy.

Uphill and downhill runs show a significantly different energy consumption.



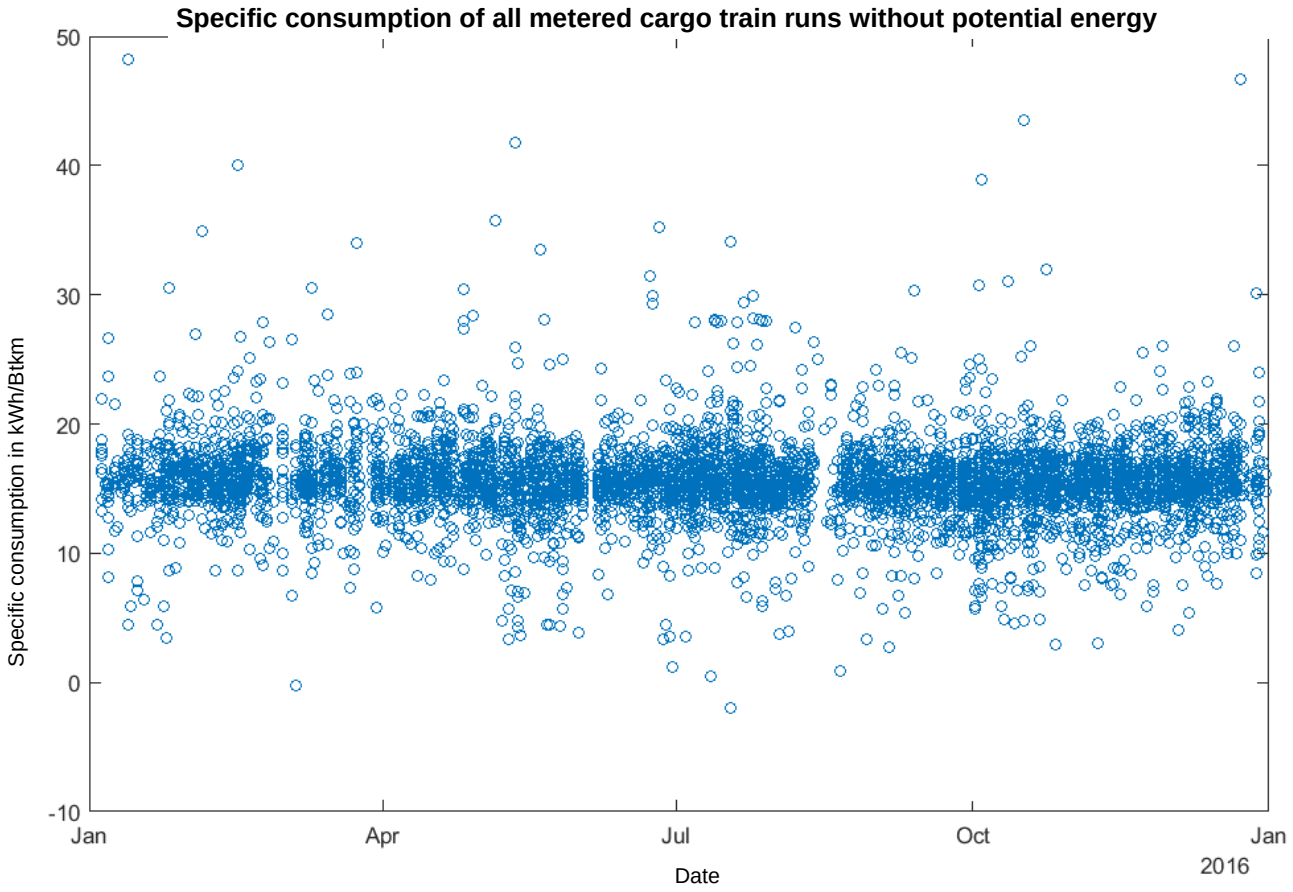
Pattern over time of the specific consumption without potential energy. The increased specific consumption values in winter are cause by increased heating.

After eliminating the effect of potential energy the consumption is more homogenous.



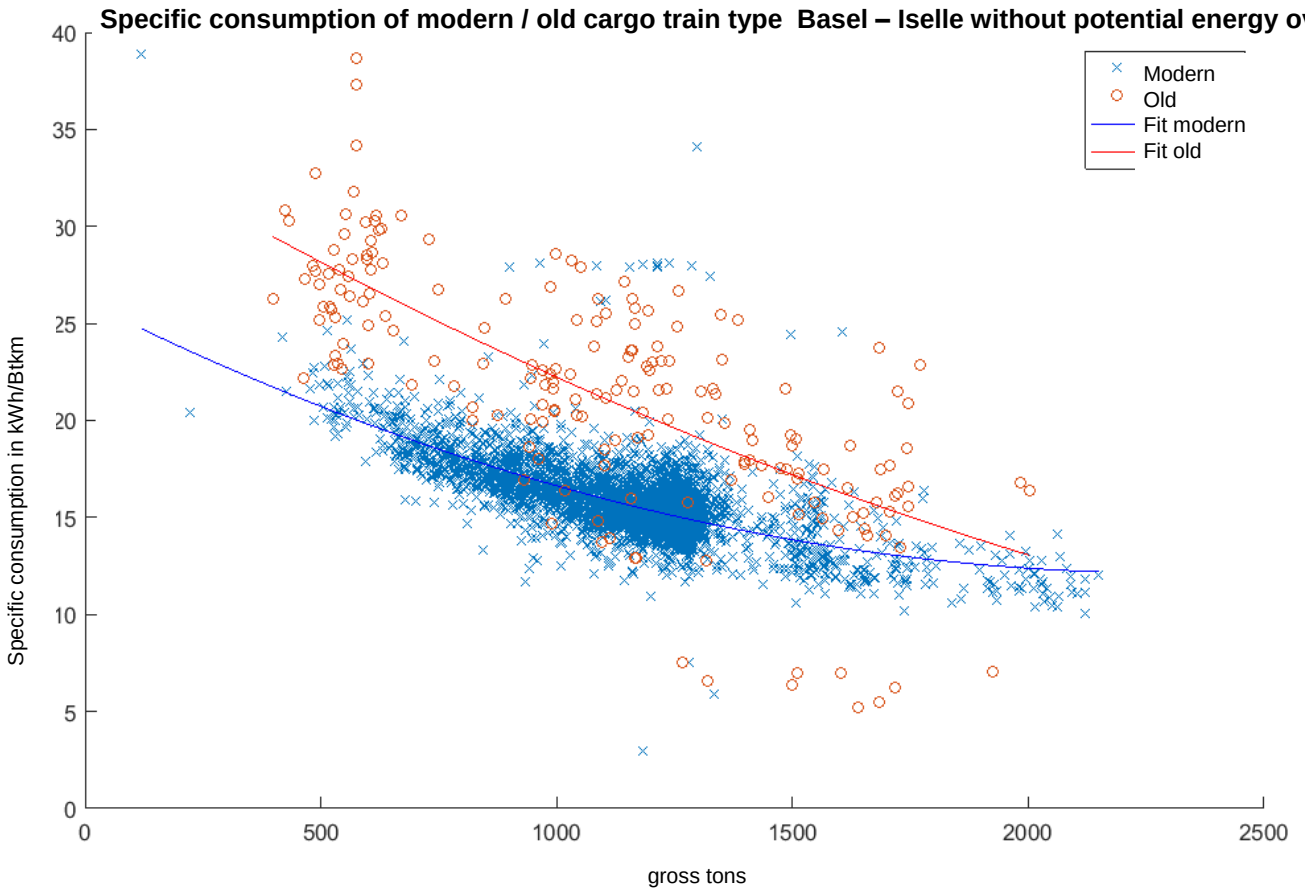
The distribution of the specific consumption values of long distance cargo trains with and without potential energy.

Energy consumption of long distance cargo trains is strongly influenced by height difference.



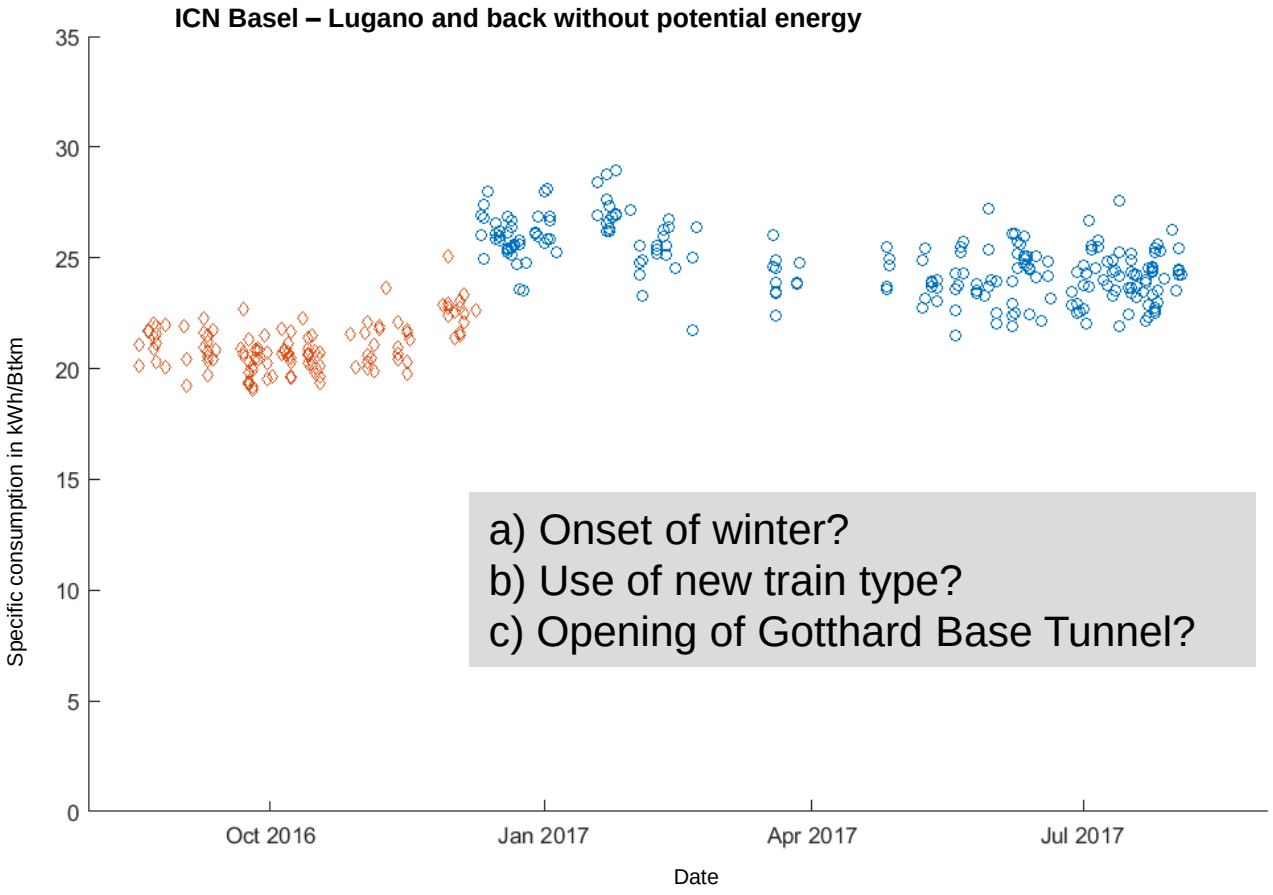
The specific energy consumption does not depend on the outside temperature. This has to be expected since there are hardly any components whose operation depends on the outside temperature.

For long distance cargo trains no variation depending on the date can be seen.

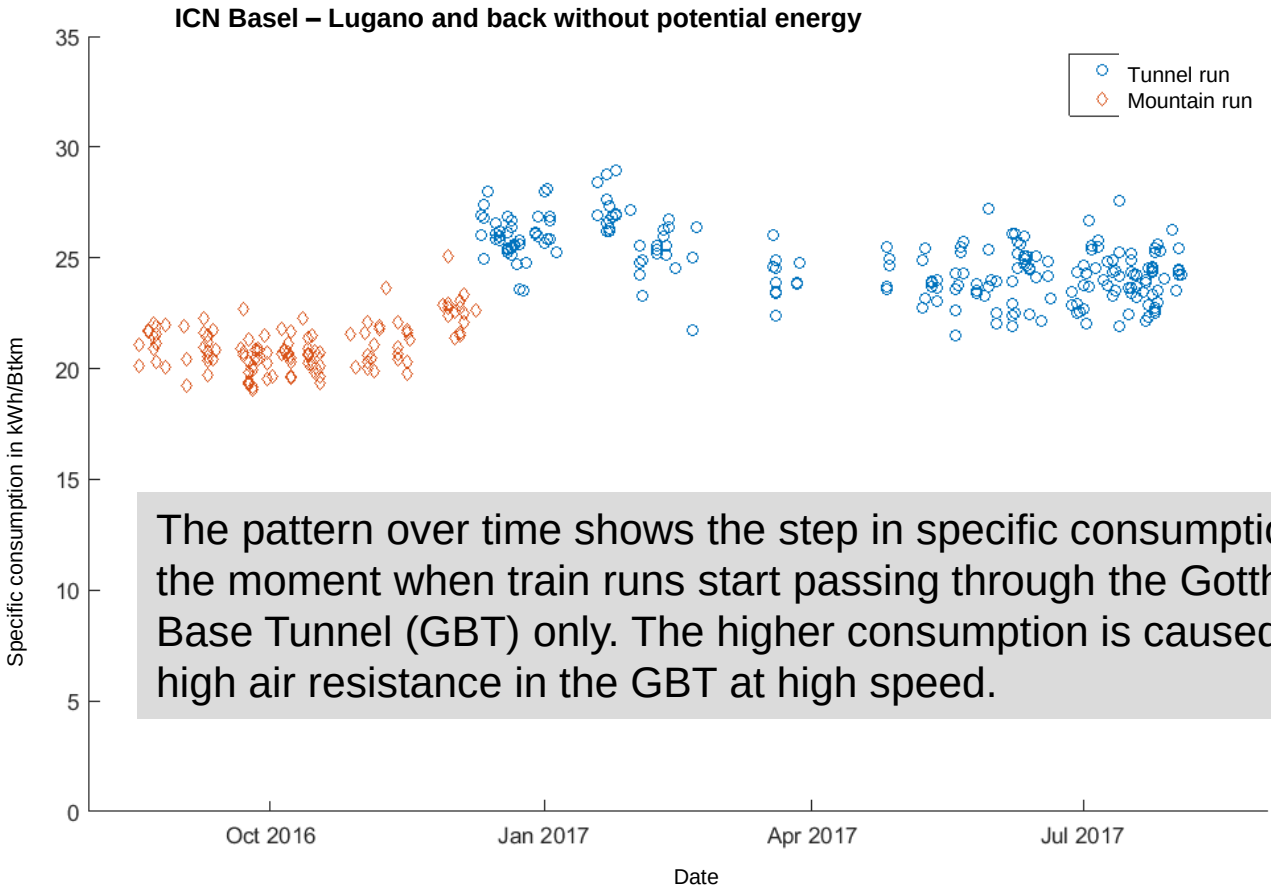


Specific consumption on the Basel – Iselle line over gross tons as function for an old and a modern train type. The old locomotives are showing a significantly higher consumption than the modern locomotives.

Weight has strong influence on the specific energy consumption of long distance cargo trains.

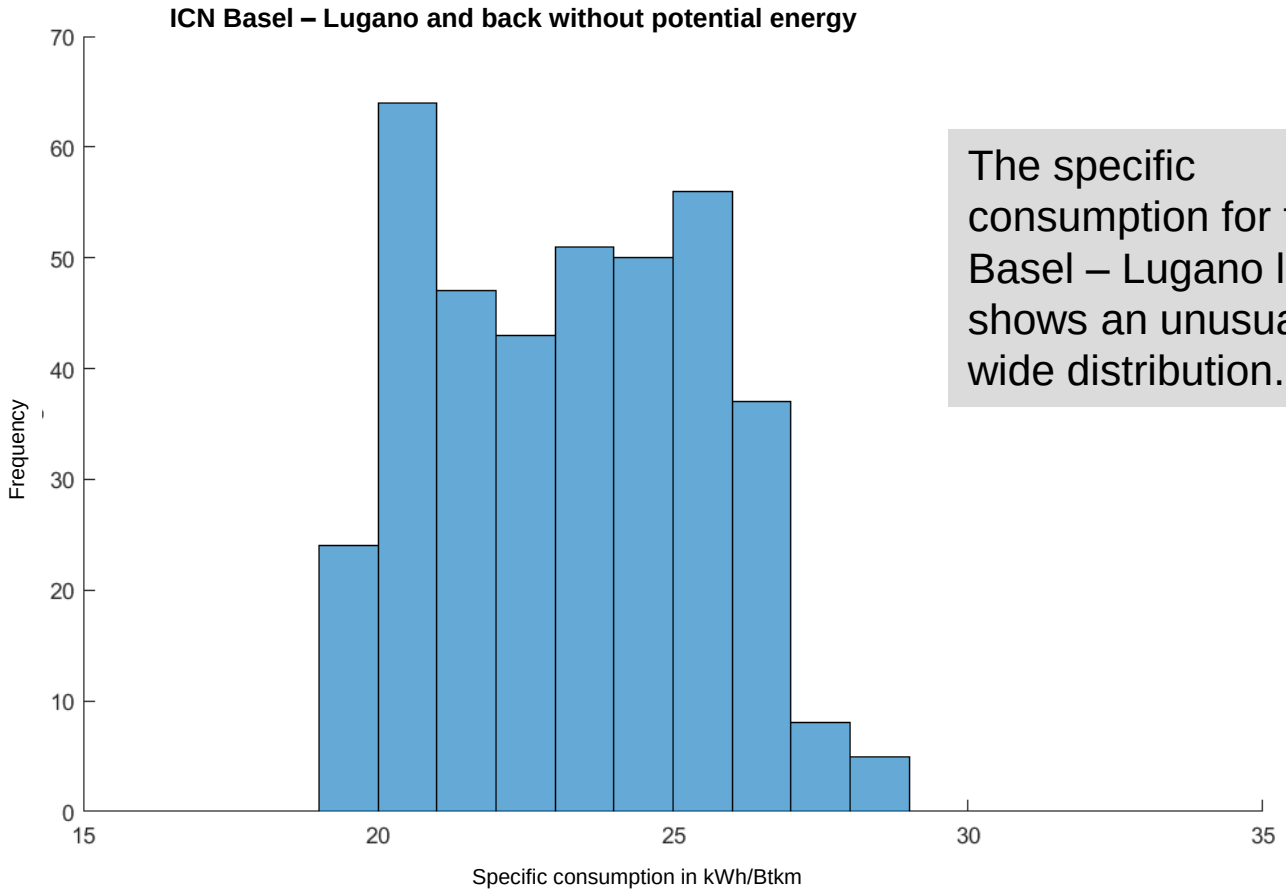


Why did the consumption on this line increase?



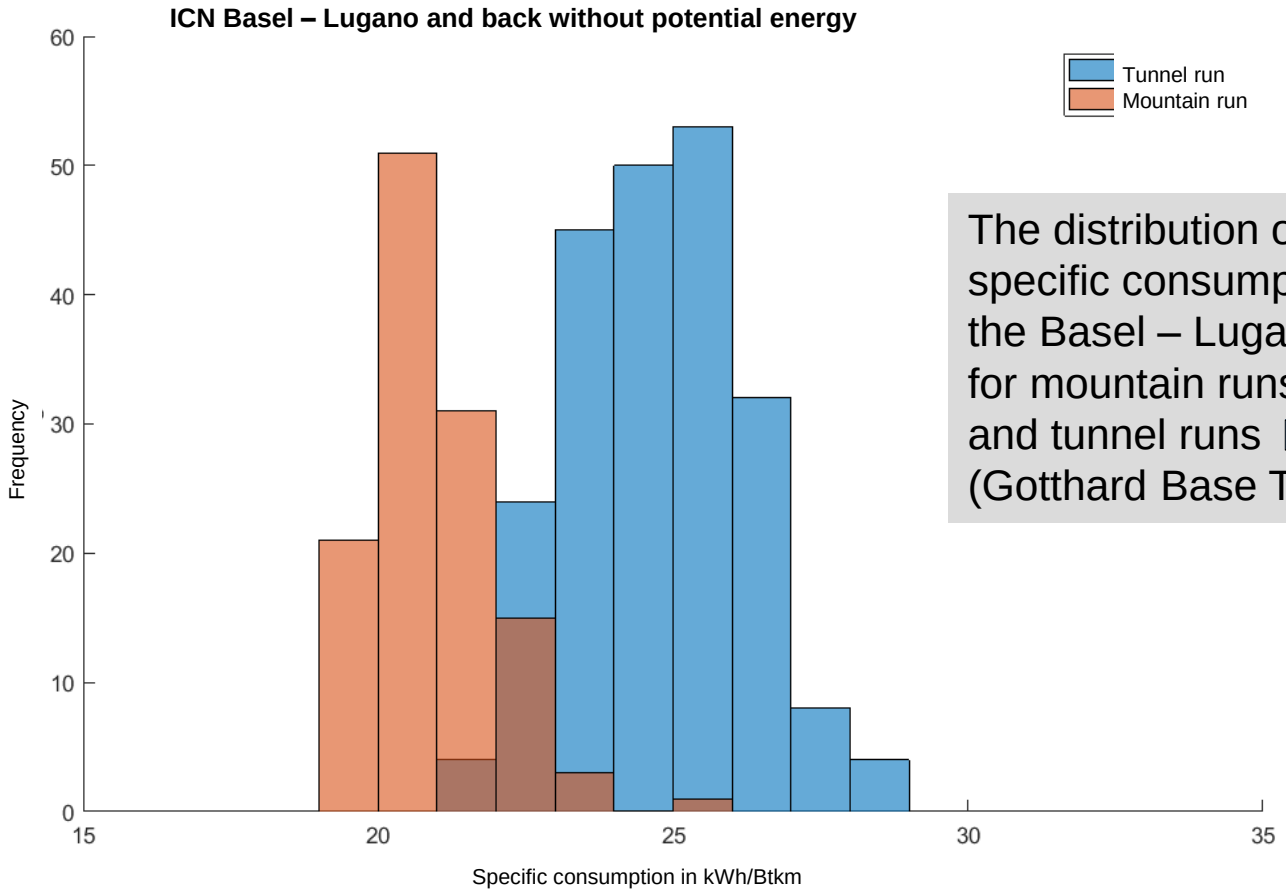
The pattern over time shows the step in specific consumption from the moment when train runs start passing through the Gotthard Base Tunnel (GBT) only. The higher consumption is caused by the high air resistance in the GBT at high speed.

At high speed tunnels have a relevant effect due to increased air resistance.



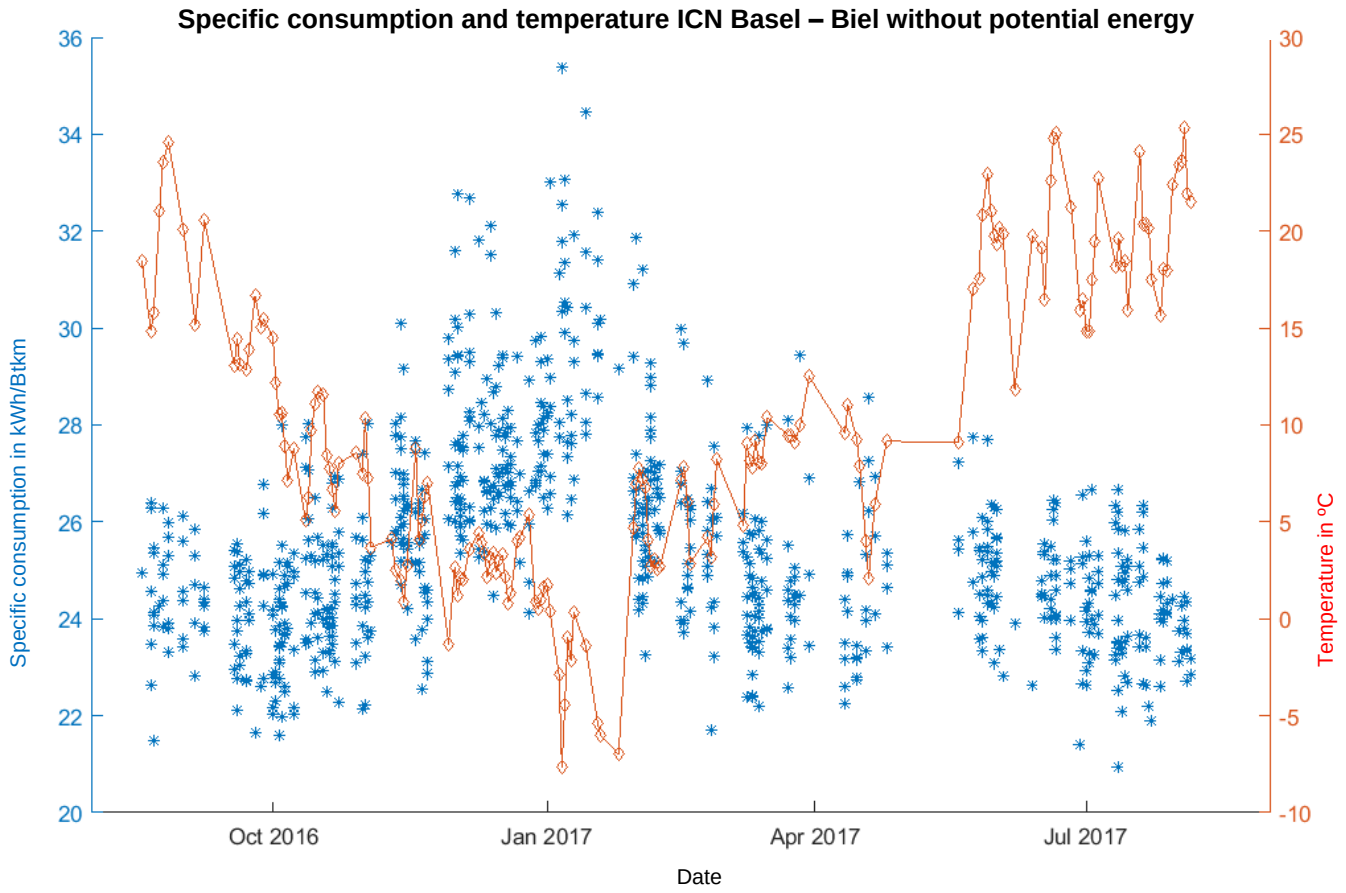
The specific consumption for the Basel – Lugano line shows an unusually wide distribution.

The «tunnel effect» can be noticed in the distribution of the specific consumption.



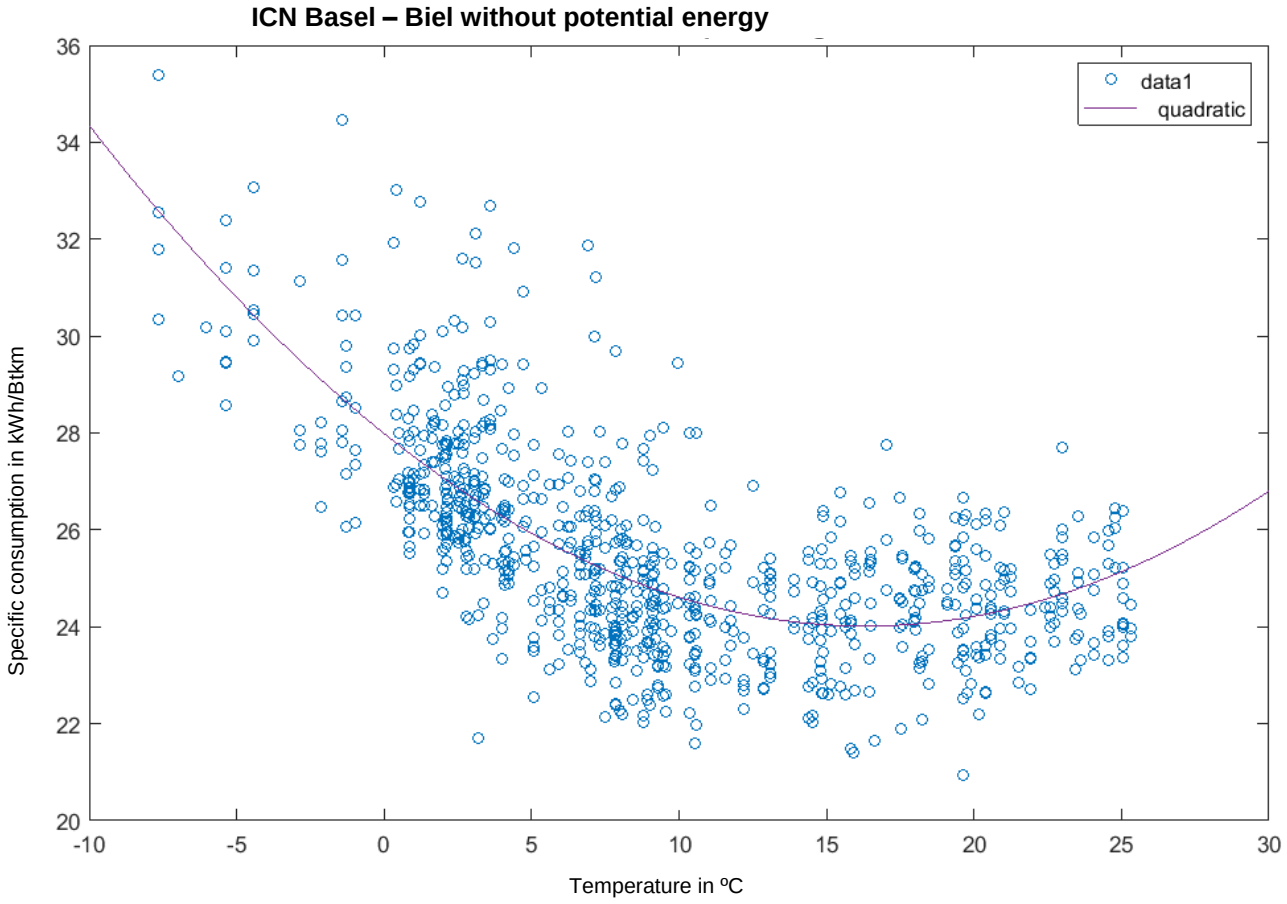
The distribution of the specific consumption for the Basel – Lugano line for mountain runs and tunnel runs (Gotthard Base Tunnel).

Mountain line and tunnel line show a different energy consumption.



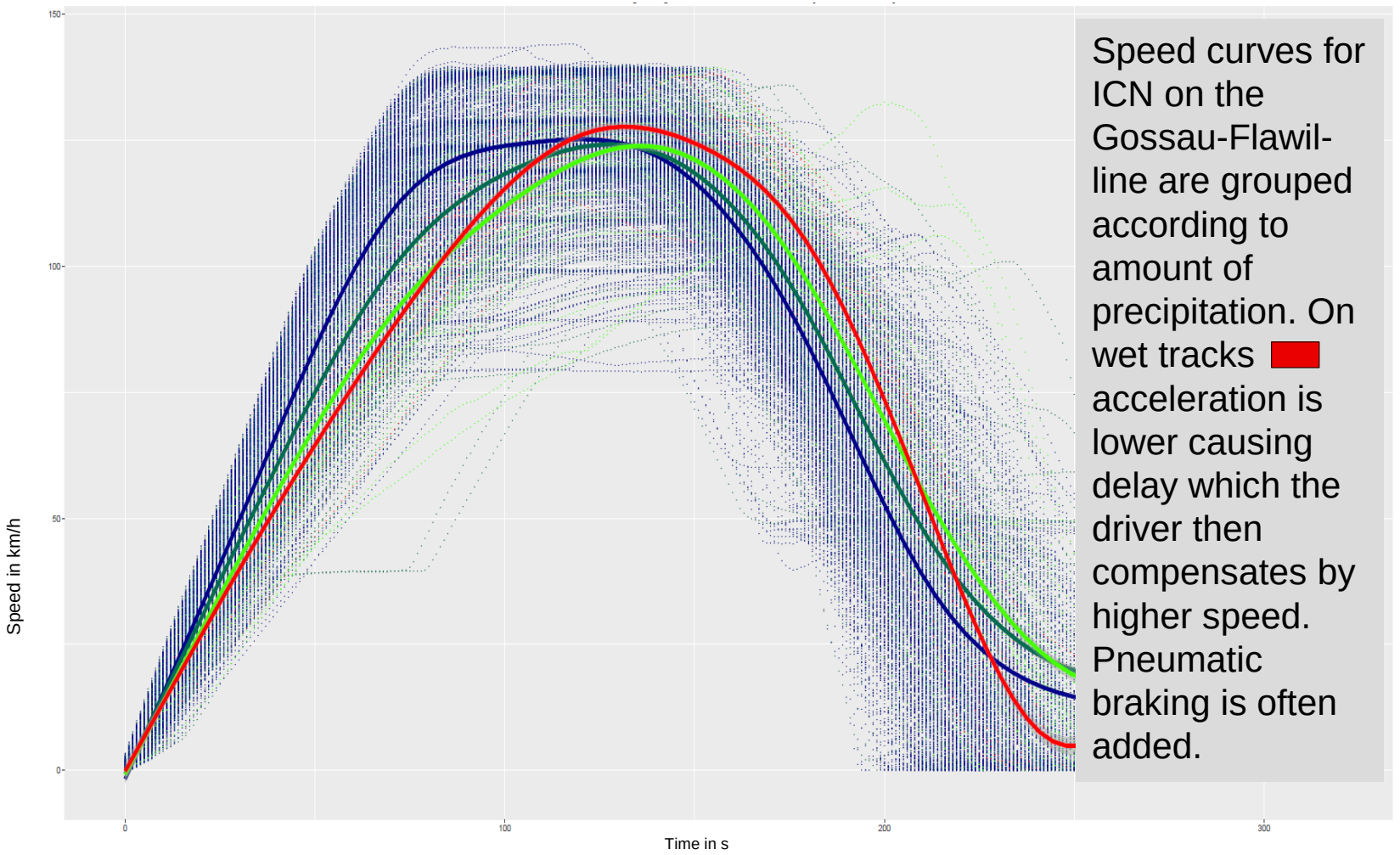
Visualisation of the relevance of temperature in pattern over time. The temperature values (red, right axis) show daily mean values in Delémont (between Basel and Biel).

Evaluations on the Basel-Biel-Line show the relevance of temperature.



Specific consumption over average daily temperature in Delémont in °C. A quadratic function already fits quite well for describing the relation between both.

The temperature effect could be modelled using a quadratic function.



Speed curves for ICN on the Gossau-Flawil-line are grouped according to amount of precipitation. On wet tracks acceleration is lower causing delay which the driver then compensates by higher speed. Pneumatic braking is often added.

Wet tracks influence acceleration and braking behaviour as well as speed selection.

Thank you.

Acknowledgement: Analyses carried through by Roland Schäfer.