# Data Science in Search for Best Predictions of **Ski Tour Difficulties**

FANS nettverksmøte | Data Science/Analytics | 13.3.2024 | Oslo

*Günter Schmudlach, Skitourenguru.com*
*Ulrich Reincke, SAS Institute*

# Difficulty of a ski tour

## Why is it important?

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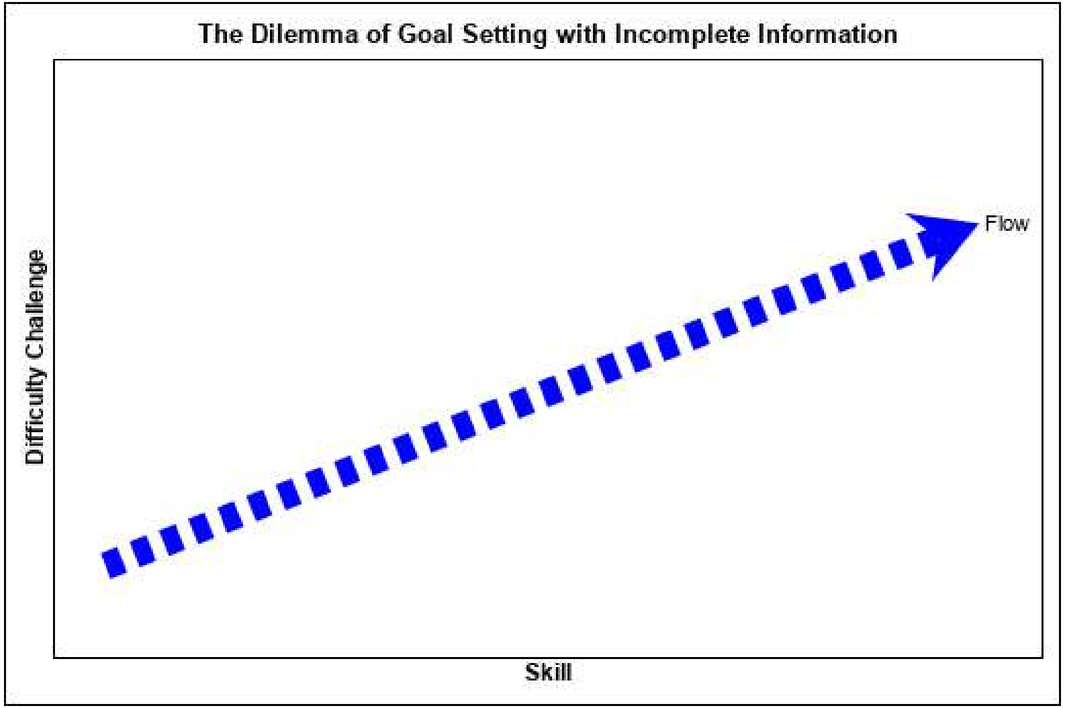

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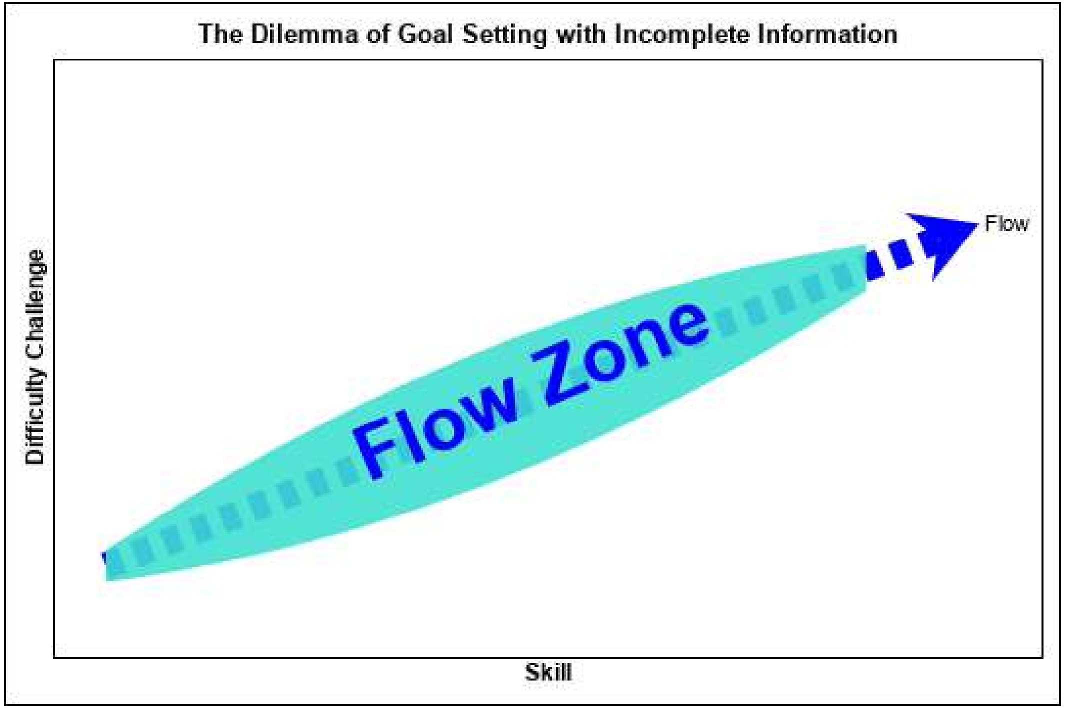

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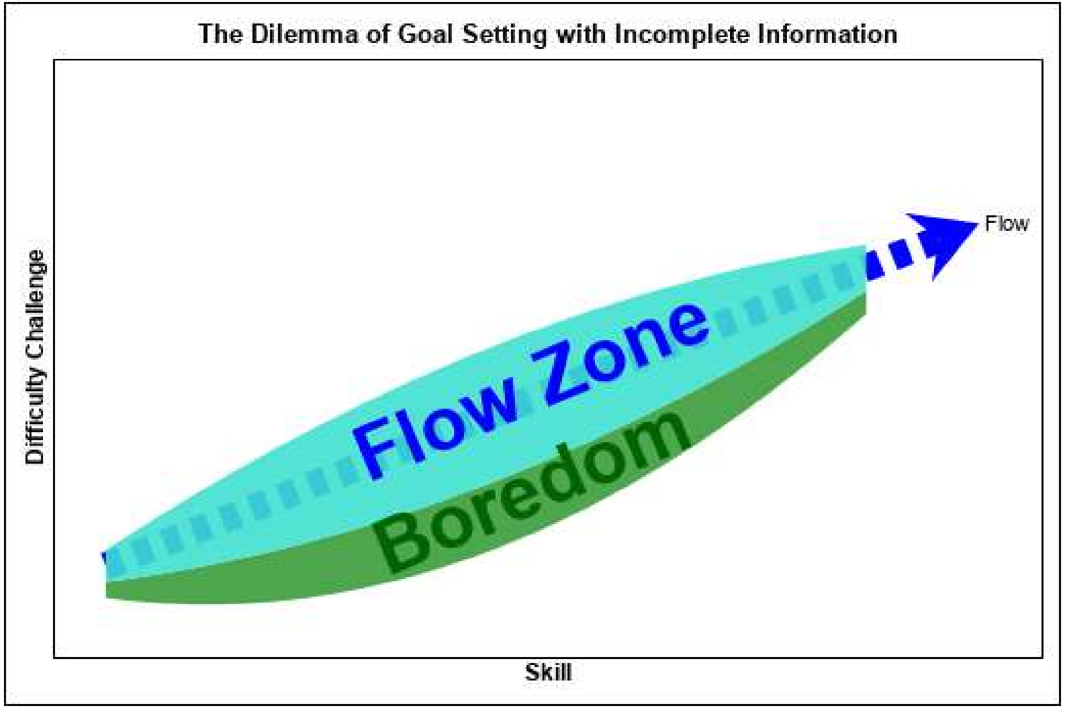

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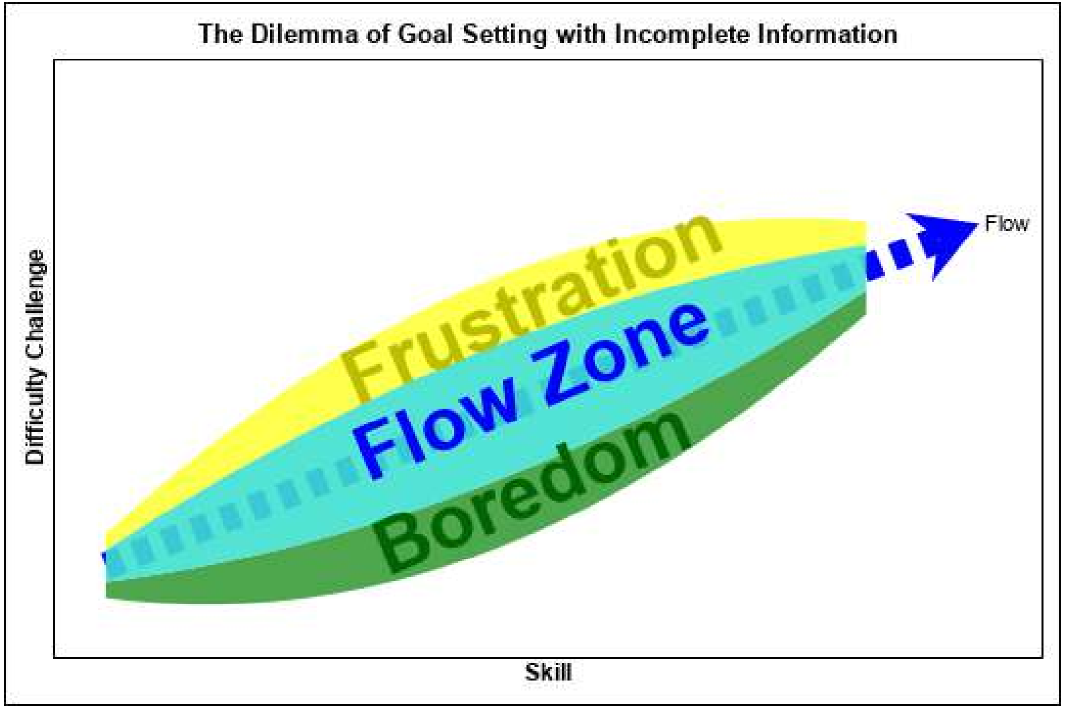

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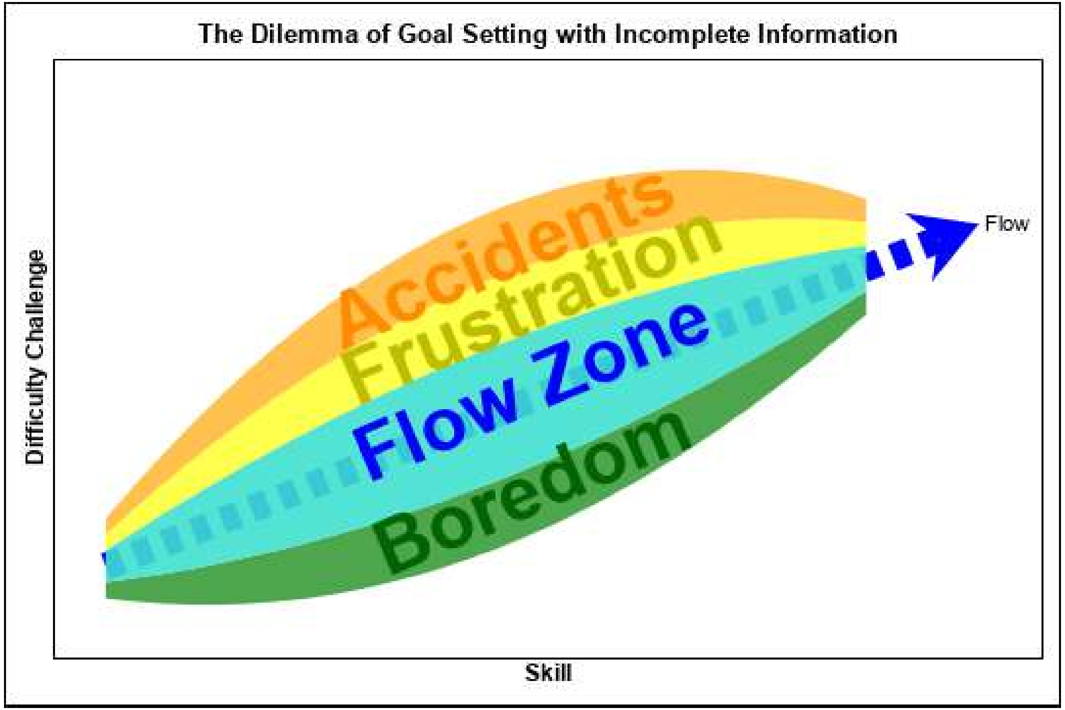
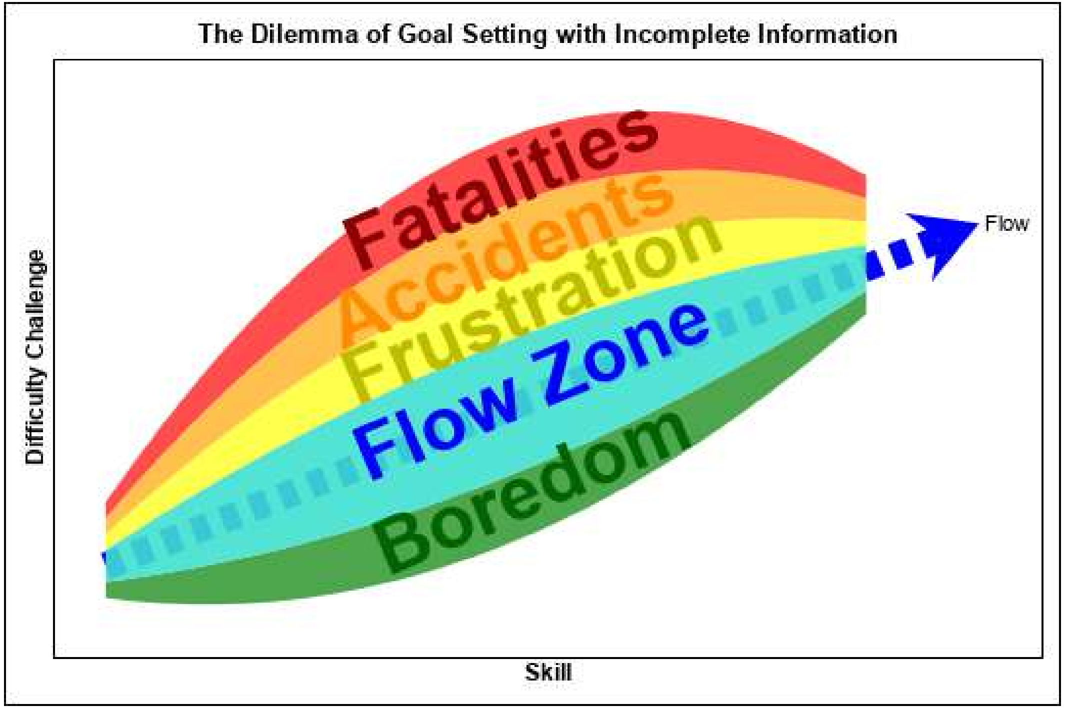


# Difficulty of a ski tour

## Why is it important?

Yearly official alpine accident statistics:
~70 fatalities of ~400 severe avalanche accidents
~25 fatalities of ~1000 severe ski tour accidents (non-avalanche)



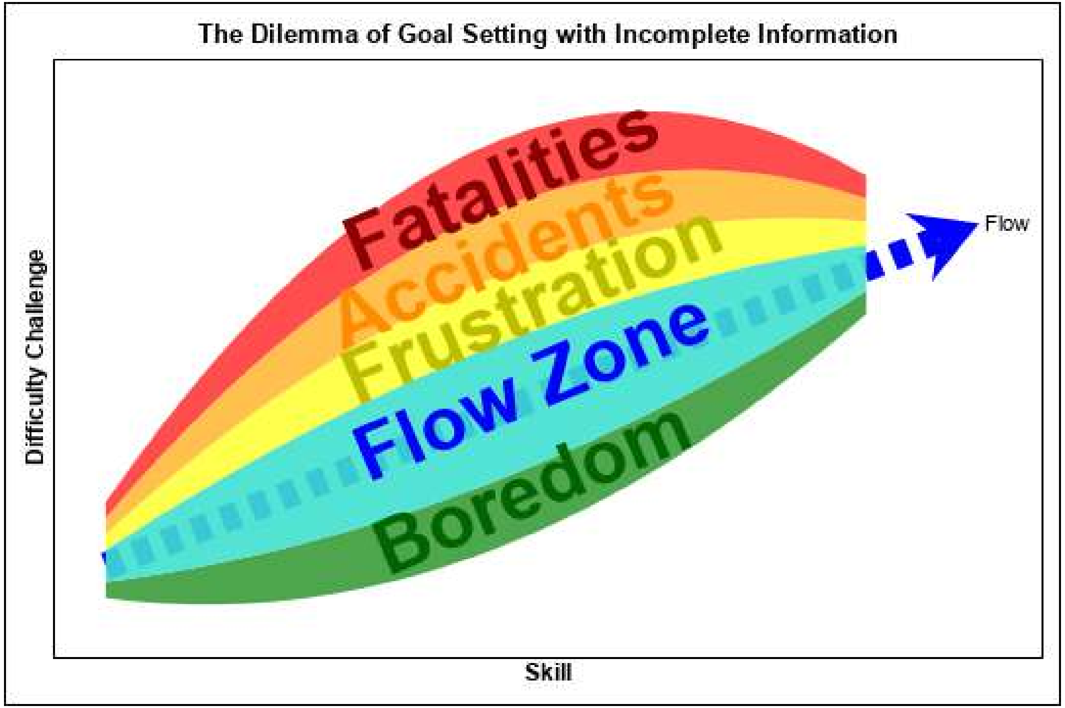
# Knowledge of a tour's difficulties is important for

## Better tour preparation, reduction of accidents and fatalities

Yearly official alpine accident statistics:

~70 fatalities of ~400 severe avalanche accidents

~25 fatalities of ~1000 severe ski tour accidents (non-avalanche)



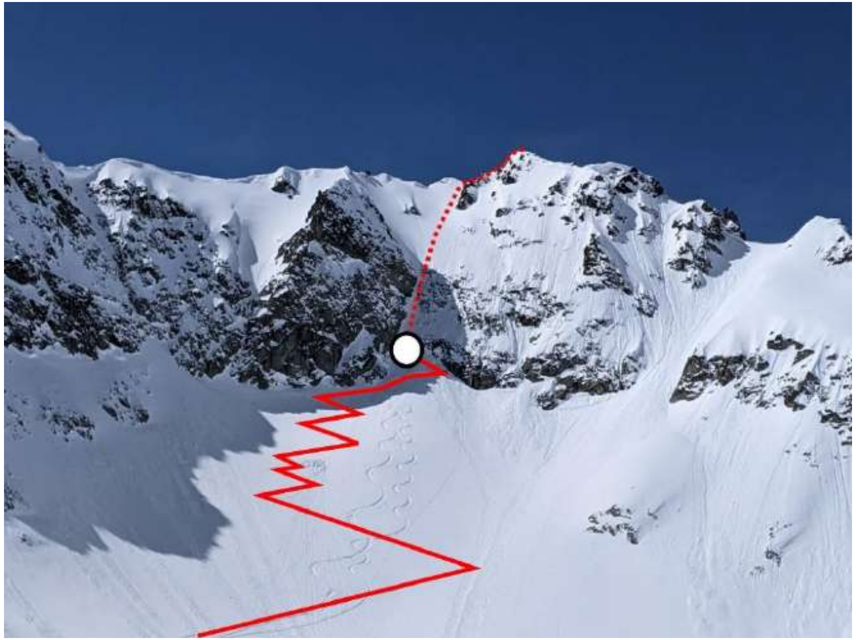

$$DIFFICULTY = f(SlopeAngle, SpeedMax, Curvature, Forestation, \ldots)$$

# Dependent Variable: Difficulty

## N=1307 Swiss Ski Tours,

Published in Swiss ski touring literature:


| DIFFICULTY | DIFFICULTY LABEL |
|---|---|
| 1 | Easy |
| 2 | Easy (+) |
| 3 | Less Difficult(-) |
| 4 | Less Difficult |
| 5 | Less Difficult (+) |
| 6 | Quite Difficult (-) |
| 7 | Quite Difficult |
| 8 | Quite Difficult (+) |
| 9 | Difficult (-) |
| 10 | Difficult |
| 11 | Difficult (+) |
| 12 | Very Difficult (-) |
| 13 | Very Difficult |
| 14 | Very Difficult (+) |
| 15 | Extremely Difficult (-) |
| 16 | Extremely Difficult |
| 17 | Extremely Difficult (+) |
| 18 | Extremely Difficult |

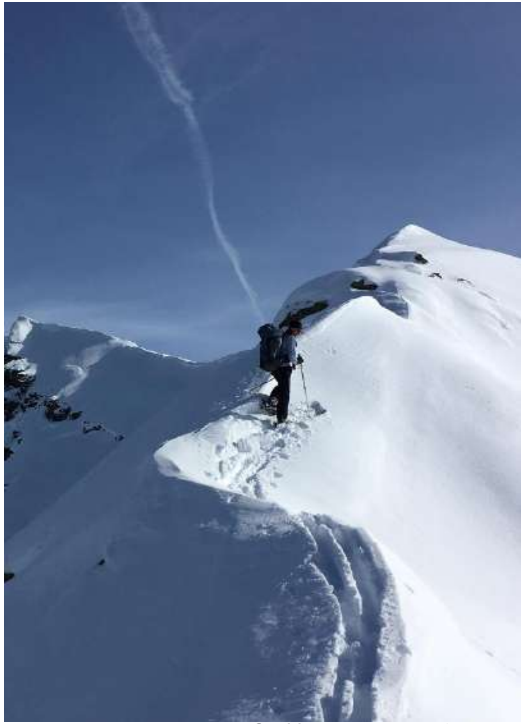


According to the SAC methodology, the difficulty level should only reflect the ski section of a tour up to the ski depot

# Main criteria for the SAC difficulty scale

## steepness, exposure to fall down, space conditions

steepness: slope angle

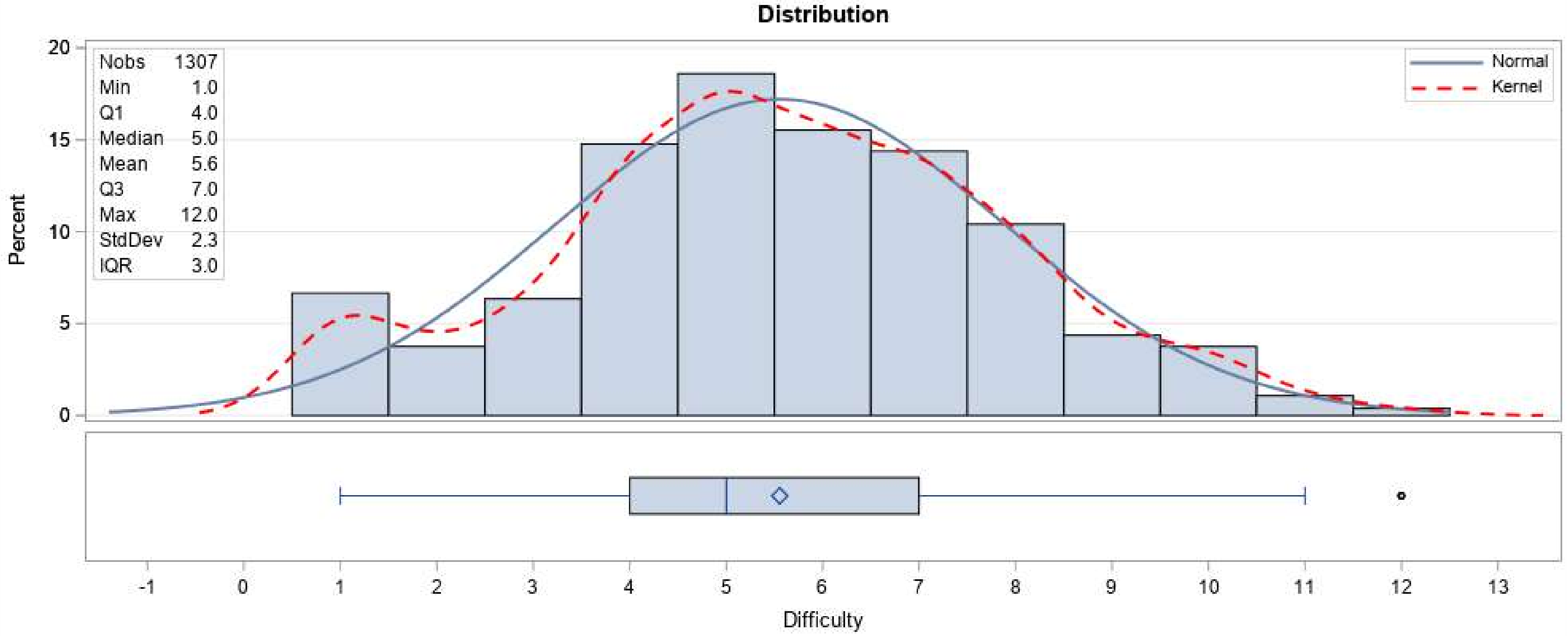


exposure to fall:  speed max

space conditions: corridor width

# target variable / dependent variable

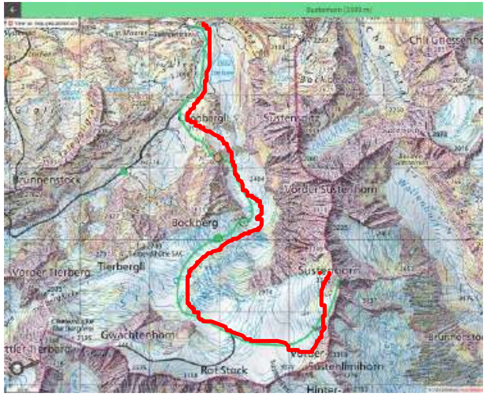
## ski tour difficulty from SAC literature



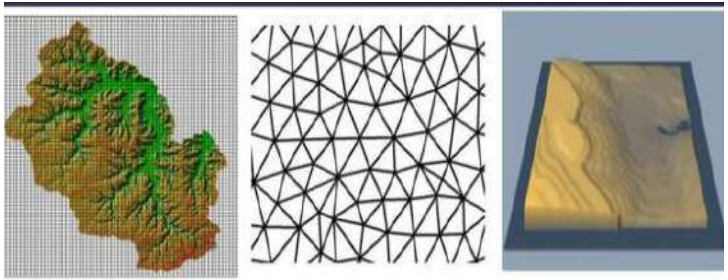
# Data preparation: from properties to prediction features

## N=1307 Swiss tours, ~9.3 mill. track meters

Local properties along each Track:




Digital Landscape Model 10m*10m



Properties:

-SlopeAngle (x,y) „steepness“

-SpeedMax (x,y) „exposure to fall“

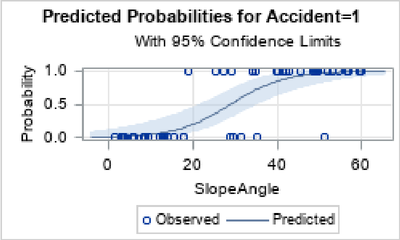
-Width (x,y) „space conditions“

-Forestation (x,y)

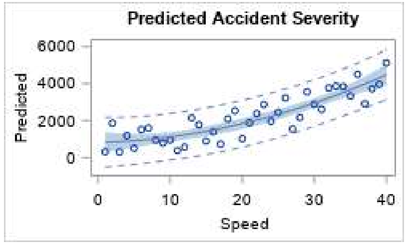
-Curvature (x,y)

-Fold (x,y)

*-Risk(x,y):=SlopeAngle (x,y)*SpeedMax (x,y)*




X



# Data preparation

## from local track properties to unique tour features

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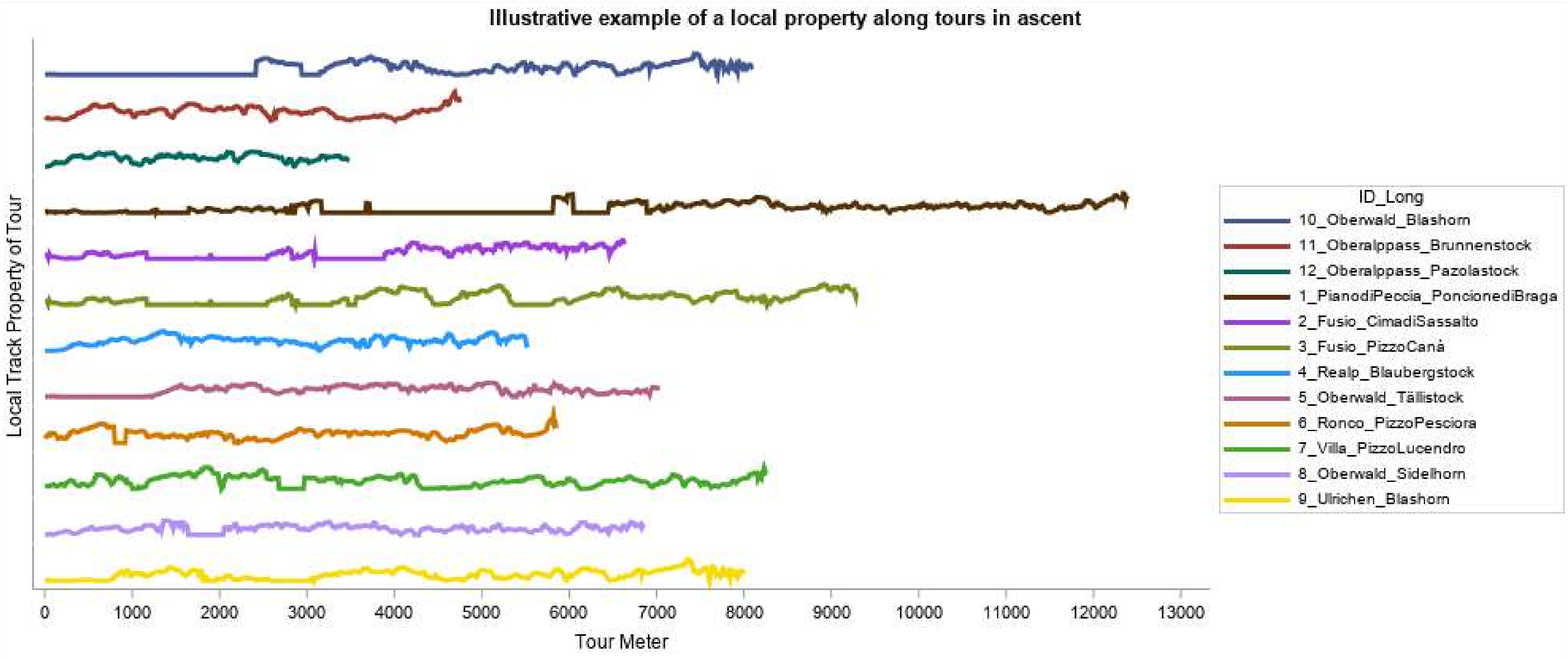
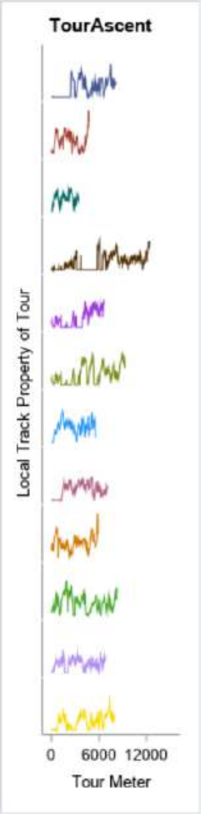



Local track properties of tours processed: Risk, Slope Angle, SpeedMax, Acceleration, Forestation, Curvature, Width,...

# Data preparation

## from local track properties to unique tour features



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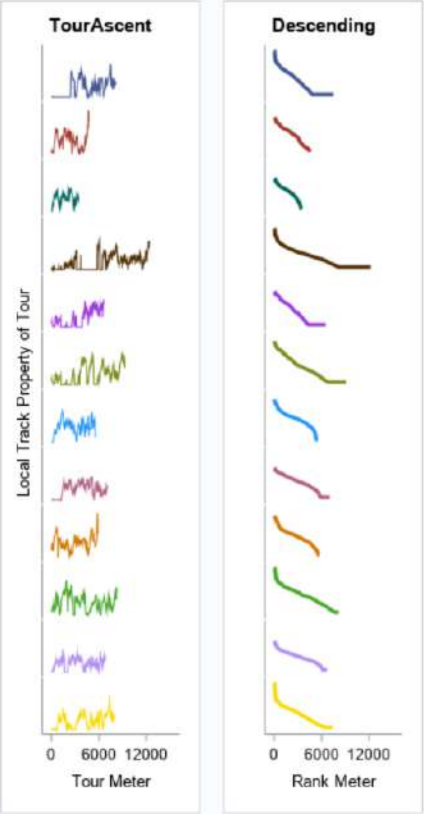

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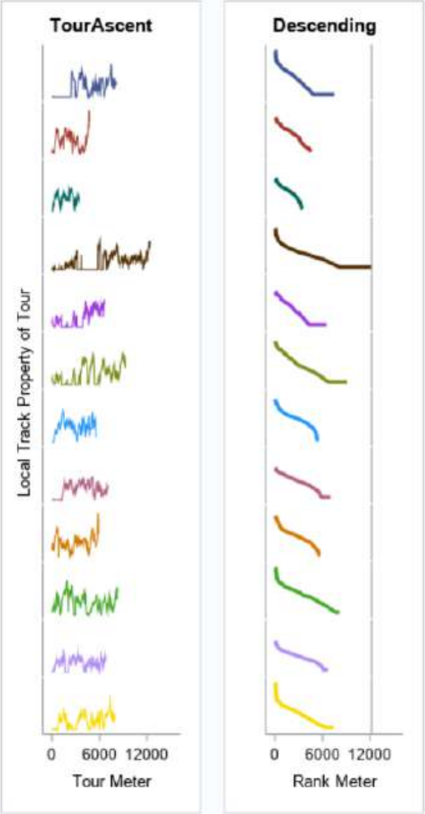

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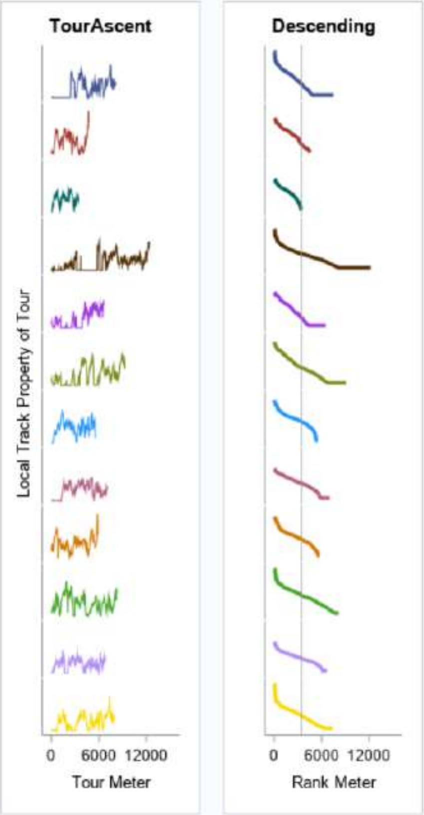

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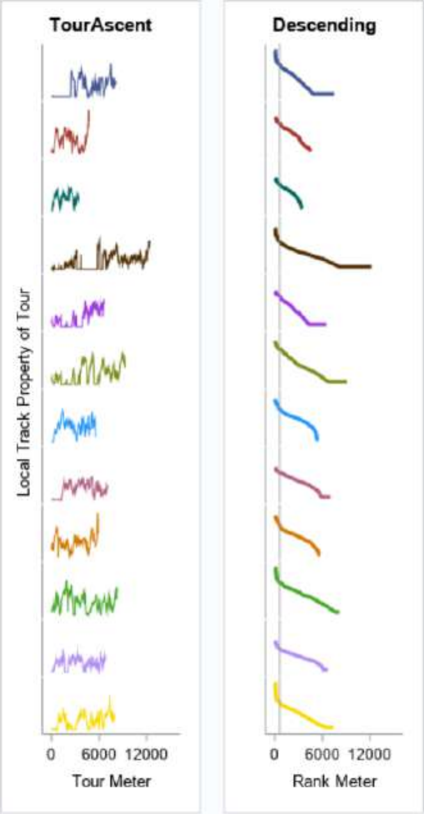

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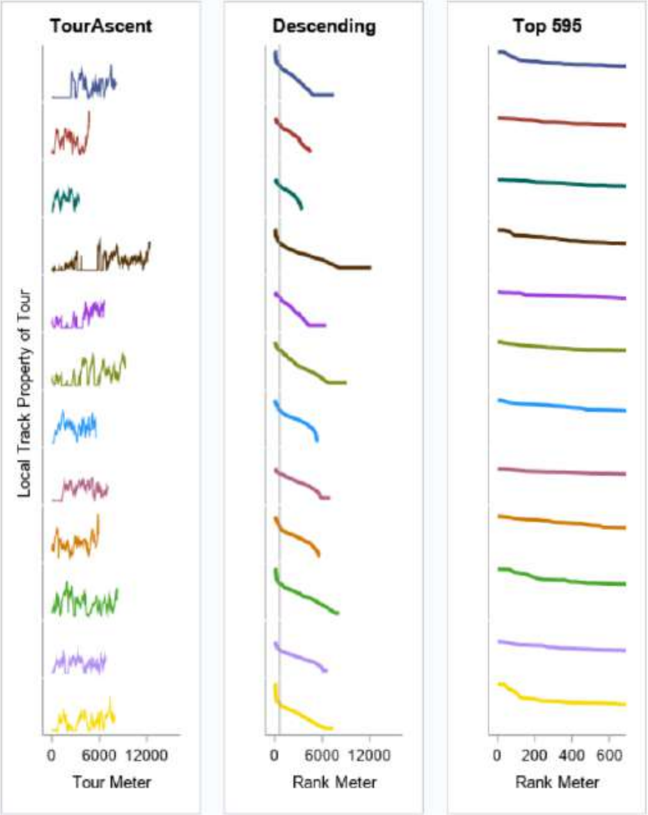

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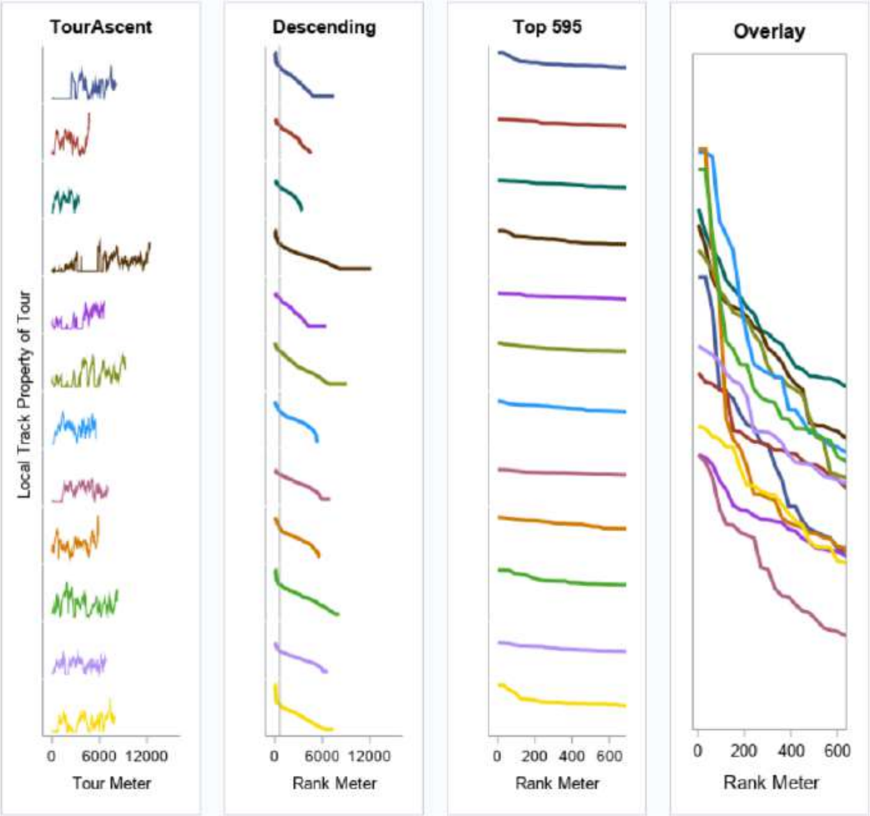

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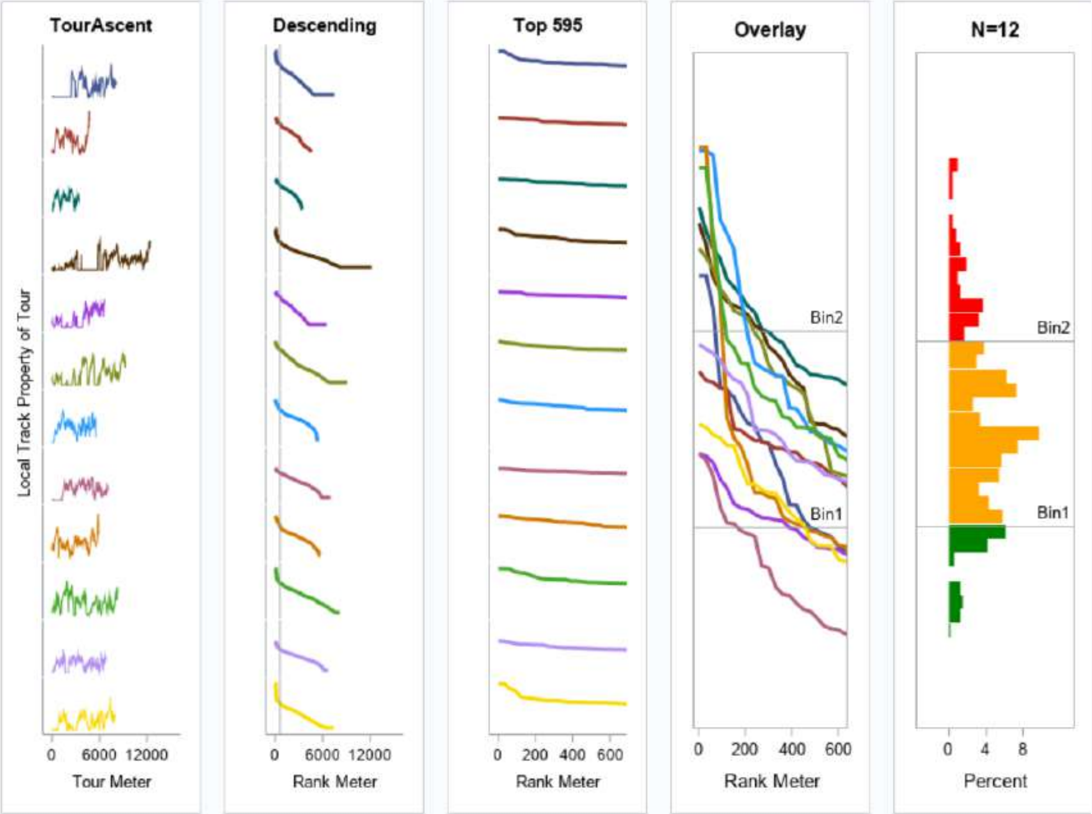


Local track properties of tours processed: Risk, Slope Angle, SpeedMax, Acceleration, Forestation, Curvature, Width,...

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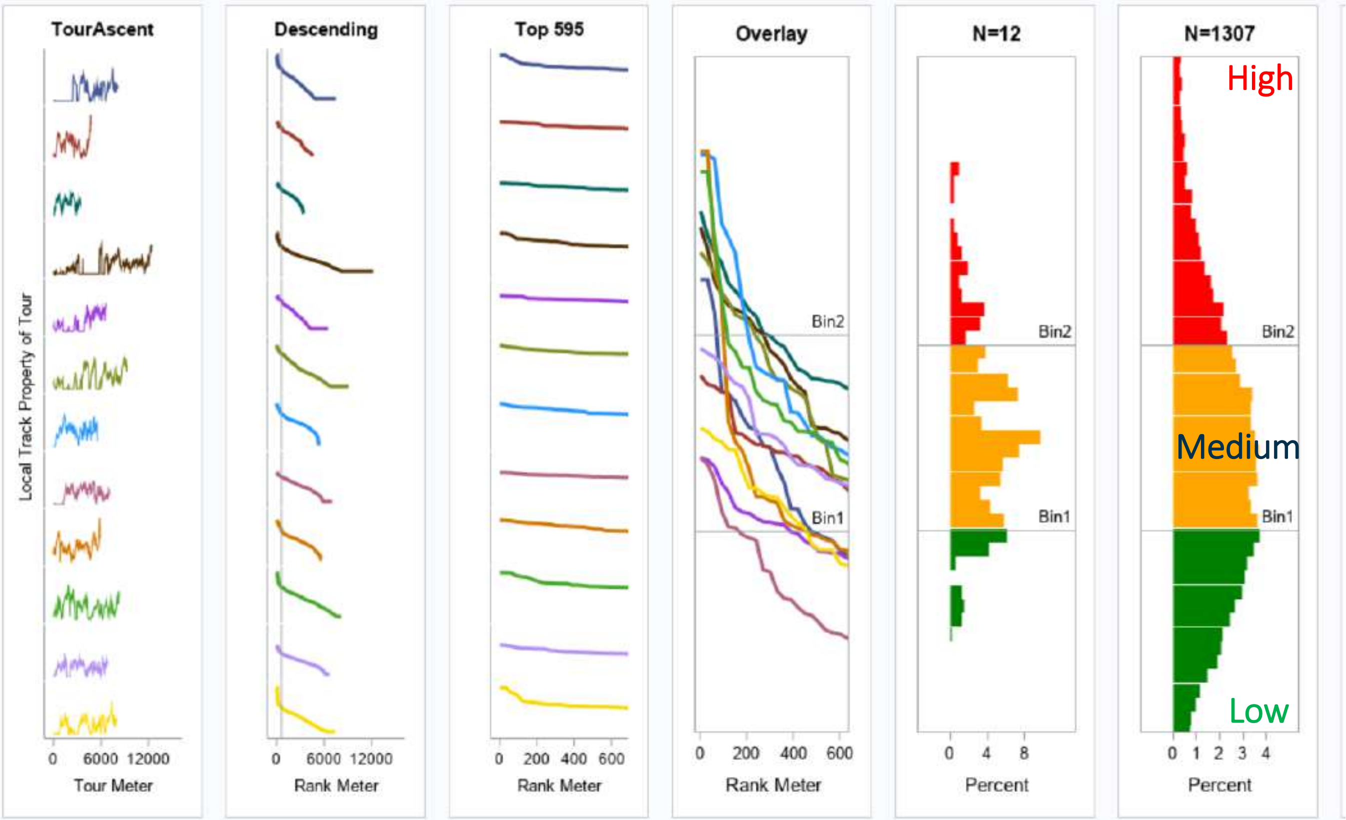


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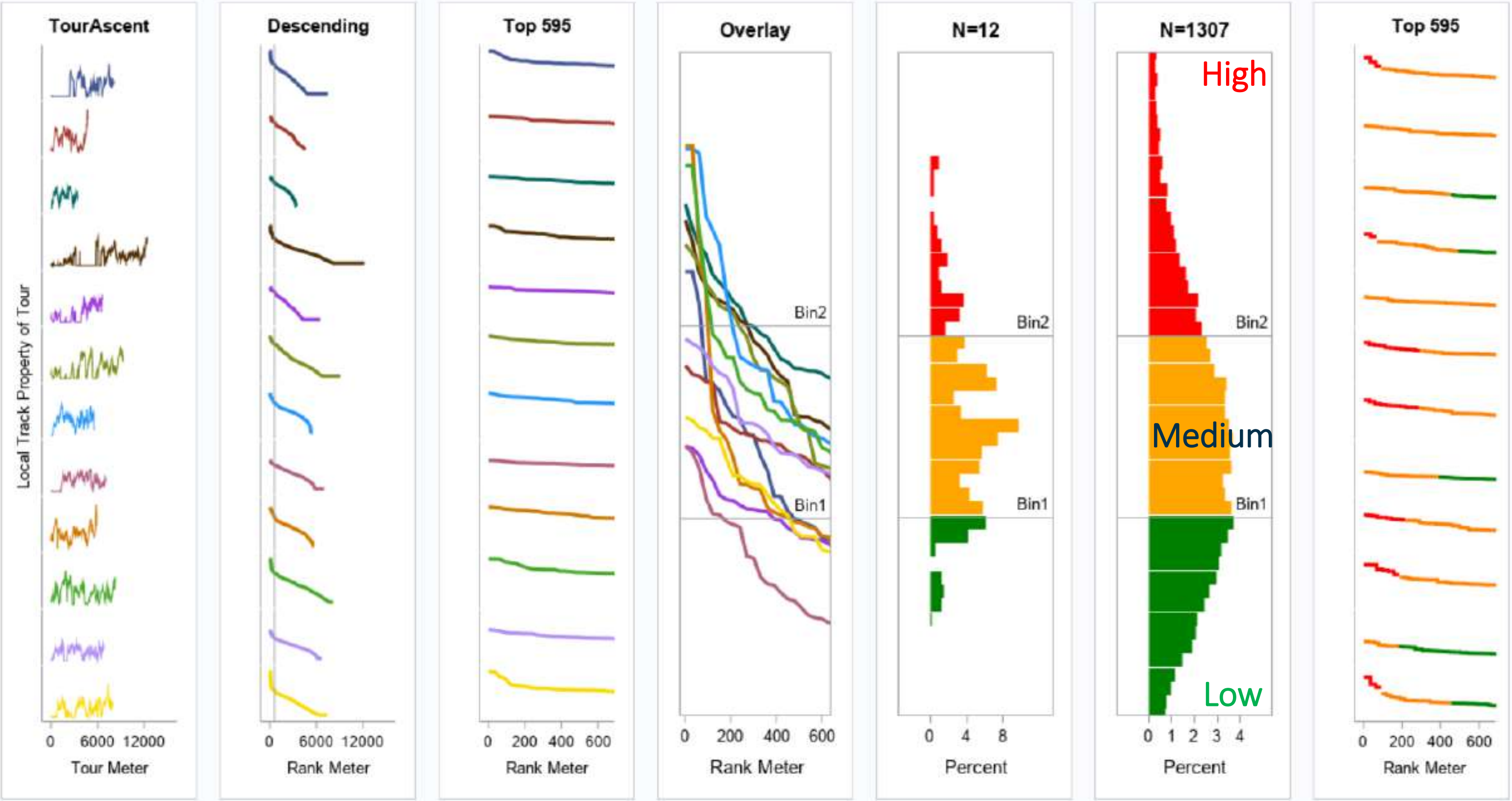


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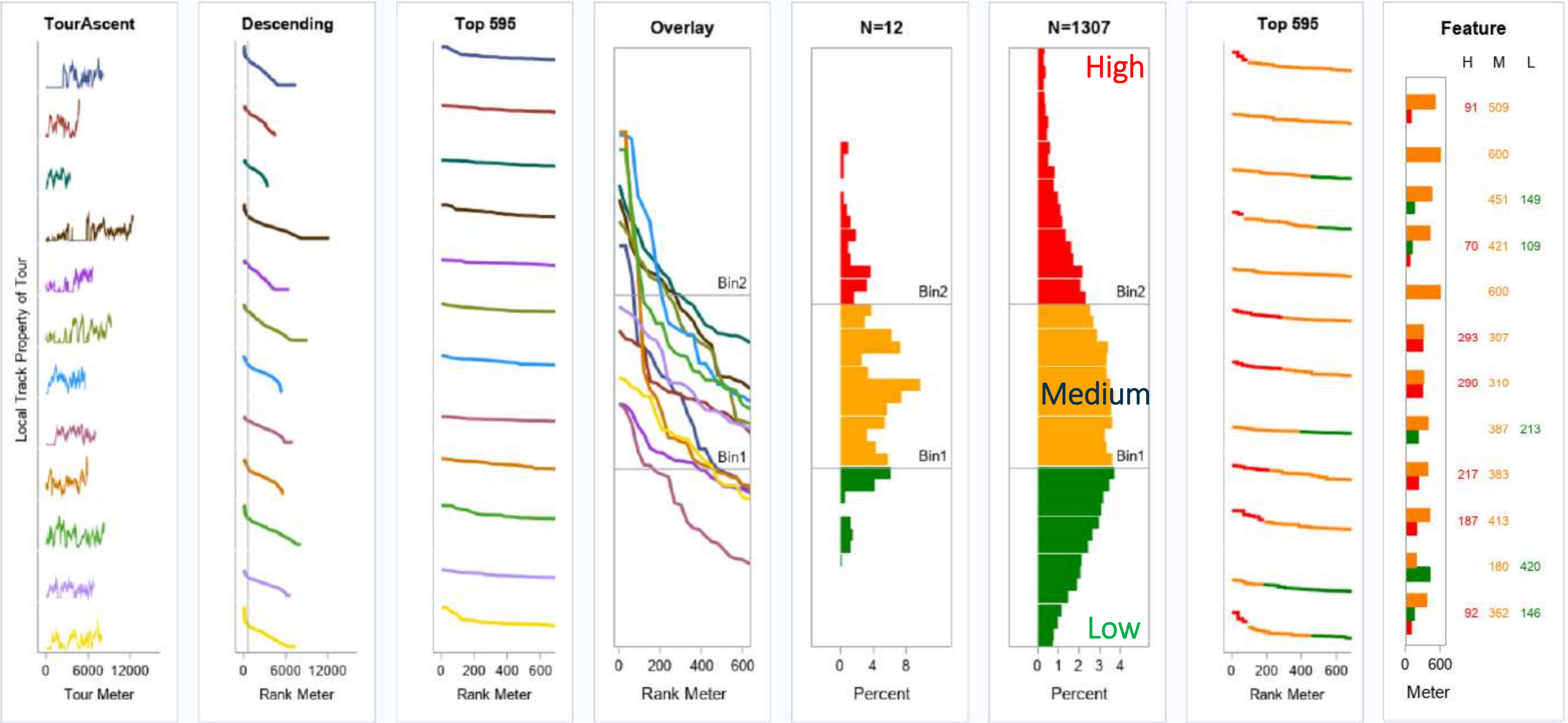


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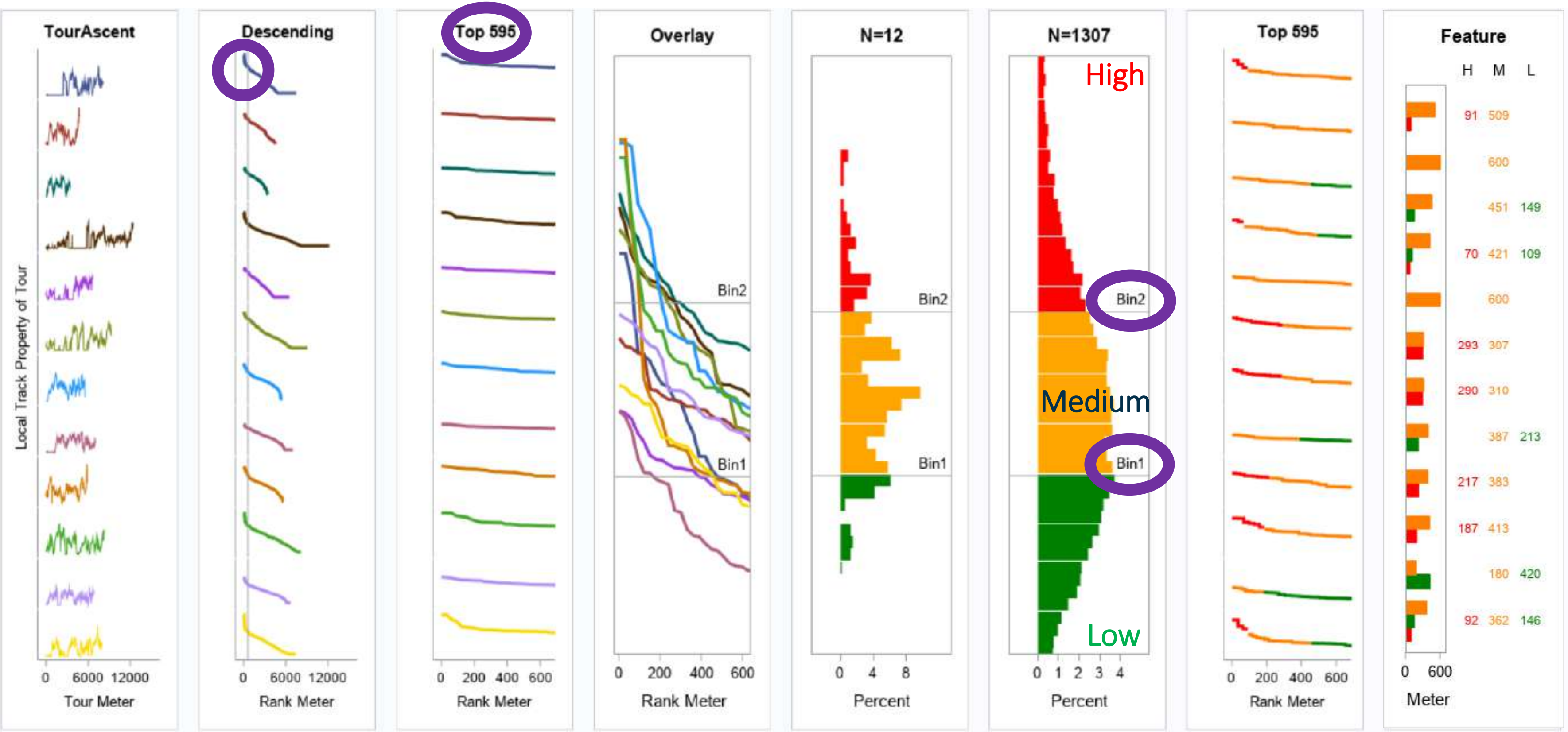


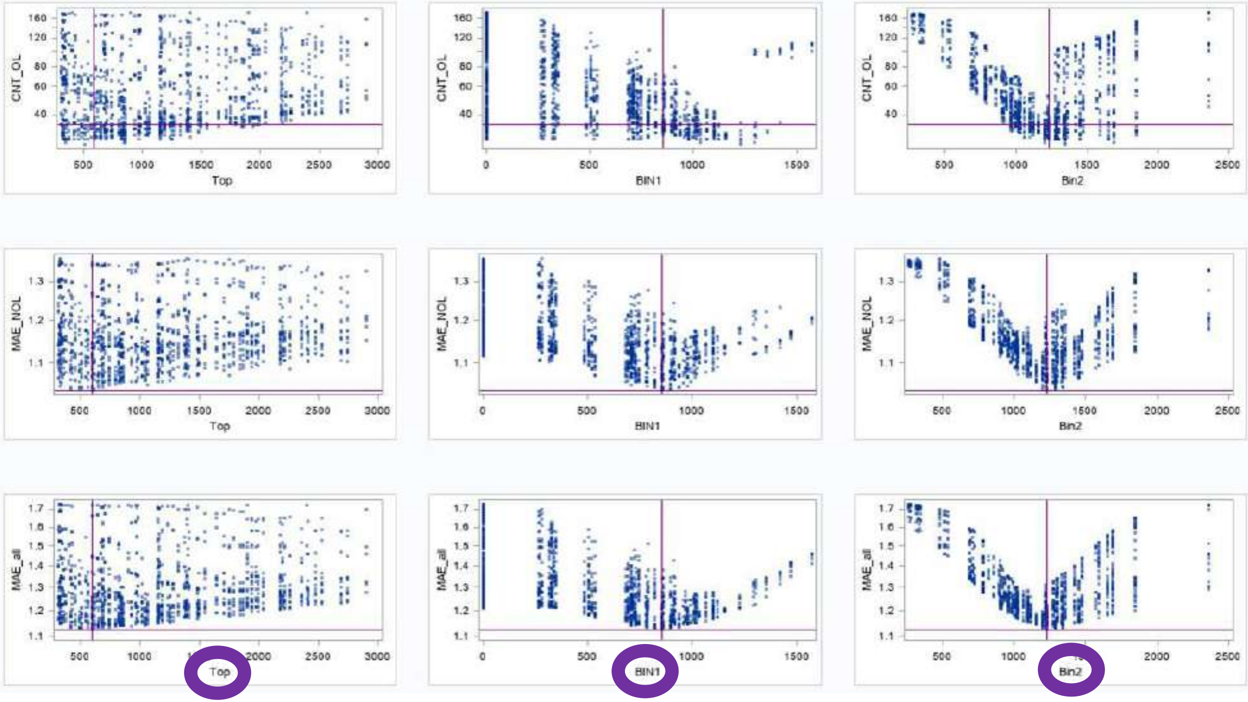

Local track properties of tours processed: Risk, Slope Angle, SpeedMax, Acceleration, Forestation, Curvature, Width,...

# How to find good segmentation parameters: **Top, Bin1, Bin2**

## „Trial and Error“ minimizing Mean Absolute Prediction Error MAE

**Optimal quantile regression model with best segmentation parameter TOP, BIN1, BIN2 (out of 5000 trials)**

| Top | BIN1 | Bin2 | Opt | MAE_all | MAE_NOL | CNT_OL | Intercept | RiskCnt_3 | RiskCnt_3f | RiskCnt_2 | RiskCnt_2f | SAC3_BEE_BEW_BVS_FRV | SAC3_TI | SAC3_ZS_GRN_GRS_GL_V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 595 | 855 | 1229 | * | 1.12596 | 1.03841 | 35 | 1.83060 | 0.00866 | 0.00686 | 0.00464 | . | -0.83060 | 0.67489 | 0 |



# from 7 properties to 107 „best“ features

**Sample of original local properties along the tour track**

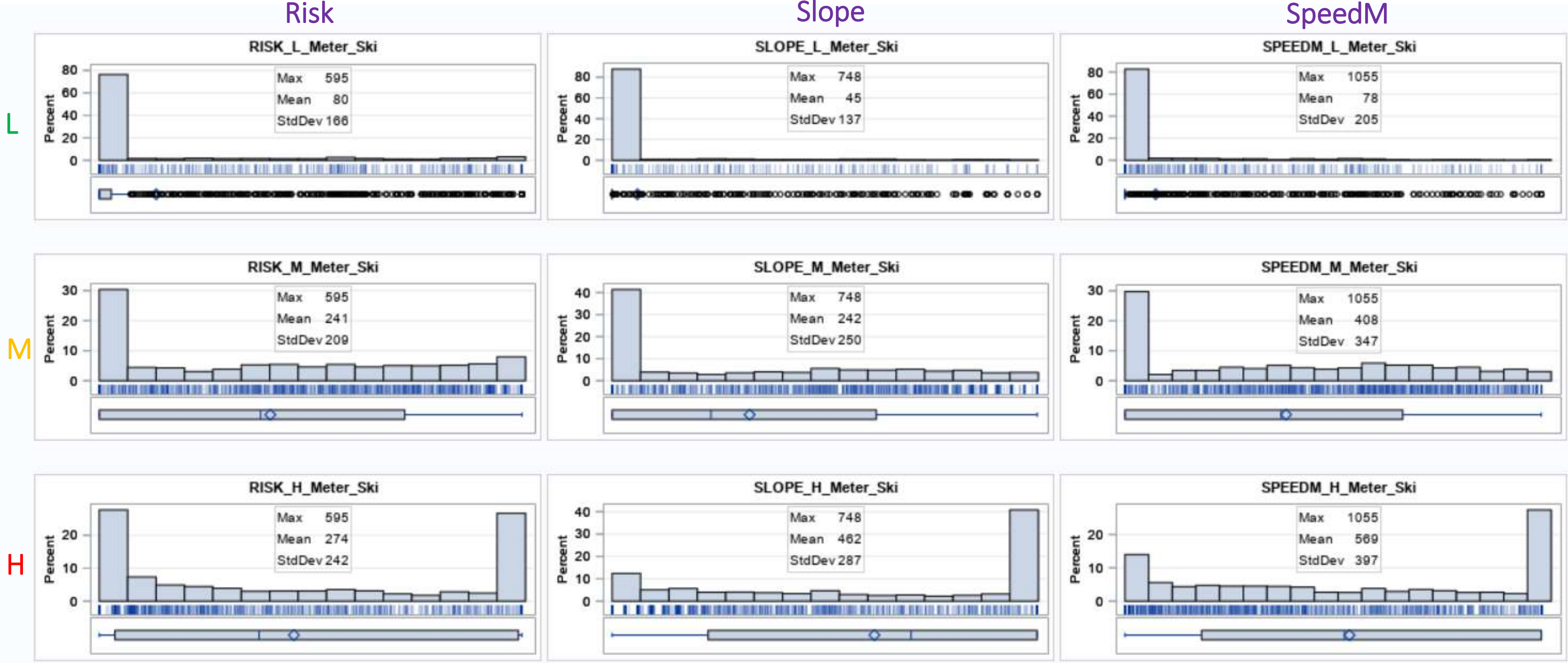
| ID_Long | Meter | Speed | SlopeAngle | Forestation | Fold | Curvature | Accelleration | Width |
|---|---|---|---|---|---|---|---|---|
| 1000_Sagliains_PizZadrell | 1 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 2 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 3 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 4 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 5 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 6 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 7 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 8 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 9 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 10 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 11 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 12 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 13 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 14 | 25 | 22.9 | 0.0 | -15.45 | -2.00 | 13 | 135 |
| 1000_Sagliains_PizZadrell | 15 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 16 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 17 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 18 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 19 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 20 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 21 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 22 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 23 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |
| 1000_Sagliains_PizZadrell | 24 | 25 | 23.0 | 0.0 | -12.78 | -5.53 | 13 | 147 |

$\sum x_t\beta_t$ $\sum x_t\beta_t$ $\sum x_t\beta_t$ $\sum x_t\beta_t$ $\sum x_t\beta_t$ $\sum x_t\beta_t$ $\sum x_t\beta_t$

**Final list of prediction feature candidates**

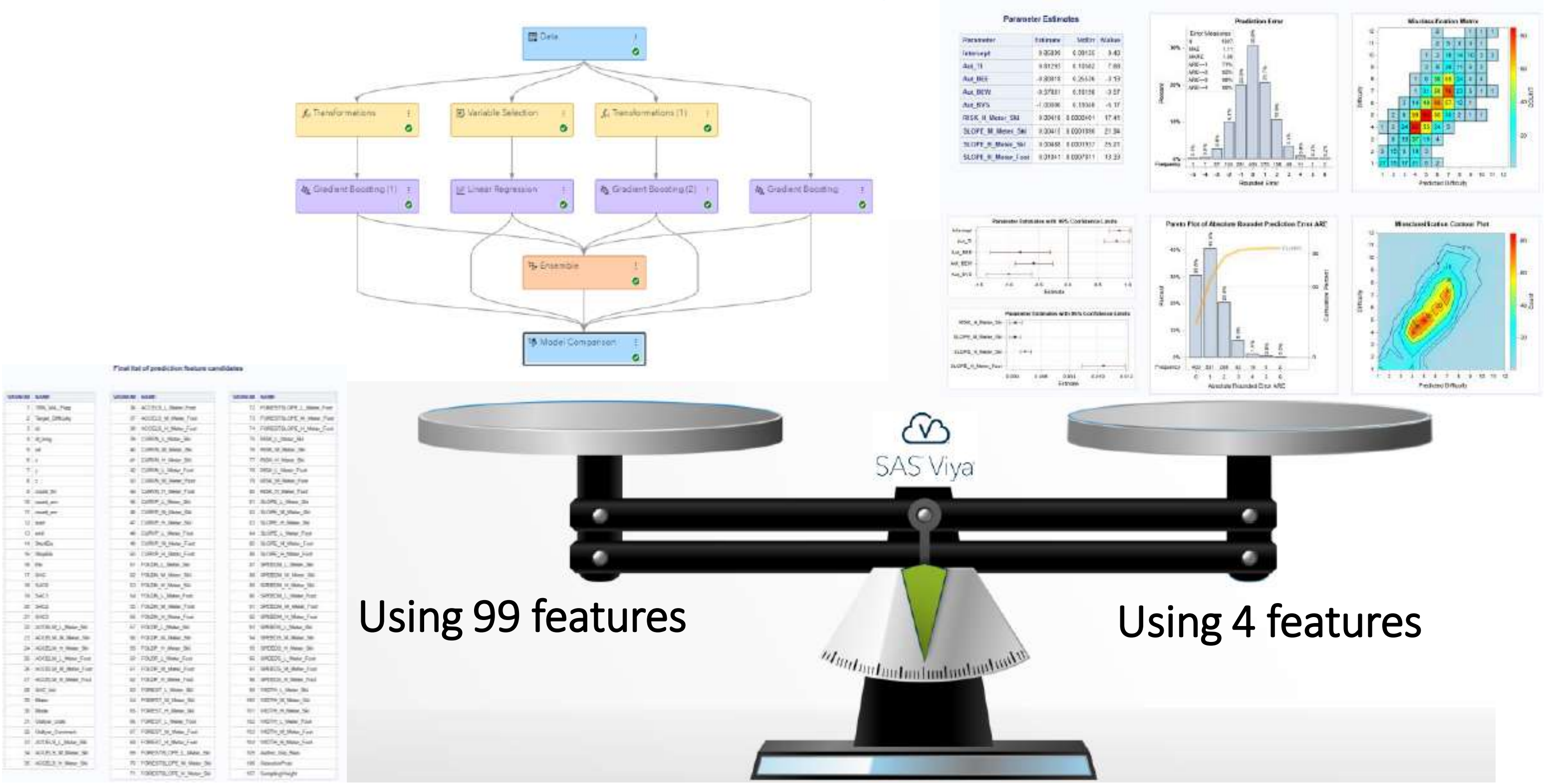
| VARNUM | NAME |
|---|---|
| 1 | TRN_VAL_Flag |
| 2 | Target_Difficulty |
| 3 | id |
| 4 | id_long |
| 5 | url |
| 6 | x |
| 7 | y |
| 8 | z |
| 9 | count_fm |
| 10 | count_am |
| 11 | count_sm |
| 12 | start |
| 13 | end |
| 14 | StartEle |
| 15 | StopEle |
| 16 | Ele |
| 17 | SAC |
| 18 | SAC0 |
| 19 | SAC1 |
| 20 | SAC2 |
| 21 | SAC3 |
| 22 | ACCELM_L_Meter_Ski |
| 23 | ACCELM_M_Meter_Ski |
| 24 | ACCELM_H_Meter_Ski |
| 25 | ACCELM_L_Meter_Foot |
| 26 | ACCELM_M_Meter_Foot |
| 27 | ACCELM_H_Meter_Foot |
| 28 | SAC_Vol |
| 29 | Meter |
| 30 | Mode |
| 31 | Outlyer_code |
| 32 | Outlyer_Comment |
| 33 | ACCELS_L_Meter_Ski |
| 34 | ACCELS_M_Meter_Ski |
| 35 | ACCELS_H_Meter_Ski |
| 36 | ACCELS_L_Meter_Foot |
| 37 | ACCELS_M_Meter_Foot |
| 38 | ACCELS_H_Meter_Foot |
| 39 | CURVN_L_Meter_Ski |
| 40 | CURVN_M_Meter_Ski |
| 41 | CURVN_H_Meter_Ski |
| 42 | CURVN_L_Meter_Foot |
| 43 | CURVN_M_Meter_Foot |
| 44 | CURVN_H_Meter_Foot |
| 45 | CURVP_L_Meter_Ski |
| 46 | CURVP_M_Meter_Ski |
| 47 | CURVP_H_Meter_Ski |
| 48 | CURVP_L_Meter_Foot |
| 49 | CURVP_M_Meter_Foot |
| 50 | CURVP_H_Meter_Foot |
| 51 | FOLDN_L_Meter_Ski |
| 52 | FOLDN_M_Meter_Ski |
| 53 | FOLDN_H_Meter_Ski |
| 54 | FOLDN_L_Meter_Foot |
| 55 | FOLDN_M_Meter_Foot |
| 56 | FOLDN_H_Meter_Foot |
| 57 | FOLDP_L_Meter_Ski |
| 58 | FOLDP_M_Meter_Ski |
| 59 | FOLDP_H_Meter_Ski |
| 60 | FOLDP_L_Meter_Foot |
| 61 | FOLDP_M_Meter_Foot |
| 62 | FOLDP_H_Meter_Foot |
| 63 | FOREST_L_Meter_Ski |
| 64 | FOREST_M_Meter_Ski |
| 65 | FOREST_H_Meter_Ski |
| 66 | FOREST_L_Meter_Foot |
| 67 | FOREST_M_Meter_Foot |
| 68 | FOREST_H_Meter_Foot |
| 69 | FORESTSLOPE_L_Meter_Ski |
| 70 | FORESTSLOPE_M_Meter_Ski |
| 71 | FORESTSLOPE_H_Meter_Ski |
| 72 | FORESTSLOPE_L_Meter_Foot |
| 73 | FORESTSLOPE_M_Meter_Foot |
| 74 | FORESTSLOPE_H_Meter_Foot |
| 75 | RISK_L_Meter_Ski |
| 76 | RISK_M_Meter_Ski |
| 77 | RISK_H_Meter_Ski |
| 78 | RISK_L_Meter_Foot |
| 79 | RISK_M_Meter_Foot |
| 80 | RISK_H_Meter_Foot |
| 81 | SLOPE_L_Meter_Ski |
| 82 | SLOPE_M_Meter_Ski |
| 83 | SLOPE_H_Meter_Ski |
| 84 | SLOPE_L_Meter_Foot |
| 85 | SLOPE_M_Meter_Foot |
| 86 | SLOPE_H_Meter_Foot |
| 87 | SPEEDM_L_Meter_Ski |
| 88 | SPEEDM_M_Meter_Ski |
| 89 | SPEEDM_H_Meter_Ski |
| 90 | SPEEDM_L_Meter_Foot |
| 91 | SPEEDM_M_Meter_Foot |
| 92 | SPEEDM_H_Meter_Foot |
| 93 | SPEEDS_L_Meter_Ski |
| 94 | SPEEDS_M_Meter_Ski |
| 95 | SPEEDS_H_Meter_Ski |
| 96 | SPEEDS_L_Meter_Foot |
| 97 | SPEEDS_M_Meter_Foot |
| 98 | SPEEDS_H_Meter_Foot |
| 99 | WIDTH_L_Meter_Ski |
| 100 | WIDTH_M_Meter_Ski |
| 101 | WIDTH_H_Meter_Ski |
| 102 | WIDTH_L_Meter_Foot |
| 103 | WIDTH_M_Meter_Foot |
| 104 | WIDTH_H_Meter_Foot |
| 105 | Author_Grp_Bias |
| 106 | SelectionProb |
| 107 | SamplingWeight |

Counting your steps like the fitness app of your smart phone

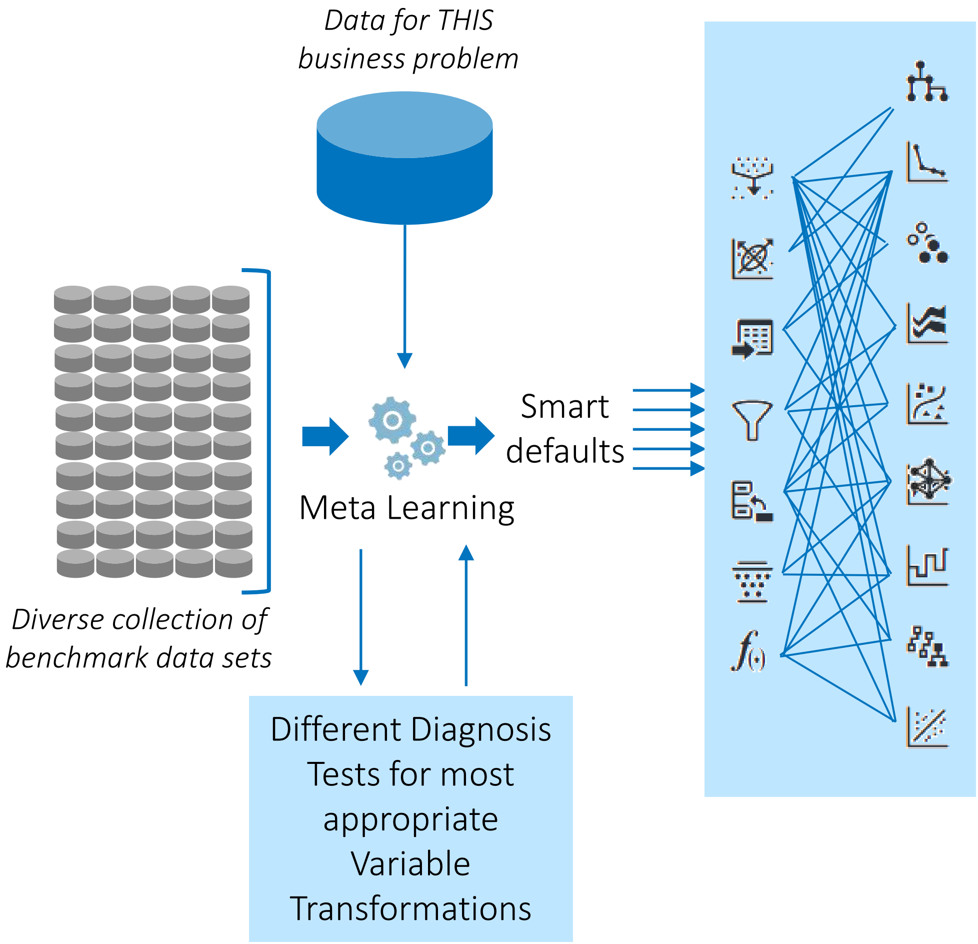

Risk
Slope
SpeedM
L
M
H
RISK_L_Meter_Ski
Max 595
Mean 80
StdDev 166
SLOPE_L_Meter_Ski
Max 748
Mean 45
StdDev 137
SPEEDM_L_Meter_Ski
Max 1055
Mean 78
StdDev 205
RISK_M_Meter_Ski
Max 595
Mean 241
StdDev 209
SLOPE_M_Meter_Ski
Max 748
Mean 242
StdDev 250
SPEEDM_M_Meter_Ski
Max 1055
Mean 408
StdDev 347
RISK_H_Meter_Ski
Max 595
Mean 274
StdDev 242
SLOPE_H_Meter_Ski
Max 748
Mean 462
StdDev 287
SPEEDM_H_Meter_Ski
Max 1055
Mean 569
StdDev 397
Percent

# What predictive modeling approach did we take?

## Machine Learning vs. Statistical Model



# Data Science Pilot Action



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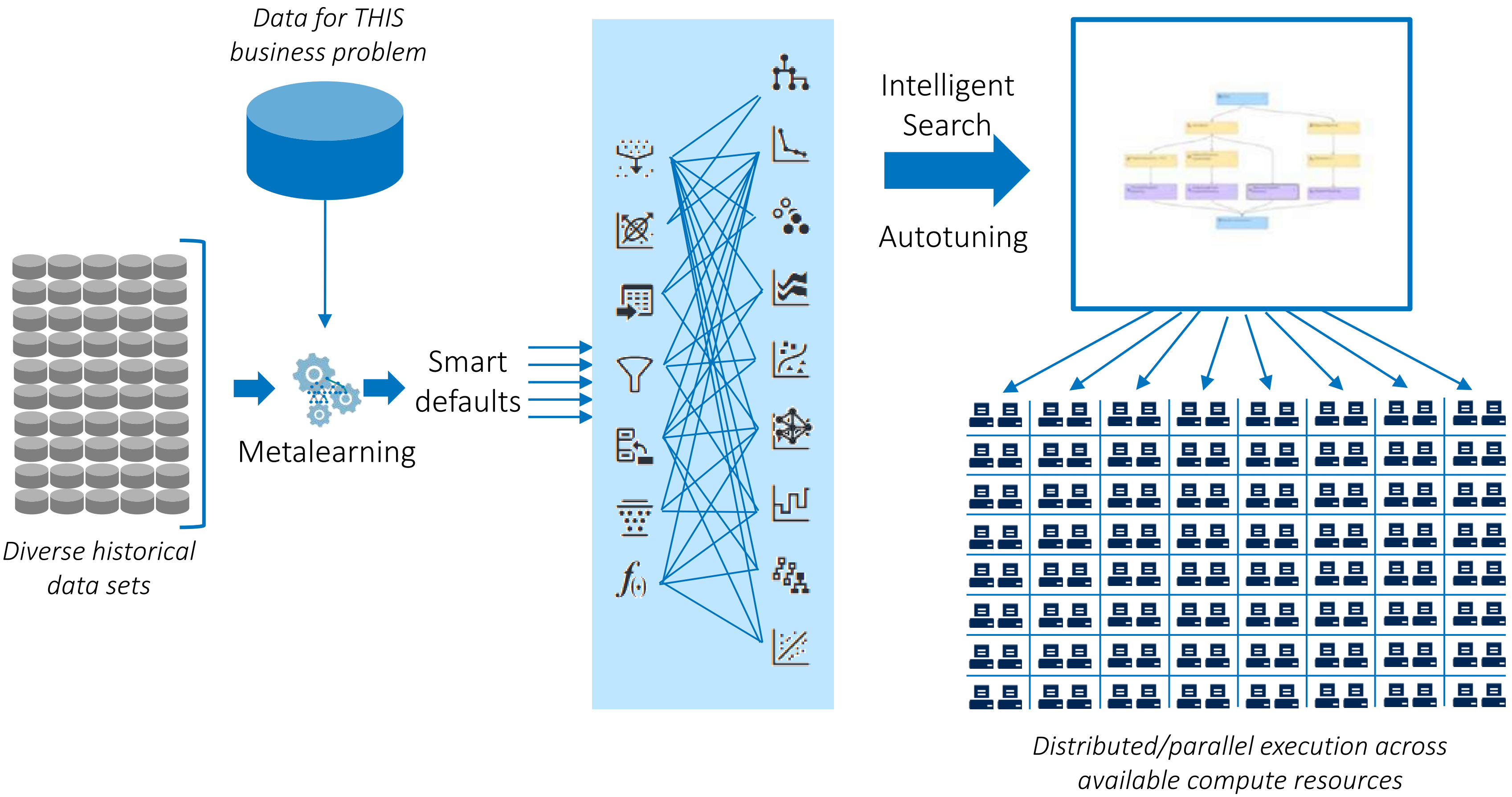

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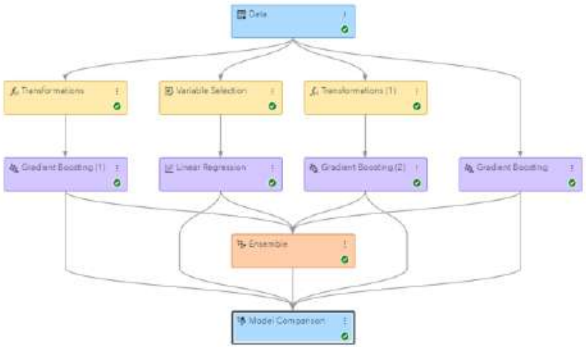
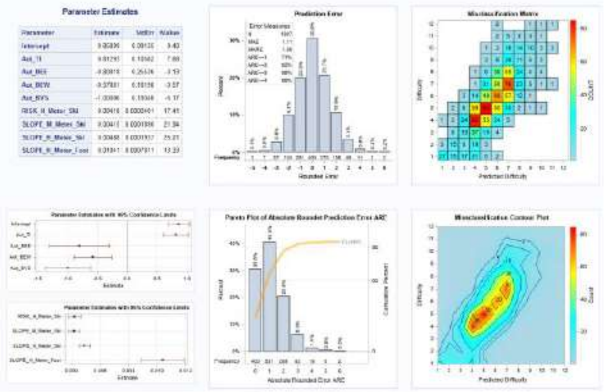


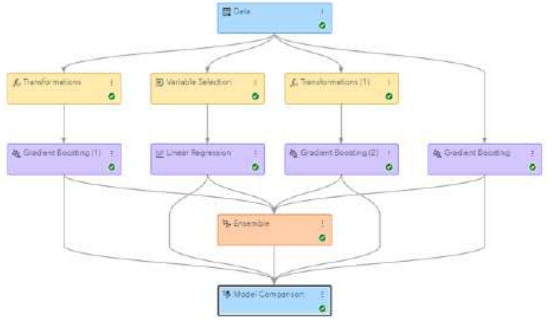


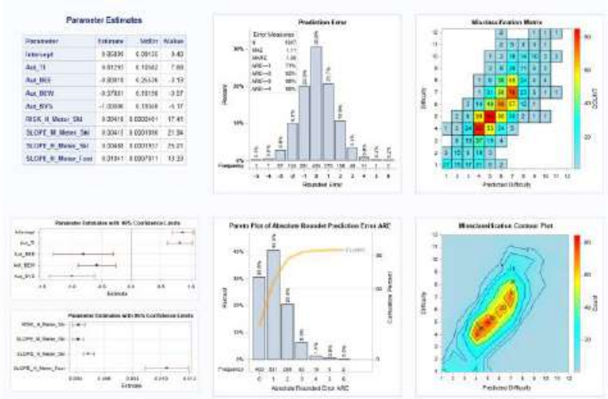
Using 99 features
Accuracy: 1.05 (MAE)

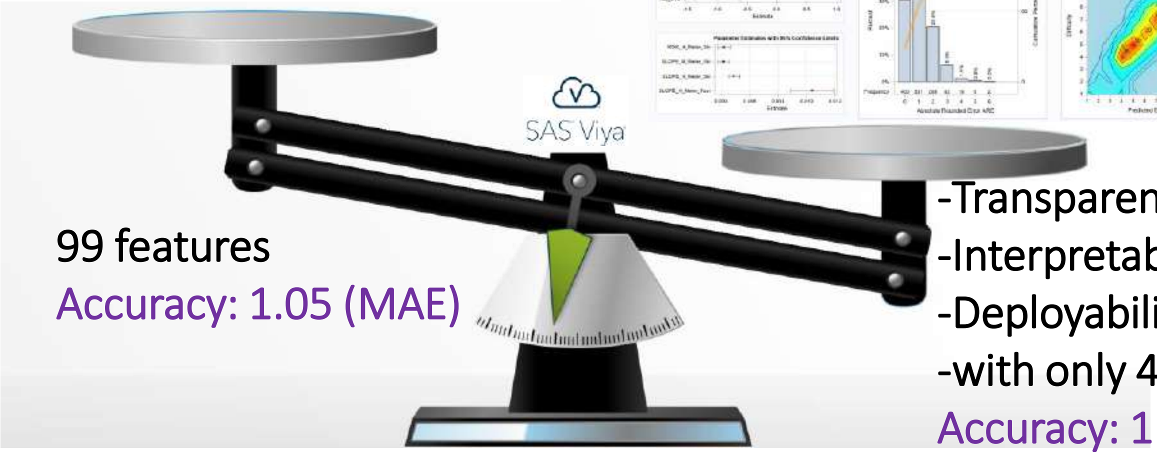
Using 4 features
Accuracy: 1.11 (MAE)

# What Results did we get?

## Transparency, Interpretability, Deployability outweighted Accuracy






99 features

Accuracy: 1.05 (MAE)

-Transparency

-Interpretability,

-Deployability

-with only 4 features

Accuracy: 1.11 (MAE)

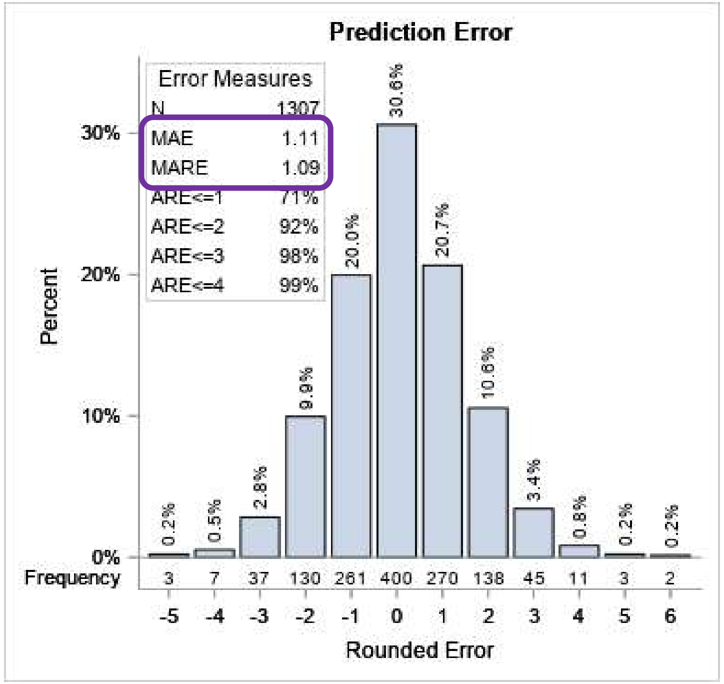
# Variable selection with quantile regression

## For median of difficulty

The HPQUANTSELECT Procedure
Quantile Level = 0.5

| Selection Summary | | | | |
|---|---|---|---|---|
| Step | Effect Entered | Number Effects In | AIC | SBC |
| 0 | Intercept | 1 | -185.5716 | -180.3961 |
| 1 | RISK_H_Meter_Ski | 2 | -984.6951 | -974.3442 |
| 2 | SLOPE_H_Meter_Foot | 3 | -1216.9940 | -1201.4675 |
| 3 | Aut_BVS | 4 | -1246.9930 | -1226.2911 |
| 4 | Aut_BEW | 5 | -1277.7180 | -1251.8405 |
| 5 | SLOPE_H_Meter_Ski | 6 | -1307.2939 | -1276.2410 |
| 6 | SLOPE_M_Meter_Ski | 7 | -1484.6233 | -1448.3949 |
| 7 | Aut_TI | 8 | -1510.2989 | -1468.8950 |
| 8 | Aut_BEE | 9 | -1522.1704* | -1475.5910* |

| Fit Statistics | |
|---|---|
| Objective Function | 725.08515 |
| R1 | 0.40396 |
| Adj R1 | 0.40028 |
| AIC | -1522.17042 |
| AICC | -1522.03163 |
| SBC | -1475.59101 |
| ACL | 0.55477 |

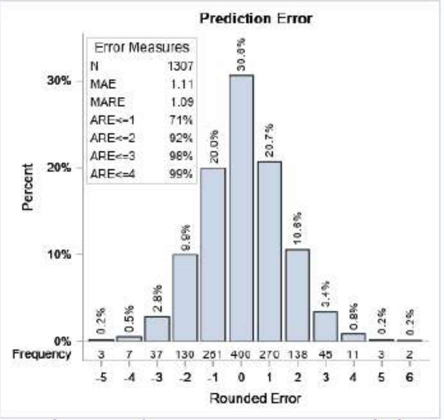


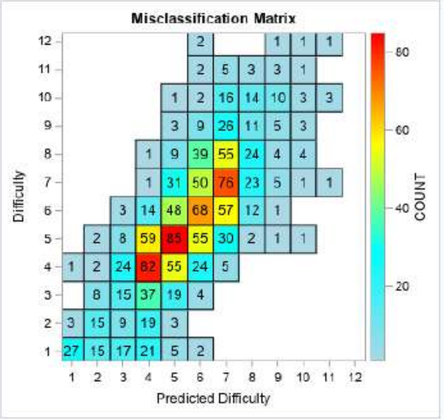

Risk:=SlopeAngle*SpeedMax

## Method: Quantile Regression - PROC HPQUANTSELECT

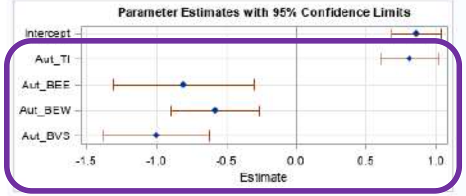
### Parameter Estimates

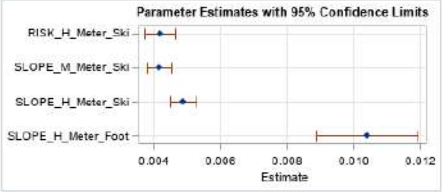
| Parameter | Estimate | StdErr | tValue |
|---|---|---|---|
| Intercept | 0.85899 | 0.09135 | 9.40 |
| Aut_TI | 0.81293 | 0.10582 | 7.68 |
| Aut_BEE | -0.80018 | 0.25536 | -3.13 |
| Aut_BEW | -0.57861 | 0.16198 | -3.57 |
| Aut_BVS | -1.00000 | 0.19346 | -5.17 |
| RISK_H_Meter_Ski | 0.00418 | 0.0002401 | 17.41 |
| SLOPE_M_Meter_Ski | 0.00415 | 0.0001890 | 21.94 |
| SLOPE_H_Meter_Ski | 0.00488 | 0.0001937 | 25.21 |
| SLOPE_H_Meter_Foot | 0.01041 | 0.0007811 | 13.33 |

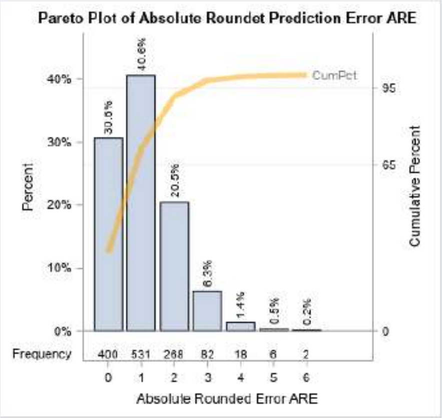


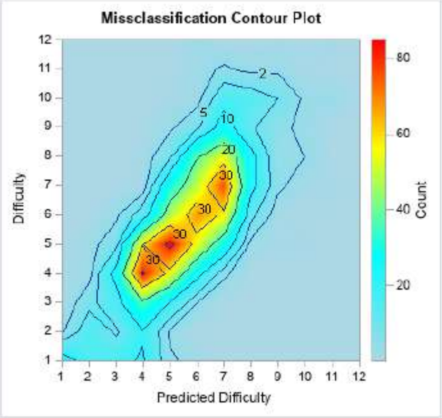




# Four out of 12 selected author dummy variables



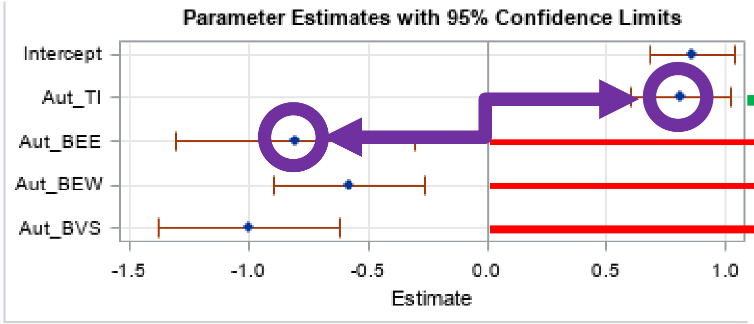



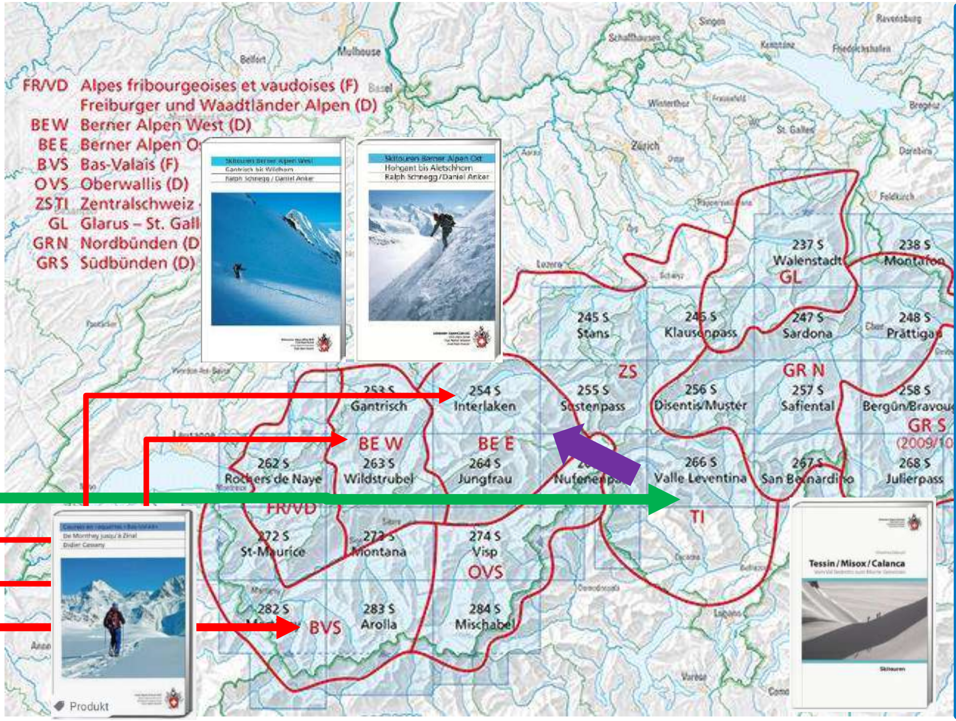
# Significant author dummy variables

## Systematic Overrating vs Underrating bias detected for difficulty

| Error Measures | |
|---|---|
| N | 1307 |
| MAE | 1.11 |
| MARE | 1.09 |
| ARE<=1 | 71% |
| ARE<=2 | 92% |
| ARE<=3 | 98% |
| ARE<=4 | 99% |

| Parameter | Estimate | StdErr | tValue |
|---|---|---|---|
| Intercept | 0.85899 | 0.09135 | 9.40 |
| Aut_TI | 0.81293 | 0.10582 | 7.68 |
| Aut_BEE | -0.80018 | 0.25536 | -3.13 |
| Aut_BEW | -0.57861 | 0.16198 | -3.57 |
| Aut_BVS | -1.00000 | 0.19346 | -5.17 |



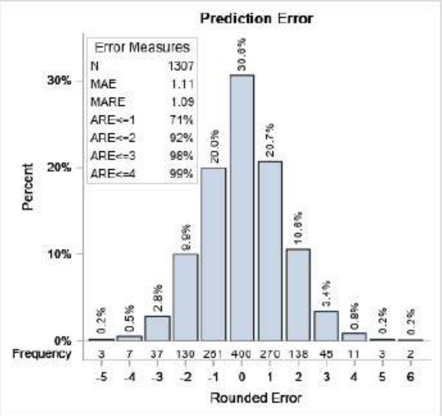



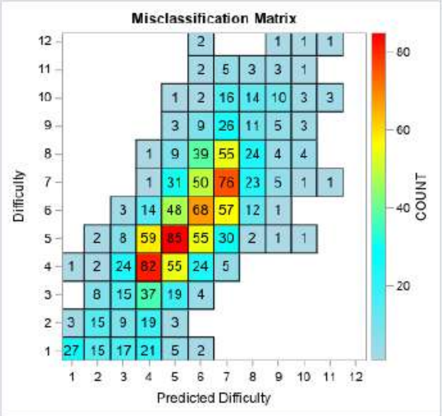

| DIFFICULTY |
|---|
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |
| 6 |
| 7 |
| 8 |
| 9 |
| 10 |
| 11 |
| 12 |
| 13 |
| 14 |
| 15 |
| 16 |
| 17 |
| 18 |

## Method: Quantile Regression - PROC HPQUANTSELECT

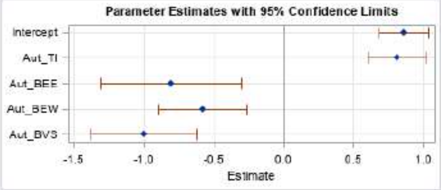
### Parameter Estimates

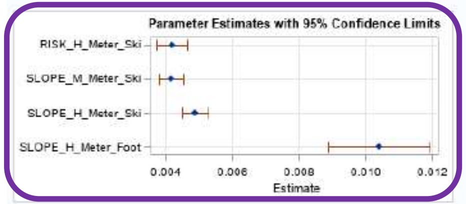
| Parameter | Estimate | StdErr | tValue |
|---|---|---|---|
| Intercept | 0.85899 | 0.09135 | 9.40 |
| Aut_TI | 0.81293 | 0.10582 | 7.68 |
| Aut_BEE | -0.80018 | 0.25536 | -3.13 |
| Aut_BEW | -0.57861 | 0.16198 | -3.57 |
| Aut_BVS | -1.00000 | 0.19346 | -5.17 |
| RISK_H_Meter_Ski | 0.00418 | 0.0002401 | 17.41 |
| SLOPE_M_Meter_Ski | 0.00415 | 0.0001890 | 21.94 |
| SLOPE_H_Meter_Ski | 0.00488 | 0.0001937 | 25.21 |
| SLOPE_H_Meter_Foot | 0.01041 | 0.0007811 | 13.33 |

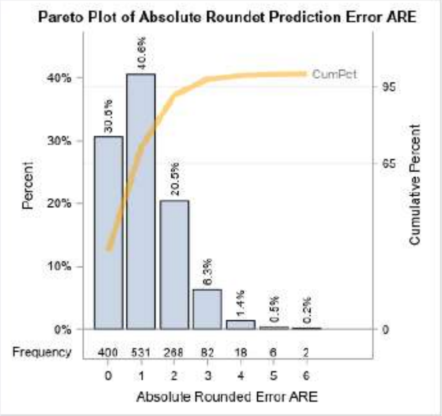


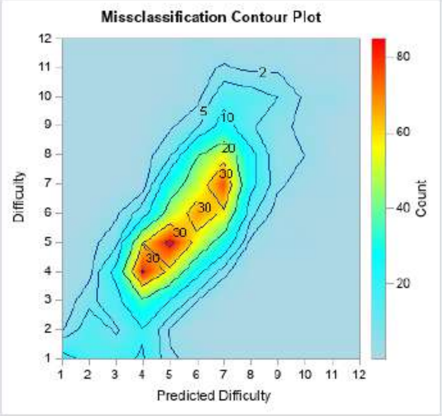




Selected four out of ~20 000 ski tour features derived from local track properties



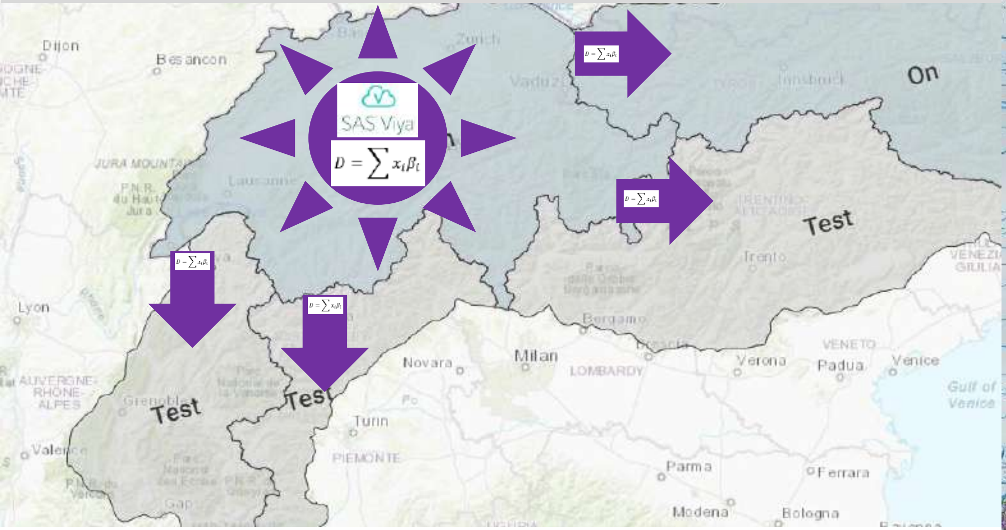
# Model deployment to expand services of skitourenguru.ch

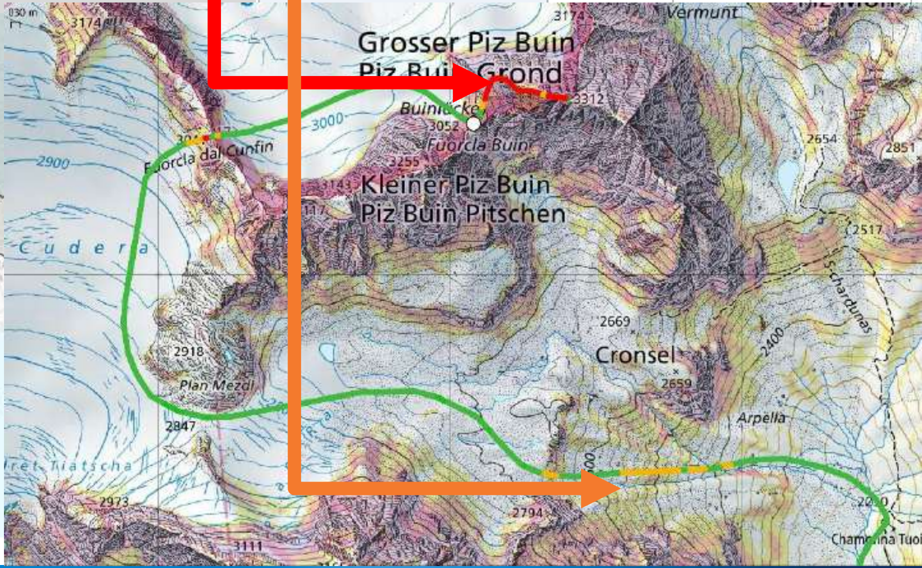
## to 4 neighboring countries with ~10 000 additional unrated ski tours

SKITOURENGURU

P_Difficulty=0.859+( 418*RISK_H_Meter_Ski
+ 415*Slope_M_Meter_Ski
+ 488*Slope_H_Meter_Ski
+1041*Slope_H_Meter_Foot )/100000

| Parameter | Estimate | StdErr | tValue |
|---|---|---|---|
| Intercept | 0.85899 | 0.09135 | 9.40 |
| RISK_H_Meter_Ski | 0.00418 | 0.0002401 | 17.41 |
| SLOPE_M_Meter_Ski | 0.00415 | 0.0001890 | 21.94 |
| SLOPE_H_Meter_Ski | 0.00488 | 0.0001937 | 25.21 |



# Model Deployment and Integration

SKITOURENGURU

East Alps


## What's Skitourenguru

Skitourenguru supports you in the selection and planning of a suitable ski tour with low avalanche risk. For this purpose, Skitourenguru assigns daily an avalanche risk to thousands of ski tours in the alpine region:

| Symbol | Values | Avalanche risk |
|---|---|---|
| ▲ | 0–1 | Low avalanche risk |
| ▼ | 1–2 | Elevated avalanche risk |
| ● | 2–3 | High avalanche risk |

In addition Skitourenguru marks static route cruxes with grey rings:

| Symbol | Class | Meaning |
|---|---|---|
| ○ | 1 | Avalanche terrain |
| ◎ | 2 | Typical avalanche terrain |
| ◉ | 3 | Very typical avalanche terrain |

On site and in the individual slope usually information becomes accessible that is not available to Skitourenguru. The information presented on Skitourenguru is subject to uncertainties (see Handbook). Therefore Skitourenguru must not be the only criterion to access a slope.

## Choose a region

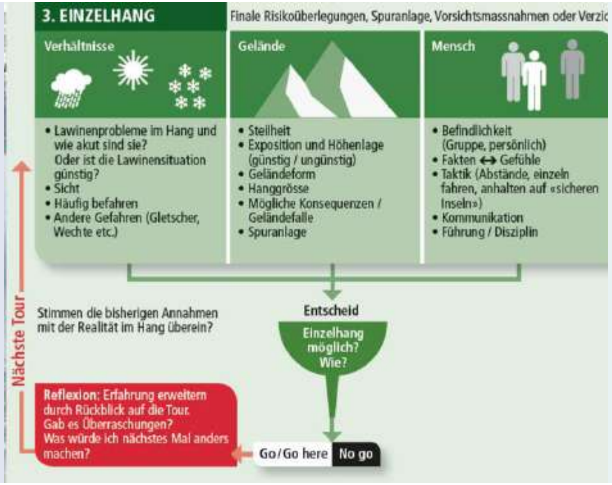
| Region | State | Edition | Valid |
|---|---|---|---|
| Switzerland | On | 17.30 h | 16.4.2021–17.00 h |
| East Alps | On | 18.30 h | 16.4.2021–18.00 h |
| France | Test | 16.30 h | 16.4.2021–18.00 h |
| Nothwest-Italy | Test | 16.30 h | 16.4.2021–16.00 h |
| Notheast-Italy | Test | 17.30 h | 16.4.2021–16.00 h |

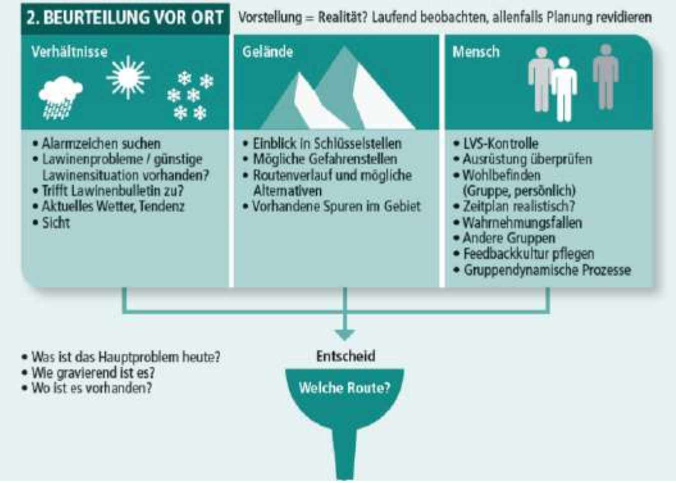
## Partners

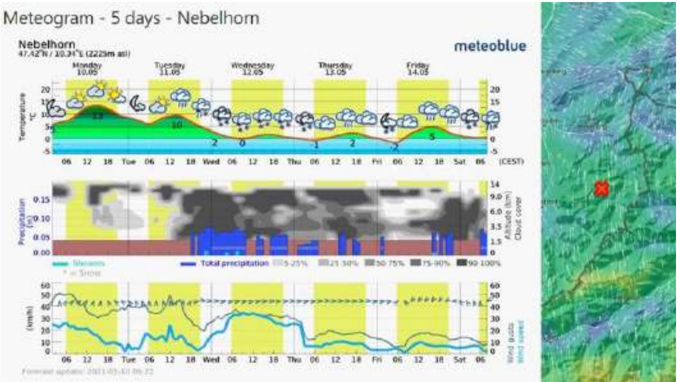
Skitourenguru is supported among others by the following partners

# Off course, skitourenguru does not exempt you from

## applying the recommended avalanche and risk assessment strategies

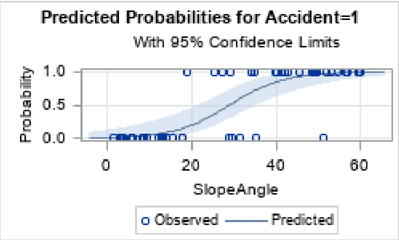
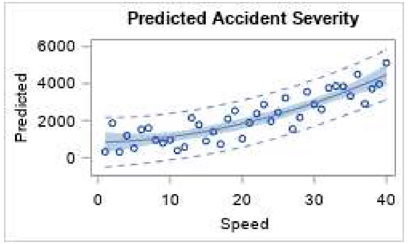



# Takeaways:

## What did we achieve?

Difficulty ~  X 





| DIFFICULTY | DIFFICULTY LABEL |
|---|---|
| 1 | Easy |
| 2 | Easy (+) |
| 3 | Less Difficult(-) |
| 4 | Less Difficult |
| 5 | Less Difficult (+) |
| 6 | Quite Difficult (-) |
| 7 | Quite Difficult |
| 8 | Quite Difficult (+) |
| 9 | Difficult (-) |
| 10 | Difficult |
| 11 | Difficult (+) |
| 12 | Very Difficult (-) |
| 13 | Very Difficult |
| 14 | Very Difficult (+) |
| 15 | Extremely Difficult (-) |
| 16 | Extremely Difficult |
| 17 | Extremely Difficult (+) |
| 18 | Extremely Difficult |

- We are proposing a new definition of **difficulty** metric derived from interaction of two local track properties: **slope angel and speed of falling** acting as proxies for accident probability and severity
- Overall, this metric is consistent with the unique human and cultural expertise published in the extensive SAC ski touring literature from which our model was trained.
- The discretionary range of the SAC methodology and prediction error margin is in the range of 1.1 to 1.8 levels of the 18-step SAC difficulty scale (i.e. "+" or "-")
- An additional advantage of this methodology is its independent from prevailing weather and snow conditions at the moment of manual rating.
- We still have ongoing discussions with incorporation of the foot section in this model.
- The model provides the basis for fast and automatic bulk scoring prediction for up to ~10000 tours throughout the alps in AT, DE, IT, FR. It will support the expansion of Skitourenguru's services.

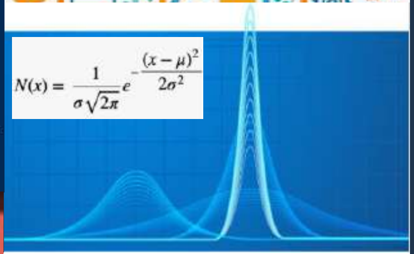
Günter Schmudlach, Skitourenguru GmbH, Zürich CH


Ulrich Reincke, Principal Data Scientist, SAS, Heidelberg, DE

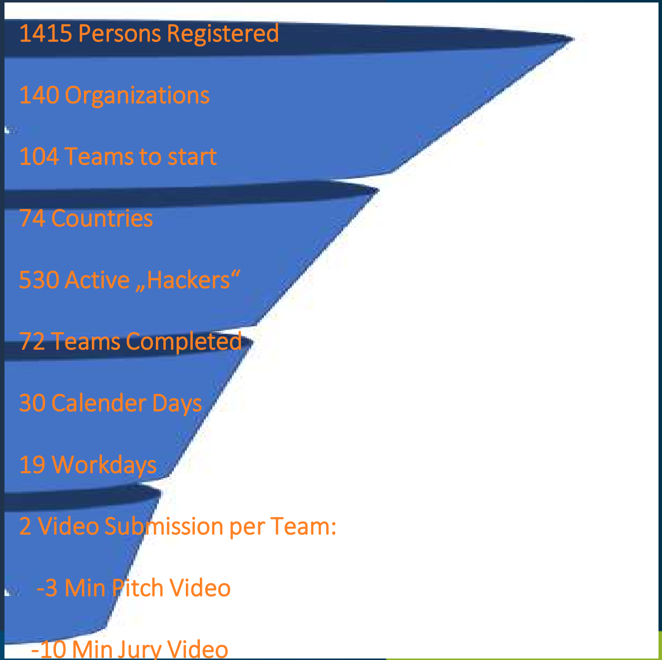
**Thank you for your attention. And don’t forget: Always put safety first**

# Example SAS Hackathon 2023

Productivity, Speed,
Fast, Reliable, Trustworthy , Fair Results without Bias




[Look at this year's innovative Use Cases and fantastic results]()

## Outlyer list with absolute prediction error gt 3.5

Type=Overrating

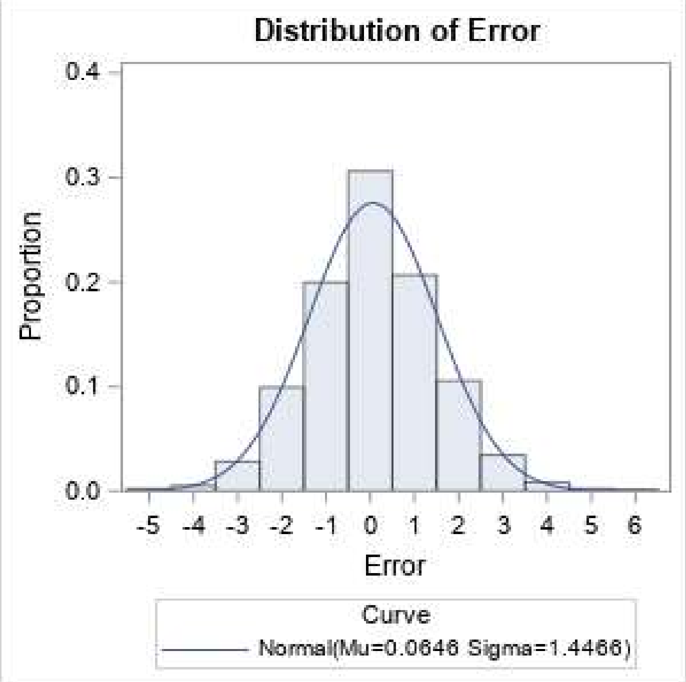
| id_long | Difficulty | P | E | SAC0 | Outlyer_Comment | StartEle | StopEle | Ele | RISK_H_Meter_Ski | SLOPE_H_Meter_Ski | SLOPE_M_Meter_Ski | SLOPE_H_Meter_Foot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1258_Hasen_Gotterli | 1 | 5 | -4 | ZS | | 449 | 1394 | 945 | 0 | 748 | 0 | 0 |
| 171_Cons_PizTerri | 7 | 11 | -4 | GRN | | 1468 | 3146 | 1789 | 595 | 748 | 0 | 360 |
| 564_Küblis_Chrüz | 1 | 5 | -4 | GRN | Different Route | 809 | 2190 | 1384 | 157 | 372 | 376 | 0 |
| 255_Furggels_Stelli | 1 | 5 | -4 | GRN | Manual Underrat | 1198 | 2047 | 976 | 147 | 643 | 105 | 0 |
| 912_Mühlebach_Ärnergale | 1 | 5 | -4 | VSE | Different Route | 1232 | 2621 | 1391 | 169 | 629 | 119 | 0 |
| 387_MittlerRossfal_Hochalp | 1 | 5 | -4 | GL | Compromise | 899 | 1527 | 650 | 234 | 264 | 484 | 0 |
| 535_Ladstafel_Mittaghorn | 5 | 9 | -4 | VSE | | 1924 | 3004 | 1080 | 595 | 748 | 0 | 220 |
| 358_Latsch_CuolmdaLatsch | 1 | 6 | -5 | GRS | Road above 1600 | 1609 | 2294 | 686 | 244 | 748 | 0 | 0 |
| 1035_HospizSimplonp_MonteLeone | 5 | 10 | -5 | VSE | | 1998 | 3548 | 1657 | 508 | 698 | 50 | 290 |
| 1466_Sufers_VizanPintg | 1 | 6 | -5 | GRN | Road above 1600 | 1413 | 2513 | 1120 | 423 | 748 | 0 | 0 |

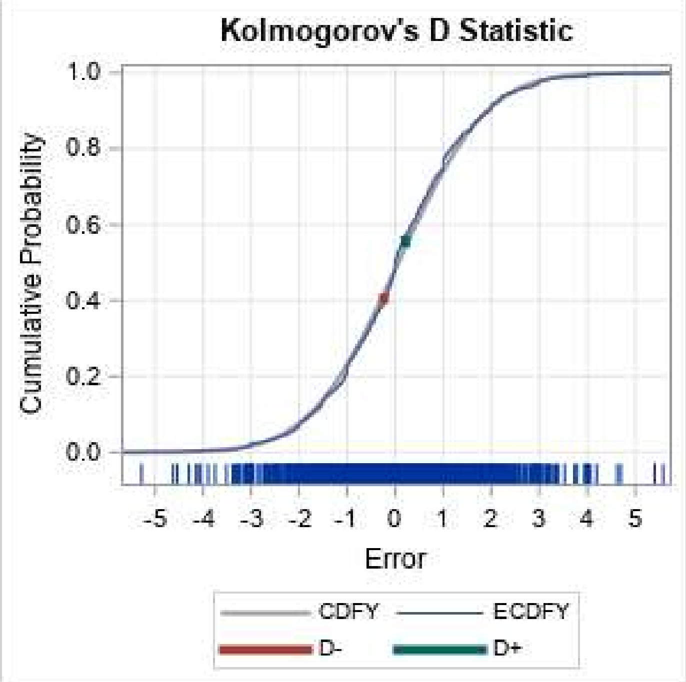
Type=Underrating

| id_long | Difficulty | P | E | SAC0 | Outlyer_Comment | StartEle | StopEle | Ele | RISK_H_Meter_Ski | SLOPE_H_Meter_Ski | SLOPE_M_Meter_Ski | SLOPE_H_Meter_Foot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 903_MayensdeMérib_PointedeVouasso | 12 | 6 | 6 | BVS | | 1728 | 3481 | 1755 | 595 | 748 | 0 | 0 |
| 367_ZurEich_GrosBrun | 12 | 6 | 6 | BEW | Compromise | 951 | 2098 | 1147 | 595 | 748 | 0 | 0 |
| 1231_Engi_Gufelstock | 11 | 6 | 5 | GL | Compromise | 812 | 2434 | 1622 | 260 | 748 | 0 | 0 |
| 706_ChantSura_PizRadönt | 10 | 5 | 5 | GRS | Other Ski Depot | 2330 | 3056 | 751 | 28 | 120 | 147 | 300 |
| 407_Urnerboden_Läckistock | 11 | 6 | 5 | ZS | Compromise | 1376 | 2483 | 1107 | 455 | 697 | 51 | 0 |
| 725_Dürrboden_Leidhorn | 9 | 5 | 4 | GRS | Compromise | 2006 | 2930 | 925 | 150 | 292 | 456 | 0 |
| 507_H.d'Allières_VanildesArtses | 11 | 7 | 4 | FRV | Other Ski Depot | 1006 | 1986 | 980 | 127 | 0 | 707 | 250 |
| 613_Diavolezza_PizCambrena | 11 | 7 | 4 | GRS | | 2978 | 3595 | 855 | 595 | 748 | 0 | 0 |
| 736_Brigels_Bifertenstock | 11 | 7 | 4 | GRN | | 1285 | 3416 | 2173 | 595 | 748 | 0 | 0 |
| 818_Jochstock_ReissendNollen | 11 | 7 | 4 | ZS | | 2508 | 3002 | 493 | 595 | 748 | 0 | 0 |
| 886_LeFlon_Chambairy | 10 | 6 | 4 | BVS | | 1046 | 2198 | 1151 | 595 | 748 | 0 | 0 |
| 916_BourgSt.Berna_MontVélan | 10 | 6 | 4 | BVS | | 1916 | 3721 | 1805 | 595 | 748 | 0 | 0 |
| 1448_Münster_HejiZwächte | 9 | 5 | 4 | BEE | Compromise | 1387 | 3083 | 1696 | 323 | 748 | 0 | 0 |
| 1236_Elm_Grüenenspitz | 9 | 5 | 4 | GL | Other Ski Depot | 960 | 2354 | 1394 | 94 | 316 | 432 | 60 |
| 1227_Horb_Frümsel | 11 | 7 | 4 | GL | Other Ski Depot | 887 | 2261 | 1374 | 22 | 113 | 635 | 300 |
| 591_Tschlin_Muttler | 8 | 4 | 4 | GRS | Other Ski Depot | 1533 | 3290 | 1758 | 44 | 22 | 726 | 30 |

# Prediction Residuals / Error

## Test for normality (N=1307)




### Kolmogorov's D Statistic

The UNIVARIATE Procedure
Fitted Normal Distribution for Error

| Goodness-of-Fit Tests for Normal Distribution | | | | |
|---|---|---|---|---|
| Test | Statistic | | p Value | |
| Kolmogorov-Smirnov | D | 0.03076998 | Pr > D | 0.168 |
| Cramer-von Mises | W-Sq | 0.33496573 | Pr > W-Sq | 0.110 |
| Anderson-Darling | A-Sq | 1.76279181 | Pr > A-Sq | 0.126 |

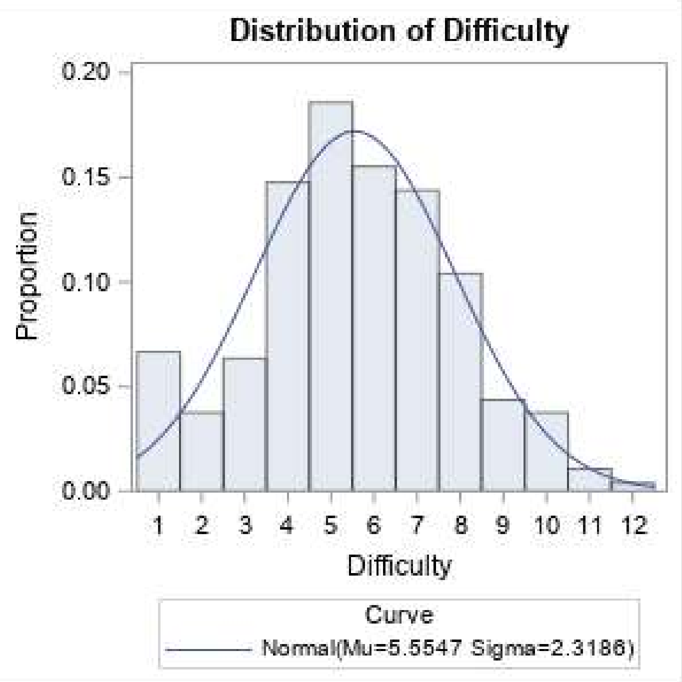
### Kolmogorov's D Statistic

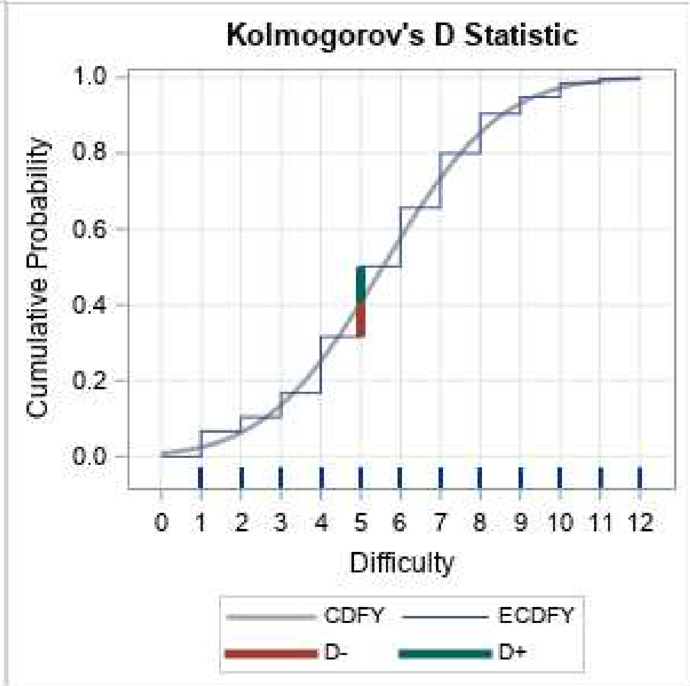
| D |
|---|
| 0.03077 |

| Kolmogorov D | | | | |
|---|---|---|---|---|
| | Error | Value | Low | High |
| D- | -0.232248 | 0.0269607 | 0.3917368 | 0.4186975 |
| D+ | 0.2099216 | 0.03077 | 0.5400028 | 0.5707728 |

# Target Variable Difficulty

## Test for normality (N=1307)




### Kolmogorov's D Statistic

The UNIVARIATE Procedure
Fitted Normal Distribution for Difficulty (diff)

| Goodness-of-Fit Tests for Normal Distribution | | | | |
|---|---|---|---|---|
| **Test** | **Statistic** | | **p Value** | |
| Kolmogorov-Smirnov | D | 0.0956892 | Pr > D | <0.001 |
| Cramer-von Mises | W-Sq | 2.0483810 | Pr > W-Sq | <0.001 |
| Anderson-Darling | A-Sq | 11.8013910 | Pr > A-Sq | <0.001 |

### Kolmogorov's D Statistic

| D |
|---|
| 0.0956892 |

| Kolmogorov D | | | | |
|---|---|---|---|---|
| | x | Value | Low | High |
| D- | 5 | 0.0902327 | 0.3152257 | 0.4054584 |
| D+ | 5 | 0.0956892 | 0.4054584 | 0.5011477 |

# Data preparation: from properties to features