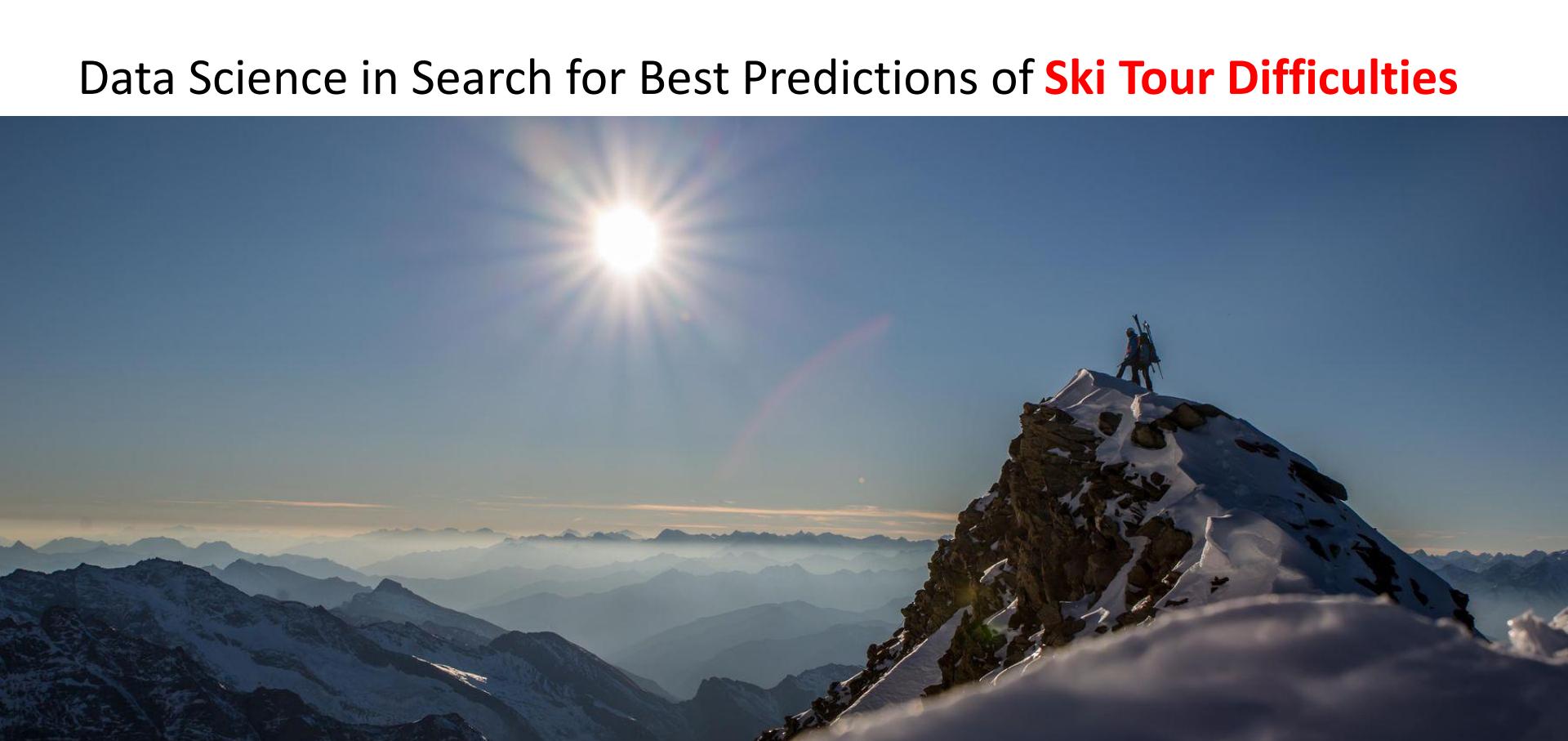


# Data Science in Search for Best Predictions of **Ski Tour Difficulties**



**SDS2021**

SWISS CONFERENCE  
ON DATA SCIENCE

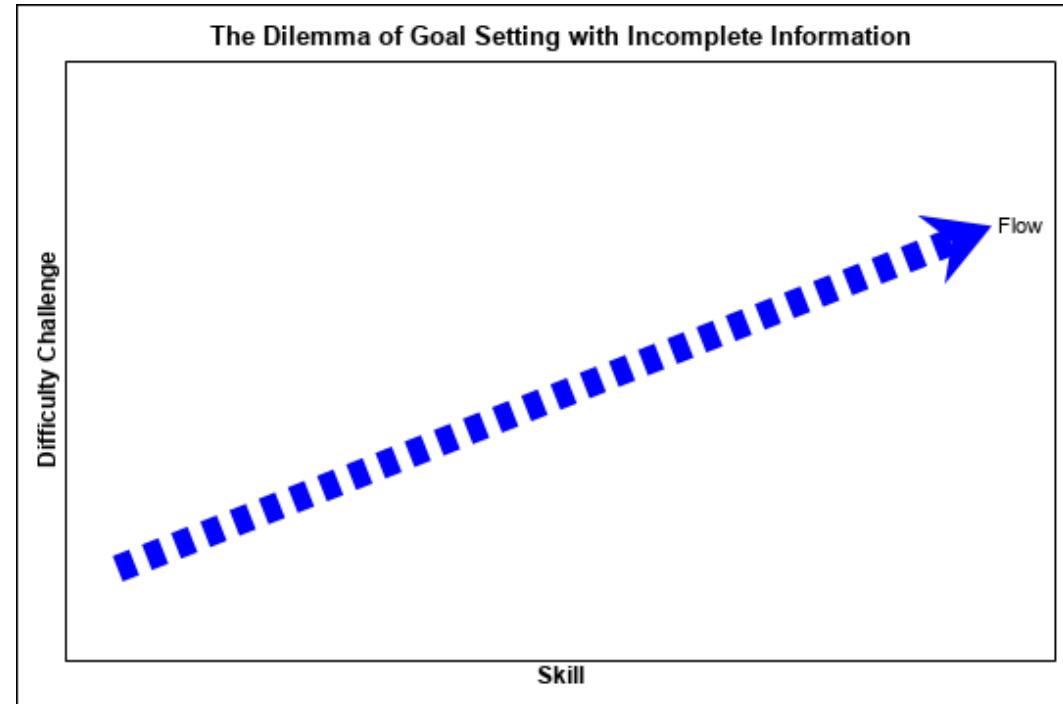
*Günter Schmudlach, Skitourenguru.ch  
Ulrich Reincke, SAS Institute*

# Difficulty of a ski tour

## Why is it important?

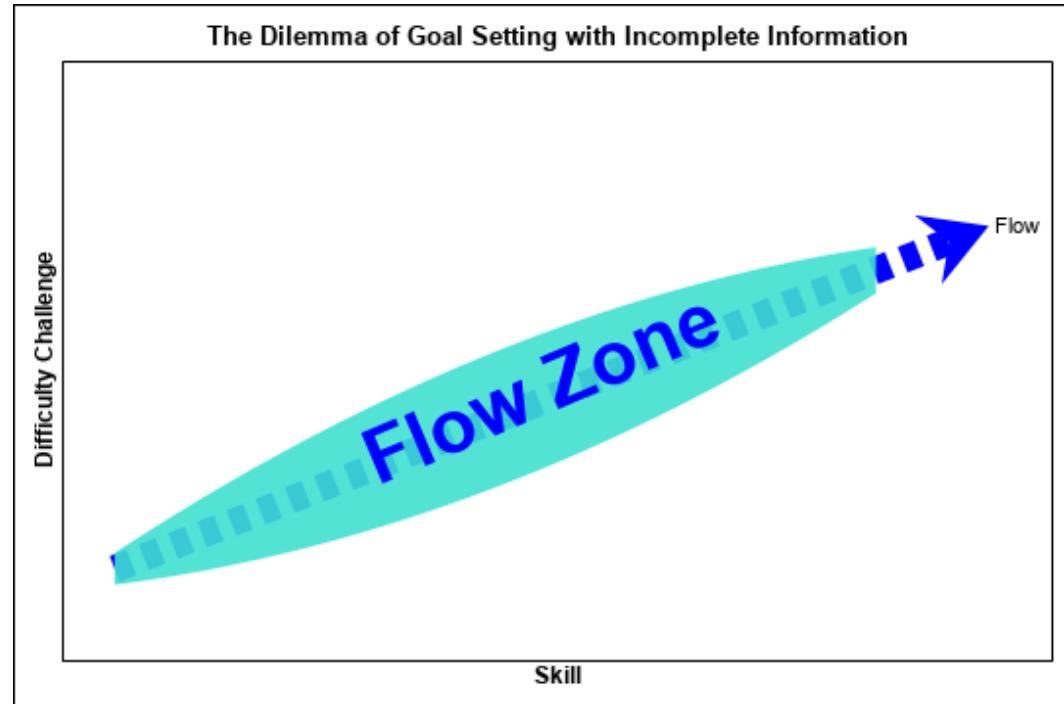
# Difficulty of a ski tour

## Why is it important?



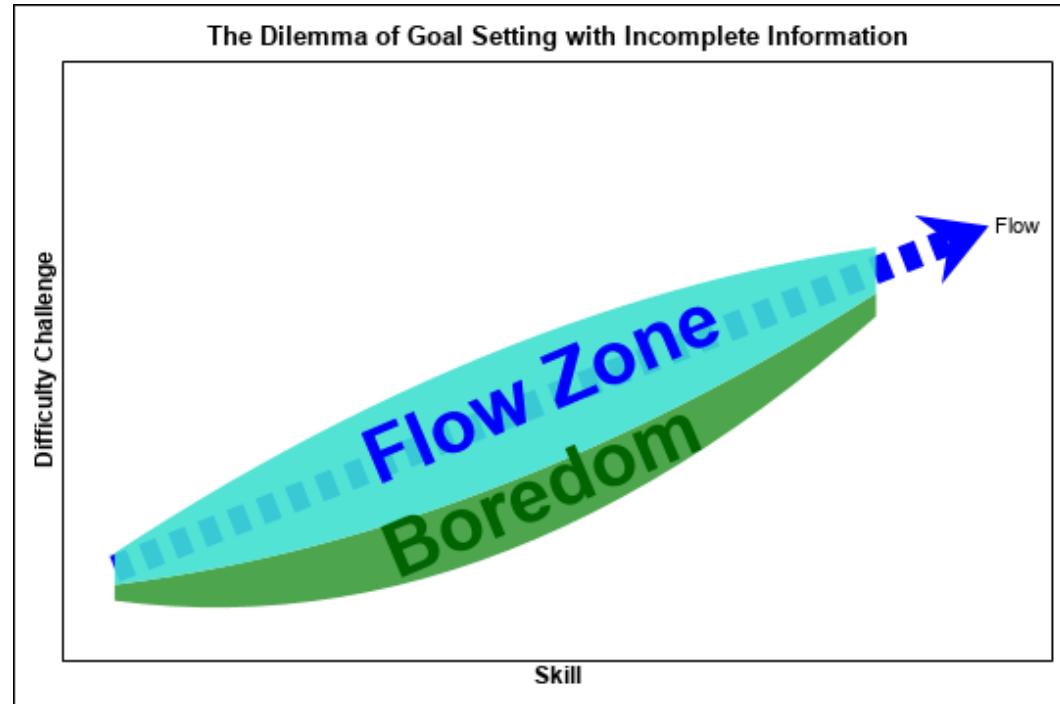
# Difficulty of a ski tour

## Why is it important?



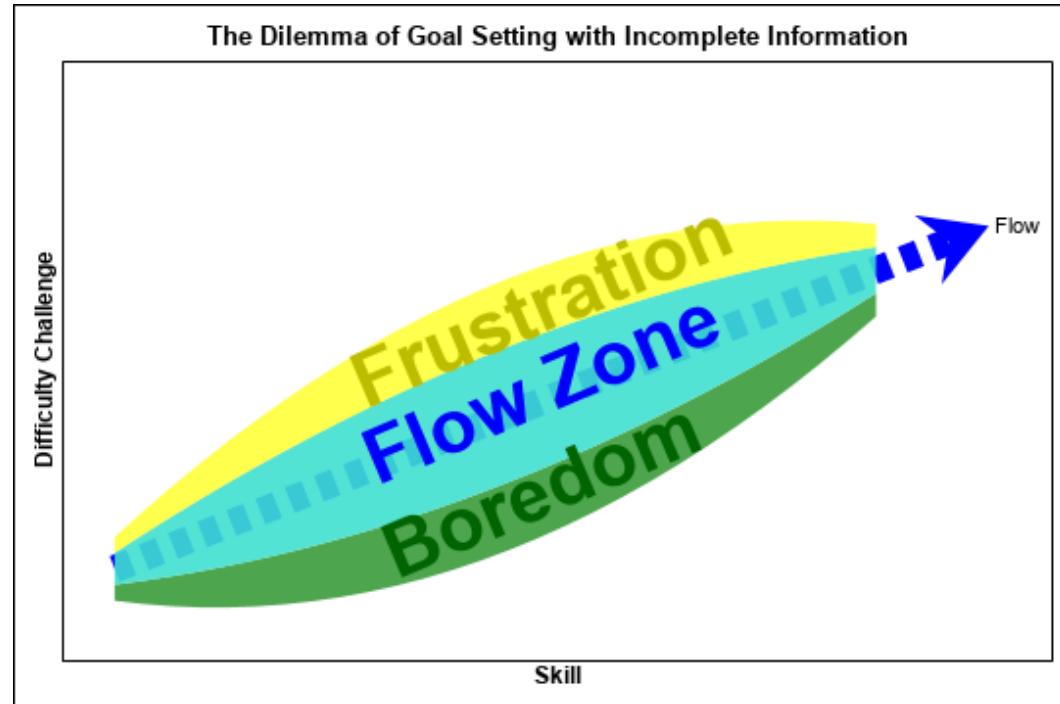
# Difficulty of a ski tour

## Why is it important?



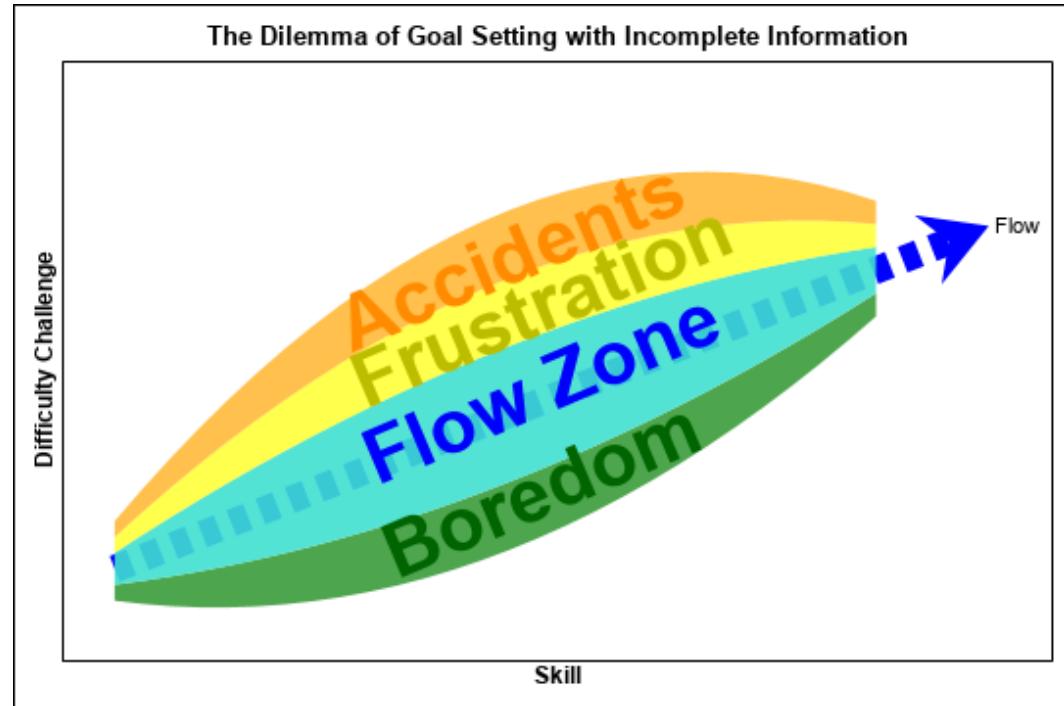
# Difficulty of a ski tour

## Why is it important?



# Difficulty of a ski tour

## Why is it important?



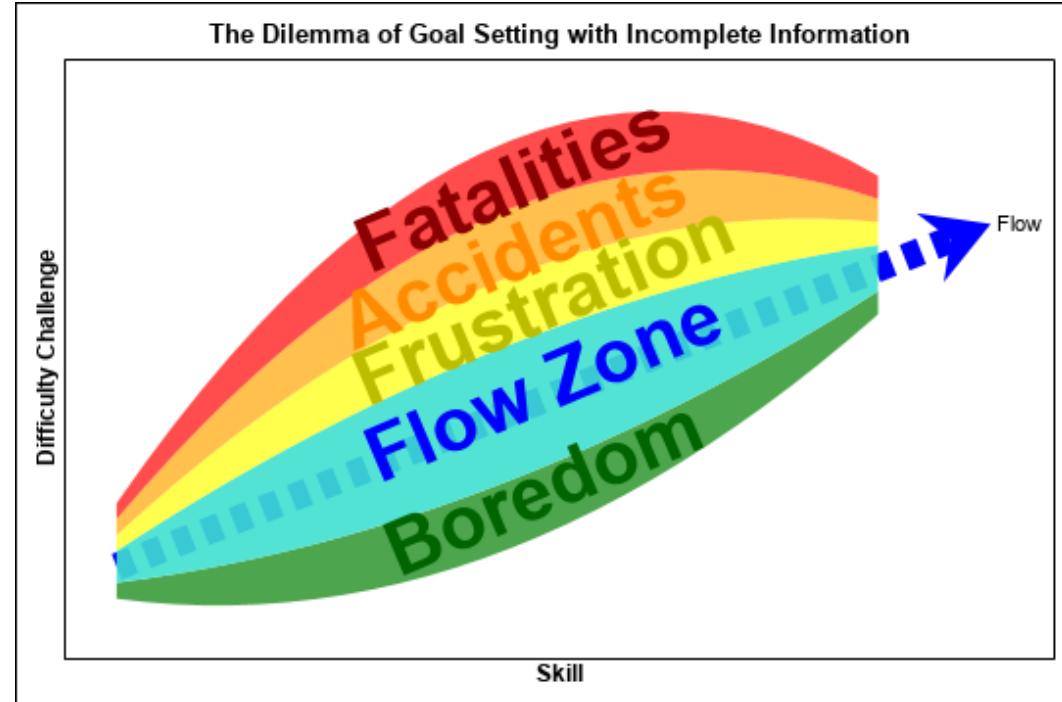
# Difficulty of a ski tour

## 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)



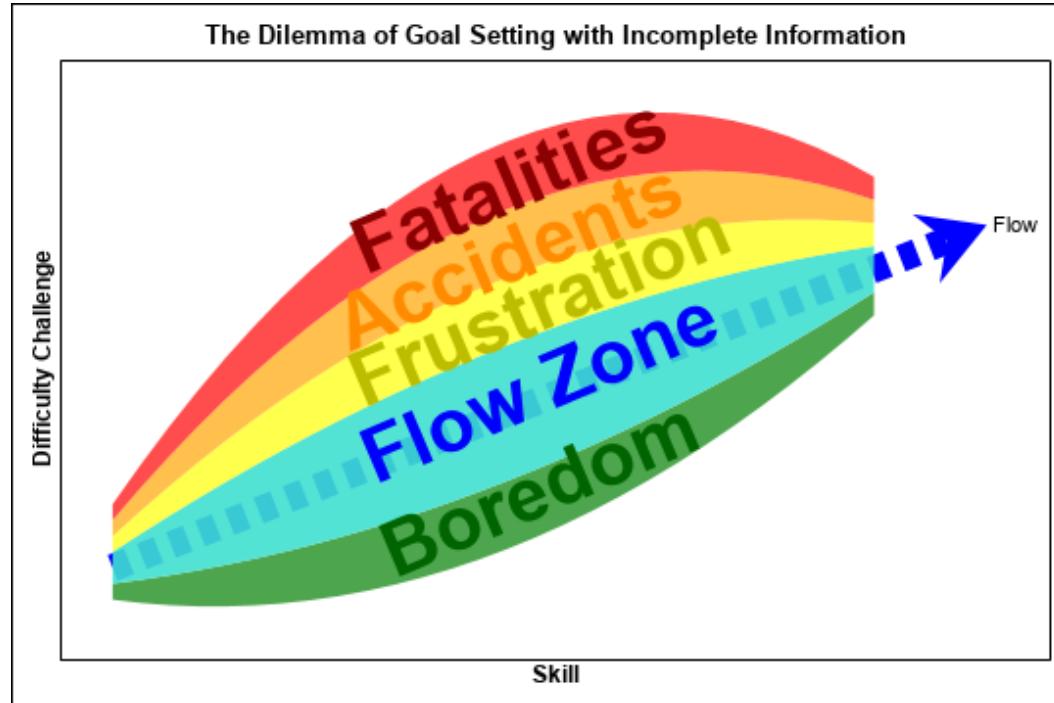
# Knowledge of a tour's difficulties is important for

## 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)



$$\text{DIFFICULTY} = f(\text{SlopeAngle}, \text{SpeedMax}, \text{Curvature}, \text{Forestation}, \dots)$$

# 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



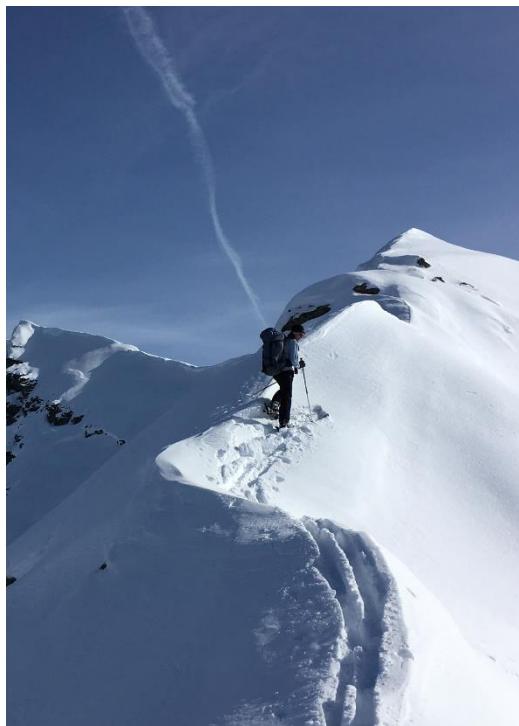
According to the SAC methodology, the difficulty level should only reflect the ski section of a tour up to the ski depot

# Main criteria for the SAC difficulty scale

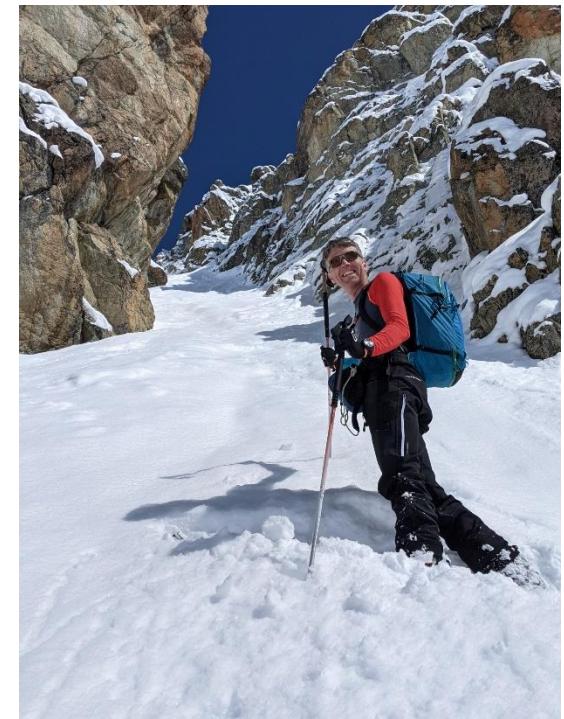
## steepness, exposure to fall down, space conditions



steepness: slope angle



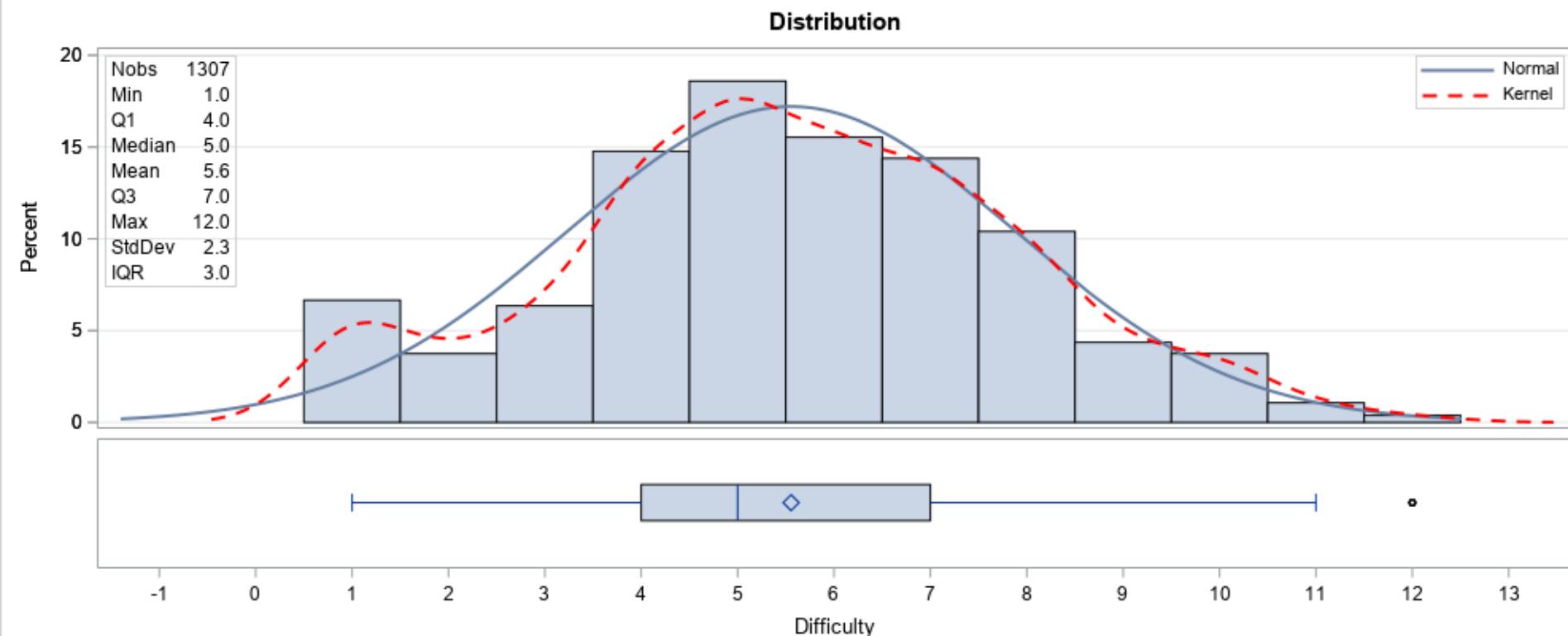
exposure to fall: speed max



space conditions: corridor width

# target variable / dependent variable

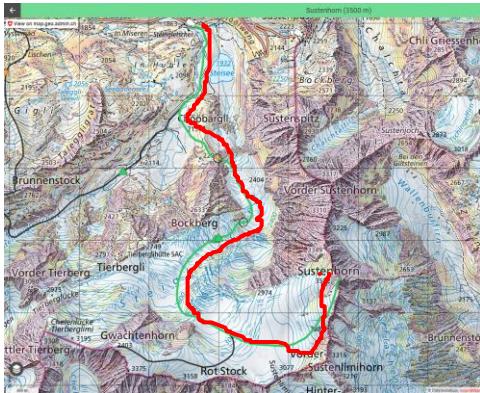
## ski tour difficulty from SAC literature



# Data preparation: from properties to prediction features

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

Local properties along each **Track**:

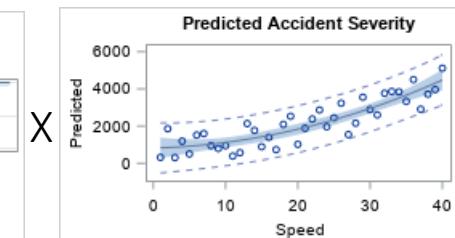
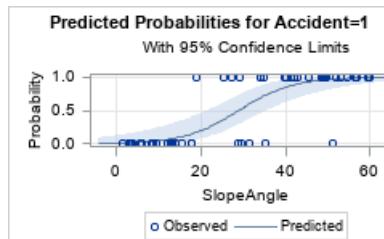
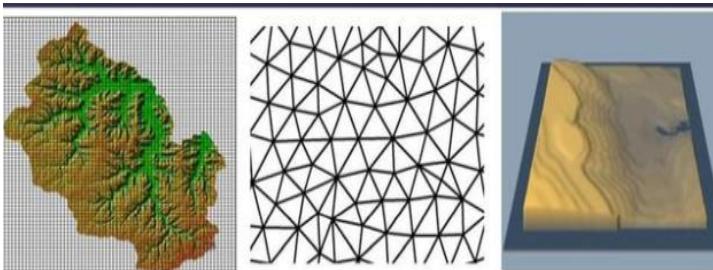


Properties:

- SlopeAngle ( $x,y$ ) „steepness“
- SpeedMax ( $x,y$ ) „exposure to fall“
- Width ( $x,y$ ) „space conditions“
- Forestation ( $x,y$ )
- Curvature ( $x,y$ )
- Fold ( $x,y$ )

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

Digital Landscape Model 10m\*10m



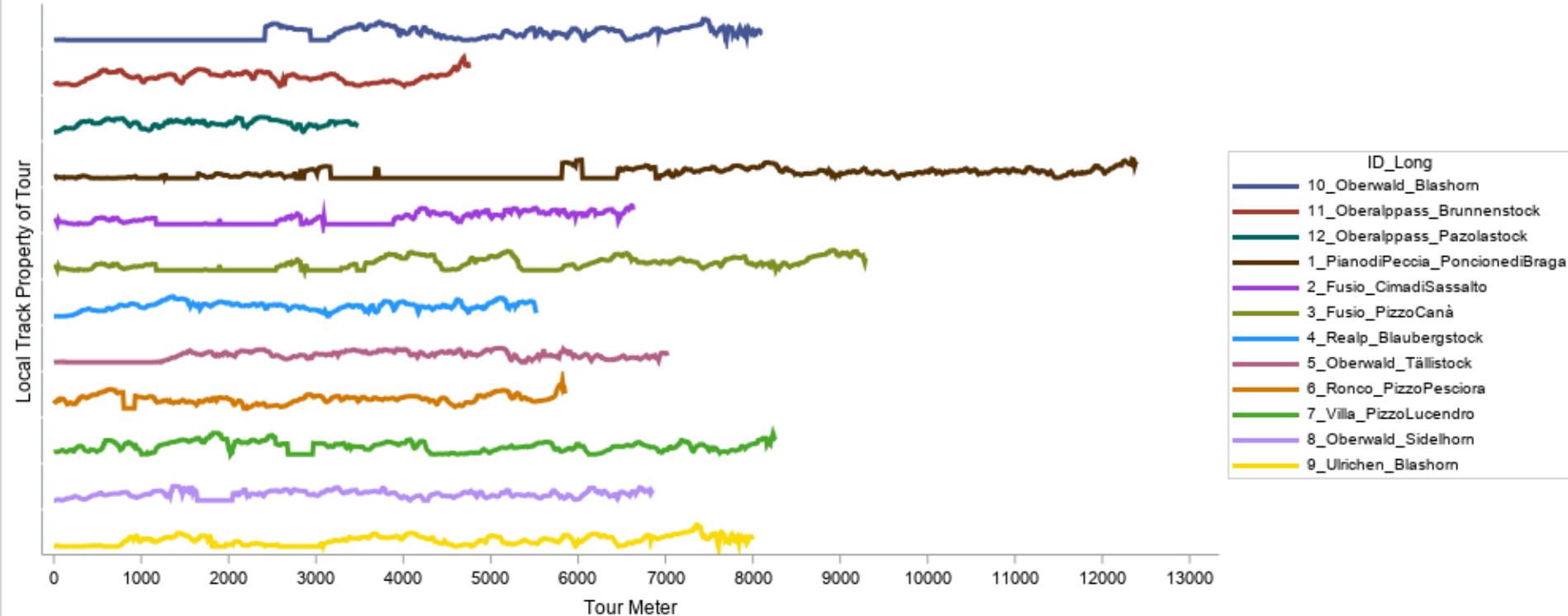
# Data preparation

## from local track properties to unique tour features

# Data preparation

## from local track properties to unique tour features

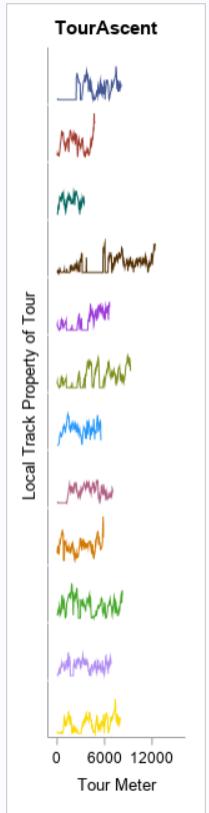
Illustrative example of a local property along tours in ascent



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

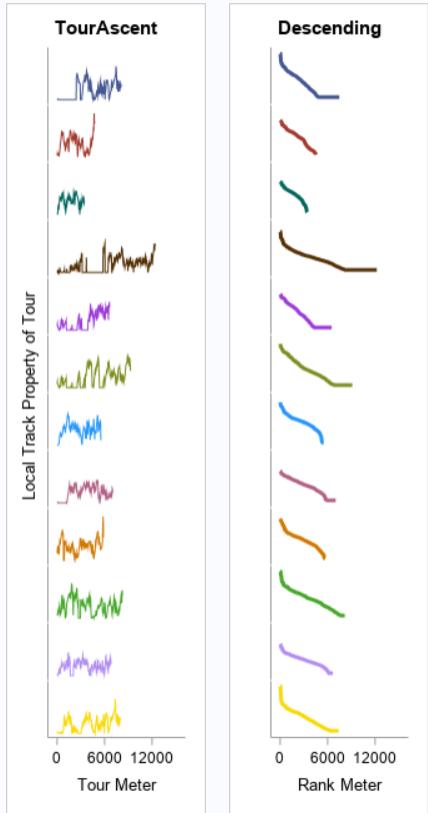
# Data preparation

## from local track properties to unique tour features



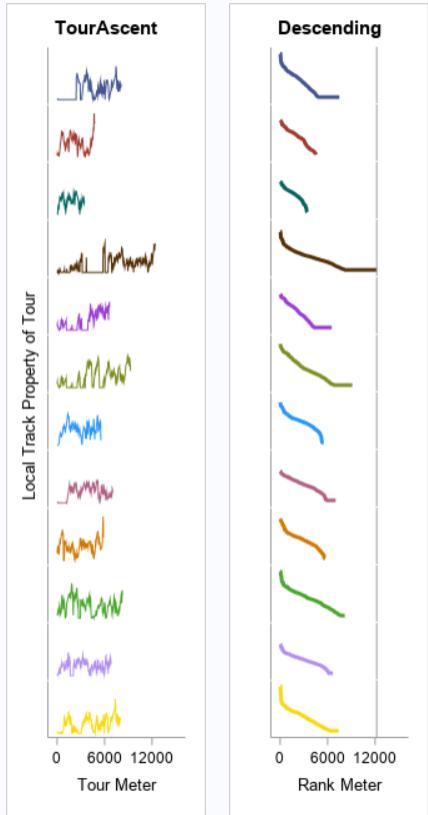
# Data preparation

## from local track properties to unique tour features



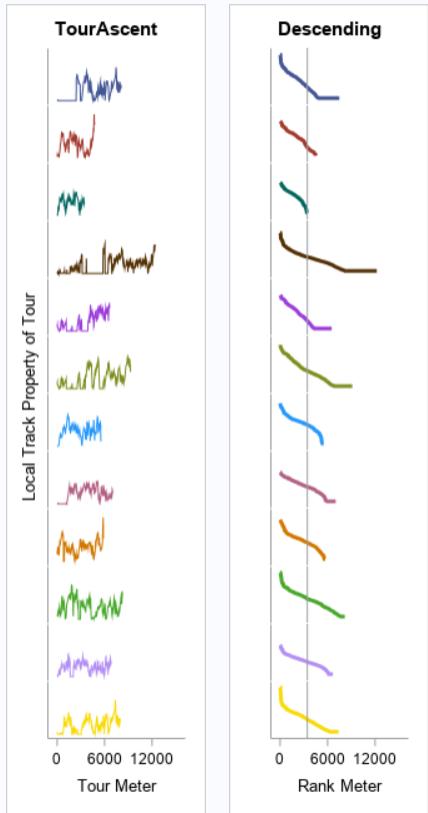
# Data preparation

## from local track properties to unique tour features



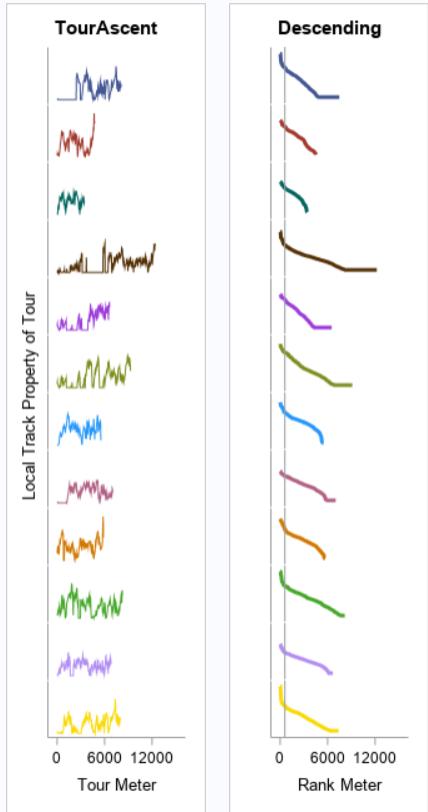
# Data preparation

## from local track properties to unique tour features



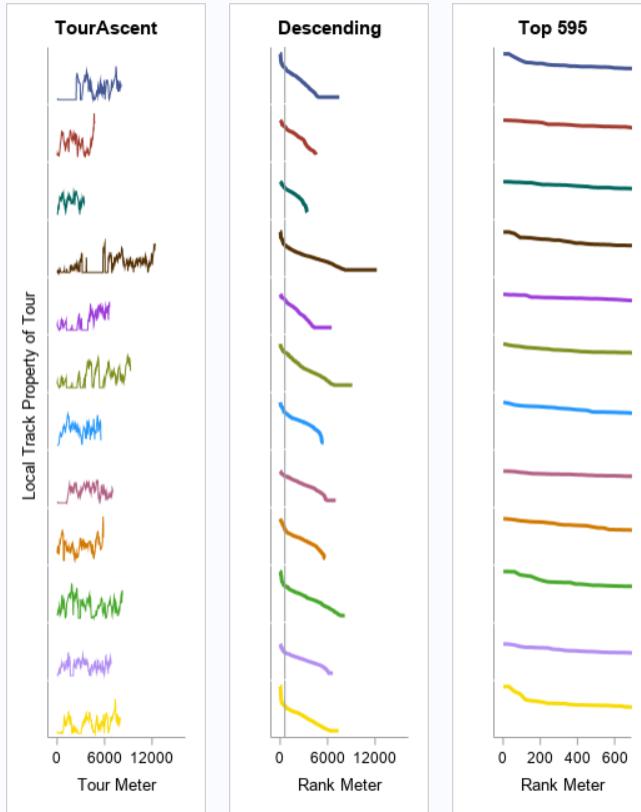
# Data preparation

## from local track properties to unique tour features



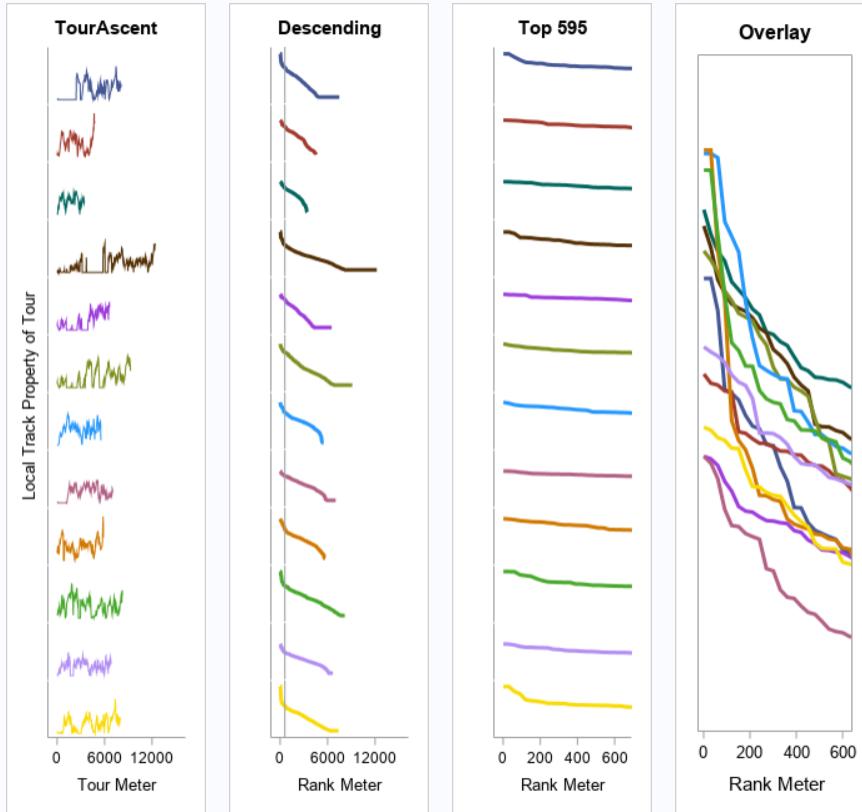
# Data preparation

## from local track properties to unique tour features



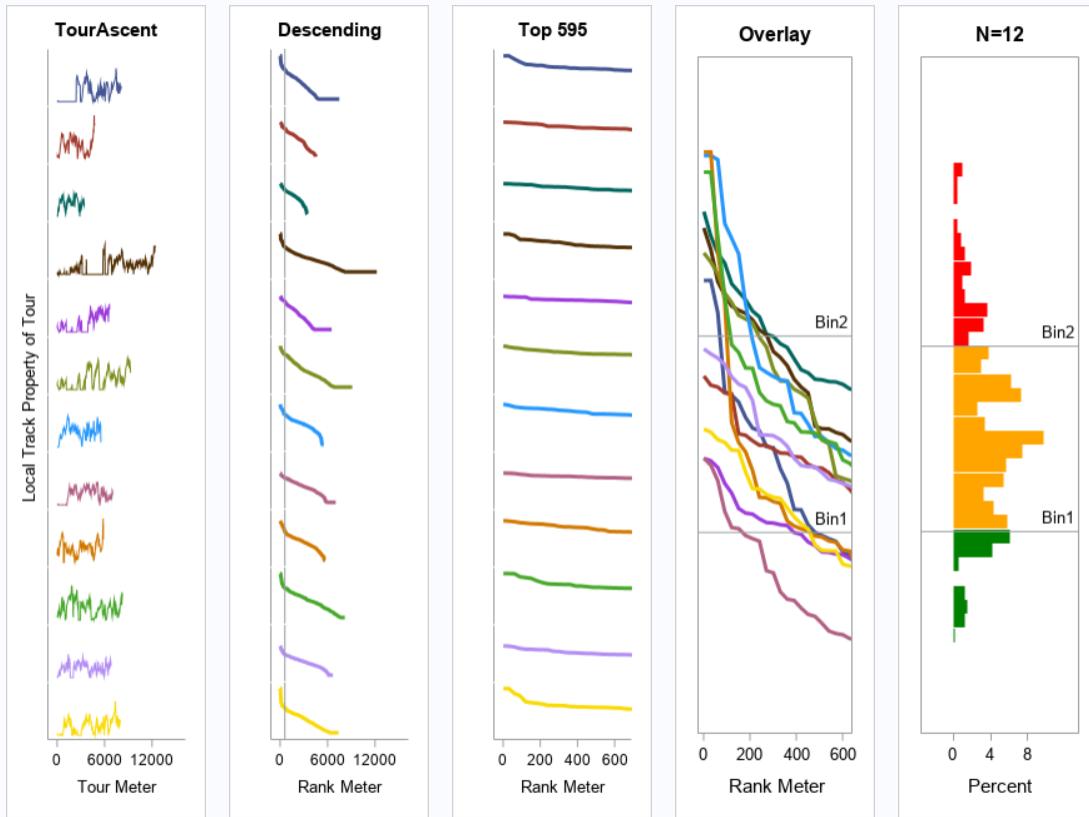
# Data preparation

## from local track properties to unique tour features



# Data preparation

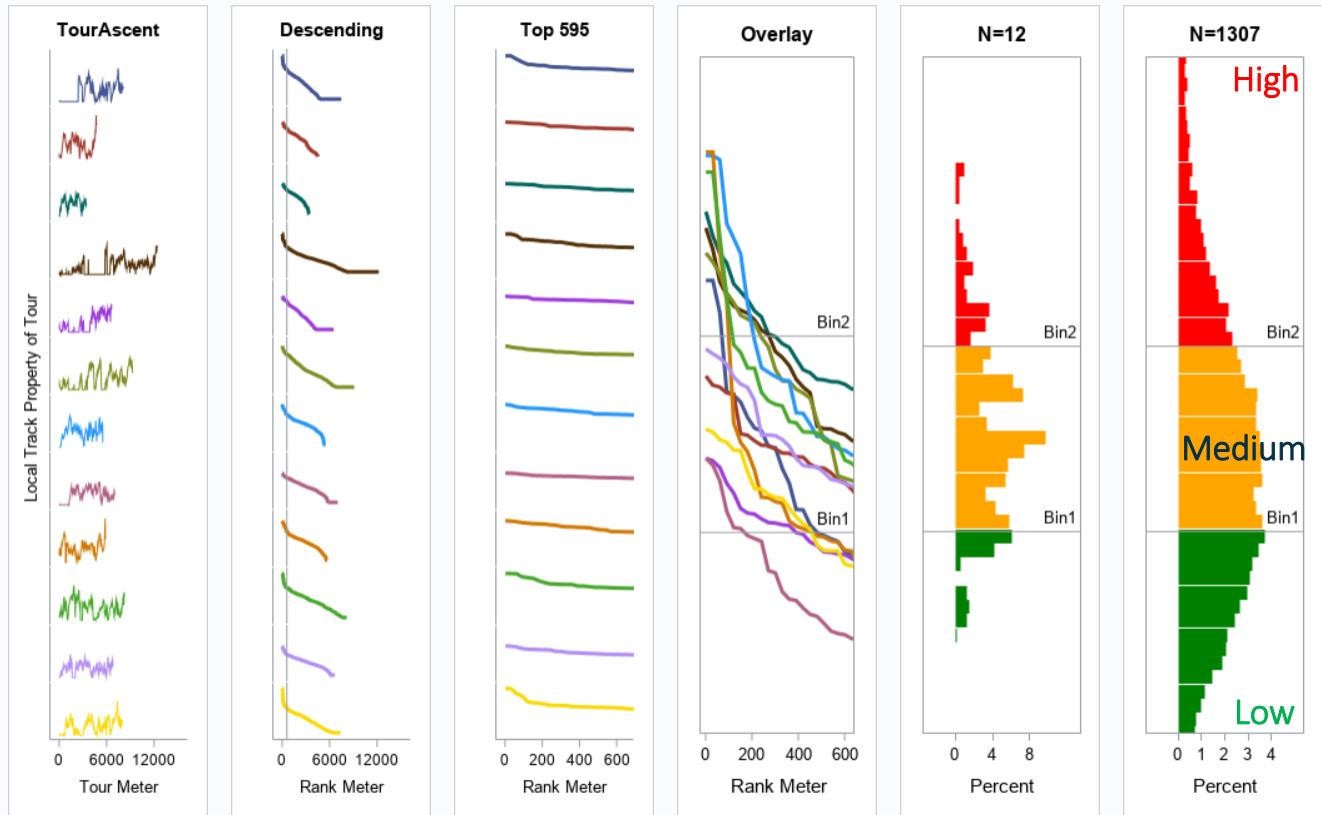
## from local track properties to unique tour features



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

# Data preparation

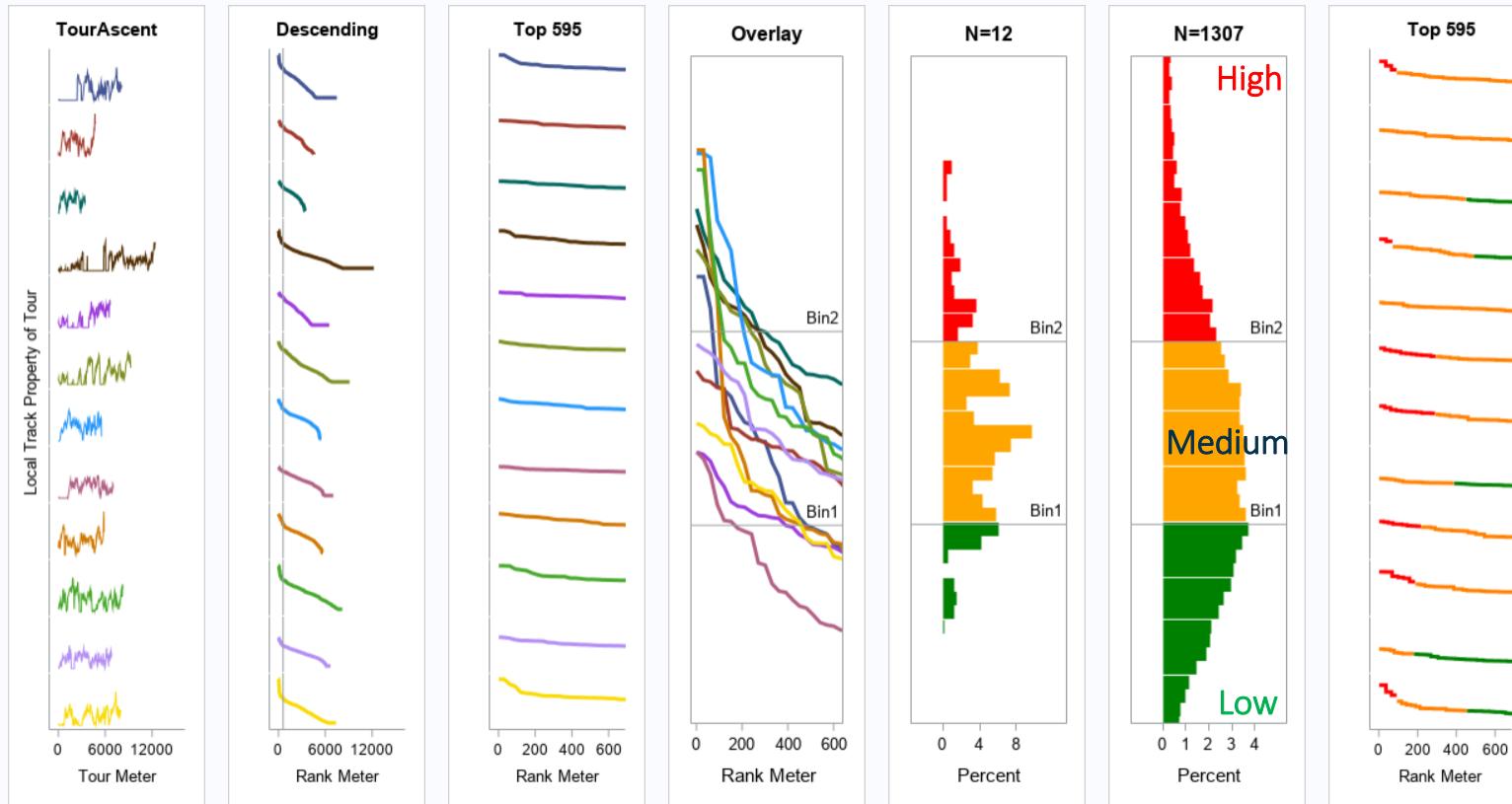
## from local track properties to unique tour features



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

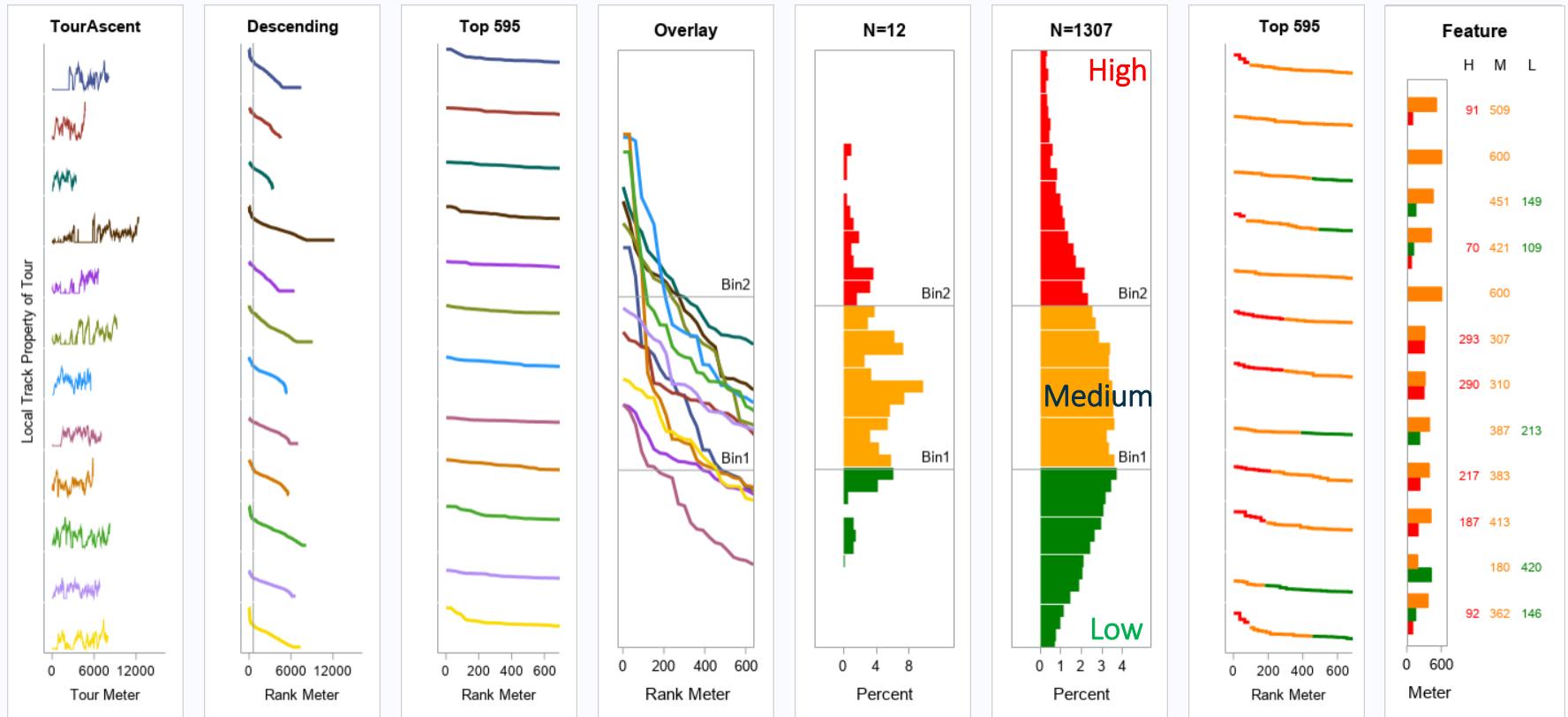
# Data preparation

## from local track properties to unique tour features



# Data preparation

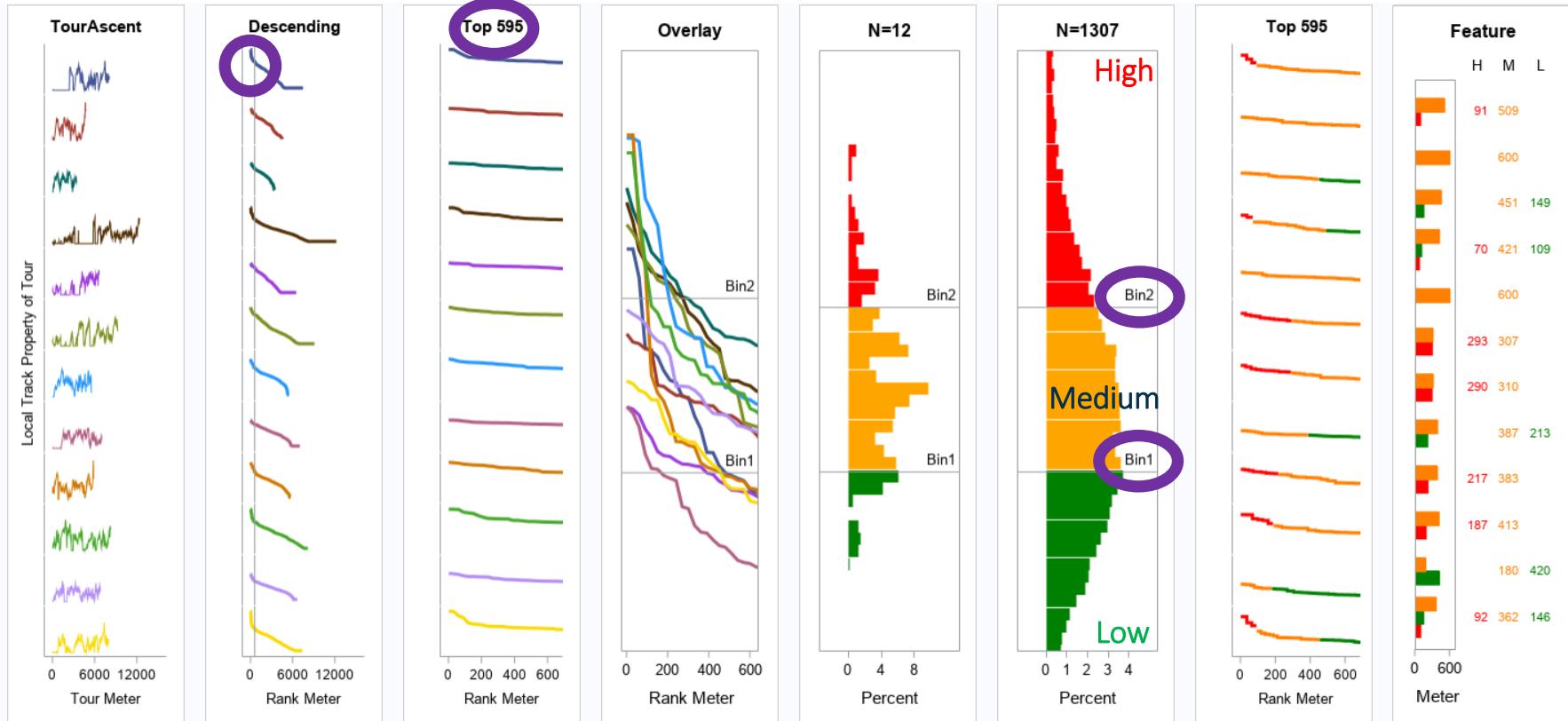
## from local track properties to unique tour features



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

# Data preparation

## from local track properties to unique tour features



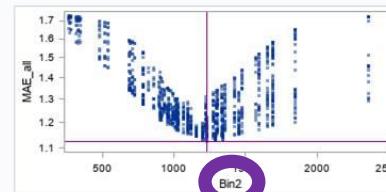
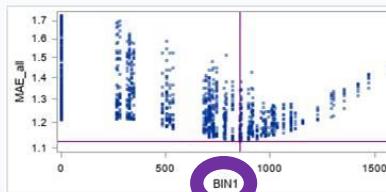
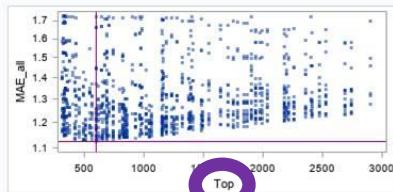
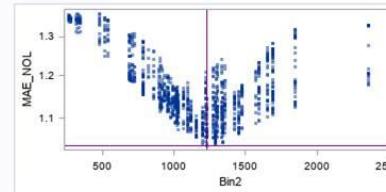
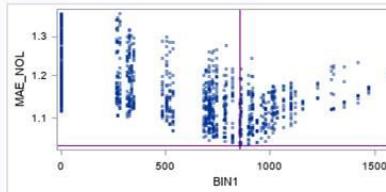
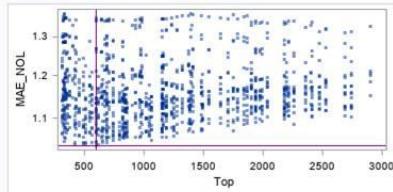
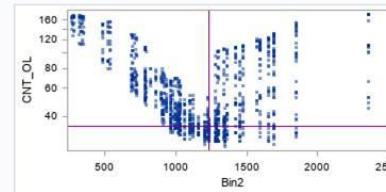
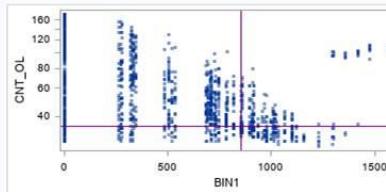
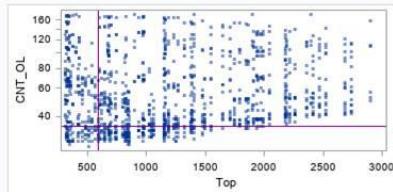
Local track properties of tours processed: Risk, Slope Angle, SpeedMax, Acceleration, Forestation, Curvature, Width,...

# 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_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	Acceleration	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

$$\sum x_i \beta_i \quad \sum x_i \beta_l \quad \sum x_i \beta_l \quad \sum x_i \beta_l \quad \sum x_i \beta_l \quad \sum x_i \beta_i \quad \sum x_i \beta_l$$



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_fn
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

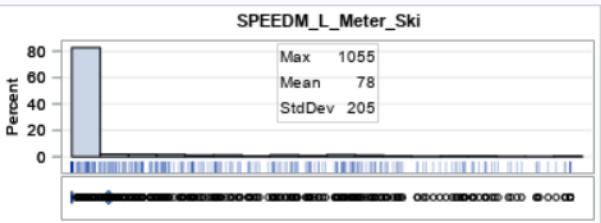
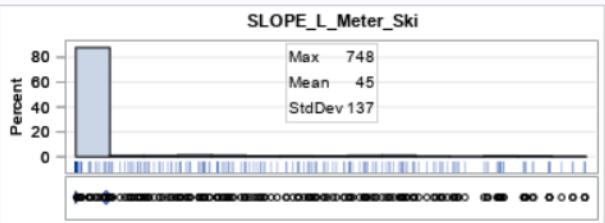
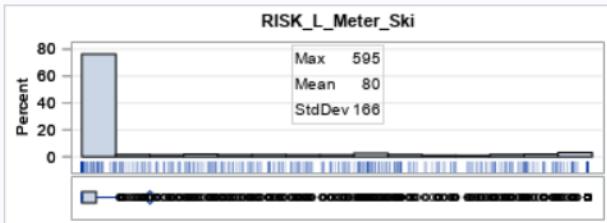
VARNUM	NAME
36	ACCELS_L_Meter_Foot
37	ACCELS_M_Meter_Foot
38	ACCELS_H_Meter_Foot
39	CURVN_L_Meter_Ski
40	CURVN_M_Meter_Ski
41	CURVN_H_Meter_Ski
42	CURVN_L_Meter_Foot
43	CURVN_M_Meter_Foot
44	CURVN_H_Meter_Foot
45	CURVP_L_Meter_Ski
46	CURVP_M_Meter_Ski
47	CURVP_H_Meter_Ski
48	CURVP_L_Meter_Foot
49	CURVP_M_Meter_Foot
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

VARNUM	NAME
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

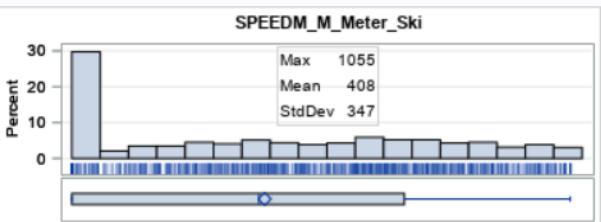
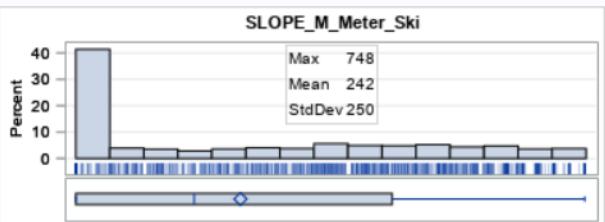
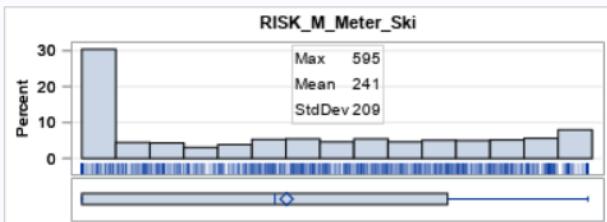
Counting your steps like the fitness app of your smart phone



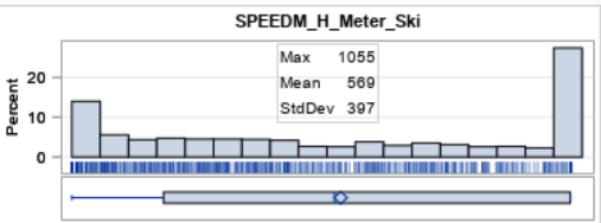
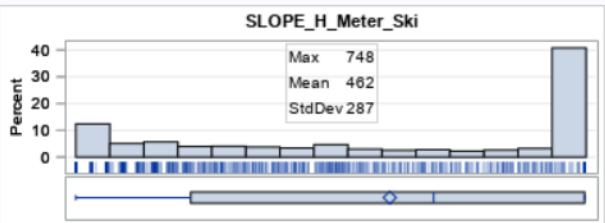
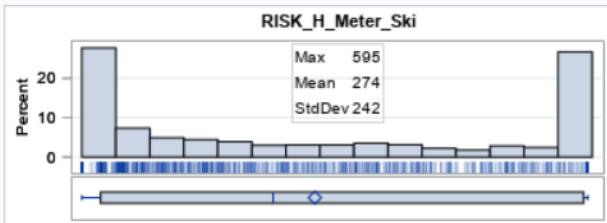
# Risk



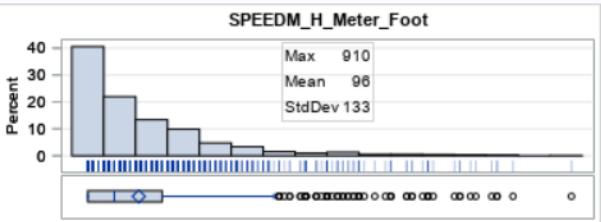
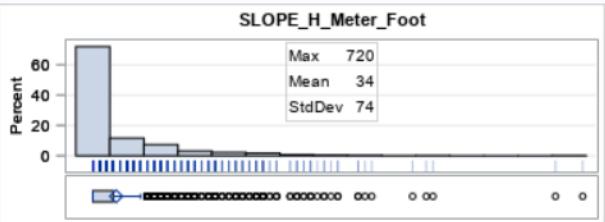
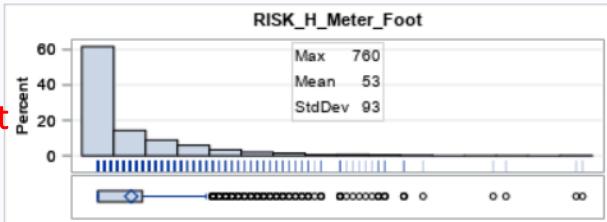
M



H

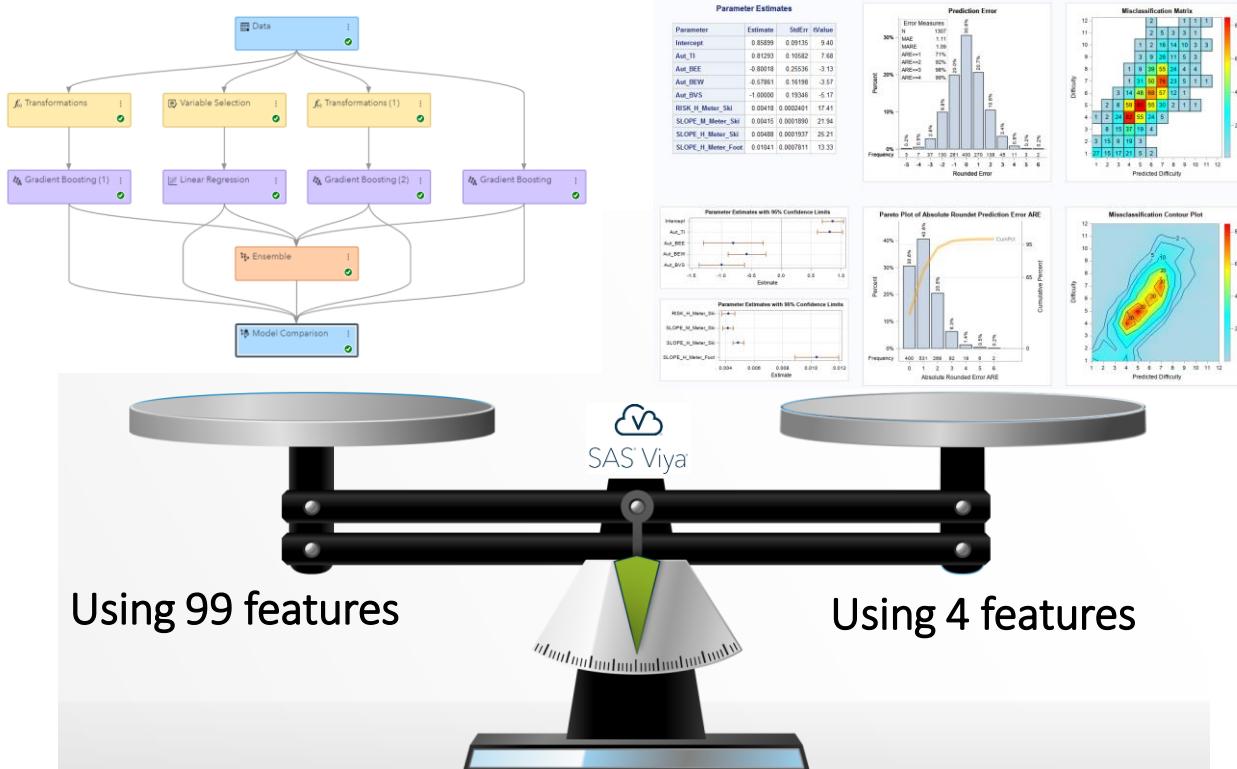


Foot



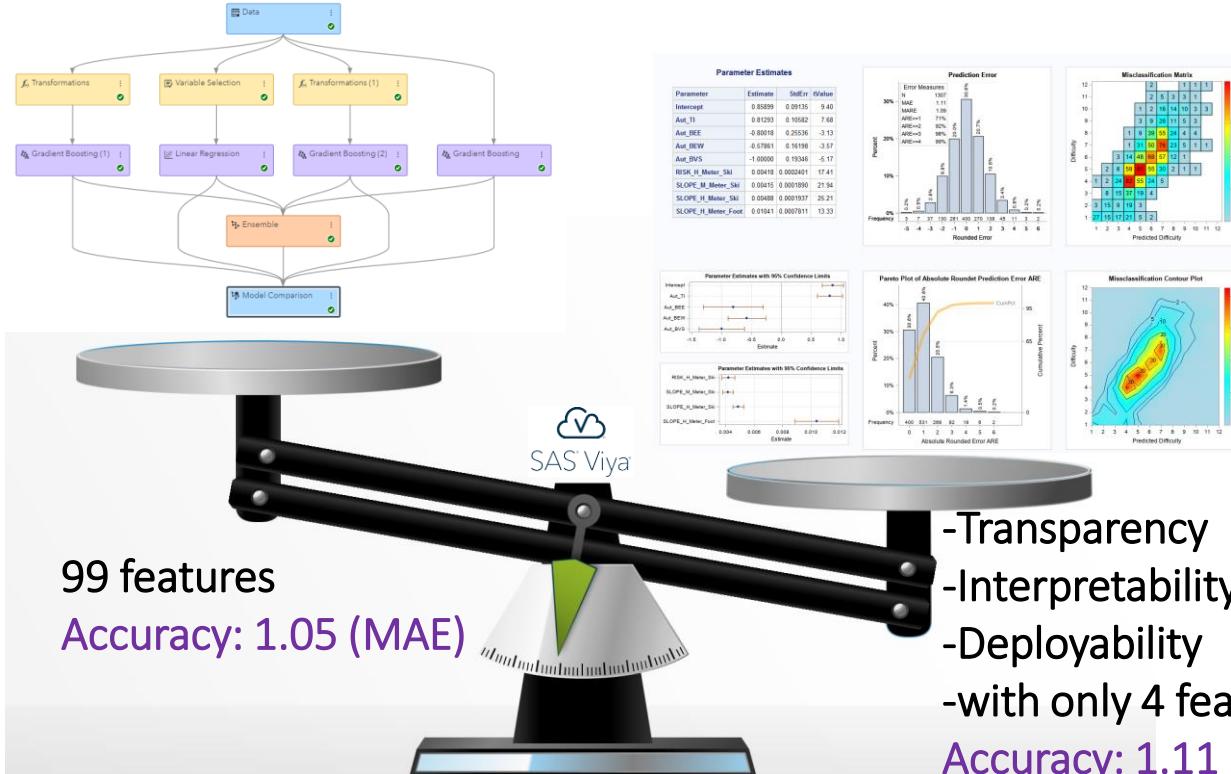
# What predictive modeling approach did we take?

## Machine Learning vs. Statistical Model



# What Results did we get?

## Transparency, Interpretability, Deployability outweighed Accuracy



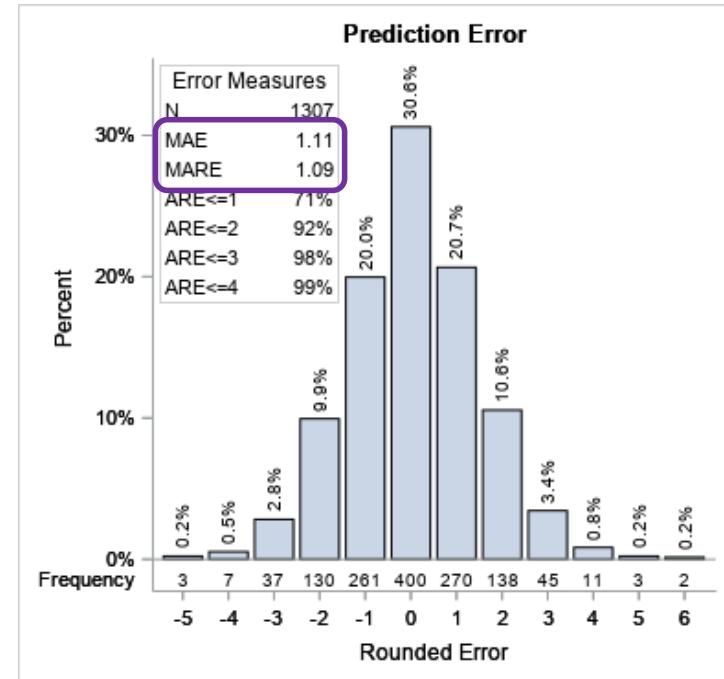
# Variable selection with quantile regression

## 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*

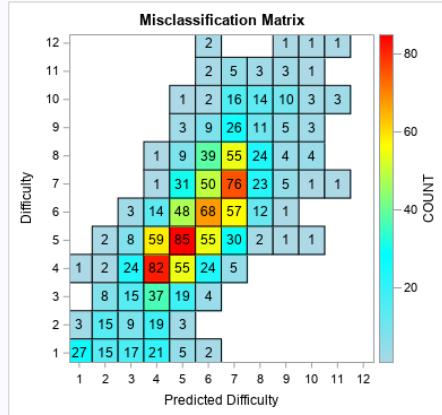
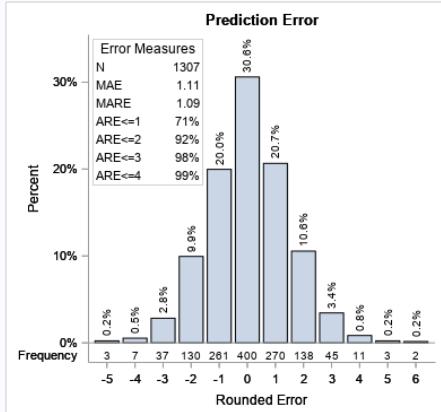
Fit Statistics	
Objective Function	725.08515
R1	0.40396
Adj R1	0.40028
AIC	-1522.17042
AICC	-1522.03163
SBC	-1475.59101
ACL	0.55477



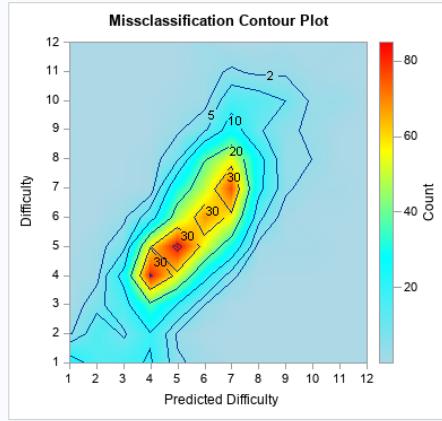
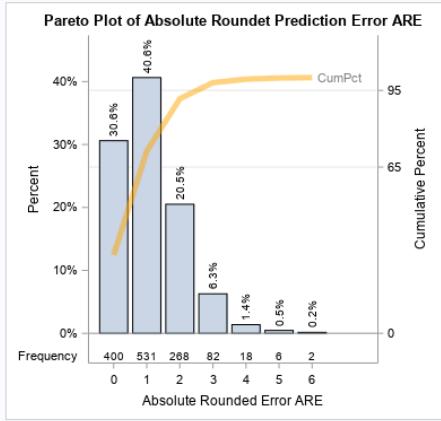
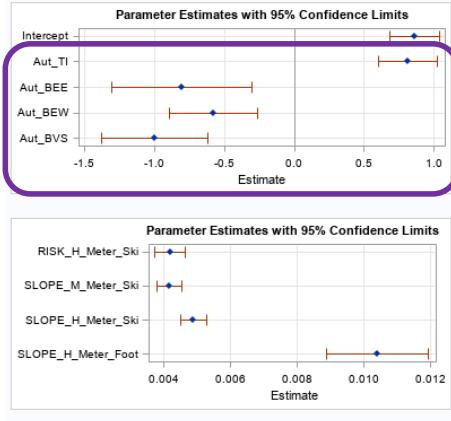
Risk:=SlopeAngle\*SpeedMax

**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

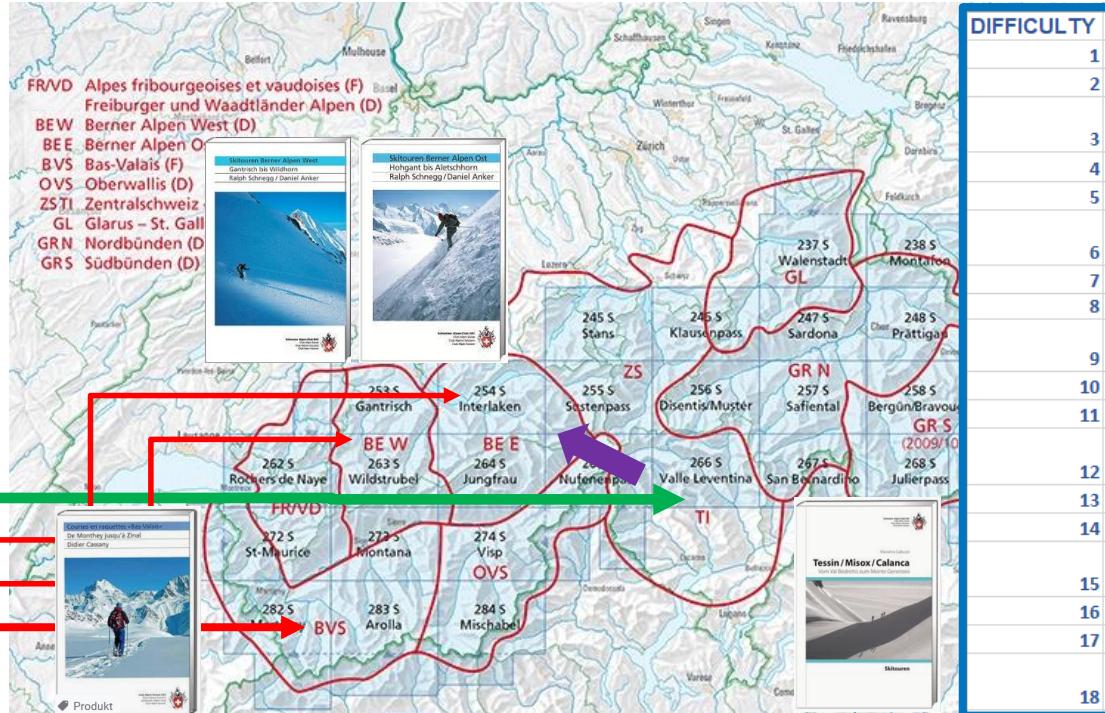
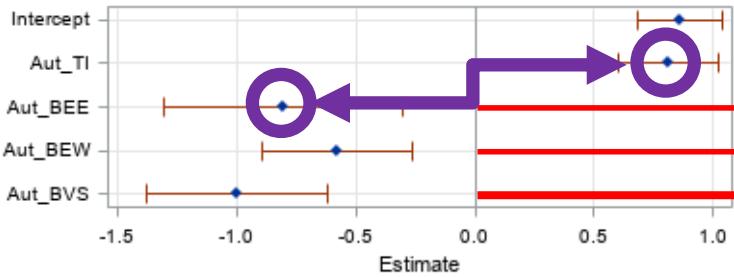
Systematic Overrating vs Underrating bias detected for difficulty

## Error Measures

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

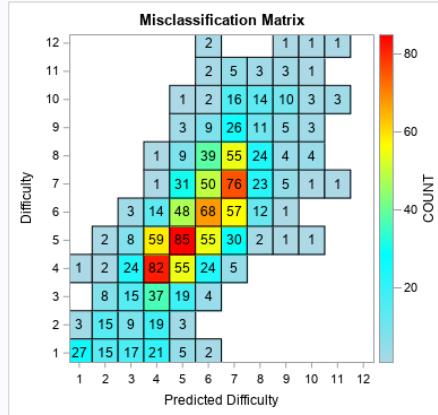
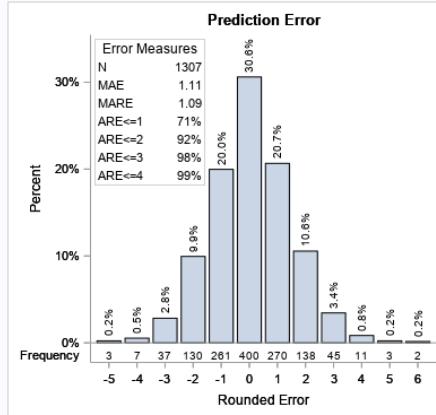
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Intercept	0.85899	0.09135	9.40
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Aut_BEE	-0.80018	0.25536	-3.13
Aut_BEW	-0.57861	0.16198	-3.57
Aut_BVS	-1.00000	0.19346	-5.17

Parameter Estimates with 95% Confidence Limits

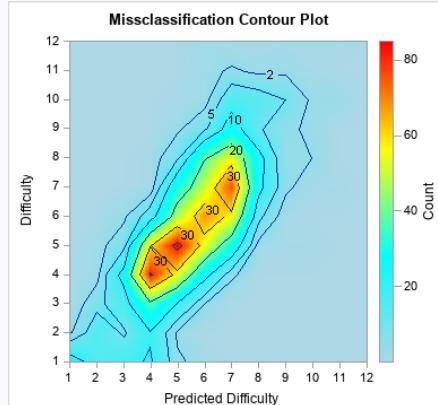
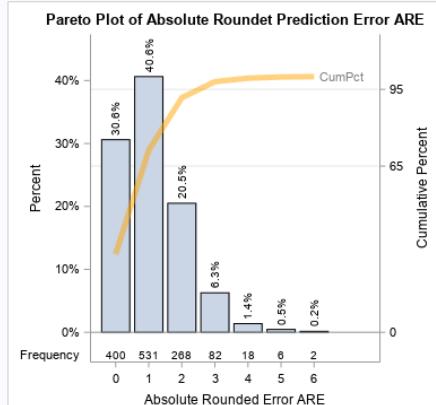
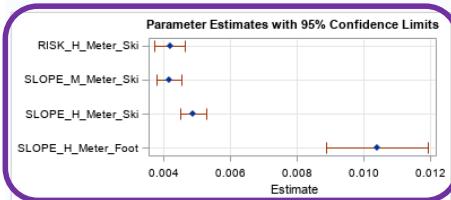
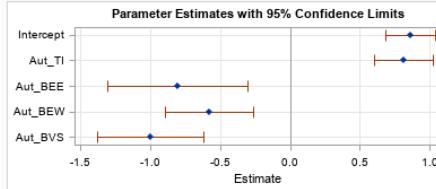


**Parameter Estimates**

Parameter	Estimate	StdErr	tValue
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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

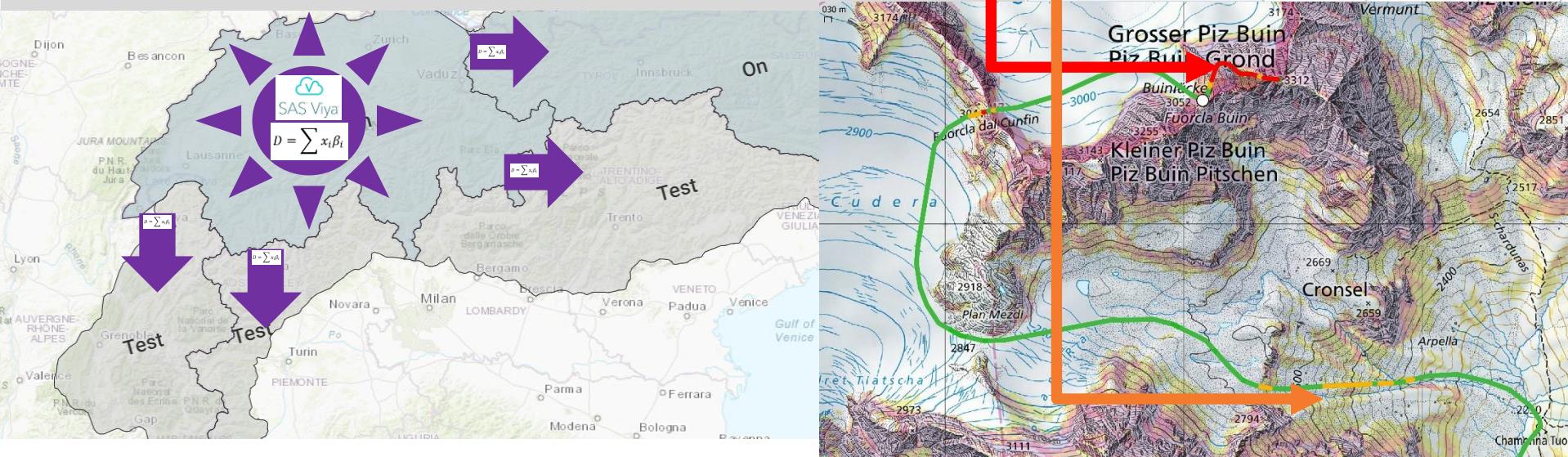


# Model deployment to expand services of skitourenguru.ch to 4 neighboring countries with ~10 000 additional unrated ski tours

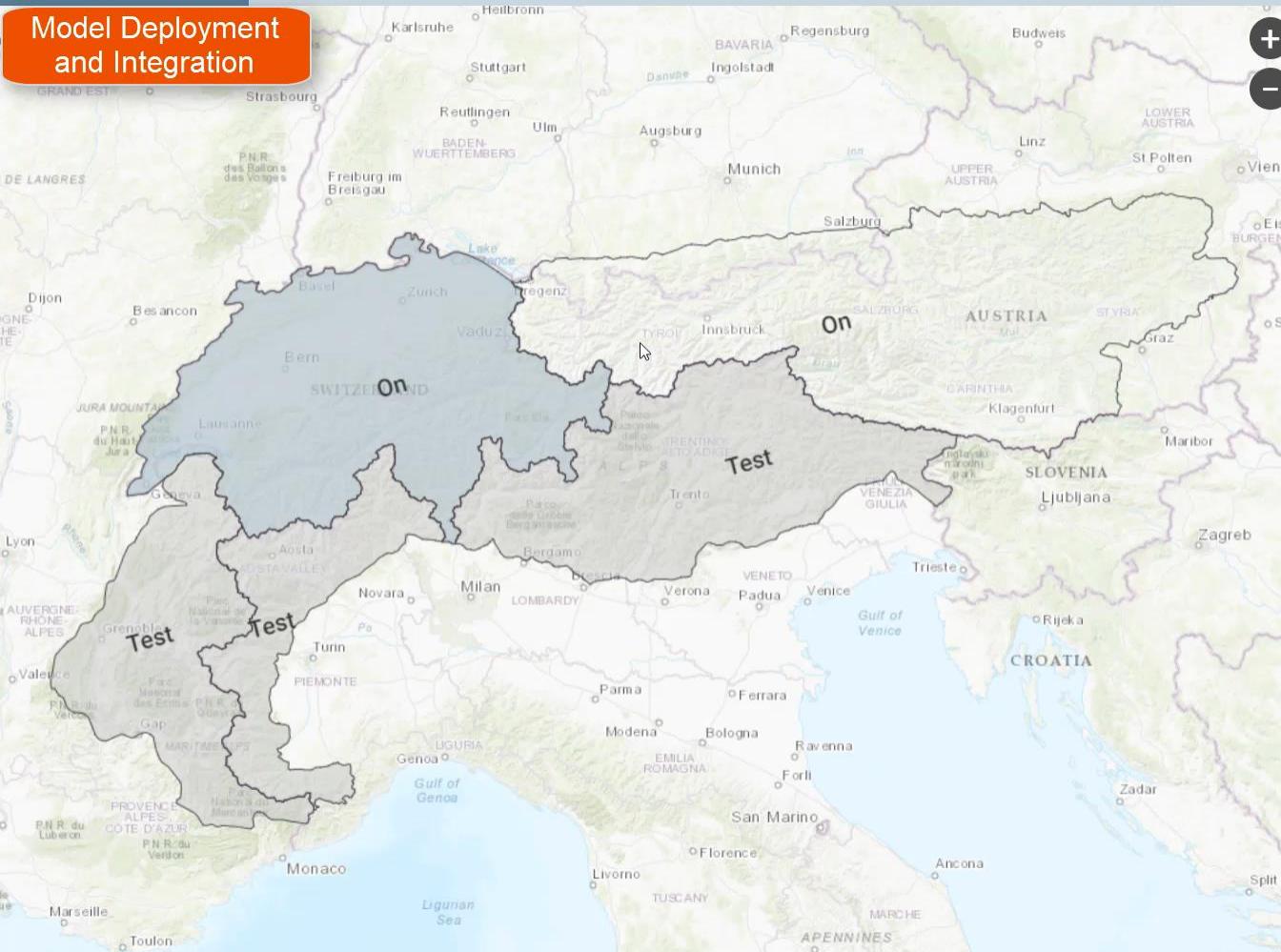


$$P_{\text{Difficulty}} = 0.859 + (418 * \text{RISK\_H\_Meter\_Ski} + 415 * \text{Slope\_M\_Meter\_Ski} + 488 * \text{Slope\_H\_Meter\_Ski} + 1041 * \text{Slope\_H\_Meter\_Foot}) / 100000$$

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



## 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
Northwest-Italy	Test	16.30 h	16.4.2021–16.00 h
Northeast-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

## BEURTEILUNGS- UND ENTSCHEIDUNGSRAHMEN 3x3

### 1. PLANUNG

#### Verhältnisse



- Lawinenbulletin
- Wetterbericht
- Tourenportale im Internet (mit Vorsicht)
- Tageszeit / Jahreszeit
- Weitere Infos

#### Tourenziel mit Alternativen und Zeitplan

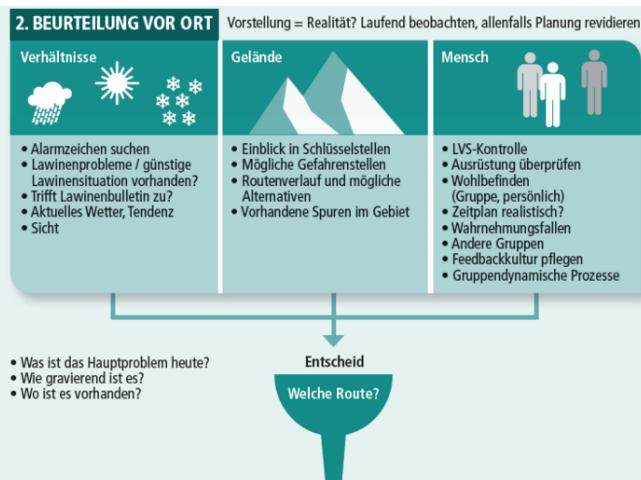
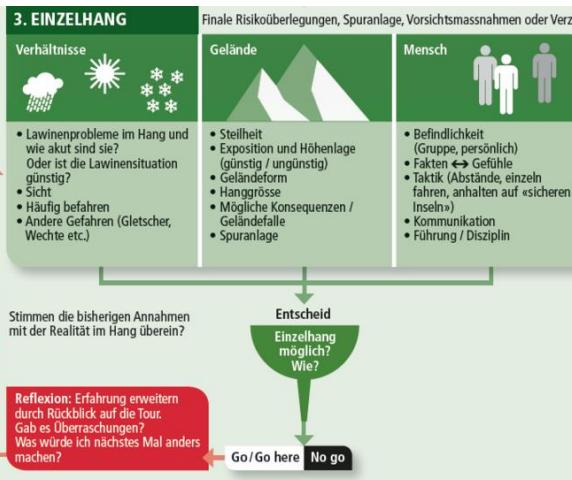
#### Gelände



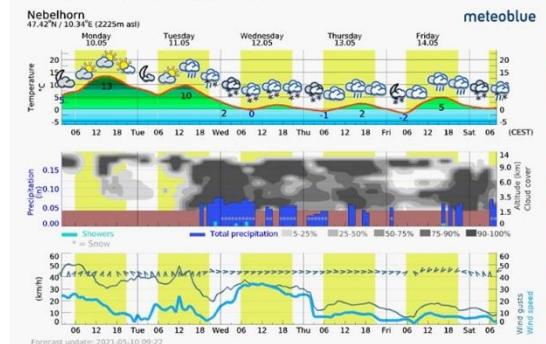
- Routenverlauf auf Karte 1:25'000 planen, inkl. Alternativen
  - Führerliteratur und Skitourenkarte
  - Schlüsselstellen suchen und beurteilen
  - Infos von Ortskundigen
- Wer kommt mit?
  - Gruppengröße?
  - Verantwortung und Erwartungen der Teilnehmer klären
  - Verfassung Gruppe / Leiter
  - Ausrüstung
  - Zeitplan

#### Entscheid

Welche Tour ist möglich?

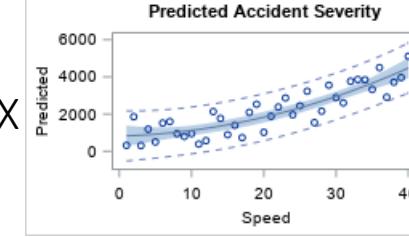
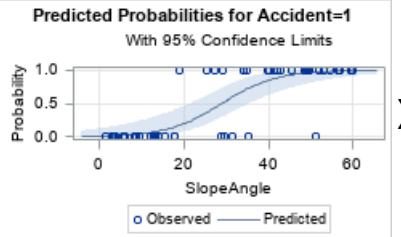


Meteogram - 5 days - Nebelhorn



# Takeaways: What did we achieve?

Difficulty ~



- We are proposing a new definition of **difficulty** metric derived from interaction of two local track properties: **slope angle** 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.

Final last words: with the “ML-AI-hype” don’t forget your data management and statistics skills. They still may play an important role.

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

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**

### Outlyer list with absolute prediction error gt 3.5

Type=Overrating

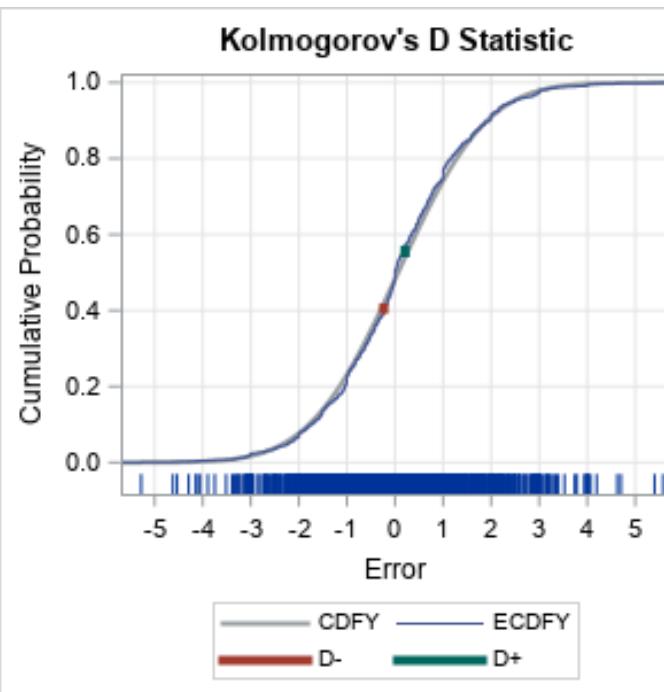
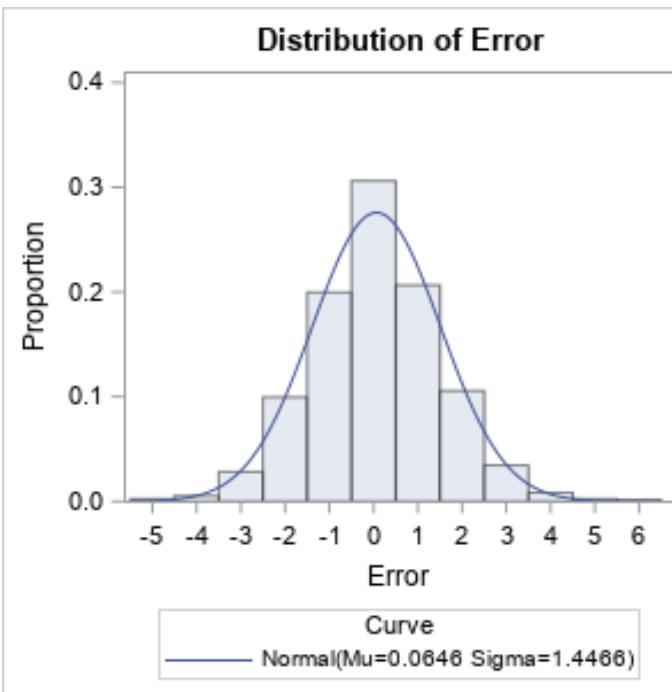
<b>id_long</b>	<b>Difficulty</b>	<b>P</b>	<b>E</b>	<b>SAC0</b>	<b>Outlyer_Comment</b>	<b>StartEle</b>	<b>StopEle</b>	<b>Ele</b>	<b>RISK_H_Meter_Ski</b>	<b>SLOPE_H_Meter_Ski</b>	<b>SLOPE_M_Meter_Ski</b>	<b>SLOPE_H_Meter_Foot</b>
1258_Hasen_Gotterli	1	5	-4	ZS		449	1394	945	0	748	0	0
171_Cons_PizTerri	7	11	-4	GRN		1468	3146	1789	595	748	0	360
564_Küblis_Chruz	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_Ärnnergale	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_CuoImdaLatsch	1	6	-5	GRS	Road above 1600	1609	2294	686	244	748	0	0
1035_HospizSimplon_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

<b>id_long</b>	<b>Difficulty</b>	<b>P</b>	<b>E</b>	<b>SAC0</b>	<b>Outlyer_Comment</b>	<b>StartEle</b>	<b>StopEle</b>	<b>Ele</b>	<b>RISK_H_Meter_Ski</b>	<b>SLOPE_H_Meter_Ski</b>	<b>SLOPE_M_Meter_Ski</b>	<b>SLOPE_H_Meter_Foot</b>
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_PizRadont	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_Grünenspitz	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

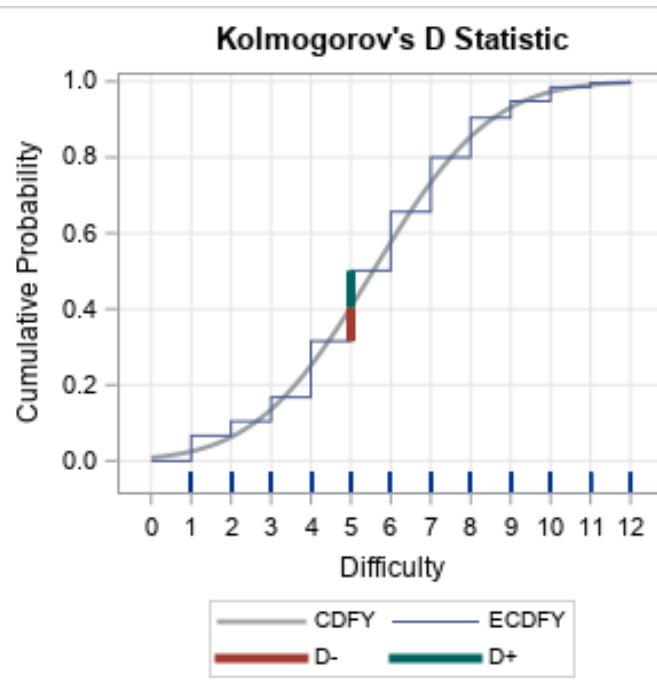
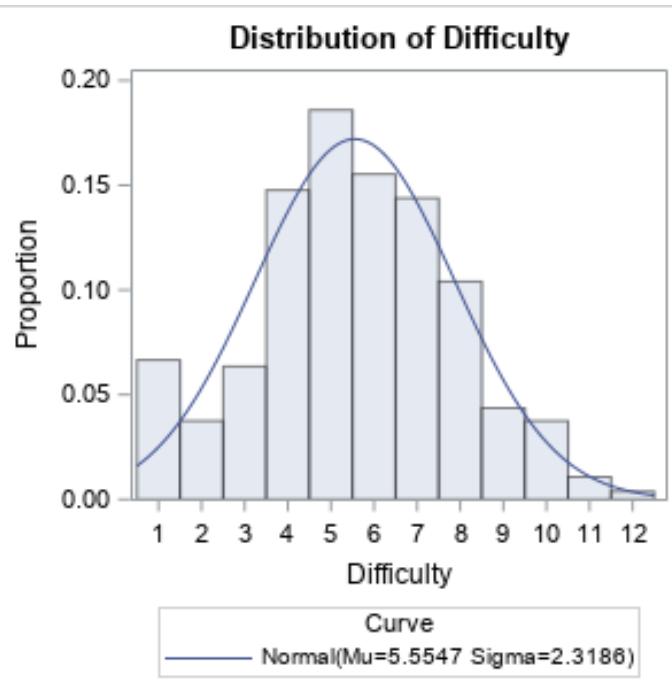
**Kolmogorov's D Statistic**

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	
	D	Pr > D		
Kolmogorov-Smirnov	0.0956892	<0.001		
Cramer-von Mises	2.0483810	<0.001		
Anderson-Darling	11.8013910	<0.001		

**Kolmogorov's D Statistic**

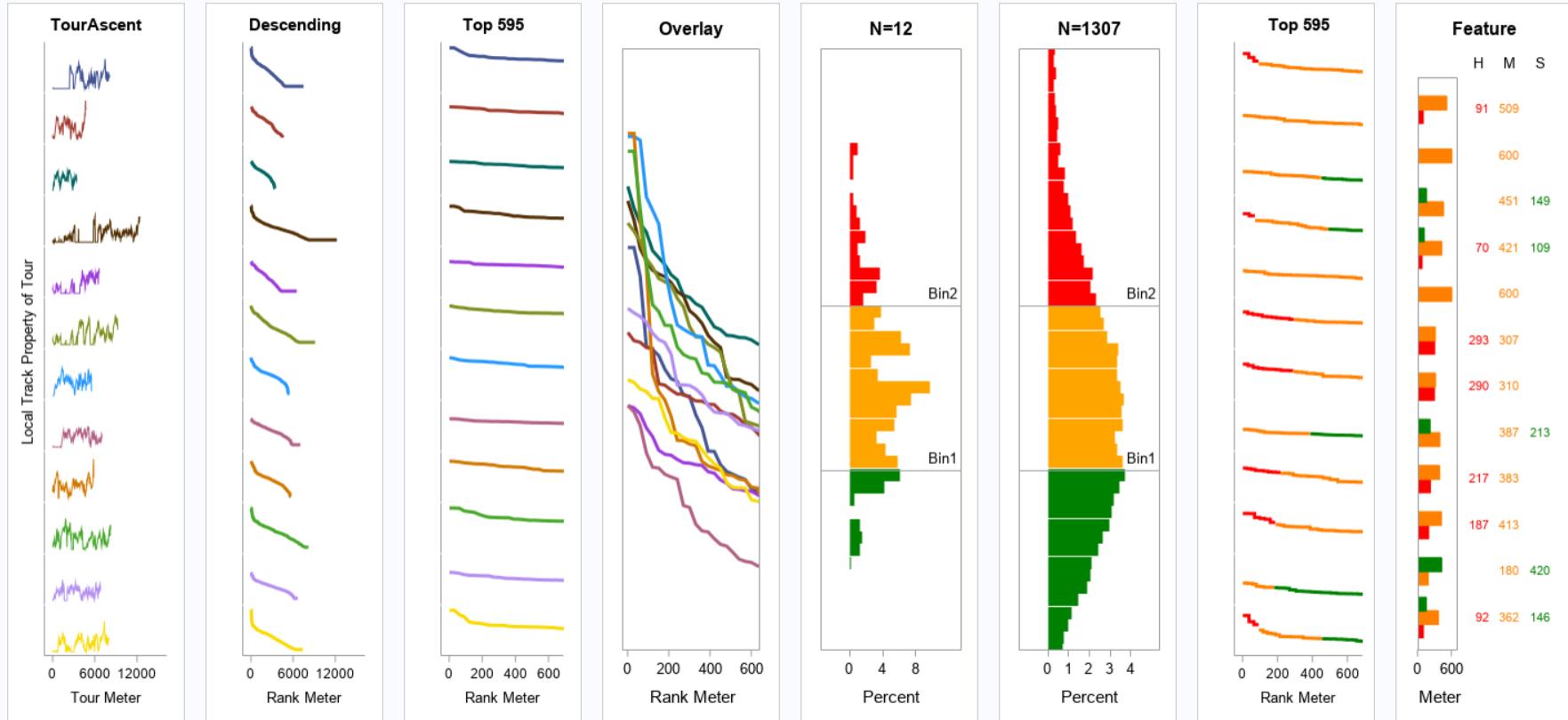
<b>D</b>	0.0956892
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**Kolmogorov D**

	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

Illustrative example of local property along tour tracks



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