Using Ground-Based Harvesting Machinery on Steep Slopes

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FUTURE FORESTS RESEARCH

FOREST Engineering

UNIVERSITY OF CANTERBURY

Forest Harvesting in New Zealand

- Pine plantations, 25 year rotation, large clear cuts,
- Ground-based machines most common and cost-effective harvesting → primarily modified excavator and large wheeled grapple skidders…

– lifted and widened track base and modified cab for better vision and improved protection.

New Zealand Steep Terrain

“up to 25% increase in productivity” - (Acuna et al. 2010)

NZ Machine Limits

OSH Limit		Static Load Limit (tonne)						
	Slope (%)	1	1.5	2	2.5	3	3.5	4
	10							
	20							
	30							
	40							
	50							
	60							
	70							
	80							
	90							

Forest Practice Code:

30% (18°) Wheeled,

40% (23°)Tracked

Static stability dependant on load position and machine type (MacLean & Visser 2011)

Study Purpose

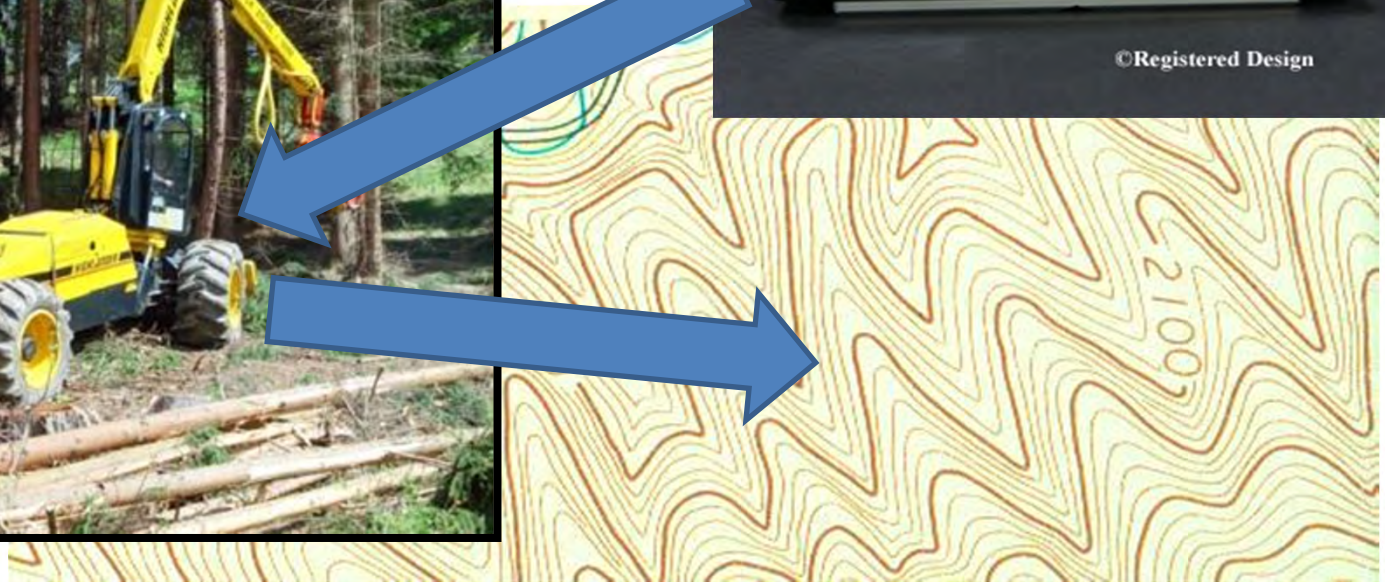
- What are the actual machine slopes of machines harvesting on ‘steep’ terrain in NZ?
- What is the relationship between machine slope and ground slope?
- Are there differences between machine types?
- Are purpose built machines (i.e. European) better than excavator based (NZ) machines?

Machine Comparison

- Comparisons will be made between; wheeled vs. tracks, functions using similar machines e.g. felling vs. shovelling and European vs. New Zealand machines.

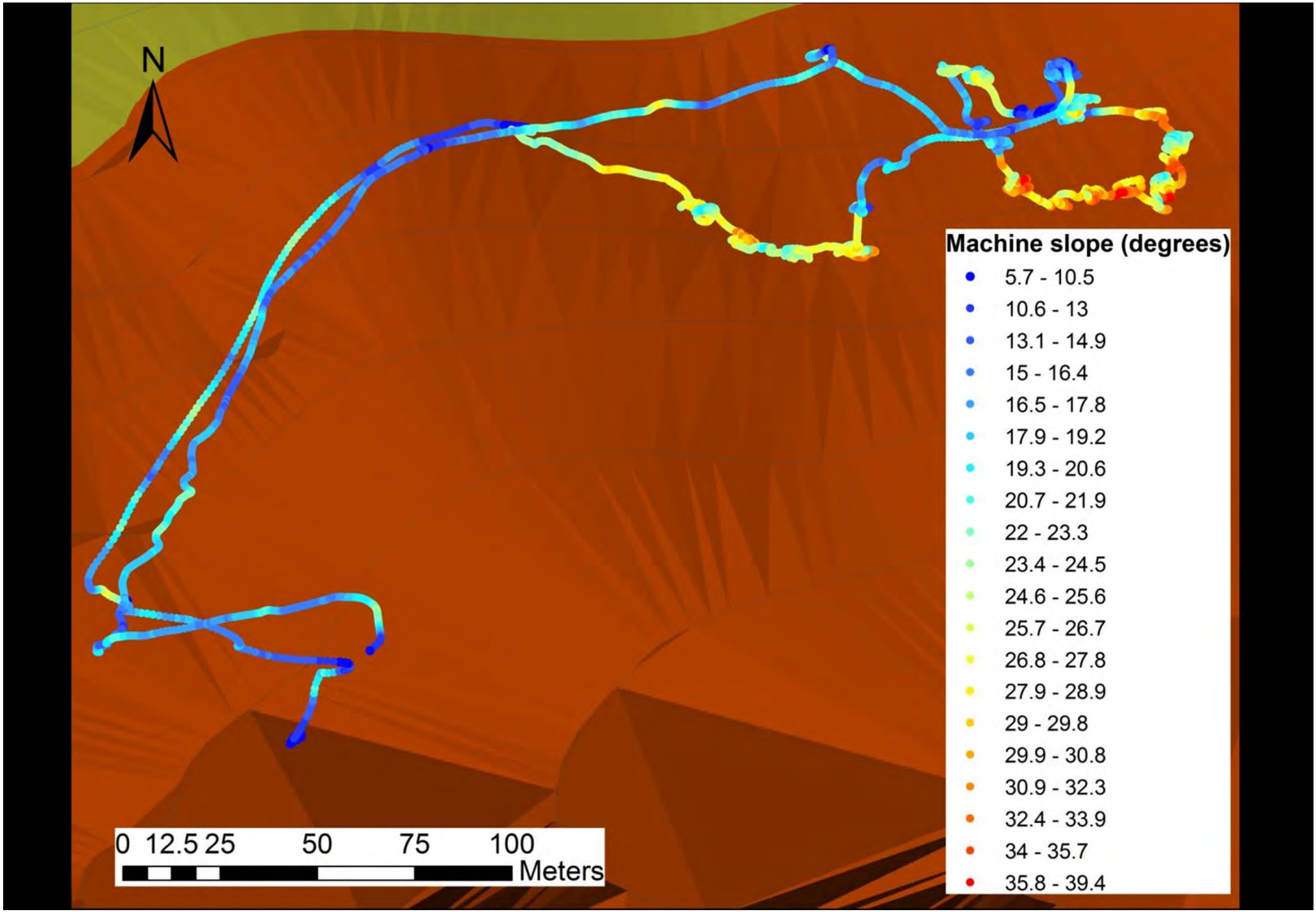
Methodology

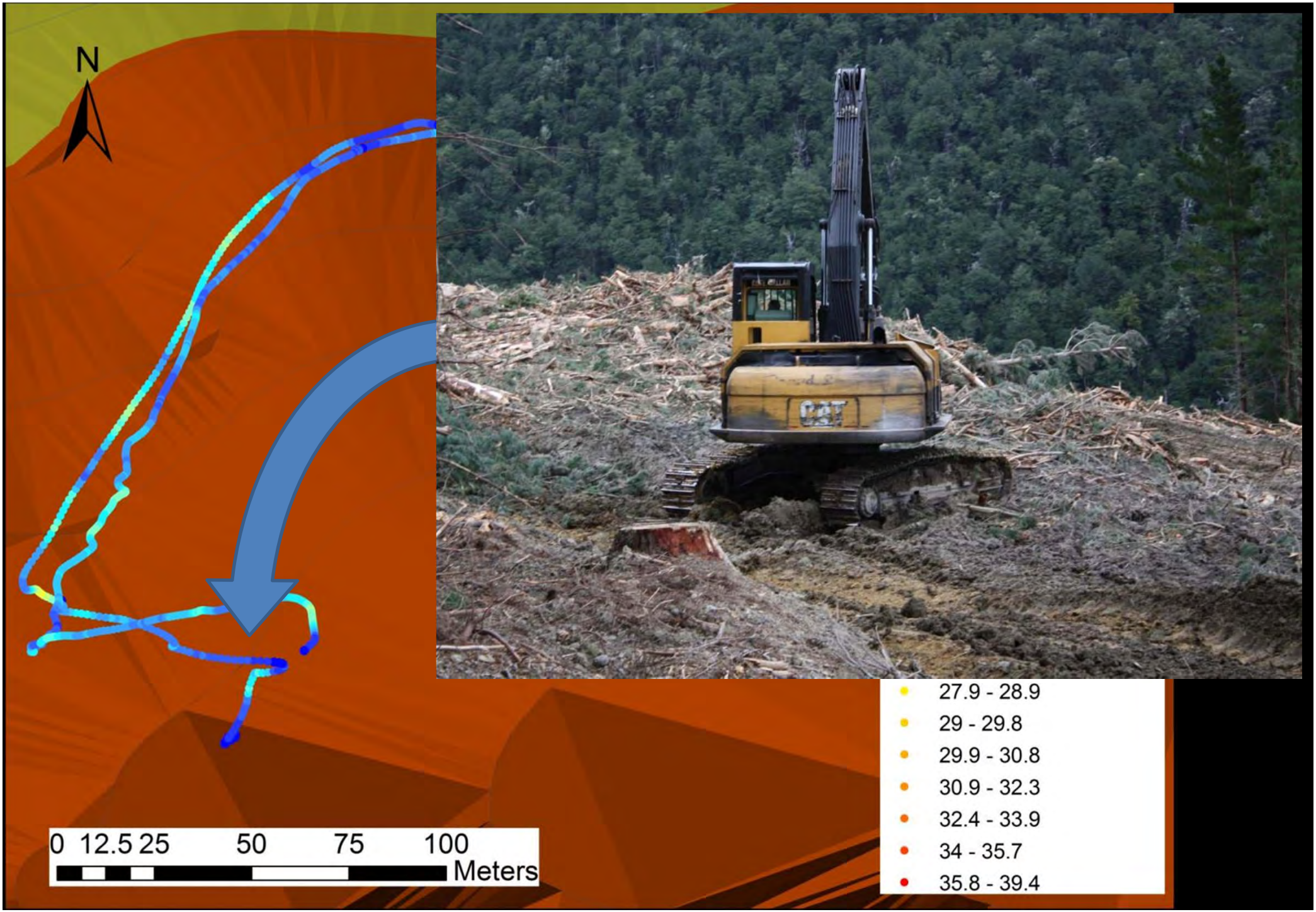
- Measure actual machine slope (Digital Inclinometer)
- Machine location (GPS) + Slope Map (GIS)
- Replicated study in NZ and Europe

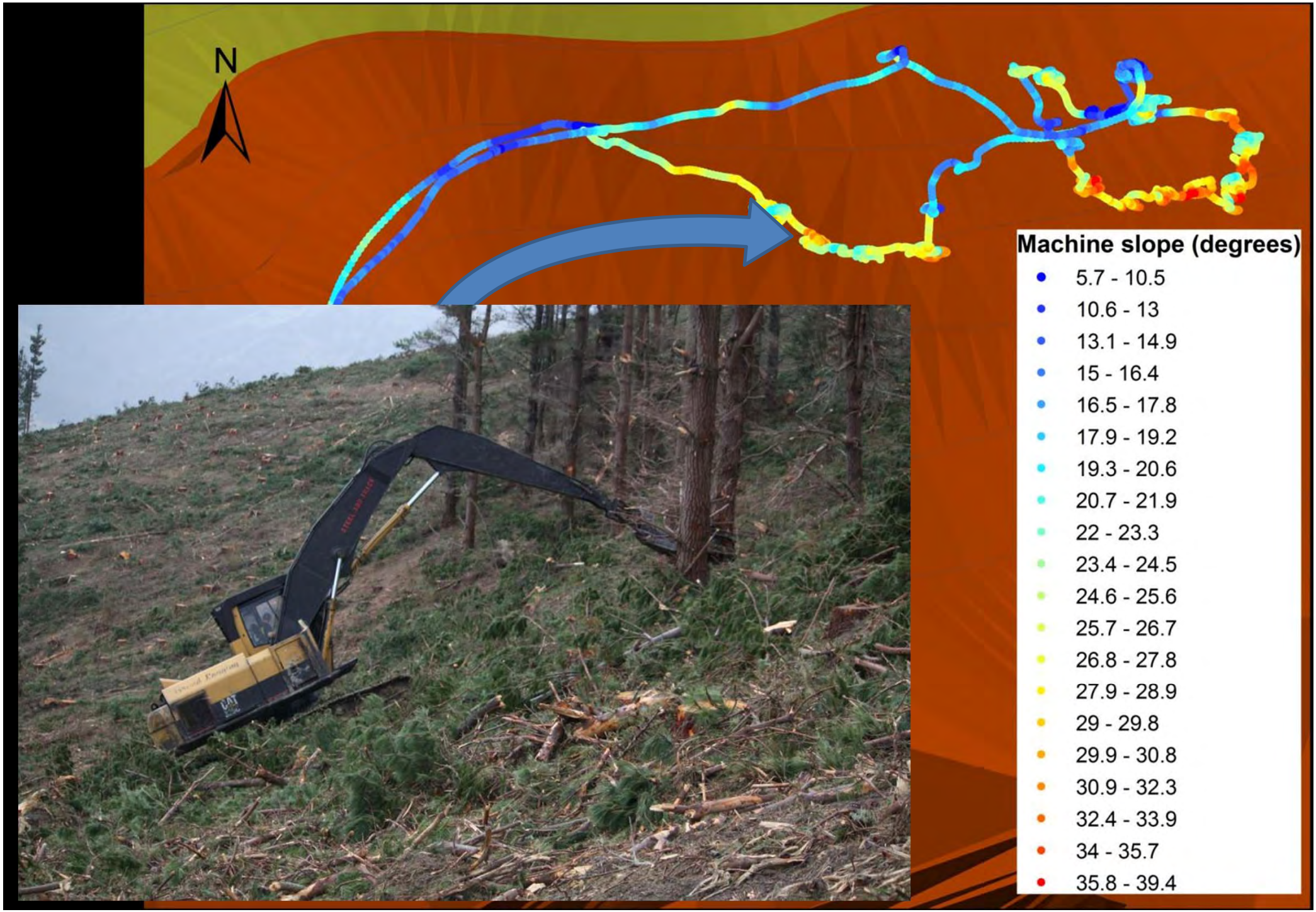


Data Collection and Analysis

- Machine slope collected using data loggers along all three axis
- The vehicle is tracked using GPS
- Data is combined for a spatial representation
- The terrain slope established using digital terrain models


N
Machine slope (degrees)
5.7 - 10.5
10.6 - 13
13.1 - 14.9
15 - 16.4
16.5 - 17.8
17.9 - 19.2
19.3 - 20.6
20.7 - 21.9
22 - 23.3
23.4 - 24.5
24.6 - 25.6
25.7 - 26.7
26.8 - 27.8
27.9 - 28.9
29 - 29.8
29.9 - 30.8
30.9 - 32.3
32.4 - 33.9
34 - 35.7
35.8 - 39.4
0 12.5 25 50 75 100
Meters


N
CAT
27.9 - 28.9
29 - 29.8
29.9 - 30.8
30.9 - 32.3
32.4 - 33.9
34 - 35.7
35.8 - 39.4
0 12.5 25 50 75 100
Meters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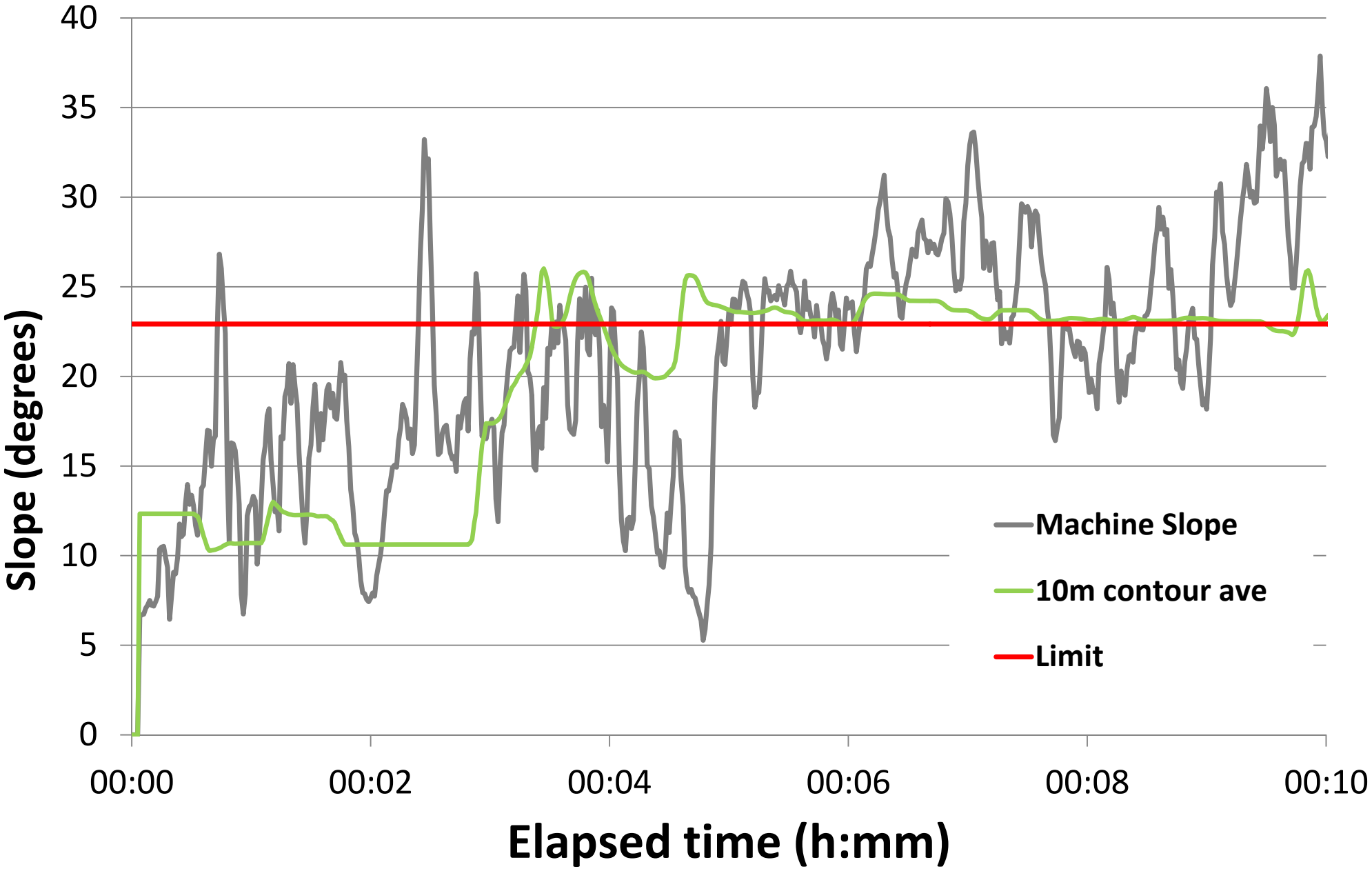
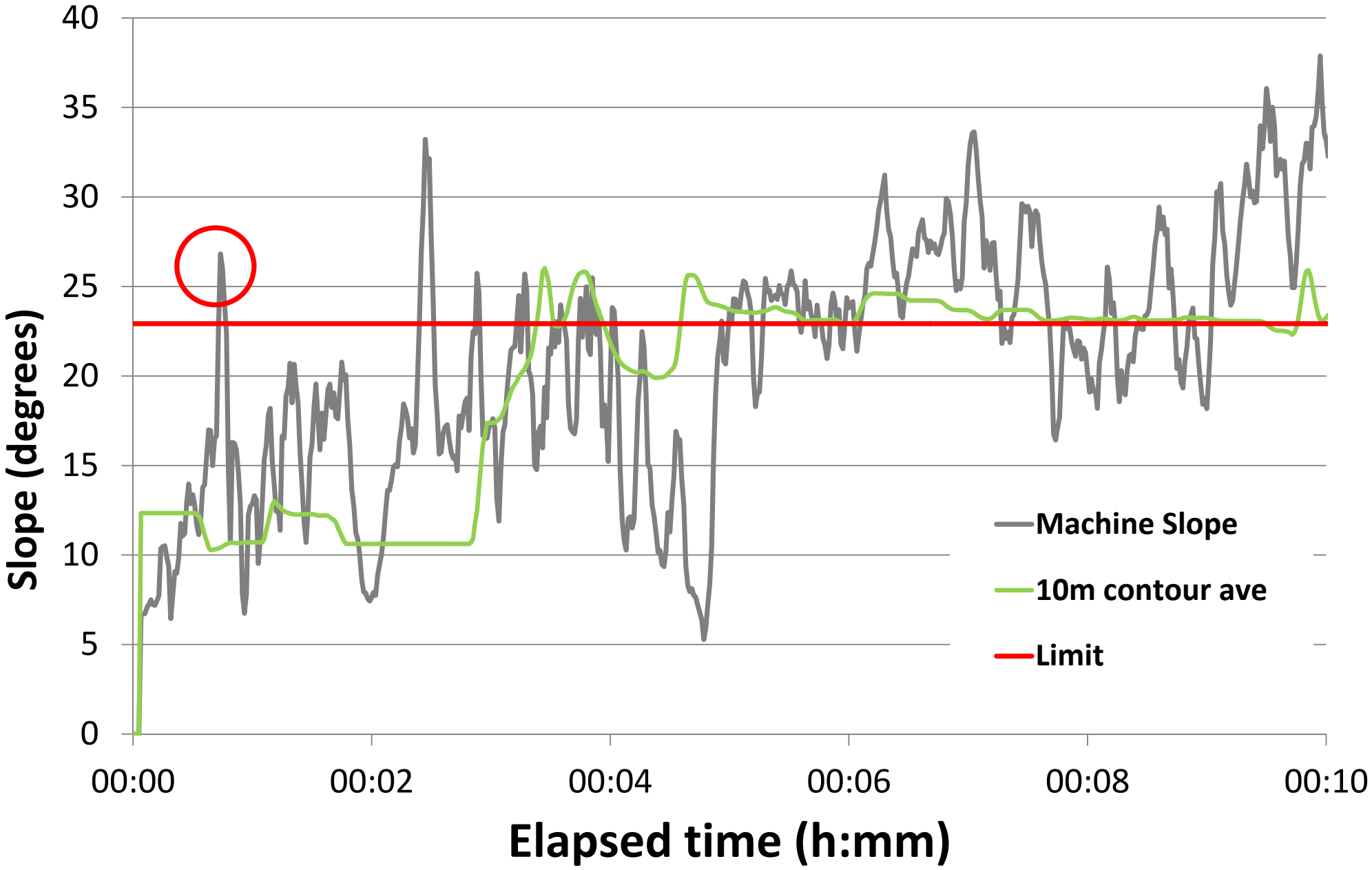
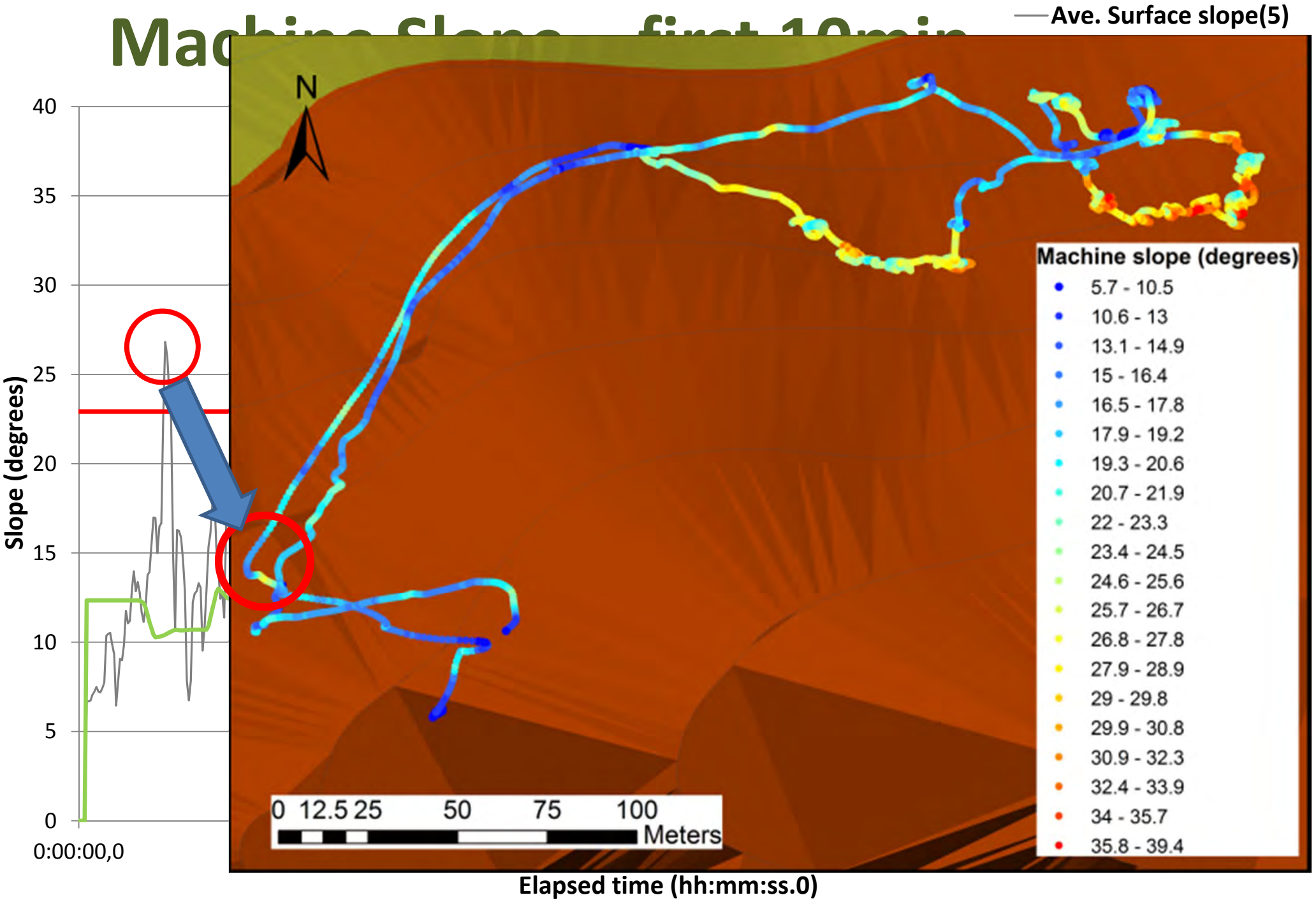
25.7 - 26.7
26.8 - 27.8
27.9 - 28.9
29 - 29.8
29.9 - 30.8
30.9 - 32.3
32.4 - 33.9
34 - 35.7
35.8 - 39.4

Machine Slope – first 10min



Machine Slope – first 10min




Mac
Ave. Surface slope(5)
N
40
35
30
25
20
15
10
5
0
Slope (degrees)
0:00:00,0
Elapsed time (hh:mm:ss.0)
Machine slope (degrees)
5.7 - 10.5
10.6 - 13
13.1 - 14.9
15 - 16.4
16.5 - 17.8
17.9 - 19.2
19.3 - 20.6
20.7 - 21.9
22 - 23.3
23.4 - 24.5
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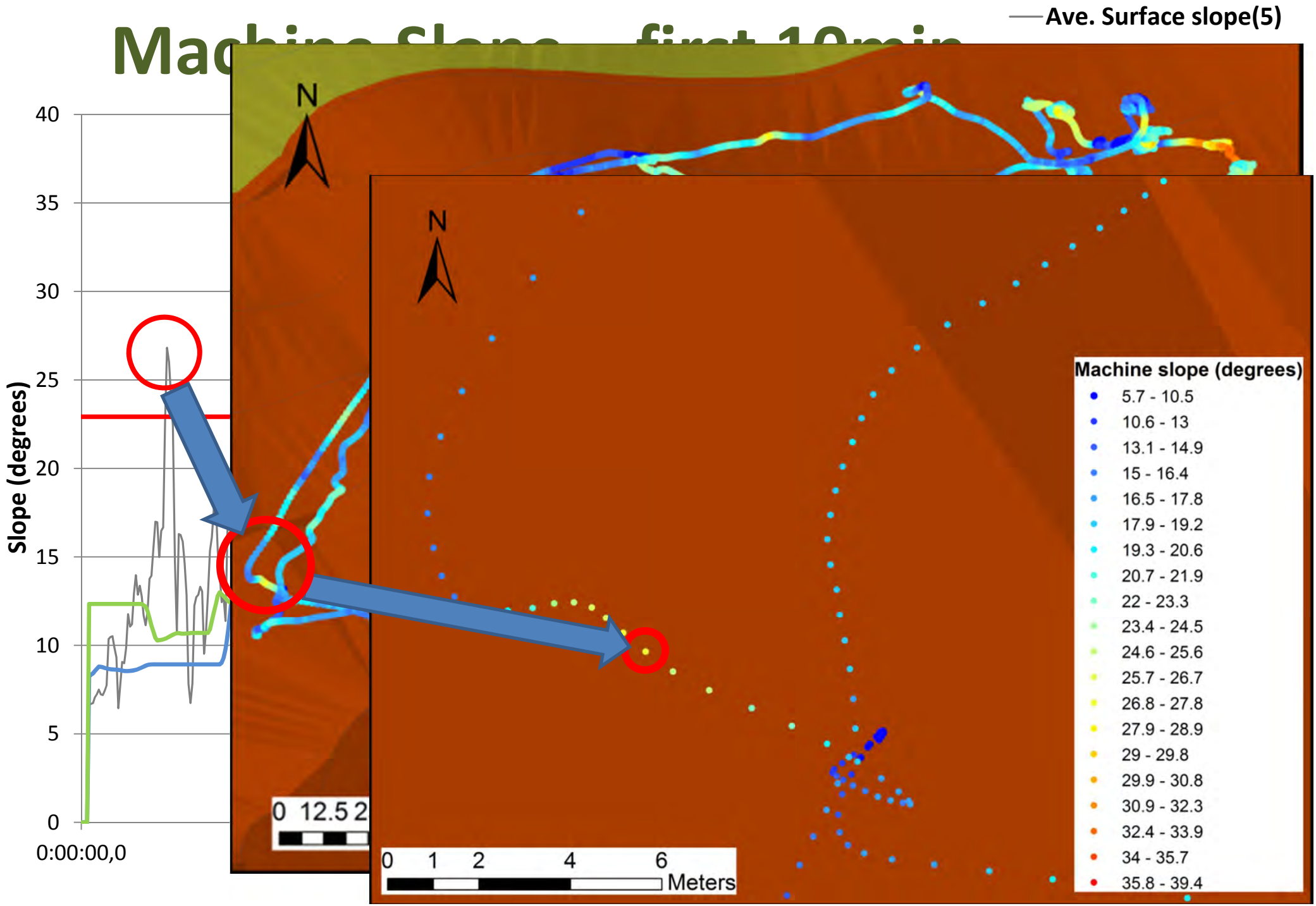
27.9 - 28.9
29 - 29.8
29.9 - 30.8
30.9 - 32.3
32.4 - 33.9
34 - 35.7
35.8 - 39.4
0 12.5 25 50 75 100
Meters


Ave. Surface slope(5)
Slope (degrees)
40
35
30
25
20
15
10
5
0
0:00:00,0
N
N
0 12.5 2
0 1 2 4 6
Meters
Machine slope (degrees)
5.7 - 10.5
10.6 - 13
13.1 - 14.9
15 - 16.4
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17.9 - 19.2
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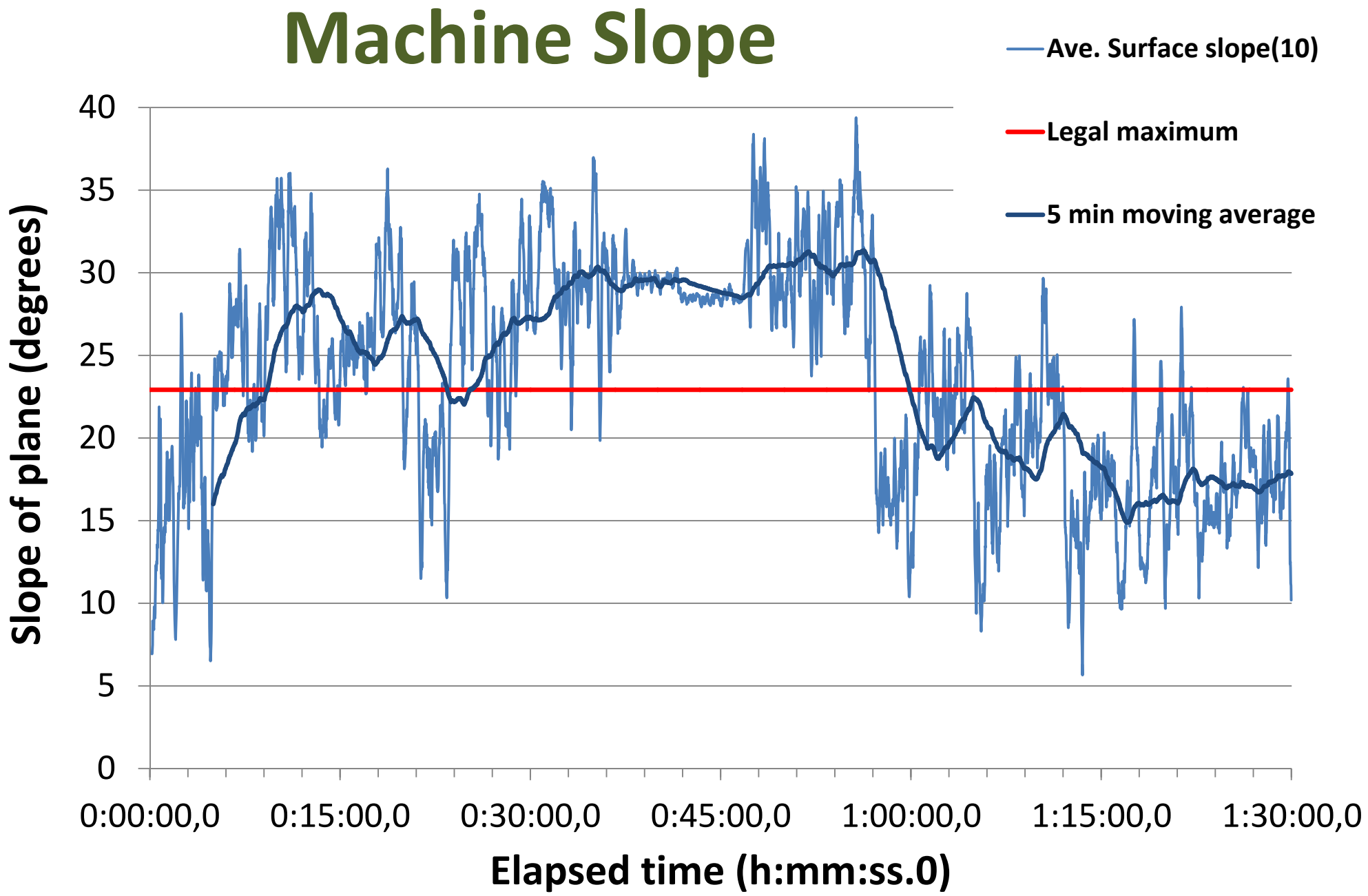
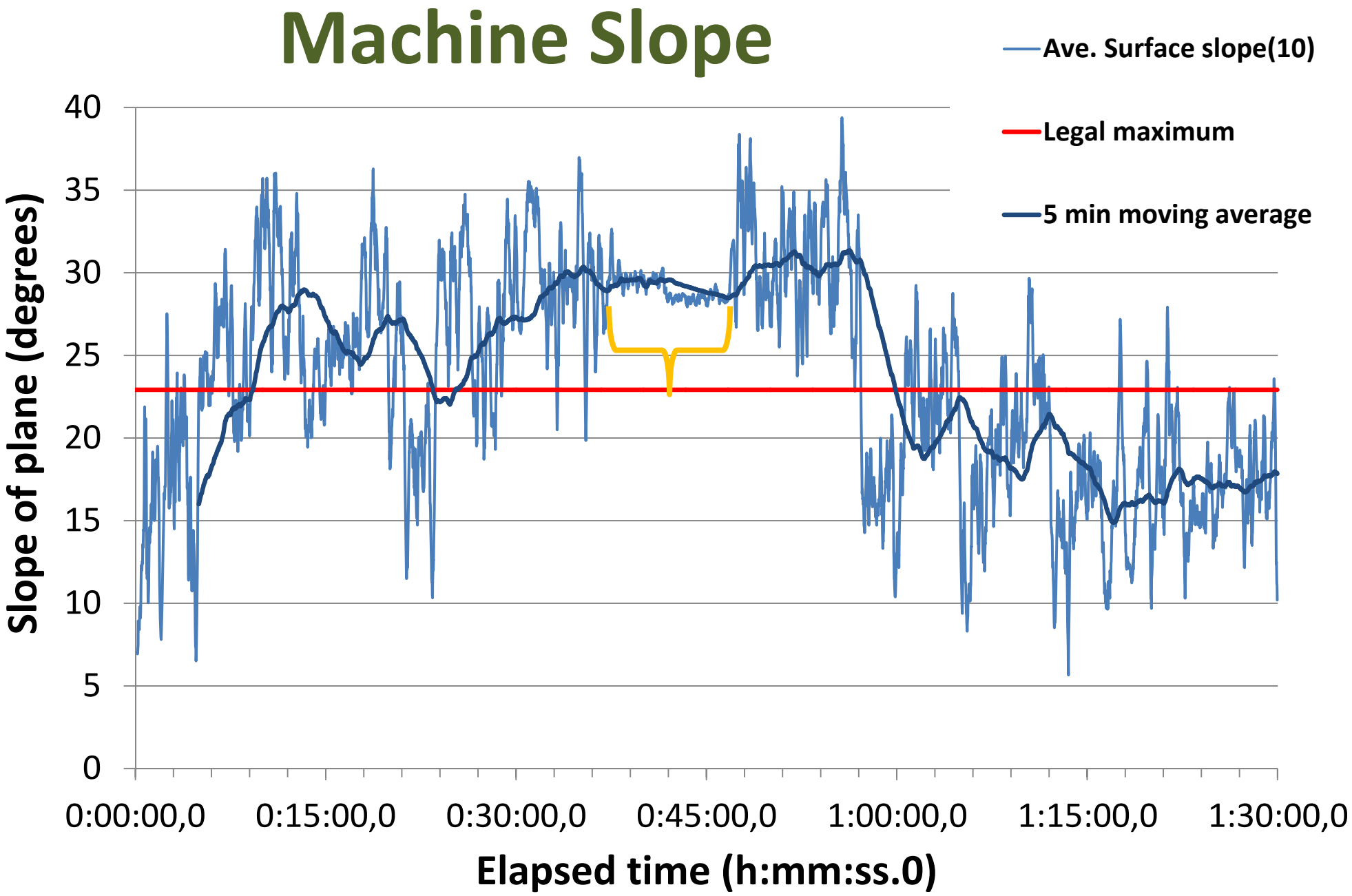
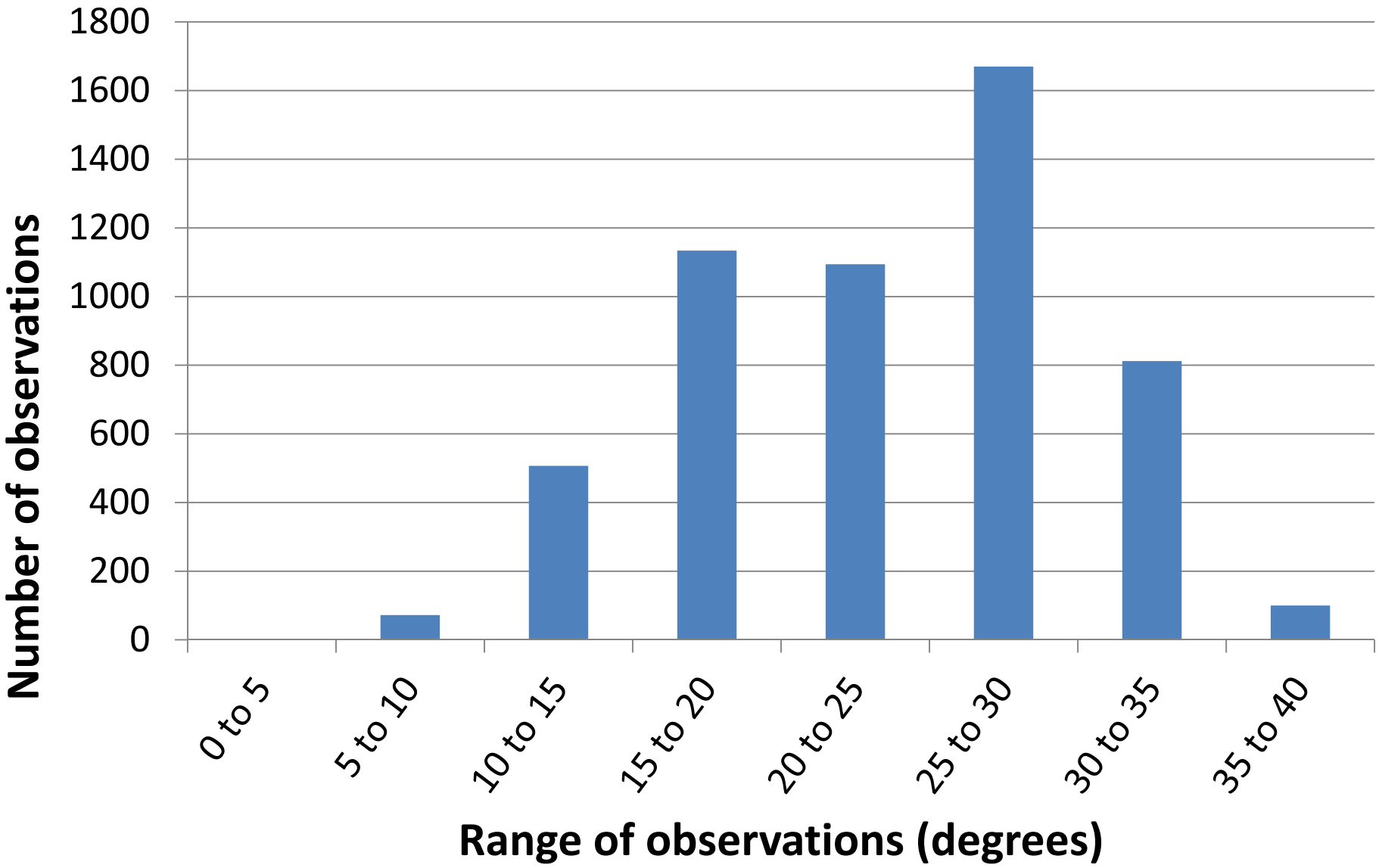

Machine Slope
Ave. Surface slope(10)
Legal maximum
5 min moving average
Slope of plane (degrees)
40
35
30
25
20
15
10
5
0
0:00:00,0
0:15:00,0
0:30:00,0
0:45:00,0
1:00:00,0
1:15:00,0
1:30:00,0
Elapsed time (h:mm:ss.0)


Machine Slope
Ave. Surface slope(10)
Legal maximum
5 min moving average
Slope of plane (degrees)
40
35
30
25
20
15
10
5
0
0:00:00,0
0:15:00,0
0:30:00,0
0:45:00,0
1:00:00,0
1:15:00,0
1:30:00,0
Elapsed time (h:mm:ss.0)

Distribution of Machine slope



The Machines experience

- Machine slope vastly different to terrain slope
- Reasons:
  - Skid trails affect the machines operating slope and are not factored into the DTM calculations
  - Driving over obstacles such as stumps particular when operating a rigid tracked vehicle
  - Operator skill – taking care on the steep slopes and not on the lower slopes.

Where to from here

- Early phase of study, so welcome any and all input!!
- Further data collection in New Zealand during November with the crews shifting onto steep terrain with the drier summer conditions
- Data also collected from machines in Europe with a focus on purpose built steep terrain machines