Rees analysis

Associated references: Brasington et al. (2012), Williams et al.(2013b) and Marco Redolfi's thesis.

This notebook contains the analysis of the relationship between the morphological active width (MAW) and the t/Txnr ratio at the Pinzano site along the Tagliamento river. Some other relationships with the exner timescale are investigated. The methodology is as follow:

1. Estimate relationship between water discharge, depth and sediment flux from cross-sections and uniform flow model
2. Import the water depth measurements from the gauging station
3. Average the water depth every hour
4. Calculate Q from the water depth and Qs, Wetted width, Water depth, Txnr, t/Txnr and dimensionless streamm power w* every hour.
5. Detecting flood from the water discharge time serie based on a critical discharge Qc (Q>Qc are considered floods)
6. Import survey time period and for each compute the mean_Q_above_Qc, max_Q_above_Qc, mean_Ww_above_Qc, max_Ww_above_Qc, sum_t_Txnr_above_Qc, mean_w_*above_Qc, max_w*_above_Qc.
7. Compute DoDs envelops
8. Compute the MAW as follow:

$$\frac{Area\ of\ morphological\ changes}{Reach\ length\ *\ Max\ wetted\ width}$$

for the survey time period.

Some information:

- Data collected between October 2009 and May 2010
- 10 storms
- DEM resolution : 0.5 m
- Water level data every 15min from September 2009 to March 2011 at a gauging station located 1 km downstrea the confluence between Invincible creek and the Rees river (single channel confined)
- Qcr = 30 m3/s

Estimate relationship between water discharge, depth and sediment flux

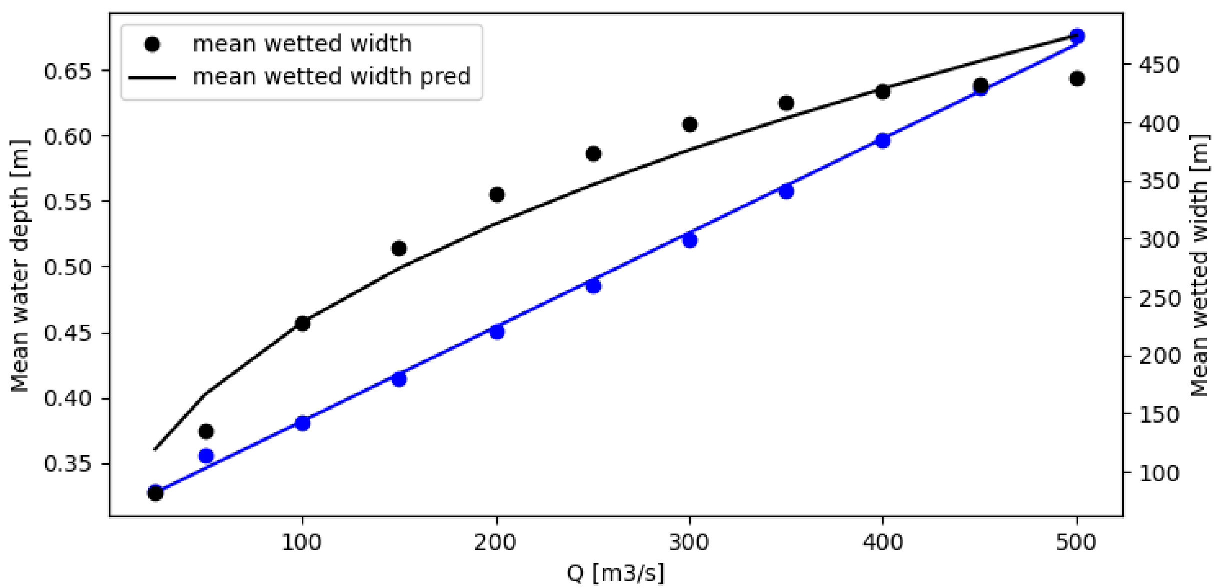
Estimate Q-Ww and Q-H from graphflood simulations (not used)

This section presents results from Graphflood hydraulic simulations. The aim is to estimate the relationships between Q, the wetted width and the water depth. The investigated water discharges are: 24, 50, 100, 150, 200, 250, 300, 350, 400, 450, and 500 m3/s.

```
Power Law Model:
  Parameters: [28.09386047  0.45482062]
  R-squared: 0.9581
Logarithmic Model:
  Parameters: [ 128.15460911 -344.80788324]
  R-squared: 0.9886
slope: 0.0007195606069199373, intercept: 0.3098268719165368
```

```
<matplotlib.legend.Legend at 0x210328af220>
```

Figure



From the uniform flow model

In the end, the relationships of the wetted width, the water depth and the sediment flux with the water discharge is estimated from a uniform flow model applied on cross-sections (see Q-Qs_Q-Ww_curves.csv file). In total, there are 10 cross-sections spaced of 200 m to each other (see prepare_uniform_flow_model.py file). The model has been applied on the e00 DEM.

Import water discharge dataset and average Q every hour

Calculate Q, Qs, Ww, Water depth, Txnr, t/Txnr and, w*

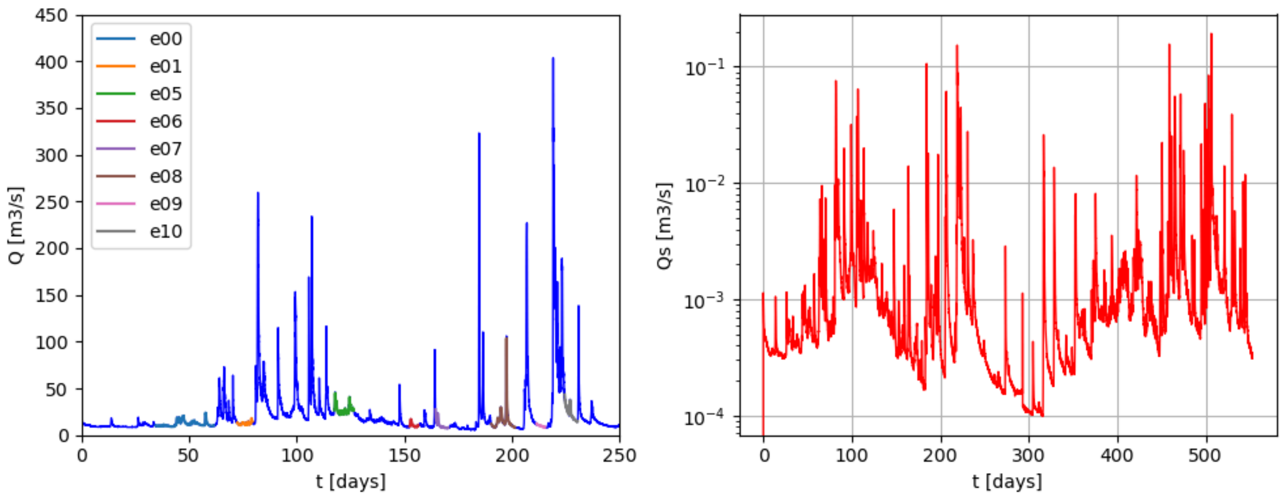
```
C:\Users\thoma\AppData\Local\Temp\ipykernel_89108\2605502357.py:27: RuntimeWarning: invalid v
alue encountered in scalar divide
  t_txnr = (time_step*60)/((1-porosity)*((depth*(wetted_width**2))/Qs))
C:\Users\thoma\AppData\Local\Temp\ipykernel_89108\2605502357.py:43: RuntimeWarning: invalid v
alue encountered in scalar divide
  txnr = ((1-porosity)*((depth*(wetted_width**2))/Qs))/3600 # in hours
```

Import survey time periods and set an id for each survey

	t [min]	h [mm]	Q [m3/s]	t [days]	smoothed Q [m3/s]	Qs [m3/s]	Ww [m]	hw [m]	t_Txnr	T
0	0	717	19.30000	0.000000	0.00000	0.000000	0.000000	0.210000	NaN	
1	15	710	18.90000	0.010417	0.00000	0.000000	0.000000	0.210000	NaN	
2	30	704	18.70000	0.020833	0.00000	0.000000	0.000000	0.210000	NaN	
3	45	704	18.70000	0.031250	18.90000	0.001135	105.466402	0.225120	0.000544	459.
4	60	699	18.40000	0.041667	18.67500	0.001114	104.899543	0.224940	0.000540	463.
...	...	...	...	...	...	...	...	...	...	
53068	796020	289	8.79524	552.791667	8.64110	0.000322	74.158747	0.216913	0.000324	771.
53069	796035	285	8.67140	552.802083	8.66411	0.000323	74.247545	0.216931	0.000325	770.
53070	796050	285	8.67140	552.812500	8.66411	0.000323	74.247545	0.216931	0.000325	770.
53071	796065	283	8.60996	552.822917	8.68700	0.000325	74.335752	0.216950	0.000325	769.
53072	796080	254	7.75504	552.833333	8.42695	0.000309	73.326002	0.216742	0.000318	785.

53073 rows × 12 columns

Figure

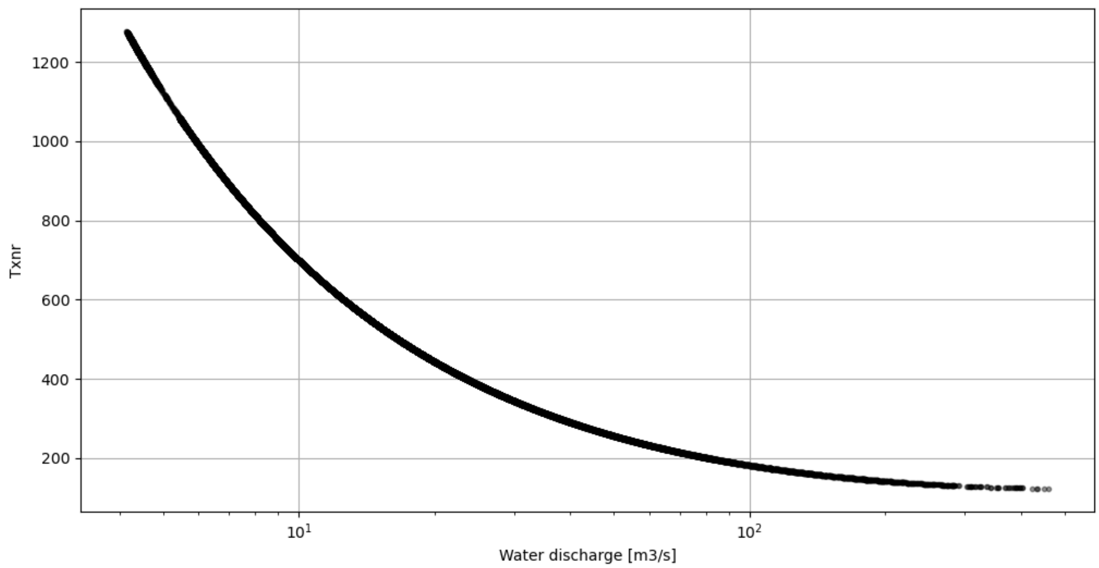


Dataframe statistics

	t [min]	h [mm]	Q [m3/s]	t [days]	smoothed Q [m3/s]	Qs [m3/s]	Ww
count	53073.000000	53073.000000	53073.000000	53073.000000	53073.000000	53073.000000	53073.000
mean	398040.000000	499.941251	19.783430	276.416667	19.782660	0.001902	98.91
std	229814.996329	299.492243	25.013958	159.593747	24.947412	0.006459	37.56
min	0.000000	87.000000	4.141160	0.000000	0.000000	0.000000	0.000
25%	199020.000000	318.000000	9.142400	138.208333	9.150000	0.000353	76.09
50%	398040.000000	448.000000	13.475360	276.416667	13.475000	0.000658	90.57
75%	597060.000000	593.000000	21.075560	414.625000	21.076060	0.001353	110.76
max	796080.000000	3337.000000	475.261160	552.833333	459.300590	0.193186	443.25

Txnr-Q relationship

Figure

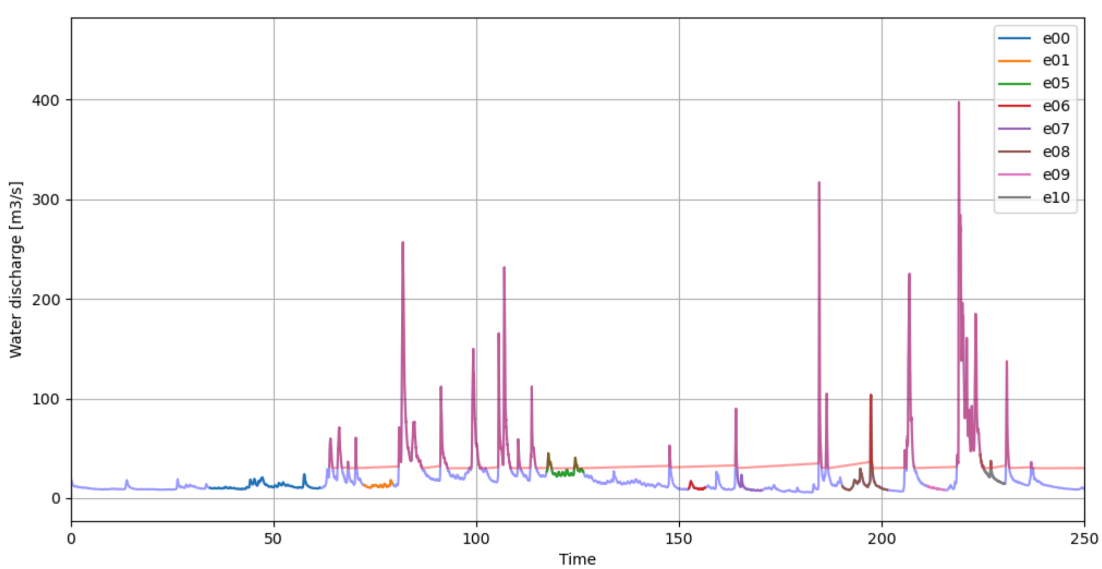


Estimate Txnr for floods

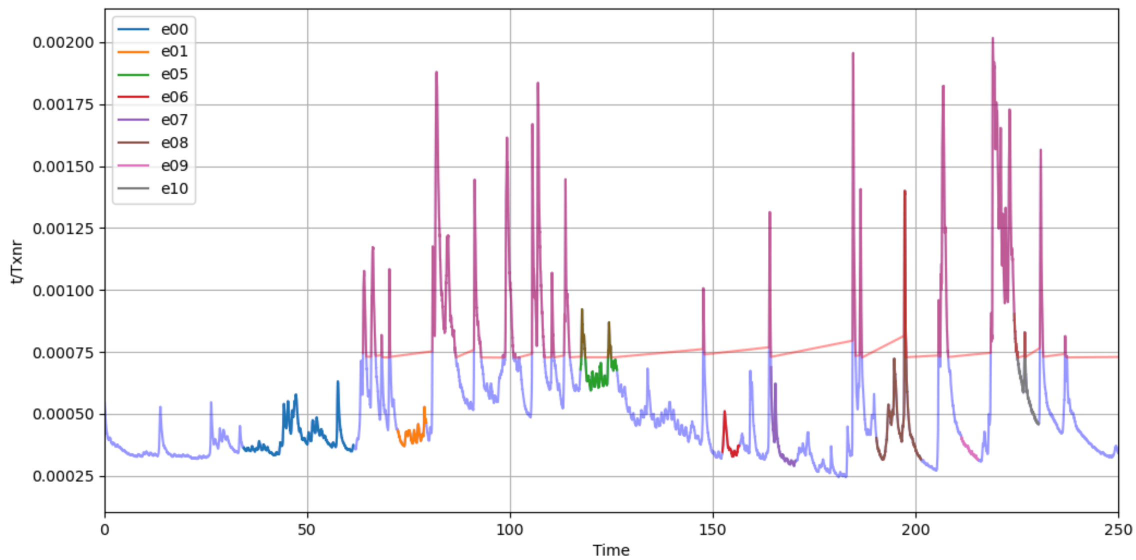
Detect floods

All periods in red are considered floods where sediment transport occurs. The critical discharge Qc is 30 m3/s.

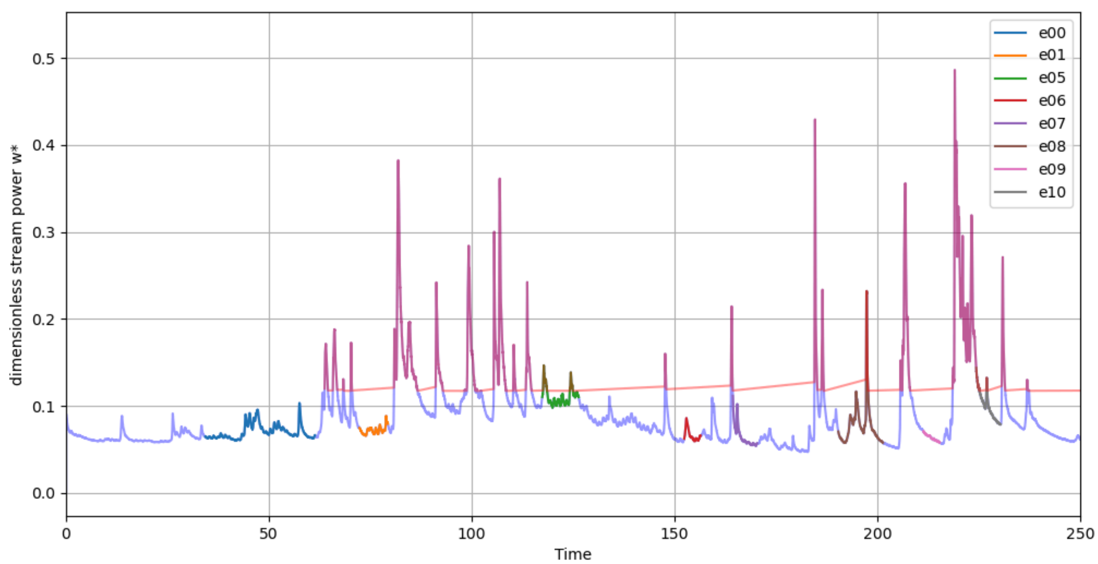
Figure



Figure



Figure

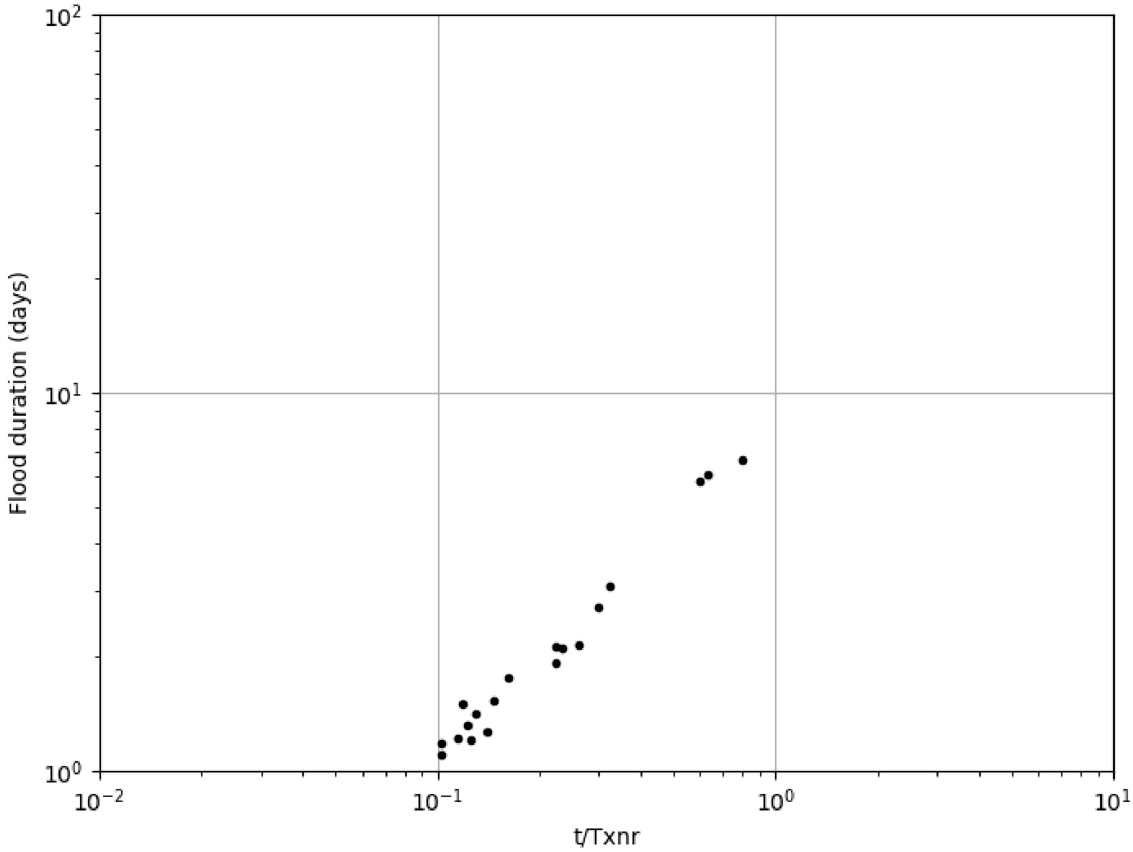


Compute flood statistics

	flood id	t_Txnr_sum	max_Q	mean_Q	duration_days
0	1	0.073455	59.85000	46.370886	0.812500
1	2	0.102086	70.70000	49.013785	1.104167
2	3	0.015461	36.57500	33.286250	0.197917
3	4	0.028625	60.62500	43.471875	0.322917
4	5	0.596015	256.87500	68.222040	5.812500
...	...	...	...	...	...
70	71	0.019920	36.70938	32.784306	0.260417
71	72	0.036770	51.80500	39.887234	0.437500
72	73	0.006757	32.74190	31.672363	0.083333
73	74	0.032247	74.22505	51.281574	0.333333
74	75	0.044071	80.90940	47.798179	0.479167

75 rows × 5 columns

Figure



Surveys statistics

Survey time periods are unpaired numbers. Pair numbers are time periods between two surveys. Each variables is computed where Q > Qc.

	surveys_id	Q_max	t_txnr_sum	Ww_max	w_mean
0	0	0.00000	0.000000	0.000000	NaN
1	1	0.00000	0.000000	0.000000	NaN
2	2	70.70000	0.219626	190.961165	0.147486
3	3	0.00000	0.000000	0.000000	NaN
4	4	256.87500	1.525155	341.256669	0.169314
5	5	44.99681	0.130342	155.825345	0.128252
6	6	52.77279	0.028290	167.413642	0.141111
7	7	0.00000	0.000000	0.000000	NaN
8	8	89.80363	0.044031	212.661352	0.164481
9	9	0.00000	0.000000	0.000000	NaN
10	10	316.88863	0.145676	375.071716	0.192516
11	11	103.62276	0.046070	226.809447	0.169537
12	12	225.15028	0.253387	321.602148	0.193674
13	13	0.00000	0.000000	0.000000	NaN
14	14	397.40058	0.736970	415.297334	0.227966
15	15	43.41147	0.078892	153.330426	0.126652
16	16	459.30059	3.484906	443.251252	0.167024

Compute variables for each DoDs

	start_index	DoD_name	t_txnr_sum	Ww_max	w*
0	1	e01-e00	0.219626	190.961165	0.147486
1	3	e05-e01	1.655497	341.256669	0.148783
2	5	e06-e05	0.158632	167.413642	0.134682
3	7	e07-e06	0.044031	212.661352	0.164481
4	9	e08-e07	0.191746	375.071716	0.181026
5	11	e09-e08	0.299457	321.602148	0.181605
6	13	e10-e09	0.815863	415.297334	0.177309
7	15	e10-e00_envDoD	3.384851	415.297334	0.162196
9	15	e10-e00_DoD	3.384851	415.297334	0.162196

Morphological active width

All DEMs/DoDs does not have the same extent:

- the upstream part of DEM e06 is much narrower than the other DEMs
- DEMs e00, e01, e05, e08, and e10 are more or less similar.

Compute DoD envelops

```
Array Shape: Rows = 4780, Columns = 3400, Bands = 1
Raster successfully created at C:\Users\thoma\Documents\Trento\python\Data\Rees\Data\envDoDs
\thresh.tif
```

```
<osgeo.gdal.Dataset; proxy of <Swig Object of type 'GDALDatasetShadow *' at 0x0000021035C5F60
0> >
```

Compute morphological active width

The morphological active width is calculated on a mask corresponding to the area of the e09 DEM.

The morphological active width is computed as follow:

$$\frac{Area\ of\ morphological\ changes}{Reach\ length\ *\ Max\ wetted\ width}$$

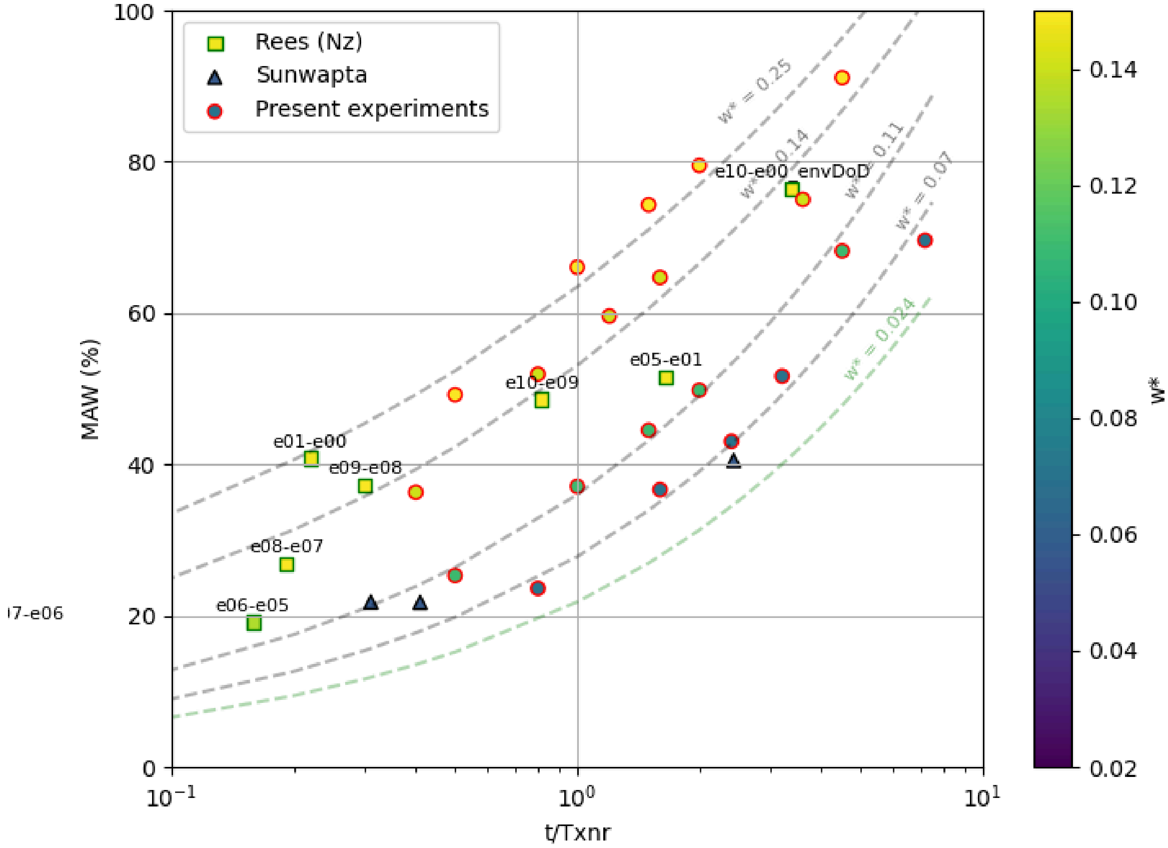
```
The total corridor area is 367027.3596364198 m2
The total corridor area is 655895.3181702627 m2
The total corridor area is 321769.0201852873 m2
The total corridor area is 408735.1191632688 m2
The total corridor area is 720887.8383245511 m2
The total corridor area is 618119.328836573 m2
The total corridor area is 798201.4763478222 m2
The total corridor area is 798201.4763478222 m2
The total corridor area is 798201.4763478222 m2
```

	start_index	DoD_name	t_txnr_sum	Ww_max	w*	MAW (%)
0	1	e01-e00	0.219626	190.961165	0.147486	40.787286
1	3	e05-e01	1.655497	341.256669	0.148783	51.495603
2	5	e06-e05	0.158632	167.413642	0.134682	19.139428
3	7	e07-e06	0.044031	212.661352	0.164481	18.010319
4	9	e08-e07	0.191746	375.071716	0.181026	26.900995
5	11	e09-e08	0.299457	321.602148	0.181605	37.216196
6	13	e10-e09	0.815863	415.297334	0.177309	48.594122
7	15	e10-e00_envDoD	3.384851	415.297334	0.162196	76.452345
9	15	e10-e00_DoD	3.384851	415.297334	0.162196	56.450503

MAW-Txnr-w* relationship

```
63.46018011632202 0.277589165299307
```

Figure



Rees (Nz)
Sunwapta
Present experiments
w* = 0.25
w* = 0.14
w* = 0.11
w* = 0.07
w* = 0.024
e10-e00
envDoD
e05-e01
e10-e09
e01-e00
e09-e08
e08-e07
e06-e05
)7-e06
MAW (%)
t/Txnr
w*