



## **Best Sails**

### Past Seasons Weather Routing Study

Metplan.org

October 21, 2022

The background consists of two large, overlapping geometric shapes. A teal-colored shape is in the upper-left corner, and a light beige shape is in the lower-left corner. The rest of the page is white. The word "Introduction" is centered in the white area.

# Introduction

# Introduction

## Product Description

Past Seasons Weather Routing is a modern and useful tool for planning navigation strategies. Historical data set of atmospheric and sea conditions (wind, wave, current etc.) is used in order to simulate routes for the past 5 seasons, departing November 1<sup>st</sup>, 4<sup>th</sup> and 8<sup>th</sup>.

### Desired Benefits:

- ▶ safety
- ▶ performance
- ▶ comfort

# Introduction

## Boat Settings



The boat speed is given by a cross table of true wind speed (TWS) and true wind angle (TWA), known as "polar" (1).

A waves polar is also used and applies a correction to the boat speed for different wave heights and angles (3) .

# Introduction

## Boat Settings



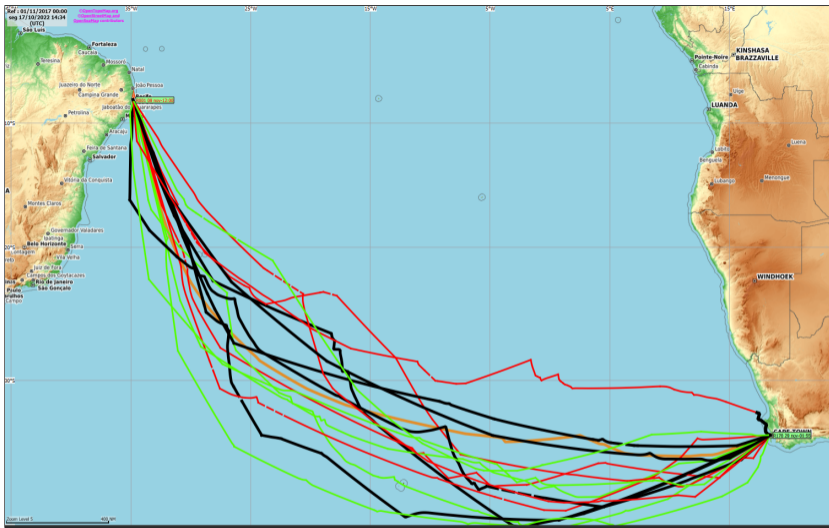
The sails definition and sail selection tables can be found in 4.

When sailing boat speed is less than 4.5kt (VMG), than constant velocity at 5.5kt (motoring).

## Boat Speed (polar) corrections:

- ▶ upwind: 85%
- ▶ downwind: 85%
- ▶ night: 90%
- ▶ best angle upwind: auto
- ▶ best angle downwind: auto
- ▶ crossed sea: 97% (swell above 2.5m)
- ▶ gusts: 95% (greater than 30% of wind speed)
- ▶ tacks/gybes: 70% during 10 min (2 cranks)

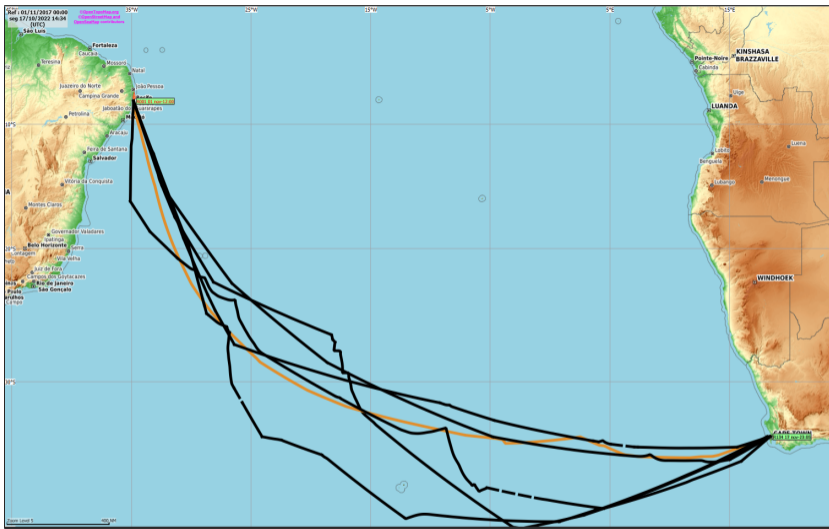
Routes starting on November 01<sup>st</sup>, 04<sup>th</sup>  
and 08<sup>th</sup>



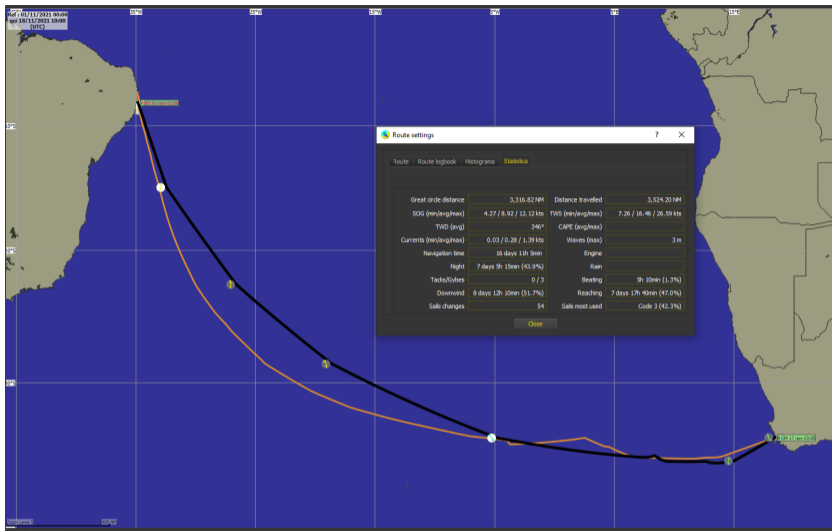
**Figure 1:** The orange route is the "pilot" route, constructed from most frequent conditions from digital pilot charts. There are routes departing on Nov 1<sup>st</sup> (black), Nov 4<sup>th</sup> (red) and Nov 8<sup>th</sup> (green) : 2021,2020,2019,2018,2017.



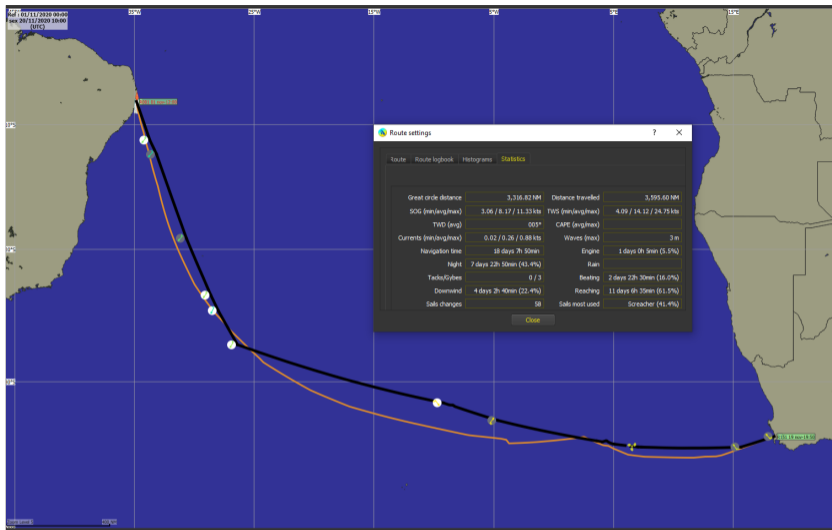
Routes starting on November 01<sup>st</sup>



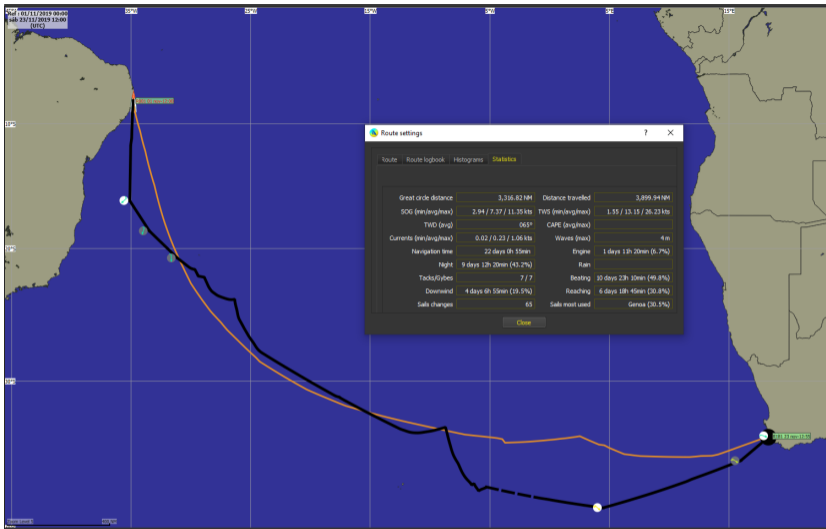
**Figure 2:** The orange route is the "pilot" route, constructed from most frequent conditions from digital pilot charts. The black routes are the simulated ones departing Nov 1<sup>st</sup>: 2021,2020,2019,2018,2017.



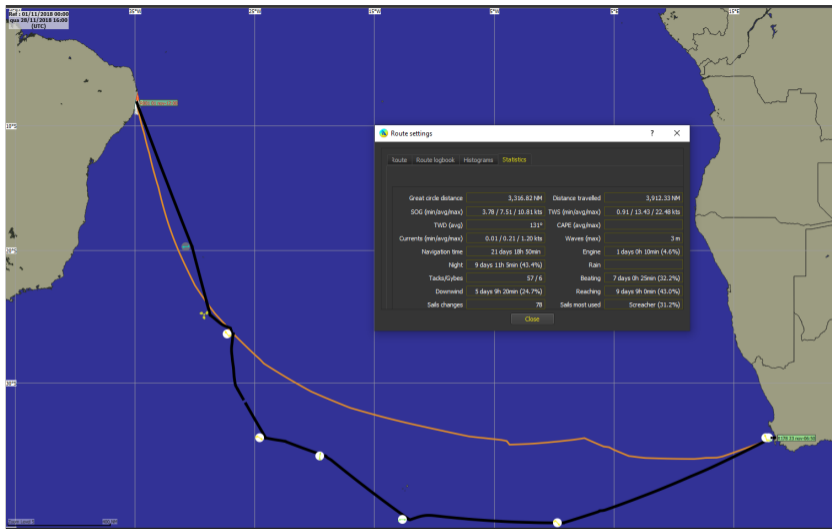
**Figure 3:** 2021 route. It took 16 days. Mostly downwind 52% and 47% reaching. No tacks and only 3 gybes. 54 sail changes, with Code 3 the most used (42%). Average SOG around 9 kt. Maximum TWS of 26.7kt. Maximum wave height of 3m. La Niña (5).



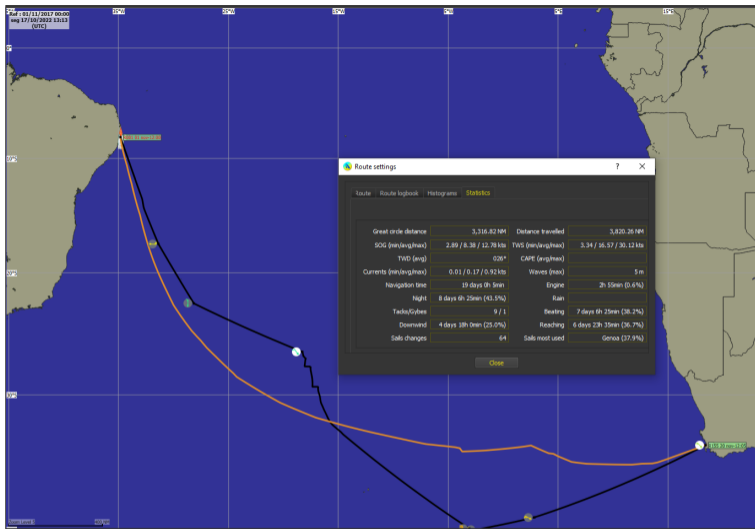
**Figure 4:** 2020 route. It took 18 days. Mostly reaching (61%) and downwind (22%). No tacks and 3 gybes. Average SOG around 8.2 kt. Maximum TWS of 25kt. Maximum wave height of 3m. Engine use for 1 day. 58 sail changes, with Screacher the most used (41%). La Niña (5).



**Figure 5:** 2019 route. It took 22 days. Beating 50% and reaching 31%. 7 tacks and 7 gybes. 65 sail changes, mainly Genoa 30%. Average SOG around 7.4 kt. Maximum TWS of 26kt. Maximum wave height of 4m. Neutral (5).



**Figure 6:** 2018 route. It took 22 days. Reaching at 43% of and beating 32%. 57 tacks and 6 gybes. Average SOG of 7.5 kt. Maximum TWS of 22.5kt. Maximum wave height of 3m. Weak El Niño (5).



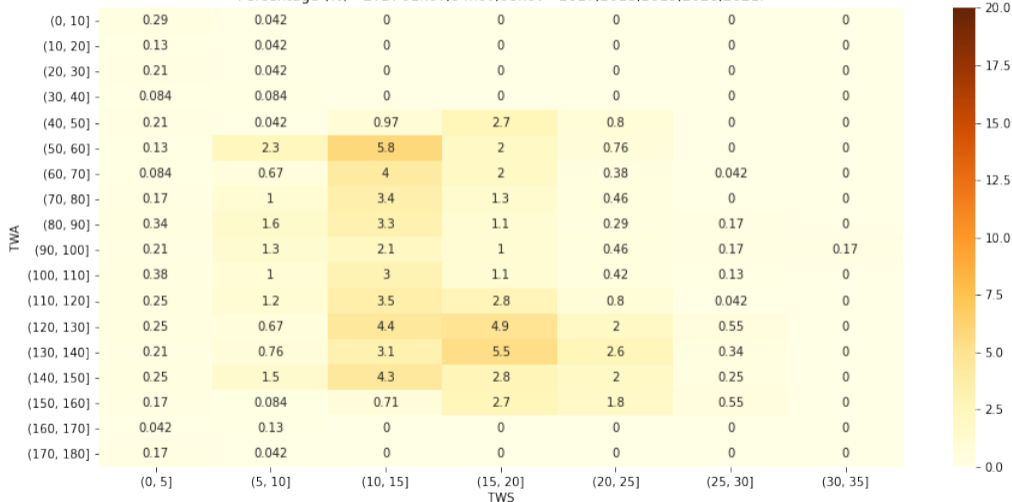
**Figure 7:** 2017 route. It took almost 19 days. Beating at 38% and reaching 37%. 9 tacks and 1 gybe. Average SOG of 8.4 kt. Maximum TWS of 30kt. Maximum wave height of 5m. Orange route is "pilot" route. Weak La Niña (5).

	Minimum	Average	Maximum
Duration	16 day(s) 11 hour(s) 5 minute(s)	19 day(s) 12 hour(s) 33 minute(s)	22 day(s) 0 hour(s) 55 minute(s)
Duration (dd:hh:mm:ss)	16:11:5:0	19:12:33:0	22:0:55:0
Beating time	0:5:10:0	5:16:20:0	10:23:10:0
% beating	1.3	27.5	49.8
Reaching time	6:18:45:0	8:10:19:0	11:6:35:0
% reaching	30.8	43.8	61.5
Downwind time	4:2:40:0	5:9:49:0	8:12:10:0
% downwind	19.5	28.66	51.7
Engine time	0:0:0:0	0:17:18:0	1:11:20:0
Ortho distance (nm)	3317	3317	3317
Distance sailed (nm)	3534	3752	3912
Added distance	217	436	596
Boat speed min (kt)	2.9	3.4	4.3
Boat speed average (kt)	7.4	8.1	8.9
Boat speed max (kt)	10.8	11.7	12.8
TWS min (kt)	0.9	3.4	7.3
TWS average (kt)	13.2	14.7	16.6
TWS max (kt)	22.5	26.0	30.1
Waves height max (m)	3.0	3.6	5.0

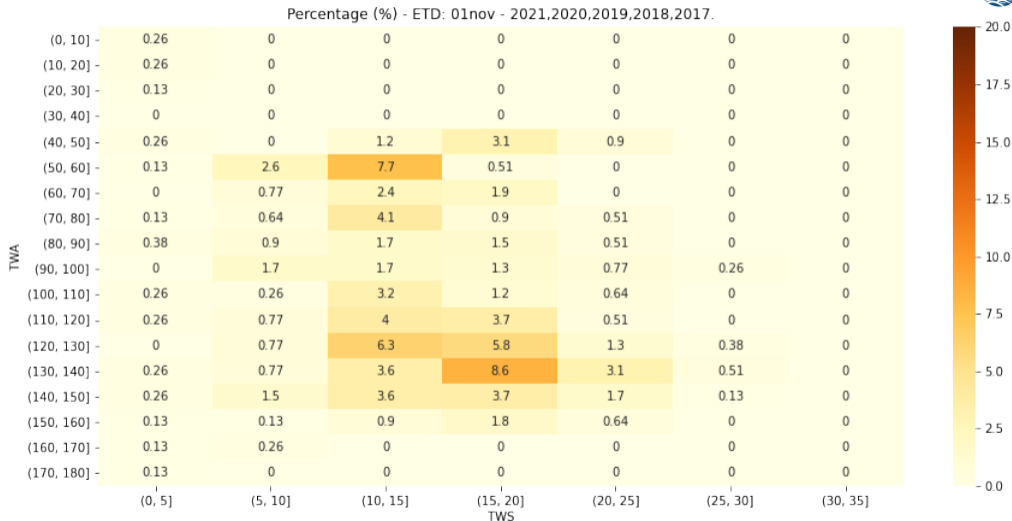


Cross Table (TWS/TWA) - Nov 01<sup>st</sup>, 04<sup>th</sup>  
and 08<sup>th</sup>.

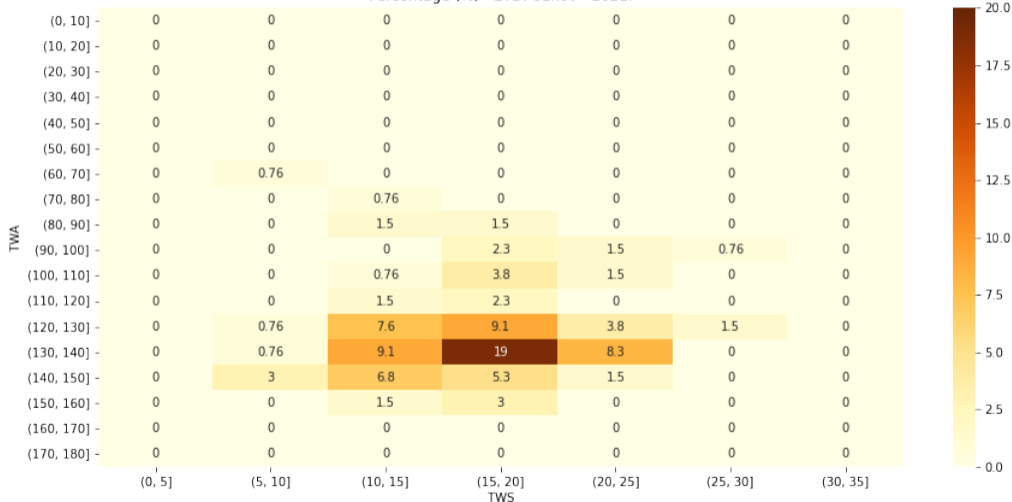
Percentage (%) - ETD: 01nov,04nov,08nov - 2017,2018,2019,2020,2021.



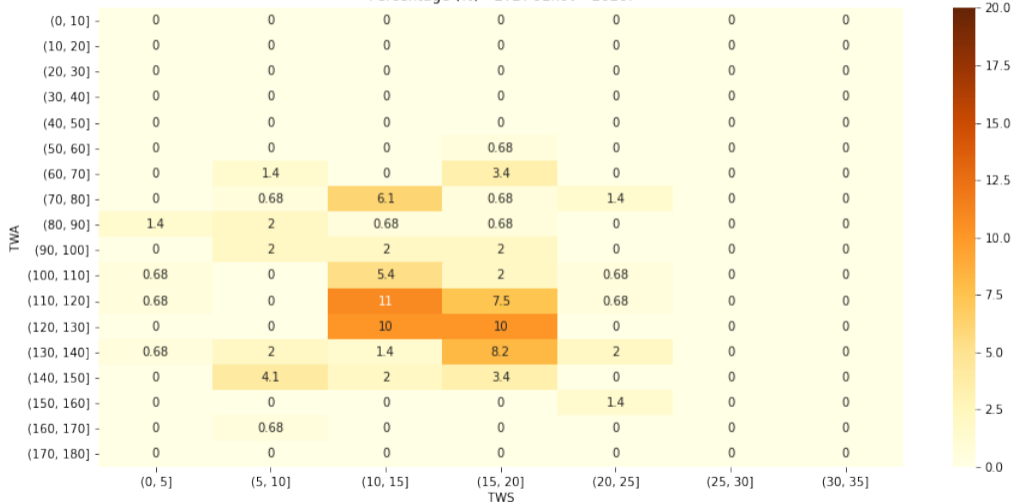
# Cross Table (TWS/TWA) - Nov 01<sup>st</sup>



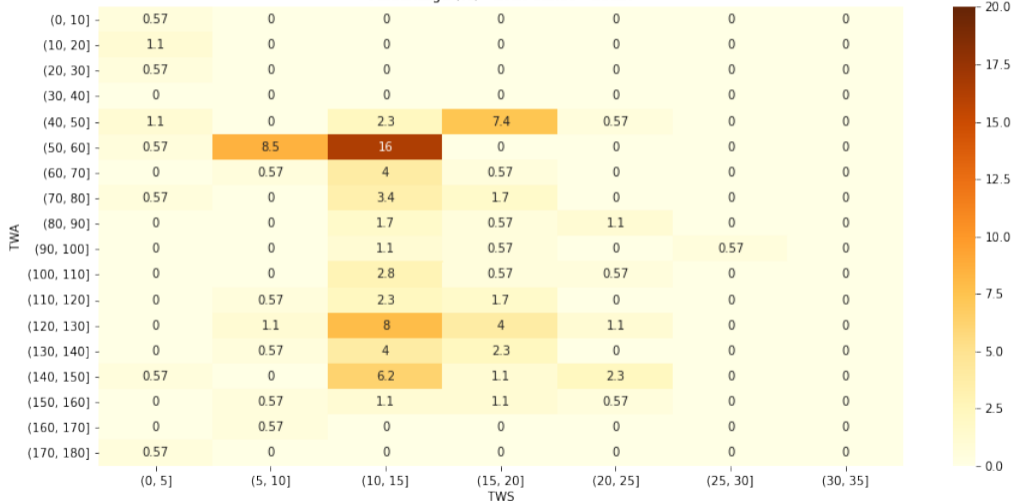
Percentage (%) - ETD: 01nov - 2021.

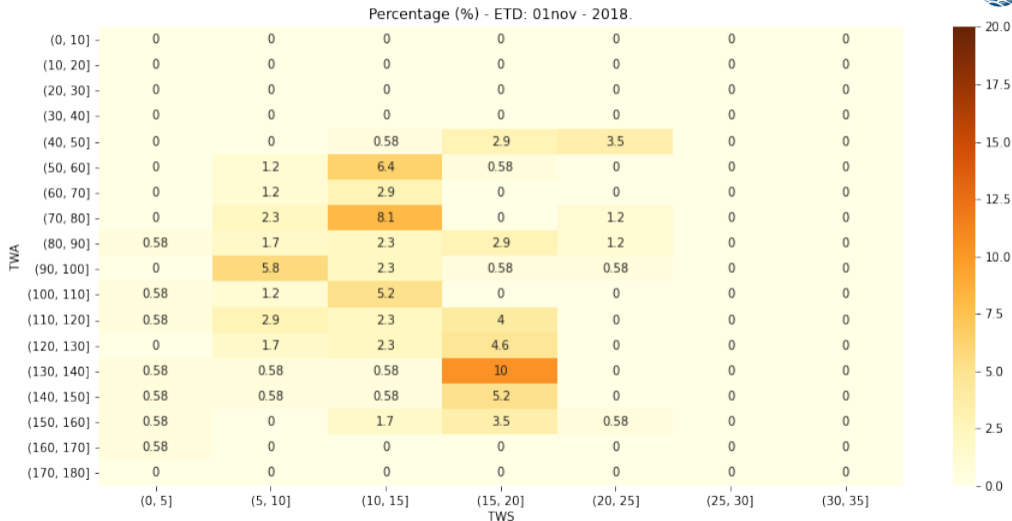


Percentage (%) - ETD: 01nov - 2020.



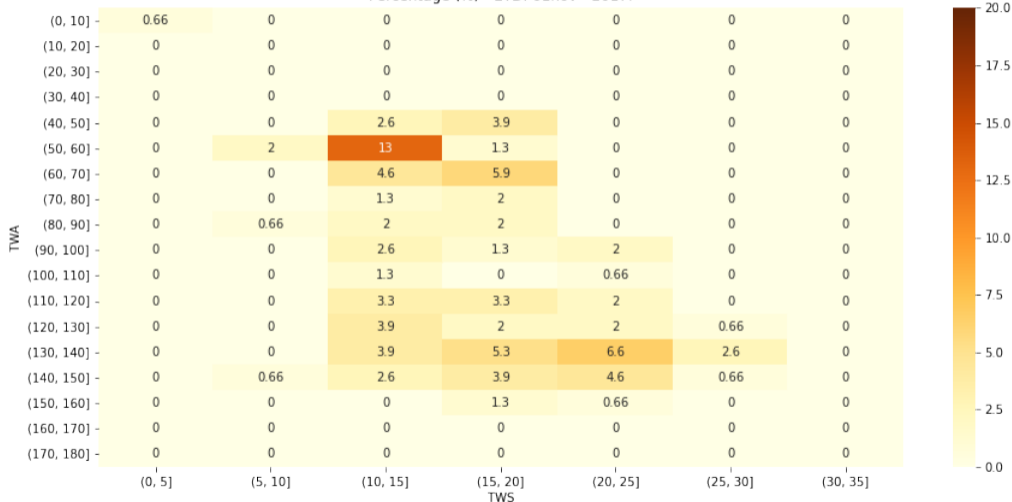
Percentage (%) - ETD: 01nov - 2019.





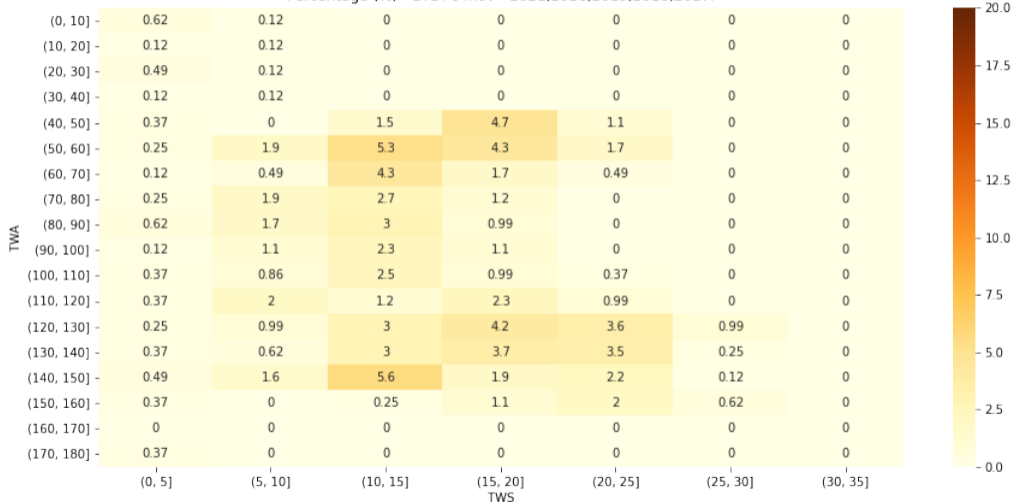


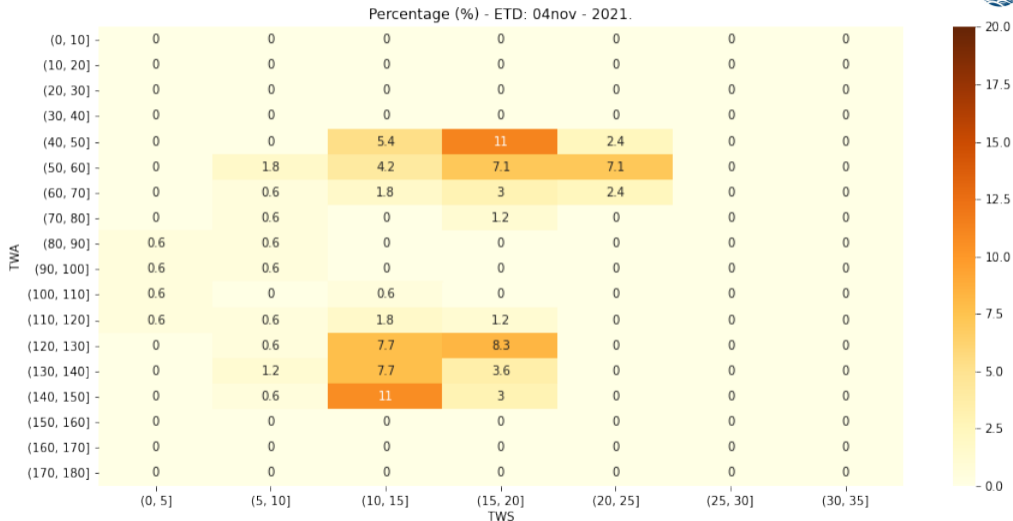
Percentage (%) - ETD: 01nov - 2017.



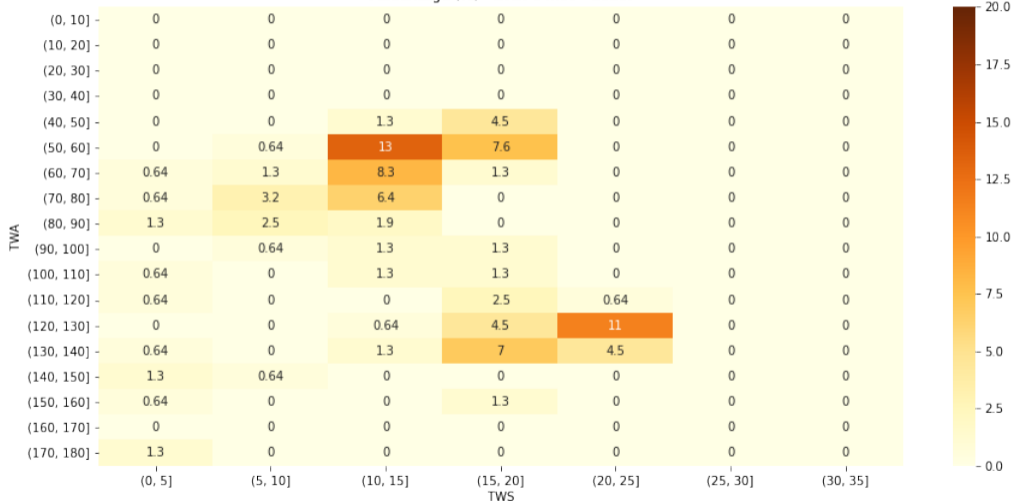
Cross Table (TWS/TWA) - Nov 04<sup>th</sup>

Percentage (%) - ETD: 04nov - 2021,2020,2019,2018,2017.

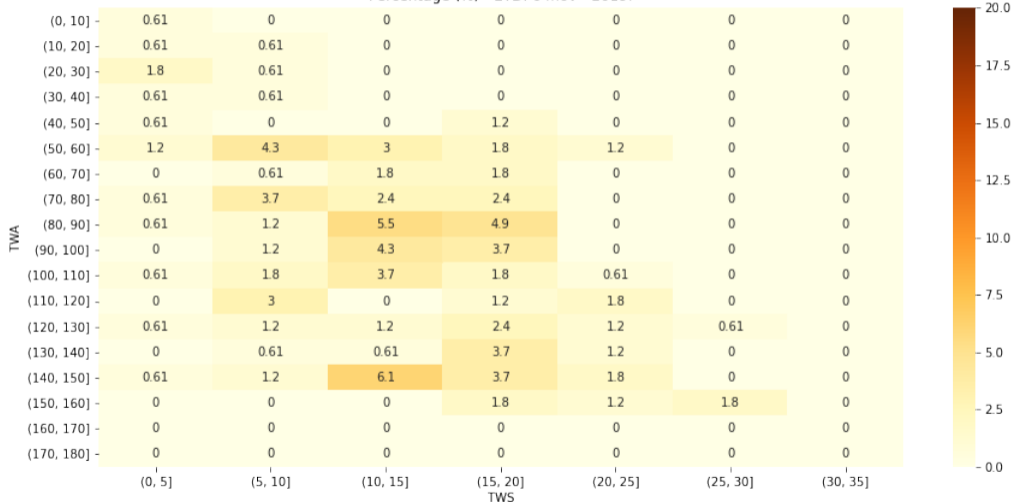




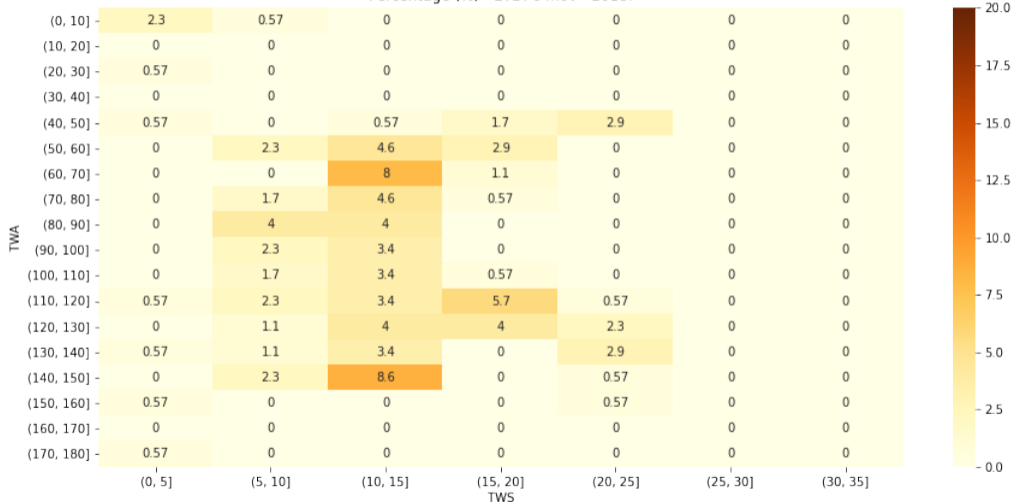
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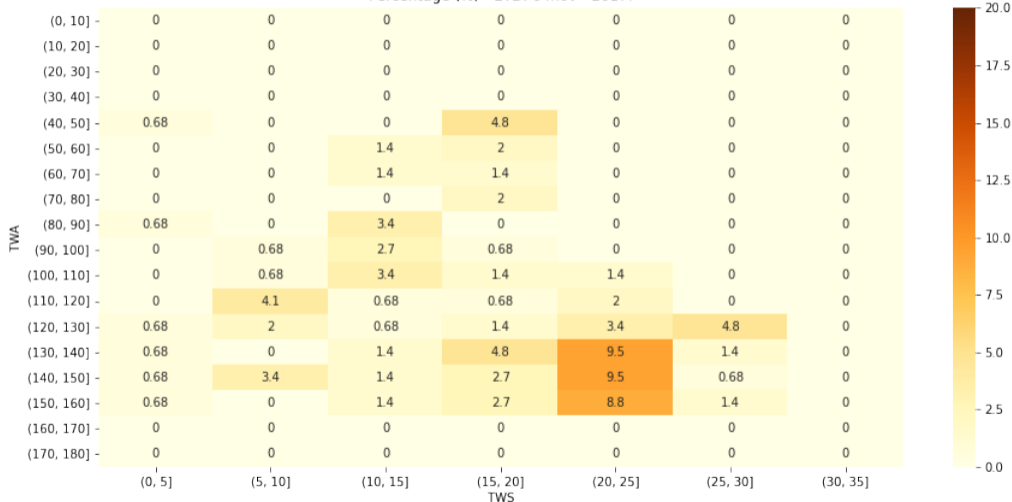
Percentage (%) - ETD: 04nov - 2019.



Percentage (%) - ETD: 04nov - 2018.



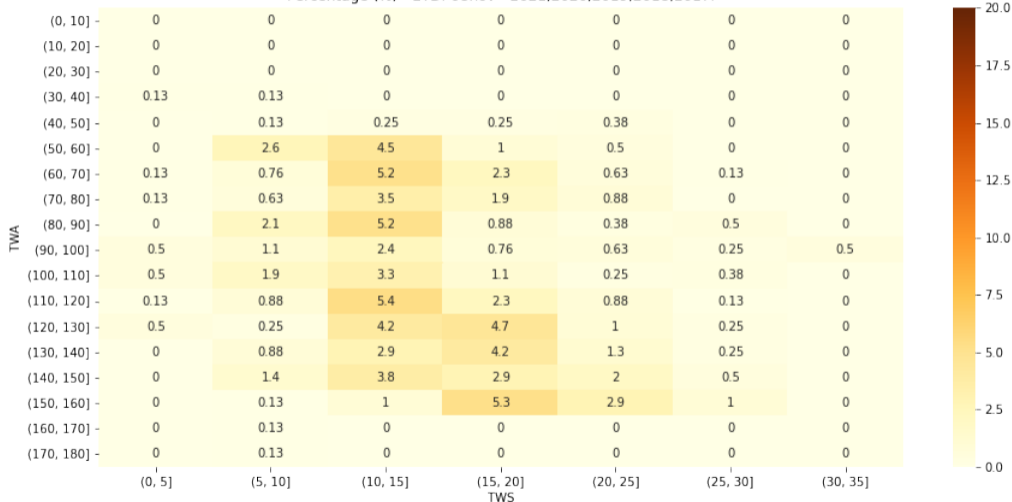
Percentage (%) - ETD: 04nov - 2017.



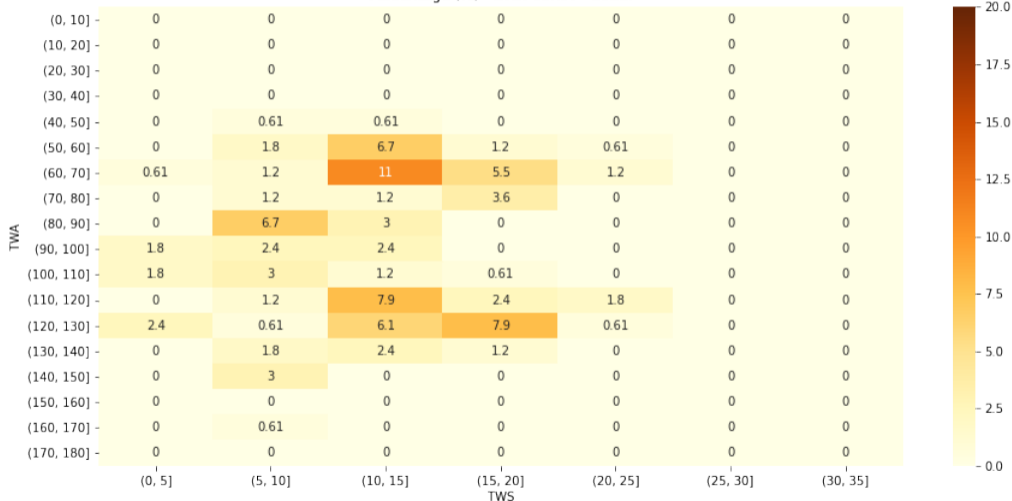


Cross Table (TWS/TWA) - Nov 08<sup>th</sup>

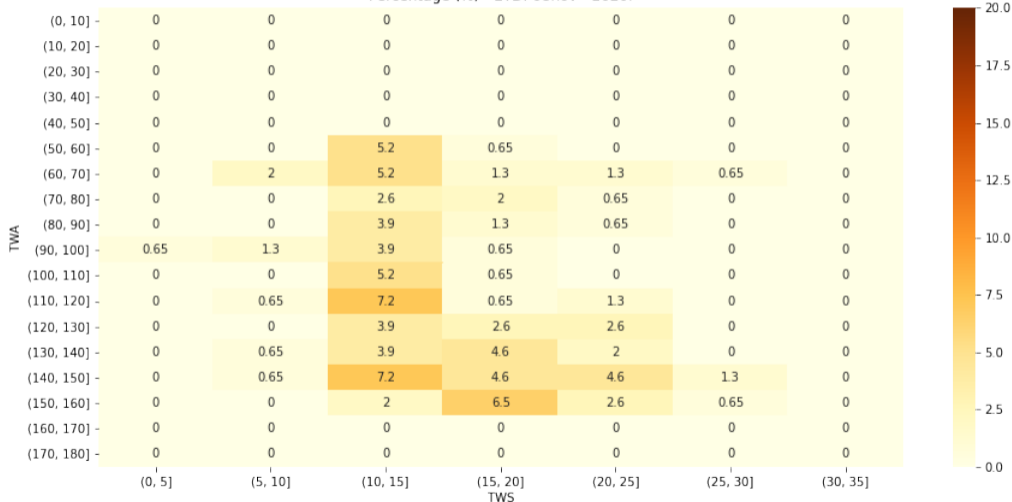
Percentage (%) - ETD: 08nov - 2021,2020,2019,2018,2017.



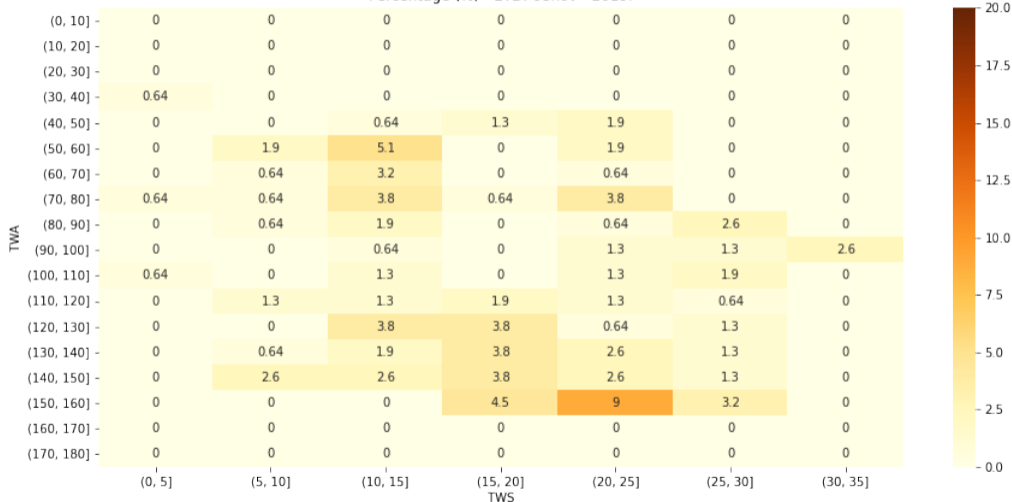
Percentage (%) - ETD: 08nov - 2021.



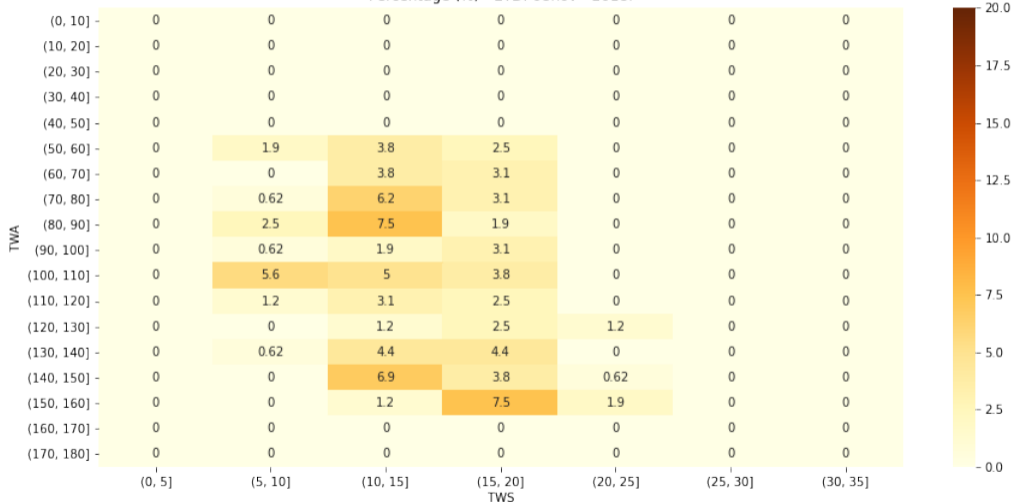
Percentage (%) - ETD: 08nov - 2020.



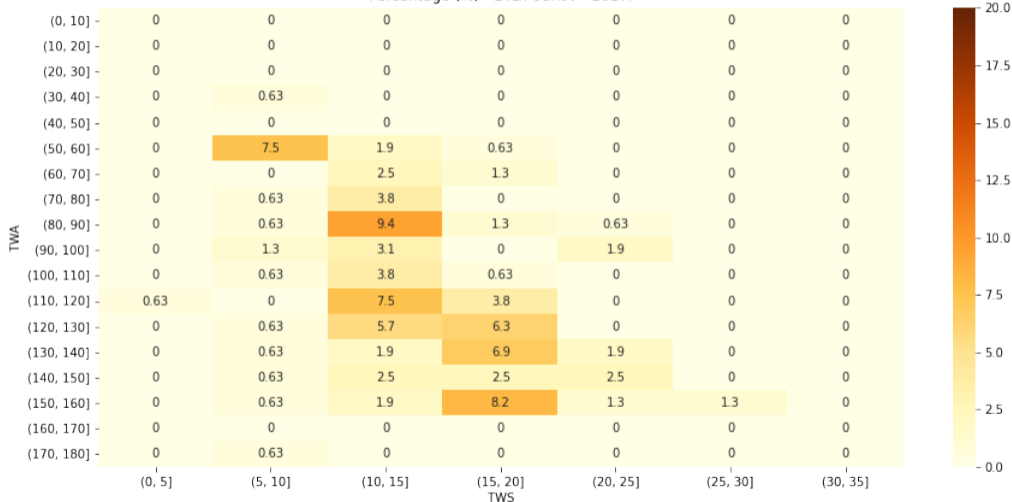
Percentage (%) - ETD: 08nov - 2019.



Percentage (%) - ETD: 08nov - 2018.



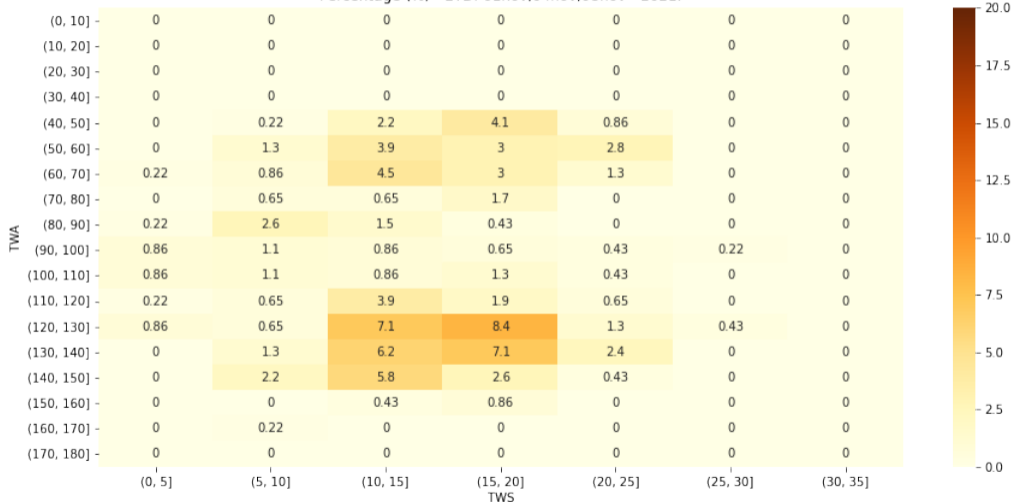
Percentage (%) - ETD: 08nov - 2017.



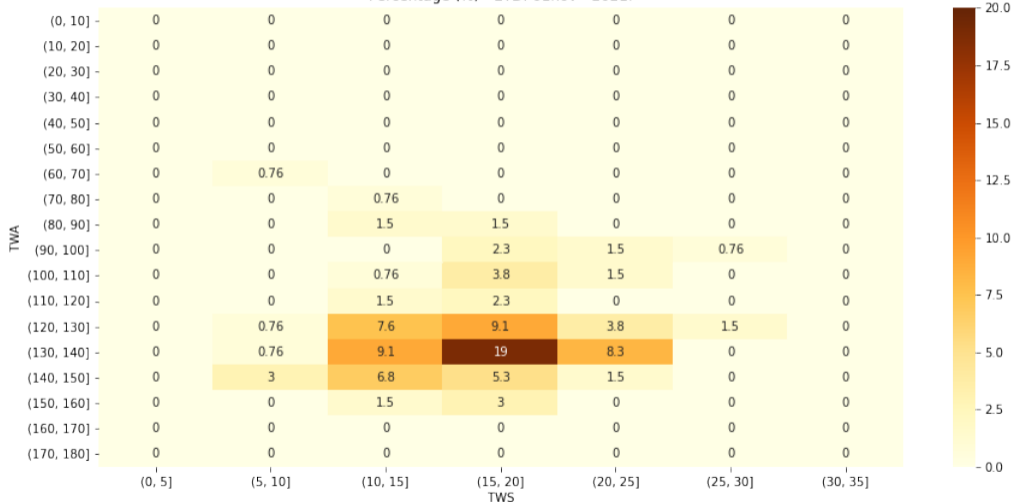
## Cross Table (TWS/TWA) - 2021

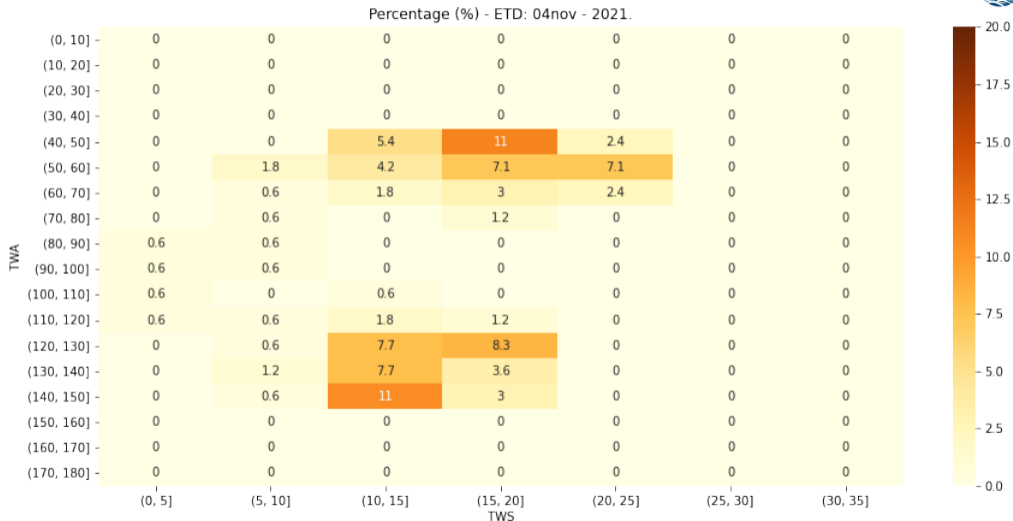


Percentage (%) - ETD: 01nov,04nov,08nov - 2021.

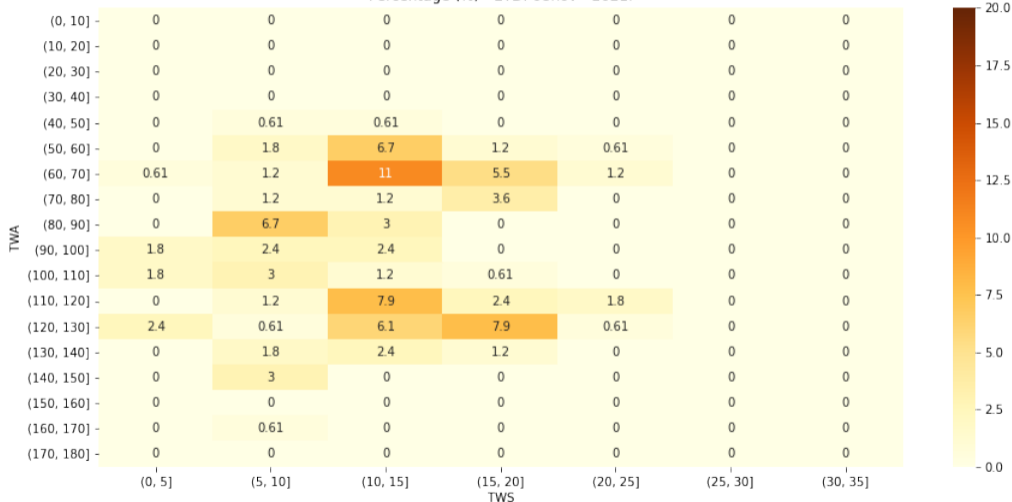


Percentage (%) - ETD: 01nov - 2021.



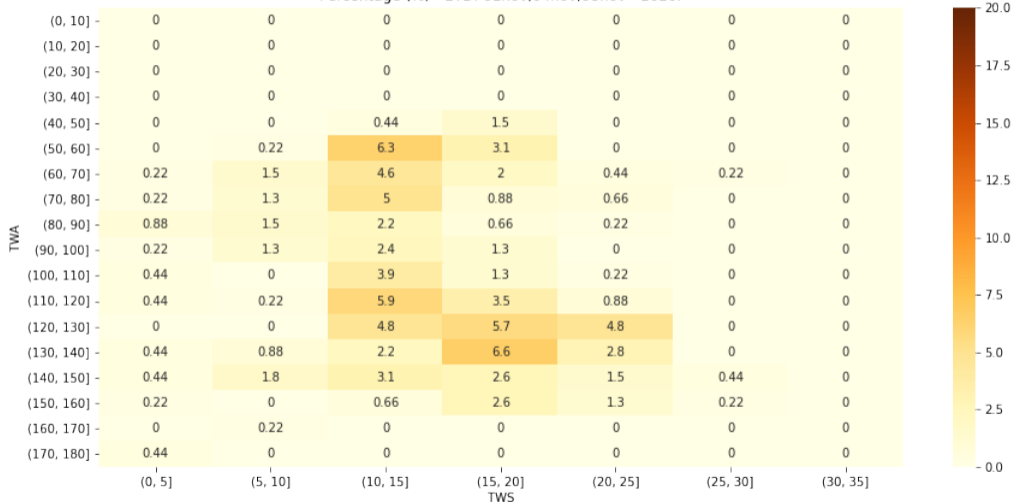


Percentage (%) - ETD: 08nov - 2021.

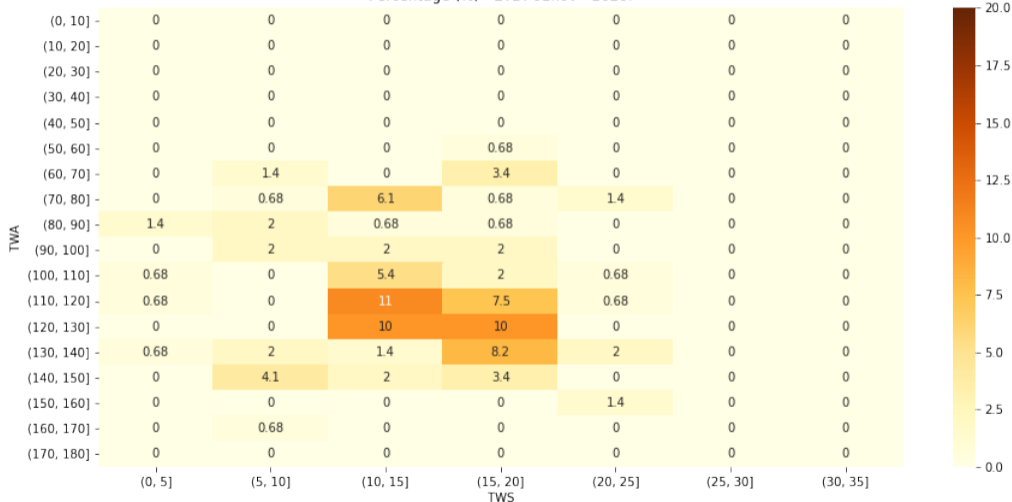


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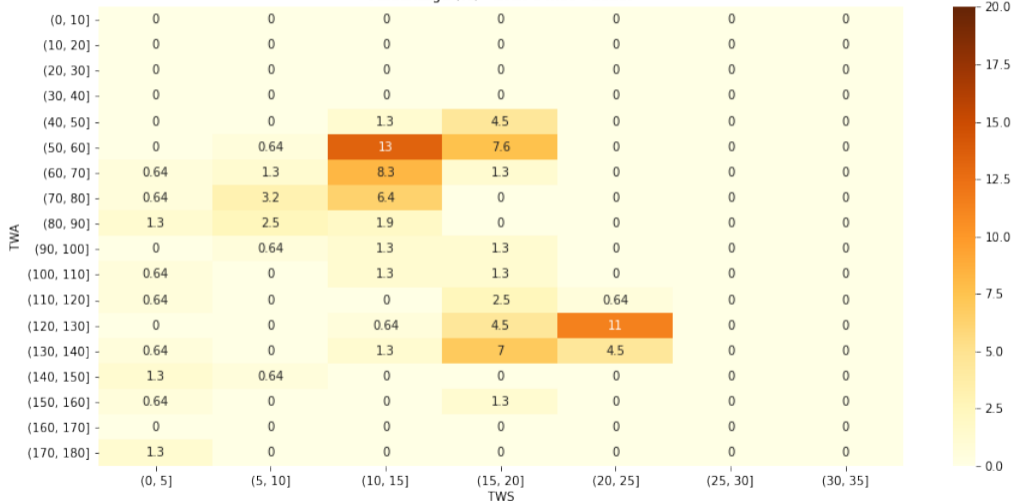
Percentage (%) - ETD: 01nov,04nov,08nov - 2020.



Percentage (%) - ETD: 01nov - 2020.

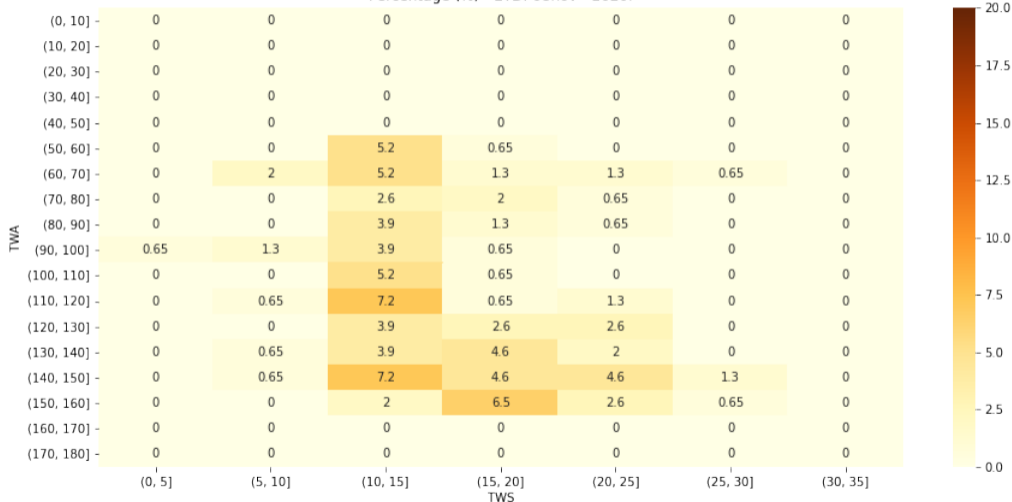


Percentage (%) - ETD: 04nov - 2020.



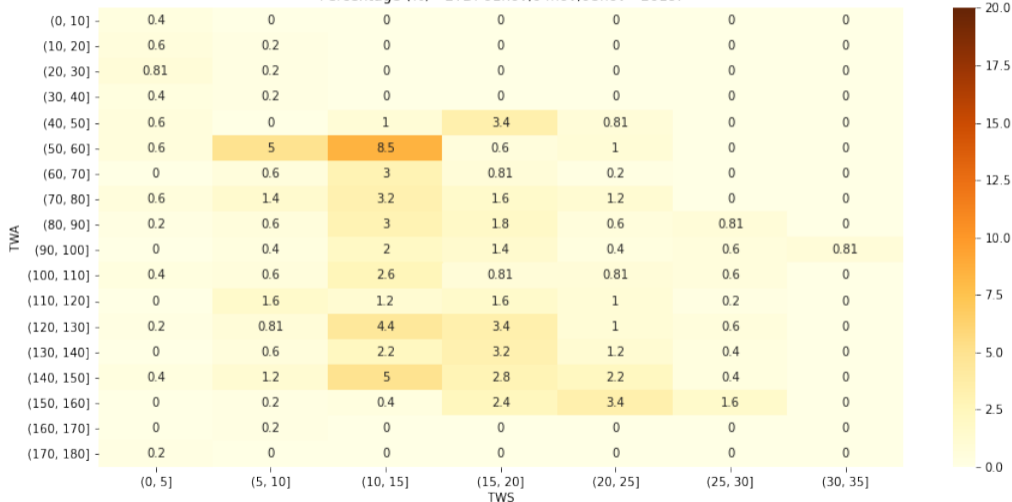


Percentage (%) - ETD: 08nov - 2020.

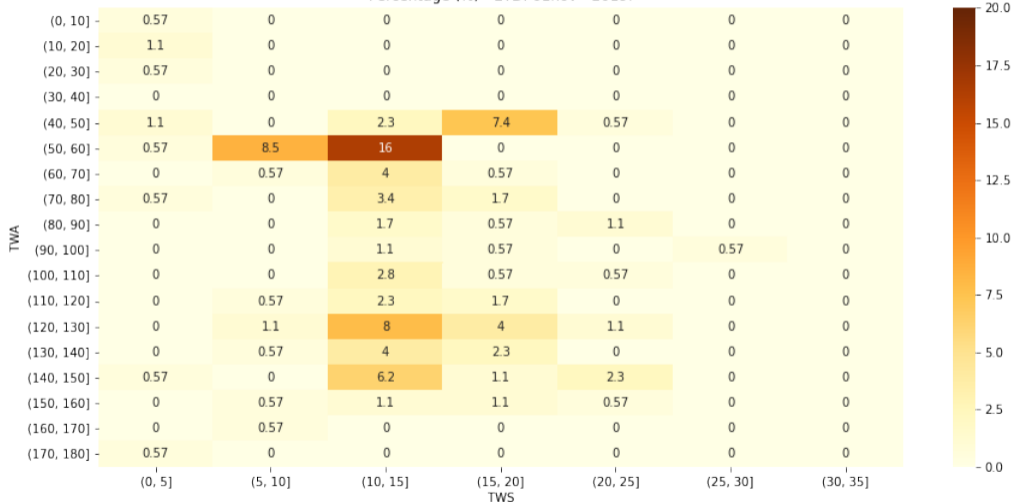


## Cross Table (TWS/TWA) - 2019

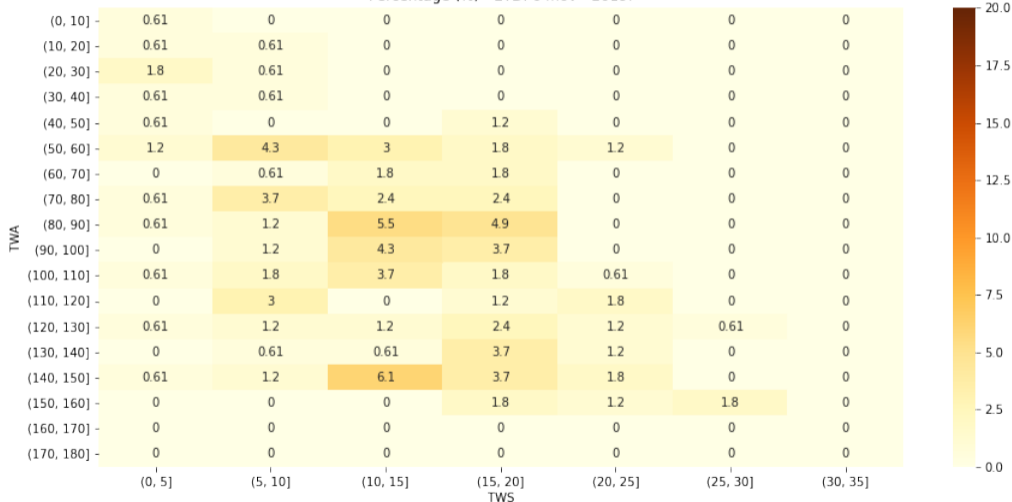
Percentage (%) - ETD: 01nov,04nov,08nov - 2019.



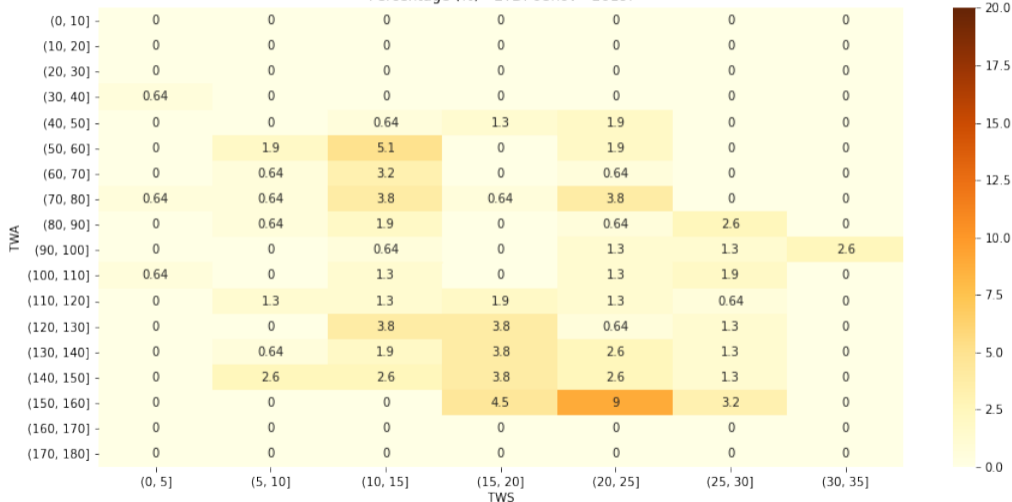
Percentage (%) - ETD: 01nov - 2019.



Percentage (%) - ETD: 04nov - 2019.

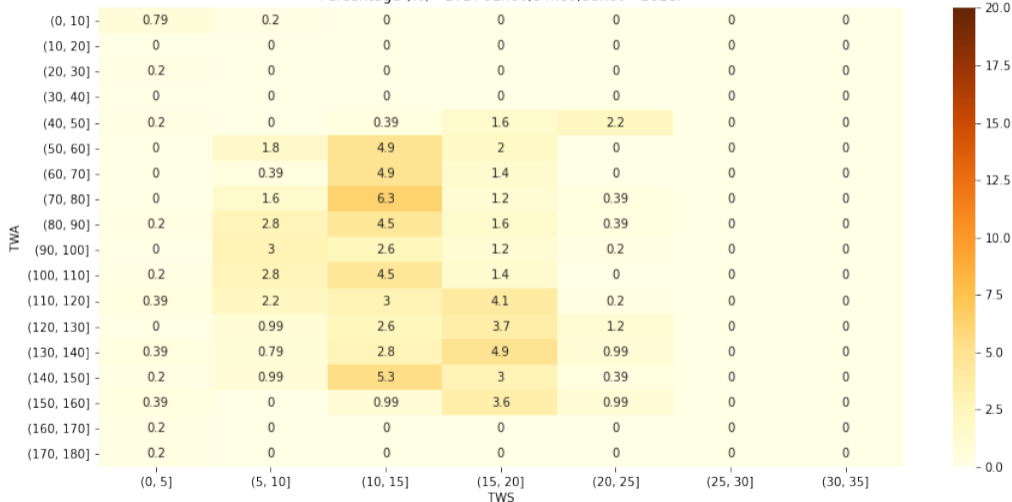


Percentage (%) - ETD: 08nov - 2019.



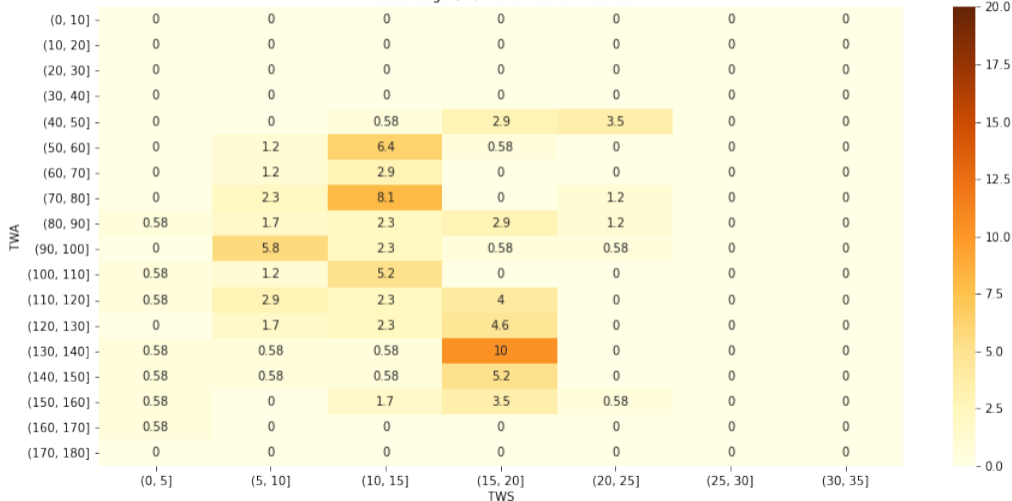
## Cross Table (TWS/TWA) - 2018

Percentage (%) - ETD: 01nov,04nov,08nov - 2018.

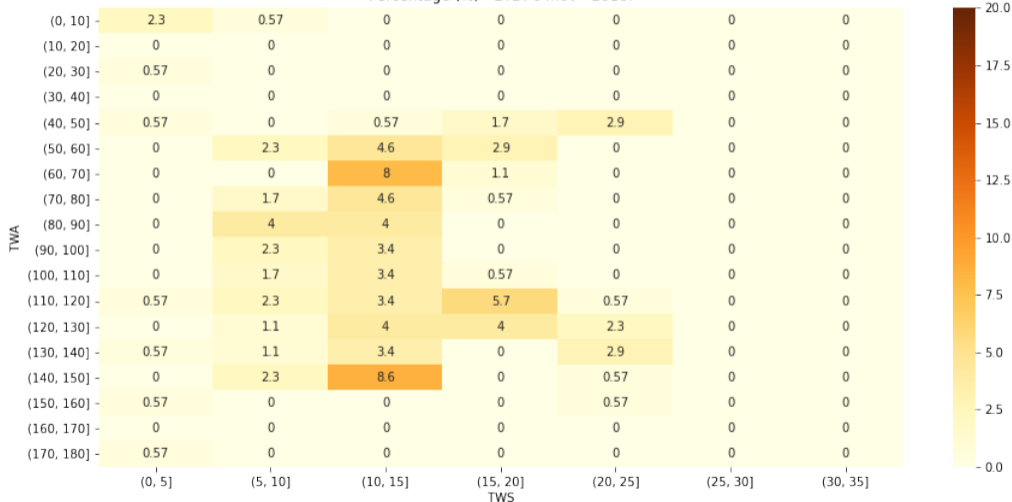




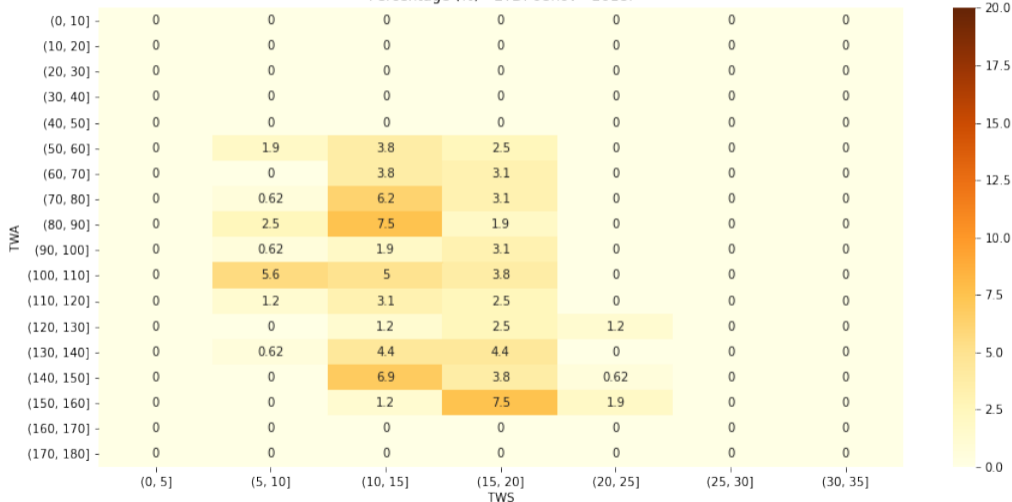
Percentage (%) - ETD: 01nov - 2018.



Percentage (%) - ETD: 04nov - 2018.

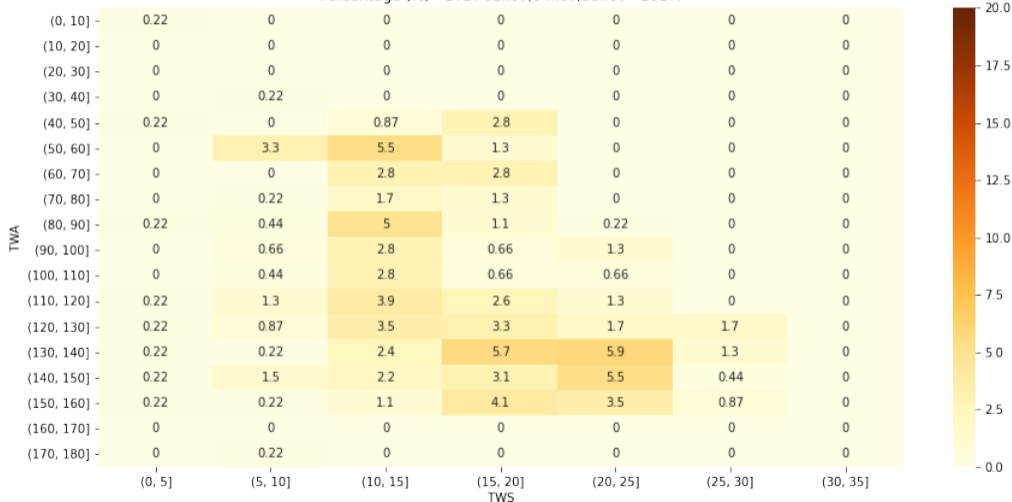


Percentage (%) - ETD: 08nov - 2018.

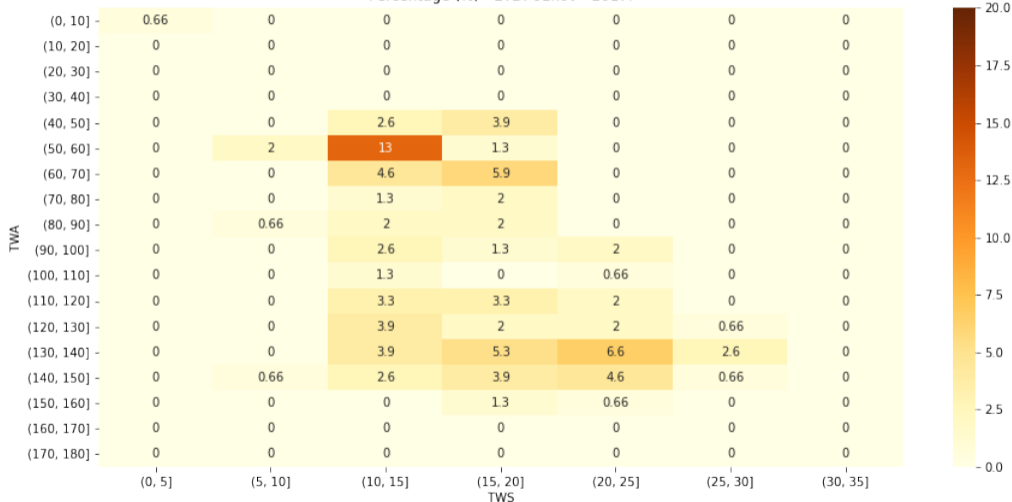


## Cross Table (TWS/TWA) - 2017

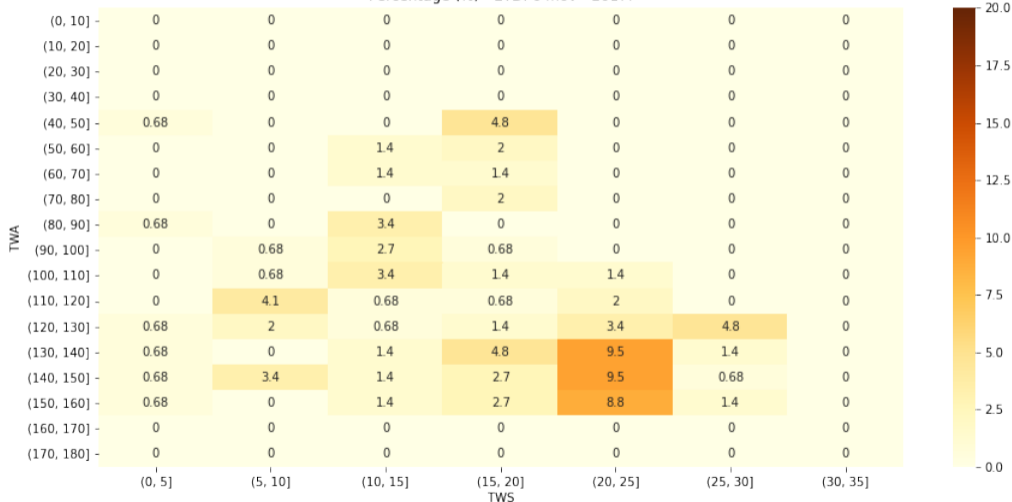
Percentage (%) - ETD: 01nov,04nov,08nov - 2017.



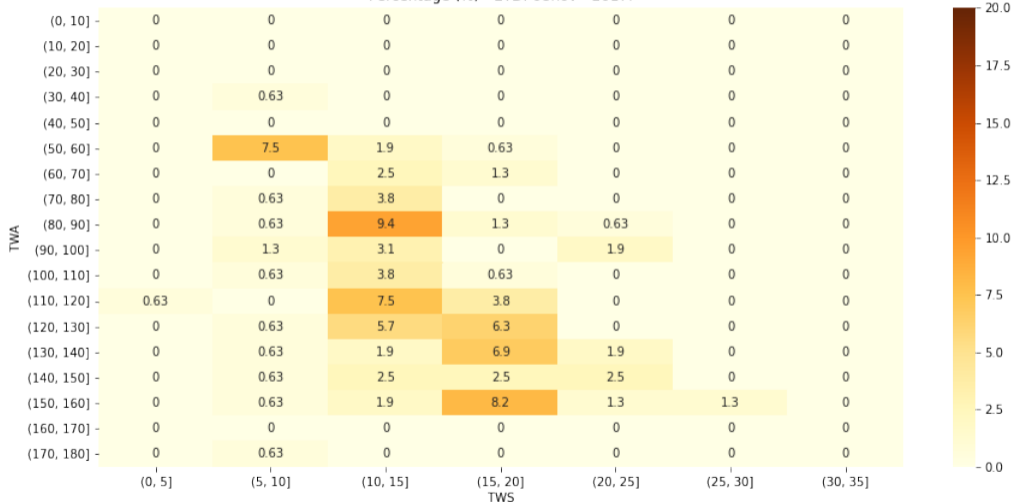
Percentage (%) - ETD: 01nov - 2017.



Percentage (%) - ETD: 04nov - 2017.



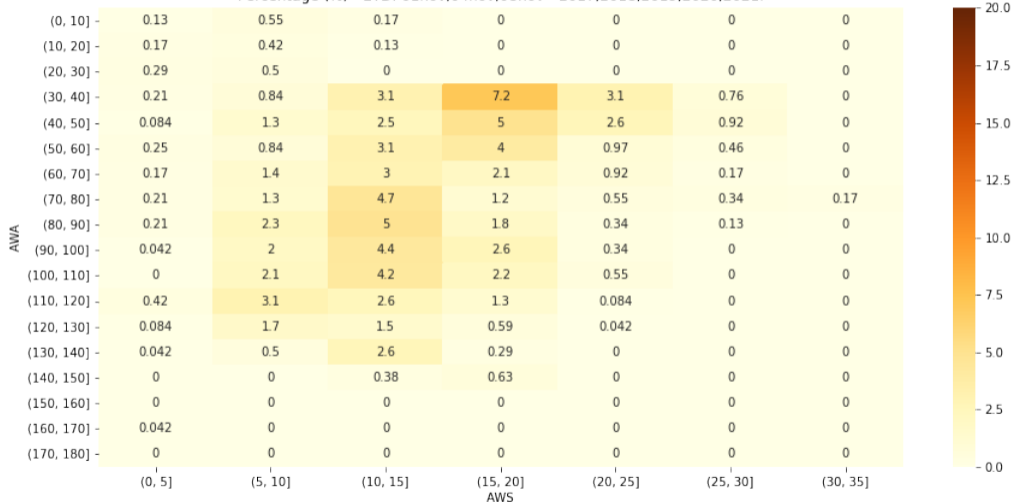
Percentage (%) - ETD: 08nov - 2017.





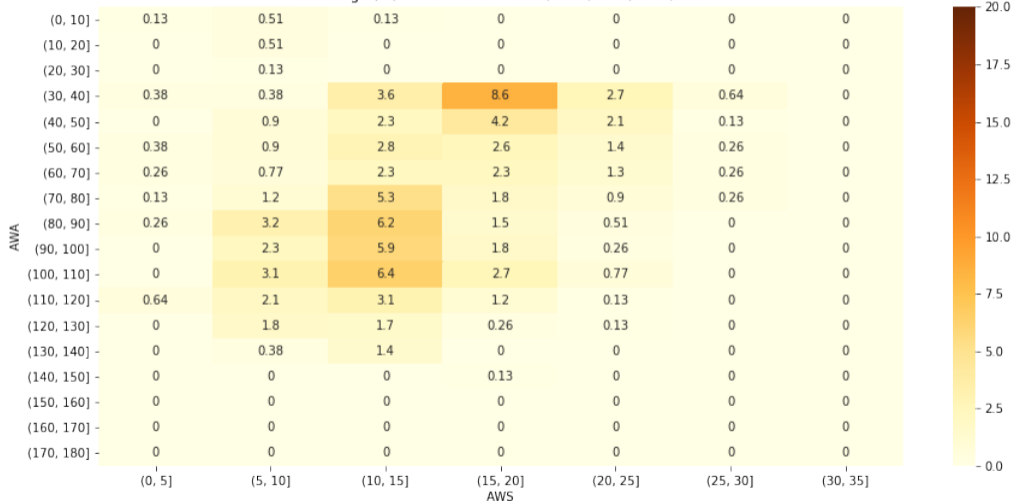
Cross Table (AWS/AWA) - Nov 01<sup>st</sup>, 04<sup>th</sup>  
and 08<sup>th</sup>.

Percentage (%) - ETD: 01nov,04nov,08nov - 2017,2018,2019,2020,2021.

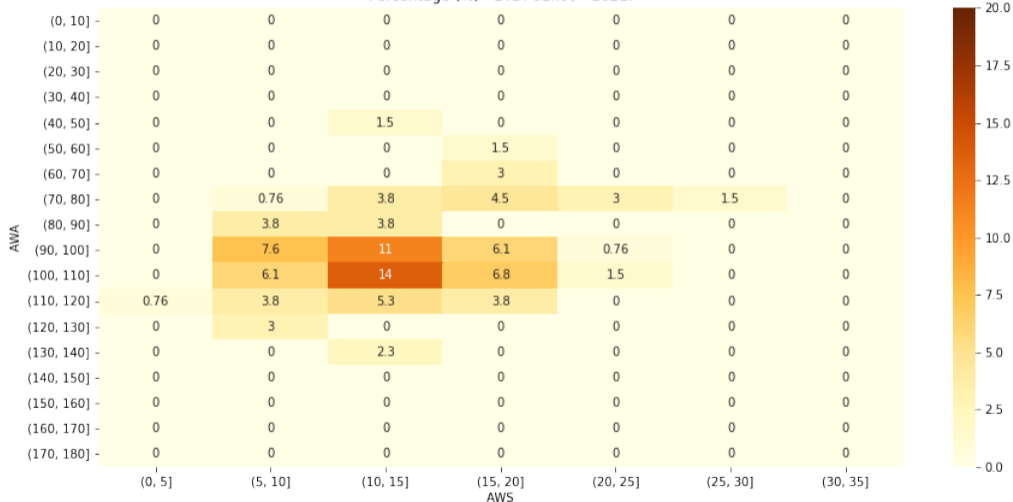


# Cross Table (AWS/AWA) - Nov 01<sup>st</sup>

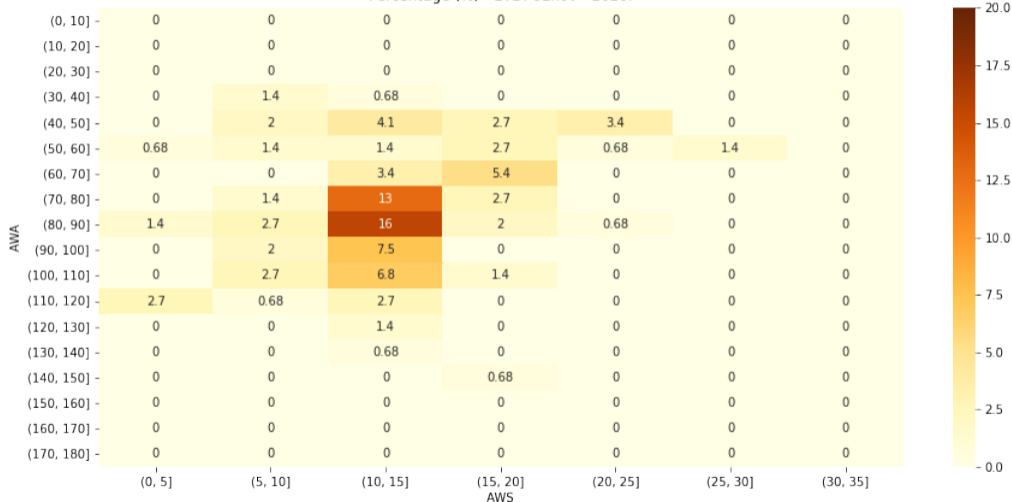
Percentage (%) - ETD: 01nov - 2021,2020,2019,2018,2017.

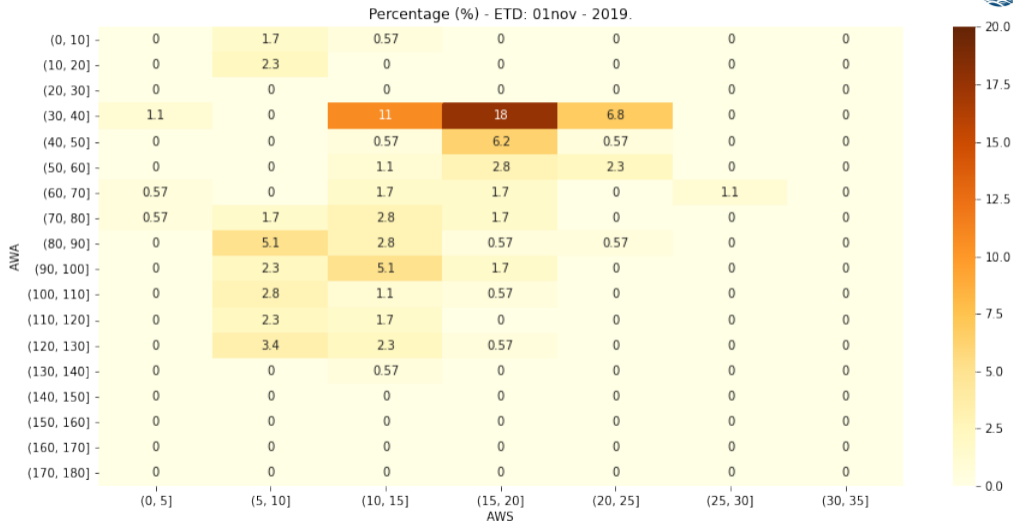


Percentage (%) - ETD: 01nov - 2021.

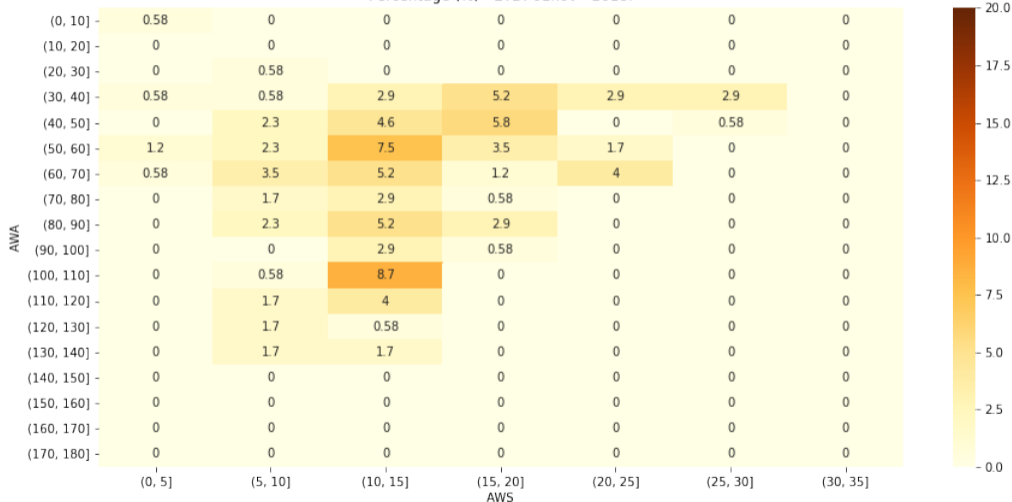


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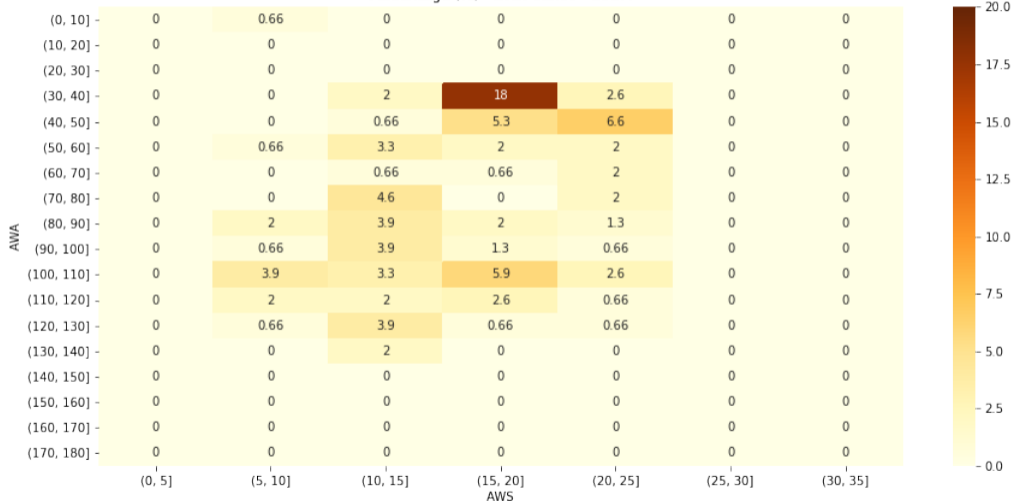


Percentage (%) - ETD: 01nov - 2018.

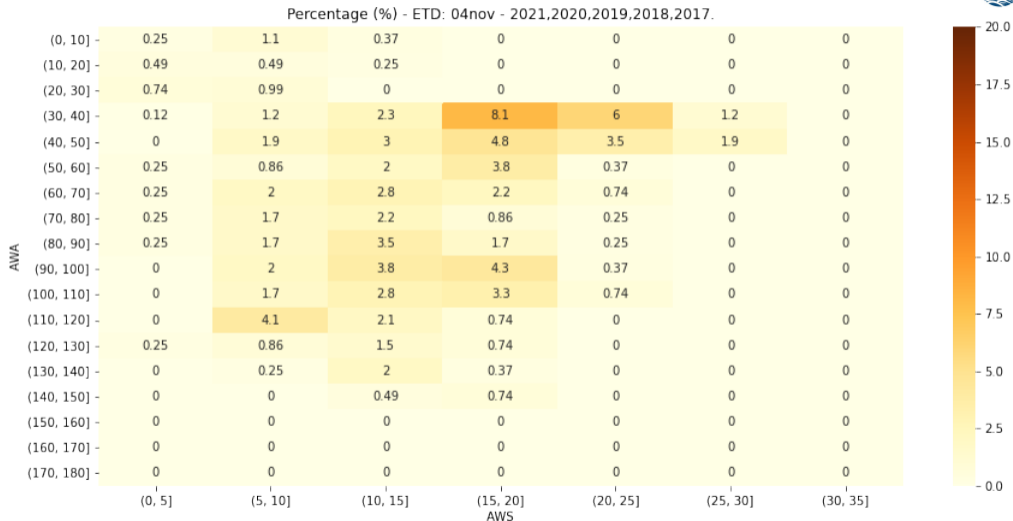




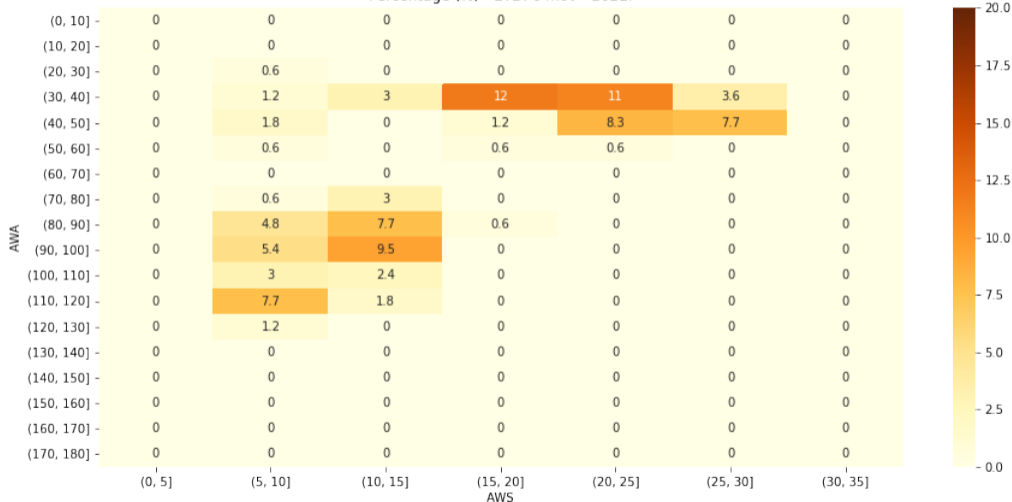
Percentage (%) - ETD: 01nov - 2017.



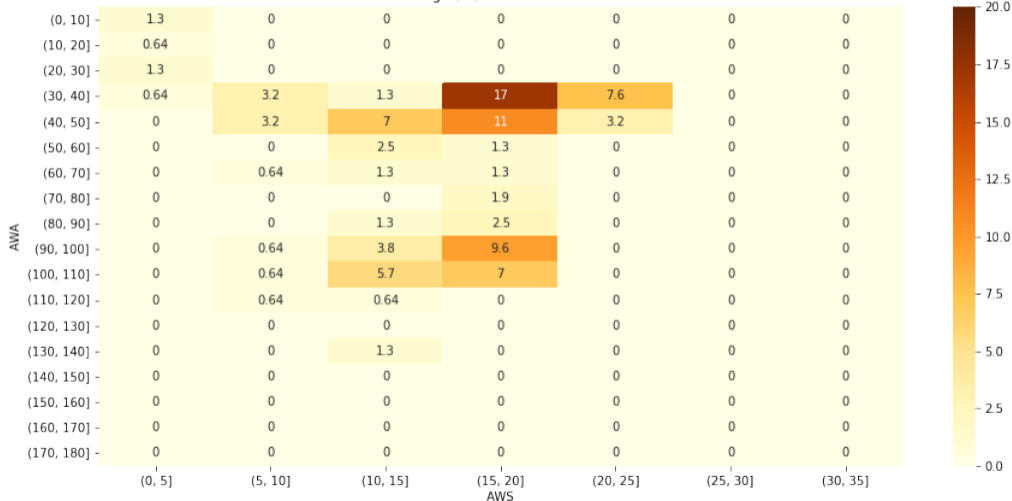
Cross Table (AWS/AWA) - Nov 04<sup>th</sup>

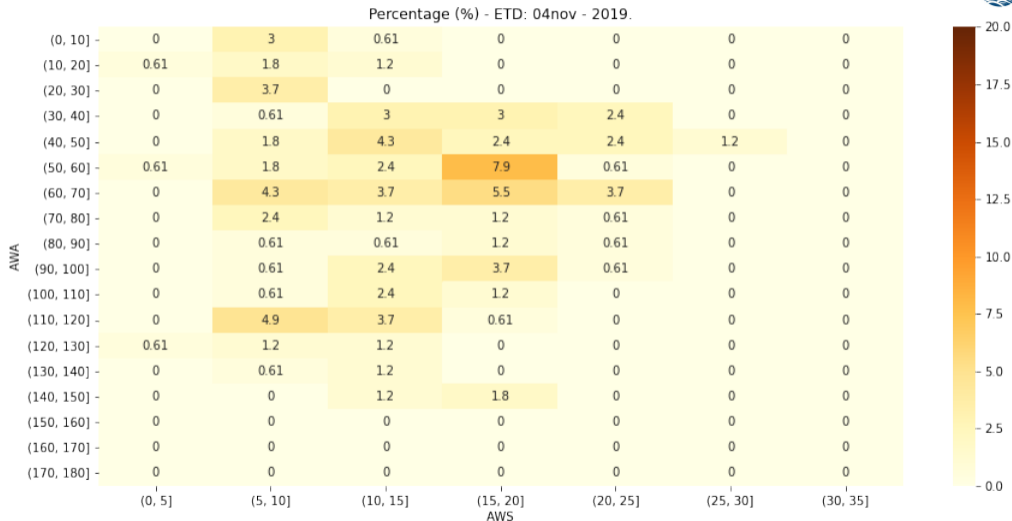


Percentage (%) - ETD: 04nov - 2021.

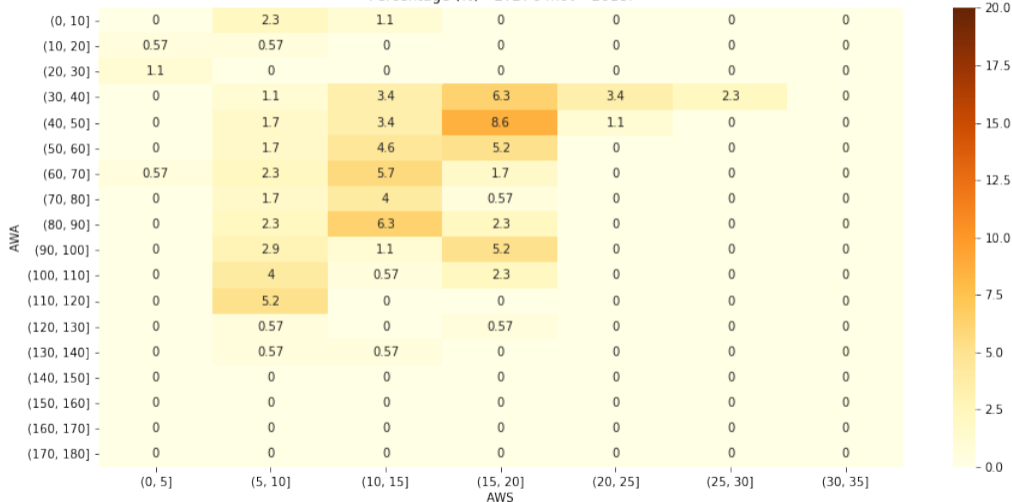


Percentage (%) - ETD: 04nov - 2020.

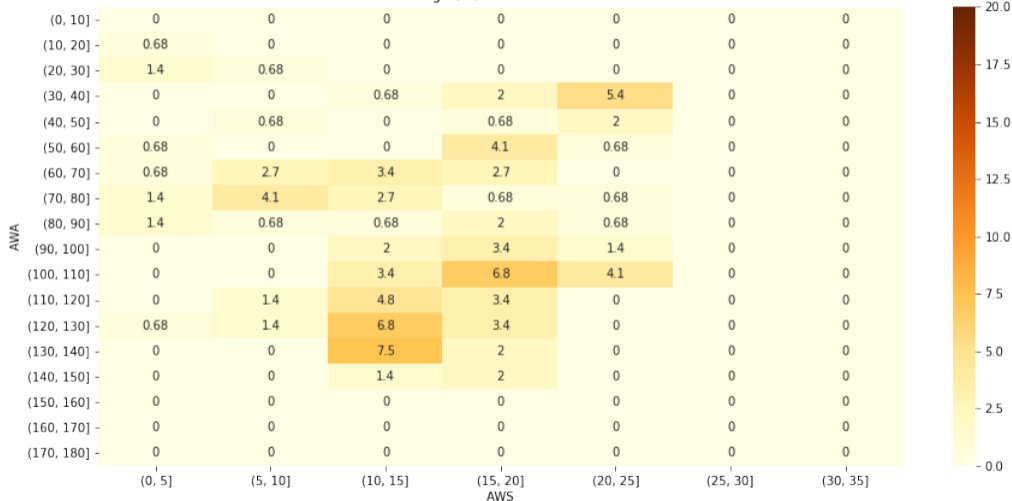




Percentage (%) - ETD: 04nov - 2018.



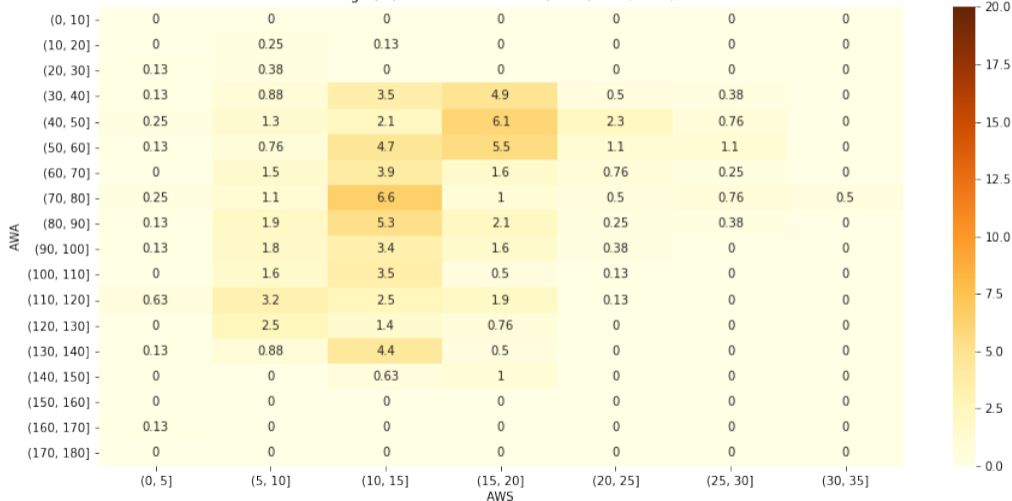
Percentage (%) - ETD: 04nov - 2017.



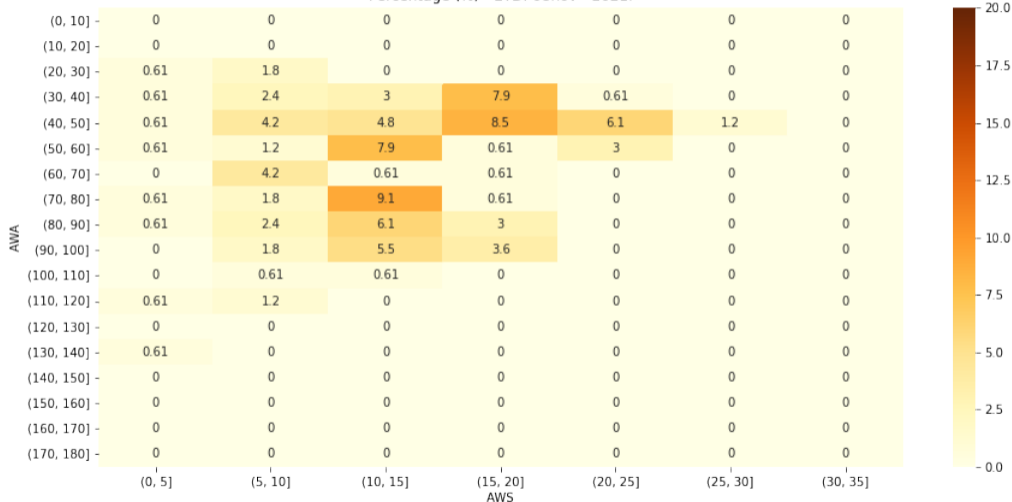


Cross Table (AWS/AWA) - Nov 08<sup>th</sup>

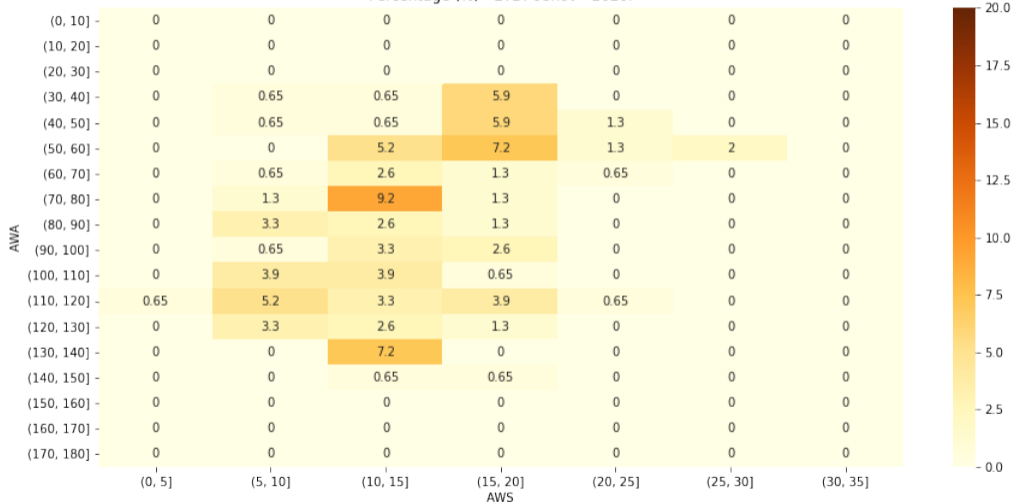
Percentage (%) - ETD: 08nov - 2021,2020,2019,2018,2017.

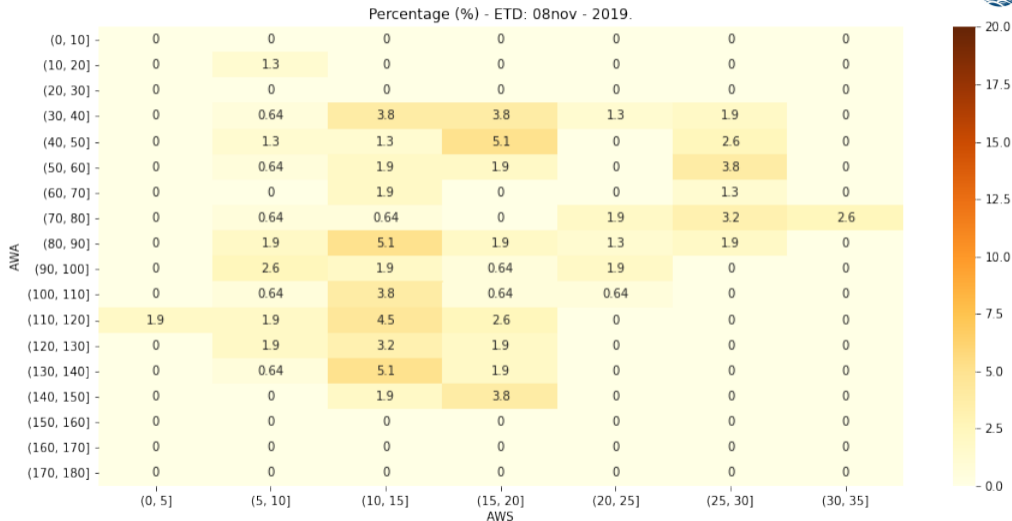


Percentage (%) - ETD: 08nov - 2021.

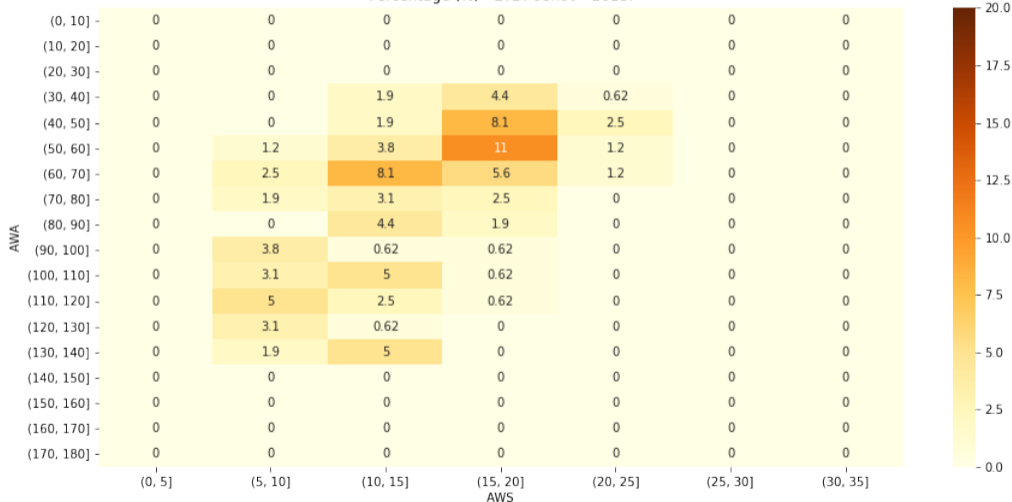


Percentage (%) - ETD: 08nov - 2020.

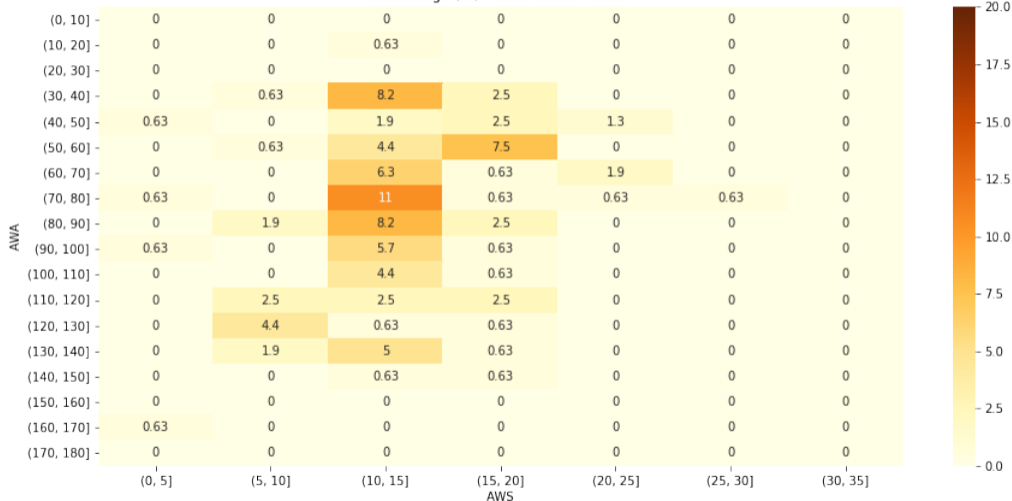




Percentage (%) - ETD: 08nov - 2018.



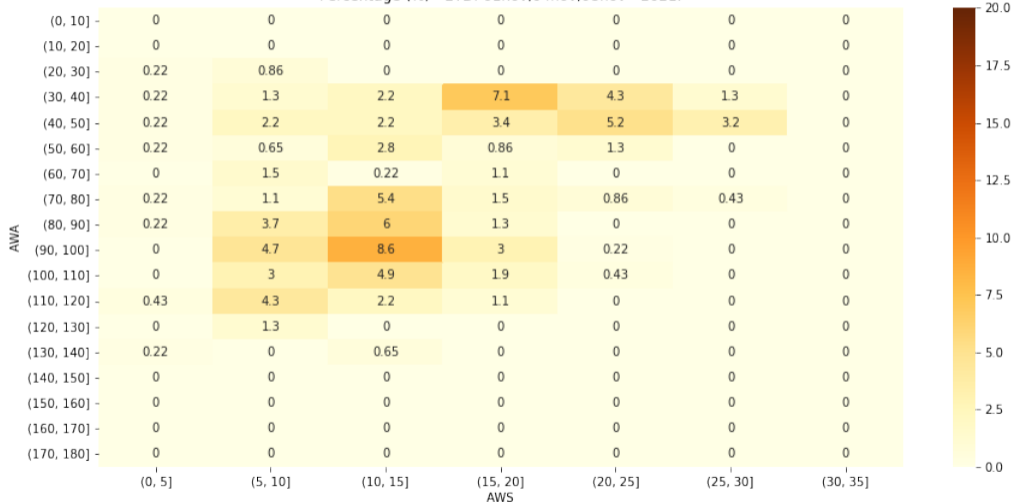
Percentage (%) - ETD: 08nov - 2017.



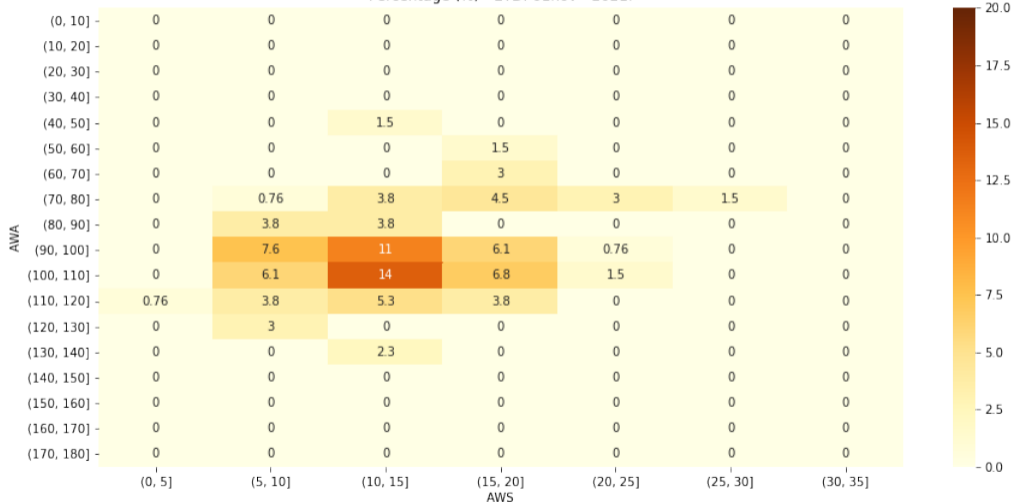
## Cross Table (AWS/AWA) - 2021



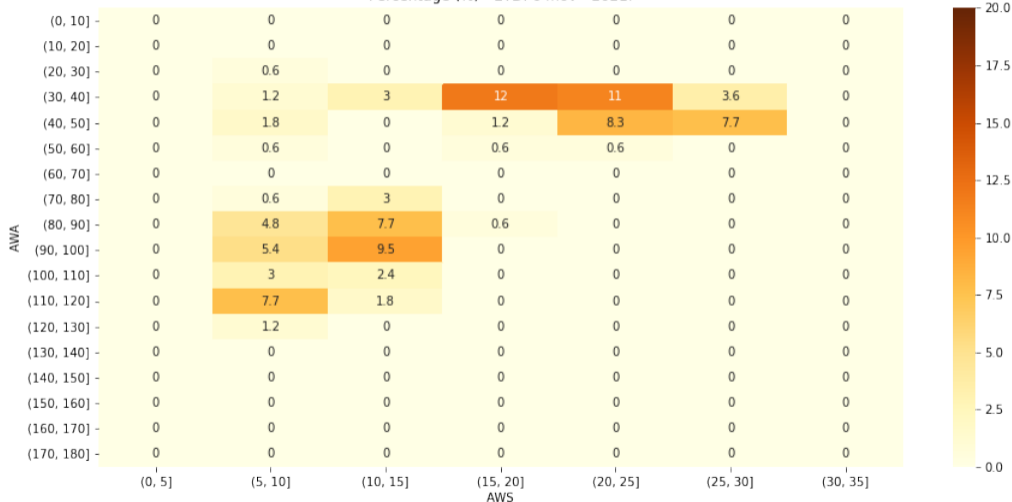
Percentage (%) - ETD: 01nov,04nov,08nov - 2021.

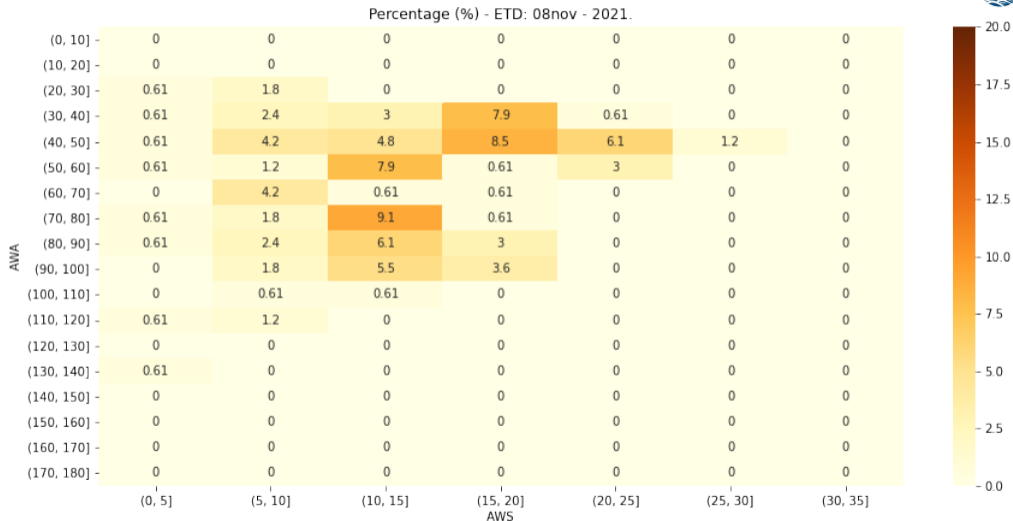


Percentage (%) - ETD: 01nov - 2021.



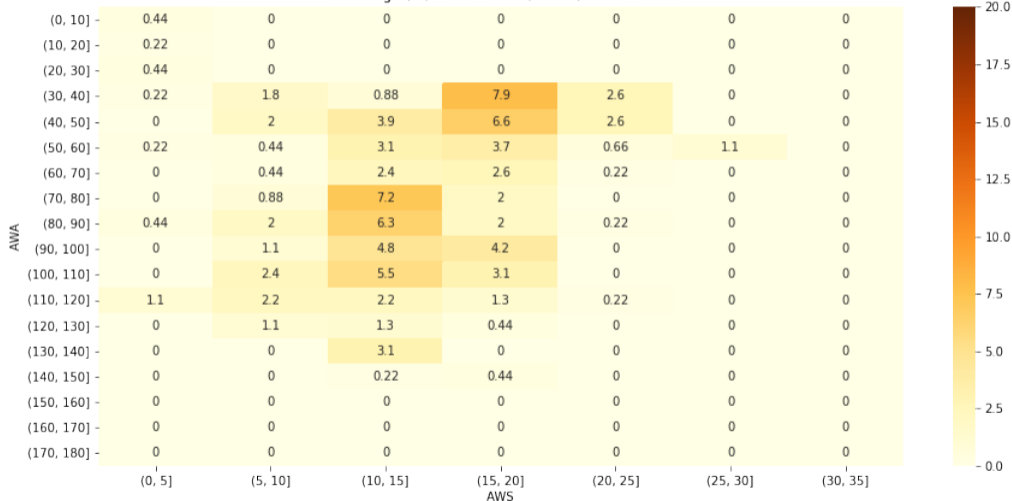
Percentage (%) - ETD: 04nov - 2021.



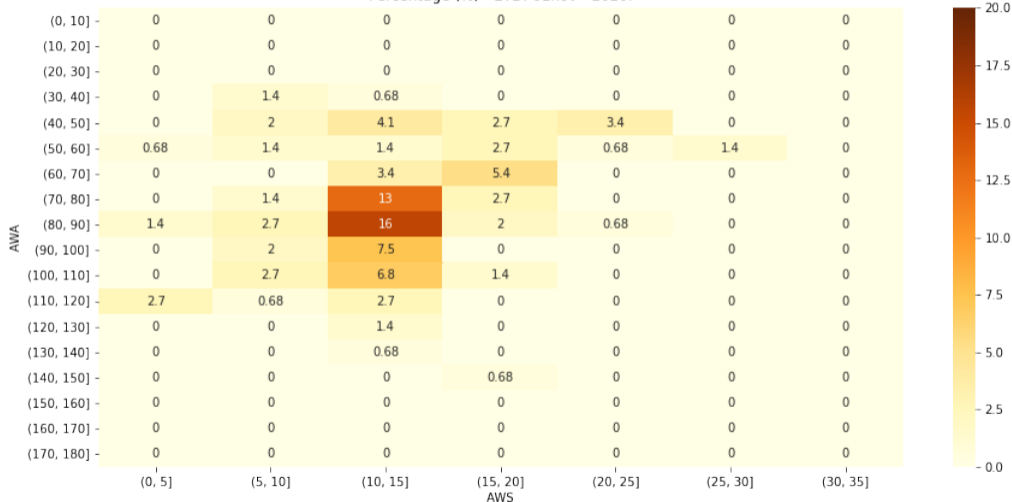


# Cross Table (AWS/AWA) - 2020

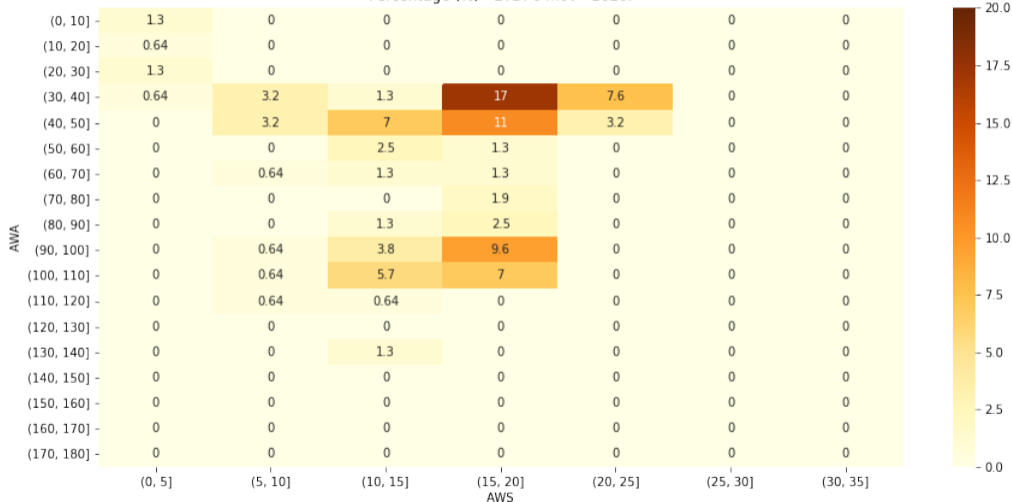
Percentage (%) - ETD: 01nov,04nov,08nov - 2020.



Percentage (%) - ETD: 01nov - 2020.

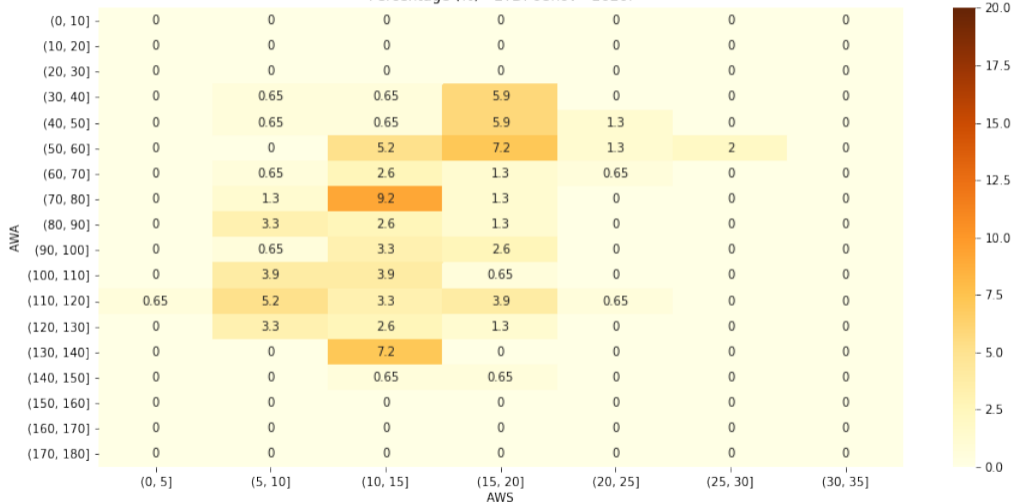


Percentage (%) - ETD: 04nov - 2020.



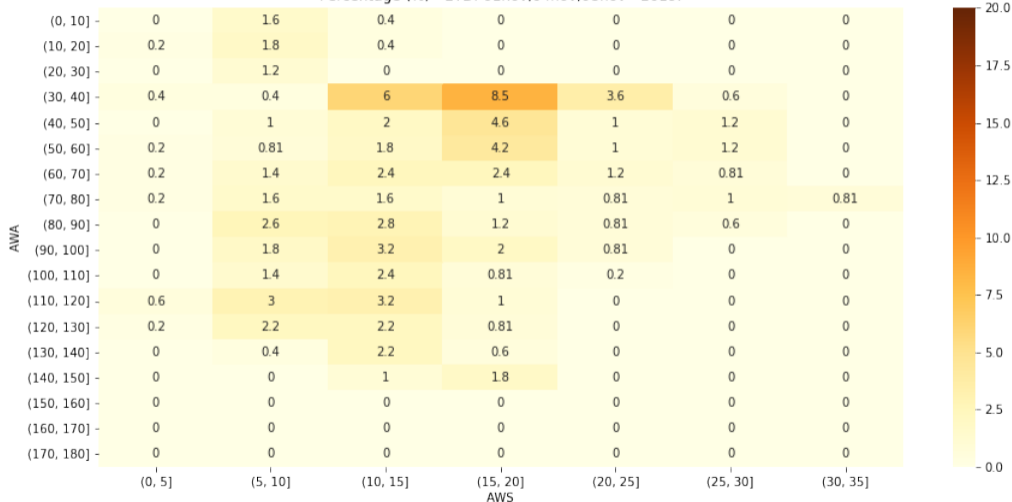


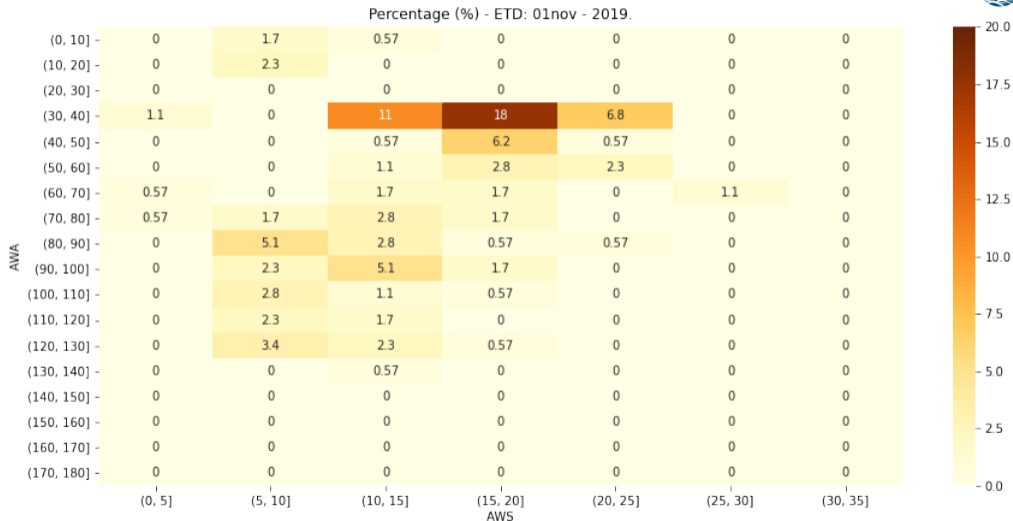
Percentage (%) - ETD: 08nov - 2020.

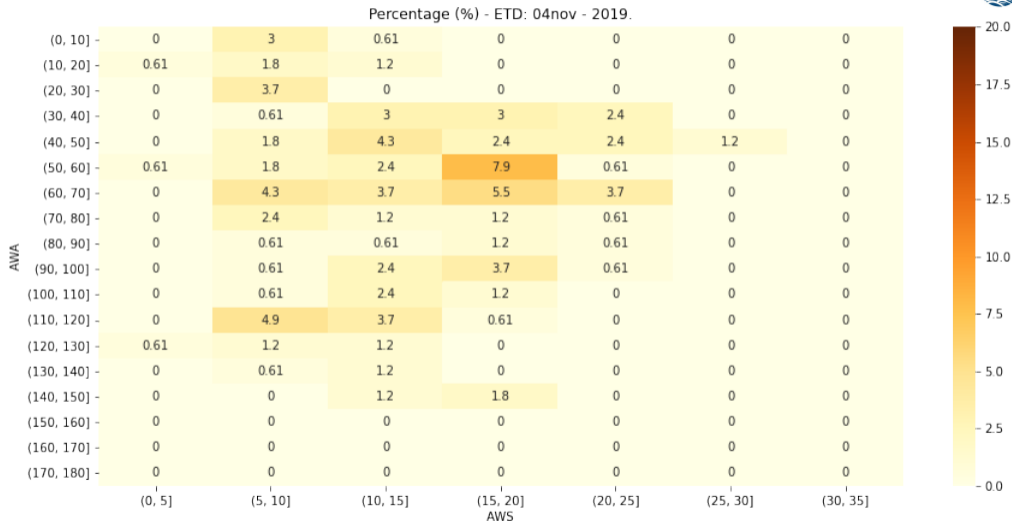


## Cross Table (AWS/AWA) - 2019

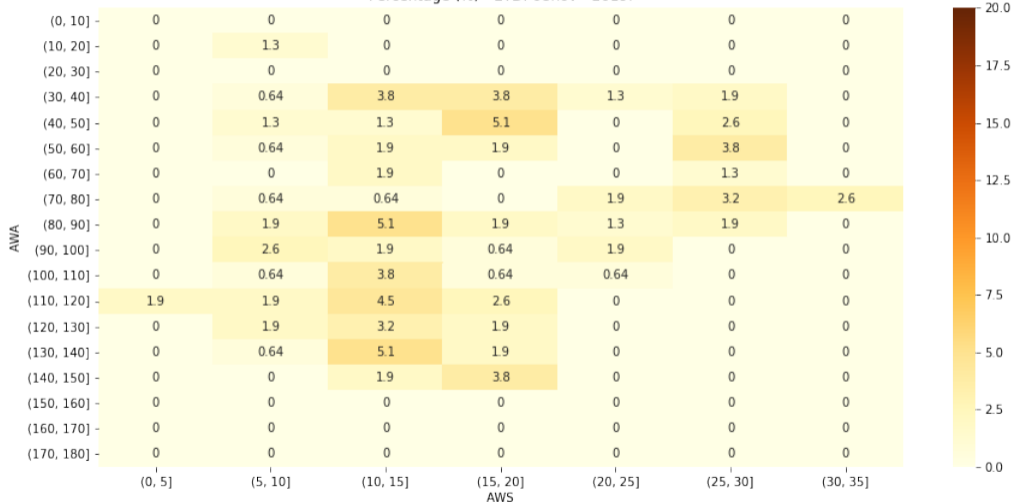
Percentage (%) - ETD: 01nov,04nov,08nov - 2019.





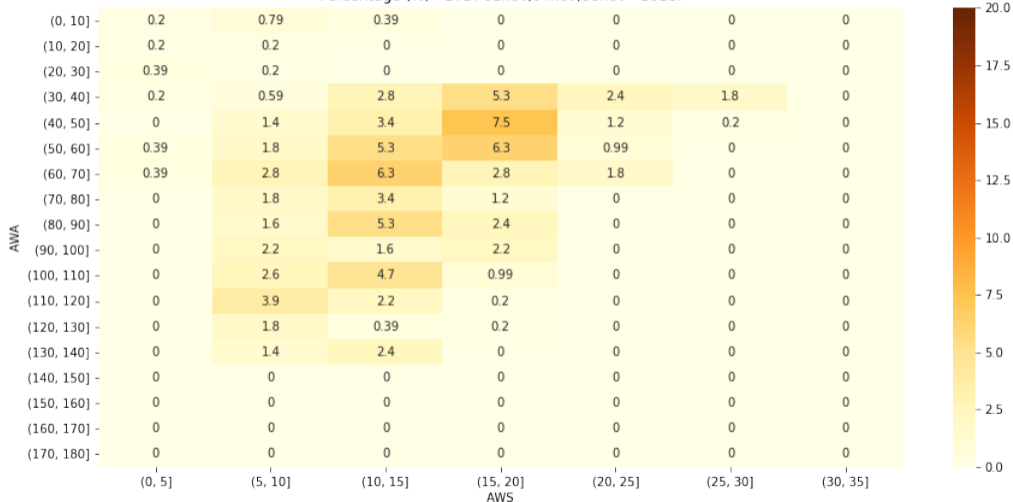


Percentage (%) - ETD: 08nov - 2019.



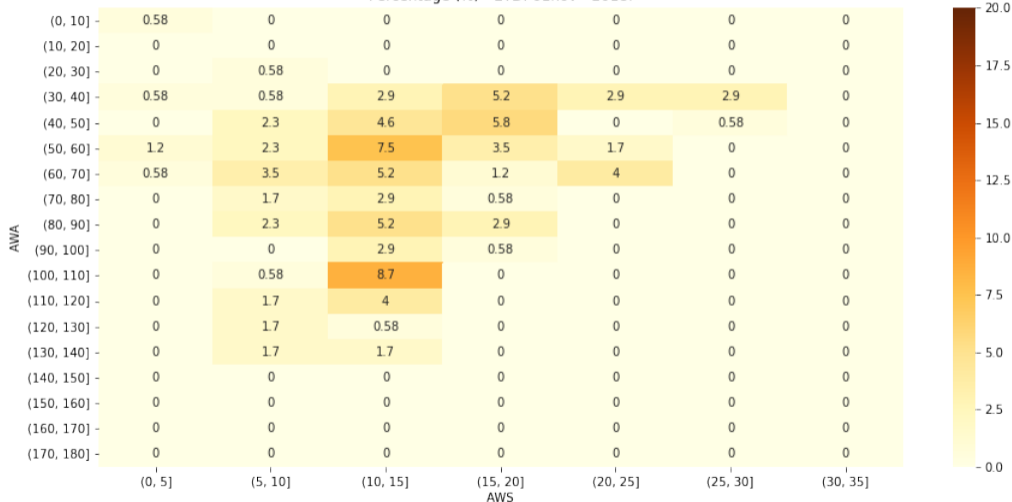
# Cross Table (AWS/AWA) - 2018

Percentage (%) - ETD: 01nov,04nov,08nov - 2018.

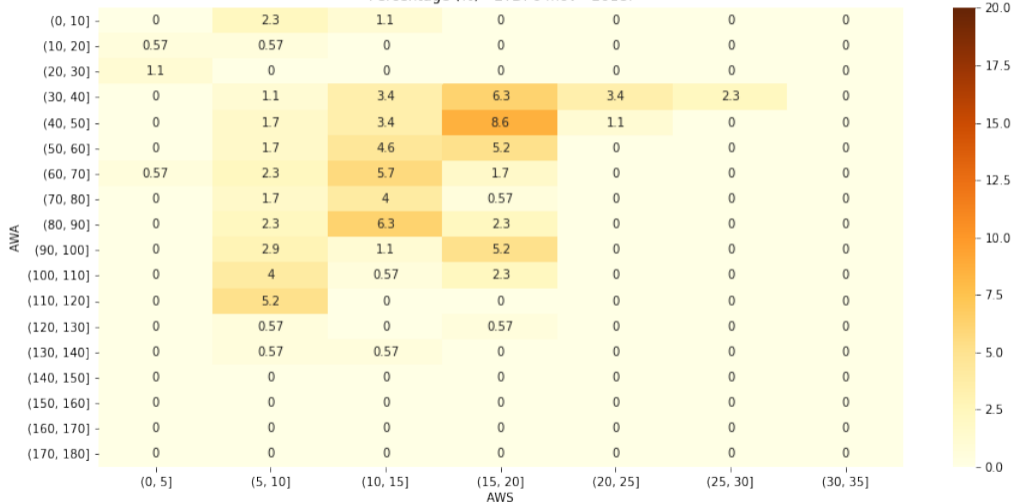




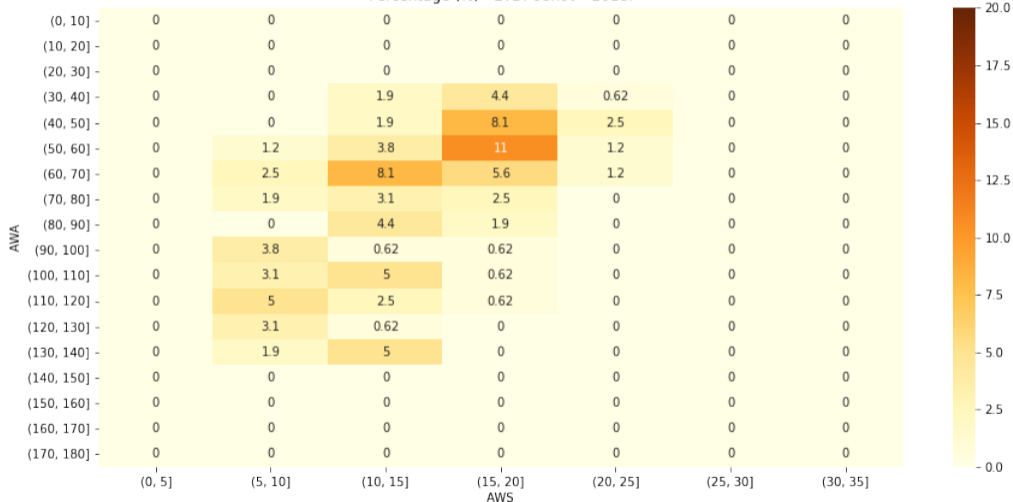
Percentage (%) - ETD: 01nov - 2018.



Percentage (%) - ETD: 04nov - 2018.

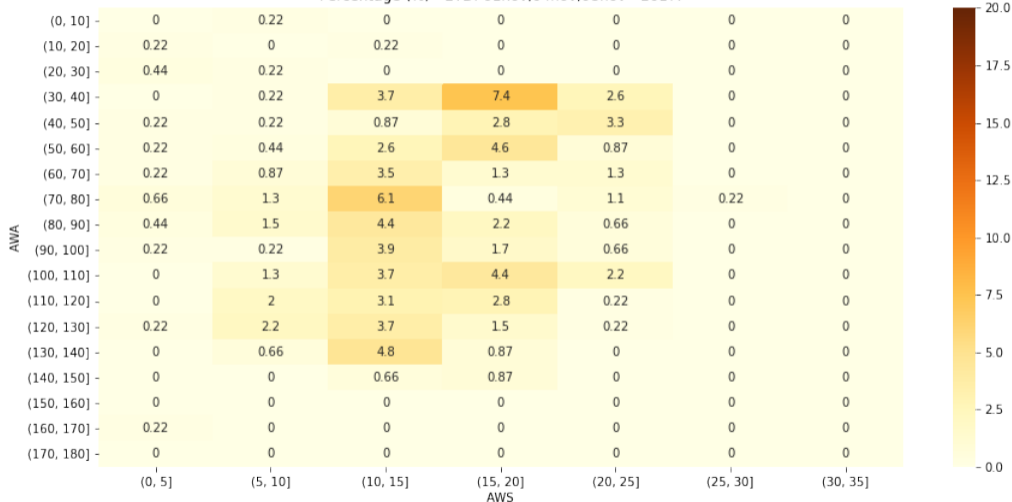


Percentage (%) - ETD: 08nov - 2018.

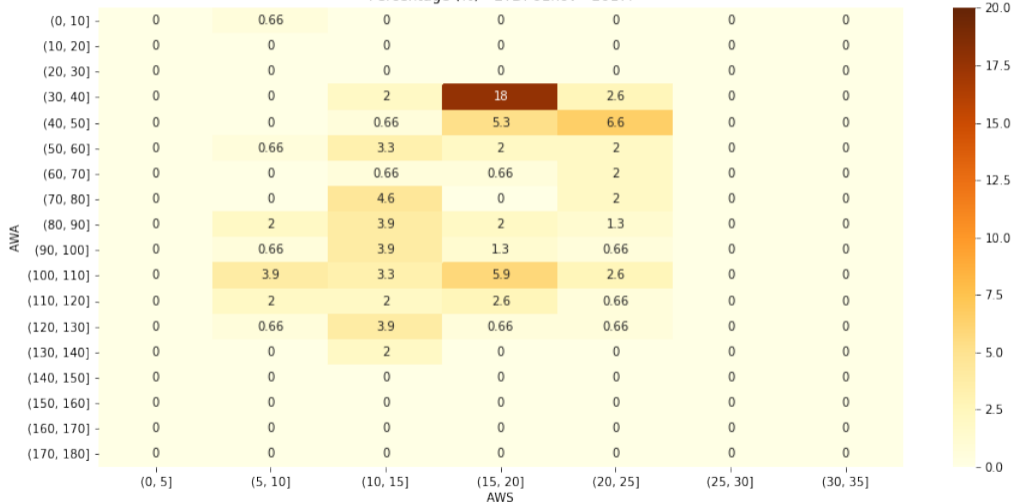


## Cross Table (AWS/AWA) - 2017

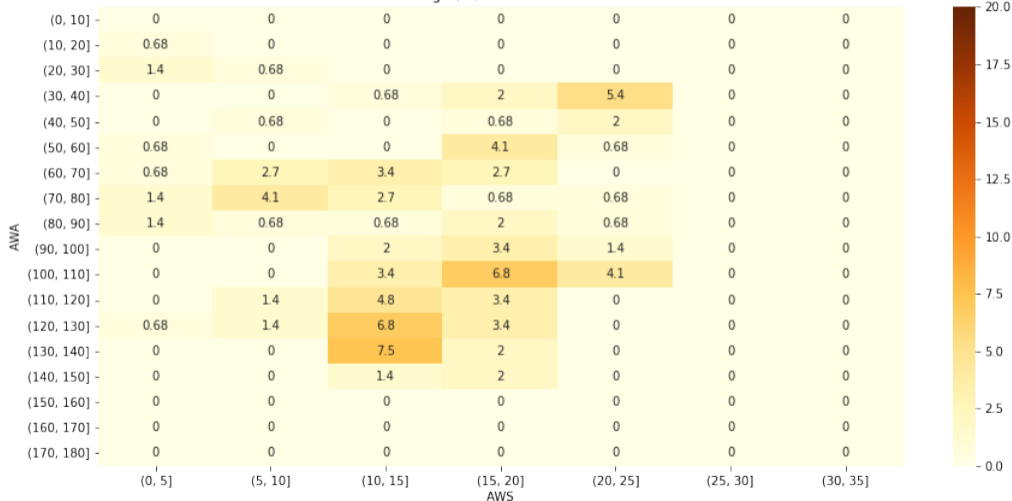
Percentage (%) - ETD: 01nov,04nov,08nov - 2017.



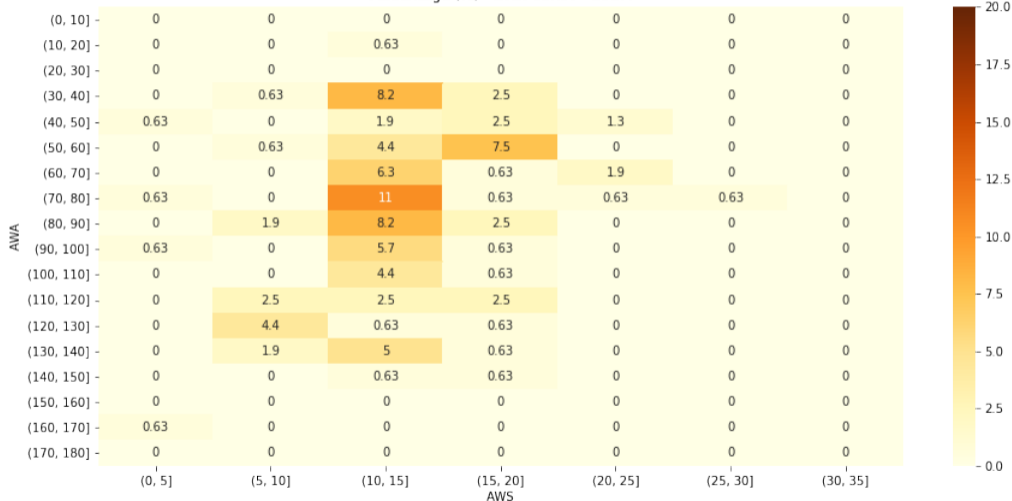
Percentage (%) - ETD: 01nov - 2017.



Percentage (%) - ETD: 04nov - 2017.

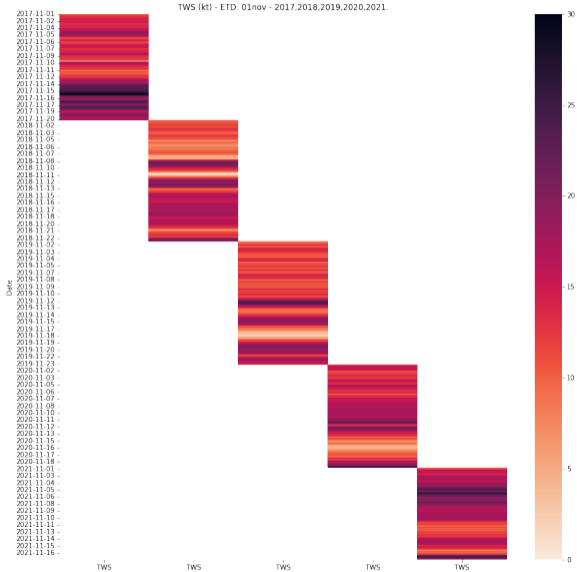


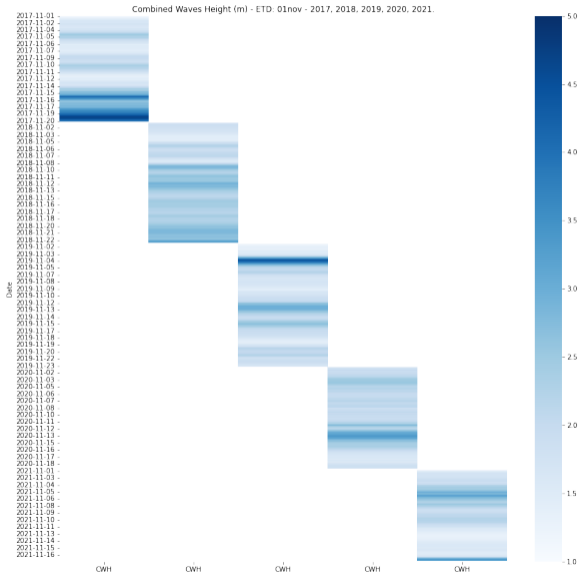
Percentage (%) - ETD: 08nov - 2017.

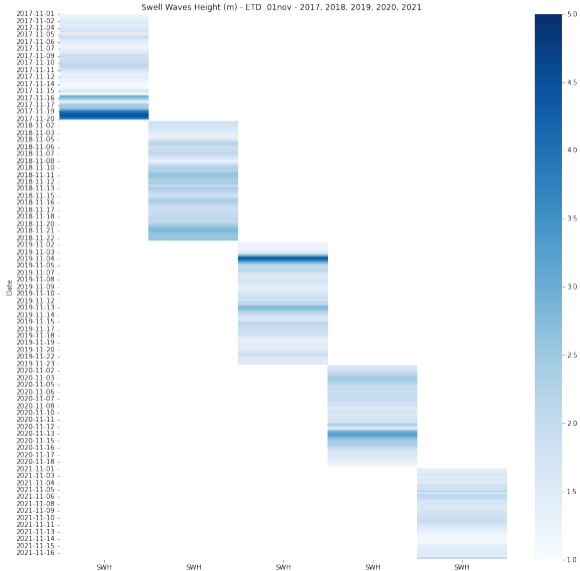


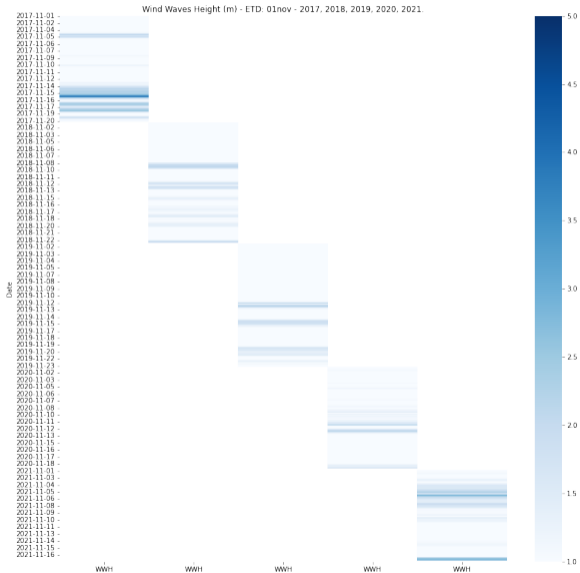


Heatmap - Nov 01<sup>st</sup>









The background consists of two large, overlapping geometric shapes. A teal-colored shape is in the upper-left corner, and a light gray shape is in the lower-left corner. The rest of the page is white.

Remarks

# Best Sails



All the simulated routes implies in significant number of sail changes. The 2021 simulation changed sail 54 times, the smallest number. In 2017, 64 sail changes, the higher number. The complete list of sail choices along the route can be found in the log book files by clicking *here*.

- ▶ In 2021 **Code 3** was the most used (42%) due to predominance of downwind (51%) force 5.
- ▶ **Screacher** was the most used in 2020 (41%) and 2018 (31%) due to predominance of reaching (61% and 43% respectively) force 4 or 5.
- ▶ **Genoa** was the most used in 2019 (30%) and 2017 (38%) due to predominance of beating (50% and 38% respectively) force 4;

# Atmospheric Conditions



- ▶ Marked variability of atmospheric/sea conditions between years.
- ▶ Marked variability of conditions between different departure days in the same year.
- ▶ The passage duration varies from 16 (2021) to 22 days (2019).
- ▶ Prevailing wind force 4 and 5.
- ▶ Prevailing reaching and downwind sailing.
- ▶ Wind direction tends to shift counterclockwise as atmospheric synoptic systems pass through (for example, cold fronts and extra-tropical cyclones).



- ▶ It seems to be a number of 1 to 3 atmospheric systems passing through during the passage.
- ▶ La Niña was present in the last two years in which general conditions seemed to be more favourable.
- ▶ The synoptic scale transient weather systems (fronts and cyclones) seems to have important contribution.
- ▶ The choice of departure day and pathway can be more determinant than the presence or not of La Niña or El Niño.

# Sea Conditions



The mean waves directions tends to predominate from E or NE at the initial part and changes to SW from the middle to the end of the passage. Mostly due to swell direction contribution. Wind waves, as expected, follow the wind directions. When combined waves heights are higher, they tend to be at the same direction as wind waves. That occurs mostly when wind speed is above 20 kt.

- ▶ Maximum Combined Significant Wave Height varies from 3 to 5 m.
- ▶ Maximum Wind Waves Height from 2 to 4m.
- ▶ Maximum Swell Waves Height from 2 to 5m.

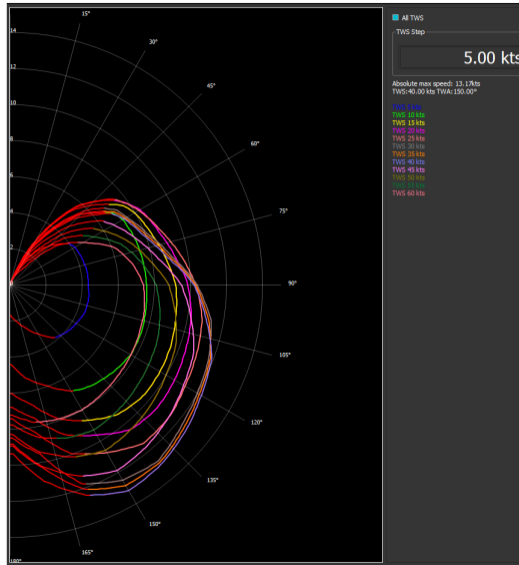
# Appendix A



## Boat Performance Table (Polar Data)

TWA/TWS	0.0	5.0	8.0	10.0	12.0	15.0	20.0	24.0	30.0	40.0	60.0
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.0	0.00	3.00	4.50	5.50	6.40	6.40	6.70	6.80	5.50	5.00	1.50
45.0	0.00	3.60	5.30	6.50	7.20	7.30	7.70	7.80	6.80	6.20	2.80
50.0	0.00	4.15	6.00	7.30	8.00	8.20	8.60	8.90	7.80	7.10	4.00
55.0	0.00	4.70	6.80	8.20	8.90	9.00	9.30	9.40	8.50	8.10	4.80
60.0	0.00	4.90	7.10	8.50	9.10	9.40	9.80	9.90	8.80	8.60	5.50
70.0	0.00	5.00	7.20	8.70	9.30	9.80	10.30	10.60	9.60	9.30	7.20
80.0	0.00	5.10	7.30	8.80	9.50	10.30	10.90	11.40	10.70	10.40	8.10
90.0	0.00	5.10	7.40	8.90	9.80	10.80	11.60	12.10	12.20	12.00	8.70
100.0	0.00	5.20	7.50	9.00	10.00	11.00	12.00	12.60	13.30	13.00	8.90
110.0	0.00	5.20	7.40	9.10	10.20	11.20	12.20	12.80	13.80	14.00	9.00
120.0	0.00	5.00	7.10	9.10	10.40	11.30	12.40	13.00	14.10	14.40	9.10
130.0	0.00	4.80	6.80	8.80	10.00	11.30	12.50	13.30	14.50	14.90	9.20
140.0	0.00	4.50	6.20	8.50	9.40	11.00	12.30	13.20	15.00	15.30	9.30
150.0	0.00	3.70	5.70	8.00	8.90	10.20	11.30	12.20	14.70	15.50	9.40
160.0	0.00	3.00	4.90	7.00	7.90	9.30	10.40	11.30	13.80	14.60	9.30
170.0	0.00	2.40	4.30	6.20	7.00	7.90	8.80	9.50	11.20	13.00	9.10
179.0	0.00	2.00	3.70	5.20	6.00	7.10	8.00	8.50	10.00	11.00	8.50
180.0	0.00	2.00	3.70	5.20	6.00	7.10	8.00	8.50	10.00	11.00	8.50

# Boat Performance Diagram (Polar Diagram)



# Appendix B



## Waves Polar

TWS=5	0	1	2	5	10
0	100	95	90	80	50
45	100	97	95	90	70
90	100	100	98	95	90
135	100	101	102	103	105
180	100	102	103	105	108
TWS=10	0	1	2	5	10
0	100	97	95	90	60
45	100	98	97	93	77
90	100	100	100	97	93
135	100	102	103	105	110
180	100	103	105	110	115
TWS=20	0	1	2	5	10
0	100	95	90	85	70
45	100	99	98	95	84
90	100	100	100	98	96
135	100	102	104	106	112
180	100	104	107	115	118
TWS=30	0	1	2	5	10
0	100	98	95	90	80
45	100	100	99	96	90
90	100	100	100	99	97
135	100	103	105	108	115
180	100	105	108	115	120

# Appendix C



Sails definition and sails selection criteria.

	TWA/TWS	5	8	10	12	15	18	20	22	24	30	40
	45	3	3	2	2	2	1	1	1	1	8	8
	50	3	3	2	2	2	1	1	1	1	8	8
	55	3	3	2	2	2	1	1	1	1	8	8
	60	3	3	2	2	2	1	1	1	1	8	8
	70	3	3	4	4	2	2	1	1	1	8	8
	80	4	4	4	4	2	2	1	1	1	8	8
	90	4	4	4	4	4	4	2	1	1	8	8
	100	5	4	4	4	4	4	2	2	1	1	8
	110	5	5	5	4	4	4	4	2	2	1	8
	120	7	5	5	5	5	5	4	2	2	1	8
	130	7	7	7	7	5	5	5	4	4	2	8
	140	7	7	7	7	7	7	6	5	4	2	8
	150	7	7	7	7	7	7	6	6	5	2	8
	160	7	7	7	7	7	7	6	6	6	2	8
	170	7	7	7	7	7	7	6	6	6	2	8
	180	7	7	7	7	7	7	6	6	6	2	8

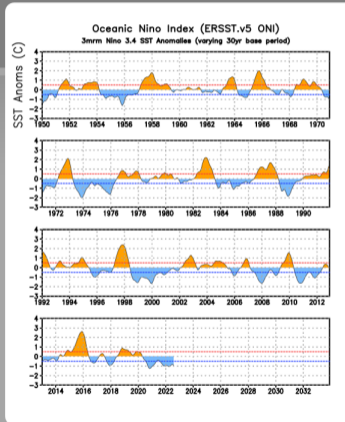
1	Buja
2	Genoa
3	Code 0
4	Screacher
5	Code 3
6	Spi A2
7	Spi A2G
8	Storm Jib

# Appendix D

## ONI (°C): Evolution since 1950

The most recent ONI value (July - September 2022) is  $-0.9^{\circ}\text{C}$ .

El Niño ↑  
Neutral  
La Niña ↓



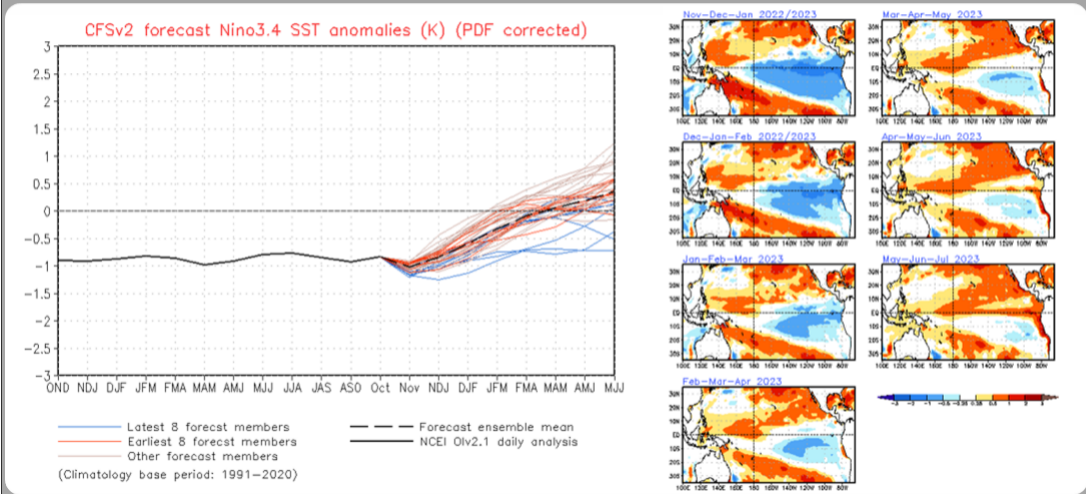
**Figure 8:** Oceanic Niño Index - El Niño (blue), La Niña (orange).

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2010	1.5	1.2	0.8	0.4	-0.2	-0.7	-1.0	-1.3	-1.6	-1.6	-1.6	-1.6
2011	-1.4	-1.2	-0.9	-0.7	-0.6	-0.4	-0.5	-0.6	-0.8	-1.0	-1.1	-1.0
2012	-0.9	-0.7	-0.6	-0.5	-0.3	0.0	0.2	0.4	0.4	0.3	0.1	-0.2
2013	-0.4	-0.4	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.5	-0.3	0.0	0.2	0.2	0.0	0.1	0.2	0.5	0.6	0.7
2015	0.5	0.5	0.5	0.7	0.9	1.2	1.5	1.9	2.2	2.4	2.6	2.6
2016	2.5	2.1	1.6	0.9	0.4	-0.1	-0.4	-0.5	-0.6	-0.7	-0.7	-0.6
2017	-0.3	-0.2	0.1	0.2	0.3	0.3	0.1	-0.1	-0.4	-0.7	-0.8	-1.0
2018	-0.9	-0.9	-0.7	-0.5	-0.2	0.0	0.1	0.2	0.5	0.8	0.9	0.8
2019	0.7	0.7	0.7	0.7	0.5	0.5	0.3	0.1	0.2	0.3	0.5	0.5
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0
2022	-1.0	-0.9	-1.0	-1.1	-1.0	-0.9	-0.8	-0.9				

**Figure 9:** Oceanic Niño Index - El Niño (blue), La Niña (red).



The CFS.v2 ensemble mean (black dashed line) indicates La Niña persisting into the Northern Hemisphere winter 2022-23, and then transitioning to ENSO-neutral in January-March 2023.



**Figure 10:** Forecasts indicate La Niña persisting into Southern Hemisphere summer 2022-2023.