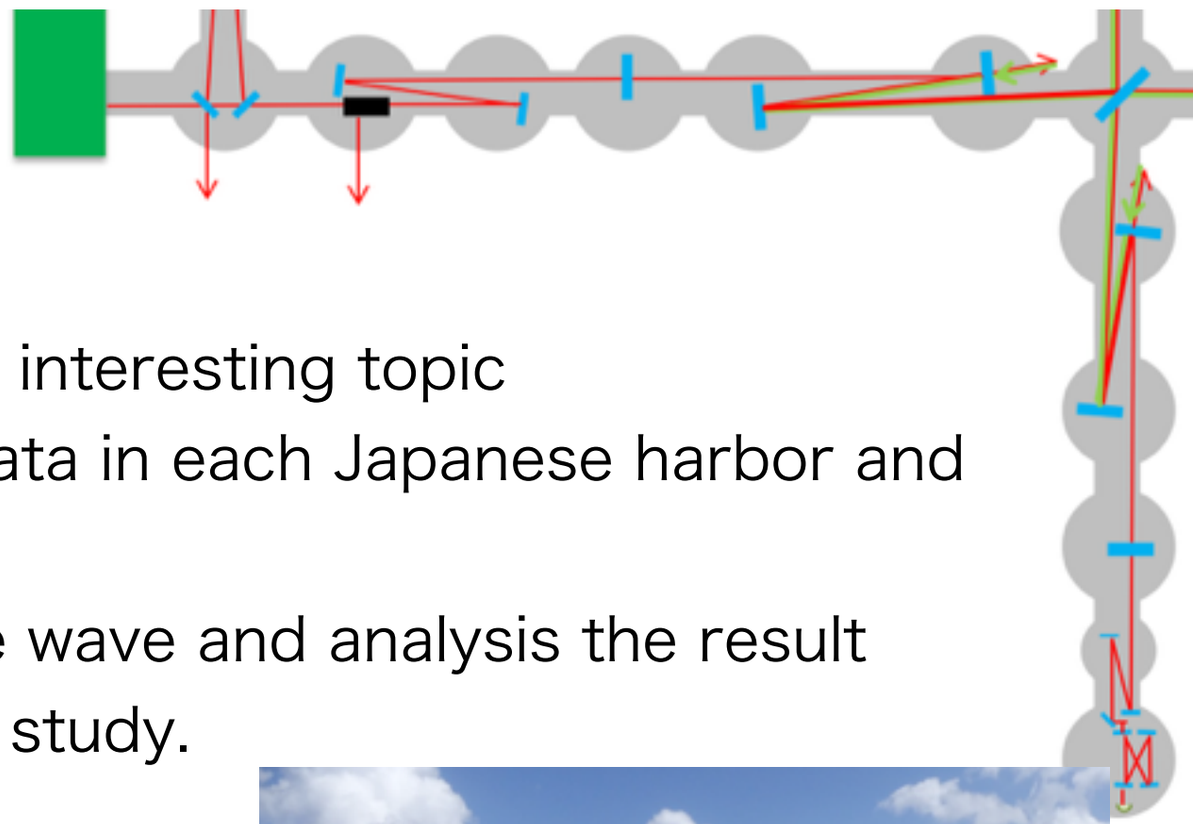
Waves and KAGRA seismometer

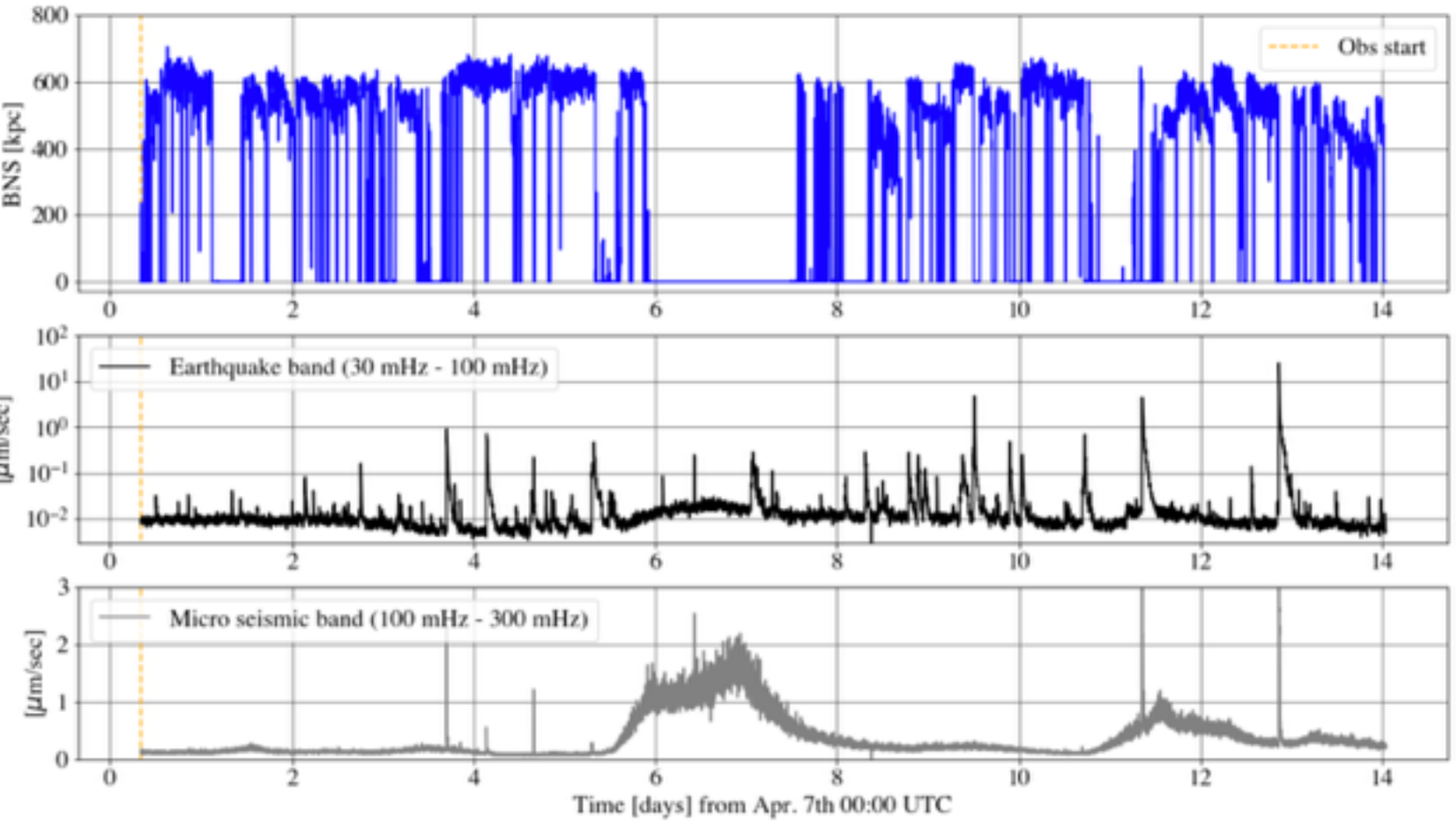
VK PEM meeting
2021/10/28(Thu) 19:00

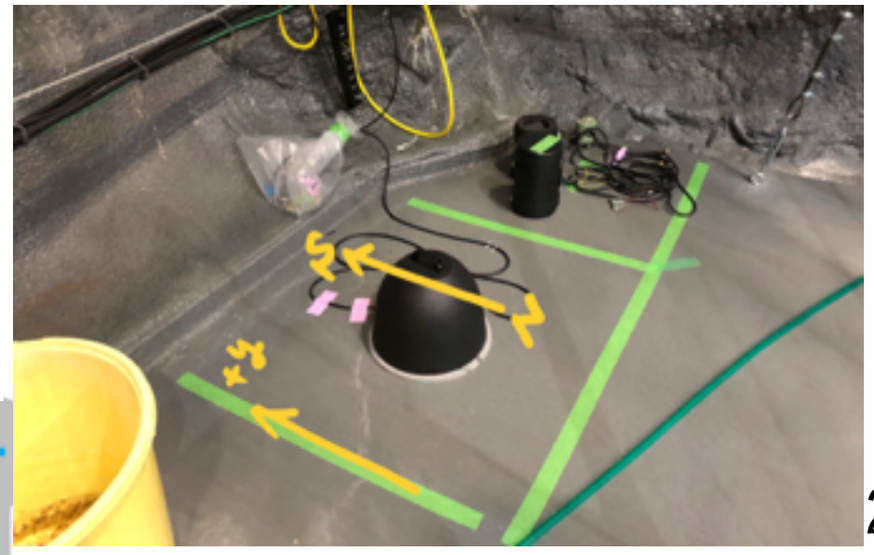
Main worker : Souta Hoshino (B4, Niigata University)
Reported by T.Yokozawa

Purpose

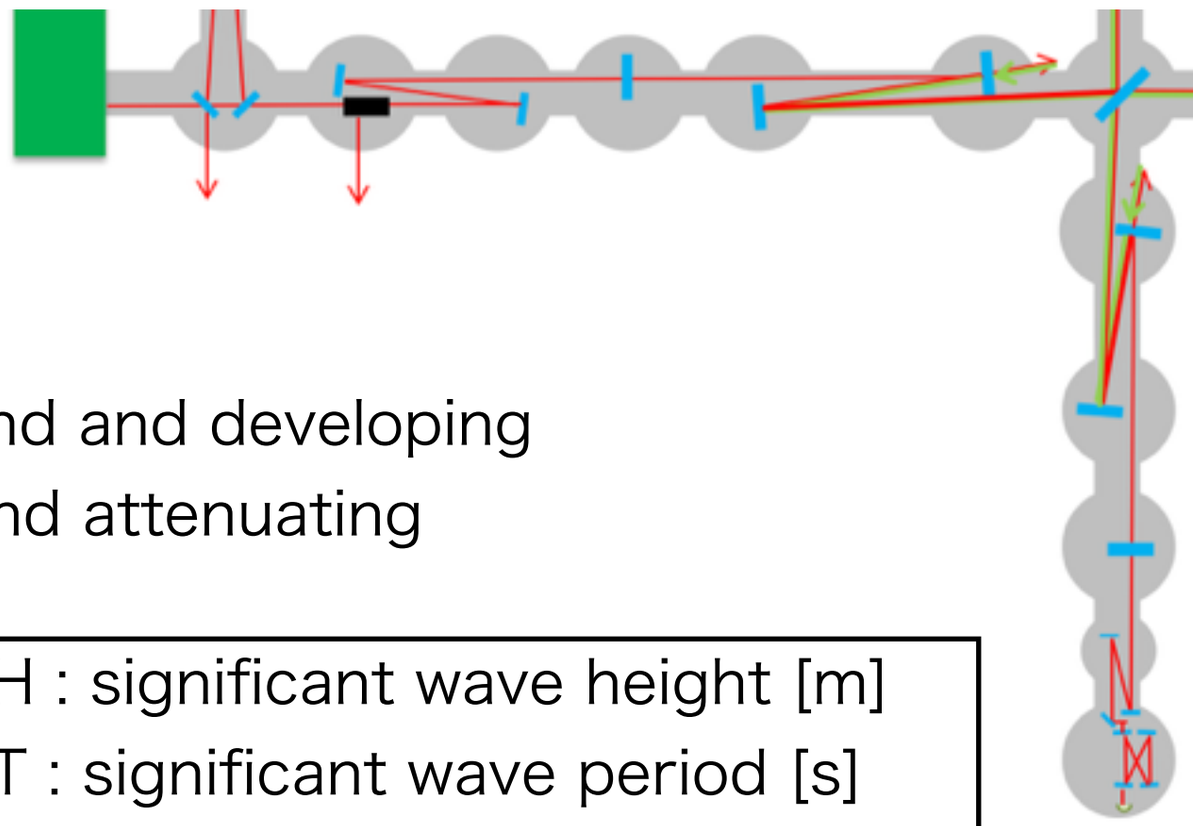


- Microseismic noise is very important and interesting topic
- We are studying by checking the wave data in each Japanese harbor and KAGRA seismometer.
- We are learning the knowledge about the wave and analysis the result
- Today, we will report the progress of our study.





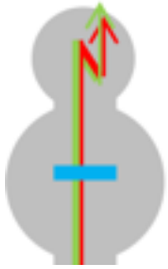
Waves



- Wind waves(風浪) and swells(うねり)
  - Wind waves : Receive the energy from wind and developing
  - Swells : Out of the effect from the wind and attenuating

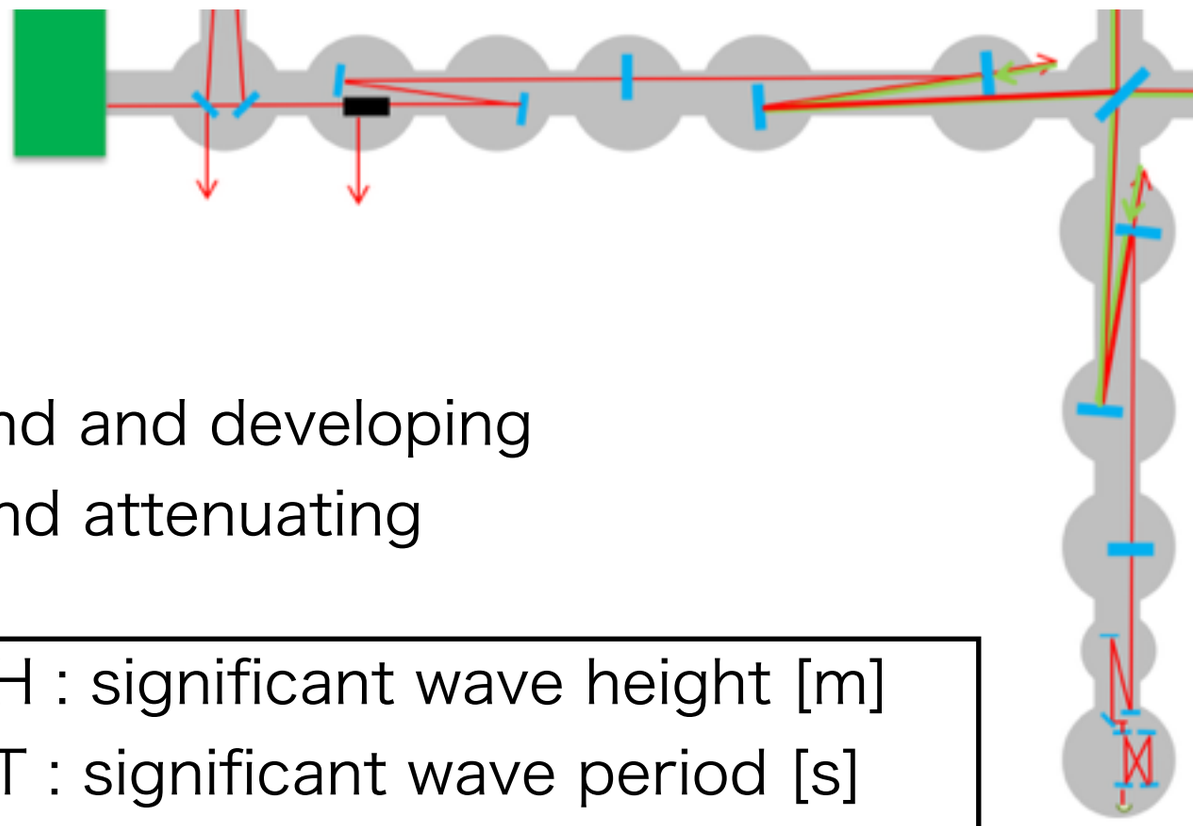
$$H = 7\times10^{-4}UF^{1/2}$$
$$T = 7\times10^{-2}U^{1/3}F^{1/3}$$

H : significant wave height [m]
T : significant wave period [s]
U : wave velocity [m/s]
F : Blow distance(吹送距離) [m]



Period[s] and height[m] defined by zero-up-cross method

Waves



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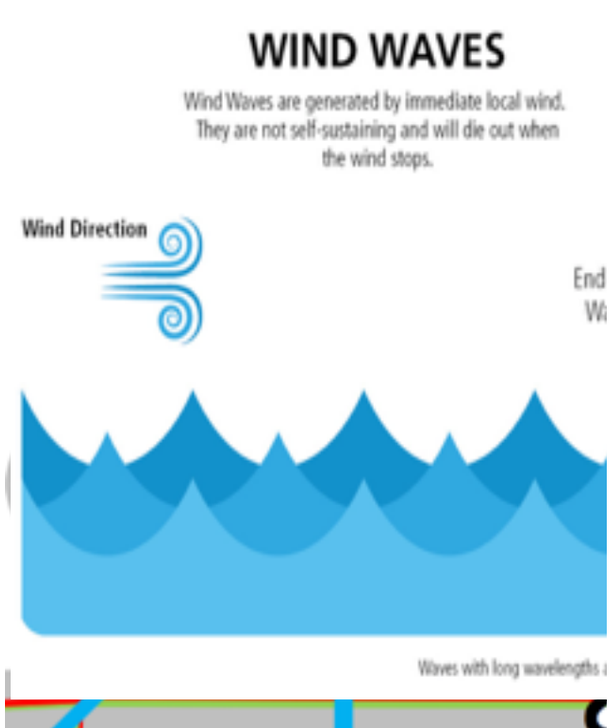
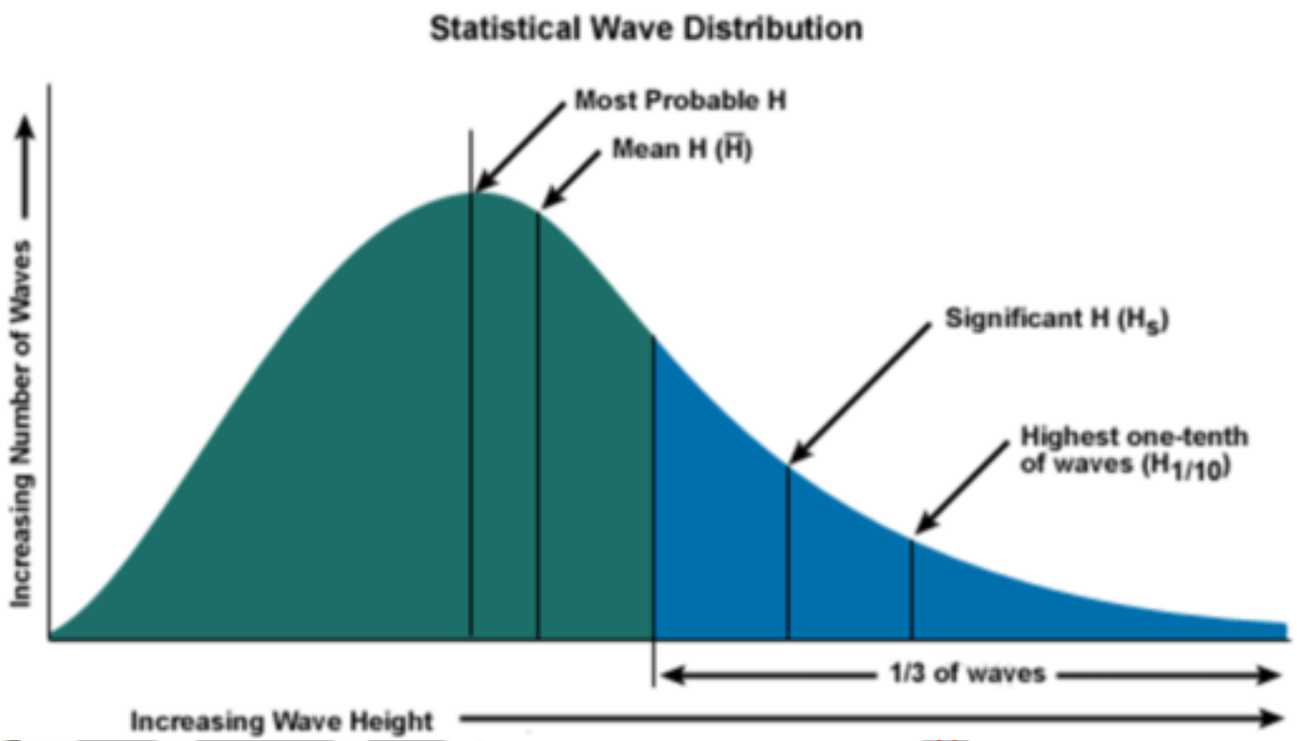
- Significant : upper 1/3 of height histogram





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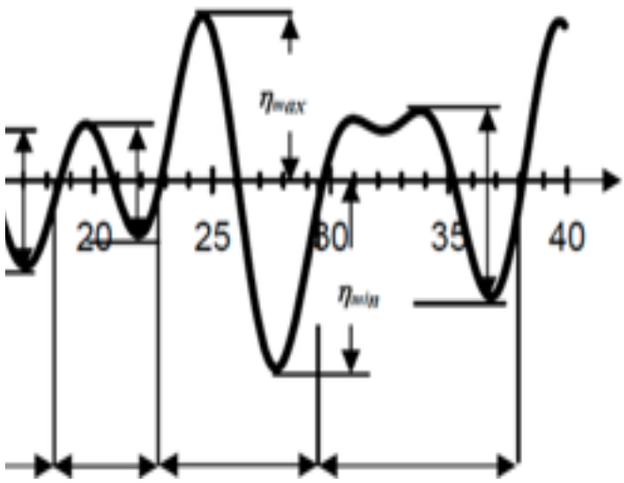
ss method



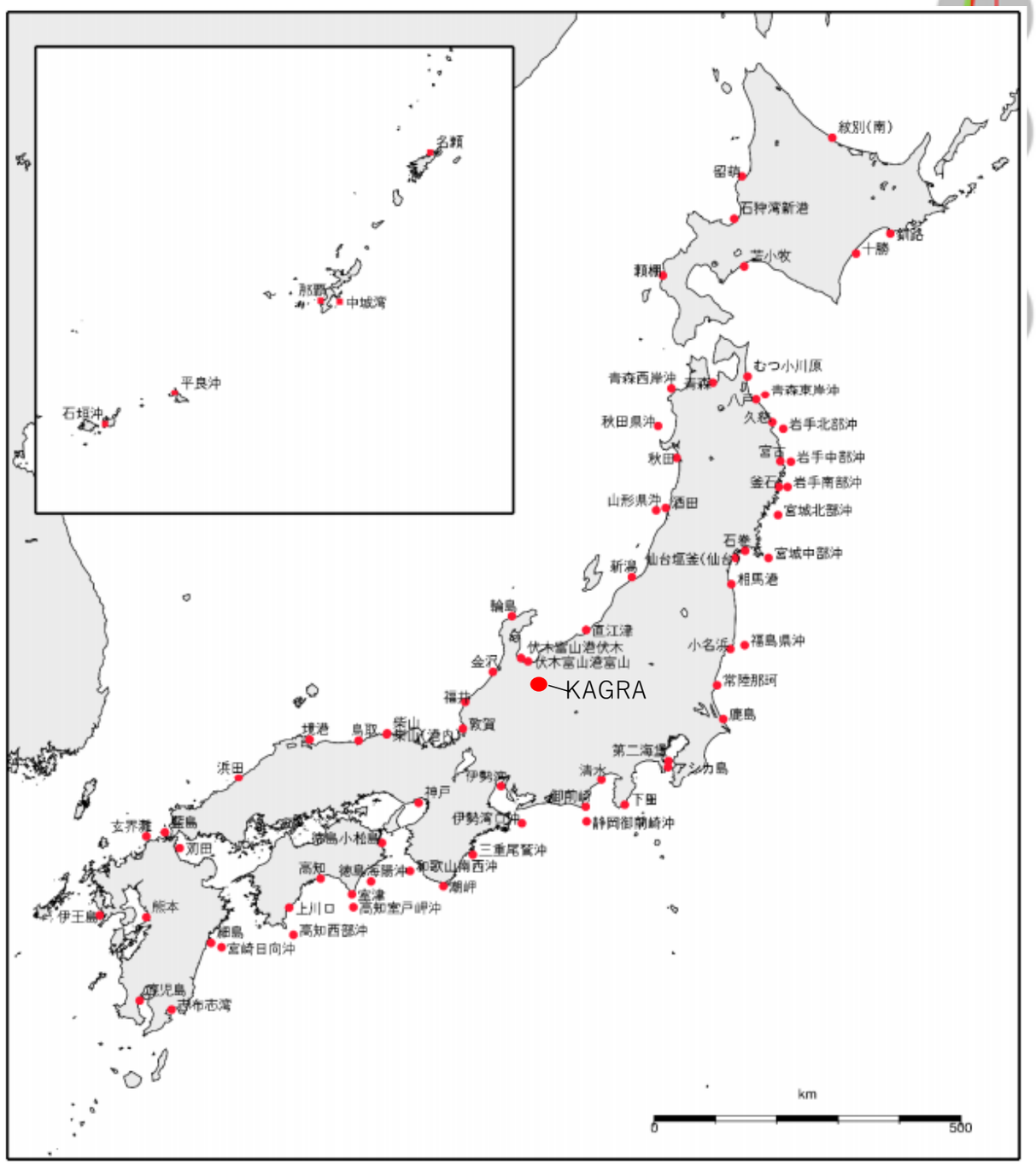
Japanese wave data

- NOWPHAS :
  - Nationwide Ocean Wave information network for Ports and HArbourS
    https://www.pari.go.jp/unit/kaisy/nowphas/
    (Japanese)
    - txt data with every 20 minutes
    - height and period for various data
      - mean wave, significance wave, 1/10 wave, maximum

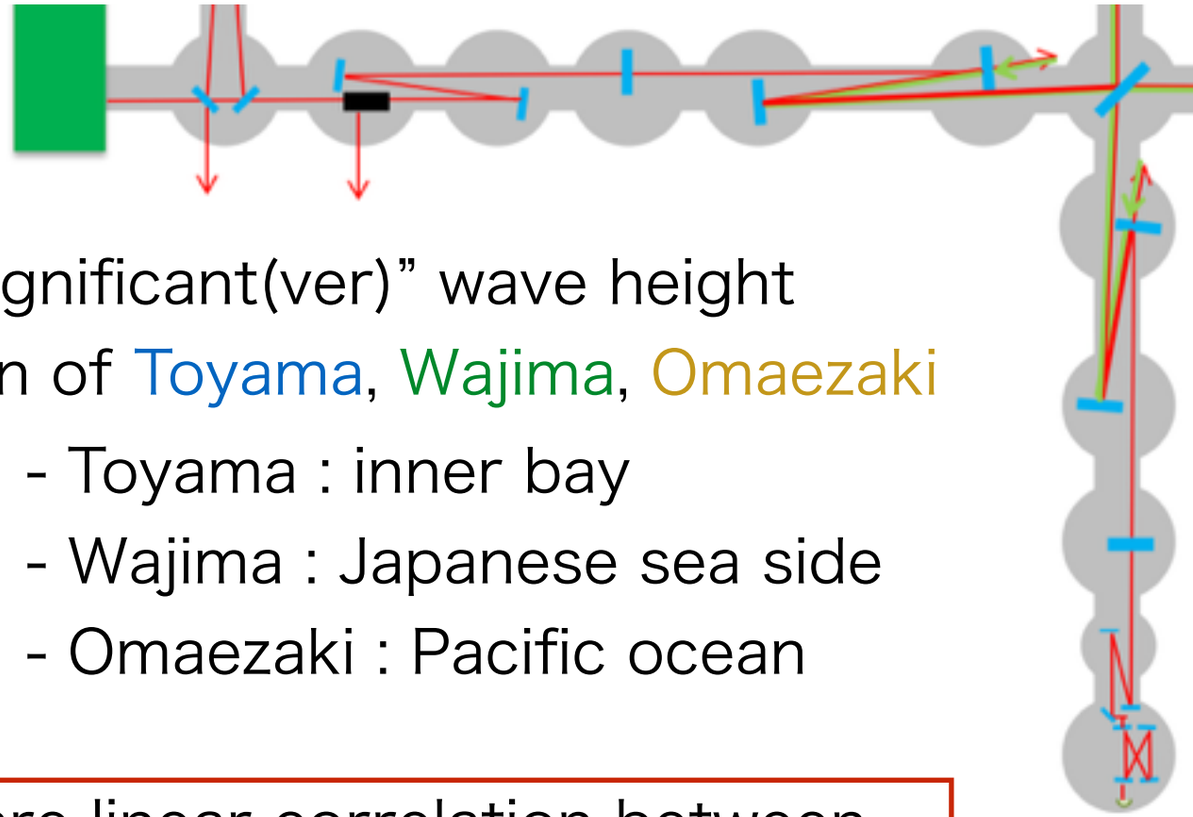
【波浪台帳】
FORMAT(I4,3I2,2I6,4(F6.2,F6.1),I6)

10	20	30	40	50	60	70	80

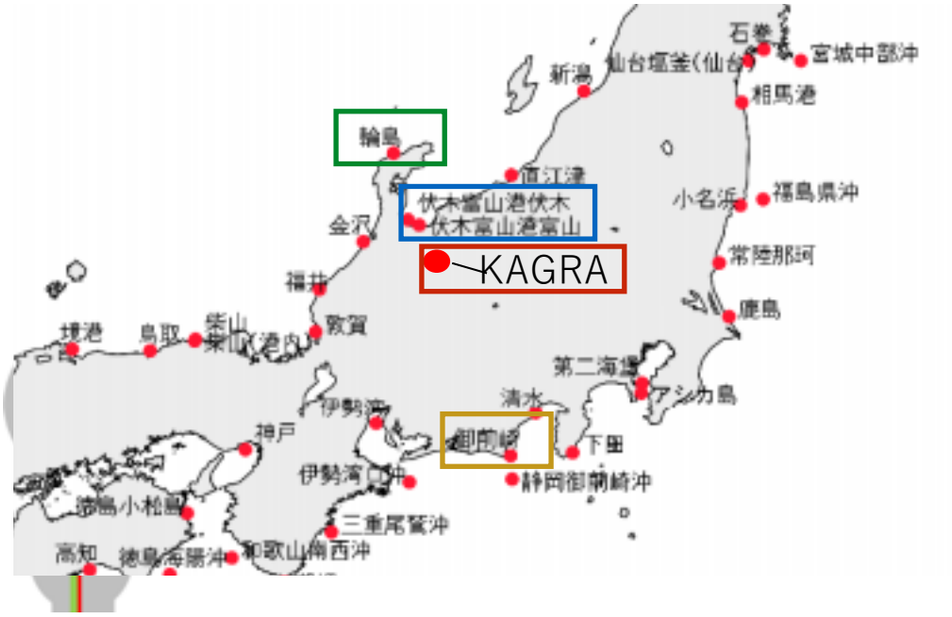
I4 年	3I2 月	日	時	I6 フラグ	I6 波数（波）	F6.2 波高（m）	F6.1 周期（sec）	F6.2 波高（m）	F6.1 周期（sec）	F6.2 波高（m）	F6.1 周期（sec）	F6.2 波高（m）	F6.1 周期（sec）	I6 波向（度）	
						平均波		有義波		1/10波		最高波			
604	留萌														
2001	1	1	0	0	166	0.94	7.1	1.42	9.8	1.69	10.1	1.95	9.3	114	
2001	1	1	2	0	164	0.92	7.3	1.43	9.9	1.76	10.5	2.49	7.8	115	
2001	1	1	4	0	154	0.92	7.7	1.50	10.7	1.89	11.1	2.25	8.8	113	
2001	1	1	6	4	9999	99.99	999.9	0.78	8.3	99.99	999.9	99.99	999.9	95	
2001	1	1	8	7	205	0.94	5.6	1.54	6.7	1.92	7.0	2.51	6.3	9999	
2001	1	110		66	9999	99.99	999.9	66.66	666.6	99.99	999.9	99.99	999.9	9999	
2001	1	112		77	9999	99.99	999.9	0.86	777.7	99.99	999.9	1.38	777.7	9999	
2001	1	114		77	9999	99.99	999.9	77.77	777.7	99.99	999.9	99.99	999.9	9999	(*1)
2001	1	116		9999	9999	99.99	999.9	99.99	999.9	99.99	999.9	99.99	999.9	9999	
2001	1	118		0	317	0.13	3.8	0.21	5.3	0.27	5.1	0.35	5.4	6666	(*2)
2001	1	120		0	455	0.22	2.6	0.33	3.1	0.41	3.0	0.56	2.3	9999	
2001	1	122		9999	9999	99.99	999.9	99.99	999.9	99.99	999.9	99.99	999.9	9999	

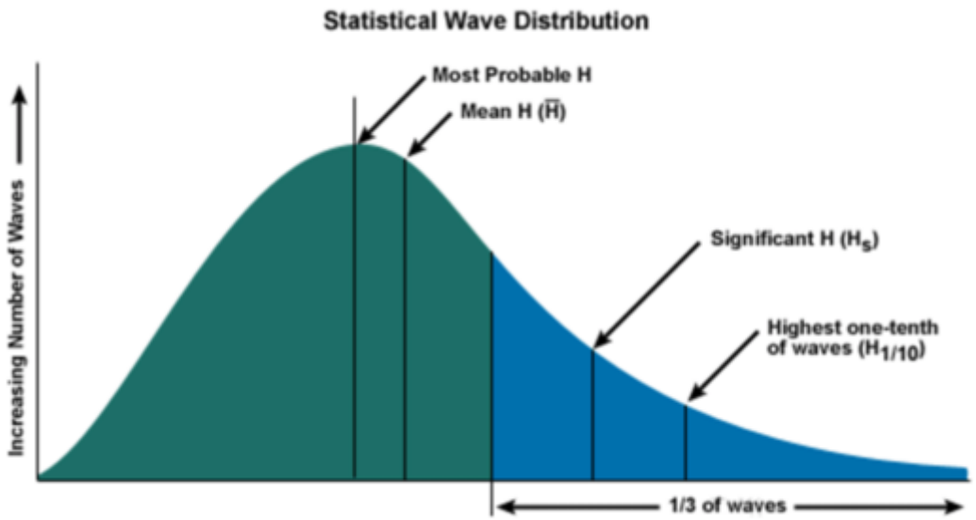


Wave information

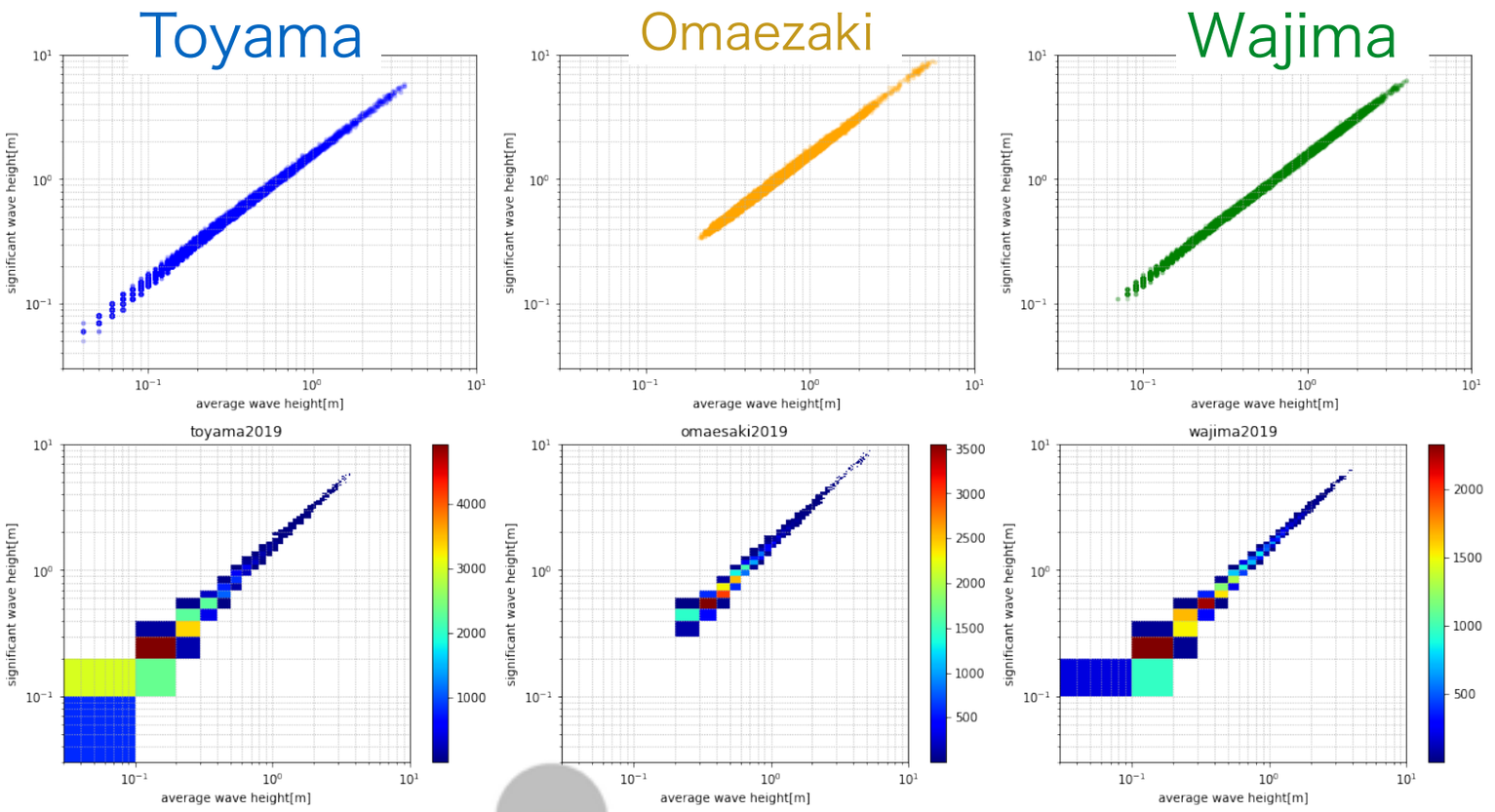


- Comparison between “average(hori)” and “significant(ver)” wave height
  - Basically, we compare the wave information of Toyama, Wajima, Omaezaki
  - Upper figure : Scattered plot
  - Lower figure : 2D plot (0.1 m resolution)
    - Toyama : inner bay
    - Wajima : Japanese sea side
    - Omaezaki : Pacific ocean

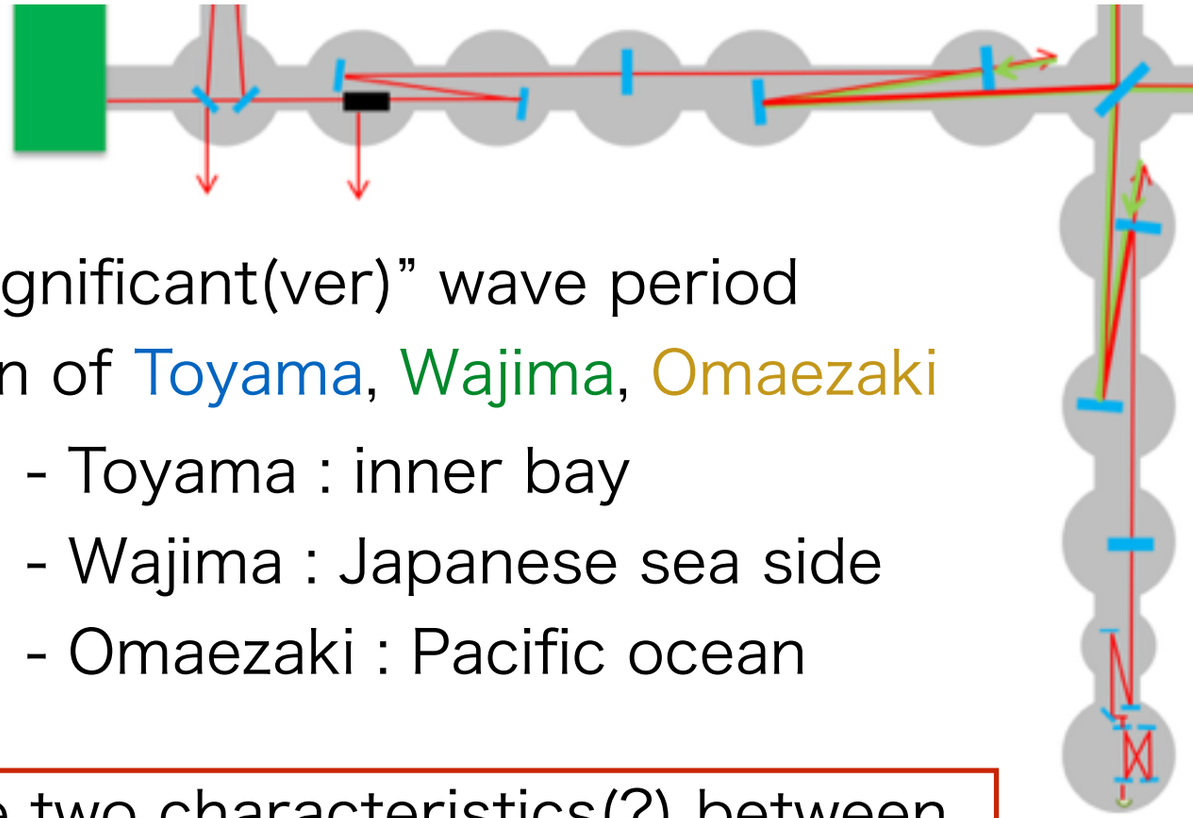




- There are linear correlation between “significant” and “average” wave height



Wave information



- Comparison between “average(hori)” and “significant(ver)” wave period
  - Basically, we compare the wave information of Toyama, Wajima, Omaezaki
  - Upper figure : Scattered plot
  - Lower figure : 2D plot (0.1 m resolution)
    - Toyama : inner bay
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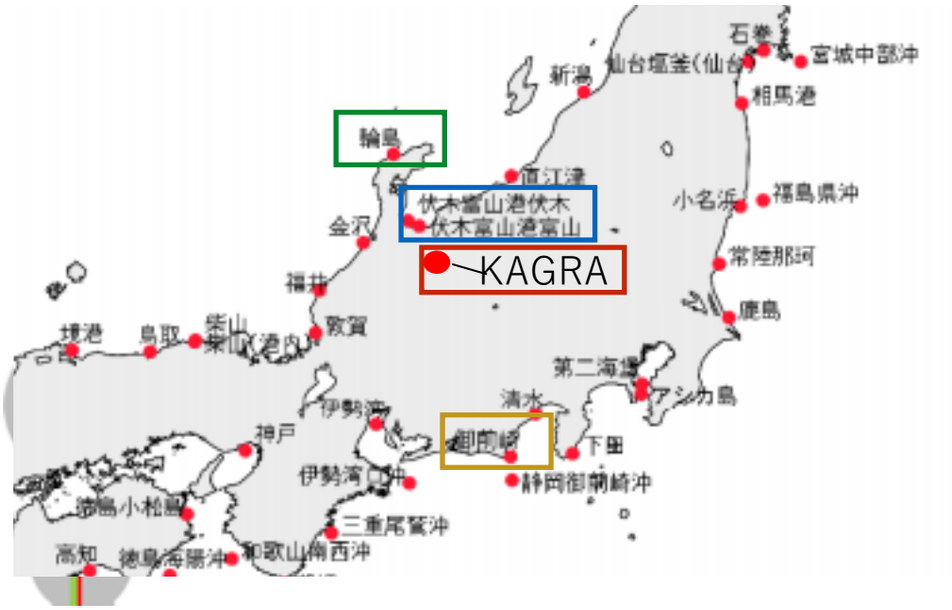
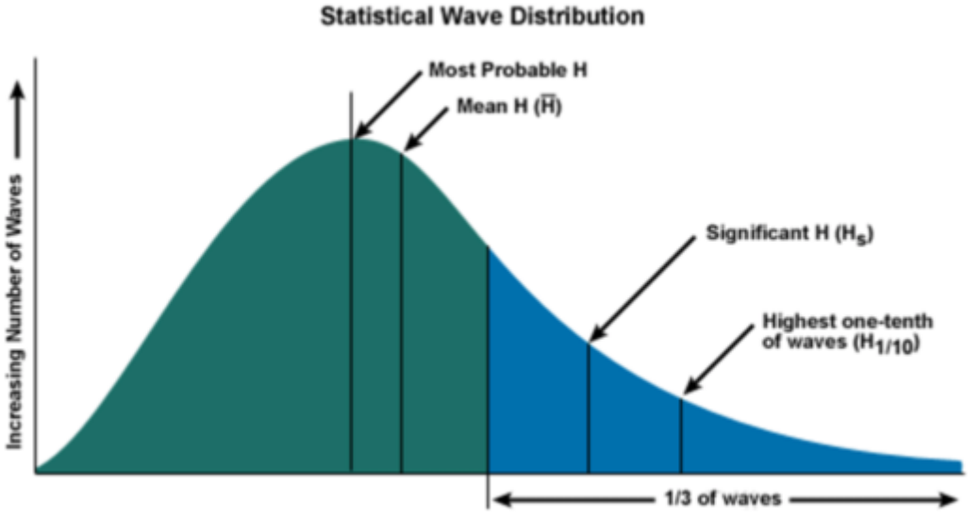
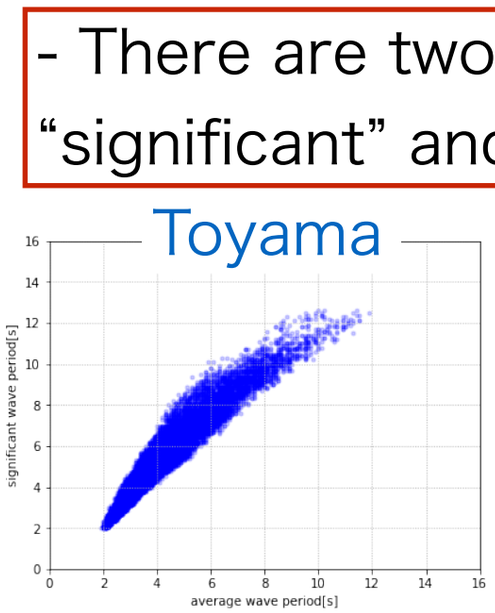
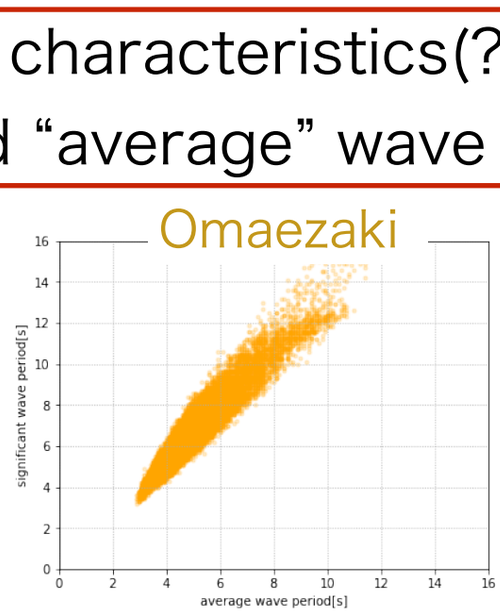
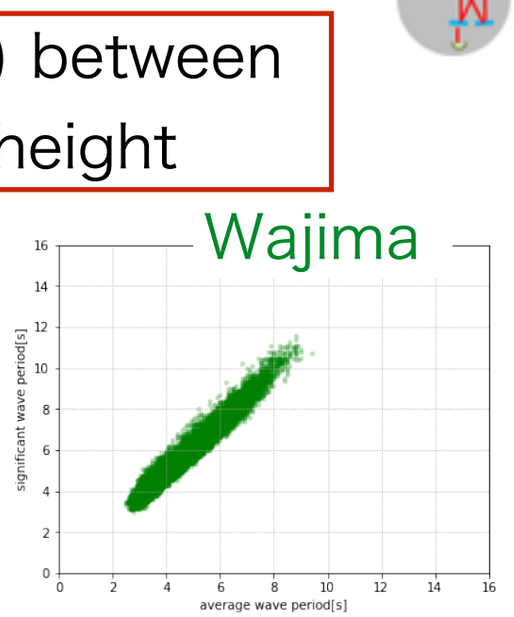


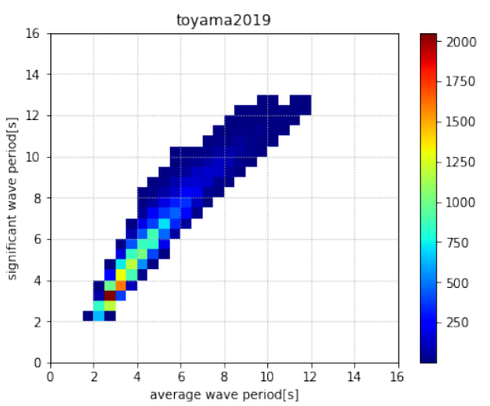


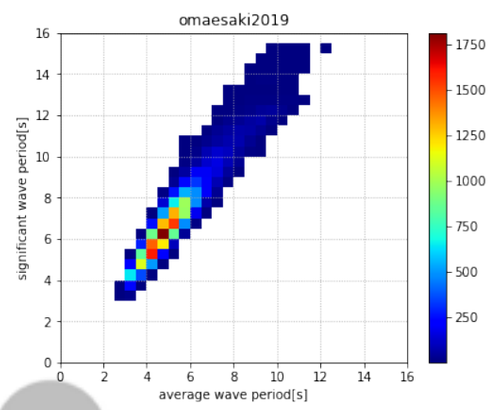
- There are two characteristics(?) between “significant” and “average” wave height

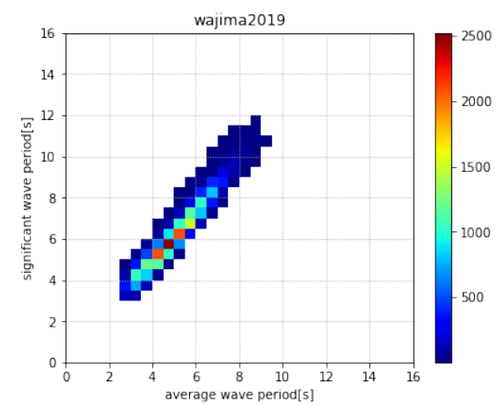


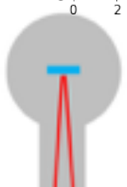












Wave information

- Comparison between significant wave “period” and “height”
  - Basically, we compare the wave information of Toyama, Wajima, Omaezaki
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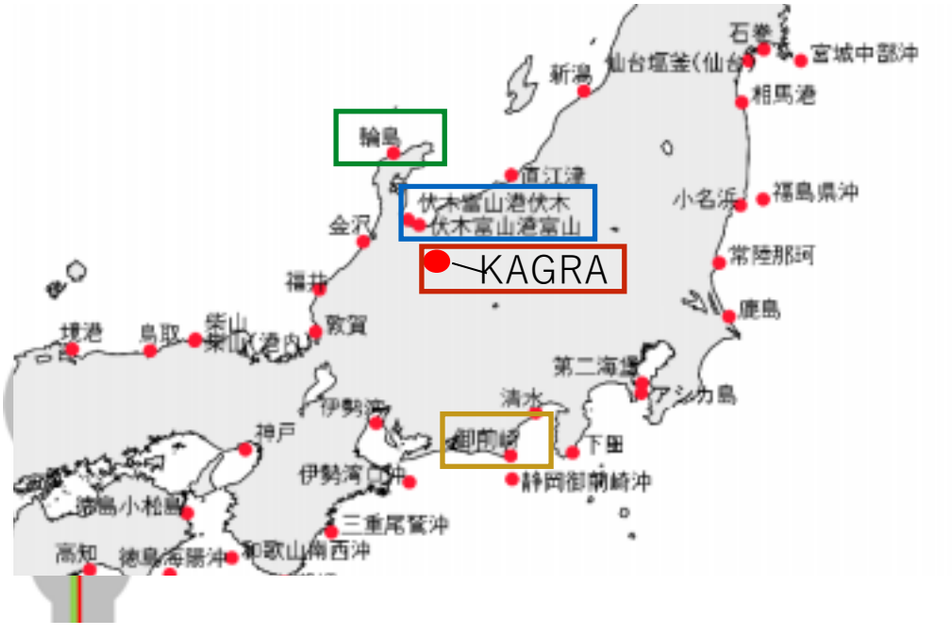
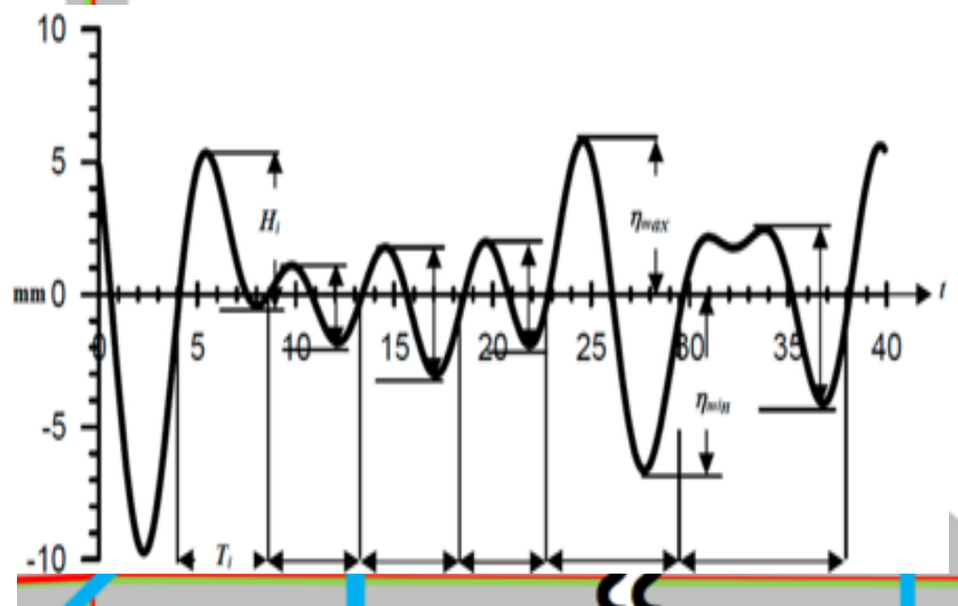
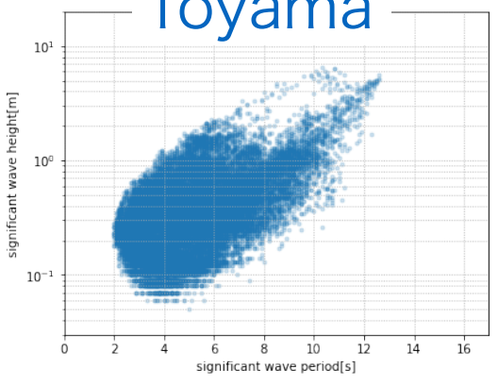
  - Lower figure : 2D plot (0.1 m resolution)



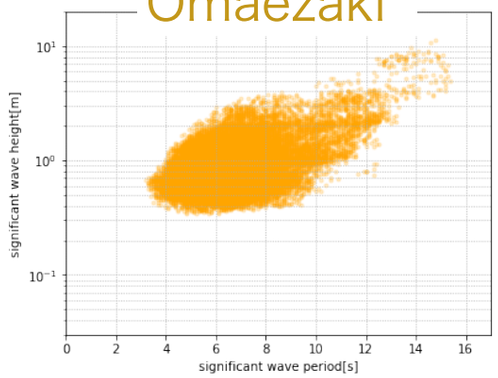


- There are two characteristics(?) between significant wave “period” and “height”

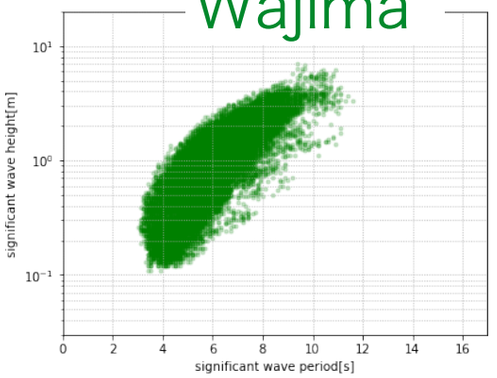
Toyama

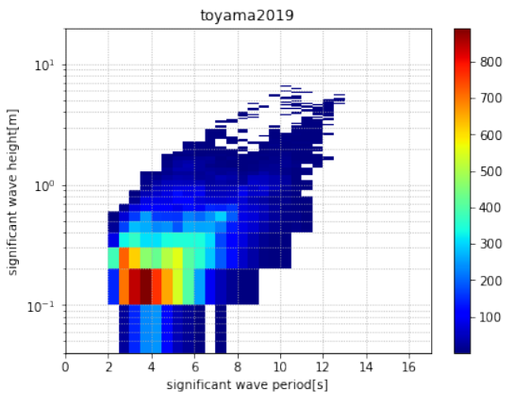


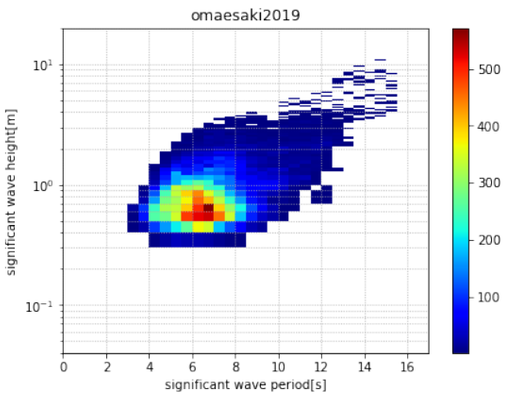
Omaezaki

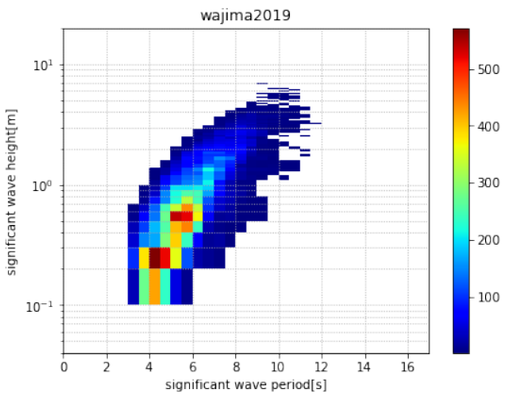


Wajima







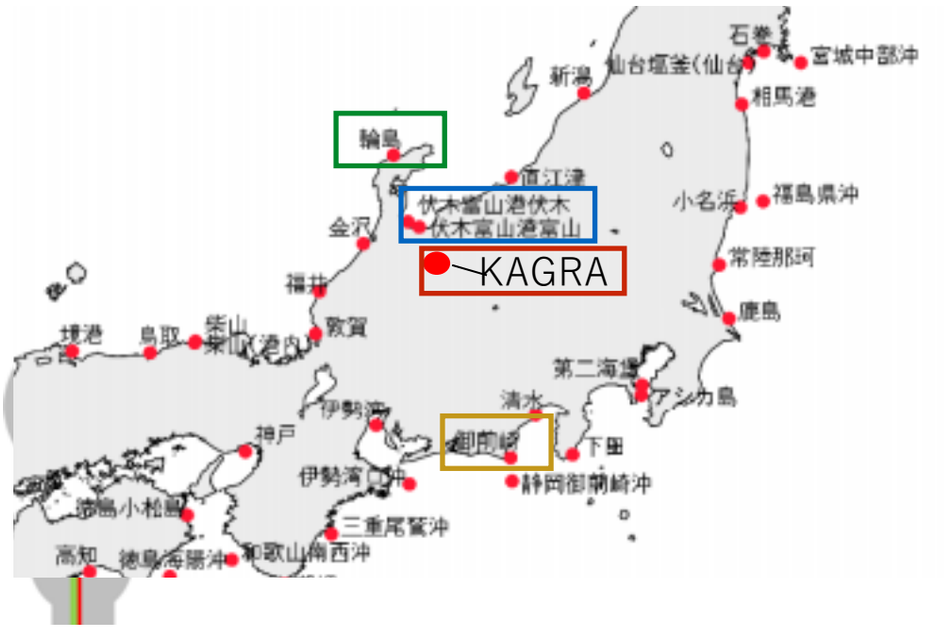


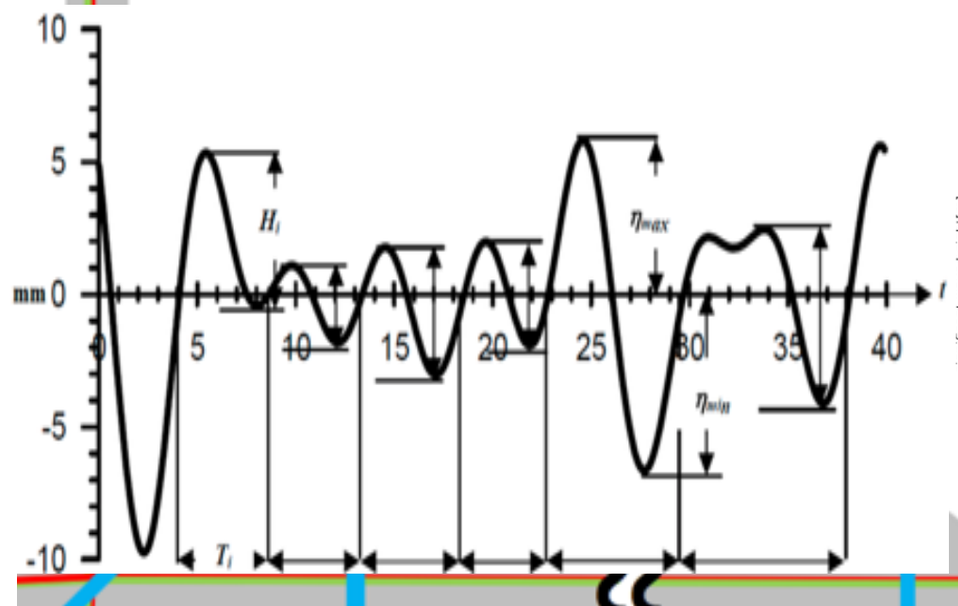
Wave information

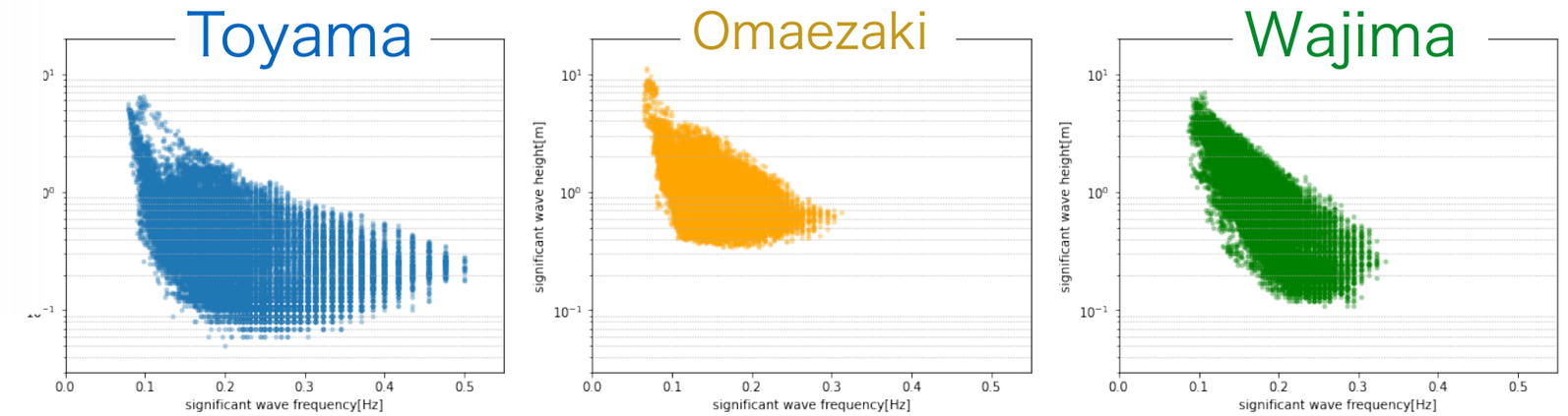
- Comparison between significant wave “frequency” and “height”
  - Basically, we compare the wave information of Toyama, Wajima, Omaezaki
  - Upper figure : Scattered plot
  - Lower figure : 2D plot (0.1 m resolution)

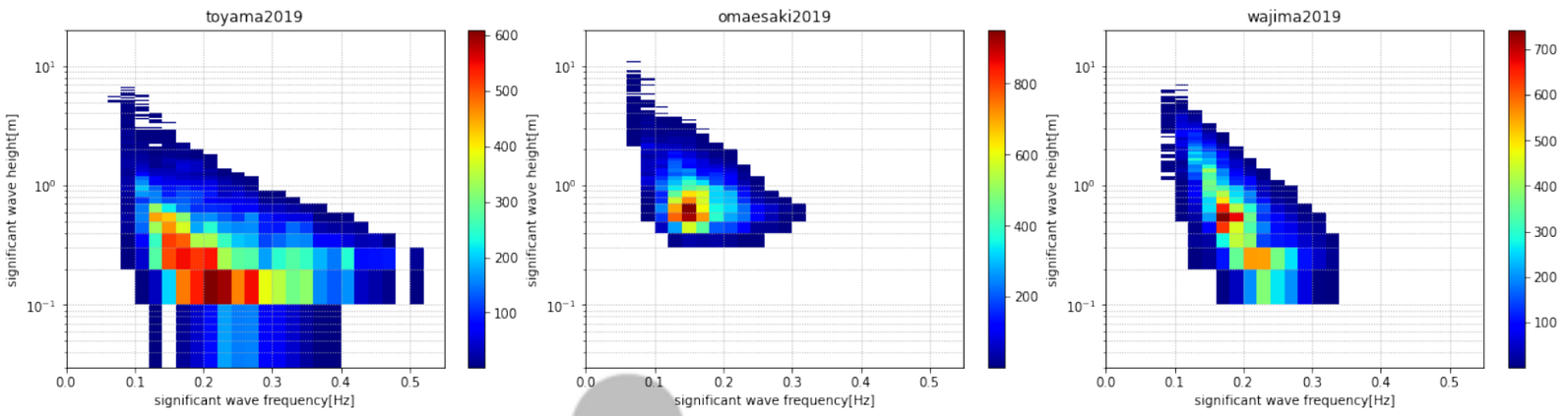
- Changed the horizontal axis from period[s] to frequency [Hz]

- There are inverse proportional between significant wave “period” and “height”









Saturated wave

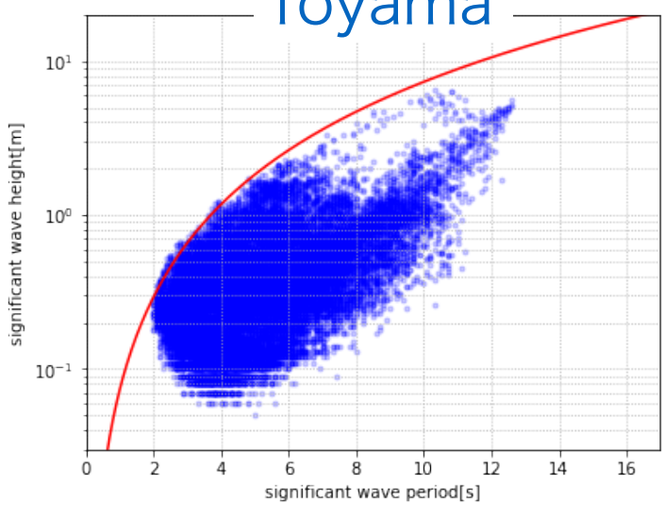
$$H = 7\times10^{-4}UF^{1/2}$$
$$T = 7\times10^{-2}U^{1/3}F^{1/3}$$

$$H = 3\times10^{-2}U^{2}$$
$$T = 0.64U$$

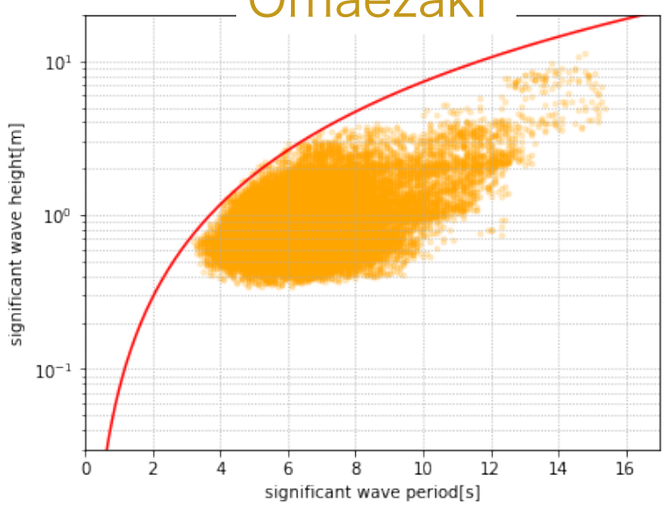
$$H = \frac{3}{40.96}T^{2}$$

- Calculate the “saturated” wave relation between significant wave period (frequency) and height, actually, we can see the saturated wave in each bay

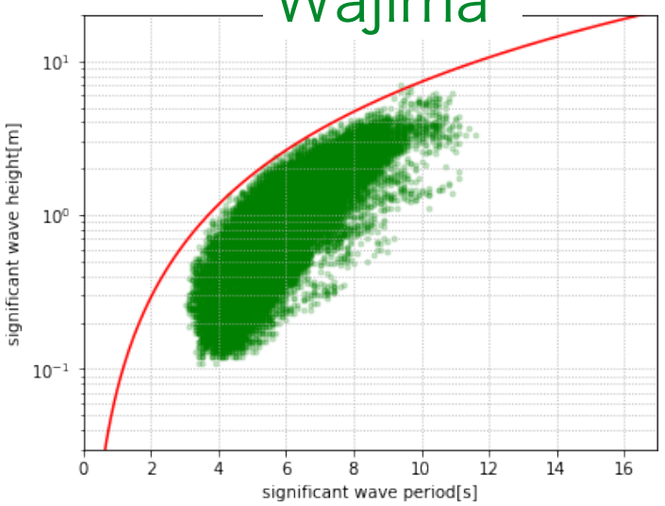
Toyama

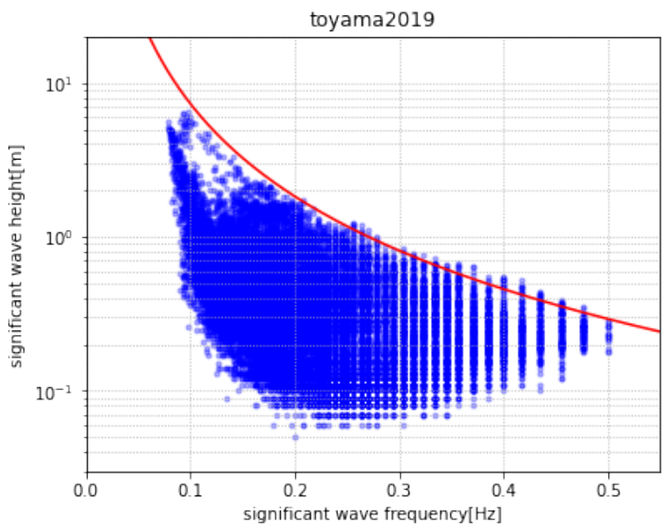


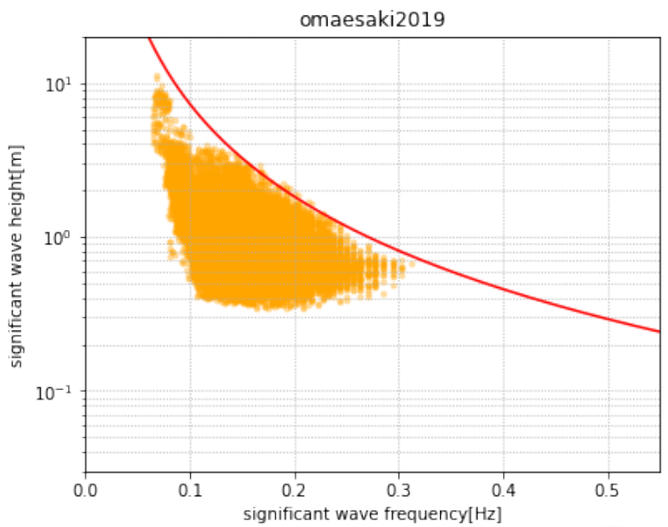
Omaezaki

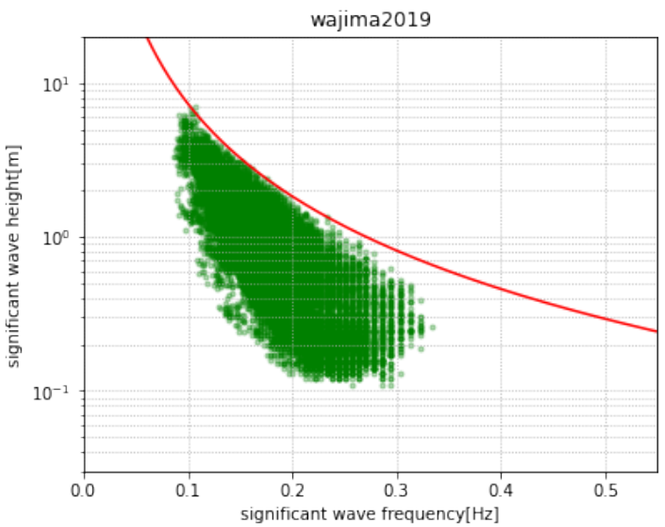


Wajima

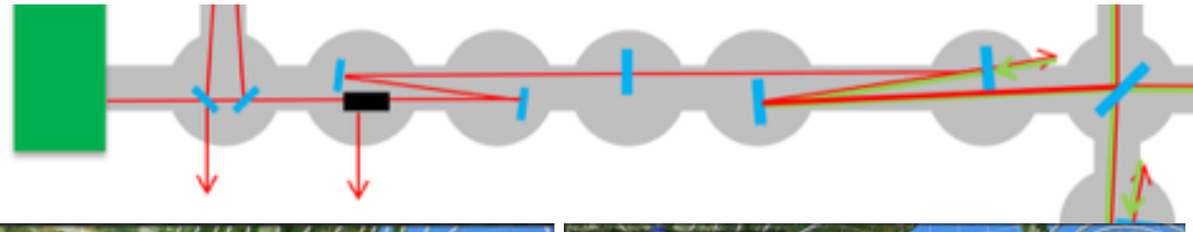


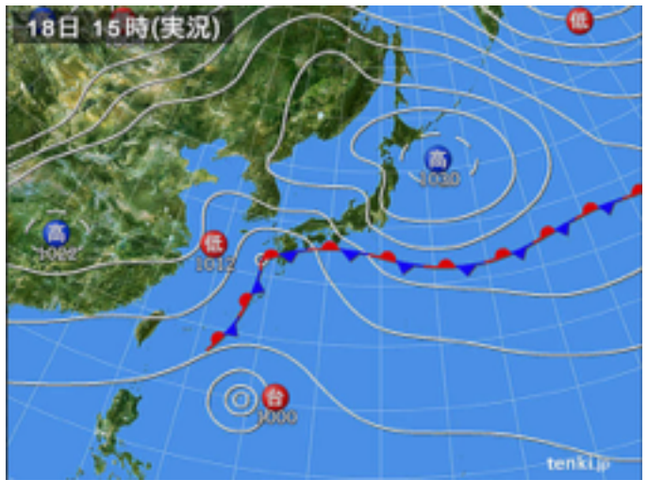




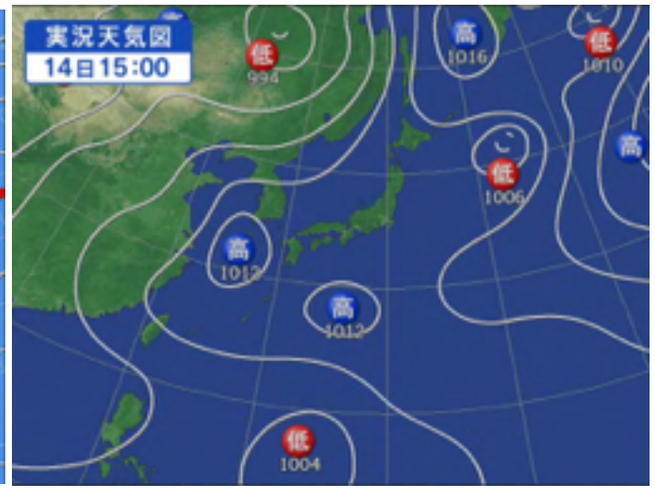


Seasonal wave



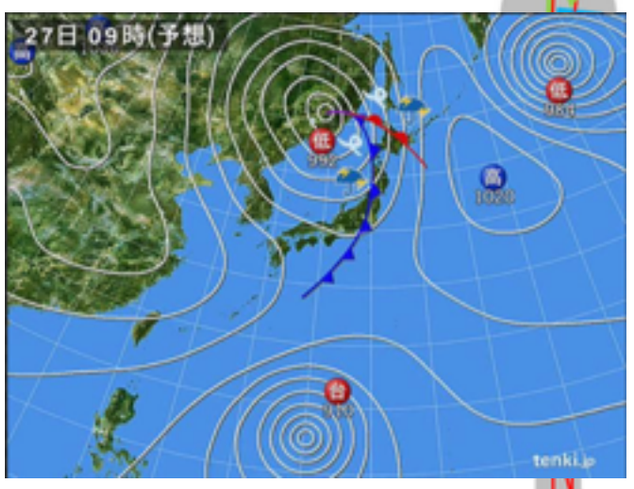


Spring/Autumn

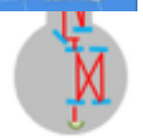


Summer

Winter



Typhoon



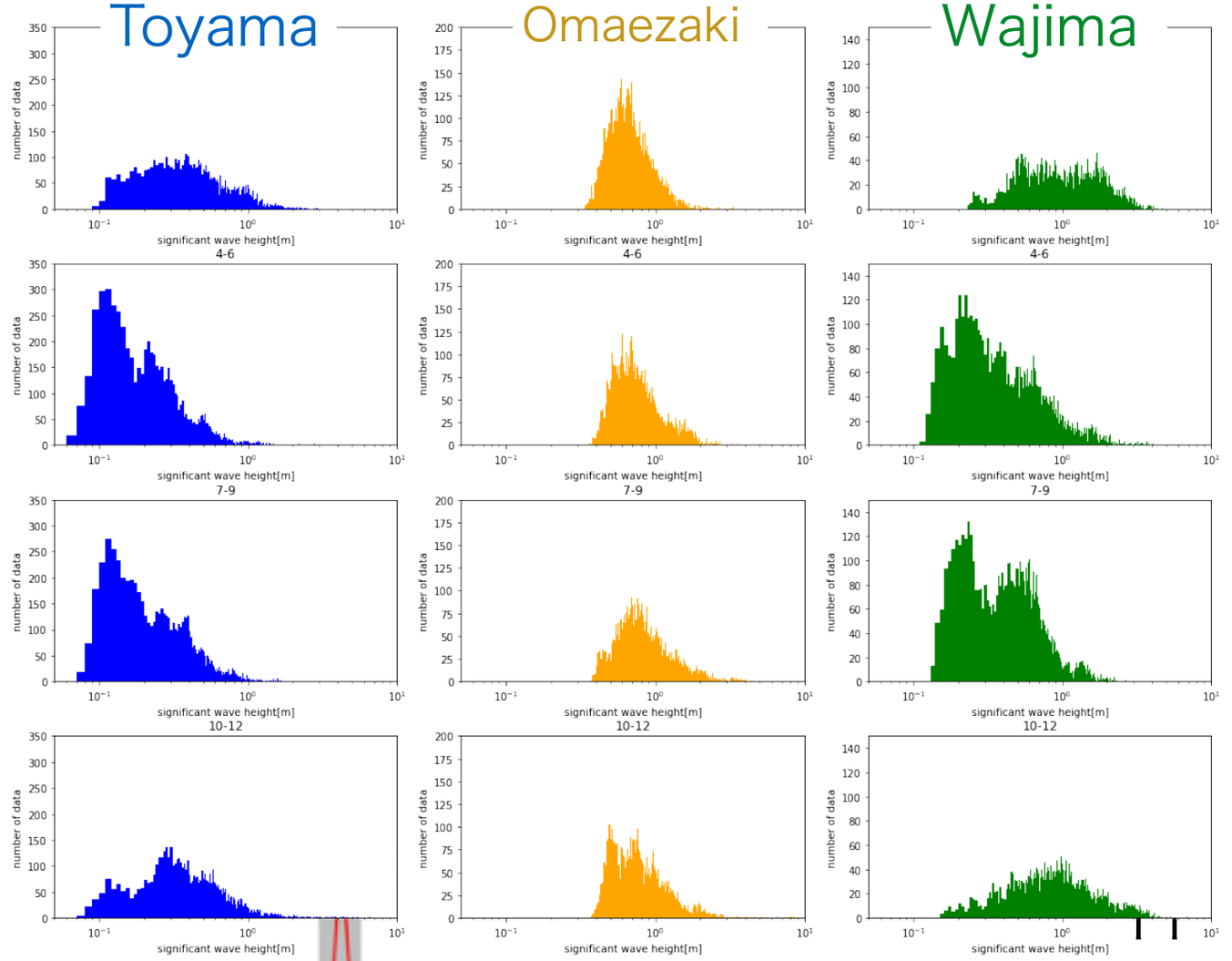
- The detail of seasonal wave analysis is ongoing
  - There are strong wind in Japanese sea side
  - There are typhoon sometimes

Jan.-Mar.

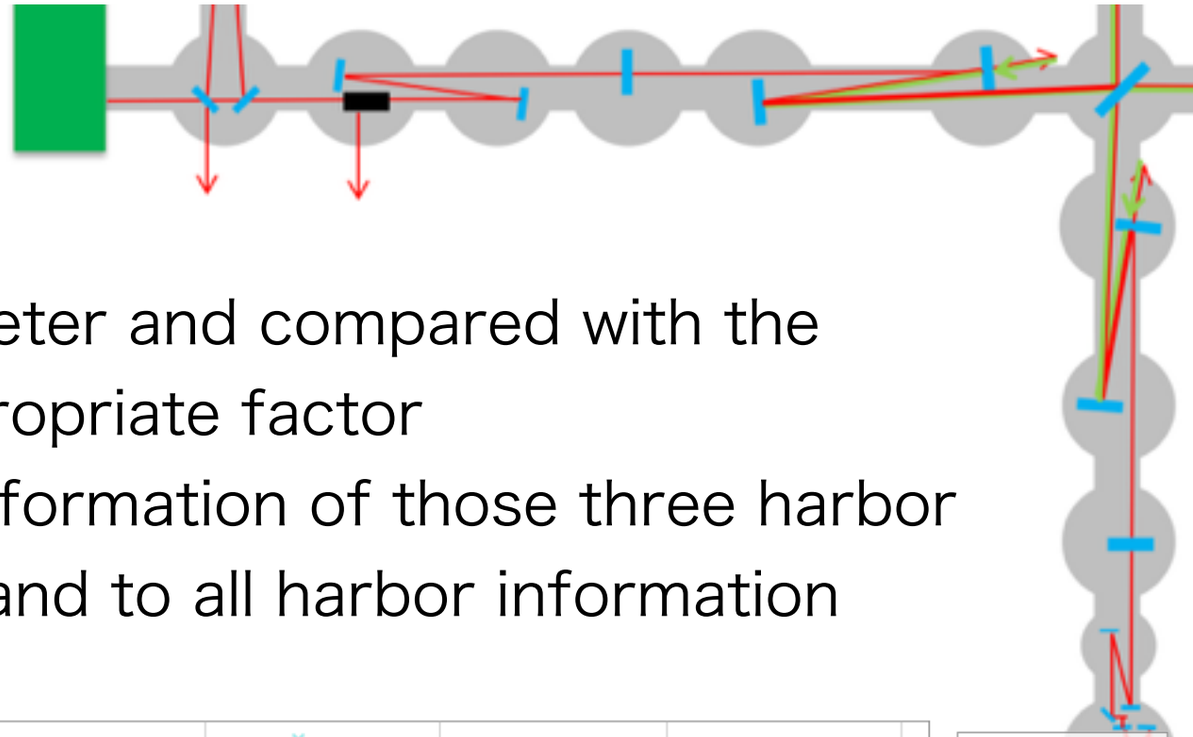
Apr.-Jun.

Jul.-Sep.

Oct.-Dec.

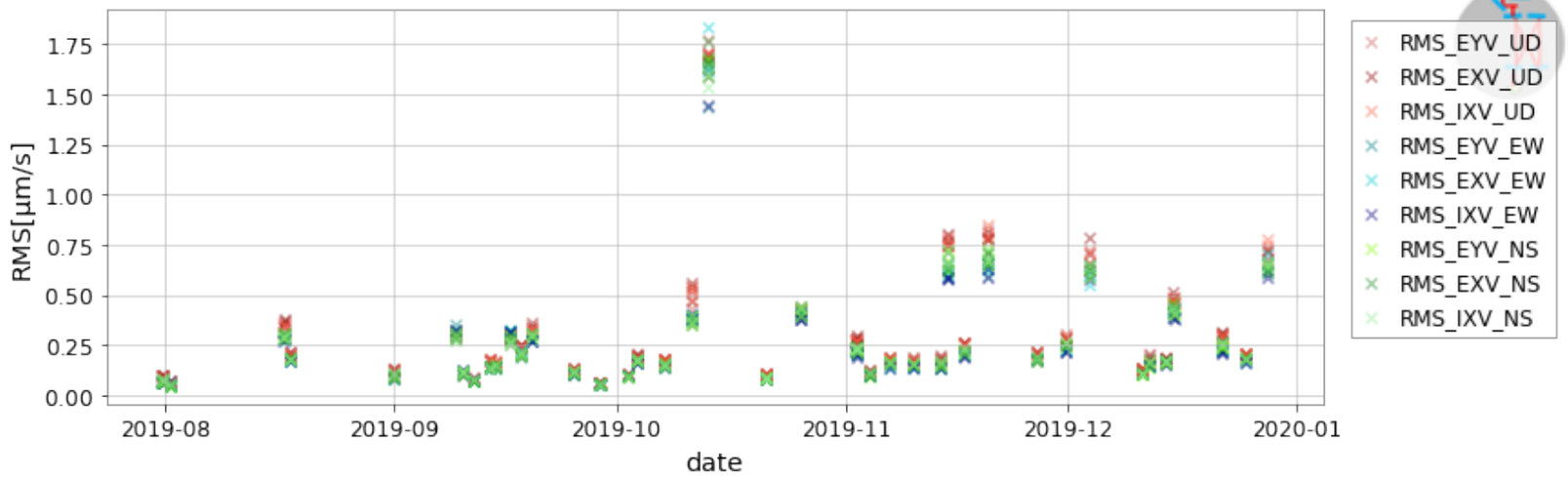


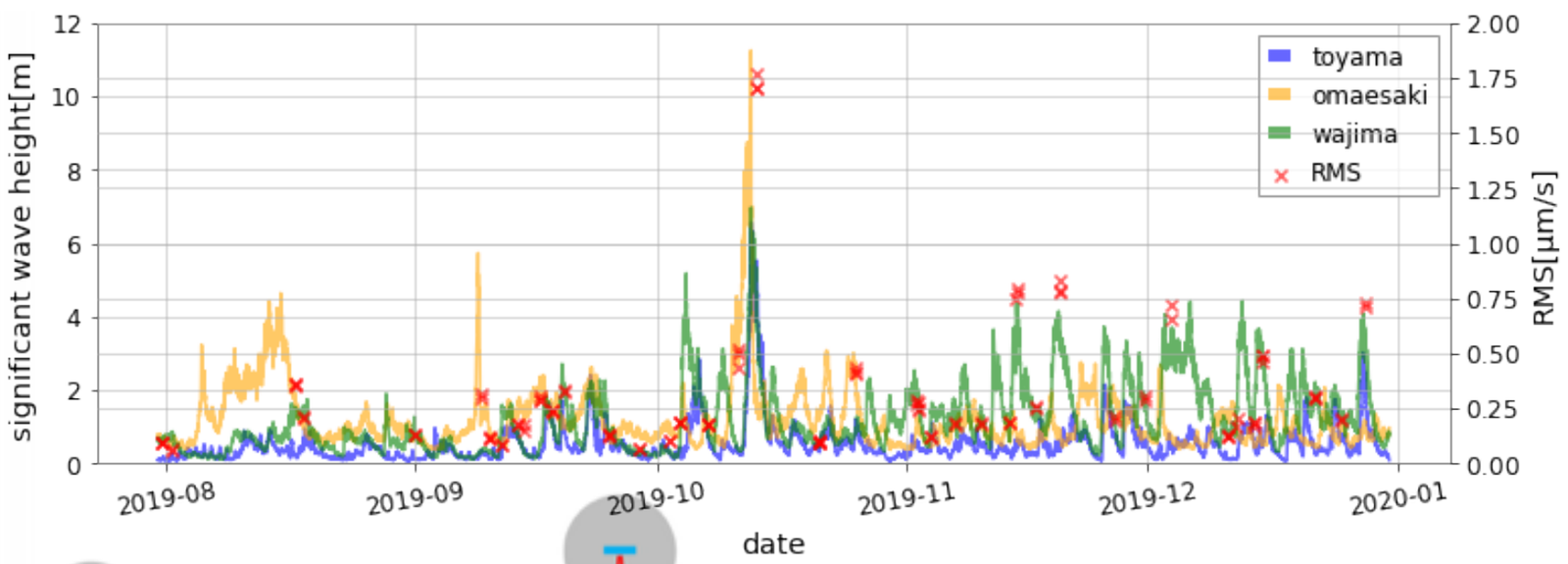
wave height and seismometer



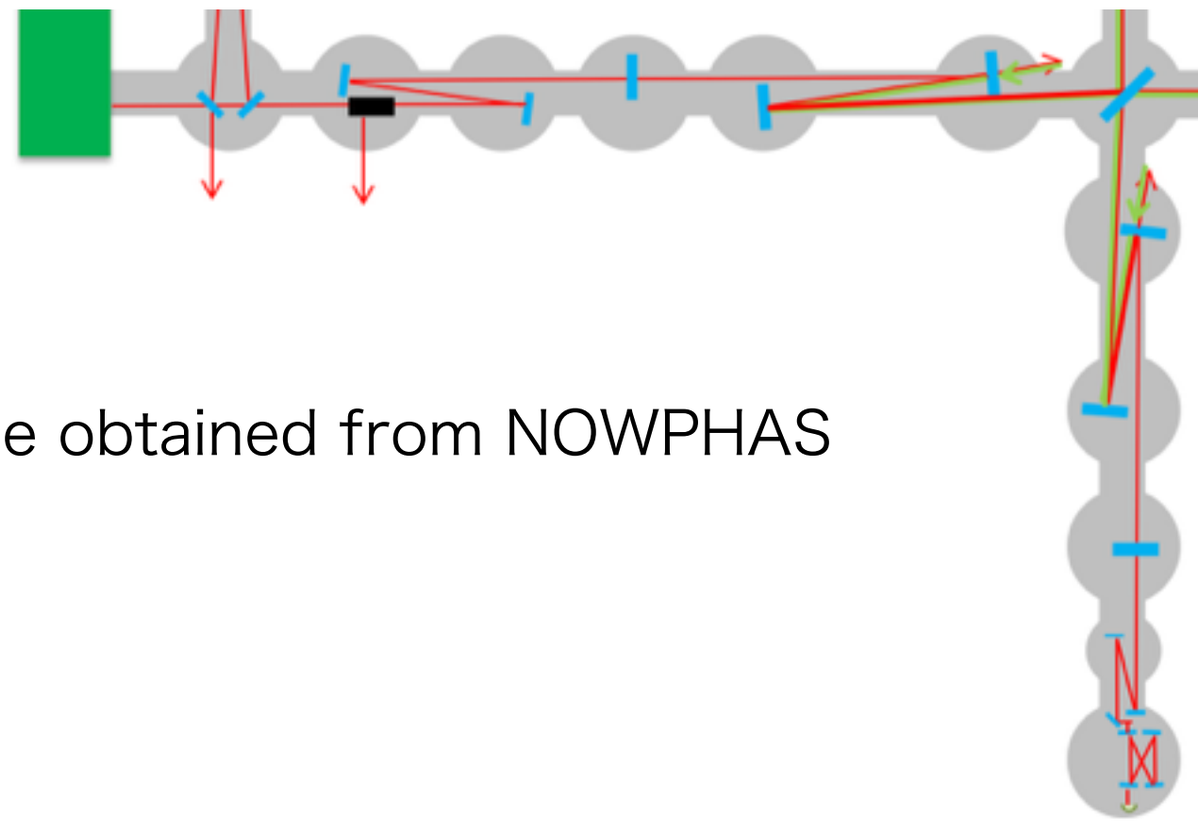
- Calculate the RMS using KAGRA seismometer and compared with the significant wave height with multiplying appropriate factor
  - We can reconstruct the RMS from the information of those three harbor significant wave height information -> Expand to all harbor information

RMS calculation
- Using center/Xend/Yend seismometer (X,Y,Z direction)
- 0.05 - 5 Hz bandpass filter
- Calculate RMS every 20min

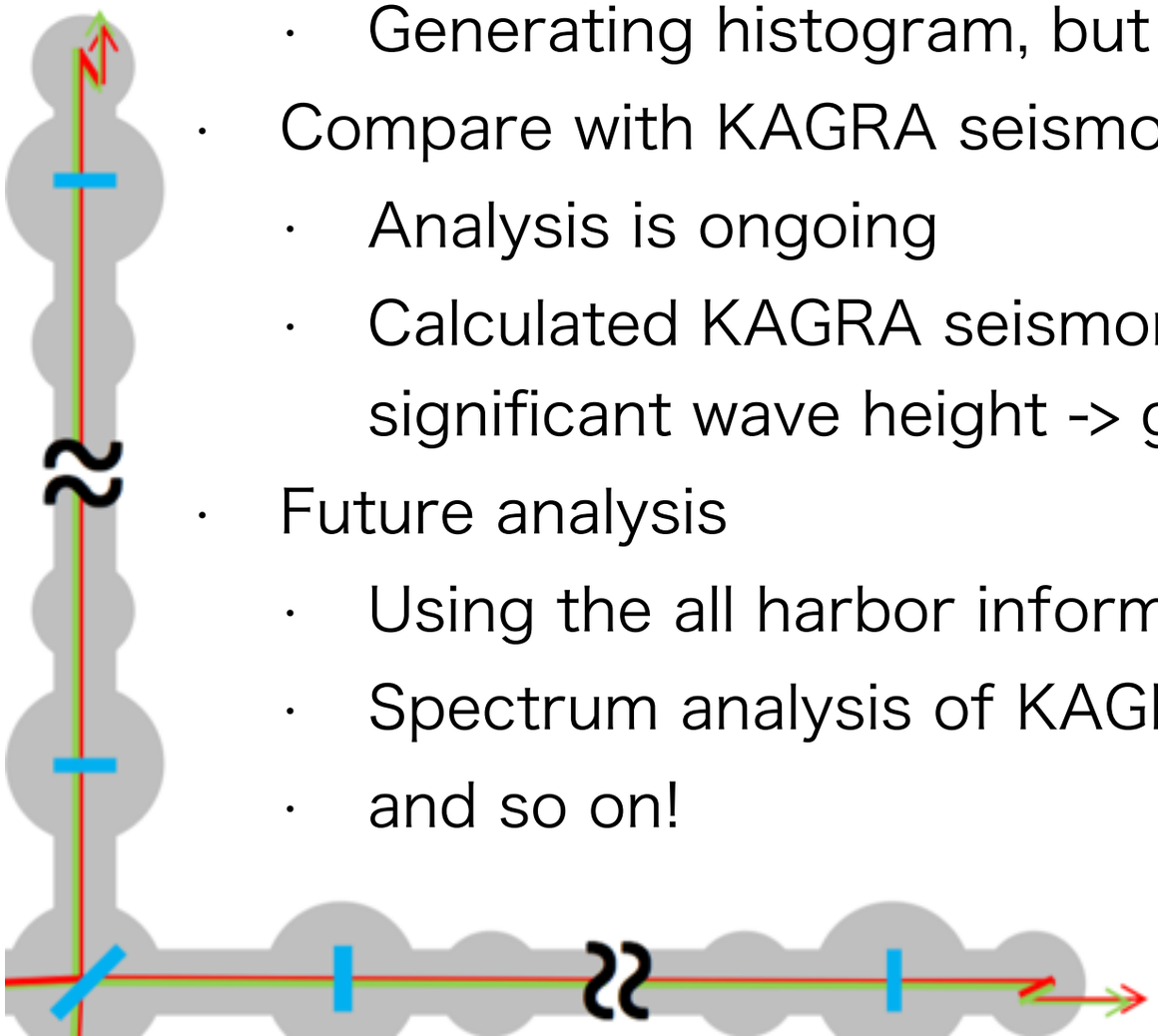




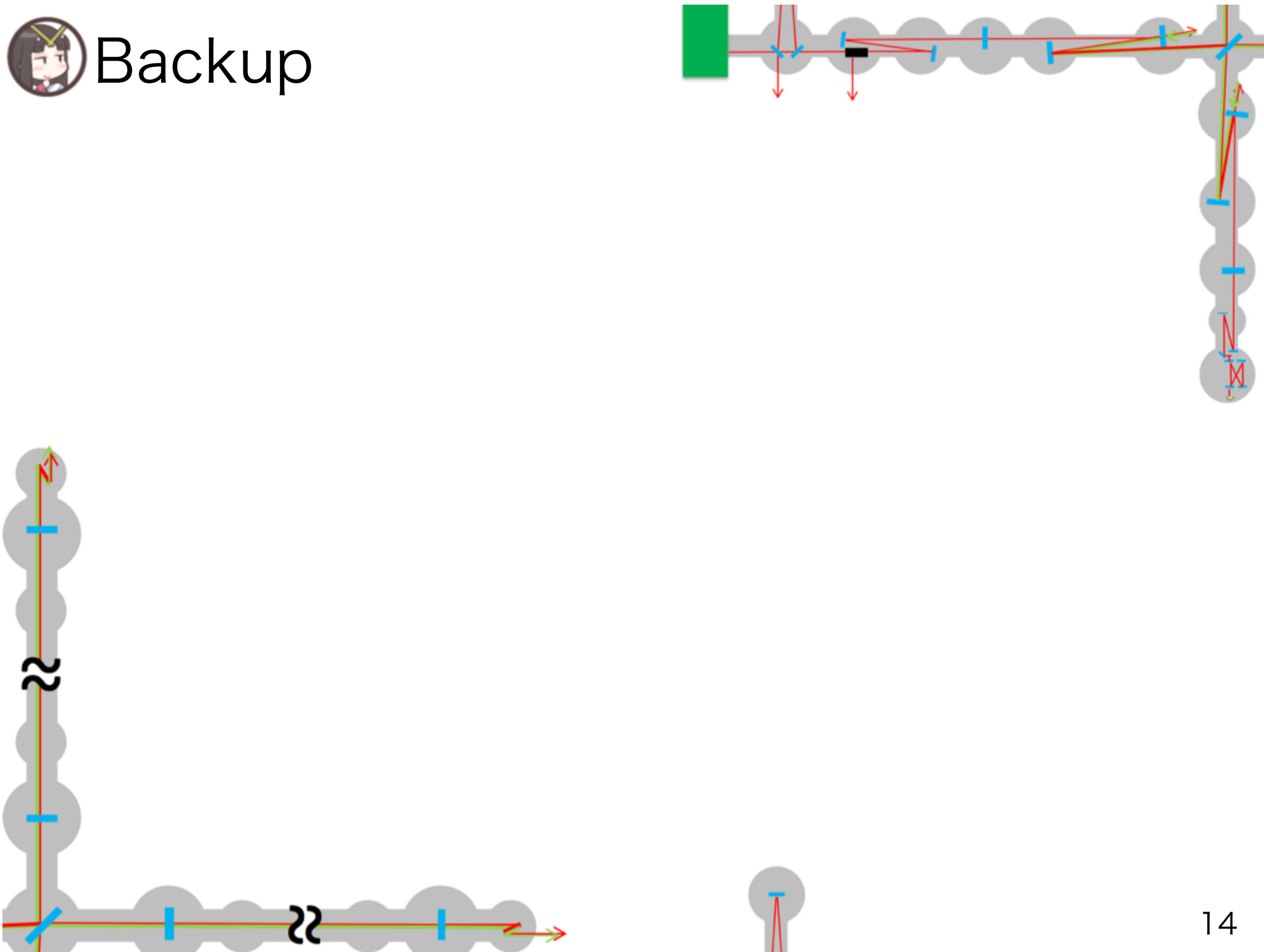
Summary

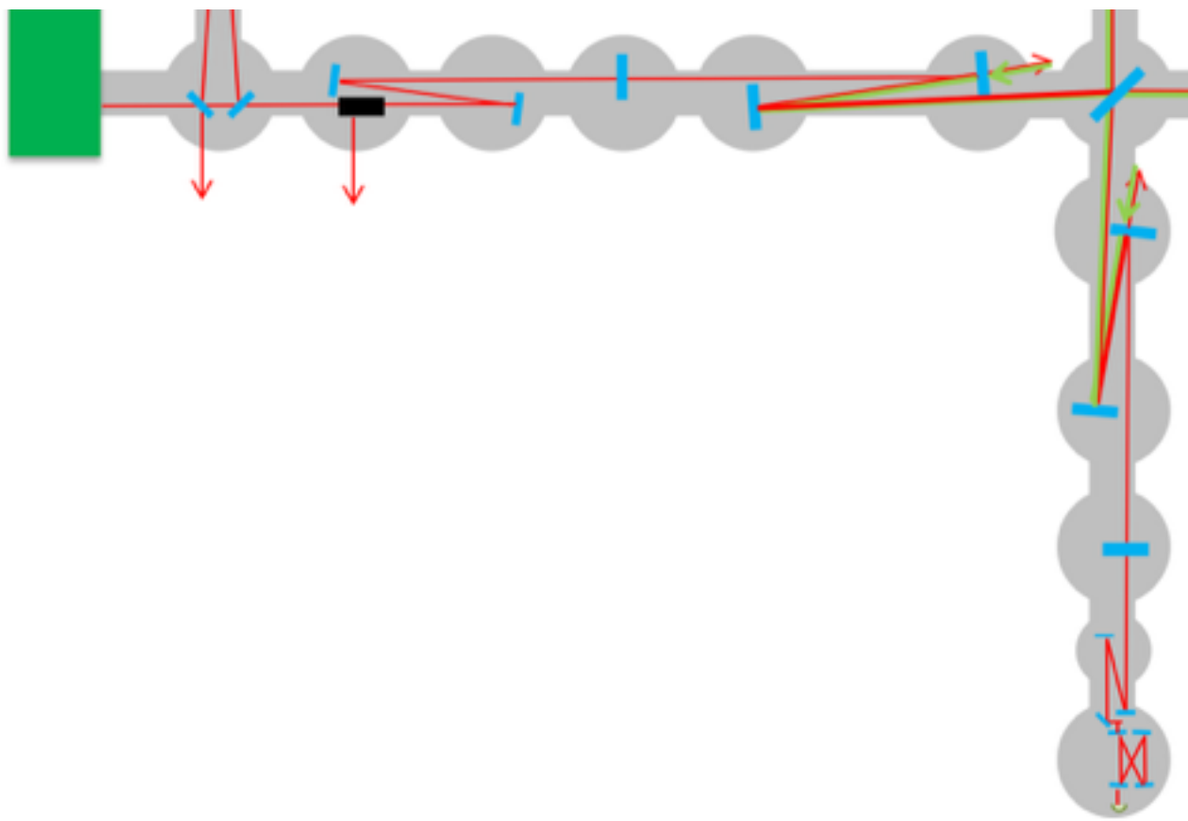


- Studying about the wave
  - Japanese wave information can be obtained from NOWPHAS
  - Wind waves and swells
  - Various scattered plot
  - Saturated wave
- Seasonal wave analysis
  - Generating histogram, but analysis is ongoing -> Future meeting
- Compare with KAGRA seismometer
  - Analysis is ongoing
  - Calculated KAGRA seismometer RMS and compared the significant wave height -> good reconstruction!
- Future analysis
  - Using the all harbor information
  - Spectrum analysis of KAGRA seismometer and comapre
  - and so on!

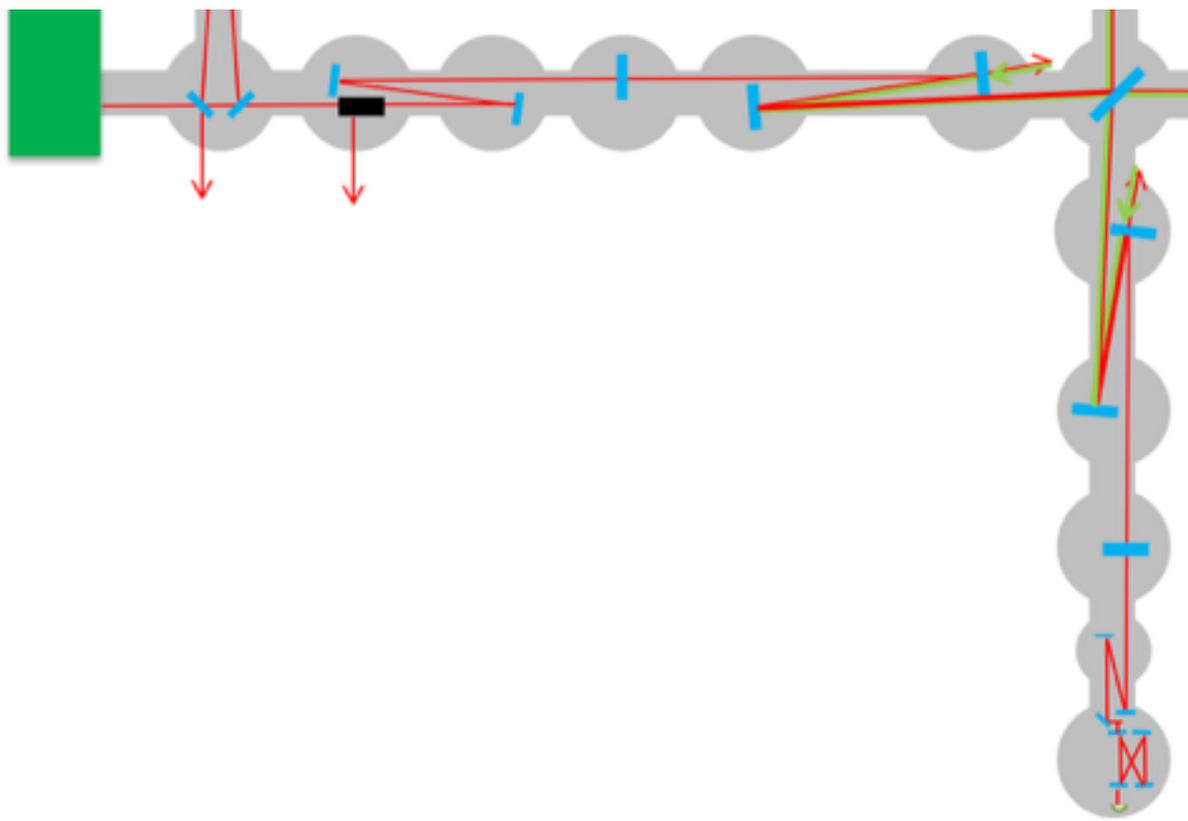


Backup





		日本海側					太平洋側			
		toyama	wajima	fukui	naoetu	tottori	omaesaki	kasima	simoda	murotu
日本海側	toyama	1.00	0.58	0.50	0.50	0.66	0.17	0.38	0.22	-0.01
	wajima	0.58	1.00	0.92	0.92	0.87	-0.02	0.25	0.34	0.03
	fukui	0.50	0.92	1.00	0.89	0.89	-0.01	0.24	0.39	0.06
	naoetu	0.50	0.92	0.89	1.00	0.80	-0.11	0.14	0.30	-0.04
	tottori	0.66	0.87	0.89	0.80	1.00	0.11	0.39	0.42	0.09
太平洋側	omaesaki	0.17	-0.02	-0.01	-0.11	0.11	1.00	0.35	0.70	0.57
	kasima	0.38	0.25	0.24	0.14	0.39	0.35	1.00	0.36	0.08
	simoda	0.22	0.34	0.39	0.30	0.42	0.70	0.36	1.00	0.55
	murotu	-0.01	0.03	0.06	-0.04	0.09	0.57	0.08	0.55	1.00



		日本海側					太平洋側			
		toyama	wajima	fukui	naoetu	tottori	omaesaki	kasima	simoda	murotu
日本海側	toyama	1.00	0.62	0.63	0.68	0.68	-0.09	0.12	0.10	-0.07
	wajima	0.62	1.00	0.87	0.80	0.78	-0.12	0.13	0.01	-0.20
	fukui	0.63	0.87	1.00	0.78	0.83	-0.14	0.12	0.02	-0.19
	naoetu	0.68	0.80	0.78	1.00	0.73	-0.15	0.08	0.01	-0.14
	tottori	0.68	0.78	0.83	0.73	1.00	-0.09	0.14	0.10	-0.12
太平洋側	omaesaki	-0.09	-0.12	-0.14	-0.15	-0.09	1.00	0.26	0.54	0.31
	kasima	0.12	0.13	0.12	0.08	0.14	0.26	1.00	0.34	0.01
	simoda	0.10	0.01	0.02	0.01	0.10	0.54	0.34	1.00	0.41
	murotu	-0.07	-0.20	-0.19	-0.14	-0.12	0.31	0.01	0.41	1.00