Meteorological analysis of waterspout phenomenon over Kepulauan Seribu October 23rd, 2017

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Abstract. On October 23rd, 2017 at 16.15 UTC or 09.15 LT a rare phenomenon of waterspout occured over Kepulauan Seribu. The waterspout identified as a short-lived waterspout because it lasted for 15 minutes. The local people of Kepulauan Seribu said that this rare phenomenon created a wind gust and high waves train as it moves. Eventhough this phenomenon just lasted for only 15 minutes but it was enough time to make local people frightened. Meteorological analysis was done by us to find out the natural trigger of the waterspout. We are using analitical method of research by using visual data from Himawari 8-EH satellite, weather radar from BMKG, radiosonde, streamline, sea surface temperature data, reanalysis model, and surface weather data from global, regional, and local scale. Based from the data and parameters, the waterspout was triggered by a very-local atmospherical unstabillity that made up a very-high convective *Cumulonimbus* cloud that developed the waterspout. Hopefully this research can be an additional reference for meteorological officer to make a waterspout early warning notice to reduce the hazard that made by waterspout to the local people of Kepulauan Seribu.

1. Introduction

Generally watersoput is a nonsupercell tornado over water formed by convective type cloud (Cumulonimbus, Cumulus) that usually destructive to its surrounding. The funnel diameters of waterspout range from a few up to 100 m or more; lifetimes average 5–10 minutes, but large waterspouts can persist for up to one hour. [AMS, 2012; Golden, 1971; Golden, 1974]. Joseph Golden describes five stages of waterspout development:

a. Dark spot. A prominent circular, light-colored disk appears on the surface of the water, surrounded by a larger dark area of indeterminate shape and with diffused edges.
b. Spiral pattern. A pattern of light and dark-colored surface bands spiraling out from the dark spot which develops on the water surface.
c. Spray ring. A dense swirling annulus (ring) of sea spray, called a cascade, appears around the dark spot with what appears to be an eye similar to that seen in hurricanes.
d. Mature vortex. The waterspout, now visible from water surface to the overhead cloud mass, achieves maximum organization and intensity. Its funnel often appears hollow, with a surrounding shell of turbulent condensate. The spray vortex can rise to a height of several hundred feet or more and often creates a visible wake and an associated wave train as it moves.
e. Decay. The funnel and spray vortex begin to dissipate as the inflow of warm air into the vortex weakens.

On October 23rd, 2017 at 16.15 UTC or 09.15 LT a rare waterspout phenomenon occured between the sea of Pulau Pramuka and Pulau Kelapa (5°41'52.8"S 106°34'58.8"W) that lasted for 15 minutes. The waterspout made up a wind gust and high waves that disrupt the activity of the local people around the area. Reported from the local people of Kepulauan Seribu there were three cells of waterspouts spotted. Kepulauan Seribu itself located in the north of Jakarta and Java Sea. Because of Kepulauan Seribu surrounded by sea, the weather dynamics there are dominated by local meteorological factor.

Figur 1. Three waterspout cell spotted in Kepulauan Seribu between the sea of Pulau Pramuka and Pulau Kelapa on October 23rd, 2017 at 16.15 UTC or 09.15 LT [10].

2. Observation Data and Research Method

2.1. Observation data

Observation Data were taken from index of sea surface temperature around Indonesia region on October 2017 from National Oceanic and Atmospheric Administration (NOAA); gradient mean sea level wind analysis from Australian Government Bureau Of Meteorology (BOM) on October 23rd, 2017, 00.00 UTC; visual data from Himawari 8-EH satellite October 23rd, 2017, 00.00-03.00 UTC; visual data from BMKG radar on October 23rd, 2017, 00.00-03.00 UTC; radiosonde analysis from Soekarno-Hatta Cengkareng Meteorological Station on October 23rd, 2017, 00.00 and 12.00 UTC; reanalysis meteorological model from Weather Research and Forecasting Analysis (WRF) on October 23rd, 2017 00.00 UTC from Badan Meteorologi Klimatologi dan Geofisika (BMKG); and surface air observation data from data Tanjung Priok Jakarta Utara Meteorological Station on October 22nd, 2107, 21.00-23.00 UTC and October 23rd, 2017, 00.00-03.00 UTC.

2.2. Research Method.

We are using a descriptive research method from the data and parameters from the meteorological factor. The analysis taken from the visual data and index of sea surface temperature, streamline, WRF, radiosonde, and surface air observation. The cloud type observation taken from top cloud temperature visual data of Himawar*i* 8-EH satellite and BMKG radar.

3. Results and Discussion

3.1. Satellite Analysis

The first analysis is focused on the movement from the cloud cell that indicated as a triggerer of the waterspout. Visual data is taken from Himawari 8-EH satellite from Badan Meteorologi Klimatologi

dan Geofisika (BMKG) on October 23rd, 2017, 00.00-03.00 UTC around Kepulauan Seribu. The visual data of Himawari 8-EH satellite shows us the top cloud temperature from 10.4 micro meters wave radiation and it is classified with contouring of colour, the black to dark blue colour shows us there is no significant formulation of cloud (no significant weather), and the yellowish-orange to red colour shows us the formulation of significant cloud. The more red colour spotted the colder temperature of the cloud will be, and the colder temperature of the cloud the higher height of the cloud that have the a high-potency of Cumulonimbus cloud forming on the area will occur. On Figure 2 we can see the development of Cumulonimbus by seeing the reddishorange contour with the top cloud temperature estimated on -60°C occured in the north east of Kepulauan Seribu at 00.00 UTC. The cloud were keep moving to the west and reached its maximum development over the sea of Kepulauan Seribu at 02.00 UTC or 09.00 LT, when at 09.15 LT three cells of waterspout were spotted in the area.

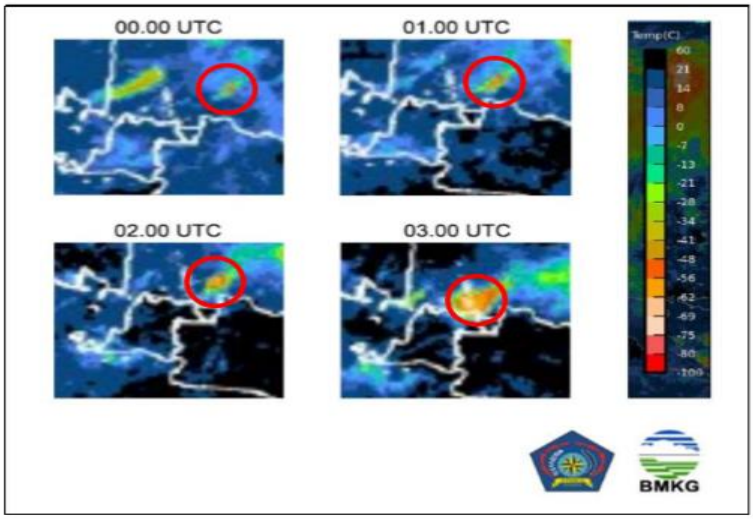

Figure 2. Visual data from Hmawari 8-EH satellite shows us the development of the *Cumulonimbus* cloud cell over Kepulauan Seribu on October 23rd, 2017 at 00.00-03.00 UTC.

3.2. Weather Radar Analysis.

The analysis method of the visual data from weather radar is the same with the analysis of Himawari 8-EH satellite above by seeing the development and the movement of the Cumulonimbus cloud. Figure 3 shows us the area that covered by Cumulonimbus cloud with the reddish-orange contour that indicates the top cloud temperautre is on the range of -50 to 58°C, on this range of temperature, the species of cloud that are formed is categorized as a high convective cloud that refers to *Cumulonibus* cloud.

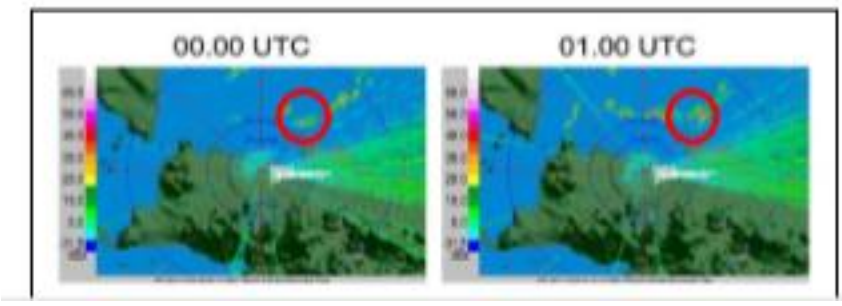

Figure 3. Visual data interpretation of weather radar from BMKG on October 23rd, 2017 at 00.00-03.00 UTC.

3.3. Surface Air Condition Analysis

The surface air condition at 02.00 UTC from Tanjung Priok Meteorological Station as the closest meteorological station from Kepulauan Seribu on Table 1 shows us this results: 6 octas coverage of clouds, with 4 octas coverage of low cloud Altostratus, calm surface wind, and the surface temperature is on 31,4 ^{o}C, relative humidity 54%, no significant weather, and the trend of air pressure shows no significant decreasing or increasing point which can make the atmosphere contition becomes unstable. In the other side on the nearly same time in Kepulauan Seribu there was a Cumulonimbus cloud cell that indicates an unstable atmosphere condition. This cloud cell above Kepulauan Seribu blew a high wind speed at 11-15 knots (based on Beaufort scale) that made up three waterspouts. The significant difference of atmosphere condition between the meteorological station and Kepulauan Seribu indicates the waterspouts were triggered by the very-local meteorological factor.

Table 1. Synoptic weather data from Tanjung Priok Meteorological Station on October 22nd23rd, 2017 (WMO number: 96741).

No.	DD/MM/YYY	Time (UTC)	Codes
1.	22/10/2017	21.00	AAXX 22214 96741 32556 70000 10279 20232 30098 40102 57001 82571 333 56000 82622 84361 806// 803//=
2.	22/10/2017	22.00	AAXX 22224 96741 42556 70000 10277 20228 30101 40105 83511 333 56000 83622 85461 806// 804//=
3.	22/10/2017	23.00	AAXX 22234 96741 42557 80000 10276 20226 30104 40108 83571 333 56000 83622 86461 806// 804//=
4.	23/10/2017	00.00	AAXX 23004 96741 32558 60000 10282 20226 30109 40113 51011 82511 333 20276 55100 55508 50078 56000 59010 82623 84462 806// 804//=
5.	23/10/2017	01.00	AAXX 23014 96741 42559 51604 10296 20236 30116 40120 81511 333 56000 81622 83462 806// 804//=
6.	23/10/2017	02.00	AAXX 23024 96741 42560 60000 10315 20240 30118 40122 84511 333 56000 84621 806//=
7.	23/10/2017	03.00	AAXX 23034 96741 32560 60404 10314 20249 30116 40120 52007 333 56000 57803 81820 83520 80857 805//=

3.4. Sea Surface Temperature Analysis

Another factor that gives the contribution to waterspout is sea surface temperature (SST). Figure 4 shows us the analysis of sea surface temperature on October 2017 taken from National Oceanic and Atmospheric Administration (NOAA). Generally in the Java Sea and Kepulauan Seribu are on warm

condition (26,6-32,1^{0}C). With the warm condition of the sea it will trigger the increasing of evaporation around the area that can form convective clouds.

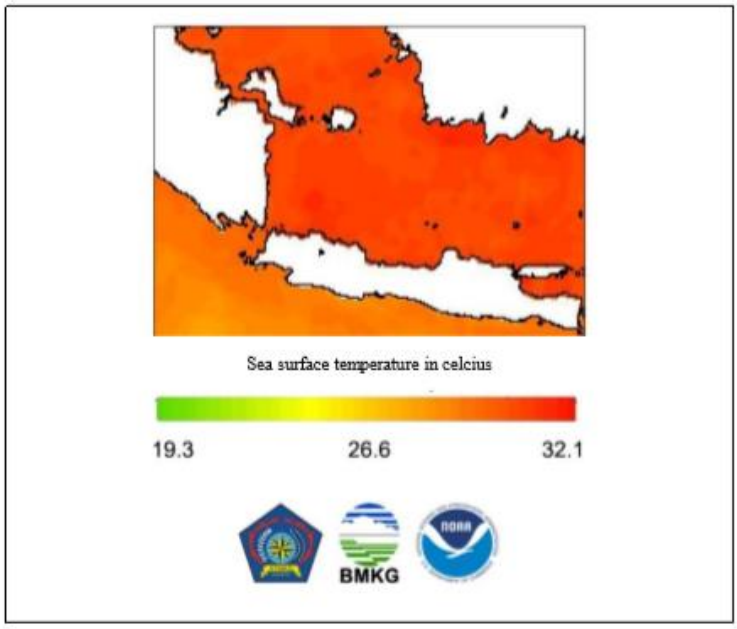

Figure 4. Sea surface temperature (SST) analysis around Java Sea on October 2017.

3.5. Radiosonde Analysis

Table 2. Radiosonde indexes analysis from Soekarno-Hatta Cengkareng Meteorological Station on October 21st – 23rd, 2017 (WMO number: 96749).

DD/MM/YYYY	Time (UTC)	SI	LI	KI	TT	SWEAT	CIN	CAPE
21/10/2017	00	1,66	-1,66	33,6	42,2	194,6	-90,4	766,2
	12	-4,30	-4,56	36,6	49,7	248,1	-72,9	1302
22/10/2017	00	0,15	-2	34,5	43,5	196,5	-64,5	785,7
	12	-2,57	-4,59	33,0	47,5	223,7	-49	1772
23/10/2017	00	-0,26	-0,99	19,8	43,7	212,7	-77,2	273

The waterspout occured on 09.15 LT (02.15 UTC) with the closest observation time of radiosonde is at 00.00 UTC. As seen from Tabel 2 the atmosphere condition is relatively stable, but it can be unstable if it injected by additional energy. This condition is explained by the CAPE index 273 (<500); CIN index -77,2 (between -10 to -100); LI -0,99 (between 0 to -2); SI -0,26 (between 0 to -3) that indicate the atmosphere condition could be unstable but it has to be supported by higher air parcel force. SWEAT index 212,7 (<300); TT index 43,7 (<45); and KI 19,8 (between 15 to 20) that indicate the activity of thundersorm is relatively weak.

3.6. Streamline Analysis

From Figure 5, we can see the air stream flows from 1010 mb high pressure spot in the north west of Australia to the lower pressure spot 1006 mb in the north east of Papua. The impact of that air stream flow is the air masses from Indonesia is forced to be pulled to the lower pressure spot, including the air masses in Kepulauan Seribu. We can see the significant 70o diversion of wind direction in Kepulauan Seribu at the speed of 20 knots. This diversion can cause the instability of the atmosphere condition.

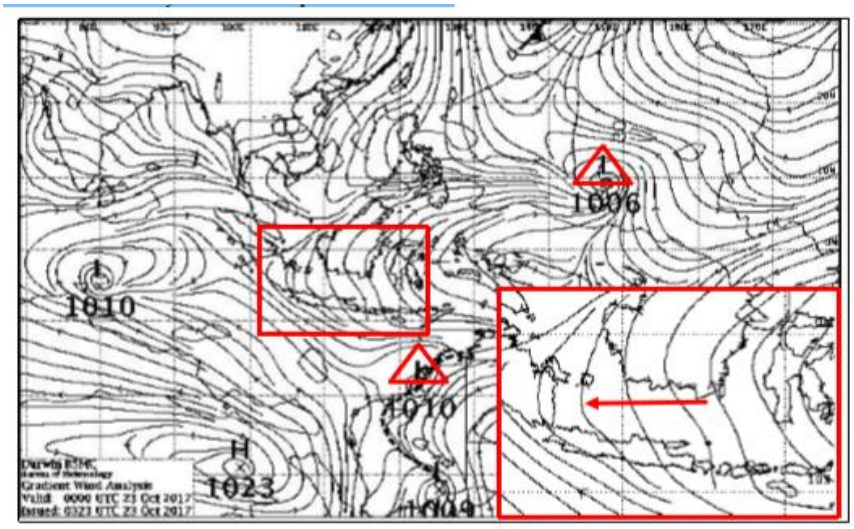

Figure 5. Streamline analysis from Bureau Of Meteorology (BOM) Australia on October 23rd, 2017 at 00.00 UTC.

3.7. Weather Research and Forecasting (WRF) Analysis

The next analysis is focused on WRF model taken from Badan Meteorologi Klimatologi dan Geofisika (BMKG) on October 23rd 2017 at 00.00 UTC analysis period. From **Figure 6** we can see the south east wind dominated over Kepulauan Seribu but in the south west of Java Sea (Kepulauan Seribu) the wind direction is distorted with the opposite direction at the maximum 15 knots wind speed. This variable wind direction indicates the sea breeze occured in that region. This sea breeze has enough energy to flow and bring the waterspout cells to get close into Kepulauan Seribu. From this case we can conclude that sea breeze as a very-local meteorological factor dominated the atmosphere dynamics near the sea shore of Jakarta and Kepulauan Seribu.

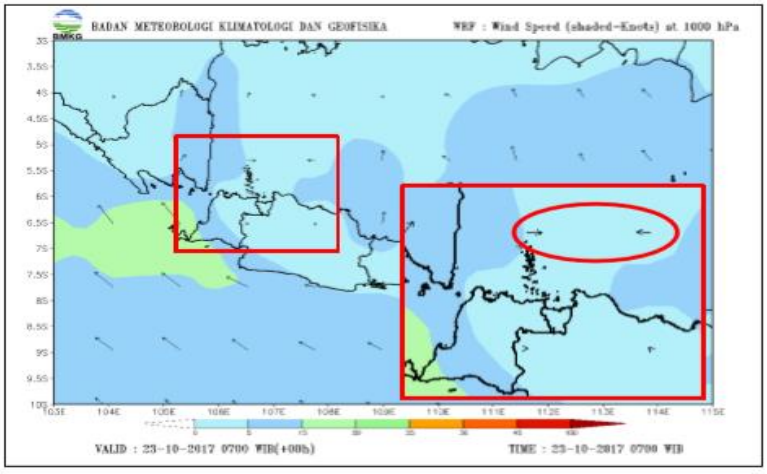

Figure 6. Weather Reasearch and Forecasting (WRF) analysis on October 23rd 2017 at 00.00 UTC.

3.8 Discussion

The waterspout occured in Kepulauan Seribu on October 23rd, 2017 at 09.15 LT or 02.15 UTC. The waterspout can be detected from the visual data of satellite, radar, streamline, and Weather Research and Forcasting (WRF). The development of the convective cloud started at 00.00 UTC and reached its maximum form at 03.00 UTC, with the top cloud temperature reached between -50 to -60

oC. On the range of that temperature indicates the instability of the atmosphere condition. This condition is well-correlated with the analysis of WRF model that shows the distortion of wind direction, it indicates the strong sea breeze that brings the waterspout cells closer to Kepulauan Seribu. From the streamline analysis we also found the diversion of wind direction that causes the condition around the area becomes unstable. From sea surface temperature analysis in general, in the Java Sea and Kepulauan Seribu are on warm condition (26,6-32,10C). With the warm condition of the sea it will trigger the increasing of evaporation around the area that can form convective clouds. But from the synoptic analysis from Tanjung Priok Meteorological Station and radiosonde analysis from Soekarno-Hatta Cengkareng there is no significant factor that can be the triggerer of the waterspout.

4. Conclusion

From the results and discussion, we can conclude that the waterspout was triggered by a very-local factor that brought closer to Kepulauan Seribu by sea breeze. The factor can be observed in satellite, weather radar, streamline, and WRF, but with synoptic and radiosonde observation the factor can't be observed, this could be happened because of the distance from the observation spot couldn't reach the actual range condition in Kepulauan Seribu.Other paragraphs are indented.

The waterspout phenomenon could occur suddenly even with a small index of lability. More intensive study of waterspout especially in Kepulauan Seribu is strrongly recommended. The sufficient number of weather observation instrument like Automatic Weather Station (buoy) is highly recommended to make the data more tightly so the weather forecast in Kepulauan Seribu can be more precise and accurate. With more precise and accurate weather forecast could make local people in Kepulauan Seribu feel safer and also can safe more lives of thousand fisherman that do their daily bussiness around the sea of Kepulauan Seribu.

References

[1] AMS Glossary-American Meteorological Society 2012 *Waterspout* Available at: http://glossary.ametsoc.org/wiki/Waterspout/
[2] Golden J H 1971 Waterspouts and Tornadoes over South Florida *Monthly Weather Rev.* **99** 146
[3] Golden J H 1974 The Life Cycle of Florida Keys' Waterspouts I *J. App. Meteorol.* **13** 676
[4] SE Asia-Australian Government Bureau Of Meteorology 2017 *Gradient Wind Analysis (Manual)* Available at: http://www.bom.gov. au/cgi-bin/charts/charts.browse.pl
[5] Badan Meteorologi Klimatologi dan Geofisika 2017 *Himawari 8 EH* Available at: http://www.bmkg.go.id/satelit
[6] Badan Meteorologi Klimatologi dan Geofisika 2017 *Index Of WRF Indonesia* Available at: http://diseminasi.meteo.bmkg.go.id/ WRF/indo_201710/ 201710230000/indonesia
[7] Mihaljovic J, et al 2016 Tornadic Waterspout Event in Split Croatia–Analysis of Meteorological Environment *J. Geographical Institute* **66 (2)** 185
[8] Putri A R, et al 2015 Description Of Atmospheric Parameters due to Waterspout in Tarakan August 26th 2015 (North Kalimantan-Indonesia) *The 6th International Symposium for Sustainable Humanosphere Science School 2016* **6** pp 64-69
[9] National Oceanic and Atmospheric Administration 2017 *Sea Surface Temperature Analysis October 2017* Available at: http://polar.ncep.noaa.gov/sst
[10] Anonim 2017 *Three Waterspout Spotted in Kepulauan Seribu on October 23rd, 2017* Available at: https://akcdn.detik.net.id