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by Muhammad Irfan

Submission date: 19-Jul-2020 05:25PM (UTC+0700)

Submission ID: 1359294520

File name: Irfan_2020_J._Phys.__Conf._Ser._1568_012028-1.pdf (909.93K)

Word count: 2477

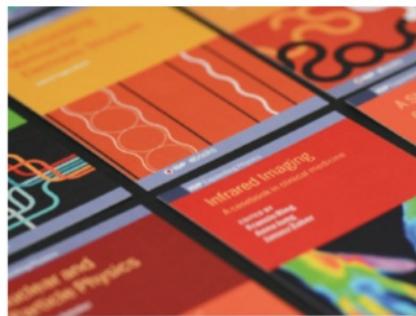
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To cite this article: M Irfan *et al* 2020 *J. Phys.: Conf. Ser.* **1568** 012028

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Study of groundwater level and its correlation to soil moisture on peatlands in South Sumatra

M Irfan^{1,2*}, N Kurniawati^{1,2}, M Ariani¹, A Sulaiman³ and I Iskandar^{1,2}

¹Department of Physics, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia,

²Graduate School of Sciences, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia,

³Agency for Assessment and Application Technology, Jakarta, Indonesia

*iskhaq.iskandar@gmail.com; irfplg@yahoo.com

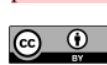
Abstract. Hydrological and climatological parameters in several locations on peatlands in South Sumatra have been measured directly by a system called Sensory data transmission Service Assisted by Midori Engineering laboratory (SESAME). The parameters are rainfall, temperature, soil moisture, and groundwater level. This research has studied the groundwater level fluctuations and looks for the correlation between groundwater level and soil moisture in four locations, namely Saleh River 1 (SR1), Saleh River 2 (SR2), Lumpur River 1 (LR1), and Lumpur River 2 (LR2). The results are expected to be useful for fire disaster mitigation on peatlands, especially in South Sumatra. Based on time series data of groundwater level, the results show that there has been a sharp decrease in groundwater level at locations SR1, SR2, and LR1. The statistic calculation results show that groundwater level has a significant correlation with soil moisture in four study sites. The correlation coefficients obtained for SR1, SR2, LR1, and LR2 are $r = 0.88, 0.97, 0.87$ and 0.92 , respectively.

1. Introduction

Peatlands are water saturated soils and consist of organic material with a thickness of more than 50 cm. The area of tropical peatlands in the world is around 40 million hectares, of which 50% are in Indonesia. Peatlands in Indonesia are mainly spread on the islands of Sumatra, Kalimantan, Sulawesi and Papua. The area of peatlands in South Sumatra is around 8.7 million hectares [2–7].

Peatland is very flammable, including in Indonesia especially in the dry season [8,9]. The impact of this fire incident is very detrimental to public health, especially those on the islands of Kalimantan and Sumatra [8, 10–12]. In an effort to mitigate fire disasters, the government of the Republic of Indonesia in collaboration with the Japanese government has installed a system of monitoring and direct measurement in the field of hydrology and climatology parameters at several locations on peatlands in Indonesia including in South Sumatra. This measurement system is called Sensory data transmission Service Assisted by Midori Engineering laboratory (SESAME) [13]. The parameters measured are rainfall, groundwater level, soil moisture, and temperature.

Hydrological parameters that are closely related to fire events in peatlands are groundwater level and soil moisture [14–20]. The lower the water level and the lower the soil moisture value, the peat land will be more flammable [15,21]. Research related to the characteristics and correlations between these two parameters needs to be done in an effort to provide input for parties related to fire disaster mitigation

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efforts. Previous research related to the correlation of climatological hydrological parameters is: a strong correlation between GWL and RF [22,23], a linear correlation between GWL and SM [4], a strong correlation between RF and SM in low soil layers [24]. This study has examined the characteristics of groundwater level fluctuations and look for correlations between the groundwater level and soil moisture in peatlands in South Sumatra based on SESAME measurement data.

2. Data

The data used in this study are groundwater level and soil moisture derived from SESAME measurement data for the period of July 1, 2017 to August 5, 2019. Data was collected at 4 locations namely Saleh River 1 (SR1), Saleh River 2 (SR2), Lumpur River 1 (LR1), and Lumpur River 2 (SR2). The coordinate points for the locations SR1, SR2, LR1 and LR2 are: (- 2,911, 105,082), (-2,677, 105,143), (-3.143, 105,184), and (-3.458, 104,921). The map of study location is shown in Figure 1.

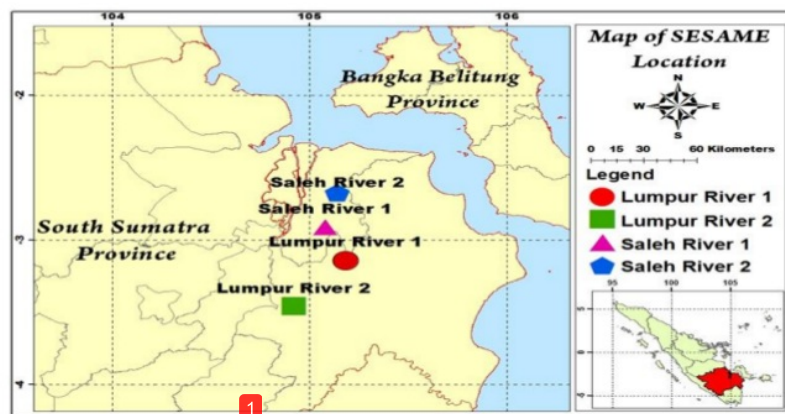


Figure 1. Map of study location.

3. Methodology

The steps of this study consist of: download data from the SESAME website, make a time series graph of groundwater level parameters, determine the linear regression equation that states the relationship between groundwater level and soil moisture using the equations of (1) - (3), determine the correlation coefficient between the two parameters using equation of (4), and determine the significance of the correlation between the two parameters using equation (5)[25]–[30].

3.1. Linier regression n

The general form of linier regression is:

$$y = a + bx, \tag{1}$$

$$a = \frac{(\sum y \sum x^2) - (\sum x \sum xy)}{N(\sum x^2) (\sum x)^2}, \tag{2}$$

$$b = \frac{N(\sum xy) - (\sum x \sum y)}{N(\sum x^2)(\sum x)^2}, \tag{3}$$

where y is a dependent variable, x is an independent variable, a is intercept and b is slope.

3.2. Linier correlation

The mathematical formula for calculating the value of the correlation coefficient (r) is:

$$r_{xy} = \frac{1}{N-1} \sum_{i=1}^N \frac{(x_i - \bar{x})(y_i - \bar{y})}{s_x s_y}, \quad (4)$$

where s_x and s_y are standard deviation for each variables of (x, y) .

3.3. t test

The equation for calculating the value of t test is

$$t = r_{xy} \sqrt{\frac{n-2}{1-r_{xy}^2}}, \quad (5)$$

where r_{xy} is the correlation coefficient obtained and n is the amount of data. If the t test value is greater than t table then the correlation between the two variables is significant.

4. Result and discussion

A time series graph of fluctuations in groundwater level values in the four study sites is shown in Figure 2. The results of statistical calculations on linear regression equations and correlation coefficients are shown in Figure 3.

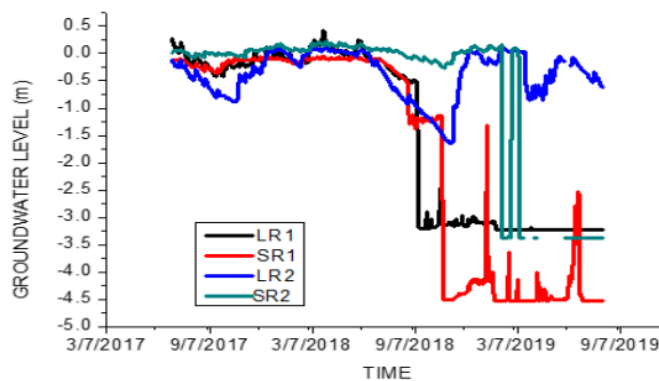


Figure 2. The time series graph of groundwater level data on four location of research: LR1, SR1, LR2, and SR2.

Figure 2 shows a sharp decrease in groundwater level values in 3 study sites SR1, SR2, and LR1. Whereas in LR2 the value of GWL did not decrease significantly. This decline began to occur in November 2018 for the SR1 location, in February 2019 for SR2, and September 2018 for LR1. The decline in the value of groundwater level is likely due to the lack of rainfall from the end of 2018 until October 2019. The decline in the value of this ground level can also occur due to the creation of illegal canals that drain water from peatlands into a plantation [5]. In order to understand the exact cause, further comprehensive research is needed on this incident.

Figure 3 shows the correlation coefficient (r) value between groundwater level and soil moisture for the four study sites that are $r = 0.88, 0.97, 0.87$ and 0.92 respectively for SR1, SR2, LR1, and LR2. All r values obtained are close to 1 and this indicates a strong correlation between the two parameters. The t test that was carried out resulted in the value of t test = 48.37, 116.80, 47.81, and 63.96 for SR1, SR2, LR1, and LR2, respectively. This study uses 725 data, 2 variables, and degrees of freedom 0.05 so that the value of t table is 1.96 is obtained. Because the t test values for the four study sites are greater than the t table values, the correlation between groundwater level and soil moisture at the four locations is significant. To predict groundwater level values based on soil moisture values, we can use equations in Figure 3 that are $y = 19.029x + 125.21$, $y = 22.622x + 88.977$, $y = 29.162x + 120.94$, and $y = 63.152x$

+ 111.6, respectively for SR1, SR2, LR1, and LR2, where y is groundwater level and x is soil moisture. Statistical results are summarized in Table 1.

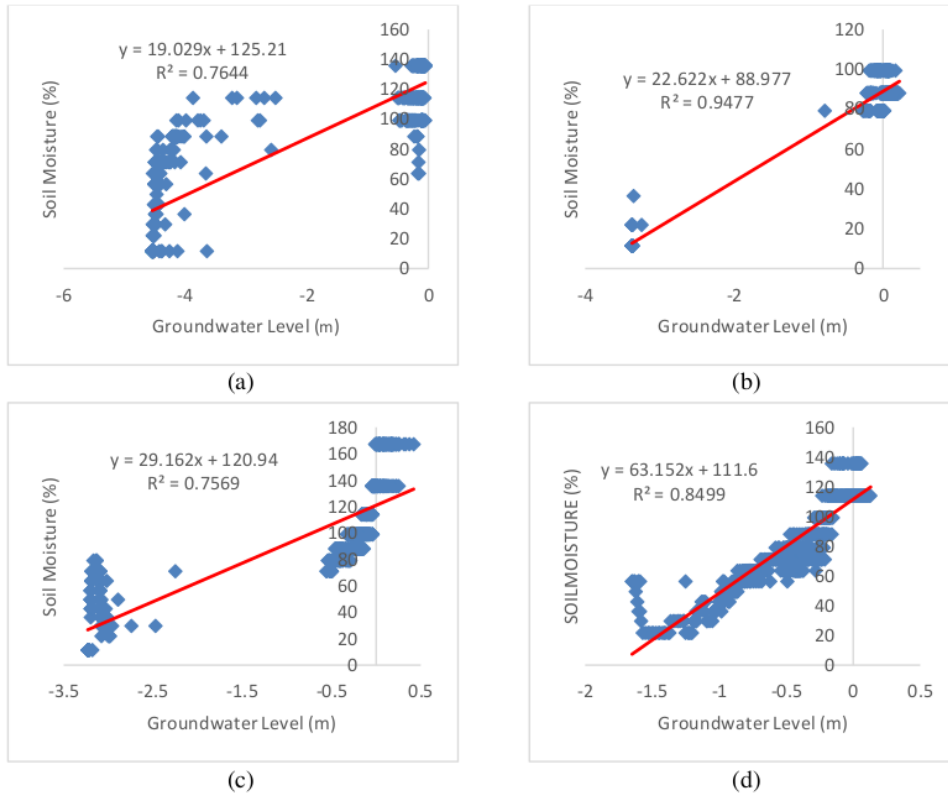


Figure 3. The linier regression graph of relationship between groundwater level and soil moisture on four location of research: (a) SR1, (b) SR2, (c) LR1, (d) LR2.

Table 1. The summary of the results of statistical calculations

Parameter	SR 1	SR 2	LR 1	LR 2
r	0.88	0.97	0.87	0.92
t test value	48.37	116.80	47.81	63.96
t table value	1.96	1.96	1.96	1.96
Correlation	significant	significant	significant	significant

5. Conclusion

The analysis shows that there has been a sharp decline in groundwater levels at the sites of Saleh River 1, Saleh River 2, and Lumpur River 1. This sharp decrease was due to minimal rainfall in the period. There is a possibility of this decline due to the canal which is near the measurement station that causes the peatland water level to fall, so that further research is needed to examine the cause of this sharp peatland water level drop. It has also been found that there is a significant correlation between groundwater level and soil moisture in the four research locations so that the empirical linear regression equation that has been obtained can be used to predict groundwater level values based on soil moisture values and vice versa.

Acknowledgements

We thank to Sriwijaya University for supporting this research activity through the Hibah Unggulan Kompetitif 2019 for the first author and a Hibah Unggulan Profesi 2019 for the last author. We also thank the Peatland Restoration Agency for providing SESAME data.

References

- [1] Hidayat H *et al.* 2017 Hydrology of inland tropical lowlands: The Kapuas and Mahakam wetlands *Hydrol. Earth Syst. Sci.* **21** 2579
- [2] Osaki M and Tsuji N 2015 *Tropical peatland ecosystems* Mitsuru Osaki (Sapporo Japan: Springer) pp 1–651
- [3] Kobayashi S 2015 Peatland and peatland forest in Brunei Darussalam *Tropical Peatland Ecosystem*, ed Mitsuru O and Nobuyuki T (Springer, Tokyo) pp 75-89
- [4] Hamada Y, Tsuji N, Kojima Y, Qirom M, Sulaiman A, Firmanto, Jagau Y, Irawan D, Naito R, and Sari 2016 *Guidebook for estimating carbon emissions from tropical peatlands in Indonesia* (Jakarta: Indonesia-Japan Project for Development of REDD+ Implementation Mechanism, Technical cooperation project between Ministry of Environment and Forestry Indonesia and Japan International Cooperation Agency) p. 47.
- [5] Ananto E E 2017 *Pengolahan lahan gambut di Provinsi Sumatera Selatan* (Palembang: Badan penelitian dan Pengolahan Pertanian) pp. 195-197
- [6] Millar D J, Cooper D J, and Ronayne M J 2018 *J. Hydrol.* **561** 908
- [7] Iriana W *et al.* 2018 *Indonesia Sci. Rep.* **8** 1
- [8] More S, Evans C D, Page S G, Garnet M H, Jones T G, Freeman C, Hooijer A, Wiltshare A J, Limin S H, and V. Gauci 2013 *Nature* **493** 660
- [9] Sloan S, Locatelli B, Wooster M J, and Gaveau D L A 2017 *Glob. Environ. Chang.* **47** 95
- [10] Iskandar I, Utari P A, Lestari D O, Sari Q W, Setiabudidaya D, Khakim M Y N, Yustian I, and Dahlan Z 2017 *AIP Conf. Proc.* **1857** 1
- [11] Margono B A, Potapov P V, Turubanova S, Stolle F, and Hansen M C 2014 Primary forest cover loss in indonesia over 2000-2012 *Nat. Clim. Chang.* **4** 730
- [12] Lestari D O, Sutriyono E, Sabaruddin, and Iskandar I 2018 *J. Phys. Conf. Ser.* **1011** 1
- [13] Shigenaga Y, Takashi H, Teguh R, Kencana W, Yokoyama S, Adi J 2013 *Proceedings of International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia* (Indonesia) pp 207-212
- [14] Reeve A S, Warzocha J, Glaser P H, and Siegel D I 2001 *J. Hydrol.* **243** 91
- [15] Aguilera H, Moreno L, Wesseling J G, Jiménez-Hernández M E, and Castaño S 2016 *Catena* **147** 709
- [16] Wang Y, Yang J, Chen Y, De Maeyer P, Li Z, and Duan W 2018 *Sci. Rep.* **8** 1
- [17] Melling L, Katimon A, Joo G K, Uyo L J, and Sayok A 2013 Hydraulic Conductivity and Moisture Characteristics of Tropical Peatland Preliminary Investigation (*Preprint* <https://www.researchgate.net/publication/257268967>)
- [18] Li B, Wang L, Kaseke K F, Li L, and Seely M K 2016 *PLoS One* **11** 1
- [19] Tekeli A E and Fouli H 2017 *Water Resour. Manag.* **31** 1243
- [20] Iiyama I, Osawa K, and Nagai T 2012 *Soil Sci. Plant Nutr.* **58** 543
- [21] Nuruddin A A, Leng H M, and Basaruddin F 2006 *Journal of Applied Sciences* **6** 2517
- [22] Fistikoglu O, Gunduz O, and Simsek C 2016 *Water Resour. Manag.* **30** 5625
- [23] Abdullahi M G and Garba I 2016 *J. Remote Sens. GIS* **4** 1
- [24] Wang H, Gao J E, Zhang M J, Li X H, Zhang S L, and Jia L Z 2015 *Catena* **127** 80
- [25] Irfan M, Mardiansyah W, Khakim M Y N, Ariani M, Sulaiman A, Iskandar I 2019 *Int. J. GEOMATE* **17** 124
- [26] Irfan M, Mardiansyah W, Ariani M, Sulaiman A, and Iskandar I 2019 *J. Phys. Conf. Ser.* **1282** 1

- [27] Kim T K 2015 *Korean Journal of Anesthesiology* pp 1-7
- [28] Holden J and Burt T P 2003 *Hydrol. Process.* **17** 1227
- [29] Ateş C, Kaymaz O, Kale H E, and Tekindal M A 2019 *Comput. Math. Methods Med.* **2019** 1
- [30] Gerald B 2018 *Int. J. Appl. Math. Theor. Phys.* **4** 50

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