Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

Article

Solar Activity Cycles Recur Epidemic and Pandemic Viruses: Space Weather's Alerts

Ramy Mawad [1,*], Hanafy M. Madbouly [2], Essam Ghamry [3] and Ehab M. B. Mahdy [4]

[1] Astronomy & Meteorology Department, Faculty of Science, Al-Azhar University, Nasr City, Cairo, 11488, Egypt; ramy@azhar.edu.eg .
[2] Faculty of Veterinary medicine, Beni Suef University; hmmadbouly@gmail.com
[3] National Research Institute of Astronomy and Geophysics, Helwan 11421, Cairo, Egypt; essamgh@nriag.sci.eg.
[4] Agricultural Research Center, National Gene Bank, Giza, Egypt; ehabmawad@gmail.com.
* **Correspondence**: ramy@azhar.edu.eg

Abstract: In this paper, we study pandemic viruses that spread during the period (1759-2020). Our findings and results include the following: (1) the pandemic severity level has a negative correlation with the strength of solar activity; (2) pandemic viruses have three types according to their compatibility with solar activity association. Most of them spread through the quiet Sun, where viruses survive better in cold and rainy weather; (3) the emergence of new strains of influenza viruses was manifested in two ways. First, the annual epidemics due to antigenic drift. Second, pandemics recur at 1-12 solar cycles (~11-120 years) due to new virus subtypes resulting from virus reassortment; (4) pandemic viruses have two groups according to their recurring period: first, recurring in nine solar cycles; second, recurring in twelve solar cycles. Furthermore, we reassortment pandemic viruses from their previous spread in the same periodic classification. Moreover, we derivative a periodicity formula of each subtype of pandemic viruses as spread date.

Keywords: Space weather; Solar terrestrial connection; Climate change; Solar cycle; Environment; Epidemiology

1. Introduction

Astronomically, the annual spread of seasonal epidemic virus' depends on annual seasons which depends on the inclination of Earth's equator on the ecliptic plane, or the projection angle of sunlight on Earth. On the same day of each year, the slope of the sunlight (i.e. the altitude angle of the Sun) is approximately the same. However, the weather is not the same. Because the climate is varying according to interior and exterior factors. The solar activity is the important exterior factor. The solar activity varies, and it has a cycle called "solar cycle". The shortest solar cycle is about 11 years. Most of the subtypes of viruses that spread in the winter season annually, called "epidemic virus". Some viruses are not spread seasonally in each year, but it spreads on irregular long periods. These viruses are called "pandemic virus''. Previous studies correlated the pandemic viruses with solar activity especially at quiet Sun (called solar minimum too) (Tapping et al., 2001; Potter, 2001; Yeung, 2006; Vaquero and M.C.Gallego, 2007; Karim et al., 2011; Karim and Abbas, 2014; Towers, 2017; Wickramasinghe et al., 2017; Qu and Wickramasinghe, 2020). Tapping et al. (2001) added a mathematical function to predict the spread time of pandemic viruses according to the nearest sunspot maximum. The solar activity provides an environment sometimes suitable for virus's spread.

The cyclic variations of solar irradiance are found correlated with the mean daily sunspot number (Erlykin and Sloan, 2009). The solar ultraviolet radiation (UV) that is not suitable for viruses is varying with solar activity too. The authors of (Lytle, 2005) suggests that the inactivation of viruses in the environment by solar UV radiation plays a role in the seasonal occurrence of influenza. The ultraviolet A radiation (UVA) in sunlight is much less photochemically active and therefore generally less harmful than ultraviolet B radiation (UVB) (de Gruij and der Leun, 2000). Solar activity causes a suitable environment for viruses on Earth (Schubert et al., 2019), impacting on the geomagnetic field and causing

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

geomagnetic disturbance (Mawad et al., 2014). In addition, Schubert et al., (2019) found that magnetically guides virus stamping for the targeted infection of single or groups of cells. They found that gene's cells are exposed to a weak magnetic field (MF). Extremely low frequency weak magnetic fields enhance the resistance of NN tobacco plants to the tobacco mosaic virus and elicit stress-related biochemical activities (Zaporozhan, 2010).

Maunder Minimum can give the effect of solar activity on Earth's climate during the period between 1650-1715 where there was very little sunspot activity (Trebbi et al., 2007). Thus, solar activity was coupled to climate and led to tabulations of sunspot number as an indication of solar activity. The authors of (Feulner, 2011) concluded that the solar changes have contributed to small climate oscillations occurring on time scales of a few centuries. The authors of (Friis-Christensen and Lassen, 1991; Bard and Frank, 2006; Erlykin et al., 2009; Feulner, 2011; Yousef, 2000, 2014, 2011a, 2011b; Mawad, 2015, 2018; Zhen et al., 2018; Yousef et al., 2018) investigated the correlation between solar activity and global temperature. Tapping et al., (2001) studied the variation of global temperature with solar activity. They found the globally averaged rate of ionization produced by cosmic rays in the atmosphere. Additionally, they found that long term variations in the global average surface temperature have a similar cyclic component. NASA (1999) reported that the variation of both air temperature and water vapor pressure have similar behavior and parallel approximately. Zhen et al. (2018) demonstrated that the phenomenon of global warming is caused by excessive CO_2 emissions, while Mawad (2015) and Mawad et al. (2018) found that the current rising trend in the concentration of greenhouse gases including CO_2 is natural and correlates with solar activity and Earth's orbit.

Several scientists assumed that we are going to a cold epoch or little ice age according to the association between solar activity and climate change (Friis-Christensen and Lassen, 1991; Yousef, 2000; Yeung, 2006; Akasofu, 2010; Yousef, 2011a, 2014). The Earth is going to a cooling epoch. This climate change corresponds to the Gleissberg cycle which is reaching 80-120 years (Yousef, 2011a, 2014).

Viruses survive better in cold weather because it has a protective gel-like coating that allows it to survive in the air and be passed from person to person. During the past 300 years, 10 pandemics have occurred. The point of origin was suggested as China, Russia, and Asia. The analytic data indicates that Europe and America are considered a focus of spreading especially in the winter season (Potter, 2001).

The interval of time between pandemics varies from a decade (1889–1900 and 1957–1968) to some 50 years (1729–1733 and 1781–1782); the interval has not significantly increased or decreased over time, suggesting that increased population and travel are not determining factors. The interval between pandemics in the period from 1700 to 1889 is approximately 50–60 years and for the period since 1889 is 10–40 years (WHO, 2009). Therefore, be shortening. It is unrewarding to attempt to seek a pattern for pandemics that will allow predictions, but it is self-evident from the history of pandemics that each year that passes brings the next pandemic one year closer. The World Health Organization (WHO), believe that the world was closer to another influenza pandemic than it has been any time since 1968 when the last of the 20th century three pandemics swept the globe. The March 2005 plan includes guidance on roles and responsibilities in preparedness and response; information on pandemic phases; and recommended actions for before, during, and after a pandemic (WHO, 2009).

The new era beginning from the third thousand years, started from the year 2000, indicates new types of pandemics otherwise flu pandemics. Three types of coronaviruses pandemics occurred during 2003–2004 (SARS), 2013–2014 (MERS), and 2019–2020 (COVID-19) as mentioned by (WHO, 2009). Nevertheless, the scientists did not predict the accurate spread time of coronavirus COVID-19, when and where? Epidemics viruses such as all types of influenza were discovered to be spreading at certain times each year. It is a temporal and spatial phenomenon (Shek and Lee, 2003). Viboud et al. (2006) found epidemics have recurred with a highly predictable seasonal pattern, which is felt predominantly during the winter months. They stated that, in northern latitudes, influenza viruses circulate from November to March, while in the southern hemisphere influenza occurs primarily from May to September. Potter (2001) studied the annual epidemics and found the spread epidemic viruses coinciding with the rainy season.

Few studies correlated the spread of pandemic viruses with solar activity. They found that some subtypes of the pandemic viruses are spread through the quiet Sun (solar minimum) (Tapping et al., 2001; Potter, 2001; Yeung, 2006; Vaquero and M.C.Gallego, 2007; Karim et al., 2011; Karim and Abbas, 2014; Towers, 2017; Wickramasinghe et al., 2017; Qu and Wickramasinghe, 2020). In this paper, we discuss the correlation of pandemic viruses to solar activity cycles and we suggest an accurate prediction model for specific subtypes of pandemic viruses. The paper can be organized as follows. In Section 2, pandemic viruses are described. The predictions of the pandemic year are presented in section 3.

In Section 4 we give seasonal epidemic viruses. We discuss the results and present the conclusions of this paper in section 5.

2. Pandemic viruses

The smallest solar activity cycle, as manifested by the 11-years variation in the number of spots and faculae, has been observed systematically since 1749. Sunspots are now available since approximately 1750 at Royal Observatory of Belgium, Brussels (WDC-SILSO). Here in the current study, we depend on this observed data, where the Maunder Minimum appears, a period where the solar activity was practically null. The intensity of the activity cycle, as measured by its peak in the annual mean sunspot count, is not the same from one cycle to another. The inspection of figure 1 (blue curve) reveals the modulation of the envelope of the maxima of about 80-120 years. This period is known as the Gleissberg cycle Yeung (2006).

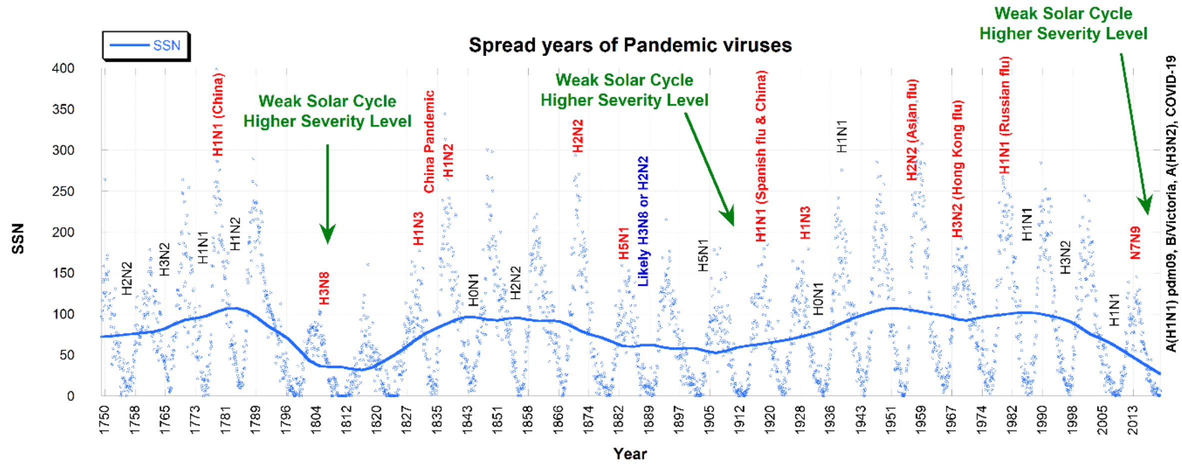

Figure 1: The lower panel is the sunspot numbers SSN, blue points are the SSN, and it is smoothed lined in the blue line. Pandemic viruses marked by black and red for that occurred during quiet Sun and active Sun, respectively.

Table 1 contains a list of pandemic viruses that are recurring or repeating within each solar activity. We notice that pandemic viruses such as influenza or coronaviruses correlate with solar activity. We found that most of these pandemic viruses were spread during the quiet Sun. This result agrees with previous studies of Tapping et al. (2001) which have studied fewer pandemic cases than us. But we found some of these viruses were spread during active Sun too, they did not report that. We found that the pandemic viruses which have higher severity of pandemic are spread during weaker solar cycles, especially in the Gleissberg cycle, such as the periods 1800-1820, 1900-1920, and 2020.

Table 1: Spread times of pandemic viruses, collected by authors from Tapping et al. (2001), Potter (2001); Towers (2017), and Viboud et al. (2006), and solar activity data collected from concrete data by SILSO, NASA.

Solar Cycle	pandemic Infections at quiet Sun			pandemic Infections at active Sun			Start (Minimum)	Smoothed minimum ISN (start of cycle)	Maximum	Smoothed maximum ISN	Time of Rising (years)	Duration (years)	Spotless days
	Subtype	Name	Year	Subtype	name	Year							
1	H2N2		1759				1755-02	14.0	1761-06	144	6.3	11.3	
2	H3N2		1767				1766-06	18.6	1769-09	193	3.3	9.0	
3	H1N1		1776	H1N1	China (Autumn)	1781–1782	1775-06	12.0	1778-05	264	2.9	9.3	
4	H1N2		1791				1784-09	15.9	1788-02	235	3.4	13.6	
5							1798-04	5.3	1805-02	82	6.8	12.3	
6	H3N8		1808				1810-08	0.0	1816-05	81	5.8	12.8	
7	H1N3		1831				1823-05	0.2	1829-11	119	6.5	10.5	
8	China (winter)		1830–1833	H1N2		1837	1833-11	12.2	1837-03	245	3.3	9.7	

 doi:10.20944/preprints202208.0046.v1

9	H0N1		1948				1843-07	17.6	1848-02	220	4.6	12.4	
10	H2N2		1858				1855-12	6.0	1860-02	186	4.2	11.3	561
11				H2N2		1873	1867-03	9.9	1870-08	234	3.4	11.8	942
12				H5N1		1886	1878-12	3.7	1883-12	124	5.0	11.3	872
13	Likely H3N8 or H2N2	1889–1890 flu pandemic	1889–1890				1890-03	8.3	1894-01	147	3.8	11.8	782
14	H5N1		1904				1902-01	4.5	1906-02	107	4.1	11.5	1007
15				**H1N1**	Spanish flu & China	**1918–1920**	1913-07	2.5	1917-08	176	4.1	10.1	640
16				H1N3		1930	1923-08	9.4	1928-04	130	4.7	10.1	514
17	H0N1		1935				1933-09	5.8	1937-04	199	3.6	10.4	384
18							1944-02	12.9	1947-05	219	3.3	10.2	382
19				H2N2	Asian flu	1957–1958	1954-04	5.1	1958-03	285	3.9	10.5	337
20				H3N2	Hong Kong flu	1968–1969	1964-10	14.3	1968-11	157	4.1	11.4	285
21				H1N1	Russian flu	1977-1978	1976-03	17.8	1979-12	233	3.8	10.5	283
22	H1N1		1991				1986-09	13.5	1989-11	214	3.2	9.9	257
23	H3N2		1997	H5N1	SARS, Bird Flu	2002-2003	1996-08	11.2	2001-11	180	5.3	12.3	619
24	H1N1	2009 flu pandemic	2009-2010	H7N9		2015	2008-12	2.2	2014-04	116	5.3	*In progress*	817
25	A(H1N1) pdm09, B/Victoria, A(H3N2), COVID-19	Corona	2019–2020				2020-04	(3.46 as at August 2019)					

This result indicates that weak solar cycles have higher pandemic severity and vice versa. i.e. we have weaker pandemic severity every 11 years, and stronger pandemic severity each ~80-120 years according to the period of solar Gleissberg cycle. Thus, we expect that we will face lower severity pandemic of viruses in the next solar maximum (i.e. in the year ~2025), and higher severity pandemic of viruses in the next solar minimum (i.e. in the year ~2031) similar to coronavirus COVID-19 and Spanish virus (H1N1).

3. Prediction of the pandemic year

According to the foundations in the previous section and Table 1, which is concluded that the pandemic viruses will be recurring in a periodic cycle. We listed the distinct of each subtype listed in table 1 with its spread years as shown in table 2. We found that some spread periodic cycles are different from subtype to others. The subtypes H1N1, H2N2, and H3N2 have a lot of spread years, then we can put the accurate formula for these predictions of spread time. While other subtypes have a little spread time, then the prediction of spread time of them will have lower accuracy. We have

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

new subtypes such as H7N9, Victoria, and COVID-19. They have one record of spread time. We can consider them as a reassortment of Spanish flu (H3N8 or H2N2).
Most of the subtypes have periodic cycles of its recurring equals nine solar cycles (one hundred years). The subtype H3N2 has a period equal to 18 solar cycles. It duplicates the period nine solar cycle. Then we can consider its period is 9 solar cycles by considering the half of its period is not recorded in the table.
We can classify the periodic cycles of pandemic viruses as two types:
1. Recurring in nine solar cycles: such as H2N2, H5N1, H1N2, H1N3, H3N8, and H7N9. We can consider H0N1 has a nine periodic solar cycle instead of 8 solar cycles. H3N2 assumed nine solar cycles. We can include the subtypes Victoria and coronavirus COVID-19 to this group by assuming these subtypes are a reassortment of Spanish flu (H3N8 or H2N2).
2. Recurring in twelve solar cycles: we have the subtype H1N1 only in this group. We can consider its period is 6 solar cycles for early alarms for humans.
The accuracy of these periods depends on the available data collected in table 2.
Thus, we can put a formula to predict the spread time for each subtype of pandemic viruses. Our method depends on the start time of each solar cycle. The most we can talk about, the quiet Sun is not occurring on a specific date, it takes a period of maybe 2 years. Here we will consider that this solar minimum will occur on a specific date, so we can estimate it. We must take in our account that the spread time may happen before or after the calculated day.
In the first step, we need to convert from solar cyclic number to date and vice versa. The conversion from solar cycle number to its start date (i.e. year) determines by the following formula

$$Y = Y_0 + P_0 * C \qquad (1)$$

Y_0 is the initial year, it equals 1744.4, P_0 is the length of the solar cycle, P_0 equals 11.075, C is the solar cycle number and Y is the year. This formula proposed to determine the start date of the specified solar cycle number. The constants are Y_0 and P_0 calculated by the fitting of solar cycle parameters recorded in table 1.
The inverse conversion, from the start year of the solar cycle to solar cycle number determines from:

$$C = -157.43 + 0.090253 * Y \qquad (2)$$

Then, we can put a prediction formula for a pandemic year as follows:

$$C_p = C_0 + n * P \qquad (3)$$

Where C_p is the pandemic solar cycle for the specified subtype. C_0 is the initial solar cycle of specified pandemic subtype virus (i.e. first date of spread in table 1). n is the spread number of pandemic subtype virus, it equals 0, 1, 2, …, ∞. The value 0 indicates the first spread time listed in table 2, 1 indicates the second spread time, and so on. P is the periodic factor. It is considered constant for each subtype virus. This value listed in table 1. After calculating the value of C_p, then we can substitute this value in equation 1 to calculate its spread year.
We can substitute from equation 3 into equation 1 to get the final formula:

$$Y = 1744.4 + 11.075 * (C_0 + n * P) \qquad (4)$$

Some of the subtypes of pandemic viruses are spread during active Sun. Then Y must be corrected by adding the interval to solar maximum from solar minimum (A). Solar maximum interval A equals ~5 years (i.e. ~0.5 solar cycle). It may be greater or smaller than 5, it varies from solar cycle to others. but it is considered here equals 5 solar cycles for solar maximum. Thus, the final formula will be

$$Y = 1744.4 + 11.075 * (C_0 + n * P) + A \qquad (5)$$

For a pandemic of solar minimum, A becomes equal to 0. But for pandemic spread at solar maximum, A becomes equal to 5. some of the pandemic viruses may have a custom A value. We must take it into our account.
For example, the first spread of subtype H3N8 was in 1808 (C_0=6), 1889 (C_0=1). It has a periodic factor that equals 8 solar cycles (P=8). We assumed A equals 0, then
The first spread (n=0):

$$Y = 1744.4 + 11.075 * (6 + 0 * 7) + 0 = 1810.85 \text{ [1808 N3N8]}$$

The second spread (n=1):

$$Y = 1744.4 + 11.075 * (6 + 1 * 7) + 0 = 1888.375 \text{ [1808 N3N8]}$$

We can repeat the same example of subtype H3N8 by assuming a periodic factor equals 9 solar cycles (P=9) and A equals -2, then

$$Y = 1744.4 + 11.075 * (7 + 0 * 9)-2 = 1819.925$$

The second spread (n=1):

$$Y = 1744.4 + 11.075 * (7 + 1 * 9)-2 = 1919.6 \text{ [Spanish flu]}$$

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

The third spread (n=2):

$Y = 1744.4 + 11.075 * (7 + 2 * 9)-2 = 2019.275$ *[Reassortment of coronavirus COVID-19]*

The fourth spread (n=3):

$Y = 1744.4 + 11.075 * (7 + 3 * 9)-2 = 2120.95$ *[predicted for a future]*

Another example: The subtype H2N2 was spread three times, 1759 (C_0=1), 1858 (C_0=10), 1958 (C_0=19), we can check the prediction of its spread time.

The first spread (n=0):

$Y = 1744.4 + 11.075 * (1 + 0 * 9) +4 = 1759.475$

The second spread (n=0):

$Y = 1744.4 + 11.075 * (1 + 1 * 9) +4 = 1859.15$

The third spread (n=2):

$Y = 1744.4 + 11.075 * (1 + 2 * 9) +4 = 1958.825$

The fourth spread (n=2):

$Y = 1744.4 + 11.075 * (1 + 3 * 9) +4 = 2058.5$

We expect that we will face a pandemic virus in the next solar maximum (~2025). Besides, we will face a pandemic virus in the next solar minimum. We can calculate the start time of the next solar cycle 26 by using equation 1 as follows:

$Y = 1744.4 + 11.075 * 26 = 2032.35$

Most spread time of pandemic viruses was spread before our calculated by about 2-3 years, then we can consider A equals 2 to give as an accurate pandemic date.

Table 2: The periodicities of epidemic viruses.

Virus subtype	Repeat times	Spread years	C_0	P	11-year periodicity	Repeats count at Active Sun	Spread years
H1N1	6	1776, 1918, 1977, 2009, 2019	3	6	Every 12/6 cycles	1	1918–1920
H2N2	4	1759, 1858, 1873, 1889, 1958	1	9	Very 9 cycles, may repeat/extend after 3 years	1	1957–1958
H3N2	4	1767, 1968, 1997, 2019	2	9	Every 18 cycle, may repeated every 3/2	1	1968–1969
H5N1	2	1886, 1904	12	9	Every 9 cycles	1	2002-2003
H0N1	2	1948, 1935	9	8	Every 8 cycles		
H1N2	2	1791, 1837	4	--	Unknown		
H1N3	2	1831, 1930	7	9	Every 9 cycles		
H3N8	2	1808, 1889	6	7	Every 7 cycles		
H7N9			24	--	Unknown	1	2015
Victoria	1	2019	25	--	Unknown		
Covid-19	1	2019	25	--	Unknown		

4. Seasonal epidemic viruses

The seasonal epidemic viruses are recurring each year as mentioned in section 1. The breakdown of the "peak months of flu activity" over 34 years between 1982 and 2016 shown in table 3 are occurs during months (CDC, 2019):

1. February was the peak month for flu activity in 14 of the 34 flu seasons, making it the most common month for peak flu activity.
2. December followed February, with the highest flu activity in seven of the 34 flu seasons.
3. March is third, with flu activity peaking this month in six seasons during the 34-season period.
4. January was the least common month to facilitate peak flu activity, with the flu peaking this month in only five of the 34 flu seasons.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

Every season plays out differently, but typically the peak of cold and flu season is between December and February. In fact, according to the CDC, for 34 years dating back to 1982, February was the peak month of flu activity during 14 seasons. The annual epidemics are due to antigenic drift.

Table 3: Months of flu activity from 2010 – 2020.

Flu Season	**2019-2020**	**2018-2019**	**2018-2019**	**2016-2017**	**2015-2016**	**2014-2015**	**2013-2014**	**2012-2013**	**2011-2012**	**2010-2011**
Peak		Mid-February	January and February	Mid-March	Mid-March	Late December	Late December	Late December	Mid-March	Early February
Most common strain	, B/Victoria	H3N2 & H1N1	(H3N2	H3N2	2009 H1N1	H3N2	2009 H1N1	H3N2	H3N2	H3N2

Figure 2 shows that the seasonal epidemic viruses correlate with precipitations. Peak month of flu activity increases with average rainfall in the amount of mm and number of days. This result indicates that the rainy weather is a suitable environment for epidemic viruses. According to this fact, we can expect that the amount of peak month of flu activity increases or decreases each year according to the rainfall amount. The rainfall is varying from year to year. It depends on solar activity; we will discuss it in the next section (section 3).

The most strain of seasonal flu is A/H3N2, A/H1N1, B. Number of infected peoples: 5–15% (340 million – 1 billion) (WHO, 2009), 3–11% or 5–20% (240 million–1.6 billion) (Tokars et al., 2018; CDC, 2019).

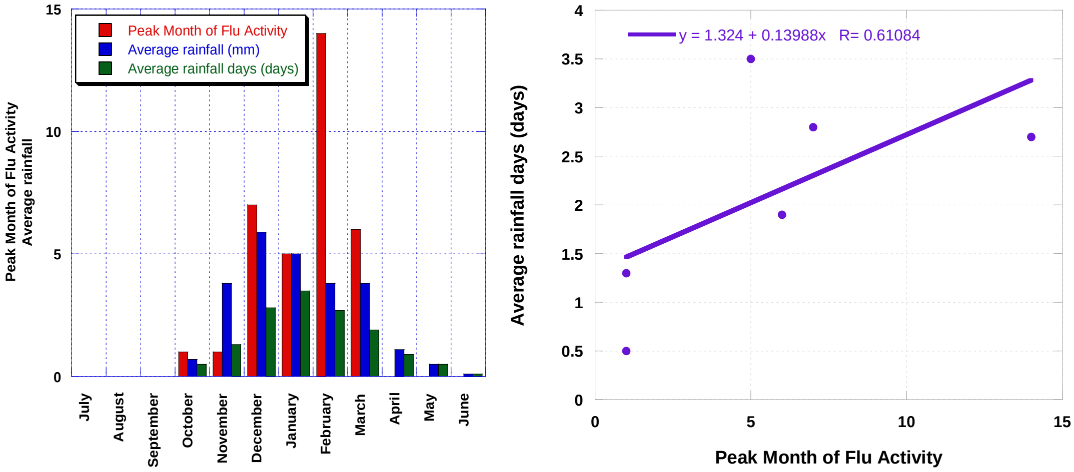

Figure 2: Peak Month of Flu Activity (red bars) during the period 1982-1983 through 2017-2018 Obtained from CDC. It is associated with average rainfall values by days per month (green bars) and amount per mm (blue bars). Weather data obtained from Weather Atlas for Cairo region.

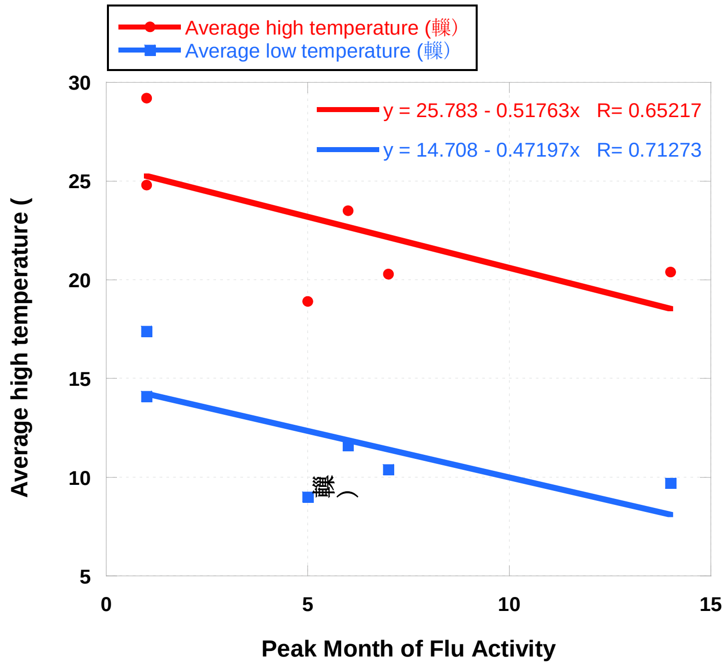

Figure 3: Peak Month of Flu Activity during the period 1982-1983 through 2017-2018 Obtained from CDC with average higher (red) and lower (blue) temperature obtained from Weather Atlas for the Cairo region.

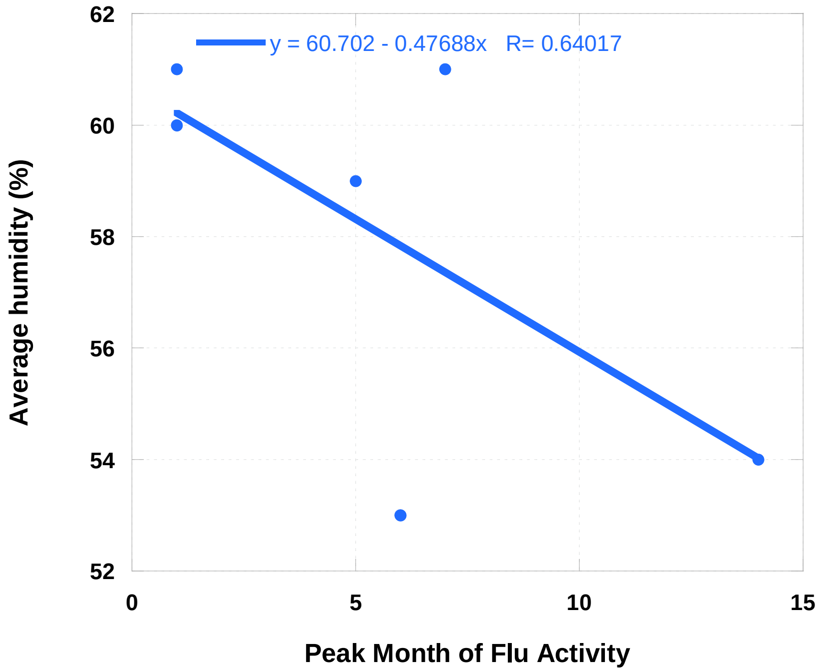

Figure 4: A plot of Peak Month of Flu Activity during the period 1982-1983 through 2017-2018 Obtained from CDC with relative humidity obtained from Weather Atlas for the Cairo region.

We plotted the Peak Month of Flu Activity that was estimated during the period 1982-1983 with the rainfall days (Figure 2 – right plane), higher and lower temperature (Figure 3), and relative humidity (Figure 4). These figures show that the Peak Month of Flu Activity is correlated positively with rainfall (correlation coefficient R equals 0.61) and correlated negatively with both lower temperature (R=0.71) and relative humidity (R=0.64).

5. Discussion and conclusions

The solar activity cycles are the important exterior source of the variability in the atmospheric environment on the Earth that sometimes become suitable for pandemic virus's spread. Emerging new strains of influenza viruses were manifested in two ways. The annual epidemics (seasonal epidemic) are due to antigenic drift; and pandemics that occur at 1-12 solar cycles (~11 to 108 years) intervals due to new virus subtypes resulting from virus reassortment.

We tabled a list of pandemic viruses that occurred during the period 1759-2020. We found that each subtype of pandemic viruses is recurring in each solar activity (every ~11 years). We notice that pandemic viruses correlate with solar activity. Most of these pandemic viruses have been spread during the quiet Sun. Minor of these pandemic viruses have been spread during the active Sun.

The severity level of the pandemic has a negative correlation with the strength of the solar cycle. The higher severity of pandemic occurs during weaker solar cycles, especially each solar Gleissberg cycle (i.e. every nine solar cycles, it equals about a hundred years). weak solar cycles have occurred during the periods 1800-1820, 1900-1920, and 2020. Besides, we found that during weak solar cycles, the pandemic viruses spread around the quiet sun. while during strong solar cycles, pandemic viruses spread around the active Sun. The recurring of pandemic viruses has two types: (1) recurring in nine solar cycles: such as H2N2, H5N1, H1N2, H1N3, H3N8, and H7N9. We can consider H0N1 has a nine periodic solar cycle instead of eight solar cycles. H3N2 assumed nine solar cycles. We can include the subtypes Victoria and coronavirus COVID-19 to this group by assuming these subtypes are a reassortment of Spanish flu (H3N8 or H2N2); (2) recurring in twelve solar cycles. We have the subtype H1N1 only in this group. We can consider its period as six solar cycles for early alarms for humans.

The pandemic viruses which are associated during quiet Sun starts its spread in cold regions (i.e. temperate or subtropical zones, such as European cities). While the pandemic viruses which are associated during active Sun started its spread at hot regions (i.e. tropical zones such as near-equatorial cities). We expect that the globe will face lower severity pandemic of viruses in the next solar maximum (i.e. in the year ~2025), and higher severity pandemic of viruses in the next solar minimum (i.e. in the year ~2031) similar to coronavirus COVID-19 and Spanish virus (H1N1).

Tapping et al. (2001) suggested a mathematical function to predict the spread time of pandemic viruses according to the nearest sunspot maximum. Their study did not modulate a prediction for pandemic viruses for a specification of subtype of any virus. Unlike Tapping et al. (2001), we suggest a formula that can predict the spread time of pandemic virus for each subtype as

$$Y = 1744.4 + 11.075 * (C_0 + n * P) + A$$

Where Y is the spread time of pandemic virus. C_p is the pandemic solar cycle for the specified subtype. C_0 is the initial solar cycle of specified pandemic subtype virus (i.e. first date of spread in table 1). n is the spread number of pandemic subtype virus, it equals 0, 1, 2, …, ∞. The value 0 indicates the first spread time listed in table 2, 1 indicates the second spread time, and so on. P is the periodic factor. It is considered constant for each subtype virus. This value listed in table 1. After calculating the value of C_p, then we can substitute this value in equation 1 to calculate its spread year. A is the solar maximum interval. It equals 0 or ~5 years (~0.5 solar cycle) for pandemic viruses spread at quiet or active Sun, respectively.

Regarding Figures 2-4, the precipitation which is forced by the solar activity as an external factor is a suitable environment for virus' spreading. This means that the nearby coastal regions and rainy regions have higher severity than other regions. The virus spread time can be predicted according to solar activity prediction. It agrees with the conclusion of Aller et al. (2005) which found that the aerosolized from the sea surface are largely associated with organic matrices of transparent exopolymeric particles. These particles may assist in the persistence and viability of viruses and bacteria in the upper atmosphere during long-distance transport. The temperature and relative humidity are predictable parameters that are followed by the solar activities and the global temperature is correlated to solar activity (Friis-Christensen and Lassen, 1991; Bard and Frank, 2006; Erlykin et al., 2009; Feulner, 2011; Yousef, 2000, 2014, 2011a, 2011b; Mawad, 2015, 2018; Zhen et al., 2018; Yousef et al., 2018). This conclusion agrees with previous studies that found the spread of influenza has been correlated with rainy seasons (Shek and Lee, 2003; (Viboud et al., 2006) and transmission of viruses was found to be dependent on both temperature and relative humidity (Lowen et al., 2007; Pica et al., 2012).

Finally, we should be on guard for the coming years because next year will be a quiet solar activity which is associated with higher severity levels of pandemic viruses. We expected that the next solar minimum (~2030) will face a higher

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2022 doi:10.20944/preprints202208.0046.v1

severity of pandemic viruses too. Accordingly, we recommend the scientists to excavate deep in the icebergs in Greenland and Antarctica to expect the future spread of subtypes of pandemic viruses.

Declarations

Acknowledgments

Authors thank data source providers: World Data Center - Sunspot Index and Long-term Solar Observations (WDC-SILSO) for sunspot numbers (http://sidc.be/silso/), National Oceanic and Atmospheric Administration (NOAA), and Centers for Disease Control and Prevention (CDC) for data of Peak Month of Flu Activity of seasonal epidemics (https://www.cdc.gov/flu/about/season/flu-season.htm).

Authors' Contributions

Conceptualization, R.M.; Data curation, R.M. and H.M.M.; Formal analysis, R.M., E.M.B.M; Funding acquisition, R.M.; Investigation, all; Methodology, R.M., E.M.B.M and E.G; Software, R.M.; Writing – original draft, R.M.; Writing – review & editing, R.M. and E.G. All authors have read and agreed to the published version of the manuscript.

Availability of data and materials

Mawad, Ramy; et al., 2022, "Solar activity - Pandemic viruses", https://doi.org/10.7910/DVN/CBJK2T, Harvard Dataverse, V1

Funding

The publication of this research is supported by the Science and Technology Development Fund STDF and The Egyptian Knowledge Bank (EKB).

Ethics approval and consent to participate

This article does not contain any studies with participants performed by any of the authors.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

Akasofu, S. On the recovery from the Little Ice Age. *Natural Science*, 2010, **2**, 1211-1224. http://dx.doi.org/10.4236/ns.2010.211149

Aller JY, Kuznetsova MR, Jahns CJ, Kemp PF. The sea surface microlayer as a source of viral and bacterial enrichment in marine aerosols. *J Aerosol Sci.*, 2005, **30**, 801–12. http://dx.doi.org/10.1016/j.jaerosci.2004.10.012

Bard, E.; Frank, M. Climate change and solar variability: What's new under the sun? *Earth and Planetary Science Letters*, 2006, **248**, 1–14. http://dx.doi.org/10.1016/j.epsl.2006.06.016

CDC Centers for Disease Control and Prevention, How CDC Estimates the Burden of Flu Illness Averted by Vaccination, 2019, https://www.cdc.gov/flu/vaccines-work/how-cdc-estimates.htm

de Gruij, F.R.; Jan C. van der L., Environment and health: 3. Ozone depletion and ultraviolet radiation, CMAJ. 2000, 163(7), 851–855.

Erlykin; A.D., T. Sloan, A.W., Wolfendale, Solar activity and the mean global temperature, *Environ. Res. Lett.* 2009 **4**, 014006.

Feulner, G. Are the most recent estimates for Maunder Minimum solar irradiance in agreement with temperature reconstructions? *Geophys. Res. Lett.*, 2011, **38**, L16706. https://doi.org/10.1029/2011GL048529

Friis-Christensen, E.; Lassen K. Length of the Solar Cycle: An Indicator of Solar Activity Closely Associated with Climate, *Science*, 1991, **254**, 8-700. https://doi.org/10.1126/science.254.5032.698

Karim, L.M. AL-Kazzaz, A.L., Hafedh, M.A. and Hafedh, A.A. Viruses from space and its relation with solar activity, *Journal of College of Education*, 2011, **3**(1), 229-236.

Karim, Laith M.; Abbas, Marwa H. *Iraqi Journal of Science*, 2014, Vol **55**, No.2A, pp:556-560.

Lowen, A.C.; Mubareka, S.; Steel, J.; Palese, P. Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature, *PLOS Pathogens*, 2007, **3**, 10, e151. https://doi.org/10.1371/journal.ppat.0030151

Lytle, C.D.; Sagripanti, J.L., Predicted Inactivation of Viruses of Relevance to Biodefense by Solar Radiation, Journal of virology, 2005, 14244–14252 https://doi.org/10.1128/JVI.79.22.14244-14252.2005

Mawad, R. On the correlation between Earth's orbital perturbations and oscillations of sea level and concentration of greenhouse gases, *J. Modern Trends in Phys.* 2015, **15**, 1-9. https://doi.org/10.19138/mtpr/(15)1-9

Mawad, R. Shahinaz Yousef, Doaa G. Teama, Walid Abdel-Sattar, "The impact of the earth's orbital perturbation on the global warming," *AGU 2018 Fall Meeting*, 2018. abstract 465021.

Mawad, R.; Youssef M.; S. M. Yousef and W. Abdel-Sattar, "Quantized variability of Earth’s magnetopause distance," J. Modern Trends in Phys. R., 2014, 14, 105-110. https://doi.org/10.19138/MTPR/(14)105-110

NASA Earth observatory in 1999, https://www.earthobservatory.nasa.gov/features/BOREASAlbedo/albedo_3.php

Pica, N.; Chou, Y.Y.; Bouvier, N.M.; Palese, P. Transmission of influenza B viruses in the guinea pig. J. Virol, 2012, 86, 4279–4287. https://dx.doi.org/10.1128%2FJVI.06645-11

Potter C.W. A history of influenza, *Journal of Applied Microbiology*, 2001, **91**, 572-579. https://doi.org/10.1046/j.1365-2672.2001.01492.x

Qu, J.; Wickramasinghe, N.C. The world should establish an early warning system for new viral infectious diseases by space-weather monitoring, *MedComm.* 2020, 1–4. https://doi.org/10.1002/mco2.20

Schubert, R.; Herzog, S.; Trenholm, S. et al. Magnetically guided virus stamping for the targeted infection of single cells or groups of cells. *Nat Protoc*, 2019, **14**, 3205–3219 https://doi.org/10.1038/s41596-019-0221-z

Shek, L.P.; Lee, B.W. Epidemiology and seasonality of respiratory tract virus infections in the tropics. *Paediatr Respir Rev*, 2003, **4**: 105–111. https://doi.org/10.1016/s1526-0542(03)00024-1

Tapping, K.F.; Mathias, R.G.; Surkan, D.L. Influenza pandemics and solar activity. *Canadian Journal of Infectious Diseases*, 2001, **12**, 61-62. Google Scholar

Tokars, J.I; Rolfes, M.A; Foppa, I.M.; Reed C. An evaluation and update of methods for estimating the number of influenza cases averted by vaccination in the United States. *Vaccine,* 2018, **36**(48), 7331-7. https://doi.org/10.1016/j.vaccine.2018.10.026

Towers, S. Sunspot activity and influenza pandemics: a statistical assessment of the purported association, *Epidemiology and Infection*, 2017, **145**, 13,2640-2655. https://doi.org/10.1017/S095026881700173X

Trebbi, G.; Borghini, F.; Lazzarato, L.; Torrigiani, P.; Calzoni, L.; Betti, L. Extremely low frequency weak magnetic fields enhance resistance of NN tobacco plants to tobacco mosaic virus and elicit stress-related, *Bioelectromagnetics*, 2007, **28**(3) 214-223. https://doi.org/10.1002/bem.20296

Vaquero, J.M.; M.C.Gallego. Sunspot numbers can detect pandemic influenza A: The use of different sunspot numbers, *Medical Hypotheses*, Volume **68**, Issue 5, 2007, Pages 1189-1190.1. https://doi.org/10.1016/j.mehy.2006.10.021

Viboud, C.; Alonso, W.J.; Simonsen, L. Influenza in tropical regions. *PLoS Med*, 2006, **3**: e89. https://doi.org/10.1371/journal.pmed.0030089

WHO, World Health Organization. Pandemic Influenza Preparedness and Response: *A WHO Guidance Document*. 2009.

Wickramasinghe, N.C., Edward J. Steele, Wainwright, M.; Tokoro, G.; Fernando, M.; Qu, *J. Astrobiol Outreach*, 2017, **5**, 2, 1000159. https://doi.org/10.4172/2332-2519.1000159

Yeung, J.W.K. A hypothesis: Sunspot cycles may detect pandemic influenza A in 1700–2000 A.D., Medical Hypotheses, 2006, 67,5, 1016-1022.
https://doi.org/10.1016/j.mehy.2006.03.048

Yousef, S.M. (2011a): Solar induced climate changes and cooling of the earth, *Conference of Modern Trends in Physics Research, World Scientific*, 2011, 296-308. https://doi.org/10.1142/9789814317511_0035

Yousef, S.M. The solar Wolf-Gleissberg cycle and its influence on the Earth. *ICEHM2000*, Cairo University, Egypt, 2000, 267- 293.

Yousef, S.M., Cool Earth and Mars in response to deduce solar activity, *IAGA symposium*, 2011b.

Yousef, S.M., Expected cooling of the Earth and its implications on good security, *Bulletin De L. Institute Egypte*, Tom LXXX, 2014, 53-82.

Yousef, S.M.; Ramy, M.; S.M. Robaa; Doaa, G.T.; Moheb M.; El-Dine, R.S.; Elfaki, H. Right now we are on the Brink of an Ice Age in Europe and America and a Rainy Epoch on the Sahara and Arabia, *AGU 2018 Fall Meeting*, Washington, 2018, 468811.

Zaporozhan, V.; Ponomarenko, A. Mechanisms of Geomagnetic Field Influence on Gene Expression Using Influenza as a Model System: Basics of Physical Epidemiology, *Int. J. Environ. Res.* 2010, **7**(3), 938-965. https://doi.org/10.3390/ijerph7030938

Zhen, Li;, Jianping Y.; Yunfei X.; Jian C.; Yankai B.; Hanqing C. Multiresolution Analysis of the Relationship of Solar Activity, Global Temperatures, and Global Warming, *Advances in Meteorology*, 2018, 2078057. https://doi.org/10.1155/2018/2078057