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Solar forcing on cyclones - case study: Gonu 2007

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Abstract- This paper establishes the physical cause and effect relationships between solar stimuli and terrestrial responses. The solar stimuli in our case is a fast stream of solar wind emanated from a coronal hole. This stream got through the Earth's magnetosphere like a bullet and hit a particular spot of the troposphere above the Arabian Sea on 31 May 2007. There the protons, ions and electron energies were deposited and heated the atmosphere. The hot spot expanded and formed a low-pressure spot above the Sea thus accelerated evaporation. The electric charges in this particular spot act as nuclei for water condensation and formation of intense clouds. As a second step, solar wind streams hit the two polar atmospheres, inducing two surface Meridional wind velocities that moved equator wards. The northern wind and the southern winds met at the cloud spot over the Arabian Sea and formed a torque that caused the clouds to rotate about the central eye. Thus, Hurricane Gonu was fully developed on early June 2007. Thus, the stimuli is the coronal hole stream and the response is the hurricane.

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Keywords- Solar wind; coronal hole; hurricane; Arabian Sea; magnetosphere; Gonu; Oman.

1. INTRODUCTION

Since the 19 centuries there have been several attempts to link hurricane numbers and tracks to space weather. In 1872 Meldrum found a correlation between Indian cyclones and the sunspot number [cited in Hoyt and Schatten (1997)]. Another encouraging piece of evidence on solar forcing on cyclones is the appearance of three prominent solar periodicities in the periodicities of Atlantic number of cyclones and the length of cyclone season as shown in fig 1 after [Hoyt and Schatten (1997)] and their reference. Recently, Mendoza (2011), reported on the effects of space weather on hurricane Activity.

A growing mass of evidence suggests that transient events on the sun affect our weather and long-term variations of the sun's energy output affect our climate. Solar terrestrial exploration can help establishes the physical cause and effect relationships between solar stimuli and terrestrial responses. When these relationships are understood, science will have an essential tool for weather and climate prediction.

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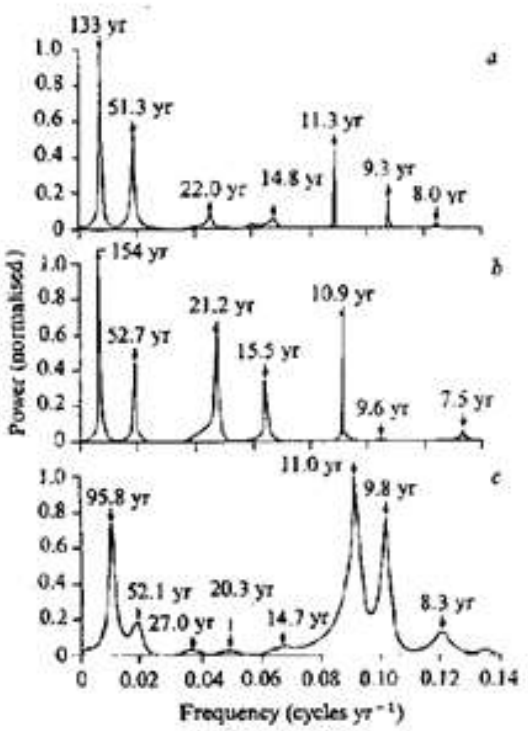

Fig. 1. Comparison of a) solar periodicities and periodicities of b) Atlantic number of cyclones and c) the length of cyclone season. Notice the common periodicities near 11, 22 and 51-52 years. This figure is reproduced from Hoyt and Schatten (1997).

Fig. 2. Hurricane Gonu as it approaches Oman.

This paragraph was written by Robert D. Chapman as part of a proposal for a five-year plan for Solar Terrestrial Programs in the National Aeronautics and Space Administration [Herman and Goldberg (1978)].

Now this view is fulfilled as the present paper found the solar Stimuli that caused hurricane Gonu. The solar stimuli that cause flash floods over Mekkah Al Mukaramah, Jeda and Medinah Al Munawarah have also been found and to be reported elsewhere.

In the present paper, the authors suggest a hurricane-initiated solar bullet mechanism that is capable in the first place of initiating a low-pressure region; and secondly the meeting of oppositely directed winds at this low-pressure region providing the necessary torque for inducing the rotational cyclonic motion.

The present paper will focus on tropical cyclone, Gonu that affected the Arabian Gulf coast in June 2007. Gonu is the strongest tropical cyclone on records in the Arabian Sea.

We will try to develop an alert system for cyclone formation and intensification based on alerts of solar disturbances.

2. GENERAL INFORMATION ABOUT CYCLONE GONU

Cyclones in the Indian Ocean tend to form between April and December, with peaks in May and November. India Meteorological Department IMD is the official Regional Specialized Meteorological Centre RSMC in this basin. Meanwhile, the Joint Typhoon Warning Center JTWC releases unofficial advisories. Based on the JTWC analysis, Super Cyclonic Storm Gonu. Affected four areas Oman, United Arab Emirates, Pakistan and Iran. It was initiated in the North Indian Ocean on 31/05/2007. It rapidly intensified to attain peak winds of 240 km/h on June 3, according to the Indian Meteorological Department. Gonu weakened after encountering dry air and cooler waters, and early on

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June 6, it made landfall on the eastern-most tip of Oman, becoming the strongest tropical cyclone to hit the Arabian Peninsula. It then turned northward into the Gulf of Oman and dissipated on June 7 after making landfall in southern Iran (Wikipedia).

Early on June 2 the JTWC classified it Tropical Cyclone 02A while it was located about 685 km southwest of Mumbai, India (JTWC, 2007). The storm steadily intensified; early on June 2the IMD upgraded it to deep depression status and later in the day the IMD classified the system as Cyclonic Storm Gonu while it was located 760 km southwest of Mumbai, India. With a solid area of intense convection, it rapidly intensified to attain severe cyclonic status early on June 3, and with good outflow the JTWC upgraded it to the equivalent of a Category 1 tropical cyclone. Gonu rapidly deepened and developed a well-defined eye in the center of convection. Late on June 3, the IMD classified the storm as Very Severe Cyclonic Storm Gonu, upon which it became the most intense cyclone on record in the Arabian Sea. The IMD upgraded it to Super Cyclonic Storm Gonu late on June 4, with sustained winds reaching 240 km/h and an estimated pressure of 920 mbar. After maintaining peak winds for about 9 hours, the IMD downgraded Gonu to very severe cyclonic storm status early on June 5. Its eye became cloud-filled and ragged, and the cyclone gradually weakened as it continued tracking northwestward. On June 6, the cyclone turned to the north-northwest as an approaching shortwave trough created a weakness in the ridge, and later that day the JTWC downgraded Gonu to tropical storm status. The IMD followed suit by downgrading Gonu to severe cyclonic storm status and later to cyclonic storm status early on June 7 [El Rafy and Hafez (2008)]. A brief summary of the development hurricane Gonu is given by O'Hara and Falvey (2007).

3. STEPS OF FORMING CYCLONE GONU

(1) A fast-solar wind stream emanated from the coronal hole seen in fig 3. A coronal hole is a dark cold region in the solar corona where open magnetic fields exist. This condition allows fast streams of ions, protons and electrons to escape from the sun.
(2) Three ion streams were detected by satellite near earth (fig 4).
(3) The first stream reached earth on 31 May 2007 and opened the magnetosphere (the Earth's magnetic cocoon).
(4) This stream penetrated to the lower layers of the troposphere in the Arabian Sea at a small spot and dissipated its energy there, ionized the air, charged it and heat it up. We call this step the bullet step.
(5) The air in this spot expanded thus its pressure was reduced. It is this spot that was seen on 31 May in fig 5 after O'Hara and Falvey (2007). This location is the birth place of tropical cyclone Gonu on 3106z May 2007. At that time, this particular spot was near noon facing the sun. It was issued poor on 31 May 1130z.
(6) The reduction of pressure and the charging of the air over the Arabian Sea accelerated evaporation and cloud formation
(7) Figure 6 shows daily mean anomalies in 500 mb level geopotential height on 2 June.: A cell of negative anomaly can be noticed, this is Gonu. El Rafy and Hafez (2008) found that this cell migrated northward through the period of study until 7 June. The track of the negative anomaly almost coincided with the track of Gonu.
(8) The earth's wind circulation is crucially determined by the situation in the two polar caps. This is in turn determined by precipitation of the solar wind into the two polar atmospheres. Solar wind streams entered the Northern polar cap and an air depression moved eastward in such a way as to be on the same longitude with a similar depression in the Southern Polar cap on line with the Guno cell as seen in fig 7. This produced two surface Meridional wind velocity components of opposite directions.
(9) Fig 8 shows the surface Meridional wind velocities on the 3rd of June 2007. The arrows indicate the two opposite directions of the wind as they meet at Gonu cell. Those two opposite components acted as a torque that caused the cell to rotate, and this is how the cyclone developed.

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Fig. 3. Three solar wind streams flowing from the indicated coronal hole reached the Earth on May 31, June first and 2nd. Credit: SOHO Extreme Ultraviolet Telescope.

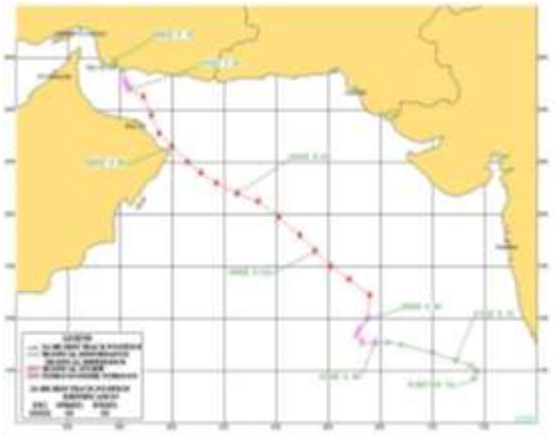

Fig. 5. Evolution and track of cyclone Gonu after O'Hara and Falvey (2007). Notice its birth on 31 May 2007.

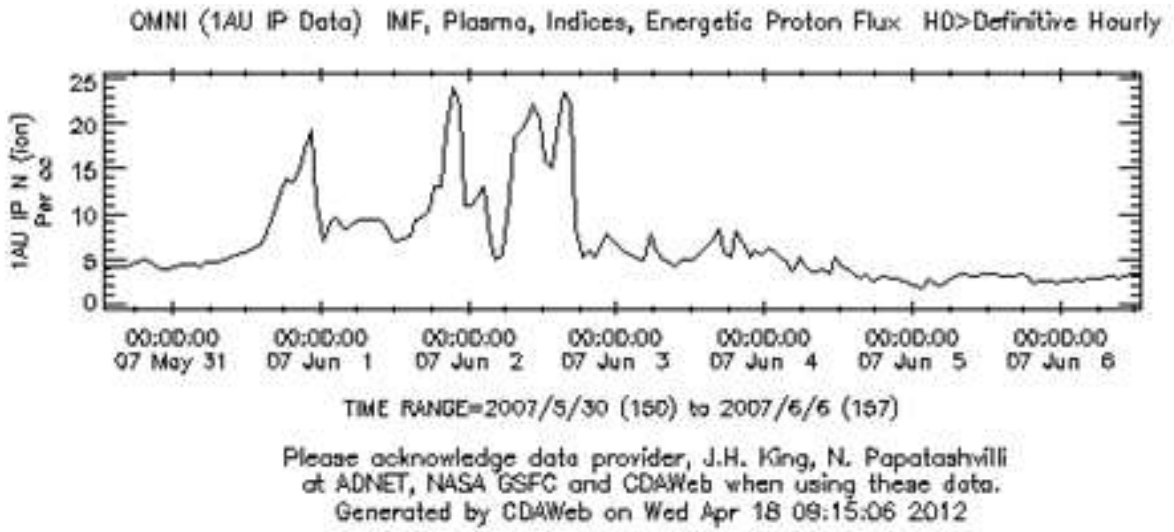

Fig. 4. Three ion streams are detected by satellite. The first one to the left reached the earth on 31 May 2007 and initiated cyclone Gonu in the Arabian Sea.

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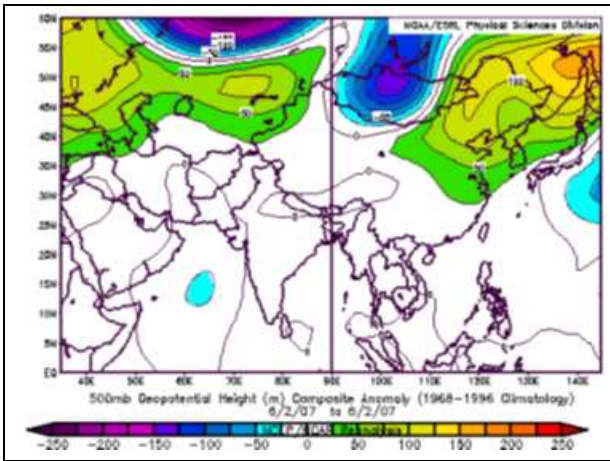

Fig. 6. Daily mean anomalies in 500mb level geopotential height on 2 June: A cell of negative anomaly can be noticed. This cell is Gonu.

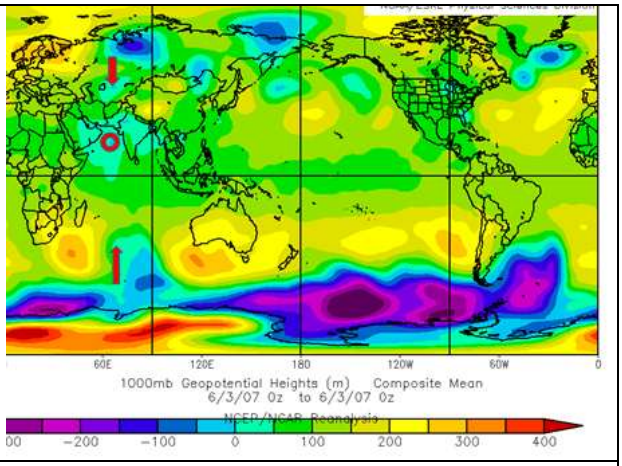

Fig. 7. 1000mb geopotential height on the third of June 2007 showing two depressions in the northern and southern polar caps on line with Gonu cell.

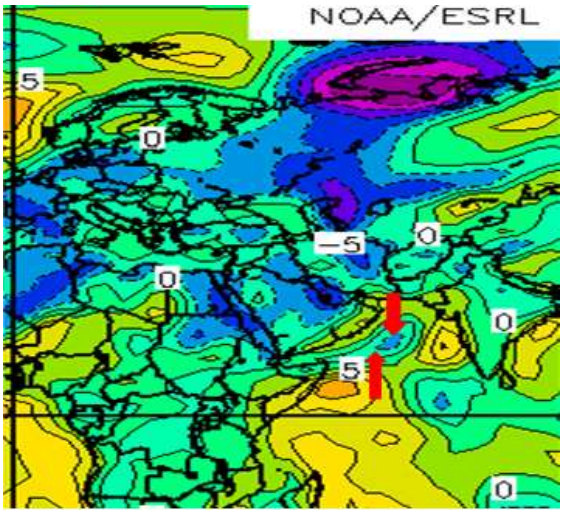

Fig. 8. Surface Meridional wind velocities on the 3rd of June 2007. The arrows indicate the two opposite directions of the wind as they meet at Gonu cell. Those two opposite components acted as a torque that caused the cell to rotate.

4. A MECHANISM FOR SOLAR FORCING ON CYCLONES

(1) The Bullet theory: Solar Wind streams of protons, electrons and ions can open a gate through the magnetosphere at day time and reach a particular spot over the Indian Ocean or Arabian Sea (or any area of water) as seen in fig 9 thus heating that spot of air by dissipating their energy there through collisions and ionization of air.

(2) This air heating will cause the air to expand and thus lower the pressure in this spot over the sea.

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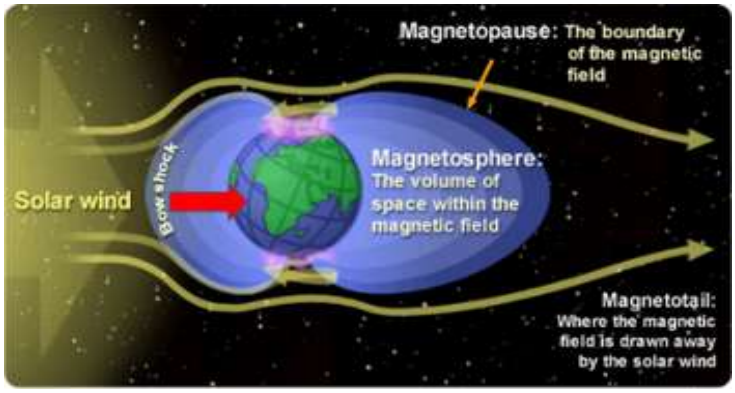
(3) Reduced pressure will enhance evaporation of water and increase clouds rapidly. In addition, the charged particles will serve as nuclei of water condensation and help in forming clouds.

(4) Part of this stream or the following streams can also enter the earth from the night side through the Van Allen outer belts into the two polar atmospheres producing geomagnetic storms and dissipating their energy there producing the aurora and heating these atmospheres, expanding the air and thus reducing the pressure, hence changing the wind circulation. The surface Merdinal wind directed down and up meet at the reduced pressure spot and form a torque that causes the spot to rotate forming the cyclonic movement (fig. 10). The cyclone develops into hurricane with increased evaporation.



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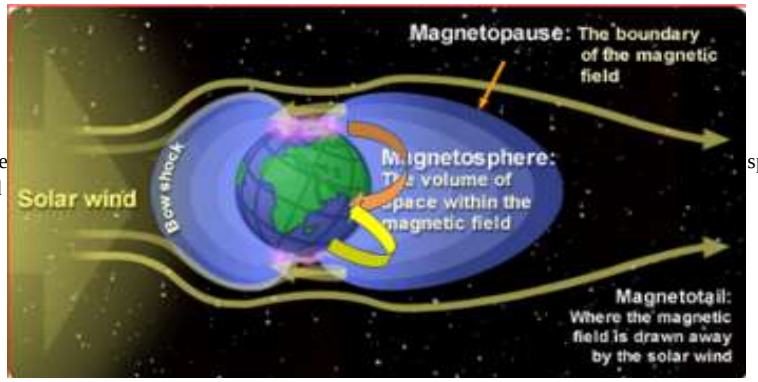

spot that will expand and

Fig. 10. Meeting of Northern and Southern winds in Arabian Sea initiate a tourque that produce cyclonic rotation.

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5. CONCLUSION

The study of Hurricanes that struck Oman is of particular interest. Such hurricanes with tornado outbreak can be traced back to the destruction of the people of Aad.

Maps of cyclones that hit Oman between 1977 and 2010 are given by Rathath center for weather forecast.

We presented evidences for the initiation of Hurricane Gonu on 31 May 2007 by a stream of solar wind that emanated from a solar coronal hole. This stream of protons, ions and electrons hit the troposphere like a bullet at a small area above the Arabian Sea. Heat was dissipated there and caused the parcel of air there to expand and became a small low depression area (fig 5). The conditions in this charged low pressure parcel of air over the Ocean are very favorable for rapid evaporation of water and formation of clouds.

Solar wind streams also entered the two polar regions and thus caused low depression regions in a similar way. The Northern polar atmosphere moved eastward and was almost on line with its southern counterpart and the small low depression over the Arabian Sea. The surface Meridional winds moved equator wards and met at the clouds formed by the solar wind stream that moved northward. This caused coupling of the vertical velocity components and forced the clouds to spin forming the cyclonic motion and development of the hurricane.

The first proposed step of the mechanism is also applicable for the formation of Cumulonimbus clouds.

An early warning system of hurricanes based on coronal hole fast solar wind streams is possible to develop however we would appreciate that NOAA earth system research laboratory ESRL can release Plots 6 hours NCEP/NCAR immediately. We have to know the exact spot on earth of hitting the fast-solar wind stream and watch out if the hitting is over water. This will cause a depression that can develop to Cumulonimbus clouds or cyclones if streams of solar wind also hit the Polar Regions.

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REFERENCES

Mendoza , B, The Effects of Space Weather on Hurricane Activity. *Recent Hurricane Research-Climate, Dynamics, and Societal Impacts*, InTech, 2011, p. 85.

Hoyt, D. V. and K. H. Schatten: The Role of the Sun in Climate Change, Oxford. University Press, 1997.

El Rafy A. M. and Hafez Y. Y. (Ap 2008). Anomalies in meterological fields over northern Asia and it's impact on Hurricane Gonu. 28th *Conference on Hurricanes and Tropical Meteorology*, 28 April – 2 May 2008, Orlando, FL, AMS, USA.

Herman, J. R. and Goldberg (1978): Sun, weather, and climate. New York, Dover Publications.

O'Hara, J. F. and Falvey, R. J., 2007. 2007 Annual Tropical Cyclone Report. US Naval Martime Forecast Center Martime Forecast Center/ Joint Typhoon Warning Center, Pear harbor, Hawai. L.T.Vancas, M. USN-Editor.

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