京都大学 海洋観測塔創設50周年記念誌
編者

OCEAN SURFACE TEMPERATURE AND SOLAR CYCLE

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2010 DECEMBER 20

PREFACE

This is a part of the extensive research works undertaken in relation to the project started in Kyoto University in 1960. This contents are an contribution dedicated for the memorial years of the 50th years after the start of the research work in the project referring to the Oceanographic Tower of Kyoto University.

The project was planned first by Professors Shoitiro Hayami and Denzaburoo Miyadi, both of them had been the leaders of researches in the field of natural sciences in Kyoto University.

The early stage of the researches in this project had concerned for problems on ocean current and primary product in the coastal zones.

In the last ten years, satellite monitoring had been developed to obtain information of the ocean surface.

In this volume, a part of the advanced research works undertaken in relation to the project, though the interested problems cover the sea surface temperature at the Azores in the Northeast Atlantic Ocean and the solar cycle variations.

In this work, the researches have been promoted with our understanding about the solar activity cycle and the sea surface temperature are the specific and important factors for predicting the natural processes in relation to the human activity.

Ocean current is widely accepted an ocean water motion controlled by the earth rotation, nevertheless the other factors are also playing to take part of the specific ocean flow pattern. As far as we concern to the ocean current as a kind of simple water motion, it must be simply considered that the problem could be solved in a field of geohydrodynamics introducing several artificial parameters for convenience.

As for the solar activity, astronomical scientists has given us its specific property though we have to clarify what relation is between the ocean current ad solar activity.

It is necessary, here, to see what mechanism of the solar activity. In this work, it is introduced that the magnetohydrodynamics of an linealized model might give an approximated theoretical solution for the solar cycle though a paramer is included.

The solar system is consisted by the several planets and their astronomical satellites. What is important for us is related to the various kinds of the natural phenomema.

As one of the specific examples in the solar planetary system, one case study on satellite monitoring of lunar shadow formed on the earth surface at the solar eclipse in July 2009.

The project has been extended and updated so that the research must be continued for finding many findings in the natural processes.

The editor feels it his honor to introduce a memories in a form of this work for the 50 years activity.

Lastly, the editor has to notice that this project has been continued without any support after the other type of official research system in Kyoto University has been aimed for helping the new age of the human activity.

The editor has to notice here what is important is to promote the research successively with a balanced understanding of the human activity.

The author appreciate very much for many supports during the research works.

2010 December 20

Shigehisa Nakamura

The editor (retired and active),

Monitored Solar Cycle in Relation to Sea Surface Temperature at Azores in the Northeast Atlantic Ocean

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Abstract—This is a brief note to the monitored solar cycle in relation to the sea surface temperature at a station in the ocean. First of all, a short note on the monitored solar cycle as a part of "Astronomy". One of the most classic interests for the scientists is "global magnetism" of the sun just like the main magnetic field of the earth. A note is given to a part of the observed result of sea surface temperature trend fit well to sun spot number index trend introduced in 2009 by the Azores Science group.

1. INTRODUCTION

This is a brief note to the monitored solar cycle in relation to the sea surface temperature at a station in the ocean. First of all, the author introduces a short note on the monitored solar cycle as a part of astronomy. It must be familiar to the scientists what the author notes as a briefing of the astronomical knowledge especially for realizing what should be considered about the relation between the sea surface temperature variations at Azores in the Atlantic Ocean and the sun spot number index variations during the time period of 1960 to 2007. A notice is given whether the fitting trends of the two factors could be possible to extend for the following several ten years.

2. SOLAR CYCLE

A convenient index of the solar cycle is the sun spot relative number, for example, Chapman ever written in his publication in 1964 [1] . As for the two types of "sun spot models", the first one is an empirical one. The second one is the magnetohydrostatic model. These models has been developed, for example, by Stix, 1989[2].

A part of solar cycle variation of sun spots is introduced in a diagram, for example, as found in Figure 1. So-called solar cycle has been well known by the geophysical scientists though its dynamical mechanism has been extensively studied in the fields related to astronomy.

This 11 year cycle was found first by Schwabe in 1844. Hale had the first scientist of the magnetic field in sun spots in 1908. Hale had observed them by 1923 and formulated his polarity rules on his bases of three consecutive cycles. That is to say, Hale's rules are so as that:

(1) the magnetic orientation of leader and follower spots in bipolar groups remains the same in each hemisphere over each 11-year cycle,
(2) the bipolar groups in the two hemispheres have opposite magnetic orientation,
(3) the magnetic orientation of bipolar groups reverses from one cycle to the next.

Chapman[1] and Stix[2] had noted in his publication to a more detailed terms. For example, trends of the solar cycle variation of sun spots, prominences, and faculae. The numbers of northern and southern polar faculae are drawn with a sign in order to indicate the alternating magnetic polarity (which was published by Sheeley in 1964). Stix[1] had given the signs of plus or minus mark magnetic reversals at the poles in 1974.

3. BUTTTERFLY DIAGRAM

Another important result is known as butterfly diagram introduced by Maunder in 1922. The systematic behaviour of bipolar sun spot groups is readily understood in terms of a subsurface mean toroidal magnetic field, which is a field where lines of force are circles around the solar axis [1, 2].

In addition to the mean toroidal field there is a mean poloidal magnetic field. Cowling (1934) stated first the line-of-sight component of the magnetic vector field **B**. The mean field electrodynamics has been developed since 1955 by Parker and his followers.

4. SEA SURFACE TEMPERATURE

In 2007, the Azores Scientific Group showed that the observed sea surface temperature during the time period of 1960 to 2007 has shown a significant trend to fit the solar cycle variation of sun spots for four consecutive solar cycles. Nevertheless, it is hard to accept what has introduced by the Azores Group for helping to understand any global trend of the sea surface temperature on the planet earth. The scientists for dynamics of the ocean and atmosphere have found already any dynamical processes of the geophysical fluid motions are not so simple to see on a basis of a limited data observed on the earth surface. The Azores Group had a lucky position of their station for obtaining their interesting finding.

5. DISCUSSIONS AND CONCLUSIONS

The author here has to note whether the Azores Scientific Group could show a same trend for their extensive observation of the sea surface temperature in relation to solar spots for about several ten years trends of the two physical factors.

The ocean scientists have learned that the sea surface thermal pattern on the earth is not so simple that it is hard to take it easy to relate the sea surface temperature variations at Azores in the Atlantic Ocean to the sun spots number variations as an index of the solar activity.

The ocean water has a complicated system of the ocean water motion between the earth crust surface and the atmospheric layer under an affect of the solar radiation.

So that, a global understanding of the ocean thermal transferring system should be taken into consideration at discussing on the sea surface temperature variations for obtaining a more reasonable understanding in a physical scope.

Finally, it is expected that a more advanced research should be promoted for a dynamical understanding of the various processes appear on the earth under the effect of the solar radiation.

REFERENCES

[1] Chapman, S. 1964 Solar plasma, geomagnetism, and aurora, Gordon and Breach, New-York, 141p.
[2] Stix, M. 1989 The Sun-An introduction, Springer-Verlag, 390p.

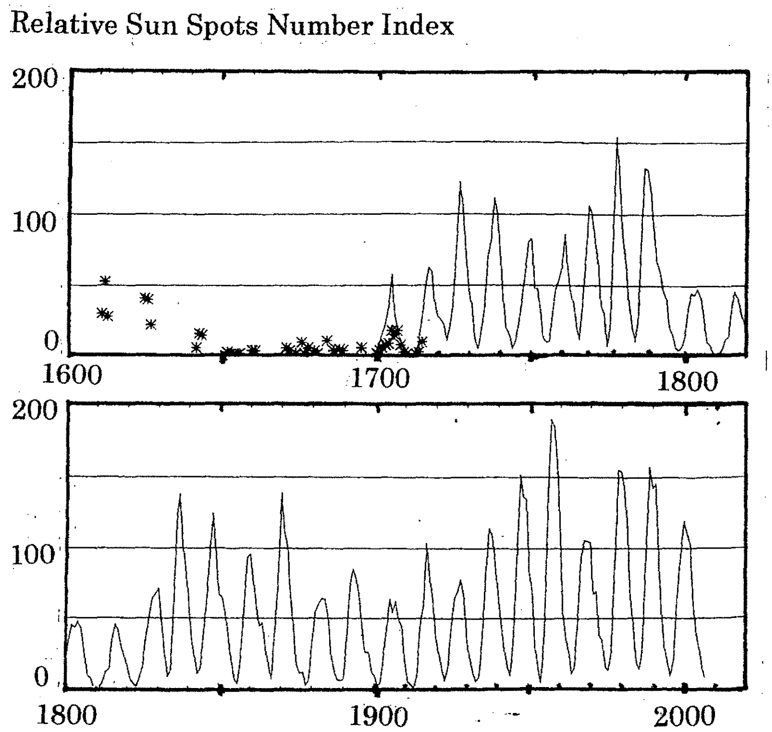

Figure 1 Solar cycle variation of sun spots

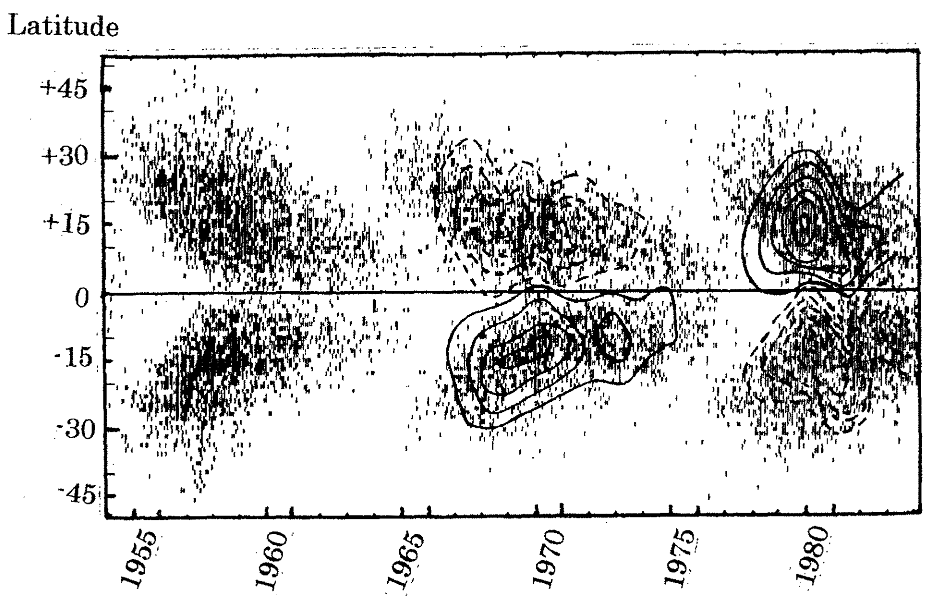

Figure 2 Butterfly diagram from Mt.Wilson Observatory
(courtesy R.Howard, National Solar Observatory)
Note:-(1) contours of radial mean field
(from Mt.Wilson and Stanford magnetograms)
(2) each vertical bar marks a sun spot
(3) the contours are (a) for solid positive 27 μ T, 54 μ T, ...,
(b) for dashed negative -27 μ T, -54 μ T, ...

Monitored Solar Cycle in Relation to an Approximated Model

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Abstract—This is a note concerning a significant trend of the 11 year cycle in the solar activity. The monitored solar cycle for about 100 years has been studied by the scientists in order to develop a numerical model for the solar cycle in a scope of dynamical electromagnetism. This solar cycle model could be a key to an answer at considering any one of the geophysical processes on the planet earth.

1. INTRODUCTION

This is a note to help a significant trend of the 11 year cycle in the solar activity. The monitored solar cycle for about 100 years is studied by an approximated model in order to understand a specific property of solar activity in a scope of dynamical electromagnetism. Chapman[1, 2] and Stix[3], for example, noted the early state of the researches related to the solar cycle and solar activity specified by the sun spots number index in an annual time unit. This solar cycle model could be a key to an answer at considering any one of the geophysical processes on the earth as a planet in the solar system.

2. Maxwell Equations

In order to start for studying solar cycle, Maxwell equations are introduced first for the magnetic field B, the electric field E, and the electric current density j, i.e.,

$$\operatorname{div} B = 0 \,, \quad \text{.....(1)}$$

$$\operatorname{curl} B = \mu\, j \,, \quad \text{.....(2)}$$

$$\operatorname{curl} E = -(\partial / \partial t) B \,, \quad \text{.....(3)}$$

where, the mark μ is the magnetic permeability (for free space, in this case). In equation of (2), an approximation is assumed for non-relativistic, or slow phenomena (neglected the displacement current).

When the field is in a material with electric conductivity σ, the current is σ times the electric field (known as Ohm's law). When the material is in motion, it is taken into account of that the law valid in the co-moving frame of reference (i.e.,$j = \sigma E$). In a case of motion (say, v for $v \ll c$), transformation to the frame at rest is as $j = j$ and $E = E + v\text{x}B$. Then, $J = \sigma (E + v\text{x}B)$. Eliminating E and j in the above equations, the induction equation is written as

$$(\partial / \partial t) B = \operatorname{curl}(v\text{x}B) - \operatorname{curl}(\eta \operatorname{curl} B), \quad \text{.....(4)}$$

where, magnetic diffusivity is $\eta = 1/(\mu \sigma)$.

3. MEAN-FIELD ELECTRODYNAMICS

The solar cycle could be solved referring essentially to the Maxwell equations for the magnetic field B, the electric field E, and the electric current density j [1]. Then, an induction equation is reduced. Electric conductivity of the sun could be determined as that of the ionized gas (or plasma) following to Spitzer(1962). For the case of the dynamo problem in terms of a mean magnetic field, $B=[B]+b$, where $[B]$ may be understood as an average over longitude or, more generally, as an ensemble average. Then, $[b]=0$. In a same way, $v=[v]+u$. Substituting these two into the induction equation, fluctuating part is obtained after separating the mean part.

Following Moffatt(1978) with some assumptions, the mean part $[B]$ and the fluctuating part b can be separately described, i.e.,

$$(\partial / \partial t)[C] = \mathrm{curl}([v] \mathrm{x} [B] + \varepsilon - \eta\, \mathrm{curl}[B]), \quad \text{...(5)}$$

$$(\partial / \partial t) b = \mathrm{curl}([v] \mathrm{x} b + u \mathrm{x} [B]) + G - \eta\, \mathrm{curl}\, b), \quad \text{...(6)}$$

where, $\varepsilon = [u \mathrm{x} b]$, and $G = u \mathrm{x} B - [u \mathrm{x} b]$.

Under some specific condition, the value of ε is shown as following, i.e.,

$$\varepsilon = \alpha [B] - \beta\, \mathrm{curl}[B] + \dots, \quad \text{...(7)}$$

where,

$$\alpha = -(1/3) \int_0^\infty [u(t)\, \mathrm{curl}\, u(t-t')] \mathrm{d}t', \text{ and } \beta = (1/3) \int_0^\infty [u(t)\, u(t-t')] \mathrm{d}t', \quad \text{...............(8)}$$

One of the way to describe feature of the mean-field induction eqution is the term involving α (that is called as the α effect).

Following to Knause (1967), $\alpha \simeq +1\Omega$ (or -1Ω) is the mean angular velocity of the Sun. The sign of α depends on helicity of the flow in the solar convection.

Stix(1976) has shown the meridional cross sections for contours of constant toroidal field strength and poloidal lines of force (cf. Figure 1). The arrows are indicating strength and sign of polar field. An illustration is given in an adjusted time scale for 11 years for each half-cycle.

Theoretical butterfly diagram (contours of constant toroidal field) in an oscillatory kinematic $\alpha\,\Omega$ dynamo is shown by Steenbeck and Krause in 1969 (cf. Figure 2).

The numerical results noted above is obtained under several assumption with some conditions, so that specific patterns could be demonstrated on the bases of the dynamical theory in an approximated forms as introduced by Stix [1].

The author here has to notice that the scientists should have their understanding of the specific pattern in the solar activity at considering the geophysical processes on the planet earth.

4. CHAOTIC DYNAMO

As a dynamic system, the magnetohydrodynamic dynamo is capable of chaotic behaviour.

Such can be seen from the numerical integrations mentioned, for example, by Stix [1].

A simplified expression of the model can be written as follow, i.e.,

$$(\partial / \partial t)A = 2\mathrm{D}B - A, \quad \text{(9)}$$

$$(\partial / \partial t)B = \mathrm{i}A - (1/2)\mathrm{i}\,\Omega A' - B, \quad \text{(10)}$$

$$(\partial / \partial t)\Omega = -\mathrm{i}AB - \nu\,\Omega \quad \text{(11)}$$

where, A' is complex conjugate of A.

System (9) to (11) is a complex generalization of a system first studied by Lorenz in 1963 as a model of turbulent convection. The system in this work likes to the Lornz system. It has chaotic solutions but also has solutions which are periodic in time.

5. DISCUSSIONS AND CONCLUSIONS

A theoretical background is introduced in a form of shortened expression. This might be helpful for realizing the monitored solar activity or the 11 year cycle of the sun spots number index. This work might be well related to the various geophysical processes found on the planet earth. Nevertheless, it is yet necessary to consider how complicated processes appear in the earth as well as in the sun.

It should be aware of an advanced research to be promoted even at present for our dynamical understanding of the sun as well as the planet earth where we are living.

REFERENCES

[1] Chapman, S., and J. Bartels 1940 Geomagnetism, Oxford University Press, London, 1049p.

[2] Chapman, S. 1964 Solar plasma, geomagnetism, and aurora, Gordon and Breach, New-York, 141p.

[3] Stix, M. 1989 The Sun-an introduction, Astronomy and Astrophysics Library, Springer-Verlag, 390p.

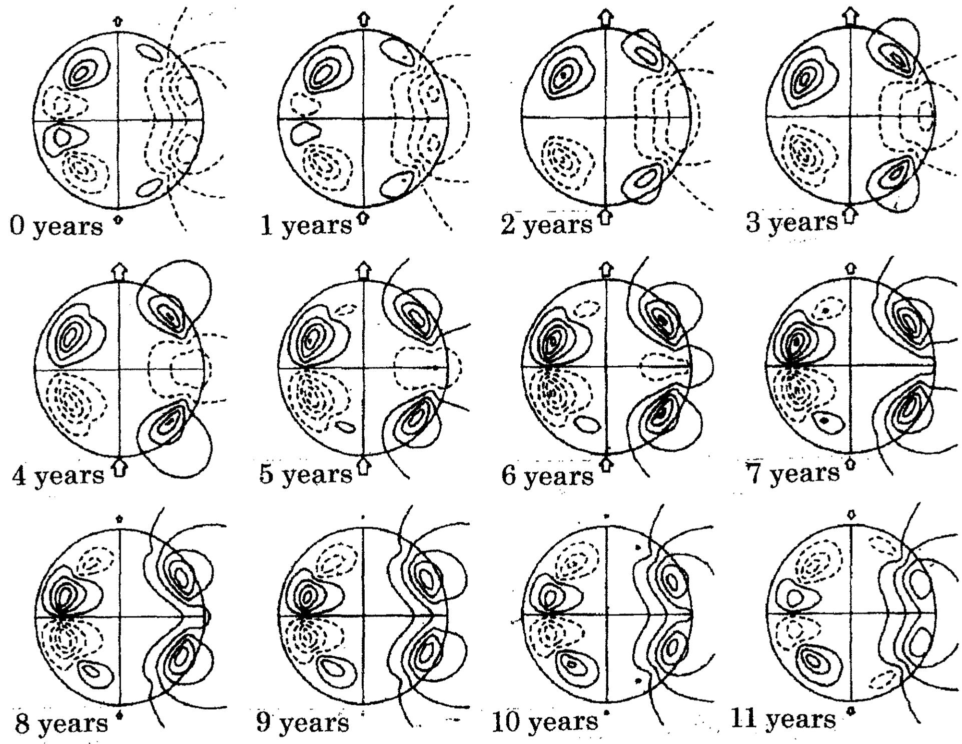

Figure 1 Oscillatory kinematic α Ω dynamo model
In each illustration in every year, the meridional cross section is shown as (1)
(1) on the right-contours of constant toroidal field strength,
(2) on the left-contours of constant poloidal lines of force.
(3) arrows indicate strength and sign of the polar field,
(4) time scale is adjusted to 11 years for each half-cycle.
(5) refer to Stix (1976)

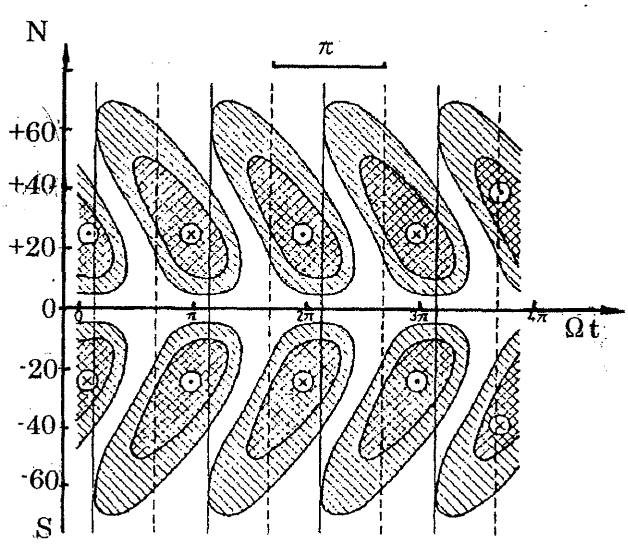

Figure 2 Theoretical butterfly diagram (contours of constant toroidal field) in an oscillatory kinematic α Ω dynamo model
(cf. Steenbeck and Krause, 1969).

Satellite Monitoring of Lunar Shadow on the Earth at Solar Eclipse

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Abstract— This an introduction to a satellite monitoring of the lunar shadow tracking on the earth surface at the predicted solar eclipse. One of the specific events is the one on 22 July 2009 in the low latitude zone of the western Pacific. A brief notice is given in relation of the solar eclipse on the planet earth in a scope of geophysical science.

1. INTRODUCTION

This is an introduction to a satellite monitoring of the lunar shadow tracking on the earth surface at the predicted solar eclipse. This is a part of the extensive research work at the Shirahama Oceanographic Observatory, Kyoto University. The project was started in 1960. For this project an offshore fixed tower was settled in the northwestern Pacific after one of the project leaders, Professor Shoitiro Hayami of Geophysics, in Kyoto University. Professor Hayami had ever been a member of the observation group for a solar eclipse on an island, Losop Island, in the north western Pacific in an early year around 1930.

In advance of the 50years Anniversary of "the Shirahama Oceanographic Tower", we had a chance for the satellite monitoring of the solar eclipse. This is the first time of the satellite monitoring of the predicted solar eclipse on the earth surface.

On 22 July 2009, the solar eclipse track passed just neighbor of the Japanese Islands. This solar eclipse might be a tiny impact to "the geophysical processes on the earth" now.

After reviewing the history of human activity on the earth, we can aware that the processes on the planet earth have been governed in the solar system.

Essentially, research on the "Solar Eclipse" has been promoted in the fields related to the section of "Astronomy". Hence, it should be raised as an interdisciplinary research on the solar activity in relation to the global processes on the earth.

The author here introduces a notice to the solar eclipse observed on the earth after his idea for a satellite monitoring of a solar eclipse in a scope of his interests.

2. SATELLITE MONITORING

In this work, the author introduces first some note to the lunar shadow on the earth surface at the solar eclipse. As a special reference, the event of the solar eclipse on the date of 22 July 2009 is taken for his convenience. The reference data was obtained by the satellite GMS-2 which has been operated on a synchronized orbital motion with the earth at the height of 800km just above the earth's surface on the equator.

The satellite GMS-2 is operated for the purpose of monitoring the various geophysical processes on the earth. A sensor mounted on the satellite has a function to send us about the information of the various geophysical processes including the radiations out of the earth radiation. The author concentrated his interest in this work to the data of the earth surface pattern monitored as a passive signal in the visible band of the solar radiation reflected on the earth surface and of the earth radiation out of the earth surface.

As for the temperature, it is described in an accuracy of 0.5 degree C. The author has a wish to have the interested date in a form of an accuracy of 0.1 degree C In order to have a more detailed pattern as a reduced result from the satellite monitoring data.

By this time, the author has worked to see what satellite thermal pattern on the ocean surface or the land surface could be obtained in the infrared band of the radiation out of the ocean surface or the land surface.

The data of the satellite GMS-2 is successively processed and distributed through the Web-site by the Japanese Meteorological Agency as the service for public and citizen uses.

The resolution of a pixel size in an imagery of the earth surface pattern is about 4km square. Nevertheless, we have to be aware of some restriction at utilizing the data obtained by the satellite GMS-2. Some part of the data should be strictly processed after the exactly assured reference of the data.

3. PREDEICTED SOLAR ECLIPSE

Each one of the solar eclipses is predicted properly by the National Astronimical Observatory, Tokyo to issue every year in the series of the annual publication as the "Chronological Scientific Tables", which is available for the public and citizen use as well as the scientists in the related fields to the astronomy and geophysics. The edition No.82 of this Table is for 2009.

In Figure 1, an illustration of the lunar shadow zone on the earth surface at the event on 22 July 2009 is introduced in a modified form of the original 2009 issue of the National Astronomical Observatory.

Main shadow zone is shown along an expected line track. Shadow zones at the start and at the end of the solar eclipse are also shown by the distorted circle as a projection of the main and sub shadow zones covering the interested zones.

As for the main solar eclipse shadow, the astronomical prediction about the solar eclipse on 22 July 2009 could be specified by the factors related to the main shadow, that is to say, to indicate the location and time of the solar eclipse shadow. After the evaluation by the National Astronomical Observatory, the specifying data set is given as follow;

	Time (JST)	Location
Start of partial ecliptic shadow	2009 July 22/ 08h 58.3m	84 43' E/ 19 03'N
Start of main ecliptic shadow	2009 July 22/ 09h 52.8m	70 31' E/ 20 21'N
Meridional Center (Concentric)	2009 July 22/ 11h 33.0m	143 22'E/ 24 37'N
End of main eclipse shadow	2009 July 22/ 13h 17.8m	157 41'W/ 12 55'S
End of partial ecliptic shadow	2009 July 22/ 14h 12.4m	171 51'W/ 14 14'S

At the time of the meridional center, a bright ring of the solar beam is formed by the fringe (4%) of the sun.

4. TRACKING OF SOLAR ECLIPTIC SHADOW

A data set for the solar eclipse shadow on the earth surface was issued as a special data set through the Web-site by the Japanese Meteorolgical Agency.

The data set consist the northern hemisphere as a synthesized foot print of the monitoring sensor of the satellite GMS-2 to demonstrate the movement of the solar ecliptic shadow pattern in a step of 15min from the time of 0900-JST to 1400-JST. The data is simply distributed the solar ecliptic shadow pattern reduced after processing the signal radiation for the visible band which was monitored by the sensor mounted on the satellite GMS-2.

The solar ecliptic shadow pattern could be seen along a path projected on the earth following the factors shown above to specify the solar eclipse event. Nevertheless, the cloud distribution was the contaminating factor at seeing the solar ecliptic shadow.

With the author's experience of the daily pattern of the earth surface, especially, of the ocean surface, the author found that the shadow pattern reduced after processing the earth radiation of the visual band is coarsely consistent to the astronomical prediction.

It was unfortunate this time that no data was supplied for the reduced pattern in the infrared band. So that, it is expected what thermal pattern was obtained in the shadow zone at the interested solar eclipse event to the details in the successive work.

5. CONCLUSIONS

A satellite monitored solar eclipse shadow on the earth was introduced. This time, the available data was the radiation in the infrared band reflected on the earth surface and radiated out of the earth surface. The data was obtained by the satellite GMS-2.

The astronomical prediction of the solar eclipse on 22 July 2009 was consistent to the reduced result after processing the data of the satellite monitoring of the radiation in the visible band.

It should be encouraged to promote a research on the thermal pattern at an event of the predicted solar eclipse by a satellite monitoring of the solar eclipse.

Referring to the data obtained and monitored by the satellite, the special and timely pattern of an interested solar eclipse shadow can be seen to help for realizing a more detailed knowledge of an environmental and the other geophysical processes instead of the limited numbers of the discrete local observations obtained on the earth surface in the past.

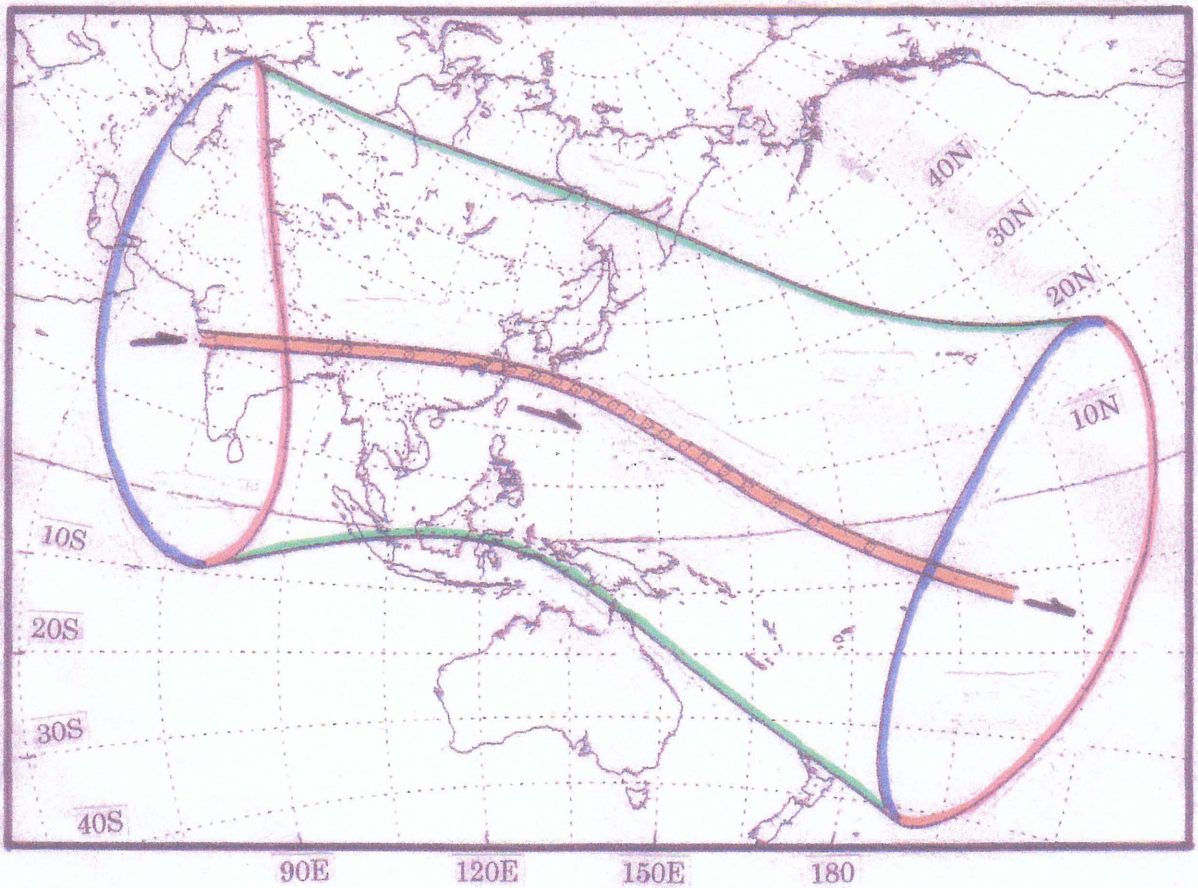

Figure 1 Solar eclipse shadow belt on the earth surface
On 2009 July 22.
(Refer to the National Astronomical Observatory)

1. Orange color line for the main shadow belt zone
2. Red color line at each case of the west and east parts
   for the start of the solar eclipse at sun rise and at sun set
3. Blue color line at each case of the west and east parts
   For the end of the solar eclipse at sun rise and at sun set
4. Green color lines for the northern and southern limits
   of the sub-shadow belt centering the main shadow zone
5. Arrows (in black color mark) shows the shadow movement
   with the time elapse.

Documentation Notes

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