第7回 宇宙環境シンポジウム, 東京国際フォーラム, Oct.19-20, 2010

SUN

地磁気観測ネットワークの現状と今後の展望

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1. はじめに
2. 地磁気観測ネットワークの現状
   2.1 ULTIMA コンソーシアム
   2.2 MAGDAS/CPMN Project
3. MAGDASの成果
4. 今後の展望

Geospace

Figure courtesy of Space Physics and Aeronomy Section Slide Set, American Geophy

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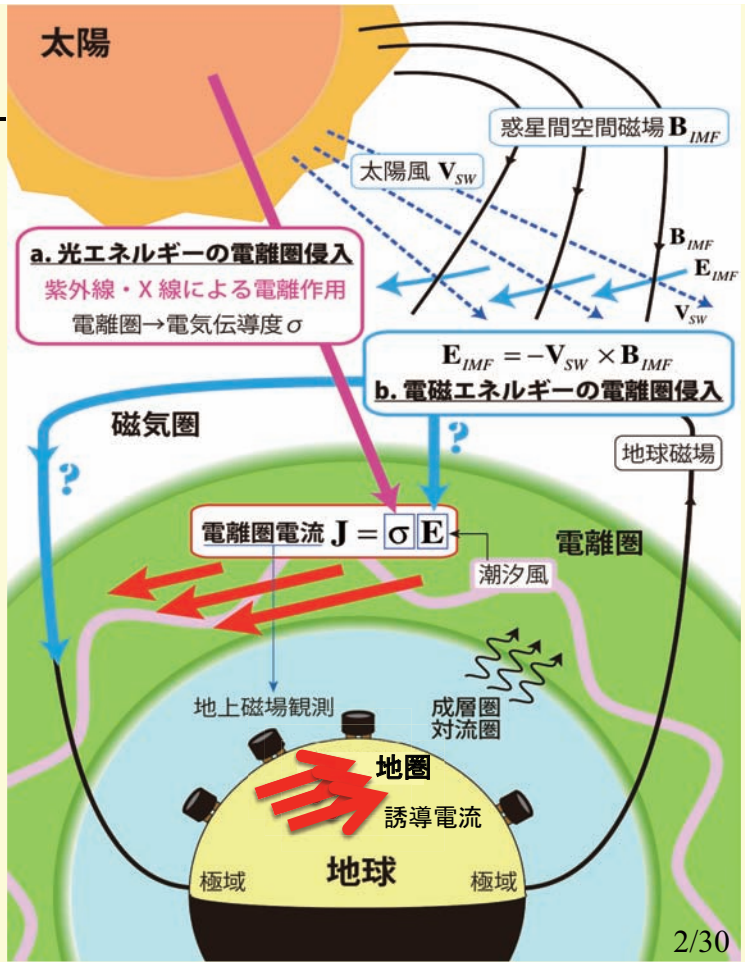
1. 日地(太陽地球系)科学の創成

:太陽圏から地圏までの結合過程の解明

i) 太陽光エネルギー
～10^{12} MW

ii) 太陽風電磁エネルギー
10^{4}–10^{7} MW

iii) 太陽光エネルギーの宇宙線遮蔽(雲)効果



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2.1-1 Annual ULTIMA General Meeting

at San Francisco on Dec. 13 , 2009

- **ULTIMA Meetings**
  (1) at UCLA on Nov. 17, 2006
  (2) at Kyoto on Oct. 24, 2007
  (3) at Tsukuba on Nov.14, 2008
- **Bylaws signed by members**
  - **Membership**
  - **Collaboration**
  - **Annual meetings**
  - **Communications**

(Counterclockwise from the front left: Kiyo Yumoto, Brian Fraser, Peter Chi, Mark Moldwin, David Milling, Ian Mann, Vassilis Angelopoulos, Chris Russell; Not pictured: Ray Walker, Eftyhia Zesta)

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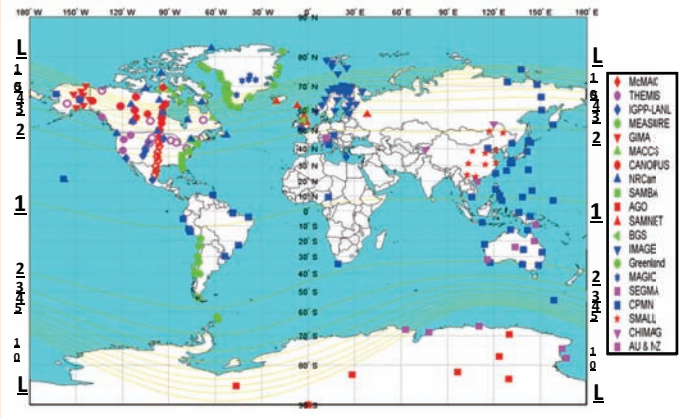
2.1-2 Purpose of ULTIMA

(Ultra Large Terrestrial Magnetometer Array)



(1) ULTIMA is an international consortium that aims at promoting collaborative research through the use of ground-based magnetic field observatories.

(2) ULTIMA is composed of individual magnetometer arrays in different countries/regions.

(3) It provides a platform for each of them to easily and efficiently collaborate with other arrays in order to expand observation coverage.

(4) It also helps identify the importance and need of individual arrays to continue operation or establish new stations in their host countries.

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2.1-3. Present ULTIMA Members

Kiyohumi Yumoto (Chair)	MAGDAS/CPMN	
Chris Russell	IGPP/LANL, THEMIS ground mag.	
Brian Fraser	Australian Magnetometer Network	
Ian Mann	CARISMA	
Eftyhia Zesta	SAMBA	
Mark Moldwin	MEASURE	
Vassilis Angelopoulos	THEMIS ground mag.	
Mark Engebretson	MACCS and AGO	
Massimo Vellante	SEGMA	
Peter Chi (Secretary)	McMAC, Falcon	

- More members in the ground magnetometer community are being invited.

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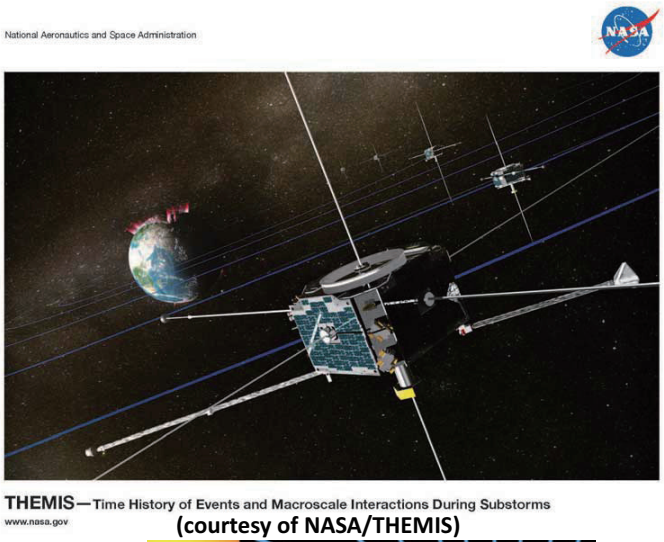
2.1-4 Connection to Science Satellite Projects

- **Joint observations by satellites and ground magnetometers** have been one widely used methodology to investigate a wider region of the geospace environment.



(courtesy of NASA/THEMIS)

ULTIMA

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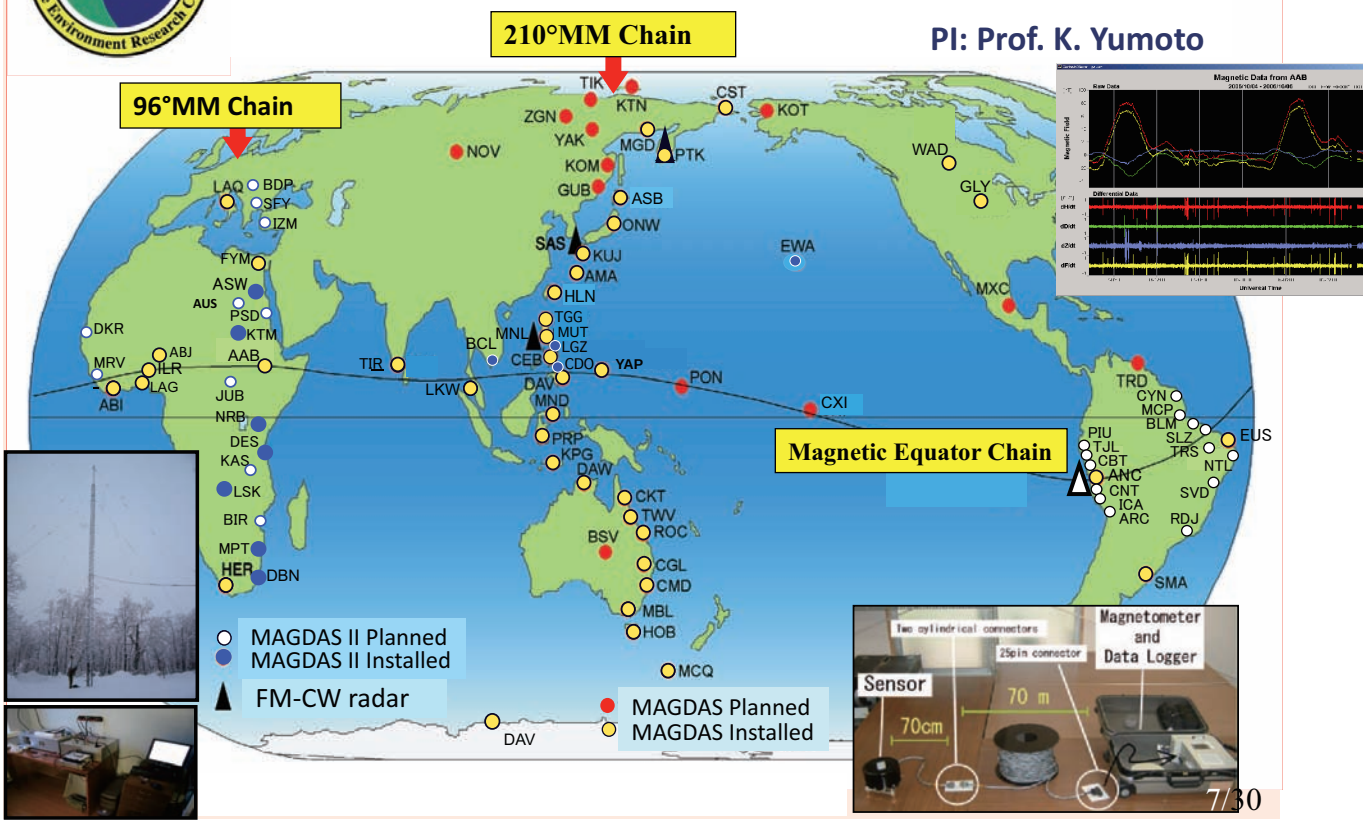
2.2 MAGDAS (MAGnetic Data Acquisition System) Network at SERC, Kyushu Univ.

PI: Prof. K. Yumoto



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2.2-2 MAGDAS Installation 2008, Lagos, Nigeria

Sensor Hut Construction

Fluxgate Sensor

Solar Cell

Launching Ceremony

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2.2-3 MAGDAS data come to SERC in real time

Space Environment Research Center
Kyushu University

[http://www.serc.kyushu-u.ac.jp/]

Data Management,
Database Construction and
Data Analysis

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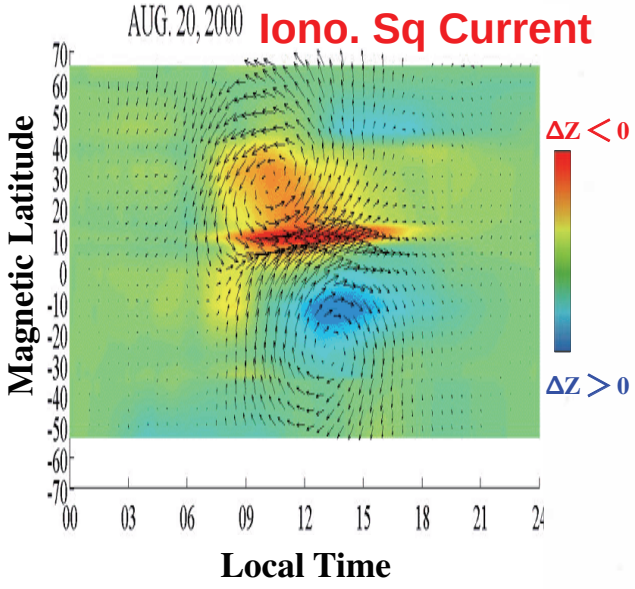
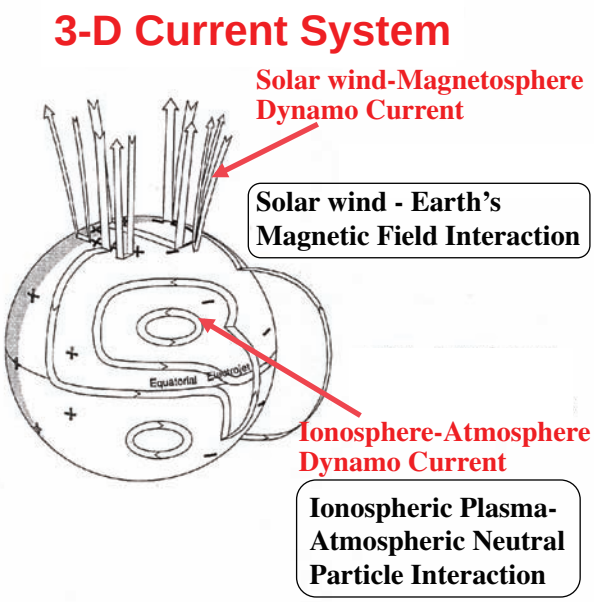
3.1 Imaging of MAGDAS Data (1)

for Understanding of Solar wind-Magnetosphere-Ionosphere-Atmosphere Coupling system and its environment change





(left) Global equivalent ionospheric current pattern obtained from the ordinary MAGDAS/CPMN data.
(right) Three-dimensional current system in geospace.

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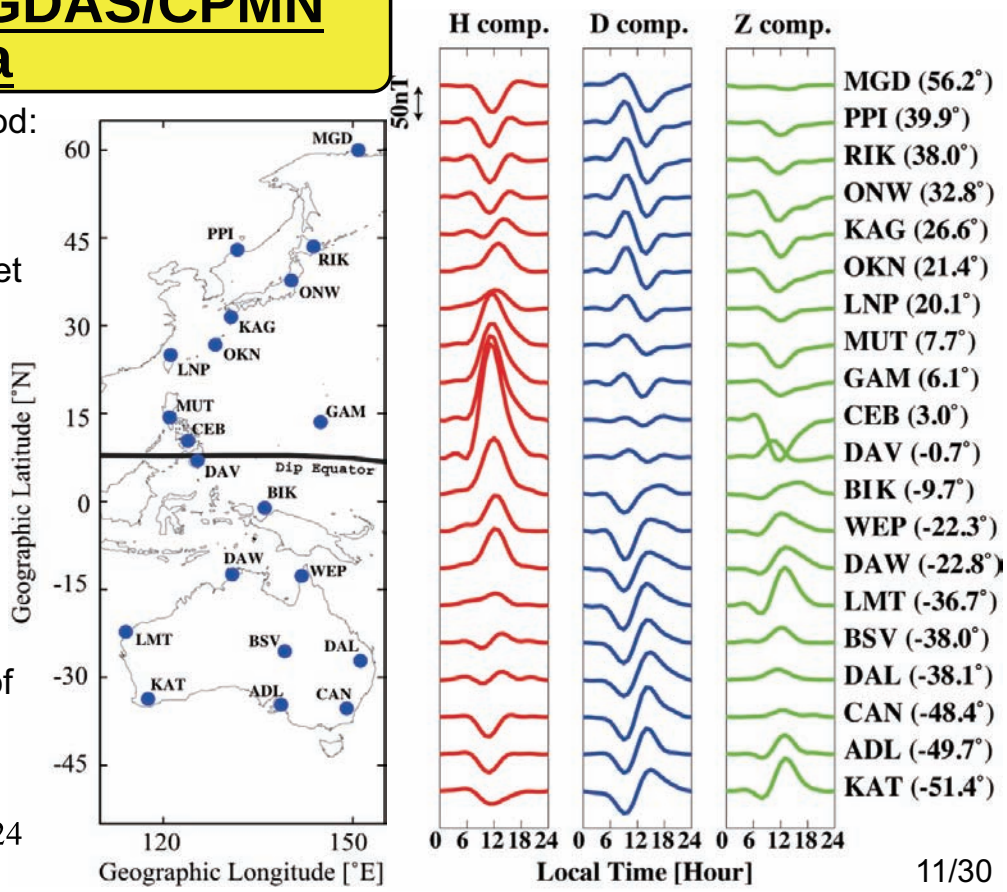
3.2 MAGDAS/CPMN Data

- Analysis Period: 1996 - 2007
- Magnetic Quiet Days: Kp≤2+
- 20 Stations: (Yumoto et al., 2001)
- Hourly Value of Horizontal Sq Amplitude:

$$\sum_{i=1}^{24}\sqrt{H_i^2 + D_i^2}\,/\,24$$



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3.3 Empirical Sq Model by fitting Least-Squares Method

1. Solar Activity (SA)

$$F(SA) = a_1 + a_2 SA$$

2. Day of Year (DOY)

$$G(DOY) = b_1 + \sum_{i=1}^{3}(b_{2i}\cos 2\pi \bullet DOY + b_{2i+1} sin 2\pi \bullet DOY)$$

3. Local Time (LT)

$$H(LT) = c_1 + \sum_{i=1}^{4}(c_{2i}\cos\frac{\pi i \bullet LT}{12} + c_{2i+1} sin\frac{\pi i \bullet LT}{12})$$

4. Lunar Age (LA)

$$I(LA) = d_1 + \sum_{i=1}^{2}(d_{2i}\cos\frac{\pi i \bullet LA}{12} + d_{2i+1} sin\frac{\pi i \bullet LA}{12})$$

$S = \sum(d_j - X_j(t_j))^2$, where $X(t_j)=F \cdot G \cdot H \cdot I$

d_j : observed values, $X_j(t_j)$: empirical model

(See Kakinami et al., Ann. Geophys., 2009)

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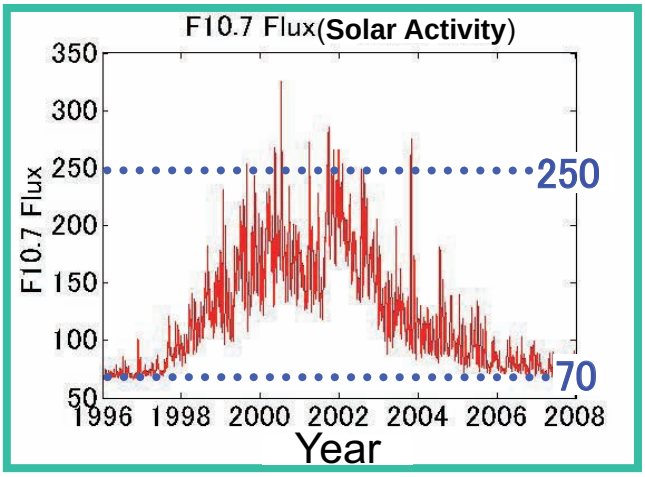
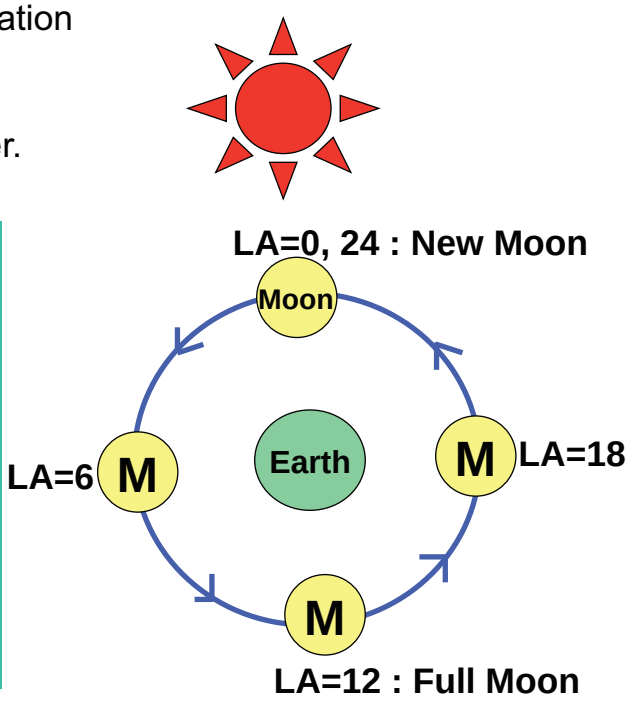
3.4 Solar Activity (F10.7) and Lunar Age

◆ Solar Activity : F10.7 index ◆ Lunar Age

Solar Radiation ：related with UV ionization
Wave Length : 10.7cm (2.8GHz).
Daily values observed from 1947.
Good correlation with Sunspot Number.
Unit: $10^{-22} W / m^2 Hz$





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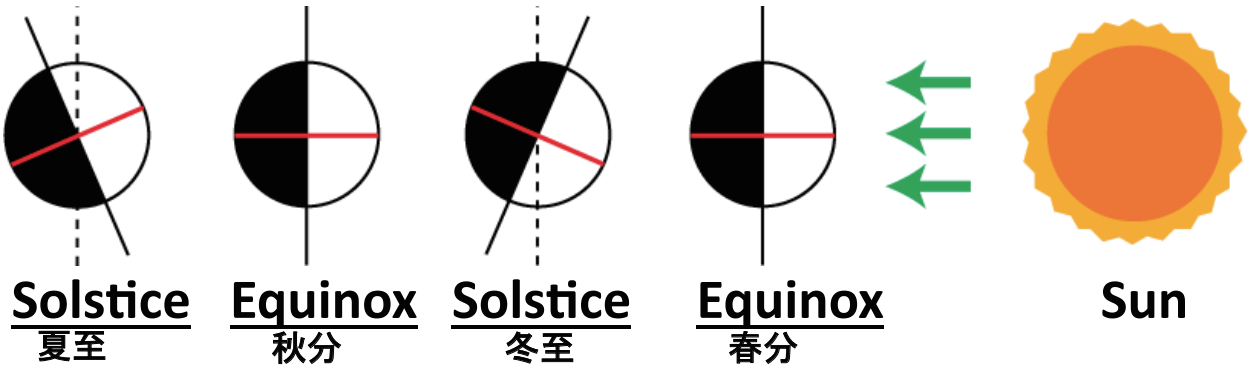
3.5 Dependence of Ionospheric Currents on Season



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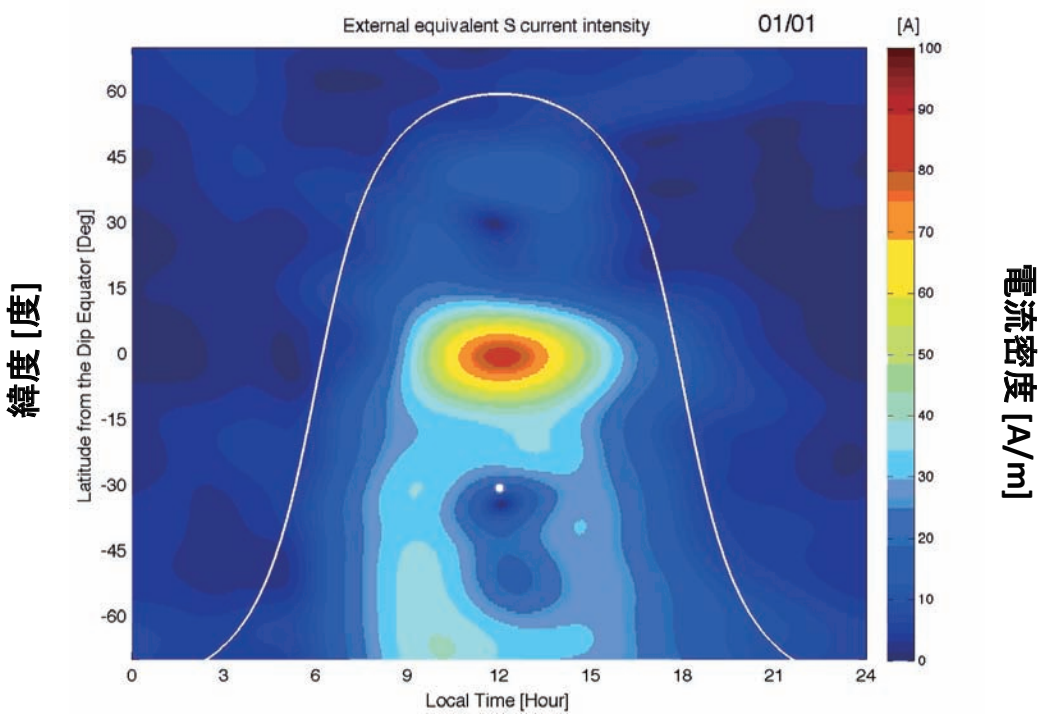
3.6 Dependence of Ionospheric Current Density on Season



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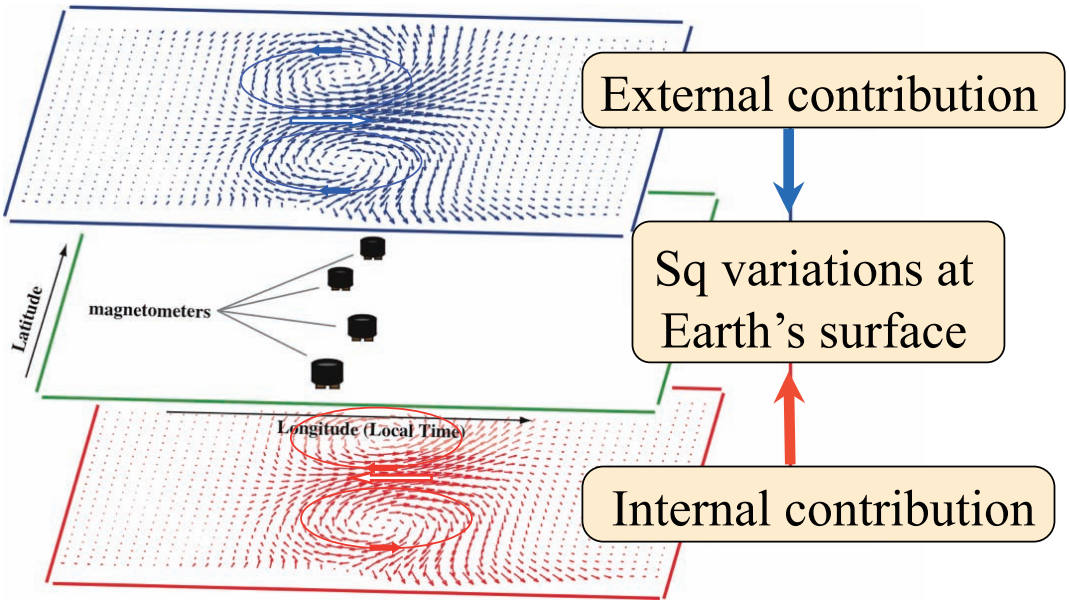
3.7 Spherical Harmonic Analysis of Sq Variation



M=6
N= m+17

(see Cambel, 1990)

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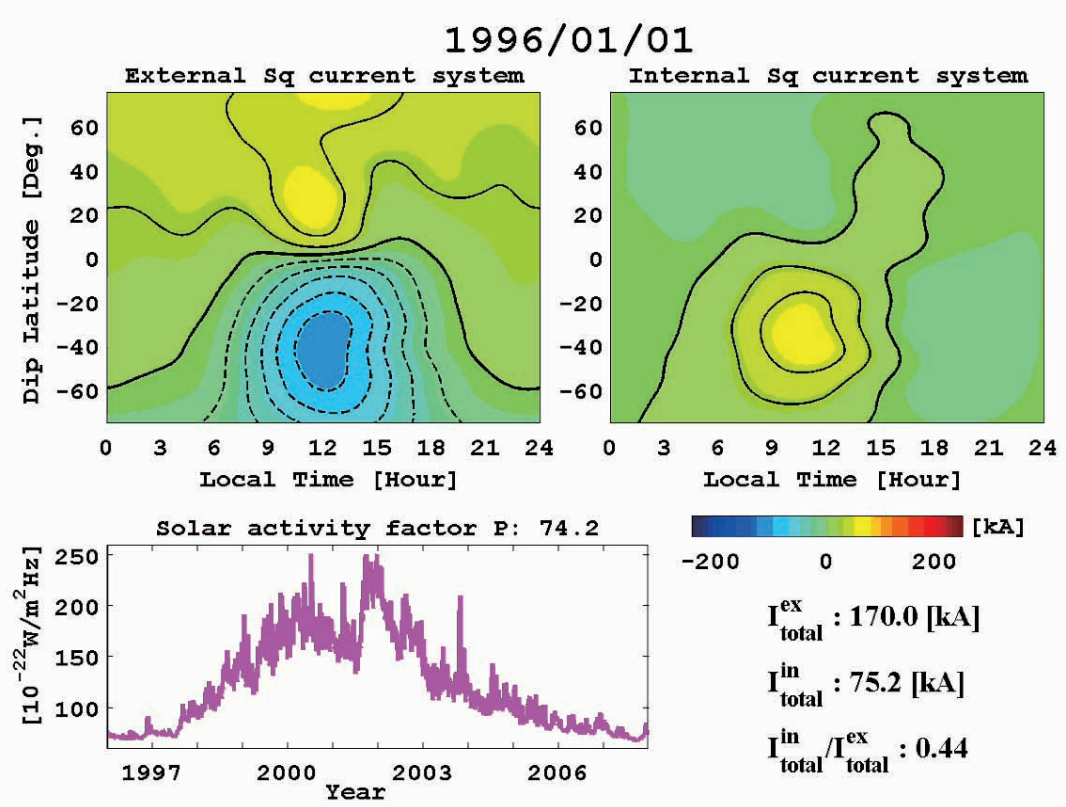
3.8 Sq Currents in the Ionosphere and Lithosphere as a Function of Solar Cycle Activity (F10.7)



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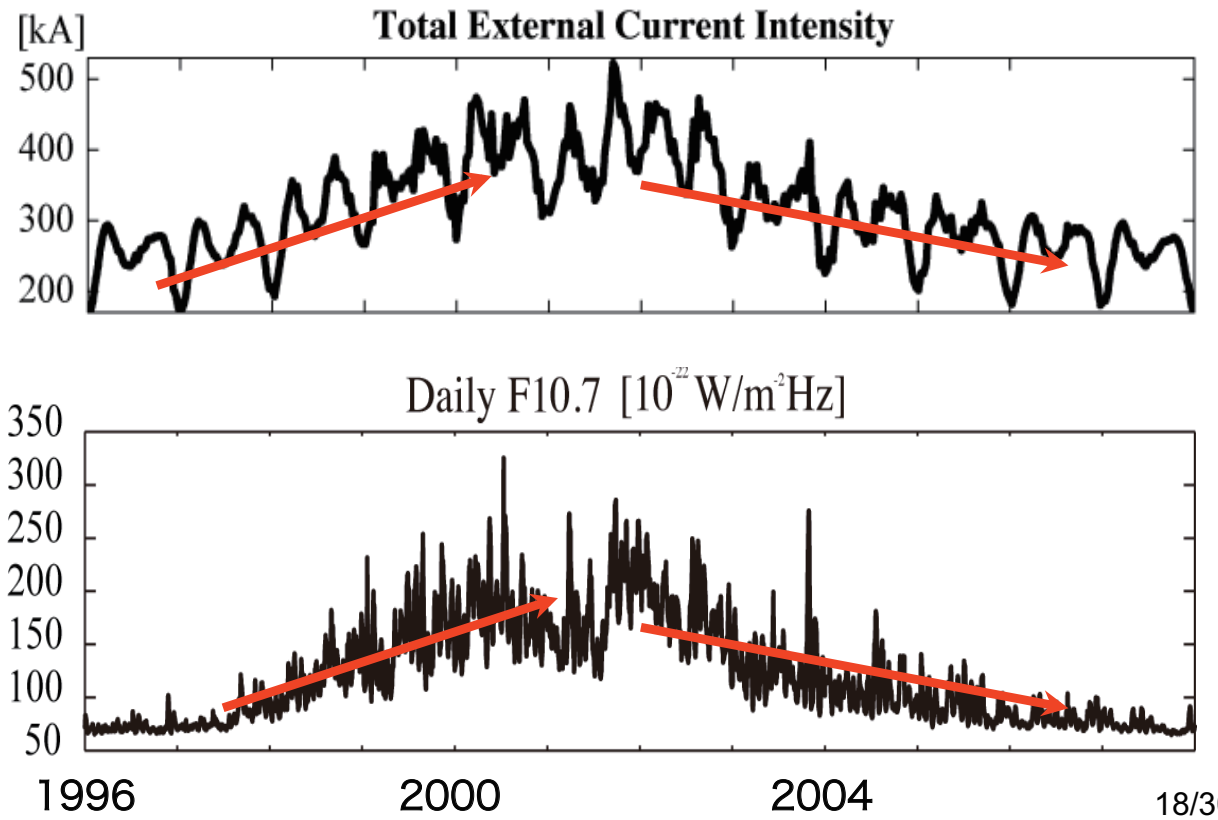
3.9 Solar Cycle Variation of Sq Current Intensity



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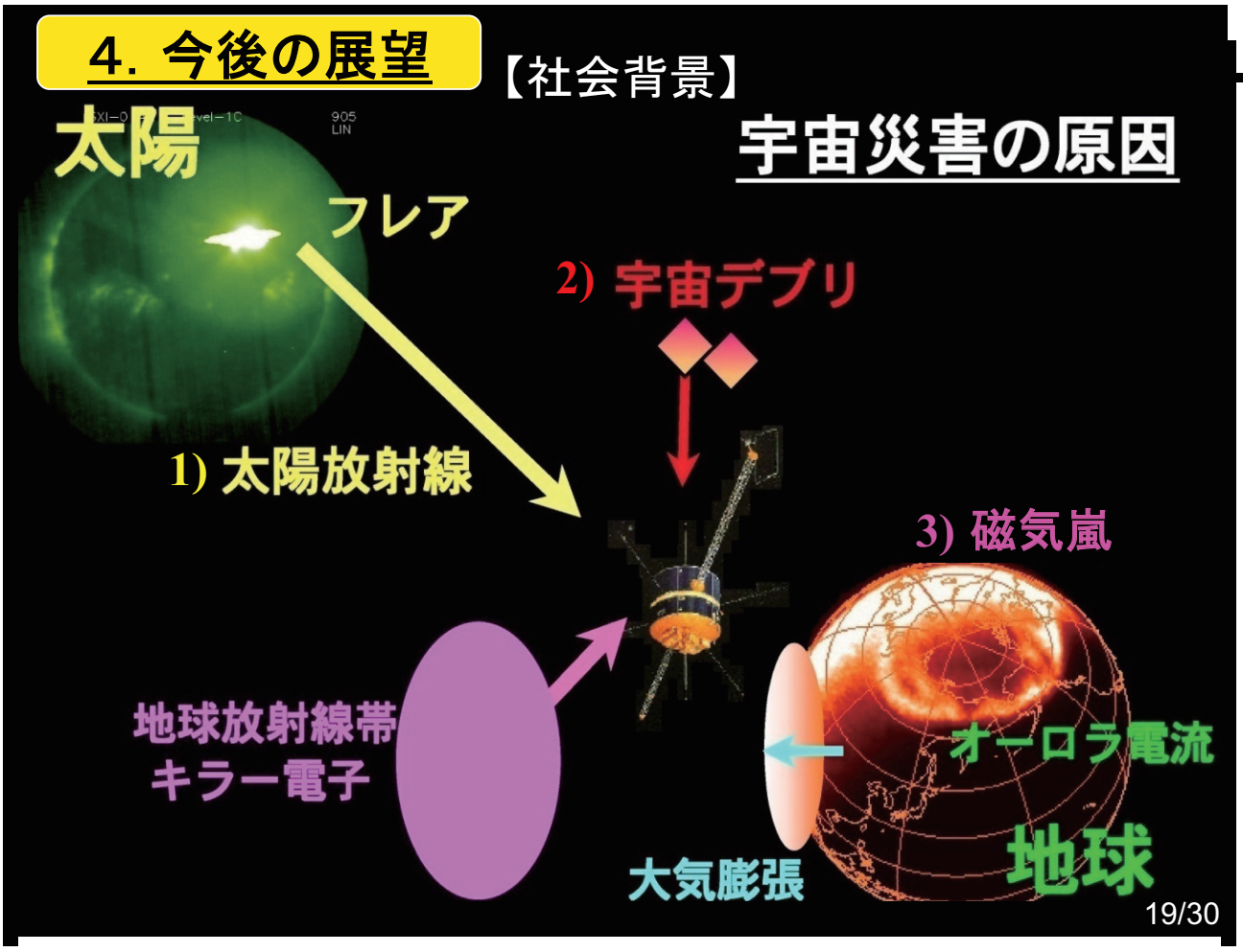
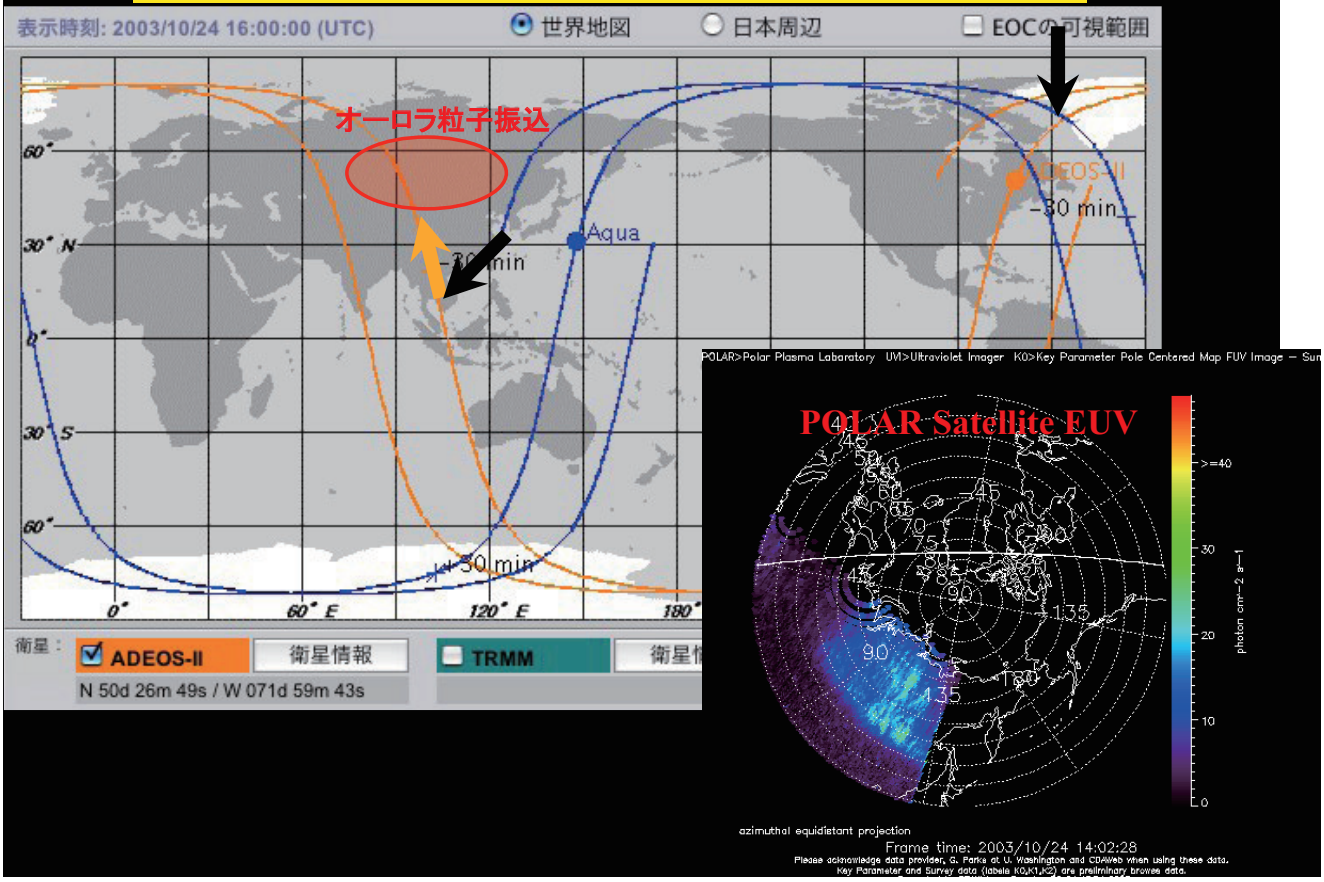
4. 今後の展望

【社会背景】

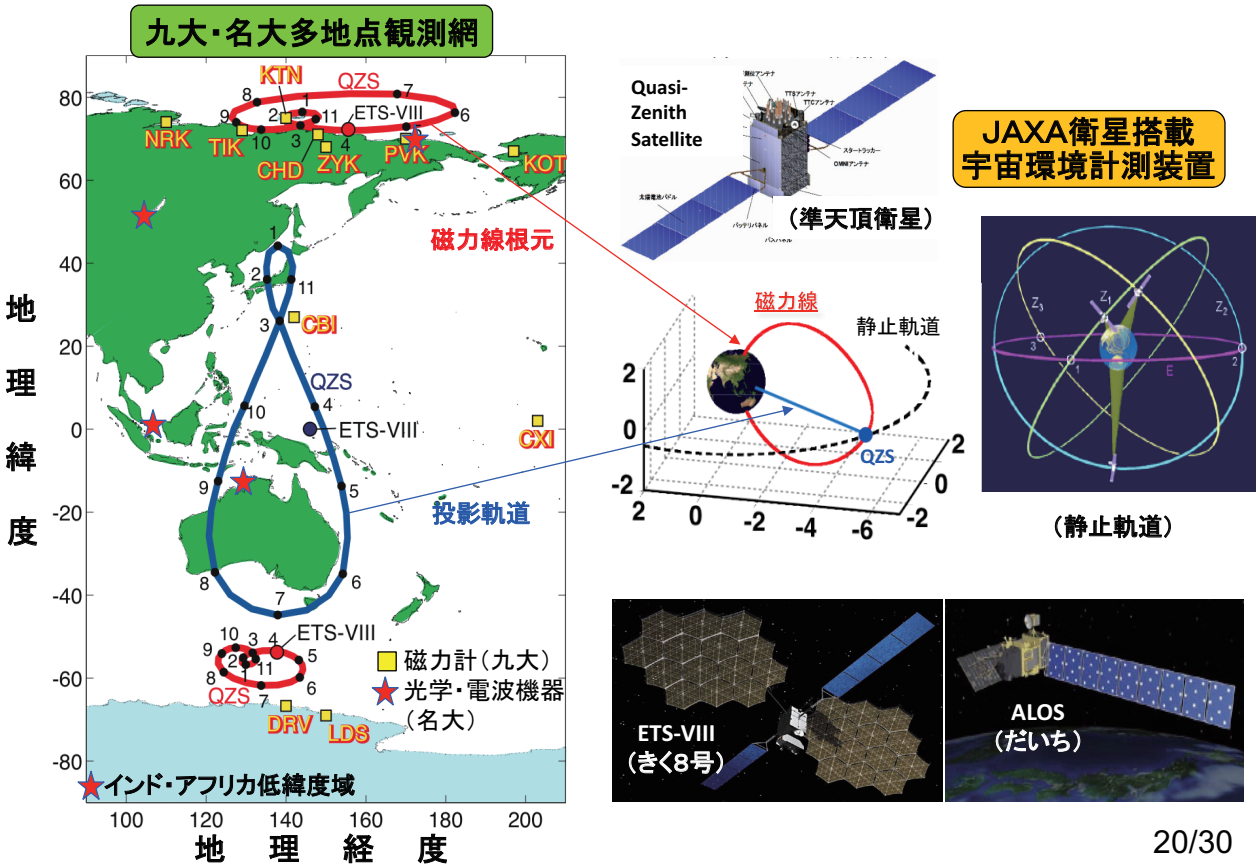


4.1-2 SC-性孤立擾乱 (SSD)による衛星破壊

4.1-3 SSDと「みどり2号」衛星軌道



4.2 地上観測群JAXA衛星による磁気嵐宇宙環境の連携観測



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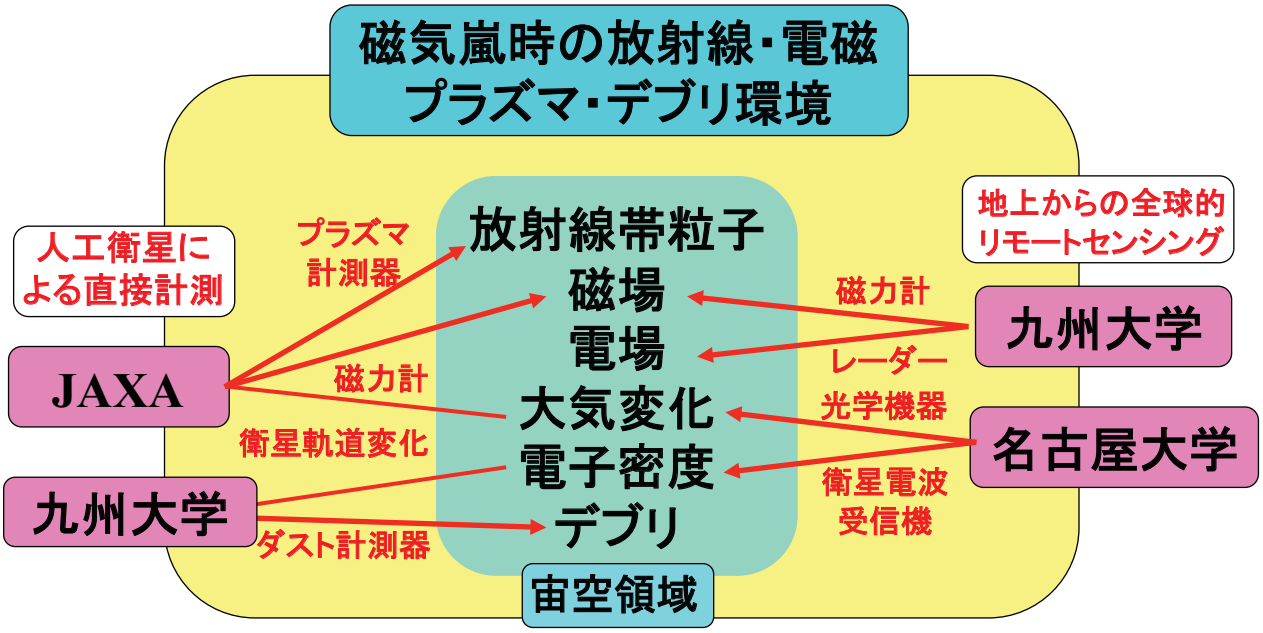
4.2–2　各機関の観測研究の役割分担と連携



磁気嵐時の宇宙環境を理解するためには、人工衛星による直接観測と地上多地点観測によるリモートセンシングの連携は不可欠

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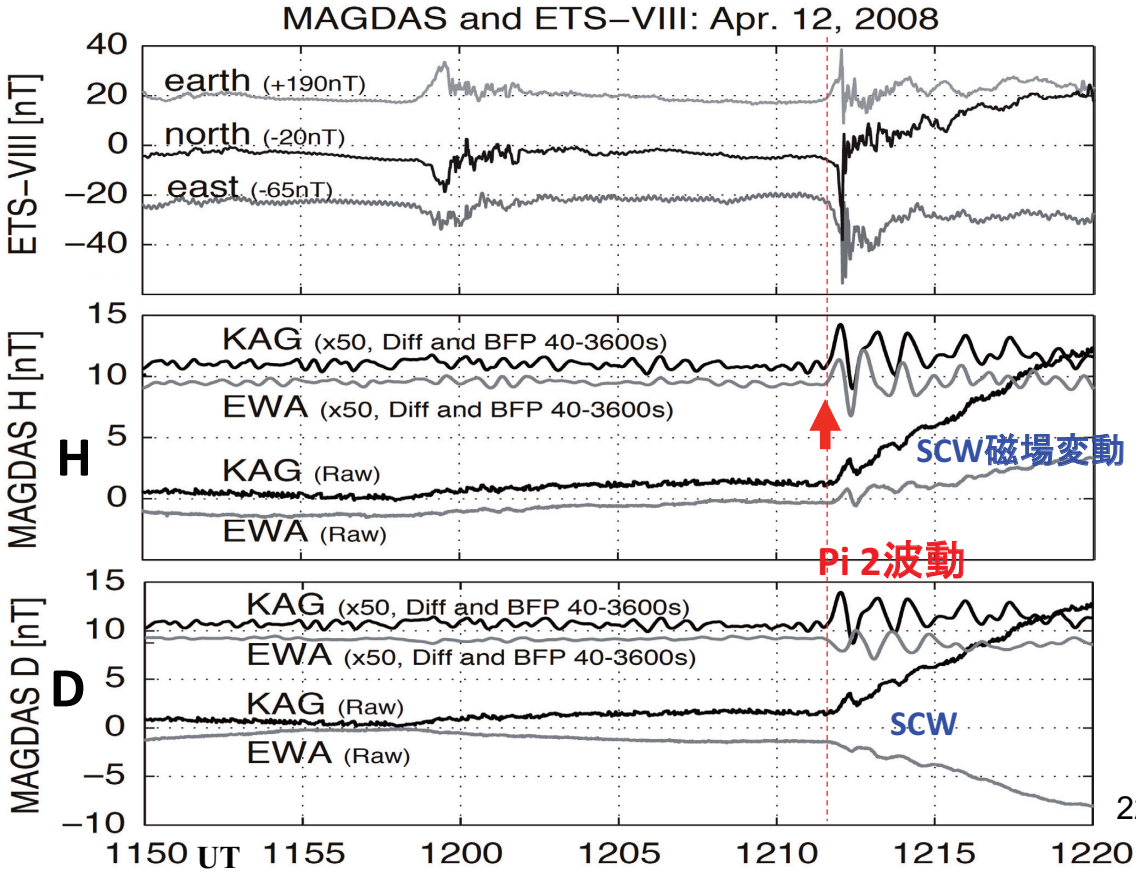
4.2–3　磁気圏嵐時の地上衛星同時観測



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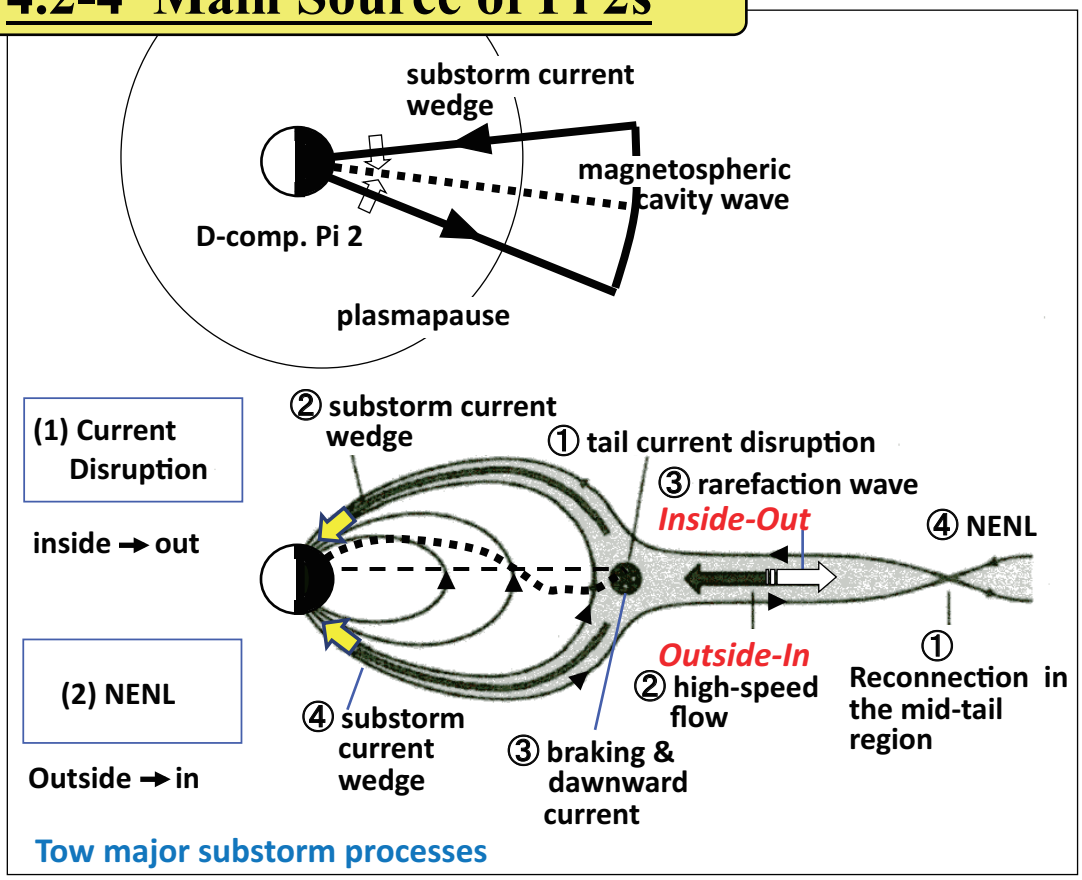
4.2-4 Main Source of Pi 2s



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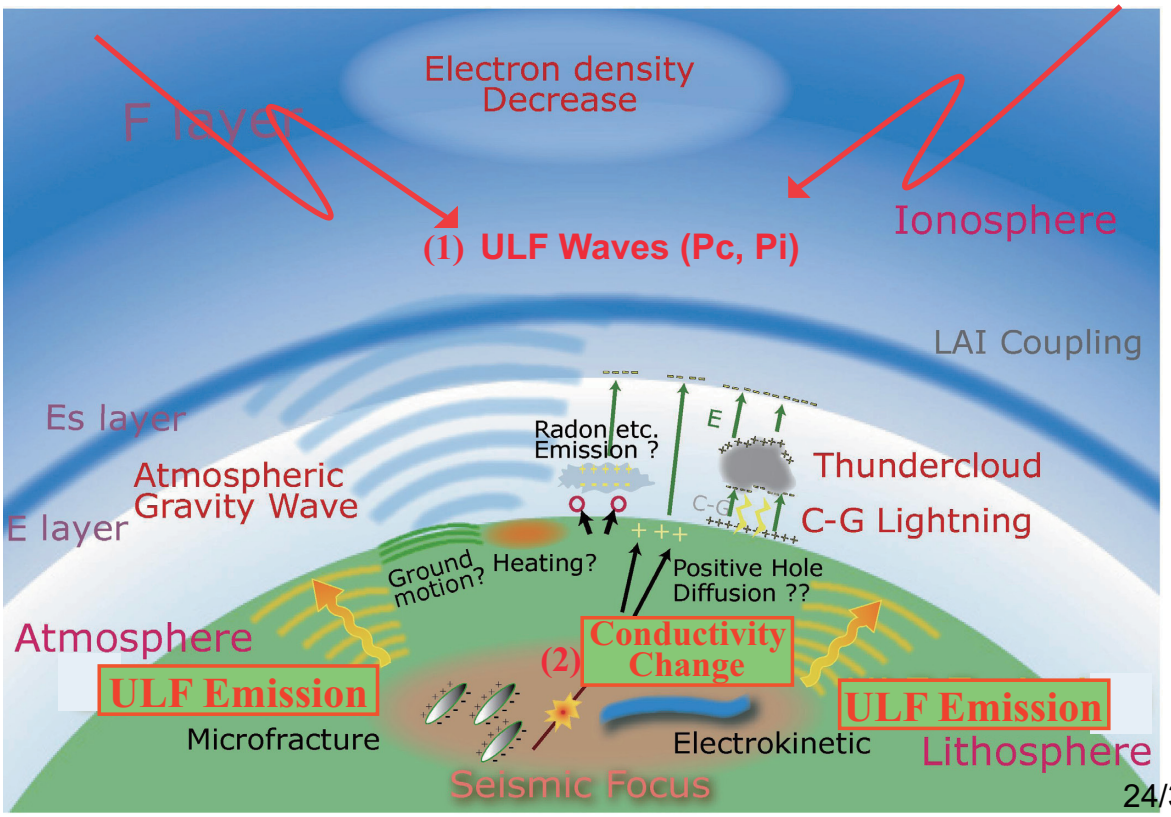
4.3 Magnetic Anomaly Associated with Great EQs in Litho-Space (P-I-A-L sphere)



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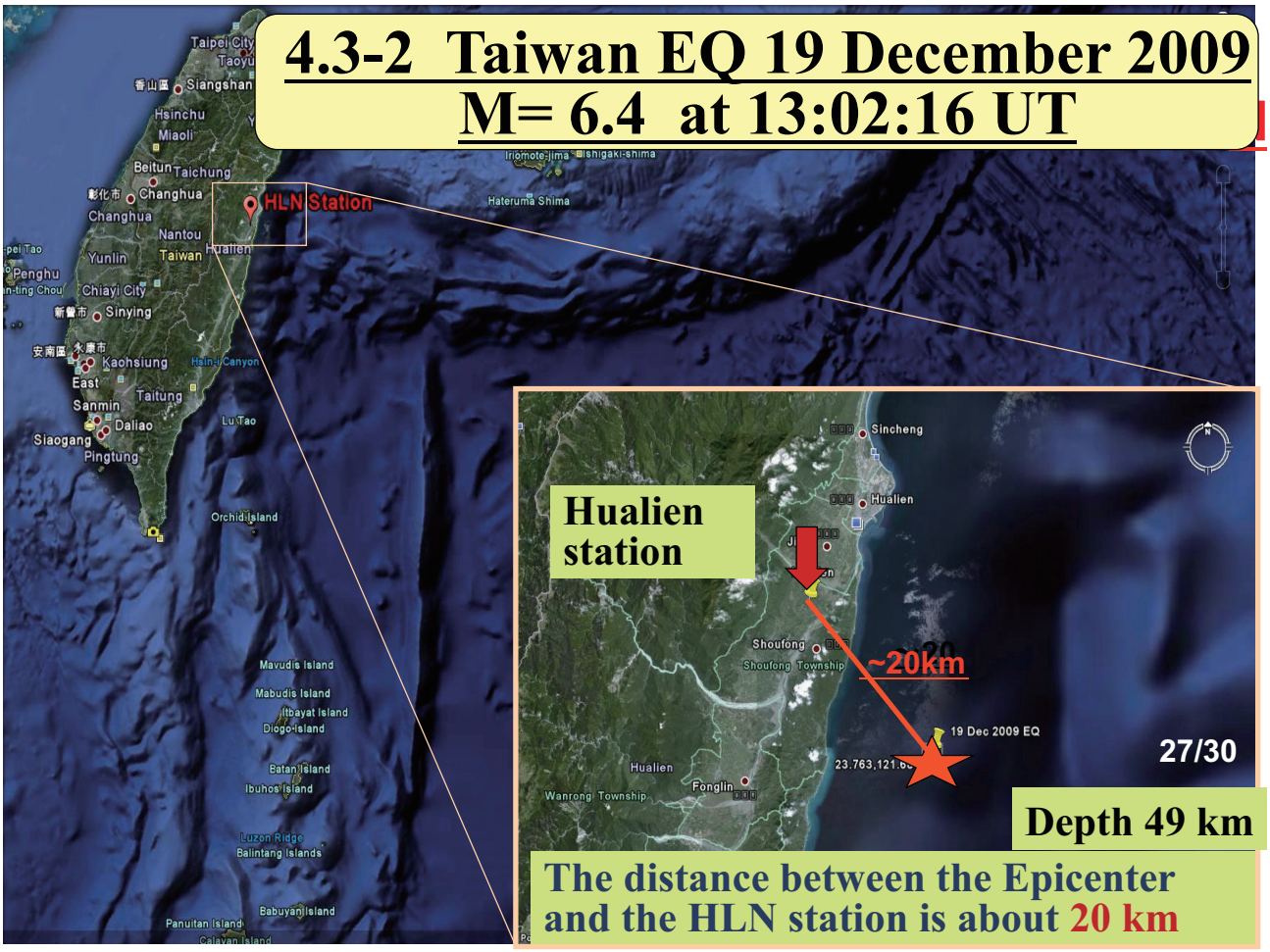
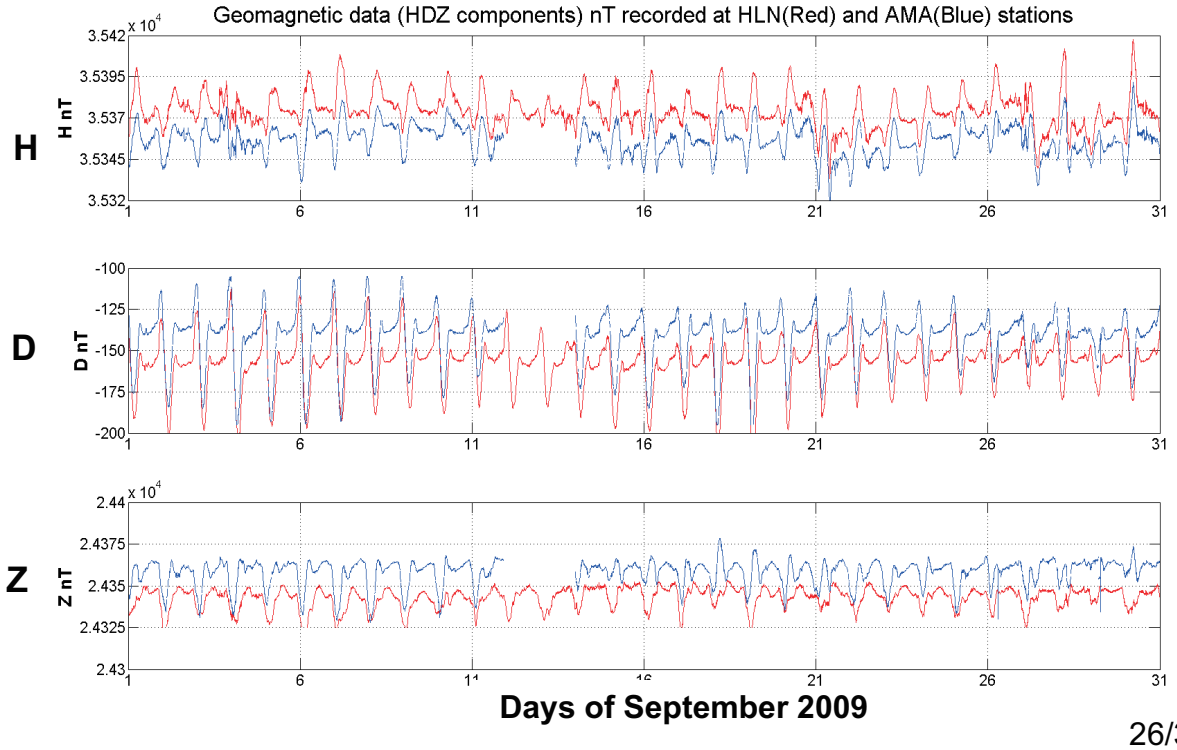


4.3-3 Geomagnetic Data (HDZ) at HLN (~20km) and AMA (~900km) Stations during September 2009



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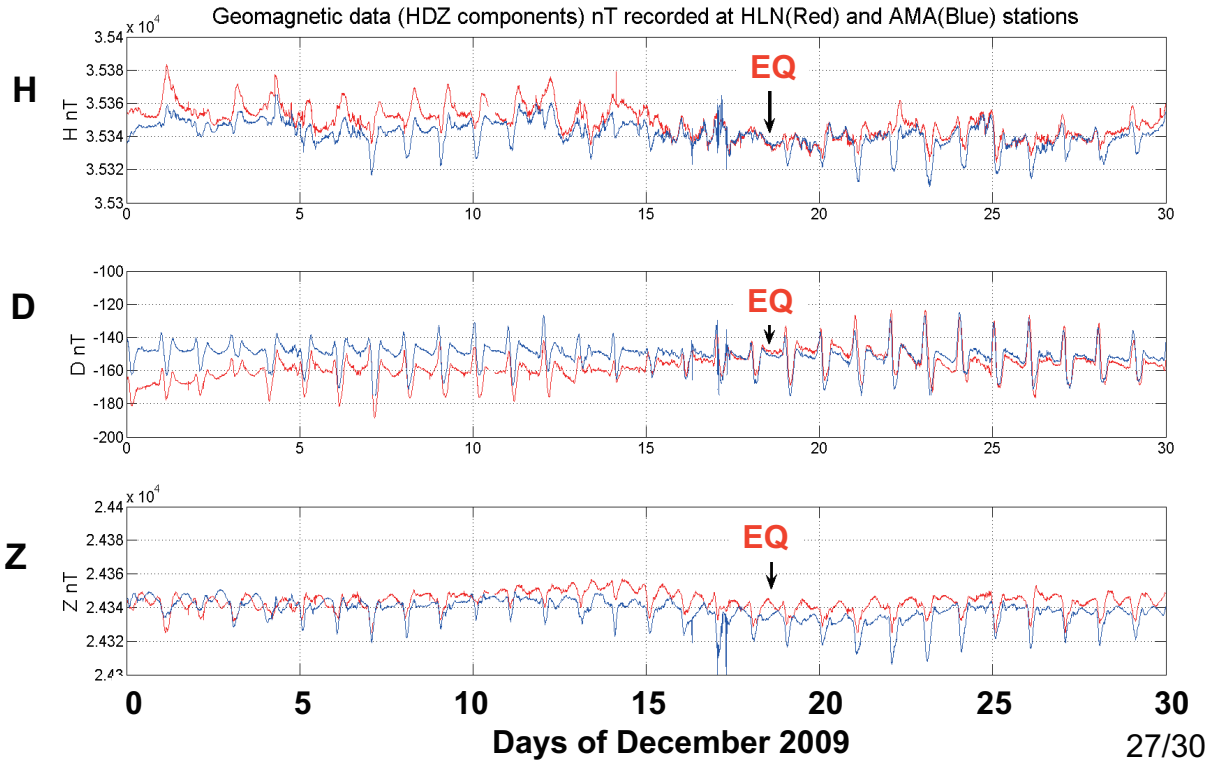
4.3-3.2 Geomagnetic Data (HDZ) at HLN (~22km) and AMA(~900km) Stations during December 2009



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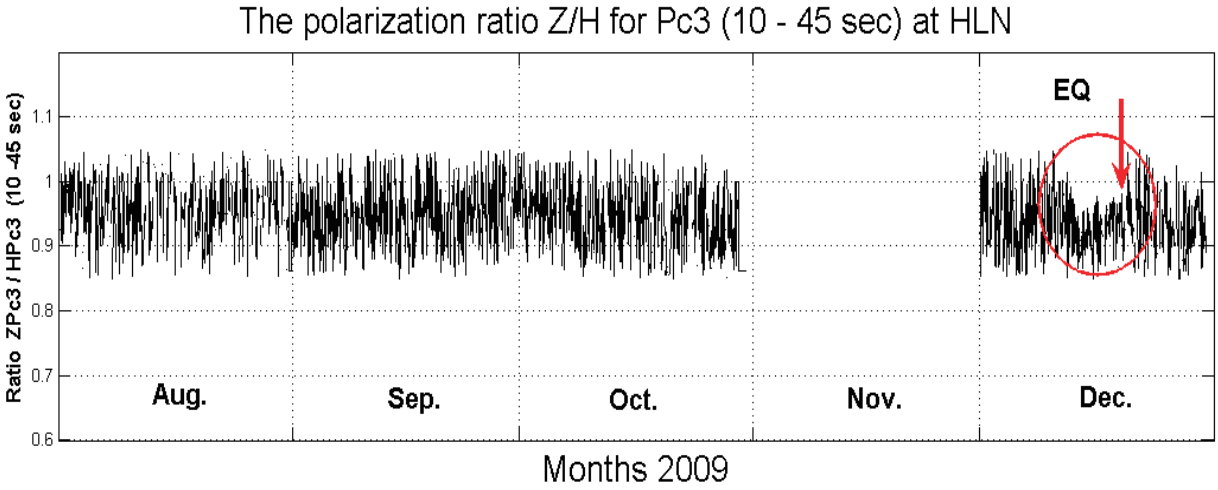
4.3-4 Hourly Averaged Values of Pc3 Polarization Ratio (Z/H) at HLN

(Aug.- Dec . 2009) **Takla et al.(2010)**



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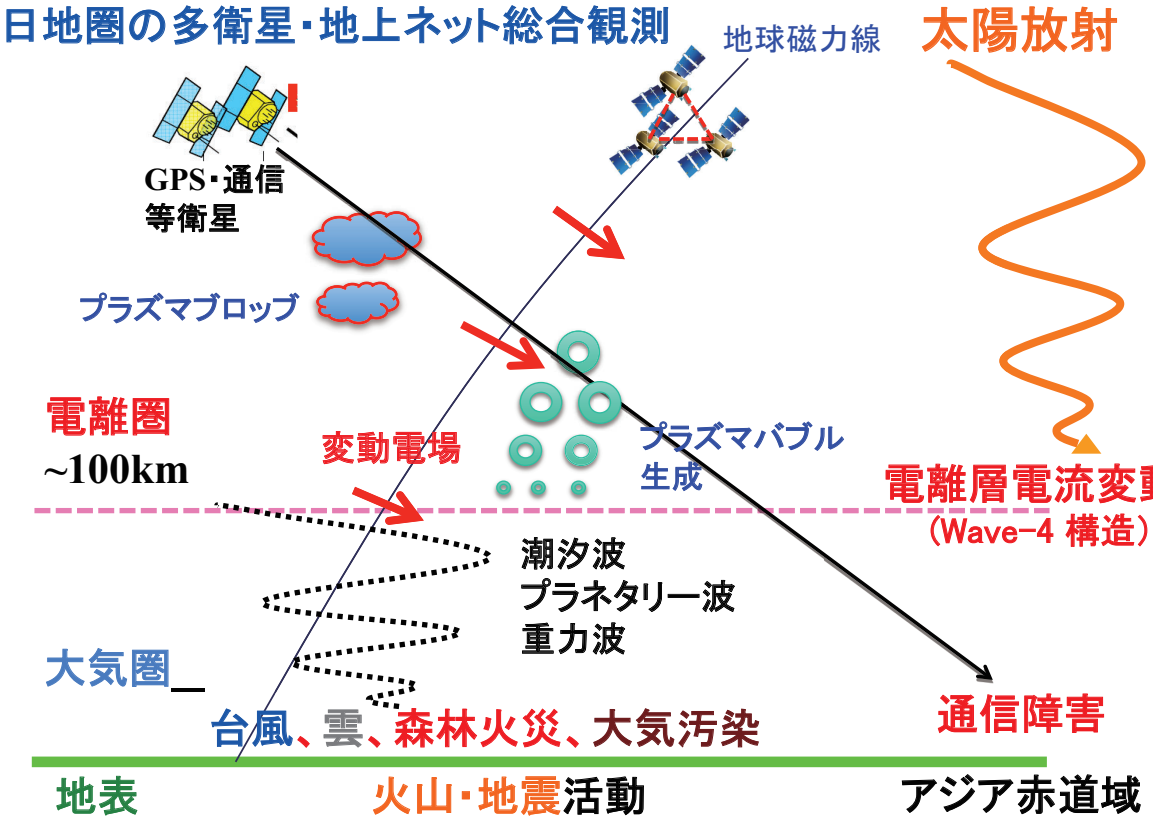
4.4 太陽面–電離圏–大気圏–地圏結合の観測的研究



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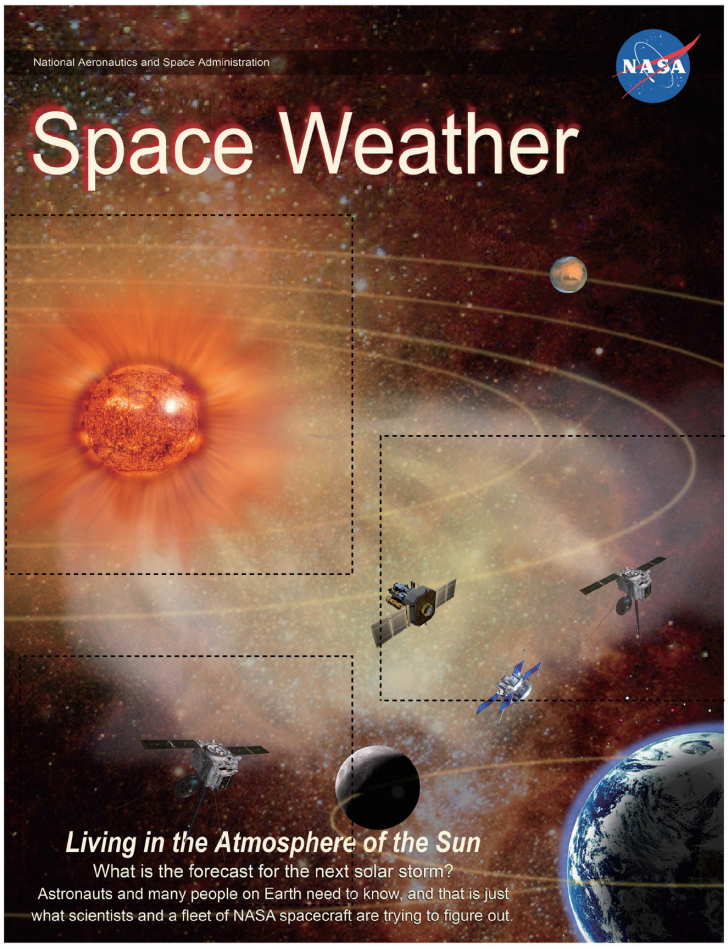

4.5 まとめ

1) 太陽環境と地球環境と一体化した地上衛星観測研究

➡ 日地科学への展開

“Living in the Atmosphere of the Sun”→
「太陽大気と生きる」

2) 全球局所統合型観測

・研究の南北問題の解決
・人的ネットワーク形成

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