Optical Mesosphere Thermosphere Imagers (OMTIs)

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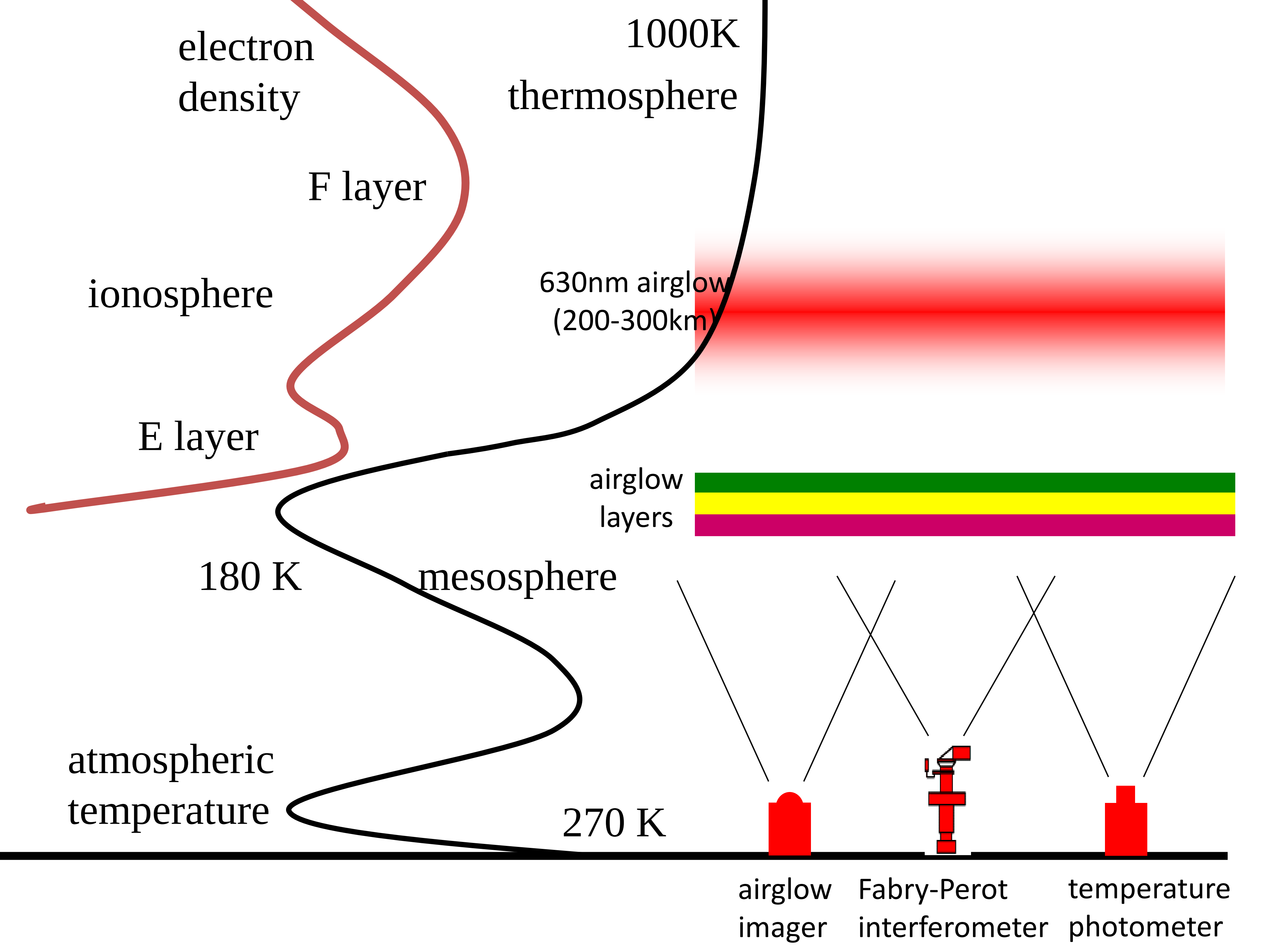
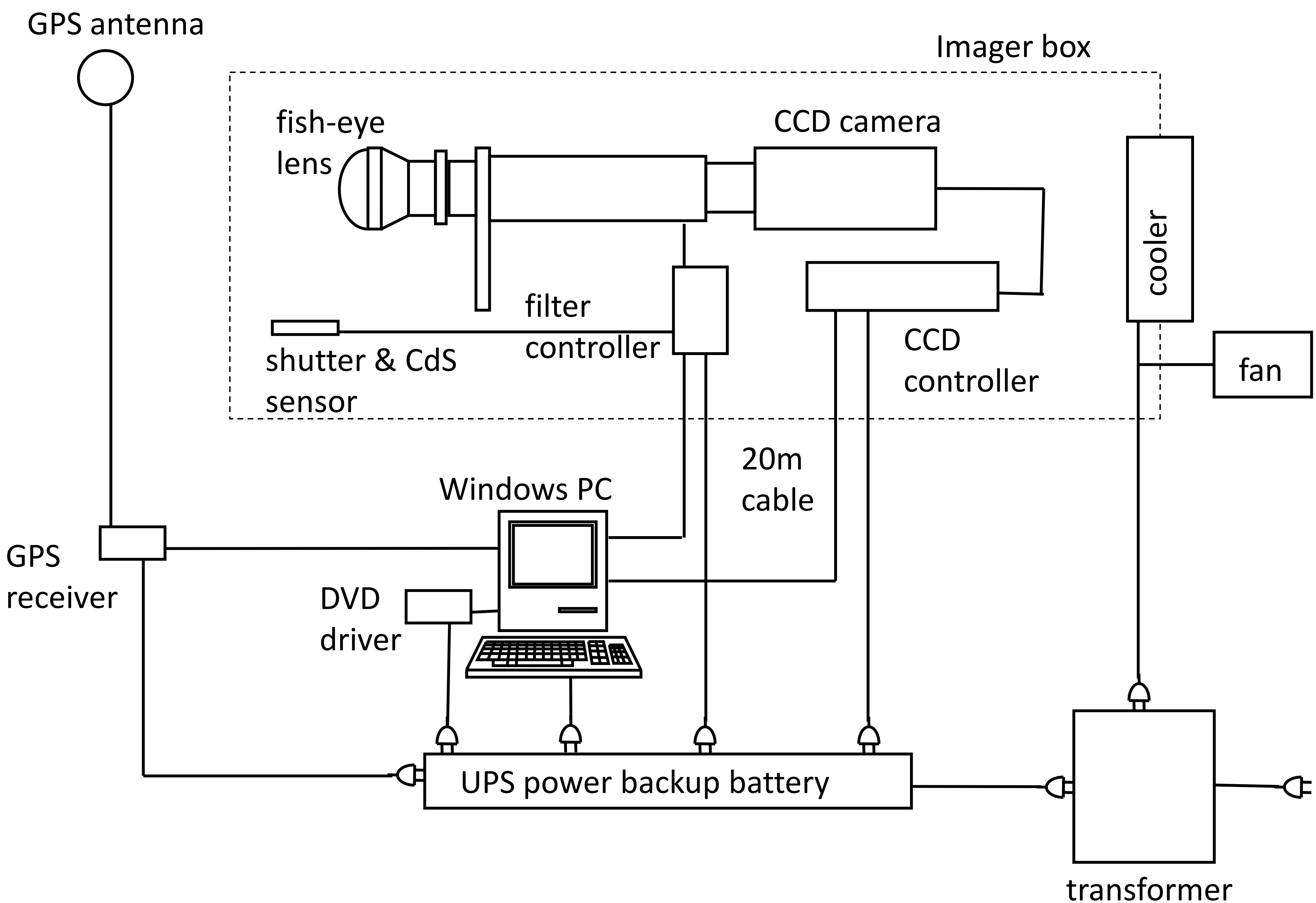
Solar-Terrestrial Environment Laboratory, Nagoya University, JAPAN

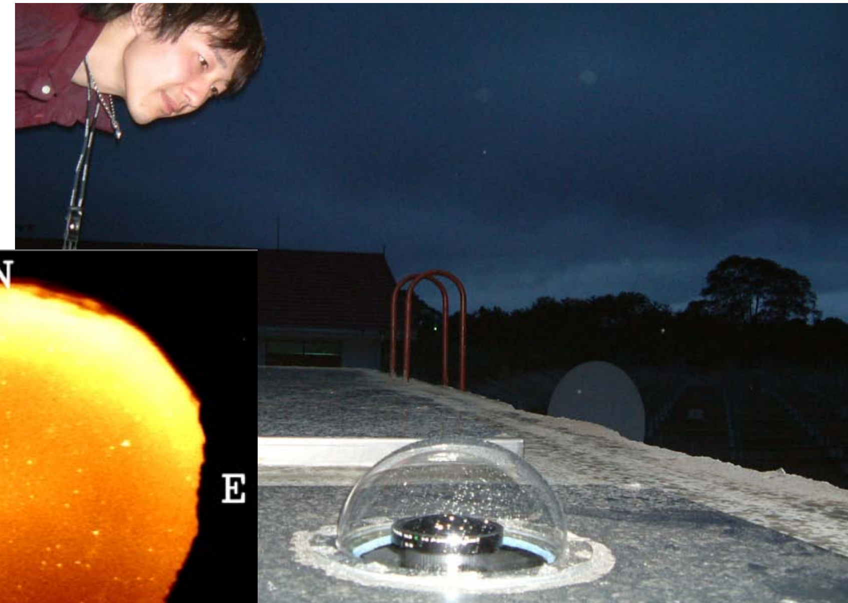
International Space Weather Initiative (ISWI) UN/NASA/JAXA Workshop, Helwan, Egypt, November 7, 2010

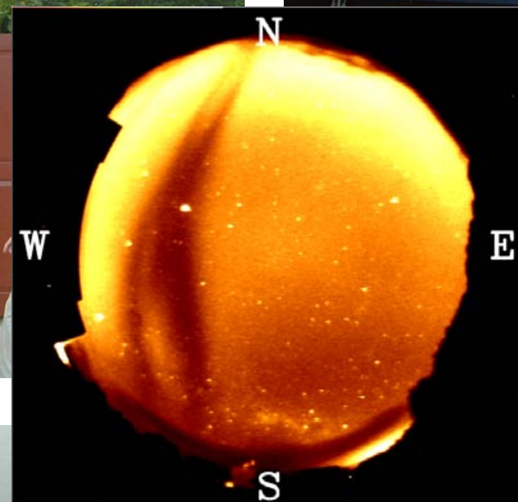

electron
density
1000K
thermosphere
F layer
ionosphere
630nm airglow
(200-300km)
E layer
airglow
layers
180 K
mesosphere
atmospheric
temperature
270 K
airglow
imager
Fabry-Perot
interferometer
temperature
photometer

all-sky airglow imager system



Airglow imager at Kototabang, Indonesia(Oct.26, 2002-)



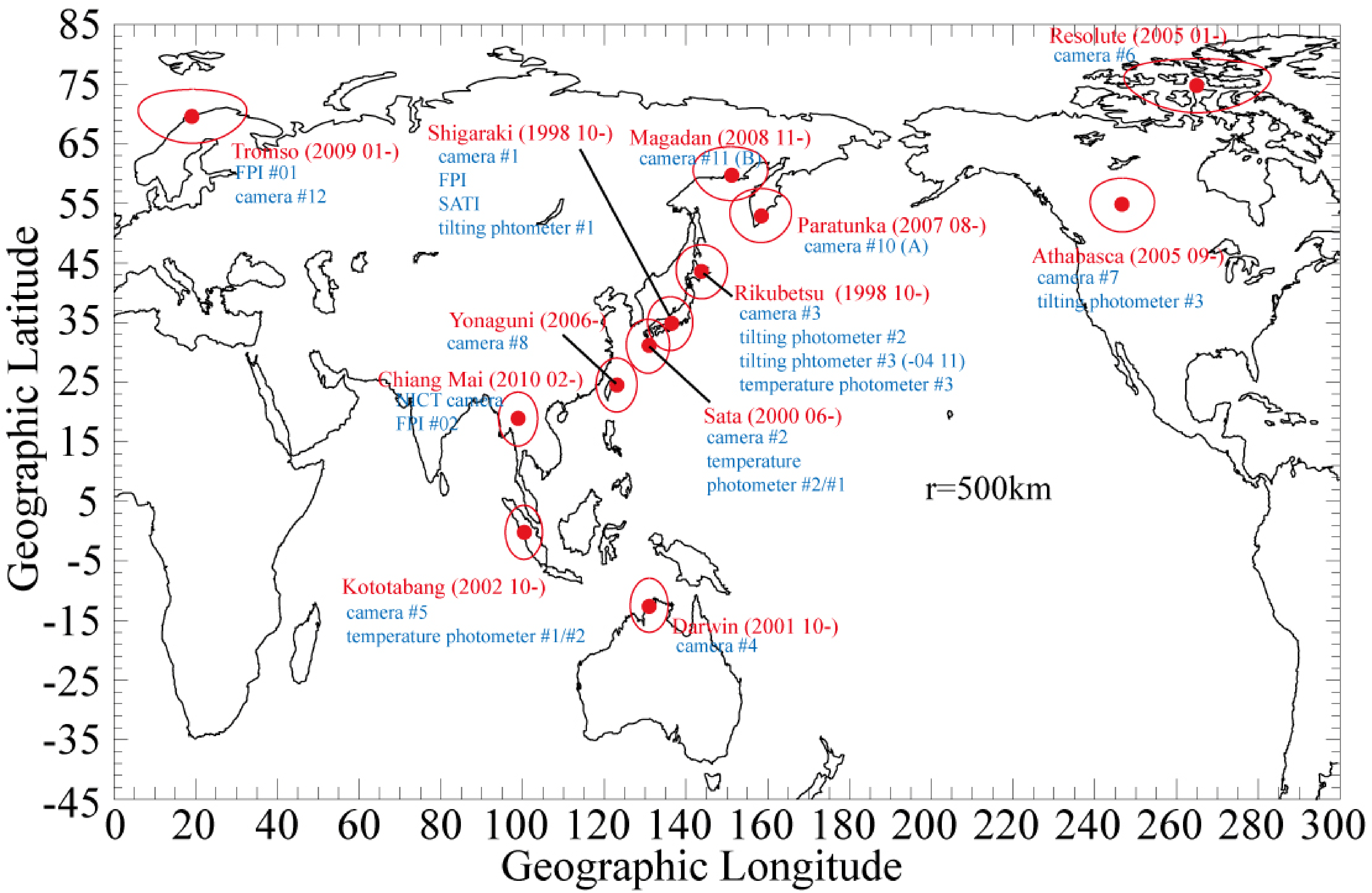


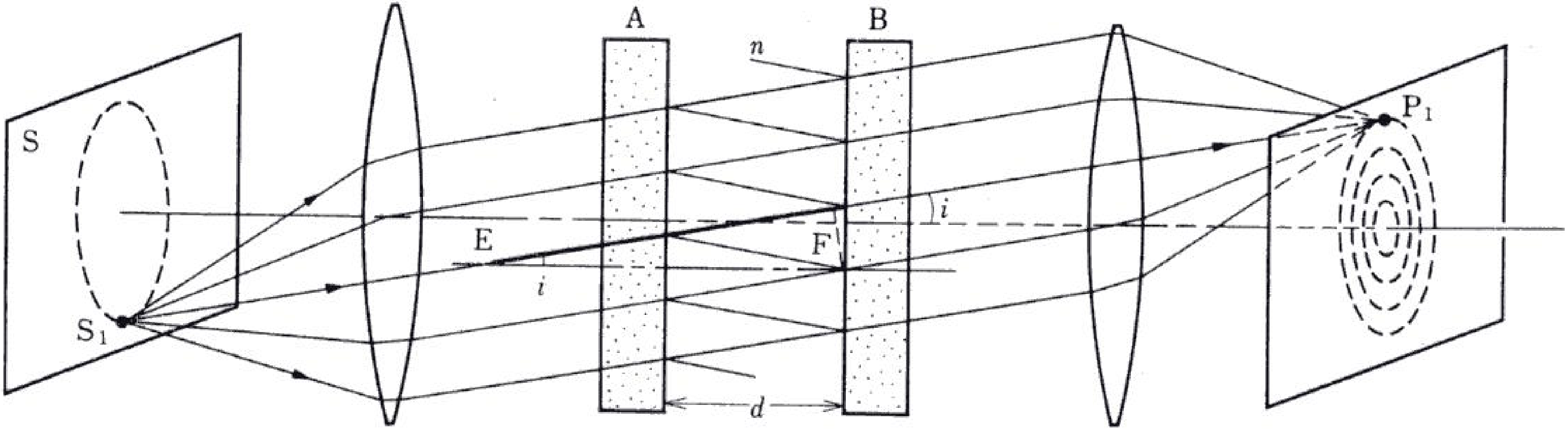

all-sky camera

camera
GPS

PC room


http://stdb2.stelab.nagoya-u.ac.jp/omti/



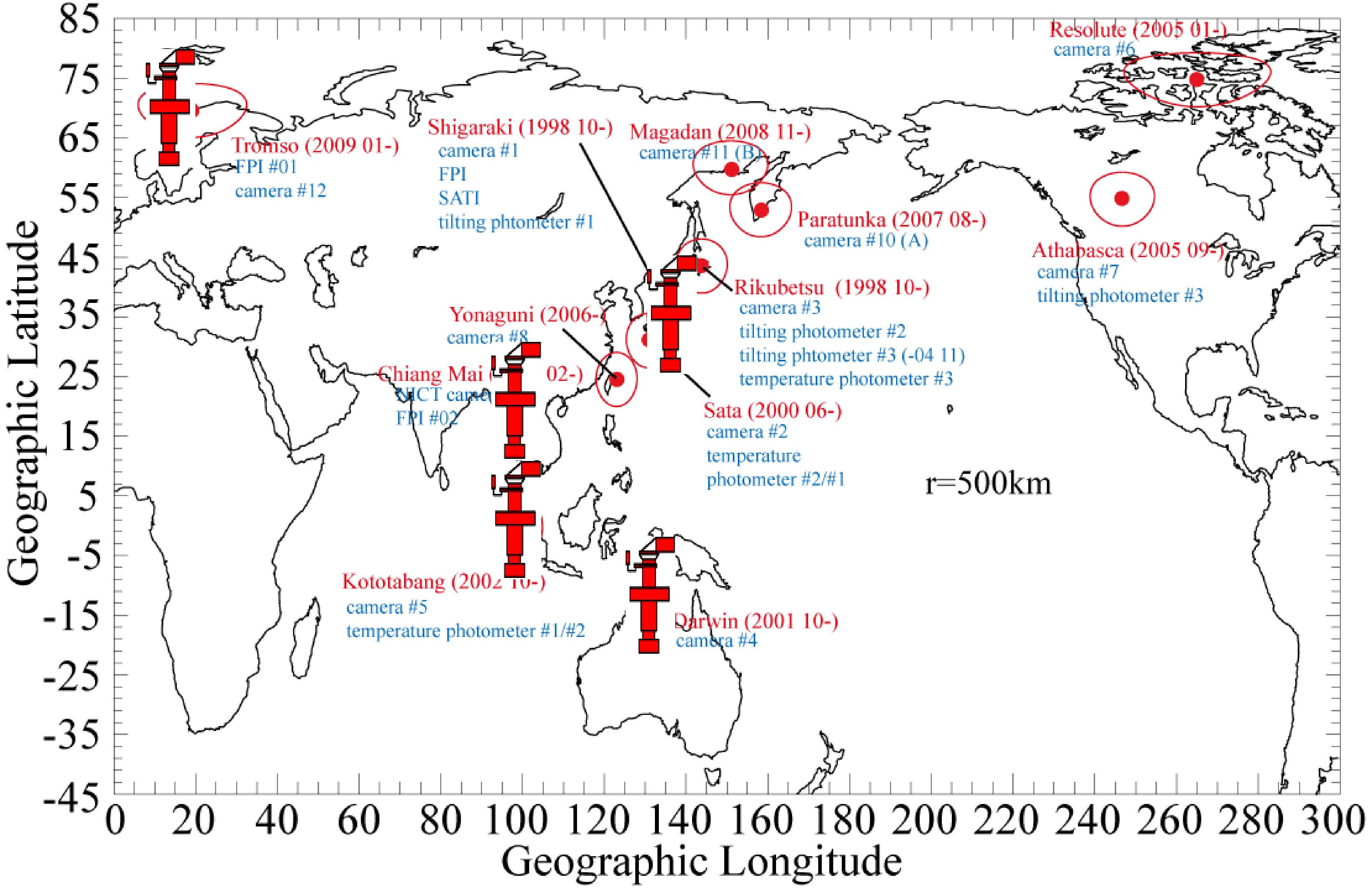


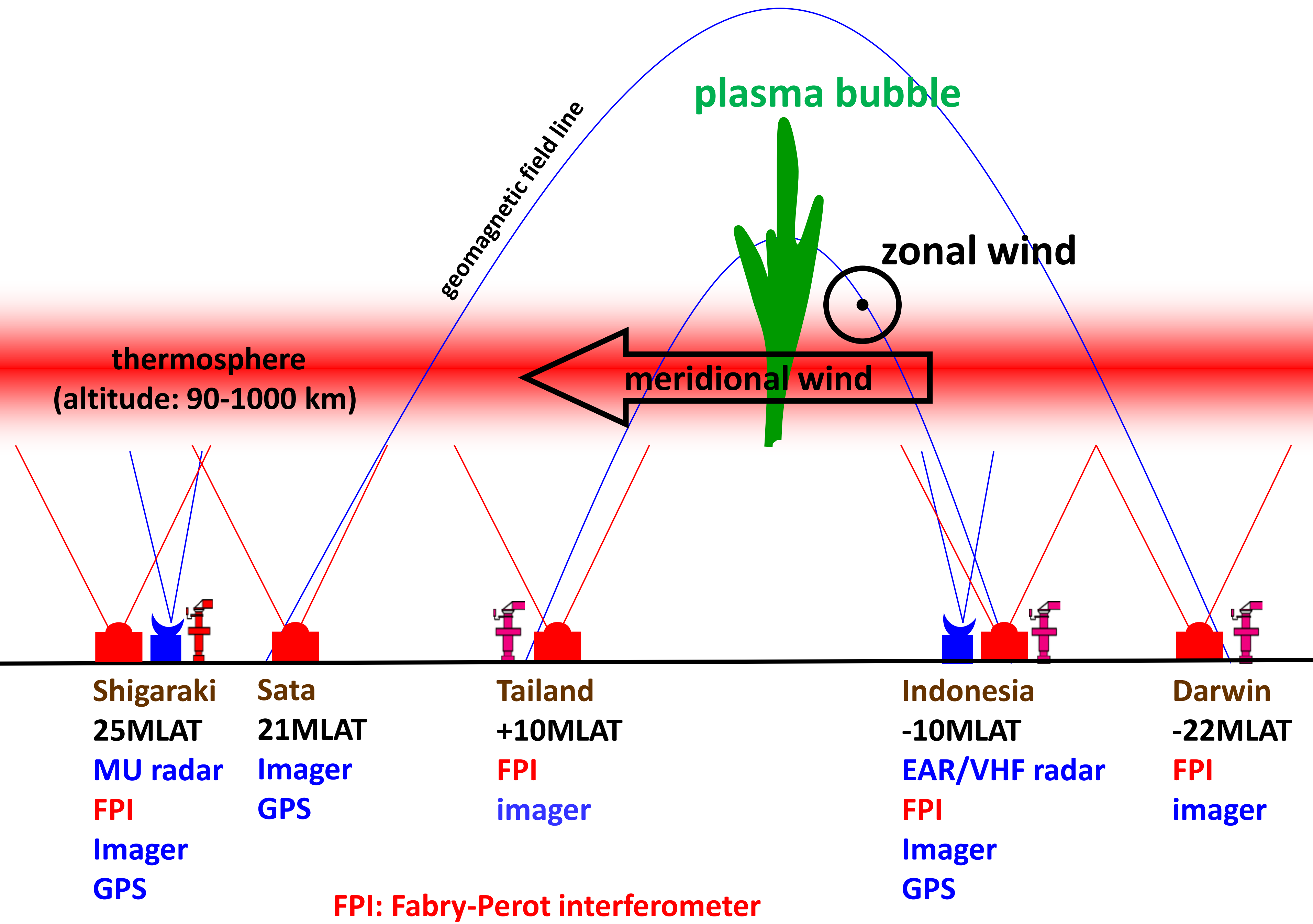
（a） etalon または Fabry-Perot 干渉計
光路長差 EF = $2nd\cos i$

$$m = 2\mu d \cos i / \lambda$$

Fabry-Perot interferometer

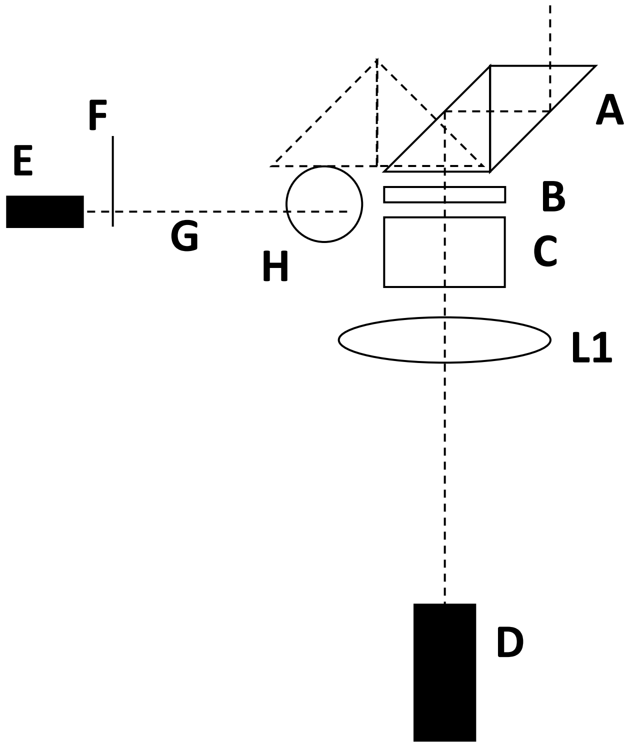
Development of Fabry-Perot interferometers





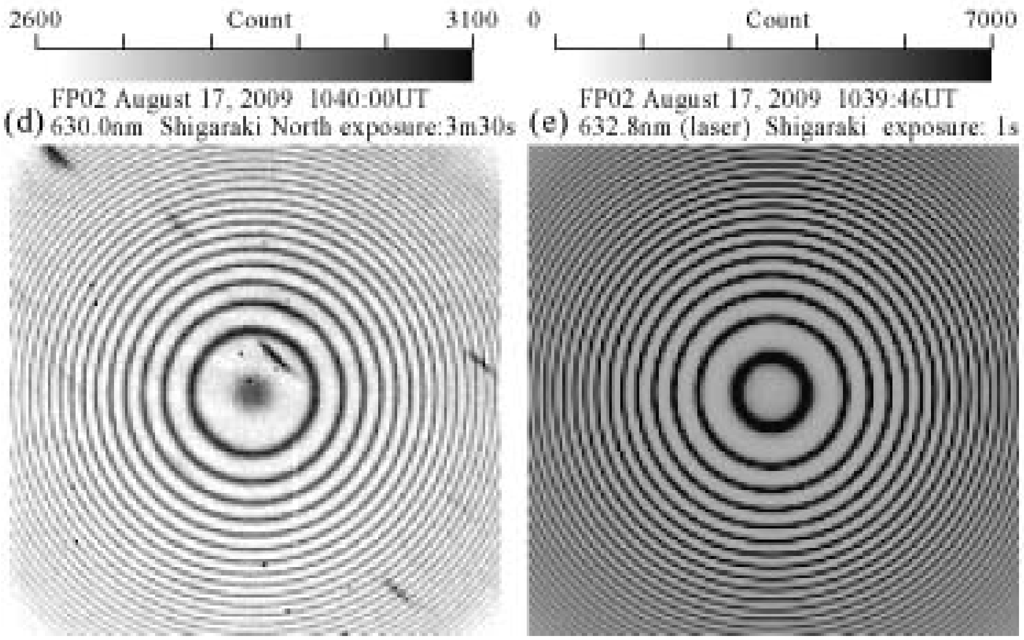
plasma bubble
geomagnetic field line
zonal wind
thermosphere
(altitude: 90-1000 km)
meridional wind
Shigaraki
25MLAT
MU radar
FPI
Imager
GPS
Sata
21MLAT
Imager
GPS
Tailand
+10MLAT
FPI
imager
Indonesia
-10MLAT
EAR/VHF radar
FPI
Imager
GPS
Darwin
-22MLAT
FPI
imager
FPI: Fabry-Perot interferometer

(2) Low-Latitude-FPI x 3



A: sky scanner, aperture: 4.0inchΦ (101.6mmΦ)
B: interference filter (3inchΦ=76.2mm, 630.0nm)
C: sealed etalon, 70mmΦ, d=15mm,
incident angle<1.4126 deg, R=0.76
L1: achromat, 80mmΦ, f=270mm
D: CCD camera (Hamamatsu C4742-98-26KWG2)
1024x1024 pixel, 13.312mmx13.312mm

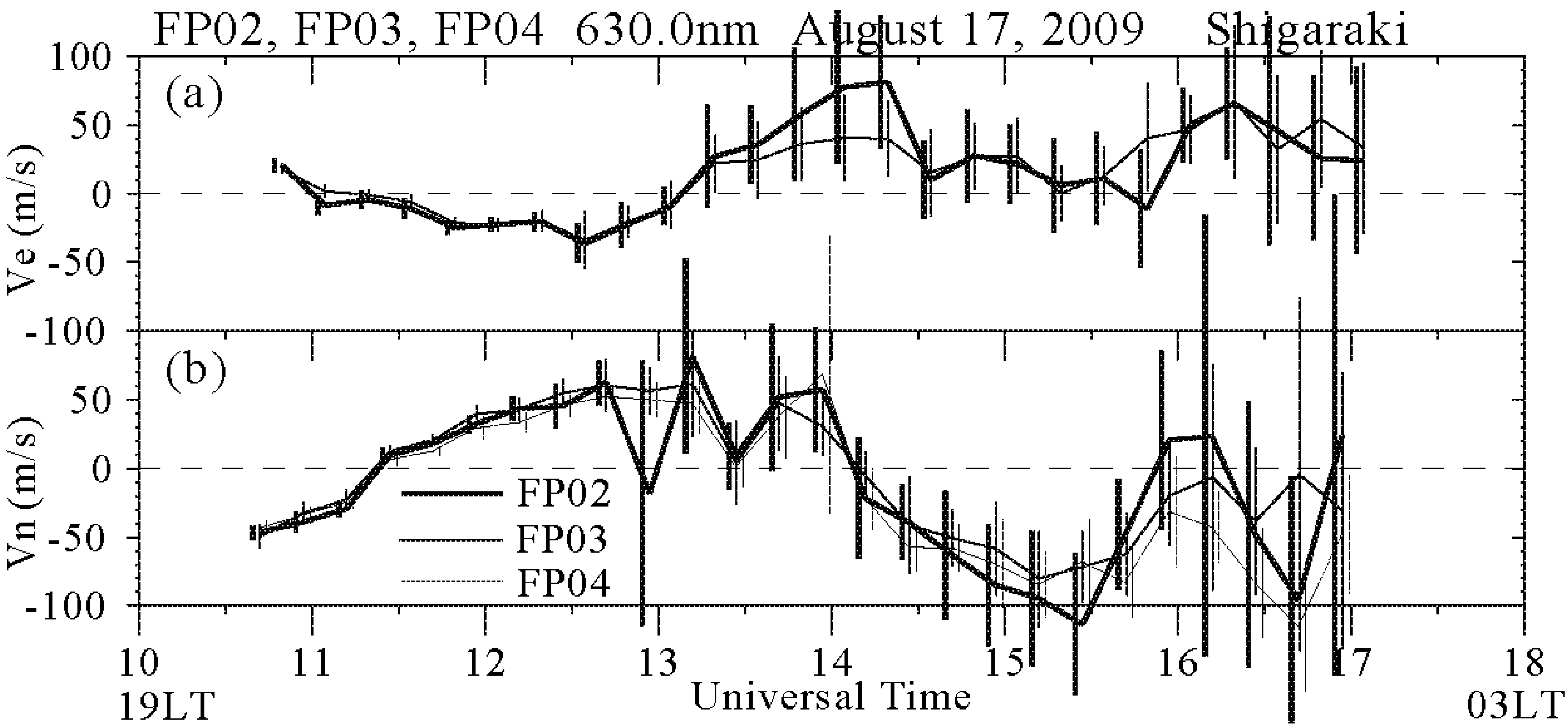
E: frequency-stabilized He-Ne laser
F: laser shutter
G: optical fiber
H: scattering box




Chiang Mai

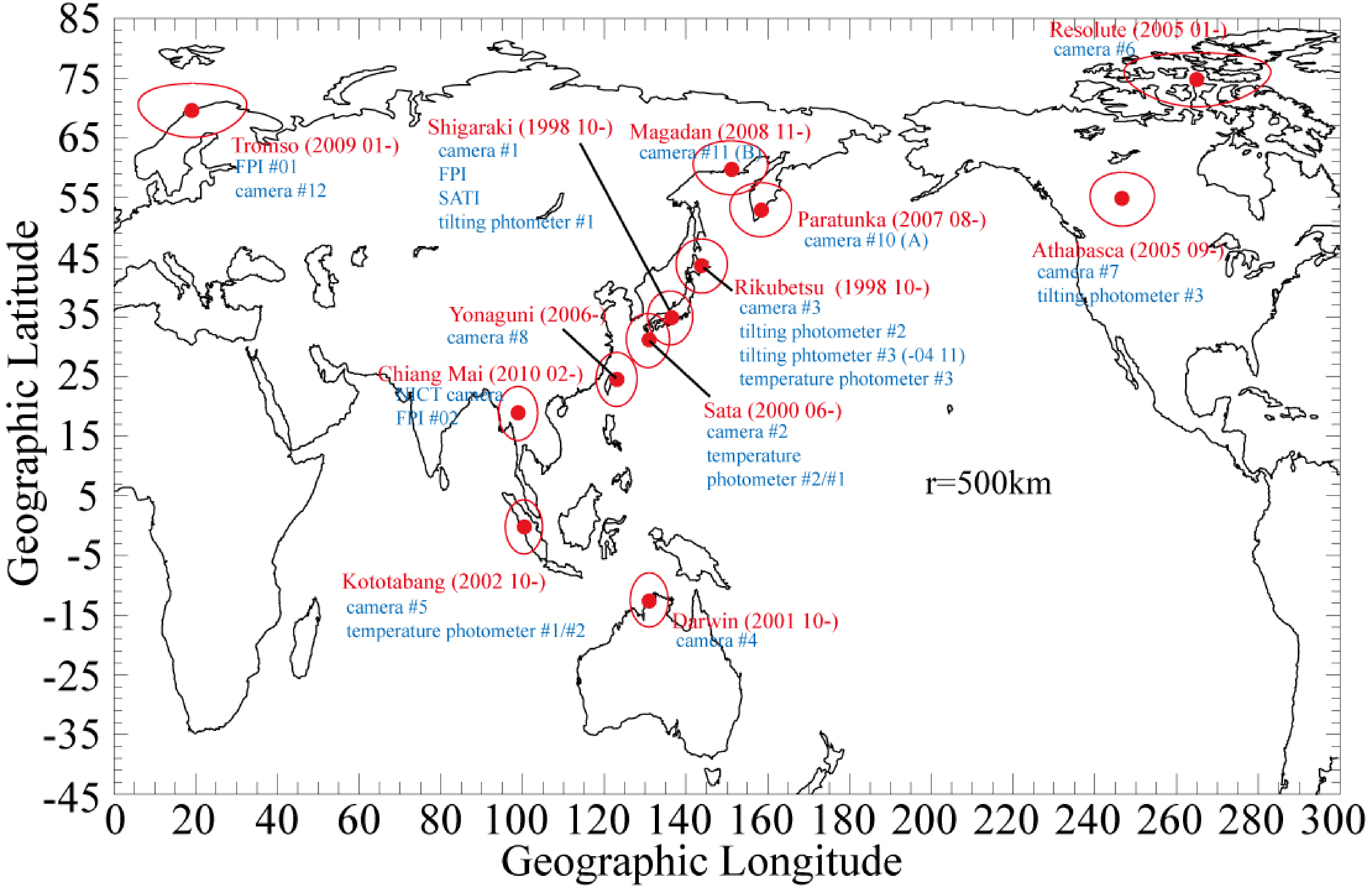

Kototabang


Chiang Mai



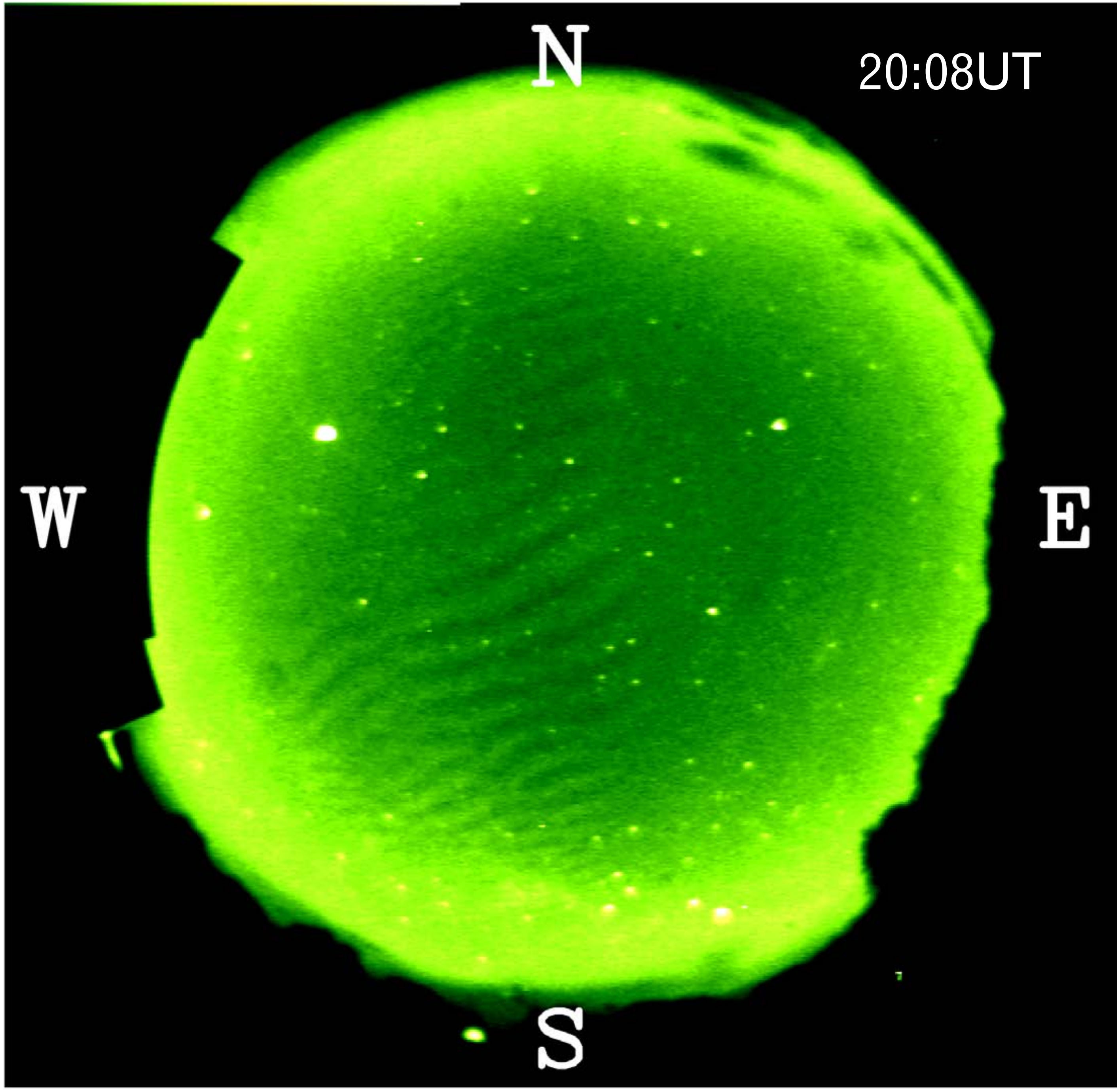
FP02, FP03, FP04 630.0nm August 17, 2009 Shigaraki
(a)
(b)
Ve (m/s)
Vn (m/s)
100
50
0
-50
-100
FP02
FP03
FP04
10
11
12
13
14
15
16
17
18
19LT
Universal Time
03LT

http://stdb2.stelab.nagoya-u.ac.jp/omti/

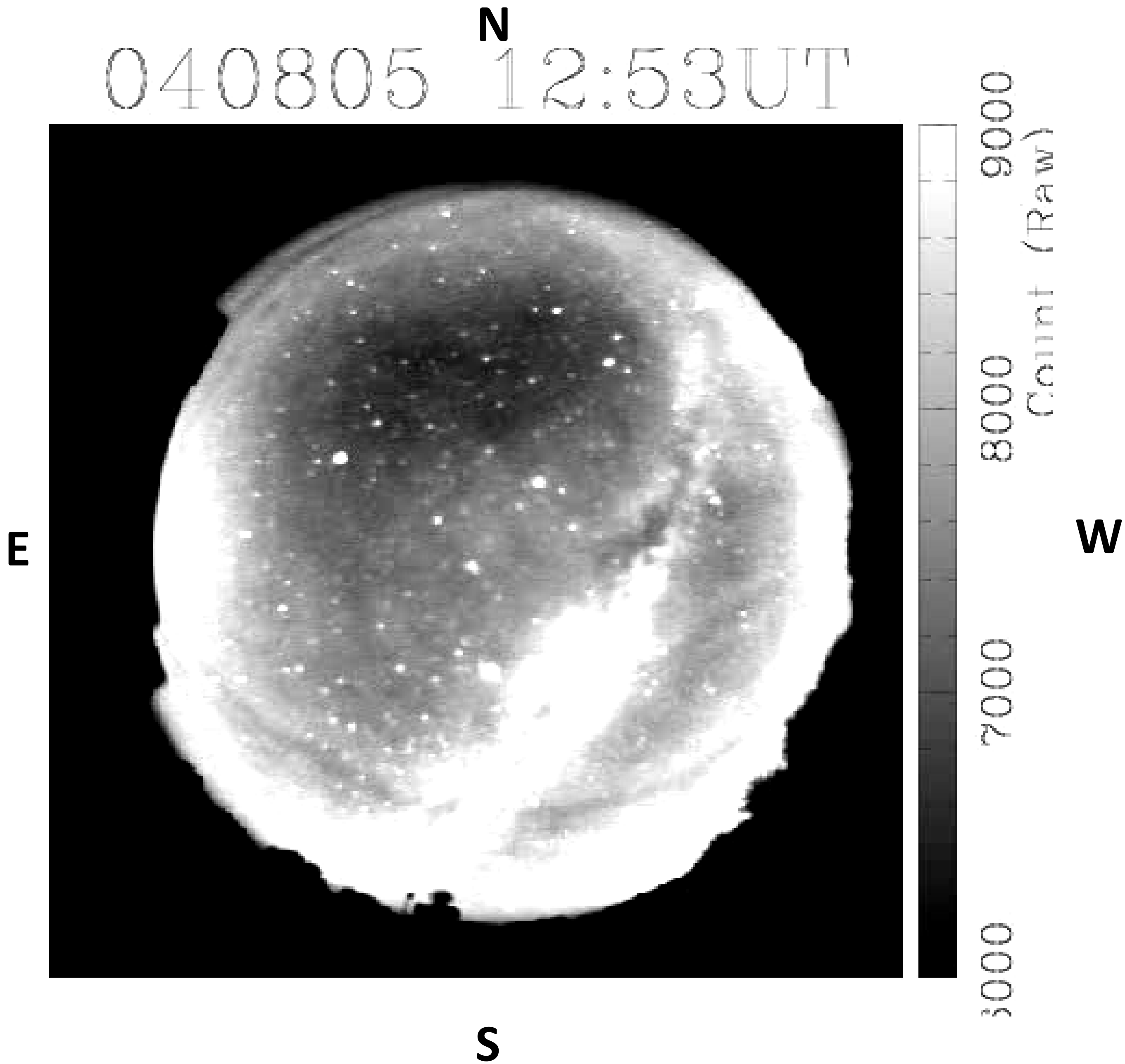


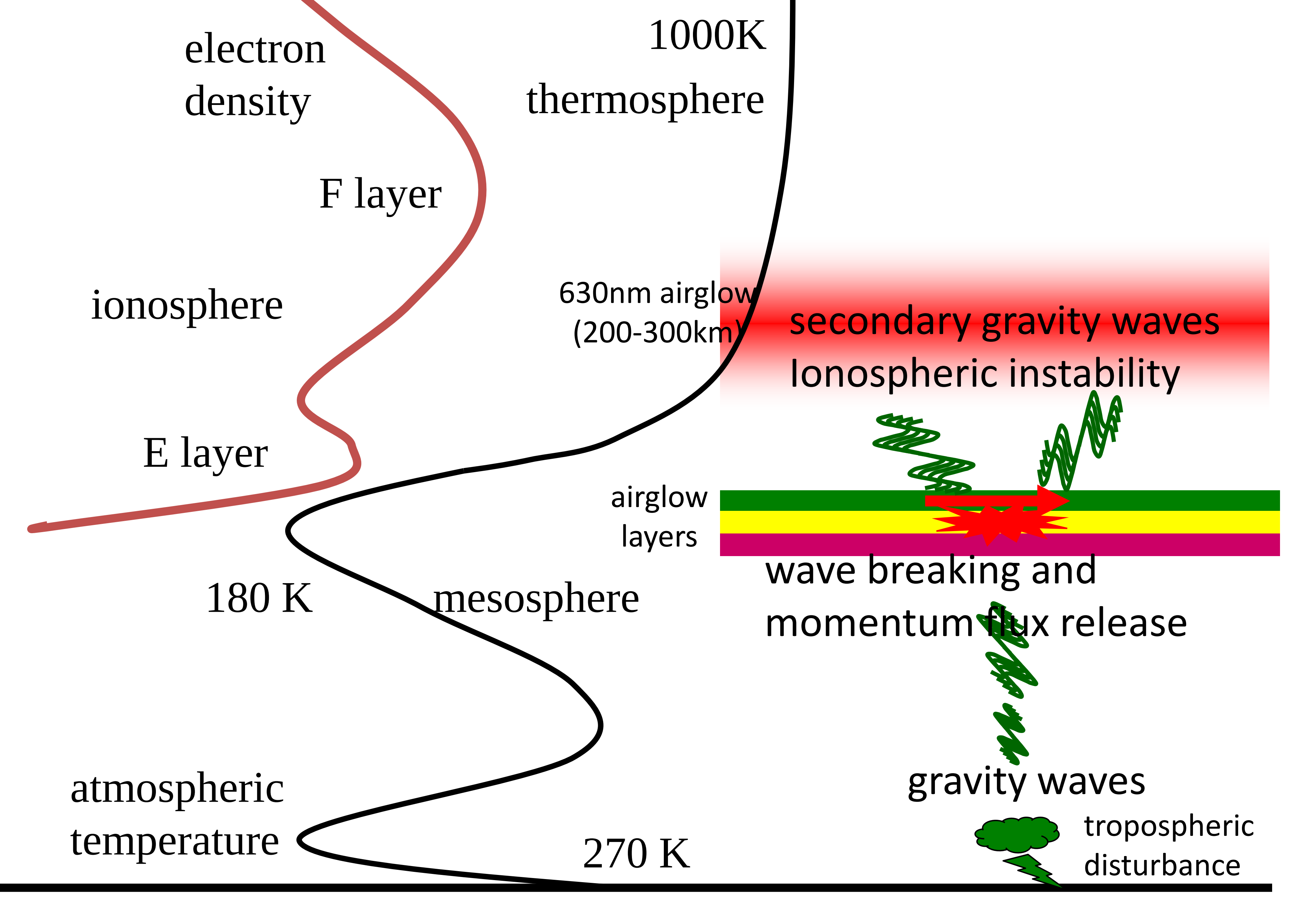
March 6, 2003
Kototabang

557.7nm image (90-100km) atmospheric gravity waves in the mesosphere

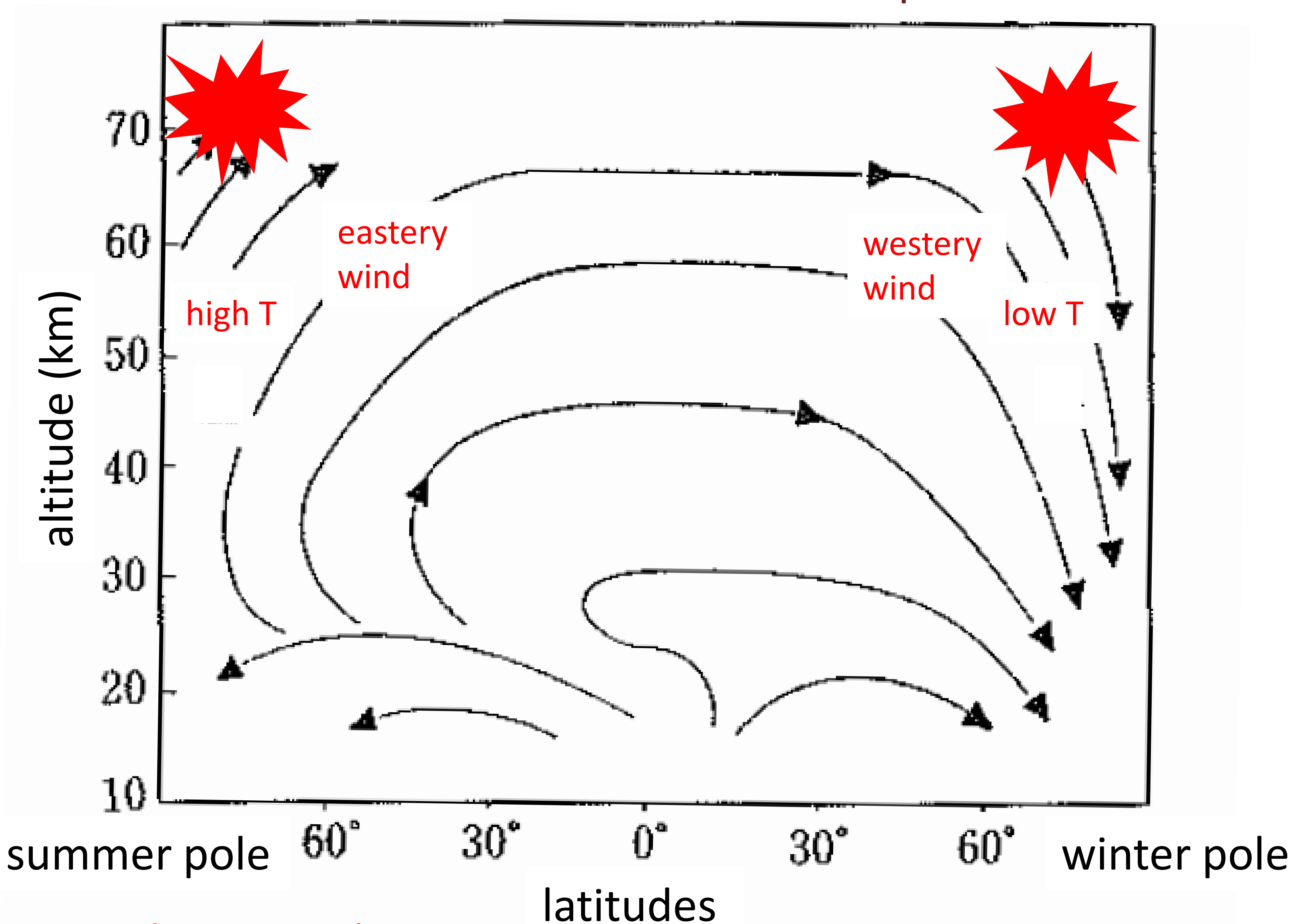


gravity waves (<100km scale)   (557.7 nm, OH-band)




electron
density
1000K
thermosphere
F layer
ionosphere
630nm airglow
(200-300km)
secondary gravity waves
Ionospheric instability
E layer
airglow
layers
180 K
mesosphere
wave breaking and
momentum flux release
gravity waves
atmospheric
temperature
270 K
tropospheric
disturbance

meridional circulation in the middle atmosphere

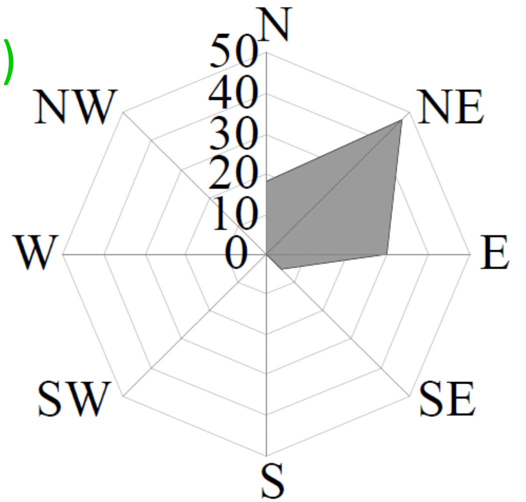


Brewer-Dobson circulation
Dunkerton (JAS, 1978)

Hirota (Global Kishogaku 1992)

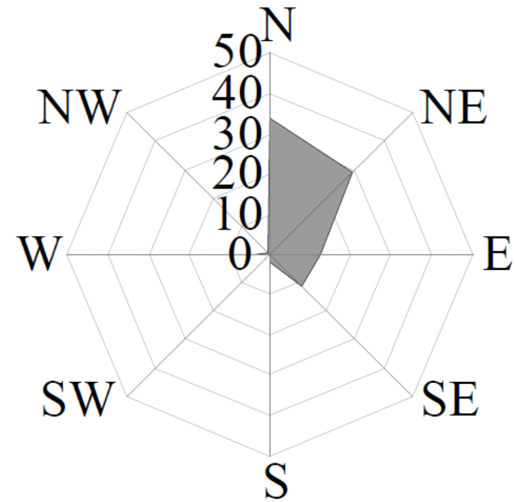
Rikubetsu OH Summer

(44N, 144E)

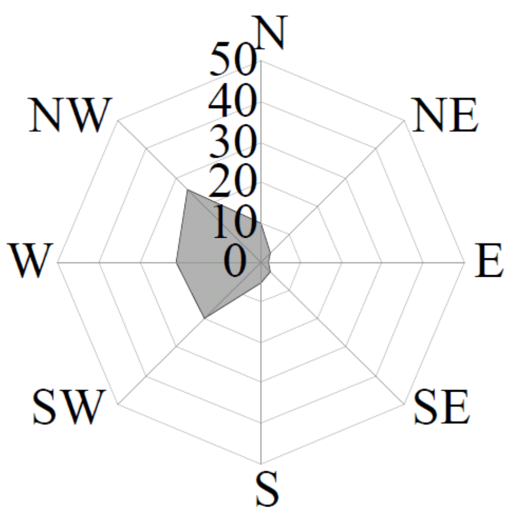


Shigaraki OH Summer

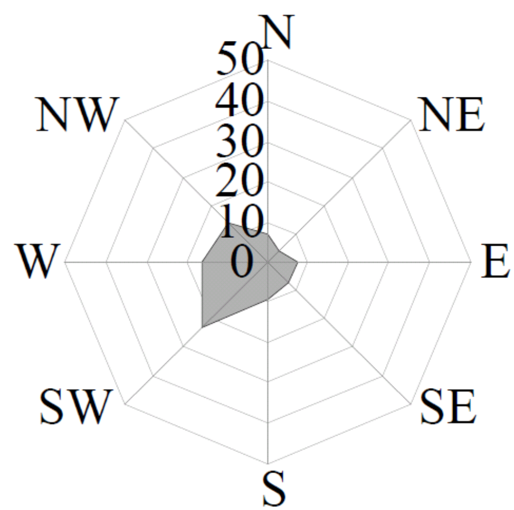
(35N, 136E)



Rikubetsu OH Winter



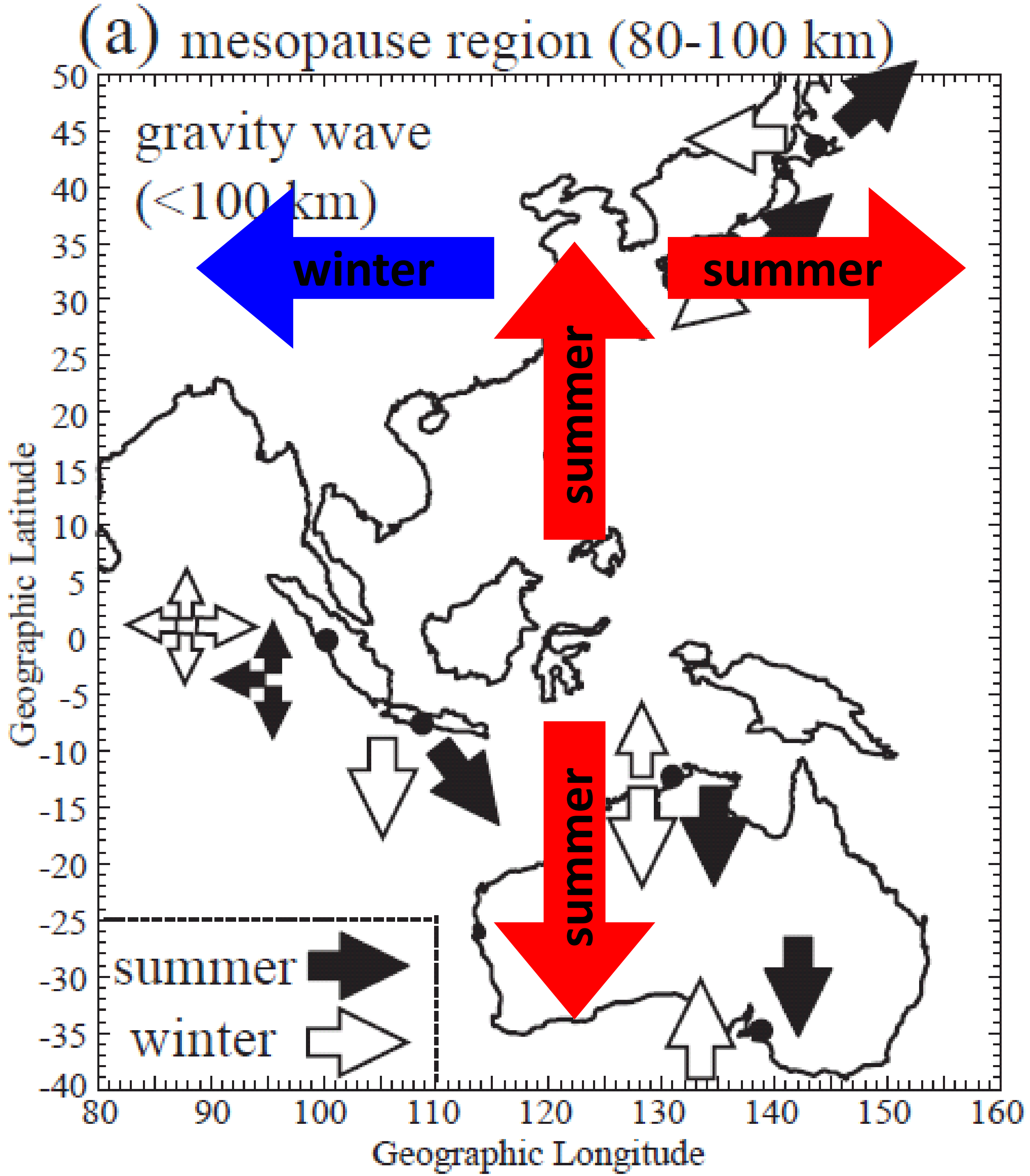
Shigaraki OH Winter



O(557.7nm) shows similar distribution

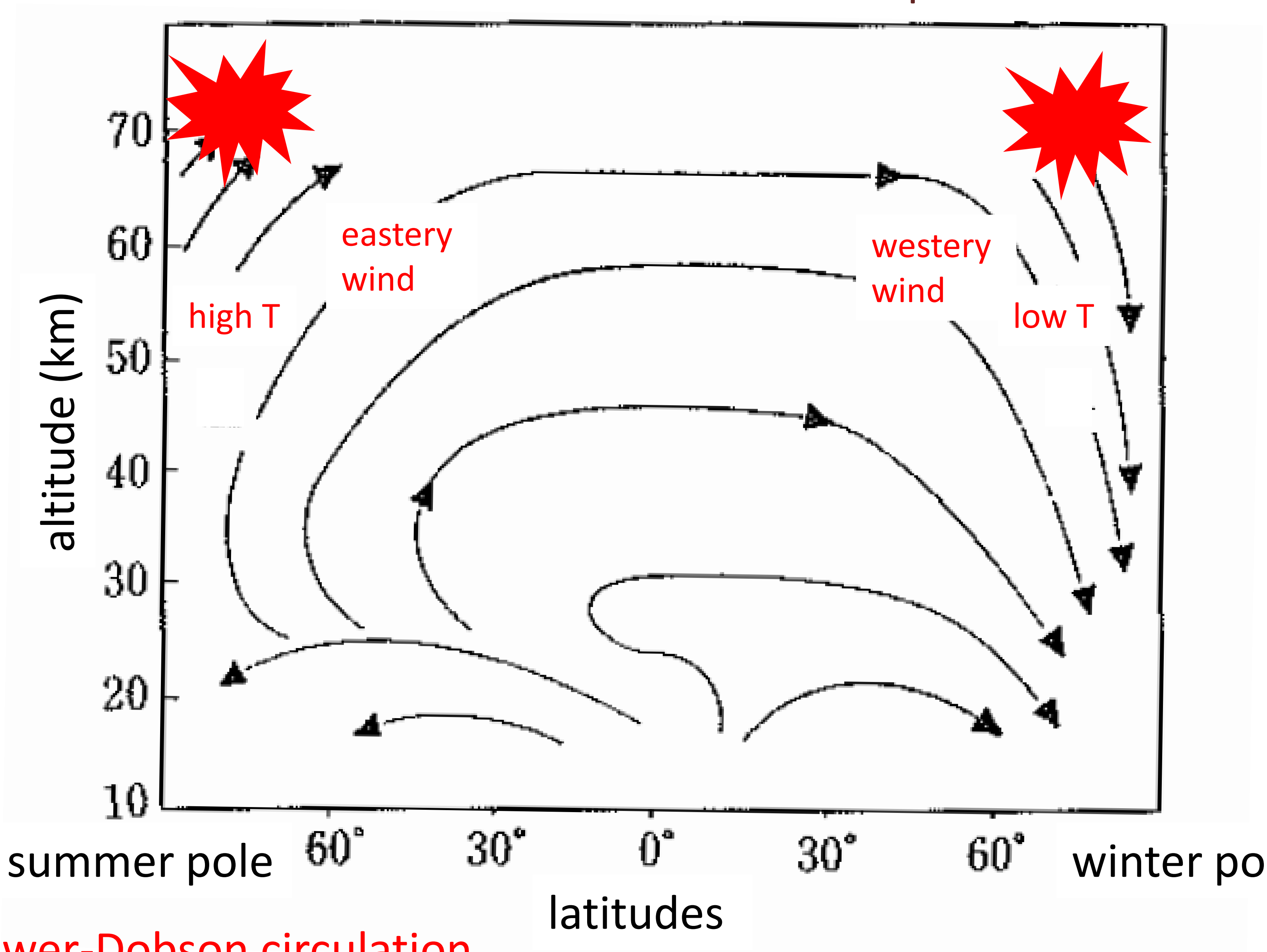
Ejiri et al. (JGR, 2003)

control factor:
northern midlatitudes
wind filtering
southern midlatitudes
ducting?
equatorial latitudes
source location



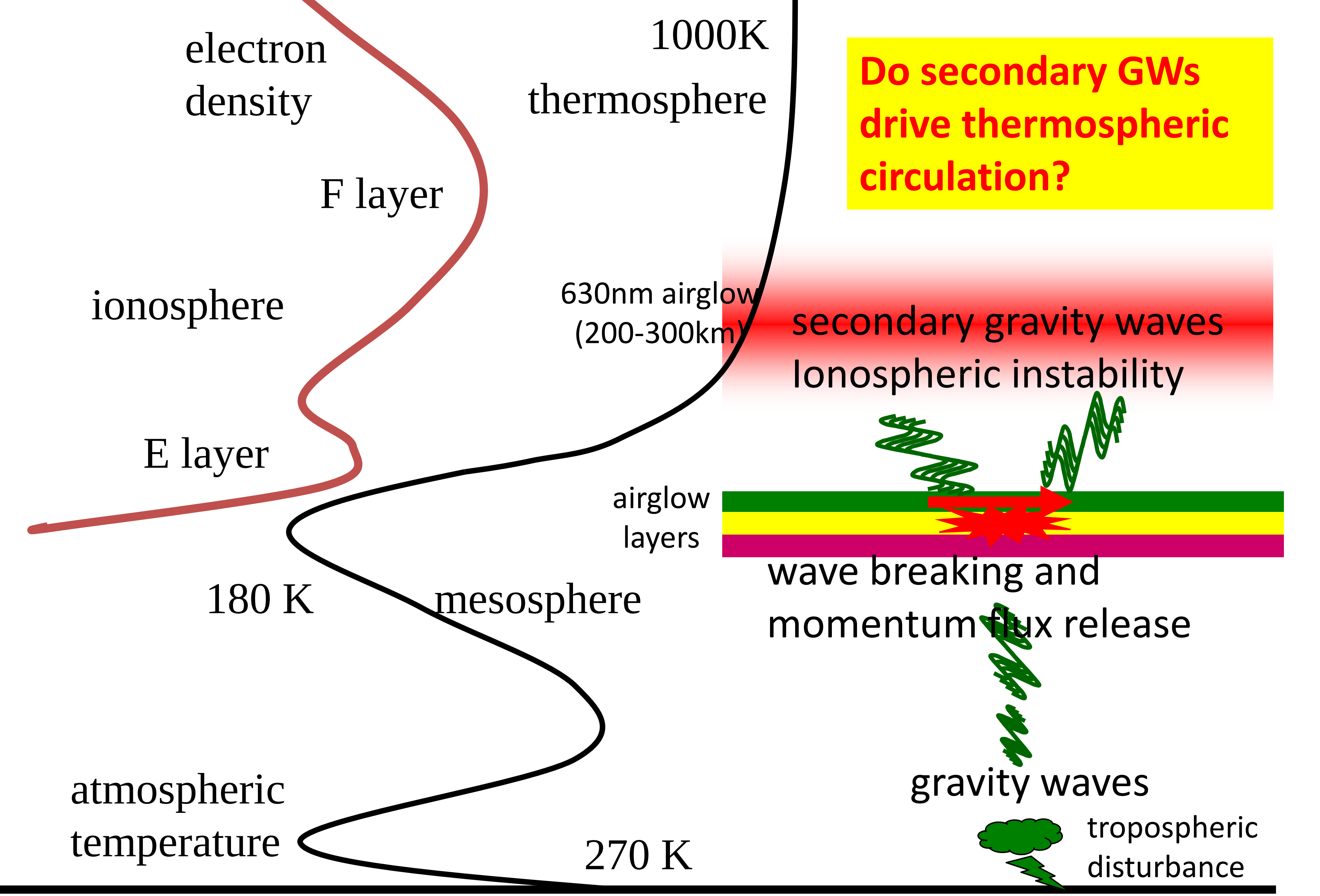
Shiokawa et al.
(EPS, 2008)

meridional circulation in the middle atmosphere



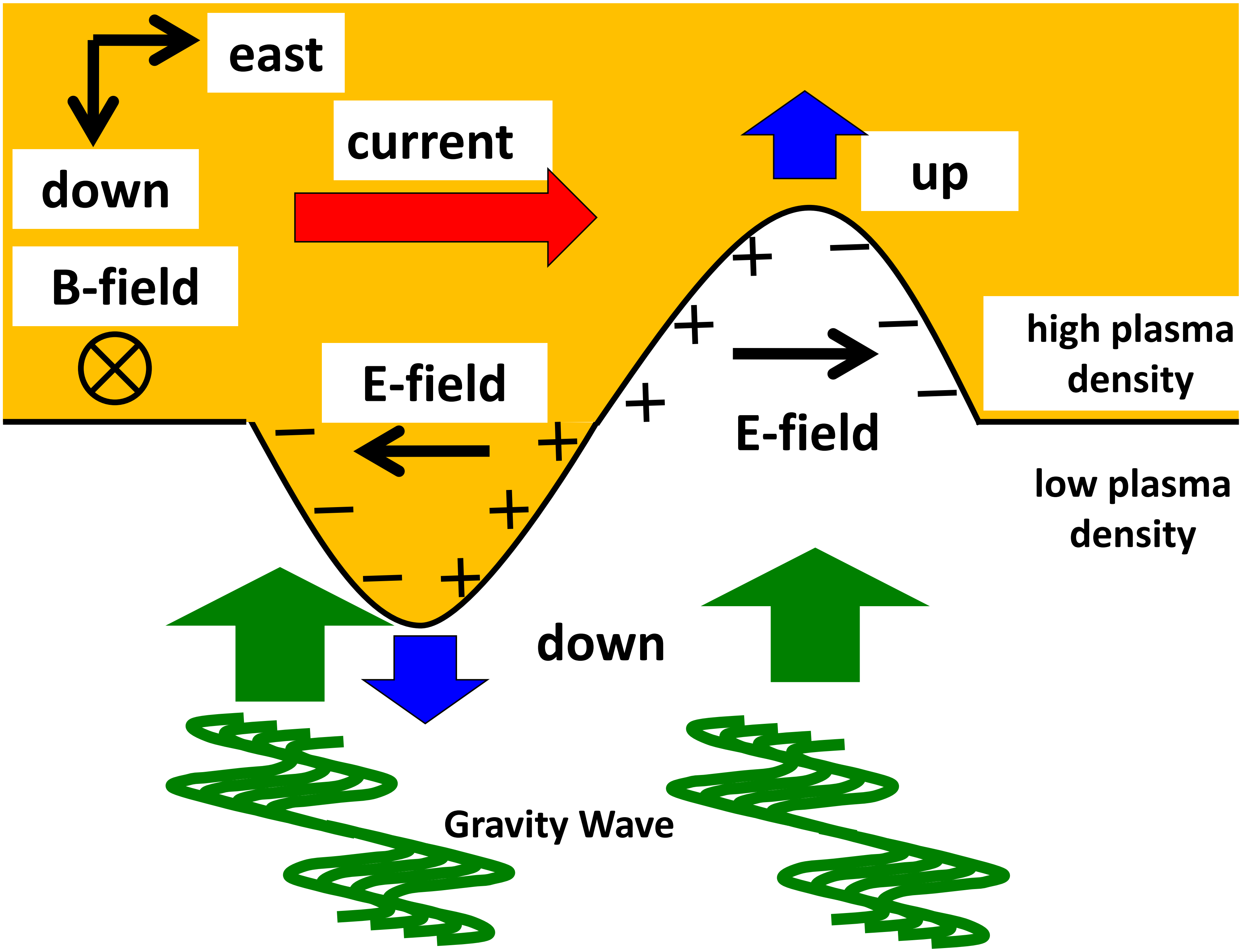
Brewer-Dobson circulation
Dunkerton (JAS, 1978)

Hirota (Global Kishogaku 1992)



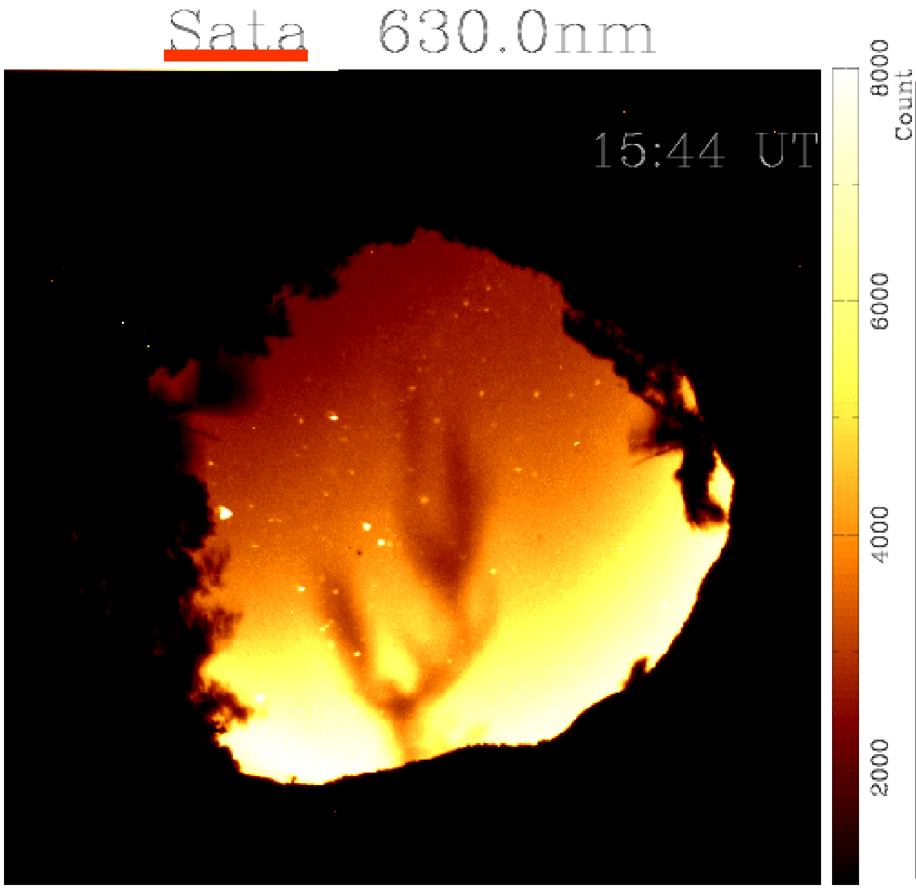
electron
density
1000K
thermosphere
Do secondary GWs
drive thermospheric
circulation?
F layer
ionosphere
630nm airglow
(200-300km)
secondary gravity waves
Ionospheric instability
E layer
airglow
layers
wave breaking and
momentum flux release
180 K
mesosphere
gravity waves
atmospheric
temperature
tropospheric
disturbance
270 K

Ionospheric (Rayleigh-Taylor type) Instability



Nov. 12, 2001

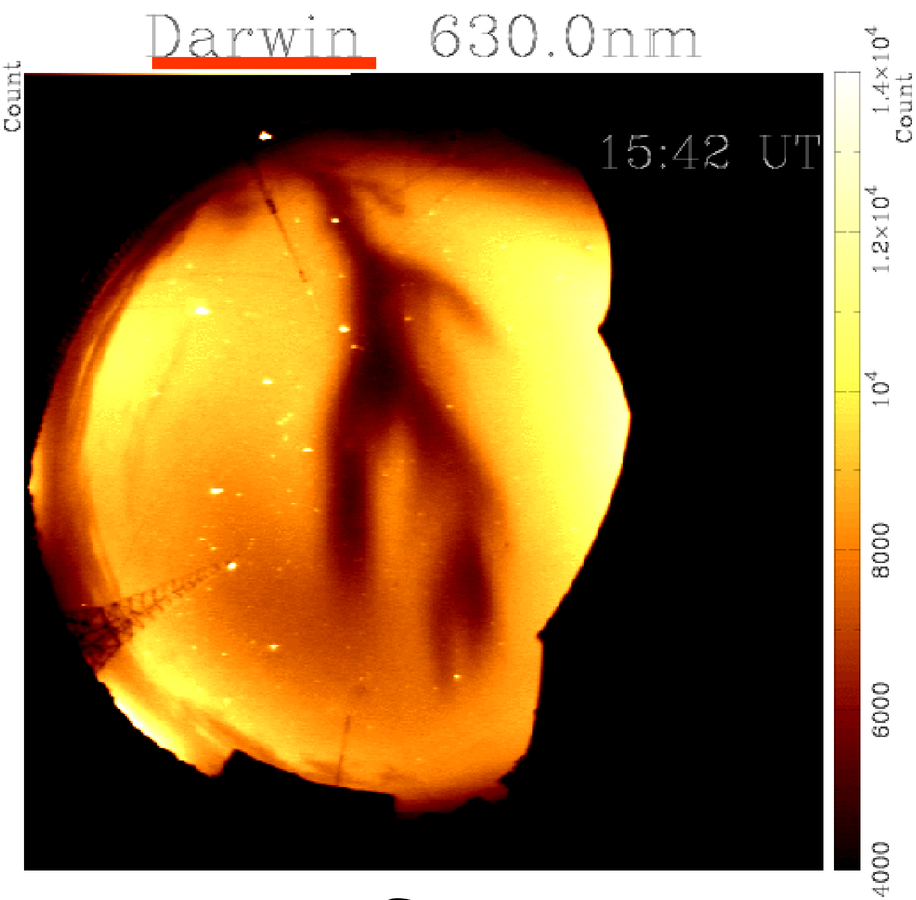
00:44LT



E

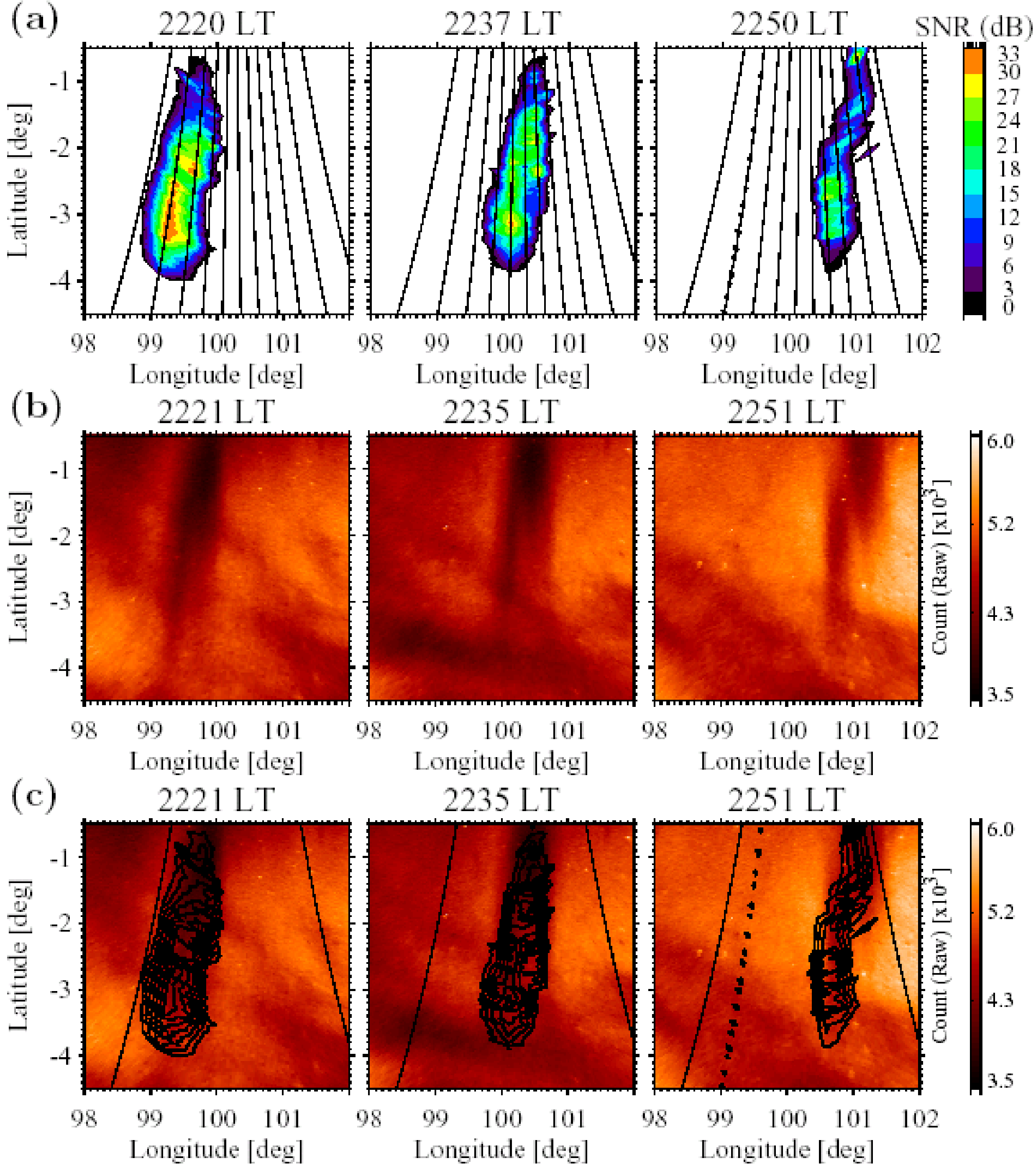
S

00:42LT



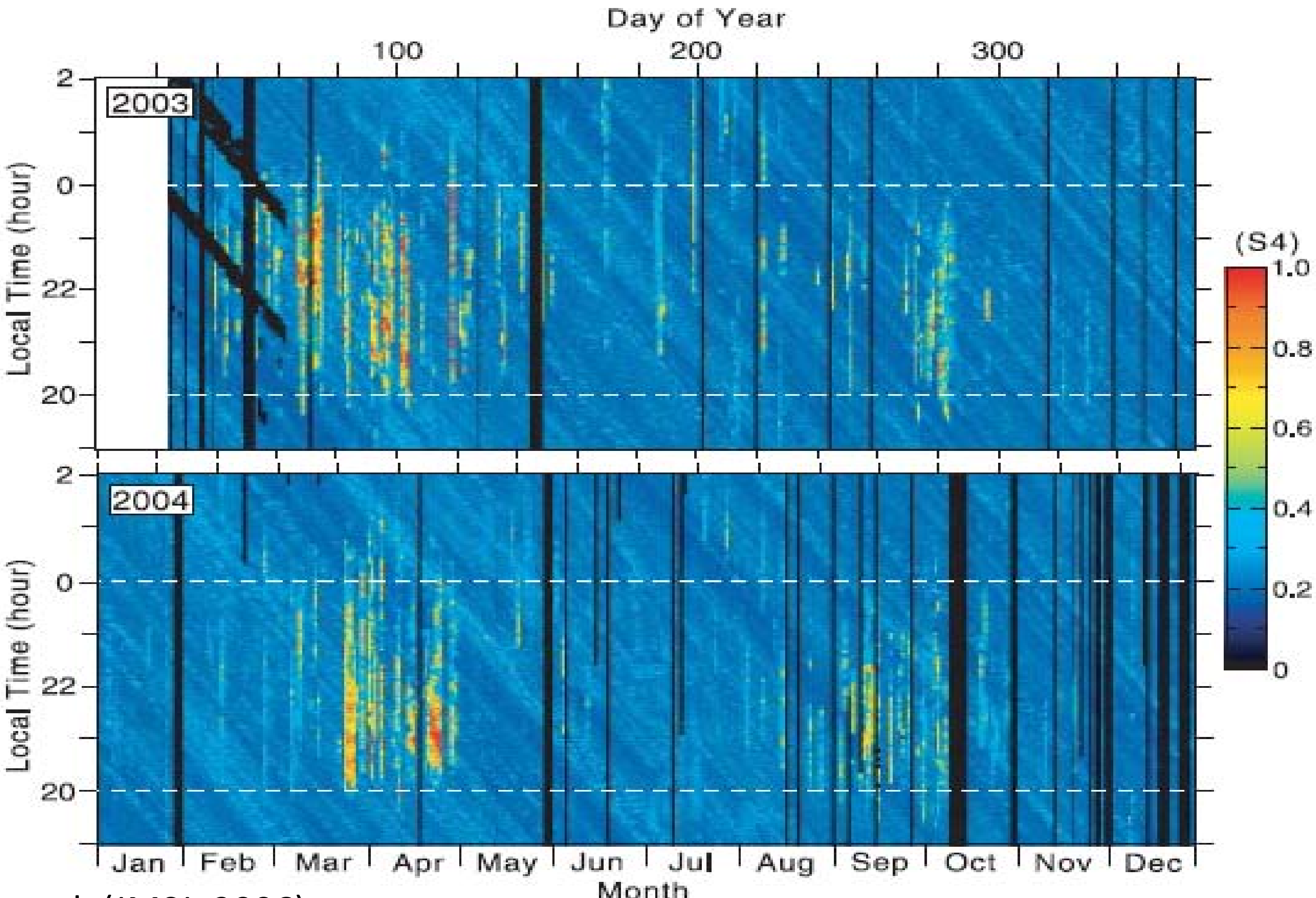
S

Otsuka et al. (GRL, 2002)



Otsuka et al.
[GRL, 2004]

day-to-day variability of bubble occurrence
Why? GW seeding or evening enhancement modulation by tides?

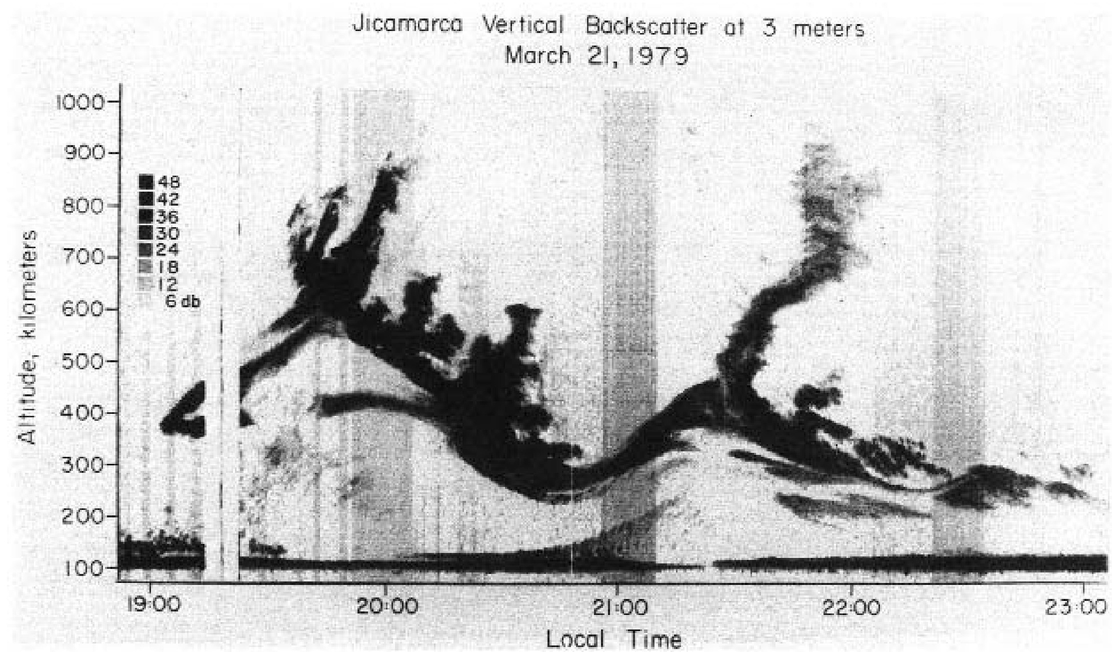


Ogawa et al. (JMSJ, 2006)

GPS scintillation = plasma bubble appearance

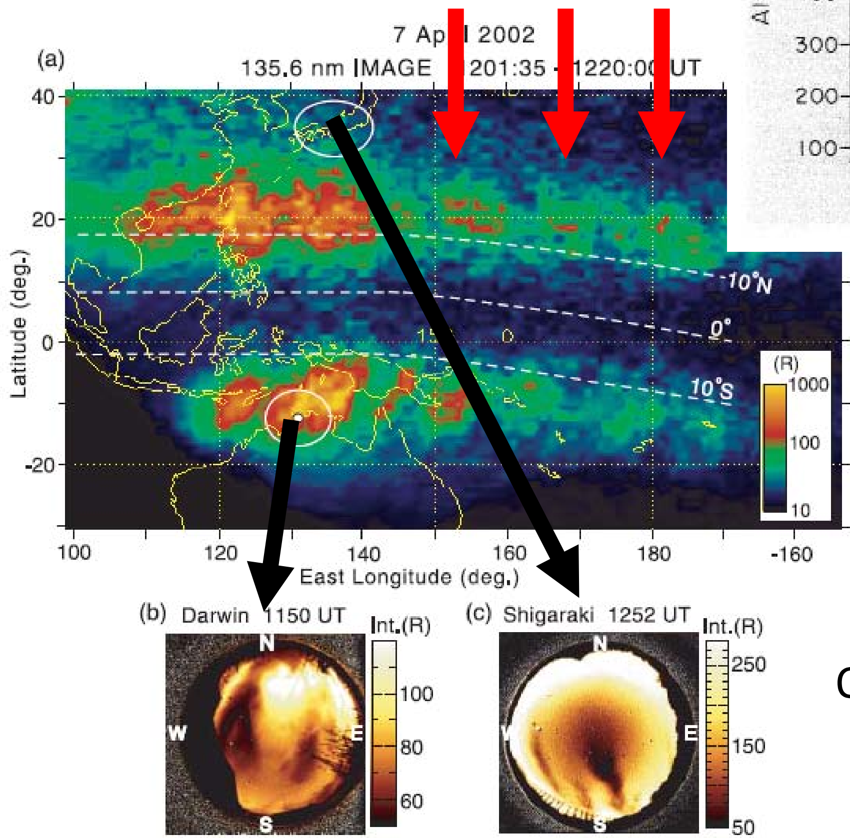
Fig. 4. Variations of GPS scintillation index (S_4) in day-local time coordinates observed at Kototabang in 2003 and 2004. S_4 values less than about 0.4 are due to background noise. Vertical black portions represent no observations due to instrumental problem.

bubble and larger-scale waves How do they interact each other?



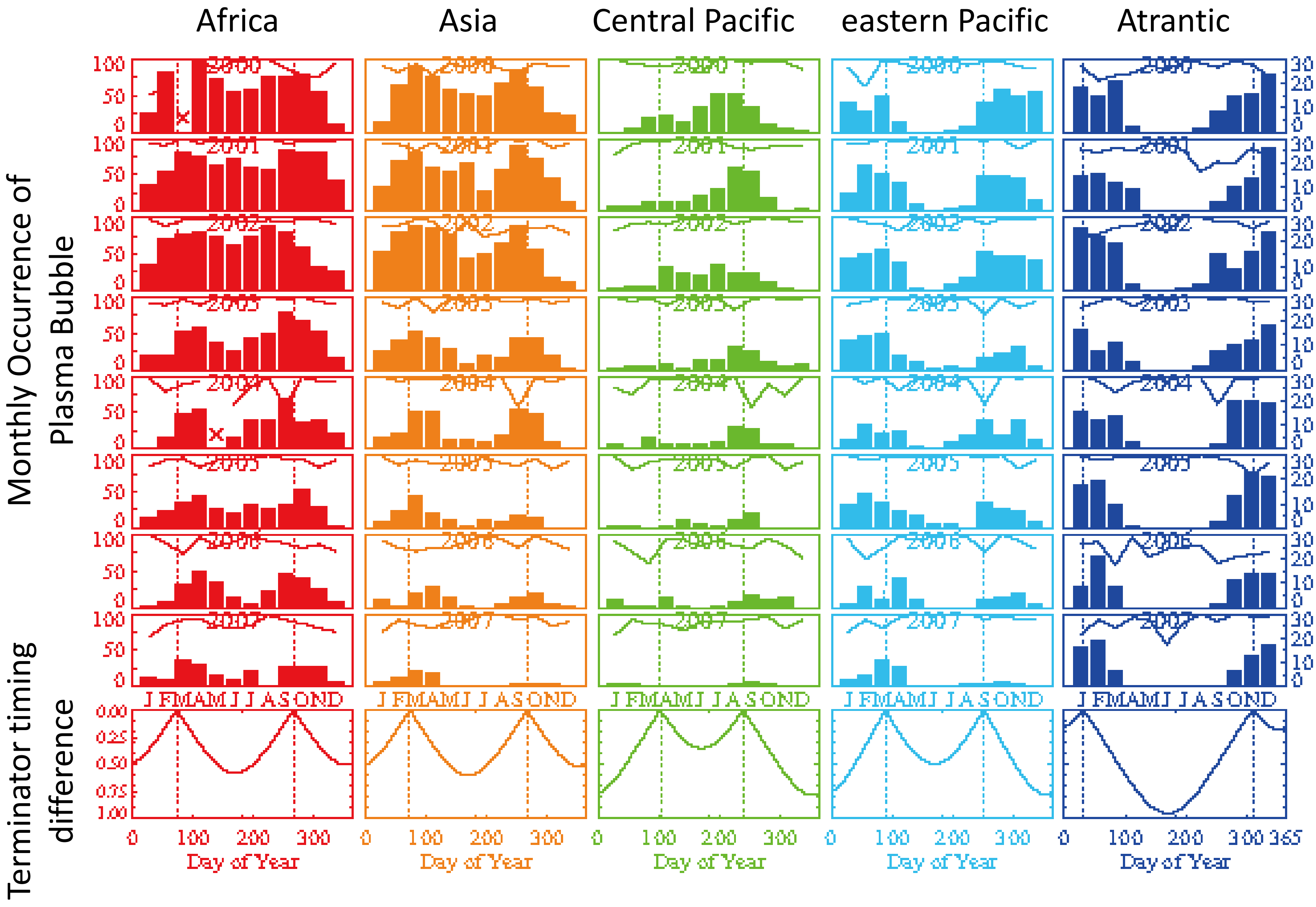
Kelley et al. (JGR, 86, 9087, 1981)

large-scale waves



Bubbles seen in airglow images

Ogawa et al. (JMSJ, 2006)



Nishioka et al. (JGR, 2008)

Summary

Optical Mesosphere Thermosphere Imagers (OMTIs)

http://stdb2.stelab.nagoya-u.ac.jp/omti/

- **12 stations in the world**
- **airglow image, thermospheric wind and temperature**

- **Gravity wave in the mesopause region**
- **Penetration of gravity waves into the ionosphere**
- **Neutral wind/temperature in the thermosphere**
  - **→ Dynamics of the thermosphere and ionosphere**
- **Plasma bubble**
  - **→Satellite communication / airplane navigation**

So far no optical measurement has been done in the African continent .