Climatology of Thunderstorm over the Indonesian Maritime Continent

Research Category: Application

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Splendid scenery from BPPT building, Jakarta

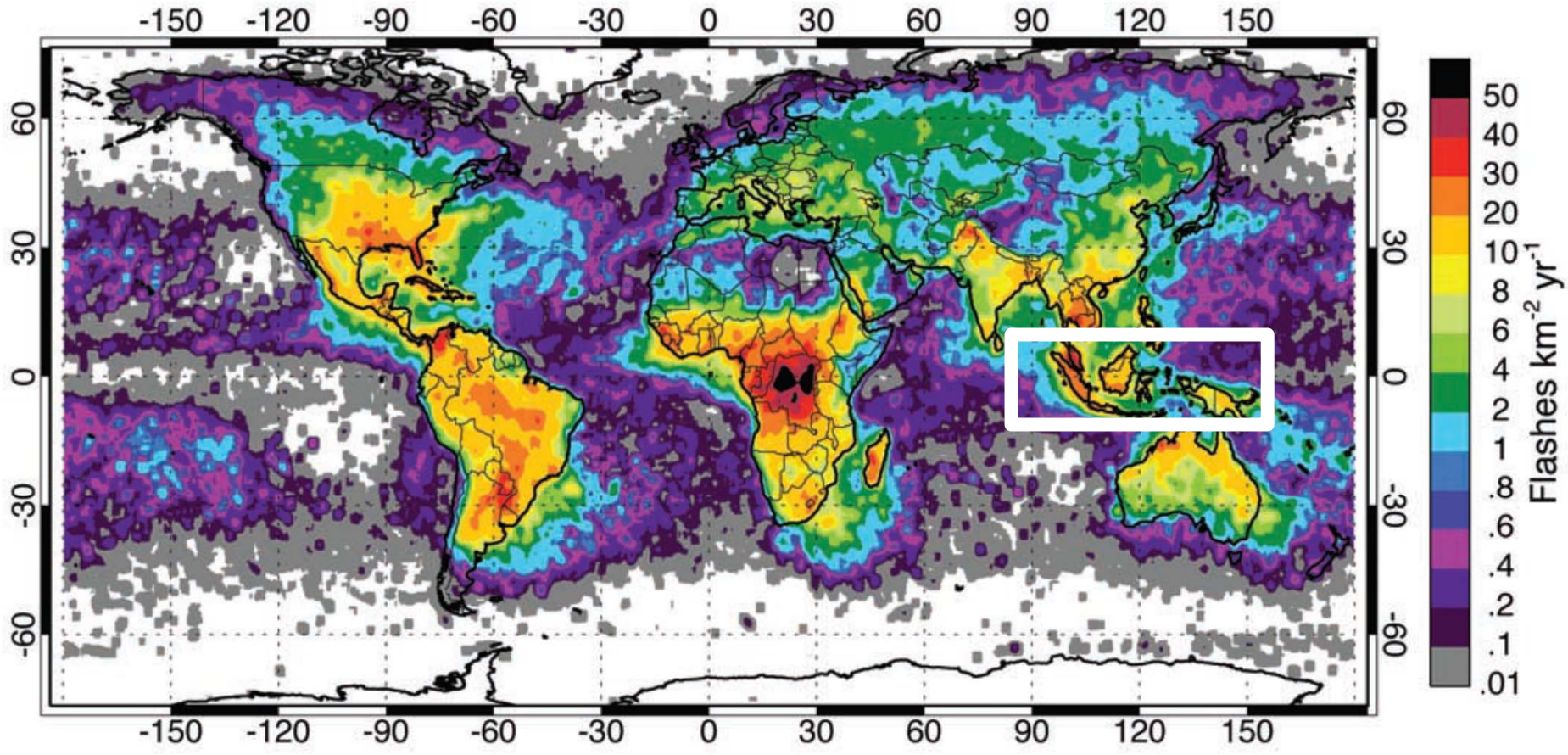
Joint PI Workshop of Global Environment Observation Mission 2013
15-17 January 2014, Tokyo

➢ Background

- ✓ **Lightning frequency** over Indonesian Maritime Continent (IMC) is quite high (Petersen and Rutledge 2001, Christian et al. 2003, Takayabu 2006, etc).
- ✓ In particular, Bogor (south of Jakarta) had 322 days of lightning in one year (*Guinness Book* in 1988).
- ✓ Lightning causes serious damage on nature and society over the IMC; forest fore, power outage, inrush/surge currents on many kinds of electronics.

➢ Objective

- ✓ Clarify lightning climatology and meso-scale characteristics of thunderstorm over the IMC, in particular over Jakarta where social damage is quite serious.



Annual distribution of total lightning activity during May 1995 to 21 March 2000 observed by Optical Transient Detector (OTD) equipped with Micro Lab-1 satellite (Christian et al. 2003)

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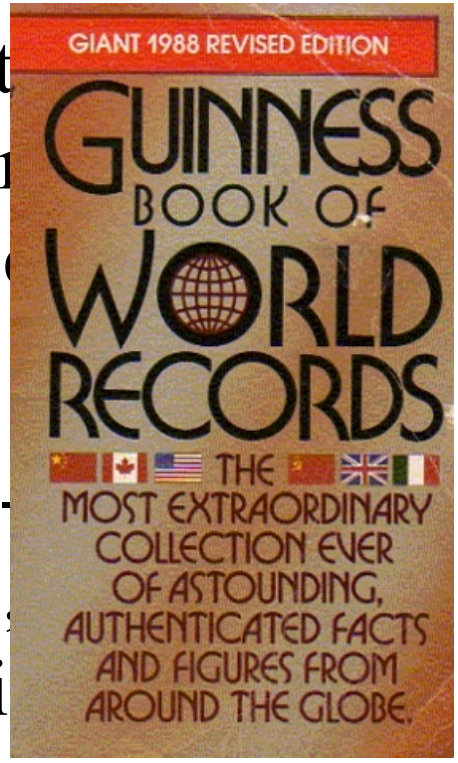

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Methodology and Schedule

JFY2013 (-2014)

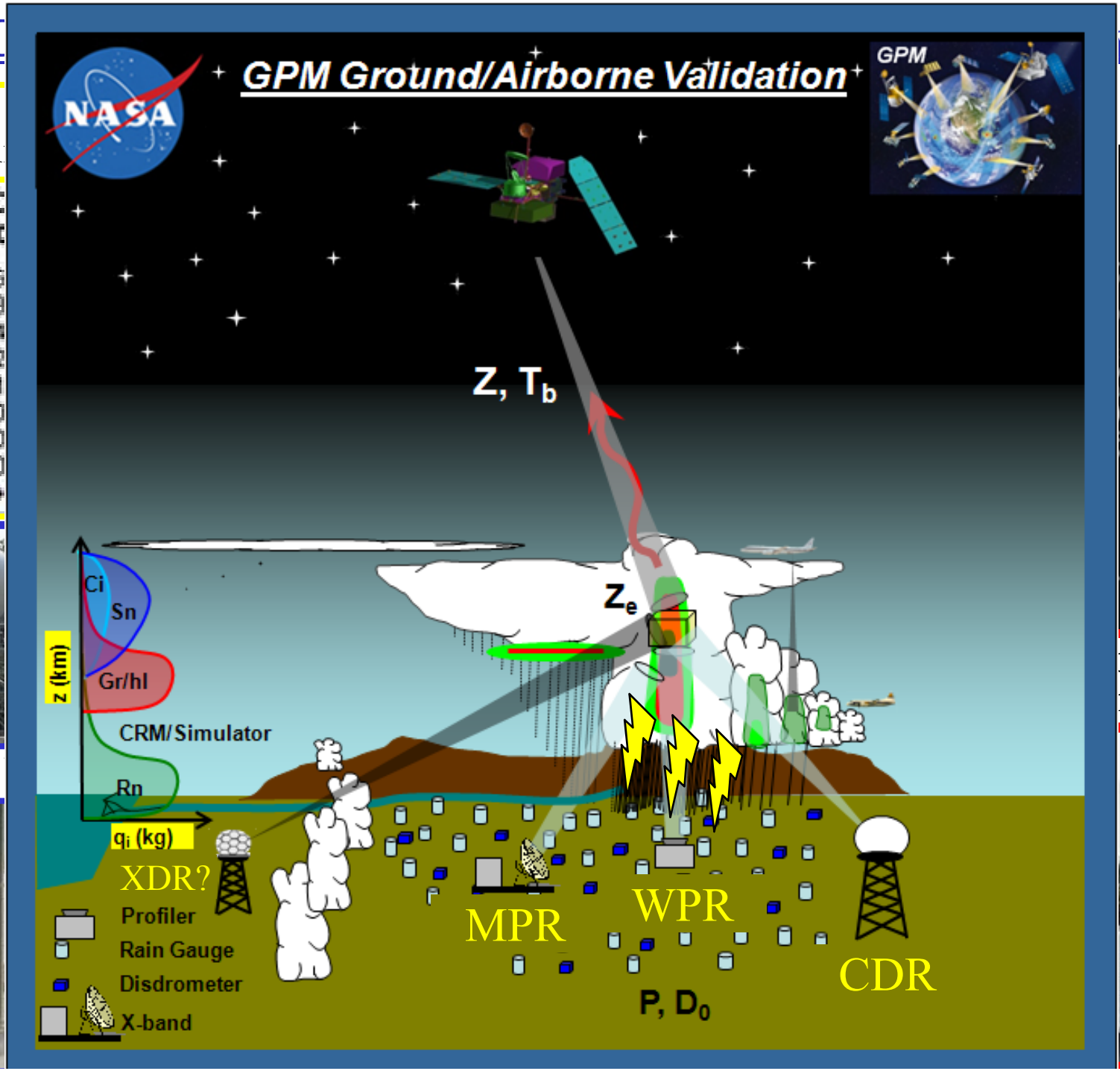
Statistical analysis of lightning and thunderstorm based on **TRMM LIS and PR** together with **long-term surface operational observation** data obtained by **BMKG and us**.

(2013-) JFY2014

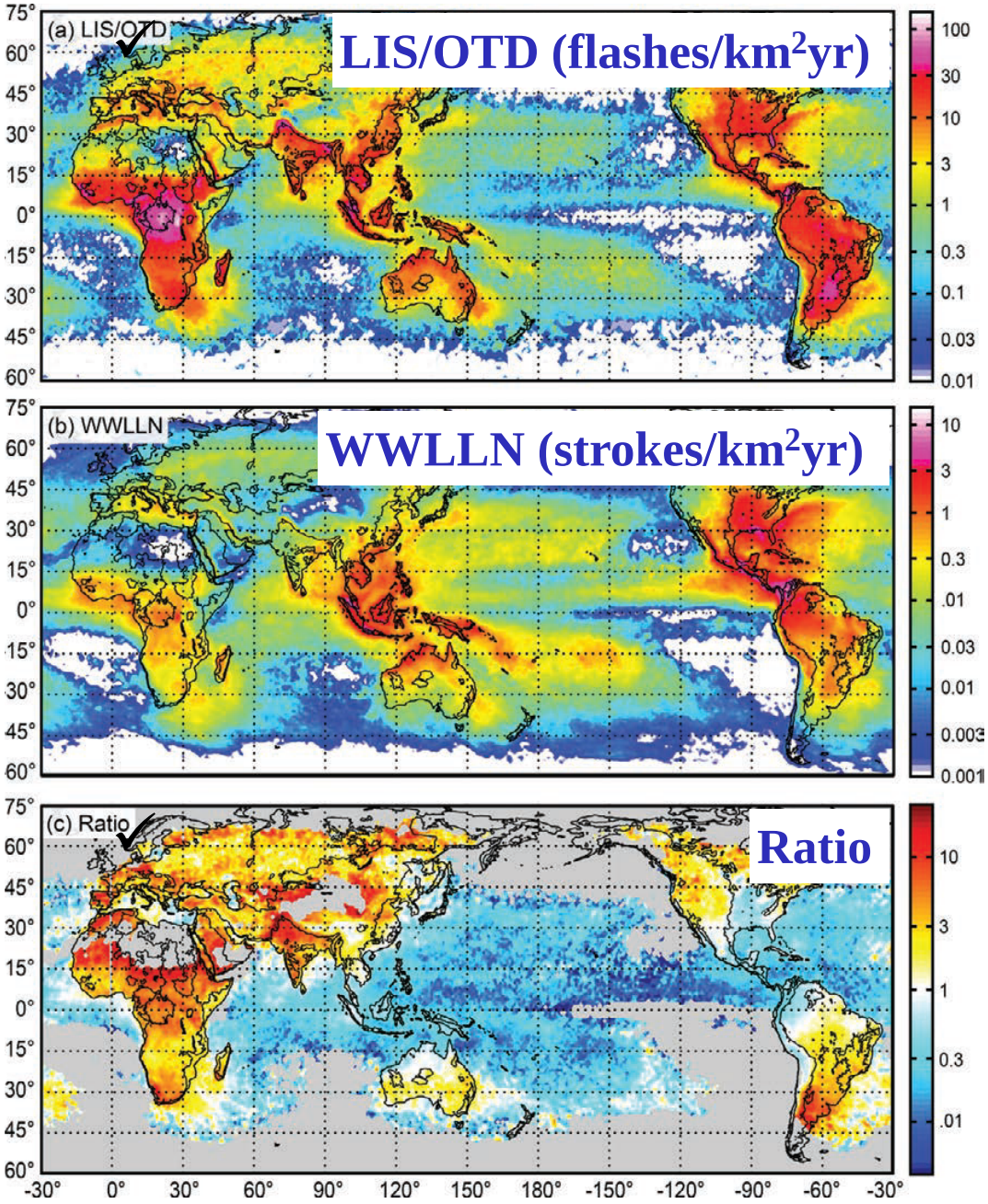
Construction of **VLF receiver network around Jakarta** for **quasi real-time lightning location and intensity detection** together with our C-band Doppler radar (CDR).

JFY2014-2015

Campaign observation to obtain meso-scale structure and dynamics **of thunderstorm over Jakarta** to focus on **graupel and other ice phase particles** inside by using GPM, our **dual-polarimetric maruti parameter radar (MPR)** , CDR, WPR, and **VLF receiver network**.


GPM Ground/Airborne Validation
GPM
NASA
Z, T_b
Z_e
Ci
Sn
Gr/hl
CRM/Simulator
Rn
z (km)
q_i (kg)
XDR?
Profiler
Rain Gauge
Disdrometer
X-band
MPR
WPR
CDR
P, D_0

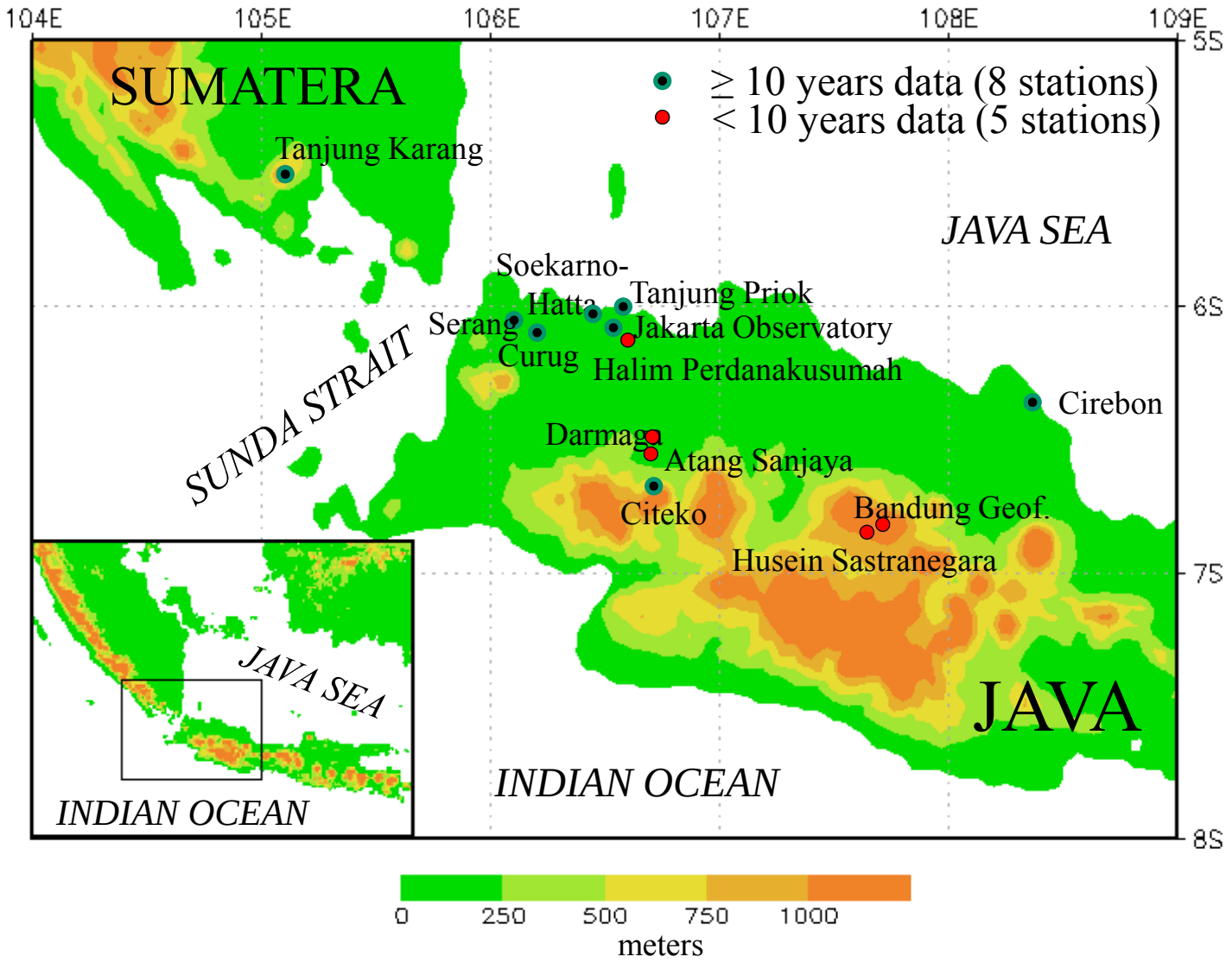
➢Some results of JFY2013



Recently, Virts et al. (2013a, b) showed comprehensive lightning climatology on diurnal, intraseasonal, and seasonal variations based on WWLLN. However, they also reported **problems with WWLLN detection efficiency (< 10%) and LIS/OTD small sampling (< 0.1% of the time fly over tropics**).

Therefore, we **firstly examine *in situ* lightning data based on SYNOP observed by BMKG** because lightning is quite local and sporadic phenomena. .

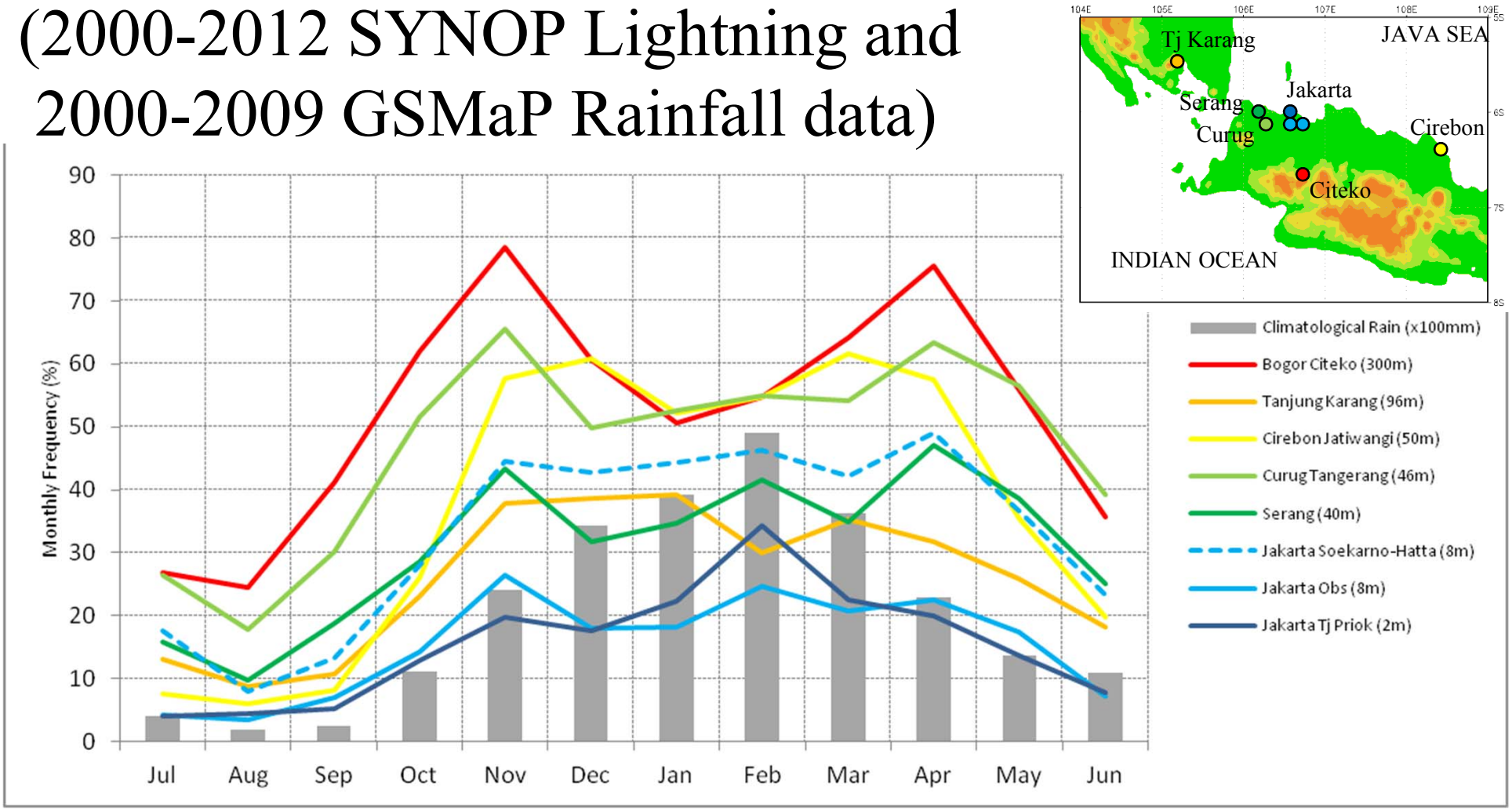
Area of Interest and SYNOP Stations



Lightning Seasonal Variation

$$MonthlyFreq. = \frac{LightningDay}{TotalDay} x100\%$$

(2000-2012 SYNOP Lightning and 2000-2009 GSMaP Rainfall data)



- All station has 13 years observation data, except for Jakarta Observatory (12 years) and Tj. Priok (11 years)
- Lightning day analysis → at least one lightning event observed in one day (TS, LT Code etc)
- Line plot → color indicates the elevation of stations

Seasonal Variation vs Elevation

$$MonthlyFreq. = \frac{LightningDay}{TotalDay} x100\%$$

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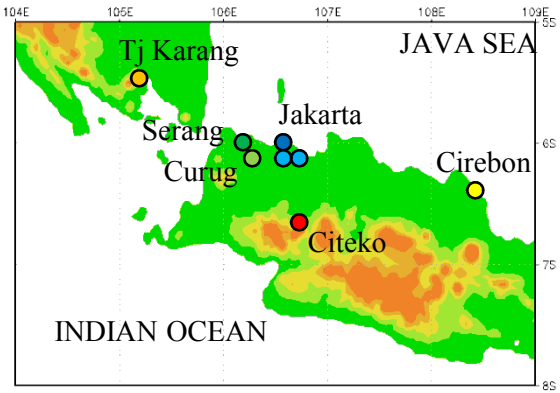
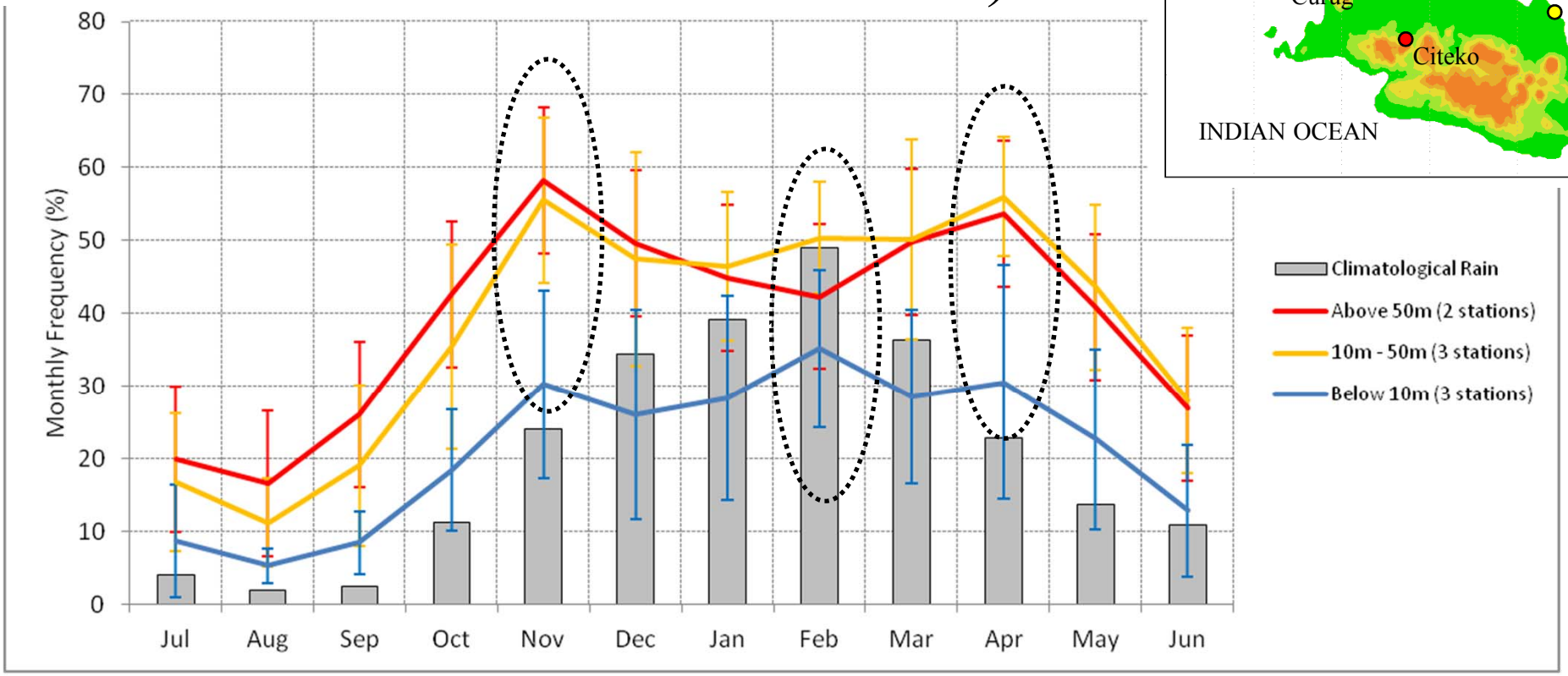
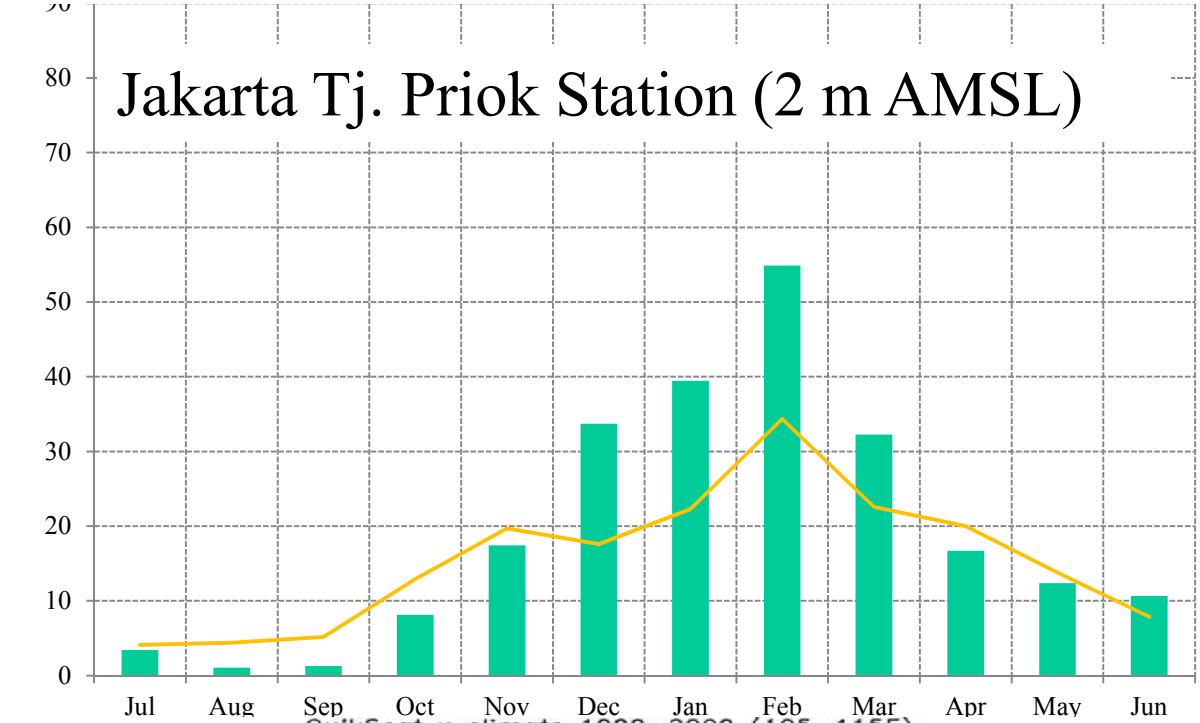
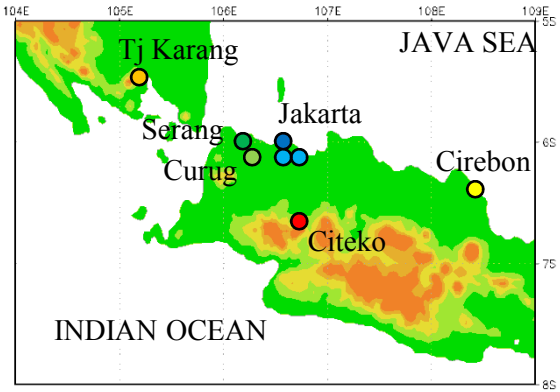
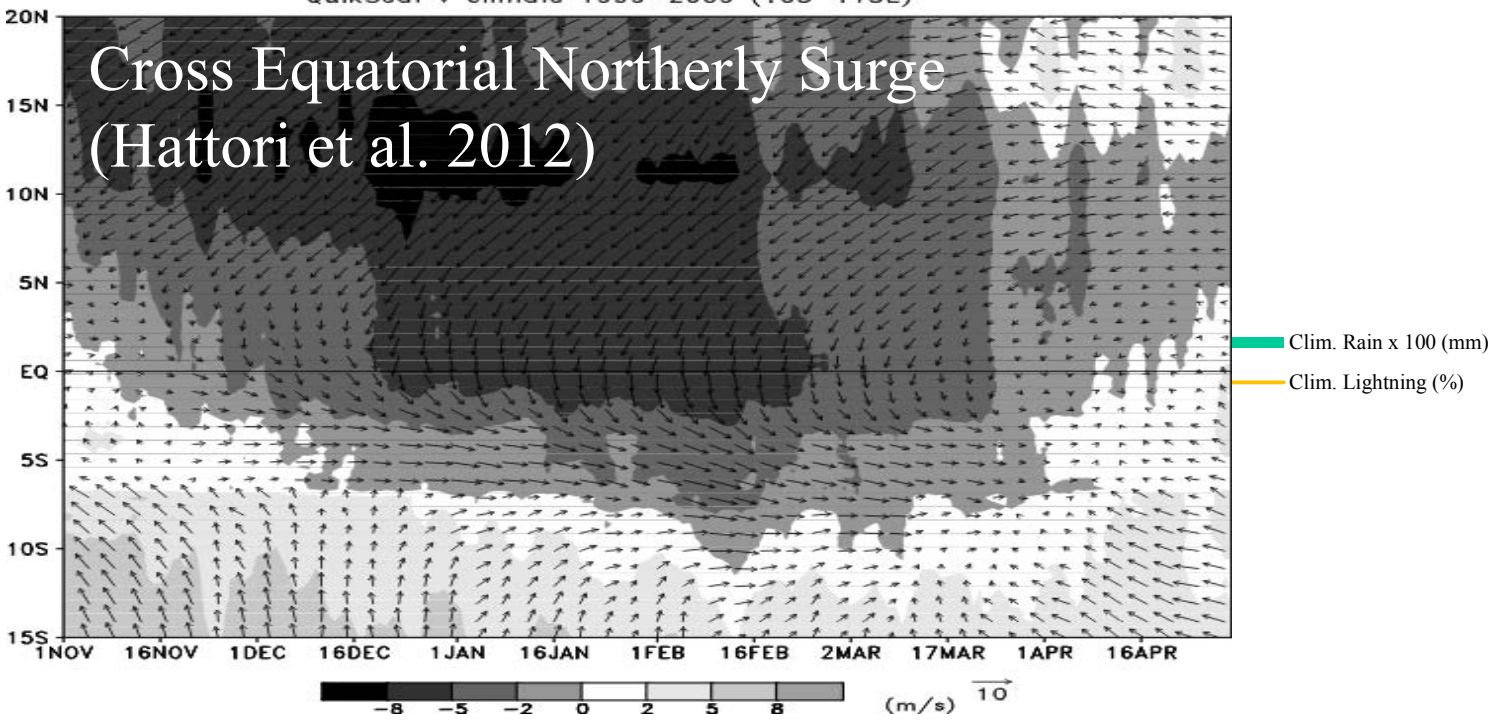




- High elevation (Mountainous region)
  → Frequency peaks in November and April
- Low elevation (Coastal region)
  → Frequency peaks in November, **February** and April

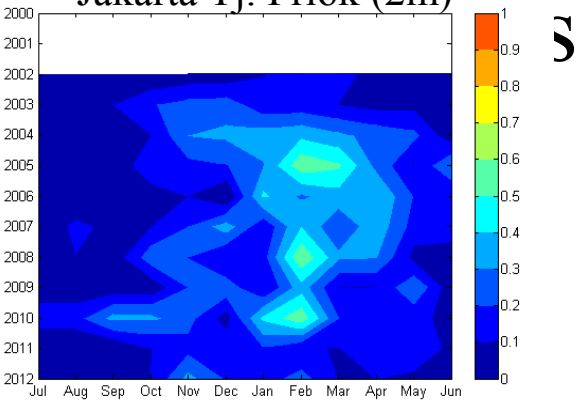

Jakarta Tj. Priok Station (2 m AMSL)
0
10
20
30
40
50
60
70
80
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun


104E
105E
106E
107E
108E
109E
6S
7S
8S
Tj Karang
JAVA SEA
Jakarta
Serang
Curug
Cirebon
Citeko
INDIAN OCEAN

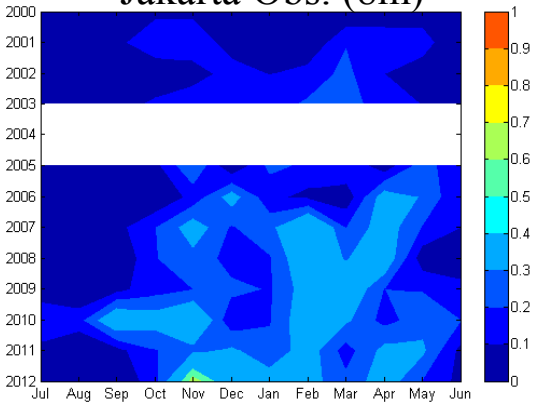

QuikScat v climate 1999–2009 (105–115E)
Cross Equatorial Northerly Surge
(Hattori et al. 2012)
20N
15N
10N
5N
EQ
5S
10S
15S
1NOV
16NOV
1DEC
16DEC
1JAN
16JAN
1FEB
16FEB
2MAR
17MAR
1APR
16APR
−8
−5
−2
0
2
5
8
(m/s)
10
Clim. Rain x 100 (mm)
Clim. Lightning (%)

Elevation 10- 50m Elevation < 10m

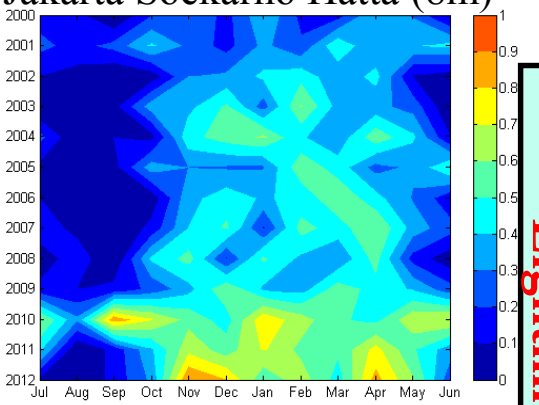
Jakarta Tj. Priok (2m)



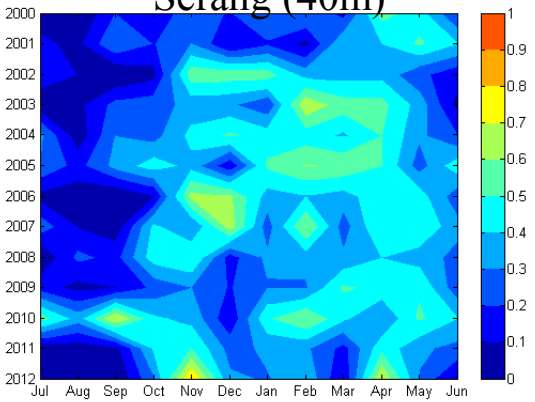
Jakarta Obs. (8m)



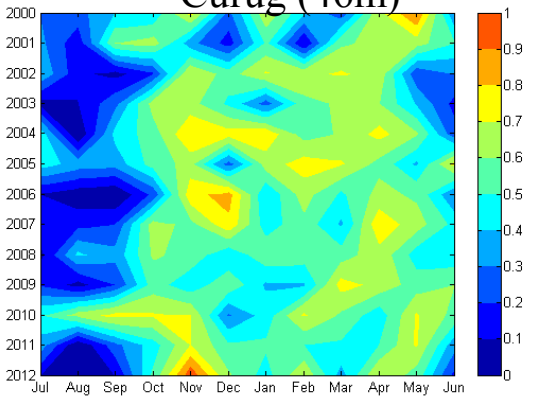
Jakarta Soekarno Hatta (8m)



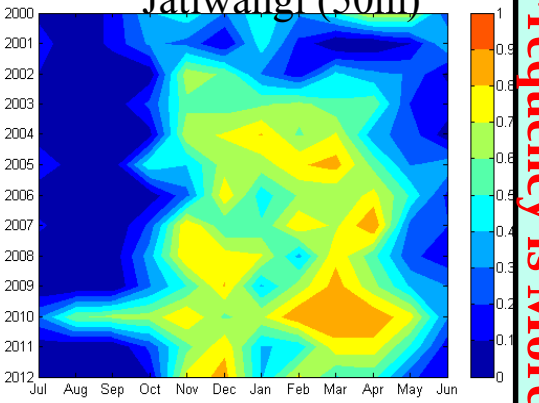
Serang (40m)



Curug (46m)

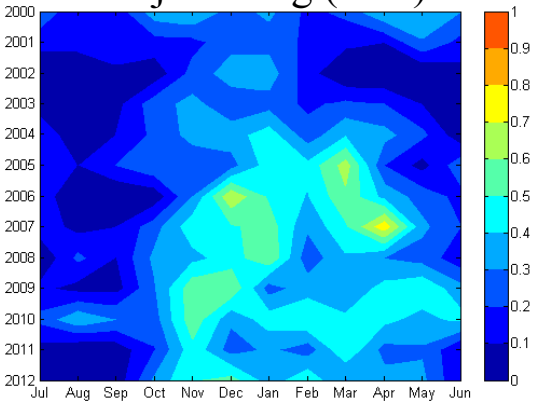


Jatiwangi (50m)

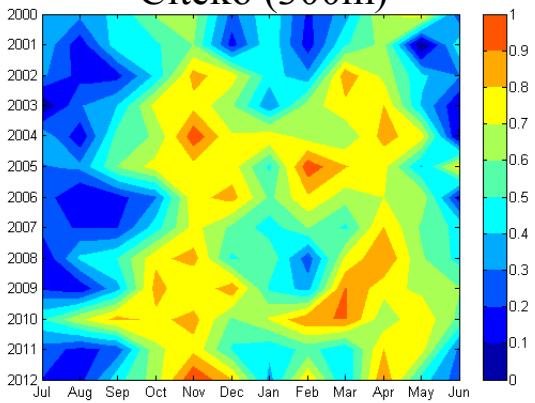


Elevation ≥ 50m

Tj. Karang (96m)



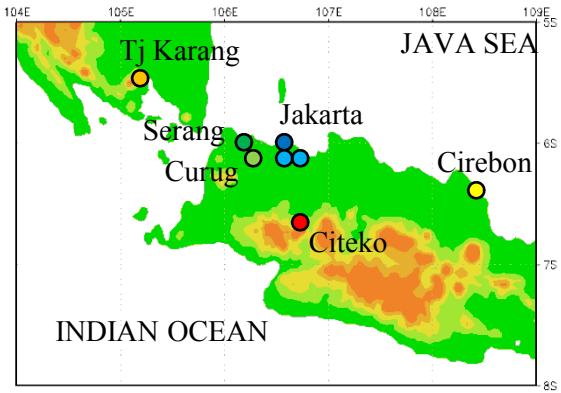
Citeko (300m)



Lightning Frequency is More Distributed

Lightning Frequency and MJO Active Phase

(2000-2012 SYNOP Lightning and 2000-2009 GSMaP Rainfall data)



India cific

(Morita et al. 2006)

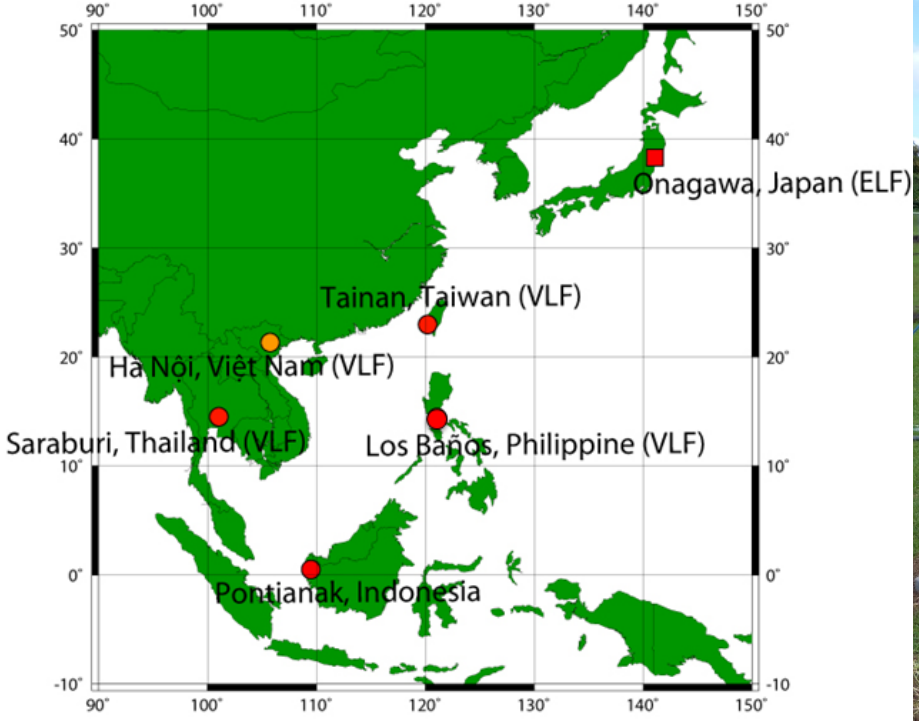
Lightning Freq. Anon eraged Lightning Freq.)x100%

- Lightning ever phase 3 (Indian ocean), then gradually

Summary and Plan in JFY2014

- ✓ We've started to analyze lightning characteristics over the IMC based on SYNOP as the ground truth data and GSMaP.
- ✓ Variability of lightning frequency around Jakarta was affected much by local conditions, e.g., topography (elevation) and proximity to the coastline.
- ✓ CENS and MJO modulated lightning frequency much around Jakarta. Some of the results were inconsistent with previous study over the equatorial ocean because **we focused on lightning over land region of the IMC**.
- ✓ Rain-yield per flash (RPF), storm height, and other **TRMM** products should be analyzed in JFY2014 as well as **MP radar and VLF receiver network** observation data.
- ✓ Vertical profiles of ice phase particles obtained by **GPM** fundamentally important for further our lightning study.

Asia VLF observation network (AVON)



- **Accuracy of geolocation :** ~10 km
- **Frequency range**
  E-fields : 1kHz-40 kHz
  B-fields : 100Hz-40kHz
- **Sampling frequency**
  100,000 Hz
- **Data channels**
  4 channels
  - vertical electric fields
  - horizontal magnetic fields (EW/NS comp.)
  - GPS signal (Irig-B)