Status and Plans of GNSS Application for Space Weather Monitoring in Indonesia

Buldan Muslim[1)], Joni Effendi[2)] and Jade Morton[3)]

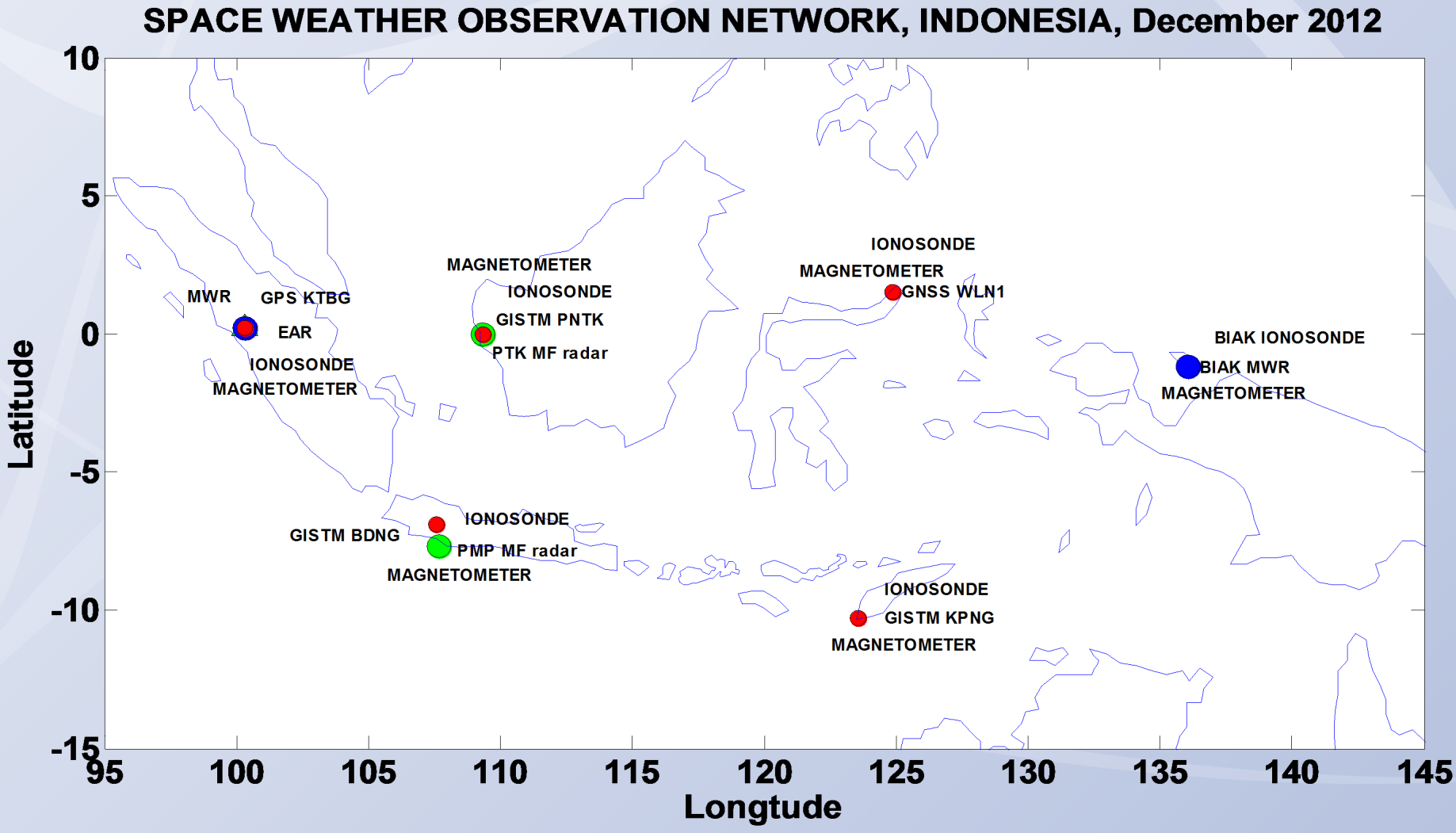
[1)]National Institute of Aeronautics and Space, LAPAN
Jl. Dr. Junjunan 133 Bandung 40173
mbuldan@gmail.com, mbudan@bdg.lapan.go.id

[2)]Geospatial Information Agency, BIG
Jl. Jakarta-Bogor Km 46, Cibinong, Indonesia

[3)]Miami University, USA

UN/Croatia Workshop on Application of Global Navigation Satellite Sistem, Baska, Croatia, 21-25 April 2013

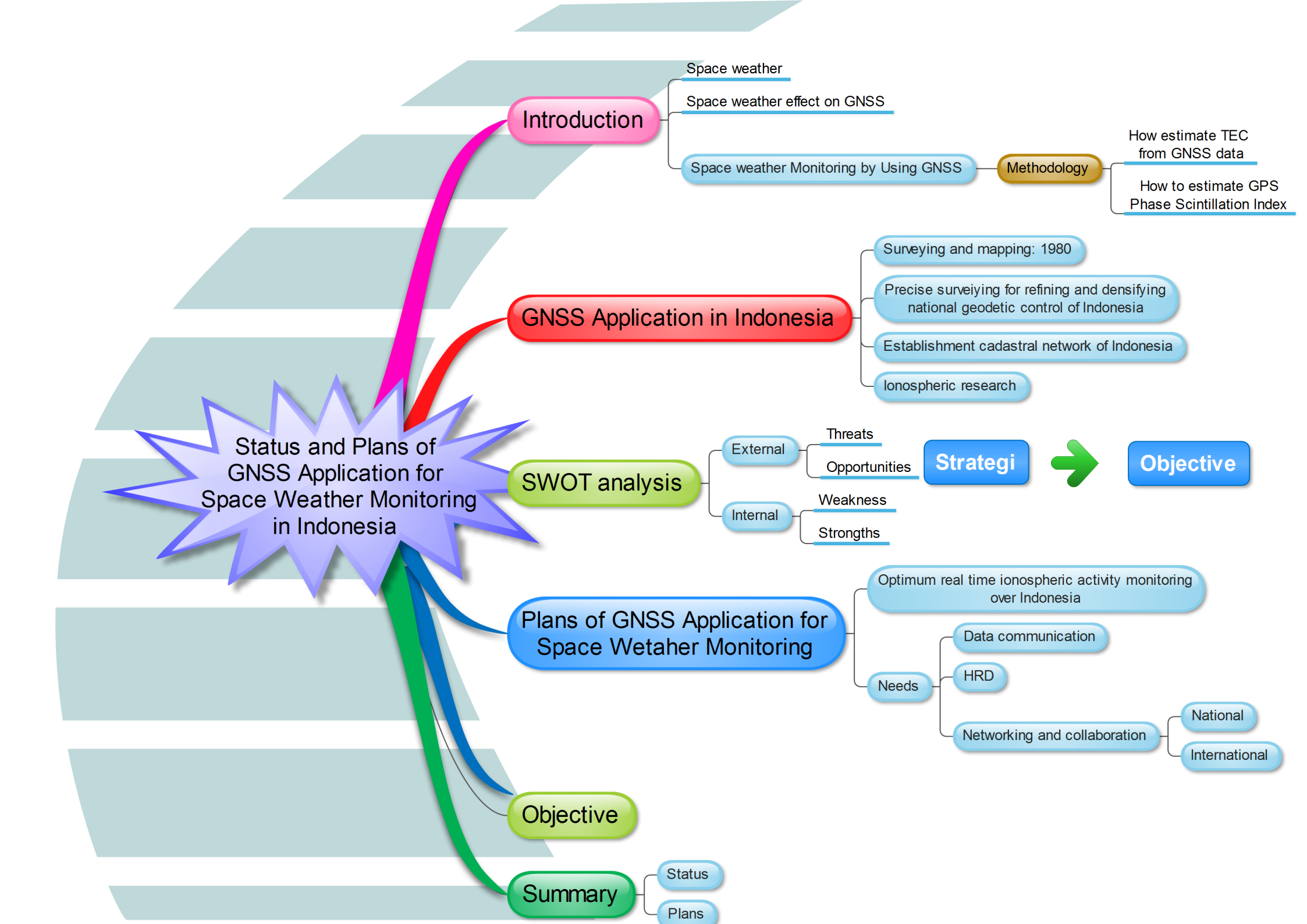
Space Weather Observation in Indonesia



EQUATORIAL ATMOSPHERE RADAR

FREK: 47 MHz
OBSERVE: IONOSPHERIC IRREGULARURY AND TROPOSPHERIC WIND

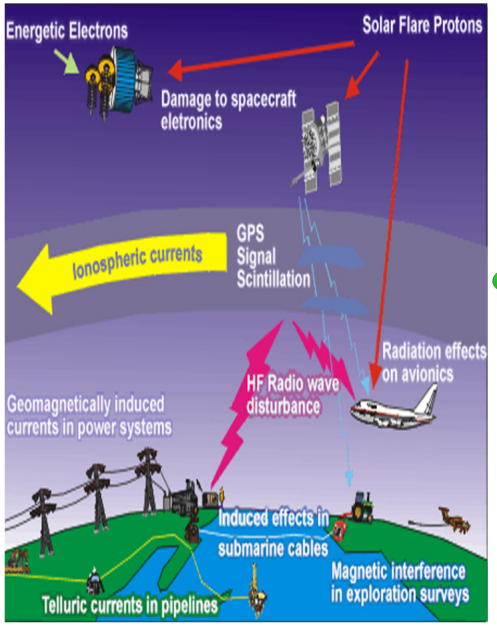
SPACE WEATHER OBSERVATION BY USING RADAR IS EXPENSIVE TO COVER INDONESIAN REGION COMPARED WITH GNSS OBSERVATION

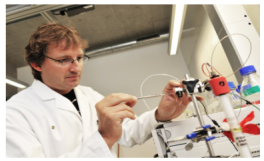

Status and Plans of GNSS Application for Space Weather Monitoring in Indonesia
Introduction
Space weather
Space weather effect on GNSS
Space weather Monitoring by Using GNSS
Methodology
How estimate TEC from GNSS data
How to estimate GPS Phase Scintillation Index
GNSS Application in Indonesia
Surveying and mapping: 1980
Precise surveiying for refining and densifying national geodetic control of Indonesia
Establishment cadastral network of Indonesia
Ionospheric research
SWOT analysis
External
Threats
Opportunities
Strategi
Objective
Internal
Weakness
Strongths
Plans of GNSS Application for Space Wetaher Monitoring
Optimum real time ionospheric activity monitoring over Indonesia
Needs
Data communication
HRD
Networking and collaboration
National
International
Objective
Summary
Status
Plans

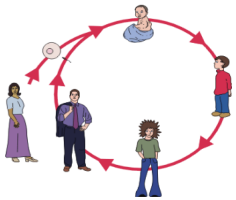
1 Introduction

Space weather

- Sun
- Solar Wind
- Magnetosphere
- Thermosphere
- Ionosphere





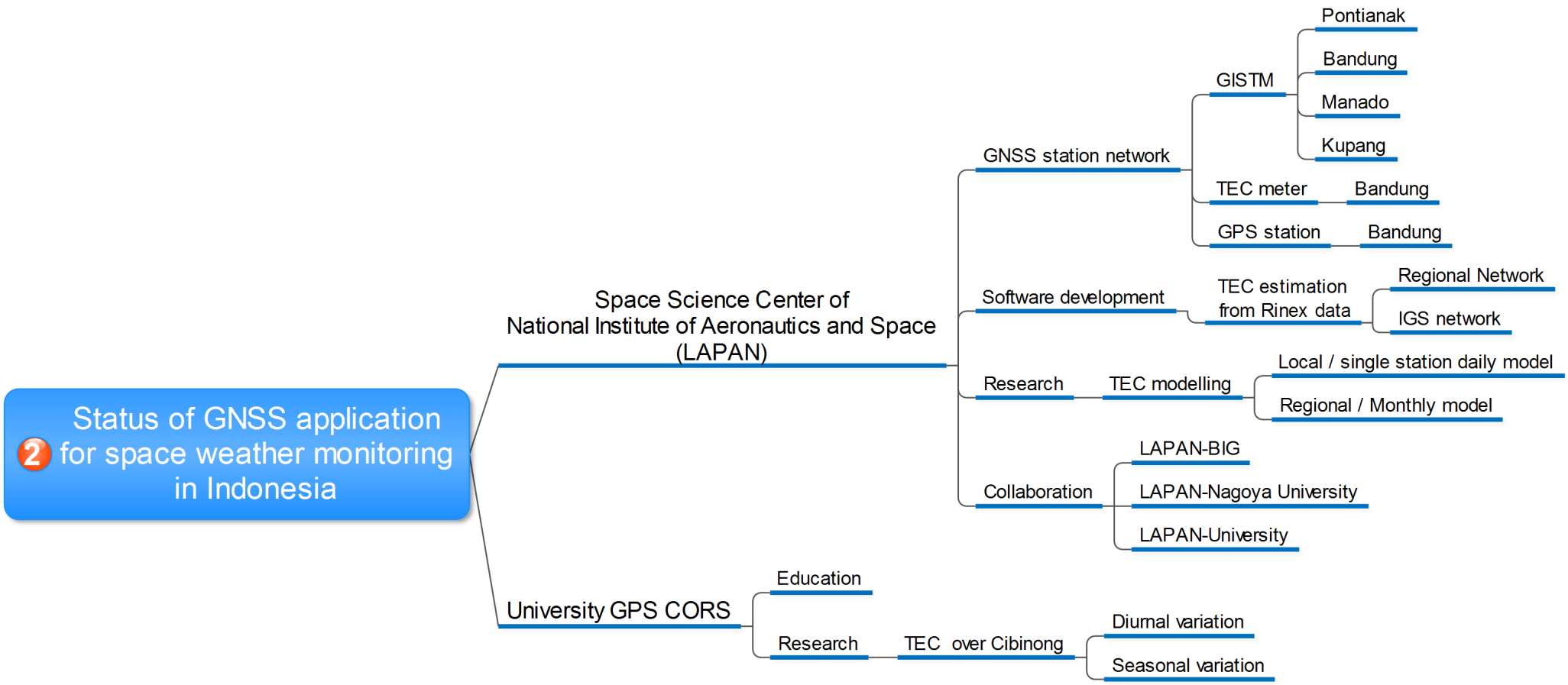


Space weather effect on GNSS

- Space element
  - Memory upsets
  - Dielectric charging
  - Radiation damage to components
- Ground element
  - Noise from the sun
    - increase during solar particle event
      - depend to frequency
- Signal propagation
  - ionospheric delay
    - decrease accuration
  - Ionospheric scintilation
    - loss of lock
      - decrease visibility of satellite
        - Decrease accurarion

Space weather Monitoring by Using GNSS

- difference of ionospheric delay between L1/L2 depend on TEC
  - Ionospheric delay depend on frequency
    - Estimate TEC
      - Difference TEC
- SNR
  - Estimate GPS Phase Scintillation Index
    - WIndowind the DTEC

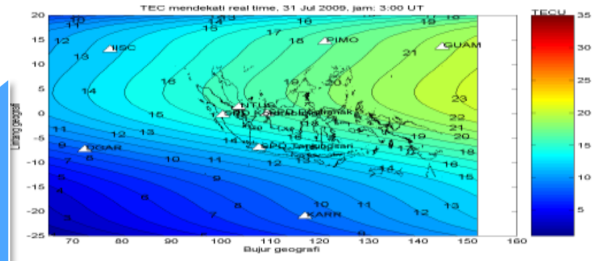

2 Status of GNSS application for space weather monitoring in Indonesia
Space Science Center of National Institute of Aeronautics and Space (LAPAN)
GNSS station network
GISTM
Pontianak
Bandung
Manado
Kupang
TEC meter
Bandung
GPS station
Bandung
Software development
TEC estimation from Rinex data
Regional Network
IGS network
Research
TEC modelling
Local / single station daily model
Regional / Monthly model
Collaboration
LAPAN-BIG
LAPAN-Nagoya University
LAPAN-University
University GPS CORS
Education
Research
TEC over Cibinong
Diurnal variation
Seasonal variation

IGS Network in and near Indonesia: BAKO, XMIS, NTUS, SAMP

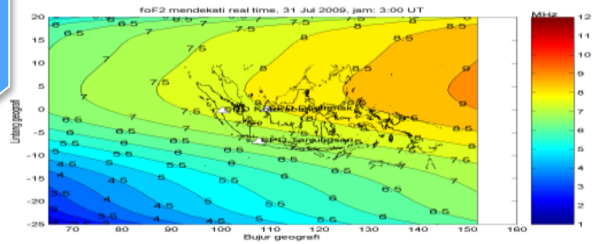
Daily regional TEC modeling using polinomial function

Global model of ionospheric slabs thikness

TEC

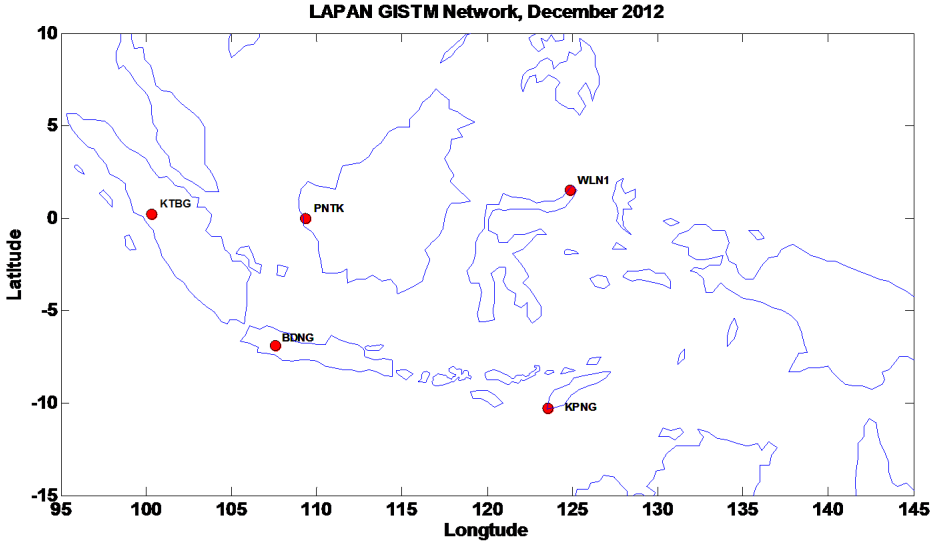


3.1. Model TEC near real time dari data GPS di Indonesia dan sekitarnya tanggal 31 Juli m 03:00 UT.

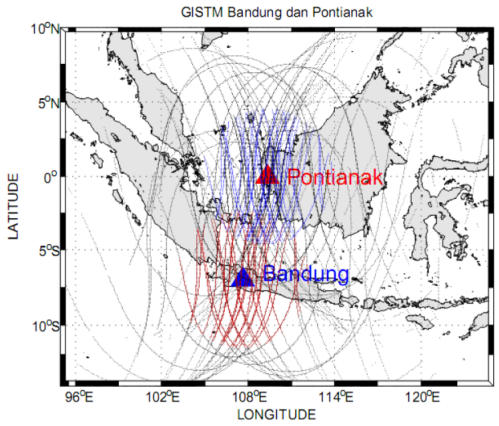


foF2

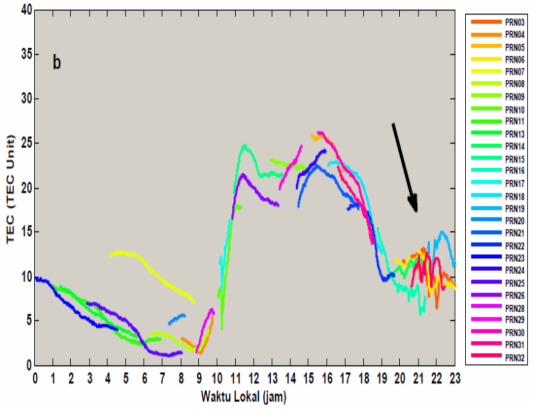
Gambar 3.2. Model foF2 near real time dari model TEC (foF2 GPS) menggunakan persamaan (2-3).



LAPAN GISTM Network: BNDG, PNTK, WALN, KPNG



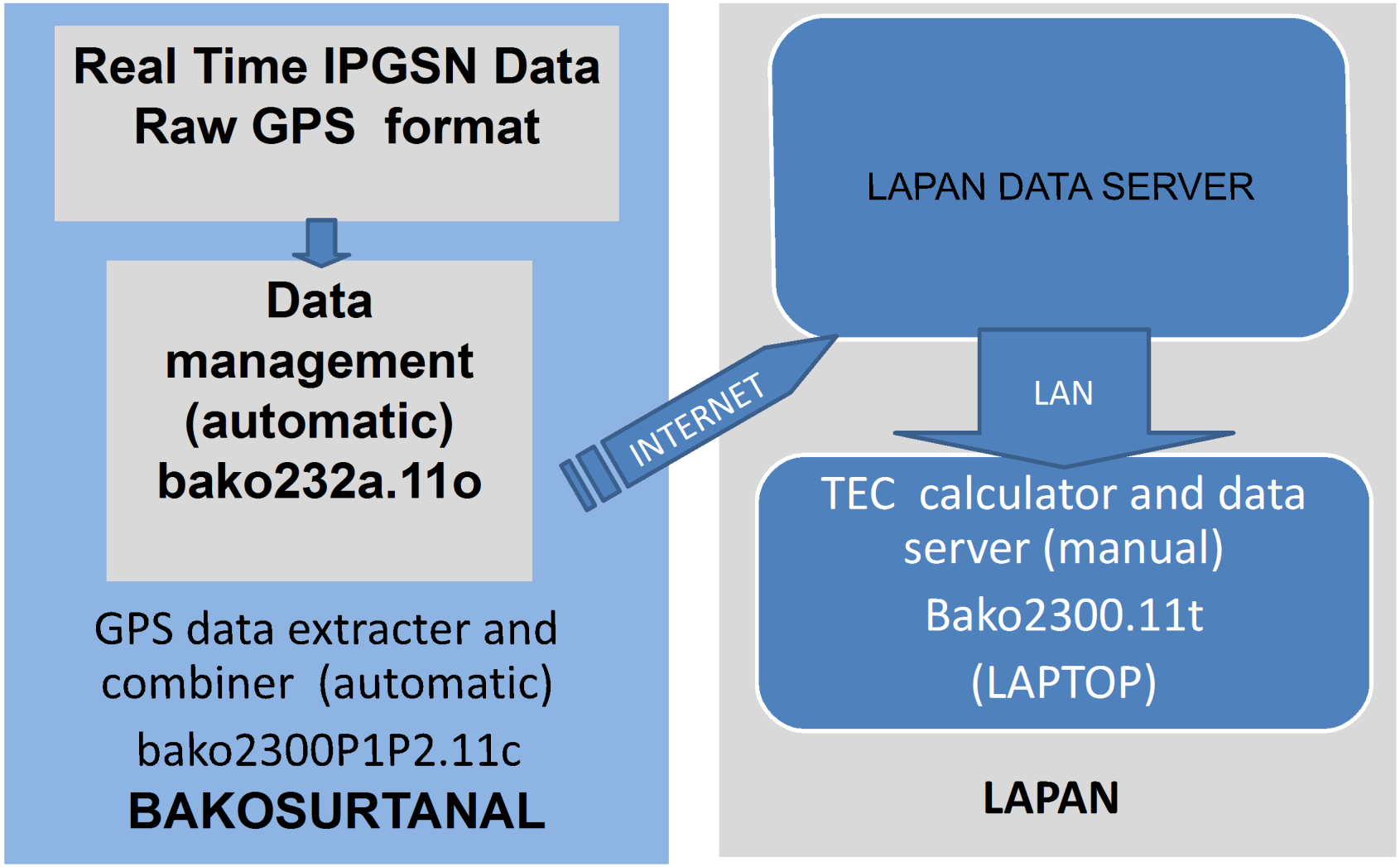
GPS satellite visibility from Pontianak and Bandung

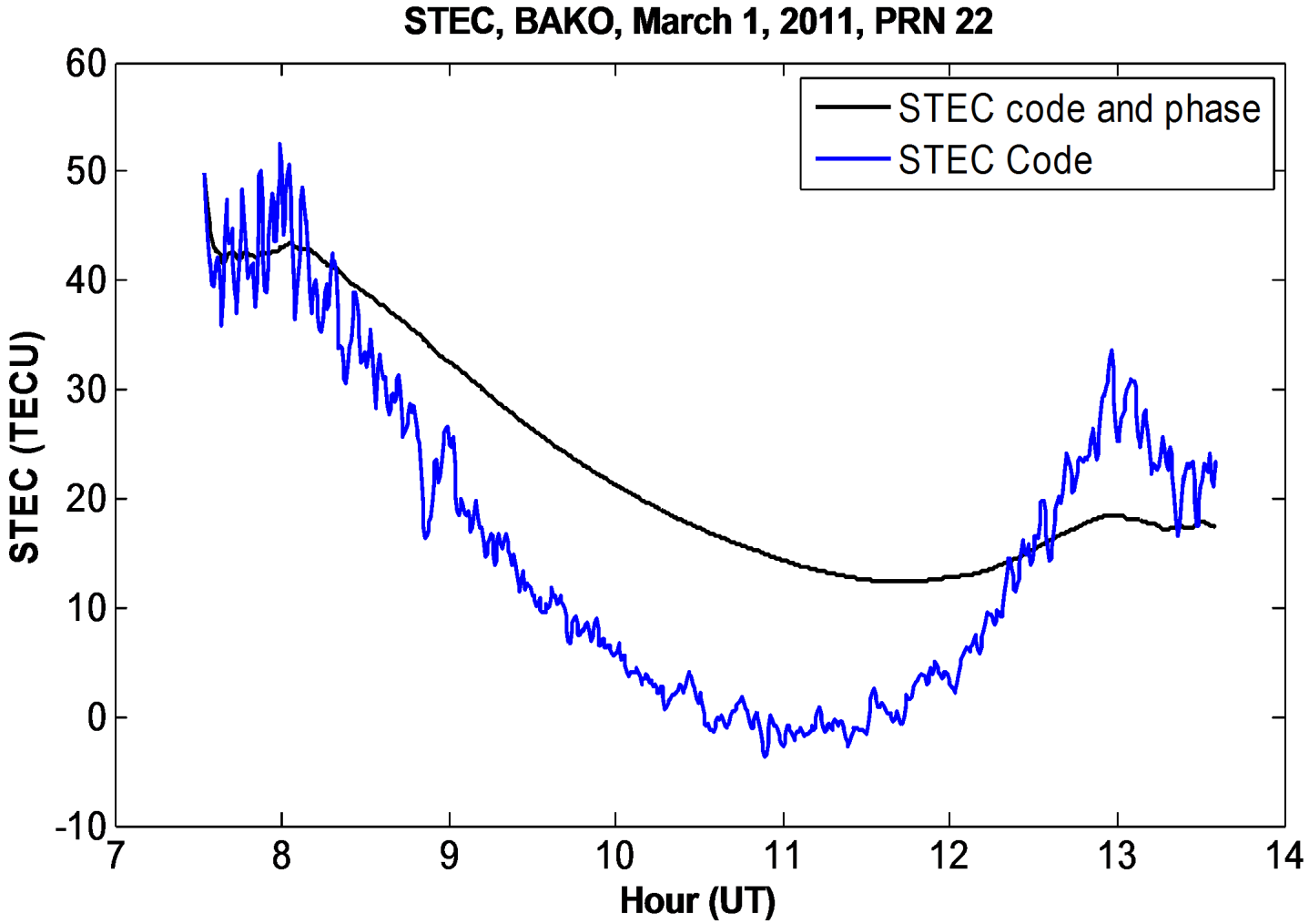


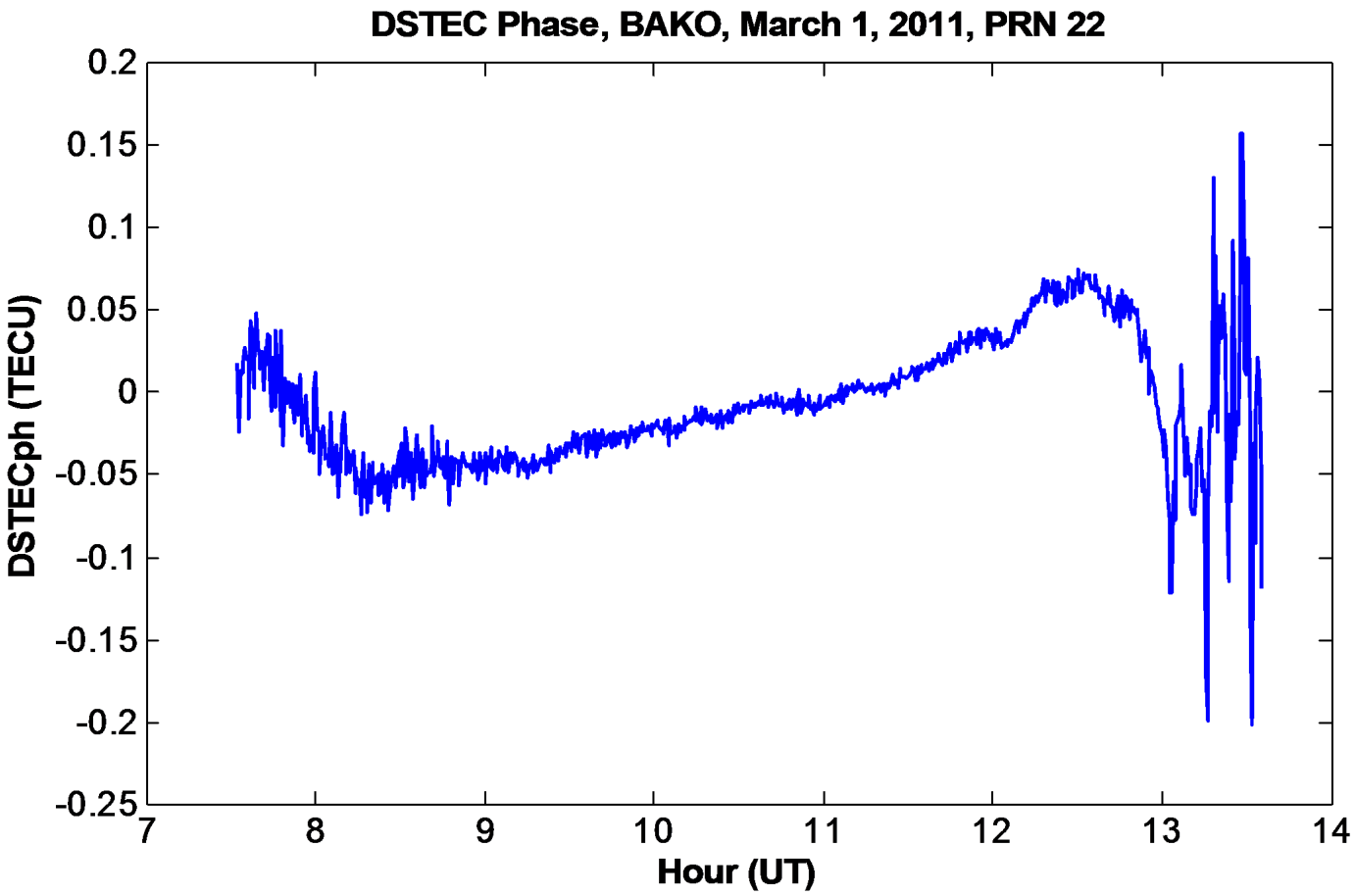
Diurnal Variation of TEC from Pontianak, Maret 10, 2009

Asnawi, Indonesian Space Science Journal, 2012

GNSS data integration strategy

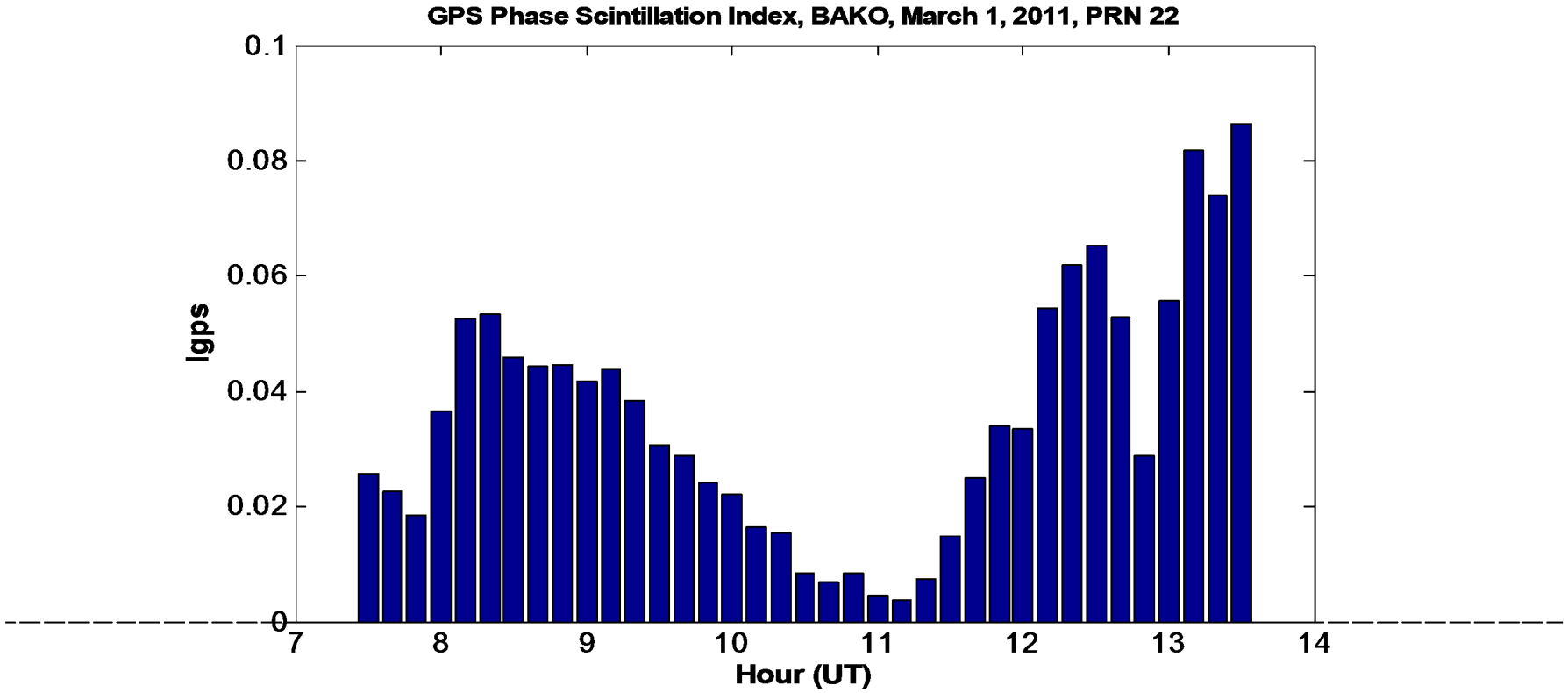



STEC, BAKO, March 1, 2011, PRN 22
STEC code and phase
STEC Code
STEC (TECU)
Hour (UT)
60
50
40
30
20
10
0
-10
7
8
9
10
11
12
13
14

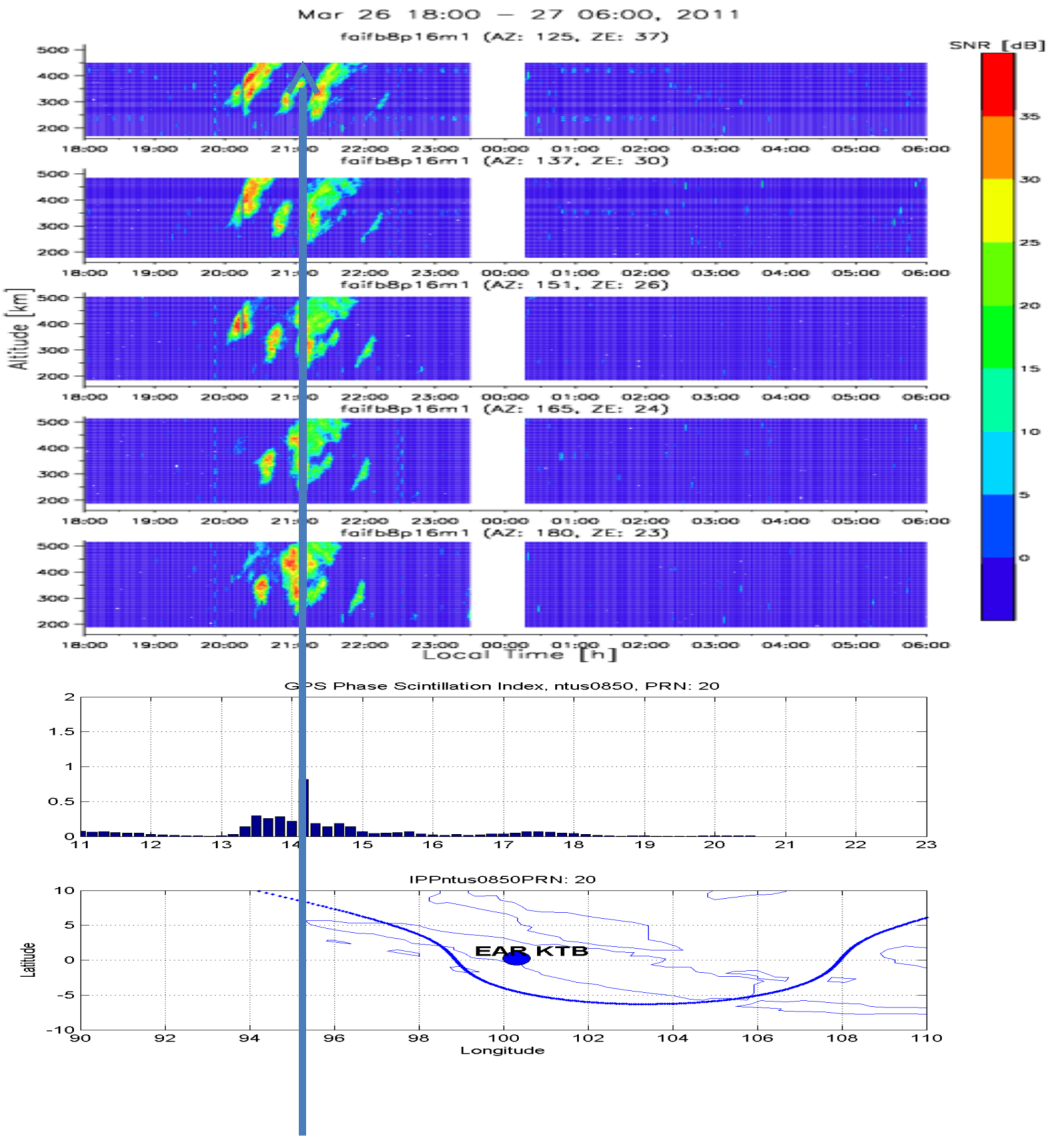

DSTEC Phase, BAKO, March 1, 2011, PRN 22
DSTECph (TECU)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
7
8
9
10
11
12
13
14
Hour (UT)

Application of GPS TEC:
GPS Phase Scintillation Index: Igps

$$Igps = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(DSTEC)^2{}_n}\,, DSTEC_n = STECph_{t+1} - STECph_t$$



Igps phase scintillation index FAI



Buldan et. al., 2011

GNSS Application for Space weather monitoring in Indonesia

3

Opportunities

- Demand of GNSS observation from JAXA,ROCOSMOS and Miami University in Indonesia
- Developing Air transportation
- Inter island HF communication
- High accuration positioning using GNSS single frequency
- Development of GNSS station network for non space weather observation
- Open ionospheric data from LEO satellite

Strengths

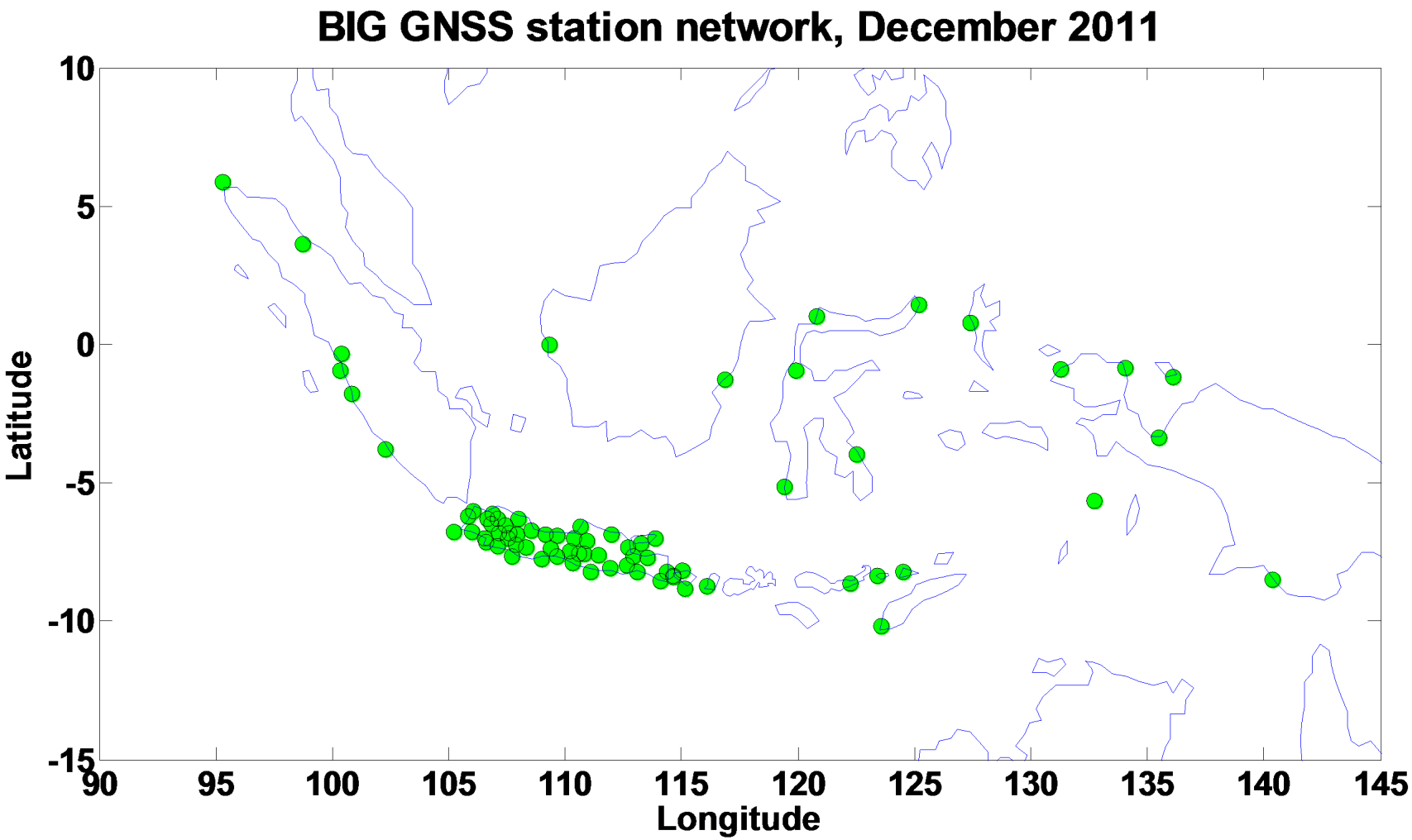
- Internet and VPN
- Laboratorium equipment
- Researcher and Engineer

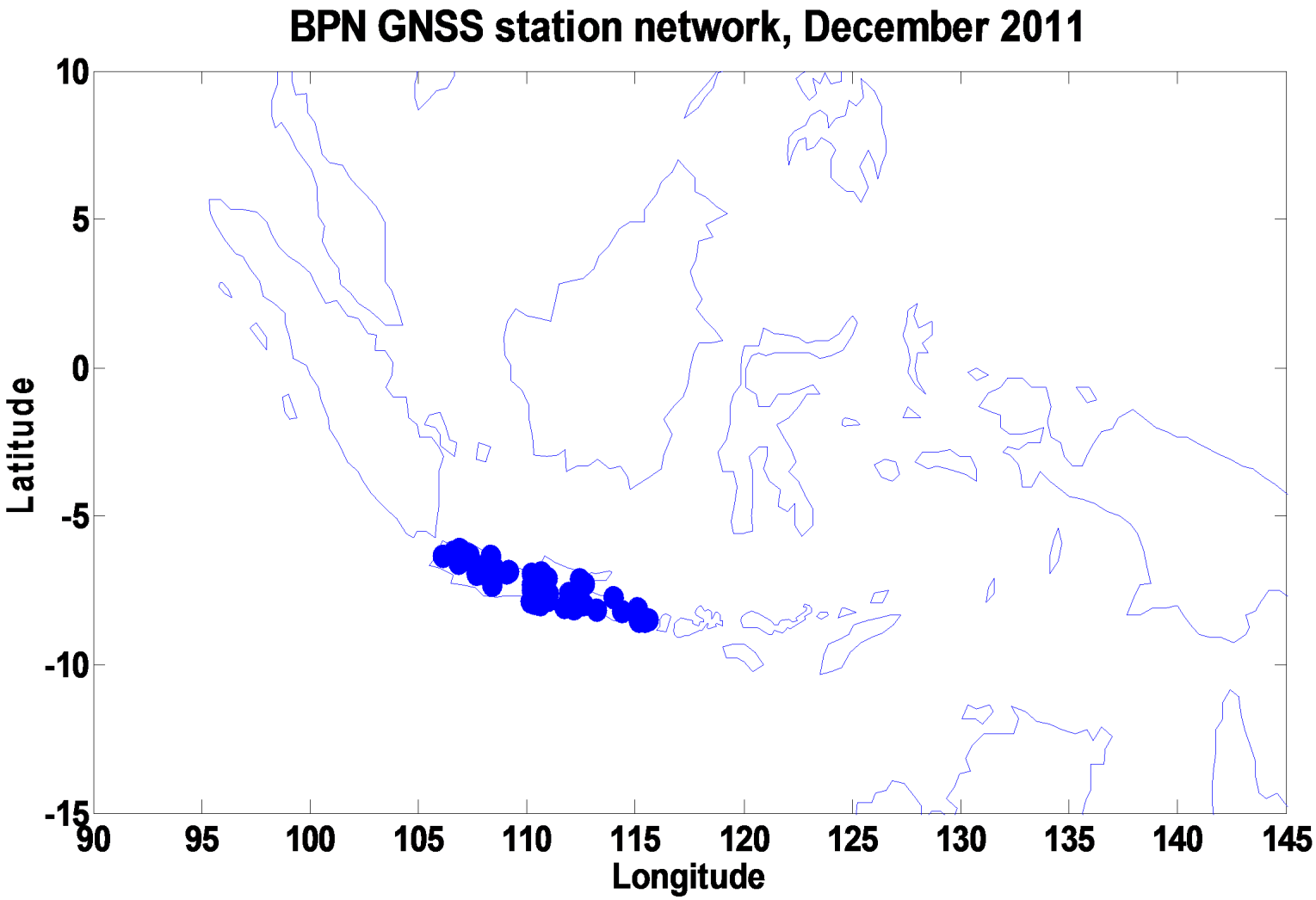
Weaknesses

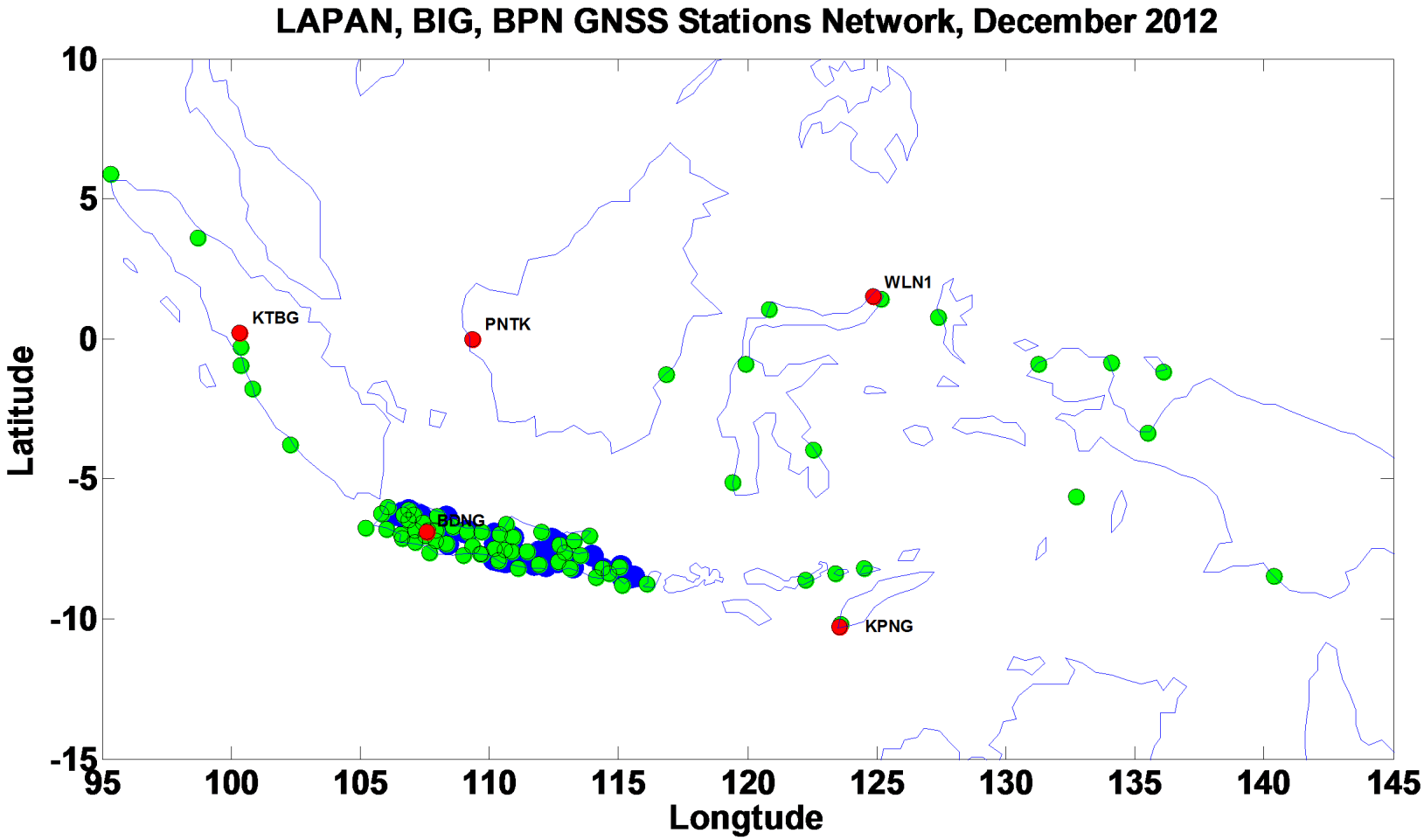
- Sectoral
- Lack of GNSS data skill HRD
- Individually
- Weak collaboration
- Low speed of data communication

Threats

- Low users awareness


BIG GNSS station network, December 2011
Latitude
Longitude
10
5
0
-5
-10
-15
90
95
100
105
110
115
120
125
130
135
140
145


BPN GNSS station network, December 2011
Latitude
Longitude
10
5
0
-5
-10
-15
90
95
100
105
110
115
120
125
130
135
140
145



5 GNSS stations of LAPAN
42 GNSS stations of BPN
77 GNSS stations of BIG

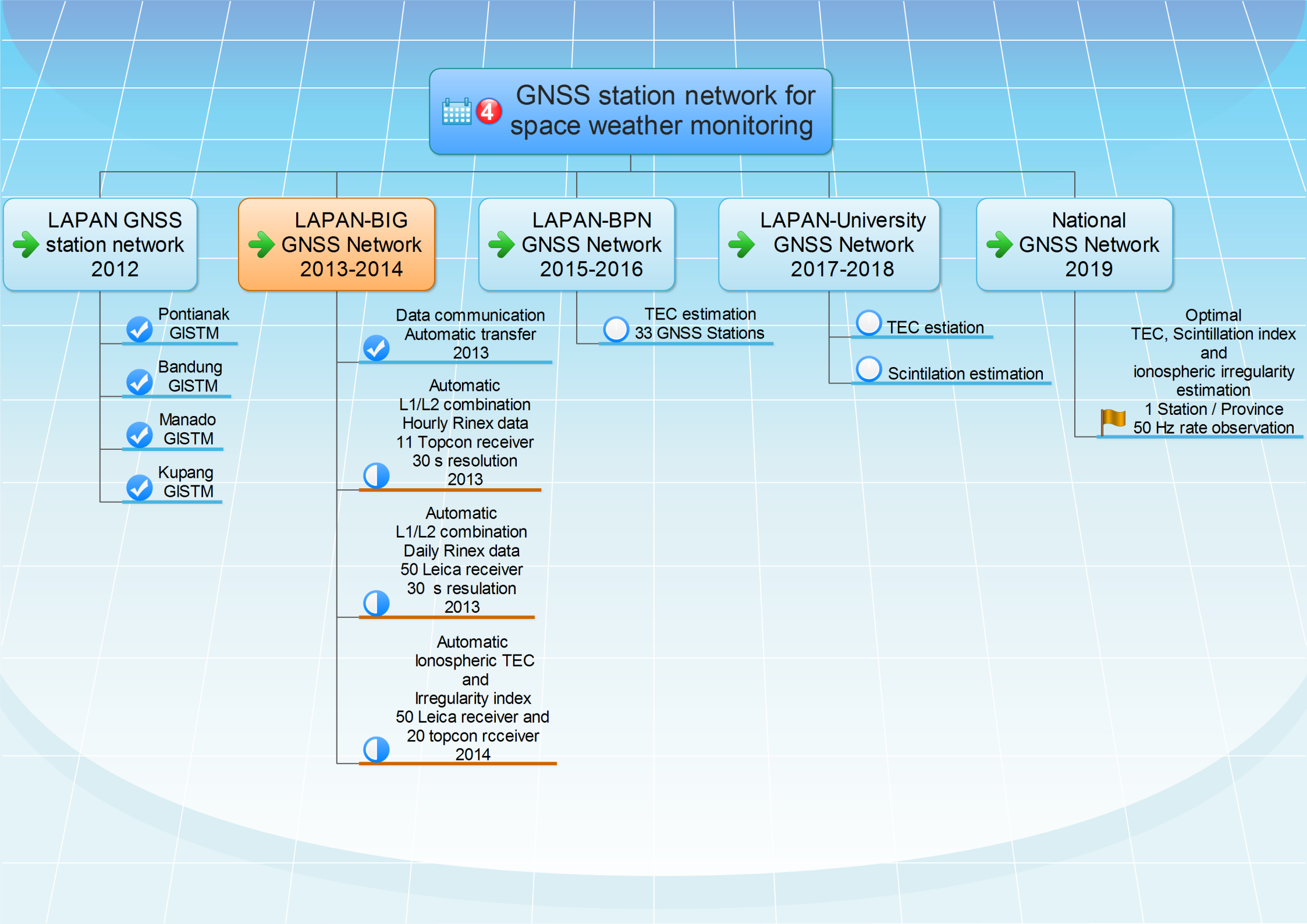
124 National GNSS stations Network in Indonesia

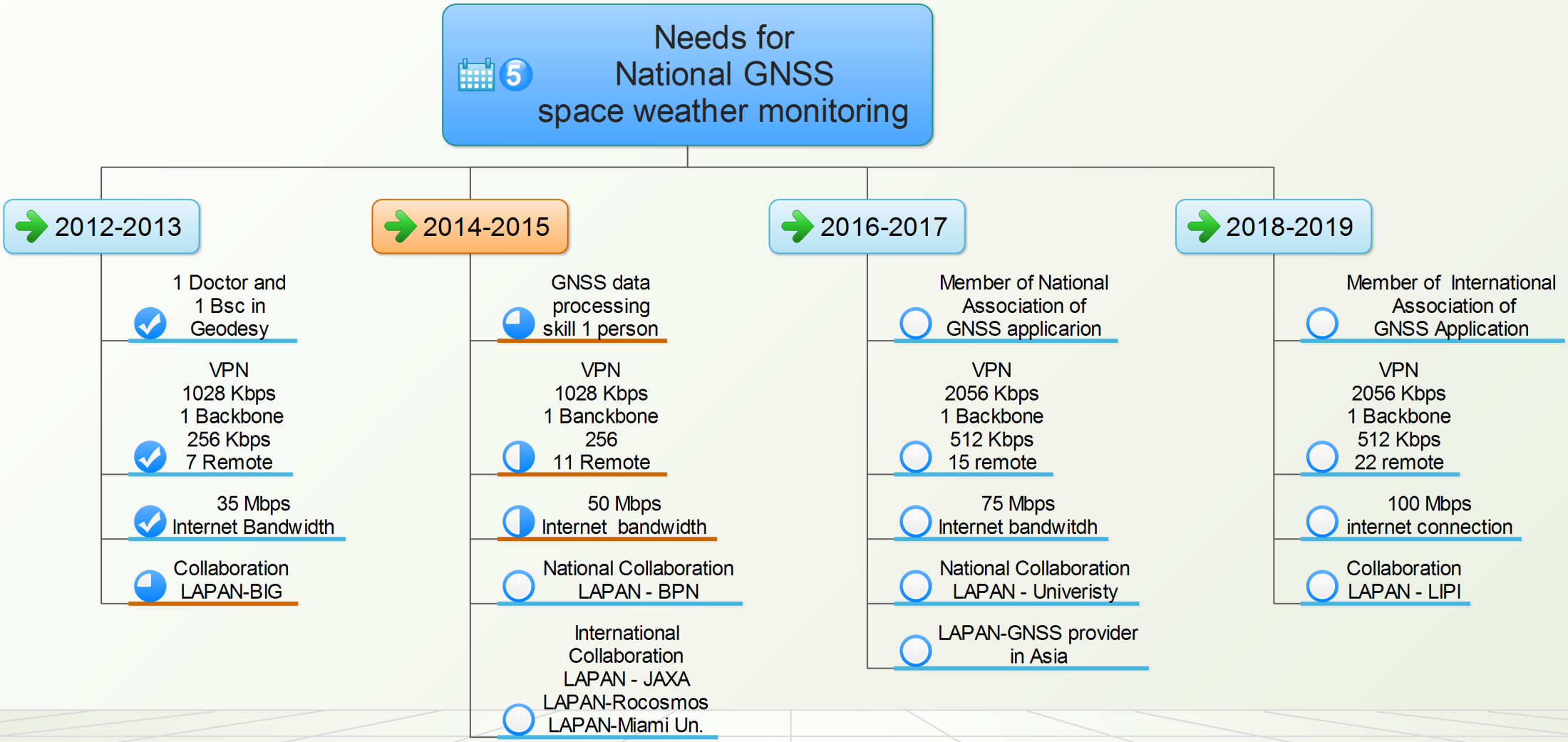
Integration and networking of the GNSS Station Netwokrs
to increase the resolution of ionospheric observation

Optamization of
Near Real Time Monitoring Space Weather
by Using Integrated National GNSS Station Network

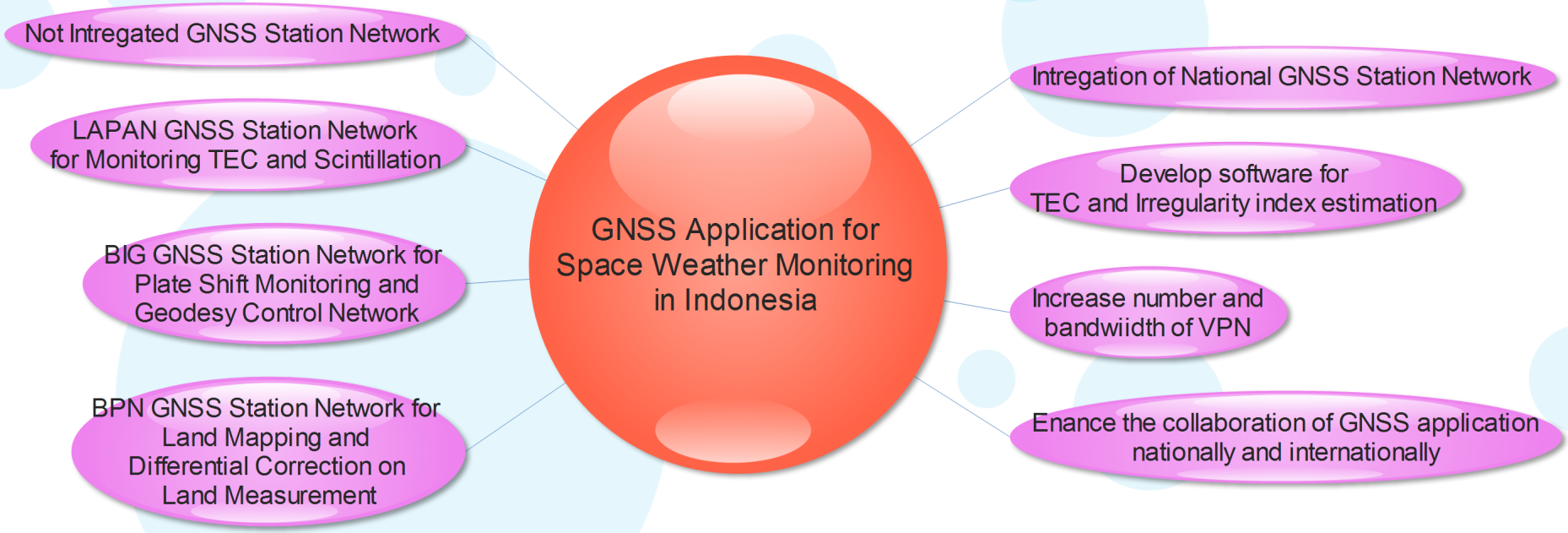
Strategy

Objective


GNSS station network for space weather monitoring
LAPAN GNSS station network 2012
Pontianak GISTM
Bandung GISTM
Manado GISTM
Kupang GISTM
LAPAN-BIG GNSS Network 2013-2014
Data communication Automatic transfer 2013
Automatic L1/L2 combination Hourly Rinex data 11 Topcon receiver 30 s resolution 2013
Automatic L1/L2 combination Daily Rinex data 50 Leica receiver 30 s resulation 2013
Automatic Ionospheric TEC and Irregularity index 50 Leica receiver and 20 topcon rceeiver 2014
LAPAN-BPN GNSS Network 2015-2016
TEC estimation 33 GNSS Stations
LAPAN-University GNSS Network 2017-2018
TEC estiation
Scintilation estimation
National GNSS Network 2019
Optimal TEC, Scintillation index and ionospheric irregularity estimation
1 Station / Province
50 Hz rate observation


Needs for
National GNSS
space weather monitoring
2012-2013
1 Doctor and
1 Bsc in
Geodesy
VPN
1028 Kbps
1 Backbone
256 Kbps
7 Remote
35 Mbps
Internet Bandwidth
Collaboration
LAPAN-BIG
2014-2015
GNSS data
processing
skill 1 person
VPN
1028 Kbps
1 Banckbone
256
11 Remote
50 Mbps
Internet bandwidth
National Collaboration
LAPAN - BPN
International
Collaboration
LAPAN - JAXA
LAPAN-Rocosmos
LAPAN-Miami Un.
2016-2017
Member of National
Association of
GNSS applicarion
VPN
2056 Kbps
1 Backbone
512 Kbps
15 remote
75 Mbps
Internet bandwitdh
National Collaboration
LAPAN - Univeristy
LAPAN-GNSS provider
in Asia
2018-2019
Member of International
Association of
GNSS Application
VPN
2056 Kbps
1 Backbone
512 Kbps
22 remote
100 Mbps
internet connection
Collaboration
LAPAN - LIPI

Summary


Not Intregated GNSS Station Network
LAPAN GNSS Station Network for Monitoring TEC and Scintillation
BIG GNSS Station Network for Plate Shift Monitoring and Geodesy Control Network
BPN GNSS Station Network for Land Mapping and Differential Correction on Land Measurement
GNSS Application for Space Weather Monitoring in Indonesia
Intregation of National GNSS Station Network
Develop software for TEC and Irregularity index estimation
Increase number and bandwiidth of VPN
Enance the collaboration of GNSS application nationally and internationally

Thank you for your attention