



SIMULATING IONOSPHERIC MITIGATION ON GNSS-BASED APPLICATIONS

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**United Nations / Fiji Workshop on the
Applications of Global Navigation Satellite Systems**

Suva, Fiji
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Outline

- GNSS application in Indonesia
- Active Ionosphere in Indonesia
- Ionosphere Observation in Indonesia
- Augmentation System
- Effect of Ionosphere on Augmentation
- Mitigation by simulation
- Next Step

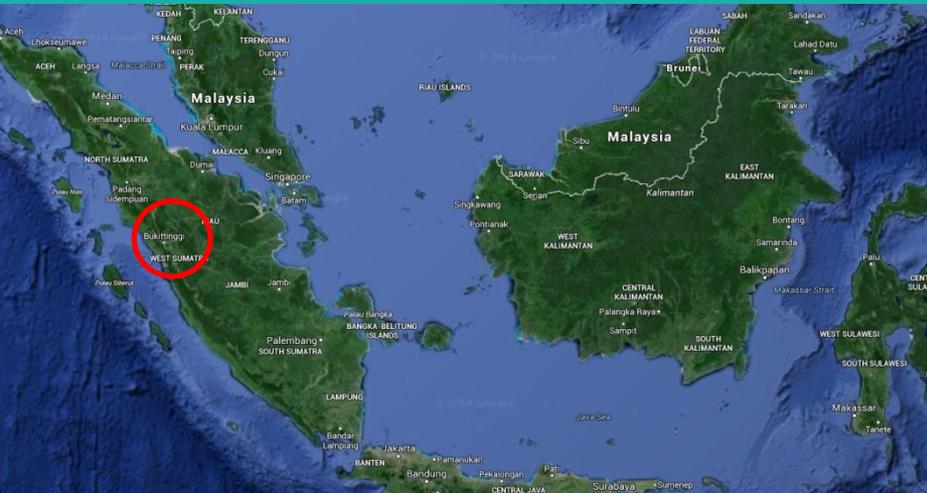
GNSS Application in Indonesia

- Reference Frame
- Surveying
- Earthquake
- Tsunami
- Space Weather
- UAV
- Sea Transportation
- Timing
- Land Vehicle
- Agriculture
- Smartphone
- **Aviation**

Active Ionosphere in Indonesia



Ionosphere Observation in Indonesia

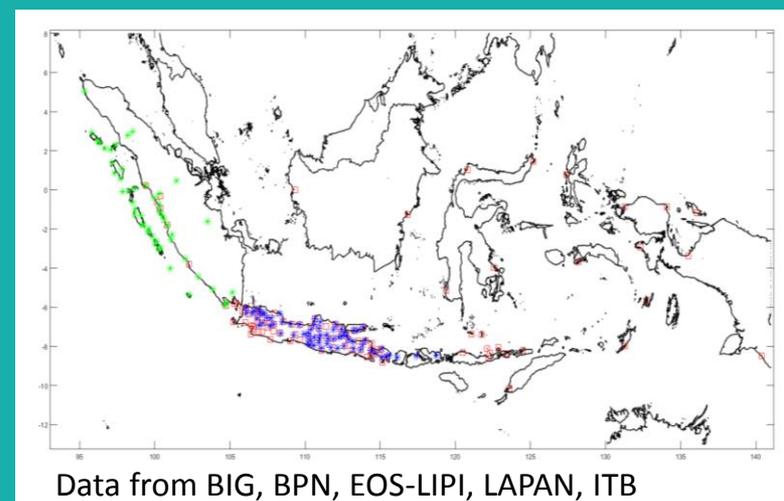
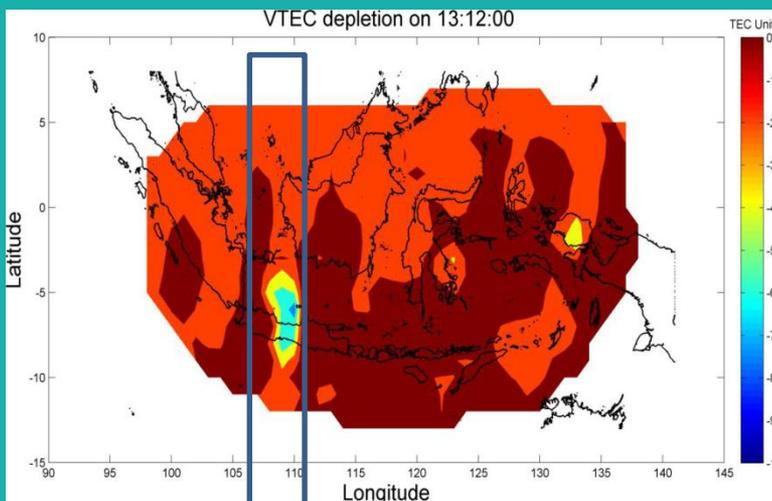
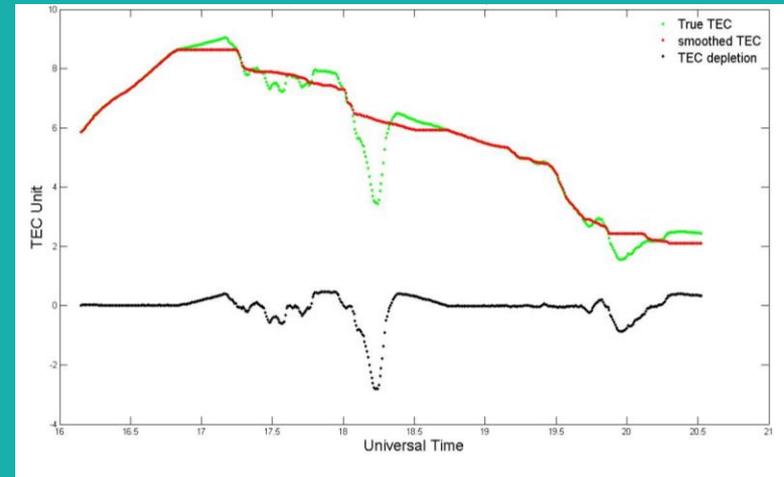
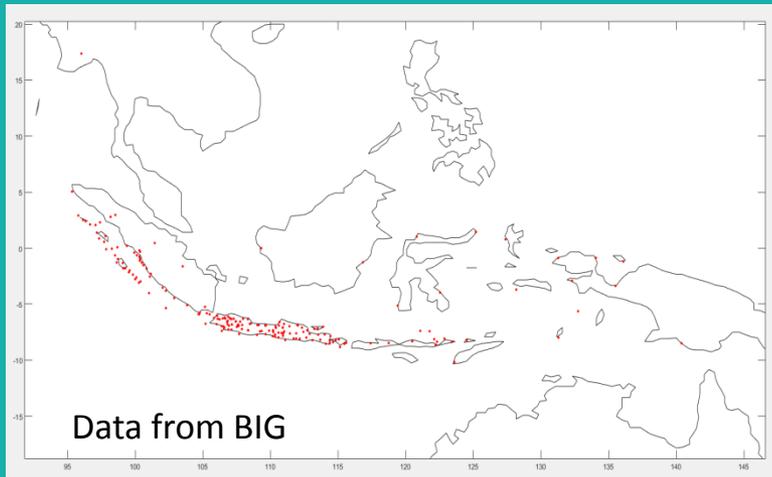


Detect Plasma bubble:

1. EAR (Equatorial Atmospheric Radar) with 560 Yagi antennas
2. Another VHF radar
3. All Sky Imager



Ionosphere Observation in Indonesia



Augmentation System

correction

SPP

DGPS

WADGPS

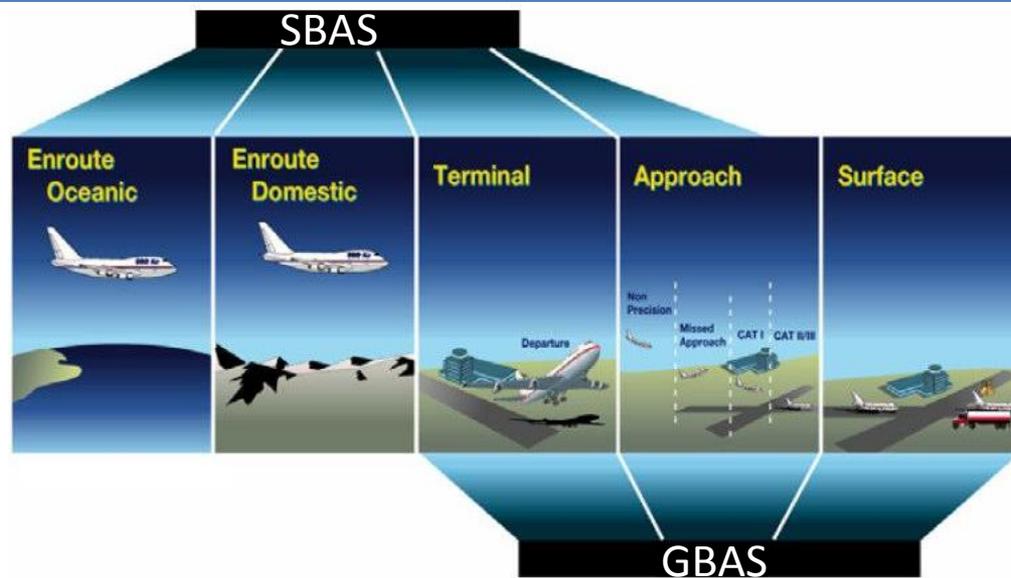
LADGPS

correction+ integrity

ABAS

SBAS

GBAS



Augmentation System



Ministry of Transportation

DGCA – Directorate of Air Navigation

Evolution PBN in Indonesia

- 2002: GPS approach Overlay with VOR-DME approach.
- 2006: stand alone GPS approach in airport where no navaid installed
- 2010: RNAV_(GNSS) at Pekanbaru airport
- 2011-2014: Expand implementation
 - RNP APCH
 - RNP AR Approach
 - RNAV-1 STAR/SID
- 2015-2016: Focussing on aviation safety improvement in Papua

Augmentation System



Ministry of Transportation
DGCA – Directorate of Air Navigation

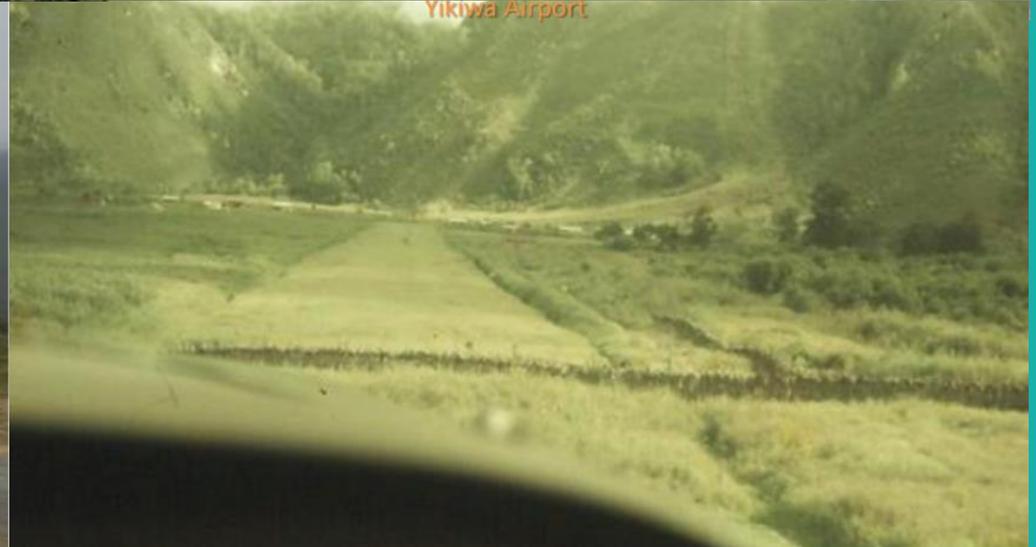
PBN for Papua



Zugappa Airport



Wamena Airport

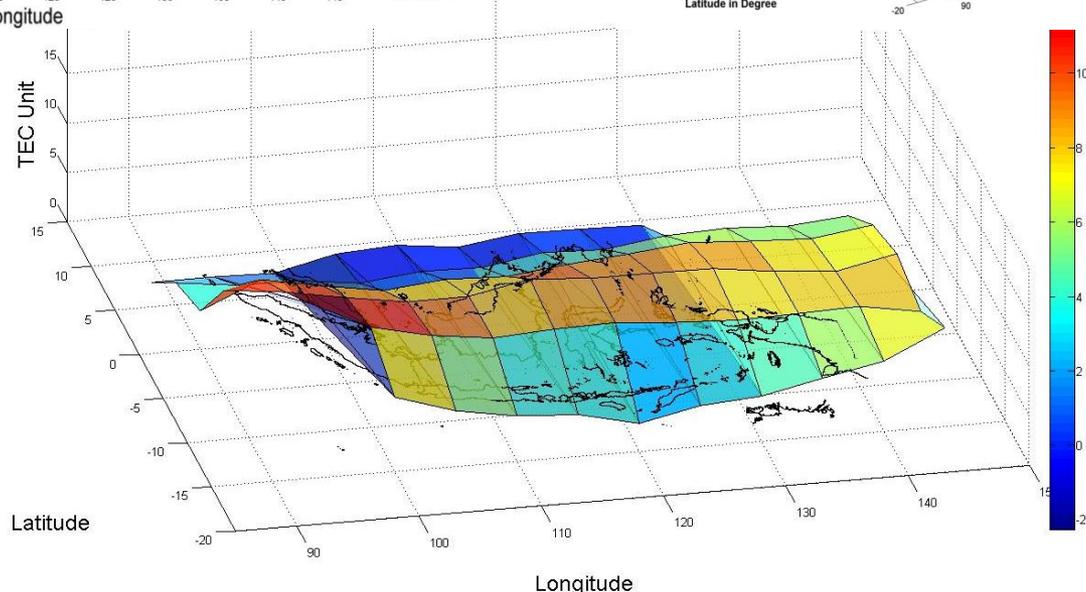
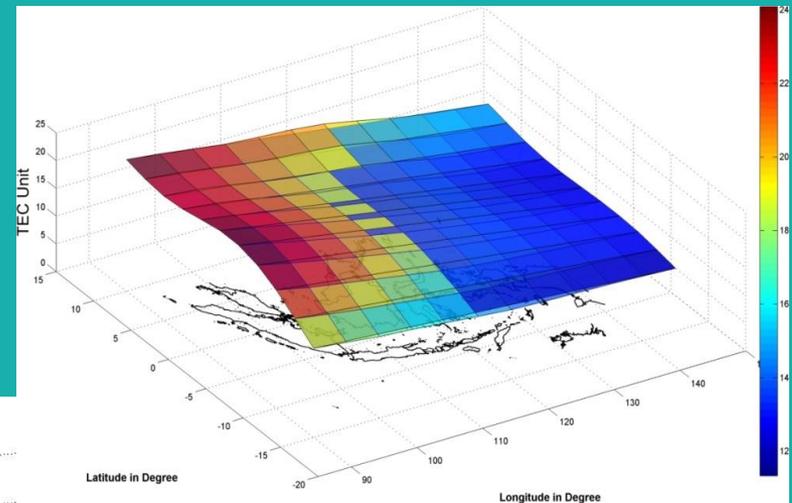
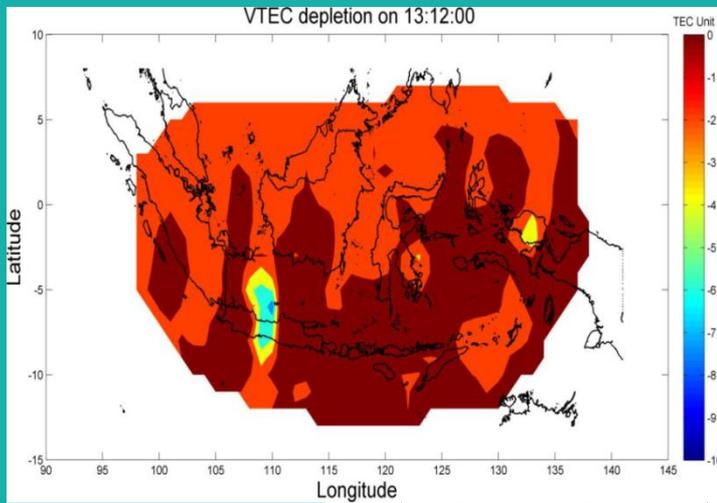


Yikiwa Airport

Effect of Ionosphere on SBAS

Date of Occurrence GPS Week/Dav(s)	Documents
W1322 D0 (5/8/2005)	DR 3 Iono Storm May 8 2005
W1327 D(s)0,1 (6/12,13/2005)	DR 8 Iono Storm June 12 2005
W1330 D0 (7/3/2005)	DR 11 two IGPs in storm state
W1376 D0 (5/23/2006)	DR 27 IGPs around Hawaii set to Do Not Use
W1398 D4 (10/26/2006)	DR 41 WAAS Ionospheric Grid Points (IGP) set to Do Not Use
W1399 D0 (10/29/2006)	DR 47 Iono Scintillation at Fairbanks
W1420 D5 (3/30/2007)	DR 52 Ionospheric Scintillation caused High Position Errors at Fairbanks
W1419 D6 (3/24/2007)	DR 53 Iono Scintillation at Juneau
W1421 D1 (4/2/2007)	DR 62 Ionospheric scintillation that caused high errors and alarm condition (Report is
W1438 D2 (7/31/2007)	DR 63 WAAS set all satellite and IGP's to Not Monitored (Report is pending)
W1468 D4 (2/28/2008)	DR 67 GIVE Monitor Trips Set IGPs to Storm State in Alaska Region
W1520 D5 (2/27/09)	DR 80 Ionospheric Scintillation caused High Position Error at Fairbanks and Kotzebue
W1578D1 (4/5/10)	DR 93 Ionospheric Storm Caused Alaska Coverage Drop
W1639D0 (6/5/2011)	DR 102 WAAS Reaction to Iono Activity June 5 2011
W1647D5-W1647D6 (8/5/11 – 8/6/11)	DR 103 WAAS Reaction to Iono Activity August 5-6 2011
W1655D1 (9/26/11)	DR 104 WAAS Reaction To Iono Activity September 26 2011
W1709D2 (10/09/12)	DR 111 Vertical Position Errors Increased at Fairbanks due to Ionospheric Scintillation
W1733D6 (3/29/13)	DR 113 Ionospheric Scintillation Causes Elevated Vertical Errors at Higher Latitude
W1742D6 (6/1/13)	DR 115 Effect on WAAS from Iono Activity on 01JUNE2013
W1783D3 (3/12/14)	DR 119 Geomagnetic Activity and Common WRS Communication Outages
W1783D1 (3/10/14)	DR 122 PRN4 and PRN20 DNU due to Iono at Equator
W1787D5 – W1787D6 (04/11/14 – 04/12/14)	DR 123 Effect on WAAS from Iono Activity April 11-12 2014
W1809D5 – W1809D6 (9/12/14 – 9/13/14)	DR 125 Effect on WAAS from Iono Activity September 12-13 2014
W1826D3 (1/7/15)	DR 126 Effect on WAAS from Iono Activity January 7 2015
W1836D2 – W1836D3 (03/17/15 – 03/18/15)	DR 127 Effect on WAAS from Iono Activity March 17 2015
W1861D3 (9/9/15)	DR 128 Effect on WAAS from Iono Activity September 9 2015
W1887D0 – W1887D1 (03/06/16 – 03/07/16)	DR 130 Ionospheric Activity Effects on WAAS Performance 6-7March 2016
W1916D3 (9/28/16)	DR133 Ionospheric Grid Points (IGPs) values set not monitored in North West service

Effect of Ionosphere on SBAS



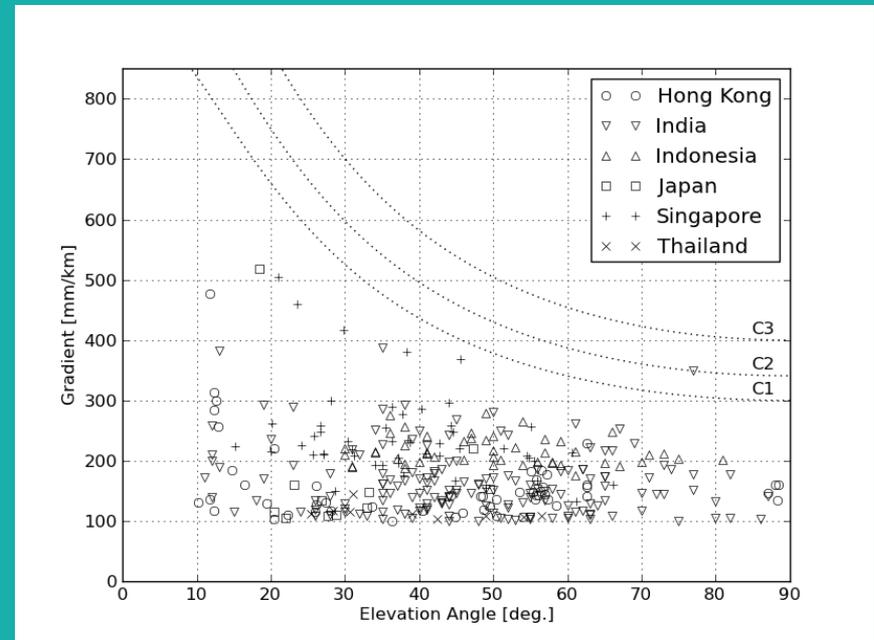
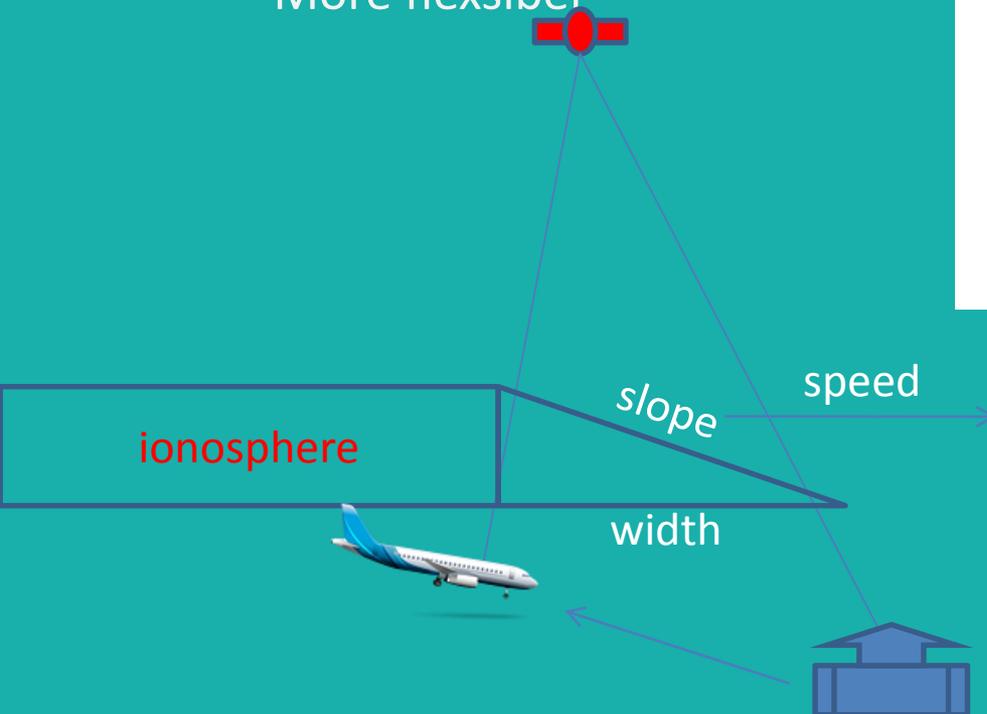
Mitigation of plasma bubble in GBAS

- **Observation**

- More real
- Limited data

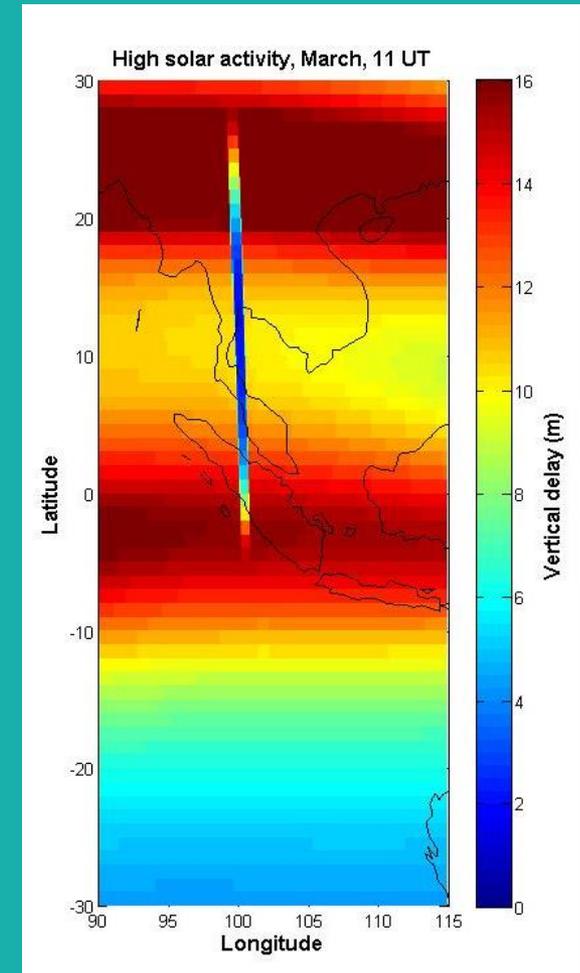
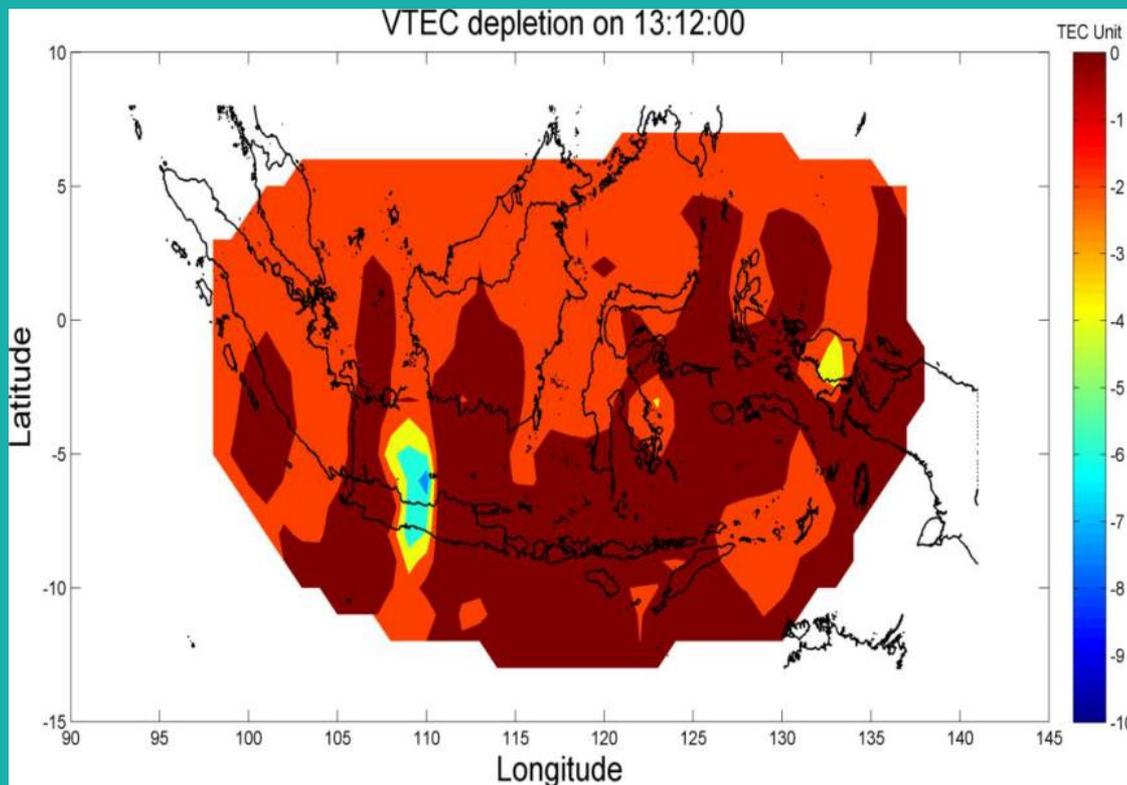
- Simulation

- More flexibel



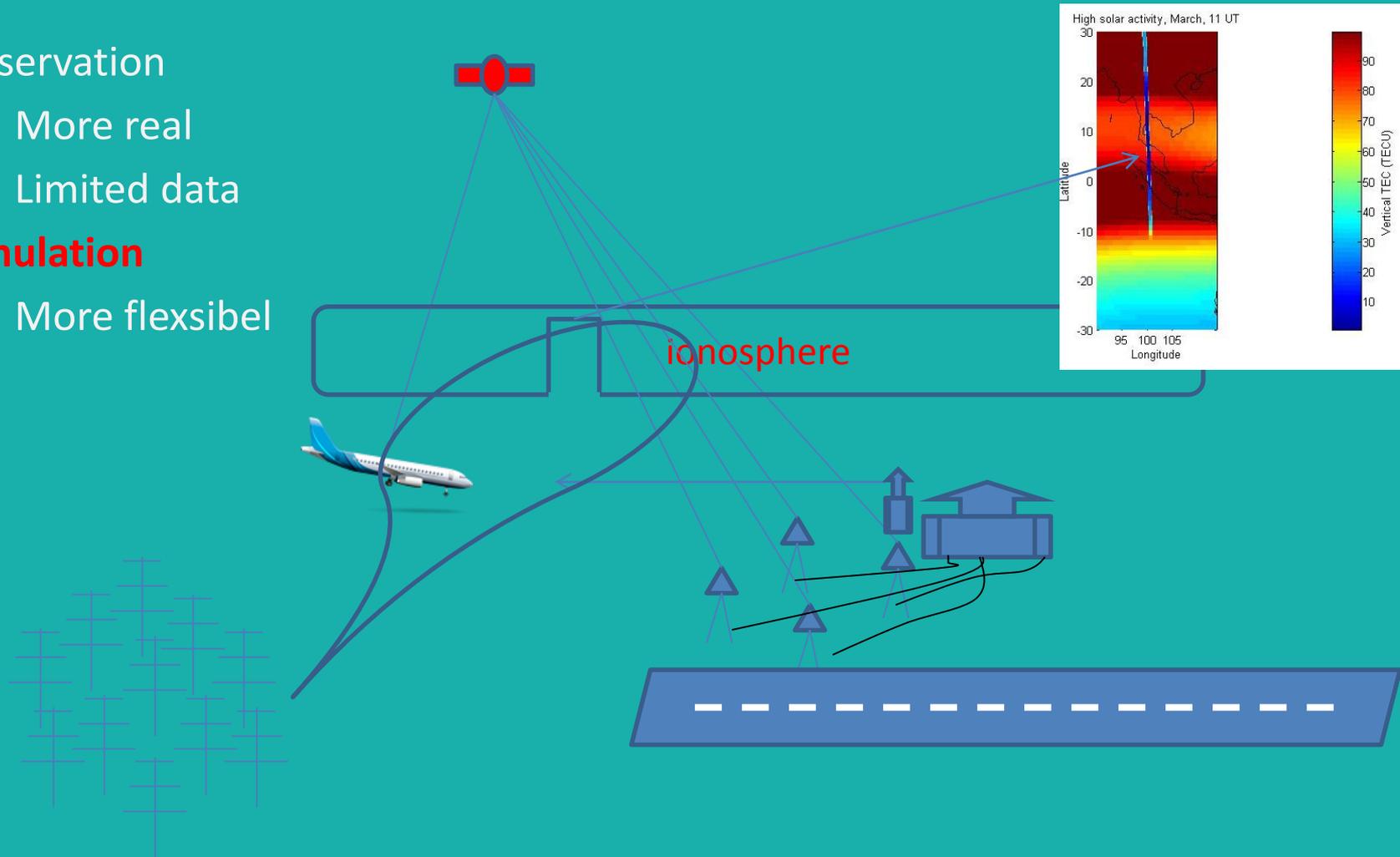
Ionospheric delay gradient model for GBAS in the Asia-Pacific Region (ICAO APANPIRG Ionospheric Studies Task Force)

Mitigation by Simulation in GBAS



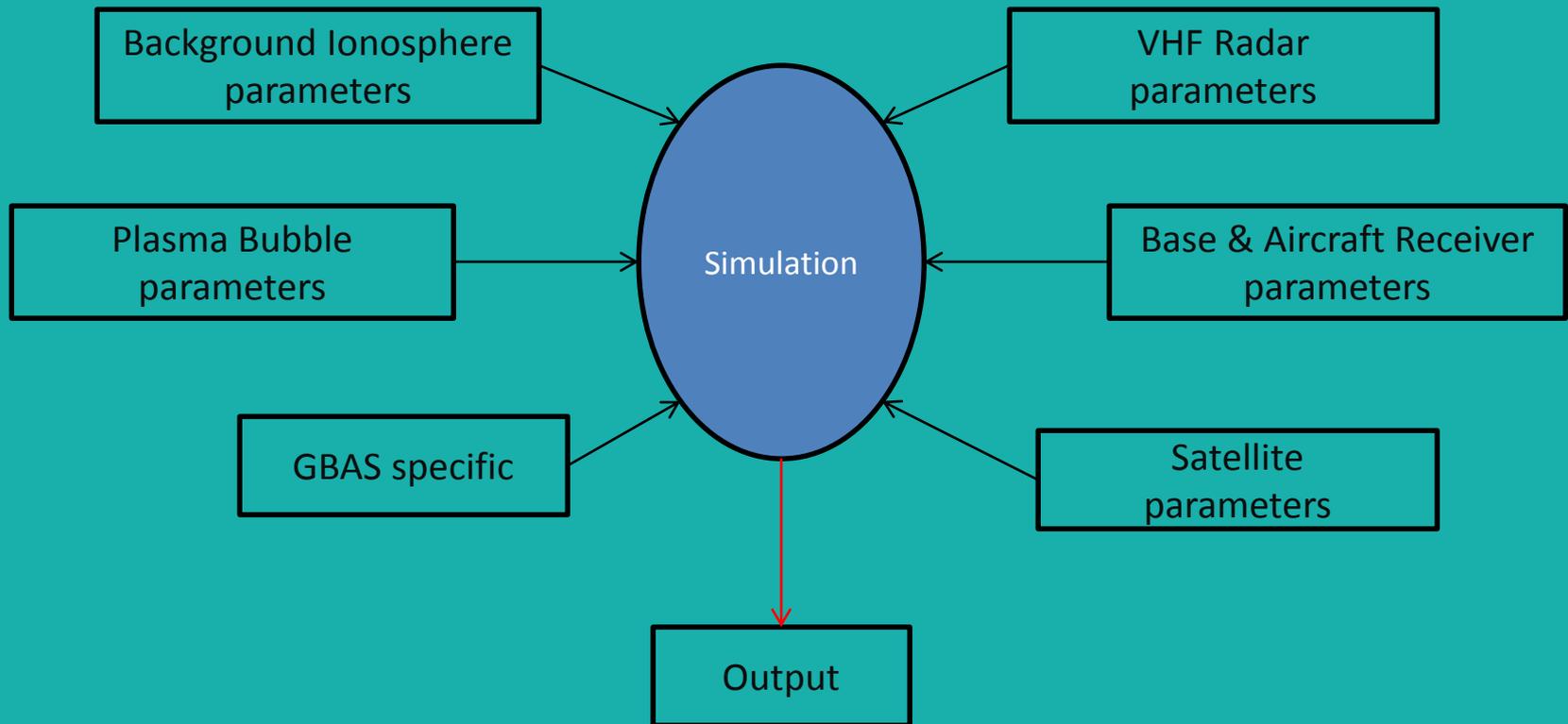
Mitigation by Simulation

- Observation
 - More real
 - Limited data
- **Simulation**
 - More flexibel



Plasma Bubble Mitigation by VHF Radar for GBAS
By: Saito (ENRI) & Slamet (LAPAN) submitted to ION

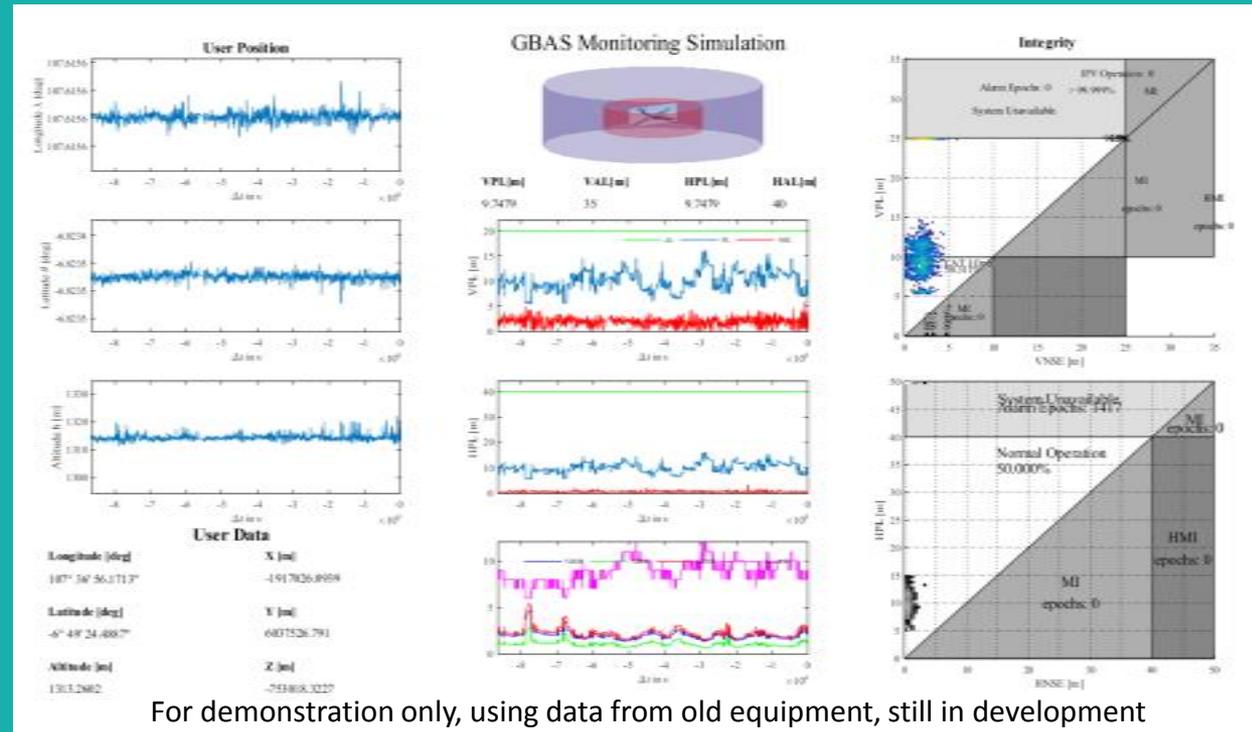
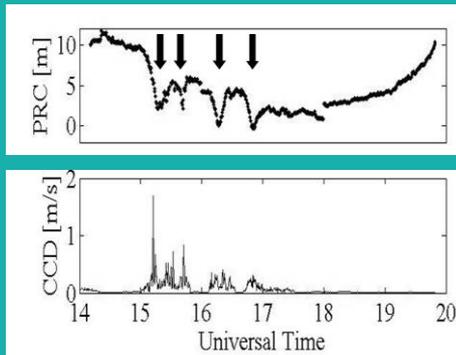
Mitigation by Simulation



Simulation developed by ENRI, Japan

Mitigation by Observation

- **Observation**
 - More real
 - Limited data
- Simulation
 - More flexibel



For demonstration only, using data from old equipment, still in development

Mitigation by Observation

Reference Station

Old equipment
(SFSC) wo L5



New equipment
(MFMC) wi L5



Next Step

- Build Ionospheric Threat Model (ITM) for SBAS in Indonesia
- Test ITM for SBAS by Simulation
- Develop appropriate ionosphere model in SBAS for Indonesia
- Test Ionospheric delay gradient model in GBAS
- Improve ionospheric delay gradient model
- Monitor Scintillation effect on L5 performance