ICG Workshop on GNSS Spectrum Protection and Interference Detection and Mitigation

Review of the GNSS IDM technology

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July.2014 Geneva

At 1st IDM workshop, it has been agreed that GNSS interference include:

- *Interference from radio systems*
  - *Intentional interference*
  - *Unintentional interference*
- *Natural Disturbance: ionospheric disturbance …*

1. Review of GNSS RFI detection and location technology

Different GNSS RFI detection and location technologies have been studied. Such as in US, EU, Russia, China…

Technologies review:

a) Fixed GNSS RFI monitoring

b) Movable GNSS RFI source detection and location

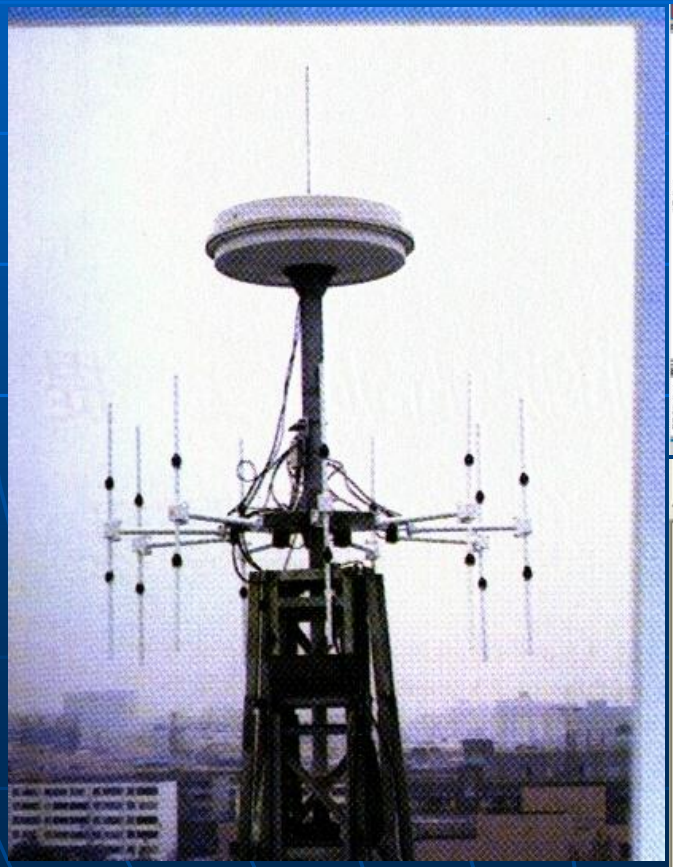
c) monitoring and location using gridding network of sensors

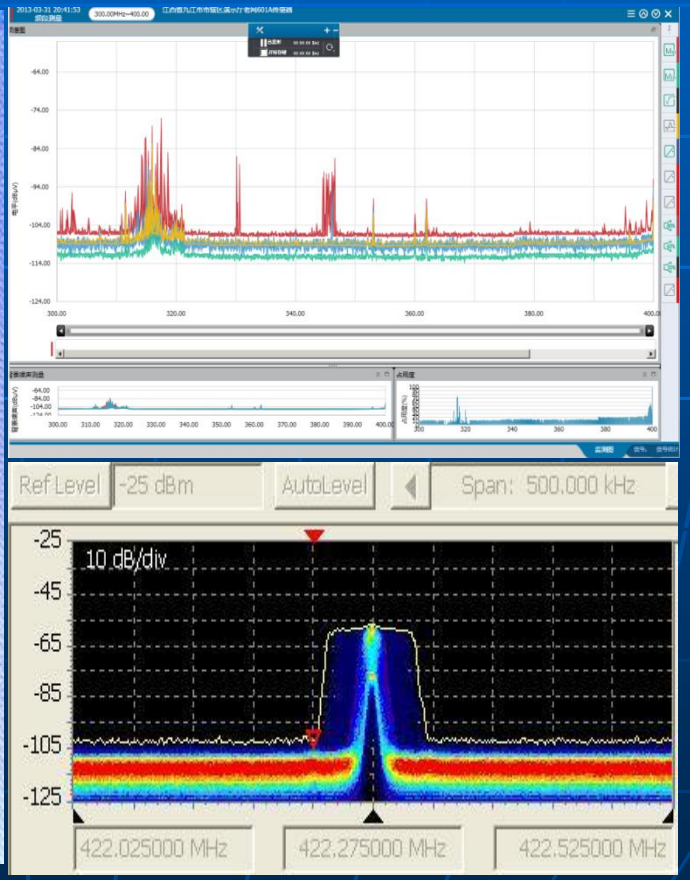
d) RFI detection using GNSS receiver

e) Jammer detection and location using cell-phone crowd-sourcings

a) Fixed GNSS RFI monitoring

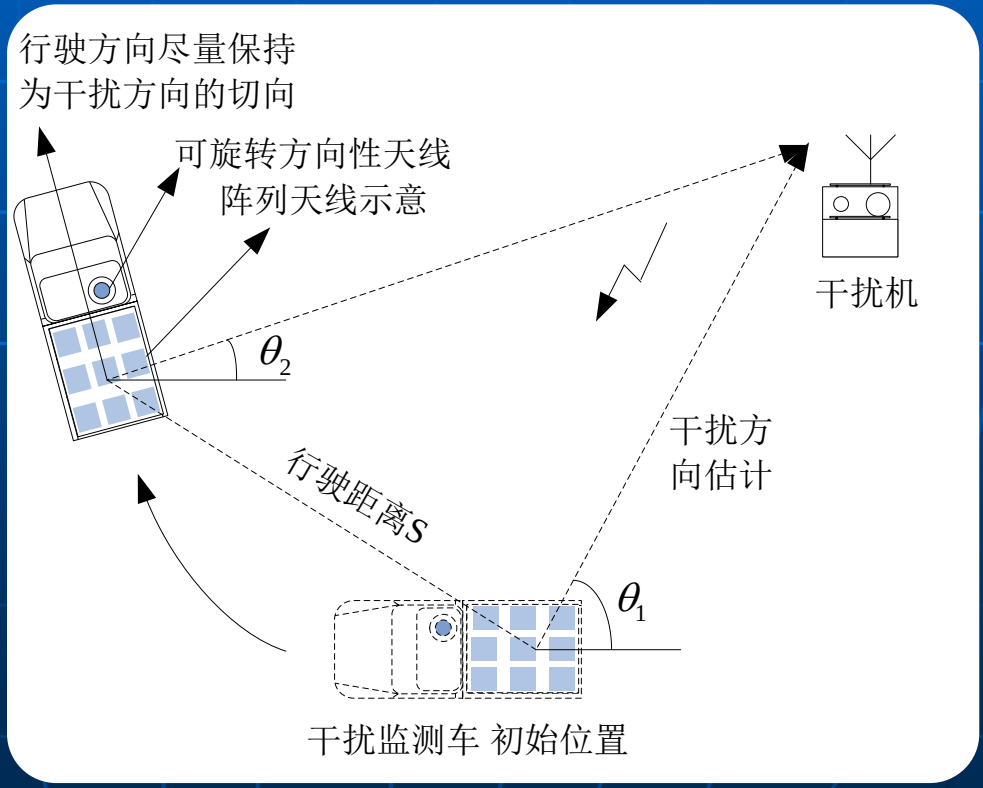
- **Spectrum monitoring: monitor GNSS spectrum with high sensitivity, measure parameters of**
- **Direction finding of RFI source： spatial spectrum**



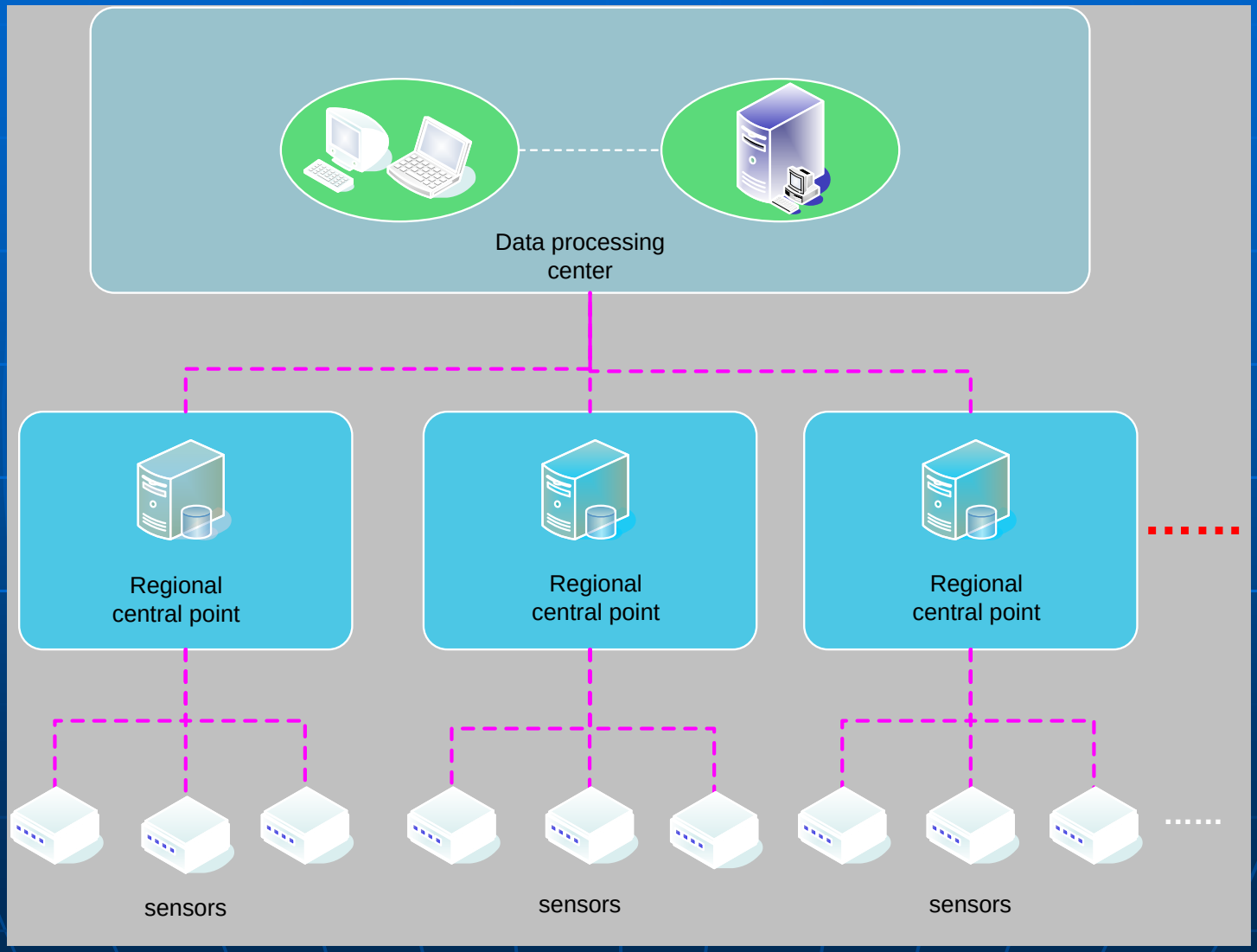


b) Movable GNSS RFI source location

- **Location of fixed GNSS RFI sources by using single movable vehicle.**
- **Location of GNSS RFI sources by using two or more movable vehicles.**



c) GNSS RFI monitoring and location using gridding network of sensors



system structure diagram

c) GNSS RFI monitoring and location using gridding network of sensors

Main function and characteristics:

- **measurements of frequency, power level, bandwidth, code rate etc.**
- **fast wideband spectrum scanning and spectrum occupancy**
- **measuring of multi stations, combined TDOA/POA location**
- **sensor : small size, light weight, unattended operation, convenient for management**

antennna

sensor

d) RFI detection using GNSS receiver

- ***When interfered, significant change appears on C/No, AGC, and received power of signal.***
- ***Interference can be detected by comprehensive monitoring and analysis of the info.***

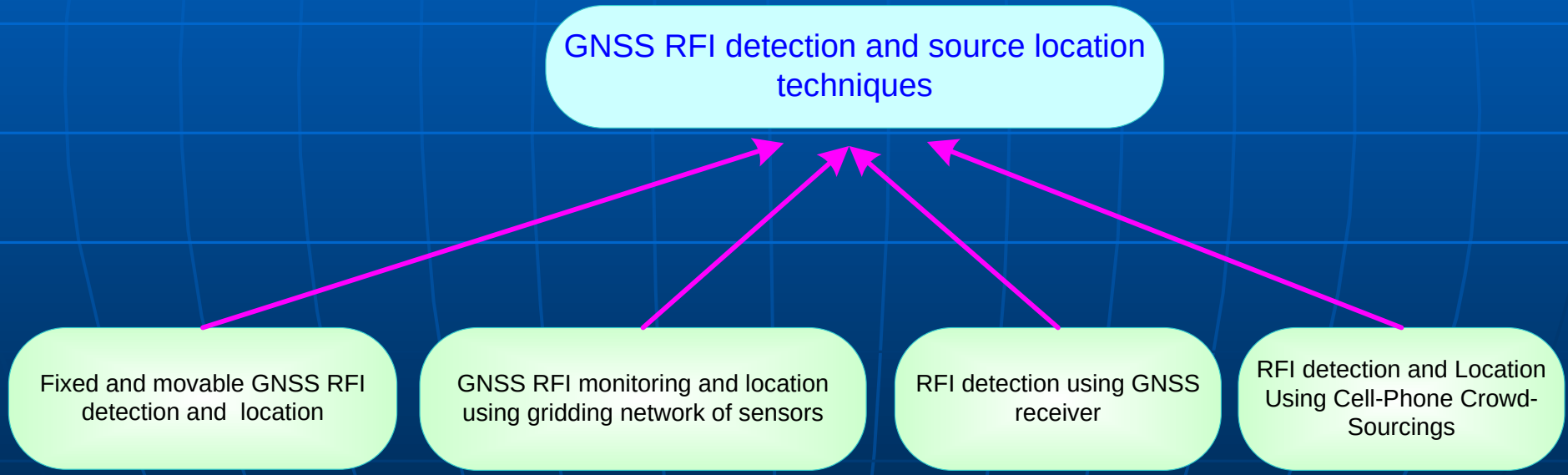
e) GNSS RFI detection and Location Using Cell-Phone Crowd-Sourcings

- ***Conceptually, phones located closer to the jamming source will see higher J/N than those further away.***
- ***The aggregate of phones, each reporting J/N and own position, provides a basis for locating the jammer. Some phones may also report the type of jammer they are seeing.***
- ***The data center can located RFI according to info from cell phones.***

Two or more detection technologies used together

- *For different cases, different techniques can be chosen for RFI detection and location.*
- *Generally one technique is used during the process.*
- *Yet RFI detection and location by using only one technique may cause uncertainty and range restriction. Two or more detection technologies may be necessary for RFI location.*

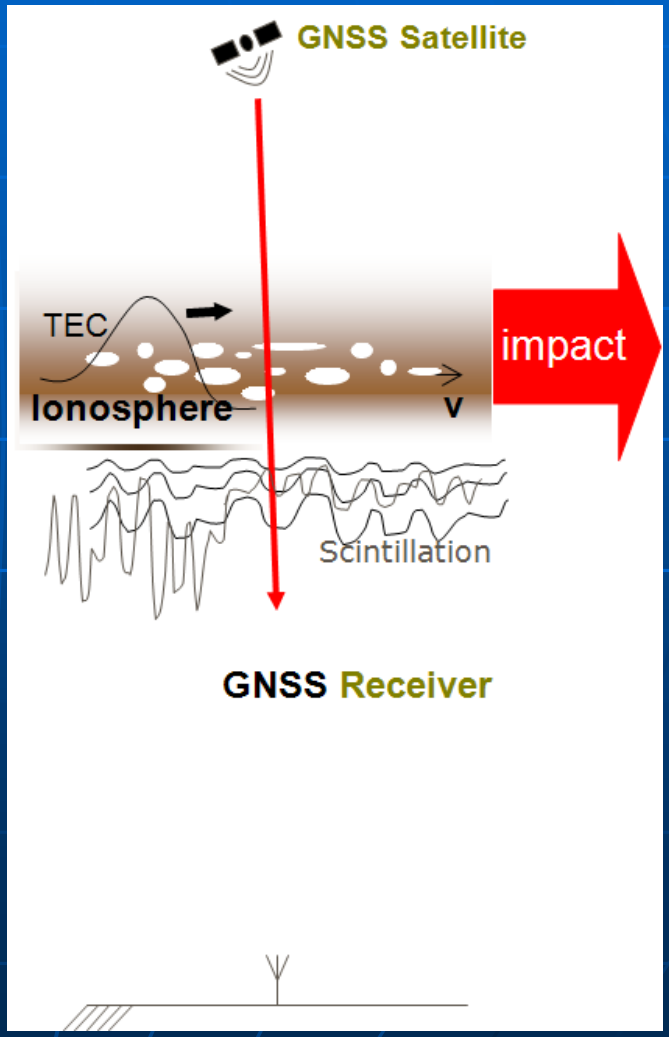
- ***Comprehensive processing of information from multi technologies:***
  - ***Extend spatial and temporal coverage,***
  - ***Improve spatial resolution and measurement dimension***
  - ***Improve system reliability***



3. Natural ionospheric disturbance

GNSS signal interference is also caused by ionospheric disturbances in Earth's environment.

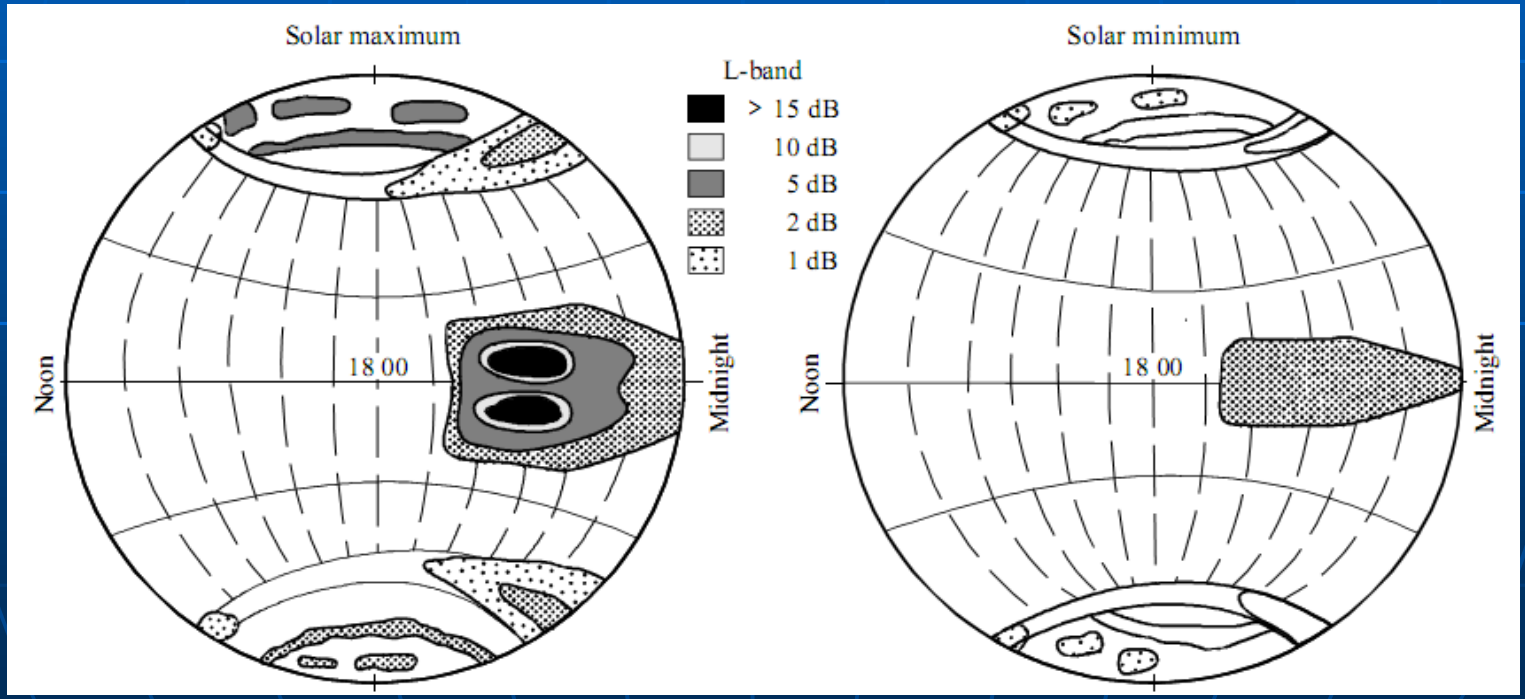
- *Ionospheric Scintillation*
- *Variations in Total Electron Content*



Ionospheric Effects on GNSS

Ionospheric scintillation

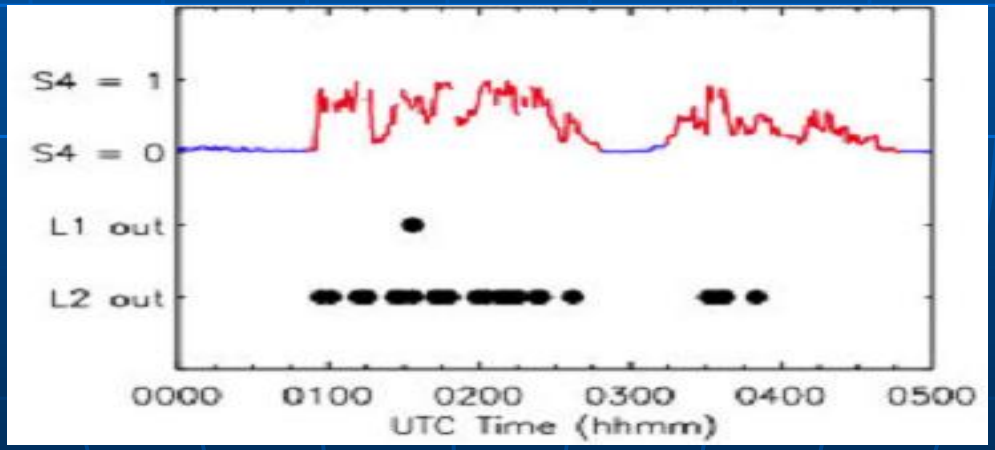
- Ionospheric scintillation can be monitored by using GNSS signals.
- Severe in the low latitude, strong in high latitude, moderate in mid latitude.



Depth of scintillation fading (proportional to density of cross-hatching) at L-band during solar maximum and minimum years [Rec. ITU-R P.531-7]

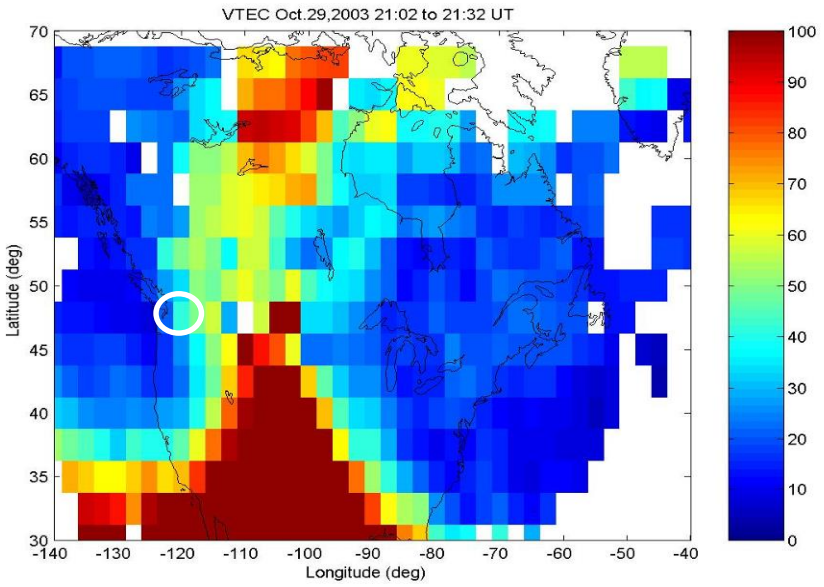
Ionospheric scintillation

- ***Ionospheric scintillation will cause increasing of the tracking loop error as the carrier phase noise ratio decrease.***
- ***Ionospheric scintillation will cause dramatic decrease of GNSS positioning accuracy, and even loss of lock.***
- ***Not only accuracy, also effects on integrity and continuity in regional.***

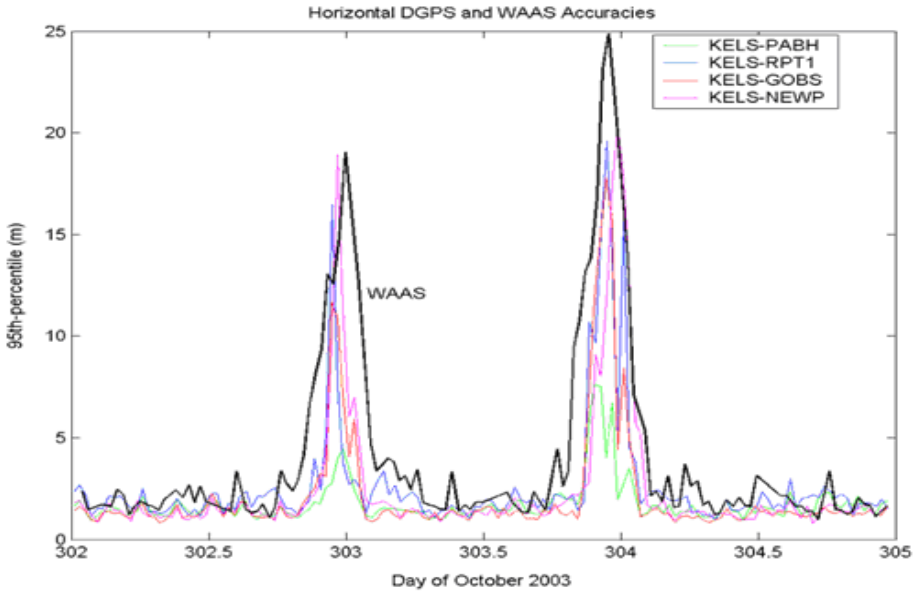


Scintillation induced loss of lock [Ref From: Robert S. Conker，2000]

- ***Variation in TEC induced delay effect on GNSS, which may also lead to great error of positioning on GNSS user.***



TEC Map [From S. Skone，2010]



Horizontal Position Errors [From S. Skone，2010]

Technology for ionospheric disturbance

- ***Detection of ionospheric disturbance***
- ***Mitigation of ionospheric disturbance***
  - **Development and improvement of GNSS receiving technology based on the analysis of ionospheric effects;**
  - **Development of Ionospheric forecast model.**

Thank you for your attention!

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