Training on EGNOS-GNSS in Africa (TREGA)

A project implemented by ICTP

Funded by the European Union

S.M Radicella, X.Otero Villamide, O.E.Abe, H.Ngaya, C.Paparini

Presented by Claudia Paparini

African School on Space Science: Related Applications and Awareness for Sustainable Development of the Region

Kigali, Rwanda – 10 July 2014

EC Contribution Agreement with ICTP
TREGA Project

The **European Commission** has signed a *Contribution Agreement* with the **International Center for Theoretical Physics** to carry out the project **TRaining on EGNOS-GNSS in Africa (TREGA)** aimed to provide technical assistance, capacity building and provision and use of a test/simulation platform for the implementation of GNSS/EGNOS in Sub-Saharan Africa.

In the Appropriateness of ICTP note that justified the EC assignment to ICTP it is written:
"The specific knowledge of the institute, and its experience in training people from developing countries, put this organization in a unique position for the participation in the project." …**"It has also organized in the past a series of Workshops on Satellite Navigation Science and Technology for Africa... The focus of the training has been to provide education to African university professors and graduate students on the use of Global Navigation Satellite Systems (GNSS) for social and economic development in Africa.**"

TREGA objectives

- To provide **training** to members of the **EGNOS-Africa Joint Programme Office** on different GNSS and EGNOS technologies, service provision and applied legal and regulatory matters.

- To select, procure and use a simulation/testing platform as a preliminary backbone infrastructure for SBAS services in Sub-Saharan Africa.

- To train a core number of African professionals to face technical problems related to the conditions of Sub-Saharan Africa, making use of the simulation/testing platform. (**training through research)**

TREGA strategy

1. Intensive all-included training of the core team of the Office concentrated in two sessions.
2. Extensive (22 months) high-level technical training of two African experts and a European professionals with the utilization of the simulation/testing platform acquired by the Project. (*Note that the platform would be transferred finally to the African continent*)

Intensive all-included training

The intensive all-included training has been concentrated in two sessions to be carried out at ICTP in Trieste during 2013 and 2014

- The first session was dedicated to Space projects management and Legal/regulatory Aspects on 15 July 2013 lasting 3 (three) weeks plus two Seminar days.

- The second session was dedicated to GNSS Systems and Applications and Service Provision, User Support and Promotion of EGNOS use in Africa. It has been carried out from 20 January to 14 March, lasting 8 (eight) weeks, including stages of the trainees in European Institutions.

Collaborating Istitutions: **Istituto Superiore Mario Boella** of Turin, Italy and **Pildo Labs.** of Barcelona, Spain

Extensive technical training: TRAINEES

The trainees have been identified and they have been hired through Special Services Agreements. The persons selected are:

Herbert NGAYA, ASECNA

Emmanuel Oladipo ABE, Federal University, Oye, Nigeria and research associate at NASRDA's Centre for Atmospheric Research

Claudia PAPARINI, ICTP and University of Trieste

The trainees started their activities in October 2013 with a training on the use of the **simulation/testing platform.**

The ICTP project team includes a technical expert, **Xurxo Otero VIllamide** (in charge of the TREGA Laboratory), contracted by ICTP for the TREGA project through a Project Contract. Furthermore he is giving intensive training for the three professionals.

The “specific condition” of Sub -Saharan Africa

From ICAO: IONOSPHERIC EFFECT ON GNSS AVIATION OPERATIONS, First Meeting of Ionospheric Studies Task Force, Tokyo, February 2012

“For APV [Approach Procedures with Vertical Guidance]operations, ionospheric delay corrections and associated integrity bounds must be obtained from a SBAS. SBAS is capable of broadcasting ionospheric integrity bounds that are sufficiently small to ensure a high availability of APV service in mid- and high-latitude regions. However, the availability of APV service may be reduced or even severely limited in relatively rare occasions (roughly 1% of the time) due to disturbances caused by a severe ionospheric storm.”

What’s magicSBAS?

magicSBAS is a multi-constellation SBAS demonstrator (GPS and GLONASS) which:

- collects data (measurements and ephemeris) from reference stations (already existing or specifically deployed) in different formats (NTRIP, RINEX, …),

- computes all necessary SBAS information (ionosphere, SV orbits and clocks, integrity…) and

- broadcasts the SBAS messages to the final user in different formats (SISNET, RTCA, RTCM…). ***magicSBAS*** can be run both in real-time (RT) or in post-processing fast mode (PS).

GMV magicSBAS **VERSION ACQUIRED**

- ***magicSBAS-RT*** is the real time version of *magicSBAS*: This version of magicSBAS can be used to provide an early pre-operational SBAS service that could be used for non-safety critical applications like mapping, precision agriculture or multi-modal transport.

- ***magicSBAS-PS*** is the fast post-processing replay version of *magicSBAS*: This version of *magicSBAS* is the ideal tool to support SBAS engineering and feasibility studies, where pre-stored scenarios are processed and the user expects fast execution.

  In addition a **Raw Data Generation Tool (EETES)** with Ionospheric Model Simulation Capabilities license is being included in the acquired platform.

  The platform has been installed in Trieste 3rd October 2013 and has already been used by the long term trainees.

Generation of RINEX Raw Data
EETES Step-by-Step Procedure

Platform: *GMV EETES* (EGNOS End-To-End Simulator). Raw data emulator able to simulate multifrequency and multiconstellation measurements and navigation messages (GPS / GLONASS / Galileo / Compass / GEO)

Definition of stations:
- Location (station coordinates, dreciever dynamics)
- Receiver channels per constellation
- Elevation
- Signal-to-noise masks

Error generator:

- Space Dynamics (Satellite Orbits and Earth rotation parameters simulated according to IERS 1995)

- Clocks constructed from Constant Offset, drifts and random walk components

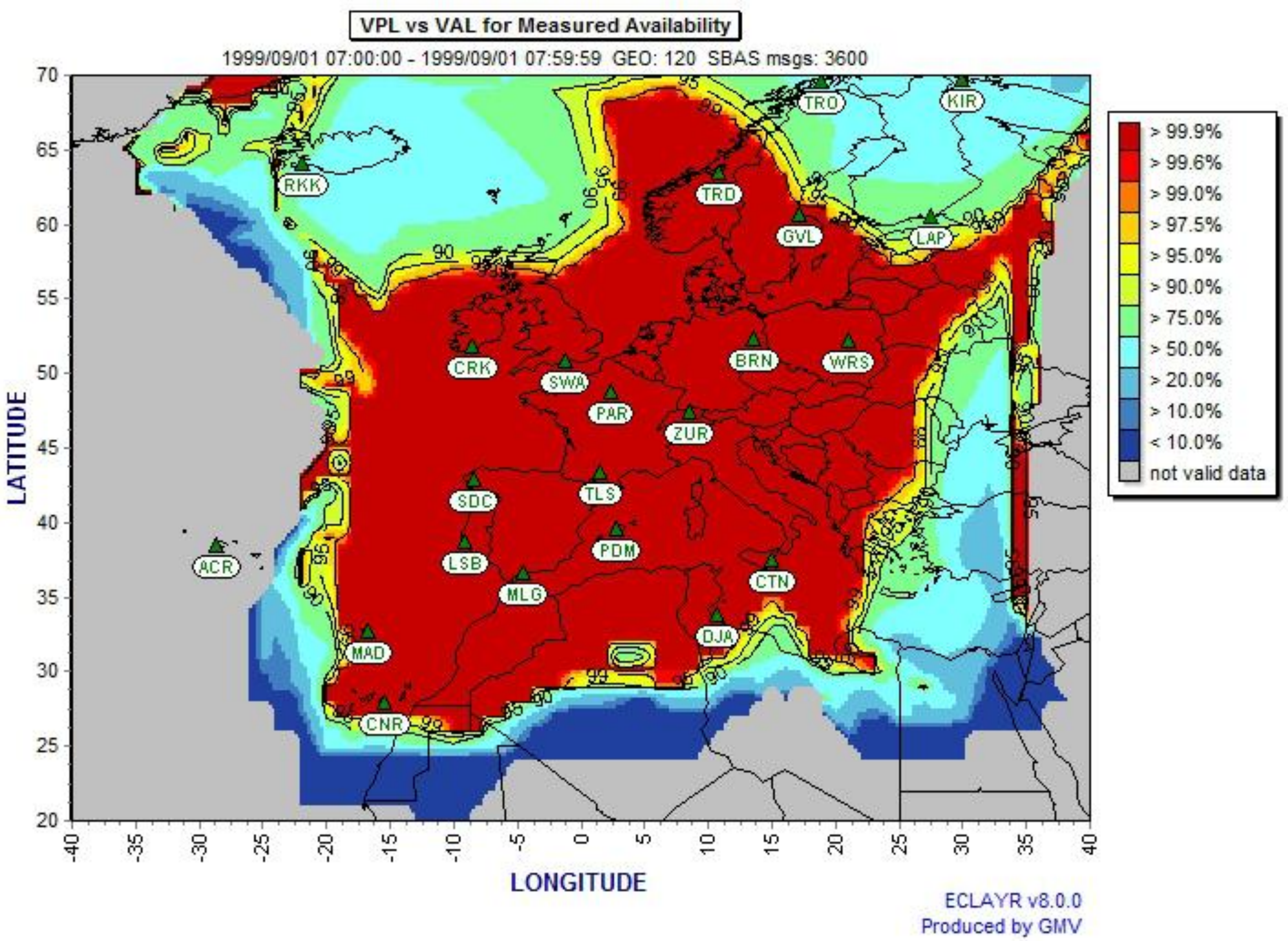
- Signal in Space:
  - Tropospheric delay (Hopfield model with standard pressure and temperature distribution)
  - Ionospheric delay (**NeQuick model** - Di Giovanni, G. and Radicella, S. M., 1990. An analytical model of the electron density profile in the ionosphere. Advances in Space Research)

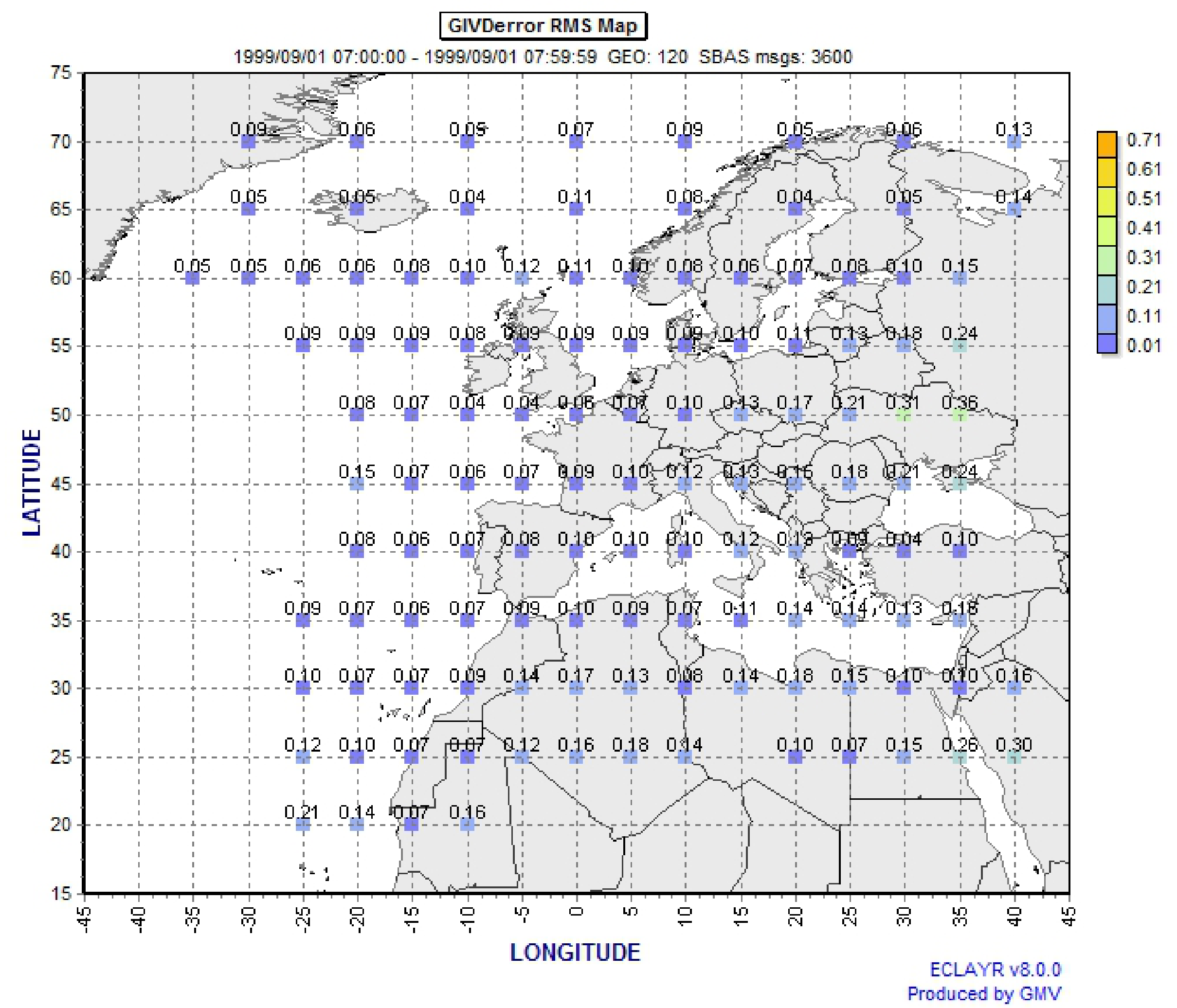
Local effects: Interference and Multipath

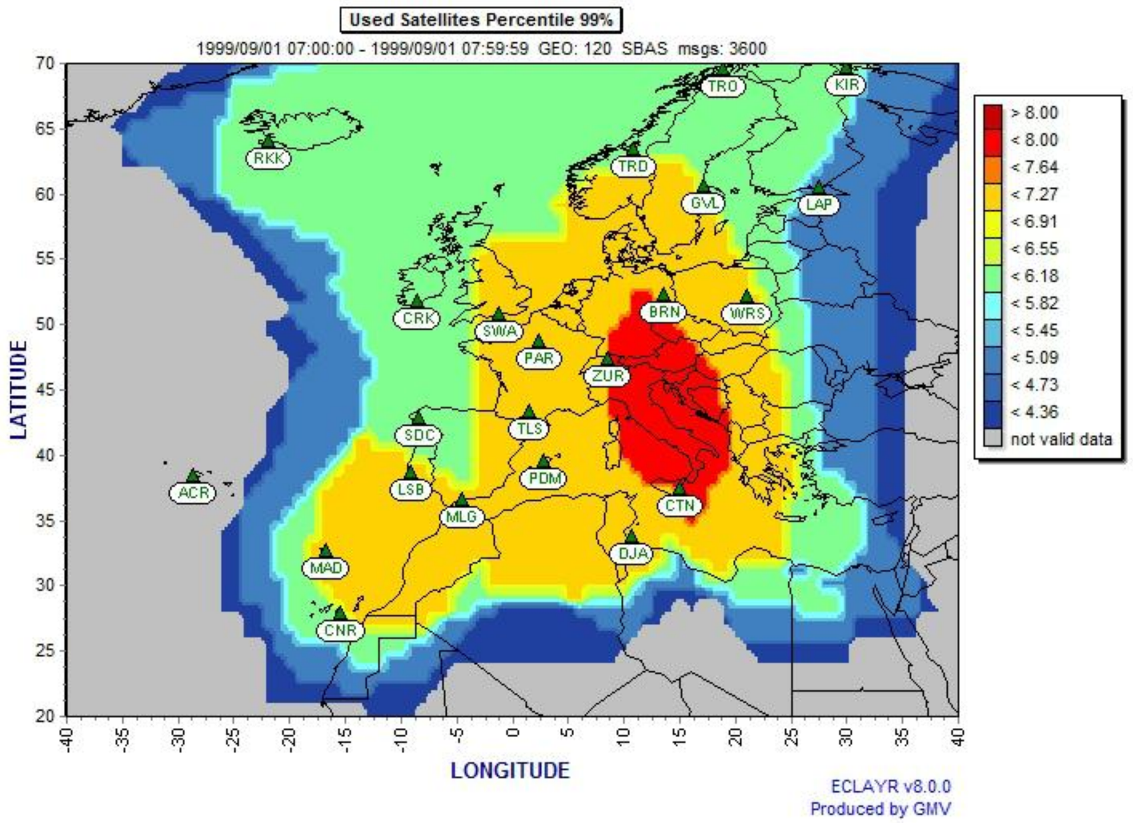
Receiver effects: Noise, cycle slips and hardware biases

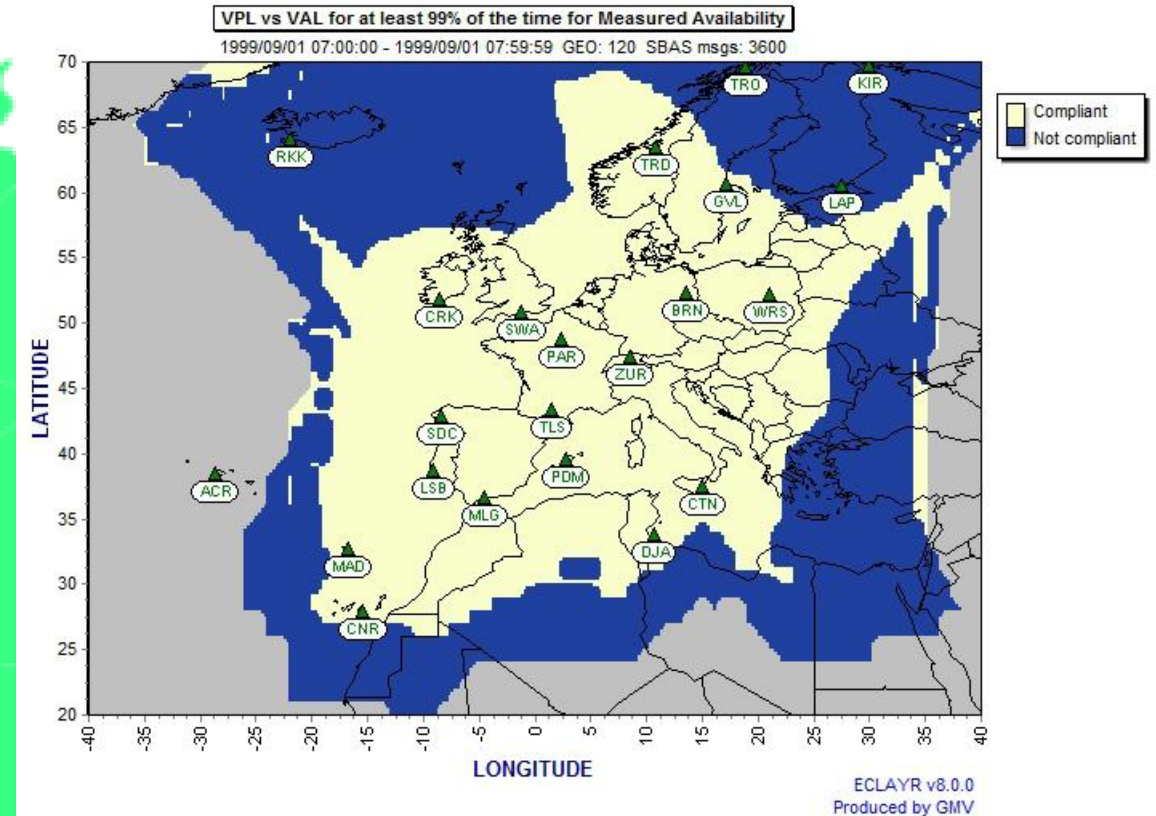
ECLAYR

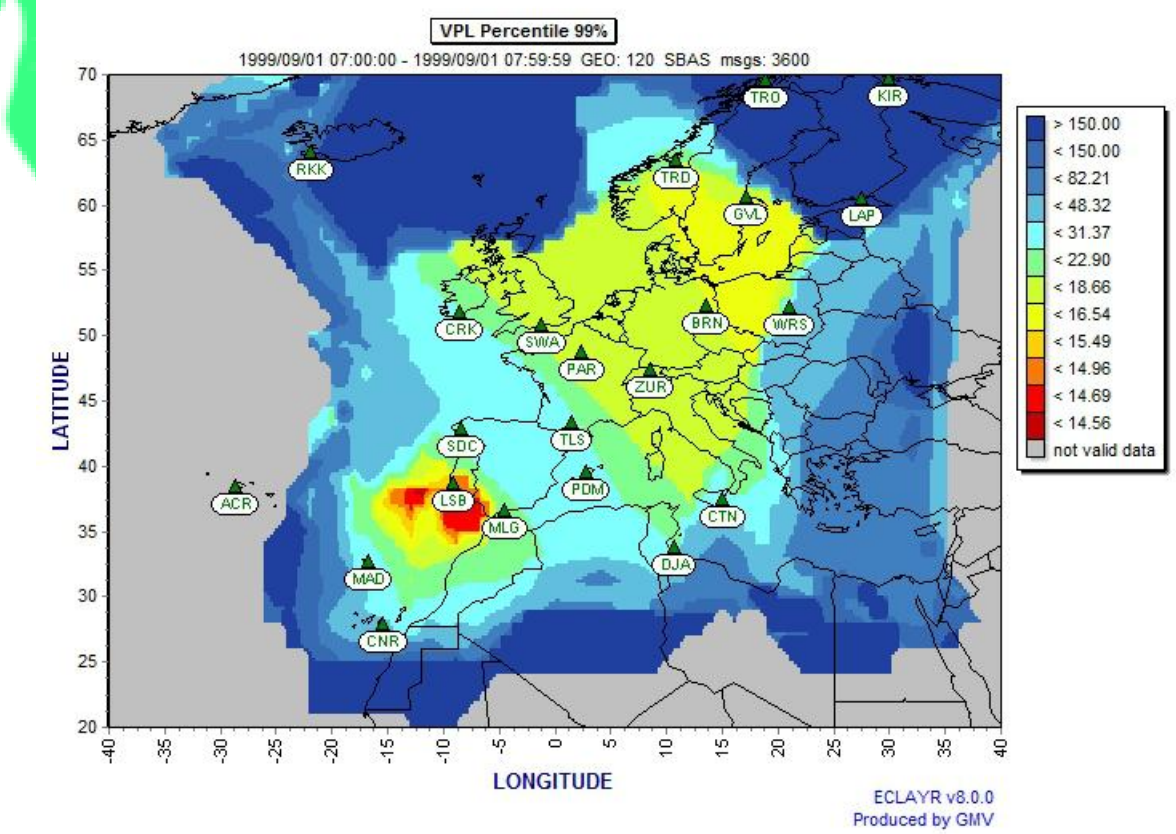
Assessment of SBAS messages compliance with respect to MOPS standards (performance check)





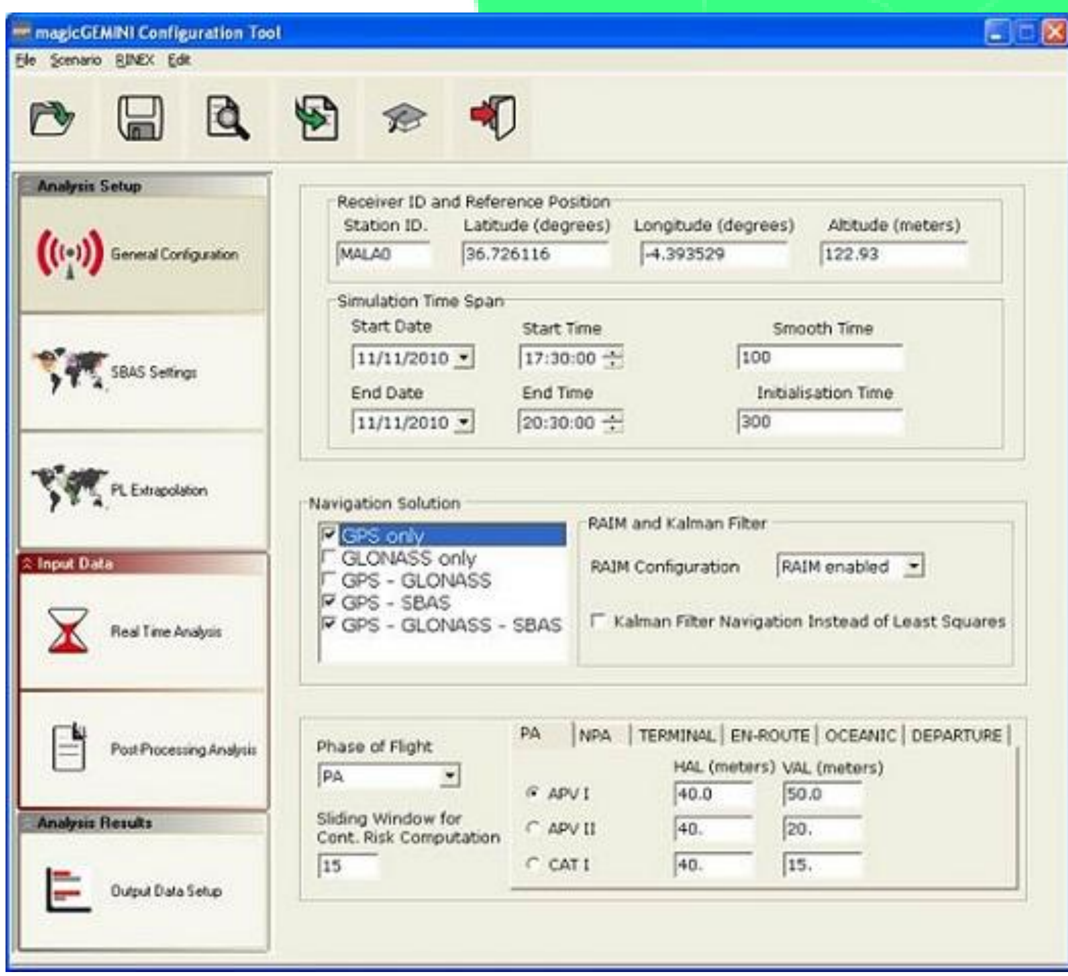

Used Satellites Percentile 99%
1999/09/01 07:00:00 - 1999/09/01 07:59:59 GEO: 120 SBAS msgs: 3600
> 8.00
< 8.00
< 7.64
< 7.27
< 6.91
< 6.55
< 6.18
< 5.82
< 5.45
< 5.09
< 4.73
< 4.36
not valid data
RKK
TRO
KIR
TRD
GVL
LAP
CRK
SWA
BRN
WRS
PAR
ZUR
SDC
TLS
ACR
LSB
PDM
MLG
CTN
MAD
DJA
CNR
LATITUDE
LONGITUDE
ECLAYR v8.0.0
Produced by GMV

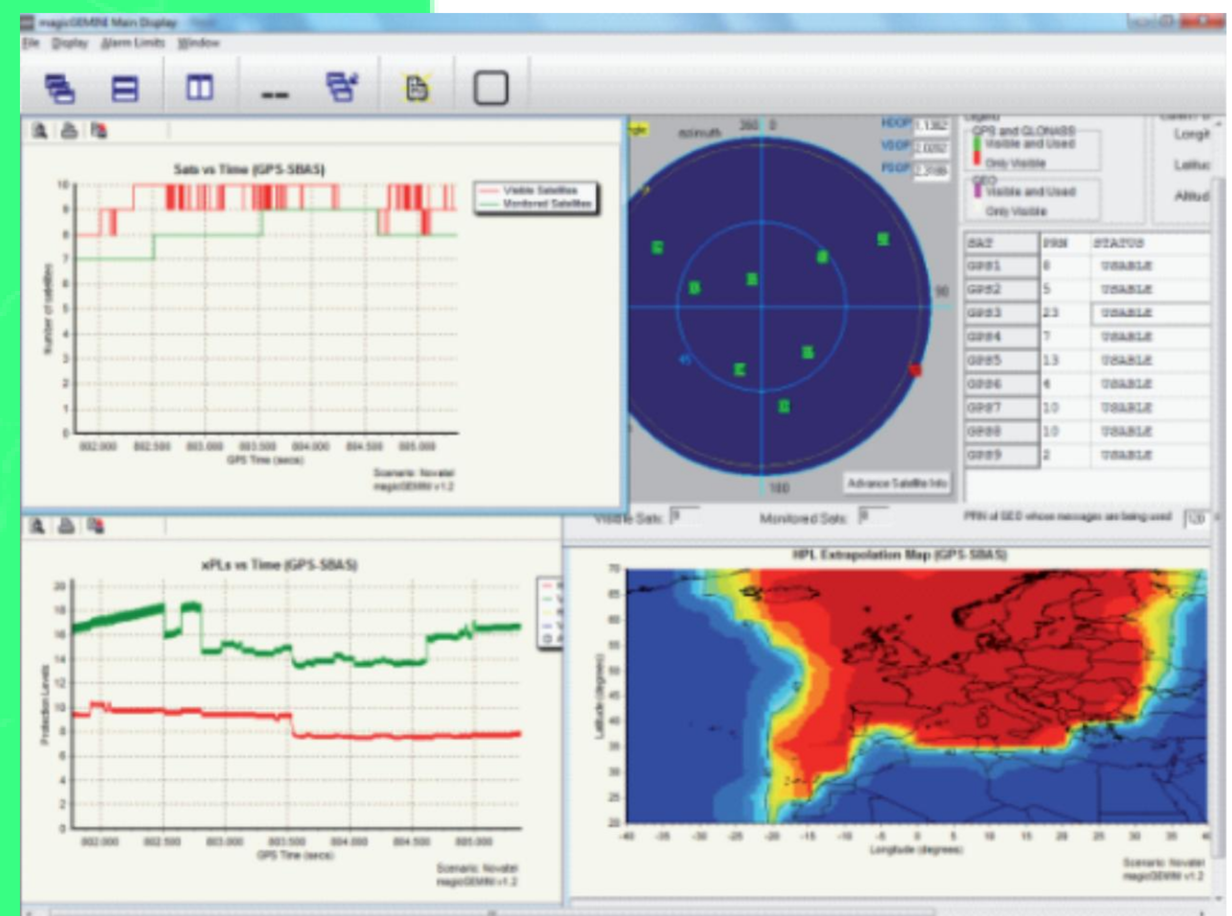

VPL vs VAL for at least 99% of the time for Measured Availability
1999/09/01 07:00:00 - 1999/09/01 07:59:59 GEO: 120 SBAS msgs: 3600
Compliant
Not compliant
LATITUDE
LONGITUDE
ECLAYR v8.0.0
Produced by GMV


VPL Percentile 99%
1999/09/01 07:00:00 - 1999/09/01 07:59:59 GEO: 120 SBAS msgs: 3600
> 150.00
< 150.00
< 82.21
< 48.32
< 31.37
< 22.90
< 18.66
< 16.54
< 15.49
< 14.96
< 14.69
< 14.56
not valid data
LATITUDE
LONGITUDE
ECLAYR v8.0.0
Produced by GMV

magicGEMINI

Real-time or off-line multi-constellation, multi-frequency receiver emulator





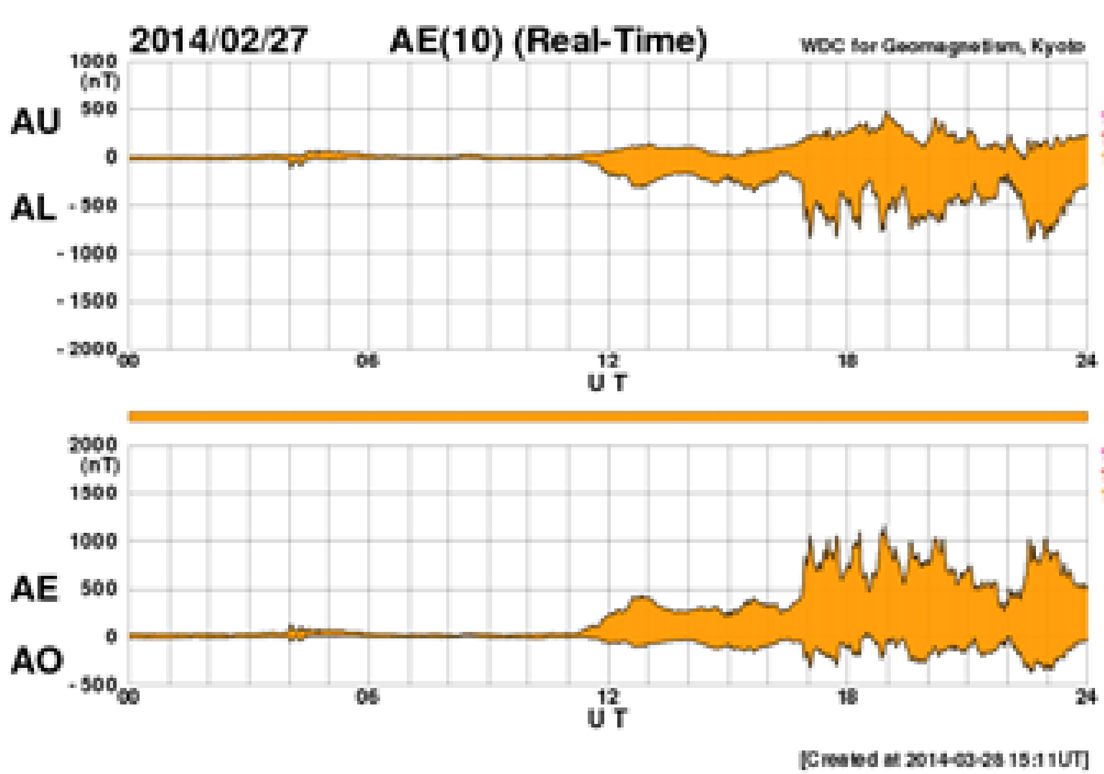
Analysis performed with magicSBAS Platform

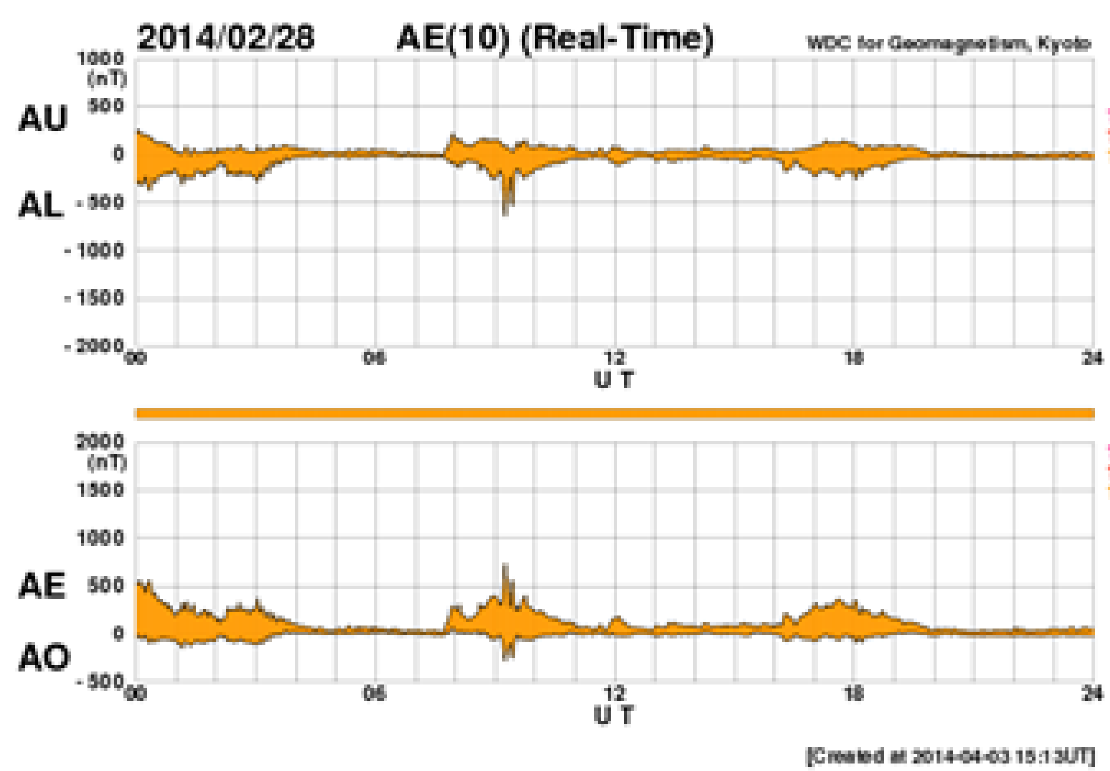
• Evaluation of EGNOS system performances for some specific days of February and March 2014 that experiment space weather events.

• Generation of RINEX files for different locations in Europe and Africa in order to simulate a SBAS system

• Simulation of EGNOS system performance for standard and extended ECAC area

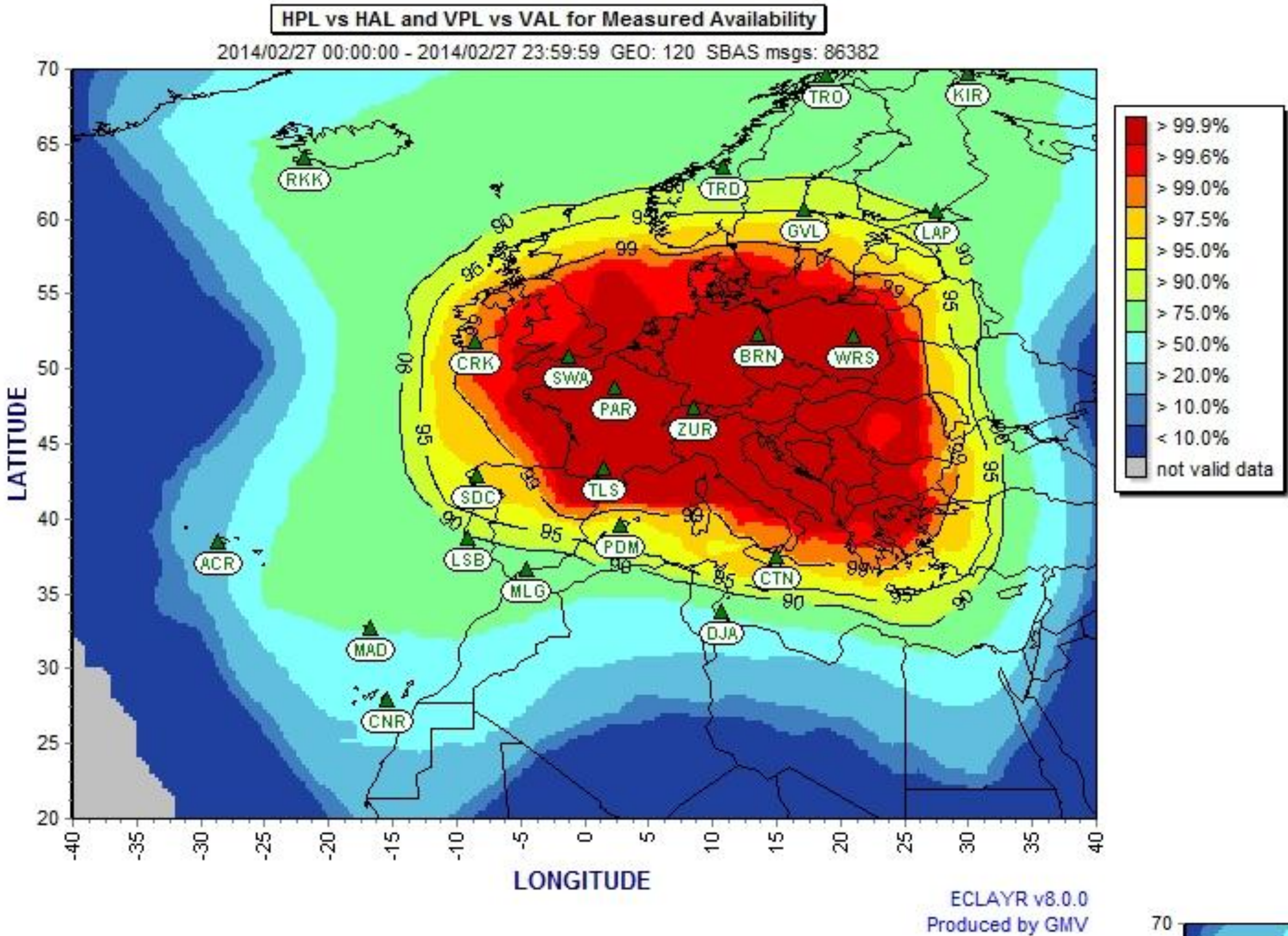
Geomagnetic indices February 2014





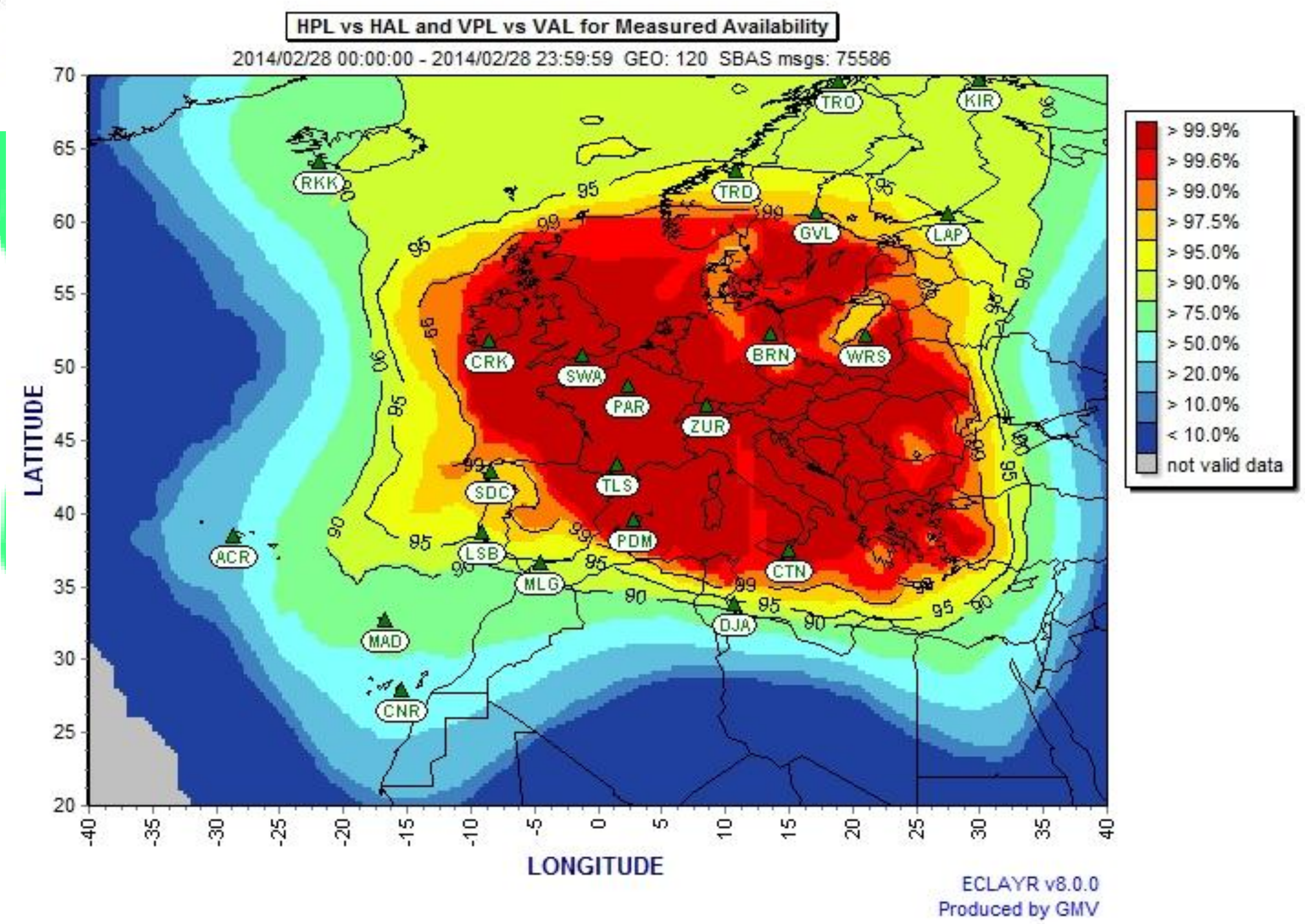
27 February 2014

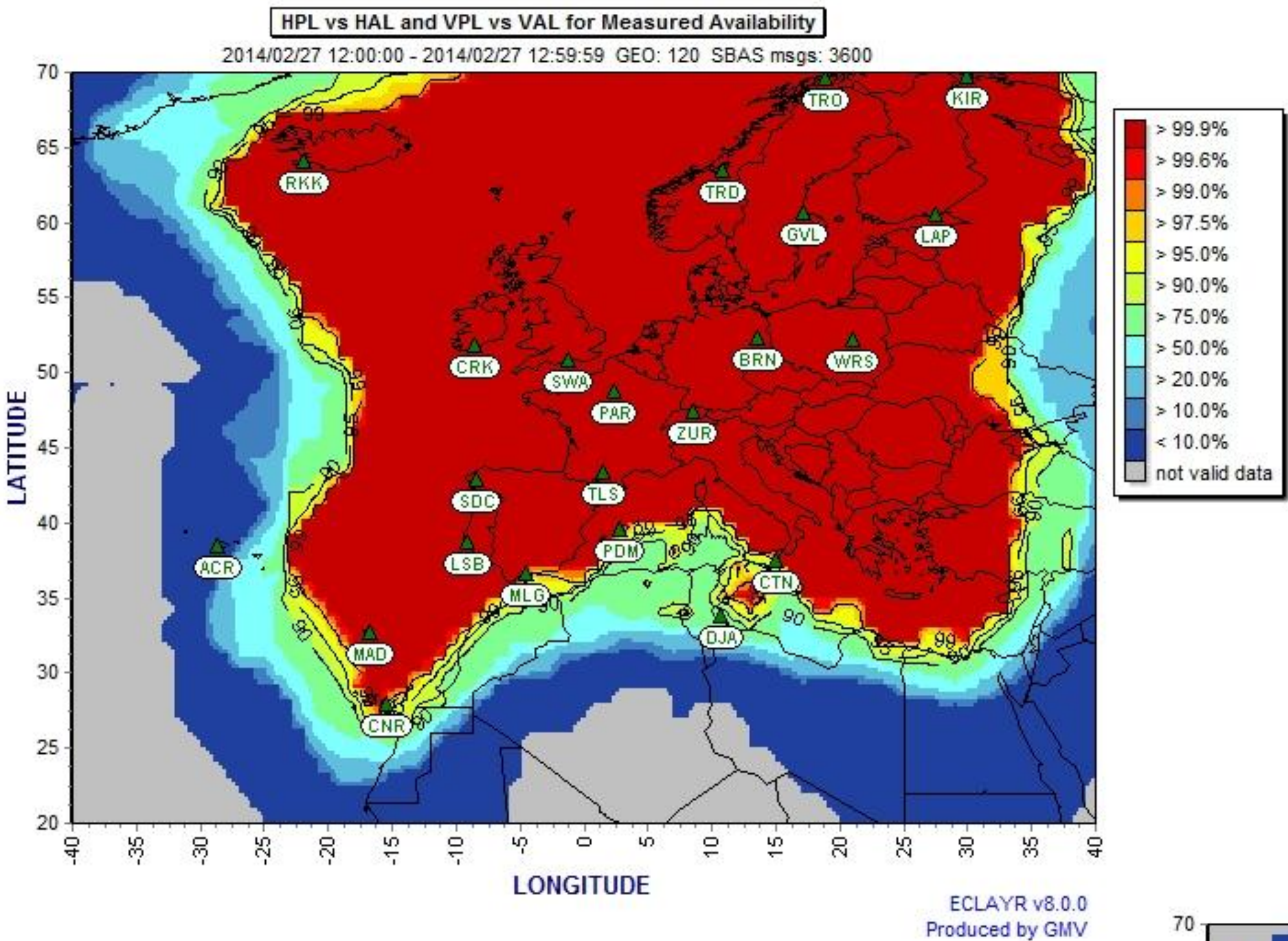
00:00:00 – 23:59:59



28 February 2014

00:00:00 – 23:59:59



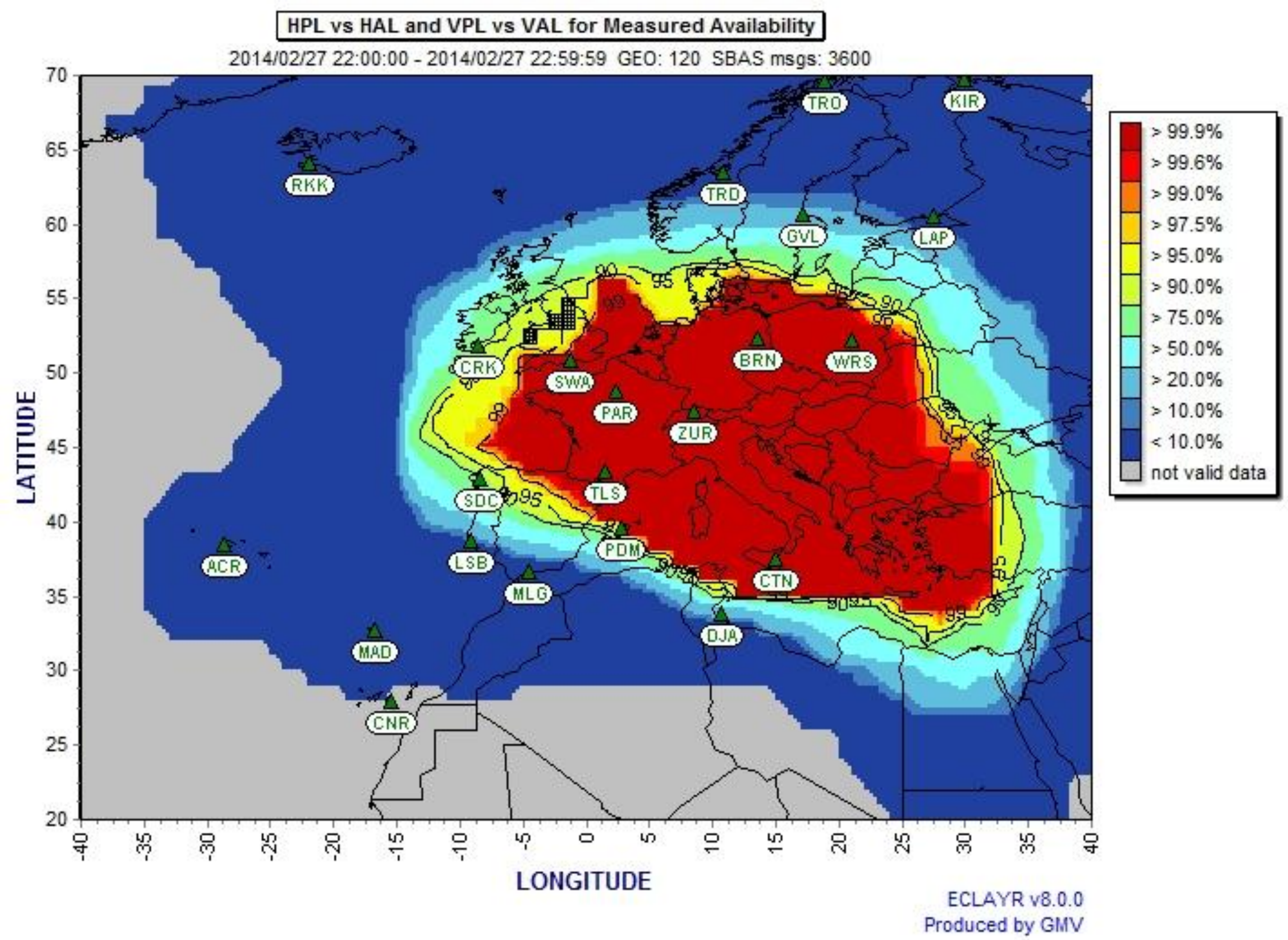


27 February 2014

12:00:00 – 12:59:59

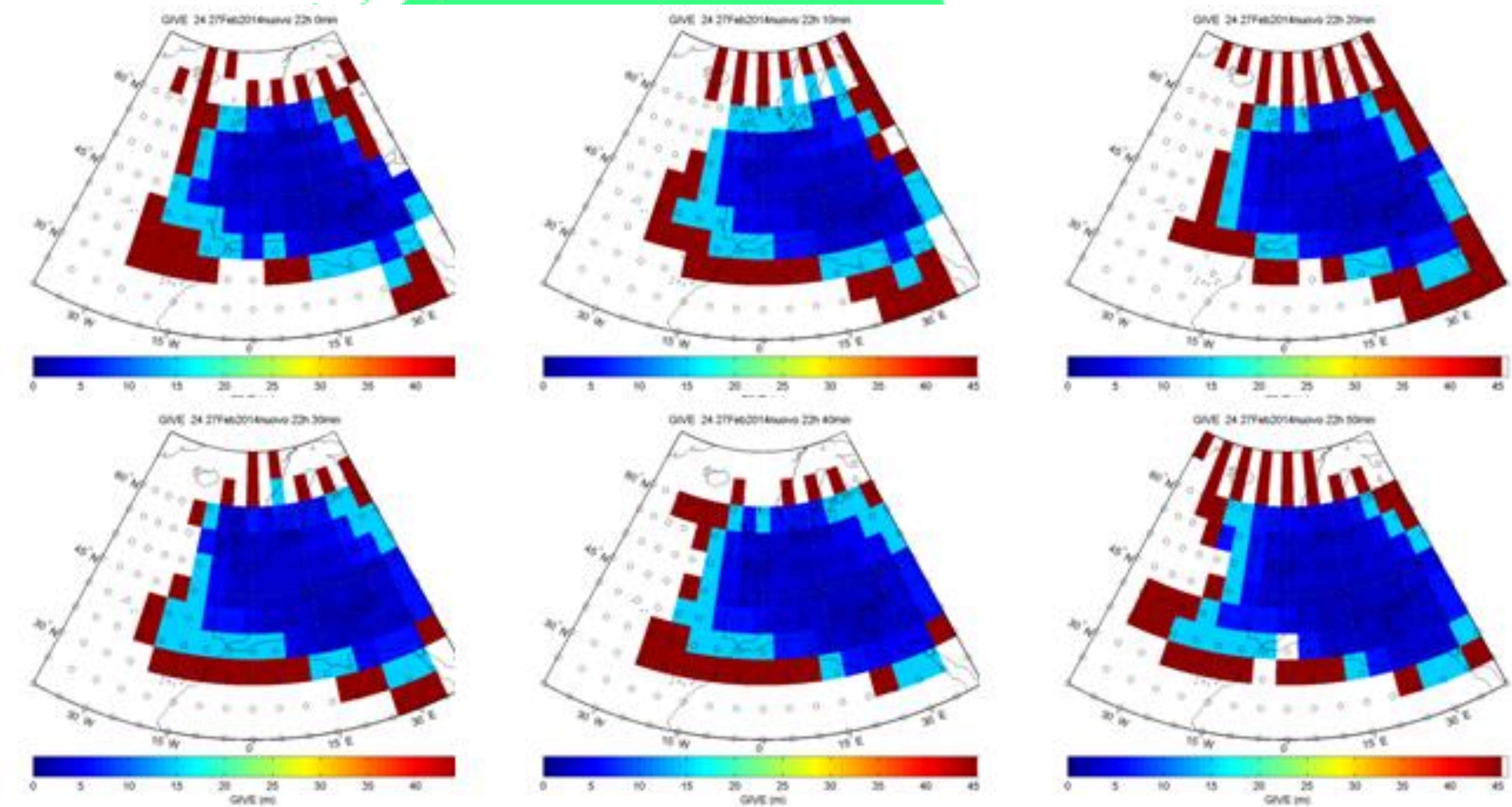
27 February 2014

23:00:00 – 23:59:59

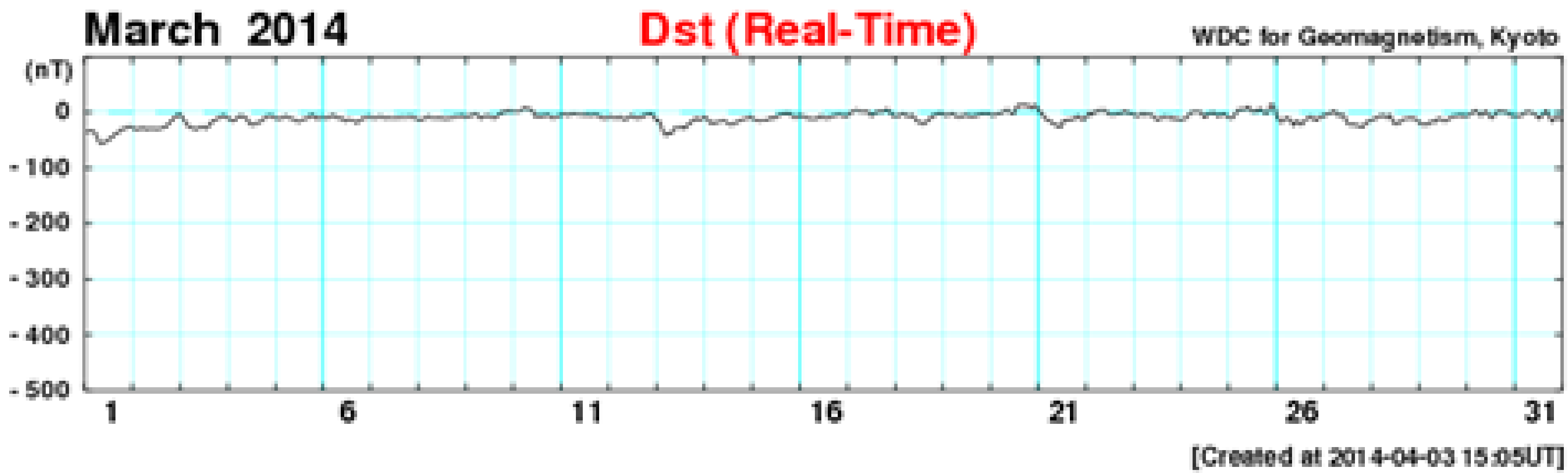


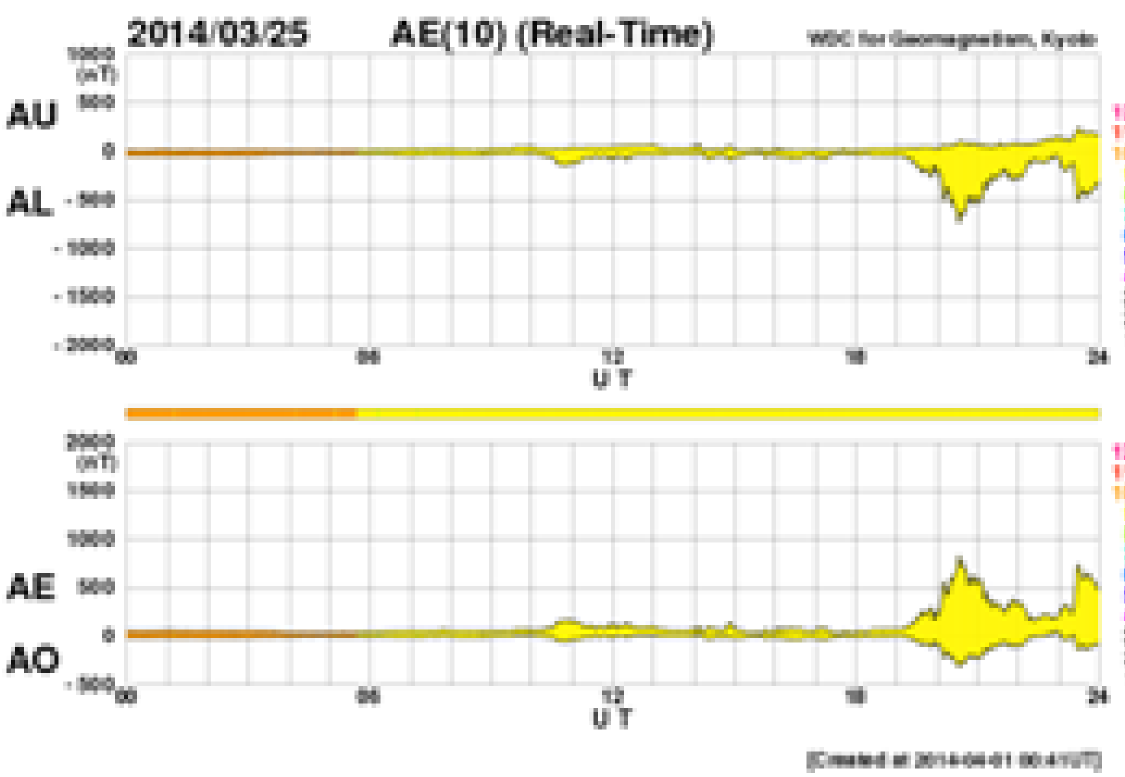
Analysis of GIVE during degradation on 27 February

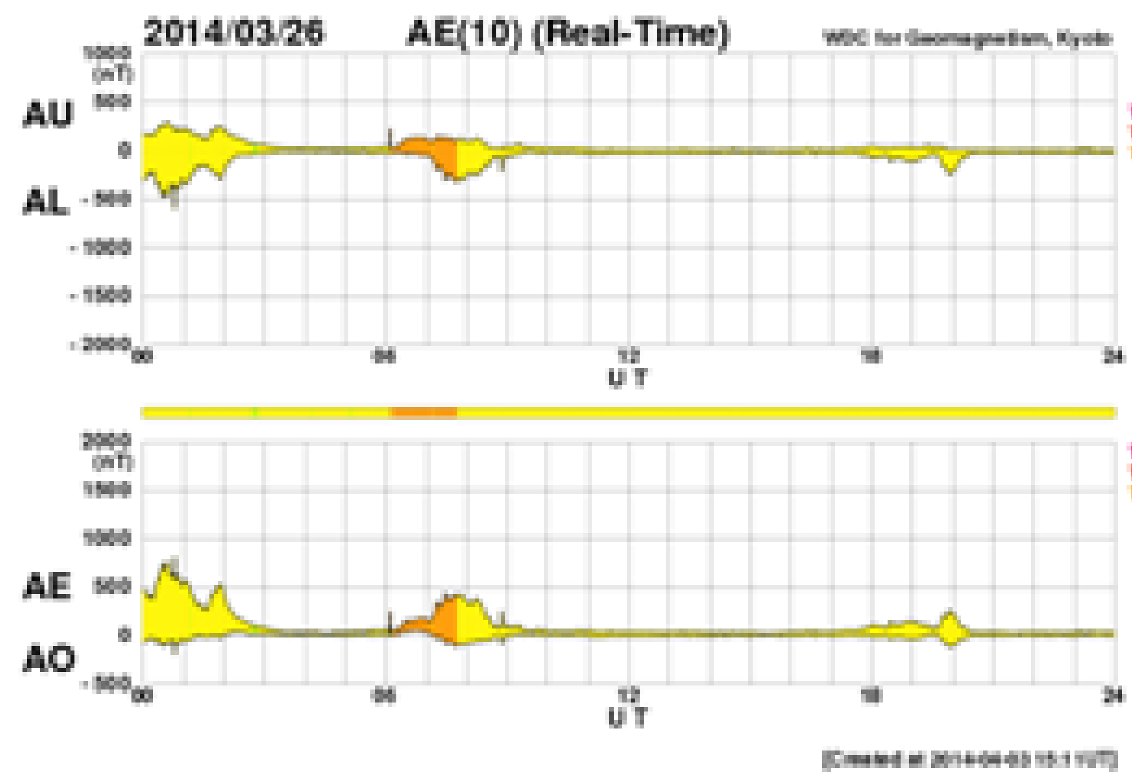
Example 22 h – 23 h, maps every 15 minutes



Geomagnetic indices March 2014

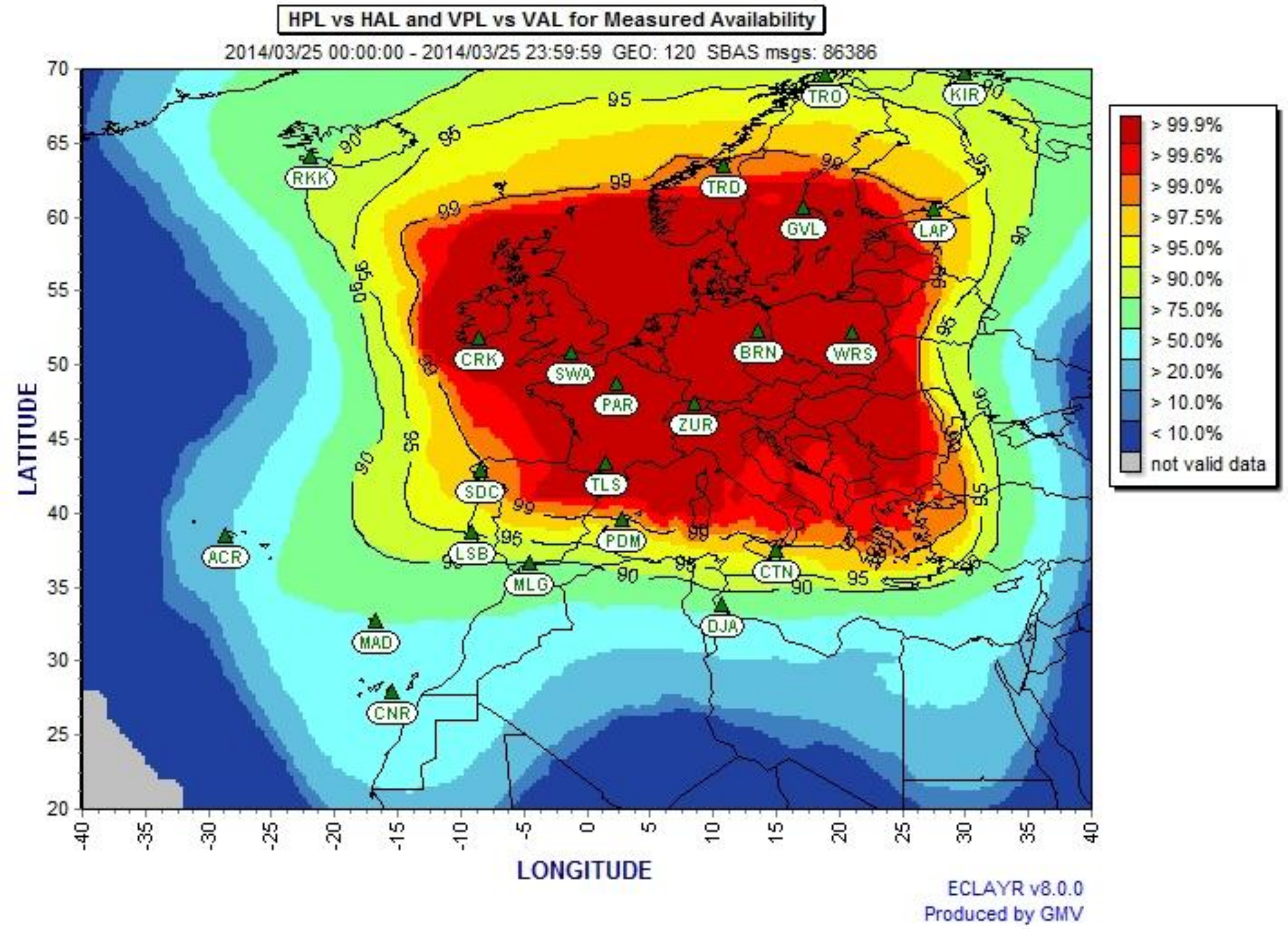


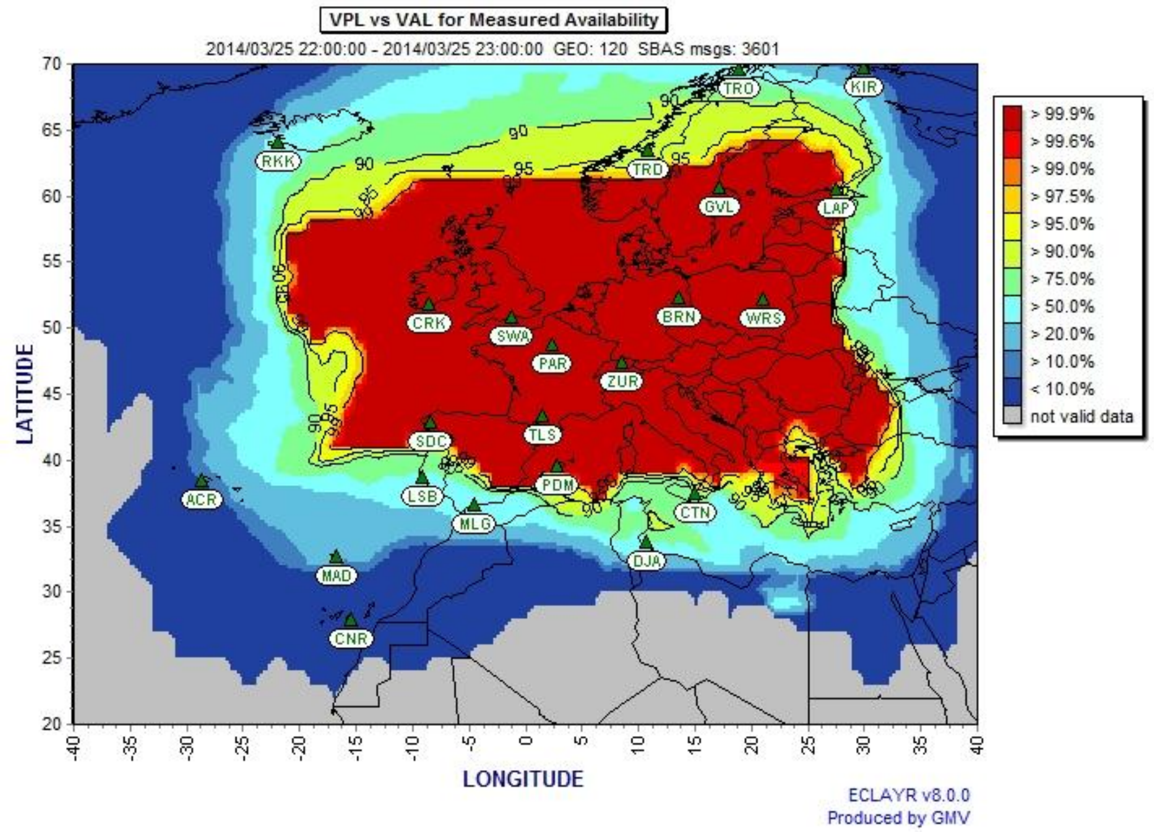




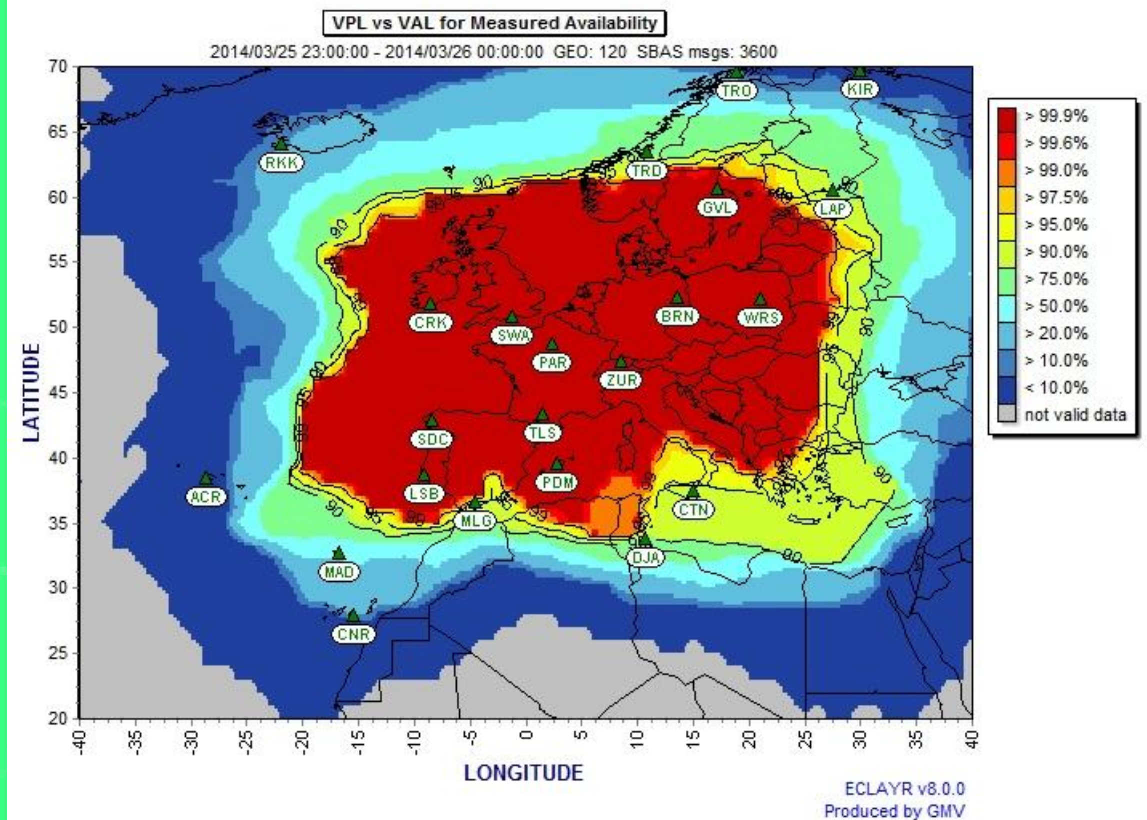
25 March 2014

00:00:00 – 23:59:59





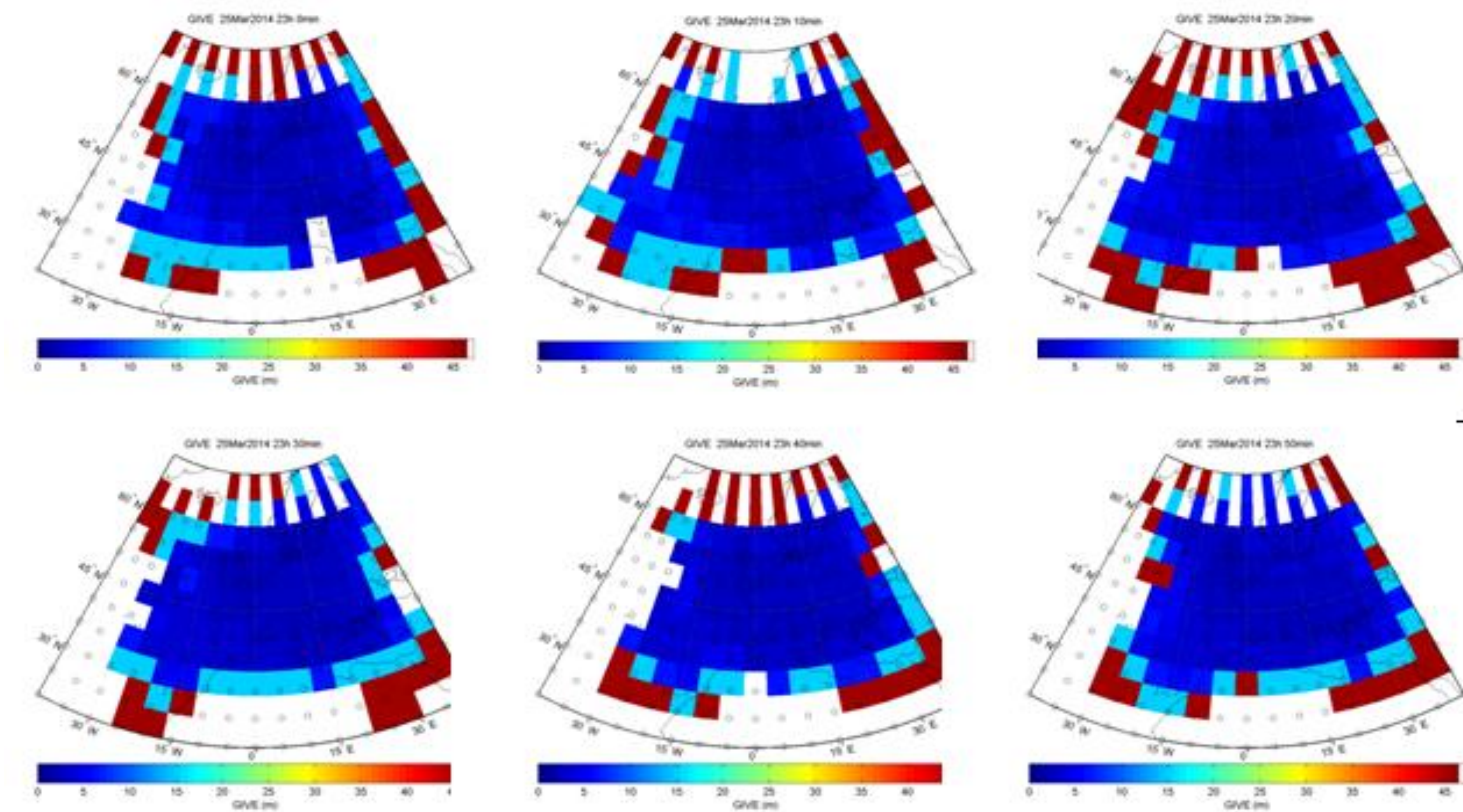
25 March 2014 22:00:00 – 22:59:59



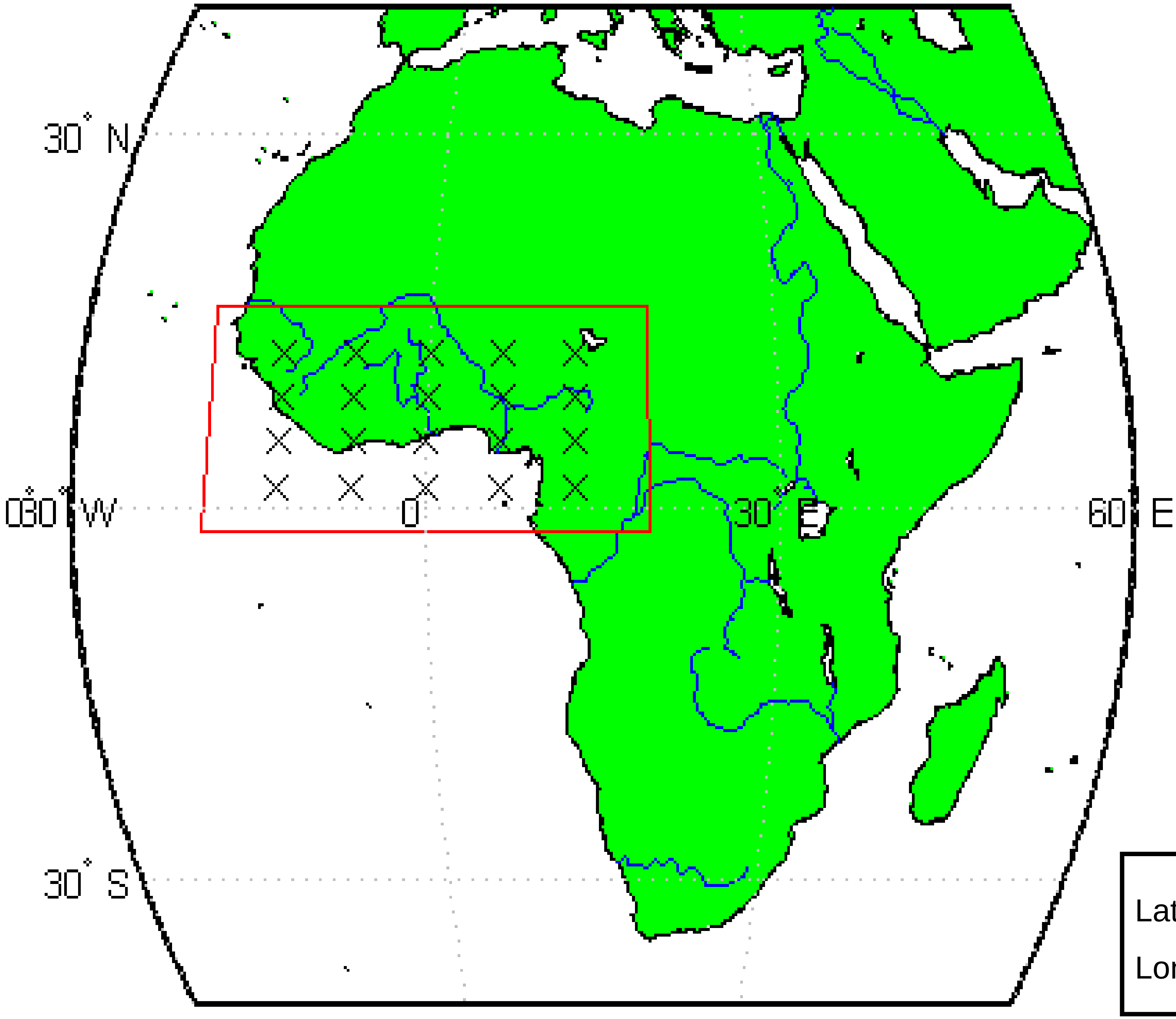
25 March 2014 23:00:00 – 23:59:59

Analysis of GIVE during degradation on 25 February

Example 23 h – 24 h, maps every 15 minutes



Simulated data over Africa

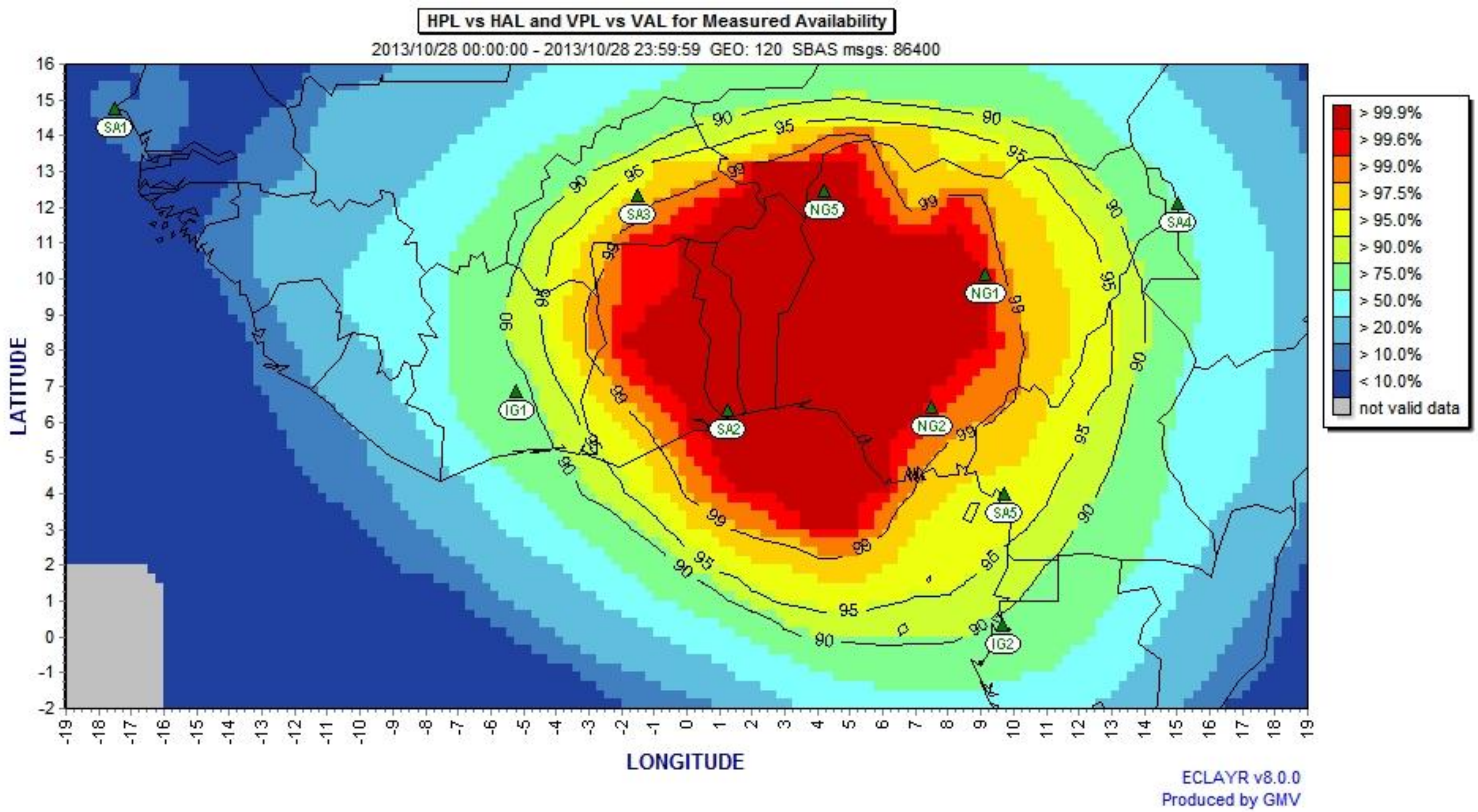


Latitude: [-5,20]

Longitude: [-20,20]

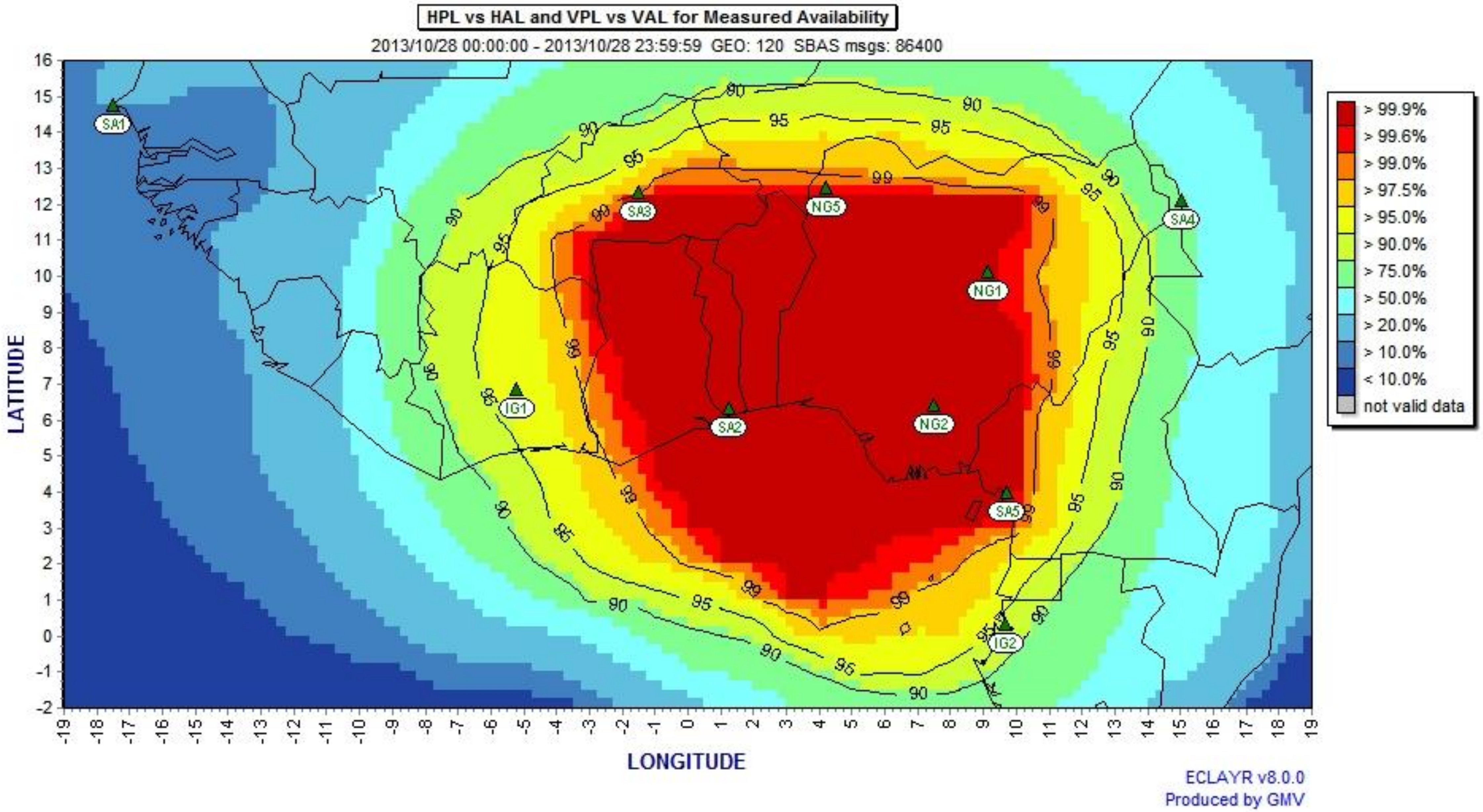
Availability graphs

- EGNOS algorithm



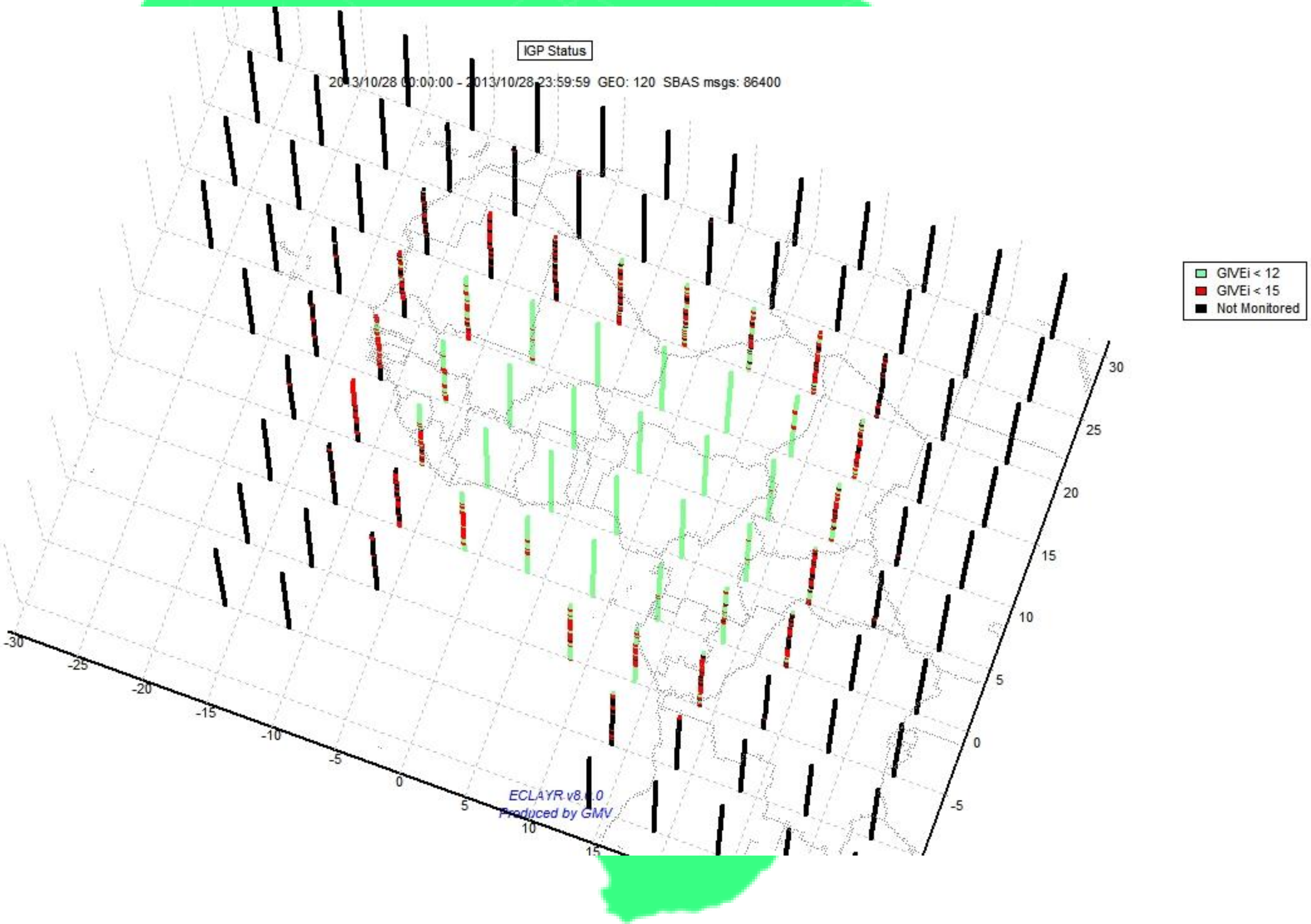
Availability graphs

- IONO algorithm



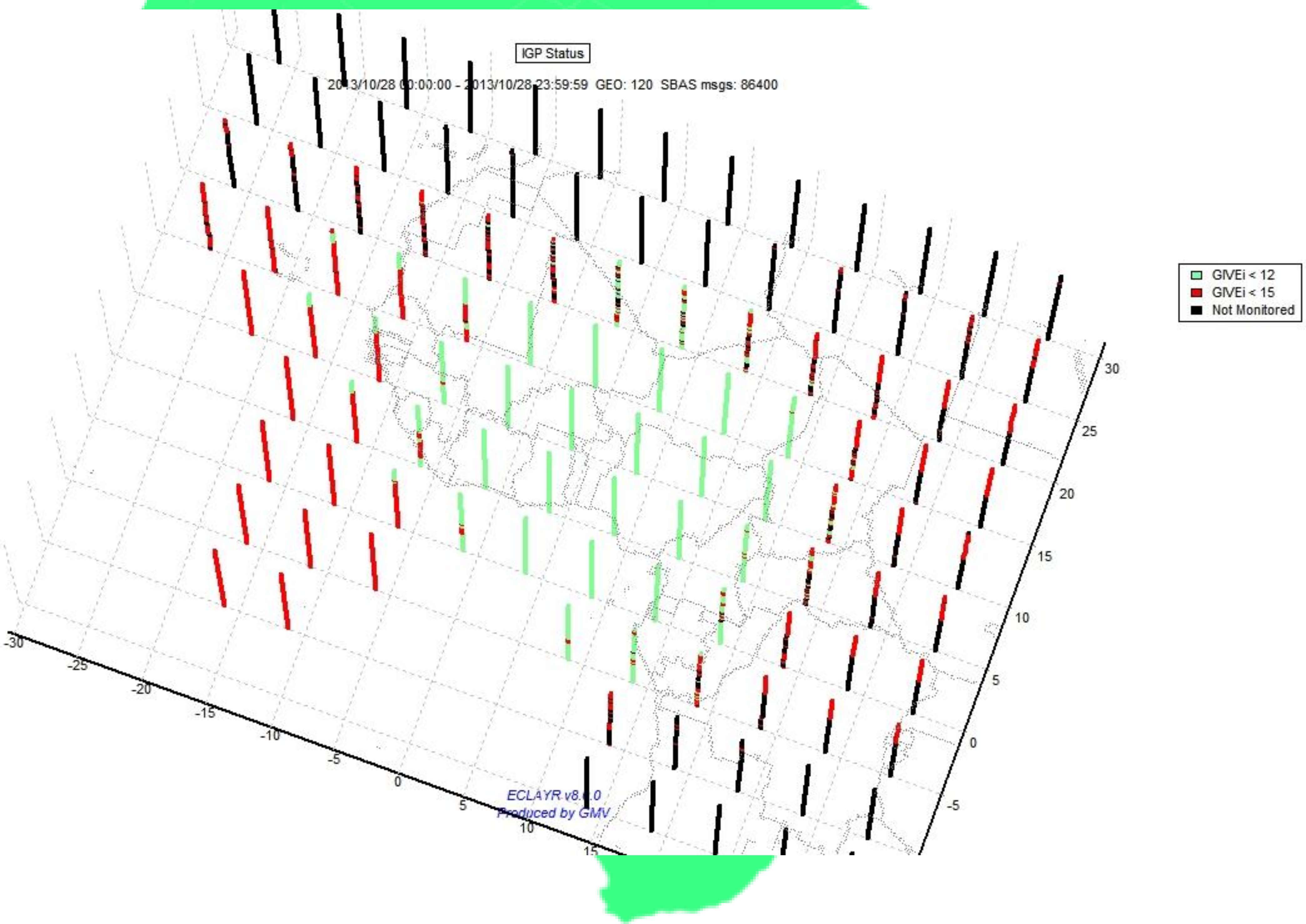
IGP monitoring

- EGNOS algorithm



IGP monitoring

- IONO algorithm



Thank you !