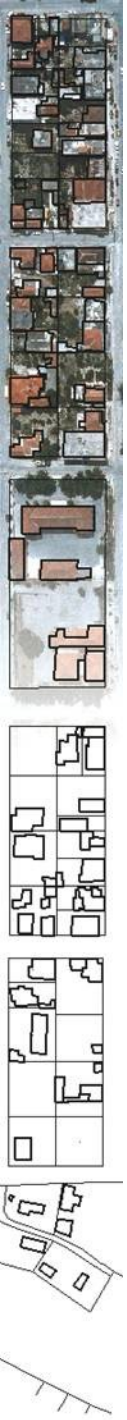

KTIMATOLOGIO S.A.

HEPOS
HEllenic POsitioning System

Impact of high ionospheric activity on GPS surveying: Experiences from the Hellenic RTK-network during 2011-2012

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Outline

1. Ionospheric activity and RTK-networks
2. Approaching the maximum of solar cycle 24
3. Experiences from the HEPOS network:
   - Feedback from the users
   - Field tests
   - Post-processing tests
4. Conclusions

1. Ionospheric activity and RTK-networks

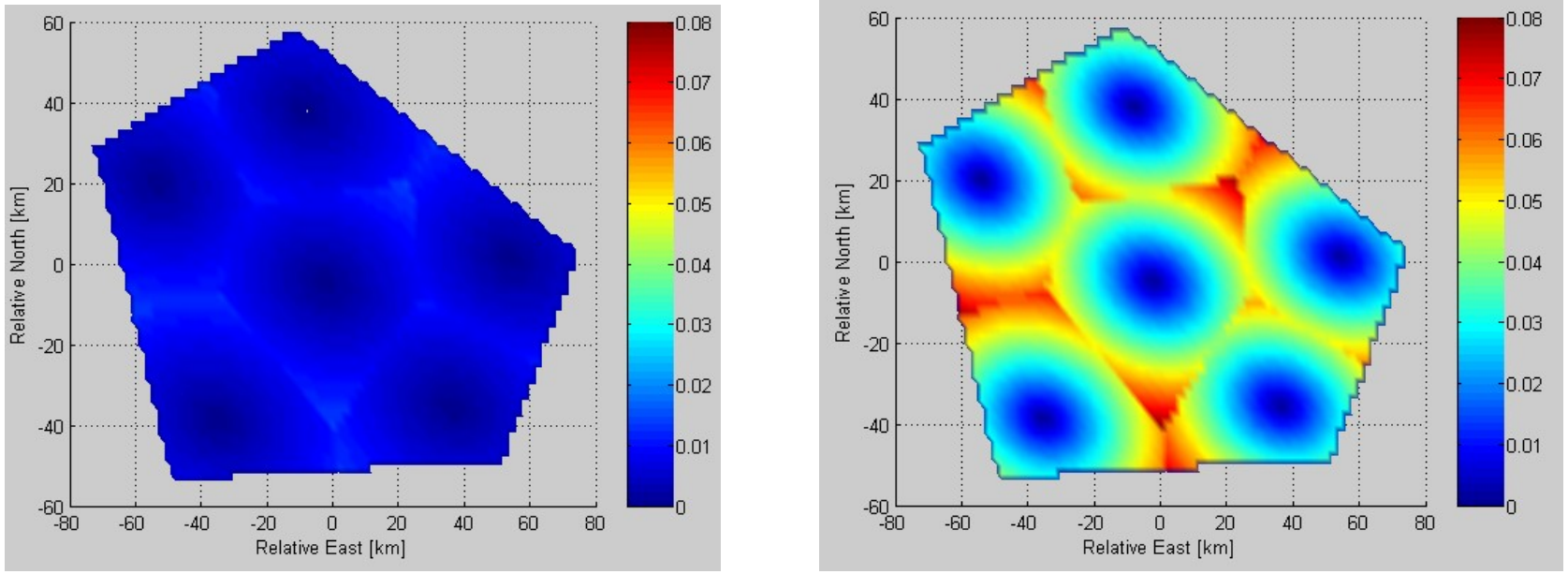
- The major drawback of Single-Base RTK is the inability to deal with distance-dependent errors.
- Ionospheric influence consists the most important distance-dependent error source.
- Network-Based RTK substantially improves RTK performance by mitigating distance-dependent errors.

1. Ionospheric activity and RTK-networks

The ability of an RTK-network to model the ionospheric errors depends mainly on:

- **the inter-station distances**
- **the conditions of the ionosphere.**

IRIU values for the same network at different times of a day



Source: Chen, X. et al., New Tools for Network RTK Integrity Monitoring, ION GPS/GNSS 2003

1. Ionospheric activity and RTK-networks

Within the area of an RTK-network the intensity and spatial variations of the ionospheric errors are usually described using the Index I95.

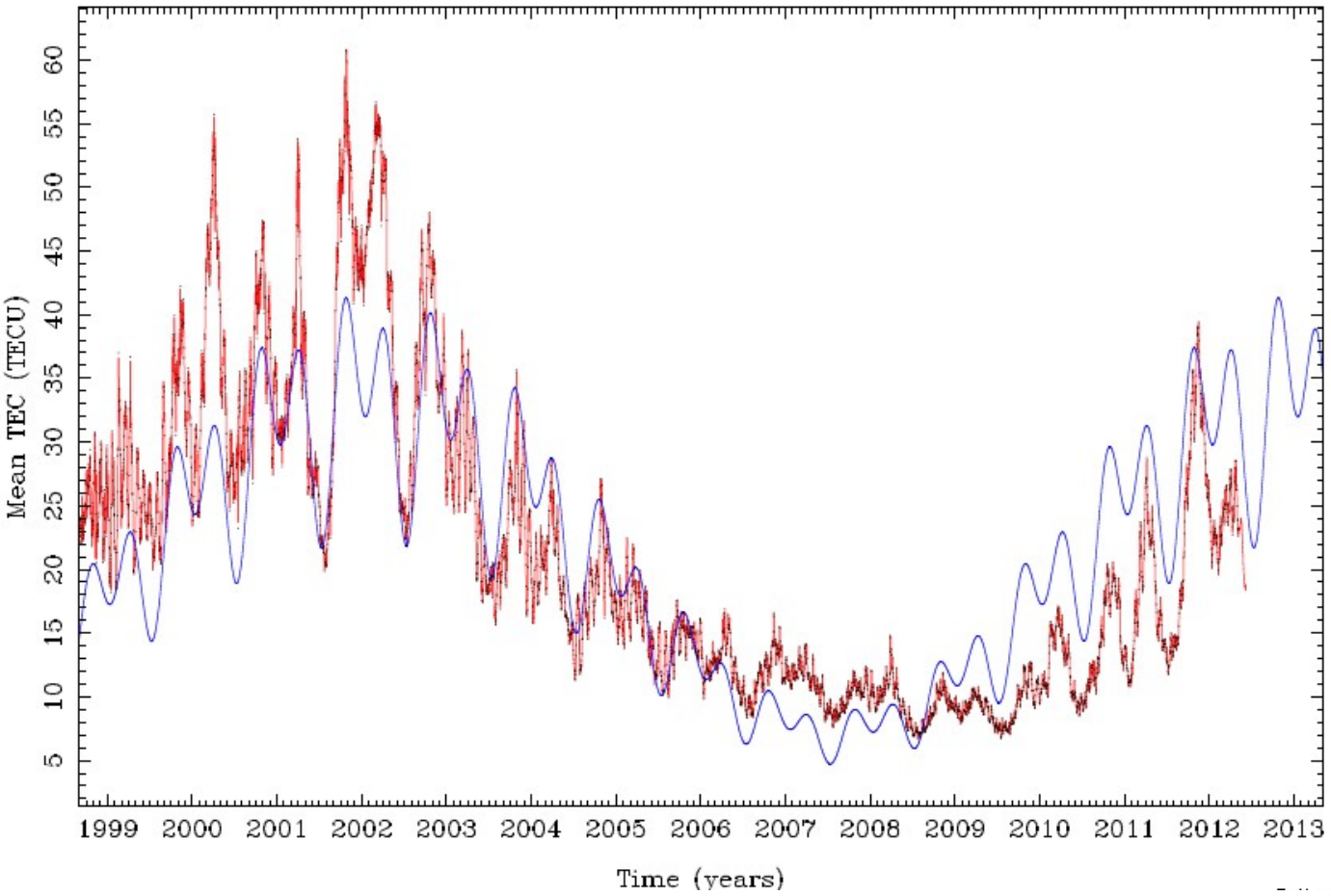
The index I95 is the 95% margin of all ΔI values in a certain period of time, where:

$$\Delta I = \sqrt{\Delta I_{LAT}^2 + \Delta I_{LON}^2}$$

2. Approaching the maximum of solar cycle 24

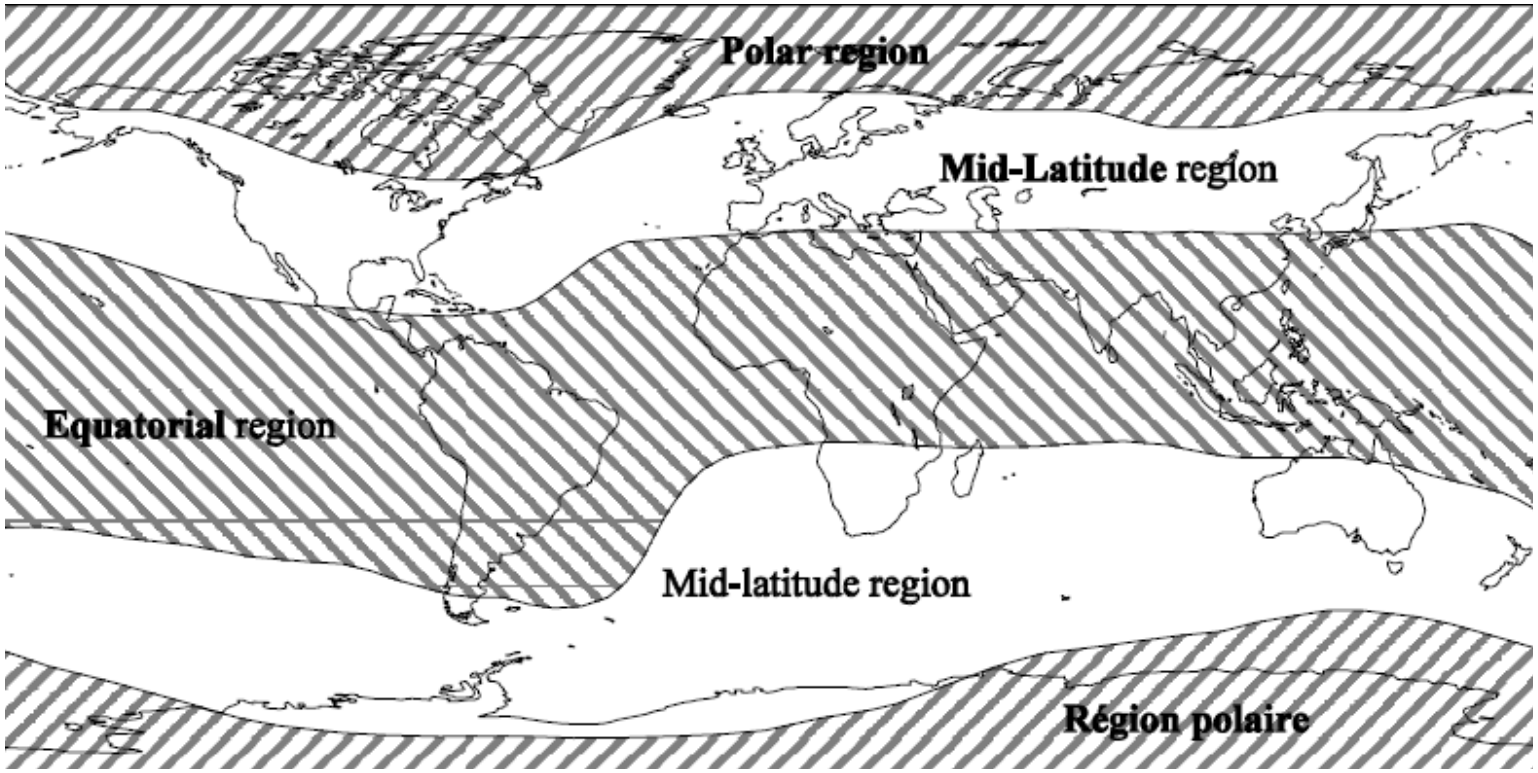
Total Electron Content (23th – 24th solar cycles)

CODE'S GIM: Mean TEC (Aug. 1998 – May 2012)



2. Approaching the maximum of solar cycle 24

The intensity of the ionospheric effects depends on the geomagnetic latitude.

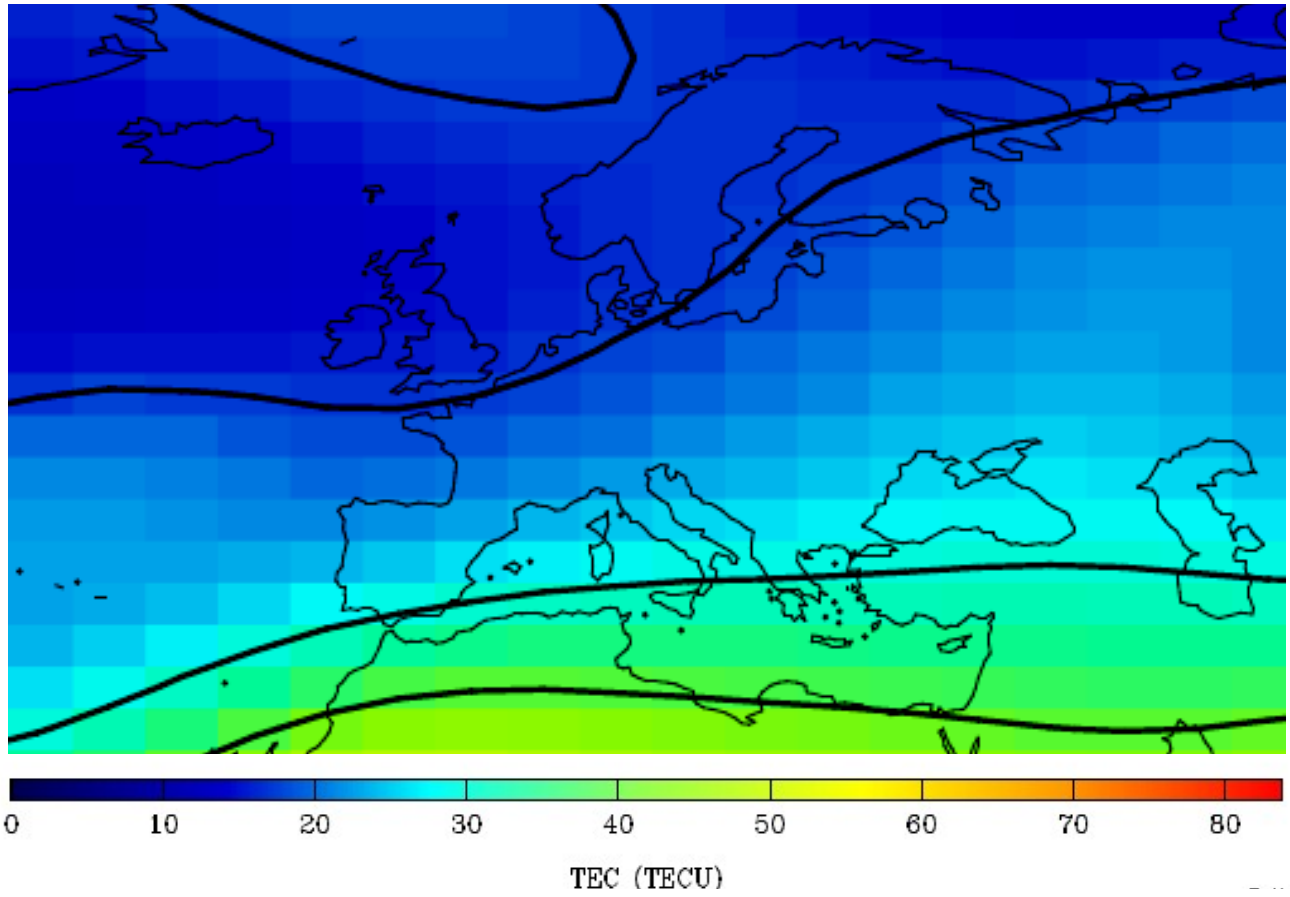


Warnant R. et al. Processing GPS measurements during periods of high ionospheric activity…, Euref 2002 Symposium

2. Approaching the maximum of solar cycle 24

Typical spatial distribution of TEC in Europe

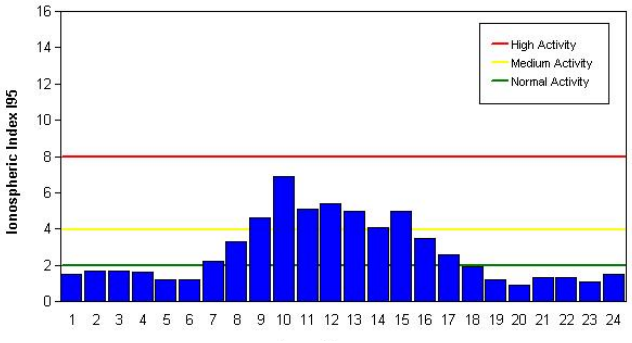
CODE'S GIM (Day 123, 2012 14:00 UT)



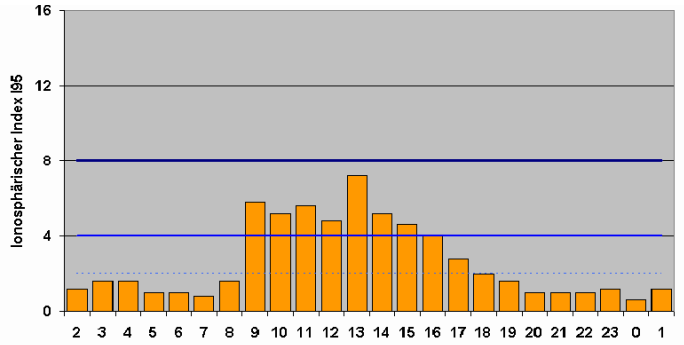
2. Approaching the maximum of solar cycle 24

Examples of I95 values in Europe (Dec. 6, 2011)

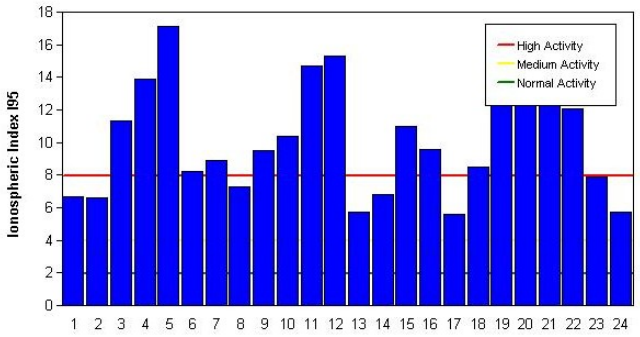
SAPOS NW



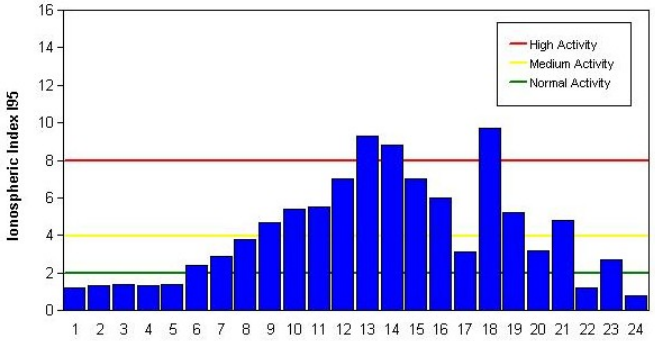
SAPOS NI



CROPOS



HEPOS



3. Experiences from the HEPOS network

Since 2011, users of HEPOS often need longer initialization times than in the previous years.

In some cases, mainly under unfavourable conditions (poor DOP, bad signal reception, long distance to the reference stations) initialization cannot be achieved.

Such difficulties were expected as we are approaching the maximum of the 24th solar cycle.

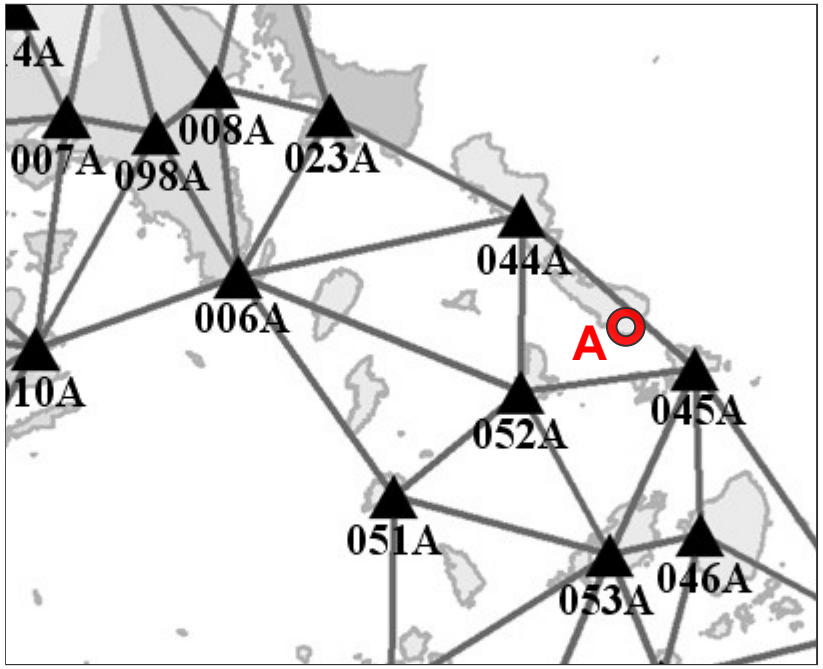
Several tests have been made to verify the relationship between longer initialization time and ionospheric activity.

Some representative examples are described in the following.

3. Experiences from the HEPOS network

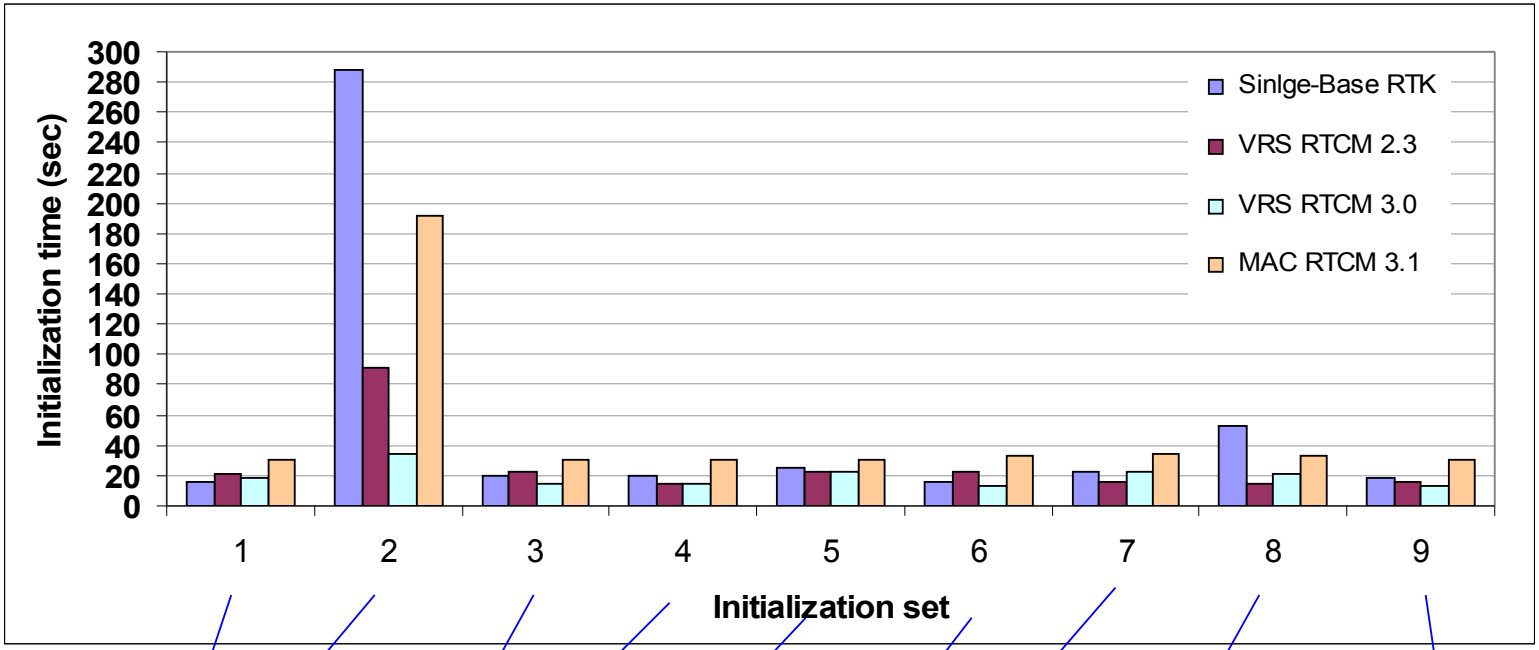
Field test (location A)

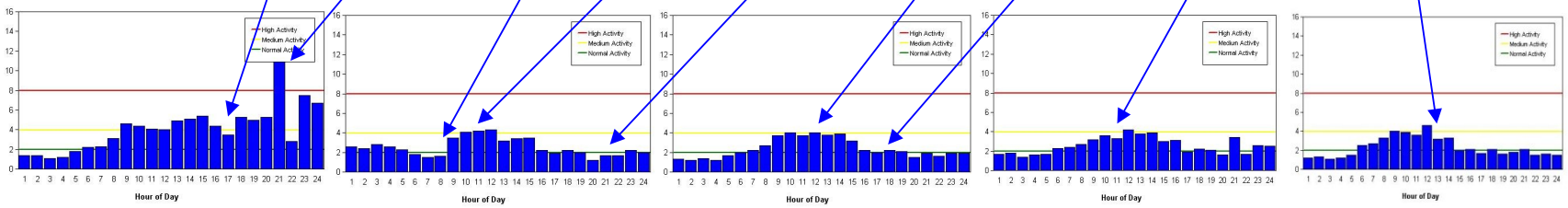
- Point A selected close to the network boundaries
- Several initialization sets at different hours of day (12.4.2012 – 16.4.2012)
- Four different RTK techniques were used during each initialization set: VRS, MAC and Single-Base from station 045A (18 Km)
- Results examined along with l95 values



3. Experiences from the HEPOS network

I95 index ~ RTK Initialization time at point A





12.4.2012 13.4.2012 14.4.2012 15.4.2012 16.4.2012

3. Experiences from the HEPOS network

Post-processing kinematic tests

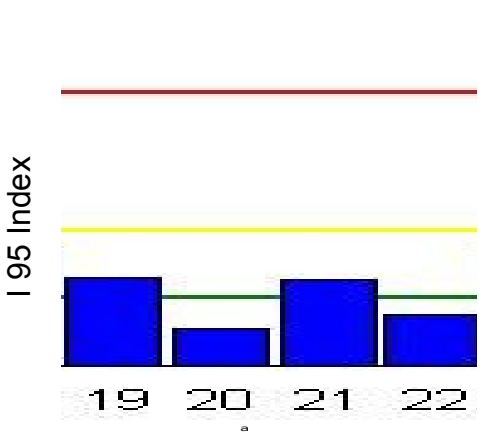
The RTK tests proved that the initialization time on a certain point can vary dramatically between hours or days depending on the ionospheric conditions.

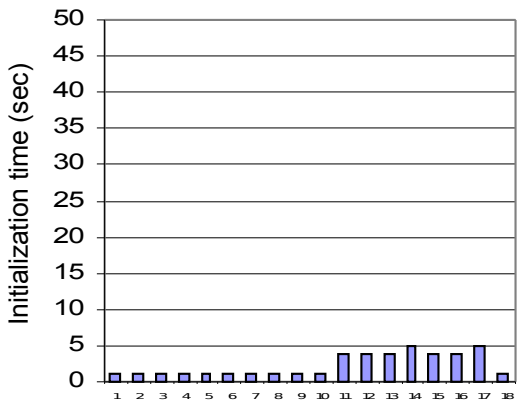
In order to investigate further the ionospheric influence on the certain days, initialization times were estimated at the office by post-processing 1-Hz VRS data (calculated for point A) in kinematic mode.

Initialization was started every 10 minutes from 19:00-22:00 on three consecutive days: on the day of high activity (12.4.2012), one day before and one day after.

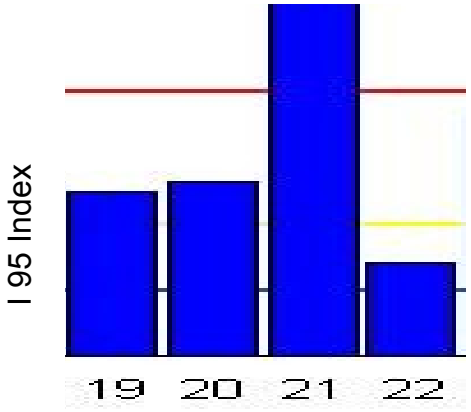
3. Experiences from the HEPOS network

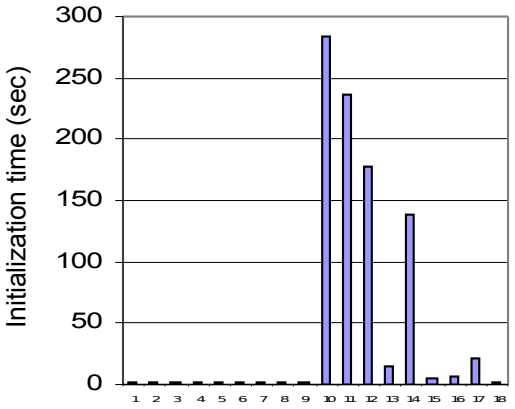
I95 index ~ PPK Initialization time at point A



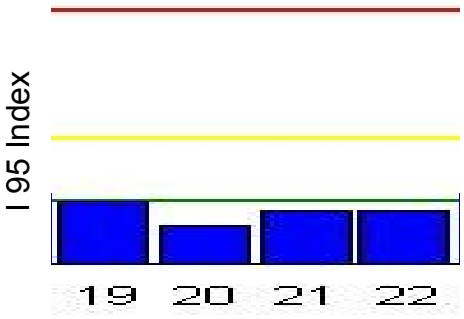


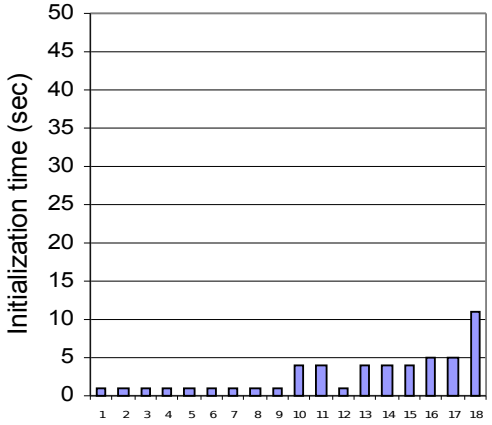
11.4.2012





12.4.2012



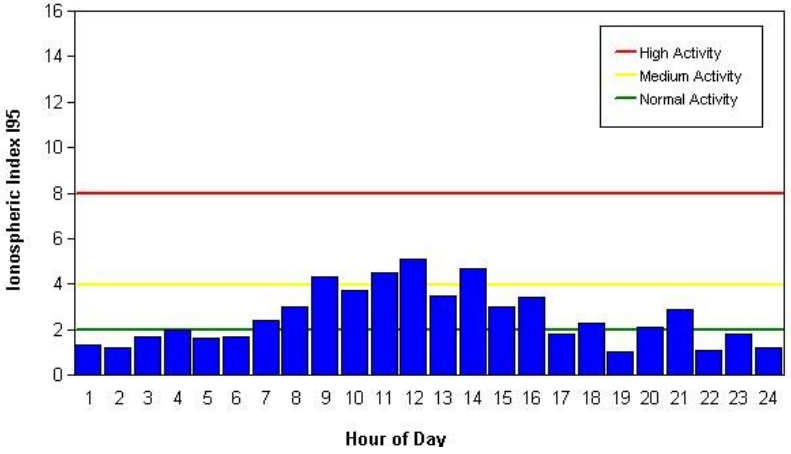


13.4.2012

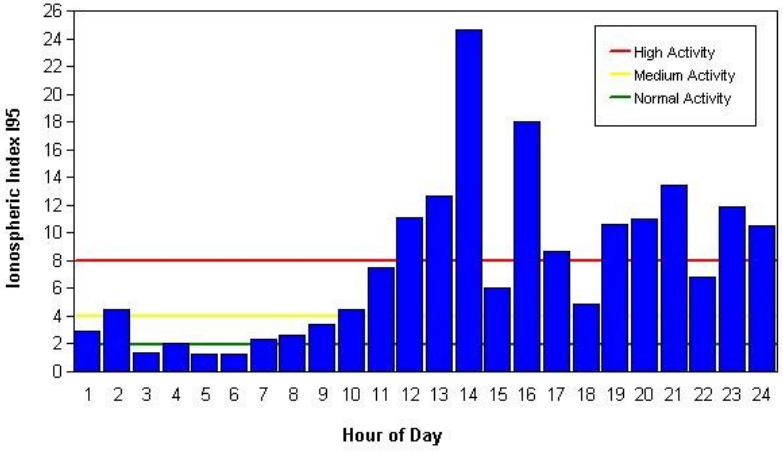
3. Experiences from the HEPOS network

I95 index for VRS Sub-network of Crete

19.3.2012



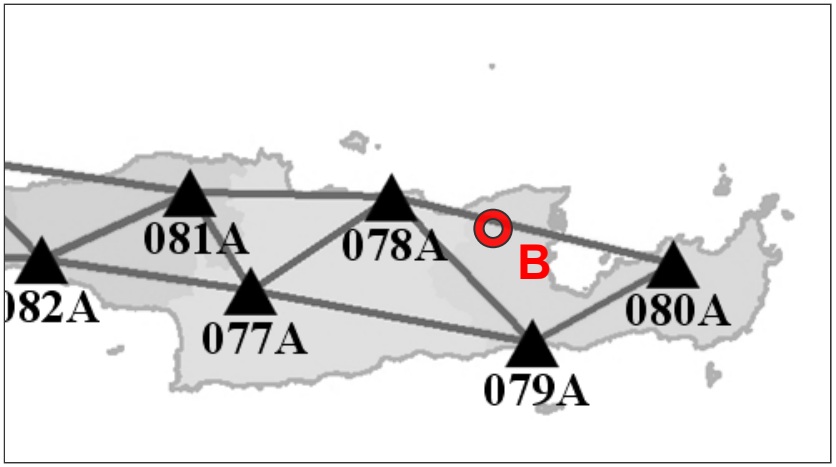
21.3.2012



3. Experiences from the HEPOS network

Post-processing test (location B)

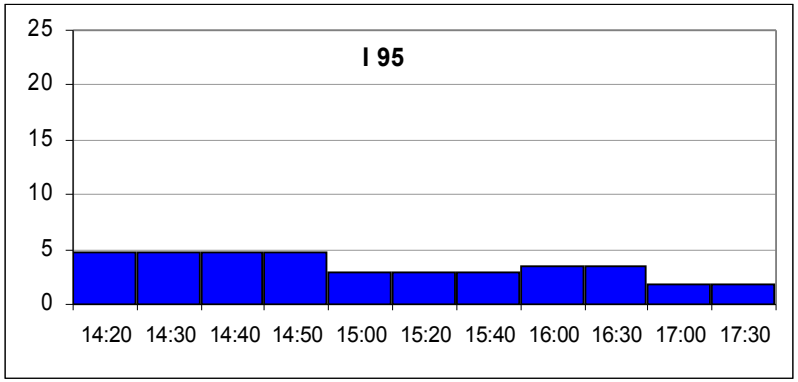
- VRS created close to the network boundaries (eastern Crete)
- VRS solved from station 078A (25 Km)
- Several initializations at different hours of days 19.3.2012 and 21.4.2012
- Results examined along with l95 values

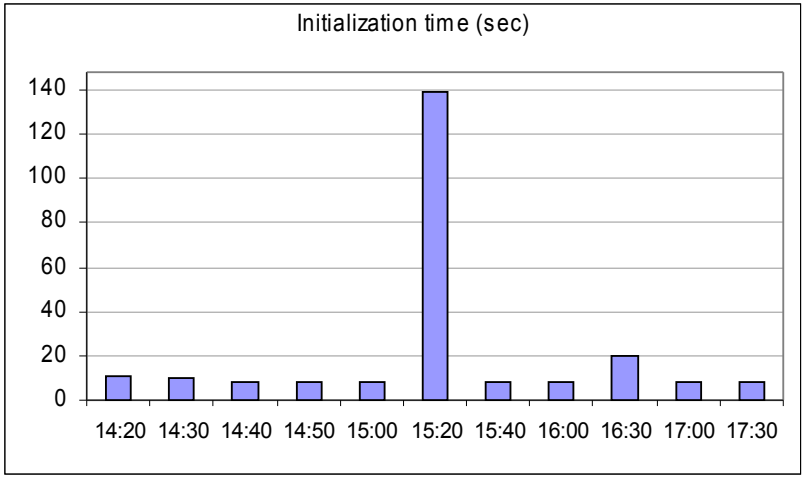


3. Experiences from the HEPOS network

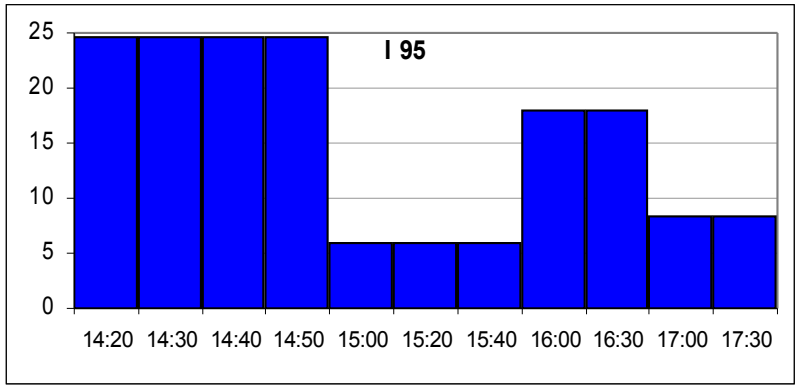
I95 index ~ PPK Initialization time at point B

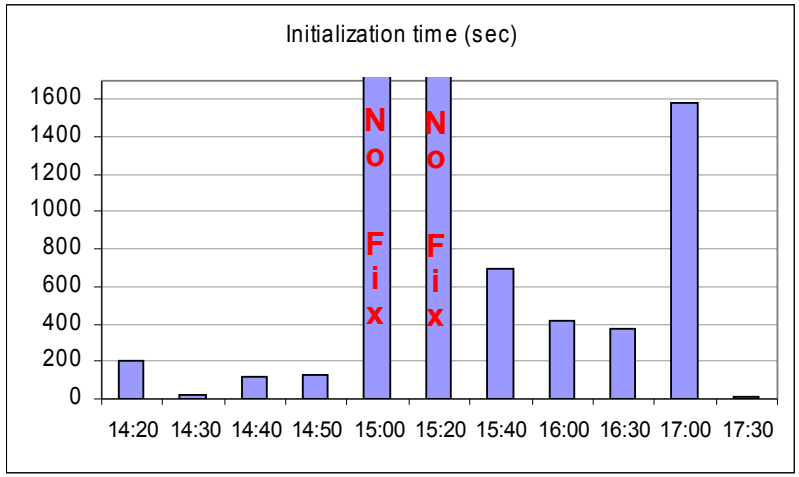
19.3.2012





21.3.2012





4. Conclusions

- Around solar maximum the ionospheric activity causes significant degradation of RTK performance (up to complete inability to initialize) even in middle latitude countries like Greece.

- The ionospheric activity can vary strongly with time: users may not be able to initialize on points it was possible a few days - or even a few hours - ago.

- Generally, network-based RTK techniques proved to be less vulnerable to ionospheric disturbances than Single-Base RTK.

Acknowledgments

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