IGS Ionospheric Working Group

IGS Ionosphere WG Status Report: Performance of IGS Ionosphere TEC Maps -Position Paper-

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Outline

- The IGS Ionosphere WG and the Final product.
- First results of the IGS rapid ionospheric product in testing period.
- Alternative weighting schemes in the combination of IAAC TEC maps.
- Conclusions and Some recommendations.

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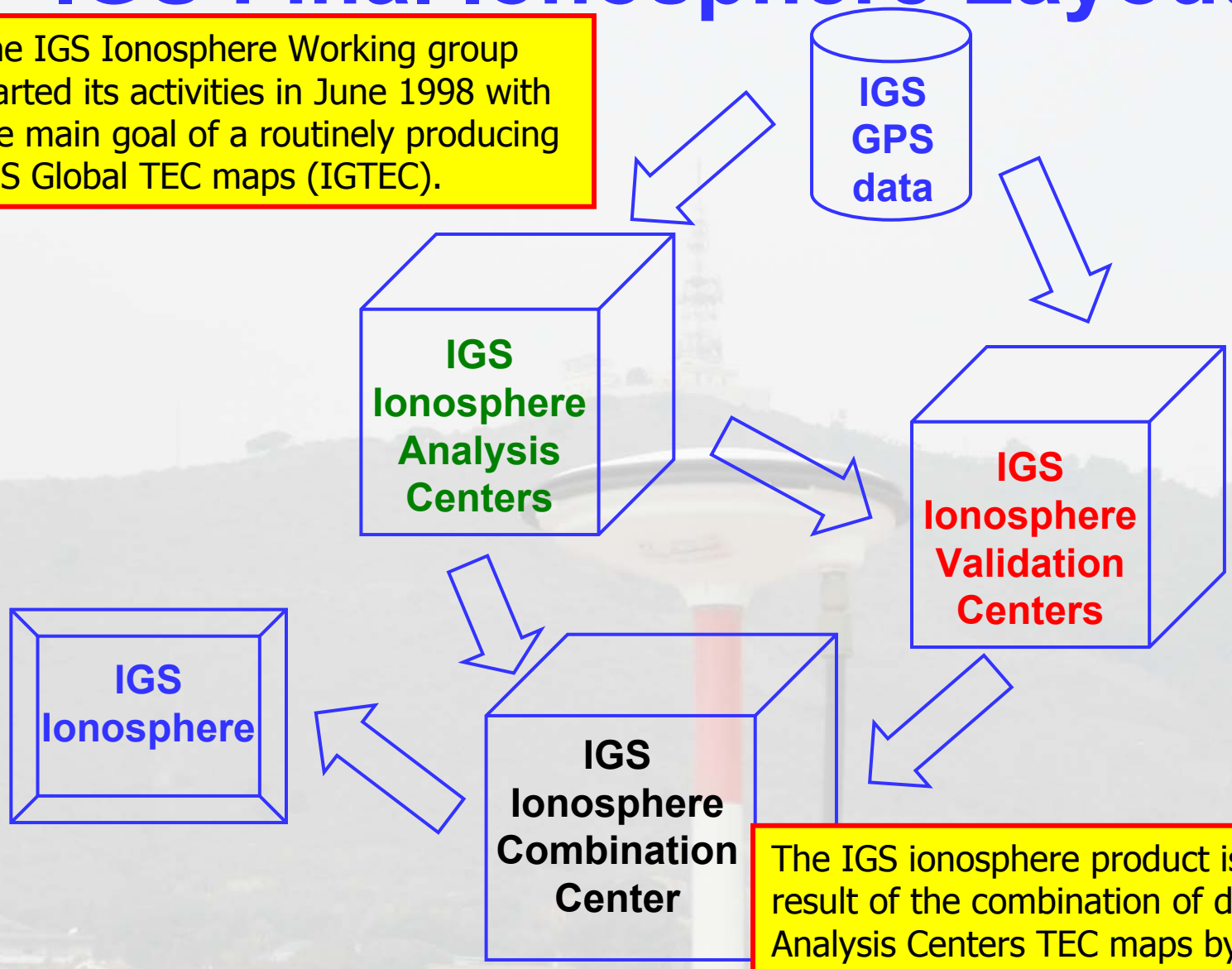
IGS Final Ionosphere Layout

The IGS Ionosphere Working group started its activities in June 1998 with the main goal of a routinely producing IGS Global TEC maps (IGTEC).



The IGS ionosphere product is a result of the combination of different Analysis Centers TEC maps by using weights computed from GPS data by Validation Centers, in order to get a more accurate product.

Example of IGS Final TEC map: 2003-347-00UT

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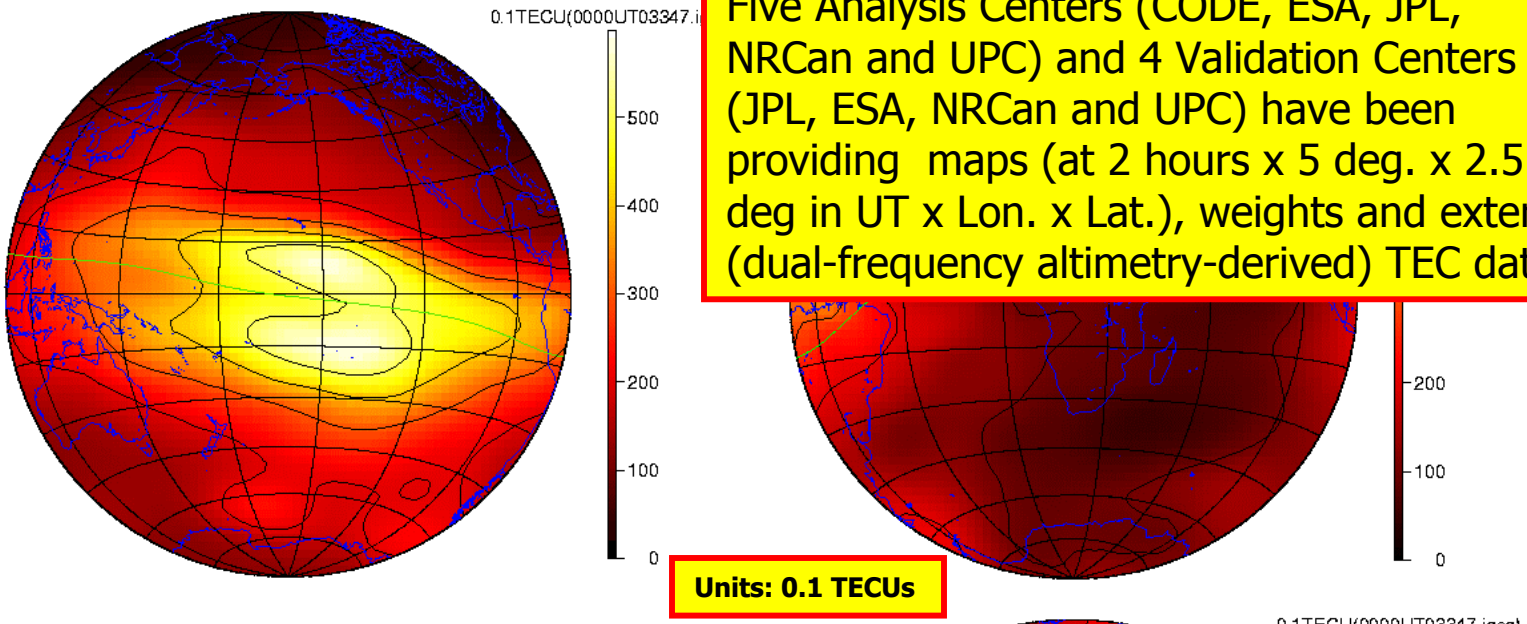
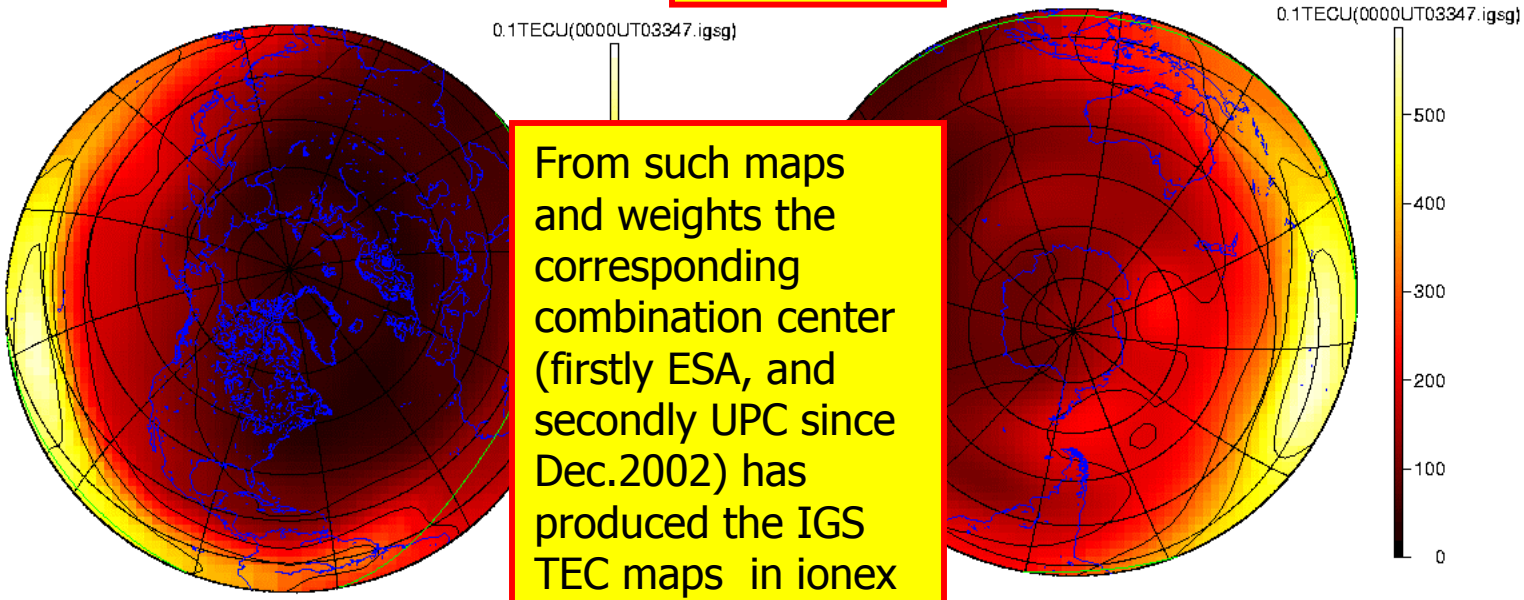


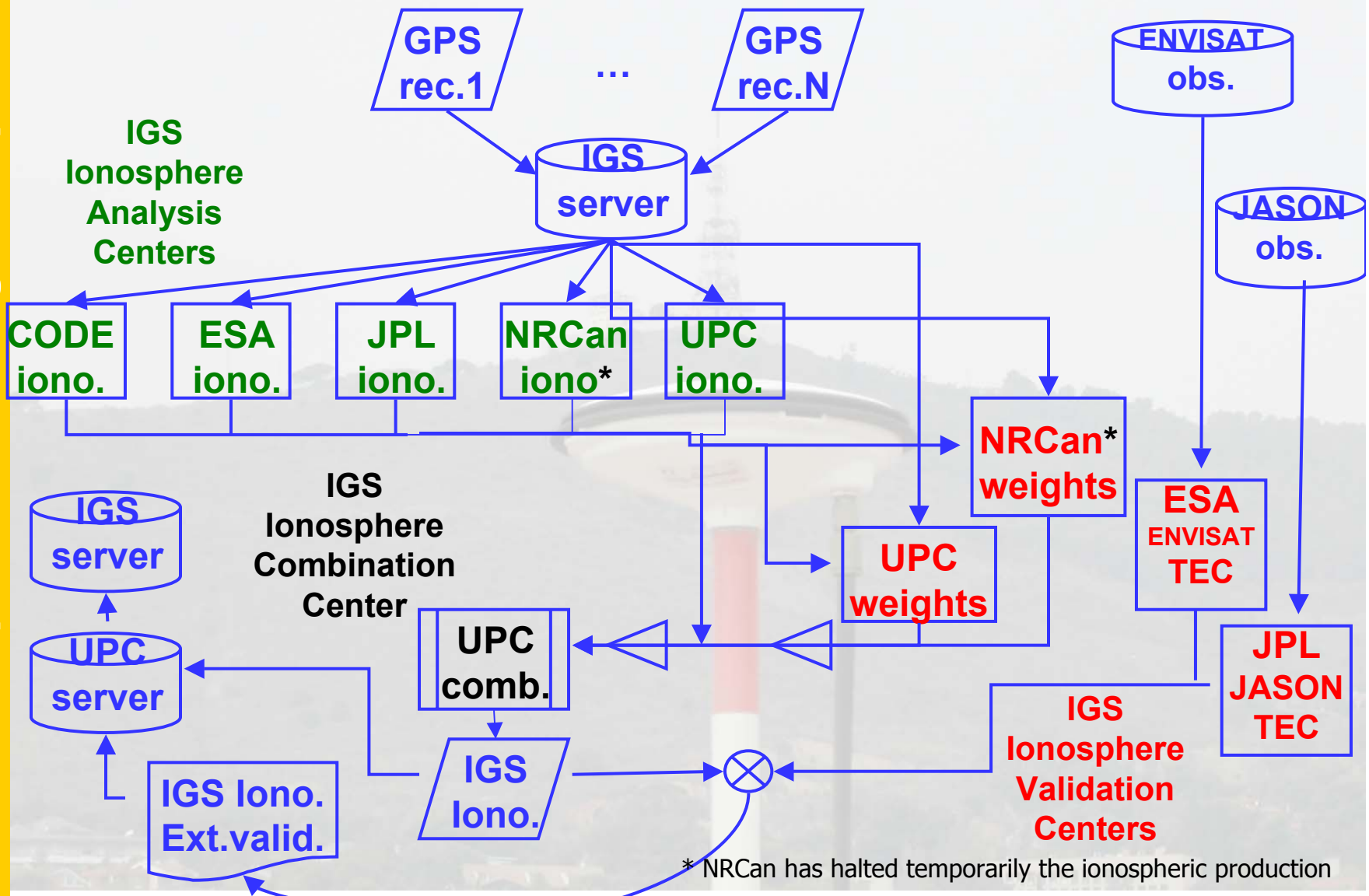
Five Analysis Centers (CODE, ESA, JPL, NRCan and UPC) and 4 Validation Centers (JPL, ESA, NRCan and UPC) have been providing maps (at 2 hours x 5 deg. x 2.5 deg in UT x Lon. x Lat.), weights and external (dual-frequency altimetry-derived) TEC data.

Units: 0.1 TECUs



From such maps and weights the corresponding combination center (firstly ESA, and secondly UPC since Dec.2002) has produced the IGS TEC maps in ionex format.

IGS Final Ionosphere Flow-Chart



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Example of comparison of IGS vs JASON: 2003-347 each 6 hours

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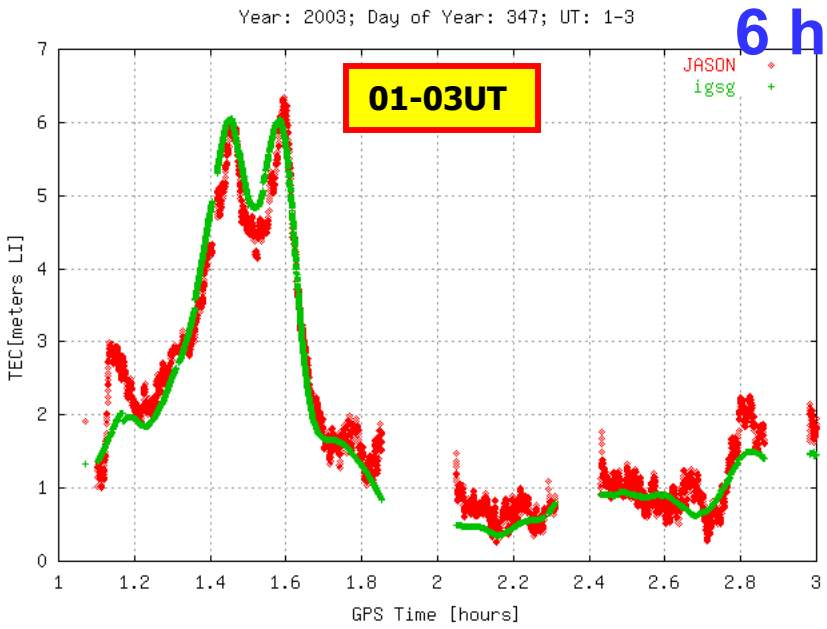
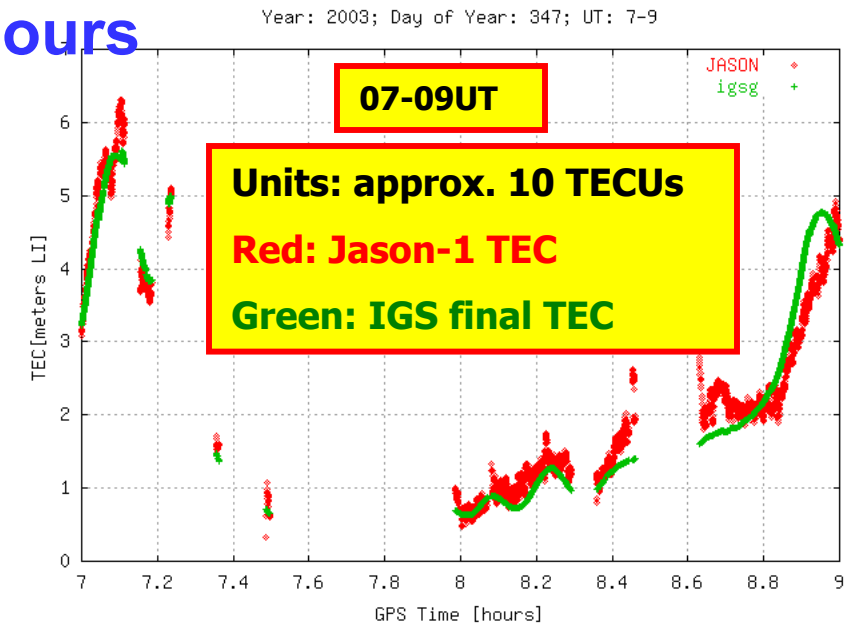
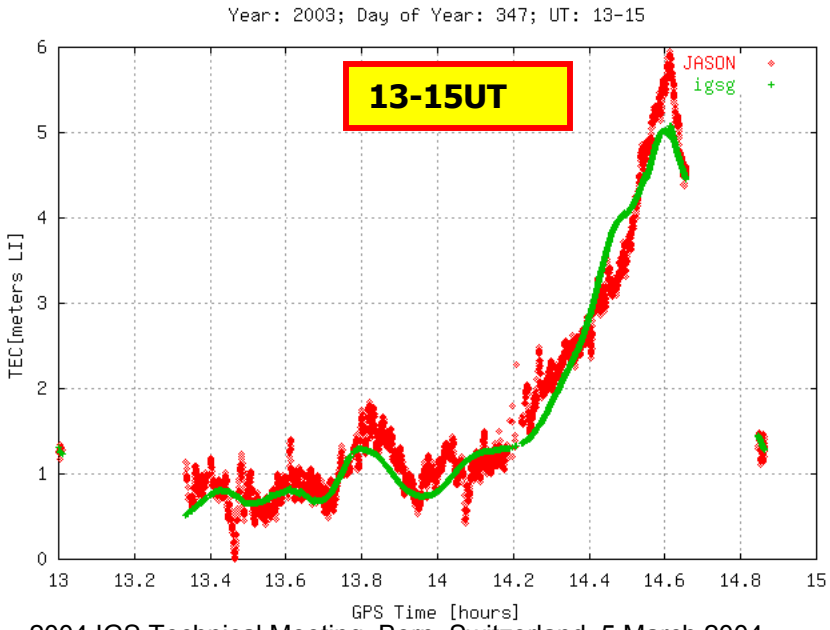


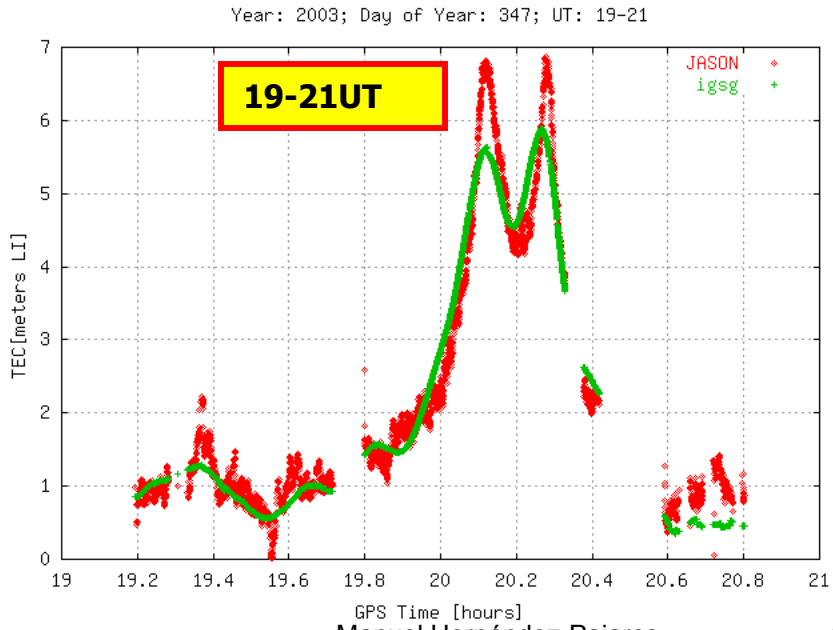


Units: approx. 10 TECUs

Red: Jason-1 TEC

Green: IGS final TEC





Final IGS TEC vs. JASON TEC

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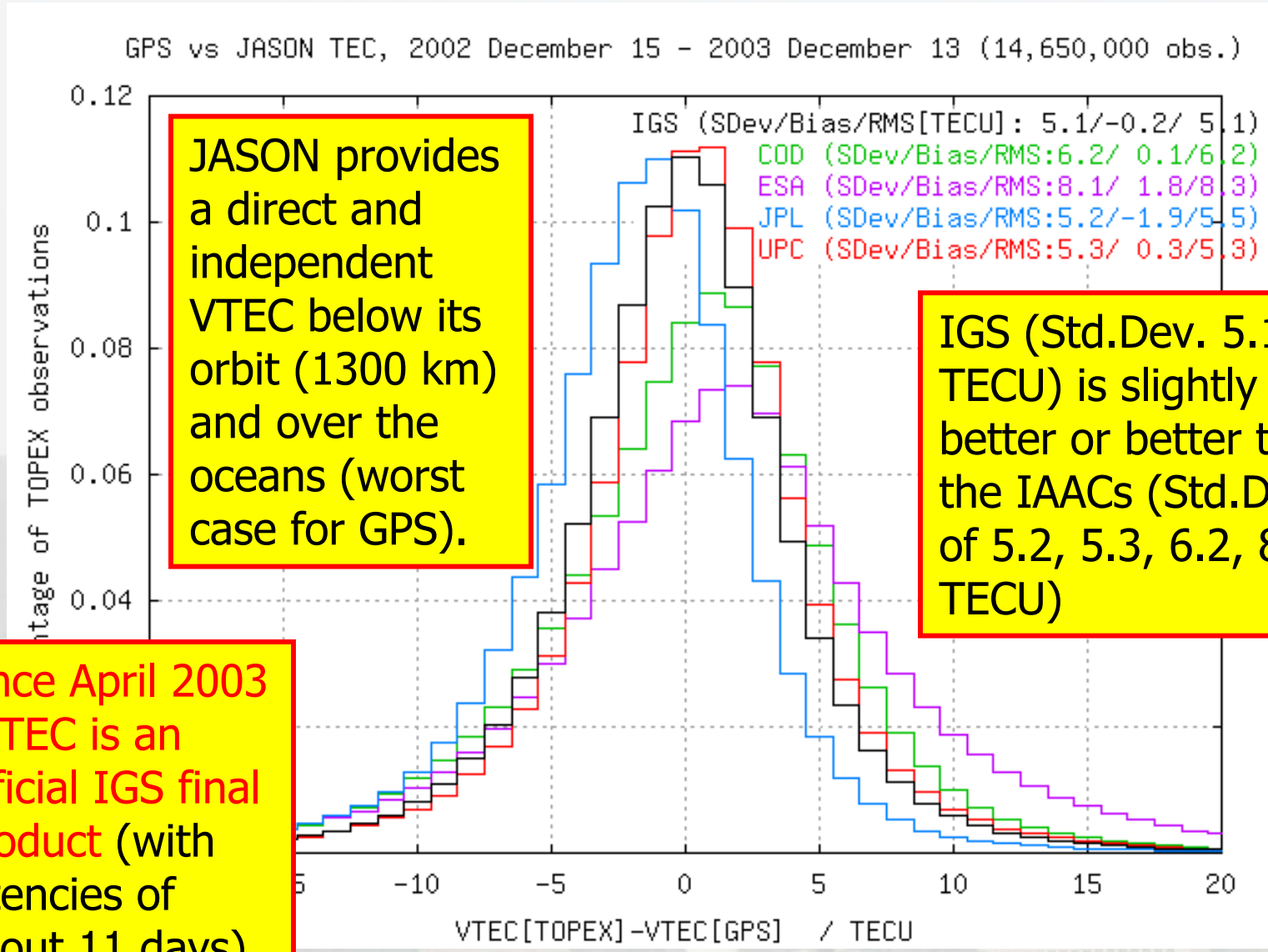

JASON provides a direct and independent VTEC below its orbit (1300 km) and over the oceans (worst case for GPS).

IGS (Std.Dev. 5.1 TECU) is slightly better or better than the IAACs (Std.Dev. of 5.2, 5.3, 6.2, 8.1 TECU)

Since April 2003 IGTEC is an official IGS final product (with latencies of about 11 days).

Ap index vs. “Relative Error”

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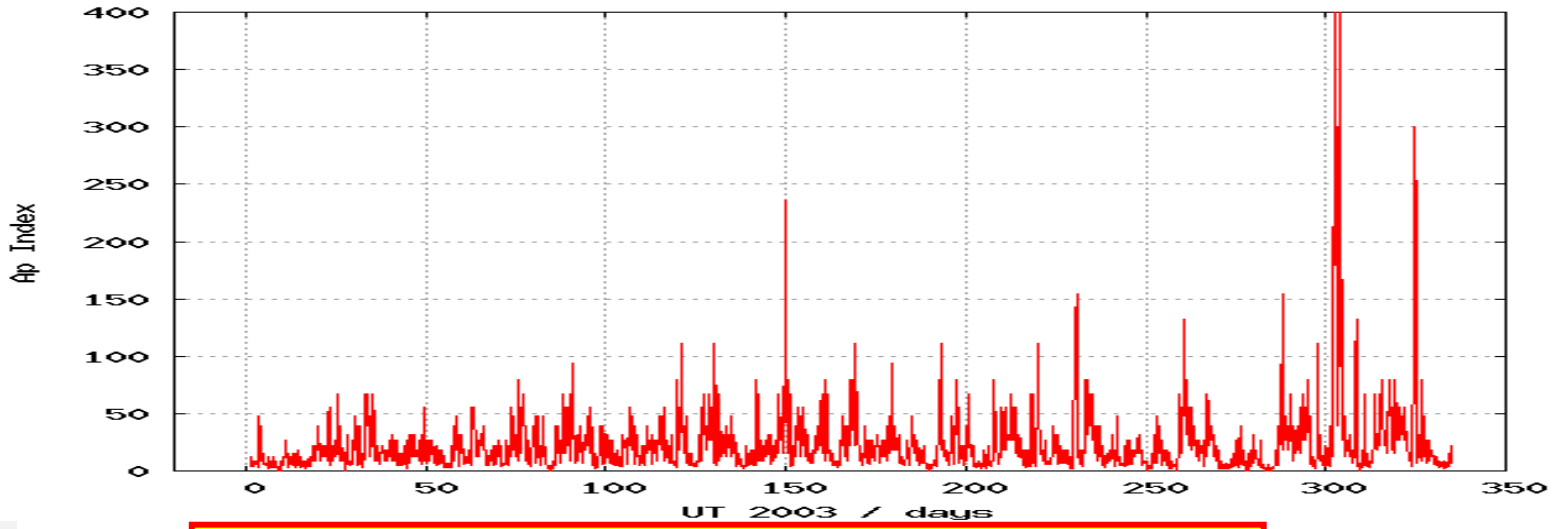
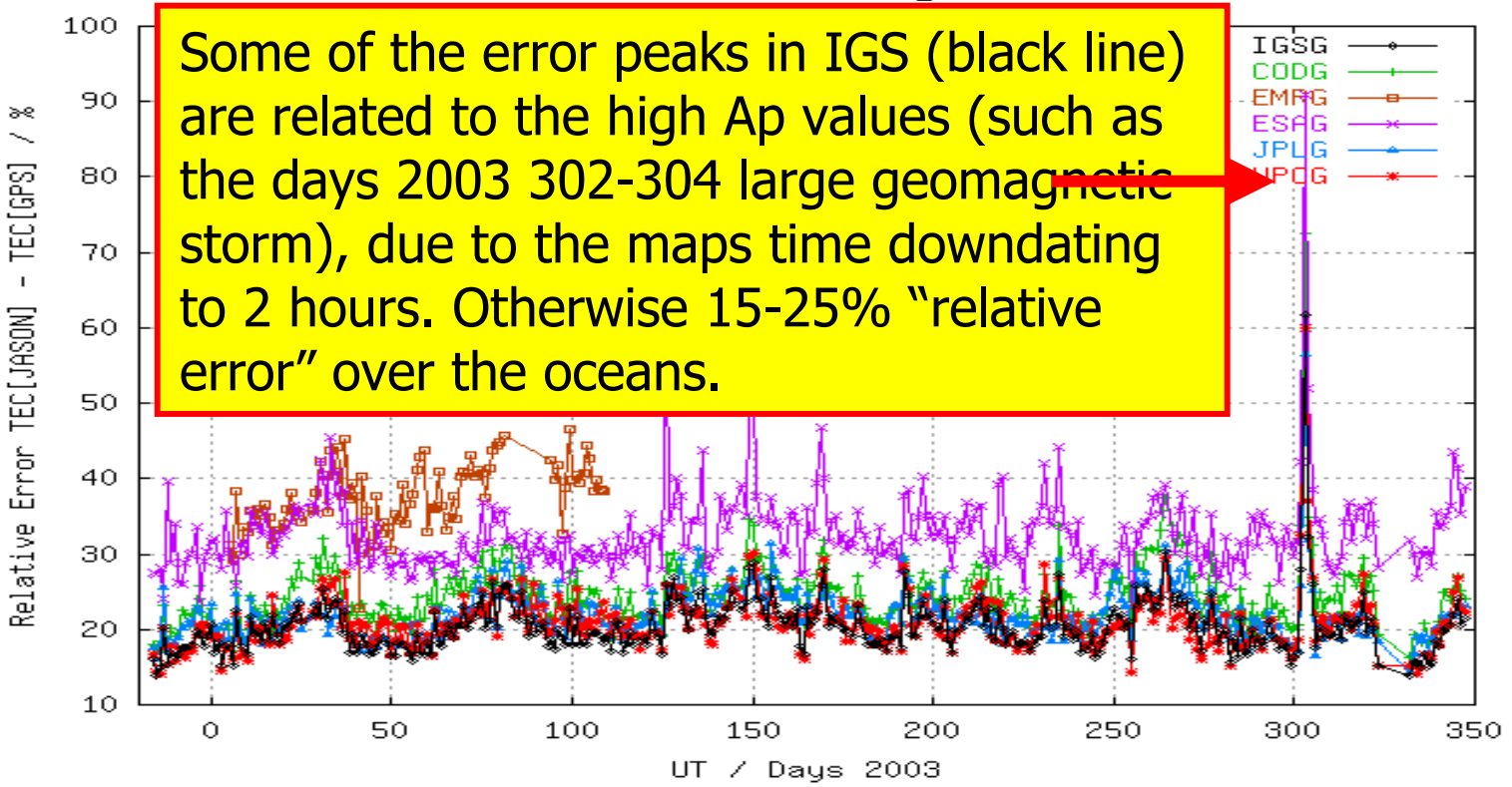
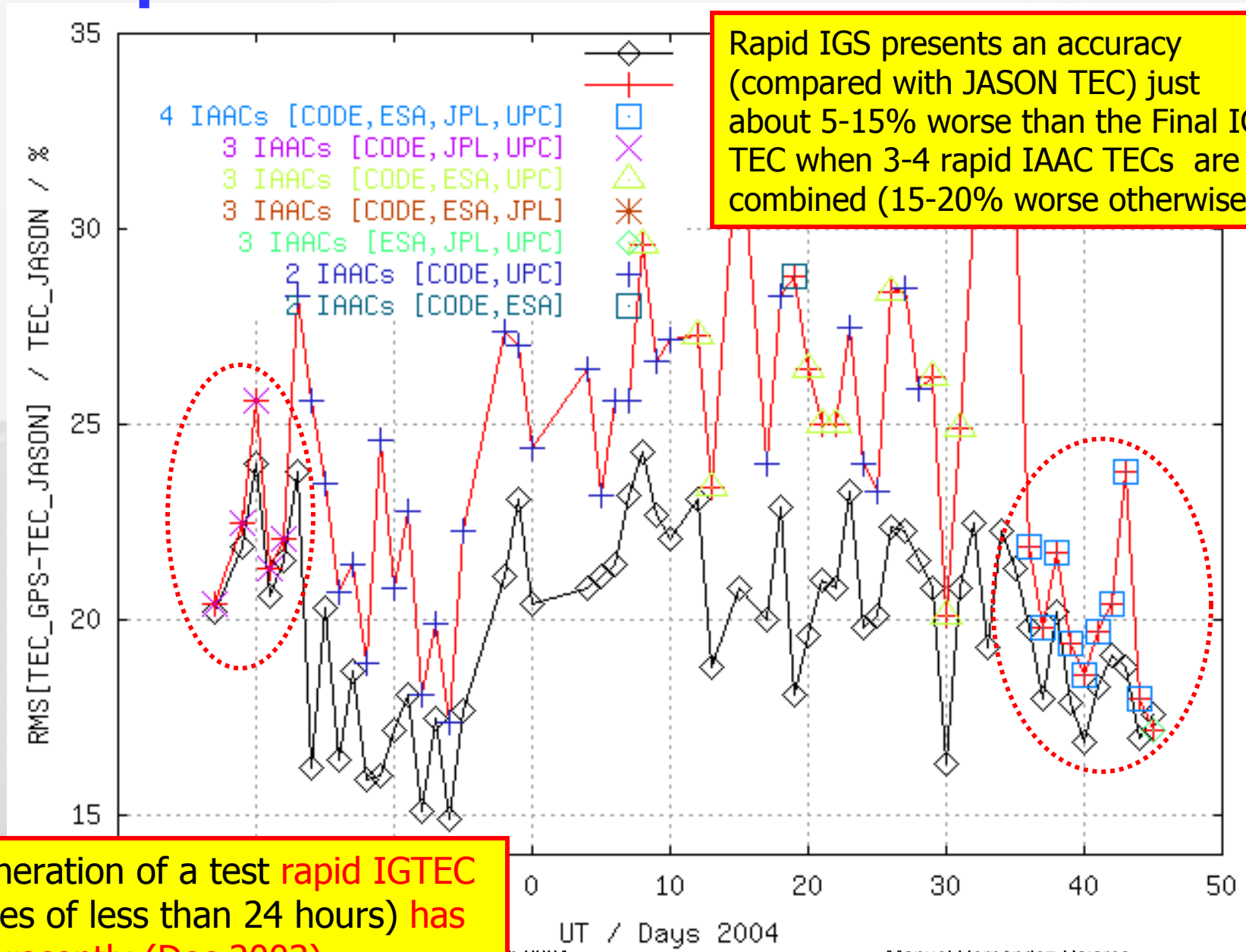




Some of the error peaks in IGS (black line) are related to the high Ap values (such as the days 2003 302-304 large geomagnetic storm), due to the maps time downdating to 2 hours. Otherwise 15-25% “relative error” over the oceans.

Rapid vs Final IGS TEC "Rel.Error"



Rapid IGS presents an accuracy (compared with JASON TEC) just about 5-15% worse than the Final IGS TEC when 3-4 rapid IAAC TECs are combined (15-20% worse otherwise).

The generation of a test rapid IGTEC (latencies of less than 24 hours) has started recently (Dec.2003).

Rapid vs Final IGS DCBs

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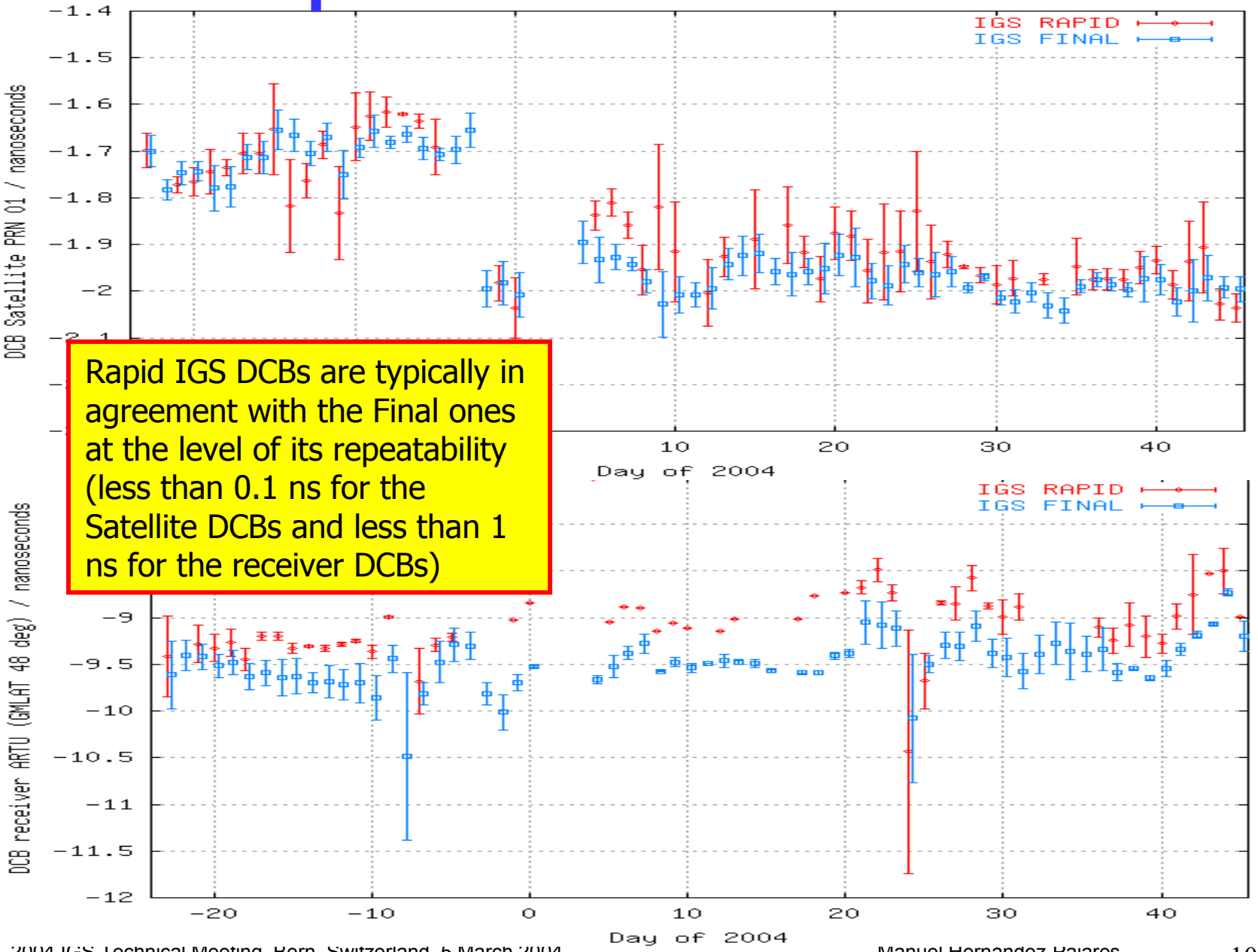

Rapid IGS DCBs are typically in agreement with the Final ones at the level of its repeatability (less than 0.1 ns for the Satellite DCBs and less than 1 ns for the receiver DCBs)

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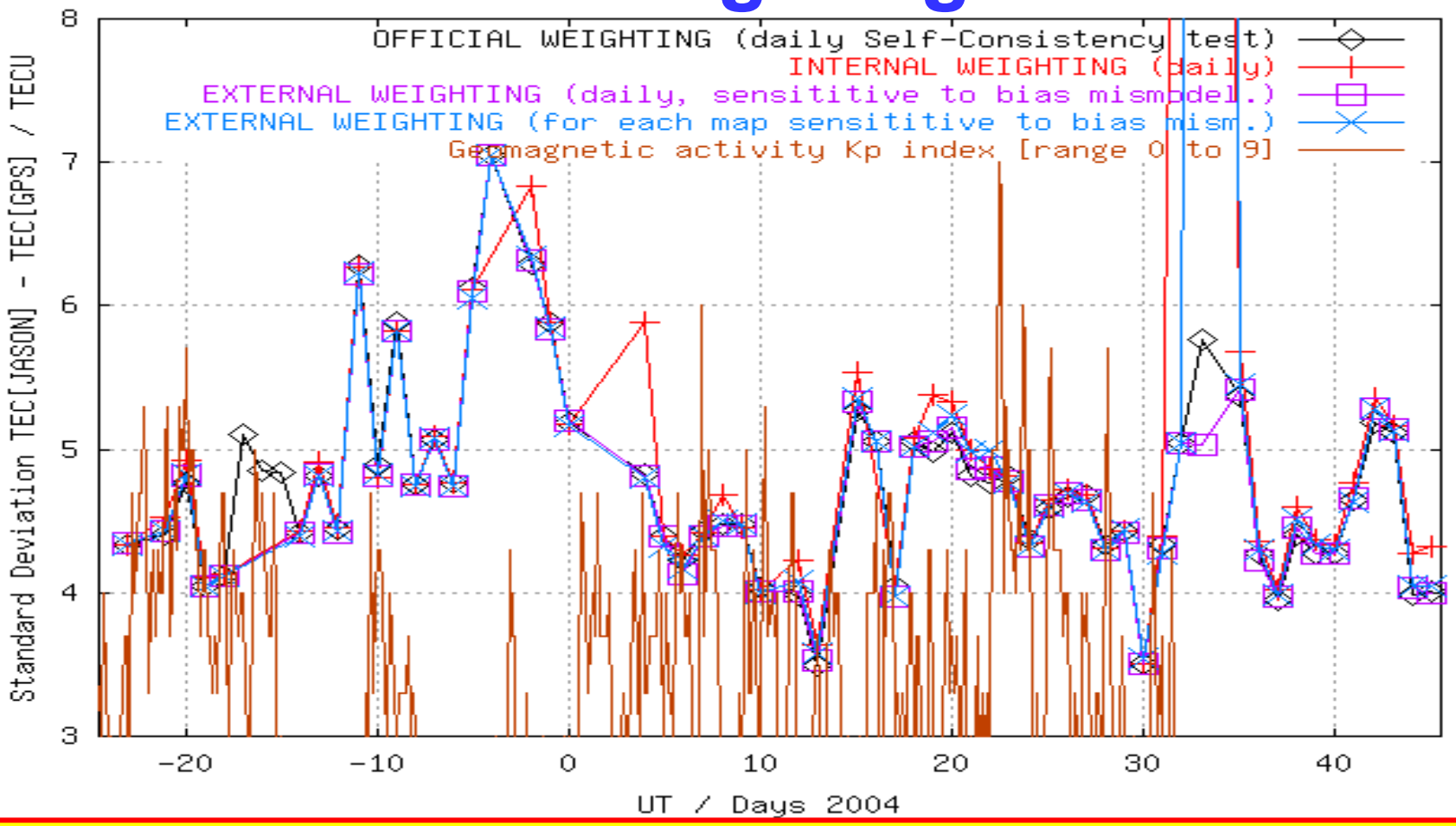
Alternative weighting schemes



- The performance between daily weighting (magenta squares) and independent map weighting (blue crosses) are very similar, including geomagnetic activity periods (days -23 to -19 and 22 to 28, 2004).
- The performance of the official weighting algorithm (bias insensitive) is very similar to that using a bias-sensitive weighting algorithm (truth: STEC referred to the max. elevation ray STEC, both observed).
- It is confirmed the best performance of external weighting strategies (presently used), compared with the internal weighting, from the deviates to the plain mean of IAAC TEC maps (red crosses).

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Conclusions

- After several improvements performed in the IAACs and IGS Ionosphere Map combination algorithms in 2003, the IGS final combination of TEC maps shows a good performance that is slightly better or even better than the individual IAAC maps, that justified our efforts to start producing the final iono product in April 2003.
- The rapid IGS TEC maps generation started, in testing mode, in December 2003 (latency less than 24 hours, as opposed to 11 days of the final product). The first maps (and DCBs) show a good accuracy (about 10% worse than the final maps) when 3-4 rapid IAACs TEC maps are combined.
- Regarding alternative weighting strategies:
  - The performance of the official weighting algorithm (bias insensitive) is similar to that using a bias-sensitive algorithm.
  - It is confirmed the best performance of external weighting strategies (presently used), compared with the internal weighting.
  - The performance between daily and independent map weighting seems very similar, including geomagnetic activity periods.

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Final Ionosphere product use (2003, from cddisa)

- 453 distinct IPs (hosts) downloaded IONEX files in 2003.
- 154,000 files donwloaded.
- 29 countries.
- Top "Non-IAAC" users (60% of files donwloaded from them, E=Education, C=Commercial, G=Government, N=Network):
- APL, US (E), TU, Vienna, Austria (E), NAO, Japan (E), CRL, Japan (G), CABLESPEED, U.S. (C/N), ENST-BRETAGNE, France (E), UWM, Poland (E), WAT, Poland (E), U.TRIESTE, Italy (E), NRAO, U.S. (E), STATE OF TENESSEE, U.S. (G), IGN, France (G), ISP, Russia (N), ALCATEL, France (C), ISP, S.Korea (N), U.MUNICH, Germany (E).
- 68% files donwloaded from "Non-IAAC" users.

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Some recommendations (updated from the splinter meeting)

•The use of the final IGS product is quite large. However for the rapid product, started in Dec.2003, very few downloads are registered from its temporarily server at UPC. In this context to promote its use, the next actions items have been adopted:

1.To send a new e-mail to the IGS e-mail list announcing the rapid product.

2.Moving the igs-iono e-mailing list to igscb.

3.Moving rapid product server from UPC to CDDISA.

•After receiving inputs from VLBI, Altimeter and Timing users, it has been decided:

1.To maintain the present generation of both final and rapid IGS TEC maps.

2.To include the list of GPS receivers used for timing in the list of IAAC used stations to compute the ionospheric product, in order to ensure IGS DCB estimations for such receivers.

•There has not been consensus between the IAACs on increasing the temporal, spatial resolution/densification of the present ionospheric products.

Thank you!

IGS Final Ionosphere ionex files at
ftp://cddisa.gsfc.nasa.gov/gps/products/ionex/

IGS Ionosphere WG download links at :
http://gage152.upc.es/~ionex3/igs_iono/igs_iono.html

You can find more details at the Position Paper.

Alternative weighting schemes (2)

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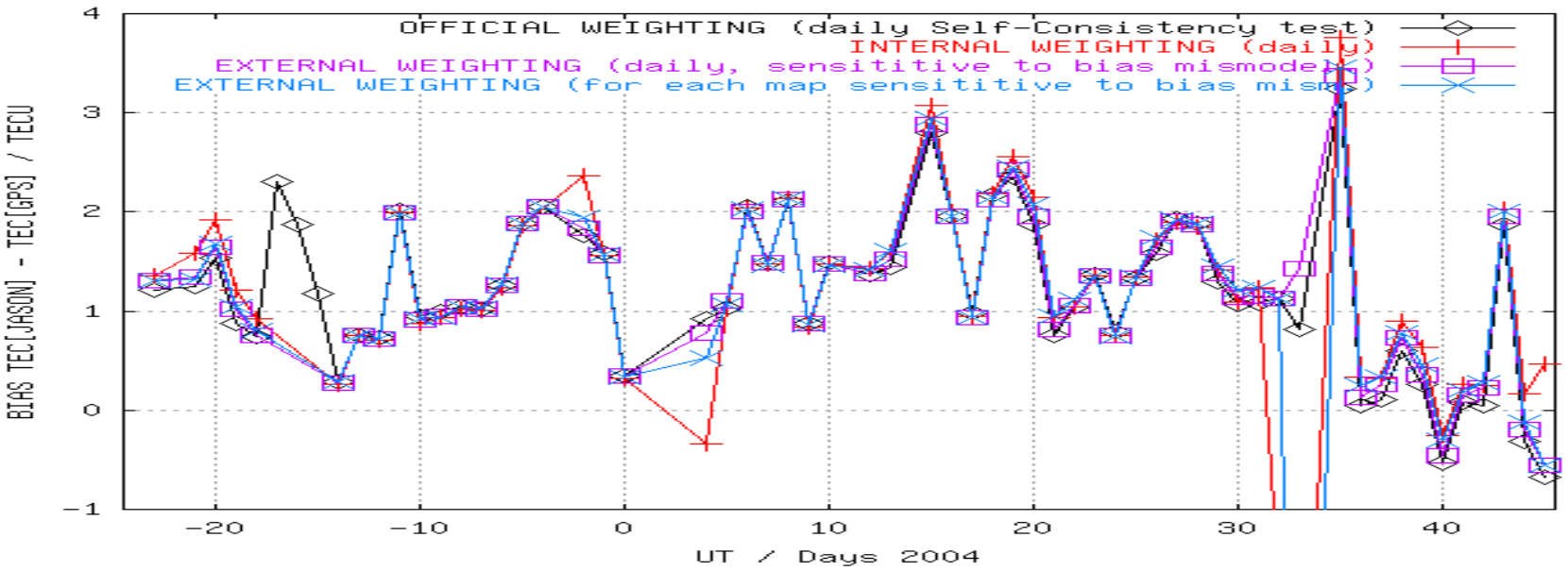

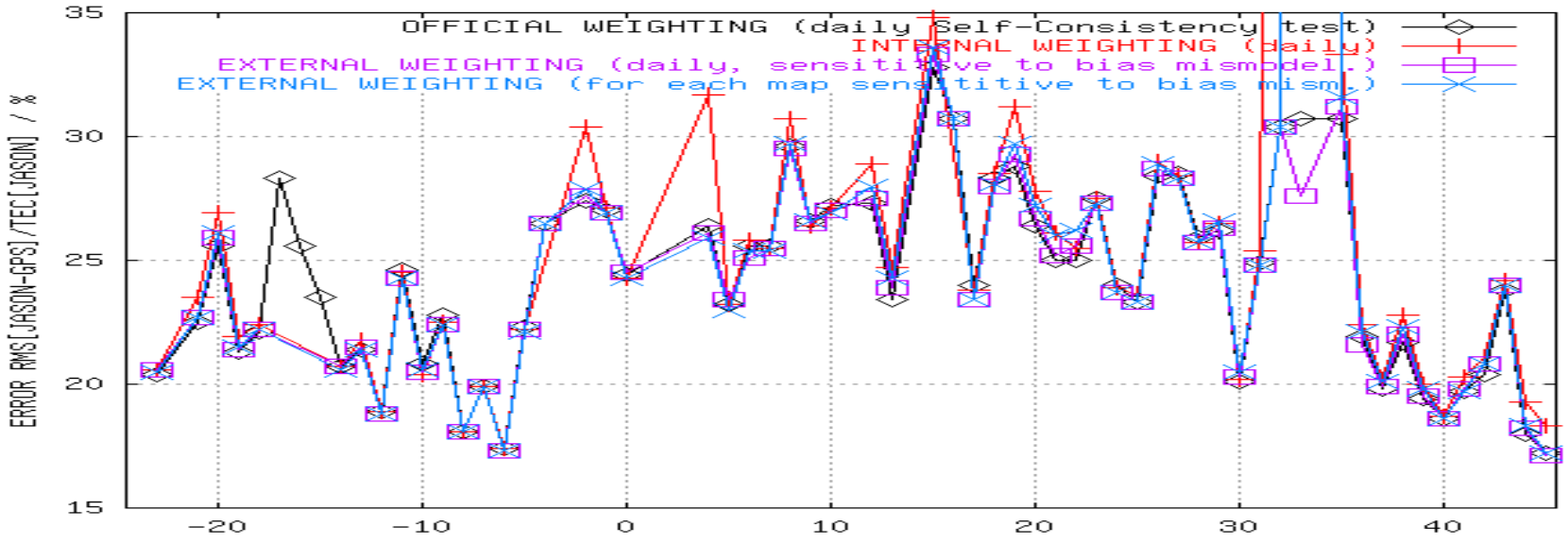

Previous results confirmed with bias and "relative error"

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IGS Ionosphere WG

- The IGS Ionosphere Working group started its activities in June 1998 with the main goal of a routinely producing IGS Global TEC maps (IGTEC).
- The IGS ionosphere product is a result of the combination of different Analysis Centers TEC maps by using weights computed from GPS data by Validation Centers, in order to get a more accurate product.
- Five Analysis Centers (CODE, ESA, JPL, NRCan and UPC) and 3 Validation Centers (JPL, NRCan and UPC) have been providing maps (at 2 hours x 5 deg. x 2.5 deg in UT x Lon. x Lat.), weights and external (dual-frequency altimetry-derived) TEC data.
- From such maps and weights the corresponding combination center (firstly ESA, and secondly UPC since Dec.2002) has produced the IGTEC in a standard ionex format.
- Since April 1st 2003 IGTEC is an official IGS final product (with latencies of about 11 days).
- The generation of a test rapid IGTEC (latencies of less than 24 hours) has started recently (mid December 2003).

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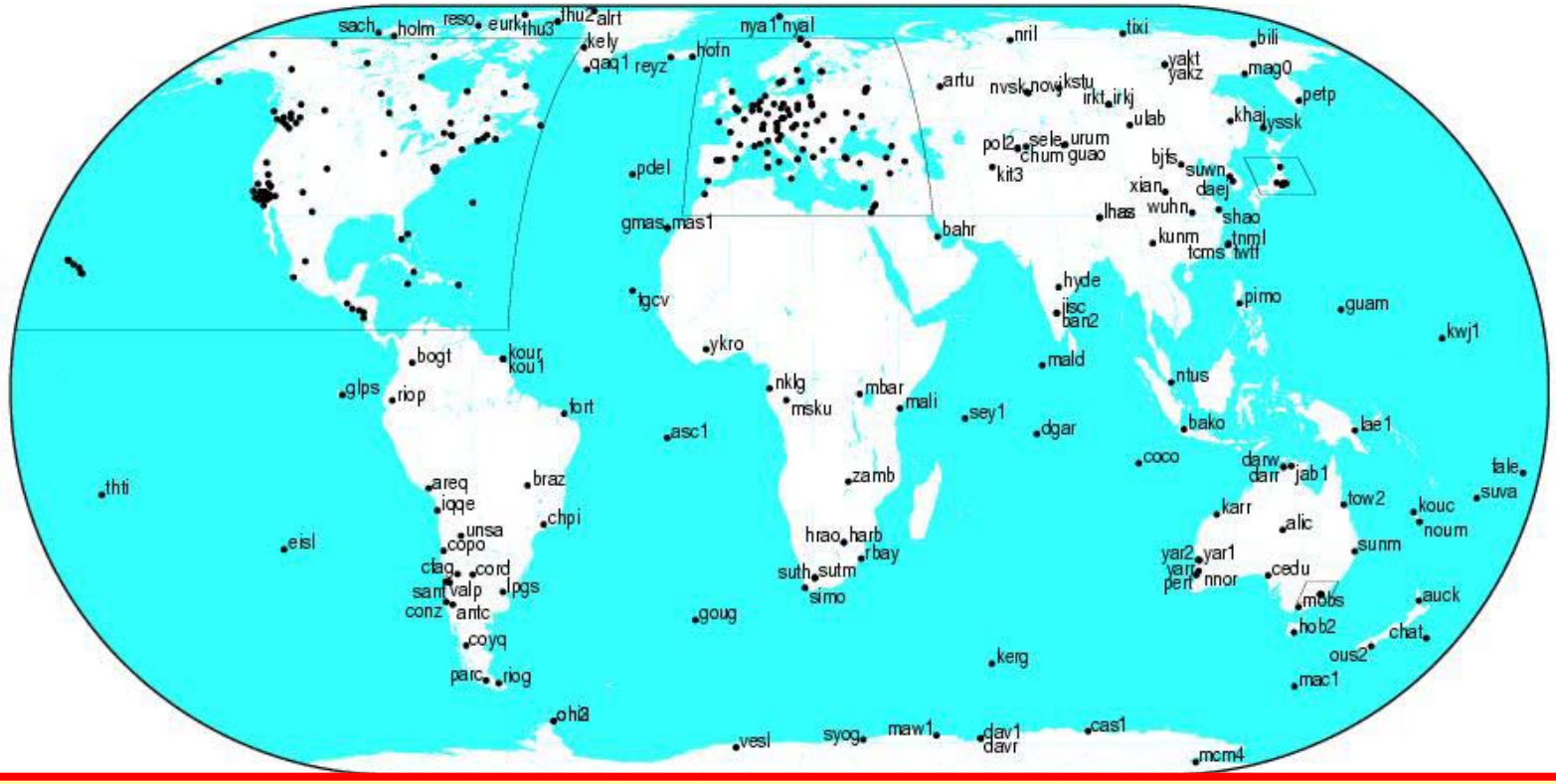
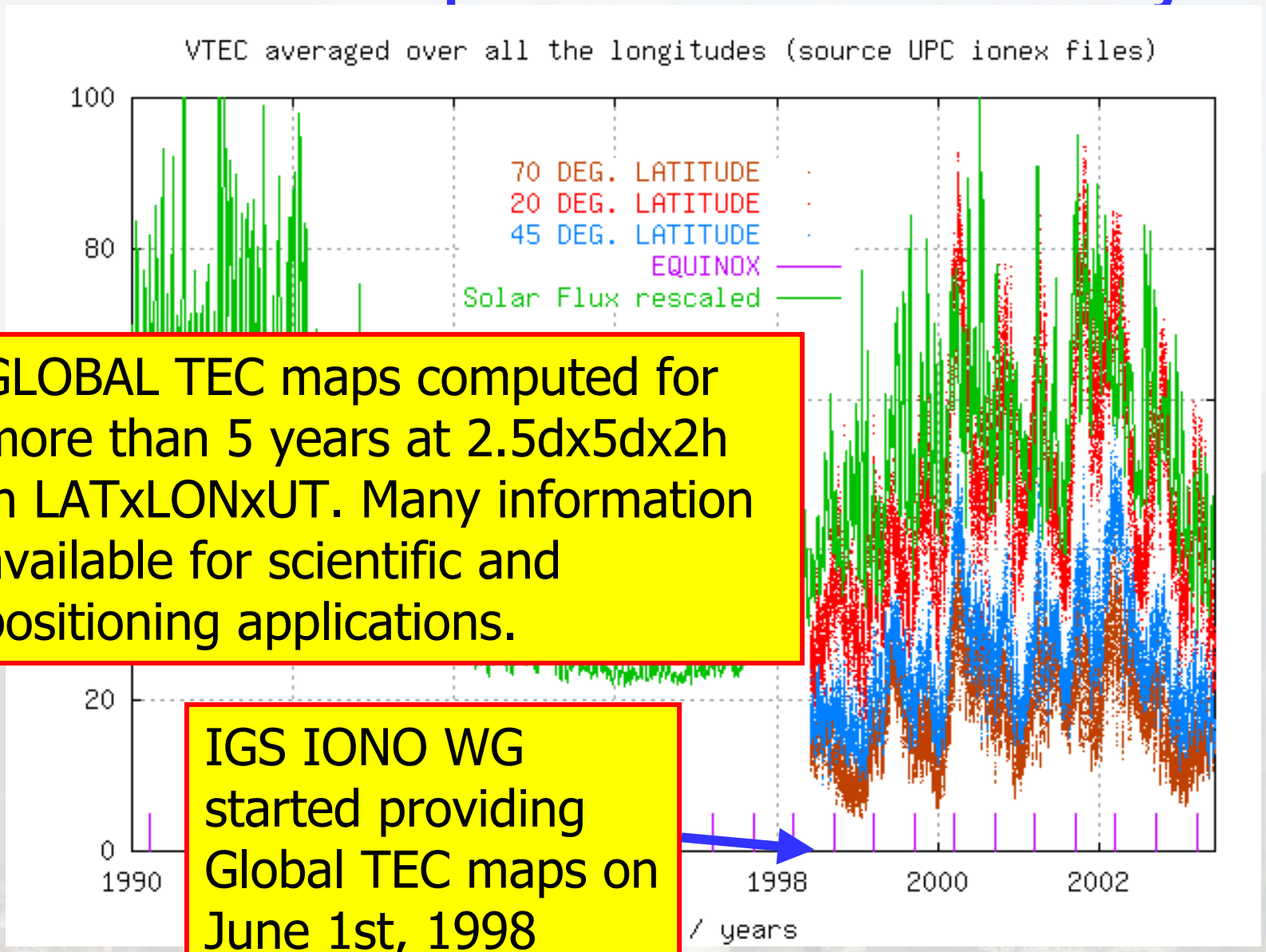
International GPS Service, IGS



GMT

IGS directly manages more than about 350 permanent GPS stations, observing some 4-10 satellites at 30 sec rate: more than 250,000 STEC worldwide observations/hour

Global TEC computed each 2 hours for 5 years



GLOBAL TEC maps computed for more than 5 years at 2.5dx5dx2h in LATxLONxUT. Many information available for scientific and positioning applications.

IGS IONO WG started providing Global TEC maps on June 1st, 1998

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Example of IGS Final TEC: 2003-347 shown each 6 hours

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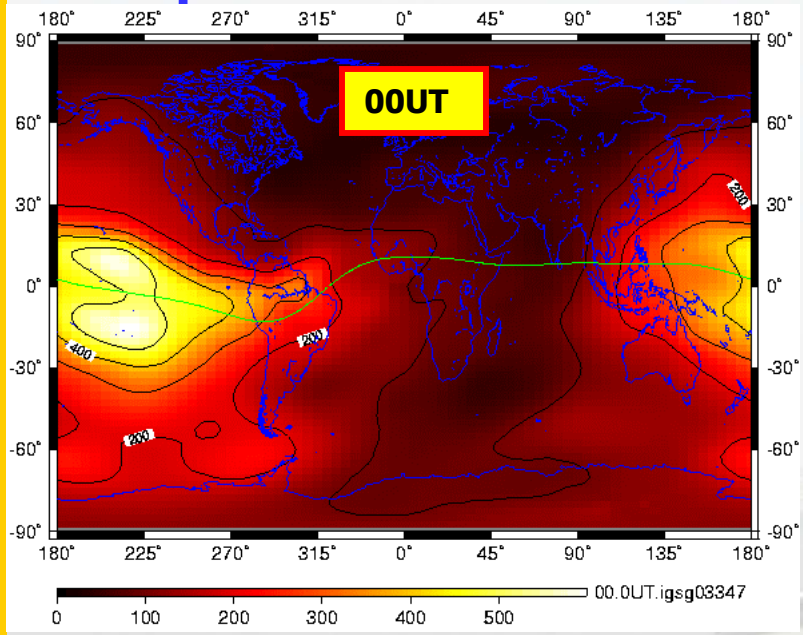
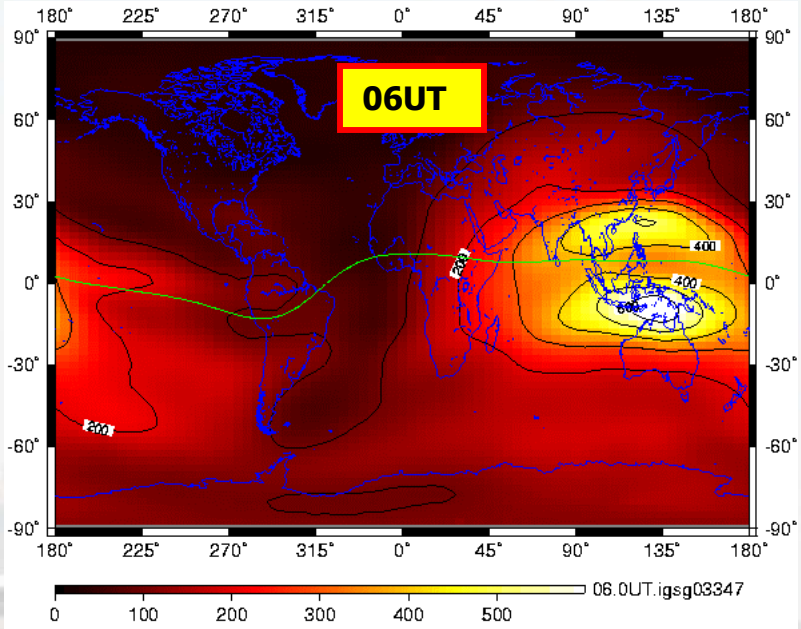
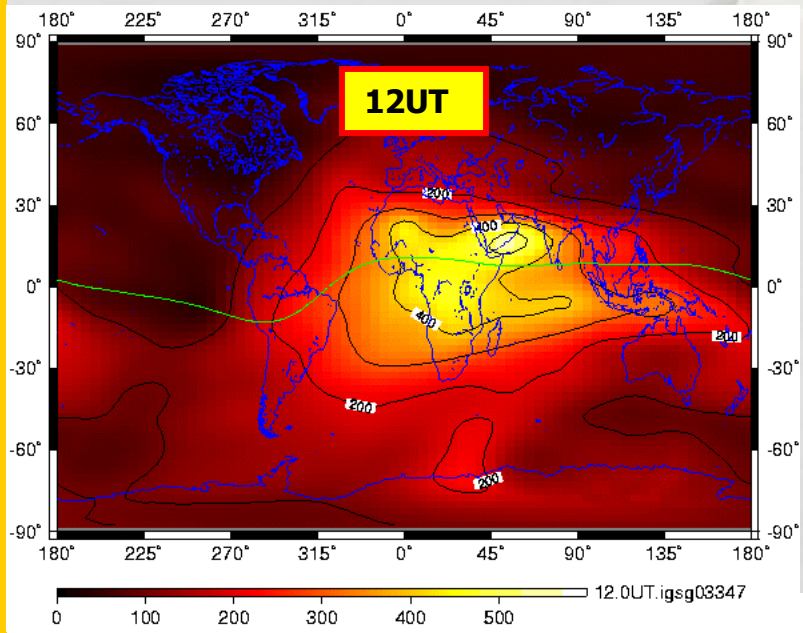
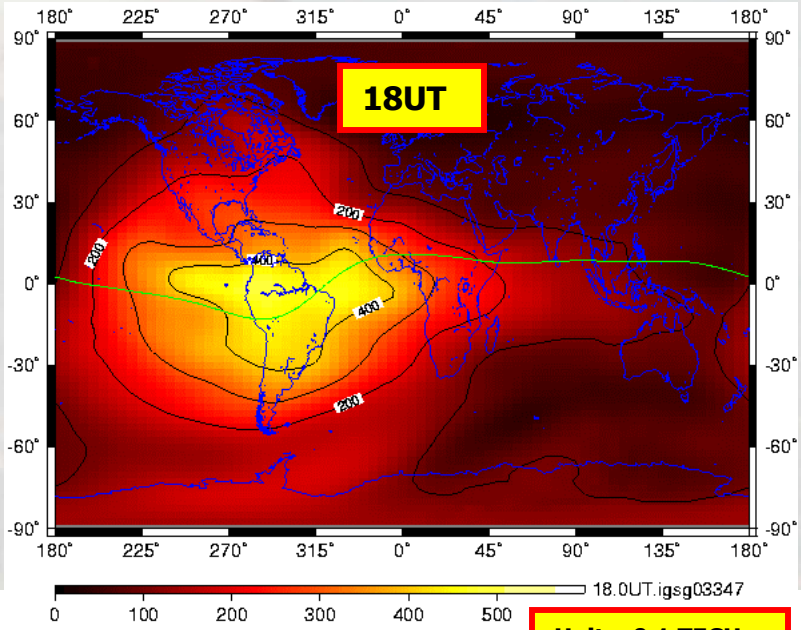


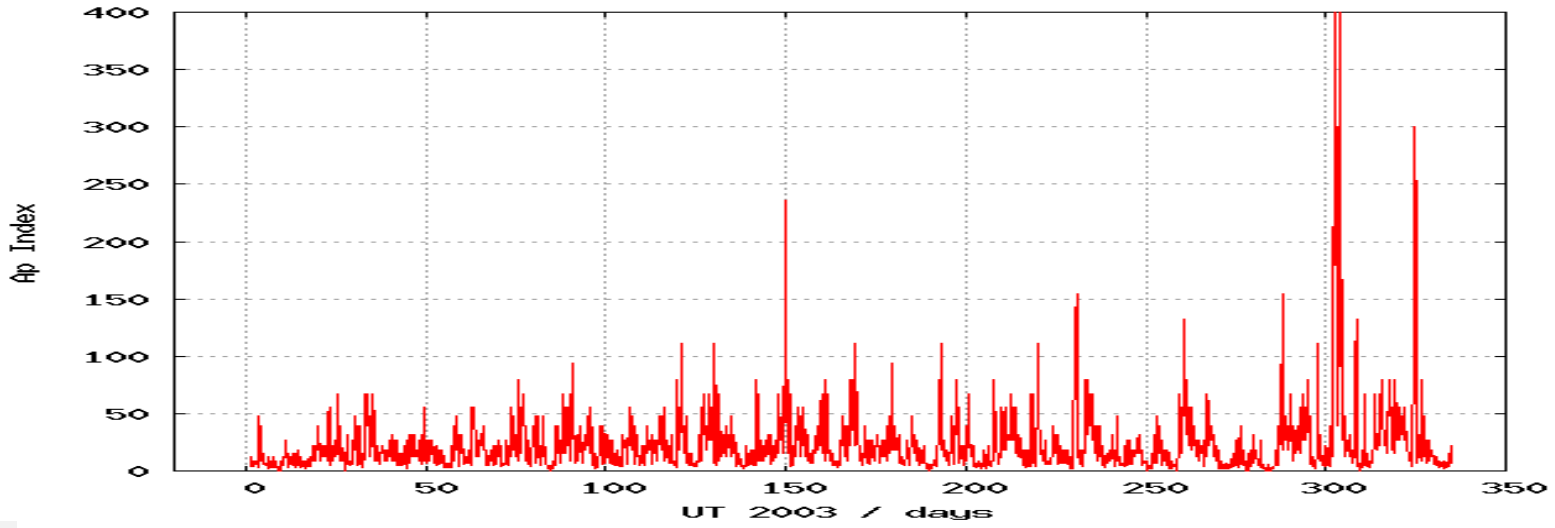


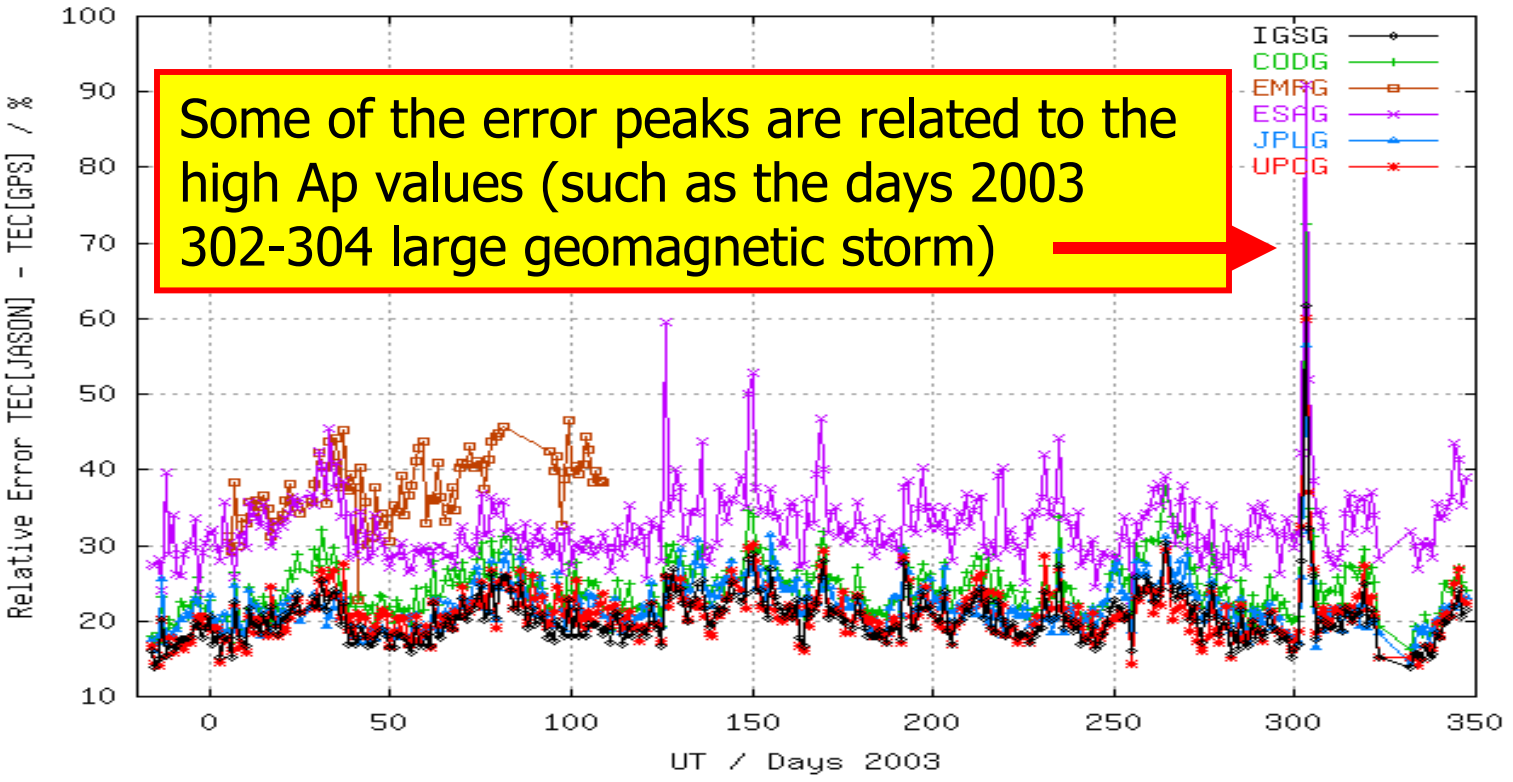




Units: 0.1 TECUs

Ap index vs. “Relative Error”





Some of the error peaks are related to the high Ap values (such as the days 2003 302-304 large geomagnetic storm)

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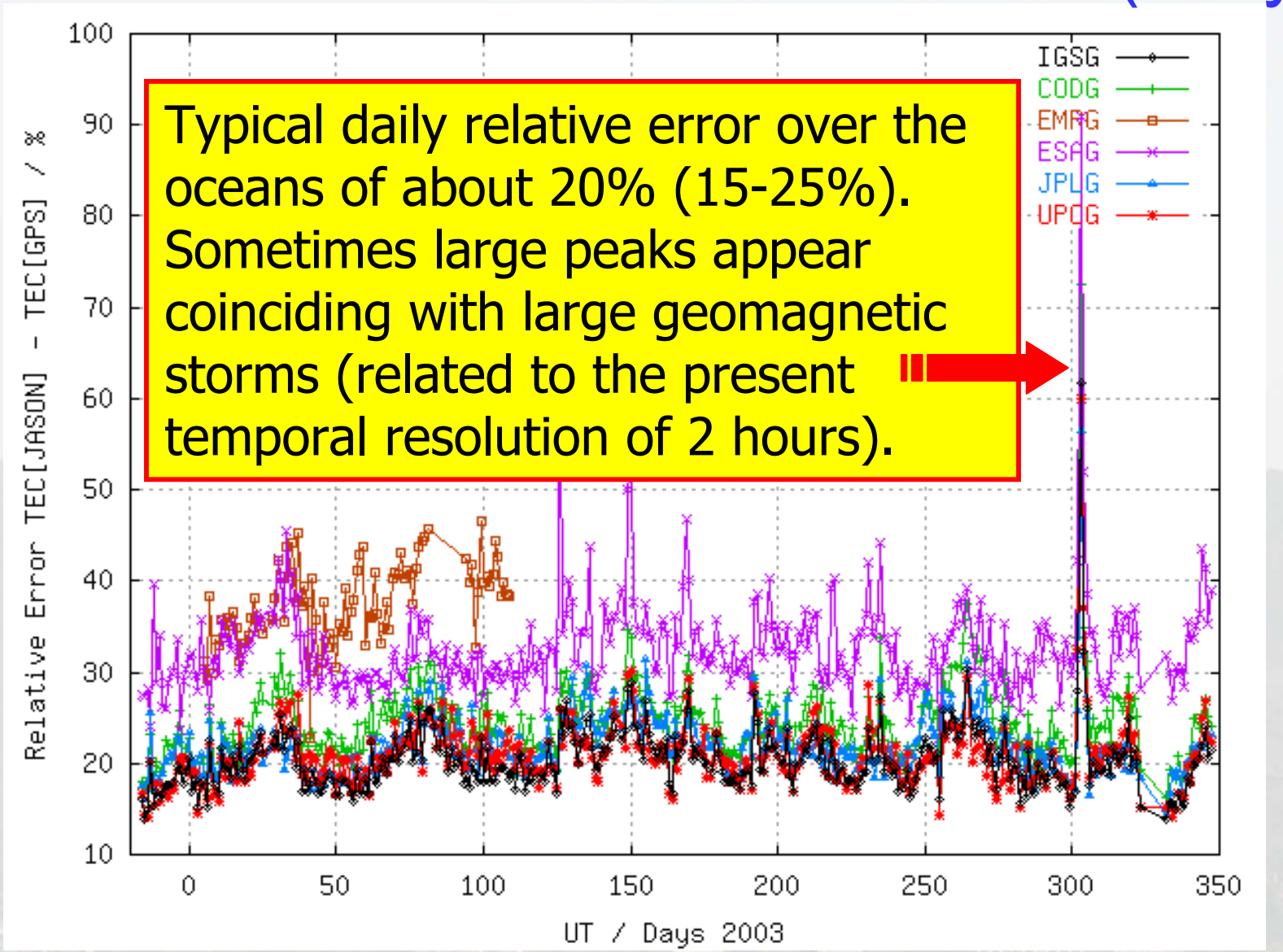
"Relative Error" vs. JASON (daily)



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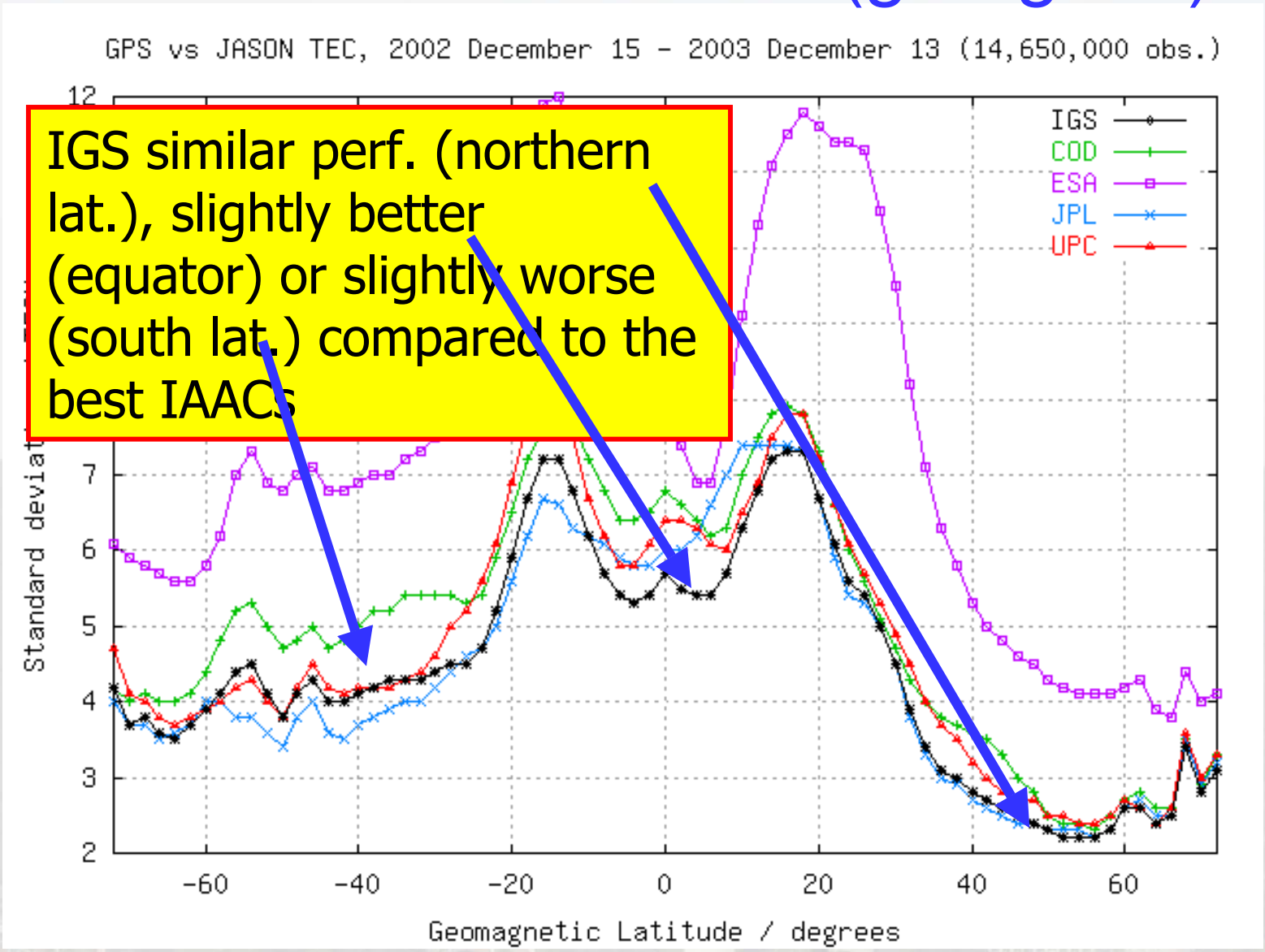
Std.Dev vs. JASON (gmag.lat.)



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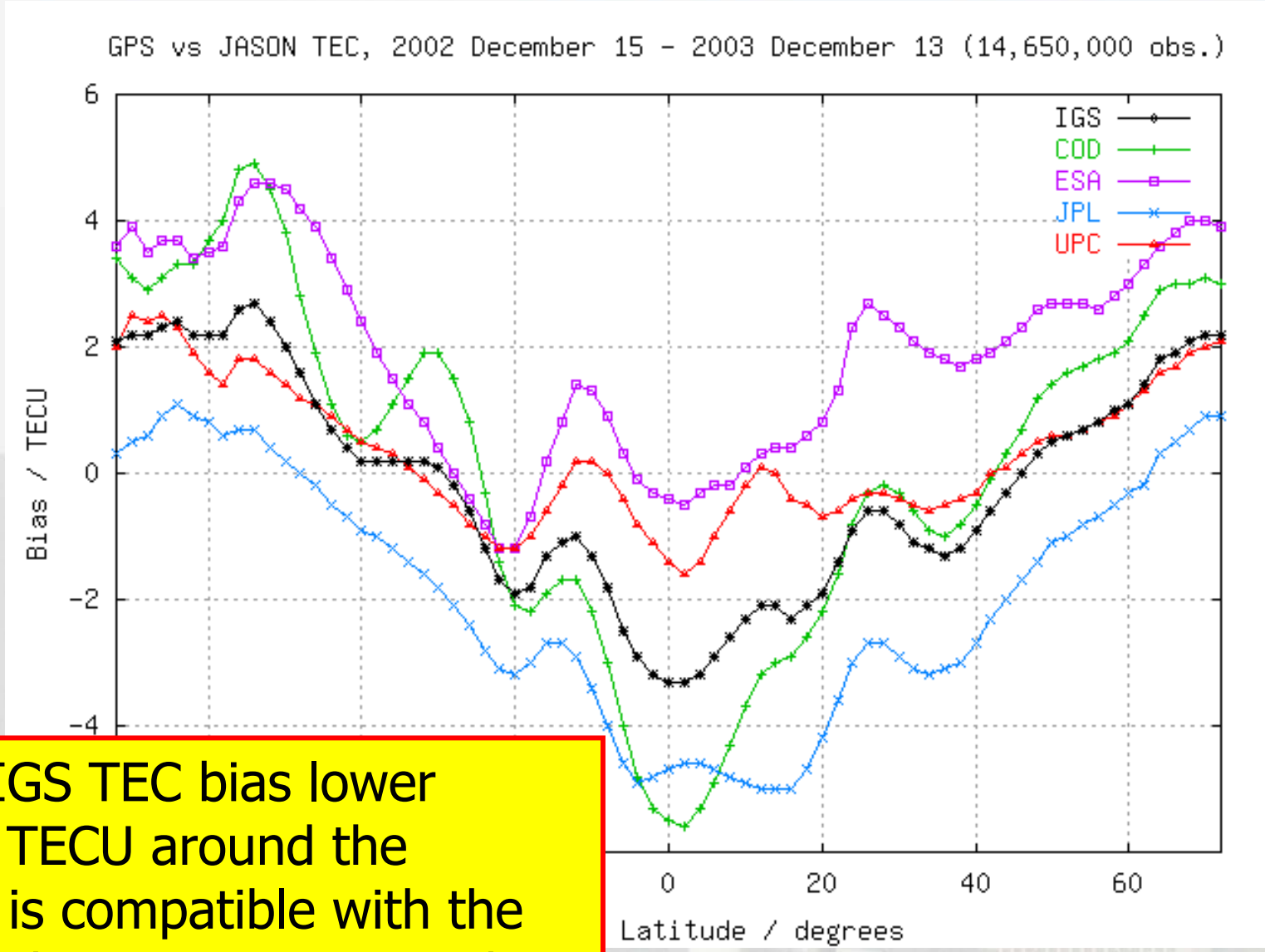
Bias vs. JASON (gmag.lat.)



JASON-IGS TEC bias lower about 5 TECU around the equator is compatible with the plasmaspheric component. The absolute bias ref. is still unclear

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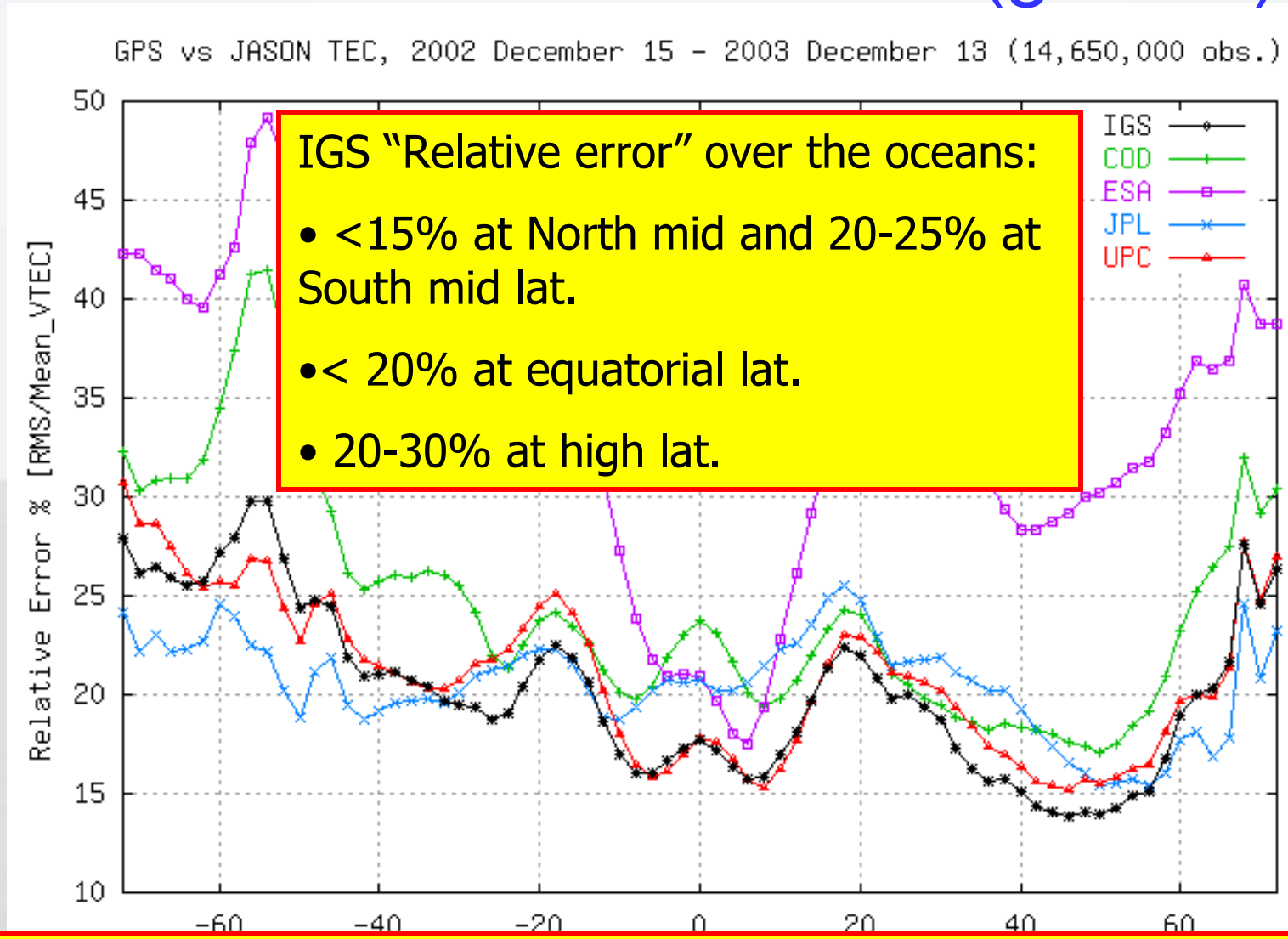
"Rel. error" vs. JASON(gm.lat.)



IGS "Relative error" over the oceans:

- <15% at North mid and 20-25% at South mid lat.
- < 20% at equatorial lat.
- 20-30% at high lat.

More performance details of the IGS final product (satellite and receiver DCBs, double dif. STEC, latency, with different data scarcity): **http://maite152.upc.es/~ionex3/doc/IGS_IONO_report_April2003_7.pdf**

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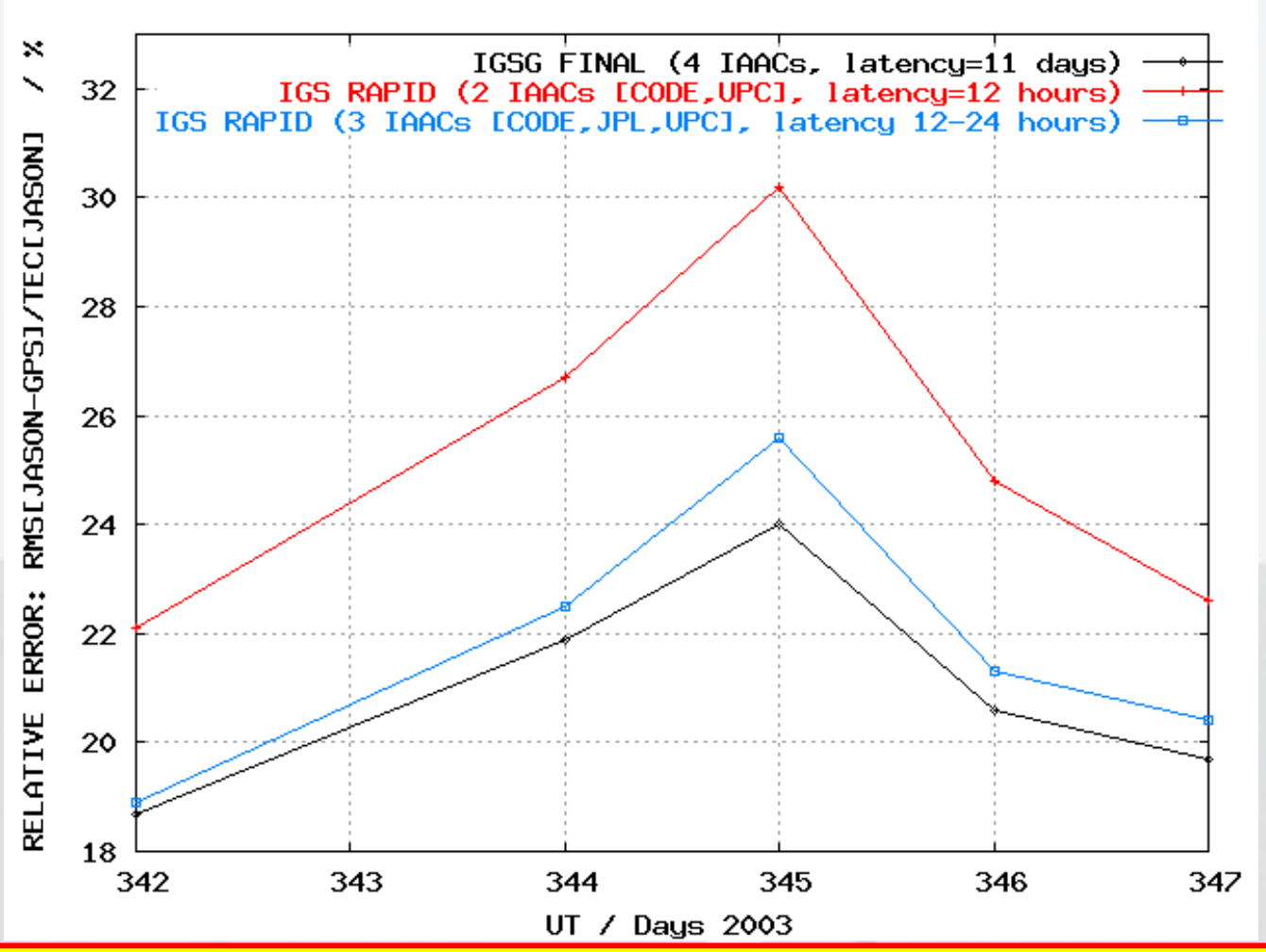
First results of the IGS Rapid Ionosphere



IGS rapid product (blue line) is just 2-5% worse than the final product (black line) during the 4 first common days of both products.

There is an improvement of about 15% (from about 26 to 22% of relative error) passing from Rapid IGS with two IAACs with a latency of 12 hours (red line) to 3 IAACs with a latency of 12-24 hours (blue line).

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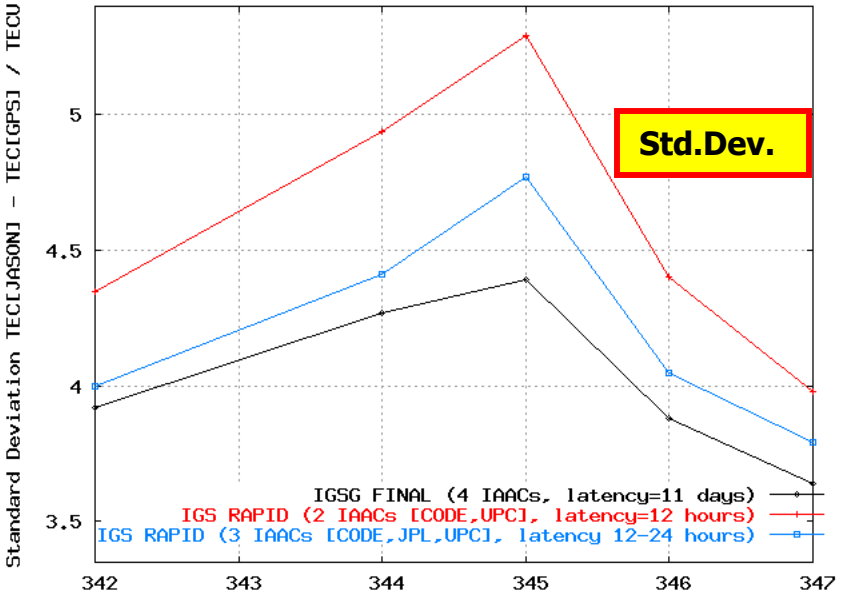
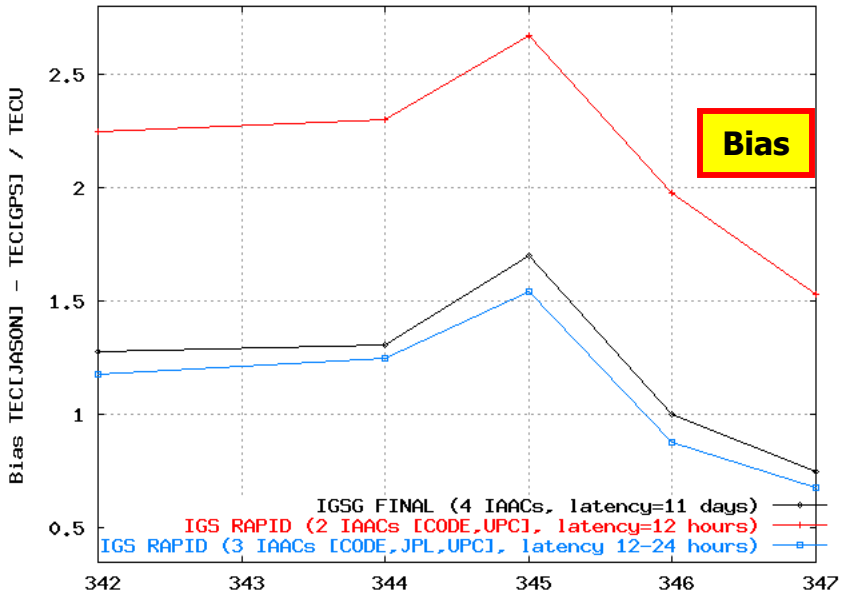
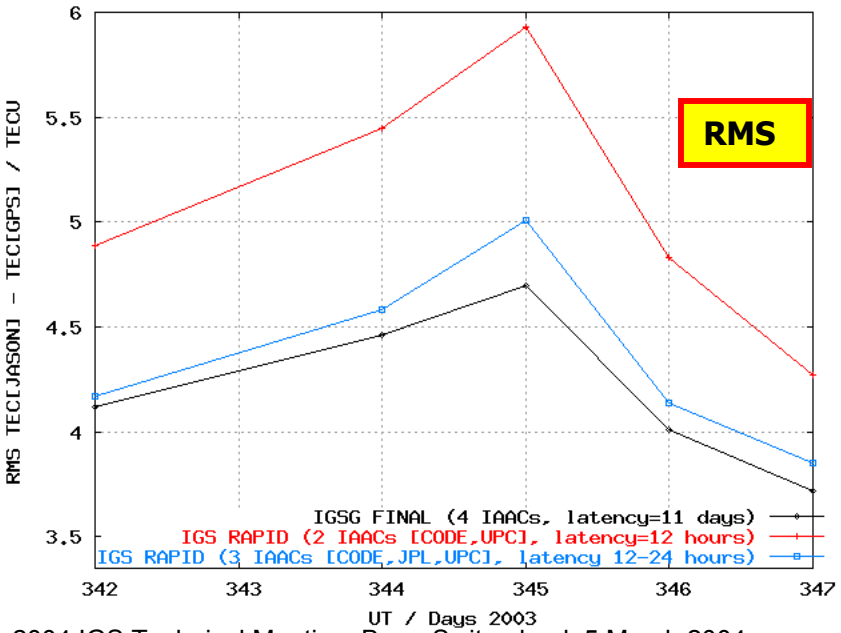
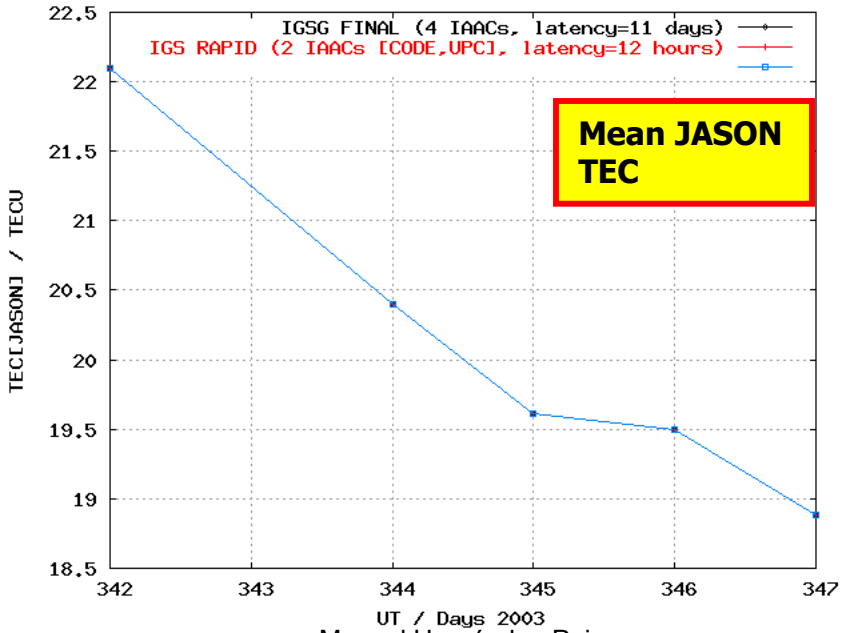
First results of the IGS Rapid Ionosphere



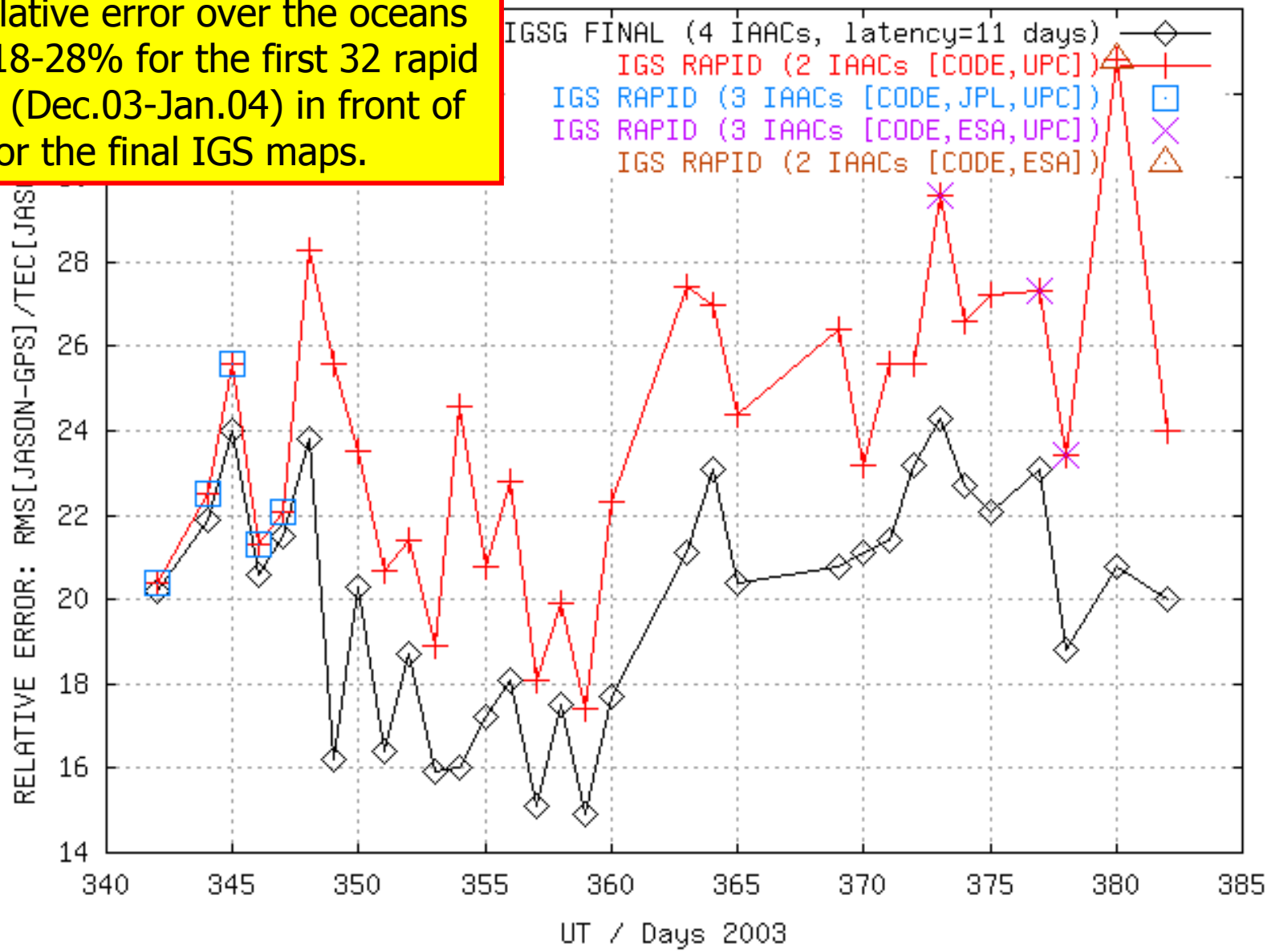






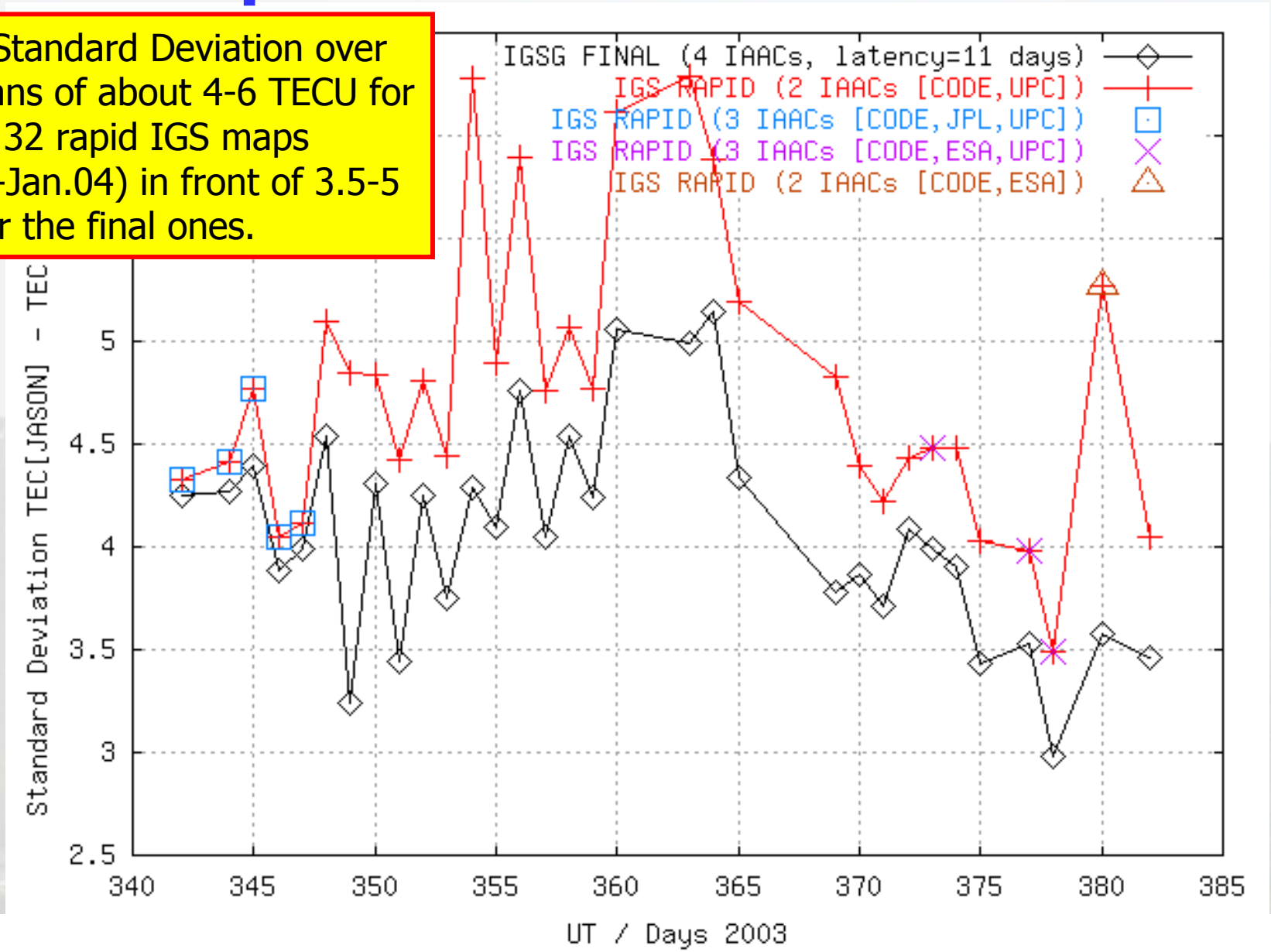
Rapid "Relative Error" vs. JASON

Typical relative error over the oceans of about 18-28% for the first 32 rapid IGS maps (Dec.03-Jan.04) in front of 15-24% for the final IGS maps.



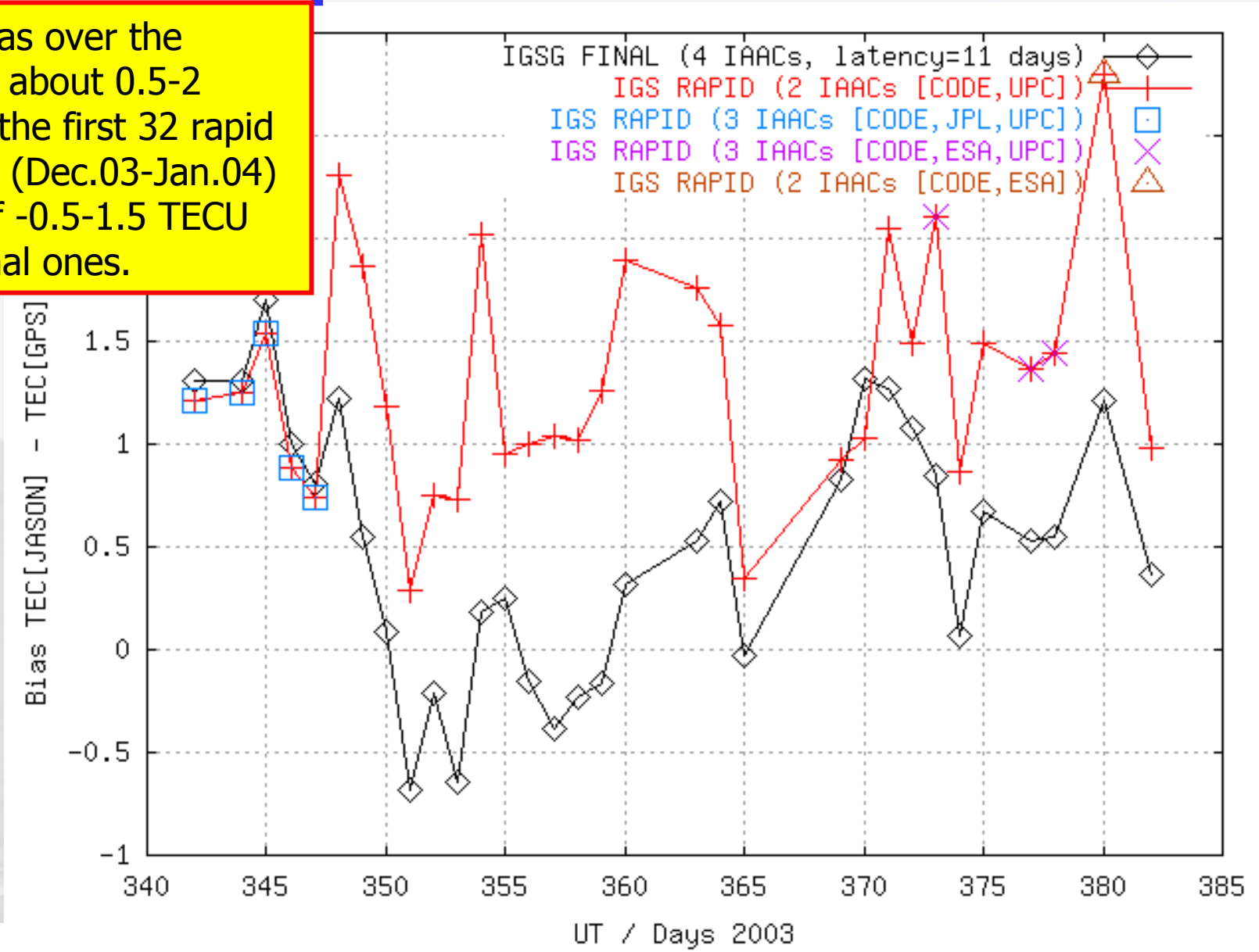
Rapid Std. Dev. vs. JASON

Typical Standard Deviation over the oceans of about 4-6 TECU for the first 32 rapid IGS maps (Dec.03-Jan.04) in front of 3.5-5 TECU for the final ones.



Rapid Bias vs. JASON

Typical Bias over the oceans of about 0.5-2 TECU for the first 32 rapid IGS maps (Dec.03-Jan.04) in front of -0.5-1.5 TECU for the final ones.



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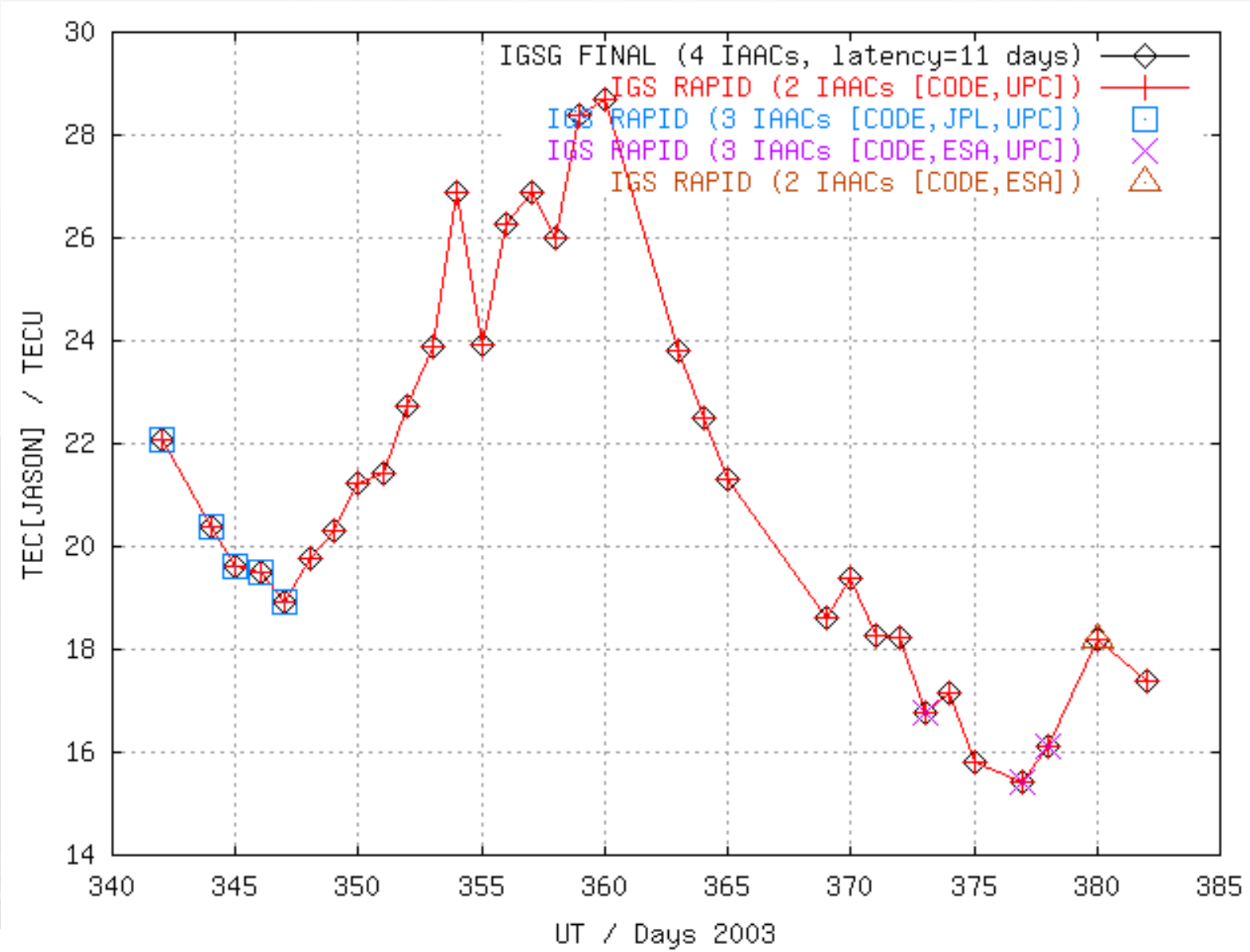
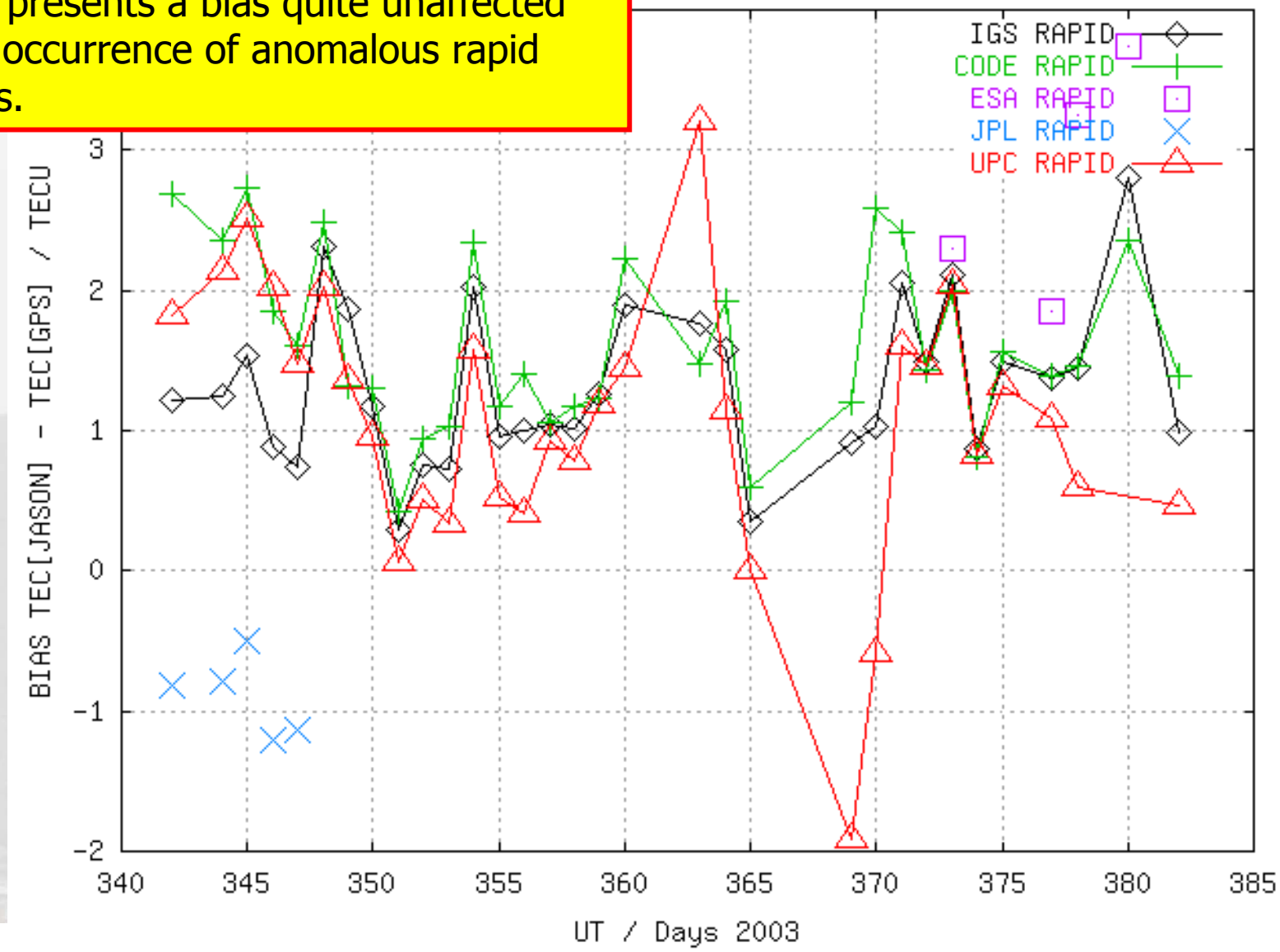
JASON daily TEC



Rapid Bias

Rapid IGS presents a bias quite unaffected under the occurrence of anomalous rapid IAAC maps.



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Rapid Std.Dev.

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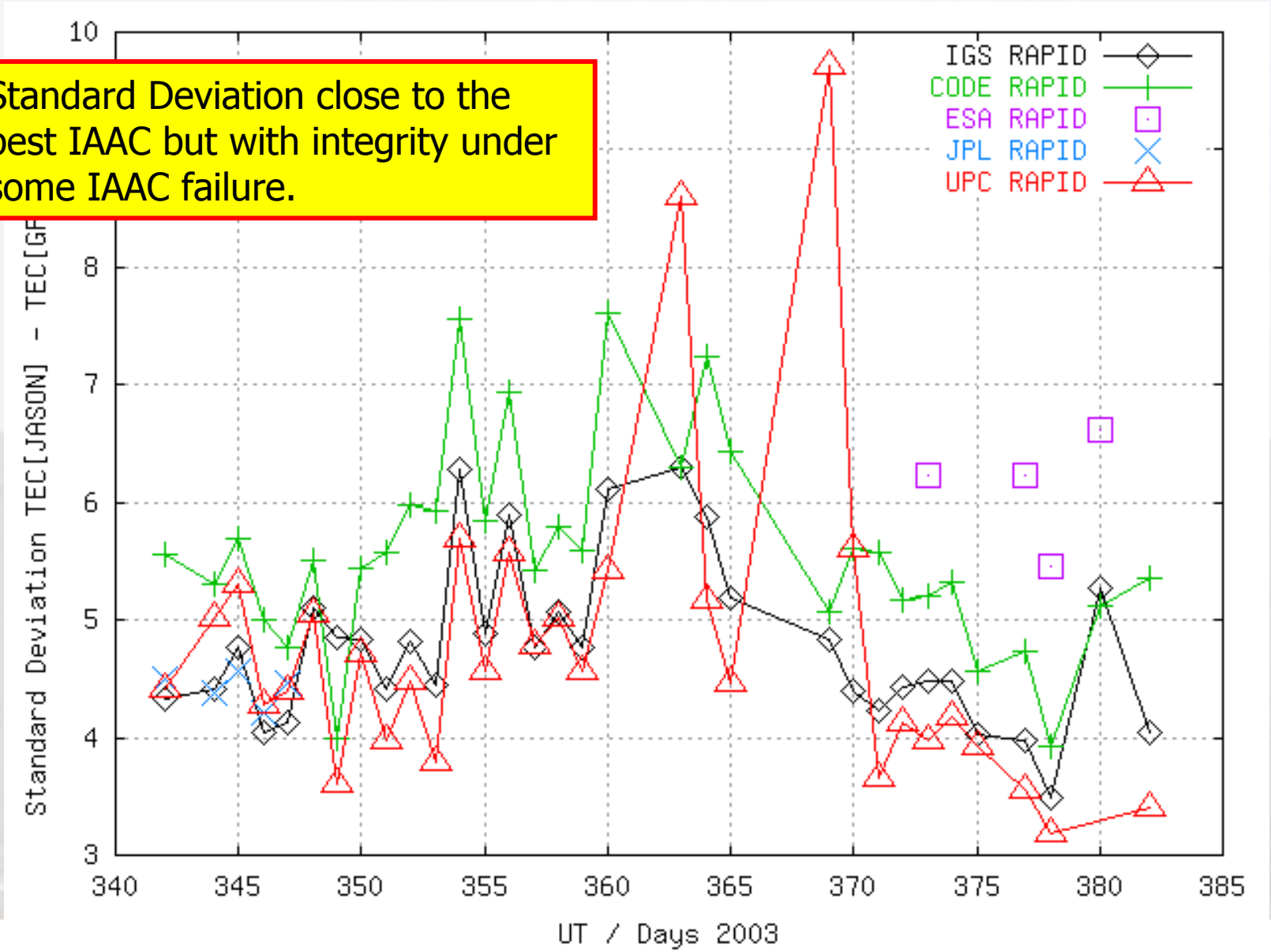
Standard Deviation close to the best IAAC but with integrity under some IAAC failure.



Rapid IGS TEC "Relative Error"

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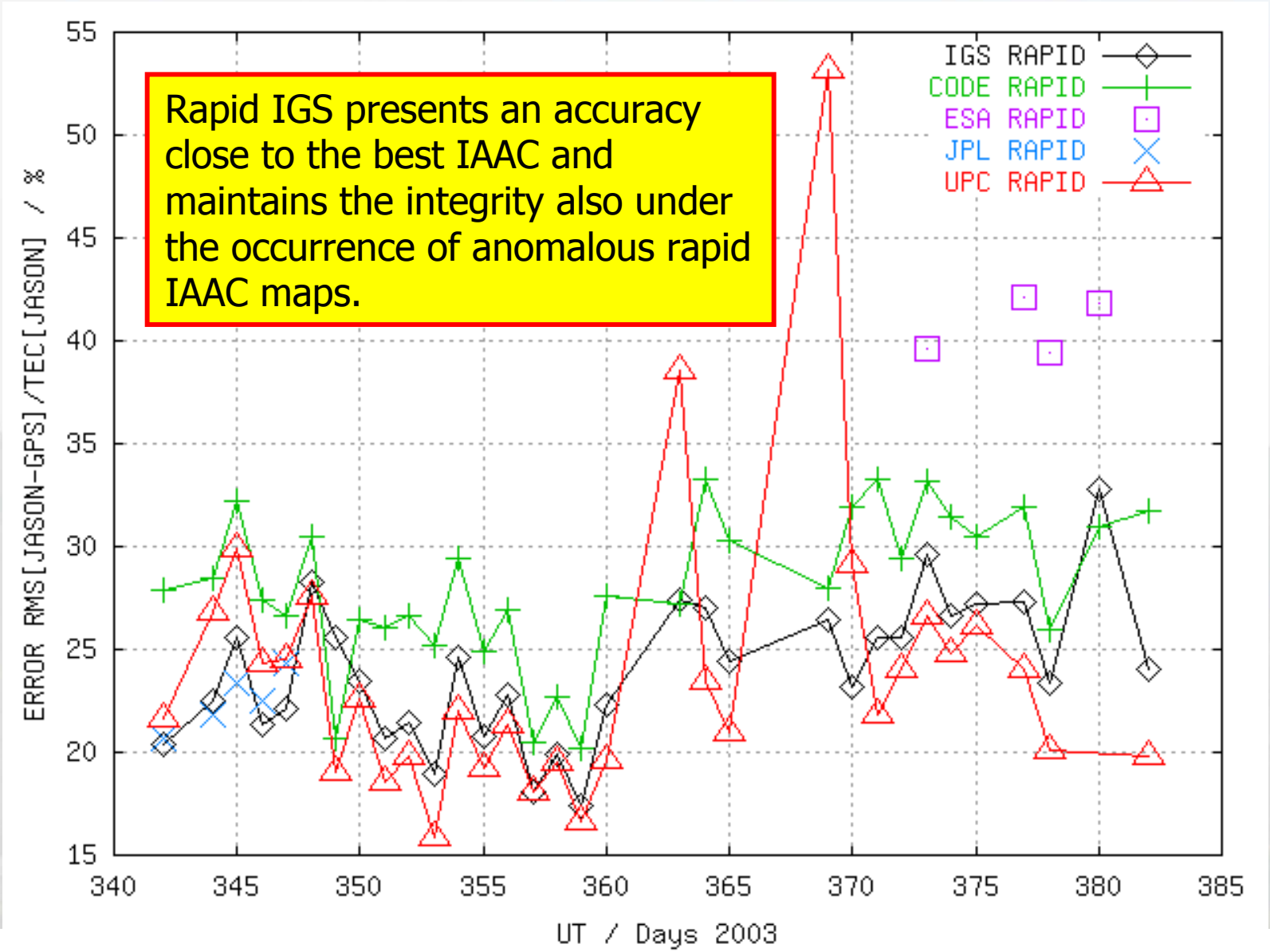

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Std. Dev. vs JASON and # GPS Stations