IGS Tropospheric Products and Services at a Crossroad

Position paper for the March 2004 IGS Analysis Center Workshop

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This position paper addresses two issues that are facing the IGS tropospheric community. These are: changes to the IGS Combined trop products, and the challenges of calibrating the many met packages in the IGS network.

Issue #1: Needed changes to the IGS Combined trop products

The IGS currently produces two trop products: Final, with latency of several weeks, and Ultra-Rapid (UR), with latency of 5-6 hours (relative to the oldest data point). The quality of both products is good, quoted at 4 mm for the Final product, and 6 mm for the UR product (based on inter-comparison among the contributing solutions). Both these products are derived through a complex procedure that combines individual solutions from several Analysis Centers (ACs).

Both products have been available in their present form and quality for several years.

The problem I see with these products is lack of users. Yes, there are occasional visitors who sample the products, but I know of no regular scientific or operational usage of these products. The contributing ACs are not using the products either, which indicates their disinterest not only in the Combined products, but also the combination process and its derived relative quality metrics for their contributions.

I do not think that the IGS should produce products that are not widely used, especially in light of the cumbersome and costly production process. As the new Tropospheric Product Coordinator I quickly realized the significant costs associated with the transfer, monitoring, and maintenance of the present combination process from JFZ, where it was developed over several years by Gerd Gendt.

We should figure out why our trop products are not used, and make the necessary adjustments. At the same time we should strive for an efficient, portable production, so as to optimize the cost-benefit ratio.

So why are the products not used, despite their fairly high accuracy?

The following are my speculations:

1. The scientific value of the Final product is in climatology, as there are no direct operational usage for this low latency product. Here the product is hurt by lack of consistency over time. As contributing ACs change their estimation strategy from time to time (e.g., different elevation angle cutoff, antenna phase maps), the combined product develops spurious ‘climatological’ signals. The product availability extends only a few years back, and there is no way to backfill without major coordinated effort from all ACs.

Required adjustment: the IGS Final trop product must be consistent in time, and must be easily regenerated, and backfilled when a better estimation strategy is available

2. The Final and UR products may not be sufficiently accurate, as they depend on a rather uneven set of solutions. Indeed, the distribution of the internal quality control metric, the standard deviation among the contributing solution, is quite broad (Fig 1,2).

   Required adjustment: the IGS Final ad UR trop products should be more consistently of higher quality

3. The integrity of the Final and UR products is compromised because the only quality control metric is based on inter-comparisons among the contributing solutions, which may have common error sources. Too often there are not enough contributed solutions for a given site, resulting in unrealistically low, or effectively non-existent (zero) sigma. (See Figs. 1,2)

   Required adjustment: develop a product for which formal errors can be rigorously derived from input. Periodic campaign will validate performance through inter-comparisons with other solutions and techniques.

4. Too few sites in either the Final or the UR products due to relatively small subset of common sites in all AC's contributions. This diminishes the scientific and operational benefits from these products.

   Required adjustment: The IGS trop product must be available for nearly every site in the IGS network.

5. The UR product is too late for weather forecasting operations.

   Required adjustment: to be useful in operational weather forecasting the product must be at most 3 hours late.

6. Reluctance of operational weather services to rely on external voluntary organization for critical operations. This common attitude is enhanced by the (correct) perception that it is not particularly challenging to generate good trop solutions.

   Required adjustment: None.

In response to these perceived problems I am proposing a new type of IGS combined tropospheric product that, in my opinion, offers significant quality and operational advantages compare to the present products. I am proposing to replace the existing products with these new products for a specific period of time, nominally two years. At the end of this period we should assess the success of these new products, and consider whether to continue productions, make adjustments to the products, or cease to production altogether.

The proposed new product is completely independent of individual contributions by the ACs. However, it rightly earns its 'IGS Combined' designation because it is derived from the IGS Combined GPS orbit and clock solution, which together with Rinex files from each site, form the input to a point-positioning-based trop estimation process. The key to its quality and robustness is the use of the extremely accurate and reliable IGS combined GPS orbit and clock solutions.

The process to derive the new product has been operational since September. For the time being only the new 'Final' products, derived from the IGS Final Combined GPS orbit and clock solutions are produced. These can be retrieved from ftp://sideshow.jpl.nasa.gov/pub/igs_trop. In a poster presented at the December AGU meeting in San Francisco (attached) we compared this new product to the current product, and discussed its many advantages. Here is a short summary of these advantages:

1. Highly efficient point-positioning-based approach enables massive production of solutions to practically all IGS stations. We plan on processing effectively every site in the IGS network (more than 300 sites per day).
2. Uniform estimation strategy insures long-term stability of the product, which is of critical value to climatology studies. Reanalysis is also easy, and years of products can be regenerated if better estimation strategy emerges. Reanalysis can start right away to establish a long and consistent time series.
3. More accurate and more robust than the legacy product (Fig. 3).
4. Better quality control and high integrity through many rigorous metrics, such as formal errors, post-fit residuals, and site position repeatabilities.
5. Arbitrary temporal resolution (up to the resolution of the Rinex file). The nominal resolution of the new product is 5 minute (the resolution of the legacy product is 2 hours).

Since the ACs have never shown interest in using the IGS combined trop combination process to assess the quality of their own solutions (indeed, it is not a very informative comparison), the elimination of the inter-comparison statistics would not be noticed. Moreover, since it is more consistently accurate, the new product is far more suitable for quality comparison by the AC's (or anybody else), and I expect to see increased usage of the new product for this purpose.

External quality assessment is essential for any operational product. In this case I propose frequent inter-comparisons with similarly derived solutions from other software packages. Most important are periodic campaigns (nominally annually) to compare the solutions with collocated WVRs and Radiosondes. Of course, if they are so inclined, ACs can inter-compare their own point-positioning-based solutions to the Combined solution, or submit their solutions to the coordinator for comparisons.

To similarly derive a new UR product would require reduced latency for the IGS Combined UR orbit and clock product. This will be discussed separately at this workshop. Until this product is in place I recommend discontinuing the formal production of the current UR trop product.

Summary of recommendations:

1. Replace the current IGS Final trop product with a higher quality, higher efficiency Final product based on the IGS Combined orbit and clock solutions
2. Discontinue the current IGS UR trop product for lack of use
3. Reduce the latency of the IGS UR orbit and clock product to 2 hours
4. Produce new IGS UR trop product based on the 2-hour latency IGS UR orbit and clock solutions

Issue #2. How to manage the many met packages around the world.

There are roughly 70 meteorological sensors in the vast IGS network. These precision instruments emerge from the factory calibrated to better than half a mbar, and are certified to remain calibrated for three years, typically. Left uncalibrated for more than three years, a met package becomes less than useful, as its data can contaminate precipitable water vapor measurements derived by combining surface pressure with GPS data.

Ensuring calibration of the various met packages in the IGS network is a logistical and financial challenge for all the responsible agencies. I have looked into several options to pool our resources together in order to realize efficiencies in managing the met sensors, and increase the meteorological and climatological value of the network.

I have received cost estimates from Paroscientific for calibration services as well as reference met sensors, which I will be happy to share with any interested party. At this stage I would like to receive expressions of interest from the relevant networks, and assess the scope of the challenge so we can begin a discussion of the possible solutions.

Please refer to ftp://sideshow.jpl.nasa.gov/pub/yeb/met_sites for a table that I extracted from the site log files, describing the sites, the type of met sensors, and the calibration status. It is clear the vast majority of met sensors have never been calibrated in the field.

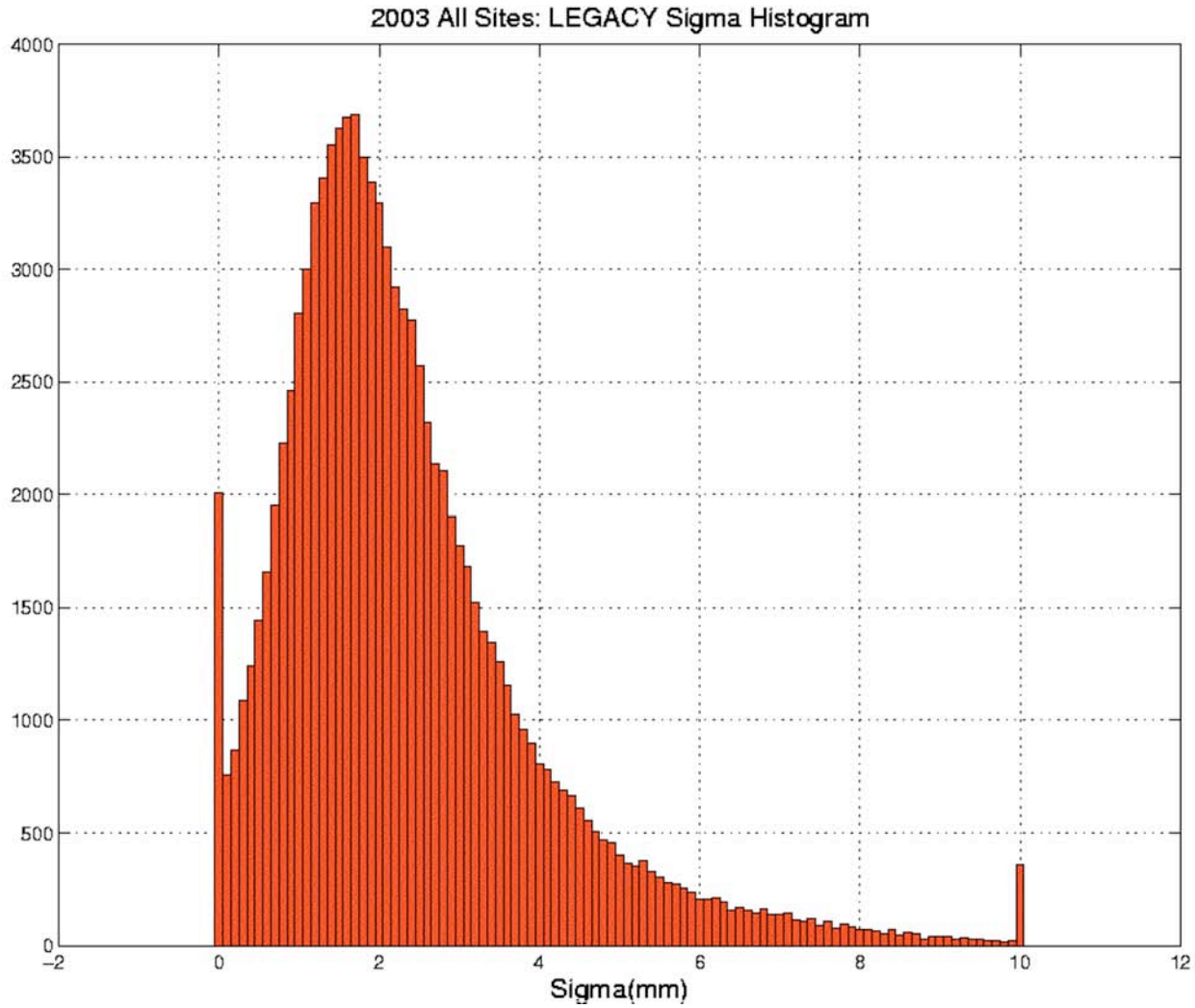

Fig 1. Histrogram of the formal errors reported for the current Combined Final trop solutions. The histogram was generated using all site solutions for 2003. Zero sigma is reported when only one solution is contributed for a given site.

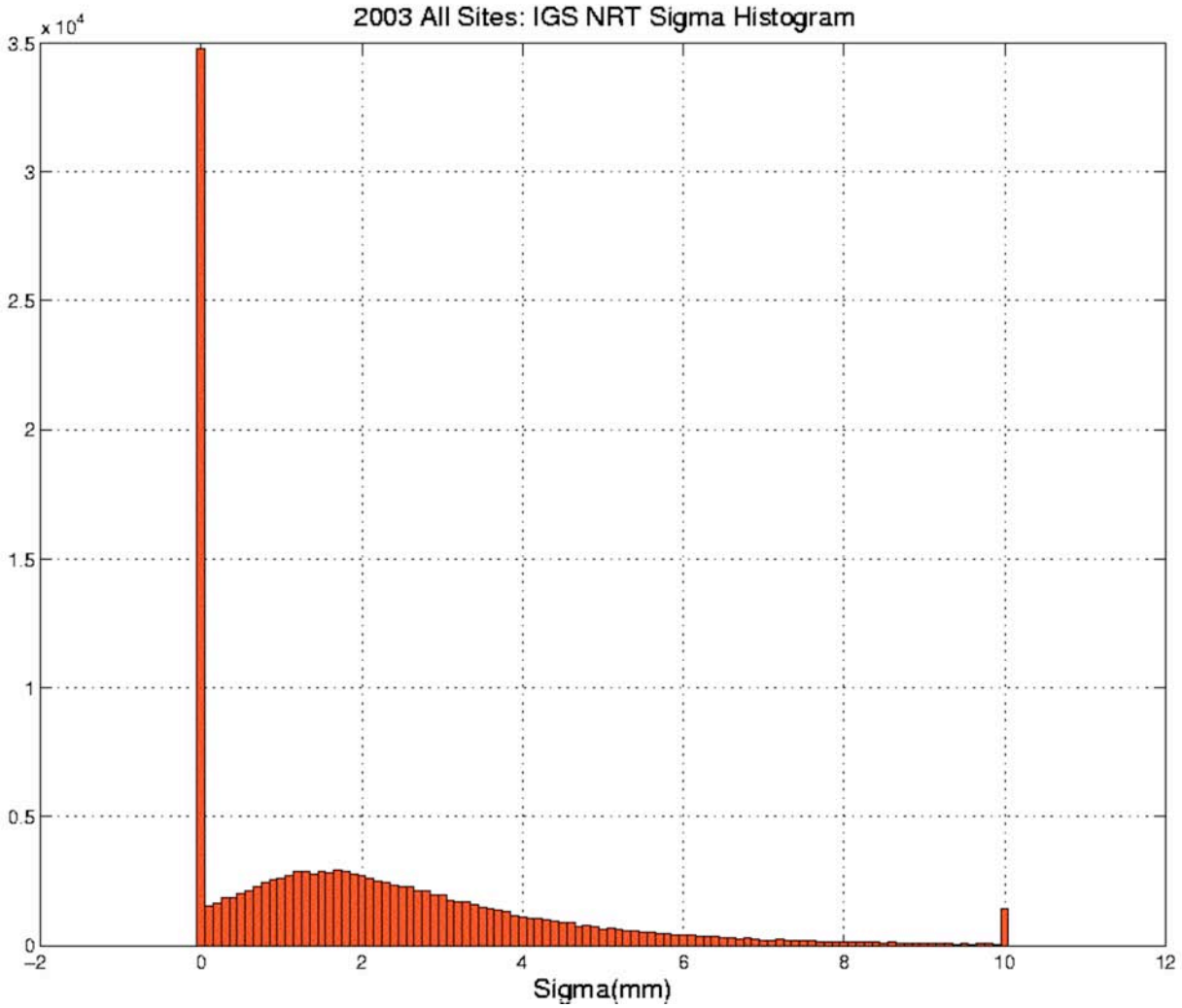

Fig 2. Histrogram of the formal errors reported for the current Combined Ultra Rapid trop solutions. The histogram was generated using all site solutions for 2003. Zero sigma is reported when only one solution is contributed for a given site.

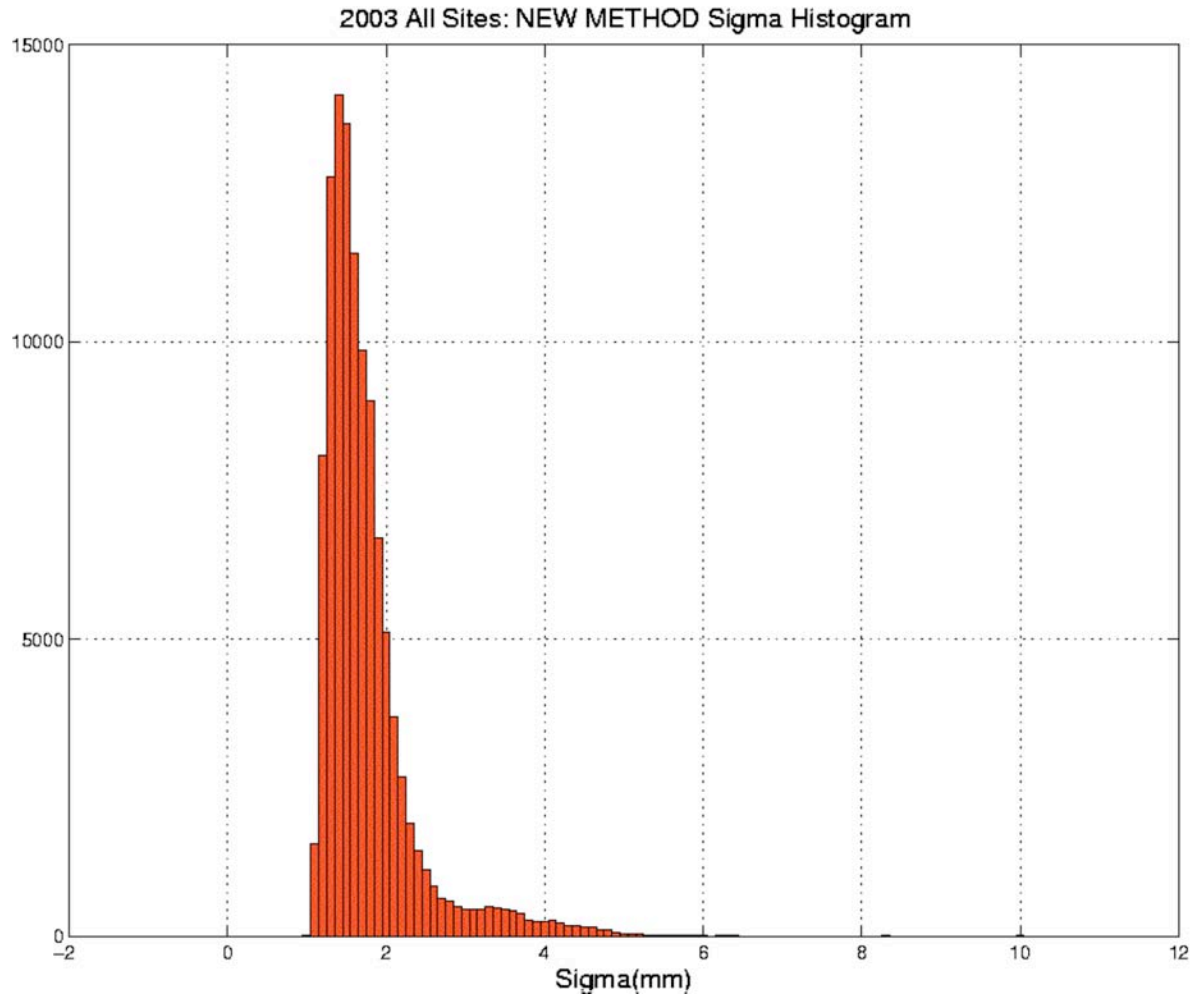

Fig 3. Histrogram of the formal errors reported for the proposed new Combined Final trop solutions (using IGS combined Final GPS orbits and clocks, 7 deg. elevation angle cutoff, estimation zenith delay and gradients as random walk processed, with 5 minute temporal resolution). The histogram was generated from daily point-positioning for a set of ~30 globally-distributed sites during 2003.