An Assessment and Comparison of WAAS Ionospheric Correction Algorithms in CONUS and Europe

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Motivation

From the WAAS performance point of view:

- Is the ionosphere any different over Europe compared to middle latitude CONUS?
- Would major storms have the same impact over Europe and CONUS?
- Would a quadratic fit improve on WAAS ionospheric residuals in the CONUS or Europe?

Outline

- Review of currently used estimation algorithms for GIM and WAAS
- Data set used for quiet and storm days: 19 days
  - Ground-truth generated using JPL's GIM software
  - 19 days coincide with the focus period CONUS storm detector is based on;
- Comparison of WAAS *planar and quadratic* ionospheric model residuals for
  - CONUS and Europe and
  - Quiet and storm days to provide measure of performance in reproducing slant TEC for the user
- Conclusions
- Acknowledgement

GIM and WAAS Ionospheric Correction Algorithm

For single shell, our Global Ionospheric Mapping (GIM) technique is

$$TEC = M(h,E)\sum_i C_i B_i(lat,lon) + b_r + b_s$$

where

TEC	is the slant TEC
$M(h_1,E)$	is the thin shell mapping function
$B_i(lat,lon)$	is the horizontal basis function (C^2, TRIN, etc);
C_{1i}	are the basis function coefficients
b_r, b_s	are the satellite and receiver instrumental biases
a_0, a_1, a_2	are the planar fit parameters
d_E, d_N	distances from IGP to IPP

WAAS Ionospheric Models

WAAS *planar* fit ionospheric model is

$$TEC = M(h,E)[a_0 + a_1 d_E + a_2 d_N]$$

Pseudo-IGP approach: IPP treated as if it were collocated with IGP

where

a_0, a_1, a_2 are the planar fit parameters,

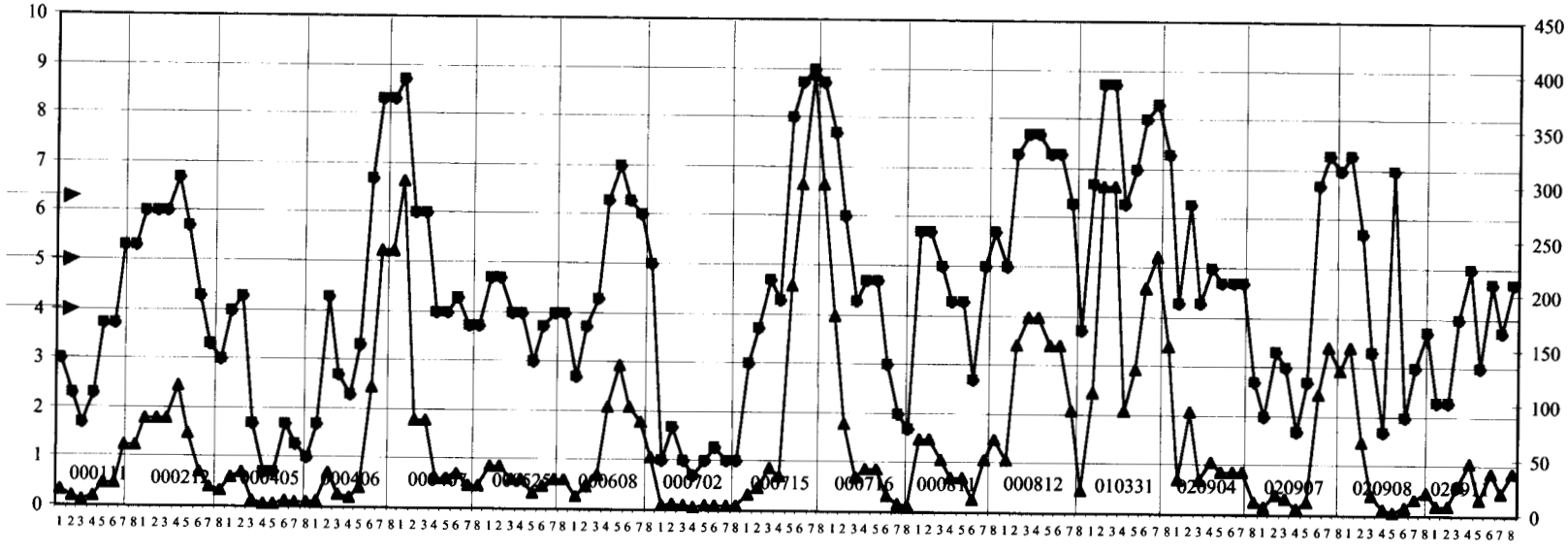
d_E, d_N are the distances from the IGP to the IPP in the eastern and northern directions, respectively.

WAAS *quadratic* fit ionospheric model is

$$TEC = M(h,E)\left[a_0 + a_1 d_E + a_2 d_N + a_3 d_E^2 + a_4 d_E d_N + a_5 d_N^2\right]$$

a_3, a_4, a_5 are the additional planar fit parameters describing quadratic and cross terms.

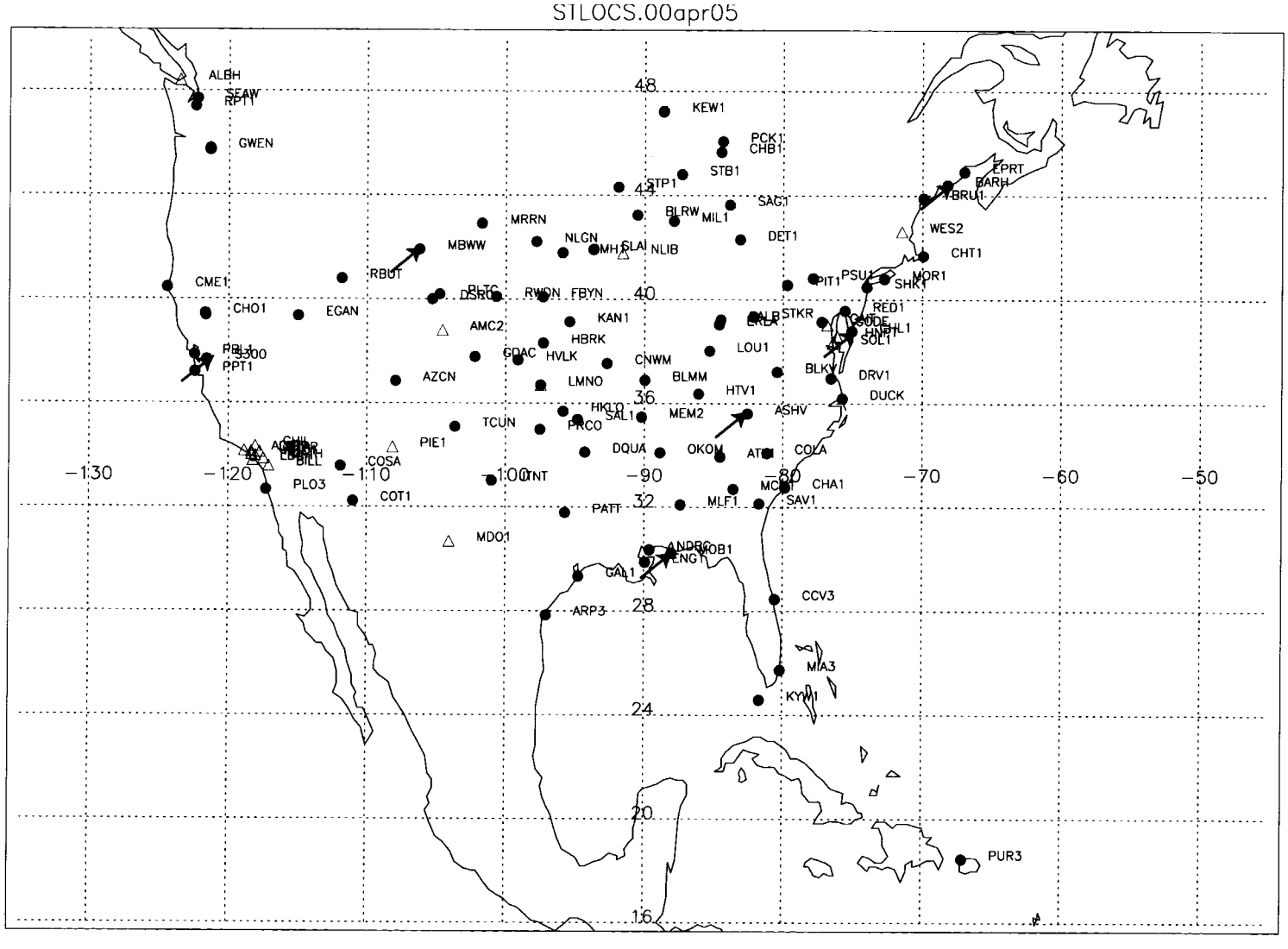
Description of Dataset



Reference:
M.Bakry El-Arini

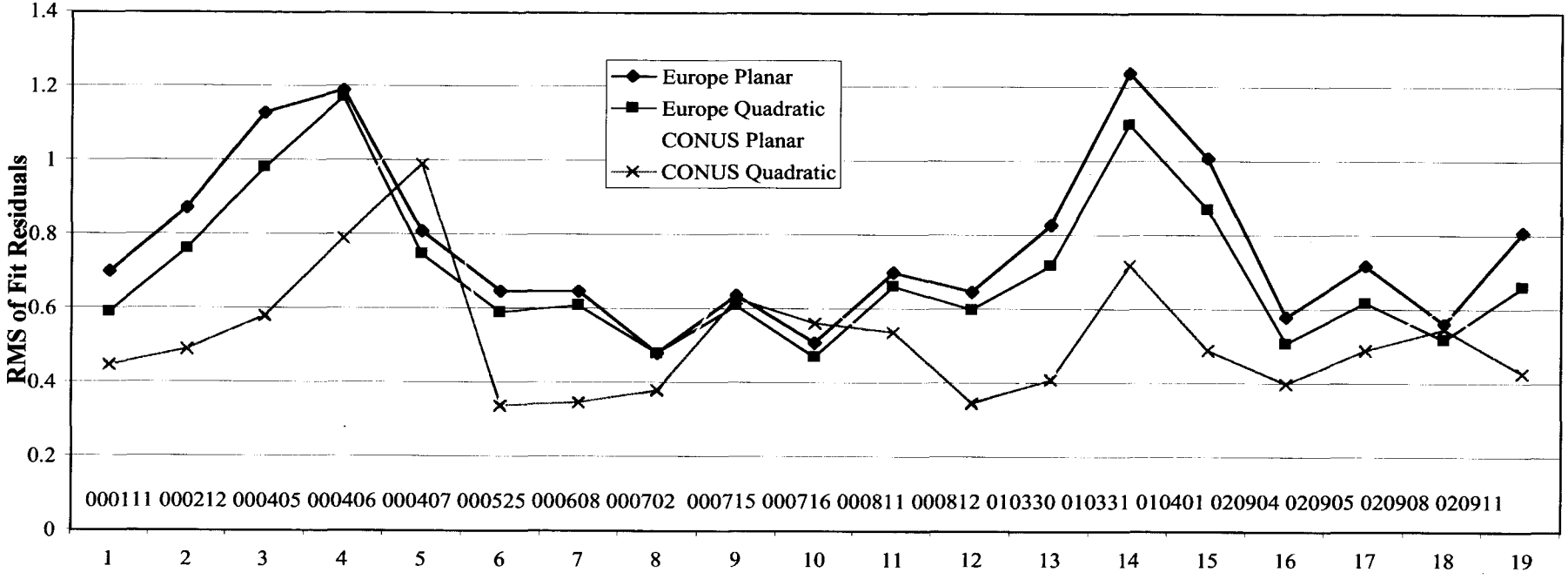
	Ap Index	Kp Index
Quiet Ionosphere	0 Ap 29	0 Kp 4.0
Minor Storm	30 Ap 49	4.3 Kp 5.0
Major Storm	50 Ap 99	5.3 Kp 6.3
Severe Storm	Ap 100	Kp 6.7

CONUS Site Distribution



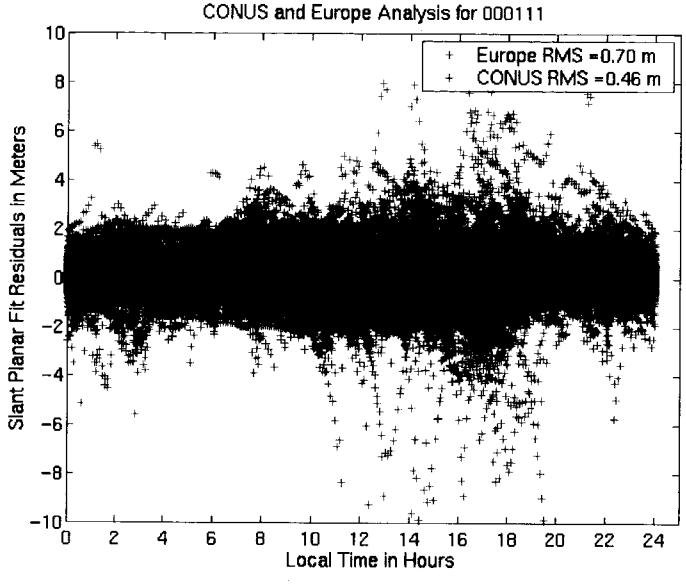
European Site Distribution

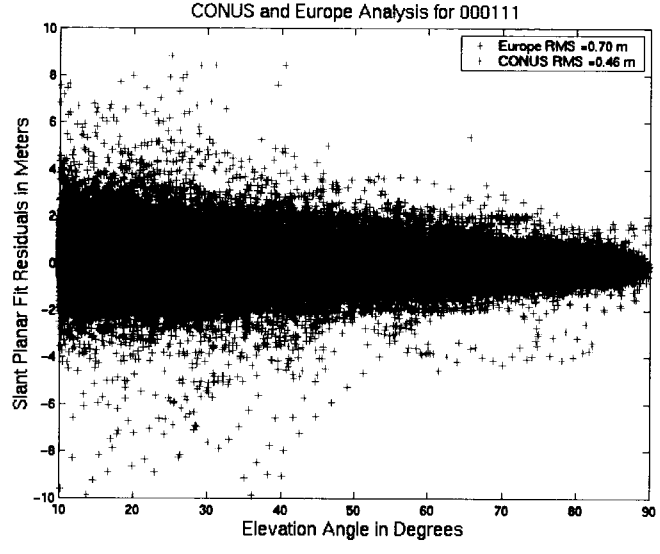
Summary of Results

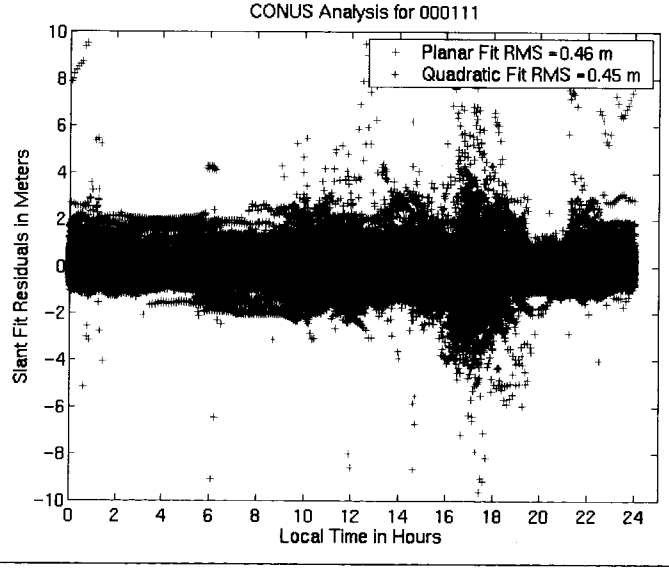


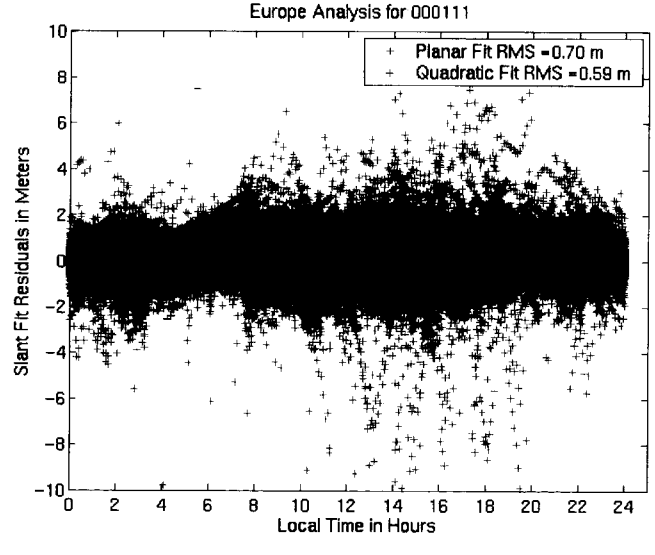
Examples 1 2 3 4

1. CONUS and European Planar Fit Residuals for 000111

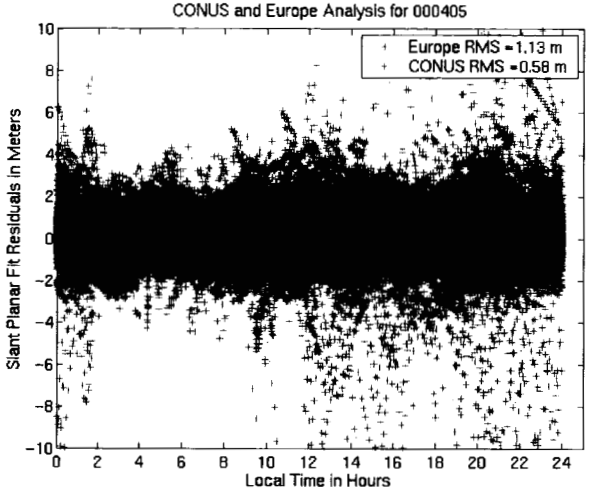


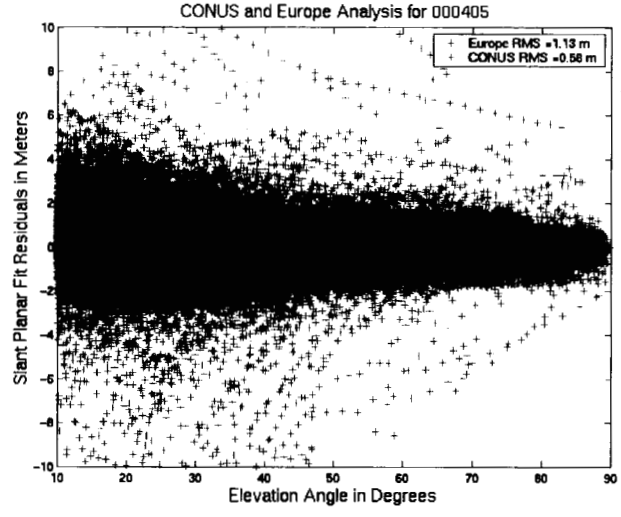


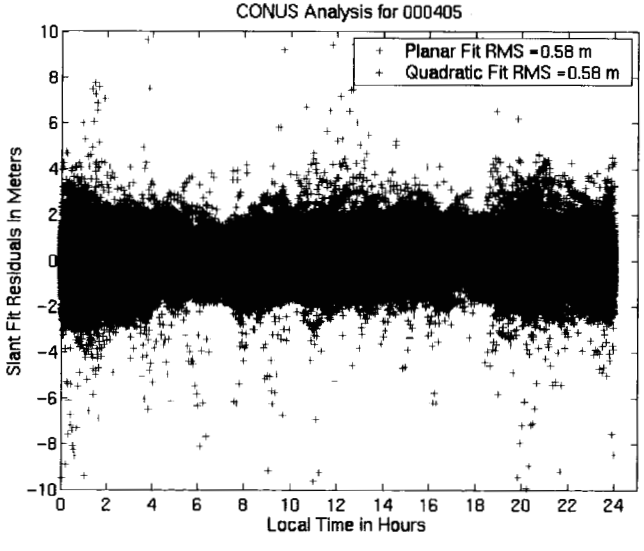


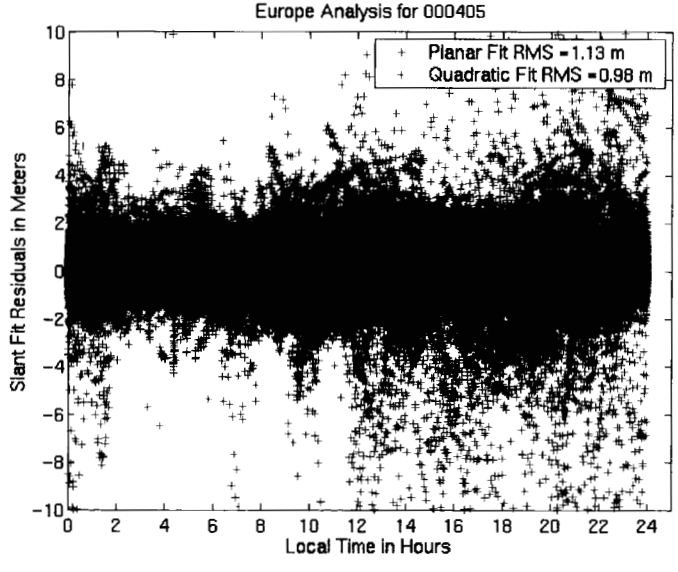


2. CONUS and European Planar Fit Residuals for 000405

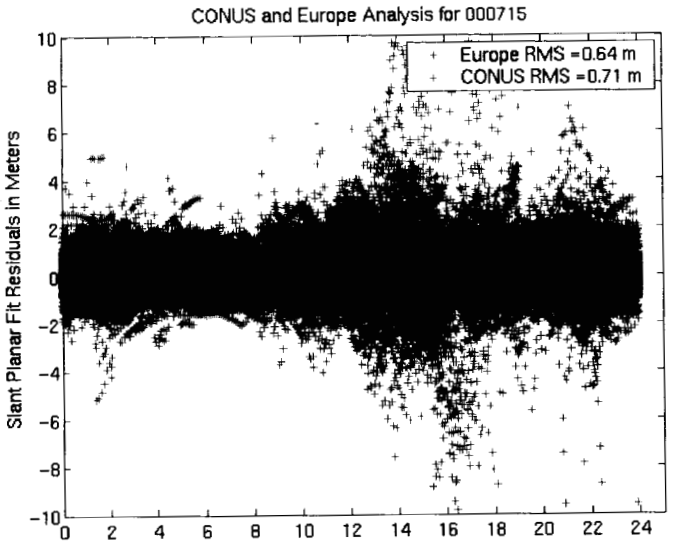


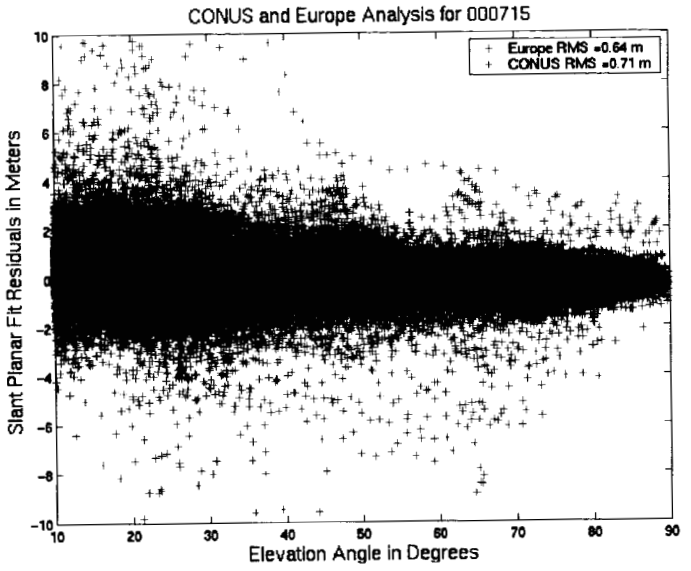


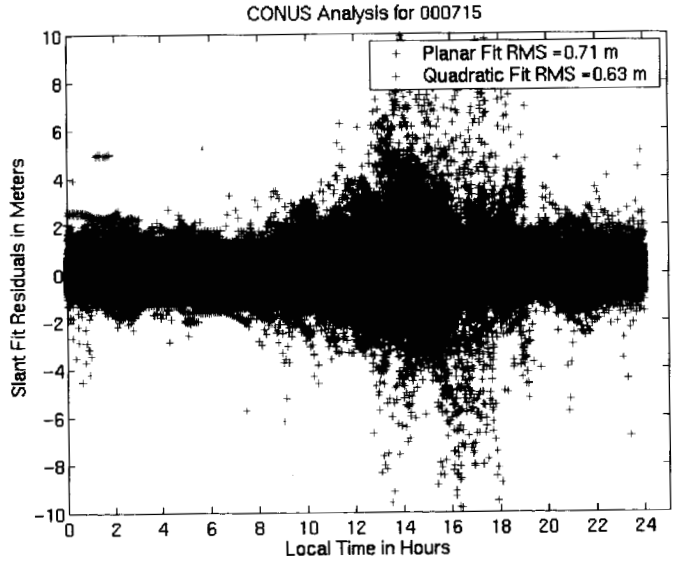


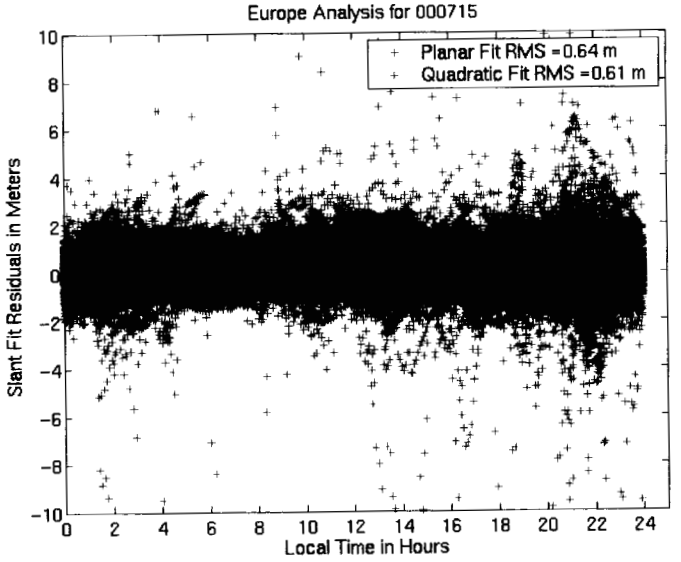


3. CONUS and European Planar Fit Residuals for 000715

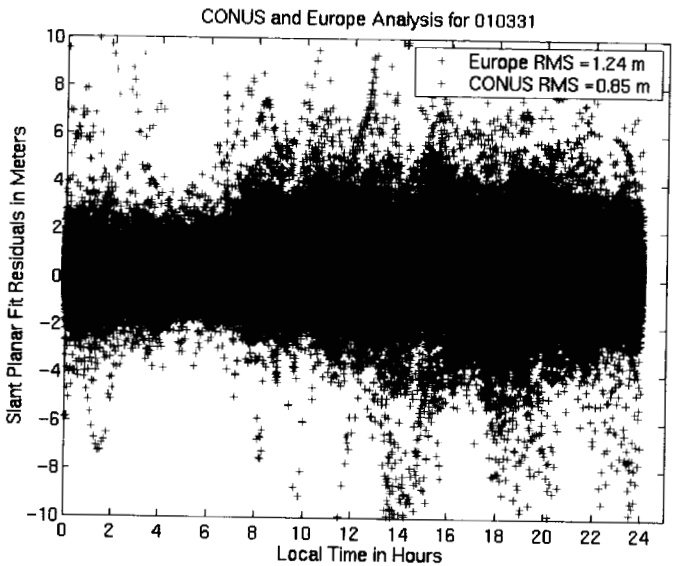


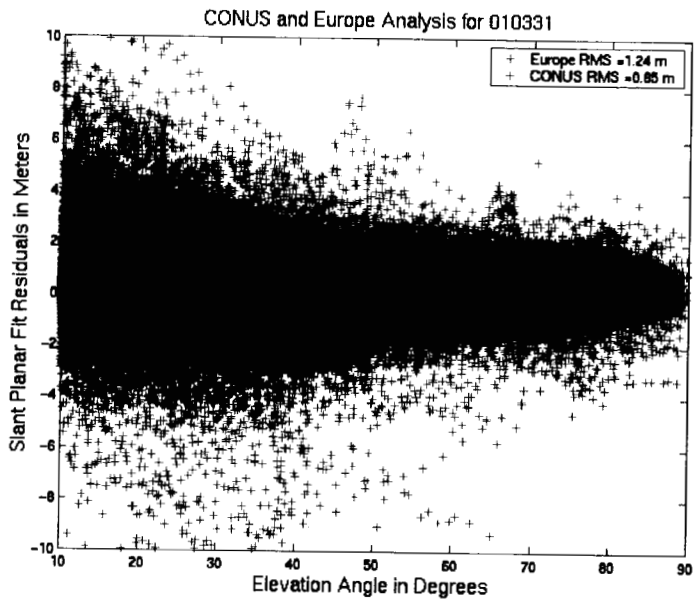


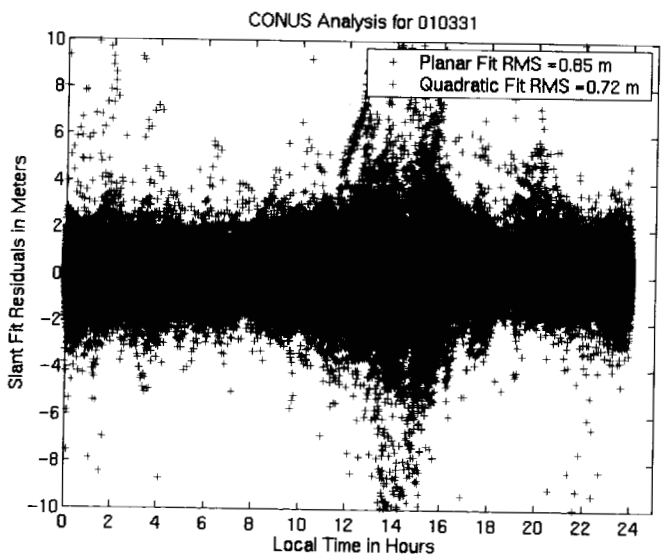


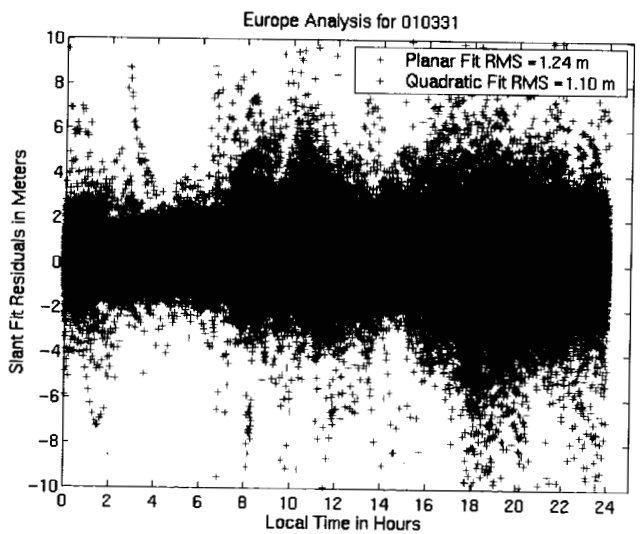


4. CONUS and European Planar Fit Residuals for 010331









Conclusions

- 15 out of 19 days show larger RMS of planar fit residuals in Europe than in CONUS.
- For large storms, such as on April 5, 2000 and March 31, 2001, Europe's planar fit residuals are significantly larger than that of CONUS.
- July 15, 2000 storm seems to have impacted CONUS more than Europe.
- Overall planar fit residuals in Europe is 77 cm; in CONUS 56 cm: CONUS residuals are 27% percent smaller on average.
- A 10 percent RMS improvement is seen in Europe when using quadratic fit over planar fit.
- A 7 percent RMS improvement is seen in CONUS when using quadratic fit instead.

Acknowledgements

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