Departamento de Controle do Espaço Aéreo
Air Space Control Department

CORRELATION AMONG GPS ERRORS AND HF MEASUREMENTS

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Summary

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Goals

- **To obtain larger knowledge about the Brazilian ionosphere behavior.**
- **To develop applications in order to provide an improvement for GPS errors correction algorithms.**
- **To provide methods to permit SBAS operation in Brazil.**

Abstract

- **A possible correlation among GPS errors due to the effect of the ionospheric equatorial anomaly and HF measurements is investigated in this paper.**

Introduction

- **A SBAS test module was implemented in Brazil. Unfortunately, measurements proved the inadequacy of that solution for an equatorial country.**
- **The existing GPS errors showed that the SBAS application cannot be used to support aeronautical systems continuously.**

Introduction (cont.)

- **Clearly, this unacceptable behavior of GPS/SBAS was due to ionospheric equatorial anomaly where, in the post-sunset period, small-scale irregularities within ionospheric bubbles or patches are sources of intense scintillation effects degrading GPS signals .**

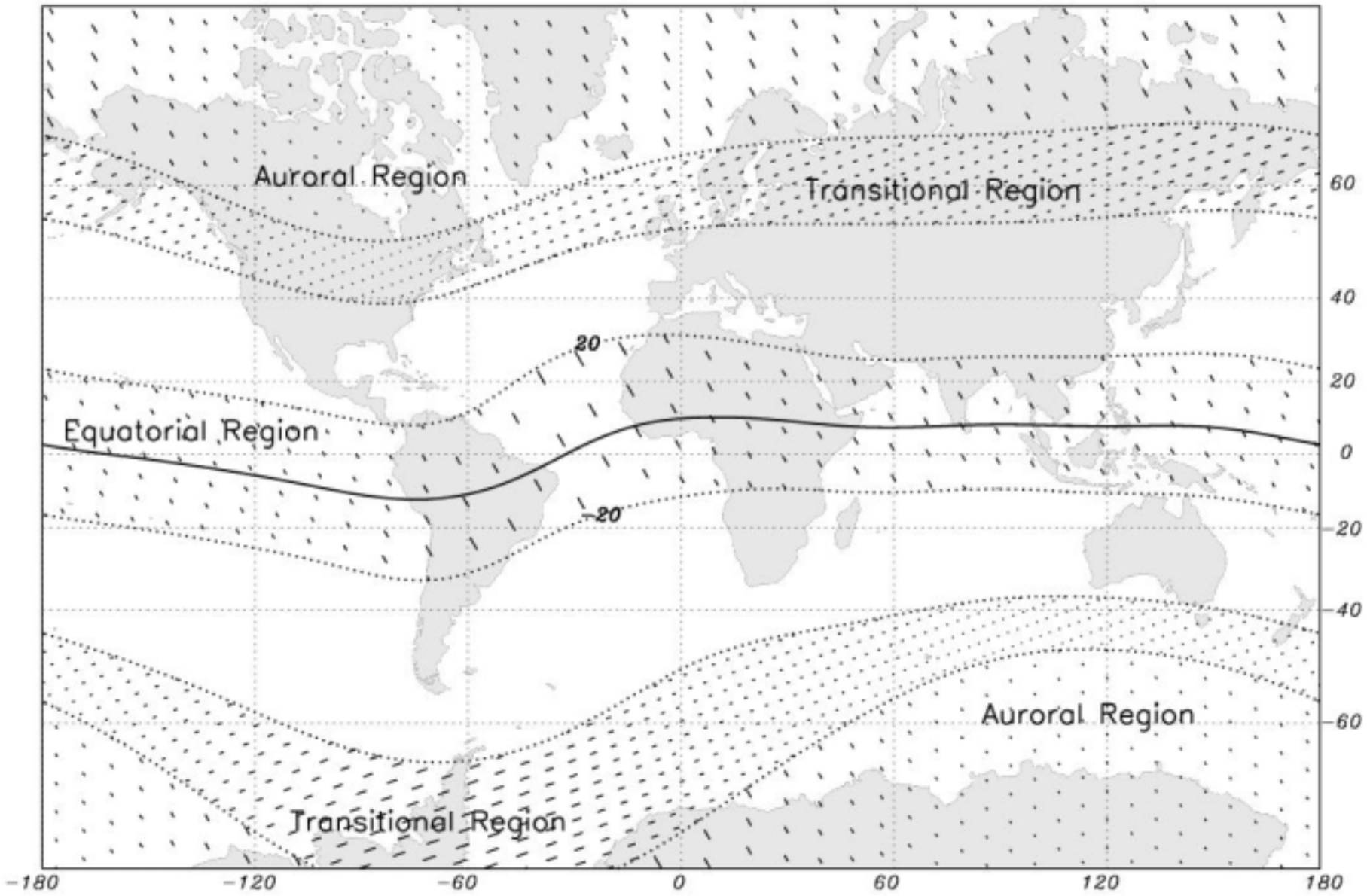
Introduction (cont.)

- **It doesn't exist, until the present moment, a method to correct the GPS errors, in order to put them in the acceptable levels to precision approach.**

Equatorial Ionosphere

- **A developed equatorial anomaly in the afternoon hours may be taken as a precursor of scintillations in the post-sunset hours.**
- **Equatorial scintillations are strongest at solar maximum, near the equinoxes in March-April and October-November.**

Equatorial Ionosphere (cont.)



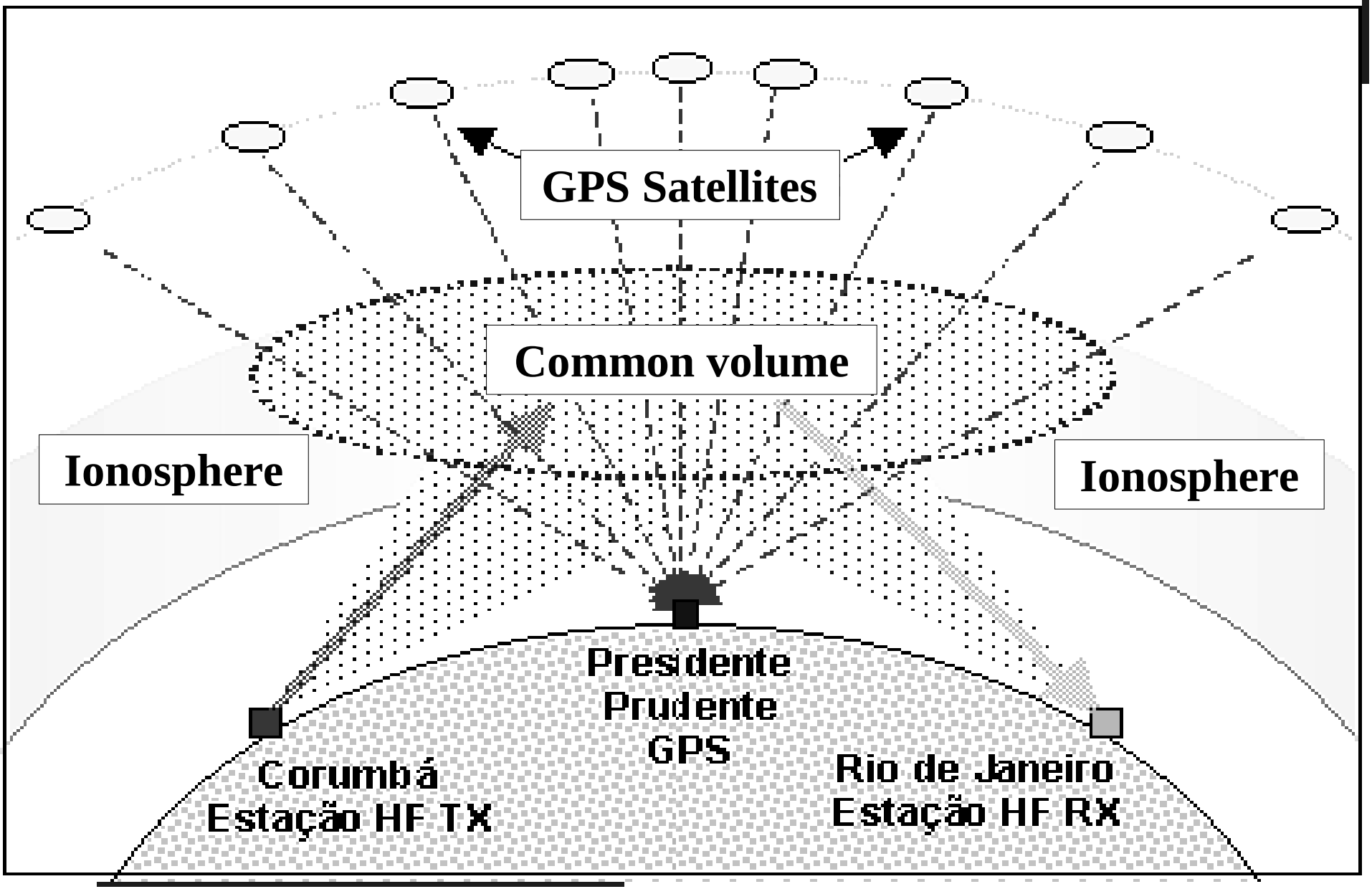
Methodology - GPS & HF

- **GPS errors are caused by scintillations due to small-scale irregularities in the ionosphere;**
- **HF radio waves propagating through the ionosphere also exhibits a multipath variations;**
- **GPS and HF signals crossing simultaneously the same portion of the ionosphere are probably highly correlated.**

Methodology - GPS & HF (Cont.)

- **A 100 W HF radio link 1500 km long, operating in the frequency of 23 MHz, was installed between Corumbá (19.02S ; 57.65W) and Rio de Janeiro (22.88 ; 43.28W).**
- **A GPS station was located near the middle point of this path in Presidente Prudente (22.12S ; 51.37W).**

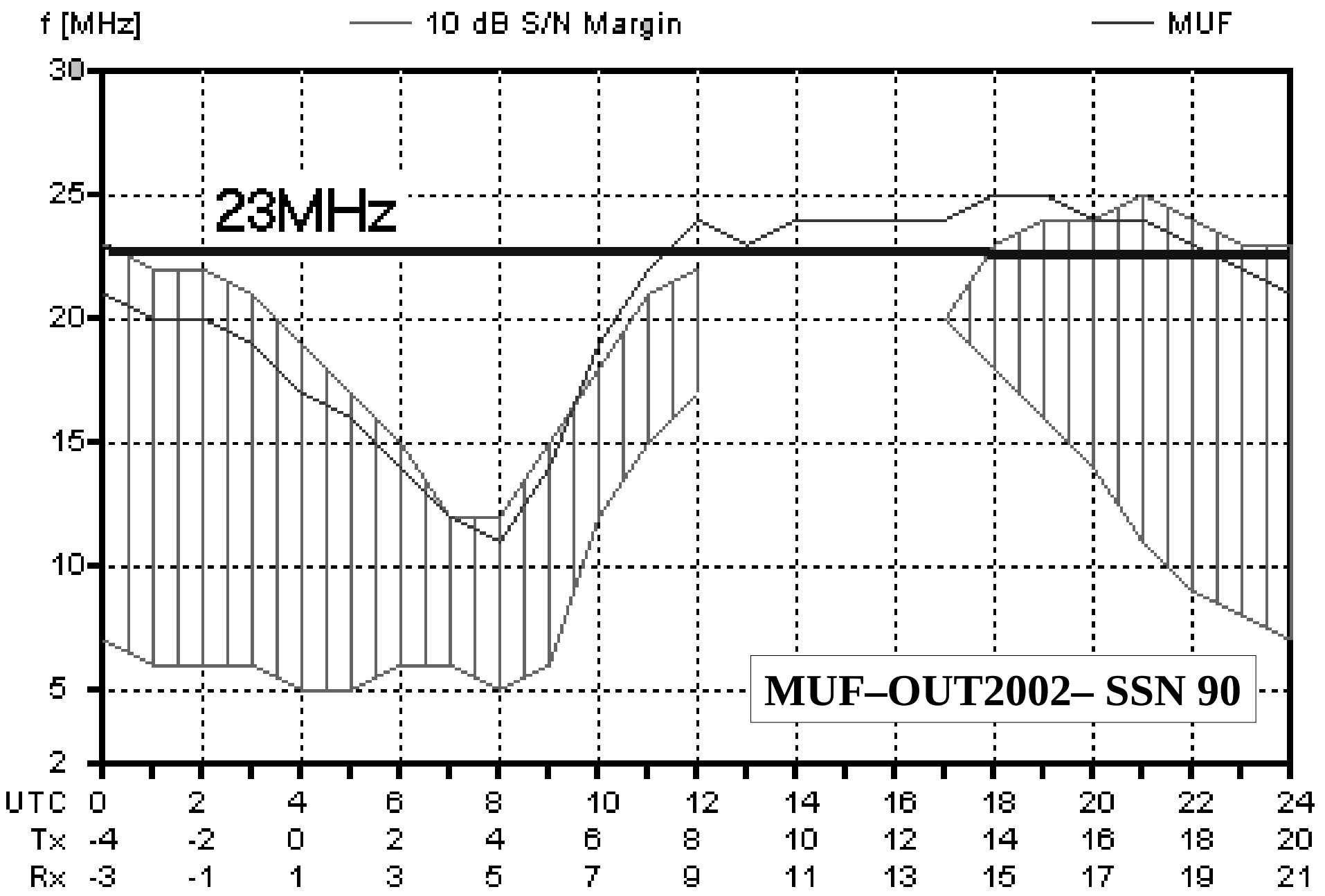
Methodology - GPS & HF (Cont.)



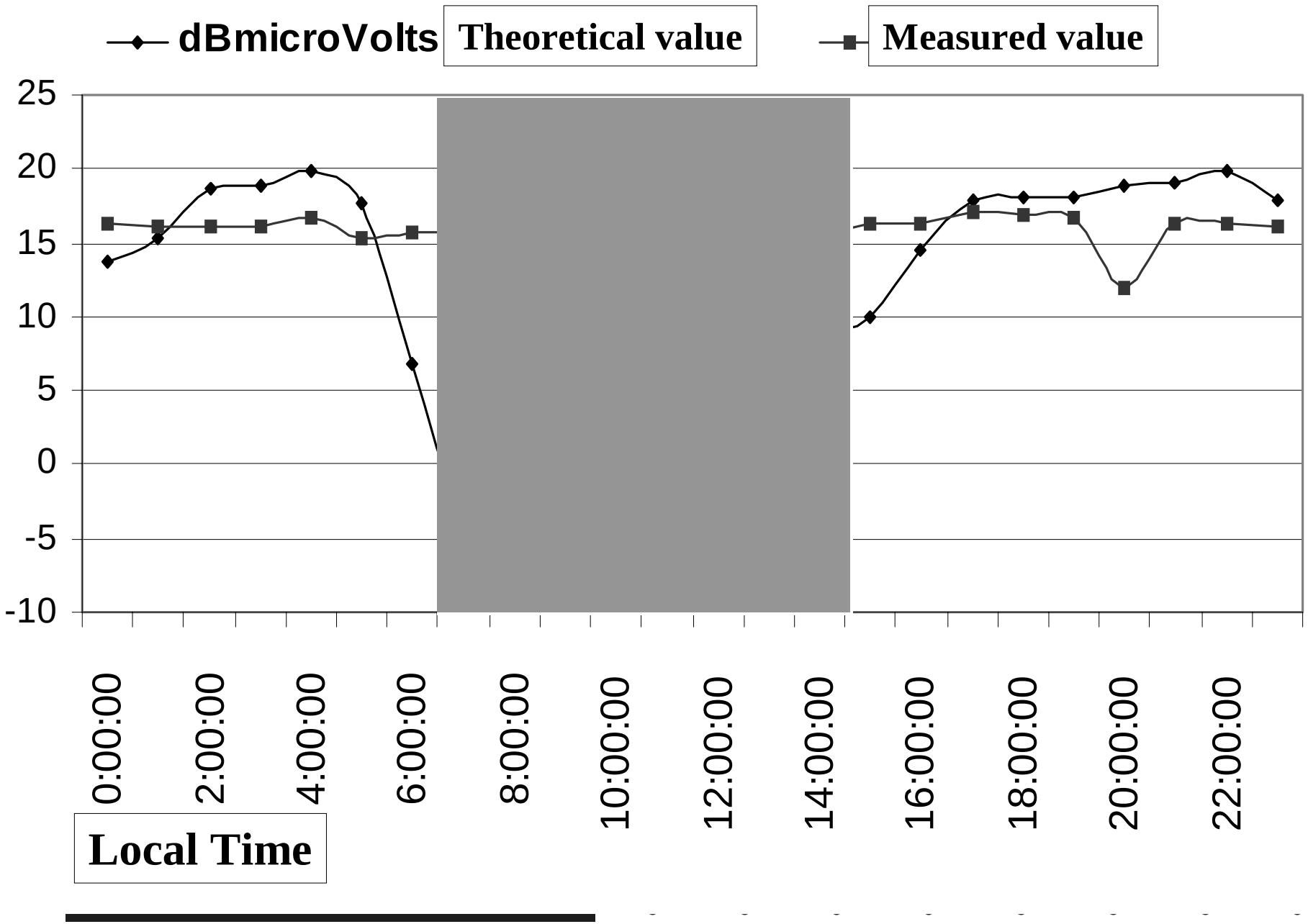
Methodology - GPS & HF (Cont.)

- **Daily, 40,000 samples of HF signal levels were registered in the period from 01 October to 06 December 2002.**
- **At the same time a GPS errors were continuously registered in Presidente Prudente.**

Methodology - GPS & HF (Cont.)

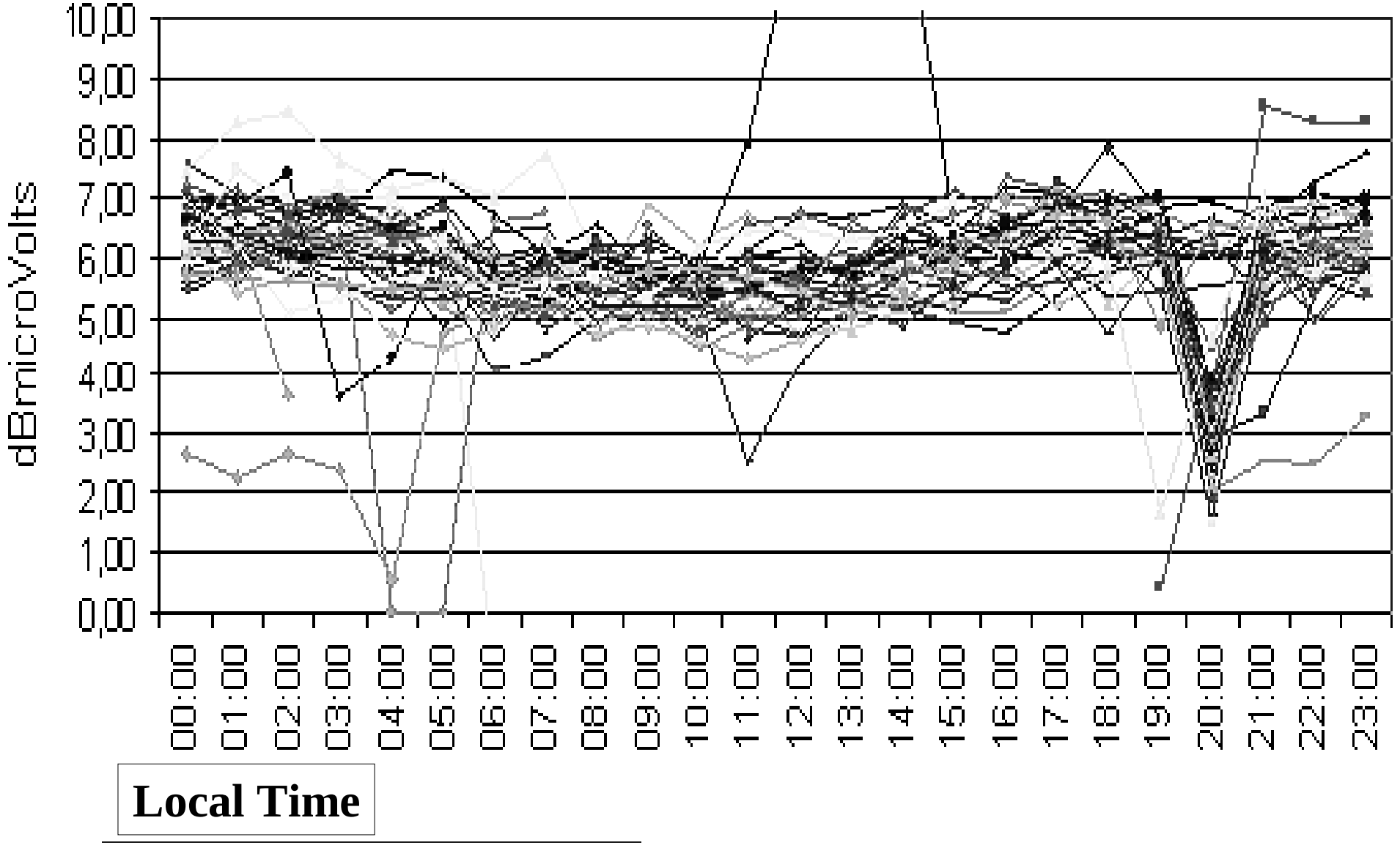


Methodology - GPS & HF (Cont.)

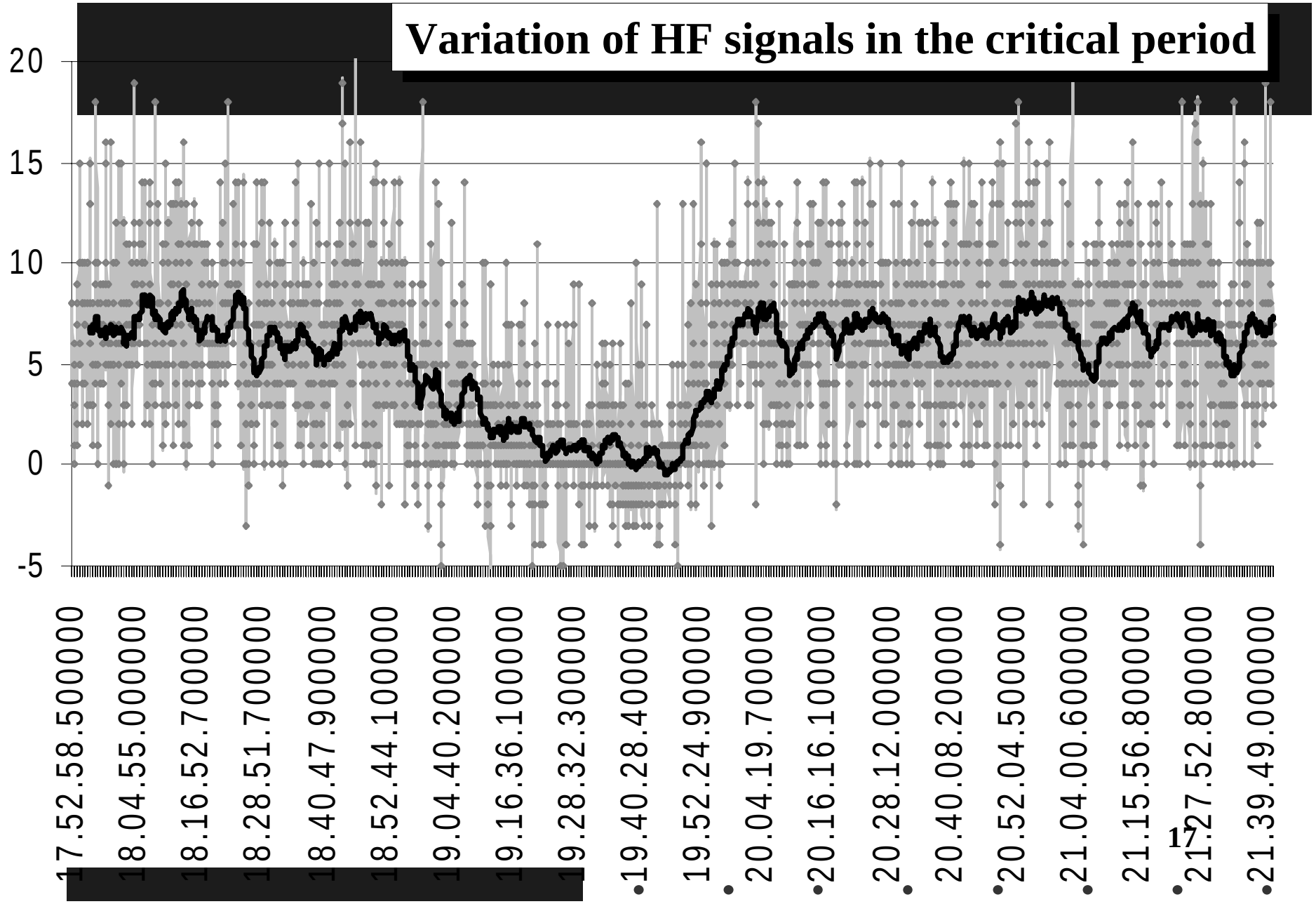


Methodology - GPS & HF (Cont.)

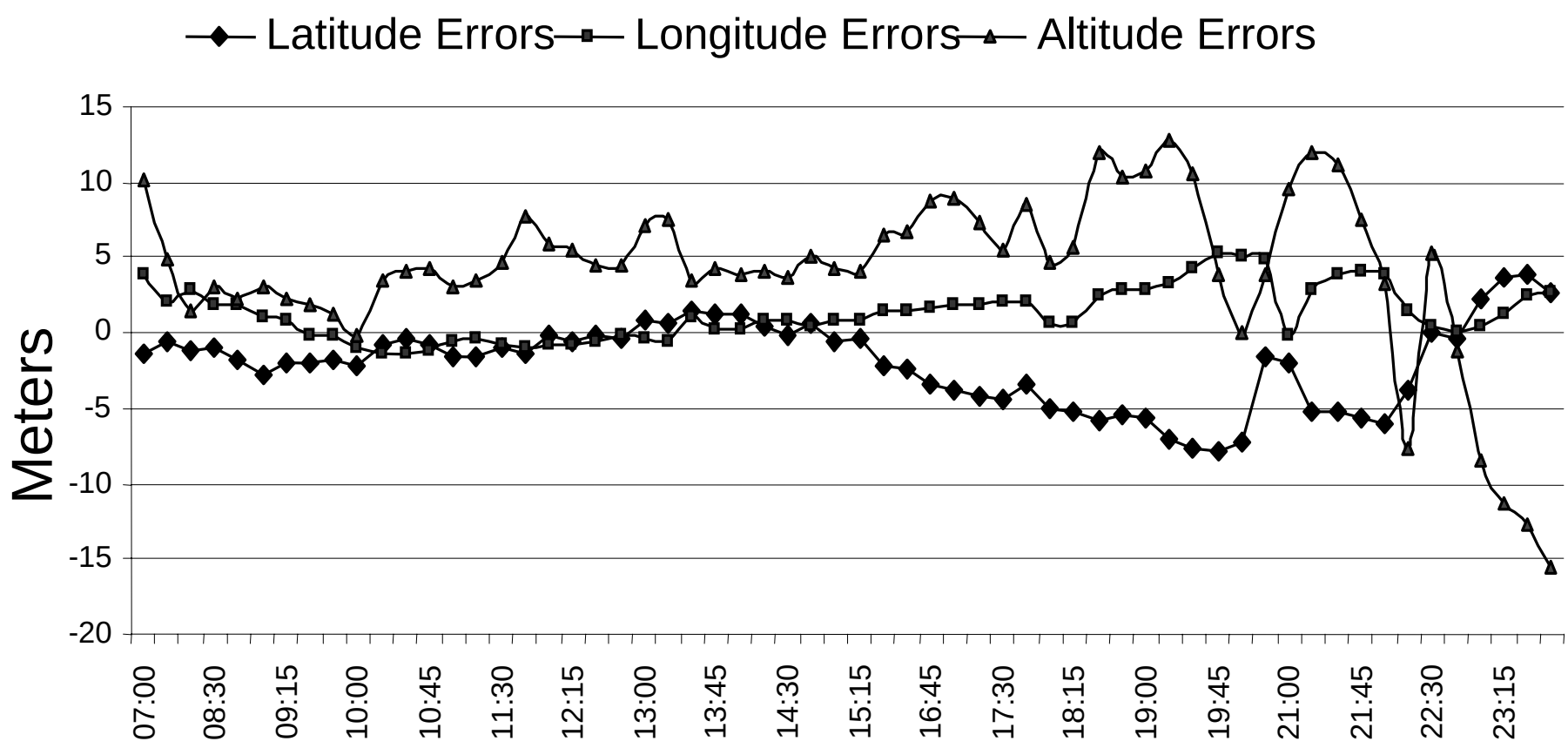
Hourly average of HF signal levels - OCT 01 to DEC 06/2003



Methodology - GPS & HF (Cont.)



Methodology - GPS & HF (Cont.)



Concluding Remarks

- **In spite of the limitations of the HF measurements, results presented in this paper constitute a clear indication that a correlation exists between GPS errors and HF radio signal variations.**

Concluding Remarks (cont.)

- Of course, more experimental data are needed, preferably at frequencies lower than 23 MHz, to better fix the starting of the abnormal behavior of HF signals, which should be used for triggering the corrective algorithm.
- On the other hand, once the equatorial anomaly is the origin of ionospheric scintillations, probably a detailed study of the phenomena described could lead to very interesting and useful results.

Acknowledgements

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