UN/USA INTERNATIONAL MEETING ON THE USE AND APPLICATIONS OF GLOBAL NAVIGATION SATELLITE SYSTEMS

13-17 DECEMBER 2004, VIENNA, AUSTRIA

FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

DEPARTAMENTO DE MATEMÁTICA APLICADA

GNSS applications at Centro de Investigação em Ciências Geo-Espaciais

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URBAN TRAFFIC FLOW PREDICTION BY USING GPS AND NEURAL NETWORKS THEORY

To study methods to recognize traffic patterns inside a city, by using:

- GPS, for GIS data acquisition and trajectories information;
- Artificial Neural Networks, as analyzing tool,

in order to answer questions like

- Which are the most used roads at 16h00 pm ?
- Which are the jam arcs concerning the atmospheric conditions ?

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Methodology

- **Digital cartography actualization - GPS**
- **Driver's trajectory acquisition - GPS**
- **Database treatment - GIS**
- **Neural Network Design**
- **Analysis of the Neural Network results**

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GPS

Differential GPS by using a City Hall Reference Station

Data precision: codes and phases for GIS update; codes for the driver's trajectories

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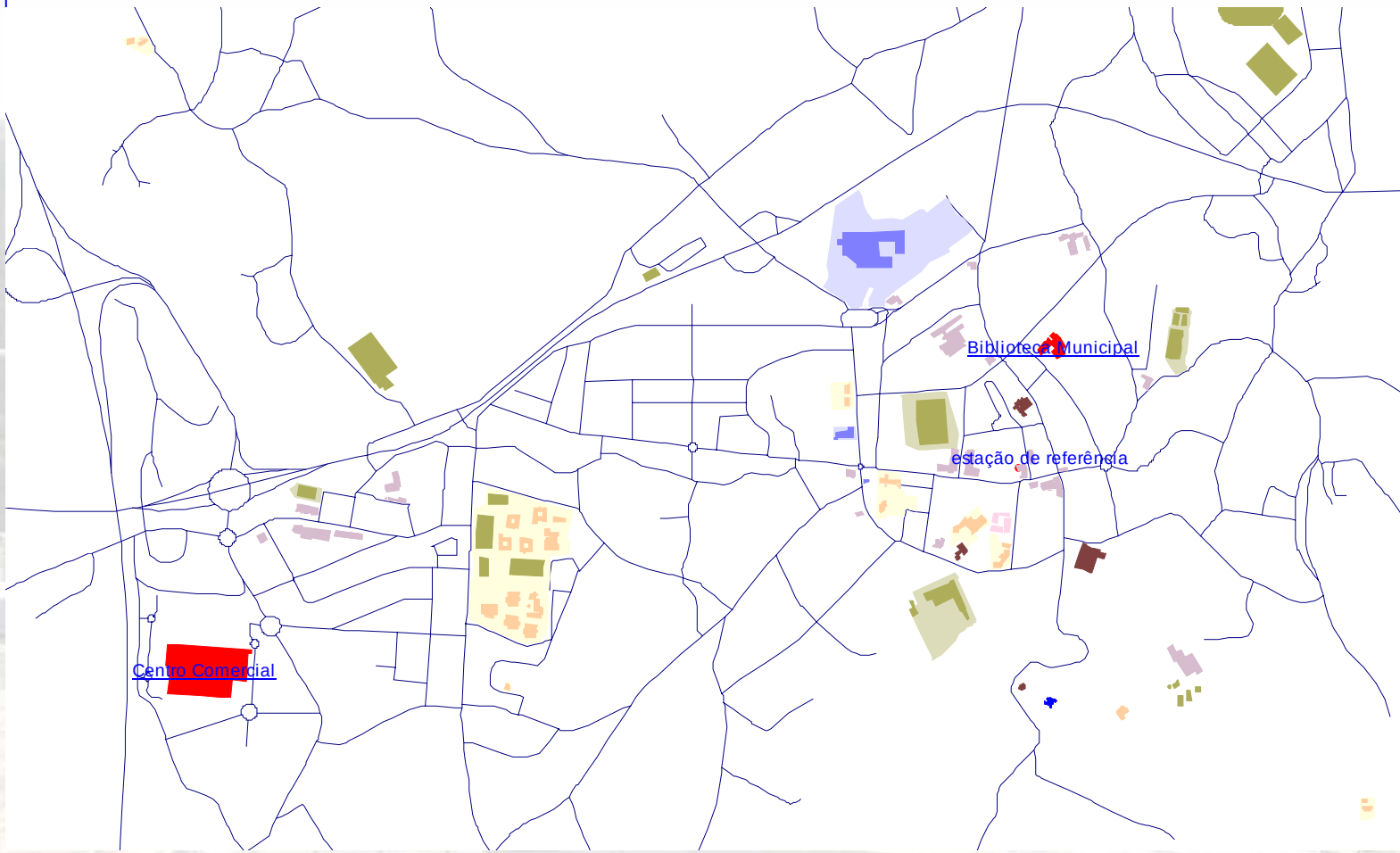
Study area



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Digital cartography actualization - GPS

Some features and attributes considered:

- Pavement maintenance
- Speed limit in each street
- Pavement, taking into account the atmospheric conditions
- Number of crossing points

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Sample drivers characteristics

- **Different ages**
- **Different cultural levels**
- **Different jobs**
- **Different knowledge of the city center**

Experiment

These persons were invited, several times, to drive under different weather conditions, at a different hour of the day, all days of the week, from one same point, in downtown, to a shopping center, 5 km away, in the periphery. Their trajectories were recorded by a Trimble GeoExplorer 3 GPS receiver

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Neural network design

By using the MATLAB neural networks toolbox, several networks were trained.

Input layer:

- **Traffic perception**
- **Pavement maintenance**
- **Speed limits**
- **Hour of the day**
- **Type of pavement face to weather conditions**
- **Number of cross-roads/ pedestrian conflicts**

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Three different studies were developed

- **Arc by arc of the road neural network**

Objective: To recognize traffic patterns

- **Static neural network, with concurrent inputs**
- **Dynamic neural network, with 4 input sequences**

Objective: Traffic prediction

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Arc by arc of the road network

Network design:

- **6 neurons in the hidden layer**
- **Learning rate (< 0.5)**
- Momentum (0.5-09)

Output in binary form:

The driver passed or not through the arc

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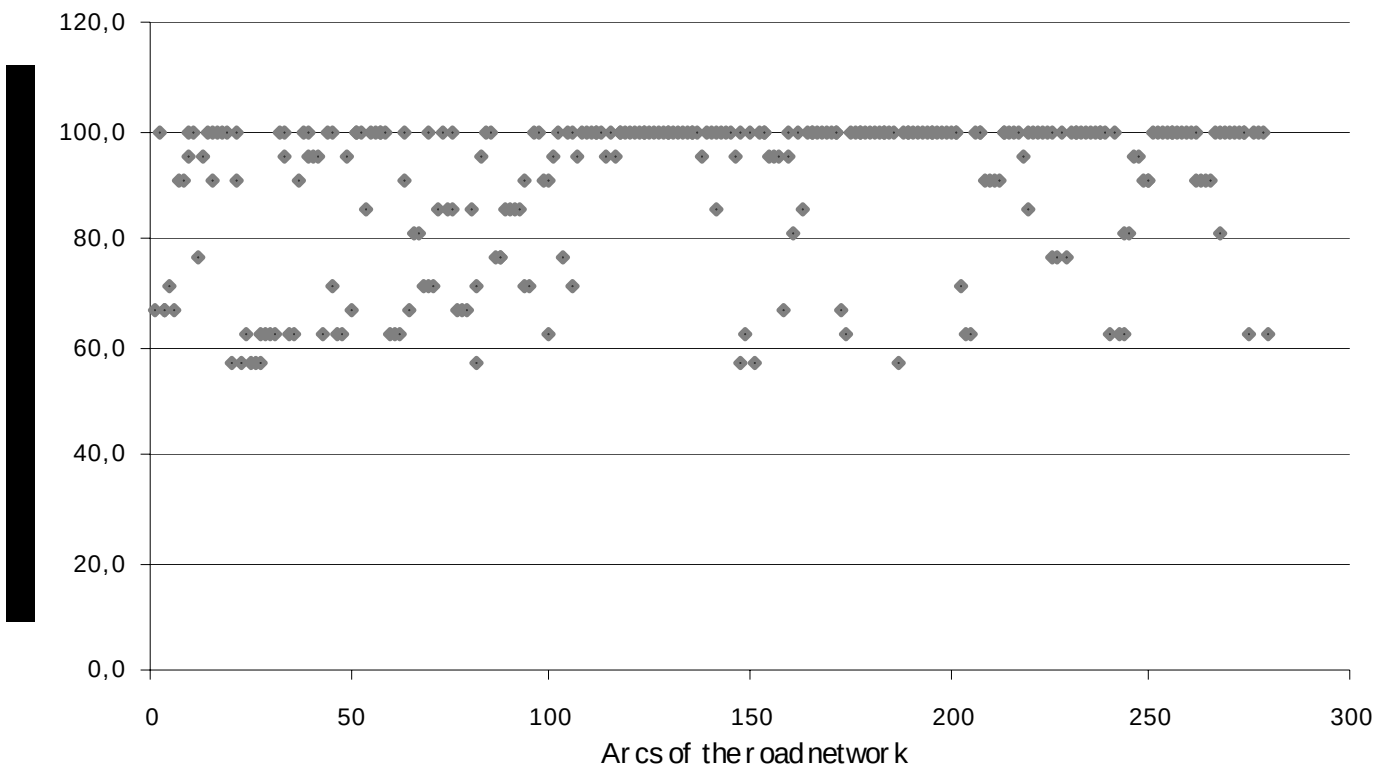
Percentage of success considering arcs traveled



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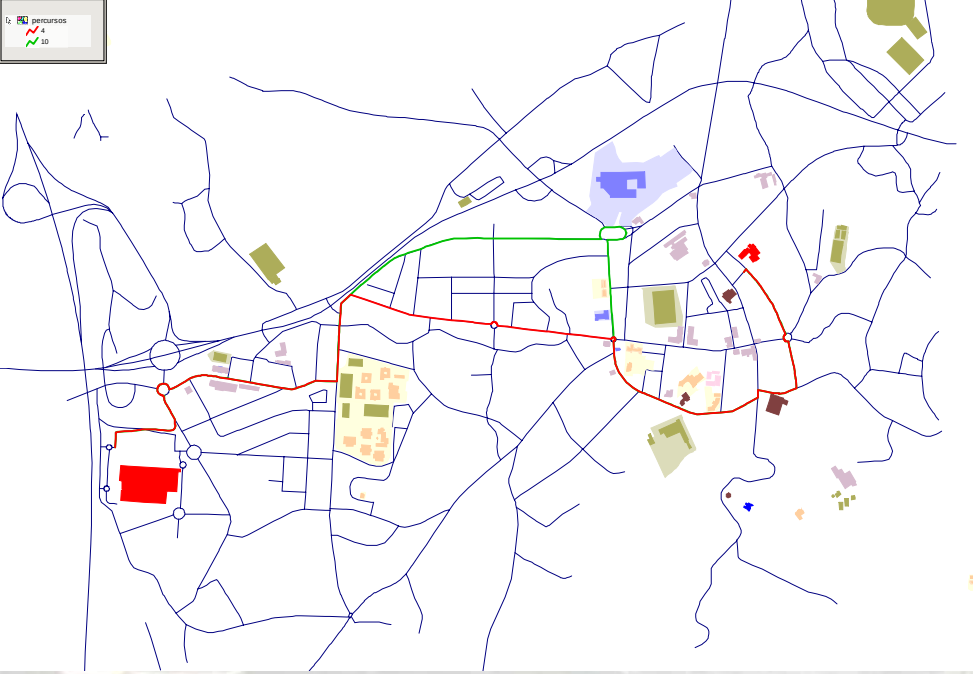
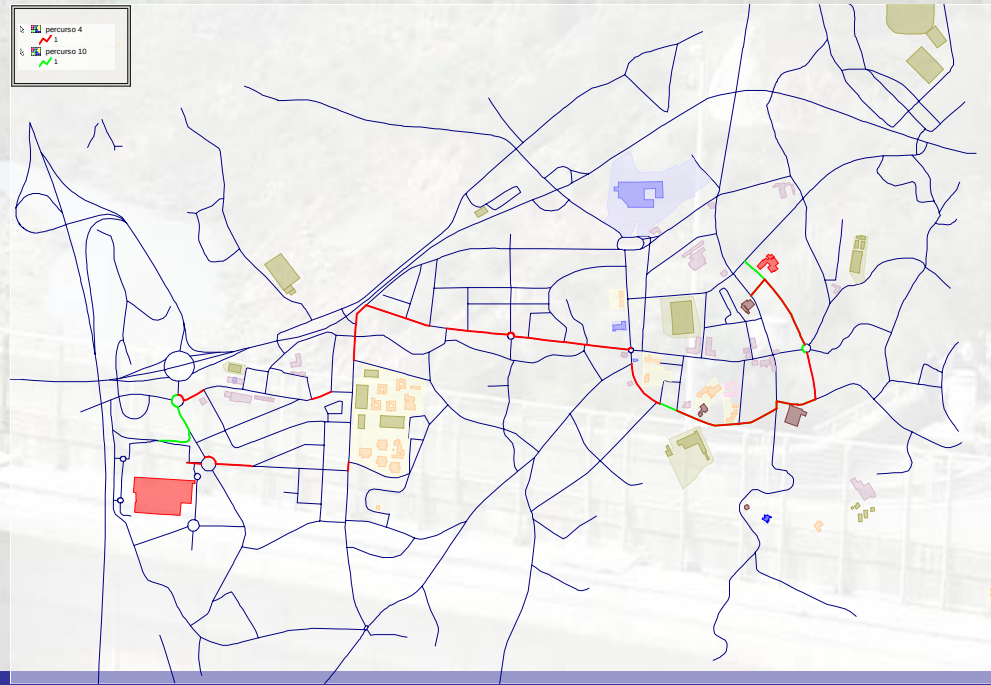
Trajectory 4 - red



←Original trajectory

GIS data

Neural Network trajectory →



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Static and Dynamic networks

Four sequences for the inputs:

- *Group 1: dry pavement and rush hour*
- *Group 2: dry pavement and not rush hour*
- *Group 3: wet pavement and rush hour*
- *Group 4: wet pavement and not rush hour*

Output:

Percentage of people that traveled through each arc in the same conditions.

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RESULTS

- Similar behavior between the dynamic and the static network
- Error of 20% in the prevision of the percentage of drivers who pass the arc

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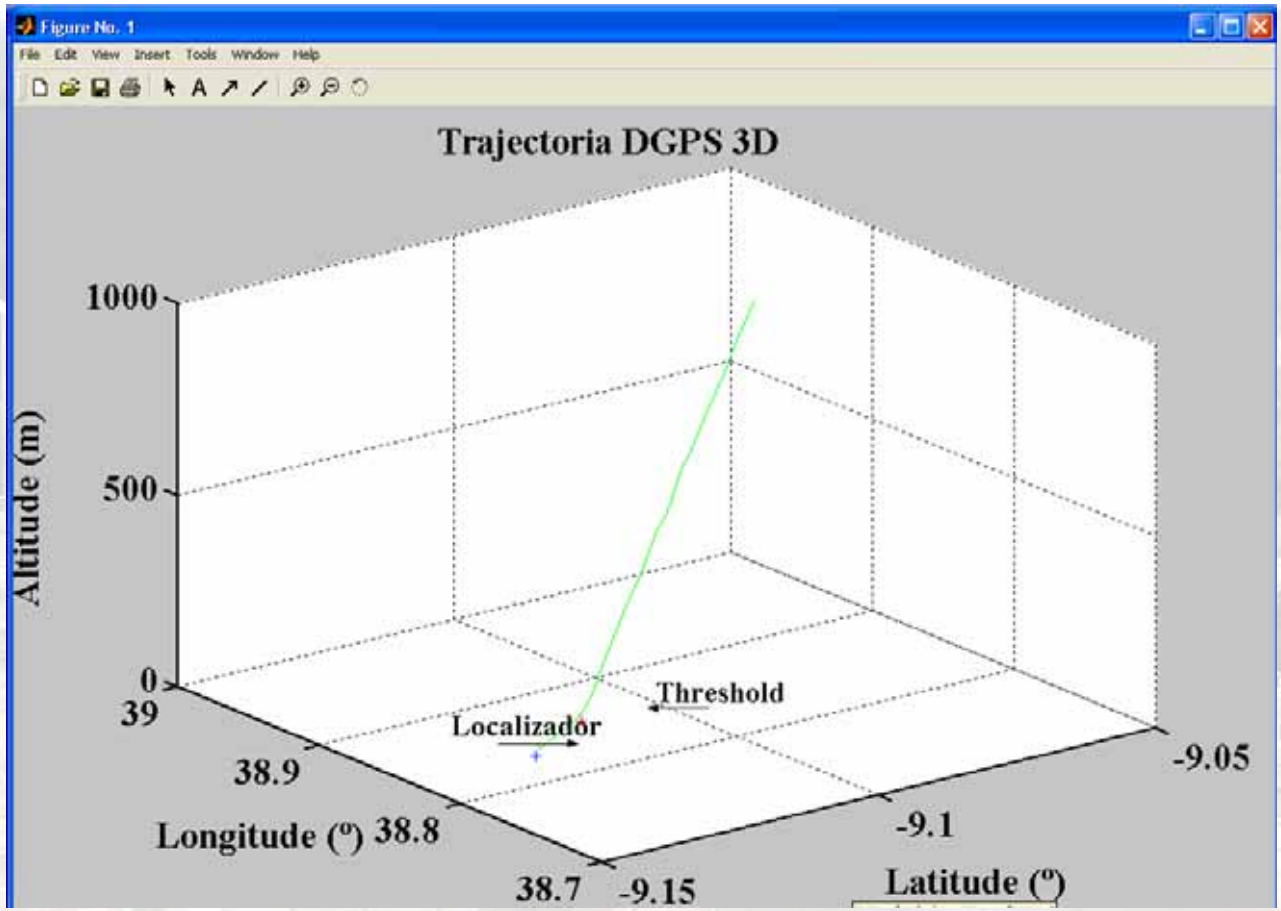
ILS calibration with DGPS



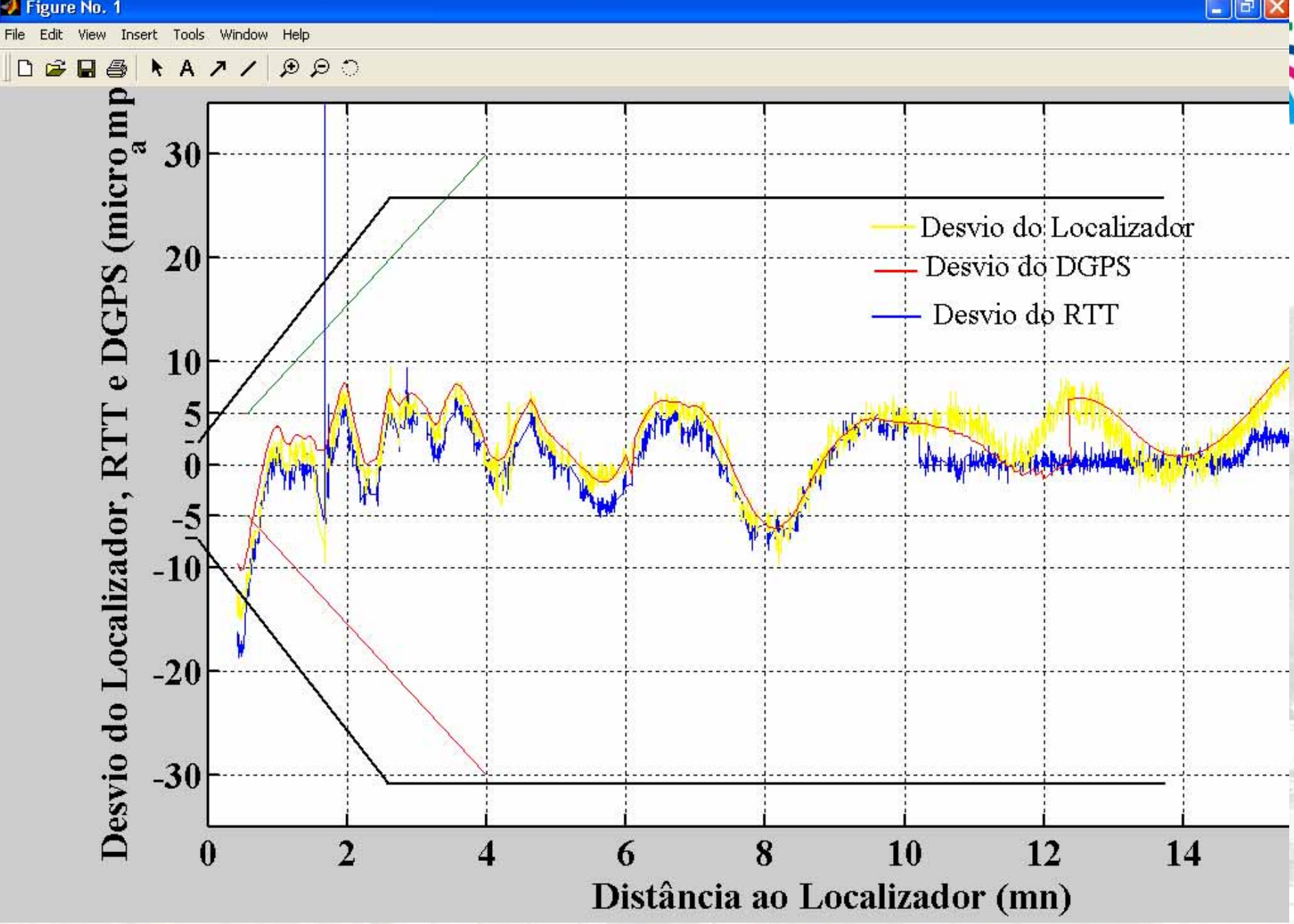


Figure No. 1
File Edit View Insert Tools Window Help
Desvio do Localizador, RTT e DGPS (micro mp a)
30
20
10
5
0
-5
-10
-20
-30
0
2
4
6
8
10
12
14
Distância ao Localizador (mn)
Desvio do Localizador
Desvio do DGPS
Desvio do RTT

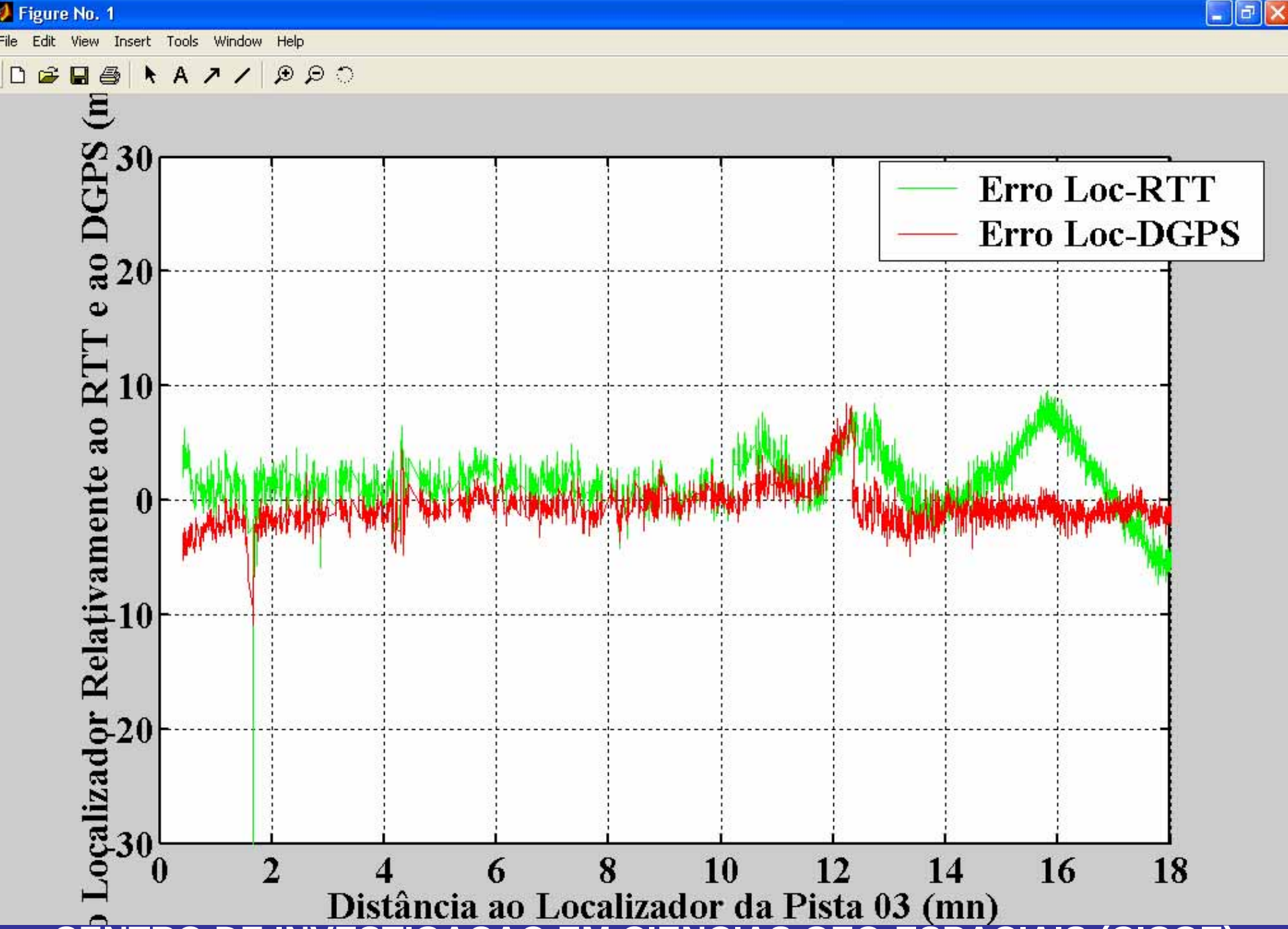


Figure No. 1
File Edit View Insert Tools Window Help
Erro Loc-RTT
Erro Loc-DGPS
30
20
10
0
-10
-20
-30
0
2
4
6
8
10
12
14
16
18
Distância ao Localizador da Pista 03 (mn)
Localizador Relativamente ao RTT e ao DGPS (m

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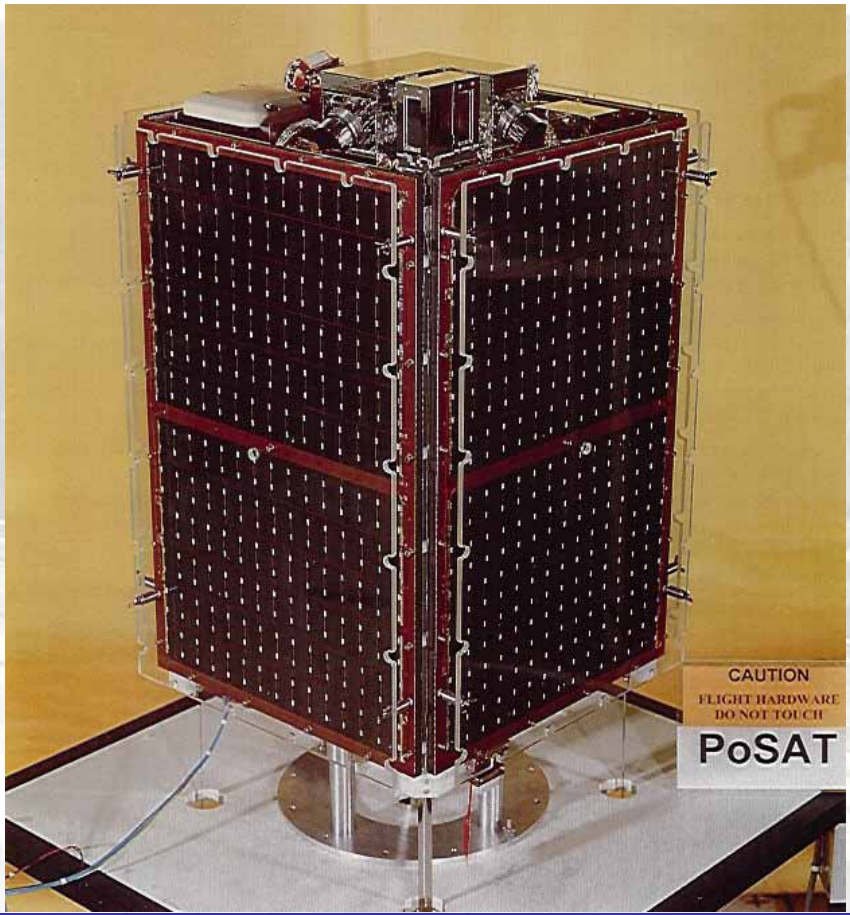
Satellite Navigation using GPS data



CENTRO DE INVESTIGAÇAO EM CIÊNCIAS GEO-ESPACIAIS (CICGE)

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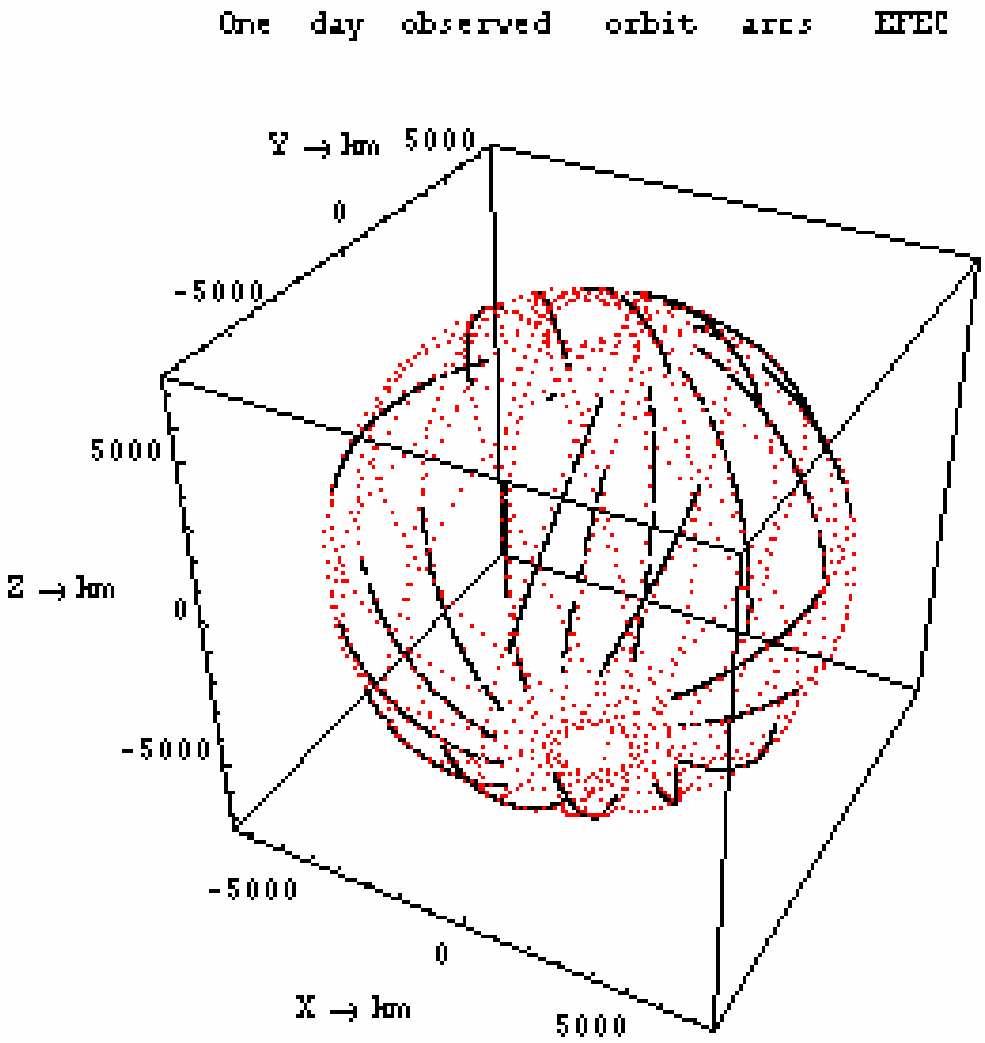

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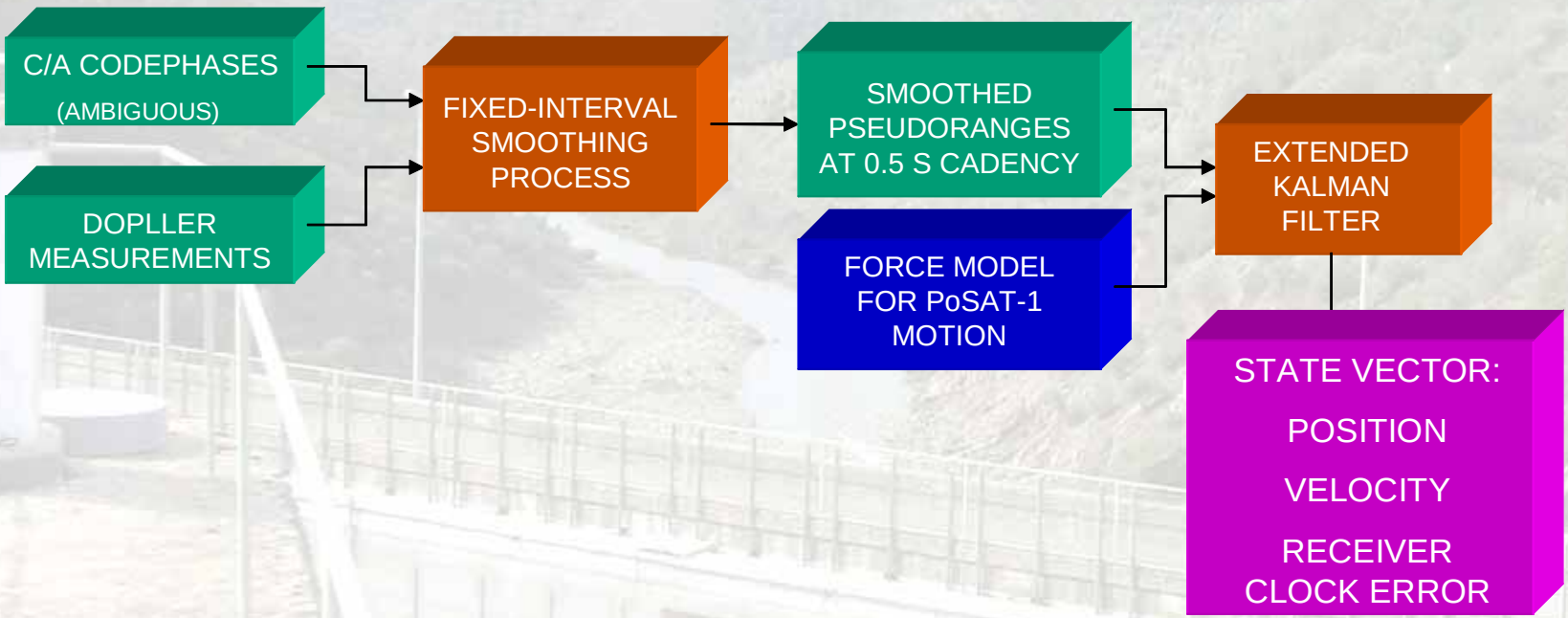
PoSAT-1 Autonomous Navigation



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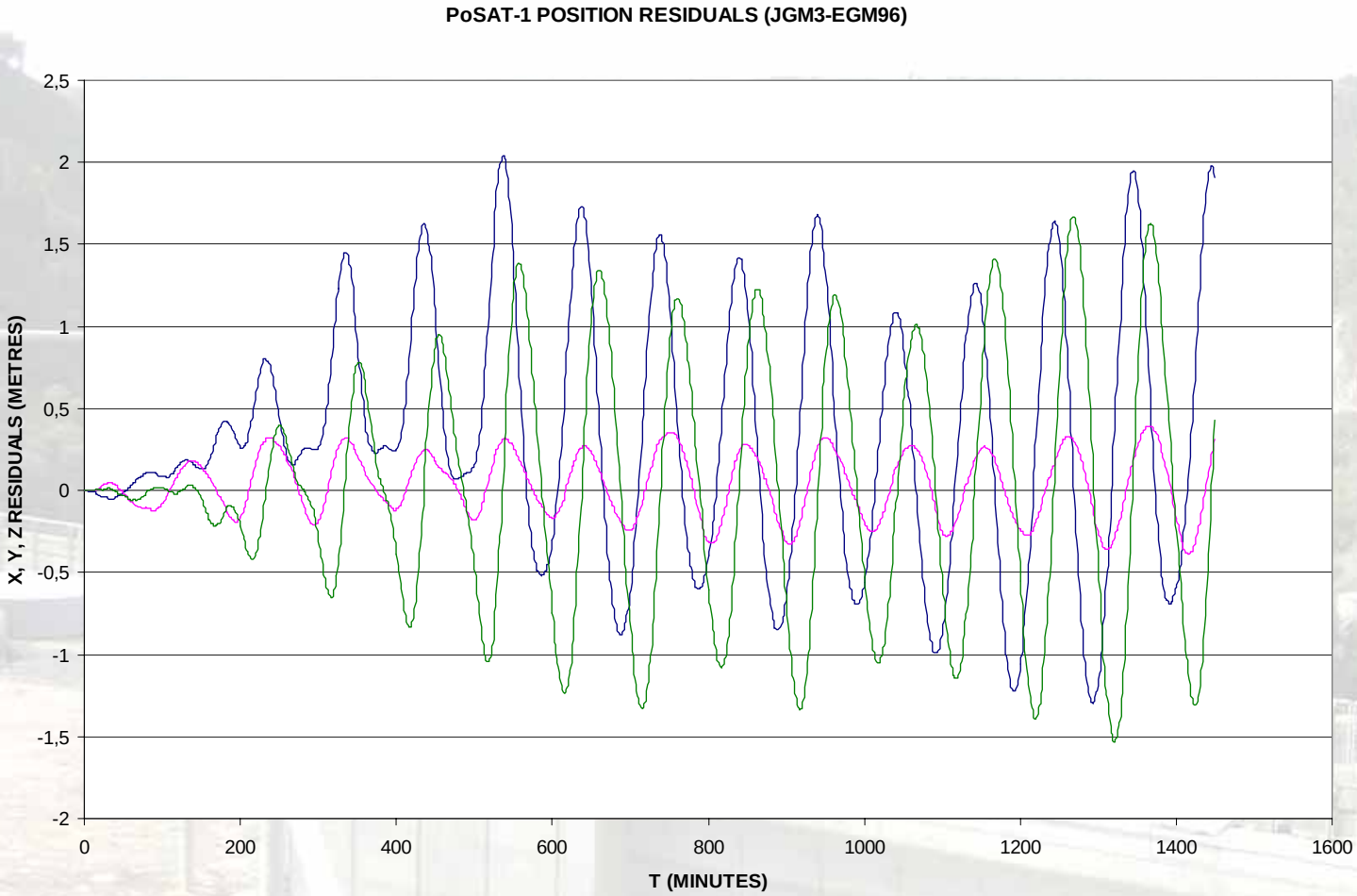
THE SENSITIVITY OF THE REDUCED DYNAMICS TO THE EARTH'S GRAVITY MODEL IN SATELLITE ORBITOGRAPHY



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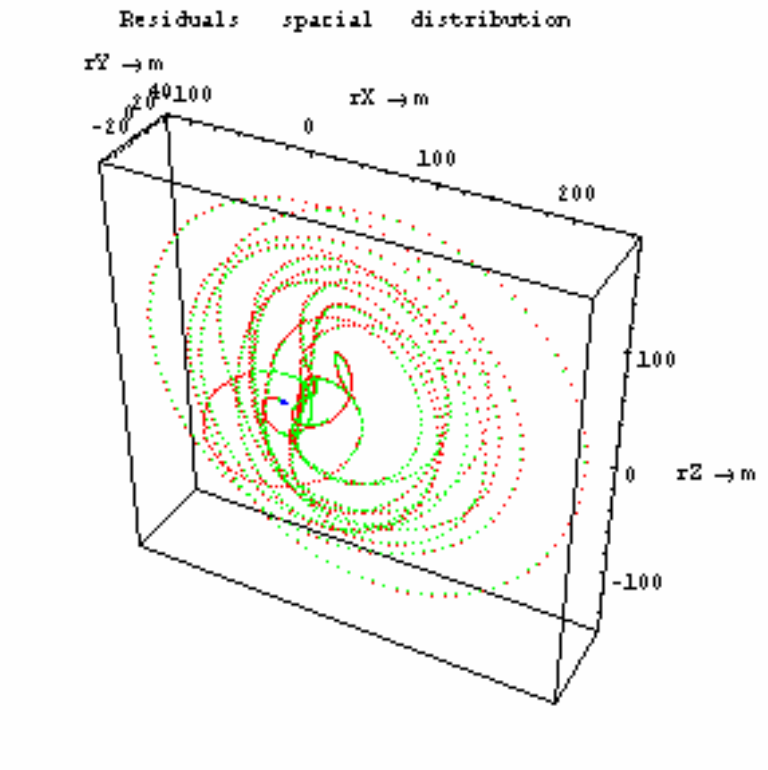
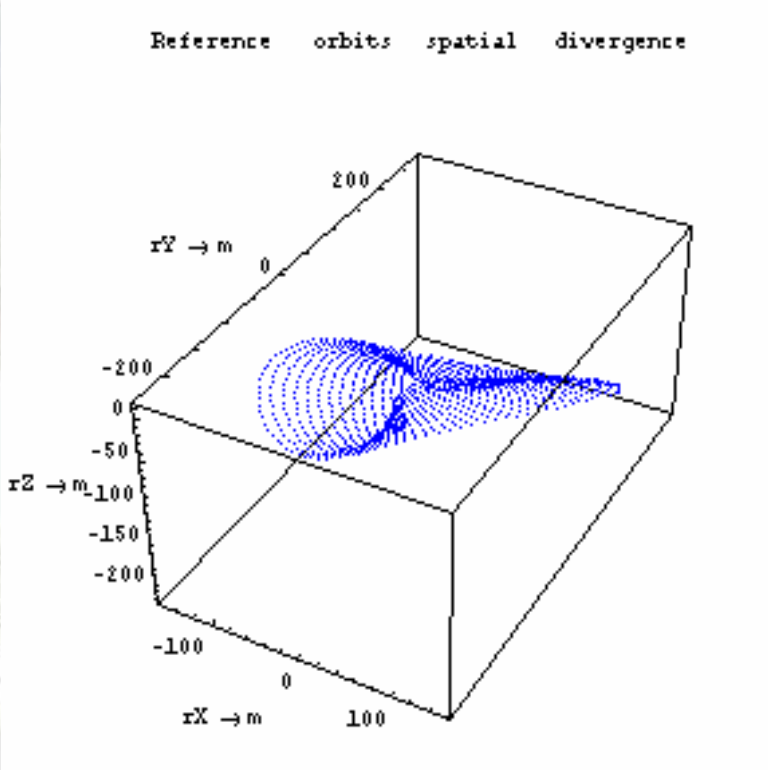
THE SENSITIVITY OF THE REDUCED DYNAMICS TO THE EARTH'S GRAVITY MODEL IN SATELLITE ORBITOGRAPHY





IONOSPHERIC STUDIES with PoSAT-1 GPS receiver data

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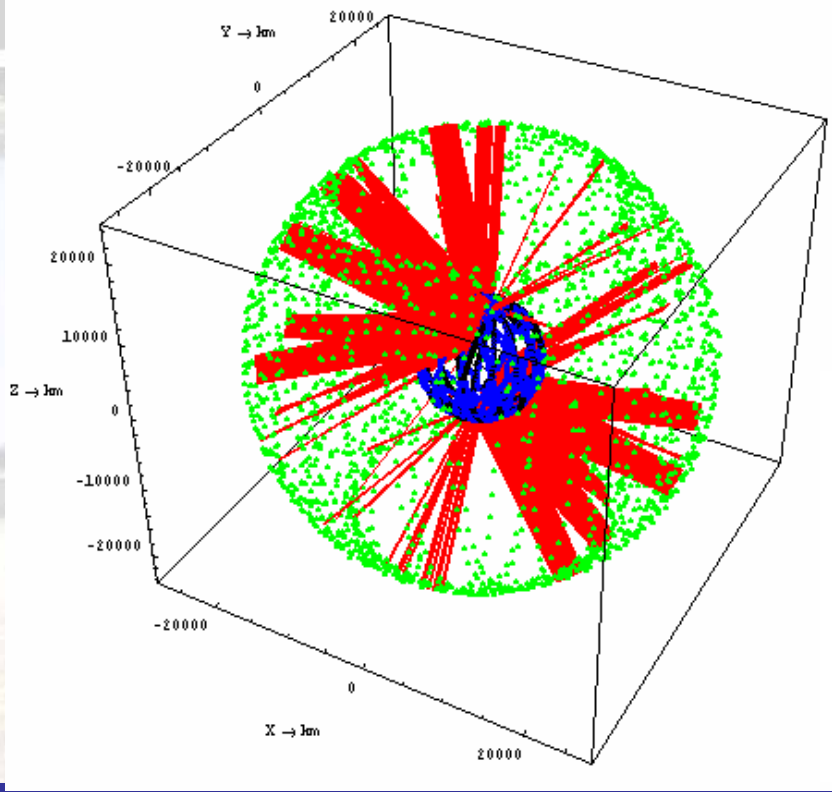
BASIC IDEA OF THE METHOD:

AS SEEN FROM BOARD, MANY CONTIGUOUS DIRECTIONS OF GPS SIGNAL PATH CROSS THE HIGH IONOSPHERE AND SOME CAN CROSS ALL THE IONOSPHERE (PoSAT AND GPS SATELLITE ARE IN OPPOSITE POSITIONS WITH RESPECT TO THE EARTH)



SOME OF THESE MEASUREMENTS CAN BE USED, IN A REVERSE PROCESS, WHERE PoSAT POSITION IS WELL KNOWN, TO EVALUATE THE TOTAL ELECTRON CONTENT (TEC)

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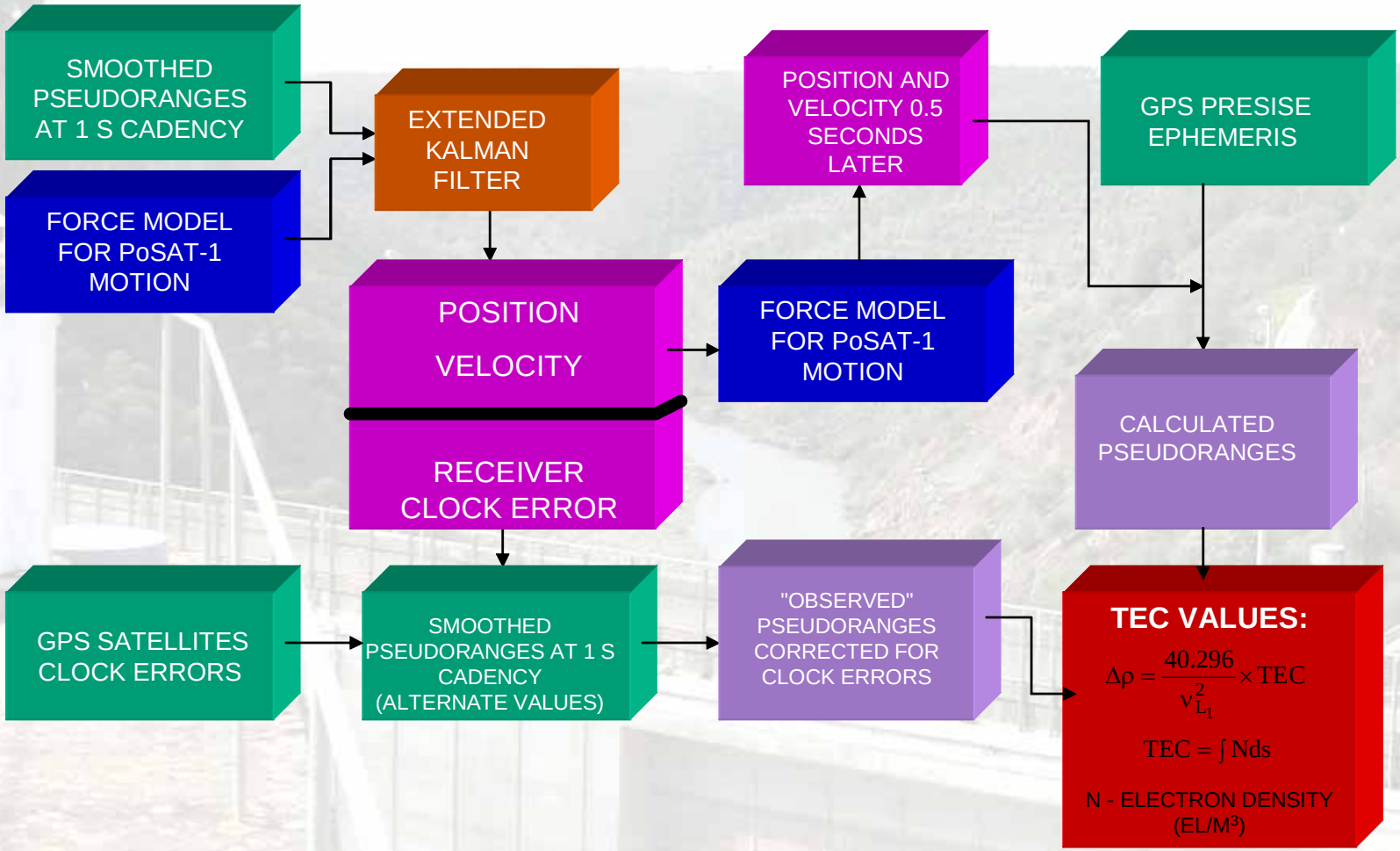
IONOSPHERIC STUDIES



IONOSPHERIC STUDIES

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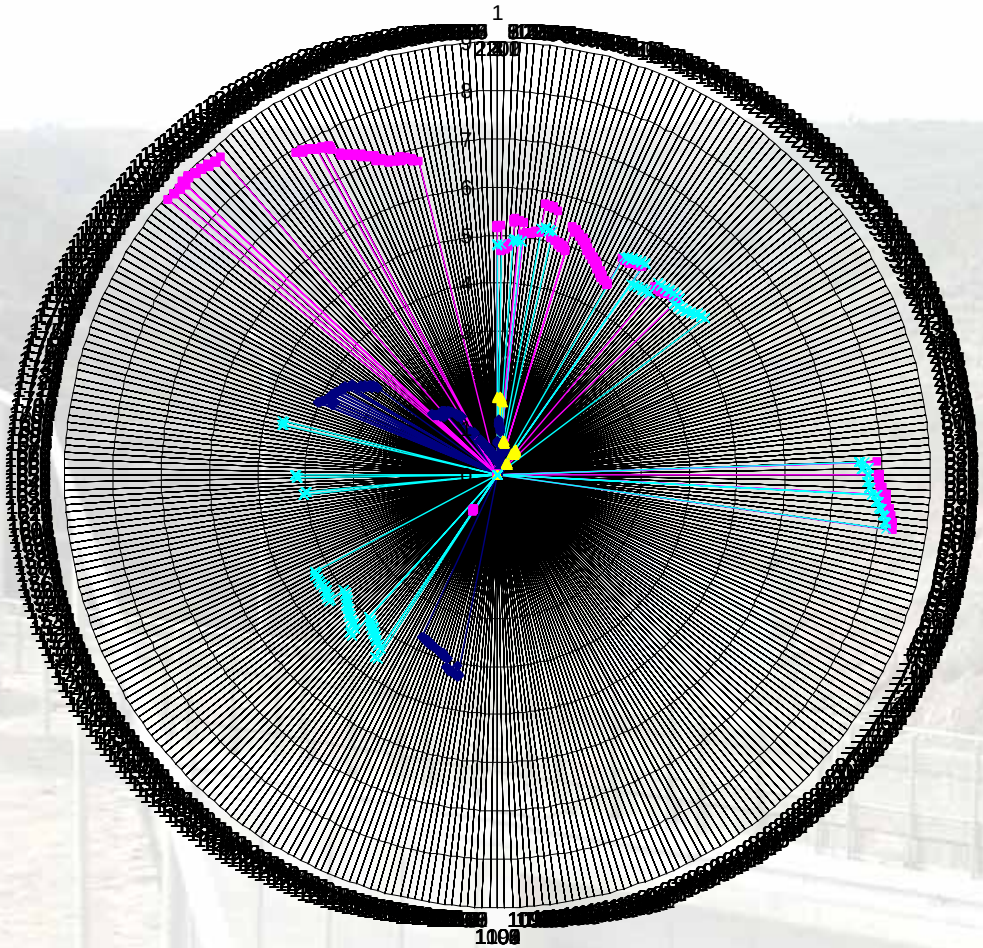

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GPS Meteorology

Data to process:

Code and carrier phases measurements available from the Portuguese GPS reference stations

IGS ultra-rapid orbits

Validation of the results:

Meteorological data, also available, from the same stations

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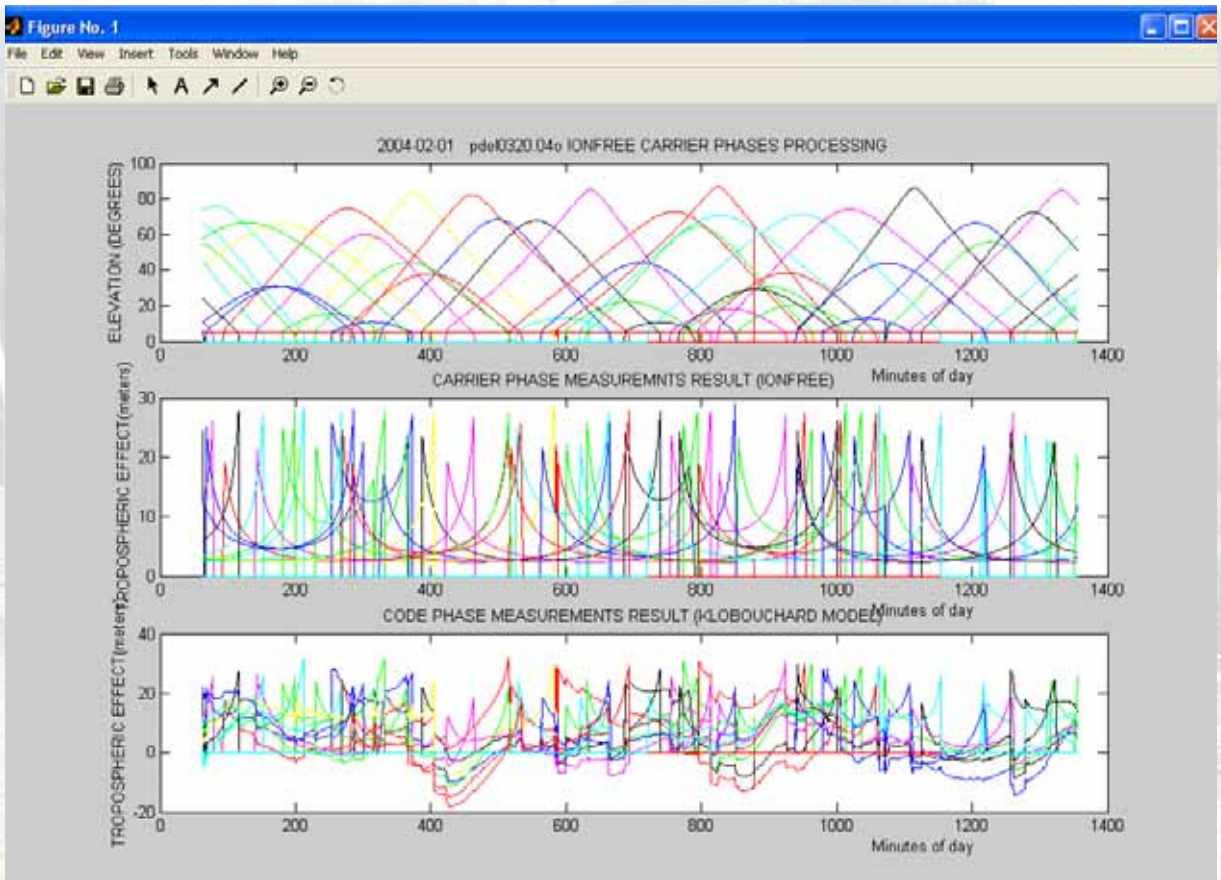
Tropospheric effect evaluation



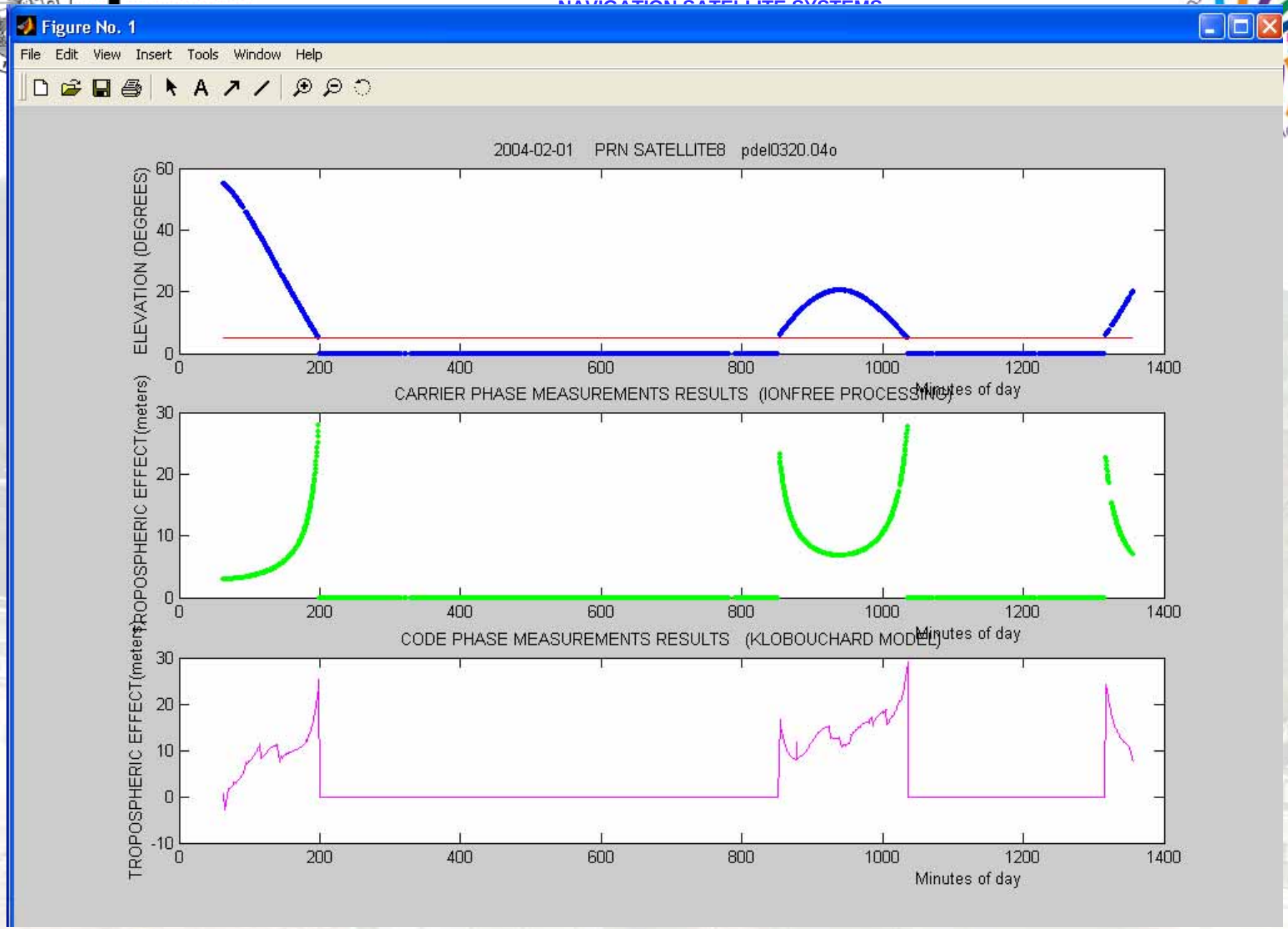


Figure No. 1
File Edit View Insert Tools Window Help
2004-02-01 PRN SATELLITE8 pdel0320.04o
ELEVATION (DEGREES)
Minutes of day
CARRIER PHASE MEASUREMENTS RESULTS (IONFREE PROCESSING)
TROPOSPHERIC EFFECT(meters)
Minutes of day
CODE PHASE MEASUREMENTS RESULTS (KLOBOUCHARD MODEL)
TROPOSPHERIC EFFECT(meters)
Minutes of day

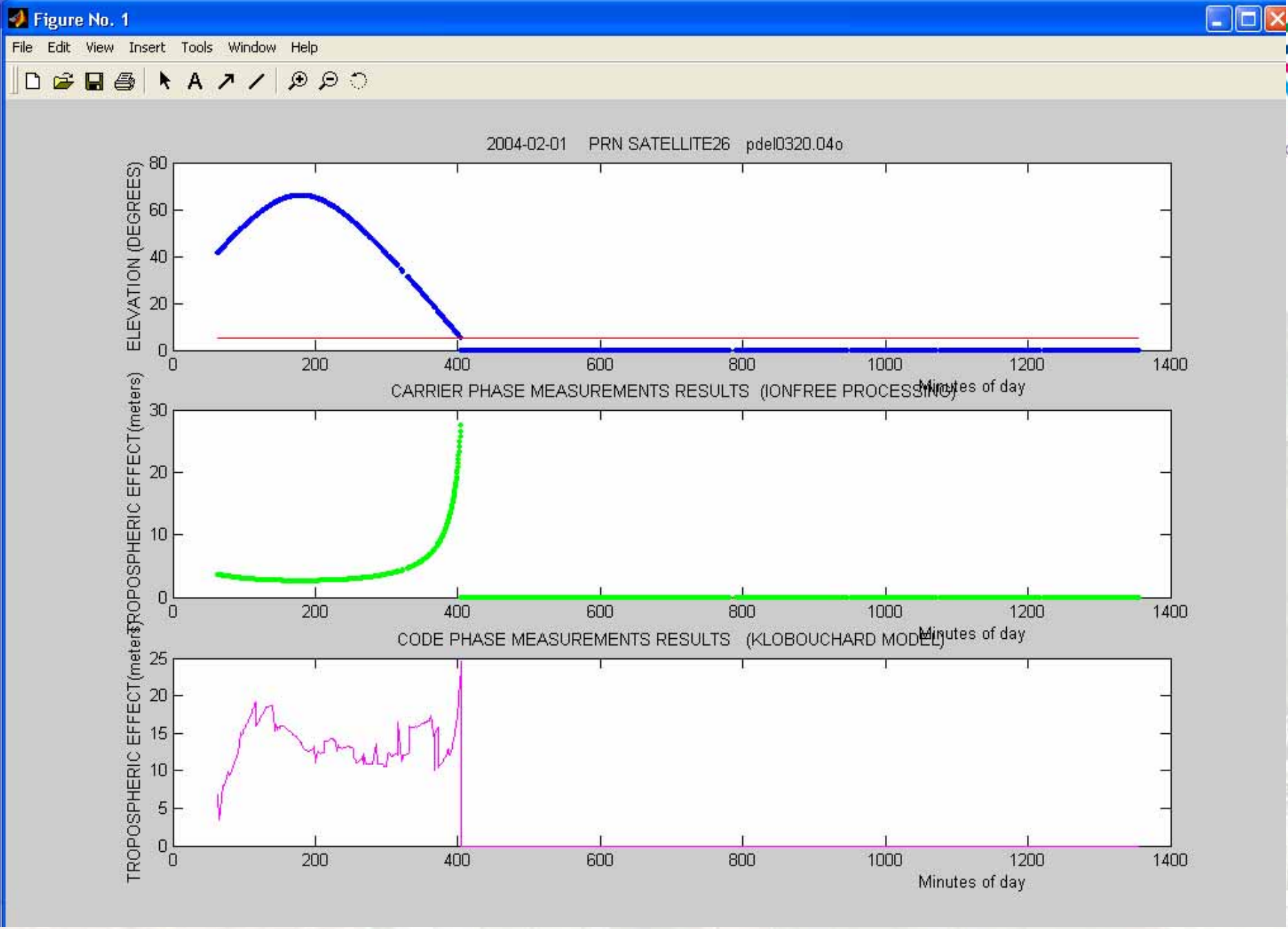


Figure No. 1
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2004-02-01 PRN SATELLITE26 pdel0320.04o
ELEVATION (DEGREES)
0 20 40 60 80
0 200 400 600 800 1000 1200 1400
Minutes of day
CARRIER PHASE MEASUREMENTS RESULTS (IONFREE PROCESSING)
TROPOSPHERIC EFFECT(meters)
0 10 20 30
0 200 400 600 800 1000 1200 1400
Minutes of day
CODE PHASE MEASUREMENTS RESULTS (KLOBOUCHARD MODEL)
TROPOSPHERIC EFFECT(meters)
0 5 10 15 20 25
0 200 400 600 800 1000 1200 1400
Minutes of day

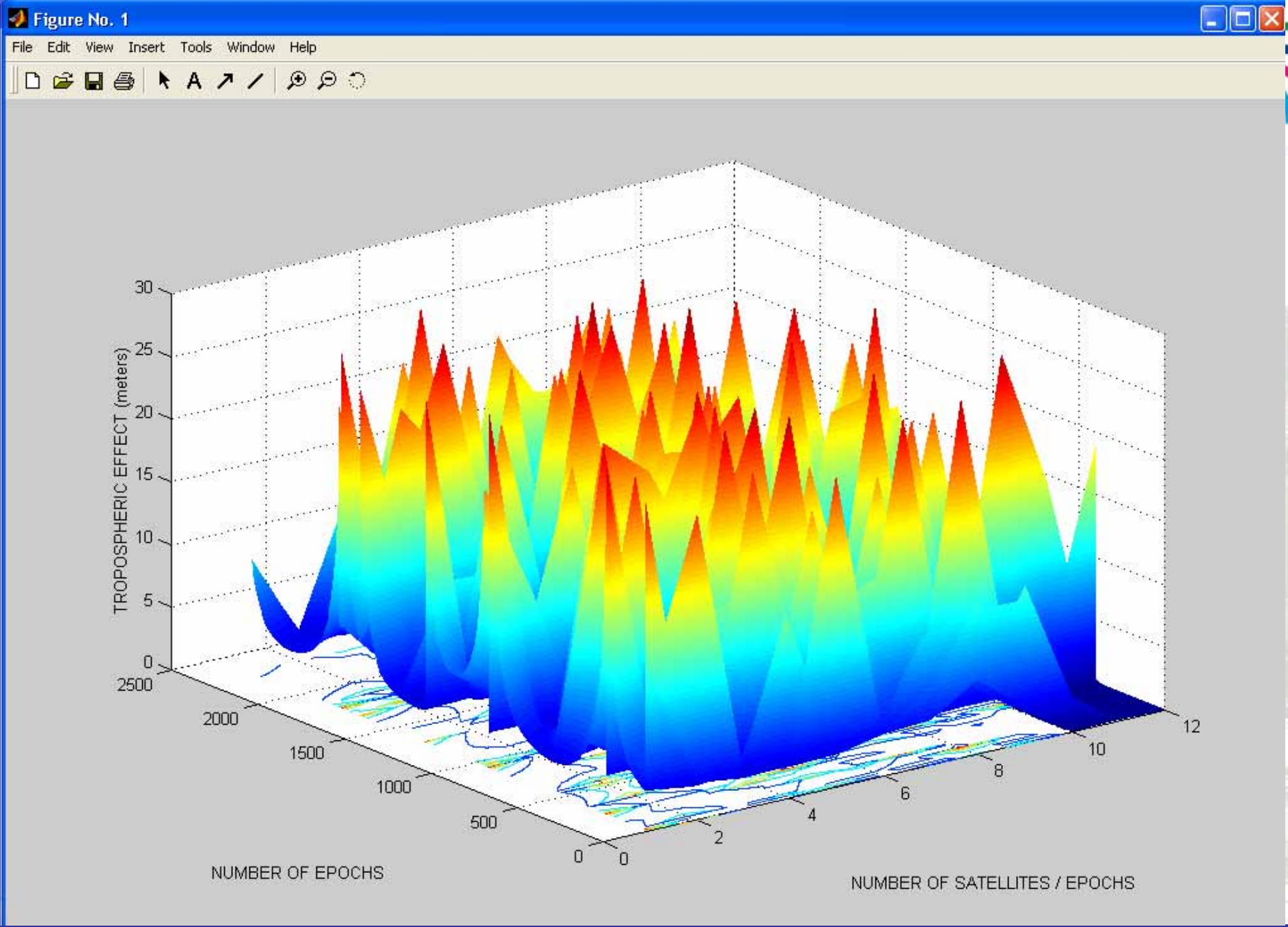
Figure No. 1
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TROPOSPHERIC EFFECT (meters)
30
25
20
15
10
5
0
2500
2000
1500
1000
500
0
NUMBER OF EPOCHS
0
2
4
6
8
10
12
NUMBER OF SATELLITES / EPOCHS

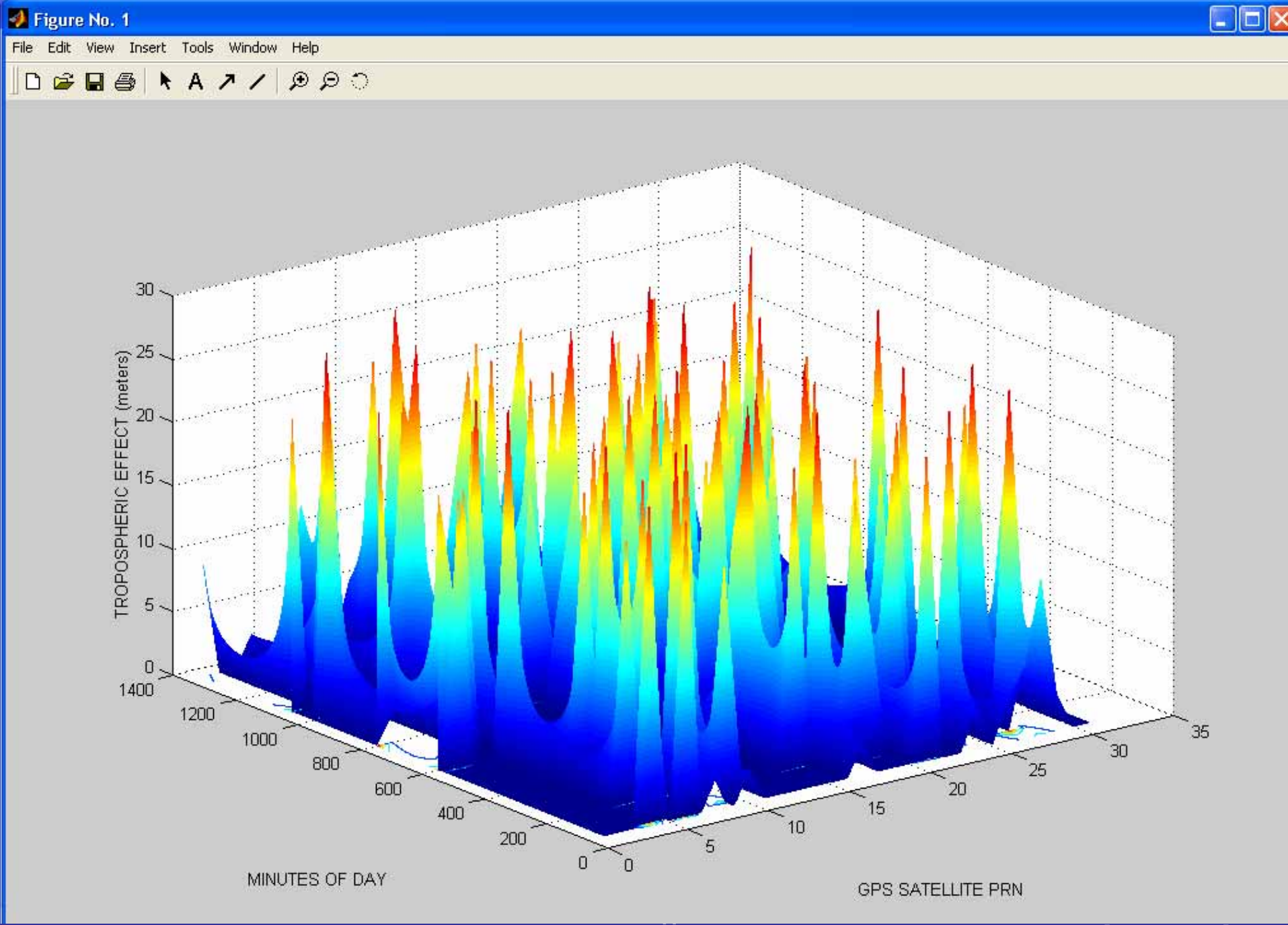
Figure No. 1
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TROPOSPHERIC EFFECT (meters)
0 5 10 15 20 25 30
MINUTES OF DAY
0 200 400 600 800 1000 1200 1400
GPS SATELLITE PRN
0 5 10 15 20 25 30 35

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Tropospheric models studied

- **SAASTAMOINEN**
- **MODIFIED HOPFIELD**
- **GOAD MODEL**
- **REMONDI MODEL (SIMILAR TO GOAD MODEL)**

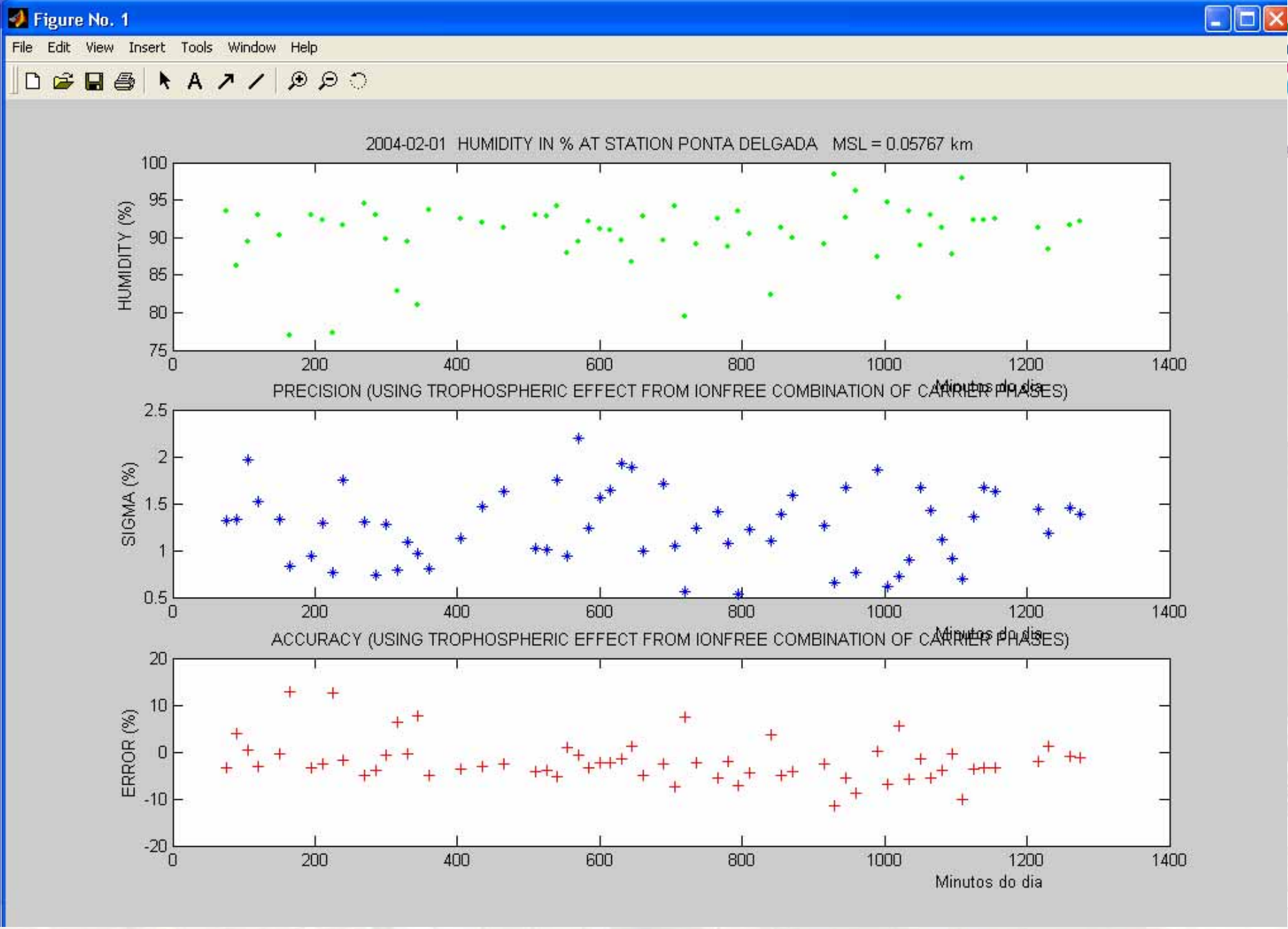
Figure No. 1
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2004-02-01 HUMIDITY IN % AT STATION PONTA DELGADA MSL = 0.05767 km
HUMIDITY (%)
PRECISION (USING TROPHOSPHERIC EFFECT FROM IONFREE COMBINATION OF CARRIER PHASES)
SIGMA (%)
ACCURACY (USING TROPHOSPHERIC EFFECT FROM IONFREE COMBINATION OF CARRIER PHASES)
ERROR (%)
Minutos do dia

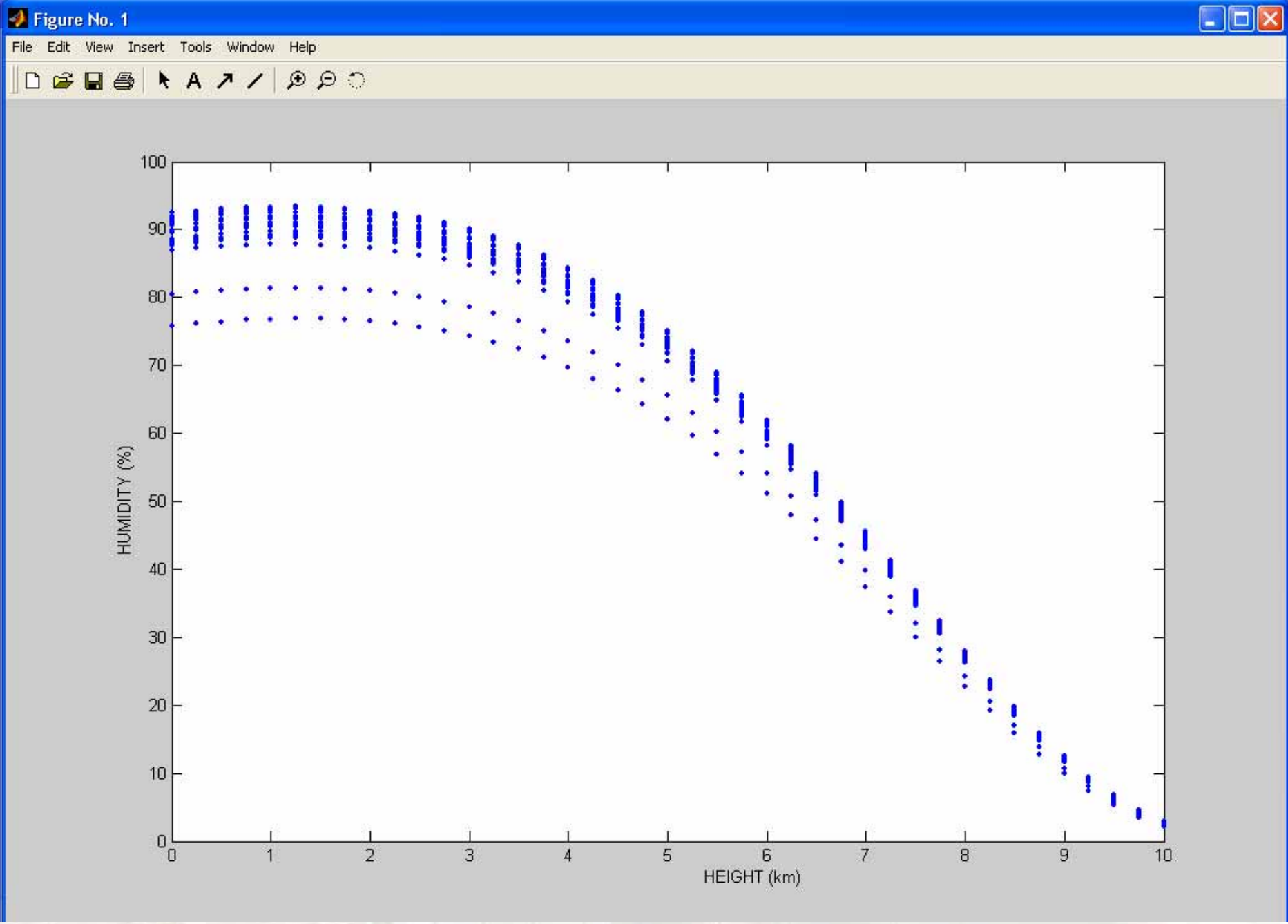
Figure No. 1
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HUMIDITY (%)
HEIGHT (km)
0 10 20 30 40 50 60 70 80 90 100
0 1 2 3 4 5 6 7 8 9 10

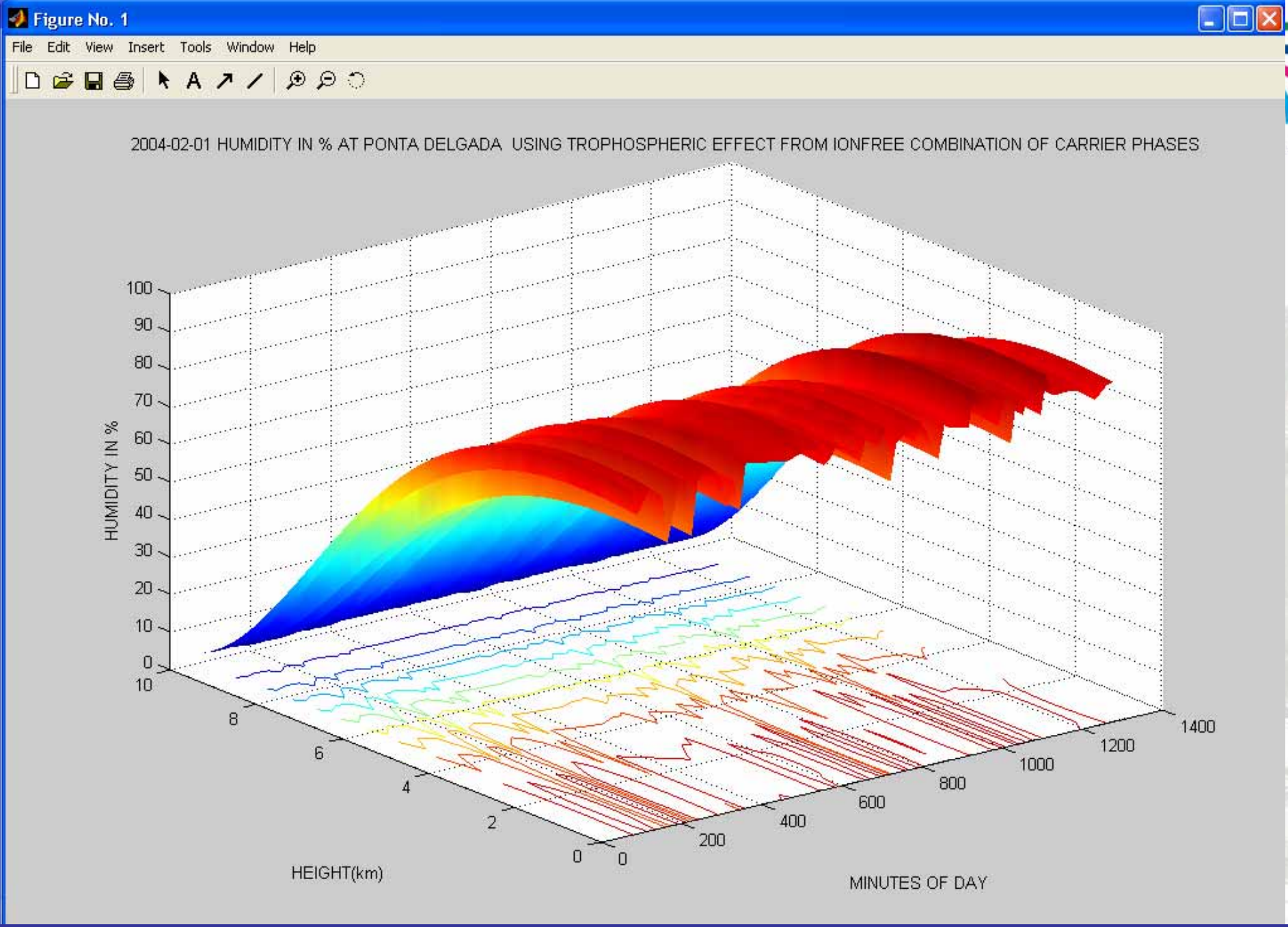
Figure No. 1
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2004-02-01 HUMIDITY IN % AT PONTA DELGADA USING TROPHOSPHERIC EFFECT FROM IONFREE COMBINATION OF CARRIER PHASES
HUMIDITY IN %
100
90
80
70
60
50
40
30
20
10
0
10
8
6
4
2
0
HEIGHT(km)
0
200
400
600
800
1000
1200
1400
MINUTES OF DAY

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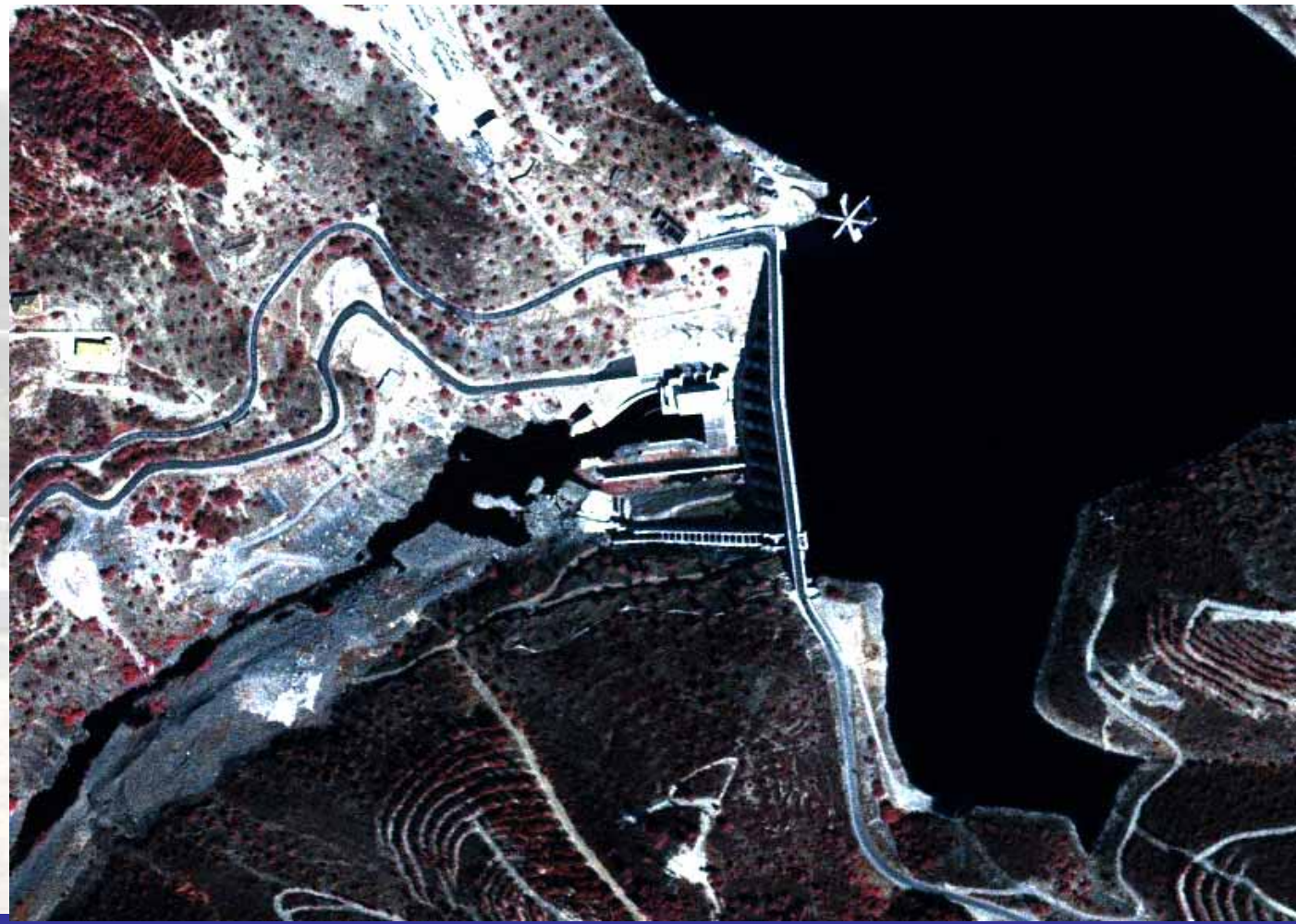
Dam control with GPS
Pracana case study



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CENTRO DE INVESTIGAÇAO EM CIÊNCIAS GEO-ESPACIAIS (CICGE)


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2002 10 9

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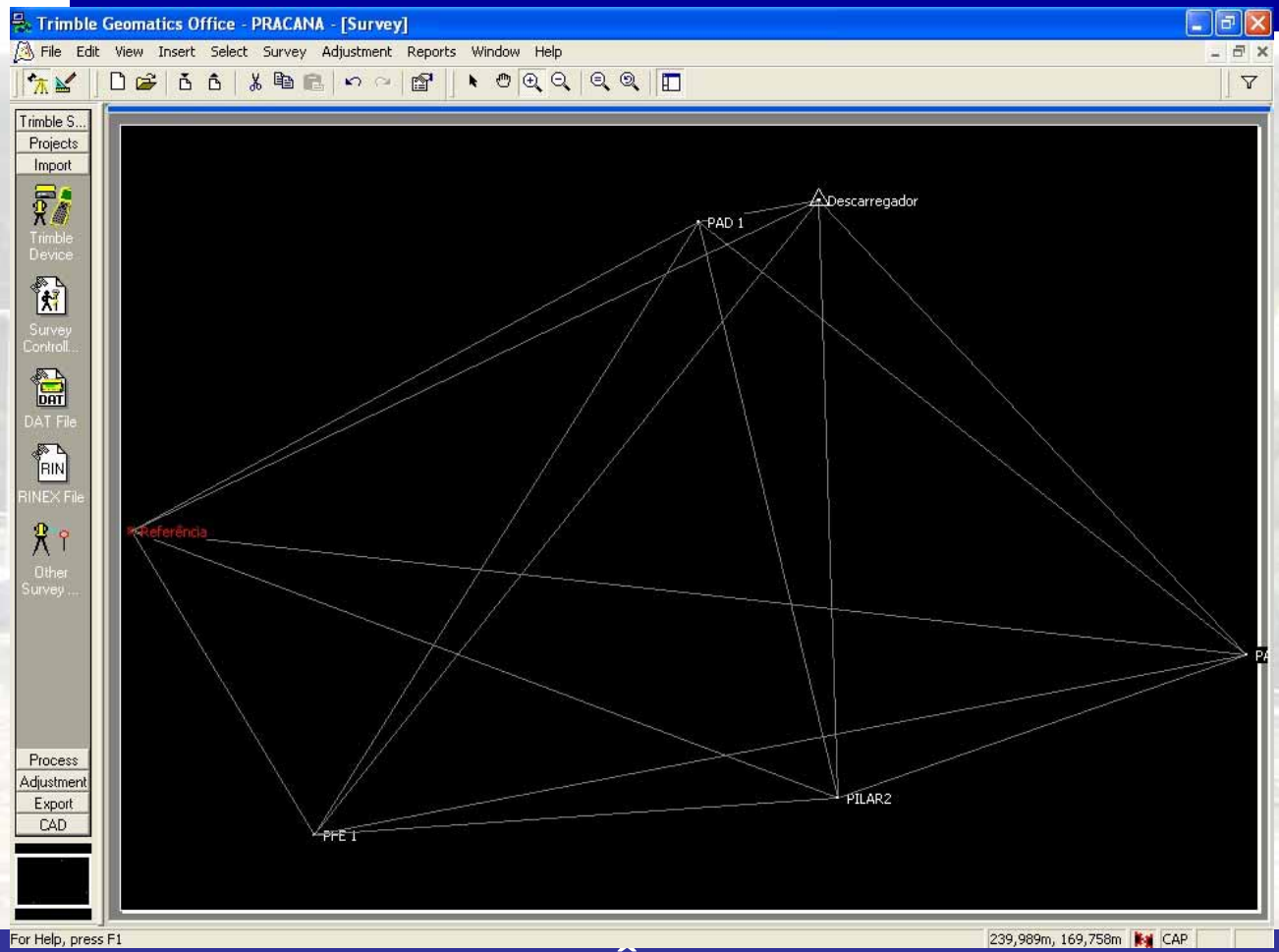
High Precision Network



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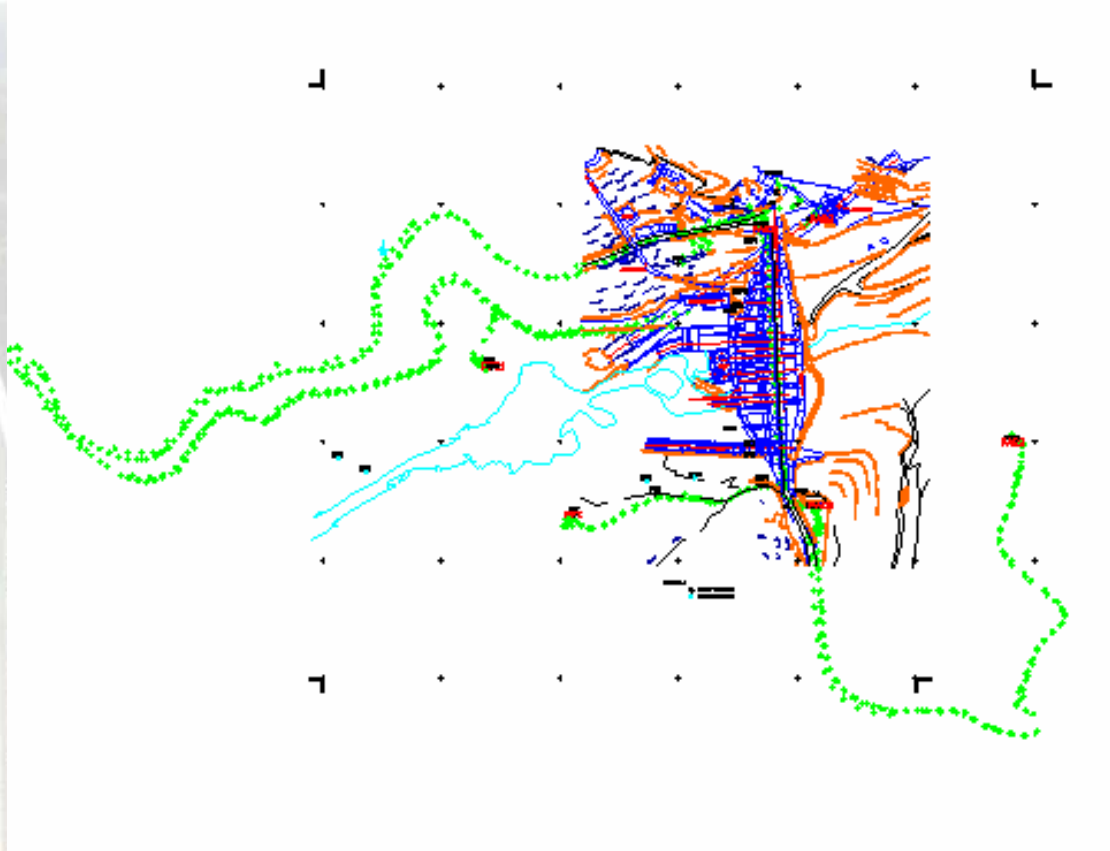
Navigation studies with GPS



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High precision Agriculture

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CENTRO DE INVESTIGAÇAO EM CIÊNCIAS GEO-ESPACIAIS (CICGE)

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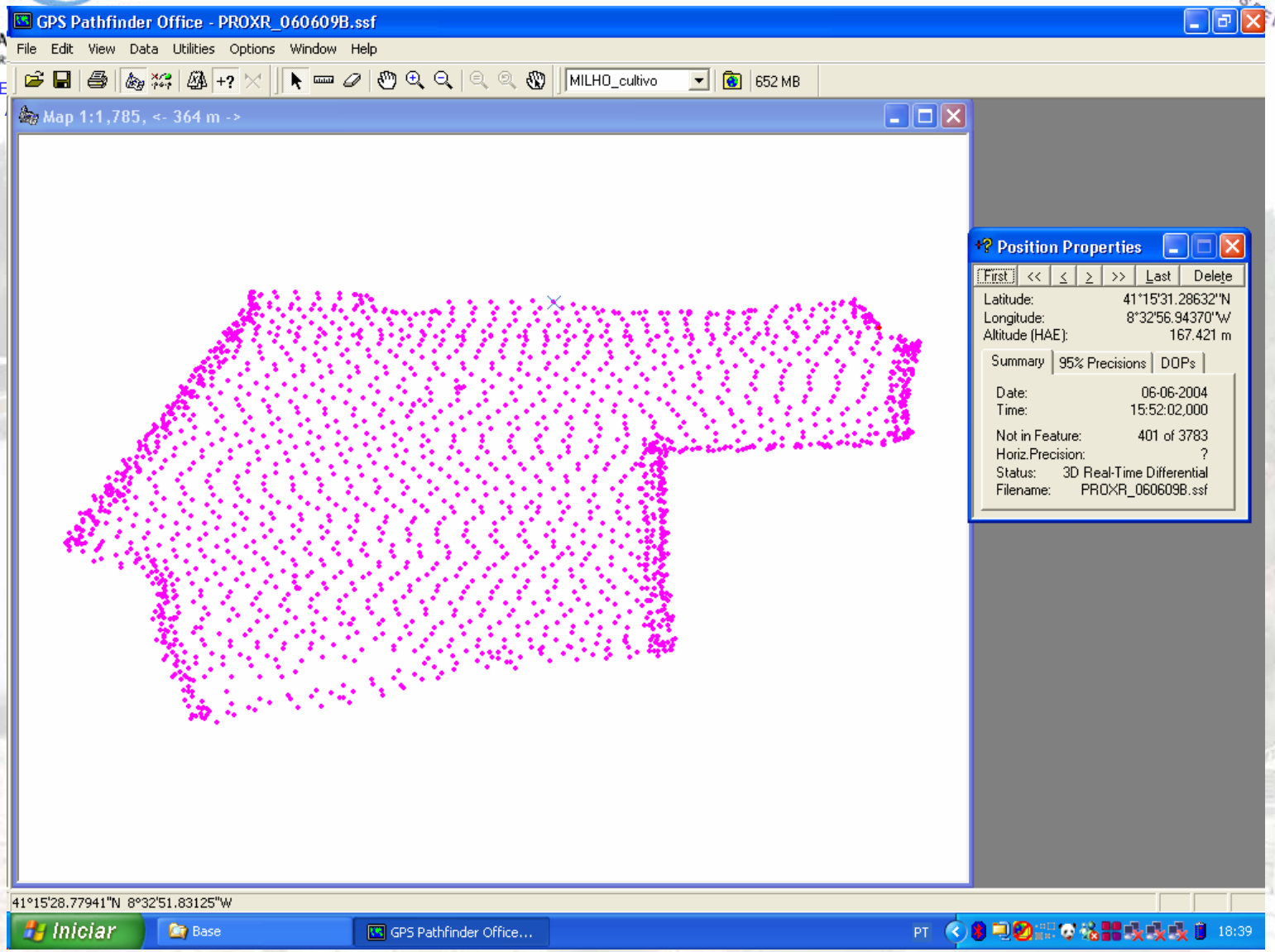

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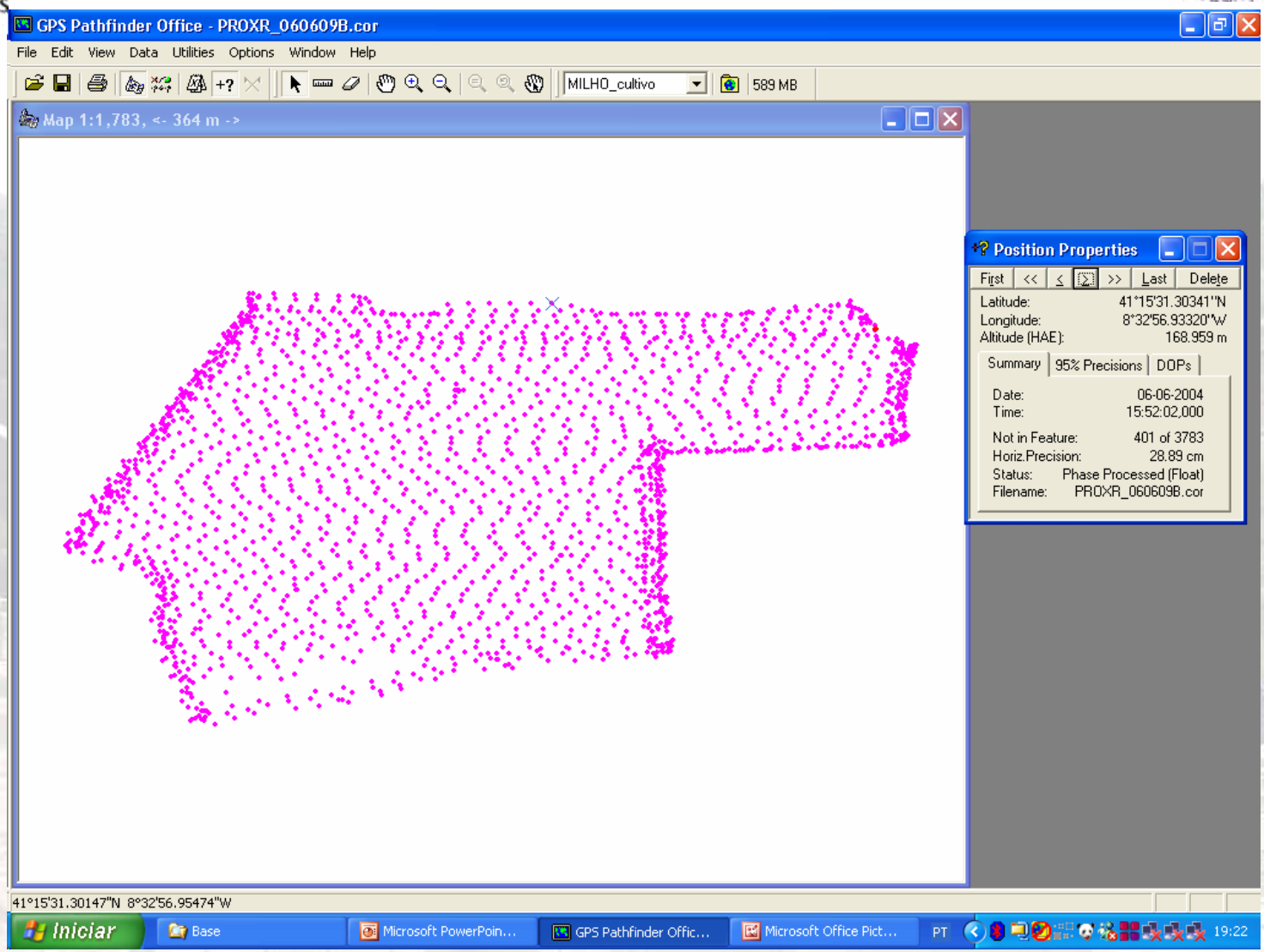

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The Portuguese Institute of Navigation - IPN

- Member of EUGIN – European Group of Institutes of Navigation – since December 2003
- Some Conferences in Navigation problems were, already, promoted by IPN
- The nº1 Journal of Navigation will be published next January