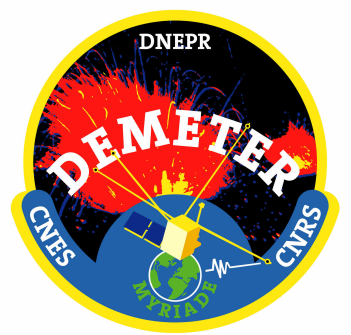

On the TEC determination from the ionospheric DORIS products

by

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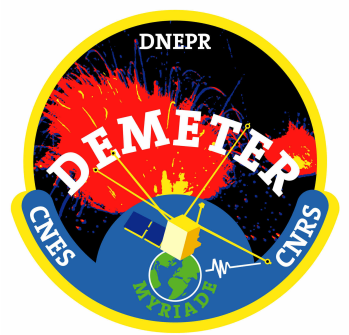
LPCE/CNRS Orléans, France

IDS Plenary meeting, 3rd May 2004, Paris

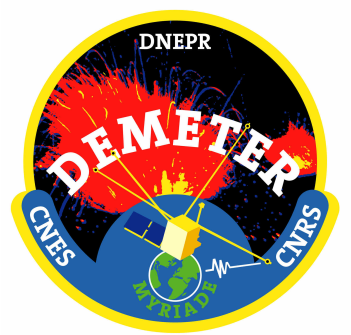


Outlines

Method to extract theTEC parameter

Problems with the data

Conclusions

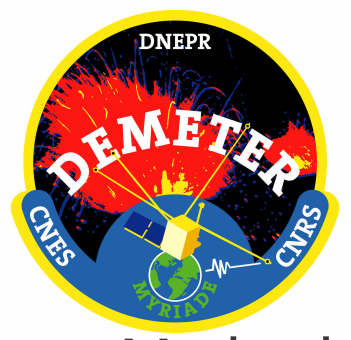


Method to extract theTEC parameter

We take the ionospheric data files from
ftp://cddisa.gsfc.nasa.gov/pub/doris/products/iono/ssa

In a file related to each pass close to a station, we use the following parameters : date, time, count interval (2GHz), ionospheric correction (2GHz), elevation angle, azimuth, station-satellite distance.

For each station, we calculate at each time the coordinates (latitude and longitude) of the satellite track and then the coordinates of the sub-ionospheric point at which the TEC will be estimated (assuming a thin ionospheric layer at a constant altitude).

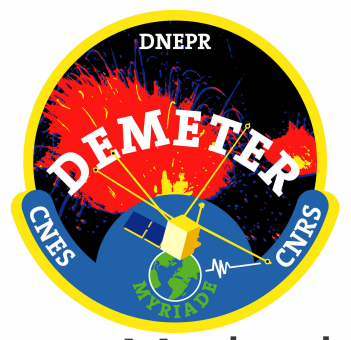


Method to extract theTEC parameter

We use the following equation between the DORIS measurements and the TEC values:

$IC(i) = c * [k_1(i) * TEC_1(i) – k_2(i) * TEC_2(i)]$ for i = 1, N

Where N is the number of measurements, IC is the ionospheric correction in m/s (0.02 cy → 0.3 mm/s at 2 GHz), c is a constant related to the frequency of emission and the count interval, k is a geometric factor to convert a slant TEC to a vertical TEC, TEC_1 is the TEC value at the subionospheric point related to measurement at the beginning of the counting period, and TEC_2 is the TEC value at the subionospheric point related to measurement at the end of the counting period.



Method to extract theTEC parameter

We assume that the TEC values can be approximated by a polynomial of degree N (N = 5) function of the latitude of the subionospheric point:

$$TEC(i) = a_0 + a_1 * lat(i) + a_2 * lat(i)^2 + a_3 * lat(i)^3 + a_4 * lat(i)^4 + a_5 * lat(i)^5$$

If we take into account the previous equation, we have:

$$IC(i) = c * [k_1(i) - k_2(i)] * a_0 + c * [k_1(i)*lat_1(i) - k_2(i)*lat_2(i)] * a_1$$
$$+ c * [k_1(i)*lat_1(i)^2 - k_2(i)*lat_2(i)^2] * a_2 + c * [k_1(i)*lat_1(i)^3 - k_2(i)*lat_2(i)^3] * a_3$$
$$+ c * [k_1(i)*lat_1(i)^4 - k_2(i)*lat_2(i)^4] * a_4 + c * [k_1(i)*lat_1(i)^5 - k_2(i)*lat_2(i)^5] * a_5$$

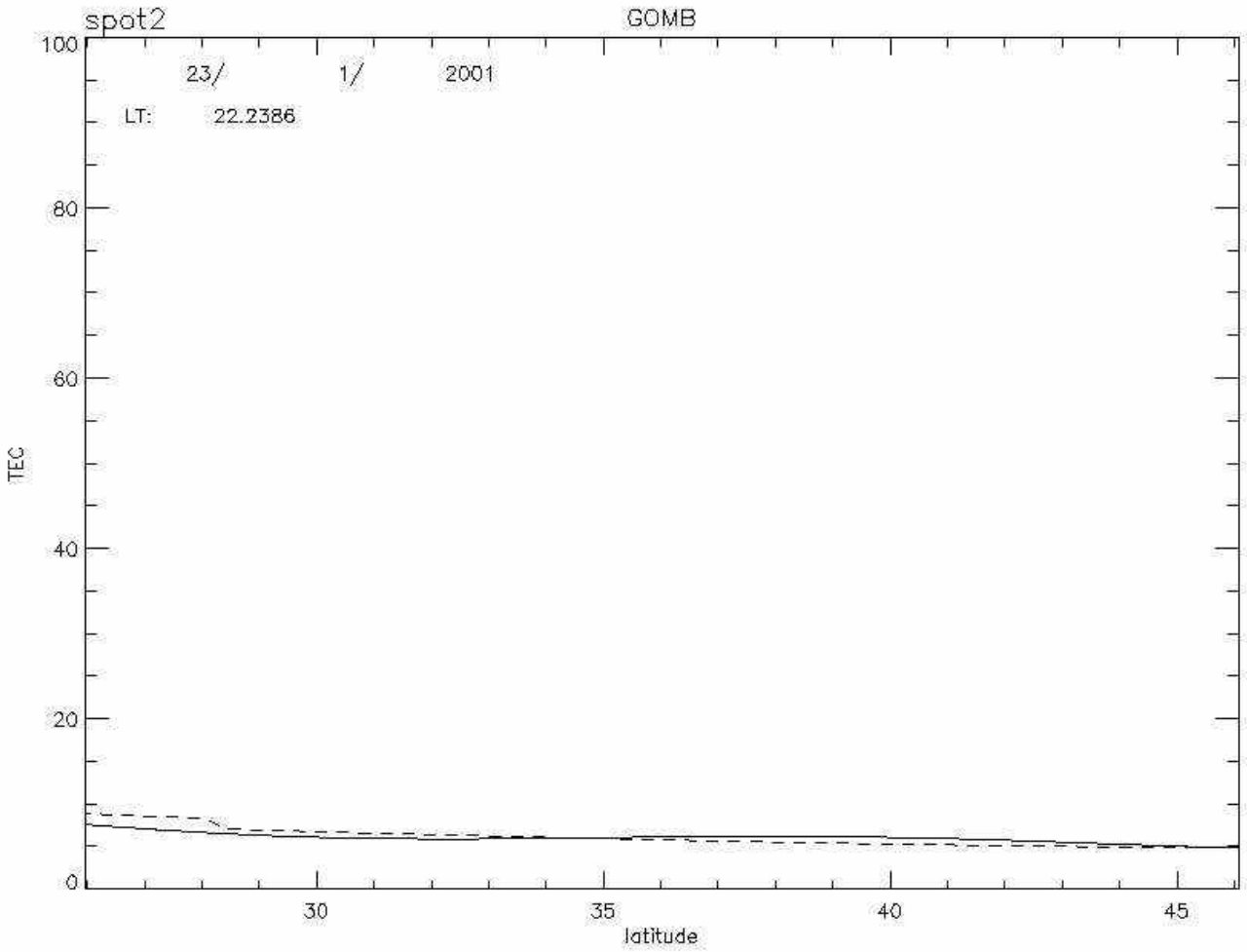
This is a matrix equation: $IC = B\ A$
where IC is the vector of the DORIS measurements (N), A is the vector of unknown polynomial coefficients (6) and B is a matrix of size N*6.

Method to extract theTEC parameter

We solve this system with a least square method (IDL software) in order to get the coefficients a_i.

We calculate the TEC values at each subionospheric point.

We compare the results with TEC values given by the IRI 2001 model.



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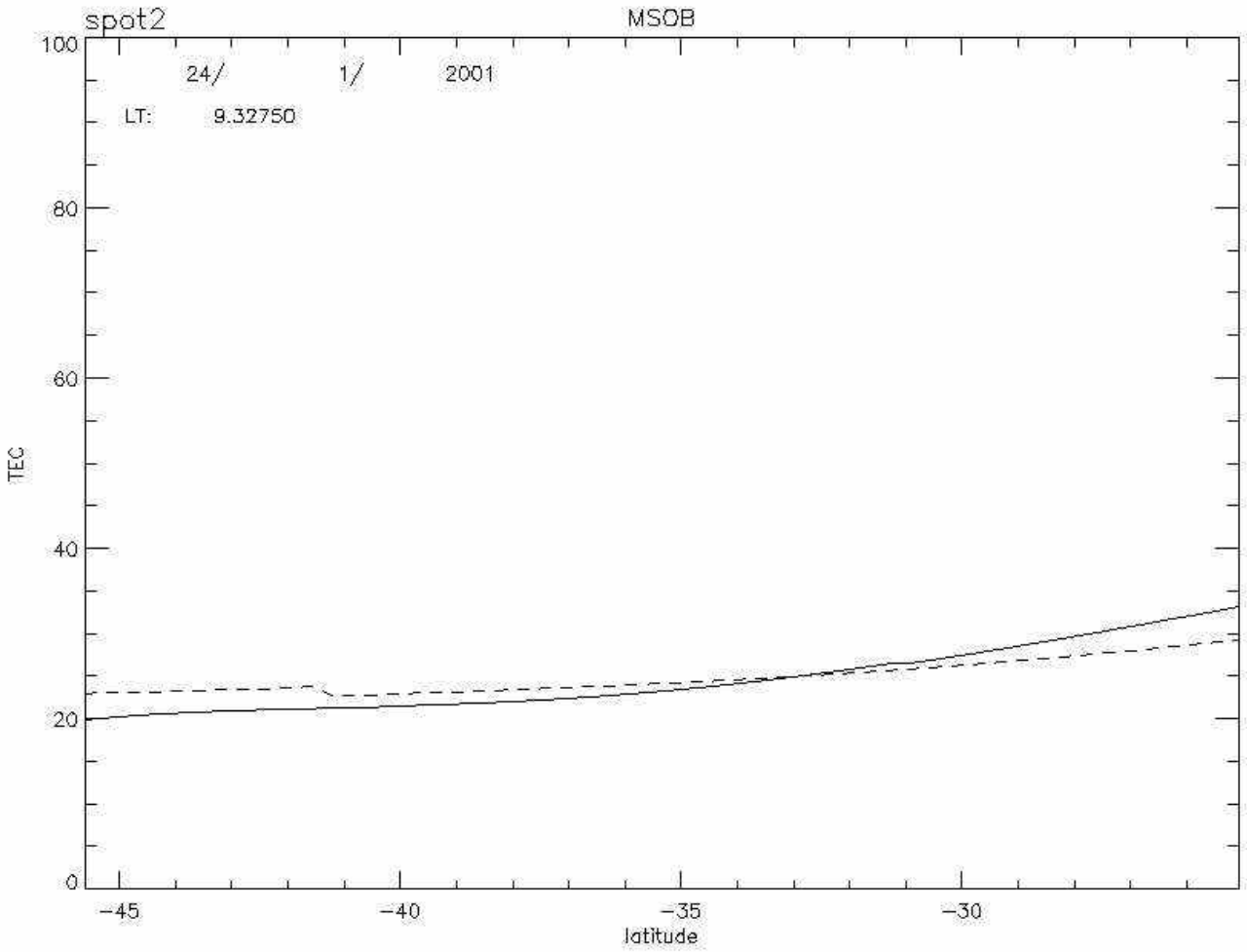

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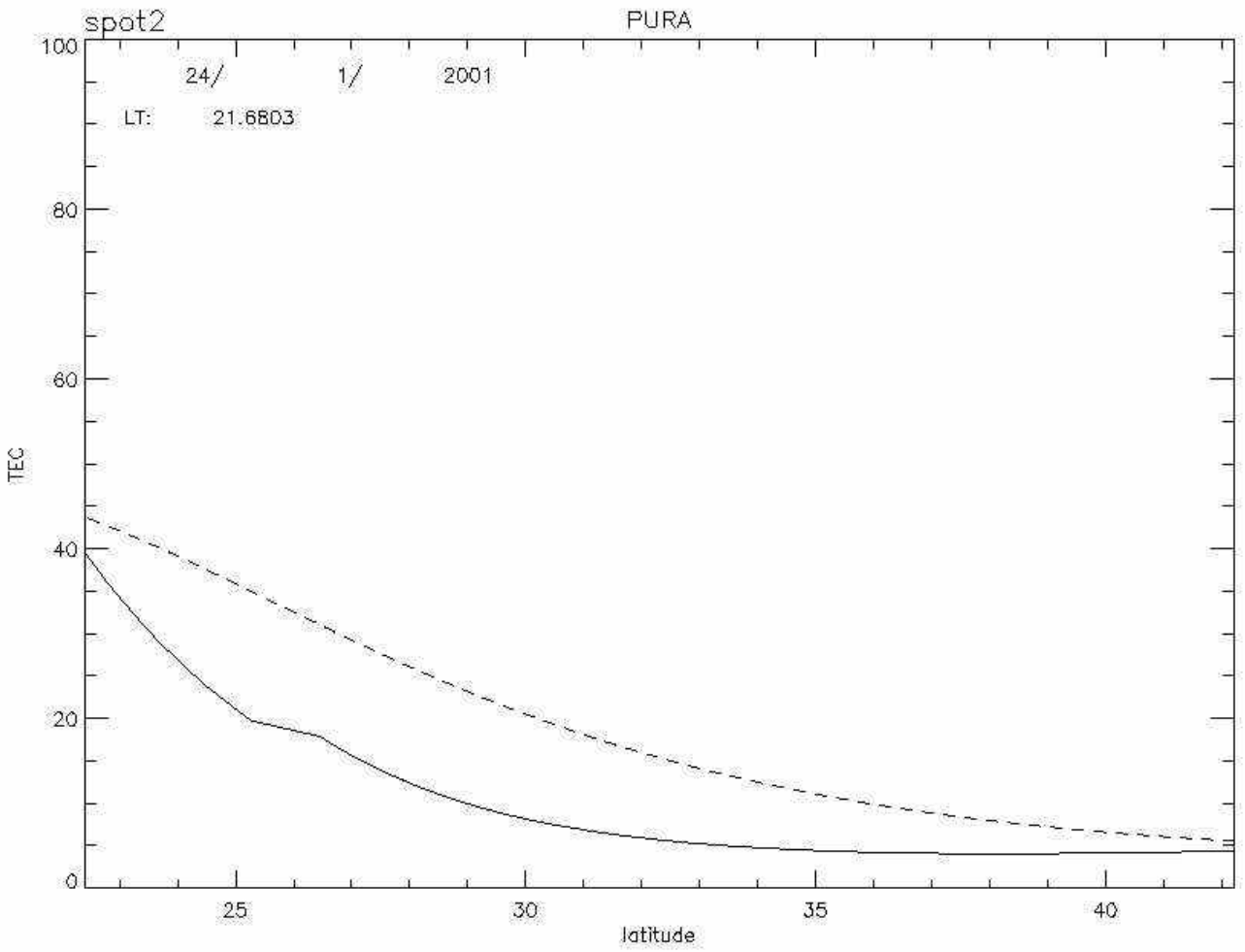
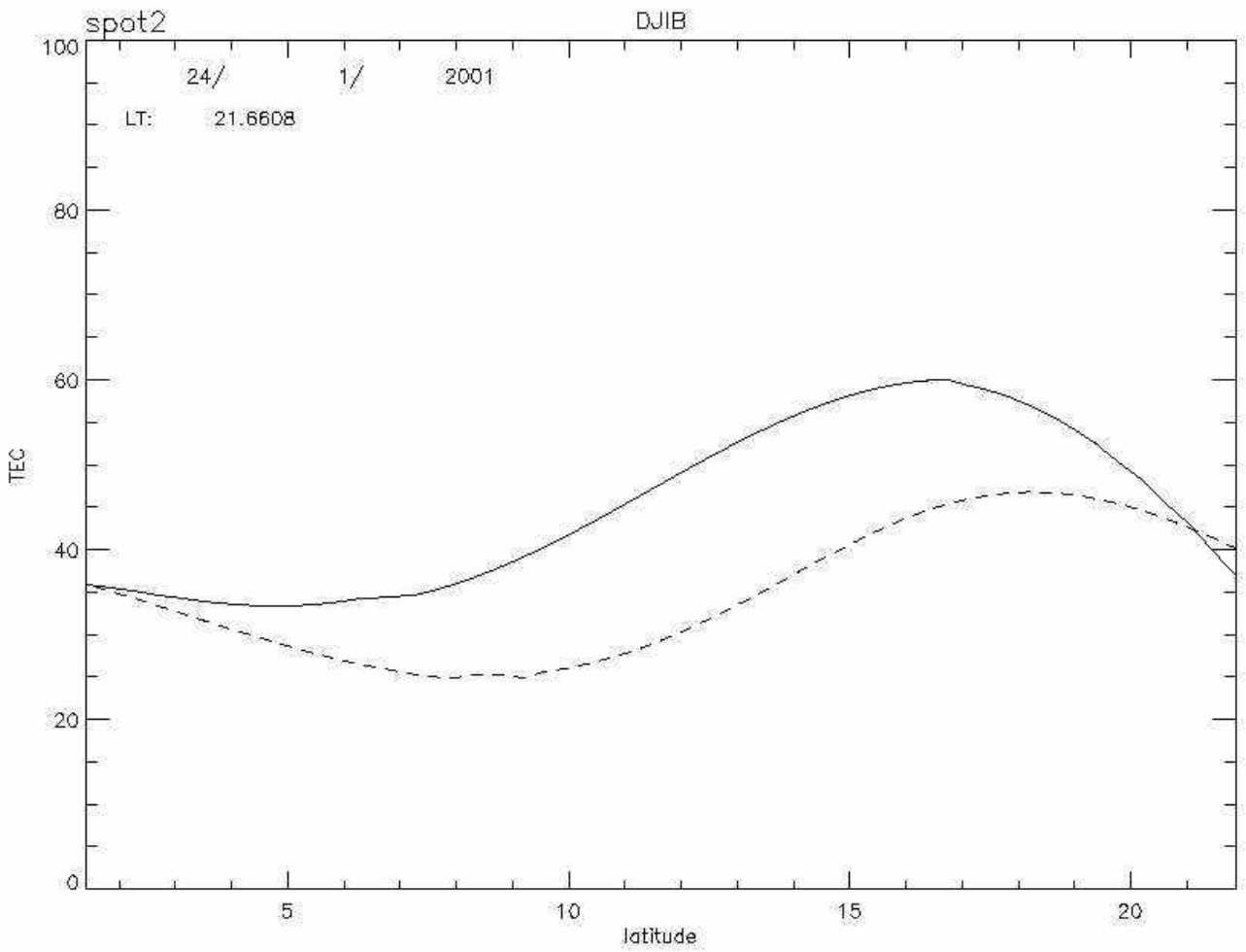


IDS Plenary meeting, 3rd May 2004, Paris



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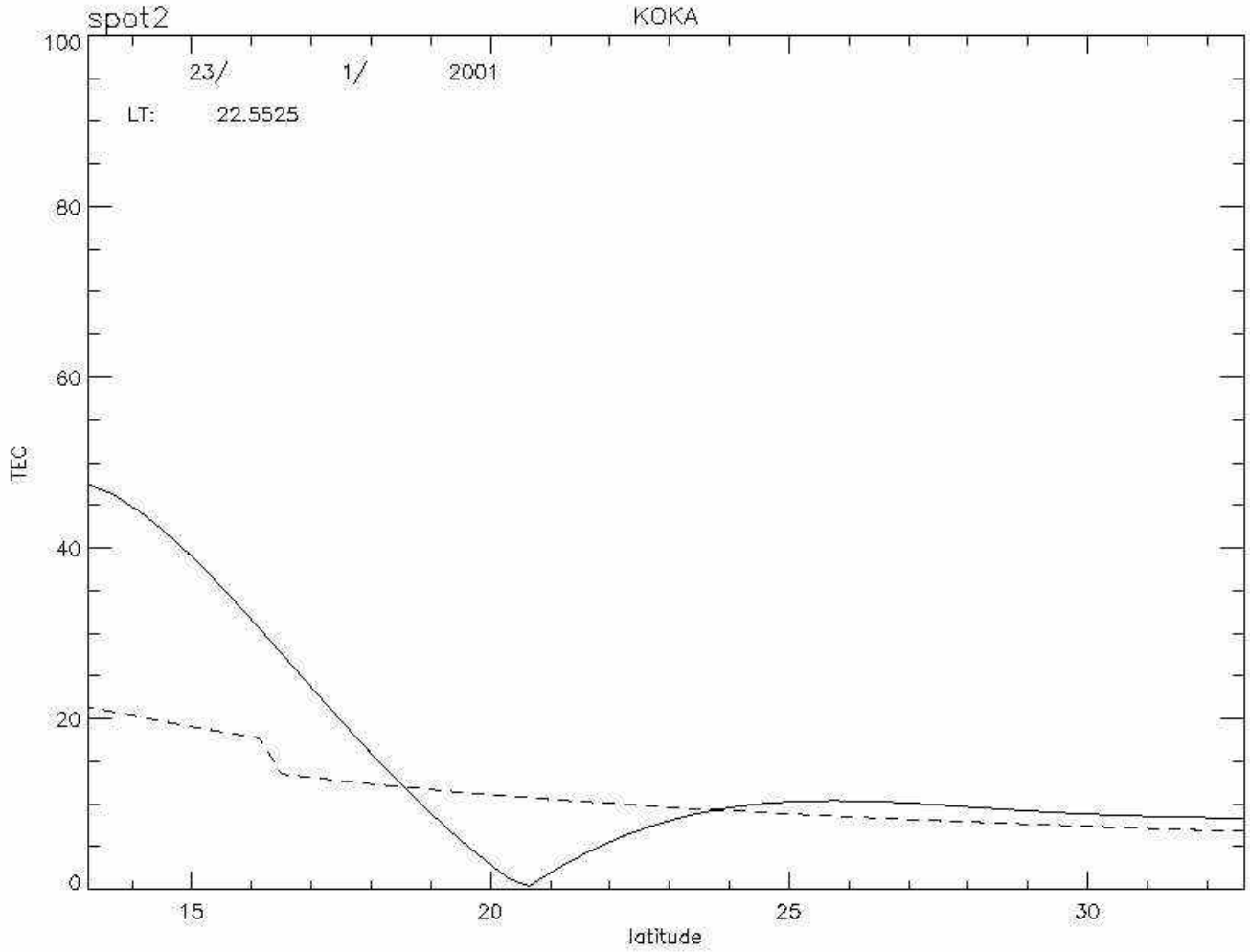

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SPOT2 KOKA 55 38.58700 22.82700 12 75

Day, Time, Elimination criteria, count period, Iono Cor., Pond

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18651	33859.99218750	-502	9.0000000	-3.783	0
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18651	33879.99218750	1	9.9999981	-5.197	1
18651	33889.99218750	1	10.0000029	-5.485	1
18651	33899.99218750	1	10.0000000	-5.586	1
18651	33909.99218750	1	9.9999981	-5.730	1
18651	33919.99218750	1	10.0000019	-5.698	1
18651	33929.99218750	1	9.9999943	-5.555	1
18651	33939.99218750	1	10.0000010	-5.316	1
18651	33949.99218750	1	9.9999990	-5.005	1
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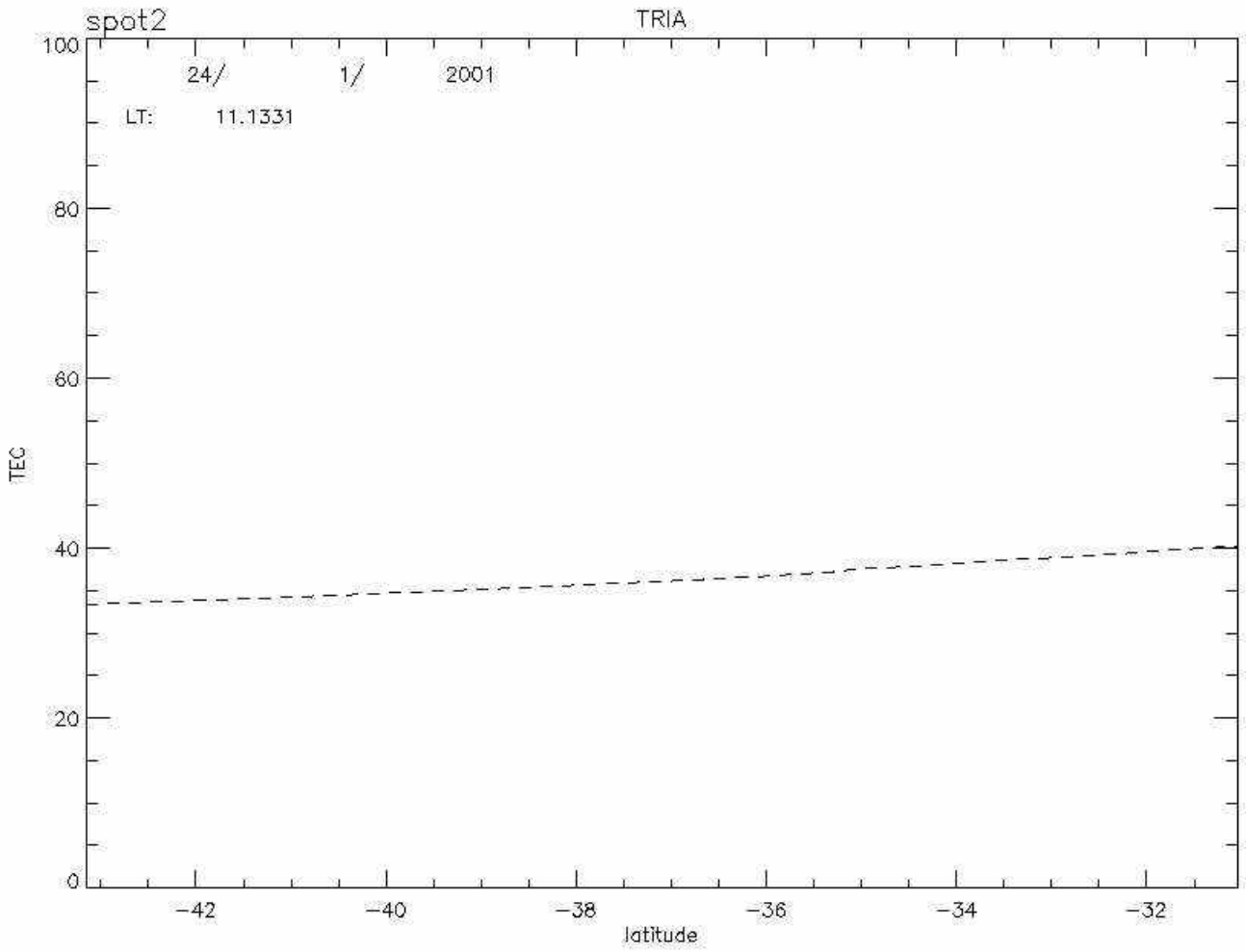
18651	33969.99218750	1	10.0000000	-4.094	1


spot2
TRIA
24/ 1/ 2001
LT: 11.1331
TEC
100
80
60
40
20
0
−42
−40
−38
−36
−34
−32
latitude

SPOT2 TRIA 28 19.41200 35.25400 19 75

Day, Time, Elimination criteria, count period, Iono Cor., Pond

18651	43319.99218750	-502	8.9999981	-1.568	0
18651	43339.99218750	1	8.9999990	-1.040	0
18651	43359.99218750	1	9.0000019	-0.978	0
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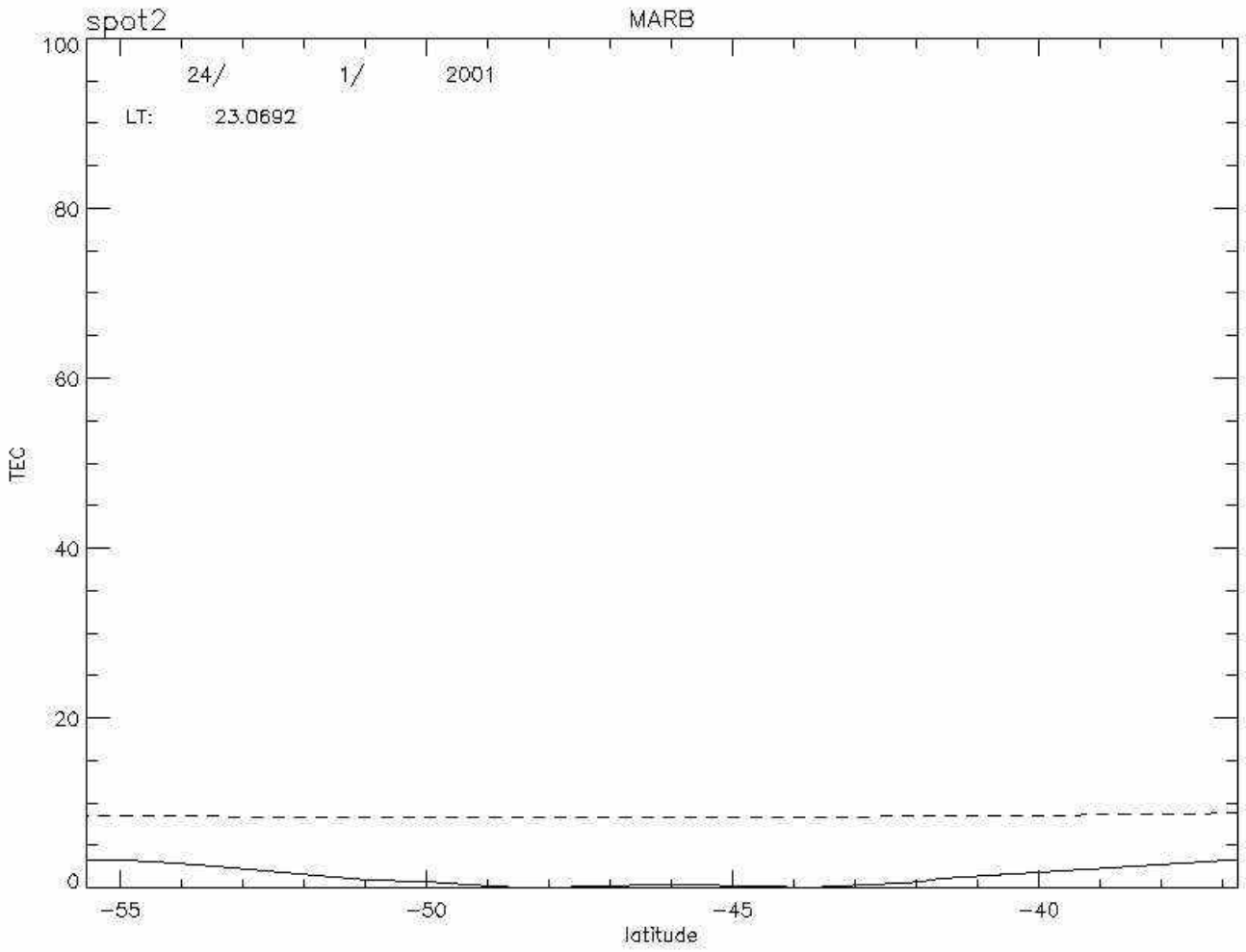
18651	43419.99218750	1	8.9999971	-0.932	0
18651	43439.99218750	1	8.9999952	-1.060	0
18651	43459.99218750	1	9.0000048	-0.904	0
18651	43479.99218750	1	8.9999962	-0.607	0
18651	43499.99218750	1	8.9999981	-0.486	0
18651	43509.99218750	1	9.0000029	-0.111	0
18651	43519.99218750	1	9.9999981	0.135	1
18651	43529.99218750	1	10.0000038	0.208	1
18651	43539.99218750	1	9.9999952	0.284	1
18651	43549.99218750	1	10.0000029	0.259	1
18651	43559.99218750	1	10.0000000	0.243	1
18651	43569.99218750	1	10.0000019	0.292	1
18651	43579.99218750	1	9.9999990	0.367	1



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SPOT2 MARB 37 60.82700 23.50710 4 53

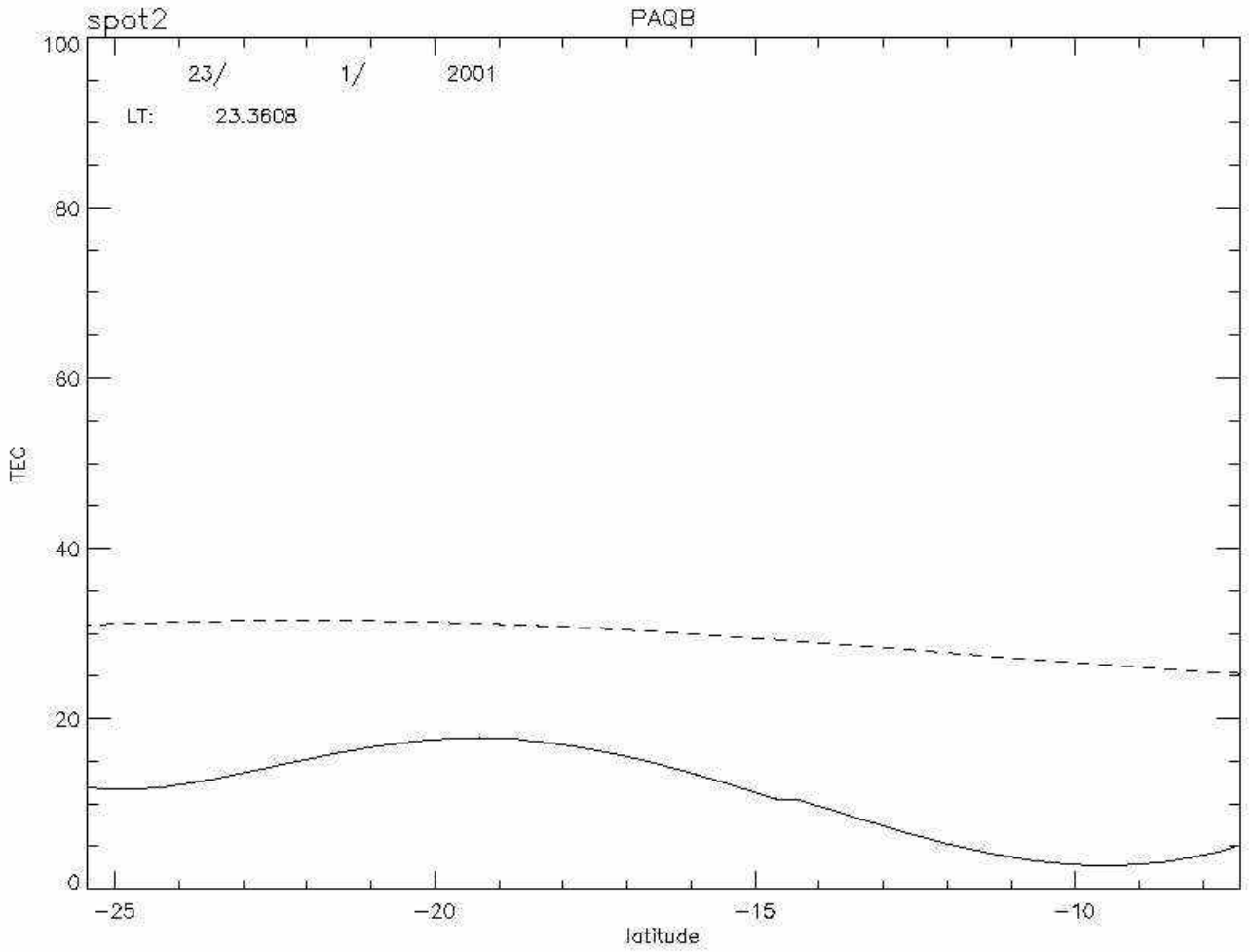
Day, Time, Elimination criteria, count period, Iono Cor., Pond

18651	75269.99218750	-502	9.0000000	-0.260	0
18651	75289.99218750	1	8.9999971	-0.265	0
18651	75309.99218750	1	8.9999990	-0.301	0
18651	75329.99218750	1	8.9999981	-0.301	0
18651	75349.99218750	1	8.9999962	-0.363	0
18651	75369.99218750	1	9.0000038	-0.462	0
18651	75389.99218750	1	9.0000000	-0.412	0
18651	75409.99218750	1	8.9999990	-0.346	0
18651	75429.99218750	1	9.0000019	-0.259	0
18651	75449.99218750	1	9.0000038	-0.161	0
18651	75469.99218750	1	8.9999981	-0.076	0
18651	75479.99218750	1	9.0000019	-0.034	0
18651	75489.99218750	1	10.0000038	-0.028	1
18651	75499.99218750	1	9.9999990	0.016	1
18651	75509.99218750	1	9.9999962	0.004	1
18651	75519.99218750	1	10.0000048	0.028	1
18651	75529.99218750	1	9.9999981	0.001	1
18651	75539.99218750	1	10.0000019	-0.040	1

SPOT2 MARB 37 60.82700 23.50710 4 53

Day, Time, Elimination criteria, count period, Iono Cor., Pond

18651	75549.99218750	1	10.0000000	-0.073	1
18651	75559.99218750	1	9.9999952	-0.038	1
18651	75569.99218750	1	10.0000057	0.002	1
18651	75579.99218750	1	10.0000000	0.054	1
18651	75589.99218750	1	9.9999981	0.060	1
18651	75599.99218750	1	9.9999971	0.106	1
18651	75609.99218750	1	10.0000010	0.009	1
18651	75619.99218750	1	10.0000029	0.053	1
18651	75629.99218750	1	10.0000000	0.073	1
18651	75649.99218750	1	9.0000010	0.108	0
18651	75669.99218750	1	9.0000048	0.142	0
18651	75689.99218750	1	9.0000038	0.144	0
18651	75729.99218750	1	9.0000057	0.193	0
18651	75749.99218750	1	8.9999990	0.258	0
18651	75769.99218750	1	8.9999990	0.298	0
18651	75789.99218750	1	9.0000038	0.326	0
18651	75809.99218750	1	8.9999905	0.371	0
18651	75829.99218750	1	9.0000029	0.414	0
18651	75849.99218750	1	8.9999943	0.440	0



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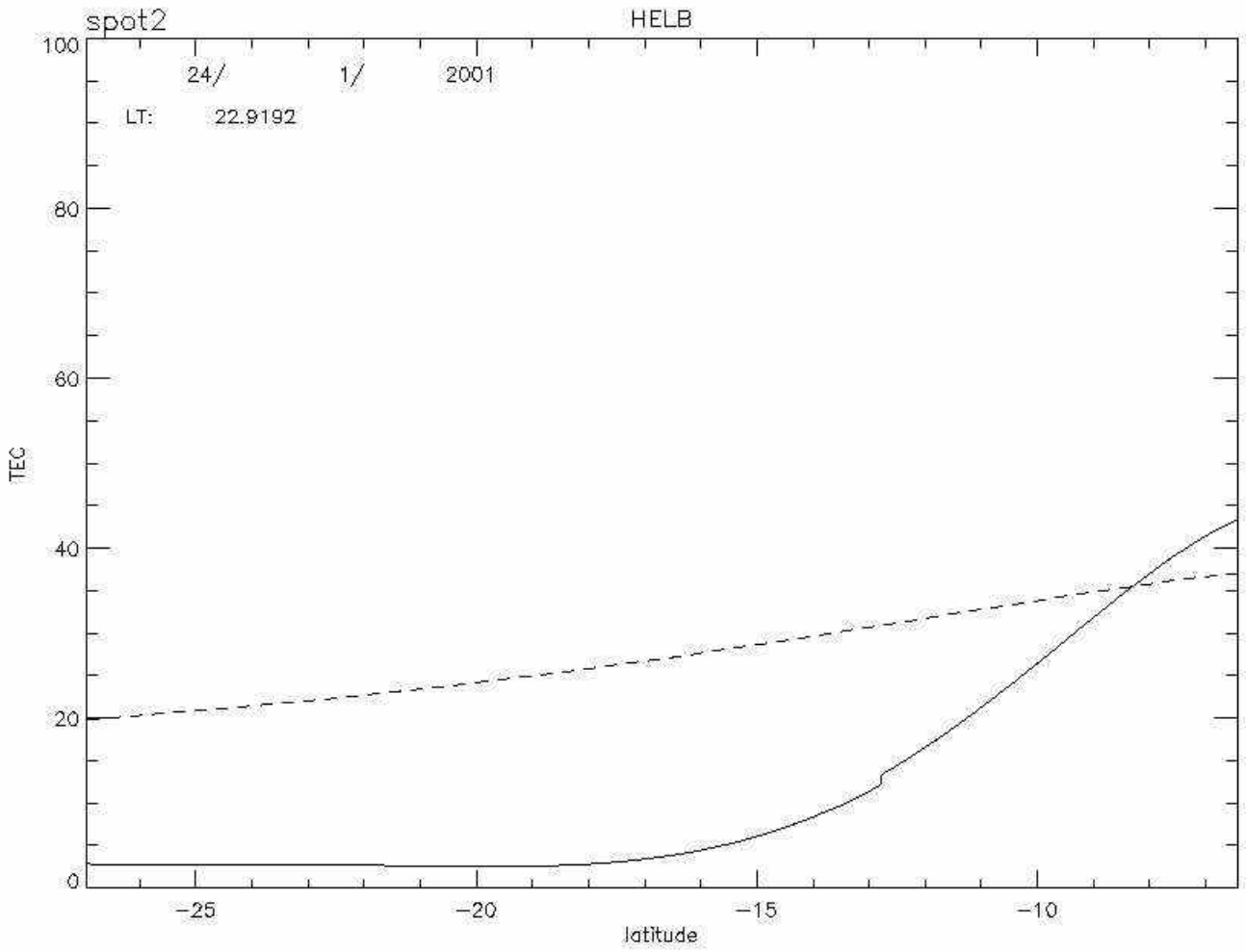
SPOT2 PAQB 37 34.87100 23.30900 24 76

18651	33169.99218750	-502	9.0000010	0.485	0
18651	33189.99218750	1	9.0000010	0.688	0
18651	33209.99218750	1	9.0000000	-0.217	0
18651	33229.99218750	1	9.0000000	-0.167	0
18651	33249.99218750	1	9.0000019	0.047	0
18651	33269.99218750	1	8.9999962	-0.117	0
18651	33289.99218750	1	8.9999971	-0.430	0
18651	33309.99218750	1	9.0000019	-0.431	0
18651	33329.99218750	1	8.9999990	-0.199	0
18651	33349.99218750	1	8.9999990	-0.058	0
18651	33369.99218750	1	9.0000000	0.378	0
18651	33389.99218750	1	9.0000029	0.756	0
18651	33409.99218750	1	9.0000000	1.091	0
18651	33429.99218750	1	8.9999981	1.007	0
18651	33449.99218750	1	8.9999962	0.935	0
18651	33469.99218750	1	9.0000067	0.771	0
18651	33489.99218750	1	8.9999981	0.846	0
18651	33509.99218750	1	8.9999933	0.679	0
18651	33519.99218750	1	9.0000067	0.609	0
18651	33529.99218750	1	9.9999924	0.594	1
18651	33539.99218750	1	10.0000038	0.556	1



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SPOT2 HELB 32 63.53200 46.45500 23 66

Day, Time, Elimination criteria, count period, Iono Cor., Pond

18651	81919.99218750	-502	9.0000029	-0.039	0
18651	81939.99218750	1	8.9999981	-0.083	0
18651	81959.99218750	1	9.0000010	-0.251	0
18651	81979.99218750	1	9.0000000	-0.151	0
18651	81999.99218750	1	8.9999981	-0.065	0
18651	82019.99218750	1	9.0000019	-0.049	0
18651	82039.99218750	1	9.0000029	-0.133	0
18651	82059.99218750	1	8.9999971	-0.154	0
18651	82079.99218750	1	8.9999952	-0.125	0
18651	82099.99218750	1	9.0000048	-0.114	0
18651	82109.99218750	1	9.0000029	-0.134	0
18651	82119.99218750	1	9.9999981	-0.146	1
18651	82129.99218750	1	9.9999971	-0.122	1
18651	82149.99218750	1	8.9999981	-0.028	0
18651	82169.99218750	1	8.9999990	0.035	0
18651	82189.99218750	1	9.0000029	0.137	0
18651	82209.99218750	1	9.0000029	0.293	0
18651	82229.99218750	1	9.0000048	0.448	0

Other Problems with the data

SPOT2 PURA 16 0.00000 0.00000 2 72

18651	5779.99169922	-501	8.9999990	-29.097	0
18651	5809.99169922	-501	9.0000038	-28.757	0
18651	5819.99169922	-501	9.9999962	-32.060	1
18651	5829.99169922	-501	10.0000019	-31.900	1
18651	5839.99169922	-501	10.0000010	-31.561	1
18651	5849.99169922	-501	10.0000019	-31.579	1
18651	5859.99169922	-501	9.9999981	-31.771	1
18651	5869.99169922	-501	10.0000019	-31.841	1
18651	5879.99169922	-501	10.0000000	-31.808	1
18651	5889.99169922	-501	10.0000029	-31.704	1
18651	5899.99169922	-501	9.9999952	-31.522	1
18651	5909.99169922	-501	10.0000010	-31.473	1
18651	5919.99169922	-501	9.9999981	-31.437	1
18651	5929.99169922	-501	10.0000038	-31.265	1
18651	5949.99169922	-501	10.0000000	-30.842	1
18651	5969.99169922	-501	8.9999981	-27.462	0

Other Problems with the data

SPOT2 MORA 13 0.00000 0.00000 30 90

18651	6399.99169922	-501	9.0000048	18.070	0
18651	6409.99169922	-501	8.9999971	18.104	0
18651	6429.99169922	-501	10.0000000	20.276	1
18651	6439.99169922	-501	10.0000048	20.317	1
18651	6459.99169922	-501	9.9999990	20.405	1
18651	6469.99169922	-501	9.9999962	20.454	1
18651	6479.99169922	-501	10.0000057	20.484	1
18651	6489.99169922	-501	9.9999981	20.610	1
18651	6499.99169922	-501	10.0000019	20.651	1
18651	6509.99169922	-501	9.9999943	20.754	1
18651	6519.99169922	-501	10.0000019	20.874	1
18651	6529.99169922	-501	9.9999990	20.944	1
18651	6539.99169922	-501	10.0000010	21.080	1

Other Problems with the data

SPOT2 KRVB 26 30.77100 23.11200 24 89

18651	9299.99218750	1	9.0000029	22.606	0
18651	9319.99218750	1	9.0000019	27.621	0
18651	9359.99218750	1	8.9999981	24.268	0
18651	9379.99218750	1	8.9999981	19.672	0
18651	9399.99218750	1	9.0000019	24.697	0
18651	9409.99218750	-950	8.9999962	29.571	0
18651	9429.99218750	1	8.9999971	26.126	0
18651	9449.99218750	1	9.0000000	22.056	0
18651	9469.99218750	-950	9.0000010	26.405	0
18651	9509.99218750	1	9.0000000	22.349	0
18651	9519.99218750	1	10.0000029	24.725	1
18651	9529.99218750	1	9.9999981	24.378	1
18651	9539.99218750	1	10.0000000	24.138	1
18651	9549.99218750	1	9.9999952	23.655	1
18651	9559.99218750	1	10.0000010	23.040	1
18651	9569.99218750	1	10.0000048	22.934	1
18651	9579.99218750	1	9.9999962	23.038	1
18651	9589.99218750	1	10.0000019	22.711	1

Other Problems with the data

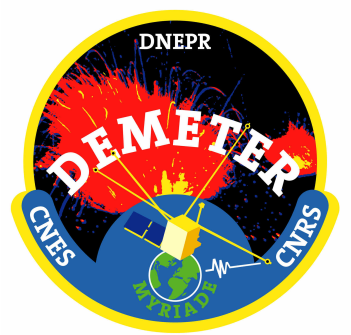
SPOT2 ADEA 26 22.89700 30.08000 3 27

18651	74559.99218750	1	8.9999971	1.542	0
18651	74569.99218750	1	8.9999971	2.606	0
18651	74579.99218750	1	9.9999971	0.421	1
18651	74589.99218750	1	10.0000010	1.218	1
18651	74599.99218750	1	10.0000010	2.450	1
18651	74609.99218750	1	10.0000038	-0.106	1
18651	74619.99218750	1	9.9999962	8.087	1
18651	74629.99218750	1	10.0000029	8.894	1
18651	74639.99218750	1	9.9999981	-1.525	1
18651	74649.99218750	1	10.0000029	-2.650	1
18651	74659.99218750	1	10.0000000	-4.819	1
18651	74669.99218750	1	10.0000000	-1.337	1
18651	74679.99218750	1	9.9999990	-0.362	1
18651	74699.99218750	1	10.0000010	-1.913	1
18651	74709.99218750	1	10.0000029	-0.531	1

Other Problems with the data

SPOT2 ADEA 16 18.64600 28.43300 2 34

18651	68709.99218750	1	8.9999981	-0.118	0
18651	68719.99218750	1	8.9999981	0.613	0
18651	68729.99218750	1	10.0000029	0.968	1
18651	68739.99218750	1	10.0000010	0.424	1
18651	68749.99218750	1	10.0000000	-0.347	1
18651	68759.99218750	1	9.9999962	-0.589	1
18651	68769.99218750	1	10.0000010	-0.098	1
18651	68779.99218750	1	10.0000010	0.090	1
18651	68789.99218750	1	9.9999971	0.221	1
18651	68799.99218750	1	10.0000019	0.807	1
18651	68809.99218750	1	10.0000000	2.940	1
18651	68819.99218750	1	9.9999981	5.072	1
18651	68829.99218750	1	10.0000048	8.224	1
18651	68839.99218750	1	9.9999962	-3.481	1
18651	68849.99218750	1	9.9999990	-1.988	1
18651	68859.99218750	1	10.0000038	-1.508	1



Other Problems with the data

- We do not know the normal situation

- We do not know how to use the parameter « elimination criteria »

- We have no criteria to eliminate wrong data

Conclusions

The DEMETER micro-satellite which will be launched on June 29, 2004 is devoted to the study of ionospheric perturbations in relation with the seismic activity.
DEMETER will perform local measurement of the electron density and during the mission we intend to take into account ionospheric data from many other sources to survey the ionosphere.