RapidEye™

geo facts
turned into knowledge

Automated extraction of Soil Line and Vegetation Features from satellite imagery

Thanigai Vaasan / Hannover / 18th November 2010

Table of Contents

- Objective
- Approach
- Tools
- Method
- Applications
- Limitations
- Conclusion

Objective

- To design and implement an automated algorithm to determine
  - Soil Line attributes – Slope and Intercept
  - Coordinates
    - Full Canopy Point
    - Dark Object Point
    - Bright Object Point (experimental)
- To visualize the results for manual verification

Approach

- Soil line can be drawn by hand with academic experience
- Some basic aspects of this experience like

Academic Tools

- Pure Mathematics
  - Cartesian Geometry
  - Trigonometry
  - Linear Algebra
- Statistics
  - Linear Regression
- Agriculture
  - Interpretation of the results

Computational Tools

- C++
  - Automated algorithm
- Gnuplot
  - Visualization of the results

Method

- Pre-processing
  - Quantize dataset
  - Removal of duplicate points
- Processing
  - Extract Soil Line and Vegetation Features
- Post-processing
  - Save soil line and features file
  - Generate soil line and features plot

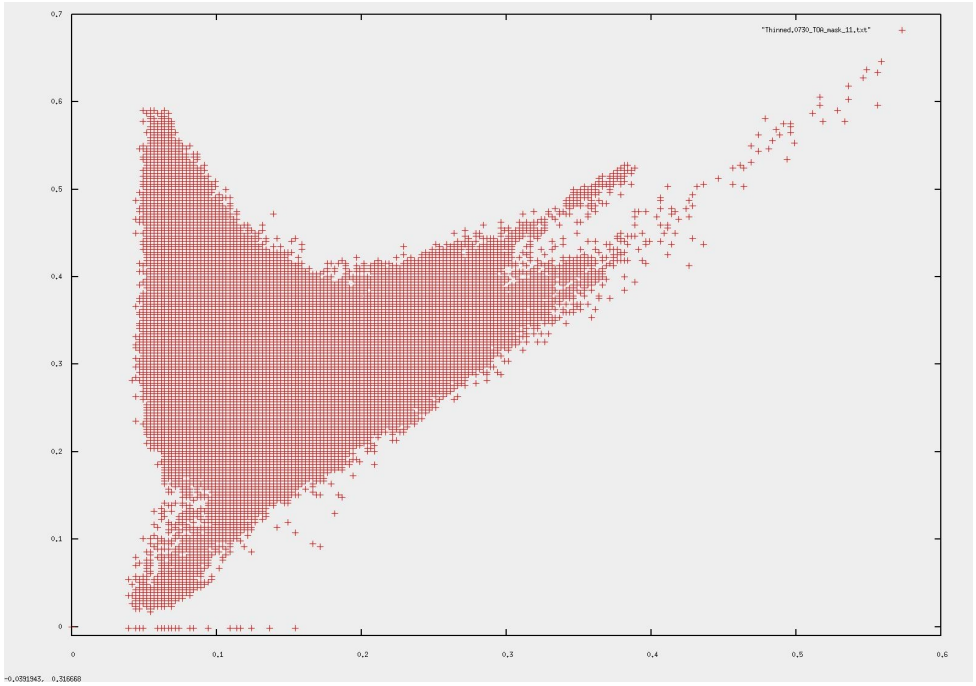
Extraction of DN values

- Extract DN values of the Red and NIR Channels of an image

0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
2.7139106E-01	3.2838097E-01
2.7139106E-01	3.3149508E-01
2.6639500E-01	3.2215273E-01
2.5640285E-01	3.1281036E-01
2.7139106E-01	3.2526684E-01
2.8887731E-01	3.4706563E-01
2.7638713E-01	3.2526684E-01
2.7139106E-01	3.1903860E-01

Red vs NIR plot

0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
0.0000000E+00	0.0000000E+00
2.7139106E-01	3.2838097E-01
2.7139106E-01	3.3149508E-01
2.6639500E-01	3.2215273E-01
2.5640285E-01	3.1281036E-01
2.7139106E-01	3.2526684E-01
2.8887731E-01	3.4706563E-01
2.7638713E-01	3.2526684E-01
2.7139106E-01	3.1903860E-01



Quantization of dataset

- Constraining a continuous set of values to a discrete set
- Shape of Red vs NIR plot remains the same
  - Results remain the same
- Necessary to streamline the feature extraction process

Duplicate points problem

- Remove duplicate points from the dataset
  - Generates Thinned dataset with unique values
  - Greatly reduces the dataset size

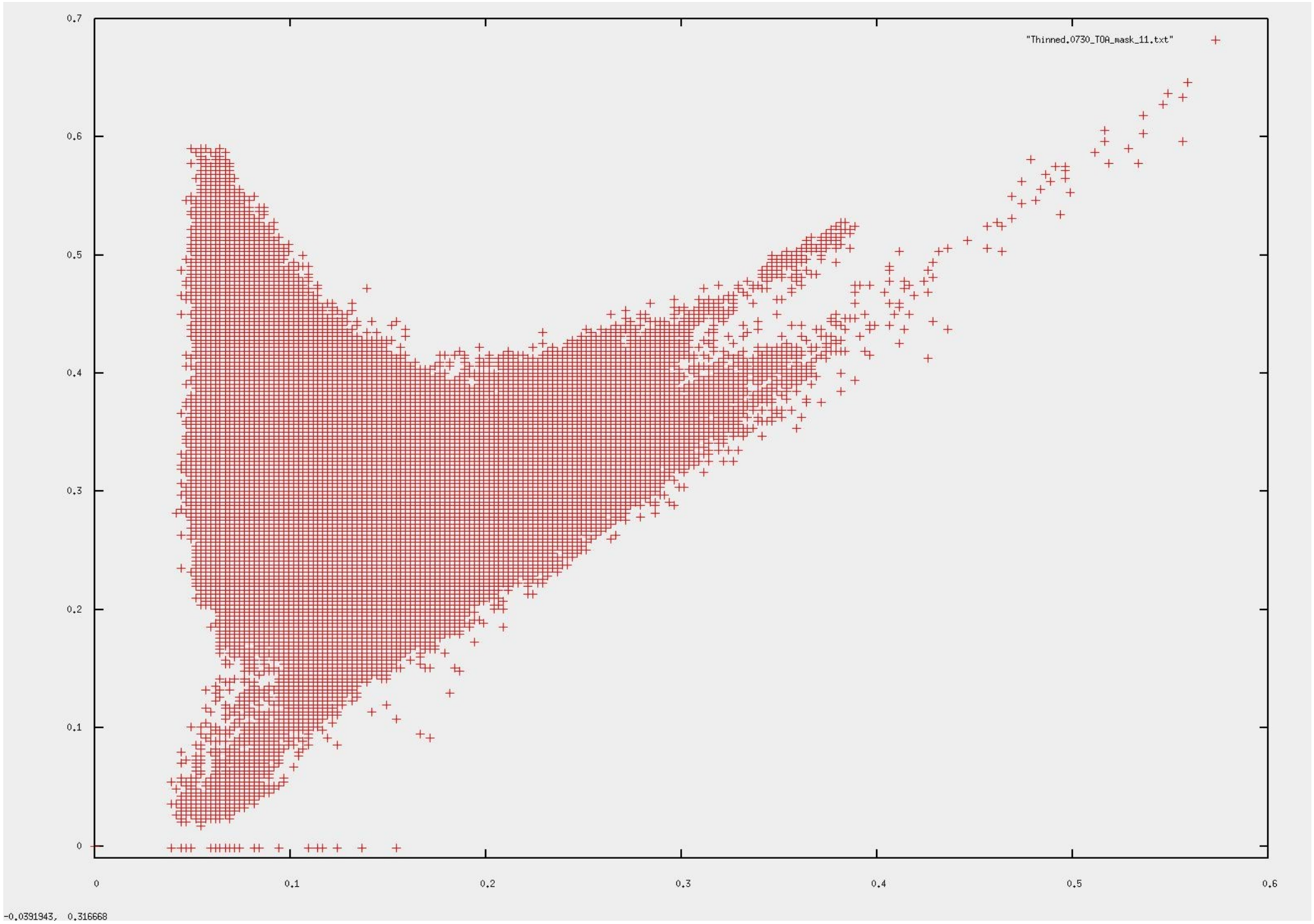
Example:

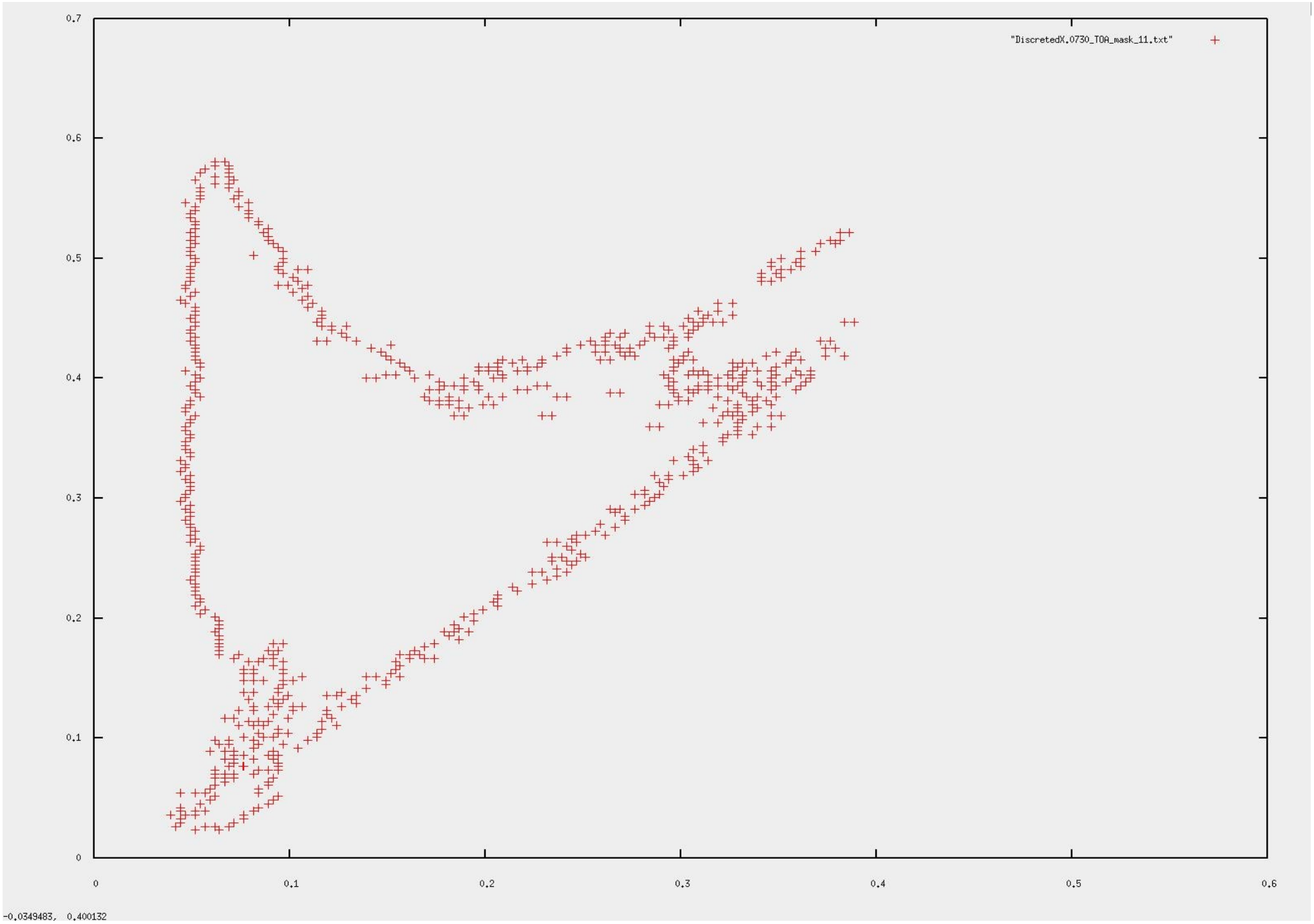
Size of an original Red vs NIR text file – 23.9 MB

Size of the Thinned Red vs NIR text file – 317 KB

Preparation

- Determine difference between two closest abscissae
- Determine difference between two closest ordinates
- Sort dataset along ascending ordinates and then re-sort along ascending abscissae
- Discretize the dataset along X axis
- Remove points lower than the valid Dark Object Point


"Thinned.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
-0.0391943, 0.316668

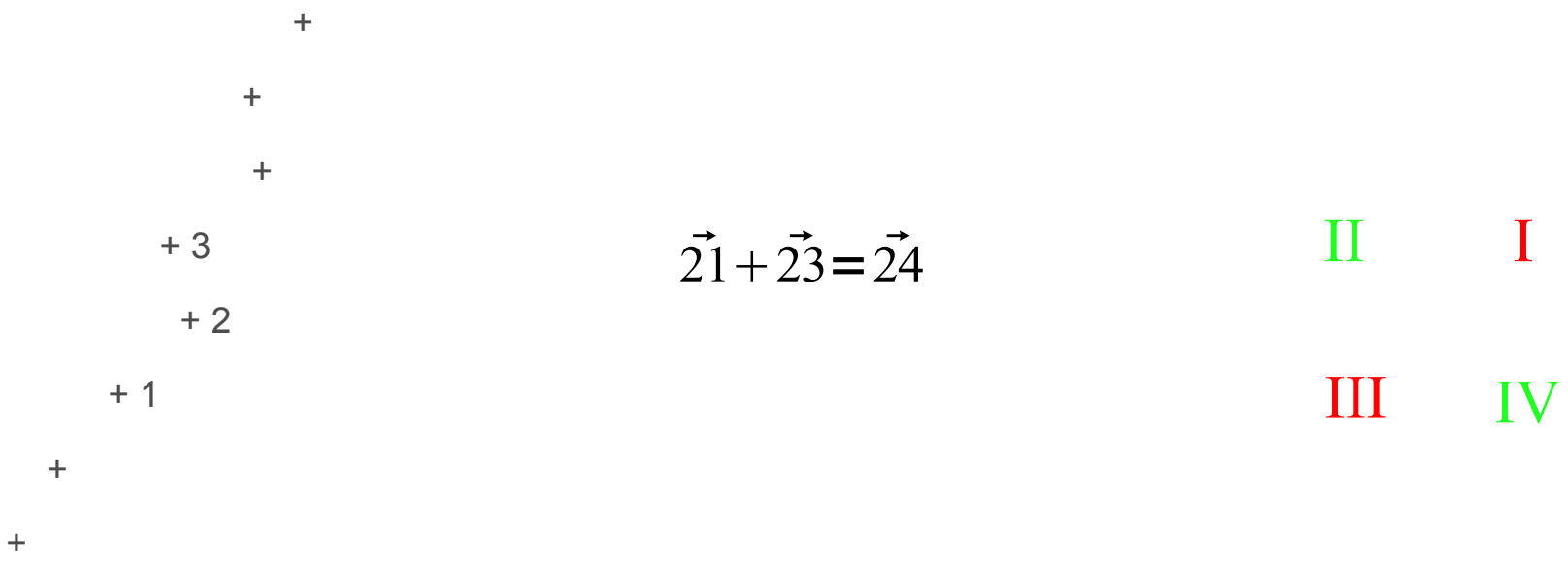

"DiscretedX.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
-0.0349483, 0.400132

Main Process

- Gather all points from the right-sided boundary which validates
  - Three point facing
    - $\vec{21} + \vec{23} = \vec{24}$
    - The unit vector of addition must be along either II and IV quadrants
  - Three point smoothness
    -

Main Process

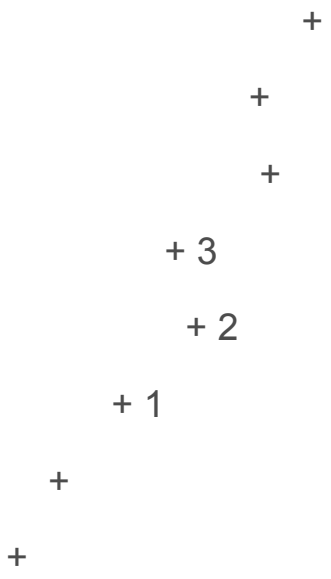
- Gather all points from the right-sided boundary which validates
  - Three point facing



The point 2 is valid if the unit vector $\hat{24}$ *is along II* or *IV quadrants*

Main process

- Gather all points from the right-sided boundary which validates
  - Three point smoothness



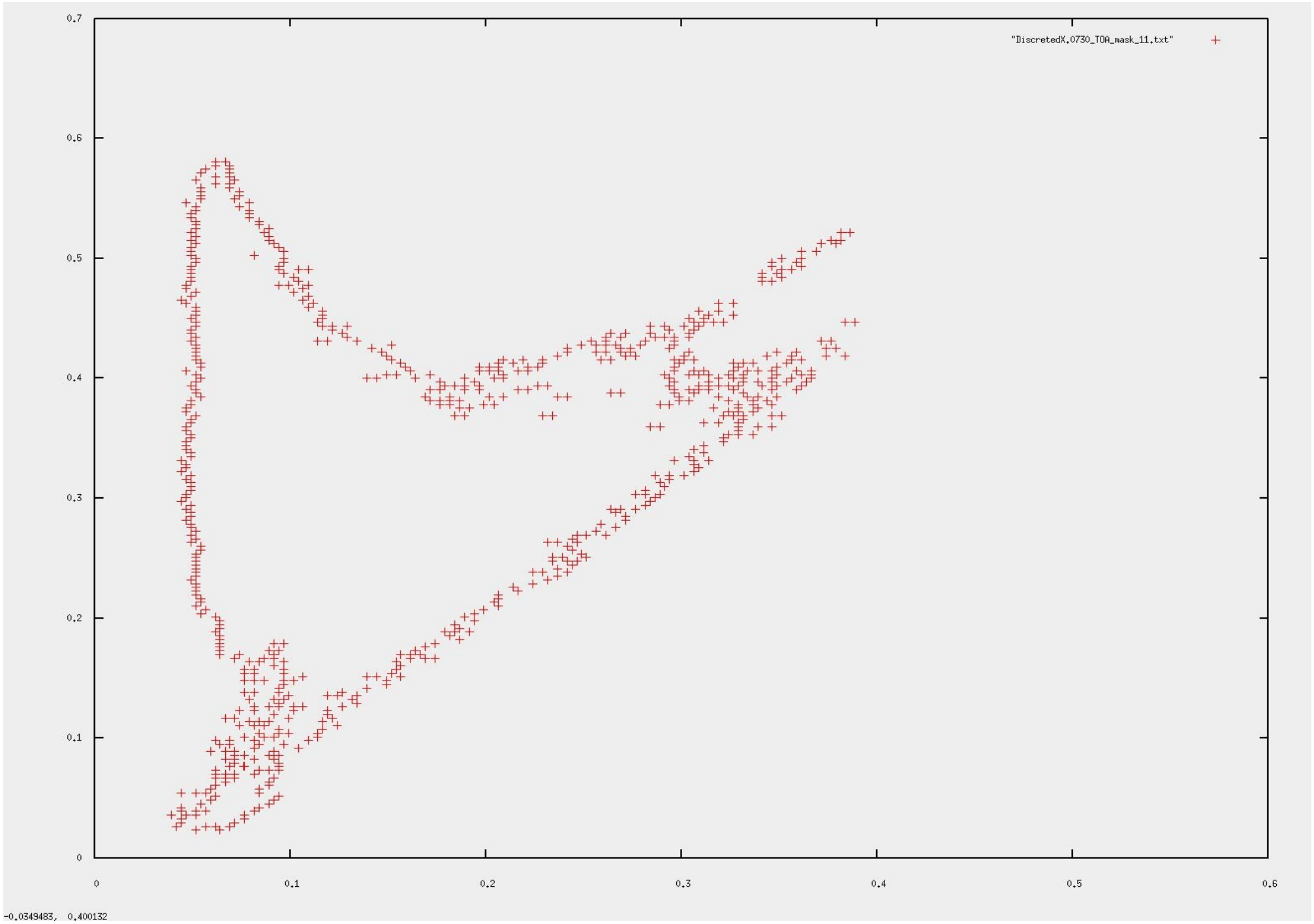
$$\alpha = \cos^{-1}\left(\frac{\vec{21}\,.\,\vec{23}}{|\vec{21}||\vec{23}|}\right)$$

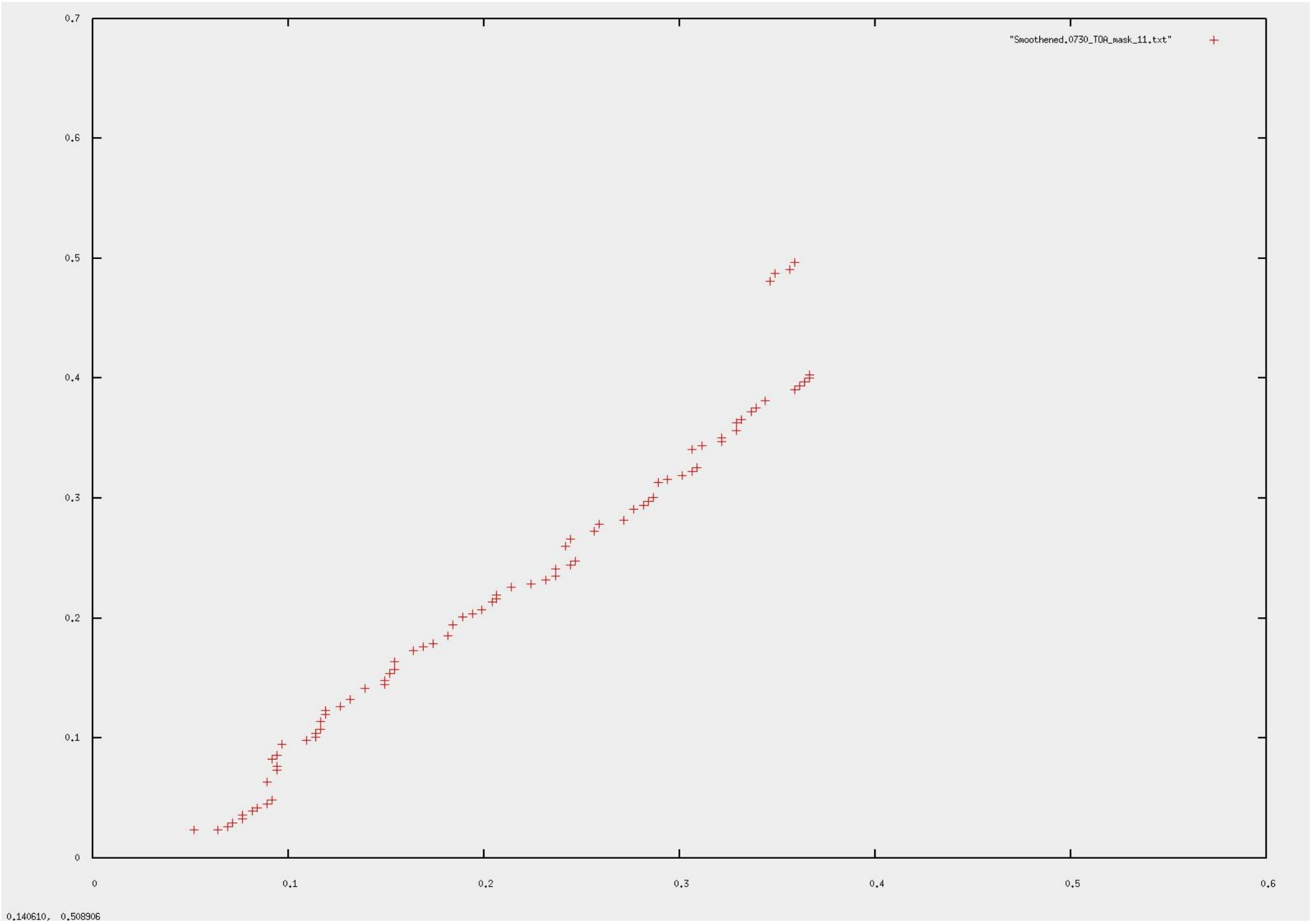
$$0 \leq \alpha \leq \pi$$

$$\forall \quad \alpha \leqslant \frac{\pi}{2} \quad \Rightarrow \quad Sharp$$

$$\forall \quad \alpha > \frac{\pi}{2} \quad \Rightarrow \quad Smooth$$

$$The\ point\ 2\ is\ valid\ , \quad if\ \alpha \ > \ \frac{\pi}{2}$$


"DiscretedX.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
-0.0349483, 0.400132

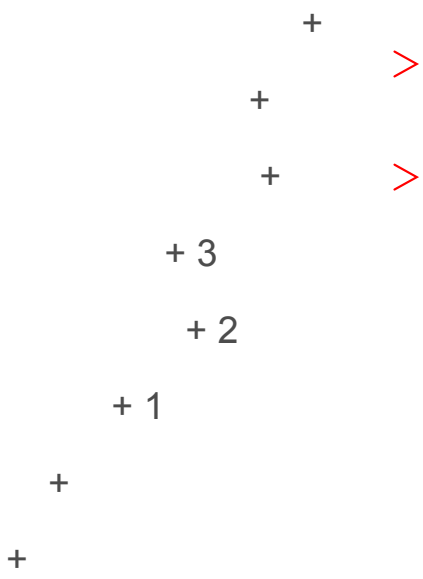

"Smoothened.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.140610, 0.508906

Main process

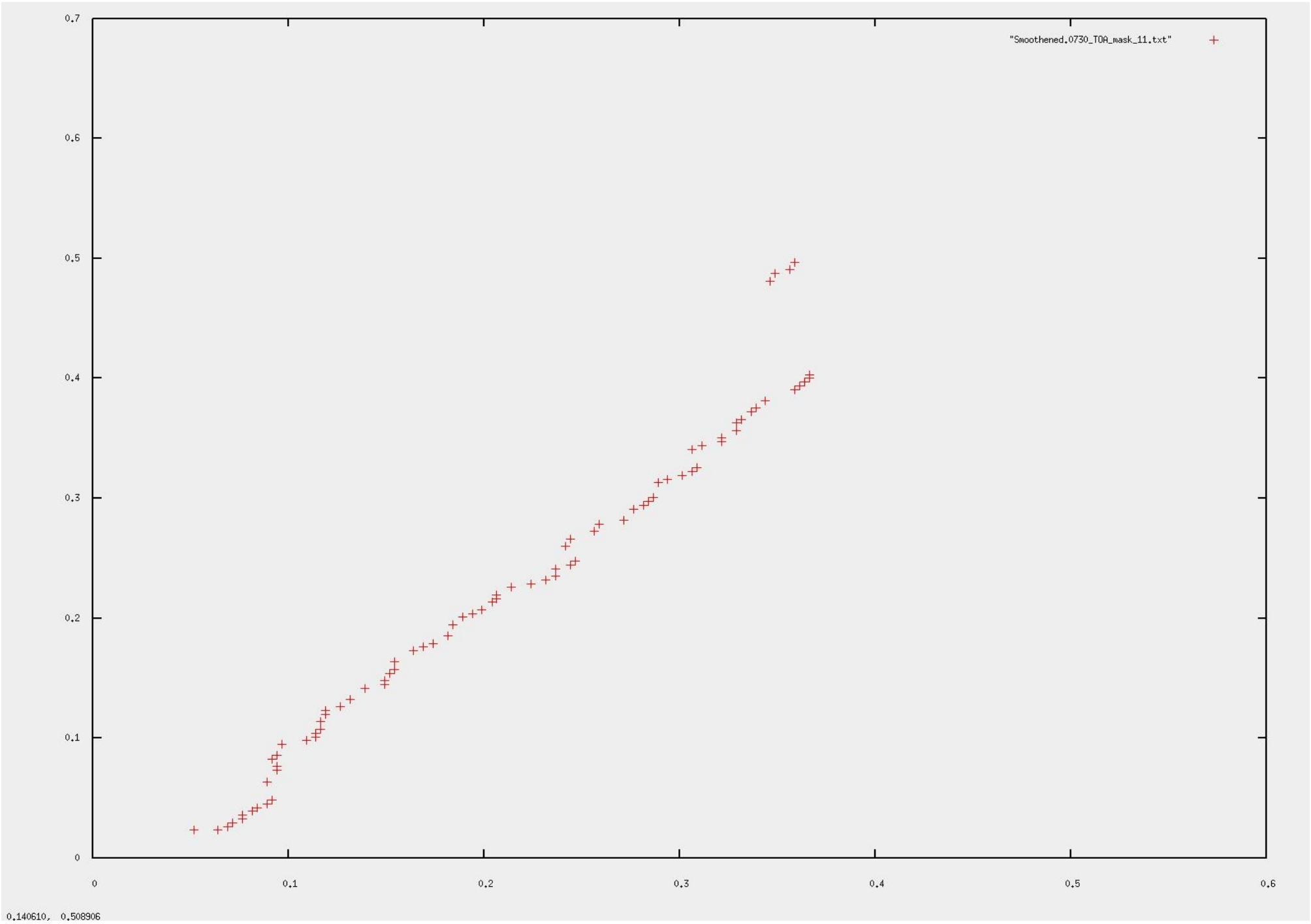
- Determine Dark Object Point (DOP)
  - DOP Nir = Ordinate of the first point in the Smoothened dataset
  - Collect all points whose ordinates are equal to DOP Nir
    - Potential DOP list
  - DOP Red = Abscissa of the centermost point in Potential DOP list
- Erase Potential DOPs
  - Erase all points whose ordinates equal DOP Nir

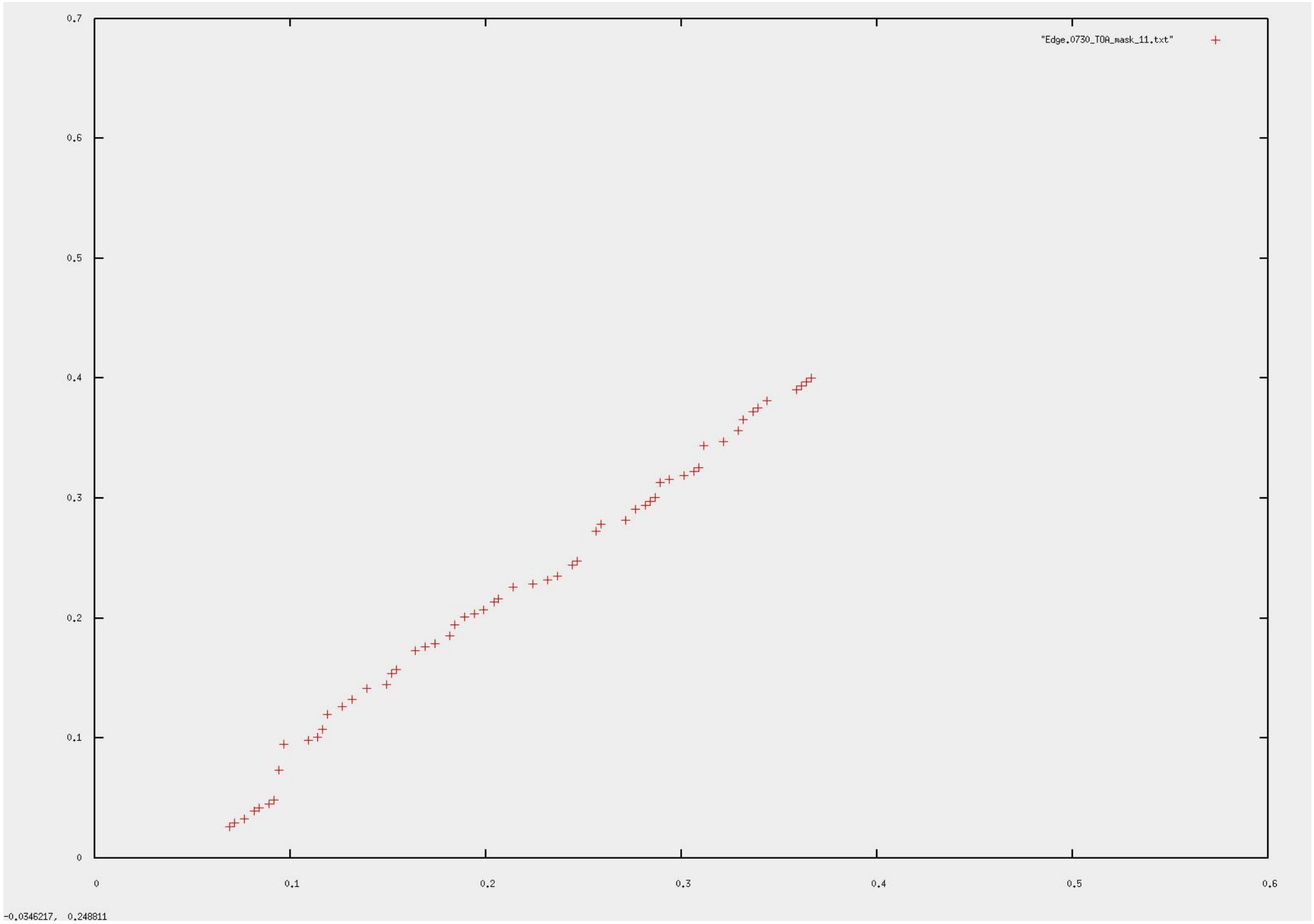
Main process

- Gather all points from the right-sided boundary which ensure
  - Three point positive slope transition



    - Collect points which correspond to consecutive positive slopes
    - Intuitively ignore points which make infinite or negative slopes


"Smoothened.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.140610, 0.508906


"Edge.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
-0.0346217, 0.248811

Soil Line coefficients

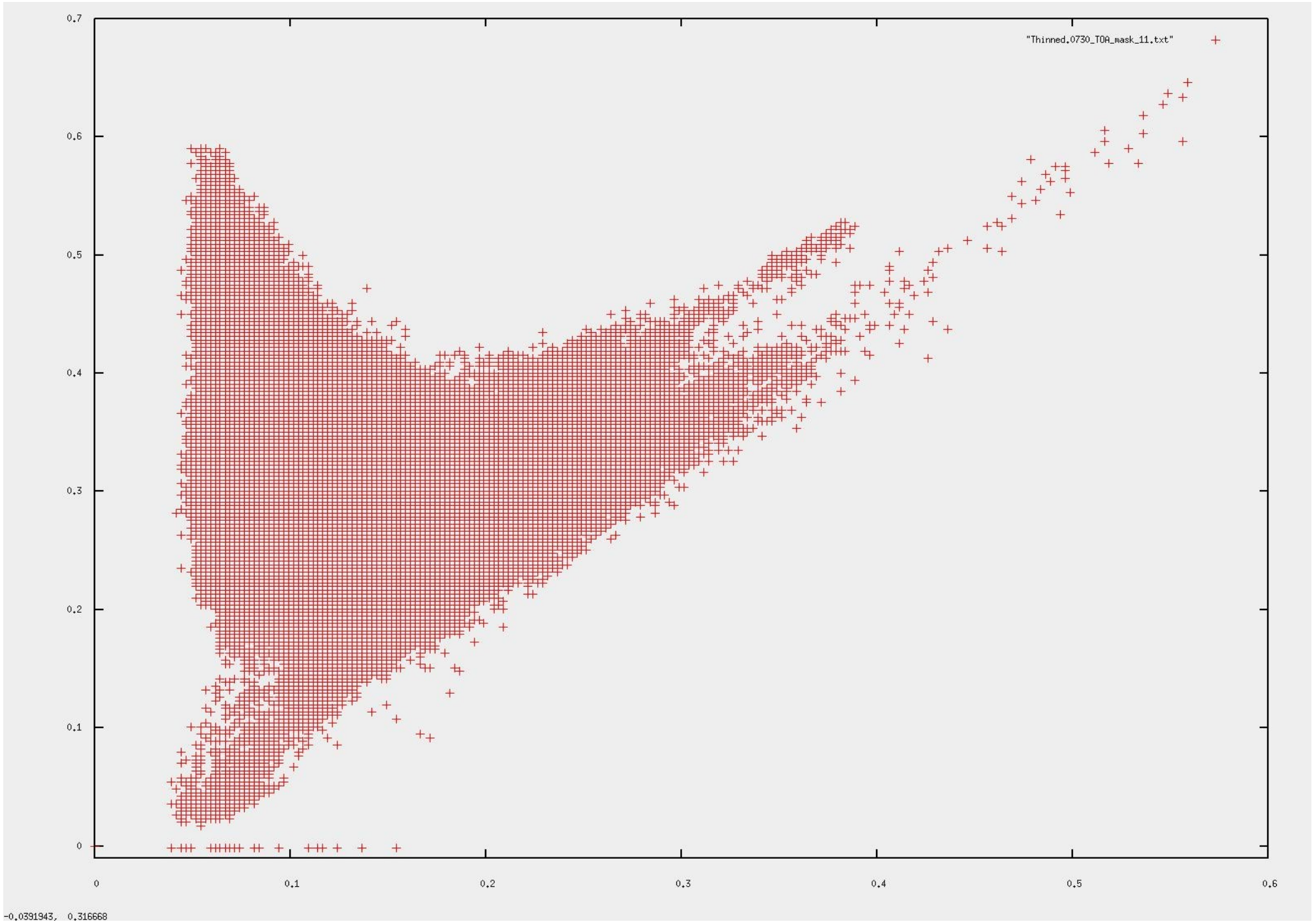
- Gather Soil Line points
  - Determine the line of regression for the points in Edge dataset
  - Collect the points which lie above the line of regression
  - Those points correspond to the Soil Line dataset

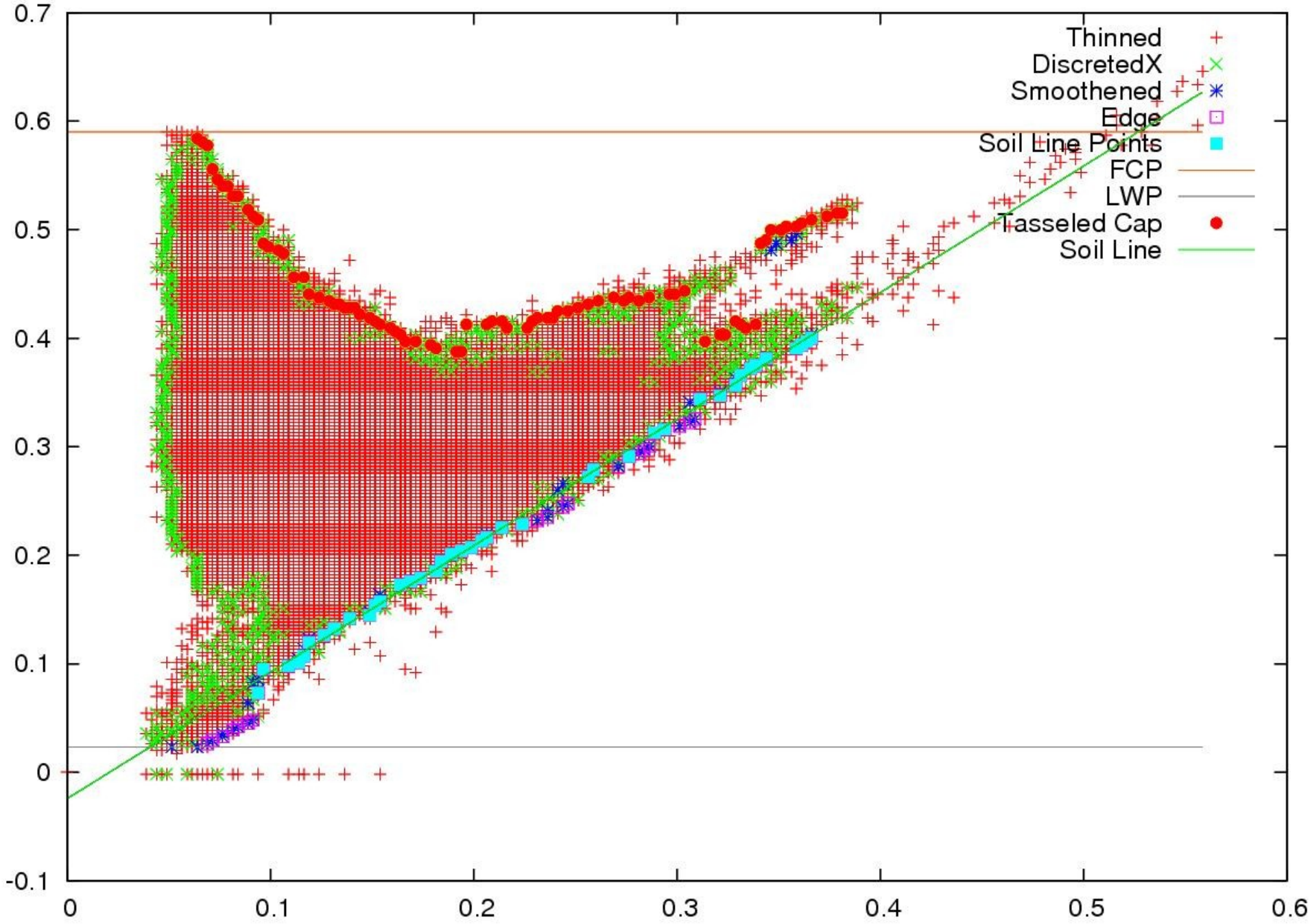
- Soil Line Coefficients
  - Determine the line of regression for the Soil Line dataset
  - The coefficients of regression denote the Slope and Intercept of the Soil Line

Vegetation Features

- Extract Tasseled Cap Points
  - Similar methodology as Soil Line Extraction but rules are different
  - FCP is determined using an independent method as the last step of the extraction of Tasseled Cap Features
  - The determined FCP is validated w.r.t. several special cases
- Soil line features are saved in Features.ImageBaseName.txt

Slope 1.53551
Intercept -0.0762188
DOP 0.0638483 0.0317913
FCP 0.109509 0.661583


"Thinned.0730_TOA_mask_11.txt"
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
-0.0391943, 0.316668


Thinned
DiscretedX
Smoothened
Edge
Soil Line Points
FCP
LWP
Tasseled Cap
Soil Line
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6

Applications

- Ground Cover Map Generation
- Dark Object Subtraction
- Other possible applications (in research)
  - Land Cover classification
  - Field Boundary Extraction

Limitations

- Extremely high vegetation
  - FCP is reliable
  -
- Extremely low vegetation
  - Soil Line is reliable
  -

Conclusion

- An algorithm to fully automate the extraction of soil line and corresponding vegetation features has been achieved
- Limitations has to be studied thoroughly to
  - Enhance the results
  - Define an indeterminable state for the results
- Further possible applications has to be identified