



TerraHidro



Curso Ferramentas para Modelagem e Monitoramento de Bacias Hidrológicas



5 a 6 de Novembro de
2015

Instituto de Geociências -
UFBA Salvador-BA

Visão Geral TerraHidro

Instrutor:

- DR. LAÉRCIO M. NAMIKAWA

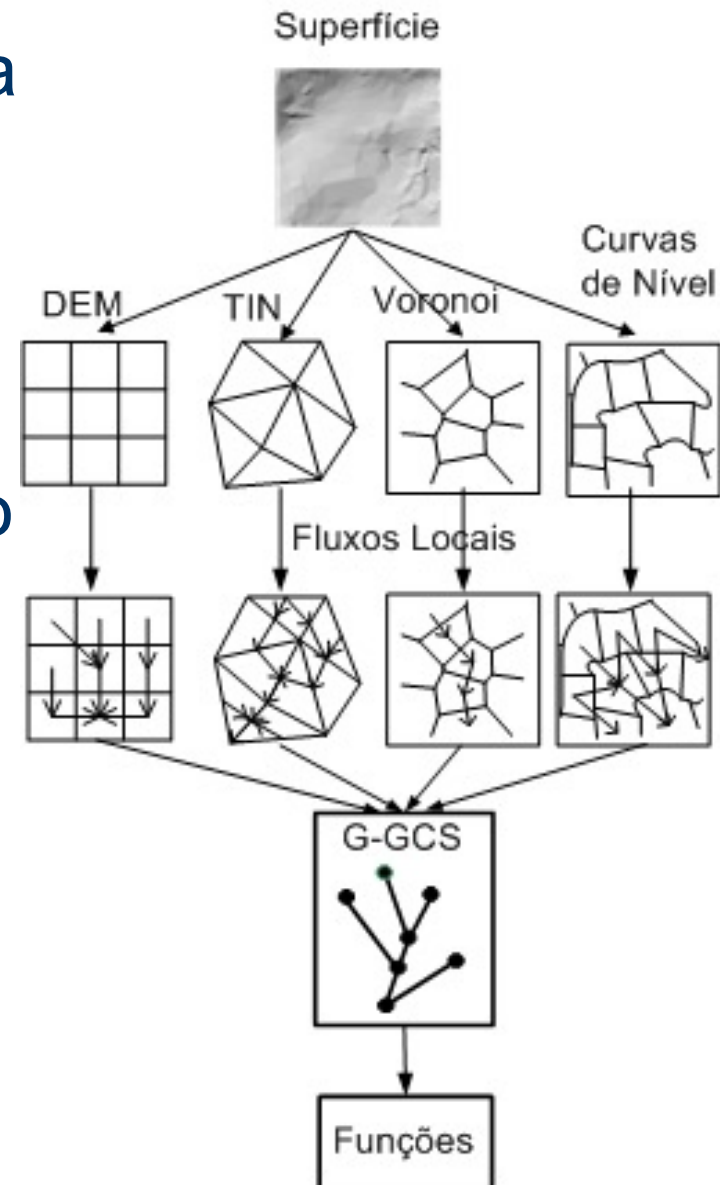
Material didático desenvolvido com:

- Dr. Sérgio Rosim (INPE)
- Dr. Thales Korting



O que é a plataforma TerraHidro?

- TerraHidro é uma plataforma para a execução de aplicações envolvendo modelagem hidrológica distribuída.
- Apresenta um novo conceito para representar o fluxo de água baseado na estrutura Grafo, em um contexto de Sistema de Informações Geográficas (SIG).



TerraHidro - Decisões de Projeto

- Modelagem hidrológica distribuída
- Pequenas e grandes bacias
- Ambiente urbano e rural
- Grandes massas de dados

TerraHidro - Desenvolvimento

- Grandes bacias
 - Parâmetros para modelos de mudanças climáticas
- Drenagem na Amazônia
 - Determinação de drenagens na área do vazio cartográfico da Amazônia.
- Minibacias
 - Delimitação de minibacias

O que pensamos para desenvolver os algoritmos?

- Alterar menos possível o Modelo de Elevação do Terreno.
- Qualidade do resultado.
- Resolver grandes áreas.

Etapas

- Determinação da direção de fluxo local.
- Cálculo da área de contribuição.
- Definição de uma rede de drenagem.
- Delimitação da bacia hidrográfica.

Determinação da direção de fluxo local

1. Calcular a direção de fluxo local.
2. Cavar canais centrais em áreas planas (espelhos d'água).
3. Resolver depressões por preenchimento quando possível.
4. Resolver depressões cavando quando não foi possível por preenchimento.

Calcular a direção de fluxo local

5	6	3
5	7	4
9	8	4

DEM

1.4	1	2.8
2	X	3
-1.4	-1	2.1

DECLIVIDADE

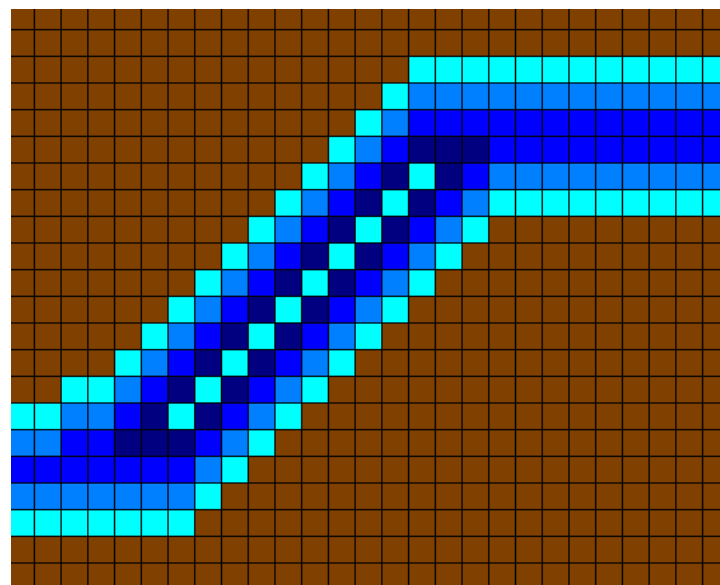
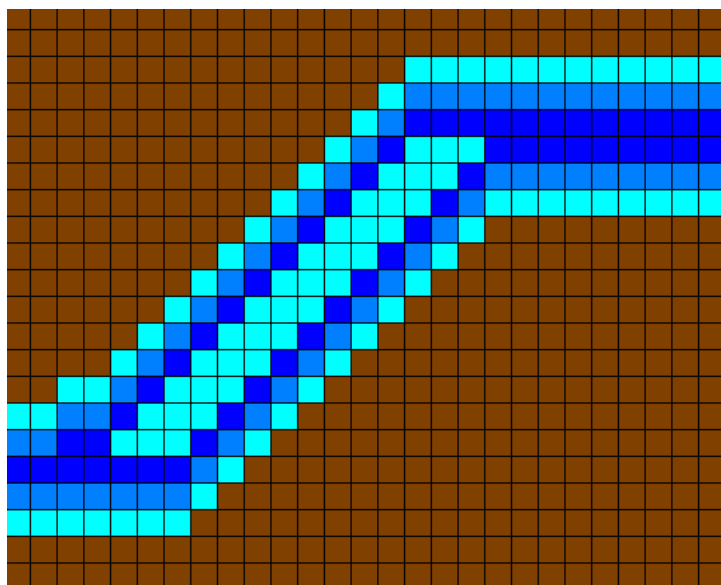
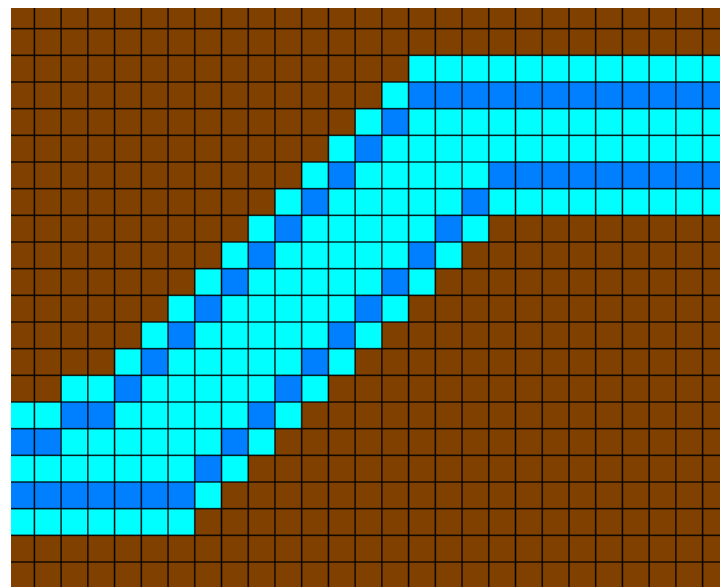
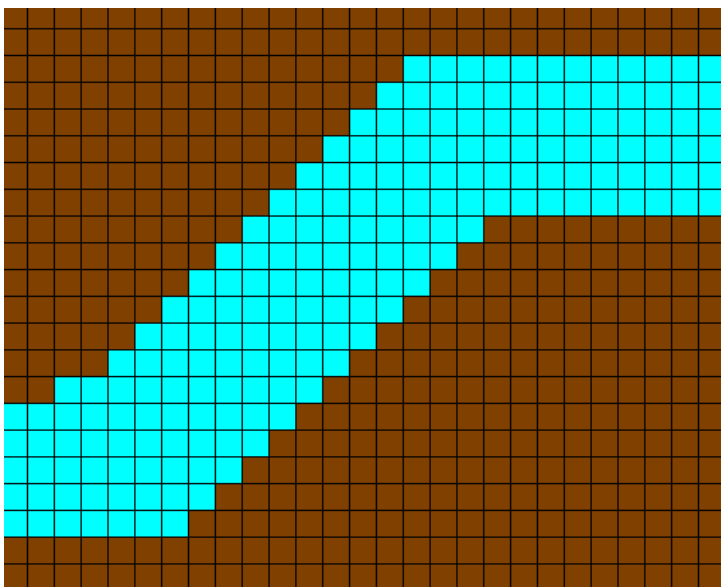
32	64	128
16	0	1
8	4	2

LDD

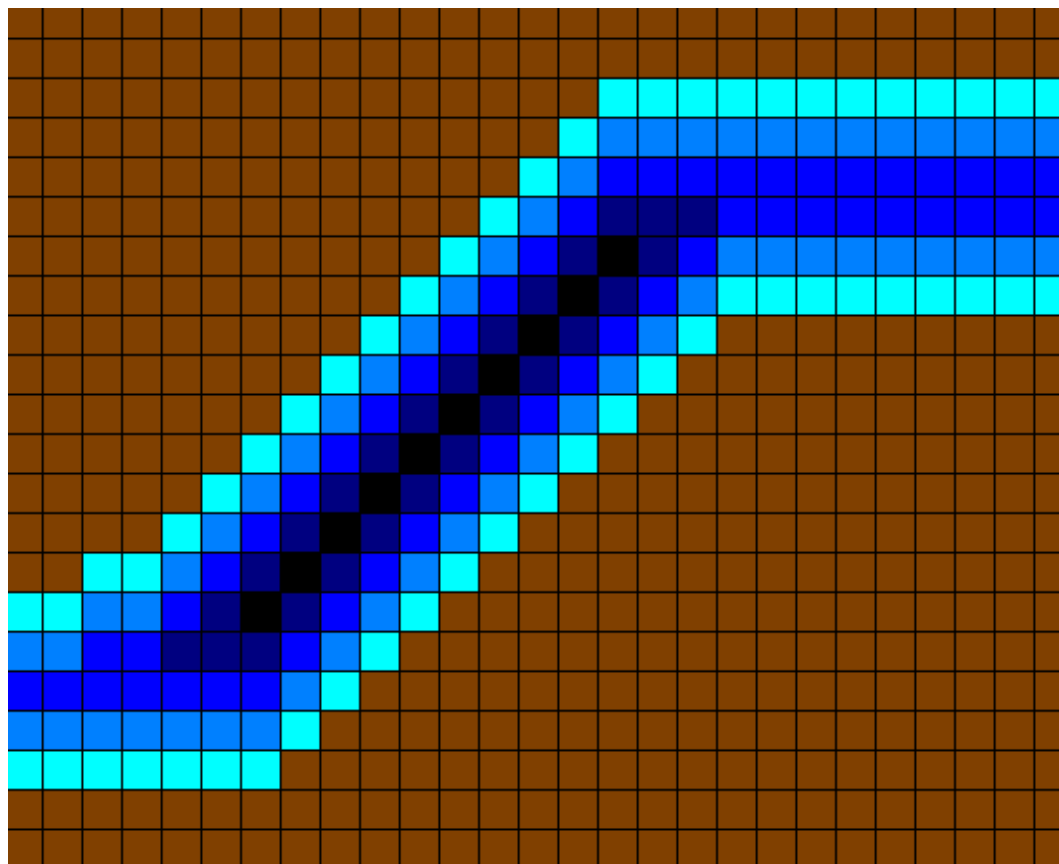
	1 →	

FLUXO LOCAL

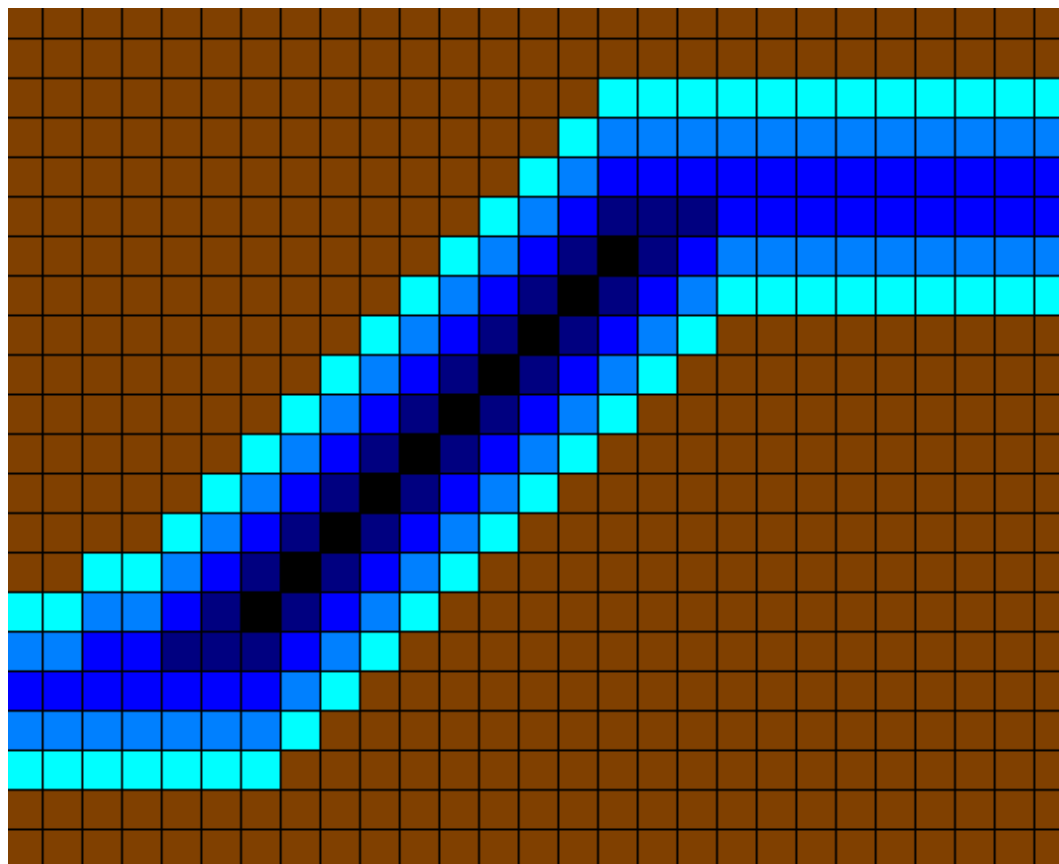
Cavar áreas planas



Cavar áreas planas



Cavar áreas planas



Resolver depressões por preenchimento

8	7	7
10	7	8
9	8	9

MNT

$$8 + 7 + 7 + 10 + 8 + 9 + 8 + 9 = 66$$

$$66 / 8 = 8.25$$

8	7	7
10	8.25	8
9	8	9

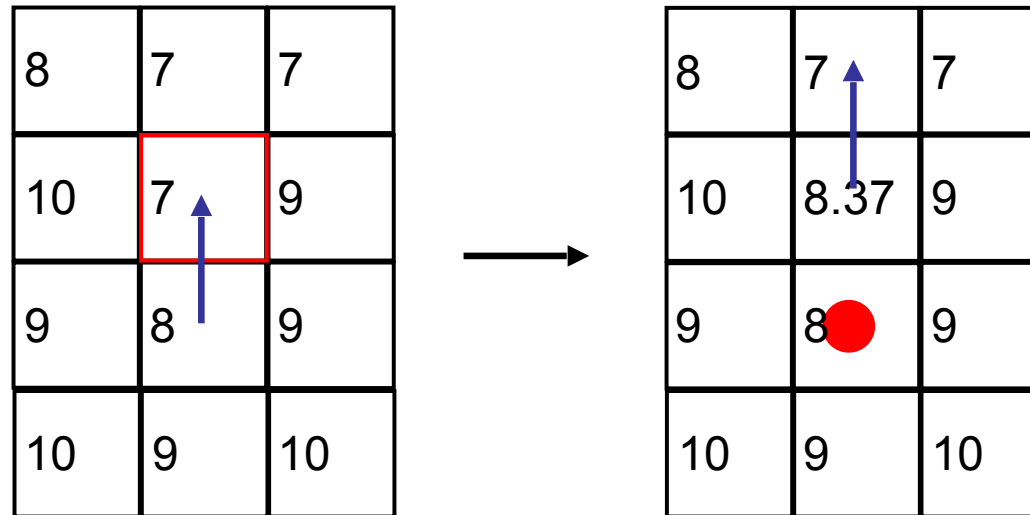
MNT

0.17	1.25	0.88
-1.7		0.25
-0.5	0.25	-0.5

Declividades

Fluxo Local

Resolver depressões por preenchimento



Quando resolver por preenchimento ocasionar outro fosso não utilizar esse método. Resolver “cavando” o MNT.

Resolver depressões “cavando”

Priority First Search - PFS

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	3.1	3.6	3.6
5.0	3.2	3.3	2.8
5.0	4.0	3.5	3.4

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	3.1	3.6	3.6
5.0	3.2	3.3	2.8
5.0	4.0	3.5	3.4

Resolver depressões “cavando”

Priority First Search - PFS

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	3.1	3.6	3.6
5.0	3.2	3.3	2.8
5.0	4.0	3.5	3.4

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	2.94	3.6	3.6
5.0	3.2	2.88	2.8
5.0	4.0	3.5	3.4

Cálculo da área de contribuição

DEM

4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	2.9	3.6	3.6
5.0	2.8	2.7	2.6
5.0	4.0	3.5	3.4

Fluxos Locais

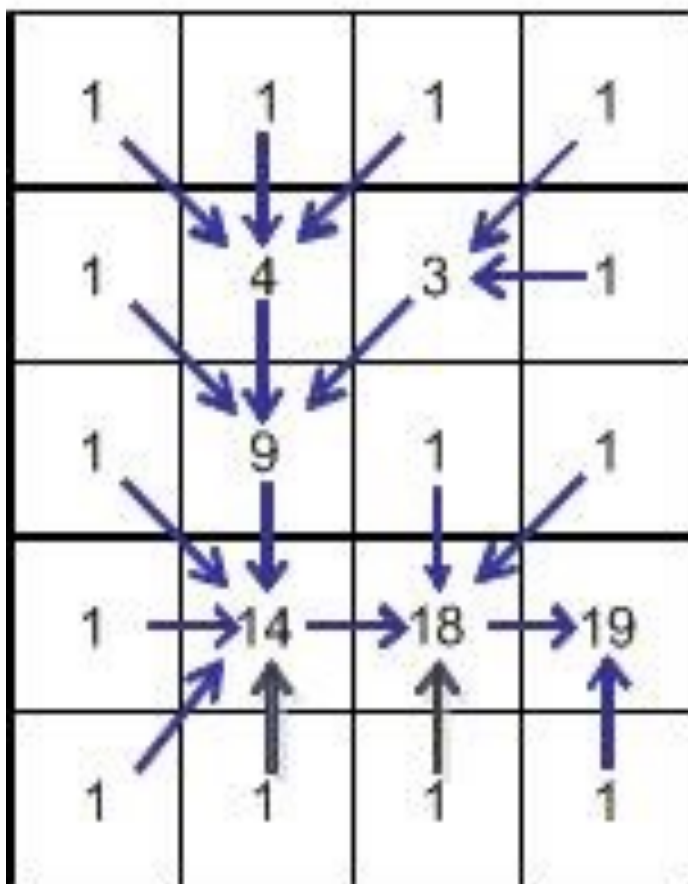
4.0	3.4	3.5	4.0
3.5	3.0	3.2	3.5
4.0	2.9	3.6	3.6
5.0	2.8	2.7	2.6
5.0	4.0	3.5	3.4

Area de Contribuição

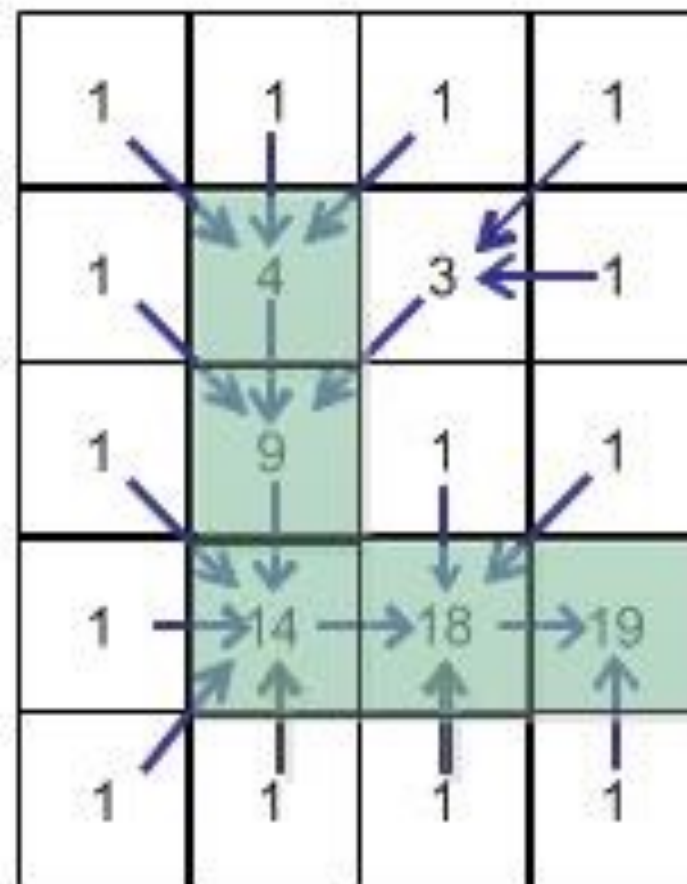
1	1	1	1
1	4	3	1
1	9	1	1
1	14	18	19
1	1	1	1

Definição de uma rede de drenagem

Área de Contrinuição



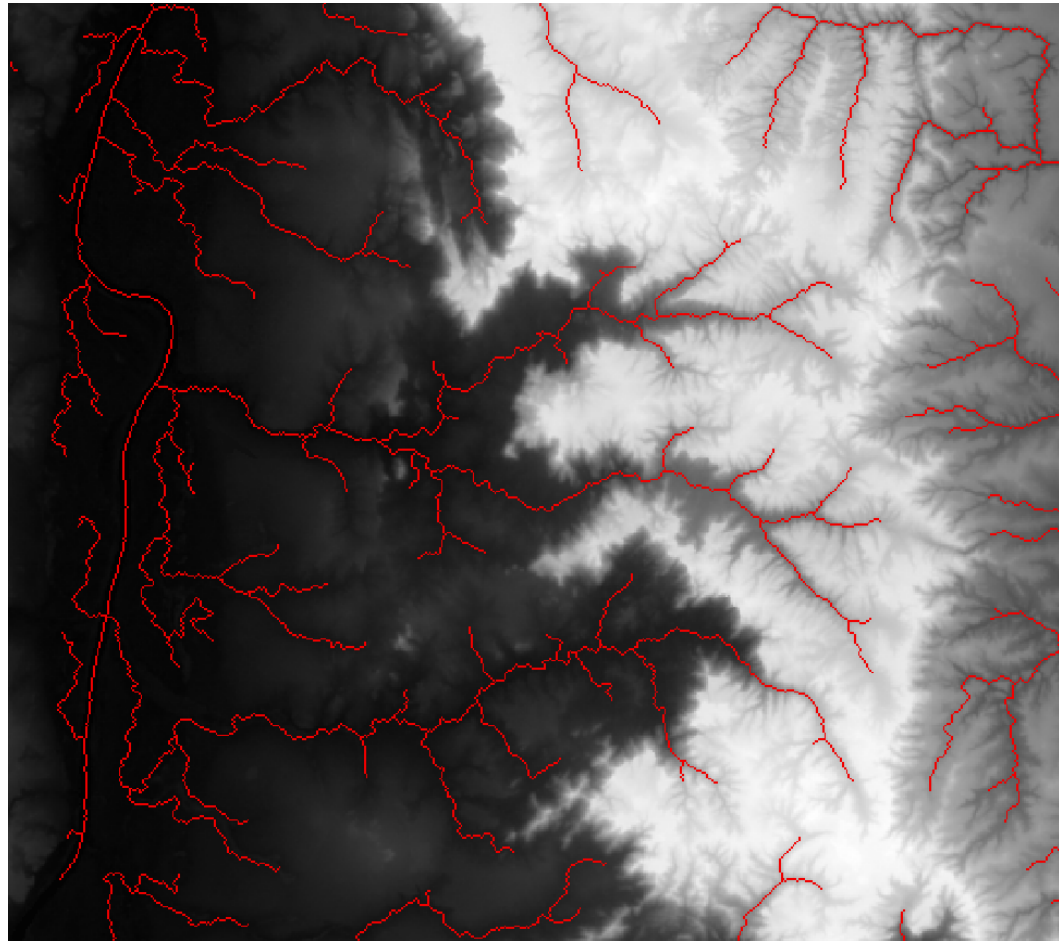
Drenagem Limiar = 4



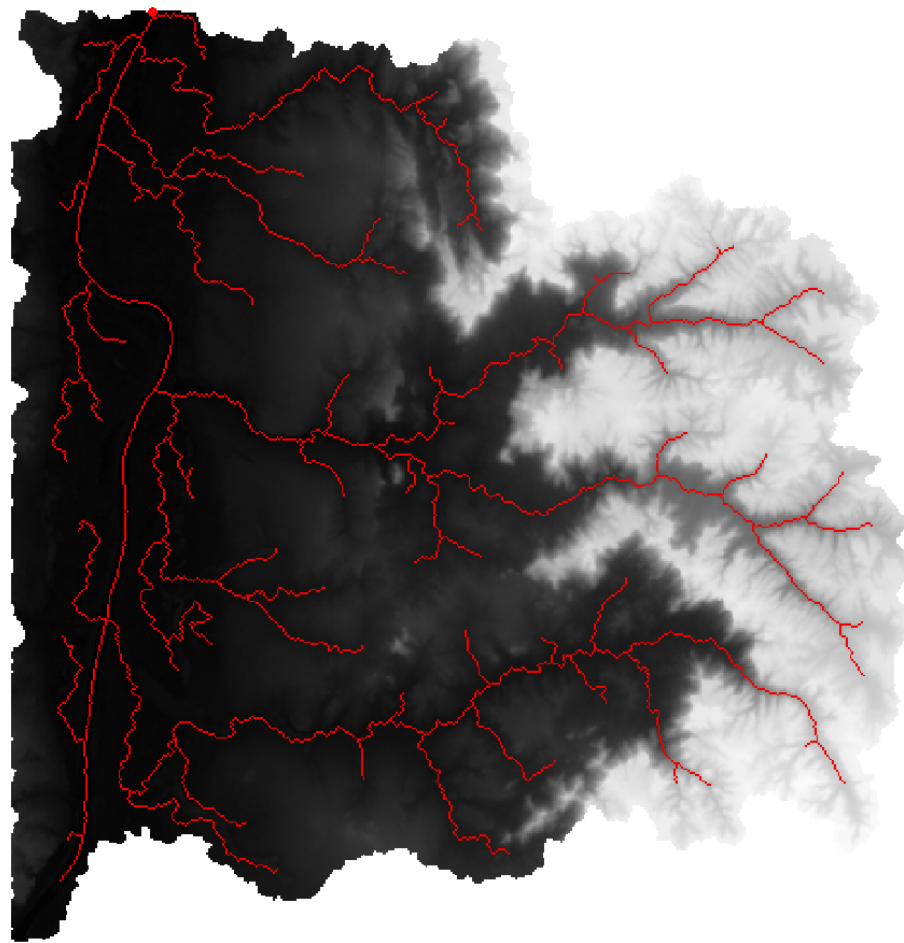
Delimitação da bacia hidrográfica



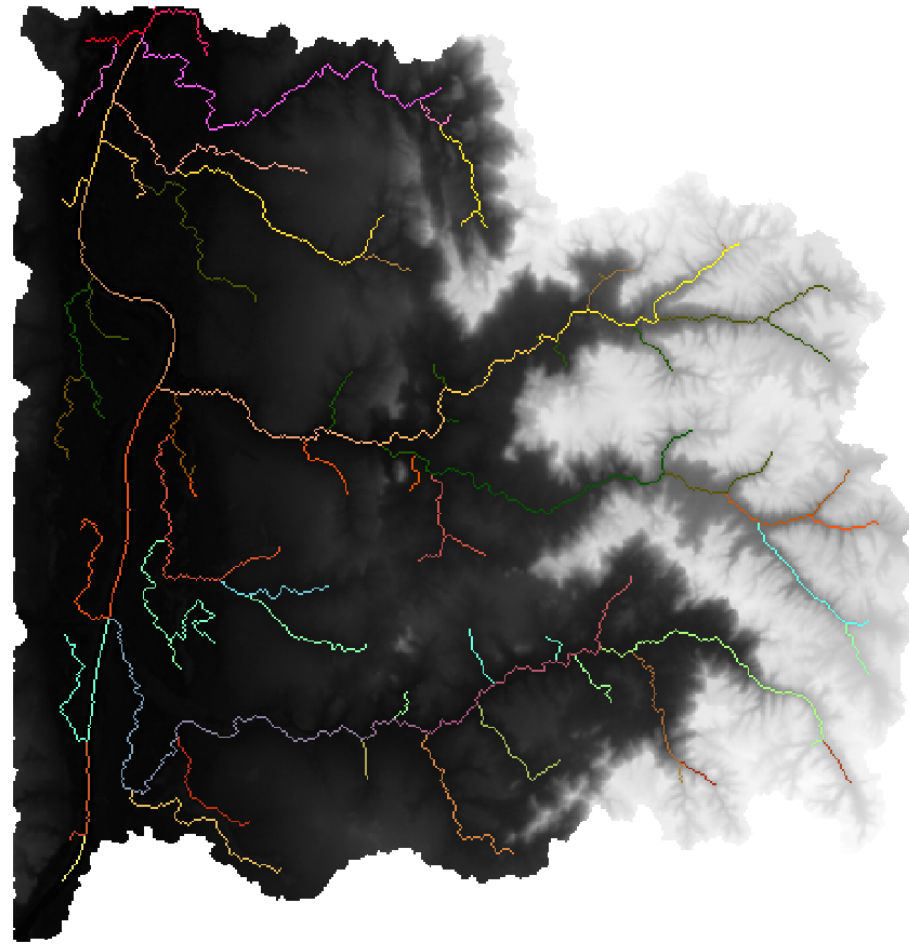
Área Acumulada / Drenagem



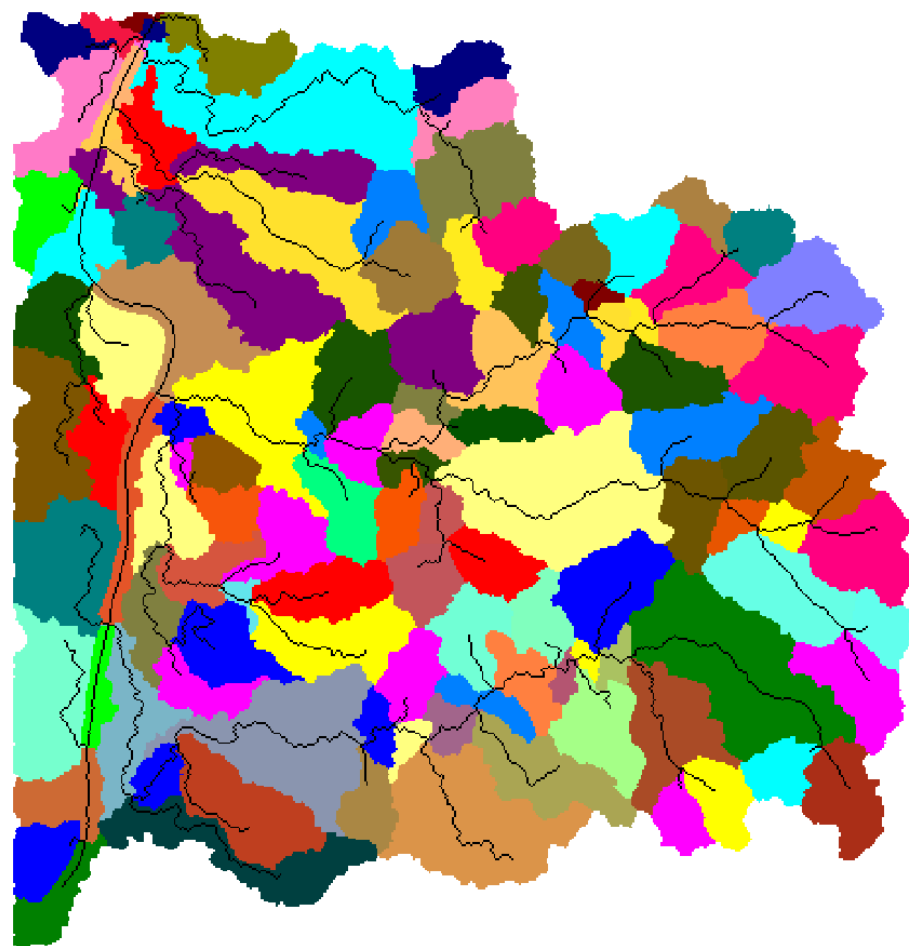
Delimitar a Bacia



Trechos de Drenagem



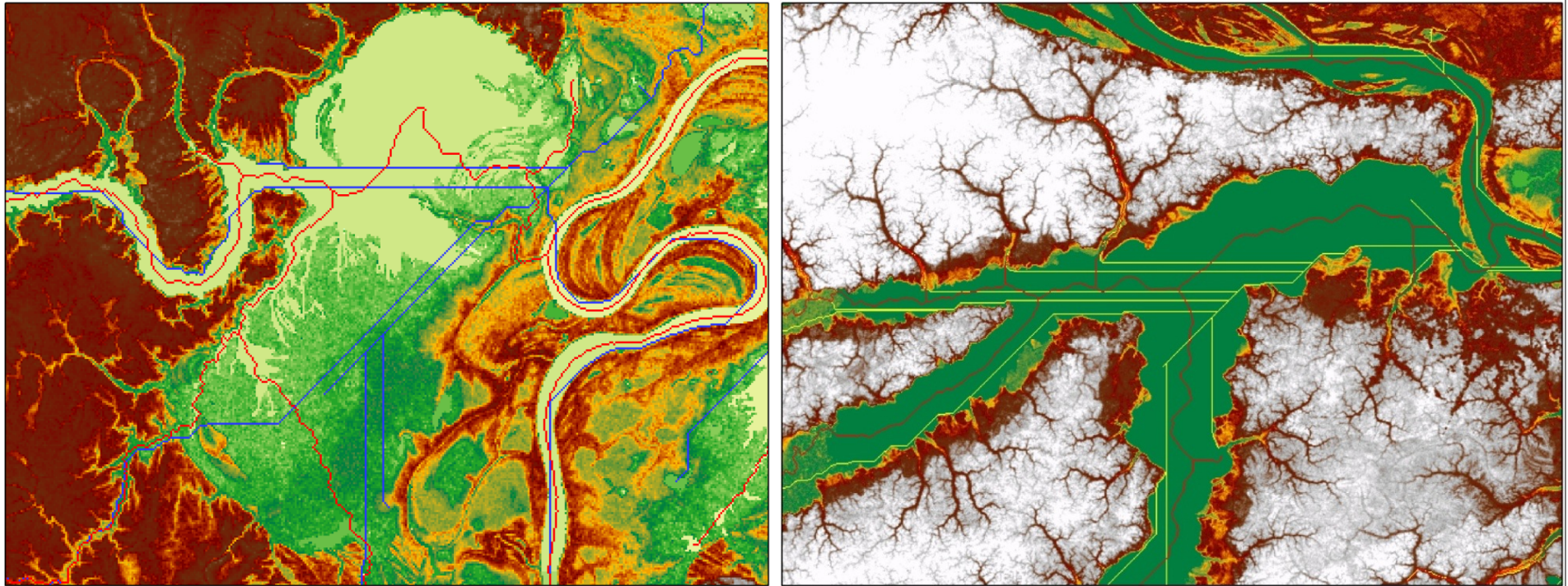
Minibacias



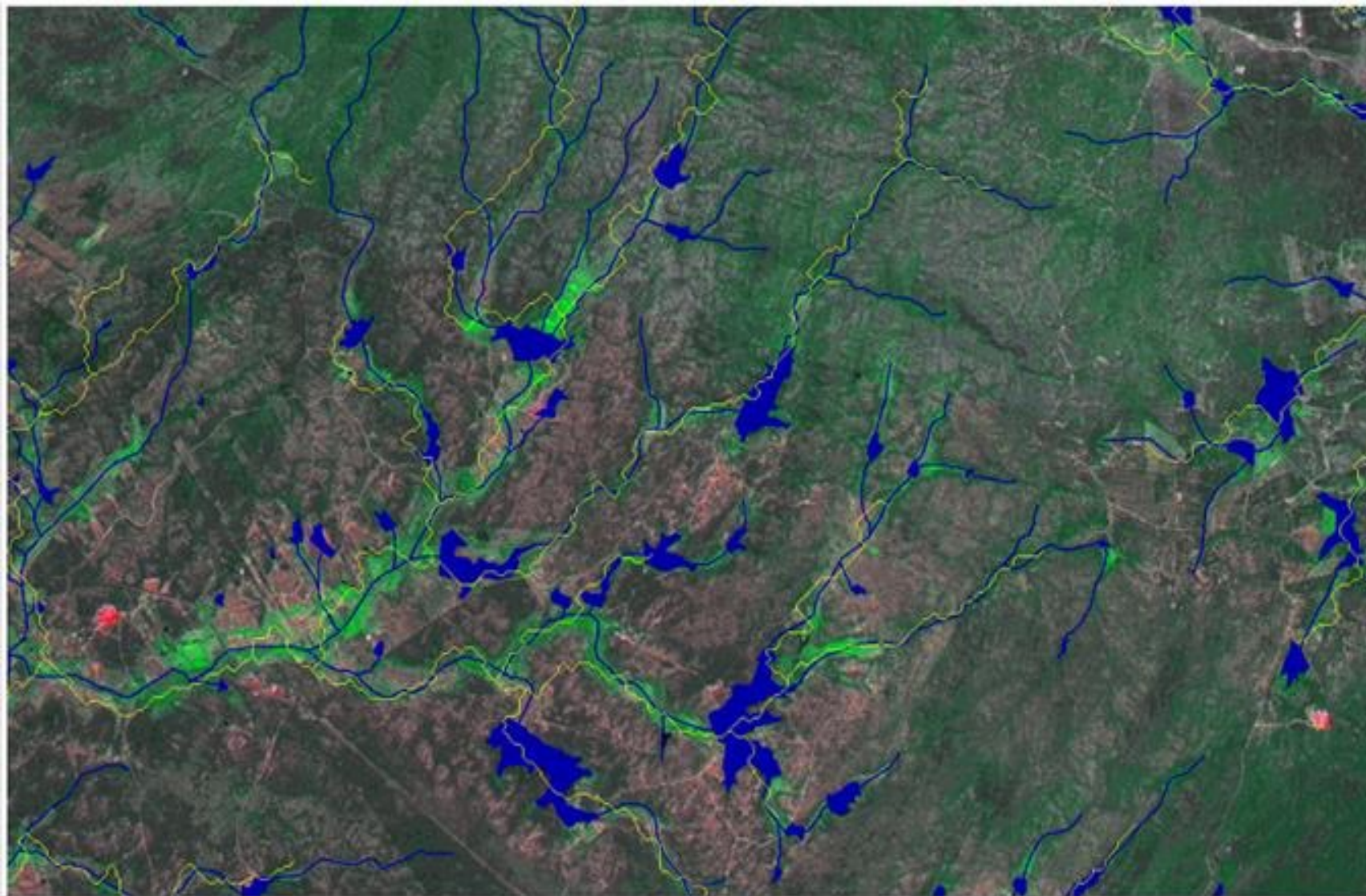
Vantagens

- 1. Processo inteiramente automatizado.
- 1. Altera menos possível o Modelo de Elevação do Terreno.
- 1. Drenagens passam pelo centro dos rios.
- 1. Resolve grandes áreas.

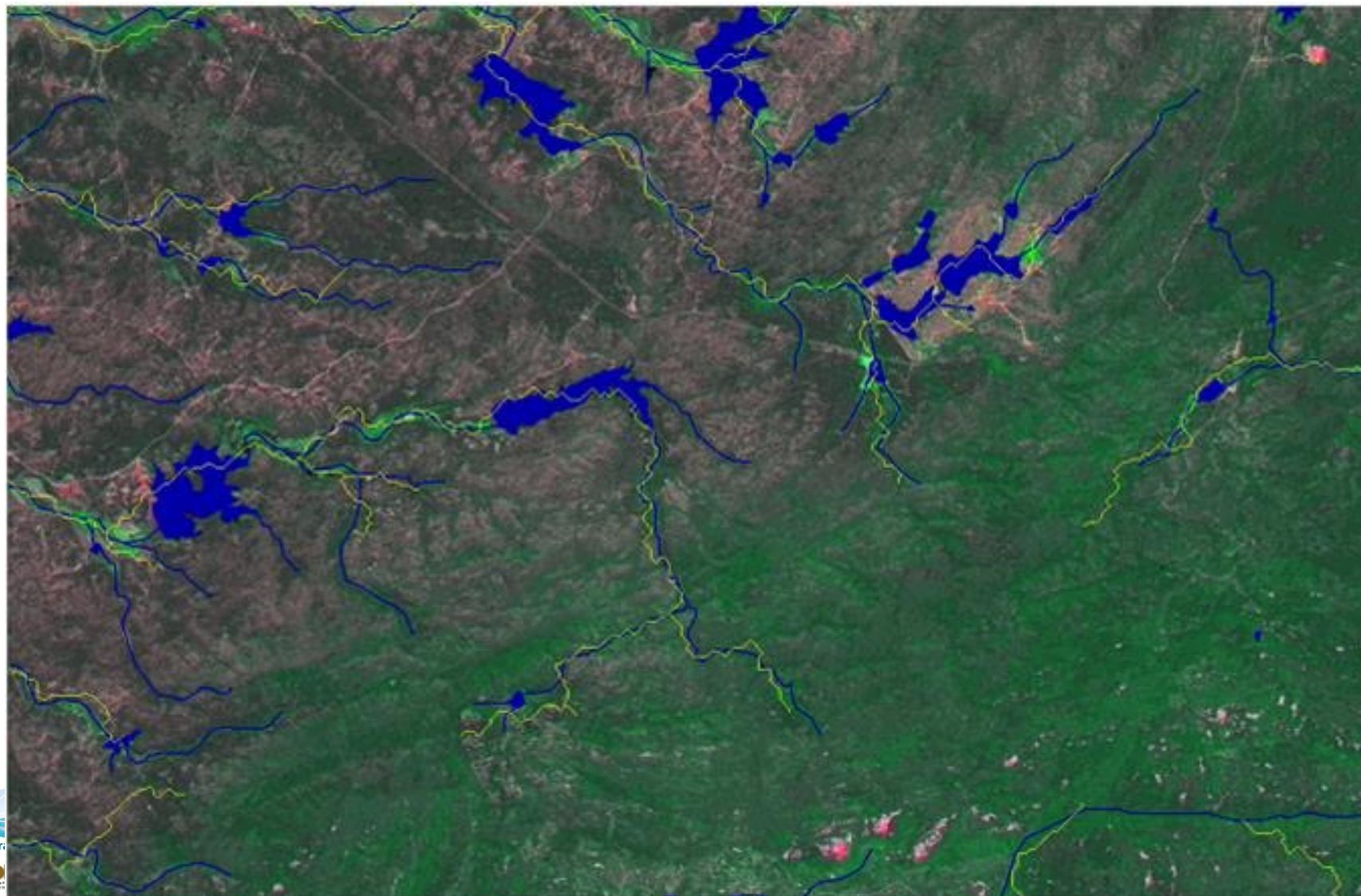
TerraHidro x ArcGis Hydro Tools – Rio Purus



Drenagem manual x automática

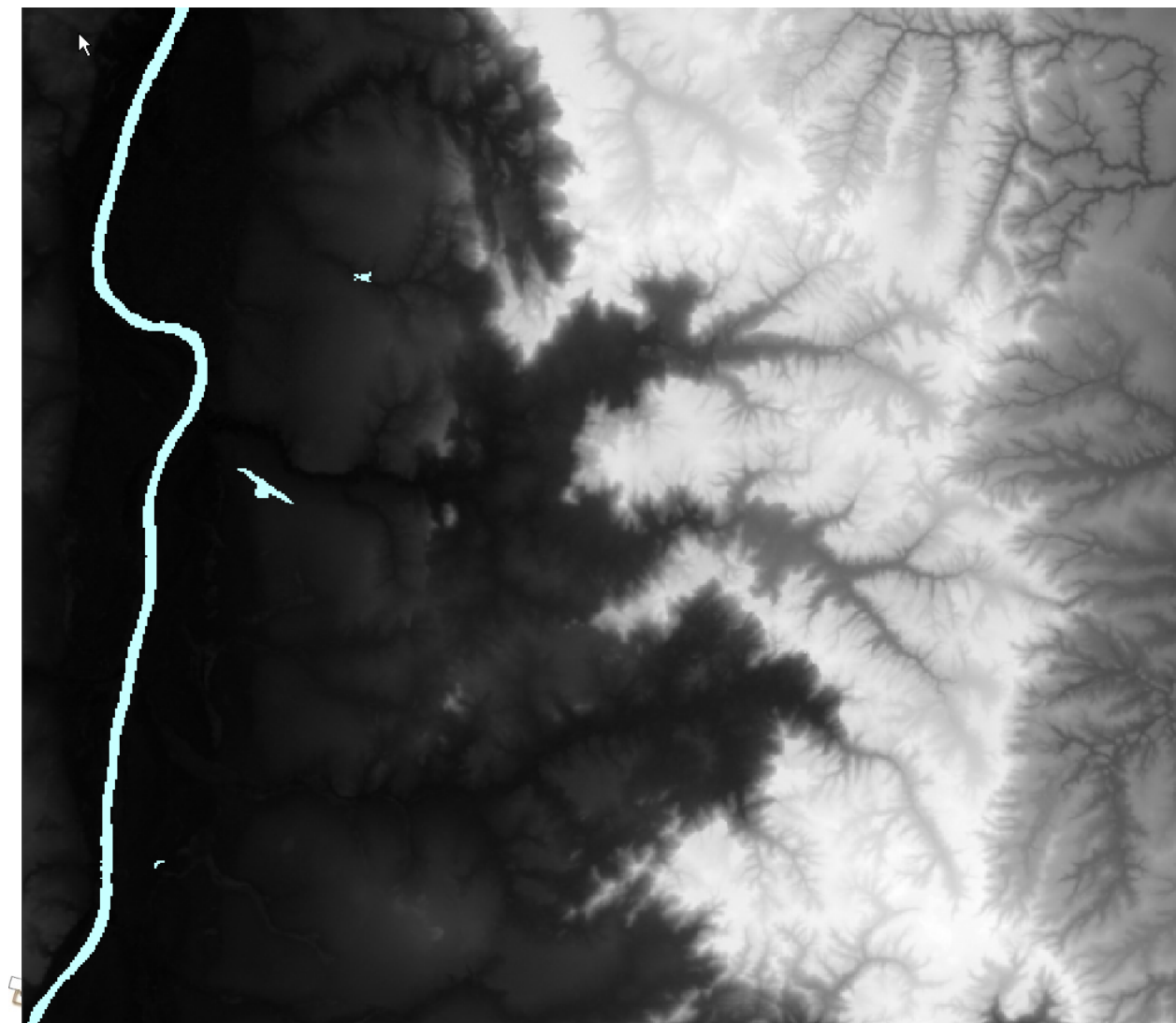


Drenagem manual x automática



RESULTADOS

Taquaruçu



x1: -48.45

y1: -10.50

x2: -48.00

y2: -10.10

Pixels: 259.139

Linhas: 479

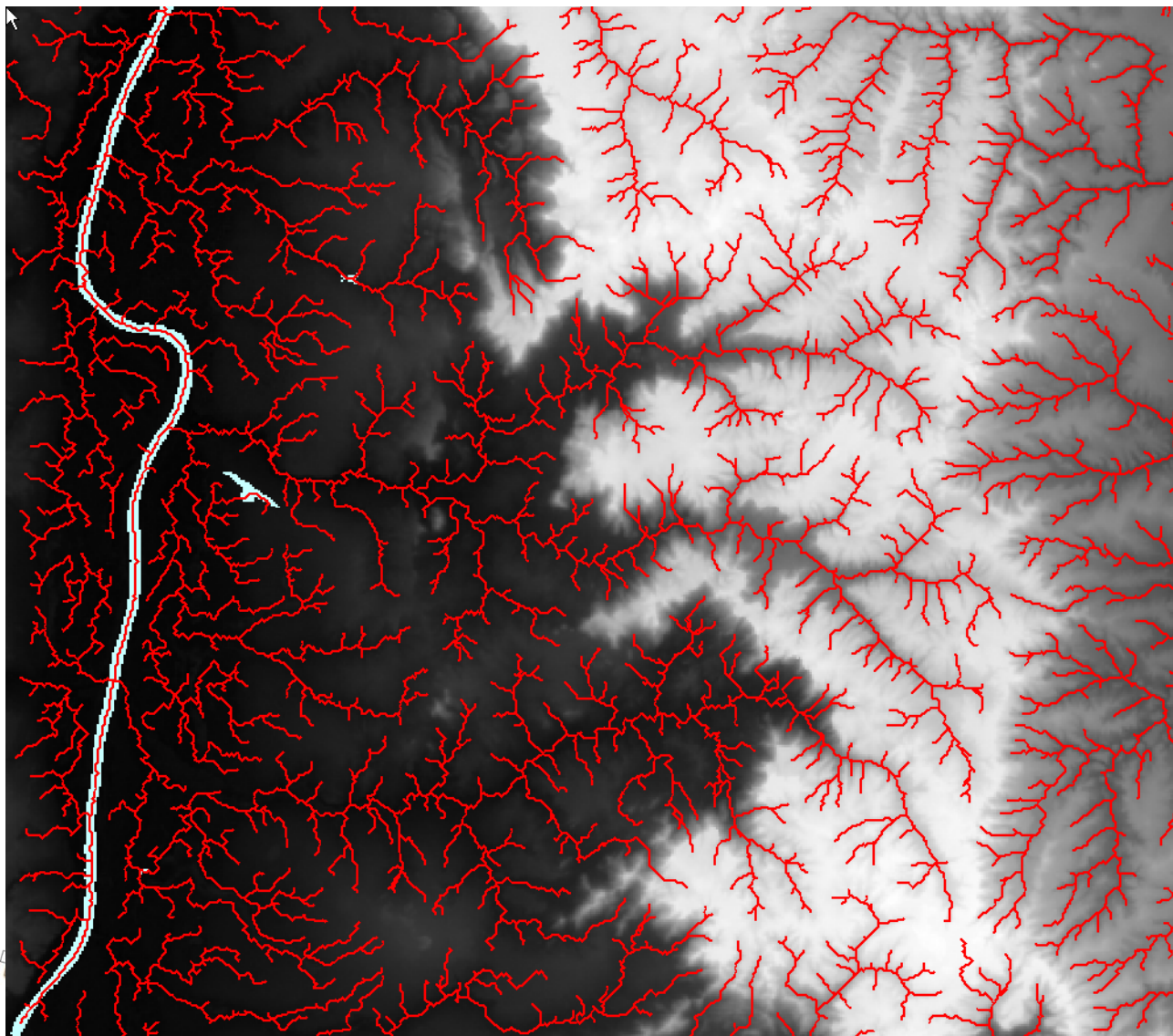
Colunas: 541

Fossos: 10.983

Tempo: 2.00 s

Acumulada: < 1 s

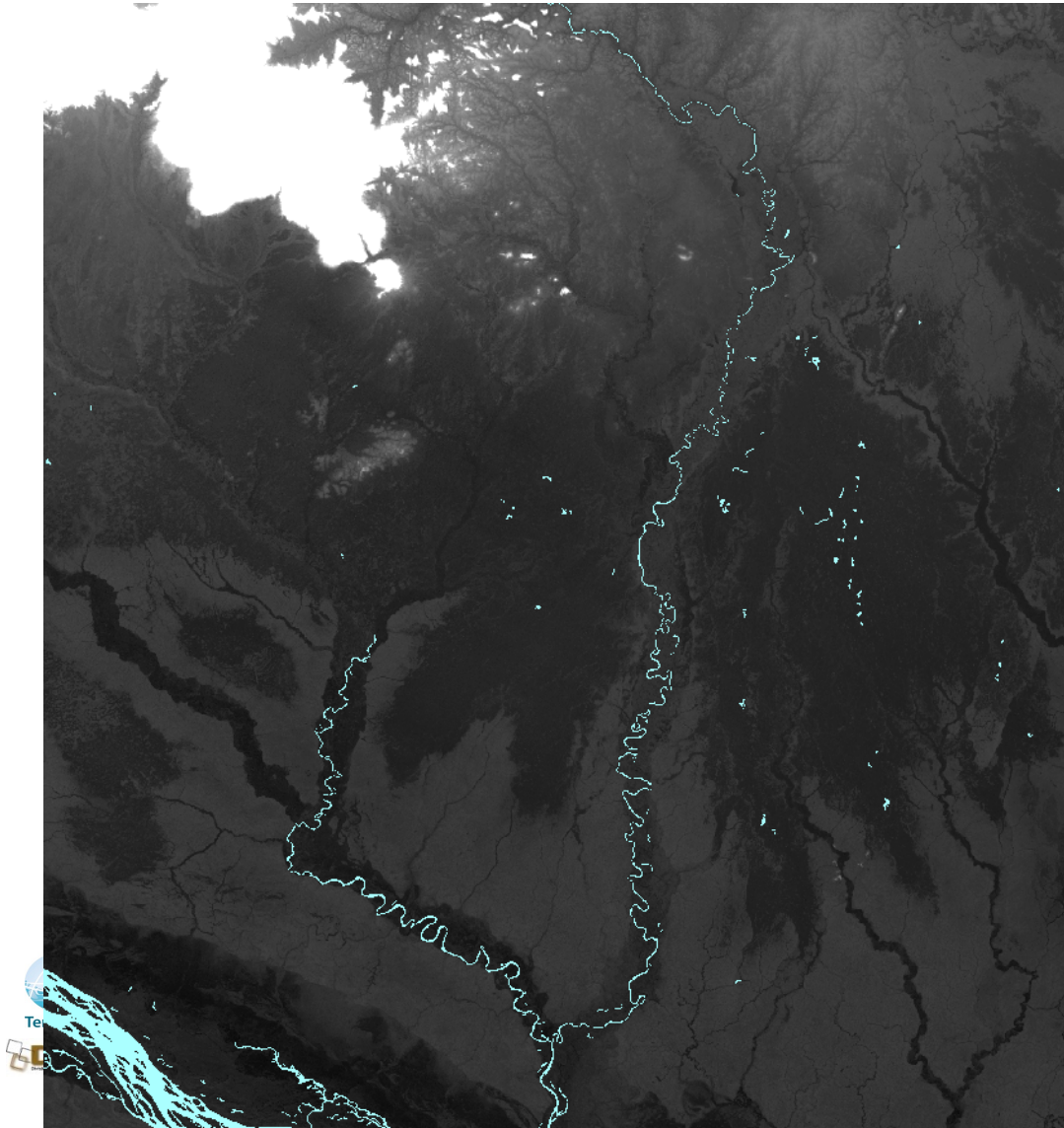
Taquaruçu Drenagem



Valor de corte: 50

Maior Ordem: 6

Getirana



Saturado em 200 metros.

x1: -63.66

y1: -0.55

x2: -62.12

y2: 1.12

Pixels: 3.734.280

Linhas: 2.024

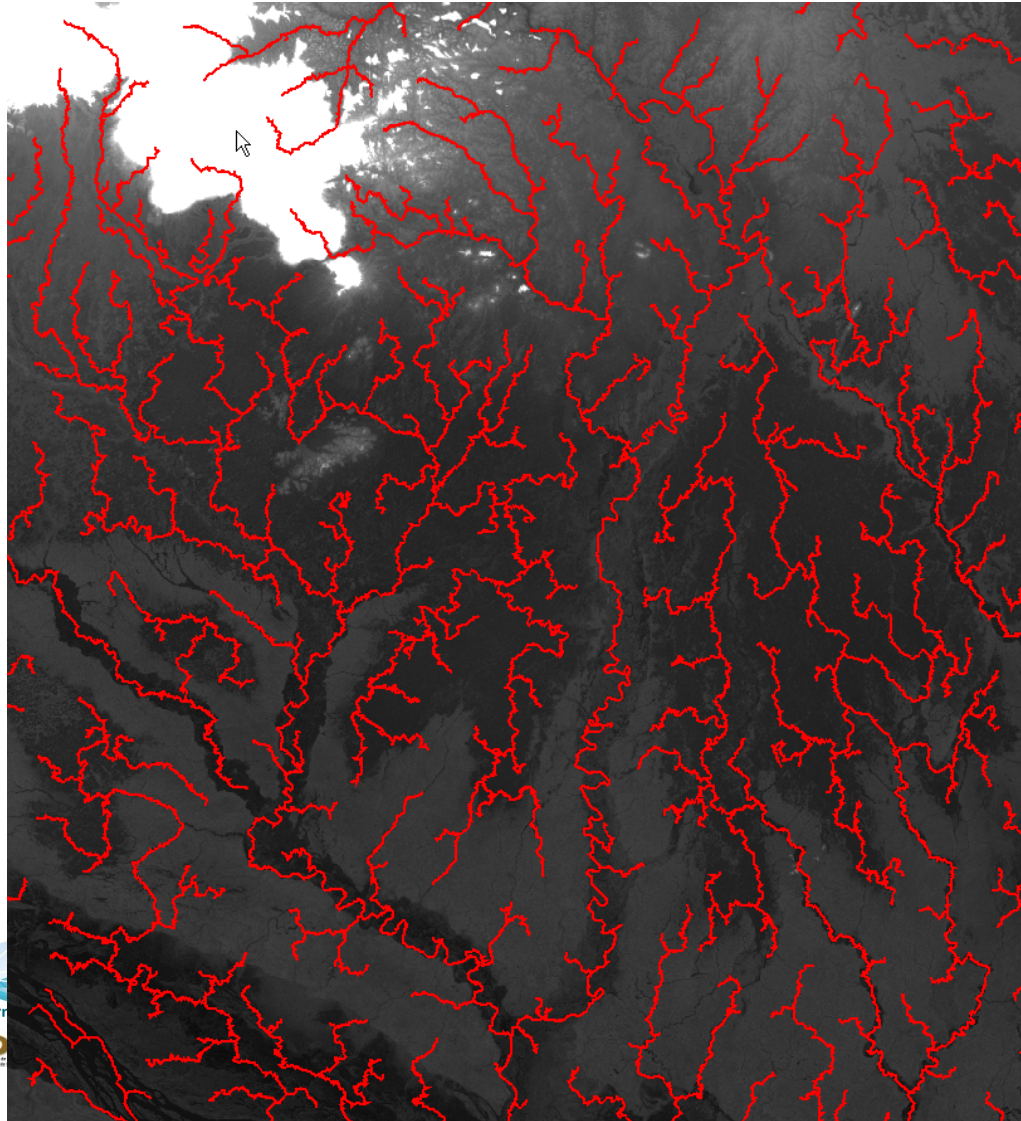
Colunas: 1.845

Fossos: 396.769

Tempo: 26:30 min

Acumulada: 1 s

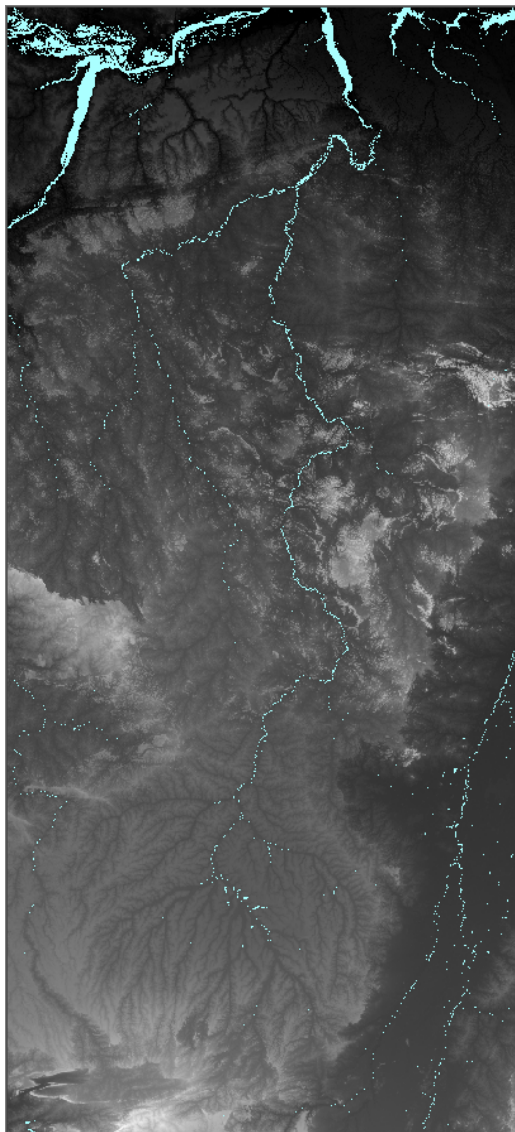
Getirana Drenagem



Valor de corte: 3.000

Maior Ordem: 5

Xingu



x1: -56.00

y1: -15.00

x2: -49.99

y2: -1.69

Pixels: 114.958.324

Linhas: 15.962

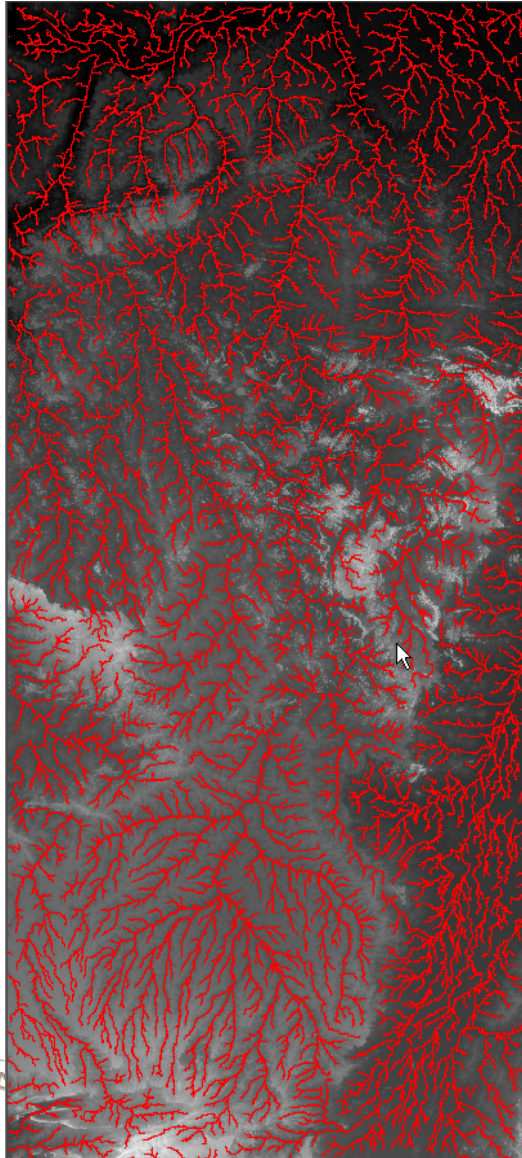
Colunas: 7.202

Fossos: 6.472.113

Tempo: 3:20:04 h

Acumulada: 2:48 min

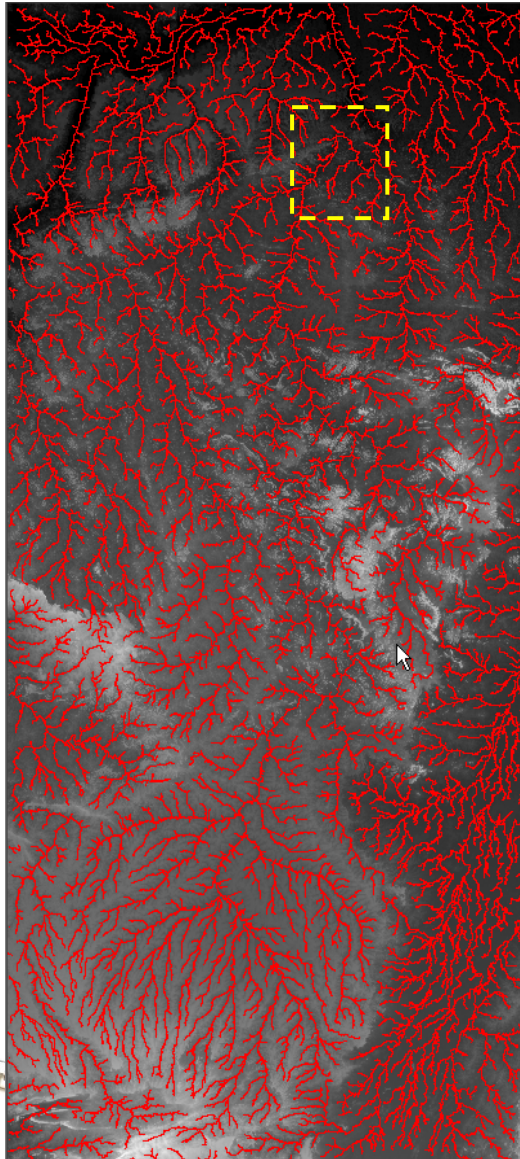
Xingu Drenagem



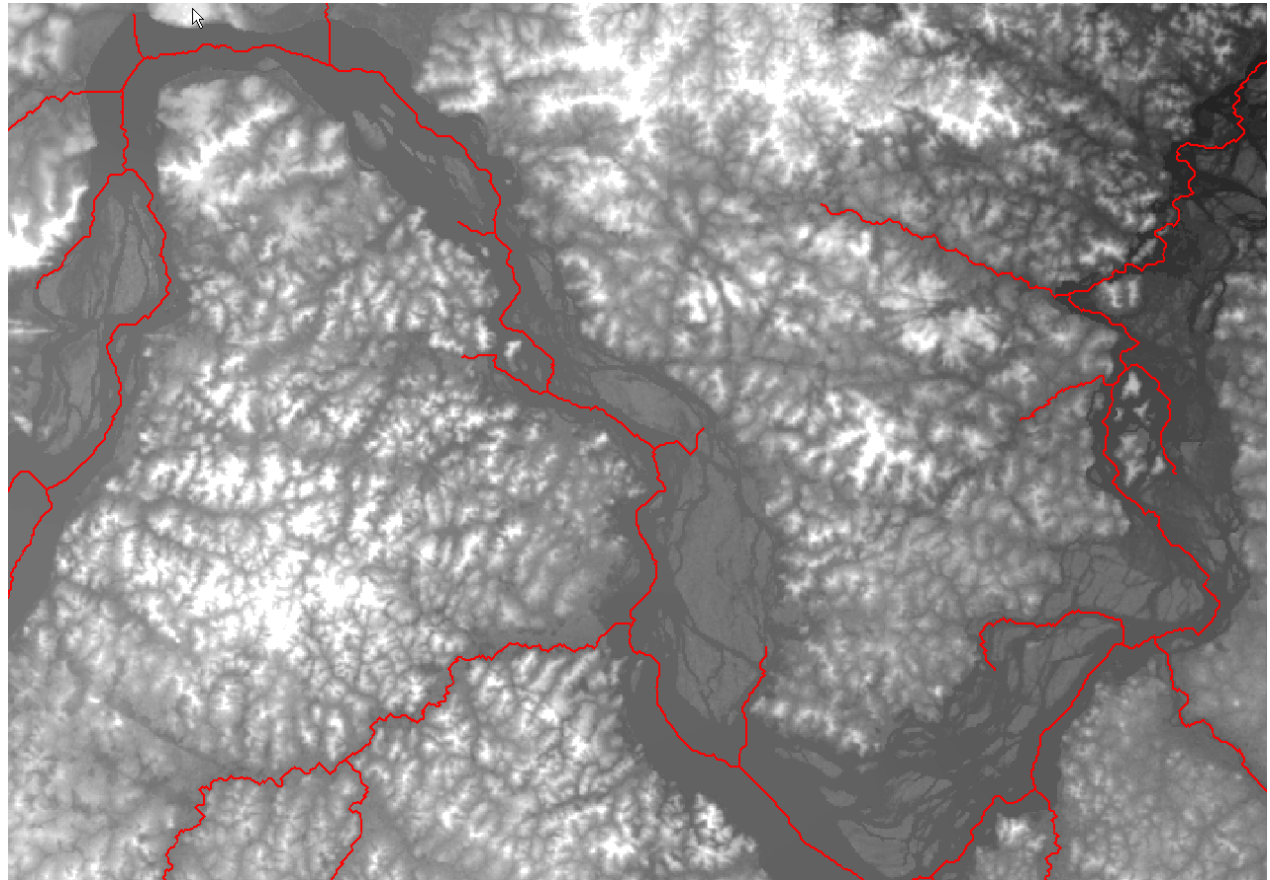
Valor de corte: 10.000

Maior Ordem: 6

Xingu Drenagem Zoom

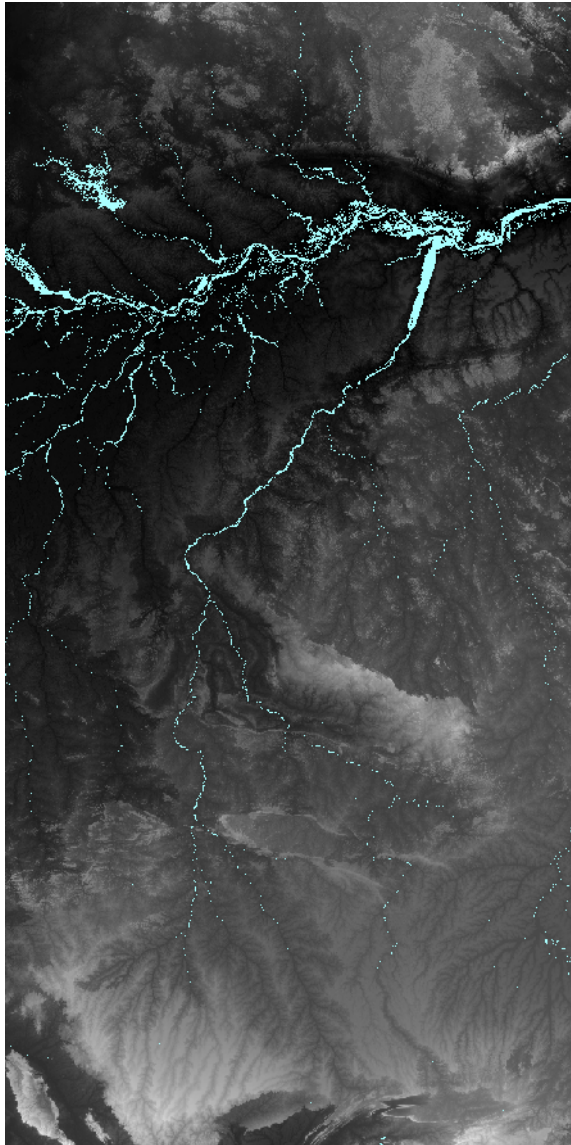


Drenagem passa pelo centro da área plana



Zoom saturado em 200 metros

Tapajós



x1: -61.00

y1: -15.00

x2: -52.99

y2: 1.00

Pixels: 184.348.801

Linhas: 19.201

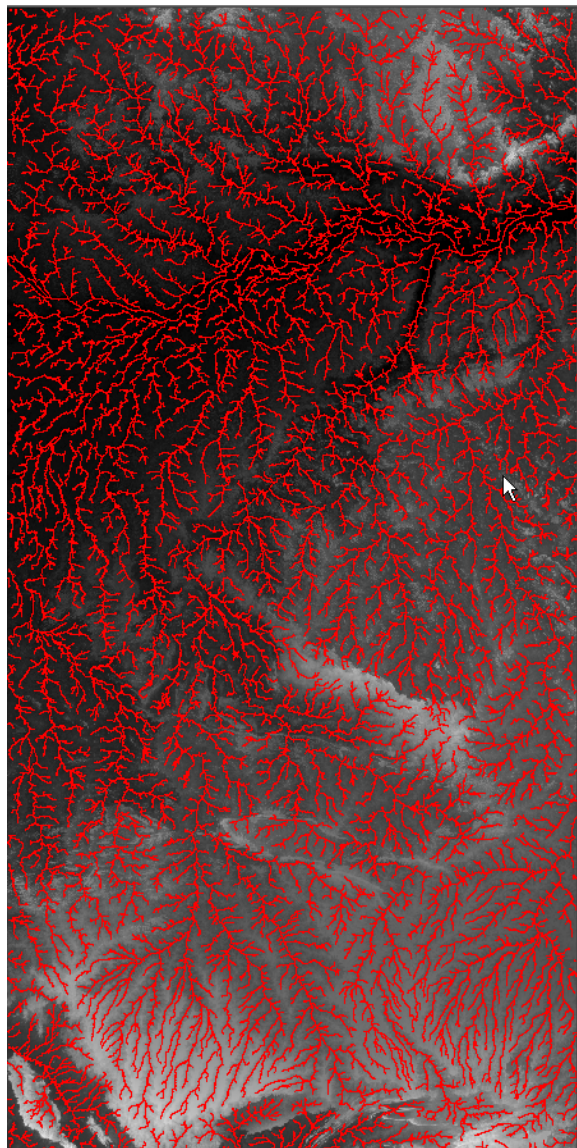
Colunas: 9.601

Fossos: 8.647.984

Tempo: 5:33:38 h

Acumulada: 10:58 min

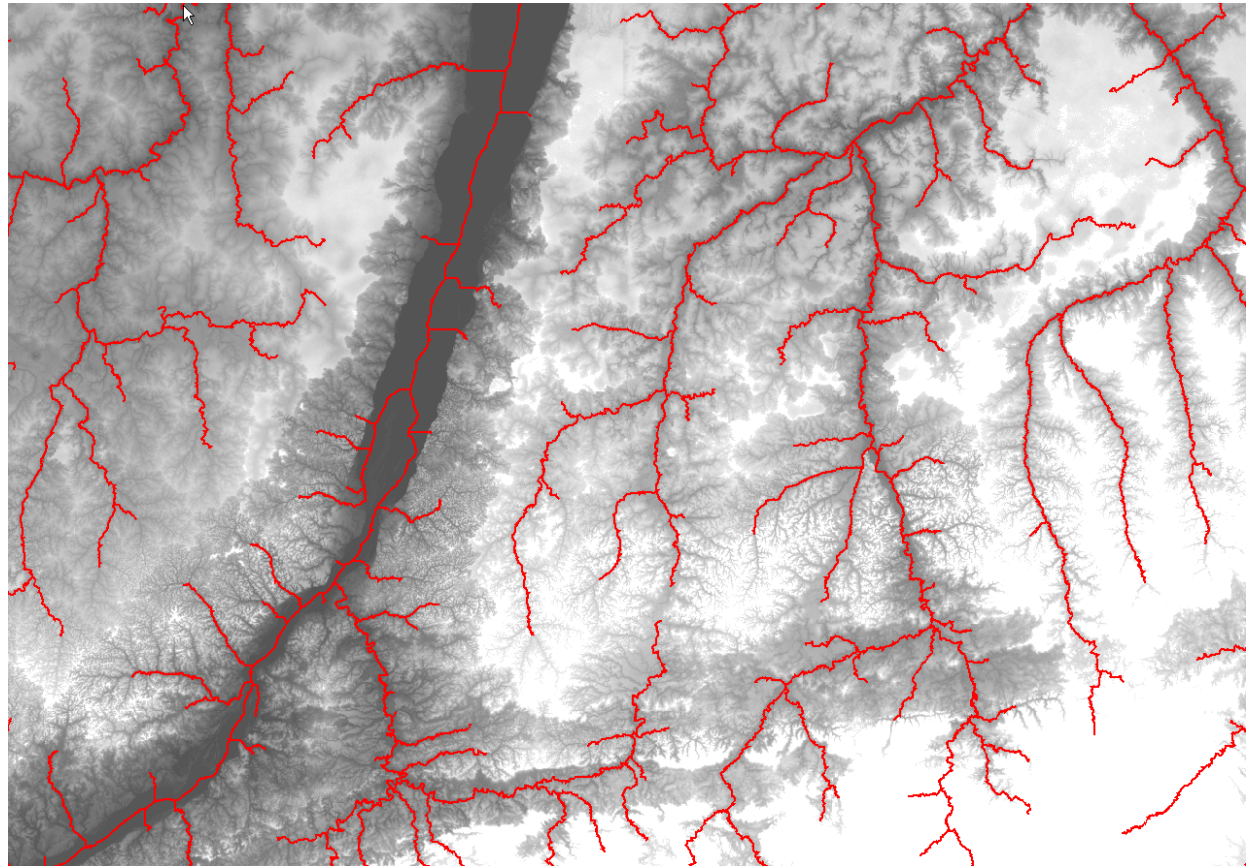
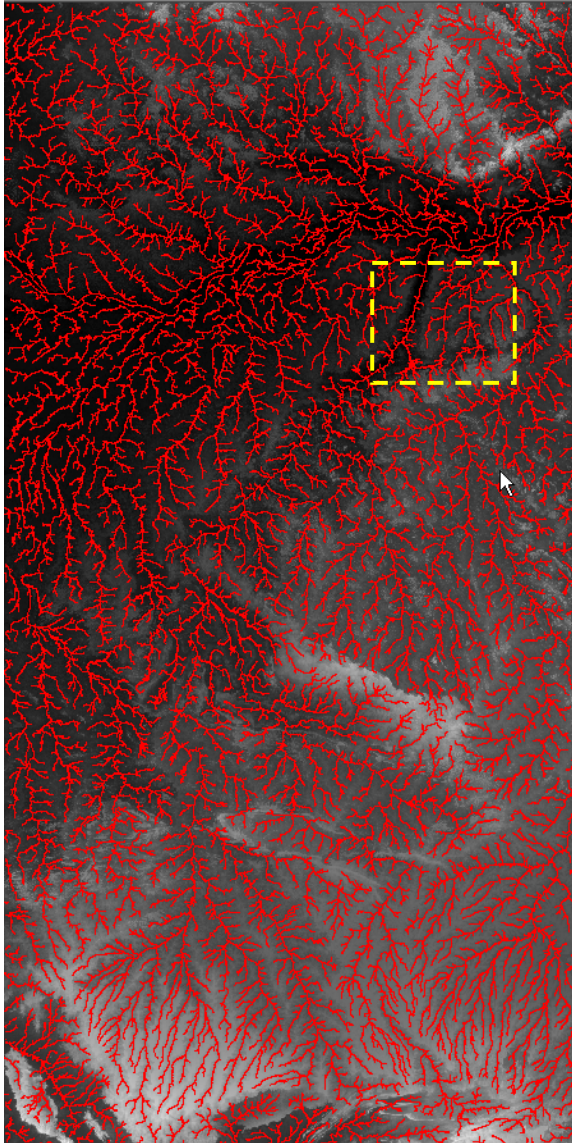
Tapajós Drenagem



Valor de corte: 10.000

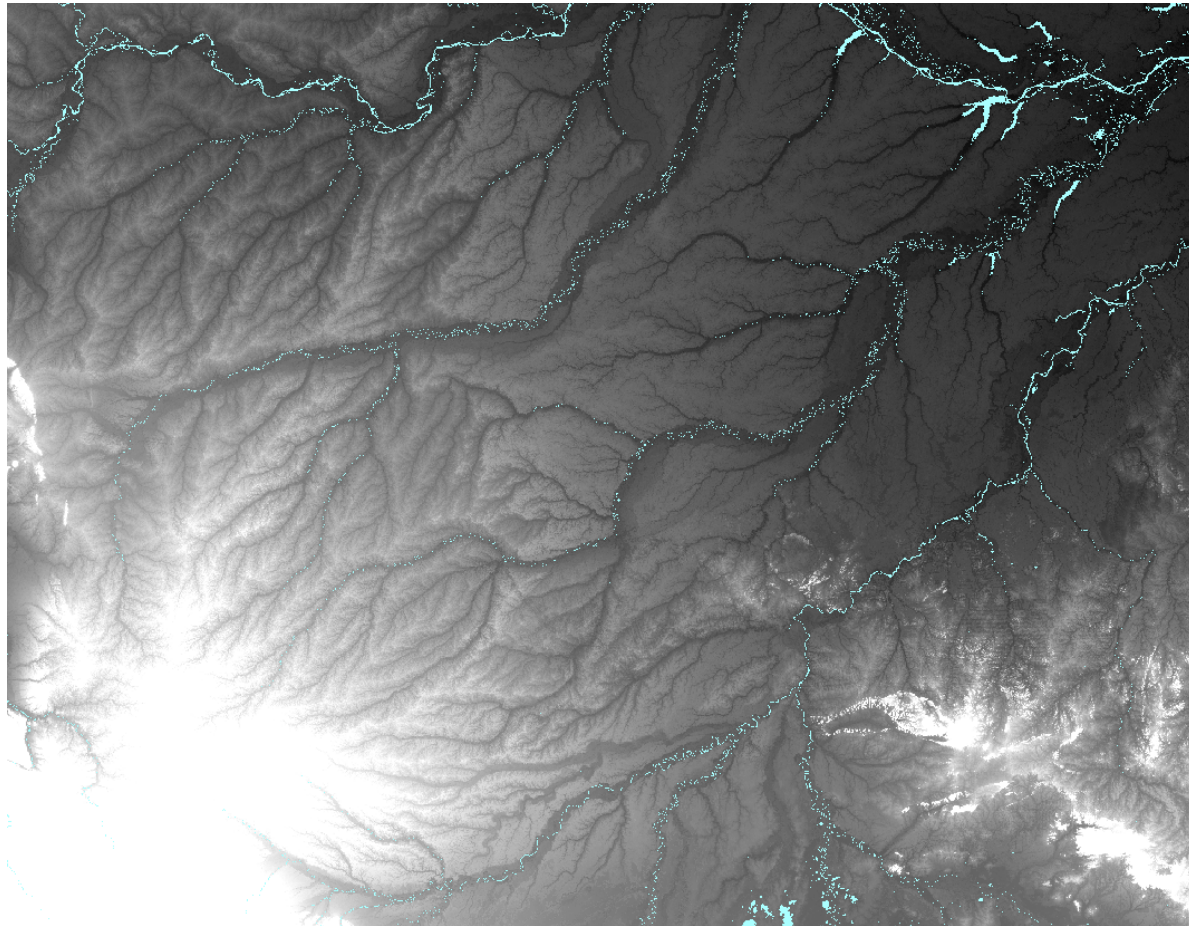
Maior Ordem: 7

Tapajós Drenagem Zoom



Zoom saturado em 200 metros

Purus



x1: -74.00

y1: -12.99

x2: -61.00

y2: -2.99

Pixels: 187.200.000

Linhas: 12.000

Colunas: 15.600

Fossos: 13.279.394

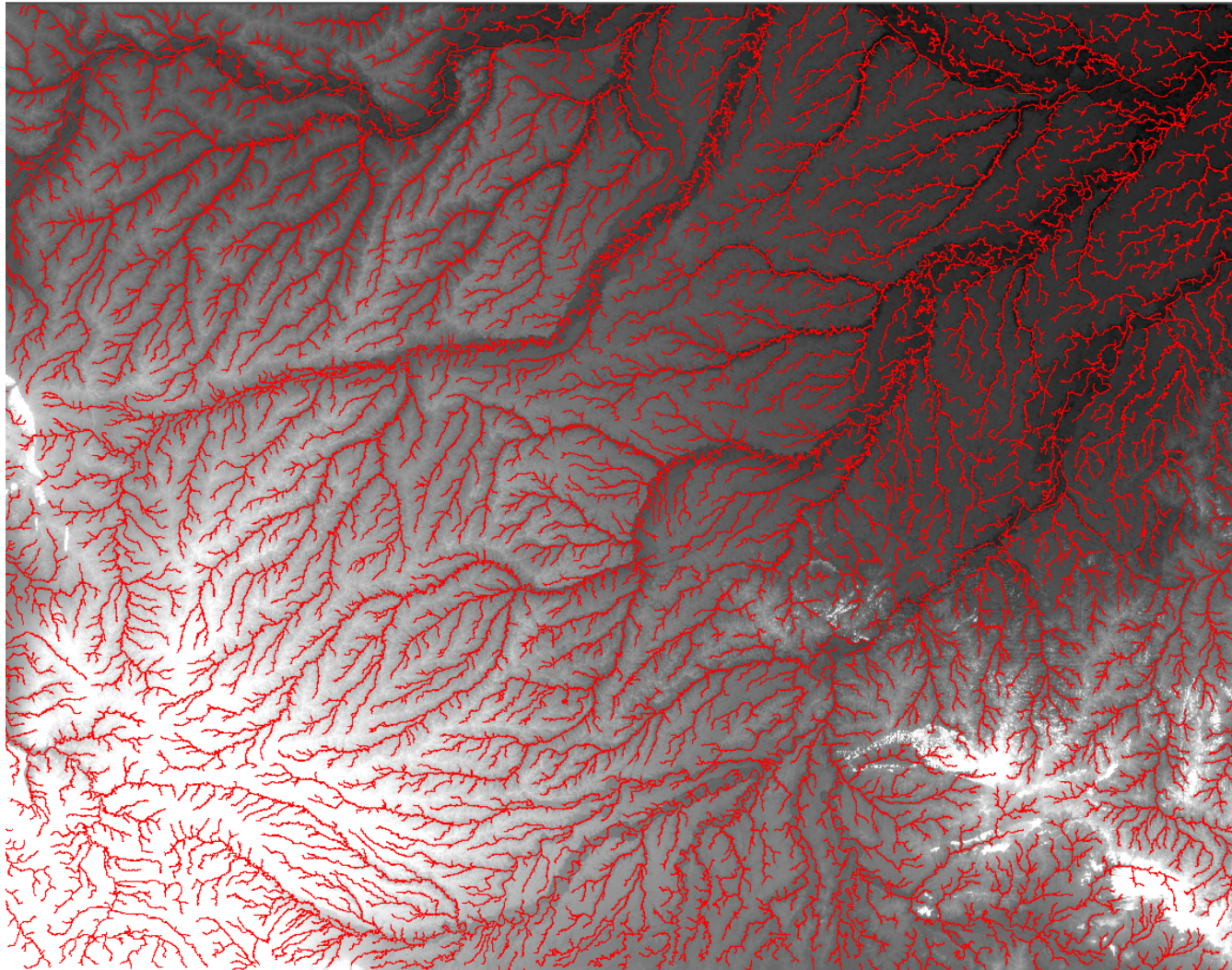
Tempo: 5:40:31 h

Acumulada: 12:07 min



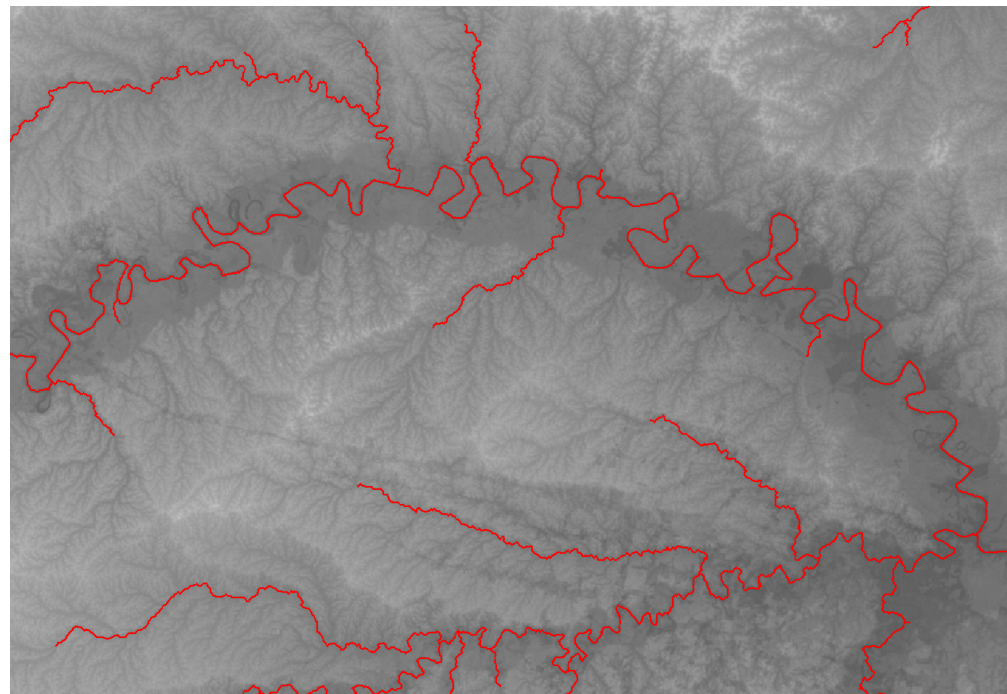
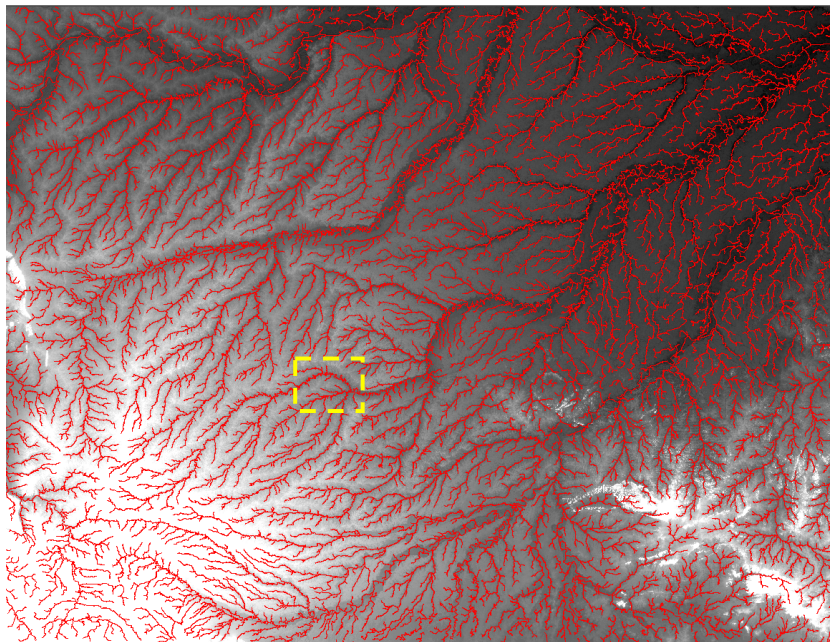
Saturado em 350 metros

Purus Drenagem

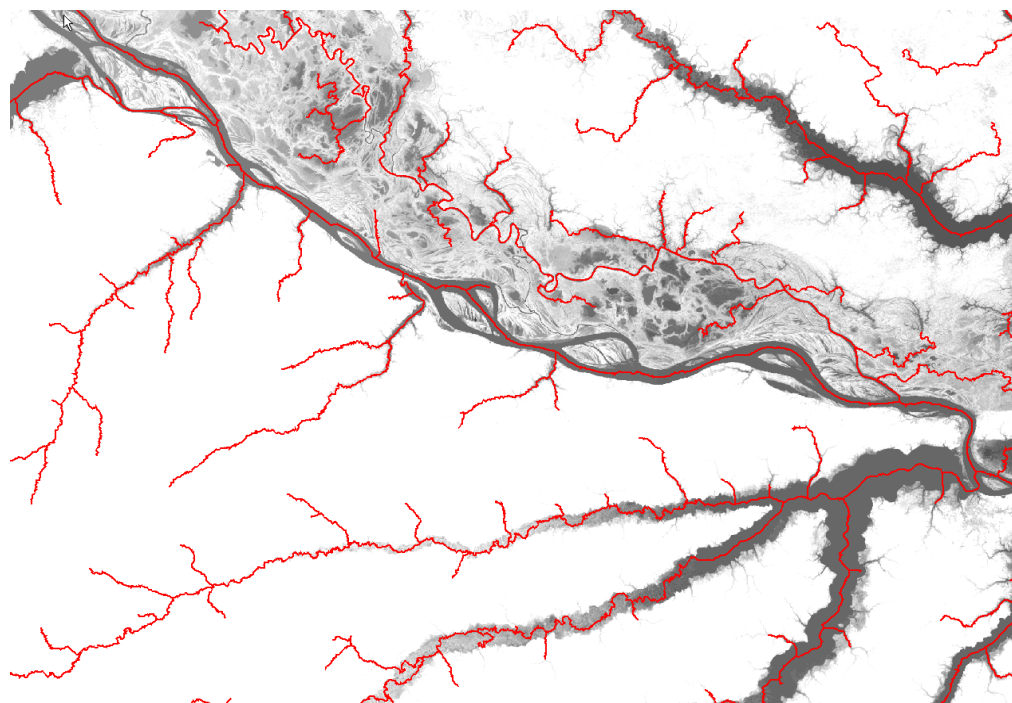
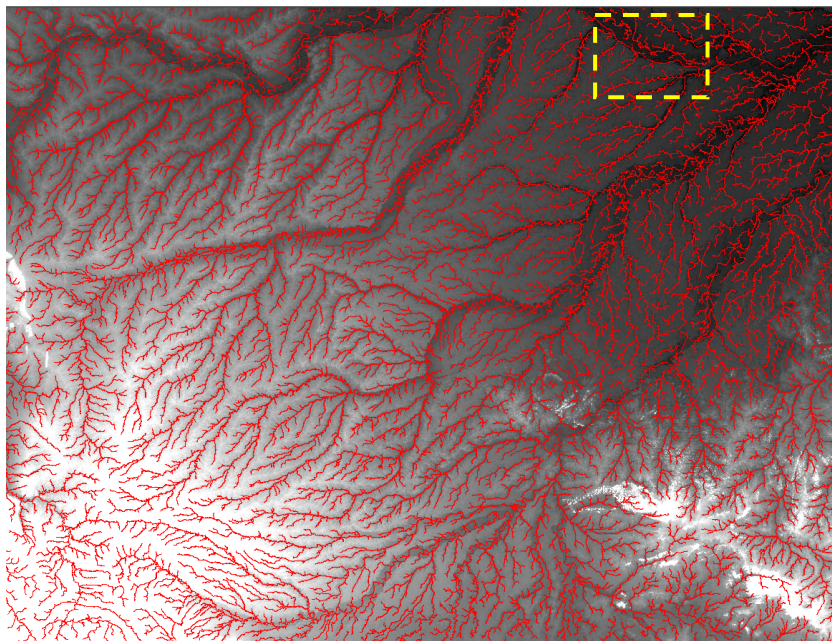


Valor de corte: 10.000 Maior Ordem: 6

Purus Drenagem Zoom1

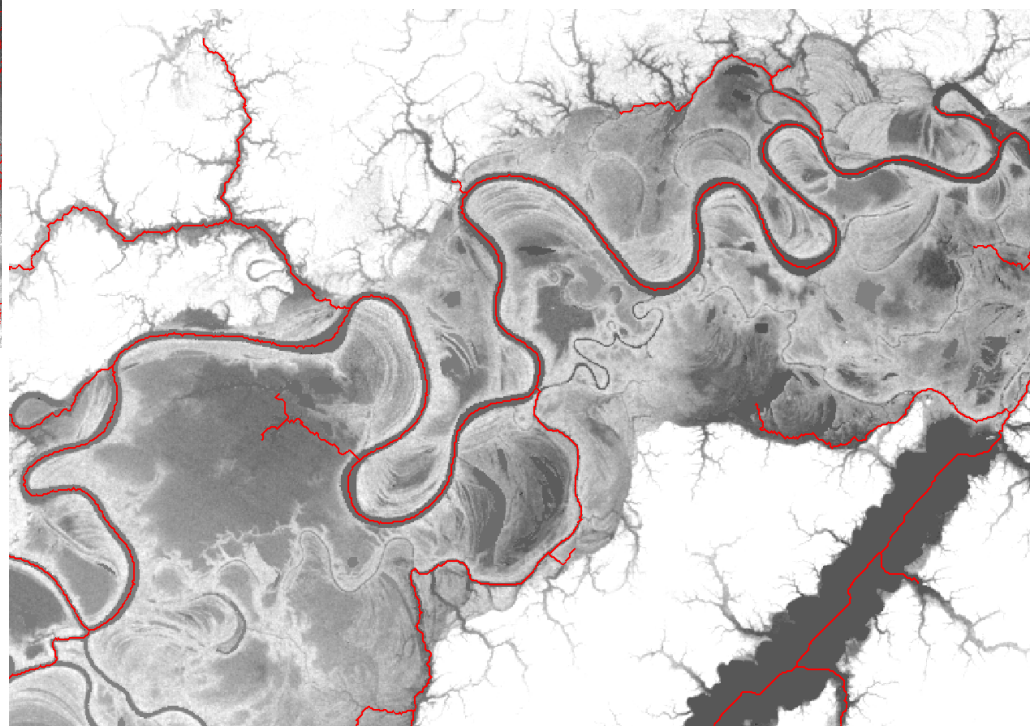
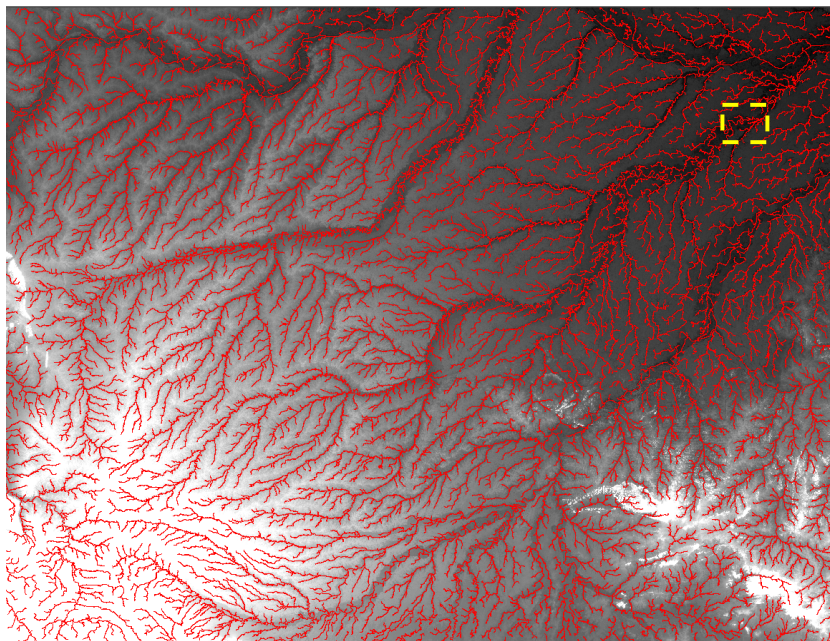


Purus Drenagem Zoom2



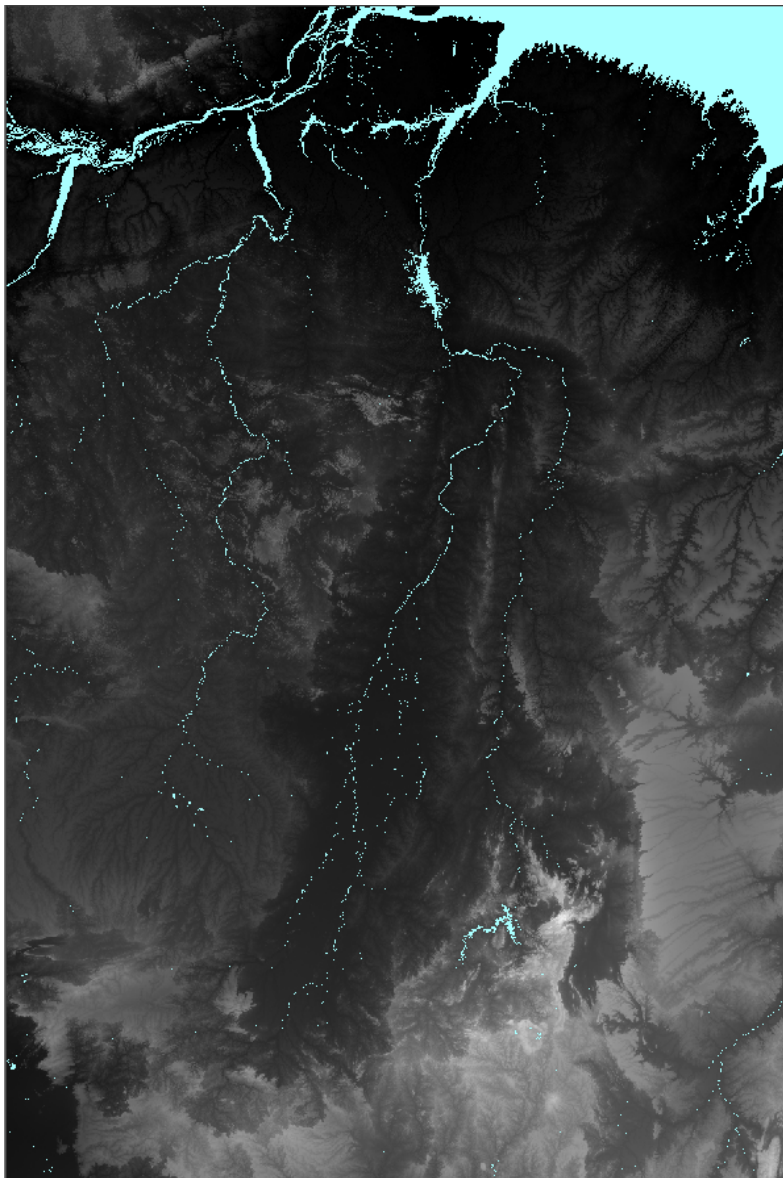
Zoom saturado em 50 metros

Purus Drenagem Zoom3



Saturado em 50 metros

Tocantins



x1: -56.00

y1: -18.00

x2: -43.99

y2: 0.00

Pixels: 311.112.004

Linhas: 21.602

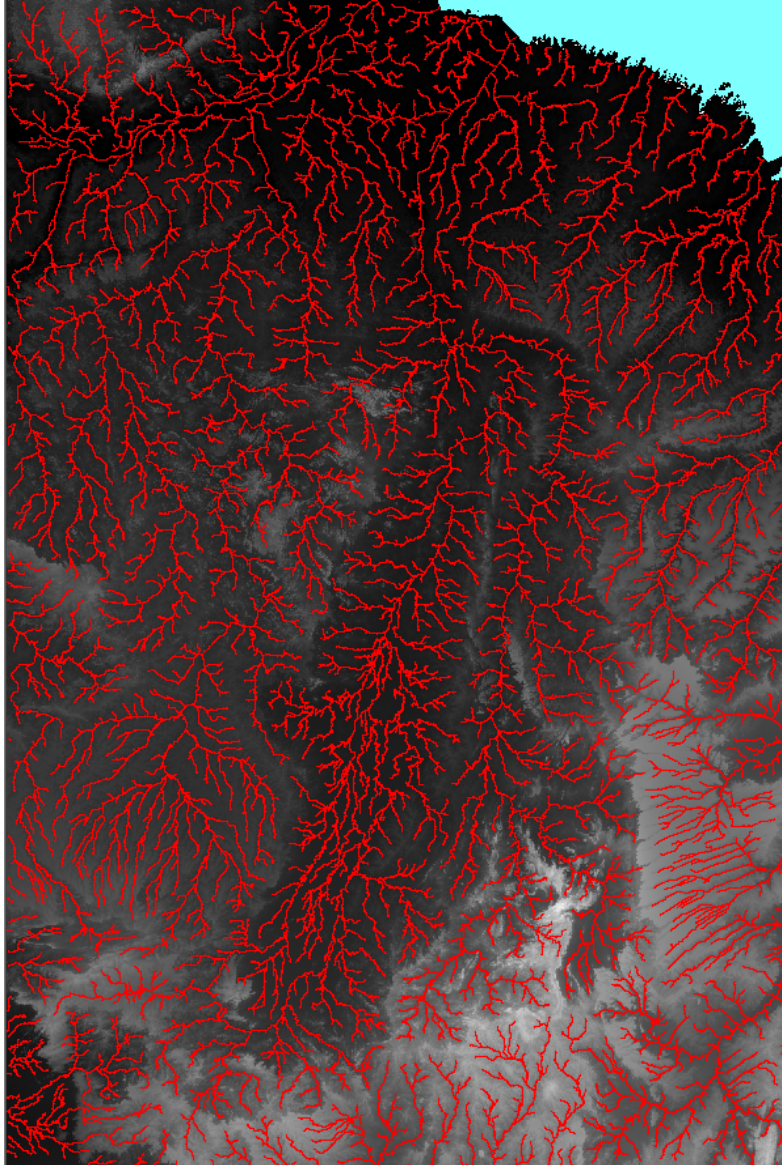
Colunas: 14.402

Fossos: 15.893.139

Tempo: 26:34:54 h

Acumulada: 14:55 min

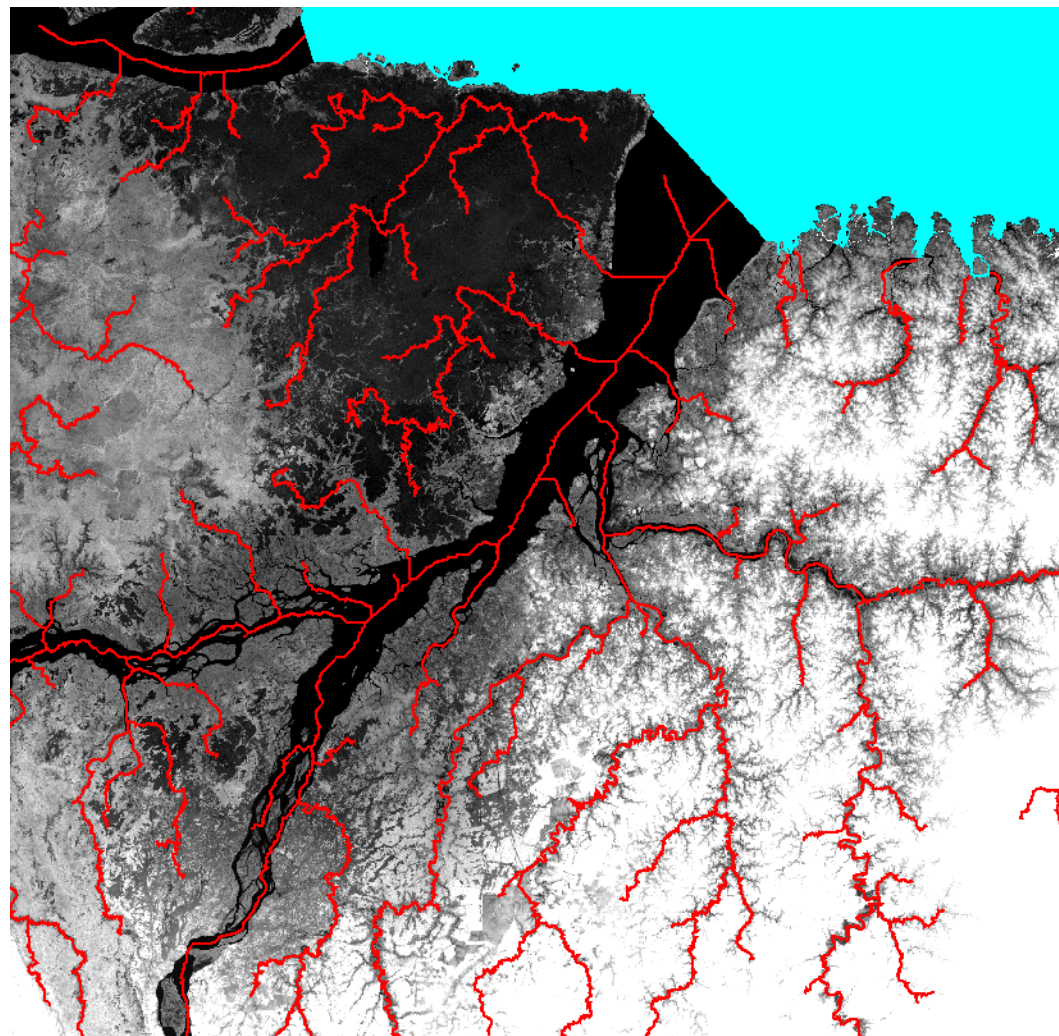
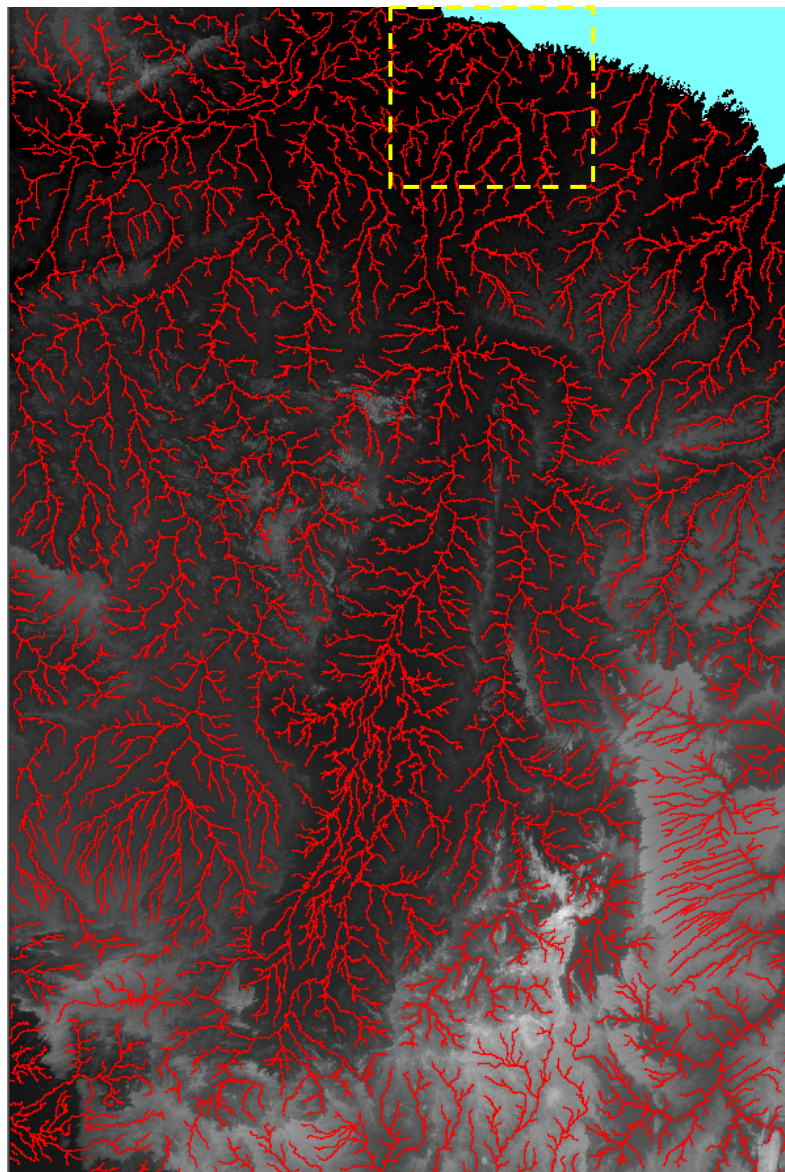
Tocantins Drenagem



Valor de corte: 30.000

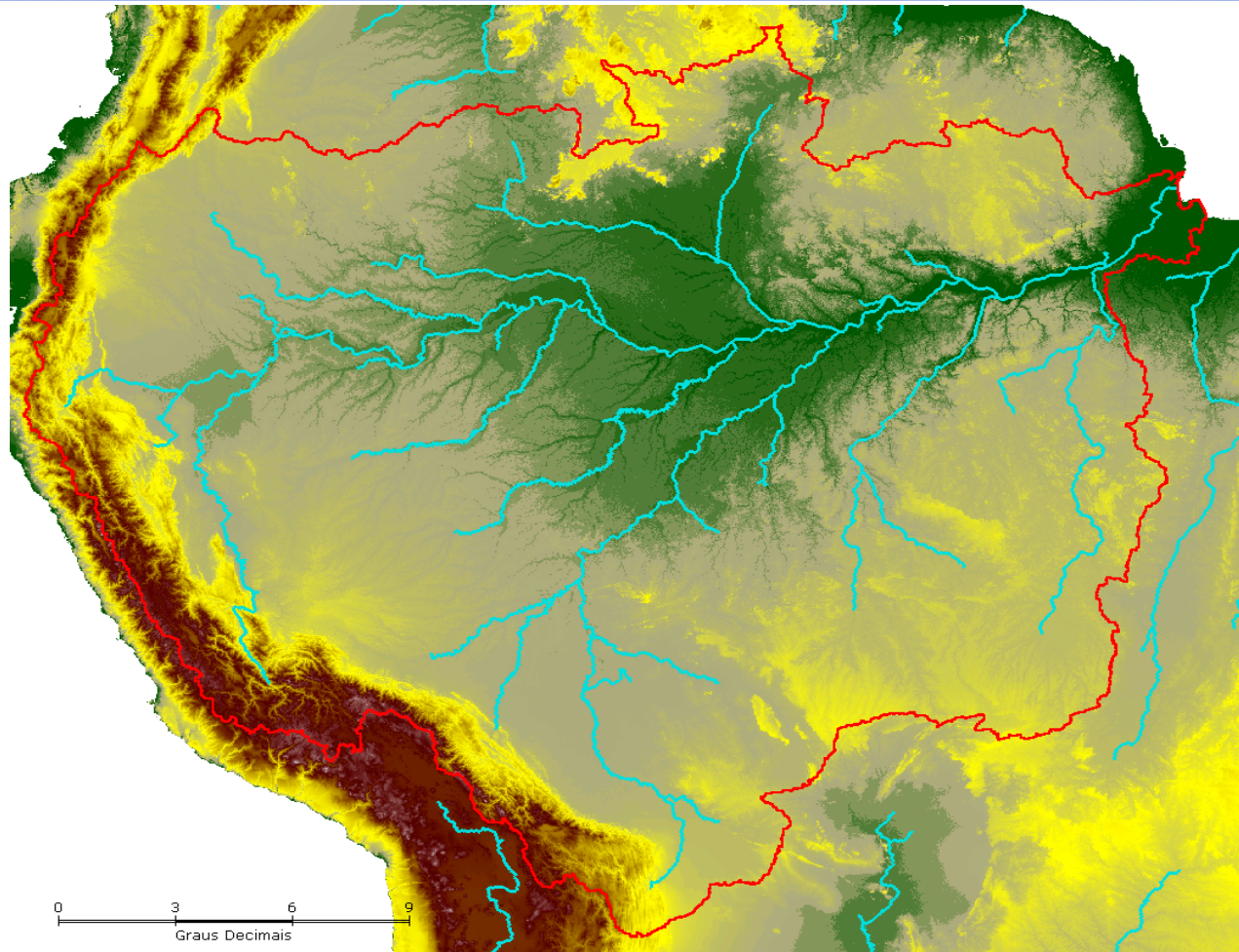
Maior Ordem: 6

Tocantins Drenagem Zoom



Saturado em 40 metros

Bacia Amazônica



0 3 6 9
Graus Decimais

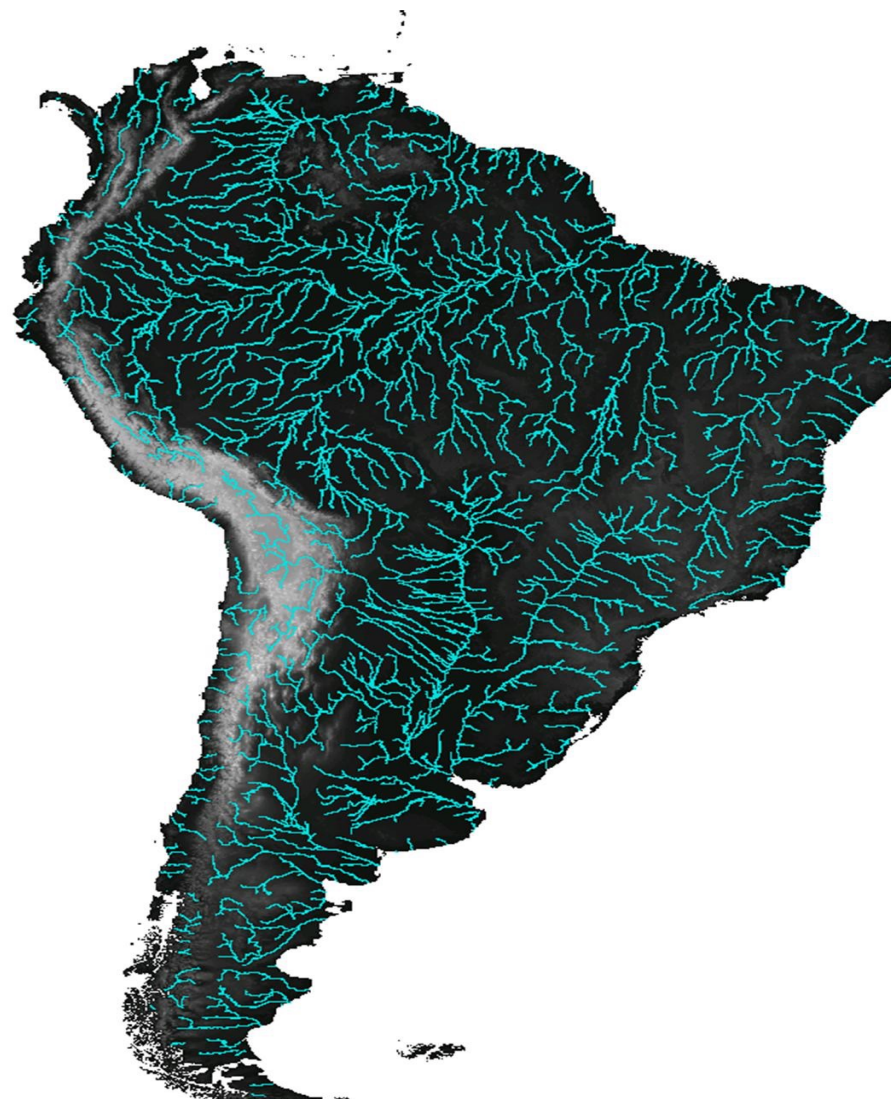


32.400 linhas

38.400 colunas

65.670.466 fossos

América do Sul

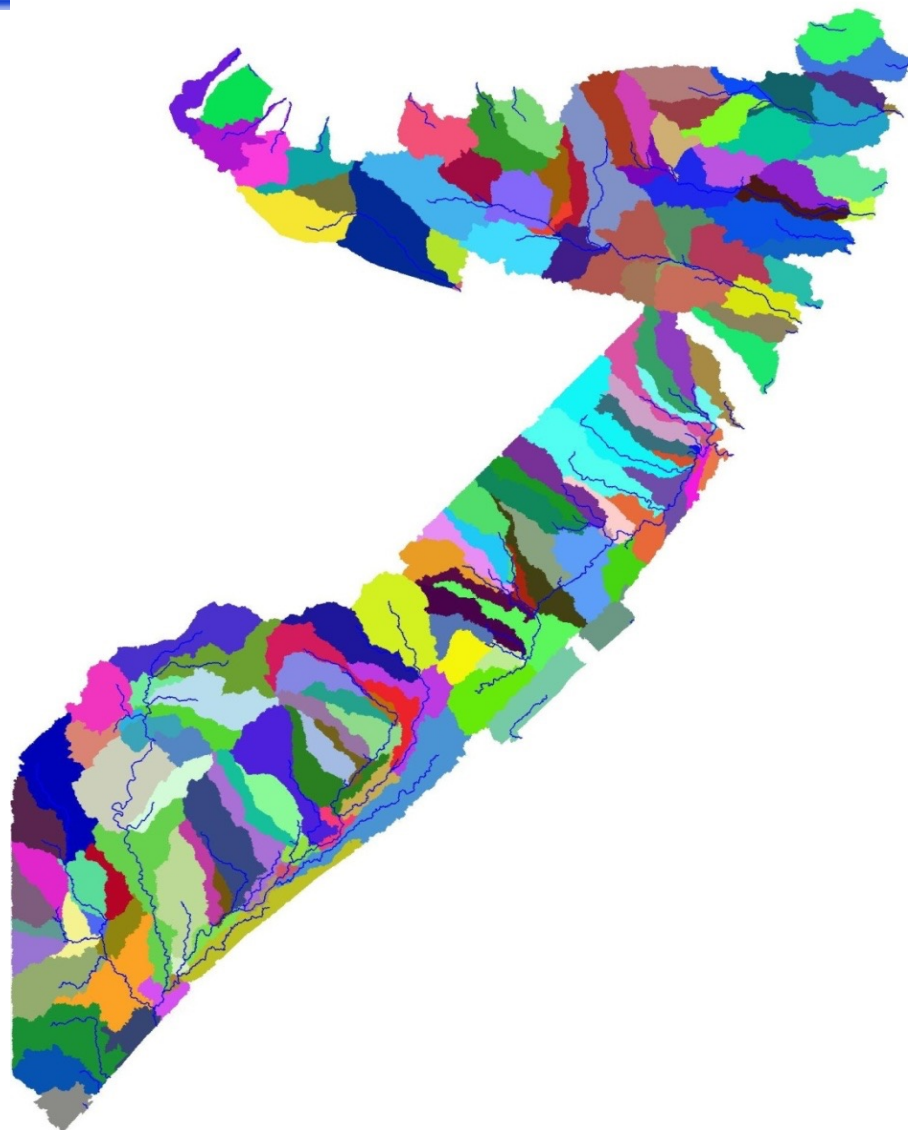


60.001 linhas

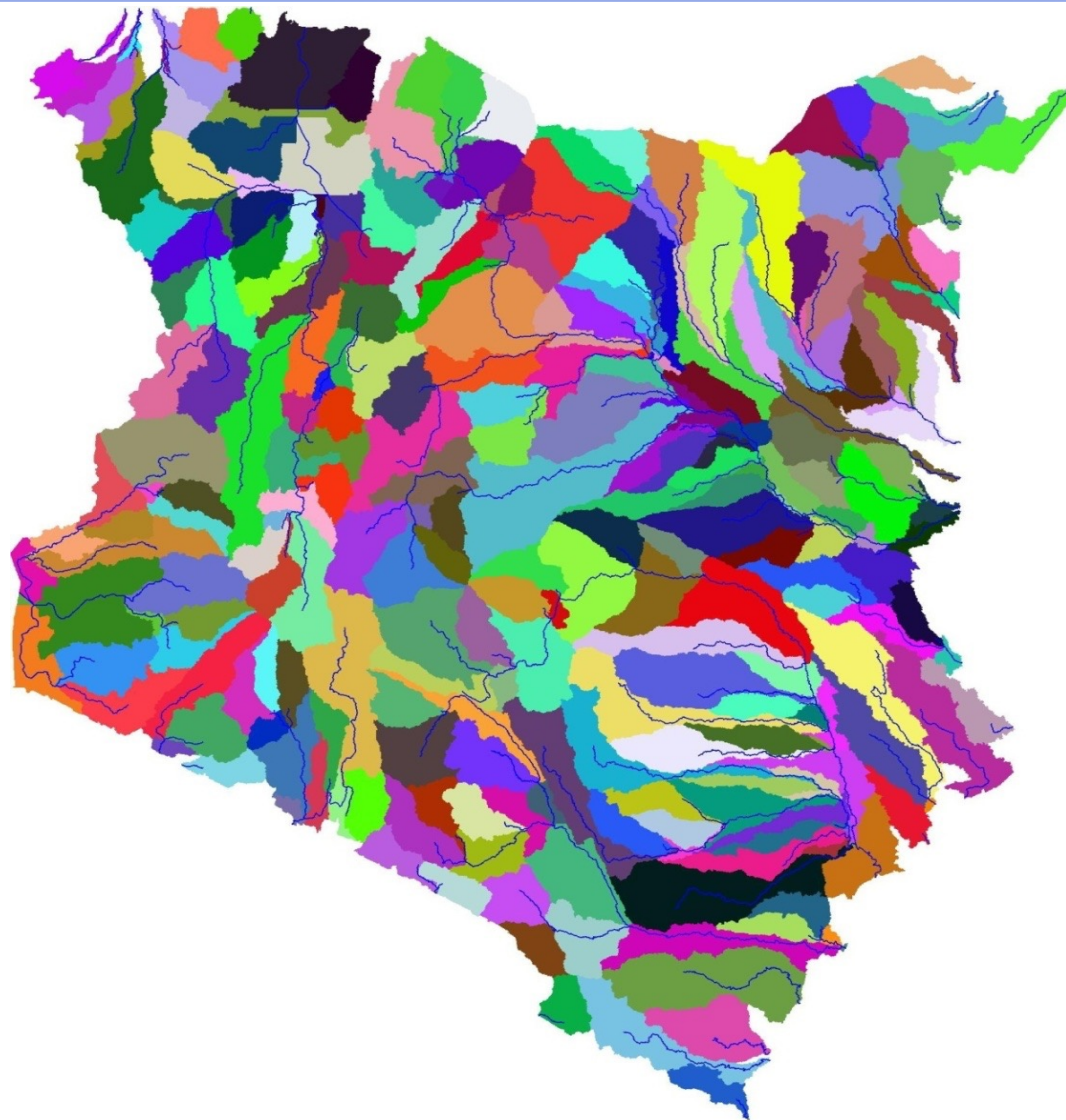
84,001 colunas

161.135.443 fossos

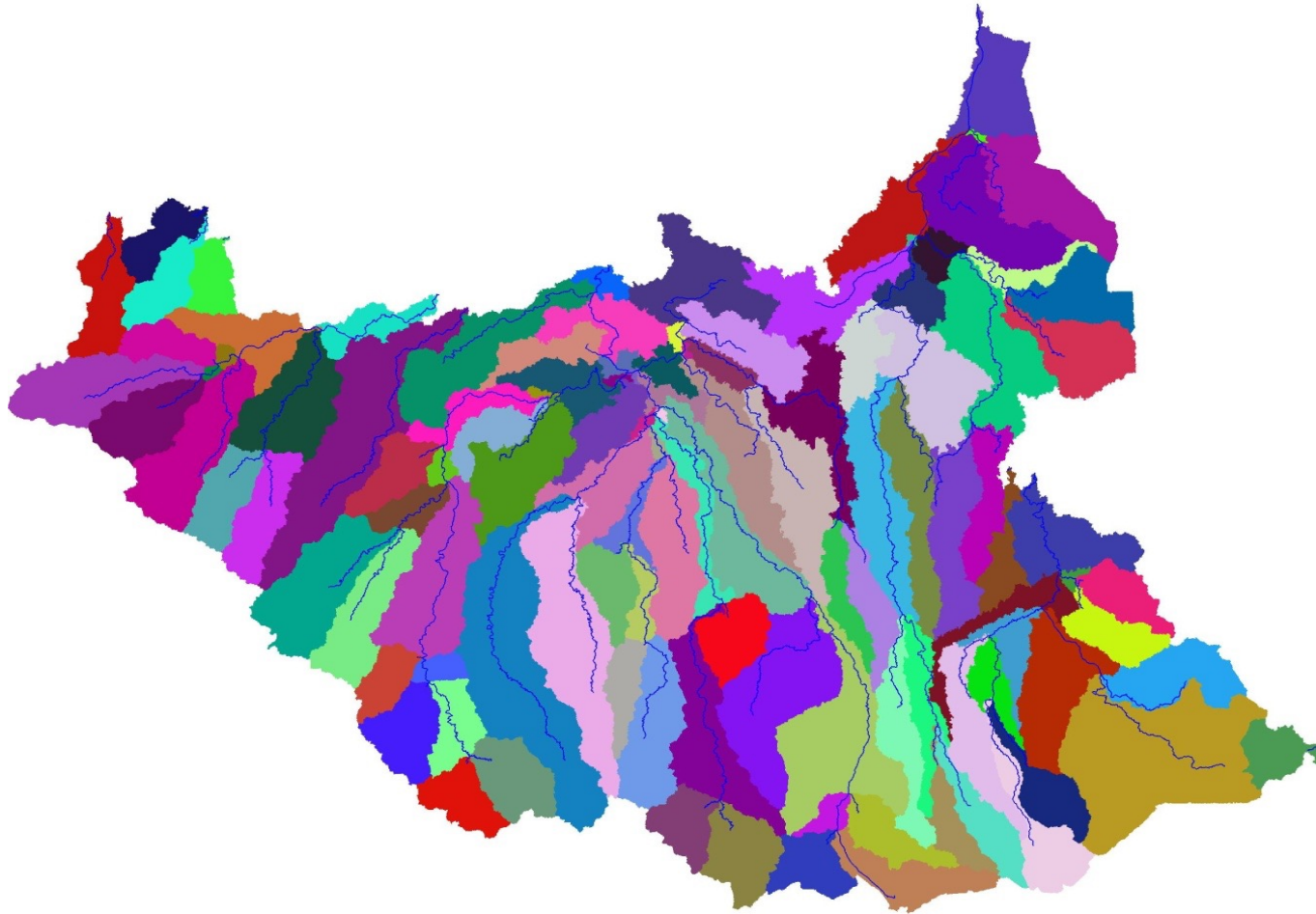
Somália



Quênia



Sudão do Sul



Conversor de LDD

Hydrological Modeling [?] [X]

Allow graph manipulation for Hydrological Modeling

Basin Converter Create Graph Upscale Graph Graph Manipulation Mask

From

LDD: Taquarucu_LDD_referencia

☒ TerraHidro
☐ Hand
☐ MGB
☐ Custom

32	64	128
16	0	1
8	4	2

☒ Use dummy

255

To

LDD: Taquarucu_LDD_Hand

☐ TerraHidro
☒ Hand
☐ MGB
☐ Custom

8	5	3
7	0	2
6	4	1

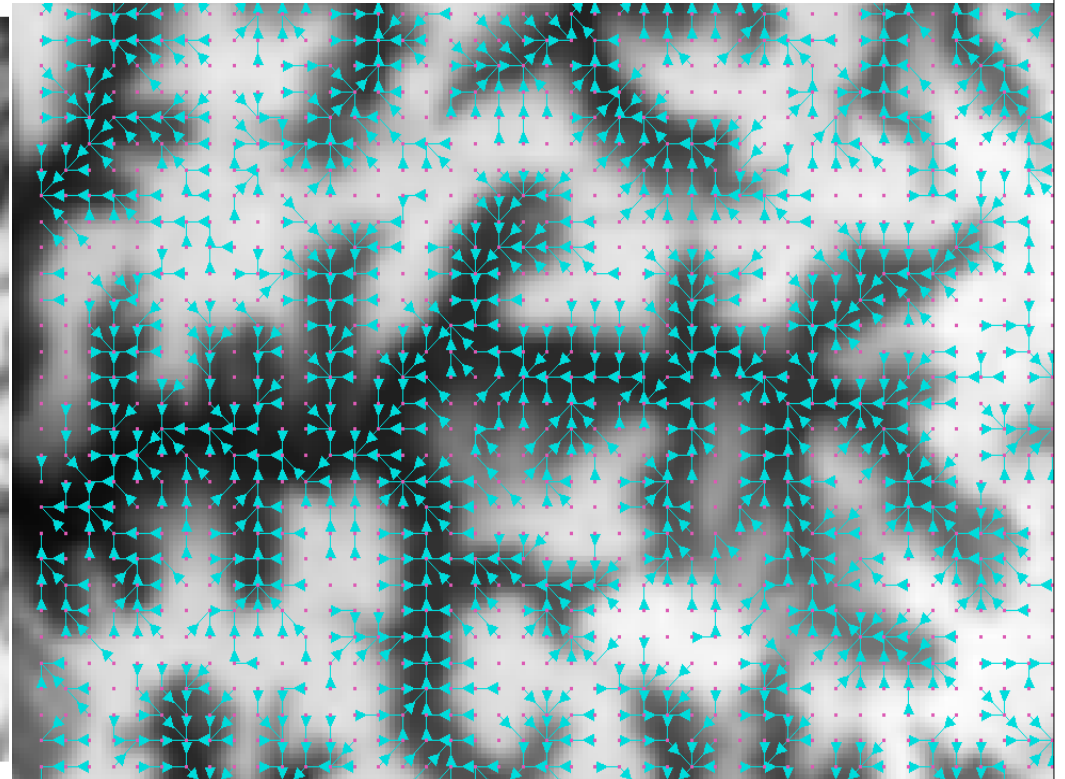
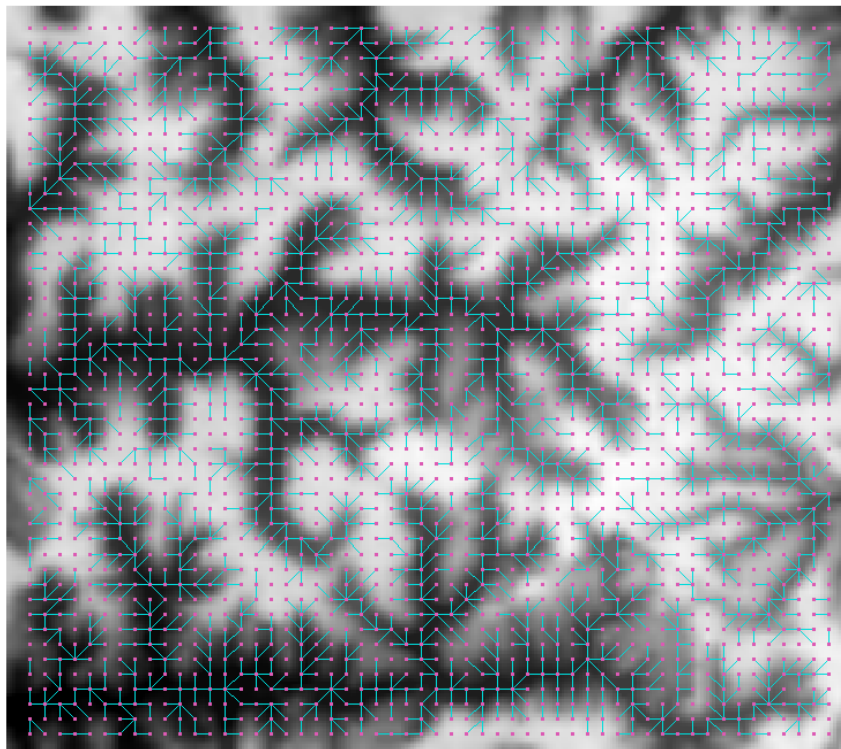
☐ Use dummy

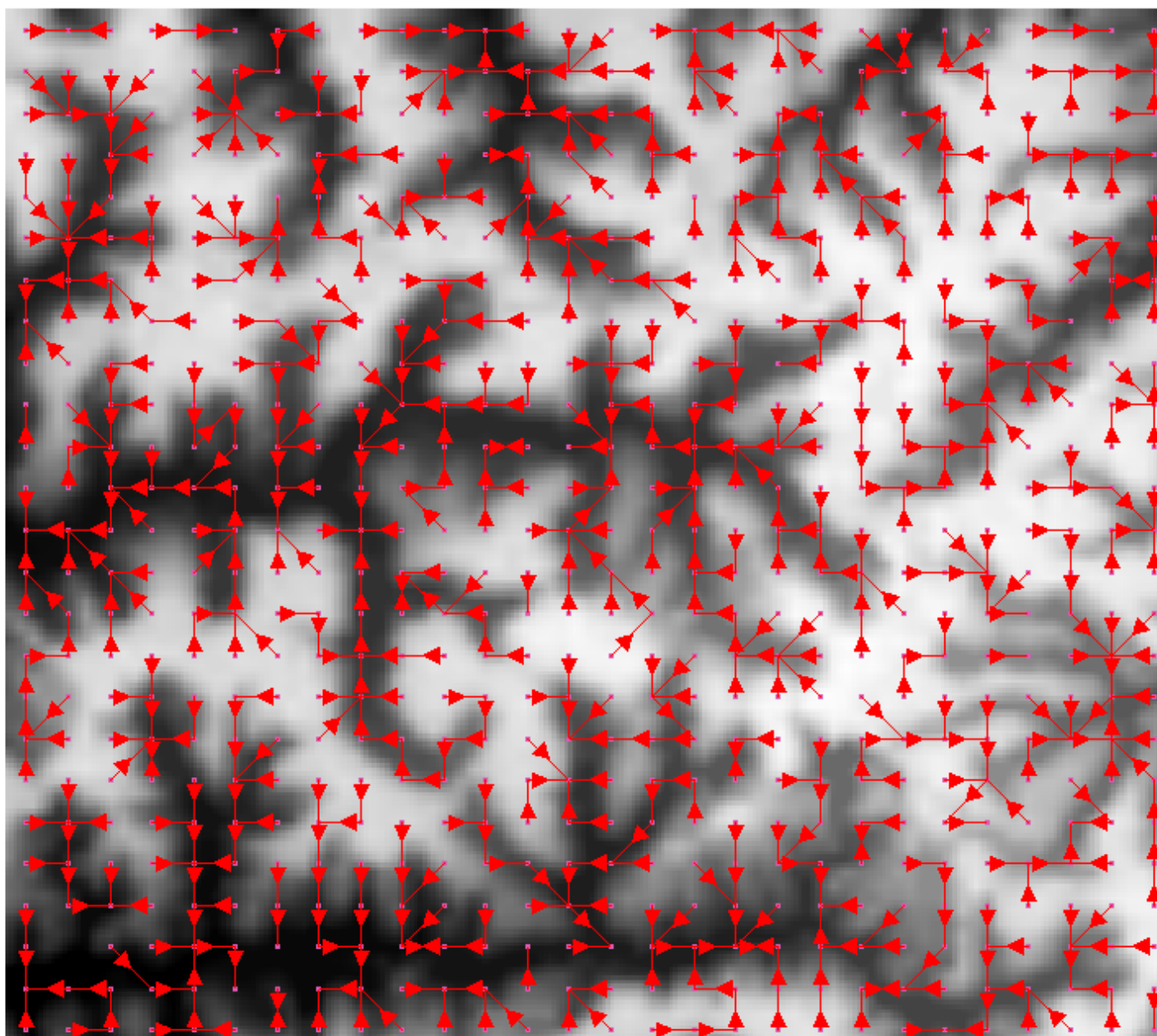
0

Convert

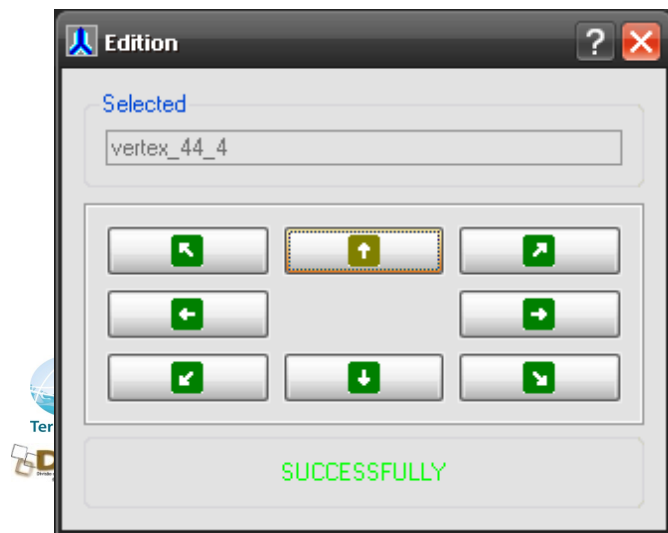
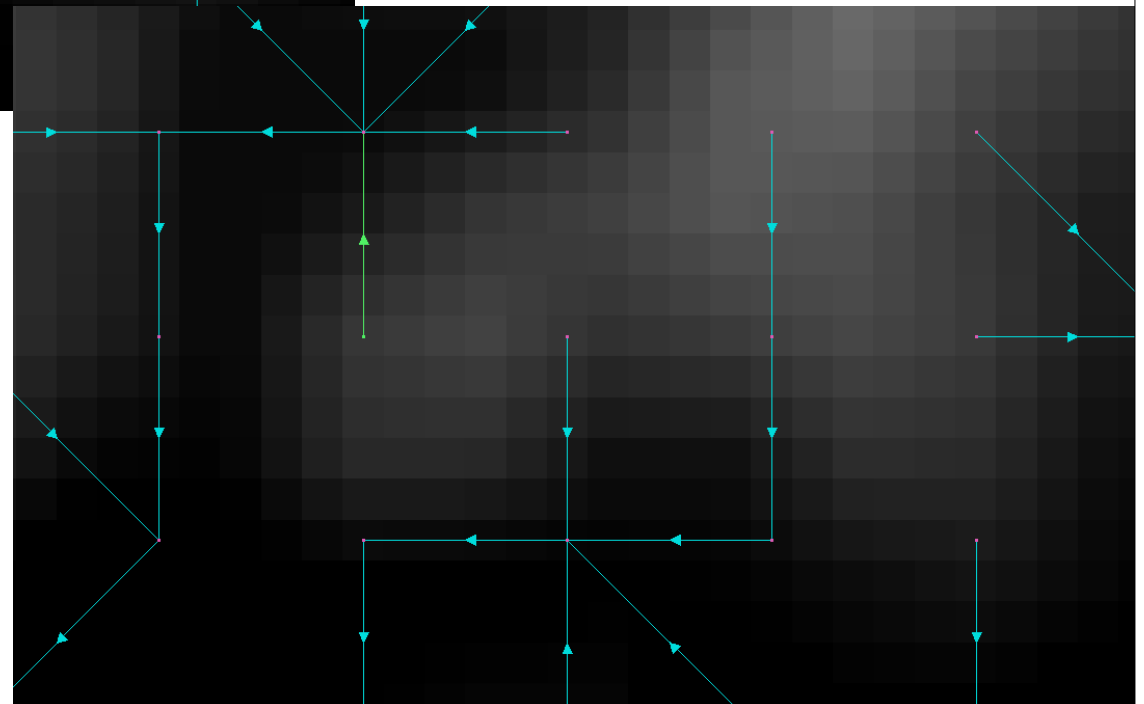
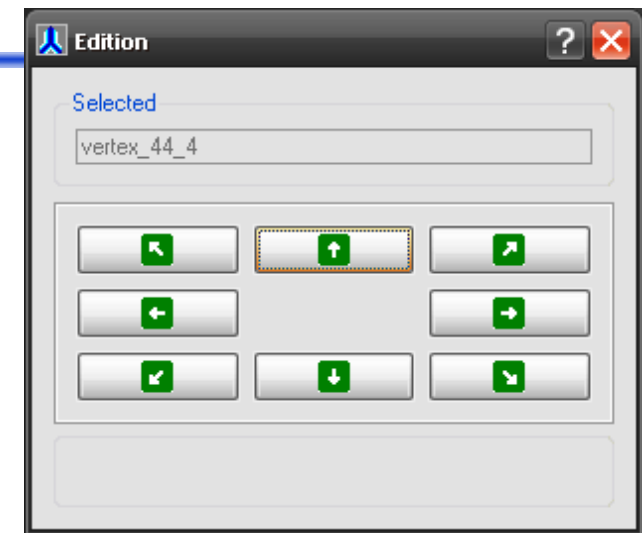
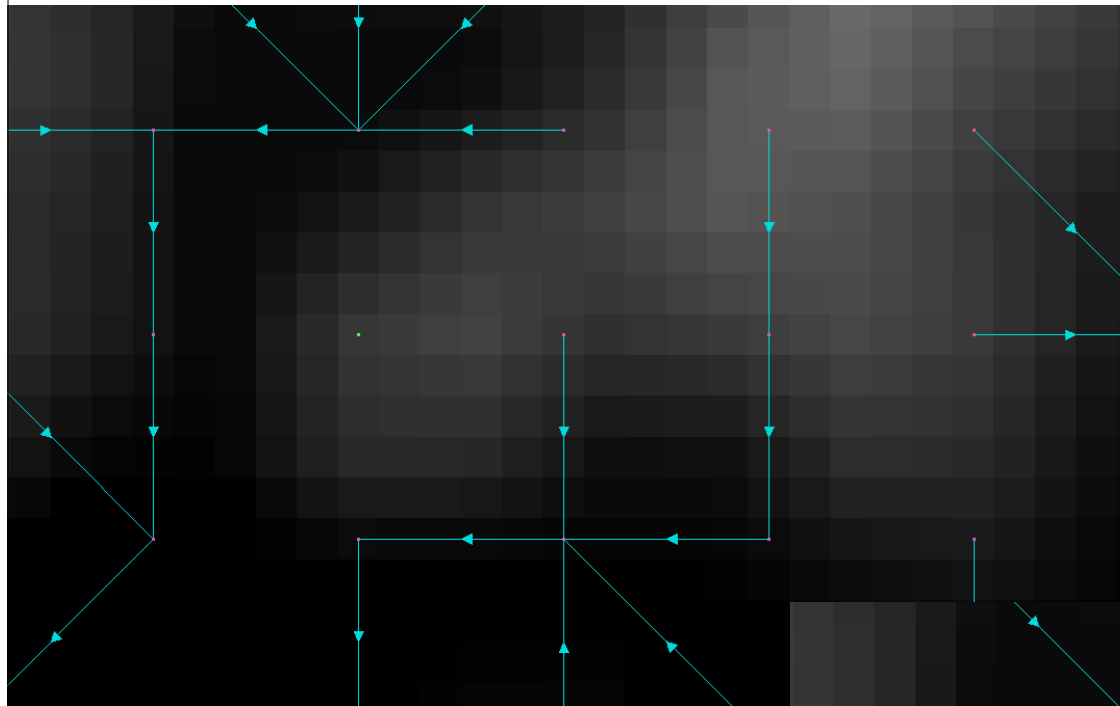
Help Close

Upscaling

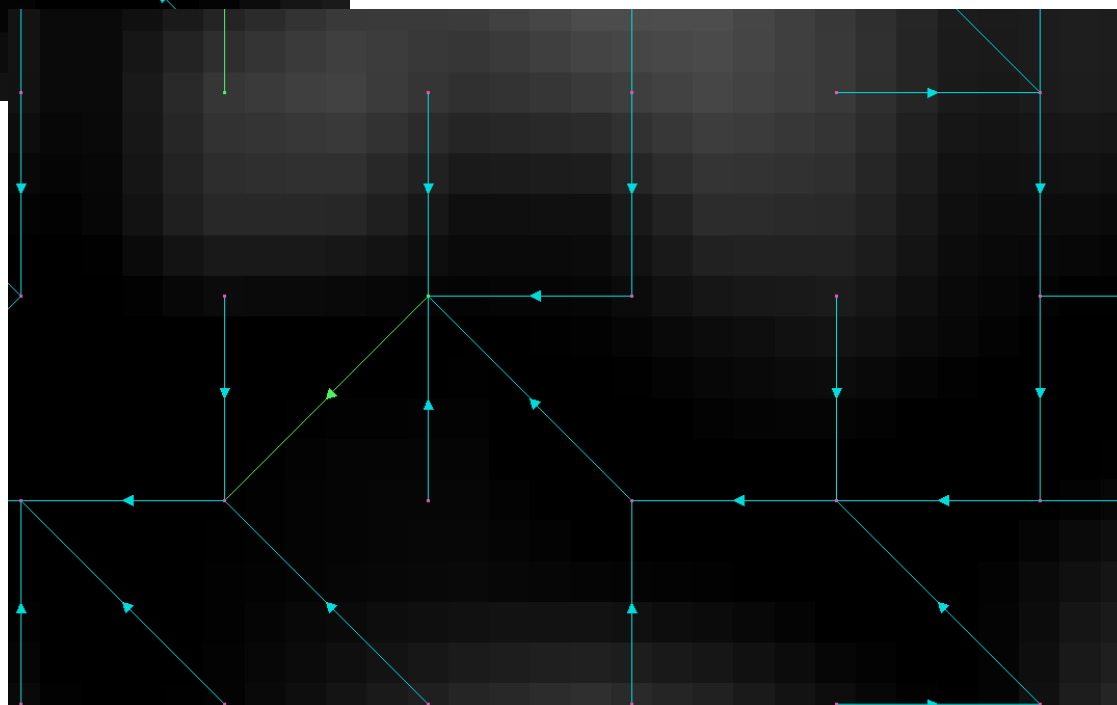
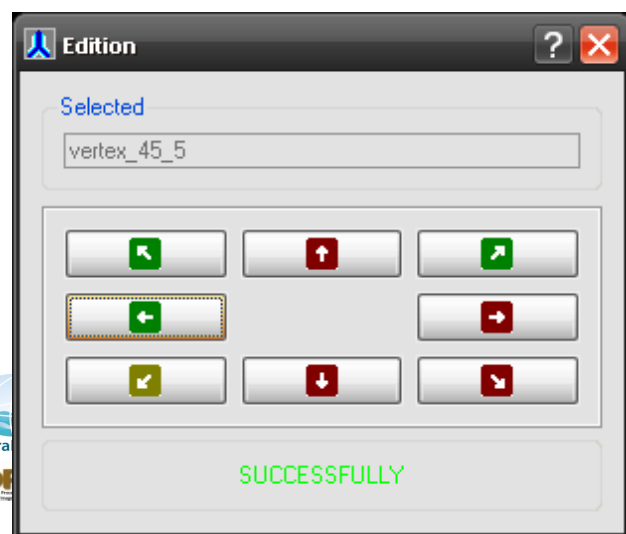
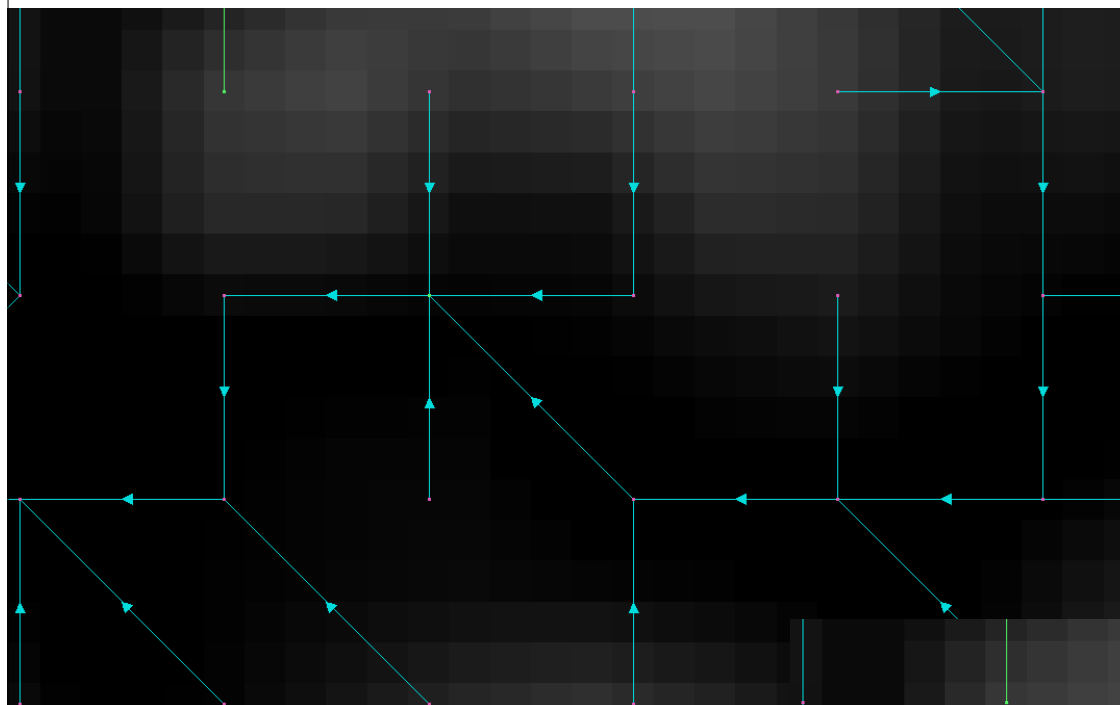




Edição de Fluxos



Edição de Fluxos

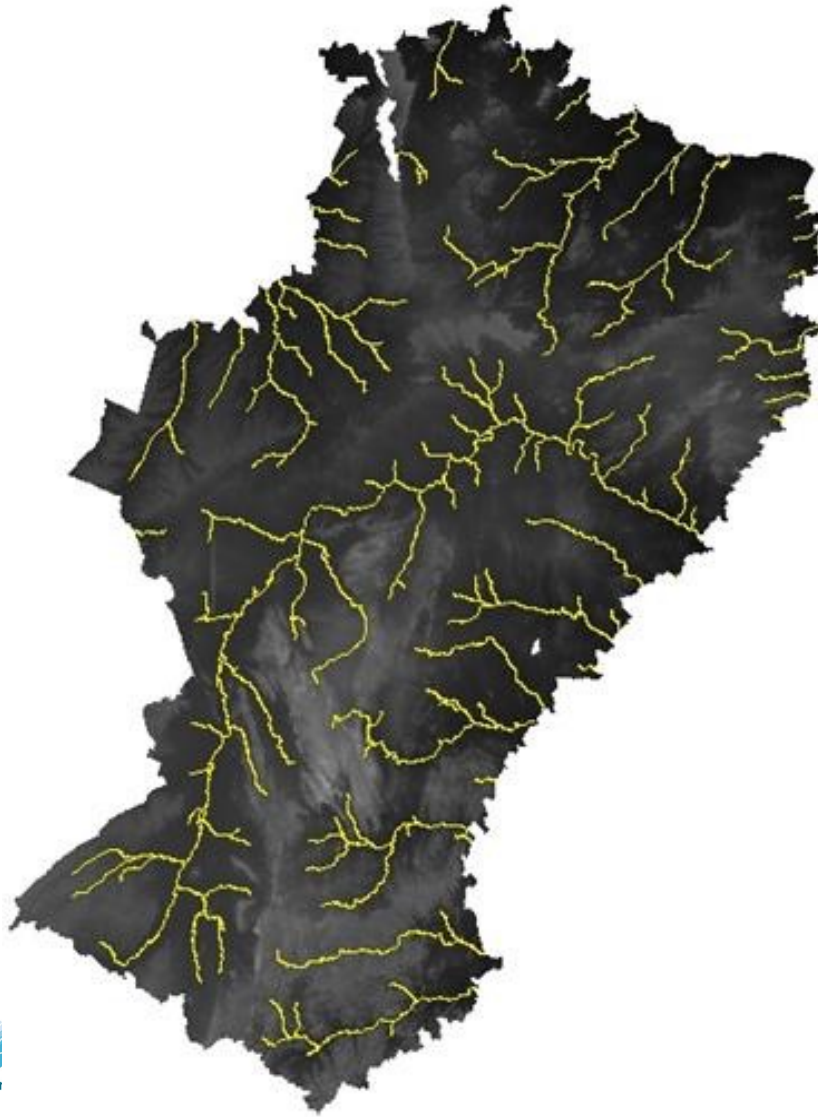


SEMIÁRIDO

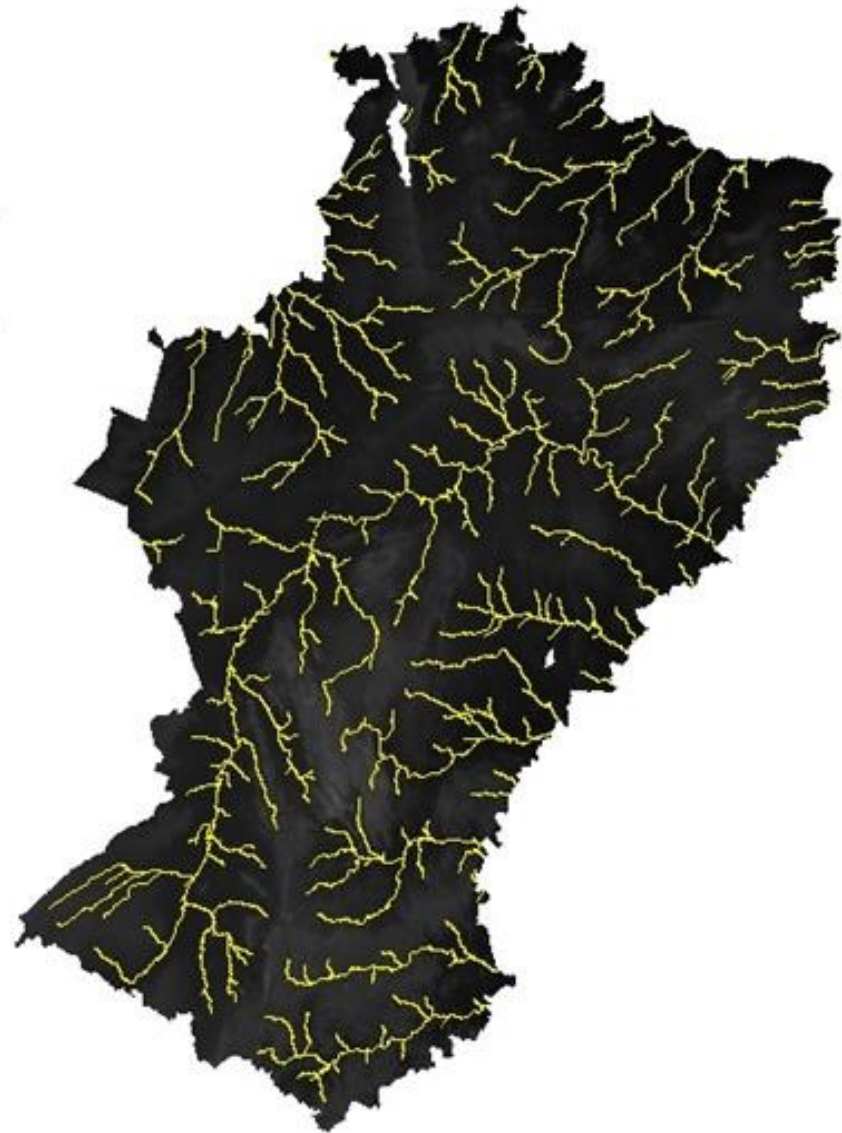
ASTER GDEM



Drenagens

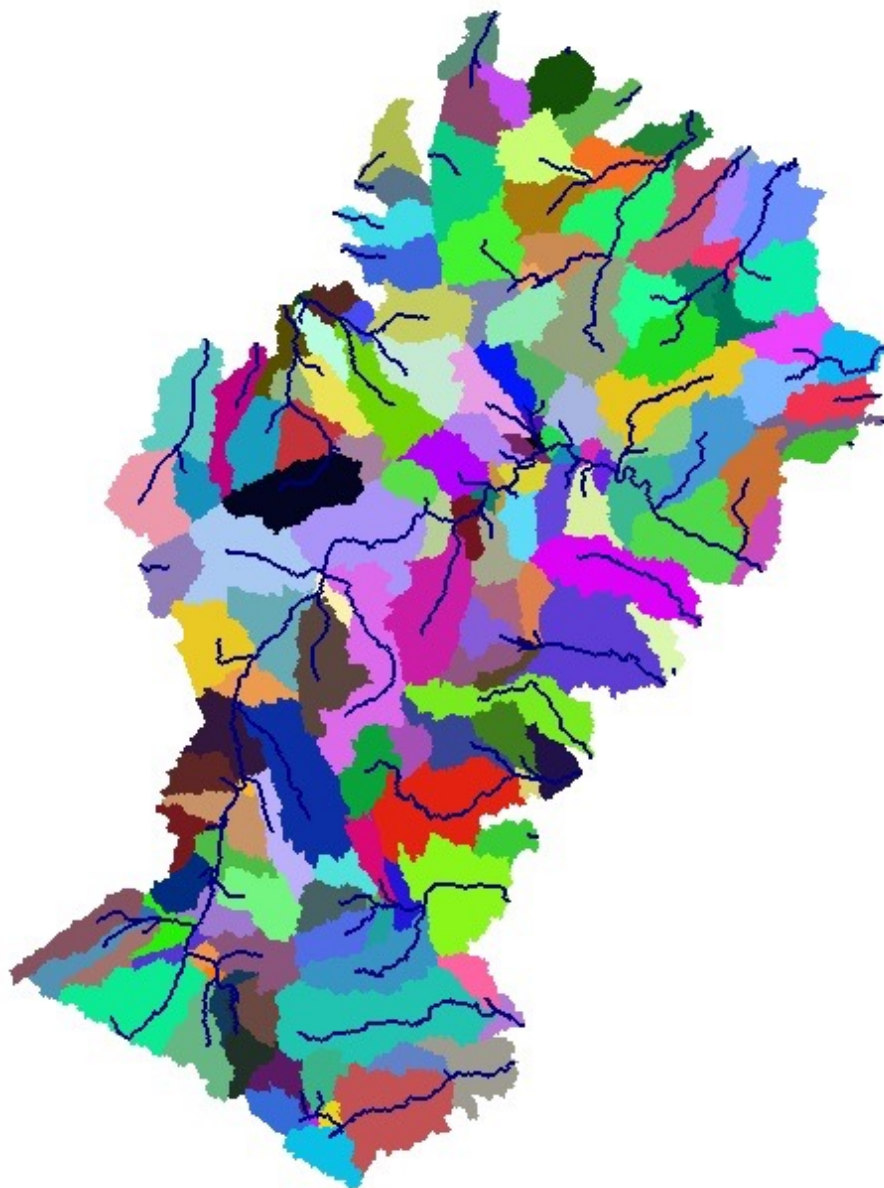


(a)



(b)

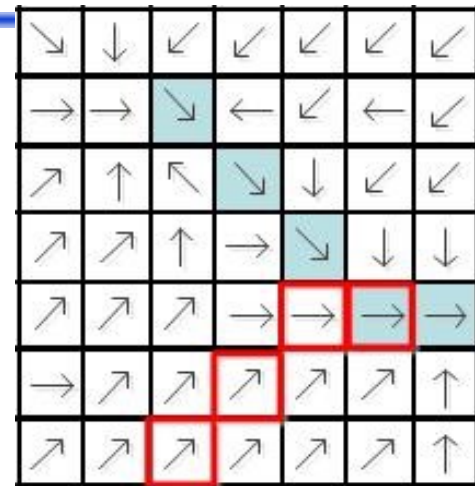
Bacias por segmento de rio



Bacia de ponto selecionado pelo usuário



HAND – Height Above the Nearest Drainage



Local Drain Direction
+
Drainage Network

56	55	56	59	62	68	70
59	52	53	55	58	66	71
67	60	56	55	58	63	66
72	68	59	56	54	55	54
72	70	67	58	54	53	50
71	70	69	65	60	55	53
72	71	72	70	67	61	57

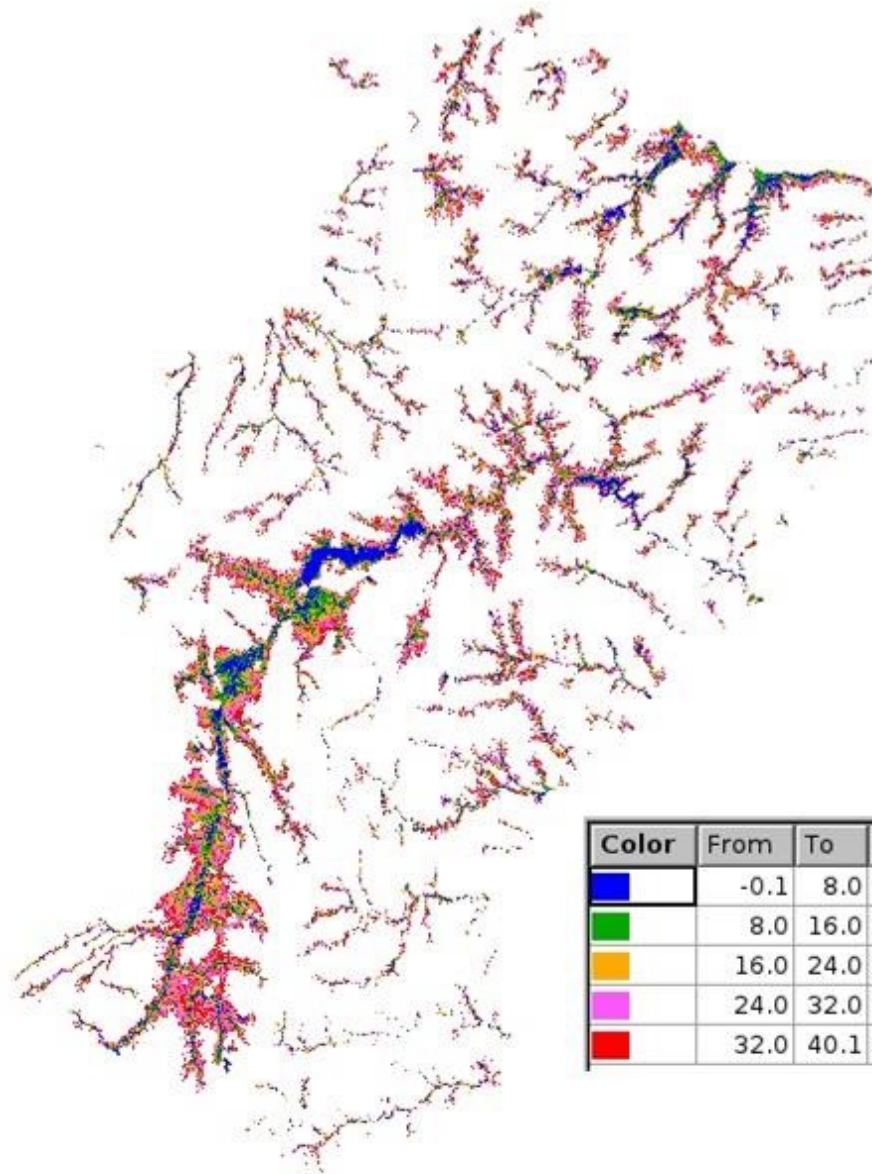
Original DEM

HAND Grid

3	2	3	6	7	13	15
6	0	0	0	3	11	17
14	7	1	0	4	9	16
19	13	4	2	0	5	4
17	15	13	4	1	0	0
16	16	15	12	7	5	3
18	17	19	17	17	11	7

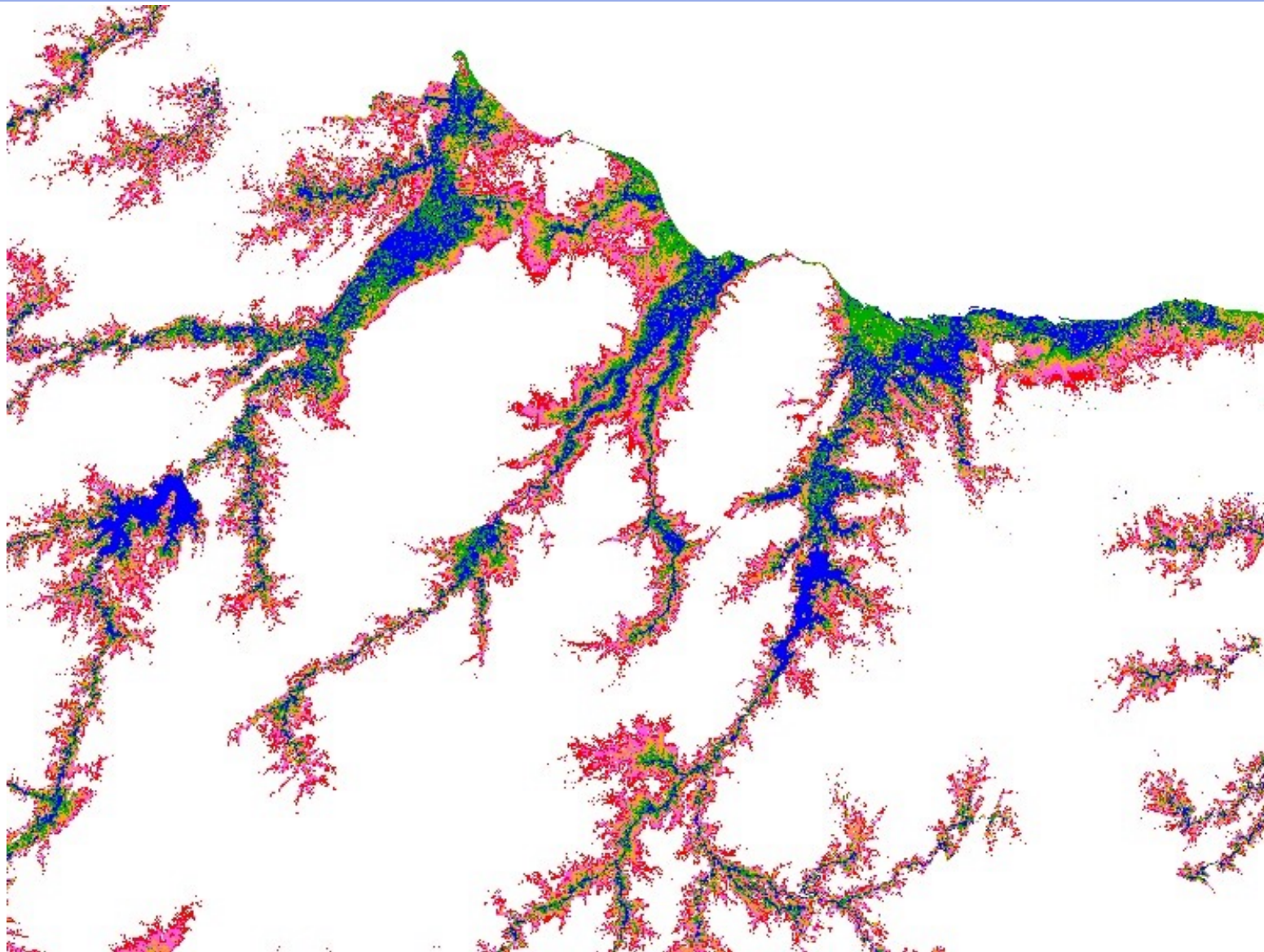
$$72 - 53 = 19$$

HAND – Semiárido

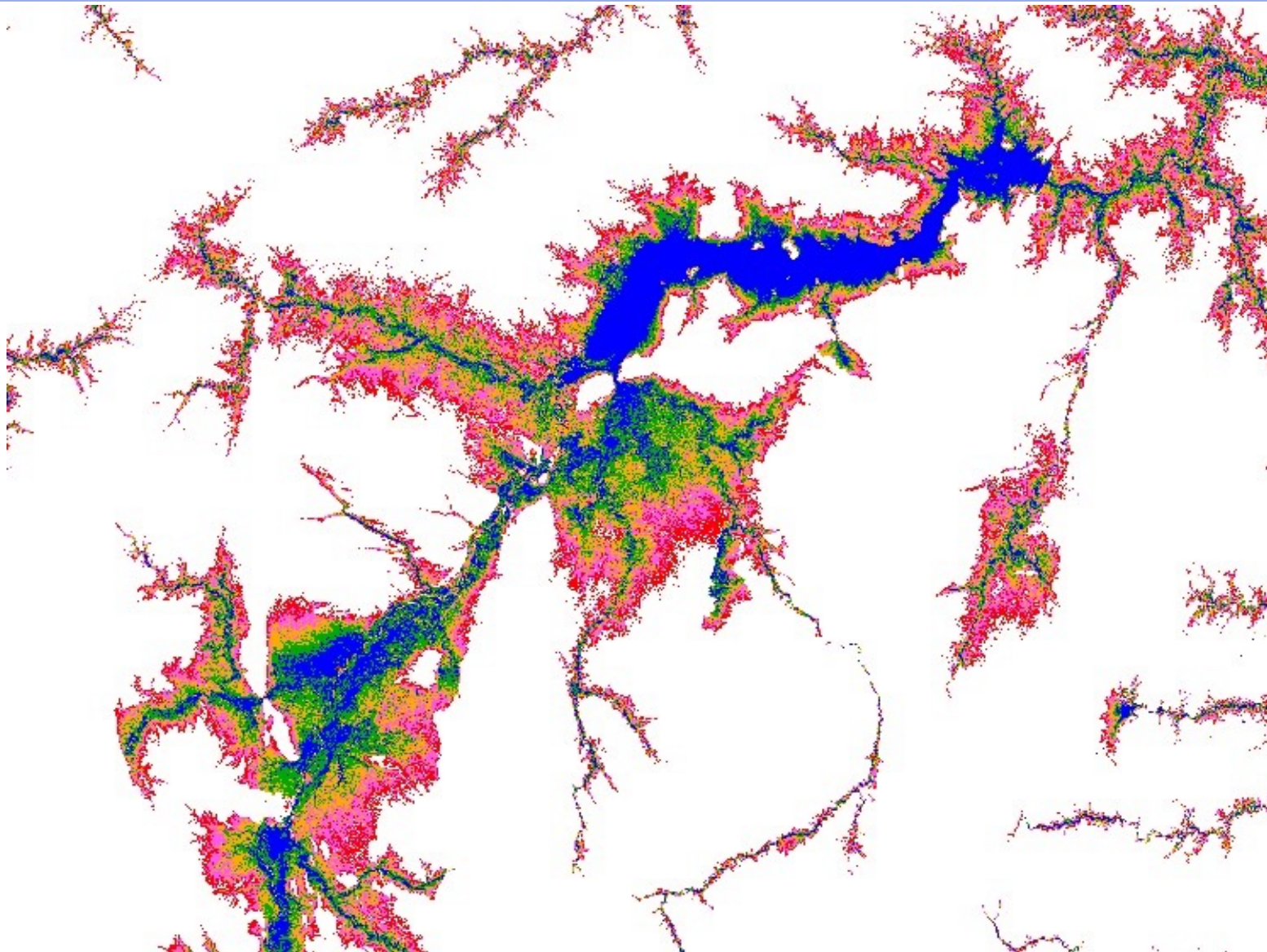


Color	From	To	Label
Blue	-0.1	8.0	-0.1 ~ 8.0
Green	8.0	16.0	8.0 ~ 16.0
Yellow	16.0	24.0	16.0 ~ 24.0
Magenta	24.0	32.0	24.0 ~ 32.0
Red	32.0	40.1	32.0 ~ 40.1

HAND – Zoom



HAND – Zoom



Áreas de Proteção Permanente

1. Projeto EXPP - FIPEP

1. Margens de rios, lagos, lagoas veredas

1. Em torno de nascentes

1. Declividade maior que 45°

1. Altitude maior que 1.800 metros

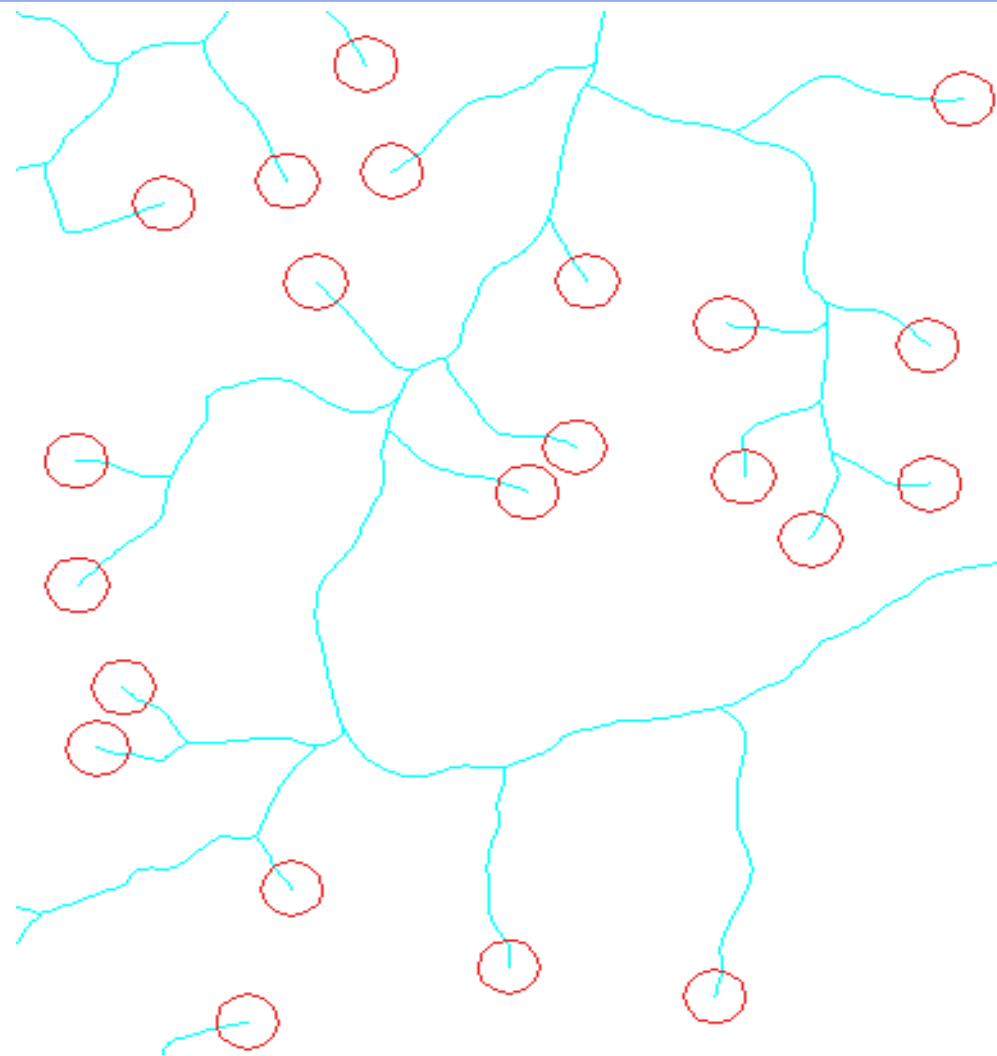
1. Chapadas e escarpas

1. Topos de morros e montanhas.

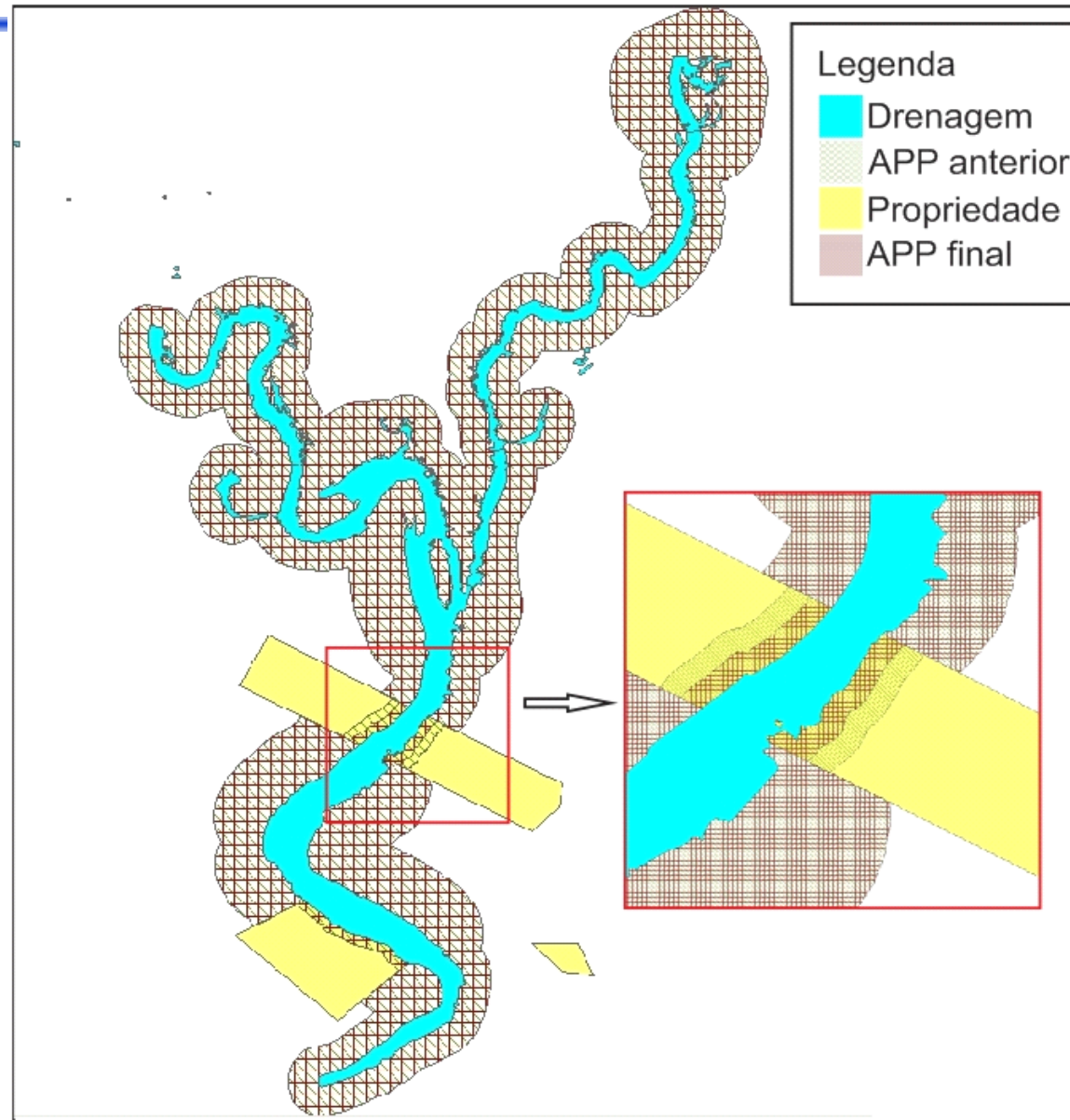


1. Linhas de cumeada

Nascentes



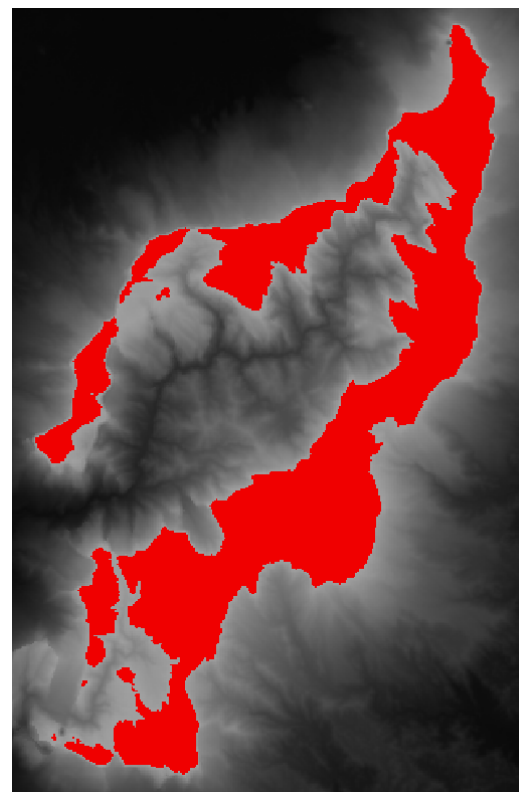
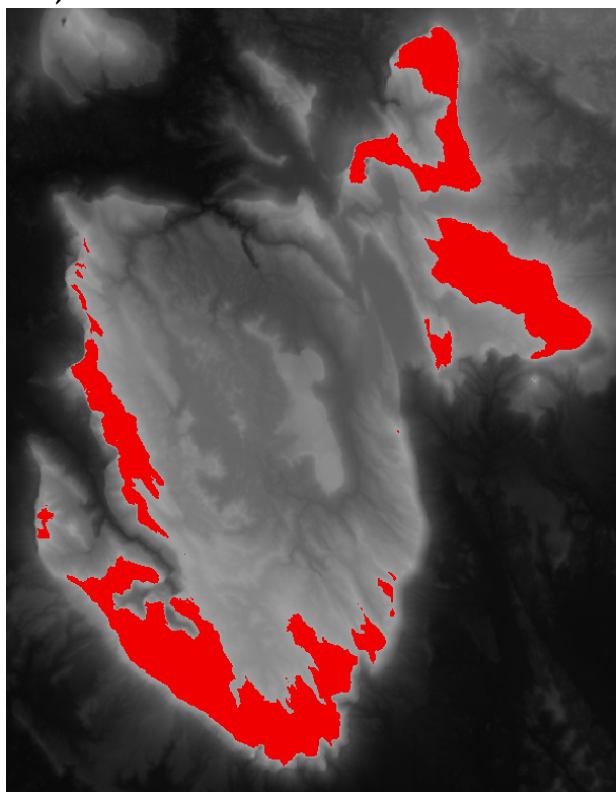
Margens dos rios



APPs

Altitudes superiores a 1800 m

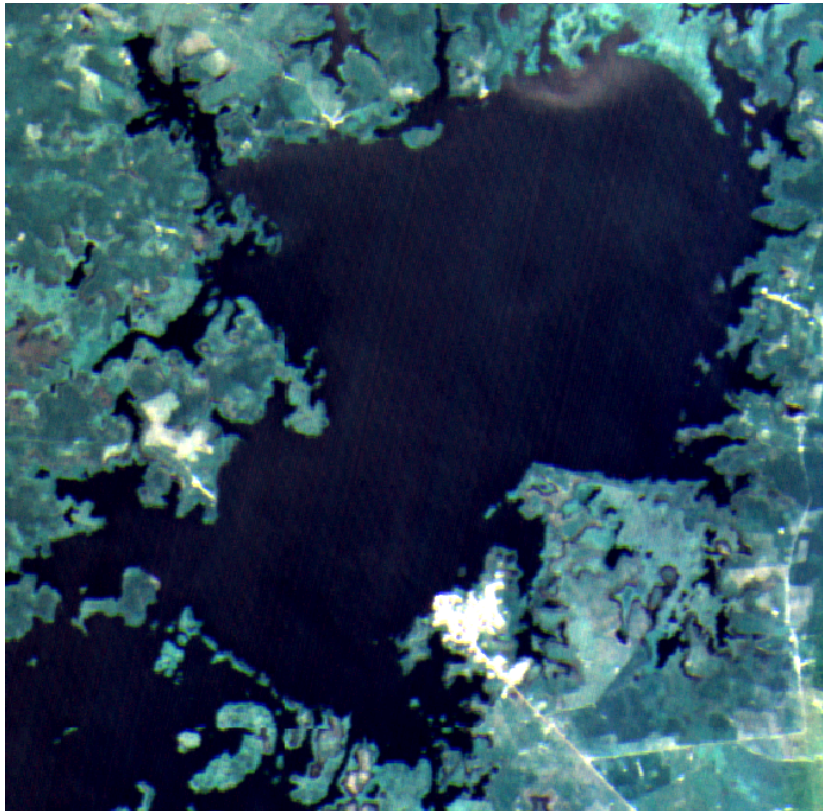
- Topografia de entrada: grade do SRTM com resolução de 90 m
- Todo ponto da grade com valor superior a 1800 é considerado como APP (vermelho)



Região da Serra do Imeri - AM (localização do Pico da Neblina)

APPs

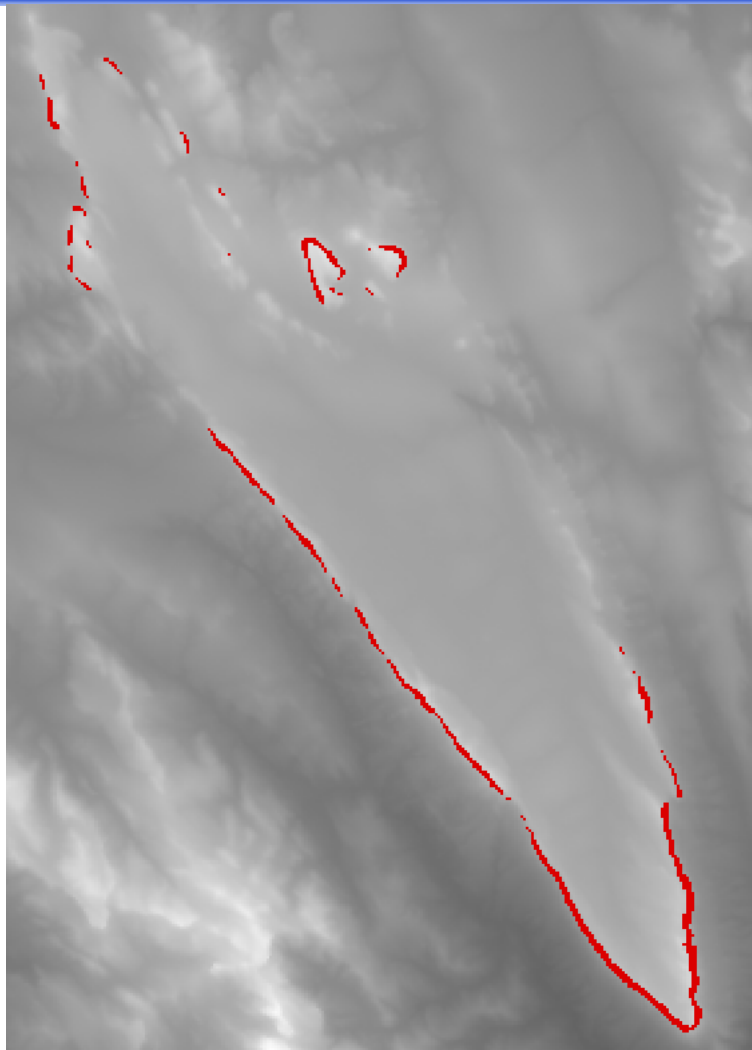
Lagos/Lagoas



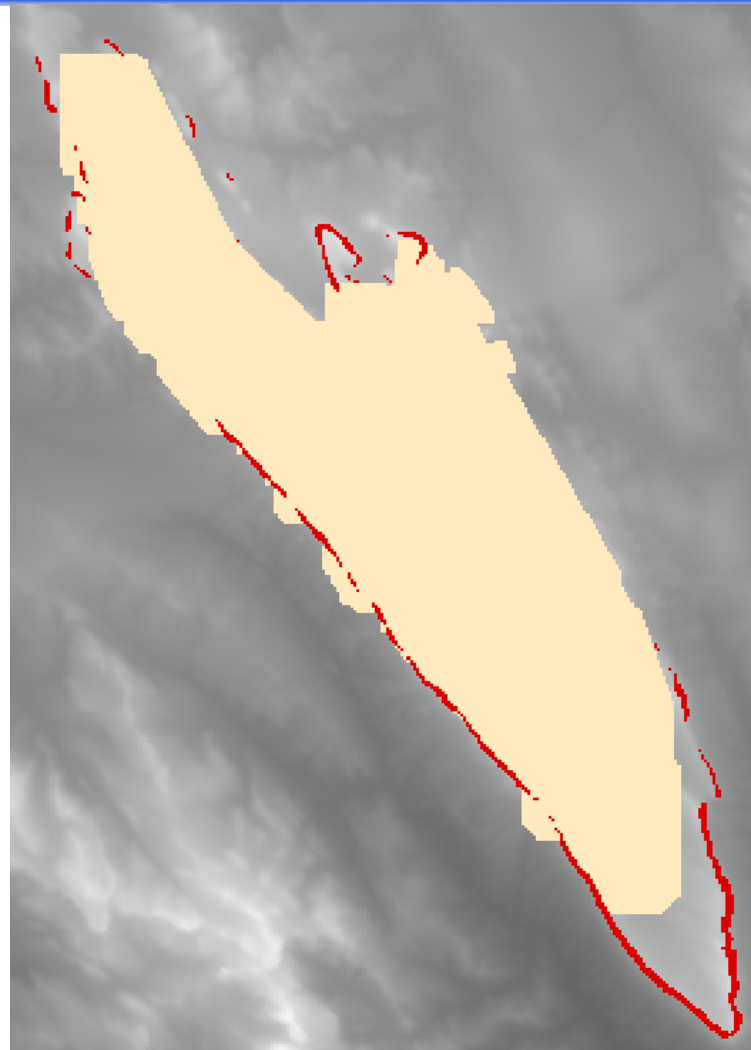
Lago Açu (MA) está localizado em área rural com área total de 0.97 ha

Polígono representando o lago (azul) com buffer de 50 m (vermelho)

APPs - Chapadas



Topografia e escarpas



Pontos de grade da chapada
Elevações: min 1137 m max 1779

TerraHidro - Futuro



Obrigado!