Snow-cover analysis with MODIS

(Snjóhulugreining með MODIS)

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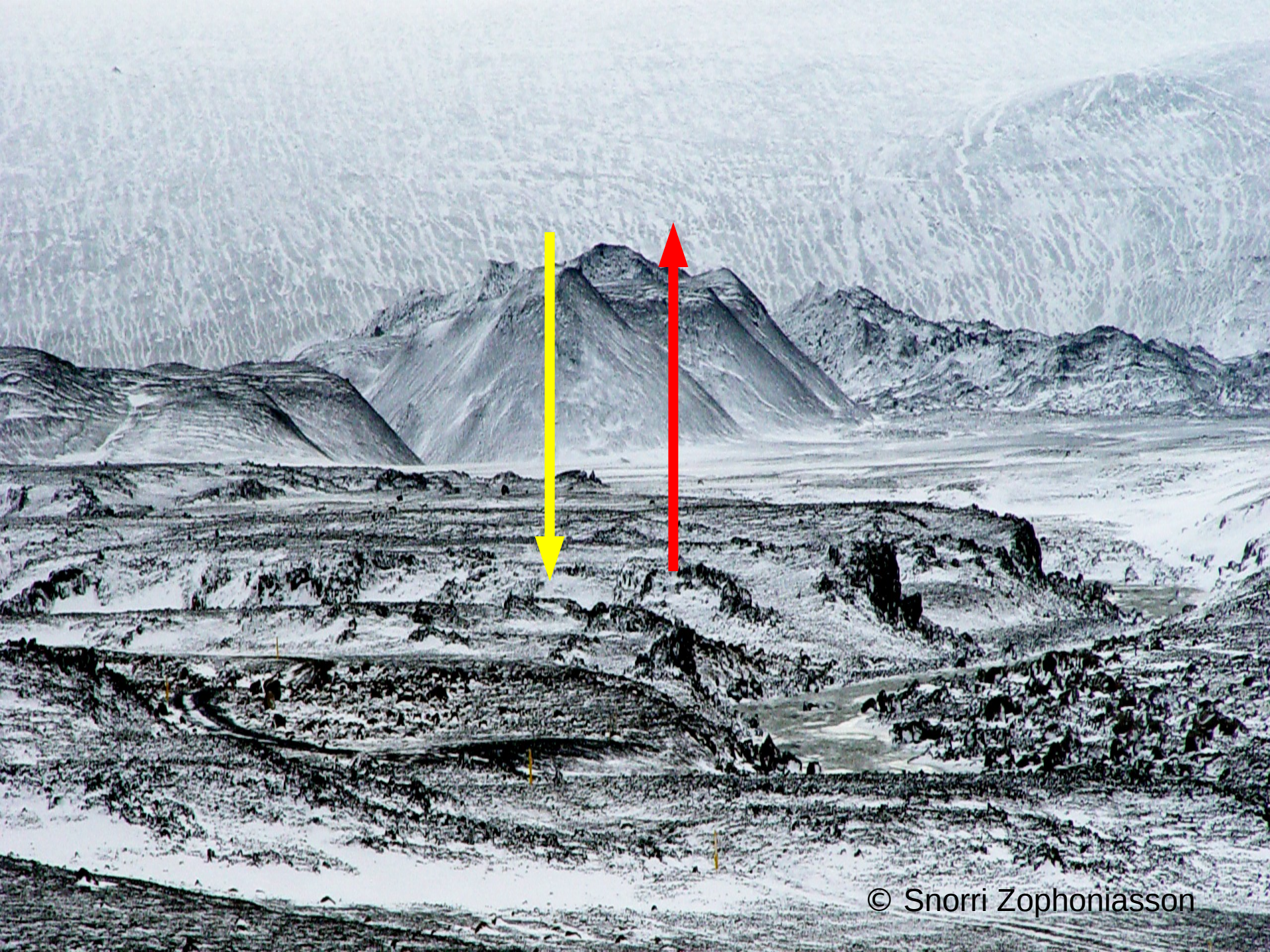
SNAPS
Snow, Ice and Avalanche Applications

Icelandic Met Office

Northern Periphery Programme 2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund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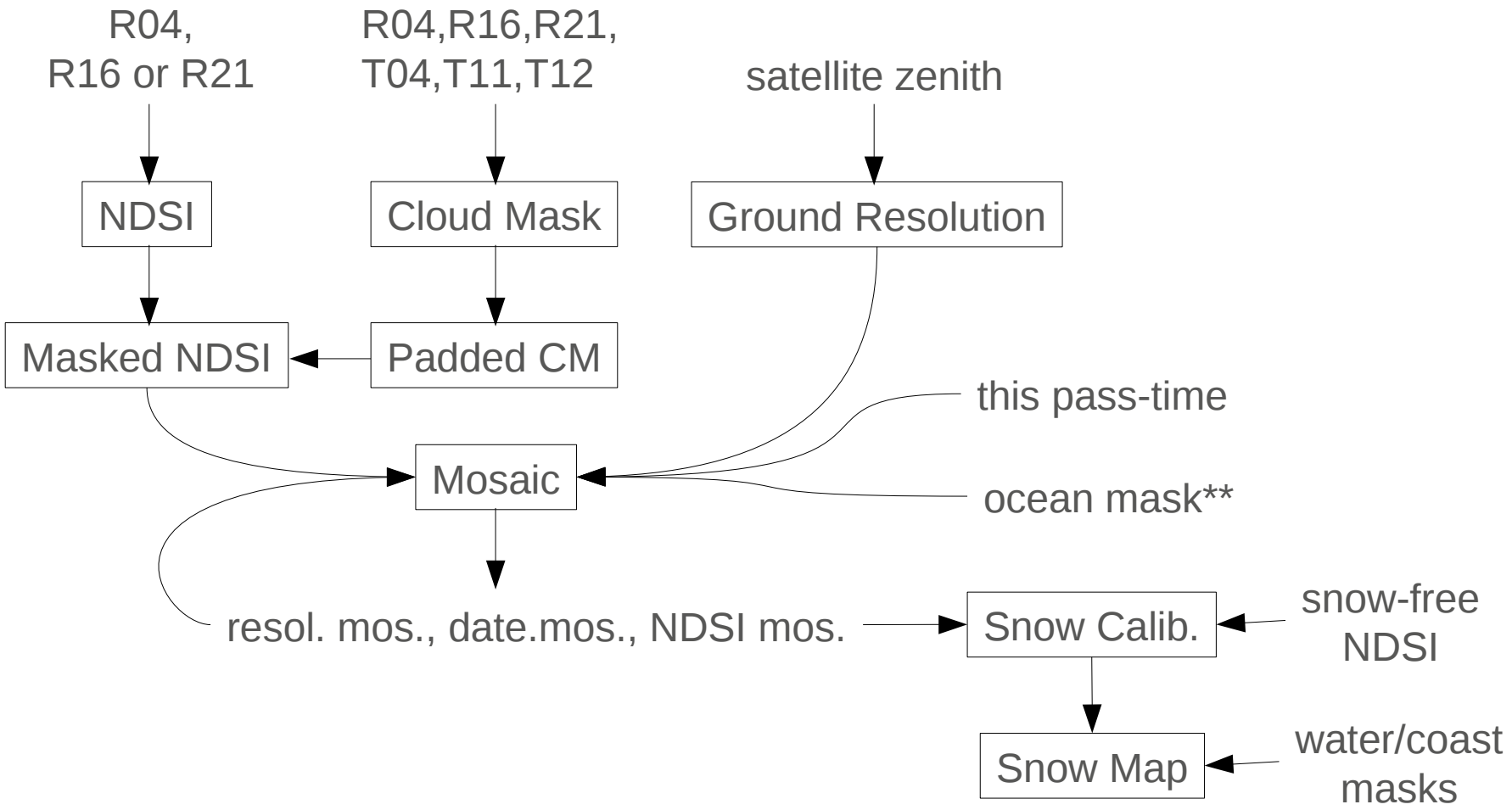
The processing chain



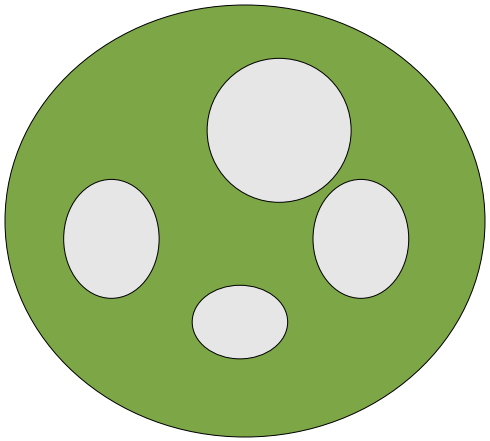
NDSI
(normalized difference snow index)

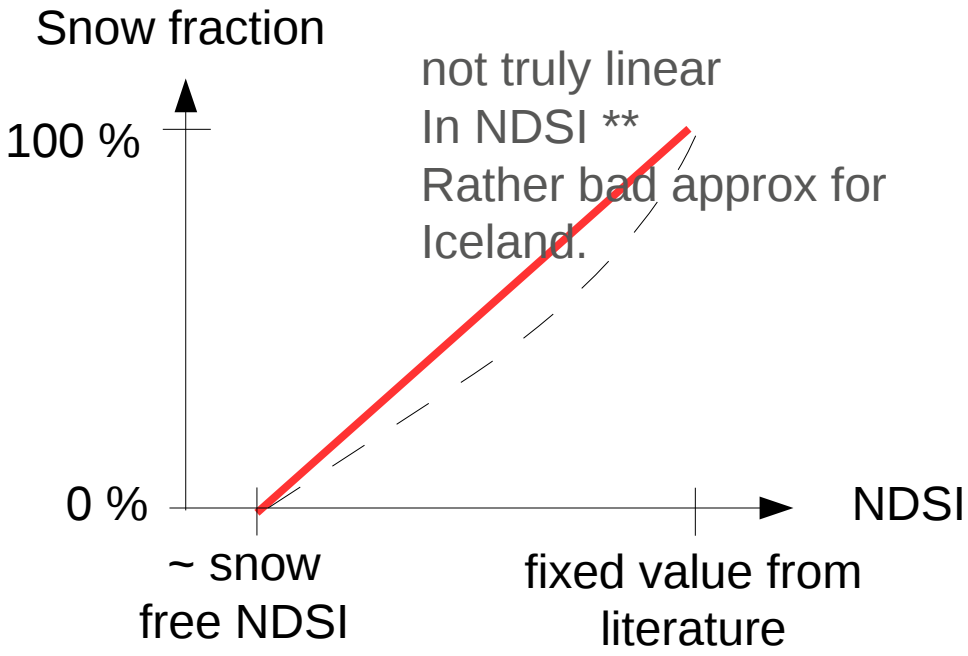
$$\text{NDSI (Terra)} = \frac{\text{R04 - R16}}{\text{R04 + R16}} \qquad \text{NDSI (Aqua)} = \frac{\text{R04 - R21}}{\text{R04 + R21}}$$

- **As Aqua has a faulty 1.6 micrometer channel, 2.1 micrometer NIR channel is being used (only Aqua)**
- **Terra and Aqua snow mapping is effectively a separate pipeline, requiring sepparate snow calibration data sets.**
- **Issues:**
  - **NDSI (R04 , R21) is known to result in somewhat smaller dynamic range of NDSI values -> Aqua snow maps are more sensitive to error.**

NDSI snow free calibration

The reflectance model:
R = f * R(snow)
(1 – f)* R(snowfree)



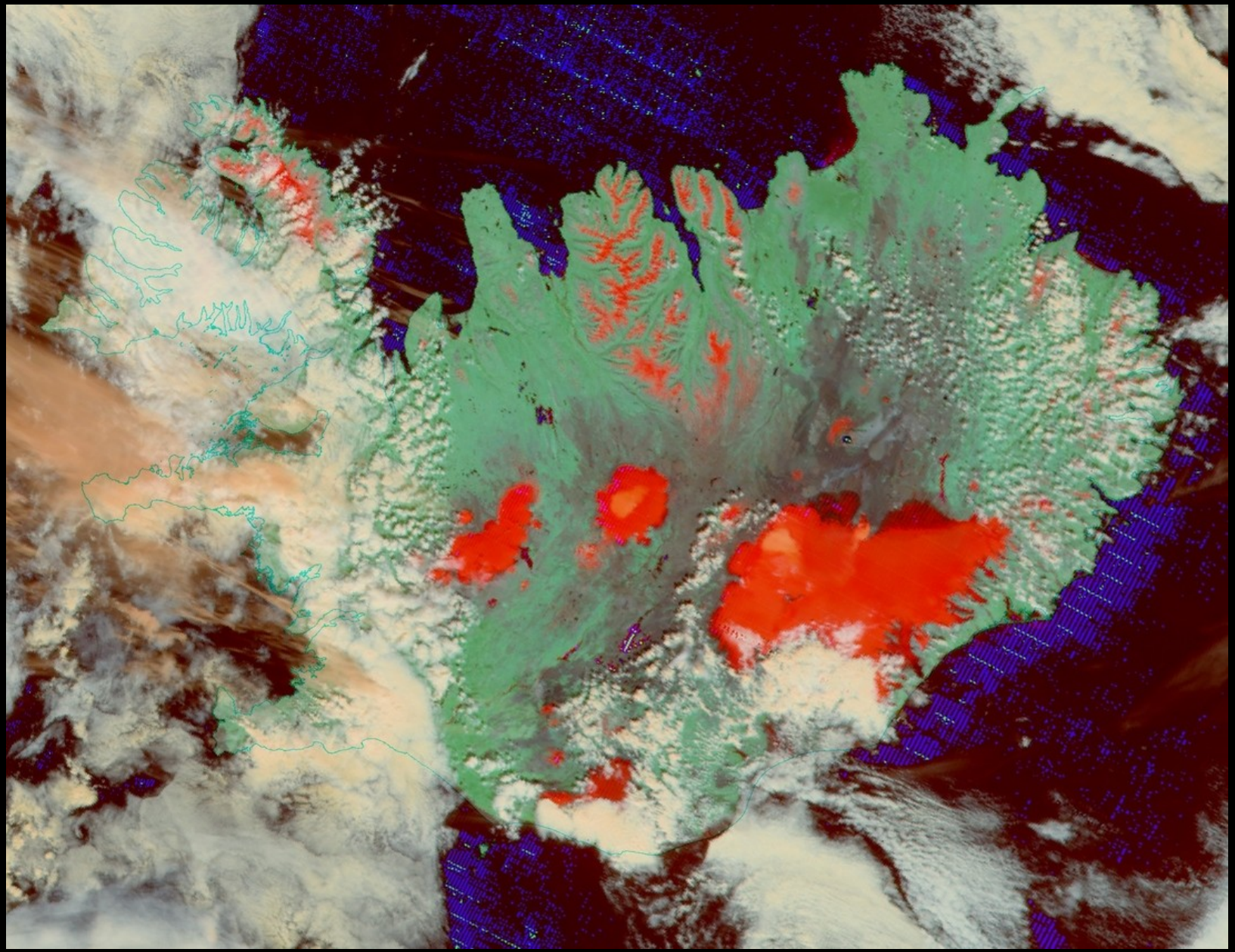


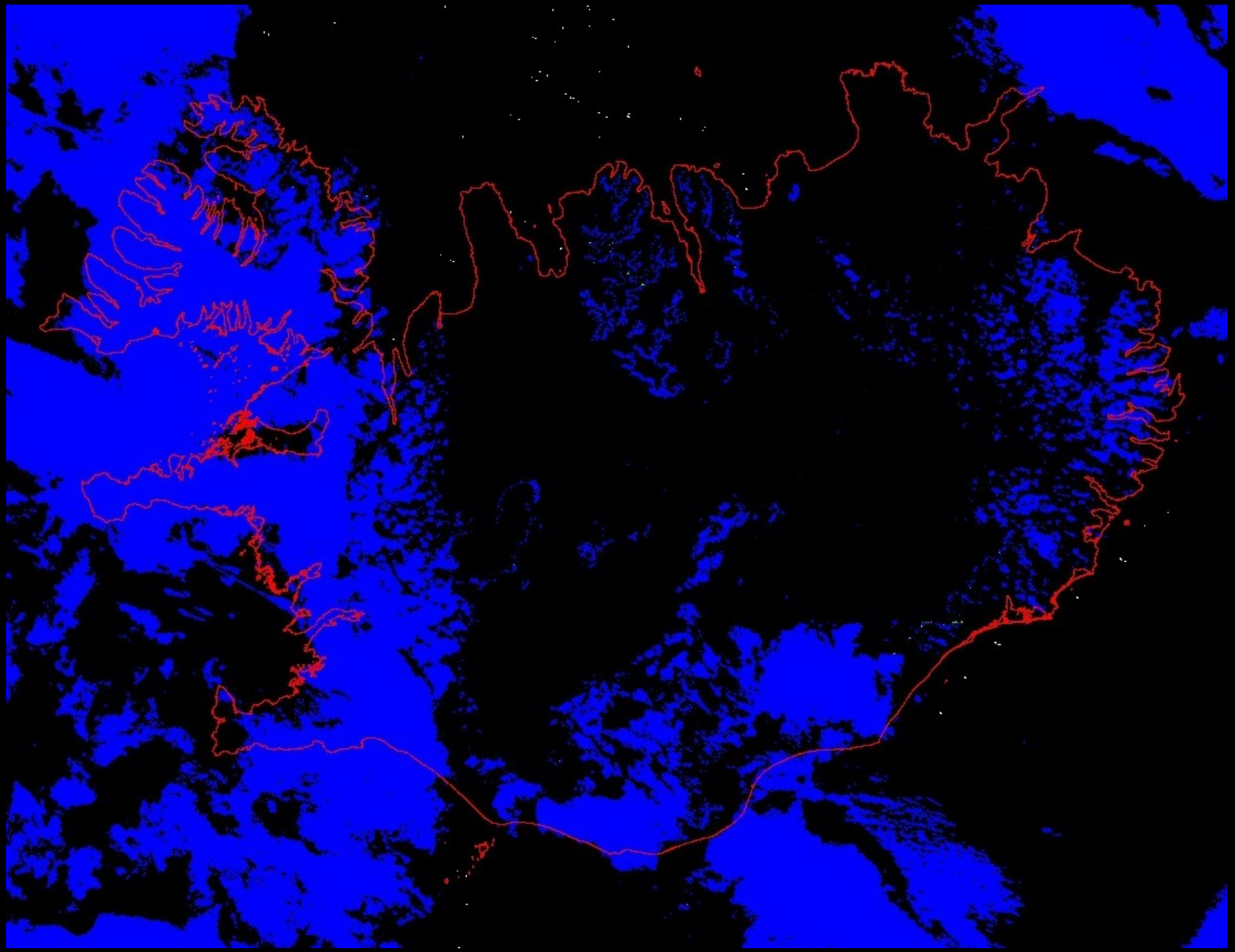
- **Linear reflectance snow model being used to model the NDSI – snow fraction relationship ****
- **For Iceland found it necessary to develop a snow-free NDSI map for calibration.**

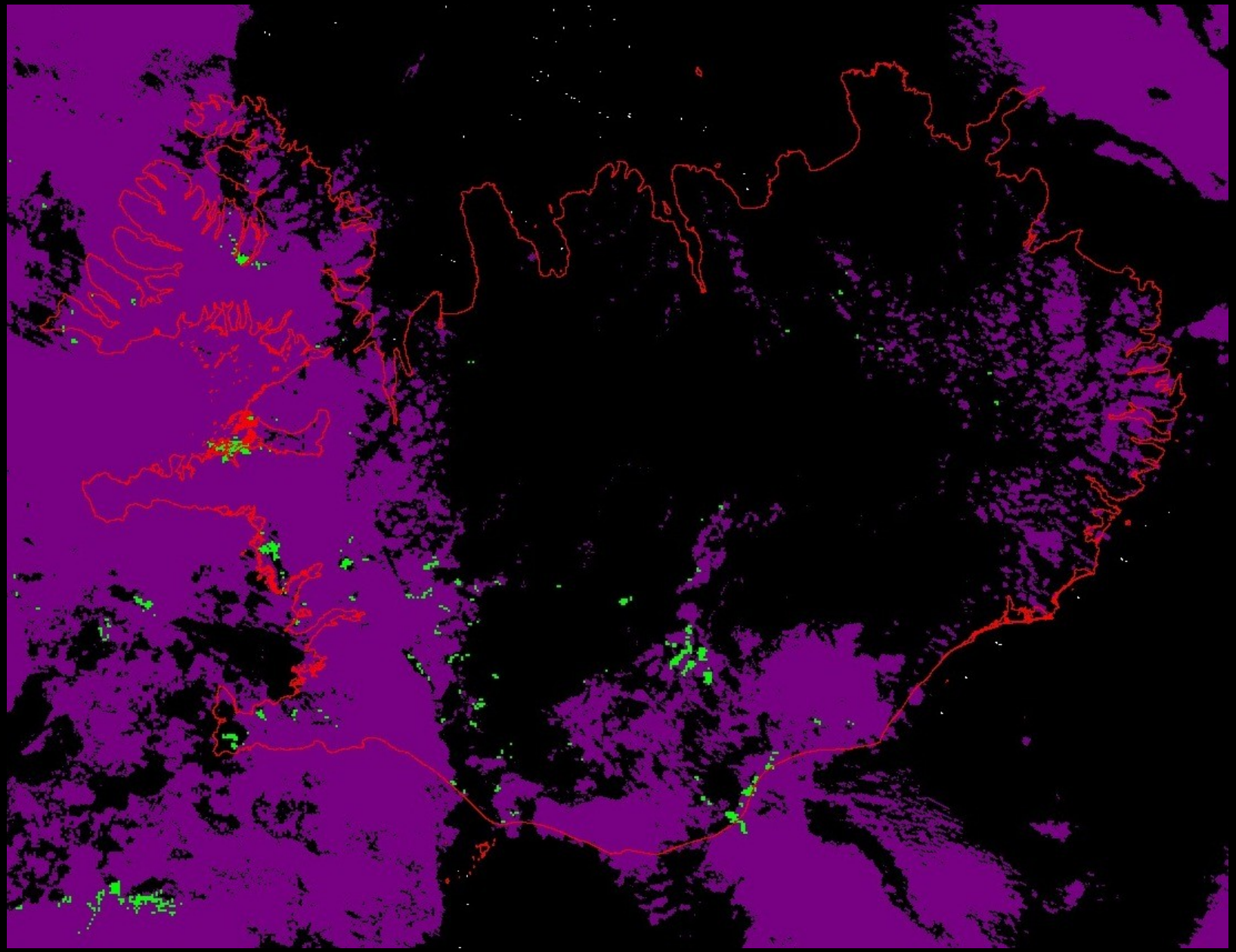
Mosaicing rules

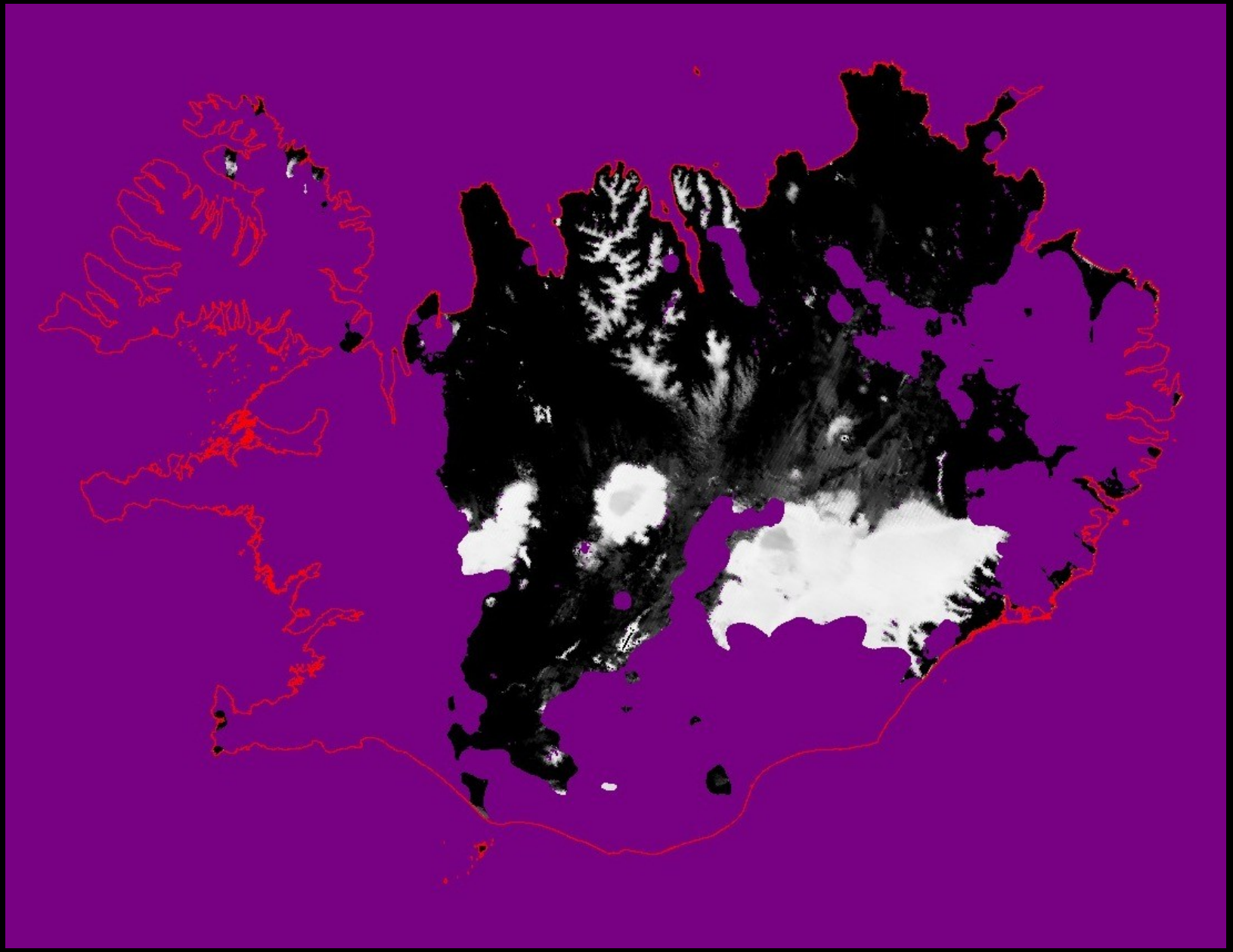
- **Currently doing 1 day mosaics in production**
- **UPDATE PIXEL IF:**
    - **IF “data avilable in new ovelay” AND**
    - **IF “new px. data resolution < 120% previous px. data resolution”**

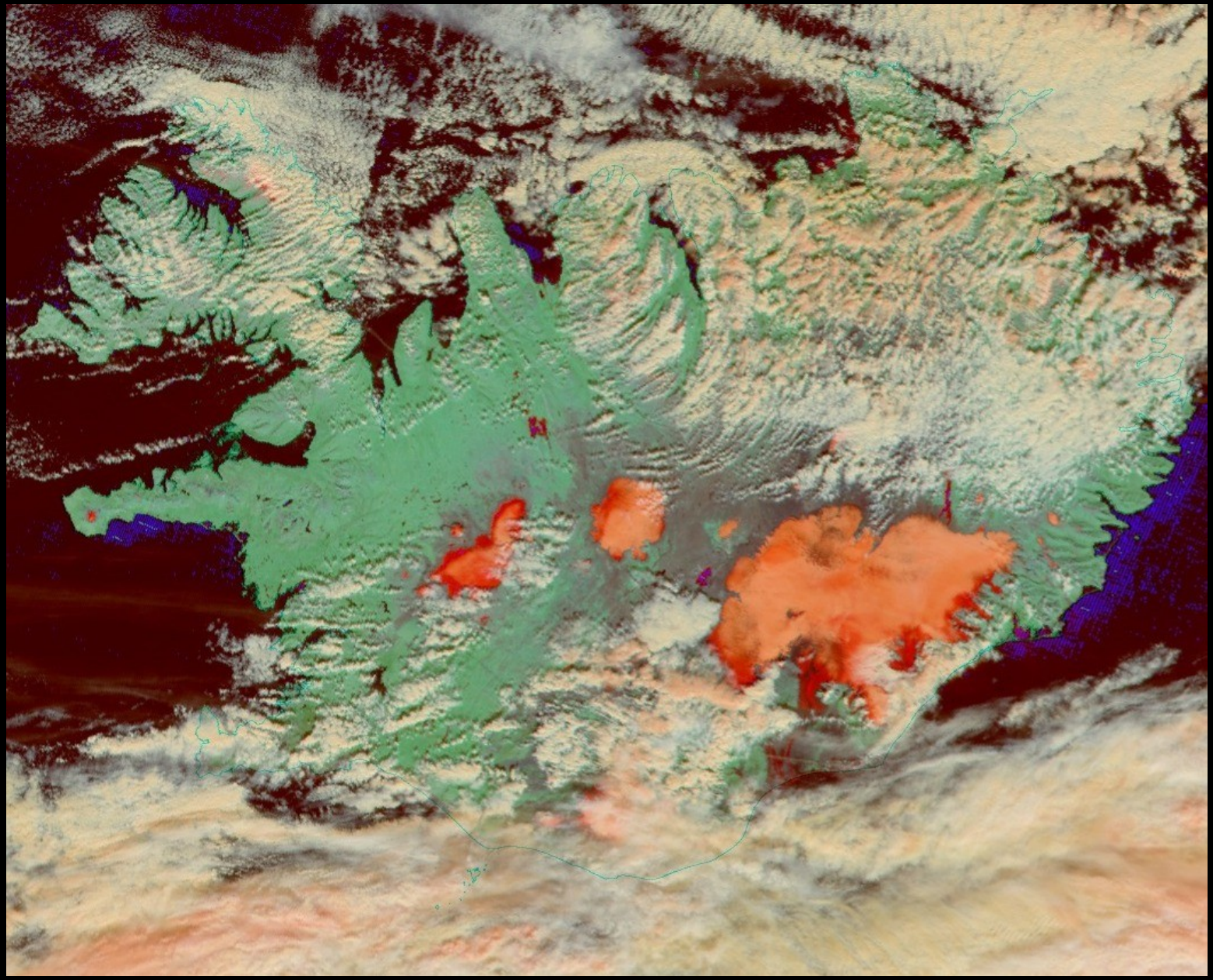
- **#1 ensures a good resolution - “near - overhead” satellite pass has higher priority than passes sampling near the swath perimeter**
- **#2 ensures that mosaic keeps updating despite “bad resolution passes”**

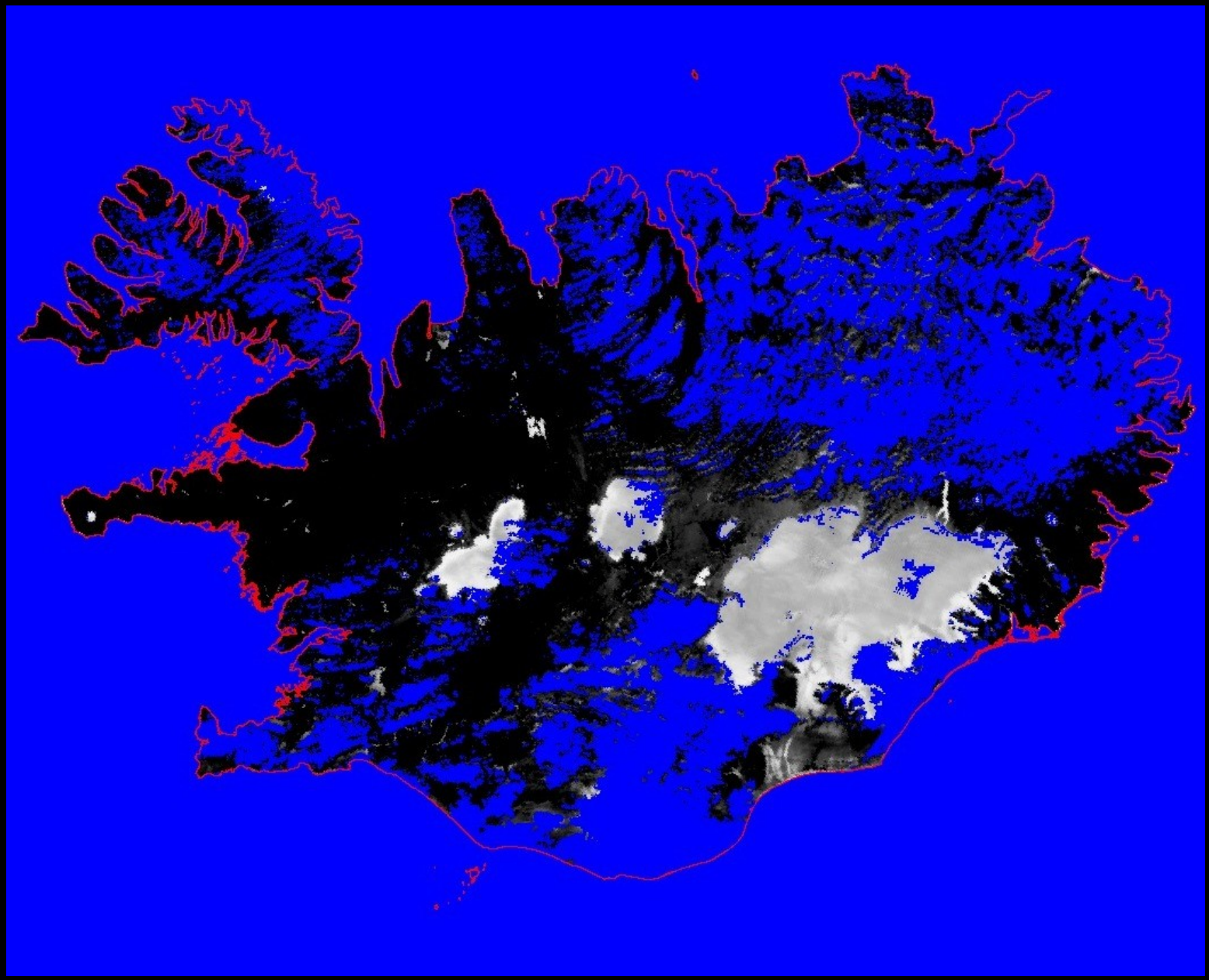






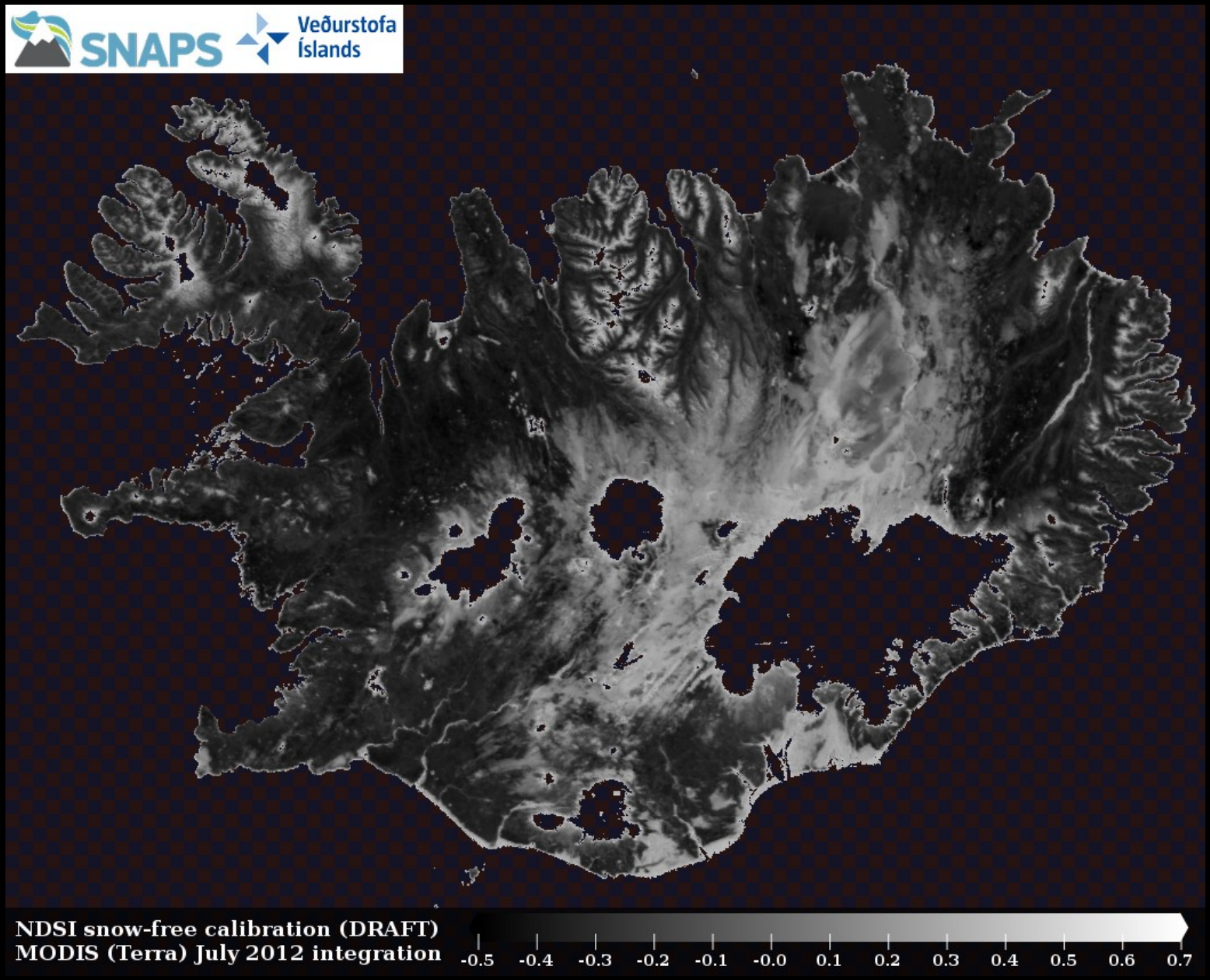


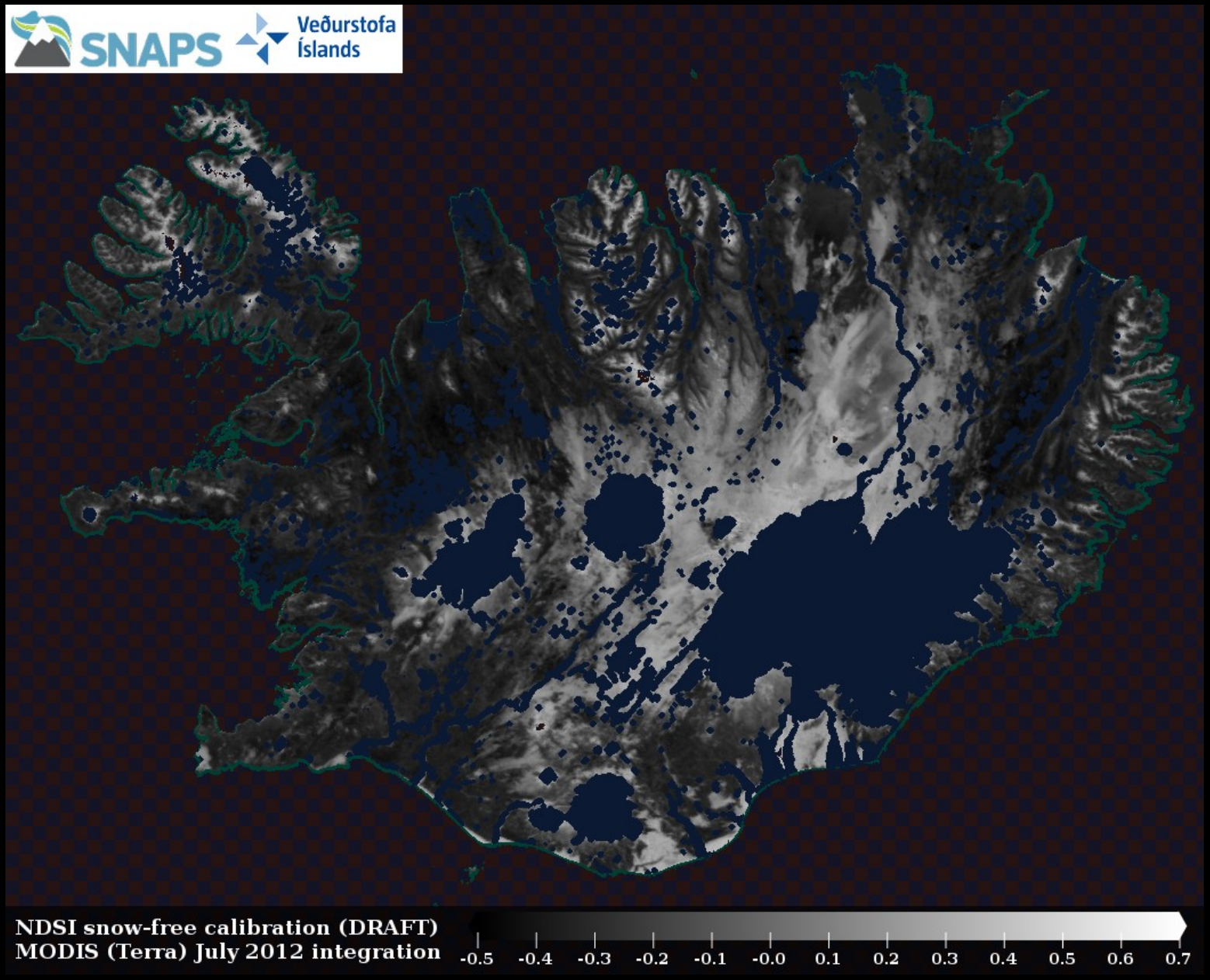




Cloud mask status

- **SCDA Opaque cloud algorithm is very effective at identifying most opaque and translucent clouds.**
  - **However, added the split window BTD>3K transparent cloud filter for good measure.**
- **SCDA leads to erroneous identification in snow cover perimeter - particularly mountainslopes – perhaps associated with non-vegitated areas**
  - **added a fix based on low NIR-reflectance, black-body and 'ground-like' seasonal temperature requirements**
- **Cloud shadows and thin cloud edges pose a problem for the quality of the NDSI mosaic**
  - **devised a cloud-mask blurring filter, convolving the cloud mask with a half-disk**


SNAPS
Veðurstofa Íslands
NDSI snow-free calibration (DRAFT)
MODIS (Terra) July 2012 integration
-0.5 -0.4 -0.3 -0.2 -0.1 -0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7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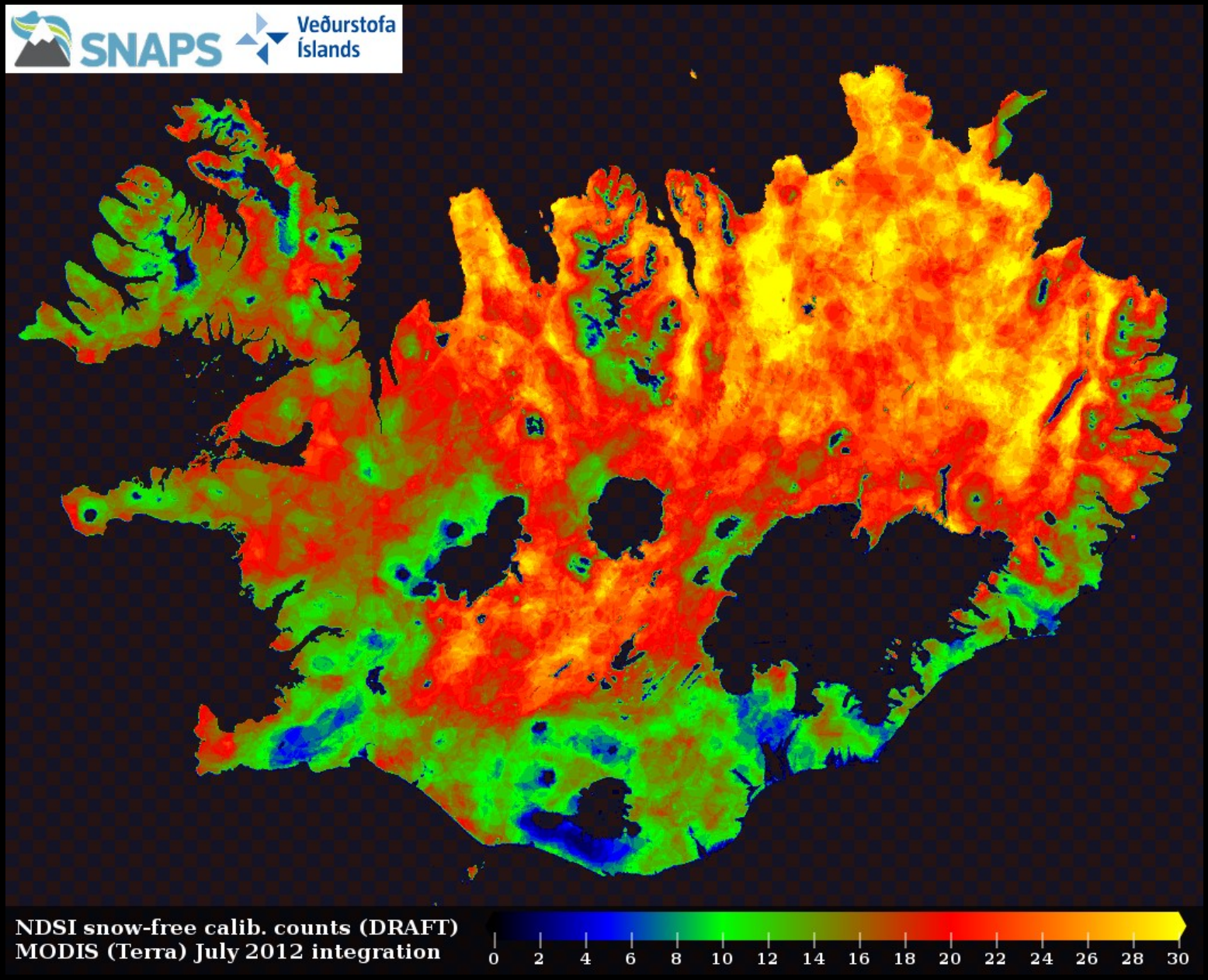
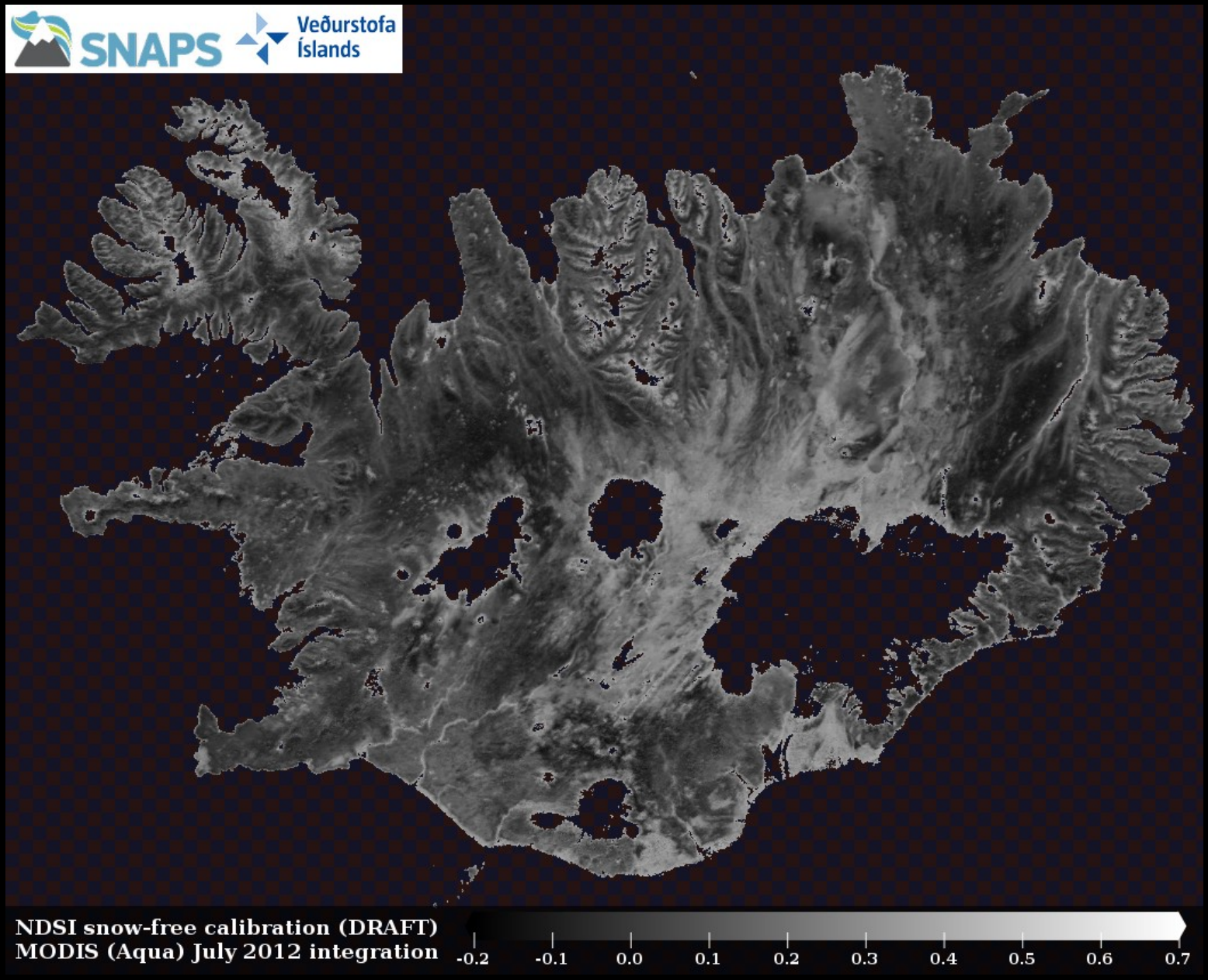

SNAPS
Veðurstofa Íslands
NDSI snow-free calib. counts (DRAFT)
MODIS (Terra) July 2012 integration
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30


SNAPS
Veðurstofa Íslands
NDSI snow-free calibration (DRAFT)
MODIS (Aqua) July 2012 integration
-0.2
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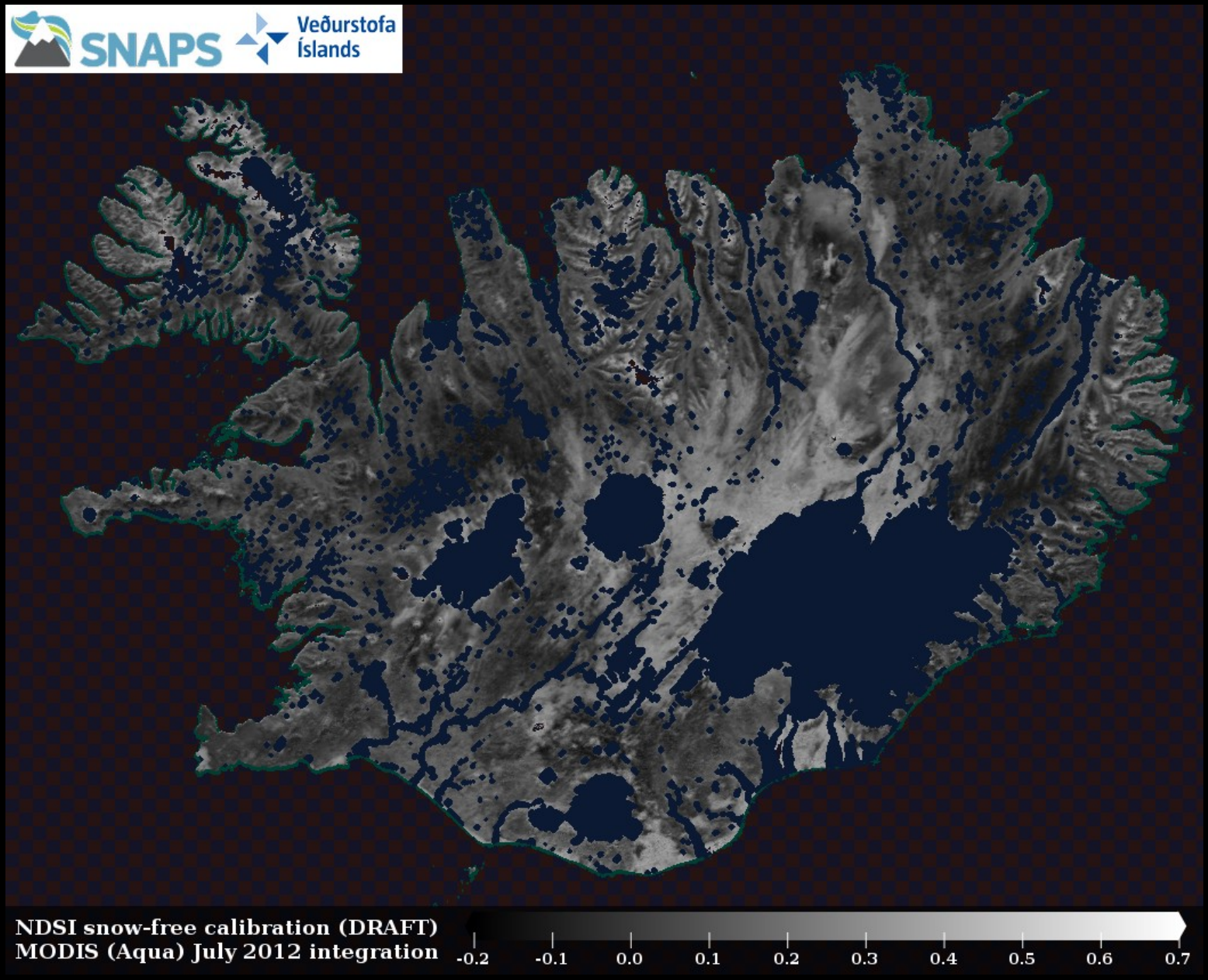
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MODIS (Aqua) July 2012 integration
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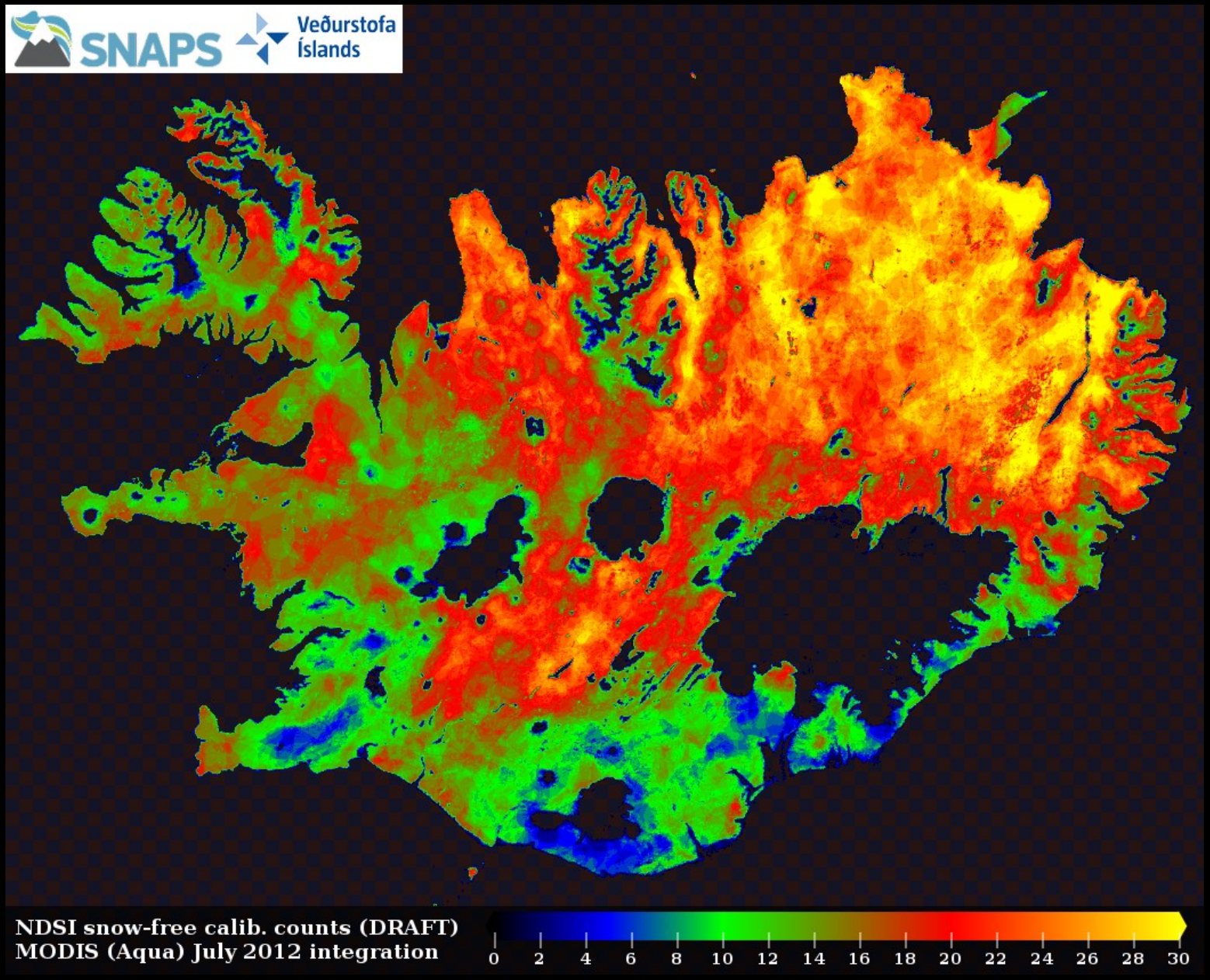
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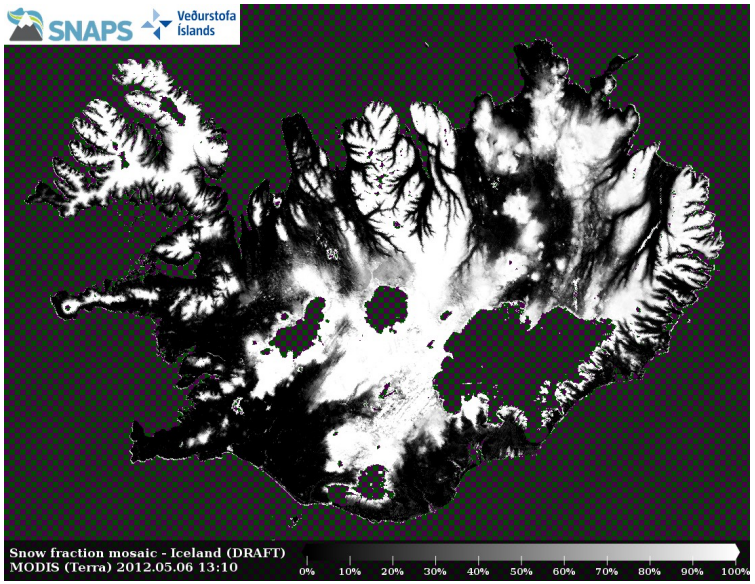
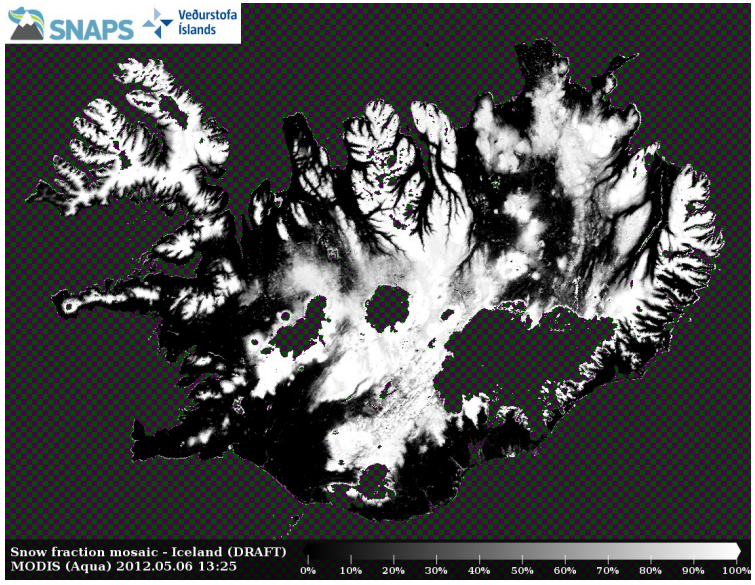
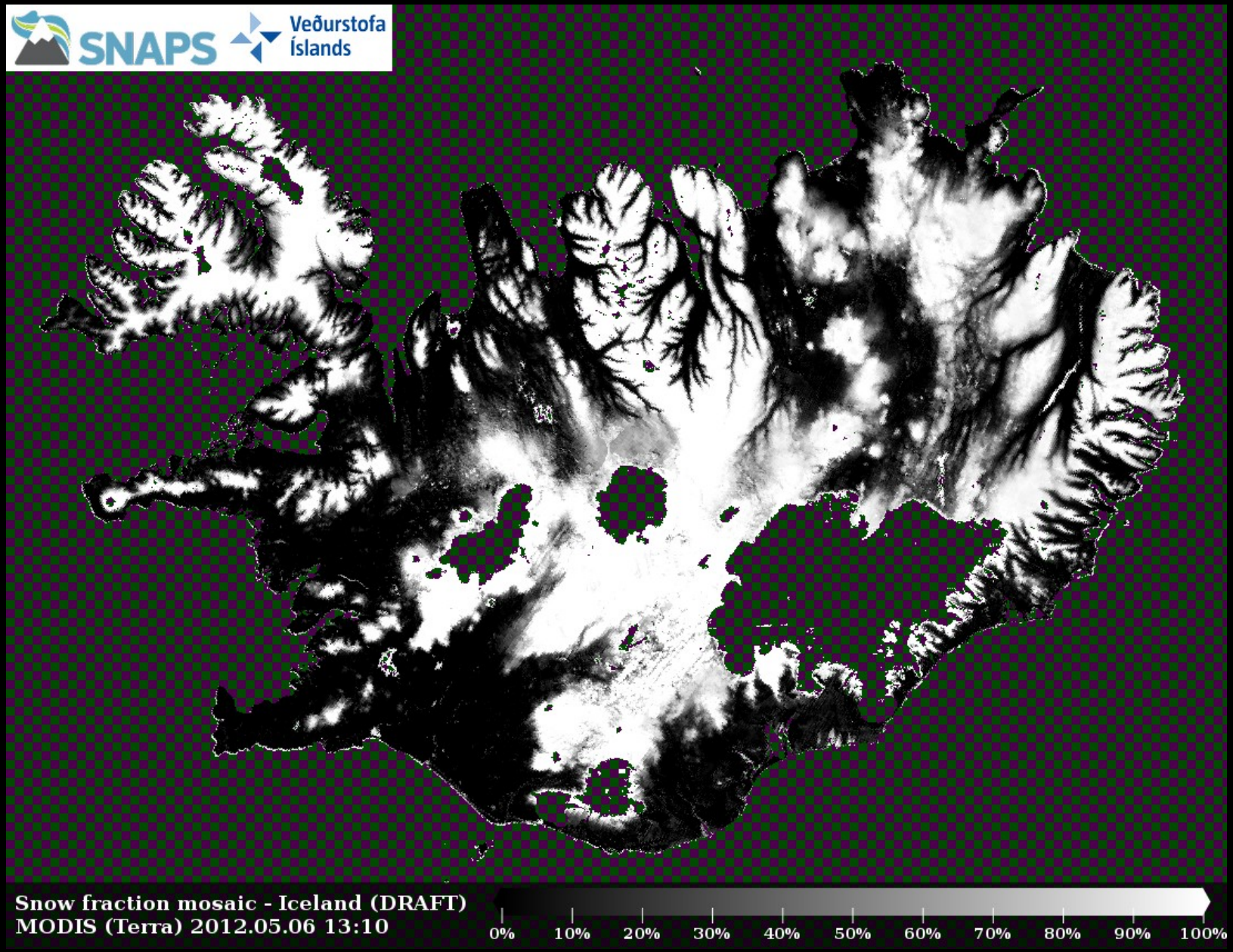
Veðurstofa Íslands
NDSI snow-free calib. counts (DRAFT)
MODIS (Aqua) July 2012 integration
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

Example snow maps

- **Have repeatedly tuned and re-analysed snow maps in the thawing period from from 29 April till July 2012.**






SNAPS
Veðurstofa Íslands
Snow fraction mosaic - Iceland (DRAFT)
MODIS (Terra) 2012.05.06 13:10
0%
10%
20%
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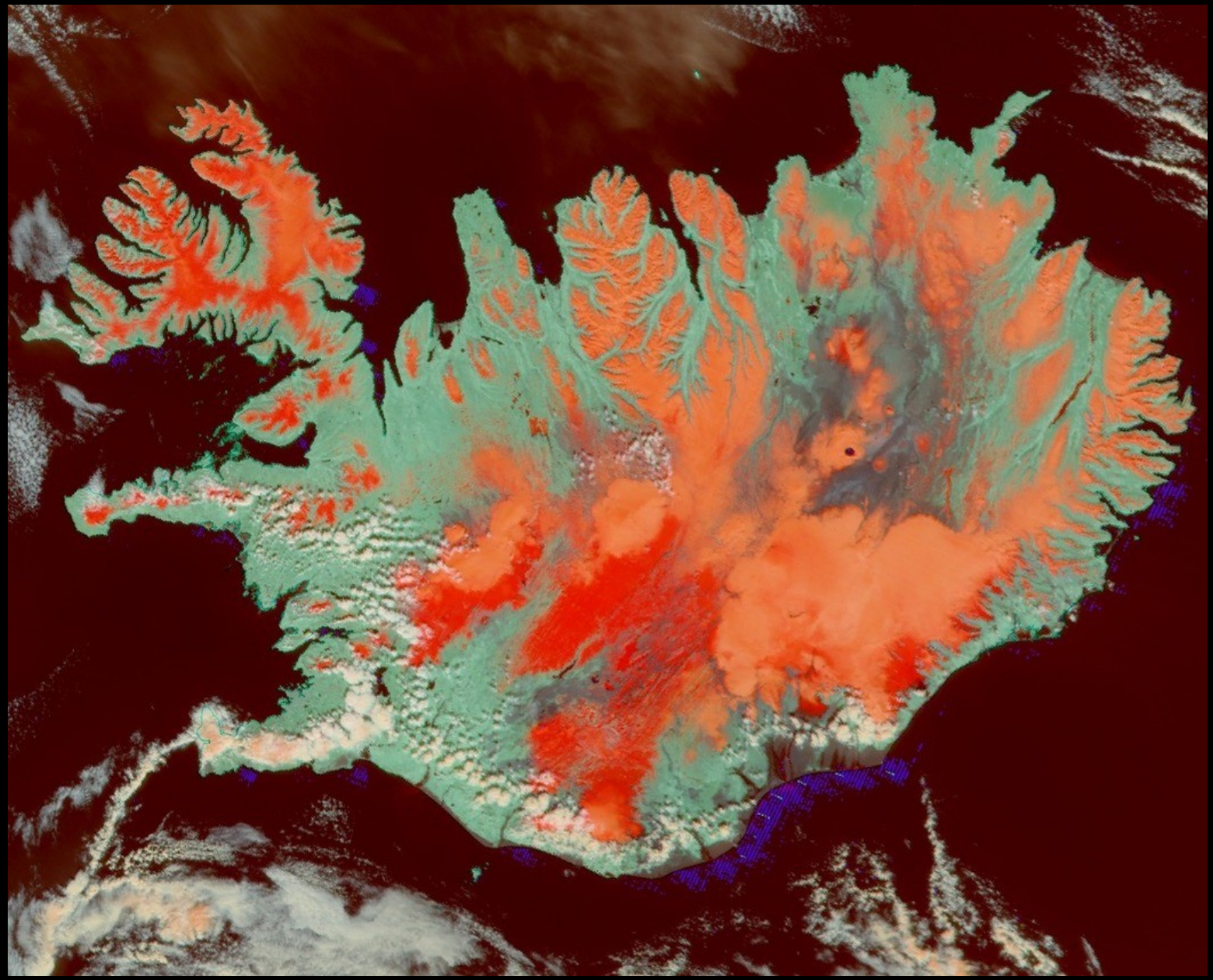
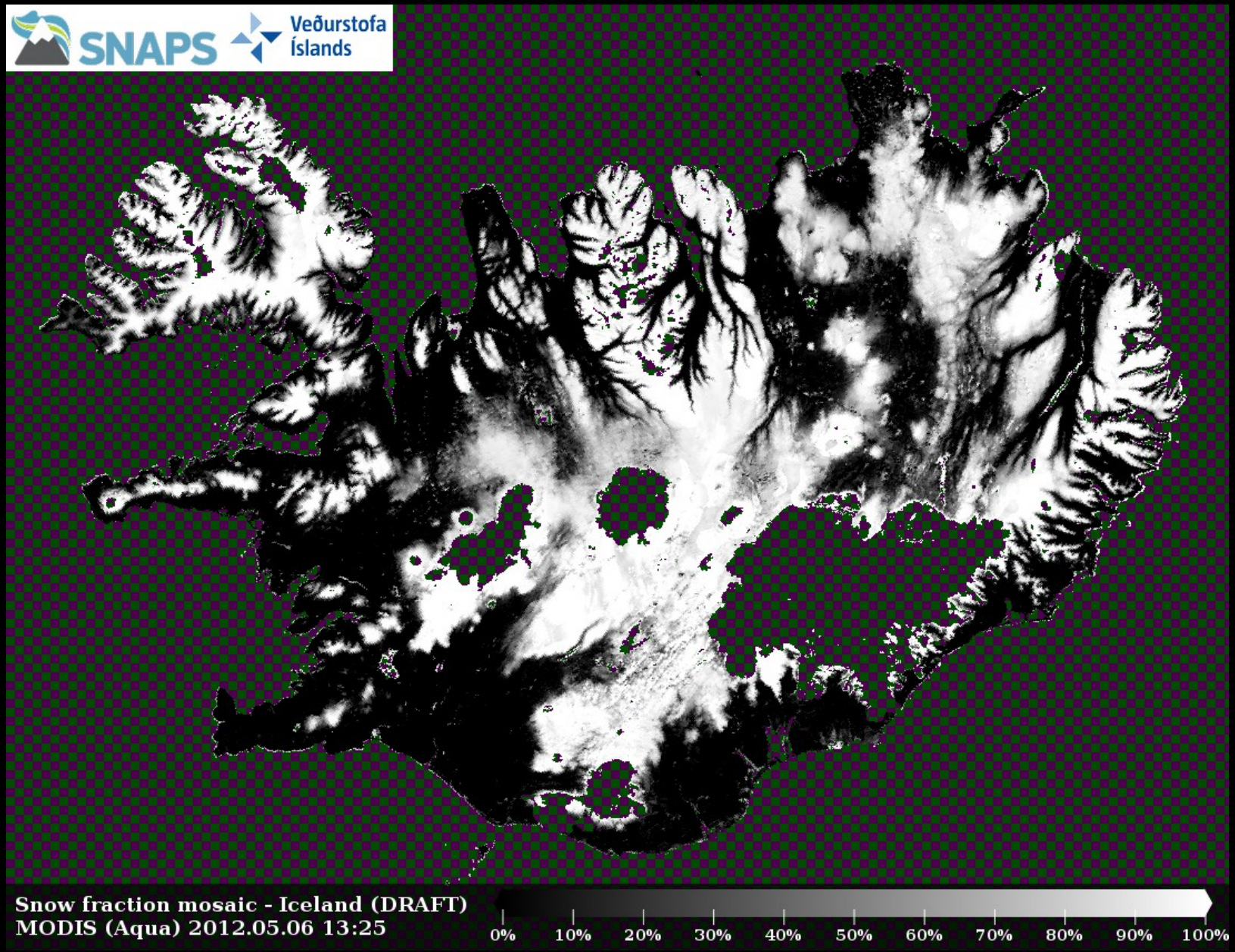
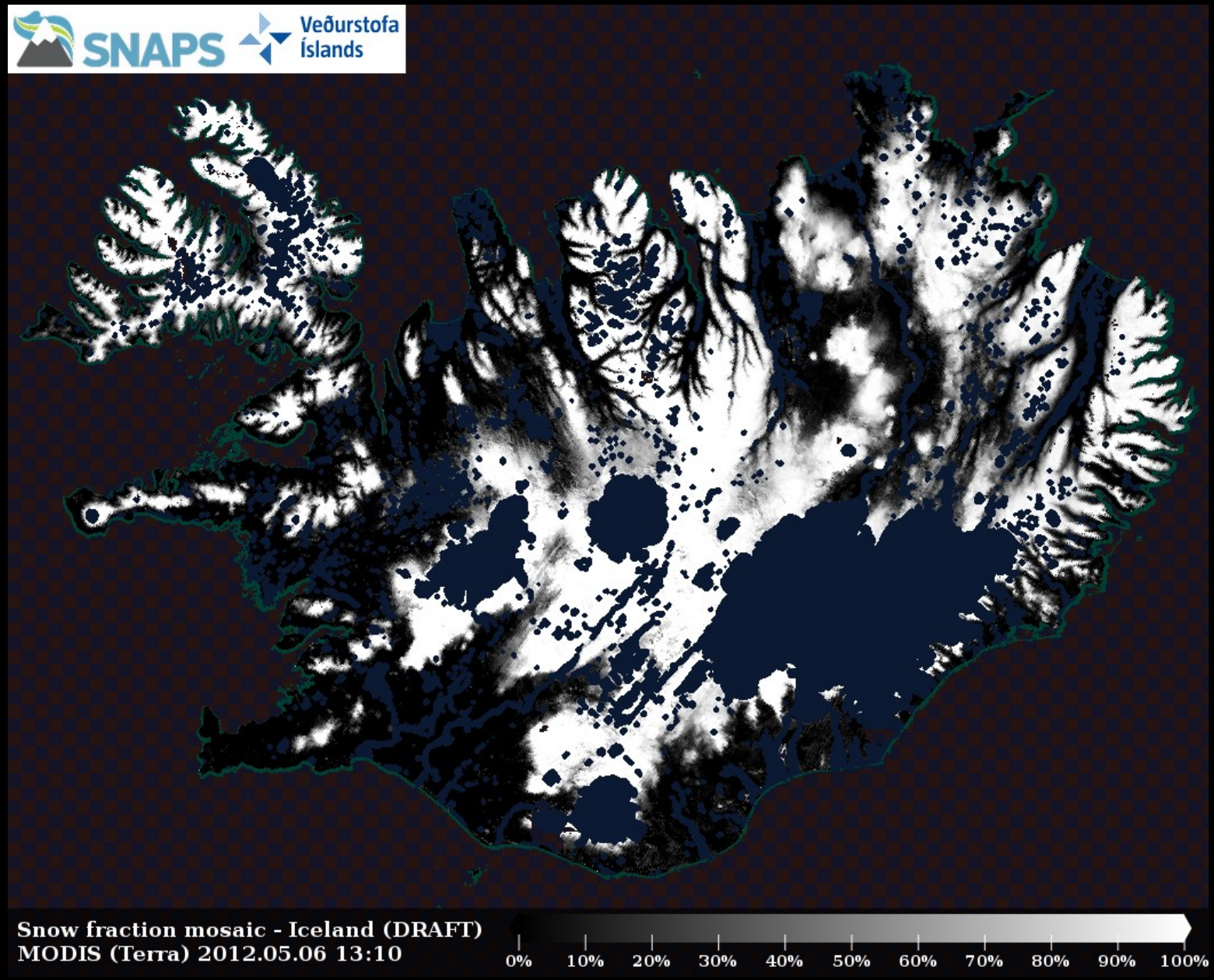
50%
60%
70%
80%
90%
100%




SNAPS
Veðurstofa Íslands
Snow fraction mosaic - Iceland (DRAFT)
MODIS (Aqua) 2012.05.06 13:25
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


SNAPS
Veðurstofa Íslands
Snow fraction mosaic - Iceland (DRAFT)
MODIS (Terra) 2012.05.06 13:10
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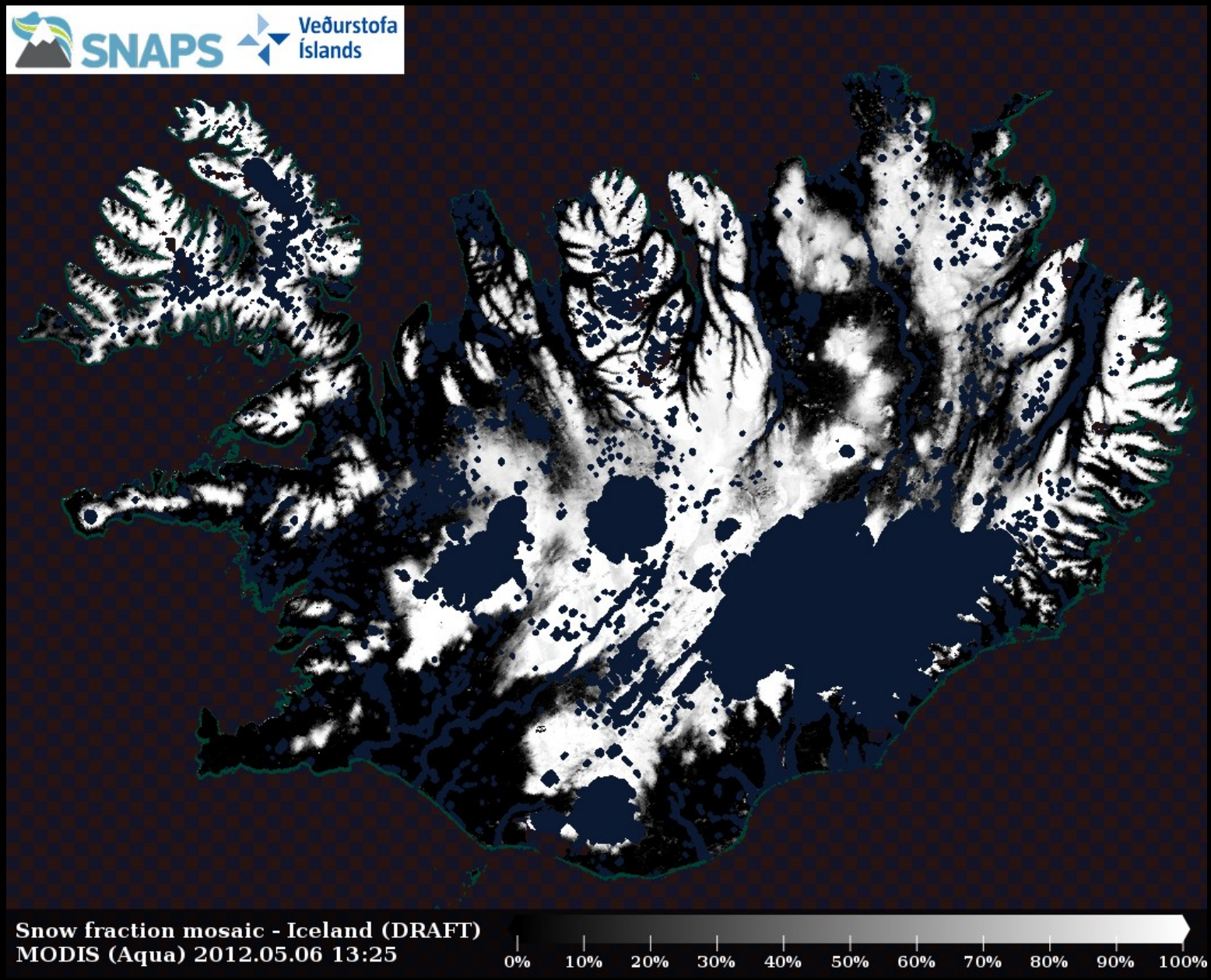

SNAPS
Veðurstofa Íslands
Snow fraction mosaic - Iceland (DRAFT)
MODIS (Aqua) 2012.05.06 13:25
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

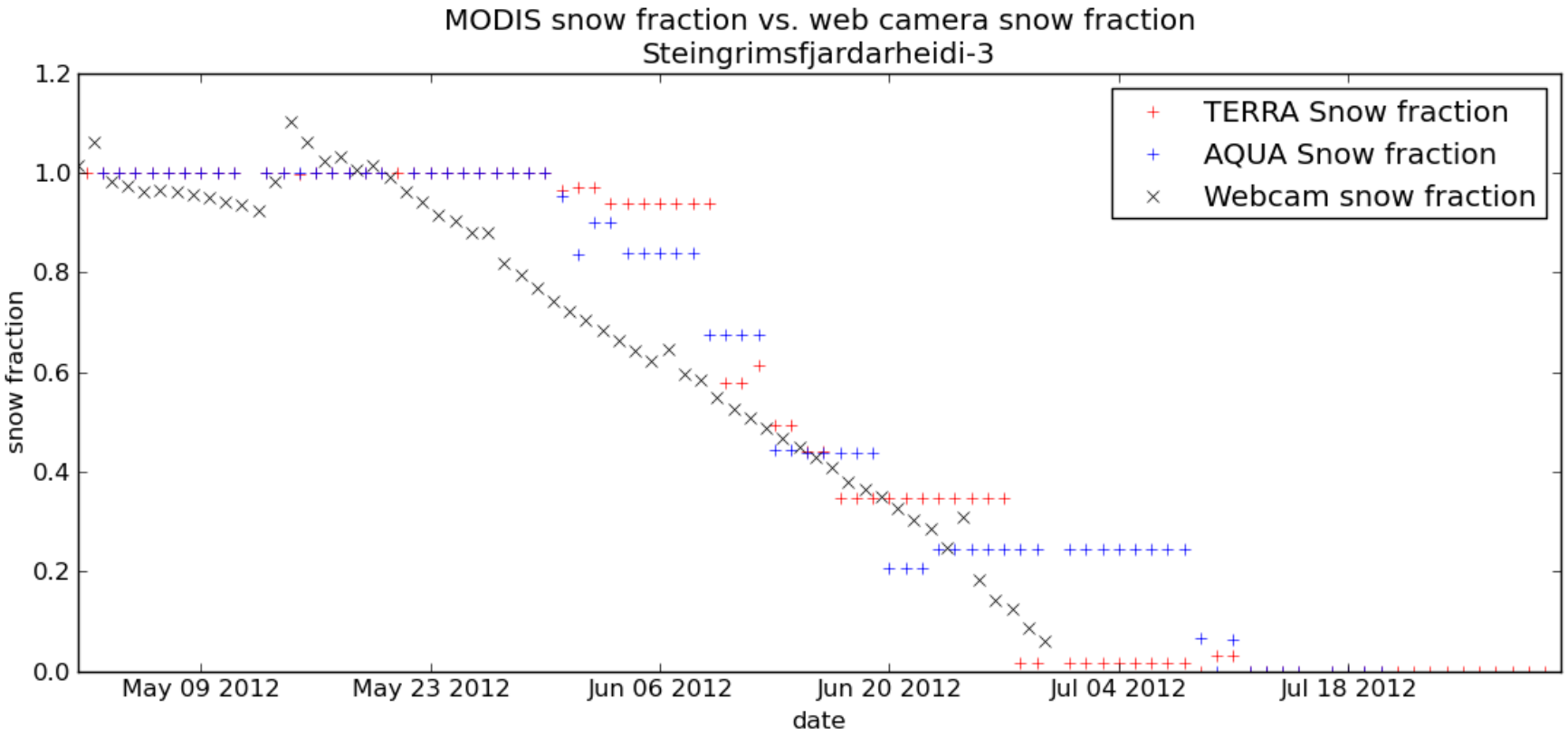
Verification attempt with the IRA web cameras

- Road cameras maintained by the Icelandic Road Authority at weather stations were used for an initial comparison / verification of the MODIS snow fraction product.
- Web camera frames can be automatically analysed simplisticly for snow fraction using a threshold on the image brightness
- Generally do not agree well on actual snow fraction
  - perhaps localization near roads?
  - or are the snow-maps wrong?

Steingrímsfjarðarheiði séð til austurs A 6 m/s 4°C
Kl. 12:55 - mán. 11. jún. 2012

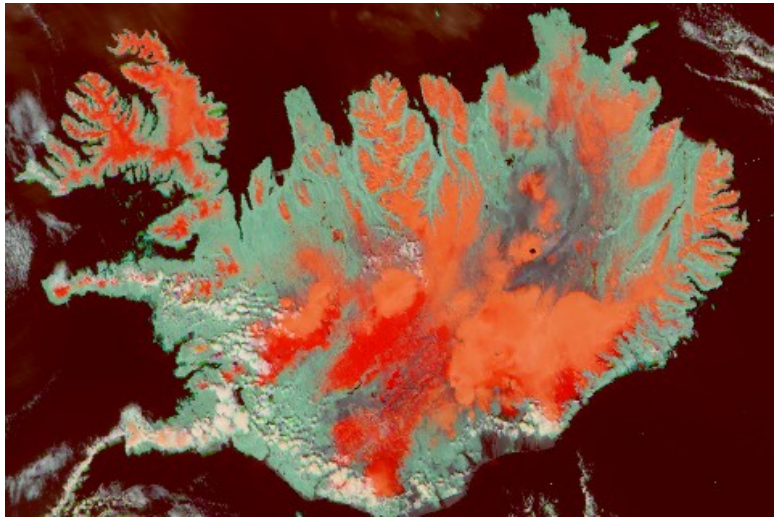
Hólmur
Nál
Selay
Drangaey
Drangavíkurhólmar
Bolungarvík
Staðarkirkja
Æðey
Vigur
Hrútey
Hólmi
Ársker
Kúhólmi
632
Borgarey
Skeggnólmi
Aðalból
Svalvogavegur
633
61
Kasarhólmi
Selárdalskirkja
60
Ós
Hörfinnsey
Urriðaey
Helluhólmar
Hrófey
Otradalur
Láginúpur
617
Amarhólmar
Eyri
60
Landhólmi
Helluhólmi
Lyngey
Hádegisey
Flatey
616
62
612
Ystey
Refshólmur
Klaufahólmi
Sundey
Þrælshólmi
Einfætlingsgil
Rauðsdalshólmar
Kiðhólmar
Stöðuley
Borðey
Þrælshólmi
Reyðarhólmi
Urðhólmur
Nóney
Strond
Ólafseyjar
Fagurey
Hnúur
Landhólmar
Kálfur
Ljótunnarstaðahólmar
Sinuhólmur
Hrísey
Stedey
Kálfhólmi
20 km

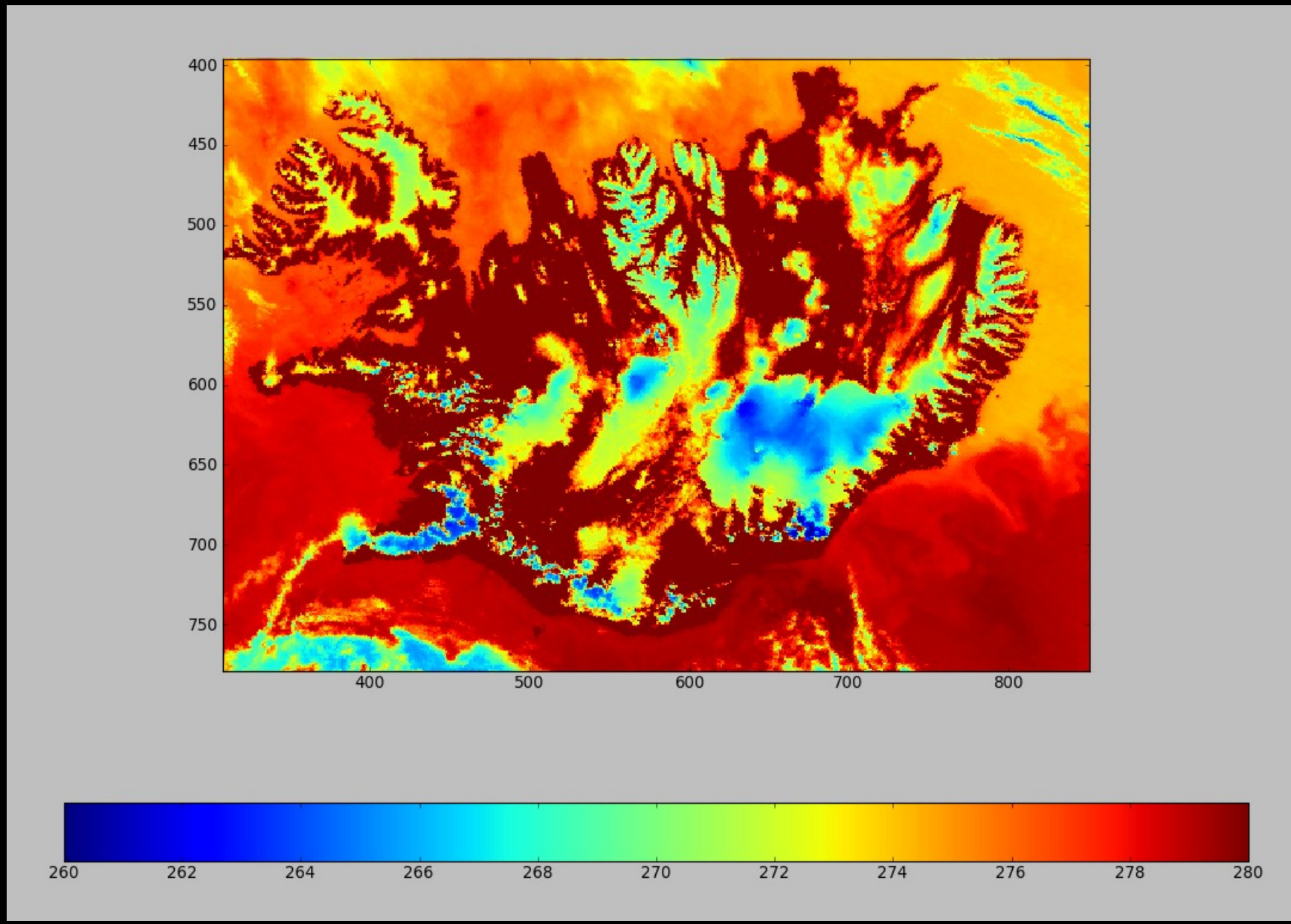
Verification attempt with the IRA web cameras



Wet or old snow?

- **The NDSI has a secret, additional information on the state of the snow cover.**
- **Some use NDSI > NDSI (100% snow) as evidence for snow-age or snow grain size**
- **It has also been noted that wet snow reduces to larger effective grain sizes**

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The processing chain

- dsfd
- ssfsdf