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Methods of flood extent mapping using SAR imagery in the Zambezi (Caprivi) Region, Namibia

Jaco Kemp[1], Mariel Bessinger[1], Melanie Luck-Vogel[2]

Zambezi Region

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Zambezi Region

Zambezi Region

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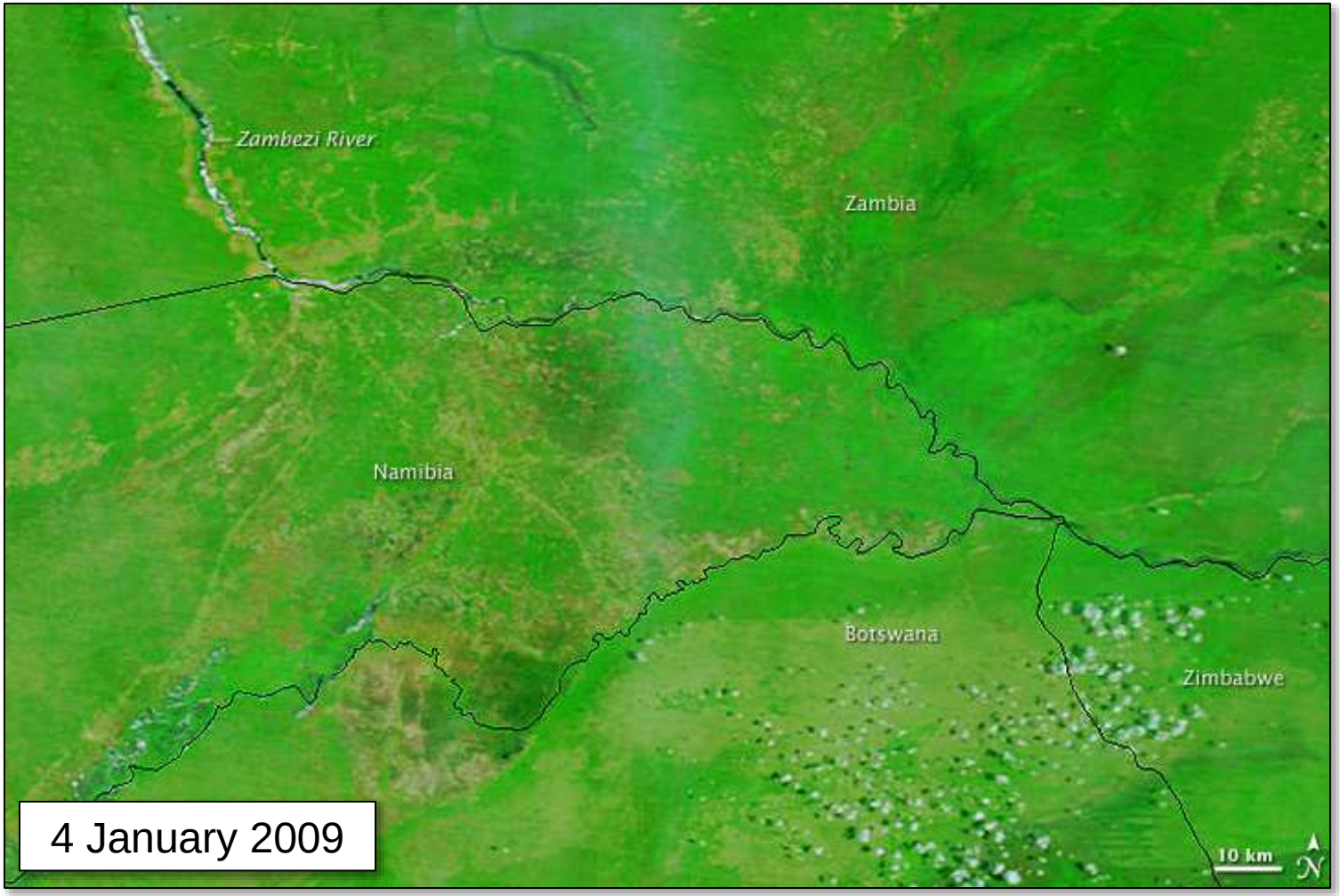
Flooding

http://en.wikipedia.org/wiki/File:Village_in_caprivi_flood_plain.jpg

Flooding



http://earthobservatory.nasa.gov/IOTD/view.php?id=38212

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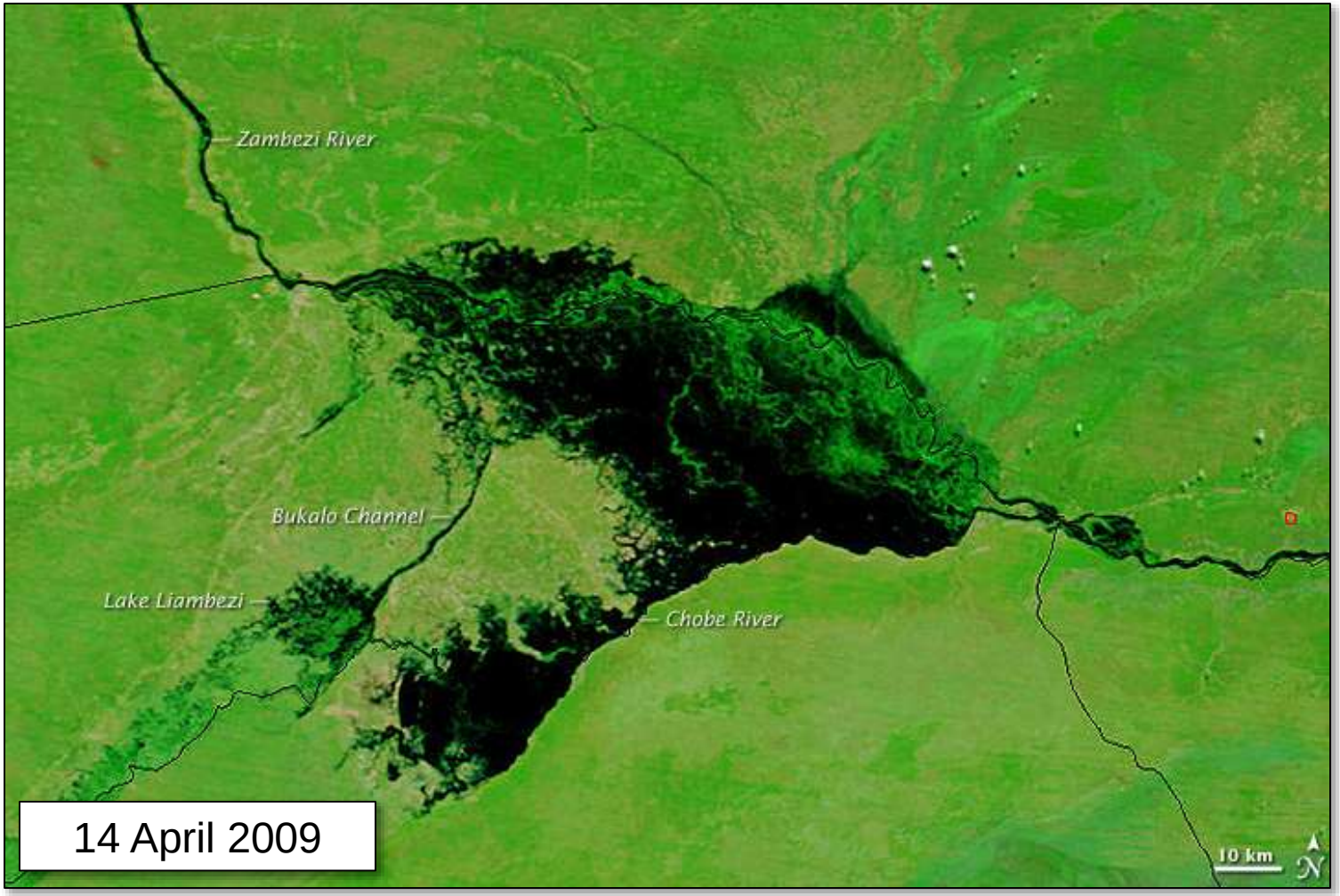
Flooding



http://earthobservatory.nasa.gov/IOTD/view.php?id=38212

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Flooding

2009 Floods

- Zambezi river level rose more than 1m between 7 March and 15 March 2009
- Rose another meter between 15 March and 22 March 2009
- Worst flooding in 40 years.
- At least 92 deaths (drowning, crocodile attacks etc)
- More than 23,000 displacements in Zambezi Region alone – more than 50,000 in total

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Flooding

2009 Floods

- Lake Liambezi and the Bukalo Channel that feeds it dried up in the 80's and 90's, prompting people to settle in the flood plain.
- Activation of the Bukalo Channel and the recovery (flooding) of Lake Liambezi caused thousands of evacuations

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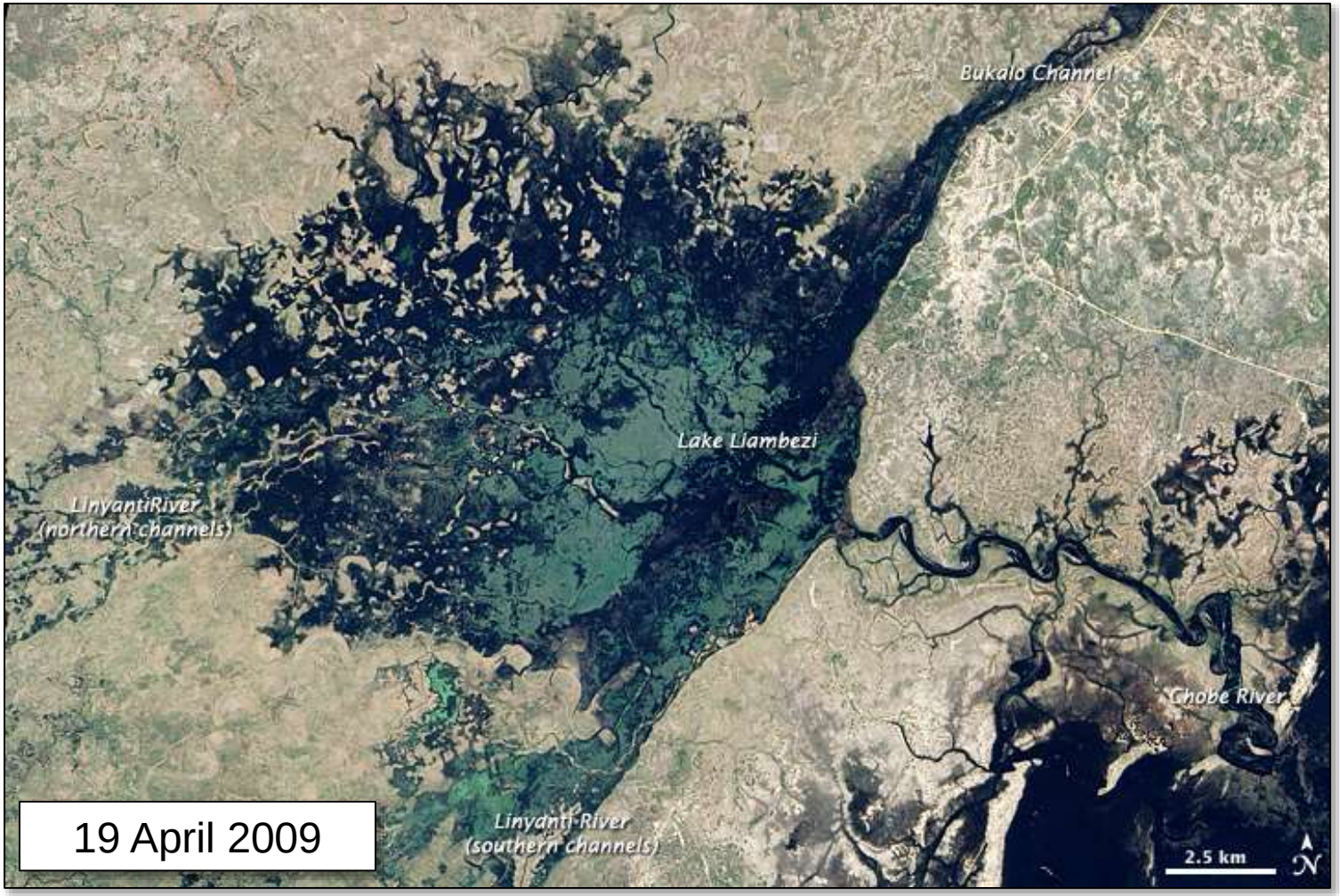
Flooding



http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=38282

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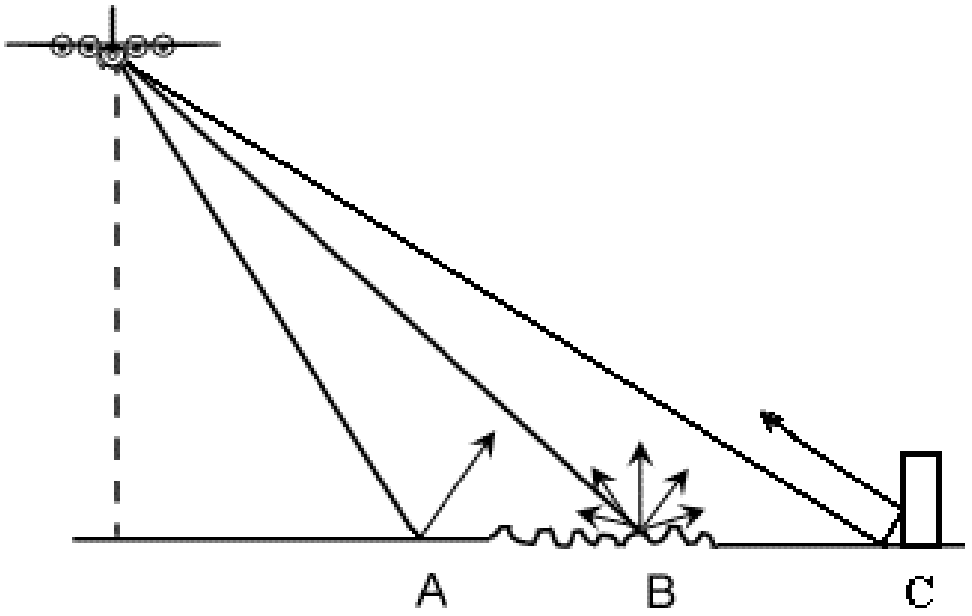
SAR Data

Synthetic Aperture Radar

- SAR satellite provide side-looking microwave illumination to the ground, and record the intensity (and phase) of the backscattered radio waves
- Surface roughness impacts the backscattered signal



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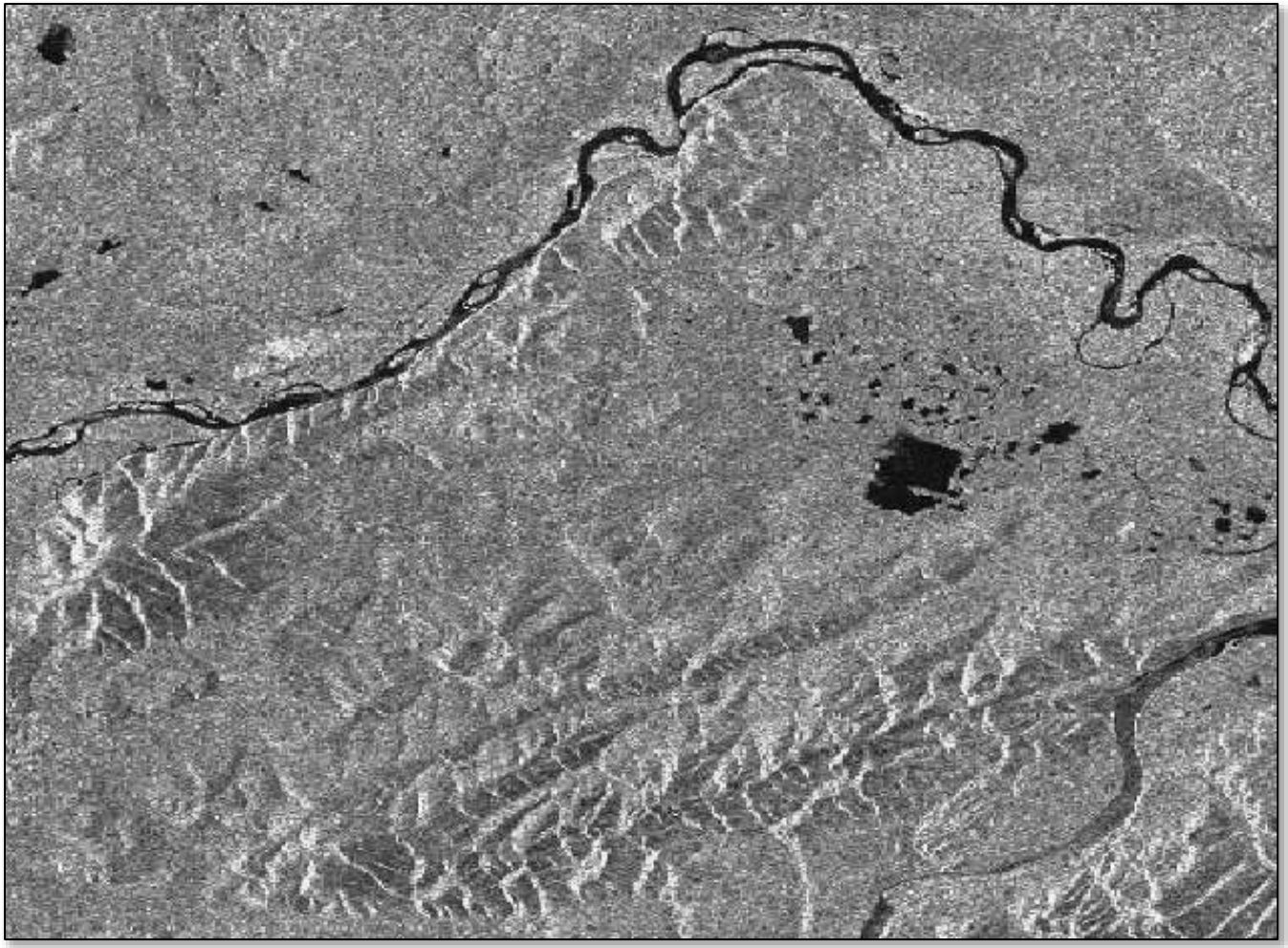

http://telin.ugent.be/~sanja/Sanja_files/images/SAR_comp_orig.jpg

SAR Data

This study

- ENVISAT ASAR Wide Swath (25 images)
  - C-band (~5cm wavelength)
  - 150m resolution
- ALOS PALSAR FBD (3 images)
  - L-band (~23cm wavelength)
  - 20m resolution
- ALOS PALSAR PLR (6 images)
  - L-band (~23cm wavelength)
  - 30m resolution

SAR Data

Sensor	Date
ASAR WSS	2006/03/12
ASAR WSS	2006/03/31
ASAR WSS	2006/04/01
ASAR WSS	2006/04/03
ASAR WSS	2006/04/17
ASAR WSS	2006/05/24
PALSAR PLR	2007/03/14
PALSAR PLR	2007/03/14
PALSAR PLR	2007/03/31
ASAR WSS	2007/04/01
ASAR WSS	2007/04/02
ASAR WSS	2007/04/04
ASAR WSS	2007/04/17
ASAR WSS	2007/04/20
ASAR WSS	2007/04/21
ASAR WSS	2007/04/23
ASAR WSS	2008/04/24
PALSAR FBD	2008/04/24
PALSAR FBD	2008/05/23
PALSAR FBD	2008/05/23

Sensor	Date
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ASAR WSS	2009/02/17
ASAR WSS	2009/03/02
ASAR WSS	2009/03/17
PALSAR PLR	2009/03/19
PALSAR PLR	2009/03/19
PALSAR PLR	2009/04/05
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ASAR WSS	2009/03/23
ASAR WSS	2009/03/24
ASAR WSS	2009/04/25
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ASAR WSS	2010/05/30

SAR Data

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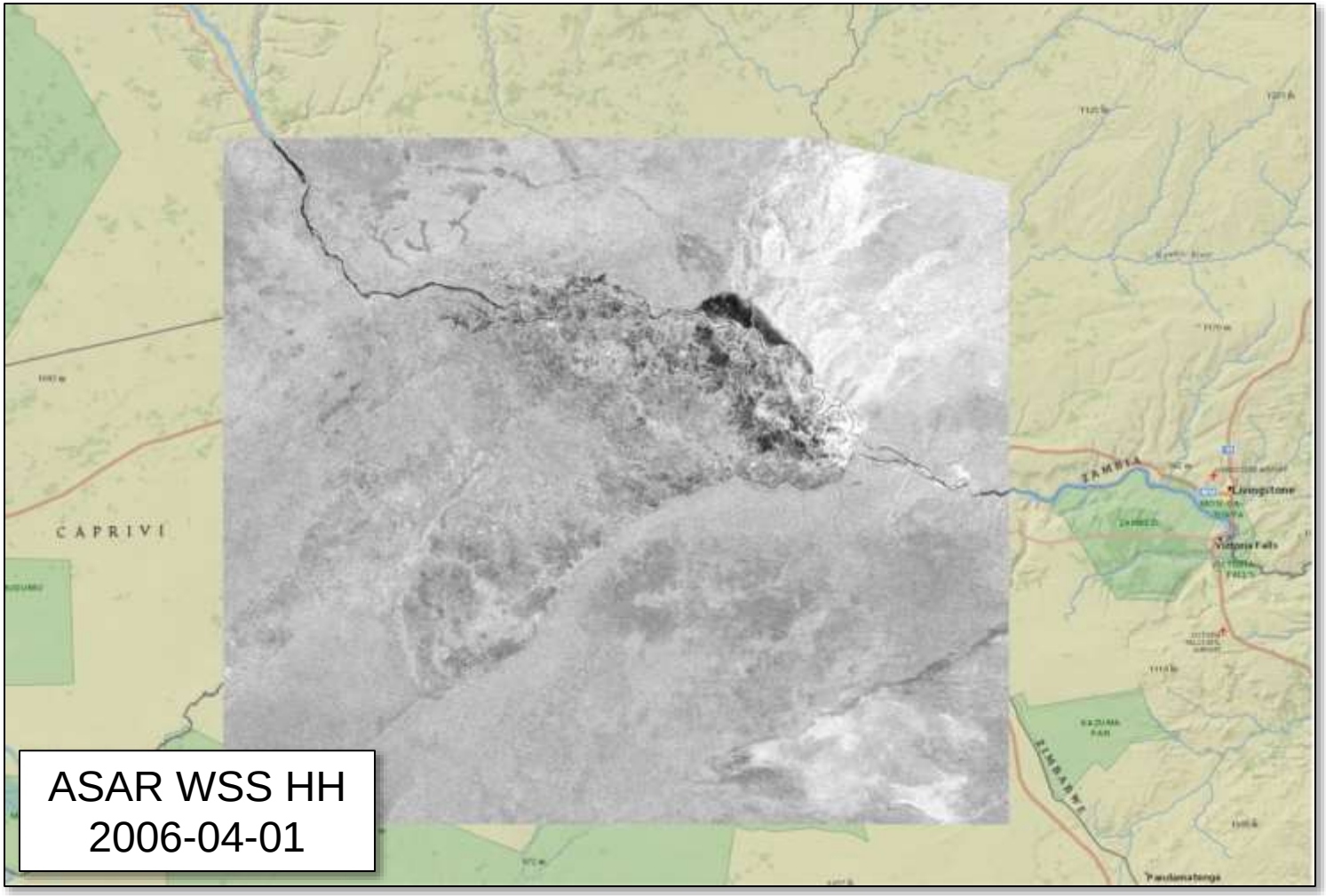
SAR Data



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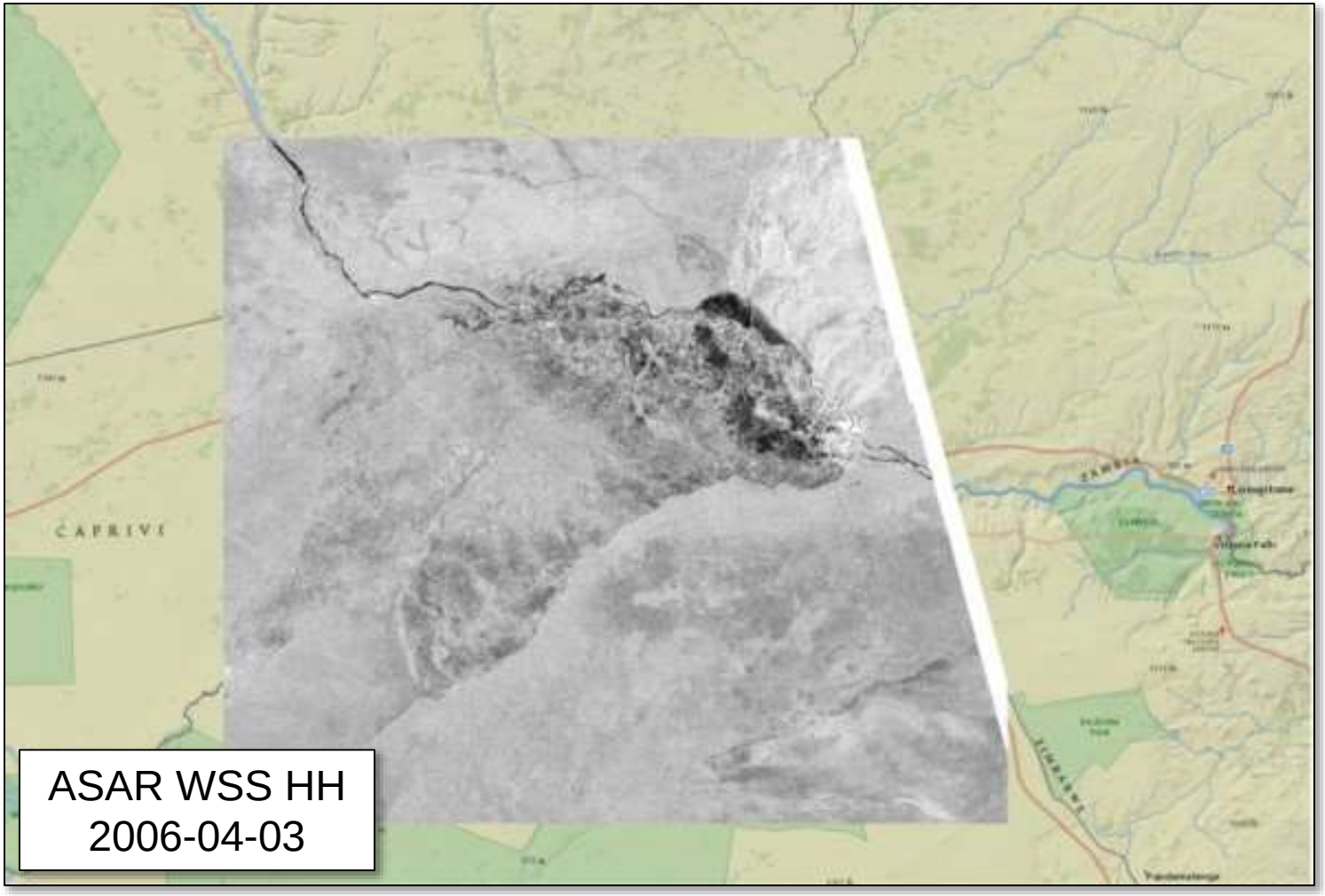

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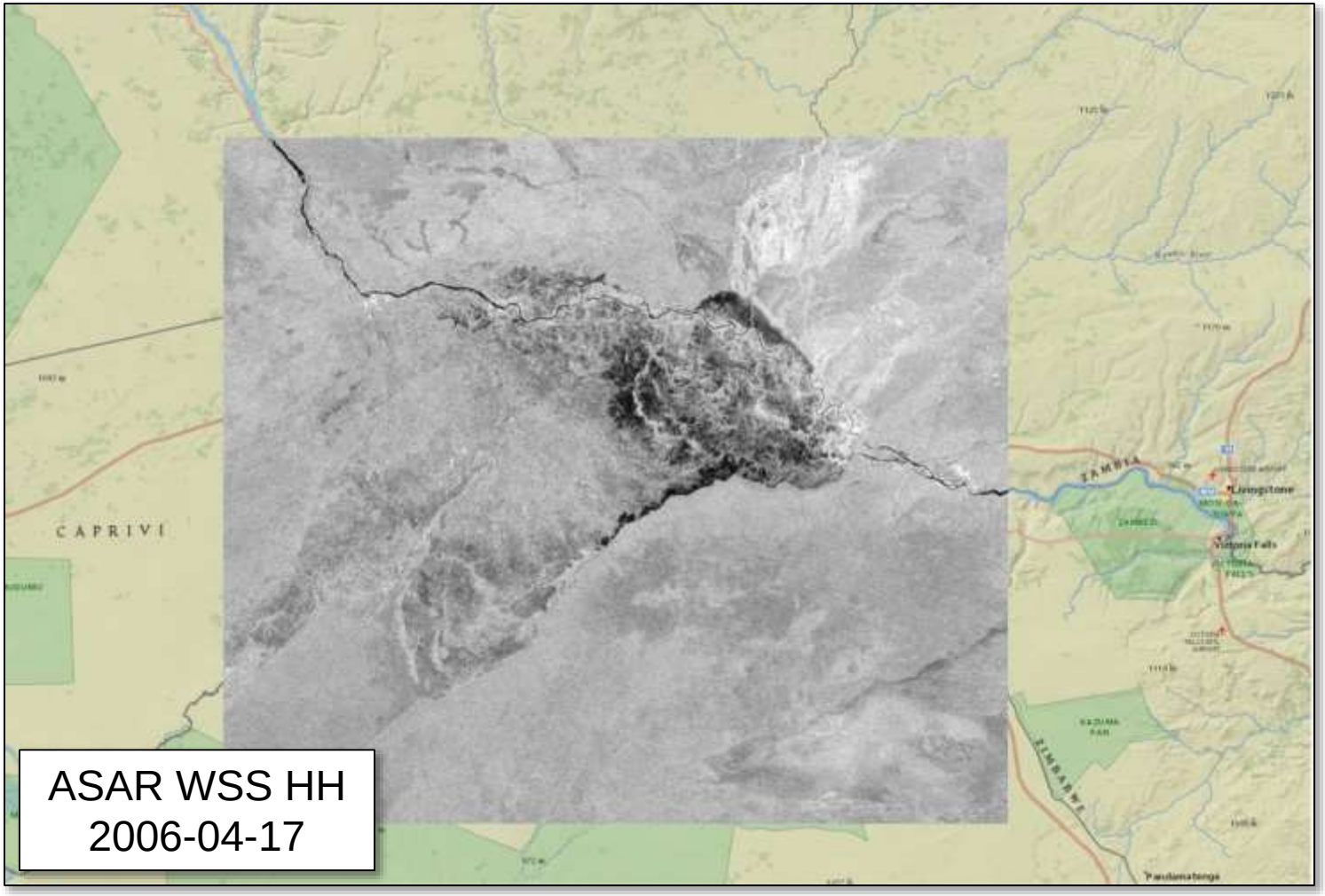

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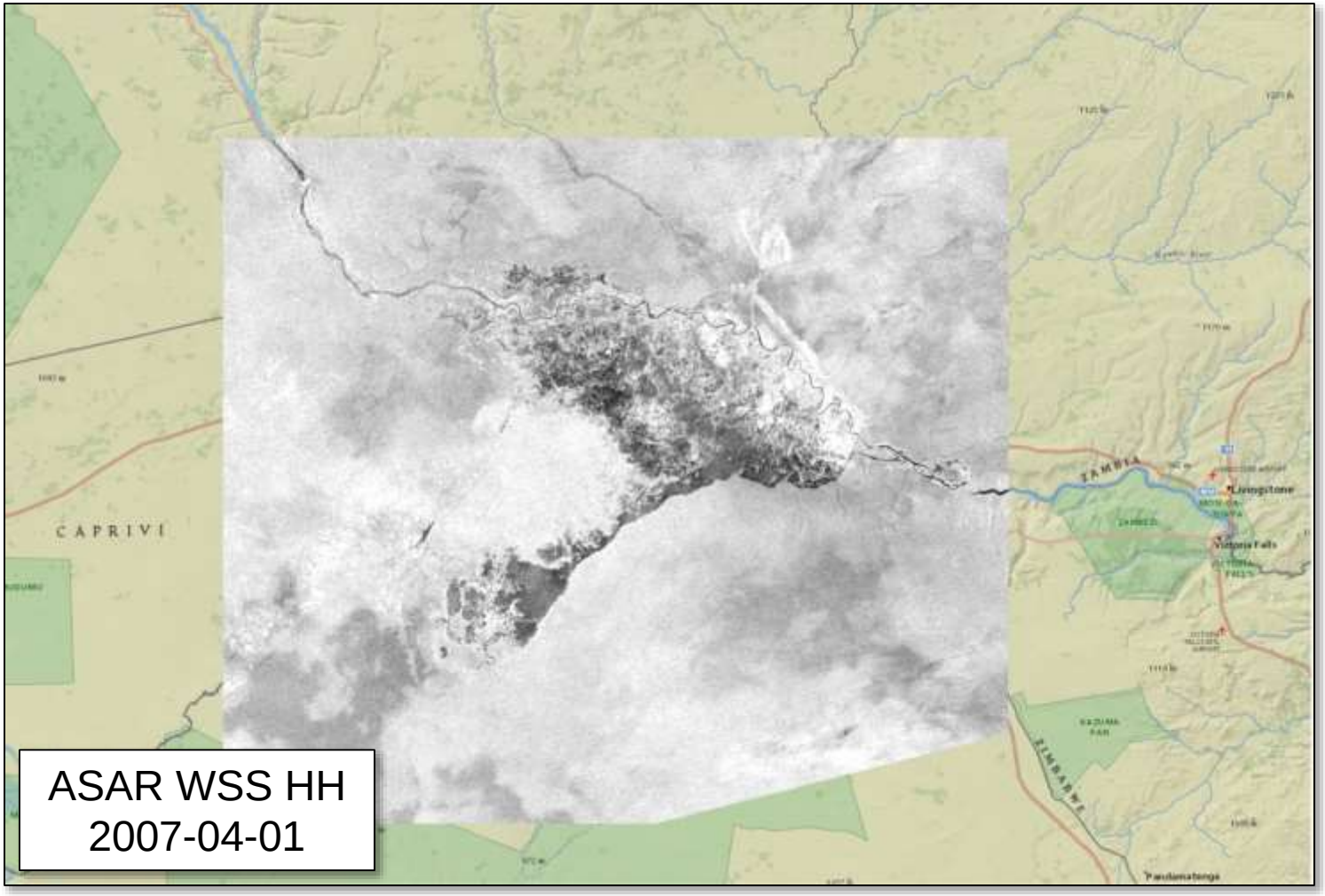

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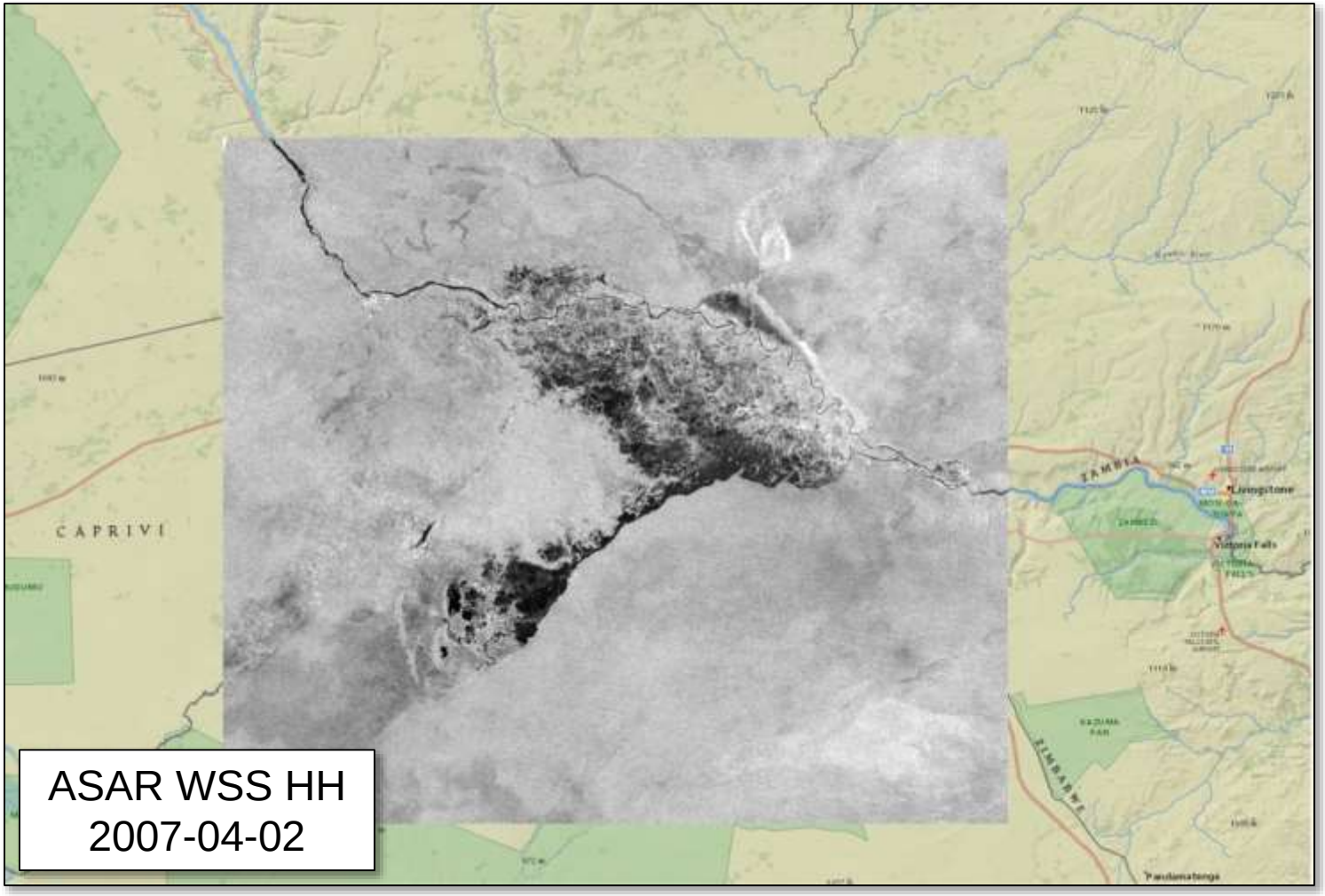

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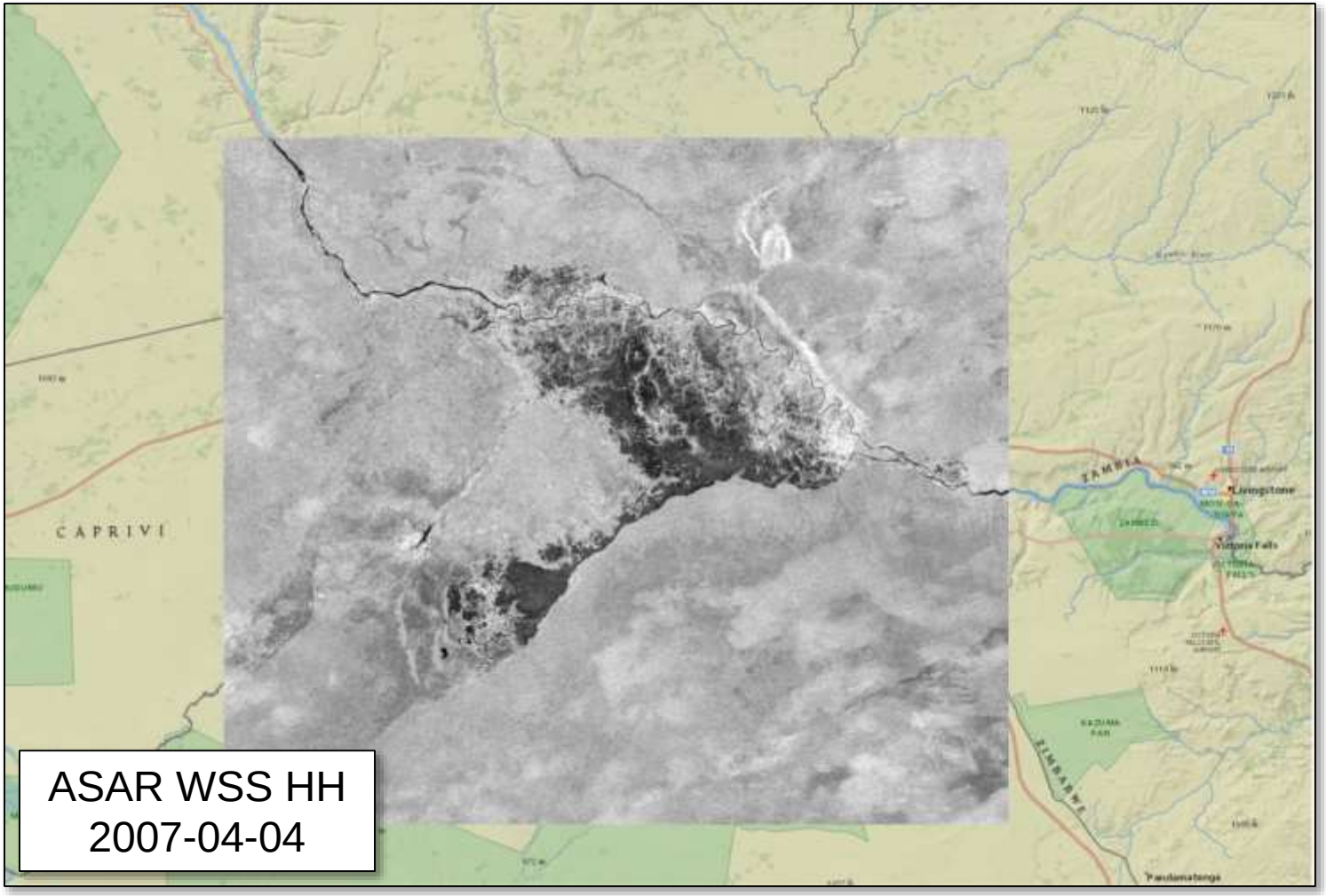

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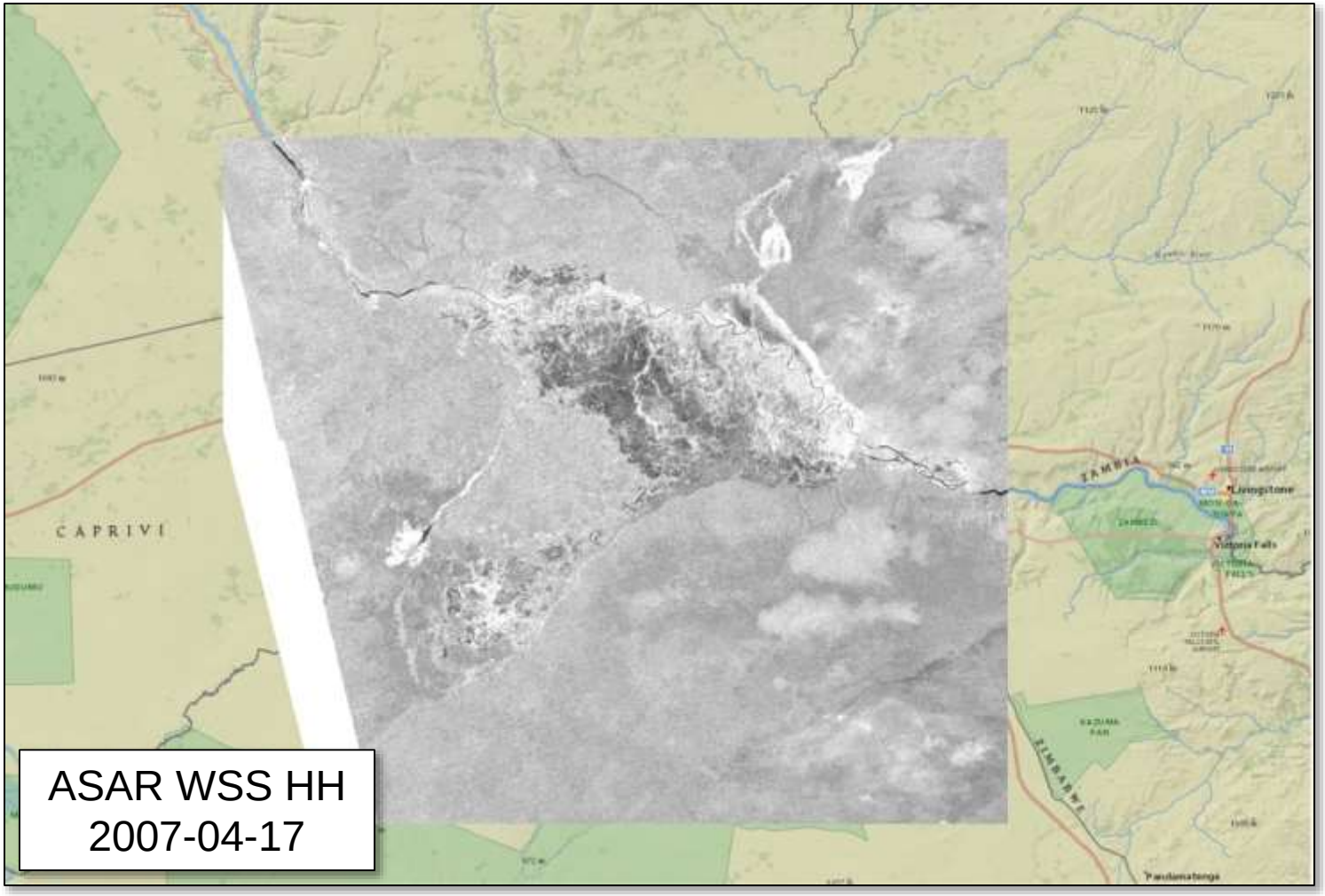

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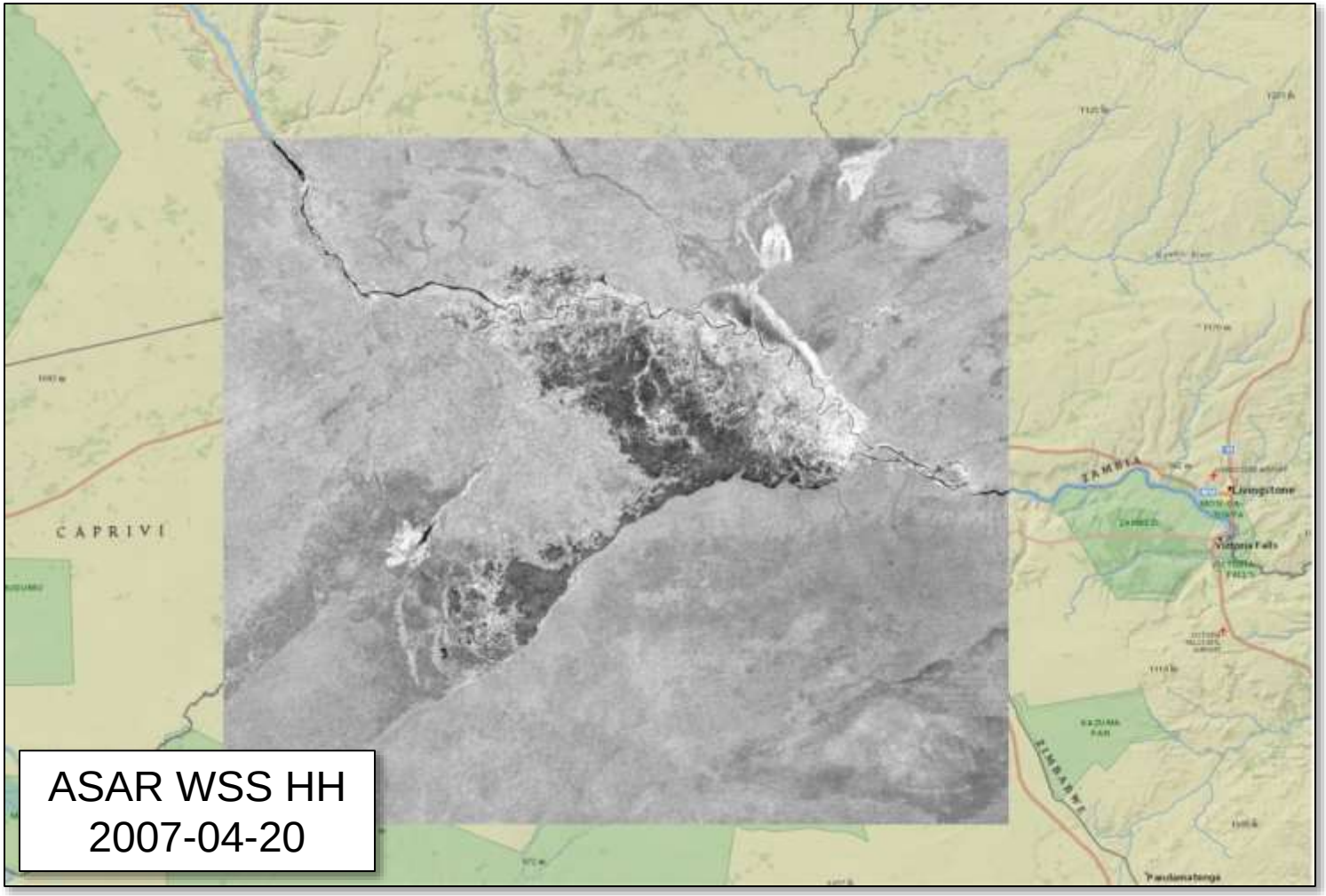

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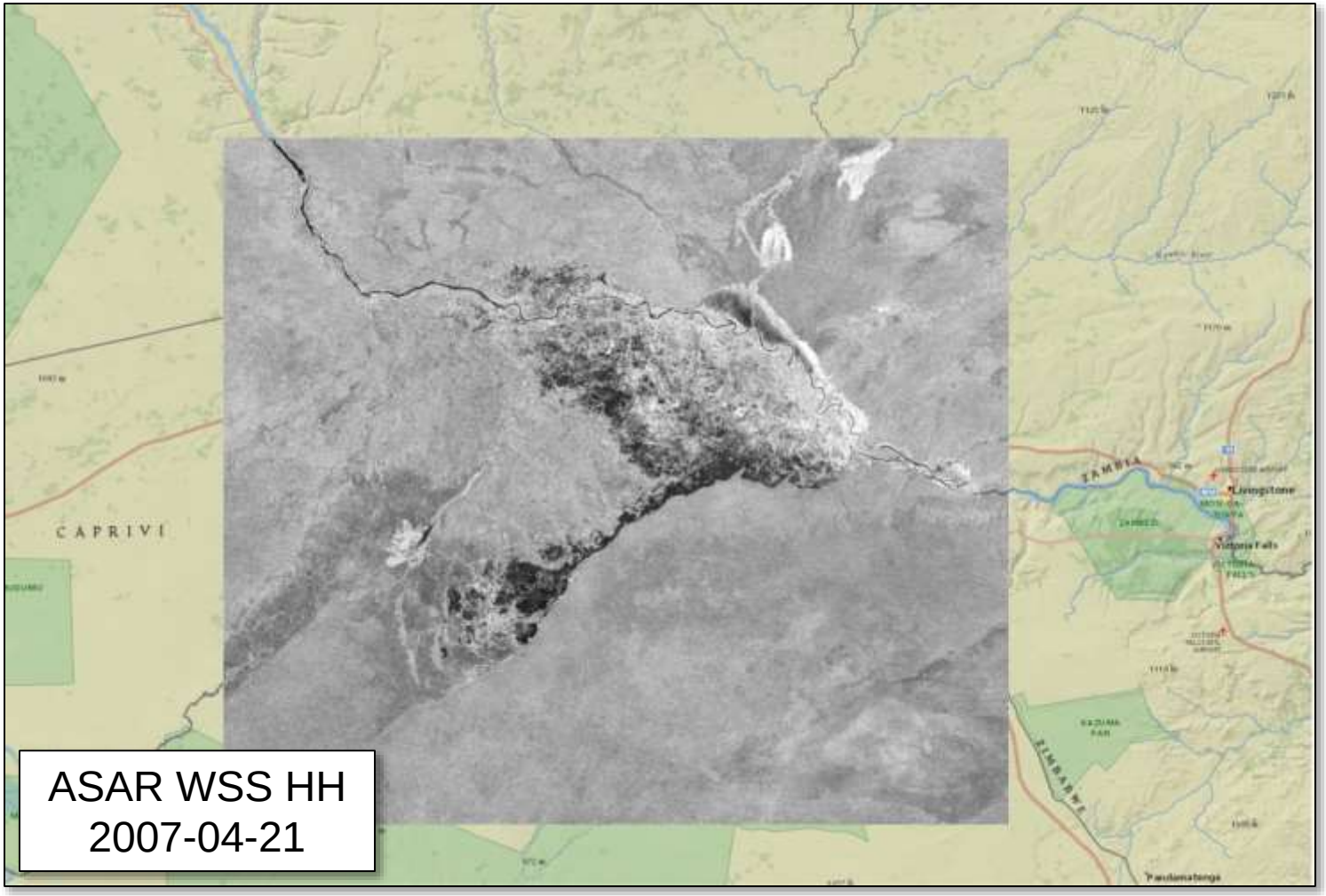

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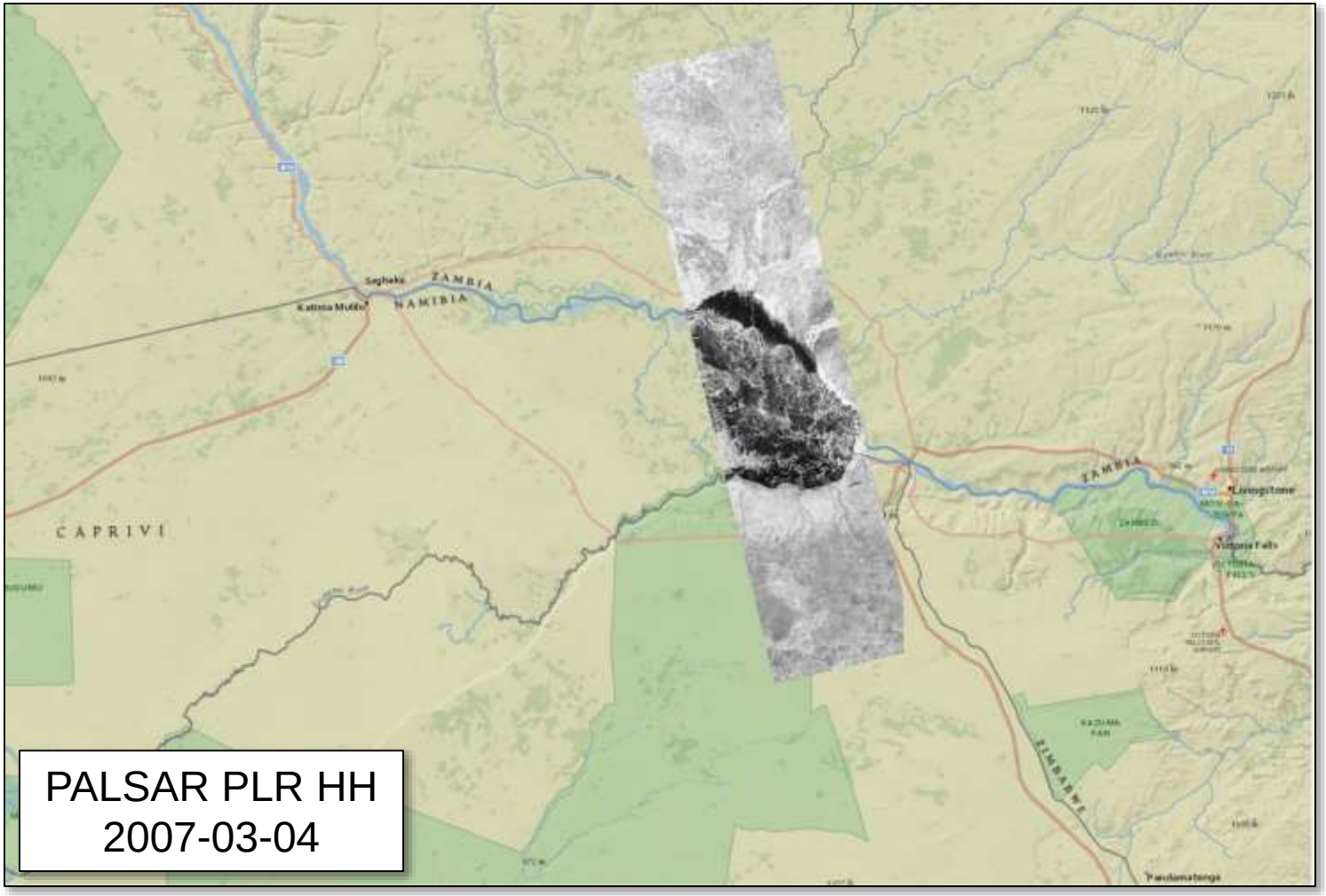

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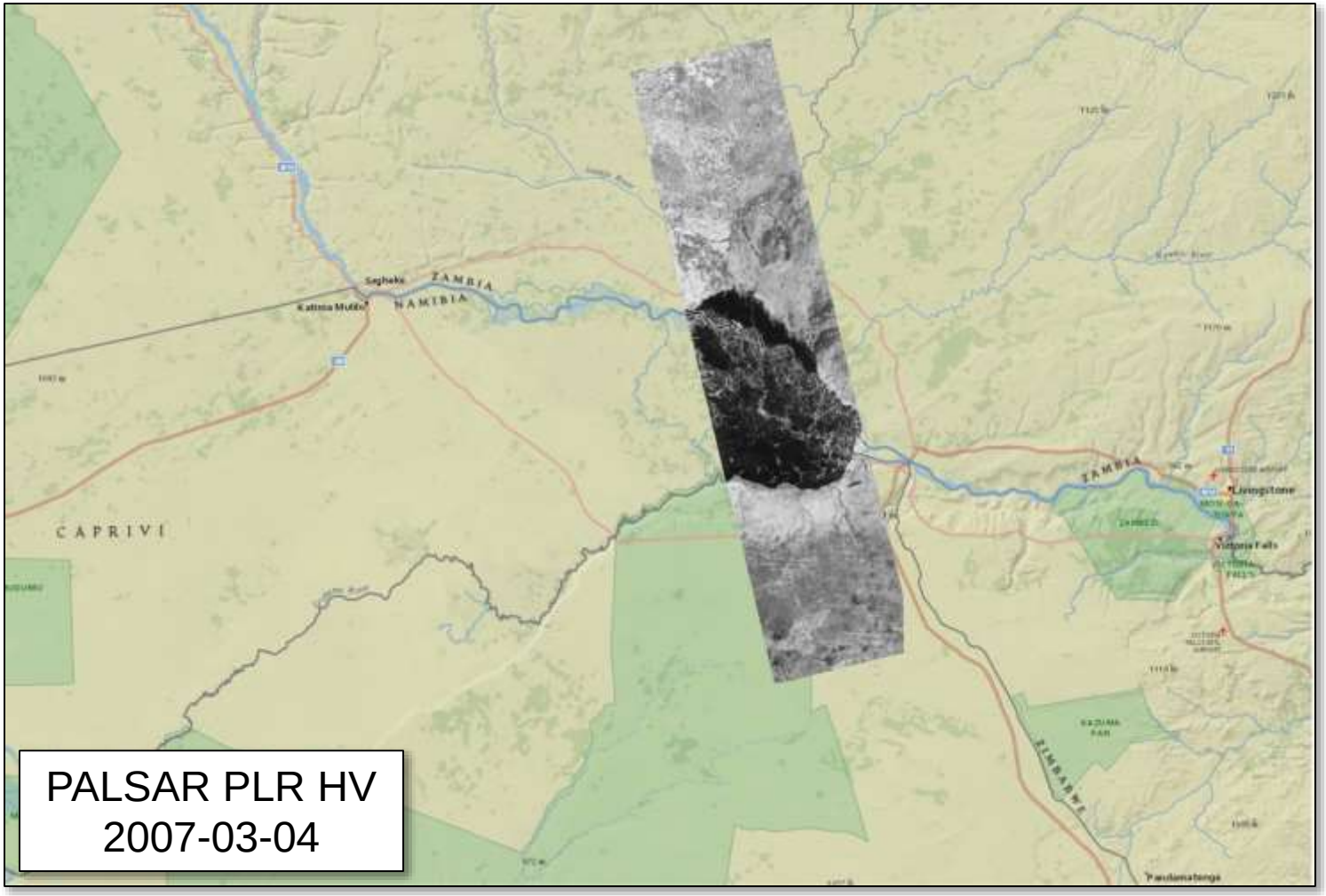

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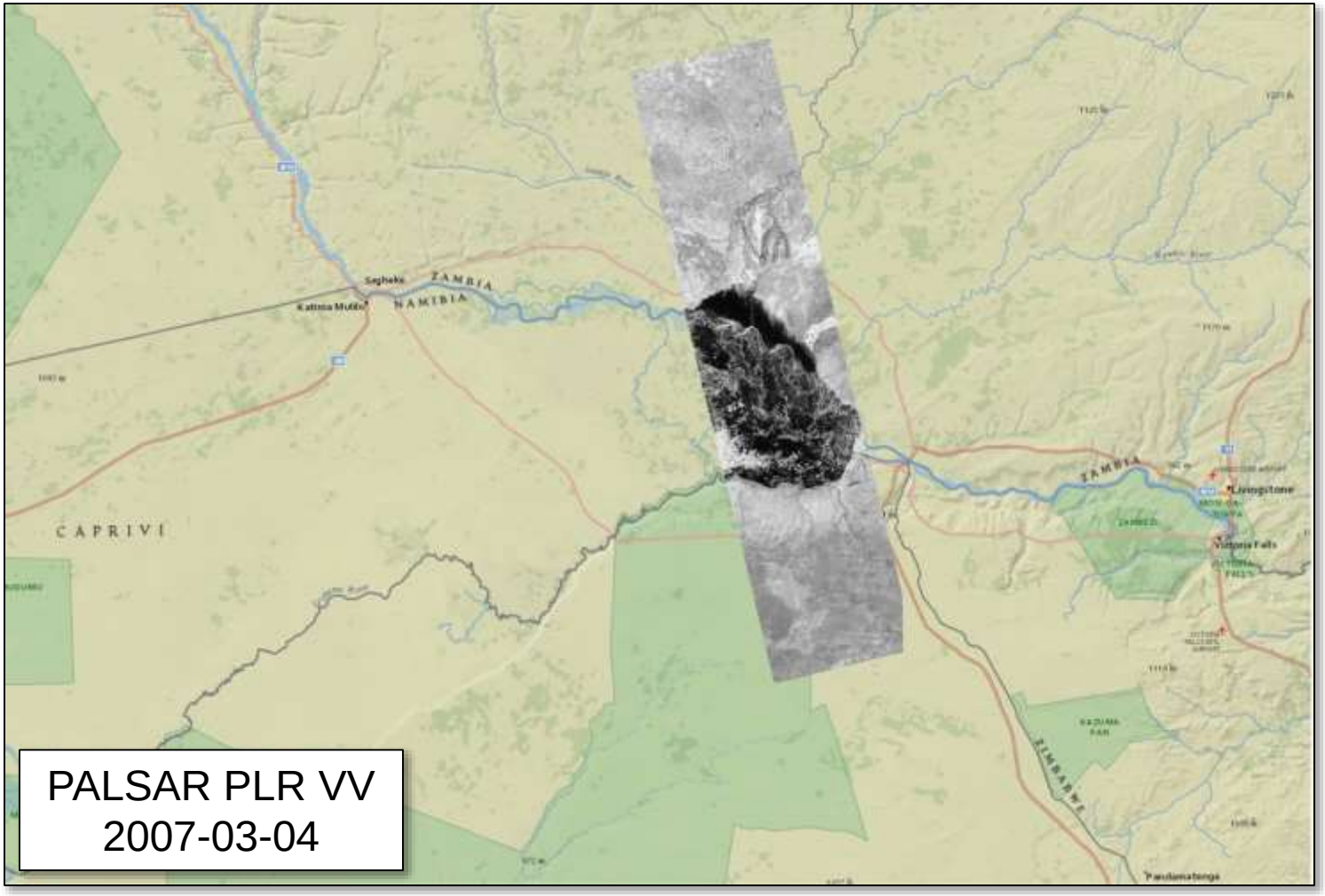

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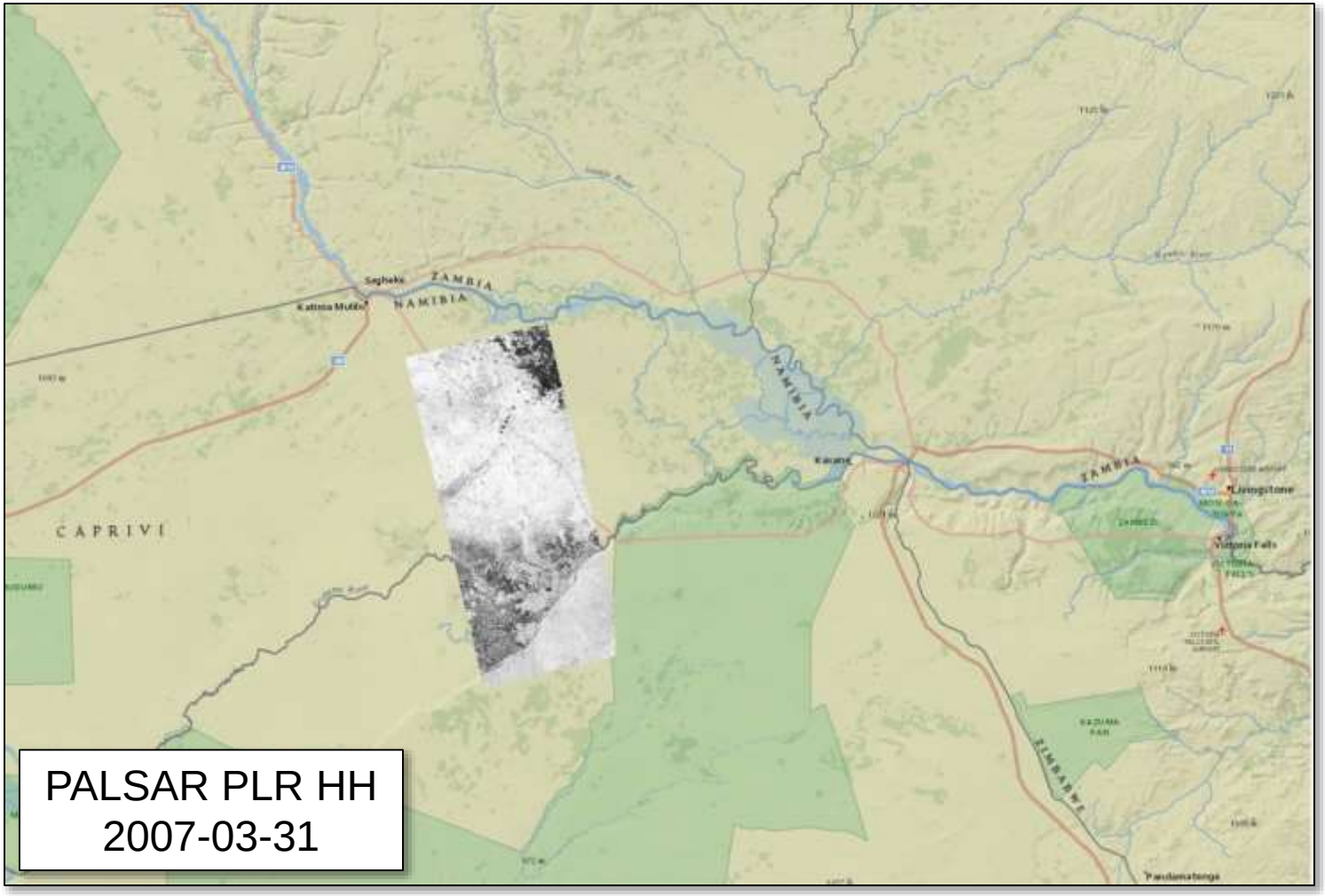

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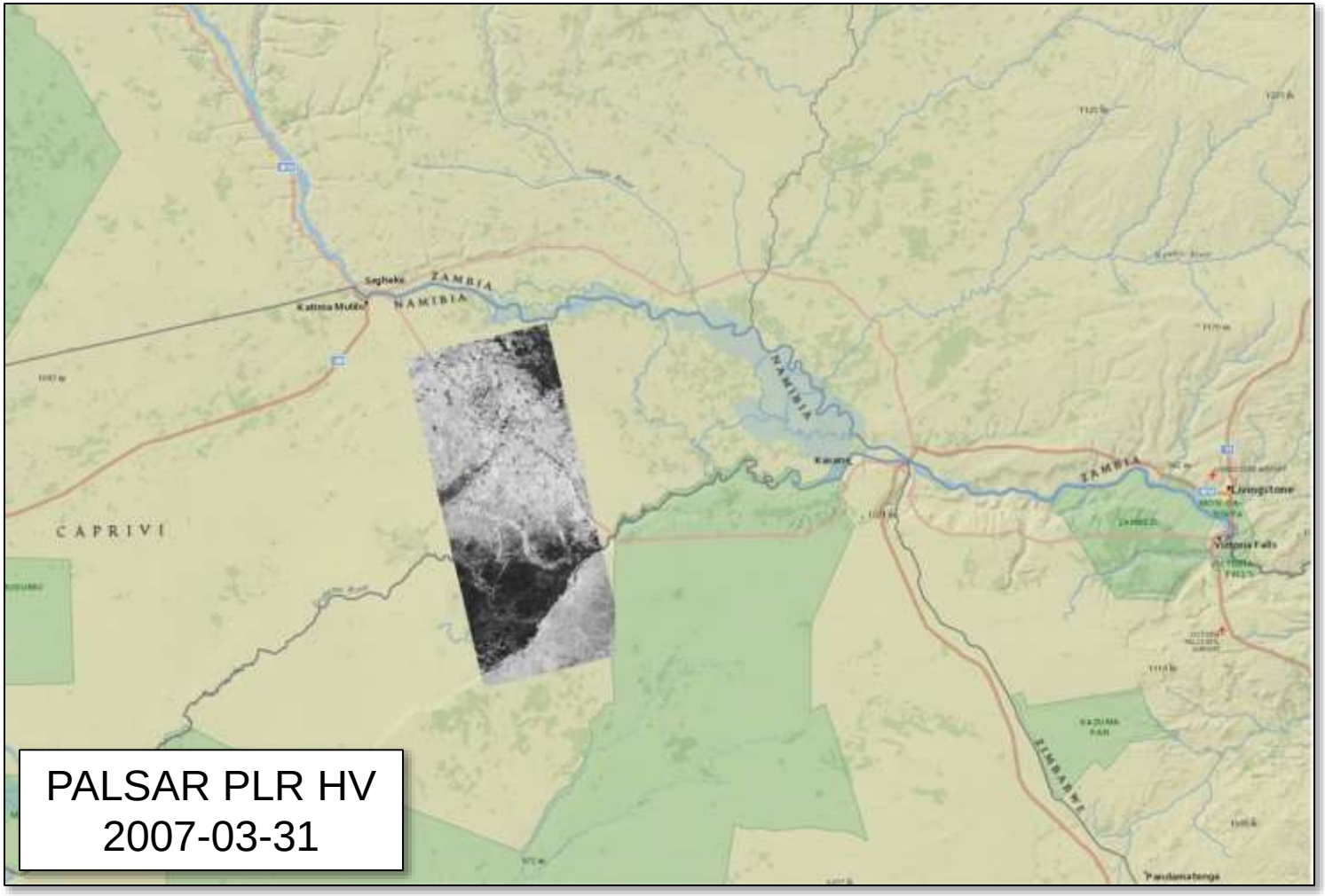

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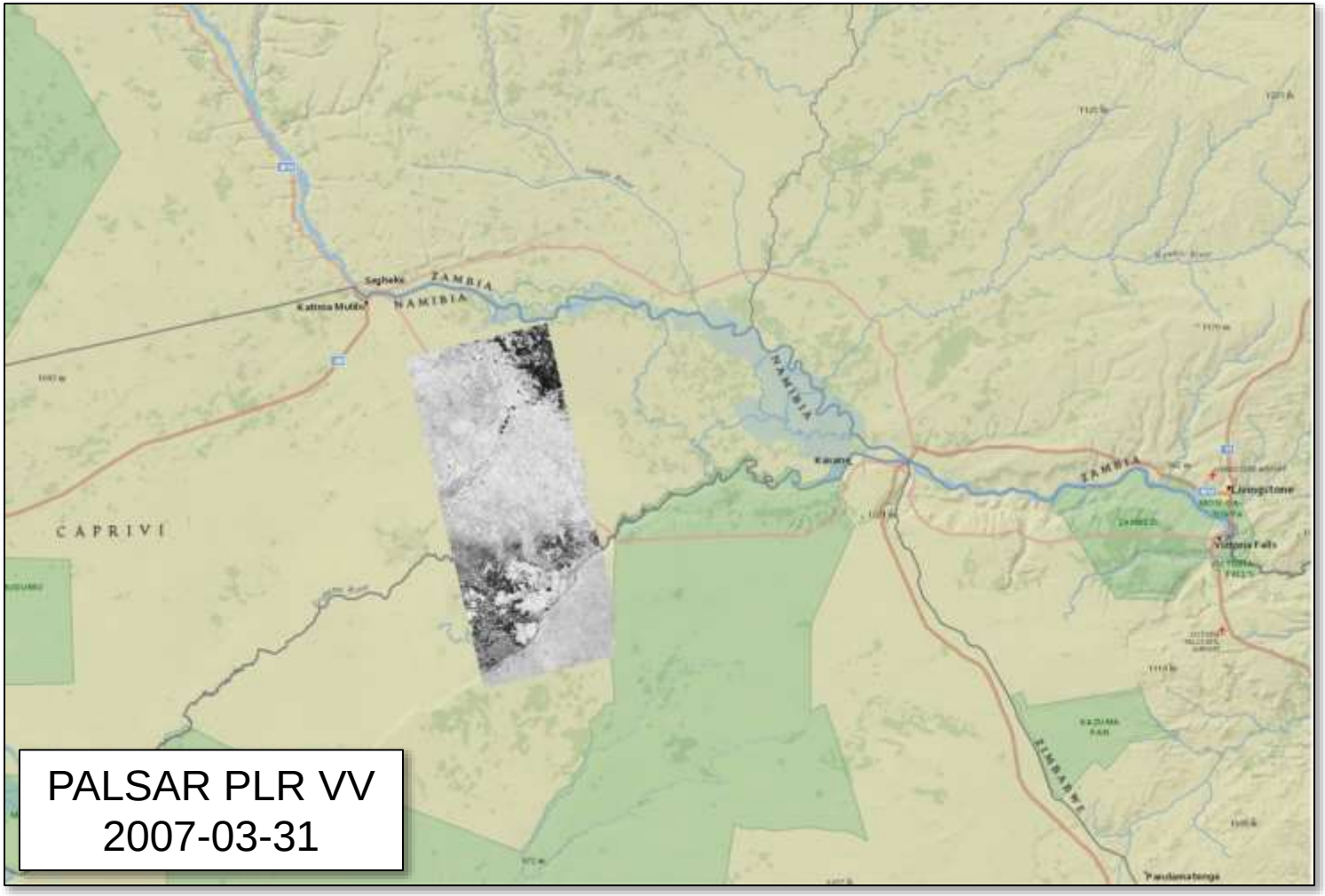

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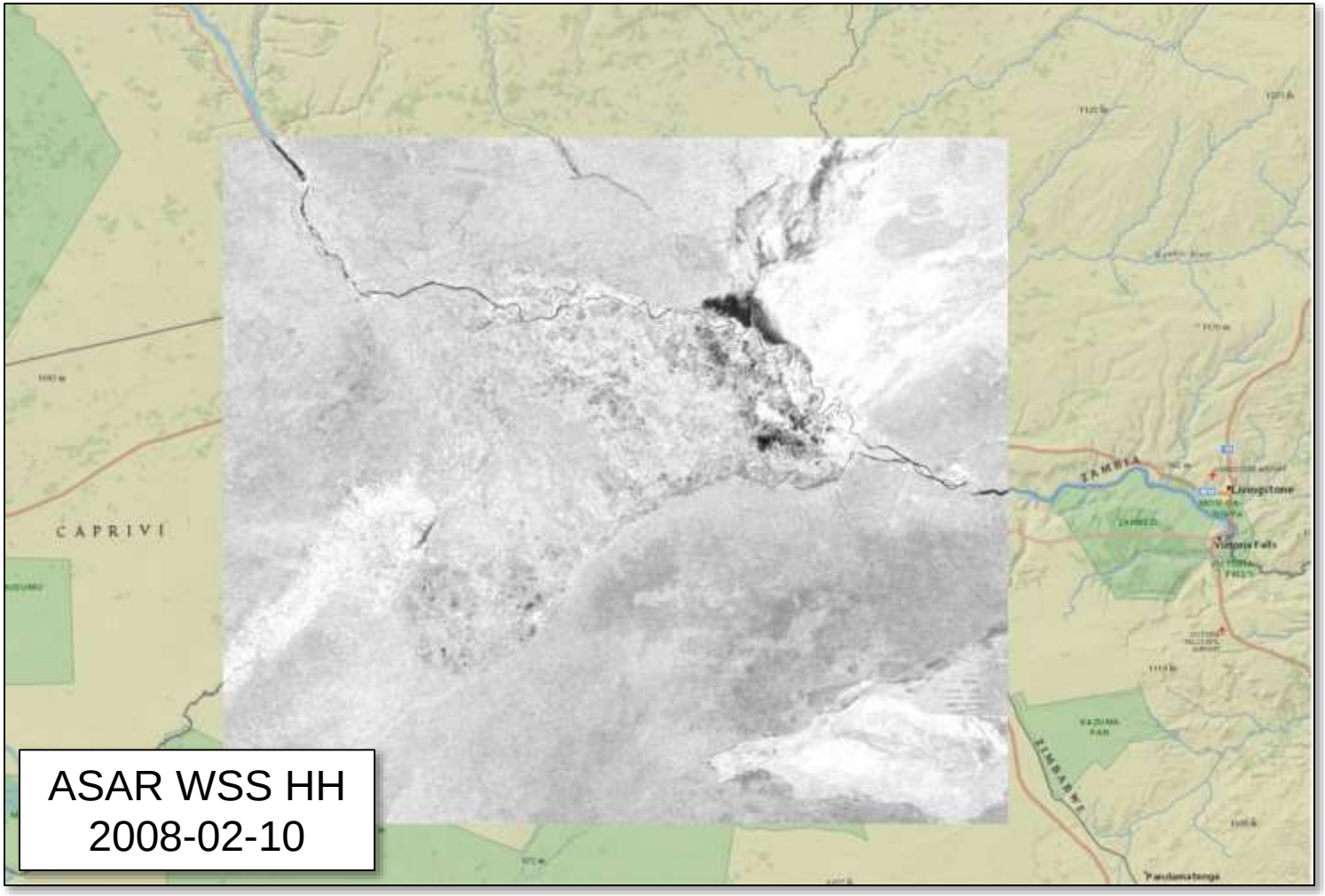

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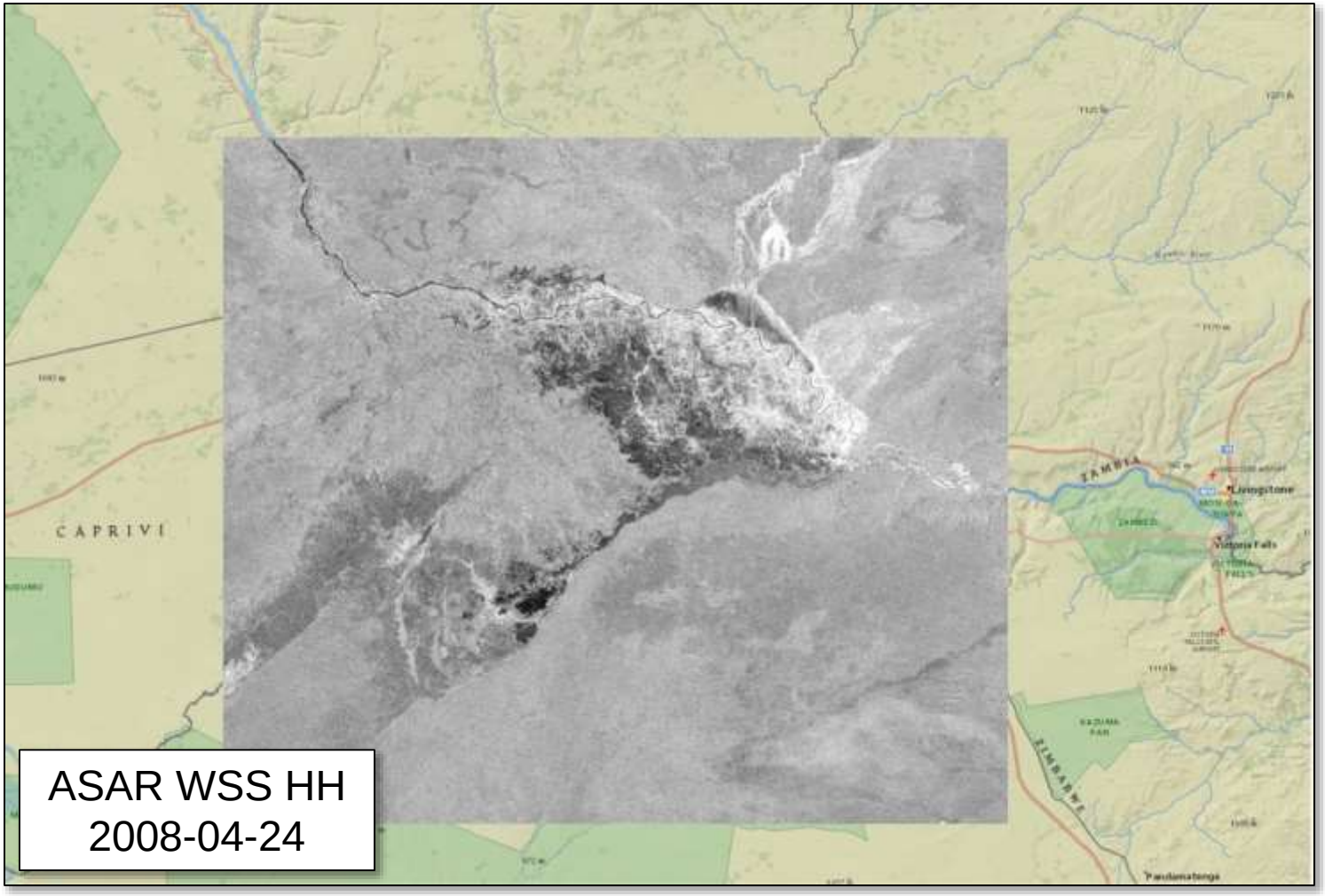

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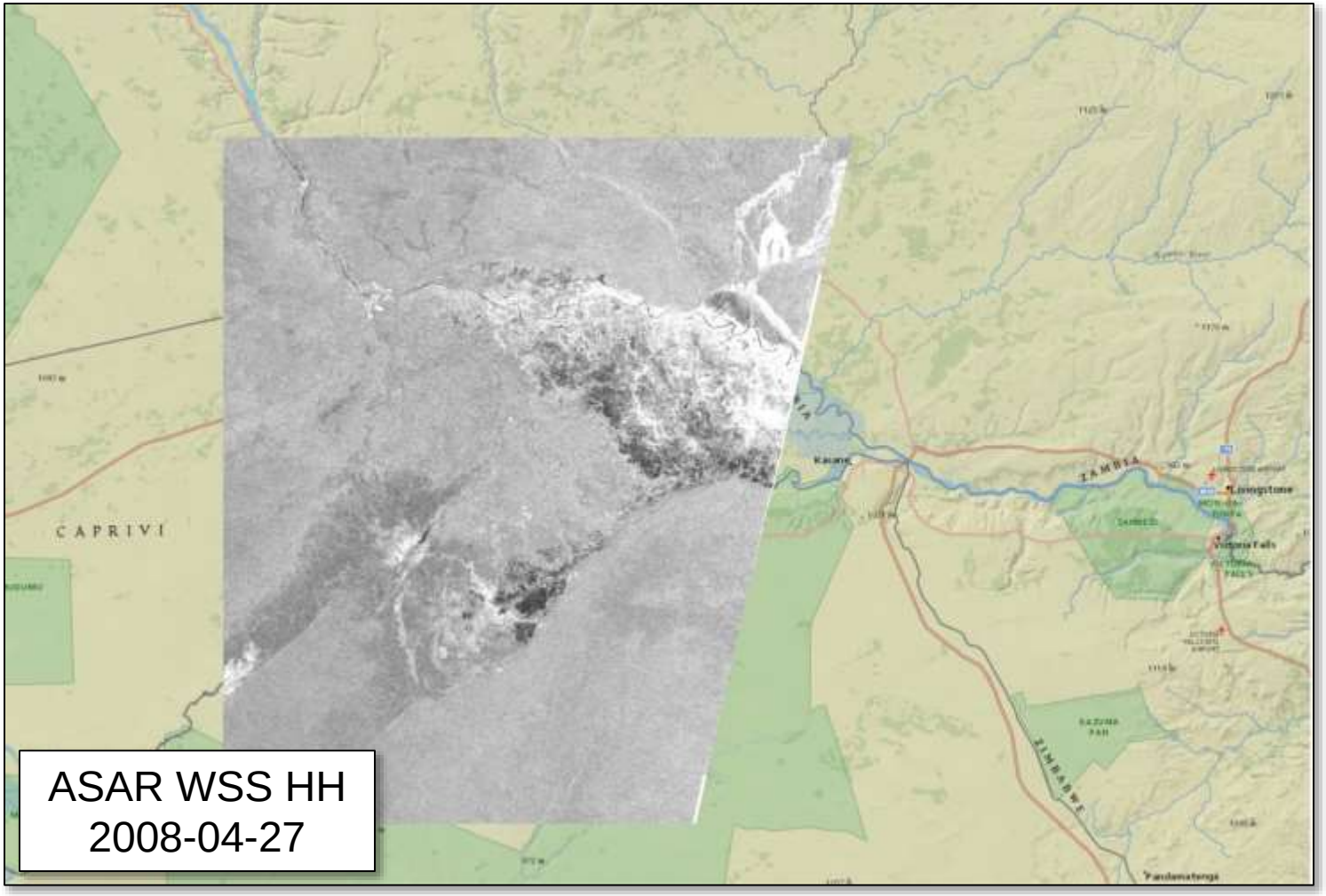

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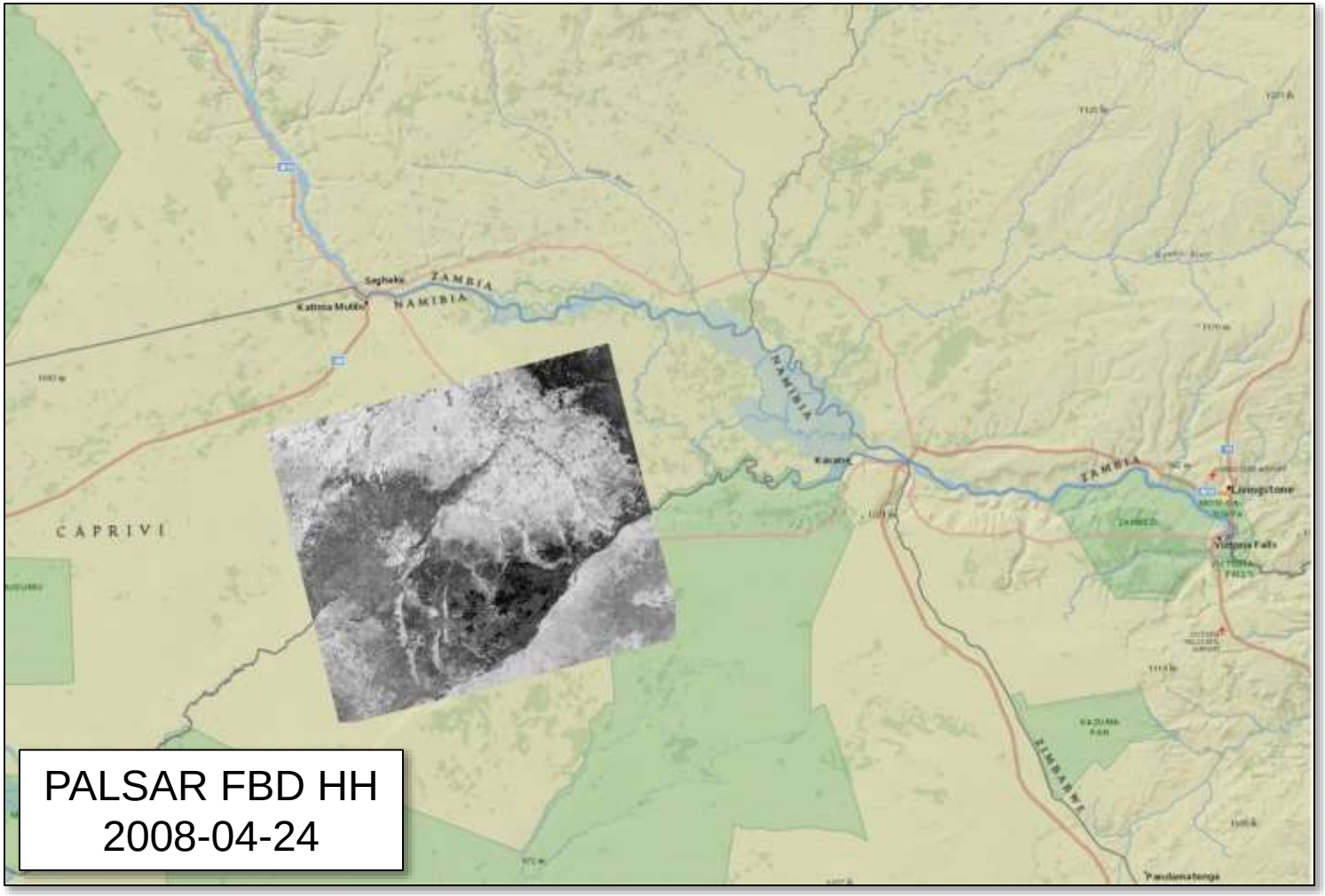

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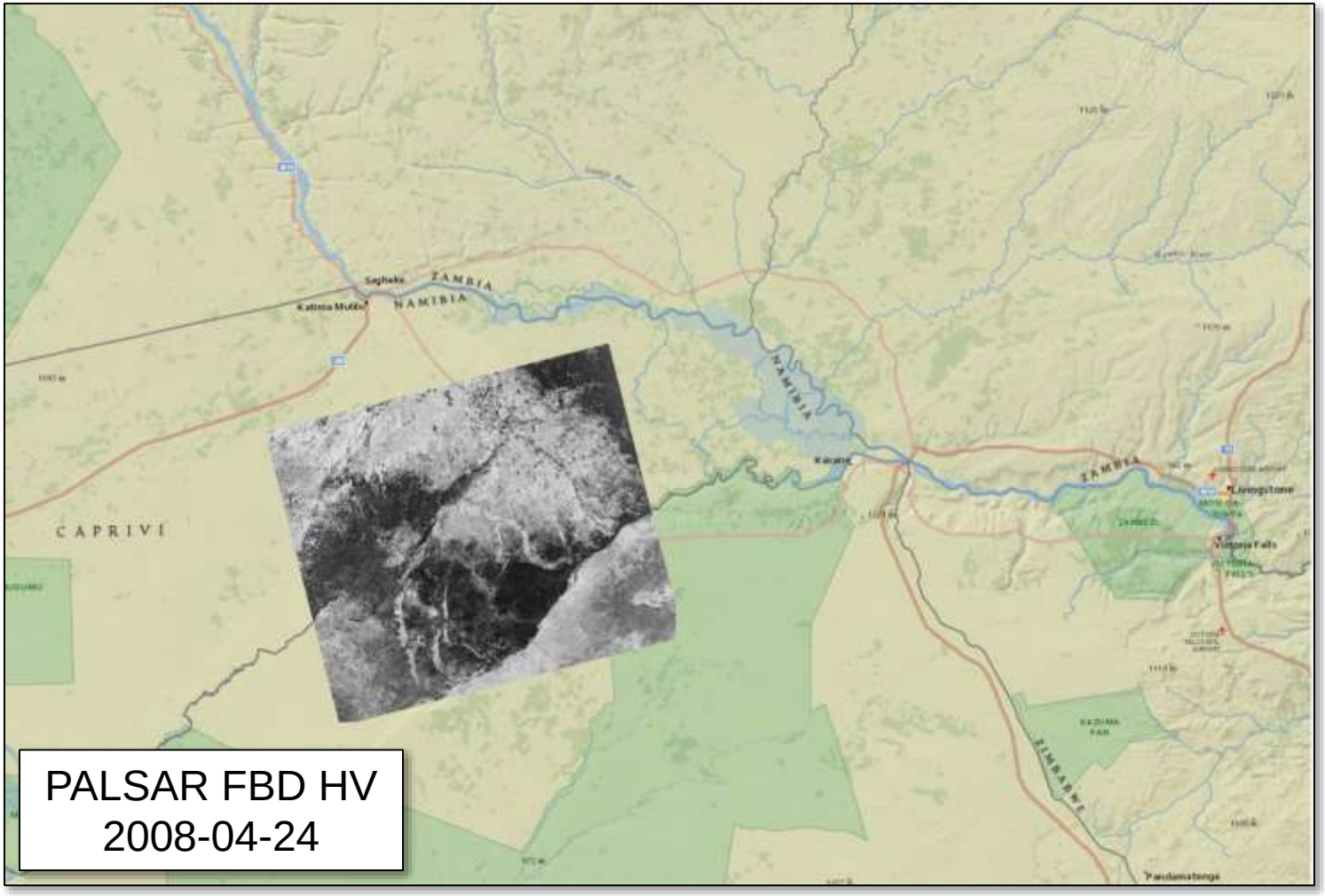

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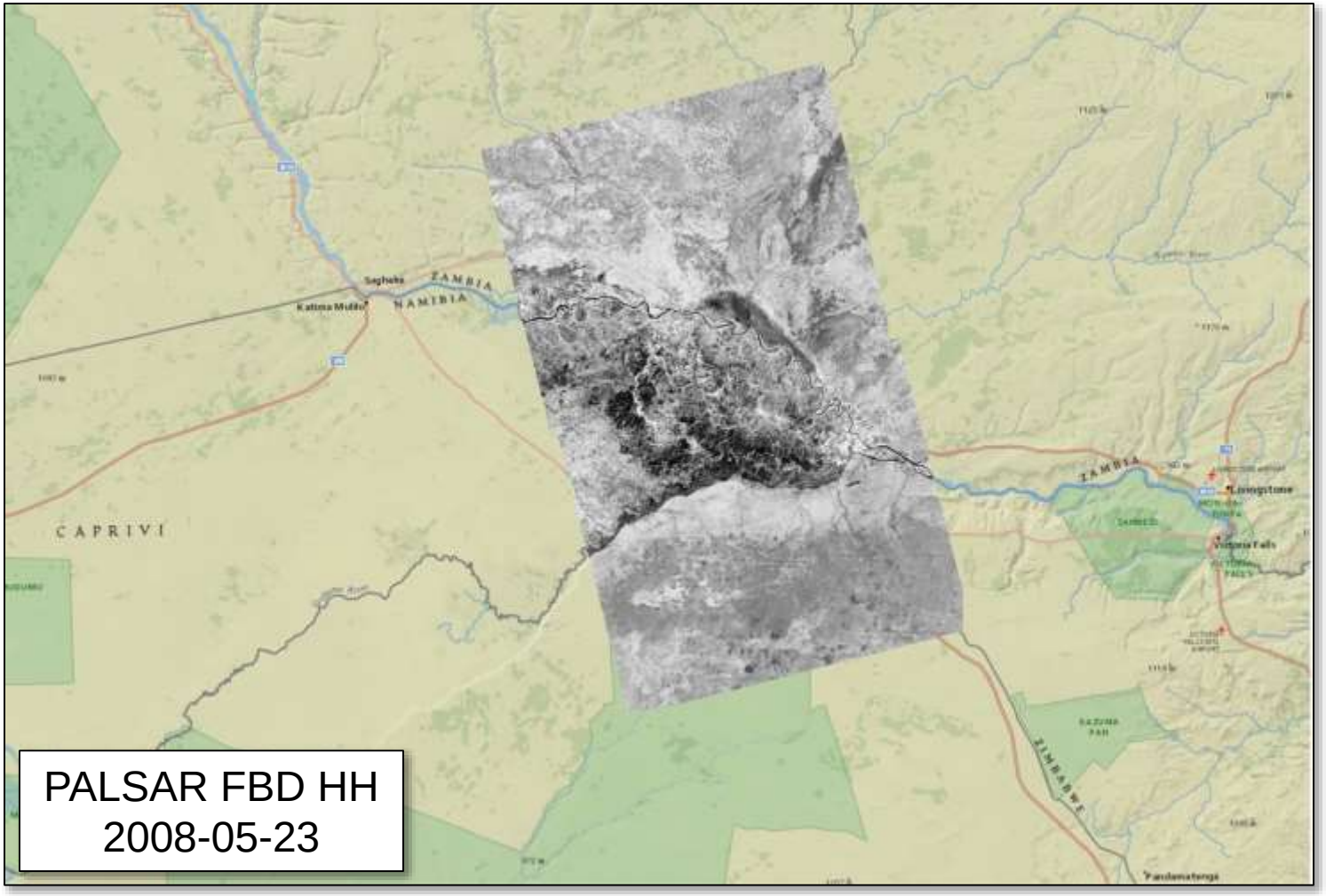

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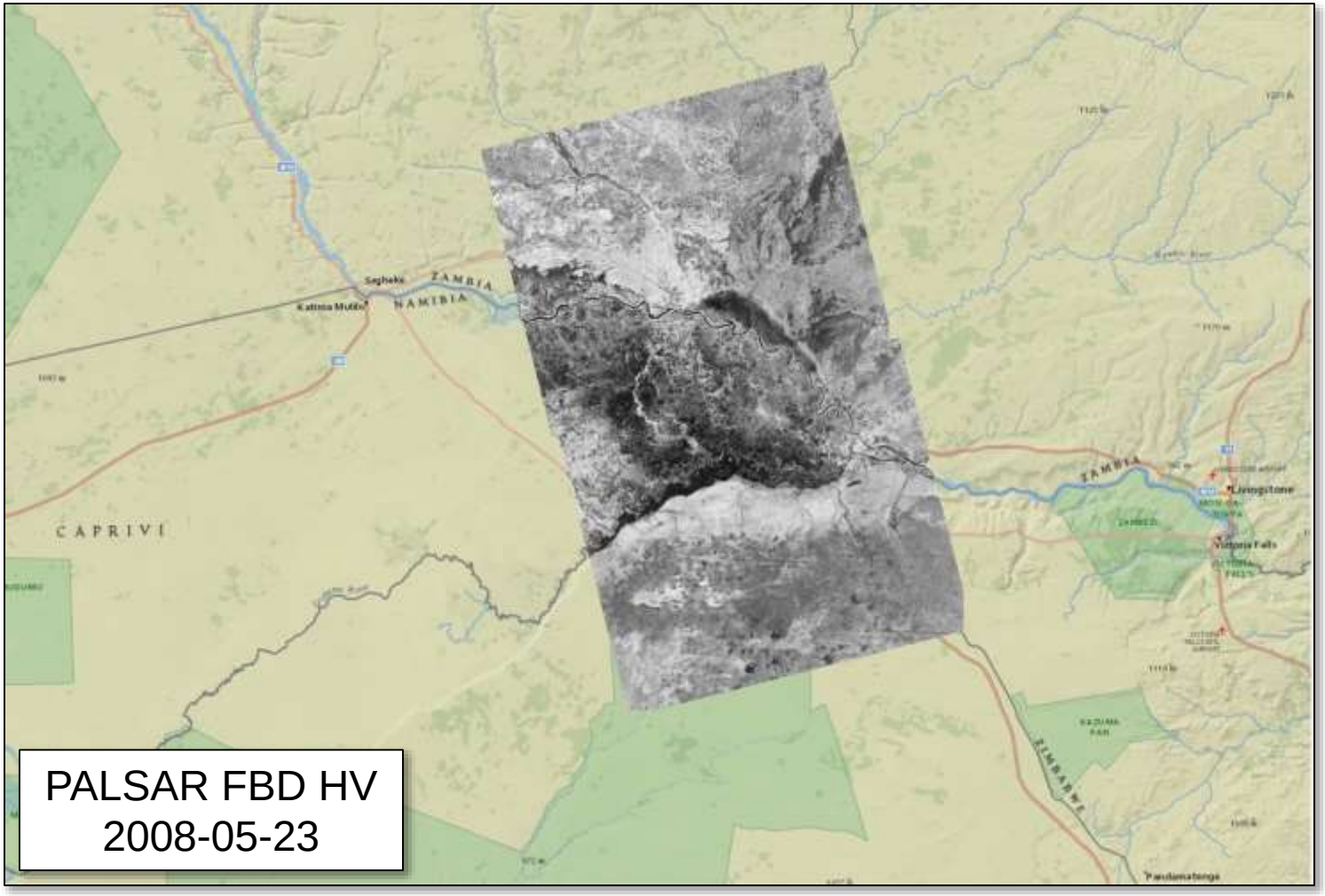

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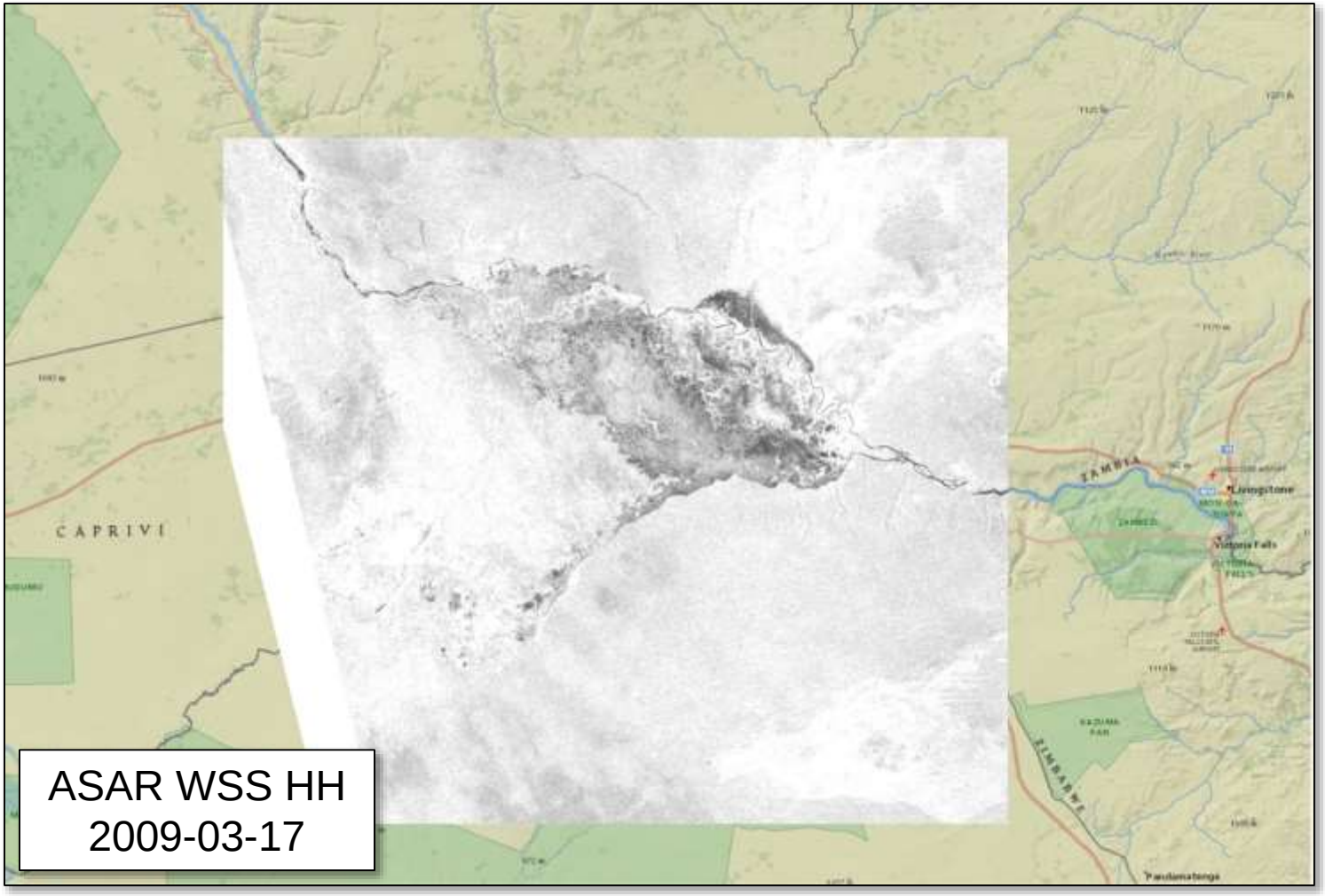

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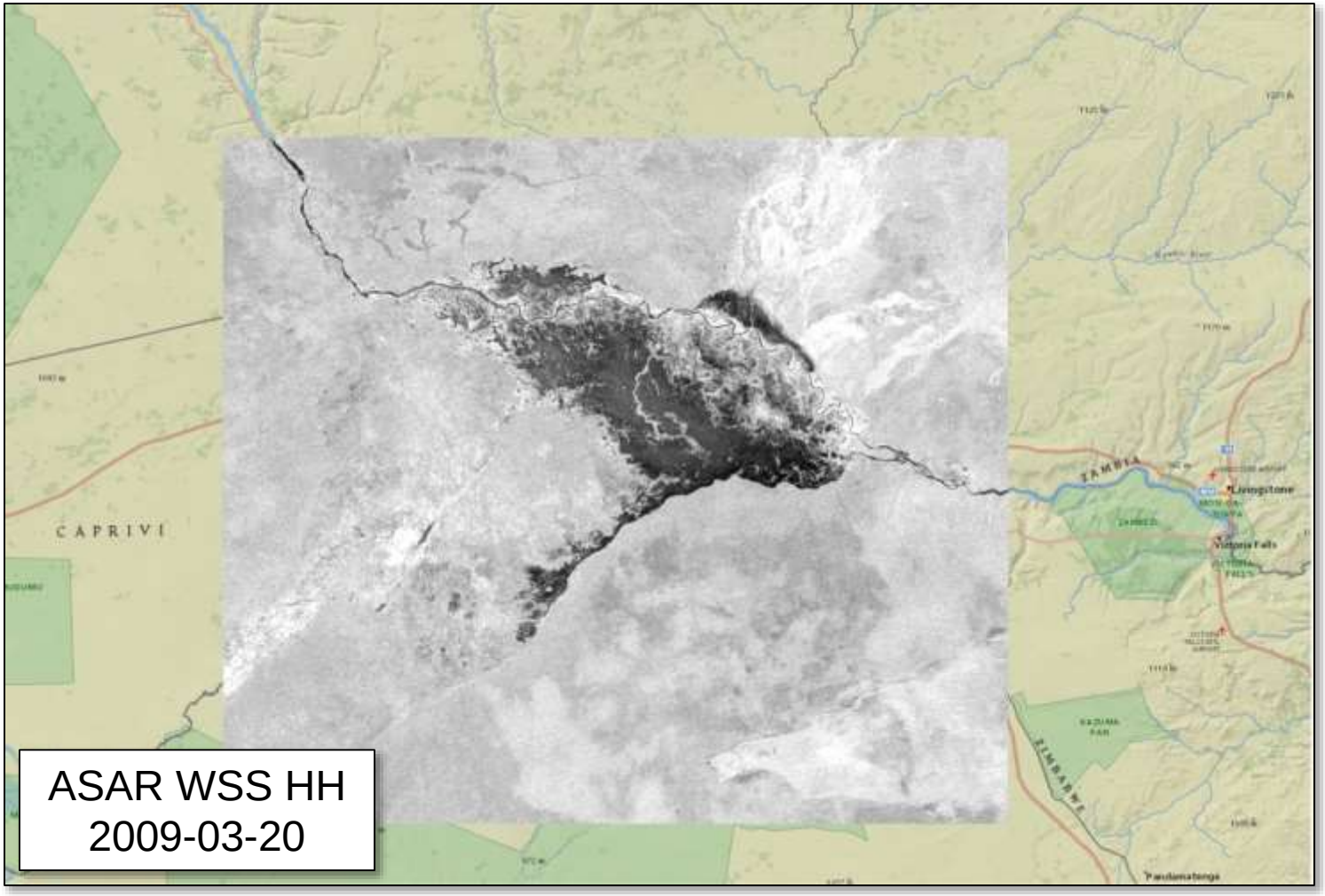

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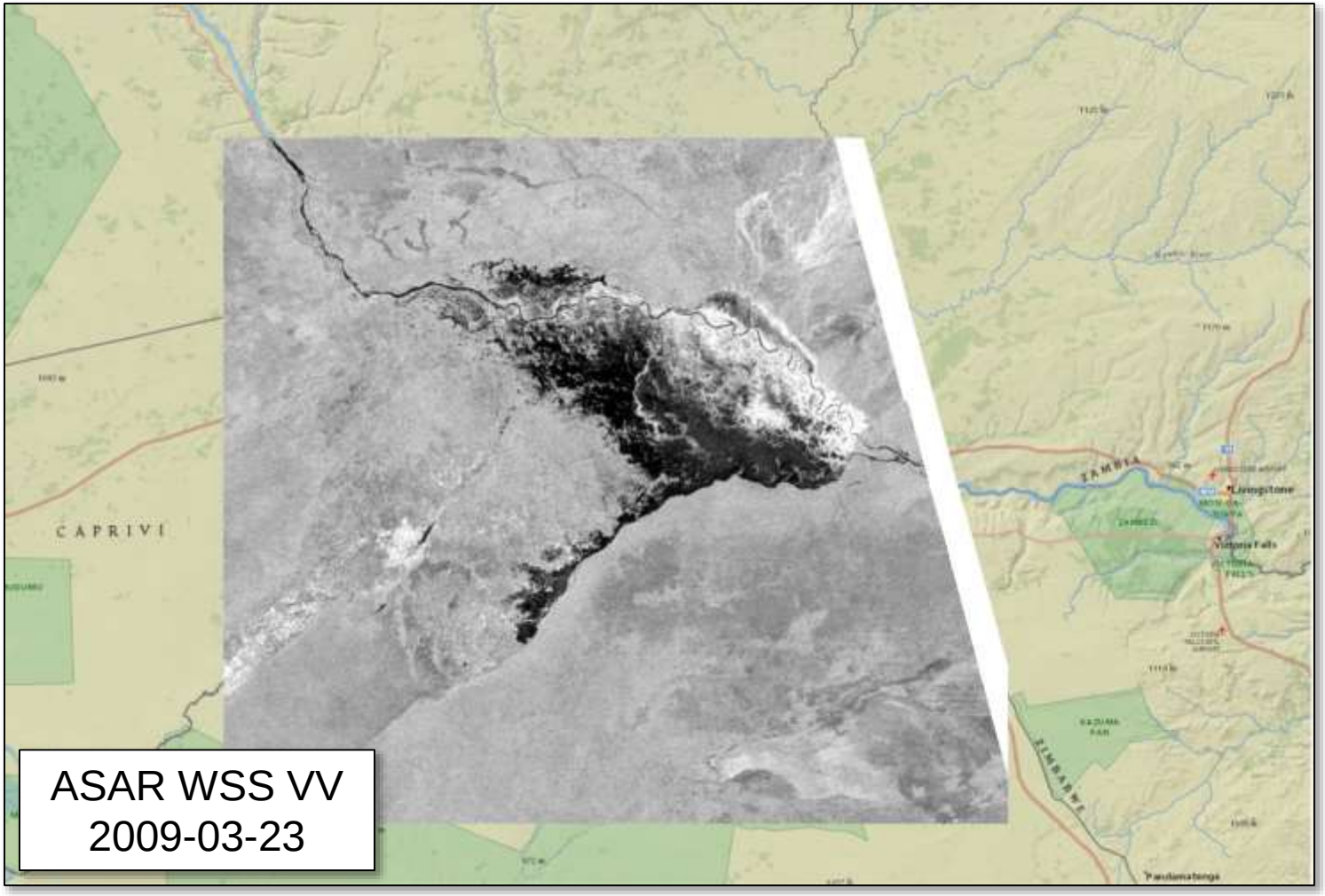

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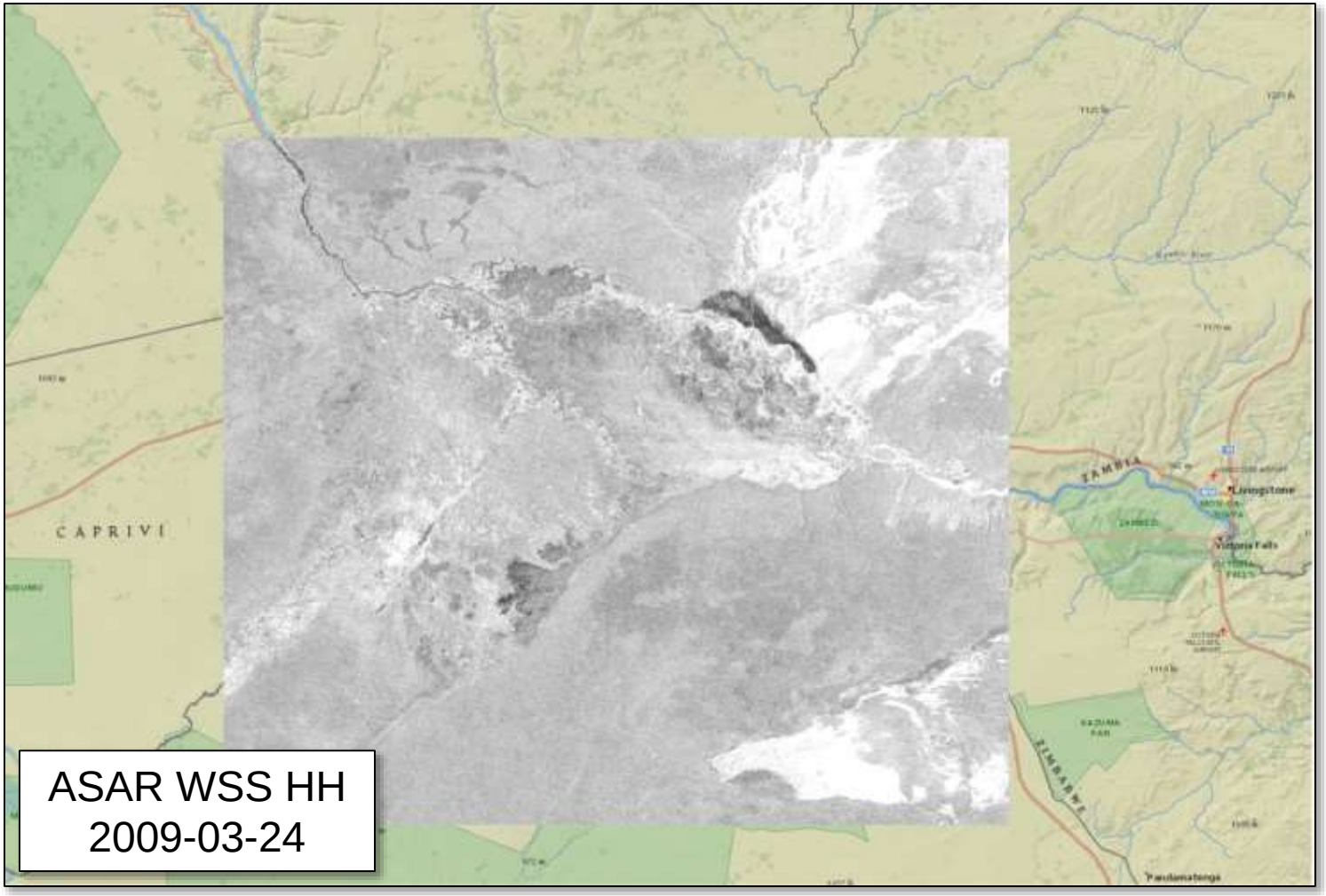

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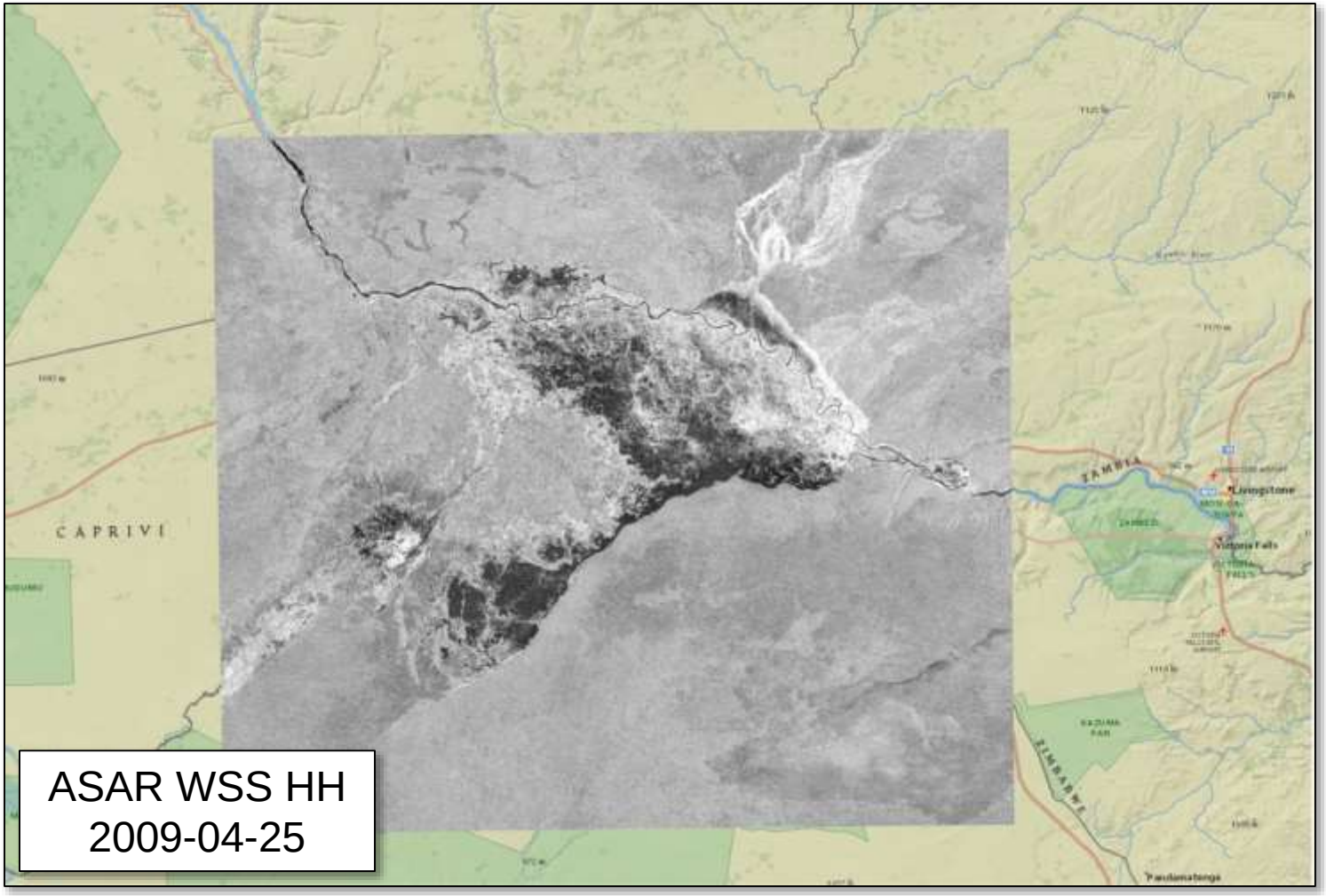

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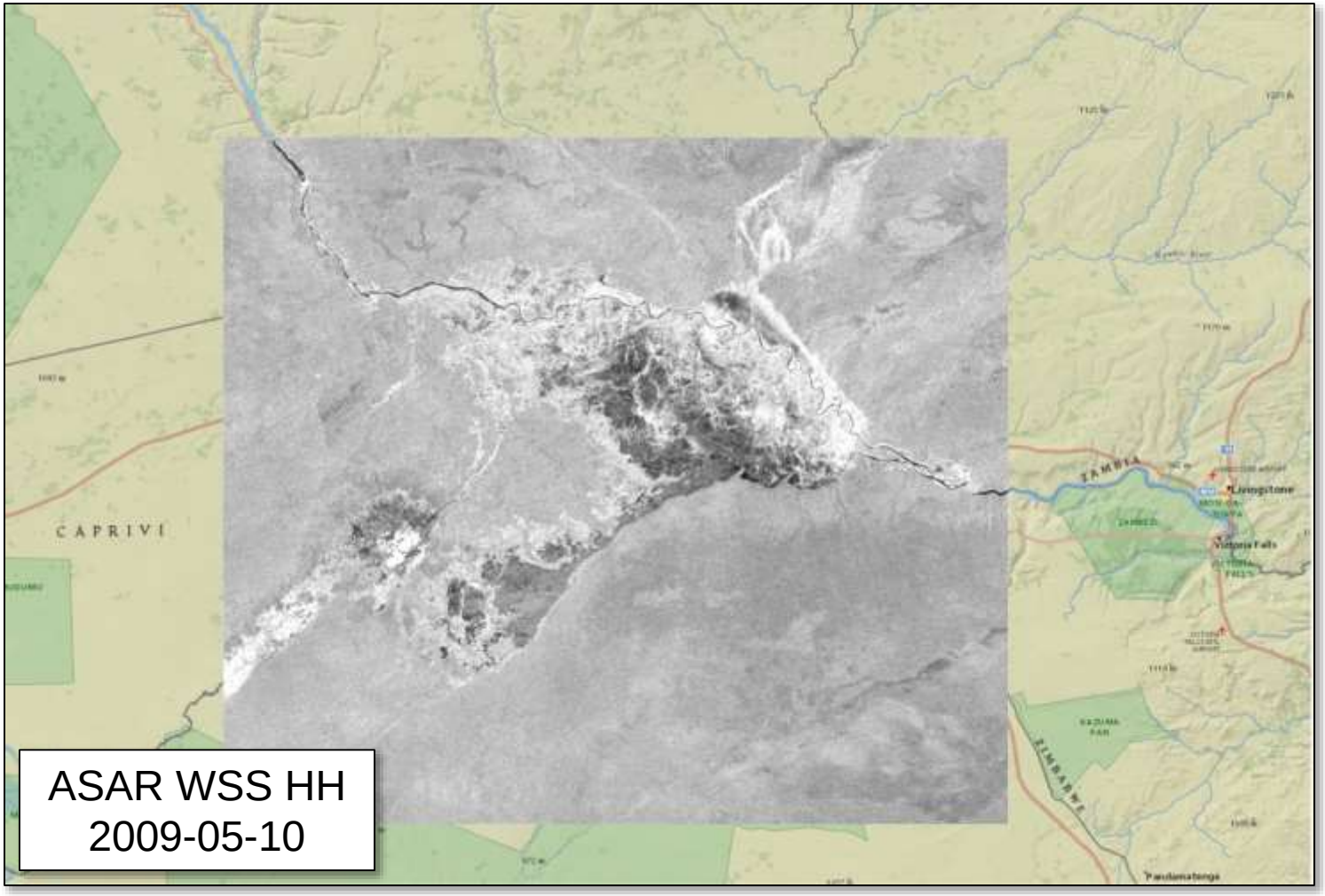

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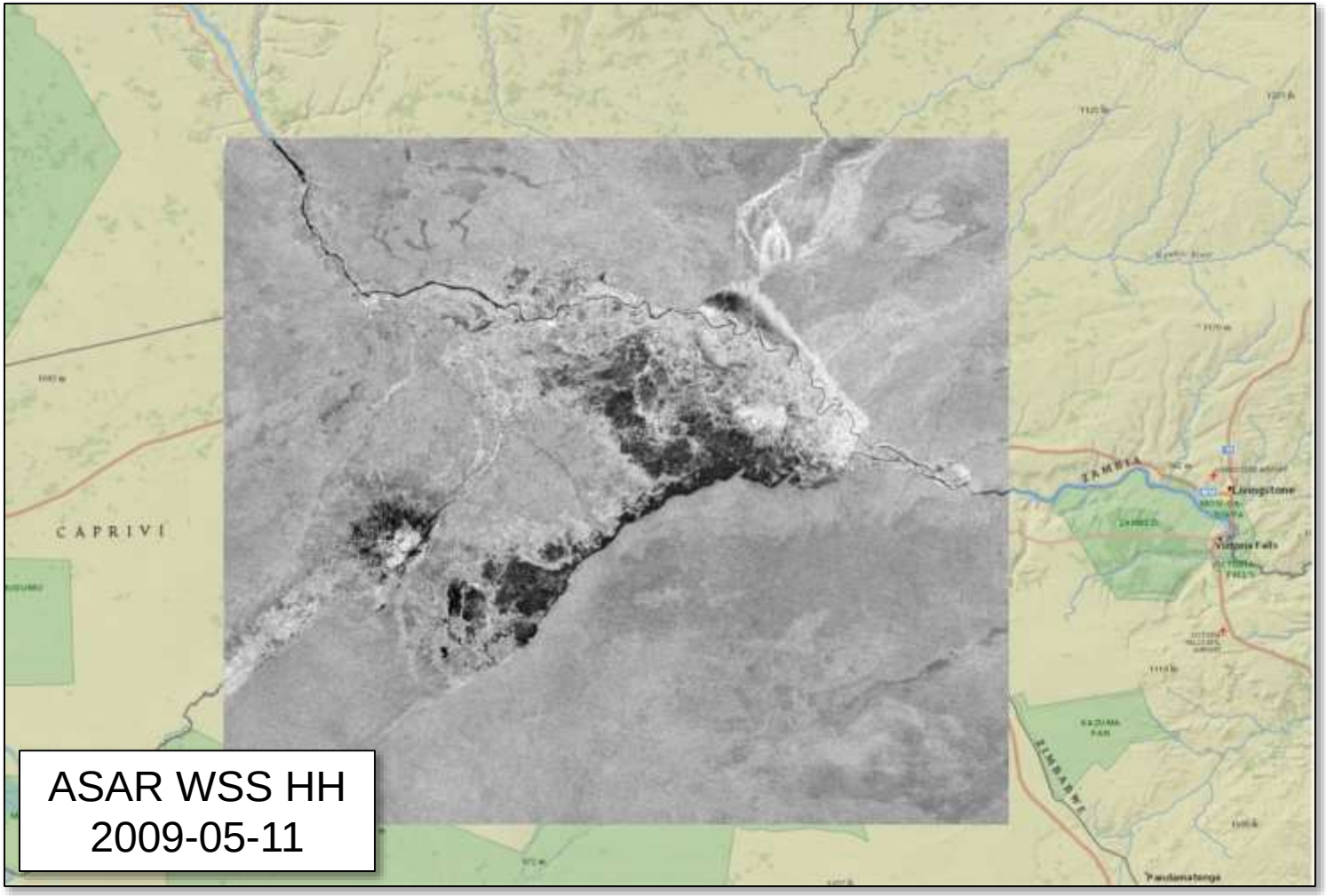

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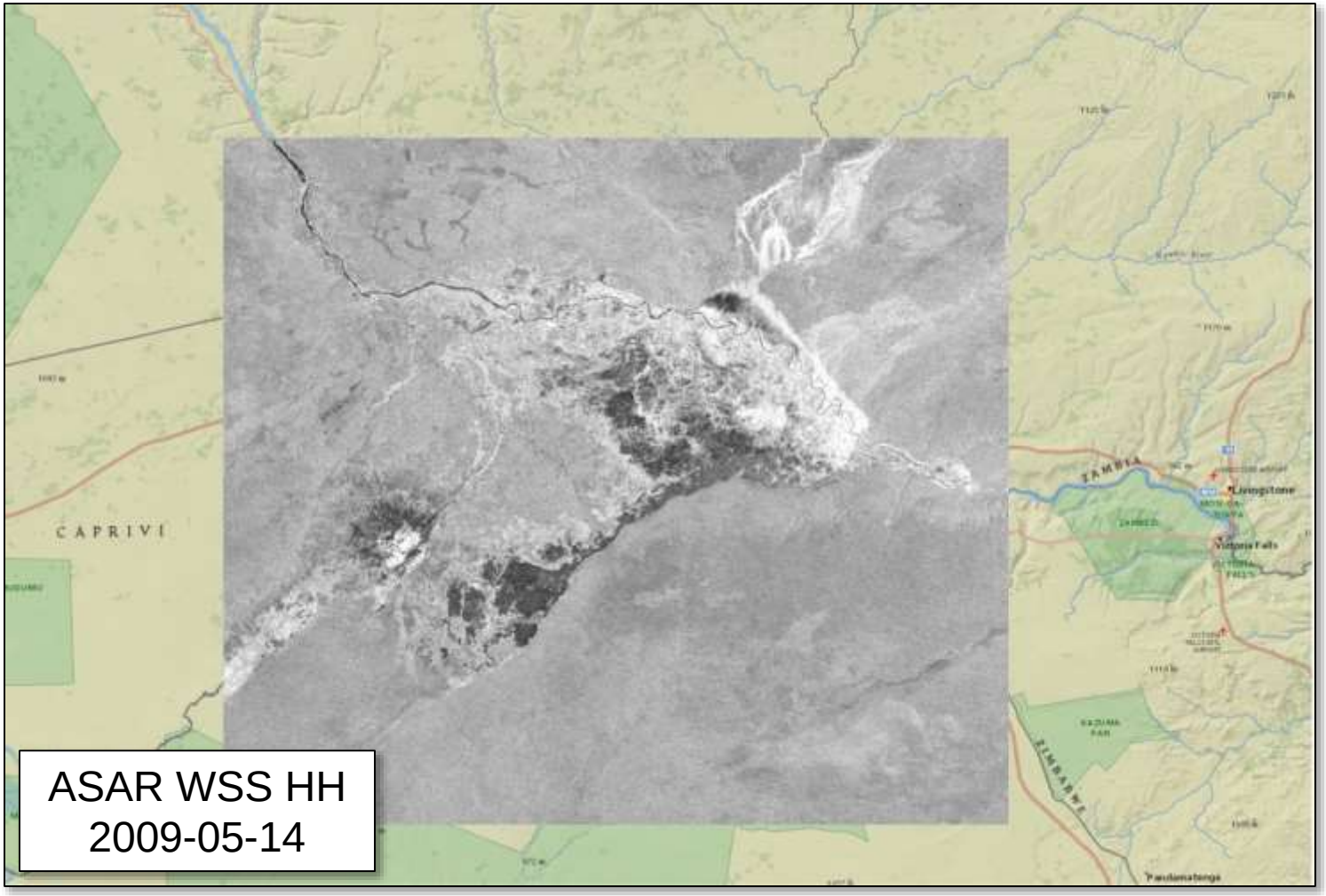

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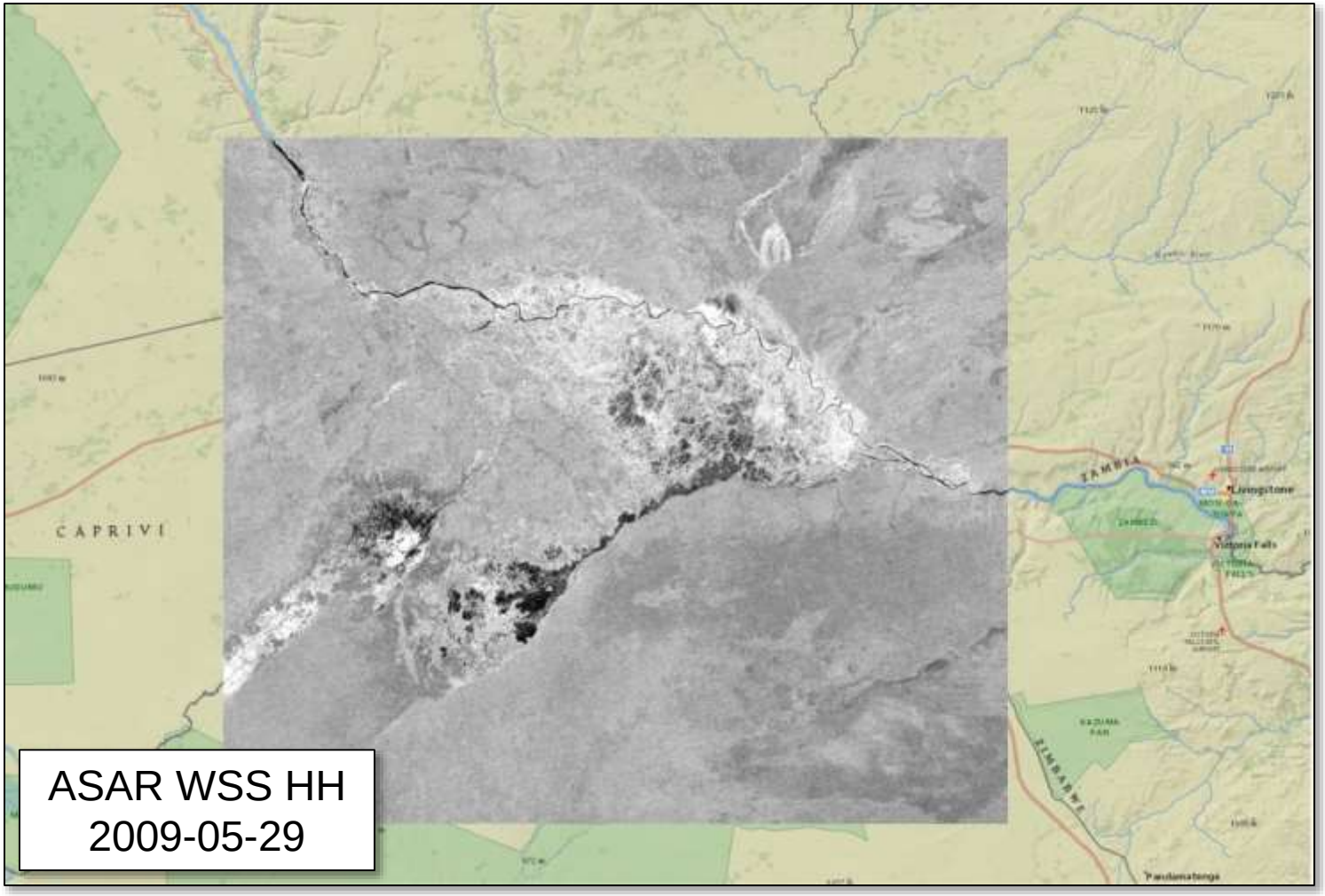

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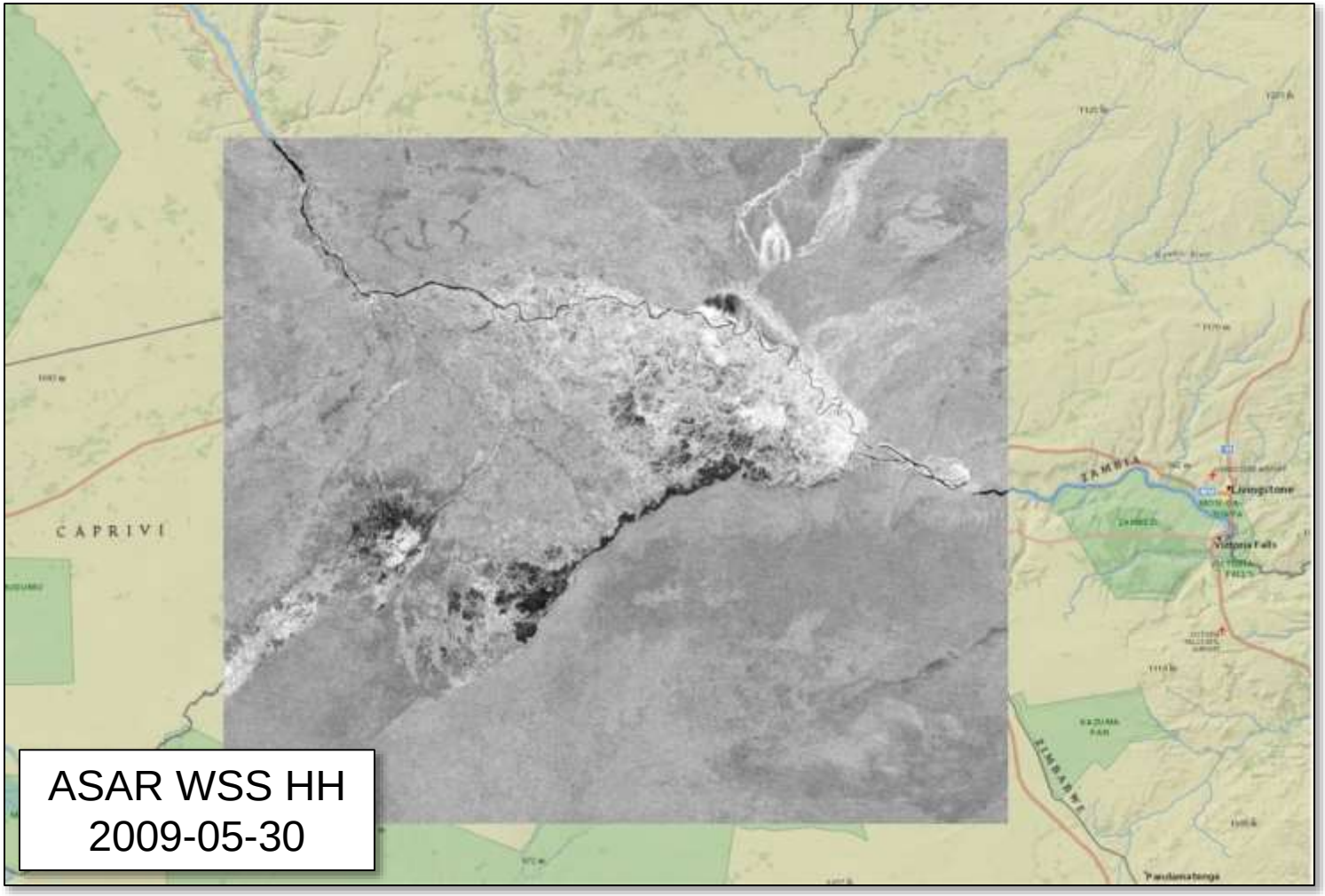

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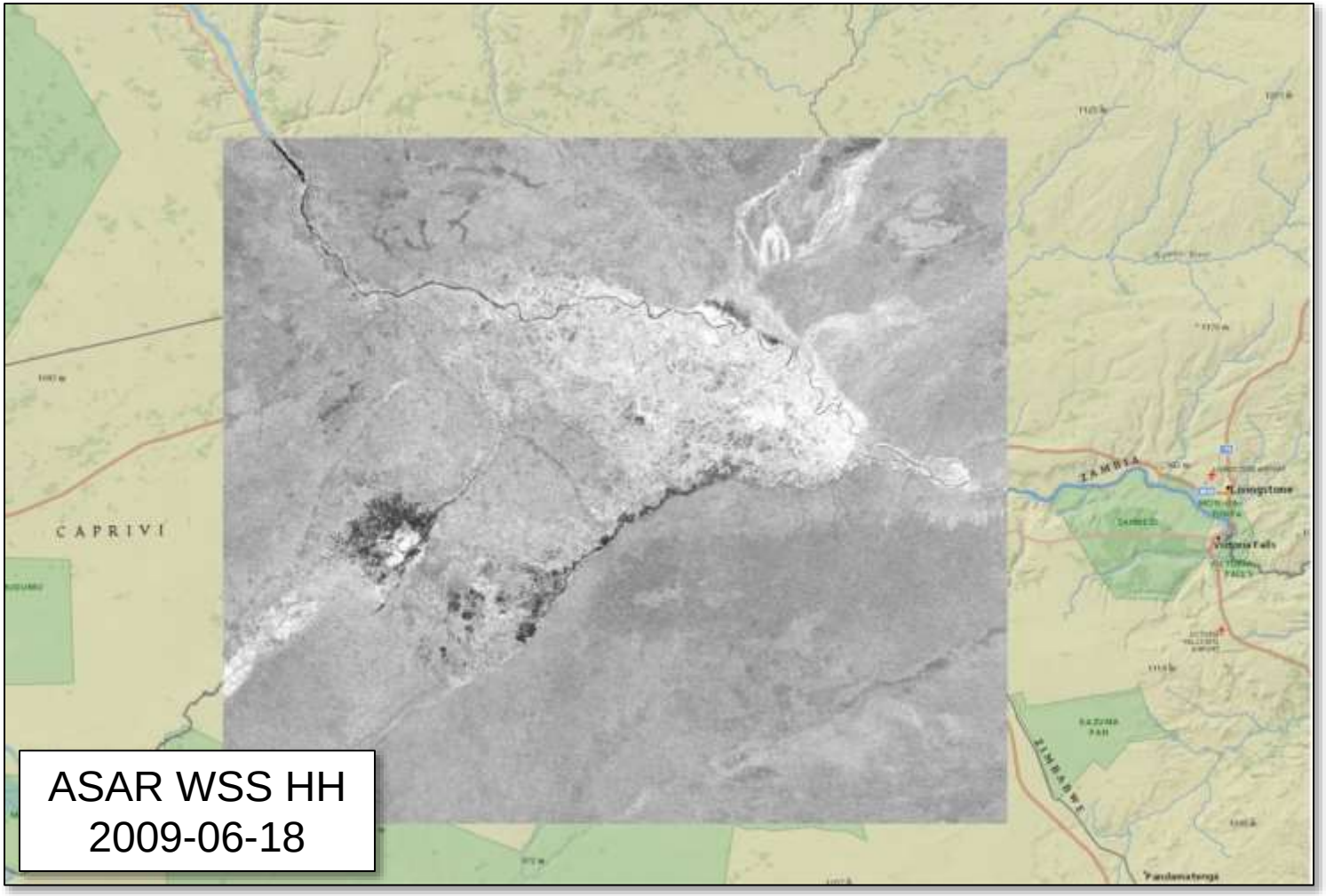

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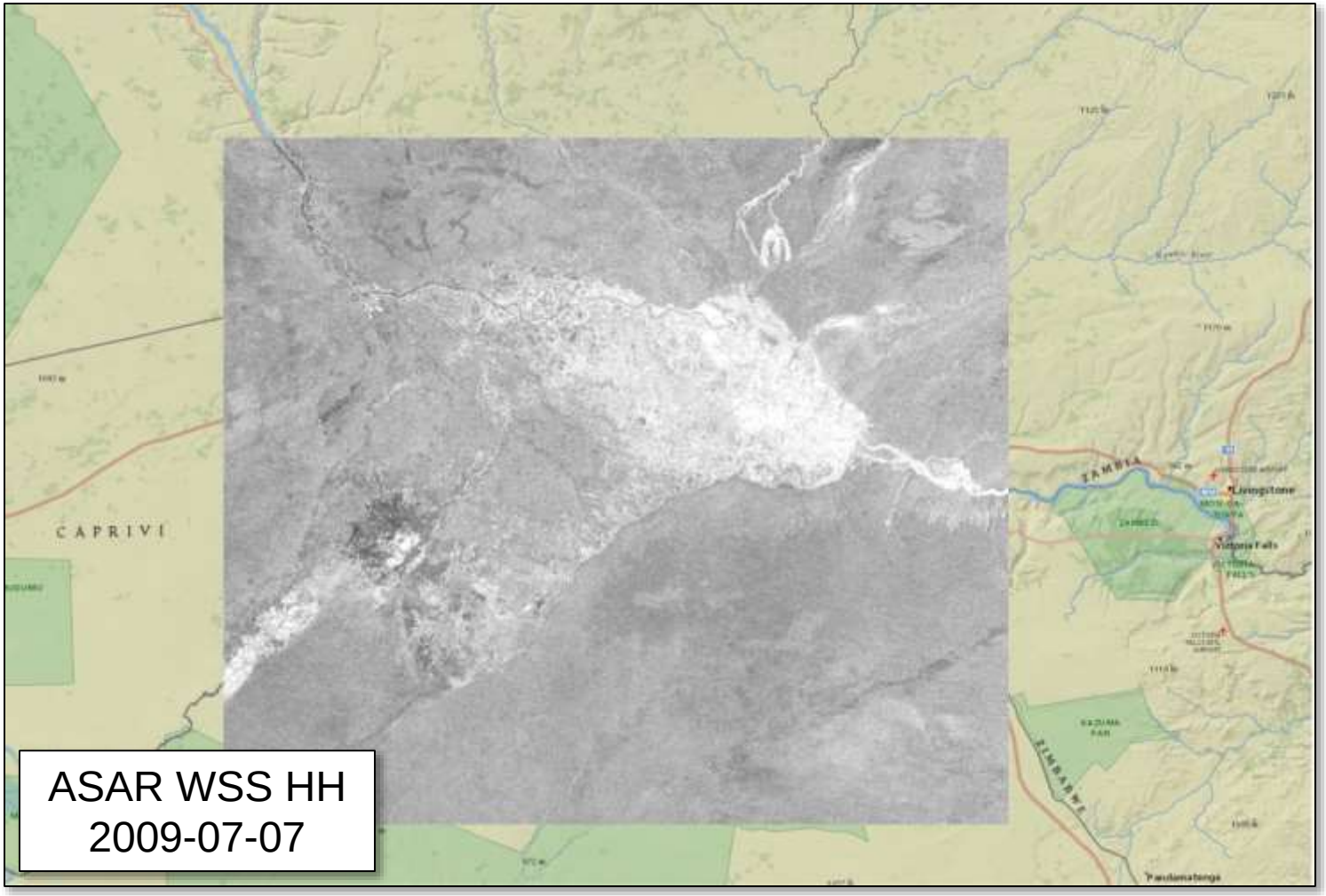

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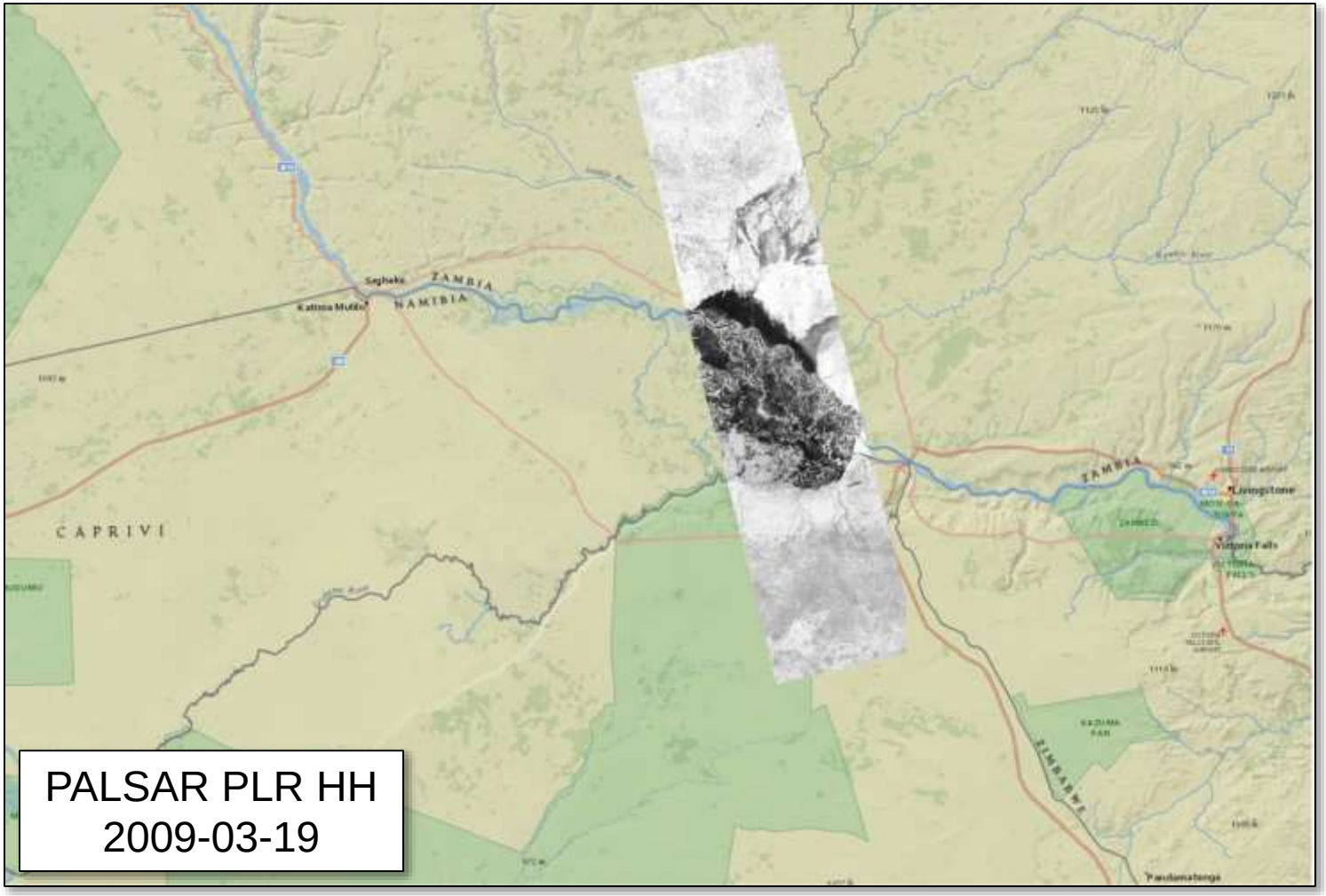

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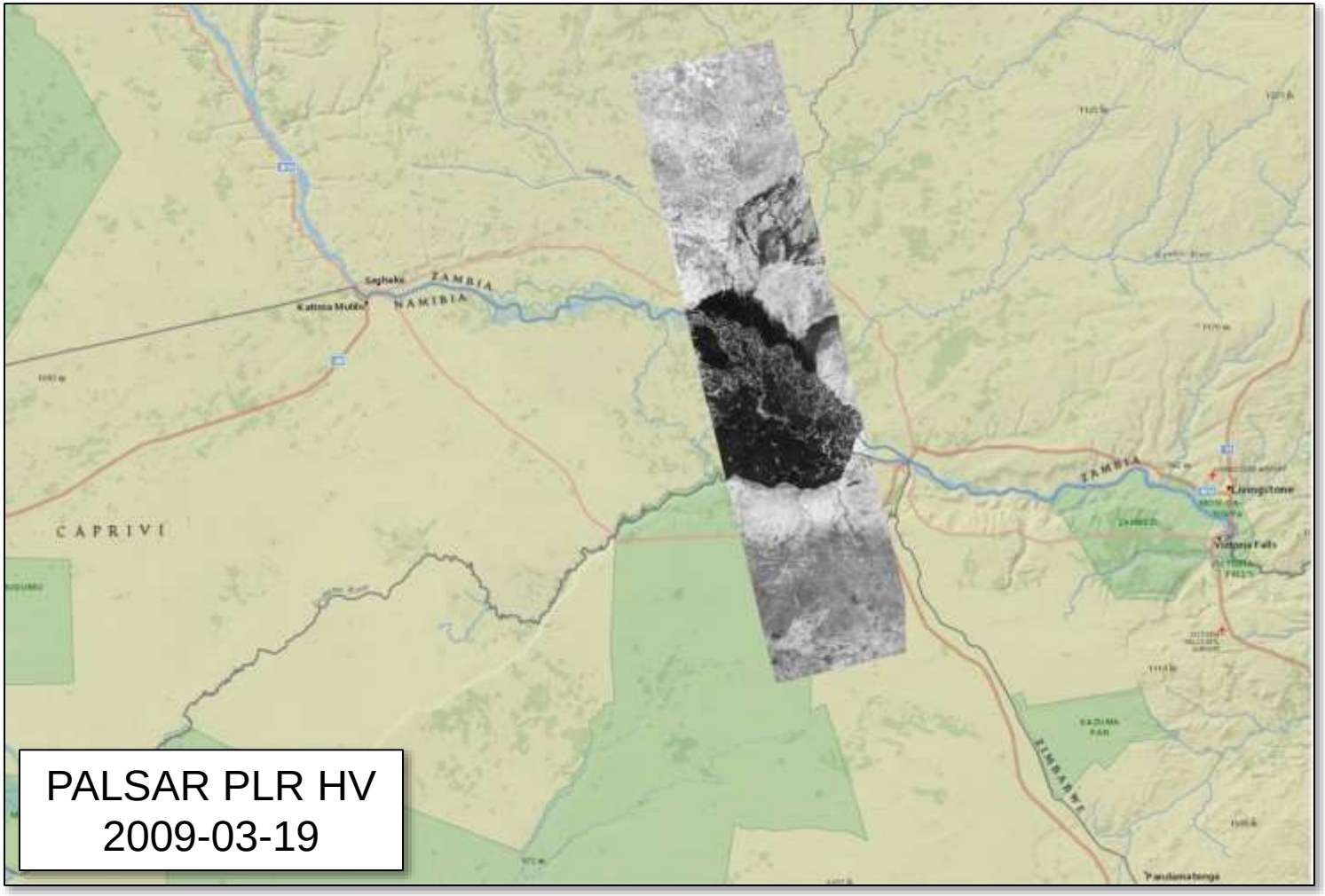

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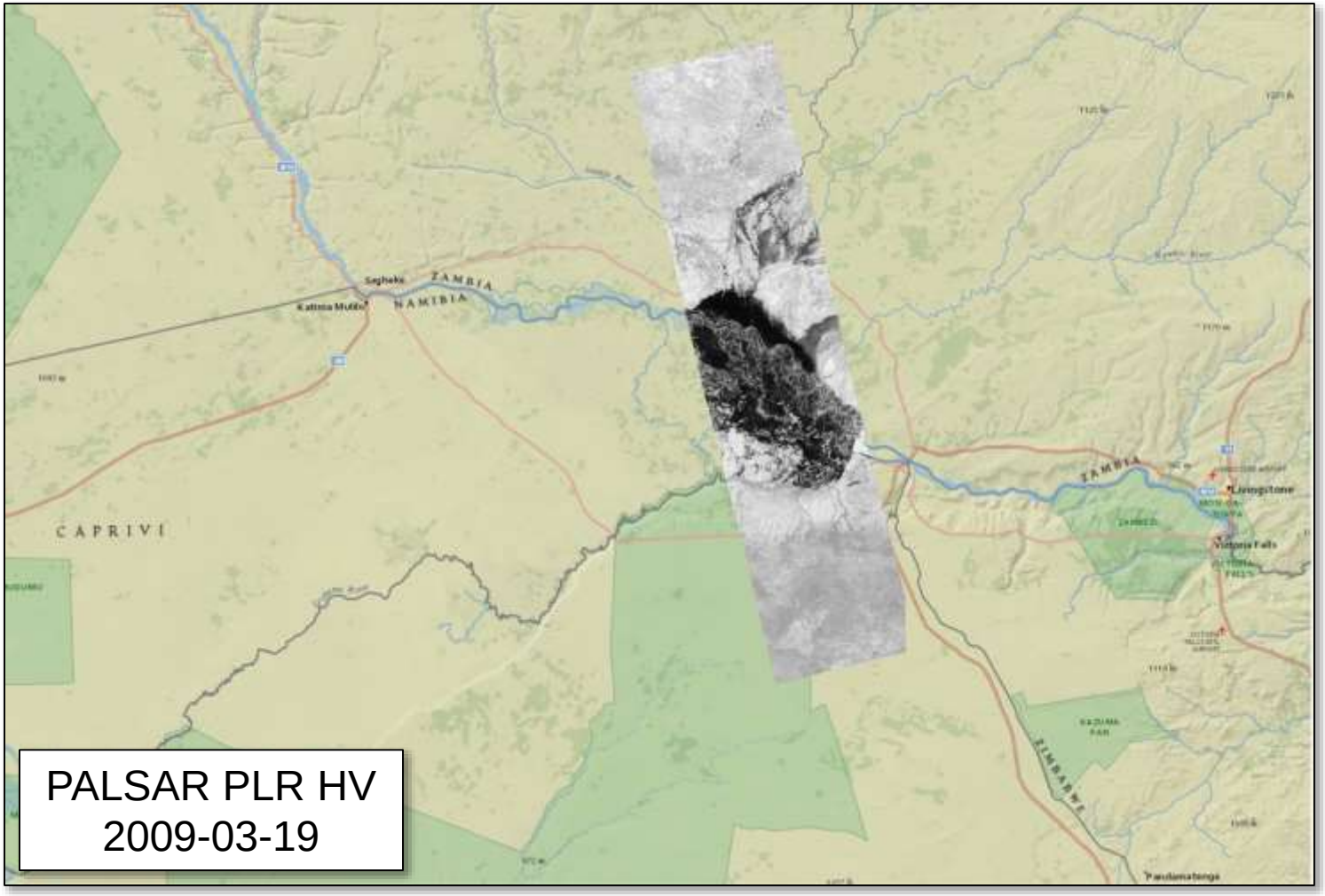

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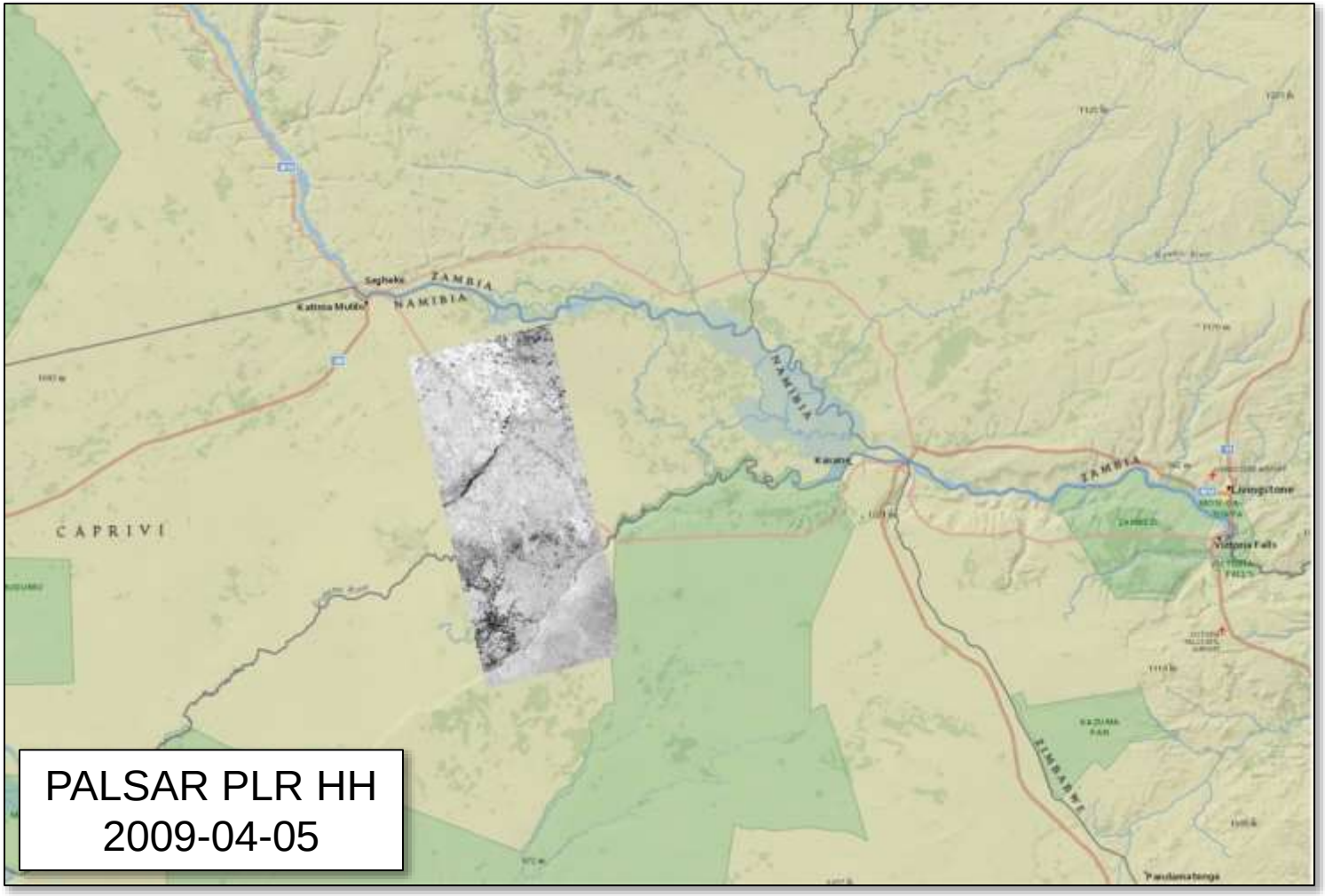

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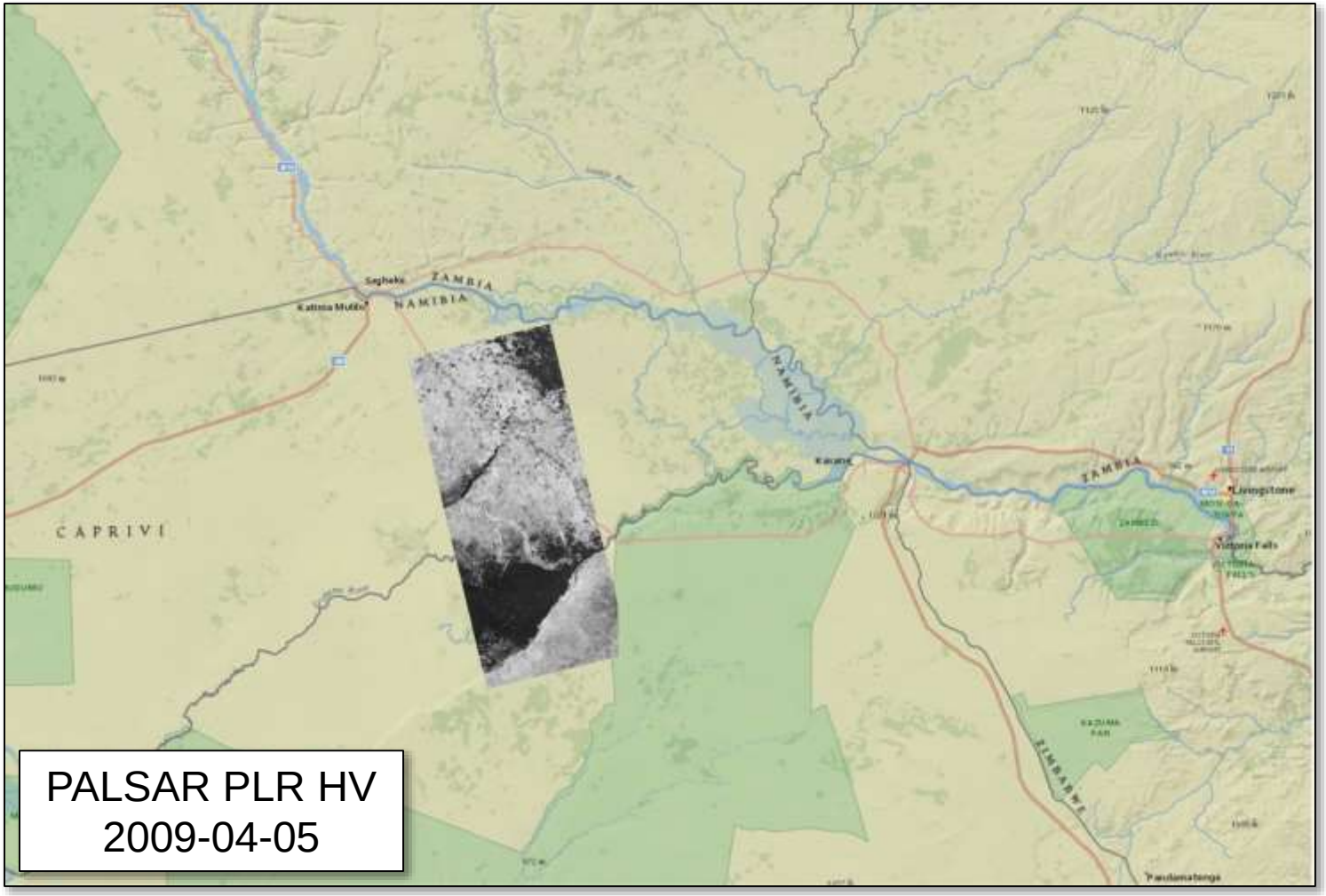

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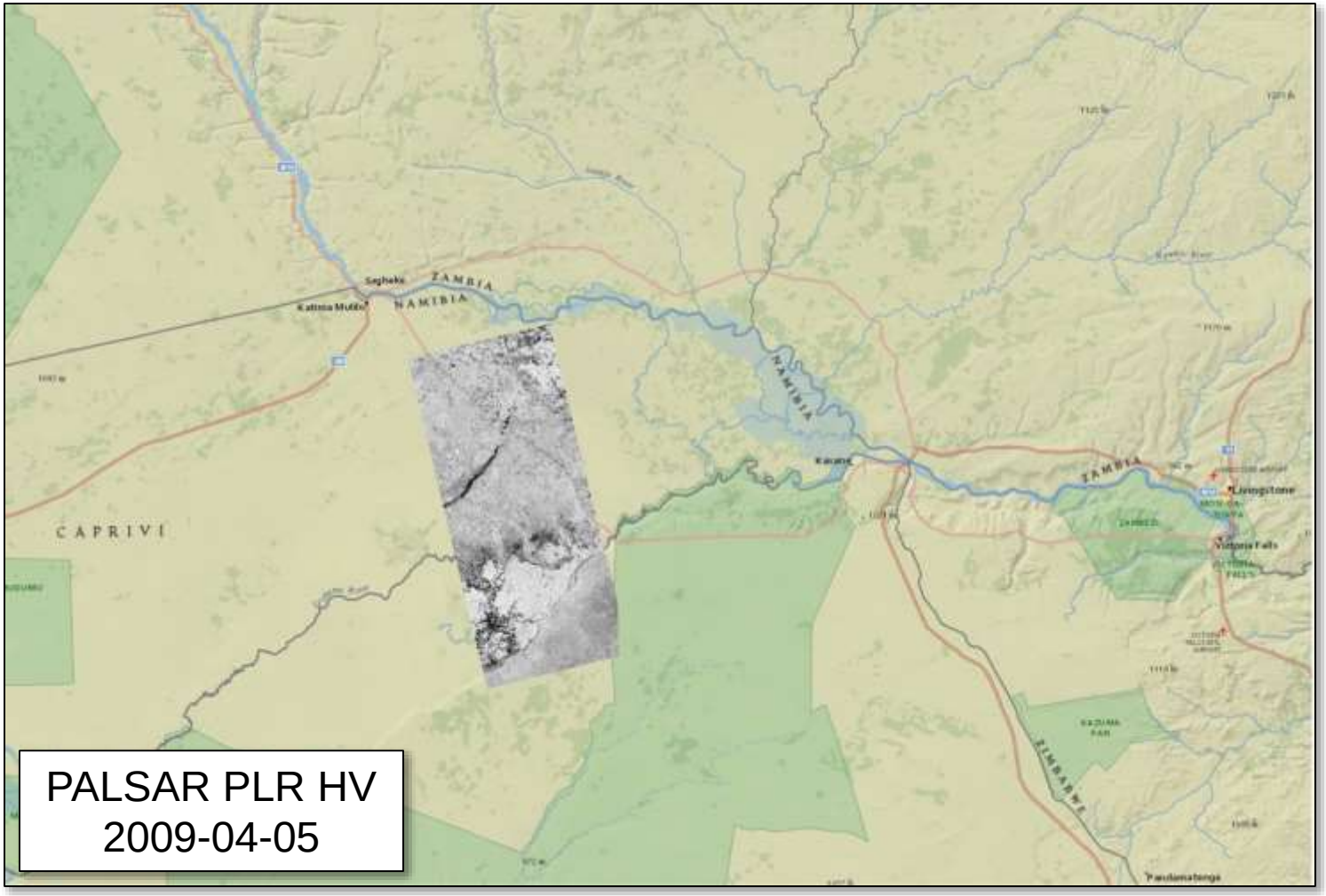

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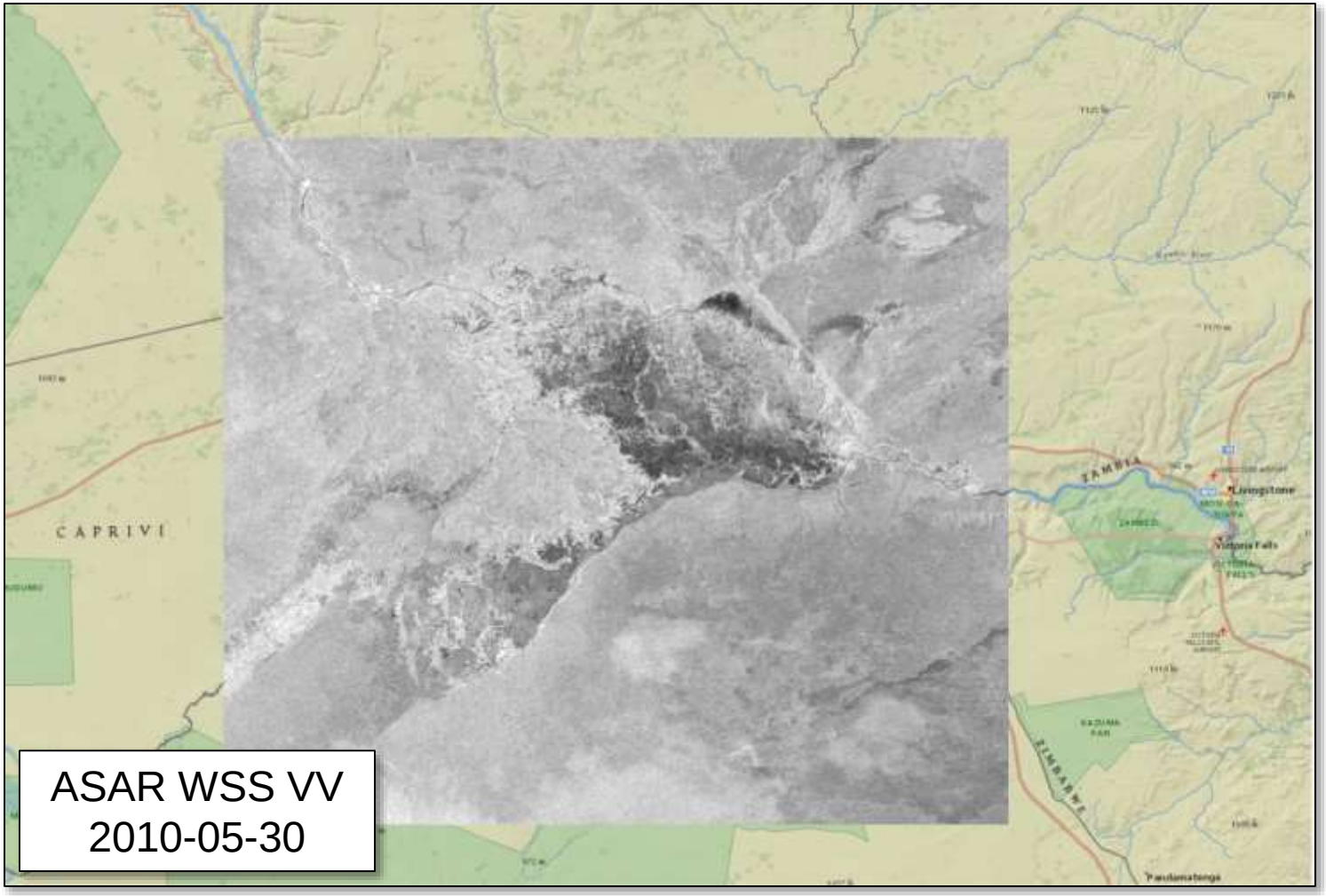

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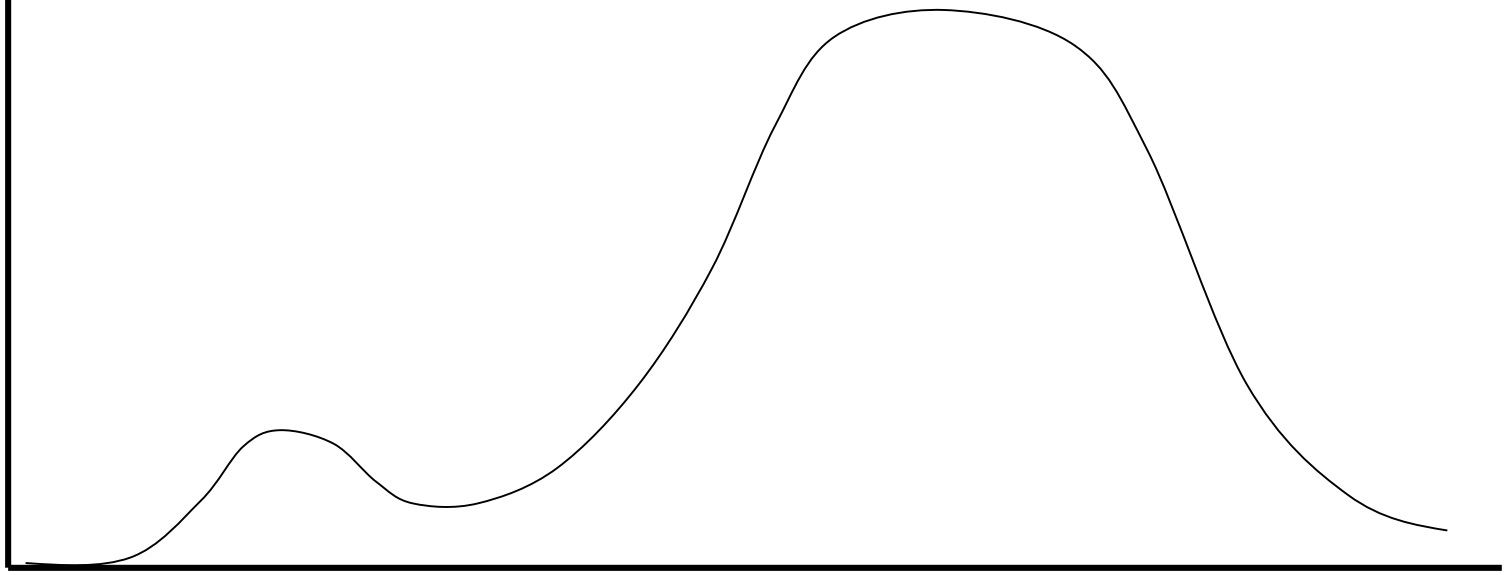
Thresholding

Bimodal case

- Lower mode corresponds to flooding



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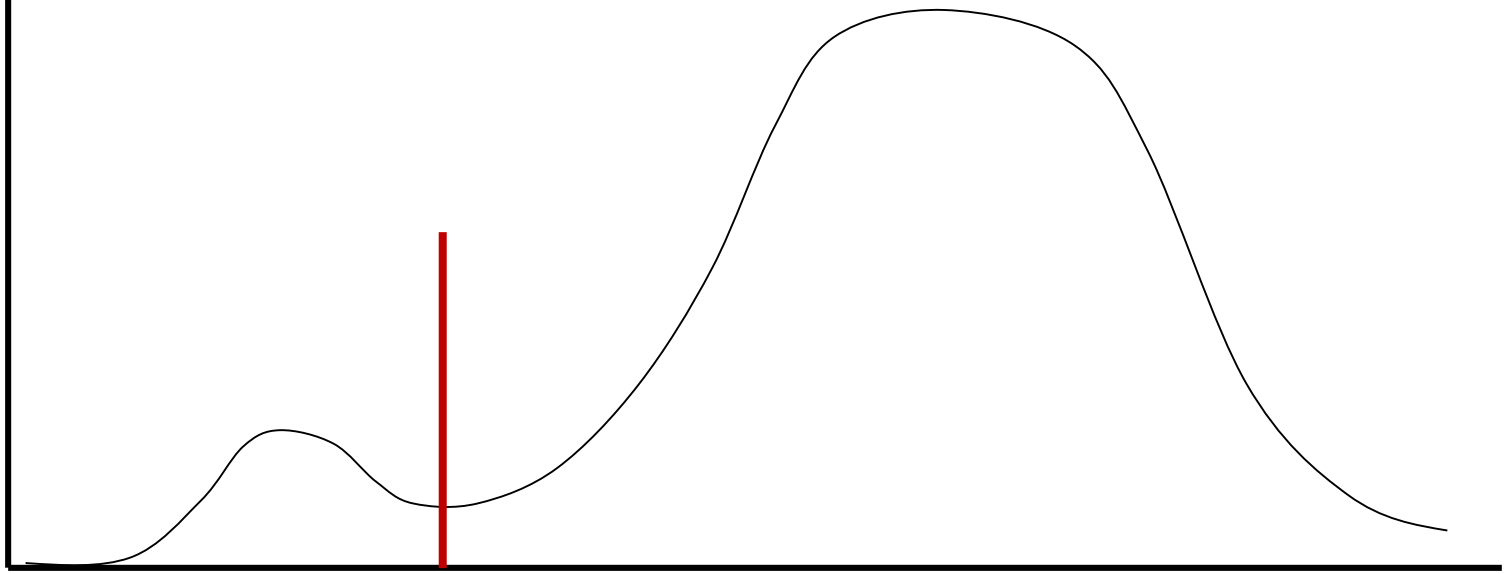
Thresholding

Bimodal case

- Lower mode corresponds to flooding
- Local minimum used to initialize thresholding



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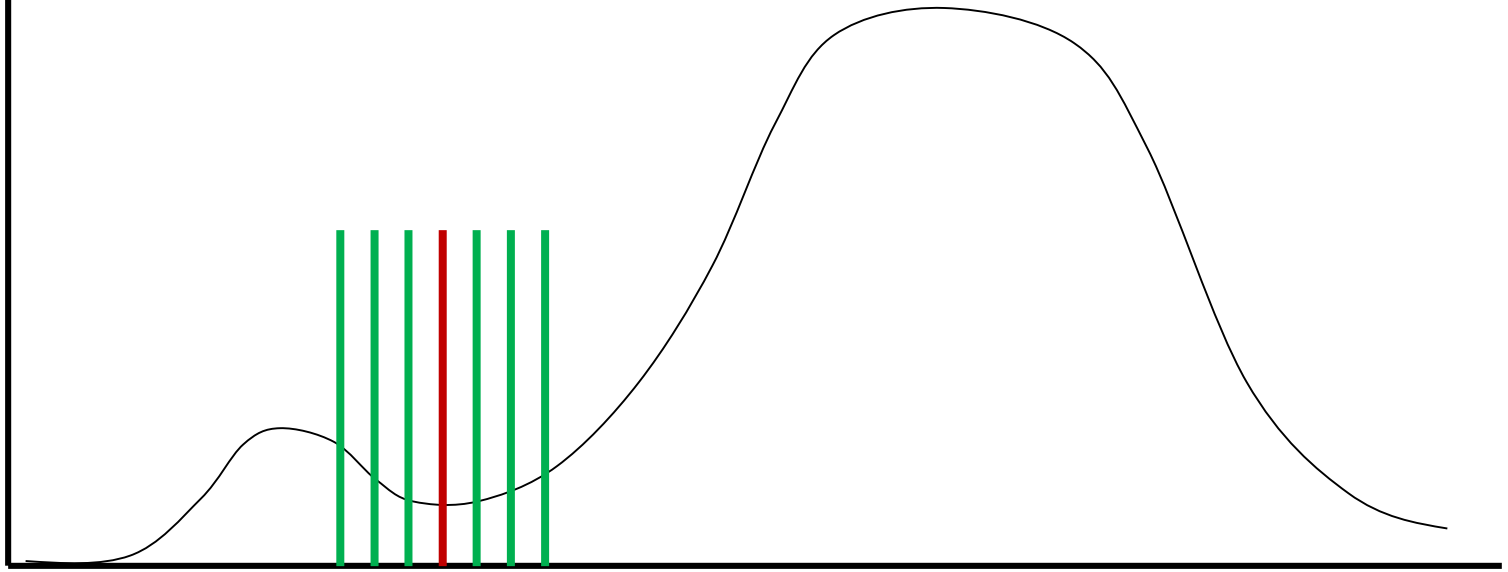
Thresholding

Bimodal case

- Lower mode corresponds to flooding
- Local minimum used to initialize thresholding
- Multiple thresholds around local minimum in 0.5 dB increments



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Bimodal case

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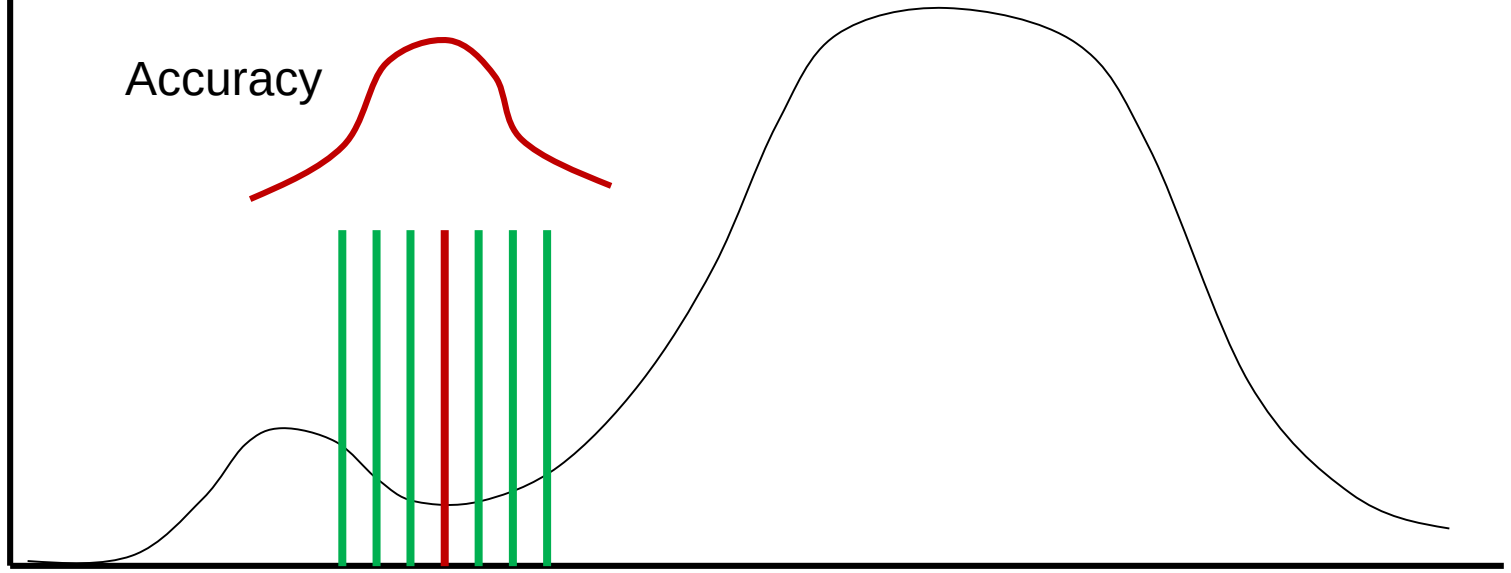

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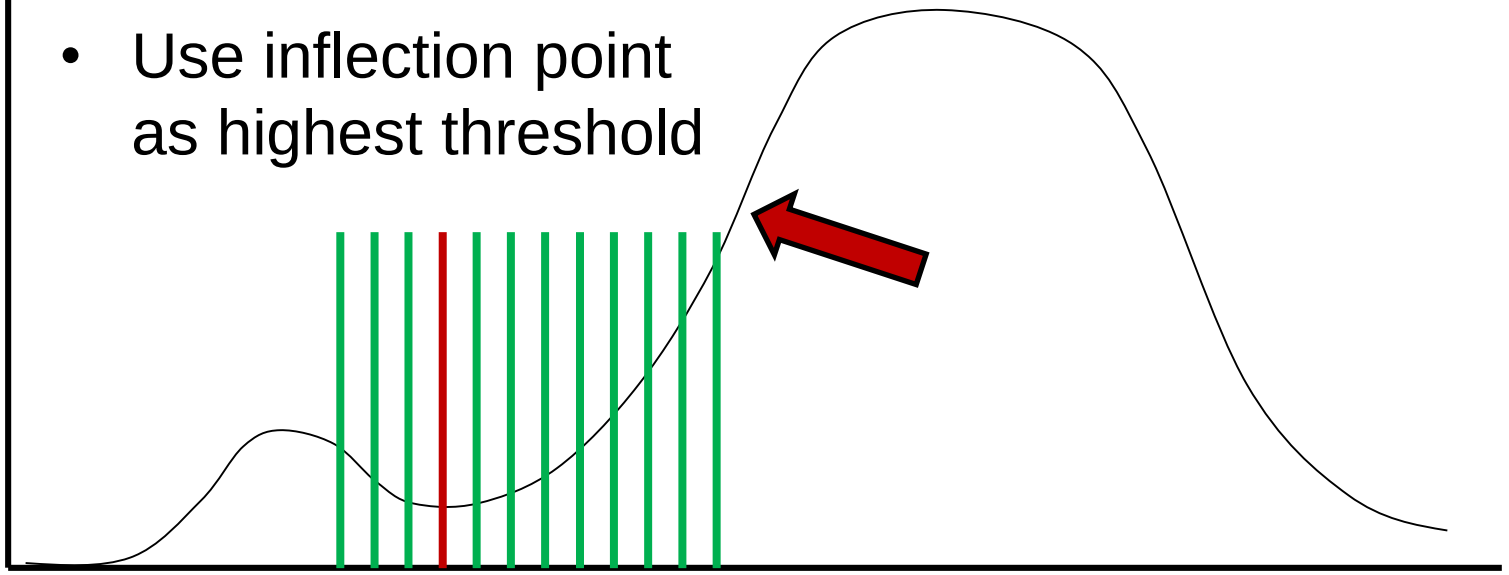
Thresholding

Bimodal case

- Lower mode corresponds to flooding
- Local minimum used to initialize thresholding
- Multiple thresholds around local minimum in 0.5 dB increments
- Use inflection point as highest threshold

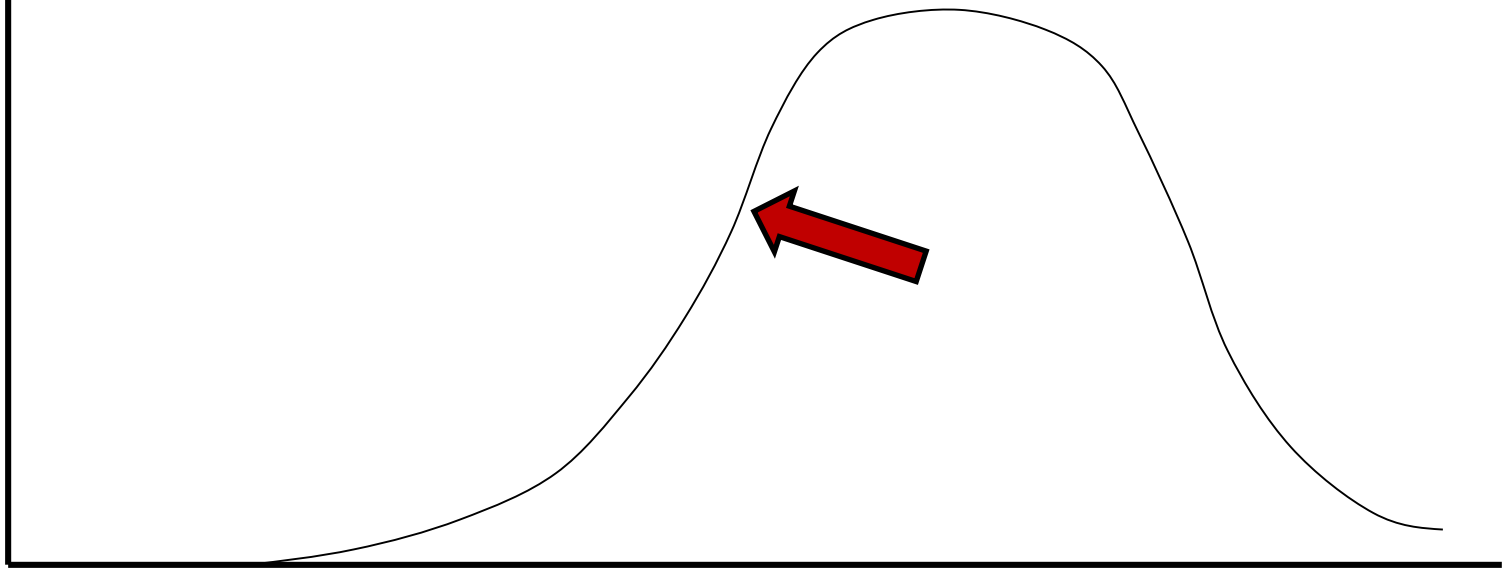


your knowledge partner

Thresholding

Single mode case

- Use inflection point as highest threshold

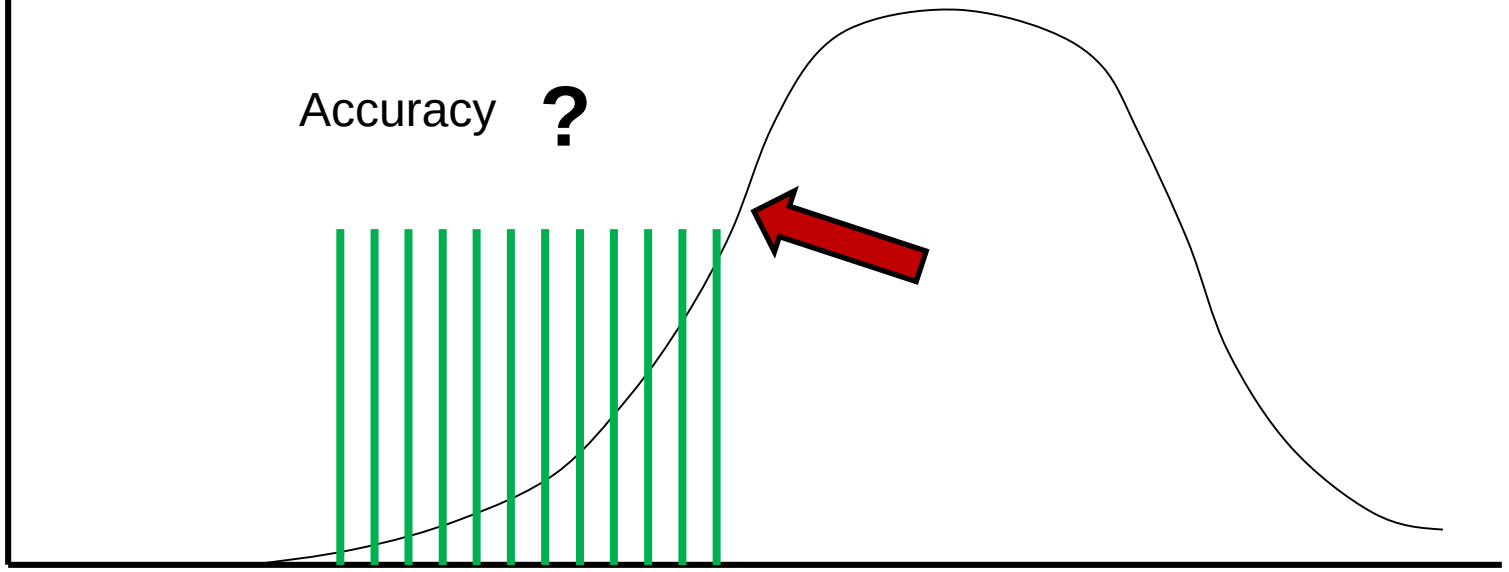


your knowledge partner

Thresholding

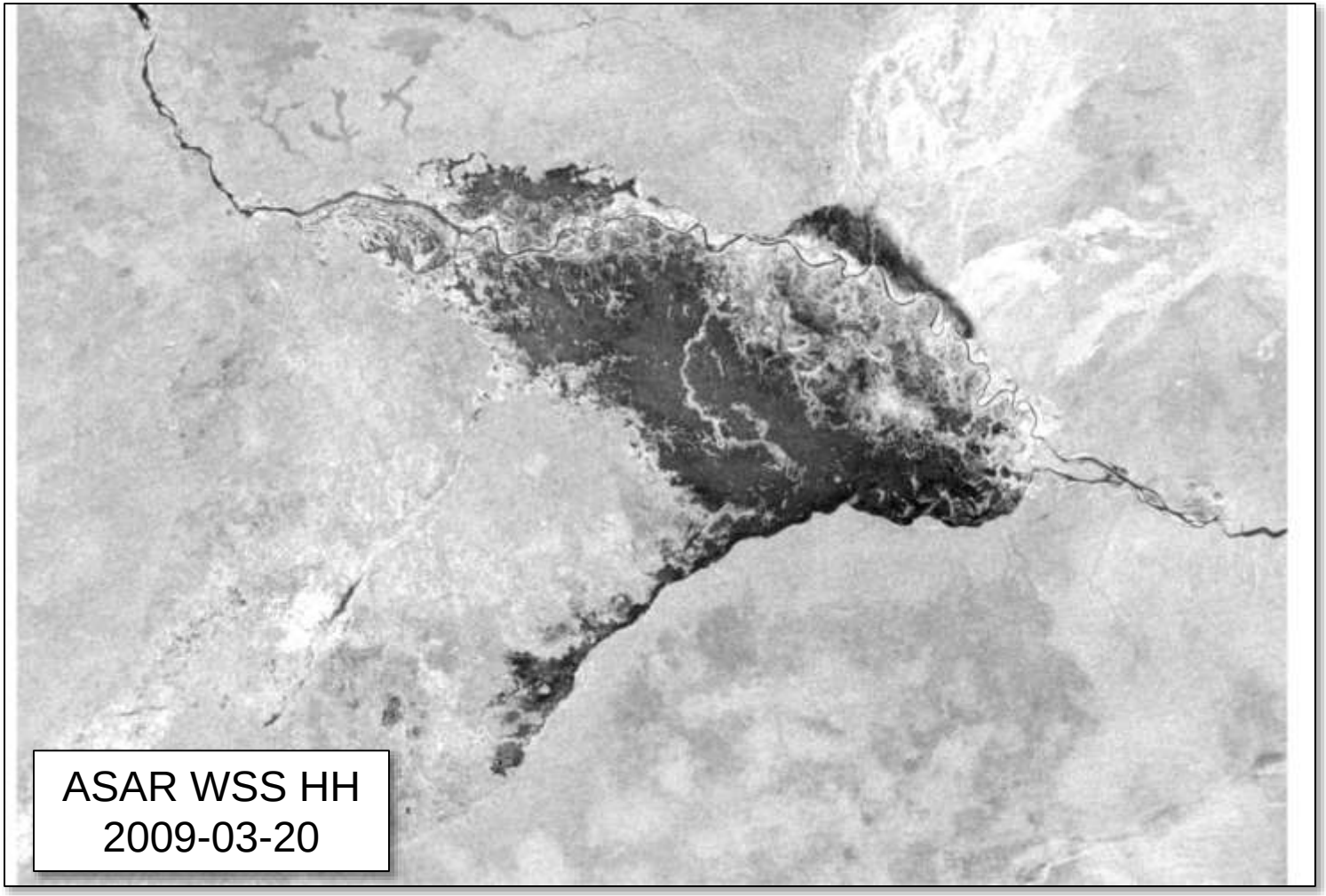
Single mode case

- Use inflection point as highest threshold



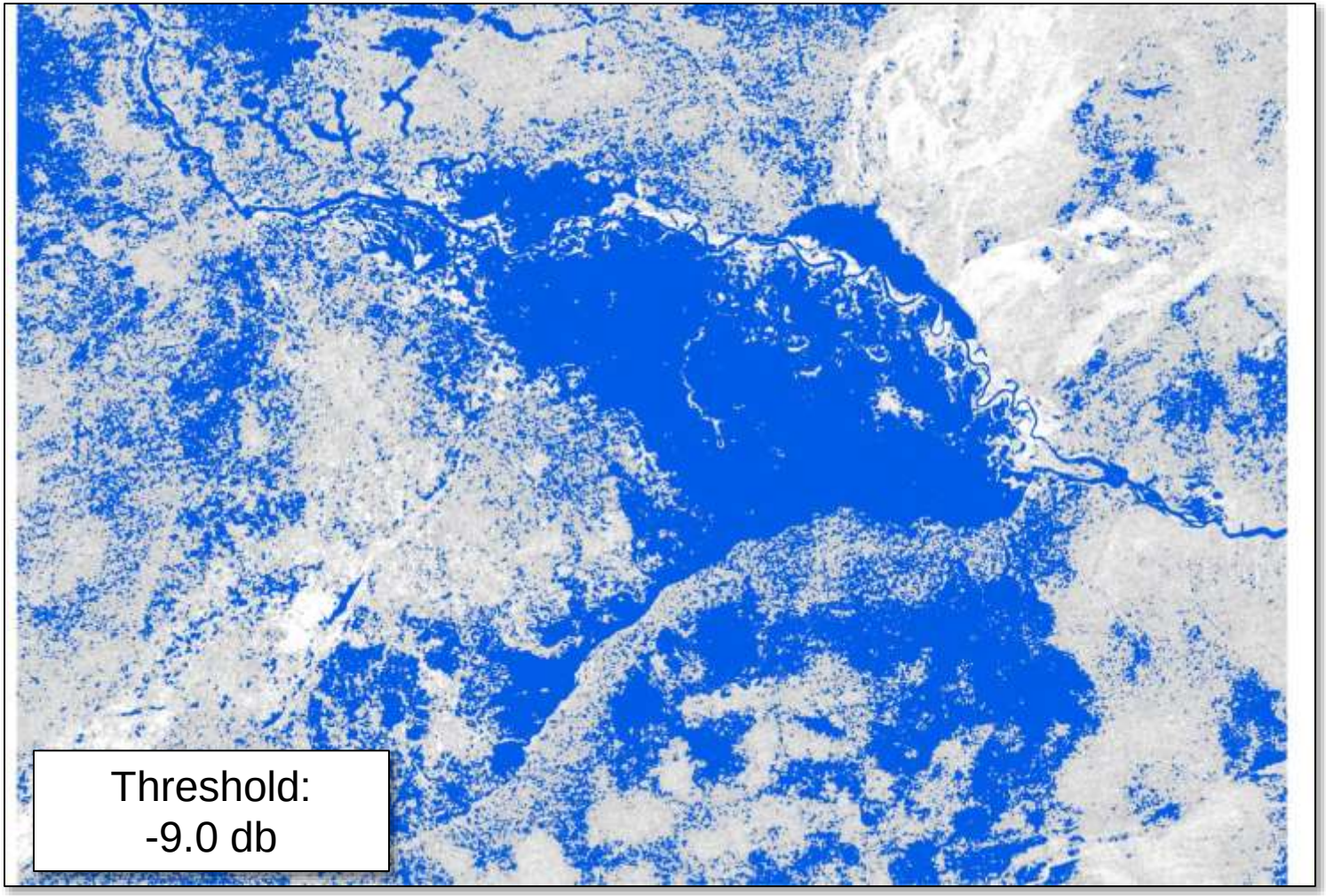
your knowledge partner

Thresholding & Validation



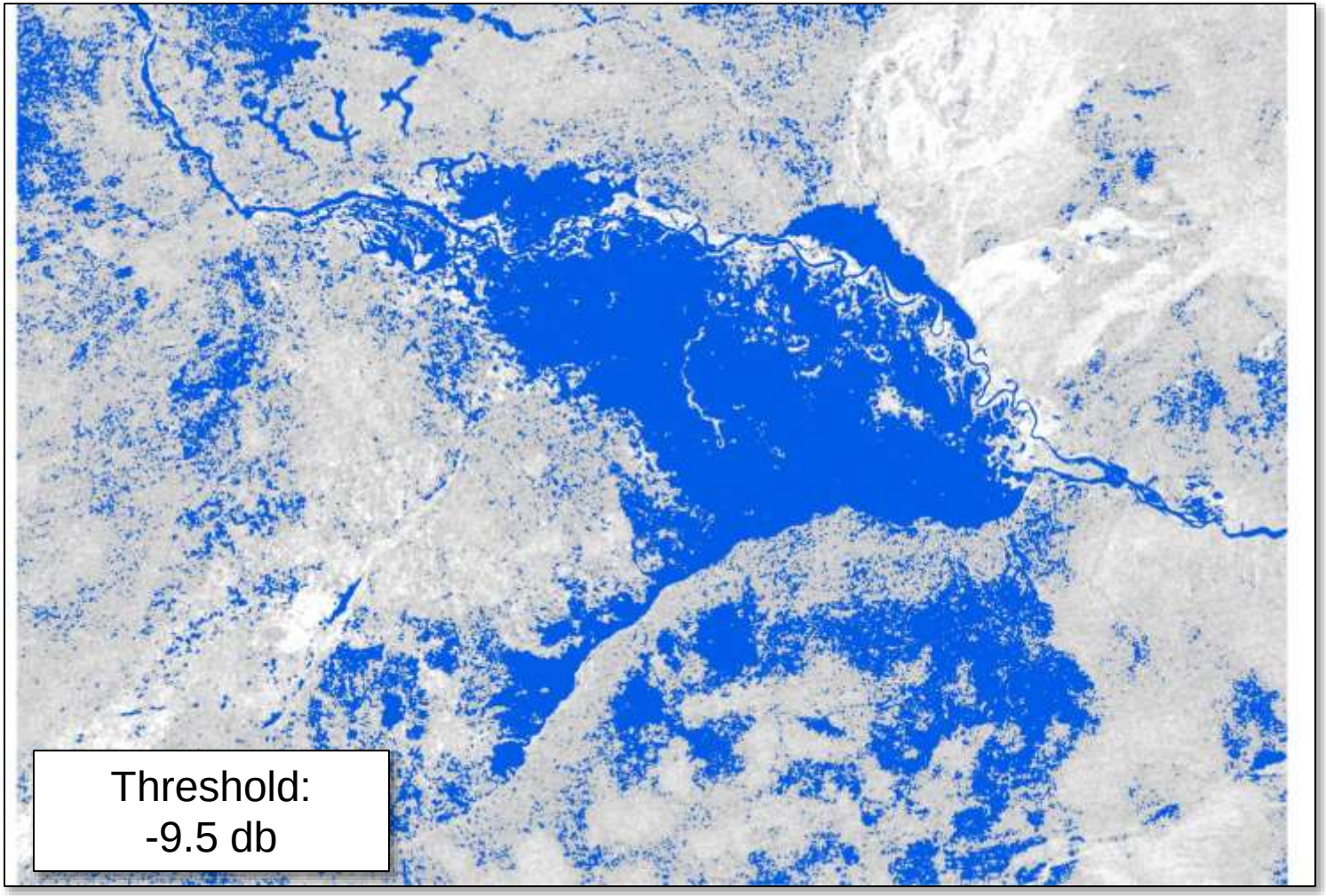
your knowledge partner

Thresholding & Validation



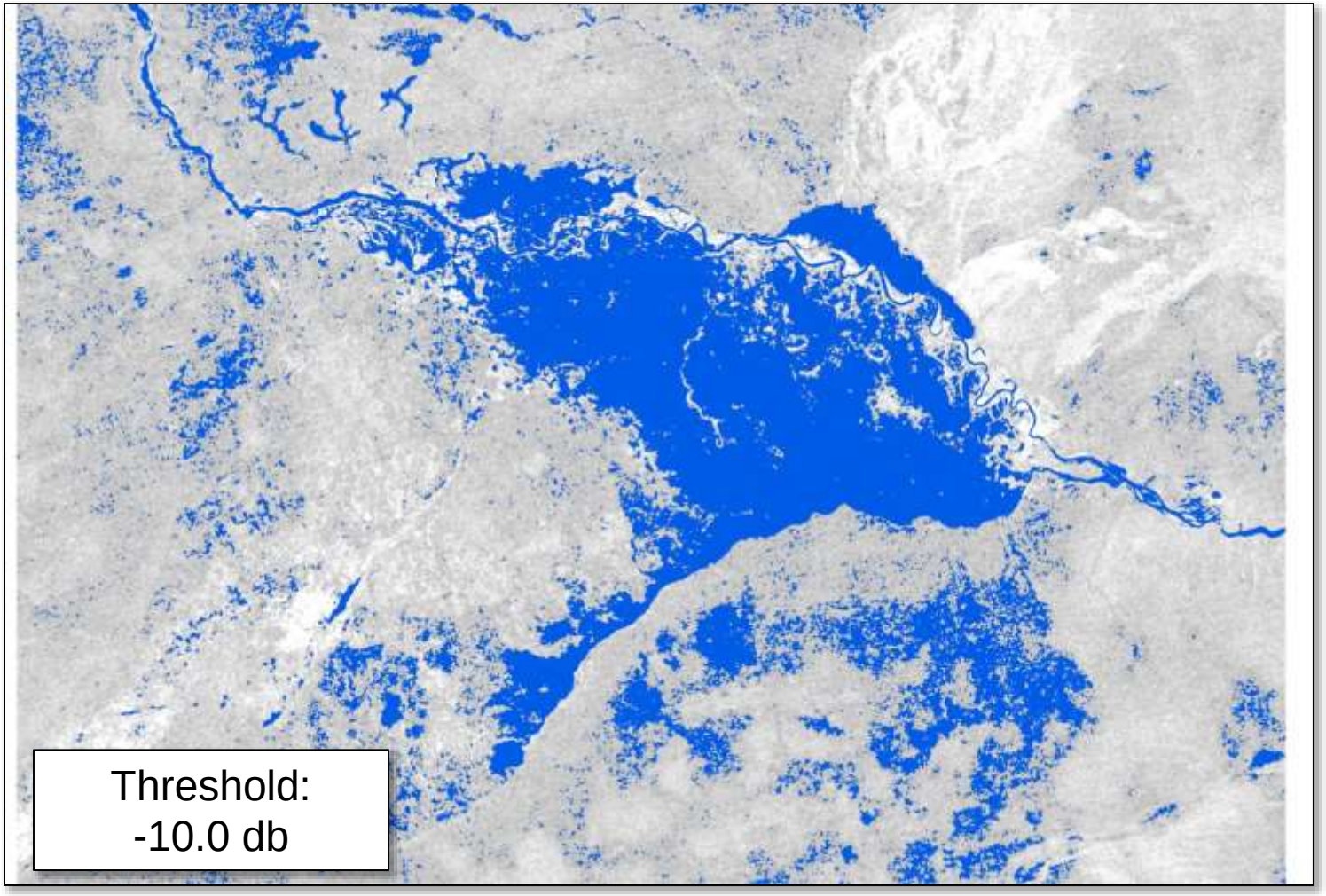
your knowledge partner

Thresholding & Validation



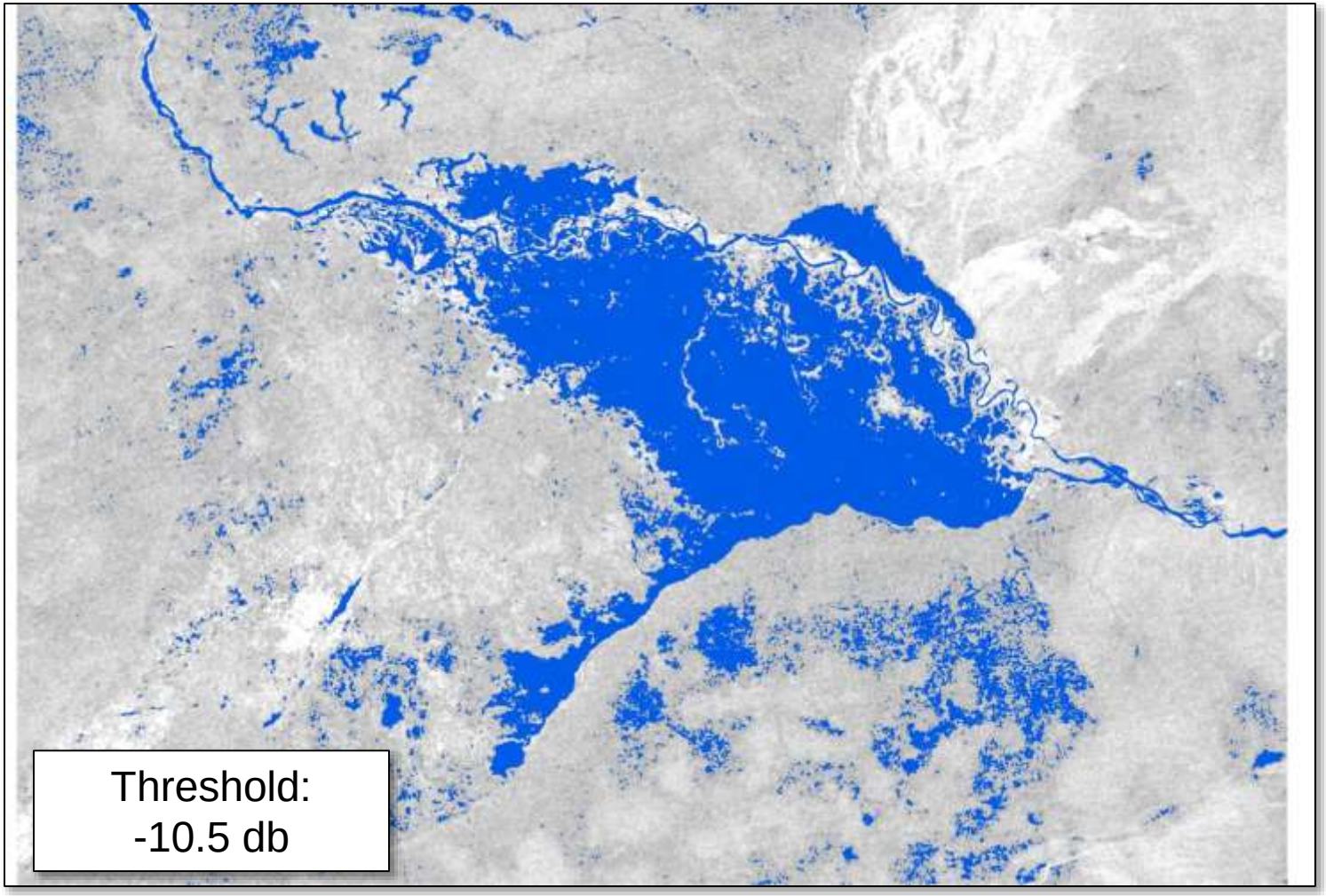
your knowledge partner

Thresholding & Validation



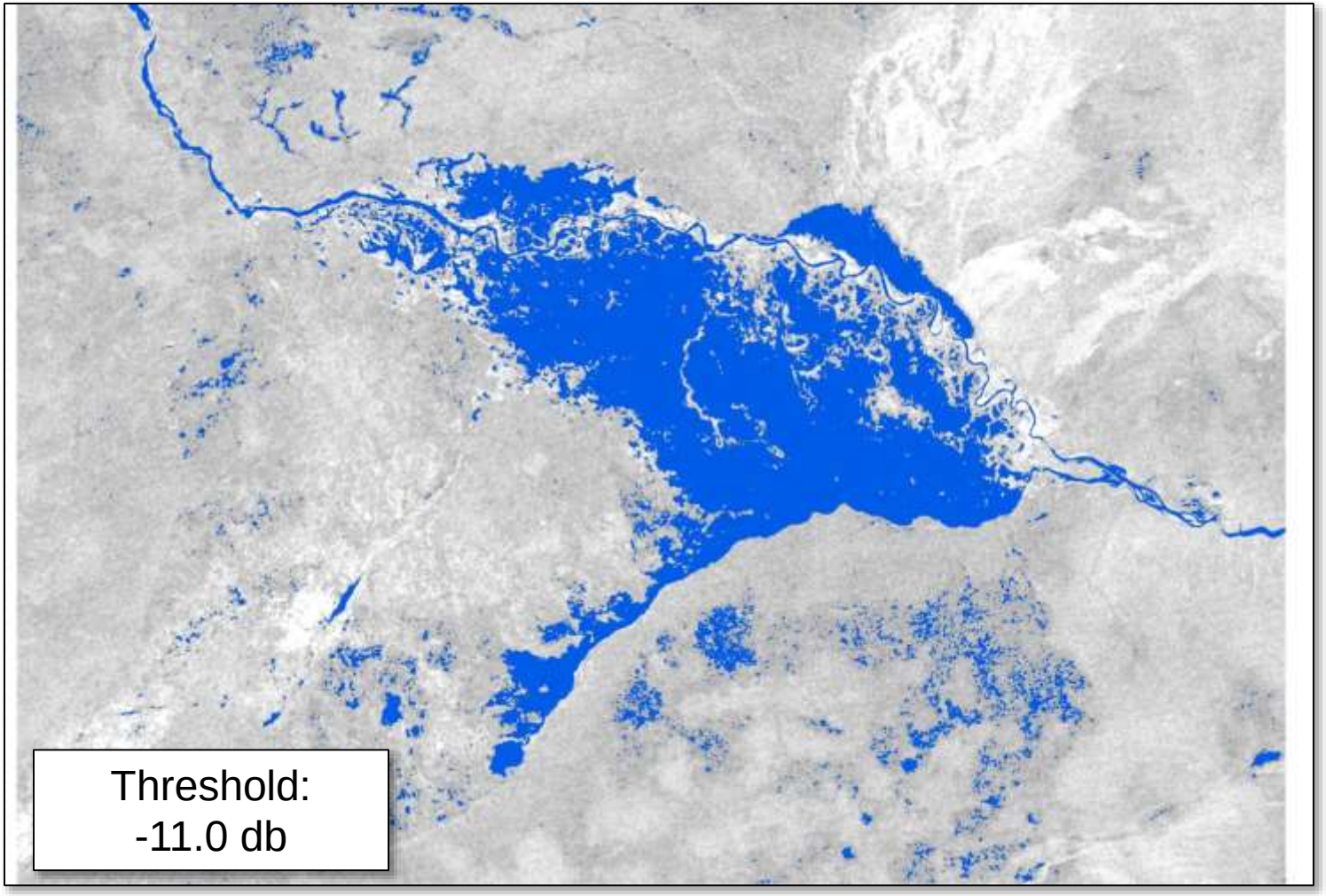
your knowledge partner

Thresholding & Validation



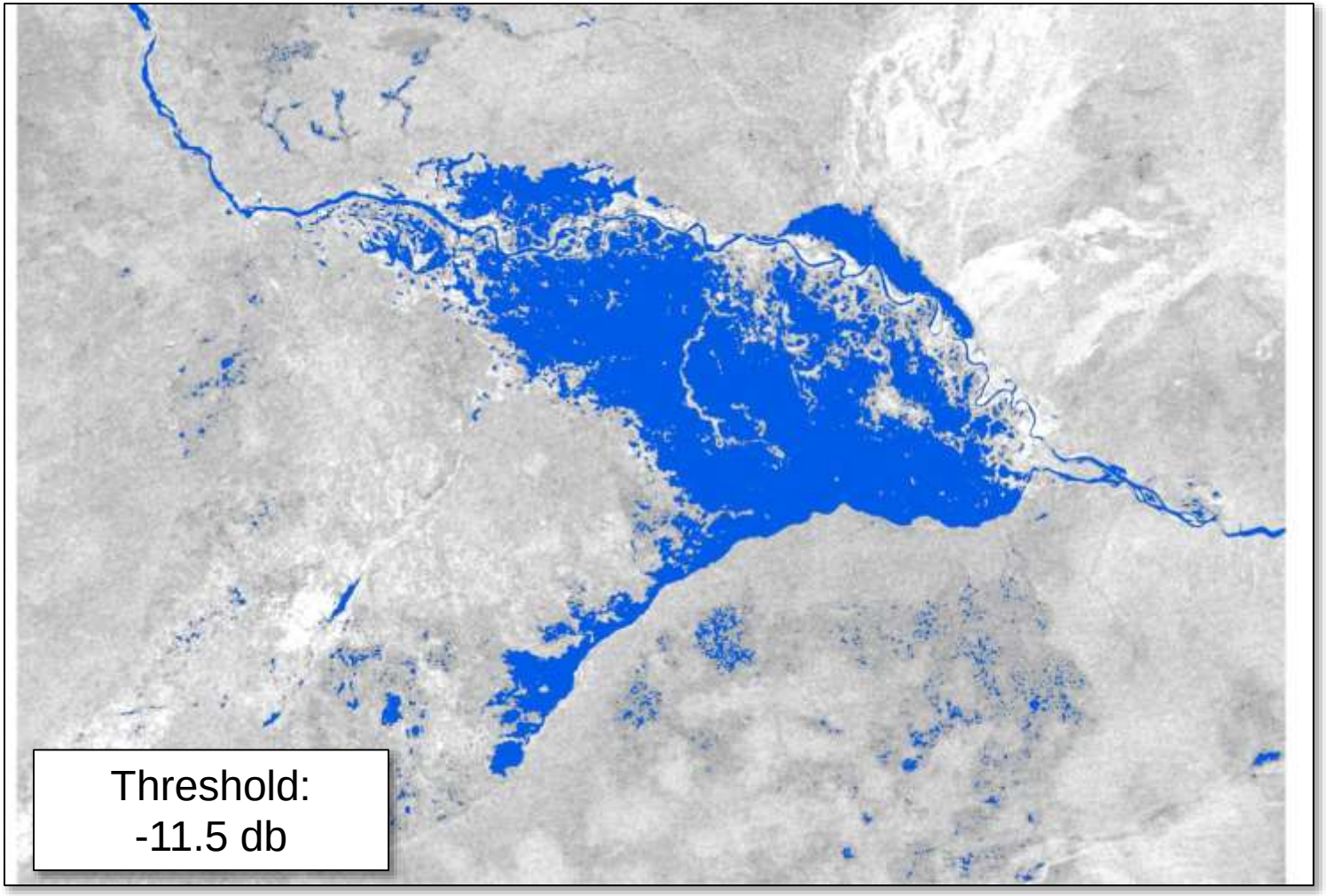
your knowledge partner

Thresholding & Validation



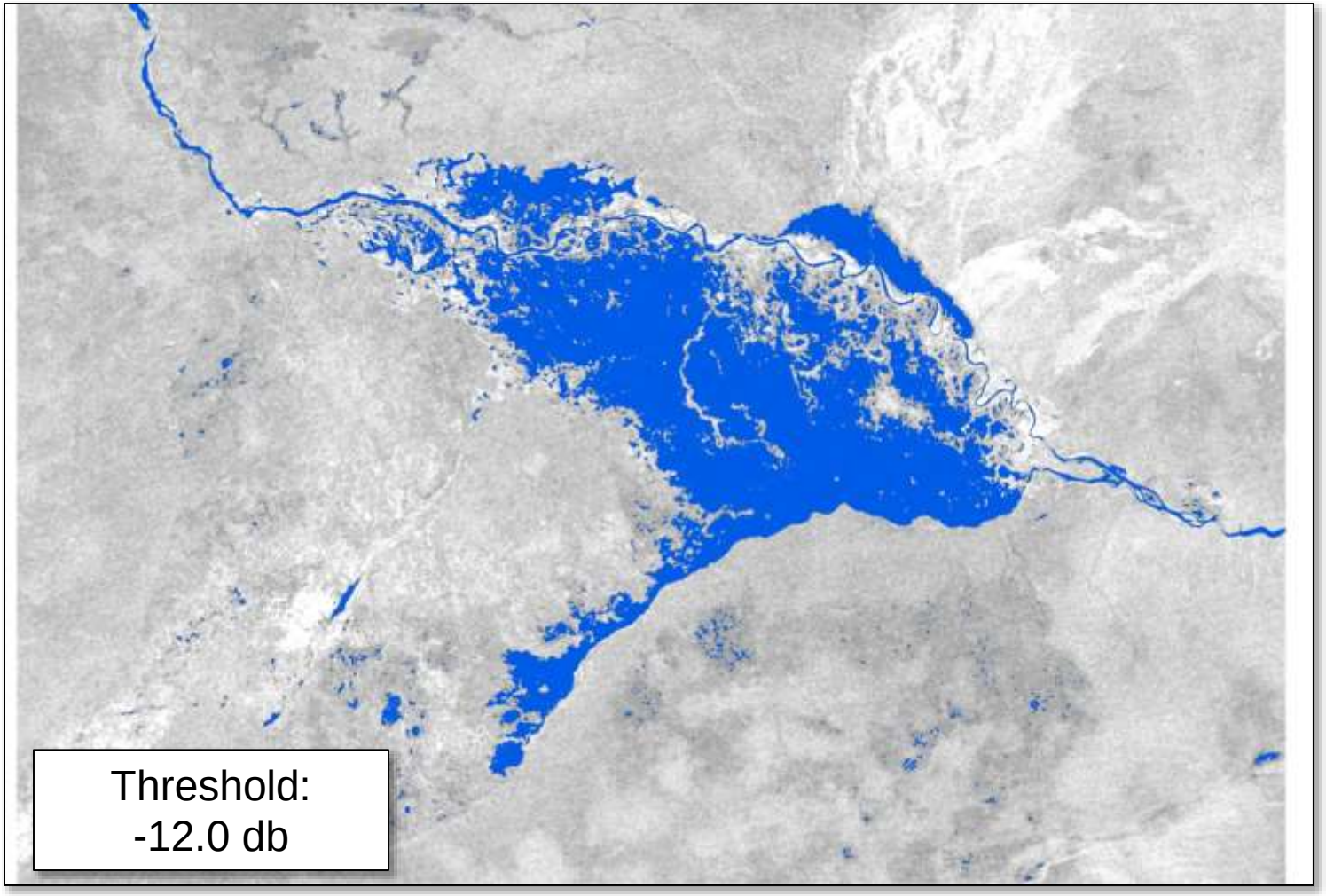
your knowledge partner

Thresholding & Validation



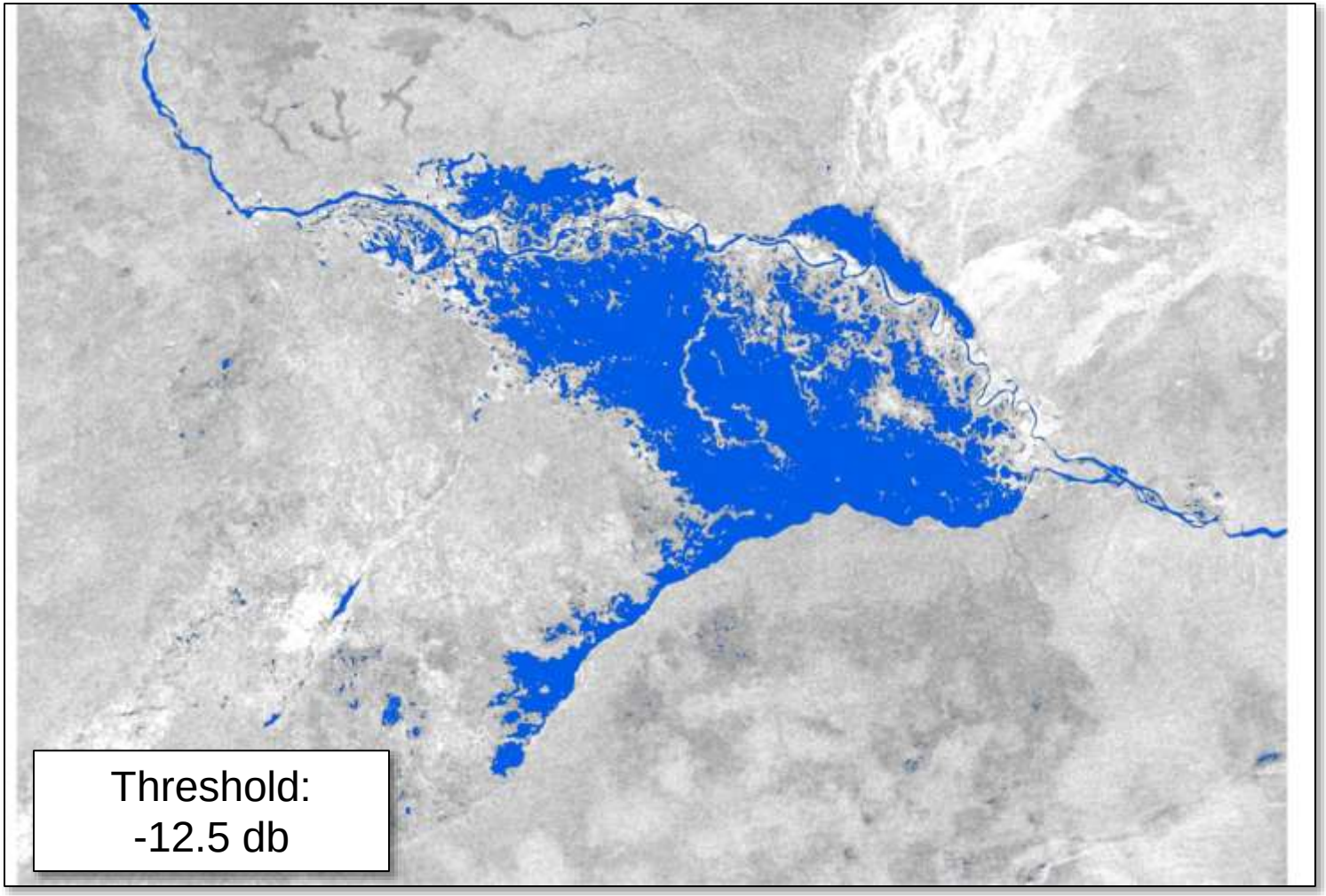
your knowledge partner

Thresholding & Validation



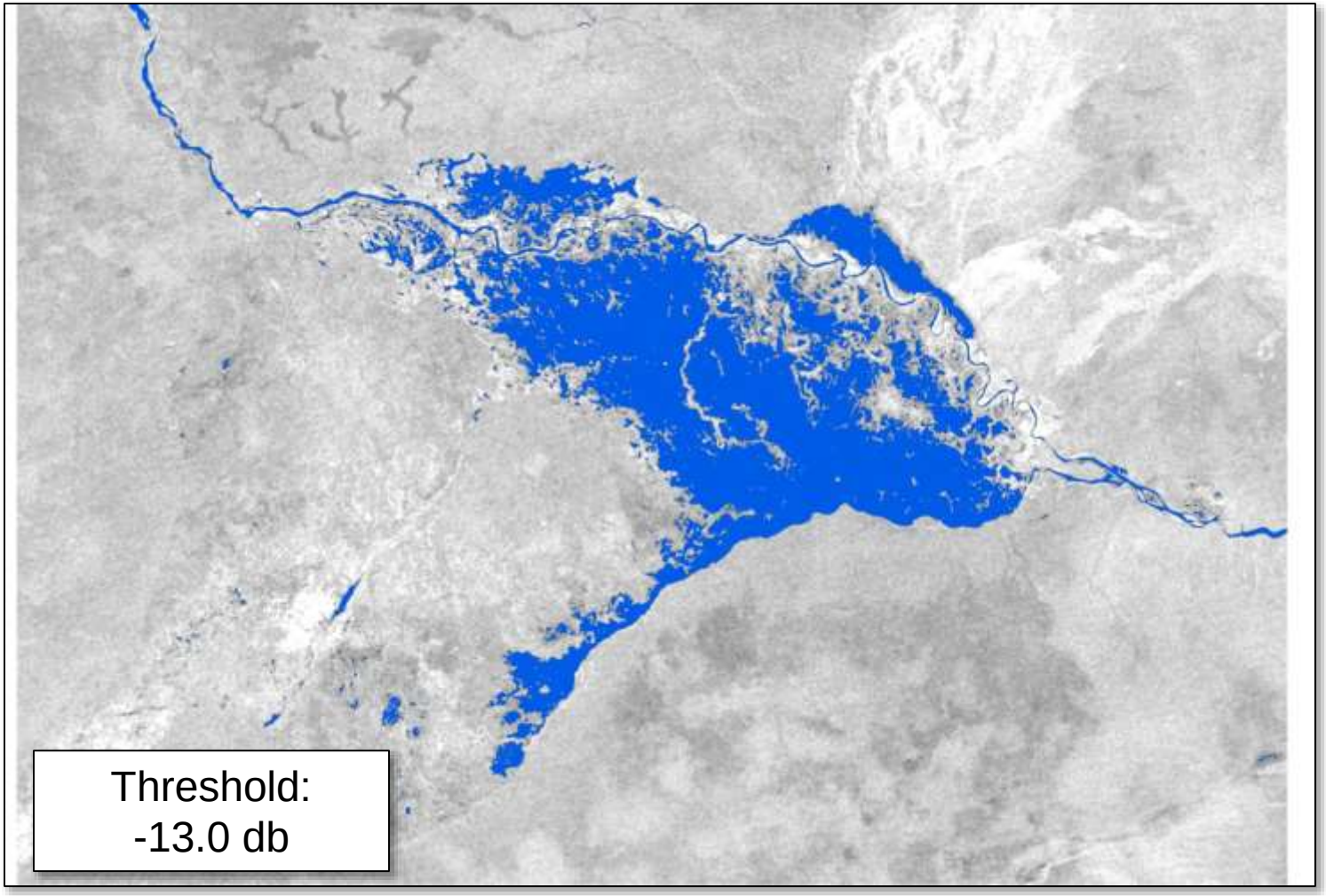
your knowledge partner

Thresholding & Validation



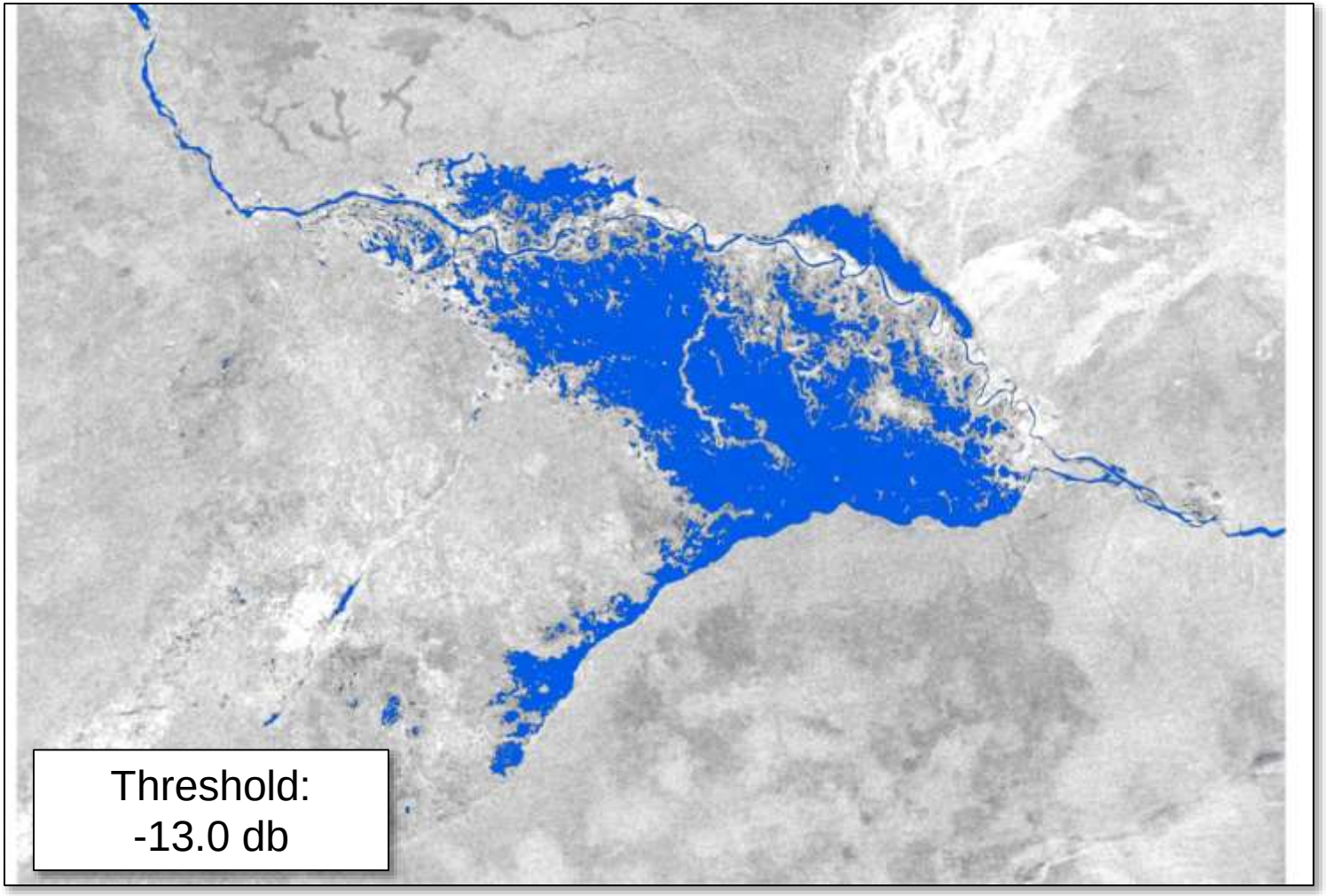
your knowledge partner

Thresholding & Validation



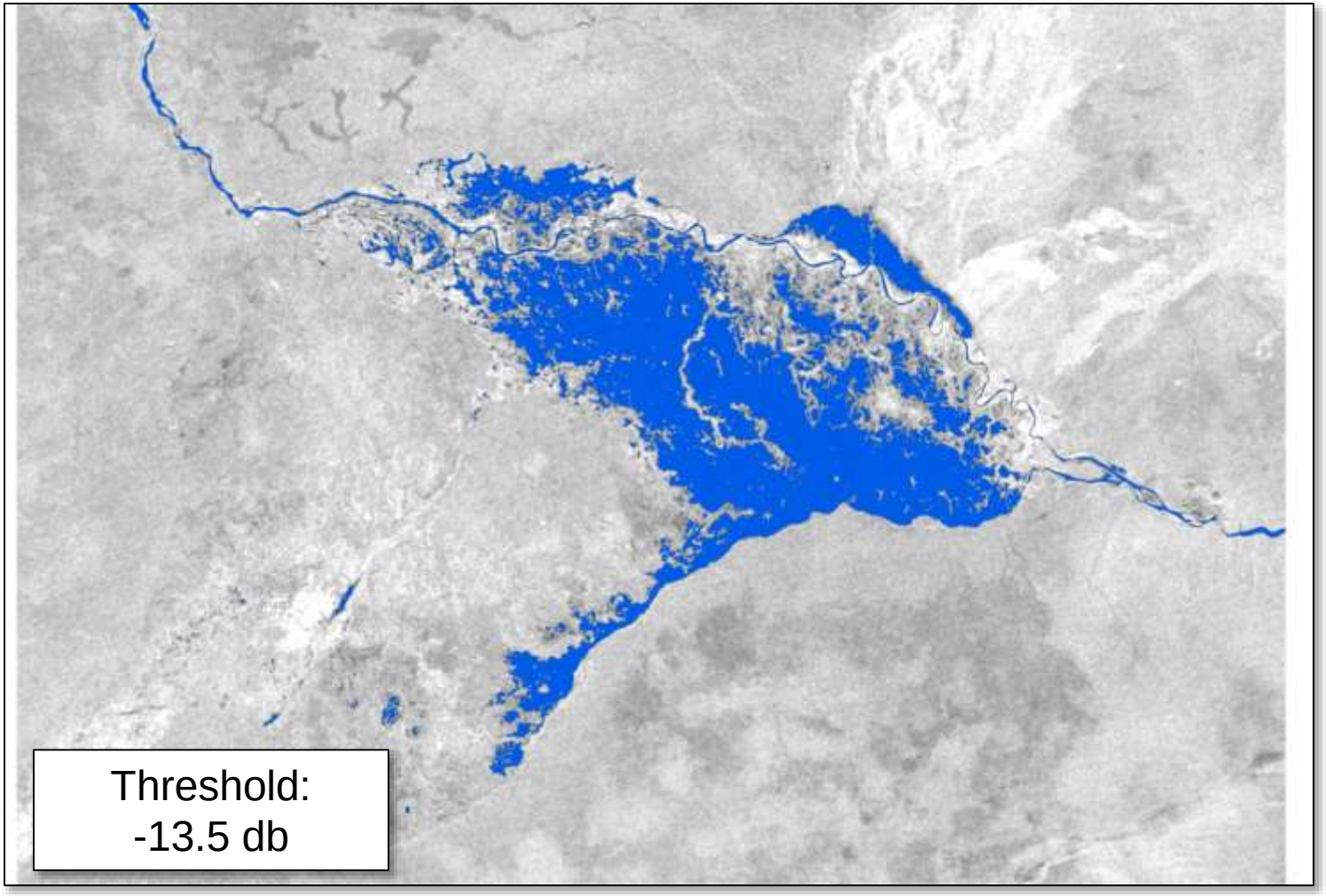
your knowledge partner

Thresholding & Validation



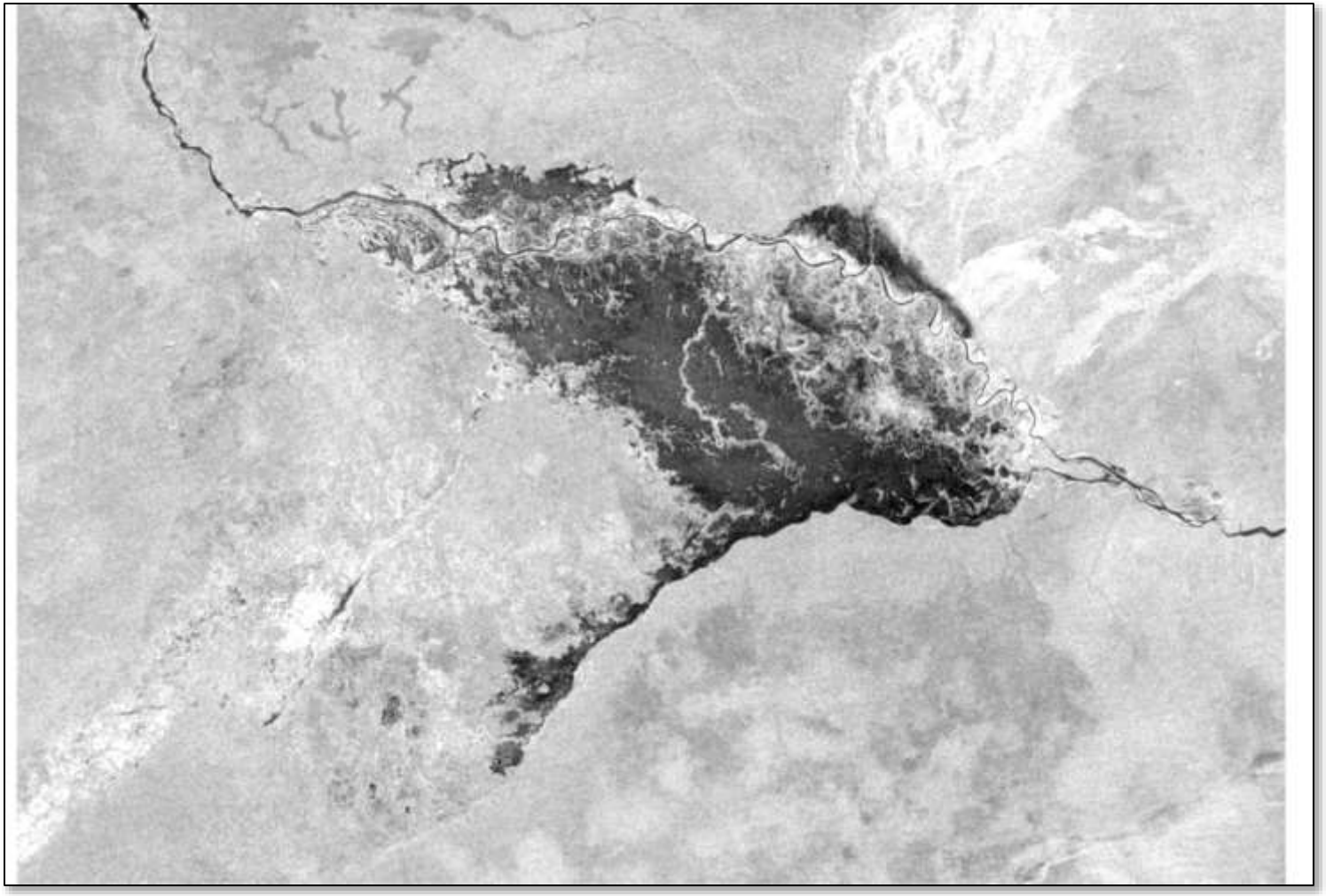
your knowledge partner

Thresholding & Validation



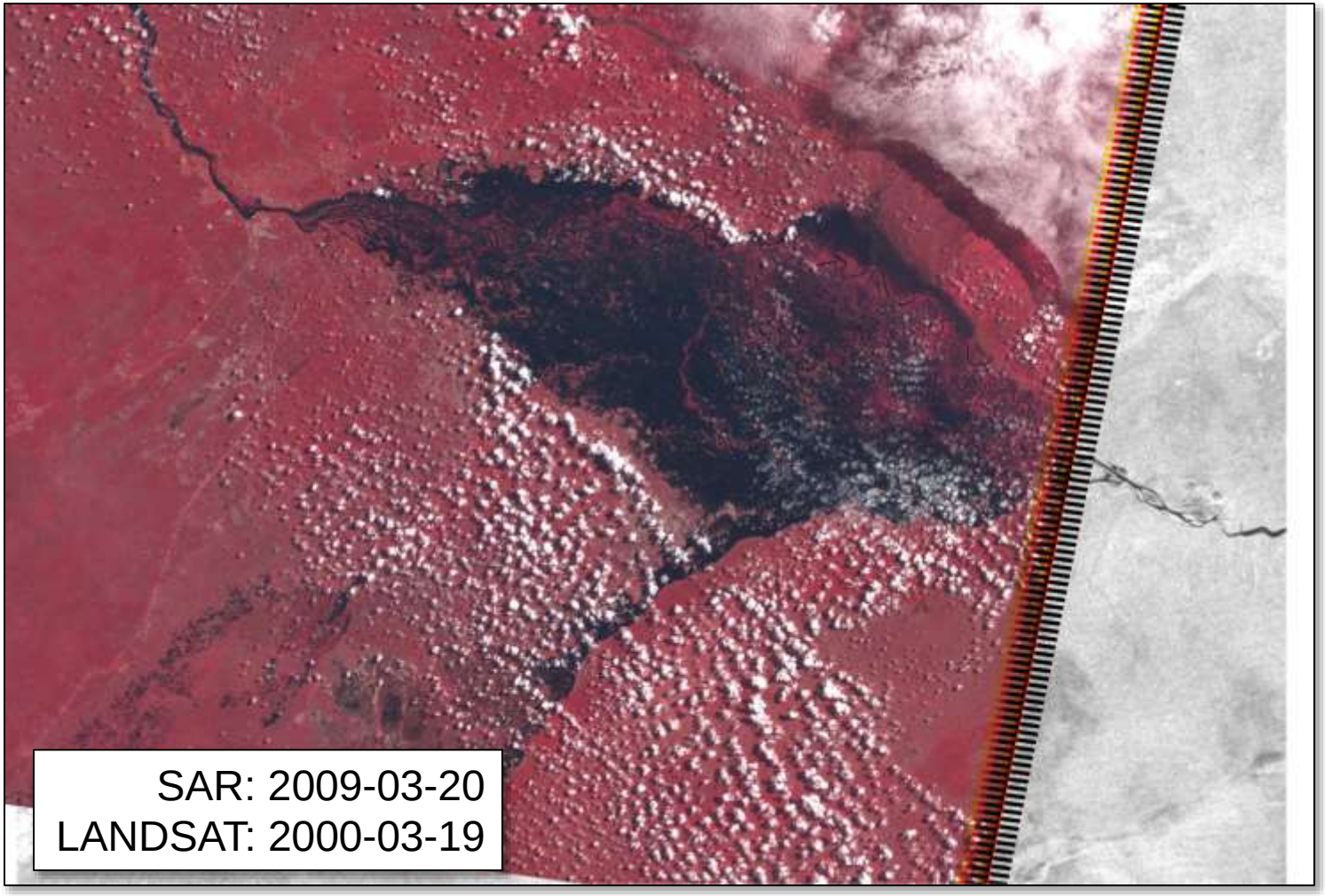
your knowledge partner

Thresholding & Validation



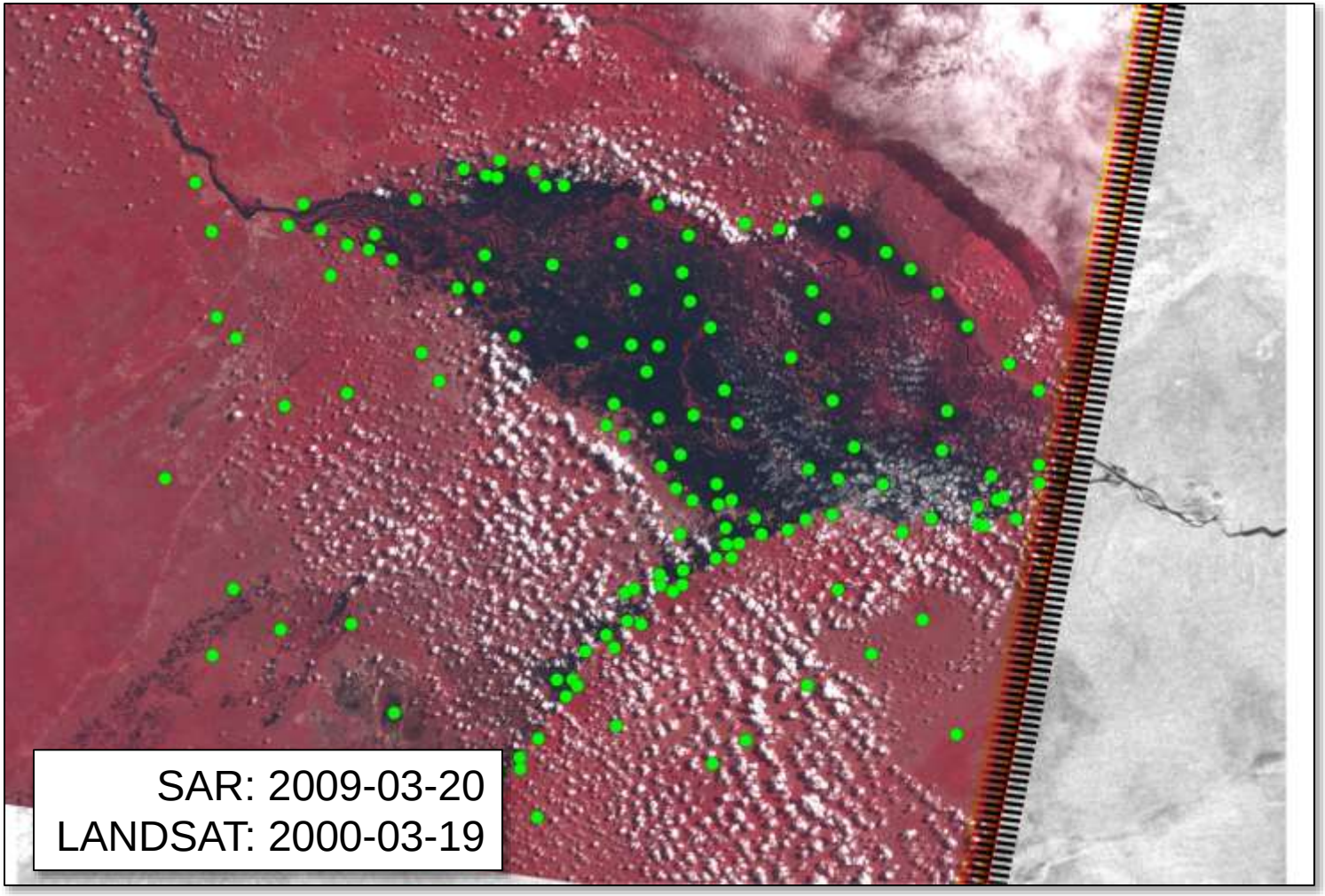
your knowledge partner

Thresholding & Validation



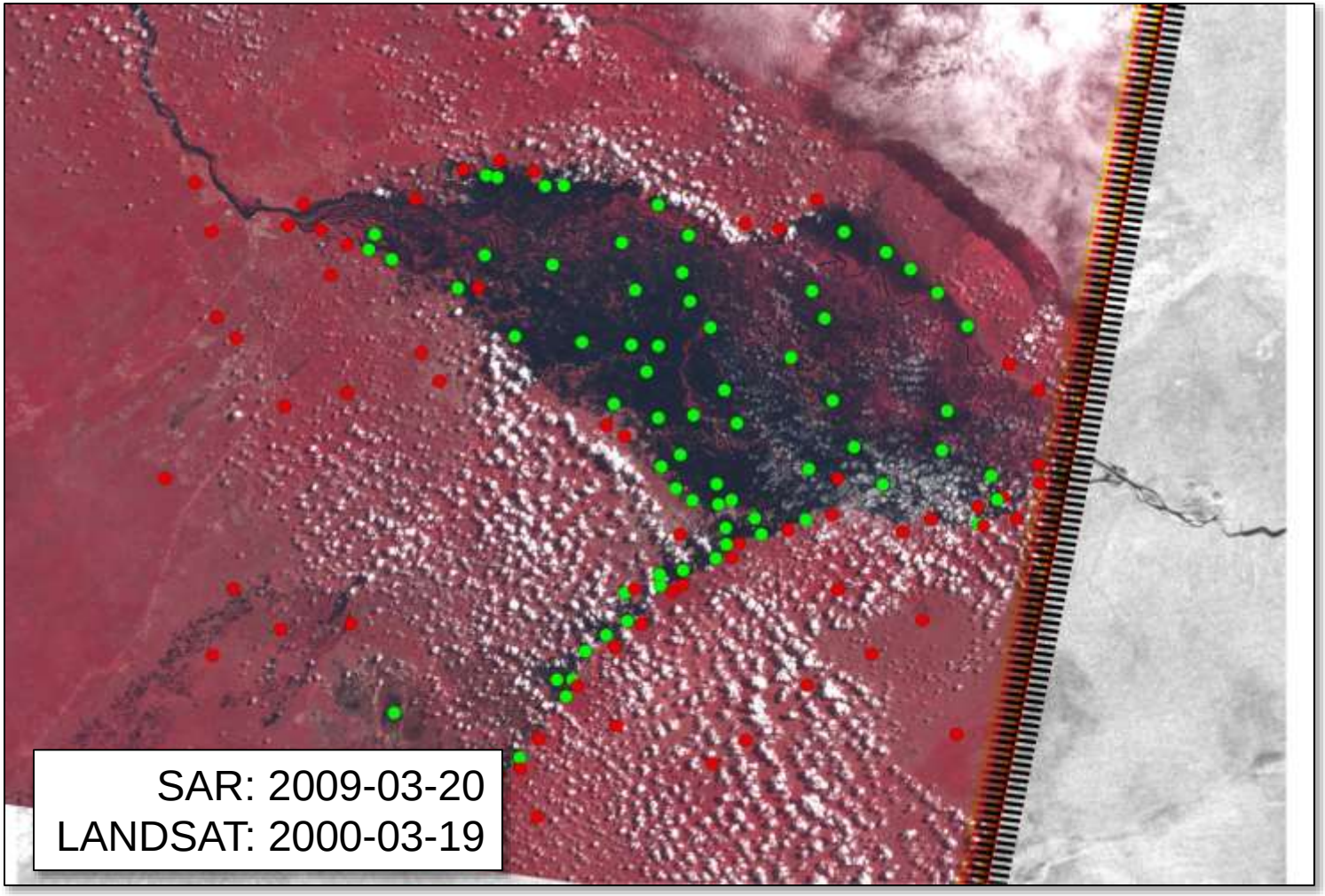
your knowledge partner

Thresholding & Validation



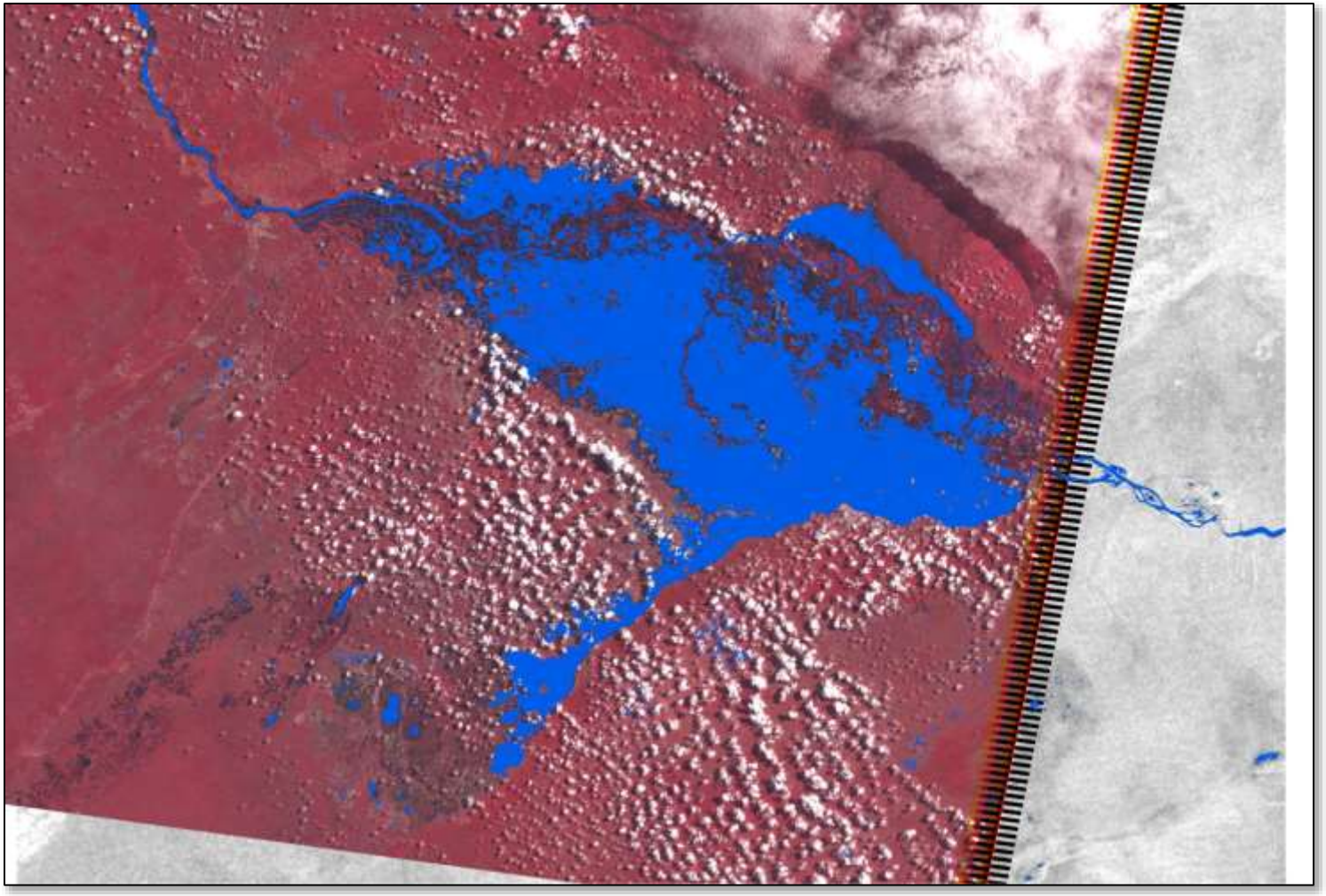
your knowledge partner

Thresholding & Validation



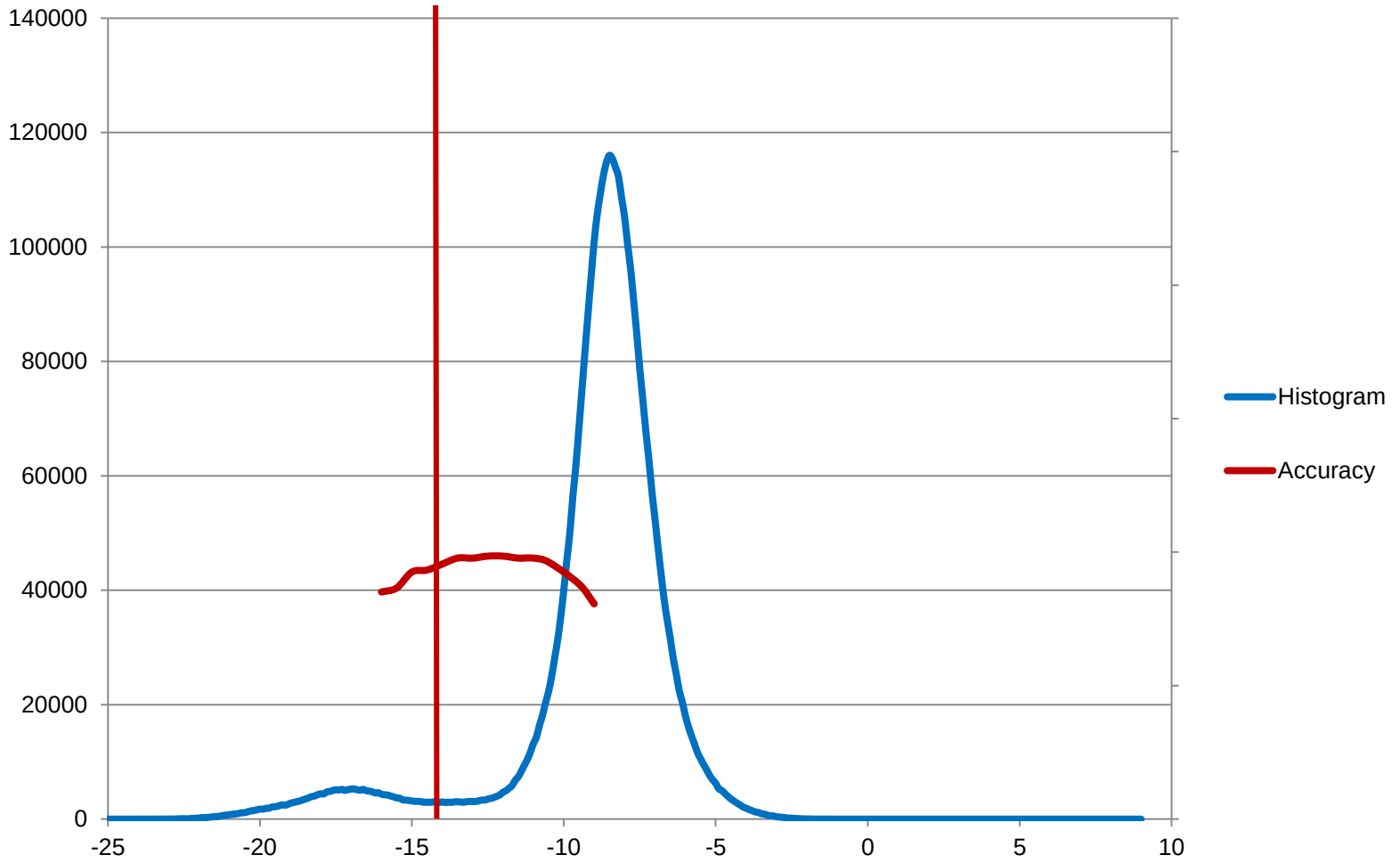
your knowledge partner

Thresholding & Validation



your knowledge partner

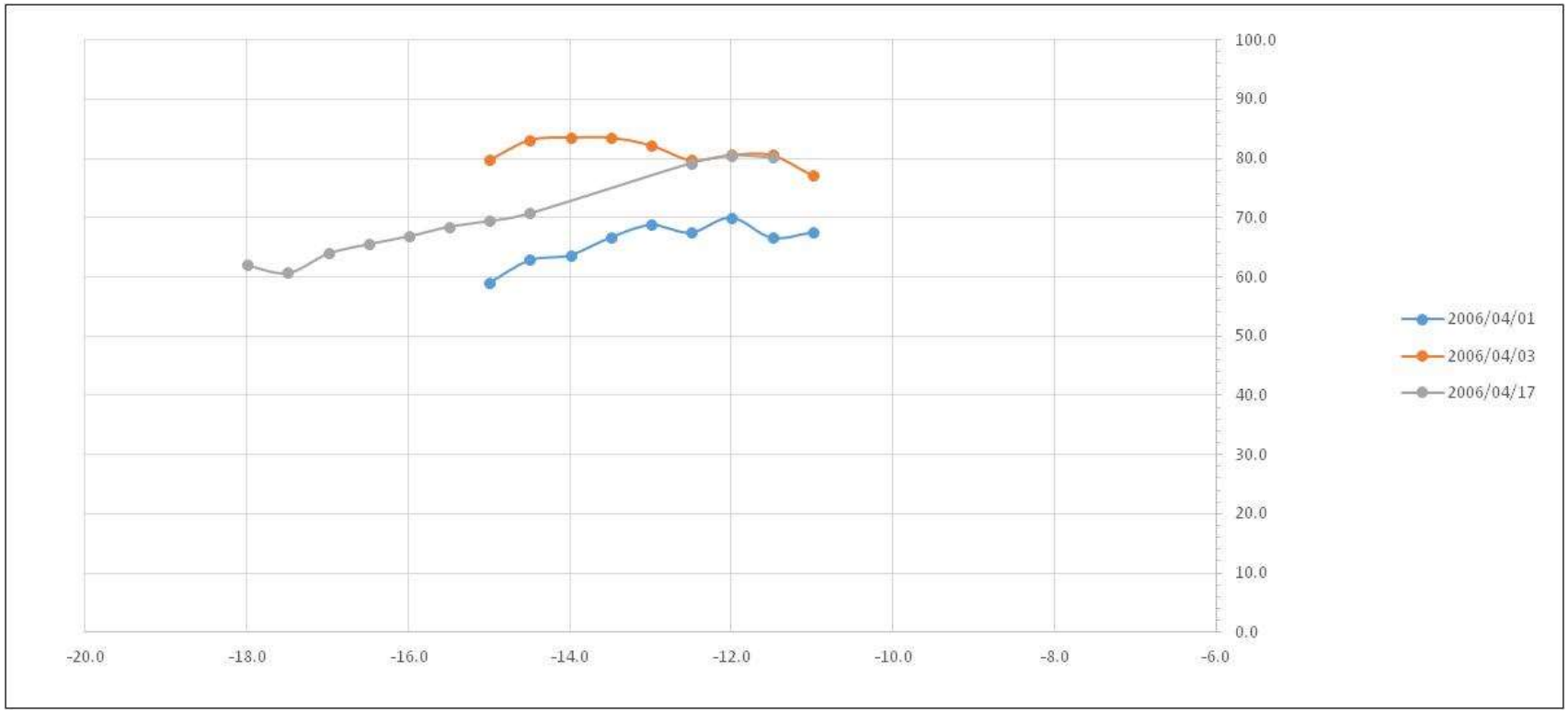
Thresholding Results



your knowledge partner

Thresholding Results

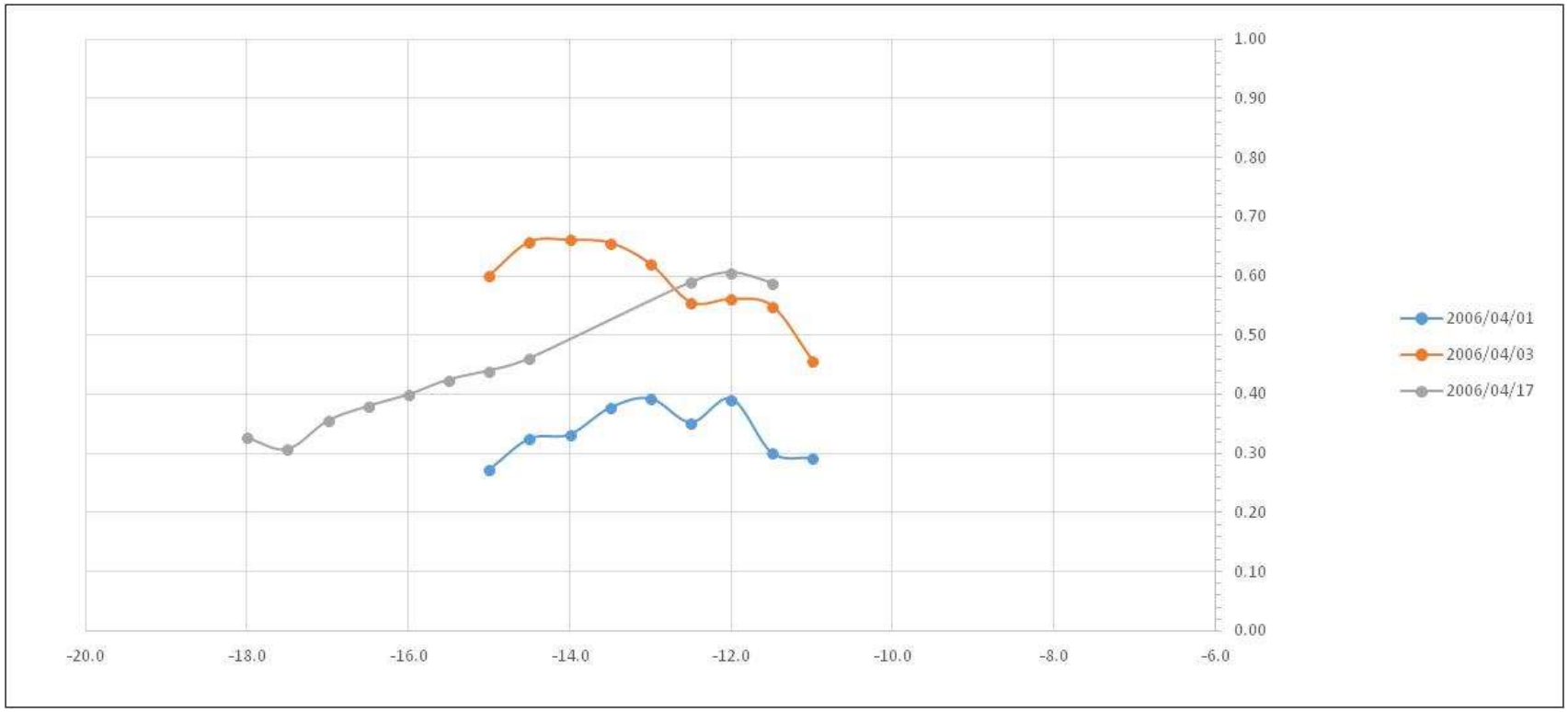
ASAR WSS – Overall Accuracy – 2006



your knowledge partner

Thresholding Results

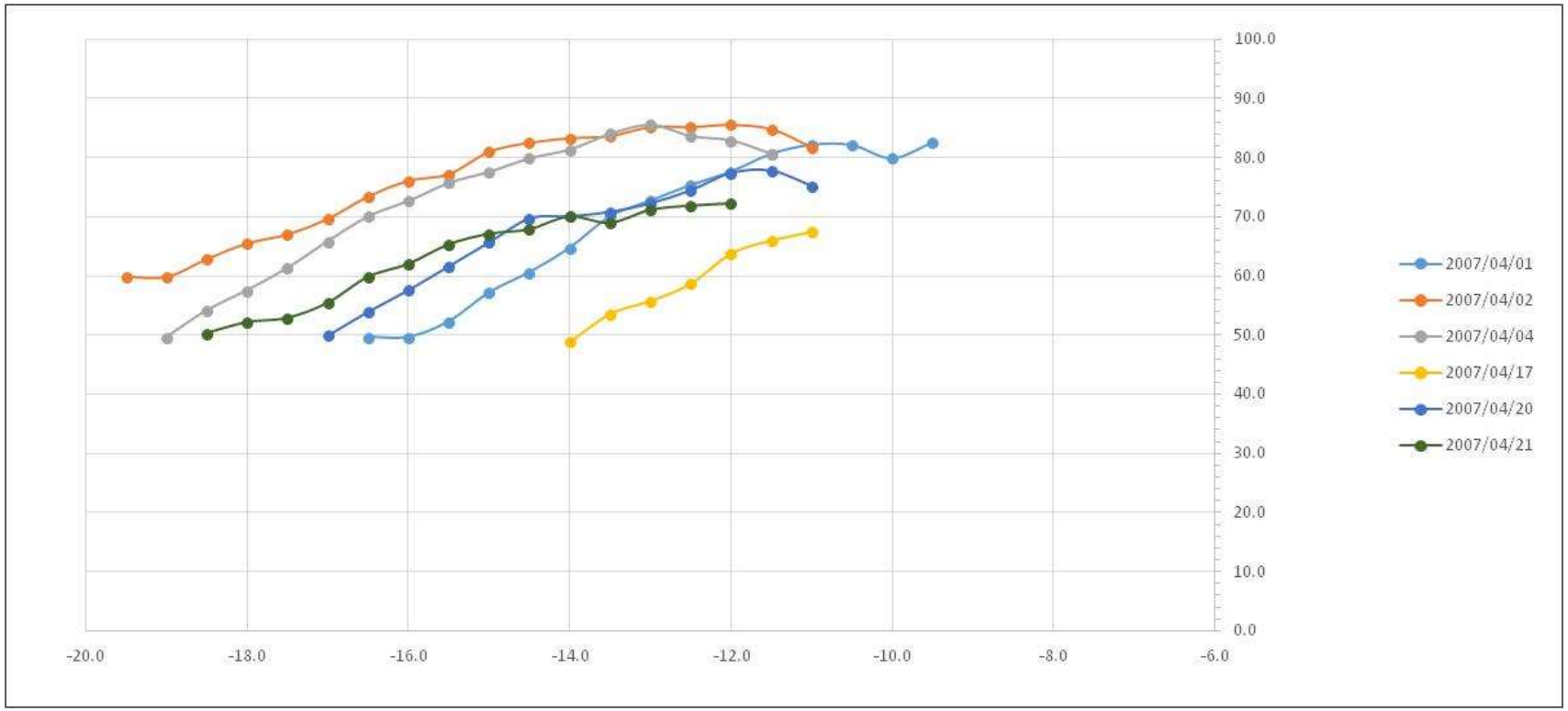
ASAR WSS – Kappa – 2006



your knowledge partner

Thresholding Results

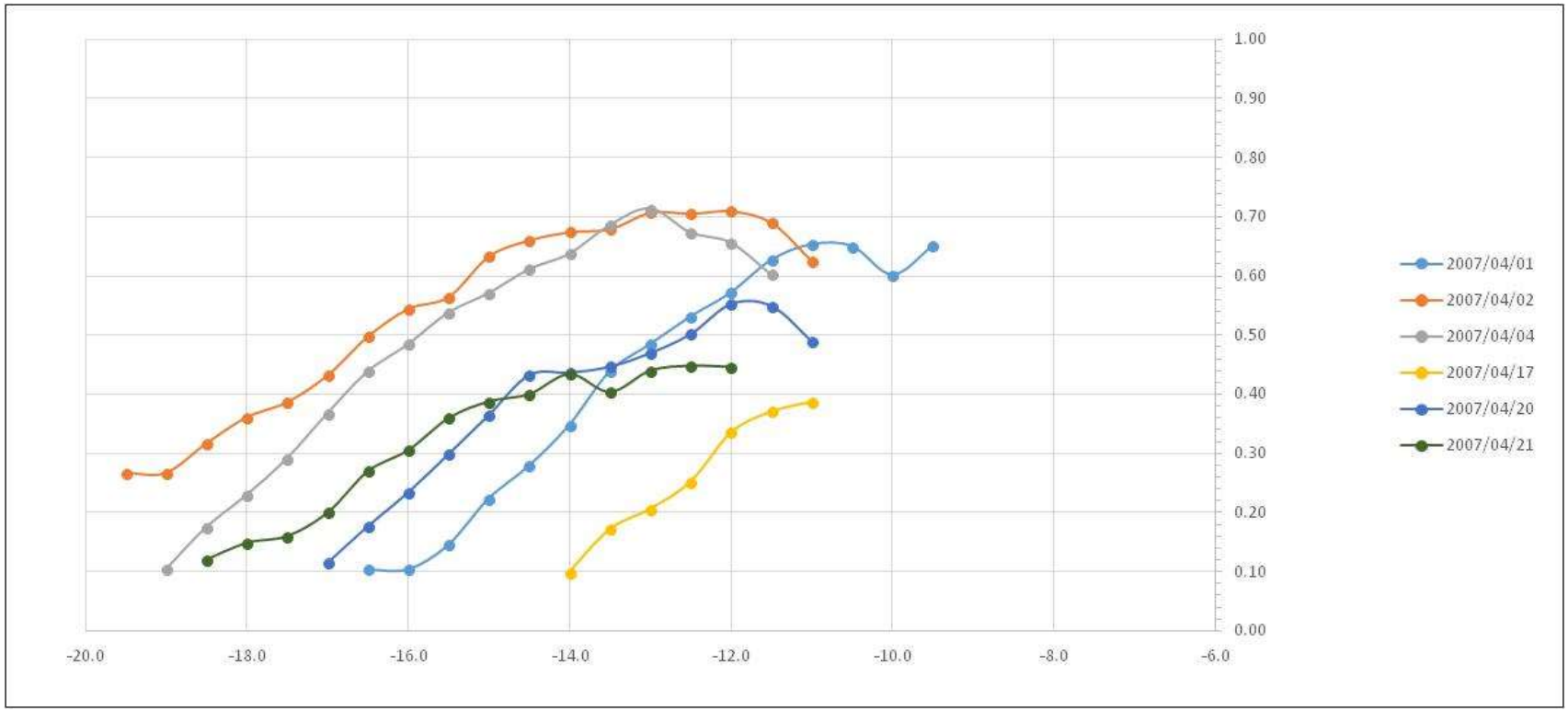
ASAR WSS – Overall Accuracy – 2007



your knowledge partner

Thresholding Results

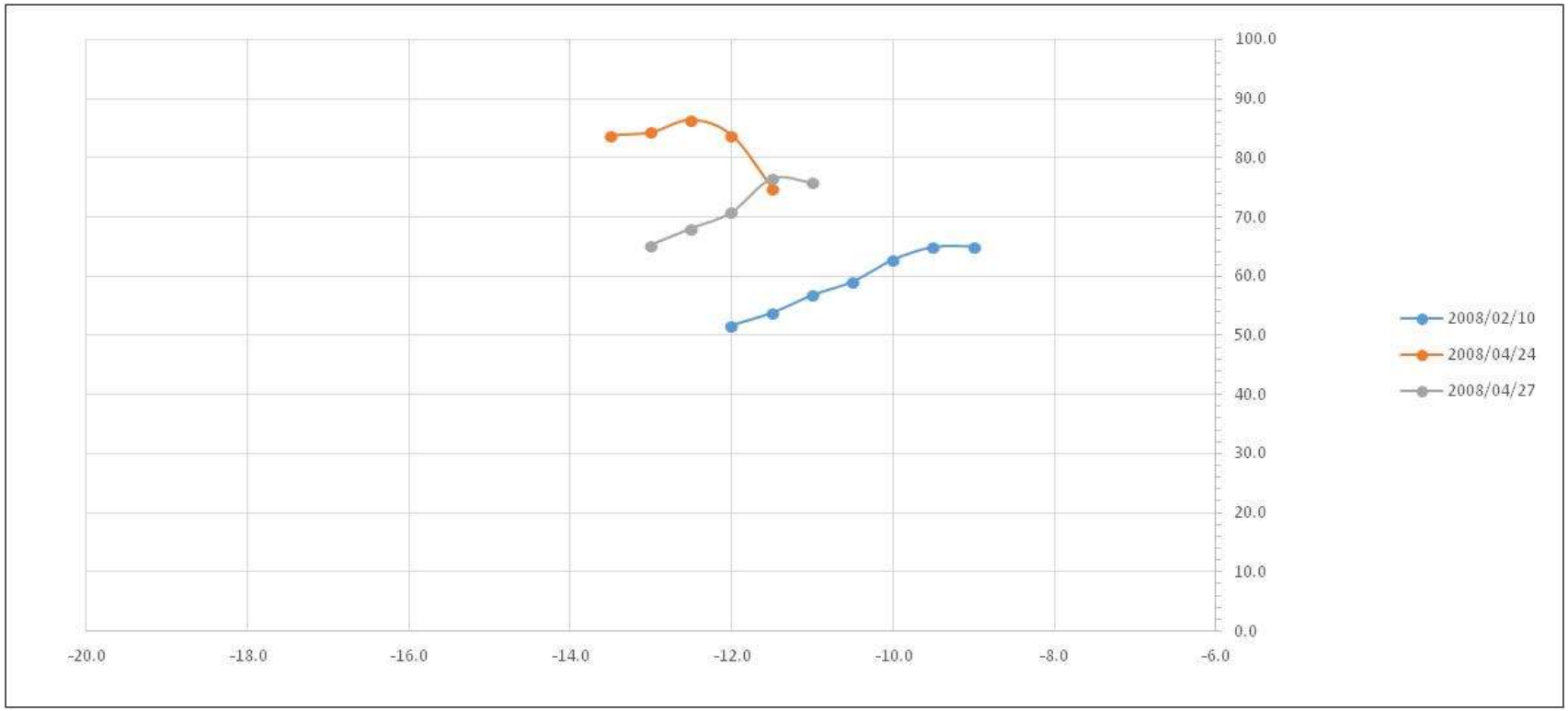
ASAR WSS – Kappa – 2007



your knowledge partner

Thresholding Results

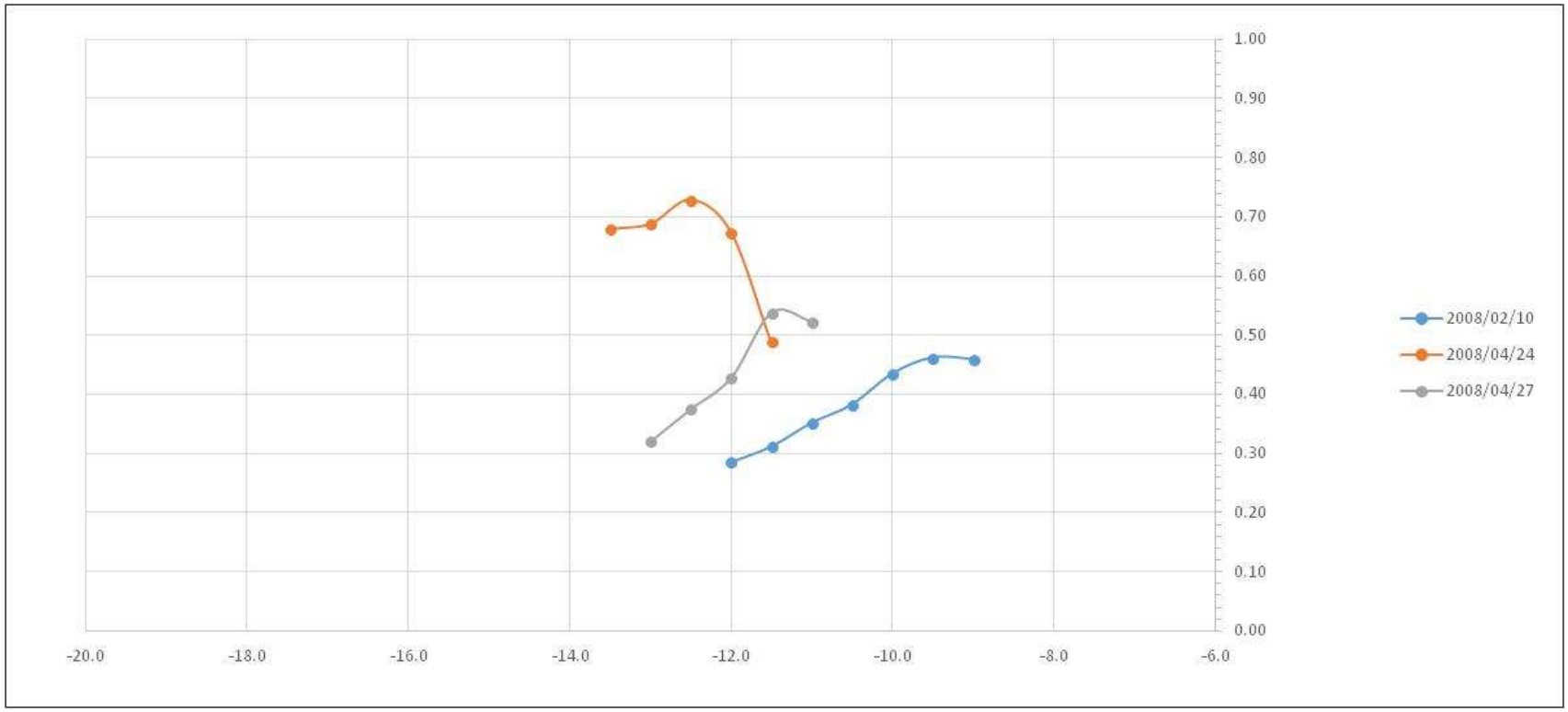
ASAR WSS – Overall Accuracy – 2008



your knowledge partner

Thresholding Results

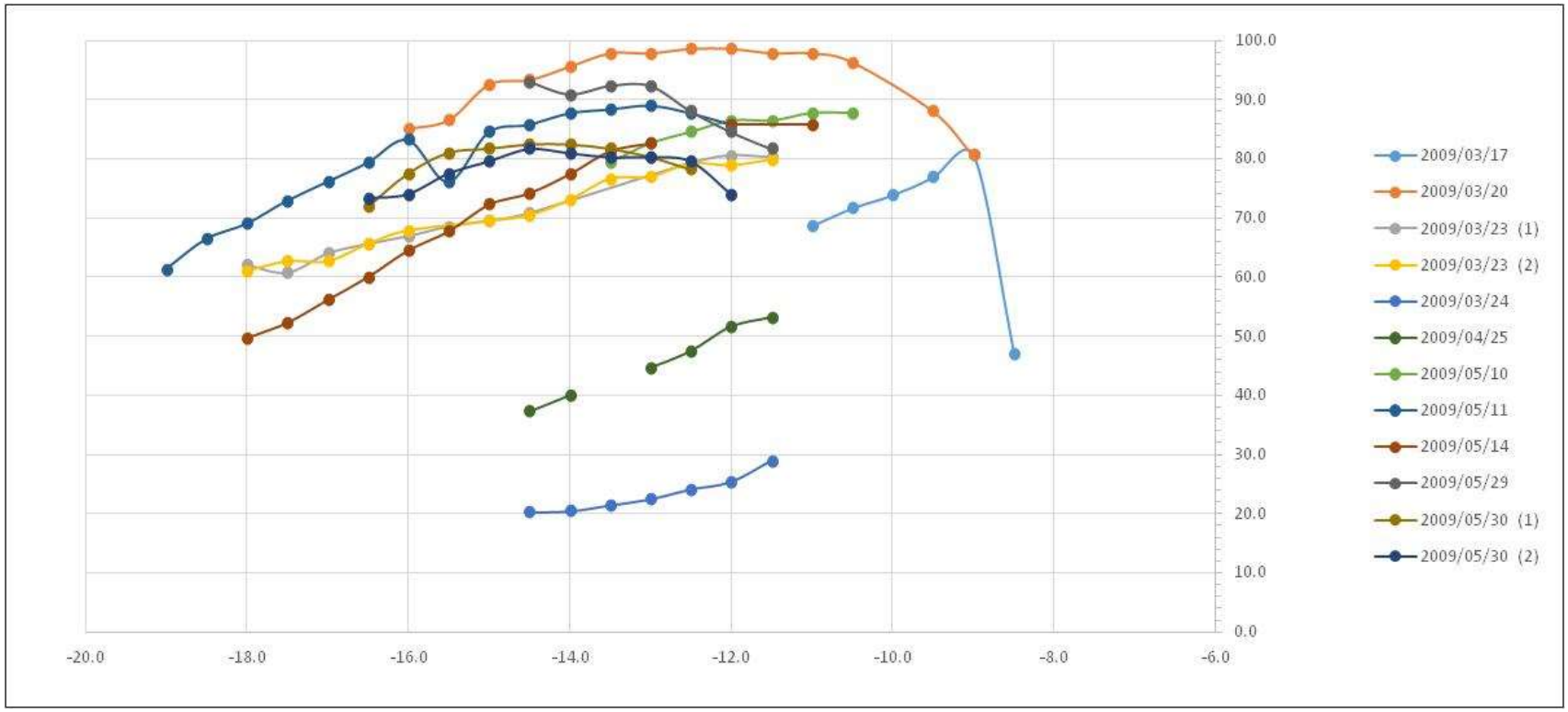
ASAR WSS – Kappa – 2008



your knowledge partner

Thresholding Results

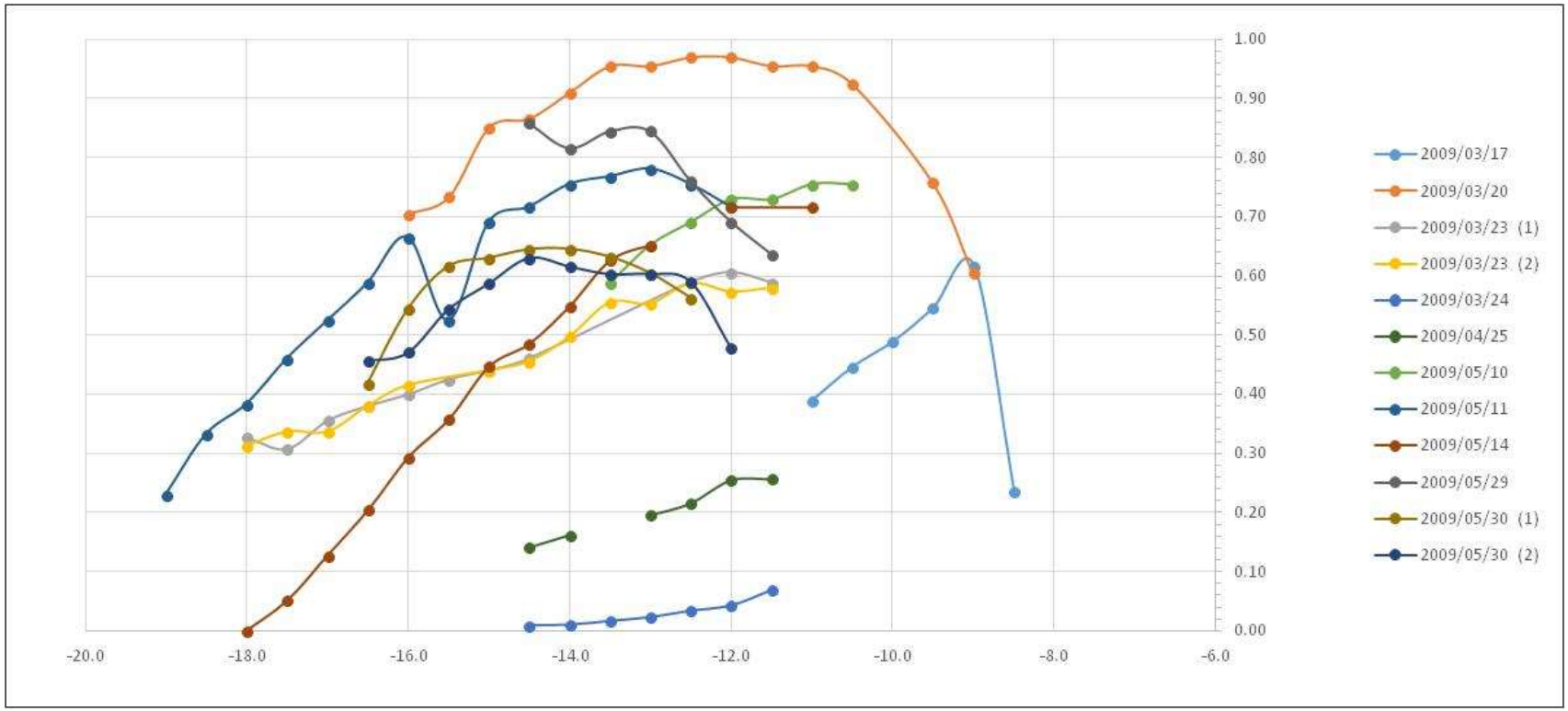
ASAR WSS – Overall Accuracy – 2009



your knowledge partner

Thresholding Results

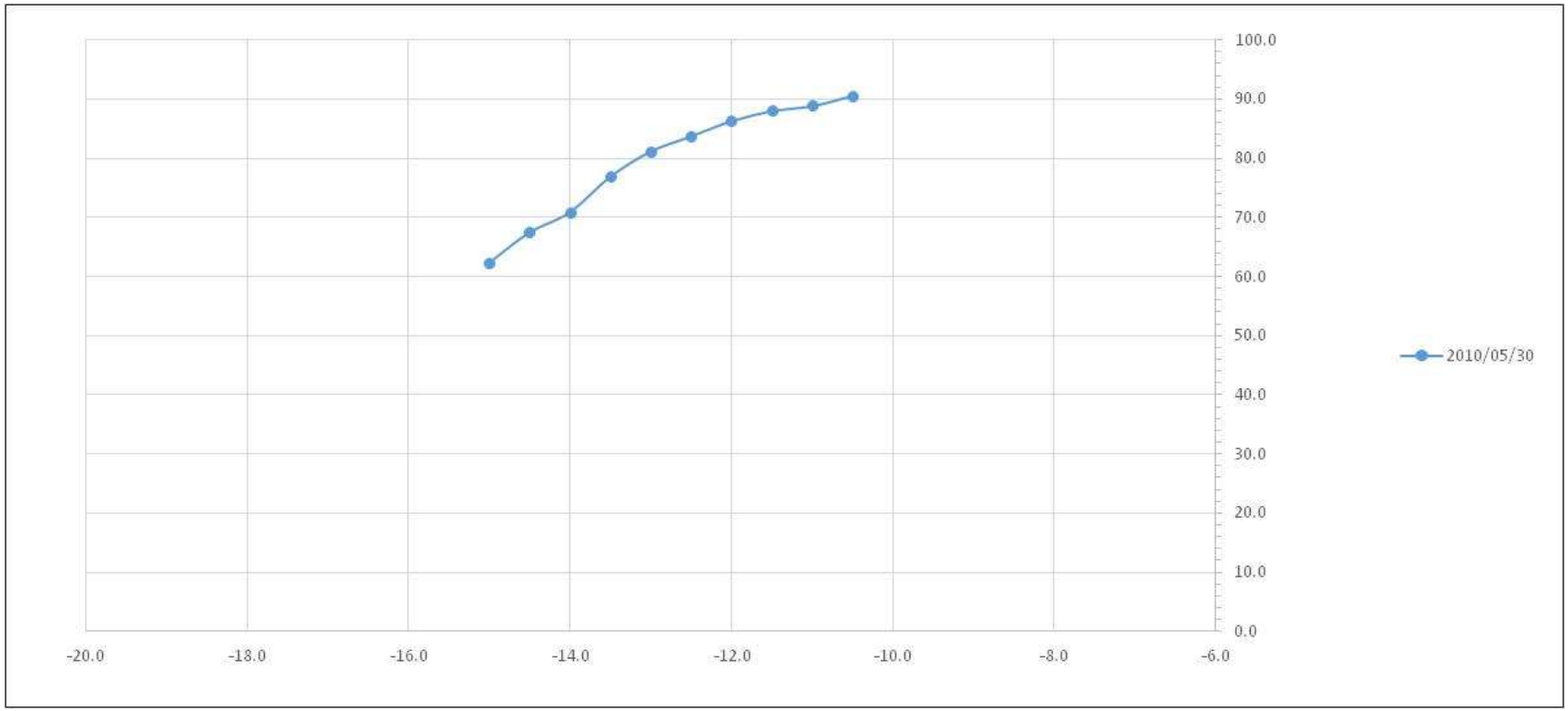
ASAR WSS – Kappa – 2009



your knowledge partner

Thresholding Results

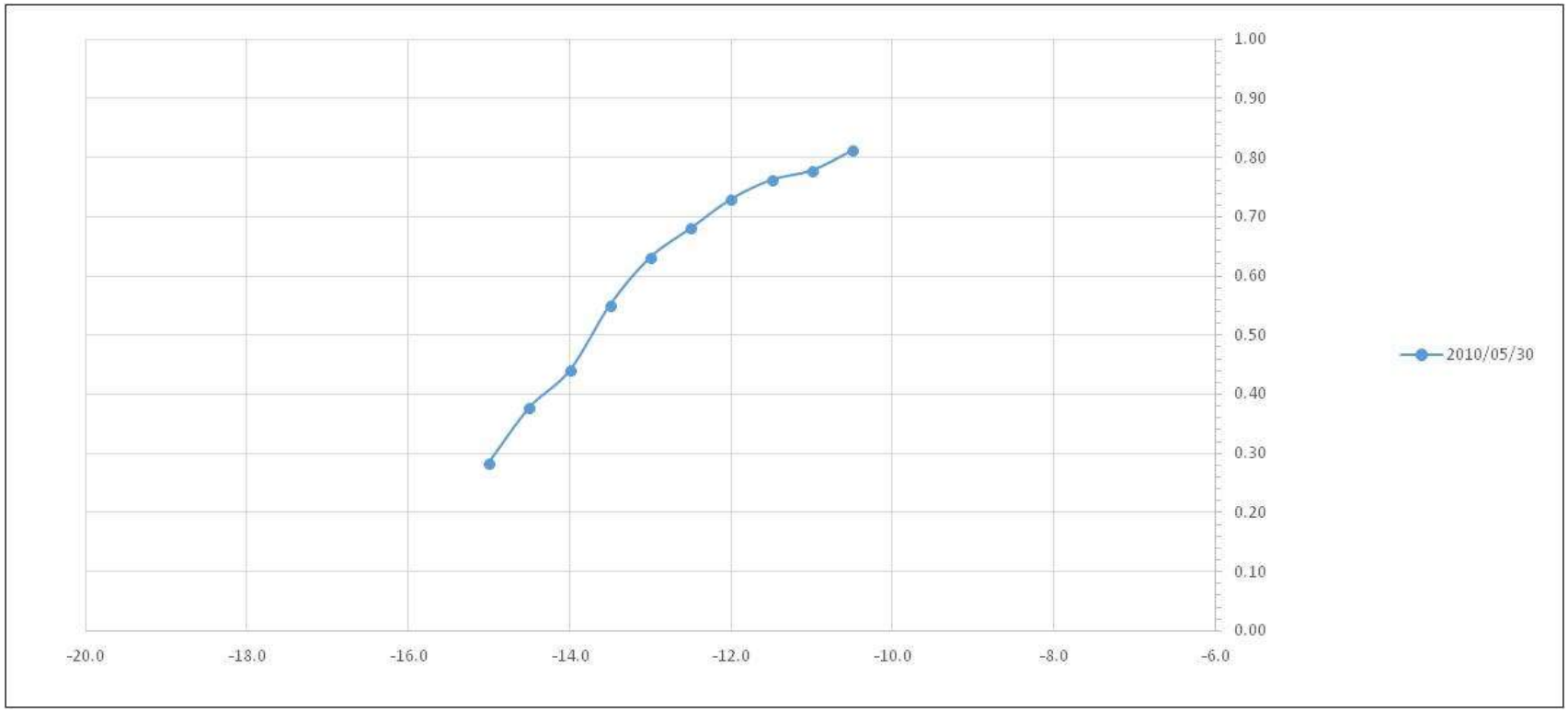
ASAR WSS – Overall Accuracy – 2010



your knowledge partner

Thresholding Results

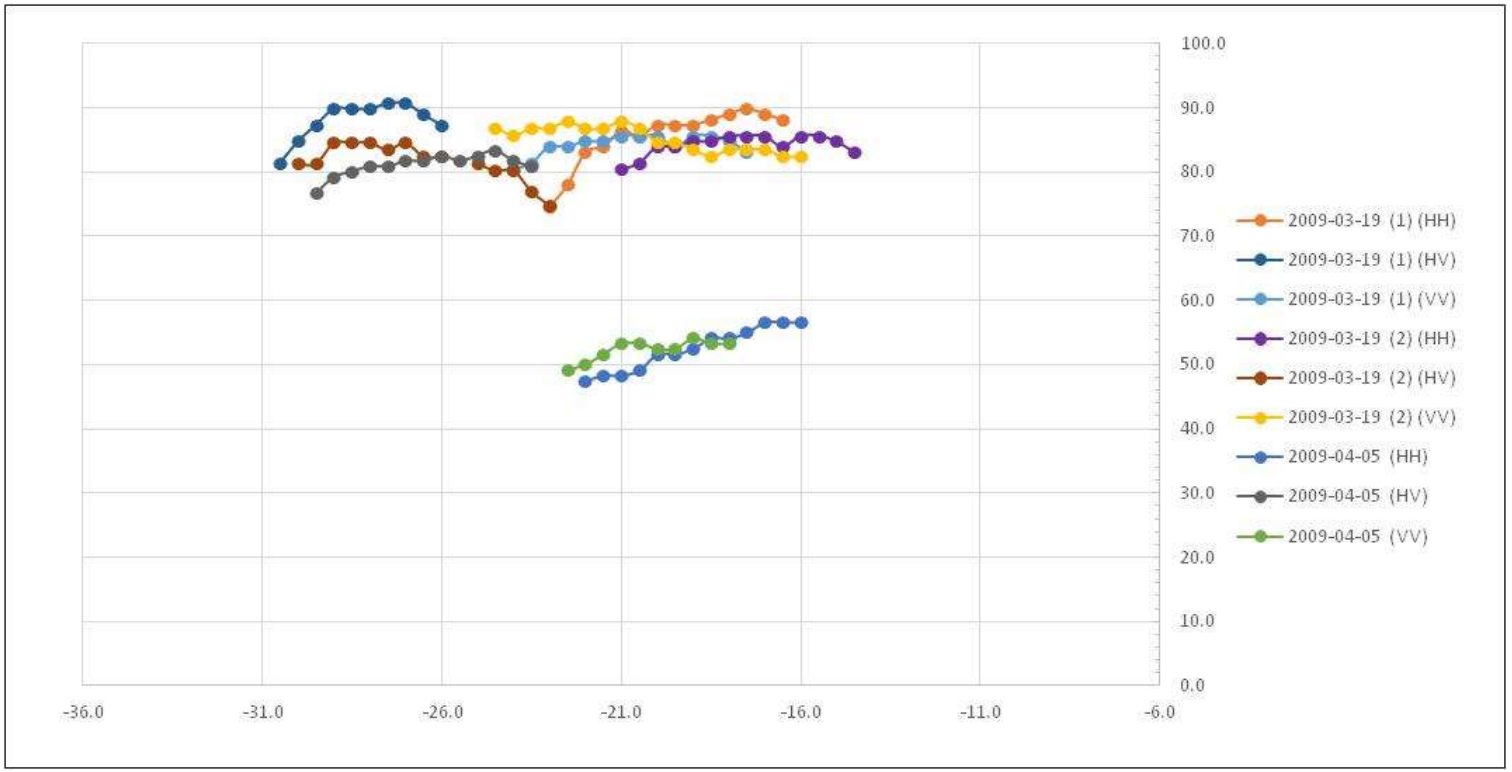
ASAR WSS – Kappa – 2010



your knowledge partner

Thresholding Results

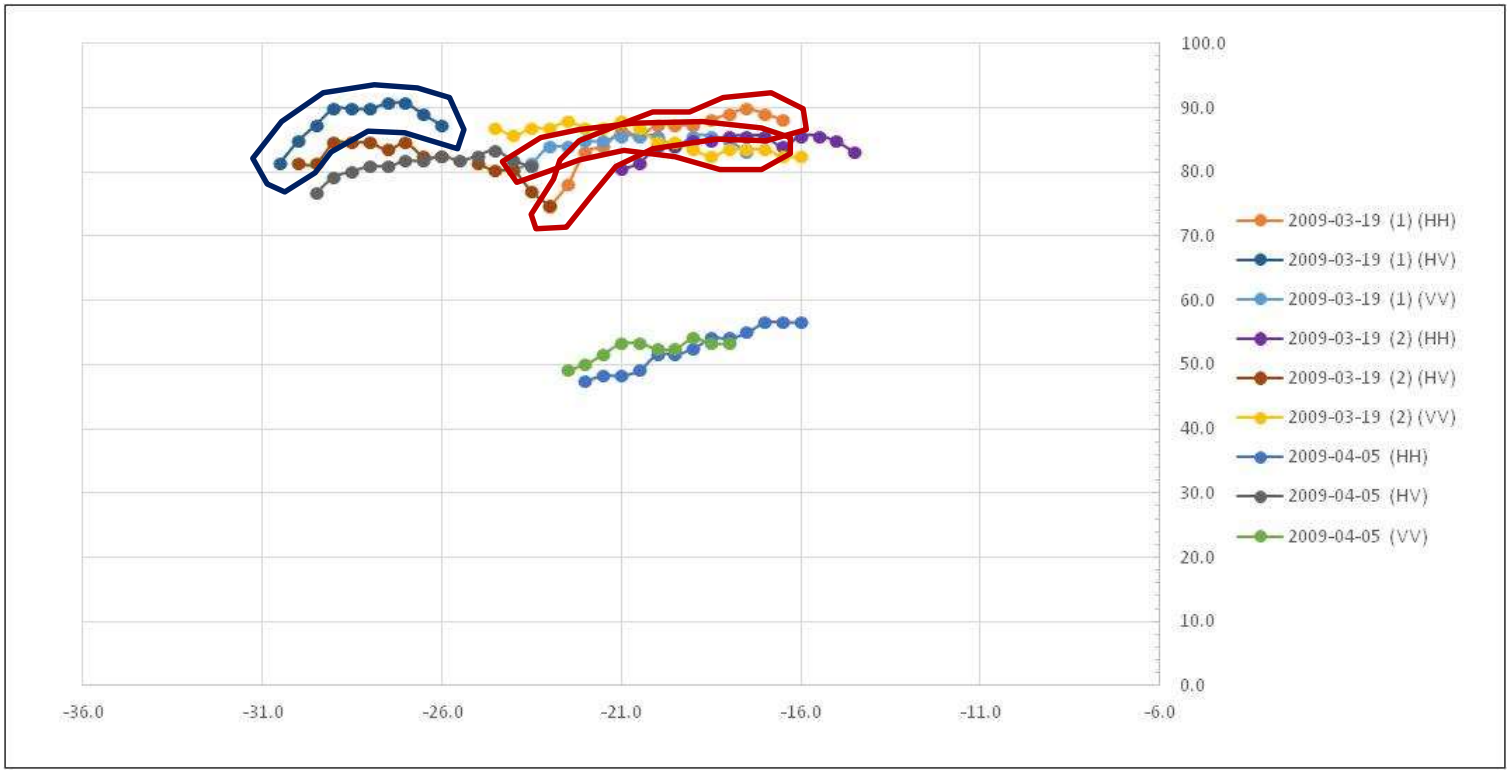
PALSAR PLR – Overall Accuracy – 2009



your knowledge partner

Thresholding Results

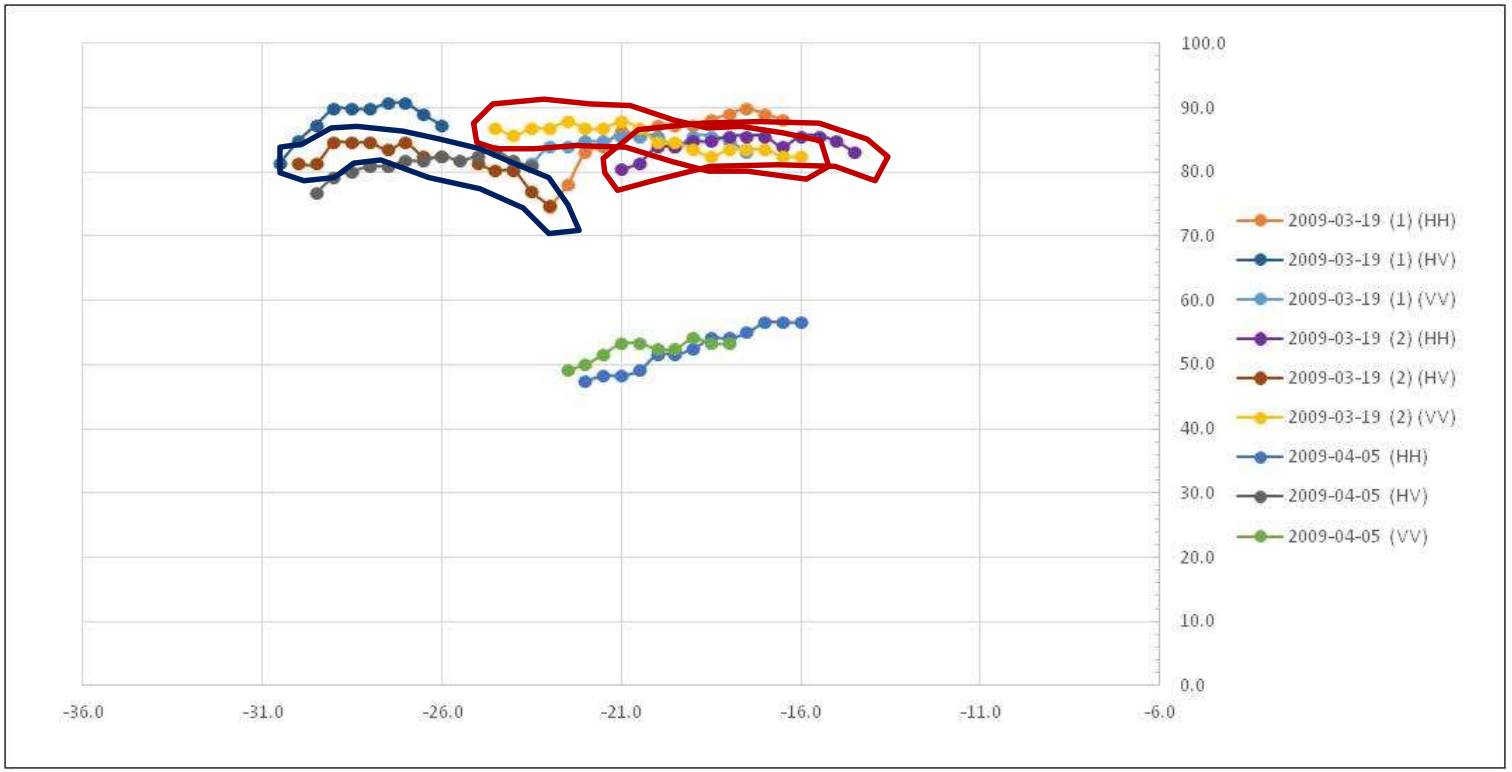
PALSAR PLR – Overall Accuracy – 2009



your knowledge partner

Thresholding Results

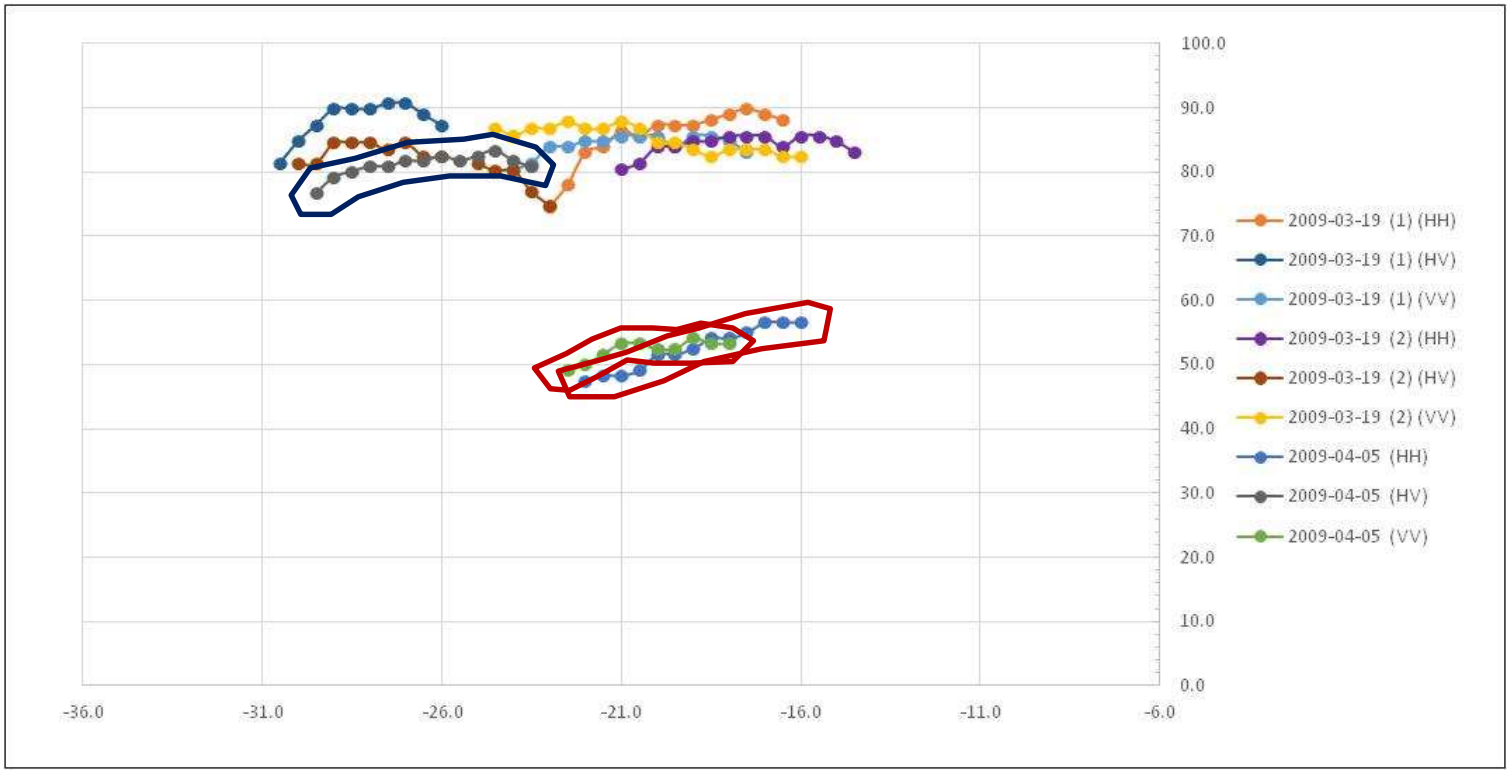
PALSAR PLR – Overall Accuracy – 2009



your knowledge partner

Thresholding Results

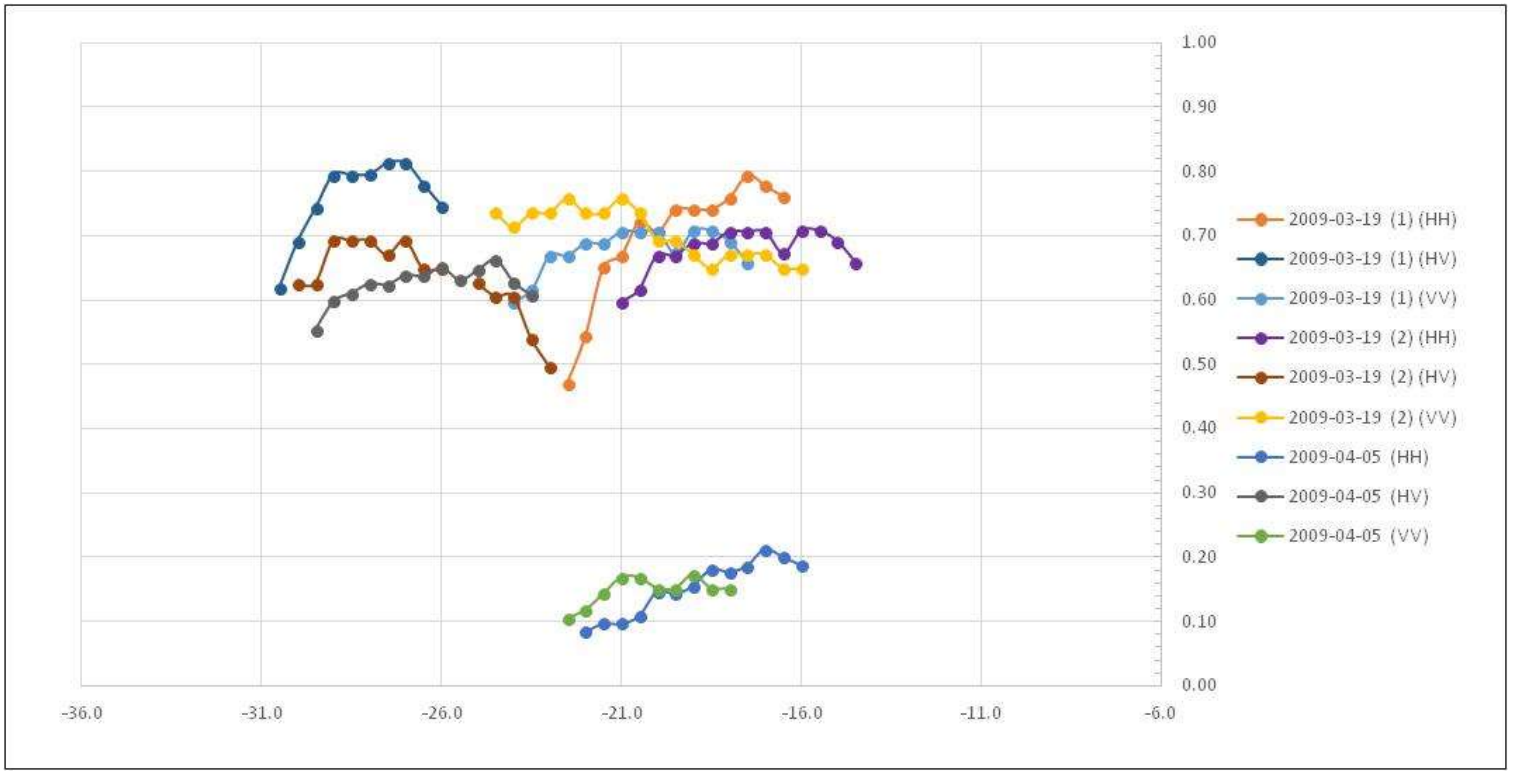
PALSAR PLR – Overall Accuracy – 2009



your knowledge partner

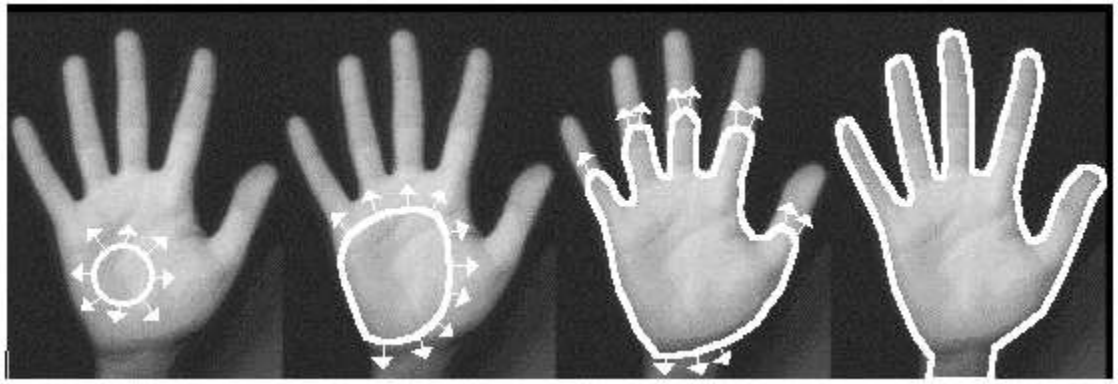
Thresholding Results

PALSAR PLR – Kappa – 2009



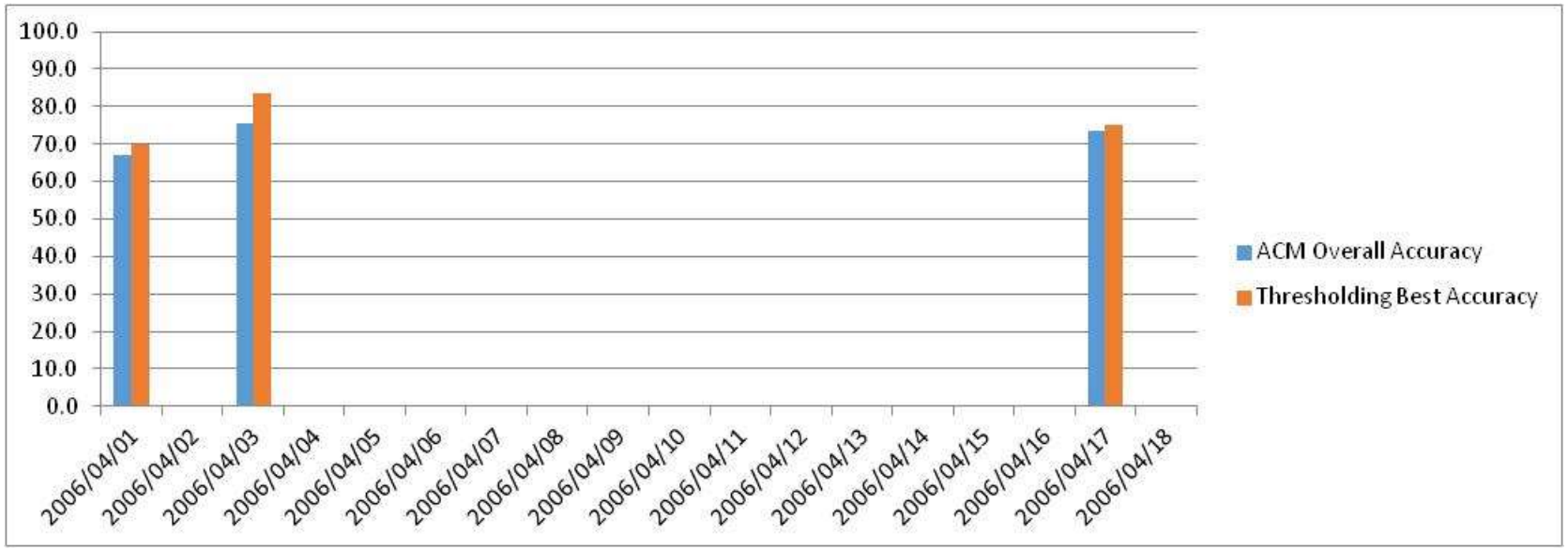
your knowledge partner

Active Contour Model



your knowledge partner

Active Contour Model

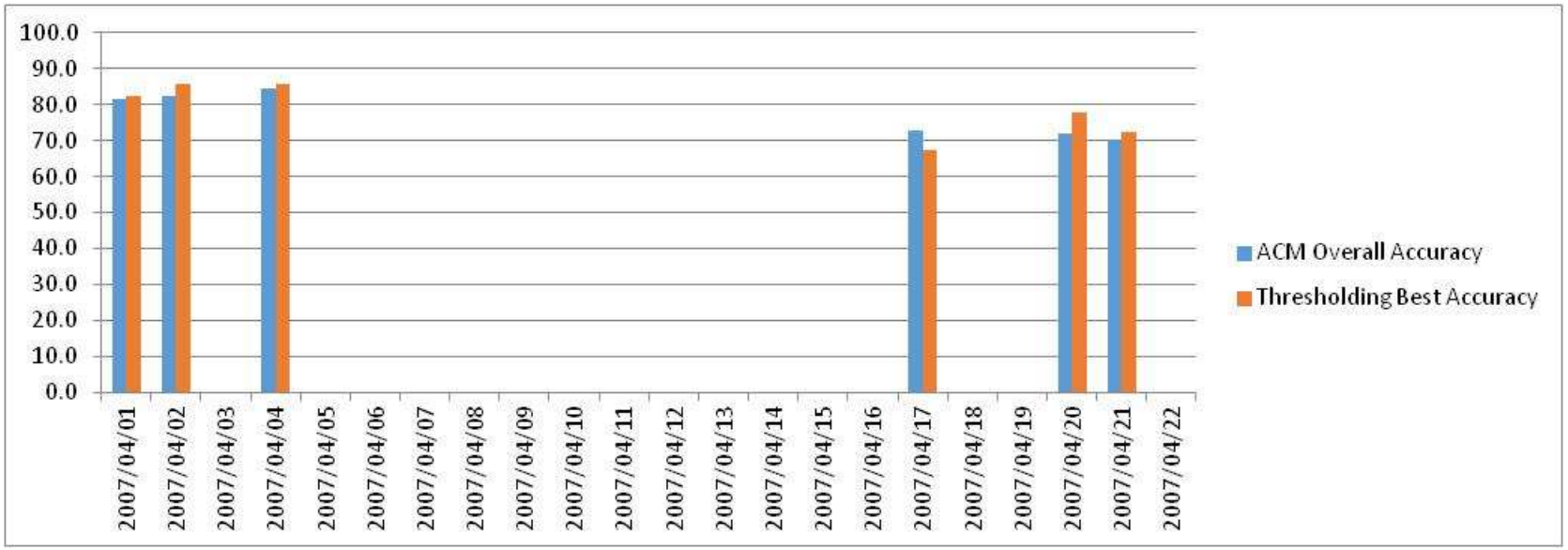


your knowledge partner

Active Contour Model

ACM vs Thresholding – 2007

ASAR

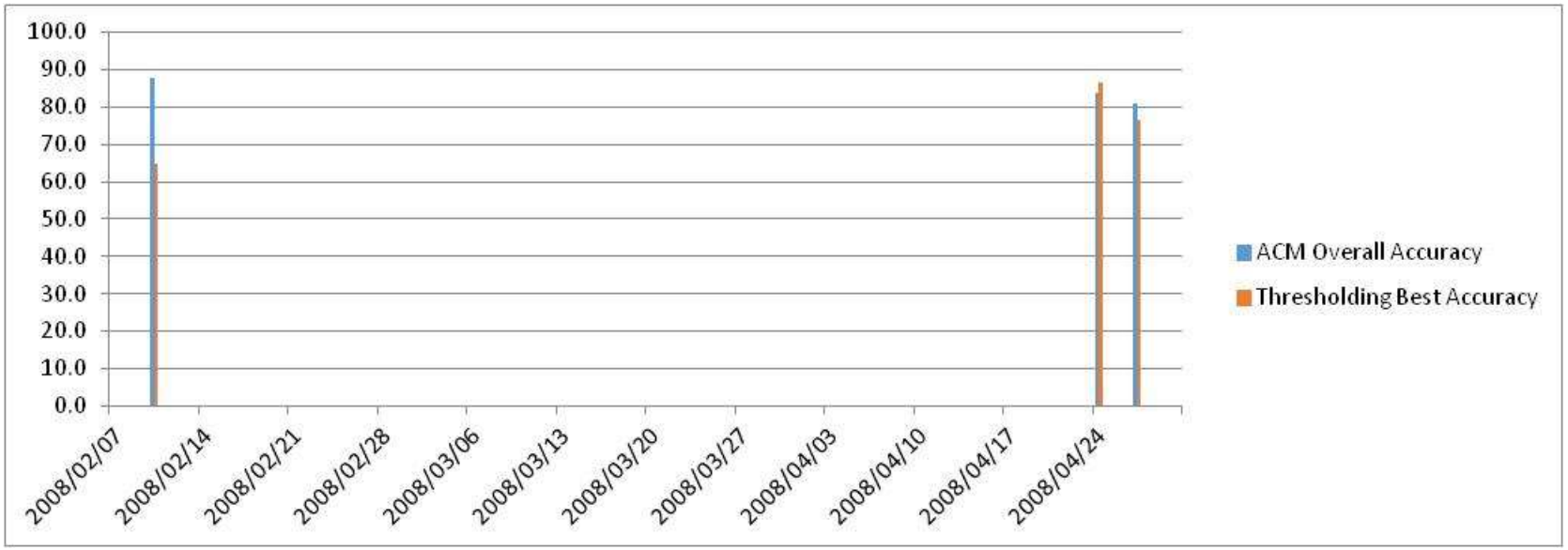


your knowledge partner

Active Contour Model

ACM vs Thresholding – 2008

ASAR

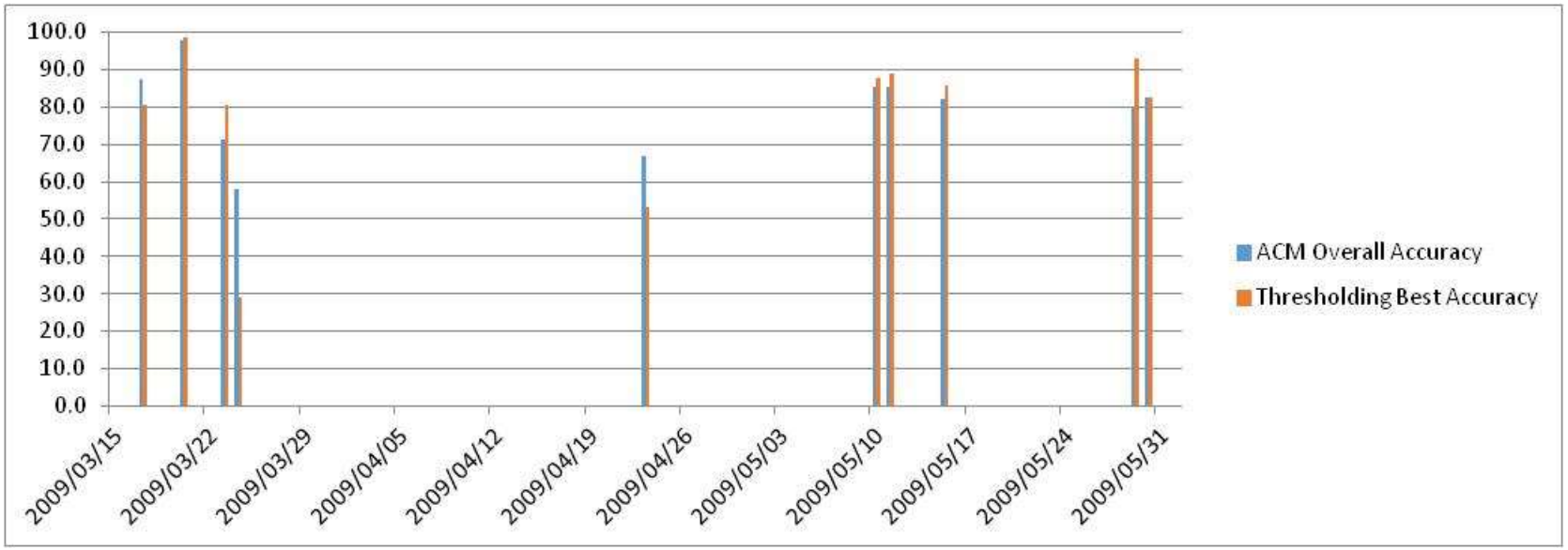


your knowledge partner

Active Contour Model

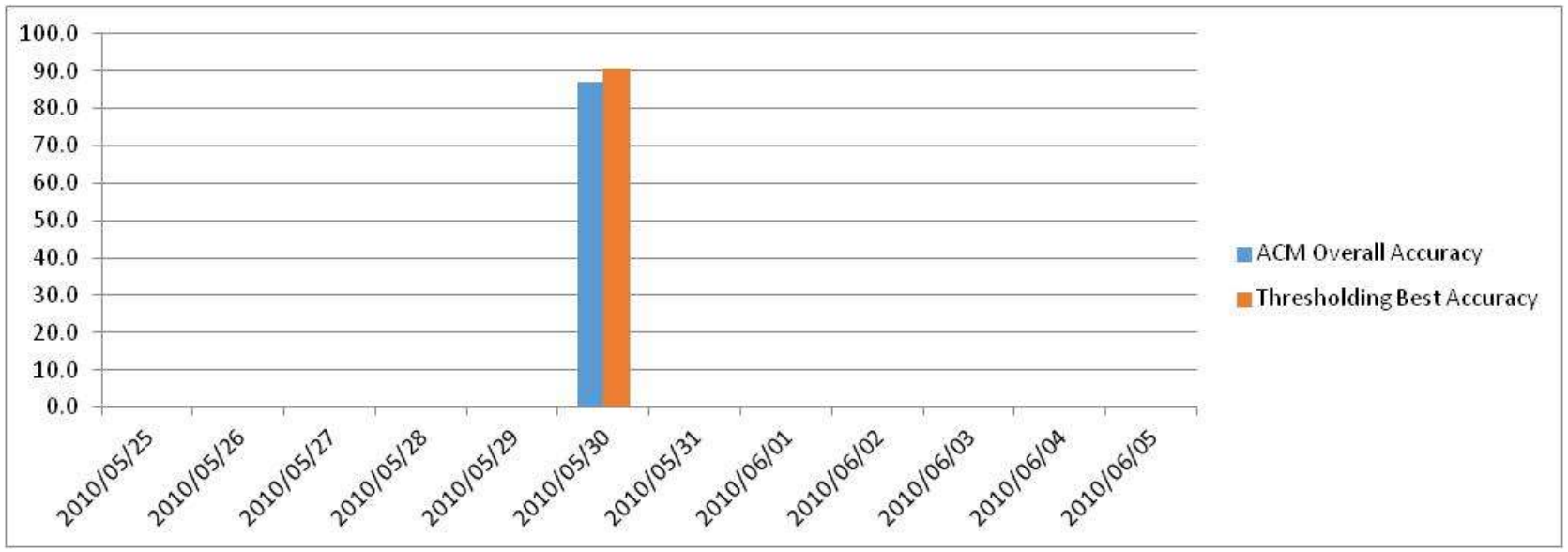
ACM vs Thresholding – 2009

ASAR



your knowledge partner

Active Contour Model

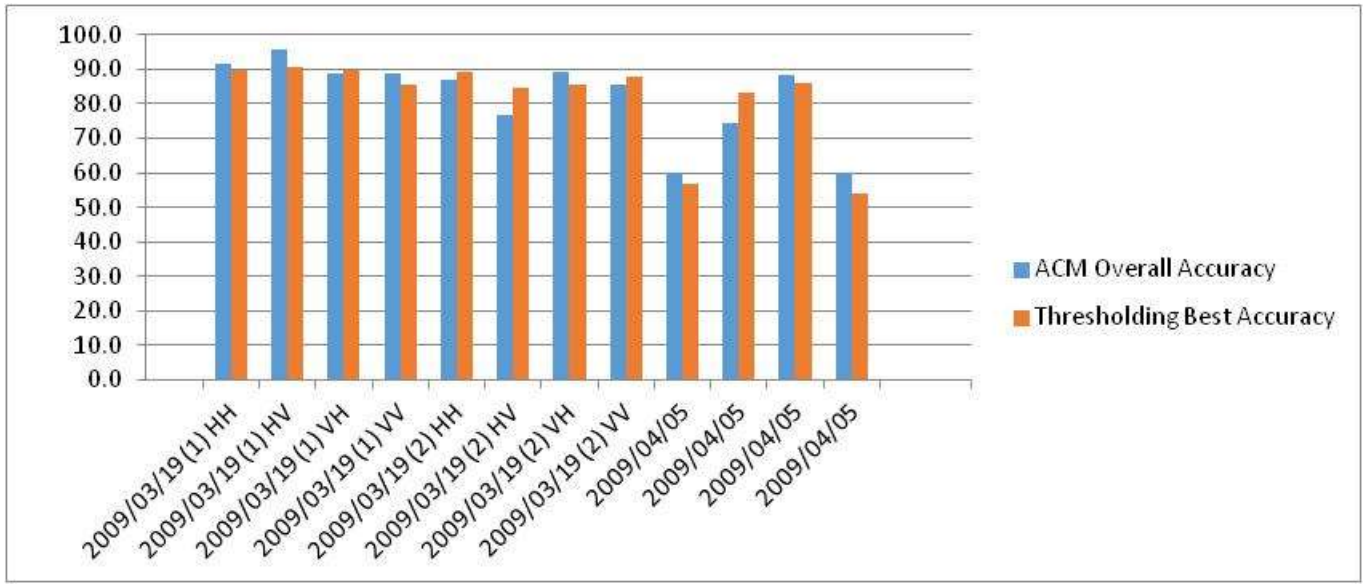


your knowledge partner

Active Contour Model

ACM vs Thresholding – 2009

PALSAR



your knowledge partner

Conclusions

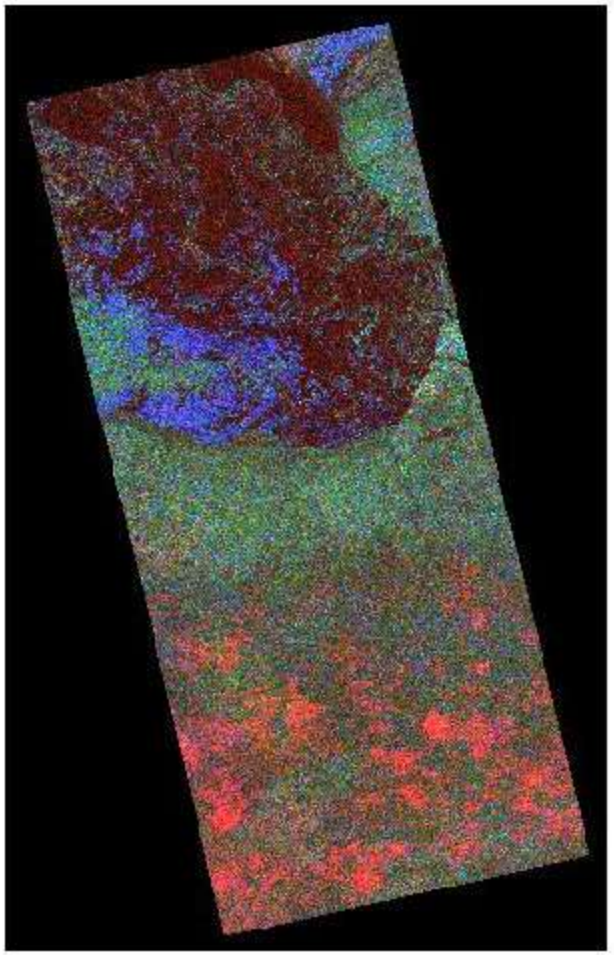
- Thresholding is a simple and generally efficient way to rapidly estimate flood extent
- Accuracy is dependant on several variables, however
- Optimal Threshold
  - ASAR: Best accuracies at -12 dB
  - PALSAR
    - Best HH accuracy at -18.5 dB
    - Best HV accuracy at -26.2 dB
    - Best VV accuracy at -20.0 dB
  - Cross-polarized marginally more accurate than co-polarized (but this needs to be studied further)

Conclusions

- Determining optimal thresholds statistically is complicated by several factors.
- Obtaining an on-screen transect over water edge might be more efficient?
- ACM performs well when SAR contrast is low, but is generally evenly matched with thresholding.
- It also requires an initial contour layer, to which it is very sensitive.

Future work

- Change detection on backscatter
- Change detection
  on interferometric coherence



your knowledge partner


End