K&C Phase 3 – Brief project essentials

The ALOS PALSAR North America mosaic

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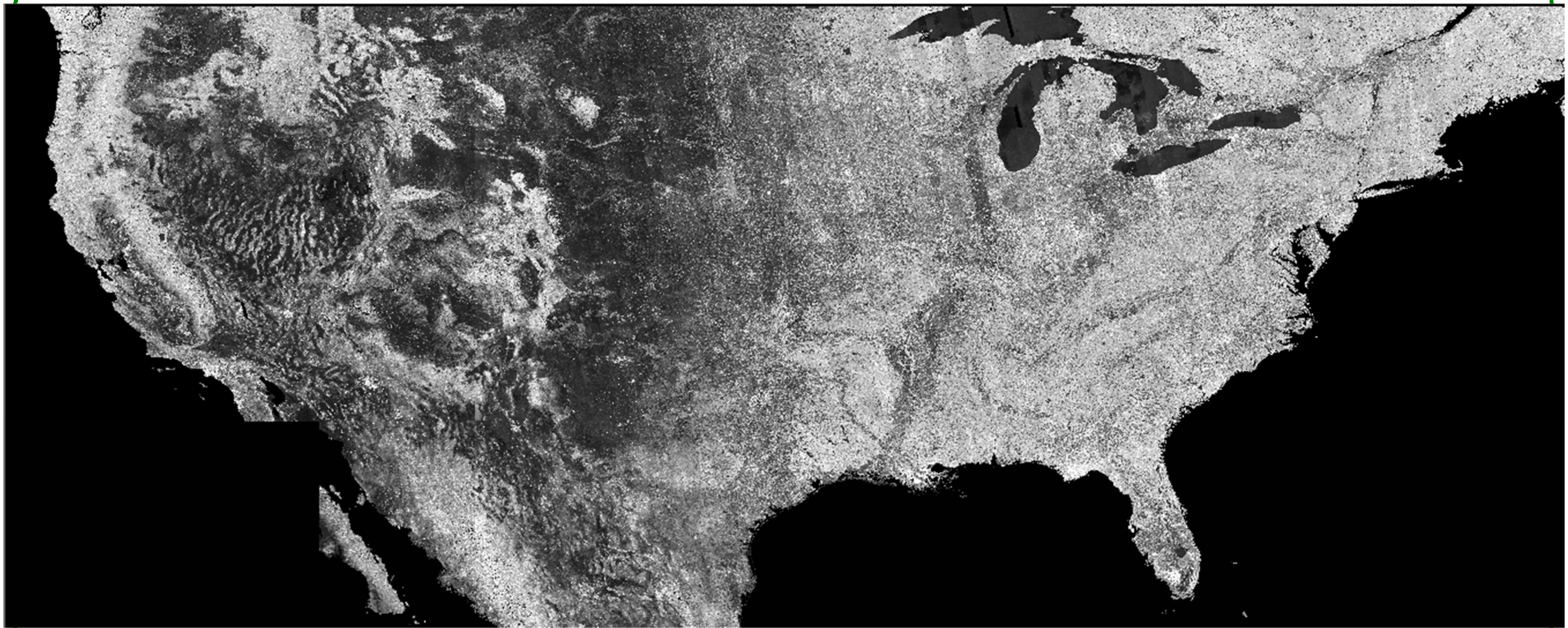
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, October 17-21, 2011

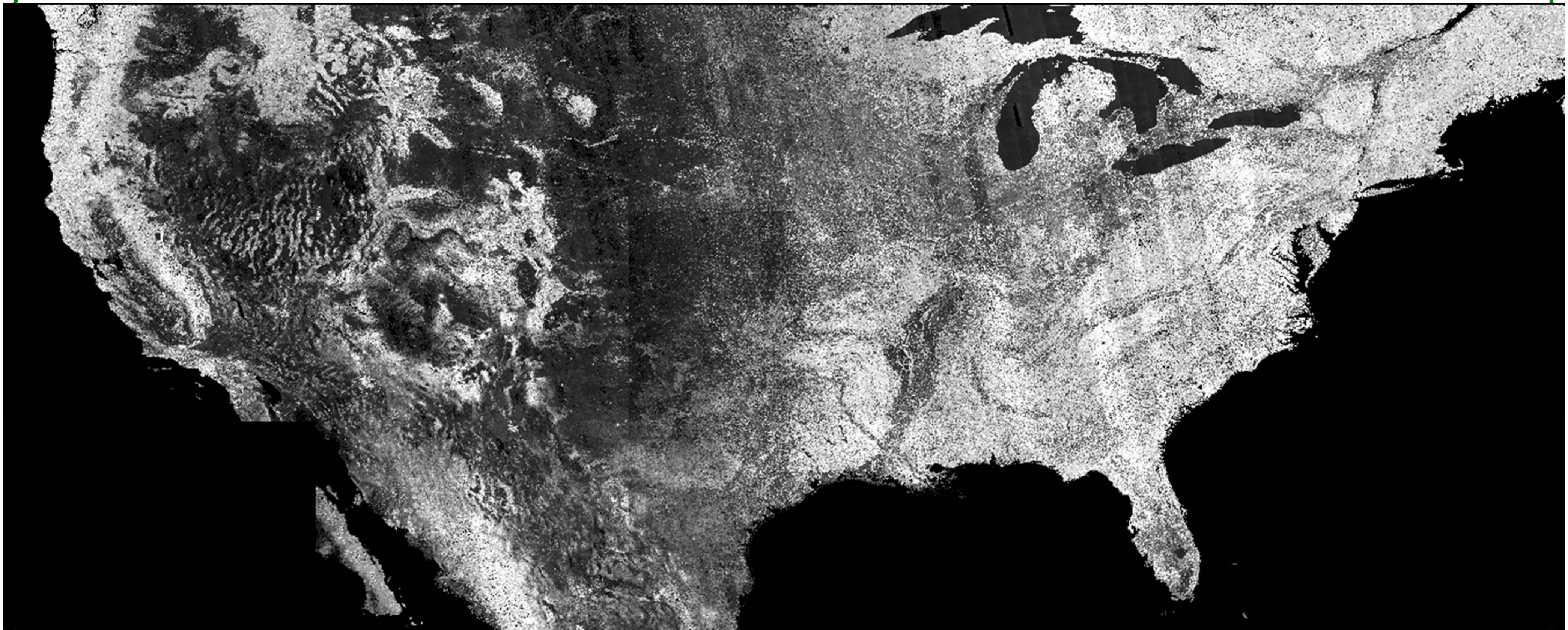
Project area(s)

The Continental USA, Alaska, parts of Mexico and Canada

HH image mosaic



HV image mosaic



Orthorectification

- Using software from gamma remote sensing
  - Orthorectify the data
  - Correct any geometric offsets
  - Correct radiometry for terrain slope
  - Apply the appropriate JAXA calibration factor
- Project the data to “UTM tiles” , defined by UTM zone definitions
  - 6 deg in longitude by 8 deg in latitude
- At JAXA’s request, missing imagery replaced with reduced-resolution frame imagery processed by ASF

Calibration assumptions

- The calibration remains constant along the image track.
- On average, the absolute calibration of the imagery does not change with time or geographic location
- The data quality is best the further the pixel is away from an edge of the image.
- In overlap regions, any radar brightness differences are due to calibration errors.
- The radar brightness of the earth's surface is not changing with time due to environmental factors, such as atmospheric conditions, soil conditions, snow cover, crop stage, or any other seasonally variant condition.
- The DEM is accurate enough to calibrate changes in radar backscatter due to the changing pixel size as a function of terrain slope.

Calibration assumptions

- **In practice, some or all of these conditions may be violated. For instance:**
  - **Some environmental conditions will result in changes in radar brightness, and these changes will be interpreted as calibration errors and a correction will be attempted, obscuring a real physical change in the radar brightness.**
    - **To minimize this error, as much as possible the data used in the final mosaic are from the summer season of 2007.**
  - **Radiometric terrain correction is limited in accuracy by the quality of the DEM**
  - **The JAXA path images sometimes appear to change calibration along track**

Calibration procedure

- Each UTM tile is constructed independently
- Construct the mosaic line by line
  - Pixel furthest from edge of image is preferred
  - In the overlap region of two images, split the brightness difference evenly to adjust the absolute calibration of the individual images
  - On average for entire line, calibration is 0dB gain.
- Manual correction for banding
  - This is unfortunately necessary, as there are unexplained calibration errors for some images.
  - Frame images are not corrected, and are assumed to be correct
  - The entire image strip is adjusted based on manual inspection.
  - Several Iterations may be required to result in minimal “banding”
- Stitch together UTM tiles to create regional mosaics and inspect for overall offsets in calibration

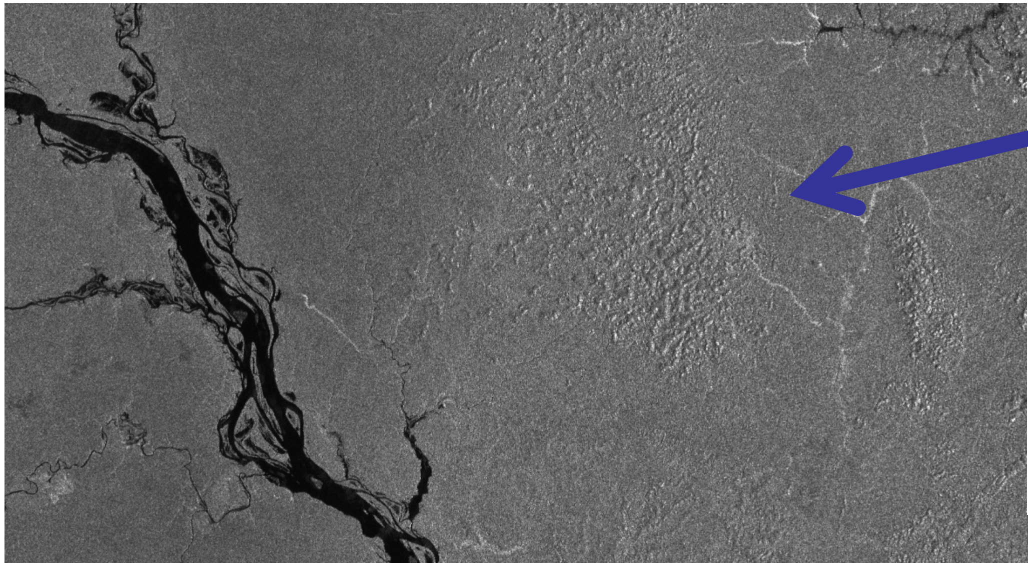
Data processed on NASA Pleiades supercomputing facility at NASA Ames

- **Over 100,000 cpu's**
- **One of the largest supercomputing facilities in the world**

Mosaic Stats

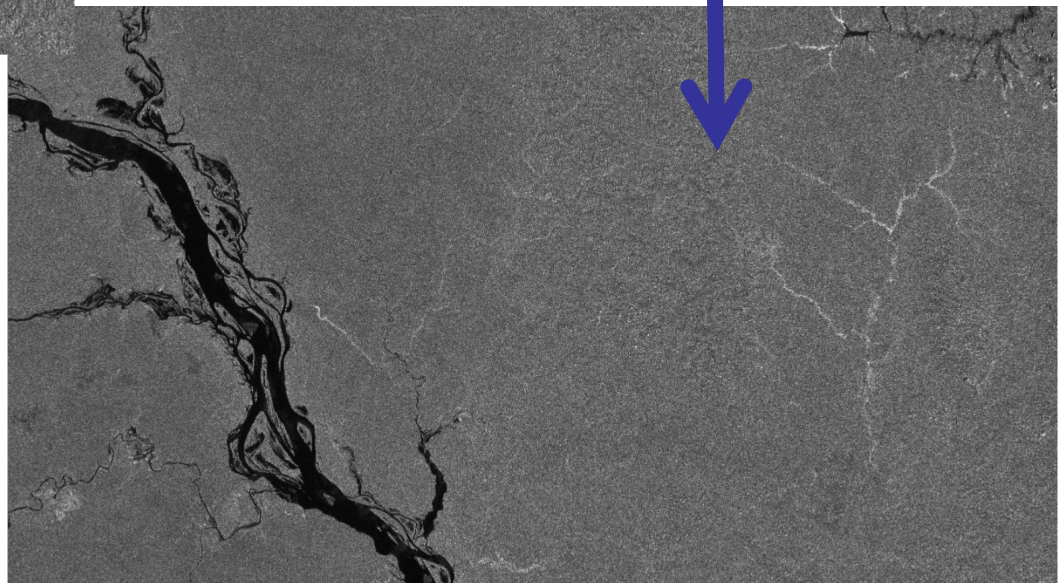
- 396 JAXA path images (segmented by UTM tile)
- 830 ASF frame images (much smaller in size)
- 23% of HH image strips manually adjusted by an average of -0.36 dB
- 34% of HV image strips manually adjusted by an average of -0.62 dB

Terrain correction to radiometry versus no Terrain correction



Terrain effects due to slope

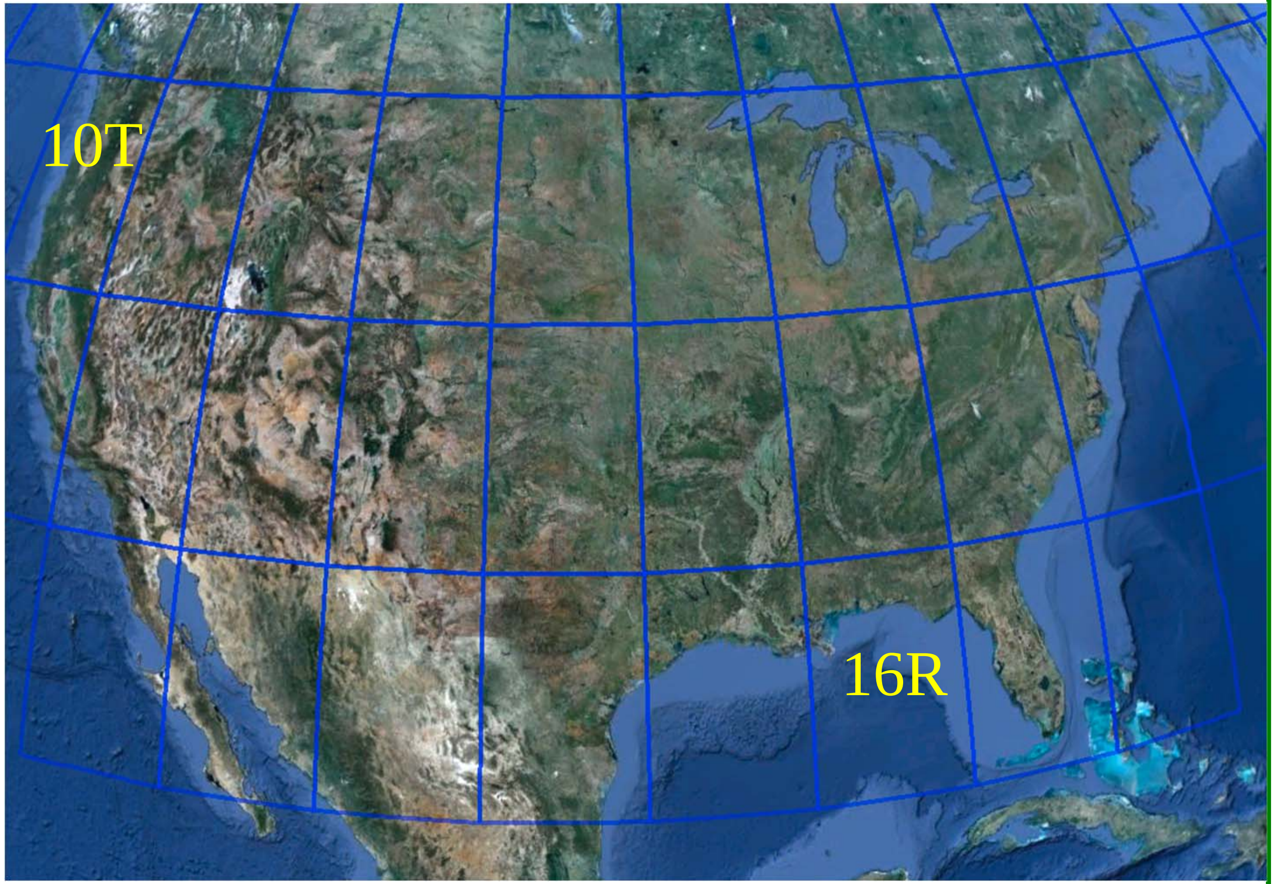
Terrain effects reduced

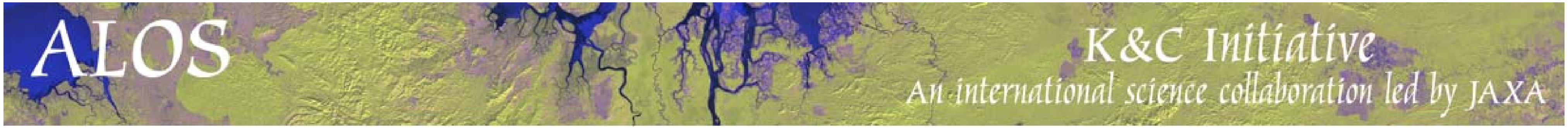


- ✓ Terrain effects can cause confusion during classification
- ✓ Correction requires accurate geolocation

Final product

- Stitch together the UTM tiles
  - Projection as desired
  - Pixel spacing as desired
  - File format as desired





Evaluate the calibration with the help of the National Land Cover Database (NLCD)

The National Land Cover Database 2001 (NLCD2001) is a 16-class (additional four classes in Alaska only) land cover classification scheme that has been applied consistently across all 50 United States and Puerto Rico at a spatial resolution of 30 meters. NLCD2001 is based primarily on the unsupervised classification of Landsat Enhanced Thematic Mapper+ (ETM+) circa 2001 satellite data.

NLCD Land Cover Classification Legend

- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

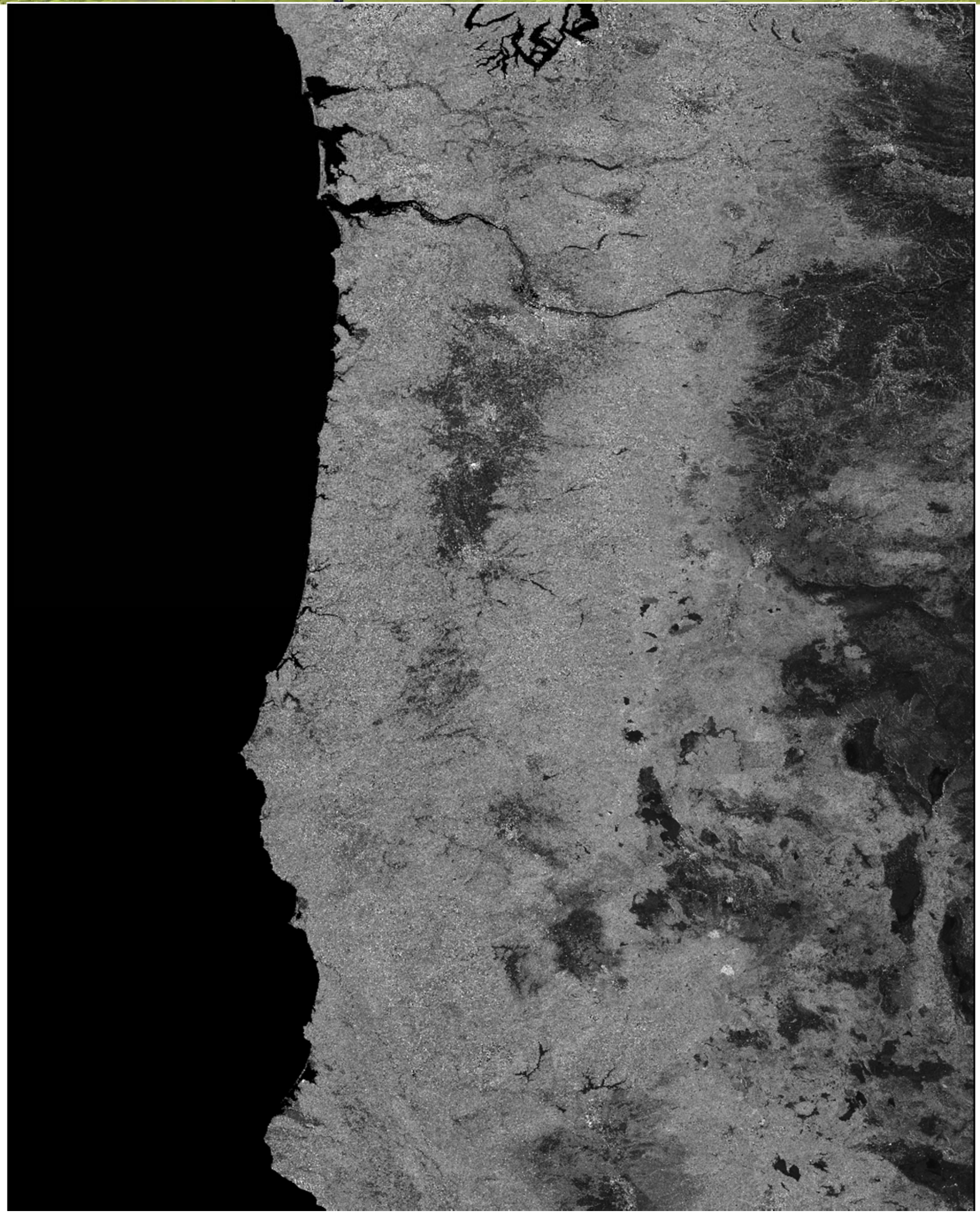
* Alaska only

http://www.mrlc.gov/nlcd2001.php

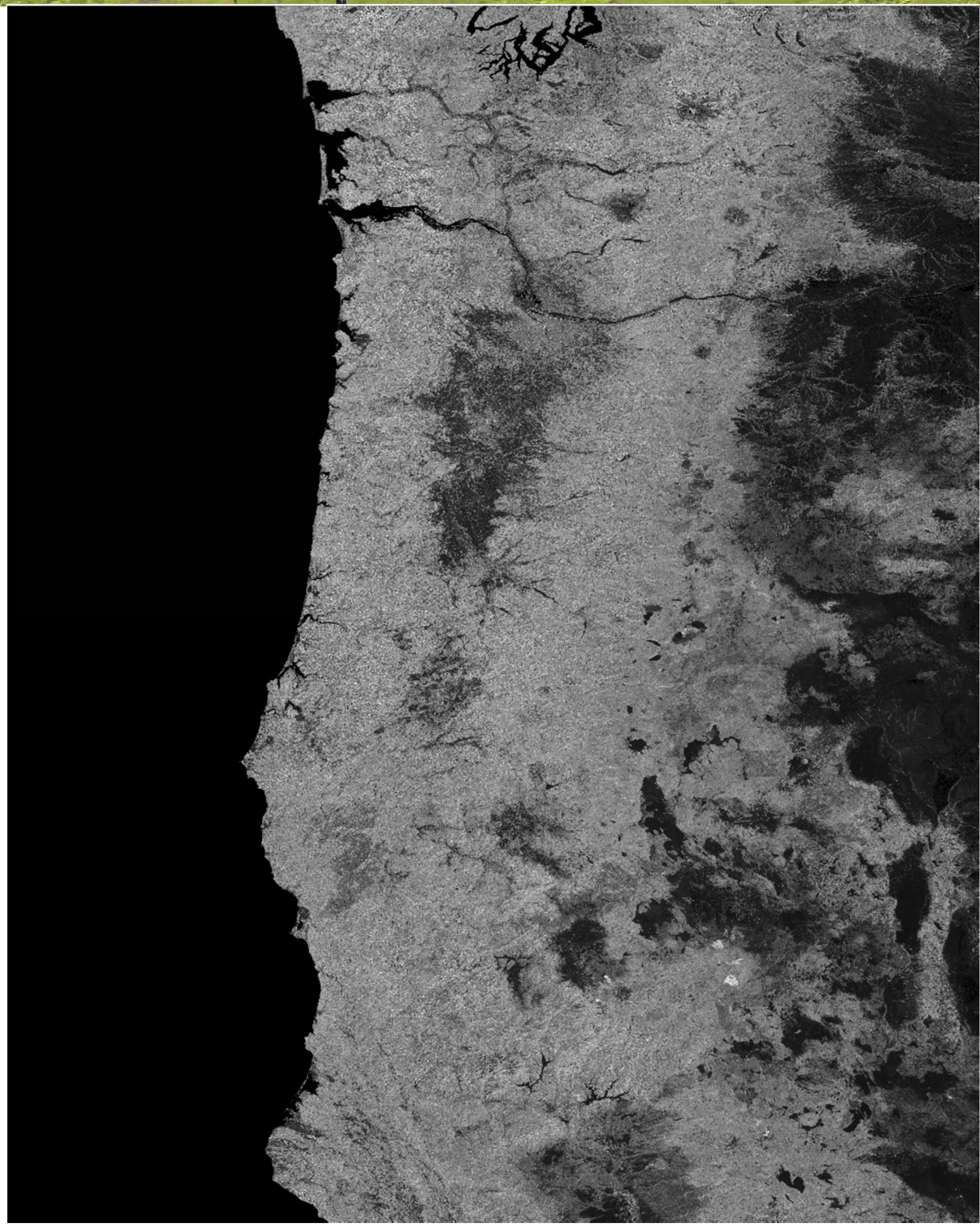
Tile 10T - Northeastern United States

- This tile has many typical land cover types and terrain slopes to evaluate the radiometric terrain correction, as well as the separability of forest/non-forest classes. Some evergreen forests have very high biomass.

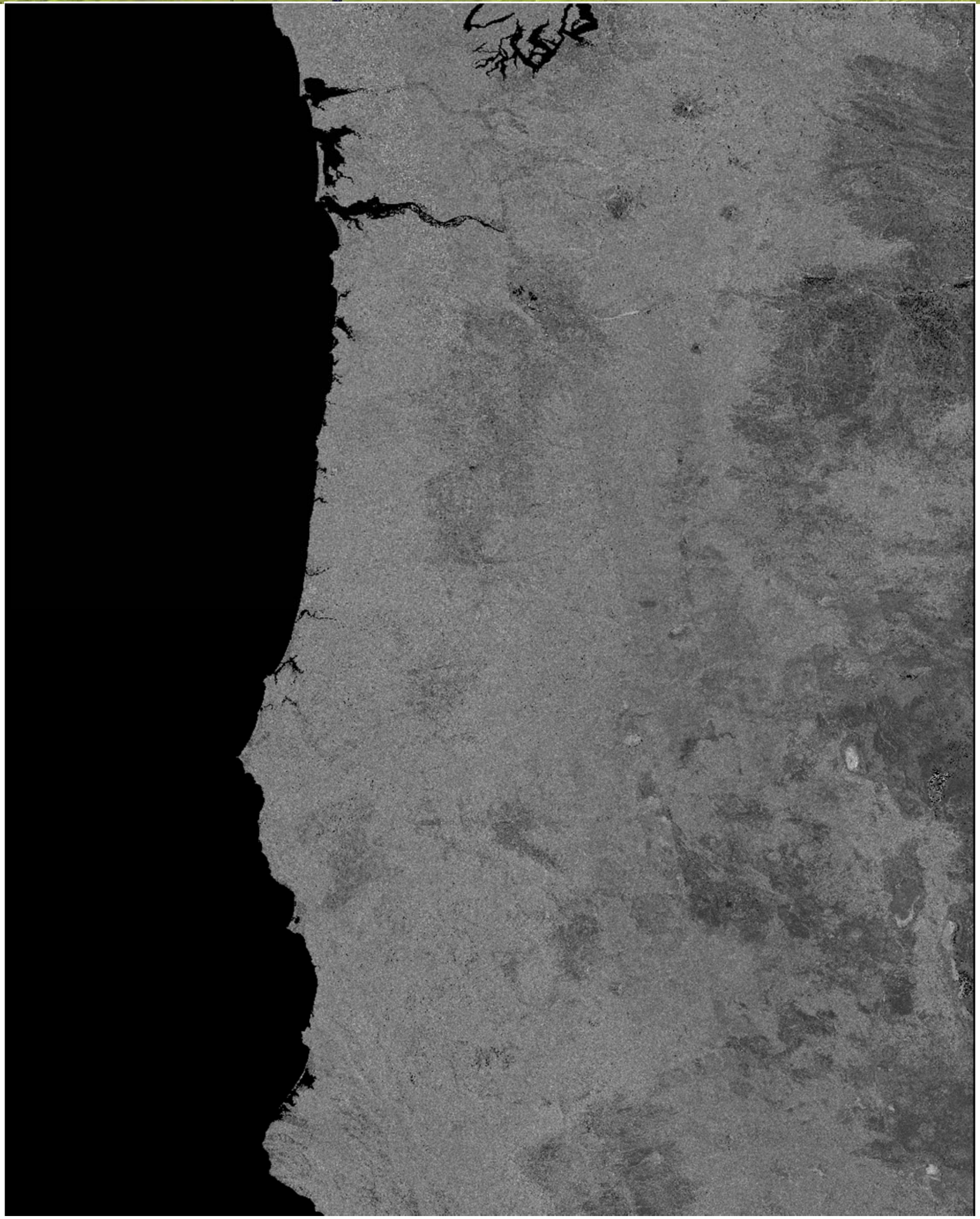
HH



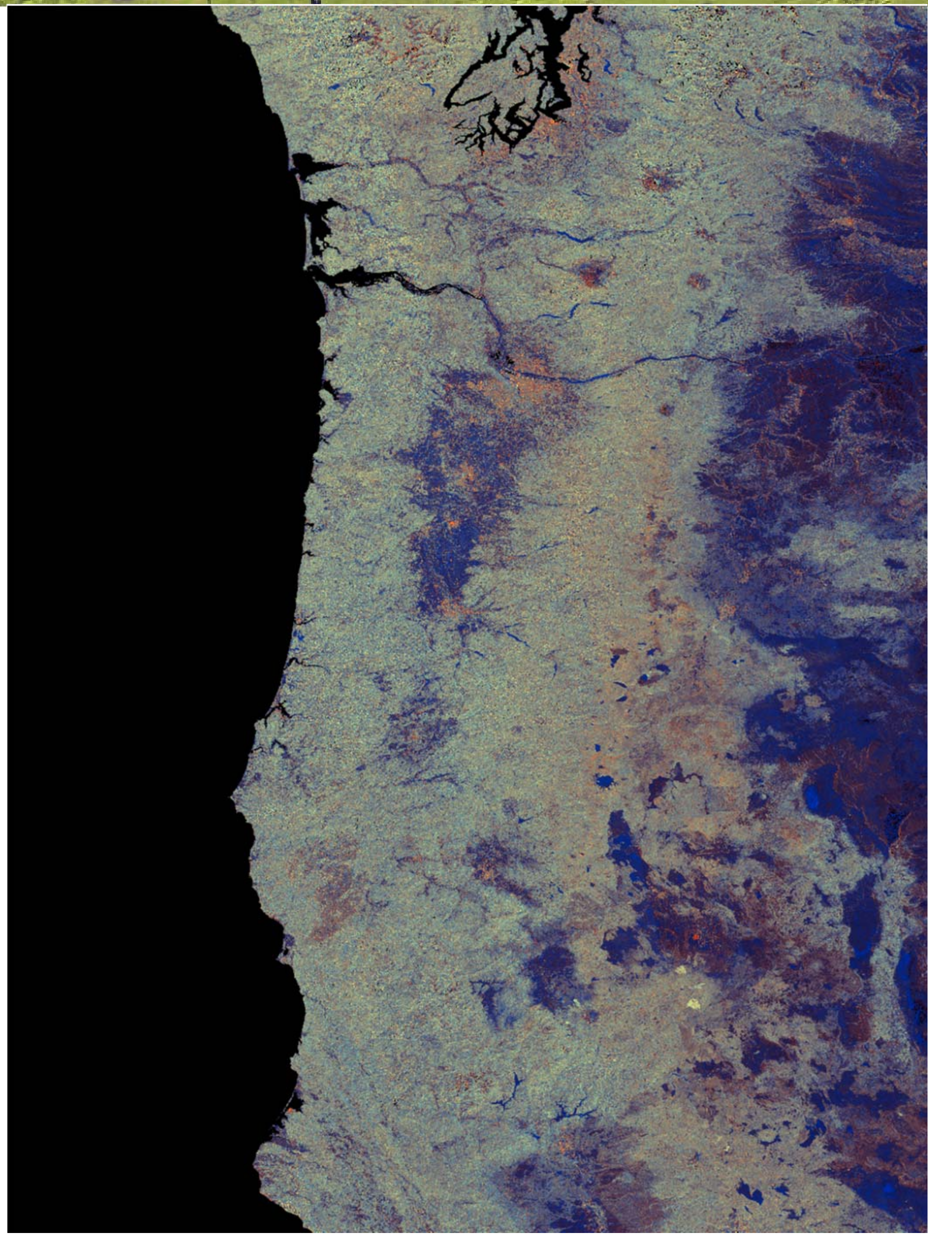
HV



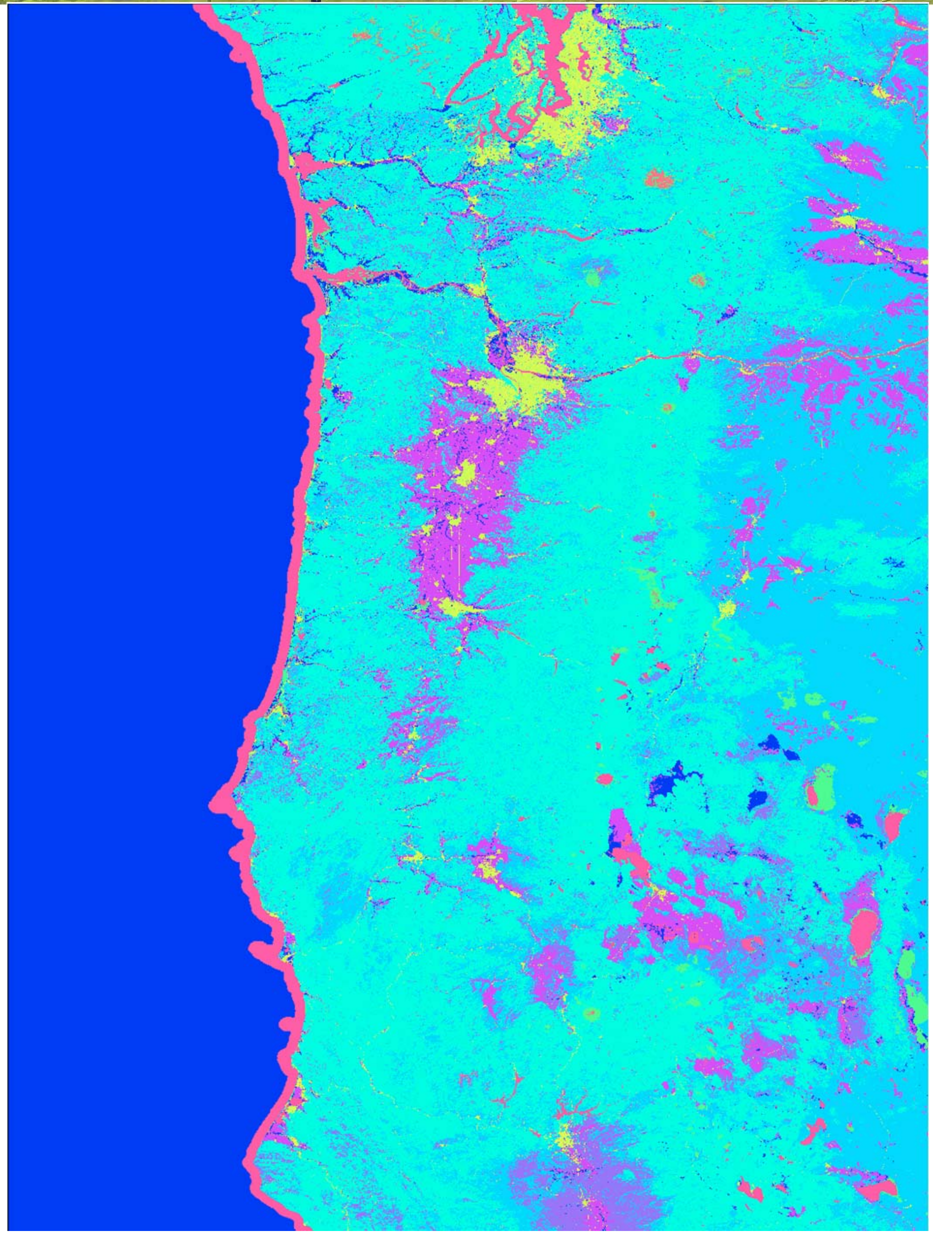
HV/HH



HH
HV
HV/HH

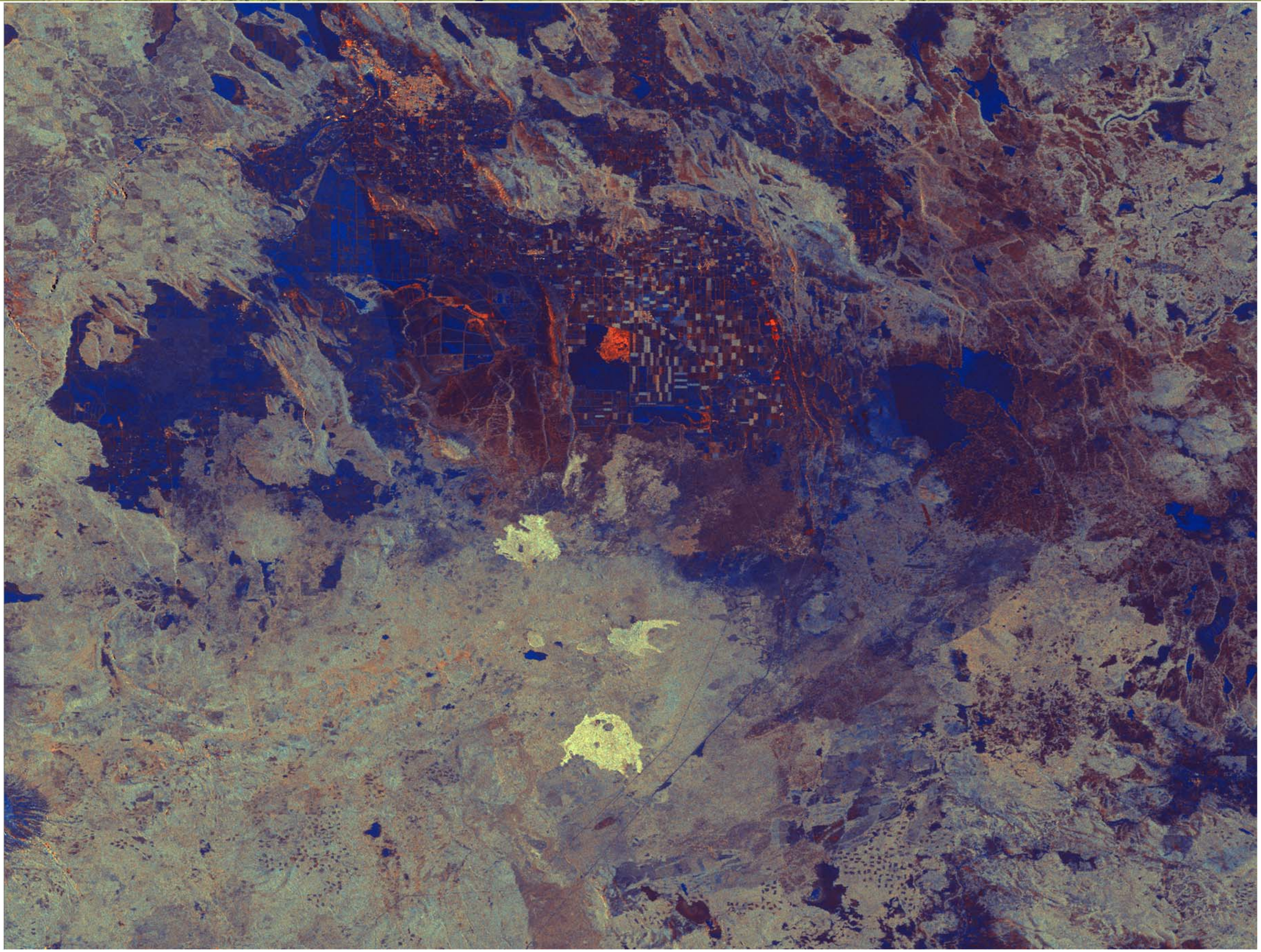


National Land Cover Database (NLCD) From Landsat



An 8 arcsec version is shown here, but it is available at 30 m pixel spacing

HH
HV
HV/HH



Zoomed into 90 m pixels

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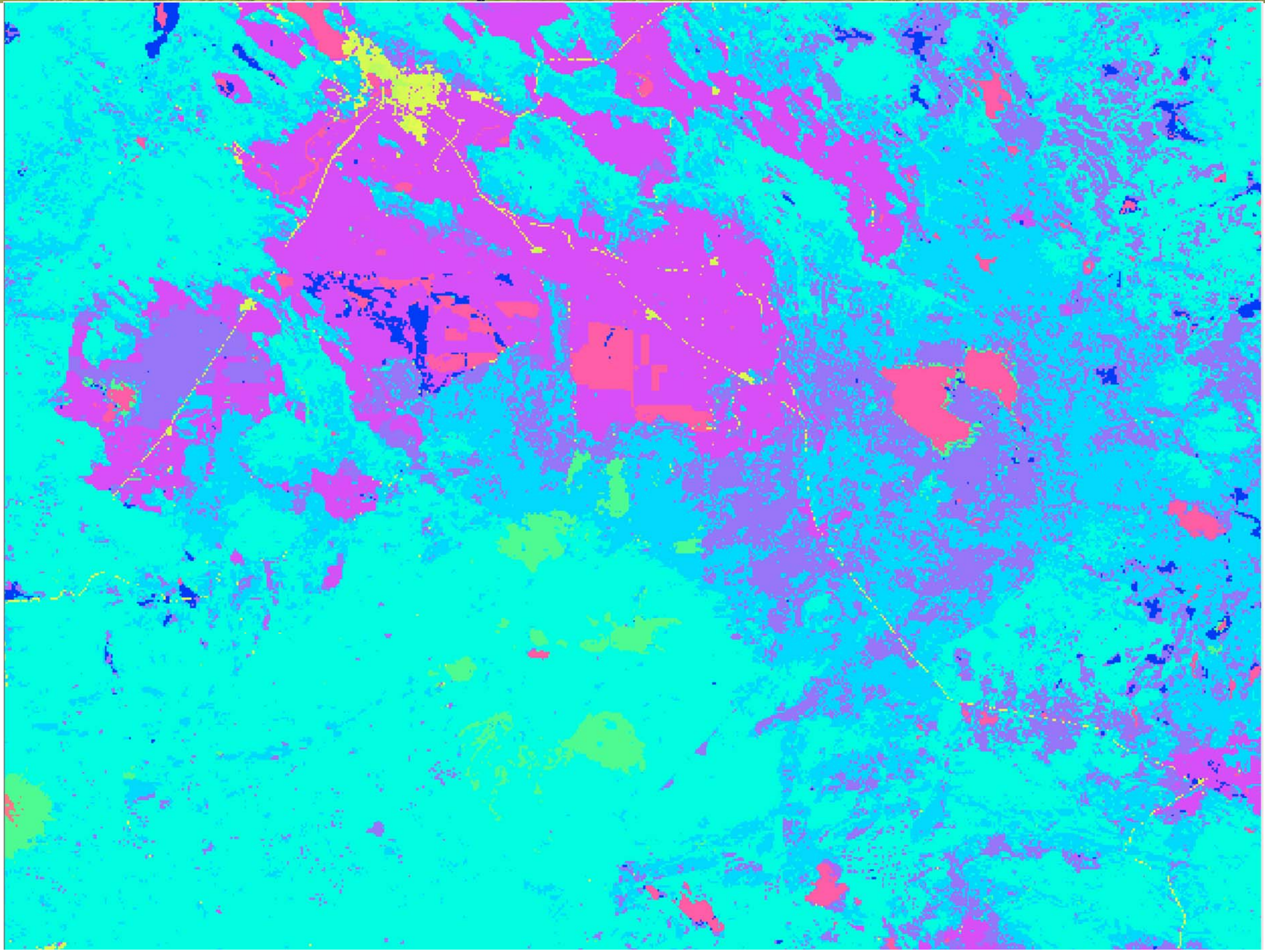
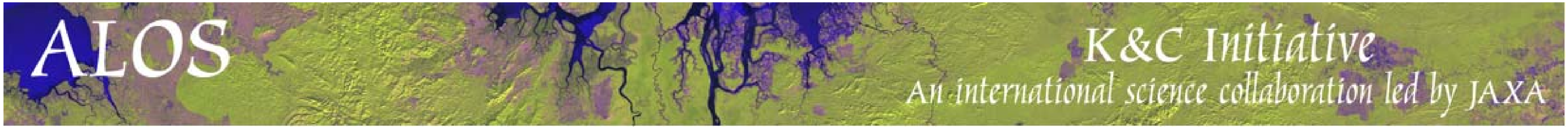
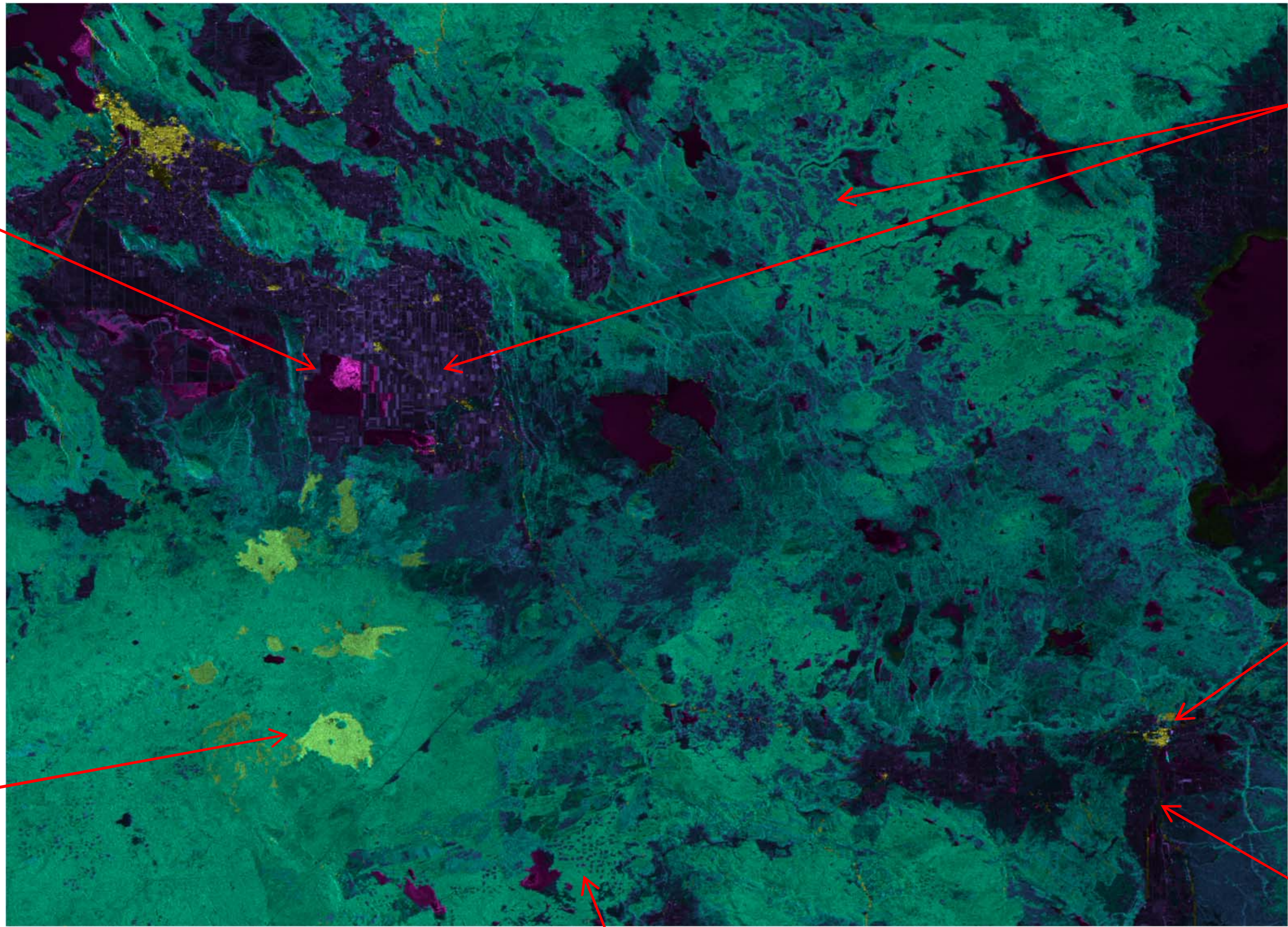
NLCD



Zoomed into 90 m pixels



HH image overlayed with NLCD



ALOS correctly identifies as wetlands of some kind, NLCD identifies as open water

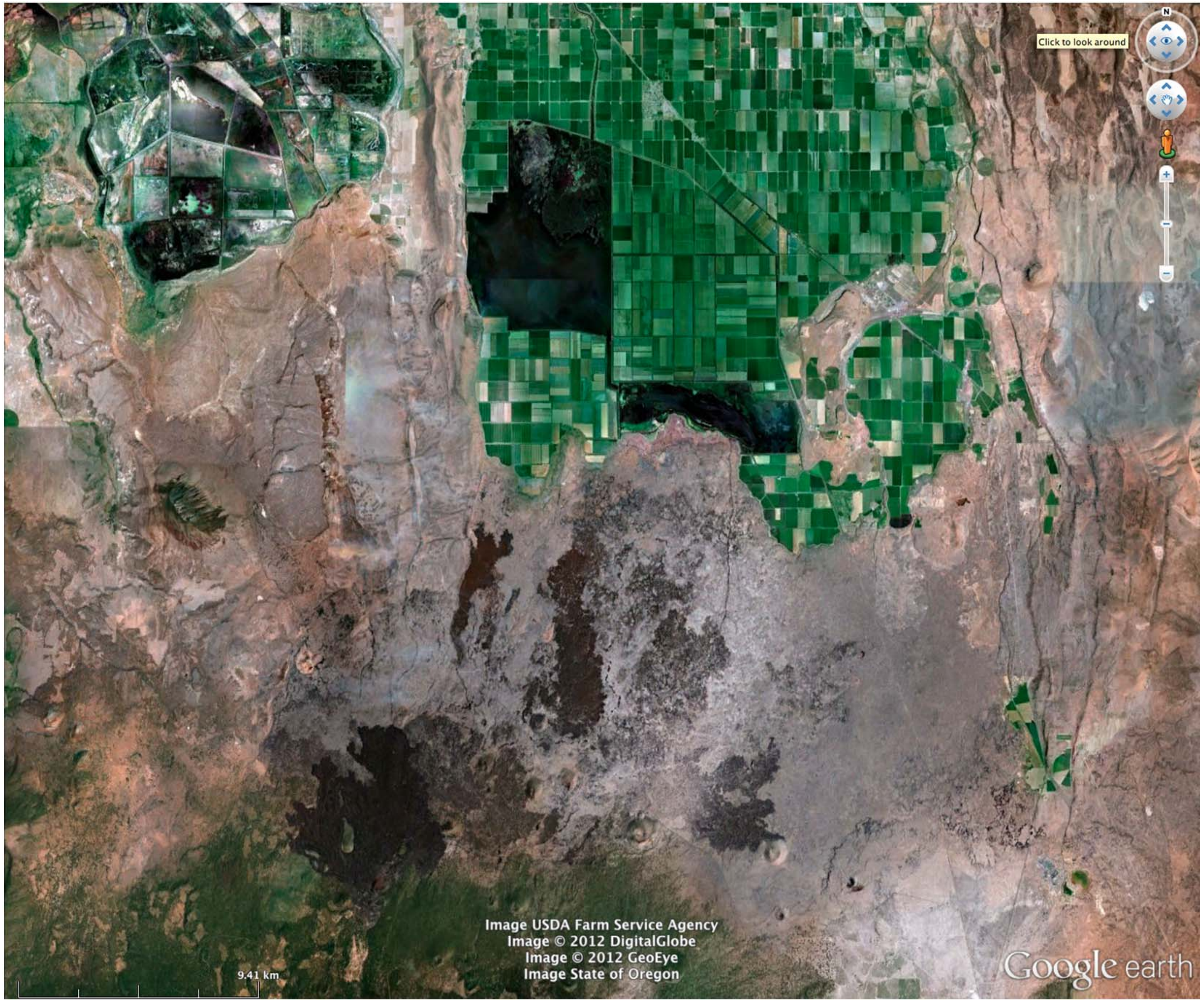
Barren, but bright at HH and HV (volcanic terrain)

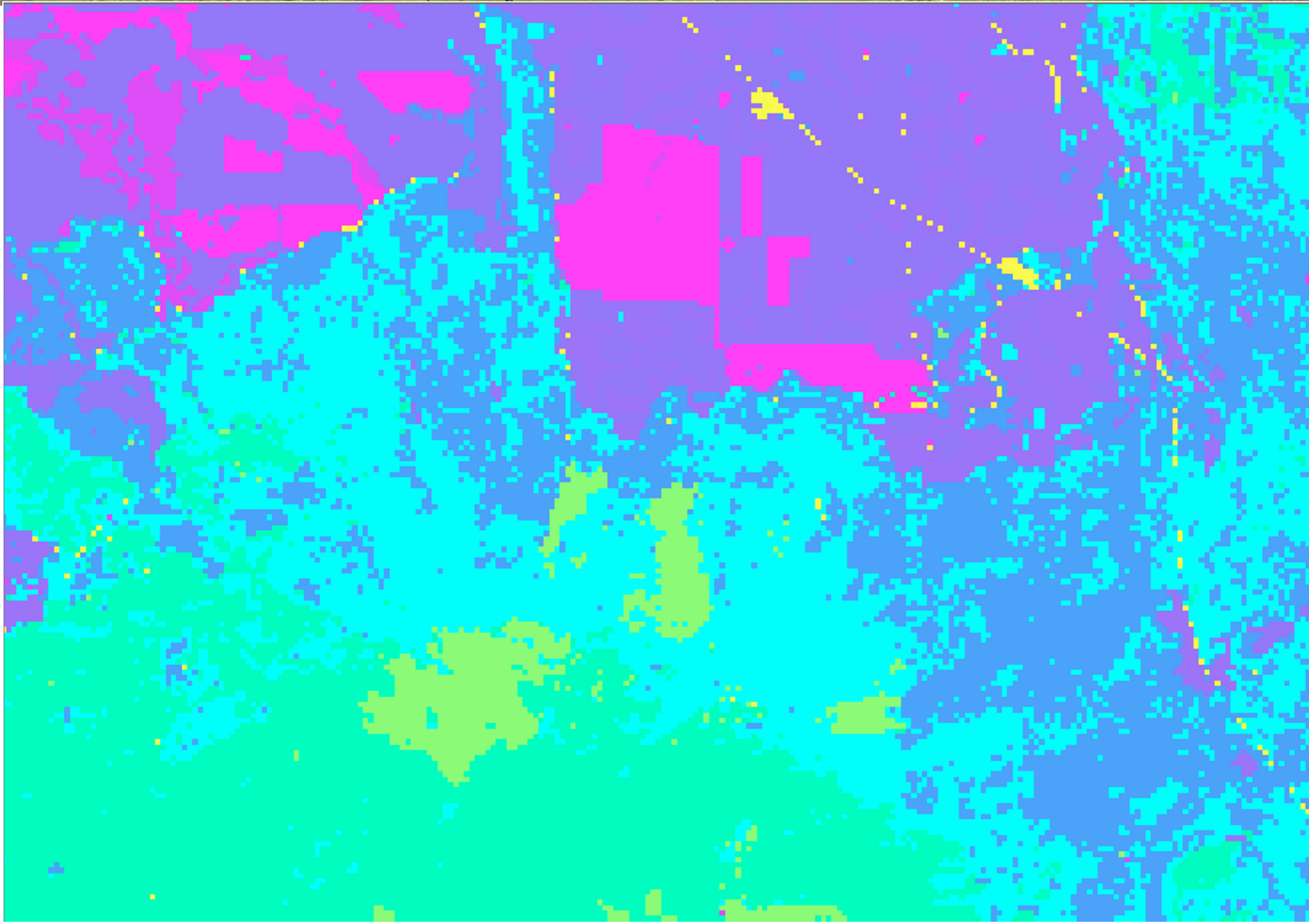
Grassland, pasture, shrub, and cultivated crops are difficult to distinguish in ALOS data

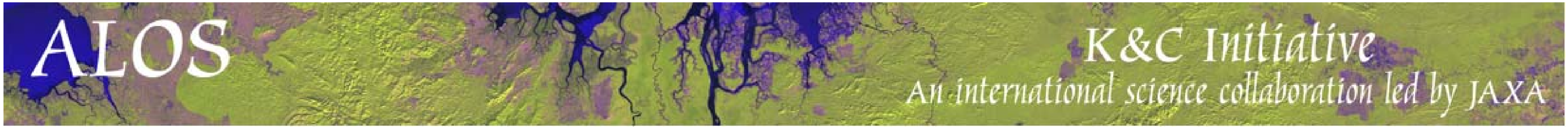
Urban areas appear to be accurately identified in NLCD

Open water accuracy is mixed, probably due to seasonal factors

NLCD identifies deforestation as grasslands/shrubs


N
Click to look around
Image USDA Farm Service Agency
Image © 2012 DigitalGlobe
Image © 2012 GeoEye
Image State of Oregon
9.41 km
Google earth

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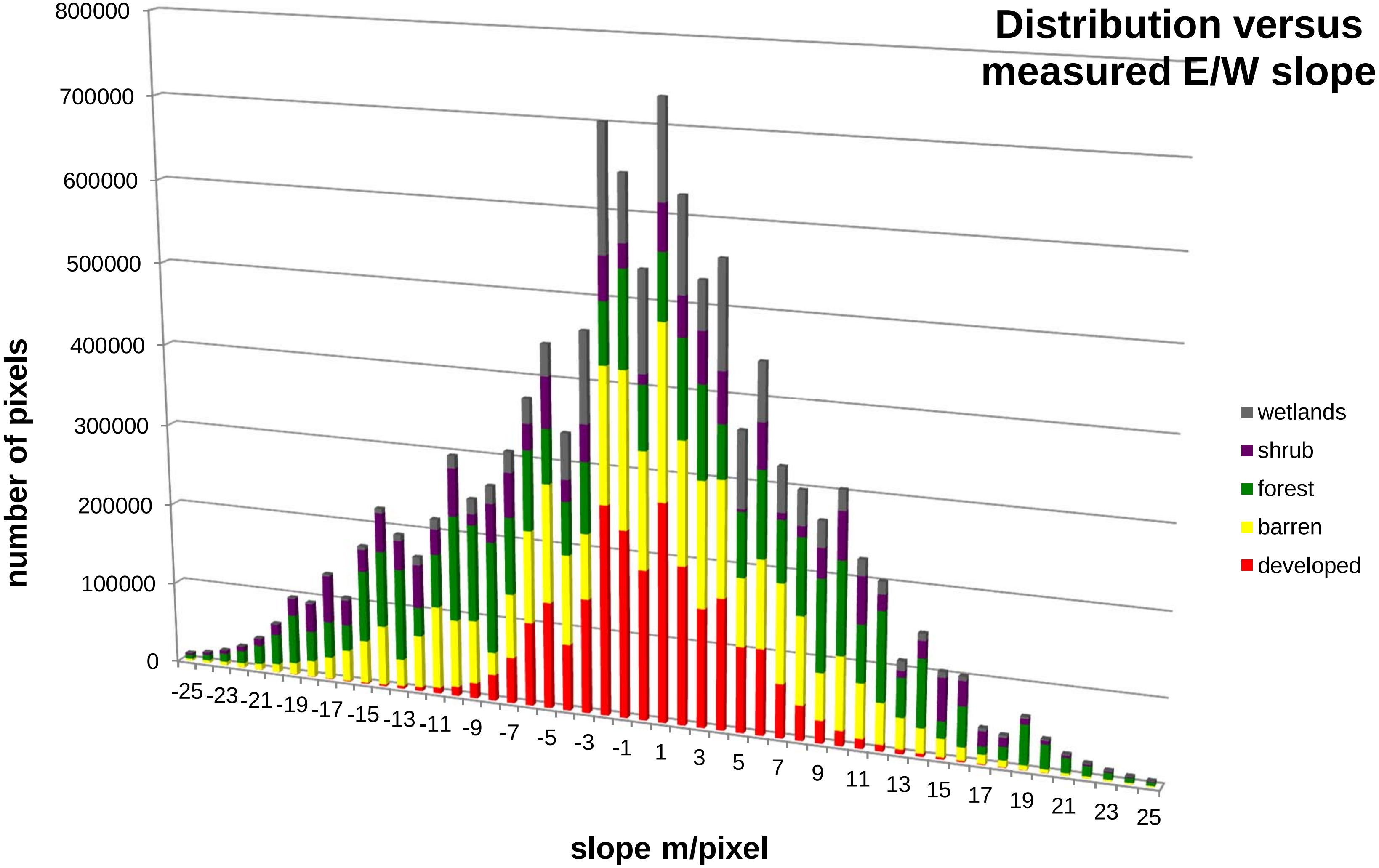
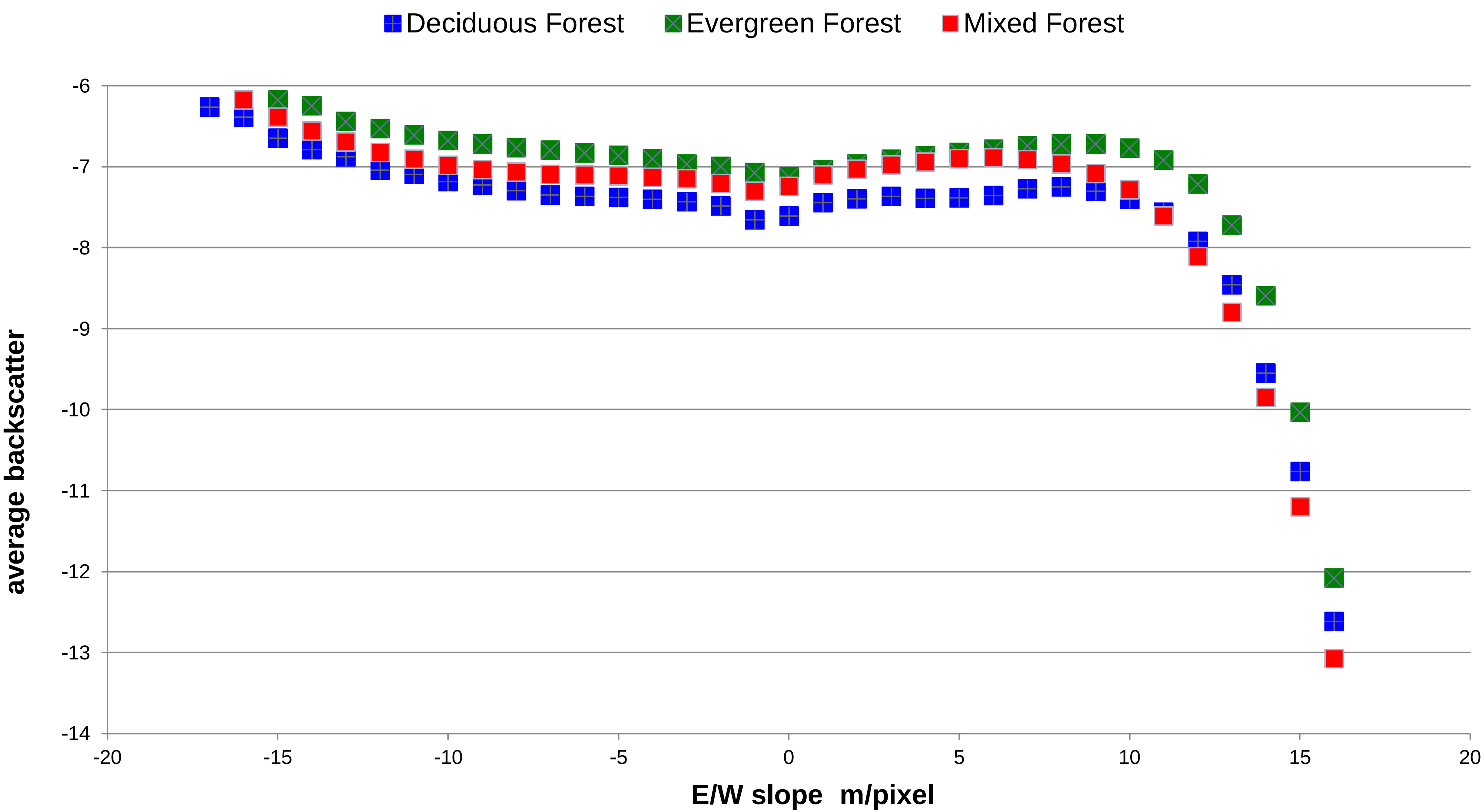
10T


Distribution versus measured E/W slope
number of pixels
800000
700000
600000
500000
400000
300000
200000
100000
0
-25 -23 -21 -19 -17 -15 -13 -11 -9 -7 -5 -3 -1 1 3 5 7 9 11 13 15 17 19 21 23 25
slope m/pixel
wetlands
shrub
forest
barren
developed

10T HH forest only



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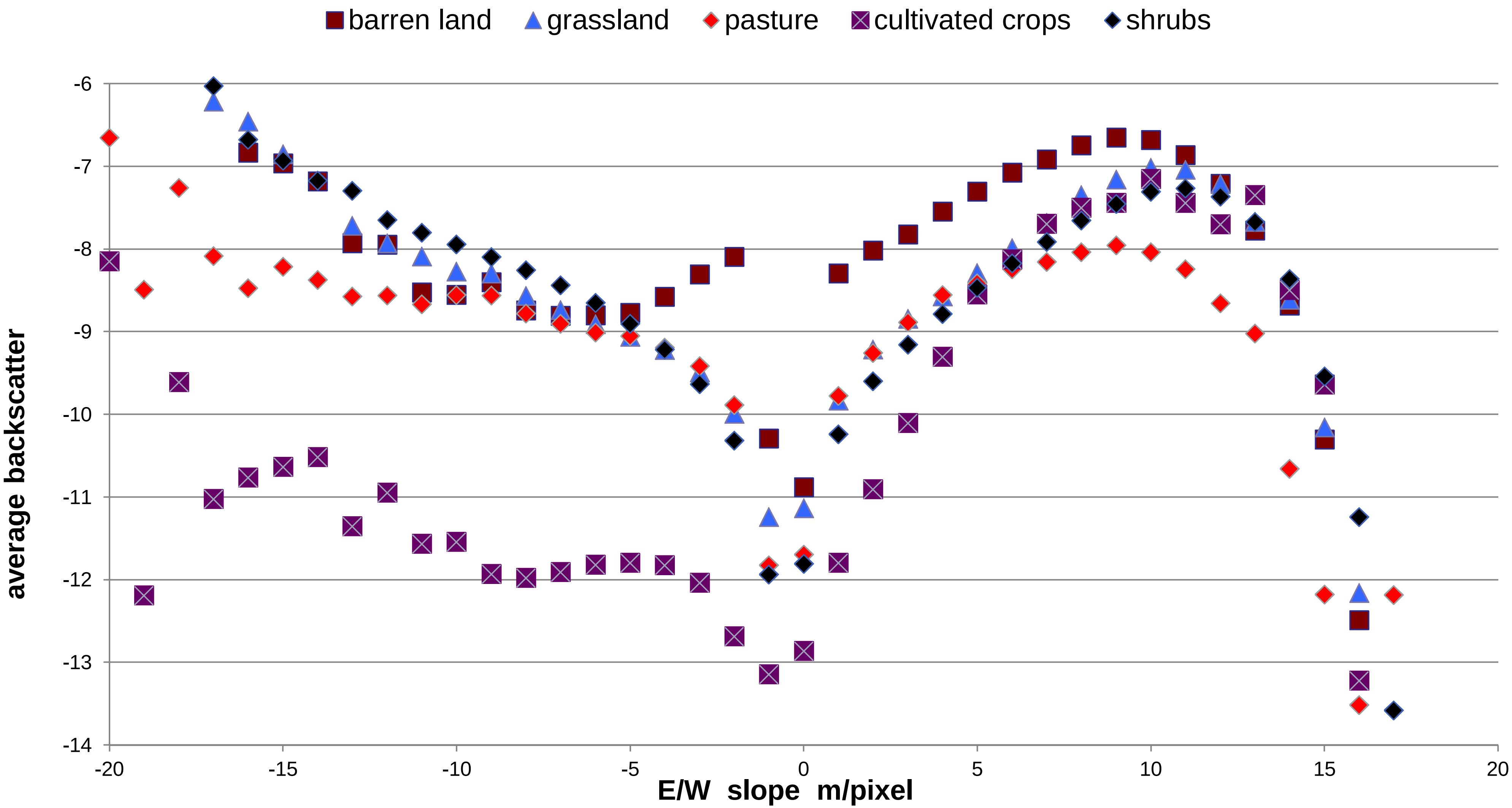
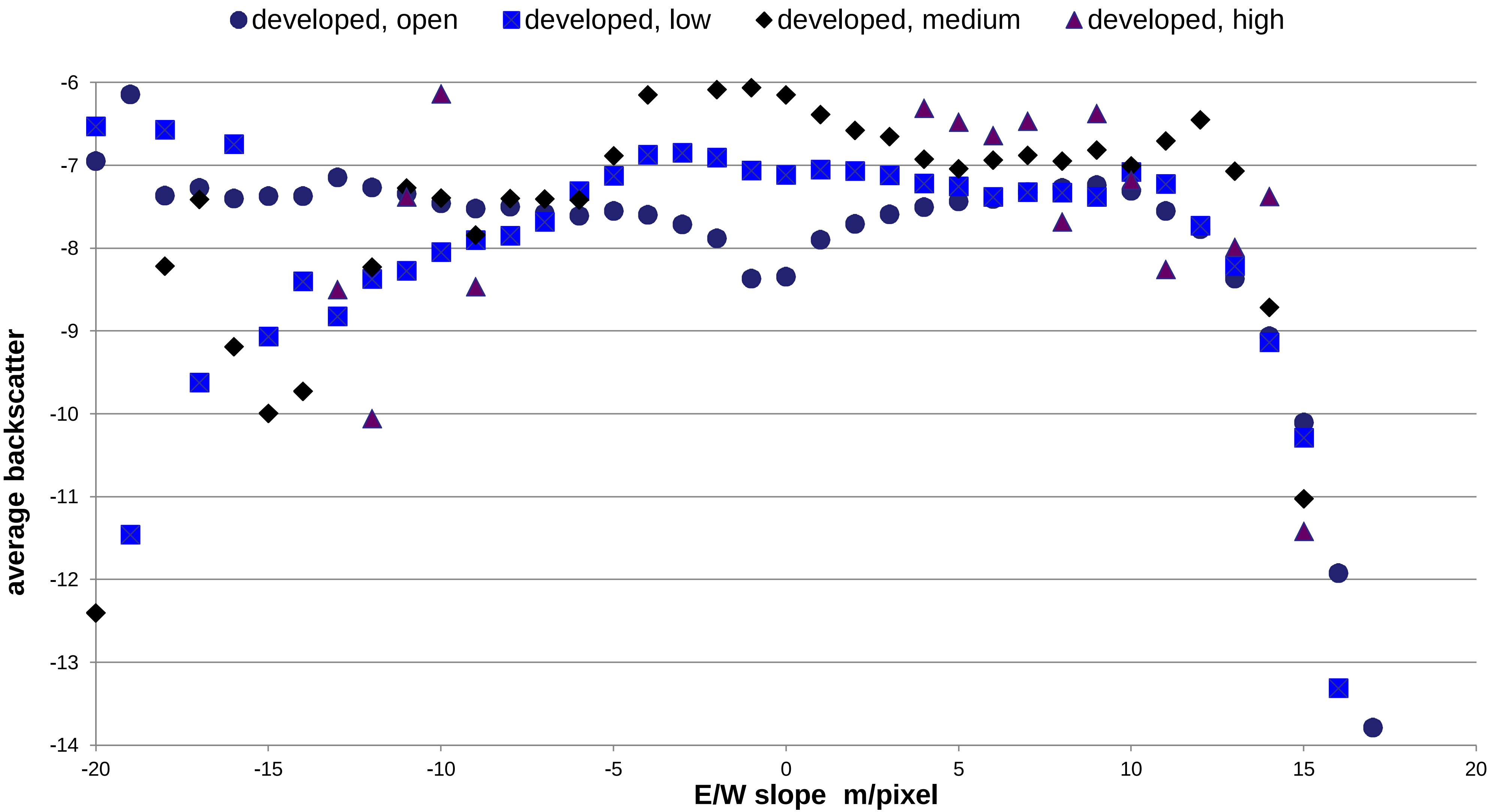
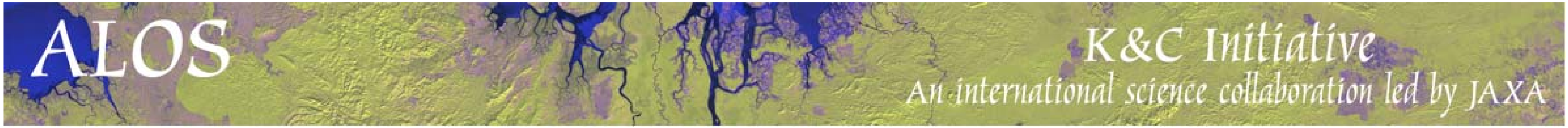
10T HH low vegetation

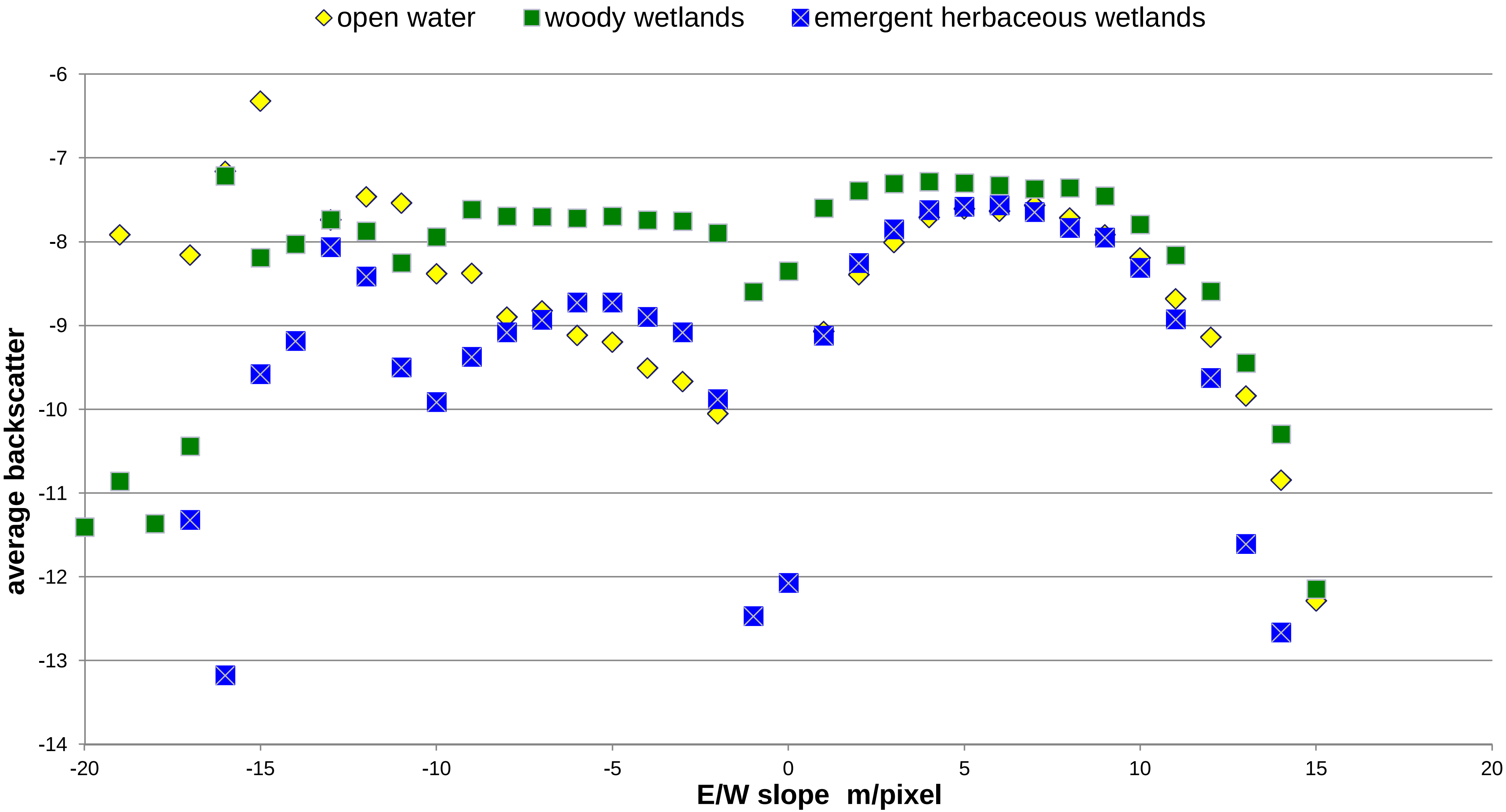


10T HH developed

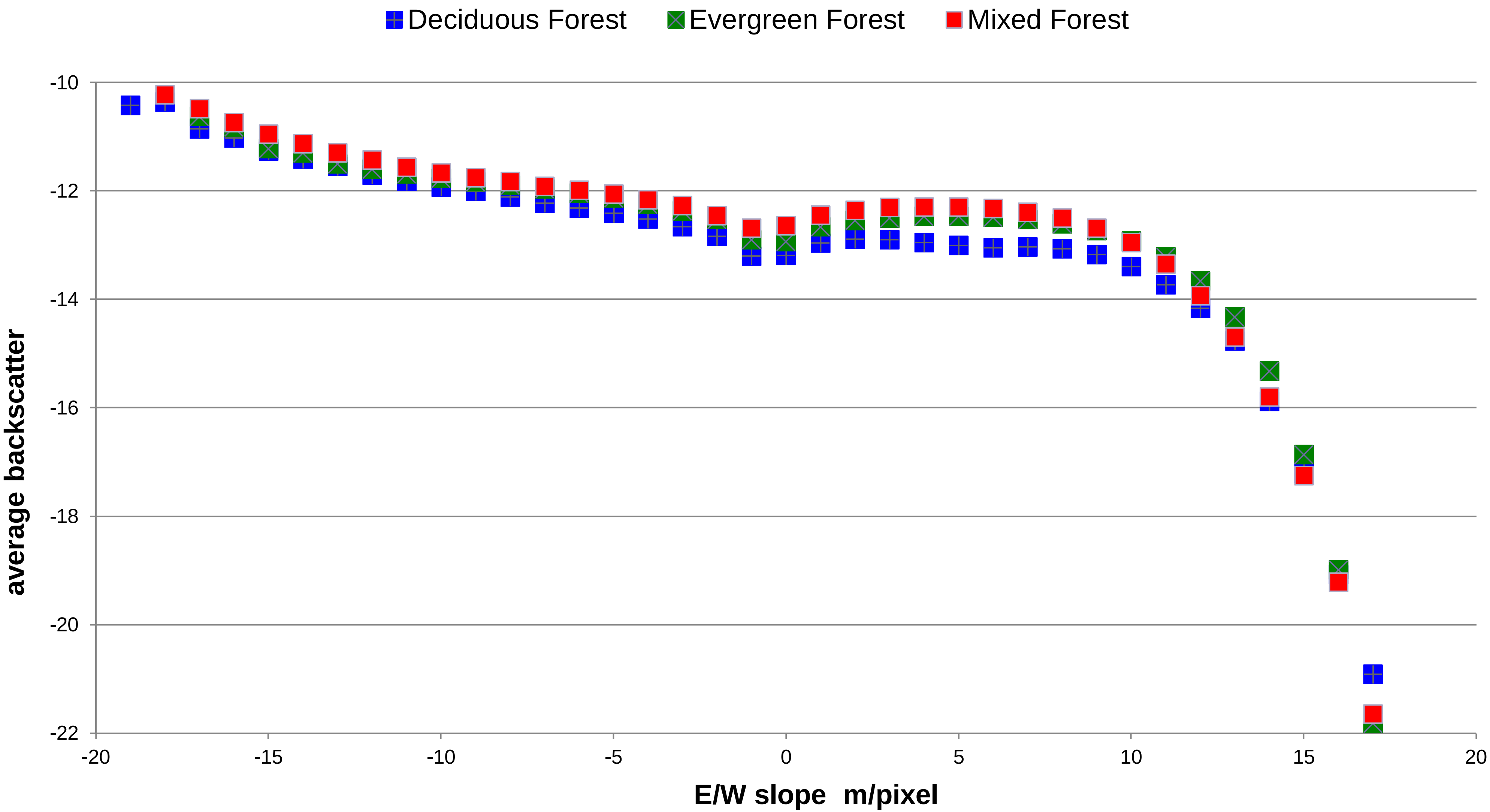


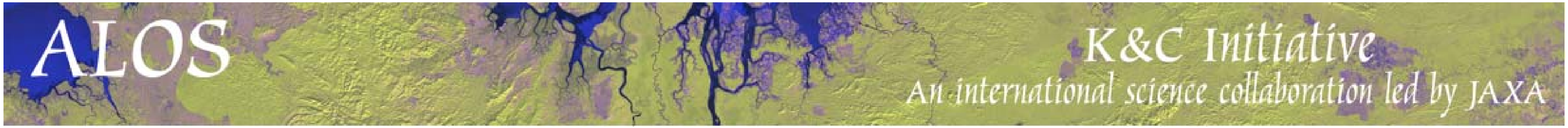


10T HH wetlands

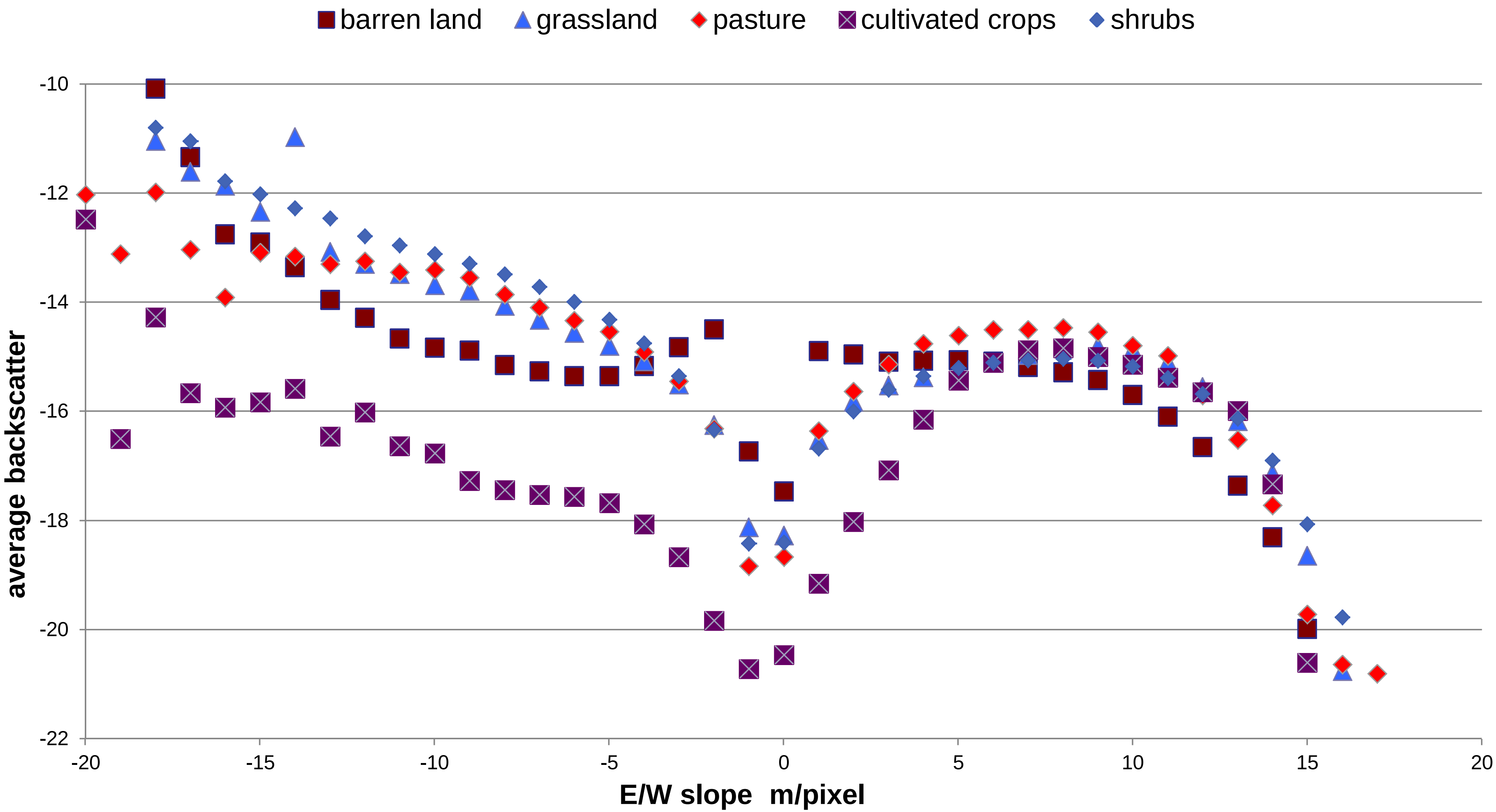


10T HV forest only





10T HV low vegetation



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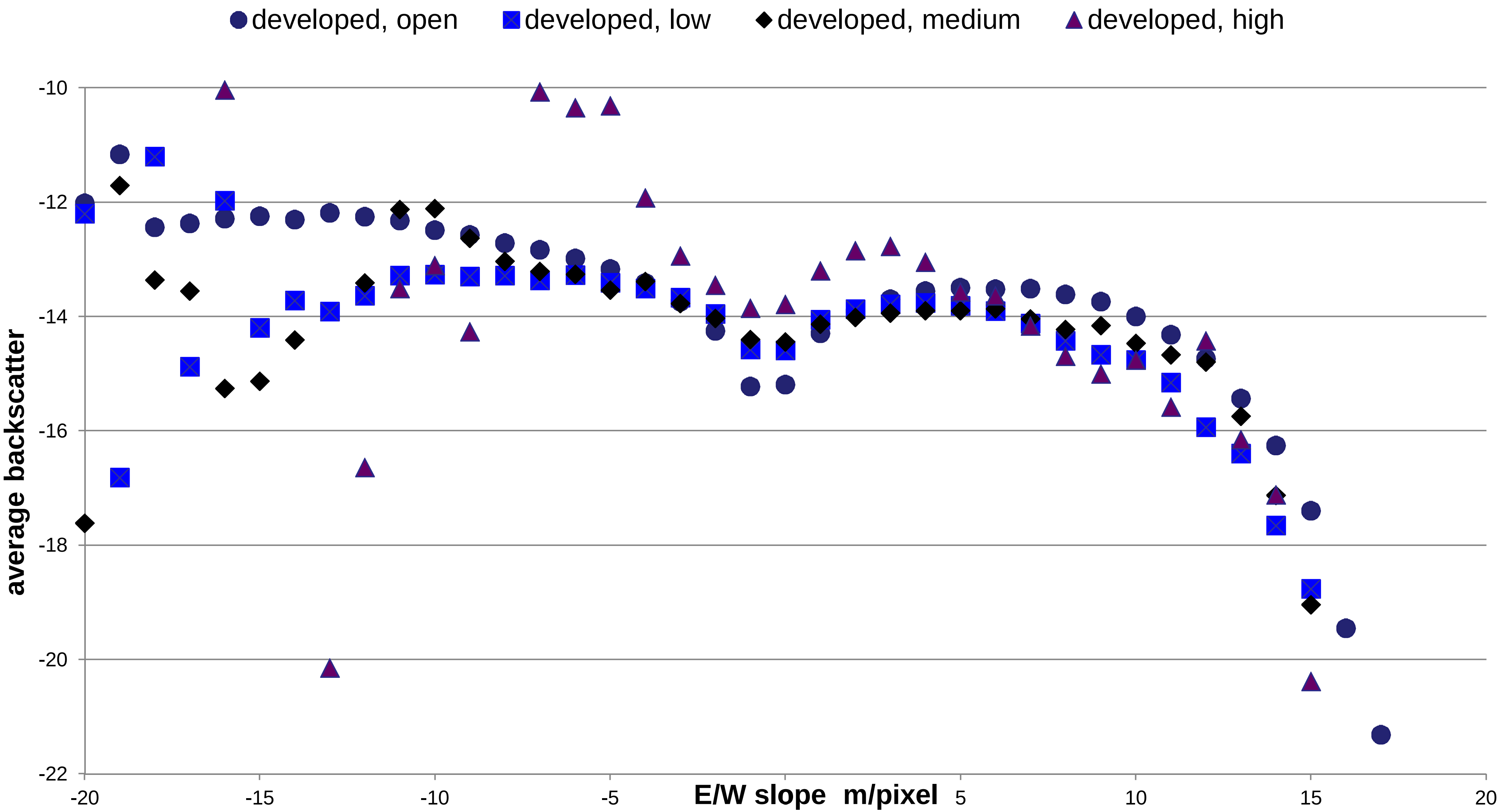
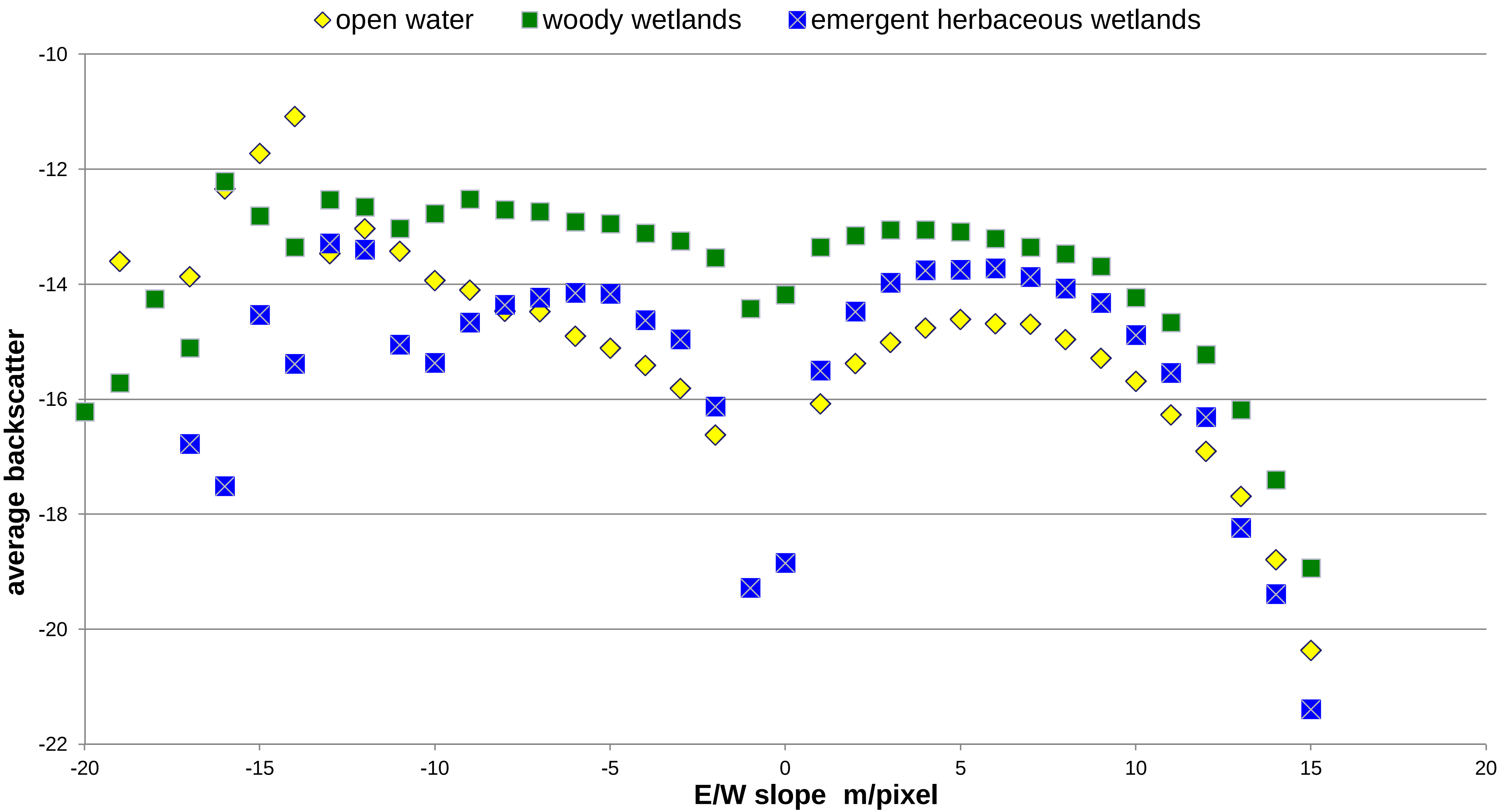
10T HV developed



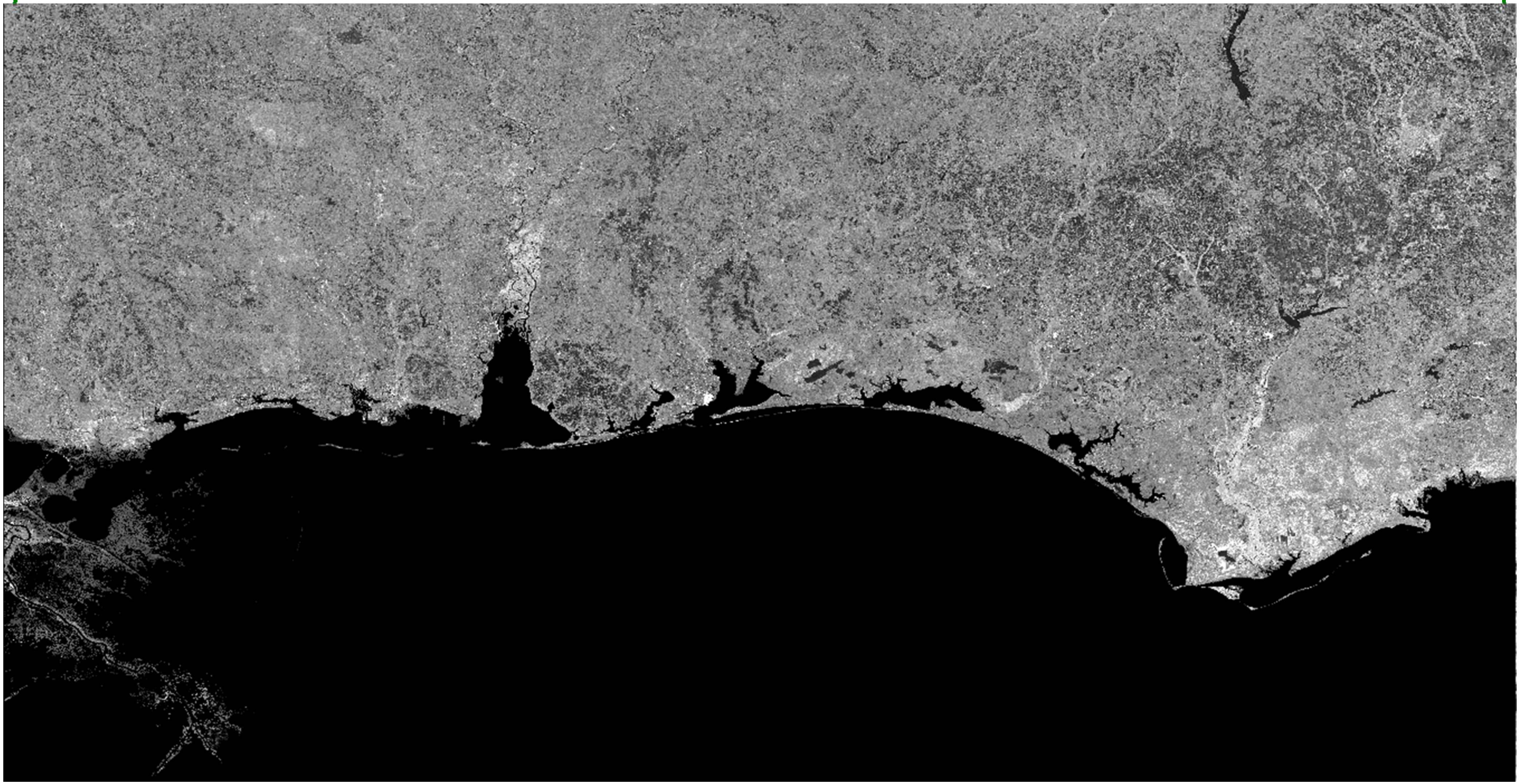
10T HV wetlands



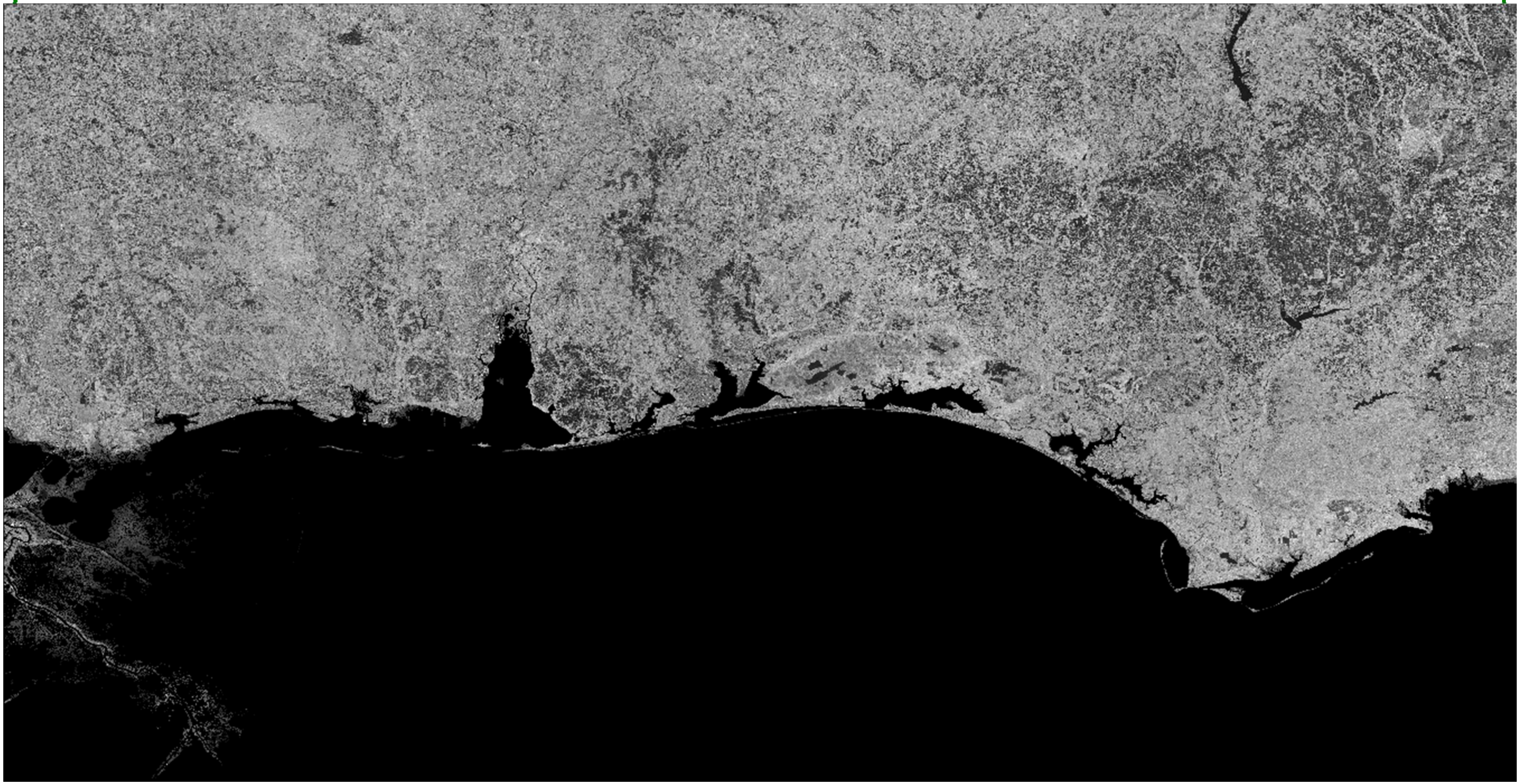
16R – Southeastern United States, Gulf Coast

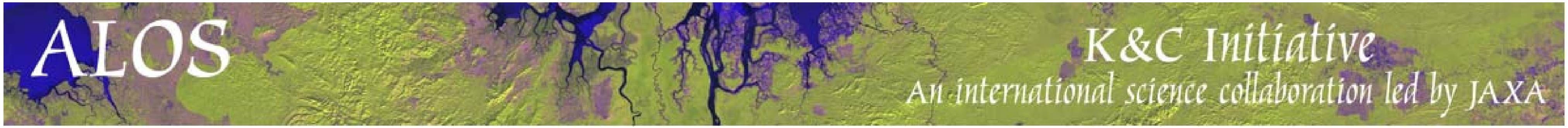
- This tile is fairly flat, with different types of evergreen/deciduous trees than 10T has, as well as more wetland regions in the coastal areas.

16R HH



16R HV

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16R RT

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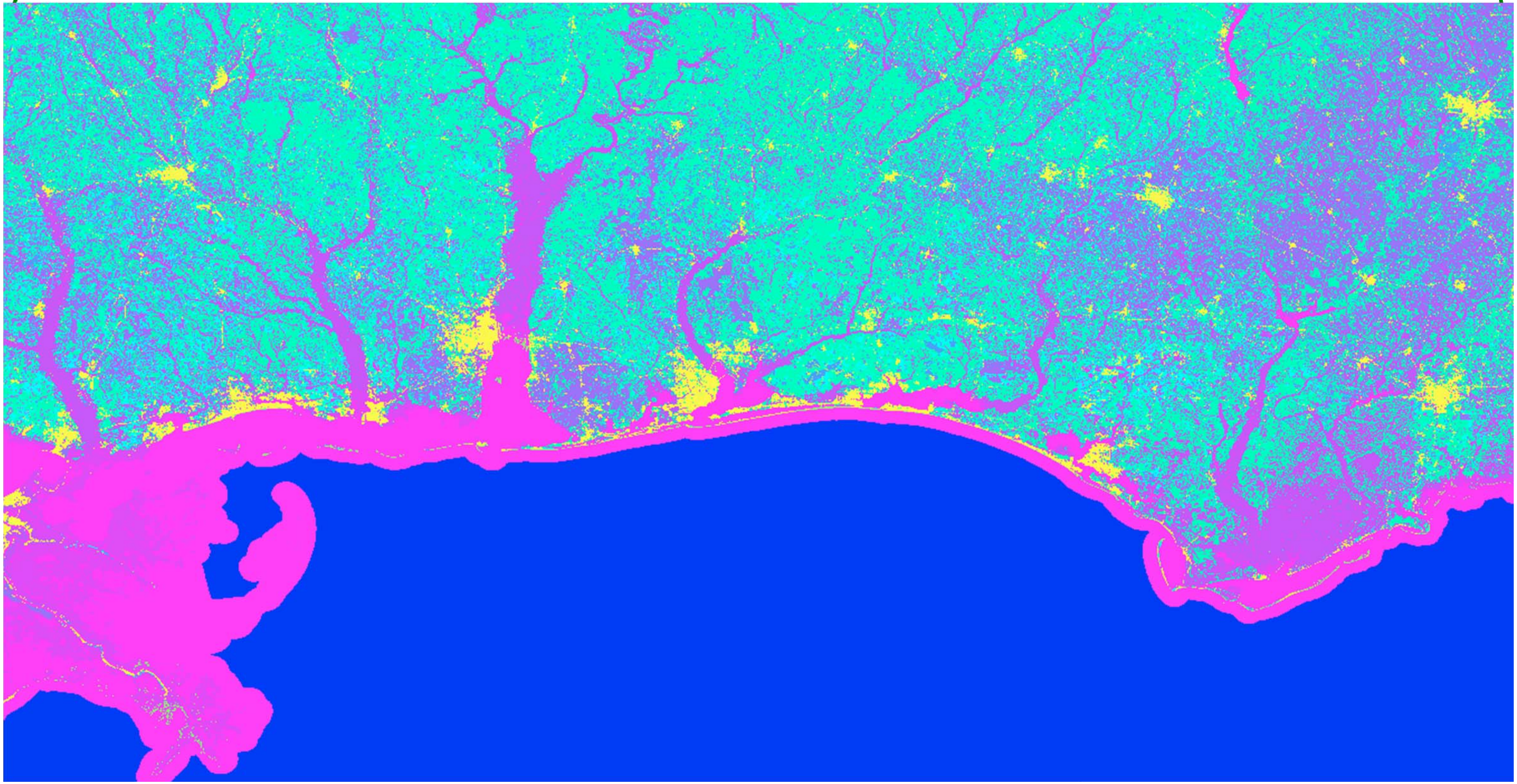
16R RT



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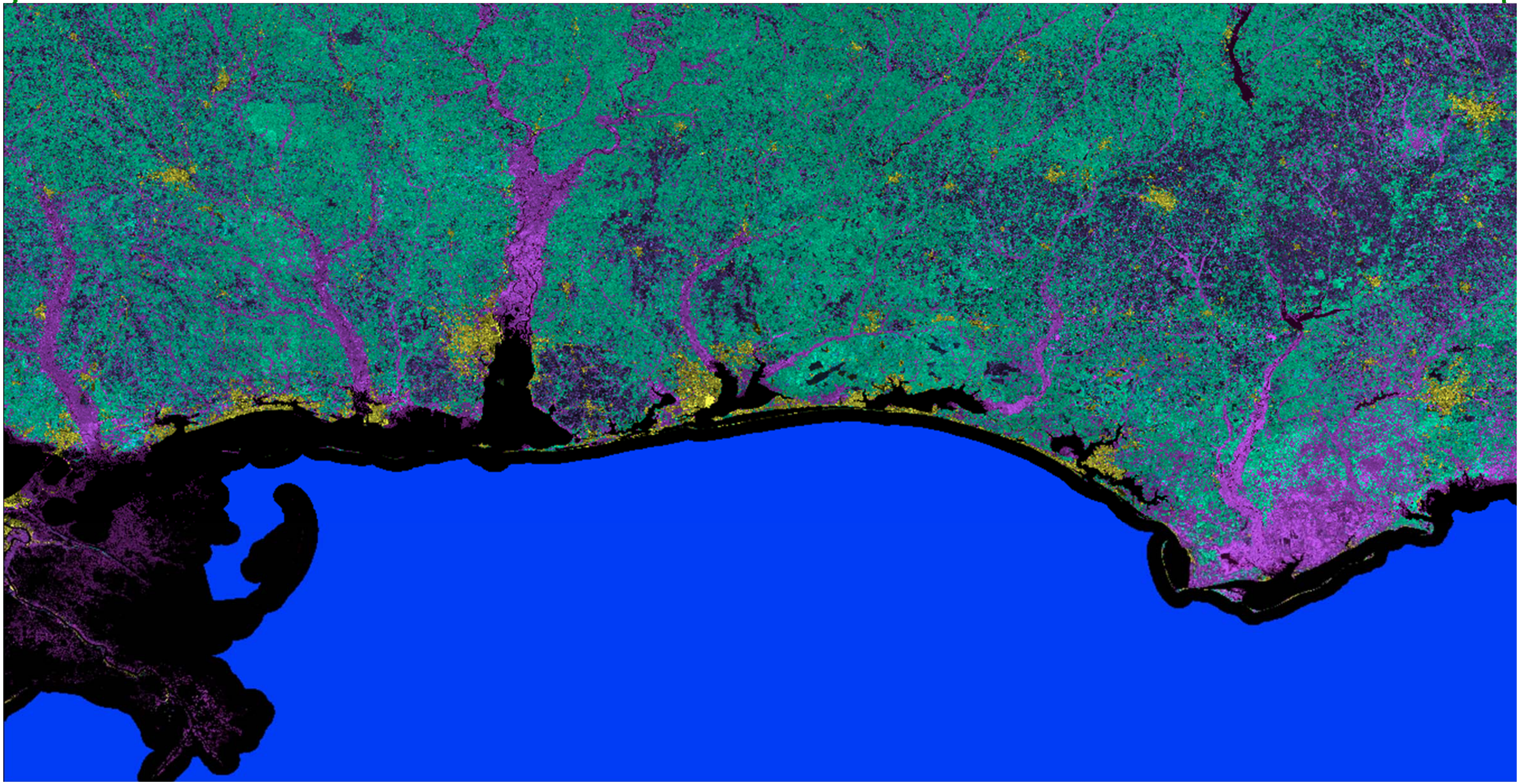
16R HH NLCD



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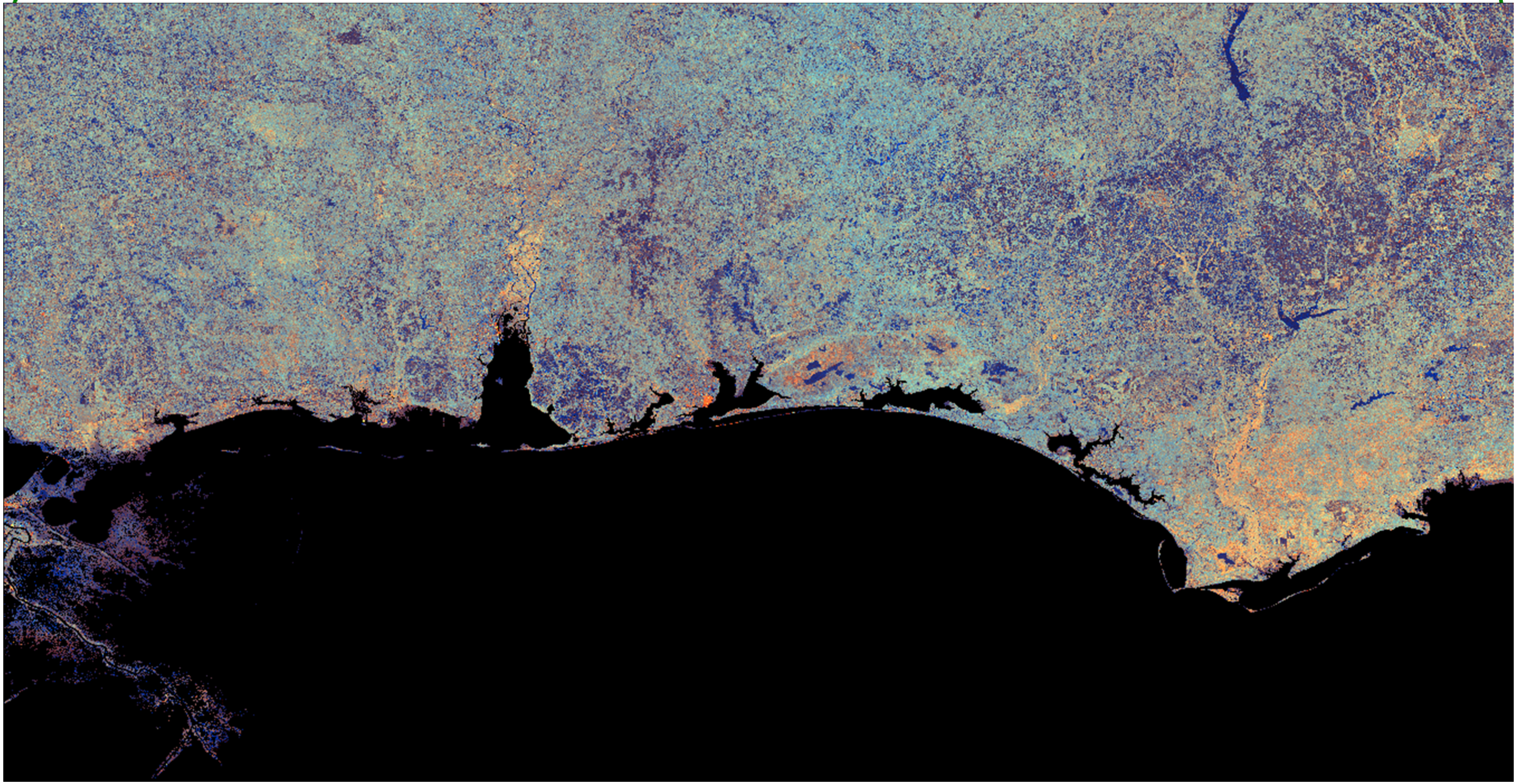
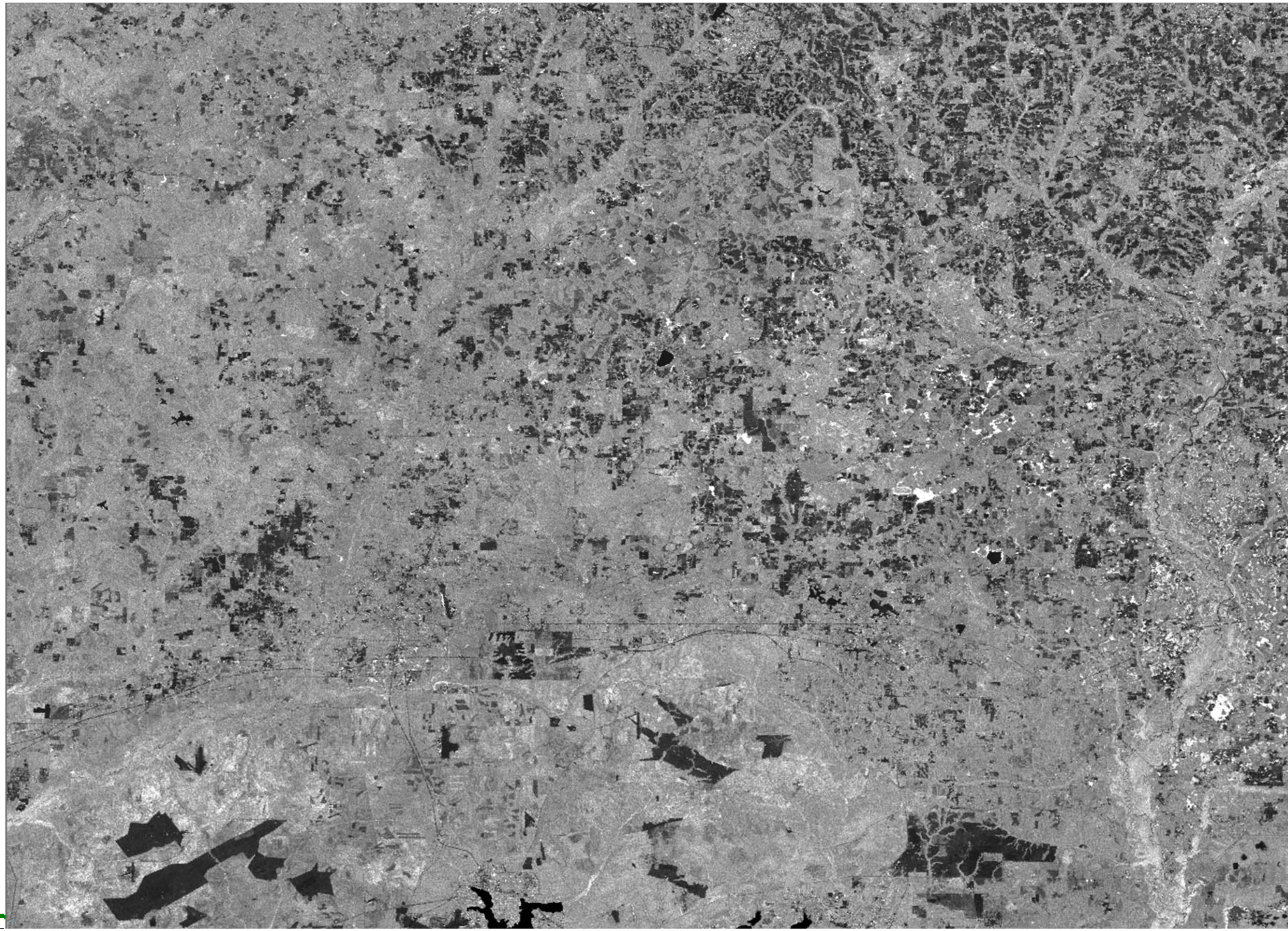
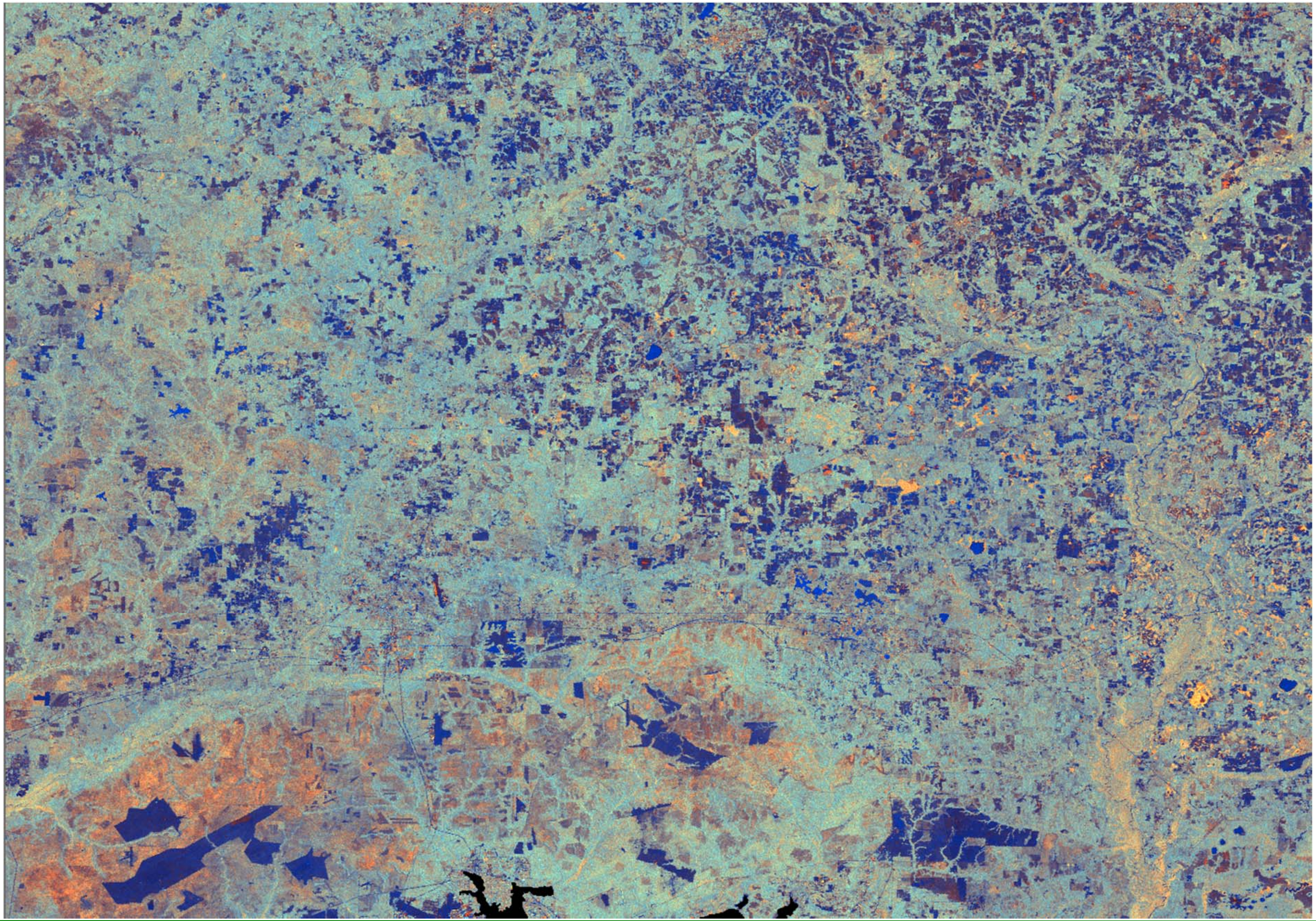
16R HH HV RT



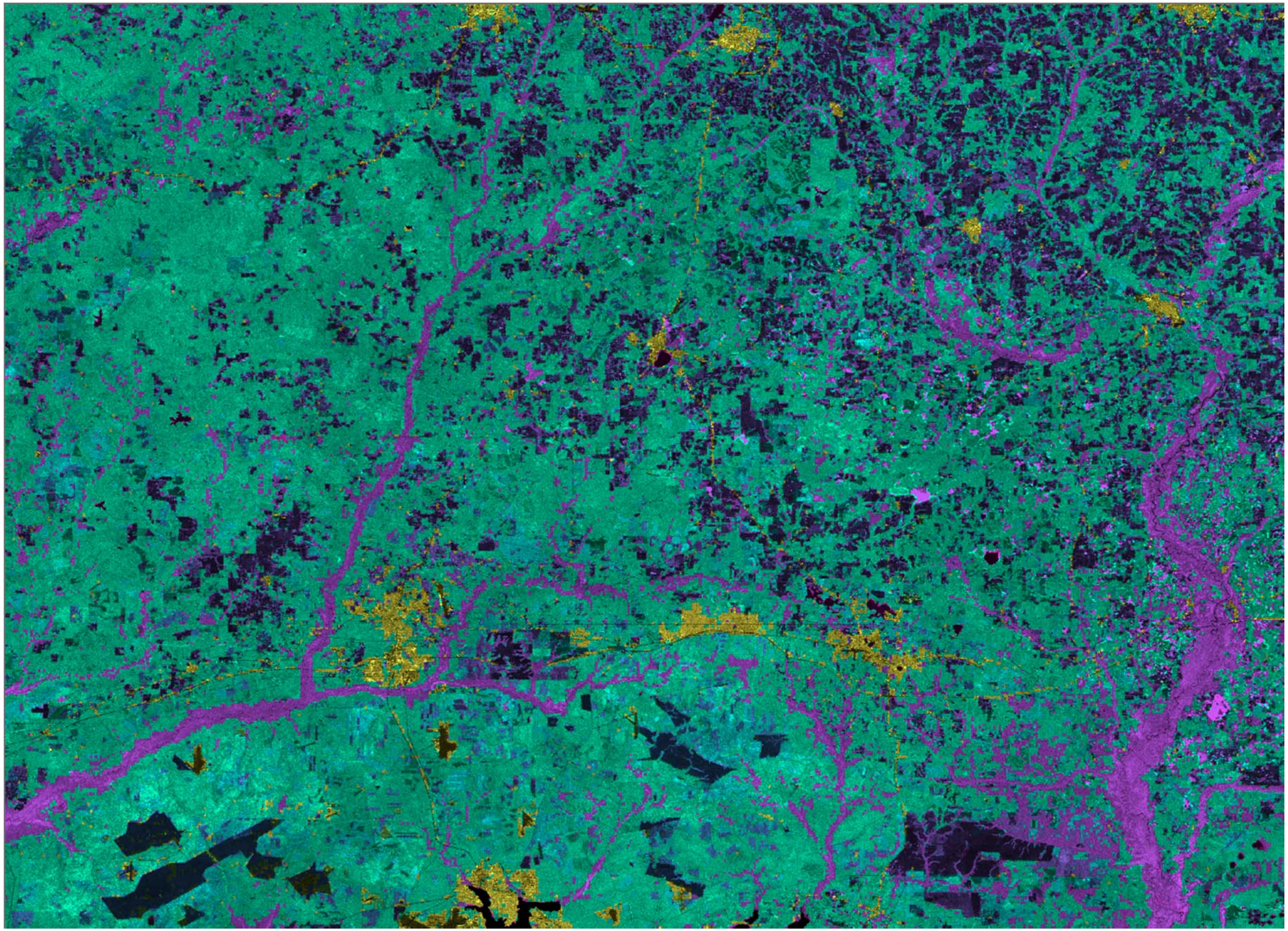
16R HH



16R HH HV RT

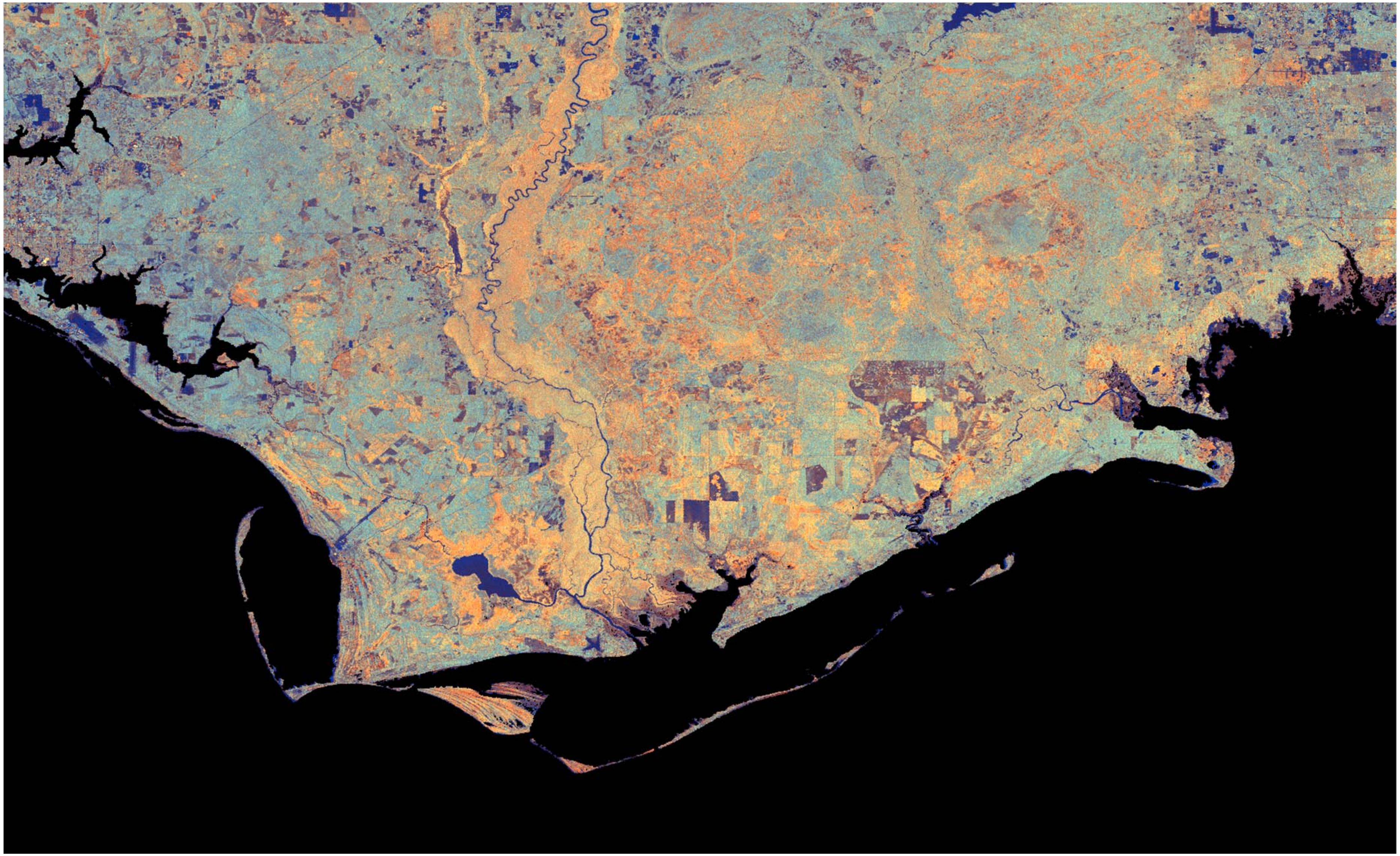


16R
HH - NLCD



Wetlands

16R
HH
HV
RT



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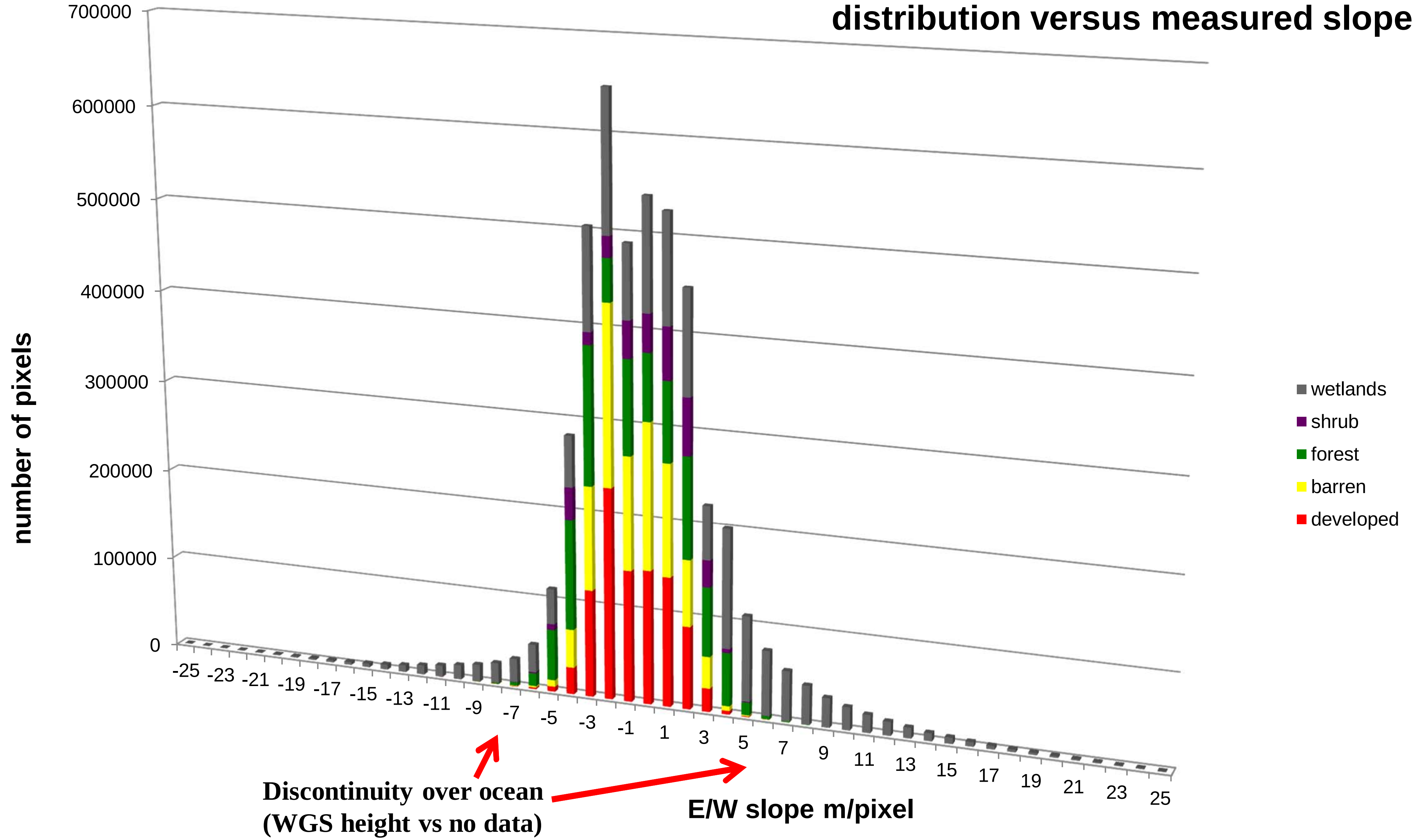
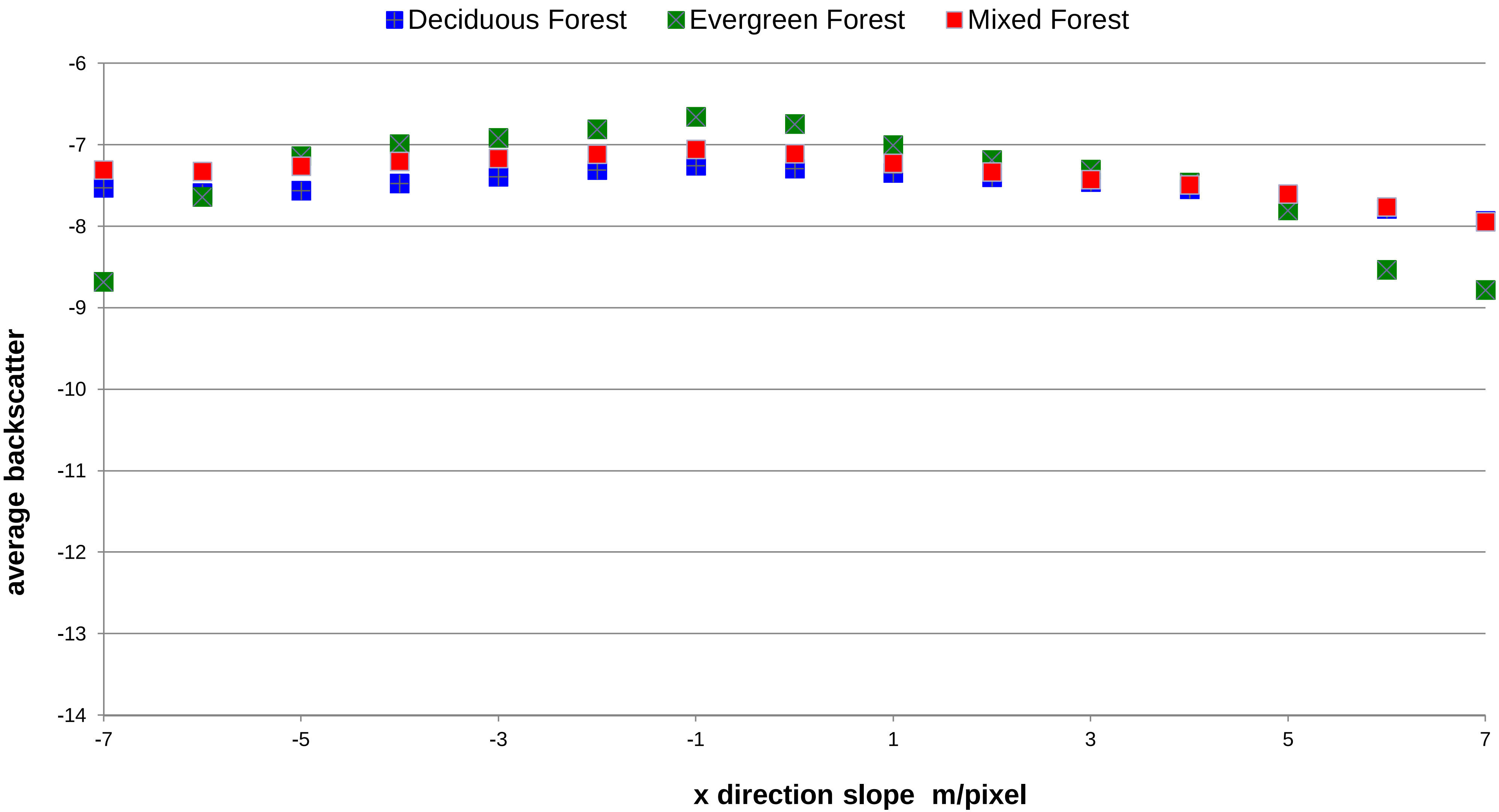
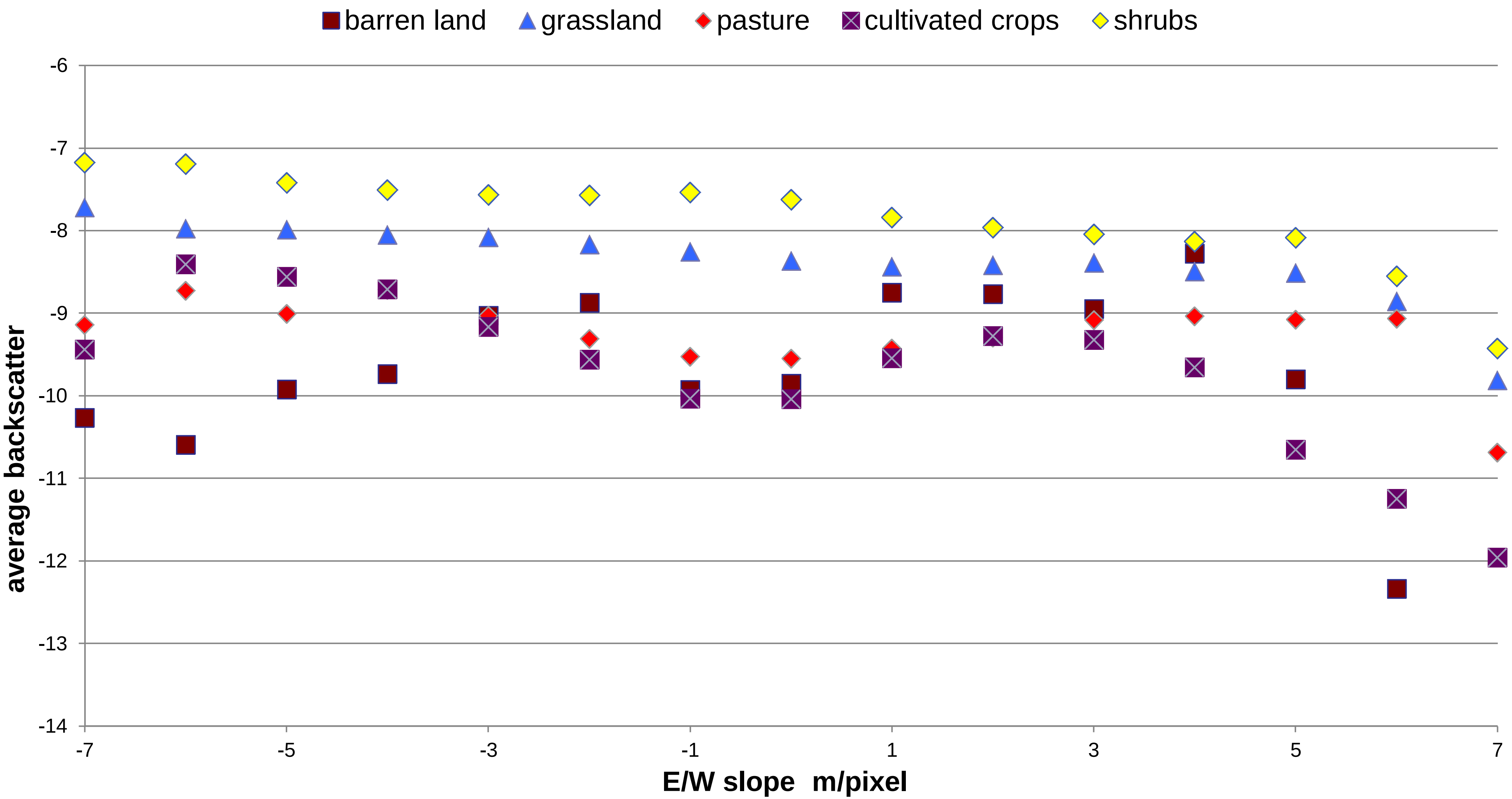
distribution versus measured slope



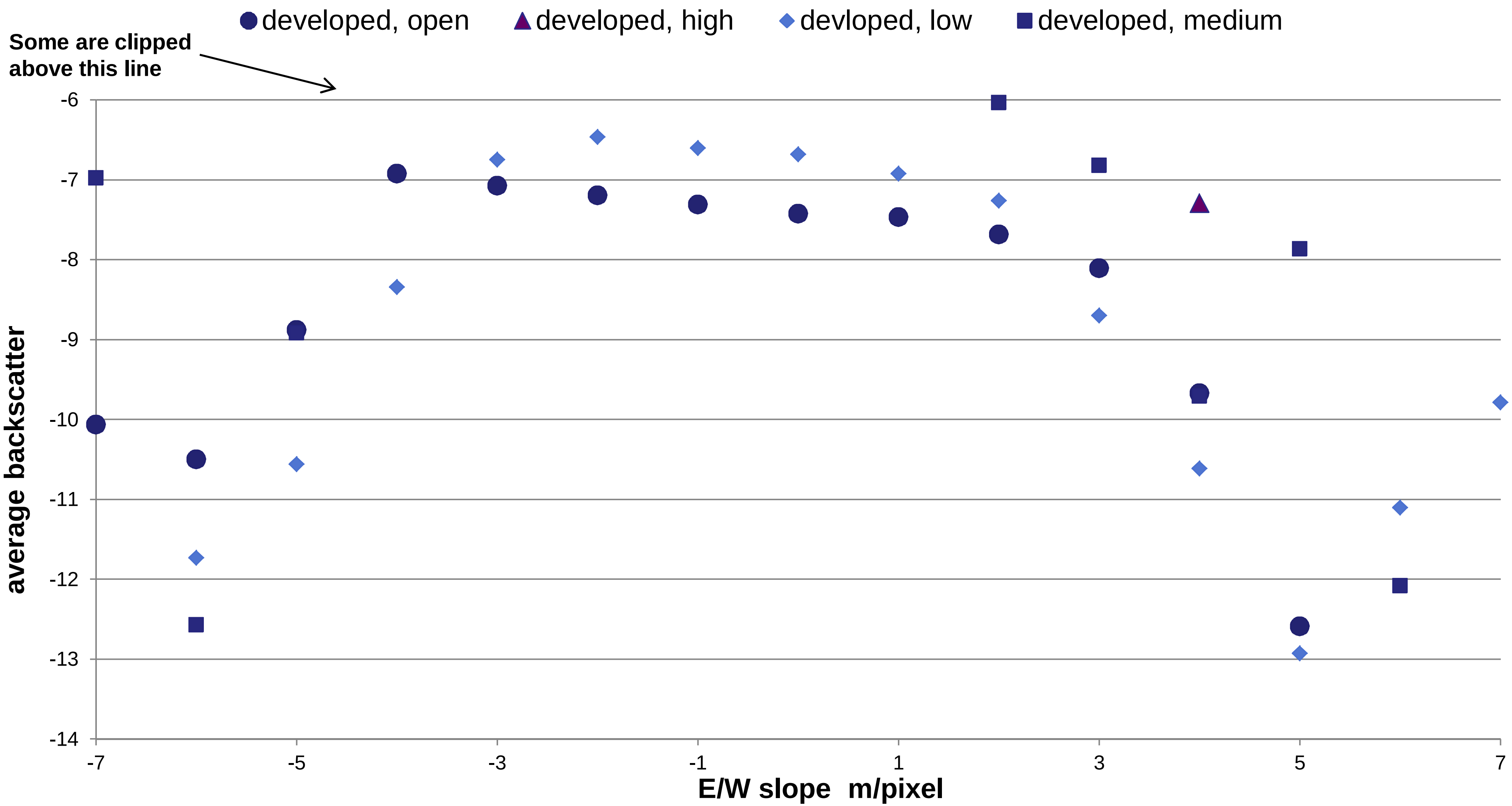
16R HH forest only

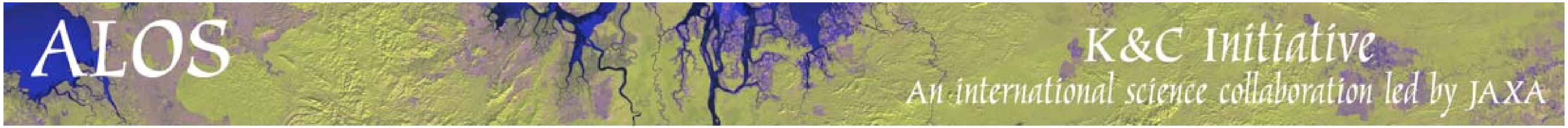


16R HH low vegetation

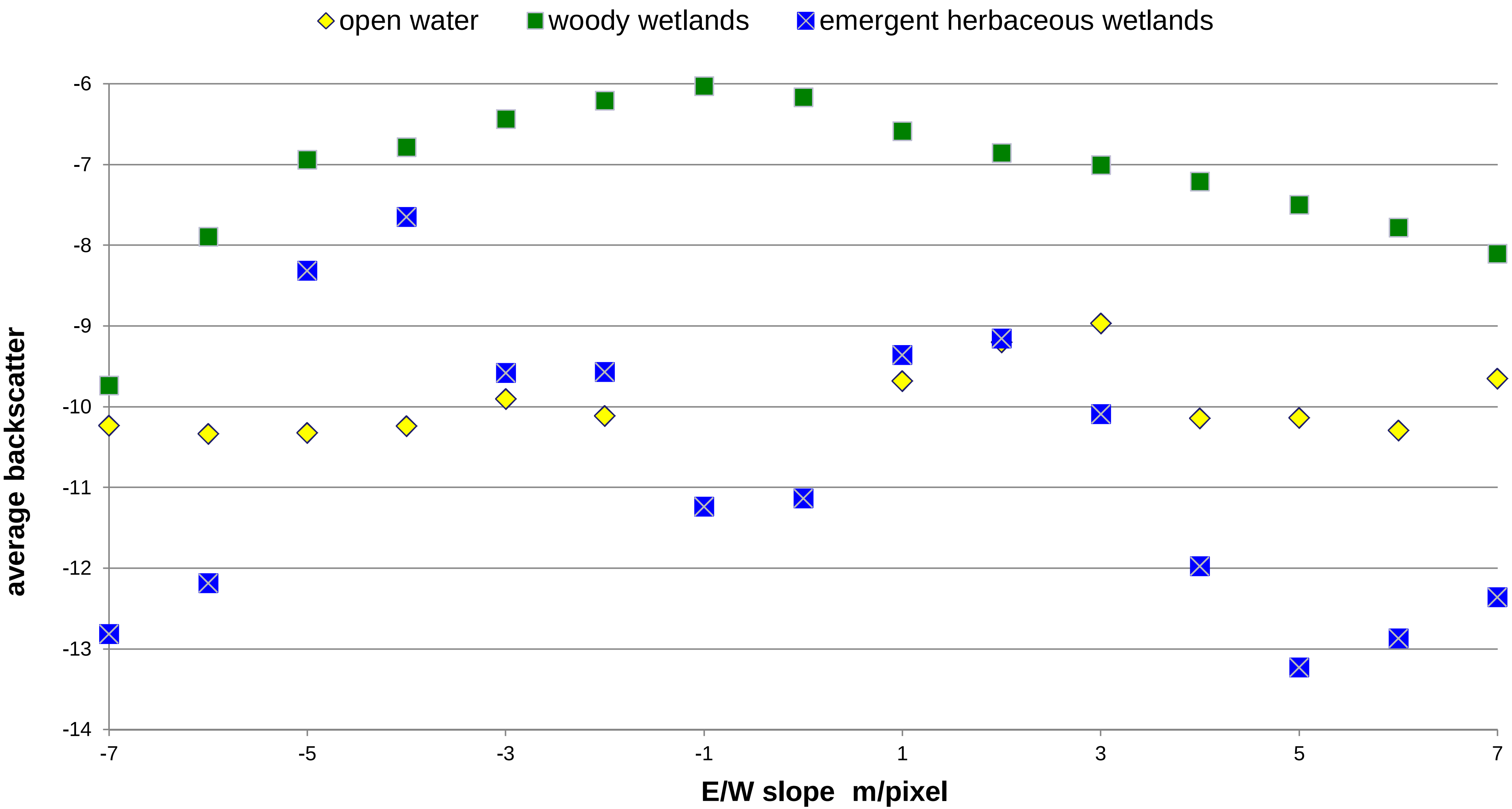


16R HH developed

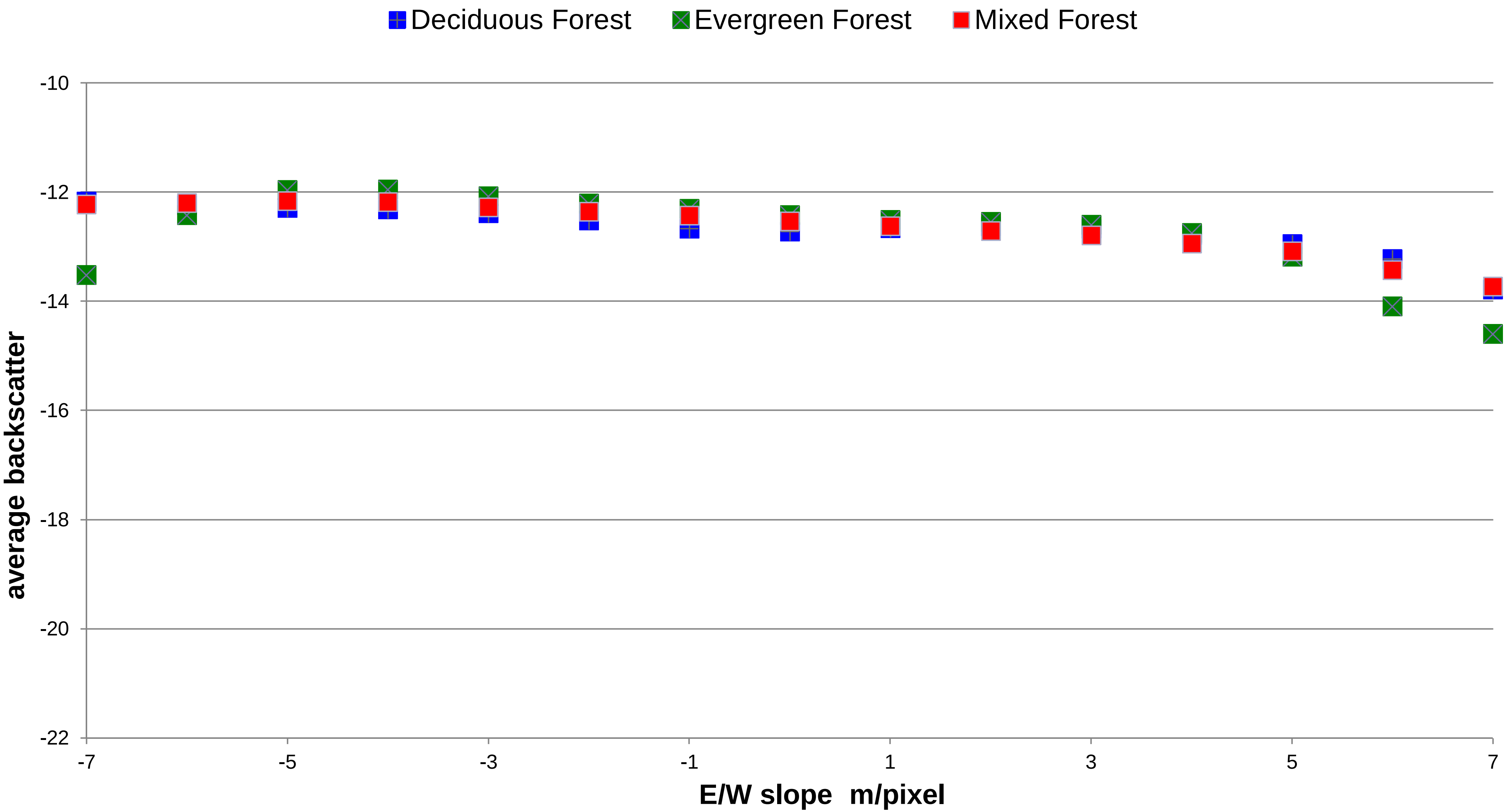


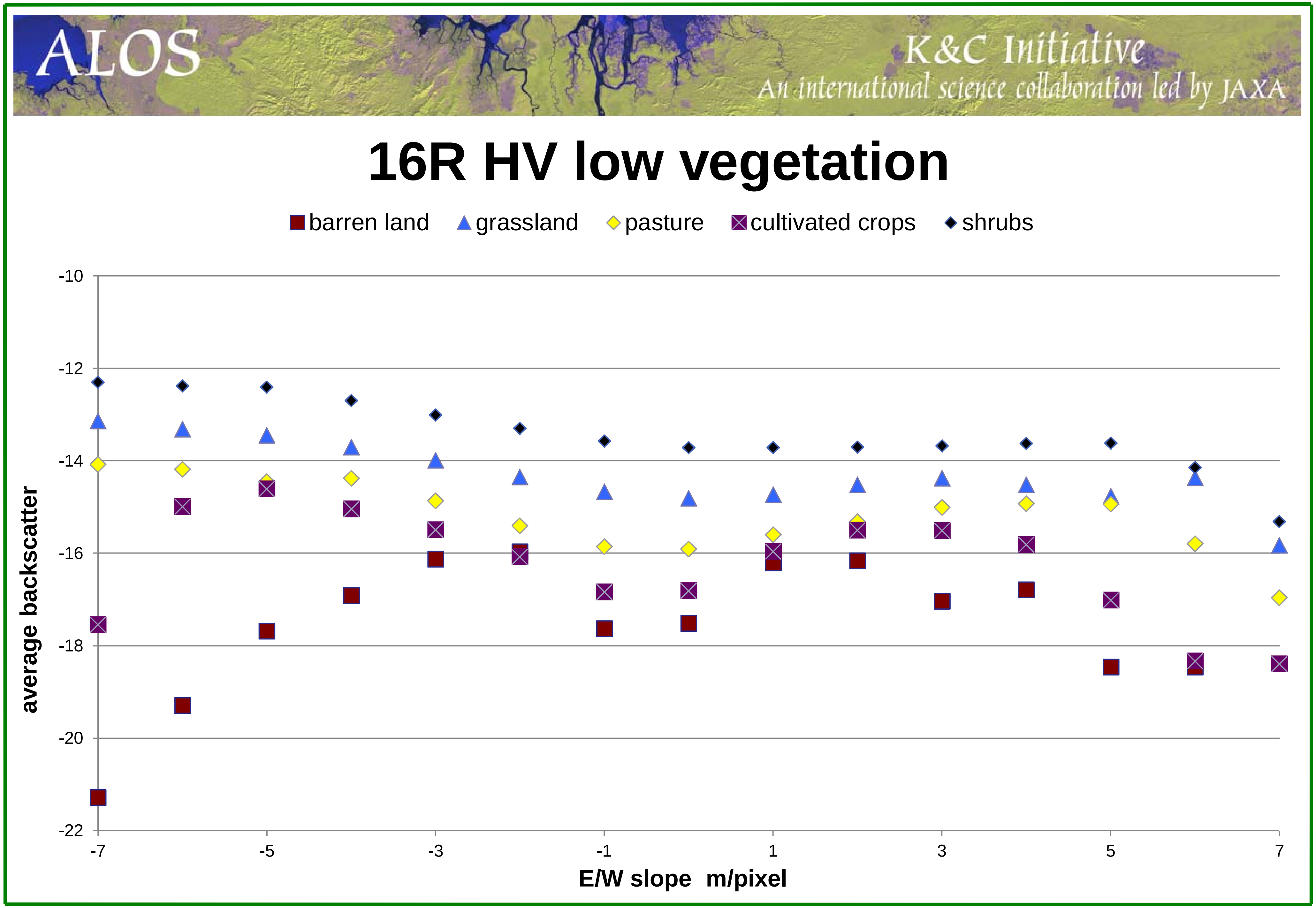


16R HH wetlands



16R HV forest only





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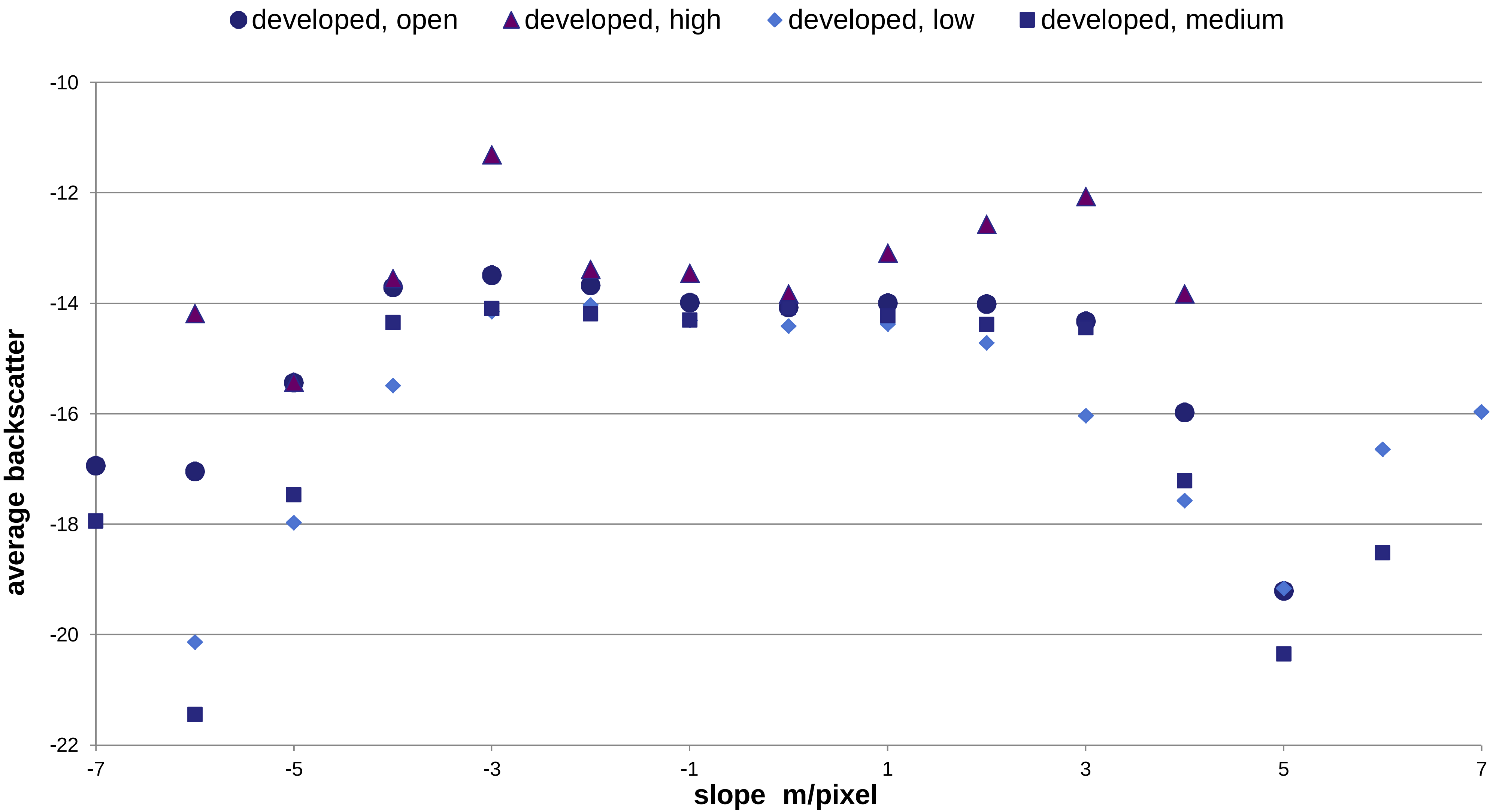
16R HV low vegetation
barren land
grassland
pasture
cultivated crops
shrubs
-10
-12
-14
-16
-18
-20
-22
-7
-5
-3
-1
1
3
5
7
average backscatter
E/W slope m/pixel

16R HV developed



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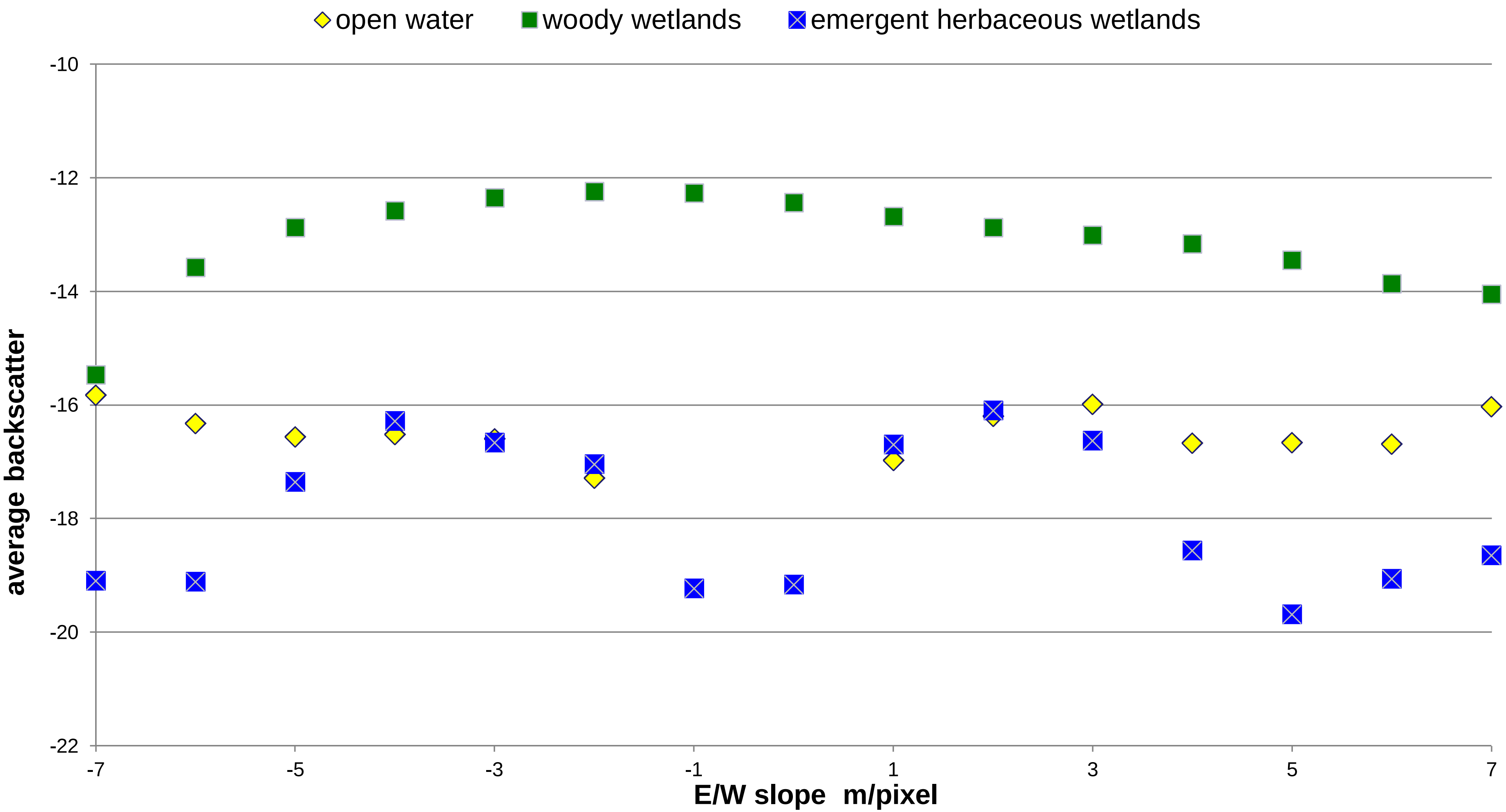
16R HV wetlands



Average linear backscattered power for NLCD classes

	10T HH	10T HV	16R HH	16R HV
Evergreen	-6.77	-11.85	-7.03	-12.30
Mixed	-7.27	-12.38	-7.23	-12.46
Deciduous	-7.30	-12.52	-7.41	-12.57
Shrub	-8.15	-13.50	-7.74	-13.46
Grassland	-8.03	-12.90	-8.24	-14.33
Barren	-7.82	-14.87	-9.30	-16.75
Pasture	-9.48	-15.69	-9.35	-15.48

Deforestation?

Volcanic terrain?

Conclusions

- Even after applying radiometric terrain correction to the PALSAR data, terrain slope is still a parameter to be considered when analyzing the data

- To produce the best possible forest/non-forest map from ALOS data, it would be desirable to use other data sources to separately identify some land cover categories, such as developed areas, volcanic areas, etc.

Project objectives and schedule

The objectives of this project is to produce a calibrated ALOS PALSAR mosaic for use in a prototype Carbon Monitoring System (CMS). Other remote sensing data being used by CMS include Icesat GLAS data, SRTM, the NED, NLCD, and MODIS.

The Continental US mosaic will be completed in April, work has already begun on Alaska, to be completed before the end of the 2012.

Support to JAXA's global forest mapping effort

The ALOS data is being compared with estimates of land cover, tree height products from GLAS, forest inventory data, and SRTM-NED. Results will be relevant to producing a forest/non-forest product.

Contacts have been made with the National forest data over the US, about whether it is possible to provide this data to JAXA. Also – ground truth data from Siqueira will be provided.

Deliverables

Describe the planned output of your project.

- ALOS PALSAR mosaic
- Publication describing methods
- Results from the prototype CMS will be delivered from co-I Saatchi.

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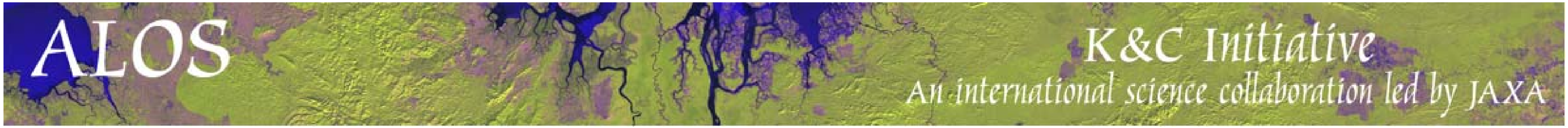

This research is undertaken within the framework of the ALOS Kyoto & Carbon Initiative. The ALOS data were provided by JAXA EORC.

Resources supporting this work were provided by the NASA High-End Computing (HEC) Program through the NASA Advanced Supercomputing (NAS) Division at Ames Research Center.

This work was partially performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.