LANDSAT TM/ETM+ IMAGE COMPOSITING FOR AMAZONIAN VEGETATION MAPPING

Jasper Van doninck and Hanna Tuomisto
Amazon Research Team, Department of Biology, University of Turku

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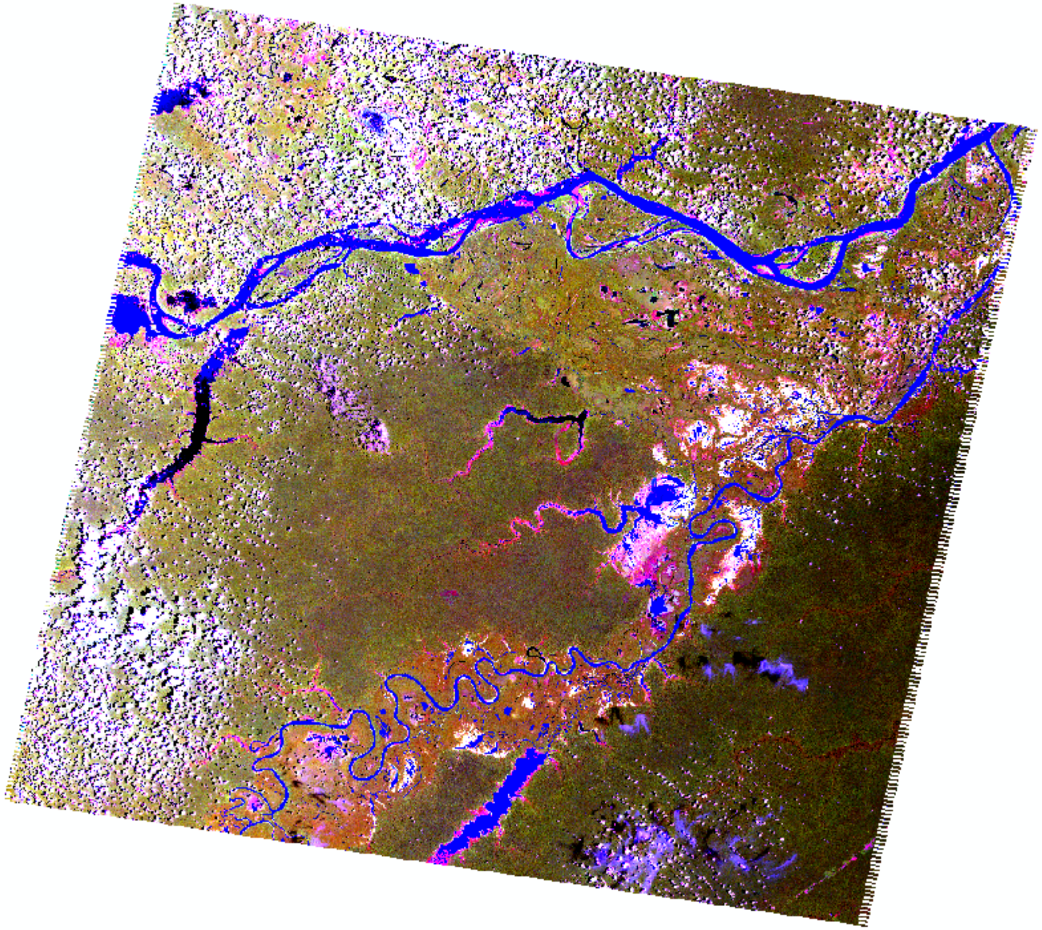
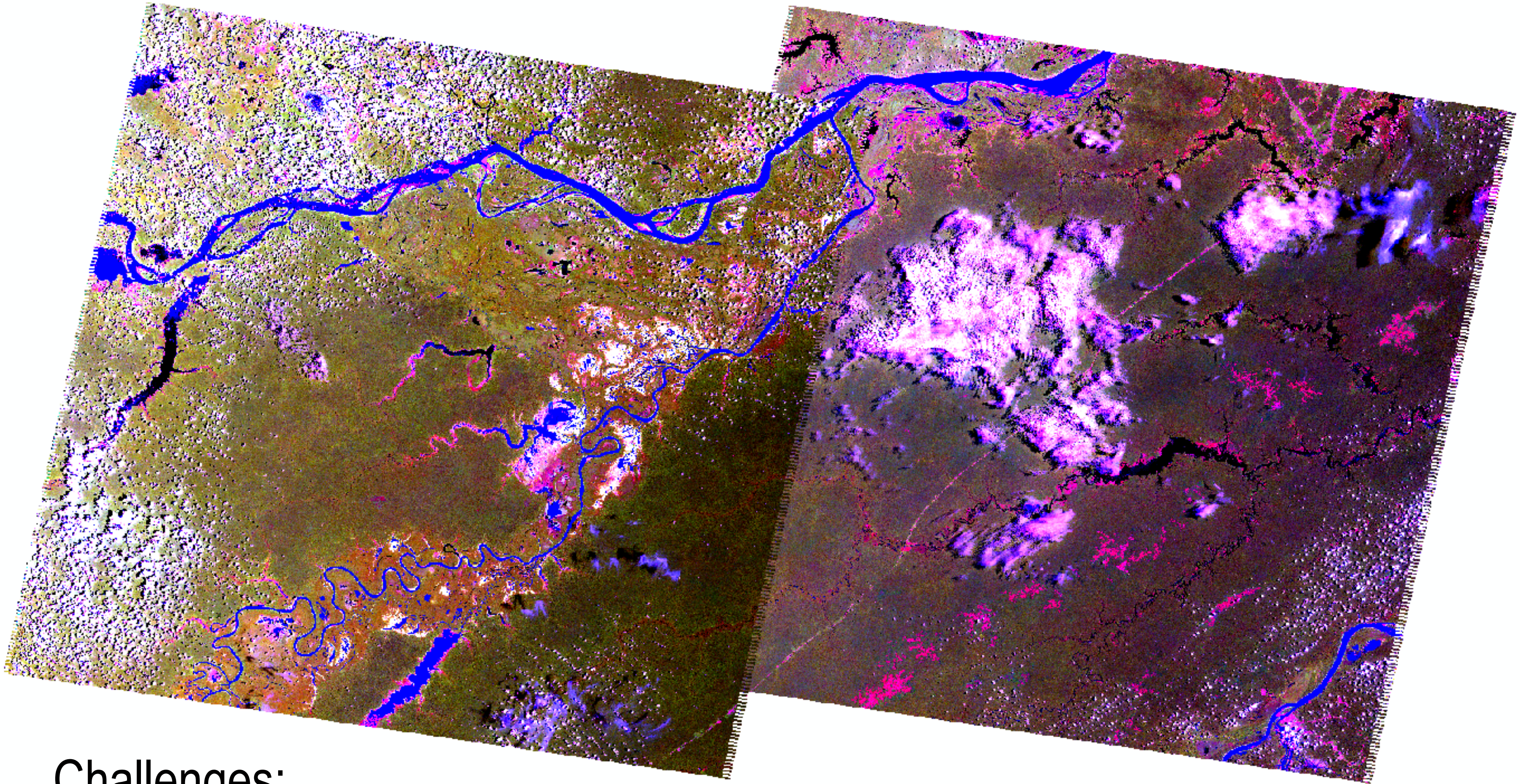
University of Turku

Landsat TM/ETM+ image compositing for Amazonian vegetation mapping



Landsat TM/ETM+ image compositing for Amazonian vegetation mapping



Challenges:

1. Normalization of directional effects
2. Pixel-based image compositing

Normalization of directional effects - methods

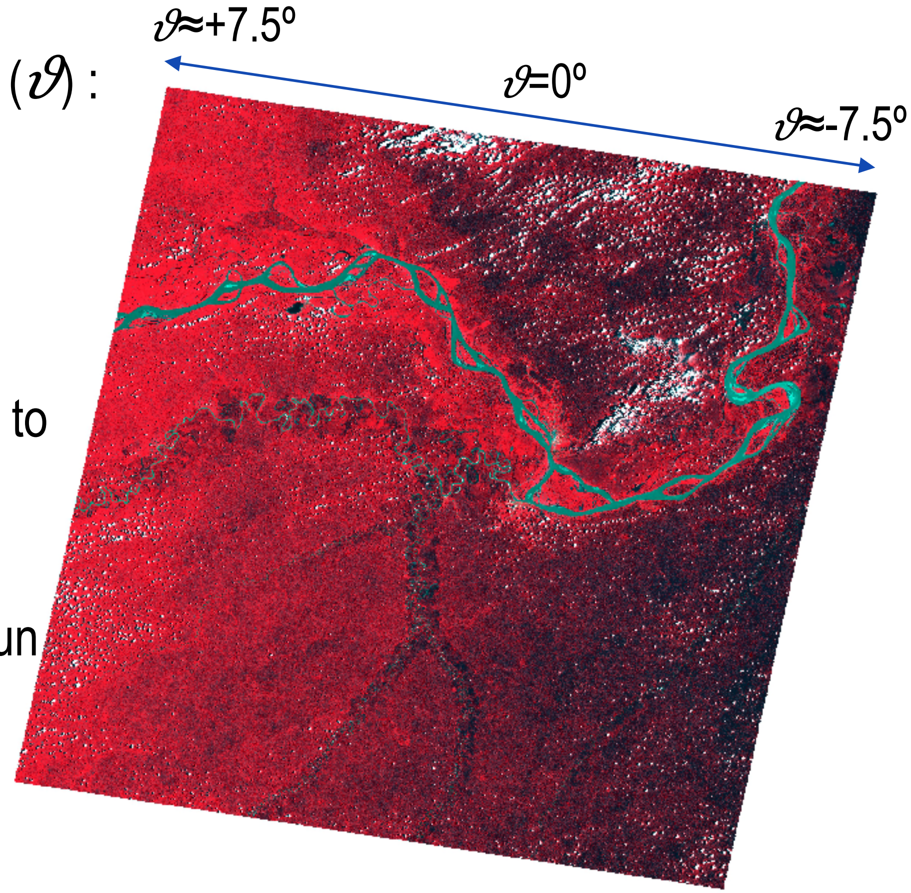
A. Empirical view zenith angle normalization

For each image linear regression of surface reflectance ($\rho(\lambda)$) versus sensor zenith angle (ϑ) :

$$\rho(\lambda,\vartheta)=\rho 0(\lambda)+\alpha(\lambda)\vartheta$$

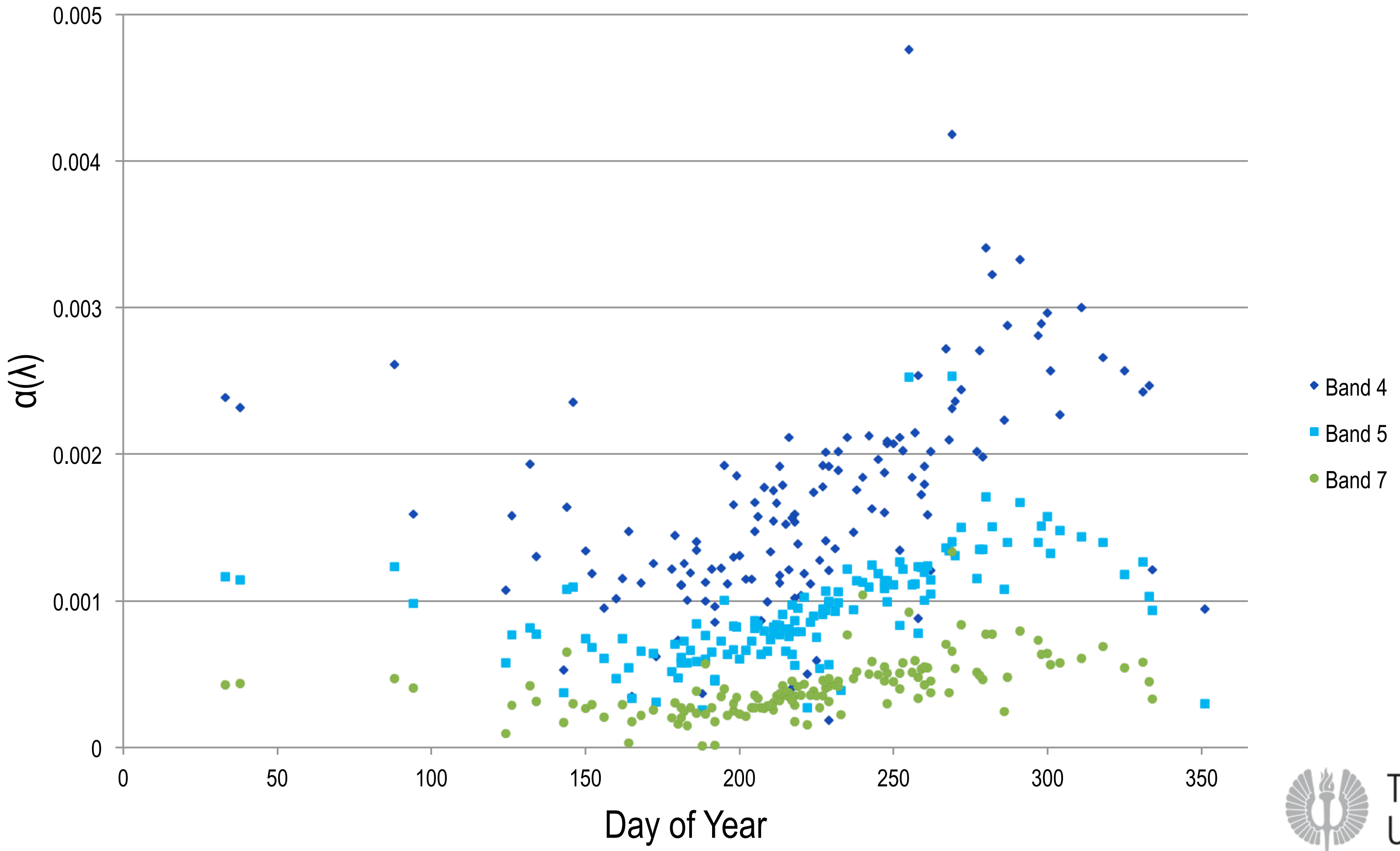
Empirical surface reflectance gradient α used to normalize to nadir viewing

Does not normalize angular configuration of sun



Normalization of directional effects - methods

A. Empirical view zenith angle normalization



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Normalization of directional effects - methods

B. MODIS BRDF model parameters

- Directional reflectance expressed as sum of isotropic, volumetric and geometric scattering component:

$$R(\theta,\vartheta,\phi,\lambda)=f_{iso}(\lambda)+f_{vol}(\lambda)K_{vol}(\theta,\vartheta,\phi)+f_{geo}(\lambda)K_{geo}(\theta,\vartheta,\phi)$$

θ: Solar zenith angle ϕ: Relative azimuth angle

- Model parameters (f_{iso}, f_{vol}, f_{geo}) inverted from multi-temporal, multi-angular Aqua/Terra MODIS observations

- Use BRDF model parameters of MODIS pixel corresponding to each Landsat pixel to normalize to nadir viewing and standard solar geometry

$$\rho(\theta_B,\vartheta_B,\phi_B,\lambda)=R(\theta_B,\vartheta_B,\phi_B,\lambda)/R(\theta_A,\vartheta_A,\phi_A,\lambda)\,\rho(\theta_A,\vartheta_A,\phi_A,\lambda)$$

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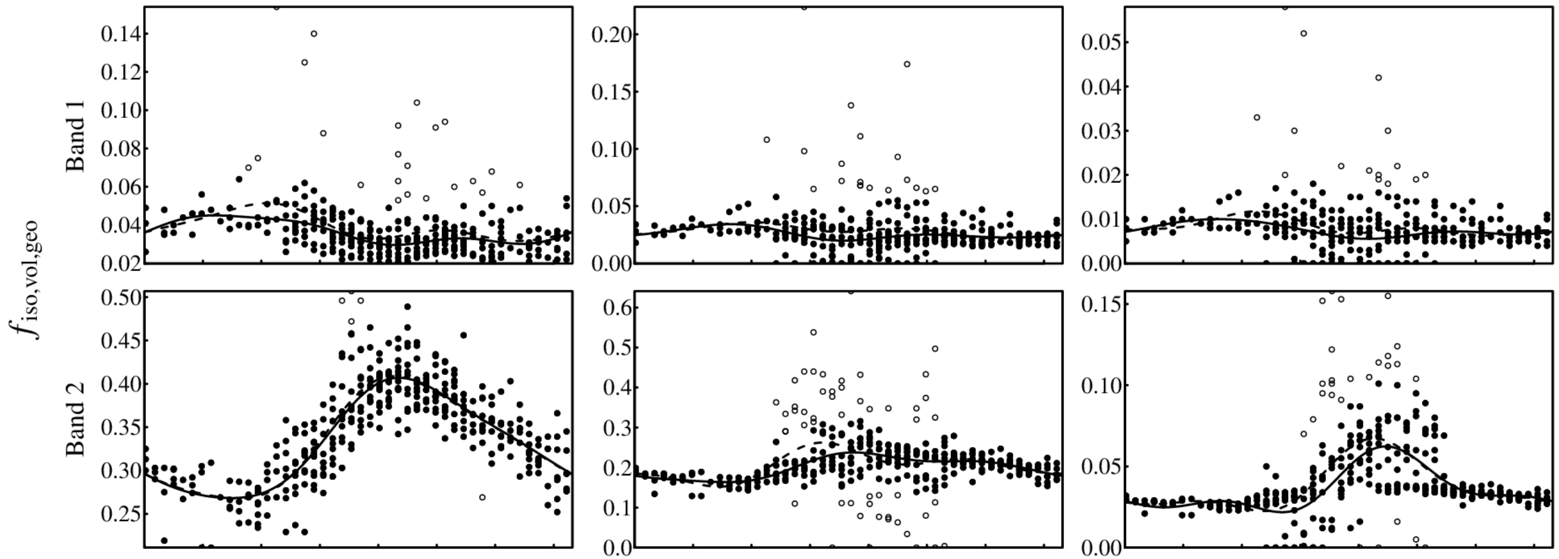
Normalization of directional effects - methods

B. MODIS BRDF model parameters

- BRDF parameters often not generated due to persistent cloud cover + gap between swaths
- No MODIS BRDF parameters before 2001



- Harmonic analysis
  1. Assumption of stable land cover
  2. Assumption of regular seasonal pattern and fixed magnitude

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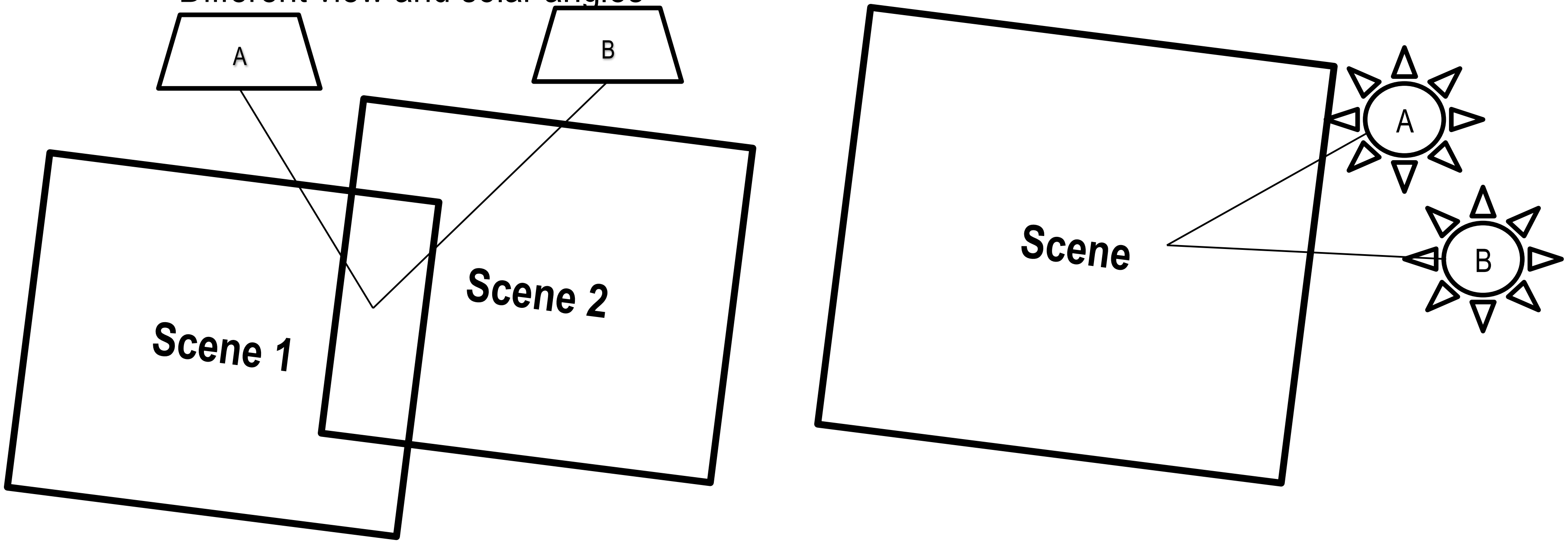
Normalization of directional effects - methods

C. Calibrate BRDF model parameters using Landsat image pairs

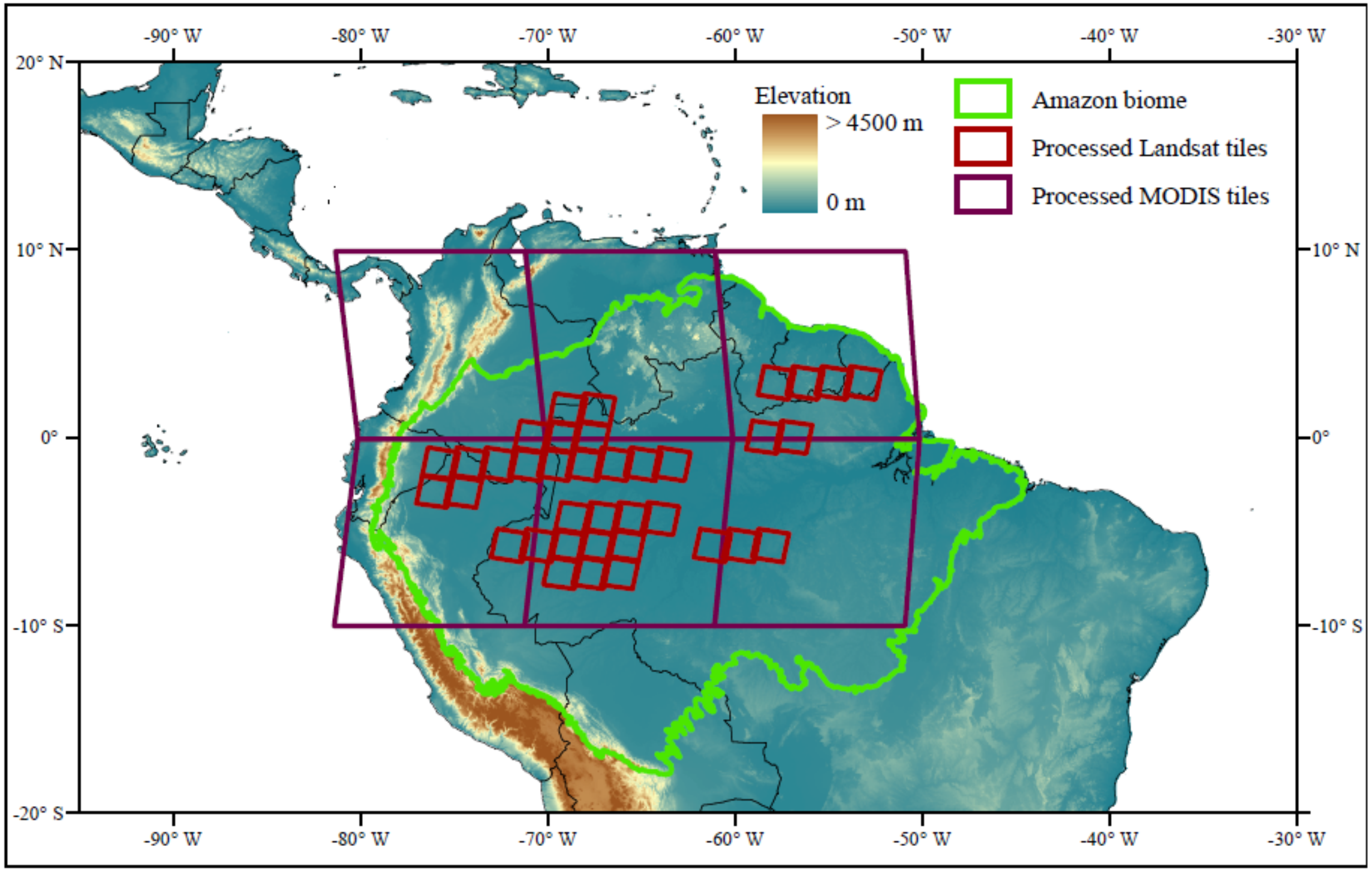
- Find 1 set of BRDF parameter for Amazonian forests
- Select pixel pairs in overlap area or from images acquired within short period
  - No land cover change
  - Different view and solar angles



- Find optimal model parameters by minimizing cost function C:

$$C=\rho(\theta_B,\vartheta_B,\phi_B,\lambda)-\gamma(A,B,\lambda)\,\rho(\theta_A,\vartheta_A,\phi_A,\lambda)$$

Normalization of directional effects - datasets



- 1974 atmospherically corrected surface reflectance (LEDAPS) TM/ETM+ images
- Over continuous forest and relatively flat terrain
- Clouds, cloud shadow and water masked

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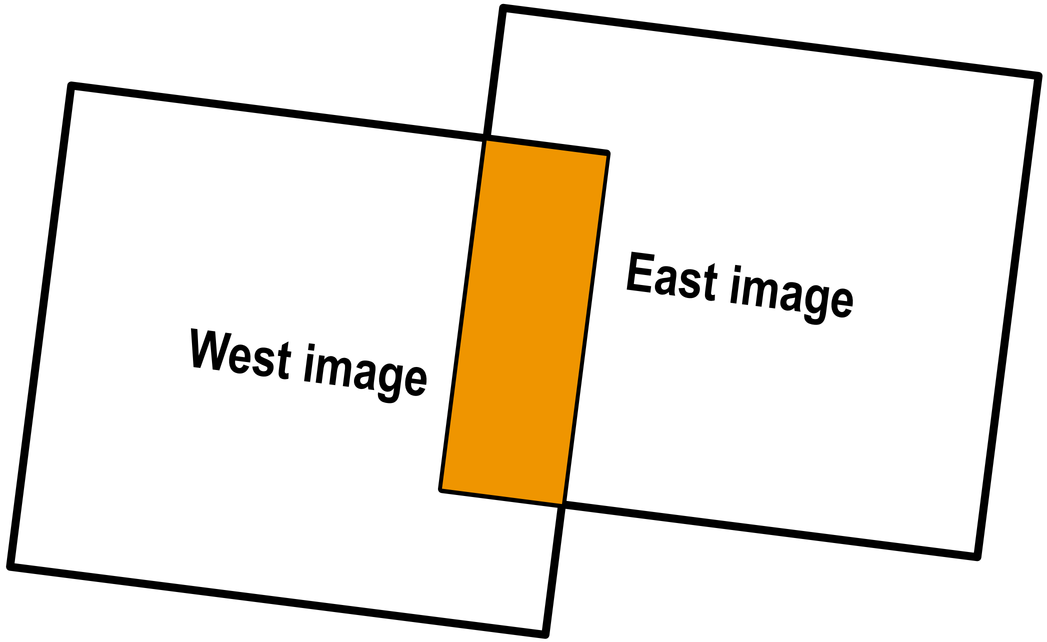
Normalization of directional effects - validation

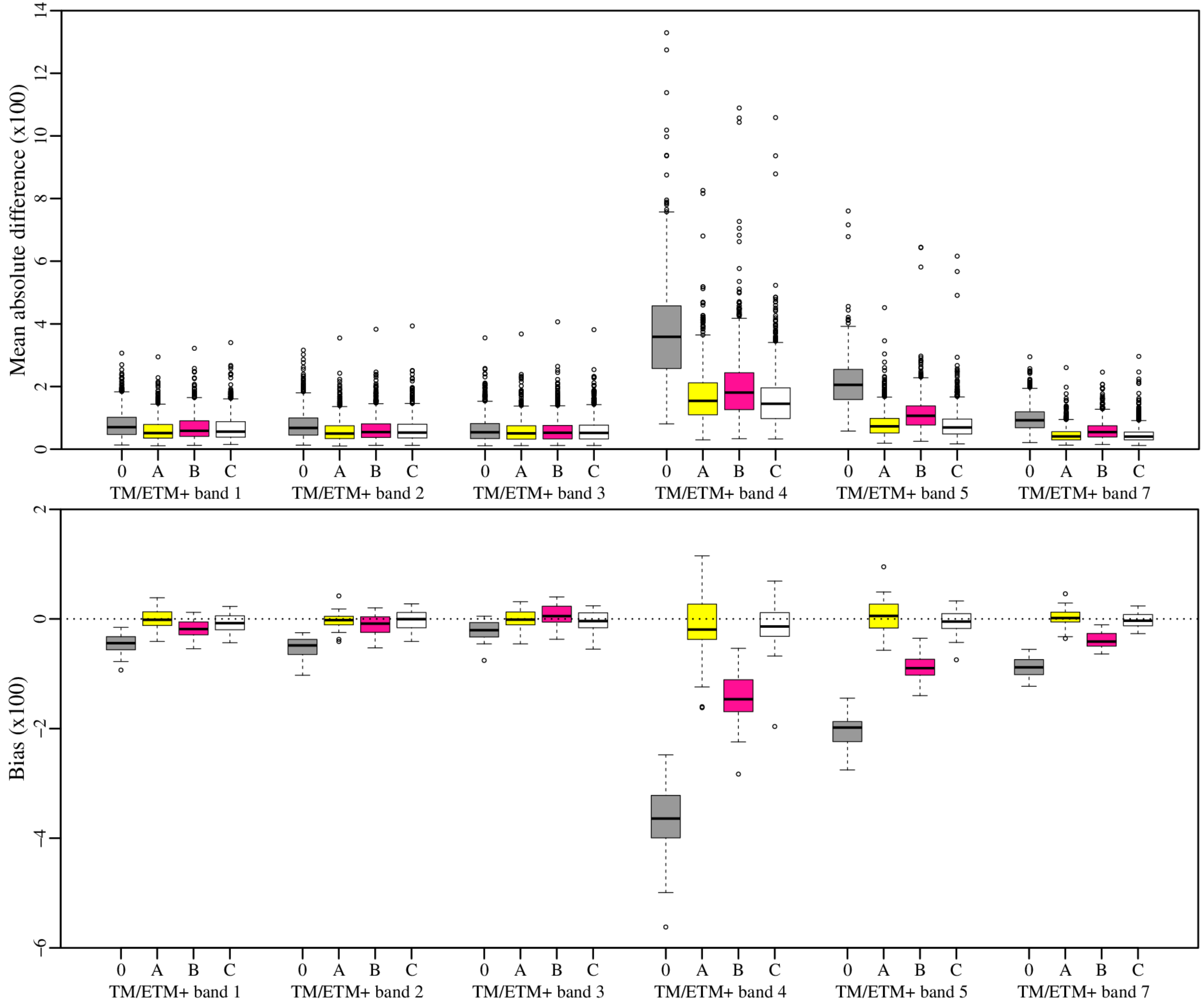
- Overlap area images from adjacent paths
- Max. 30 days time gap

→1289 image pairs

- Mean absolute difference
- Bias = difference of mean reflectance, averaged over all images for an overlap area



Normalization of directional effects - validation

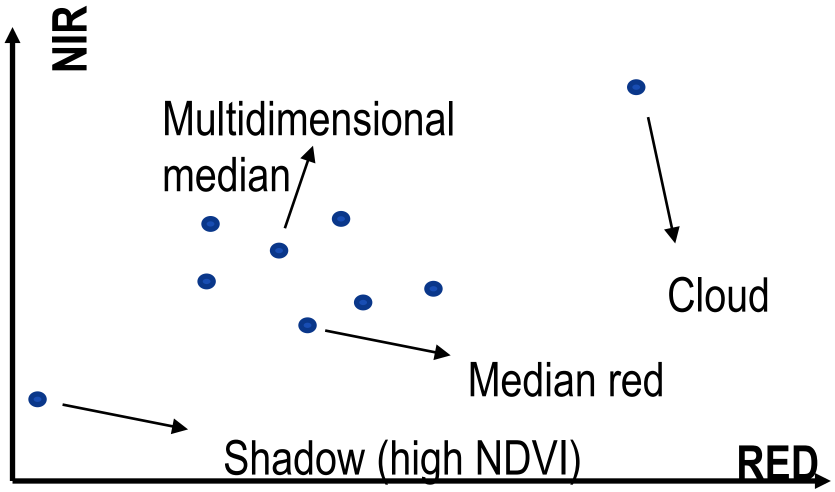


Pixel based compositing

- Reduce (random) effects of residual atmospheric contamination
- Compositing period: data avalability (# cloud-free observations) >< surface changes (land use, phenology)

  → optimal number of images for compositing?

- Influence of pixel selection criterion



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Pixel based compositing - methods

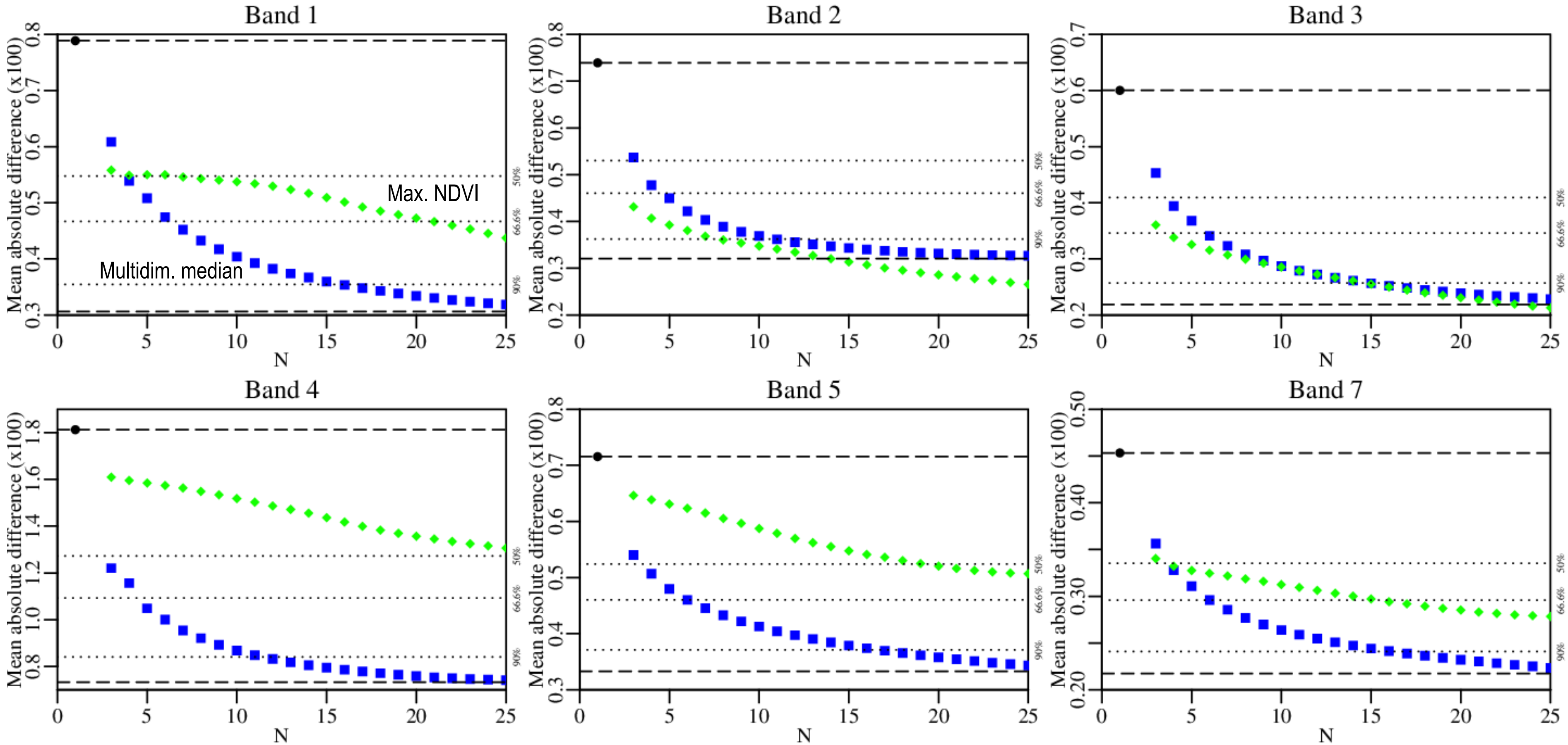
- Landsat TM/ETM+ (SLC-on)
  - LEDAPS surface reflectance
  - Path/row 001/064 (45 images) and 233/064 (50 images)
  - July, August, September, 1984-2015
  - BRDF-corrected

- Compositing criteria:
  1. Max. NDVI
  2. Multidimensional median

- Create composite images for each WRS-2 scene separately, using 3 → 25 available observations per pixel

- Validation using reflectance difference in overlap area

Pixel based compositing - results



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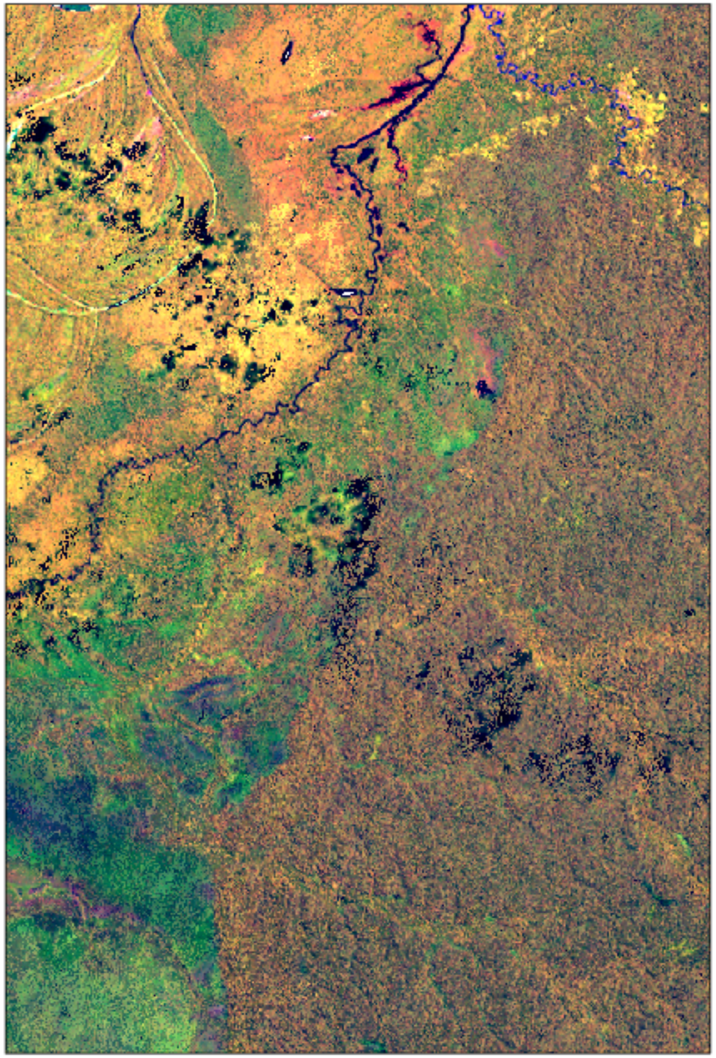
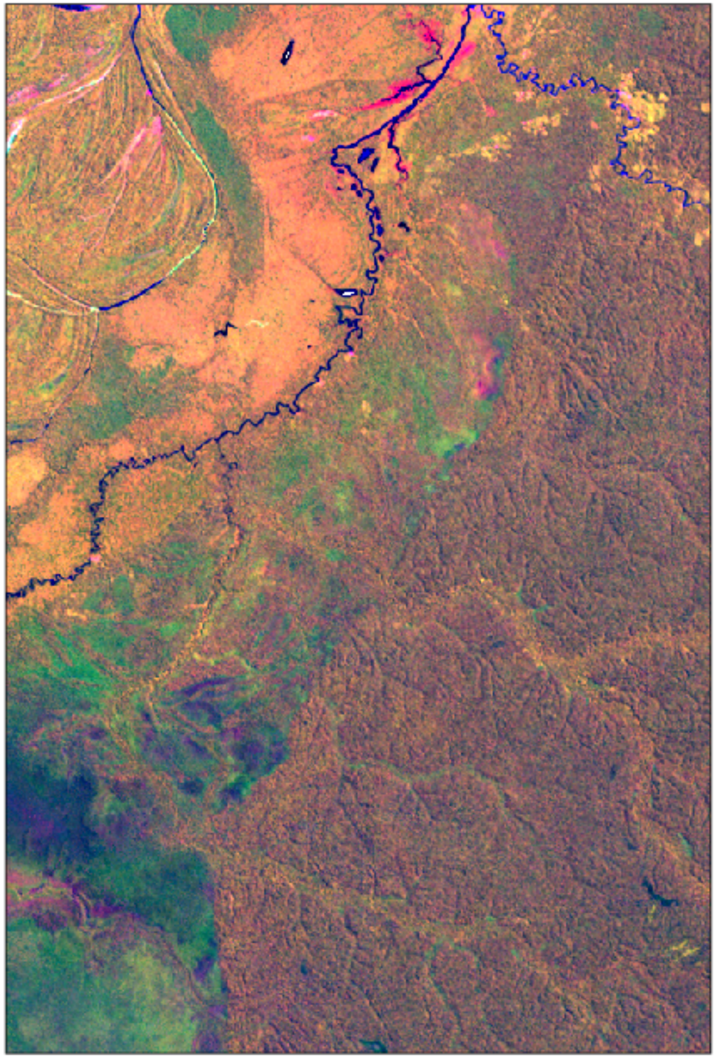
Pixel based compositing - results



Max. NDVI



Multidim. median

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Conclusions

- Largest angular effects in infrared bands
- All tested methods succeed in significantly reducing angular effects
- MODIS BRDF parameters result in systematic undercorrection in infrared bands

- Image compositing (multidimensional median criterion) can further reduce reflectance difference in overlap area with 0.25% – 1%
  - 50% of total reduction with 3-4 observations/pixel
  - 2/3 of total reduction with 5-6 observations/pixel
  - 90% of total reduction with 10-15 observations/pixel
- Median compositing succeeds in eliminating unmasked clouds + cloud shadows, max. NDVI compositing only removes clouds

Thank you!

ACADEMY OF FINLAND

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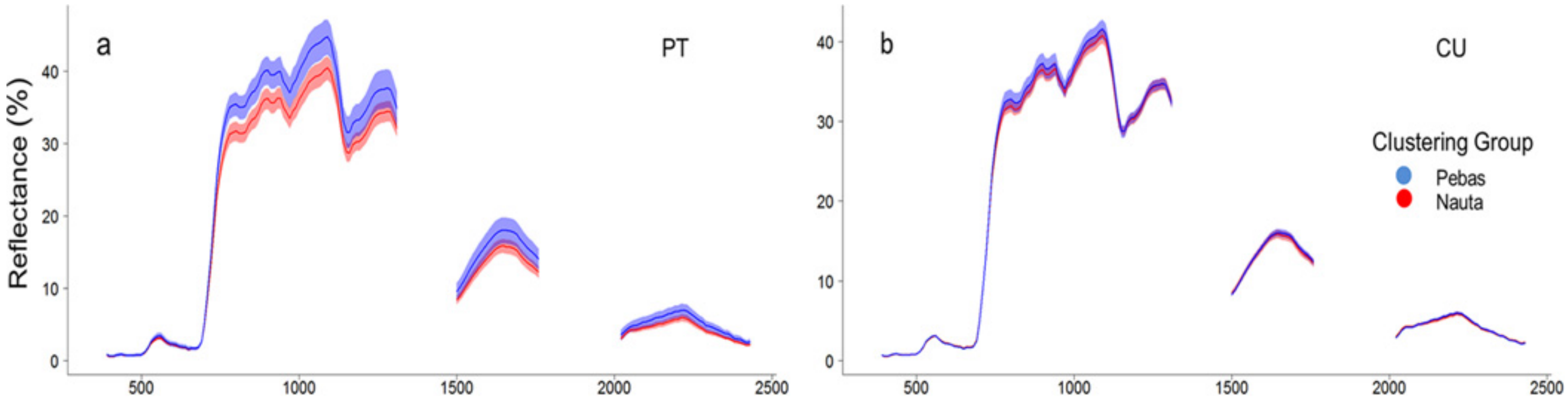
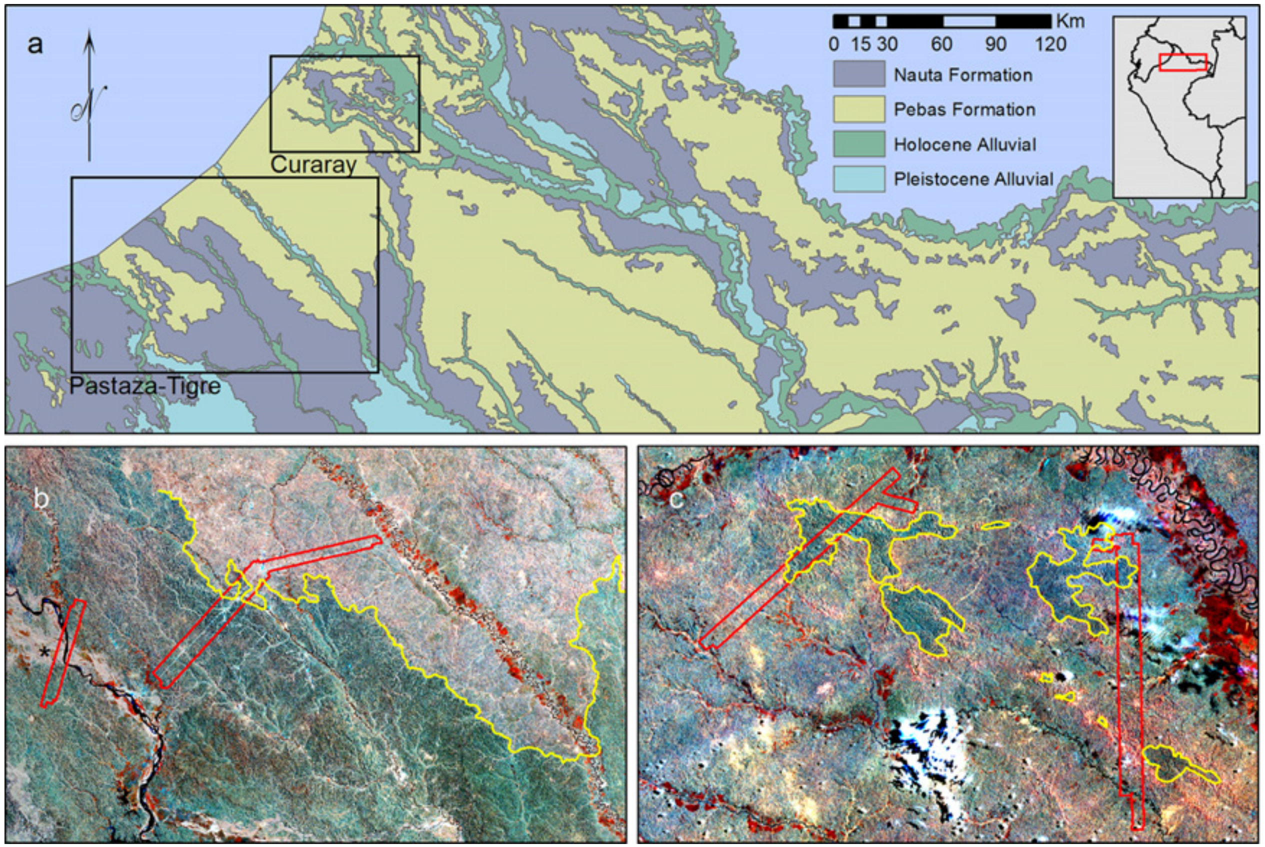
CSC





Higgins et al., 2015, PLoS ONE

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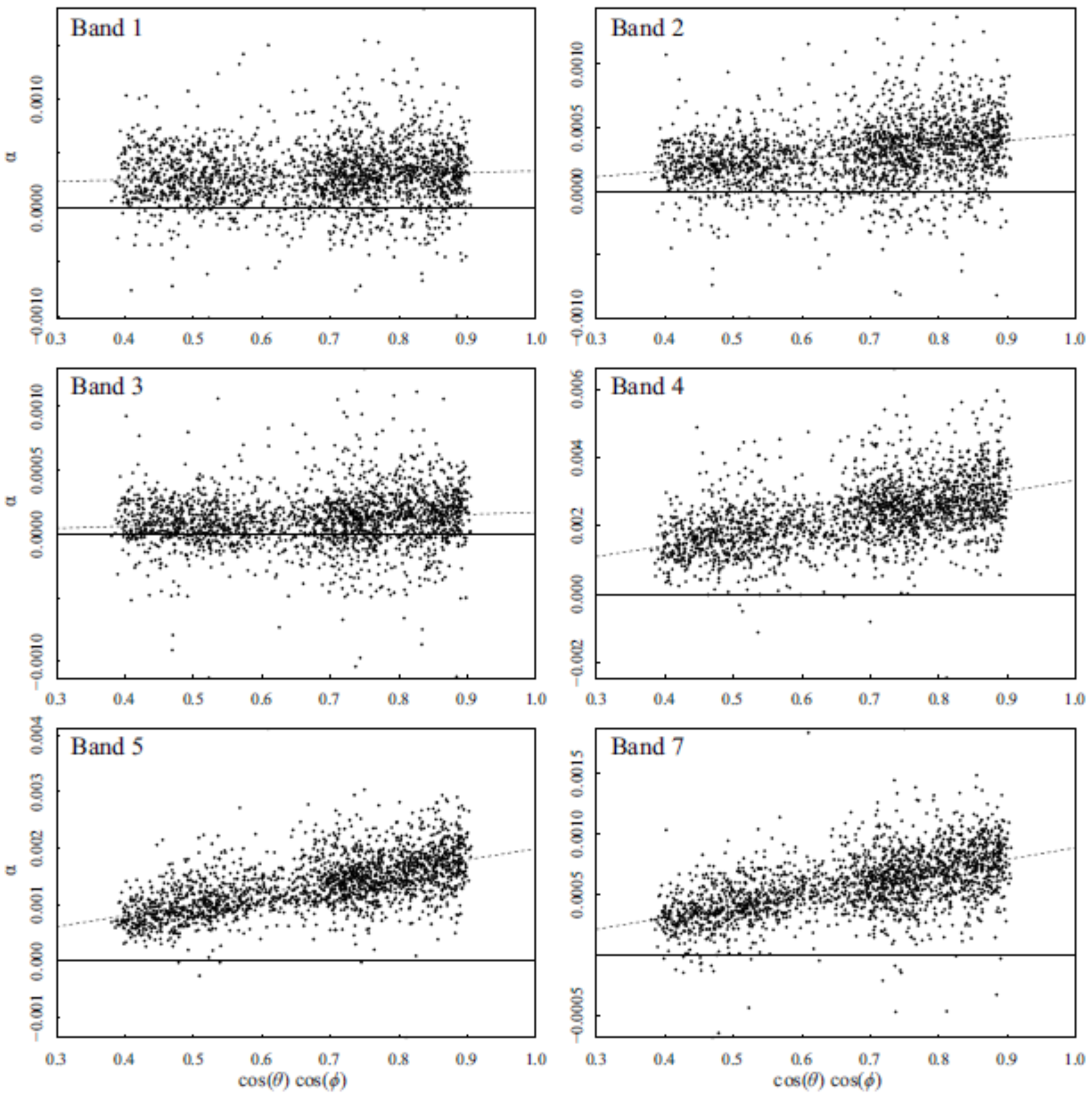

$$\alpha(\lambda) = \chi + \psi \cos(\vartheta)\cos(\phi)$$

θ: solar zenith angle

ϕ: relative azimuth angle

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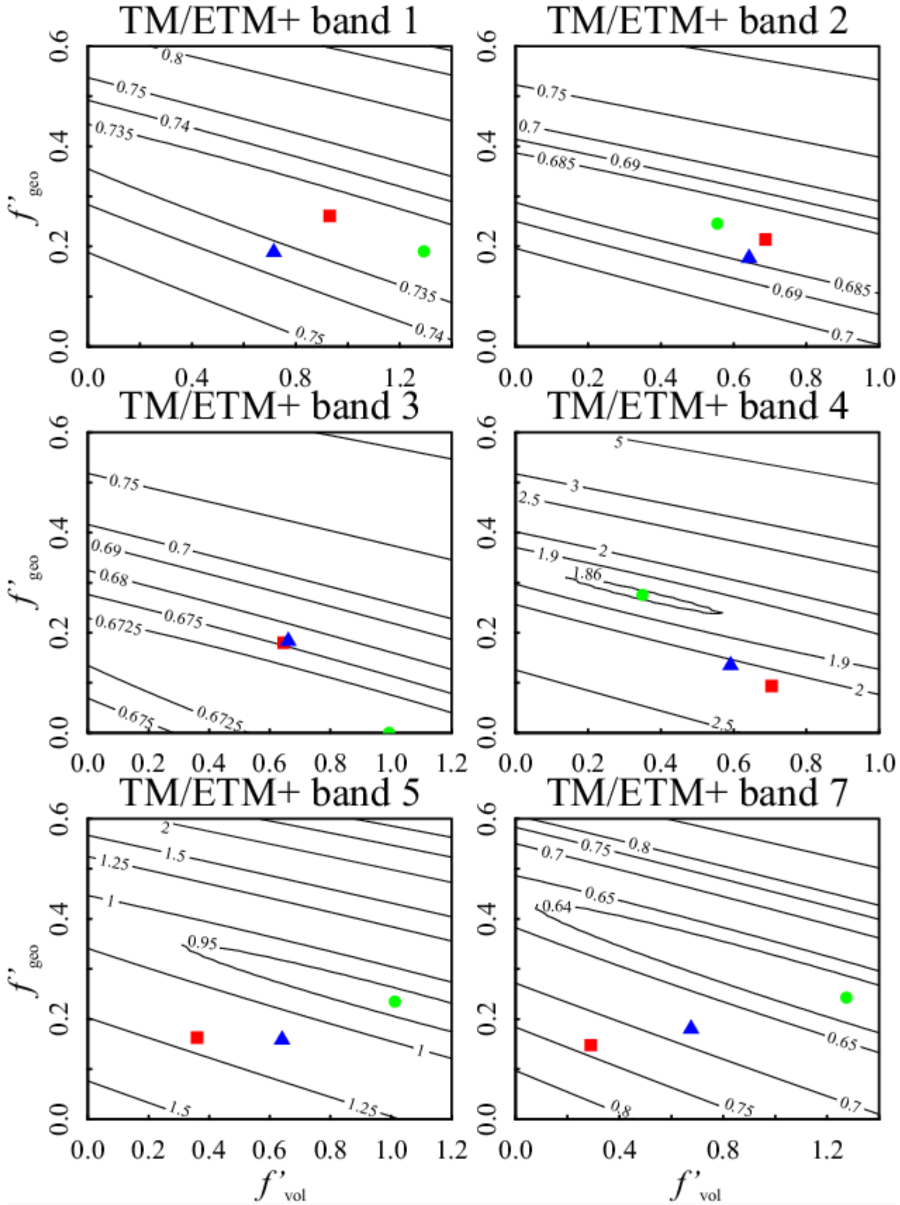
$$C = \frac{1}{N}\sum_{i=1}^{N}\left|\rho(A,\lambda) - \rho(B,\lambda)\frac{1 + f'_{vol}(\lambda)K_{vol}(A) + f'_{geo}(\lambda)K_{geo}(A)}{1 + f'_{vol}(\lambda)K_{vol}(B) + f'_{geo}(\lambda)K_{geo}(B)}\right|$$

Flood et. al, 2013



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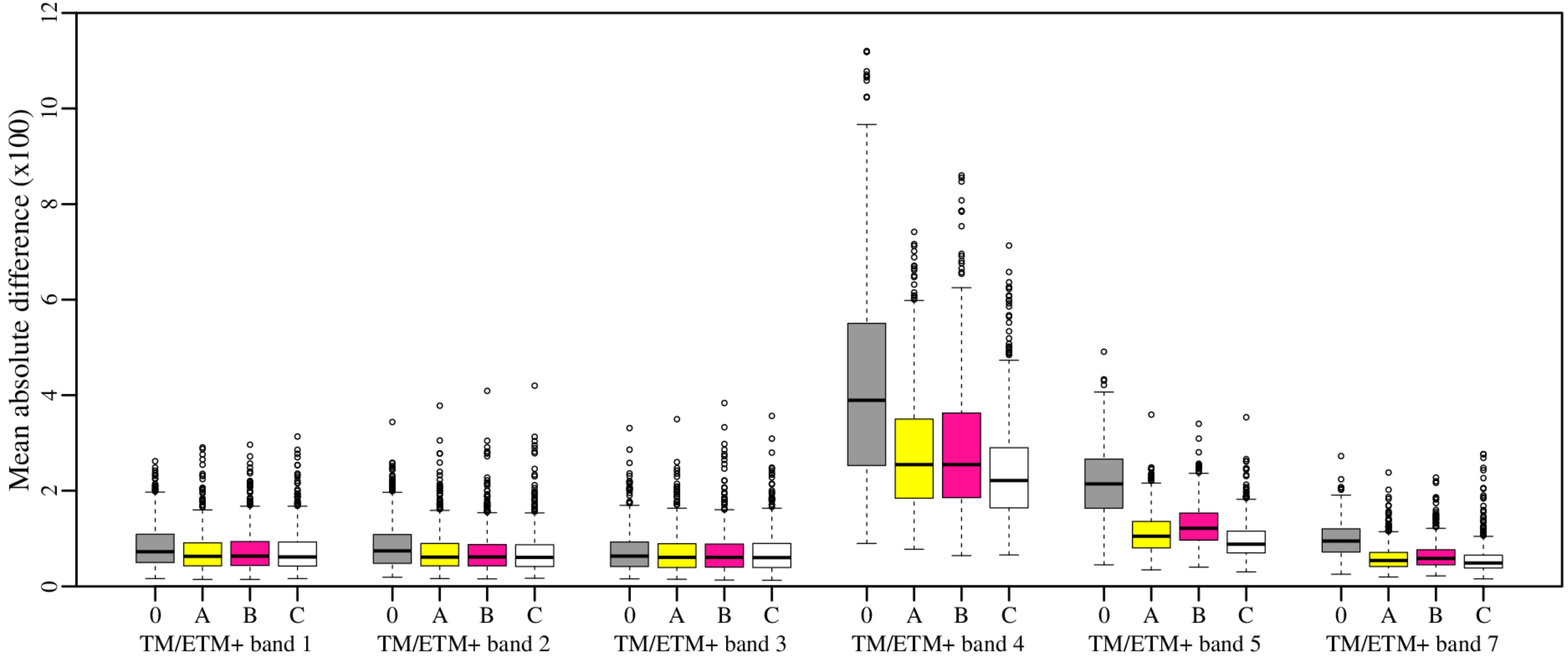

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