ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

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**ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features**

**Content**

1) Multitemporal images need calibration/normalization

2) Absolute radiometric corrections (ARC) vs. Relative radiometric normalization (RRN)

3) ARIN® procedure & software

4) ARIN contribute to normalize remote images of agricultural scenes

5) Projects, publications, registration and patent
A) Primary Process of Multi-temporal images

Calibration/ normalization

Original

Image 1                         Image 2            ......            Image N

Calibrated/ Normalized

(If land uses are invariant features multitemporal images should be quasi-identical)
ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

1) Multitemporal images need calibration/normalization
   Remote images are usually instantaneous, affected by
   atmospheric conditions, sun angle, viewing angle,
   changes in soil & plant–atmosphere system, & in the sensor calibration over time

Absolute radiometric corrections (ARC)
   Relate digital counts of image data to radiance at the surface of the Earth.
   Requires sensor calibration coefficients + Atmospheric correction algorithm +
   Related input data, among other corrections.
   For most historically remote scenes, these data are not available, and for planned
   acquisitions, the data may be difficult to obtain
   Consequently, may not always be a practical method

Relative radiometric normalization (RRN)
   based on the radiometric information intrinsic to the images themselves
   (alternative when absolute surface radiances are not required).
   RRN of imagery is important for many applications,
   land cover change detection,
   mosaicking and tracking
   vegetation indices over time,
   supervised and unsupervised land cover classification
ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

1) **Multitemporal images need calibration/normalization**  
   Remote images are usually instantaneous, affected by atmospheric conditions, sun angle, viewing angle, changes in soil & plant–atmosphere system, & in the sensor calibration over time
1) Multitemporal images need calibration/normalization

**Absolute radiometric corrections (ARC)**

Relate digital counts of image data to radiance at the surface of the Earth.

Requires sensor calibration coefficients

Atmospheric correction algorithm +

Related input data, among other corrections.

For most historically remote scenes, these data are not available, and for planned acquisitions, the data may be difficult to obtain

**CONSEQUENTLY, ARC MAY NOT ALWAYS BE A PRACTICAL METHOD**
1) **Multitemporal images need calibration/ normalization**

**Relative radiometric normalization (RRN)**

based on the radiometric information intrinsic to the images themselves (alternative when absolute surface radiances are not required).

RRN of imagery is VERY IMPORTANT For many applications, land cover change detection, mosaicking and tracking vegetation indices over time, supervised and unsupervised land cover classification

*Many RRN methods:*

- Pseudo-invariant features (PIF)
- Radiometric control set (RCS),
- Image regression (IR)
- No change (scatter-grams) (NC),
- Histogram matching (HM),
- Artificial neural net-work, etc. etc.

*ALL THESE METHODS ARE BASED IN NON-VEGETATIVE FEATURES*

ARIN is based in **VEGETATIVE PSEUDO-INVARIANT FEATURES**
ENVI 5.0
GeoEyes-1 satellite images, V1/April, V2….. V6….V7/October, 100 km² scene, Southern Spain
Partial view of the vegetative pseudo-invariant features (VPIFs) used in this study: a) CIT-citrus; b) OLI-olive; and c) POP-poplars. The VPIF SHP files are transposed automatically to other multi-temporal images during the ARIN process.
ARIN® procedure

1) selecting one or several vegetative pseudo-invariant features (VPIFs);
2) defining the same parcel or parcels for each selected VPIF in each multitemporal image;
3) extracting the VPIF spectral bands data for each image;
4) calculating the correction factors (CFs) for each image band to fit each band value to the average value of the image series; and
5) obtaining the normalized images by transforming EACH BAND OF EACH IMAGE through CF linear functions.

ARIN® software (to automate the ARIN procedure)

-- Reduce drastically the required time of image processing, from hours to a few minutes,

-- So, makes all the process economically feasible
Figure 3. NDVI evolution **variant features**: corn and wheat image timing (V1- early April to V7-early October,
Figure 3. NDVI evolution in pseudo-invariant (a: CIT, citrus; and POP, poplar grove features. (V1- early April to V7-early October)
Figure 1. ARIN flowchart

1. Load ARIN
2. Load images
3. Check if any images are present.
   - If NO, exit ARIN.
   - If YES, load shapefiles.
4. Check if any shapes are present.
   - If NO, exit ARIN.
   - If YES, extract VPIF data from images.
5. Calculate Correction Factors (CF).
7. Create new images (ARIN_output).
8. Results_ARIN.
ARIN software outcome for the CIT VPIF spectral bands of original GeoEye-1 images and the corresponding band correction factors are shown.

<table>
<thead>
<tr>
<th>PIF-1</th>
<th>Original Image</th>
<th>Image</th>
<th>Blue</th>
<th>Green</th>
<th>Red</th>
<th>NIR</th>
<th>NDVI</th>
<th>B/G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GeoEye Ventilla1 09April2010</td>
<td>420</td>
<td>333</td>
<td>188</td>
<td>1180</td>
<td>0.725</td>
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<td>GeoEye Ventilla2 01May2010</td>
<td>241</td>
<td>347</td>
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<td>1248</td>
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<td>GeoEye Ventilla3 23May2010</td>
<td>513</td>
<td>443</td>
<td>300</td>
<td>1361</td>
<td>0.639</td>
<td>1.158</td>
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<tr>
<td></td>
<td>GeoEye Ventilla4 20June2010</td>
<td>363</td>
<td>264</td>
<td>155</td>
<td>852</td>
<td>0.692</td>
<td>1.375</td>
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<tr>
<td></td>
<td>GeoEye Ventilla5 09July2010</td>
<td>237</td>
<td>319</td>
<td>120</td>
<td>1048</td>
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<tr>
<td></td>
<td>GeoEye Ventilla6 22August2010</td>
<td>322</td>
<td>247</td>
<td>149</td>
<td>815</td>
<td>0.691</td>
<td>1.304</td>
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<td></td>
<td>GeoEye Ventilla7 02October2010</td>
<td>209</td>
<td>262</td>
<td>92</td>
<td>853</td>
<td>0.805</td>
<td>0.798</td>
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<td>Mean</td>
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<td>329</td>
<td>316</td>
<td>159</td>
<td>1051</td>
<td>0.737</td>
<td>1.041</td>
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<td>70,206</td>
<td>218,32</td>
<td>0,513</td>
<td>1,627</td>
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<tr>
<td>Correction Factor</td>
<td>CF1</td>
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<td></td>
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<tr>
<td></td>
<td>0.785</td>
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<td>0.844</td>
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<td></td>
<td>1.364</td>
<td>0.912</td>
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<td></td>
<td>0.642</td>
<td>0.714</td>
<td>0.529</td>
<td>0.772</td>
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<td></td>
<td>0.908</td>
<td>1.198</td>
<td>1.025</td>
<td>1.233</td>
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<td></td>
<td>1.386</td>
<td>0.993</td>
<td>1.322</td>
<td>1.003</td>
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<tr>
<td></td>
<td>1.023</td>
<td>1.283</td>
<td>1.067</td>
<td>1.289</td>
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<tr>
<td></td>
<td>1.577</td>
<td>1.206</td>
<td>1.724</td>
<td>1.232</td>
<td></td>
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</tr>
</tbody>
</table>
Table 1. Vegetative pseudo-invariant feature (VPIF) spectral band values of the original (ORIG) and VPIF ARIN-transformed (-transf.) images.

<table>
<thead>
<tr>
<th>VPIF Images</th>
<th>Band</th>
<th>Series of images</th>
<th>Statistical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>V1   V2  V3  V4  V5  V6  V7</td>
<td>Mean  Range  S. d.</td>
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<tr>
<td>CIT¹ ORIG</td>
<td>B</td>
<td>420  241 513 363 237 322 209</td>
<td>329   304   111</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>333  347 443 264 319 247 262</td>
<td>316   196   68</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>188  107 300 155 120 149  92</td>
<td>159   208   70</td>
</tr>
<tr>
<td></td>
<td>NIR</td>
<td>1180 1248 1361 852 1048 815 853</td>
<td>1051  546  218</td>
</tr>
<tr>
<td>POP-transf.</td>
<td>B</td>
<td>334  335 347 310 341 324 307</td>
<td>328   40    15</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>322  346 350 274 324 302 281</td>
<td>314   76    30</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>158  158 197 133 175 142 129</td>
<td>156   68    24</td>
</tr>
<tr>
<td></td>
<td>NIR</td>
<td>1173 1095 1192 904 1005 906 1031</td>
<td>1044  288  117</td>
</tr>
<tr>
<td>OLI-transf</td>
<td>B</td>
<td>343  322 346 320 330 338 283</td>
<td>326   63    21</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>342  323 352 289 309 323 266</td>
<td>315   86    30</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>163  136 190 140 153 163 135</td>
<td>154   55    20</td>
</tr>
<tr>
<td></td>
<td>NIR</td>
<td>1247 1120 1088 951 1000 1029 895</td>
<td>1047  352  117</td>
</tr>
</tbody>
</table>
Table 2. Selected vegetative pseudo-invariant feature (VPIF) vegetation indices of the original (ORIG) and VPIF ARIN-, QUAC- and FLAASH–transformed (-transf.) images.

<table>
<thead>
<tr>
<th>VPIF</th>
<th>Images</th>
<th>VegIndex</th>
<th>Series of images</th>
<th>Statistical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>V1    V2  V3  V4 V5  V6  V7</td>
<td>Mean</td>
</tr>
<tr>
<td>CIT ORIG</td>
<td>NDVI</td>
<td>0,73 0,84 0,64 0,69 0,79 0,69 0,81</td>
<td>0,74</td>
<td>0,20</td>
</tr>
<tr>
<td>B/G</td>
<td></td>
<td>1,26 0,69 1,16 1,38 0,74 1,30 0,80</td>
<td>1,05</td>
<td>0,68</td>
</tr>
<tr>
<td>OLI+POP-transf.</td>
<td>NDVI</td>
<td>0,77 0,75 0,72 0,75 0,71 0,73 0,78</td>
<td>0,74</td>
<td>0,08</td>
</tr>
<tr>
<td>B/G</td>
<td></td>
<td>1,02 0,96 0,98 1,12 1,04 1,06 1,08</td>
<td>1,04</td>
<td>0,16</td>
</tr>
<tr>
<td>QUAC-transf.</td>
<td>NDVI</td>
<td>0,79 0,85 0,79 0,90 0,79 0,90 0,89</td>
<td>0,84</td>
<td>0,12</td>
</tr>
<tr>
<td>B/G</td>
<td></td>
<td>0,44 0,57 0,24 0,43 0,54 0,43 0,47</td>
<td>0,45</td>
<td>0,33</td>
</tr>
<tr>
<td>FLAASH-transf.</td>
<td>NDVI</td>
<td>0,76 0,69 0,80 0,74 0,78 0,78 0,79</td>
<td>0,76</td>
<td>0,11</td>
</tr>
<tr>
<td>B/G</td>
<td></td>
<td>0,59 0,64 0,55 0,59 0,47 0,64 0,66</td>
<td>0,59</td>
<td>0,19</td>
</tr>
</tbody>
</table>
### Table 3. Correlation coefficients between the spectral band CFs of VPIF CIT, OLI and POP

<table>
<thead>
<tr>
<th>VPIF¹</th>
<th>Spectral band</th>
<th></th>
<th></th>
<th></th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>G</td>
<td>R</td>
<td>NIR</td>
<td></td>
</tr>
<tr>
<td>CIT vs OLI</td>
<td>0.97**</td>
<td>1.0**</td>
<td>0.97**</td>
<td>0.85*</td>
<td>0.96**</td>
</tr>
<tr>
<td>CIT vs POP</td>
<td>0.98**</td>
<td>0.91*</td>
<td>0.92*</td>
<td>0.89*</td>
<td>0.93**</td>
</tr>
<tr>
<td>OLI vs POP</td>
<td>0.99**</td>
<td>0.92*</td>
<td>0.93**</td>
<td>0.85*</td>
<td>0.92**</td>
</tr>
<tr>
<td>Overall</td>
<td>0.97**</td>
<td>0.93**</td>
<td>0.92**</td>
<td>0.87**</td>
<td>0.93**</td>
</tr>
</tbody>
</table>

¹Abbreviations: VPIF; vegetative pseudo-invariant features; CIT, citrus orchards; OLI, olive orchards; POP, riparian trees; B, blue; G, green, R, read, NIR, near-infrared; *Significant at P=0.05; **Significant at P=0.01
AUTOMATIC REMOTE IMAGE PROCESSING FOR AGRICULTURE

1) PREPROCESSING

1a) Geo-referencing / Co-registration

1b) Calibration

Image 1

Image 2

......

Image n

2) CROPPING SYSTEM CLASSIFICATION AND ISOLATION (CROPCLASS)

Parcel Definition

Isolated Parcels

3) IMPLEMENTATION OF PRECISION AGRICULTURE

CLUAS (Orchard Trees Assessment)

SARI (Herbaceous Input Prescription map)

4) SITE-SPECIFIC CROP INDEXES AT MICROPLOT LEVEL

- Biomass
- Leaf Area
- Stress Zones
- Chlorophyll

- Diseases Patches
- Nitrogen Content
- Weed Patches
- Others
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FINAL COMMENTS

-- It is needed to incorporate specific modules for agriculture/ agri-environment studies

-- Otherwise remote sensing will not be economically feasible for many agriculture applications/ uses

-- ARIN module will make very easy the normalization of agricultural scenes where pseudo-invariant features are identifiable

-- ARIN can not be used in desert and frozen areas (absence of vegetation)

Our ARIN add-on IS FREE for research groups upon request
ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

5) Projects, publications, registrations & patents (IAS-CSIC)

Projects  (*Spanish Ministry of Science & Innovation*)
AGL2010- 15506 (2011-2014)

Paper:  PLOS ONE (in progress)

Registration: ARIN® software (1391/2012, 16 November)


THANK YOU FOR YOUR ATTENTION