An update on the Landsat / Sentinel-2 merged Surface Reflectance product project

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Landsat – Sentinel-2 fusion project

- Merging Sentinel-2 and Landsat data streams could provide < 5-day coverage
  - Goal is “seamless” near-daily 30m surface reflectance record
- Cross-calibration, atmospheric corrections, spectral and BRDF adjustments, regridding

**Sentinel 2A and B - LDCM Europe**

- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

**Proposed Architecture**

- **ESA S2 Archive** (800 GB/day) → **US Data Ingest - EROSA mirror** → **USGS**
- **USGS EROS** → **NASA Earth Exchange (NEX)** → **NASA R&A, Applications**
  - **Landsat+S2 Algorithms**
    - Cross-calibration
    - Atmospheric correction
    - Regridding
  - **NASA (ROSES)**
  - **USGS, USDA collab**
Landsat-8 OLI Atmospheric correction
Landsat-8 OLI Atmospheric correction Chain

OLI Atmospheric correction applying

OLI TOA 7 Bands

OLI SR 7 Bands

OLI Atmospheric correction

AOT inversion

Ancillary (Ozone, Water Vapor, DEM)

OLI TOA Band_4
OLI TOA Band_2
OLI TOA Band_4

AOT inversion based on OLI Band_4/Band_1 ratio or Band_4/Band_2 ratio

AOT Map

NDVI TOA OLI

Ratio Map (30 m)

MODIS Processing (CMG=0.05 deg, 10 years)

Terra TOA Band_3
Terra TOA Band_1
Terra TOA Band_8

MODIS Atmospheric correction

Terra SR Band_3
Terra SR Band_1
Terra SR Band_8

Ratio Map building

Ratio Band_3/Band_1
Ratio Band_8/Band_1

Ratio = a*NDVI + b

A, b Map (CMG)

Ratio map building
validation over Aeronet sites Landsat 8 SR (71 matchups)
validation over Aeronet sites Landsat 8 SR (71 matchups)
Cross-comparison with MODIS: Landsat 8 APU (~200 scenes)
Comparison NASA / CNES (1)

processing (2 100*100 km THEIA tiles)
Comparison NASA / CNES (2)
processing (2 100*100 km THEIA tiles)
BRDF adjustments
What is the issue?

• Landsat-8 and Sentinel-2 will have distinct orbit and sun/view geometry.
• To reduce time series noise, it is required to account for the sun/view geometry differences
• sun/view geometry:
  • Landsat-8 : VZA = +/- 7 deg, Aq. Time ~ 10:00 a.m
  • Sentinel-2: VZA = +/- 12 deg, Aq. Time ~ 10:30 a.m
• Spot 4 Take 5 – Maricopa Site
  • Two sets of images with two distinct VZA (~8 deg vs ~25 deg)
Spot 4 Take 5 – Maricopa Site

★ VZA ~ 25 deg
★ VZA ~ 8 deg

Pixel 1
Pixel 2
Pixel 3
Pixel 4
Pixel 5

\[ \text{Noise} = \sqrt{\sum_{i=1}^{25} (\rho(day_i) - \rho(day_i + 1))^2 / 25} \]
VJB model to correct BRDF

(Bidirectional Reflectance Distribution Function)

- VJB Model (Vermote et al. 2009)
  - Relate BRDF parameter to NDVI
  - Simplification of BRDF Kernels using 2 proxy: $R$ & $V$
  - $\rho(\theta_{\text{out}}) = \rho(\theta_{\text{in}}) \times K(\theta_{\text{in}}, \theta_{\text{out}}, R, V)$ & $\theta$ stands for $\theta_s$, $\theta_v$, $\Delta \delta$
  - using MODIS CMG (0.05°), $R$ & $V$ were found well-correlated to NDVI
    - $R = a_1 \times NDVI + b_1$
    - $V = a_2 \times NDVI + b_2$
  - $a_1, b_1, a_2, b_2$ parameters were retrieved at global scale (at 0.05°) for each MODIS band, but can be retrieved at better resolution
HiRes BRDF adjustment Methods

• Four approaches based on the VJB model
  • Constant Model (from CESBIO analysis)
    • One unique set of R and V
  • Average Model (Breon et al. 2012)
    • One unique set of $a_1, b_1, a_2, b_2$ parameters
    • Use of HR NDVI (temporal dynamic)
  • LR disaggregation of V and R through the NDVI
    • Use of LR $a_1, b_1, a_2, b_2$ parameters without disaggregation
    • Use of HR NDVI (temporal dynamic)
  • LR disaggregation of V and R through land cover (Franch et al. 2014)
    • Use of Land cover to set V and R
HiRes BRDF adjustment Results (1)
HiRes BRDF adjustment Results (1)

SPOT = 20m
MODIS = 5km (~CMG)

SPOT = 40m
MODIS = 1250m (5*250)
HiRes BRDF adjustment Results (2)
HiRes BRDF adjustment Results (3)
Conclusion

• Landsat / Sentinel Fusion Project is on track!
• On-going activities: BRDF / Spectral adjustments
• Next step: adapt the Atmospheric correction chain to Sentinel-2 (similar approach except no thermal band for Cloud masking)
• BRDF adjustments
  • Analyze deeper the results of Maricopa
  • ... but we have to keep in mind that L8/S2 sun-view geometry will be less important
  • Next step: perform similar analysis with Landsat overpass (mostly in high latitude)
  • Continue a similar experiment with SPOT-5 Take-5 (Maricopa, Boreal Forest)
Thank you!