







# SPOT4/Take5 User Workshop 18-11-2014 E CHESAPEAK SGP N MARICOPA Definition, test and evaluation of a monthly composite product for Sentinel-2, based on SPOT4 (Take5)

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#### Plan

- Definition of the Level 3A products
  - Principle
  - Variants of L3A
- Test
  - Quality criterions
- Evaluation
- Correction of the directional effects
  - Principle
  - Application



#### Level 1C :

data orthorectified reflectance at the top of the atmosphere



#### Definition

Test

**Evaluation** 

**Directional effects** 

#### Level 1C :

data orthorectified reflectance at the top of the atmosphere

#### Level 2A :

Data ortho-rectified surface reflectance after atmospheric correction, along with a mask of clouds and their shadows, as well as a mask of water and snow.



#### Definition

Test

**Evaluation** 

**Directional effects** 

#### Level 1C :

data orthorectified reflectance at the top of the atmosphere

#### Level 2A :

Data ortho-rectified surface reflectance after atmospheric correction, along with a mask of clouds and their shadows, as well as a mask of water and snow.

#### Level 3A:

Provides a synthesis of level2A Cloud/Cloud shadows free pixels





- The level 3A, produced once a month, uses less volume than the level 2A products acquired during one month.

- The level 3A provides a regular time sampling of the reflectances variation

- The level 3A product aims at minimizing the residual gaps.

#### Variables :

- Compositing method
- Period : one month, 7 days for the test
- Duration

Definition Test Evaluation Directional effects	
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#### **Level 3A products**

#### **Compositing methods**

#### **Best pixel composites**

Selection according to criteria :

- Maximum NDVI;
- Minimum blue band;
- Maximum of temperature;
- The most recent cloud free date;
- The date with the minimum cloud cover;
- The date with the minimum AOT.

# Definition, test and evaluation of a monthly composite product for Sentinel-2,<br/>based on SPOT4 (Take5)DefinitionTestEvaluationDirectional effects

#### Level 3A products

#### **Compositing methods**

Weighted average composites (Developed by CESBIO)

Weighted average of surface reflectance of cloud free pixels

The weight applied to a given pixel is greater if:

- the pixel is distant from clouds;
- the pixel has a low Aerosol Optical Thickness;
- the pixel acquisition date is close to the level 3A central date.

$$Refl(N3A) = \frac{\sum_{i=1}^{n} Wi \times (Refl(L2A))i}{\sum_{i=1}^{n} W}$$

Refl(N3A): Reflectance of the composite, W: Weight applied to Refl(L2A), Refl(2A): Reflectance of the Level 2 product, n: number of L2A involved in the composite



**Quality criteria** 

A good composite should be:

- As cloud free as possible;
- Representative of the actual surface reflectance that would have been observed by the satellite at the central date of the composite, if a cloud free image was available at that date;
- And should not present visible artifacts.
- => 3 quality criteria are developed by Theia and provided to S2-Agri project :

➢ Residual gaps;

- Fidelity to the central date;
- ≻Artifacts.



#### **Quality criteria**

#### **Residual gaps**

Counting the invalid pixels within the image (Cloud).



Composite

Invalid pixels mask



#### **Quality criteria**

#### Fidelity to the central date

Is the difference between the Level 3A surface reflectance and the Level 2A surface reflectance (reference ).

#### ➤ Reference:

- under 50% of cloud cover ;
- close to the central date -+8days







#### **Composite- Reference**

Composite

Reference

## Definition, test and evaluation of a monthly composite product for Sentinel-2, based on SPOT4 (Take5) Definition Test Evaluation Directional effects Quality criteria Fidelity to the central date



○ Fidelity to the central date index is the average of all time series values.



#### **Quality criteria**

#### Artifacts

- Artifacts : discontinuities (cleavages) that may appear along the limits of contiguous zones that are obtained with the same set of dates.

- Criteria value: Difference between the average of external border and the internal border of the contiguous zone.



Artifact on composite

Set of dates

External / internal border of the artifact

Definition

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Evaluation

**Directional effects** 

**Compositing methods** 

Weighted average



#### NDVI MVC





Definition Test Evaluation Directional effects

#### **Compositing methods**

Deep comparison between Weighted average and ESA Min clouds methods, made by D. Morin : S2Agri project.



- ESA Min clouds will often provide successive identical composites.

Definition Test Evaluation Directional effects

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Definition Test Evaluation Directional effects

#### **Compositing methods**

Deep comparison between Weighted average and ESA Min clouds methods, made by D. Morin : S2Agri project.



- ESA Min clouds will often provide successive identical composites;
- The choice of the main image in the composite is selected "randomly".



In some cases, the reference image for fidelity criterion is the composite image.



- Compositing method:
  - Weighted average provides better results;
  - NDVI MVC composites have bad quality criteria results.

Definition Test Evaluation Directional effects

#### **Optimum compositing duration**

The optimal duration is the smallest with:

- Low residual gaps;
- High fidelity to the central => Low percentile values of the difference between composites and references;
- Low Artifact presence.



Definition

Test

**Evaluation** 

**Directional effects** 

#### **Optimum compositing period**



Aquitaine Open water taken as invalid pixel



Madagascar

Definition

Test

Evaluation

**Directional effects** 

#### **Optimum compositing period**



- Optimal duration:

The application of quality criteria on the 45 Spot4-Take5 sites shows that "42 days" is generally the optimal composite duration.



**Reflectance1** ≠ **Reflectance2** 

To improve L3A product quality : use data observed with different angles.

Correcting the directional effect.



#### **Reflectance1** ≠ **Reflectance2**

**Directional effect :** difference of the reflectance :

- the same kind of land cover
- $\succ$  the same area
- => Different observations and illuminations angles.



#### Normalized Reflectance = Coefficient 1 x Reflectance1 = Coefficient 2 x Reflectance2



#### Normalized Reflectance = Coefficient 1 x Reflectance1 = Coefficient 2 x Reflectance2

Definition	Test	Evaluation	Directional effects

#### Why correct the directional effect?



Composite with non corrected images reflectances (Midi Pyrenees site )

Definition	Test	Evaluation	Directional effects

#### Why correct the directional effect?



#### Normalized Reflectance = Coefficient 1 x Reflectance1 = Coefficient 2 x Reflectance2

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#### **Normalized Reflectance**

- Coefficients are calculated using a simplified version method previously developed to process other data :

> Vermote 2009. Estimate a global map of models with MODIS;

> Use a constant coefficient.

- The applied parameters are calculated from the parts of sites acquired with different observation angles (Midi Pyrenees, Bretagne, Provence and Maricopa)



#### **Normalized Reflectance**



Without directional correction



#### **Normalized Reflectance**



With directional correction



#### Definition

Test

Evaluation

**Directional effects** 

#### **Normalized Reflectance**



With directional correction

Definition

Test

Evaluation

**Directional effects** 

#### **Normalized Reflectance**



Fidelity criteria of 42 days composites with original reflectance XS1:0



Fidelity criteria of 42 days composites with .0.1357 **normalized reflectance** 

Definition	Test	Evaluation	Directional effects

#### Conclusion

With the 45 sites of Spot4-Take5 data, we:

- Tested several methods and choose the weighted average as the best composing method;
- Developed a simplified method to correct the directional effect.

We need to:

- Finish the algorithms specification for the L3A product;
- Finish testing the directional correction method on RapideEye data (5 bands, 5m resolution) (D. Morin : S2 Agri);
- Finish testing the gap filling methods (M. Arias :S2 Agri).











Thank you for your attention