# Methods review for the Global Land Cover 2000 initiative

**Presentation made by Frédéric Achard on November 30th 2000**

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- Strategy for the analysis methodology

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- Priorities for methodological development using S1 products

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**Objectives**

## 2. Specifications of the GLC-2000 exercise

Geographical extent: World by sub-windows

Data:
S1 daily global SPOT VGT composites at 1 km resolution in Plate Carree projection from 1st Nov. 1999 to 31st Dec. 2000

The target completion date for the GLC product is early 2002

Classification scheme / Legend to be used: very soon

Validation tbd : a combined IGBP / TREES validation approach ?

## 3. Strategy for the analysis methodology

Premises

The initiative does not require a prescribed data processing methodology
It must however avoid inconsistencies in the resulting global map

Proposed strategy

Each participant will be free to develop the methodology which best suits the (ecological) conditions of his region, under the following conditions:

- the methodology must be based on S1 data
- the method used must be fully documented
- the performance of the method will have to be quantified

## 4. Categories of analysis methods

Pre-processing procedures

Geometric corrections
Radiometric corrections:
Atmospheric
Residual contamination
Bi-directional corrections
Use of BRDF models to retrieve complementary parameters
Temporal compositing
Derivation of dedicated spectral indices

Classification procedures

Supervised
Unsupervised

**Review of methods using AVHRR**

## 5. Requirements (Cihlar, 2000)

Requirements for pre-processing

The objective should be to produce a cloud-free composite image which has radiometric properties of a single-date, fixed geometry image

Requirements for classification algorithms

- Accuracy
- Reproductibility by others
- Robustness (not sensitive to small changes in input data)
- Ability to fully exploit the information content of the data
- Applicability uniformly over the whole domain
- Objectiveness (not dependent of the analyst's decisions)

## 6. Pre-processing procedures (Cihlar, 2000)

Temporal compositing

- Often based on Maximum NDVI : *de facto* standard but main drawback is to select pixels with forward-scattering geometry
- Need of further radiometric correction methods to remove 'noise' in composites

Radiometric corrections

- Atmospheric: nominal/climatological parameters are used
- Residual contamination: use of temporal dimension such as NDVI temporal trajectory
- Bi-directional:
  a) Inversion is practically impossible because requires # viewing geometries
  b) correct the data to a standard viewing geometry: requires knowledge of model to apply, ie land-cover is a pre-requisite.
  however for b) a simple land cover classification can be used and coefficients of the functions can be derived from the data itself

## 7. Classification procedures (Cihlar, 2000)

Supervised

- *a priori* knowledge of all cover types is requested
- Preferable when one knows where desired classes occur
- Variants: decision trees, neural networks, fuzzy classification, mixture modeling

Unsupervised

- Preferable over large areas where distribution of classes is not known a priori
- Advantage: comprehensive information on the spectrally pure clusters
- Disadvantages:
  Effect of controlled parameters (number of clusters, dispersion around mean)
  Potential mismatch between spectral clusters and thematic classes
- Use of a large number of initial clusters (100-400) to mitigate these problems
- Independent ground information is also required but representativeness is less crucial
- Variants: progressive generalization, enhancement, post-processing adjustments

**Review of existing methods using VGT products**

## 8. Using VGT S1 data: Key questions

Main question

How to use VEGETATION S-1 products for mapping land cover at global level with a distributed approach at continental / regional level ?

Source of information

- Spectral signatures
- Temporal spectral signatures
- Temporal spectral - angular signatures

## 9. Background : Compositing strategies by C. De Wasseige et al., 2000

Data used

S1 products from 21 October to 20 November 1999 of Northern Africa

Assessment of compositing strategies over 10 days period

- Test on: MVC-NDVI, MVC-DVI, Min Red within [Max NDVI-15%], Min VZN within [Max NDVI-15%], MVC-SWIRVI
- Performance was assessed from mean reflectance values, speckle effect, VZN distribution and visual assessment
- The most atmospheric resistant is: Min Red within [Max NDVI-15%]
- The tested compositing criteria can not remove BRDF effect in the synthesis

## 10. Example 1: European forest map prototype by H. Jeanjean et al.

Data used

3 x S10 composites from August 20 to September 21 1999 for composite image
S10 composites from April to October 1999 for temporal profiles

Pre-processing

- Re-projection to Lambert Azimuth Equal-Area projection
- monthly compositing by averaging with elimination of bad pixels (SWIR band, contamination by clouds).

Classification (T. Hame et al., 1999)

- An unsupervised classification (k-means clustering) using a geographic stratification (FIRS) with 50 clusters per stratum (numerated according to red reflectance values)
- Labeling to 5 output classes using spectral reflectance values and other available information such as CORINE database

## 11. Example 2: TREES Southeast Asia by H-J. Stibig et al., 2000

Data used:

S10 composites during 'dry' season in Insular Southeast Asia from March/April to September /November 1998 and 1999 (and some in 2000)

Pre-processing

Thresholding Blue and SWIR bands at <10% and >5%
for cloud and haze reduction and for eliminating line errors in SWIR

Compositing

- Production of monthly mosaics by Minimum SWIR to reduce remaining impact of clouds and haze, patch effects in S10 and high-value line errors in SWIR
- Further cloud-shadow masking through unsupervised classifications
- Production of bi-annual mosaic by Minimum NIR to enhance contrast between evergreen vegetation, other non-vegetation cover and burnt areas

Classification

- Unsupervised with 60 clusters (arbitrary cluster means)
- Analyst labelling (10 output classes) using ancillary data (elevation, forest map)

## 12. Example 3: TREES Madagascar by P. Mayaux et al., 2000

Data used

36 x S10 composites from October 1998 to September 1999

Compositing

Production of monthly mosaics by Minimum SWIR to reduce remaining clouds

Classification

Unsupervised with 40 clusters
Analyst labelling (6 output classes) using field knowledge and ancillary information

Validation

Using 3 Landsat TM classifications: user's accuracy of 87.8%

## 13. Example 4: Update of the TREES map of Central Africa by Eerens et al., 2000

Data used

36 x S10 composites from April 1998 to March 1999

Pre-processing

Modified SAVI for each S10
Cloud-cleaning procedure from SAVI time series

Compositing

Production of monthly mean SAVI mosaics
Production of "Phenological channels": annual SAVI-mean, -max, seasonal index and length of growing season

Classification

Supervised (Max Likelihood) with training areas from the 1992 AVHRR TREES map (10 output classes)

Validation

Spatial agreement between both maps: 89%

## 14. Example 5: Siberian land cover mapping by Bartalev et al., 2000

Data used

24 x S10 composites from March 1999 to November 1999

Pre-processing

- Detection of cloudy and snowy pixels using NDSI + thresholding in Blue band
- Detection of contaminated pixels using SWIR temporal profiles
- Normalisation of Red, NIR and SWIR reflectances for 'Hot Spot' function of MRPV model
- Retrieval of angular-independent parameters: regression parameters (slope, intercept) of bi-dimentional reflectance plots during 'stable' periods
- Retrieval of 'phenological' parameters (beginning of growing season, …) using NDVI temporal profiles (wave approximation)

Compositing

Production of 'seasonal' mosaics including mean values of reflectances (3) and ancillary channels (angular-independent (6) and 'phenological' parameters (3))

## 15. Example 6: Canada land cover mapping by Chen et al., 2000

Data used

6 x S10 composites from July 1 to August 31 1998 for composite image
S10 composites from April to October 1998 for temporal profiles

Pre-processing

- Reprojection to the Lambert Conformer Conic coordinates
- Normalisation of reflectances using model of Roujean et al. (coefficients of the model were retrieved through a regression and iteration procedure)
- Cloud elimination using a self-calibrating method based on seasonal NDVI trajectories and Red reflectance.
- Seasonal interpolation for contaminated pixels
- 16bits to 8 bits transformation

Classification

- Digital contrast enhancement: visual data analysis, sampling of cover types with low and high digital values, linear digital stretch
- Initial unsupervised classification (K-means algorithm ) with 150 clusters
- Cluster merging based on spectral similarity (Bhattacharrya Distance): 120 clusters
- Cluster merging based on spatial proximity: 100 clusters
- Cluster merging based on spectral temporal profile similarity: 50 clusters
- Cluster labeling (analyst-dependent step) using Landsat TM images, AVHRR Land Cover Map of 1995 and personal knowledge: 31 output classes

## 16. Priorities for methodological development using VGT S1 products: Pre-processing procedures

Temporal compositing

- Automatic removal of drifted images
- Further work on compositing to produce optimised 'seasonal' mosaics
- Use of dedicated spectral indices

Radiometric corrections:

- Atmospheric :

Already implemented in S1 (SMAC)
More to do for pixel-specific atmospheric contamination ?

- Residual contamination
- Use of BRDF models for:
  Retrieving inversion or complementary parameters
  Bi-directional normalization

**17. Priorities for methodological development using VGT S1 products: Use of BRDF model for radiometric 'corrections' of S1 products**

Premise: combining spectral and angular dimensions through a BRDF model should allow to improve the land cover classification
Two possible options to use BRDF models:

- to retrieve BRDF model parameters by inversion of the model using multi-angular observations
  Can multi-angular observations be obtained from multi temporal data during 'stable' vegetative periods ?
  What is feasible from S1 products ?
- to normalize the data to a standard viewing geometry
  Is a simple land cover map available everywhere ? IGBP LC map ?
  Deriving the coefficients of the functions from the data itself ?

**18. Priorities for methodological development using VGT S1 products: Classification procedures**

Supervised: Preferable when one knows where desired classes occur

Unsupervised: Preferable over large areas where distribution of classes is not known a priori

Adding ancillary type of data to the spectral values (existing land cover or topographic maps)

Use of spatial measures such as texture, patterns, shape and context

Minimize the role of the analyst/interpreter by preparing specific biophysical products: permanence of green biomass, LAI, leaf longevity

Assembling the results together (sticking the regions)

**19. Next steps for the WG methods**

Who are the participants ready support the methodological developments of the global land cover map and the WG discussions?

How to organise the Working Group work? Next meeting

Which outcomes are expected ?
A single method
A set of methods
A minimum set of guidelines
A forum for discussion

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