A NEW VEGETATION MAP OF CENTRAL AFRICA

Update of the JRC-TREES map of 1992 with SPOT-VEGETATION imagery of 1998

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In the frame of a short-term feasibility contract sponsored by the Belgian Science Policy Office, a land cover map of Central Africa was derived from imagery, registered in 1998/9 by the 1km²-resolution sensor SPOT4-VEGETATION (VGT)[1]. The map was established on behalf of the information system METAFRO-InfoSys[2] of the Belgian Royal Museum of Central Africa, and it covers the following 8 countries: Burundi, Cameroon, Central African Republic, Congo-Brazzaville, Congo-Kinshasa, Equatorial Guinea, Gabon and Rwanda.
The image classification was calibrated with information from the TREES-map[3] (Tropical Ecosystem Environment observation by Satellite), the most accurate land cover product over Central Africa so far. This TREES-map includes 10 land cover classes (see table 1) and it was established by the Space Applications Institute of the JRC (EU-Joint Research Centre, Italy), mainly on the base of NOAA-AVHRR imagery of 1992. In this light, our map should not be considered as a new, stand-alone product, but rather as an update of this TREES-map.

The purchased VGT-imagery consisted of the 36 decadal syntheses (NDVI-MVC composites or "VGT-S10" products) ranging from April 1998 until March 1999. The image set was pre-processed in the following way. First, for each decade, the Red and NIR reflectances were combined into (a modified version of) the "Soil Adjusted Vegetation Index" (SAVI)[4]. Compared to the classical Normalized Difference Vegetation Index (NDVI), the SAVI is less sensitive to variations in the reflectance of the soil background. As outlined in figure 1, a cleaning procedure was then applied to the SAVI time series in order to remove the severe cloud perturbations. From the smoothed curves, monthly mean SAVI-values were computed.

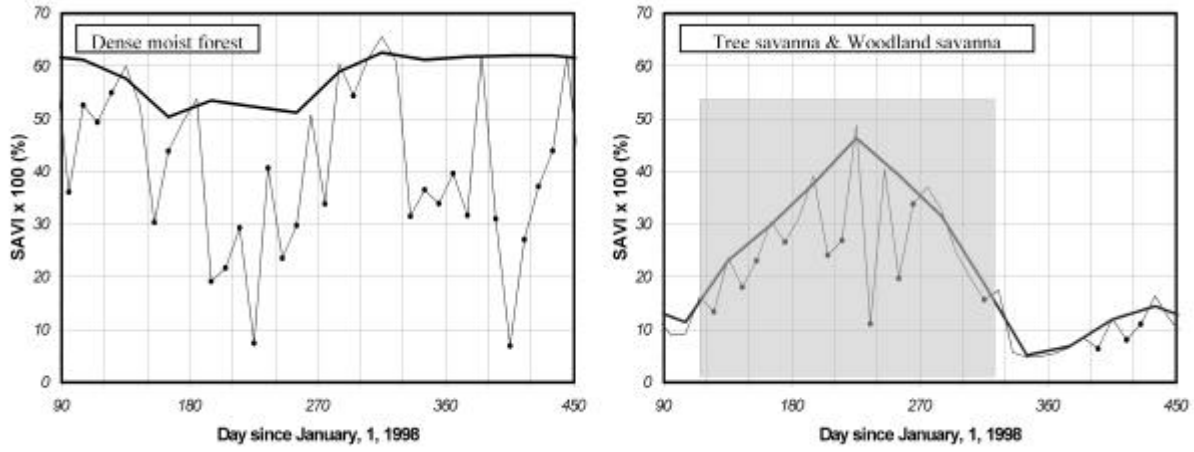


***Figure 1**: SAVI-profiles of 2 pixels with different land cover types. Thin line: original 10-daily SAVI-series; Black dots: cloudy measurements (abrupt minima); Thick line: cleaned profile with monthly SAVI-means; Box on the right: growing season (undefined for the evergreen forest on the left).*

1. For more information on the SPOT-VEGETATION sensor system, see: http://www.vito.vgt.be
2. METAFRO-InfoSys can be consulted at: http://metafro.africamuseum.be
3. Mayaux P, Janodet E, Blair-Myers C & Legeay-Janvier P, 1997, *Vegetation map of Central Africa at 1:5,000,000*, TREES Series D: thematic outputs N° 1, Space Applications Institute, EC-JRC, EUR 17322 EN
4. Major D, Baret F & Guyot G, 1990, *A ratio vegetation index adjusted for soil brightness*, Int. J. Rem. Sens., 11(5), 727-740

Finally, these monthly SAVI-profiles were used to compute "phenological" images, which describe the general shape of each pixel's growth curve by means of the following parameters: the annual SAVI-mean, -extremes and -range, a seasonality index (a mean-weighted measure for the amplitude), the start and length of the growing season, etc. Because of their high diagnostic power, these images (or at least, part of them) were used for the classification.

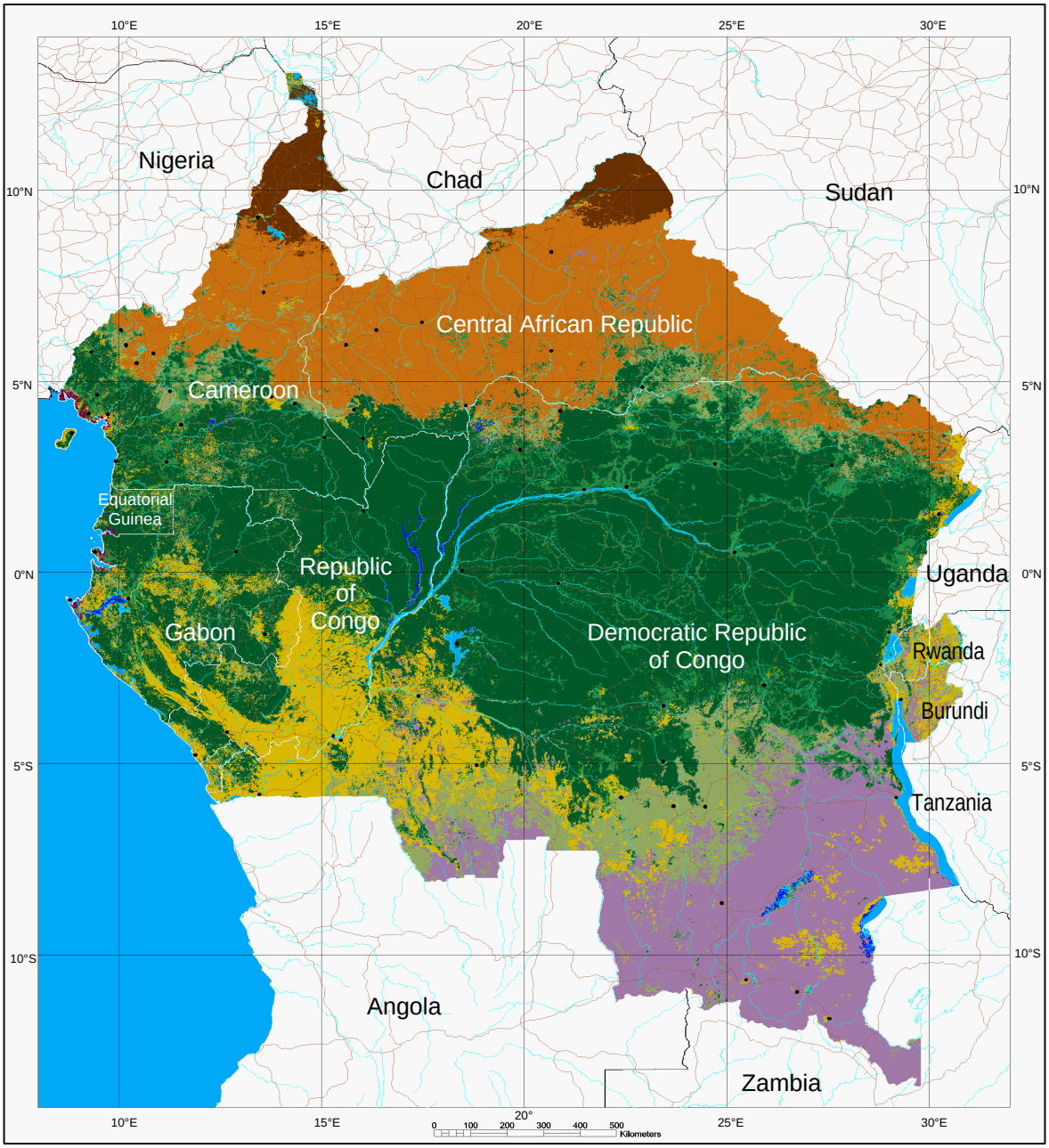
The actualized land cover map was realized by means of a supervised Maximum Likelihood algorithm, which was calibrated with training areas selected from the TREES-map of 1992. Some premiminary tests pointed out that the best results could be obtained with only 4 of the phenological images: the annual SAVI-mean and -maximum, the seasonality index and the length of the growing season. Altitude information, extracted from a Digital Elevation Model, did not improve the results. The "a priori probabilities" required by the algorithm, were defined according to a rather special scheme, which tuned the decision process in such a way that the classification was based for only 50% on the information of the imagery of 1998, and for the remaining 50% on the previous situation of 1992 (depicted by the TREES-map). In other words, before a pixel was assigned to another class than the one of 1992, the imagery had to provide convincing evidence. This approach was motivated by the fact that the traditional method of fixed, equal aprioris yielded poor results and that we only attempted to realize an update of the TREES-map.

The resulting land cover map was embellished with vector information (territorial boundaries, main rivers and roads, annotation) and plotted on A0-sheets. A reduced (and deteriorated) version is shown in figure 2. Statistical tables with the acreage distribution of the 10 land cover classes were also derived for the national and regional levels, and for both years (1992: TREES vs. 1998: VGT-update).

Table 1 shows an overall comparison, holding for the entire Central African region (except Burundi and Rwanda, not included in the TREES-map). Both maps agree fairly well (89%), which implies that no dramatic changes have taken place in the course of the last six years. However, as the updated map was not checked on the field, it remains unknown to what extent the observed deviations (11% of pixels with $k_e \neq k_t$) are due to misclassifications or to real changes. Although part of the observed deviations are certainly artefacts, a lot of deforestation "hot spots" were revealed which deserve further inspection, either by field controls or by the analysis of high resolution imagery. The most severe deforestation apparently took place in the western equatorial belt, especially in Gabon and Congo-Brazzaville.

***Table 1**: Comparison of the TREES map (true k_t, 1992) and the updated land cover map (estimated k_e, 1998). All values in % of the total nr. of pixels (4,136,571). 88.9% of the pixels are correctly classified or unchanged ($k_e=k_t$), 11.1% are misclassified or changed ($k_e \neq k_t$)*

Vegetation Class	**k_t \ k_e**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Σk_t**
Dense moist forest	**1**	***39.59***	0.05	2.37	0.49		1.80	0.03	0.03		0.05	**44.42**
Secondary forest & rural complex	**2**	0.11	***4.97***	0.37	0.05		0.24	0.01	0.02		0.01	**5.77**
Forest/savanna mosaic	**3**	0.32	0.56	***6.16***	0.21	0.05	0.07	0.00	0.02		0.00	**7.40**
Dense dry forest & miombo woodl.	**4**	0.09	0.23	0.27	***11.08***	0.00	0.12		0.01	0.00	0.04	**11.84**
Tree savanna & woodland savanna	**5**	0.30	0.53	0.69	0.00	***16.75***	0.16	0.00	0.02	0.52	0.01	**18.99**
Grasslands & bare soil	**6**	0.38	0.45	0.03	0.19	0.01	***7.33***	0.00	0.01		0.04	**8.44**
Mangrove	**7**	0.00	0.00	0.00		0.00	0.00	***0.09***	0.00		0.00	**0.11**
Swamp grasslands	**8**	0.01	0.01	0.01	0.04	0.00	0.00	0.00	***0.26***		0.02	**0.35**
Shrub savanna & steppe	**9**	0.00	0.00	0.00		0.02	0.02		0.00	***1.69***	0.00	**1.73**
Water bodies & rivers	**10**										***0.94***	**0.94**
TOTAL Estimated ΣK_e		**40.80**	**6.81**	**9.91**	**12.05**	**16.84**	**9.75**	**0.14**	**0.38**	**2.21**	**1.11**	**100.00**



Vegetation Classes & Ecological Domains

- Dense moist forest (Guineo-Congolian)
- Secondary forest & rural complex (Guineo-Congolian)
- Forest/Savanna mosaic (Guineo-Congolian)
- Dense dry forest & Miombo woodland (Zambezian/Sudanian)
- Tree savanna & woodland savanna (Sudanian/Sudano-Guinean)
- Grasslands & bare soil (Guineo-Congolian/Zambezian)
- Shrub savanna & steppe (Sudano-Sahelian/Sahelian)
- Mangrove
- Swamp grasslands (Guineo-Congolian/Zambezian)
- Water bodies & rivers

***Figure 2**: New vegetation map of Central Africa, derived from SPOT-VEGETATION imagery of 1998 (update of the JRC-TREES map of 1992).*