



Template product information package

<u>Product</u>	Phenology products
<u>Participant ID</u>	JRC

1. **General Information**

The vegetation phenology products are a GEOLAND OLF deliverable. They correspond to the assessment, from time series of vegetation indicators such as NDVI or similar products, of dates at which specific curve features appear, that can be associated by empirical correlation to phenological stages, namely start of growing season, maximum of growing season, half senescence and end of growing season.

2. **Application of the product**

Phenology stage dates are used

- to drive crop growth models
- to assess deviations in the vegetation calendar, as indicator of interannual variation of vegetation status (crop production, grass production),
- to forecast the development of climate driven diseases,
- to support long term analysis in terms of land cover change (e. g. change in vegetation type associated with permanent change in vegetation calendar)

3. **Algorithmic methodology**

The dates of occurrence of the phenological stages are derived from NDVI. They may also be derived from NDWI (water index), fCover, or temperature (this last at a resolution of 10 km). These inputs present similarities in term of shape, thus it has been decided to define a general algorithm that retrieves changes in shapes related to phenological changes.

Three main stages are required to generate the phenological products:

- Generation of a time series, from which noise due to haze or cloud cover has been removed. This operation does not rely on physics but rather on curves shapes analysis, all the physical correction being done by the core service. The method consists in re-building the curve's shape. The resulting smoothed time series must enable to retrieve the phenological stages. The smoothing operation consists in an iterative polynomial fitting (Vogt, 2002). It consists in fitting polynomial on the time series. The fitted polynomial and the original data are compared to keep the highest NDVI value for each decade (assuming that perturbations



results in decreases in NDVI), the new time series collect these maximum. The process is repeated several times.

- Among all time series, search for those that correspond to vegetation. In semi-arid region, vegetation may grow occasionally. It is important for the application to detect these areas. The amplitude of the signal must be above a threshold (its value depends on the sensor, and the input product). A variety of time series are observable over the whole continent, in term of shape, amplitude, increase rate, noise, double seasonality... Moreover, the seasonality is reversed when crossing the equator line. So the length of the time series is of 1.5 year: the last start of season is visible in any case, plus extra length for processing

- Detection of the most recent start of season. This algorithm search for the most recent increases in the time series that can correspond to the start of growth. If the detection is very recent (typically less than 3 decades) a flag of confidence 'to be confirmed' is given. If the detected start of season is more ancient, its flag is 'confirmed'. The algorithm consists in searching for a continuous period of time where the increase of curve is continuous and above the noise threshold (defined for each sensor and product).

- From the date of the last start of season, go forward and search for the occurrence of maximum of season, half senescence, end of season. The maximum is defined as the maximum of NDVI, half-senescence is the average value of minimum (start of season) and maximum of NDVI, the end of season is detected through the method of Reed et al. (crossover point between smoothed time-series and its moving average). These products may contains pixel with 'No-value', for e.g. the time series has not reach its half senescence, or its end of season. Decoupling the search of start of season and the other product, significantly save computation time. The duration of the growing season is derived from these post-processed products.

- Post-processing: use the archive to generate products with no 'No-values'. Also generate date in a format suitable for end-users.

The whole process is designed to work both in real-time and in post-season processing mode.

4. Ancillary data

No ancillary data is needed.

5. Examples

The examples below show example of product 'start of season'. The products have been generated at different dates: 01/01/2000, 01/03/2000, 01/07/2000. The images shows the progression of season on the whole continent.

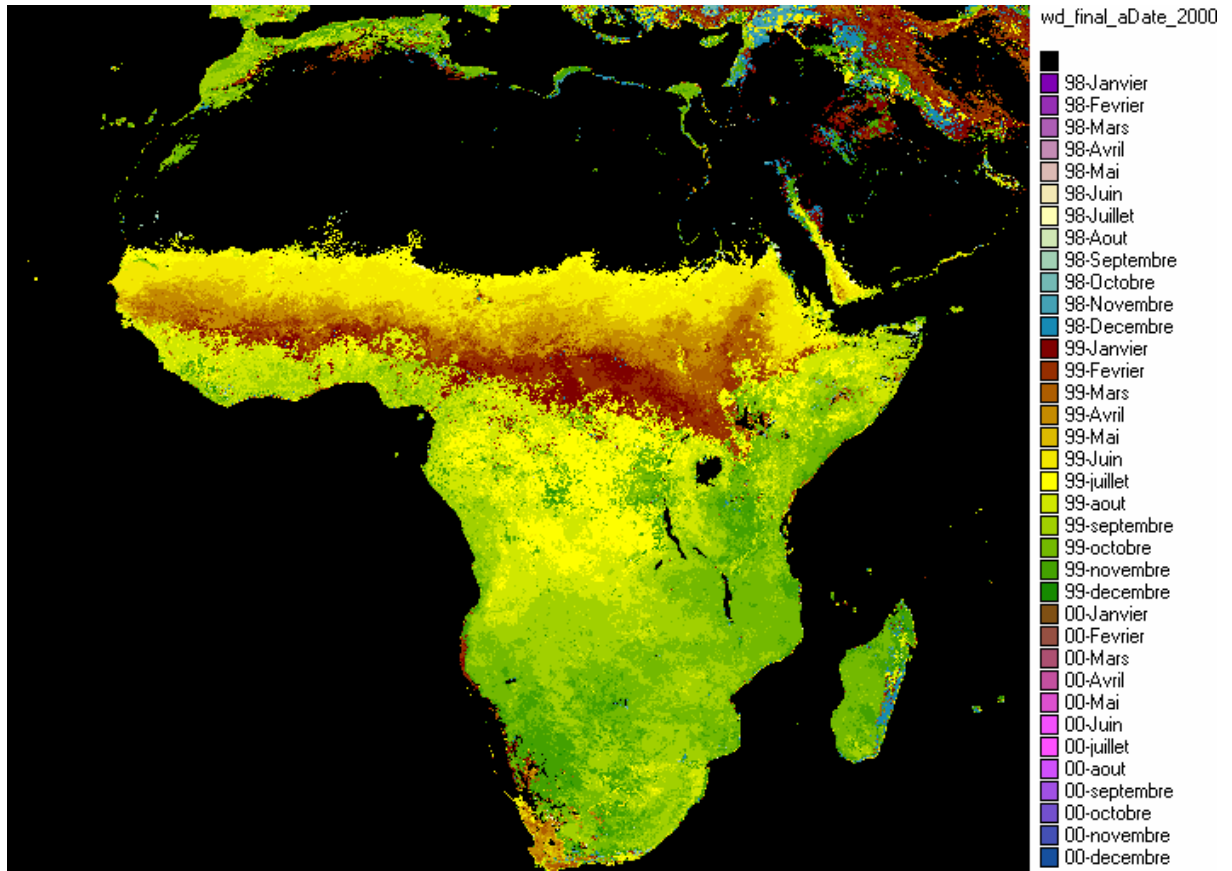


Figure 1. Start of season, generated from time series ending on 01/01/2000.

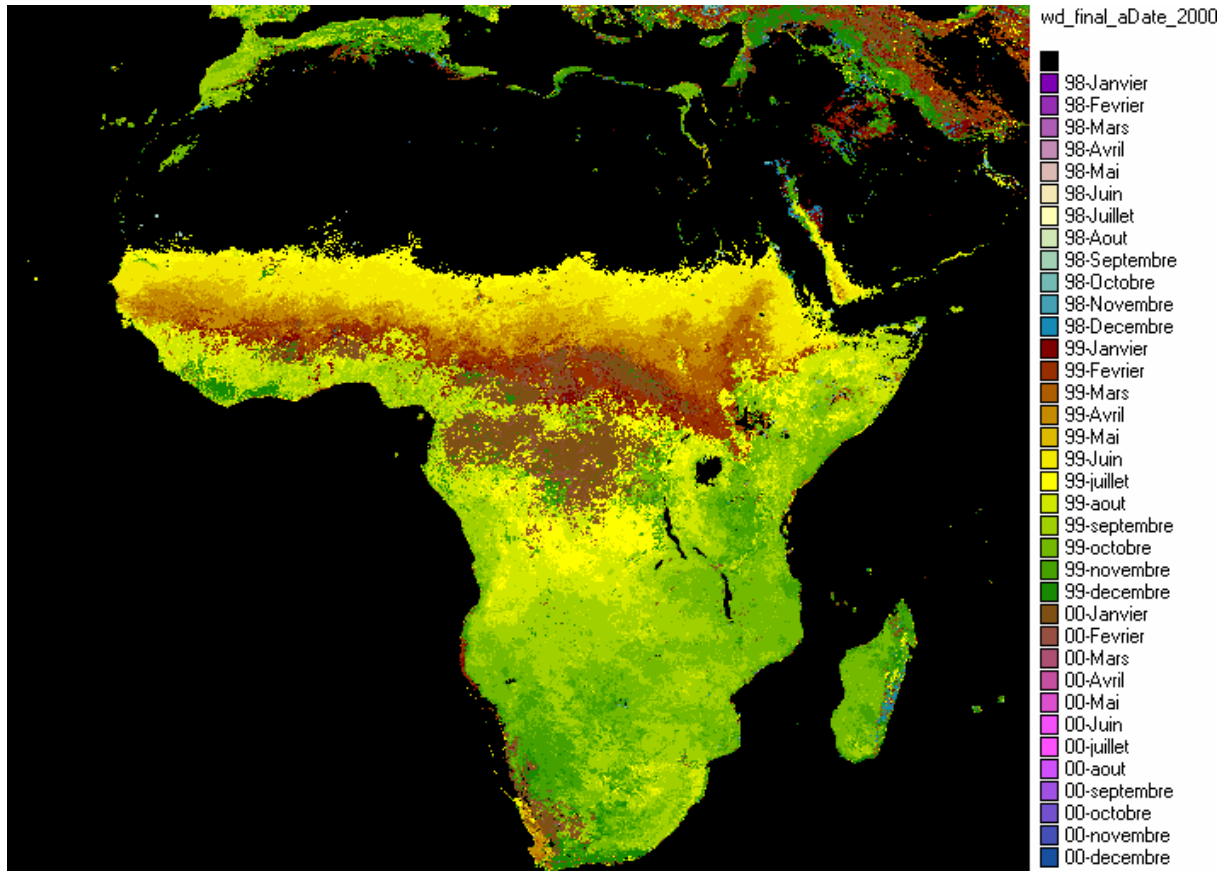


Figure 2. Start of season, generated from time series ending on 01/03/2000.

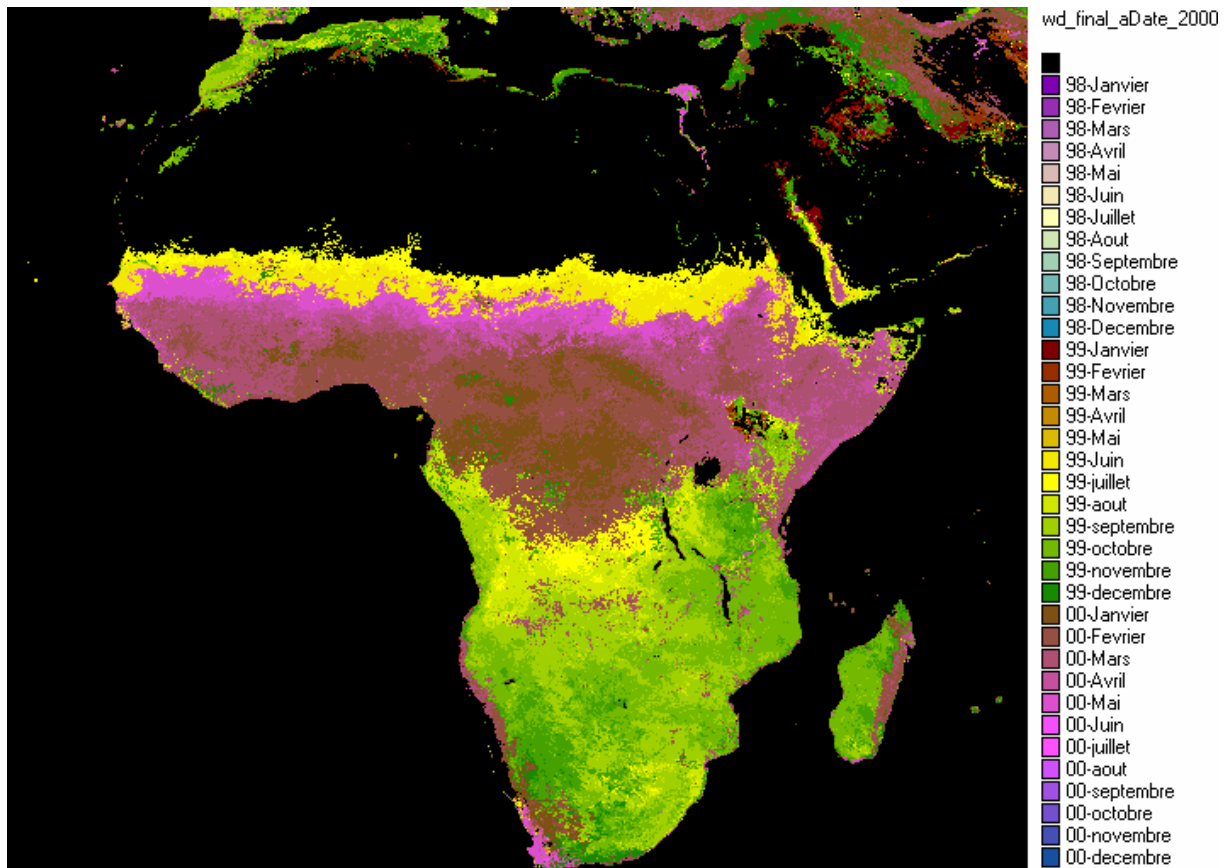


Figure 3. Start of season, generated from time series ending on 01/07/2000.

6. Validation evidence

It is well known that the agreement (in particular a time shift) between phenology assessed from remotely sensed data and real ground phenology depends on local climatic specificities. Indeed, depending on the specific vegetation type, but also on the purpose of the specific user's application, time lag between the EO-based date and the actual date may be different from place to place. This local characterisation is the duty of expert, and is beyond the scope of our mandate.

The validation will consist in checking that the phenological date estimates produced by the algorithm is consistent with the change in the NDVI curve shape, i.e. that all phenological stages visible on the curve are retrieved by the algorithm in the same way and everywhere.

An intercomparison between products generated from NOAA/AVHRR and SPOT/VEGETATION will be done, on the common period of these two sensors. The purpose is mainly to check the noise removal algorithm: time series of Spot VGT are very sensitive to atmosphere in some regions (along the coast of the Gulf of Guinea for example). Testing the noise removal there consists in checking that the resulting products are consistent with products derived from NOAA/AVHRR. The continuity of the product characteristics



enable the users to exploit product archive generated from VEGETATION/AVHRR (products starting from 1983) with products that will be generated from the VEGETATION dekadal synthesis.

The method will also be applied on fCover curves, not so much to verify the consistency of the date detection algorithm, but rather to compare the consistency of dates retrieved from NDVI and from fcover curves.

7. Estimated cost from 'pre-operational' to 'operational'

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8. References

Vogt P, 2002, "Provision of technical support to the GVM unit of SAI for the processing of remote sensing data", final report, JRC/GVM 12/03/2002
Reed B.C., Brown J.F., Vanderzee D., Loveland T.S., Merchant J.W. and Ohlen D.O., 1994, "Measuring phenological variability from satellite imagery", *Journal of Vegetation Science*, 5, 703-714

9. Technical product sheet

<u>Product name</u> <i>Vegetation phenology</i>
<u>Algorithmic Methodology</u> <i>Generation of smoothed time series, analysis of times series shapes to detect start of season, detection of max, half senescence and end of season from the season departure, post processing of products.</i>
<u>Geometric Resolution</u> <i>1 km</i>
<u>Product Accuracy</u> <i>The products do not rely on physics, but rather on NDVI temporal profile change in shape. Thus, the accuracy is constraint by</i> <ul style="list-style-type: none"> - <i>The perturbation of the NDVI time line (due to the atmosphere) and the ability to retrieve a smooth time line (i.e. that represents phenological stages). NDVI temporal profiles that are too perturbed may cause false detection (mainly for start of season). The product will be delivered with confidence flag.</i> - <i>The definition of the product themselves, e.g.: start of season corresponds to the local</i>



minimum of the NDVI time line, that is different from the actual vegetal start of season. It results mainly in a time-lag, that must be

Frequency Delivery

Every ten days

Ancillary data

No ancillary data needed

Delivery time (Time between the last data acquisition and the product delivery)

It should not exceed 3 days.

Archive

NOAA/AVHRR: from 1983 to now.