

Appendix A to Annex 1 Technical Specifications of Contract

Copernicus GL GBOC – Ground-Based Observations Collection Product and Service Detailed Technical requirements

Table of Contents

1	List of acronyms and terminology	4
2	Purpose of the document	6
3	Ground-Based Observations Collection for validating COPERNICUS Global land products	7
3.1	General requirements	7
3.1.1	Definition of EO land products and ground-based measurements.	7
3.1.1.1	EO land products	7
3.1.1.2	Ground-based measurements	8
3.1.2	Ancillary data sets	11
3.1.3	Ground-based measurements processing for validation	11
3.1.4	Technical specifications of the data to be delivered	12
3.1.4.1	Temporal coverage	12
3.1.4.2	Geographical coverage	12
3.1.4.3	Surface cover sampling	12
3.1.4.4	Data structure specifications	13
3.1.4.5	Data format specifications	13
3.1.4.6	Time definitions	14
3.1.5	Technical documentation	14
3.1.6	Data distribution policy	14
3.1.7	Data and service quality monitoring	14
3.2	Component 1 “Ground-based measurements from existing sites”	15
3.2.1.1	Purpose	15
3.3	Component 2 “Ground-based measurements from additional sites”	15
3.3.1.1	Purpose	15
3.4	Component 3: Data access and distribution	15
3.4.1	<i>Purpose</i>	15
3.4.2	Activity line “user interface”	16
3.4.2.1	The web site	16
3.4.2.2	The user support	17

3.4.3	Activity line “data access”	17
3.4.3.1	Data storage capacity	17
3.4.3.2	Data distribution through ftp	18
3.4.4	Activity line “archive Delivery”	18
4	Appendix 1: List of relevant documents/links	19
5	Appendix 2: list of reference links	21

Document evolution

Date	Individual(s)	Action	version
23/04 /2014	M. Clerici	Document created as "technical specifications"	Draft 0.1
13/05 /2015	M. Clerici and N. Gobron	Review of document for PPMT	Version 1.0
24/06 /2015	M. Clerici and N. Gobron	Include latest comments and suggestions from Market Analysis	Version 1.1

1 List of acronyms and terminology

AERONET: Aerosol Robotic Network

ASRVN: AERONET-based Surface Reflectance Validation Network

BSRN: Baseline Surface Radiation Network

CEOS: Committee on Earth Observation Satellite

ECSS: European Cooperation for Space Standardization

ECV: Essential Climate Variable

EO: Earth Observation

ESA: European Space Agency

EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites

FAPAR: Fraction of Absorbed Photosynthetically Active Radiation.

FIPAR: Fraction of Intercepted Photosynthetically Active Radiation.

Fcover: Fractional cover.

FP7: 7th Framework Programme of the European Community for research, technological development and demonstration activities

G-BOC: Ground-Based Observations Collection

GCOS: Global Climate Observing System

GTOS: Global Terrestrial Observing System

GEO: Group on Earth Observations

Geoland2: a FP7 project to demonstrate in pre-operational mode the GMES land service

GEOSS: Global Earth Observation System of Systems

GIO: GMES Initial Operations

GMES: Global Monitoring for Environment and Security

HW: HardWare

ICOS: Integrated Carbon Observation System

JRC: Joint Research Centre, European Commission

LAI: Leaf Area Index

LAD: Leaf Angle Distribution

LRM: Land Resource Monitoring Unit, JRC

PROBA-V: a BELSPO-ESA contributing mission aimed at serving as gap-filler between the end of the SPOT-

VEGETATION mission and the joint operation of Sentinel 3a and 3b

QA4EO: Quality Assurance Framework for Earth Observation

ROSAS: Robotics Station for Atmosphere and Surface

Sentinel 2: COPERNICUS operational satellites (2a and 2b) embarking two high resolution Earth Observation instruments each

Sentinel 3COPERNICUS operational satellites (3a and 3b) embarking two medium resolution Earth Observation instruments each

SW: Software

TBC: To Be Confirmed

TBD: To Be Defined

Validation: The process of assessing, by independent means, the quality of the data output data derived from the system outputs.

VEGETATION: a joint programme of France, Belgium, Sweden, Italy and to European Commission that operates a low resolution Earth Observation instrument on board the satellites SPOT 4 and SPOT5.

2 Purpose of the document

This document provides additional details in complement to the tender document. These detailed requirements are based on internationally agreed standards, on state-of-the-art practices and on well identified user needs. In the framework of the specific contracts the contractor is expected to provide the output data and services according to these requirements.

These detailed requirements will therefore be included in the definition of tasks that will be required for each specific contract.

The detailed requirements may be adapted at this occasion according to needs and circumstances.

Note: Meaning of verbal forms in the present document:

The verbal form “shall” is used whenever a provision is a requirement.

The verbal form “should” is used whenever a provision is a recommendation.

The verbal form “may” is used whenever a provision is a permission.

The verbal form “can” is used to indicate possibility or capability.

3 Ground-Based Observations Collection for validating COPERNICUS Global land products

3.1 General requirements

In order to avoid duplication of specifications all specific requirements that may be common to several components of this document are grouped in the section “general requirements”.

3.1.1 Definition of EO land products and ground-based measurements.

3.1.1.1 EO land products

The Earth Observation (EO) land products derived from space-based measurements relevant for this contract are reported hereafter, together with the reference to GCOS-GTOS Essential Climate Variables (ECV) wherever applicable.

Surface bi-directional reflectance factors (BRFs)

The measured surface reflectance is normalized by the reflectance of a reference panel that is (ideally) a Lambertian surface, illuminated and observed under identical geometric conditions. The result of this normalisation is called the Bi-directional Reflectance Factor (BRF) [14].

Surface albedo

Surface albedo refers to the instantaneous ratio of surface-reflected radiation flux to incident radiation flux over the shortwave spectral domain (dimensionless). It is defined for broad spectral regions or for spectral bands of finite width. As the scattering of light by land surfaces depends on the direction of incoming radiation and the direction of observation, various albedo definition have been introduced: white-sky (bi-hemispherical reflectance under isotropic illumination, BHRiso), black-sky (directional hemispherical reflectance, DHR under direct illumination), blue-sky (bi-hemispherical reflectance approximating ambient illumination and instantaneous atmospheric conditions, BHR) [9,2].

Fraction of absorbed PAR (FAPAR)

FAPAR is defined as the fraction of photo synthetically active radiation (PAR; solar radiation reaching the surface in the 0.4-0.7 μ m spectral region) that is absorbed by a vegetation canopy. Both black-sky (assuming only direct radiation) and white-sky (assuming that all the incoming radiation is in the form of isotropic diffuse radiation) FAPAR values may be considered. Similarly FAPAR can also be angularly integrated or instantaneous (i.e., at the actual sun position of measurement) [9,3].

Leaf Area Index (LAI)

Leaf Area Index is defined as the one-sided green leaf area per unit ground area in broadleaf canopies and

as the projected needle leaf area per unit ground area in coniferous canopies. When retrieved by EO means, an effective value is provided which depends on the retrieval scheme, i.e. radiative transfer model dimension and spatial resolution.

Fractional cover

Fractional cover refers to the proportion of a ground surface that is covered by vegetation.

Land surface temperature

Temperature of the apparent surface of land (bare soil or vegetation) - Physical unit: [K] [9].

Soil moisture

This refers to near-surface soil moisture (up to 5cm soil depth). Amount of water [m^3/m^3] contained in soil layers identified according to their depth, measured from the top of the surface.

3.1.1.2 *Ground-based measurements*

The following (continuous) ground-based parameters shall be considered:

Direct and diffuse solar radiation (multi-spectral, total, visible and near-infrared broadband) upwelling at the surface.

Atmospheric properties, such aerosols optical thickness (AOT) and down welling radiation at the canopy level.

Transmission through the canopy in various spectral bands.

Background albedo simultaneously with transmission (spatial sampling along transect).

FIPAR: Fraction of Intercepted Photo synthetically Active Radiation. It is derived from incoming and upcoming PAR at top and bottom of the canopy. It is needed over multiple years to reconstruct at least over one vegetation seasonal cycle.

Variability in canopy scattering albedo (linked to leaf colour). It should be estimated through webcams or direct measurements.

The definition of the **Leaf Area Index (LAI)** of ground-based measurements depends intrinsically on the method of measurement. Destructive method provides the LAI value as defined by ecologists. Radiometric instruments measure the light interception, e.g. the transmission through the canopy. When using radiometric measurements, such as LAI2000 or TRAC, assumptions are made on the scattering properties of the canopies and leaves.

The spatial orientation of a leaf is described by the direction of its normal to the upper surface. **Leaf Angle Distribution (LAD)** is defined by a function described the fraction of total leaf area in the horizontal layer of

unit thickness, at a fixed height, whose normals fall within unit solid angle around one direction and must satisfy a normalization criterion.

Structural knowledge gives details information of the organization or spatial arrangement (three-dimensional geometry) of a plant canopy [1].

The **Land Surface Emissivity** of an isothermal, homogeneous emitter is defined as the ratio of the actual emitted radiance to the radiance emitted from a black body at the same thermodynamic temperature (Norman and Becker 1995).

Ground and surface temperature are derived from the brightness temperatures measured by radiometer.

Surface radiance: Radiometers measure the surface leaving as well as the down-welling "sky"-radiance.

Soil moisture 'validation' measurements refer to soil moisture at 5 cm with soil and air temperature, precipitation, as well as snow depth and snow water equivalent (see <http://ismn.geo.tuwien.ac.at/>). Fractional cover and soil properties (such as **Roughness Parameters**) are also needed to make use of in-situ measurements. Since an international soil moisture network already exists, it is foreseen here to make the best selection (and ranking) of existing sites (Component 1) for which additional ECVs ground-based measurements are also available.

The following table illustrates the potential use of ground-based measurements (not exhaustive) for various land EO products validation, with a varying degree of relevance and priority.

I=Very important II= Important

Table 1: Ground Based Measurements (indicative table)

EO land products Ground based measurements	Ref	Surface reflectance	Surface Albedo	LAI	FAPAR	Fcover	Soil moisture	LST
		LP-1	LP-2	LP-3	LP-4	LP-5	LP-6	LP-7
Direct and diffuse solar radiation upwelling/down welling at the surface (visible and thermal)	RM – 1 (visible) RM – 2 (thermal)	I	I	II	II			I
Atmospheric properties (e.g. AOT)	RM – 3	I	II		II			
Roughness parameters	RM - 4						II	

Transmission through the canopy in various spectral bands (e.g. TRAC)	RM – 5			I	I	II		
Background spectral reflectance and albedo	RM – 6 (Soil BRF) RM – 7 (Soil BHR/DHR)		II	II	I			
FIPAR	RM – 8			II	I			
Variability in canopy scattering albedo, linked to leaf colors	RM – 9			II	I	II		
Leaf Area Index	RM – 10			I	II		I	
Leaf Angle Distribution	RM – 11			II	II			
Structural knowledge (using Lidar, inventories, ...)	RM – 12			II	II	I	II	
Land surface emissivity (LSE)	RM – 13							I
Ground and Surface temperature	RM – 14						I	I
Soil moisture at 5-10-15 cm	RM – 15						I	II
Meteorological properties (precipitation, air temperature)	RM – 16						I	II

All ground-based measurements shall be associated with *metadata information*: instrument type and name, exact time, date and geographical location of node measurements and transfer function.

Raw data and pixel-level value (i.e. after transfer function) with their associated uncertainties shall be made available. Traceability and description of protocols shall be provided in ancillary information following the guidelines of QA4EO (see http://www.qa4eo.org/docs/QA4EO-QAEO-GEN-DQK-006_v4.0.pdf).

3.1.2 Ancillary data sets

Ancillary data sets include any type of data set other than the ground-based measurements described in the previous sections that might be required by the properties of their processing, such as high resolution images used for the point-to-pixel conversion. These satellite data can be expected to be available through the Copernicus Data Warehouse phase 2¹ (DWH). The DWH contains data and large pre-defined datasets from various satellite providers and is accessible to registered users.

Data access conditions are described on the website mentioned in the footnote. The contractor must take all steps needed regarding licensing issues and physical access to the data so as to avoid service delay or disruption during contract execution.

3.1.3 Ground-based measurements processing for validation

The transfer function and/or model and uncertainties computation methods shall be available for each variable and site by the contractor for the purpose of the contract.

No part of it may be covered by legal protections such as it would be operated as a black-box or could not be maintained and upgraded for the purpose of the completion of this contract.

Detailed documentation of these methods shall be provided for each variable and site at the start of contract execution. The documentation shall describe the real implementation that has been done and provide all information needed to documents the requirements here after.

The level of details should allow re-computing the output data from raw data in an independent way in order to understand for example the origin of any unexpected behaviour of the product.

Choice of appropriate procedures to meet Users and QA4EO requirements shall be the responsibility of the contractor.

At the time of offer submission the various components of ground-based measurement acquisition and

¹ https://copernicusdata.esa.int/web/cscda/news/-/asset_publisher/dpC9RAHNo9WQ/content/data-warehouse-phase-2-2014-2020-to-start-on-1st-april-2015

their further methodologies shall have been submitted to, and accepted for publication by peer-reviewed journals of international fame and registered in reference systems such as DOAJ, SCOPUS, THOMPSON ISI WEB OF KNOWLEDGE, EBSCO, etc. Note: the tenderer may make use of / refer to methodologies algorithms developed a published by third party teams provided that he/she can ensure method maintenance by qualified scientists.

3.1.4 Technical specifications of the data to be delivered

The specifications described in this section are applicable to each component.

3.1.4.1 Temporal coverage

Ground-based measurements on existing networks shall cover at least a period of two past years (i.e. before 2014) and shall continue during COPERNICUS Sentinel-2 and 3-life time's missions.

Hourly raw data, when available, shall be provided for each single slot of measurements and match-up values near the time of acquisition of past, actual and future instruments (Sentinel-2 and Sentinel-3).

Measurements on future and specific ground-based acquisition shall sample at least 6 days per year and night (when applicable) corresponding to COPERNICUS Sentinel-2 and 3 overpasses over various climatic seasons.

3.1.4.2 Geographical coverage

Location of sites shall cover global coverage from north hemisphere to south hemisphere encompassing a variety of plan cover types (see next section) and climate regions.

The pixel size to be considered for up scaling (when applicable) can be first considered at 1 km resolution, but then moved to S2 (10/20 m) and S3 (300 m) resolution.

3.1.4.3 Surface cover sampling

Biome categories to be taken into consideration for collection of ground based measurement shall be either at least 14 among the IGBP land cover types or an equivalent internationally accepted standard sampled around the globe. Following a radiative transfer regime categorization, these sites shall encompass 1-D to 3-D canopy structure.

Surface reflectance and albedo, land surface temperature and soil moisture ground-based measurements should also cover 5 types of bare soils (including snow and ice).

3.1.4.4 *Data structure specifications*

This section details the contents and organization of ground based measurements (see also Annex 3.0 – par. 2.3.3):

For each site the following information are required:

1. Name
2. Location
3. Description of site
3. Responsible
4. List of PIs
5. Available Instrumentation.

For each ground-based measurement when applicable:

1. Ground-based measurements
2. Instrument type, units and operator
3. Date and time in UTC format
4. Position
- 5 Measurement protocol
- 6 Measured raw variables for each node
- 7 Associated uncertainties
- 8 Transfer function from point to pixel
- 9 Ancillary data such as high-resolution images used for the point-to-pixel conversion (when applicable)

In addition, when applicable, the Algorithm Theoretical Basis Documents (ATBD) describing the methodologies and uncertainties estimations should be provided.

3.1.4.5 *Data format specifications*

All above defined data should be stored in a single database to be accessed by the users. The results of the queries to the database should returns tables in one of the formats:

1. 'csv' (text)
2. MS xls
3. xml

For the raster products (ancillary information).

3.1.4.6 *Time definitions*

Date and times format must follow the International Standard ISO 8601 in universal times.

3.1.5 Technical documentation

For each variable, the contractor shall maintain the following documentation, subject to audit and review.

- ✧ Project management plan with schedule of tasks
- ✧ Algorithm technical Baseline document (public Domain)
- ✧ Product and service specification document
- ✧ Architecture and component design document
- ✧ Product user manual including l. a. data/ product data structure and format description (public domain)
- ✧ System and Service validation report (incl. validation plan).

3.1.6 Data distribution policy

Data distribution shall be fully compliant with the Copernicus data policy which ensures open access to output data². This data policy shall apply to all data delivered under this contract.

Open access shall be ensured to other users.

The contractor shall be responsible of the archival and distribution of the output data generated.

3.1.7 Data and service quality monitoring

If the contractor is asked to carry out any of the activities described here above he shall implement as part of these activities a data and service quality monitoring function that will generate regular reports on output data generated, output data distribution and anomalies.

² Following Article 23 Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010.

3.2 Component 1 “Ground-based measurements from existing sites”

3.2.1.1 Purpose

The purpose of this component is to ensure availability of a number of ground based measurements, for EO Land products validation, which are already collected by existing network or/and stations, and which might not be originally made available to the Copernicus actors, or whose accessibility might be difficult and not organized, due to limitations in the data policy or technical issues.

It should be noted that this component is expected to be continue during project lifetime.

3.3 Component 2 “Ground-based measurements from additional sites”

3.3.1.1 Purpose

The purpose of this component is to ensure the availability of additional variables/sites to complement existing ones.

- 1 Maintenance with additional instrumentation can be deployed over Component 1 sites and;
- 2 New sites can be installed: in this latter case, the contractor may propose site(s) common to all variables.

3.4 Component 3: Data access and distribution

3.4.1 Purpose

The purpose of this component is to distribute the ground-based measurements generated in the framework of the other two components as well as related documentation and to provide the user interface.

This component includes the following specific activity lines:

- ✦ “user interface”
- ✦ “data access”
- ✦ “archive delivery”

Whenever applicable INSPIRE guidelines on data model, metadata and web services shall be followed (see INSPIRE web site at <http://inspire.jrc.ec.europa.eu>).

Whenever applicable (web site, documentation, etc.) the contractor shall ensure due visibility and make use of the European Commission graphic charter and disclaimer.

3.4.2 Activity line “user interface”

The user interface shall be composed of the following elements:

- ✦ A web site
- ✦ The user support.

3.4.2.1 The web site

The web-site shall be the main entry point to access processed output data and related information by users. The web-site operated by the contractor may be a pre-existing one, to be adapted to the current needs.

The main functions that are expected from the web site are the following:

- ✦ access to the catalogue of ground-based data
 - anonymous
 - free-of-charge
 - access to meta-information
 - access to quick-look (jpg, colour table, sub-sampled), when applicable.
- ✦ access to the ground based data
 - free-of-charge access (no invoicing system is required),
 - requires verified registration of the user, includes on-line acceptance of the terms and conditions of the Copernicus product license.
 - after registration points to the download page
 - select variable
 - define start and end of time series
 - define of pre-identified windows or user-specific Region of Interest
 - download of selected measurements
- ✦ subscription to a “technical issue warning” mailing list
 - requires a specific registration of the user (should be proposed at the time of the registration of the user) ,
 - requires to set up a technical communication procedure, allowing to inform the users without any delay about the production incidents that could impact the proper use of the delivered product(s). This email should provide clear information about the nature and the possible impact (from a user point of view) of the problem, as well as how to overcome it.
 - Obviously, the information provided by email should be also available on the website and should be archived.
- ✦ access to downloadable relevant information for each variable, i. e.
 - variable description
 - measurements method description

- file format description
- version identification and properties / evolution of software components consistent with meta-information as above-mentioned
- known problems
- bibliographic references (downloadable or with hyperlink)

In addition to the above described website, an asset would be the implementation of Web Services (WMS and WCS) according to the OGC specifications (see <http://www.opengeospatial.org/standards/wms> and <http://www.opengeospatial.org/standards/wcs>).

The web-based service shall be compliant with INSPIRE guidelines on metadata structure and web service.

3.4.2.2 *The user support*

The user support shall be provided through email.

The user support shall be provided in English. The user support may be provided in other languages as well.

The support shall manage user requests so as to maximize satisfaction, also by re-directing requests to most appropriate staff inside the contractor's entities and to other institutions if appropriate.

The support shall maintain the web-based FAQ and feed it with requests from users and corresponding answers.

3.4.3 Activity line “data access”

This activity includes mainly the operation of a data storage capacity and the data distribution through ftp.

3.4.3.1 *Data storage capacity*

The contractor is expected to keep all data throughout the lifetime of the project as on-line data storage.

The data storage capacity shall include all raw data acquired for the completion of all activities defined in the other components.

The data storage capacity shall include all processed data generated in the framework of production activities defined in the other components.

The data storage capacity shall include all ancillary data required for the completion of production activities defined in the other components.

The data storage capacity shall be interfaced to the web-based catalogue.

The data storage capacity shall be organized in such a way that access to any of its component can be granted according to the rules laid down by the Copernicus data policy to external users through the ftp protocol.

3.4.3.2 *Data distribution through ftp*

The ftp site shall ensure timely access to newly acquired ground-based measurements (data available less than 3 days after the date of the automated measurements). In the case of specific and non-automatic measurements, up-scaling values should be available after 3 months.

The ftp site shall ensure access to archived data. Archived data are understood here as any type of data that was acquired before the most recent output data. They therefore may include (1) data retrieved from previous processing activities outside the framework of this contract, (2) data generated by the activities under the present contract.

The ftp site shall provide at least the following properties:

Access to the ftp site shall be granted only after due registration (see above under web-site);

Access priority shall be established to ensure fastest access to most recent output data;

Provide batch download possibility (time series);

Provide the data according to user-defined Regions Of Interest (ROI).

3.4.4 Activity line “archive Delivery”

At any time during the project, and upon request from the contracting authority the contractor shall deliver part of or the complete archive (including input and output data).

The archive shall be provided either through ftp or on hard disk (TBD).

The delivery address in Europe shall be defined in due time.

The requested archive may include:

- ✧ All the processed output
- ✧ All the related documentation accessible from the web site
- ✧ Database structure
- ✧ All raw EO data
- ✧ Ancillary data used for the production of the bio-geophysical parameters.

4 Appendix 1: List of relevant documents/links

1. Campbell, G.S., and J.M. Norman. 1990. The description and measurement of plant canopy structure. pp. 1-19 In: Russell, G., B. Marshall, and P.G. Jarvis (editors). *Plant Canopies: Their Growth, Form and Function*. Cambridge University Press.
2. ECV 08: Albedo: assessment report on available methodological standards and guides, 1 Nov 2009, GTOS-63
3. ECV 10: FAPAR: assessment report on available methodological standards and guides, 1 Nov 2009, GTOS-65
ECV 11: LAI: assessment report on available methodological standards and guides, 1 Nov 2009, GTOS-66
4. ECSS-M-ST-10-01C, 2008: Space management – organization and conduct of reviews.
(available from <http://www.ecss.nl/>).
5. ECV 11: LAI: assessment report on available methodological standards and guides, 1 Nov 2009, GTOS-66
6. European Commission: REGULATION (EU) No 911/2010 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 September 2010 on the European Earth monitoring programme (GMES) and its initial operations (2011 to 2013). Official Journal of the European Union L 276/1 of 20.10.2010.
<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010R0911:EN:NOT>
7. European Commission: REGULATION (EU) No 377/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010. Official Journal of the European Union, L 122/44 of 24.04.2014.
<http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1402995525044&uri=CELEX:32014R0377>
8. GCOS. 2006. “Systematic Observation Requirements for Satellite-Based Output data for Climate”. Supplemental details to the satellite based component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC. GCOS-107 (WMO/TD No. 1338).
<http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf>
9. GCOS 2011: Systematic Observation Requirements for Satellite-based data output data for Climate - 2011 Update. Supplemental details to the satellite-based component of the “Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)” GCOS 154.
<http://www.wmo.int/pages/prog/gcos/documents/SatelliteSupplement2011Update.pdf>
10. GEO workplan 2012-2015 – revision 1, 11 Dec. 2011
http://www.earthobservations.org/documents/work%20plan/GEO%202012-2015%20Work%20Plan_Rev1.pdf
11. GIO Work Programme 2012 - European Earth monitoring programme (GMES) and its initial

operations (2011 – 2013). European Commission C(2011)8027 of 11 November 2011.

http://ec.europa.eu/enterprise/policies/space/files/gmes/gio_wp2012_final_en.pdf

12. Global Land Working Group 2010: "GLOB-Land Service", the Global component of the GMES Land Monitoring Core Service. working paper of the working group on the Global component of the GMES Land Monitoring Core Services. V 3.0. hyperlink:
http://www.acceptance.ec.europa.eu/enterprise/policies/space/files/gmes/services/global_land_service_en.pdf
13. GMES Space Component Data Access Portfolio: Data Warehouse 2011-2014 (ESA – GMES-PMAN-EOPG-TN-11-0006).
http://gmesdata.esa.int/web/gsc/data_access
14. Nicodemus, F. E., J. C. Richmond, J. J. Hsia, I. W. Ginsberg, and T. Limperis (1977) Geometrical Considerations and Nomenclature for Reflectance, US Department of Commerce, National Bureau of Standards, NBS Monograph No. 160, Washington, DC.
15. Norman, G., and Becker, F. (1995). Terminology in thermal infrared remote sensing of natural surfaces. Agricultural and Forest Meteorology, Volume: 77, Issue: 3-4, Pages: 153-166, DOI: 10.1016/0168-1923(95)02259-Z
16. Olson, D. M, E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoreux, W.W. Wettengel, P. Hedao, & K.R. Kassem. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth BioScience 51:933-938
<http://www.worldwildlife.org/science/ecoregions/WWFBinaryitem4809.pdf>

5 Appendix 2: list of reference links

AERONET: <http://aeronet.gsfc.nasa.gov/>
ASRVN: <http://landval.gsfc.nasa.gov/sensor.php?SensorID=13>
BSRN: <http://www.ndsc.ncep.noaa.gov/coop/bsrn/>
ECSS: European Cooperation for Space Standardization: <http://www.ecss.nl/>
ESA page: http://www.esa.int/esaMI/Proba/SEMD16ZVNUF_0.html
CEOS EO handbook: <http://www.eohandbook.com/>
GEO 2006: GEONETCast initiative of GEO.
http://www.earthobservations.org/documents/geonetcast/GEONETCast_workshop_20060503-final.ppt,
<http://www.earthobservations.org/geonetcast.shtml>
FLUXNET: A network of regional networks: <http://fluxnet.ornl.gov/>
ICOS: <http://www.europe-fluxdata.eu/icos>
KIT: <http://www.kit.edu/english/>
METOP (EUMETSAT): <http://www.eumetsat.int/Home/Main/Satellites/Metop/index.htm>
PROBA-V International User Committee web page: <http://probav-iuc.org/>
ROSAS: <http://www.cnes.fr/web/CNES-en/1527-cnes-internships-2012.php?view=item&item=7789>
SCAN: <http://www.wcc.nrcs.usda.gov/scan/>
SURFRAD: <http://www.esrl.noaa.gov/gmd/grad/surfrad/>
TERN: <http://www.tern.org.au/>
UNCCD 1992: Convention to Combat Desertification; link: <http://www.unccd.int/en/about-the-convention/Pages/Text-overview.aspx>
UNFCCC 1992: Framework Convention on Climate Change. Link:
<http://unfccc.int/resource/docs/convkp/conveng.pdf>