1.1 Introduction

'Greenhouse gases', especially carbon dioxide, are intimately connected to climate change. Their rapid increase is challenging the scientific community, policy makers and the public. To predict future climate change accurately and find ways to manage the concentration of atmospheric carbon dioxide, the processes and feedbacks that drive the carbon cycle must first be understood. Understanding the spatial and temporal patterns of carbon fluxes on land, ocean and in the atmosphere is essential to inform the policy process. However, our current knowledge of spatial and temporal patterns is uncertain, particularly over land.

Observations of terrestrial carbon-cycle dynamics are a fundamental component of attempts to understand the carbon cycle. Understanding of the carbon cycle requires a combination of measurements and models, integrating observations (Earth observation and *in situ*), models (diagnostic and predictive), process and manipulative experiments and case studies in a 'multiple constraint' synthesis approach. The Agency intends to develop a system to deliver products for use within initiatives such as IGBP-IHDP-WCRP Global Carbon Cycle Joint Project and the GTOS-TCO Initiative and ultimately the IPCC to determine the spatial and temporal distribution of global terrestrial carbon.

1.2 Objectives

GLOBCARBON will develop a service to generate fully calibrated estimates of at land products quasi-independent of the original Earth Observation source where that source is the data provided by ESA Earth Observation satellites plus a number of other sensors that are synergistic with those systems.

The service will focus on development of a system to generate global estimates of the following:

- Fire – location, timing, area affected
- Reflectance
- f_{APAR} and LAI
- Vegetation growth cycle – timing, duration, spatial and temporal variability

The demonstrator will focus on seven complete years, from 1997 to 2003 when overlap exists between the AVHRR, VEGETATION and ERS-2 (ATSR-2) systems (from 1997/8) and AVHRR, VEGETATION, ENVISAT (AATSR, MERIS) and possibly NASA MODIS (from 2002) because the objective is to develop a flexible service that is not dependent on any single satellite system and therefore can be retrospectively applied to existing archives and used with future satellite systems.

The **Fire product** shall comprise at least some of the following elements:

- Fire location and timing – drawing on the experience of the World Fire Web, World Fire Atlas, FireM3, MODIS Rapid Fire and FF-Operat (Finland), but using AVHRR and ATSR-2/AATSR systems jointly. Both day and night-time operation should be considered.
- Fire area – drawing on extant methods and information from GLOBSCAR (ESA) and EC Global Burned Area Assessment (GBA-2000). This will however, consider the use of ATSR-2 (GLOBSCAR), VEGETATION (GBA-2000 and FireM3), AVHRR and ENVISAT AATSR/MERIS plus fire location information. It is expected that this element will draw on the surface reflectance products detailed below.

Note that where the surface reflectance product (see below) is used the option to correct for view and solar angle should be considered since it will intentionally not be included in the surface reflectance product below.

The **Reflectance product** shall comprise the following outputs:

- Satellite inter-calibration will be checked against a limited number of calibration sites to verify behaviour.
- Satellite observations will be masked for cloud using standard algorithms e.g. CLAVR **Error! Reference source not found.**. Where these do not perform well (e.g. ATSR on land) a re-specification will be included.
- Cloud shadow should also be considered using the cloud mask plus solar and view angle information.
- The atmospheric correction scheme to be introduced will be SMAC v4 with ancillary data from ECMWF (water vapour, surface pressure), climatology-based aerosol inputs as implemented in the VEGETATION processor, aerosol observation where available and GOME/TOMS ozone in line with that already implemented for SPOT-VEGETATION. For surface pressure there is a need for a DEM – the best available product for 1 km resolution is the ACE product. The specific coefficients required by SMAC will be provided. Budgeting should include the need to purchase the ECMWF data planes at the highest available resolution (½°) plus the small cost for commercial access to the ESA sponsored ACE DEM available from De Montfort University UK (http://www.cse.dmu.ac.uk/geomatics/ace/ACE_promo.htm).

The **LAI/f_{APAR} product** shall comprise the following outputs:

- Based on the separate reflectance inputs from each sensor, a model-based look-up table (LUT) will be used to calculate both f_{APAR} and LAI simultaneously from data strings comprised of all available sensor inputs.
- The LUT data and full description of how it was derived will be provided. However, the system should include the option generate the LUTs subsequently.
- The LUT search algorithm will require implementation.

The **Vegetation growth cycle** product shall comprise the following outputs based on the previously calculated f_{APAR} product:

- The start and end dates of active growth
- The peak growth
- The duration of growth
- The total amount of growth (area under the growth curve)

This product will be generated at the end of each growth year but the facility to calculate on a multi-annual basis should be included. These products will be derived using appropriate curve fitting approaches. It is important to include the ability to account for vegetation type variability using the best available global land cover map (IGBP DISCover or preferably the GLC'2000 product are suggested options but others may be considered).

1.3 Demonstrator Test Locations

The options are encompassed by the IGBP Transects. The suggested three sites are:

Siberia West Transect (8). This comprises an area from 70-110 degrees E longitude and 50-75 degrees N latitude and incorporates tundra-taiga ecosystems.

Amazon (LBA) Transect (12) extends from 18°S-12°N, 40°W-80°W. This represents the region encompassed within the Large Amazon Biosphere International Experiment and comprises dominantly tropical rainforest.

Kalahari Transect (1) comprises an area from 30°S-10°S, 15° -30°E incorporating a variety of vegetation typical of semi-arid ecosystems and coincides with the SAFARI-2000 International Experiment.