**EV Template**

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| *EV* |  |
| *Short rationale for proposing this variable as essential for understanding and monitoring carbon cycle and climate change* |  |
| *Available monitoring standards/methods/technologies (in situ + remote)* |  |
| *Uncertainties* |  |
| *Requirements for spatial and temporal scale, accuracy/uncertainty and stability* |  |
| *Operational monitoring networks (in situ + remote)* |  |
| *Available datasets* |  |
| *Main users’ categories* |  |
| *Main gaps and requirements* |  |
| *Other* |  |

**Example**

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| *new ECV* | Soil Carbon  *(1st draft by Tommaso Chiti and Antonio Bombelli)* |
| *Short rationale for proposing this variable as essential for understanding and monitoring carbon cycle and climate change* | Soil organic carbon (SOC) is an essential variable for understanding the potential future changes of the climate system. The SOC pool stores over 2,700 gigatonnes (Gt) of carbon in soils worldwide, which is well above the combined total of atmosphere (780 Gt) or biomass (575 Gt). Changes in land use/cover affect directly the SOC pool and its flux, and as a consequence the atmosphere, with the potential for the SOC pool to sequester C or become a source. It is widely accepted that the C content of soil is a major factor in its overall health. Soil carbon improves the physical properties of soil. It increases the cation-exchange capacity (CEC) and water-holding capacity of sandy soil, and it contributes to the structural stability of clay soils by helping to bind particles into aggregates. The increasing importance of including the SOC between the essential climate variables is also related to some emerging issues: a) the needs of new land for agriculture that is increasing the greenhouse gases (GHGs) emitted from soil due to management; b) the increasing concern on the possibility to reduce global GHG emissions by avoiding deforestation and degradation.  On the other side the soil carbon pool have, until recently, represented stable, long-term reservoirs for atmospheric carbon, but is becoming increasingly vulnerable to climate change, because of the permafrost thawing and the drying of organic soils in tropical and boreal peatlands, boreal forests, and tundra, combined with increases in fire frequency, that can trigger the release of uncontrolled carbon emissions from soils.  Besides, a global assessment of SOC and its dynamics is an essential input to climate change forecasting models and adaptation strategies.  *Reference*:  Lal R (2008). "Sequestration of atmospheric CO2 in global carbon pools". Energy and Environmental Science 1 (1): 86–100 |
| *Available monitoring standards/methods/technologies (in situ + remote)* | Field surveys and sampling remain essential to monitor soil carbon stocks, because the satellite imagery – while improving – are not adequate enough  give reliable information about soil carbon stocks and changes.  Nevertheless, satellite imagery and modelling efforts are necessary for spatial and temporal extrapolation.  The current methodologies for monitoring the SOC pool variations require repeated soil sampling (Stolbovoy 2005) and the consequent C analyses in laboratory by chemical methods (e.g. Walkley-Black) or more recent techniques (e.g. dry combustion).  Other emerging techniques for determining the amount of SOC comprise the visible and near infrared diffuse reflectance spectroscopy, that has produced promising results to infer SOC content in the laboratory. However, using soil spectra measured directly in the field or with airborne imaging spectrometers remains challenging due to uncontrolled variations in surface soil conditions, like vegetation cover, soil moisture and roughness. However, Stevens et al. (2008) and Morgan et al. (2009) demonstrated that SOC can be measured in the field at the expense of a slight decrease of accuracy compared to laboratory measurements. Both laboratory and field spectroscopy predicted SOC content more accurately than airborne imaging spectroscopy (AIS) due to atmospheric attenuation, low signal to noise ratio (SNR), and unstable illumination conditions during the flight (Stevens et al., 2010).  *References:*  Morgan, C.L.S., Waiser, T.H., Brown, D.J., Hallmark, C.T., 2009. Simulated in situ charac- terization of soil organic and inorganic carbon using visible near infrared diffuse reflectance spectroscopy. Geoderma 151, 249–256.  Stevens, A., Van Wesemael, B., Bartholomeus, H., Rosillon, D., Tychon, B., Ben-Dor, E., 2008. Laboratory, field and airborne spectroscopy for monitoring organic carbon content in agricultural soils. Geoderma 144, 395–404.  Stevens, A., Udelhoven, T., Denis, A., Tychon, B., Lioy, R., Hoffman, L., Van Wesemael, B., 2010. Measuring soil organic carbon in croplands at regional scales using imaging spectroscopy. Geoderma 158, 32–45.  Stolbovoy V, Montanarella L, Filippi N, Selvaradjou SK, Panagos P, Gallego J (2005) Soil sampling protocol to certify the changes in organic carbon stock in mineral soils of European Union. Version 2. EUR 21576 EN/2. 56 pp. |
| *Uncertainties* | Uncertainties are very large, particularly in carbon rich soils such as those in permafrost and peatland areas.  Reducing uncertainties requires increasing the number and frequency of samplings and improving of specific remote sensors. |
| *Requirements for spatial and temporal scale, accuracy/uncertainty and stability* | Despite the methodology adopted for sampling or measuring the SOC, an important point is the time necessary to appreciate a consistent variation in SOC so to be detected. In fact, it has been well demonstrated that if there is no any change in the land use, a time between five to ten years represent the minimum interval for repeating the sampling (*Chiti et al. 2010; Smith 2004*).  References:  Smith, P. 2004. How long before a change in soil organic carbon can be detected? Global Change Biology, 10, 1878–1883.  Chiti T, Papale D, P. Smith P, Dalmonech D, Matteucci G, Yeluripati J, Rodeghiero M, Valentini R (2010) Predicting changes in soil organic carbon in Mediterranean and alpine forests during the Kyoto Protocol commitment periods using the CENTURY model. Soil Use and Management, December 2010, 26, 475–484 |
| *Operational monitoring networks (in situ + remote)* | 1. National soil carbon network   http://iscn.fluxdata.org/Pages/default.aspx |
| *Available datasets* | At global scale, various efforts have been developed to harmonize the different soil classifications and to establish a world soil map (FAO-IIASA). While the resolution is continuously improving, in many cases is still very coarse and the number of soil profiles limited, undermining the use of these datasets, particularly for non-scientific purposes.   1. Batjes, N.H. 2008. ISRIC-WISE harmonized global soil profile dataset (Ver. 3.1). Report 2008/2, ISRIC - World Soil Information, Wageningen. (Also available at: <http://www.isric.org/isric/webdocs/docs//ISRIC_Report_2008_02.pdf?q=isric/Webdocs/Docs/ISRIC_Report_2008_02.pdf>). 2. Hiederer, R., Jones, R.J.A. & Daroussin, J. 2006. Soil Profile Analytical Database for Europe (SPADE): Reconstruction and Validation of the Measured Data (SPADE/M). Geografisk Tidsskrift, Danish Journal of Geography 106(1): 71-85. (also available at <http://rdgs.dk/djg/pdfs/106/1/06.pdf>). 3. Leenaars, J. G. B. 2013. Africa soil profiles database, Version 1.1. A compilation of georeferenced and standardized legacy soil profile data for Sub-Saharan Africa (with dataset). ISRIC Rep, 3. 4. Stolbovoy, V., McCallum, I. et al. 2002. Land Resources of Russia. (also available at: <http://www.iiasa.ac.at/collections/IIASA_Research/Research/FOR/russia_cd/download.htm>). 5. National Soil Carbon Network (2011) NSCN Database report: Profile Carbon to 1 m Depth. available on-line: http://www.fluxdata.org/nscn/DataBrowsing/SitePages/Carbonto1M.aspx>. |
| *Main users’ categories* |  |
| *Main gaps and requirements* | It is critical to harmonize the widely varying methodologies for inventory and analysis, to promote the use of standards and to ensure the continuity of georeferenced and repeated measurements for soil carbon inventories.  Repeated measurements of carbon stocks in time allow improving the calibration of models, the estimation of their evolution and quantification of the influence of factors such as changes in climate and land use. |
| *Other* |  |