Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Soil moisture

## ECV Product: Freeze/thaw

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| --- | --- | --- | --- | --- | --- |
| **Name** | Freeze/thaw | | | | |
| **Definition** | Flag indicating whether the land surface is frozen or not | | | | |
| **Unit** | Unitless | | | | |
| **Note** | Freeze/thaw is subsidiary variable of the ECV soil moisture. It is needed because most measurement techniques do not allow to measure soil moisture when the ground is frozen. Also, land-surface processes fundamentally chance when the soil is frozen. Instead of binary values (e.g. thawed = 0 and frozen = 1) probabilities (i.e. probability that the soil is frozen) may be used. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km | Size of grid cell | G | 1 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface (convective rainfall, orographic effects, etc.) |
| B | 10 | Same as for Surface Soil Moisture: Many climate and earth system models are moving to a grid size of 10 km or finer. |
| T | 50 | Same as for Surface Soil Moisture: This definition reflects a practical understanding of the boundary between climate science and other related geoscientific fields such as hydrology, agronomy, or ecology. |
| **Vertical Resolution** | N/A |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | hours | Time between measurements | G | 6 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface; Needed to depict the interplay between soil moisture, precipitation and evaporation |
| B | 24 | Same as for Surface Soil Moisture: Needed for closing water balance at daily scales |
| T | 48 | Same as for Surface Soil Moisture: Important land-atmospheric processes are missed, but drying and wetting trends can be depicted. |
| **Timeliness** |  |  | G | 1 week | Same as for Surface Soil Moisture: For climate communication and improved preparedness |
| B | 1 month | Same as for Surface Soil Moisture: To support the assessment of on-going extreme events (droughts, extreme wetness) |
| T | 1 year | Same as for Surface Soil Moisture: For assessments and re-analysis |
| **Required Measurement Uncertainty** | % | Overall classification accuracy | G | 98 | Same as for Surface Soil Moisture: More demanding goal is probably unrealistic due to high variability of soil moisture at small-scales due to changes in soil properties, topography, vegetation cover |
| B | 95 | Same as for Surface Soil Moisture: Accuracy goal as first adopted for the dedicated soil moisture satellites SMOS and SMAP. Later adopted for GCOS, and reconfirmed at the 4th Satellite Soil Moisture Validation and Application Workshop (Wagner, W., T.J. Jackson, J.J. Qu, R. de Jeu, N. Rodriguez-Fernandez, R. Reichle, L. Brocca, W. Dorigo (2017) Fourth Satellite Soil Moisture Validation and Application Workshop, GEWEX News, 28(4), 13-14.) |
| T | 90 | Same as for Surface Soil Moisture: This value traces back to the accuracy goals as specified for the SMOS and SMAP satellites designed for measuring soil moisture. |
| **Stability** | Unknown | Unknown | G | 0.005 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| B | 0.01 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| T | 0.02 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| **Standards and References** | Required Measurement Uncertainty : Confusion matrices should be computed for different periods of the year. In particular, the transition periods from frozen to thawed conditions are most critical for assessing the accuracy of the freeze/thaw estimates. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  |  | | |
| **Extremes[3]** |  |  |  | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Timeliness: same comment as for surface soil moisture. . (Timeliness should be updated to: T (48h), B (6 hours), G (3 hours). | |

### Comment 2

|  |  |
| --- | --- |
| Author: Annett Bartsch | Email: Annett.Bartsch@polarresearch.at |
| The spatial resolution requirement related to Permafrost is 1m to 100m. See NRC (2014)  National Research Council (2014). Opportunities to Use Remote Sensing in Understanding Permafrost and Related Ecological Characteristics: Report of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/18711. | |

## ECV Product: Surface Inundation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Surface Inundation | | | | |
| **Definition** | Flag indicating whether the land surface is inundated or not[VA1] | | | | |
| **Unit** | Unitless | | | | |
| **Note** | Surface inundation is subsidiary variable of the ECV soil moisture. It is needed because most measurement techniques do not allow to measure soil moisture when the soil surface is inundated. Also, land-surface processes fundamentally chance when the soil is inundated. Instead of binary values probabilities (i.e. probability that the soil is inundated) may be used. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km | Size of grid cell | G | 1 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface (convective rainfall, orographic effects, etc.) |
| B | 10 | Same as for Surface Soil Moisture: Many climate and earth system models are moving to a grid size of 10 km or finer. |
| T | 50 | Same as for Surface Soil Moisture: This definition reflects a practical understanding of the boundary between climate science and other related geoscientific fields such as hydrology, agronomy, or ecology. |
| **Vertical Resolution** | N/A |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | hours | Time between measurements | G | 6 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface; Needed to depict the interplay between soil moisture, precipitation and evaporation |
| B | 24 | Same as for Surface Soil Moisture: Needed for closing water balance at daily scales |
| T | 48 | Same as for Surface Soil Moisture: Important land-atmospheric processes are missed, but drying and wetting trends can be depicted. |
| **Timeliness** |  |  | G | 1 week | Same as for Surface Soil Moisture: For climate communication and improved preparedness |
| B | 1 month | Same as for Surface Soil Moisture: To support the assessment of on-going extreme events (droughts, extreme wetness) |
| T | 1 year | Same as for Surface Soil Moisture: For assessments and re-analysis |
| **Required Measurement Uncertainty** | % | Overall classification accuracy | G | 98 | Same as for Surface Soil Moisture: More demanding goal is probably unrealistic due to high variability of soil moisture at small-scales due to changes in soil properties, topography, vegetation cover |
| B | 95 | Same as for Surface Soil Moisture: Accuracy goal as first adopted for the dedicated soil moisture satellites SMOS and SMAP. Later adopted for GCOS, and reconfirmed at the 4th Satellite Soil Moisture Validation and Application Workshop (Wagner, W., T.J. Jackson, J.J. Qu, R. de Jeu, N. Rodriguez-Fernandez, R. Reichle, L. Brocca, W. Dorigo (2017) Fourth Satellite Soil Moisture Validation and Application Workshop, GEWEX News, 28(4), 13-14.) |
| T | 90 | Same as for Surface Soil Moisture: This value traces back to the accuracy goals as specified for the SMOS and SMAP satellites designed for measuring soil moisture. |
| **Stability** | Unknown | Unknown | G | 0.005 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| B | 0.01 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| T | 0.02 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  |  | | |
| **Extremes[3]** |  |  |  | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

 [VA1]Wouter: Definition of surface inundation needs refinement since surface inundation will likely occur at the sub-pixel level and not cover full footprints

### Comment 1

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Timeliness: same comment as for surface soil moisture. (- Timeliness should be updated to: T (48h), B (6 hours), G (3 hours). | |

## ECV Product: Root zone soil moisture

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| --- | --- | --- | --- | --- | --- |
| **Name** | Root zone  soil moisture | | | | |
| **Definition** | The root-zone soil moisture content refers to the average water content in the root-zone | | | | |
| **Unit** | m3/m3 | | | | |
| **Note** | There is no agreed definition of the depth of the root-zone layer. Considering that many in situ networks have sensors up to a depth of about 30 cm, a first definition of the root-zone layer may be 0-30 cm or similar ranges. Measuring the water content in the root-zone is either not possible (e.g. when using microwave satellites) or costly (e.g. using in situ measurements). Hence, the root-zone soil moisture content has initially not been considered by GCOS. However, as most applications require information about the soil moisture content in deeper soil layers, the root-zone soil moisture content was added to the ECV soil moisture in the GCOS 2016 Implementation Plan. Because it is relatively new variable, all specifications given above should be regarded with care. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km | Size of grid cell | G | 1 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface (convective rainfall, orographic effects, etc.) |
| B | 10 | Same as for Surface Soil Moisture: Many climate and earth system models are moving to a grid size of 10 km or finer. |
| T | 50 | Same as for Surface Soil Moisture: This definition reflects a practical understanding of the boundary between climate science and other related geoscientific fields such as hydrology, agronomy, or ecology. |
| **Vertical Resolution** | N/A |  | G | 5 | This is just a wild guess and needs to be discussed with LSM modellers |
| B | 10 | This is just a wild guess and needs to be discussed with LSM modellers |
| T | 100 | This is just a wild guess and needs to be discussed with LSM modellers |
| **Temporal Resolution** | hours | Time between measurements | G | 6 | Same as for Surface Soil Moisture: Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface; Needed to depict the interplay between soil moisture, precipitation and evaporation |
| B | 24 | Same as for Surface Soil Moisture: Needed for closing water balance at daily scales |
| T | 48 | Same as for Surface Soil Moisture: Important land-atmospheric processes are missed, but drying and wetting trends can be depicted. |
| **Timeliness** |  |  | G | 1 week | Same as for Surface Soil Moisture: For climate communication and improved preparedness |
| B | 1 month | Same as for Surface Soil Moisture: To support the assessment of on-going extreme events (droughts, extreme wetness) |
| T | 1 year | Same as for Surface Soil Moisture: For assessments and re-analysis |
| **Required Measurement Uncertainty** | m3/m3 | Unbiased root mean square error | G | 0.03 | Same as for Surface Soil Moisture: More demanding goal is probably unrealistic due to high variability of soil moisture at small-scales due to changes in soil properties, topography, vegetation cover |
| B | 0.04 | Same as for Surface Soil Moisture: Accuracy goal as first adopted for the dedicated soil moisture satellites SMOS and SMAP. Later adopted for GCOS, and reconfirmed at the 4th Satellite Soil Moisture Validation and Application Workshop (Wagner, W., T.J. Jackson, J.J. Qu, R. de Jeu, N. Rodriguez-Fernandez, R. Reichle, L. Brocca, W. Dorigo (2017) Fourth Satellite Soil Moisture Validation and Application Workshop, GEWEX News, 28(4), 13-14.) |
| T | 0.08 | Same as for Surface Soil Moisture: This value traces back to the accuracy goals as specified for the SMOS and SMAP satellites designed for measuring soil moisture. |
| **Stability** | m³/m³ per reference period (> 1 year) |  | G | 0.005 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| B | 0.01 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| T | 0.02 | Same as for Surface Soil Moisture: This value still lacks justification in the scientific literature and needs to be critically assessed. |
| **Standards and References** |  | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | Yes | No | as soil moisture may change significantly within short distances due to changes in soil properties and topography, climate change adaption measures will have to take this fine-scale variability into account. Furthermore, the expansion of irrigation systems requires new approaches for monitoring.  No, in particular the requirements for the spatial resolution would have to be pushed beyond the current goal value of 1 km, e.g. to 100 m. | | |
| **Extremes[3]** | Yes | Yes | soil moisture is highly relevant for monitoring of hydrometeorological extremes such as floods and droughts, etc.  for the dry end, but not for wet extremes. In particular for very fast events such as intense precipitation and flash floods the requirements for the temporal sampling should be pushed beyond the goal value of 6 hours, i.e. to 1 hour. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Vertical resolution: it is not clear if it refers to the number of layers of soil depth. In terms of depth it should be 100 cm as a Goal, 50 cm as a Threshold and 75 cm (B).  Timeliness: same comment as for surface soil moisture  Uncertainty: same comment as for surface soil moisture | |

### Comment 2

|  |  |
| --- | --- |
| Author: Annett Bartsch | Email: Annett.Bartsch@polarresearch.at |
| The horizontal resolution requirement for permafrost related applications is 1m to 100m. Vertical resolution requirement is 10 cm. See NRC (2014). The required depth is not confined to the root zone, it corresponds to the thickness of the active layer.  National Research Council (2014). Opportunities to Use Remote Sensing in Understanding Permafrost and Related Ecological Characteristics: Report of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/18711. | |

## ECV Product: Surface soil moisture (Also sometimes referred to as topsoil moisture, surface wetness, surface humidity

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | Surface soil moisture (Also sometimes referred to as topsoil moisture, surface wetness, surface humidity) | | | | |
| **Definition** | The depth of the topmost soil layer is often only qualitatively defined as the actual sensing depth varies with measurement technique, water content, and soil properties and usually cannot be specified with any accuracy. | | | | |
| **Unit** | m3/m3 | | | | |
| **Note** | Soil moisture refers to the average water content in the soil, which can be expressed in volumetric, gravimetric or relative (e.g. degree of saturation) units. All units can be inter-converted given the availability of soil property information (bulk density, porosity etc.), yet the use of the volumetric soil moisture content as the standard measurement unit is encouraged. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 1 | Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface (convective rainfall, orographic effects, etc.) |
| B | 10 | Many climate and earth system models are moving to a grid size of 10 km or finer. |
| T | 50 | This definition reflects a practical understanding of the boundary between climate science and other related geoscientific fields such as hydrology, agronomy, or ecology. |
| **Vertical Resolution** | N/A |  | G | 1 | For modelling bare soil evaporation and LST a very thin skin layer is required (See Dorigo et al., 2017, example from ECMWF) |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | hours |  | G | 6 | Needed to fully resolve highly-dynamic processes taking place at the land-atmosphere interface surface; Needed to depict the interplay between soil moisture, precipitation and evaporation |
| B | 24 | Needed for closing water balance at daily scales |
| T | 48 | Important land-atmospheric processes are missed, but drying and wetting trends can be depicted. |
| **Timeliness** |  |  | G | 1 week | For climate communication and improved preparedness |
| B | 1 month | To support the assessment of on-going extreme events (droughts, extreme wetness) |
| T | 1 year | For assessments and re-analysis |
| **Required Measurement Uncertainty** | m3/m3 | Unbiased root mean square error | G | 0.03 | More demanding goal is probably unrealistic due to high variability of soil moisture at small-scales due to changes in soil properties, topography, vegetation cover |
| B | 0.04 | Accuracy goal as first adopted for the dedicated soil moisture satellites SMOS and SMAP. Later adopted for GCOS, and reconfirmed at the 4th Satellite Soil Moisture Validation and Application Workshop (Wagner, W., T.J. Jackson, J.J. Qu, R. de Jeu, N. Rodriguez-Fernandez, R. Reichle, L. Brocca, W. Dorigo (2017) Fourth Satellite Soil Moisture Validation and Application Workshop, GEWEX News, 28(4), 13-14.) |
| T | 0.08 | This value traces back to the accuracy goals as specified for the SMOS and SMAP satellites designed for measuring soil moisture. |
| **Stability** | m³/m³ per reference period (> 1 year) |  | G | 0.005 | This value still lacks justification in the scientific literature and needs to be critically assessed. |
| B | 0.01 | This value still lacks justification in the scientific literature and needs to be critically assessed. |
| T | 0.02 | This value still lacks justification in the scientific literature and needs to be critically assessed. |
| **Standards and References** | Required Measurement Uncertainty :  Uncertainty refers to the error standard deviation which is assumed to be (temporally) stationary. The measurement uncertainty is commonly estimated by the unbiased Root-Mean-Square-Error (ubRMSE) over a set of so-called core-validation sites (i.e., densely-sampled situ measurement sites that are assumed to be representative for satellite-footprint-scale soil moisture conditions and dynamics), which are averaged to obtain a single representative number for retrieval quality. The application of such validation concept is pragmatic, yet a few issues should be noticed:  • Only few stations worldwide (~20) fulfil the requirements to be considered core-validation sites, which are very unlikely to be fully representative for global (uncertainty) regimes  • Uncertainties are therefore often additionally estimated over a larger set of so-called sparse sites (i.e. single station measurements) and relative to land surface models, but usually no or only an insufficient assessment of representativeness errors and/or reference data uncertainty is provided  • The impacts of site selection and estimation uncertainties are usually not investigated. Therefore, confidence ranges for measurement uncertainty estimates are hardly available.  • Measurement uncertainties alone are not a sufficient criterion for data quality. While a certain noise level (e.g., 0.04 m3/m3) might be tolerable in very dynamic soil moisture regimes, the same noise level may render a product useless in areas with lower soil moisture variability. However, in principle, the transition from mere uncertainty quantification to spatially comparable quality estimation can be easily done by transitioning to signal-to-noise ratio (SNR) based metrics.  • Uncertainty requirements commonly don’t have a traceable connection to application requirements which might differ significantly among user groups.  Taken as a whole, current concepts of specifying accuracy requirements are incomplete and partly questionable, and should therefore be revised taking into account the above described issues. Notice that EUMETSAT has recently changed their H-SAF soil moisture product requirements by specifying signal-to-noise ratio (SNR) target requirements for committed areas (global land areas excluding deserts, rainforests, and high-latitude areas with mostly frozen/snow-covered regimes) | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | Yes | No | as soil moisture may change significantly within short distances due to changes in soil properties and topography, climate change adaption measures will have to take this fine-scale variability into account. Furthermore, the expansion of irrigation systems requires new approaches for monitoring.  No, in particular the requirements for the spatial resolution would have to be pushed beyond the current goal value of 1 km, e.g. to 100 m. | | |
| **Extremes[3]** | Yes | Yes | soil moisture is highly relevant for monitoring of hydrometeorological extremes such as floods and droughts, etc.  for the dry end, but not for wet extremes. In particular for very fast events such as intense precipitation and flash floods the requirements for the temporal sampling should be pushed beyond the goal value of 6 hours, i.e. to 1 hour. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| - Vertical resolution: it is not clear if it refers to the number of layers. One layer should be the threshold. The important parameter that should be included in the ECV is the sampling depth.  - Timeliness should be updated to: T (48h), B (6 hours), G (3 hours).  - Required measurements uncertainty: Ideally it should account for land cover type as values can be different depending on the vegetation type. Also, it should be a multi-parameter approach that also accounts for Signal to noise ratio. | |

### Comment 2

|  |  |
| --- | --- |
| Author: Annett Bartsch | Email: Annett.Bartsch@polarresearch.at |
| The horizontal resolution requirement for permafrost related applications is 1m to 100m. See NRC (2014).  National Research Council (2014). Opportunities to Use Remote Sensing in Understanding Permafrost and Related Ecological Characteristics: Report of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/18711. | |

### Comment 3

|  |  |
| --- | --- |
| Author: MRI Scnatweb | Email: mountainresearchinitiative@gmail.com |
| In mountain context soil moisture data is needed for instance for ecological changes such as treeline shift. Although RS data available, daily in-situ data needed across ecotones and transects.  Based on discussions and preliminary outcomes of the GEO GNOME workshop for identifying ECVs to monitor and understand mountain climate change. More information on the workshop here: LINK. | |