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

# Surface temperature

## ECV Product: Air Temperature near Surface

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| **Name** | Air Temperature near Surface | | | | |
| **Definition** | Air temperature at a known height above surface, with the height specified in the metadata | | | | |
| **Unit** | K | | | | |
| **Note** | The terminology used here for Tx and Tn and the observing cycle only applies to land-based meteorological stations. Observations made over the ocean are not static, being mostly recorded by mobile ships and drifting buoys (Kent et al., 2019). Requirements for marine surface observations must therefore be defined in terms of the composite accuracy and sampling of the marine observing networks to achieve comparable uncertainty thresholds at similar resolution.  Breakthrough targets are generally needed for reanalysis to make good use of these data.  The issue of timescale still isn’t that clear or fully understood. For better Reanalysis, we need more sampling down to 100km and sub-daily (hourly or 3-hourly). This is also needed for monitoring of extremes.  For global temperature averages, the current network is good enough (although the 500km sampling doesn’t get made in many regions, such as Africa).  Even if we got to the goal sampling, the uncertainty in the monthly global average temperatures would be reduced, but not by much from what it is now. However, these more stringent requirements will allow regional monthly averages to be calculated. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 10 | Thorne et al. (2018) |
| B | 100 | Thorne et al. (2018) |
| T | 500 | Threshold for horizontal resolution is based on the literature and specifically over land where correlation distances tend to be smaller than over the oceans. Thorne et al. (2018) showed via repeat sub-sampling of CRUTEM4 that well-spaced networks of the order 180 stations over the globe could recreate full-field global mean land surface air temperature estimates (see details in Jones et al., 1997) for the monthly timescale. For surface air temperature over the ocean which is taken predominantly by ships and buoys this can be challenging in remote Ocean basins (see the earlier note and Kent et al., 2019). |
| **Vertical Resolution** | N/A |  | G | N/A | N/A |
| B | N/A | N/A |
| T | N/A | N/A |
| **Temporal Resolution** | hr |  | G | Sub-hourly | Required for derivation of extreme indices. |
| B | 1 | Required for CDAS-mode reanalysis assimilation. Breakthrough is the monthly average necessary to inform the global, regional and national monitoring statements from WMO and members. |
| T | 3hr/daily  (Tx/Tm) |  |
| **Timeliness** | daily |  | G | 1/24 |  |
| B | 1 | Required for CDAS-mode reanalysis assimilation. |
| T | 30 | the monthly average is  necessary to inform the global, regional and national monitoring statements from WMO and members. |
| **Required Measurement Uncertainty** | K |  | G | 0.1 | Uncertainty is assumed to include random and systematic effects. Thorne et al. (2018)  Jones et al. (1997) |
| B | 0.5 |
| T | 1 |
| **Stability** | K/decade |  | G | 0.01 |  |
| B | 0.05 |  |
| T | 0.1 |  |
| **Standards and References** | Jones, P.D., Osborn, T.J. and Briffa, K.R., 1997:  Estimating sampling errors in large-scale temperature averages.  J. Climate 10, 2548-2568.    Kent, E.C., Rayner, N.A., Berry, D.I., Eastman, R., Grigorieva, V.G., Huang, B., Kennedy, J.J., Smith, S.R. and Willett, K.M., 2019: Observing Requirements for Long-Term Climate Records at the Ocean Surface. Frontiers in Marine Science 6, Article 441, doi:10.3389/fmars.2019.00441.    Thorne, P.W., Diamond, H.J., Goodison, B., Harrigan, S. Hausfather, Z., Ingleby, N.B., Jones, P.D., Lawrimore, J.H., Lister, D.H., Merlone, A., Oakley, T., Palecki, M., Peterson, T.C., de Podesta, M., Tassone, C., Venema, V. and Willett, K.M., 2018: Towards a global land surface climate fiducial reference measurements network. Int. J. Climatol. 38, 2760-2774,  https://doi.org/10.1002/joc.5458. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** | yes | yes | Horizontal and temporal resolution | | |

[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

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| Author: Andrea Merlone | Email: a.merlone@inrim.it |
| The required uncertainty can only be requested as instrumental uncertainty, since for near surface air temperature measurement uncertainties are cannot yet be fully evaluated, due to the many influencing factors. The overall measurement uncertainty should be divided into: Instrumental uncertainty, influencing factors on the instrument, environmental uncertainties (siting) influencing the measurand and its representativeness. | |

### Comment 2

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| Author: Wilberforce Kikwasi - Tanzania Met Authority | Email: wkikwasi@gmail.com |
| The stated requirement looks fine. | |

### Comment 3

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| Author: David Berry (NOC) | Email: david.inglis.berry@googlemail.com |
| **General comments:**  The current and proposed entries in the rolling review of requirements for near surface air temperature are problematic due to a one size fits all approach and the lack of clarity over the expected use case. Clarity is also required as to whether the rolling review is targeted at individual observations or aggregated / gridded products. For example, the threshold horizontal resolution is listed as 500 km, does this mean we need the areal mean on a 500km by 500km grid or that we need one observation every 500 km? I have understood the rolling review to mean the former (500 x 500 km grid) but I know others have interpreted it as the later. This creates problems when it comes to designing / assessing observing systems and measuring performance against KPIs based on the rolling review as the target is ambiguous.  Looking at the guidelines for reviewing the GCOS ECV Product requirements my above comments are consistent with those guidelines.  **Specific comments**  Name / Definition  I would separate the entry into two separate entries, one focussed on the requirements for “mean air temperature near the surface” and another for “air temperature extremes near the surface”. This would make both the process of defining the requirements and the assessment of the observing systems against the requirements easier. This is also in agreement with the guidelines for making clear the ECV product under discussion.  Under definition I would clarify that the air temperature is required at a common reference height, typically at 2m over land and 10m over the ocean.  **Note**  It is important to note / stress that observations are rarely made at a common reference height, especially over the oceans and that in order to adjust the data to a common reference height coincident measurements of the near surface humidity, wind speed, surface temperature and pressure are all required. This is in addition to accurate estimates of the measurement height. This needs to be made clear in the rolling review, air temperature measurements on their own will not meet the threshold requirement.  Under the notes I would also highlight the applications that the different requirements are targeted at. For example, the threshold requirements are aimed at monitoring long term, global temperature changes, the breakthrough requirements are focussed on regional monitoring and the goal requirements focussed on local monitoring.  **Horizontal resolution**  There is little justification in Jones et al. (1997) or Thorne et al. (2018) for the indicated goal or breakthrough requirements for climate monitoring purposes. Given that the rolling review, and GCOS implementation plan, will be used to guide the evolution of observing systems with associated cost implications a better (more defensible) justification of the requirements is needed. The 500 km threshold level seems reasonable but again the Thorne et al paper suggests a much coarser resolution would meet the requirement. One station every 500 km would equate to ~1850 stations globally or ~550 over land assuming 30% land cover. This is ~ 3 times the number stated in Thorne et al. for the number of stations over land.  For the numbers to be defensible I would suggest the use of ERA5 or similar and sub-sample the data at different resolutions and compare against the global, regional and local means to determine the resolution required to meet the uncertainty requirement. Alternatively, the work of Jones et al. could be used to derive theoretical numbers.  **Temporal resolution**  My comments under the horizontal resolution are also applicable here.  **Timeliness**  Is hourly timeliness really required as the goal for climate monitoring? Here I think it is useful to make the distinction between observations and ECV products. I can understand the need for hourly timeliness in data assimilation, whether NWP or CDAS, but are the ECV products required within an hour of the product being produced? Are ECMWF, for example, going to release the latest reanalysis estimates within an hour of the analysis and who would the end user be? A more sensible set of requirements might be 1 month, 1 week and 1 day.  **Required measurement uncertainty**  My understanding is that these are the 2 sigma (95 % CI) measurement uncertainty due to instrumental errors. Consideration also needs to be given to sampling errors (not covered in the GUM), especially for the lower resolution products, and an estimate of the total uncertainty requirements made.  Noting that the uncertainties are the 2 sigma instrumental uncertainties, these look overly stringent, especially at the threshold level. Assuming a 1 sigma uncertainty of 0.5 K and 3 hourly observations, the instrumental uncertainty in the 500 km resolution monthly mean would be ~ 0.03 K (or 0.06K @ 2 sigma). Across 550 stations (based on 500km sampling) this would reduce to an uncertainty of < 0.01 K in the global mean, assuming there are no systematic or correlated effects. This does not include the uncertainty due to sampling errors.  **Stability**  In contrast to my other comments, the threshold stability looks far too high, this implies that over a century we would be happy with a 1 K drift due to a changing observing system, coverage and other inhomogeneities. I would have expected the values to be at least an order of magnitude smaller.  **Coverage**  Some guidance on the coverage requirements is required. For example, what proportion of the globe is required to be observed / covered by the ECV product to meet the different threshold, breakthrough and goal requirements?  **Metrics**  As per the guidelines, it would be very helpful to have the metrics column included for the above requirements to indicate whether we are talking about point observations in time / space, spatiotemporal means etc.  **Background information**  It would be helpful to make use of this to expand on the justification for the above requirements, similar to that done in the example for ECV wind product (wind vector (horizontal) in the boundary layer). Here some distinction can be made between the purely observational products and products such as the reanalyses. | |

### Comment 4

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| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| In our view the stated requirements look appropriate for climate monitoring.  Also "surface temperature" is confusing for an atmospheric ECV. We'd suggest rename it as "near-surface air temperature" to make a clear difference with "Land surface temperature". | |

### Comment 5

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| Author: MRI Scnatweb | Email: mountainresearchinitiative@gmail.com |
| For snow melt and run off in mountains spatial resolution of <500m with daily to sub daily measurements would be needed. Much better network of in situ measurements needed in mountain environments. Surface or near surface T is often used as a proxy that correlates well with other temperatures affecting biological processes. Modelled data: hard to model temperature inversion and low temperature from e.g. air pooling that can be key for persistence of organisms. Remote sensing data: Vegetation cover is integrated in the resulting detected temperature. | |

## ECV Product: Sea Ice Surface Temperature

No table in the Group

### Comment 1

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| Author: Jacob Høyer | Email: jlh@dmi.dk |
| Below is a document with a rationale for why Sea Ice Surface Temperature (IST) should be regarded as an ECV.  Included is also a requirement table. | |

**Rationale for Sea Ice Surface Temperature as an ECV**

Surface temperature observations are essential contributions to our understanding of the Earth’s climate and how it is changing. Sea Surface Temperature (SST), which is generally defined as the surface temperature over open ocean with little or no sea ice cover, is recognized as an Essential Climate Variable (ECV) (GCOS, 2016). In addition, Land Surface Temperature (LST) was identified as an ECV in 2016 and includes all surface temperatures over land areas, including land surfaces covered by snow or ice. Finally, Lake Surface Water Temperature (LSWT) was included in the Lakes ECV (GCOS, 2016). One type of surface temperature is missing from a “whole-Earth” perspective as recognized in Merchant et al.(2013) that is: sea ice surface temperature (IST).

Observations of the surface temperature of the sea ice have been performed for many decades from both satellite and in situ observations. Consistent split window infrared (IR) satellite records started in 1981 with the launch of the AVHRR/2 instrument on board NOAA 7 and in situ observations of sea ice surface temperature has existed for many more years. In a user requirement survey conducted by the ESA Sea Ice CCI project (SICCI-URD, 2012 ) the IST was given priority 1 and ranked by the users as the 4th most important parameter out of 22, only exceeded by parameters such as sea ice concentration, sea ice mean thickness and sea ice thickness distribution.

Several recent initiatives have been focusing upon measuring the sea ice surface temperature using in situ and satellite observations. IST can be determined from thermal emission at wavelengths in IR or Microwave atmospheric windows. The infrared instruments observe the radiation from the upper micrometers of the snow or sea ice surface, whereas the MW emission originates from the snow-ice interface temperature (see e.g. Tonboe et al., 2011). The IST from IR and MW can therefore be similar or very different, depending upon the snow cover on top of the sea ice. IST from IR satellites is always the skin surface and is thus used more widely for operational and climate applications.

In situ observations of the skin snow and ice surface is a difficult task using e.g. traditional buoy and air temperature measurements, whereas the temperatures can be estimated with a thermal infrared radiometer. Protocols for IST validation were developed within the ESA project Fiducial Reference Measurements For Satellite Derived Surface Temperature Measurements (FRM4STS). FRM4STS aimed at establishing SI traceability of global Fiducial Reference Measurements (FRM) for satellite derived surface temperature product validation (Theocharous et al., 2016). The focus was on surface temperature for all types of surfaces, including the sea ice, using self-calibrating infrared radiometers (see e.g., Høyer et al., 2017). Among the top recommendations from the project was the establishment of FRM observation sites for IST validation, performing observations traceable to SI units.

Operational level 2 satellite products from IR and MW observations are currently being produced for the polar regions by EUMETSAT, NASA and NOAA from the Metop and NOAA AVHRRs, (A)ATSR, VIIRS, MODIS, Sentinel3 SLSTR (in progress) and IASI instruments with a spatial resolutions from 1-12 km. In addition, downstream level 4 products are delivered within the Copernicus Marine Environment Monitoring System (CMEMS) for the Arctic SST and IST. Long term IST data records combining data from sensors in series have also been produced, such as for the AVHRRs and ATSRs (Dodd et al., 2019; ESA DUE GlobTemperature; Høyer et al., 2019) and the 34 year AASTI (version 2) IST data record based on the CLARA version 2 climate data record (Karlsson et al., 2017) using the OSISAF IST algorithm (Dybkjær et al., 2018).

User requirements surveys for IST have been carried out in several projects, such as: ESA SI CCI project, EUMETSAT Position Paper (Stammer et al., 2007; GCOS, 2016; CLiC , 2012; CMEMS 2016, 2017 & 2020; Copernicus 2018a, 2018b). However, the IST requirements are for some cases more than 10 years old, they differ in their nature and in the numbers. In addition, due to the lack of traceable IST FRM in situ observations it is difficult to test if a satellite product meets the user requirements in terms of accuracy, precision and stability.

There is thus a need for a community consensus on the IST requirements for climate applications to facilitate a common validation and uncertainty characterization within different satellite and in situ providers covering the Polar Seas ice surface temperature. Including IST as an ECV within the GCOS and WMO framework could ensure a consistent approach on the “whole Earth” perspective for surface temperatures and facilitate a wider user uptake of IST observations.

**Summary points**

* Operational and climate data records of satellite based IST are currently available from Infrared and Passive Microwave observations from several space agencies and services.
* Existing initiatives have been working with IST FRMs and establishing protocols for validating and characterizing sea ice surface temperatures.
* Measurements of IST play a key role in describing the physics of sea ice processes in the Polar regions.
* IST from Infrared observations provides a globally consistent satellite record of clear-sky, radiative temperatures of the Earth’s sea ice surface Observations from microwave instruments provide additional information through an all-sky global coverage of the snow and sea ice interface temperature. These records complement the satellite based SST, LST and LSWT records.
* IST plays a key role in surface energy balances in the Polar regions.
* IST can be used to derive the near surface air temperature in the Polar regions, which are sparse with in situ observations.
* There is a need for a community consensus on the user requirements for IST. The existing user requirements for IST are old and there is a spread of the user requirements within the different surveys.

**References:**

CLiC (2012) Observational needs for sea ice models - Short note. Discussion note from CLiC Arctic Sea Ice Working Group, http://www.climate-cryosphere.org/about, 2012.

CMEMS (2016) Bertino, L., L.A. Breivik, F. Dinesen, Y. Faugere, G. Garric, B. Hackett, J. A. Johannesen, T. Lavergne, P.-Y. LeTraon, L.T. Pedersen, P. Rampal, S. Sandven & H. Shyberg. Position paper Polar and snow cover applications User Requirements Workshop Brussels, Copernicus Marine Environment Monitoring Service, Mercator Ocean.

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Høyer, J. L. Lang, A., Tonboe, R, Eastwood, S. Wimmer, W. and Dybkjær, G. (2017) Report from Field Inter Comparison Experiment (FICE) for ice surface temperature. FRM4STS report OP-40. (http://www.frm4sts.org/wp-content/uploads/sites/3/2017/12/OFE-OP-40-TR-5-V1-Iss-1-Ver-1-Signed.pdf)

Høyer, J. L., Alerskans, E., Nielsen-Englyst, P., Thejll, P., Dybkjær, G., & Tonboe, R. (2017). Technical Report Detailed investigation of the uncertainty budget for Non-recoverable IST observations and their SI traceability.

Høyer, J. L., Dybkjær, G., Eastwood, S. and Madsen, K. S.: EUSTACE/AASTI (2019) Global clear-sky ice surface temperature data from the AVHRR series on the satellite swath with estimates of uncertainty components, v1.1, 2000-2009, Centre for Environmental Data Analysis. [online] Available from: http://catalogue.ceda.ac.uk/uuid/60b820fa10804fca9c3f1ddfa5ef42a1.

Karlsson, Karl-Göran; Anttila, Kati; Trentmann, Jörg; Stengel, Martin; Meirink, Jan Fokke; Devasthale, Abhay; Hanschmann, Timo; Kothe, Steffen; Jääskeläinen, Emmihenna; Sedlar, Joseph; Benas, Nikos; van Zadelhoff, Gerd-Jan; Schlundt, Cornelia; Stein, Diana; Finkensieper, Stephan; Håkansson, Nina; Hollmann, Rainer; Fuchs, Petra; Werscheck, Martin (2017): CLARA-A2: CM SAF cLoud, Albedo and surface RAdiation dataset from AVHRR data - Edition 2, Satellite Application Facility on Climate Monitoring, DOI:10.5676/EUM\_SAF\_CM/CLARA\_AVHRR/V002, https://doi.org/10.5676/EUM\_SAF\_CM/CLARA\_AVHRR/V002.

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| Name | Sea Ice Surface Temperature (IST) | | | | | |
| Definition | Snow and Ice skin temperature | | | | | |
| Unit | Kelvin | | | | | |
| Note | The IST requirements below are based on several requirement/recommendation documents from relevant communities and institutions, e.g. WMO, GCOS, GMES, Copernicus/CMEMS, ESA CCI, and other. Requirements for IST range widely in both in values and metric and the given values are based on these documents and expert judgments from the OSISAF High Latitude team. The main requirements cover infrared satellite IST. Specific Microwave derived IST (snow-ice interface temperature) requirements are stated in parenthesis. | | | | | |
| Requirements | | | | | | |
| Item needed | **Unit** | **Metric** | **[[1]](#footnote-1)** | | **Value** | **Derivation and References and Standards** |
| Horizontal Resolution | km | Km | G | | 1 (5) | GCOS, GMES, Copernicus/CMEMS |
| B | | 5 (15) | GCOS, GMES, Copernicus/CMEMS |
| T | | 25 (50) | WMO |
| Vertical Resolution |  |  | G | | Skin (snow-sea ice int.) | Determined by sensor – i.e. Thermal Infrared is skin, Microwave is snow-sea ice interface temperature |
| B | | Skin (snow-sea ice int.) |  |
| T | | Skin (snow-sea ice int.) |  |
| Temporal Resolution | Hour | Hour | G | | 1 | GCOS, Copernicus/CMEMS, enable diurnal analysis |
| B | | 3 | GCOS, Copernicus/CMEMS, enable diurnal analysis |
| T | | 24 | GCOS, Copernicus/CMEMS, enable seasonal and long term trend analysis |
| Timeliness | Hour | Hour | G | | 1 | GMES, For use in sea ice services |
| B | | 3 | For operational use |
| T | | N/A | For climate analysis – Non Time Critical |
| Required Measurement Uncertainty | K | STD | G | | 0.5 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| B | | 1.5 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| T | | 3.0 | Copernicus/CMEMS, GMES, EUMETSAT/OSISAF, Dybkjær et al., 2019 |
| Stability | K/decade |  | G | | 0.1 | As defined in the GCOS LST ECV requirements |
| B | | 0.2 |  |
| T | | 0.3 | As defined in the GCOS LST ECV requirements |
| Standards and References | CLiC (2012) Observational needs for sea ice models - Short note. Discussion note from CLiC Arctic Sea Ice Working Group, http://www.climate-cryosphere.org/about, 2012.  *CMEMS (2016) Bertino, L., L.A. Breivik, F. Dinesen, Y. Faugere, G. Garric, B. Hackett, J. A. Johannesen, T. Lavergne, P.-Y. LeTraon, L.T. Pedersen, P. Rampal, S. Sandven & H. Shyberg. Position paper Polar and snow cover applications User Requirements Workshop Brussels, Copernicus Marine Environment Monitoring Service, Mercator Ocean.*  *CMEMS (2017) CMEMS requirements for the evolution of the Copernicus Satellite Component. Copernicus Marine Environment Monitoring Service, Mercator Ocean and CMEMS partners.*  *CMEMS (2020) CMEMS Dashboard Upstream Satellite Data Requirements, V10.0 March 2020 (spreadsheet)*  *Copernicus (2018a) Duchossois, G., P. Strobl, V. Toumazou (Eds.) User Requirements for a Copernicus Polar Mission Phase 1 Report - User Requirements and Priorities. JRC Technical Report, doi:10.2760/22832, 2018.*  *Copernicus. (2018b) Duchossois, G., P. Strobl, V. Toumazou (Eds.) User Requirements for a Copernicus Polar Mission Phase 2 Report - High-level mission requirements. JRC Technical Report, doi:10.2760/44170, 2018.*  Dybkjær, G., R. Tonboe, M. Winstrup and J. L. Høyer (2019) Review of state-of-the-art methods and algorithms for Ice Surface Temperature retrieval algorithms - Including consolidate and refine output product requirements and software specification, Product requirement and baseline document, version 2.3. EUMETSAT document Reference Number: EUM/OPS-COPER/19/1065840.  GCOS (2016) The Global Observing System for Climate: Implementation Needs (World Meteorological Organization, GCOS-200).  OSI SAF CDOP 3 (2018) Product Requirement Document, http://www.osi-saf.org/sites/default/files/dynamic/public\_doc/osisaf\_cdop3\_gen\_prd\_1.4.pdf, Version: 1.4, 2018  SICCI-URD (2012) Sea Ice Climate Change Initiative: Phase 1 User Requirement Document (URD) SICCI-URD-03-12 Version 1.3.  Stammer, D., Johanessen, J., LeTraon, P.-Y., Minnett, P., Roquet, H., and Srokosz, M. (2007) Requirements for Ocean Observations Relevant to post-EPS, EUMETSAT Position Paper: AEG Ocean Topography and Ocean Imaging, 10 January 2007, version 3. | | | | | |
| Adaptation and Extremes | | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | | Explanation | | |
| Adaptation[[2]](#footnote-2) | ? | ? | |  | | |
| Extremes[[3]](#footnote-3) | Yes | Yes | |  | | |

## ECV Product: Soil Temperature

### Comment 1

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| Author: Jiankai Wang | Email: asd464680@gmail.com |
| Name Soil temperature  Definition Soil temperature at different depth  Unit Celsius (℃)  Note Add the Soil temperature into Essential Climate Variables. Soil temperature is an important variable and its usage is similar to the sea surface temperature(SST) in meteorology and climate.  The difference between SST and LST. Some experts may think the land surface temperature(LST) is more like SST. In fact LST and soil temperature, the LST and SST both are very different. The SST has better relation with the sea temperature at different depth(such as 1m, 10m) than LST. As a result, the SST could represent the real thermal energy of sea which has very important usage. But the LST always could not represent the thermal energy of land. The specific heat capacity of soil is much smaller than the specific heat capacity of water. Compared to water, soils conduct heat very slowly. The LST is just the skin temperature of land and changed quickly.  The reason choosing the soil temperature.  Firstly, the soil temperature at different depth could represent the thermal energy. The standard depths for soil temperature measurements are 5, 10, 20, 50 and 100 cm below the surface according to the CIMO guide (0cm is an additional in CMA); additional depths may be included.  Secondly, The LST is more difficult to measure using thermometer insitu. The temperature sensor is difficult to fit tightly to the ground and remains stable. In the case of precipitation, the fitness will change and cause unstable measurement results. The position of the temperature sensor needs to be adjusted manually. Infrared temperature sensors are expensive, so it is difficult to build them globally.  Last but not the least, soil temperature is better to represent the soil thermal energy than LST. Soil temperature is easy to measure using thermometer(0/5/10 cm) or temperature sensor( 5/10/20/50/100 cm).  (wjkaoc@cma.gov.cn) | |

### Comment 2

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| Author: Click here to enter text. | Email: wjkaoc@cma.gov.cn |
| See below: | |

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| --- | --- | --- | --- | --- | --- |
| Name | Soil temperature | | | | |
| Definition | Soil temperature at different depth | | | | |
| Unit | Celsius (℃) | | | | |
| Note | Add the Soil temperature into Essential Climate Variables. Soil temperature is an important variable and its usage is similar to the sea surface temperature(SST) in meteorology and climate.   1. **The difference between SST and LST**. Some experts may think the land surface temperature(LST) is more like SST. In fact LST and soil temperature, the LST and SST both are very different. The SST has better relation with the sea temperature at different depth(such as 1m, 10m) than LST. As a result, the SST could represent the real thermal energy of sea which has very important usage. But the LST always could not represent the thermal energy of land. The specific heat capacity of soil is much smaller than the specific heat capacity of water. Compared to water, soils conduct heat very slowly. The LST is just the skin temperature of land and changed quickly. 2. **The reason choosing the soil temperature.**   Firstly, the soil temperature at different depth could represent the thermal energy. The standard depths for soil temperature measurements are 5, 10, 20, 50 and 100 cm below the surface according to the CIMO guide (0cm is an additional in CMA); additional depths may be included.  Secondly, The LST is more difficult to measure using thermometer insitu. The temperature sensor is difficult to fit tightly to the ground and remains stable. In the case of precipitation, the fitness will change and cause unstable measurement results. The position of the temperature sensor needs to be adjusted manually. Infrared temperature sensors are expensive, so it is difficult to build them globally.  Last but not the least, soil temperature is better to represent the soil thermal energy than LST. Soil temperature is easy to measure using thermometer(0/5/10 cm) or temperature sensor( 5/10/20/50/100 cm). | | | | |
| Requirements | | | | | |
| Item needed | **Unit** | **Metric** | **[[4]](#footnote-4)** | **Value** | **Derivation and References and Standards** |
| Horizontal Resolution | km | 2.5 degrees of longitude | G | 50 | ***GUIDE TO THE GCOS SURFACE NETWORK (GSN) AND GCOS UPPER-AIR NETWORK (GUAN) (GCOS-144) (WMO/TD No. 1558):***  For the GSN, the horizontal distance between two network stations should not be less than the length of 2.5 degrees of longitude at that location (278 km at the equator). For stations beyond 60 degrees latitude (north or south) the minimum distance is fixed at the length of 2.5 degrees of longitude at 60 degrees latitude (139 km). Consequently, the minimum spacing varies from 278 km at the equator to 139 km in the polar regions.  Goal, Breakthrough: according to requirement from the OSCAR about the sea surface temperature |
| B | 150 |
| T | 139-278 |
| Vertical Resolution | cm |  | G | 0,5,10,20,50,100,180 | ***WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION (WMO-No.8):***  The standard depths for soil temperature measurements are 5, 10, 20, 50 and 100 cm below the surface; additional depths may be included.  LST is important for the satellite observation. So zero depth could be included.  Goal: At the depth of 180cm the temperature is useful for long term climate monitor and prediction.  Breakthrough: Automatic Weather Station observe could observe the soil temperature at these depth.  Threshold: The thermometer can be used at these depth. Suitable for observing stations without automatic weather stations. |
| B | 0,5,10,20,50,100 |
| T | 0,5,10,20 |
| Temporal Resolution | h |  | G | 3 | ***GUIDE TO THE GCOS SURFACE NETWORK (GSN) AND GCOS UPPER-AIR NETWORK (GUAN) (GCOS-144) (WMO/TD No. 1558):***  Regarding surface synoptic observations: the main standard times shall be 0000, 0600, 1200 and 1800 UTC. The intermediate standard times shall be 0300, 0900, 1500 and 2100 UTC. Every effort should be made to obtain surface synoptic observations four times daily at the main standard times, with priority being given to the 0000 and 1200 UTC observations required for global exchanges. |
| B | 6 |
| T | 24 |
| Timeliness | N/A |  | G |  |  |
| B |  |
| T |  |
| Required Measurement Uncertainty | K |  | G | 0.1 K | ***WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION (WMO-No.8):***  Sea-surface temperature Achievable measurement uncertainty: 0.2 K  Sea-surface temperature required measurement uncertainty: 0.1 K |
| B | 0.2 K |
| T | 0.2 K |
| Stability |  |  | G |  |  |
| B |  |
| T |  |
| Standards and References | ***WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION (WMO-No.8)***  ***GUIDE TO THE GCOS SURFACE NETWORK (GSN) AND GCOS UPPER-AIR NETWORK (GUAN) (GCOS-144) (WMO/TD No. 1558)*** | | | | |
| Adaptation and Extremes | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| Adaptation[[5]](#footnote-5) | Y | Y | Can be used to monitor frozen ground conditions. | | |
| Extremes[[6]](#footnote-6) | Y | Y | Monitoring of meteorological drought is critical. | | |

### Comment 3

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| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| We agree that Soil Temperature should be considered in the list of ECVs, or at least be a product of Land surface temperature. Part of the energy absorbed by the Earth' surface is stored in the continental masses, with all consequences in surface and surface-near surface physical processes. Soil temperature can be used as a climate indicator over sufficient long time series. We also propose to list as products a shallow-layer soil temperature (up to 5 cm) and a deeper soil temperature up to 1 meter.  Horizontal resolution (km): the current technology should allow to improve the horizontal resolution: T (100), B (50), G (10).  Timeliness almost similar as temporal resolution, with a threshold of 48h | |

1. Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review) [↑](#footnote-ref-1)
2. Is the ECV Product directly relevant to support Climate Adaptation? [↑](#footnote-ref-2)
3. Can the ECV Product be used to monitor climate extremes or aspects of extremes? [↑](#footnote-ref-3)
4. Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review) [↑](#footnote-ref-4)
5. Is the ECV Product directly relevant to support Climate Adaptation? [↑](#footnote-ref-5)
6. Can the ECV Product be used to monitor climate extremes or aspects of extremes? [↑](#footnote-ref-6)