

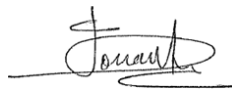


MOTECUSOMA

MONITORING THE ENERGY CYCLE FOR A BETTER UNDERSTANDING OF CLIMATE CHANGE

CCI CROSS-ECV PROJECT

ECV INVENTORY DOCUMENT

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1 Introduction

1.1 Scope and objective

This document is the ECV Inventory Document (EID, D1.2) for the ESA MOTECUSOMA project ([AD-1] and [AD-2]). It aims at identifying all relevant ECV necessary to produce and evaluate the mean, trend and variability of the EEI and TAS.

It will provide information about the data providers, time and spatial coverage, time and spatial resolution, availability of uncertainties and associated documentation.

This task also aims at identifying the other types of data needed in this project to conduct the development tasks and scientific analyses. They are mainly in-situ, climate model simulations and re-analyses covering ocean and atmosphere.

1.2 Document structure

In addition to this introduction, the document is organised to give a description per type of data:

- Essential Climate Variables (section 2.1)
- Models re-analyses (section 2.2)
- In-Situ Observations (section 2.3)

1.3 Related documents

1.3.1 Applicable documents

Table 1 List of applicable documents.

Id.	Ref.	Description
[AD1]		ESA-EOP-SC-AMT-2023-21 : Call to tender CLIMATE-SPACE - THEME II: CROSS-ECV ACTIVITIES
[AD2]	MAG-24-PTF-023	Detailed MAGELLIUM offer in response to ESA/ECSAT Request for Quotation "CCI CROSS ECV" AO/1-12062/23/I-NB

1.4 Acronyms

Table 2 List of abbreviations and acronyms.

Synonym	Description
ECV	Essential Climate Variable
EEI	Earth's Energy Imbalance
EO	Earth Observation
FDRs	Fundamental Data Records
FIDUCEO	Fidelity and uncertainty in climate data records from Earth observation
FRMs	Fiducial Reference Measurements
GEOSS	Global Earth Observation System of Systems
GIOMAS	Global Ice-Ocean Modeling and Assimilation System
GMSL	Global Mean Sea Level
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LRM	Low Resolution Mode
MSL	Mean Sea Level
NMI	National Metrology Institute
PDAP	Payload Data Acquisition and Processing
PDO	Pacific Decadal Oscillation
PTR	Point Target Response
QA4EO	Quality Assurance Framework for Earth Observation
SAR	Synthetic Aperture Radar
SI	International System of Units
SLA	Sea Level Anomaly
SLBC2	Phase 2 of the ESA Sea Level Budget Closure climate change initiative project

SLR	Sea Level Rise
SLR-SUB	Sea Level Rise Stability Uncertainty Budget
SROCC	Special Report on the Ocean and Cryosphere
SSB	Sea State Bias
SSH	Sea Surface Height
SWH	Significant Wave Height
USO	Ultra Stable Oscillator

2 Data description

2.1 ECVs

2.1.1 Earth Energy Imbalance

2.1.1.1 Ocean Heat Content

2.1.1.1.1 Absolute Sea Level

Table 3: Description of the absolute sea level data.

Data product name	Sea level gridded data from satellite observations for the global ocean from 1993 to present
Version	vDec2021
Variable(s) [units]	sla [m] tpa_correction [m]
Short description	Level 4 product of total sea level anomaly
Spatial resolution	0.25°x0.25°
Spatial coverage	global ocean
Temporal resolution	daily
Temporal coverage	01/01/1993-07/06/2023, no gaps
File format	netCDF-4 [.nc]
File size	312 Mb / year (~850-890 Kb / daily file)
Source	Copernicus Climate Change Service (C3S)

Access point	DOI: 10.24381/cds.4c328c78 https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-sea-level-global?tab=form [last access: 09/02/2024]
Access conditions	public (account needed)
Citation/acknowledgments	Copernicus Climate Change Service, Climate Data Store, (2018): Sea level gridded data from satellite observations for the global ocean from 1993 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.4c328c78 (Accessed on DD-MMM-YYYY)
Comments	The tpa_correction variable is used to correct the sea level anomaly for the TOPEX-A altimeter drift as well as a drift for the Jason-3 wet troposphere correction (WTC) using the file provided by Brown et al. (2023).

2.1.1.1.2 Manometric sea level

Table 4 Description of the manometric sea level from Spherical Harmonics

Data product name	Manometric sea level gridded data based on Spherical Harmonics from satellite observations for the global ocean from 2002 to present
Version	V4.0
Variable(s) [units]	ts_ewh [m]
Short description	GRACE ensemble L3 v2.0 updated from Blazquez et al., (2018)
Spatial resolution	1°x1°
Spatial coverage	global ocean
Temporal resolution	monthly
Temporal coverage	01/02/2024-07/06/2023, gaps between ...
File format	netCDF-4 [.nc]
File size	6 Go
Source	
Access point	DOI: 10.24400/527896/a01-2023.011 https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/barystatic-and-manometric-sea-level-changes-from-satellite-geodesy.html
Access conditions	public (account needed)
Citation/acknowledgments	Blazquez, A., Meyssignac, B., Lemoine, J.-M., Berthier, E., Ribes, A., Cazenave, A. (2018). Exploring the uncertainty in GRACE estimates of the mass redistributions at the Earth surface: implications for the global water and sea level budgets, Geophysical Journal International, 215 (1), 415–430, https://doi.org/10.1093/gji/ggy293

Comments	
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2.1.1.2 Ice sheet

Table 5: Description of IMBIE aggregated dataset for IPCC AR6.

Data product name	IMBIE aggregated dataset for IPCC AR6
Version	1.0
Variable(s) [units]	Mass balance [Gt] and cumulative mass balance [Gt/yr]
Short description	Ice sheet Mass Balance Intercomparison Exercise (IMBIE) dataset aggregated from 50 independent estimates of ice sheet mass balance
Spatial resolution	None. Datasets are available for AIS, EAIS, WAIS, AP, GIS
Spatial coverage	Antarctica Ice Sheet (AIS), East Antarctica Ice Sheet (EAIS), West Antarctica Ice Sheet (WAIS), Antarctica Peninsula (AP), Greenland Ice Sheet (GIS)
Temporal resolution	monthly
Temporal coverage	1992-01 – 2020-12
File format	ASCII (CSV)
File size	< 20 kB
Source	Ice-sheet Mass Balance Inter-comparison Exercise (IMBIE)
Access point	https://doi.org/10.5285/77B64C55-7166-4A06-9DEF-2E400398E452
Access conditions	public
Citation/acknowledgments	IMBIE Team: Antarctic and Greenland Ice Sheet mass balance 1992–2020 for IPCC AR6 (Version 1.0), UK Polar Data Centre, Natural Environment Research Council, UK Research & Innovation [data set], https://doi.org/10.5285/77B64C55-7166-4A06-9DEF-2E400398E452 , 2021
Comments	

Table 6: Description of IMBIE aggregated dataset for IPCC AR6.

Data product name	IMBIE aggregated dataset for IPCC AR6
Version	1.0
Variable(s) [units]	Mass balance [Gt] and cumulative mass balance [Gt/yr]

Short description	Ice sheet Mass Balance Intercomparison Exercise (IMBIE) dataset aggregated from 50 independent estimates of ice sheet mass balance
Spatial resolution	None. Datasets are available for AIS, EAIS, WAIS, AP, GIS
Spatial coverage	Antarctica Ice Sheet (AIS), East Antarctica Ice Sheet (EAIS), West Antarctica Ice Sheet (WAIS), Antarctica Peninsula (AP), Greenland Ice Sheet (GIS)
Temporal resolution	monthly
Temporal coverage	1992-01 – 2020-12
File format	ASCII (CSV)
File size	< 20 kB
Source	Ice-sheet Mass Balance Inter-comparison Exercise (IMBIE)
Access point	https://doi.org/10.5285/77B64C55-7166-4A06-9DEF-2E400398E452
Access conditions	public
Citation/acknowledgments	IMBIE Team: Antarctic and Greenland Ice Sheet mass balance 1992–2020 for IPCC AR6 (Version 1.0), UK Polar Data Centre, Natural Environment Research Council, UK Research & Innovation [data set], https://doi.org/10.5285/77B64C55-7166-4A06-9DEF-2E400398E452 , 2021
Comments	Identical to entry for GIS

2.1.1.3 Atmosphere Heat Content

Table 7: Description of the Atmosphere Heat Content data.

Data product name	ESA Water Vapour Climate Change Initiative (Water_Vapour_cci): A combined high resolution global TCWV product from microwave and near infrared imagers - COMBI
Version	3.1
Variable(s) [units]	kg/m ²
Short description	ESA TCWV
Spatial resolution	0.5°x0.5°
Spatial coverage	global
Temporal resolution	monthly
Temporal coverage	2002-2017
File format	netCDF4
File size	3 MB / month
Source	HTW from ESACCI WATERVAPOUR and CM SAF

Access point	https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=COMBI_V001
Access conditions	Open access, account required
Citation/acknowledgments	Schröder, Marc; Danne, Olaf; Falk, Ulrike; Niedorf, Anja; Preusker, Rene; Trent, Tim; Brockmann, Carsten; Fischer, Jürgen; Hegglin, Michaela; Hollmann, Rainer; Pinnock, Simon (2023): A combined high resolution global TCWV product from microwave and near infrared imagers - COMBI, Satellite Application Facility on Climate Monitoring, DOI:10.5676/EUM_SAF_CM/COMBI/V001, https://doi.org/10.5676/EUM_SAF_CM/COMBI/V001 .
Comments	

2.1.1.4 Earth Energy Imbalance (CERES)

Table 8: Description of the Earth Energy Imbalance from CERES

Data product name	Clouds and the Earth's Radiant Energy System (CERES) Energy Balanced and Filled (EBAF)
Version	Edition 4.2
Variable(s) [units]	W/m ²
Short description	CERES EBAF
Spatial resolution	1°x°
Spatial coverage	global
Temporal resolution	monthly
Temporal coverage	03/2000 - 11/2024
File format	netCDF
File size	31 MB
Source	NASA
Access point	https://ceres.larc.nasa.gov/data/
Access conditions	Open access, account required
Citation/acknowledgments	Loeb, N. G., and Coauthors, 2009: Towards optimal closure of the Earth's top of atmosphere radiation budget. J. Climate, 22, 748–766, https://doi.org/10.1175/2008JCLI2637.1 .
Comments	

2.1.2 Sea Surface Temperature

2.1.2.1 Sea surface temperature (CCI analysis product)

Table 9: Description of Sea Surface temperature

Data product name	European Space Agency Sea Surface Temperature Climate Change Initiative: Analysis
Version	product version 3.0
Variable(s) [units]	daily mean sea surface temperature at 20 cm depth [K] total uncertainty in the above per datum [K]
Short description	daily-mean sea surface temperatures with gaps between available daily observations filled by statistical means (level 4 analysis)
Spatial resolution	presented on a 0.05° latitude-longitude grid,
Spatial coverage	global oceans
Temporal resolution	presented daily
Temporal coverage	1.1.1980 to 31.12.2021 as climate data record, extended as an interim climate data record to a few weeks behind present time
File format	netCDF-4
File size	15 MB per day; 260 GB total volume including ICDR
Source	CDR: ESA Climate Change Initiative. ICDR Copernicus Climate Change Service and UK Earth Observation Climate Information Service
Access point	Good, S. & Embury, O. ESA Sea Surface Temperature Climate Change Initiative (SST_cci): Level 4 Analysis product, version 3.0. NERC EDS Centre for Environmental Data Analysis https://doi.org/10.5285/4a9654136a7148e39b7feb56f8bb02d2 (2024)
Access conditions	Open
Citation/acknowledgments	Embury, O., Merchant, C.J., Good, S.A. et al. Satellite-based time-series of sea-surface temperature since 1980 for climate applications. Sci Data 11, 326 (2024). https://doi.org/10.1038/s41597-024-03147-w
Comments	Note: seamless access to the combined CDR and ICDR datasets at a user-defined resolution (such as 0.25 degree) is available at www.surftemp.net , and is recommended if 0.05 degree resolution is not required (because the uncertainty is appropriately propagated by this service).

2.1.3 Sea Ice Surface Temperature

2.1.3.1 Sea and sea-ice surface temperature (C3S analysis product)

Table 10: Description of Sea and sea-ice surface temperature

Data product name	Global L4 Sea and Sea-Ice Surface Temperature (SST/IST) Climate Data Record, Copernicus Climate Change Service
Version	product version 1.0
Variable(s) [units]	daily mean sea surface temperature at 20 cm depth [K] daily mean ice surface skin temperature [K] total uncertainty in the above per datum [K]
Short description	daily-mean sea and sea-ice surface temperatures with gaps between available daily observations filled by optimal interpolation (level 4 analysis)
Spatial resolution	presented on a 0.05° latitude-longitude grid
Spatial coverage	global oceans
Temporal resolution	presented daily
Temporal coverage	1.1.1982 to 31.12.2021 as climate data record, extended as an interim climate data record
File format	netCDF-4
File size	50 MB per day; 785 GB total volume including ICDR
Source	CDR+ICDR Copernicus Climate Change Service
Access point	CDS soon
Access conditions	Open
Citation/acknowledgments	Englyst et al. (in prep) Global satellite-based sea and sea-ice surface temperatures since 1982
Comments	

2.1.4 Ice Sheet Surface Temperature

Table 11: Description of Ice Sheet Surface Temperature

Data product name	Global L4 Ice Sheet surface temperature Climate Data Record
Version	product version 1.0
Variable(s) [units]	daily mean ice surface skin temperature [K] total uncertainty in the above per datum [K]
Short description	daily-mean ice surface temperatures with gaps between available daily observations filled by optimal interpolation (level 4 analysis)
Spatial resolution	presented on a 0.01° latitude-longitude grid
Spatial coverage	global (i.e. Greenland and Antarctic Ice Sheets and shelves)
Temporal resolution	presented daily
Temporal coverage	1.1.1982 to 31.12.2024
File format	netCDF-4
File size	
Source	
Access point	Not available yet
Access conditions	Open
Citation/acknowledgments	Karagali, I., Barfod Suhr, M., Mottram, R., Nielsen-Englyst, P., Dybkjær, G., Ghent, D., and Høyer, J. L.: A new Level 4 multi-sensor ice surface temperature product for the Greenland Ice Sheet, The Cryosphere, 16, 3703–3721, https://doi.org/10.5194/tc-16-3703-2022 , 2022.
Comments	Based on AASTI/C3S and LST_cci input data

2.1.5 Land Surface Temperature

2.1.5.1 Land surface temperature (L3C)

Table 12: Description of Land Surface Temperature (L3C)

Data product name	Global L3C Land Surface Temperature (LST) Climate Data Record
Version	product version 4.0
Variable(s) [units]	daily land surface temperature (day and night) [K] daily ice surface temperature (day and night) [K] total uncertainty in the above per datum [K]
Short description	Daily clear-sky land and land-ice surface temperatures over all land surfaces, permanent ice sheets, and transient ice/snow
Spatial resolution	Presented on a 0.05° latitude-longitude grid

Spatial coverage	Global land and land ice / ice sheets
Temporal resolution	Daily (two observations – day and night)
Temporal coverage	24.02.2000 to 31.12.2021 as climate data record, extended as an interim climate data record
File format	netCDF-4
File size	120 MB per day; ~1 TB total volume including ICDR
Source	CDR (CCI) + ICDR (EOCIS)
Access point	UK JASMIN public workspace partition (https://gws-access.jasmin.ac.uk/public/esacci_lst/)
Access conditions	Open
Citation/acknowledgments	Ghent, D., Veal, K., Trent, T., Dodd, E., Sembhi, H., and Remedios, J. (2019). A New Approach to Defining Uncertainties for MODIS Land Surface Temperature. Remote Sensing, 11, 1021. doi: 10.3390/rs11091021
Comments	LST_cci Regridding and Sub-setting Tool (https://climate.esa.int/en/projects/land-surface-temperature/) can be used to correctly regrid the data to custom resolutions including correct uncertainty propagation

2.1.5.2 Land surface temperature (L2P)

Table 13: Description of Land Surface Temperature (L2P)

Data product name	L2P Land Surface Temperature (LST)
Version	product version 4.0
Variable(s) [units]	Granule surface temperature over all land, lakes, and ice surfaces [K] total uncertainty in the above per datum [K]
Short description	Land, land-ice, and lake surface water surface temperatures over all surfaces on swath grid
Spatial resolution	Presented on a 1km native grid
Spatial coverage	Global land, ice and lakes
Temporal resolution	5 minute granules
Temporal coverage	24.02.2000 to 31.12.2021 extended to end-2024
File format	netCDF-4
File size	8.5 GB per day; >60 TB total volume
Source	CCI + EOCIS
Access point	UK JASMIN public workspace partition (https://gws-access.jasmin.ac.uk/public/esacci_lst/)

Access conditions	Open
Citation/acknowledgments	Ghent, D., Veal, K., Trent, T., Dodd, E., Sembhi, H., and Remedios, J. (2019). A New Approach to Defining Uncertainties for MODIS Land Surface Temperature. Remote Sensing, 11, 1021. doi: 10.3390/rs11091021
Comments	Primarily retained for the lake surface water surface temperatures, which isn't available in the CCI LST L3C product

2.1.6 Auxiliary Data

2.1.6.1 Digital Elevation Model

Table 14: Description of Digital elevation model

Data product name	Copernicus DEM GLO-90
Version	2024_1
Variable(s) [units]	Elevation [m] Height error [m] Water body mask
Short description	Digital Elevation Model
Spatial resolution	90m
Spatial coverage	Global
Temporal resolution	Single datafile
Temporal coverage	N/A
File format	GeoTIFF
File size	~300 GB total volume
Source	ASTER, SRTM90, SRTM30, SRTM30plus, GMTED2010, TerraSAR-X Radargrammetric DEM, ALOS World 3D-30m
Access point	Copernicus Hub (https://dataspace.copernicus.eu/explore-data/data-collections/copernicus-contributing-missions/collections-description/COP-DEM)
Access conditions	Open
Citation/acknowledgments	https://doi.org/10.5270/ESA-c5d3d65
Comments	

2.2 Models and re-analyses

2.2.1 ECMWF Reanalysis (ERA5)

Table 15: Description of ERA 5

Data product name	ECMWF Reanalysis ERA5
Version	5
Variable(s) [units]	10m u-component of wind [m s ⁻¹] 10m v-component of wind [m s ⁻¹] Sea surface temperature (°C) 2m Air temperature (°C) Dew-point temperature (°C) Sea-level pressure (hPa) Vertically integrated atmospheric total energy (J/m ²) Vertically integrated atmospheric moisture and ice contents (kg/m ²) Divergence of total atmospheric energy transport (J/m ²)
Short description	ERA5 hourly data on single levels from 1940 to present
Spatial resolution	0.25° x 0.25° regular latitude-longitude grid
Spatial coverage	Globally complete
Temporal resolution	Hourly Monthly for vertical integrals
Temporal coverage	January 1940 to the present and continues to be extended forward in near real time Divergence fields: January 1979 onward
File format	netCDF-4 or GRIB
File size	1.5GB /month/variable/ensemble member
Source	Copernicus Climate Change Service (C3S) Climate Data Store
Access point	https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels?tab=overview https://cds.climate.copernicus.eu/datasets/derived-reanalysis-energy-moisture-budget?tab=overview Or via the CDS API. See https://cds.climate.copernicus.eu/how-to-api
Access conditions	Public (account needed)
Citation/acknowledgments	Copernicus Climate Change Service (2023): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S)

	Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 (Accessed on 07-MAR-2023) Mayer, J., Mayer, M., Haimberger, L., (2021): Mass-consistent atmospheric energy and moisture budget monthly data from 1979 to present derived from ERA5 reanalysis. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.c2451f6b (Accessed on 07-02-2025)
Comments	Further information is available here: https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation This site also provides information on required citation if the data are downloaded by a method other than via the CDS web interface. It is likely that both the ensemble median and the individual members will need to be used in order to propagate uncertainty.

Table 16: Description of ERA 6

Data product name	ECMWF Reanalysis ERA6
Version	6
Variable(s) [units]	u-component of wind [m s⁻¹] v-component of wind [m s⁻¹] air temperature (°C) Specific humidity in vaporous and frozen form (g/kg) Surface geopotential (J/m²) surface pressure (hPa) Vertically integrated atmospheric total energy (J/m²) Vertically integrated atmospheric moisture and ice contents (kg/m²)
Short description	ERA6 hourly data on model levels
Spatial resolution	TCO 799
Spatial coverage	Globally complete
Temporal resolution	Hourly Monthly for vertical integrals
Temporal coverage	Eventually 1950 onward
File format	GRIB
File size	n/a
Source	ECMWF Meteorological Archiving System (MARS)
Access point	https://apps.ecmwf.int/mars-catalogue/

Access conditions	ECMWF members state user account
Citation/acknowledgments	n/a
Comments	Will become available in the course of the project

2.2.2 Japanese Reanalysis for Three Quarters of a Century (JRA3Q)

Table 17: Description of JRA3Q

Data product name	The Japanese Reanalysis for three quarters of a century (JRA-3Q)
Version	1
Variable(s) [units]	u-component of wind [m s ⁻¹] v-component of wind [m s ⁻¹] air temperature (°C) Specific humidity in vaporous and frozen form (g/kg) Surface geopotential (J/m ²) surface pressure (hPa)
Short description	JRA-3Q native grid model level data
Spatial resolution	TL479 gaussian grid, 100 vertical levels
Spatial coverage	Globally complete
Temporal resolution	6-hourly
Temporal coverage	September 1947 to the present and continues to be extended forward in near real time
File format	netCDF4
File size	36 GB / month
Source	NCAR Research Data Archive
Access point	https://rda.ucar.edu/datasets/d640000/
Access conditions	Public (account needed)
Citation/acknowledgments	Data set: DOI: 10.5065/AVTZ-1H78 Kosaka, Y., S. Kobayashi, Y. Harada, C. Kobayashi, H. Naoe, K. Yoshimoto, M. Harada, N. Goto, J. Chiba, K. Miyaoka, R. Sekiguchi, M. Deushi, H. Kamahori, T. Nakaegawa, T. Y. Tanaka, T. Tokuhira, Y. Sato,

	Y. Matsushita, and K. Onogi, 2024: The JRA-3Q Reanalysis. J. Meteor. Soc. Japan, 102, 49-109 (DOI: 10.2151/jmsj.2024-004).
Comments	

2.2.3 Modern-Era Retrospective analysis for Research and Applications (MERRA)

Table 18: Description of MERRA V2

Data product name	Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2)
Version	2
Variable(s) [units]	Vertically integrated enthalpy, latent heat, kinetic energy (J/m2) Divergence of vertically integrated transport of enthalpy, latent heat, kinetic energy (W/m2) Surface pressure (hPa)
Short description	MERRA-2 integrated budget quantities
Spatial resolution	0.5x0. 625° lat/lon
Spatial coverage	Globally complete
Temporal resolution	monthly
Temporal coverage	January 1980 to the present and continues to be extended forward in near real time
File format	netCDF4
File size	17 MB / month
Source	NASA Earth observing system data and information system
Access point	https://disc.gsfc.nasa.gov/
Access conditions	Public (account needed)
Citation/acknowledgments	Global Modeling and Assimilation Office (GMAO) (2015a) MERRA-2 tavgM_2d_int_Nx: 2d, monthly mean, time-averaged, single-level, assimilation, vertically integrated diagnostics V5.12.4. https:// doi. org/ 10. 5067/FQPTQ 4OJ22 TL Global Modeling and Assimilation Office (GMAO) (2015b) MERRA-2 tavgM_2d_flux_Nx: 2d, monthly mean, time-averaged, single-level,

	assimilation, surface flux diagnostics V5.12.4. https:// doi. org/ 10. 5067/ 0JRLVL8YV2 Y4 Global Modeling and Assimilation Office (GMAO) (2015c) MERRA-2 tavgM_2d_rad_Nx: 2d, monthly mean, time-averaged, single-level, assimilation, radiation diagnostics V5.12.4. https:// doi. org/ 10. 5067/ OU3HJDS973 O0 Gelaro R et al (2017) The modern-era retrospective analysis for research and applications, version 2 (MERRA-2). J Clim 30:5419–5454. https:// doi. org/ 10. 1175/ JCLI-D- 16- 0758.1
Comments	

Table 19: Description of MERRA 21C

Data product name	MERRA-21C
Version	1
Variable(s) [units]	Vertically integrated enthalpy, latent heat, kinetic energy (J/m2) Divergence of vertically integrated transport of enthalpy, latent heat, kinetic energy (W/m2) Surface pressure (hPa)
Short description	MERRA-21C integrated budget quantities
Spatial resolution	n/a
Spatial coverage	Globally complete
Temporal resolution	monthly
Temporal coverage	At least January 2000 onward
File format	netCDF4
File size	n/a
Source	NASA Earth observing system data and information system
Access point	https://disc.gsfc.nasa.gov/
Access conditions	Public (account needed)
Citation/acknowledgments	n/a
Comments	Data not released yet, but will become available in the course of the project

2.3 In-Situ and in-situ only analyses

2.3.1 ICOADS ship/moored buoy data

Table 20: Description of ICOADS

Data product name	International Comprehensive Ocean-Atmosphere Data Set
Version	3.1 (for data until 2014) and 3.0.2 (for data after 2015) - Total files
Variable(s) [units]	Air temperature (degC) Sea-surface temperature (degC) Wind speed (m/s) Wind direction (degrees) Relative humidity (%) Sea-level pressure (hPa)
Short description	ICOADS is the leading archive of global surface marine data. The data span from the late seventeenth century to present and consist of variables recorded on ships, buoys, coastal platforms and other oceanographic instruments.
Spatial resolution	Point values
Spatial coverage	Global ocean
Temporal resolution	Instantaneous values
Temporal coverage	1692-present
File format	IMMA
File size	ca. 400MB per month
Source	Data are ingested from a range of sources: near-surface observations from the World Ocean Database; Global Ocean Surface Underway Data (GOSUD) Project; buoy measurements from the Global Tropical Moored Buoy Array (GTMBBA) and from the Canadian Oceanography and Scientific Data (OSD) archive; near-surface measurements from research vessels (RVs) from the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative. Recent data are provided from GTS and the VOS GDAC programme.
Access point	https://icoads.noaa.gov/products.html
Access conditions	Freely available

Citation/acknowledgments	Freeman, E., S.D. Woodruff, S.J. Worley, S.J. Lubker, E.C. Kent, W.E. Angel, D.I. Berry, P. Brohan, R. Eastman, L. Gates, W. Gloeden, Z. Ji, J. Lawrimore, N.A. Rayner, G. Rosenhagen, and S.R. Smith, 2017: ICOADS Release 3.0: A major update to the historical marine climate record. Int. J. Climatol. (CLIMAR-IV Special Issue), 37, 2211-2237 (doi:10.1002/joc.4775).
Comments	Additional data directly from the VOS GDAC and the GTMBA network will be incorporated. The combined ICOADS Total Files data and GDAC data will be subjected to a NOC-devised Quality Control procedure.

2.3.2 Sea-ice surface air temperature observations

Table 21: Description of CRREL, ECMWF and NP drifting stations/buoys

Data product name	CRREL, ECMWF and NP drifting stations/buoys
Version	
Variable(s) [units]	Air temperature (degC)
Short description	
Spatial resolution	Point values
Spatial coverage	Arctic and Antarctic sea ice
Temporal resolution	Hourly values
Temporal coverage	1982-present
File format	
File size	
Source	Drifting buoys obtained from the Meteorological Archival and Retrieval System (MARS) at the European Centre for Medium-Range Weather Forecasts (ECMWF) covering the period 1993–2015. U.S. Army Cold Regions Research Engineering Laboratory (CRREL) ice mass balance buoys for the period 2001–2017 (Perovich et al., 2006) and the newest generations of Seasonal Ice Mass Balance buoys (SIMB, SIMB2 and SIMB3, Polashenski et al. 2011) for the period 2021-present.

	Russian North Pole (NP) drifting ice stations mainly for the period 1982–1989 but also some for the period 2003–2012 (RU/FSR/HME/AARI and NSIDC, 1993)
Access point	https://imb-crrel-dartmouth.org/ https://data.ucar.edu/dataset/aari-russian-north-polar-drifting-station-data-from-nsidc
Access conditions	Freely available
Citation/acknowledgments	Polashenski, C., Perovich, D., Richter-Menge, J., and B. Elder. 2011. Seasonal ice mass-balance buoys: adapting tools to the changing Arctic, <i>Annals of Glaciology</i> , 52(57), 18-26
Comments	Additional data might be added

2.3.3 PROMICE/GC-NET

Table 22: Description of PROMICE/GC-NET

Data product name	Programme for Monitoring of the Greenland Ice Sheet (PROMICE) and the Greenland Climate Network (GC-Net)
Version	V20
Variable(s) [units]	Air temperature (degC) Surface temperature (degC) Ice Temperature (degC) Wind speed (m/s) Wind direction (degrees) Relative humidity (%) Air pressure pressure (hPa) Down/up-welling short/long wave radiation (W m-2) Albedo
Short description	
Spatial resolution	Point values
Spatial coverage	Greenland Ice Sheet
Temporal resolution	Hourly values
Temporal coverage	1995-present
File format	

File size	
Source	GC-NET and PROMICE Automatic Weather Stations
Access point	https://promice.org/ https://dataverse.geus.dk/dataset.xhtml?persistentId=doi:10.22008/FK2/IW73UU
Access conditions	Freely available
Citation/acknowledgments	How, P.; Abermann, J.; Ahlstrøm, A.P.; Andersen, S.B.; Box, J. E.; Citterio, M.; Colgan, W.T.; Fausto, R.S.; Karlsson, N.B.; Jakobsen, J.; Langley, K.; Larsen, S.H.; Lund, M.C.; Mankoff, K.D.; Pedersen, A.Ø; Rutishauser, A.; Shield, C.L.; Solgaard, A.M.; van As, D.; Vandecrux, B.; Wright, P.J., 2022, "PROMICE and GC-Net automated weather station data in Greenland", https://doi.org/10.22008/FK2/IW73UU , GEUS Dataverse, V20 Fausto, R. S., van As, D., Mankoff, K. D., Vandecrux, B., Citterio, M., Ahlstrøm, A. P., Andersen, S. B., Colgan, W., Karlsson, N. B., Kjeldsen, K. K., Korsgaard, N. J., Larsen, S. H., Nielsen, S., Pedersen, A. Ø., Shields, C. L., Solgaard, A. M., and Box, J. E.: Programme for Monitoring of the Greenland Ice Sheet (PROMICE) automatic weather station data, Earth Syst. Sci. Data, 13, 3819–3845, https://doi.org/10.5194/essd-13-3819-2021 , 2021.
Comments	

2.3.4 Land Surface Air Temperature

2.3.4.1 EUSTACE homogenised station data

Table 23: Description of EUSTACE

Data product name	EUSTACE / ECA&D: European land station daily air temperature measurements, homogenised
Version	product version 4.0
Variable(s) [units]	daily maximum temperature (TX) [K] daily minimum temperature (TN) [K] daily mean temperature (TG) [K]
Short description	Homogenised time series of daily temperature observations for meteorological stations throughout Europe
Spatial resolution	Station data
Spatial coverage	European stations
Temporal resolution	Three measurements (daily min, daily max, daily mean)

Temporal coverage	1850 to 31.03.2019 as individual station records
File format	ASCII
File size	~600 MB total volume
Source	EU Horizon2020 EUSTACE Project
Access point	UK CEDA Archive (https://catalogue.ceda.ac.uk/uuid/81784e3642bd465aa69c7fd40ffe1b1b/)
Access conditions	Open
Citation/acknowledgements	Squintu, AA, van der Schrier, G, Brugnara, Y, Klein Tank, A. Homogenization of daily temperature series in the European Climate Assessment & Dataset. /Int J Climatol/. 2019; 39: 1243–1261. https://doi.org/10.1002/joc.5874
Comments	

2.3.4.2 GHCN-d

Table 24: Description of GHCN-d

Data product name	GHCN (Global Historical Climatology Network) – Daily
Version	product version 4.0
Variable(s) [units]	daily maximum temperature [K] daily minimum temperature [K] daily mean temperature [K]
Short description	Daily temperature observations for meteorological stations
Spatial resolution	Station data
Spatial coverage	Global stations
Temporal resolution	Three measurements (daily min, daily max, daily mean)
Temporal coverage	1850 to present as individual station records
File format	CSV
File size	~240 GB total volume
Source	Global station data
Access point	NOAA NCEI (https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily)
Access conditions	Open

Citation/acknowledgments	Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric and Oceanic Technology, 29, 897-910, doi.10.1175/JTECH-D-11-00103.1. Durre I., M. J. B.E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated quality assurance of daily surface observations. Journal of Applied Meteorology and Climatology., 49, 1615-1633, doi.10.1175/2010JAMC2375.1. Durre, I., M.J. Menne, and R.S. Vose, 2008: Strategies for evaluating quality assurance procedures. Journal of Applied Meteorology and Climatology, 47, 1785–1791, doi: 10.1175/2007JAMC1706.1
Comments	

2.3.4.3 Berkeley Global Temperature Data

Table 25: Description of Berkeley

Data product name	Berkeley Global Daily Land
Version	
Variable(s) [units]	daily maximum temperature anomaly [K] daily minimum temperature anomaly [K] daily mean temperature anomaly [K]
Short description	Gridded Berkeley Earth Surface Temperature Anomaly Field
Spatial resolution	1° x 1°
Spatial coverage	Global
Temporal resolution	Three measurements (daily min, daily max, daily mean)
Temporal coverage	1880 to 31.12.2022
File format	NetCDF
File size	~18 GB total volume
Source	Berkeley Earth Surface Temperature Project
Access point	NOAA NCEI (https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily)
Access conditions	Open

Citation/acknowledgments	Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric and Oceanic Technology, 29, 897-910, doi.10.1175/JTECH-D-11-00103.1. Durre I., M. J. B.E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated quality assurance of daily surface observations. Journal of Applied Meteorology and Climatology., 49, 1615-1633, doi.10.1175/2010JAMC2375.1. Durre, I., M.J. Menne, and R.S. Vose, 2008: Strategies for evaluating quality assurance procedures. Journal of Applied Meteorology and Climatology, 47, 1785–1791, doi: 10.1175/2007JAMC1706.1
Comments	