CMUG Extension Phase 1 Deliverable
Reference: D5.3.v2: Combined namelist on GitHub
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Climate Modelling User Group

Extension Phase 1 Deliverable D5.3.v2: Combined project specific ESMValTool namelist for global model evaluation released at GitHub for ECVs of Task 5.3

Centres providing input: DLR, BSC, Met Office, SMHI

Version	Date	Status
2.0	10 February 2022	Submitted to ESA

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1 Combined project specific ESMValTool namelist for global model evaluation released at GitHub for ECVs of Task 5.3 Summary

Within task 5.3 ("Implementation of CCI and CCI+ products into the ESMValTool") new CCI+ data as well CCI data that have not yet been implemented into the ESMValTool in the previous CMUG phase such as, for instance, methane have been integrated into the tool. The participating CMUG partners Met Office, SMHI, BSC and DLR lead the implementation of their assigned ECV including ECV specific diagnostics. Within the ESA CCI programme, the ESMValTool will be available to the Climate Research Groups for their work.

Specifically, the following CCI/CCI+ data have been included:

CCI/CCI+ data	Dataset version	CMUG partner
Land surface temperature	ESA CCI LST based on MODIS AQUA L3 monthly data (day and night average), v1.00	Met Office
Long-lived GHGs (CH_4)	C3S XCH4 v4.2 (2020), obtained from Climate Data Store (CDS)	DLR
Water vapour	CCI/CM SAF TCWV-global (COMBI), total column water vapour over land and ocean (CDR-2), v3.1	DLR
Sea surface salinity	ESA CCI Sea Surface Salinity ECV produced at a spatial resolution of 50 km and time resolution of 1 month and spatially resampled on 25 km EASE grid and 15-day time sampling, v1.08 and v2.31	BSC
Ocean colour	ESA CCI Ocean Colour dataset, V5.0, available online at http://www.esa-oceancolour-cci.org/	SMHI

Each partner submitted a pull request upon finalization of the implementation of the ECV at the ESMValTool GitHub repository. The contributions underwent a technical and scientific review to ensure that the new code meets the high standards of the ESMValTool and that the metadata of the new datasets are complete and correct. As of January 2022, all five CMUG pull request have been merged into the ESMValTool main development branch and will therefore be included in the next official release that is scheduled for Q1/2022. The ESMValTool main development branch is publicly available and can already be used by any interested person before the next official ESMValTool release.

Successful implementation and merging of all CMUG diagnostics and ESA CCI/CCI+ datasets into the ESMValTool main development branch is the central aim of task 5.3. Originally, it was also planned to combine all "recipes" (ESMValTool configuration files specifying the input data, pre-processing steps and diagnostics to be run) into one project specific recipe (originally called ESMValTool "namelist") as a small additional step. Since the release of ESMValTool v2.0, however, the technique of single large recipes is considered rather outdated as the ESMValTool now allows for running several recipes in parallel. For this reason, it is considered an advantage to not combine all recipes into a single one but to keep all five CMUG recipes separate. This allows for more flexible and targeted use of the new diagnostics without compromising any functionality. The five merged CMUG recipes are:

Diagnostic (title)	Recipe	Scientific documentation
ESA CCI LST comparison to historical models	recipe_esacci_lst.yml	https://github.com/ESMValGroup/ESMValTool/blob/main/doc/sphinx/source/recipes/recipe_esacci_lst.rst
Diagnostics of integrated atmospheric methane (XCH4)	mpqb/recipe_mpqb_xch4.yml	https://github.com/ESMValGroup/ESMValTool/blob/main/doc/sphinx/source/recipes/recipe_mpqb_xch4.rst
Evaluate water vapour short wave radiance absorption schemes of ESMs with the observations, including ESA CCI data	recipe_cmug_h2o.yml	https://github.com/ESMValGroup/ESMValTool/blob/main/doc/sphinx/source/recipes/recipe_cmug_h2o.rst
Sea Surface Salinity Evaluation	recipe_sea_surface_salinity.yml	https://github.com/ESMValGroup/ESMValTool/blob/main/doc/sphinx/source/recipes/recipe_sea_surface_salinity.rst
Ocean chlorophyll in ESMs compared to ESA CCI observations	ocean/recipe_esacci_oc.yml	https://github.com/ESMValGroup/ESMValTool/blob/main/doc/sphinx/source/recipes/recipe_esacci_oc.rst

2 Purpose and scope of this report

The purpose of this document is to summarize the implementation of the new ECVs and ECV specific diagnostics into the ESMValTool by providing information on the CMUG pull requests that have been merged into the ESMValTool main development branch that is publicly available at the ESMValTool GitHub repository (https://github.com/ESMValGroup/ESMValTool).

3 Merged pull requests

The following sections summarize the pull requests that have been opened at the GitHub repository by the different CMUG partners, reviewed by technical and scientific reviewers and merged into the ESMValTool main development branch. This description is taken from deliverable report D5.3.v1 and updated as needed.

3.1 Land surface temperature [Met Office]

This diagnostic compares ESA CCI LST to multiple historical ensemble members of CMIP models. It does this over a defined region for monthly values of the land surface temperature. The result is a plot showing the mean difference of CCI LST to model average LST, with a region of +/- one standard deviation of the model mean LST given as a measure of model variability.

The recipe and diagnostic need the all-time average monthly LST from the CCI data, which is created as the mean of the daytime and nighttime overpass values. We use the L3C single sensor monthly data. A CMORizing script calculates the mean of the daytime, and nighttime overpasses to give the all-time average LST. This is so that the monthly means output from CMIP models ("Amon") can be used. We created such a dataset from the Aqua MODIS data from CCI. An example output from this diagnostic is shown in *Figure 1*.

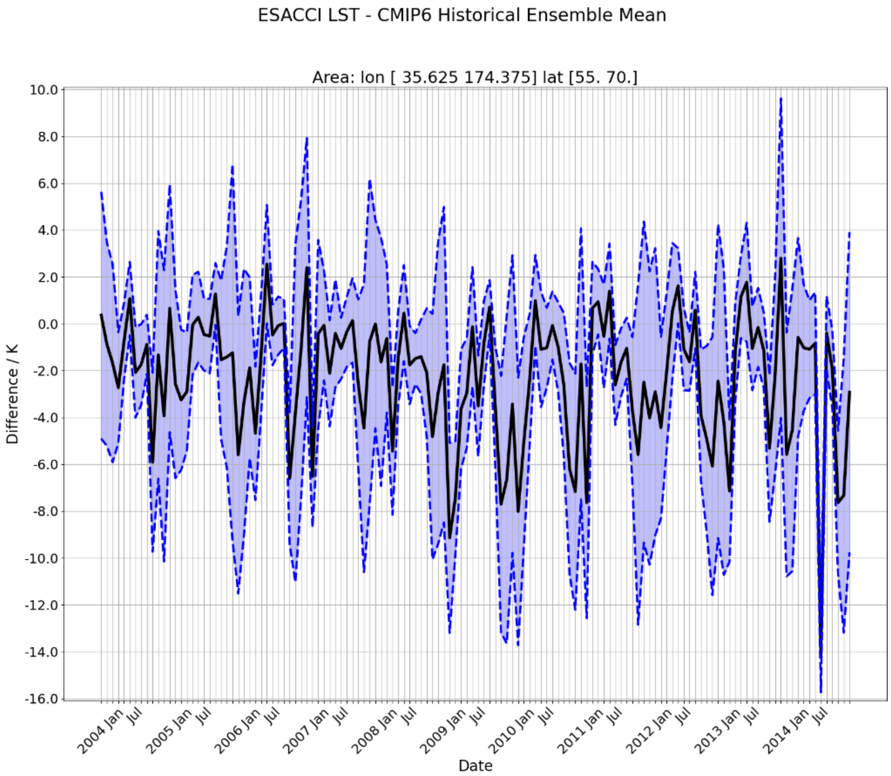

Figure 1: Timeseries of the ESA CCI LST minus mean of CMIP6 ensembles. The selected region is 35°E-175°E, 55°N-70°N. The black line is the mean difference, and the blue shaded area denotes one standard deviation either way of the individual ensemble member's difference in LST. Models used for this are UKESM1 members r1i1p1f2 and r2i1p1f2, and CESM members r2i1p1f1 and r3i1p1f1. We have used the entire timeseries of available CCI data 2004-2014 inclusive.

3.2 Long-lived GHGs (CH_4) [DLR]

The recipe has been extended and now consists of three (previously two) diagnostics:

- Monthly mean time series of XCH4 (area weighted) for pre-defined regions (global, Northern Hemisphere, Southern Hemisphere). This diagnostic can also be applied to user-defined regions and a multitude of datasets. An example of this diagnostic is shown in *Figure 2*.
- Annual cycles of XCH4 for pre-defined regions (global, Northern Hemisphere, Southern Hemisphere). This diagnostic can also be applied to user-defined regions and time periods.
- Annual growth rates of XCH4 for pre-defined regions (global, Northern Hemisphere, Southern Hemisphere). This diagnostic can also be applied to user-defined regions and time periods.

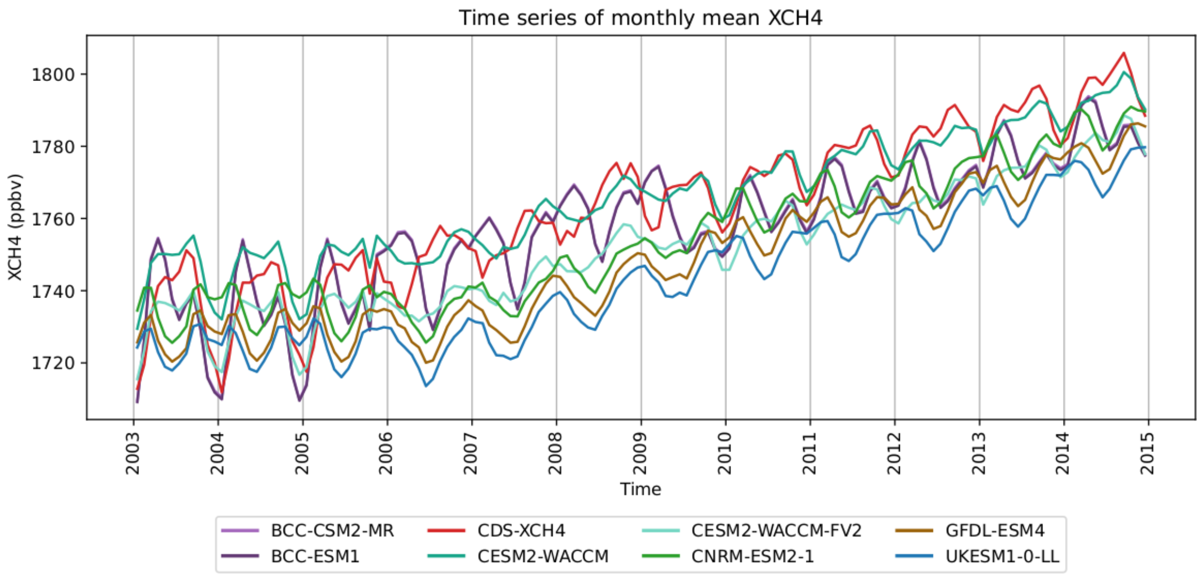

Figure 2: Comparison of the global mean monthly mean time series of the observational dataset "ESA-CCI XCH_4, L3" downloaded from the Climate Data Store (red line, "CDS-XCH4") and emission-driven simulations of seven CMIP6 models. Shown are global means for the time period 2003 to 2014.

3.3 Water vapour [DLR]

The recipe contains several diagnostics to use ESA CCI water vapour data to evaluate CMIP models listed below. Currently, we use data from the (preliminary) dataset "CCI/CM SAF TCWV-global (COMBI) total column water vapour over land and ocean (CDR-2), version 3.1". ERA-Interim reanalysis data are used as a replacement for the not yet available vertically resolved CCI data (CDR-3 and CDR-4). As soon as CDR-3 and CDR-4 data become available, we will extend the CMORizing script for ESA CCI water vapour data and use them in these diagnostics.

- The diagnostic deangelisf3f4.py reproduces figures 3 and 4 from DeAngelis et al. (2015) comparing models with different schemes for water vapour short wave radiance absorption with the observations. The ESA CCI CDR-2 data can be used as a replacement of the RSS, SSMI and TOVS data used in DeAngelis et al. (2015).
- The diagnostic diag_tropopause.py plots a given variable at the cold point tropopause height, here specific humidity (hus) is used. This will be calculated from the ESA CCI water vapour data CDR-4, which are planned to consist of three-dimensional vertically resolved monthly mean water vapour data (in ppmv) with spatial resolution of 100 km, covering the troposphere and lower stratosphere. The envisaged temporal coverage is 2010-2014. The calculation of hus from water vapour in ppmv will be part of the CMORizing script. Here, ERA-Interim data are used (example shown in *Figure 3*). Additionally, the diagnostic has been tested on several CMIP6 data sets.
- The diagnostic diag_tropopause_zonalmean.py plots zonal mean for given variable at all pressure levels between 250 and 1 hPa and at cold point tropopause height. Here specific humidity (hus) is used. This will be calculated from the ESA CCI water vapour data CDR-3, which are planned to contain the vertically resolved water vapour ECV in units of ppmv (volume mixing ratio) and will be provided as zonal monthly means on the SPARC Data Initiative latitude/pressure level grid (SPARC, 2017; Hegglin et al., 2013). It covers the vertical range between 250 hPa and 1 hPa, and the time period 1985 to the end of 2019. The calculation of hus from water vapour in ppmv will be part of the CMORizer script. Currently, ERA-Interim data are used in addition to CMIP6 model data until CDR-3 data become available.

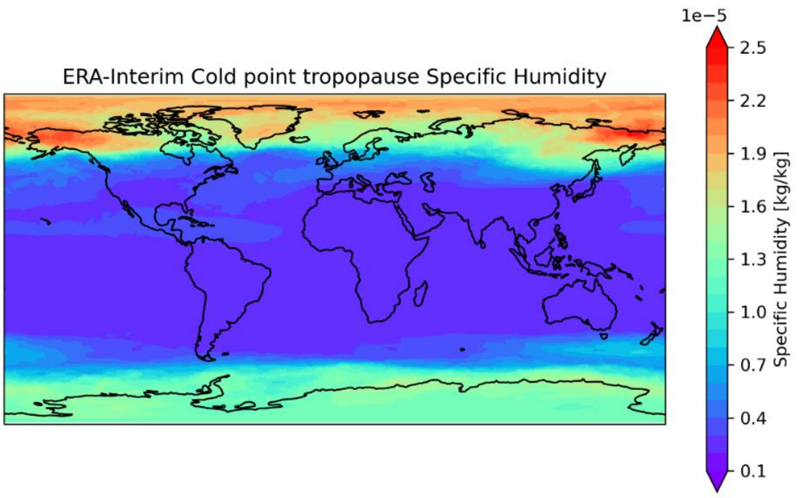

Figure 3: Map of the average specific humidity (hus) at the cold point tropopause from ERA-Interim data. The diagnostic averages the complete time series, here 2010-2014.

3.4 Sea surface salinity [BSC]

This recipe compares regional means of sea surface salinity from models with a reference dataset (ESA CCI Sea Surface Salinity ECV produced at a spatial resolution of 50 km and time resolution of 1 month and spatially resampled on 25 km EASE grid and 15 days of time sampling, version 1.08 and version 2.31). To do this, the recipe generates plots for the timeseries of each region and a radar plot showing the correlation of the dataset and the reference timeseries for each region. An example of such a radar plot is shown in Figure 4.

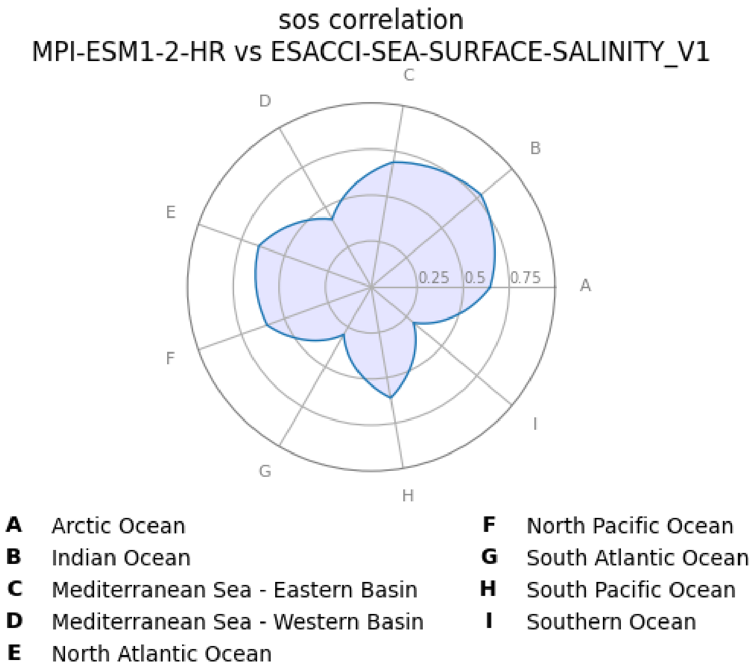

Figure 4: Radar plot showing correlation of average sea surface salinity from MPI-ESM1-2-HR for multiple regions with the observations (ESACCI-SEA-SURFACE-SALINITY_V1).

3.5 Ocean colour [SMHI]

This recipe compares ocean surface chlorophyll from CMIP models to ESA CCI ocean colour chlorophyll. We use the merged sensor geographic monthly chlorophyll-a data (processing level L3S) (Sathyendranath et al., 2019) and monthly model data. Multiple models and different observational versions can be used by the script. Figure 5 shows the surface chlorophyll from ESA CCI ocean colour data version 5.0 and the CMIP6 model NorESM2-LM. This model overestimates chlorophyll compared to the observations in the tropics and mid-latitudes and underestimate chlorophyll in the polar regions.

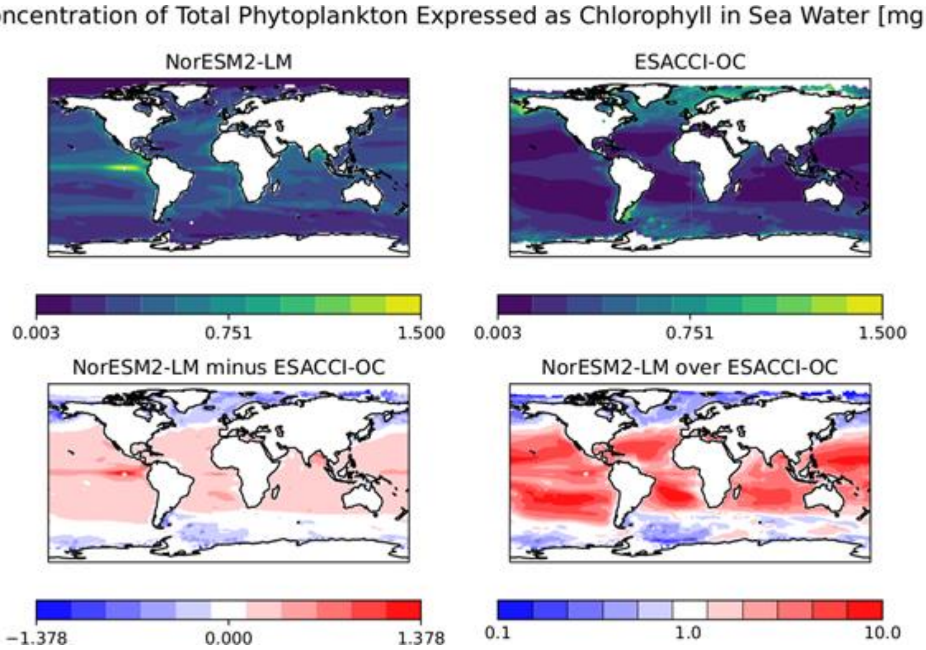

Figure 5: Top row: Maps of the ESA CCI OC v5.0 chlorophyll and the CMIP6 model NorESM2-LM (ensemble member r1i1p1f1) both averaged for 1998-2014 (top row). Bottom row: The model bias and ratio of model versus ESA CCI OC data.

4 References

DeAngelis, A. M., Qu, X., Zelinka, M. D., and Hall, A.: An observational radiative constraint on hydrologic cycle intensification, Nature, 528, 249, 2015.

Hegglin, M. I., et al., SPARC Data Initiative: Comparison of water vapor climatologies from international satellite limb sounders, J. Geophys. Res. Atmos., 118, 11824-11846, doi:10.1002/jgrd.50752, 2013.

Sathyendranath, S, et al.: An ocean-colour time series for use in climate studies: the experience of the Ocean-Colour Climate Change Initiative (OC-CCI), Sensors: 19, 4285, doi: 10.3390/s19194285, 2019.

SPARC: The SPARC Data Initiative: Assessment of stratospheric trace gas and aerosol climatologies from satellite limb sounders, M. I. Hegglin and S. Tegtmeier (eds.), SPARC Report No. 8, WCRP-5/2017, available at www.sparc-climate.org/publications/sparc-reports/sparc-report-no8/ , 2017.