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Executive Summary

This Climate Assessment Report (CAR) describes User Case Studies by the Climate Research Group during the third phase of ESA's Ozone CCI project (2025-2026). This first issue of CAR summarises the implementation of Ozone CCI datasets into ESMValTool, which have been developed and generated during earlier phases of the project. The main objective of this work was to ensure the participation of ozone column and profile data sets for the CMIP7 Rapid Evaluation Framework that will freeze participating ECV products early 2026.

At the time of writing this issue, algorithm development and ECV product generation are ongoing intensively and fully reprocessed ECV products are planned in the coming months. A next issue will describe User Case Studies on long-term ozone changes in the upper troposphere lower stratosphere (UTLS) ozone and on the assessment of transport in Chemistry-Climate Models (CCMs).

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1 Implementation of Ozone CCI datasets into ESMValTool

The Earth System Model Evaluation Tool (ESMValTool; Eyring et al., 2020; Lauer et al., 2020; Righi et al., 2020; Weigel et al., 2021; Schlund et al., 2023; Lauer et al., 2025; Schlund et al., 2025) is an open-source community-developed diagnostics and performance metrics tool for the evaluation and analysis of Earth System Models (ESMs). ESMValTool allows for a comparison of single or multiple models against predecessor versions and observations. The aim of ESMValTool is to take model evaluation to the next level by facilitating analysis of many different ESM components, providing well-documented source code and scientific background of implemented diagnostics. Traceability and reproducibility of the results are ensured by providing detailed provenance records for all output. While originally designed to facilitate a more comprehensive and rapid evaluation of models participating in the Coupled Model Intercomparison Project (CMIP; Durack et al., 2025), the tool can also be used to analyze output from regional models, a large variety of gridded observational data and reanalysis datasets. The development of ESMValTool is supported by several national and international projects, such as ESA CCI CMUG. ESMValTool was used for data processing and analysis for international reports such as the Intergovernmental Panel on Climate Change's Sixth Assessment Report (IPCC, 2021) and was selected as one of the evaluation tools for the CMIP7 Rapid Evaluation Framework (REF; Hoffman et al., 2025).

The following four datasets recommended by the Ozone CCI team have been implemented into ESMValTool:

Table 1 Ozone CCI datasets newly implemented into ESMValTool.

Dataset	Variables	Data archive	Product version	Time period
GTO-ECV	total column ozone (toz)	CDS	L3, MERGED-UV (monthly gridded merged column product from GOME-type sensors), v2000	1995-2023
SAGE-CCI-OMPS+	Mole fraction of ozone in air (o3)	CDS	L3, CMZM (monthly zonal mean merged concentration product from limb sensors), v0008	1984-2023
MEGRIDOP	mole fraction of ozone in air (o3)	CDS	L3, CLLG (monthly gridded merged concentration product from limb sensors), v0005	2001-2024
IASI	total column ozone (toz); mole fraction of ozone in air (o3)	BIRA-IASB WebDAV	L3, MERGED (monthly gridded merged product from IASI sensors), v1.0	2008-2023

Implementation of the datasets into ESMValTool consists of providing Python scripts for (1) automatically downloading the Ozone CCI data from the Copernicus Climate Data Store (CDS) or via BIRA WebDAV and (2) reformatting the data to follow the standards defined by the Climate Model Output Rewriter (CMOR) that is commonly used for ESM output. Reformatting of the data includes adjusting the definition of the grid (longitude, latitude, vertical levels, time) and metadata such as units, variable names and attributes.

Specifically, units have been converted from mol m^{-2} to m for total column ozone and from mol m^{-3} to mol mol^{-1} for vertical ozone profiles. For this, auxiliary data such as air partial column profile and air temperature/air pressure provided with the original Ozone CCI datasets have been used. The horizontal and vertical gridding of the data have not been changed. In particular, SAGE-CCI-OMPS+ and MEGRIDOP data are kept on the 41 height levels (km) used in the original Ozone CCI dataset, IASI data are kept on the original pressure levels that vary with latitude, longitude and time. Daily IASI values have been aggregated to monthly values.

Examples of the four datasets implemented are given in Figure 1, showing the multi-year annual average total column ozone from (a) GTO-ECV and (b) IASI, as well as the multi-year zonally averaged ozone profiles from (c) IASI, (d) MEGRIDOP and (e) SAGE-OMPS.

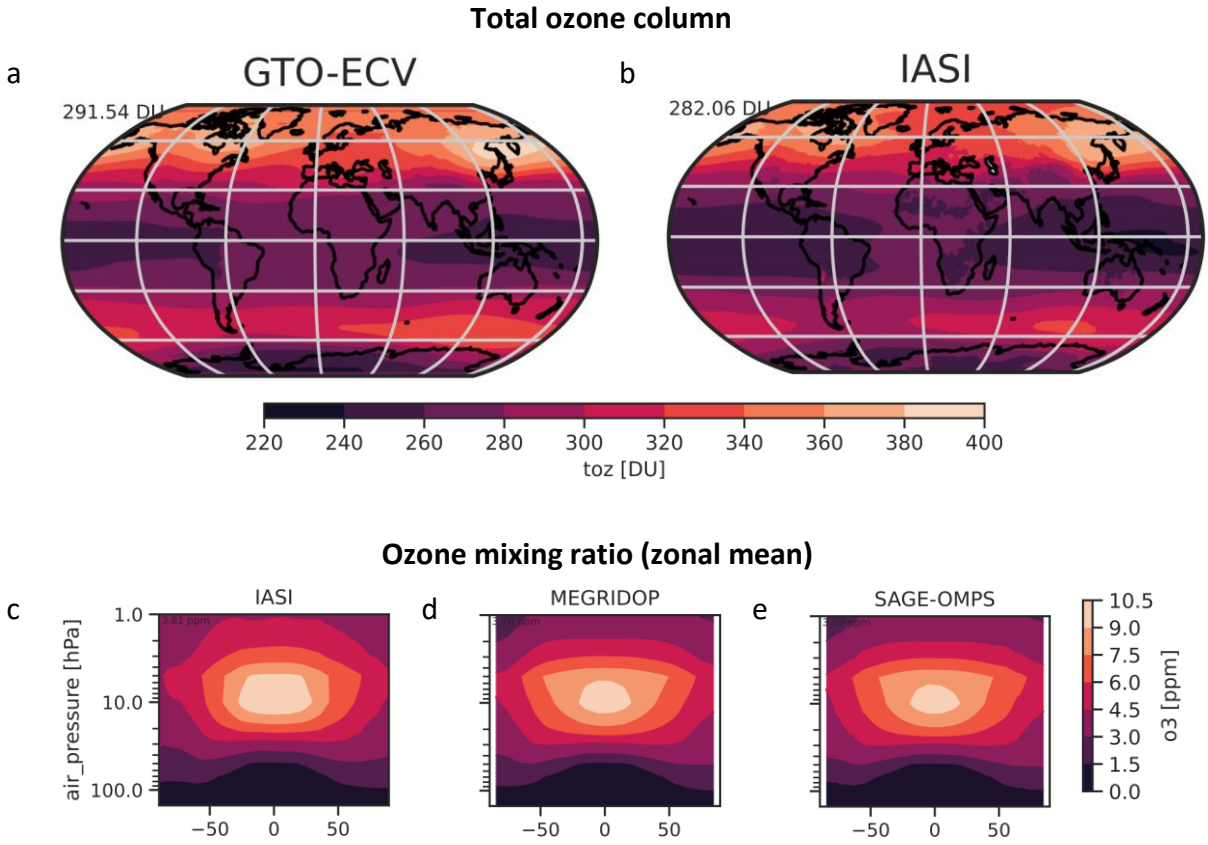

Figure 1 Multi-year (2008-2022) annual average (top) total column ozone in Dobson Units (DU) and (bottom) ozone mixing ratio in ppm from ESA CCI Ozone. (a) GTO-ECV, (b, c) IASI, (d) MEGRIDOP, (e) SAGE-OMPS.

In addition to the downloading and reformatting scripts, an ESMValTool "recipe" has been created to take advantage of the newly implemented datasets for the evaluation of ESM output. A recipe is a configuration file that defines all input data, preprocessing steps, and diagnostics to be applied. The recipe developed creates geographical maps of the total column distribution, zonal mean plots of the stratospheric ozone concentration, and time series of Northern (NH) and Southern Hemisphere (SH) average high-latitude total ozone columns in March (NH) and October (SH) to assess the temporal evolution of the minimum ozone concentrations. The recipe also creates Hovmoeller plots (time vs. latitude) for total column ozone.

In the following, examples of plots created with the new recipe are shown, including Hovmoeller plots month vs latitude and time vs latitude of total column ozone (Figure 2 and Figure 3, respectively) as well as time series of the annual minimum monthly mean total ozone columns averaged over the Northern and Southern Hemisphere polar regions (Figure 4). An additional recipe created for CMIP7 REF uses the GTO-ECV dataset as a reference for comparisons with ESM output. In addition to the examples shown in Figure 2, Figure 3 and Figure 4, the map and zonal mean plots shown in Figure **1** are also included for evaluation of the CMIP7 models.

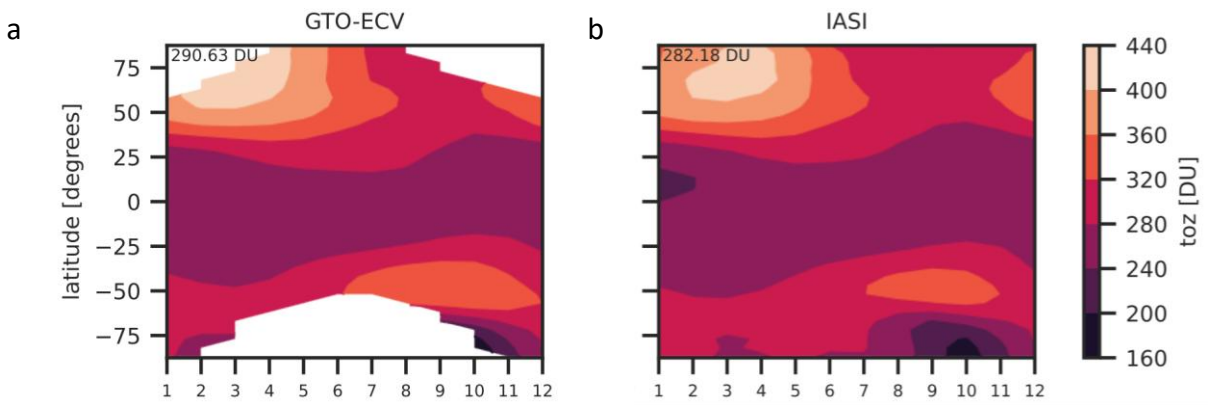

Figure 2 Hovmoeller plot (month vs. latitude) of monthly mean total column ozone averaged over the years 2008-2022 from (a) GTO-ECV) and (b) IASI.

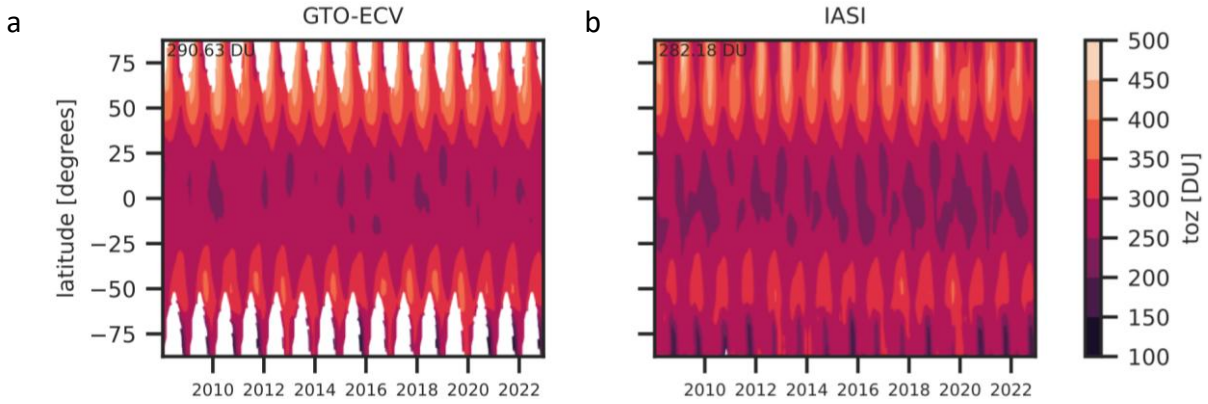

Figure 3 Hovmoeller plot (time vs. latitude) of monthly mean total column ozone from (a) GTO-ECV) and (b) IASI for the time period 2008-2022.

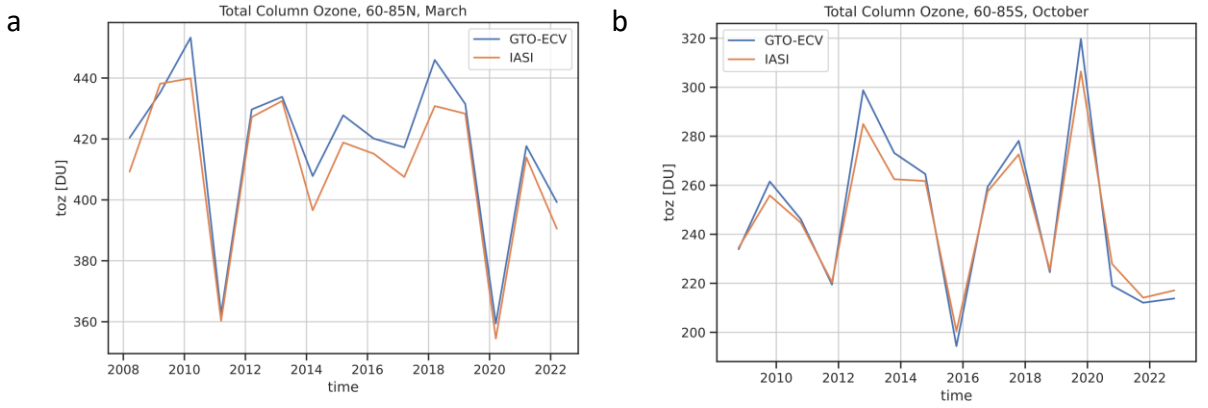

Figure 4 Time series of monthly mean total column ozone from GTO-ECV (blue) and IASI (orange) averaged over the high-latitude belt 60°-85° for the month of minimum total column ozone values. (a) Northern Hemisphere (March) and (b) Southern Hemisphere (October).

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