# SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

**Reporting year** …2021……..……

**Project Title:** …The dynamics of the stratosphere in the OpenIFS climate model……..……

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**Computer Project Account:** …SPITSERV……..……

**Principal Investigator(s):** …Federico Serva……..……

…Chiara Cagnazzo……..……

**Affiliation:** …CNR……..……

**Name of ECMWF scientist(s) collaborating to the project** (if applicable) ……..……

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**Start date of the project:** …January 2019……..……

**Expected end date:** …December 2021……..……

**Computer resources allocated/used for the current year and the previous one** (if applicable)
Please answer for all project resources

| | | Previous year | | Current year | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | 1 000 000 | 1 000 000 | 8 000 000 | 1 140 000 |
| **Data storage capacity** | (Gbytes) | 21 000 | 0 | 41 000 | 10 000 |

## Summary of project objectives (10 lines max)

The initial plan of the Special Project was to investigate the sensitivity of the OpenIFS model to different configurations (spatial and vertical resolution in particular) with a focus on the changes in the stratospheric dynamics. Due to the delayed release of the new model version, the activities were focused on another available model, EC-EARTH, which is using an older version of IFS, but the process of including OpenIFS (43r3) as its new atmospheric component is currently ongoing.

## Summary of problems encountered (10 lines max)

In the last year the activities were mostly devoted to set up the needed software tools required to produce well-formatted EC-EARTH outputs, following the CMIP6 protocol standards. For this reason the execution of longer and more expensive simulations has been postponed, and shorter tests (up to about one decade of simulation) were done with EC-EARTH, in its coupled atmosphere-ocean configuration. To ensure optimal use of the resources, the Support team kindly agreed to reduce the allocation in the second half of 2020 and moved 2M SBU to the reserve for the use of other projects.

## Summary of plans for the continuation of the project (10 lines max)

A series of simulations were carried out in order to test the whole production workflow, which required both adjustments on the EC-EARTH model (accessible through the svn repository) and the adaptation of the processing software (ece2cmor3) to run external scripts, needed to derive some additional diagnostics. The working software is publicly available since the release https://github.com/EC-Earth/ece2cmor3/releases/tag/v1.8.0 of ece2cmor3. In the rest of the year, additional simulations will be carried out and the output processed with the formatting chain for sharing with interested parties. The results will be useful for comparison with previous model versions and to inform next developments and improvements of the next EC-EARTH.

## List of publications/reports from the project with complete references

While the data is still under production, the experience with the model setup is described in the EC-EARTH 3 description paper, currently under review for Geoscientific Model Development.

*Döscher, R., and coauthors: The EC-Earth3 Earth System Model for the Climate Model Intercomparison Project 6, Geosci. Model Dev. Discuss. [preprint], https://doi.org/10.5194/gmd-2020-446, in review, 2021.*

## Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The major focus on the last 12 months has been on the model setup to obtain data compliant with the CMIP requirements. Since it was not possible to store the raw data (as they take ~20GB per simulation month), resources were released in large amounts during 2020, with the support of the Special Project team

As said above, the work during the reporting period was mostly technical, and required preparing a set of tools to be used to process the model GRIB outputs, converting it in the netCDF format and adjust variables and their metadata in order to comply with the CMIP initiative convention. Longer simulations (decades) were also produced and processed to test the robustness of the procedure, which should be portable to other infrastructures. To illustrate how the information looks like, here is an excerpt from one of the file headers for a variable not present in the standard GRIB tables, but processed with python scripts and GRIB/netCDF libraries:

```
float tntnogw(time, plev, lat) ;
              tntnogw:standard_name =
"tendency_of_air_temperature_due_to_dissipation_of_nonorographic_gravity_waves" ;
              tntnogw:long_name = "Temperature Tendency Due to Non-Orographic Gravity
Wave Dissipation" ;
              tntnogw:comment = "Temperature tendency due to dissipation of parameterized
nonorographic gravity waves." ;
              tntnogw:units = "K s-1" ;
              tntnogw:cell_methods = "longitude: mean time: mean" ;
              tntnogw:history = "2021-01-13T17:27:12Z altered by CMOR: Reordered
dimensions, original order: lat plev time." ;
              tntnogw:missing_value = 1.e+20f ;
              tntnogw:_FillValue = 1.e+20f ;
[…]
// global attributes:
              :Conventions = "CF-1.7 CMIP-6.2" ;
              :activity_id = "CMIP" ;
              :branch_method = "standard" ;
              :branch_time_in_child = 0. ;
              :branch_time_in_parent = 0. ;
              :contact = "cmip6-data@ec-earth.org" ;
              :creation_date = "2021-01-13T17:27:13Z" ;
              :data_specs_version = "01.00.33" ;
              :ece2cmor_git_revision = "0dedcd409ee8af0da2d168d28bb994e837ab1e49-changes"
              :experiment = "1 percent per year increase in CO2" ;
```

The amount of detail provided is important when the aim is to compare results from different models, or from different versions or realizations of the same model. The native GRIB does not provide much information, as some variable were introduced for our purposes, while here information on the run and other ancillary data is included. To illustrate some of the fields added with the ‘extended’ version of the model, in Fig. 1 some temperature tendency terms are reported for an average sample year.

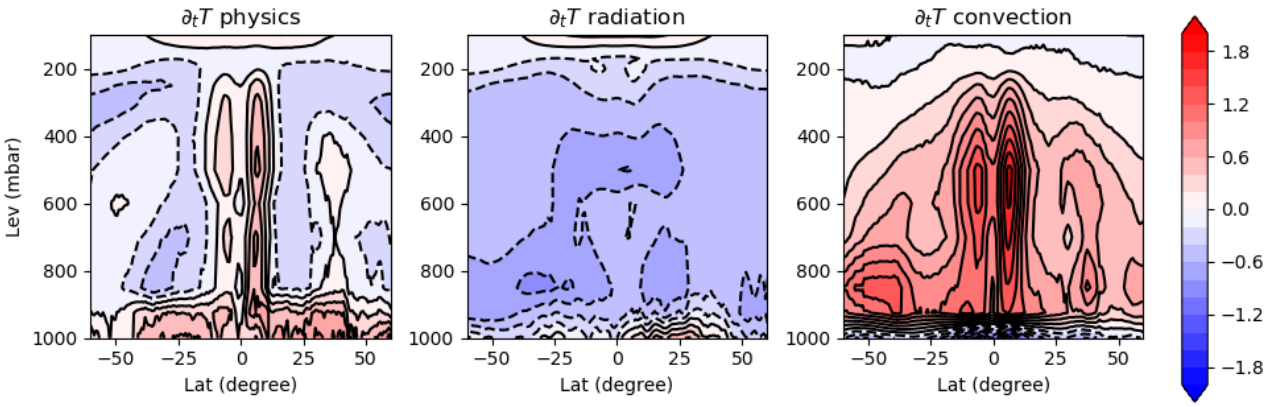


Figure 1: Sample time and zonal mean temperature tendencies from one year of simulation of the EC-EARTH model, for cumulated physical processes (left), sum of longwave and shortwave tendencies (middle) and convective processes (right). Units (originally K/s in the files) are scaled to K/day for visual clarity.

The leftmost plot is for the diabatic heating term, which includes the physical processes such as radiation (sum of all-sky short and long wave terms, middle) and convection (right). Compared against analyses presented in the literature for other datasets (e.g. reanalysis), the patterns are realistic for the model. The warming in the inner tropical region is mostly due to the convective heat exchanges, while the effect of long-wave radiative cooling and warming due to short-wave absorption are visible near the top of the plotted domain.
Preliminary analysis of the existing outputs prepared by the consortium have been presented in the model description paper (Doescher et al., 2021), for which details can be found in the relevant section.

The rest of the allocated resources will be used to execute a set of simulation with the model in the default configuration, in order to contribute the data to the multimodel CMIP archive, especially in the context of the dynamics and circulation analyses, by considering the standard DECK runs. A small part for the computational resources in 2021 were also employed to extend the runs done with a stratosphere-resolving version of the ECHAM model, which was used in an earlier Special Project (SPITCHCG), in order to produce additional outputs for studying the simulated circulation. Analyses are ongoing and relevant results will be hopefully available in due time for the final report.

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