REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: …………………ITALY…….…………………………..…

Principal Investigator[1]**:** ………………Annalisa Cherchi…………….……

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Project Title: Effects of aerosols reduction on the Asian summer monsoon prediction skill: the case of summer 2020 with COVID-19 confinements

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2022	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for 2022-2024: (To make changes to an existing project please submit an amended version of the original form.)		**2022**	**2023**	**2024**
High Performance Computing Facility	(SBU)	709800		
Accumulated data storage (total archive volume)[2]	(GB)	2100		

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests asking for 3,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

The Institute for the Atmospheric Sciences and Climate at National Research Council (CNR-ISAC) is member of the EC-Earth consortium (http://www.ec-earth.org/) aimed at building a European community earth system model combining efforts of different research institutes from ten European countries. CNR-ISAC is partner in several international efforts including EU H2020 projects and in WCRP activities, either in the framework of the sixth phase of the Coupled Model Intercomparison Project (CMIP6, https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6) or in some specific seasonal to sub-seasonal initiatives (S2S, https://www.wcrp-climate.org/modelling-s2s).

The climate prediction group of the Barcelona Supercomputing Center Earth Sciences department (ES-BSC) undertakes advanced research to forecast climate variations from one month to several years into the future and from regional to global scales. The climate prediction group coordinates the work of the Climate Prediction Working Group of the EC-Earth consortium and generates routinely Initial Conditions (ICs) for its operational decadal climate prediction system based on the EC-Earth model. These ICs are also employed for the seasonal prediction activities at the BSC and will be shared to produce the climate prediction experiments envisaged in this project.

The Royal Netherlands Meteorological Institute (KNMI) is the Dutch national weather service and the national research and information centre for climate. KNMI is a member of the EC-Earth consortium, where it coordinates the technical working group and the working group on atmospheric composition. KNMI participates in various international climate modelling activities, including CMIP and EU H2020 projects such as FORCeS and EUCP.

Among others CMIP6 MIPs and experiments using the EC-Earth3 model (Döscher et al 2021), CNR-ISAC, ES-BSC and KNMI have contributed to the COVID-MIP framework (Lamboll et al 2020; Jones et al 2021). COVID-MIP has been included within DAMIP (Gillett et al 2016) as a set of special experiments to account for the effects of reduced emissions due to COVID-19 confinement and related modified scenario projections.

The main idea behind the COVID-MIP experimental setup has been to evaluate the effects of the emission reductions detected during the boreal spring 2020 (Forster et al 2020) on the climate of the period 2020-2024, when compared to the standard SSP2-4.5 scenario. Results from this COVID-MIP experiments evidence models' consensus on reduced aerosol amounts and associated increase in surface shortwave radiation fluxes, mostly localized over Asia (Jones et al 2021). Global-scale effects on near-surface temperature or rainfall during the period are small (Jones et al 2021), however as most of the reductions in aerosols loads are localized over Asia, we expect to identify specific effects there. The objective of this special project is to evaluate the effects of the detected decreased emissions during the boreal spring of 2020 on the monsoon precipitation over Southeast and East Asia during the subsequent summer and in its seasonal prediction skill.

Aerosol's reduction and summer monsoon precipitation over Southeast and East Asia

The fact that Northern Hemisphere anthropogenic aerosols influence Southeast and East Asian summer monsoon precipitation is well known in the literature (Turner and Annamalai, 2012; Ayantika et al 2021; Dong et al 2019; among others). There is growing evidence that increased Asian emissions of anthropogenic aerosols in the late 20th century have weakened the east Asian summer monsoon and have reduced precipitation over northern China (Wang et al 2017; Dong et al 2019). These changes in anthropogenic aerosols emissions are also responsible of the weakening of the South Asian summer monsoon in the second half the 20th century, counteracting the effect of increased GHG (Ayantika et al 2021; Bollasina et al 2011; Undorf et al 2018; Wilcox et al 2020). Changes in the anthropogenic aerosols burden in the Northern Hemisphere, and specifically over the Asian continent, may have specific and direct effect also on the sub-seasonal evolution of the summer monsoon (Dave et al 2017; Ayantika et al 2021). In the summer of 2020, the monsoon precipitation has been declared to be about 8% above the long-term average (IITM, https://mol.tropmet.res.in/monsoon-interannual-timeseries/) but with a weak monsoonal circulation with consequences also for wind power generation (https://india.ul.com/wp-content/uploads/sites/35/2021/02/White-paper-on-India-Wind-Anomalies-by-Guru-Ranjan-Velu.pdf). The monsoon circulation weakening could have been influenced by increased temperature gradient between the warmer Indian Ocean and the cooler Indian subcontinent (https://science.thewire.in/environment/monsoon-season-surplus-imd-weather-prediction-el-nino-la-nina/), likely related with the reduced atmospheric emissions because of COVID-19 lockdowns across the globe.

According to the above, the idea is to use the efforts and collection of data with detected reduced emissions of GHG and other atmospheric gases, including aerosols, during the spring 2020 (where most of the actions to contain COVID-19 diffusion have been implemented worldwide, with restrictions in travels and other activities) and perform a forecast starting 1st of May to predict the summer 2020 (particularly over India and in relation to the Southeast Asian summer monsoon) to be compared with the 2020 control hindcasts already performed at BSC and not including the "COVID-19 forcing" described above .

Planned experiments and analyses

The planned experiment is a case-study forecast for summer and fall 2020 (with May 1st as starting date) using the same atmospheric forcing adopted within the CMIP6 DAMIP COVID-MIP framework (Gillett et al 2016; Lamboll et al 2020). The forecast ensemble will consist of at least 60 members to better account for the internal variability (noise) and maximise the capability to identify the effects of the "COVID-19 forcing".

To evaluate and understand the role of the different atmospheric forcing, this experiment will be compared with the 2020 forecasts prepared by BSC using the same version of the EC-Earth model and initial conditions but employing external forcing conditions that do not include the "COVID-19 forcing" (i.e., taken from the historical forcing prepared for CMIP6; Eyring et al 2016). The 2020 control experiment produced by BSC is done in the framework of the H2020 projects APPLICATE and INTAROS, and the Climate Model User Group of ESA.

The analysis will be dedicated to the effects of the "COVID-19 forcing" on the forecast, with a specific focus on the performance in the prediction of the summer monsoon precipitation over India and over other parts of the South and East Asian monsoons. Specific attention will be dedicated to the effect of the changes in the anthropogenic aerosols (Ayantika et al 2021). Changes in the prediction skill for specific phenomena, like the onset and the length of the monsoon season will be evaluated considering specific metrics for climate model outputs (i.e., Alessandri et al 2015; Chevuturi et al 2021). The skill and performance will be based also on the retrospective forecasts 1990-2019 available at BSC performed with the same version of EC-Earth.

Summary of experiments and resources

The experiment planned in this special project is a 60-member ensemble seasonal forecast started May 1st 2020 to predict the subsequent summer and fall. In this experiment, atmospheric forcings are prescribed following the protocol of the CMIP6 COVID-MIP (implemented within DAMIP).

Configuration and justification of resources

We will use EC-Earth3.3 in its seasonal hindcast configuration: IFS cycle 36r4, NEMO3.6, LIM3, OASIS3-MCT and XIOS 2 (input/output server). The default resolution is T255 with 91 vertical levels in the atmosphere, and ORCA1 with 75 vertical levels in the ocean. Based on the extensive evaluation performed in the framework of the EC-Earth consortium, the optimal configuration (without LPJG) on cca is obtained by using 11 nodes, i.e. 396 total cores. The processors are allocated such that 216 are for IFS, 108 for NEMO, 1 for XIOS and 1 for the runoff mapper. With this optimal configuration, we estimate that the model requires about 16900 SBUs per year (on cca). Overall, the total resources estimated for the project is rounded to 709800 SBUs, which includes a buffer of 20% to account for potential differences if the resources are provided in the new HPC Atos in Bologna from early 2022 and not on cca (about 10%), for failing jobs that will need to be repeated (about 5%) and for potential need of extra tests for the porting to the new HPC (about 5%). The summary of the planned simulations is reported in Table 1.

In term of storage the requirement is about 50 Gb per year of simulation, considering monthly means for the atmosphere and the ocean and some 6-hourly atmospheric variables. Therefore, the total storage required for the project is 2100 GB.

Experiment name	Description	Start dates	SBU/year	Ensemble members	Total years	Total SBU
COVID-seas	Seasonal forecast experiment for summer and fall 2020 (7 months)	1	16900	60	35	591500
20% buffer					7	118300
Total					42	709800

Table 1: Experiment planned in this project, total years of simulation and details of the resources needed.

In case additional resources will become available through applications to PRACE and similar programmes, further simulations will be performed likely enlarging the number of members.

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