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

Reporting year ……2026……

Project Title: … Quantifying biosphere-atmosphere interactions: the impacts from vegetation volatile emissions, plant phenology and lake greenhouse gas emission……..……..……

Computer Project Account: ……spdktang……..……

Principal Investigator(s): Jing Tang……..……

Affiliation: University of Copenhagen……..……

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

Start date of the project: ……2026……

Expected end date: ……2028……..……

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)			45000000	23500000
Data storage capacity	(Gbytes)			115692	

Summary of project objectives (10 lines max)

This part of the project focuses on 1) establishing and tuning EC-Earth3-AerChem configurations for studying biosphere–atmosphere interactions related to vegetation volatile emissions, and 2) coupling state of the art phenological module into EC-Earth3 for quantifying the impact of phenology shifts on water cycle. The main objective is to prepare a stable and scientifically reliable coupled modelling framework in which LPJ-GUESS simulated biogenic volatile organic compound emissions and vegetation phenology can be linked to atmospheric and climate responses. The work aims to evaluate 1) how interactive vegetation-derived BVOC emissions differ from prescribed emission inventories and how these differences affect aerosols, clouds, radiation, atmospheric composition and etc., and 2) phenology-hydrology interaction. The first-year priority is therefore model tuning, technical testing, diagnostic development and comparison with reference simulations and reanalysis products.

Summary of problems encountered (10 lines max)

The first project period required more technical tuning than initially expected before production simulations could be started. EC-Earth3-AerChem is computationally demanding, especially when dynamic vegetation and atmospheric chemistry diagnostics are included. Test simulations showed sensitivity to parameter choices, initial conditions and model configuration, requiring several rounds of tuning and evaluation. Some experiments also encountered technical interruptions or unstable behaviour during long integrations, which required restart handling and additional monitoring. Moreover, before coupling the LPJ-GUESS with new phenology module into EC-Earth, we firstly coupled it into a regional climate model (RCA4, with lower computing resource requirements) for testing the feedback of phenology shifts to atmosphere, during some simulation processes, there was a problem of cumulative simulation deviation due to differences in calculation accuracy.

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

The next step is 1) to finalise the tuned EC-Earth3-AerChem configuration and continue stability tests, and 2) to couple the stabilized LPJ-GUESS with new phenology module into EC-Earth3. We will evaluate candidate configurations using global energy balance, near-surface temperature and radiation fields variables. Once the configuration is sufficiently stable, we will proceed with the planned comparison between interactive LPJ-GUESS BVOC emissions and prescribed BVOC emission inputs. The analysis will focus on the chain from BVOC emissions to SOA, CCN, Ozone, cloud radiative effects and near-surface temperature responses. We will also continue improving the restart, archiving and post-processing to support longer production simulations. We will reveal the pathways through which phenology shifts affect water cycle by controlling phenology in the coupling model, and conducting various scenario experiments, and quantify the impact degree of each pathway.

List of publications/reports from the project with complete references

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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.

During the first project year, the work focused on EC-Earth3 tuning and spin-up, which is a necessary step before launching the planned coupled BVOC production simulations. Considerable effort was spent on setting up the model configuration, testing different parameter combinations, checking restart procedures, organising output streams and establishing diagnostics for model stability.

A series of tuning experiments has been conducted. The four experiments shown in the figure 1, MN08, MN09, MN13 and MN14, represent the later stage of this tuning process rather than the full amount of work completed. Earlier tests were used to exclude unstable or clearly biased configurations, improve the technical setup and gradually narrow down the parameter space.

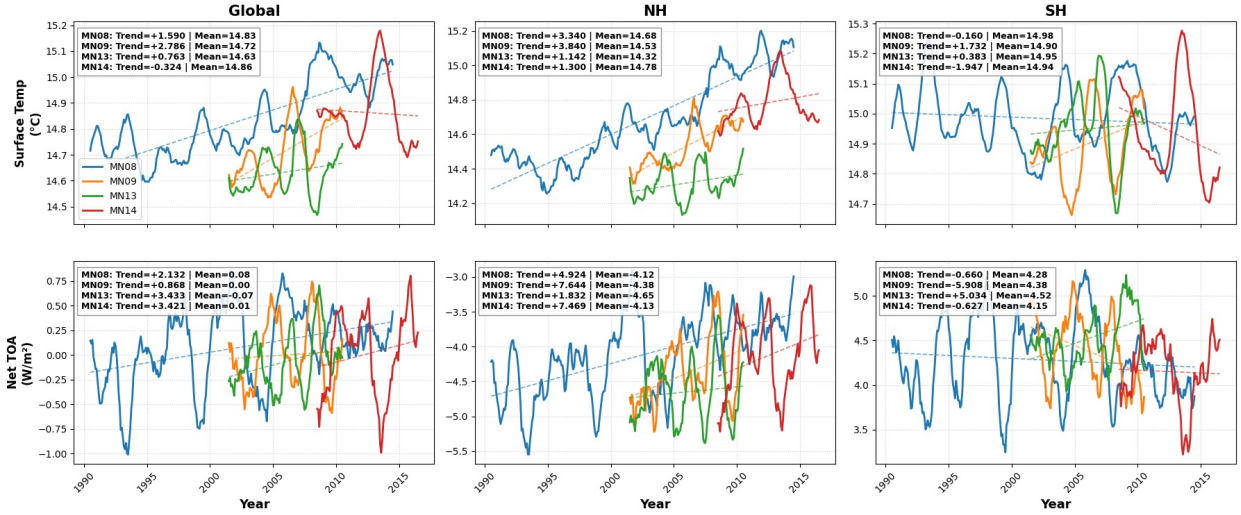

Fig. 1 Coupled EC-Earth3 spin-up comparison for selected tuning experiments.

The tuning assessment is based on a set of global energy-balance and climate diagnostics, including TOA Net LW, TOA Net SW, netTOA, LWCF, SWCF, NetSFC and tas. The figure only shows tas and netTOA as two key summary diagnostics, but the full evaluation also considers the shortwave and longwave components, cloud radiative effects and surface energy balance. This allows us to diagnose whether an apparently improved netTOA results from physically consistent changes or from compensation among different radiation terms.

Overall, the tuning experiments show progress toward a more stable and better-balanced model state. Compared with earlier tests, the later-stage configurations show more reasonable global surface temperature and improved netTOA behaviour. Temperature trends and residual radiative imbalances are not yet fully removed, but the simulations indicate that the tuning is moving in the expected direction.

Concurrently, the LPJ-GUESS phenology module, parameterized specifically for the Chinese region, was coupled into the regional climate model RCA4 to evaluate its localized performance prior to full integration into the Earth system model EC-Earth. Our results demonstrate substantial improvements in simulating both spring and autumn phenology: at the spatial scale, the widespread systematic biases $\pm$ 100 days) inherent in the original model were effectively eliminated, with simulated phenological mismatches sharply converging toward zero across the entire domain; at the plant functional type (PFT) level, the simulated probability density distributions of both the start (SOS) and end (EOS) of the growing season achieved high statistical consistency with observational benchmarks across all

biomes (DBF, DNF, GRASS, and EG, figure 2). These findings confirm that the optimized phenology module provides a robust representation of terrestrial ecological mechanisms, establishing a reliable foundation for capturing large-scale land-atmosphere feedbacks.

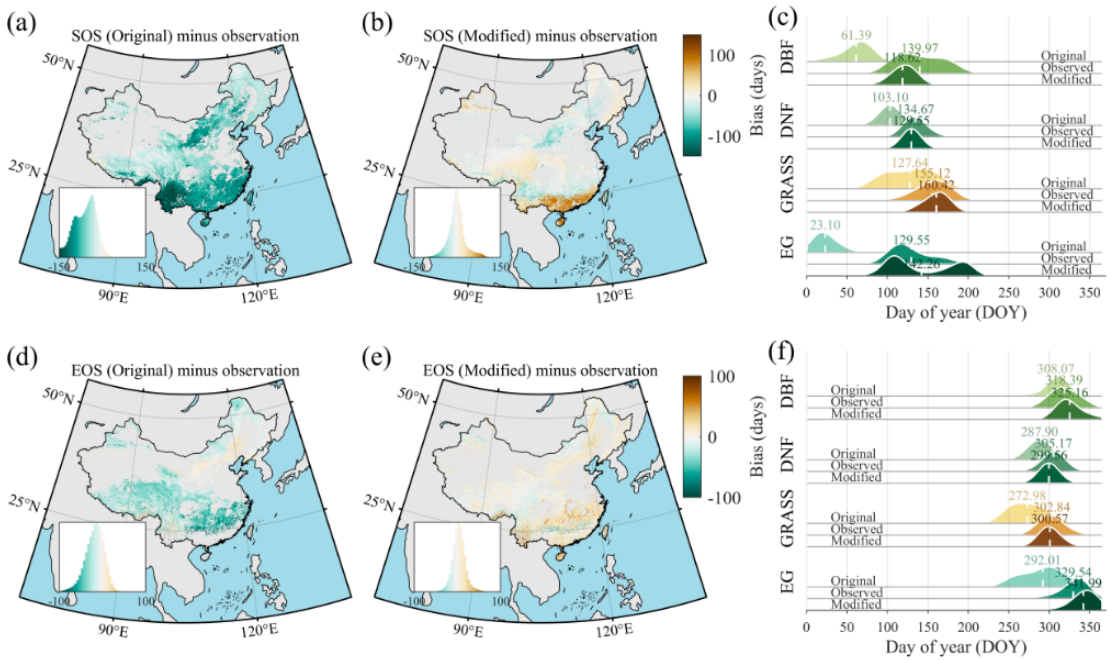

Figure 2. Evaluation of simulated vegetation phenology over China from 1982 to 2018.