# REQUEST FOR A SPECIAL PROJECT 2017–2019

**MEMBER STATE:** UNITED KINGDOM


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**Project Title:** The Role of the Asian Summer Monsoon as a driver of European Summer Circulation Variability

| | | |
|---|---|---|
| If this is a continuation of an existing project, please state the computer project account assigned previously. | **SP** __________________ | |
| Starting year:<br>(Each project will have a well-defined duration, up to a maximum of 3 years, agreed at the beginning of the project.) | 2017 | |
| Would you accept support for 1 year only, if necessary? | YES ☒ | NO ☐ |

| **Computer resources required for 2017-2019:**<br>(To make changes to an existing project please submit an amended version of the original form.) | | **2017** | **2018** | **2019** |
|---|---|---|---|---|
| High Performance Computing Facility | (SBU) | 8 380 800 | 6 285 600 | |
| Accumulated data storage (total archive volume)[2] | (GB) | 24,000 | 48,000 | |

***An electronic copy of this form must be sent via e-mail to**:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

………24 June 2016………………

*Continue overleaf*

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

[2] 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.

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# Extended abstract

*It is expected that Special Projects requesting large amounts of computing resources (1,000,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.*

## Motivation

This proposal is part of a PhD project at the University of Reading in collaboration with the University of Oxford and within a wider NERC-funded project (SummerTIME). The overall aim of the SummerTIME project is to explore the drivers of variability and change in the European summer sirculation. The focus of the PhD project is on the role of the Asian Summer monsoon as one of these drivers for European summer circulation and climate. Our ability to predict European climate at extended ranges (sub-seasonal to seasonal and beyond) depends on the ability of our models to correctly represent remote drivers of the European circulation and the teleconnection pathways from those remote drivers.

One such potential driver is the Asian Summer Monsoon ASM. Two main mechanisms have been proposed for the role of the Asian Summer Monsoon in influencing the climate over Europe. The first mechanism proposed by Rodwell and Hoskins (1996;2001) links the strength of the subtropical anticyclone over the Eastern North Atlantic and Mediterranean Sea to descent induced by the Rossby-wave response to the diabatic heating associated with the Asian Monsoon. The second mechanism proposed by Ding and Wang (2005) relies on a circumglobal teleconnection pattern in which the interaction of the divergent flow associated with diabatic heating in the monsoon with the upper level jets acts as a Rossby-wave source with subsequent downstream development along the wave guide influencing the North Pacific and Atlantic Jet. The downstream waves may subsequently reinforce the Asian Monsoons. Ding and Wang (2005) and Ding et al. (2011) argue that this mechanism may be an important teleconnection pathway through which ENSO influences the summer Northern Hemisphere extratropics via the ENSO-Monsoon teleconnection.

## Progress so far

In the first part of this project we are using atmospheric reanalyses data to identify evidence of the influence of the Asian Summer Monsoon on European climate in summer and potential teleconnection pathways on both seasonal and sub-seasonal timescales. Correlation analysis of monthly mean precipitation, surface temperature and upper and lower-level geopotential anomalies have identified significant correlations between heating in the South Asian (Indian) Summer Monsoon and European Summer Temperature and Precipitation on seasonal timescales, for example figure 1 shows the correlation between precipitation (diabatic heating) over NE India and precipitation globally. In June there is a strong negative correlation with precipitation over the Mediterranean region consistent with the Rodwell and Hoskins mechanism, whilst in July there are significant positive correlations with Northern European Precipitation. However it is not possible to identify a causal relationship from this correlation analysis. Over the coming 3 months we will extend this analysis to sub-seasonal timescales, the use of lag-correlations will allow us to analyse the time evolution of these teleconnection pathway's and develop hypothesis on causal relationships..

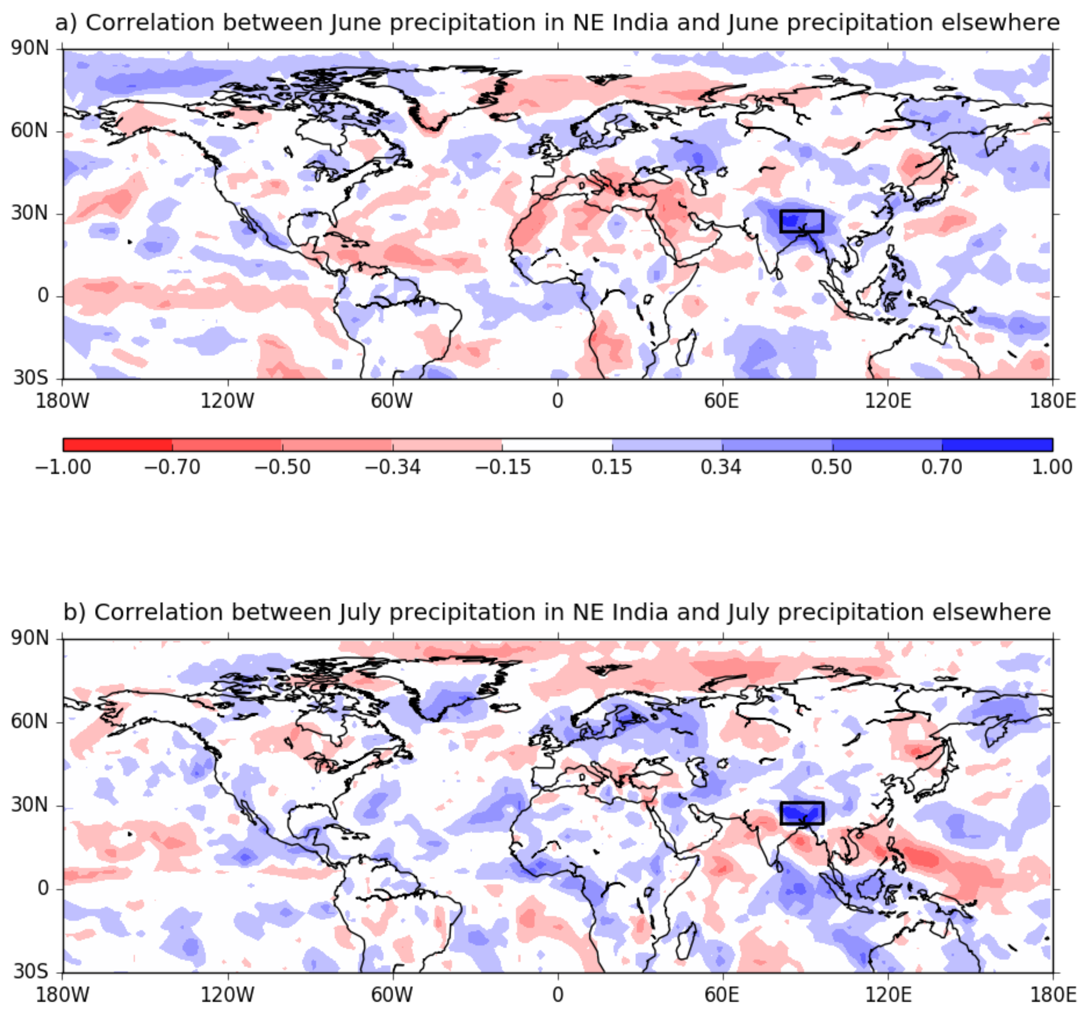


*Figure 1: Correlation between monthly mean GPCP precipitation in NE India (80°E-100°E, 22.5°N-32.5N°), with global precipitation precipitation for (a) June and (b) July for the period 1979-2014. ,*

**Scientific plan and suggested experiments**

Following analysis of the reanalysis data we propose to repeat the analysis for the reforecast datasets from the operational ECWMF and Met Office seasonal forecast systems to evaluate the representation of these teleconnections in operational forecast systems. The representation of these teleconnections in operational prediction systems depend on a number of factors: e.g. the ability of the model to simulate the observed heating anomalies over the Indian Summer Monsoon region; the models ability to capture the Rossby Wave Source depends on the simulated location and vertical profile of the heating and the structure and location of the sub-tropical jet; the Rossby Wave propagation depends on the background extra-tropical state; and the response of the North Atlantic circulation on the correct representation of the response to the local circulation to the forcing from the Rossby Waves. On sub-seasonal timescales biases in any of these aspects can lead to errors in the representation of the teleconnection patterns.

We then propose to perform a series of experiments in the coupled ECMWF model to identify the causal links between precipitation of the Asian Summer Monsoon and the flow conditions over Europe. We are going to apply the nudging, or relaxation, technique following the methodology of Jung el al. (2010) to identify the remote response over Europe to the forcing from the nudging over a given region of relevance of the Asian Summer Monsoon. The relaxation technique applies a nudging (pulling) of the model state towards a prescribed state (here towards the ERA-Interim reanalysis) within a limited region of the atmosphere while the rest of the atmosphere is left to freely evolve according to the model dynamics. By comparison with no-relaxation control simulations, the impact of that source region on forecast errors in remote areas (Europe) can be estimated. By comparison of the simulation teleconnection pathways with observed teleconnections we can begin to identify sources of error in the operational forecast experiments.

We would expect these experiments to begin in mid-2017.

Specifically We propose the following set of experiments:

1. Control (without relaxation) hindcasts with the model version described below over the period 1981-2016 started on each 1st May with a forecast length of 4 months and an ensemble size of 30 members. We opt to reduce the size of the ensemble compared to System 4 because of computational constraints while keeping a large-enough ensemble to be able to analyse the results probabilistically. (2017)

2. Relaxation hindcast experiments with the same model version, ensemble size and over the same hindcast period with relaxation of region A. It is important to have a full set of hindcasts with the relaxation to establish circulation anomalies for particular events based on a matching climatology. (2017)

3. Same as 2. but for region B. (2017)

The precise definition of regions A & B remain to be determined based on the ongoing and planned anlaysis of reanalysis and operational hindcasts, but region A will be defined to capture the large scale Indian heating anomaly similar to the correlated heating pattern in India captured in figure 1a) which is correlated with the Mediterranean precipitation, and region B will be a smaller region likely focused on the NE India heating identified in figure 1b) correlated with the NW European precipitation

4. Following these experiments we expect to perform a set of further sensitvity experiments (2018), the exact design to based on our initial findings, but these will likely focus on e.g.

    a. A repeat of experiments 1,2 & 3 above but using a later start date (e.g. June 1st) to explore the impact of the model bias evolution on the teleconnection pathway, or

    b. An additional set of hindcasts for an additional nudging region, or

    c. Experiments in an uncoupled framework to explore the both the impact of air-sea coupling on the teleconnection and further elucidate the effect of coupled model biases on the teleconnection pathways

**Modelling system**

We propose to run retrospective forecast experiments with the coupled IFS/NEMO system in its seasonal forecast configuration. We plan to use the IFS model version CY41R1 which is more recent that the operational seasonal forecasts from System 4 and has been widely tested by the partners already. We plan to run the simulations in the horizontal resolution $T_L255$ with 60 vertical levels. The ocean model NEMO 3.4 will be used in its standard 1°/L42 configuration. The nudging of the wind, temperature and humidity-related fields will be towards the ERA-Interim reanalysis.

**Justification of computer resources**

The required computing resources for our proposed experiments have been estimated as follows:

- Costs for a 1-member 4-month long control hindcasts over 36 hindcast years (1981-2016): 73 440 SBU

- Costs for a 1-member 4-month long relaxation hindcast over 36 hindcast years (1981-2016): 102 960 SBU

All estimates are approximate numbers derived from test experiments on the Broadwell nodes on the cca HPC.

These costs lead to the following overall requirements:

Experiment 1: 2 203 200 SBU

Experiments 2 and 3: 3 099 800 SBU (for each experiment)

**Total for 2017 : 8 380 800 SBU**

Costs for 2018 are based on performing 4a. from both region A&B for three months from June 1st (which is equivalent to ¾ of the 2017 requirement)

**Total for 2018: 6 285 600 SBU**

## References


Ding Q. and B. Wang, 2005. Circumglobal Teleconnection in the Northern Hemisphere Summer. *J. Climate*, **18**, 3483-3505.

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Jung, T., T. N. Palmer, M. J. Rodwell, and S. Serrar, 2010: Understanding the Anomalously Cold European Winter of 2005/06 Using Relaxation Experiments. *Mon. Wea. Rev*., **138**, 3157–3174.

Rodwell, M. J., and B. J. Hoskins, 1996: Monsoons and the dynamics of deserts. *Quart. J. Roy. Meteor. Soc.*, **122**, 1385-1404.

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