REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Germany……………..…………………………………………...…

Principal Investigator[1]**:** Moritz Pickl…………………………………………………….……

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Other researchers:
Dr. Christian Grams……………………………………………….……
Dr. Julian Quinting…………………………………………….……

Project Title:
Sensitivity of diabatically enhanced outflow on error representation in ensemble prediction…………………………………….……

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.)	2020	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2020-2022: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	700.000	650.000	650.000
Accumulated data storage (total archive volume)[2]	(GB)	15.500	31.000	46.500

Continue overleaf

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[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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Project Title: Sensitivity of diabatically enhanced outflow on error representation in ensemble prediction ….………………………..

Extended abstract

Background and motivation

The Helmholtz Young Investigator Group "**S**ub-Seasonal Atmospheric **Pre**dictability: The role of **D**iabatic **Out**flow" (SPREADOUT) at KIT, Germany, aims at understanding how dynamical and physical processes on synoptic time scales affect predictability and forecast skill in the extended range. A special focus lies on the role of cloud-condensational processes in weather systems, which can modulate the large-scale flow configuration by injecting low-PV air into the upper troposphere and thereby amplify the Rossby wave pattern (e.g. Wernli, 1997; Grams et al., 2011, Joos and Wernli, 2012). Strong latent heating and concomitant diabatic outflow is often associated with ascending air streams in the warm sector of extra-tropical cyclones, so-called warm conveyor belts (WCBs, Madonna et al., 2014). Recent studies show the relevance of WCBs in triggering downstream development of baroclinic waves (Grams and Archambault, 2016) and blocking events (Pfahl et al., 2015). This points towards the necessity of a correct representation of WCBs in NWP models for accurate forecasts (Grams et al., 2018), which is affected by the cloud-microphysics parametrizations in the forecast model (Joos and Wernli, 2012; Joos and Forbes, 2016).

In the framework of "SPREADOUT", the concept of weather regimes is used to describe the flow configuration in the Euro-Atlantic sector. Weather regimes are persistent, quasi-stationary, and recurrent large-scale flow patterns governing atmospheric variability over continent-size regions and on time-scales of several days to a few weeks. (e.g. Michelangeli et al., 1995). While the predictive skill in the medium range depends on the weather regime at initial time of the forecast itself, current NWP-systems still struggle with the correct forecast of transitions between weather regimes, especially with the one from a zonal to a blocked situation (Ferranti et al., 2015). These misrepresentations are of significant relevance for weather prediction centers, as they can lead to high-amplitude forecast errors over large regions (Rodwell et al., 2013). In case studies, some of these forecast busts were linked to erroneous representations of diabatic processes in synoptic-scale weather systems (Martínez-Alvarado et al., 2016; Grams et al., 2018). Further, regions with strong diabatic activity (e.g. WCBs) help to translate small-scale errors (e.g. from wrong initial conditions) to the large scale (Grams et al., 2018).

Project description

In this project we aim to investigate model error growth related to the WCB and in particular its outflow intensity in the ECMWF ensemble prediction system, with a focus on sensitivities on the ensemble configuration. In order to better understand how model error growth related to the WCB affects weather regime life cycles, selected case studies of regime transitions shall be performed with the IFS-model, in close collaboration with Dr. Simon Lang, ECMWF. The ensemble prediction system accounts for uncertainties in the forecast model by adding stochastic perturbations to the physical tendencies supplied by the parametrizations (stochastic physics perturbation tendencies, SPPT (Leutbecher et al., 2017)). In a preliminary study, we analyzed three different IFS ensemble simulation setups of a severe forecast bust in which a WCB played an important role (for a detailed description of the case, see Grams et al., 2018): the operational setup, one without SPPT-scheme and one without initial condition perturbations, provided by Dr. Simon Lang from ECMWF. Even though the forecast error is mainly driven by initial condition errors in this case, we found substantial differences in the representation of the WCB between the operational and non-SPPT-setup, with the southern WCB-branch having less trajectories when model uncertainties are absent (Figs. 1 and 2). This raises the hypothesis that the increments added by the SPPT-scheme influence the WCB and potentially amplify the error growth.

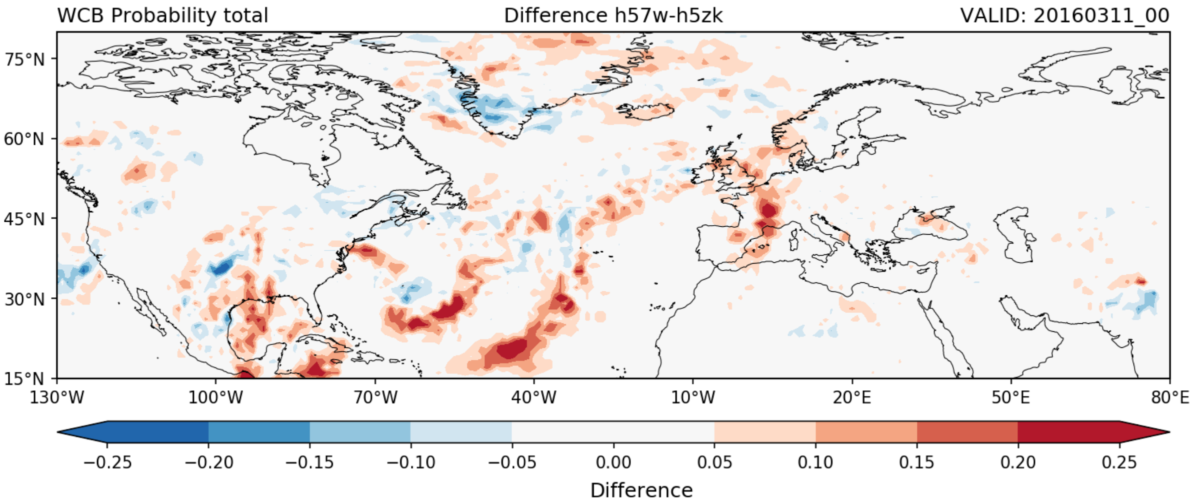

Fig. 1: Difference of WCB-probabilities between the control experiment (h57w) and the experiment with disabled SPPT (h5zk) at lead time 96h, initialized on 20160307 00 UTC. Trajectories are identified as WCB-structures when they ascent at least 550 hPa within 48 hours and touch a closed cyclone mask at least during one time step. Probabilities at every grid point are then calculated as ratio of trajectory hits and ensemble members (here 51). Red (blue) contours indicate areas where more (less) WCB-trajectories are present in the control experiment than in the non-SSPT-experiment.

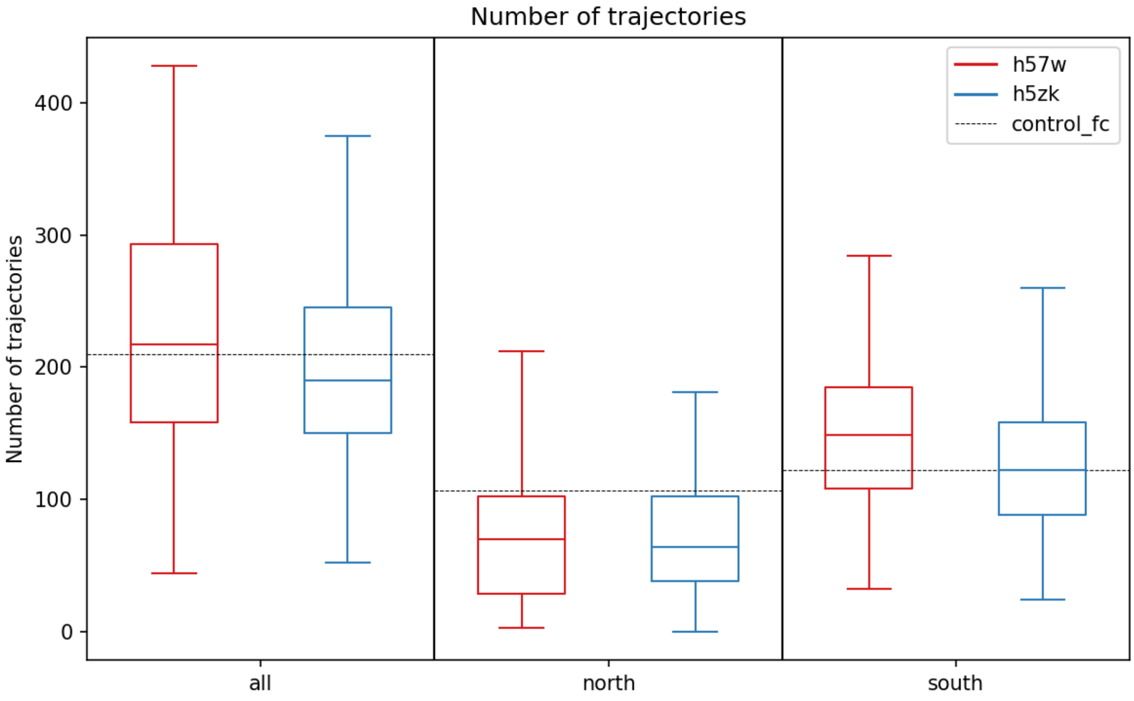

Fig. 2: Boxplot of number of WCB-trajectories in the control experiment (h57w, red boxes) and the non-SPPT-experiment (h5zk, blue boxes) for all WCB-trajectories (left), the northern branch (middle) and the southern branch (right) over the 51 ensemble members. Trajectories start at lead time +48h, initialized on 20160307 00 UTC.

The special project consists of two working packages (WP):

WP1: Modelling the sensitivity of diabatic outflow

In WP1, sensitivity experiments of weather regime transitions, during which diabatic processes are assumed to play a key role, will be performed. In close collaboration with Dr. Simon Lang, IFS ensemble simulations with enabled/disabled initial condition perturbations and model error uncertainties (SPPT) will help to gain further insights in how forecast error grows and is translated across the scales in diabatically driven weather systems. It is planned to conduct 10 case studies with 15 days lead time and 10 ensemble members at spectral resolution of TCo319 (~36 km at 55° N) with hourly output of all relevant fields and SPPT-tendencies. Complementary, we will perform deterministic simulations with DWD's forecast model ICON of each case at a comparable resolution (~39 km) to test for model dependencies. This requires 2.000.000 SBUs of computing resources and 45 TB of data storage, in total.

WP2: Post-processing of model output

We apply a Lagrangian perspective to analyze the characteristics and sensitivities of diabatic outflow associated with mid-latitude weather systems and to detect WCB air stream in the experiments. With the Lagrangian Analysis Tool (LAGRANTO), trajectories can be calculated, filtered by criteria and projected onto an Eulerian grid, and variables can be traced along their course (Sprenger and Wernli, 2015). Additionally, an instantaneous (Eulerian) metric for diabatic outflow (which is currently under development) shall be applied. For the post-processing working package, additional computing resources of 100.000 SBUs and 1.5 TB of data storage are required.

In total, this sums up to 2.100.000 SBUs and 46.5 TB of data storage, distributed over the project duration of 3 years:

	Computing resources		Data storage	
Year	WP1	WP2	WP1	WP2
2020	700.000 SBUs	40.000 SBUs	15 TB	0.5 TB
2021	650.000 SBUs	30.000 SBUs	30 TB	1 TB
2022	650.000 SBUs	30.000 SBUs	45 TB	1.5 TB
total	2.100.000 SBUs		46.5 TB	

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