REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: Austria

Principal Investigator[1]: Dr. Stefano Serafin ……………………………….……

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Project Title: Impact of Aeolus on the prediction of tropical dynamics
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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPATSERA**	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2021	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2021-2023: (To make changes to an existing project please submit an amended version of the original form.)		**2021**	**2022**	**2023**
High Performance Computing Facility	(SBU)	**0**	**3,000,000**	**2,000,000**
Accumulated data storage (total archive volume)[2]	(GB)	**0**	**9,000**	**12,000**

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 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.

Principal Investigator: Dr. Stefano Serafin

Project Title: Impact of Aeolus on the prediction of tropical dynamics

Extended abstract

Impact of Aeolus on tropical dynamics:

The main aim of this project is to analyse the impact of Aeolus measurements on the prediction of tropical waves and their connections to rainfall. For this purpose, we will analyse data denial experiments conducted by Michael Rennie at ECMWF, conduct additional forecast experiments from these analyses and conduct additional assimilation/forecast data denial experiments for specific periods.

Project Description:

In August 2018, the Aeolus satellite carrying the first UV Doppler lidar in space (ALADIN) was successfully launched. The particular gap that Aeolus is closing in the global observing system is measurements of winds in cloud free regions and thus Aeolus is expected to substantially improve respective analysis fields. Figure 1 shows some first very promising results of data impact experiments that indicate that statistically significant improvements in forecasts of winds in the tropics are found out to about five days. Despite these large impact in the tropics, where wind cannot be inferred from the balance with the mass field, most studies so far have primarily focused on midlatitude dynamics and global statistics.

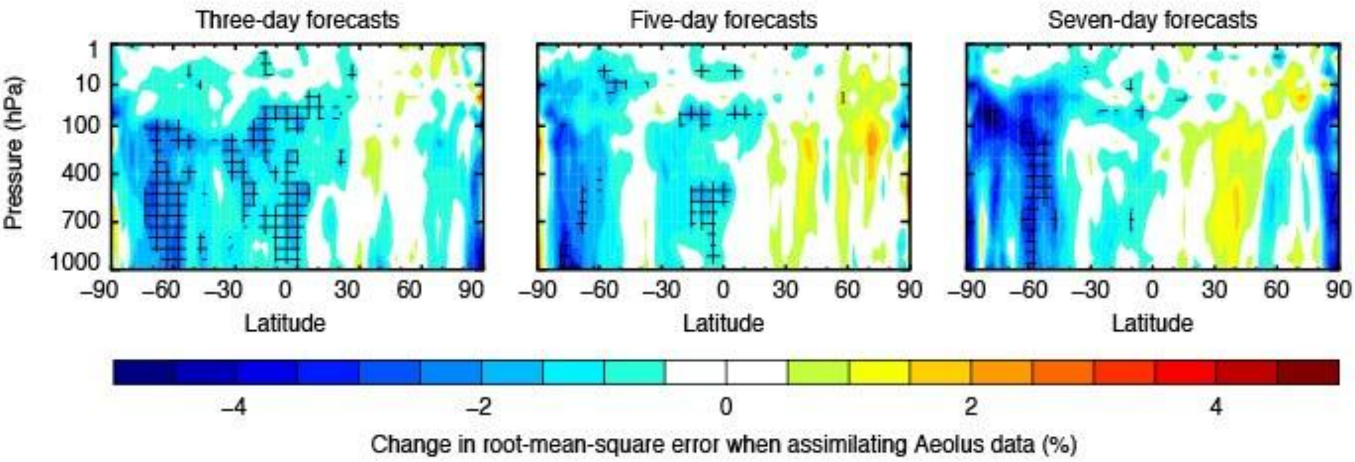

Figure 1: Change in wind forecast errors (shading) through the assimilation of Aeolus data during 2 August–18 October 2019. Cross-hatching indicates statistical significance at the 5% level. Credit: ECMWF.

The project we would like to propose here aims to close this gap through a sophisticated analysis of tropical dynamics, specifically the coupling of tropical waves with precipitation.

A prime opportunity for this research is the upcoming Aeolus Cal/Val campaign during three weeks in June-July 2021 in Cape Verde, which will involve three research aircraft (German and French Falcon, NASA DC8). Our study of the coupling of wind, waves and convection will be integrated in the international research program ASKOS, which will also deploy advanced instrumentation on Cape Verde to provide observations of unprecedented quality and coverage for the wind and aerosol components of Aeolus. Cape Verde during boreal summer is ideal for such a study. The generally high aerosol loading is interesting because it will allow the measurement of both aerosol optical properties and wind, thus opening the way to the study of the interaction between the two.

During this time of year, Cape Verde and the adjacent coast of West Africa are located close to the axis of the midlevel African easterly jet that allows for the formation of synoptic-scale African easterly waves (AEWs) that typically reach their maximum intensity in this region. AEWs interact with convection and its mesoscale organization through modifications in humidity, temperature and vertical wind shear *[Fink and Rainer, 2003; Schlueter et al. 2019a]*, and often serve as initial disturbances for tropical cyclogenesis. In addition, the tropical atmosphere sustains different types of planetary waves (inertia-gravity waves, mixed Rossby-gravity waves, Kelvin waves, ...) that also interact with monsoon convection and AEWs *[Schlueter et al. 2019b]*.

It will be of particular interest to investigate to what extent and how improvements in analysis data carry through to better forecasts. This applies to both the waves themselves and also to the associated rainfall (and possibly dust in collaboration with ASKOS-AEROSOL). This aspect may even be extended to tropical cyclogenesis. The analysis of tropical waves requires the application of adequate tools to extract wave information from the model data. Techniques using time wave filtering *[Wheeler & Kiladis 1999]* or instantaneous projection onto wave patterns *[Yang et al. 2003]* will be applied. These tools will enable extracting planetary equatorial waves information, solutions of the classical shallow water theory, and waves generated by synoptic-scale tropical disturbances (AEWs) (see example Figure 2).

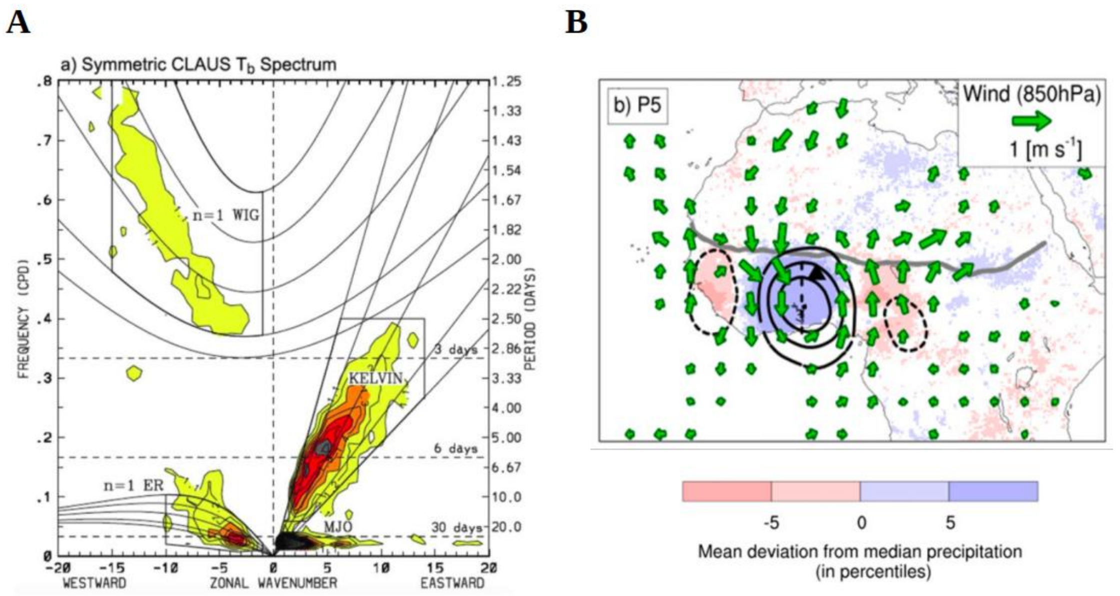

Figure 2: A**)** Observational evidence for the appearance of the Kelvin mode in frequency–wave number spectra of the atmosphere. *From* Wheeler & Kiladis (1999) B**)** *Composites of days with significant tropical depressions (AEWs) signal in phase 5 (wet phase) over West Africa during the extended monsoon season (March–October): Significant anomalies of 850-hPa wind (green arrows) and divergence at 200 hPa. Adapted from Schlueter et al.(2019b).*

Proposed experiments:

It is proposed to conduct additional data denial experiments (with and without the assimilation of Aeolus) for a selected period of interest (e.g. the 1-month Cal/Val field campaign in 2021) in the first year. The resolution of the experiments shall be TCo399 following previous impact experiments of Michael Rennie at ECMWF and the experiments shall include forecasts up to a lead time of 15 days.

Furthermore, we propose to conduct additional forecast experiments with a lead time of 15 days for selected periods (1-2 months) with increased temporal output for a more detailed analysis of tropical waves. These forecast experiments shall be conducted in years 2+3 and shall be initialized using assimilation experiments conducted by Michael Rennie.

Wave information will be extracted from both the control run and denial experiments and comprehensive analyses will be conducted to statistically compare the impact of Aeolus data on wave type, amplitude, propagation and coupling to rainfall. These results can again be compared to those obtained from satellite information of rainfall and OLR.

References:

Fink, Andreas H., and Andreas Reiner. "Spatiotemporal variability of the relation between African easterly waves and West African squall lines in 1998 and 1999." Journal of Geophysical Research: Atmospheres 108.D11 (2003).

Schlueter, Andreas, et al. "A systematic comparison of tropical waves over northern Africa. Part I: Influence on rainfall." Journal of Climate 32.5 (2019): 1501-1523.

Schlueter, Andreas, Andreas H. Fink, and Peter Knippertz. "A systematic comparison of tropical waves over northern Africa. Part II: Dynamics and thermodynamics." Journal of Climate 32.9 (2019): 2605-2625.

Wheeler, Matthew, and George N. Kiladis. "Convectively coupled equatorial waves: Analysis of clouds and temperature in the wavenumber–frequency domain." Journal of the Atmospheric Sciences 56.3 (1999): 374-399.

Yang, Gui-Ying, Brian Hoskins, and Julia Slingo. "Convectively coupled equatorial waves: A new methodology for identifying wave structures in observational data." Journal of the atmospheric sciences 60.14 (2003): 1637-1654.