REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: Ireland

Principal Investigator[1]: Geoffrey Bessardon

Affiliation: Met Éireann

Address: 65/67 Glasnevin Hill

Dublin 9

D09 Y921

Ireland

Other researchers: Emily Gleeson

Project Title: LAI sensitivity testing in HARMONIE-AROME for NWP forecasting for Ireland

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.)	2021	
Would you accept support for 1 year only, if necessary?	YES [X]	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)	9M		
Accumulated data storage (total archive volume)[2]	(GB)	18		

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: Geoffrey Bessardon

Project Title: LAI sensitivity testing in HARMONIE-AROME for NWP forecasting for Ireland

Extended abstract

1. Background

The Irish Meteorological Service, Met Éireann, is one of the 26 national meteorological services in Europe and North Africa forming the HIRLAM (High Resolution Limited Area Model) and ALADIN (Aire Limitee Adaptation Dynamique Developpement International) consortia which uses the shared ALADIN-HIRLAM numerical weather prediction system for operational weather forecasting. Since 2011, Met Éireann has been using the HARMONIE-AROME canonical configuration of this system. Met Éireann currently uses cycle 40 of the system operationally (Bengtsson et al. 2017) and uses ALADIN non-hydrostatic dynamics (Benard et al. 2010), non-hydrostatic mesoscale (MesoNH) physics (Lafore et al. 1998) and the SURFEX (Surface Externalisee) externalised surface scheme (Masson et al. 2013). Surface processes and physiography issues have been identified as some of the factors limiting the HARMONIE-AROME performances (Bengtsson et al. 2017) leading to work around SURFEX and its inputs across the HIRLAM community.

The fluxes between the surface and the atmosphere are multiple from snow, orography, land, town, aerosols, sea leading to horizontal heterogeneity. To deal with the heterogeneity of the atmosphere, the surface in SURFEX is divided within a grid mesh into several homogeneous tiles type: Nature, Lakes, Town, and Sea. A land cover map containing the tile information is used to obtain each tile fraction over the grid mesh. Every tiles and patches receive the same atmospheric forcing and the resulting fluxes is calculated and then averaged over the grid box.

Since cycle 40, SURFEX in HARMONIE-AROME runs with two patches on the nature tile (grouping different vegetation types: P1=open land and P2=forest). In P1 roughness length (z_0) for grass and crops respectively are defined by the following equations and depend on leaf area index (LAI).

$$z_0 = 0.13 * LAI/6 \quad (1)$$

$$z_0 = 0.13 * \min\left(1.0, e^{((LAI-3.5)/1.3)}\right) \quad (2)$$

Near the surface, horizontal winds follow a logarithmic wind profile inversely proportional to z_0:

$$U(z) = \frac{u_*}{k}\log\left(\frac{z}{z_0}\right) \quad (3)$$

Equation (3) is associated with the expressions of z_0 (1) and (2) and shows that winds over grassland and crops are inversely proportional to LAI.

The next cycle of HARMONIE-AROME, cycle 43, uses the latest version of the ECOCLIMAP (Masson et al. 2003) land cover map, ECOCLIMAP-SG (CNRM (n.d.)). ECOCLIMAP-SG, contrary to previous versions, uses external tree height, albedo and LAI data inputs. As shown by the green colour on figure 1 in ECOCLIMAP-SG Ireland is mainly covered by grassland; thus the choice of the appropriate LAI input is important for accurate surface wind representation over Ireland.

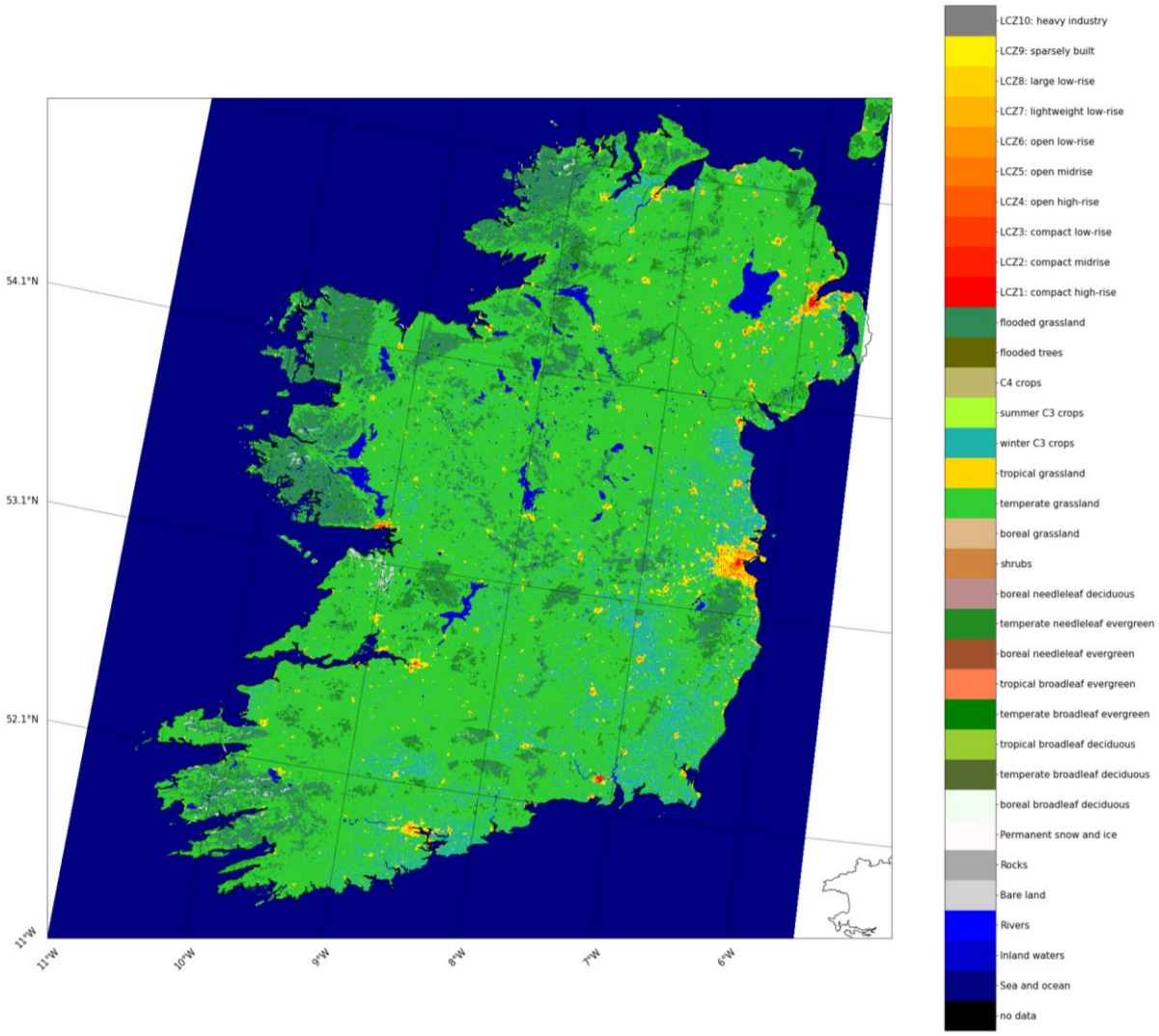

Figure 1 ECOCLIMAP-SG land cover types over Ireland

CNRM suggests two multiyear climatologies as input for ECOCLIMAP-SG (CNRM (n.d.)): the 2014-2016 Copernicus satellite LAI data at 300m-resolution, and the 1999-2016 Copernicus satellite LAI data at 1km-resolution, brought to 300m resolution using a Kalman filter. Sensitivity testing for the June 2018 Drought over Ireland using HARMONIE-AROME cycle 43 showed that the LAI multiyear climatologies are not appropriate for representing the LAI during extreme events such as a drought. The implementation of ECOCLIMAP-SG, (including the multiyear climatology of LAI) leads to too strong winds forecast (Bessardon et al. 2020). This overestimation was due a combination of a change in vegetation type, change of LAI input and need for retuning equations such as (1) and (2) following these changes.

This study will primarily focus on comparing different climatologies of LAI data and near-real time LAI data to assess the benefits of near real-LAI under different meteorological conditions.

2. SBU justification for the various Experiments

Figure 2 represents the current (orange) and the previous (red) operational domain for Ireland. Both operational domains have a horizontal grid spacing of 2.5 km and 65 vertical levels with the current and previous operational domain covering 1000x900 and 500 x 540 grid points respectively. Running the current and previous for one 24-hour forecast cycle costs approximately 13000 SBUs and 4000 SBUs respectively

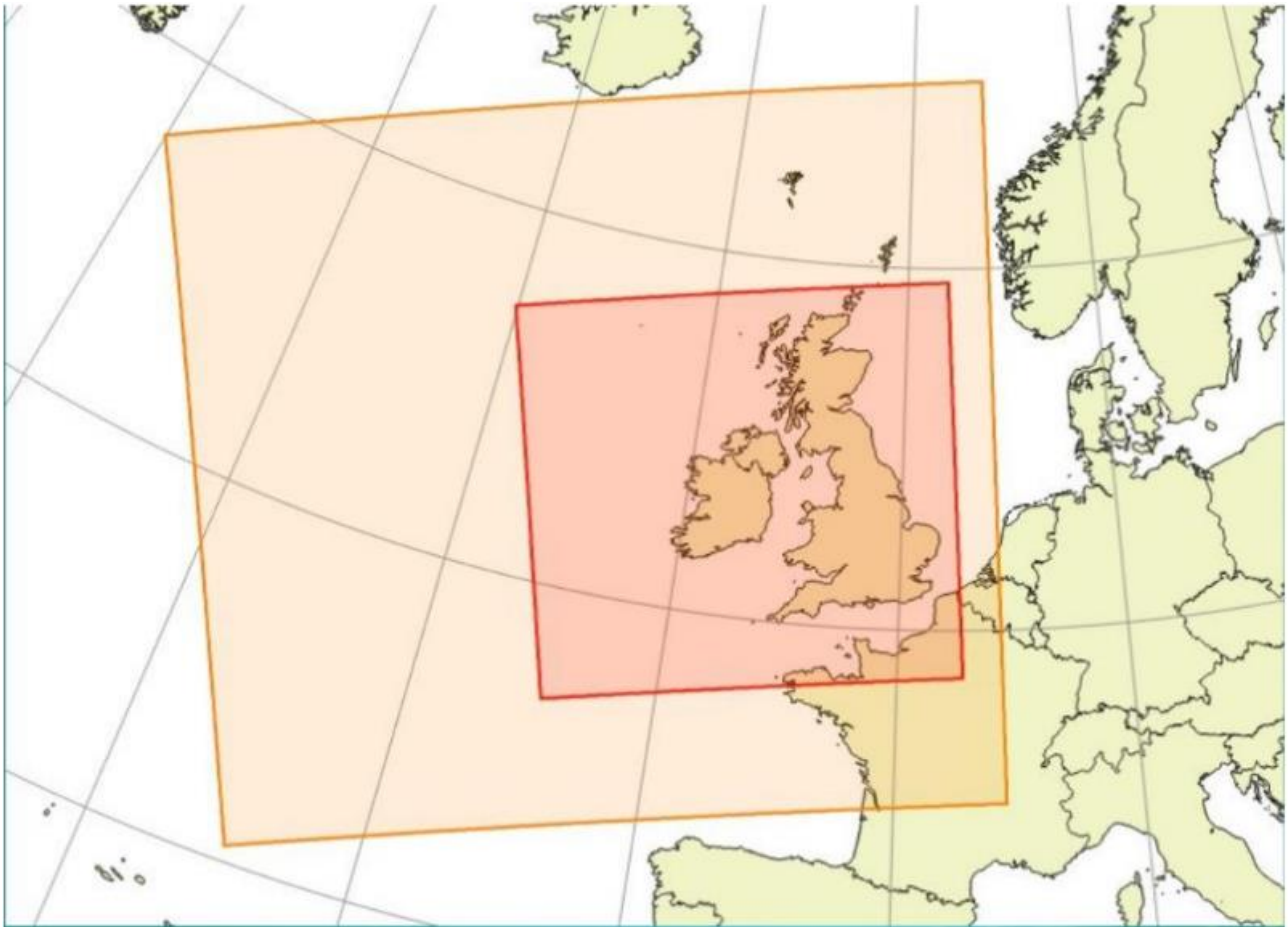

Figure 2 Irish operational domain in orange, old operational domain in red.

The requested resource of 9 MSBUs will be spent as follows:

- A series of 16 1-month long HARMONIE-AROME cycle 43 simulations, using the 2014-2016 Copernicus satellite LAI data (Copernicus Service information. (n.d.)) at 300m-resolution. The chosen month will be selected a large range of meteorological conditions following and differing from Ireland climatology. SBU estimate: 2M SBUs.
- A series of 16 1-month long HARMONIE-AROME cycle 43 simulations, using the 1999-2016 Copernicus satellite LAI data (Copernicus Service information. (n.d.)) at 1km-resolution, brought to 300m resolution using a Kalman filter. The chosen month will be selected a large range of meteorological conditions following and differing from Ireland climatology. SBU estimate: 2M SBUs.
- A series of 16 1-month long HARMONIE-AROME cycle 43 simulations using ECOCLIMAPv2.5. The chosen month will be selected a large range of meteorological conditions following and differing from Ireland climatology. SBU estimate: 2M SBUs.
- A series of 16 1-month long HARMONIE-AROME cycle 43 simulations, using the corresponding period PROBA-V satellite LAI data at 300m-resolution. The chosen month will be selected a large range of meteorological conditions following and differing from Ireland climatology. SBU estimate: 2M SBUs.
- Some discussion occurs to change the expression of z_0 parameters the remaining units will be used to test the change of these parameters

3. Benefits of the Project

The use of multiyear climatological data is showing its limit for extreme weather events such as the 2018 Drought (Bessardon et al. 2020) and the use of near-real time LAI data have not been tested over Ireland. The use of near near-real time LAI over Ireland should reduce the surface wind errors during extreme events and should preserve the wind quality during "regular" meteorological conditions. A thorough analysis of the benefits of using near-real time LAI under a range of meteorological conditions is needed and this special project will enable an evaluation to be done over the Irish domain.

4. References

Benard, P., J. Vivoda, J. Masek, P. Smolıkova, K. Yessad, C. Smith, R. Brozkova, and J.-F. Geleyn, 2010: Dynamical kernel of the Aladin-NH spectral limited-area model: Revised formulation and sensitivity experiments. Quart. J. Roy. Meteor. Soc., 136 (646), 155–169, doi:10.1002/qj.

Bengtsson, L., U. Andrae, T. Aspelien, Y. Batrak, J. Calvo, W. de Rooy, E. Gleeson, B. Hansen-Sass, M. Homleid, M. Hortal, K. Ivarsson, G. Lenderink, S. Niemelä, K.P. Nielsen, J. Onvlee, L. Rontu, P. Samuelsson, D.S. Muñoz, A. Subias, S. Tijm, V. Toll, X. Yang, and M.Ø. Køltzow, 2017: The HARMONIE–AROME Model Configuration in the ALADIN–HIRLAM NWP System. Mon. Wea. Rev., 145, 1919–1935, https://doi.org/10.1175/MWR-D16-0417.1

Bessardon, G., Gleeson, E., (2020) Physiography sensitivity testing over Ireland. Retrieved from http://www.umr-cnrm.fr/aladin/spip.php?article344

CNRM. (n.d.). Wiki - ECOCLIMAP-SG - CNRM Open Source Site. Retrieved October 29, 2019, from https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/wiki

Copernicus Service information. (n.d.). Copernicus Global Land Service - Leaf Area Index. Retrieved June 17, 2020, from https://land.copernicus.eu/global/products/LAI

Lafore, J. P., and Coauthors, 1998: The Meso-NH Atmospheric Simulation System. Part I: adiabatic formulation and control simulations. Ann. Geophys., 16 (1), 90–109, doi:10.1007/s00585-997-0090-6.

Masson, V., Champeaux, J. L., Chauvin, F., Meriguet, C., & Lacaze, R. (2003). A global database of land surface parameters at 1-km resolution in meteorological and climate models. Journal of Climate. https://doi.org/10.1175/1520-0442-16.9.1261

Masson, V., and Coauthors, 2013: The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes. Geosci. Model Dev., 6 (4), 929–960, doi:10.5194/gmd-6-929-2013. Napoly, A., A. Boone, P. Samuelsson, S. Gollvik, E