Project Number: 101062427

Project Acronym: PALEOSIM

Project Title: PALEOclimate modelling of Small Islands in the Mediterranean and possible impacts on arthropod habitats

PCDP: Personal Career Development Plan

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1 Project Overview

PALEOSIM (PALEOclimate modelling of Small Islands in the Mediterranean and possible impacts on arthropod habitats) focuses on the climate and Land-Use Change (LUC) impacts on arthropod habitats of small islands using a Regional Climate Model (RCM).

PALEOSIM is a multidisciplinary investigation of the climate and associated arthropod habitats in the Circum-Sicilian Islands (CSI). For the first time, the RegCM can combine the Convection Permitting (CP) and Paleoclimate modes to produce 2 km resolution simulations between 21,000 ka and 2100CE. This span of time is characterised by slow climate and geomorphological variation at the beginning, and rapid anthropogenic climate change and LUC at the end. The paleoclimate simulations will shed light on the role humanity has played in the ecological destabilisation of many of these small islands.

The research component of the project is divided into 3 work packages (WPs) that prioritise specific milestones and achievements required to reach the objectives of the project. The primary goal required for the project is to link the meteorological parameters of climate models to the ecological state of various arthropod groups – this is hence tackled within WP1. The remaining research WPs apply the accomplishments of WP1 to the simulations run during the project. Since the historical scenario (1995-2014) will be the baseline for all simulations, and can be compared to the most reliable reference data, this is handled within WP2 (together with the future scenarios). WP2 also tackles the challenge of CP mode for a new domain at 2 km resolution. The final step of complexity is to add the paleoclimate component to the achievements of WP1 and 2, into WP3, where all the scenarios put together will improve our understanding of past climate changes on the CSI, and showcase the potential of small islands RCM simulations. The project will provide new insight into the expected habitat changes arthropods may experience in the future, and help mitigate the destruction of these fragile ecosystems.

Three additional WPs handle the management of the project, including knowledge transfer, dissemination, and general project management (WP4-6 respectively). Training required to obtain a better understanding of ecology, field-work, and paleoclimate analysis makes up WP4. Two secondments at the Abdus Salam International Centre for Theoretical Physics (ICTP) and a 6-month placement at Esplora Interactive Science Centre (EISC) are also included in WP4.

By the end of October 2022, a Project Management System was setup by the Marie Curie Fellow (MCF), Dr James Ciarlo`. The system is maintained and updated through Google Sheets[1] which includes tasks, a gantt chart, finances, and any other data required throughout the project. This marked the achievement of the first project milestone: M6.1 - Successful setup of Project Management Plan.

An integral part of the preparation and management of the project included the setup of a Financial Management Plan, a Risk Contingency Management Plan, and a Data Management Plan; these are described below.

[1] PALEOSIM management sheet: https://docs.google.com/spreadsheets/d/1t34UC8uc1yC5olWkslyRdKfXGz0Eu1ftof5EyLWyjL0/edit?usp=sharing

1.1 Financial Management Plan

Although not all project expenses can be known in advance, a list of expected expenses was prepared and is detailed in Table 1, below. The list is also maintained and updated within the project management sheet described in the previous section.

As of the writing of this report, the expenses listed up to month 6 have been confirmed; two books required for ecology training, and the flights and accommodation associated with the first secondment at the ICTP (booked for the 15th Jan – 16th Mar 2023).

Although many expected expenses are subject to change, they are described below. The table includes three publications, listed as deliverables within the project proposal, and the expense associated for 'open-access' for each journal (also subject to possible change). Expenses associated with the second secondment at the ICTP are based on the first, and listed flight prices as of mid-December 2022 (this is also true for all other flights, trains, and ferries). Estimates for accommodation were made from averages on booking.com.

Several trips are envisaged for this project: 2 secondments to the ICTP in Trieste, Italy (15th Jan – 16th Mar 2023); an additional journey to Trieste for the joint CORDEX Conference and RegCM Workshop (Sep/Oct 2023); the European Congress of Entomology (ECE) in Heraklion, Crete (16-20th Oct 2023); American Geophysical Union (AGU) Fall Meeting (11-15th Dec 2023); and European Geosciences Union (EGU) 2024 (14-19th April 2024). The project also includes 3 trips to some of the Circum-Sicilian islands, at yet unspecified dates.

The current expenses total to €25,421.58 out of €30,000.00 allotted for the project, with a remaining budget of €4,578.42. This will account for any remaining expenses (some unconfirmed, and others unexpected). These may include 1 or 2 additional fieldwork trips to Sicily (estimated at €230 each), hard drives for backup and storage (current prices include €420 for 12TB storage[2] – additional information in Section 1.3), and other expenses that may arise from the proxy application training (TR3 in the project proposal) and placement.

Table 1. List of expected expenses of PALEOSIM. The list includes a general description, expected cost, the associated WP and task abbreviation, as well as the project month associated with the task/expense. The items are organised in the order of the when the expenses are expected to be made. Every shaded section represents the itemized expenses of each trip.

Expense	Cost (€)	WP	T	m #
Book: The Insects (5th Ed) - Gullan & Cranston	78.00	4	TR1	2
Book: Insect Ecology (5th Ed) - Schowalter	162.75	4	TR1	2
SC1: Trieste flights - 15 Jan - 16 Mar	156.96	4	SC1	6
SC1: Trieste accommodation	1100.00	4	SC1	6
Open-access: npj Climate and Atmospheric Science	2690.00	1	D1.1	10
SC2: Trieste flights - Jul/Aug	280.00	4	SC2	12
SC2: Trieste accommodation	1100.00	4	SC2	12

[2] Prices obtained from AtoZ Electronics, Malta

CORDEX/RegCM Conference: Trieste flights	280.00	5	C/W0	14
CORDEX/RegCM Conference: Trieste accommodation	700.00	5	C/W0	14
ECE 2023: flights	354.00	5	C1	15
ECE 2023: Heraklion accommodation	270.00	5	C1	15
AGU 2023: Year Membership	50.39	5	C2	17
AGU 2023: Application	70.54	5	C2	17
AGU 2023: Registration	604.63	5	C2	17
AGU 2023: San Francisco flights	961.00	5	C2	17
AGU 2023: San Francisco accommodation	1500.00	5	C2	17
Open-access: Journal of Advances in Modelling Earth Systems	2116.21	2	D2.1	19
Field-work (Pelagian): flights	160.00	1	T1.2	20
Field-work (Pelagian): ferries	33.00	1	T1.2	20
Field-work (Pelagian): accommodation	180.00	1	T1.2	20
Field-work (Aeolian): flights	50.00	1	T1.2	20
Field-work (Aeolian): trains	20.00	1	T1.2	20
Field-work (Aeolian): ferries	159.00	1	T1.2	20
Field-work (Aeolian): accommodation	360.00	1	T1.2	20
Field-work (Egadi, Pantelleria & Ustica): flights	160.00	1	T1.2	20
Field-work (Egadi, Pantelleria & Ustica): coaches	15.10	1	T1.2	20
Field-work (Egadi, Pantelleria & Ustica): ferries	110.00	1	T1.2	20
Field-work (Egadi, Pantelleria & Ustica): accommodation	360.00	1	T1.2	20
EGU 2024: Lifetime Membership	500.00	5	C3	22
EGU 2024: Application	40.00	5	C3	22
EGU 2024: Registration	450.00	5	C3	22
EGU 2024: Vienna flights	150.00	5	C3	22
EGU 2024: Vienna accommodation	700.00	5	C3	22
Open-access: Nature Climate Change	9500.00	3	D3.1	24
Estimated Total	**€ 25421.58**			
Estimated Unused	**€ 4578.42**			

1.2 Risk Contingency Management Plan

During the preparation of the project proposal several potential problems were outlined, and while no major risks were predicted this list remains important for the duration of the project. Although the situation remains unchanged, the risks and associated mitigations plans have been discussed with Prof. Mifsud, and will continue to be updated with the progress of the project. The potential risks and current mitigation plans are detailed in Table 2, below.

Table 2. Risk Management Chart for all WPs of PALEOSIM. The chart includes potential risk, level of risk, associated WP or task (T), and the mitigation plan.

#	Risk	Level	WP/T	Mitigation Plan
1	Field-work hazards	low	T1.2	Safety precautions and common-sense practices have been outlined to avoid injury during field-work. These include: not entering private properties; watching one's footing and surroundings; avoiding dangerous terrain; carrying a first-aid kit; having a travel partner and a communication device, especially in unfamiliar places; and informing a friend/family member of your intended whereabouts. In unfamiliar territory, a guide may be hired for, and possibly applying for a first-aid refresher course.
2	COP participants	med.	T1.2	Participation in the COP is not guaranteed: the field-work will mitigate this in-part, and will continue until month 20 to ensure that some data is obtained from different isles in the CSI. Furthermore, Bioblitz activities will encourage participation together with the researchers. Should these activities also fail, the iNaturalist database would provide enough data for project requirements.
3	COP quality and safety	low	T1.2	When promoting the COP, instructions are provided to ensure that the data being delivered is reliable, and participation efforts do not harm the photographed specimens and their habitat. Helpful safety instructions are also included together with a disclaimer that participants are solely responsible for their safety. Furthermore, no personal data about the participants will be collected.
4	Observation data access	low	T1.3	Acquisition of new station data is not guaranteed, and some data is available against payment, however several reference and observation data-sets are accessible through the ICTP.
5	Supercomputer breakdown/ Simulation instability	med.	T2.3, T3.3	The simulations will be run concurrently for efficiency and the total estimated running time has been overestimated by to account for any delays.
6	GCM data access	med.	T2.3, T3.3	Some PMIP data is available on ESGF, the rest is available upon request from various institutes. 2 out of 3 GCMs have already been selected and data access has been confirmed.
7	Lack of storage space	low	T2.3, T3.3	A 20-year simulation generates large output files with several variables unnecessary to the project, therefore key variables will be processed during the run and stored at a lower capacity. Additional detail is provided in the DMP.
8	Computational budget	low	T2.3, T3.3	7.9-12.8M core hours will be needed, including an additional 15% to account for configuration tests, crashes, and post-processing; 50M hours/year are available to ICTP on CINECA HPC.
9	PMIP scenario access	low	T3.3	Most PMIP GCMs did not run all the 4 required paleoclimate scenarios; using 3 GCMs will ensure that at least one is available for each scenario. From the 2 GCMs selected, one has all 4, and the other has 2 (discussions are ongoing with Stockholm University to add a third).
10	Software license/failure	low	WP1-3	The RegCM is an open-source RCM with a community support system and technical support available at the ICTP. The processing tools are freely available with online technical support.

11	Loss of data	low	WP1-3	All downloaded and processed data will be stored on local hard drives and backed up. Any scripts prepared will be backed up on an open-source online platform (such as GitHub). More information available in DMP.
12	Reliable results	low	WP1-3	Multiple parameters from 3 GCMs will be combined to reliably describe a habitat.
13	Project budget	low	WP1-5	Project costs, which include field-work travel, station data, computer storage, are well below the amount provided by the fellowship. These are detailed and maintained in the FMP.
14	Language limitations	low	WP1-5	English is the main language at the UM, to operate all the software, and communicate with technical staff; Italian will also be required for communication activities in Sicily; The MCF is experienced with both.
15	Late schedule	med.	WP1-5	Simulation instability may slow the progress of the simulations and publication of results. Social restrictions may disrupt conference participation and field trips. Regular meeting with the supervisors will enable the team to identify and mitigate any delayed schedules.
16	COVID-19	low	WP1-5	The entire research team is fully vaccinated and willing to take a booster, furthermore all the essential tasks can be done by correspondence in case of a lockdown/quarantine.

1.3 Data Management Plan

PALEOSIM is a project that requires handling of large data-sets; some downloaded, and others generated. For the duration of the project, this needs to be stored safely (and backed up), and once completed, the data needs to be made freely available for distribution.

The largest sources of data generation are the simulations. The intermediate EUR-11 (0.11° European) simulations will be provided by the ICTP, as these are currently being generated for CMIP6[3] CORDEX[4]. The 2km CSI domain, according to the most recent domain tests should be made up of 397x397 grid cells. As the simulations are not yet completed, and with uncertainty on some of the PMIP[5] GCM data sources, the estimates presented below are based on the CORDEX EUR-11 and the EUCP[6] Alps simulations available at the ICTP.

The variables required from the processed output of the simulations will determine what is required throughout the project. For the analysis of arthropod habitats, daily mean, maximum and minimum near-surface air temperatures (tas, tasmax, tasmin), precipitation (pr), total soil moisture (mrso), and mean and maximum near-surface wind speed (sfcWind, sfcWindmax) are the most important parameters required; these are represented as "day[1]" in Table 3. Additional daily parameters ("day[2]") should also be processed for the possibility of a change in analysis structure; these include evaporation rate (evspsbl), near-surface relative and specific humidity (hurs, huss), surface and mean sea level pressure (ps, psl), duration of sunshine (sund), surface temperature (ts), eastward and northward near-surface wind (uas, vas), and height of boundary layer (zmla). A few fixed (fx) variables must also be backed up; these include surface altitude (orog), land area fraction (sftlf), and land-use information (the latter is not currently stored and the possibility of preserving this variable, remains uncertain).

[3] https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6
[4] https://cordex.org/
[5] https://pmip.lsce.ipsl.fr/
[6] https://www.eucp-project.eu/

Table 3. EUR-11 CORDEX variables to store for PALEOSIM simulations. The variables are divided according to the frequency (freq.) of the output files. The file sizes provided are for a single year of an EUR-11 simulation (527x527 grid cells). The total size of each group of variables is also represented per year of EUR-11. The day variables are divided into two groups of different priority [1 and 2].

freq.	total size	variables (size)
fx	~7.50MB	orog (2MB), sftlf (5.5MB), landuse (?)
mon	135.00MB	evspsbl (9.5MB), hurs (8.3MB), huss (8.5MB), mrso (5.6MB), pr (9.6MB), ps (6.7MB), psl (4.9MB), sfcWind (8.9MB), sfcWindmax (8.9MB), sund (5MB), tas (6.7MB), tasmin (9.7MB), tasmax (6.8MB), ts (6.8MB), uas (9.8MB), vas (9.8MB), zmla (9.3MB)
day[1]	1.65GB	tas (225MB), tasmin (230MB), tasmax (228MB), pr (228MB), mrso (159MB), sfcWind (313MB), sfcWindmax (313MB)
day[2]	2.55GB	evspsbl (267MB), hurs (313MB), huss (313MB), ps (230MB), psl (176MB), sund (57MB), ts (228MB), uas (341MB), vas (341MB), zmla (341MB)
3hr	6.70GB	tas (1.8GB), pr (1.3GB), mrso (1.1GB), sfcWind (2.5GB)

Using the variables defined above, and the data summary in Table 3, the day[1], monthly (mon), and fx variables should be all extracted, to provide the necessary data for analysis and additional basic tests (if necessary). This priority group [A] should occupy a maximum of 484.8GB of storage for 3 GCM each with 8 scenarios (1 historical, equivalent of 3 future, 4 paleoclimate) of 20-year runs. If possible, the addition of day[2] and the 3 hourly (3hr) variables listed in Table 3 should also be included. The priority [B] group encompasses all the frequency groups defined in Table 3, reaching a maximum storage requirement of 2.9TB for all simulations.

Since the configuration of the CP simulations is building on the ICTP simulations run for the EUCP project, the additional variables required for this project are also being considered for storage and distribution, as these include several high-frequency variables that may be useful to the project or others interested in the study domain. The additional variables (listed in Table 4) include atmospheric cell area (areacella), maximum convective available potential energy (CAPE), maximum convective inhibition (CIN), total water content of soil layer (mrsol), surface snow amount (snw), total cloud fraction (clt), condensed and ice water path (clwvi, clivi), potential evapotranspiration (evspsblpot), surface upward latent and sensible heat flux (hfls, hfss), total and surface runoff (mrro, mrros), water vapour path (prw), surface downwelling shortwave and longwave radiation (rsds, rlds), surface upwelling longwave radiation (rlus), and eastward and northward winds at 100 m (ua100m, va100m). The list also includes variables that contain vertical atmospheric data: geopotential height (zg), specific humidity (hus), air temperature (ta), eastward and northward winds (ua, va), and upward air velocity (wa). This priority group [C] together with [B] and [C] should occupy a total of 68.8TB of storage.

Table 4. Additional variables required for the EUCP project that are still in consideration to store for PALEOSIM simulations. The variables are divided according to the frequency (freq.) of the output files. The file sizes provided are for a single year of an Alps simulation (602x572 grid cells). The total size of each group of variables is also represented per year of the Alps simulation. The variables marked with * include pressure level data at 1000, 925, 850, 700, 500, and 200 hPa.

freq.	total size	variables (size)
fx	8MB	areacella (8MB)
day	3.3GB	CAPE (487MB), CIN (487MB), mrsol (2.3GB), snw (53MB)
6hr	7.1GB	ps (1.0GB), psl (718MB), zg* (5.4GB)
3hr	77.8GB	hus* (14.9GB), ta* (11.1GB), ua* (16.3GB), va* (16.4GB), wa* (19.1GB)
1hr	233.9GB	CAPE (2.8GB), CIN (1.9GB), clt (6.1GB), clwvi (7.4GB), clivi (4.7GB), evspsbl (8.2GB), evspsblpot (8.4GB), hfls (8.6GB), hfss (8.8GB), huss (7.4GB), mrro (6.4GB), mrros (1.9GB), mrso (5.3GB), mrsol (54GB), pr (2GB), prw (7.4GB), ps (6GB), psl (4.2GB), rsds (4.3GB), rlds (6.9GB), rlus (7.3GB), sfcWind (8.3GB), snw (1.1GB), ts (5.9GB), tas (5.9GB), uas (8.7GB), vas (8.7GB), ua100m (8.6GB), va100m (8.6GB), zmla (8.1GB)

A step-wise description of these three priority groups is shown in Table 5. This information is adjusted from the EUR-11 and Alps grids to fit the current CSI-2km grid, with a factor of 0.567 and 0.457 respectively, to account for the difference in grid-sizes. The project proposal suggested over 100TB of processed storage required as these estimates were based on preserving all possible processed output, however, as a fraction of these variables are required for the project, this can now be updated to a more manageable <3TB of storage, or 72 TB for the additional high-frequency variables.

The raw data generated by the simulations is typically large and can be carefully maintained by in-situ processing of the output, but also by avoiding the production of unrequired data files. The RegCM groups the model output in different file categories[7]: surface variables (SRF; 9.8GB/yr) contains most of the variables prioritized above, which will be extracted at a frequency of 24xdaily (1 hourly); statistics variables (STS; 154MB/yr) include daily means, maxima, and minima of some SRF variables; several save files (SAV; collectively 3.47GB/yr) are produced, necessary to continue the simulation in case software or hardware issues arise; atmosphere files (ATM; 76GB/yr) containing variables with vertical distribution[8]; and radiation files (RAD; 28.6GB/yr). For the PALEOSIM project, the SRF, STS, and SAV files would be the most important raw files required, but the ATM and RAD would be needed to generate the additional variables, hence the simulations will be set to process the required variables *in-situ* to reduce the size of the output.

Table 5. Estimated storage size for 2km CSI (397x397 grid cells) simulations, based on variables defined in Table 3 and Table 4, making up three priority groups of RegCM output. The sizes describe 1 year data (1yr), a full 20-year simulation (20yr), the WP2 scenarios (historical and equivalent of 3 future; 4sc) each with 20-year simulations, the WP2 and 3 scenarios (addition of 4 paleoclimate; 8sc), and 3 GCMs (3mod) each with 8 scenarios.

group	file types	size 1yr	size 20yr	size 4sc	size 8sc	size 3mod
A	fx, mon, day[1]	1.0GB	20.2GB	80.8GB	161.6GB	484.8GB
B	fx, mon, day[1,2], 3hr	6.2GB	124.0GB	496.0GB	992.0GB	2.9TB
C	fx, mon, day, 3hr, 6hr, 1hr	146.8GB	2.9TB	11.5TB	22.9TB	68.8TB

[7] The file sizes described are adjusted from an EUCP Alps simulation

[8] The ATM files are only required for the intermediate EUR-11 simulations, to drive the 2km CSI domain

The storage required for the management and production of these simulations is reasonable enough to be handled within the available storage of the CINECA's Marconi cluster, made accessible by the ICTP, as long as *in-situ* processing is performed. Once the post-processing is complete, the data can be stored on the ESGF[9] node accessible on Marconi (which currently has over 250TB of available storage), with the intention of making it publicly available through the ESGF servers[10].

The computational requirements of the simulations remain, yet unchanged from those mentioned in the proposal. The simulations are estimated to require ~1 month each (with multiple simulations running concurrently) and the WP2 simulations are estimated to consume ~4.75M core hours, with an additional 2.1-6.3M core hours for WP3. These were estimated using a 2 km resolution simulation (400x400 grid cells – similar to the current CSI domain) on CINECA's Marconi cluster using 720 processors and 177 GB of RAM. Currently, the ICTP operates with 50M core hours per year on CINECA's Marconi cluster.

Furthermore, a high-storage external hard-drive[11] will be purchased to serve primarily as a backup storage device at the University of Malta (UM), and a local access to make distribution of data possible in case the ESGF system becomes unavailable. An 8 or 12 TB external drive will be also sufficient to store the first two priority groups and additional data including climate reference and station data, arthropod observation data from iNaturalist, paleoclimate proxy data, and processed data from the CORDEX and EUCP analysis of WP1.

Data from the citizen-science program, will be made publicly available through the Epicollect app that is currently being used to collect the data. The scripts used for the project will be backed up and made public on GitHub. All links and access information will be included on the project website and research publications.

[9] https://esgf-data.dkrz.de/projects/esgf-dkrz/
[10] The exact manner of this process will be clarified during the secondments
[11] Currently 8TB drive is available at €300 from Scan Malta, and a 12TB drive at €420 from AtoZ Electronics.

2 Short-Term Objectives

The outcomes and expected accomplishments of PALEOSIM make up the entirety of the short-term objectives of the MCF.

2.1 Research results

The research component of the project is expected to produce at least three publications, one from each of the research WPs. The first should present the research conducted through WP1 to compose a proof of concept of the climate impacts on arthropod habitats using existing climate simulation. The intention is to submit this first paper to 'npj Climate and Atmospheric Science'. The application of these findings onto specially designed high-resolution simulations, conducted for WP2, should be compiled into a second paper, currently inended for the 'Journal of Advances in Modelling Earth Systems'. Finally, the research into regional paleoclimate modelling and the full compilation of the project results should go into a final paper, currently intended for 'Nature Climate Change'.

The project progress shall be disseminated through several research presentations given throughout the remaining months of the project. Currently, four conference and one workshop presentations are projected. Months 14 and 15 (September and October 2023) of the project should include the first 3 conference and workshop presentations of PALEOSIM. The first two, the CORDEX Conference and the RegCM Workshop, are back-to-back events, held in Trieste, Italy to bring together the CORDEX and RegCM communities. Attending these events will provide an important networking opportunity with members of the regional climate modelling community. The third conference is the XII European Congress of Entomology, to be held in Heraklion, Crete. Presenting PALEOSIM during this conference will provide an important opportunity to interact and network with the entomological community. The remaining two conferences are the American Geophysical Union (AGU) Fall Meeting 2023 to be held in San Francisco, USA in December of 2023, and the European Geosciences Union (EGU) Annual General Meeting to be held in Vienna, Austria in April 2024. These are high-profile conferences that attract Geoscientists from across the globe and thus will provide a broad variety experts as an audience to the project presentations.

The results of PALEOSIM are scheduled to be presented through 5 seminars, distributed throughout the 18 months of the project. The first one was successfully presented at the UM in November of 2023 where the project was introduced to students and staff of the University, as well as members of the public. From the remaining seminars, two will also be held at the UM, while one will be held at the ICTP in Trieste, and the last at EISC. These seminars will be opportunities to learn and improve event preparation techniques as well as disseminating project results to an audience of varied expertise.

2.2 Research skills and techniques

As the MCF is an early career researcher who has focused on regional climate modelling, this project provides an opportunity to study and experience different scientific disciplines with the support of professionals.

Entomology and ecology training has already begun with Prof. David Mifsud, an entomologist and environmental scientist, who is providing individual training through book recommendations and regular topical discussions. Prof. Mifsud is also providing training through frequent field-work activities to observe and identify arthropods in their natural habitat. His team of researchers also share their experience, especially with regards to citizen science. The field-work and citizen-science programs will at times be combined via 'Bioblitz' activities to train potential volunteers. The reading material provided, continuous networking, and field-work activities will, by the end of the project, prove invaluable experiences to improve the skills and techniques related to entomology and ecology of the MCF, who up to this point, has had minimal professional experience in biology-related disciplines.

Although the MCF has experience with regional climate modelling, the supervision of Dr Erika Coppola will provide necessary support to improve upon research skills relating to Convection Permitting modelling. The two secondments taking place during the start of WP2 and again at the start of WP3, will facilitate this process.

Access to the ICTP research team (through Dr Coppola) will also provide the opportunity to learn about the setup and interpretation of paleoclimate models and scenarios. Prof. Aaron Micallef, a marine geologist, will lead the first-hand training on the study of paleoclimates, proxies, and related analytical techniques and interpretations.

2.3 Research management

The Marie Skłodowska-Curie Actions (MSCA) grant is an opportunity for the MCF to manage a project. The preparation of the proposal has already provided a significant experience in the preparation of such projects. Although the management WPs (WP3-6) of PALEOSIM were carefully prepared for this purpose, the experience of managing the project and adapting to new problems and opportunities will be an essential learning tool for future projects.

2.4 Communication skills

The extensive dissemination plan outlined in the project proposal gannt chart will provide numerous learning opportunities. Apart from the Seminars and Conferences, activities such as European Researchers' Nights, public talks, appearances at local schools, bioblitz events, website updates, and news items (publication of articles, and possibly TV or radio appearances) will allow the MCF to become a more effective science communicator.

2.5 Other professional training (course work, teaching activity)

As an extra precautionary measure for the field-work activities, especially those on the Sicilian islands, the MCF intends to apply for a First Aid referesher course in the coming months. Furthermore, the UM Doctoral school allows the possibility of a wide array of courses for its employees that can be beneficial – one such example is a course to enhance teaching and learning.

Finally, the MCF has already returned to teaching a Liberal Arts course to the general public at the UM (entitled "Dinosaurs and the Evolution of Life on Earth") which also provides an

opportunity for continuous self-improvement. Moreover, in February of 2023 he will also start a new course entitled, “Climate Change: From the Ancient Past to Alien Planets” which will prove a new opportunity to tackle the challenging task of sharing climate science to the public.

2.6 Anticipated networking opportunities

As of the writing of this report, the project has already led to a broader scientific network for the MCF, starting with the research team that work with Prof. Mifsud, as well as the communications team at EISC (amongst which is Mr David Cilia, co-supervisor of PALEOSIM).

While the researcher already has ties to the ICTP where he will conduct his secondments, the experience will allow the opportunity for new connections throughout his stay there. The seminars, conferences, and public events will also likely provide new opportunities for networking.

Finally, since the study domain for PALEOSIM is greatly linked to Sicily, the MCF has reached out to Prof. Giorgio Sabella from the University of Catania, to collaborate in research and communication efforts throughout the project.

2.7 Other activities (community, etc) with professional relevance

Several bioblitz activities will be organised throughout the research phase of the project, to encourage the public to participate in the citizen-science program, while providing instructions on the requirements of the project. Public participation can be a challenging aspect and each iteration of the activity, allows for new learning opportunities on how to reach out to the public.

Following the research phase of the project, the MCF will collaborate with the EISC to create a public display that showcases the results of the project in a manner that should be both informative and entertaining. This will take place throughout the last 6 months of the project, during the placement at EISC.

3 Long-Term Career Objectives

After the completion of PALEOSIM, the MCF plans to continue pursuing an academic career with particulat interest in climate impacts, extreme mediterranean climate (such as tropical-like cyclones), and even changes in local climate. The MCF would like to see a greater academic effort to understand the small-scale process that govern local-scale events. To achieve this, an interdisciplinary approach needs to be maintained, with a team of dedicated researchers working towards a singular objective. The primary opportunity to reach this objective lies in the European Research Council (ERC) Starting Grant, where Dr Ciarlo` will be able to start building a research with a unified objective. The ERC Starting Grant would also provide the necessary funds to buy a state-of-the-art computer cluster to operate the high-performance experiments required for such analyses.