The **Institute of Earth Systems (IES)** at the University of Malta conducts research on climate and related trends at both local and regional level. Subthemes include the understanding of regional past and current climate, impacts of climate change on biodiversity, health and infrastructure. It has built a knowledge-base to assist students and researchers performing studies on climate change and its impacts on many sectors.

The following are some of the salient scholarly publications and student dissertations in this field.

NB: IES staff members are indicated in blue; names of authors who carried out their research while reading for a degree with the Institute are in bold.

PUBLICATIONS

Attard C, Galdies C and Conrad E (2018). Can 3D visualizations really convince small island coastal communities about the true risks of sea level rise? Springer Verlag. *In press*.

Inundation due to sea level rise is among the most expensive and deadly coastal hazards that can gradually impact small island coastal communities. The intent of this research is to look at ways how coastal island communities can be convincingly informed about the impacts of sea level rise; an understanding of these potential impacts is critical for people to engage in related adaptation actions. Effective climate communication may require more than just using language; the use of virtual reality, 3D spatial technology, and digital elevation models can prove equally or even more powerful to enable the portrayal of risks and dangers posed by climate change. Using a case study in Malta, we mapped impacts of the effects of sea-level rise on valuable real estate, critical public infrastructure, and natural resources. Coastal communities were then asked for their views on sea level rise after looking at precise but different modes of visualization of the same impact at specific coastal locations. Results showed a general preference for 3D over 2D visualizations, for various reasons, including a perception that these better reflect reality; 3D visualisations were also shown to be more effective in convincing respondents about the significance of sea level rise impacts. The results of this study provide valuable insights for local authorities to understand what may be needed to communicate messages related to climate change in an effective manner, ultimately contributing to enhancement of coastal resilience and climate adaptation.

Keywords *Climate change, sea level rise, 2D & 3D visualisations, public perception, Malta, small island states*

Agius A, **Galdies C**, **Bonnici A J** and Azzopardi J (2017). Improving weather forecasts by updating the surface boundary conditions of a numerical weather prediction model for the Maltese Islands. In book: *Emergent Realities for Social Wellbeing: Environmental, Spatial and Social Pathways*, Edition: 1, Publisher: University of Malta, Msida and Malta Environment and Planning Authority, Floriana, Malta. Editor: S Formosa.

> *The aim of this study was to improve NWP model boundary conditions by revising the land use categories and identify any significant improvement to weather forecasts made thereafter. The land use categories, which followed the USGS 24-category Land Use Categories, were significantly improved in terms of category type and distribution. To determine the effectiveness of these improved boundary conditions, the precipitation and temperature forecasts were generated with the default and improved land use categories. These were then compared against the meteorological observations where an overall improvement in forecast accuracy was identified.*

Cassar L F, **Galdies C** and **Xuereb N** (2017). Evaluating risks from sea-level rise on metapopulations of *Brachytrupes megacephalus* (Lefèbvre, 1827) on the island of Malta. *Proceedings of 4th International Congress on Biodiversity "Man, Natural Habitats and Euro-Mediterranean Biodiversity"*, Malta, 17-19 November 2017.

> *Brachytrupes megacephalus Lefèbvre, 1827 is a relatively large cricket species with predominant but not exclusive distribution across northern Africa. It favours sandy habitats in coastal and Saharan hyper-arid regions. The crepuscular species is also known to occur within locations on Europe's central Mediterranean littoral. As a result of evident scant European distribution, the species is designated protection status through the EU Habitats Directive (92/43/EEC) and the Bern Convention, and is currently afforded protection in 21 Natura 2000 sites in Italy and Malta; moreover, the IUCN lists its threat status in Europe as 'vulnerable'. The species' distribution in the Maltese Islands is restricted to fragmented populations on northern coastal sites in Malta and one site in Gozo.*
>
> *The present contribution seeks to evaluate the level of vulnerability of populations of this stenoecious species occurring on Malta to sea-level rise. Following ground-truthing during stridulation activity, drone survey technologies are used to identify and cartographically delineate the spatial extent of sub-populations. Sea-level rise visualization, through an island-wide contour dataset, is utilized to provide topographical information. Three contour heights above current sea-level, each with a five-metre interval, are selected. The vector lines, at five, ten and fifteen metres, respectively, represent three projected scenarios of sea-level rise due to climate change and storm surges over known B. megacephalus population areas. High-resolution satellite imagery is used as a basemap to facilitate visualization of spatial impact, while landmarks and road networks are vectorised to enable area recognition. Results showing spatial impact on the sub-populations of Brachytrupes megacephalus serve to explore linkages within the landscape to ensure connectivity with suitable habitat on elevated terrain.*

Micallef S, **Micallef A** and **Galdies C** (2017). Application of the Coastal Hazard Wheel to assess erosion on the Maltese coast. *Ocean & Coastal Management*. In press. doi:10.1016/j.ocecoaman.2017.06.005

> *This study provides an assessment of erosion hazard on the Maltese coast via application of the Coastal Hazard Wheel, a tool that also facilitated analysis of a number of other inherent coastal hazards including ecosystem disruption, gradual inundation, salt water intrusion, and flooding. The CHW characterises the coastal environment by considering geological layout, wave exposure, tidal range, flora and fauna, sediment balance and storm climate. Application of the CHW identified coastal erosion to present a high to very high influence on the Maltese coastline, with 45.7% of the coast exhibiting a low level of erosion hazard, 12.1% a moderate level, 12.6% a high level and 18.4%, a very high level of erosion hazard.*

Peyron O, Combourieu-Nebout N, Brayshaw D, Goring S, Andrieu-Ponel V, Desprat S, Fletcher W, **Gambin B**, Ioakim C, Joannin S, Kotthoff U, Kouli K, Montade V, Pross J, Sadori L and Magny M (2017). Precipitation changes in the Mediterranean basin during the Holocene from terrestrial and marine pollen records: a model–data comparison. *Clim. Past* 13, 249-265. doi:10.5194/cp-13-249-2017

> *Climate evolution of the Mediterranean region during the Holocene exhibits strong spatial and temporal variability, which is notoriously difficult for models to reproduce. We propose here a new proxy-based climate synthesis synthesis and its comparison – at a regional (∼ 100 km) level – with a regional climate model to examine (i) opposing northern and southern precipitation regimes and (ii) an east-to-west precipitation dipole during the Holocene across the Mediterranean basin. Using precipitation estimates inferred from marine and terrestrial pollen archives, we focus on the early to mid-Holocene (8000 to 6000 cal yr BP) and the late Holocene (4000 to 2000 cal yr BP), to test these hypotheses on a Mediterranean-wide scale. Special attention was given to the reconstruction of season-specific climate information, notably summer and winter precipitation. The reconstructed climatic trends corroborate the north–south partition of precipitation regimes during the Holocene. During the early Holocene, relatively wet conditions occurred in the south–central and eastern Mediterranean regions, while drier conditions prevailed from 45° N northwards. These patterns then reverse during the late Holocene. With regard to the existence of a west–east precipitation dipole during the Holocene, our results show that the strength of this dipole is strongly linked to the reconstructed seasonal parameter; early-Holocene summers show a clear east–west division, with summer precipitation having been highest in Greece and the eastern Mediterranean and lowest over Italy and the western Mediterranean. Summer precipitation in the east remained above modern values, even during the late-Holocene interval. In contrast, winter precipitation signals are less spatially coherent during the early Holocene but low precipitation is evidenced during the late Holocene. A general drying trend occurred from the early to late Holocene, particularly in the central and*

eastern Mediterranean. For the same time intervals, pollen-inferred precipitation estimates were compared with model outputs, based on a regional-scale downscaling (HadRM3) of a set of global climate-model simulations (HadAM3). The high-resolution detail achieved through the downscaling is intended to enable a better comparison between site-based paleo-reconstructions and gridded model data in the complex terrain of the Mediterranean; the model outputs and pollen-inferred precipitation estimates show some overall correspondence, though modeled changes are small and at the absolute margins of statistical significance. There are suggestions that the eastern Mediterranean experienced wetter summer conditions than present during the early and late Holocene; the drying trend in winter from the early to the late Holocene also appears to be simulated. The use of this high-resolution regional climate model highlights how the inherently patchy nature of climate signals and paleo-records in the Mediterranean basin may lead to local signals that are much stronger than the large-scale pattern would suggest. Nevertheless, the east-to-west division in summer precipitation seems more marked in the pollen reconstruction than in the model outputs. The footprint of the anomalies (like today, or dry winters and wet summers) has some similarities to modern analogue atmospheric circulation patterns associated with a strong westerly circulation in winter (positive Arctic Oscillation–North Atlantic Oscillation (AO–NAO)) and a weak westerly circulation in summer associated with anticyclonic blocking; however, there also remain important differences between the paleo-simulations and these analogues. The regional climate model, consistent with other global models, does not suggest an extension of the African summer monsoon into the Mediterranean. Therefore, the extent to which summer monsoonal precipitation may have existed in the southern and eastern Mediterranean during the mid-Holocene remains an outstanding question.

Galdies C and **Mallia N** (2017). Losses, damages and return period of extreme weather events in the Maltese islands. In book: *Emergent Realities for Social Wellbeing: Environmental, Spatial and Social Pathways*, Edition: 1, Publisher: University of Malta, Msida and Malta Environment and Planning Authority, Floriana, Malta. Editor: S Formosa.

Small island states are highly vulnerable to the pervasive impact of natural disasters on their population, environment and economy; however research in this area as far as weather disasters and their after-effect is concerned is considerably limited. This is especially true for the Maltese islands. The scope of this paper is to provide a much-needed evaluation of local extreme weather events and their economic impact, and even more challenging, on their return period in light of a changing climate. This is done by researching the insurance loss and damage following a select number of Maltese extreme weather events that have occurred between 2011 and 2013. It is hoped that this knowledge will encourage further national risk mitigation and prevention measures.

Pace M, Borg JA, **Galdies C** and Malhotra A (2017). Influence of wave climate on architecture and landscape characteristics of *Posidonia oceanica* meadows. *Mar. Ecol.* 38, e12387. doi:10.1111/maec.12387

> *Seagrass meadow characteristics, including distribution, shape, size and within meadow architectural features, may be influenced by various physical factors, including hydrodynamic forces. However, such influences have hardly been assessed for meadows of the ecologically important and endemic Mediterranean seagrass Posidonia oceanica. The distribution of P. oceanica meadows at five sites in the Maltese Islands was mapped to a depth of c. 15 m using a combination of aerial photography and SCUBA diving surveys. Estimates of wind generated wave energy and energy attenuated by depth were computed usingthe hydrodynamic model WEMo (Wave Exposure Model). The results indicate that landscape and architectural features of P. oceanica meadows located within the 6–11 m depth range are significantly influenced by wave climate. Posidonia oceanica meadows tend to be patchier and have low overall cover, more complex patch shapes and reduced within-patch architectural complexity along a wave exposure gradient from low to high energy. The findings from the present study provide new insight into the influence of hydrodynamic factors on the natural dynamism of P. oceanica meadow landscape and architecture, which has implications for the conservation and management of the habitat.*

Gambin B, Andrieu-Ponel V, Médail F, Marriner N, Peyron O, MontadeV, Gambin T, Morhange C, Belkacem D and Djamali M (2016). 7300 years of vegetation history and climate for NW Malta: a Holocene perspective. *Clim. Past* 12, 273-297. doi:10.5194/cp-12-273-2016

> *This paper investigates the Holocene vegetation dynamics for Burmarrad in Northwest Malta and provides a pollen-based quantitative palaeoclimatic reconstruction for this centrally located Mediterranean archipelago. The pollen record from this site provides new insight into the vegetation changes from 7280 to 1730 cal BP which correspond well with other regional records. The climate reconstruction for the area also provides strong correlation with southern (below 40° N) Mediterranean sites. Our interpretation suggests an initially open landscape during the early Neolithic, surrounding a large palaeobay, developing into a dense Pistacia scrubland ca. 6700 cal BP. From about 4450 cal BP the landscape once again becomes open, coinciding with the start of the Bronze Age on the archipelago. This period is concurrent with increased climatic instability (between 4500 and 3700 cal BP) which is followed by a gradual decrease in summer moisture availability in the late Holocene. During the early Roman occupation period (1972–1730 cal BP) the landscape remains generally open with a moderate increase in Olea. This increase corresponds to archaeological evidence for olive oil production in the area, along with increases in cultivated crop taxa and associated ruderal species, as well as a rise in fire events. The Maltese archipelago provides important insight into vegetation, human impacts, and climatic changes in an island context during the Holocene.*

Galdies C and Galdies J (2016). From climate perception to action: strategic adaptation for small island farming communities - A focus on Malta. *CIHEAM Watch Letter* n°37, 98-103.

> *Located in the central Mediterranean Sea, the Maltese islands are prone to a set of climate change impacts that are specific to the region. Local climatological records show a warming trend of both the annual maximum and minimum temperatures, where the incidence of warmer nights is becoming increasingly common (Galdies, 2012). Warmer winters may result in increased outbreaks of pests as more of them become capable of surviving the colder season. Longer summers would also allow insects to develop more efficiently. Local records also show an increased incidence of heat waves, impacting local agricultural activities among other sectors (Galdies, 2015; Galdies et al., 2016), while the increasing number of consecutive dry days suggest increasingly drought conditions. Climate change projections for this small State suggest that climate variability may increase in the future and climate extremes are likely to become more frequent (Government of Malta, 2014). Once the frequency of these impacts start to exceed a certain magnitude they will start threatening the stability of many of the island's economic sectors (Baldacchino & Galdies, 2015), especially agriculture (Government of Malta, 2012).*

Galdies C, **Said A**, Camilleri L and **Caruana M** (2016). Climate change trends in Malta and related beliefs, concerns and attitudes toward adaptation among Gozitan farmers. *European Journal of Agronomy* 74, 18-28. doi:10.1016/j.eja.2015.11.011

> *In this study we report the results obtained from an island-wide survey aimed at researching an under-emphasized key feature of climate change adaptation – namely willingness to adapt on the basis of the perceptions and beliefs held by the Gozitan livestock and crop farmers. Some of the main objectives of this study included the: (1) determination of whether the current perception is in line with the observed climatic changes at the local scale, and (2) identification of the typology of these farmers, together with those factors that affect both skepticism and acceptance of climate change. This study provided an important first step in the objective validation of local farmers' perceptions of climate change, as well as in the development of a comprehensive understanding of their attitude, beliefs, willingness and capacity to adjust their practices in response to climate change. The results pointed to several important conclusions that can be used to inform research, outreach strategies and policy formulation, targeting the Gozitan farming sector to adapt to climate change without delay. The forgoing analysis showed a dire need for more information both on impacts and risks, as well as on ways how to introduce new farming techniques and practices.*

Peyron O, Combourieu-Nebout N, Brayshaw D, Goring S, Andrieu-Ponel V, Desprat S, Fletcher W, **Gambin B** and Magny M (2016). The climate of the Mediterranean basin during the Holocene from terrestrial and marine pollen records: A model/data comparison. *Climate of the Past Discussions*, 1-33. doi:10.5194/cp-2016-65

> *Quantitative pollen-based precipitation estimates were generated along a longitudinal gradient from the Alboran (West) to the Aegean Sea (East); they are derived from terrestrial pollen records from Greece, Italy and Malta as well as from pollen records obtained from marine cores. Because seasonality represents a key parameter in Mediterranean climates, special attention was given to the reconstruction of season-specific climate information, notably summer and winter precipitation. The reconstructed climatic trends corroborate a previously described north-south partition of precipitation regimes during the Holocene. During the early Holocene, relatively wet conditions occurred in the south-central and eastern Mediterranean region, while drier conditions prevailed from 45° N northwards. These patterns reversed during the late Holocene, with a wetter northern Mediterranean region and drier conditions in the east and south. More sites from the northern part of the Mediterranean basin are needed to further substantiate these observations. With regard to the existence of a west-east precipitation dipole during the Holocene, our pollen-based climate data show that the strength of this dipole is strongly linked to the seasonal parameter reconstructed: Early Holocene summers show a clear east-to-west gradient, with summer precipitation having been highest in the central and eastern Mediterranean and lowest over the western Mediterranean. In contrast, winter precipitation signals are less spatially coherent. A general drying trend occurred from the early to the late Holocene; particularly in the central and eastern Mediterranean. However, summer precipitation in the east remained above modern values, even during the late Holocene interval.*
>
> *Pollen-inferred precipitation estimates were compared to regional-scale climate modelling simulations based on the HadAM3 GCM coupled to the dynamic HadSM3 and the high-resolution regional HadRM3 models. Climate model outputs and pollen-inferred precipitation estimates show remarkably good overall correspondence, although many simulated patterns are of marginal statistical significance. Nevertheless, models weakly support an east to west division in summer precipitation and there are suggestions that the eastern Mediterranean experienced wetter summer and winter conditions during the early Holocene and wetter summer conditions during the late Holocene. The extent to which summer monsoonal precipitation may have existed in the southern and eastern Mediterranean during the mid-Holocene remains an outstanding question; our model, consistent with other global models, does not suggest an extension of the African monsoon into the Mediterranean.*

Baldacchino G and **Galdies C** (2015). Global Environmental Change: Economic and Labour Market Implications for Small Island Territories. *Xjenza Online* 3(2), 81-85.

> *No abstract available.*

Galdies C (2015). Potential future climatic conditions on tourists: A case study focusing on Malta and Venice. *Xjenza Online* 3(2), 6-25. doi:10.7423/XJENZA.2015.2.01

> *The main purpose of this study is to quantify important climatic shifts that took place over Malta and Venice that could be considered as a determining factor on their choice as two prime tourist destinations. Rather than making use of traditional tourist climate indices, this study identifies long-term trends in weather variables and their derived bioclimatic indices. These climate derivatives are based on a set of high temporal observations (some of which are collected every 30 minutes) and are thus able to capture valuable information that traditional monthly distribution cannot provide. The derivatives obtained from the elementary meteorological observations showed that the level of comfort experienced by visiting tourists over the long term is deteriorating due to increased heat stress. Nonetheless, the increased occurrence of optimal wind speed conditions, as well as a reduced occurrence of gale storms and wind chill events is making these destinations more attractive. A careful study of the output of IPCC climate model projections sheds light on a critical future bioclimate condition during current peak visiting months (July and August) at both destinations. This may imply a required shift, as a form of adaptation, of the visiting periods at these two destinations. This study should allow tourist planners to determine which weather element is a likely future obstacle to the overall bioclimatic suitability of outdoor tourism activities.*

Djamali M, **Gambin B**, Marriner N, Andrieu-Ponel V, Gambin T, Gandouin E, Lanfranco S, Médail F, Pavon D, Ponel P and Morhange C (2013). Vegetation dynamics during the early to mid-Holocene transition in NW Malta, human impact versus climatic forcing. *Veget. Hist. Archaeobot.* 22(5), 367-380. doi:10.1007/s00334-012-0380-0

> *A pollen diagram was constructed for the early- to mid-Holocene transition (ca. 7350–5600 cal. b.p./5400–3650 b.c.) from the Burmarrad ria located in NW Malta. The vegetation at ca. 7350–6960 cal. b.p./5400–5010 b.c. was characterized by an almost tree-less steppe-like open landscape. Early Holocene dry climatic conditions were most probably due to intensification of the subtropical monsoon circulation that strengthened the subtropical anticyclonic descent over the central Mediterranean and blocked the penetration of humid air masses from the North Atlantic Ocean. At ca. 6950 cal. b.p./5000 b.c., the steppe-like vegetation was suddenly replaced by a Mediterranean evergreen forest or dense scrub dominated by Pistacia cf. lentiscus trees. This event, which has simultaneously been recorded in southern Sicily, was most probably caused by the southward shift of the ITCZ permitting the eastward movement of the North Atlantic cyclonic systems. Traces of human activities are evident in the pollen diagram since the beginning of the record but become more pronounced from the onset of the Temple Cultural Phase at ca. 6050 cal. b.p./4100 b.c. with a gradual decline of tree pollen. We suggest that the early- to mid-Holocene vegetation transformation was mainly controlled by a regional climatic change that occurred in a landscape only slightly impacted by human activities.*

Salgado L M, Farrugia R N, **Galdies C** and Sant T (2013). Verifying Meteorological Station Wind Speed Data for Long-term Resource Studies: The MIA Luqa Wind Databases at Malta. *Wind Engineering* 01/2013, 37(6), 605-616.

> *Short-term wind measurements at a candidate wind turbine installation site strive to capture a fingerprint of candidate site wind conditions. Coupling this fingerprint with a historical data set from a nearby reference station enables the projection of the candidate site's longer-term wind characteristics. This paper focuses on the historic wind datasets compiled by the Meteorological Office of Malta International Airport, Luqa. As the only station having in excess of 20 years of wind speed and direction data, this database is significant and useful as a long-term reference station. The position of the Maltese island makes this station a useful node for weather-related data and for validation of computational tools in the central Mediterranean region. The focus of this paper is primarily on a period when the station and measurement equipment went through an upgrade and relocation. A downward shift of 0.75 ms –1 in the wind speed was identified. The analyses presented in this paper identify and test hypotheses for this shift including aspects such as the station's relocation, the use of new sensors, using a different monitoring structure type and other factors.*

Galdies C (2012). Temperature trends in Malta (central Mediterranean) from 1951 to 2010. *Meteorol. Atmos. Phys.* 117(3-4), 135-143. doi:10.1007/s00703-012-0187-7

> *There is as yet scanty published information on climate trends at a local scale within the central Mediterranean region. This is the most updated study that focuses on detailed understanding of air temperature shifts based on standard observations gathered from the Maltese islands. This analysis leads to a number of conclusions, most significant being (1) that the rate of change in the mean temperature is +1.1 °C between 1951 and 2010, (2) a warming trend of +1.2 and +1.1 °C exists in the maximum and minimum temperature, respectively, over the same period, (3) that the strongest anomalous warming has occurred during the last 30 years, particularly during the months of June, August and October, and (4) the local temperature trend is in the same category of air temperature trends detected in the nearby Island of Sicily (Catania, Italy), Perpignan (France) and Dar el-Beida (Algeria). Local data also show differences in the temperature trends, especially pronounced between the two 30-year periods of 1951–1980 and 1981–2010. This study provides an understanding of temperature shifts at recommended small spatio-temporal scales.*

UNPUBLISHED DISSERTATIONS

1. M.Sc. research

Busuttil, R (2017). The global solar ultraviolet index: measurement and health issues in Malta.

This dissertation evaluated the awareness, knowledge and behaviour of the Maltese general population in relation to the Global solar ultraviolet index (UVI) and sun protection using a telephone based survey. It also assessed whether the UVI forecasts published by the Malta Meteorological Office are an accurate representation of the local UVR exposure using a broadband filter radiometer to measure integrated erythemally weighted ultraviolet radiation (UVER) data. Finally this study evaluated long term trends in the incidence of skin cancer in Malta using the Malta Cancer Registry data. The survey results have shown a very high awareness of the negative impacts of excessive sun exposure, a relatively high familiarity with the significance of a UVI of 9 and substantial high follow-up of the published forecasts in the media. Despite this only 26% of those interviewed claimed that the UVI forecasts impacted on their work or leisure activities. This study also demonstrated a good correlation between the published UVI forecasts and the integrated erythemally weighted ultraviolet radiation (UVER) data, since 81% of the forecast data was within +/- 1 UVI of the UVER data. Furthermore, this dissertation has shown that all skin cancer types have increased significantly over these last 20 years, especially Melanoma skin cancer cases which have more than doubled during this period. This study has established that although the Maltese general population is familiar with the UVI concept and is aware of the negative impacts of excessive UVR exposure this is not resulting in an increased use of sun protection mechanisms. In addition, although it has evidenced good correlation between forecast UVI figures and ground based UVER readings, the introduction of ground based UVER data by the national meteorological office would ensure the daily validation of such forecasts especially in the spring and summer months when UVR is very high.

Deguara, C (2017). Vulnerability to Sea Level Rise at selected coastal areas of the Maltese Islands.

This study focuses on two popular coastal localities in the Maltese Islands; Ghadira and Marsaxlokk, and the level of impacts these might experience from three future sea-level rise scenarios. Such analysis was conducted by identifying various variables which might be affected or affect the vulnerability of the area from future sea-level rise. These identified variables were categorised into three groups; physical, socio-economic or ecological variables and then their level of vulnerability was ranked according to various assessment criteria. Ultimately the coastal vulnerability index (CVI) method was used which enabled the possibility to assess the level of vulnerability each coast has from future sea level rise and any coastal changing processes this might bring. This study

allows comparative studies and assist in setting of goals and objectives for future management options.

Caruana, E (2012). Assessing the risk of coastal hazards on the North East and East Coast of Malta.

The main aim of this study is to identify the risk and assess the vulnerability of natural hazards: tsunami, storm surge, flooding and sea level rise on the north-east and east coast of Malta. Various techniques are applied to collect reliable data to conduct this research. Coastal assessment models are utilized to display visual predictions of tsunami events and the impacts of sea level rise which are the potential coastal hazards. Results show a high vulnerability to natural hazards in the north east and east coast of Malta. A social survey shows a limited knowledge and awareness of coastal hazards among locals and consequently lack of preparedness and higher vulnerability. Concluding remarks recommend mitigation measures to reduce risk resulting in fewer fatalities, less damages and economic loss. In addition this research provides an important tool for local and governmental decision-makers in providing a sustainable plan for prospective development. The future of land and sea resources that coastal areas offer to human population depends prominently on well-informed and prudent planning.

2. Research carried out within the B.Sc. (Hons) in Earth Systems

Rapinett, L (2017). Identifying Local Climatological Trends of Aviation – Related Weather Parameters.

This focuses on five meteorological parameters that are potentially dangerous for aircrafts especially when landing over the airfield. The main aims of this study were (i) to analyse the local weather trends of five weather parameters: thunderstorms, fog, hail, wind gust and 50mm or more rainfall, and (ii) to investigate whether these five parameters are increasing or decreasing. The study showed an increase in the occurrence of thunderstorms and a slight increase in the occurrence of hail over 56 years. The occurrence of the other parameters which include fog, wind gust, and 50mm or more rainfall resulted in a decrease over the same study period. Furthermore, the yearly data, using the Mann – Kendall test resulted in weather trends in fog and wind gust. No weather trends were resulted in thunderstorms, hail, and 50mm or more rainfall.

Farrugia, J (2016). Local Tourism Susceptibility to Climatic Change. Case Study: The Maltese Islands.

Tourism in Malta is one of the main local economic pillars. In 2014, a total of 1,689,809 inbound tourists visited the Maltese Islands, with a total tourist‟ expenditure of €1.5 billion. Indeed, the local agreeable climate is a preeminent tourism motivational-factor.

However, due to climate change, the meteorological conditions of the Maltese Islands are expected to deteriorate in the future, particularly during the hot season. As a matter of fact, the mean average temperature of Malta was 18.5ºC for the time-period 1951 – 1980. On the other hand, the mean average temperature of Malta was 19.2ºC for the time-period 1981 – 2010. The frequency of summer heat-waves has also increased. For this reason, this study; which focuses on the possible implications related to tourism trends in Malta in a warming age; was put into effect where several tourists (n=785) were surveyed and their feedback was assessed (CI=9%). Questionnaire data was collected between July 31st and November 27th 2015. Results of this study strongly suggest that Malta‟s tourism industry is susceptible to climate change. However, climate change will likely encourage deseasonalization and thus shoulder months could become alternative holiday seasons. Future climatic uncertainty inevitably remains a limitation of this empirical study. Nonetheless, this study should serve as a useful, research reference-tool regarding local tourism susceptibility to climatic change.

Vella, K (2016). Analysing the Output of CMIP5 Models to Assess the Future Climate of the Maltese Islands.

Faced with the realities of a changing climate, small island states such as the Maltese Islands which are geographically located in a "hotspot" region, are most vulnerable to climate change. Future climate predictions through simulations of latest the climate models will serve as a fundamental factor for local authorities, policy and decision-makers, to better-anticipate the potential future impacts of climate change.

The main aim of this study was to-assess future-climate-projections of the Maltese Islands for years 2050 and 2070 for the climatic parameters of: (i) mean-minimum-temperature, (ii) mean-maximum-temperature and (iii) total precipitation. This has been successfully-achieved through the analysis of the latest 11 Coupled Model Intercomparison Project phase 5 (CMIP5) models addressing the four Representative-Concentration-Pathways (RCPs). Another aim was to assess the statistical significance between the 11 CMIP5-model outputs of future predictions for Malta, which was done by clustering-analysis. This study shows a gradual increase in both mean minimum and maximum temperatures for-the-projected-years and a strong decrease in total-precipitation in 2050 with a slight increase in 2070. The 11-CMIP5 model-outputs were further clustered in two-on the basis of their monthly projections for mean minimum and maximum temperature, and for total-precipitation at 95% confidence level.

Gatt, M (2014). Identifying climatic trends of bright sunshine hours and related driving forces in the central Mediterranean.

Analysing trends in bright sunshine hours (BSH) is a common area of study in climatology. The current study analyses, for the first time, the monthly and yearly trends of BSH durations over the central Mediterranean region over the 1978-2012 climatic period. The meteorological stations included are; Luqa (Malta), Messina and Trapani

(Sicily), Tunis, Jendouba, Kairouan, Gafsa and Gabes (Tunisia), of which data was accessed from the German Weather Service (Deutscher Wetterdienst DWD) from the Maritime Climate Monitoring Centre. The influence of other climatic indices on BSH duration, as measured over the Maltese Islands is also studied. These include; cloud cover, relative humidity, vapour pressure and wind speed for the period of 1978-2010 and aerosol optical thickness for the period 2005-2012.