

RESEARCH GROUP OF METEOROLOGY AND CLIMATOLOGY

Leader: Professor Helena Flocas

Members: Dr. John Kouroutzoglou, Dr. E. Bitsa, , John Samos (Ph.D student), J. Chaniotis (PhD student) postgraduate students within the context of their dissertation work.

Collaboration with: Assist. Prof. Maria Hatzaki, Faculty of Geology and Geoenvironment, NKUA, Dr. P. Patlakas

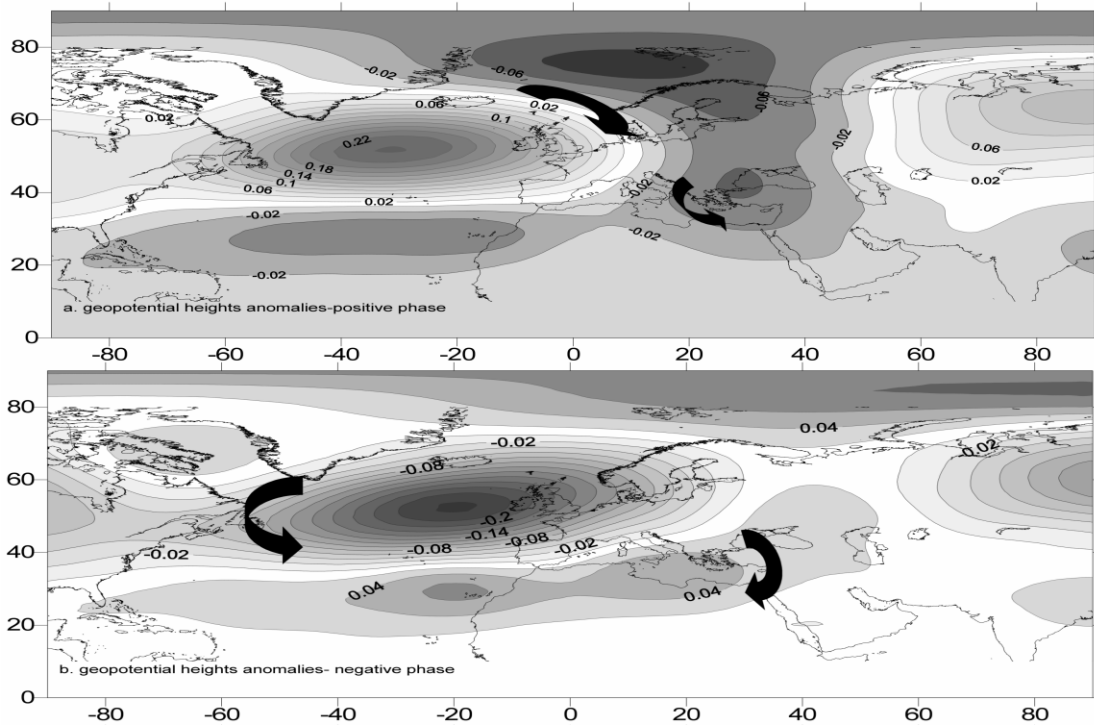
Research activities

The research activities of the group are related with:

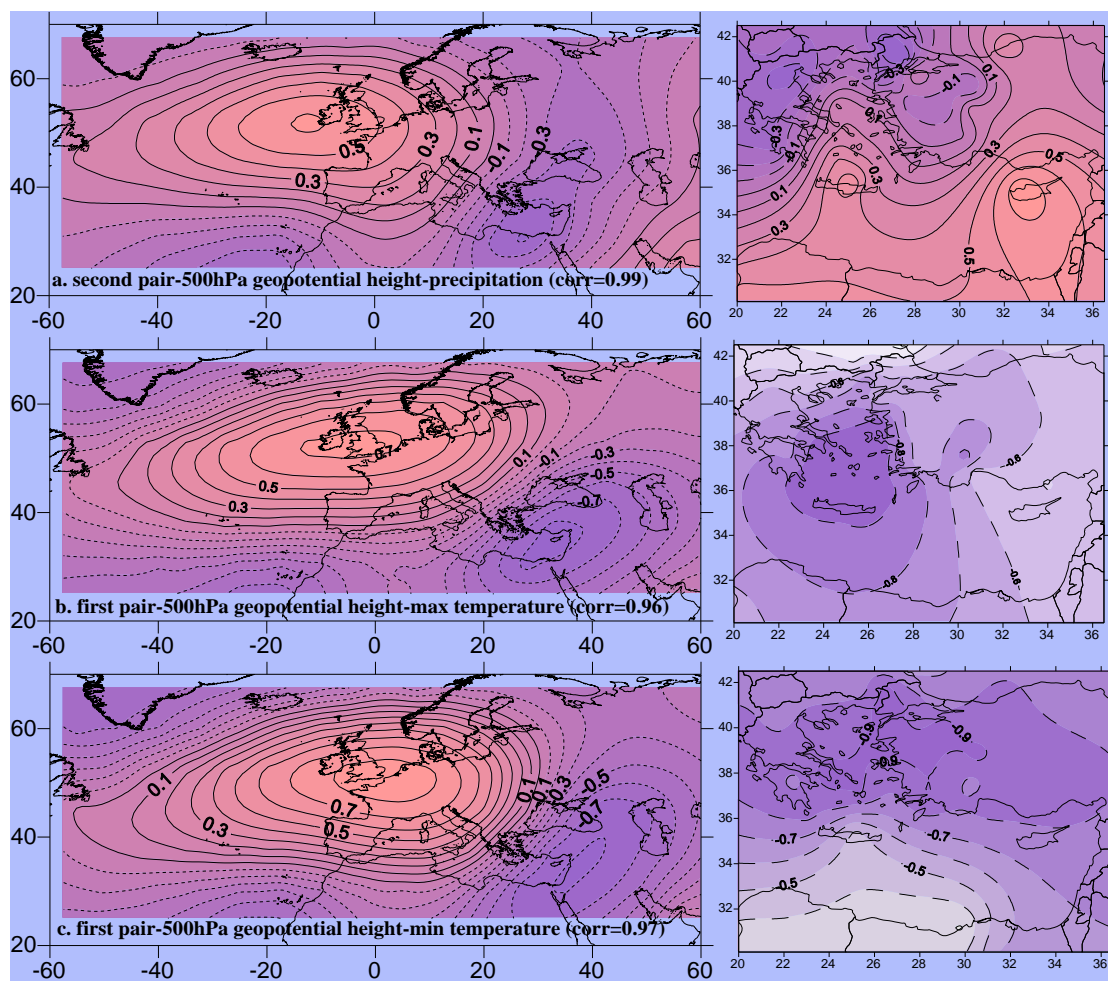
- Natural Climatic Variability and Climate change
- Climate Dynamics
- Climatic Extremes
- Synoptic and Dynamic Meteorology
- Mediterranean cyclones and cyclonic tracks
- Mediterranean migratory anticyclones and tracks
- Cold fronts in the Mediterranean
- Biometeorology: estimation of human thermal balance under extreme conditions
- Classification of atmospheric circulation- Relationship to environment

More specifically:

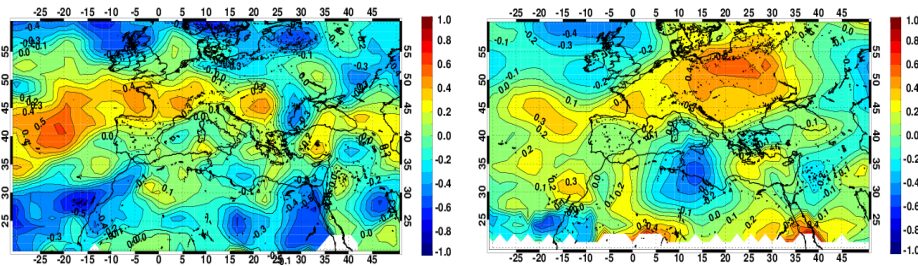
- **Natural climatic variability, including teleconnection patterns and blocking: identification with the aid of advanced statistical methods, frequency analysis, impact on regional climate**



Identification of the poles of the teleconnection pattern of Eastern Mediterranean (EMP) with the aid of Correlation Analysis and Rotated Principal Component Analysis

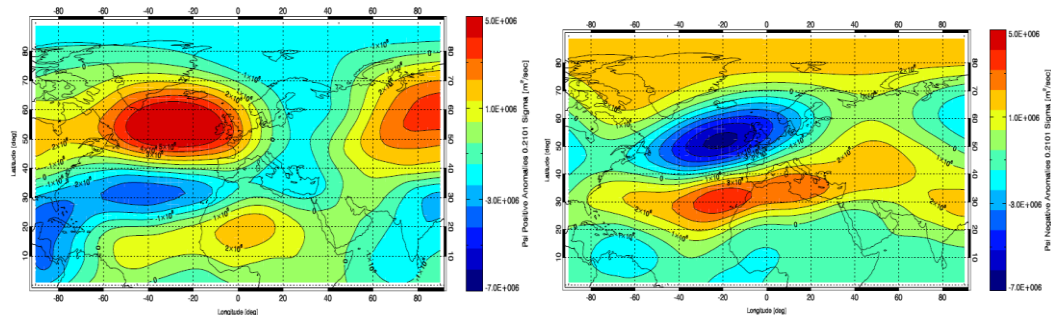


The impact of EMP on precipitation and temperature regime with the aid of Regularised Canonical Correlation Analysis

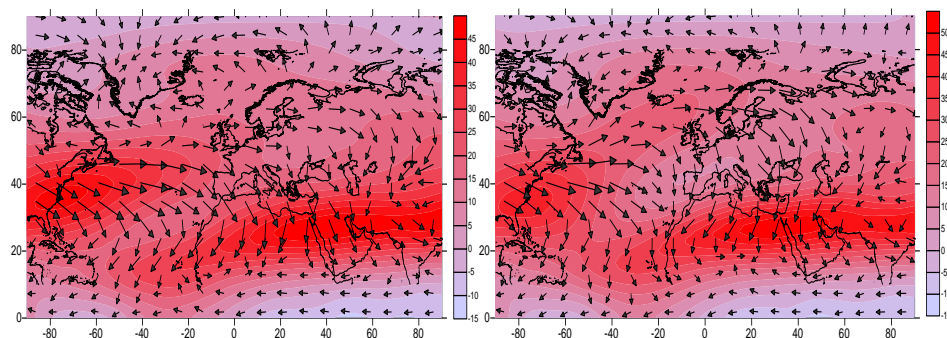


Spatial distribution of correlation coefficients between winter NAO index and anticyclonic system density (left) and depth (right).

- **Climate dynamics: the role of Rossby waves, jet stream, interaction between stratosphere and troposphere, diabatic heating, transient eddies in climatic variability and climatic extremes**

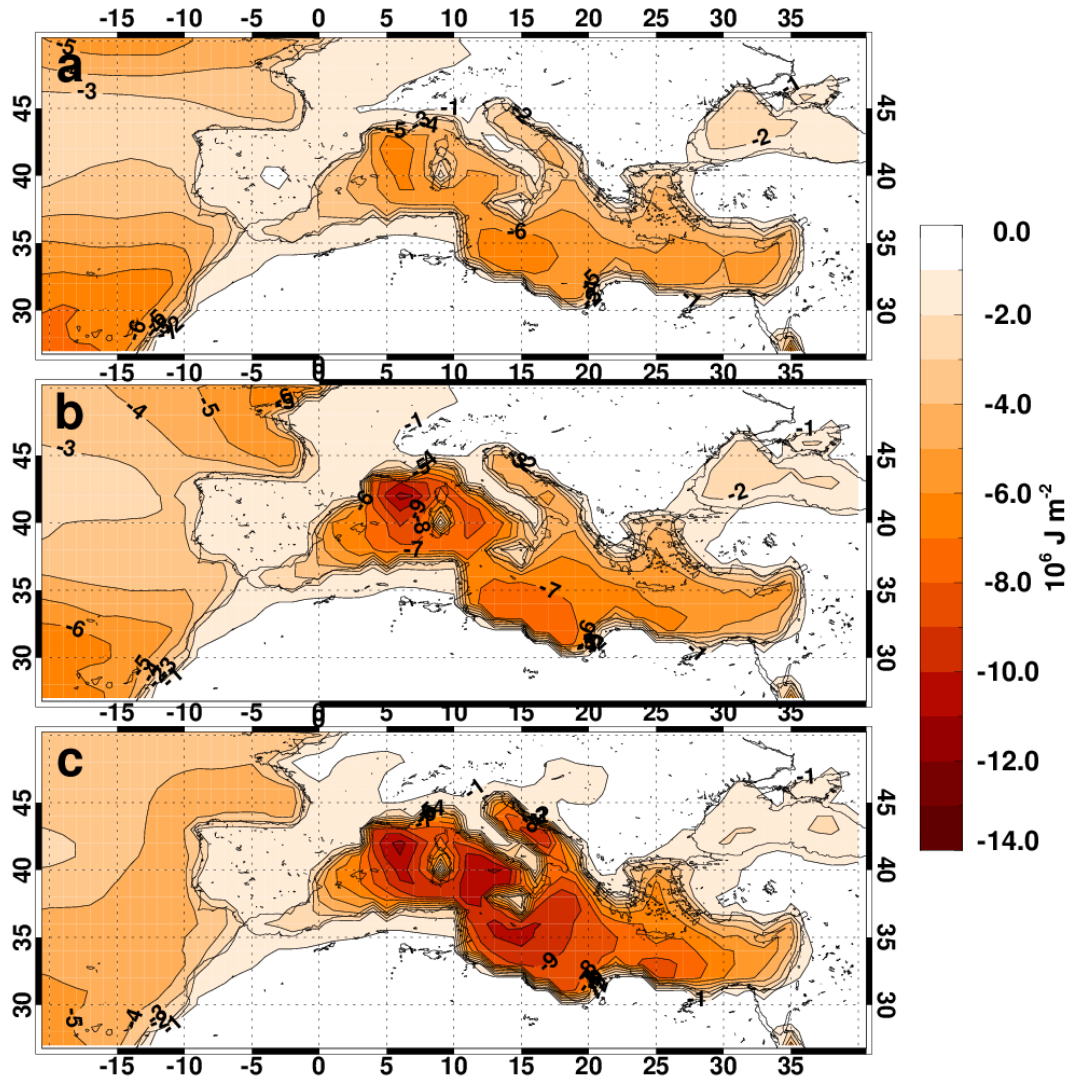


Anomalies of streamfunction at level $\sigma=0.2101$ during the positive and negative phase of EMP

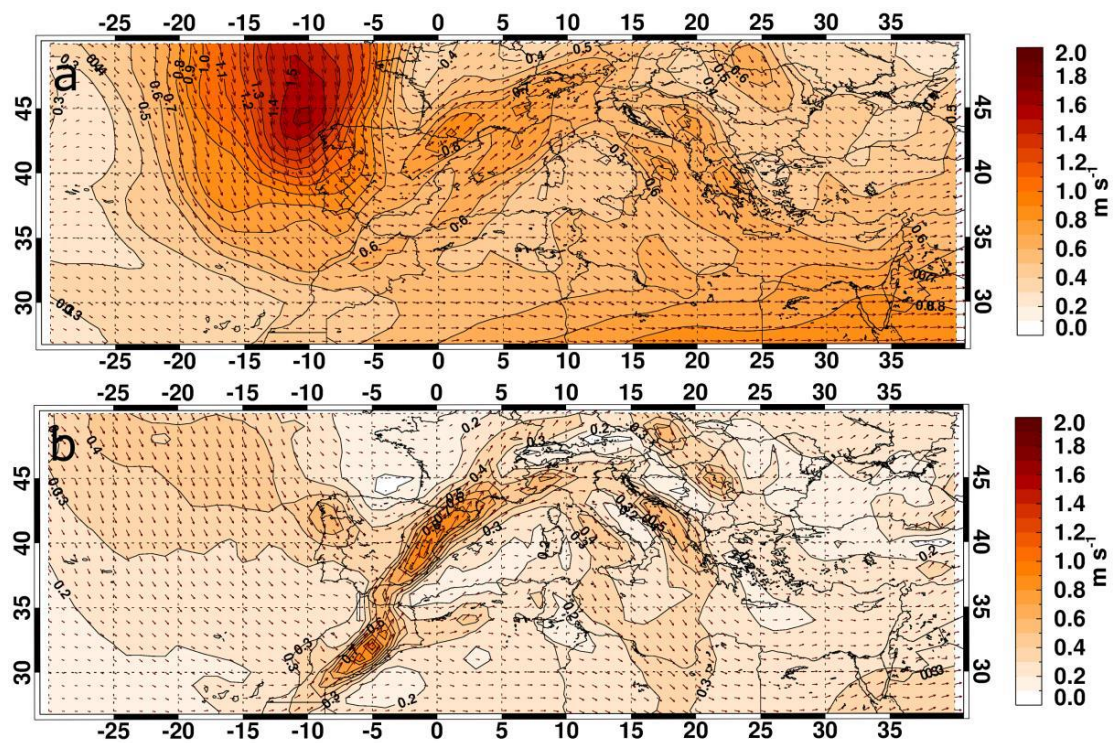


Anomalies of E-vectors during the positive and negative phase of EMP

The development of explosive cyclones in the Mediterranean

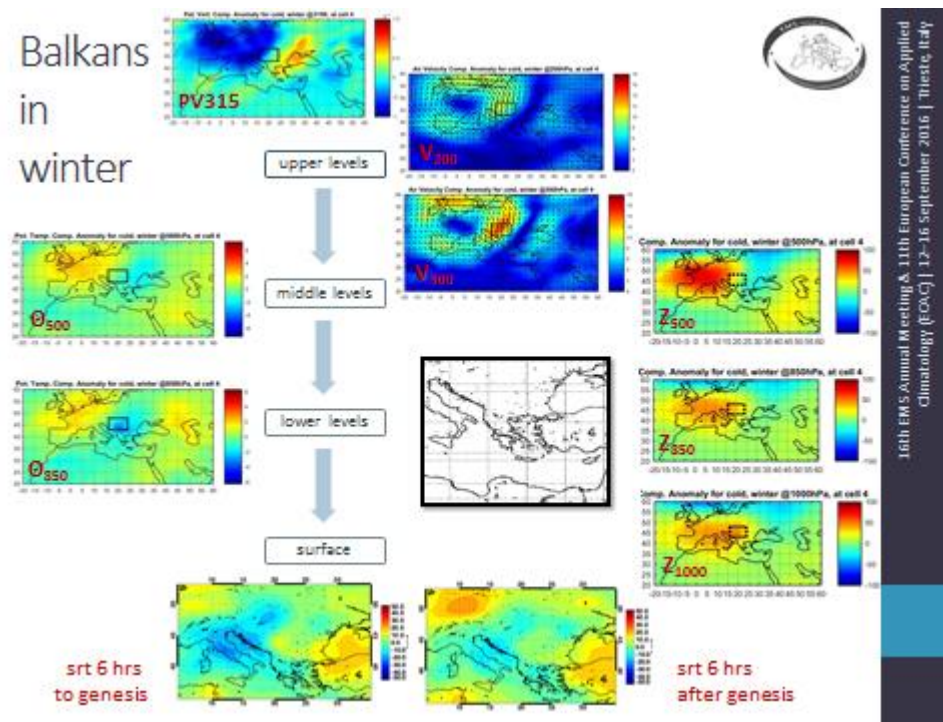


Composite latent heat fluxes a) 24hr before the explosive cyclogenesis (D-1), b) 3 at the time of the explosive cyclogenesis (D) and c) 24hr after the time of the explosive cyclogenesis (D+1) for the strongest CM explosive cyclones.



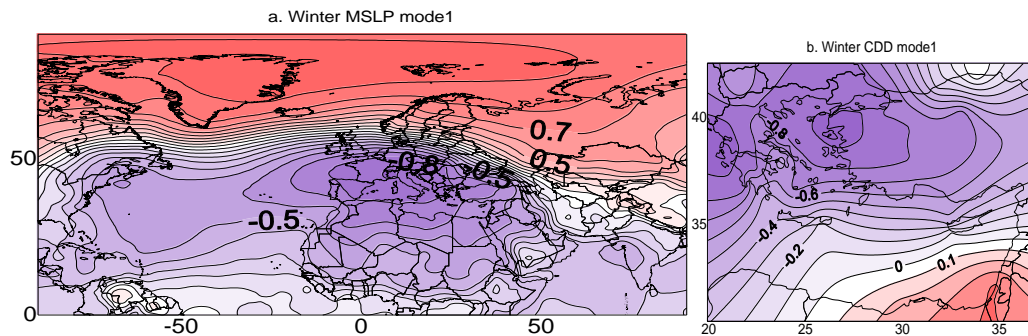
a) Composite 500-300 hPa thermal wind and b) Composite 850-700 hPa thermal wind for the WM explosive cyclones at the time of explosive cyclogenesis.

The development of migratory anticyclones in the Mediterranean

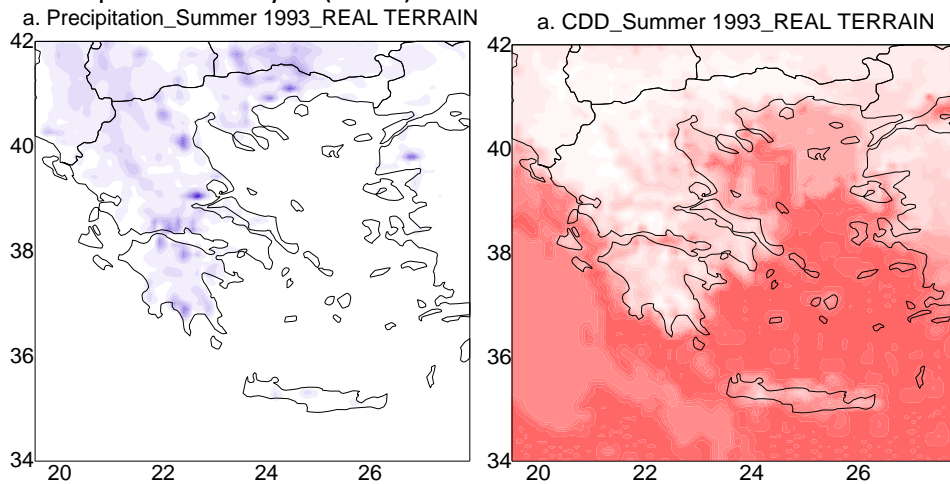


Dynamics of cold anticyclones generating over Balkans

- **Climatic extremes: focusing on temperature and precipitation extremes, responsible large scale atmospheric circulation and orography with the aid of reanalysis data and RCM simulations**

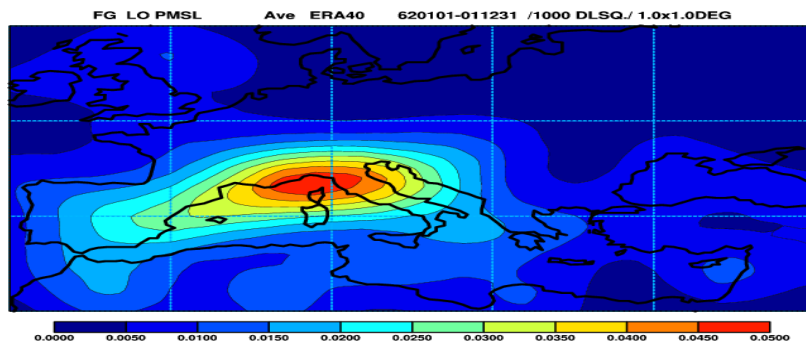


An atmospheric circulation pattern responsible for the occurrence of prolonged dry spells in Eastern Mediterranean during winter with the aid of Singular Value Decomposition Analysis (SVDA)

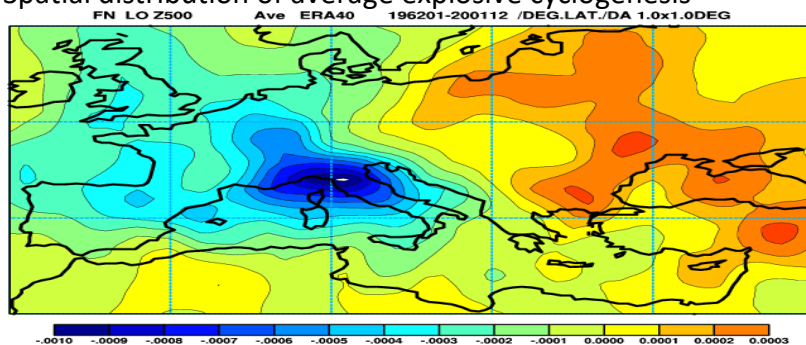


Distribution of precipitation and prolonged dry spells in Greece during an extreme summer, as derived from the simulation of regional climatic model ReGCM3

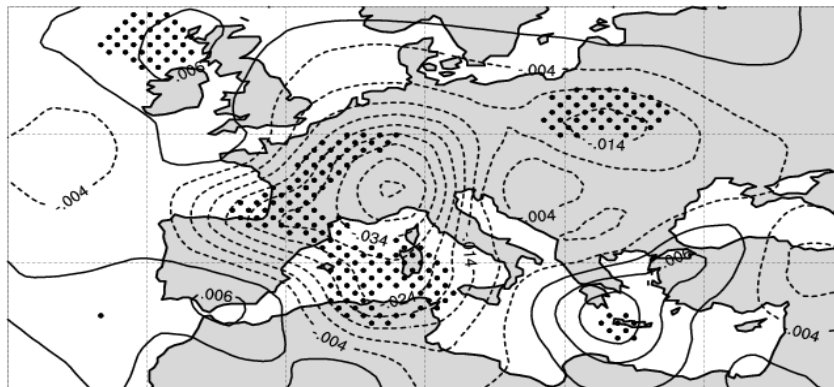
- **Mediterranean cyclones and cyclonic tracks: identification with the aid of MS algorithm and analysis of dynamic/kinematic characteristics, at the surface and in the vertical at various isobaric surfaces. Special emphasis on explosive cyclones**



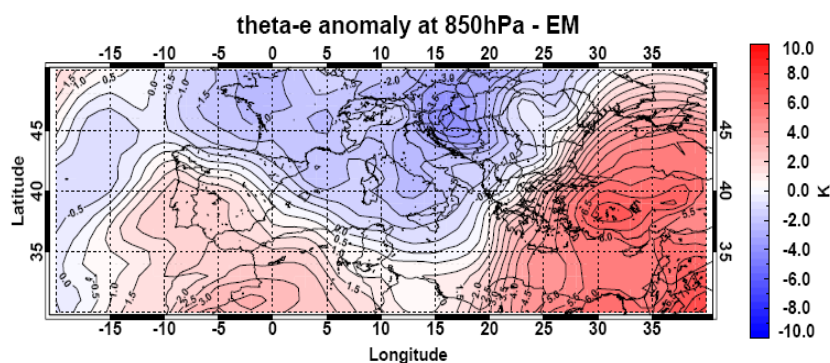
Spatial distribution of average explosive cyclogenesis



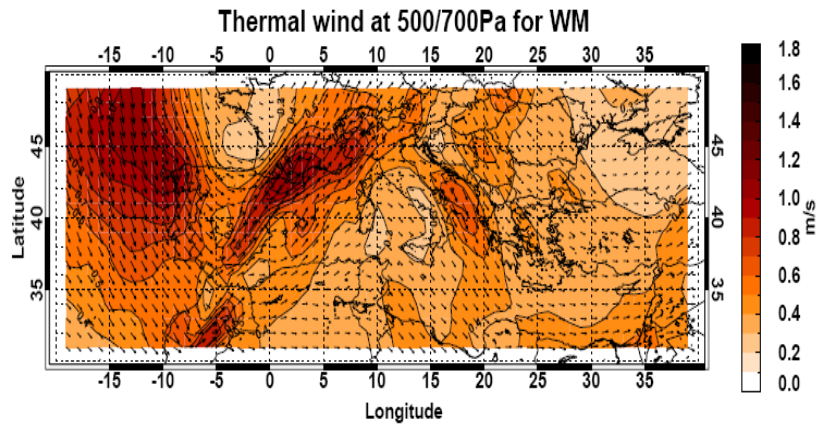
Spatial distribution of meridional fluxes at 500 hPa (e.g average number of of explosive cyclones crossing northwards across a west-east area unit normal to the motion per unit time.



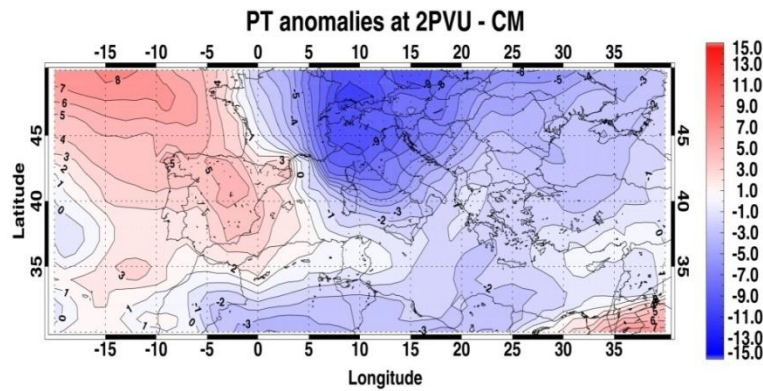
Spatial distribution of the decadal trend of the average 500hPa cyclone intensity. The dots indicate areas with statistical significant trends at 95%.



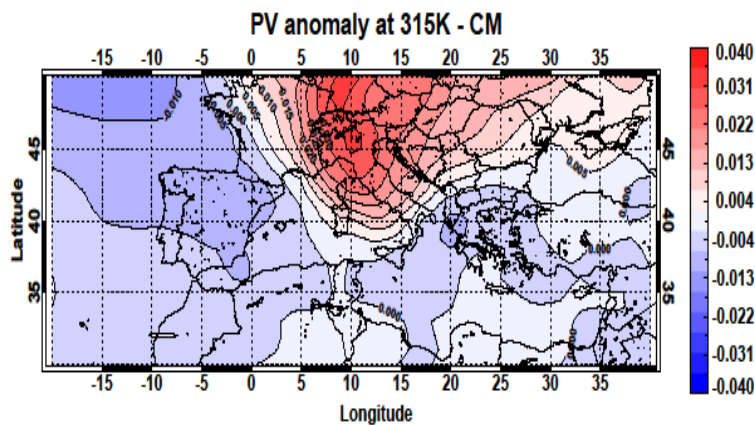
Composite anomaly of equivalent potential temperature at 850hPa for the cases of explosive cyclones in Eastern Mediterranean



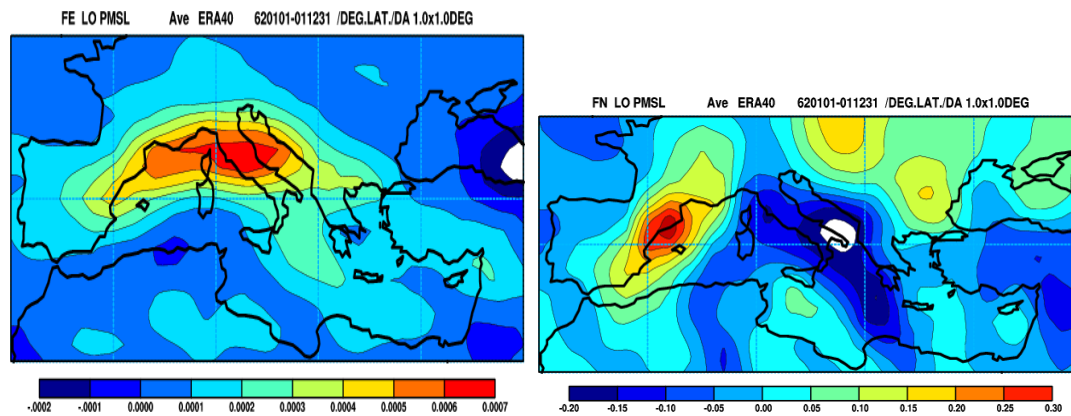
Composite of Thermal wind for the layer 500-700 hPa as derived from the explosive cyclones in Western Mediterranean



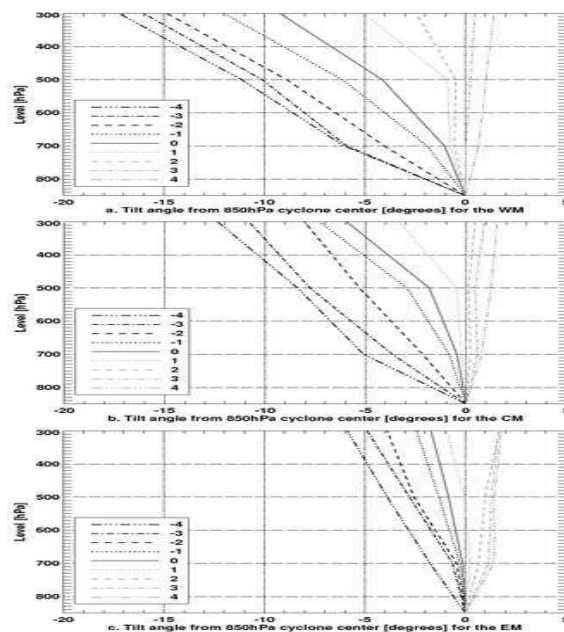
Composite anomaly of potential temperature at the iso-PV level 2 PVU for the cases of explosive cyclones in Central Mediterranean



Composite anomaly of potential vorticity at isentropic level 315 K for the cases of explosive cyclones in Central Mediterranean

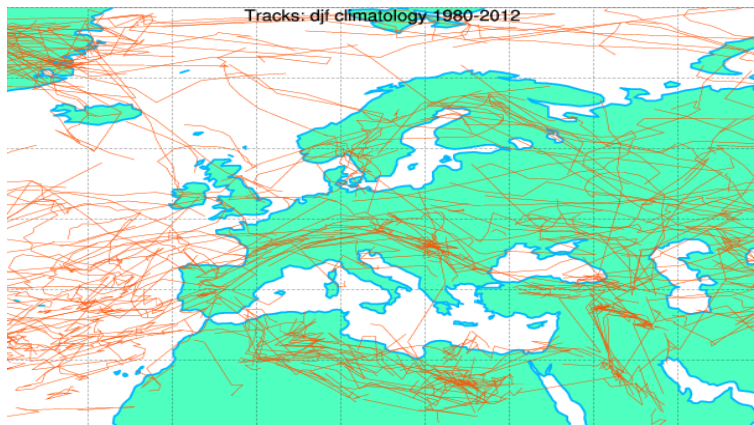


Spatial distribution of the average zonal (left) and meridional (right) component of motion of Mediterranean explosive cyclones

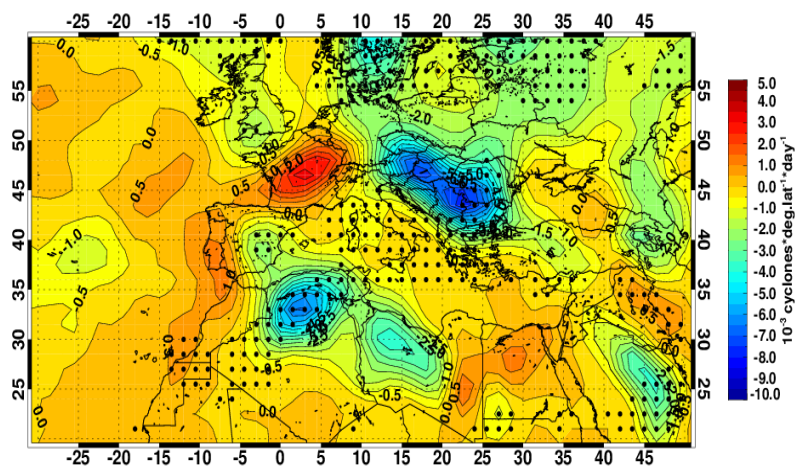


Results of the vertical tracking algorithm for explosive cyclones in the Mediterranean

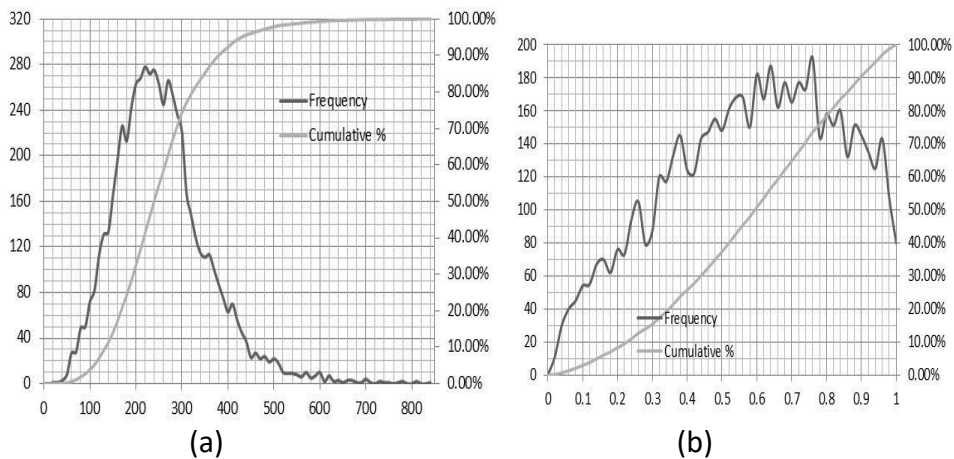
- **Mediterranean migratory anticyclones and tracks: identification with the aid of MS algorithm and analysis of dynamic/kinematic characteristics at the surface. Trend analysis.**



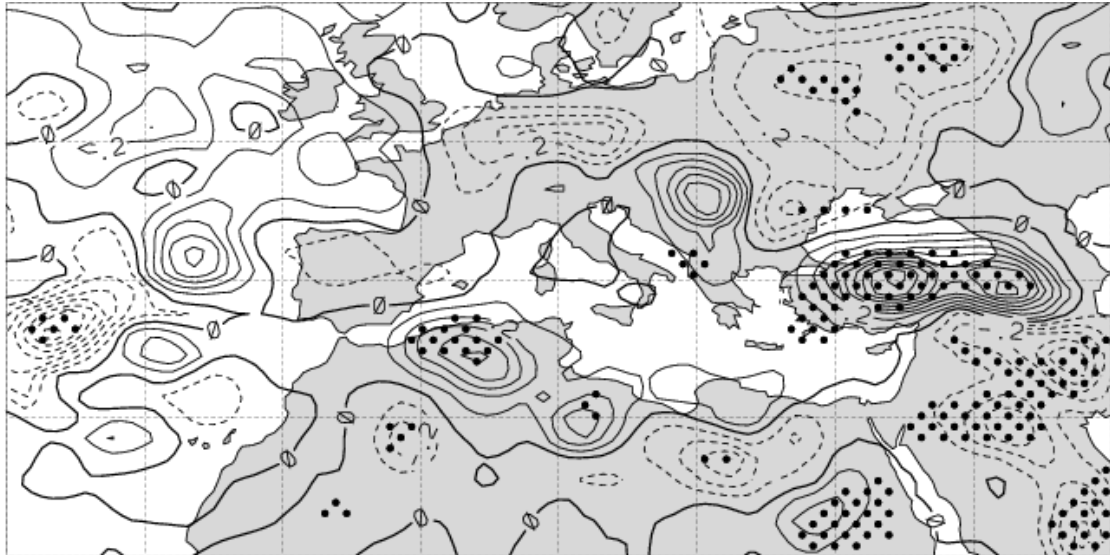
Anticyclonic tracks



Meridional component of anticyclone propagation

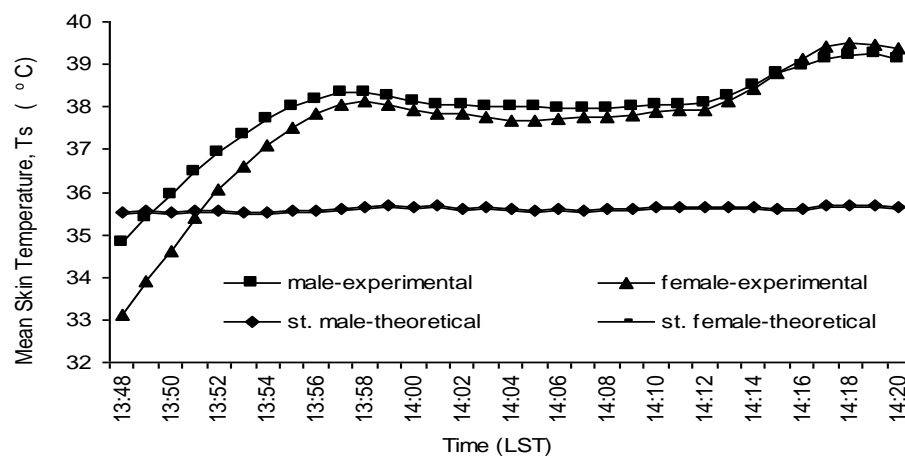


Frequency distribution of (a) the mean 6-h displacement of the anticyclonic tracks, (b) the ratio between the vector and the mean 6-h displacement for the track population with at least one step in the Mediterranean

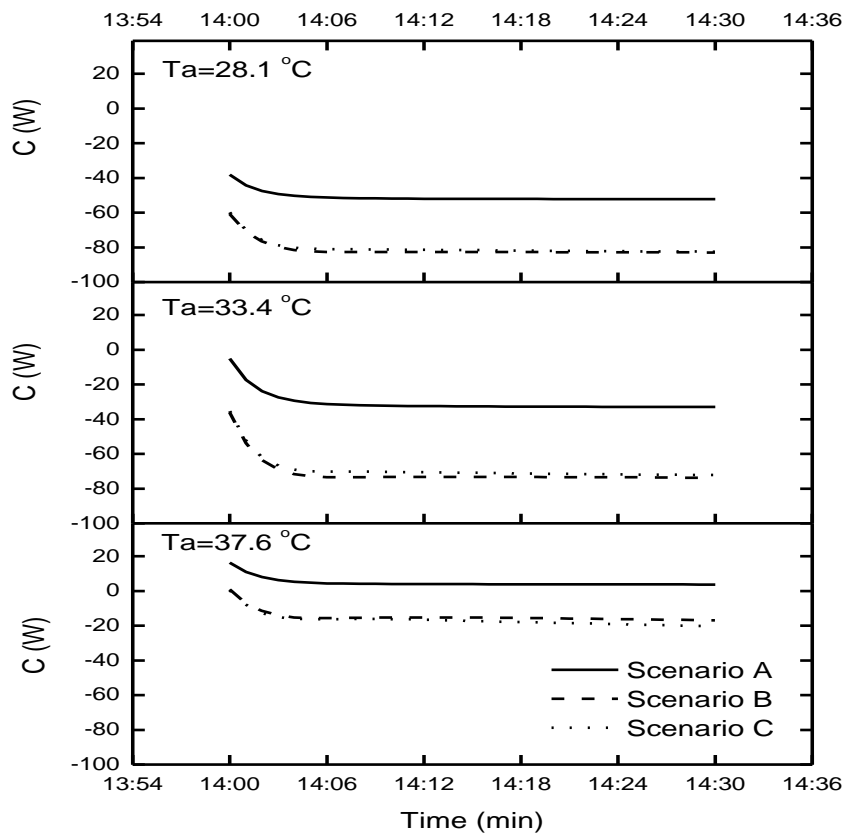


Trends of anticyclonic system density during December-October-November

- **Biometeorology:** thermophysiological measurements with the aid of a multi-sensor device applied on the triceps of the arm of subjects and estimation of human heat balance terms under extreme conditions

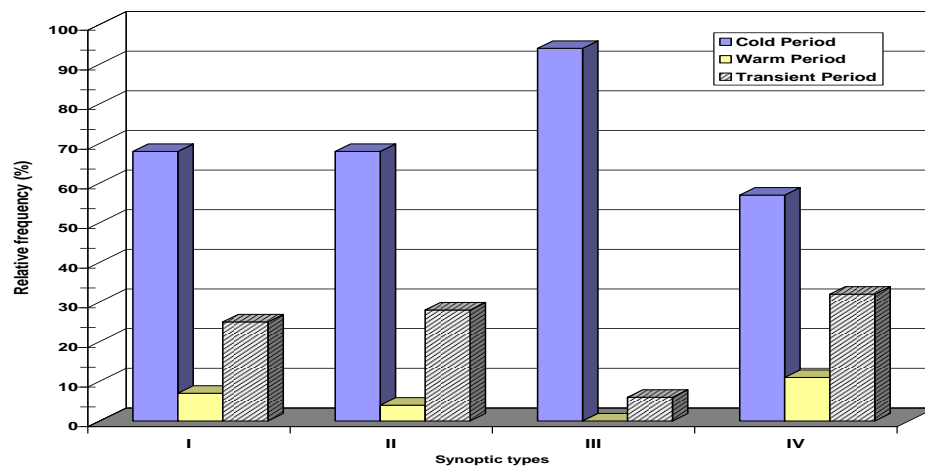


Average mean skin temperature (T_s) for two individual subjects during the 33 minute long track (2.5 km) in the Campus of the University of Athens for three extremely hot summer days. The average theoretical mean skin temperature for two standard persons under the same conditions is also drawn.

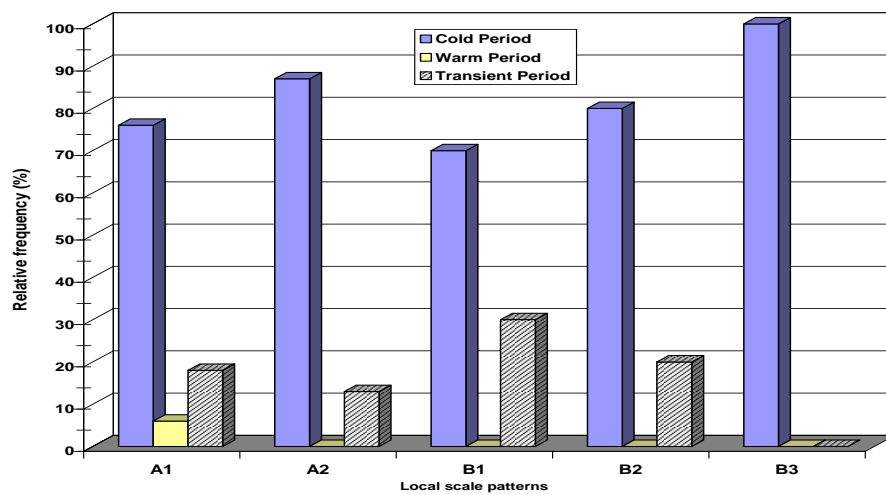


Simulation of convective heat fluxes of human body for three different scenarios of environmental conditions with the aid of the model IMEM

- Classification of atmospheric circulation- Relationship to environment:** Environment to circulation classification and vice versa with the aid of semi-empirical methods or charts. Relationship of the large and local scale atmospheric circulation with air quality status, heat island, mortality, transboundary air pollution

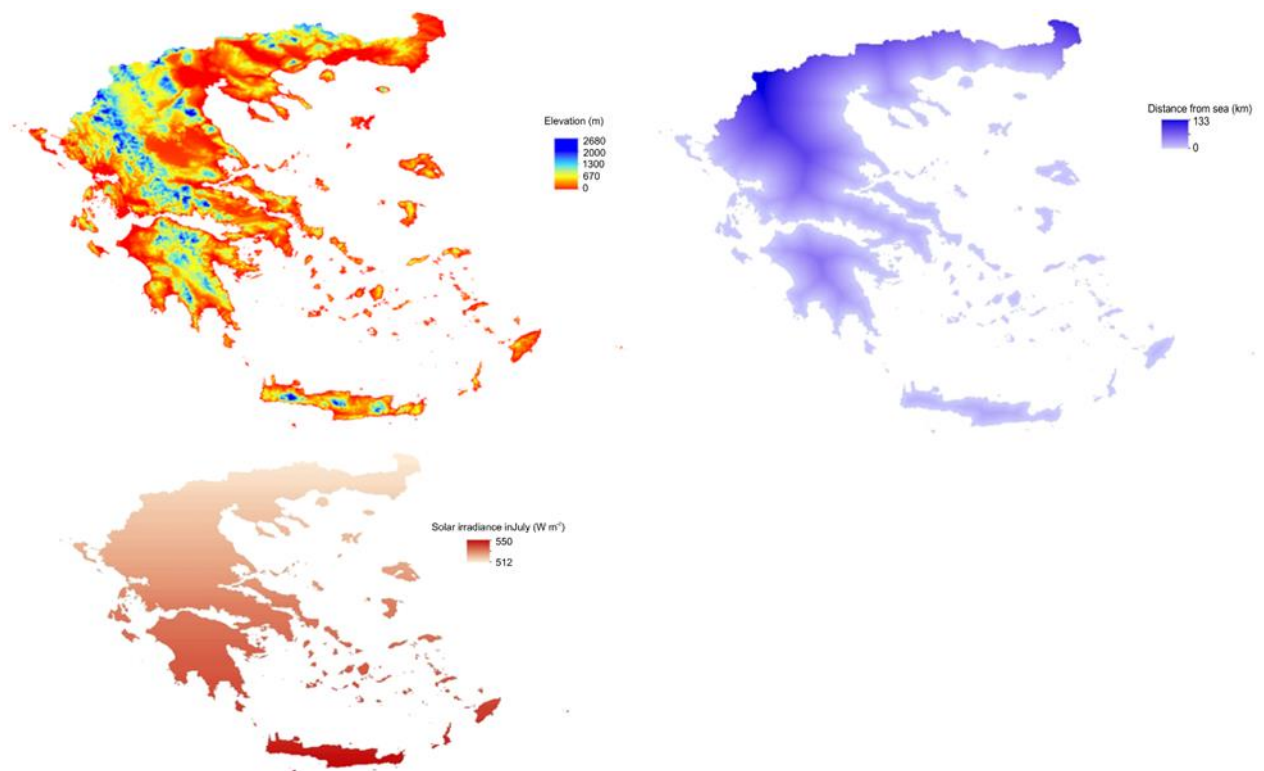


Relative frequency (%) of the synoptic types prevailing during air pollution episodes in Thessaloniki for the cold, warm and transient period.

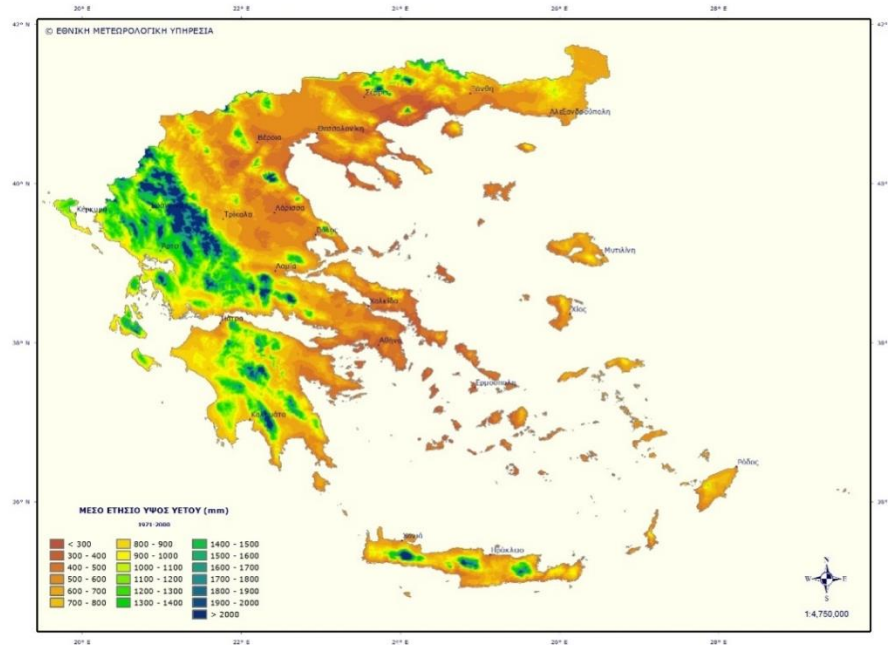


Relative frequency (%) of the local scale patterns responsible for air pollution episodes in Thessaloniki for the cold, warm and transient period.

- **Developing gridded data sets of precipitation for Greece based on homogenized time series (climatic atlas)**

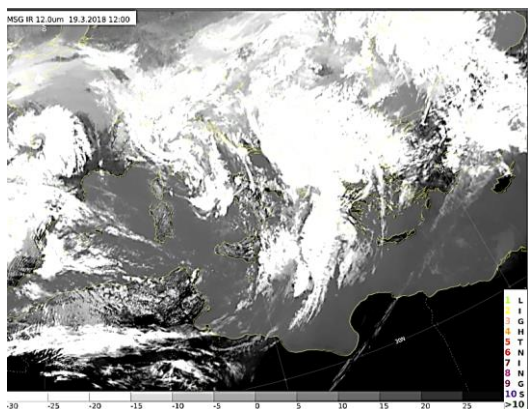


Main geophysical parameters used in MISH as predictors: Elevation (m), Euclidean distance from coastline (Km) and solar irradiance (w/m2).

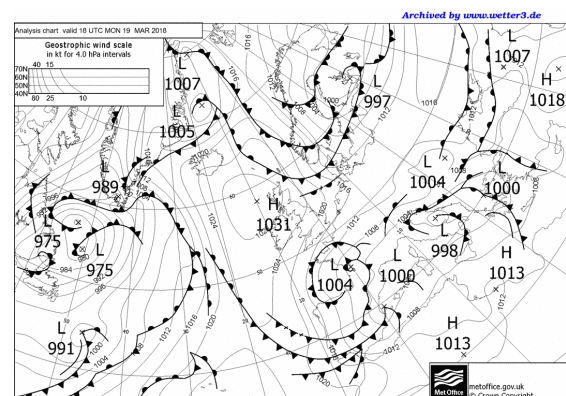


Annual precipitation map

- Development of an algorithm to identify cold fronts in the Mediterranean on a climatological basis (MedFTS)



(a)



Satellite image (IR 12 μ m) of the Mediterranean sea at 19 March 2018, 12:00UTC, (b) synoptic surface chart over the area of interest at the same time, (c) identified fronts **with the aid of MedFTS** for $d\phi_{crit} = 30^\circ$ and $|U|_{crit} = 5 \text{ m s}^{-1}$. Red lines represent the identified fronts, whereas colored areas show the magnitude of the total wind $|U|$ at the grid points where the $d\phi$ criterion is met. (d) Respective results for the case of solely the dv criterion for $dv_{crit} = 6 \text{ m s}^{-1}$.

Infrastructure

The members of the group work in a separate laboratory of Building 5 of the Department of Environmental Physics-Meteorology, Faculty of Physics, University of Athens.

The group makes use of the existing infrastructure of the Department but it has access to their own databases, software, models, computational equipment. The infrastructure of the group includes:

- A powerful workstation with Unix operation system for the implementation of the MS Algorithm and the climatic model
- Two computational systems with Windows OS with statistical software (e.g. SPSS and Statistica), Interactive Data Language (IDL),
- Technical computing software (MatLab), the analysis and display algorithm GrADS, R - Programming Environment for Data Analysis and Graphics
- The tracking algorithm MS developed by University of Melbourne, Australia and modified by our group for Mediterranean along with the Vertical Tracking Algorithm that was developed by our group in collaboration with the University of Melbourne
- The front identification algorithm MedFTS that was developed by our group in collaboration with the University of Melbourne
- The regional climatic model ReGCM3
- A Data Base of daily Temperature and Rainfall at 20 surface stations covering Greece
- Climatic Data bases of station data in the Mediterranean region, for a time period of the last 50 years that have been checked for their homogeneity and quality. Also, reanalysis data (NCEP and ERA), GCM and RCM model data for the present and future climate.

Research programs

The group has participated in research projects, funded by European funds, related to Climate:

1. ENSEMBLES (2004-2010) "Ensembles based predictions on climate changes and their impacts" (contract number GOCE-CT-2003-505539).
2. STARDEX (2002-2005) "Statistical and Regional dynamical Downscaling of Extremes for European regions" (Contract no: EVK2-CT-2001-00115).

3. SEMCLIMED ("Impact of climatic changes on wild plant species in the Mediterranean region and conservation activities", 2006-2008 (Interreg IIIB-MEDOCC))
4. ECATS "Environmentally compatible air-transport system (ECATS)-Network of Excellence", 2005-2011), including study of climatic changes related with airplane contrails.
5. ERACOBUILT The square mile retrofit project including study of variations in heating and cooling degree days related with climatic changes 2015-2016
6. ICARUS (Integrated Climate forcing and Air pollution Reduction in Urban Systems). Horizon 2010 2016-2020 (collaboration with Democritus Research Centre) including design and implementation of appropriate abatement strategies to improve the air quality and reduce the carbon footprint in European cities

Also, the leader has coordinated the following projects:

1. "Study of teleconnections of atmospheric circulation affecting the Eastern Mediterranean Climate" (2005-2007). Funded in the Framework of the project "Pythagoras II- Support of University Research Groups" with 75% from European Social Funds and 25% from National Funds.
2. "Study of anomalies of atmospheric circulation in Northern Hemisphere that form during extreme climatic phenomena in Eastern Mediterranean".(2005-2008) Funded by the EU (75% of the public expenditure), the General Secretariat for Research and Technology-Ministry of Development (25% of the public expenditure) and the private sector, within the frame of Measure 8.3 of the Operational Program "Competitiveness" -Third Support Framework (PENED 2003).
3. "Influence of monsoons in climatic extremes in Eastern Mediterranean during summer" (2011-2014). Funded in the Framework of the project "Hrakteitos II- Support of University Research Groups" with 75% from European Social Funds and 25% from National Funds (ESPA 2007-2013).
4. "A climatology of anticyclonic activity in the Mediterranean: tracks, vertical structure and dynamics (2012-2014). Funded in the Framework of the project "Support of postdoctoral research" from European Social Funds and 25% from National Funds (ESPA 2007-2013).

Collaborations

The group has collaborated with other scientific groups, providing meteorological or climatological expertise: at the same Department (air pollution modelling, physics of buildings), or other Faculties (Medicine, Biology, Geology) at the same University or other Universities/Institutions in Greece and Europe, including University of Reading (UK), UK Meteorological Office, University of Karlsruhe(Germany), JRC-ISPRA, University of Melbourne (Australia), National Observatory of Athens, Department of Geology (Univ. of Thessaloniki), National Technical University of Athens, Technical University of Crete, University of Southampton. All these collaborations have resulted in publications in journals or conference proceedings.

The group has long term collaboration with members of the Department of Meteorology and Climatology, School of Geology, University of Thessaloniki, with respect to climate changes and regional climate of Mediterranean, recently with the aid of the model ReGCM.

The leader of the group along with two members has been collaborating with Prof. Simmonds (University of Melbourne) and his group since 2008 with respect to the application of the MS cyclonic tracking algorithm (that has been developed by Prof. Simmonds) in the Mediterranean. Recently, this collaboration is extended to the study of Mediterranean mobile anticyclones.

The group is currently collaborating with the National Meteorological Service, aiming at exploring the role of surface fluxes in the explosive cyclogenesis in the Mediterranean with the aid of the model COSMOS.

The group is also collaborating with the HYDROMECH Lab, Technical University of Crete within the context of the project REINFORCE, aiming at exploring the characteristics of floods in Crete and contributing to their forecasting.

Recent publications of the group in international journals (since 2010)

1. Mavrakis, A., Flocas, H., Mavromatidis E., Kallos, G., Theoharatos, G., Christidis, A., 2010: A case of nighttime high ozone concentration over the Greater Athens area. *Meteorologische Zeitschrift*, 19, 35-45.
2. Oikonomou, C., Flocas, H., Hatzaki, M., Nisantzi, A., Asimakopoulos D.N., 2010: Relationship of extreme dry spells in Eastern Mediterranean with large scale circulation. *Theoretical and Applied Climatol.*, 100, 137-151.
3. Hatzaki, M., Flocas, H., Oikonomou C., Giannakopoulos, C., 2010: Future changes in the relationship between intense precipitation with large scale circulation. *Advances in Geosciences*, 23, 31-36.
4. Kouroutzoglou, J., Flocas, H.A., Keay, K., Hatzaki, M., D. 2011: Climatological aspects of explosive cyclones in the Mediterranean. *Int. J. Climatol.*, 31, 1785-1802, doi: 10.1002/joc.2203
5. Flocas, H.A., I. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, D. N. Asimakopoulos, V. Bricolas, 2010: On cyclonic tracks over the Eastern Mediterranean. *J. Climate*, 23, 5243-5257 doi: 10.1175/2010JCLI3426.1
6. Flocas, H.A., Hatzaki, M., Tolika, D., Anagnostopoulou, C., Giannakopoulos C., Kostopoulou E., Kolokitha H., Tegoulis, J., 2010: Ability of RCM/GCM couples to represent the relationship of large scale circulation to climate extremes over Mediterranean. *Climatic Research Climatic Research*, 46, 197-209, doi: 10.3354/cr00984.
7. Mavrakis, A., Flocas, H., Mavromatidis E., Kallos, G., Theoharatos, G., Christidis, A., 2010: A case of nighttime high ozone concentration over the Greater Athens area. *Meteorologische Zeitschrift*, 19, 35-45
8. Oikonomou, C., Flocas, H.A., Katavoutas, G., Hatzaki, M., D.N. Asimakopoulos, Zerefos, C., 2010: On the relationship of orography with extreme dry spells in

- Greece. *Advances in Geosciences*, 25, 161-166. Doi: 10.5194/adgeo-25-161-2010.
9. Kouroutzoglou, J., Flocas, H.A., Keay, K., Hatzaki, M., D. 2011: Climatological aspects of explosive cyclones in the Mediterranean. *Int. J. Climatol.*, 31, 1785-1802, doi: 10.1002/joc.2203
 10. Kouroutzoglou, J., Flocas, H.A., Keay, K., Hatzaki, M., D. 2011: Assessing the characteristics of explosive cyclones under different resolution. *Theor. Appl. Climatol* 105, 263-275, DOI 10.1007/s00704-010-0390-8
 11. Kouroutzoglou J., Flocas H.A., Keay K, Simmonds I., Hatzaki M., 2012: On the vertical structure of explosive Mediterranean cyclones. *Theor. Appl. Climatol.* 110, 155-176, DOI 10.1007/s00704-012-0620-3.
 12. Zagouras, A., A Argiriou, H.A. Flocas, G. Economou, S. Fotopoulos, 2012: An advanced Method for Classifying Atmospheric Circulation Types based on Prototypes Connectivity Graph. *Atmospheric Research*, 118, 180-192.
 13. Flocas, H.A., Kountouris P., Kouroutzoglou J., Hatzaki, M., Keay, K., Simmonds, I., 2012: Vertical characteristics of cyclonic tracks in eastern Mediterranean during the cold period of the year. *Theor. Appl. Climatol.* DOI: 10.1007/s00704-012-0737-4 (on line)
 14. Halios, C., C. G. Helmis, H.A. Flocas, S. Nyeki, D. N Assimakopoulos, 2012: On the variability of surface environment response to synoptic forcing over complex terrain: A multivariate data analysis approach. *Meteorology and Atmospheric Physics*, 118, 107-115
 15. Zagouras, A., A Argiriou, H.A. Flocas, G. Economou, S. Fotopoulos, 2012: An advanced Method for Classifying Atmospheric Circulation Types based on Prototypes Connectivity Graph. *Atmospheric Research*, 118, 180-192.
 16. Kouroutzoglou J., Flocas H.A., Keay K, Simmonds I., Hatzaki M., 2013: A high resolution climatological study on the comparison between surface explosive and ordinary cyclones in the Mediterranean. *Regional Environmental Change*, 14, 1833-1846, DOI 10.1007/s10113-013-0461-3
 17. Zagouras A., Argiriou A.A., Economou G., Fotopoulos S. and Flocas H.A., 2013: 'Weather maps classification over Greek domain based on isobaric line patterns: a pattern recognition approach', *Theoretical and Applied Climatology* 114: 691-704.
 18. Philipopoulos K, Deligiorgi D., Yiannikopoulou, I. Flocas H A., 2013: A dynamical-statistical downscaling approach for simulating air temperature time series. *Global Nest*, 15, 261-270.
 19. Korologou, M., Flocas H., Mihalopoulou H., 2014: Developing an index for heavy convective rainfall over a Mediterranean coastal area. *Natural Hazards Earth Systems Science*, doi:10.5194/nhess-14-2205-2014, 14, 2205-2214.
 20. Hatzaki, M., Flocas H., Simmonds I., Kouroutzoglou, J., Keay, K., Rudeva, I., 2014: Seasonal aspects of an objective climatology of anticyclones affecting the Mediterranean. DOI: 10.1175/JCLI-D-14-00186.1, *J. Climate*, 24, 9272-9289.
 21. Calafat, F.M., E. Avgoustoglou, G. Jordà, H. Flocas, G. Zodiatis, M. N. Tsimplis, J. Kouroutzoglou, 2014: The ability of a barotropic model to simulate sea level extremes of meteorological origin in the Mediterranean Sea, including those

- caused by explosive cyclones. *Journal of Geophysical Research-Ocean* 10.1002/2014JC010360, 119 (11), 7840-7853.
22. Katavoutas, G., Flocas H., Mazarakis A. 2015: Thermal comfort under non-steady- state conditions:the case after the transition from an indoor to outddor hot environment. DOI 10.1007/s00484-014-0836-2 *Int. J. Biometeorology*, 59, 205-216.
 23. Rizou D., Flocas H., Athanasiadis P., Bartzokas, A., 2015: Relationship between the Indian summer monsoon and the large-scale circulation variability over the Mediterranean *Atm. Research*, 152, 159-169.
 24. Kouroutzoglou J., Flocas H.A., Hatzaki M., Keay K, Simmonds I., 2015: On the dynamics of a case of explosive cyclogenesis over Mediterranean. *Meteorology and Atm. Physics* 127, 49-73.
 25. Mavrakis, A., Salvati, L. and Flocas H., 2016: Mixing Ratio as indicator of Climate Variations at a Local Scale: Trends in an Industrial Area of the Eastern Mediterranean, *International Journal of Climatology*, 36: 1534–1538, DOI: 10.1002/joc.4410 .
 26. Taylor, M., Retalis A and Flocas H., 2016: Particulate matter estimation with photochemistry: a modeling approach using neural networks and synoptic clustering. *Aerosol and Air Quality Research* 16: 2067–2084 doi: 10.4209/aaqr.2015.07.0481.
 27. Flocas, H.A., Tsanis, J., Katavoutas, G., Kouroutzoglou J., Tsanis J, Iordanidou V., Alexakis D., 2016: Cyclonic tracks associated with flood events in Crete Greece. *Theoretical and Applied Climatology*, doi 10.1007/s00704-016-1946-z,
 28. Kouroutzoglou J., Avgoustoglou E., Flocas H.A., Hatzaki M., Skrimizeas P., Keay K., 2017:Assessment of the role of surface sea fluxes on Eastern Mediterranean explosive cyclogenesis with the aid of the regional model COSMO.GR *Atmospheric Research*, 208, 132-147.
 29. Gofa F. , Boucouvala D., Louka P. Flocas H. A., 2018: Spatial verification approaches as a tool to evaluate the performance of high resolution precipitation forecasts. *Atmospheric Research*, 208, 78-87.
 30. Dimitropoulou, E.; Assimakopoulos, V.D.; Fameli, K.M.; Flocas, H.A.; Kosmopoulos, P.; Kazadzis, S.; Lagouvardos, K. 2018: Estimating the Biogenic Non-Methane Hydrocarbon Emissions over Greece.*Atmosphere*, 2018, 9, 14; doi:10.3390/atmos9010014
 31. Halios C., Flocas H, Helmis C., Asimakopoulos D., Mouschouras P., 2018: Observations of urban environmental variability under large-scale circulation patterns over Athens, Greece. *Atmosphere*9, 00; doi:10.3390/atmos9020000
 32. Rizou D., Flocas H., Hatzaki M., and Bartzokas, A., 2018: A statistical investigation of the Indian summer monsoon impact on the eastern Mediterranean circulation. *Atmosphere*, 9, 90; doi:10.3390/atmos9030090
 33. Stergiopoulou A., Katavoutas G., Samoli E., Dimakopoulou K., Papageorgiou I., Karagianni P., Flocas H, Katsouyanni, K., 2018: Assessing the associations of daily respiratory symptoms and lung function in schoolchildren using Air Quality Indicators: results from the RESPOZE panel study in Athens, Greece,*Science of the Total Environment*, *Science of the Total Environment*, 633 (2018) 492–499

34. Katavoutas G. and Flocas H., 2018: Universal Thermal Climate Index (UTCI) and synoptic circulation patterns over an urban Mediterranean environment. *Global Nest Journal* Vol 20, No 3, pp 39-49
35. Patlakas, P., Stathopoulos C., Flocas H., Kalogeri C., Kallos G., 2019: "Regional climatic features of the Arabian Peninsula" *Atmosphere*, *Atmosphere* 2019, 10, 220; doi:10.3390/atmos10040220
36. Gofa F. , Mamara A., Anadranistakis M. and Flocas H., 2019: Developing Gridded Climate Data Sets of Precipitation for Greece Based on Homogenized Time Series, *Climate*, 7, 68; doi:10.3390/cli7050068
37. Bitsa E. , H. Flocas , J. Kouroutzoglou, M. Hatzaki, I. Rudeva and I. Simmonds, 2019: Development of a Front Identification Scheme for Compiling a Cold Front Climatology of the Mediterranean. *Climate* 2019, 7, 130; doi:10.3390/cli7110130