Meteorology and Weather Forecasting

Leader: Professor Helena Flocas

Members: Dr. J. Kouroutzoglou, Dr. E. Bitsa, Dr. P. Patlakas, J. Samos (Ph.D student), J. Chaniotis (Ph.D student),

Collaboration with: Dr. C. Kalogeri , Dr. C. Stathopoulos , MSc D. Diamantis , BSc K. Kornilakis

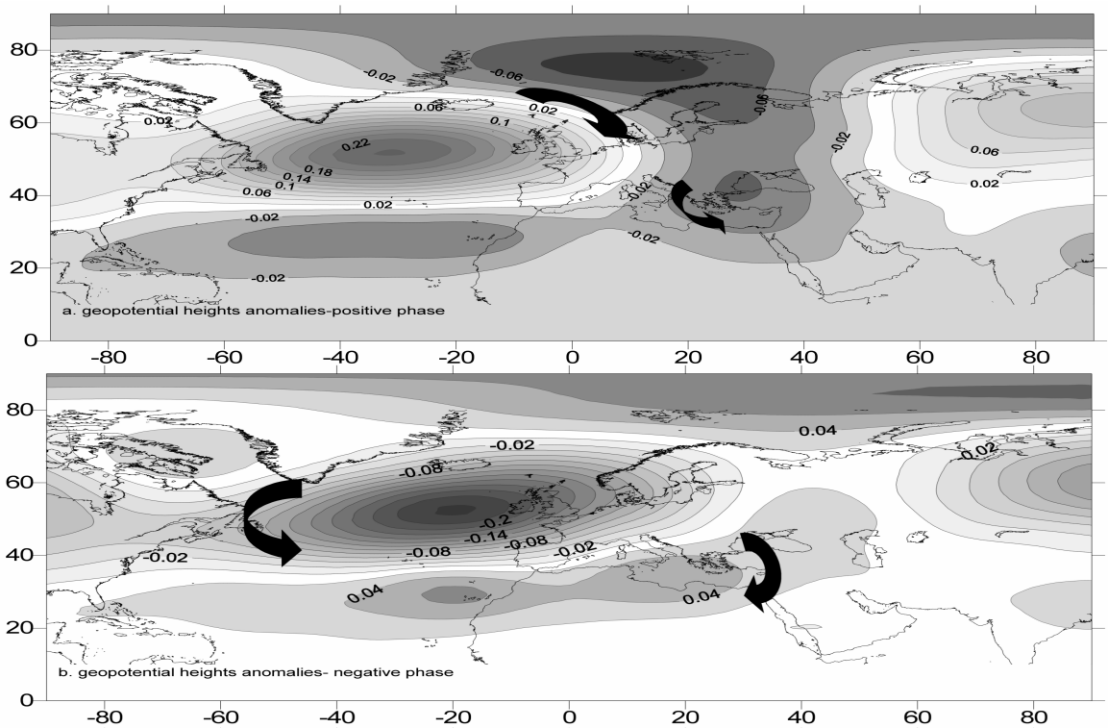
This group consists of postdoc collaborators and PhD students of Prof. Flocas that work in Meteorology and Atmospheric Dynamics. Recently, the group included postdoc collaborators of Emeritus Professor G. Kallos after his death in 2022 (following the approvement of the members of the Section of Environmental Physics-Meteorology) that work on atmospheric modelling and weather forecasting.

Research activities

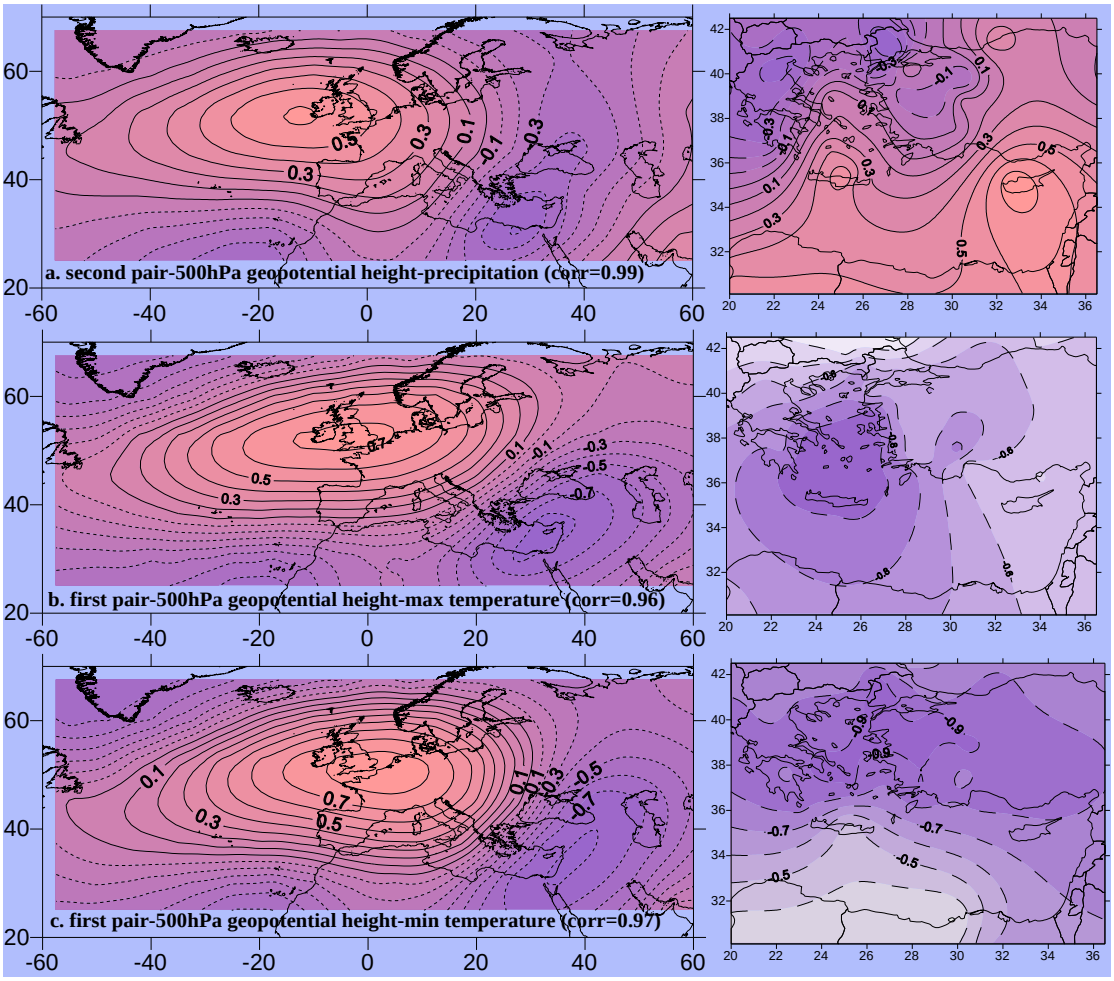
The research activities in Meteorology are related to Natural Climatic Variability and Climate change, Climate Dynamics and Climatic Extremes, Synoptic and Dynamic Meteorology, cyclones and cyclonic tracks, cold fronts and convective systems in the Mediterranean

More specifically:

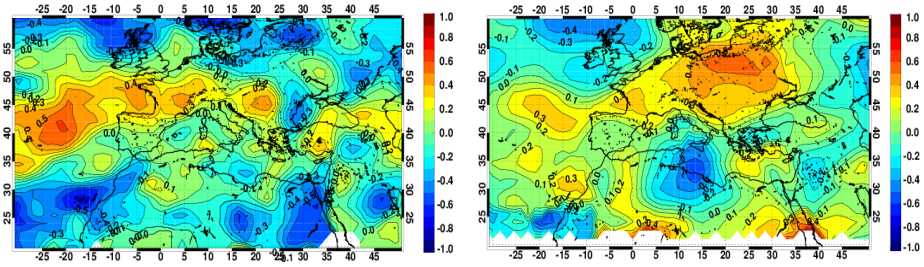
- **Natural climatic variability, including teleconnection patterns and blocking: identification with the aid of advanced statistical methods, frequency analysis, impact on regional climate**



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

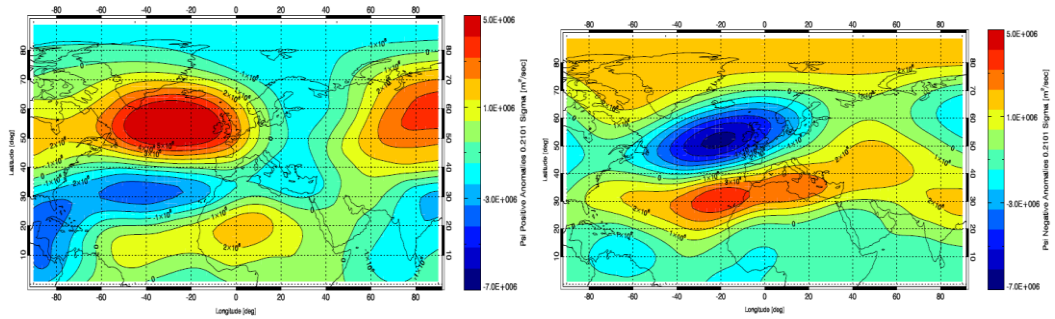


The impact of EMP on precipitation and temperature regime with the aid of Regularised Canonical Correlation Analysis

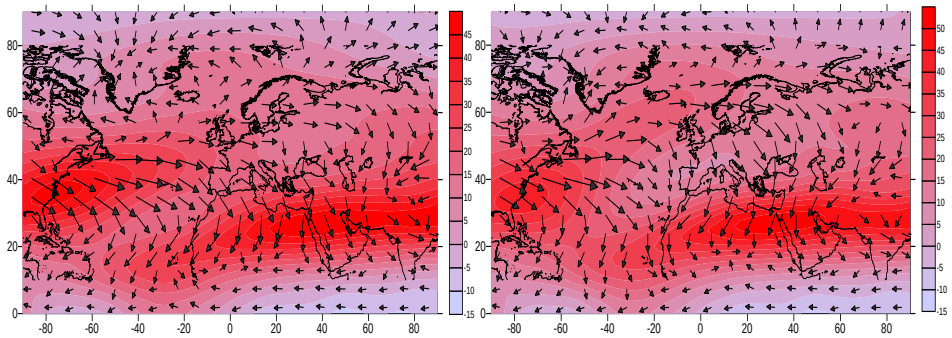


Spatial distribution of correlation coefficients between winter NAO index and anticyclonic system density (left) and depth (right).

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

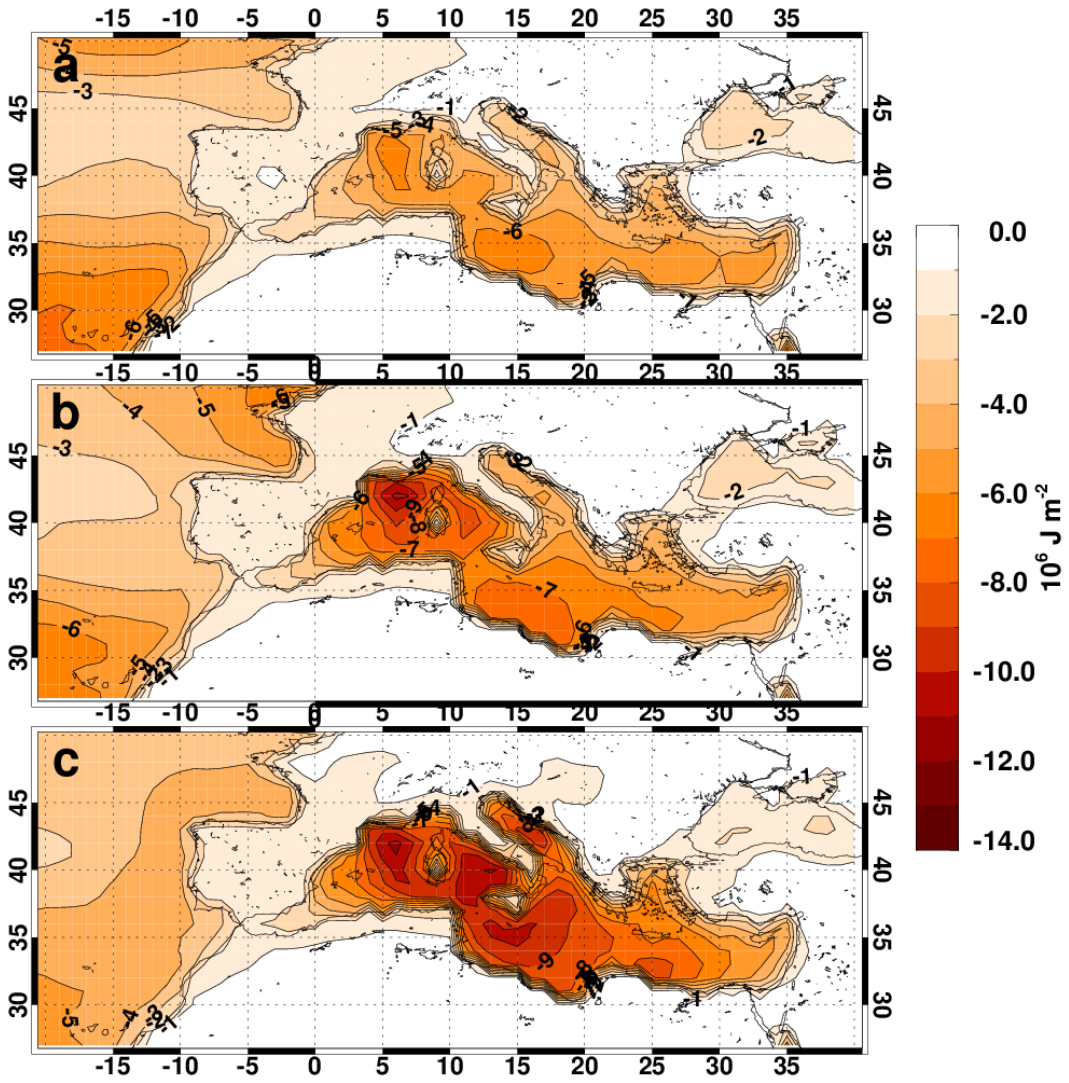


Anomalies of streamfunction at level σ=0.2101 during the positive and negative phase of EMP



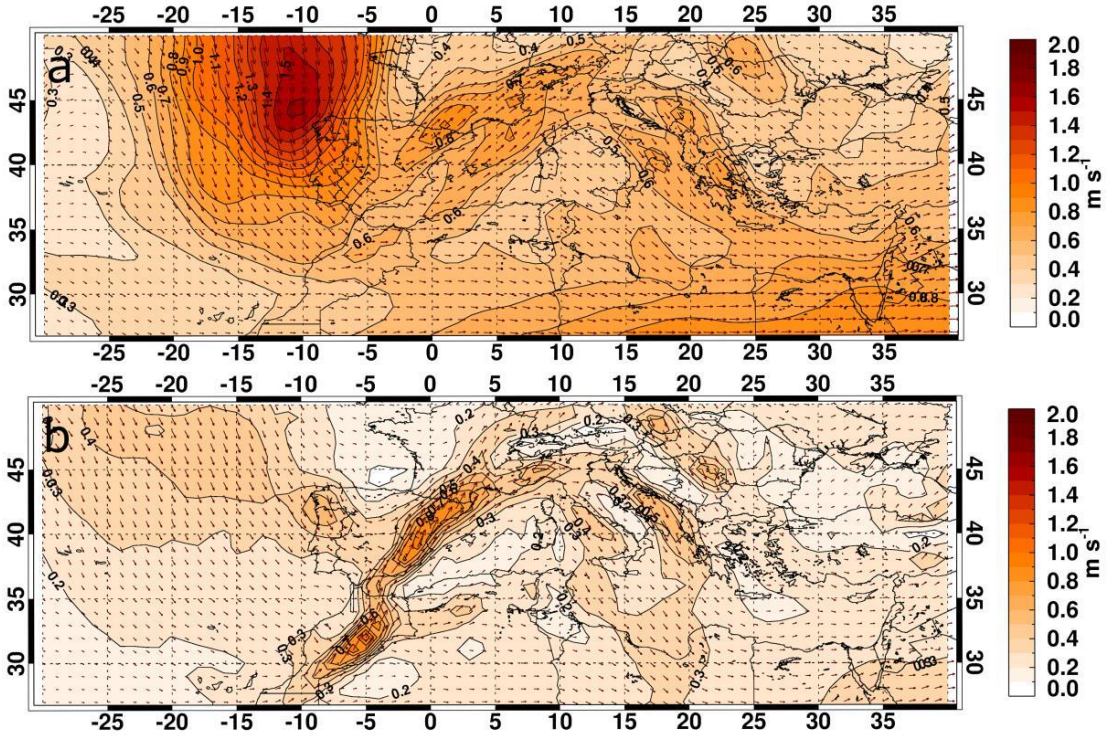
Anomalies of E-vectors during the positive and negative phase of EMP

The development of explosive cyclones in the Mediterranean



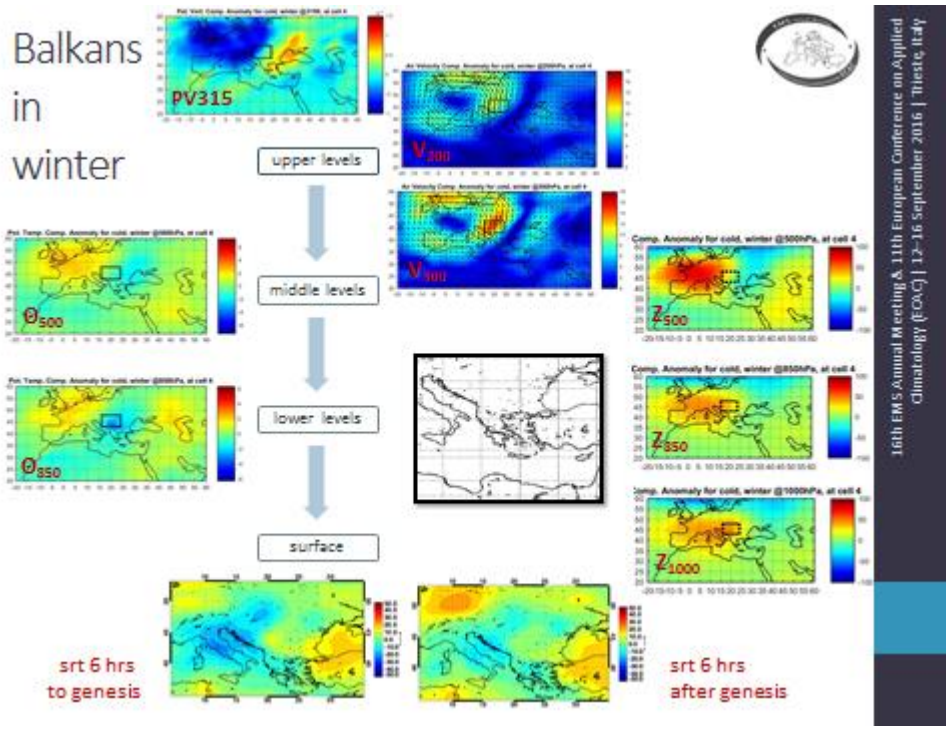
Composite latent heat fluxes a) 24hr before the explosive cyclogenesis (D-1), b)

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.



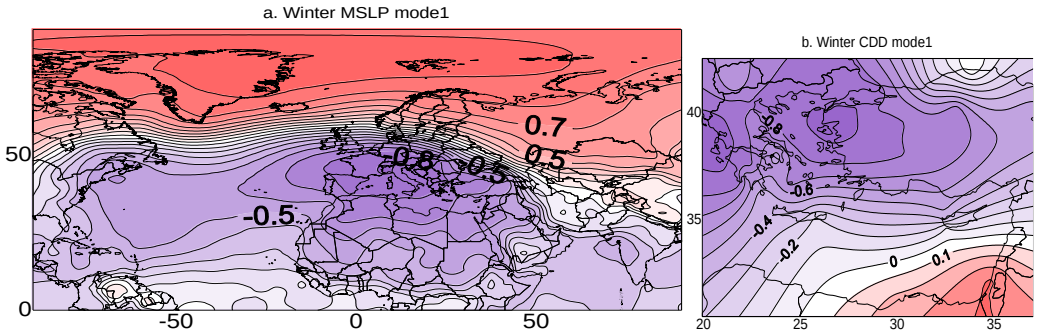
a) Composite 500-300 hPa thermal wind and b) Composite 850-700 hPa thermal wind for the WM explosive cyclones at the time of explosive cyclogenesis.

The development of migratory anticyclones in the Mediterranean

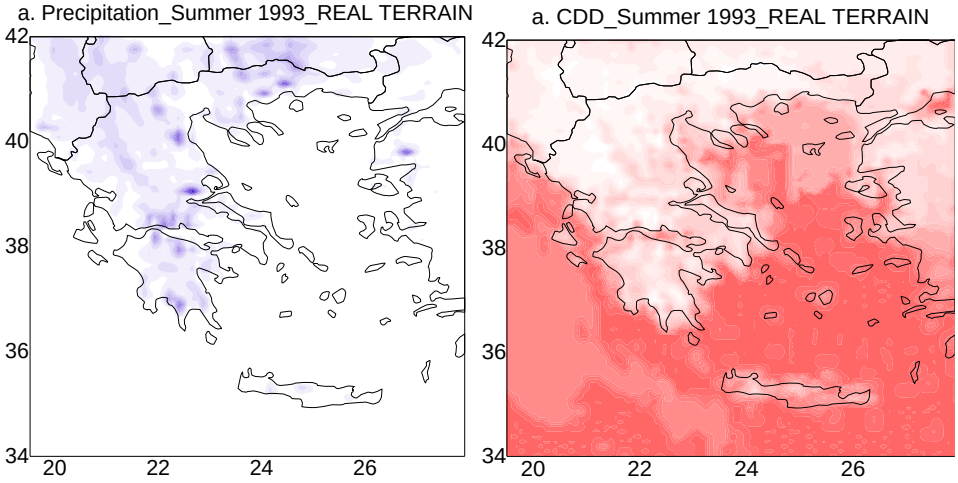


Dynamics of cold anticyclones generating over Balkans

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

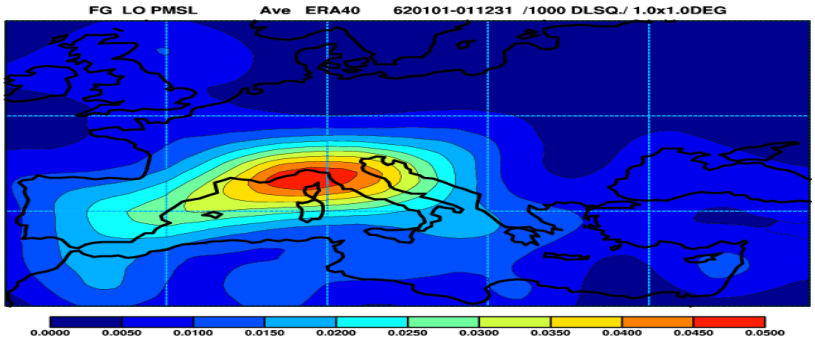


An atmospheric circulation pattern responsible for the occurrence of prolonged dry spells in Eastern Mediterranean during winter with the aid of Singular Value Decomposition Analysis (SVDA)

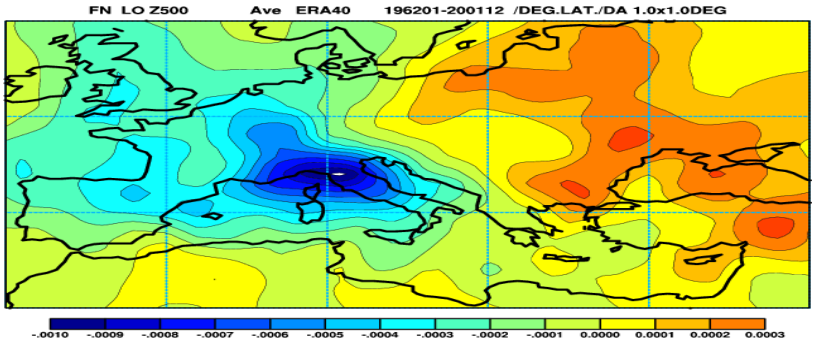


Distribution of precipitation and prolonged dry spells in Greece during an extreme summer, as derived from the simulation of regional climatic model ReGCM3

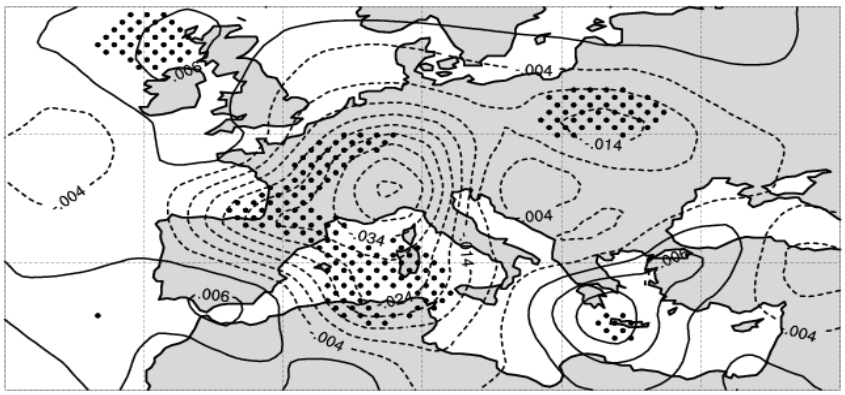
- **Mediterranean cyclones and cyclonic tracks: identification with the aid of MS algorithm and analysis of dynamic/kinematic characteristics, at the surface and in the vertical at various isobaric surfaces. Special emphasis on explosive cyclones**



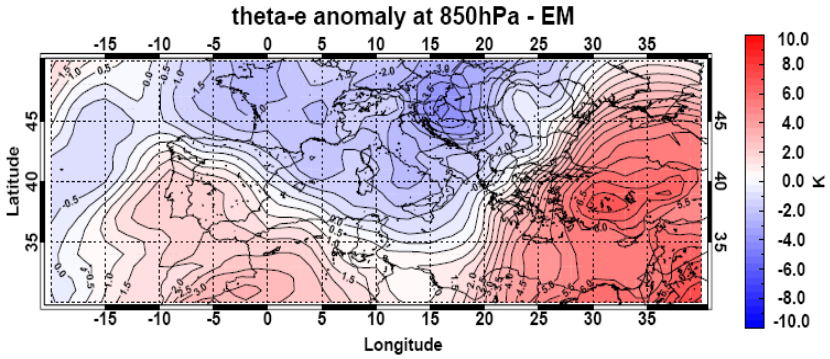
Spatial distribution of average explosive cyclogenesis



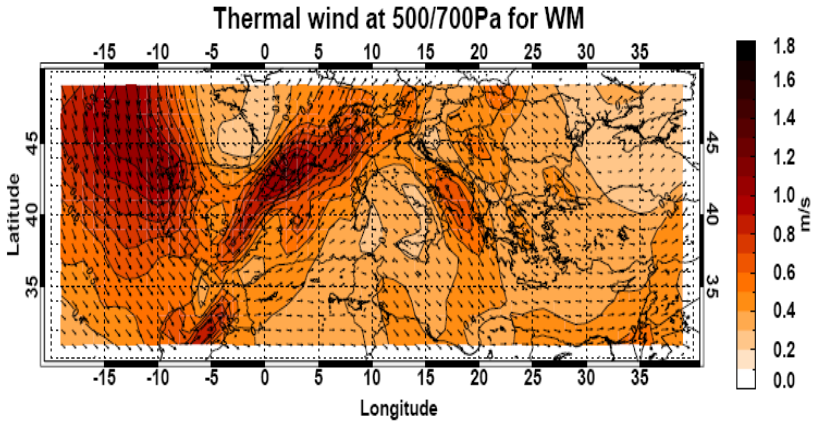
Spatial distribution of meridional fluxes at 500 hPa (e.g average number of of explosive cyclones crossing northwards across a west-east area unit normal to the motion per unit time.



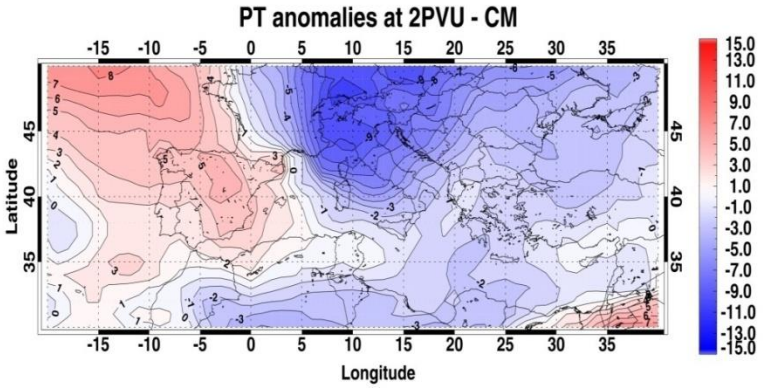
Spatial distribution of the decadal trend of the average 500hPa cyclone intensity. The dots indicate areas with statistical significant trends at 95%.



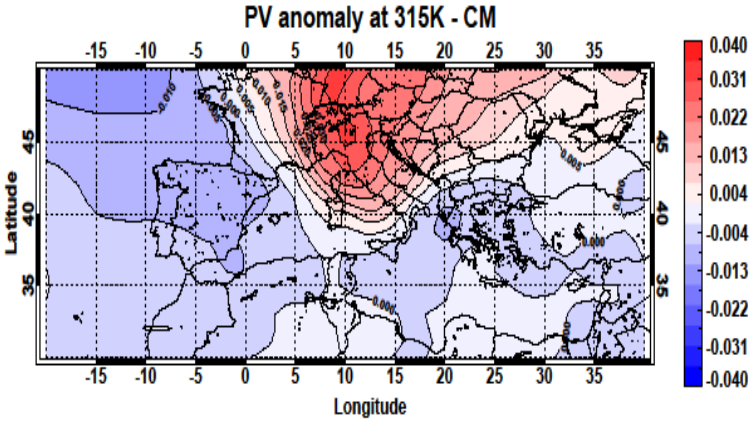
Composite anomaly of equivalent potential temperature at 850hPa for the cases of explosive cyclones in Eastern Mediterranean



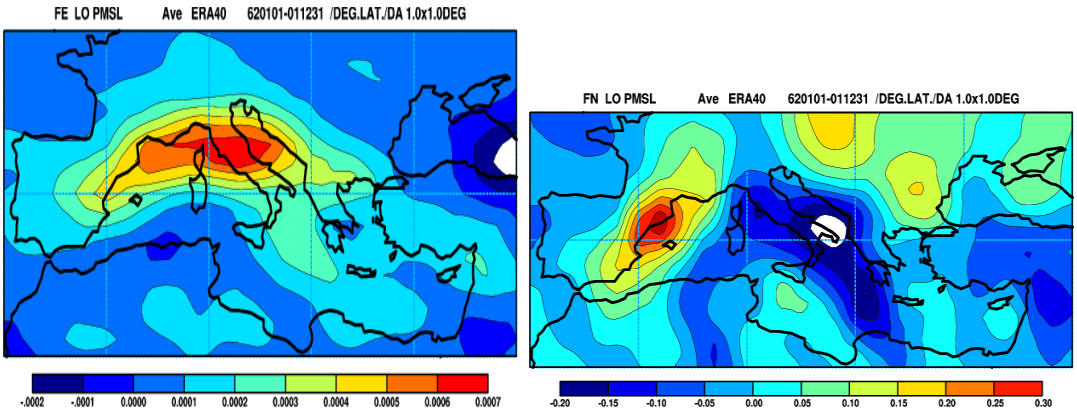
Composite of Thermal wind for the layer 500-700 hPa as derived from the explosive cyclones in Western Mediterranean



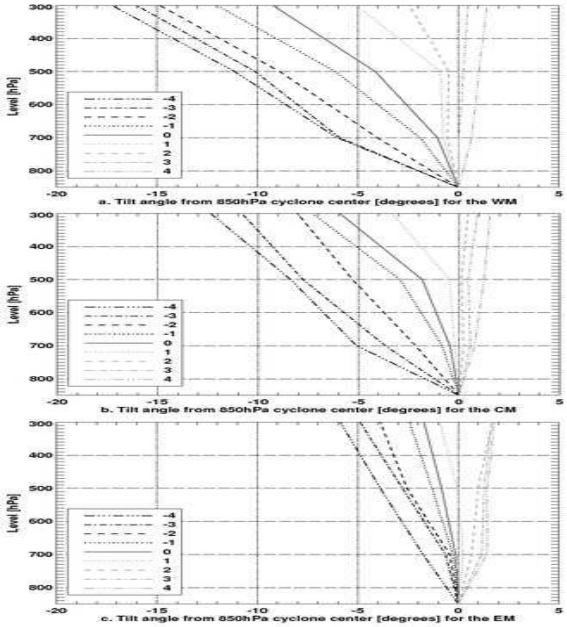
Composite anomaly of potential temperature at the iso-PV level 2 PVU for the cases of explosive cyclones in Central Mediterranean



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

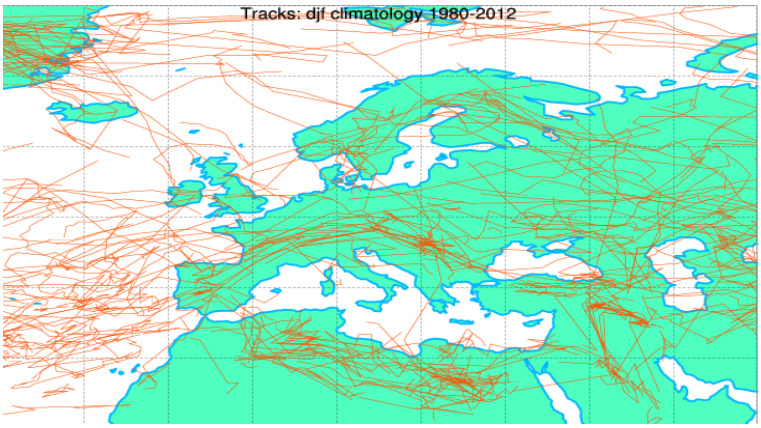


Spatial distribution of the average zonal (left) and meridional (right) component of motion of Mediterranean explosive cyclones

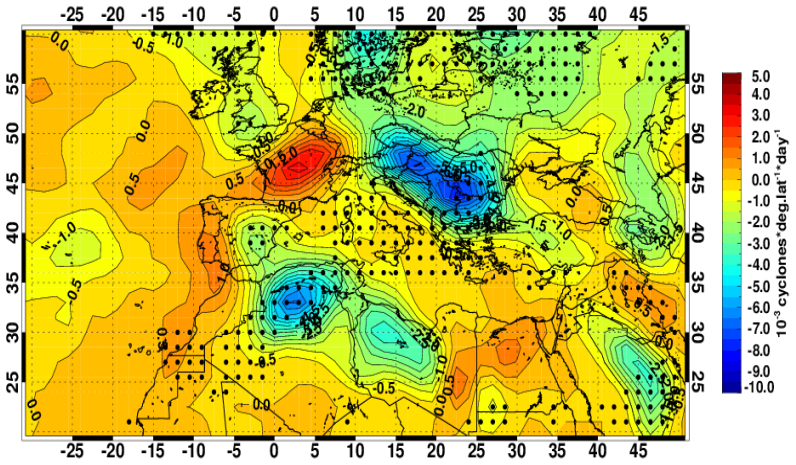


Results of the vertical tracking algorithm for explosive cyclones in the Mediterranean

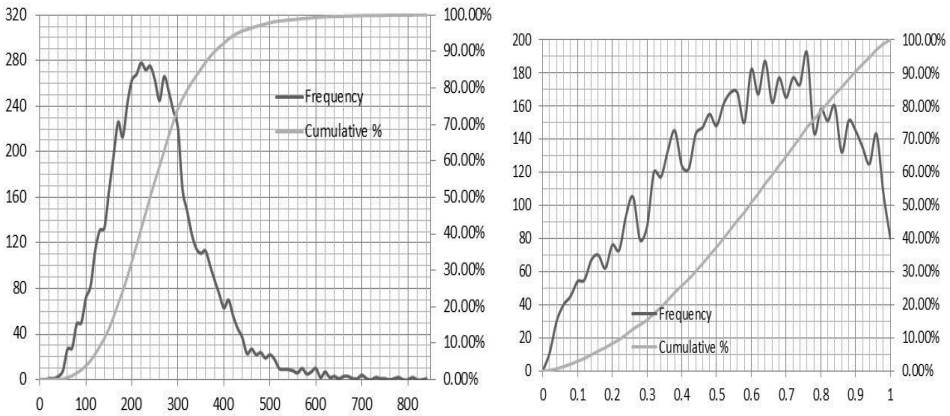
- **Mediterranean migratory anticyclones and tracks: identification with the aid of MS algorithm and analysis of dynamic/kinematic characteristics at the surface. Trend analysis.**



Anticyclonic tracks

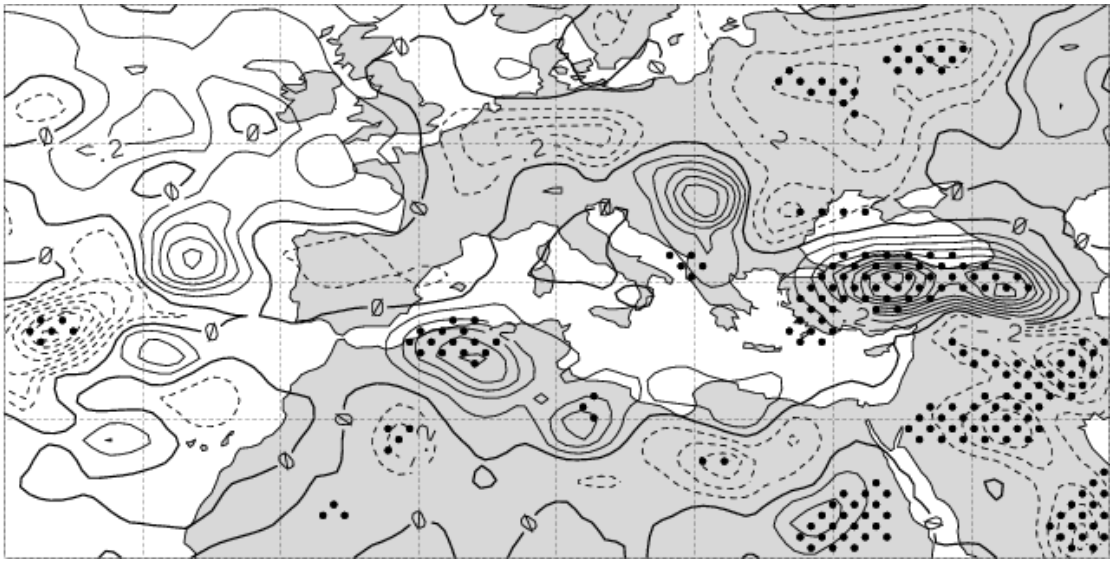


Meridional component of anticyclone propagation



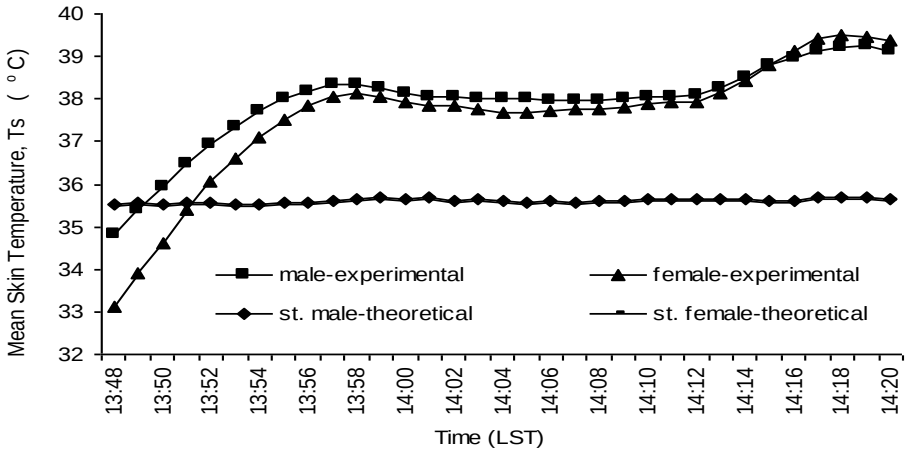
(a) (b)

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

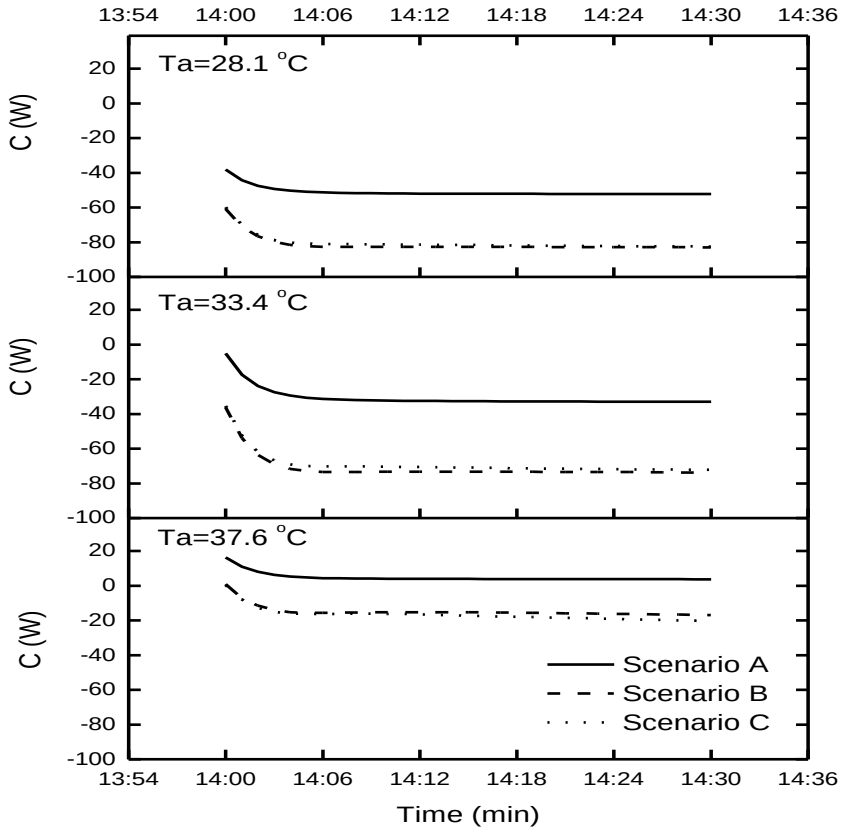


Trends of anticyclonic system density during December-October-November

- **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**

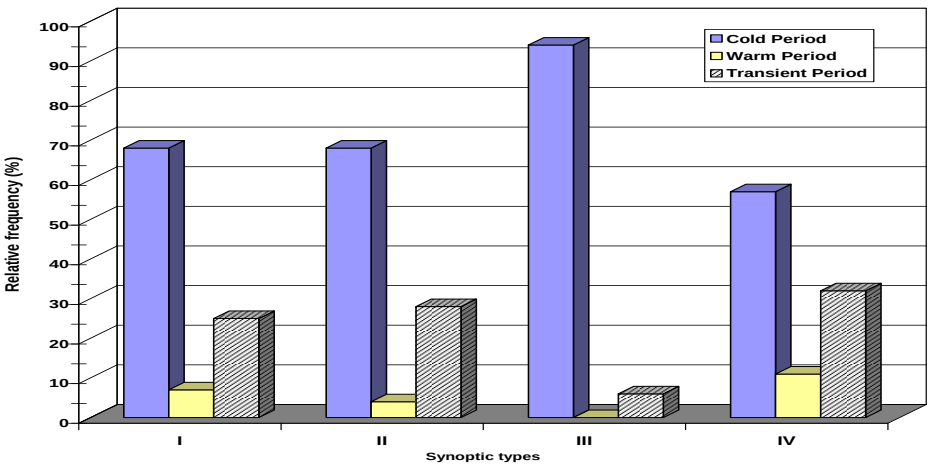


Average mean skin temperature (Ts) for two individual subjects during the 33 minute long track (2.5 km) in the Campus of the University of Athens for three extremely hot summer days. The average theoretical mean skin temperature for two standard persons under the same conditions is also drawn.

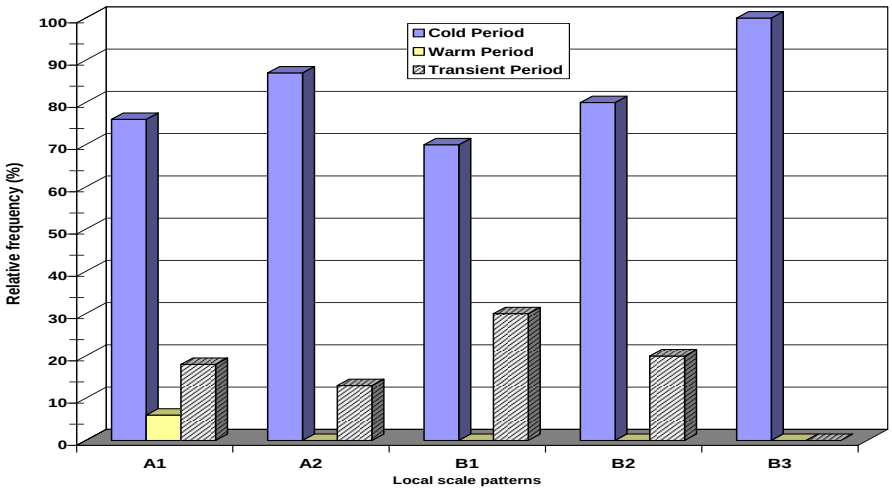


Simulation of convective heat fluxes of human body for three different scenarios of environmental conditions with the aid of the model IMEM

- **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**

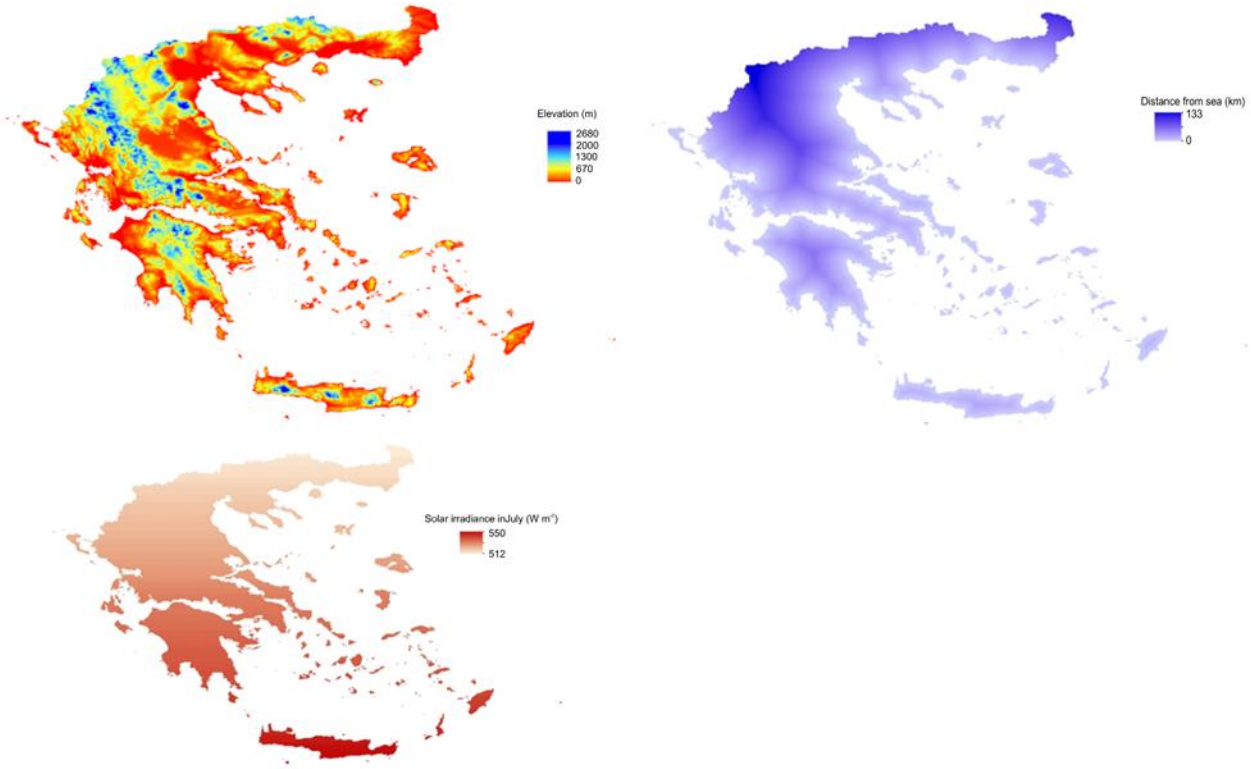


Relative frequency (%) of the synoptic types prevailing during air pollution episodes in Thessaloniki for the cold, warm and transient period.

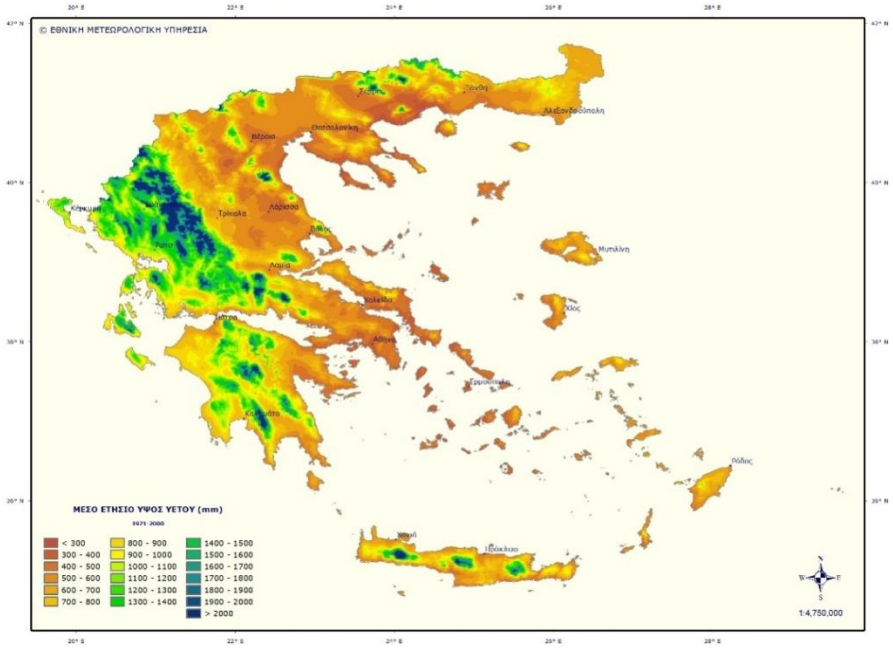


Relative frequency (%) of the local scale patterns responsible for air pollution episodes in Thessaloniki for the cold, warm and transient period.

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

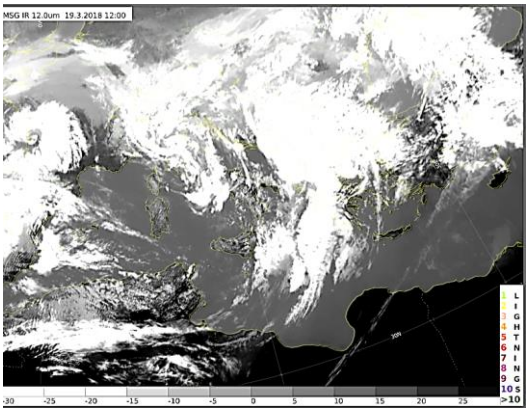


Main geophysical parameters used in MISH as predictors: Elevation (m), Euclidean distance from coastline (Km) and solar irradiance (w/m2).

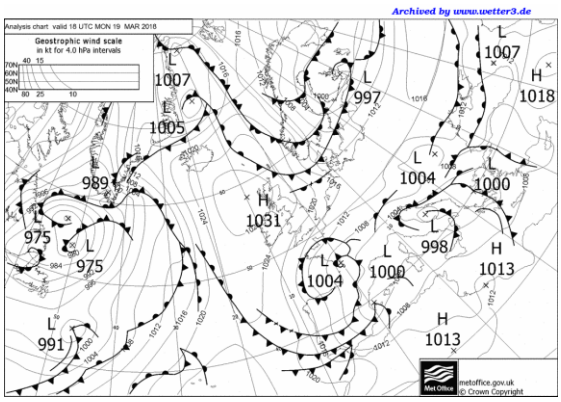


Annual precipitation map

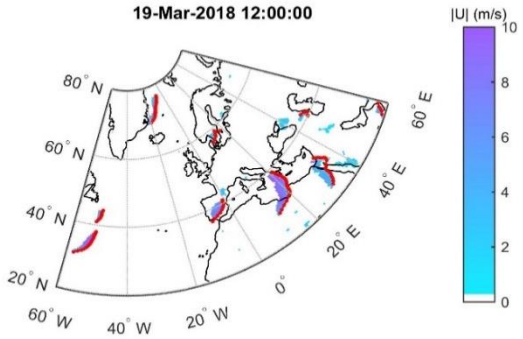
- **Development of an algorithm to identify cold fronts in the Mediterranean on a climatological basis (MedFTS)**



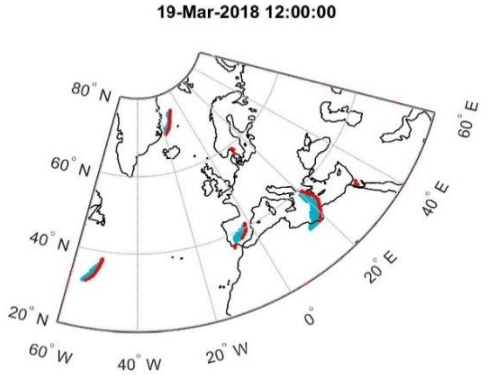
(a)



(b)



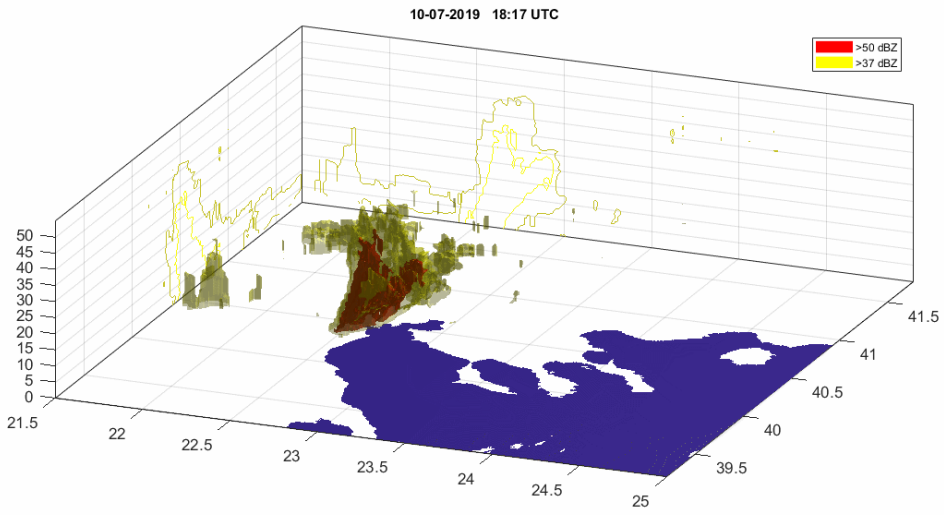
(c)



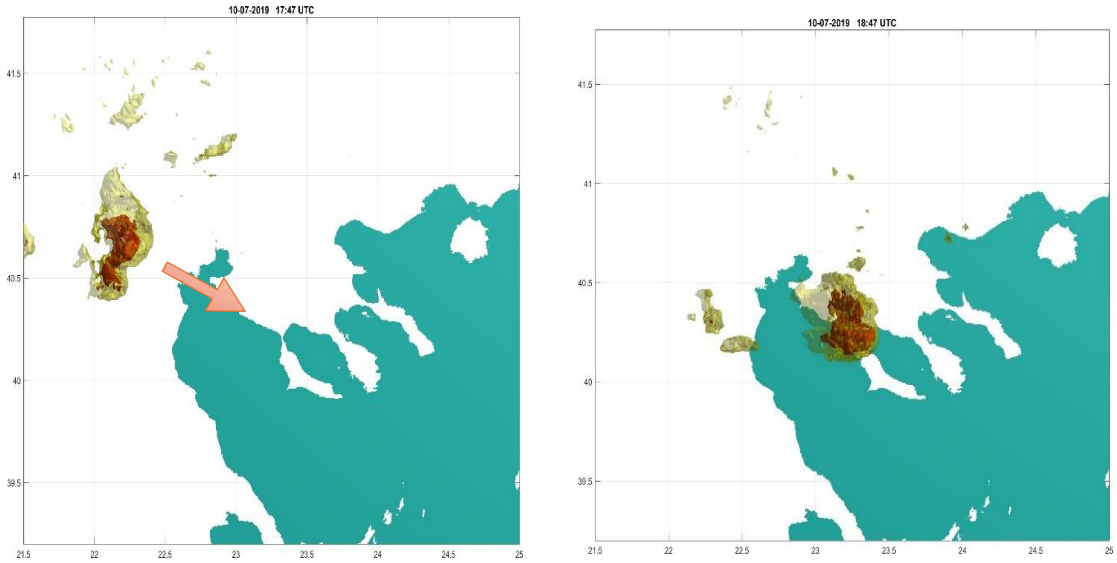
(d)

Satellite image (IR 12μm) 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° and $|U|_{crit}$ = 5 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 m s^{-1}.

- Development of algorithms to estimate the movement of convective systems based on radar data for further helping the nowcasting of these systems



Three- dimension representation of the super cell case that affected Halkidiki Greece in July 2019 on the basis of radar data.



Estimation of the propagation velocity of the super cell which it represents accurately its actual track

The research activities in weather forecasting are related to atmospheric dynamics, physics and chemistry, soil dust cycle, climatic variability and wave modelling. Of particular interest are applications related to model development and integrated applications,data assimilation,weather,wave and air quality forecasting, agricultural applications and wind energy.

During a period of 40 years' research of Prof. Kallos, modeling tools and integrated systems have been developed. These modeling systems have been implemented and run operationally in authorities and institutes worldwide. The main models that have been

developed in the context of EU projects and funded work of PhD students of the group are:

1. The SKIRON/Dust modeling system is the first integrated limited area modeling system for regular weather prediction and dust cycle in the atmosphere funded by EU projects. SKIRON is a unique modeling system that provides dust load concentration and deposition forecasts worldwide. It is in operational use by the (http://forecast.uoa.gr) with more than 15.000 visitors per day. It is installed and used operationally in many places and countries.
2. The RAMS/ICLAMS system (The Integrated Community Limited Area Modeling System based on RAMS): This system has been developed initially at the framework of CIRCE project and continued afterwards in the frame of PhD work of the members of the group. It is based on the RAMS modeling system and includes several other capabilities. The most important of them are: a) Direct coupling of the dust cycle with 8-size bins b) Direct coupling of the sea salt cycle with 2-size bins c) Direct coupling of the gas, aqueous chemistry, gas to particle conversion and heterogeneous chemistry c) Detailed cloud microphysical scheme with 7 categories of hydrometeors d) Treatment of CCN, GCCN, IN as predictive quantities e) State of the art radiation scheme (RRTM) f) Aerosol Radiation-Cloud-Precipitation interactions. The system is appropriate for cloud microphysical, regional and microclimatic simulations.

Other modelling systems include:

1. The Mercury Modeling System : Both modeling systems SKIRON and RAMS have been used in order to develop two modeling systems appropriate for simulations of the mercury cycle in the atmosphere. This development was performed at the framework of MAMCS , MERCYMS and NYSERDA projects .
2. POSEIDON system: This is an integrated marine weather and sea state forecasting system that is in operational use at the Hellenic Centre for Marine Research (HCMR). It is based on SKIRON/DUST modeling system.
3. NHREAS forecasting system: This is an integrated high-resolution weather and sea state forecasting system that was developed initially for the Hellenic National Meteorological Service for optimal routing and ship safety operations (integration of LAPS, RAMS and WAM models). The system is used also from the DANAOS SHIPPING&SOFTWARE for optimal routing on worldwide basis.
4. WAM system: It is a state of the art wave analysis and prediction model with some unique capabilities. It is fully parallelized, running on nesting form and has an advanced data assimilation system. It is fully coupled with RAMS/ICLAMS model for air-sea interaction research.
5. Mediterranean Air Quality Forecasting System: The AM&WFG has developed an air quality forecasting system for the Mediterranean Region. This system is based on the CAMx, SKIRON/Dust and RAMS/ICLAMS models. A similar system has been developed for the Arabian Peninsula and State of Texas.
6. Weather Forecasting Activities for Athens Olympics 2004: The AM&WFG had developed and operated the weather, wave and air quality forecasts for Athens Olympics 2004. The contract was with the Ministry of Culture/General Secretariat for Athens Olympics, the Organization ATHENS2004 and the Hellenic National Meteorological Service (HNMS). This forecasting system is based on the SKIRON/Dust, NHREAS and WAM models. Elements of this system are set up in operation for various olympic organizations to support specific athletic teams .

7. WASSF I & II system: This is an integrated system developed for the oil industry of Saudi Arabia. It includes weather, dust, floods, wave, sea currents and tides forecasts that are based on SKIRON/Dust, RAMS/ICLAMS, LAPS, WAM, MICOM and CREST models.
8. Qatar Regional Modeling System (QRM): It is an integrated forecasting system developed for Qatar Civil Aviation Authority/Meteorology Department. The system includes weather, dust, floods, wave, sea currents and tides forecasts that are based on SKIRON/Dust, RAMS/ICLAMS, LAPS, WAM and MICOM models.
9. MARINA PLATFORM: Marine Renewable Integrated Application Platform (MARINA Platform). Development of a large online database(20 years) for high resolution wind, wave, currents and tidal data for North Atlantic, Mediterranean and Black Sea. FP7 FP7-ENERGY - Project 241402.
10. SAUDI ARABIA CLIMATIC DATABASE: The AM&WFG developed a 30-year meteorological and dust climatological database of high spatial and temporal resolution. It includes several meteorological and dust parameters. Timeseries and summary reports are easily prepared. It is used for several engineering applications in Saudi Arabia and nearby countries.
11. ENI marine forecasts: Weather forecasting for 18 locations around the earth.This forecasting system is set up and runs operationally for the ENI oil Company of Italy .

Infrastructure

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) 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 b) The front identification algorithm MedFTS that was developed by our group in collaboration with the University of Melbourne that is under further development

The modelling infrastructure of the modelling group includes a high speed network connection to support services worldwide. More specifically it has the necessary hardware and software for both research and operations. The infrastructure includes a cluster with 2048 intel cores in 48 nodes, highspeed internal network and 380 TB online storage and a number of dedicated servers and workstations. The entire system is supported with UPS systems and backup generator that guarantees a full day and week availability. It has also a number of workstations with different configurations. The computer cluster is supported with the necessary cooling systems.

Publications

http://scholar.uoa.gr/efloca

https://forecast.uoa.gr/en/publications