The Peculiarities of Ianos among Mediterranean Tropical-Like Cyclones

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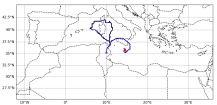
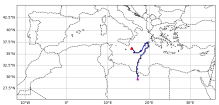
18$^{\text{th}}$ Plinius Conference on Mediterranean Risks

Chania, 2 October 2024

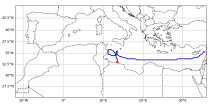
Case Studies


Leucosia, Jan 1982

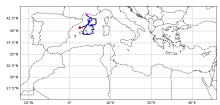

Callisto, Sep 1983

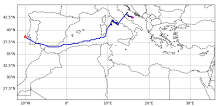

Celeno, Jan 1995

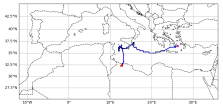

Cornelia, Oct 1996

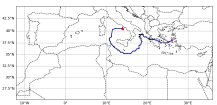

Zeo, Dec 2005

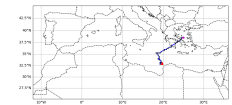

Maria, Sep 2006


Rolf, Nov 2007

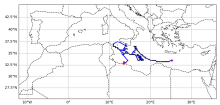

Ilona, Jan 2014

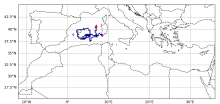

Qendresa, Nov 2014

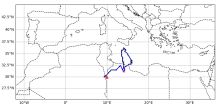

Numa, Nov 2017

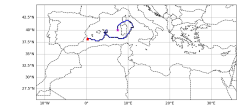

Zorbas, Sep 2018

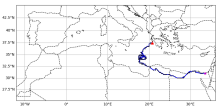

Ianos, Sep 2020


Apollo, Oct 2021


Blas, Nov 2021


Helios, Feb 2023


Juliette, Feb 2023


Daniel, Sep 2023

17 cyclones studied using ERA5 reanalysis

Hart Parameters

The presence of a **warm core** can be evaluated from the **cyclone thermal wind** (Hart 2003):

$$-V_T^L = \left(\frac{\partial \Delta z}{\partial \ln p}\right)_{900\text{hPa}}^{600\text{hPa}} \qquad -V_T^U = \left(\frac{\partial \Delta z}{\partial \ln p}\right)_{600\text{hPa}}^{300\text{hPa}}$$

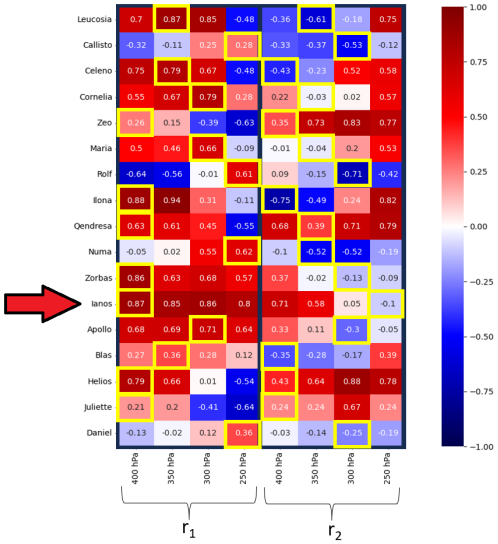
- **Deep warm core** cyclones: $-V_T^L, -V_T^U > 0$
- **Deep cold core** cyclones: $-V_T^L, -V_T^U < 0$
- **Hybrid** cyclones (warm seclusions) $-V_T^L > 0, -V_T^U < 0$

Here, a **radius of 2°** and the **layers 925-700 hPa** and **700-400 hPa** are used.

Peculiarities of Ianos

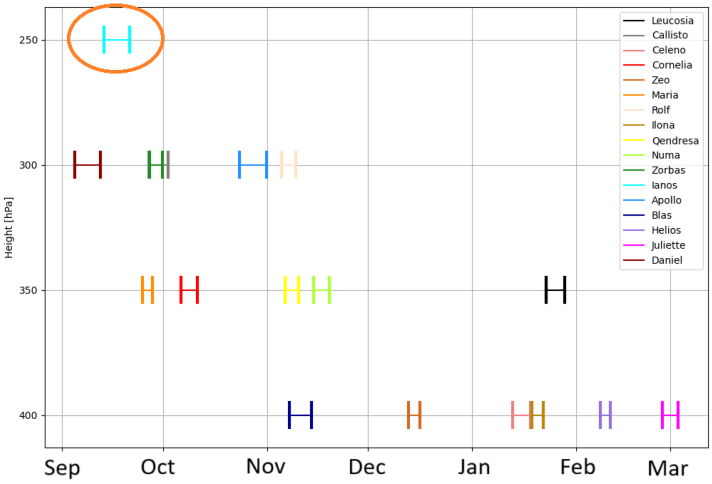
Pearson correlation coefficients at 250, 300, 350 and 400 hPa along the trajectories of the cyclones:

- r_1: correlation between $-V_T^U$ and RH
- r_2: correlation between $-V_T^U$ and PV



Peculiaities of Ianos

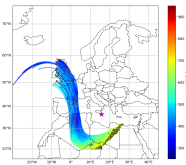
Height of the lowest Pearson correlation coefficient between $-V_T^U$ and PV

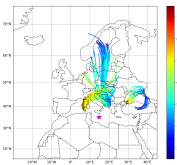


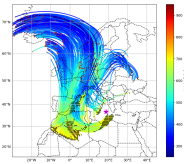
Dry Intrusions

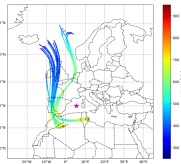
- An upper-troposphere/low stratosphere **dry intrusion** is usually identified when a descent of at least **400 hPa/48 h** occurs (Raveh-Rubin 2017)
- However, in the Mediterranean, a less steep descent is possible, so a **threshold of 300 hPa/48 h** has been used
- **Back-trajectories** computed with **Hysplit** and **LAGRANTO** starting from 1500, 3000, 5000 m a.s.l.

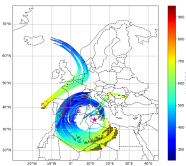
Dry Intrusions


Leucosia


Callisto


Celeno


Cornelia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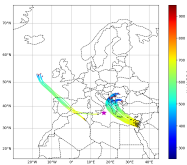
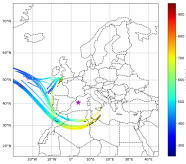
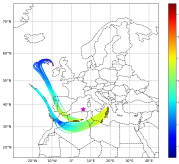
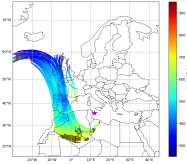
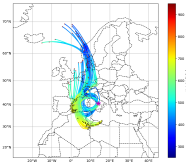

Maria


Rolf


Ilona


Qendresa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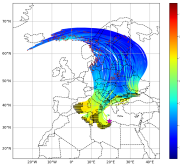
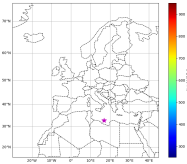
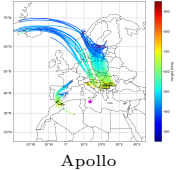
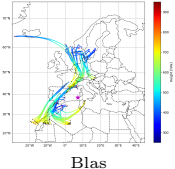
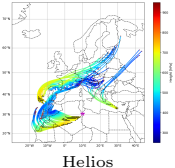
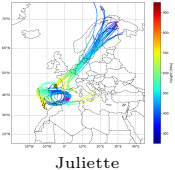

Zorbas

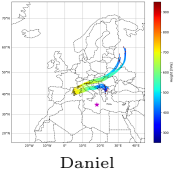

Ianos


Apollo


Blas

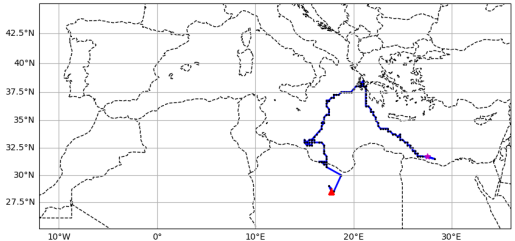

Helios


Juliette


Daniel

Ianos

- **Start**: 13 September 2020 13 UTC
- **End**: 21 September 2020 04 UTC
- **Maximum intensity** while Ianos was approaching Greece.



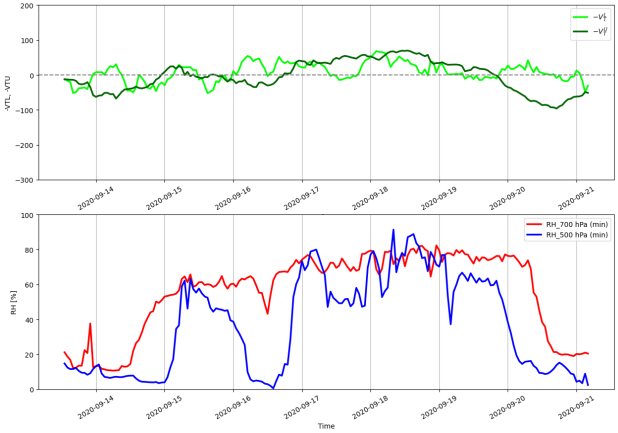
Trajectory of Ianos obtained from ERA5 reanalysis. The red triangle represents the beginning of the tracking time, the magenta star represents the ending of the tracking time.

Tropical-Like Phases

Two tropical-like phases:

- first short tropical-like phase on 15 September
- main tropical-like phase from 16 September evening

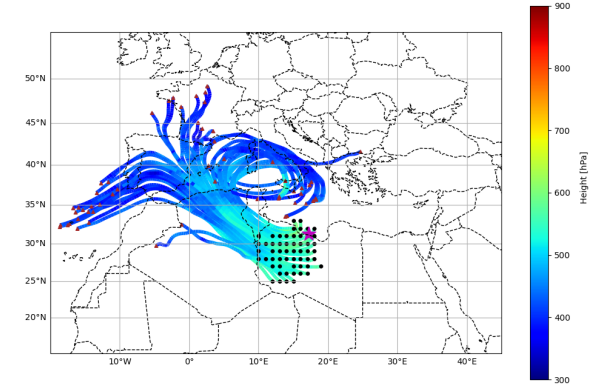
Both tropical-like phases are preceded by **dry intrusions in the upper troposphere**



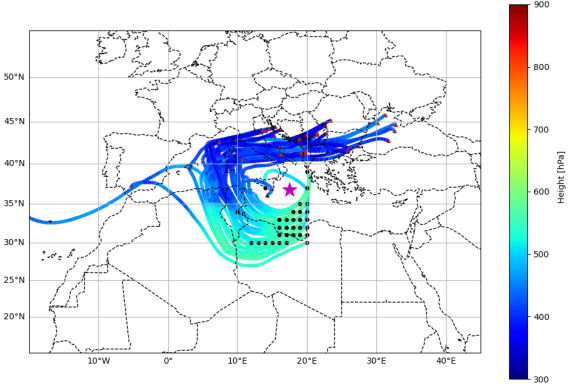
Dry Phases

Presence of **weak descents** during both the dry phases (descent of **250 hPa/60 h**)

Starting time: 14 September 12 UTC



Starting time: 17 September 00 UTC

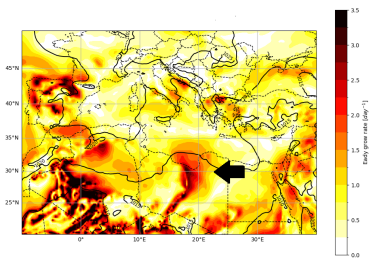


Baroclinicity

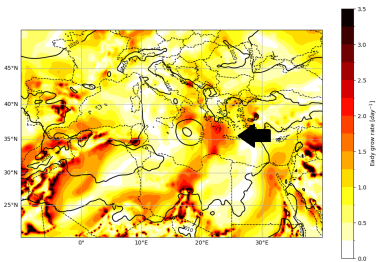
Analysis of the maximum **Eady growth rate** σ_{BI} highlights that the environment around Ianos was **baroclinic** during most of its life, including the two phases where the weak PV streamers were present.

$$\sigma_{BI} = 0.31 \cdot f \cdot \left|\frac{\partial \mathbf{v}}{\partial z}\right| \cdot N^{-1}$$

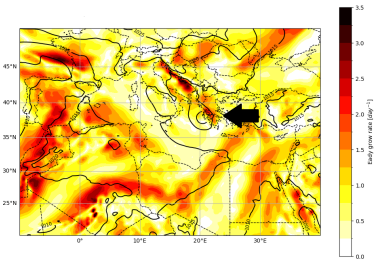
13 Sep 18 UTC



16 Sep 15 UTC

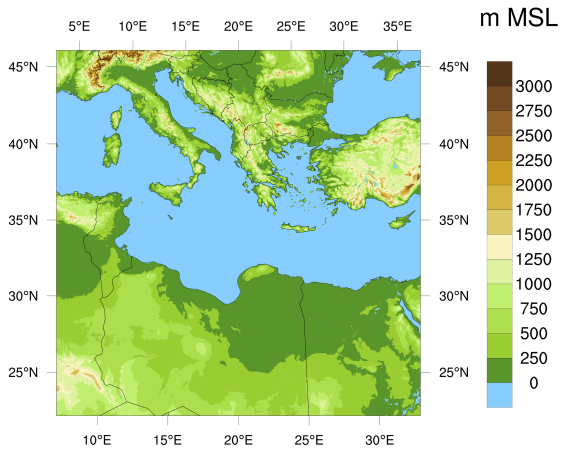


18 Sep 00 UTC



Simulation with the WRF Model

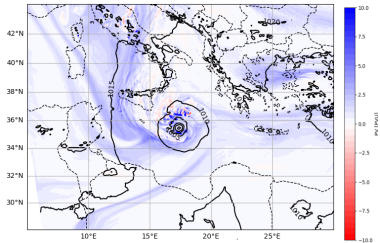
- 3 km grid spacing
- ECMWF-IFS forecasts as initial and boundary conditions
- Asymmetric Convective Model 2 (ACM2) PBL scheme
- Noah land surface model
- WRF single-moment 7-class microphysics
- SST updated every 24 hours (data from the NASA Jet Propulsion Laboratory)



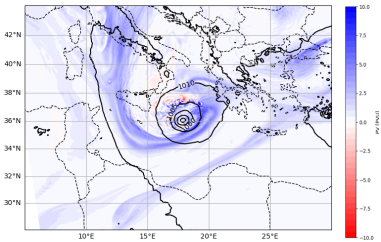
Simulation with the WRF Model

PV @ 300 hPa and mean sea level pressure

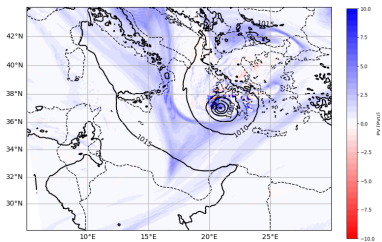
16/09 15 UTC



17/09 01 UTC



17/09 17 UTC



Surface Pressure Tendency Equation (Fink 2012)

$$\underbrace{\frac{\partial p_{sfc}}{\partial t}}_{DP} = \underbrace{\rho_{sfc}\frac{\partial \phi_{p_2}}{\partial t}}_{D\phi} + \underbrace{\rho_{sfc}R_d\int_{sfc}^{p_2}\frac{\partial T_v}{\partial t}d\ln p}_{ITT} + \underbrace{g(E-P)}_{EP} + \underbrace{RES_{PTE}}_{RES}$$

The ITT term can be further decomposed:

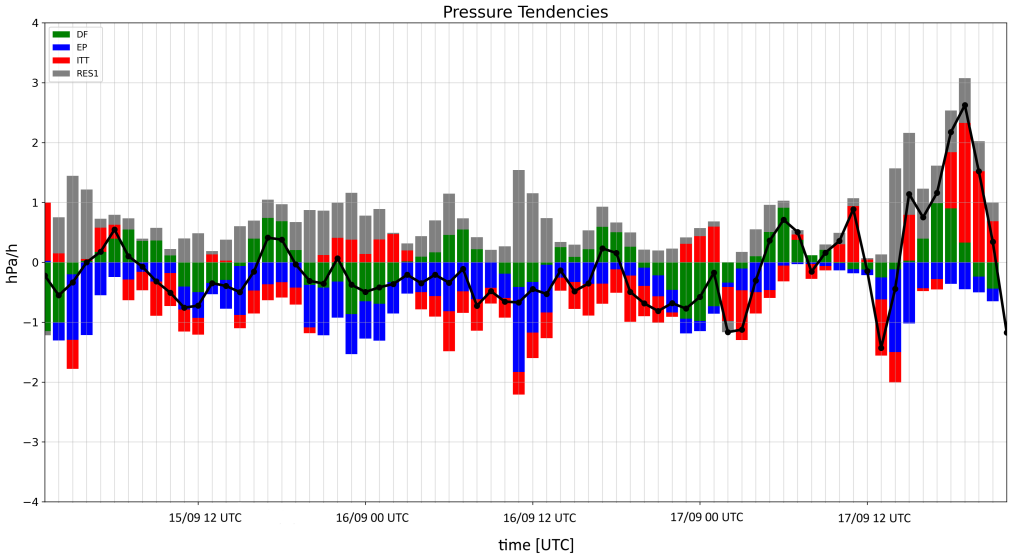
$$ITT = \underbrace{\rho_{sfc}R_d\int_{sfc}^{p_2} -\bar{v}_h\cdot\nabla_p T_v d\ln p}_{TADV} + \underbrace{\rho_{sfc}R_d\int_{sfc}^{p_2}\left(\frac{R_d T_v}{c_p p} - \frac{\partial T_v}{\partial p}\right)\omega d\ln p}_{VMT}$$
$$+ \underbrace{\rho_{sfc}R_d\int_{sfc}^{p_2}\frac{T_v Q}{c_p T}d\ln p}_{DIAB} + \underbrace{RES_{ITT}}_{RES}$$

where:

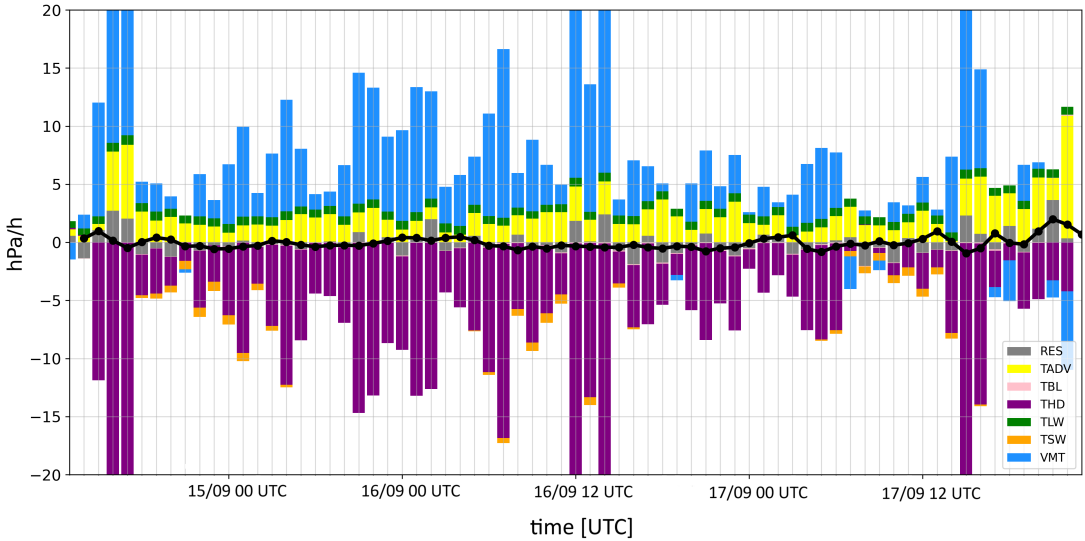
$$DIAB = TBL + THD + TLW + TSW$$

PTE calculation tool kindly provided by Stavros Dafis.

Surface Pressure Tendency



Surface Pressure Tendency



Summary and Conclusions

- Ianos has the highest correlation between V_T^U and RH at 250 hPa
- Ianos is the only cyclone among the 17 case studies with the lowest correlation between V_T^U and PV at 250 hPa
- Ianos is the only cyclone with no signal of dry intrusions with a descending threshold of 300 hPa/48h
- The environment is baroclinic during most of the cyclone life, with the presence of two PV streamers that have a role in the cyclogenesis and intensification of Ianos
- PTE analysis highlights in Ianos a continuous cold advection, the warming of the atmospheric column is mainly caused by latent heat release

THANKS FOR YOUR KIND ATTENTION!