A Model Intercomparison Project (MIP) to improve predictions of Mediterranean cyclones

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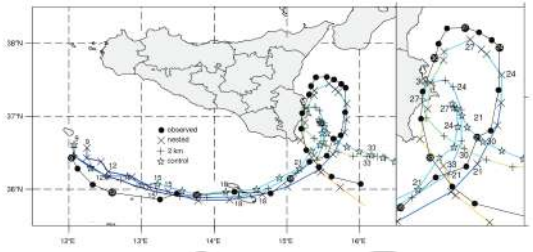
2nd MedCyclones & 9th European Storm Workshop, Toulouse, June 2023

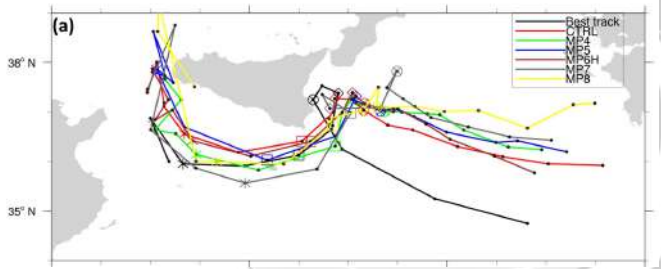
How to best predict Mediterranean cyclones?

*Investigating the predictability of a Mediterranean tropical-like cyclone using a **storm-resolving** model*



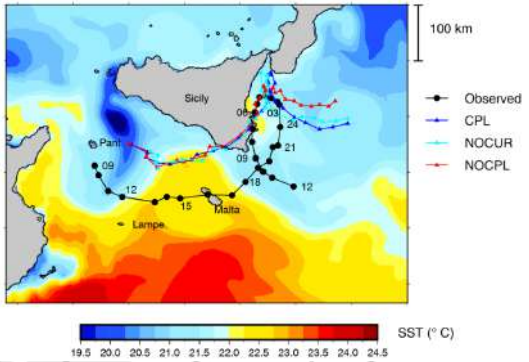
Cioni et al. (2018)

*Sensitivity of a Mediterranean Tropical-Like Cyclone to **Physical Parameterizations***



Pytharoulis et al. (2018)

*Surface processes in the 7 November 2014 medicane from **air–sea coupled** high-resolution numerical modelling*



Bouin & Lebeaupin Brossier (2020)

→ *very different models & configurations…*

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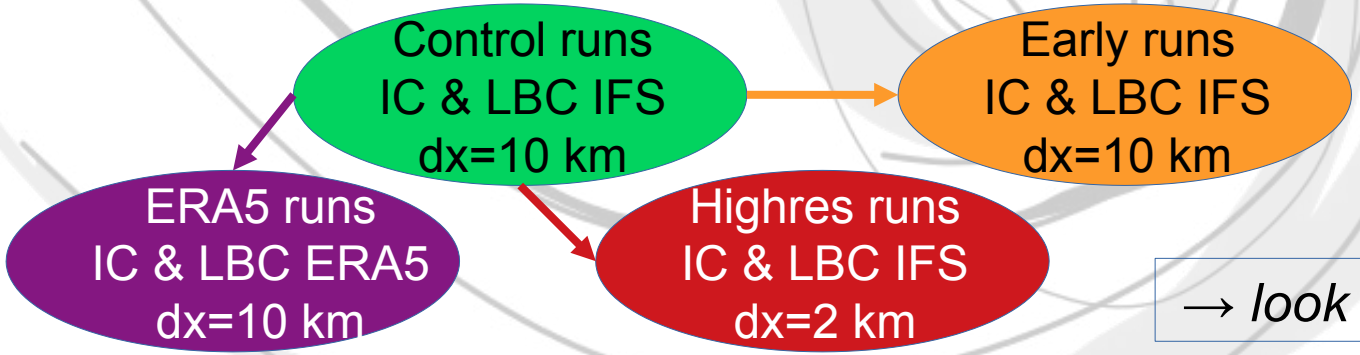
Model intercomparison to better understand dynamics & predictability

Models involved in the intercomparison

- 6 models: BOLAM, HARMONIE-AROME, Méso-NH, MetUM, MOLOCH, WRF
- 5 setups of WRF & 2 setups of Méso-NH

Common modelling framework

- Same domain, horizontal resolution, initial and lateral boundary conditions
- Data interpolated on same levels & grid + centralized on server



→ *look for robust response!*

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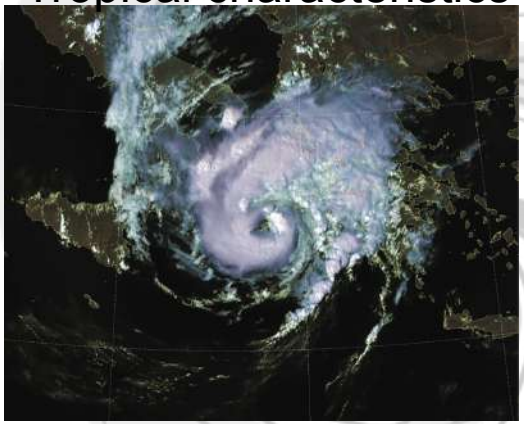
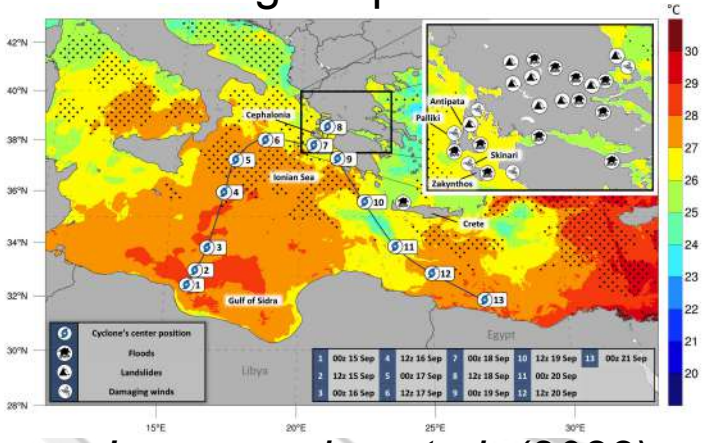
Case study: Medicane Ianos (Sep 2020)

Tropical characteristics



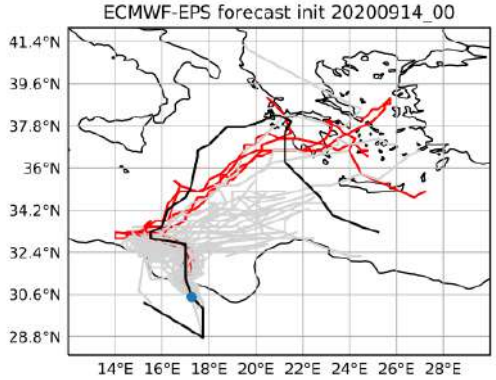
Smart (2020)

High impact



Lagouvardos et al. (2022)

Poor predictability



MSLP < 1000 hPa: **8%**

+ occurred at the starting of COST Action MedCyclones (10/2020-09/2024)

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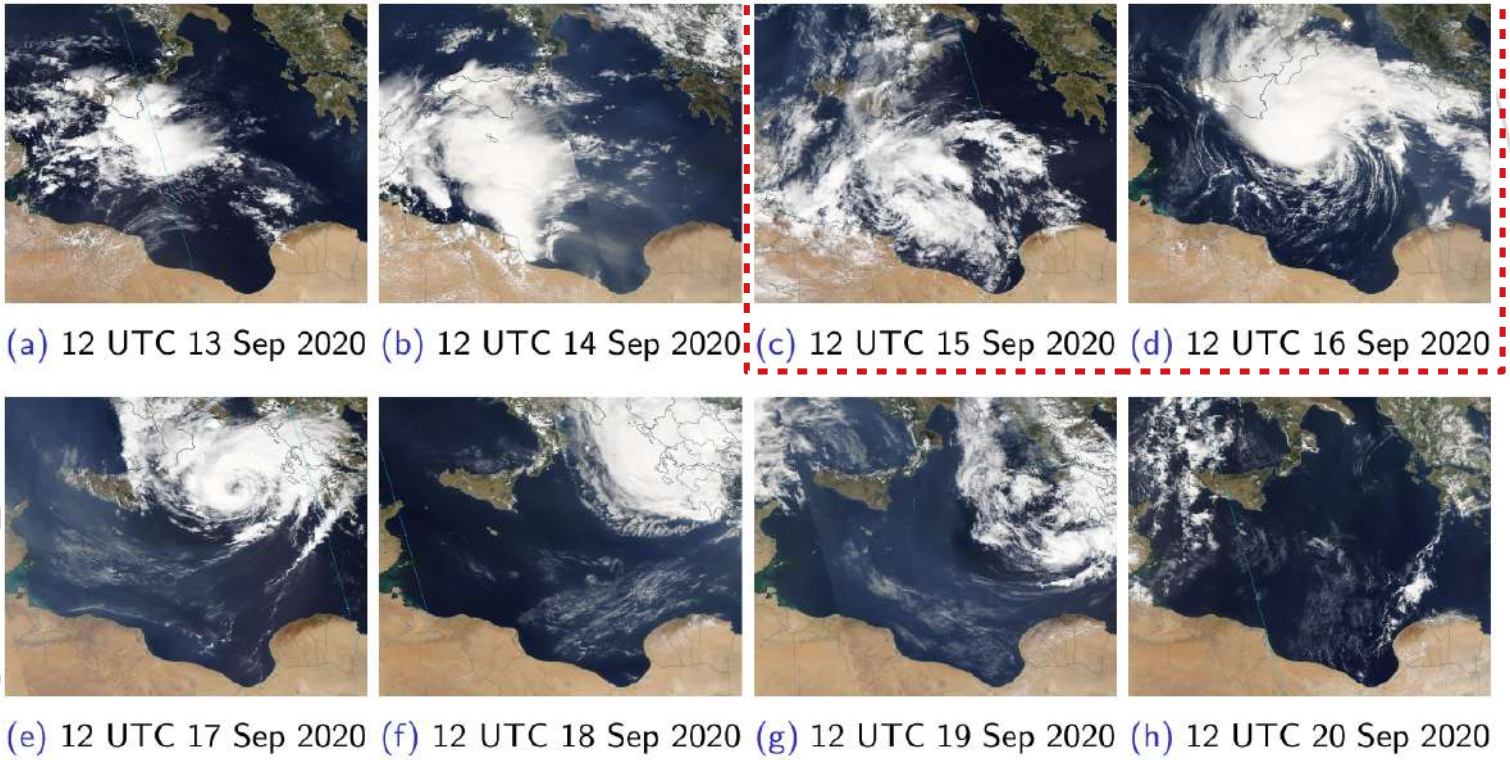
Chronology

1. pre-existing convection

2. cyclogenesis phase



(a) 12 UTC 13 Sep 2020 (b) 12 UTC 14 Sep 2020 (c) 12 UTC 15 Sep 2020 (d) 12 UTC 16 Sep 2020

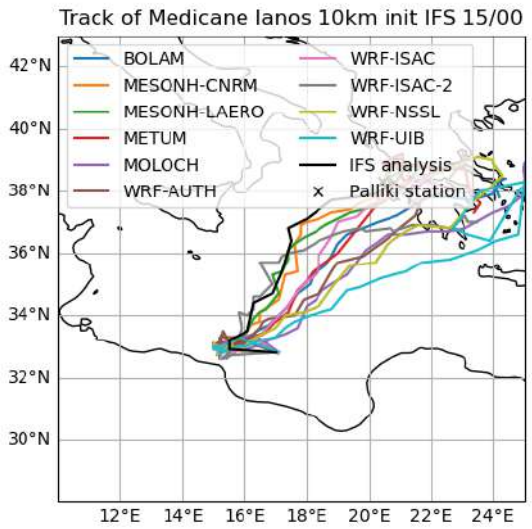
(e) 12 UTC 17 Sep 2020 (f) 12 UTC 18 Sep 2020 (g) 12 UTC 19 Sep 2020 (h) 12 UTC 20 Sep 2020

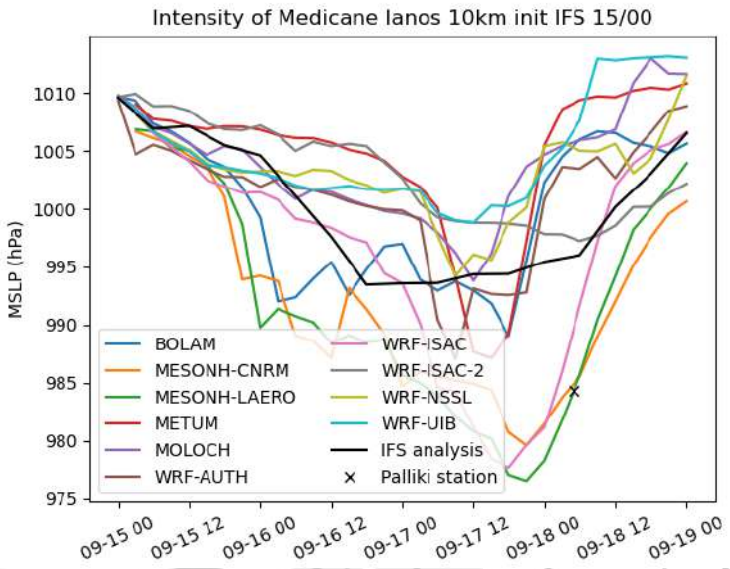
3. mature phase

4. landfall and dissipation

visible imagery from MODIS instrument aboard AQUA satellite; time is approximate. https://worldview.earthdata.nasa.gov/

Control runs: initialization IFS 15 Sep 00 UTC, 10 km resolution





- Track shifted southeastward and cyclone too shallow (though no reference intensity)
- Large spread in track and intensity, both between models and between WRF setups

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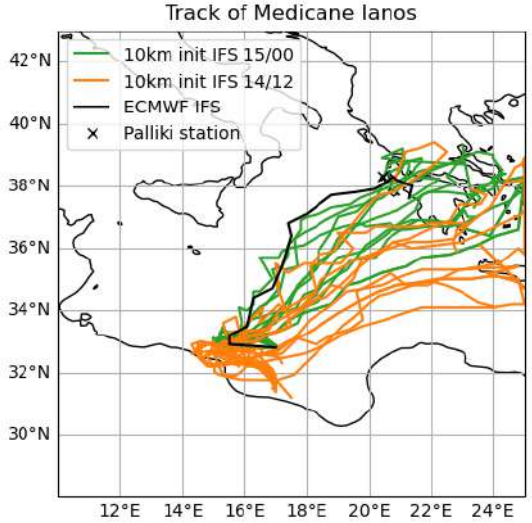
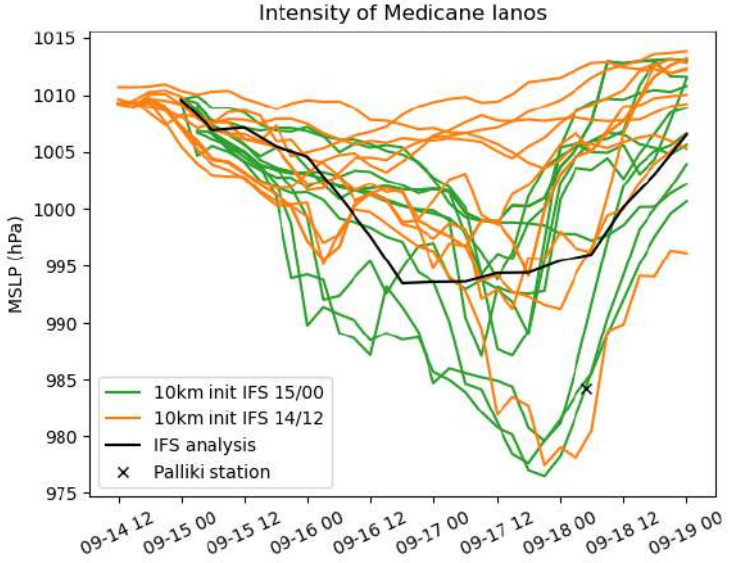
Sensitivity to initialization time: early (14/12) vs control (15/00)





- Poor results with earlier initialization and no cyclone for even earlier initialization
- Link between track and intensity: southeastward shift = weaker cyclone

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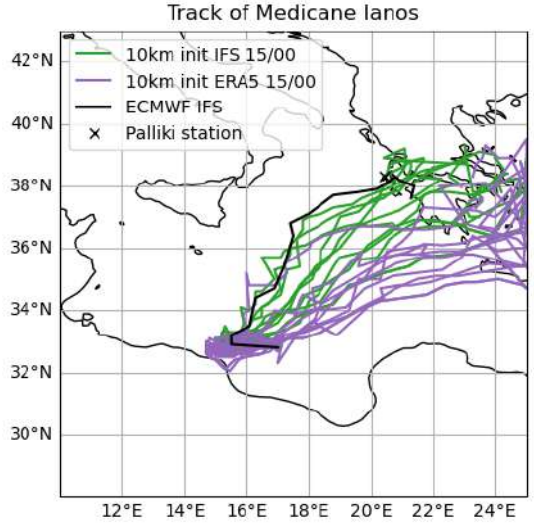
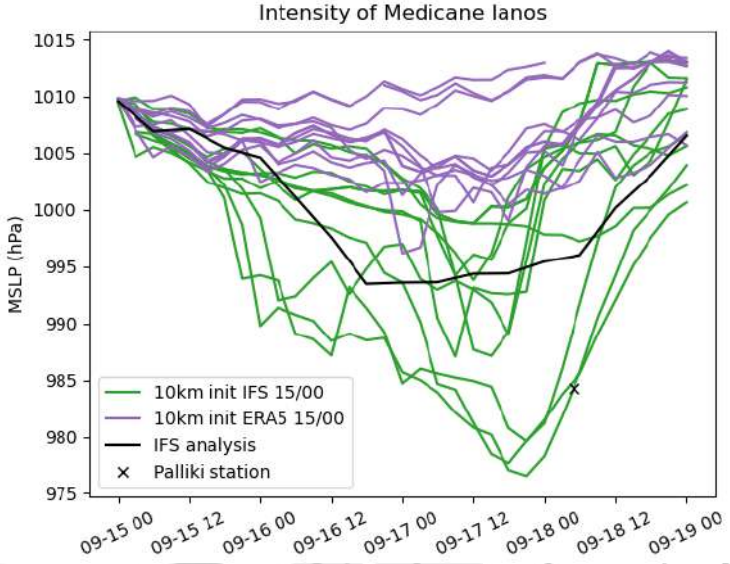
Sensitivity to initial conditions: ERA5 vs control (IFS)





- Poor results with ERA5 initialization
- Confirmed by mixing ERA5 initial & IFS lateral boundary conditions

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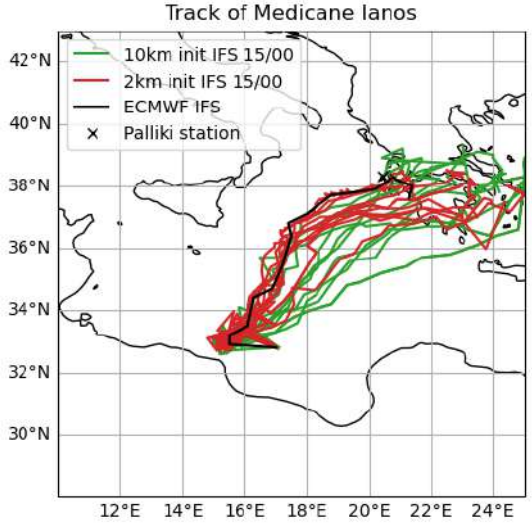
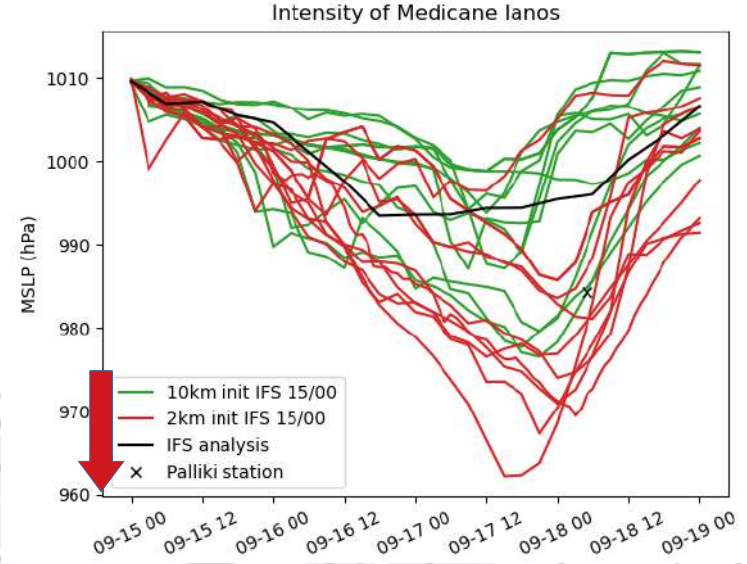
Sensitivity to horizontal resolution: highres (2 km) vs control (10 km)





- Improved track (reduced error & spread) and deeper cyclone with higher resolution
- Suggests crucial role of the representation of convection (explicit vs parameterized)

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Phasing between cyclone and large-scale dynamics

Control runs

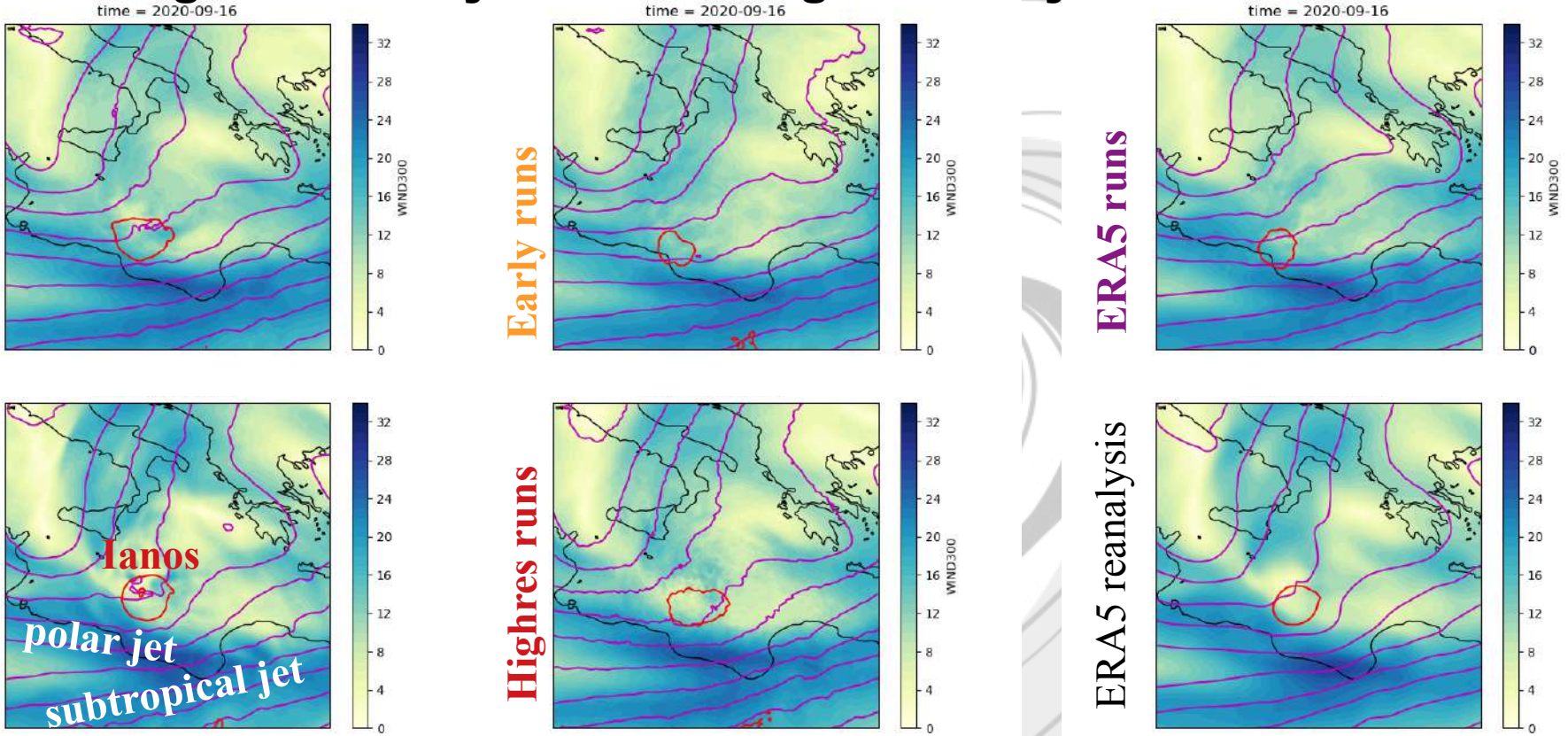
Early runs

ERA5 runs

IFS analysis

Highres runs

ERA5 reanalysis

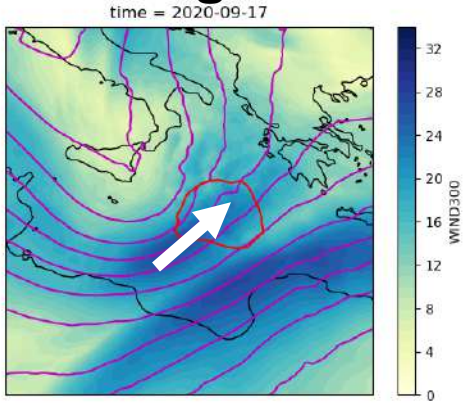


16 Sep 00 (t+24h)

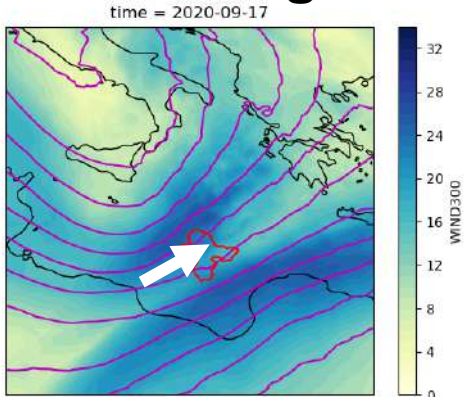
300 hPa wind (shading) and geopotential (pink), MSLP (red)

Phasing between cyclone and large-scale dynamics

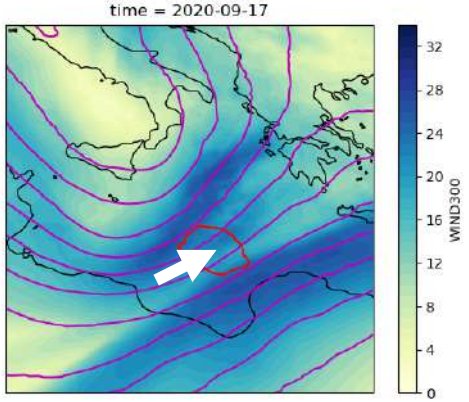
Control runs



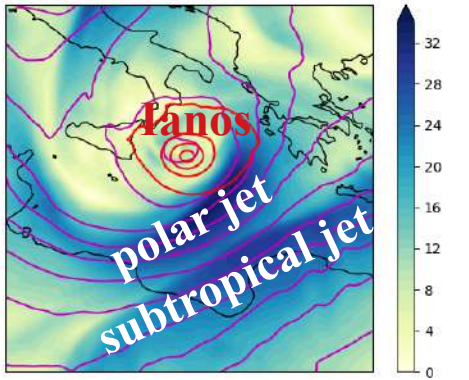
Early runs



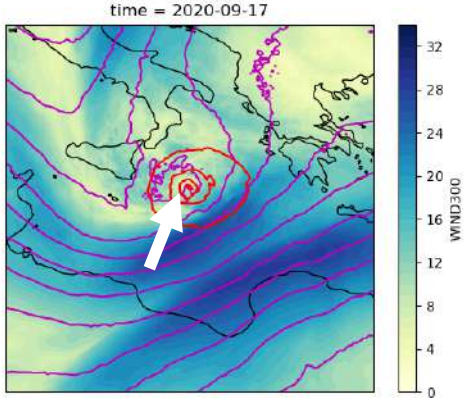
ERA5 runs



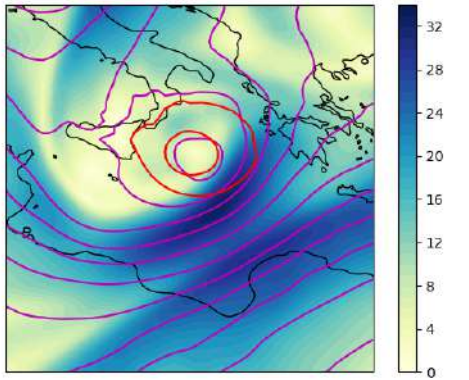
IFS analysis



Highres runs



ERA5 reanalysis

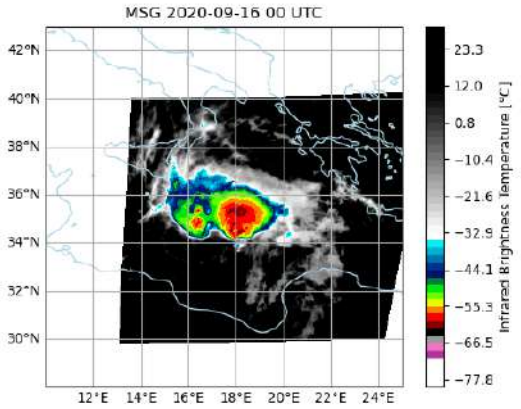


17 Sep 00 (t+48h)

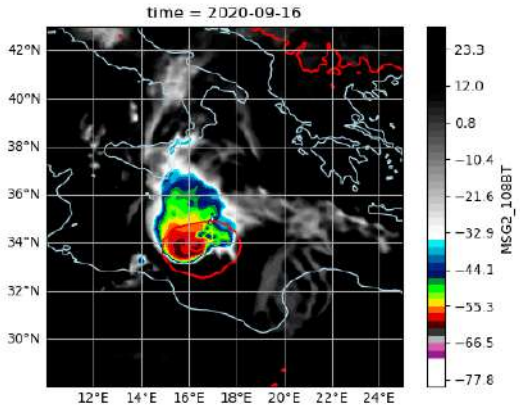
300 hPa wind (shading) and geopotential (pink), MSLP (red)

Role of convection in cyclone-dynamics interaction

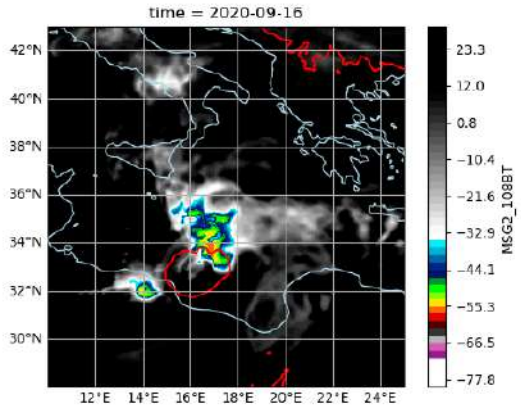
16 Sep 00 (t+24h)



(a) IR 10.8-μm observation



(b) Init IFS: good track

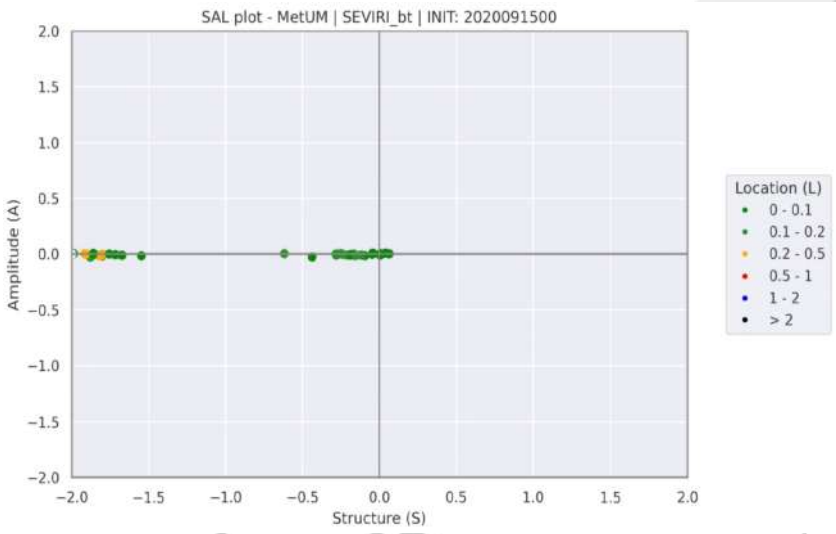


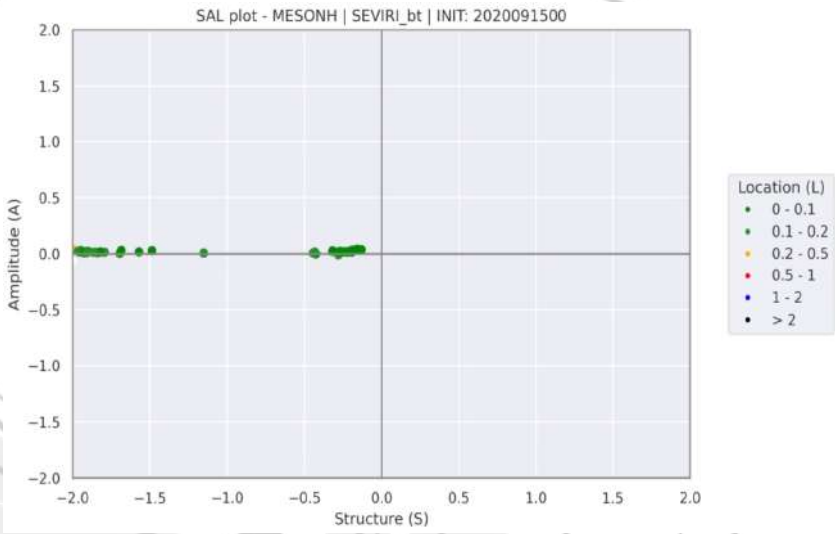
(c) Init ERA5: poor track

- Intense convection observed during cyclogenesis and prior to the bifurcation of tracks
- Example illustrates contrast between intense/weak convection with good/poor track
  → *see next talk by Claudio Sanchez for detailed dynamical analysis*

Observed and simulated infrared brightness temperature

Systematic evaluation of the representation of convection





- Assessment against satellite observations using object-based SAL and FSS metrics
- First results suggest contrast in Structure (extent) rather than Amplitude & Location
  → *work in progress by Juan Jesus Gonzalez Aleman & Carlos Calvo-Sancho*

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Conclusions

Model Intercomparison Project to improve predictions of Mediterranean cyclones

▶ Collective effort with >10 models and setups to provide **robust** results

▶ Data used to assess coastal hazard through ensemble modelling (Ferrarin et al. 2023)

Focus on poorly predicted **cyclogenesis** of Medicane Ianos (Sep 2020)

1) Strong sensitivity to initial conditions: **cyclogenesis hardly captured using ERA5**
   → *Important for weather and climate studies as ERA5 is widely used!*

2) Strong sensitivity to horizontal resolution: **explicit convection clearly improves track**
   → *Representation of convection controls synoptic scale via upscale error growth*
   → *Important for the next generation of weather and climate models!*

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