What determines the Predictability of a Mediterranean Cyclone?

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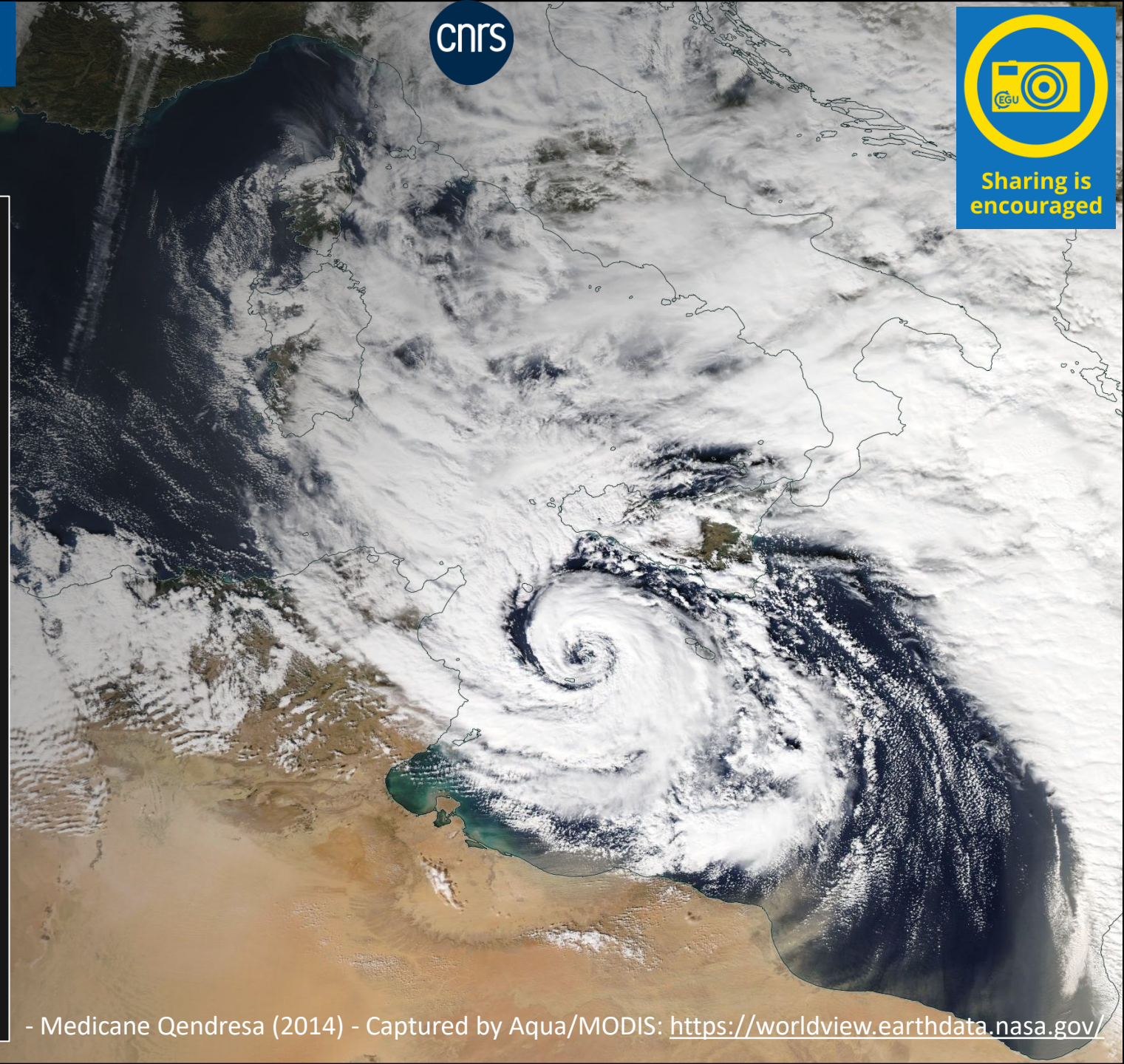
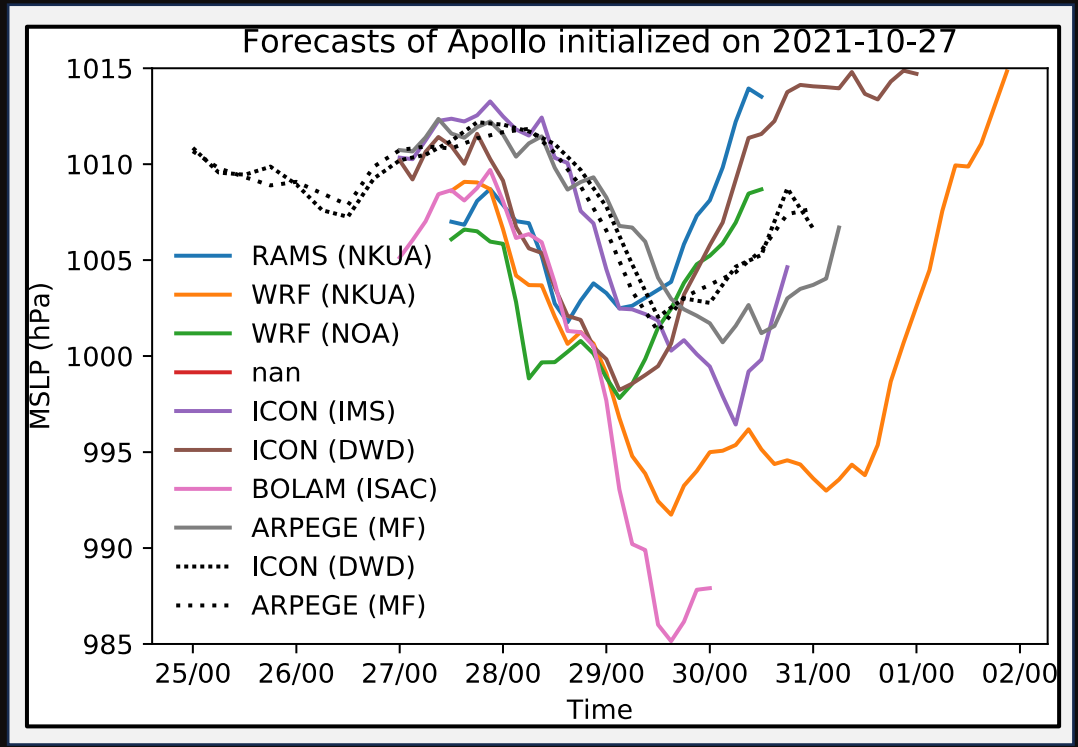


- Medicane Qendresa (2014) - Captured by Aqua/MODIS: https://worldview.earthdata.nasa.gov/

Why the predictability is an important challenge in the Mediterranean?

11 000 people were killed in Lybia after heavy rains generated by storm Daniel (2023)

Some cyclones remain poorly predicted



Comparison of different NWP systems for a forecast of Medicane Apollo
- MedCyclones DynForMed Initiative -

In the Mediterranean, previous works on predictability focussed mainly on case studies

-> How to systematically investigate the predictability ?

1. Need of a Reference DataSet

Climatology and reference tracks

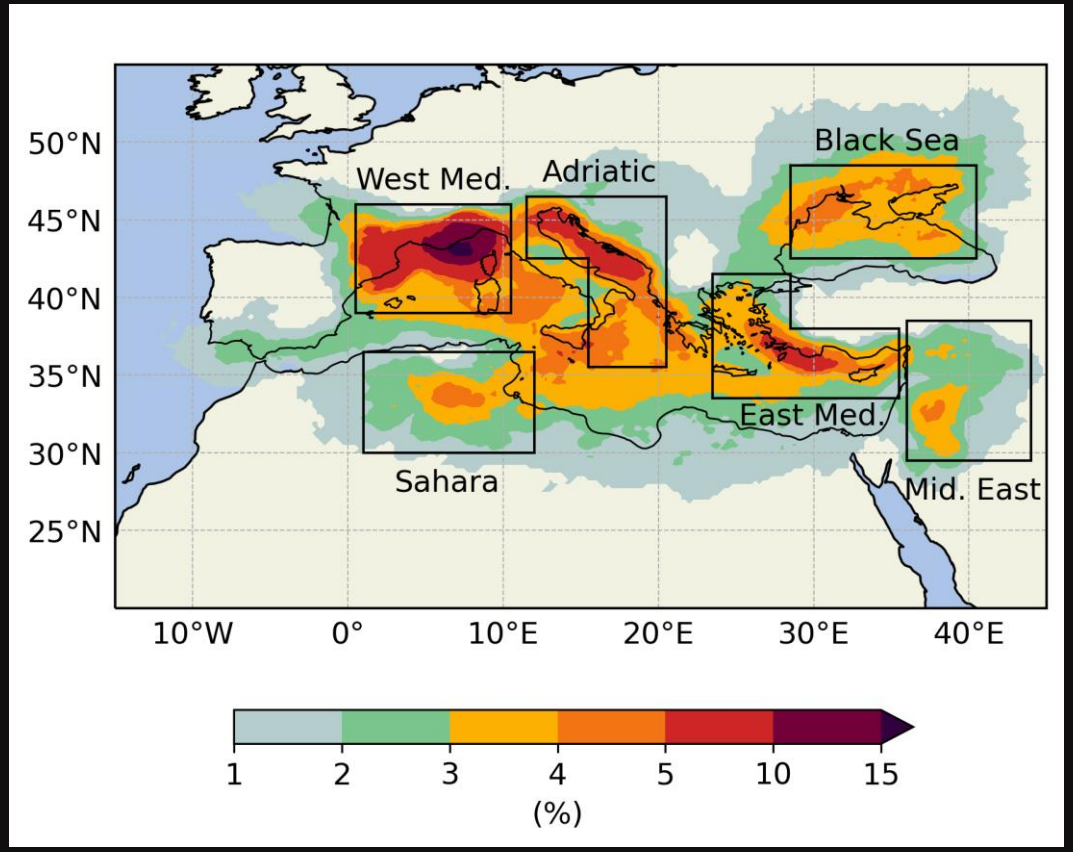
Inputs for the tracking (algorithm developed at the CNRM and adapted for the Mediterranean, [Plu and Joly, 2023])

- Vorticity at 850 hPa
- Horizontal wind 850 hPa and 700 hPa

2853 cyclones (deeper than 1005 hPa) tracked in ERA5
Only for the Mediterranean region, 2001-2021

- The Gulf of Genoa is the main hotspot (*West Med.)*
- Cyclones also detected over arid areas (*Sahara or Mid. East*)

Consistent with an intercomparison [Flaounas *et al.*, (2023)]



Probability to found a track point inside a radius of 100 km
Percentages are relative to the total number of trajectories
=
Strike Probabilities

In the Mediterranean, previous works on predictability focussed mainly on case studies

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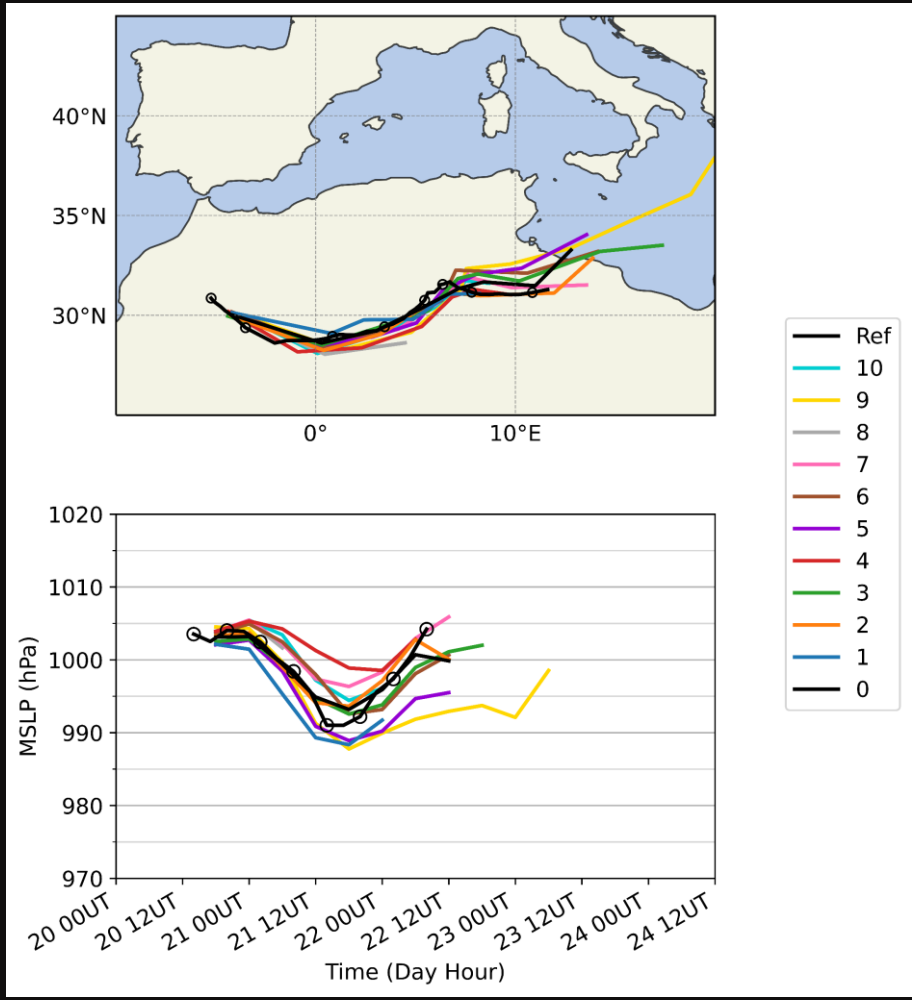
1. Need of a Reference DataSet

2. Track cyclones in Ensemble Reforecasts

IFS Ensemble Reforecasts (Oct 2001 – Oct 2021)



Tracking of a cyclone in IFS reforecasts
The reference corresponds to ERA5, 0 is the control member

- 10 + 1 members
- Horizontal resolution 0.25 °
- 6 h output frequency limited here until 7 days lead time
- Ensemble Data Assimilation ERA5 + Singular Vectors
- Initialisation at 00 UTC on Mondays and Thursdays
- Same model configuration over the 20 years

Use of another algorithm (ECMWF) to track cyclones
in the reforecasts using ERA5 trajectories as a reference

Result: The 2853 cyclones (deeper than 1005 hPa)
are successfully tracked in IFS Ensemble Reforecasts

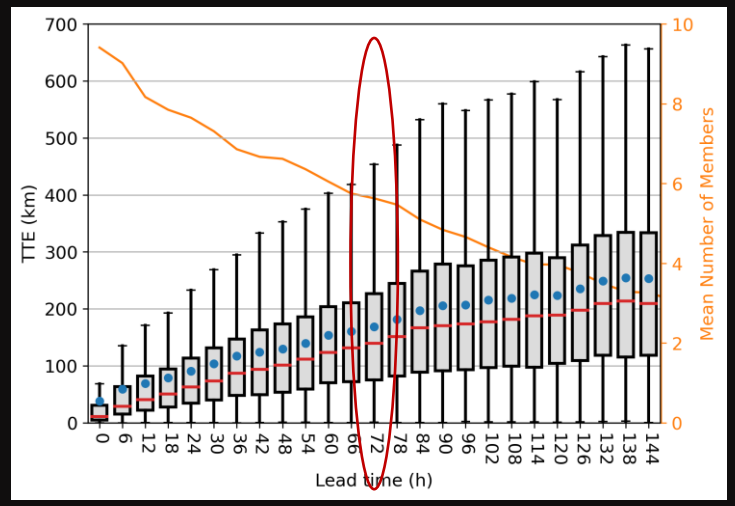
In the Mediterranean, previous works on predictability focussed mainly on case studies

-> How to systematically investigate the predictability ?

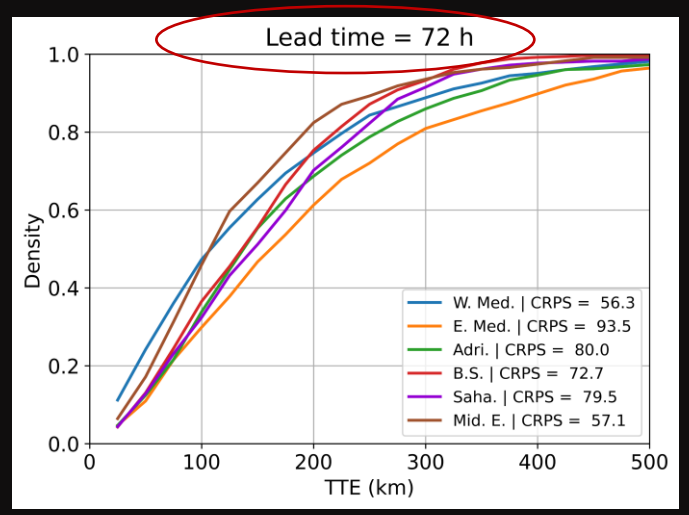
1. Need of a Reference DataSet
2. Track cyclones in Ensemble Reforecasts
3. But how to measure the predictability?

The Cumulative Density Function Error (CDFE)

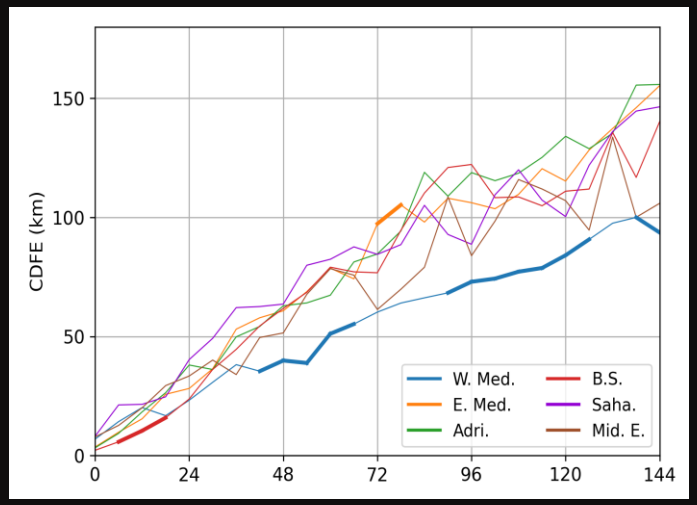
A new metric to summarise a CDF of errors (of intensity or of location)
Inspired from the well-known Continuous Ranked Probability Score (CRPS)



Total track error (km) distribution



CDFs at a specific lead time



CDFE at every lead times

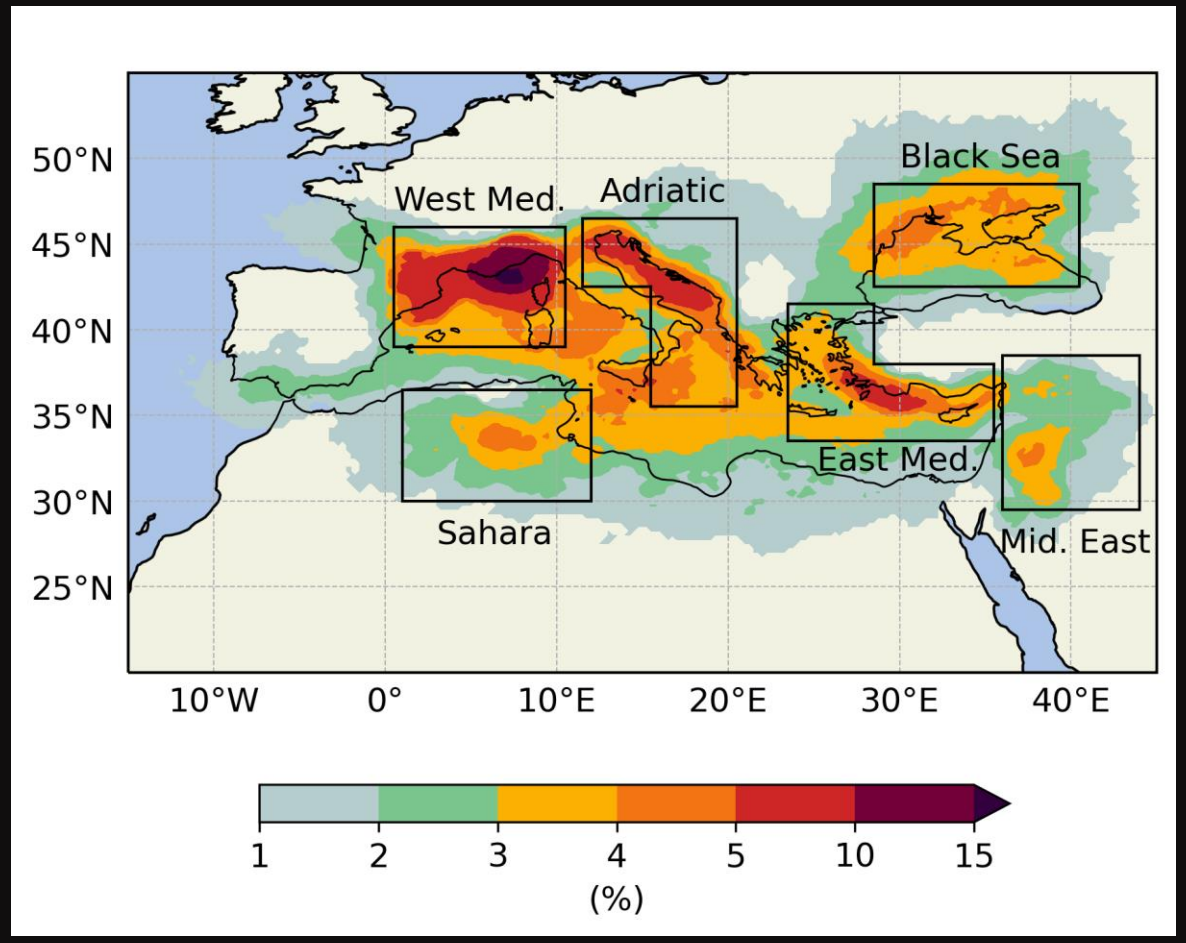
Same dimension as the variable on which it is applied: ↗ CDFE = ↘ Predictability

In the Mediterranean, previous works on predictability focussed mainly on case studies

-> How to systematically investigate the predictability ?

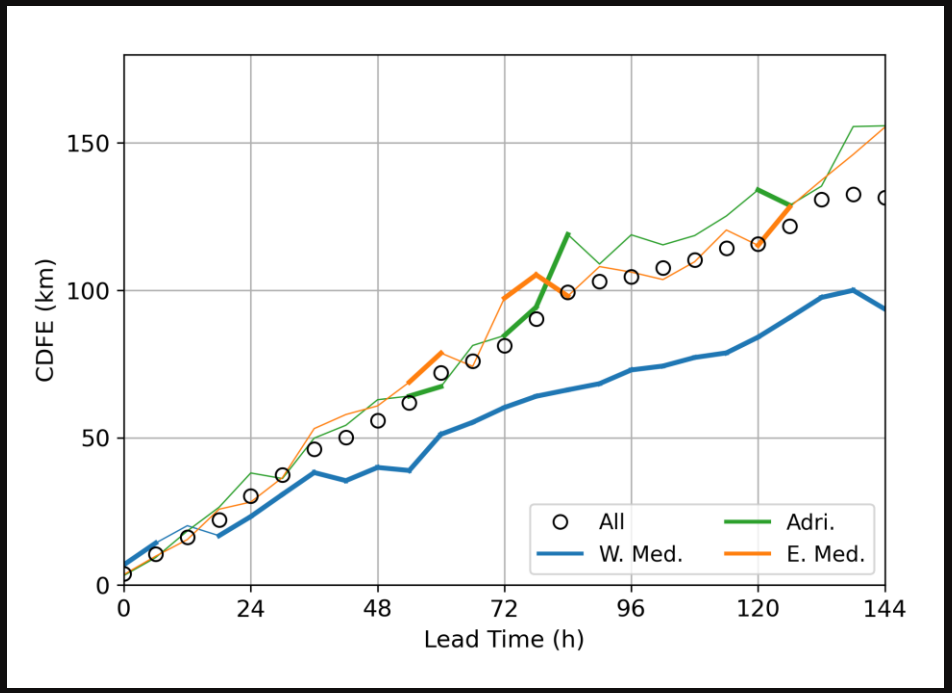
1. Need of a Reference DataSet
2. Track cyclones in Ensemble Reforecasts
3. But how to measure the predictability?
4. What determines the predictability of a Mediterranean cyclone?

Regional differences



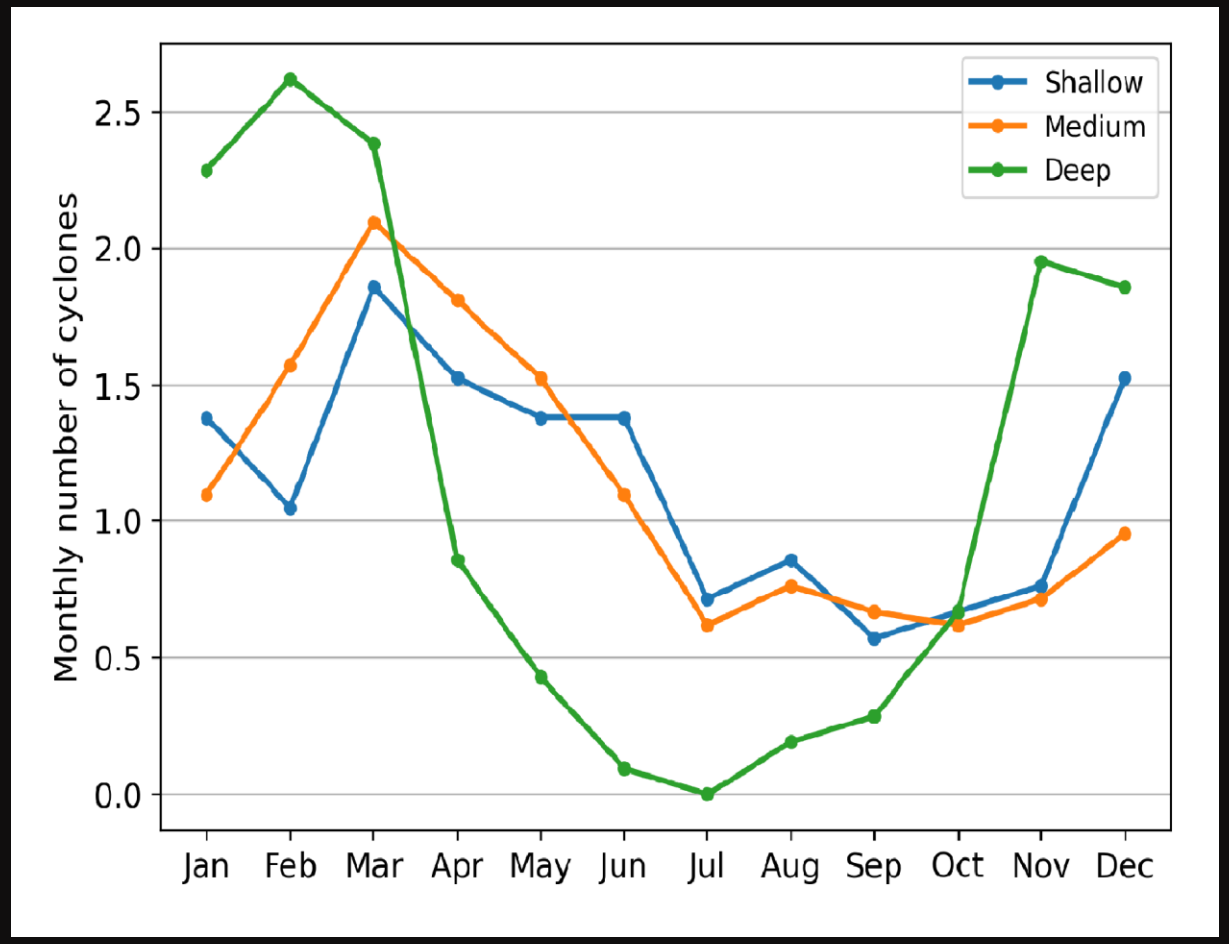
Probability to found a track point inside a radius of 100 km
Percentages are relative to the total number of trajectories

Better predictability of the **location** in the **West Med.**



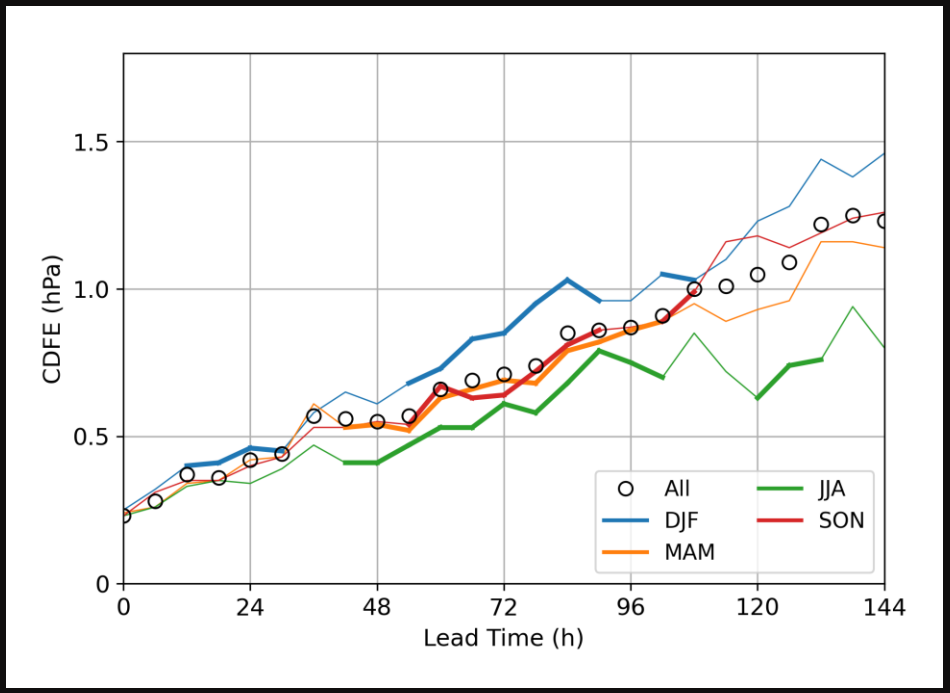
CDFE of the Total Track Errors for different regions
Thick line = Statistically significant

Seasonal differences



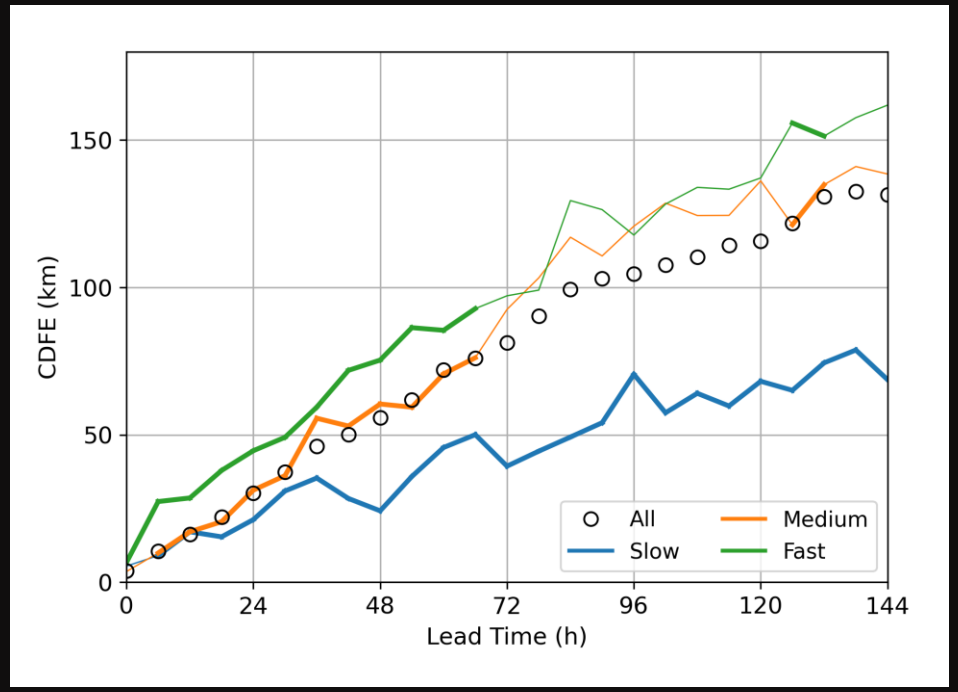
Monthly mean number of cyclones in
3 categories of intensities (based on minimum MSLP)

Poorer predictability of the **intensity** in **winter**



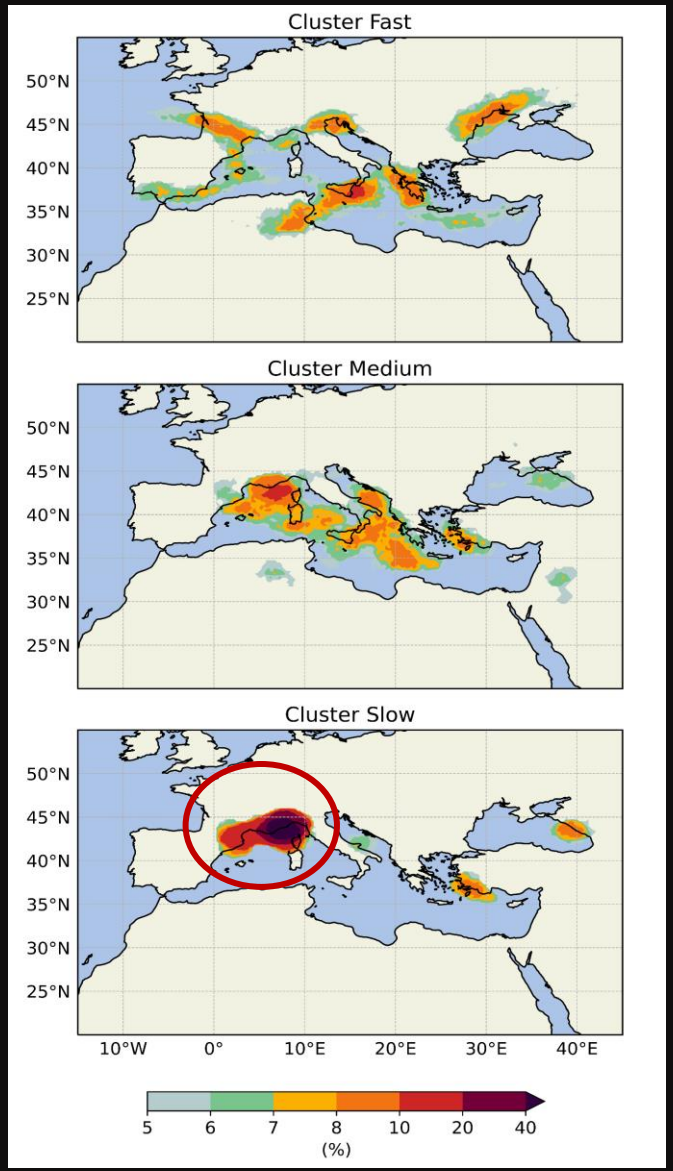
CDFE of the MSLP Errors for different seasons
Thick line = Statistically significant

Differences between velocity classes



CDFE of the Total Track Errors for different speeds
Thick line = Statistically significant

Better predictability of the **location** for **slow cyclones**
→ link with **West Mediterranean** cyclones



Strike probabilities (radius = 100 km)
for 3 classes of cyclones speeds

Take home messages

- ❑ Use of reanalysis (ERA5) and ensemble reforecasts (IFS) to provide a systematic evaluation of predictability
  2853 cyclones tracked in the Mediterranean (2001-2021)

- ❑ Errors in the position of slow cyclones mainly located in the West Mediterranean are the smallest

- ❑ Errors in the intensity of deep winter cyclones are the greatest

Next step: What are the physical processes involved in the loss of predictability?

➢ Hypotheses: Large scale error growth or local heat release in clouds over the Mediterranean

For more details

Doiteau, B., Pantillon, F., Plu, M., Descamps, L., and Rieutord, T., 2024,
What determines the predictability of a Mediterranean cyclone?
EGUsphere, 2024, 1–29, doi.org/10.5194/egusphere-2024-675