Uncertainty quantification products for the Extremes Digital Twin

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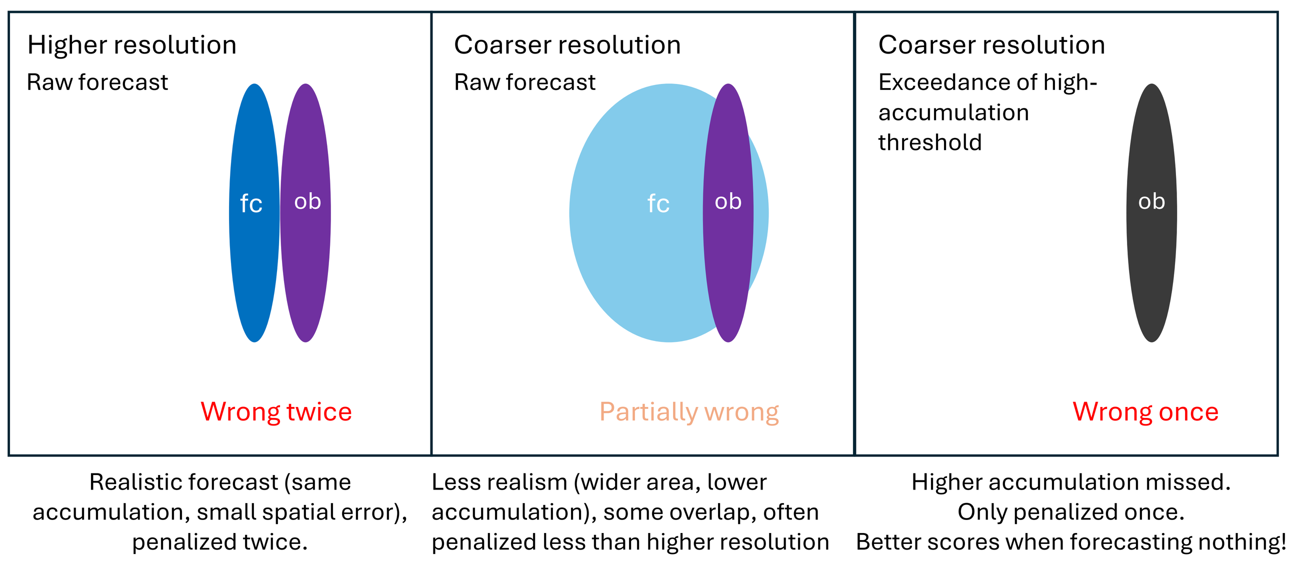
1. Motivation

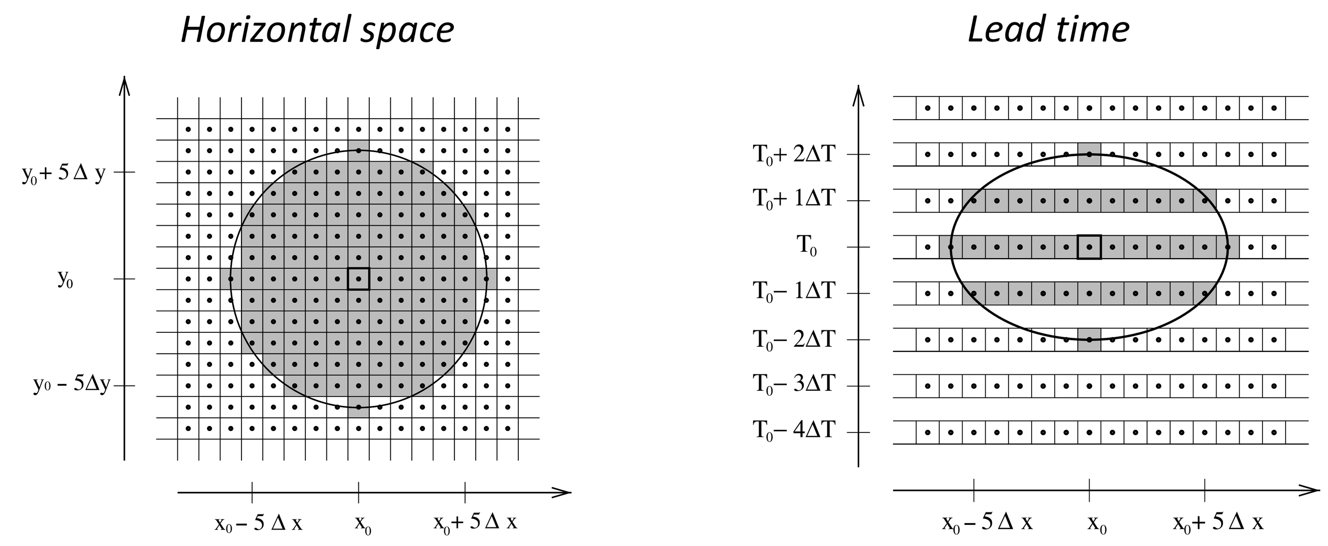
The aim of this work is to develop uncertainty quantification products for the Extremes Digital Twin (DT) of Destination Earth (DestinE). Currently, the Extremes DT has 4.4 km horizontal resolution. Although this resolution is still not enough to fully remove the need for parametrisation of convection, forecasted fields of certain variables (precipitation, wind gust) are already exhibiting greater small-scale variability. This could lead to the worsening of the so-called double penalty problem, in which even small misplacements are penalised twice (once where an occurrence is forecast and not observed and once where observed and not forecast), leading to larger overall forecast errors. Traditionally, this problem is reduced by using probabilistic forecasts, however, at the moment the classical ensemble forecast capacity of Destination Earth is very limited (experimental ensemble forecasts are run only for selected case studies). Consequently, in the first step such prototype products are investigated which rely on a deterministic high-resolution forecast. The neighbourhood method, presented on this poster, is a simple approach to develop such products.



2. Neighbourhood method – background

The aim of the neighbourhood method is to characterize uncertainty from a single high-resolution deterministic forecast run. In the case of high-resolution models (parts of the) uncertainty comes from location errors or timing errors of forecasted weather phenomena. Uncertainty related to location errors is represented by constructing a pseudo-ensemble from neighbouring grid points in horizontal space. Uncertainty related to timing errors is constructed by investigating a time window incorporating forecast lead times before and after the actual lead time. Following this construction, the two main free parameters of the method that require investigation are the size of the search radius in horizontal space and the width of the time window.

The neighbourhood method is used widely in kilometre-scale limited area models. The main difference in the present implementation is the processing of global fields.

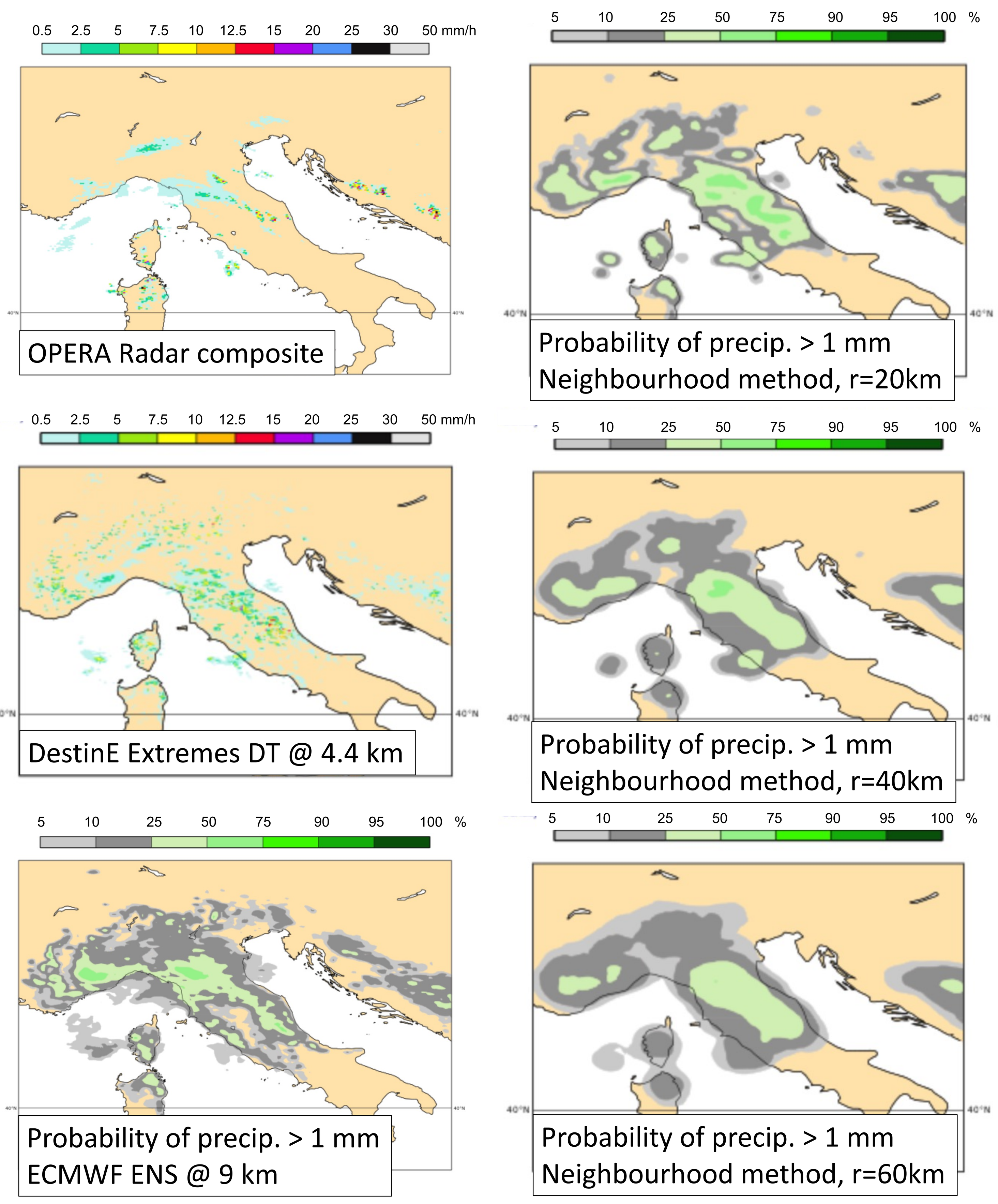


Schematic description of the neighbourhood method. Left: searching neighbouring grid points in horizontal space; right: searching neighbouring grid points in time. Figure source: *Theis et al., 2005.*

3. Case studies

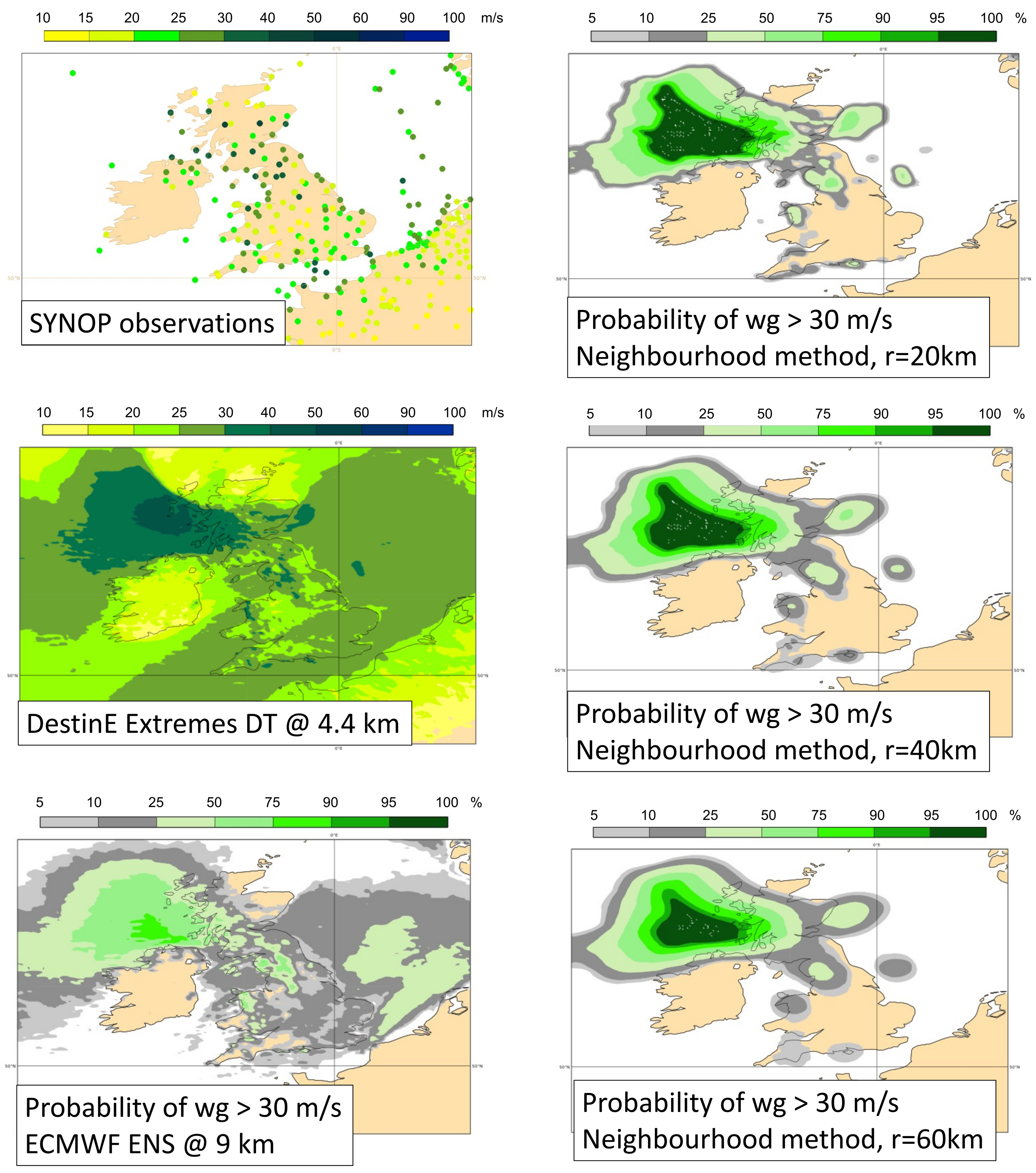
Several case studies involving convective precipitation and wind gusts have been investigated and the uncertainty information provided by the neighbourhood method was compared to the raw DestinE Extremes DT forecast, to uncertainty information derived from the operational 9 km ECMWF ensemble and to observations. These cases studies were also used to get a first impression about the sensitivity on the free parameters (neighbourhood size and time window) of the method.

Precipitation



Case study for convective precipitation over Italy. One hourly accumulated precipitation for 24th June 2024 12 UTC (+36 h lead time). On the right column neighbourhood probabilities computed from the DestinE Extremes DT with different horizontal radius settings are shown (time shift was ±1 h for all three cases).

Wind gust



Case study for wind gusts over the UK. One hourly maximum wind gusts for 22nd January 2024 00 UTC (+48 h lead time). On the right column neighbourhood probabilities computed from the DestinE Extremes DT with different horizontal radius settings are shown (time shift was ±1 h for all three cases).

4. Summary

- The neighbourhood method was implemented on the global fields of the DestinE Extremes DT. It is a cheap and easy to implement method to avoid the double penalty problem in high resolution models
- Neighbourhood probability fields derived from the DestinE Extremes DT are similar to ECMWF ENS (9 km) probabilities
- Settings of free parameters (radius, time shift) have considerable impact on the neighbourhood probability field, and require tuning to be most effective

5. Future plans

- Implement the neighbourhood method for other variables (temperature, cloudiness, …)
- Include in the computation: orography, land-sea mask
- Tune the free parameters of the method (horizontal radius, time shift) → use objective verification
- The neighbourhood method could be combined with the 4.4 km DestinE ensemble to improve spread, as a small ensemble still have a double penalty problem if the uncertainty is larger than the features of interest

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