Karlsruher Institut für Technologie

WAVES TO WEATHER

A tool to identify large-scale dynamical precursors of European extreme precipitation

A W2W Transfer project in collaboration with ARPAE Bologna and ECMWF

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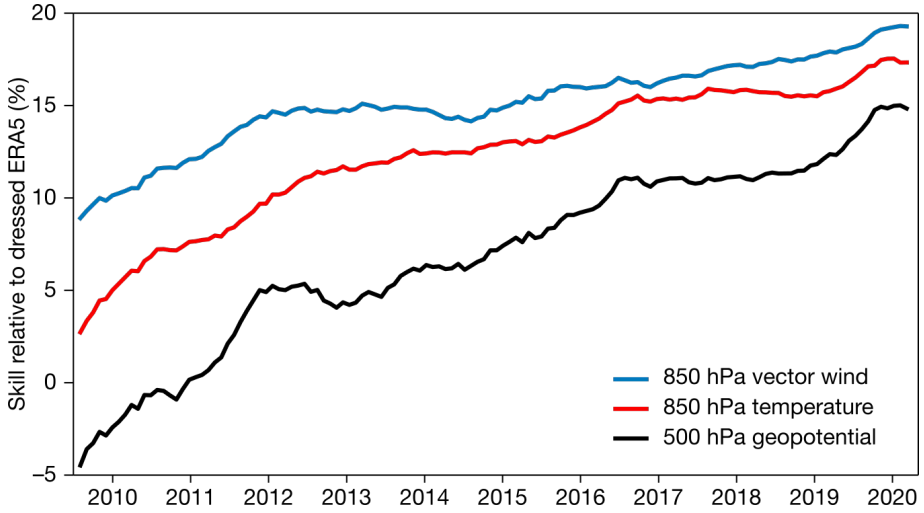
- Federico Grazzini (LMU)
- Laura Ferranti, Linus Magnusson, Frédéric Vitart (ECMWF)

ECMWF

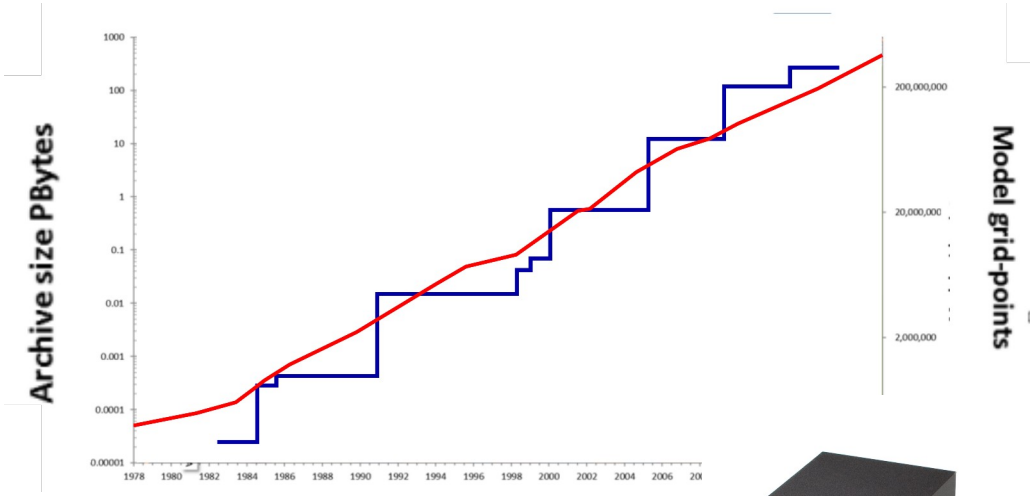
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

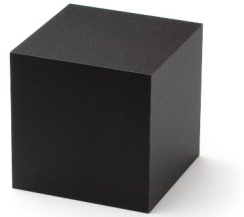
We are increasing skill but also data

Linear skill increase

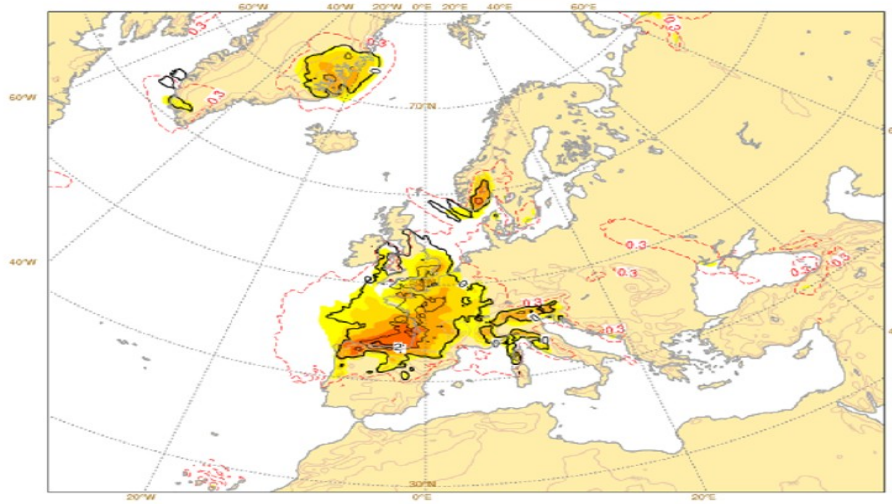


Exponential increase in data

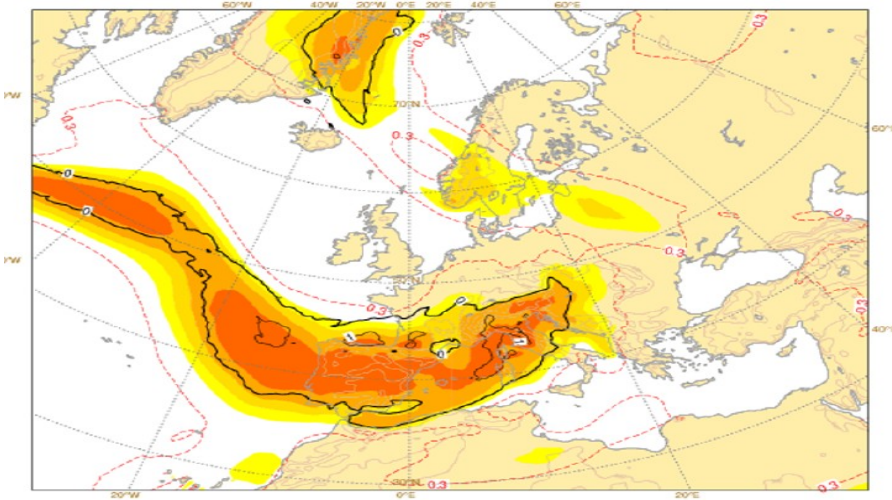




As data volumes expand, models are becoming increasingly a black box



Direct precip forecast



Integrated vapour transport forecast

Extreme Forecast Index, +96h

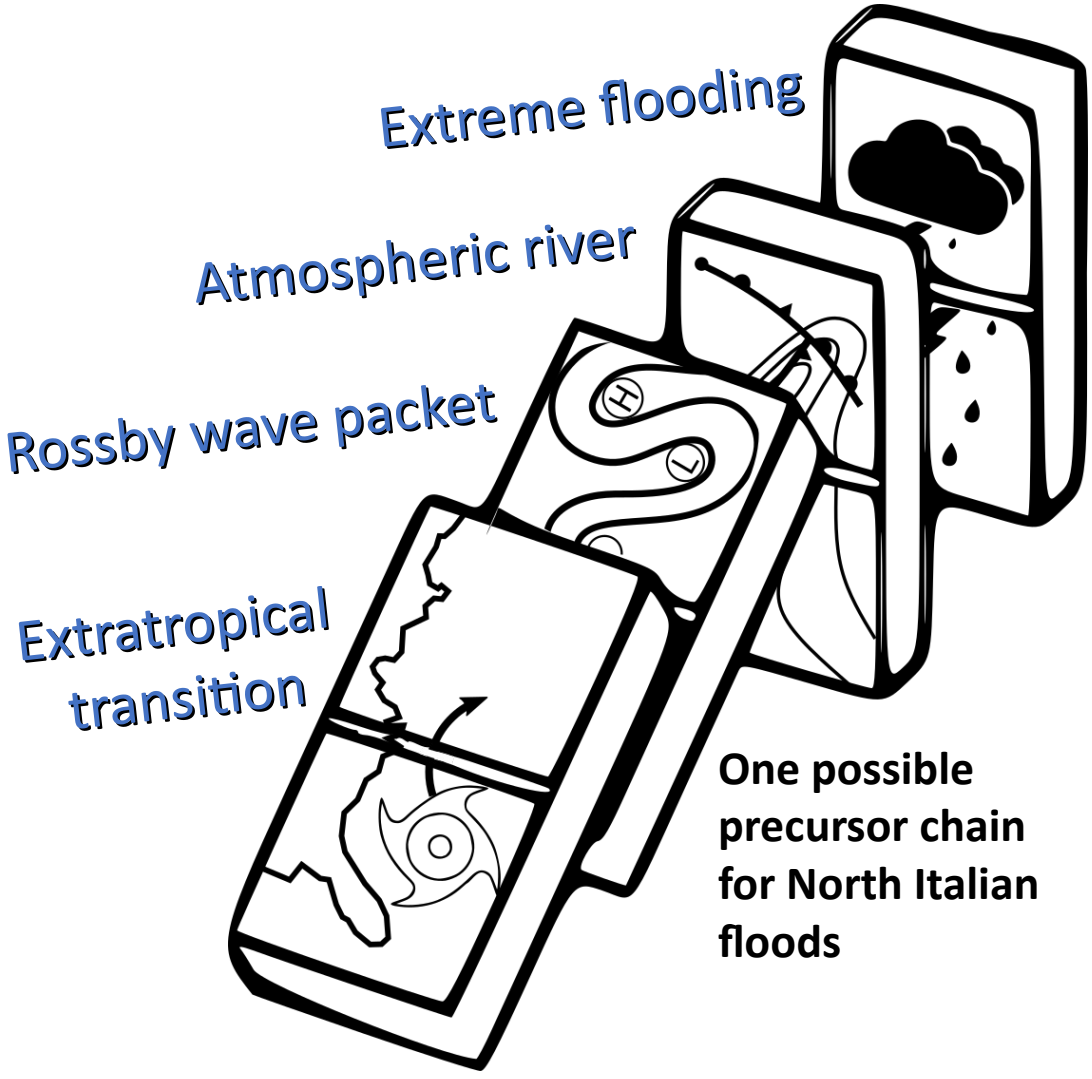
Storm Alex,

03.10.2020

500mm precip in 12 hr!

Every weather event (and every forecast) has a **story**

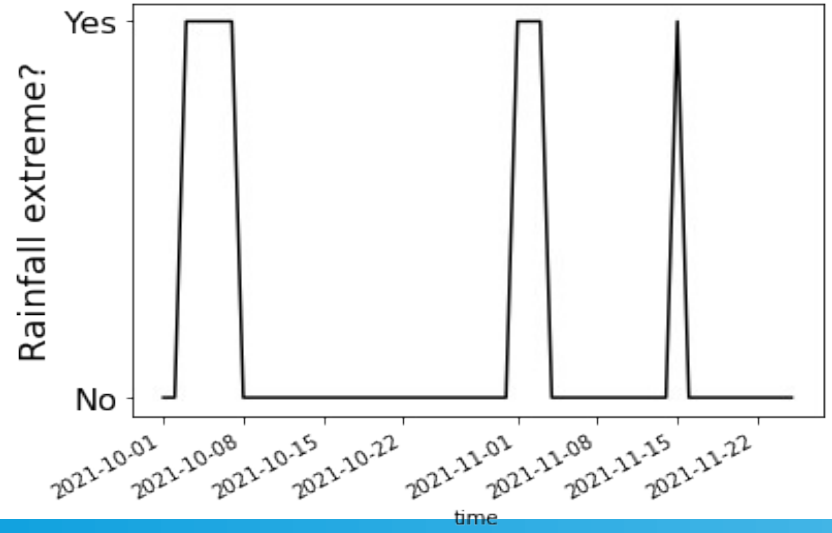
Mapping out the **large-scale precursors** of an event makes it easier to understand and predict

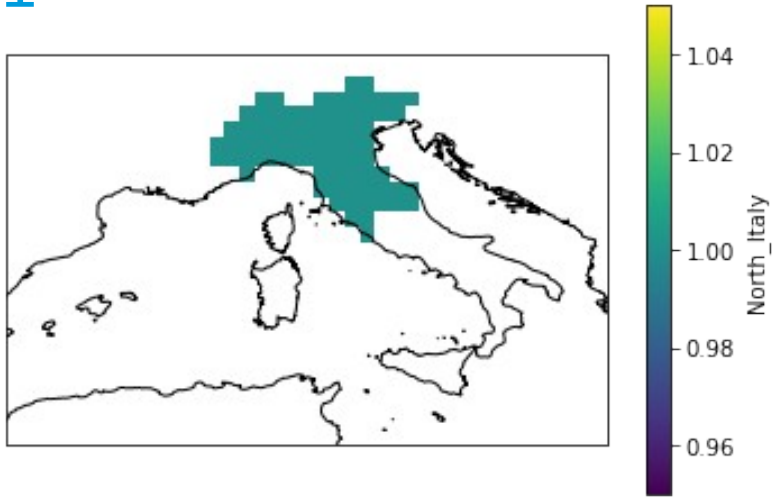


One possible precursor chain for North Italian floods

Extreme rainfall definition

- Looking at 90th percentile extremes relative to a monthly climatology in ERA5
- Looking only at 1st day of multi-day events – 6.5% occurrence
- For SON ~260 events between 1979-2021





Theory to forecasting in NI Rainfall prediction

In previous project T1 we have identified 3 EPE types: Cat1, Cat2, Cat3. They are characterized by different ingredients and predominance of dynamic vs thermodynamic processes

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DOI: 10.1002/qj.3635

RESEARCH ARTICLE

Extreme precipitation events over northern Italy. Part I: A systematic classification with machine-learning techniques

Federico Grazzini[1,2] | George C. Craig[1] | Christian Keil[1] | Gabriele Antolini[2] | Valentina Pavan[2]

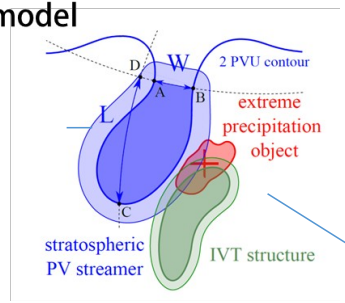
Received: 25 March 2020 | Revised: 26 November 2020 | Accepted: 19 December 2020
DOI: 10.1002/qj.3969

RESEARCH ARTICLE

Extreme precipitation events over northern Italy. Part II: Dynamical precursors

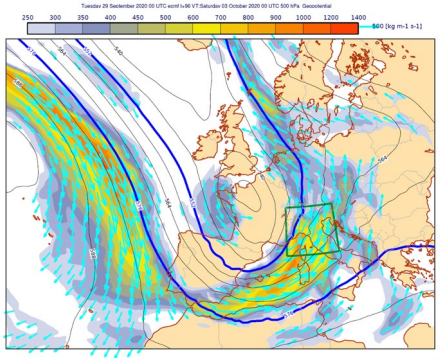
Federico Grazzini[1,2] | Georgios Fragkoulidis[3] | Franziska Teubler[3] | Volkmar Wirth[3] | George C. Craig[1]

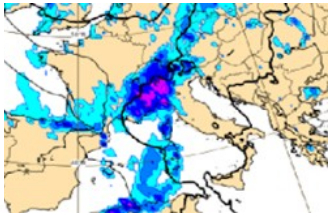
conceptual model



Adapted from De Vries 2020

operational forecast





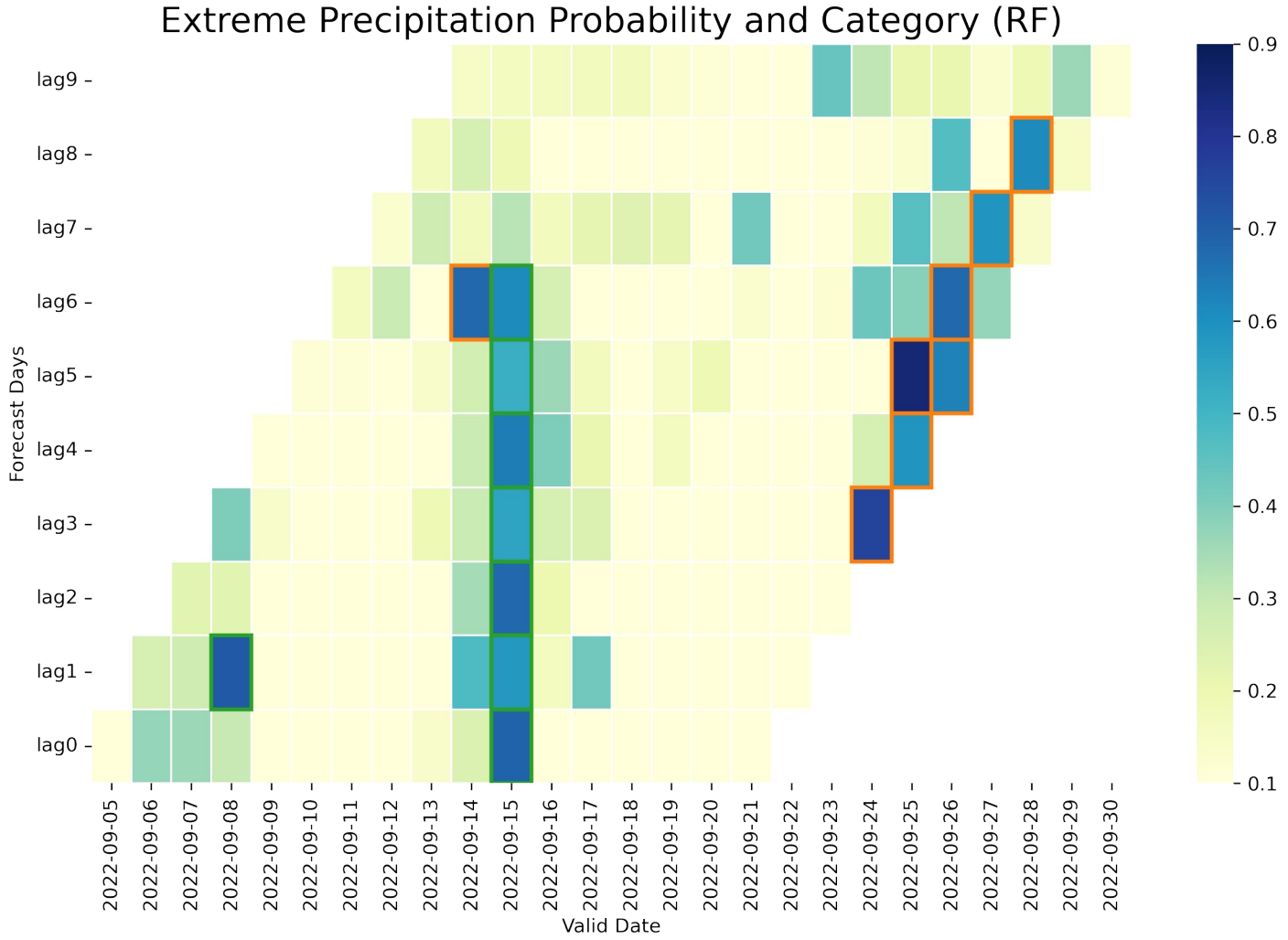
Random Forest Model

Step I

EPE prediction (y/n)

Step II

Classification (cat1,cat2,cat3)


Extreme Precipitation Probability and Category (RF)
Forecast Days
lag9
lag8
lag7
lag6
lag5
lag4
lag3
lag2
lag1
lag0
Valid Date
2022-09-05
2022-09-06
2022-09-07
2022-09-08
2022-09-09
2022-09-10
2022-09-11
2022-09-12
2022-09-13
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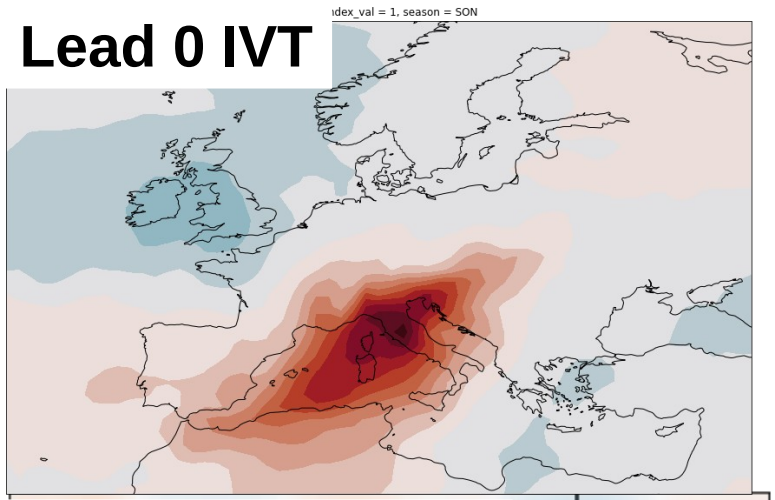
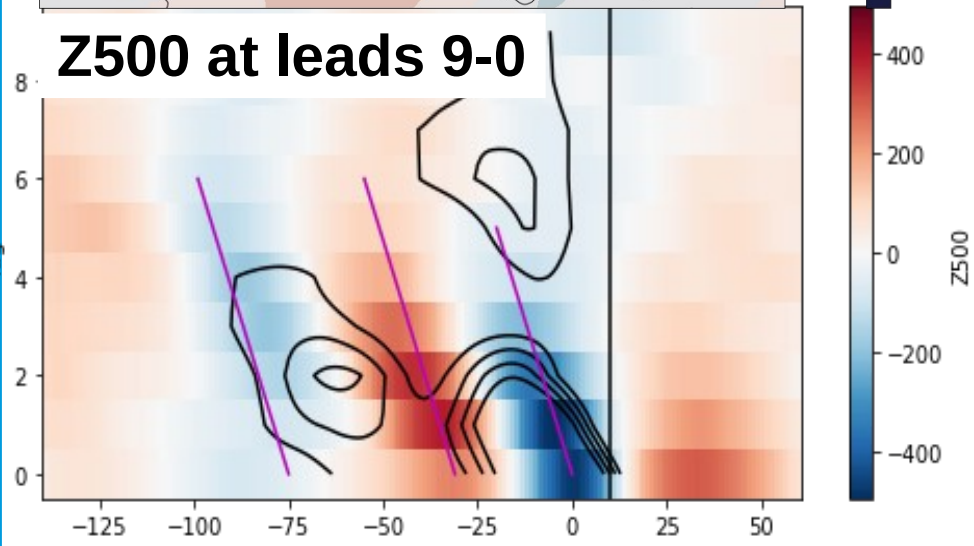
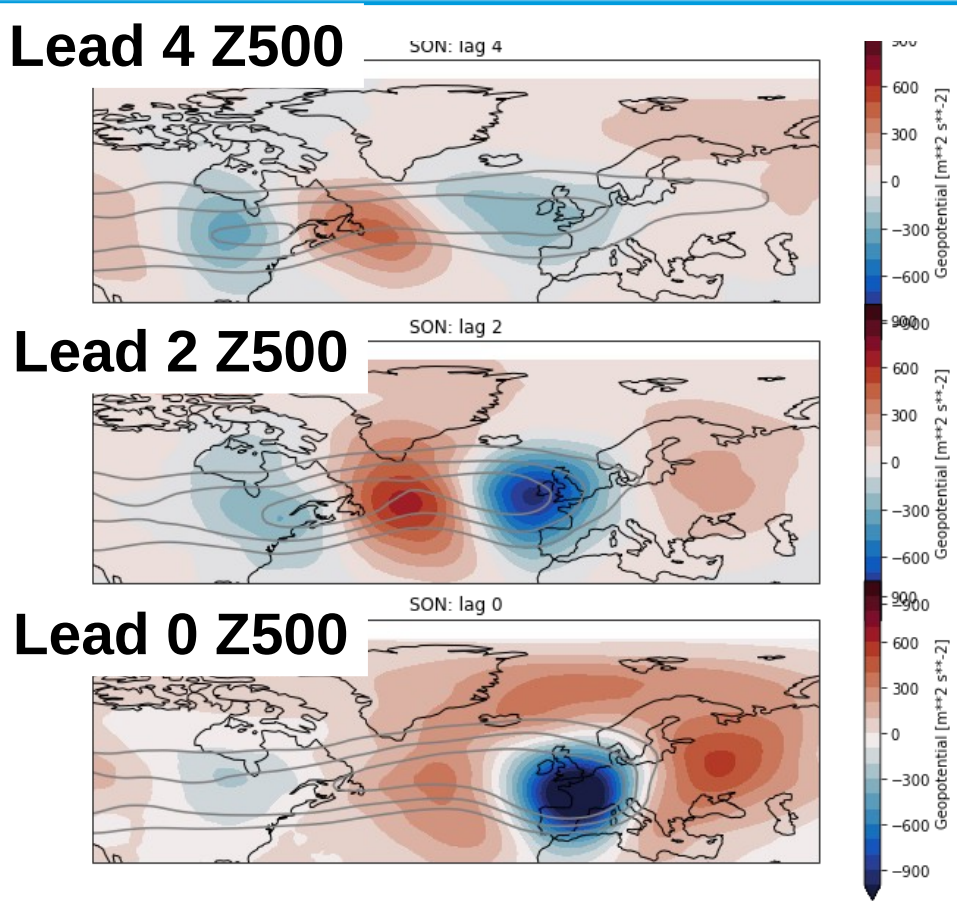
2022-09-25
2022-09-26
2022-09-27
2022-09-28
2022-09-29
2022-09-30
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Dynamics of North Italian Rainfall

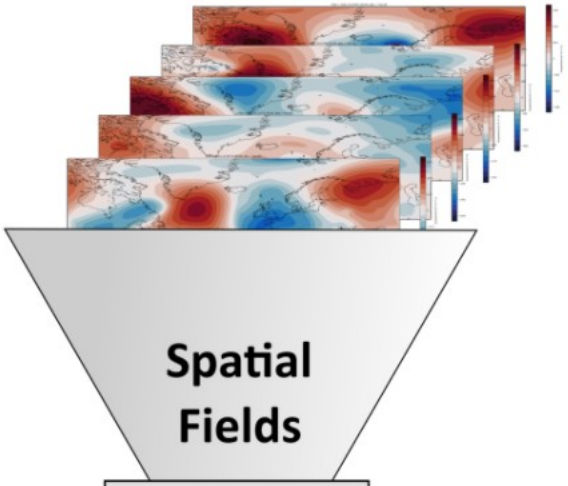


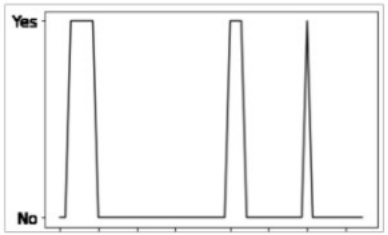




Domino: A Python package for compositing spatiotemporal data

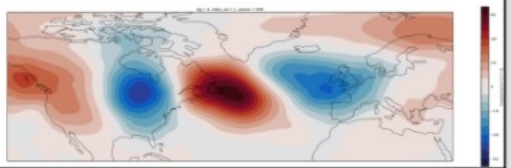
https://github.com/joshdorrington/domino





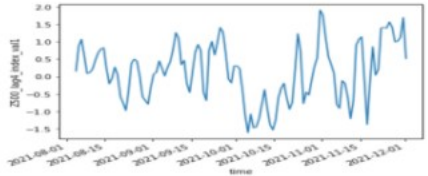
Event Definition

Compute Composites



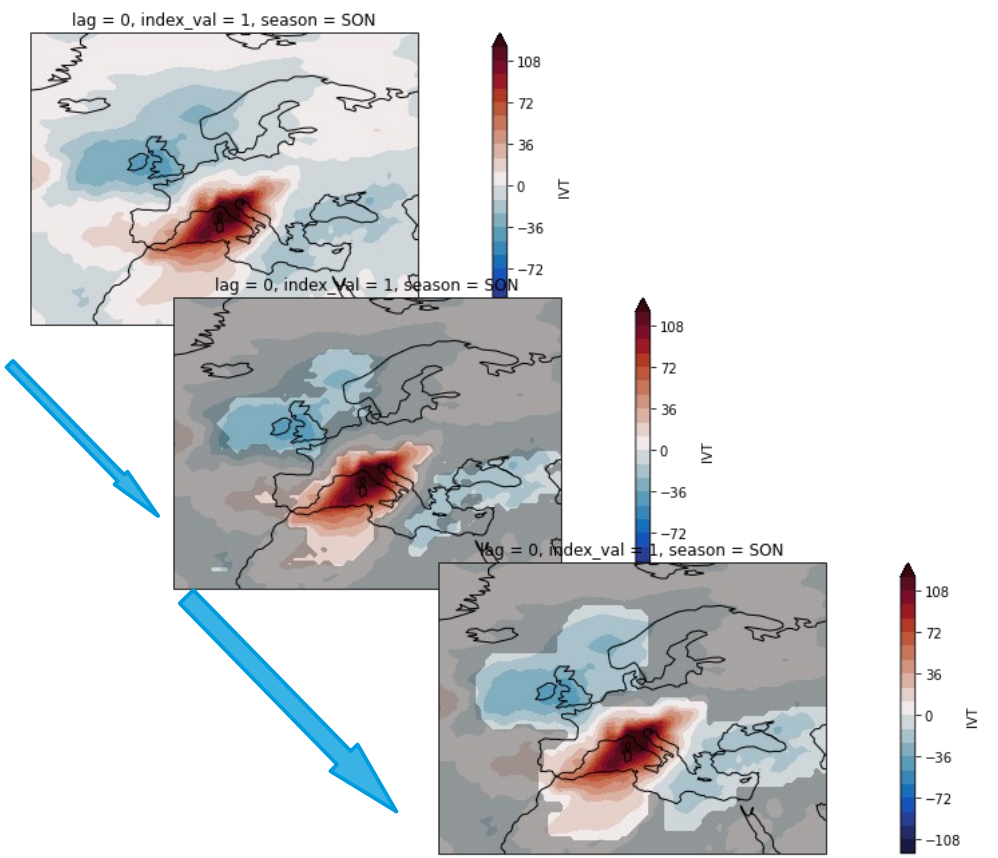
Precursor fields

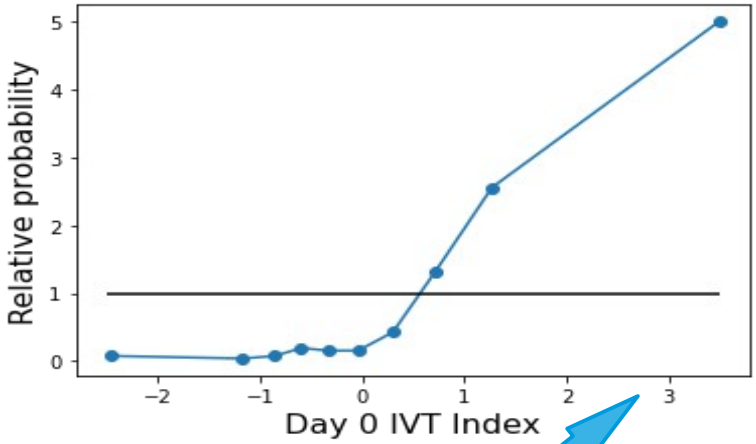
Reduce to scalar indices

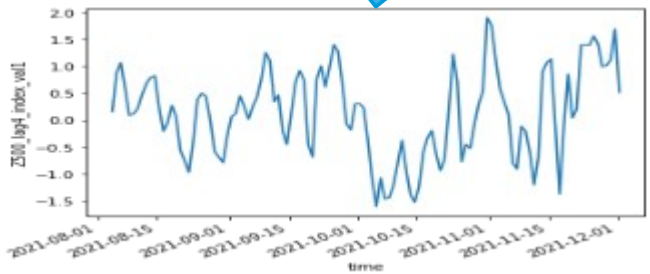


Precursor activity index

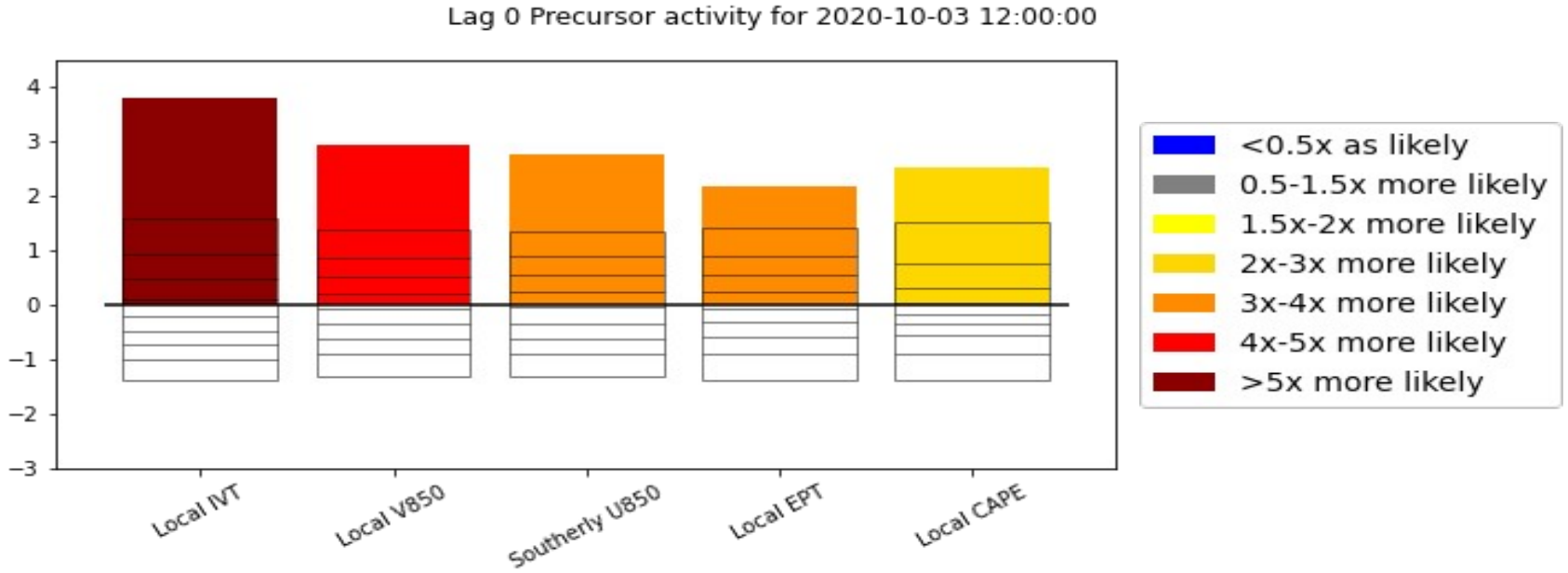
From composites to predictors





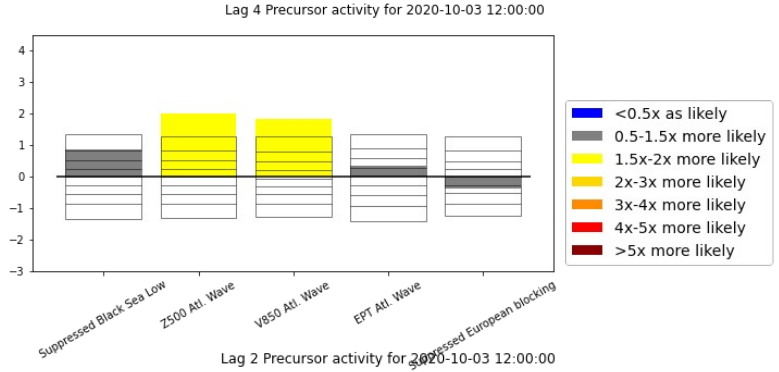


The Activity Monitor

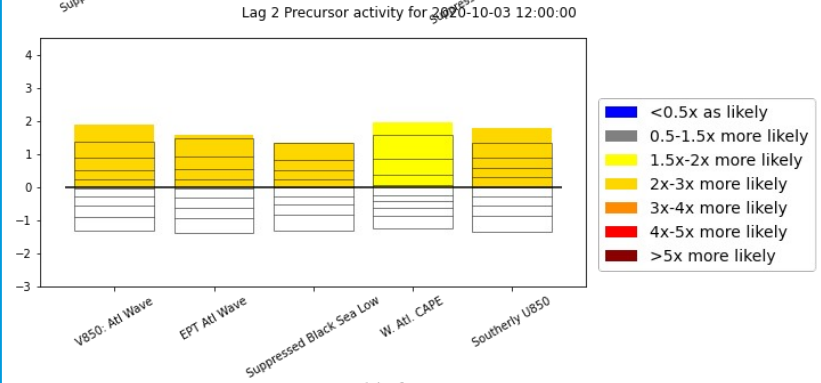


Storm Alex, 03.10.2020

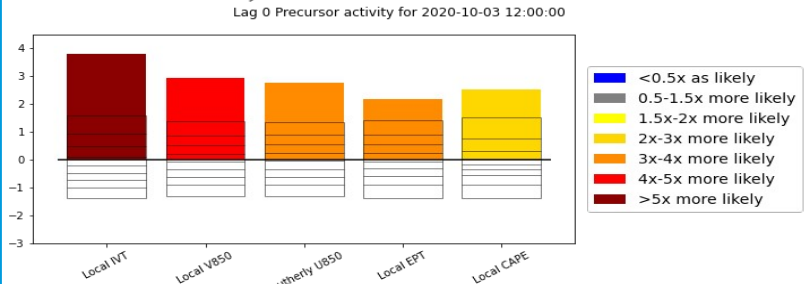
Precursors from different forecast days can be used together



4 days before: Elevated wave activity

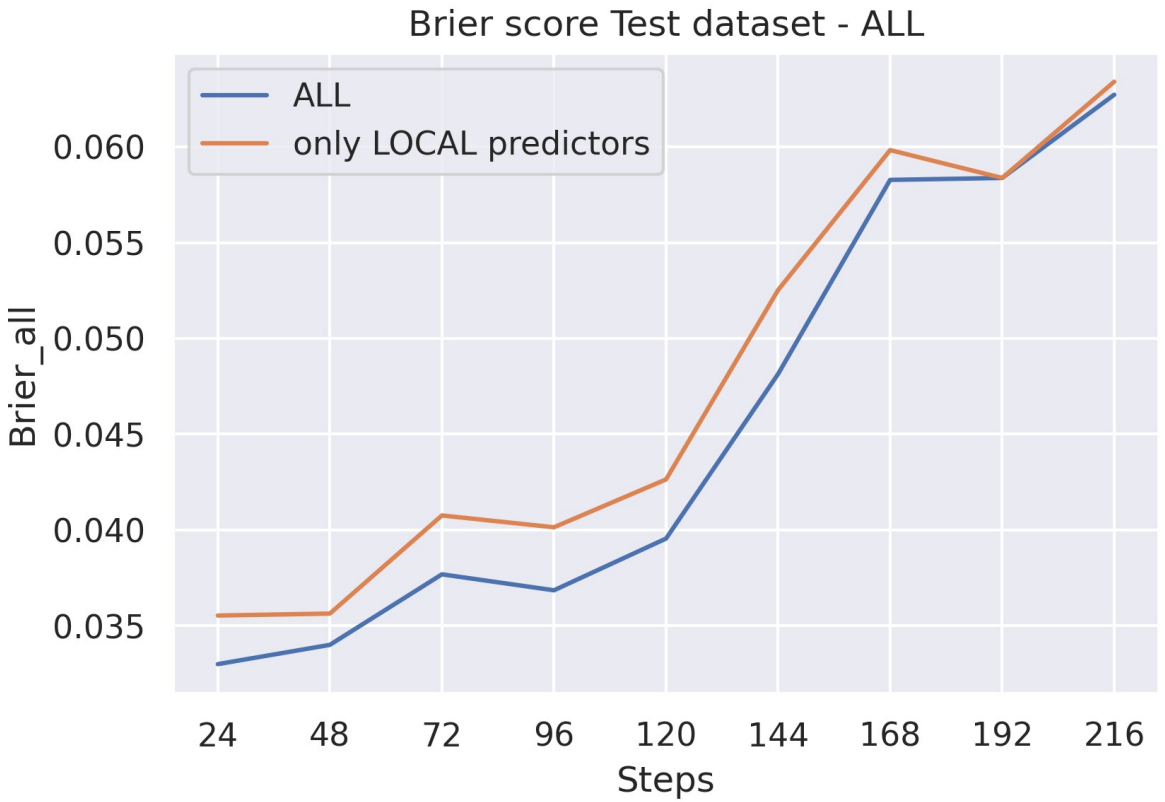


2 days before: Strong wave, high CAPE, low pressure



Day 0: Extreme IVT, strong trough and CAPE

Including nonlocal predictors improves the RF



Current challenges

- Identifying the presence of multiple pathways into an extreme event
-
- Handling seasonality: trade off between sample size and uniqueness of dynamics
-
- How to best supplement ensemble forecast data with the precursor analysis?

Conclusions and future development

- We are working towards summarising the high dimensional atmospheric circulation in a data-efficient and application relevant way
- Our automated approach can be easily extended to different event definitions
- Integrate with IFS to track precursors in model output and ultimately develop hybrid system
- Report near-realtime precursor activity, computed from ERA5, as a public web-app