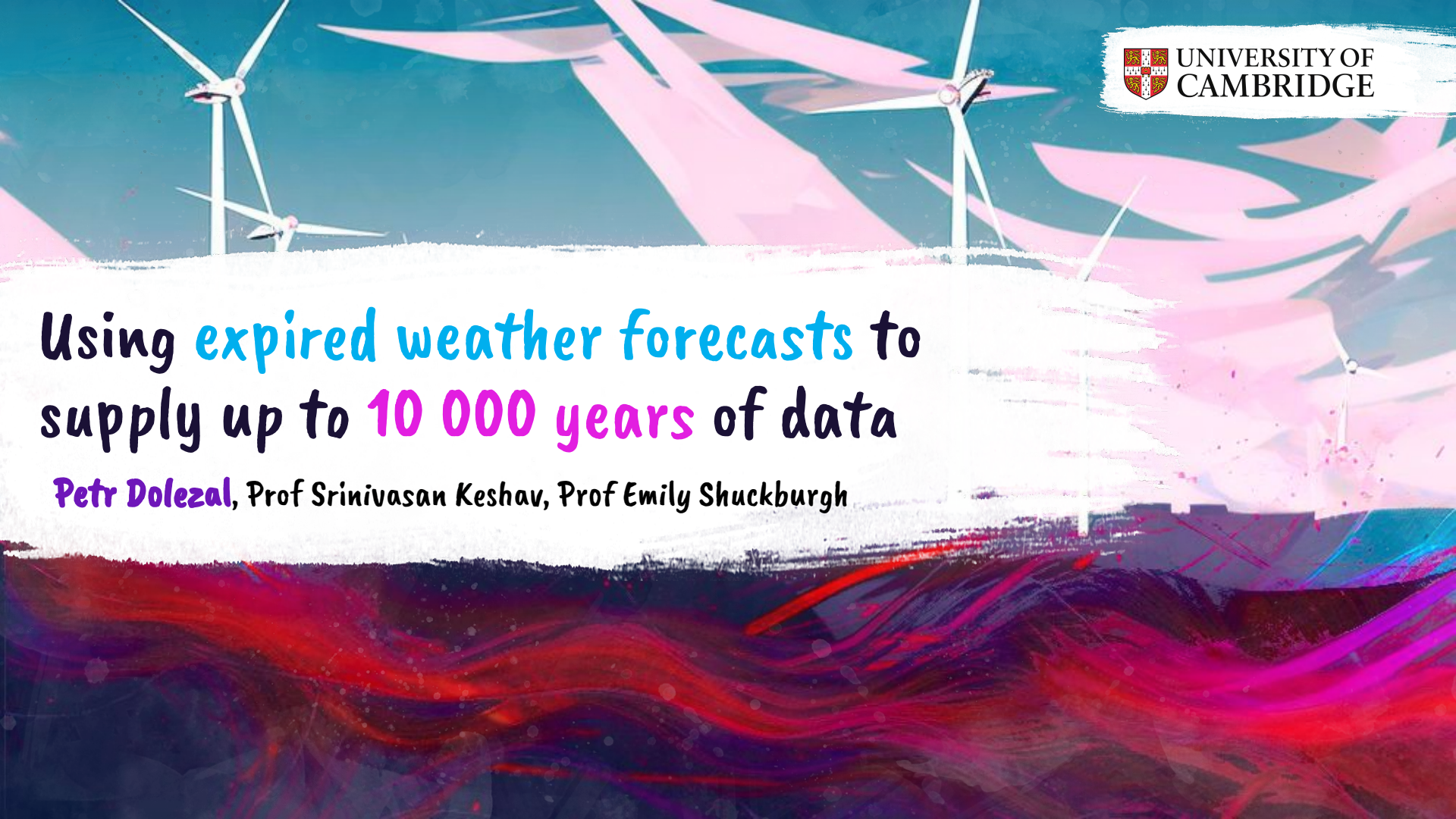
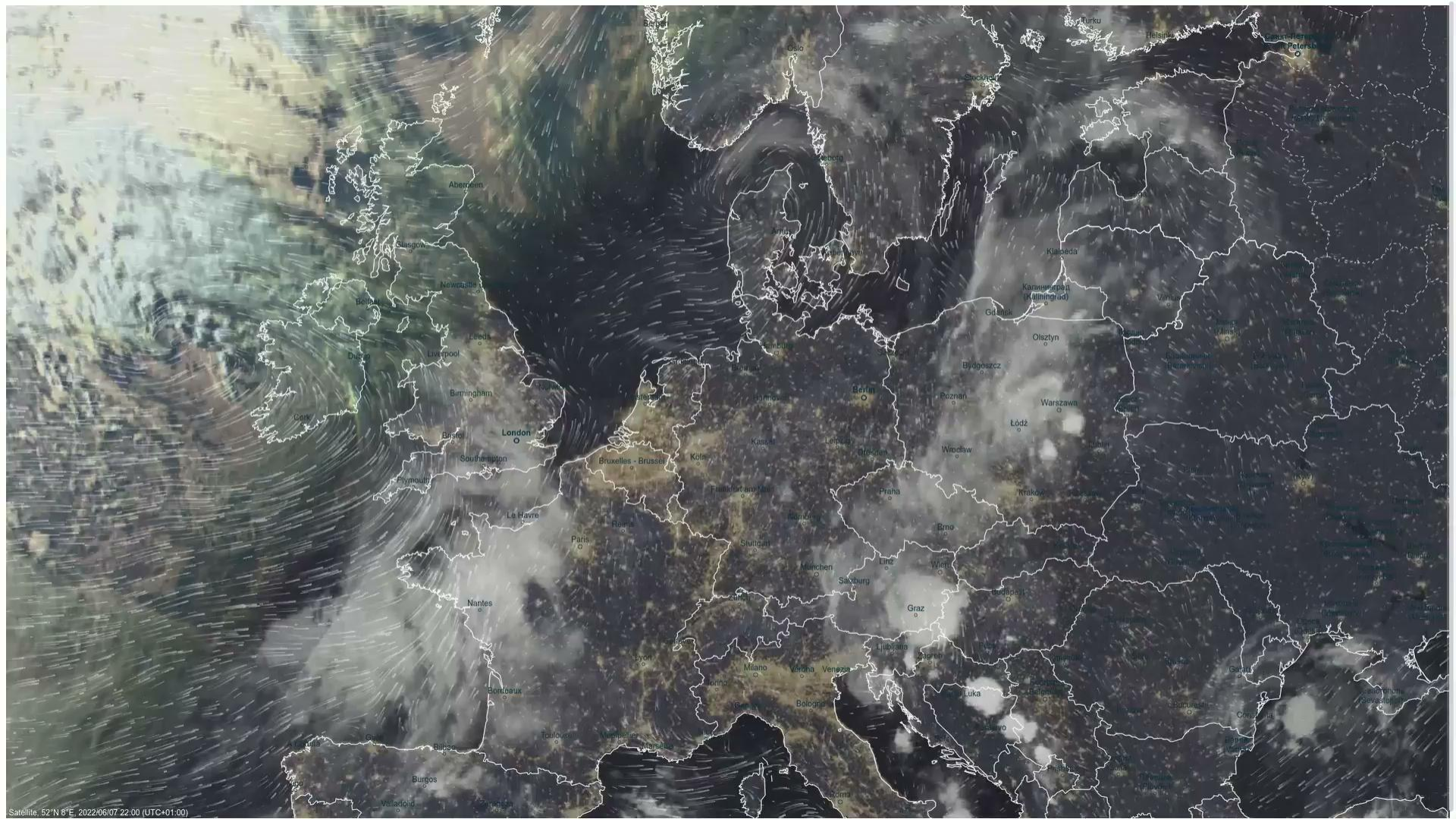


UNIVERSITY OF CAMBRIDGE

Using expired weather forecasts to supply up to 10 000 years of data

Petr Dolezal, Prof Srinivasan Keshav, Prof Emily Shuckburgh



Satellite, 52°N 8°E, 2022/06/07 22:00 (UTC+01:00)

Context and background

- Modelling electricity **grids with** a large proportion of **renewables**
- Focusing on **power transmission** between different regions
- Using **PyPSA-Eur** – an open model of a European power grid [1]
- Using **ML** techniques for speed up to analyze large amount of scenarios

[1] Jonas Hörsch, Fabian Hofmann, David Schlachtberger, and Tom Brown. *PyPSA-Eur: An open optimisation model of the European transmission system.* arXiv:1806.01613, doi:10.1016/j.esr.2018.08.012.

What are expired weather forecasts?

European Centre for Medium-Range Weather Forecasts

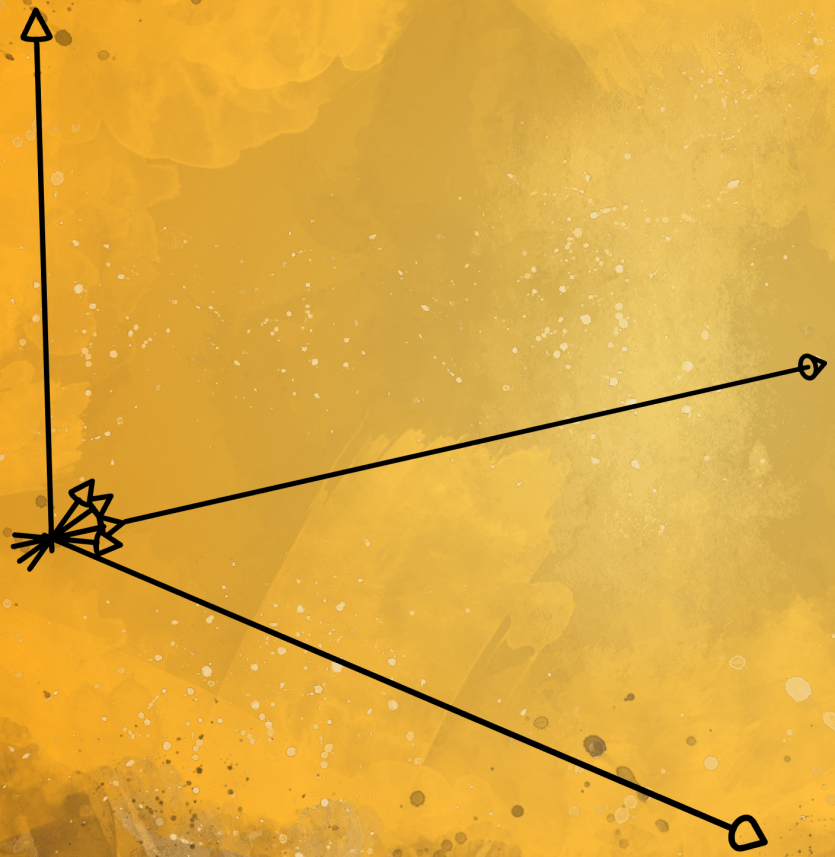
HRES - single High Resolution Forecast (10 days, #9km)

ENS - 51-member ensemble forecast (15 days, #18km)

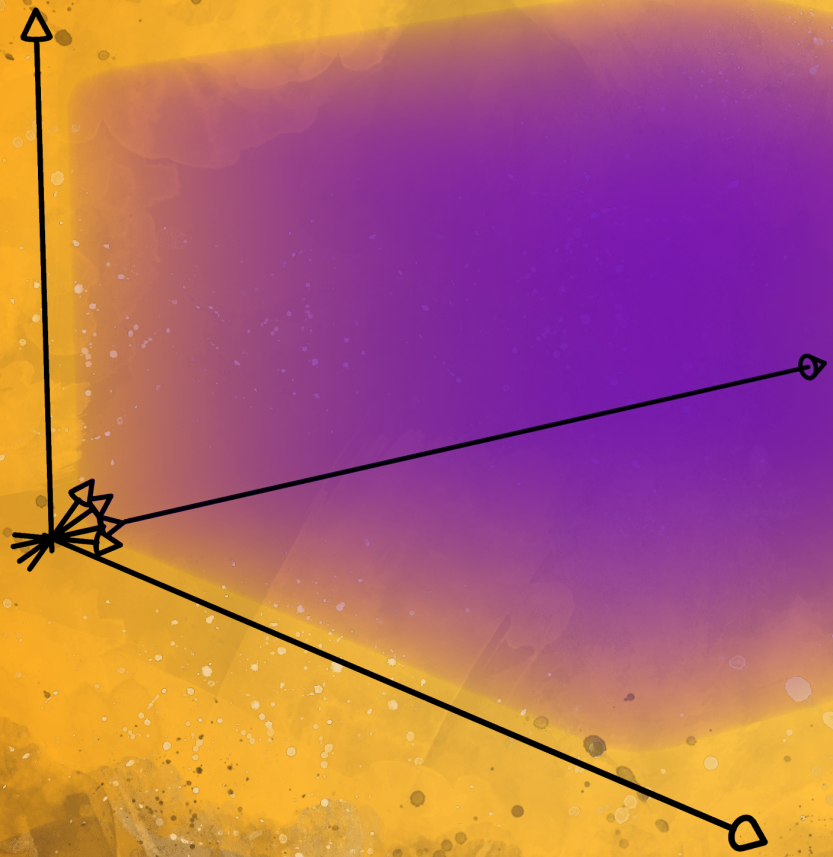
ENS Extended - twice weekly extended to 46 days (#36km)

ERA 5 - reanalysis: IFS physical model fitting measured data (#31 km)

Integrated Forecast System (IFS)

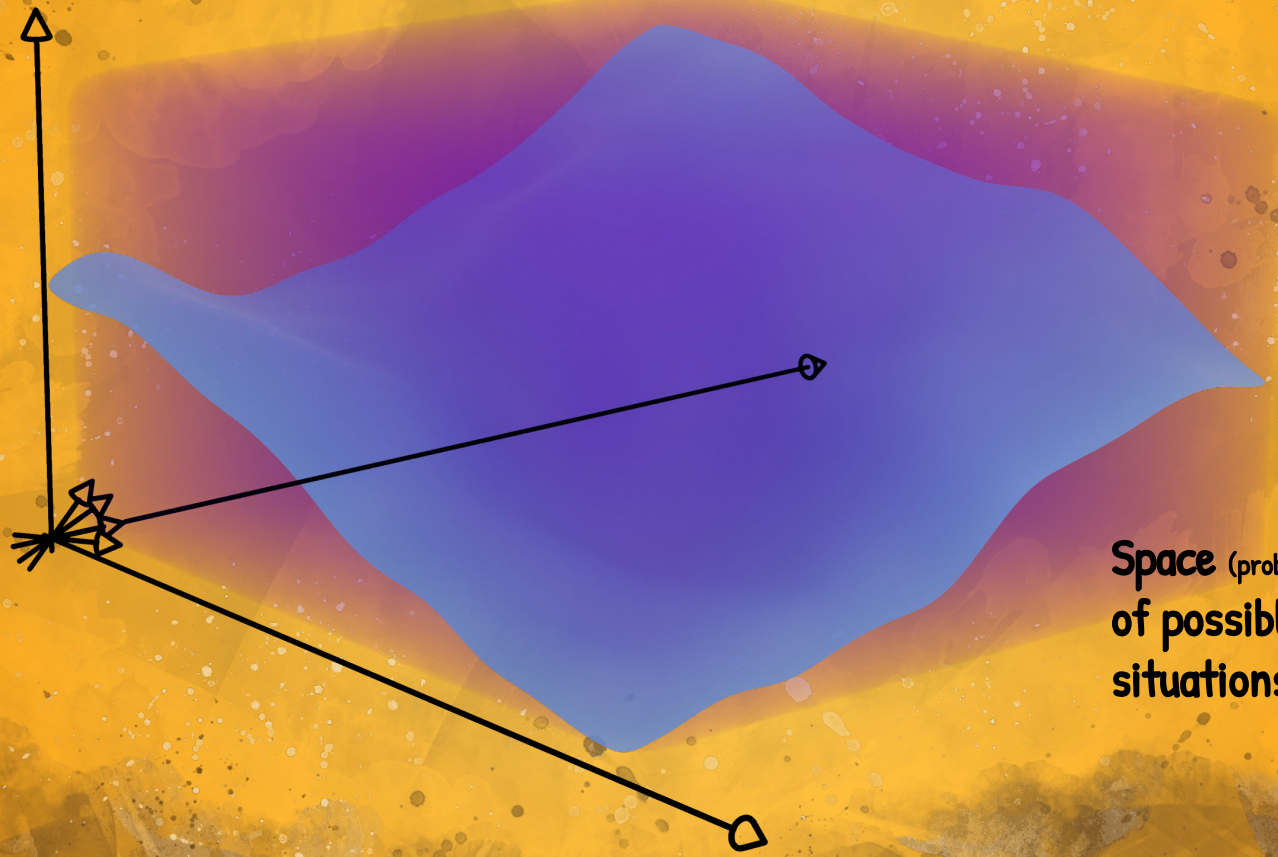


$\mathbb{R}^{N \text{ variables} \times N \text{ spatial points}}$

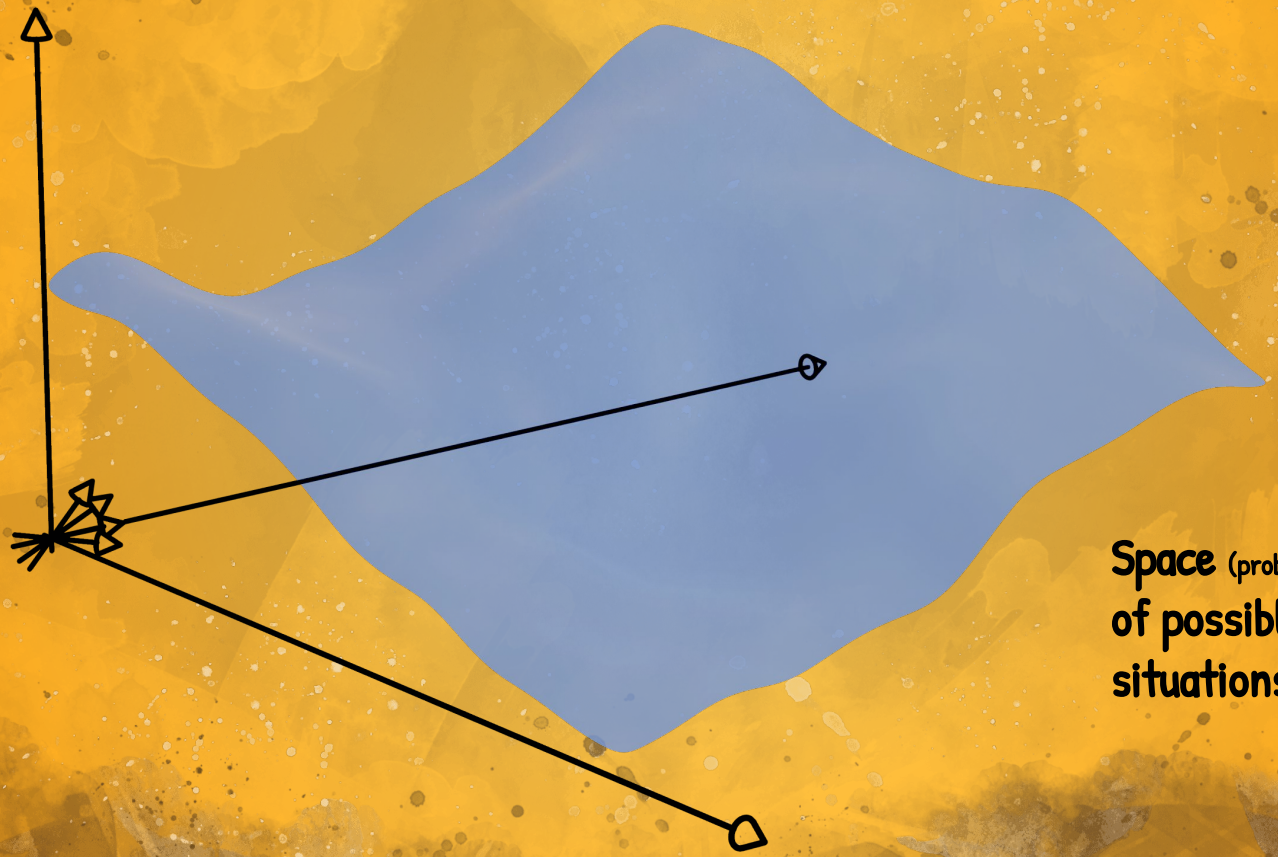


$$U(\mathbb{R}^{\text{N variables} \times \text{N spatial points}})$$

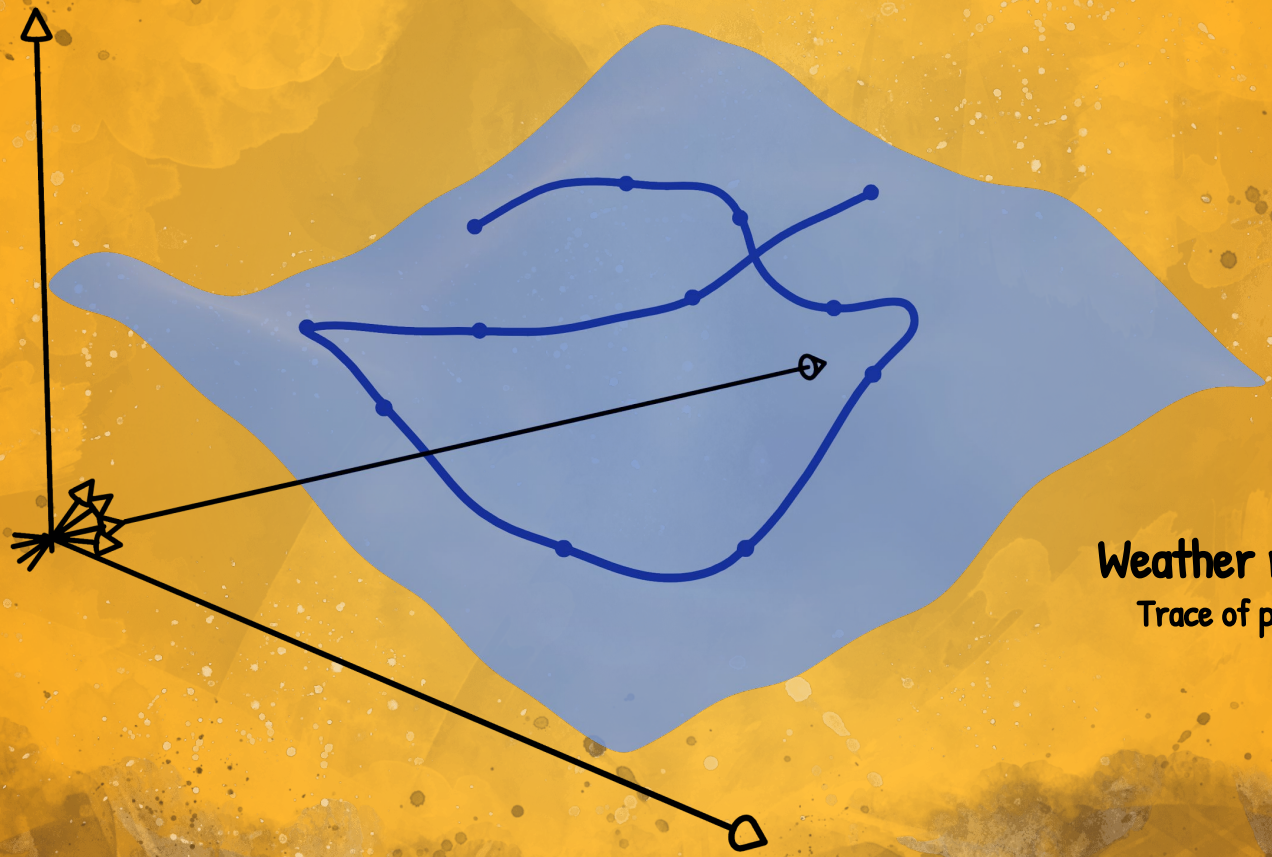
* between some min and max



Space (probability distribution) of possible weather situations

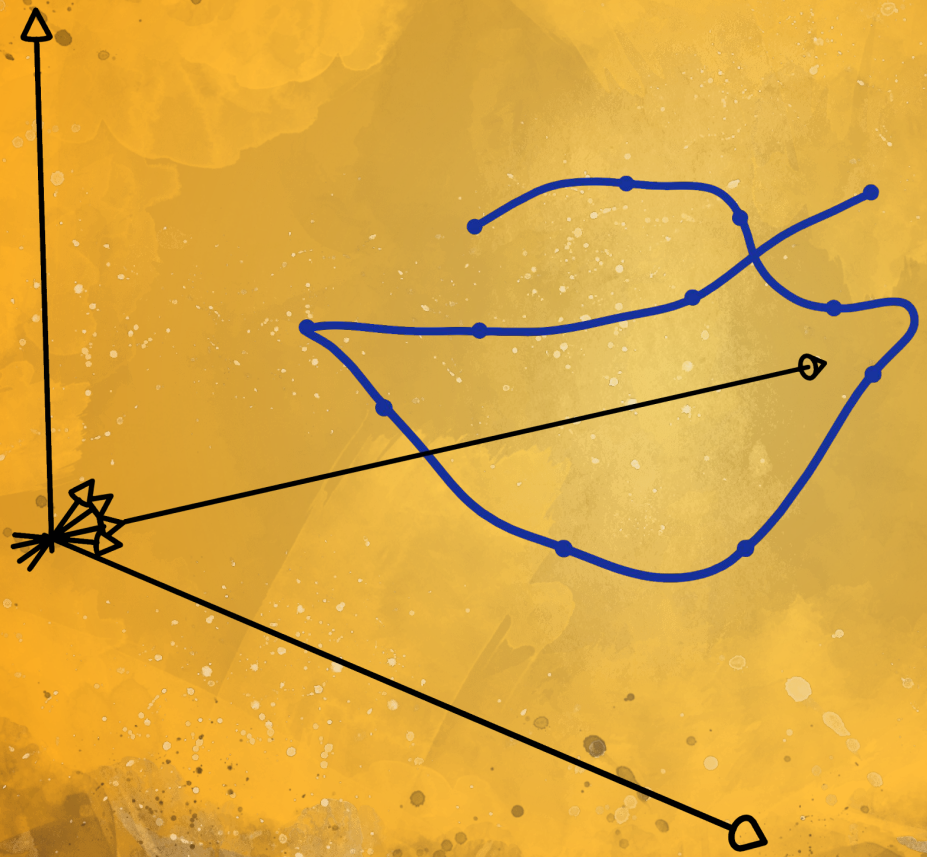


Space (probability distribution) of possible weather situations



Weather record / ERA5

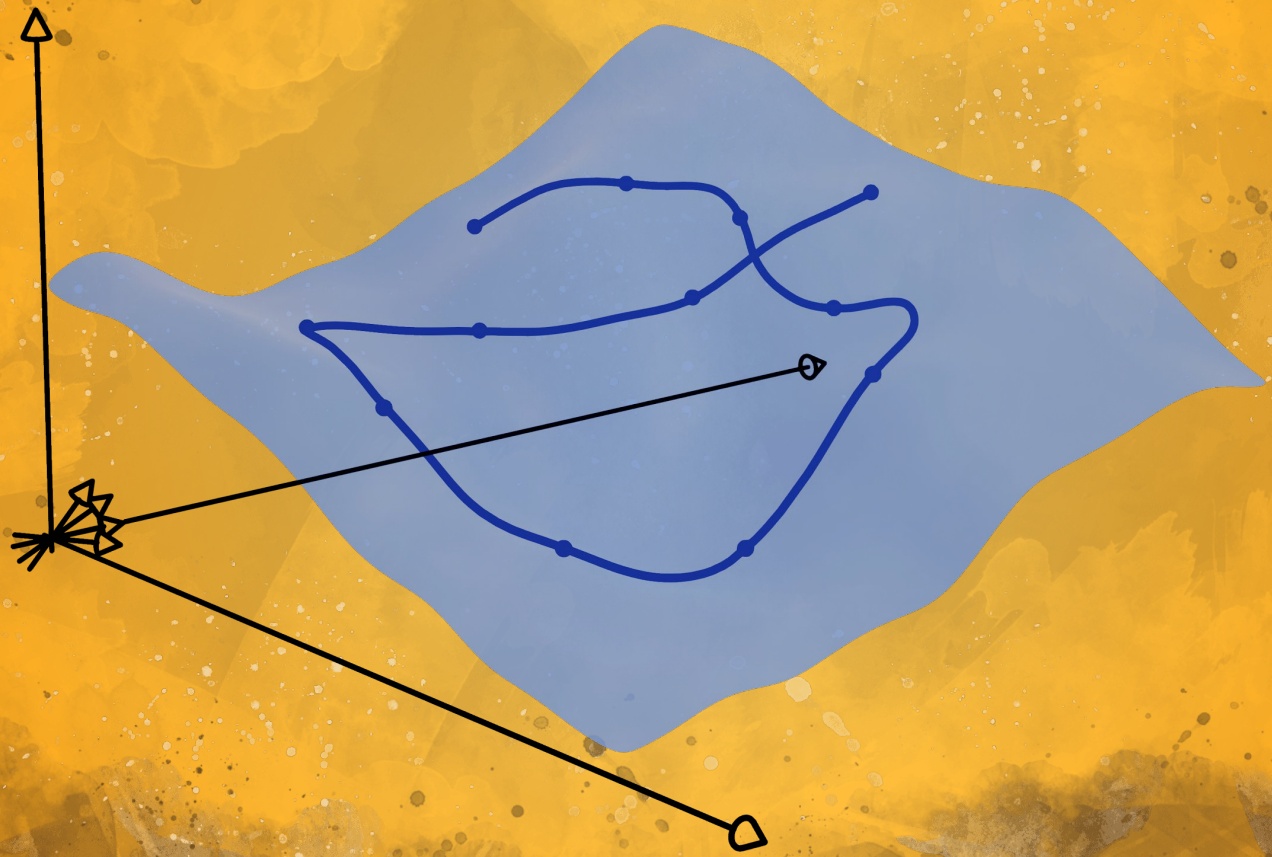
Trace of past observations

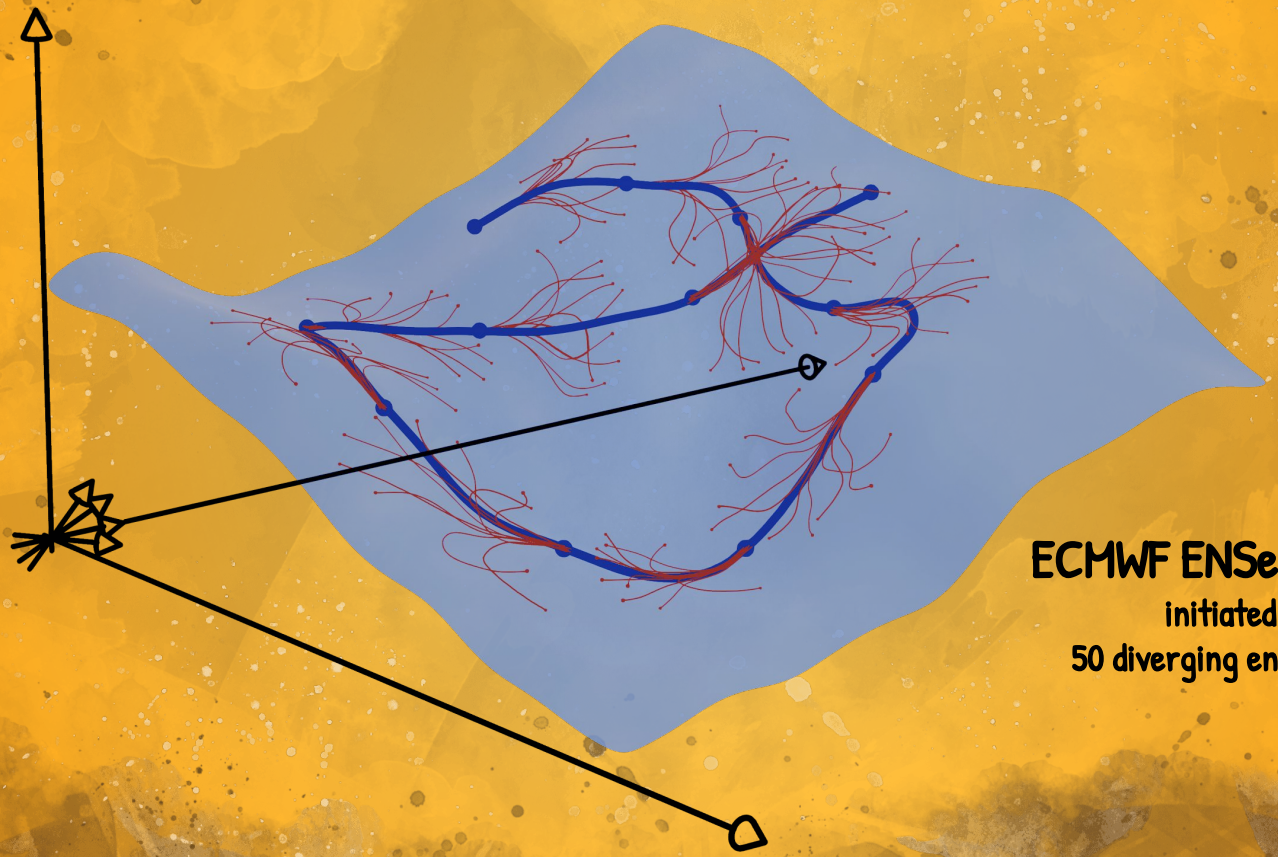


Weather record / ERA5

Trace of past observations

(current evaluation of renewable systems)

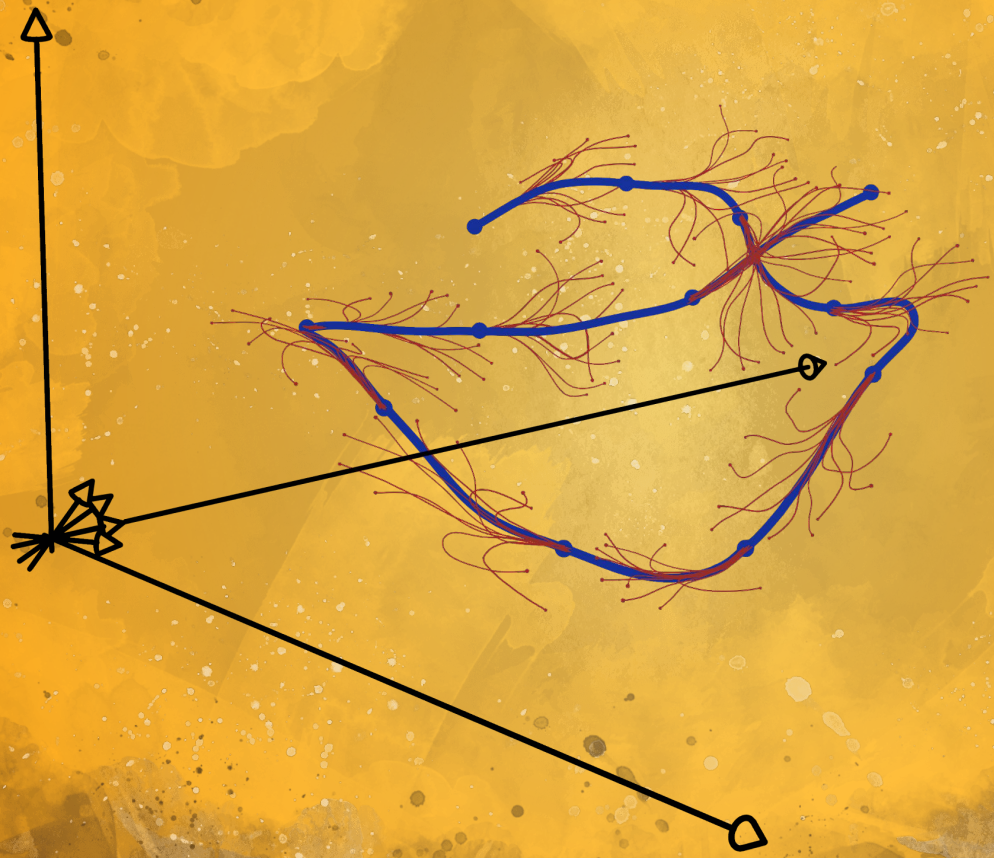




ECMWF ENSemble forecast

initiated 2x a week

50 diverging ensemble members



ECMWF ENSemble forecast

initiated 2x a week

50 diverging ensemble members

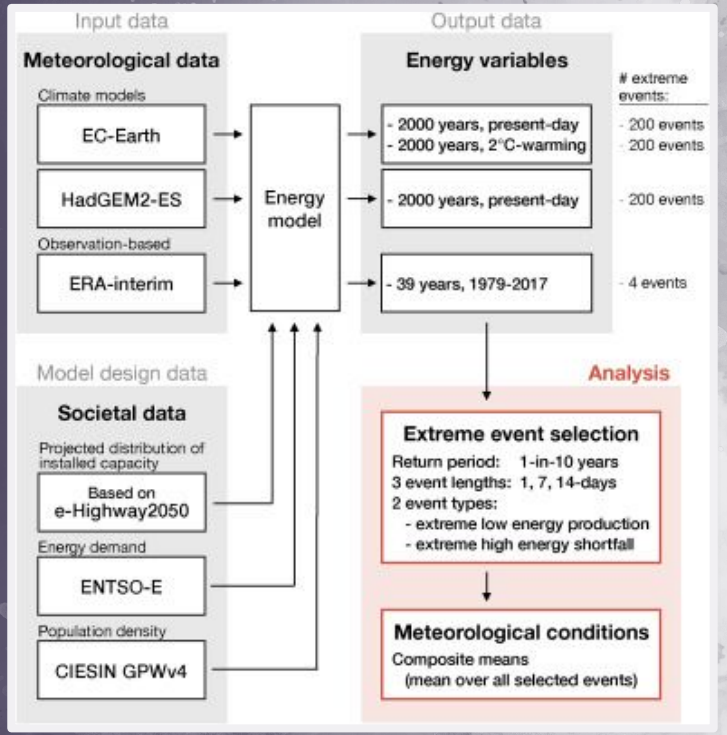
ECMWF ENSemble forecast

initiated 2x a week

50 diverging ensemble members

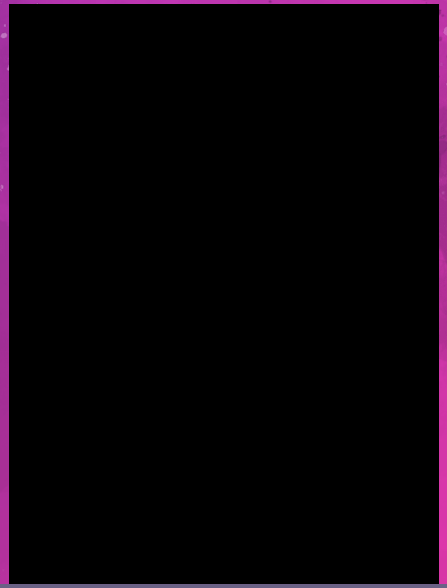
Comparison to GCM Ensembles

- Another approach is using downscaled GCM ensembles (EURO-CORDEX)
- How do you deal with climate-change related distribution shift?
- E.g. van der Wiel, 2019, https://doi.org/10.1016/j.rser.2019.04.065



Collating the ENS dataset

- Past forecast runs are stored on an **offline tape** storage in the ECMWF MARS archive
- Limiting variables and cropping to Europe, only about 3GB are extracted from each forecast tape
- The request for each run falls in a **queue**
  - Rate of Download ≈ 4 months of ENS runs / week
    ≈ 130 Years eq (116 GB)
- the Archive data is under CC BY license



```
2023-05-14 23:51:42 Request submitted
2023-05-15 21:30:13 Processing request
2023-05-15 21:30:13 mars - Request cost: 444,000 fields, .
    78.0496 Gbytes online,609.218 Gbytes on 2 tapes .
2023-05-15 21:30:13 mars - Transfering 687.27 GB .
2023-05-15 21:30:13 Transfering 6.21 GB into output.grib .
2023-05-15 21:41:51 Done
```

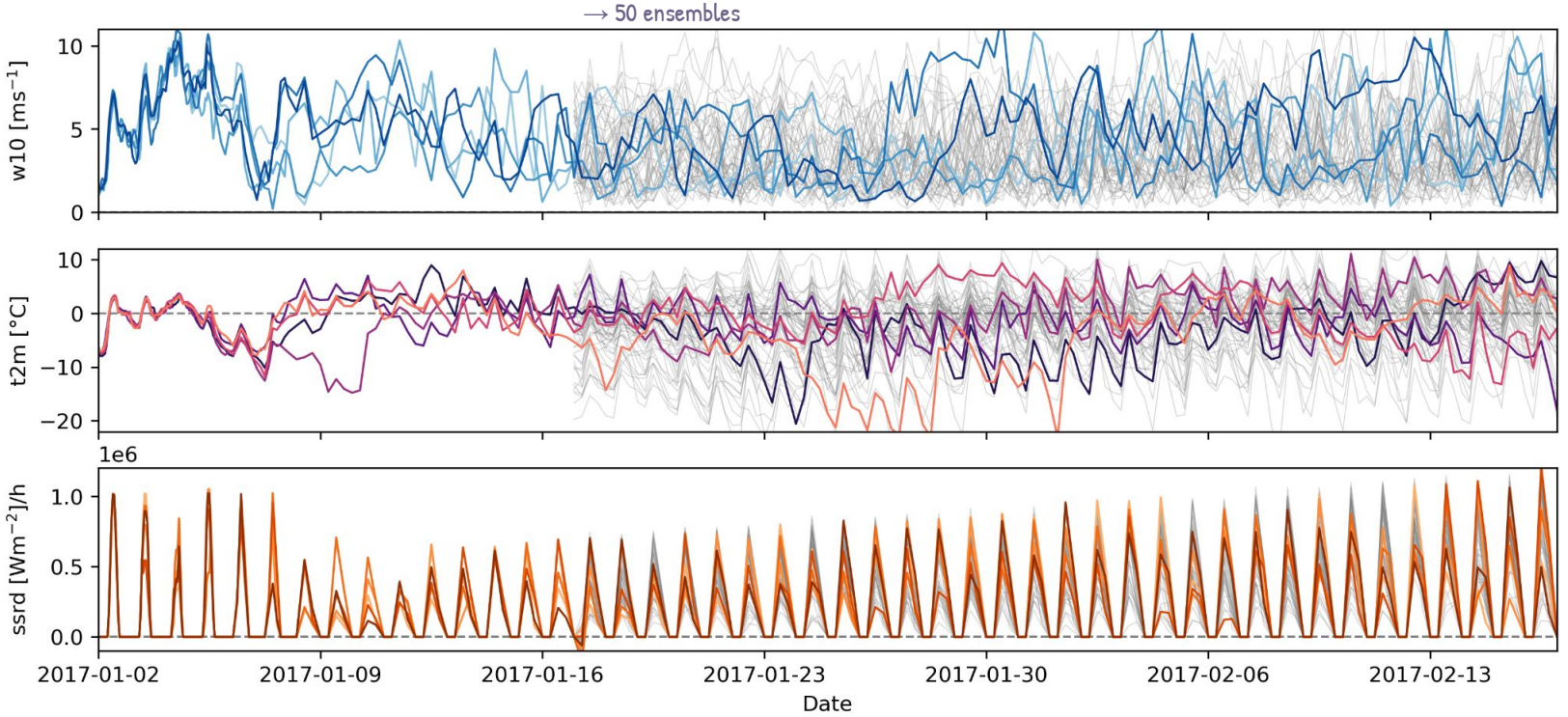
What are the relevant variables?

t2m	[C]	2 metre temperature
w10	[m s**-1]	10m wind speed
w100	[m s**-1]	100m wind speed
ssrd	[J m**-2/h]	Δ Surface short-wave (solar) radiation downwards
strd	[J m**-2/h]	Δ Surface long-wave (thermal) radiation downwards
ssr	[J m**-2/h]	Δ Surface net short-wave (solar) radiation
ro	[m]	Runoff
stl4	[C]	Soil temperature level 4
d2m	[C]	2 metre dewpoint temperature
sp	[Pa]	Surface pressure

Wind Speed at 10m

2m temperature

Surface short-wave radiation downwards

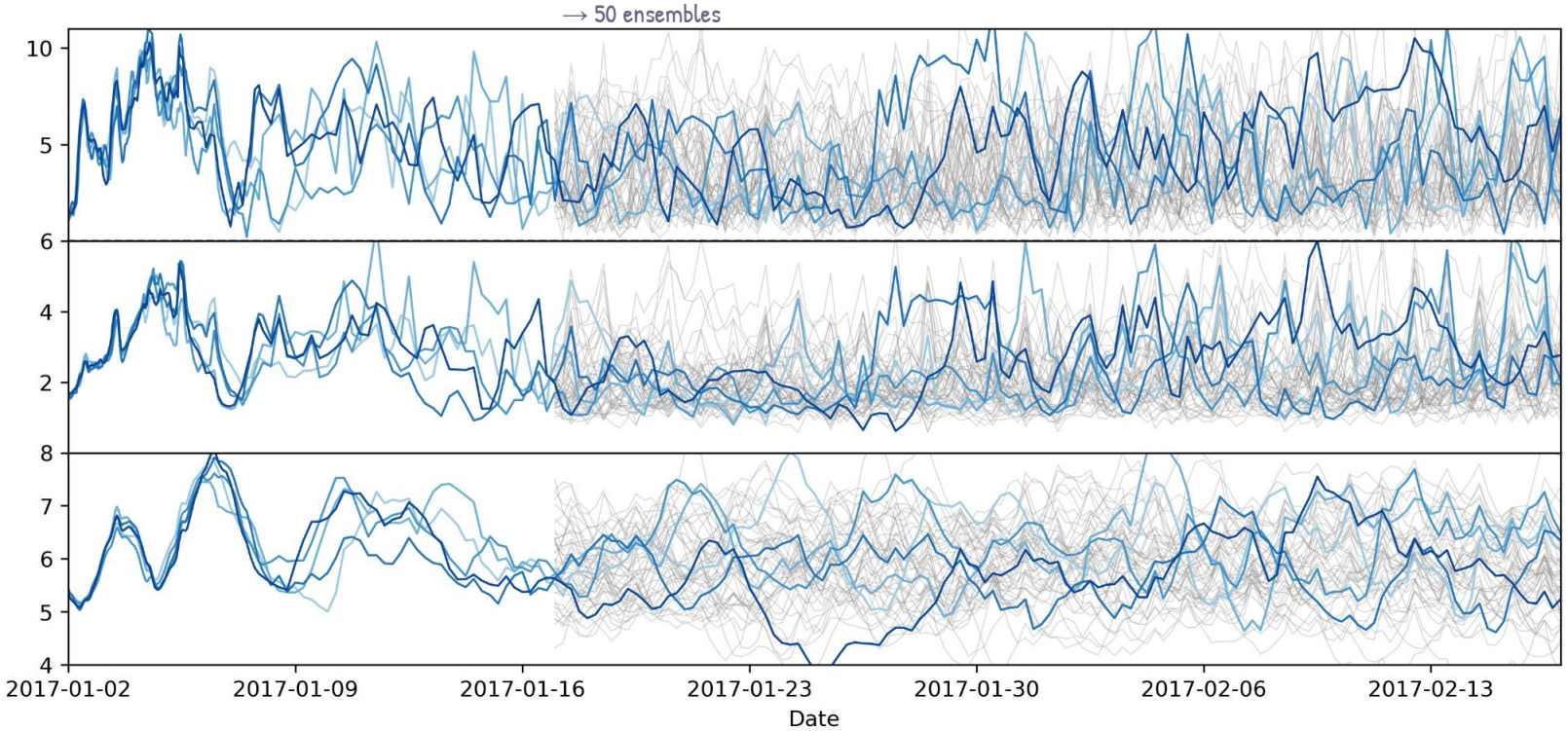


ENS Extended expired forecast for Vienna (2017-01-02)

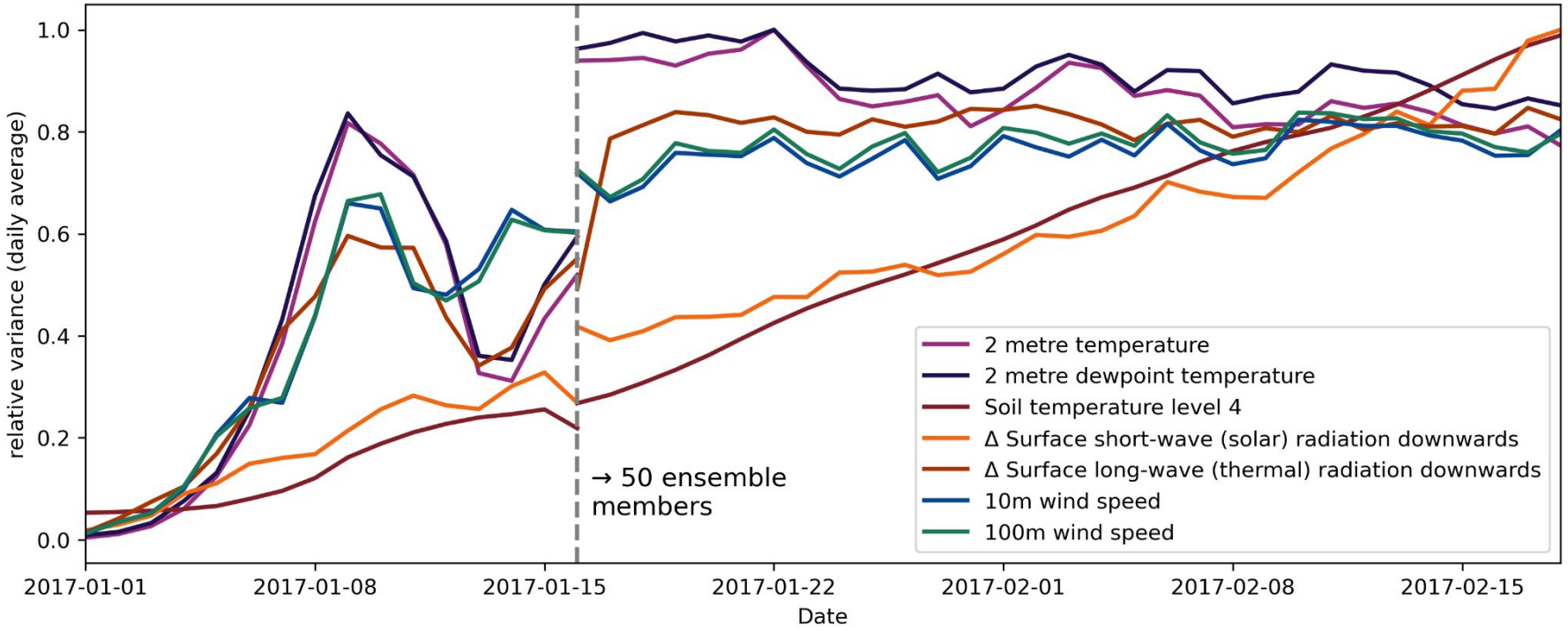
in Vienna

over Austria

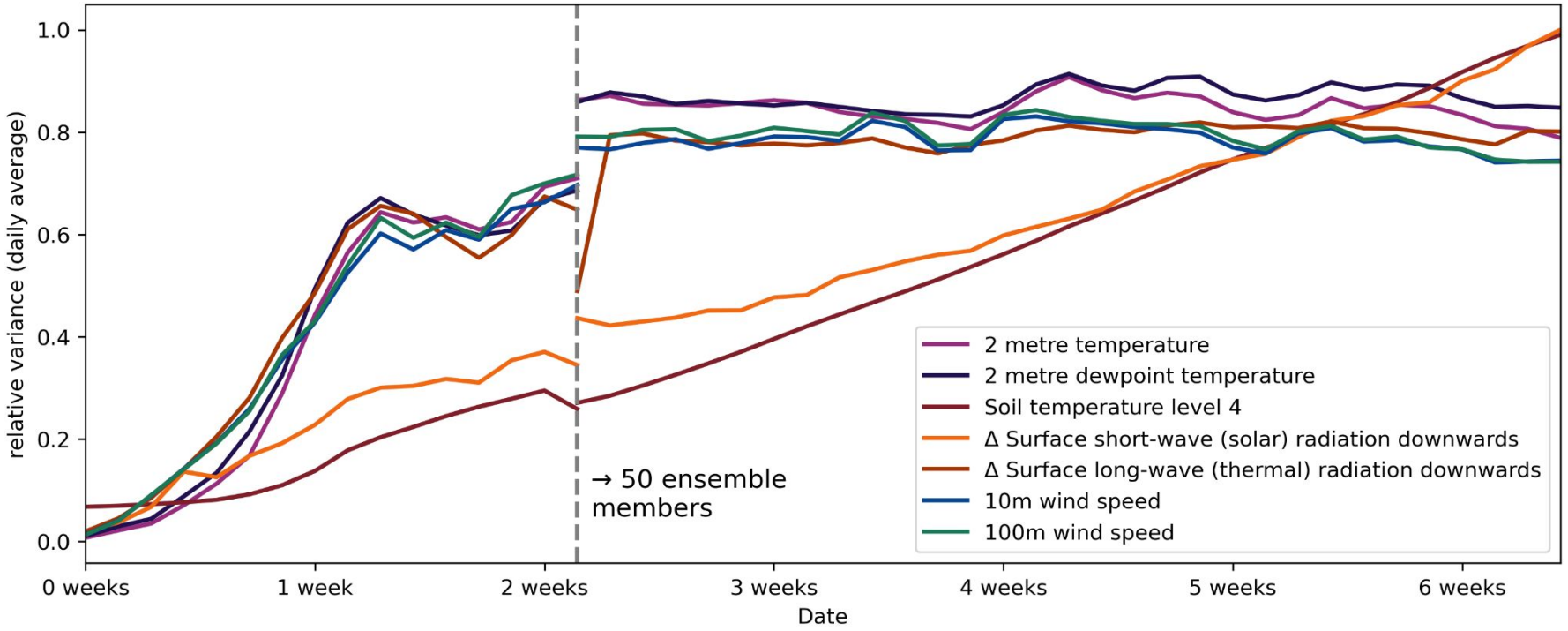
over Europe



ENS Extended expired forecast (2017-01-02) - 10m wind speed [m/s]



Variance between ENS Extended ensemble members



Variance between ENS Extended ensemble members (averaged over a month)

ENS Extended forecast

51 ensemble members ×

2 runs per week ×

4 weeks per run ×

Run since 2008:

× 14 years

5,712 y

ENS Extended forecast

51 ensemble members ×

2 runs per week ×

4 weeks per run ×

Run since 2008:

× 14 years

ENS Reforecast

20 initial conditions* ×

11 ensemble members ×

2 runs per week ×

4 weeks per run

Run since 2016:

× 6 years

16,272 y

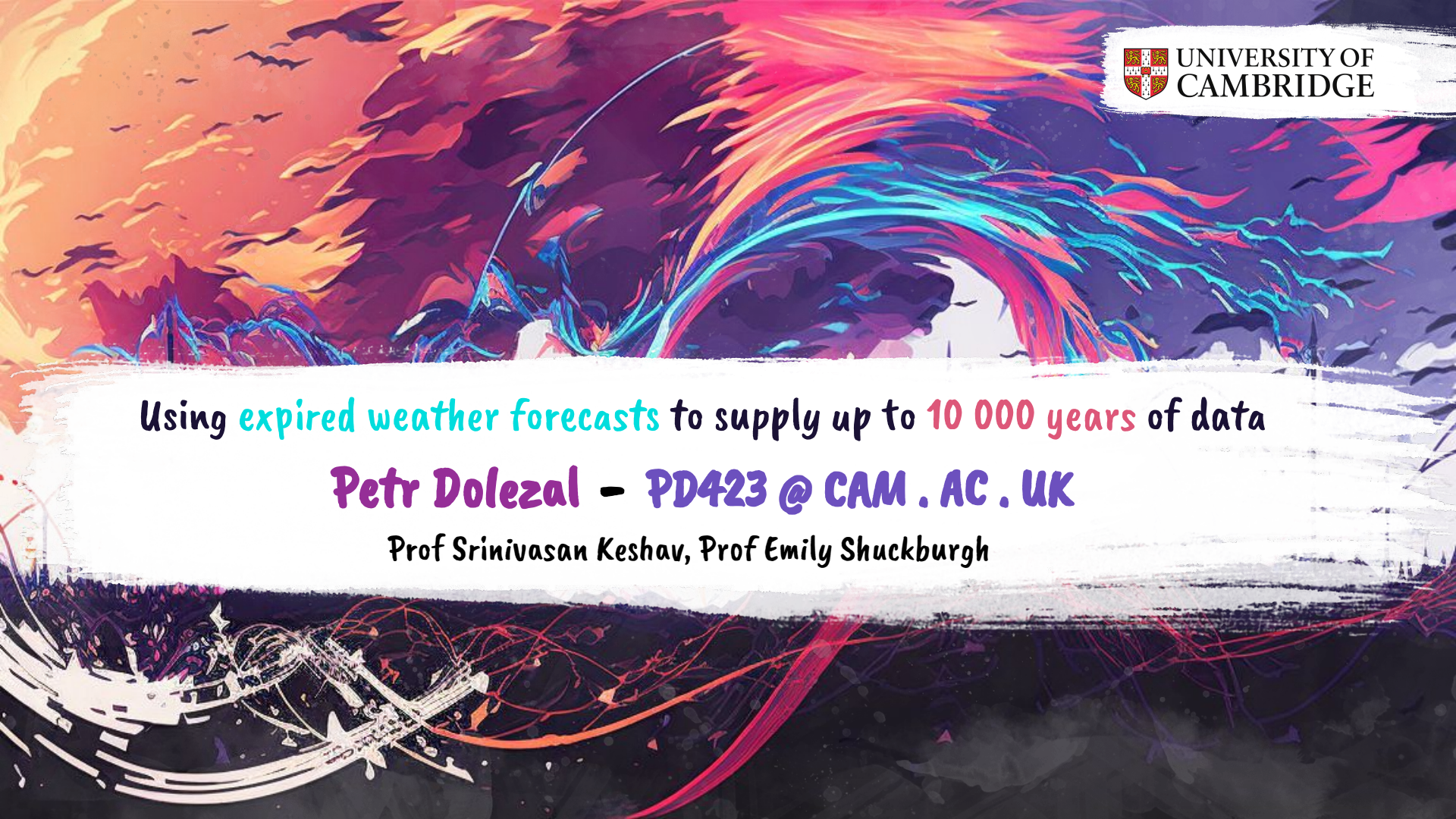
*same day of year in the past 20 years

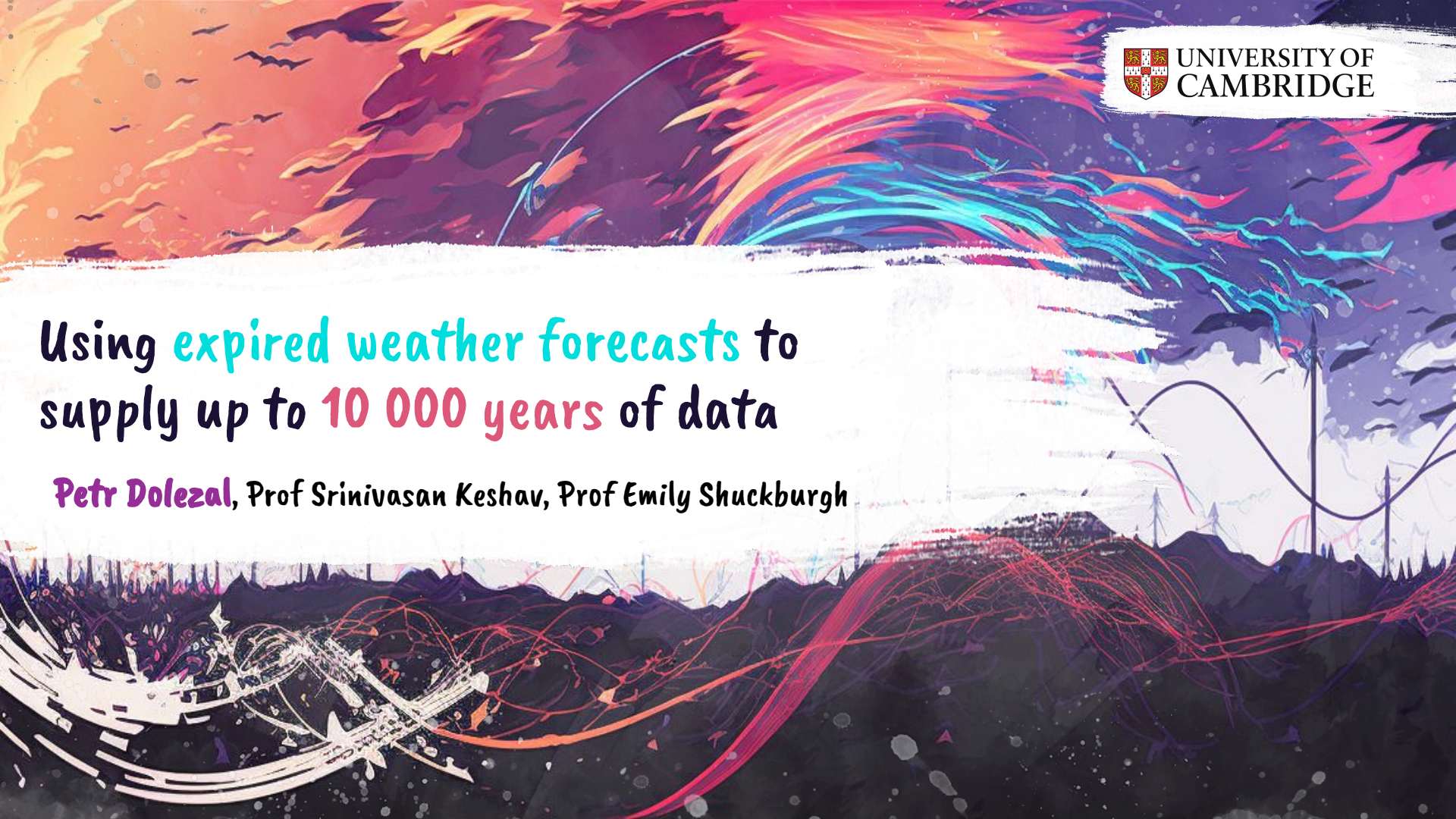
What are the caveats?

- Temporal resolution is the main limiting factor
- Spans multiple model cycles
- Different measure of quality (low bias vs high skill)

???

(tell us what else might be a problem)

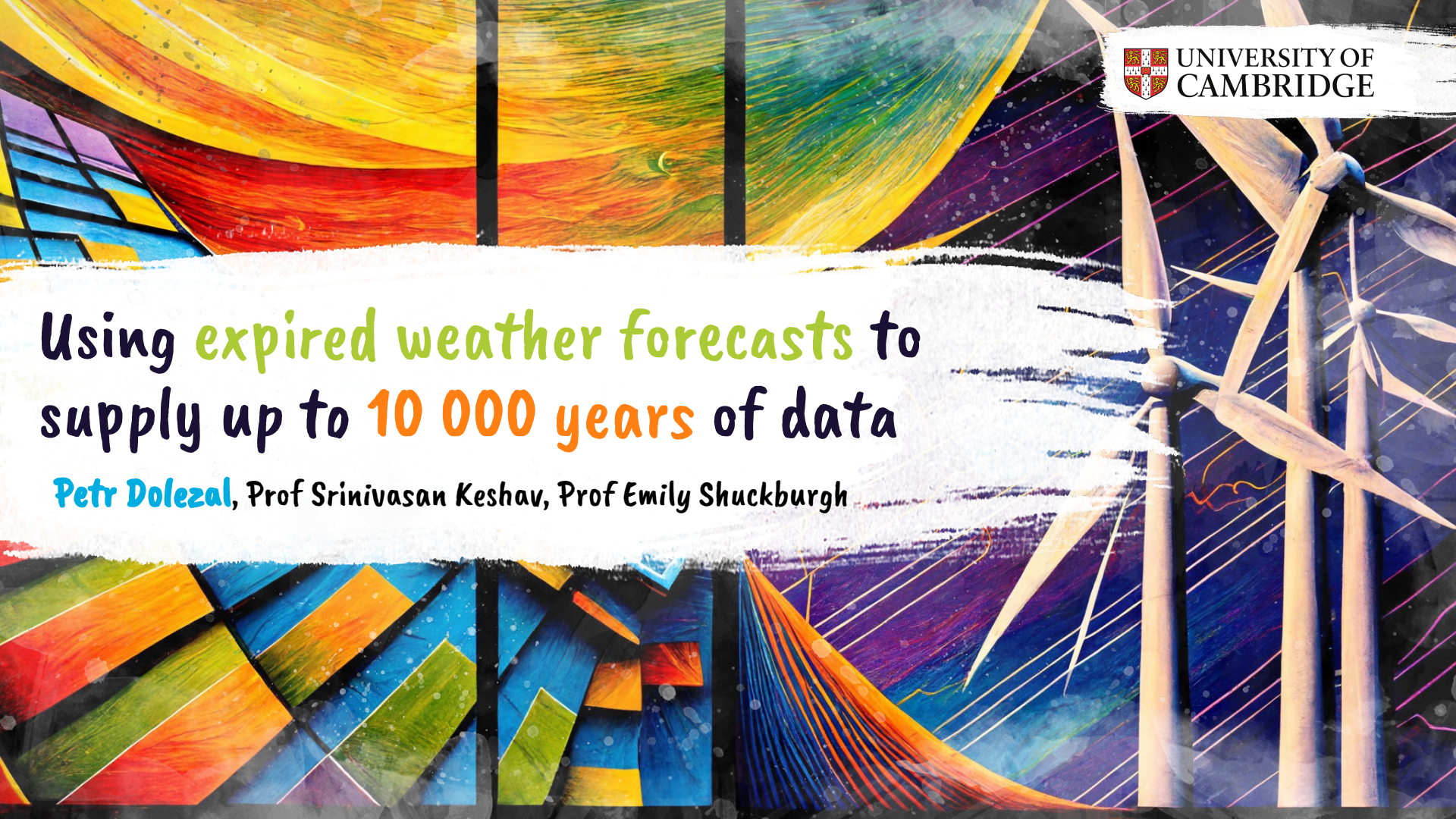

UNIVERSITY OF CAMBRIDGE
Using expired weather forecasts to supply up to 10 000 years of data
Petr Dolezal - PD423 @ CAM . AC . UK
Prof Srinivasan Keshav, Prof Emily Shuckburgh



UNIVERSITY OF CAMBRIDGE

Using expired weather forecasts to supply up to 10 000 years of data

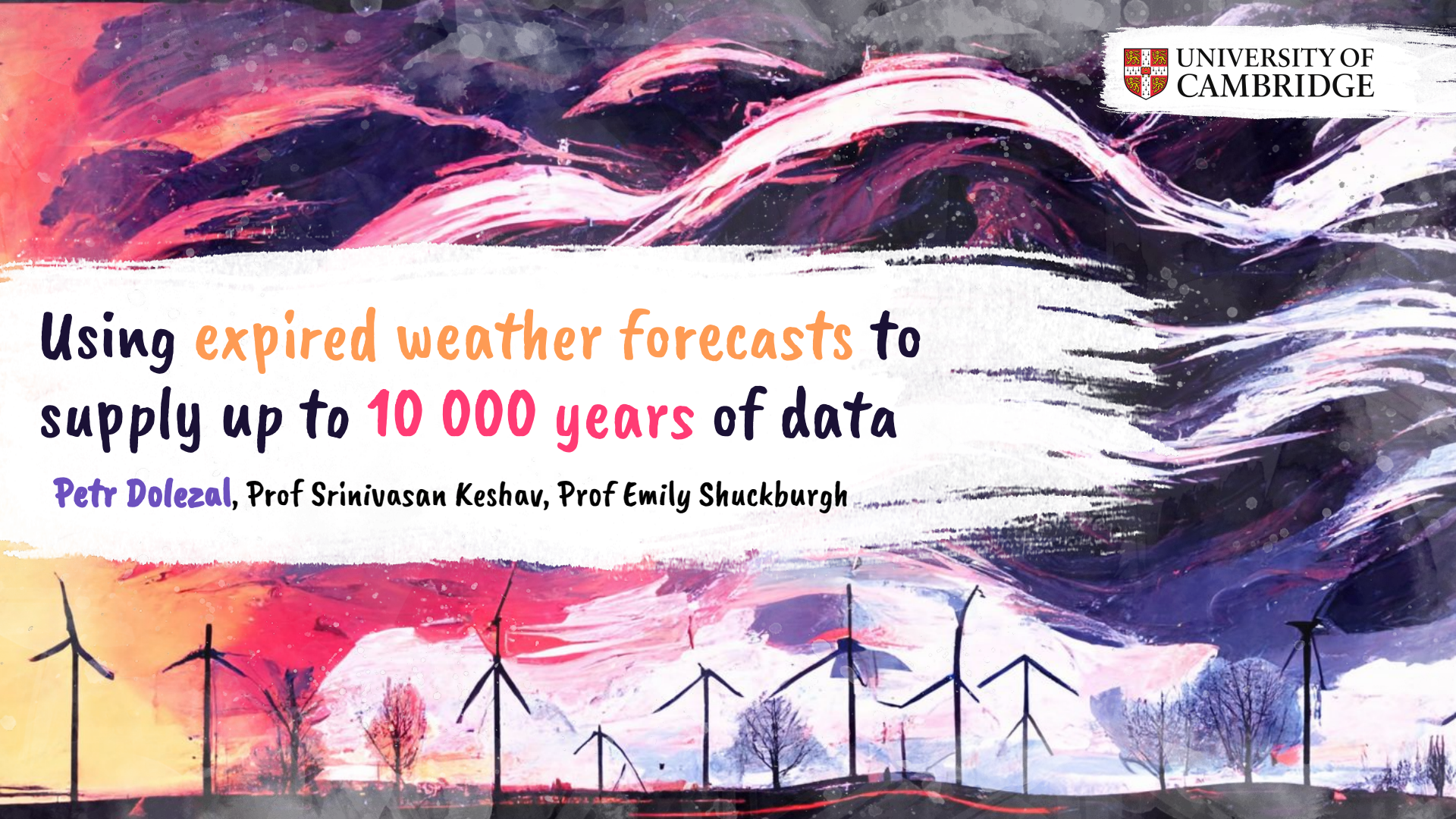
Petr Dolezal, Prof Srinivasan Keshav, Prof Emily Shuckburgh



UNIVERSITY OF CAMBRIDGE

Using expired weather forecasts to supply up to 10 000 years of data

Petr Dolezal, Prof Srinivasan Keshav, Prof Emily Shuckburgh


UNIVERSITY OF CAMBRIDGE
Using expired weather forecasts to supply up to 10 000 years of data
Petr Dolezal, Prof Srinivasan Keshav, Prof Emily Shuckburgh