



**CAFE**  
Climate Advanced Forecasting  
of sub-seasonal Extremes



# *Ensemble weather forecast with a stochastic weather generator and analogs of the atmospheric circulation*

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# Introduction

## Ensemble weather forecast is needed...

- ⊙ To trigger early action to mitigate weather catastrophes,
- ⊙ To optimize decisions for agriculture sector (crops, fertilization...), energy sector and water management,
- ⊙ Attribution of extreme events.

### CLIMATE CHANGE

## Studies tying weather extremes to global warming gain rigor

Record-shattering events spur climate attribution advances

By Paul Voosen

In June 2021, a jet stream charged with heat and chaotic energy from a nearby cyclone stalled over the Pacific Northwest. The mass of trapped air baked the already hot landscape below to a record 49.6°C. More than 1000 people died from heat exposure.

Scientists quickly began working to figure out how much of the blame for the heat wave could be laid to global warming. But the heat was so unusual, the weather so weird, that it broke their methods. "It challenged our techniques, our climate models, and our statistical analysis methods," says Michael Wehner, a climate scientist at Lawrence Berkeley National Laboratory who participates in the World Weather Attribution (WWA) initiative. WWA ultimately issued a statement, find-

events so extreme that there is no historical record for comparison.

In one existing method, researchers use climate models to simulate decades of climate history under current conditions and in preindustrial times, before warming set in. They tally up weather events that are similar to the extreme at hand in the two simulations and compare the frequencies to see whether warming increased the odds of the event occurring. In a second method, they shorten the timescale and run a model several hundred times under current and preindustrial conditions to see how often the extreme event would occur in each world. In a third method, researchers force models to re-create the actual atmospheric conditions recorded in the few years leading up to an event, then see how they unfold in counterfactual worlds with less warming. Although

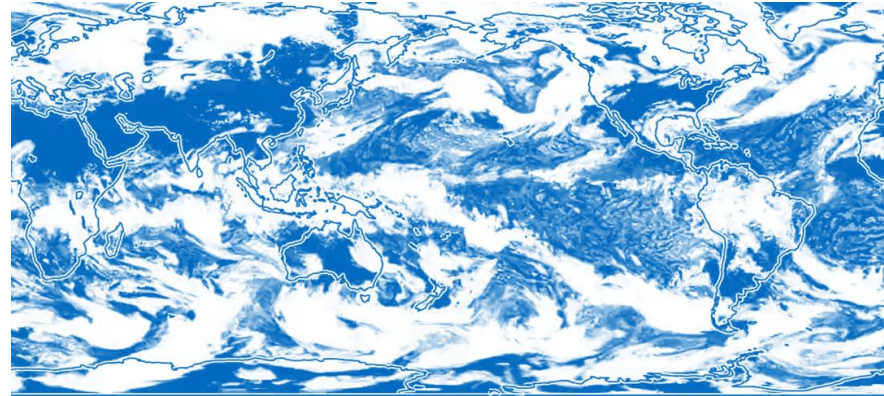
©Paul Voosen - SCIENCE 17 June 2022.

# Introduction

## Sub-Seasonal forecast

- ◎ The Gap between weather and Climate forecasting,
- ◎ Sources of predictability associated to the atmosphere (Madden Julian Oscillation..)  
Ocean conditions, Land processes (Soil moisture, snow cover..),
- ◎ Helps to mitigate weather extremes and to make decisions.

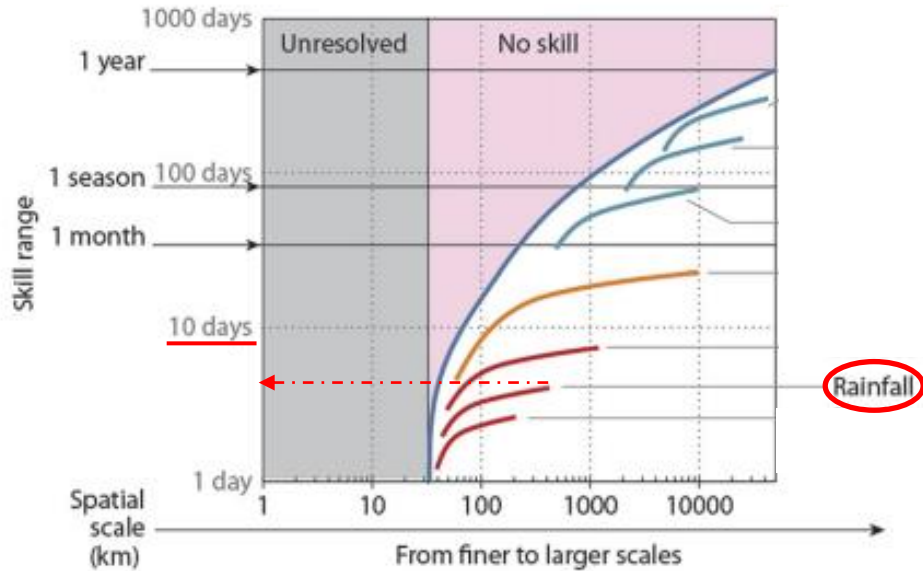
*Few days to years...*



©Kris Karnauskas @OceansClimateCU (Twitter)

# Current state of Art

## Evolution of the skill scores



©W.Robertson & Vitart 2019

## Scientific challenge

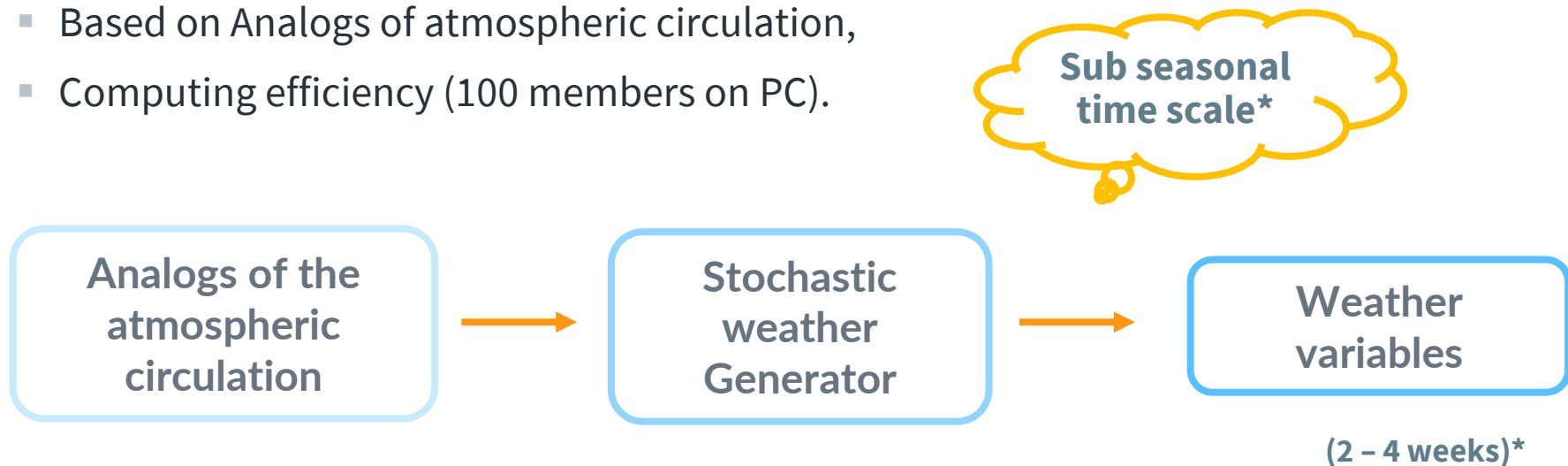
Would it be possible to improve the forecast @ a sub seasonal lead time, using a statistical - probabilistic approach?

For precipitation in Europe?

MJO tropics?

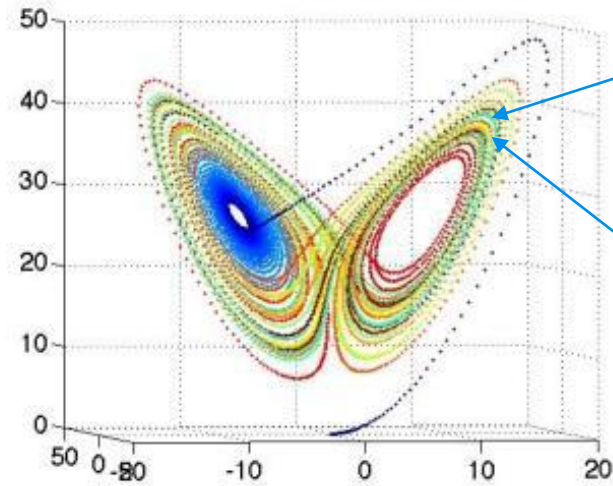
# Our forecast approach

- Stochastic weather generator developed by P. Yiou (2013) ,
- Tested on **NAO** (Yiou and Déandreis, GMD, 2019), **precipitation** (Krouma et al., GMD, 2022), **MJO** (Krouma et al., ESD, 2022)
- Based on Analogs of atmospheric circulation,
- Computing efficiency (100 members on PC).

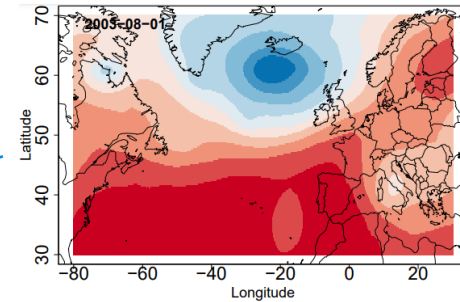


# Analogs of the atmospheric circulation

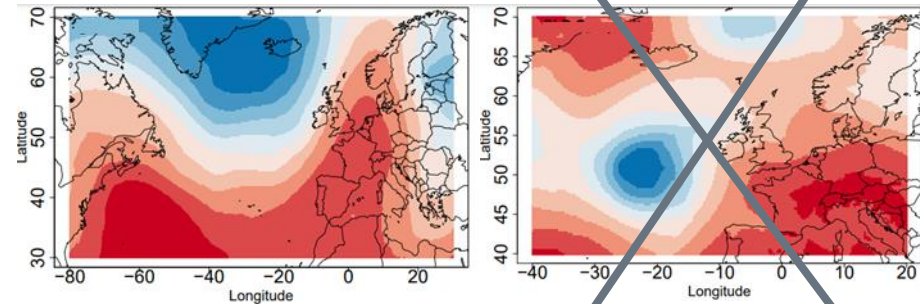
Recurrence in phase space



Day "d"



Day analog d'



©Faranda et al., 2017, Yiou., 2013

# How it works?

**Today is 27/09/2022,  
we would like to forecast precipitation for 5 days  
ahead**

**How will we proceed?**

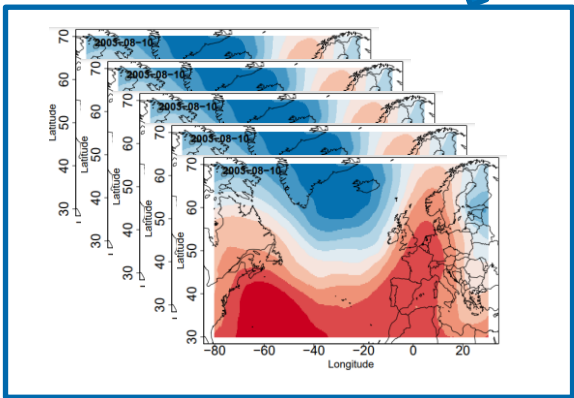


# How it works?

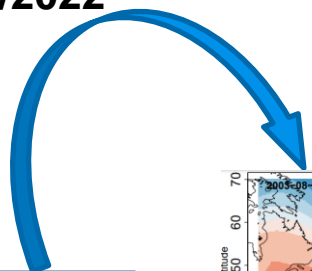
Today:  $d = 27/09/2022$

Analog of today is  $d' = 03/09/1994$

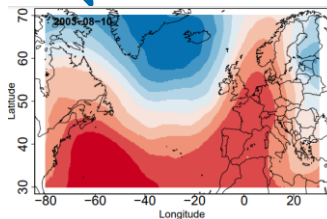
Forecast in 5 days  $d = 07/09/1994$



20 Analogs



03/09/1994

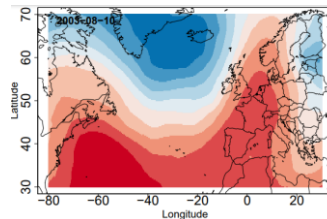


Precip 1

Today



07/09/1994



Precip 2

Forecast for 01/10/2022

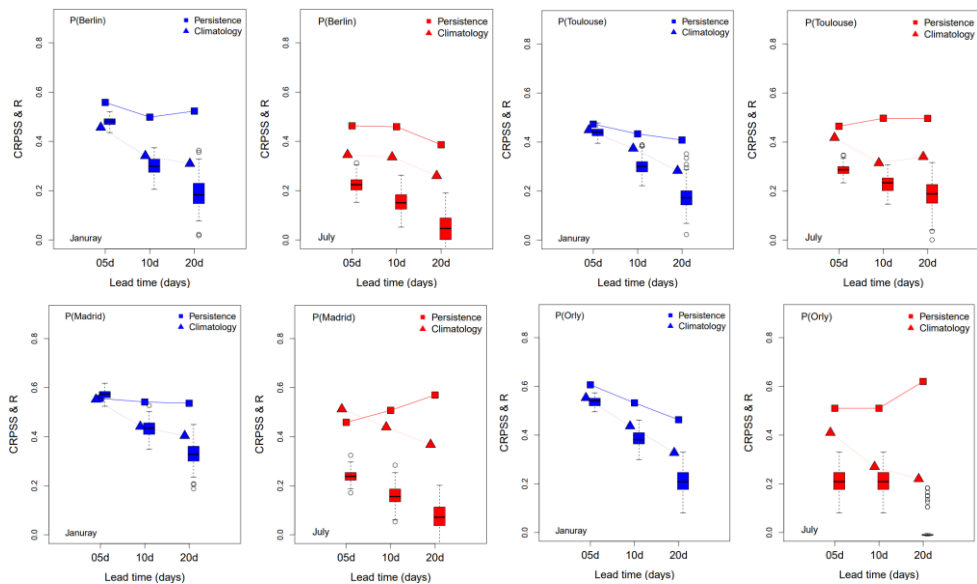
SWG

©Krouma et al., (GMD) 2022, Platzer et al., (JAS) 2021.



# Ensemble forecast of European precipitation

- As proof of concept, Analog-SWG was able to forecast the precipitation up to 10 days in winter at local level in different European areas (Krouma et al., GMD, 2022)
- Improving the forecast of European precipitation for 35 days ahead using dynamical models. (Krouma et al., to be submitted). → See the poster session.

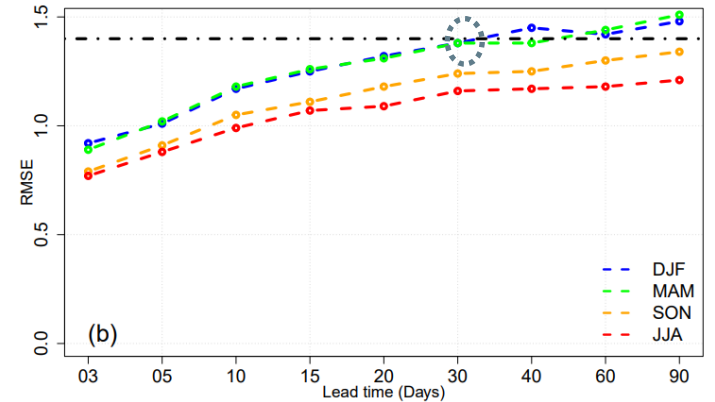
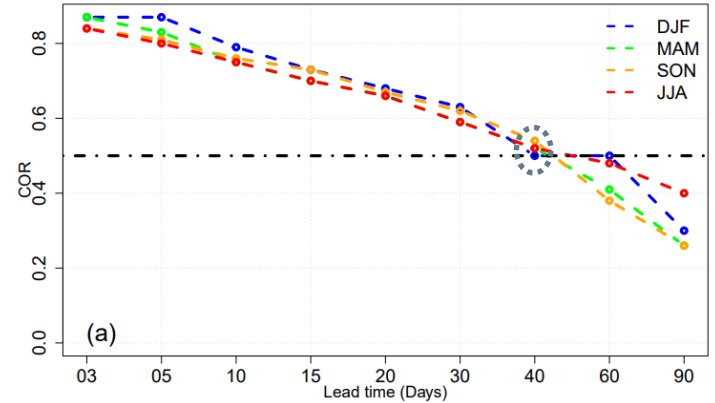


Precipitation forecast skill for European cities

©Krouma et al., (GMD) 2022.

# Ensemble forecast of the MJO

- ◎ The forecast is sensitive to seasons → The forecast for DJF and MAM has a good skill until 30 days. However, JJA and SON the SWG forecast is good until 40 days.
- ◎ Good discrimination skill of the SWG forecast → to distinguish between events and nonevents of the MJO amplitude until 40 days (Krouma et al., ESD, 2022).



©Krouma et al., (ESD) 2022

# Applications @company



Wind farm company for wind forecast ( ARIA do Brasil),



Agriculture sector for precipitation forecast (ARIA do Brasil),



Ship routing company (onging proposal).

# Conclusions

- ◎ The performance of analogs weather generator shows skill to forecast the European precipitation and MJO indices.
- ◎ Atmospheric circulation is useful for weather forecasting.
- ◎ The HC-SWG showed its capacity to distinguish between events and non-events of precipitation as well as extreme precipitation at least for a lead time of 10 days and MJO (active/inactive Amplitude),
- ◎ The comparison with ECMWF & machine learning forecasts confirmed the good performance of SWG quantitatively and qualitatively.

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