Setting the ground for AI-enhanced drought monitoring and forecasting

https://edo.jrc.ec.europa.eu
https://edo.jrc.ec.europa.eu/gdo

Arthur H. Essenfelder

European Commission - Joint Research Centre

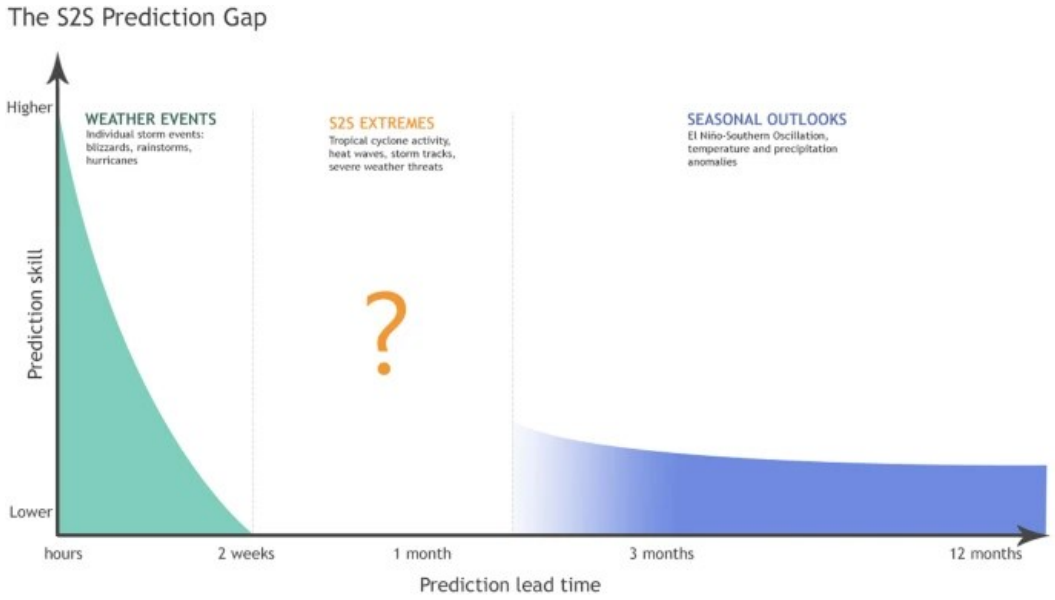
arthur.hrast-essenfelder@ec.europa.eu

ITUevents, in collaboration with the WMO and the UN Environment Programme
Workshop on "Artificial Intelligence for Natural Disaster Management"
24 October 2022

Challenges in *(AI/ML for)* Sub-Seasonal and Seasonal Forecasting

Sub-Seasonal to Seasonal (S2S) Forecasting

- Weather forecasts have greatly improved over the past decades
  - E.g.: Forecasts at day 5 are nowadays more accurate than day 3 forecasts issued in the 1980s
- Yet, prediction skill sharply decreases after weeks 1 or 2
  - Increasing evidence shows that the various sources of S2S predictability are not always independent and interact with longer or shorter timescales (e.g. Madden Julian Oscillation impacts on extratropical weather)
  - The “loss” of skill is particularly true for low-frequency events, such as extreme weather events including tropical cyclones, droughts, floods and heat waves.
- The recent advancements in S2S modelling capabilities and data availability offers a fertile ground for AI/ML application
  - The ever increasing quality and quantity of monitoring/observational and reanalysis data to support big-data analysis and deep-learning models
  - The development and refinement of AI/ML algorithms can help unravelling the complexity of S2S forecasting
  - The increasing developments in computing power (e.g. Supercomputers, Tensor Processing Unit (TPU) by Google, Tensor Cores by Nvidia)



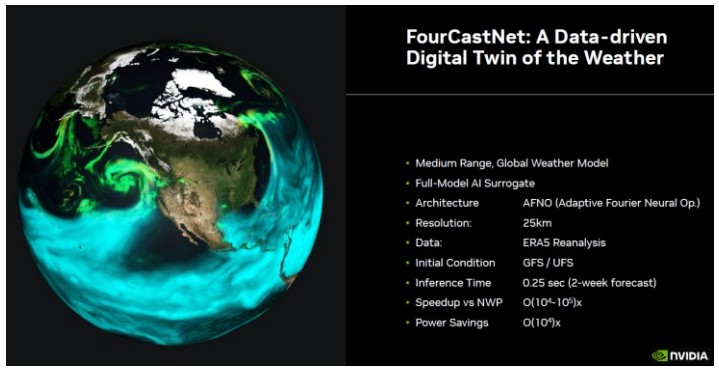
Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

Source: Mariotti, A., Ruti, P.M. & Rixen, M. Progress in subseasonal to seasonal prediction through a joint weather and climate community effort. *npj Clim Atmos Sci* **1**, 4 (2018). https://doi.org/10.1038/s41612-018-0014-z

European Commission

Current Initiatives in AI/ML for S2S Forecasting

Source: arXiv:2202.11214 [physics.ao-ph]



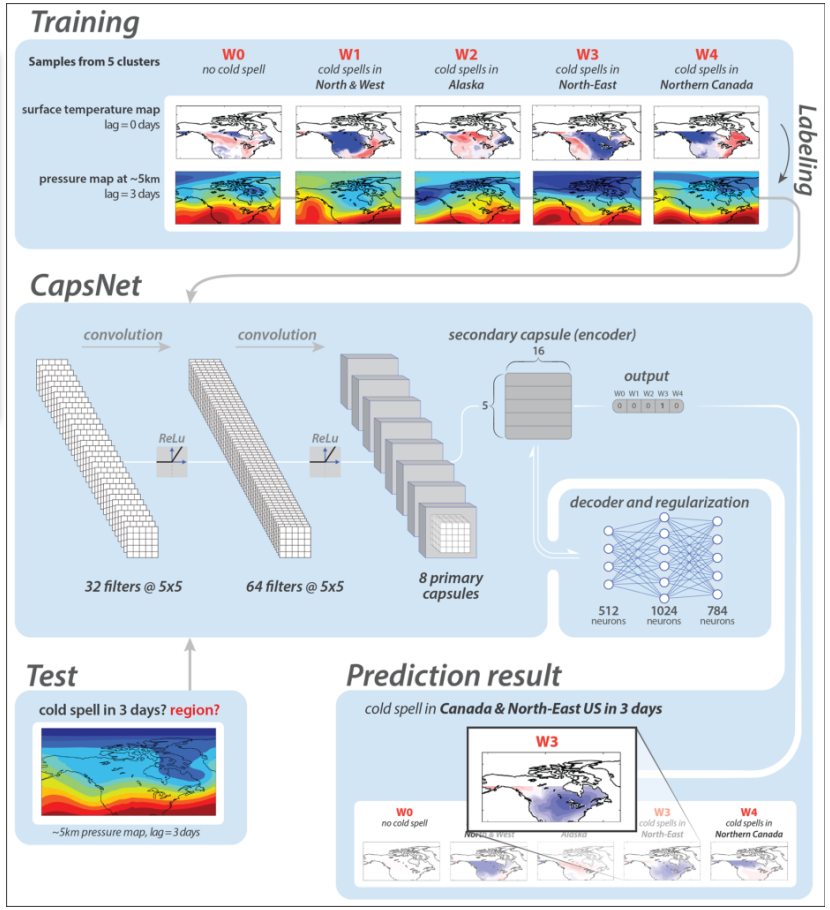
Source: arXiv:2202.11214 [physics.ao-ph]

CLINT
CLIMATE INTELLIGENCE

EXTREME EVENTS
HOTSPOTS
MACHINE LEARNING

XAIDA

AI4CS
AI-enhanced Climate Services



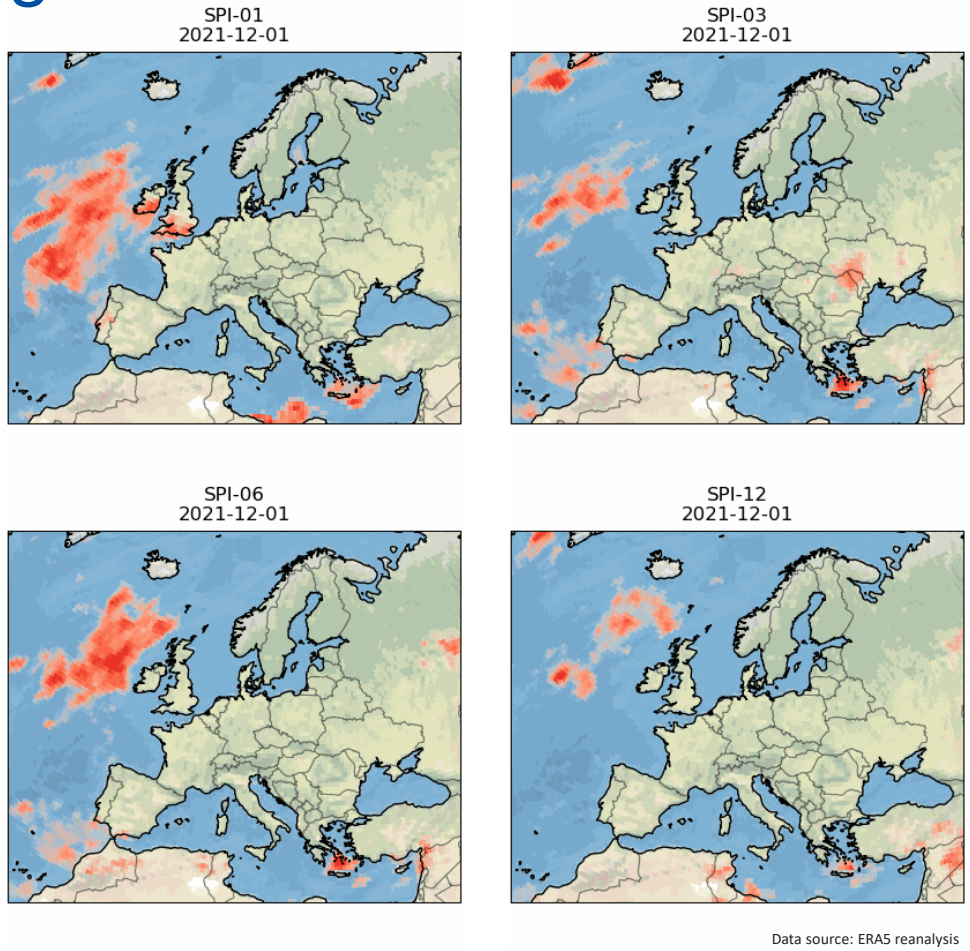
Source: Chattopadhyay et al., 2020, https://doi.org/10.1029/2019MS001958, CC BY 4.0

European Commission

Challenges in S2S Forecasting for Droughts

Drought S2S Forecasting

- Why extreme events, such as droughts, matter?
  - High-impact, low-frequency event are economically and environmentally relevant
- S2S forecasting of slow-onset events is challenging:
  - As slow-onset events usually fall under the S2S forecasting horizon, extreme events such as drought are particularly challenging to forecast
- Moreover, droughts are not trivial to define in time and space
  - E.g., with respect to rapid-onset events such floods, tropical cyclones, or even heat waves, droughts are not trivially identifiable
  - Moreover, a “same” drought event might impact a variety of sectors in different ways, leading to the definition of different types of droughts (e.g. meteorological, hydrological, agricultural)
- The main challenge is on predicting the probability of large-scale, long-lasting patterns a few weeks in advance, and their impacts on the environment and the society:
  - E.g., through new weather/climate services, early warnings and actions in response to extreme events



AI-enhanced Climate Services

European Commission

European (EDO) and Global (GDO) Drought Observatories

Standardized Precipitation Index (SPI)

- SPI at SYNOP stations from the MARS database
- SPI at SYNOP stations interpolated to 0.25dd grid
- interpolated SPI for Eurostat NUTS3 regions

Soil Moisture Anomaly (SMA)

- Last Daily Soil Moisture Index (SMI)
- Last Daily Soil Moisture Index (SMI) Forecast
- Last Daily Soil Moisture Index (SMI) Anomaly Forecast
- Ten-daily Soil Moisture Index (SMI)
- Ten-daily Soil Moisture Index (SMI) Anomaly

Vegetation Productivity (fAPAR) Anomaly

- fAPAR values
- fAPAR anomalies

Low-Flow Index

- Observed flows
- LISFLOOD model output

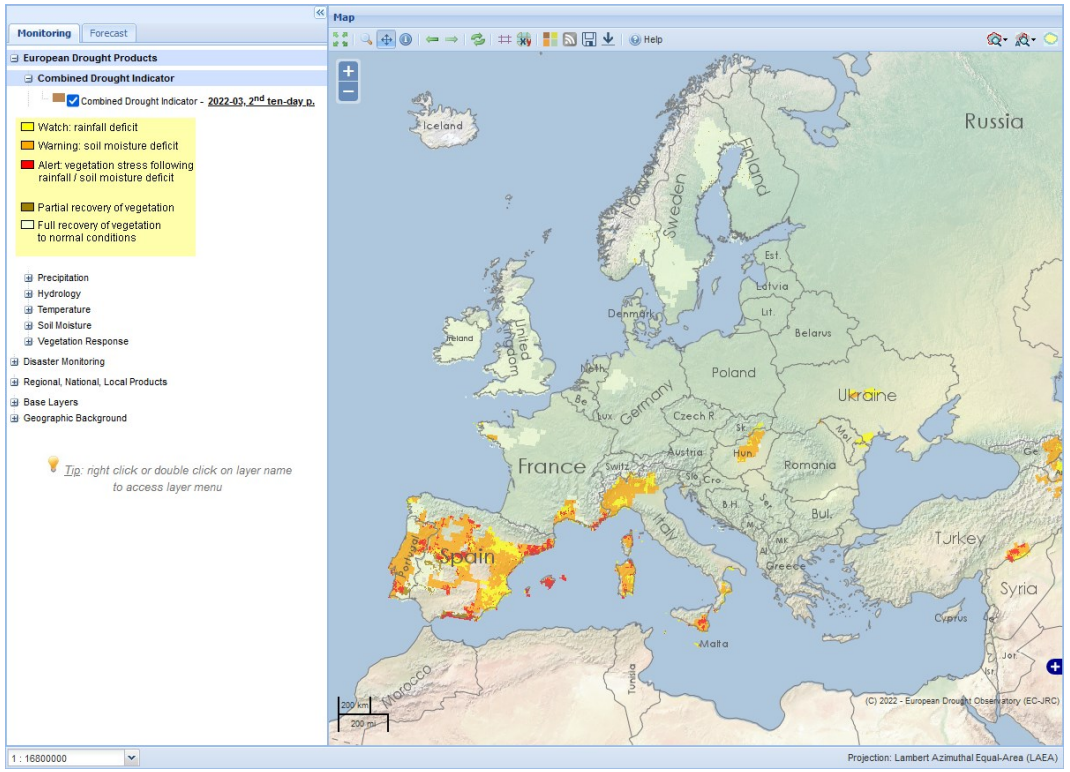
Heat and Cold Wave Index (HCWI)

- Daily minimum and maximum temperatures (Tmin and Tmax)
- Daily temperature amplitude (Tmax minus Tmin)
- Daily maximum temperature anomaly
- Calendar day thresholds used to detect heat and cold waves
- Strongest yearly heatwaves, and most recent in current year

Indicator for Forecasting Unusually Wet and Dry Conditions

GRACE Total Water Storage (TWS) Anomaly

Combined Drought Indicator



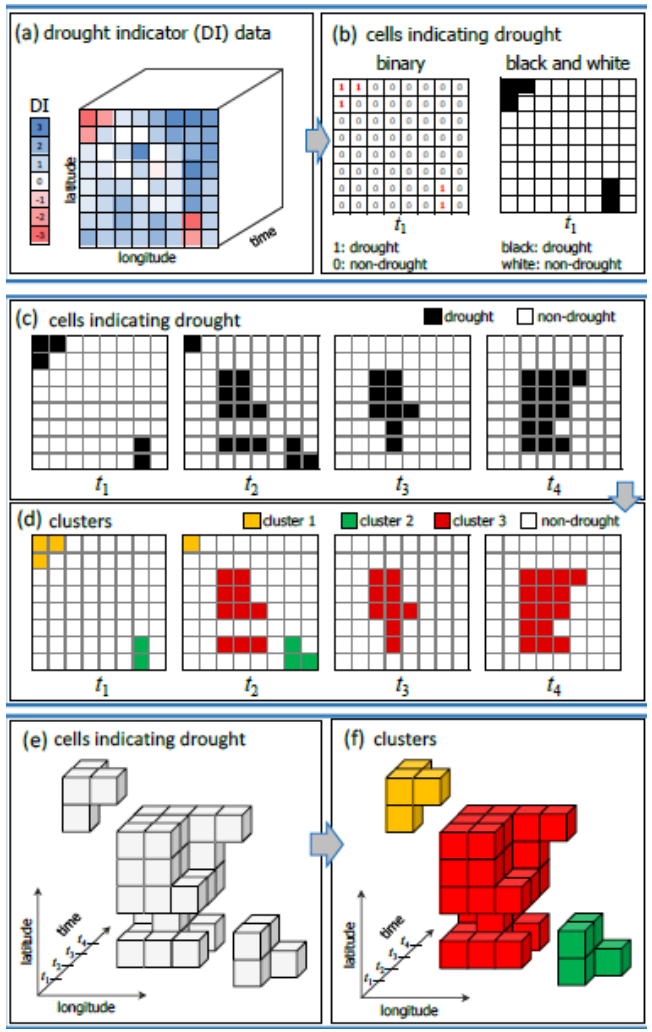
Climate Change

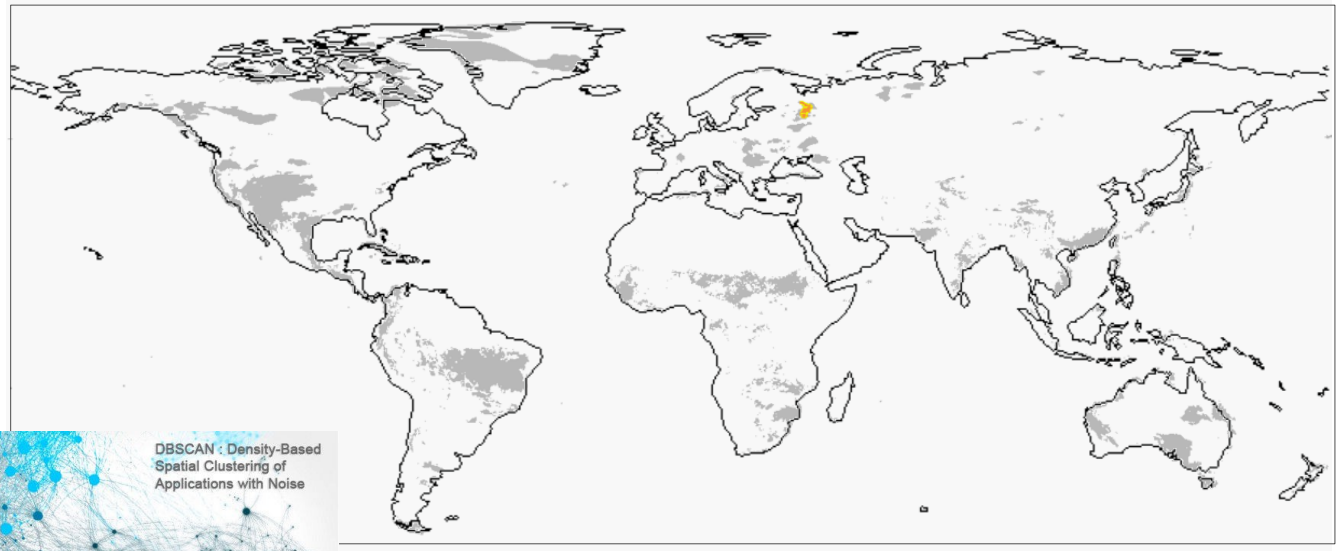
Land Monitoring

Emergency Management

European Commission

Drought event clustering & tracking





Identify drought events and monitor their spatio-temporal evolution

- Drought dynamics
- Predictability
- Impacts assessment
- Preparedness and risk

Source: Vitali-Diaz et al. 2022

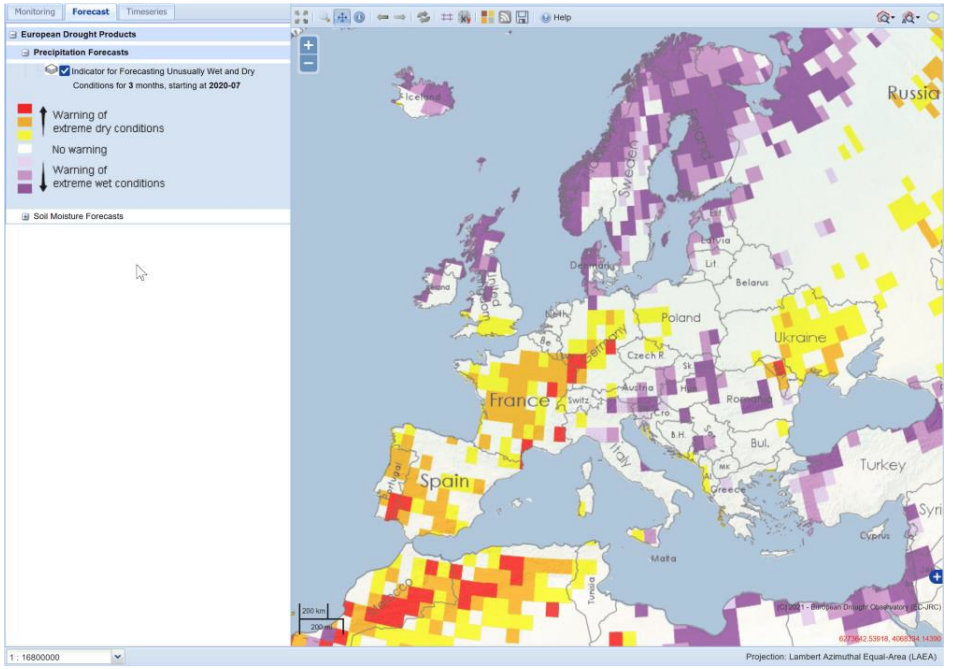
European Commission

Forecasting drought

Indicator for Forecasting Unusually Wet and Dry Conditions

- based on ECMWF SEAS5 long-range (seasonal) forecasts
- SPI forecasts 1, 3, and 6 months in advance
- analysis for likelihood of the occurrence of an extreme event
- both dry and wet anomalies forecasted

ALARM LEVELS		INTERPRETATION
WET	DRY	
0		No alarm
1	1	An unusual wet or dry event is forecasted, with large model reliability and / or forecast intensity. This forecast has a 10-year return period (based on the 36-year re-forecast period of SEAS5).
2	2	An unusual wet or dry event is forecasted, with a continued increase in model reliability and a larger forecast intensity. This forecast represents a 20-year return period.
3	3	Maximum level of alert. An unusual wet or dry event is forecasted, with both model reliability and forecast intensity at their maximum (based on the 36-year re-forecast period of SEAS5).

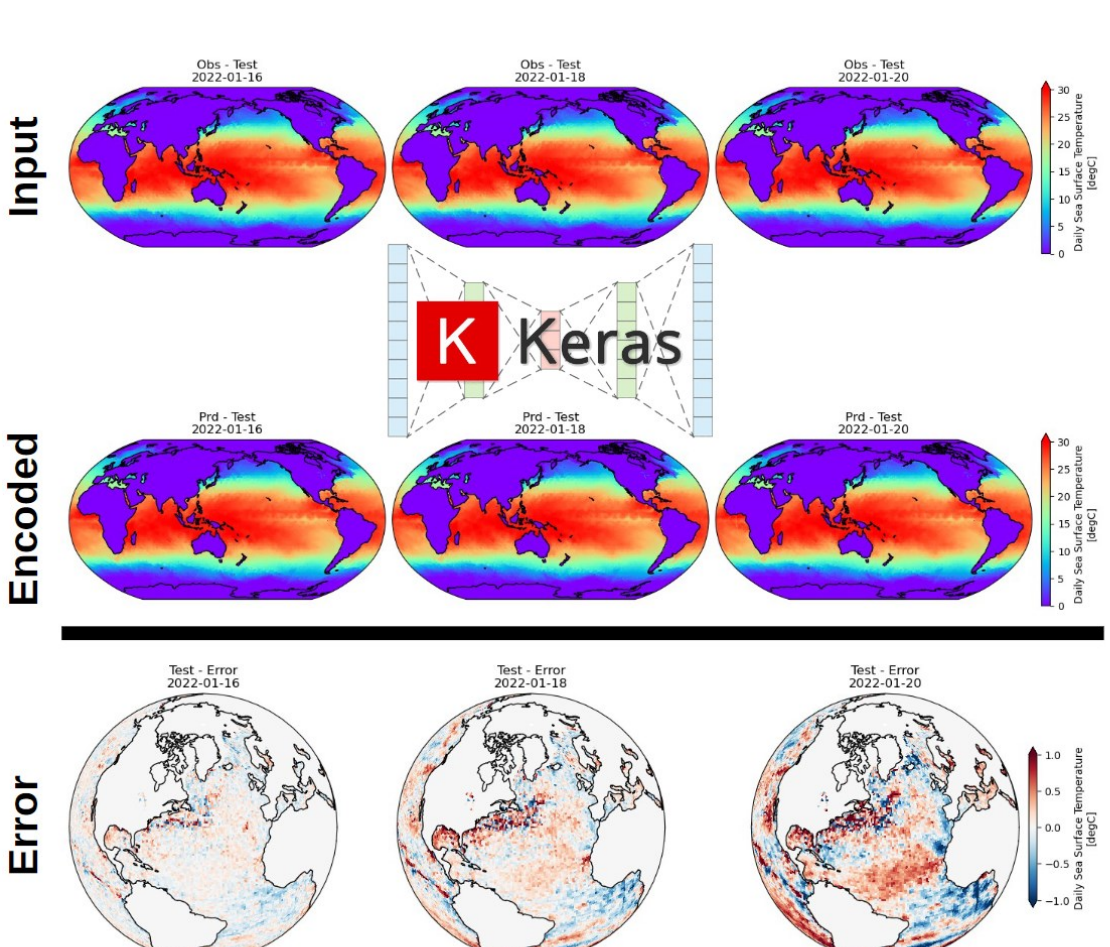


Ongoing development: Copernicus multi-system long-range weather predictions; skill enhancement; drought predictability and concurrent events

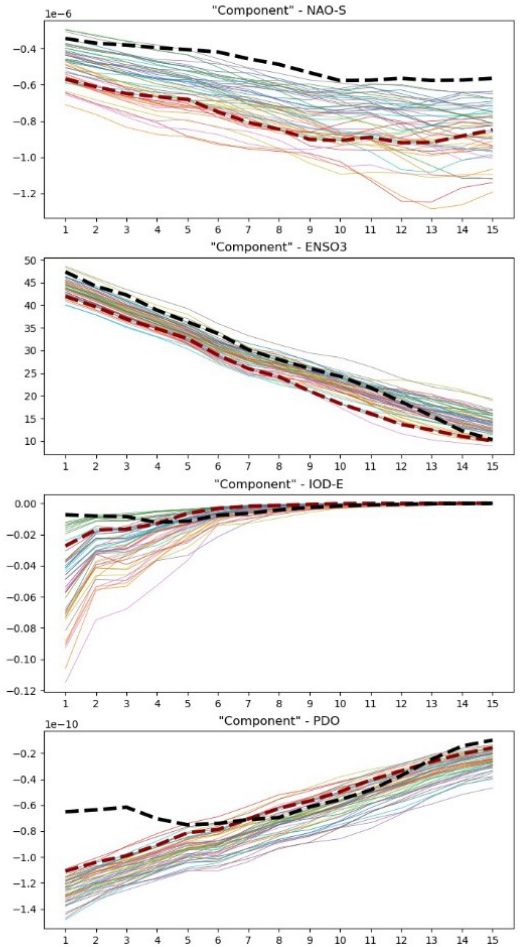
DATA → **Sectoral Information**

European Commission

AI-Enhanced Drought Forecasting?



Application



European Commission

Thank you

arthur.hrast-essenfelder@ec.europa.eu

ITUevents, in collaboration with the WMO and the UN Environment Programme

Workshop on "Artificial Intelligence for Natural Disaster Management"

24 October 2022

The information and views here expressed do not necessarily reflect an official position of the European Commission.

Except otherwise noted, © European Union (2022). All Rights Reserved

European Commission