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Universidade Vigo

Impactos de los eventos meteorológicos extremos en el sector energético: de Filomena a los incendios de 2025

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WEMC World Energy & Meteorology Council

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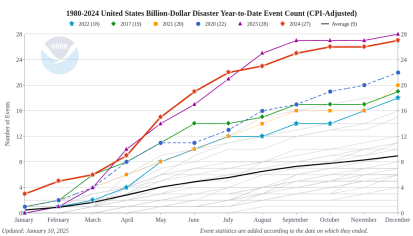
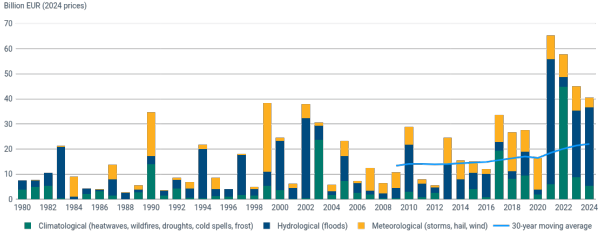
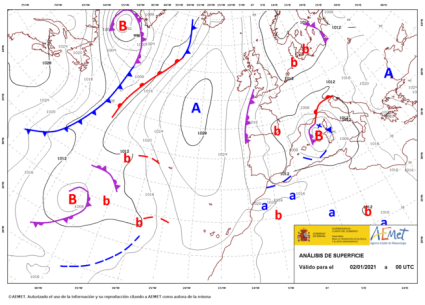
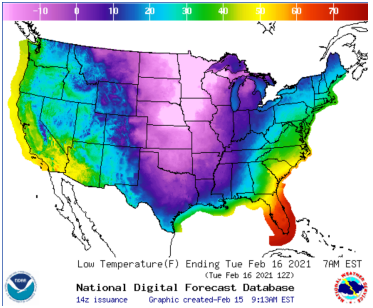
- The increasing share of renewable energy makes the energy system more dependent on weather.
- In summary, we need better meteorological information for energy (and life) security.

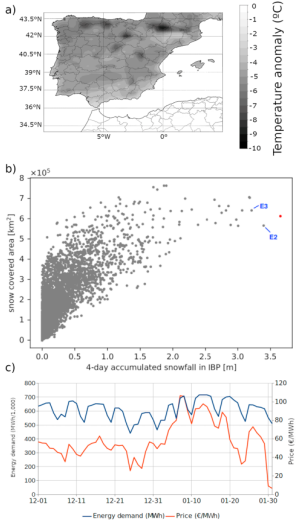




Filomena and Uri







Añel et al. (2024), Weather Clim. Soc., DOI: 10.1175/WCAS-D-23-0115.1
& Zschenderlein & Wernli (2022) Nat. Haz. Earth Systm. Sci., DOI: 10.5194/nhess-2021-396.

Consequences

Filomena

- Only 50 incidents of fallen transmission lines in Madrid and Castilla La-Mancha (27,000 clients affected, only a few for several days).
- Increase in electricty demand of 13% compared to previous weeks.
- Slight increase in electricity prices.
- Damages estimated in 1.2 billion USD (AON PLC, 2021).
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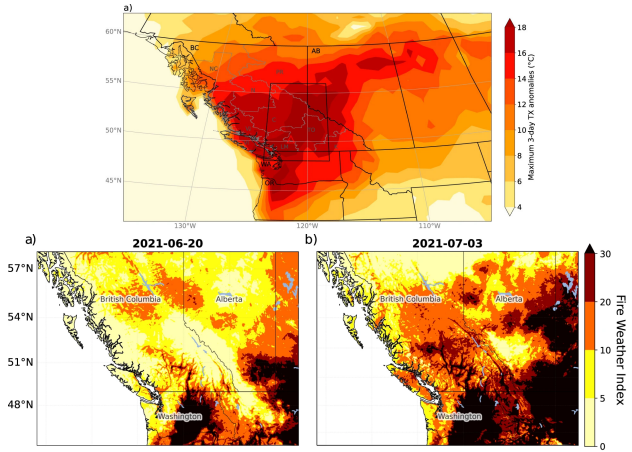
Uri

- Demand increased from 40 GW to 70 GW (all-time peak demand in Texas).
- First time that an annual peak demand happened in Winter.
- 4 million people affected for several days.
- Electricy prices of 9,000 USD/MW$\cdot h^{-1}$.
- Frozen coal and gas power plants, and water pumps in nuclear power stations.
- 20% of the U.S. refinery capacity shutdown.
- 246 deaths attributed.
- Damages estimated in up to 130 billion USD (NCEP, 2023).
- Lack of interconnection, no renewables, and heavy reliance on fossil technologies caused a disaster.

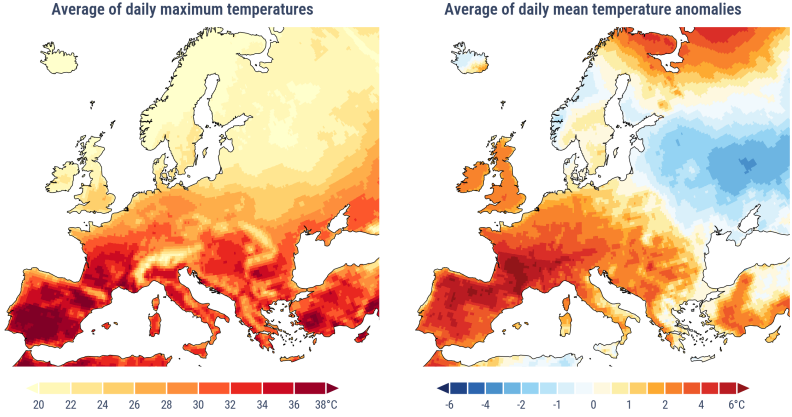
Wildfires
PNW 2021 and Spain 2025



White et al. (2023). Nat. Commmun., DOI: 10.1038/s41467-023-36289-3.

Surface air temperature during the August 2025 heatwave (8–18 August)

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF



Consequences

Pacific North West 2021

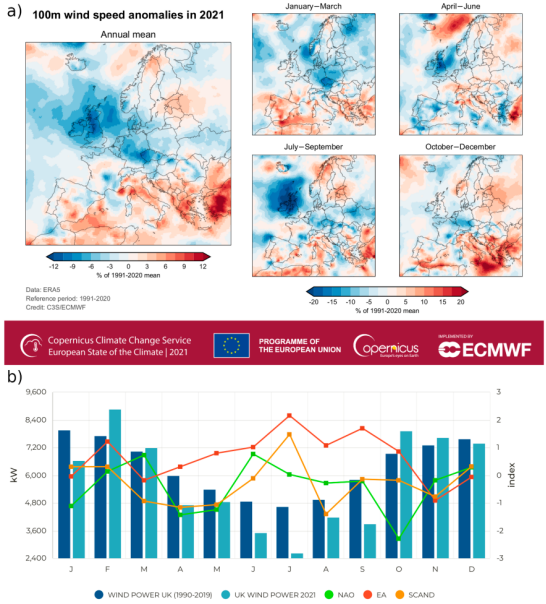
- Wildfires lasted since the end of May until the 30th of October.
- 187,562 ha burned and 1674 km2.
- 6^{th} generation wildfire with pyrocumulus.
- 90% of all power infrastructures totally burned during the Lytton wildfire.
- The Russell City Power Center exploded, leaving 600,000 houses without power.
- The Oregon-California interconnections were burned. The Pacific DC Interconnnection had to be limited.
- Deficit between demand and generation of 5,500 MW, record peak demand in BC (8,568 MW) and electricity prices of 1,500 USD/MW$\cdot h^{-1}$.
- Rolling blackouts.
- Estimated cost of 10,8 billion USD (NOAA/NCEI 2023).

Consequences

Spain 2025

- 358.000 ha burned. In Galicia 7% of the country (74% more than the "official" figures) (Copernicus, 2025).
- 8 deaths.
- Rocketed CO_2 emissions.
- Transmission lines burned and up to 15 days to restore supply; use of fuel generators in the meantime.
- "De-energizations" of high and medium voltage lines were carried out to allow helicopters and cargo planes to unload water without risk of electric arc. Despite it several electric arcs and shutdowns by air ionization due to smoke happened (Red Eléctrica, 2025).
- Stops in hydropower stations to avoid damage on turbines from ash and debris (CHMS, Naturgy, Iberdrola, 2025).
- Need to stop wind power farms to avoid internal damage in transformers due to smoke (Galician Wind Power Association, 2025).
- Reduced PV production.
- Closure of industrial areas fingerprinted in a 9.1% lower than average demand (CaixaBank Research, 2025).

Wind droughts UK 2021



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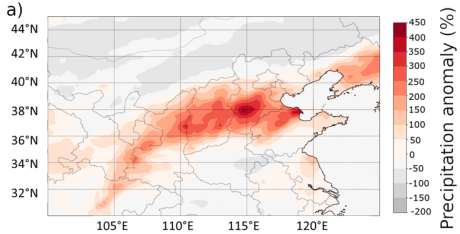
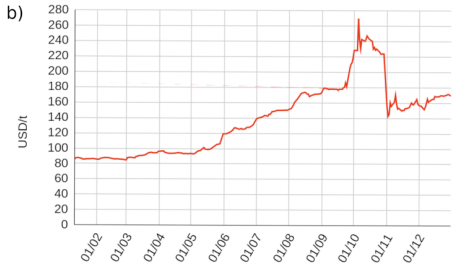
Consequences

UK Wind drought 2021

- Annual mean wind speeds 0.6 m/s lower.
- Wind power production 43% lower than the historical average (1990-2019). Second year with the lowest wind power production (Scottish Power/Iberdrola).
- Annual wind power contribution to the mix was 14% than in 2020 despite a 5.3% rising in installed capacity (UK Government).
- Need to restart a coal plant to cover the deficit in production. Unexpected increase in CO_2 emissions.

Floods
Shanxi 2021
(and at a lower scale Queensland 2022)





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Precipitation anomaly was 450% the historical mean (ERA5) after a September with an anomaly of 300%. (Peaks of 285.2 mm in 12 hours). El Niño boosted precipitations.

Consequences

Floods in Shanxi 2021

- 10% of the coal mines had to fully stop.
- More than 60% of China suffered power outages along September-October.
- Problems to provide heating to the population during a extreme cold event following the floods.
- Direct economic cost of up to 770 million USD.
- Inflaction in China rised by 0.91%.

Floods
DANA Valencia 2024

Consequences

DANA Valencia 2024

- 155,000 clients affected (50% recovered in 48 hours and 98% in five days).
- 23 High Voltage Towers felt + 12 damaged + 20 km of lines.
- Quart de Poblet substation flooded.
- 80 fossil fuel generators deployed and repair works lasting for months.
- It did not pose a major problem to the grid thanks to the good interconnection.

Conclusions

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- Nuclear and natural gas production and supply are vulnerable to droughts, heatwaves and cold waves.
- Renowables greatly improve resilience agains extreme weather.
- Spain has shown to have a higly resilient energy system compared to other countries despite well known issues (lack of international connectivity, fossil fuel dependence, etc.).