Dal passato al futuro per capire come cambia il clima nel presente

Erika Coppola , ICTP Earth System Physics (ESP) Section

Le sfide del XXI secolo:il Clima 9 Giugno 2025



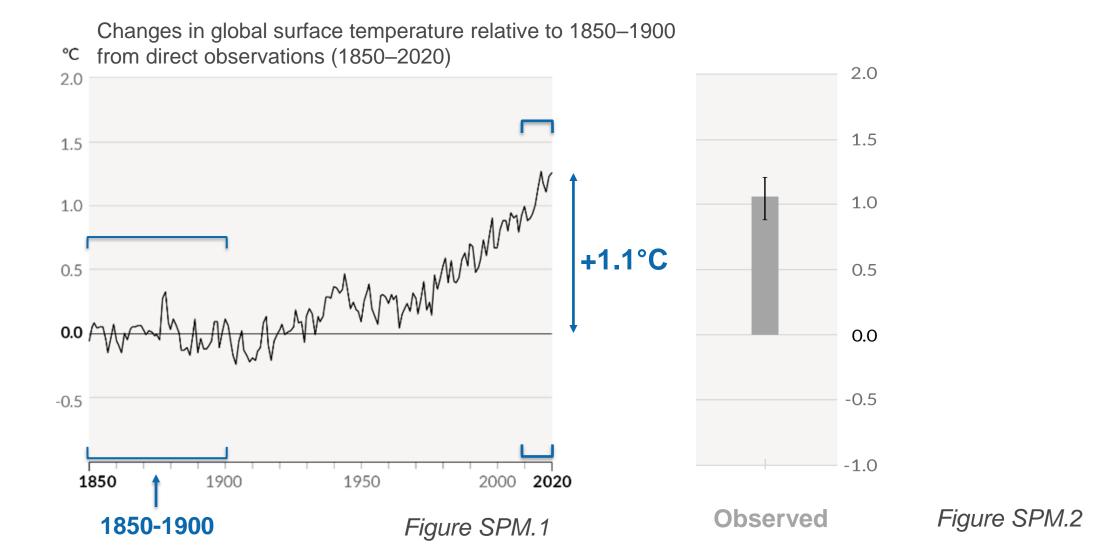


INTERGOVERNMENTAL PANEL ON Climate change

IOCC

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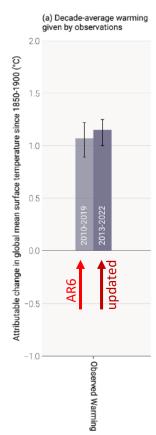
Observed warming is driven by emissions from human activities



Observed warming and Carbon Budget updates

+ 1.14 °C averaged over the 2013–2022

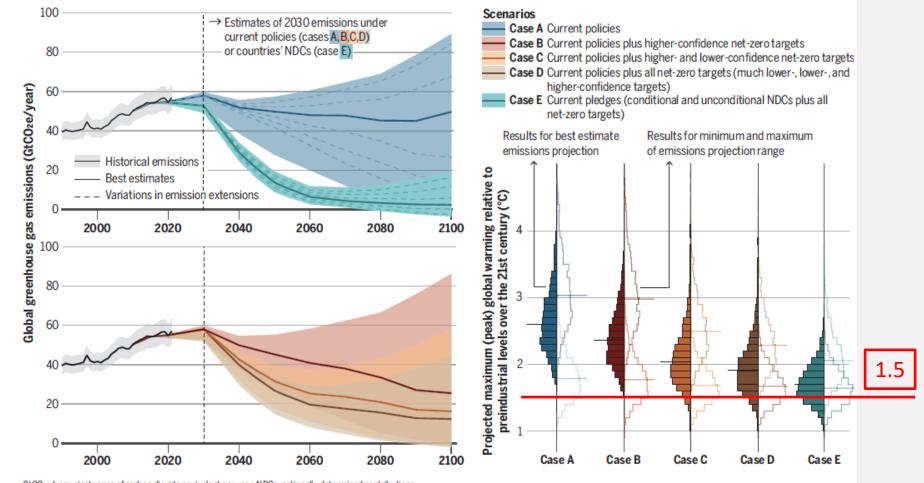
Observed Warming



Historical cumulative CO ₂ emissions (1850–2019) AR6 WGI Table SPM.2	2390 (±240; <i>likely</i> (66 %–100 % probability) range)					
Remaining carbon budgets Case/update	Base year Estimated remaining carbon budgets from the beginning of base year (GtCO ₂)					
Likelihood of limiting global warming to temperature limit.		17 %	33 %	50 %	67 %	83 %
1.5 °C from AR6 WGI	2020	900	650	500	400	300
+ AR6 emulator update	2020	750	500	400	300	200
+ as above with AR6 scenario update	2020	750	500	400	300	200
+ as above with warming update	2023	500	300	250	150	100
(2013–2022) (best estimate)						
1.7 °C from AR6 WGI	2020	1450	1050	850	700	550
+ AR6 emulator update	2020	1250	900	700	600	450
+ as above with AR6 scenario update	2020	1300	950	750	600	500
+ as above with warming update	2023	1100	800	600	500	350
(2013-2022) (best estimate)						
2°C from AR6 WGI	2020	2300	1700	1350	1150	900
+ AR6 emulator update	2020	2050	1500	1200	1000	800
+ as above with AR6 scenario update	2020	2200	1650	1300	1100	900
+ as above with warming update	2023	2000	1450	1150	950	800
(2013–2022) (best estimate)						

Forster et al., (2023) Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence. Earth System Science Data https://doi.org/10.5194/essd-15-2295-2023

Likelyhood to reach global climate targets



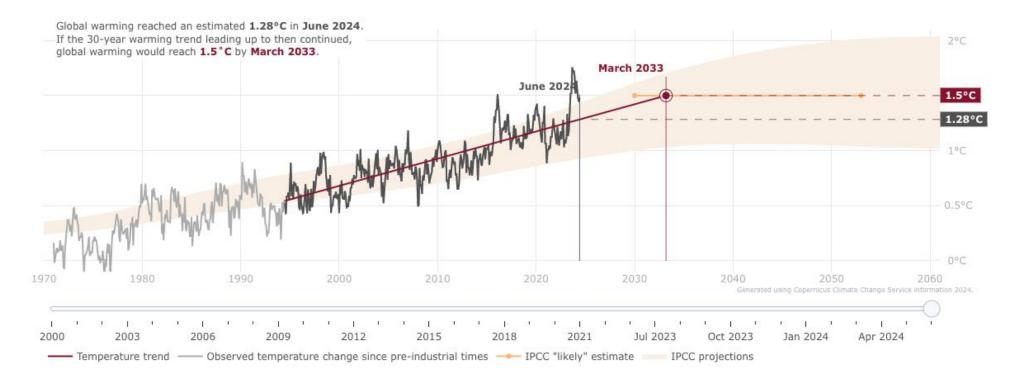
GtCO2e/year, gigatonnes of carbon dioxide equivalent per year; NDCs, nationally determined contributions.

Rojet et al., (2023) Credibility gap in net-zero climate targets leaves world at high risk. Science DOI: 10.1126/science.adg6248

Copernicus Climate Change Service

How close are we to reaching a global warming of 1.5°C?

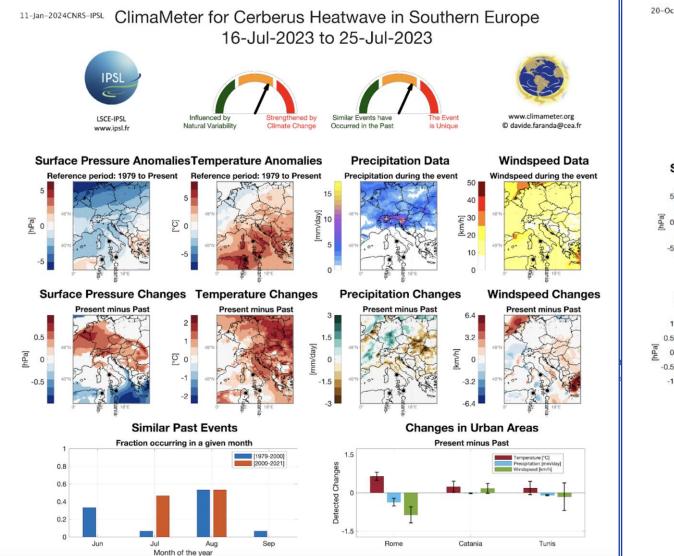
Reaching 1.5°C of global warming - a limit agreed under the Paris agreement - may feel like a very distant reality, but it might be closer than you think. Experts suggest it is likely to happen between 2030 and the early 2050s. See where we are now and how soon we would reach the limit if the warming continued at today's pace. Use the slider to explore how the estimate changes in time.

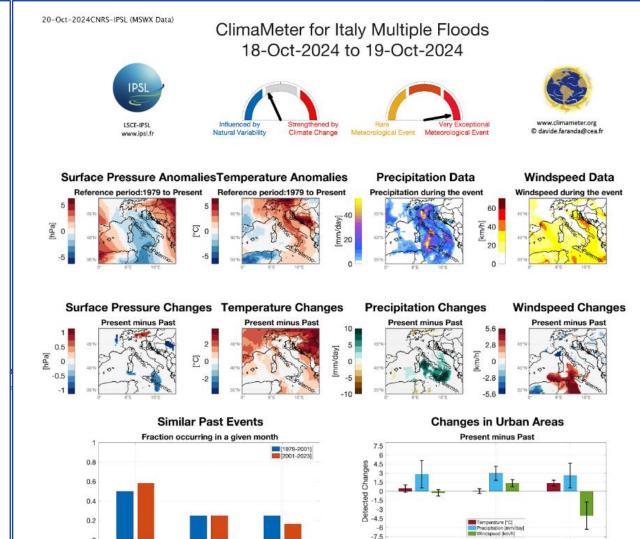


https://climate.copernicus.eu/

Attribution

Present: attribution





Sep

Oct

Month of the year

Nos

Bologna

Palermo

Genos

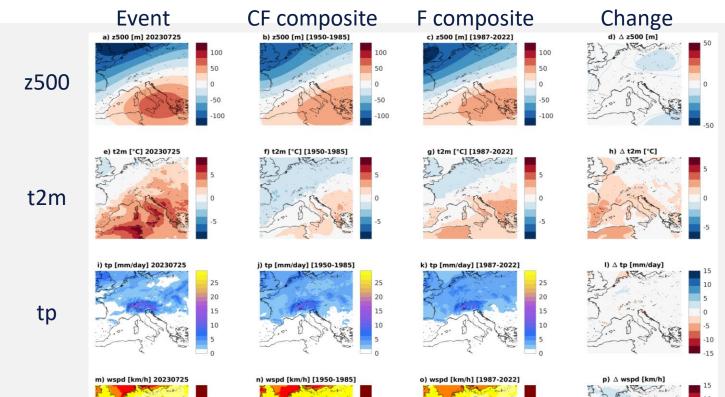
SECTION TITLE

2023/07/15-25 Cerberus Heatwave in Southern Europe

wspd

Results based on ERA5

- Event associated with a highpressure system over southern Italy.
- Strong positive anomalies in temperature observed.
- No significant change identified in geopotential height.
- Significant increase in temperature can be observed in the factual period.



SECTION TITLE

Results based on

2023/07/15-25 Cerberus Heatwave in Southern Europe

- Ensemble average of changes at 1.5, 2, 3, and 4 K global warming levels.
- "+": significant change (based on t-tests at a =0.05, controlled for false discovery rate at $a_{FDR} =$ 0.05).
- "x": consistent change with 80% of ensemble members agrees on sign of change.

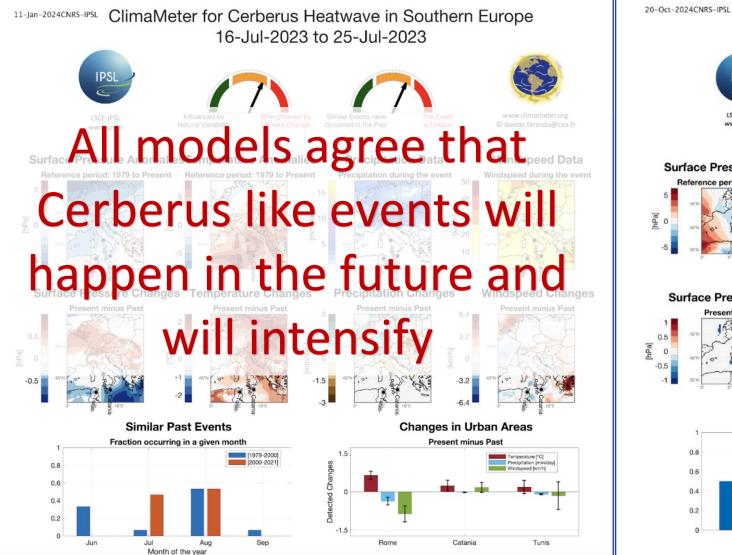
HighResMIP CMIP5 CMIP6 CORDEX **Higher Resolution** t2m t2m t2m t2m CORDEX, t2m CMIP5, t2m CMIP6, t2m HighResMIP, t2m CORDEX, t2m CMIP5, t2m CMIP6, t2m HighResMIP, t2m CMIP5, t2m CORDEX. t2m CMIP6. t2m CMIP5, t2m CORDEX, t2m CMIP6. t2m

2 K

3 K

Attribution

Summary so far

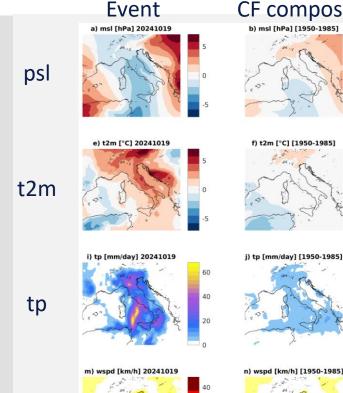


20-Oct-2024CNRS-IPSL (MSWX Data) ClimaMeter for Italy Multiple Floods 18-Oct-2024 to 19-Oct-2024 IPSL www.climameter.org ISCE-IPSI Influenced b C davide.faranda@cea.fr www.ipsl.fr Natural Variability Climate Change Meteorological Event Meteorological Event Surface Pressure AnomaliesTemperature Anomalies Windspeed Data Precipitation Data Reference period:1979 to Present Reference period:1979 to Present Precipitation during the event Windspeed during the event Surface Pressure Changes Temperature Changes **Precipitation Changes** Windspeed Changes Present minus Past Present minus Past Present minus Past Present minus Pas Similar Past Events **Changes in Urban Areas** Fraction occurring in a given month Present minus Past 7.5 [1979-2001] 1.5 1.5 -3 4.5 mperature [*C] ocipitation [mm/da eed jkm/h -7.5 Sep Oct Bologna Palermo Genoa

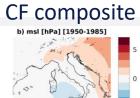
Month of the year

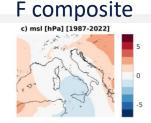
2024/10/18-19 Italy Multiple Floods **Results based on ERA5**

- Event associated with a lowpressure system over Italy.
- Strong positive anomalies in precipitation observed.
- No significant change . identified in mean sea level pressure.
- Significant increase in . precipitation can be observed in parts of southern Italy in the factual period.

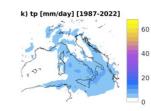


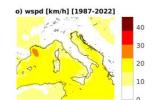
wspd



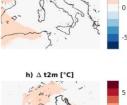


g) t2m [°C] [1987-2022]

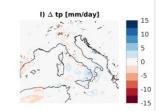


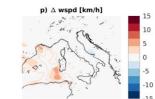












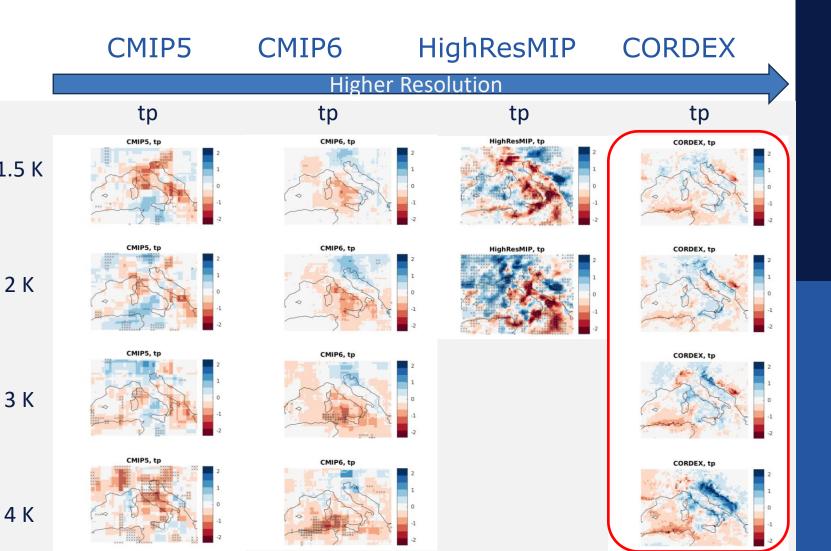
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SECTION TITLE

2024/10/18-19 Italy Multiple Floods

Results based on

- Ensemble average of • 1.5 K changes at 1.5, 2, 3, and 4 K global warming levels.
- "+": significant change ٠ (based on t-tests at a =0.05, controlled for false discovery rate at a_{FDR} = 0.05).
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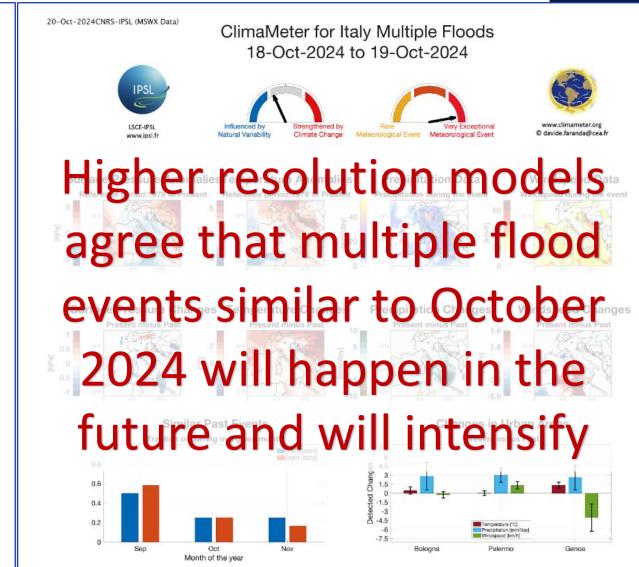


Attribution

Summary so far

ClimaMeter for Cerberus Heatwave in Southern Europe 11-Jan-2024CNRS-IPSL 16-Jul-2023 to 25-Jul-2023 IPSL All Anoral Surface Press Lie Anoral e Song and a song a so Cerberus like events will happen in the future and will intensify Similar Past Events **Changes in Urban Areas** Fraction occurring in a given month Present minus Past [1979-2000] [2000-2021] 0.8 0.6 0.4 0.2 Rome Catania Tunis

Month of the year



A New Scientific Frontier in Climate Science High-Resolution Kilometer-Scale Regional Climate Modeling

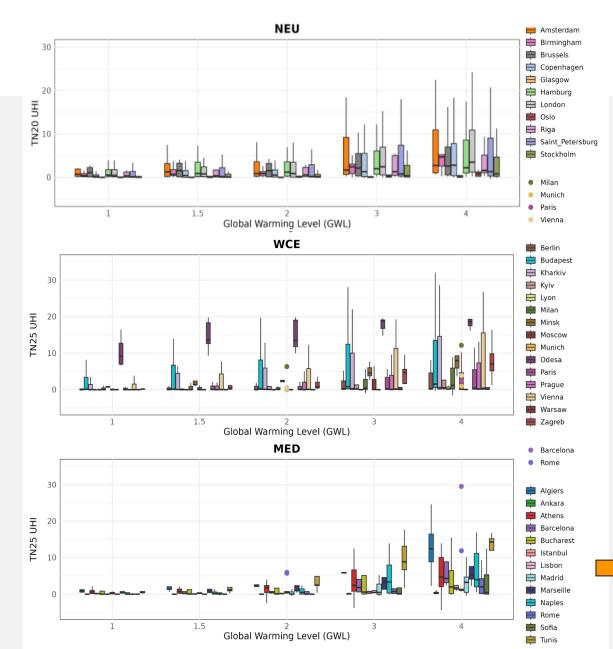
 Total Precipitation 2001/10/01 00

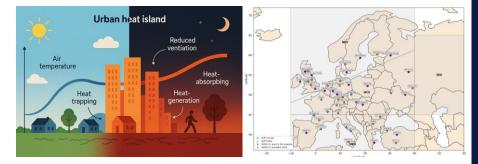
 50°W
 25°W
 0°
 25°E
 50°E



10°S 20°S 30°S 40°S 50°S 80°W 70°W 60°W 50°W 40°W **Mechanistic Understanding** – To unravel the interactions between fine-scale processes (modulated by topography and land surface heterogeneity) and large-scale atmospheric forcings, which are critical for reducing uncertainties in climate projections.

Climate Change Signal Assessment – To evaluate how global climate change alters key regional phenomena, such as extreme precipitation, convective storms, and mesoscale convective systems, which are poorly resolved in coarser models. **Actionable Climate Information** – To generate decision-relevant data for impact, vulnerability, and adaptation assessments, supporting policymakers, urban planners, and stakeholders in climate resilience planning. UHI





Urban Heat Island for TN20 & TN25:

Difference between urban and countryside at each GWL (1,1.5, 2, 3 and 4) for cities in Northern Europe (NEU) using "TN20 index" and for Western Central Europe (WCE) and Mediterranean (MED) using "TN25". The analysis is done with different thresholds, depending on the region considered: 20 °C is the right value to highlight the UHI effect across the GWLs for Northern cities; 25 °C is instead used for WCE and MED.

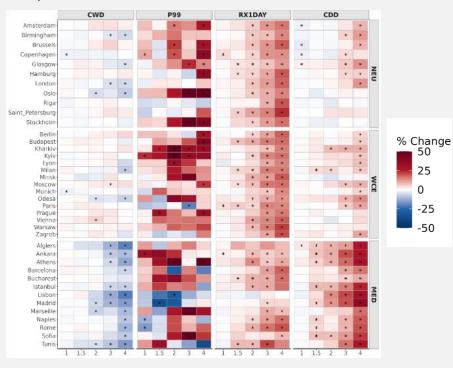
Boxplots for EUR-11 and Dots for CPCMs ALP-3 median.

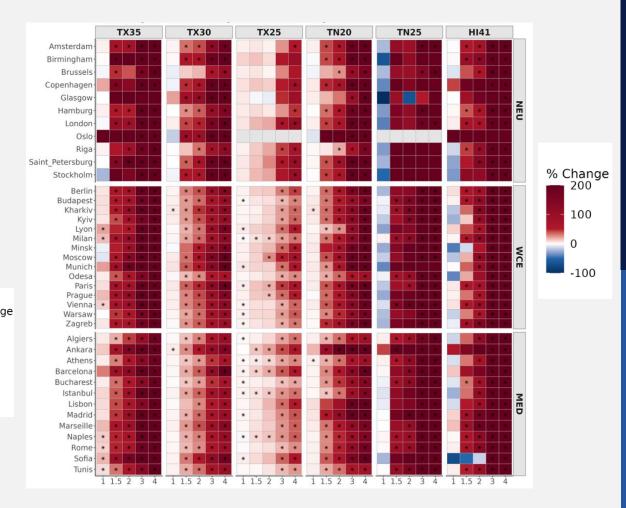
Increased effect of UHI with GWLs, enhanced in CPCMs.

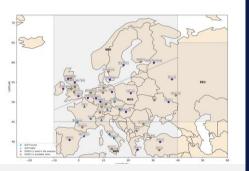
UHI

Change (%) and Significance at Global Warming Levels for several Hazard Indices:

The mean percent change computed with respect to the reference period for each index and the selected cities of Europe, as detected by the urban masks of the models. The asterisk (*) marks the significant changes at 95%. The average is computed over the cities using the urban masks available for each model. The idea is to see if cities are "Hot spots" of climate change or they reflect the regional climate response.







Summary

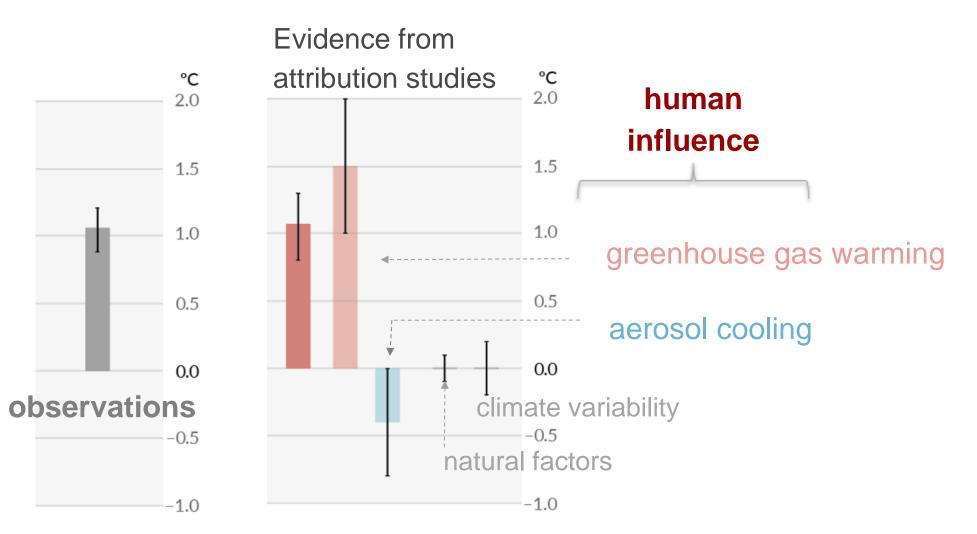
- Global warming is already intensifying present-day extreme events in many regions around the world.
- Current climate events can be studied to better understand the role of human-induced warming.
- Model ensembles help evaluate future event evolution and assess the suitability of different models for specific types of extremes.
- **High-resolution climate projections are essential** for accurately analyzing events at **local scales**.
- Increasing availability of kilometer-scale projections enables the study of for example urban climate impacts, providing valuable insights for adaptation and mitigation strategies

Thank you

coppolae@ictp.it

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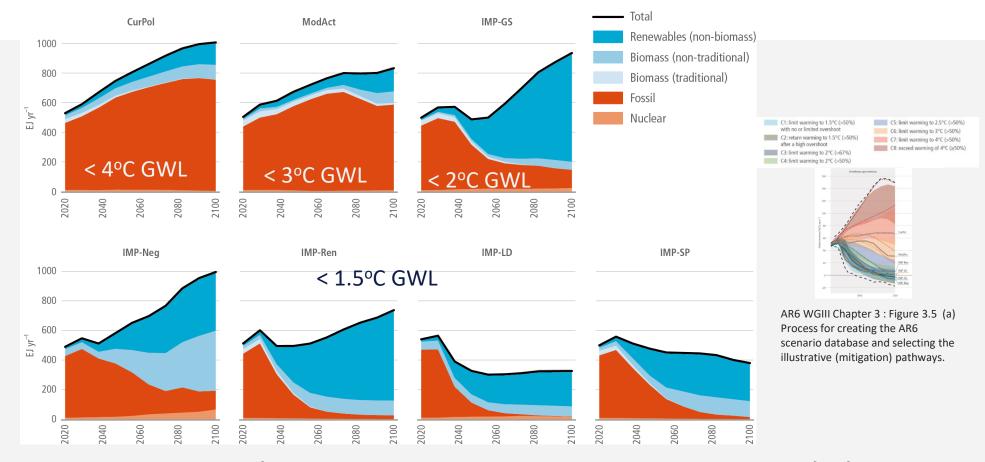
Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling



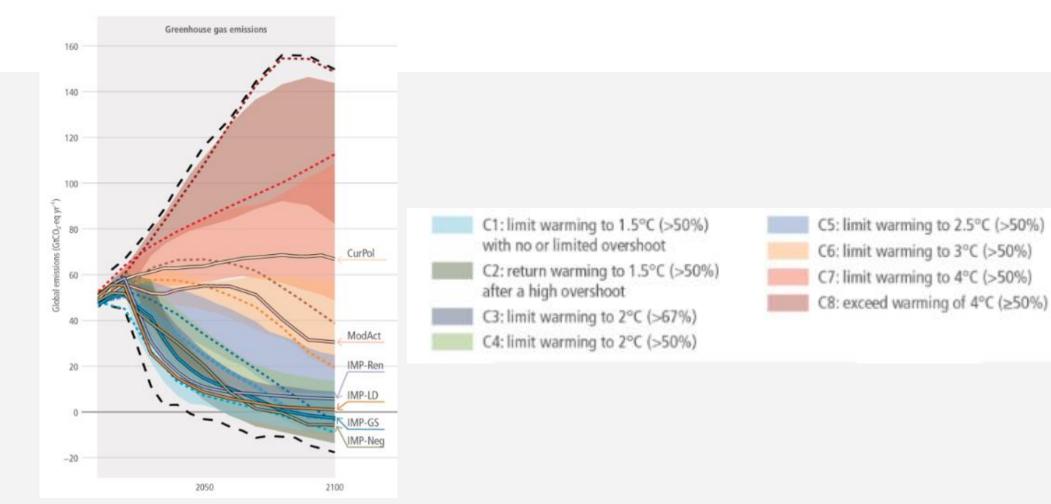
Adapted from Figure SPM.2

Energy system & scenarios

Temperature < 2°C GWL Energy production scenarios



AR6 WGIII Chapter 3 : Figure 3.8 |The energy system in each of the illustrative pathways (IPs).



AR6 WGIII Chapter 3 : Figure 3.5 (a) Process for creating the AR6 scenario database and selecting the illustrative (mitigation) pathways.