

Multi-physics ensembles for operational weather-event attribution

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The Durban floods of 11 and 12 April 2022

- Loss of life: 544 people died
- ~ 7000 houses destroyed
- ~ 40 000 people displaced

- 450 mm rain in 48 hours
- Cut-off low weather system



https://www.npr.org/2022/04/13/1092753563/flooding-climate-change-south-africa

President Cyril Ramaphosa on 13 April 2022: "This disaster is part of climate change. It is telling us that climate change is serious, it is here".



South African President Cyril Ramaphosa, left, speaks to various grieving family members, as part his visit and assessing the damage following the heavy rainfall which resulted in roads collapsing, properties damaged and lives lost outside of Durban. *Kopano Tlape/South African Government Communication and Information Services via AP*

https://www.npr.org/2022/04/13/1092753563/flooding-climate-change-south-africa

The Pakistan floods of August/September 2022: more than 1/3rd of the country was under water



An image of Sindh province, taken on August 28 from NASA's MODIS satellite sensor. https://edition.cnn.com/2022/08/31/asia/pakistan-floods-forms-inland-lake-satellite-intl-hnk/index.html

Pakistan floods are 'a monsoon on steroids', warns UN chief

By Simon Fraser

BBC News

🕓 21 hours ago





Watch: A 'monsoon on steroids' - UN chief in Pakistan floods

Pakistan is facing "a monsoon on steroids", the UN's secretary general has warned, after floods submerged a third of the country.

The prime minister of Pakistan has made a number of powerful statements:

- "What happened in Pakistan will not stay in Pakistan".
- "Why are my people paying the price of such high global warming through no fault of their own?".
- "It is therefore entirely reasonable to expect some approximation of justice for this loss and damage"

More than 2 million people were directly affected by the Ocro 2022 floods in Nigeria

Floods: Nigeria suffering climate change effects, says Buhari

25th October 2022



https://punchng.com/floods-nigeria-suffering-climate-changeeffects-says-buhari/

By Stephen Angbulu

Loss and Damage under the UNFCCC

The Paris Agreement reaffirmed the Warsaw International Mechanism for Loss and Damage as the main vehicle under the UNFCCC process to avert, minimize and address loss and damage associated with climate change impacts, including extreme weather events and slow onset events.

https://unfccc.int/topics/adaptation-and-resilience/the-bigpicture/introduction-to-loss-and-damage

Is climate change to blame for the KwaZulu-Natal floods?



Figure 1: Remarkably similar weather systems (cut-off lows) caused severe flooding in the Durban area in (a) September 1987, (b) April 2019 and (c) April 2022.

https://issafrica.org/iss-today/is-climate-change-to-blame-for-kwazulu-natals-flood-damage

https://edition.cnn.com/2022/05/13/africa/south-africa-floods-climateintl/index.html

'Traditional' statistical approach to climate change attribution

- Championed by World Weather Attribution service with a large media footprint given its 'real-time', operational application.
- Multi-model ensemble of GCMs applied to 'pre-industrial' and curent (~ +1.2 ° C) worlds
- Combined with observations to calculate return periods, verify models and undertake bias-correction
- Disadvantages: not event specific, not convection-permitting

world weather attribution

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https://www.worldweatherattribution.org



WWA study 350

- Climate change - 300 increased the intensity of the - 250 'Durban Floods' by 4-8% - 200
- Rainfall events of - 150 this intensity (2-day rainfall totals) are - 100 twice as likely as they are supposed to be due to climate change.

https://www.worldweatherattribution.org/climate-change-exacerbated-rainfallcausing-devastating-flooding-in-eastern-south-africa/

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Weather event attribution (case-by-case approach)

- Pioneered around North Atlantic hurricane landfall
- Insert the 'actual' weather system in 'cooler' and 'warmer worlds'.
- One approach to generate these worlds is to detrend the initial conditions using for example, reanalysis data.
- But for which variables? Physical inconsistencies may be problematic.

IOP Publishing Environ. Res. Lett. 13 (2018) 054014

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Environmental Research Letters



Weather event attribution (case-by-case approach)

- Intialization imply from a detrended 'analysis' or is some form of 'spin-up' preferable?
- Option for perturbed physics and IC-ensembles.
- Advantages: Event-specific, higher resolution possible towards convectionpermitting simulations.
- Disadvantages: results may be model dependent; existence of system assumed in cooler world.

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Environmental Research Letters



Did the storm develop a barotropic structure once the surface low moved into the Indian Ocean?



The subtropical low on 2022-04-12 at 17:45 SAST; First classification of a subtropical low south of 30 °S by RSMC La Reunion-Tropical Cyclone Centre/Meteo-France.

Experimental design: Durban attribution simulations



Event-attribution modelling at the GCI: 72-member parameterisation-based ensemble applied to current, cold and warm worlds



'Current world' control ensemble member: c3-m0-b0



500 hPa 2022-04-12 12Z



-16-15-14-13-12-11-10-9 -8 -7 -6



CAM C384 4 km res grid (every 8th point) for Durban event-attribution study



72 ensemble members (perturbed physics) for 'current', cold and warm worlds.

Temperature and humidity detrended, vs only temperature detrended.

'Analysis initialisation' vs spin-up approach using spectral nudging

rlong0=28.5 rlat0=-29.5 schmidt=.16 viewrad=1.2 ndeg=5 d='C48 32km KatseDam4km'





Summary: Durban event-attribution study-in progress

- Cut-off low deeper in a colder world – more vigorous dynamics
- Cut-off low holds more moisture in a warmer world, potentially more barotropic
- Control simulations: 350 mm (current) vs 400 mm (cold) vs 500 mm (warmer world)
- More research based on full ensemble needed to assess the role of climate change.

Proposed new WGNE project on perturbed physics and attribution

- Develop methodologies for operational event-attribution studies.
- Convection permitting simulations.
- Multi-model ensemble (to make sure results are not result dependent).
- Explore the need for 'spinning up' cold and warm worlds (e.g. spectral nudging for 'assimilation'), vs initialising straight from detrended reanalysis/analysis.
- Which variables should be detrended, and what should be left for the model?
- Clearly more methodological research/work is needed here; the minimum outcome should be multi-model, convection-permitting event-attribution ensembles towards operational event-attribution.
- Guidelines for WMO S-GDPFS (WIPPS) future operationalisation.
- Side-benefit: insights into changing predictability in a warmer world.