World Weather Attribution

Imperial College London

Climate Detectives: How does climate change affect extreme weather events?

(and the crucial role of Earth Observations)

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1) Climate detectives

What is attribution and who are WWA

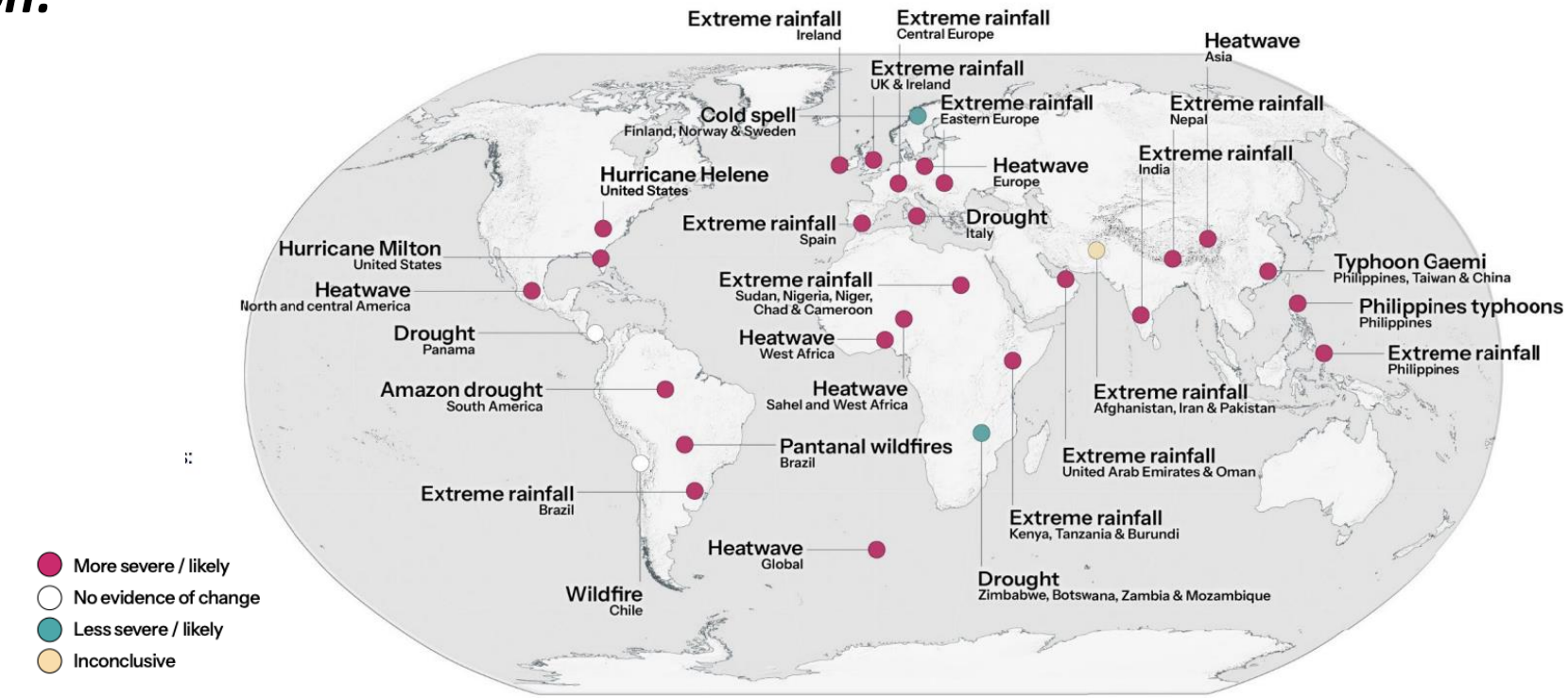
Extreme event attribution

- Extreme event attribution broadly: ***Assessing whether and to what extent climate change influenced a specific extreme weather event.***

1. And who are WWA

Extreme event attribution … but rapid

- Extreme event attribution broadly: ***Assessing whether and to what extent climate change influenced a specific extreme weather event.***
- World Weather Attribution: ***Doing this fast, when people are asking the question.***

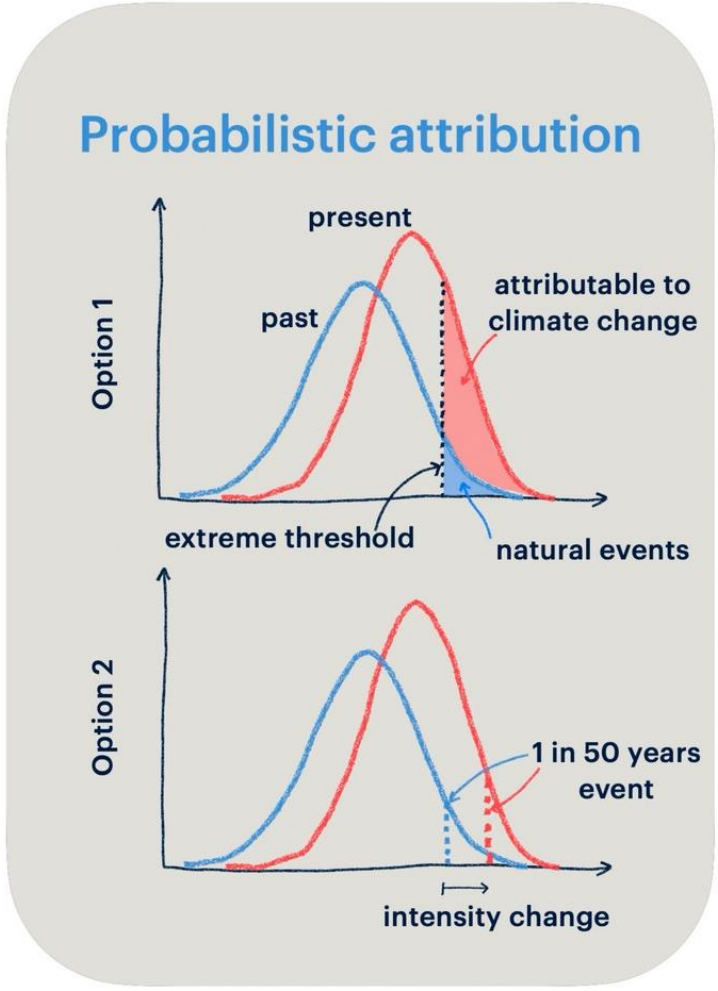


2) Finding the fingerprint

How rapid event attribution works

In theory

- Young (~20 years) but rapidly evolving field of study
- Methods vary primarily by degree of conditioning
- Gold standard is multi-method approach
- WWA rapid attribution (primarily) using **probabilistic event attribution**



1) Thompson, V., Ermis, S. and Athanase, M. (2026), The need for multi-method extreme event attribution. Weather, 81: 40-45. https://doi.org/10.1002/wea.7779

In practice

- **Results not peer reviewed**
- **Use peer reviewed methods**

Protocol

1. Trigger
2. Event definition
3. Observed probability and trend
4. Model evaluation
5. Multi-model attribution
6. Hazard synthesis
7. Vulnerability & exposure
8. Communication

In practice

- **Results not peer reviewed**
- **Use peer reviewed methods**

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Observations underpin everything!

In practice

Protocol

1. Trigger

- Impacts-based
- Set of thresholds for each hazard type
- Absolute and relative thresholds
- Requires reported impacts

Hazard	Monitoring	Threshold
Flood	• Google alert ("flood") • Reliefweb: Alert and Ongoing Disasters • ECHO Daily Flash • GDACS Alert • IFRC GO Emergencies	1. ≥100 deaths OR 2. ≥1,000,000 people affected[1] OR 3. ≥50% of total population affected OR 4. Declaration of State of Emergency/Disaster (at state or national level)

[1] People affected is defined as, "People requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance." (EMDAT), OR exposed to the extreme event

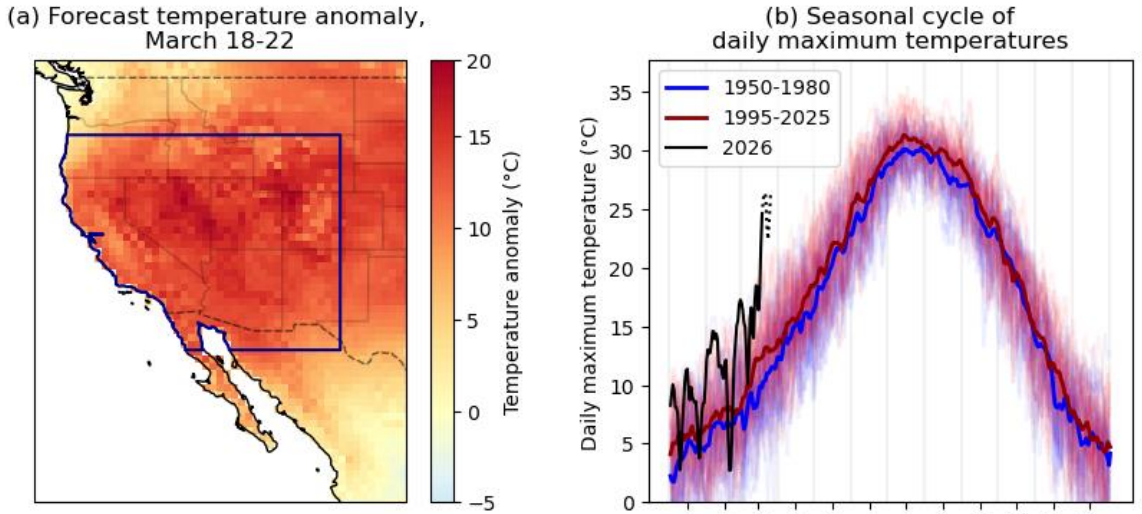
In practice

Protocol

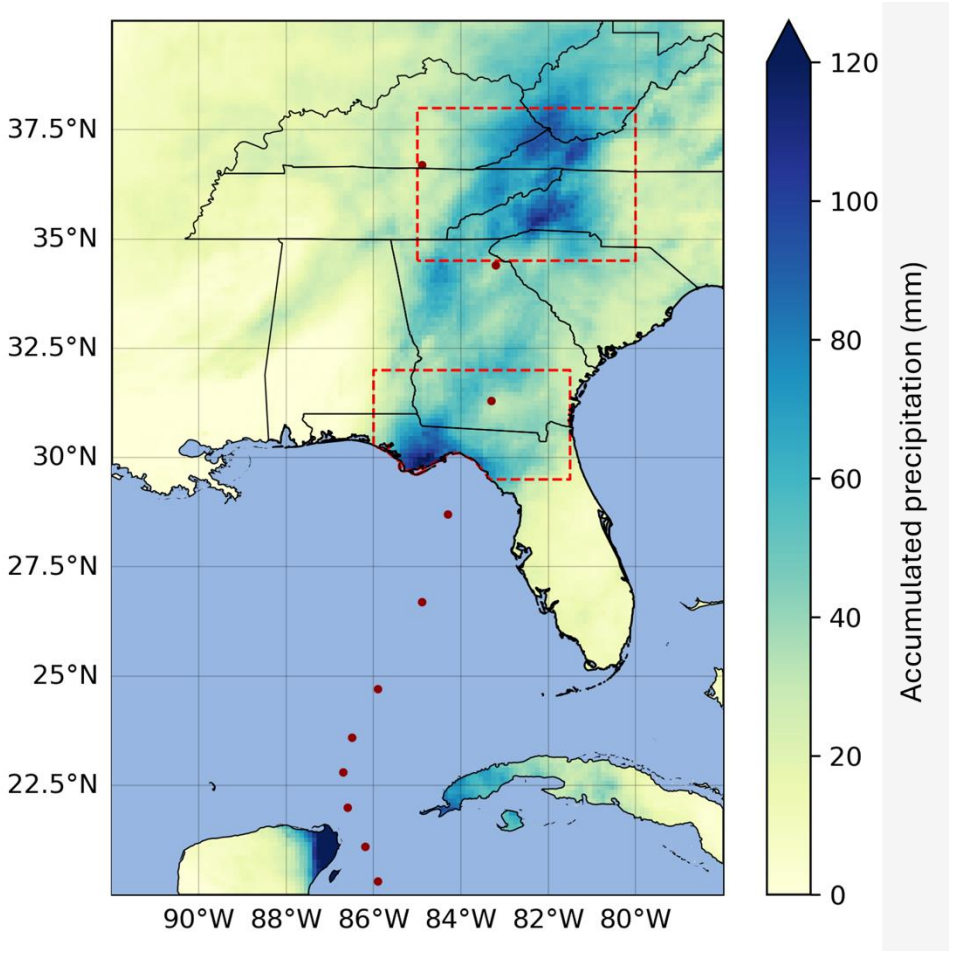
1. Trigger

2. Event definition

- Aim to capture impacts and meteorology:
  - Meteorological variables
  - Spatial and temporal extent
  - Seasonality
  - Other factors e.g. preconditioning



Data from ERA5: forecast, analysis & reanalysis.



Accumulated precipitation over the southeastern US from 25-27th September 2024. The track of Hurricane Helene is shown as a series of red points, and the study regions in red. The borders of the affected states are shown for reference. Data from IMERG.

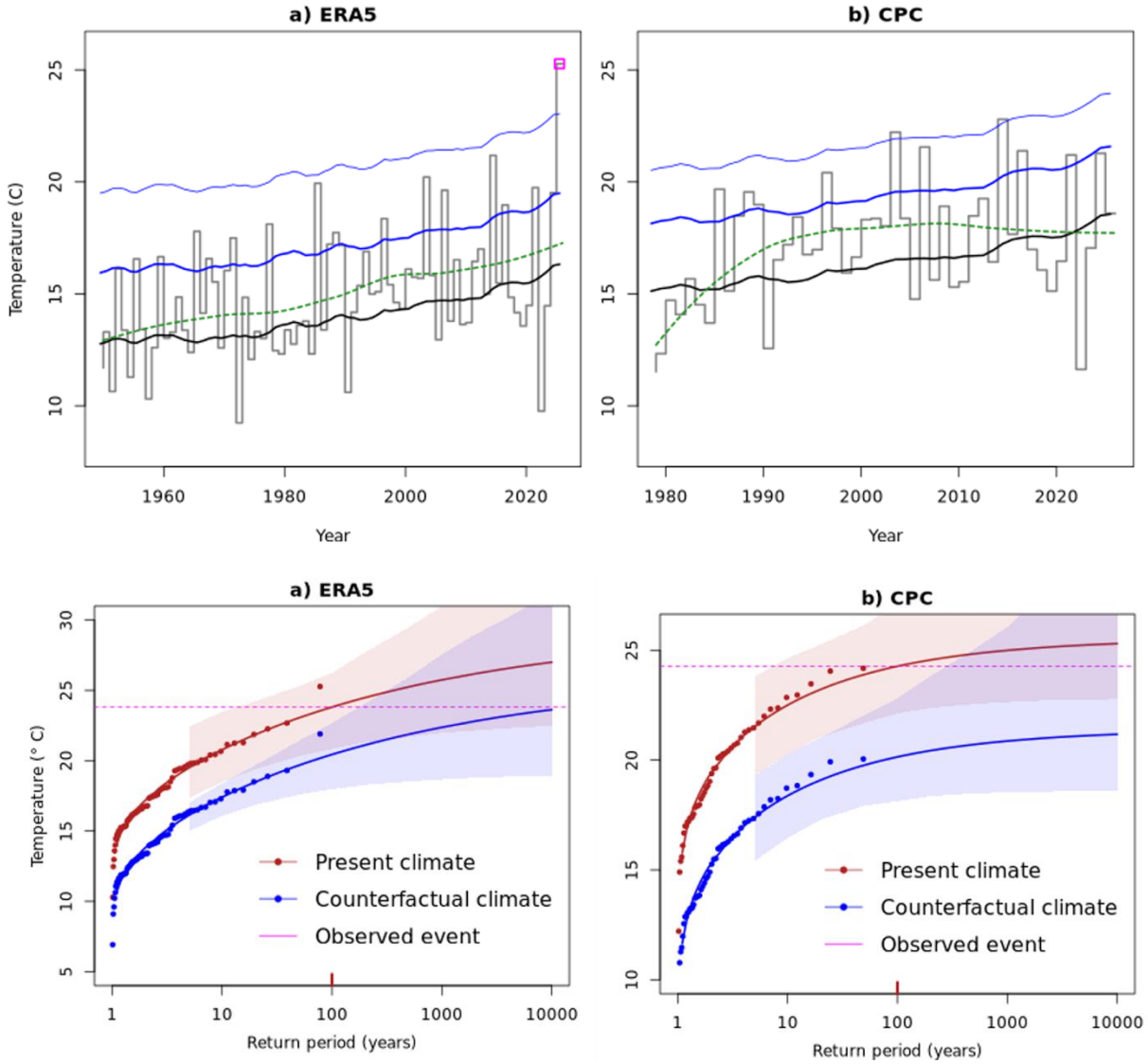
In practice

Protocol

1. Trigger
2. Event definition
3. **Observed probability and trend**

Use weather stations and gridded observation-based data products:

- Reanalysis/integrated e.g. ERA5/MSWX/MSWEP
- Station-based e.g. CPC/GPCC
- Satellite-based e.g. CHIRPS/GPM-IMERG/TAMSAT



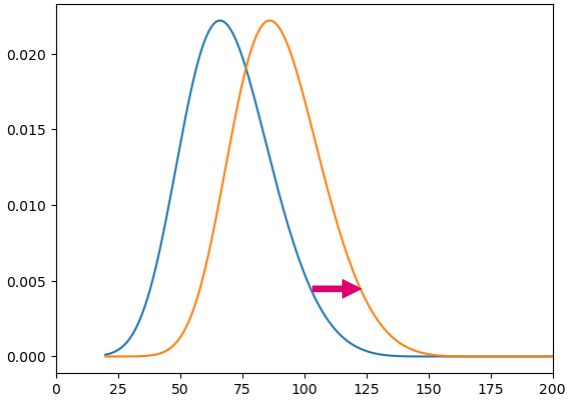
In practice

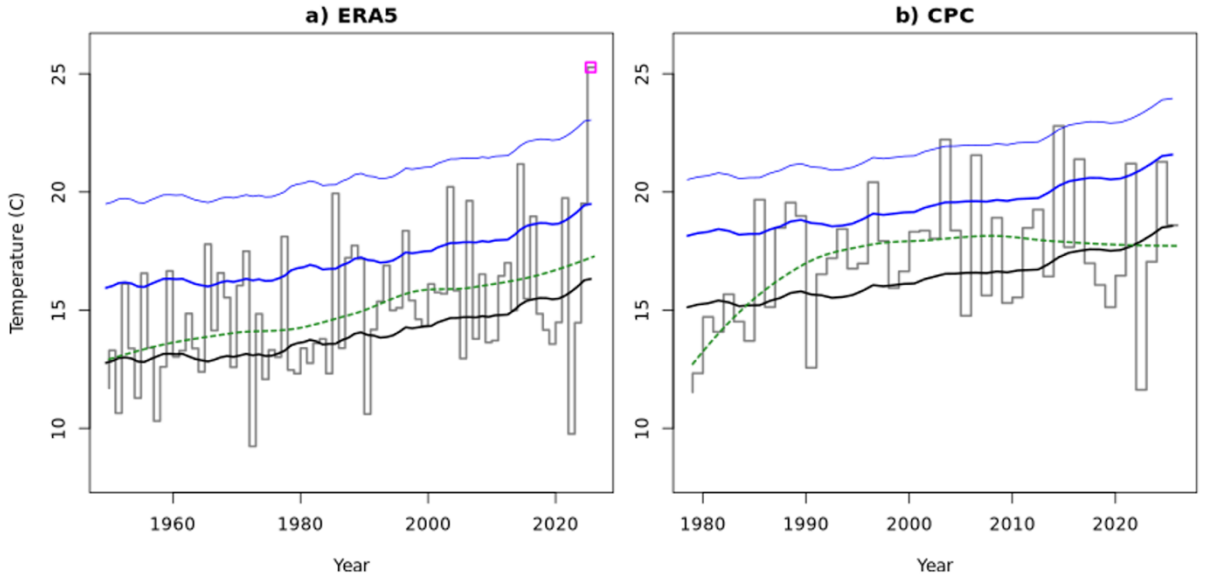
Protocol

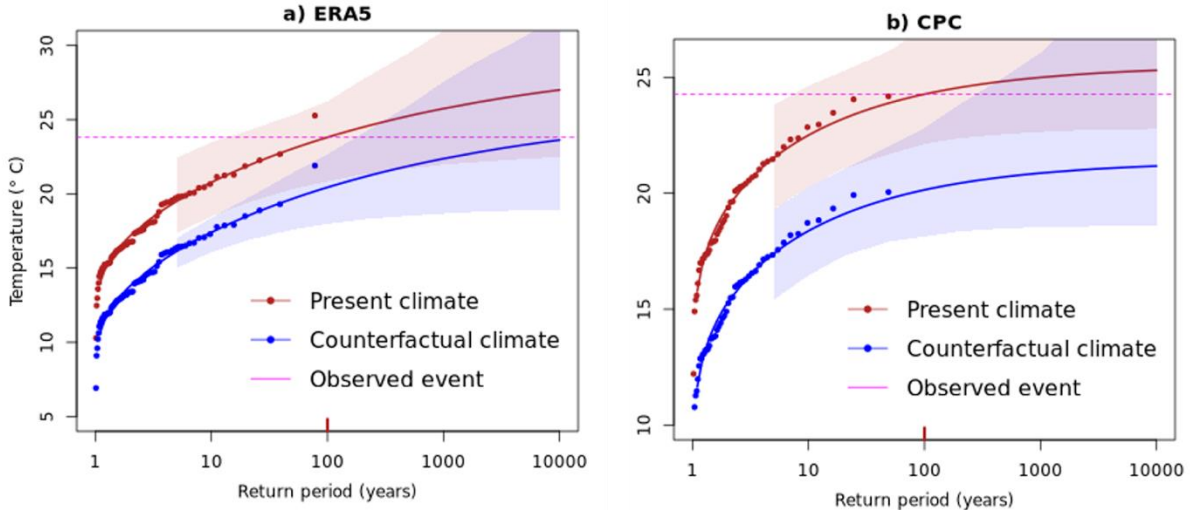
1. Trigger
2. Event definition
3. **Observed probability and trend**

Fit a statistical model to time series:

- Non-stationary GEV with GMST as a covariate
- Temperatures assumed to shift with GMST
- Evaluate likelihood and intensity at each covariate level



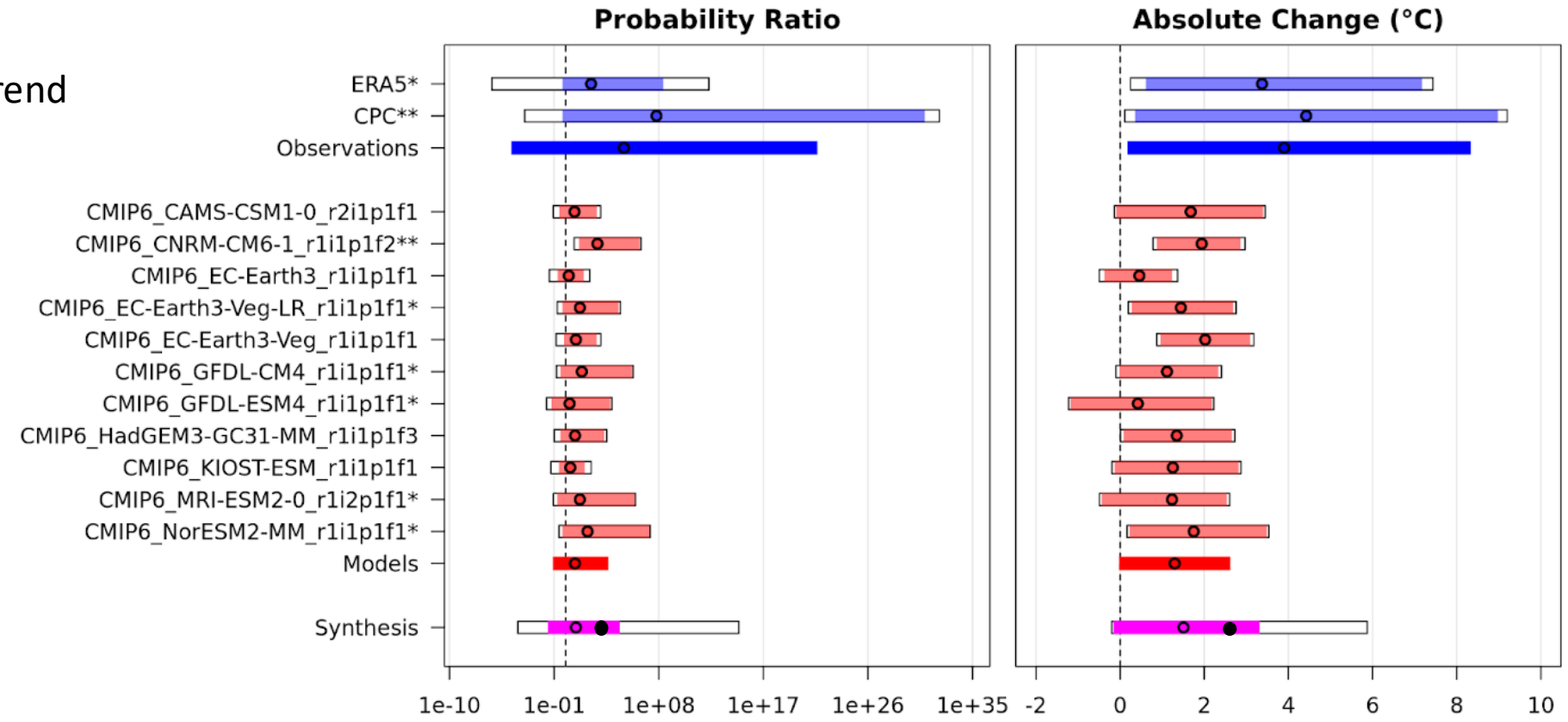




In practice

Protocol

1. Trigger
2. Event definition
3. Observed probability and trend
4. **Model evaluation**
5. **Multi-model attribution**
6. **Hazard synthesis**
7. Vulnerability & exposure
8. Communication



In practice

Protocol

1. Trigger
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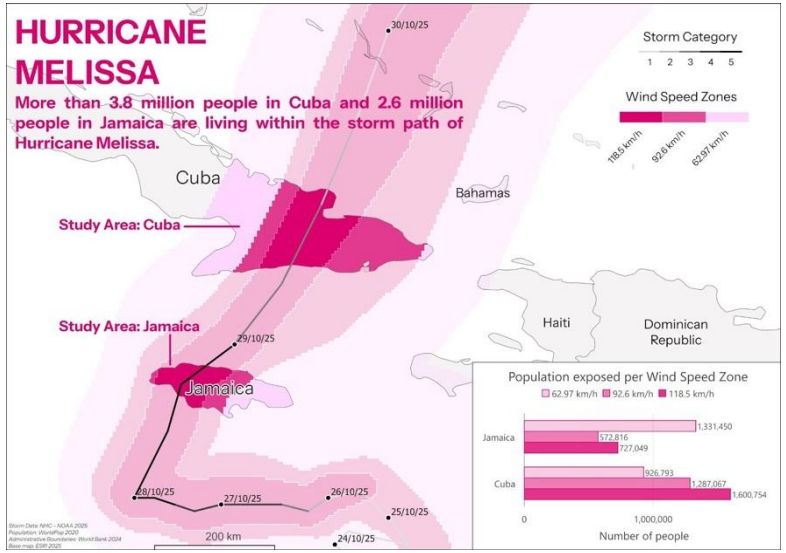
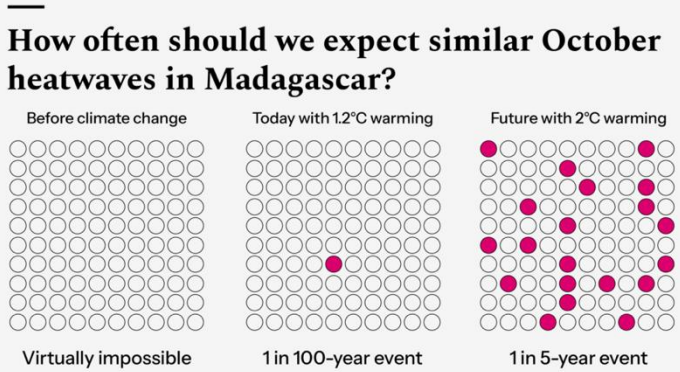
7. **Vulnerability & exposure**
8. **Communication**

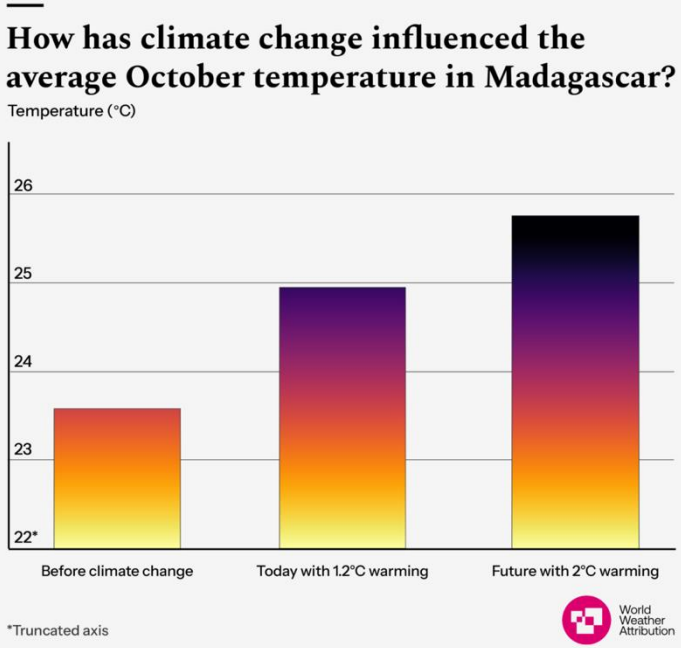
Timeline ~1-2 weeks

Main communication channels:

- Embargoed press release
- Press briefing
- Graphics to communicate main findings



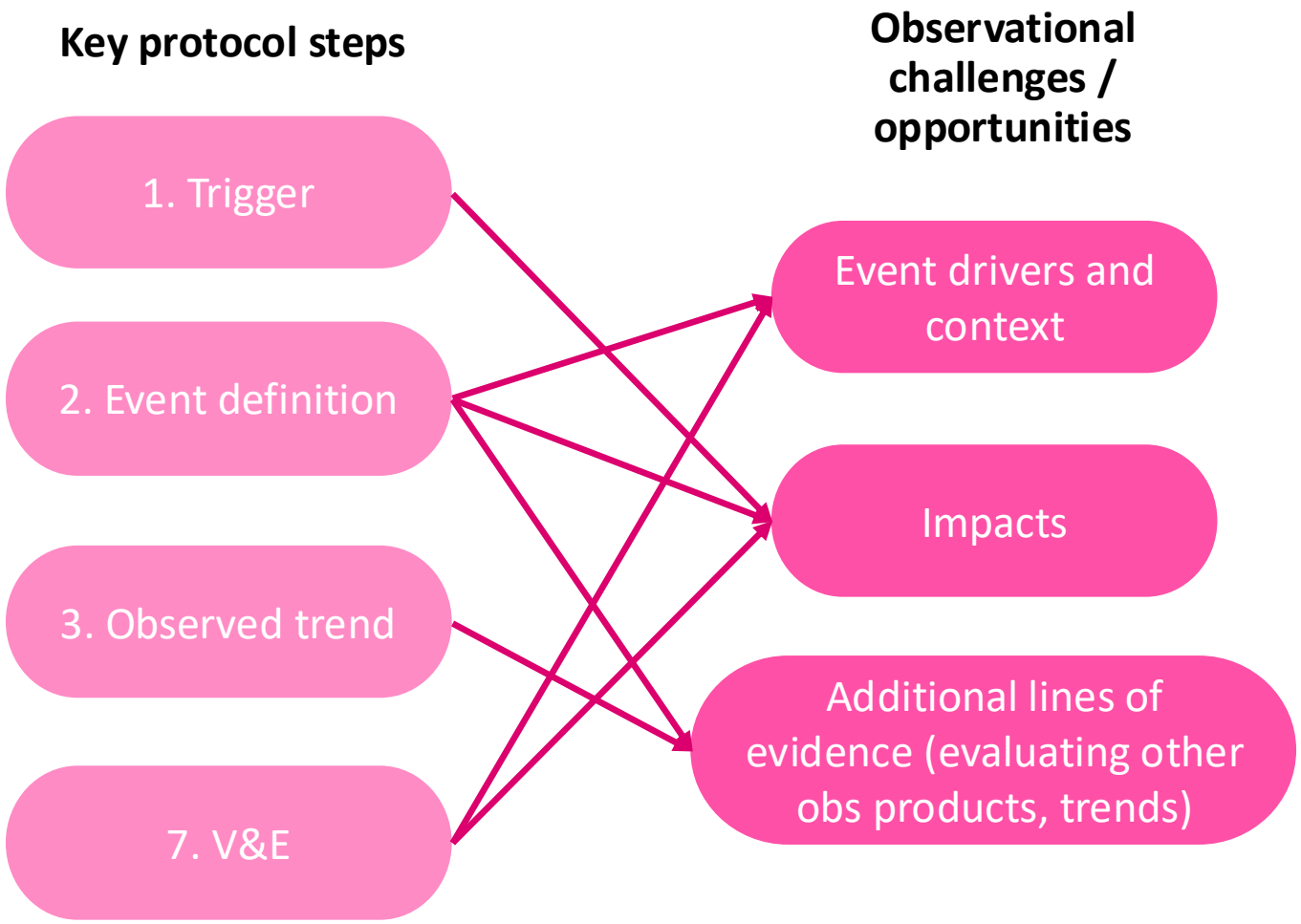




3) Gathering more evidence

Earth observations in attribution

Observations underpin everything!



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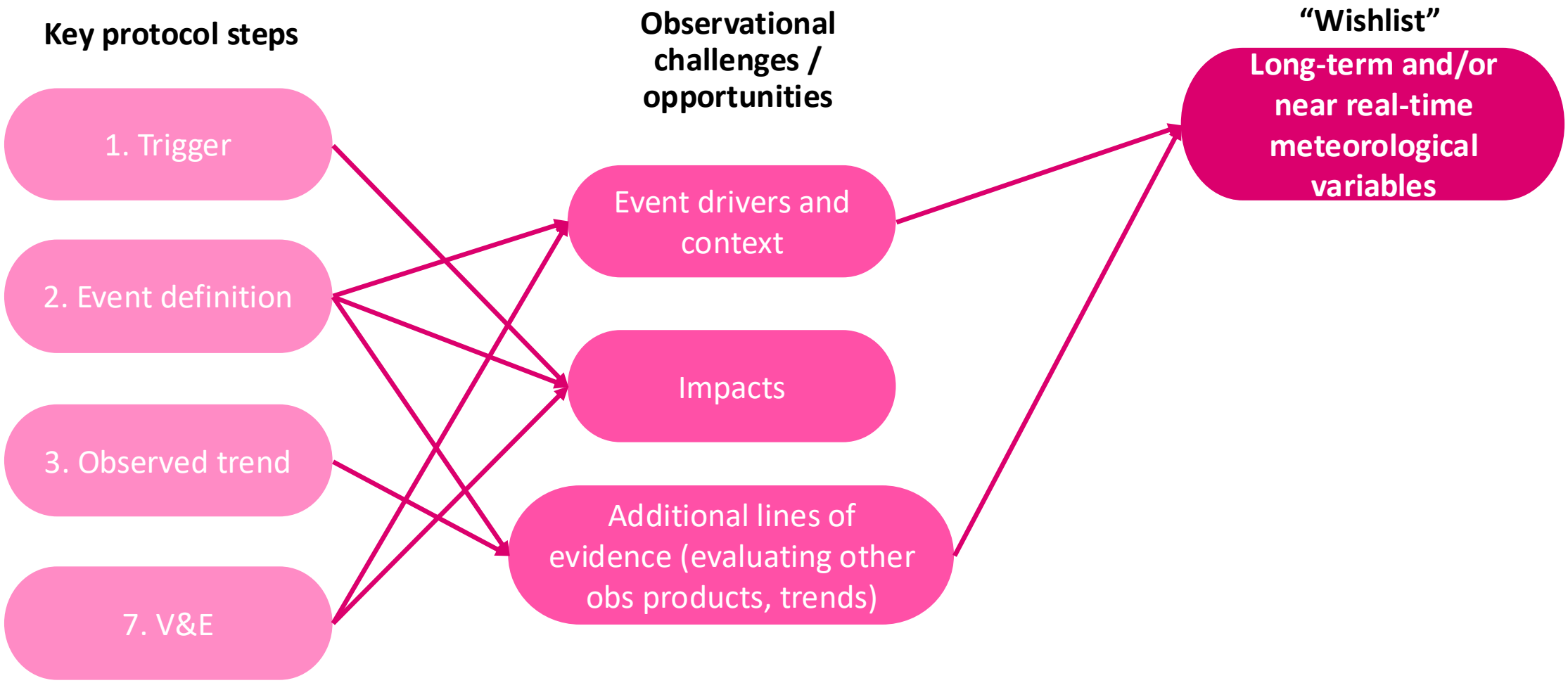

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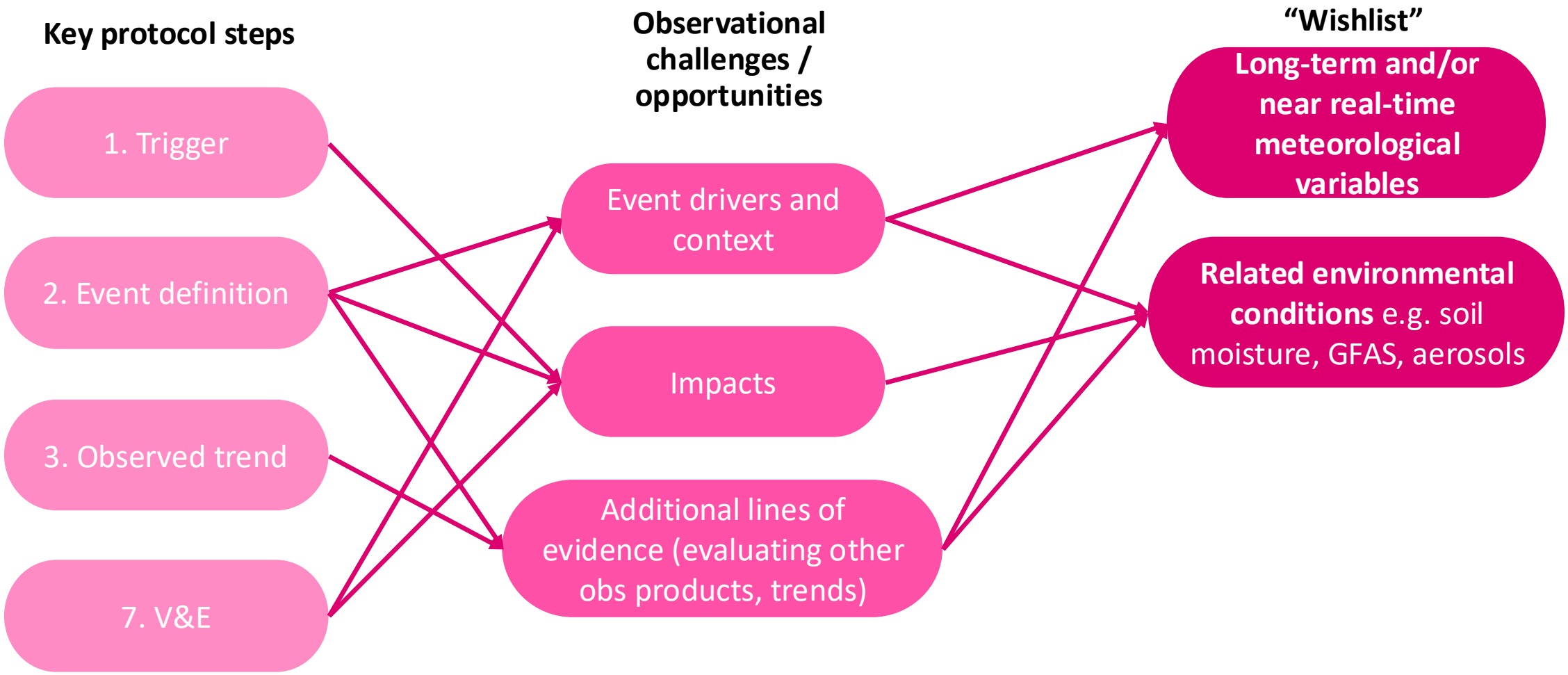

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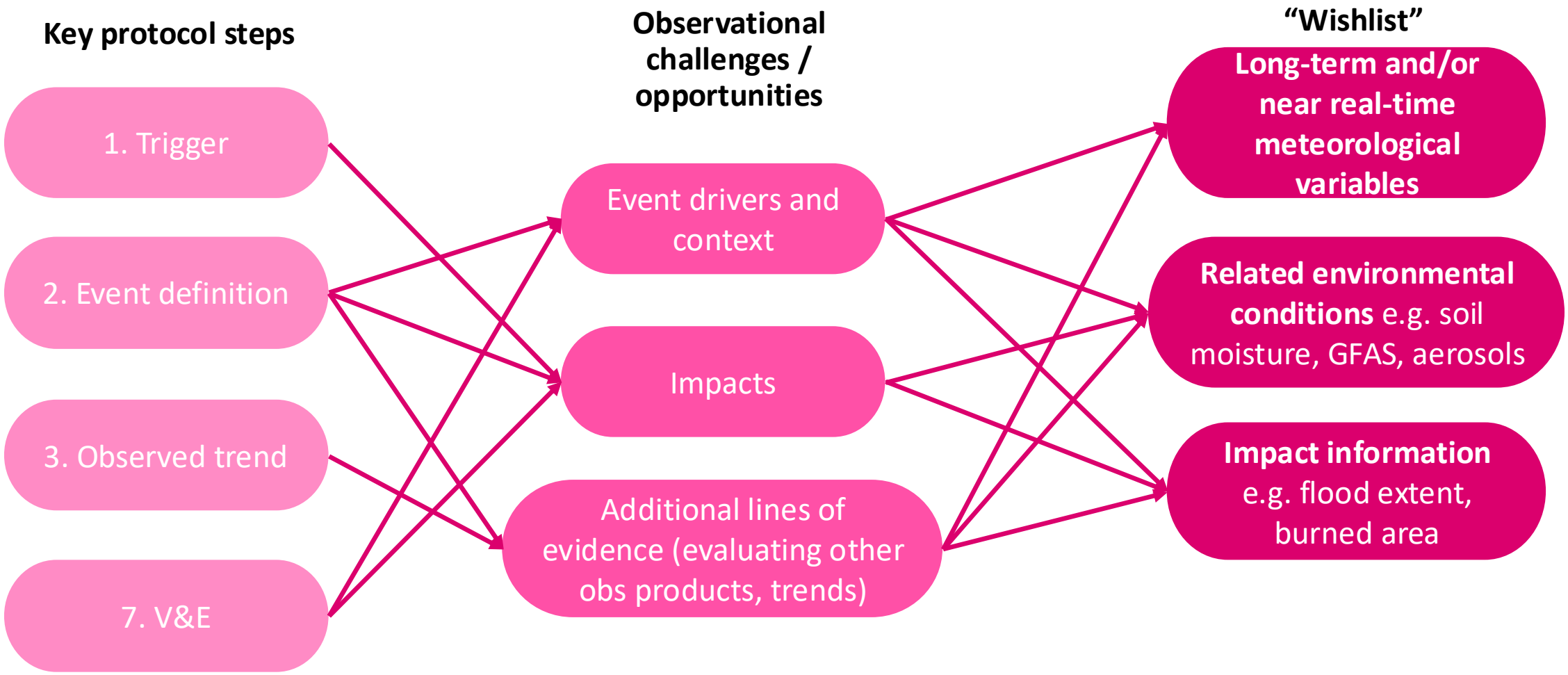

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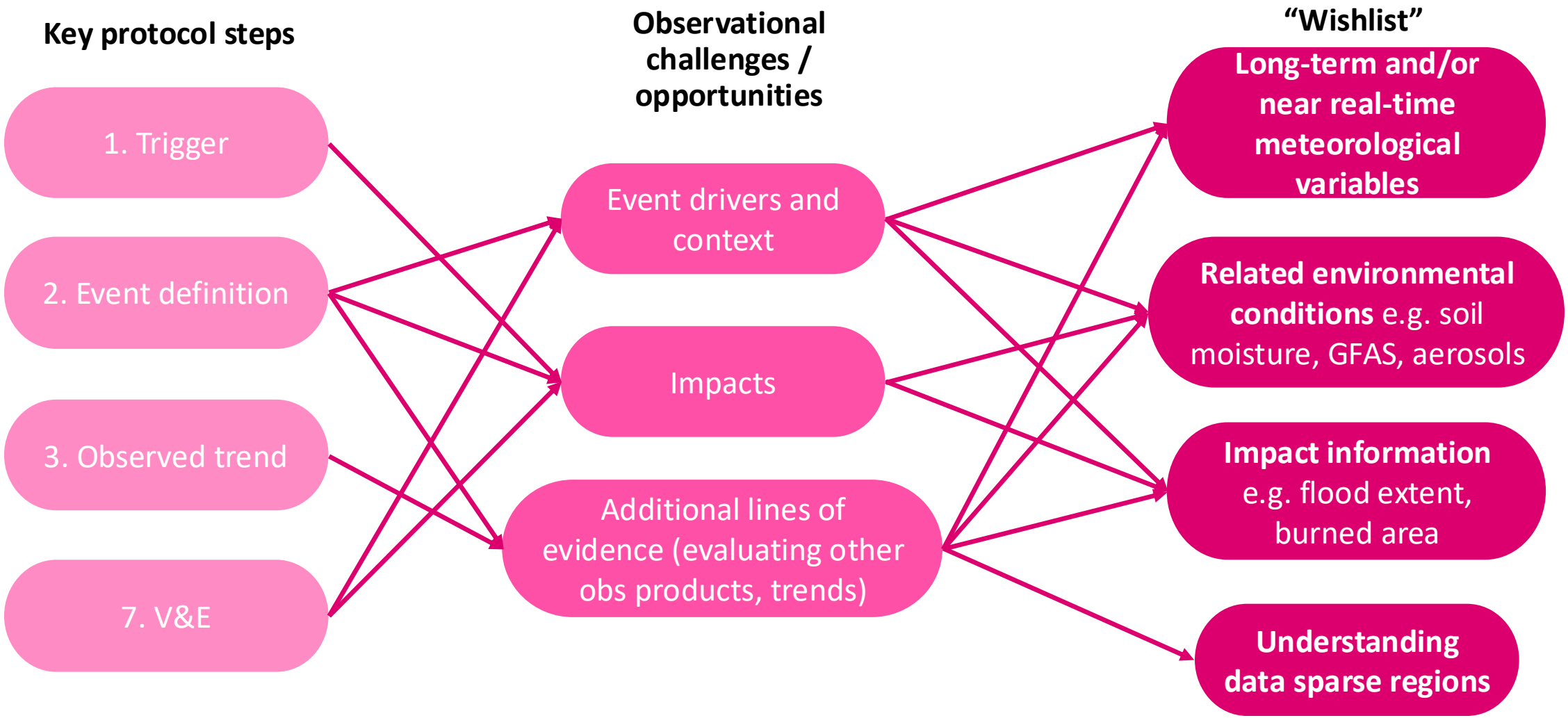

Thank you! Any questions?

References

1) Thompson, V., Ermis, S. and Athanase, M. (2026), The need for multi-method extreme event attribution. Weather, 81: 40-45. https://doi.org/10.1002/wea.7779
2) Beck, H. E. et al (2022). MSWX: Global 3-hourly 0.1° bias-corrected meteorological data including near-real-time updates and forecast ensembles. Bull. Amer. Meteor. 103, E710–E732, https://doi.org/10.1175/BAMS-D-21-0145.1.
3) Beck, H. E. *et al*. MSWEP V2 global 3-hourly 0.1° precipitation: Methodology and quantitative assessment. *Bull. Amer. Meteor.* 100, 473–500, https://doi.org/10.1175/BAMS-D-17-0138.1 (2019).
4) Clarke et al., (2024), Climate change key driver of catastrophic impacts of Hurricane Helene that devastated both coastal and inland communities. World Weather Attribution – rapid study.
5) Clarke et al., (2026), Record-shattering March temperatures in Western North America virtually impossible without climate change. World Weather Attribution – rapid study.

Additional dataset details and references on the following slide.

Thank you! Any questions?

Key observational datasets

1) **ERA5** - The European Centre for Medium-Range Weather Forecasts's 5th generation reanalysis product, ERA5, is a gridded dataset that combines historical observations into global estimates using advanced modelling and data assimilation systems (Hersbach et al., 2020).
2) **MSWX -** The Multi-Source Weather dataset (Beck et al., 2022), which combines various observational and reanalysis-based data (including ERA5) for reliable bias-corrected weather variable estimates, at 3-hourly intervals from 1979 to near real-time, and at 0.1° spatial resolution globally.
3) **MSWEP** - The Multi-Source Weighted-Ensemble Precipitation v2.8 dataset (updated from Beck et al., 2019) is fully global, available at 3-hourly intervals and at 0.1° spatial resolution, available from 1979 to ~3 hours from real-time. This product combines gauge-, satellite-, and reanalysis-based data, including ERA5.
4) **CPC -** This is the gridded product from NOAA PSL, Boulder, Colorado, USA known as the CPC Global Unified Daily Gridded data, available at 0.5° x 0.5° resolution, for the period 1979-present.
5) **GPCC -** This is the Full Data Daily Product Version 2022 of daily global land-surface precipitation totals based on precipitation data provided by national meteorological and hydrological services, regional and global data collections as well as WMO GTS-data (Ziese et al., 2022).
6) **CHIRPS** - The rainfall product developed by the UC Santa Barbara Climate Hazards Group called “Climate Hazards Group InfraRed Precipitation with Station data” (CHIRPS; Funk et al. 2015). Daily data are available at 0.05° resolution, from 1981-present. The product incorporates satellite imagery with in-situ station data.
7) **IMERG -** This product uses NASA's Integrated Multi-satellitE Retrievals for GPM (IMERG) algorithm for combining information from the GPM satellite constellation to estimate precipitation over the majority of the Earth's surface (Rozante et al. 2010). IMERG fuses precipitation estimates collected during the TRMM satellite’s operation (1998 - 2015) with recent precipitation estimates collected by the GPM mission (2014 - present). IMERG is available from 1998 to present in near real-time with estimates of Earth’s precipitation updated every half-hour.
8) **TAMSAT -** The Tropical Applications of Meteorology using SATellite and ground-based observations, Maidment et al., (2017), is a daily rainfall dataset based on using high-resolution thermal-infrared observations to identify precipitating clouds. Daily rainfall data are available at 0.0375° x 0.0375° spatial resolution over the African continent from 1983 to the present.

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