WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

Climate, climate change, their impact and resilience building

Dr Boram Lee (blee@wmo.int)

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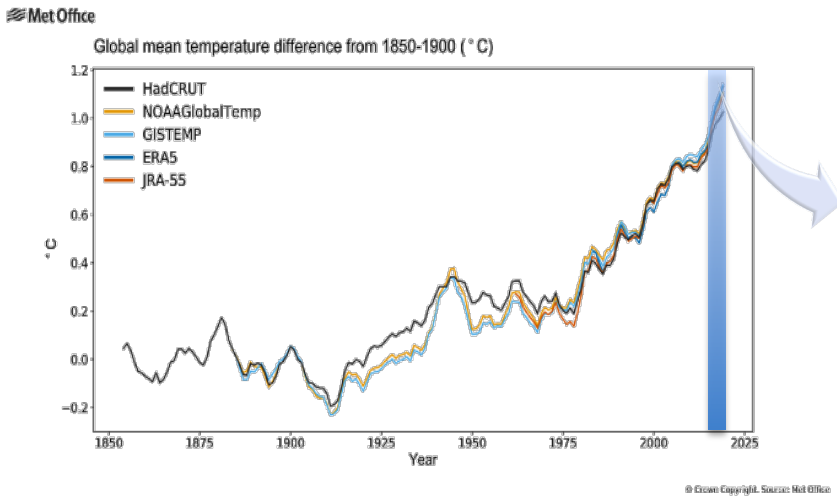
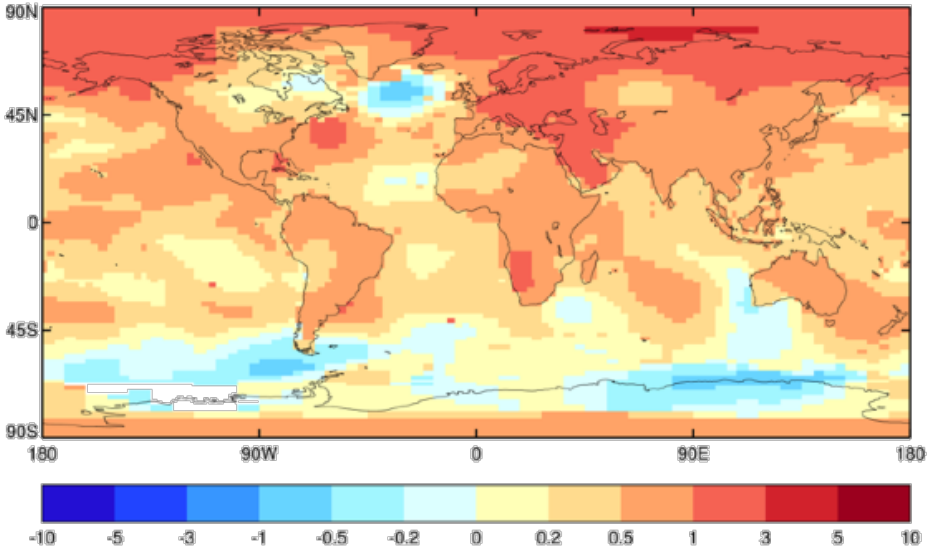
World Meteorological Organization
Organisation météorologique mondiale

The Global Climate 2015-2019





Source NASA GISTEMP v4

- 2015–2019: Warmest five-year period (0.2 °C higher than 2011–2015)
- **2016: Warmest year on record, ever** (1 °C higher than pre-industrial period)

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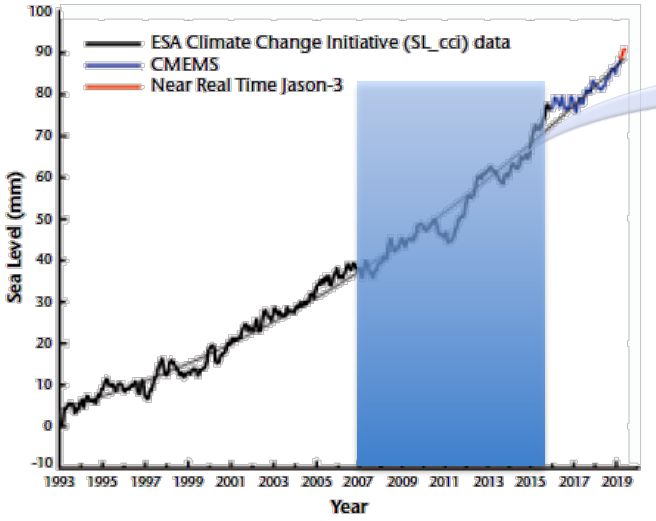
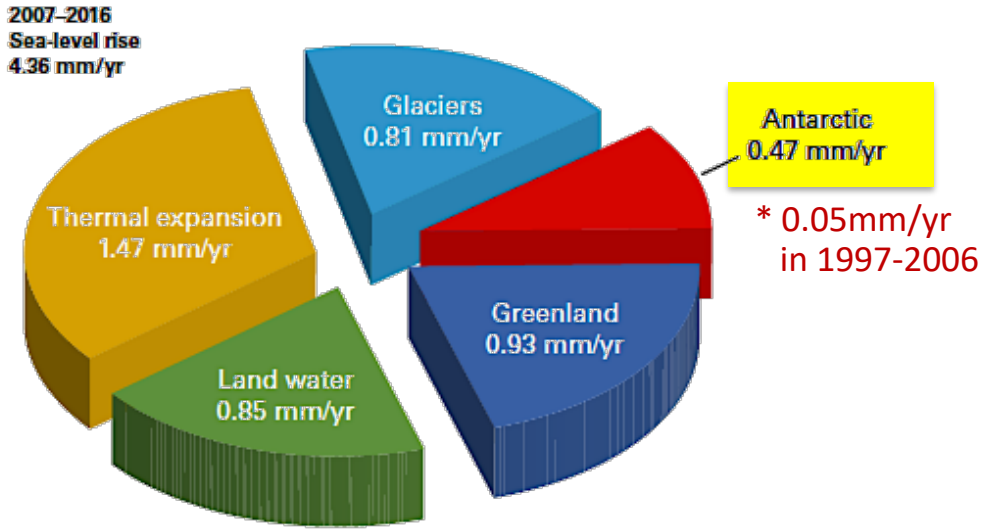
(https://library.wmo.int/doc_num.php?explnum_id=9936)

The Global Climate 2015-2019





* 0.05mm/yr in 1997-2006

- Substantially faster sea level rise:
  5mm/year for 2014-2019 (3.2mm/year since 1993)
- **Ice melt: major contributor for latest changes in trend**

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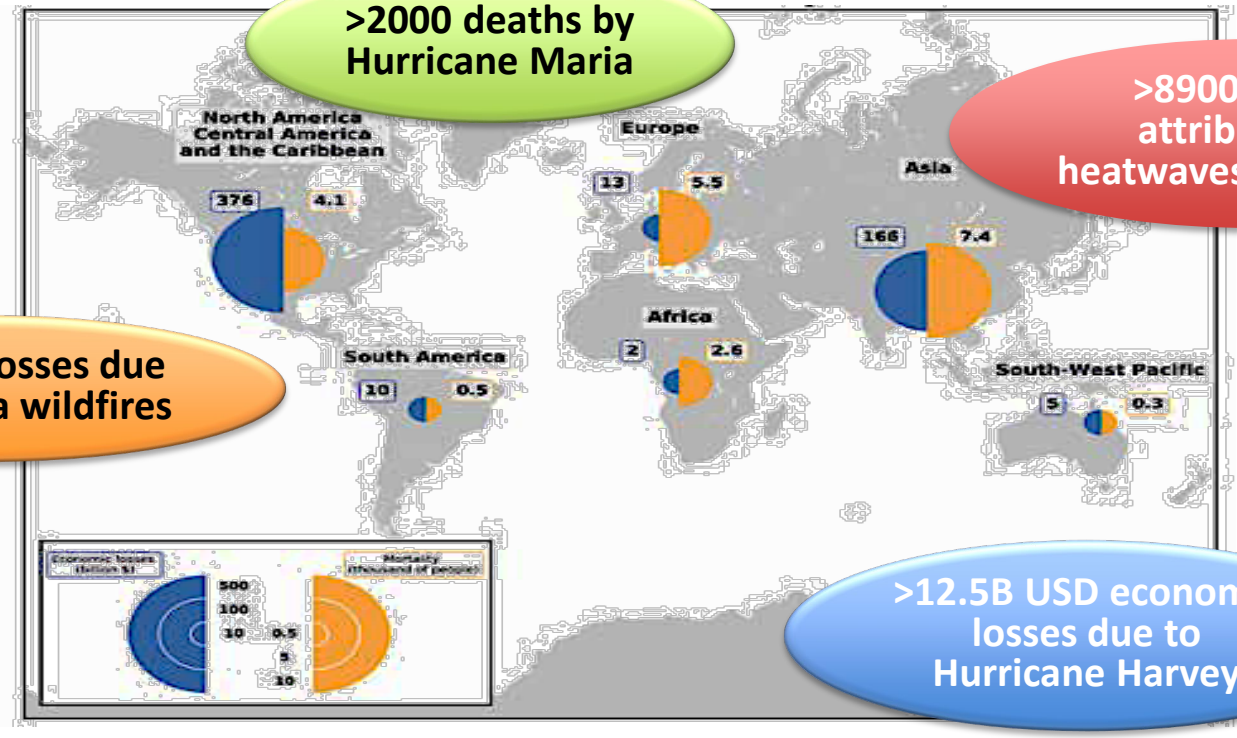
(https://library.wmo.int/doc_num.php?explnum_id=9936)

The Global Climate 2015-2019



- Deadly heatwaves: **attributable to human influence**
- Costly tropical cyclones, unprecedented drought and wildfires

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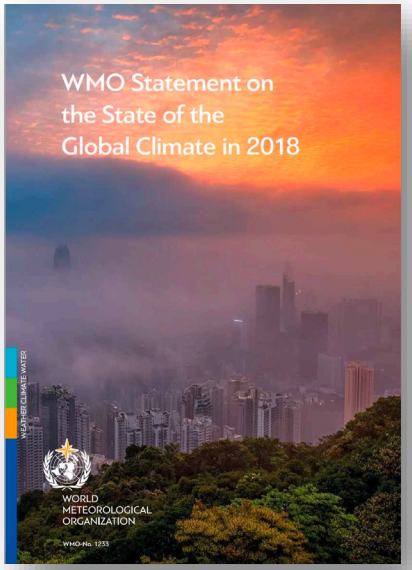
WMO Statement on Annual State of Climate



- Complements IPCC Assessment Reports and Special Reports, providing a **snapshot on key climate indicators and extreme events** with historical and geographical context

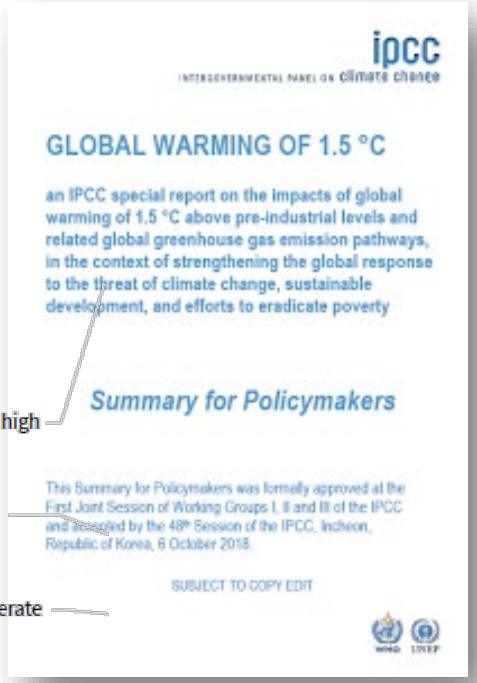
Temperature and energy	Atmoshperic composition	Ocean and water	Cryosphere
Surface temperature	Atmospheric CO_2	Ocean acidification	Glaciers
Ocean heat		Sea level	Arctic and Antarctic sea-ice extent

- Allows analysis of climate change signals separated more clearly from natural modes of variability (e.g. El Niño-Southern Oscillation)

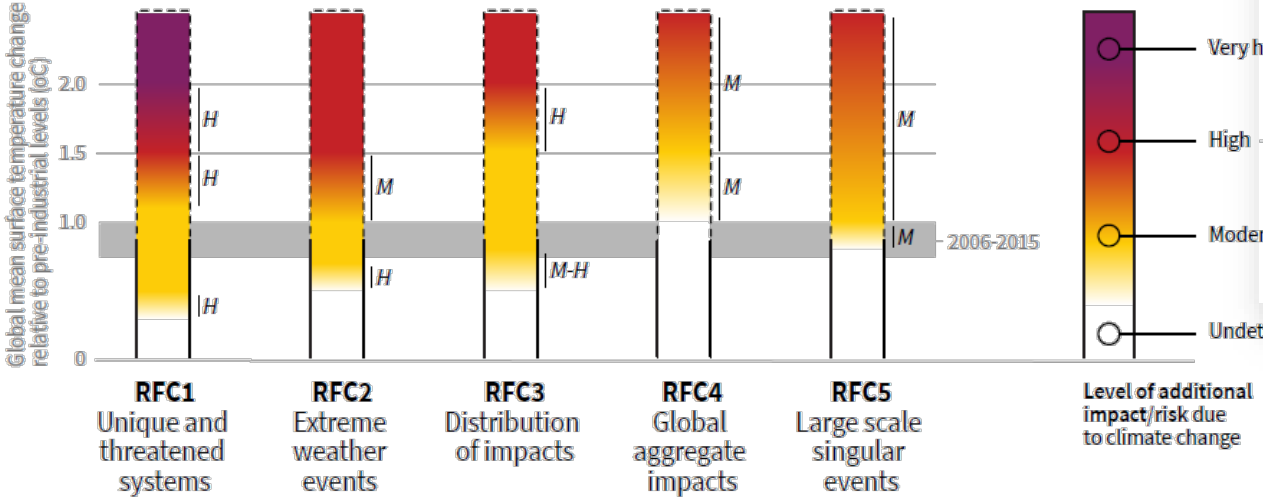
(https://library.wmo.int/doc_num.php?explnum_id=5789)

Extremes and Risks

… We are **not** on track to meet climate change targets and rein in temperature increases…



Impacts and risks associated with the Reasons for Concern (RFCs)



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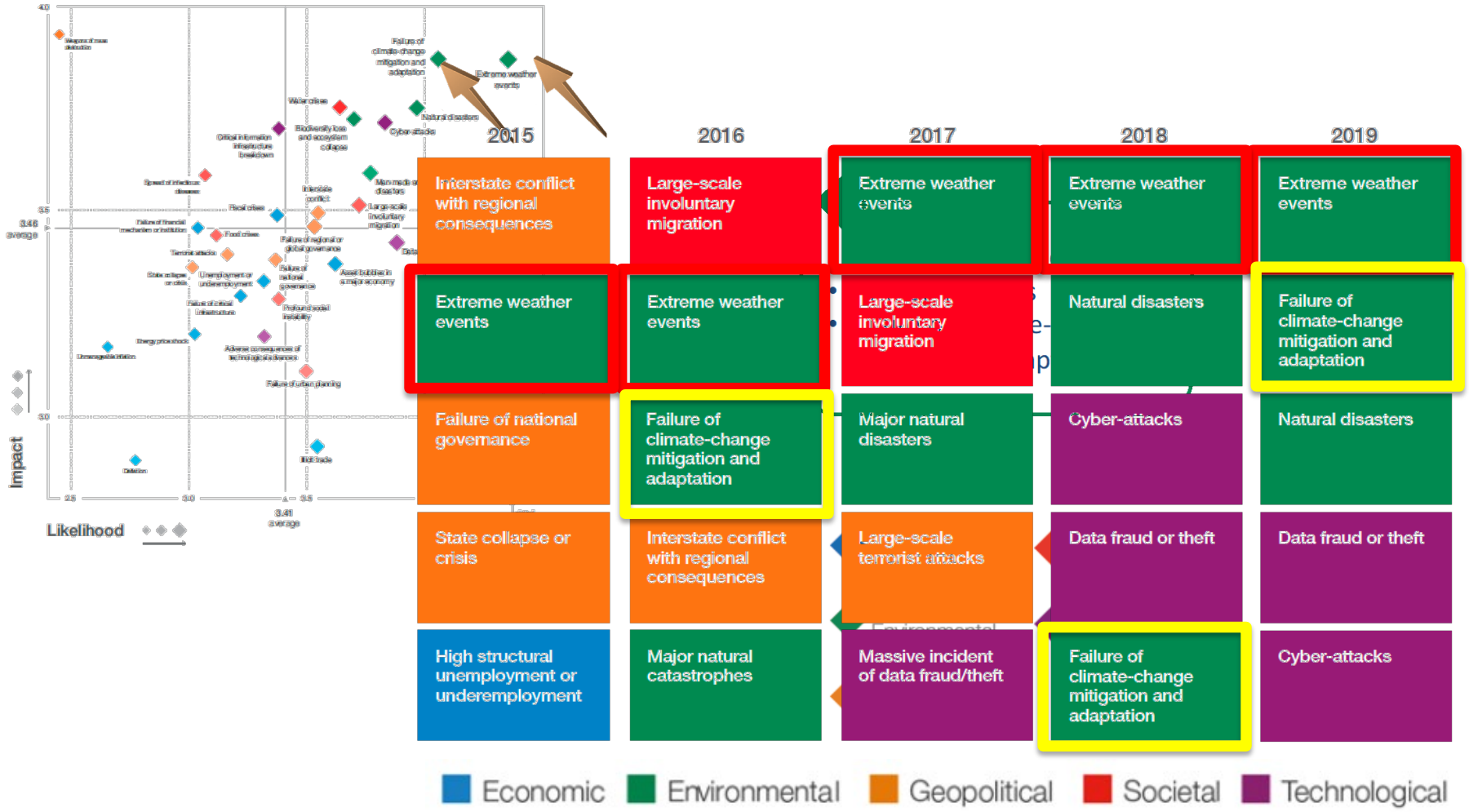
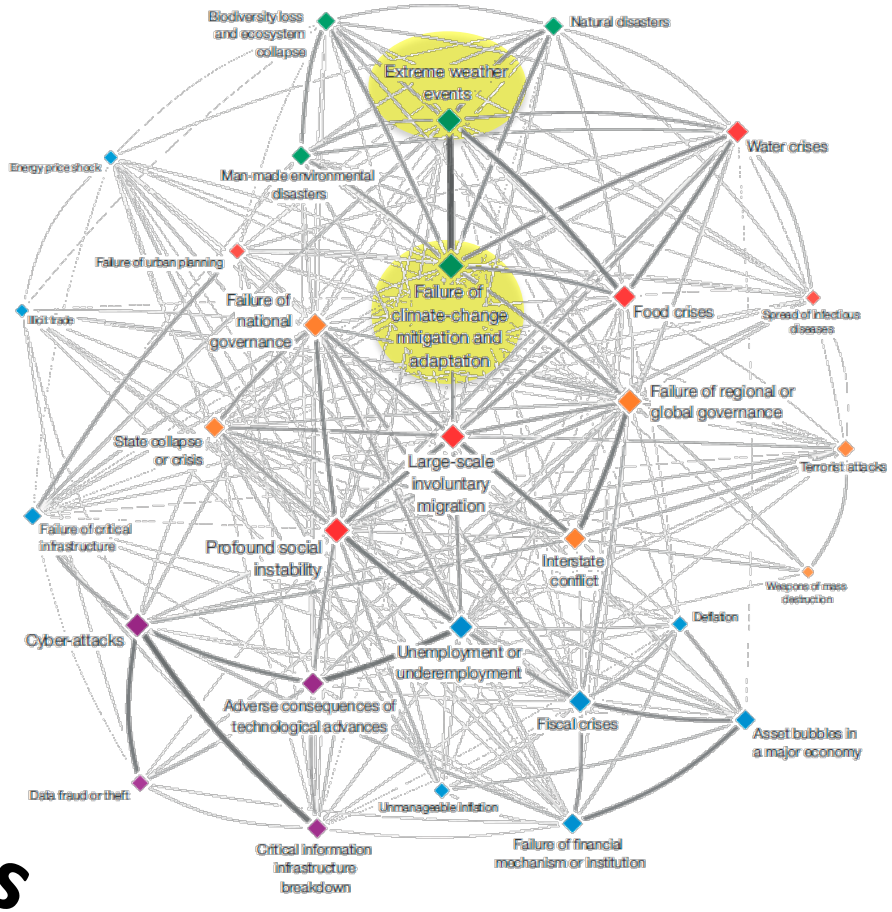
Extremes and Risks



(Global Risk Landscape 2019, World Economic Forum)

Extremes and Risks

Systemic risks



Economic | Environmental | Geopolitical | Societal | Technological

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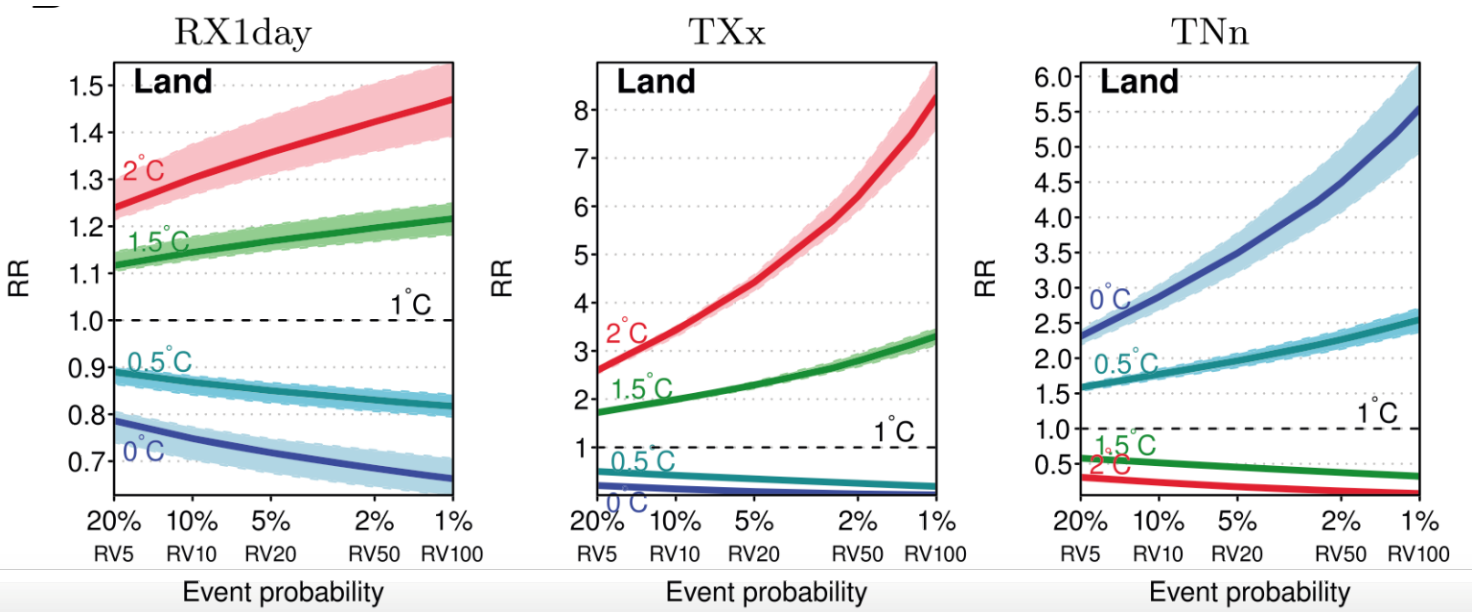
(Global Risk Landscape 2019, World Economic Forum)

Extremes and Risks



Changes in the risk will not be uniform

- Larger increase with stronger warming
- Larger increase with rarer events

+ society values, metrics of loss…

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(Kharin et al., 2018)

Climate, Changes, Impact and Resilience

- Climate resilience: prioritized by international agencies and national governments.
- A long-term view is relevant to decision-making of now.
- Climate model projections can be relied upon to guide mitigation plans and broad adaptation strategies.

Climate, Changes, Impact and Resilience

Are climate (change) information fit for purpose?

Guidance to use of climate (change) information for adaptation & mitigation actions?

(relevance, resolution & scale, precision, confidence, advice…)

- Climate resilience: prioritized by international agencies and national governments
- A long-term view is relevant to decision-making of now.
- Climate model projections can be relied upon to guide mitigation plans and broad adaptation strategies.

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Stationary paradigm (infrastructure design)

- Collect annual maximum (e.g., peak flood) data
- Fit the data to a probability distribution (e.g. Generalized Extreme Value distribution)
- Infer from the fitted distribution the 1/*p*-year return value
- Use the return value as a design value based on stationarity assumption:

"climate has not changed in the past and will not change in the future"

(X.Zhang, 2019)

Stationary or Non-stationary ?

Some quotes…

- *"Stationarity is dead: whither water management?"* (Milly et al., Science 2008)
  - **substantial anthropogenic change of the Earth's climate alters the means and extremes** … will continue to the foreseeable future

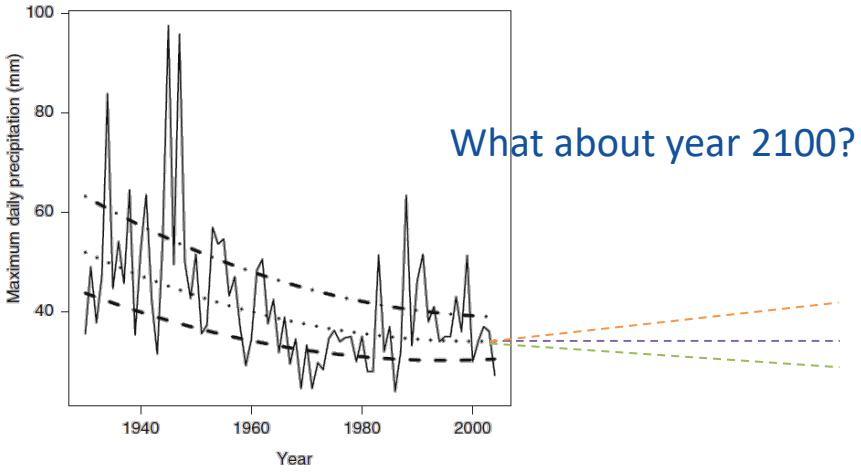


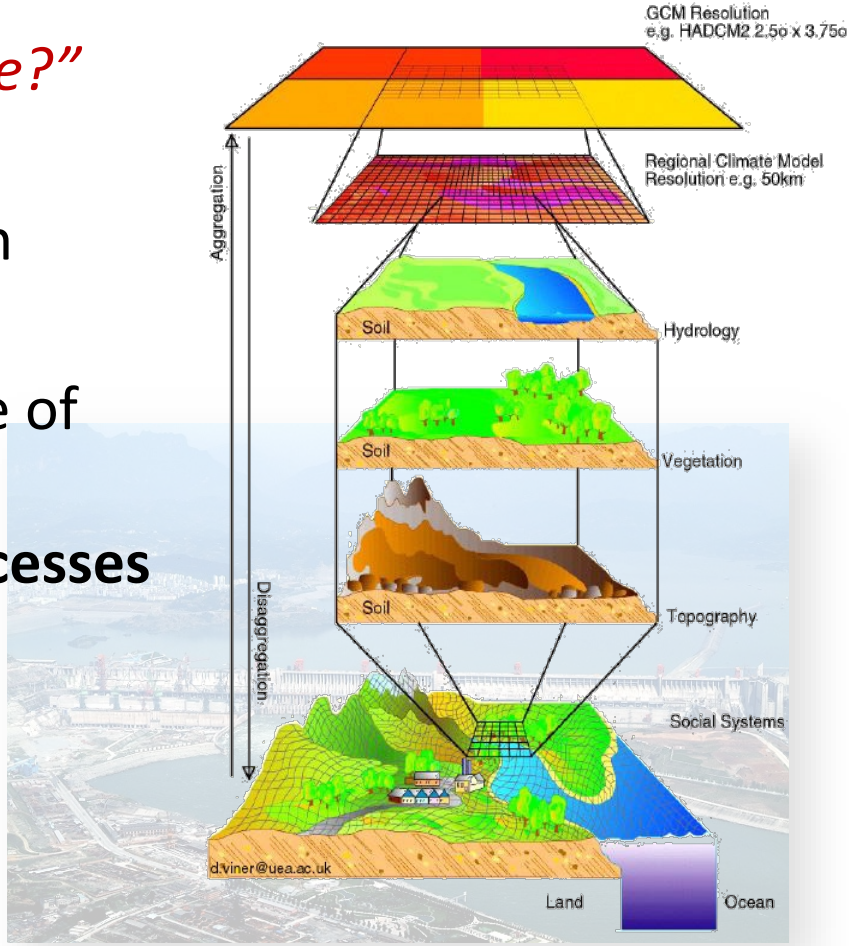
Fig. 2.6 Winter (May–October) time series of maximum daily precipitation amount (mm) at Manjimup, Western Australia during 1930–2004, along with selected quantiles [0.25 (*dashed curve*), 0.5 (*dotted curve*), 0.75 (*dot-dashed curve*)] for fitted nonstationary GEV distribution with quadratic trend in location parameter and linear trend in log-transformed scale parameter

(X.Zhang, 2019)

Stationary or Non-stationary ?

Some quotes…

- *"Stationarity: wanted dead or alive?"* (Lins and Cohn, AWARA 2011)
  - change is not synonymous with nonstationarity
  - prudent and reasonable course of action requires **long-term understanding on climate processes**



(X.Zhang, 2019)

Stationary or Non-stationary ?

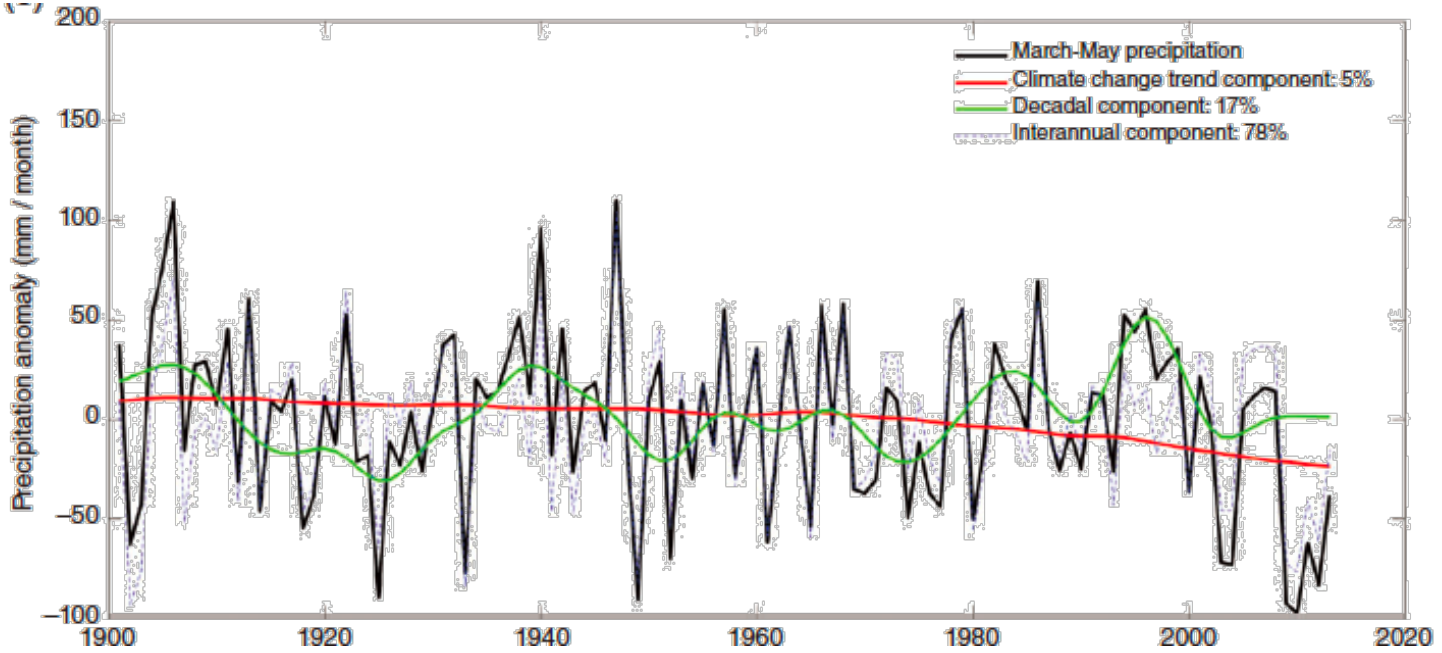
Some quotes…

- *"Stationarity is undead: uncertainty dominates the distribution of extremes"*
  (Serinaldi and Kilsby , AWR 2015)
  - Need not only at-site time series but additional data analyses
  - Need carefully designed modeling strategy, or additional uncertainty may be introduced
  - Need clear understanding of "probabilities" as well as "risk of failure"

(X.Zhang, 2019)

Climate information on different scales

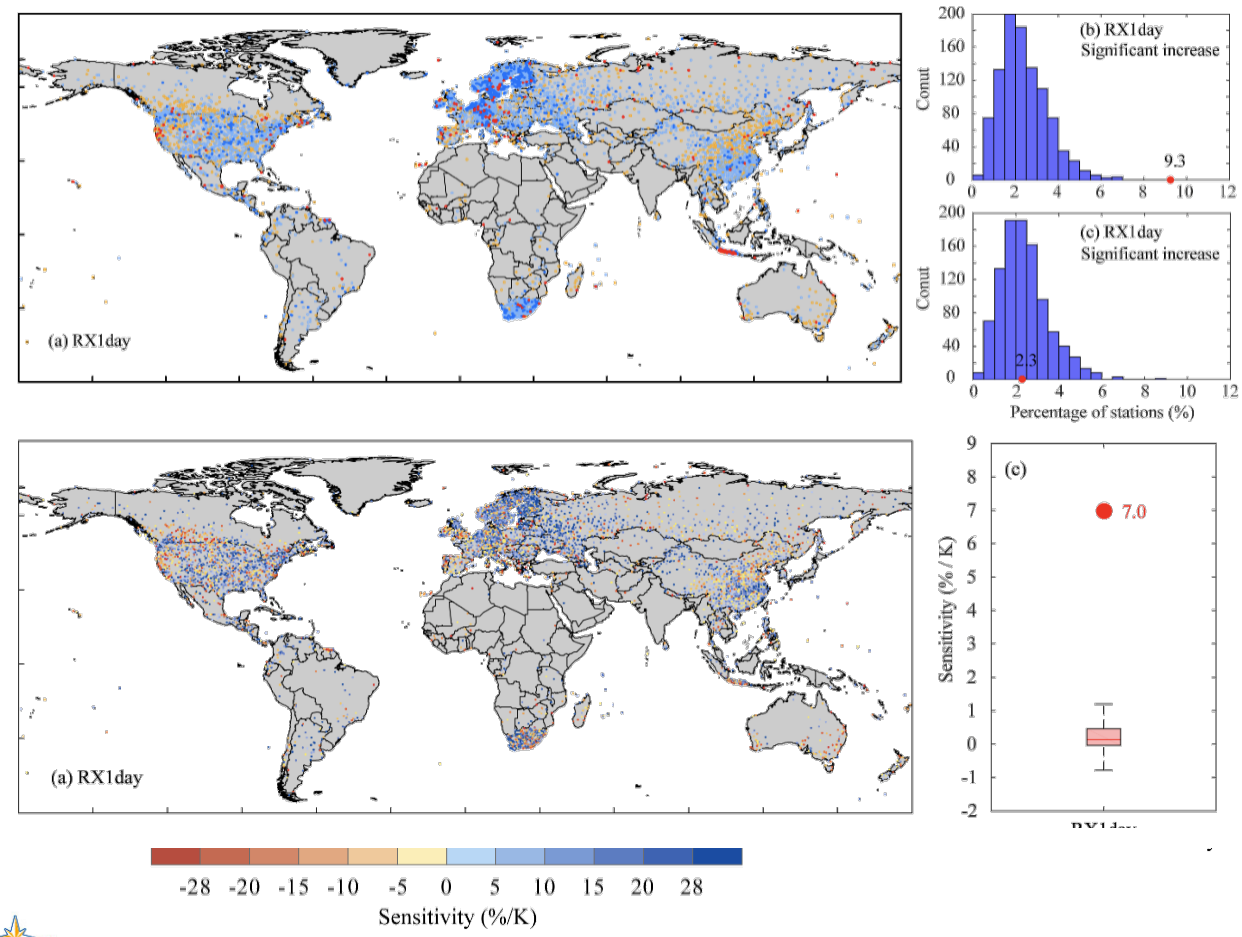
Timescales of variability for March–May rainfall over the East African domain



Use and misuse of climate change projections:
potential pitfalls of conflating decadal signals with longer-term trends…

(Nissan et al. WIREs Clim Change 2019)

Local changes in a future climate



- Difficult to detect a trend at individual locations;
- Evidence of heavy Precipitation intensification at the global scale
- Association between Temp. and Precip.

(Sun et al., in preparation)

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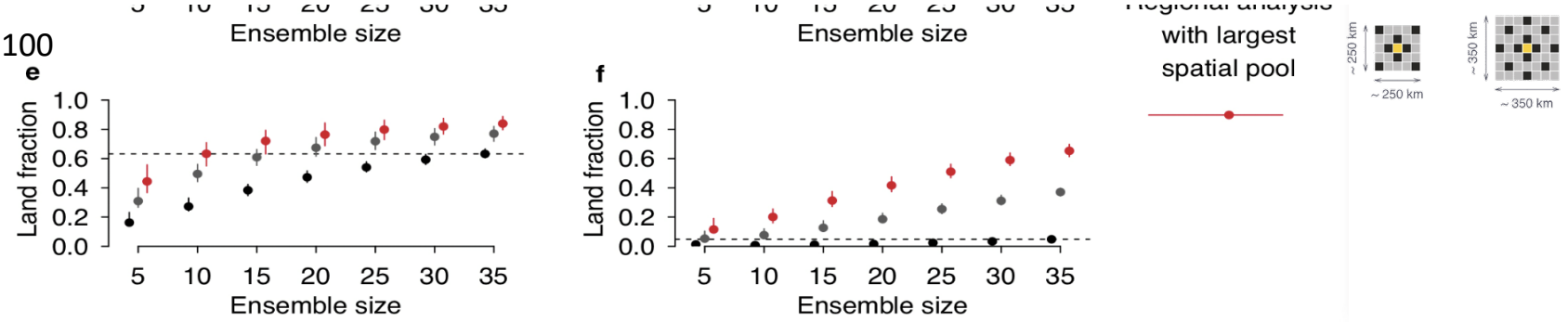
Local changes in a future climate

Temperature scaling relationships: historical relationship between extreme precipitation and temperature to provide **guidance about precipitation extremes in a future warmer climate.**

- TSR estimated from the limited historical observations are unlikely to be able to provide reliable guidance for future adaptation planning at local spatial scales.
- TSR based on multiple regional climate simulations do provide a feasible basis

2036-2100



(Li et al., Earth's Future 2018)

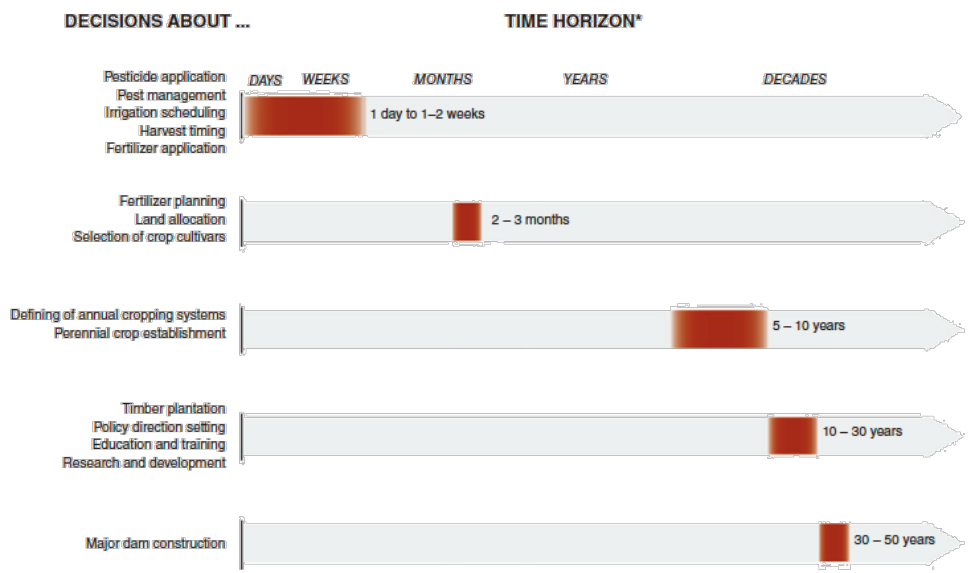
Climate, Changes, Impact and Resilience

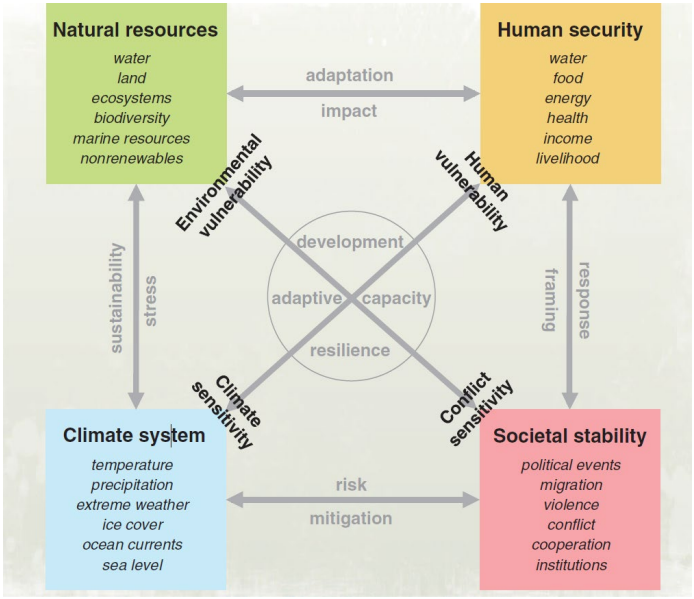
So, what are the implications?

- **Impacts are local/regional, adaptation also requires local/regional specific projection**
  - Changes are difficult to estimate locally or regionally based on historical data
  - Historical estimation cannot and should not be extrapolated to the future in a simplistic manner
- **Climate projections available in a range of precision and scales…**
  - Climate model simulations are not panacea (e.g., Lack of proper processes, still relatively low resolution)
  - model projections should not be used at its face value in many applications (especially at local/regional scale)

Climate, Changes, Impact and Resilience

- Considering requirements for decision-making: societal / socio-economic / scales …





Scheffran et al. Science 2012
Analytical framework of linkages between climate system, natural resources, human security, and societal stability

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Climate, Changes, Impact and Resilience

Recapping…

- There is a clear evidence at the global scale of anthropogenic influence on climate and extremes.
- Various statistical methods have been used to detect, to attribute and to project climate and its changes in extreme. These methods always come with assumptions. Understanding the assumptions are key to proper application of these methods.
- Foresights of physical / societal / socio-economic changes should be available, matching scales with climate information and requirements for decision-making.

For assessment and decision support: recalling fundamentals

- Do we secure and project sufficient **resources** to in-depth scientific analyses needed to develop reliable CC projections?
- What local to global **governance and legislative arrangements** best support equitable and sustainable CC mitigation and adaptation?
- What are **key obstacles** towards societal resilience across different sectors and SDGs, while facing climate change and emerging extremes?
  (Data? Knowledge? Perception? Governance? Compliance?)

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Thank you

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Some Definitions

IPCC Good Practice Guidance Paper on Detection and Attribution, 2010

- **Detection of change** is the process of demonstrating that the climate or a system affected by the climate has changed in some defined statistical sense
- **Attribution** is the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence
- Casual factors refer to external influences
  - **Climate**: anthropogenic and/or natural
  - Systems affect by climate: climate change

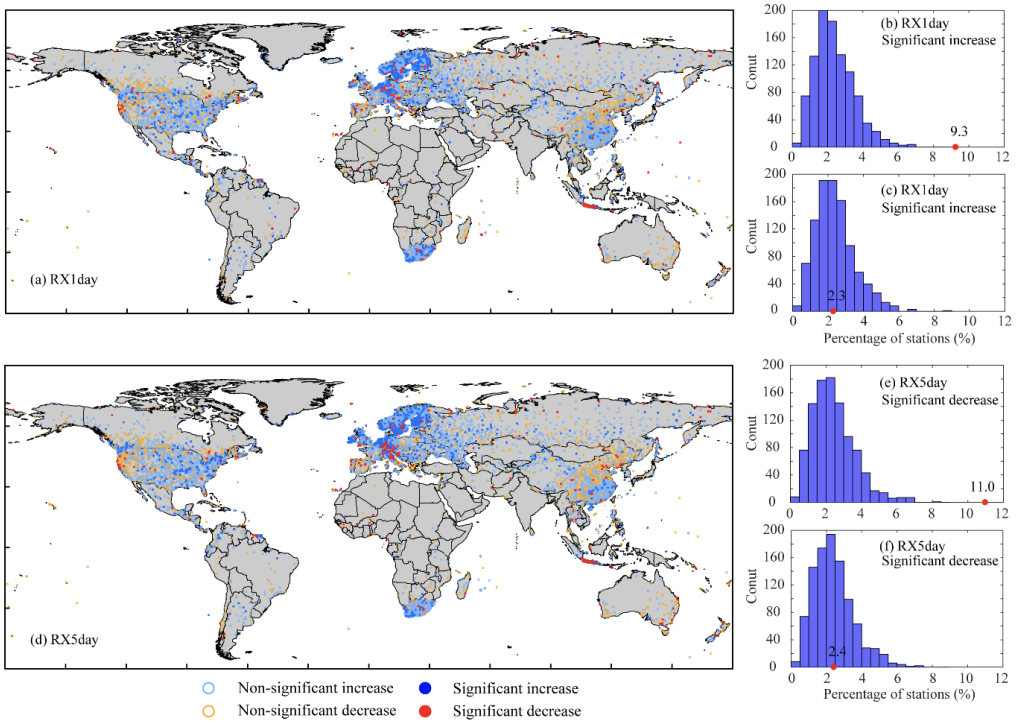
CC Detection and Attribution

Four Core Elements

- Observations of climate indicators
- An estimate of external forcing
  - how external drivers of climate change have evolved before and during the period under investigation (e.g., GHG and solar radiation)
- A quantitative physically-based understanding of how external forcing might affect these climate indicators.
  - normally encapsulated in a physically-based model
- An estimate of climate internal variability
  - often, but not always, derived from a physically-based model

What we have learnt

- No significant trends in most stations
- Percentage of stations with statistically significance increase trend larger than expected by chance
- Percentage of stations with statistically significance decrease trend is not different from that by chance
- Conclusion: 1) Difficult to detect a trend at individual locations; 2) Evidence of heavy precipitation intensification at the global scale



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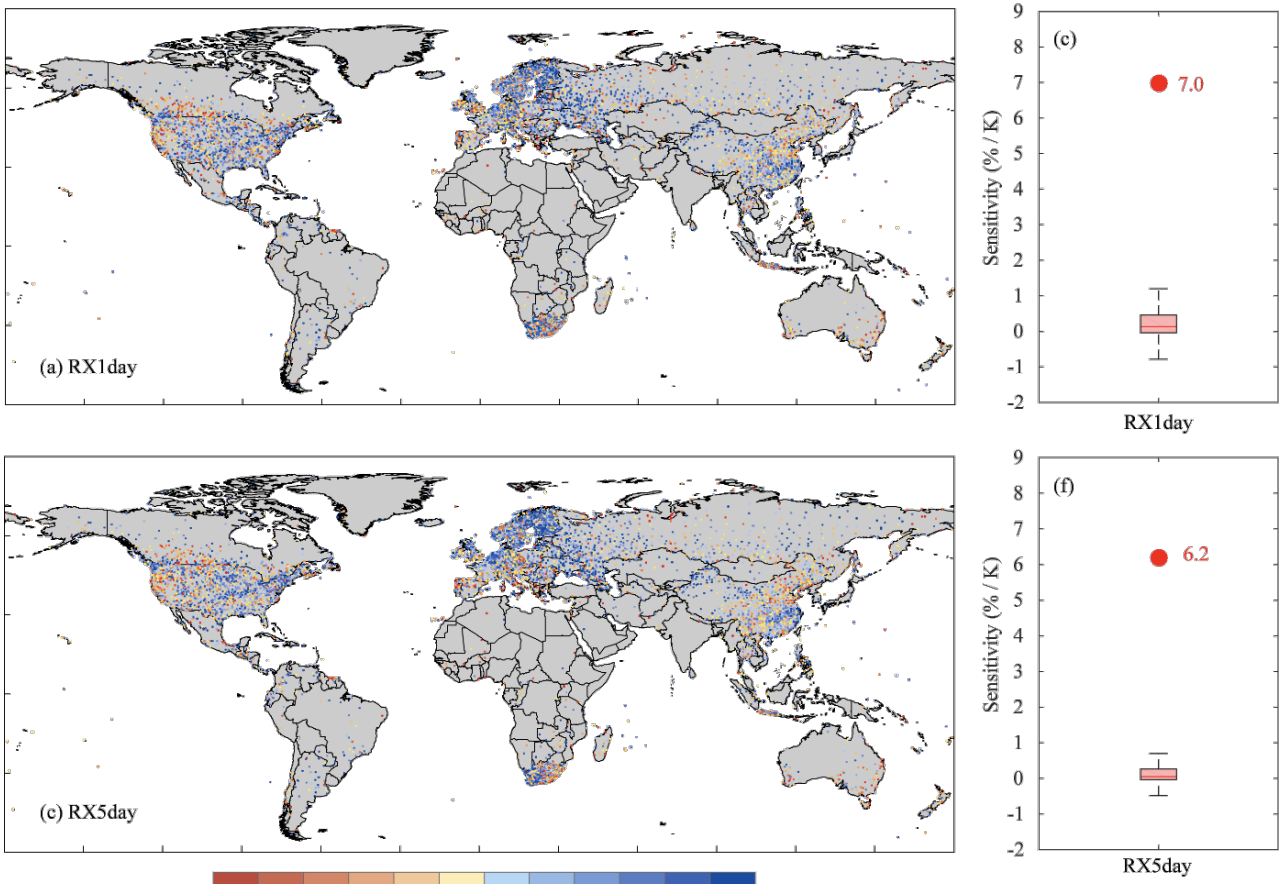
Is there an association between annual maximum 1-day precipitation and global mean temperature?

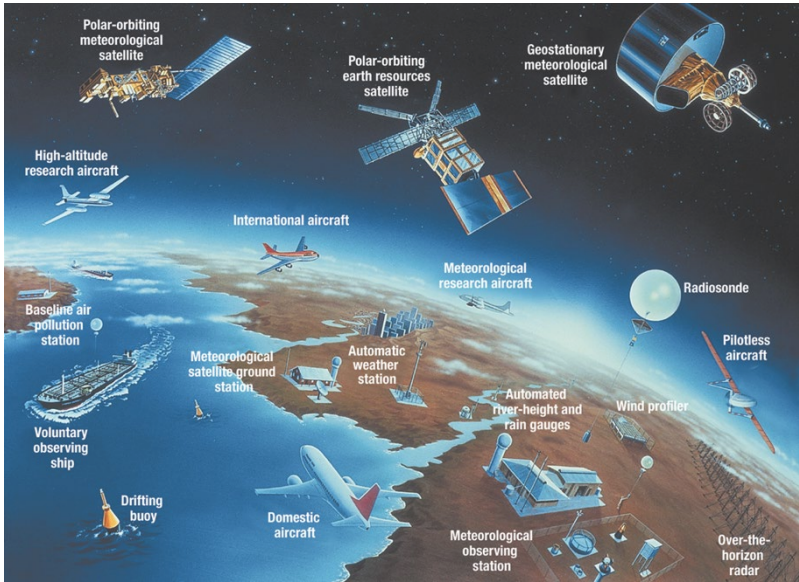


Sun et al. 2019 in preparation

WMO – Who we are

- UN Specialized Agency on **Weather, Climate & Water**
- 186 Member States and 6 Member Territories, HQs in Geneva
- 2nd oldest UN Agency, since 1873

- Coordinates work of > 200 000 national experts from meteorological & hydrological services, academia (& private sector)
- Founder and host agency of IPCC (1st World Climate Conference)
- Co-Founder of UNFCCC (2nd World Climate Conference)



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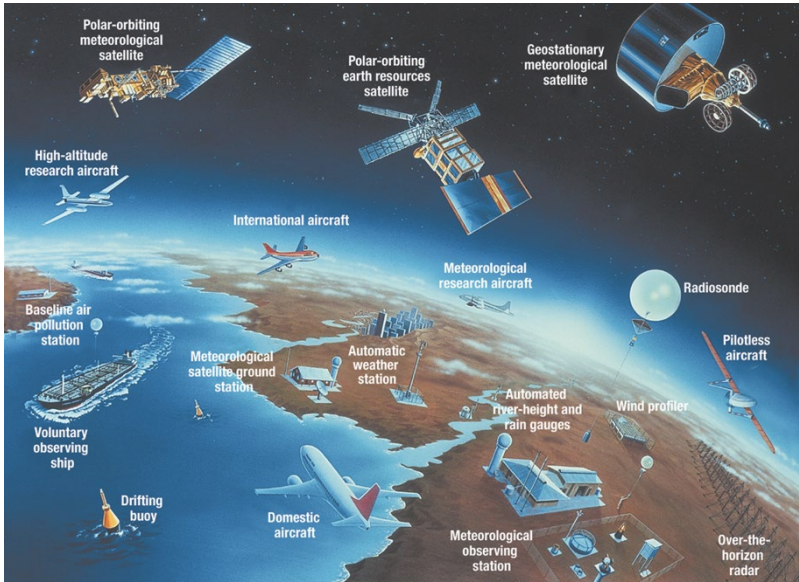
WMO – Mission & Key Activities

- World **Climate**
- **Weather**, disasters & safety
- **Water** resources

- **Data** & technology
- Strengthening the national **service** capabilities
- Earth system research
- Global public-private-academic engagement



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WMO: Annual State of Climate

WMO OMM

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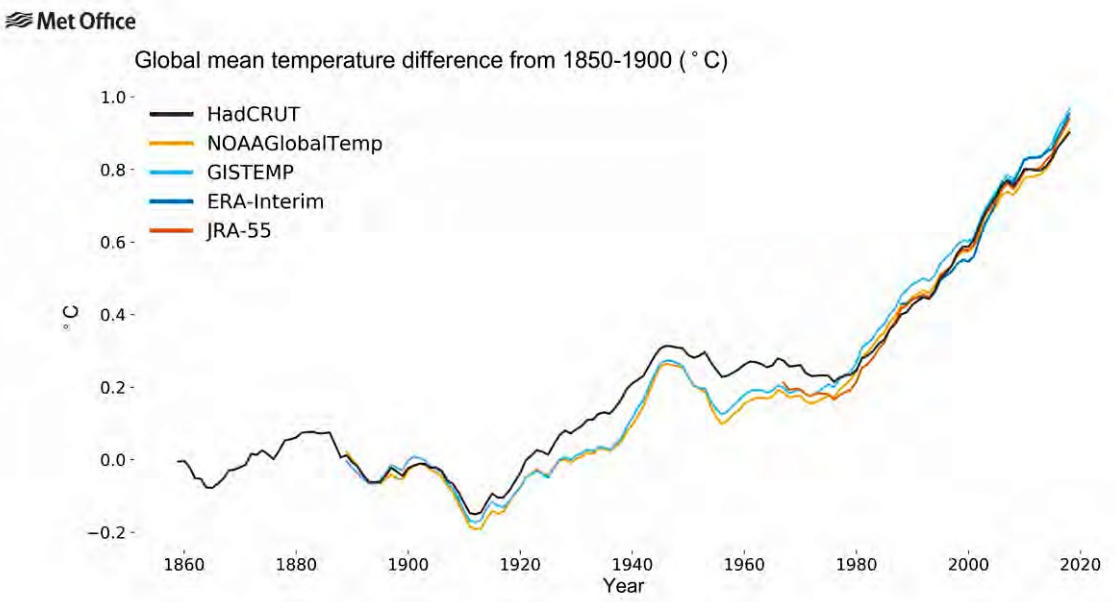
Every bit of warming matters

- Average global temperature reached approximately 1 °C above pre-industrial levels
  - 2018 was the fourth warmest year on record
  - 2015–2018 were the four warmest years on record as the long-term warming trend continues

5 years (2014-2018)

1.04 ± 0.09°C

Warmest La Niña year



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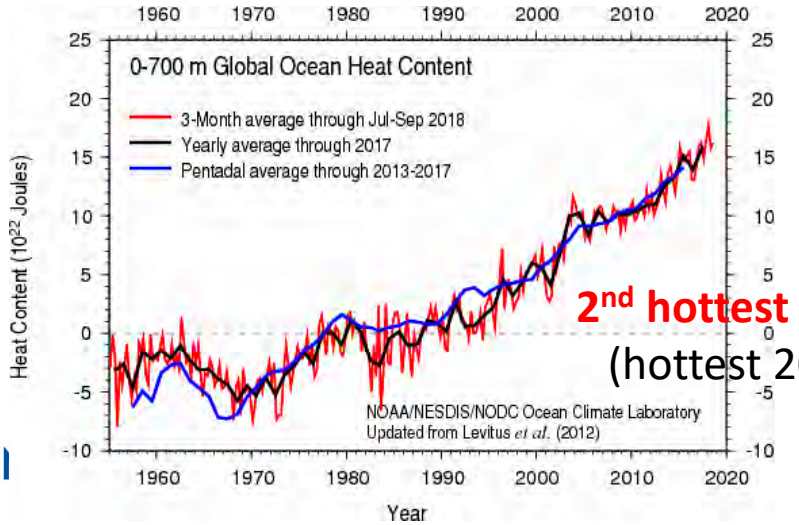
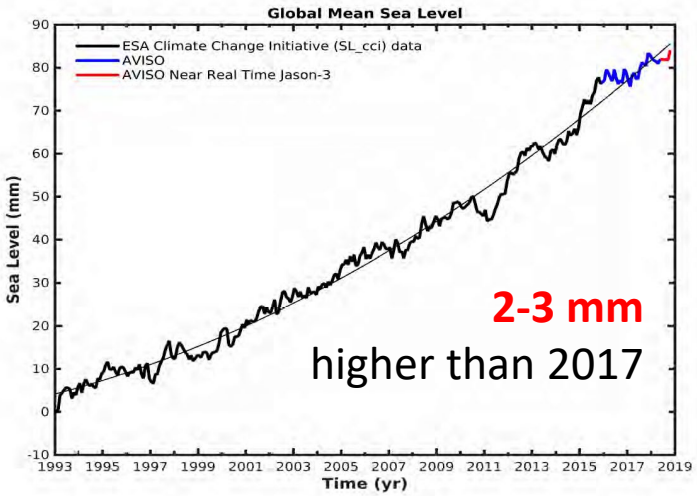


2nd hottest year (hottest 2017)



2-3 mm higher than 2017

Every bit of warming matters

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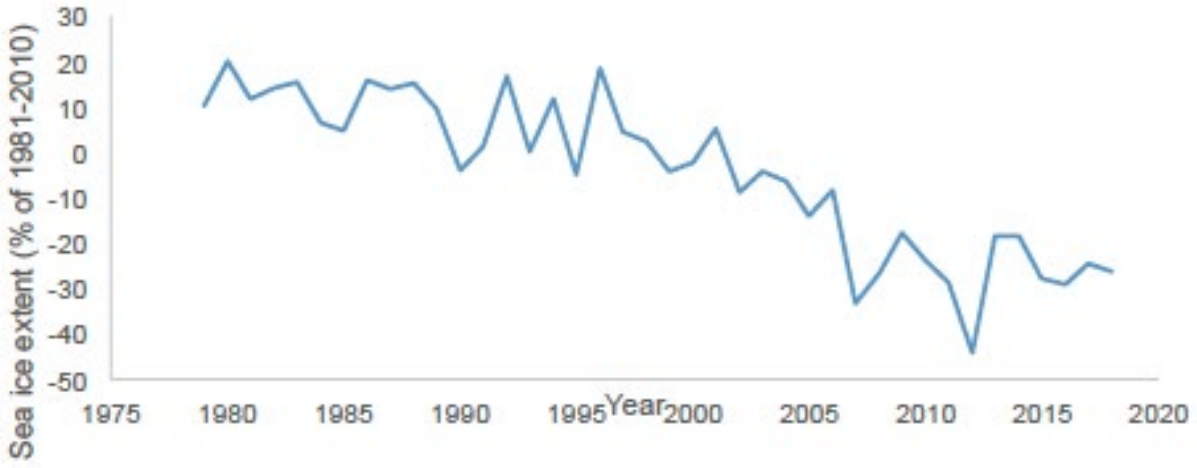
  - 2018 was the fourth warmest year on record
  - 2015–2018 were the four warmest years on record as the long-term warming trend continues
  - Ocean heat content is at a record high and global mean sea level continues to rise
  - Artic and Antarctic sea-ice extent is well below average

28% below average in Sep 2018



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Climate information on different scales

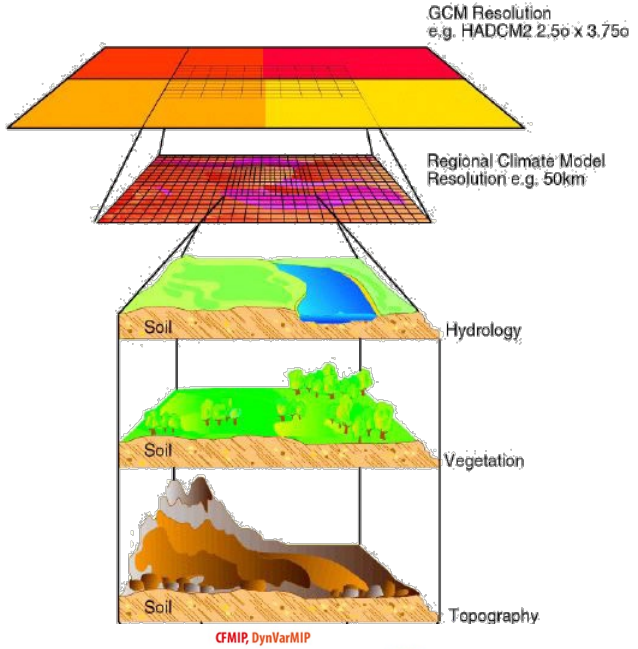
1) Global assessments:

Global General Circulation Models,
e.g. ~300 km to ~100 km

2) National or continental scale assessments:

Global General Circulation Models

Regional Climate Models, on e.g. ~50 km



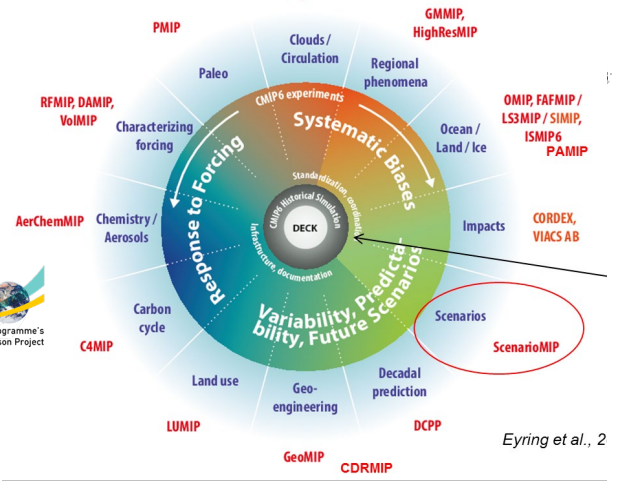
WCRP CORDEX

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

WCRP World Climate Research Programme

CMIP The World Climate Research Programme's Coupled Model Intercomparison Project



Eyring et al., 2

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Climate information on different scales

1) Global assessments:

Global General Circulation Models,
e.g. ~300 km to ~100 km

2) National or continental scale assessments:

Global General Circulation Models

Regional Climate Models, on e.g. ~50 km

3) Regional (subcontinental) assessment:

Regional Climate Models, on ~50 km to ~10 km

4) Local assessment:

(Non-hydrostatic) Regional Climate Models,
on ~1 km to ~100 m

Combined approaches of dynamic & statistical downscaling

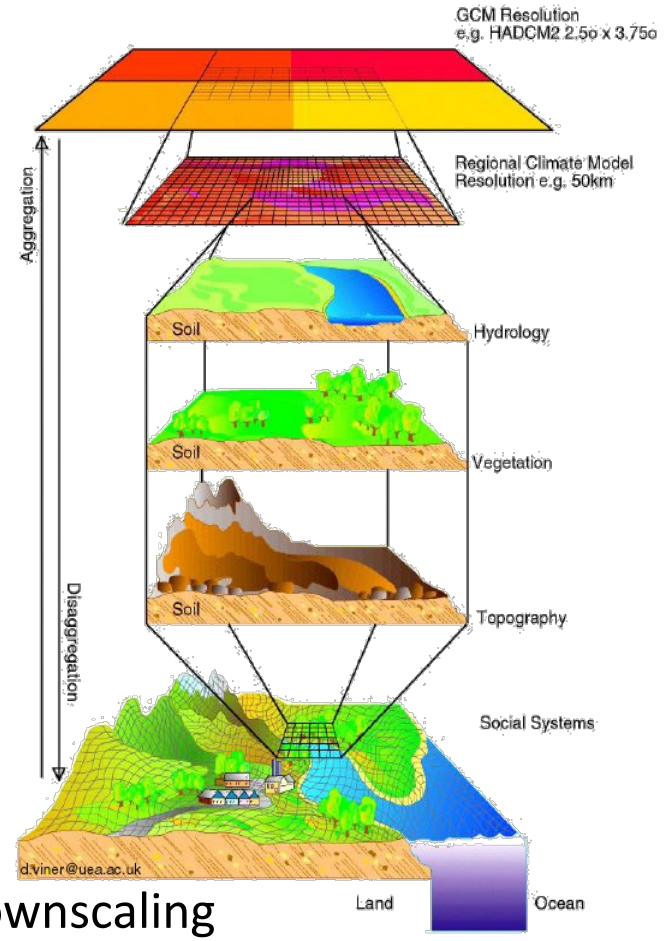
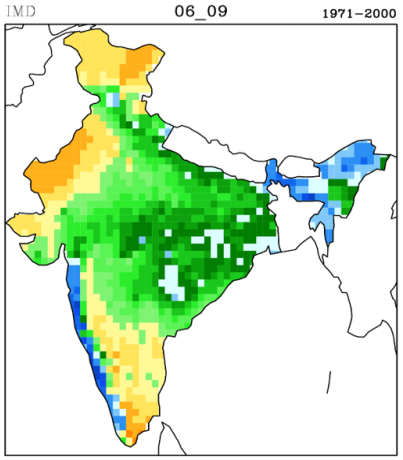


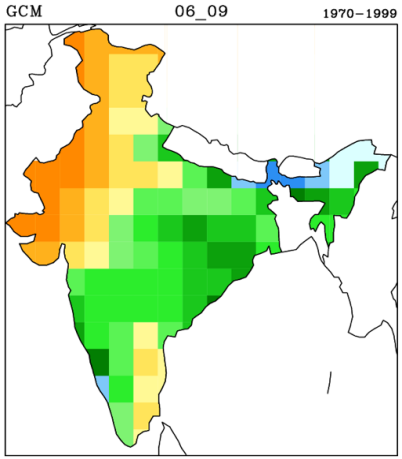
Figure source: David Viner, CRU, University of East Anglia, UK

Climate information on different scales

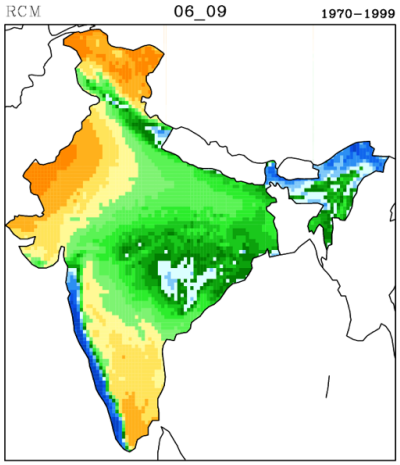
Obs. ~ 55Km

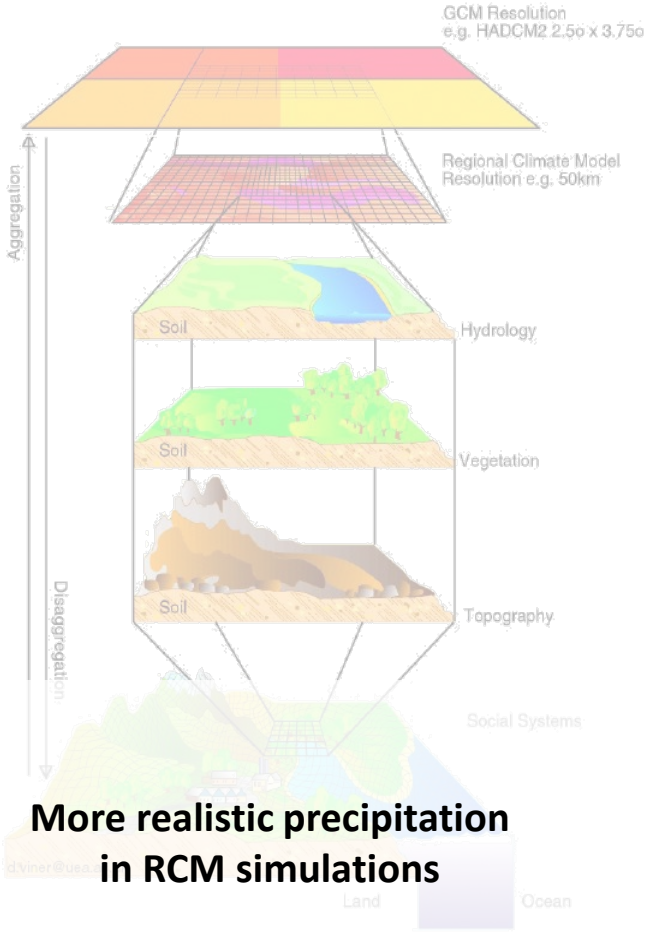


GCM ~200Km



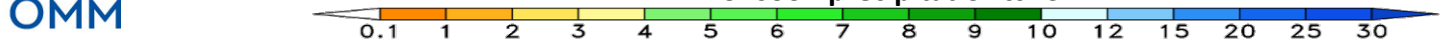
RCM ~25Km





More realistic precipitation in RCM simulations

Monsoon precipitation JJAS



mean of 3 RCMs driven by 2 GCMs, 1970-1999. *Source*: *Pankaj Kumar, High Noon Project, MPI-M*

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Climate, Changes, Impact and Resilience

(Aviation Example)

- How should aviation infrastructure be designed and built so that CO_2 emissions are limited; and more extreme weather events, water scarcity, sandstorms, or any impact attributable to a changing climate, can be withstood?

ICAO, 2019: Climate change: Adaptation. Climate adaptation synthesis analysis

Climate, Changes, Impact and Resilience

(Aviation Example)

- Identified 8 categories for potential climate impacts
- A climate change risk assessment is required to determine the climate change vulnerabilities, before an adaptation strategy is developed.

ICAO, 2019: Climate change: Adaptation. Climate adaptation synthesis analysis

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World Climate Research Programme
(WMO-ISC-IOC)