The continuing evolution of the “Key Risks” of climate change

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Drawing on work from:

History: Joel Smith, John Schellnhuber, Rik Leemans

IPCC AR5: Michael Oppenheimer, Rachel Warren, Joern Birkmann, Stephane Hallegatte, Bob Kopp, Rachel Licker, Katie Mach, Phillippe Marbaix, Michael Mastrandrea, Hans Poertner, Bob Scholes, Kiyoshi Takahashi, Jeff Price, Jean-Pascal van Ypersele, Gary Yohe

IPCC AR6: Rachel Warren, Matthias Garschagen, Alex Magnan, Maarten Van Aalst, Zelina Ibrahim

Special Reports: Rachel Warren, Kate Calvin, Alex Magnan

GTAP Annual Meeting, Warsaw, 19 June 2019
Emissions are rising

Thanks to: O. Edenhofer
Reaching the $2^\circ \mathrm{C}$ or $1.5^\circ \mathrm{C}$ Paris goals

INDCs strengthen mitigation action ...

... but are by far not enough to close mitigation gap.

Thanks to:
O. Edenhofer

“A key risk is defined as a potentially severe risk relevant to the interpretation of ‘dangerous anthropogenic interference with the climate system’ (DAI), in the terminology of United Nations Framework Convention on Climate Change (UNFCCC) Article 2, meriting particular attention by policy makers in that context. ...”
Key Risks and Reasons for Concern

Key Risks → Reasons for Concern → Burning Embers

By region and by sector:
Loss of biodiversity
Loss of endemic species
Reduced economic growth
Coastal damage from SLR
Loss of coral reefs
Mortality/morbidity from extreme heat
Reduced food security
Increased violent conflict
Etc. ...

Risks to/associated with:
1. Unique and threatened systems
2. Extreme weather events
3. Distribution of impacts
4. Global aggregate impacts
5. Large-scale singular events

RFCs

Global Mean Warming
The UN Framework Convention on Climate Change

Article 2 OBJECTIVE:

“The ultimate objective ... is to achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”
Reasons for Concern by IPCC Assessment Report

- 5 global Reasons for Concern
- Function of Global Mean Temperature
**Risk**: The potential for negative consequences to human or ecological systems

**Key risk**: relevant to the definition and elaboration of “dangerous anthropogenic interference (DAI) with the climate system,”
Key risk criteria (AR6), related to:

1. the nature of adverse consequences for systems
   - Magnitude
   - Irreversibility
   - Potential for thresholds/tipping points

2. uncertainty in the adverse consequences
   - Likelihood of serious consequences

3. the timing of the risk
   - Persistence
   - Timing, rate of change in risk

4. the ability to respond to the risk
   - Limited ability to reduce hazards, exposure, or vulnerability
   - Limited ability to adapt to/cope with impact should it occur
at least medium confidence that impacts are both detectable and attributable to climate change; also considering magnitude

Increasing magnitude or likelihood of impacts

Risk of severe and widespread impacts; “high” on one or more KR criteria

“high” on all KR criteria, including limited ability to adapt
Underlying Risk Judgements
RFC1: Unique/Threatened Systems

Definition
- Geographic range restricted by climate
- High endemism or other distinctive properties

Examples
- Coral reefs, unique indigenous communities, tropical glacier systems, mangrove ecosystems, etc.
“Recent”
detection and attribution of impacts on Arctic, mountain and coral reef systems (Cramer et al., 2014, WG2 Ch. 18)
Informed by overarching Key Risks:
- Risks to low-lying coastal zones and small island developing states
- Risk of loss of marine and coastal ecosystems
- Risk of loss of terrestrial and inland water ecosystems
At least medium confidence in D & A

Global assessments, major role of climate change:
- Arctic marine ecosystems, shrubs, livelihoods of indigenous people
- Coral bleaching
- Glaciers, permafrost

IPCC AR5 WG2 Ch. 18 (Cramer et al.), Figure 18-5.
RFC1: Unique/Threatened Systems

~2.5 C
Very high risk to species and ecosystems, limited ability to adapt
  nearly ice free Arctic in September, most CMIP5 models (WG1 Ch. 12)
  many species highly vulnerable (e.g. Foden et al., 2013; 2 C warming: 24-50% of birds, 22-44% of amphibians, 15-32% of corals)
  limited adaptation, based on coral reefs, species quantitative evidence for Arctic sea ice, coral reefs

“Recent”
detection and attribution of impacts on Arctic, mountain and coral reef systems (Cramer et al., 2014, WG2 Ch. 18)
RFC2: Extreme Weather Events

Definition

- Risk to human health, livelihoods, assets, and ecosystems
- Risk from heat waves, heavy rain, drought and associated wildfires, and coastal flooding

Informed by 7 of 8 overarching Key Risks
RFC2: Extreme Weather Events

\[\sim 1.5 \text{ C (2030s)}\]

Projected temperature and precipitation extremes, e.g.:
- 25-30\% of daily maximum temperatures exceed historical 90th percentile value (AR5)
- 20-year precipitation events become 14-year events (SREX)

"Recent"

Detection/attribution of extreme heat impacts:
- coral reefs
- human health/mortality in some regions
Also consideration of current vulnerability
RFC3: Distribution of Impacts

Definition

- Disproportionate impacts due to uneven distribution of physical climate change hazards, exposure or vulnerability
- Unevenness with respect to geographic location, income and wealth, gender, age, or other physical and socioeconomic characteristics
RFC3: Distribution of Impacts

~1.5-2.5 C
Projected regional yield impacts and water scarcity, especially toward 2.5 C
- Yield loss especially in low latitudes
- “Severe” (>20%) reduction in water resources for 8-14% of population, esp. around Mediterranean

“Recent”
Detection/attribution of yield impacts:
- Wheat in Europe, S America
  “Early warning” of impacts on food security
- Some positive impacts also detected
RFC3: Distribution of Impacts

~4.5°C
Large impacts on crop yields and water resources
Limited scope for agronomic adaptation
➢ Other types of adaptation possible

“Recent”
Detection/attribution of yield impacts:
➢ Wheat in Europe, S Asia
“Early warning” of impacts on food security
➢ Some positive impacts also detected
Features of RFCs from BE diagram

Evidence base is uneven across RFCs
Judgments in some RFCs based primarily on physical impacts
Some RFCs based on few sectors involved
  RFC on distribution of impacts draws heavily on agriculture
Some risks figure prominently across several RFCs
  coral reefs, arctic systems, biodiversity inform RFCs 1, 2, 4, 5
Sensitivity to development pathway and adaptation not included
Method of arriving at risk judgments not transparent
Evolution since AR5
IPCC Special Report on 1.5 C (2018)
Fleshed out assessment at low levels of warming

Updated assessment up to 2.5°C warming

Overall increase in risks

Biggest changes:
• RFC1: Risks to coral reefs
• RFC4: Risks of aggregate economic impacts
• RFC5: Risks from sea level rise due to ice sheet melting

Hoegh-Guldberg et al., 2018.
IPCC Reasons for Concern

AR5, 2014

(RFC1) Risks to unique and threatened systems
(RFC2) Risks associated with extreme weather events
(RFC3) Risks associated with the distribution of impacts
(RFC4) Risks associated with global aggregate impacts
(RFC5) Risks associated with large-scale singular events

SR 1.5, 2018

RFC1 Unique and threatened systems
RFC2 Extreme weather events
RFC3 Distribution of impacts
RFC4 Global aggregate impacts
RFC5 Large scale singular events
IPCC Special Report on Climate Change and Land
Risks due to climate change and societal conditions

Draft, not for citation or dissemination!
Definition of RFCs (all preliminary thoughts!)

Likely to retain five global RFC categories for continuity

Possible additional aggregations of key risks into RFCs for:
  - Sectors
  - Regions
  - New topical aggregations with less overlap
  - Differentiated by adaptation levels
  - Differentiated by development pathways
Evolution of methods for risk judgments

SR 1.5 C
  Similar to Fifth Assessment Report

SR Climate Change and Land
  Formal expert elicitation

SR Ocean and Cryosphere
  Expert judgment with scoring of risk indicators

Sixth Assessment Report
  Expert judgment with scoring of key risk criteria?
  Precedents in the literature: Piontek et al., 2014; Byers et al., 2018.
## Climate risks in context

### Climate and Poverty
**Shock Waves Report (World Bank, Hallegatte et al., 2015)**

<table>
<thead>
<tr>
<th>Effect of climate change (vs no climate change), 2030</th>
<th>3-122</th>
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<tr>
<td>Effect of pessimistic (vs optimistic) development pathway, 2030</td>
<td>758</td>
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### Climate and Hunger
**Hasegawa et al., 2018**

<table>
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<tr>
<th>Effect of climate change (vs no climate change), 2050</th>
<th>~5-85</th>
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<tbody>
<tr>
<td>Effect of pessimistic (vs optimistic) development pathway, 2050</td>
<td>~500</td>
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Conclusions and open questions

Key risks and Reasons for Concern remain an important means of communicating climate change risk results

Approaches are evolving to improve on weaknesses, but issues remain

Questions:

- What if new methods of assessing key risks lead to changes in risk judgments, independent of change in evidence?
- How (and whether) to take relative risk into account?
- How to transparently reflect risks of mitigation?
- How to synthesize assessment of key risks with assessment of mitigation and of climate outcomes?