# DISRUPTIONS, SHOCKS, EXTREME EVENTS: IMPLICATIONS FOR SCENARIO AND MODEL DEVELOPMENT

Vanessa Schweizer

Department of Knowledge Integration

UNIVERSITY OF WATERLOO
FACULTY OF ENVIRONMENT

Aspen Global Change Institute, 21 July 2021

# GUIDING QUESTIONS

The linear system for CMIP6: Human systems → Earth systems → Impacts

- What different methods to describe uncertainty should be integrated to provide a more fulsome understanding of the system?
- Are there feedbacks that could alter an originally assumed scenario such that the linear system breaks down?
- How might current methods to link human & earth systems be enhanced to expand understanding?
- Have choices in (applying) the RCP/SSP framework been the right ones?

# TERMINOLOGY

- Extreme event
- Shock: Sudden, high-impact event (e.g. COVID-19 pandemic)
- Disruption
  - Prolonged interruption to the *status quo*? or
  - Discontinuity (i.e. emergence of new trend)?

# DIFFERENT PERSPECTIVES RE: TIME

(inspiration from Scherpenisse et al. 2021)

## Chronos

- Time series
- Frequentist probabilities
  - 'Most likely' future might mean $p_{max}$
- Extreme events, etc. modelled to motivate decision-makers to 'get on track' less risky than SQ

## Kairos

- Events (opportune/inopportune)
- Bayesian probabilities
  - 'Most likely' future a matter of path; event-tree of possibilities 'collapses'
- Extreme events, etc. can be modelled to explore contingency, generate options
  - Support decision-makers to 'stay on track' despite disruption

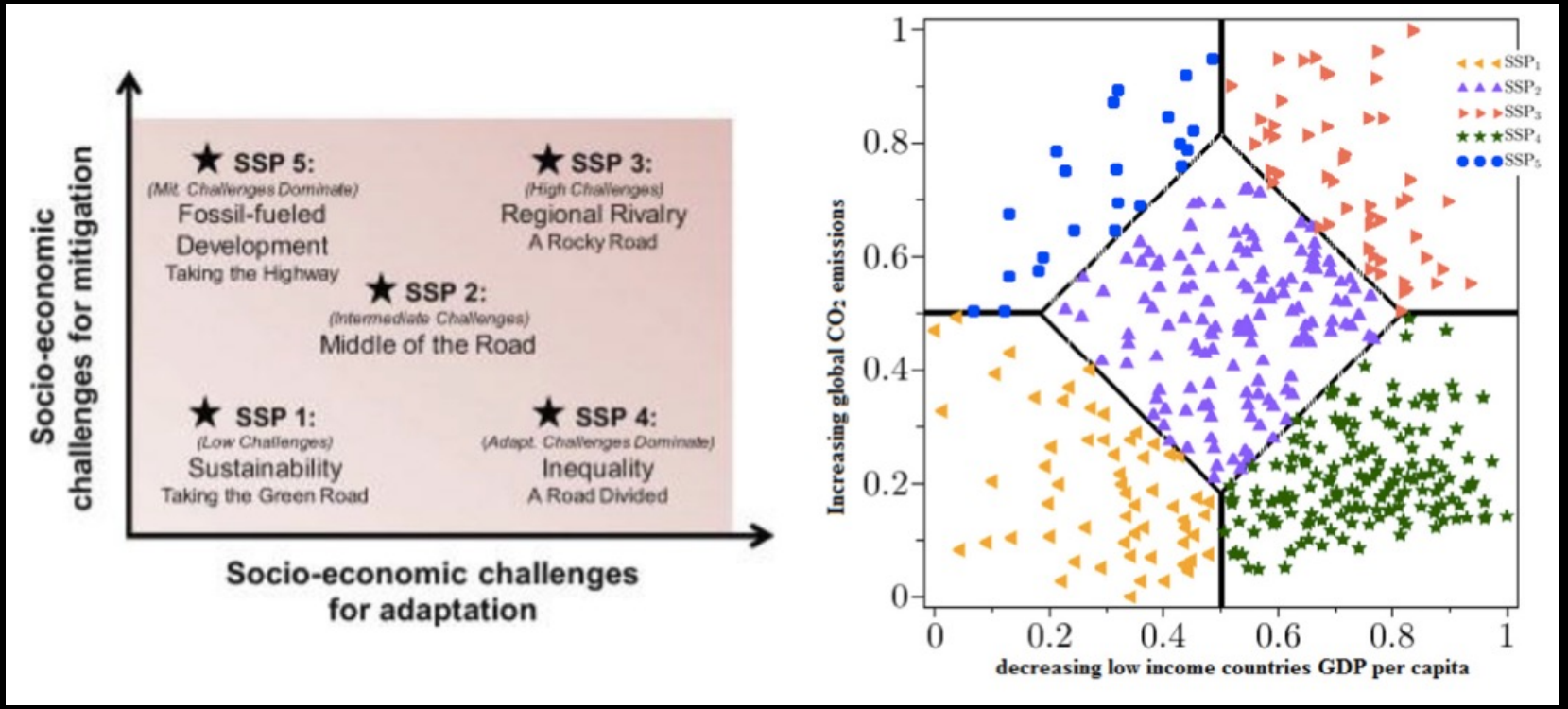
Chronos & Kairos orientations employ different methods to grapple with uncertain futures; how might we integrate for more fulsome understanding of human-earth system we inhabit?

# MODELLING KAIROS

- ‘Scan’ for events (opportune/inopportune)
  - Requires large number of cases / model realizations ($10^2$, $10^3$, …, $10^6$ or more)
  - Factorial research designs (i.e. running models systematically)
  - Examples of methods: Scenario discovery (Bryant & Lempert 2010, Lamontagne et al. 2018), cross-impact balances (Weimer-Jehle 2006, Schweizer & O’Neill 2014)
- Events of interest/relevance: Scenarios that ‘break’
  - Collapse
  - Policy fails to achieve key objective
  - Evolution/succession (i.e. significant alteration of originally assumed scenario; breakdown of ‘linear system’)

# EXAMPLE: SCENARIOS THAT 'BREAK'

(variants from 'marker' SSPs)




Guivarch et al. (2016) *Env. Mod. Software*

[Description of removed figure: Scatterplot at left that includes 'historical track' of each model realization relative to an ensemble mean]

Guivarch et al. (in review)

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# EXAMPLE: SCENARIOS THAT 'BREAK'

(the mirage of SSP5: Fossil-fueled Development)

[Description of removed figure: Three panels of alternative groups of variants of SSP5 that include 'historical track' of each model realization relative to an ensemble mean tracked over the years 2025 – 2090.

- Left panel: Stable SSP5 variants that retain their 2025 designation into 2090
- Middle panel: Unstable SSP5 variants that appear to be examples of SSP5 in 2025 but meet SSP2 performance metrics by 2090
- Right panel: Unstable SSP5 variants that appear to be examples of SSP5 in 2025 but meet SSP4 performance metrics by 2090]

Guivarch et al. (in review)

- The majority of cases classified SSP5 in 2025 (relative to an ensemble mean) evolve into some other SSP by 2090
- However, SSP1 scenarios were the most stable, with 82% retaining their designation into 2090

# FUTURE RESEARCH: CHRONOS-KAIROS INTEGRATION

- Might a scanning MIP be informative?
  - Run ‘fast’ integrated models systematically
  - Target verification with more detailed model simulations?
  - Steps resemble SAS, but systematic scans have debiasing effect compared to stories
- Innovation in model/scenario linking?
  - Current practice: link processes, elements, logics (Zurek & Henrichs 2007)
  - What about extreme events, shocks as focusing events for ‘turning points’ in human systems? (Zscheischler et al. 2018, Scherpenisse et al. 2021)

# FUTURE RESEARCH: SSP-RCP FRAMEWORK

- Scenario matrix architecture supports Chronos-Kairos integration
  - 'Menu' of SSP-RCP options supports exploratory Kairos-oriented research
  - Chronos-oriented research remains important for verification (e.g. SSP replications of RCPs)
  - Learning requires both exploration + testing
- SSP updates for uneven COVID recoveries?
  - Or are SSP4, SSP3 sufficient for such scenarios?
- Climate interventions (e.g. CDR, albedo modification) -- are existing RCPs sufficient for modelling them?

# REFERENCES


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# BACKUP

# RESEARCH DESIGN CHALLENGE

How might modelling exercises and scenario designs account for a more relevant range of plausible futures incorporating extreme events, shocks, disruptions?

Before HOW, ask WHY

- What are the research goals (i.e. purpose)?
  - Advancing scientific knowledge?
  - Producing policy relevant science?
  - One set of research activities may not satisfy both masters
- Research approaches should be “fit for purpose”