Expectations on climate model outcomes

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Overview

• Climate modellers’ use of scenarios

• What can you expect from results?
  • Look at land-use, AQ and carbon budgets

• Risk-based narratives
  • Role/requirement for how we present analysis
Background on scenarios

- 100s of scenarios in the literature / WG3 database.
  - Climate modellers only care about 5 of them
    - 1 more than last time 😊

- ESMs will run ScenarioMIP tier-1 scenarios, plus SSP1-1.9
Background on scenarios

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• ESMs will run ScenarioMIP tier-1 scenarios, plus SSP1-1.9
  • Plus 5-3.4-overshoot
Background on scenarios

- CMIP5 use of RCPs accepted to have too little spread in short-lived forcers
  - SLCF, LU uncertainty/de-coupling from global forcing better represented in SSPs

- Some (e.g. HadGEM2-ES) activity to populate more of the matrix
  - Not all possible – driving data required
What can we expect? LUMIP (land-use)

- No results yet, but past experience shows importance of biophysical effects as well as carbon emission/sequestration.

Davies-Barnard et al., 2014: biophysical effect in RCPs offsets carbon emission/sequestration.

- RCP4.5 → net warming

Early UKESM1 results.
- 20th century cooling effects (0.2-0.4 °C) due to land-use change?
What can we expect? LUMIP (land-use)

• HadGEM2-ES, and maybe UKESM1, very sensitive to land-use as a physical forcing
  • Maybe too sensitive? Obs are lacking

• Scenarios should consider full effects of land-use as well as just carbon
  • We don’t yet know the right answer, but we know that neglecting this is the wrong answer…
  • Andrews et al., 2017, estimate -0.4 Wm-2 from 20th century LUC
What can we expect? AQ

- No results yet, but emulator approach allows source/receiver relationships to be investigated
- Look at role of local vs remote emissions on AQ (ozone here)
- Role of atmospheric chemistry
  - Methane emissions strongly affect ozone too

- Decision making around climate/AQ often disjointed (different timescales)
  - Expect more analysis of co-benefits/unintended consequences
Most regions show large historical increases but decrease in future emissions and large range over South Asia and Middle East.
CMIP6 – Surface O$_3$

Annual mean surface O$_3$ response (relative to 2015) over to CMIP6 future emission scenarios.

Wide variety in future O$_3$ response, particularly South Asia and Middle East. Only strong mitigation pathways can reduce surface O$_3$.
What can we expect? Carbon budgets

• SR15 vs AR5?
  • Revised up remaining carbon budget.
  • Mainly methodological, rather than new modelling, advance
    • Baseline?
    • Obs SSTs/surface air/coverage
    • Model biases in carbon sinks/warming rates
    • Total vs remaining budget

• CMIP6
  • Will bring new models/results
  • Could strongly affect budget calculations
What can we expect? Carbon budgets

• C4MIP – carbon cycle feedback experiments

• Some early results indicate possibly important changes in TCRE
  • Approx 50:50 split between uncertainties from climate sensitivity and carbon cycle feedbacks
    • Both are changing…
What can we expect? Carbon budgets

• ECS – higher or lower? Good question
  • Emergent constraint suggests low (2.8: Cox et al., 2018)
  • Carbon/oxygen constraint on ocean heat uptake suggests high (Resplandy et al., 2018)
  • Some CMIP6 models emerging with high ECS (possibly >5°C)

• Carbon cycle
  • Reduced land sink due to nitrogen limitations – more models consider nutrient effects
  • Increased sensitivity to warming due to permafrost thaw – few models include interactively

• All these things point to increased TCRE/reduced carbon budgets?
What can we expect? Carbon budgets

- Two models have high TCRE
  - (implies lower emissions allowed)
- Stems mainly from high climate sensitivity

(estimated TCRE from alpha, beta, gamma)

(IPCC AR5 assessed range)

(CAUTION: PRELIMINARY RESULTS)
Risk-based narratives

• Rowan Sutton – ESD opinion article (https://www.earth-syst-dynam.net/9/1155/2018/)
• Don’t only focus on “likely range”
• Tails of distribution crucial to communicate
• “low probability / high impact”
• We need to know implications of high climate sensitivity even if we think relatively unlikely
Risk-based narratives

• IAM /scenario example: BECCS?
• Scenarios achieving 1.5 or 2 degrees contain large amounts of BECCS
• These include many assumptions, including:
  • Climate sensitivity
  • Carbon cycle response to CO2 removal
  • Crop yield to free up land
  • Biofuel productivity
  • Efficiency of burning fuel/sequestering carbon
  • …
• Each/any of these may be possible… but all have to happen
  • What are risks if some of these parameters fall in the tails of their distribution?
• Split assumption/decision uncertainty from physical (uncontrollable)
Summary

• CMIP6 simulations underway – expect emerging results over next few months
  • WG1 papers deadline only a year away!

• Focus on 5 scenarios.
  • SSPs advance over RCPs
  • Great if we can increase engagement between communities

• ESMs give unprecedented detail on physical/spatial processes
  • Biophysical effect of land-use, regional AQ impacts of policies
  • New feedbacks affect carbon budgets (likely downwards?)

• Move towards risk-based narrative to presenting results
  • Open challenge for all of us
references

• Andrews et al., 2017, Clim. Dyn. Land-use ERFs
• Davies-Barnard et al., 2014, ERL. Full effects of land-use change
• Jones et al., 2016., GMD. C4MIP experimental design
• O’Neill et al., 2016., GMD. ScenarioMIP experimental design
• Sutton, 2018, ESD. IPCC and risk.