Climate Metrics and Their Application to Black Carbon

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Marcus C. Sarofim
Environmental Scientist
Climate Science & Impacts Branch
Climate Change Division

IPCC Expert Meeting on Metrics

- Conclusions
  - GWP shortcomings have been identified, but the GWP continues to be useful
  - Metric effectiveness depends on the policy goal. The GWP was not designed with a specific goal In mind.
  - The GWP100 is used in Kyoto, but is sensitive to time horizon chosen, which can be a value judgment
  - Information on policy goals can facilitate research on alternative metrics.
- Research Recommendations
  - Many: Uncertainty, SLCFs, mitigation costs, climate damages, post-horizon effects, rate of change, regional differences, geoengineering applications, etc.
  - Study implications of metrics for policy frameworks.

Bonn Meeting on Metrics

- AR4 GWPs will be adopted in 2015
- Some elements of the discussion:
  - Any new metric (in 2020 or beyond) should be based on the best science
  - There is value in consistency: any replacement to the GWP100 should offer very clear advantages.
  - For a GTP-based metric, what time scale is appropriate?
    - Parallel to the GWP = 100 years
    - Estimated time until 2 degrees (50 years, updating regularly)
  - Possibilities of a multi-basket approach?
  - Future meetings will be scheduled to continue the discussion

BC Report to Congress

- BC metric values are sensitive to formulation
- No single metric is widely accepted yet
- Several metrics have been applied: GWP, GTP, SFP, STRE.
- Controversy exists for comparisons between long-lived GHGs and short-lived particles
  - Illustrative examples can be ok
  - Issues involve Time scale, nature of impact, inclusion of processes, regional vs. global values (both for emissions and for impacts), etc.

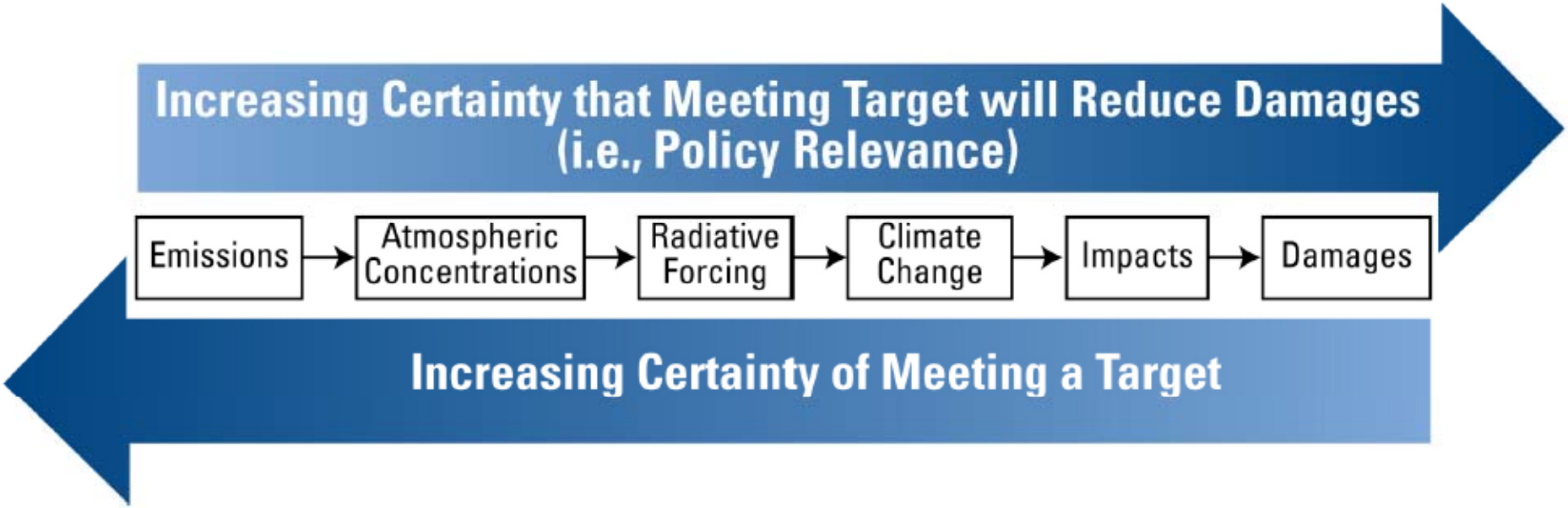

Figure 2-24. Cause and Effect Chain from Emissions to Climate Change, Impacts, and Damages. (Adapted from Fuglestvedt et al., 2003.) The arrows indicate that a policy could focus on different elements along the causal chain and, depending on whether the policy focuses on the emissions or damages end of the chain, can determine the certainty of meeting the stated policy target versus the certainty of reducing damages at issue.

Table 2-8. Examples of Commonly Used Metrics for GHGs.

Metric Type	Climate Impact	Baseline Forcer	Emissions Type	Spatial Scale	Includes Rate of Change?
GWP (Global Warming Potential)	Integrated radiative forcing	CO_2	Pulse	Global	No
GTP-pulse (Global Temperature Potential)	Temperature	CO_2	Pulse	Global	No
GTP-sustained	Temperature	CO_2	Sustained	Global	No
STRE (Surface Temperature Response per unit continuous Emission)	Temperature	CO_2	Sustained	Global	No
SFP (Specific Forcing Pulse)	Energy	Joules/gram	Pulse	Global or regional	No
Cost-effectiveness Metrics (e.g., Manne and Richels, 2001, Global Cost Potential)	Mainly temperature	CO_2 or $ value	Optimal emissions calculation	Global	Optional
Value of Damages (e.g., Social Cost of Carbon, Global Damage Potential)	Range of climate damages	$ value	Pulse	Global	Limited

- Additionally: Temporal frame and/or weighting, implicit valuation, baseline emissions scenario.

Range of BC values

- Black Carbon Report to Congress range:
  - 48 to 4600
- Consistency issues (Sarofim 2010, Bond et al. 2011 on SFPs)
  - Carbon lifecycle assumptions
  - Mixing state of particles for direct effect
  - Inclusion of snow albedo effects
  - Inclusion of indirect cloud effects

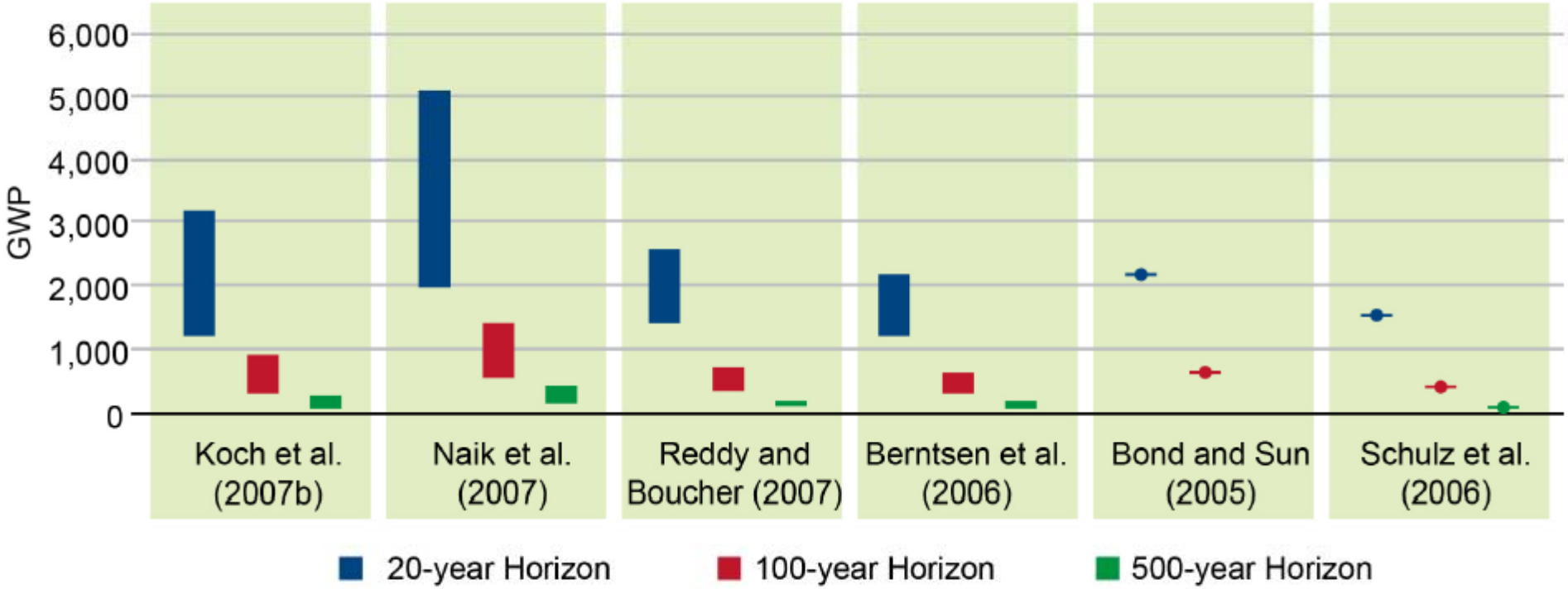

Figure 2-25. Ranges and Point Estimates for Regional Estimates of GWP Values for One-Year Pulse Emissions of BC for Different Time Horizons. The GWP values in the Y axis of the figure refer to the number of tons of CO_2 emissions which are calculated to be equivalent to one ton of BC emissions based on the particular metric. (Adapted from Fuglestvedt et al., 2010.) Note that the first four studies referenced evaluated GWP values for different sets of regions; Bond and Sun (2005) and Schulz et al. (2006) produced global estimates only.

Special Issues Regarding BC

- Geographic dependence
  - Latitudinal and seasonal, based on solar intensity
  - Surface albedo and snow deposition
  - Atmospheric lifetime variability (weather and combustion source)
- Time scale
  - NRC, 2011: “two separate control knobs”
- “Effective forcing” (eg, forcing -> temperature relationship)
- Co-emissions (Organic carbon)

Evaluating the cost of imperfect metrics

- O'Neill (2003): "good enough"
- Berntsen et al. (2010): "combined target and metric"
- Johannson et al. (2006): "pretty close"

OAP BC Involvement

- Arctic Task Force
- EPA reports
- The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants
- Academic Literature