Bioenergy and climate metrics

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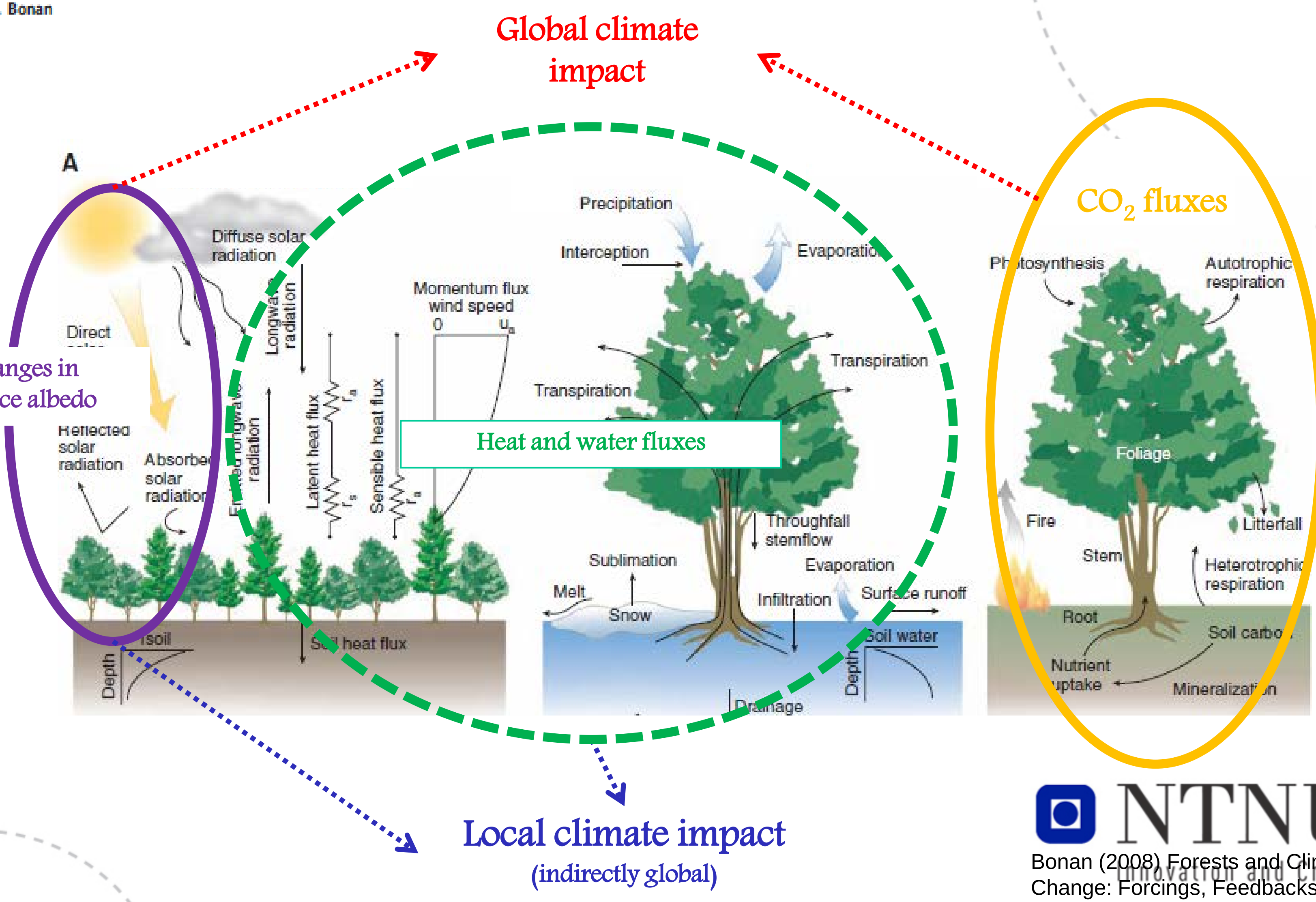
Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests

Gordon B. Bonan



Bonan (2008) Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests, Science Vol. 320 no. 5882 pp. 1444-1449

Table 8.5 | Confidence level for the forcing estimate associated with each forcing agent for the 1750–2011 period. The confidence level is based on the evidence and the agreement as given in the table. The basis for the confidence level and change since AR4 is provided. See Figure 1.11 for further description of the evidence, agreement and confidence level. The colours are adopted based on the evidence and agreement shown in Figure 1.11. Dark green is "High agreement and Robust evidence", light green is either "High agreement and Medium evidence" or "Medium agreement and Robust evidence", yellow is either "High agreement and limited evidence" or "Medium agreement and Medium evidence" or "Low agreement and Robust evidence", orange is either "Medium agreement and Limited evidence" or "Low agreement and Medium evidence" and finally red is "Low agreement and Limited evidence". Note, that the confidence levels given in Table 8.5 are for 2011 relative to 1750 and for some of the agents the confidence level may be different for certain portions of the Industrial Era.

	Evidence	Agreement	Confidence Level	Basis for Uncertainty Estimates (more certain / less certain)	Change in Understanding Since AR4
Well-mixed greenhouse gases	Robust	High	*Very high*	Measured trends from different observed data sets and differences between radiative transfer models	No major change
Tropospheric ozone	Robust	Medium	*High*	Observed trends of ozone in the troposphere and model results for the industrial era/Differences between model estimates of RF	No major change
Stratospheric ozone	Robust	Medium	*High*	Observed trends in stratospheric and total ozone and modelling of ozone depletion/Differences between estimates of RF	No major change
Stratospheric water vapour from CH_4	Robust	Low	*Medium*	Similarities in results of independent methods to estimate the RF/Known uncertainty in RF calculations	Elevated owing to more studies
Aerosol–radiation interactions	Robust	Medium	*High*	A large set of observations and converging independent estimates of RF/Differences between model estimates of RF	Elevated owing to more robust estimates from independent methods
Aerosol–cloud interactions	Medium	Low	*Low*	Variety of different observational evidence and modelling activities/Spread in model estimates of ERF and differences between observations and model results	ERF in AR5 has a similar confidence level to RF in AR4
Rapid adjustment aerosol–radiation interactions	Medium	Low	*Low*	Observational evidence combined with results from different types of models/Large spread in model estimates	Elevated owing to increased evidence
Total aerosol effect	Medium	Medium	*Medium*	A large set of observations and model results, independent methods to derive ERF estimates/Aerosol–cloud interaction processes and anthropogenic fraction of CCN still fairly uncertain	Not provided previously
Surface albedo (land use)	Robust	Medium	*High*	Estimates of deforestation for agricultural purposes and well known physical processes/Spread in model estimates of RF	Elevated owing to the availability of high-quality satellite data
Surface albedo (BC aerosol on snow and ice)	Medium	Low	*Low*	Observations of snow samples and the link between BC content in snow and albedo/Large spread in model estimates of RF	No major change
Contrails	Robust	Low	*Medium*	Contrails observations , large number of model estimates/Spread in model estimates of RF and uncertainties in contrail optical properties	Elevated owing to more studies
Contrail- induced cirrus	Medium	Low	*Low*	Observations of a few events of contrail induced cirrus/Extent of events uncertain and large spread in estimates of ERF	Elevated owing to additional studies increasing the evidence
Solar irradiance	Medium	Medium	*Medium*	Satellite information over recent decades and small uncertainty in radiative transfer calculations/Large relative spread in reconstructions based on proxy data	Elevated owing to better agreement of a weak RF
Volcanic aerosol	Robust	Medium	*High*	Observations of recent volcanic eruptions/Reconstructions of past eruptions	Elevated owing to improved understanding

Notes:

The confidence level for aerosol–cloud interactions includes rapid adjustments (which include what was previously denoted as cloud lifetime effect or second indirect aerosol effect). The separate confidence level for the rapid adjustment for aerosol–cloud interactions is very low. For aerosol–radiation interaction the table provides separate confidence levels for RF due to aerosol–radiation interaction and rapid adjustment associated with aerosol–radiation interaction.

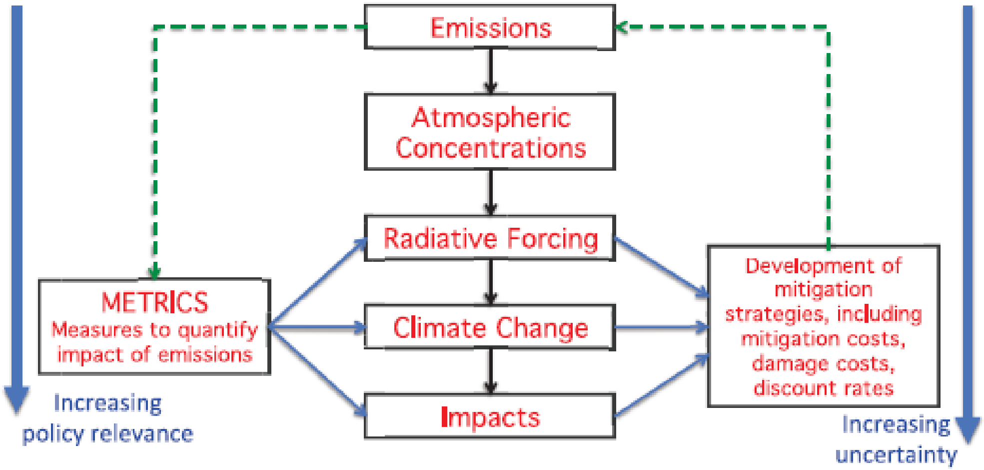


Figure 8.27 | The cause–effect chain from emissions to climate change and impacts showing how metrics can be defined to estimate responses to emissions (left) and for development of multi-component mitigation (right). The relevance of the various effects increases downwards but at the same time the uncertainty also increases. The dotted line on the left indicates that effects and impacts can be estimated directly from emissions, while the arrows on the right side indicate how these estimates can be used in development of strategies for reducing emissions. (Adapted from Fuglestvedt et al., 2003, and Plattner et al., 2009.)

Table 8.7 | GWP and GTP with and without inclusion of climate–carbon feedbacks (cc fb) in response to emissions of the indicated non-CO_2 gases (climate-carbon feedbacks in response to the reference gas CO_2 are always included).

	Lifetime (years)		GWP_{20}	GWP_{100}	GTP_{20}	GTP_{100}
CH_4[b]	12.4[a]	No cc fb	84	28	67	4
		With cc fb	86	34	70	11
HFC-134a	13.4	No cc fb	3710	1300	3050	201
		With cc fb	3790	1550	3170	530
CFC-11	45.0	No cc fb	6900	4660	6890	2340
		With cc fb	7020	5350	7080	3490
N_2O	121.0[a]	No cc fb	264	265	277	234
		With cc fb	268	298	284	297
CF_4	50,000.0	No cc fb	4880	6630	5270	8040
		With cc fb	4950	7350	5400	9560

Notes:

Uncertainties related to the climate–carbon feedback are large, comparable in magnitude to the strength of the feedback for a single gas.

[a] Perturbation lifetime is used in the calculation of metrics.

[b] These values do not include CO_2 from methane oxidation. Values for fossil methane are higher by 1 and 2 for the 20 and 100 year metrics, respectively (Table 8.A.1).

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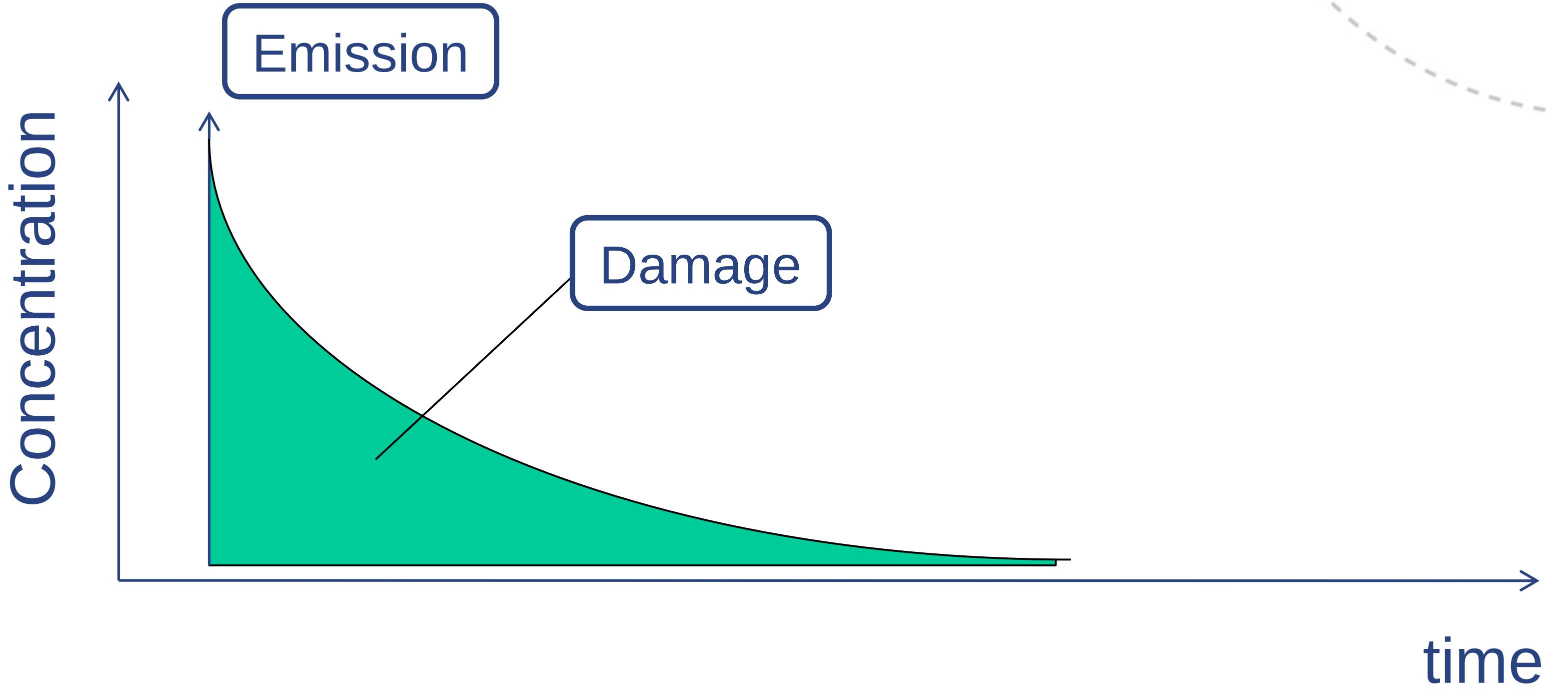
LCA - Emissions and Impacts

From an environmental insult to stress or damage



LCA - Emissions and Impacts

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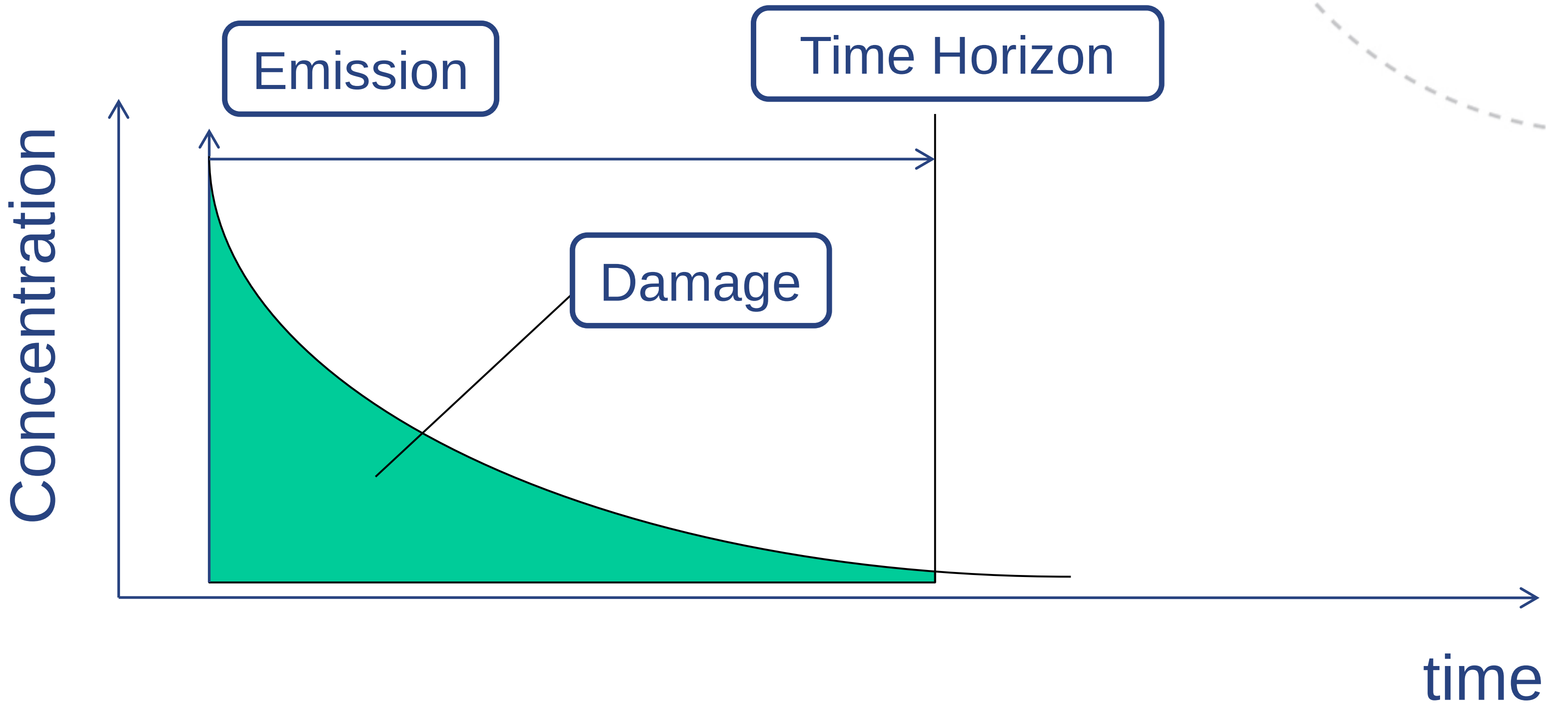
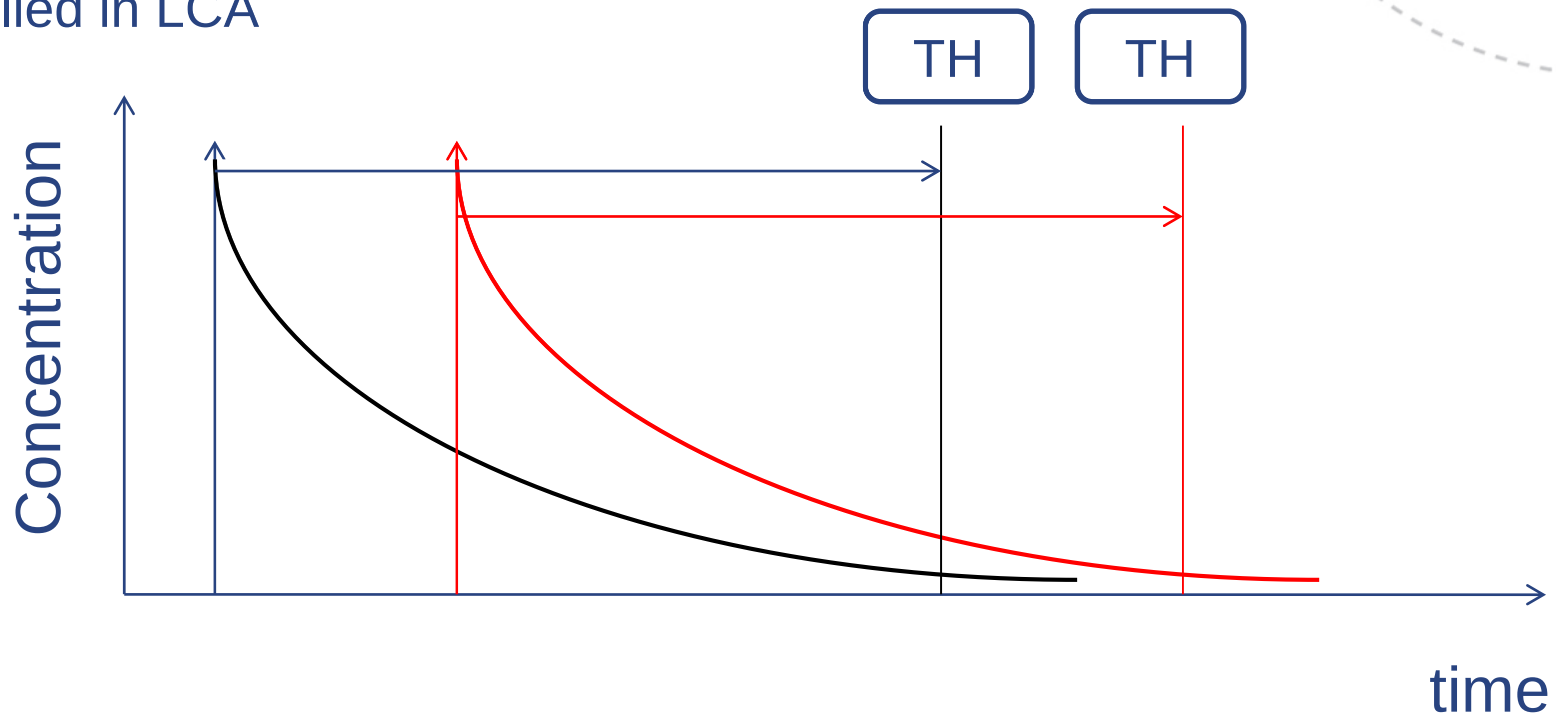


Sliding and fixed time windows

Two perspectives

Sliding windows: impacts are assessed over a constant period of duration from the time of each individual emission.

Applied in LCA

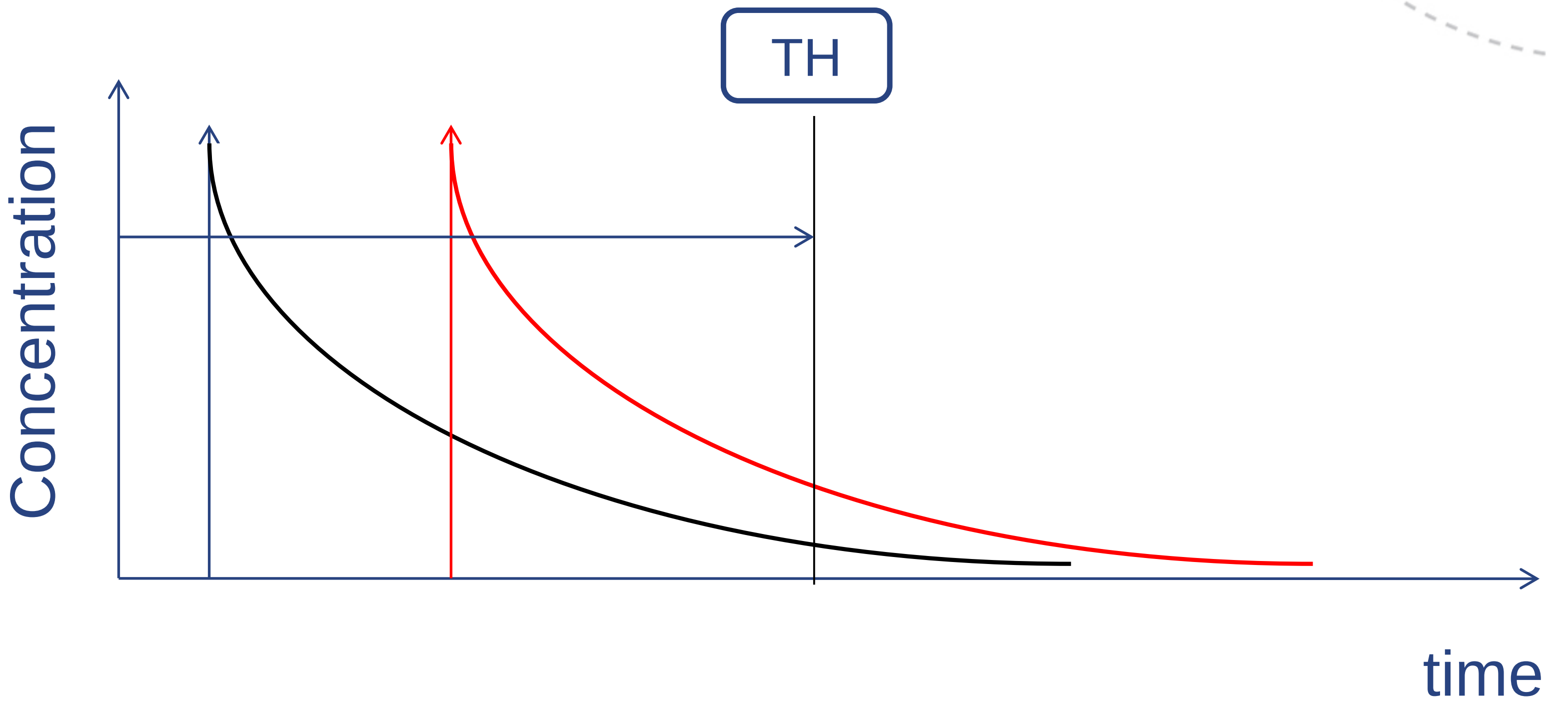


Sliding and fixed time windows

Two perspectives

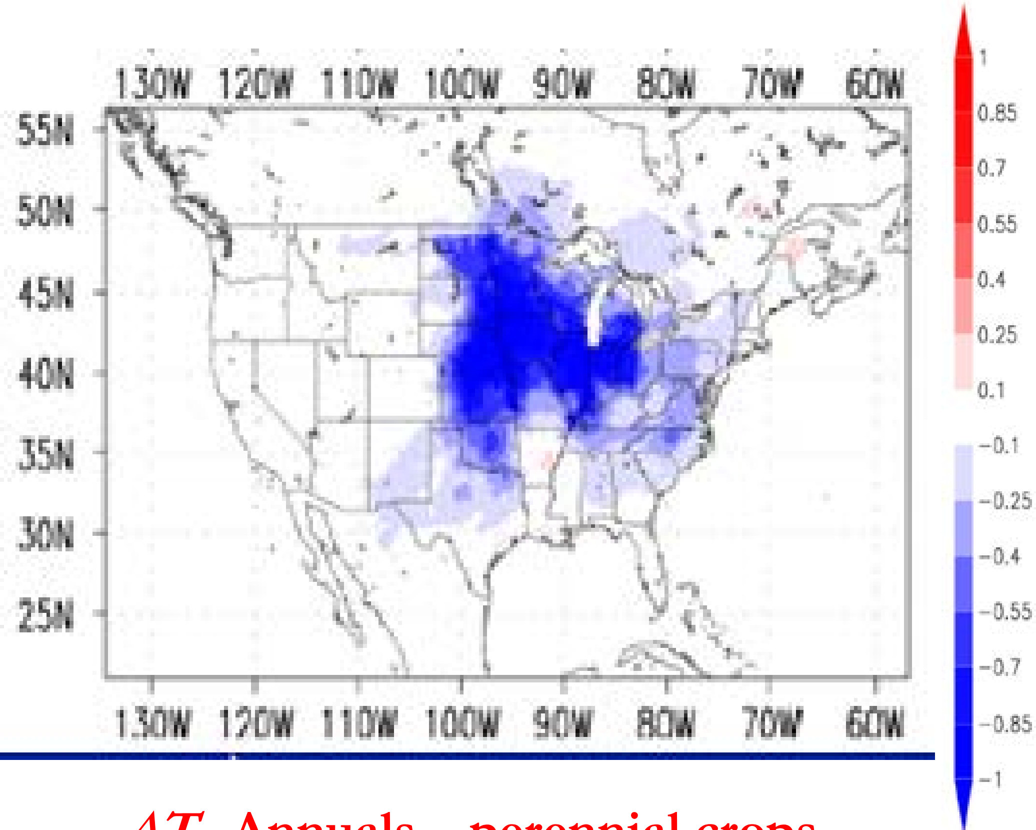
Fixed window: impacts are assessed over a fixed period of time.

Climate scenario assessments.



Direct climate effects of perennial bioenergy crops in the United States

Matei Georgescu[a,1], David B. Lobell[b], and Christopher B. Field[c]



ΔT_s, Annuals – perennial crops

- Regional climate modeling simulation of replacing annual crops with perennial crops in the U.S. Midwest for bioenergy (~84 Mha)
- Local and regional cooling from enhanced evapotranspiration
- Local, regional, and global cooling from higher surface albedo
- Results demonstrate that a thorough evaluation of costs and benefits of bioenergy-related LUC/LCC «**must include potential impacts on the surface energy and H_2O balance to comprehensively address important concerns for local, regional, and global climate change»**

Key Points

- Multiple forcings need to be understood to understand climate impacts of bioenergy
- IPCC: GWP is forcing not warming per se
- IPCC: GTP as alternative metric
- Time and damage perspective
- LC Impact assessment independent of CLCA or ALCA
- ESMs , RCMs needed to assess large scale land cover changes.
- LCA depend on these to do develop robust metrics.

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