# Treaty Verification and the Atmosphere

- UNFCCC vs Kyoto
- How top-down methods work
- The problem of processes
- The atmosphere as consistency check
- Integrating models into the process

# United Nations Framework Convention on Climate Change

stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system

- Concentration controlled by total flux;
- Engineers and economists might suggest pricing total flux;
- Inequitable, infeasible and risky.

# Kyoto Protocol

- Does not have a separate objective from UNFCCC;
- Control the controllables;
- Deliberately limited scope;

# Some Snippets

**2.1.a.ii** Protection and enhancement of sinks, afforestation and reforestation;

**2.1.a.iii** Sustainable agriculture;

**2.1.a.vii** Reduce transport emissions;

**2.1.a.viii** Methane emissions from landfills

**2.1.b** Improving transparency and accountability.

# Article 3.3

The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner

# Some other Snippets

**3.4** Other agricultural changes to be considered for 2nd period;

**3.9–3.12** Can transfer sources and sinks;

**5.1** Everyone has their own reporting system but methodology must be agreed;

**8.1** Inventories will be reviewed;

**10.1.a** Countries should improve emission factors etc;

# Article 12, the CDM

**12.3** Annex I countries can pay for emission reductions in non-Annex I

**12.5b** "Real, measurable, and long-term"

**12.10** CDM reductions can happen before the commitment period.

**17** The COP makes the rules on verification of emissions trading.

# How top-down methods work

- Take best possible picture of fluxes
  - Fluxes usually divided into processes then into gridded patterns
- Insert fluxes into atmospheric model then compare with observations
- Adjust fluxes to improve match to observations, concentrating on most uncertain regions and processes
- Can infer net flux to atmosphere but is by-product
- Remember lateral transport

# The problem

- If two processes have the same fingerprint on the atmosphere they are indistinguishable
- If the spatial structure of processes can't be distinguished we cannot separate them
- Example: forest "thickening" vs reforestation in the same region. One might be Kyoto-relevant, one not.
- Probably no improvement in measurement precision or density will solve this

# What can one do?

- Use first stage of inversion process
- Take best estimate of fluxes including uncertainties
- Create ensemble of fluxes consistent with priors and uncertainties
- Insert in transport model and assess consistency with data
- Less scientifically interesting than inversions but also more feasible

# Regional vs Global

- In global case it's hard to attribute a mismatch to any sector or region since errors are transported
- Can be done in regional domains provided the concentration boundary conditions are well-specified
- Satellite measurements can provide these

# Model-based carbon accounting

- Based loosely on Australian National Carbon Accounting System http://www.greenhouse.gov.au/ncas/
- Observe changes in land cover from satellite (25m resolution)
- Use knowledge of site history, forcing and vegetation type to infer change in carbon stock
- Model may range from lookup table to full ecosystem model
- Any model depends on semi-empirical parameters determining, e.g. productivity
- Parameters can be measured at points but not everywhere

# Australian Net Primary Productivity

| Model | Aust. NPP (GtC/y) | reference |
|---|---|---|
| RFBN | 3.33 | Roderick et al. (2001) |
| Olson | 2.89 | Gifford et a.. (1992) |
| Miami | 2.47 | Pittock and Nix (1986) |
| CASA-VGPM | 2.00 | Field et al. (2001) |
| CEN-W | 1.77 | Kirschbaum (1999) |
| GRASP | 1.67 | Carter (2002) |
| Century | 1.21 | Parton (2002) |
| Miami (oz) | 1.12 | Roxburgh (2002) |
| VAST (stat) | 0.96 | Barrett (2002) |
| BiosEquil | 0.93 | Raupach et al. (2002) |
| VAST (model) | 0.65 | Barrett and Xu (2002) |
| SDBM (optimised) | $0.8 \pm 0.2$ | Kaminski et al. (2002) |

Data taken from www.greenhouse.gov.au/ncas/

# Notes

- National changes in carbon stock would scale almost linearly with these NPP estimates
- Hence reporting could vary by a factor 5
- Each of these NPP estimates would have seasonal and diurnal signatures in the atmosphere
- The bottom study used these atmospheric signatures to constrain NPP although it has many other weaknesses

# Conclusions

- The ultimate limitation on using top-down methods for accounting is the accounting requirement not the precision
- Consistency checking provides a method for testing an inventory
- Atmospheric methods can constrain the models that underpin accounting systems