Simulating the Contemporary Carbon Balance of Europe

Chris Jones
Rob Harrison, Venkata Jogireddy, David Pearson

JULES Launch Meeting, October 2006
Outline

- Overview of CarboEurope simulations
  - Gridded version of JULES
- Early results
- Technical aspects, limitations, questions
- Future work
- Request to JULES developers
Introduction

- CarboEurope-IP is a large European Integrated Project
- Work under the “Continental Integration” component is focussed on estimating the European regional carbon balance
  - Especially response to 2003 summer heat/drought wave
  - Both “top-down” inversions and “bottom-up” modelling
- Hadley Centre is contributing simulations to a model intercomparison activity
- Using grid-enabled version of JULES
  - Many thanks to Doug Clark for making this possible
  - Same JULES code/science
  - Added infrastructure to run over a grid
    - Lat/lon referenced
    - Gridded input data, ancillary data (soil properties etc)
    - Gridded output of diagnostics
    - Can select sub-domain at run-time, model extracts portion of driving data
CarboEurope simulations

- 3 key activities
  - Simulate European regional carbon balance and compare results across models and with inversion estimates
  - Site level simulations to be compared with observed carbon and moisture fluxes
  - Transport of simulated carbon fluxes for comparison with observed atmospheric CO₂ measurements

- 2 main outcomes
  - Estimate of European carbon balance and its sensitivity to climate anomalies
    - Including estimate of uncertainty due to multi-model structural differences
  - Indication of model deficiencies
    - Where/why do other models do better (e.g. no crops in JULES)
    - Where/why do all models do well/badly
Results – spinup carbon stores

- JULES run with TRIFFID in equilibrium mode to spin-up carbon stores
  - Vegetation fractions prescribed (no dynamic vegetation in these expts)
  - Soil/veg C store initialised at constant values
Results – changes to carbon stores

- Soil and veg carbon evolve during the simulation
  - Climate data for 1958-69 cycled
  - Steadily increasing CO2
- Still some spin-up in early stage
- We’re interested in the last few decades

- European land carbon uptake:
  - 1980s = 78 TgC yr\(^{-1}\) (39, 39 in veg, soil respectively)
  - 1990s = 163 TgC yr\(^{-1}\) (41, 122)
  - 2000-2005 = 54 TgC yr\(^{-1}\) (76, -22)

- Must stress: no land management in these runs yet
Results – contemporary carbon sink

- Mean summer (MJJAS) NEP for 1998-2002 shows net carbon sink across most of Europe
Results – contemporary carbon sink

- Mean summer (MJJAS) NEP for 1998-2002 shows net carbon sink across most of Europe

- 2003 heat/drought wave causes large negative anomaly in summer NEP across much of West Europe

- Cool, wet conditions in NE Europe also give negative anomaly
Results – other CarboEurope models

- Plenty of similarities
  - France

- Plenty of differences
  - Scandinavia

- Analysis is ongoing
These fluxes will be fed into transport model and compared with atmospheric CO2 measurements.
Technical considerations

- Spatial resolution?
  - 1 degree runs performed so far
  - 0.25 degree runs required

- Does it give more detail?
  - Yes
- Is it a real improvement?
  - Don’t know

- Is it worth 16 times cost of data and run time?
  - Don’t know

- Large runs can be easily split with gridded version of JULES
  - Simple change to namelist
  - No need to split driving data
  - Need to re-combine output
**Technical considerations**

- **Sub daily weather**
  - JULES currently has no representation of any cycle not caught in the driving data
    - Short runs at specific site may have hourly obs
    - Long runs over large domain unlikely to have sub-daily data (or even daily data)
  - For these expts, have added diurnal cycle of T, SW, precip, with daily mean preserved
    - Need to analyse how important this is
    - First look shows only small differences
      - But… NEP is balance between large fluxes in/out, so small differences could still be important
Future work

- Data assimilation
  - or “model-data fusion”

- Adjoint of JULES and transport model (a la CCDAS) could be used to optimise model parameters
  - Also provides properly quantified uncertainty bounds

- Factorial experiments to attribute carbon flux/store changes to processes
  - CO2 rise
  - Climate change
  - Land management
Final request

- To all developers of JULES
- Please don’t forget the carbon cycle!
- When making changes to science of JULES, remember to test the impact on carbon fluxes as well as heat/moisture
  - Just because TRIFFID can be turned on/off within JULES doesn’t mean it should be forgotten!