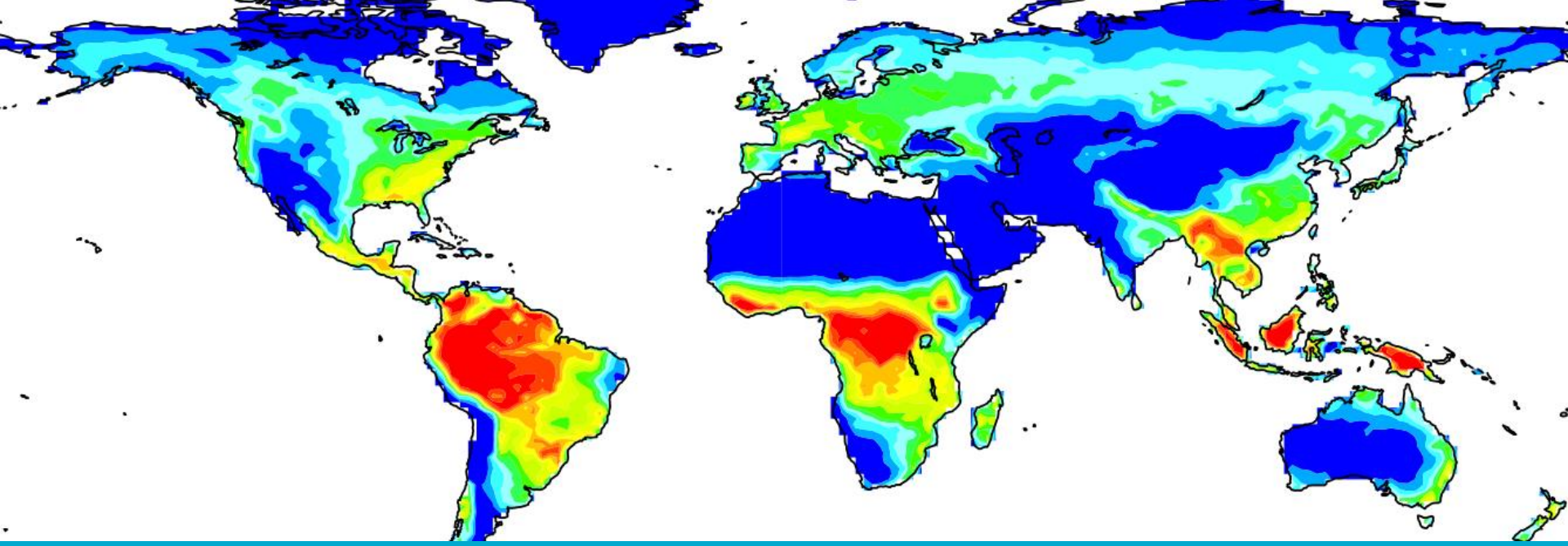


The CABLE land surface model in ACCESS

Tilo Ziehn

14th May 2018

OCEANS AND ATMOSPHERE FLAGSHIP
www.csiro.au

What is CABLE?

- **C**ommunity **A**tmosphere **B**iosphere **L**and **E**xchange
- Australian community land surface model for stand-alone (offline) and online use
- Coupled to
  - global models: ACCESS (UM-atmosphere), CCAM, Mk3L
  - regional models: WRF (via NASA's Land Information System)
  - air pollution model: TAPM
- Open source, but user registration required to access code repository
- Around 120 users with CABLE repository access from 21 Australian institutions and 14 other countries

CABLE timeline

1990: First land surface model developed in CSIRO.

1997: Another model - Soil Canopy Atmosphere Model (SCAM) -developed with an empirical photosynthesis model

1998: Two-leaf (sunlit, shaded) canopy model developed

2003: CSIRO Biosphere Model (CBM) developed

2006: CBM and SCAM combined to form CABLE version 1.0. Last released update v1.4b in Sep 2008.

2010: CASA-CNP, a global biogeochemical model of C, N and P developed

2012: CABLE2.0 released. CABLEv1.8 in ACCESS1.3 for CMIP5. CABLE roadmap.

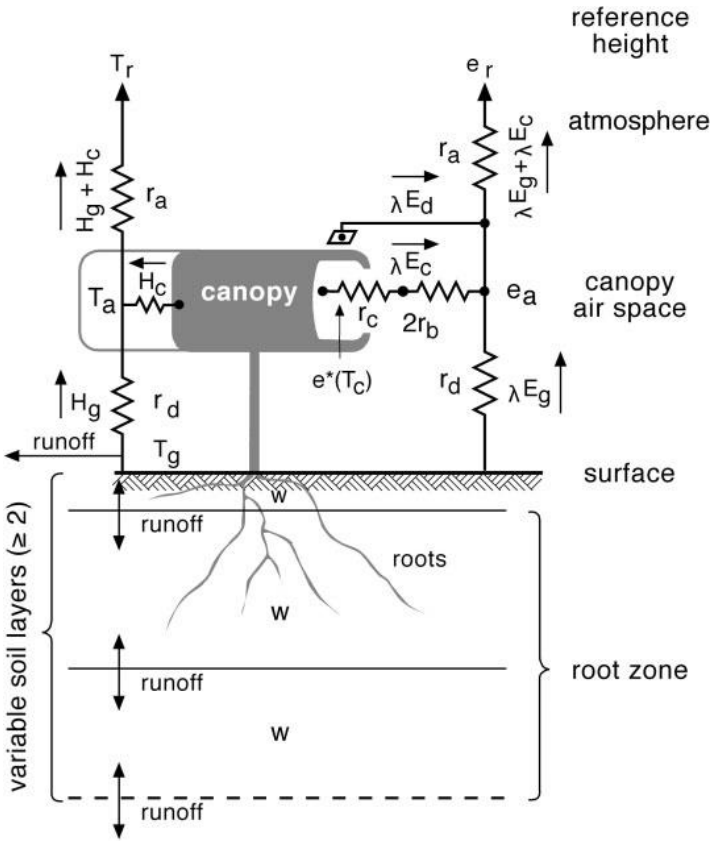
2014: CABLE2.2.3 in ACCESS-ESM1 / ACCESS1.4

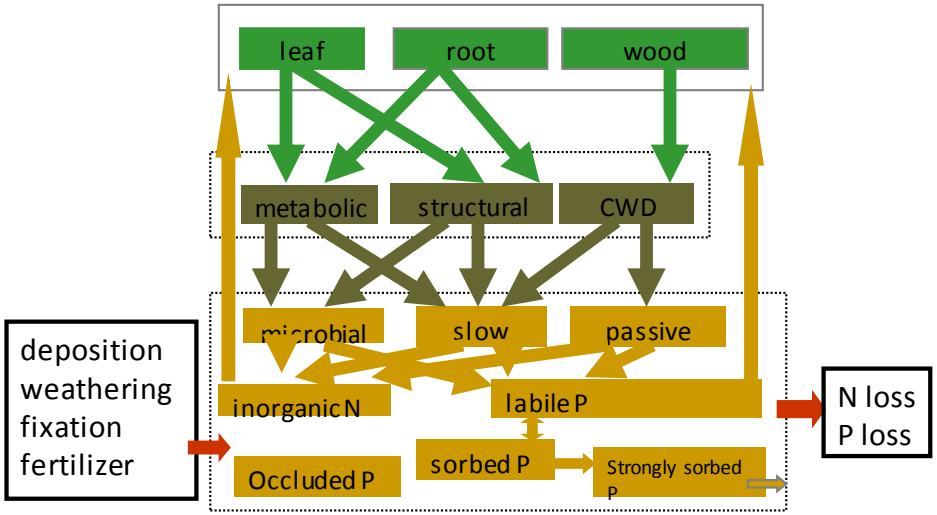
2015: CABLE becomes Open Source

CABLE Wiki page, trac page with ticketing system (https://trac.nci.org.au/trac/cable/wiki)
Main technical documentation in: Kowalczyk et al., CMAR tech report, 2006; Wang et al., BG, 2010; Wang et al., JGR, 2011.

CABLE components

1. Radiation
2. Canopy micrometeorology
3. Surface flux
4. Soil and snow
5. Ecosystem respiration
6. Dynamics of carbon pools (CASA-CNP)



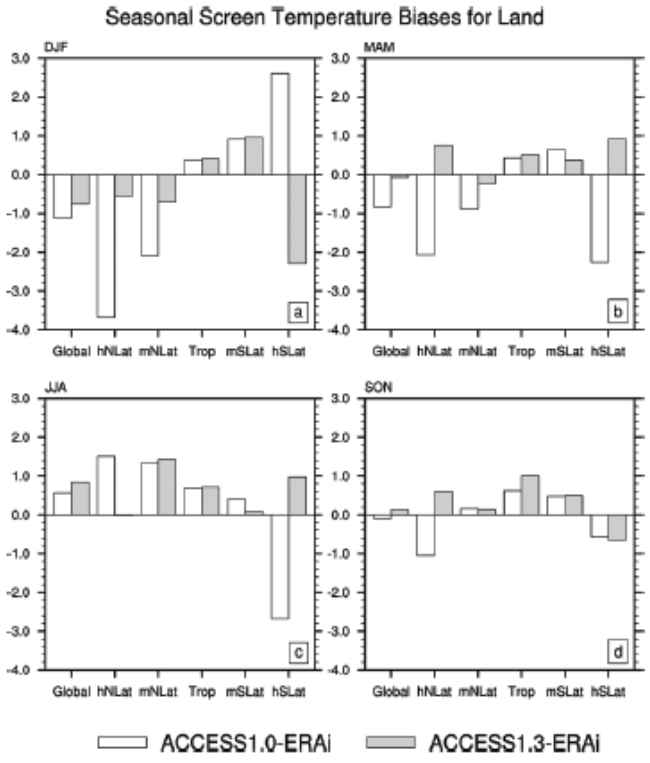


Biophysics (original CABLE) + **Biogeochemistry** (CASA-CNP) = **CABLE** (current)

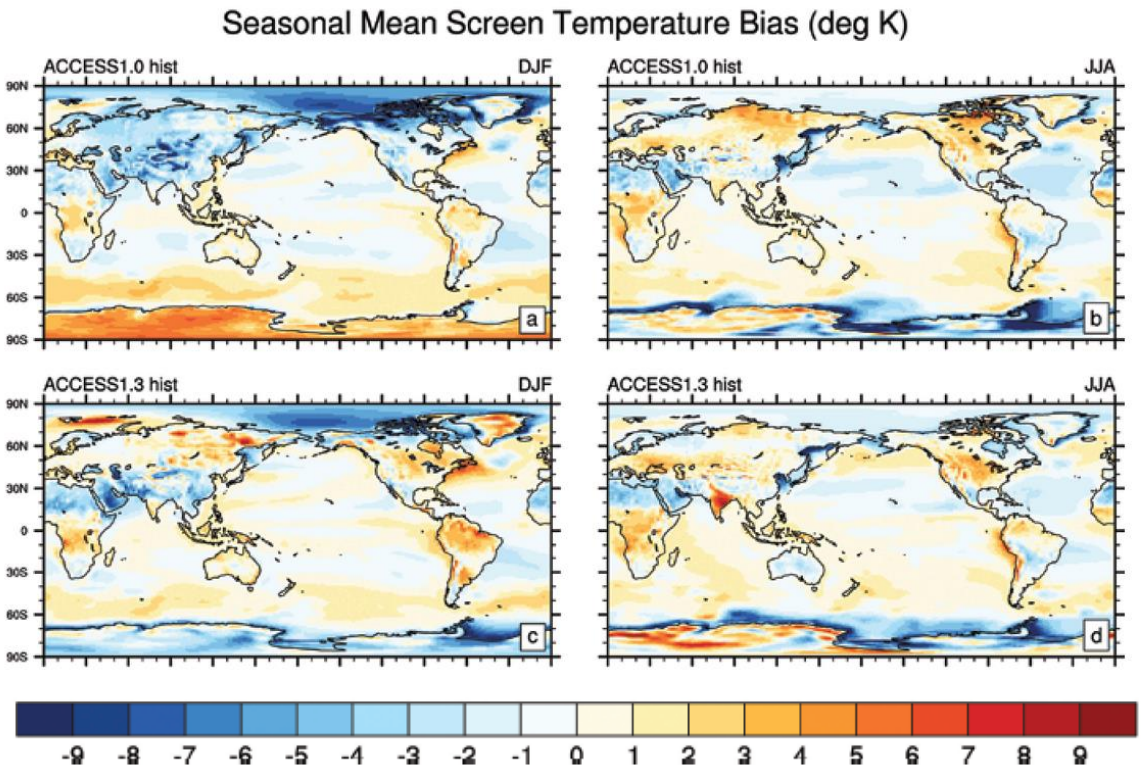
ACCESS components/versions

	ACCESS-1.3	ACCESS-1.4 / ESM1	ACCESS-ESM1.5	ACCESS-CM2 / ESM2
Atmosphere	UM7.3 approx. GA1 (no dust)	UM7.3 approx. GA1	UM7.3 approx. GA1	UM10.6 GA7.1
Land	CABLE1.8	CABLE2.2.3 (CASA-CNP)	CABLE2.2.4 (CASA-CNP)	CABLE (CASA-CNP)
Coupler	OASIS3.2-5	OASIS-MCT	OASIS-MCT	OASIS-MCT
Sea ice	CICE4.1	CICE4.1	CICE4.1	CICE5
Ocean	MOM4.1	MOM4.1 (WOMBAT)	MOM5 (WOMBAT)	MOM5 (WOMBAT)
	CMIP5 submission		CMIP6 submission	CMIP6 submission (CM2 only)

ACCESS-1.3: land climate assessment



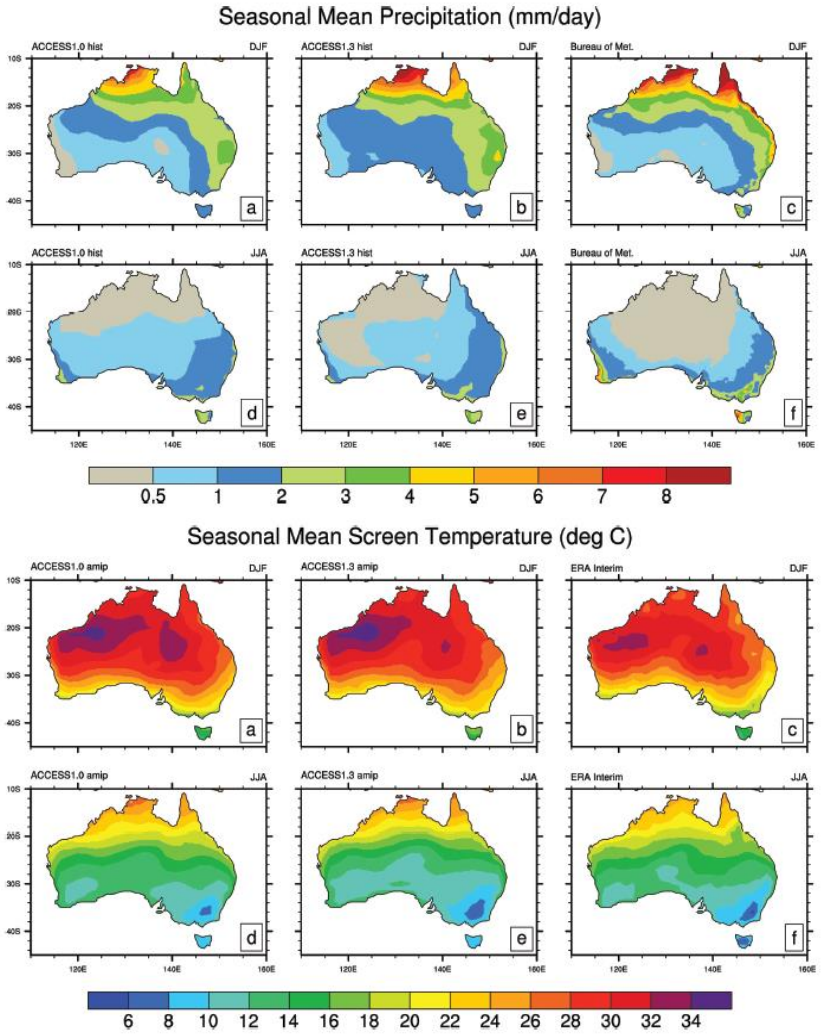
AMIP

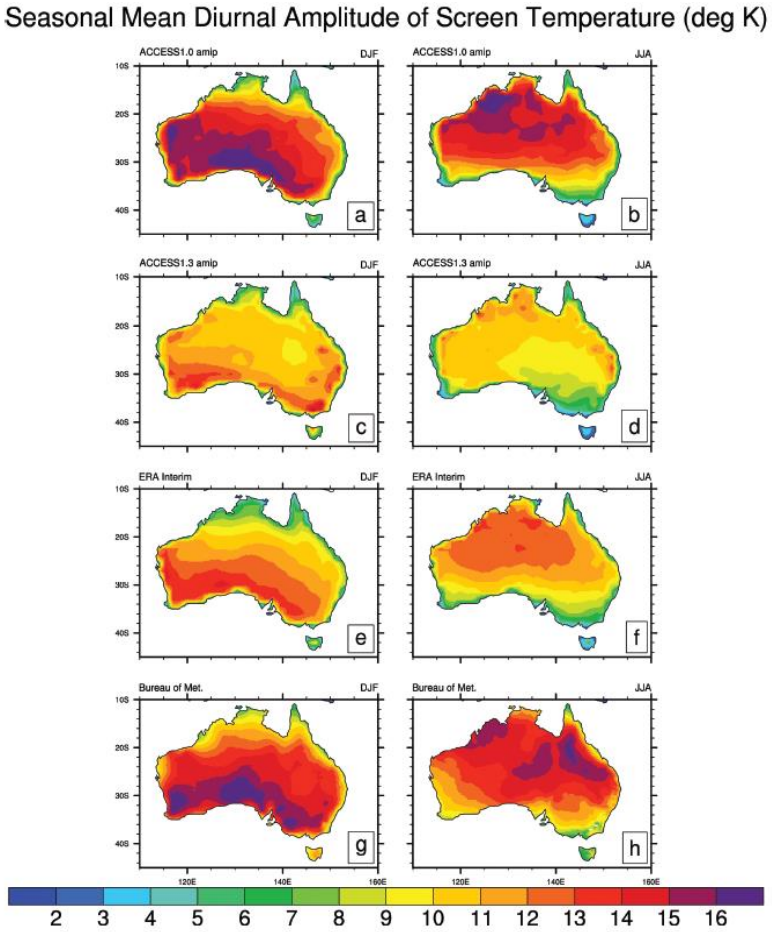


Coupled

Kowalczyk et al, AMOJ, 63, 65-82, 2013.

ACCESS-1.3: land climate assessment for Australia





Kowalczyk et al, AMOJ, 63, 65-82, 2013.

ACCESS-ESM1: simulations and results

https://accessdev.nci.org.au/trac/wiki/access/ACCESS_ESM1_catalogue

1. **Concentration driven (prescribed atmospheric CO_2)**
   a. Pre-industrial control run: 1000 years with PresLAI, 1000 years with ProgLAI
   b. Historical simulations: PresLAI and 3 ensemble members for ProgLAI
   c. Future Scenarios: RCP2.6, RCP4.5 and RCP8.5 for PresLAI and ProgLAI, 3 ensemble members for ProgLAI
   d. Climate Sensitivity and feedback analysis: 1% and 4xCO_2 for ProgLAI
   e. Sensitivity to aerosols: no anthropogenic aerosols for ProgLAI, 3 ensemble members
2. **Emission driven (prescribed CO_2 emissions)**
   a. Pre-industrial control run: 200 years for ProgLAI
   b. Historical simulation for ProgLAI
   c. Future Scenarios: RCP8.5 for ProgLAI

The carbon cycle in the Australian Community Climate and Earth System Simulator (ACCESS-ESM1) – Part 1: Model description and pre-industrial simulation

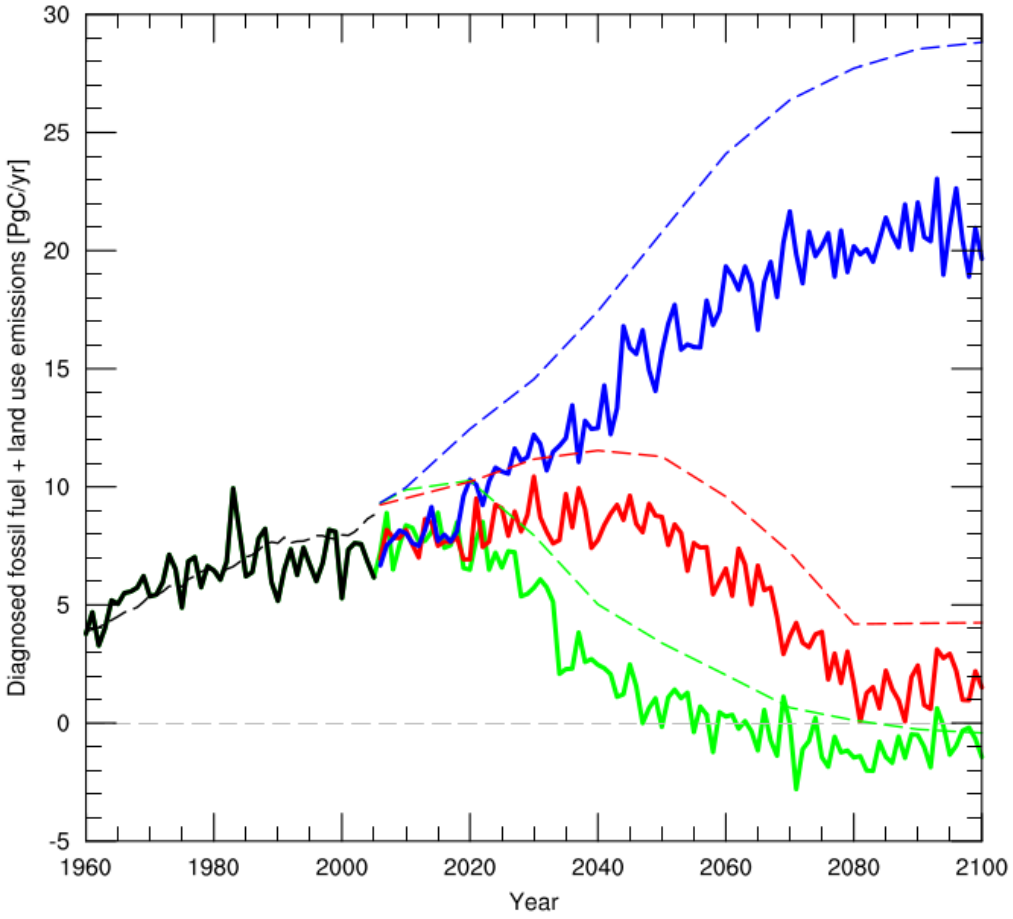
Rachel M. Law[1], Tilo Ziehn[1], Richard J. Matear[2], Andrew Lenton[2], Matthew A. Chamberlain[2], Lauren E. Stevens[1], Ying-Ping Wang[1], Jhan Srbinovsky[1], Daohua Bi[1], Hailin Yan[1,a], and Peter F. Vohralik[3]

The carbon cycle in the Australian Community Climate and Earth System Simulator (ACCESS-ESM1) – Part 2: Historical simulations

Tilo Ziehn[1], Andrew Lenton[2], Rachel M. Law[1], Richard J. Matear[2], and Matthew A. Chamberlain[2]

ACCESS-ESM1: assessment of allowable emissions

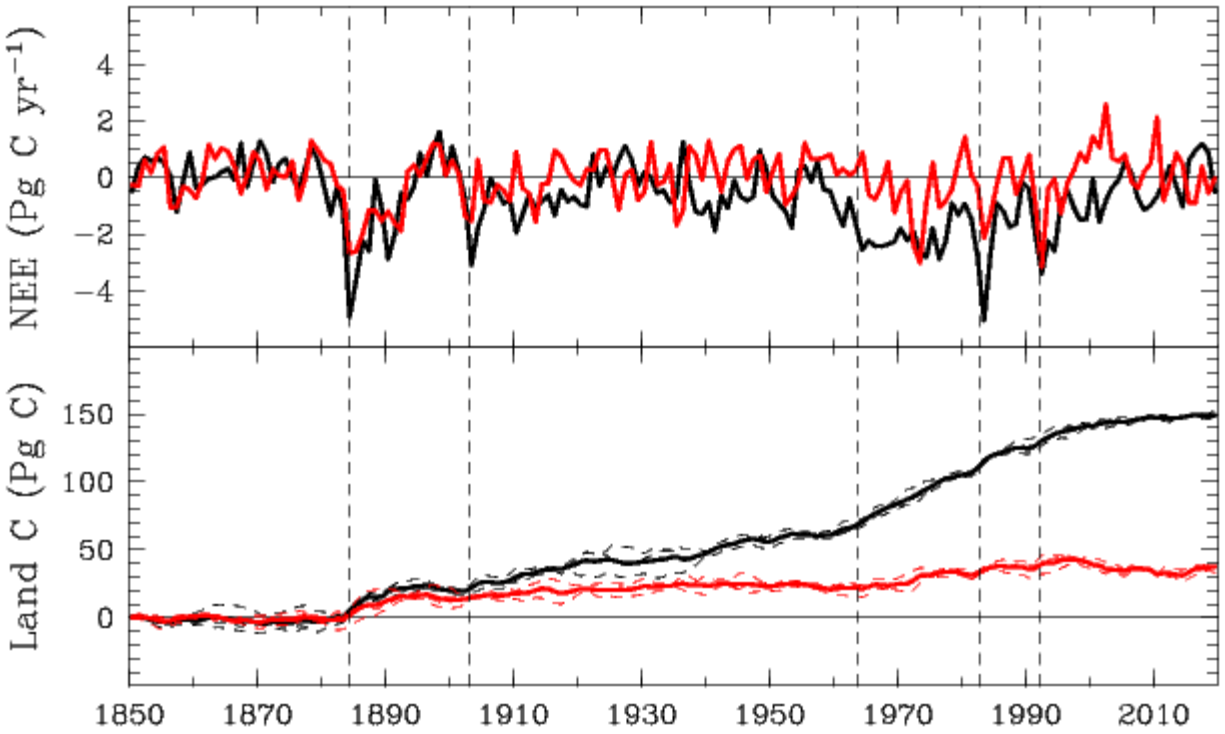
Fossil + land-use = Prescribed atmospheric increase + land uptake + ocean uptake



	IAM	ACCESS
Historical	469 PgC	456 PgC
RCP2.6	381 PgC	202 PgC
RCP4.5	807 PgC	559 PgC
RCP8.5	1971 PgC	1471 PgC

Nutrient limitation in ACCESS-ESM1 results in lower allowable emissions than other models. Greater emission reductions required to stay below 2°C warming.

ACCESS-ESM1: impact of anthropogenic aerosols



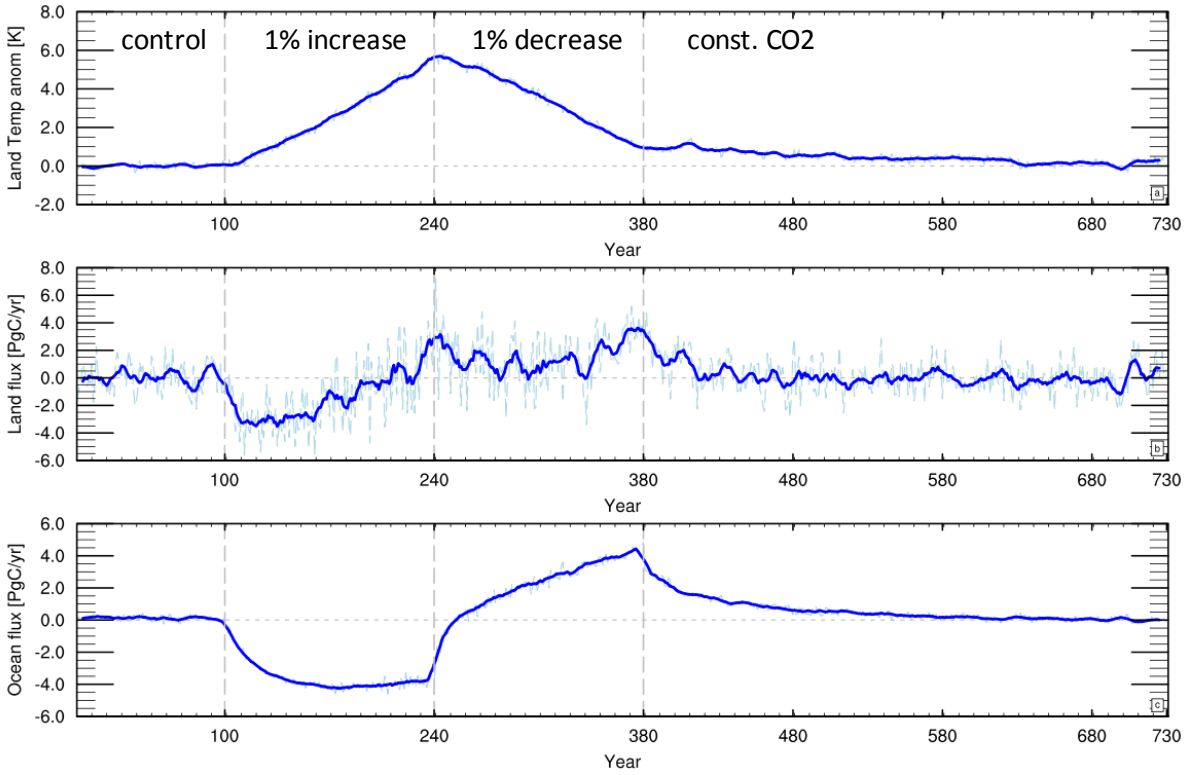
Net ecosystem exchange (+ve source to atmosphere, -ve sink)

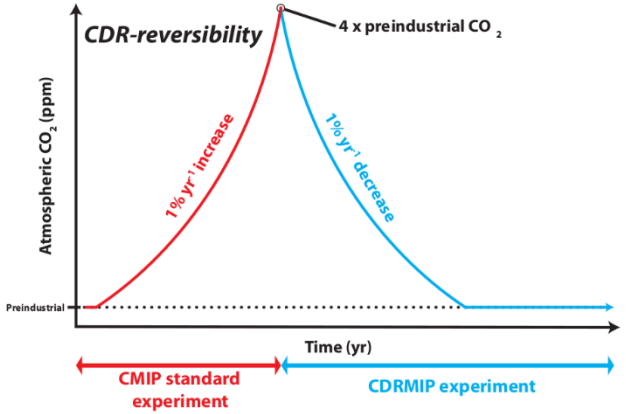
Cumulative land carbon uptake since 1850

Black: control, red: no anthropogenic aerosol

What's driving difference? Not direct impact of aerosols on carbon.
Impact through climate. Temperature? Precipitation? Radiation (direct/diffuse)?
Note: Prescribed atmospheric CO_2

ACCESS-ESM1: carbon cycle reversibility experiment





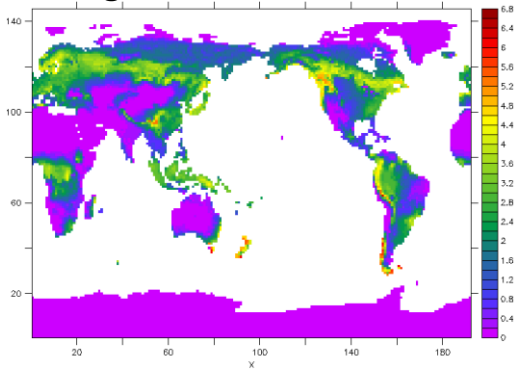
- Temp increase of about 4°C over 140 yrs of CO_2 increase
- After CO_2 removal temp still 1°C above pre-industrial

- Land becomes neutral soon after CO_2 removal, ocean remains source even after CO_2 removal
- When is equilibrium reached again? Regional differences?

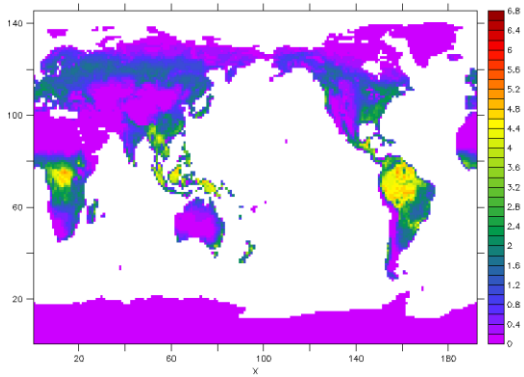
ACCESS-ESM1.5 and CMIP6

- Improvements/Changes
  - Improved land carbon conservation
  - Land use and land cover change capability
  - Improved prognostic LAI (and arctic sea ice)
  - MOM5
- Participation in CMIP6
  - Spin-up runs commenced (with CMIP5 forcing)
  - Committed to DECK runs (i.e. control run, 1%CO_2 increase, 4xCO_2, historical run)
  - MIPS: Scenario MIP, C4MIP, CDR-MIP, (GeoMIP)
- Computational requirements
  - Runs on raijin using 384 cores
  - Approx. 3h for 1 simulation year (max. of 8 simulation years per day)
  - N96 resolution for atmosphere (1.25°x1.875°), 38 levels
  - Ocean: 1°, 50 levels

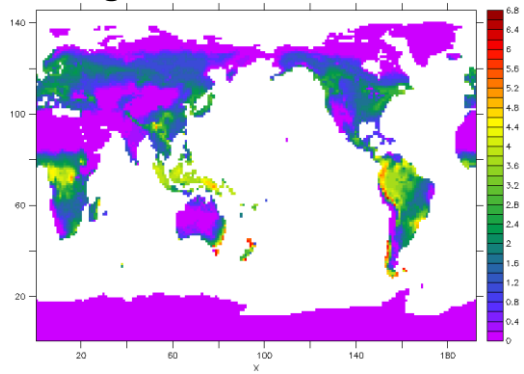
ProgLAI ACCESS-ESM1



LAI observations



ProgLAI ACCESS-ESM1.5



Summary and conclusions

- CABLE is a state-of-the art land surface model (but other models are catching up / getting ahead)
- CABLE performs well in ACCESS
- New CABLE developments need to consider ACCESS application (not just offline)
- ACCESS-ESM requires CABLE with biogeochemistry component CASA-CNP
- ACCESS-ESM1 well tested and documented
- ACCESS-ESM1.5 finalized and preparation for CMIP6 commenced
- ACCESS-ESM2 development (based on ACCESS-CM2) in near future

Thank you

Earth System Modelling
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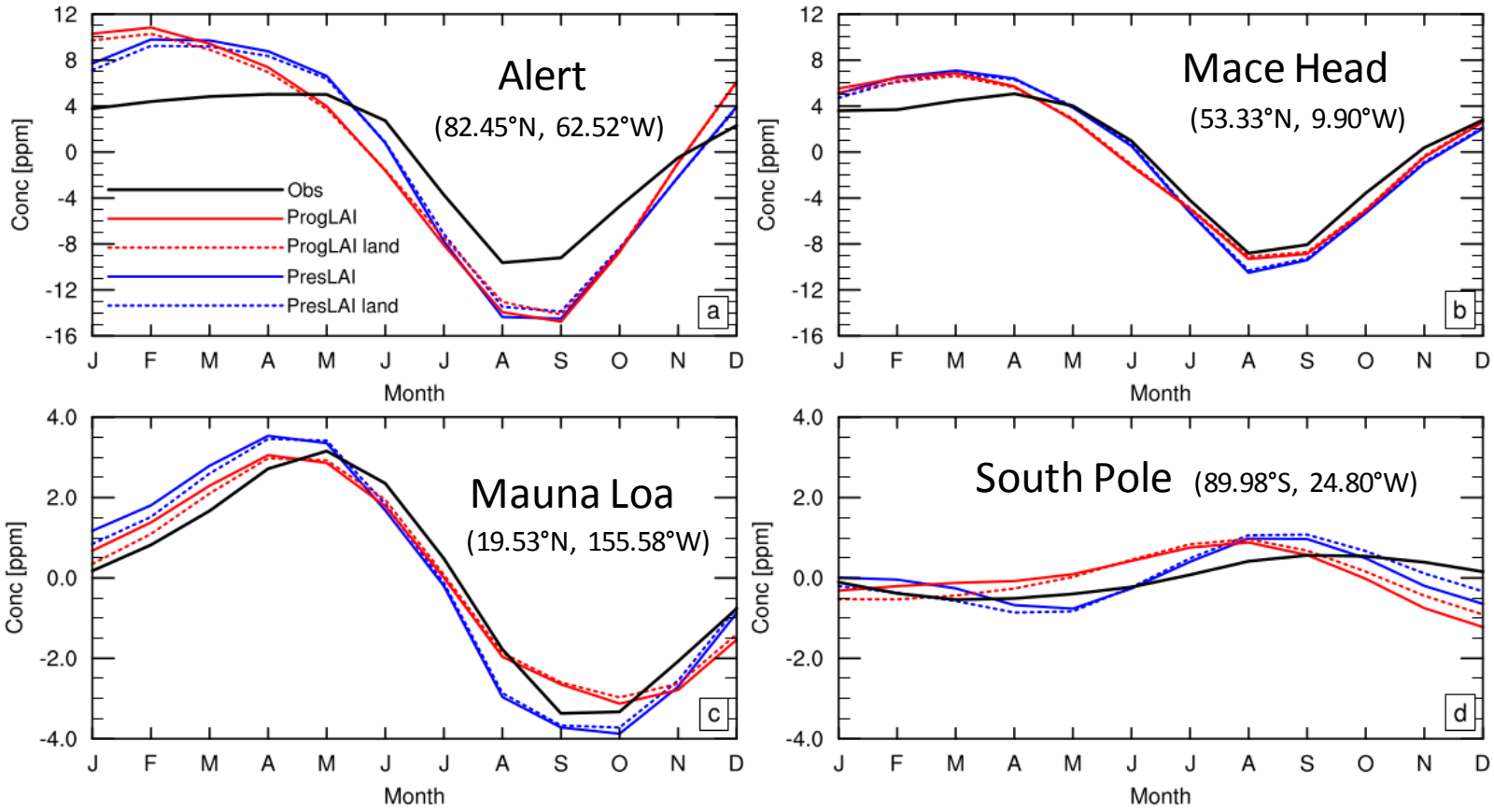
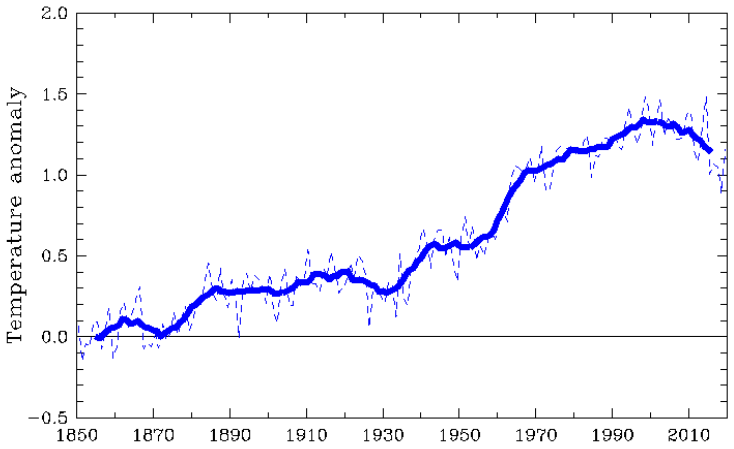
Atmospheric CO_2

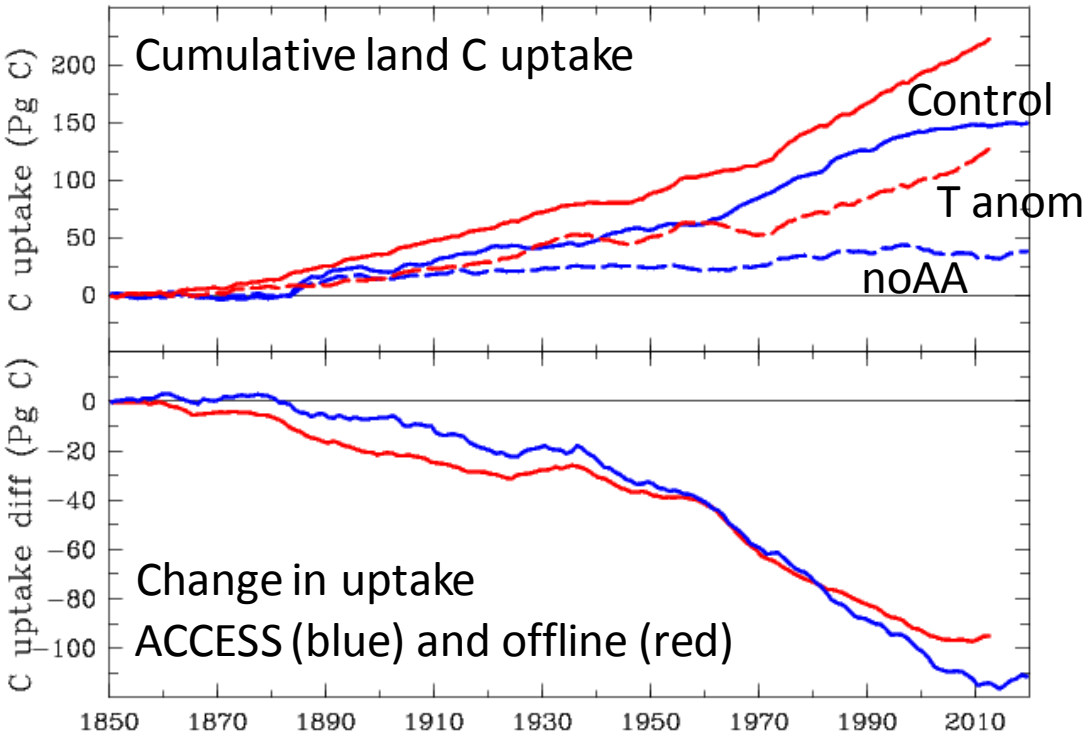


What's driving the difference?

- Offline CABLE runs with imposed global land temperature anomaly



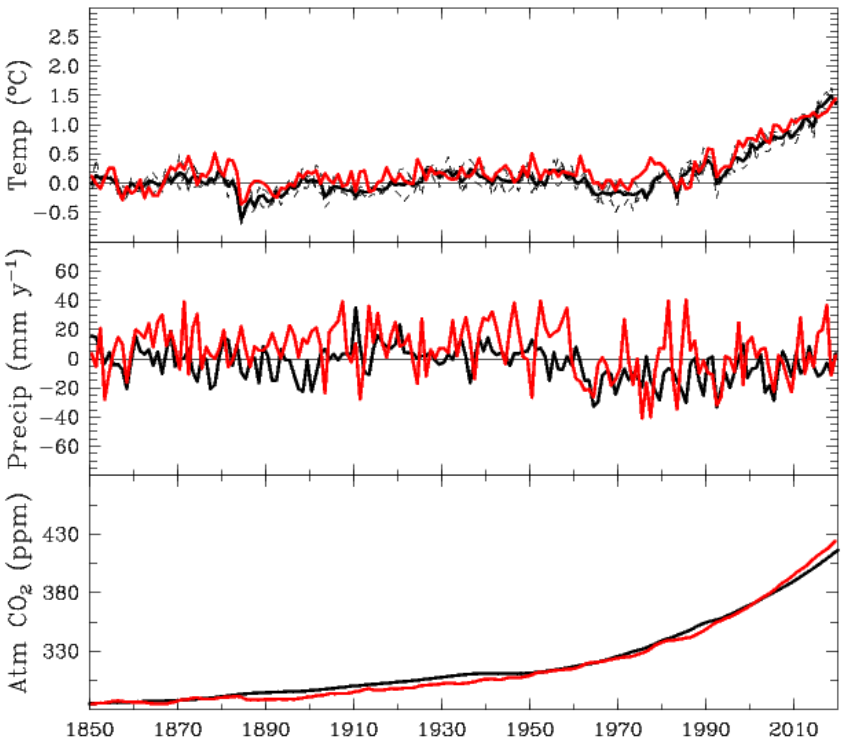
Imposed temperature anomaly: noAA-control, 10 year running ensemble mean



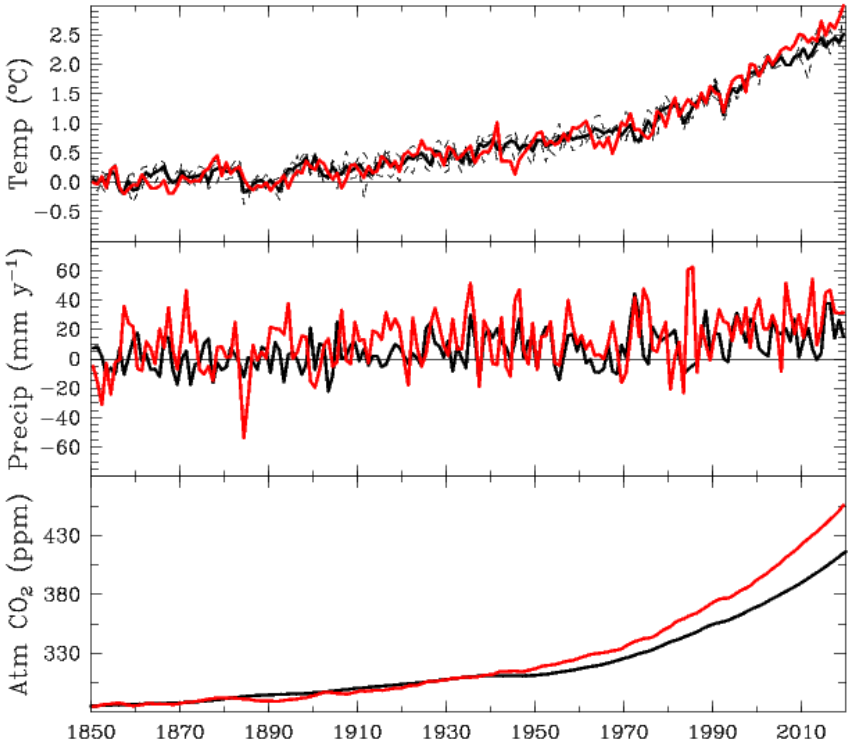
Magnitude of land carbon uptake different between ACCESS and offline, but change in uptake very similar

Emissions driven results - climate

Control



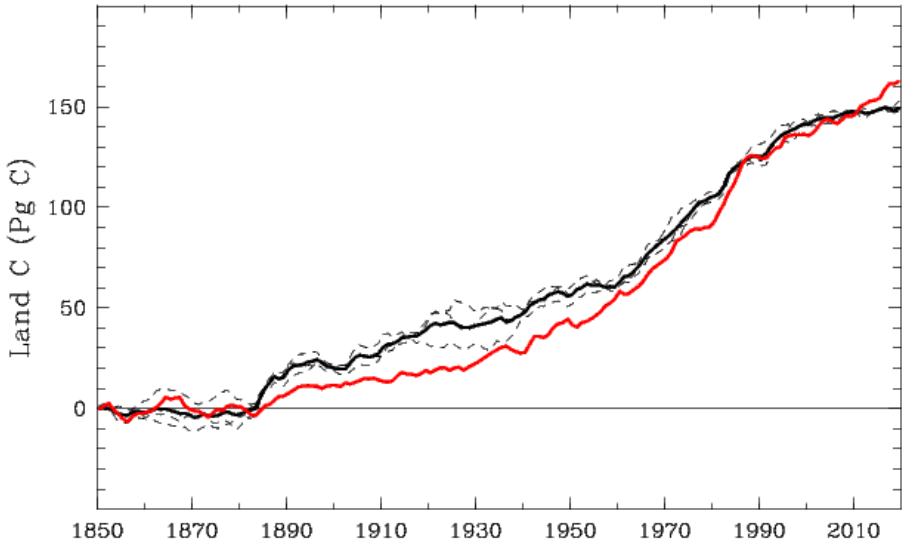
noAA



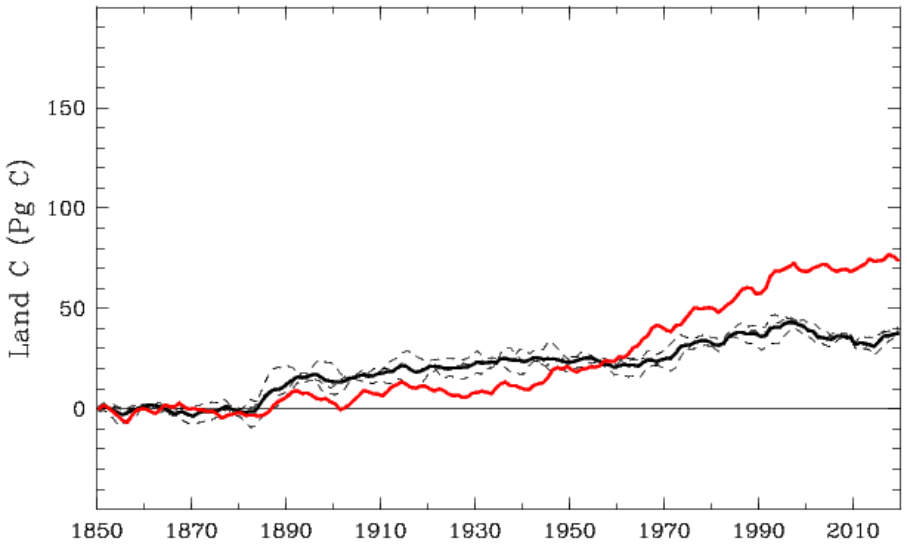
Black: prescribed atmospheric CO_2 (ensemble mean). Red: Emissions-driven, interactive CO_2

Emissions driven results – carbon uptake

Control



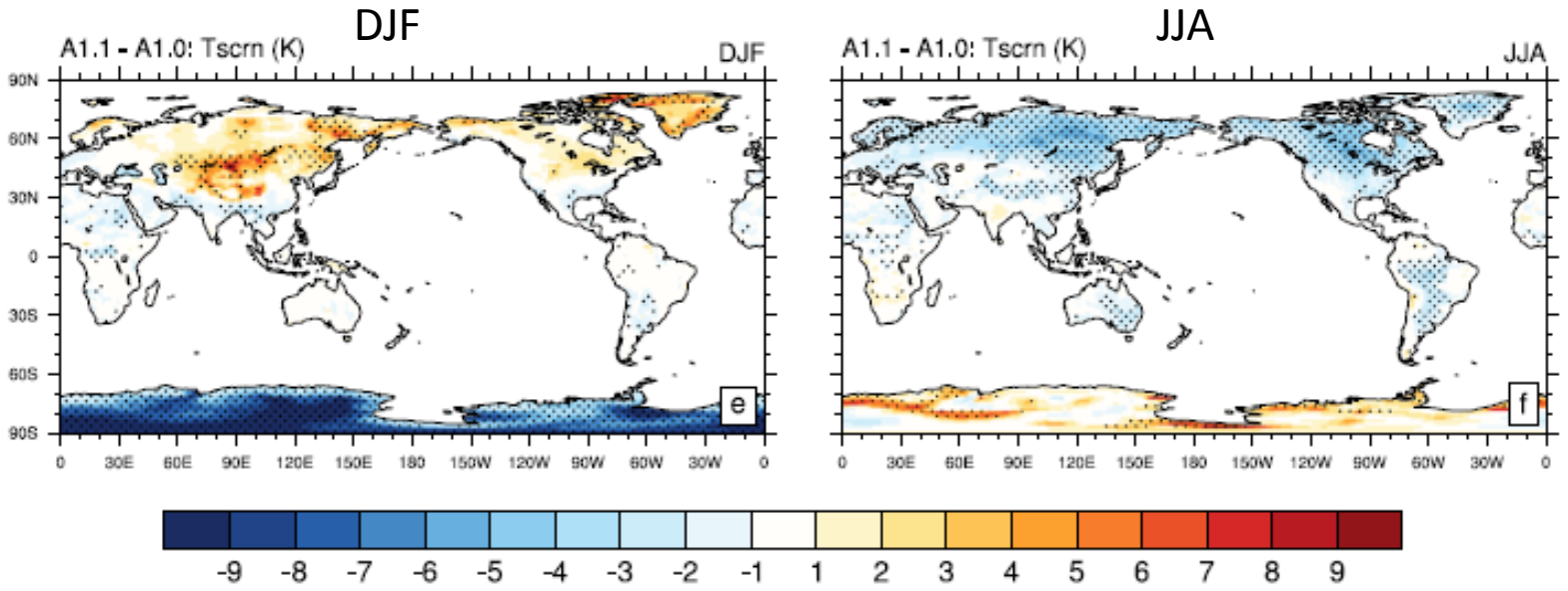
noAA



Black: prescribed atmospheric CO_2 (ensemble mean). Red: Emissions-driven, interactive CO_2

ACCESS with MOSES or CABLE comparison

CABLE minus MOSES difference in 1979-1998 mean surface air temperature

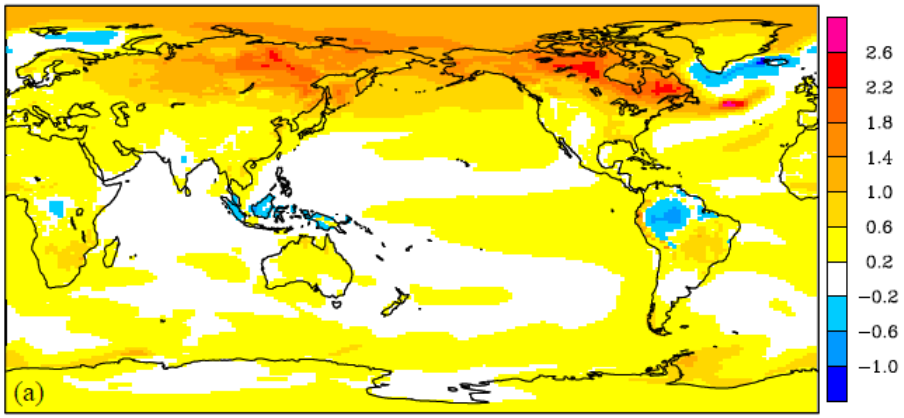


DJF: more variable year to year, differences mainly driven by snow process representation
JJA: more consistent year to year, differences from canopy representation and moisture fluxes/clouds

Kowalczyk, E. A. et al., Geosci. Model Dev., 9, 2771–2791, 2016.

ACCESS-ESM1: developing and testing new code

- Inclusion of land carbon cycle and interactive leaf area index (ProgLAI)
  - Overestimate of evergreen needleleaf vegetation
  - Warmer temperature in northern high-latitudes
  - Reduced Arctic sea-ice



Temperature difference (ProgLAI – PresLAI)

April sea-ice thickness