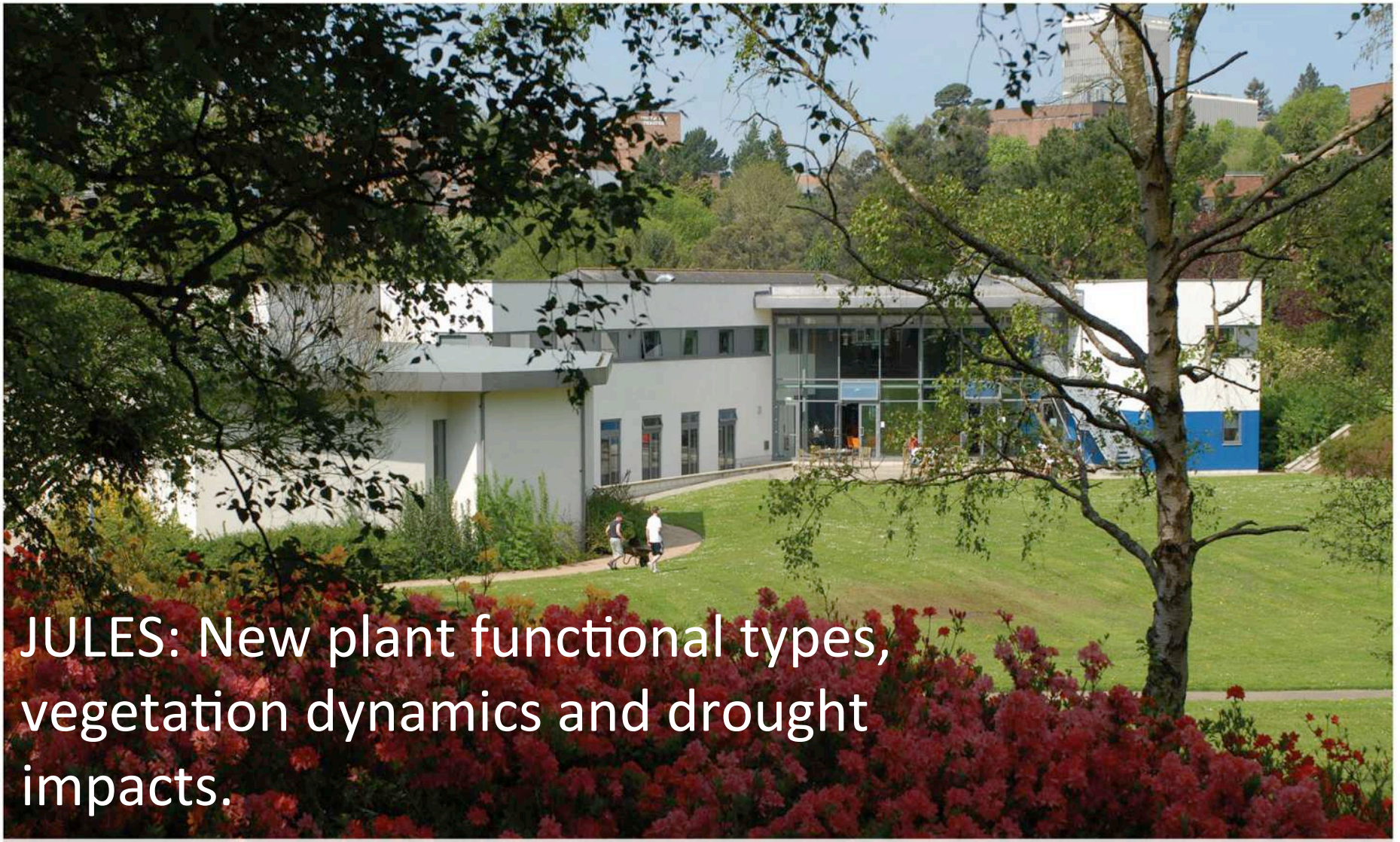


JULES: New plant functional types, vegetation dynamics and drought impacts.

Anna Harper, Pierre Friedlingstein, Peter Cox, Andy Wiltshire, Chris Jones, Margriet Groenendijk, Eddy Robertson

University of Exeter

Met Office Hadley Centre

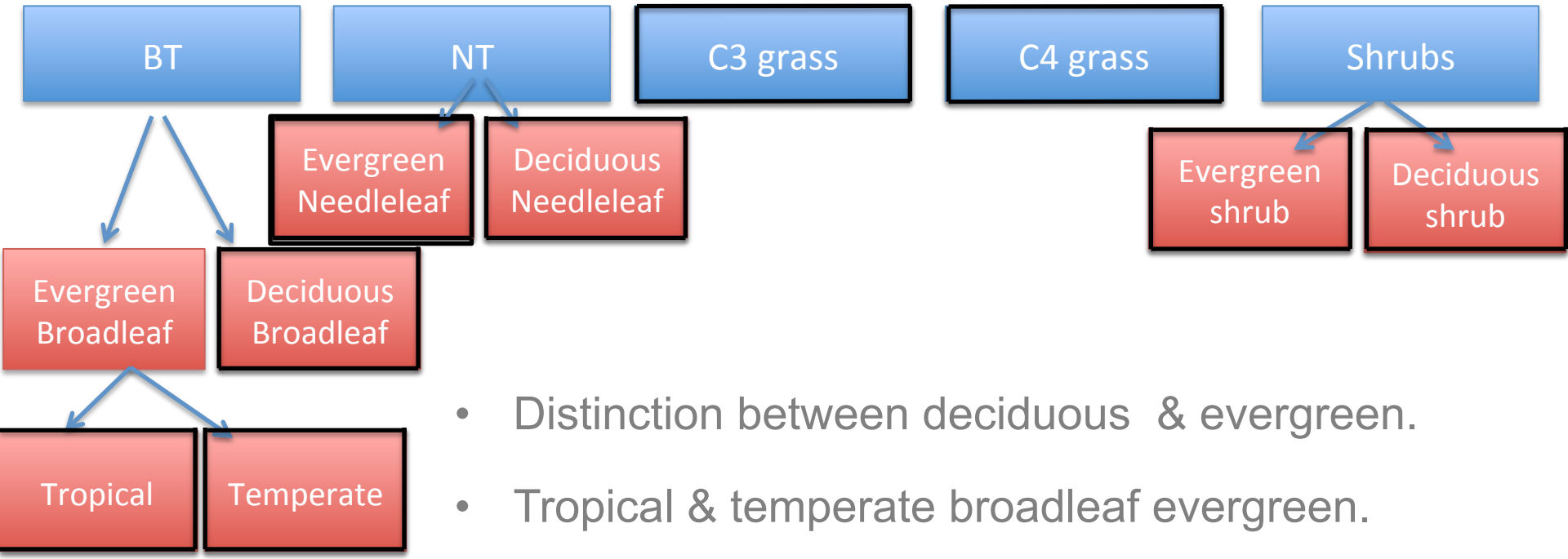
Natural Environment Research Council

Outline

- New PFTs
  - Introduction
  - Data
  - Global model results: Fluxes and Vegetation Dynamics
  - Evaluation of GPP
- Applications
  - 2010 Amazon drought

JULES Plant Functional Types

(from 5 to 9)



- Distinction between deciduous & evergreen.
- Tropical & temperate broadleaf evergreen.

What's new?

- 9 plant functional types (but flexible # is possible)
- Trait-based physiology:
  - data-derived parameters N_{mass} (kg N kg leaf^{-1}) and leaf mass per unit area (LMA: kg leaf m^{-2}) replace N_{l0} and σ_L.

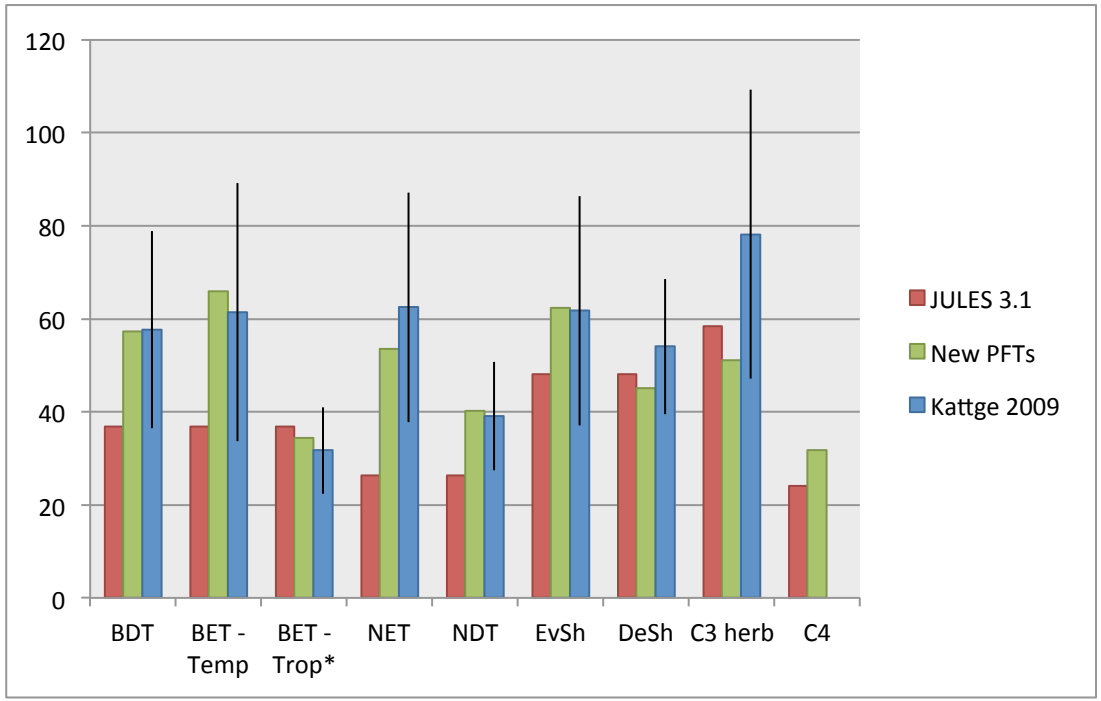
$$N_{area} = LMA * N_{mass}$$

  - V_{cmax} is calculated from regressions from global dataset, so a slope (v_{sl}) and intercept (v_{int}) replace n_{eff}.

$$V_{c\max,25} = v_{sl} * N_{area} + v_{\text{int}} \qquad V_{c\max,25} = n_{eff} * N_{l0}$$

  - Switch between old and new approach with l_trait_phys.
- Height-based competition so number of PFTs is flexible
  - Switch between old and new with l_height_dom.

New physiology and PFTs



V_{cmax} = maximum rate of carboxylation of Rubisco, related to Rubisco and export limited rates of photosynthesis in JULES

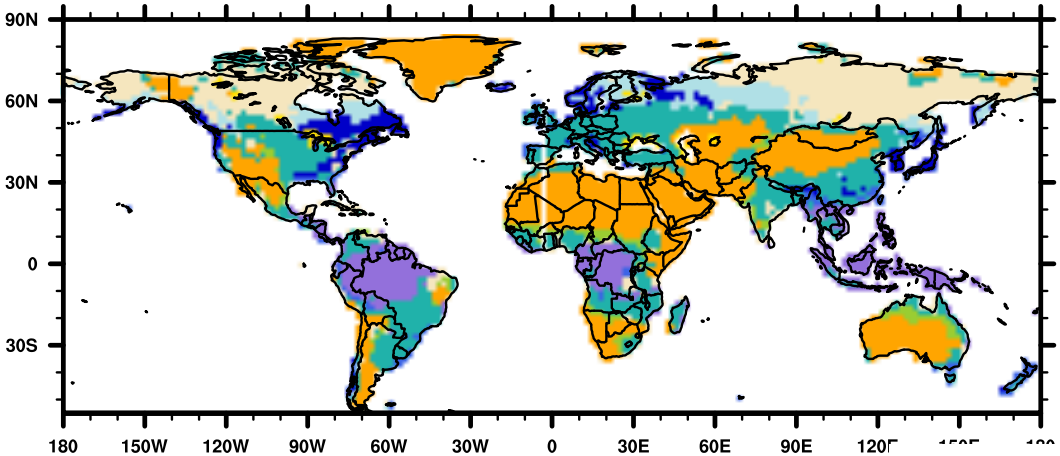
- Represents larger diversity of ecosystems.
- Updated V_{cmax} based on:
  - Observed leaf nitrogen, LMA, and V_{cmax} relationships
  - In progress: Optimizing $V_{cmax,25}$ against Fluxnet observations (NEE, GPP, and LH).

Kattge et al. 2009: Quantifying photosynthetic capacity and its relationship to leaf nitrogen content for global-scale terrestrial biosphere models. *Global Change Biology.*

Global vegetation with new PFTs

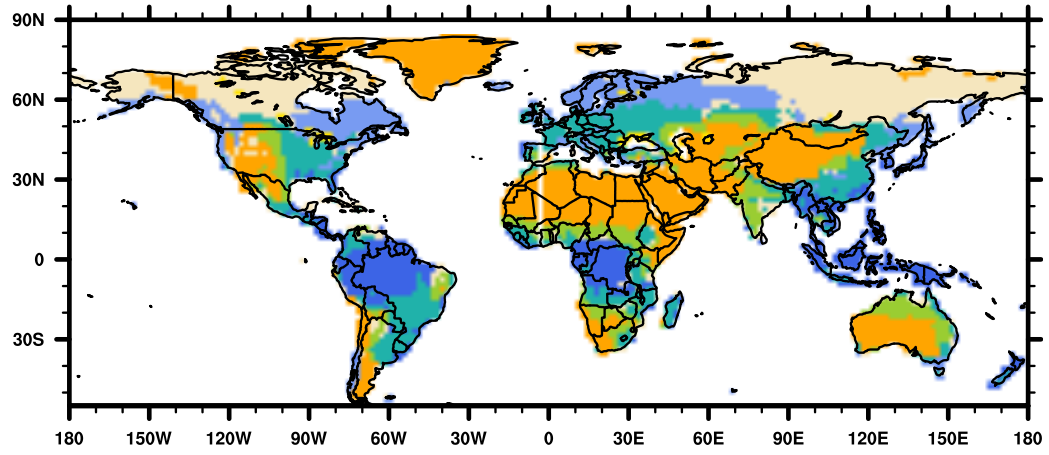
"TRENDY S3" style simulation: Uses time-varying climate, CO2, and land use from 1860-2012

JULES3.2 New PFTs vegetation, 2010



- Soil
- Water
- Urban
- Deciduous shrubs
- Evergreen shrubs
- C4 grass
- C3 grass
- Needleleaf deciduous trees
- Needleleaf evergreen trees
- Broadleaf deciduous trees
- Broadleaf evergreen trees (Temperate)
- Broadleaf evergreen trees (Tropical)

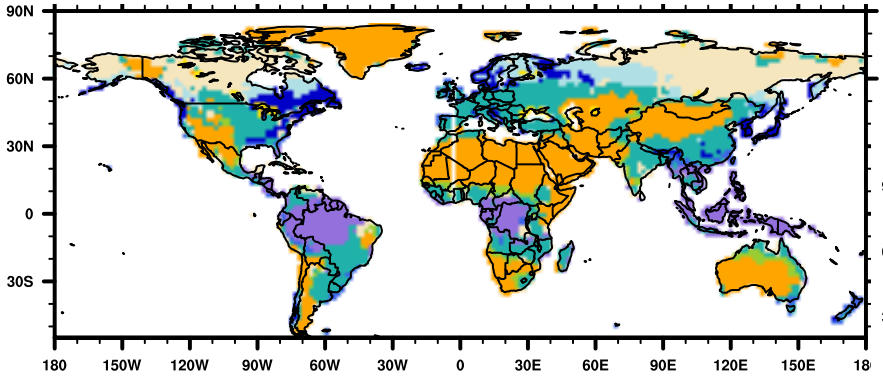
JULES3.2 TRENDY S3 vegetation, 2010



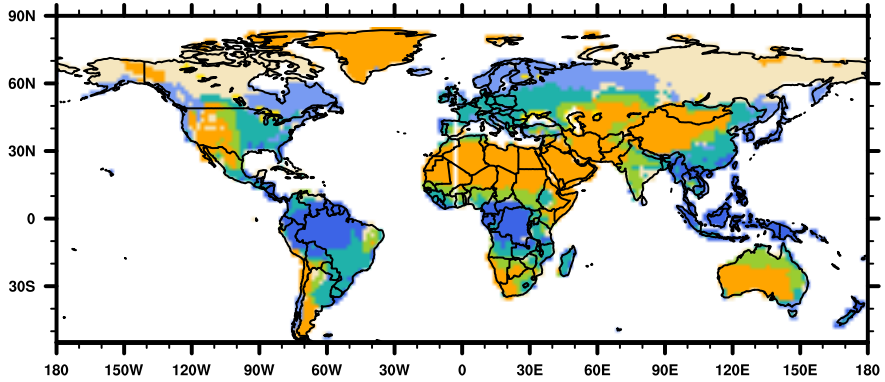
- Soil
- Water
- Urban
- Shrub
- C4 grass
- C3 grass
- NT
- BT

Vegetation coverage with new PFTs

JULES3.2 New PFTs vegetation, 2010



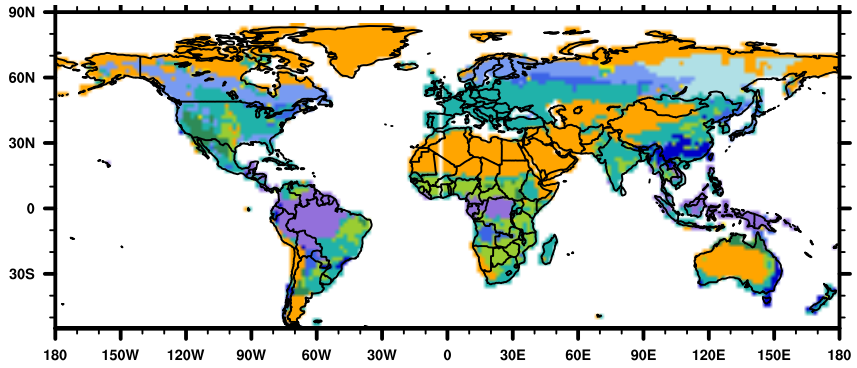
JULES3.2 TRENDY S3 vegetation, 2010



Soil
Water
Urban
Deciduous shrubs
Evergreen shrubs
C4 grass
C3 grass
Needleleaf deciduous trees
Needleleaf evergreen trees
Broadleaf deciduous trees
Broadleaf evergreen trees (Temperate)
Broadleaf evergreen trees (Tropical)

Soil
Water
Urban
Shrub
C4 grass
C3 grass
NT
BT

ESA LCCS: Observed land cover, 2000
(Andy Hartley, Mike Sanderson)

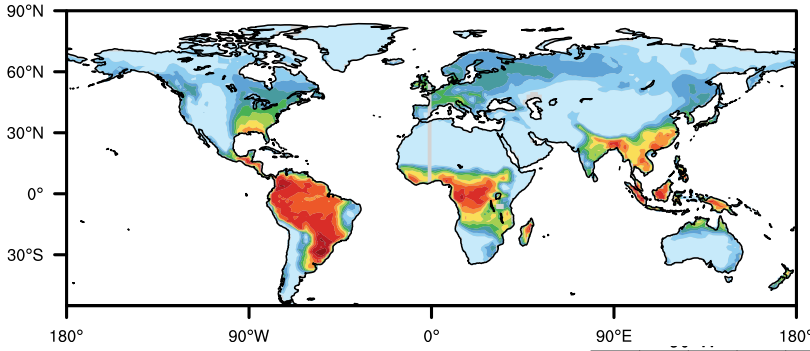


Soil
Wat
Ur
DSh
ESh
C4
C3
NDT
NET
BDT
BET-Te
BET-Tr

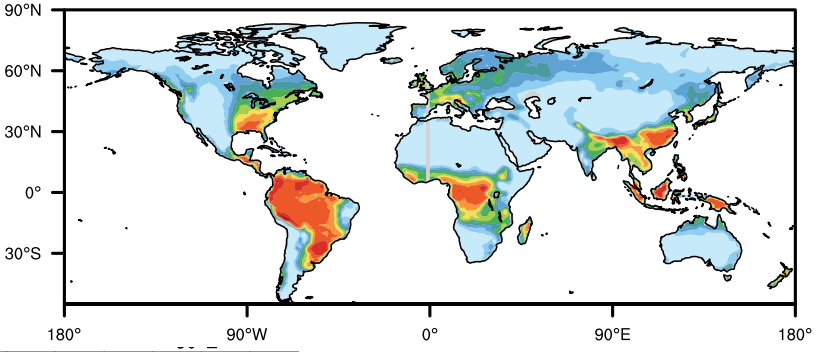
- Tropics mostly good, boreal forest is lacking.
- The DGVM parameters are untuned, so it can likely get much better.

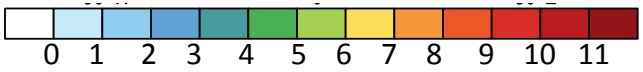
GPP with new PFTs

JULES3.2 Old PFTs GPP, 1982-2012
Global = 148 GtC/yr



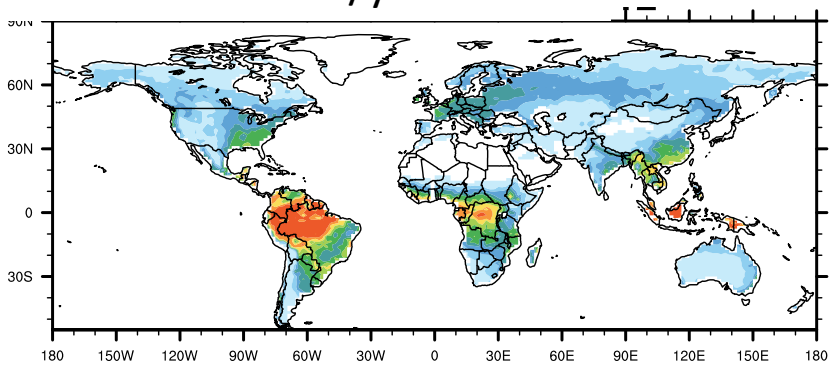
JULES3.2 New PFTs GPP, 1982-2012
Global = 142 GtC/yr





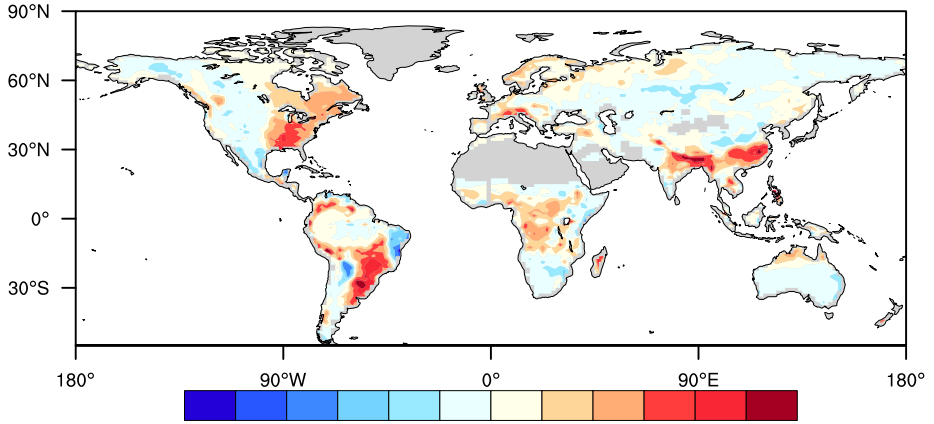
gC m^{-2} d^{-1}

MTE GPP*, 1982-2012
Global = 115 GtC/yr

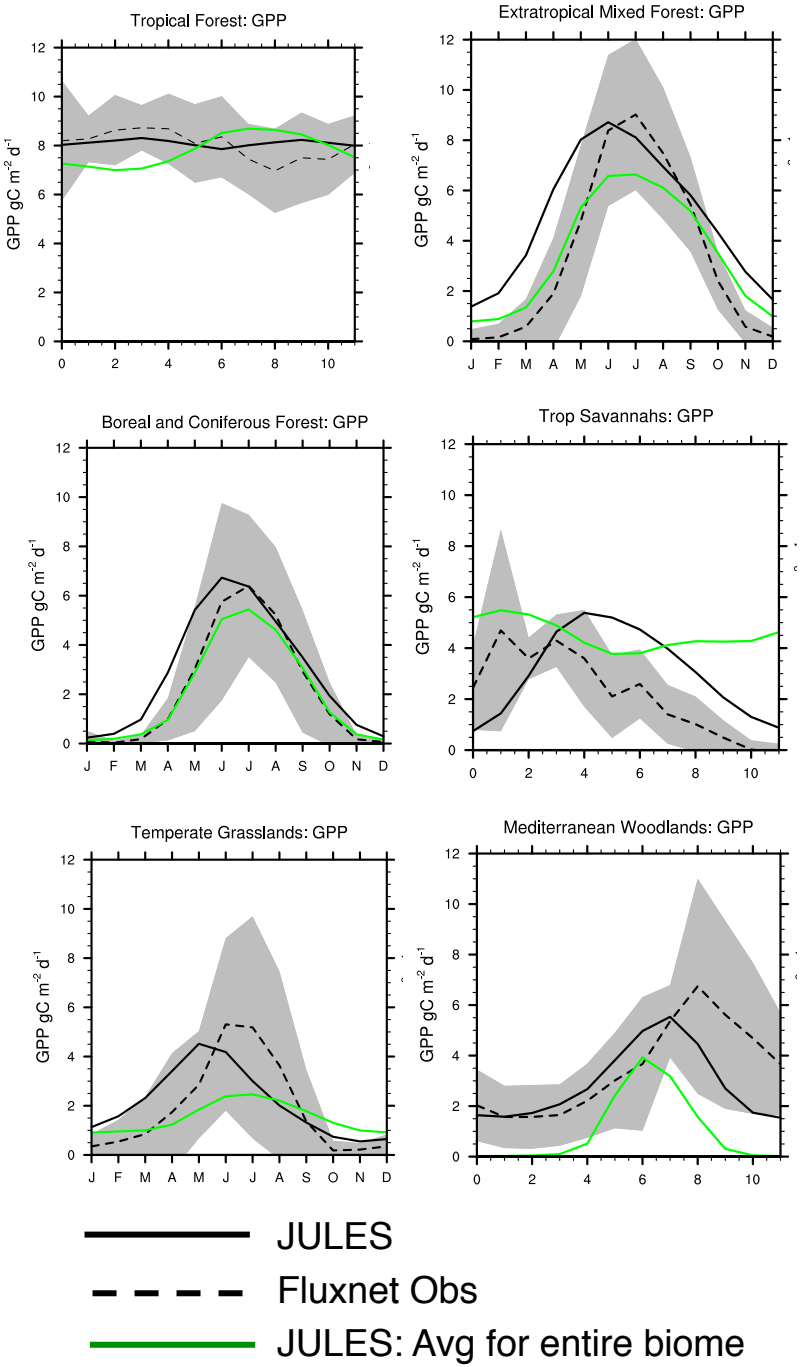


*Model tree ensemble, based on upscaled Fluxnet data: Jung *et* al. 2011, *JGR*

New PFTs - MTE GPP, 1982-2012

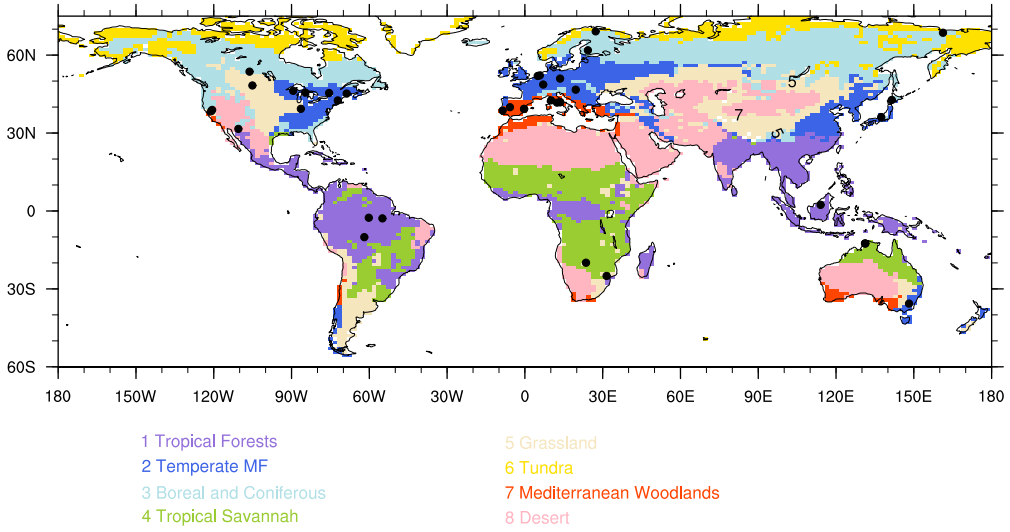


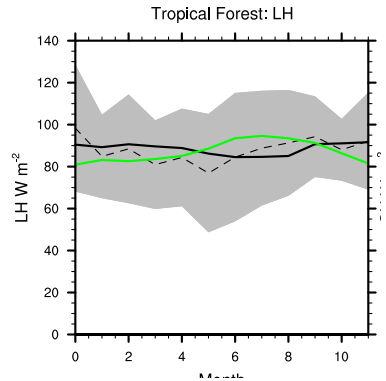
gC m^{-2} d^{-1}

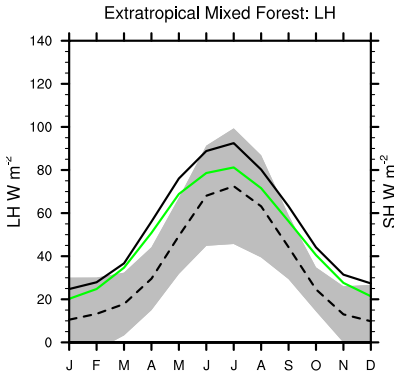


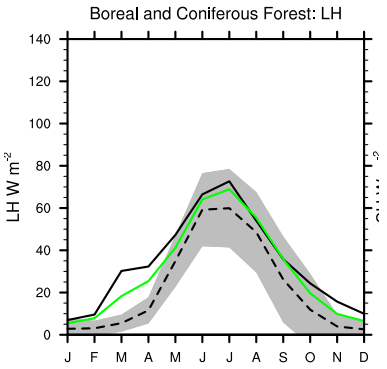
Biome-scale GPP

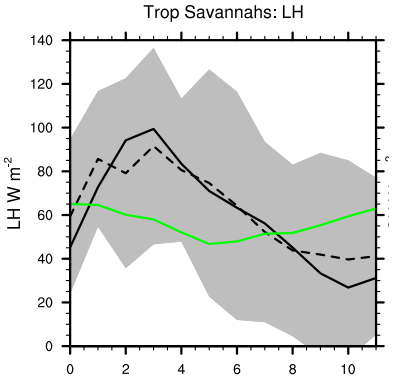
- Annual GPP is too high in most biomes according to MTE and Fluxnet individual sites.
- Fluxnet exceptions: It is too low in Tropical Savannah & Tundra.
- Seasonally: Spring GPP is too high in forests and grasslands.
- Savannah

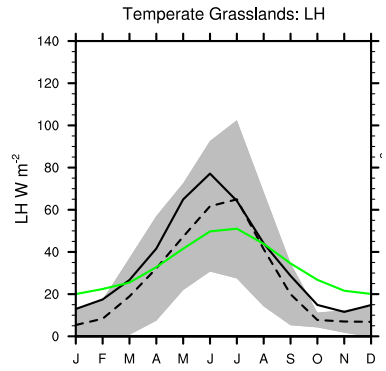


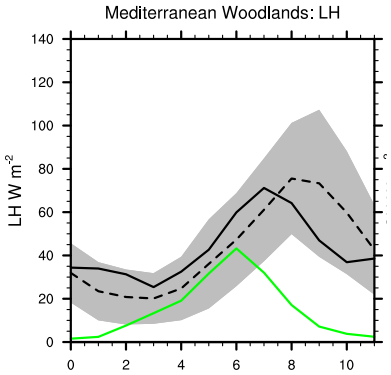


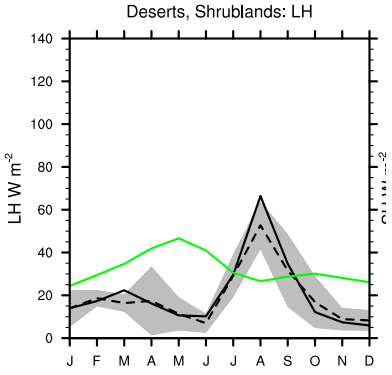












Biome-scale LH

- JULES LH is close to the Jung et al. dataset – a little low in forests.
- Tropical savannah and tundra sites: JULES has low LH (GPP was also low).
- In ADJULES we will try to optimize both of these fluxes together with the net ecosystem exchange of carbon.

JULES

Fluxnet Obs

JULES: Avg for entire biome

http://www.nasa.gov/multimedia/nasatv/index.html#.U7OuHo1dUfI