Global Research Alliance on Agricultural Greenhouse Gases - benchmark and ensemble crop and grassland model estimates

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FACCE-JPI CN-MIP
GHG model inter-comparison
An international and collaborative work

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ON AGRICULTURAL GREENHOUSE GASES

Aimes:

i) *To benchmark and inter-compare crop and grassland models for agricultural GHG emissions and removals,*

ii) *To test mitigation options by system/region*

> 40 scientists: modelers, site data providers, statisticians from 30 institute.

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Arable crops

- DailyDaycent (CA)
- CERES-EGC (FR)
- STICS v.8.2 (FR)
- APSIM v.7.5 (AU) APSIM v.7.6 (NZ)
- Agro-C v.1.0 (China)
- SALUS (USA)
- Infocrop (India)
- EPIC 810 (IT)
- DSSAT45-NGAS (AU)
- DNDC95 (CA)
- FASSET v2.5 (Spain)

Both

- Daycent v4.5 (USA) Daycent v4.5 (IT)
- Daily Daycent v.2010 (UK)
- Landscape DNDC (UK)

Grasslands

- PaSim (FR)
- APSIM-SoilWater APSIM-SWIM v.7.6 (NZ)
- APSIM -GRAZPLAN (AU)
- SPACSYS (UK)

Ecosystem models

- DairyModel/ Ecomod v.5.3.1 (AU)
- CenW (NZ)
- LPJmL v.3.5.3 (GE)

24 simulation models

from 11 countries

process-oriented to simpler models

Source: 3rd Workshop 'Model inter-comparison on agricultural GHG', 8-9 March 2016 – Rome, Italy

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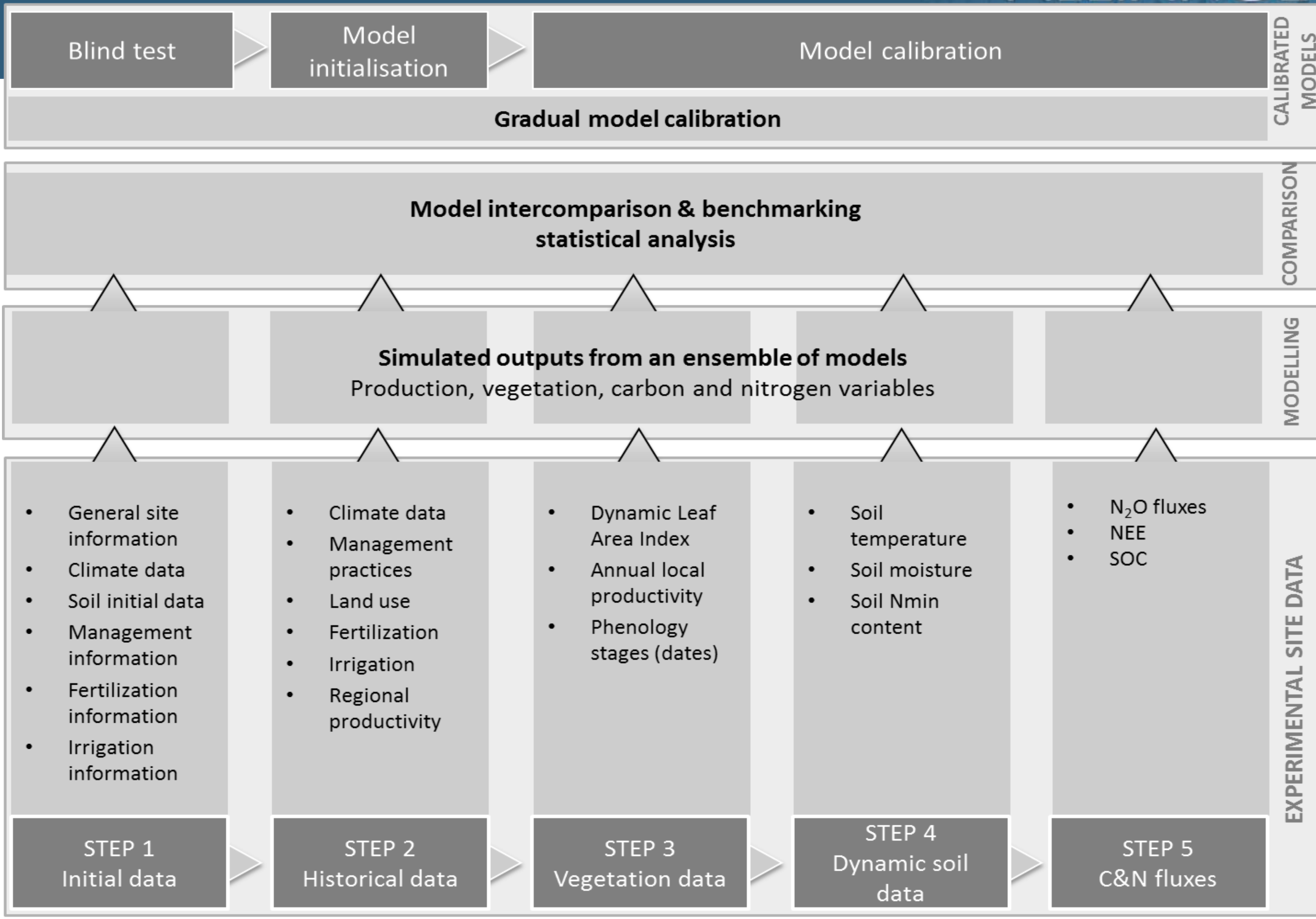

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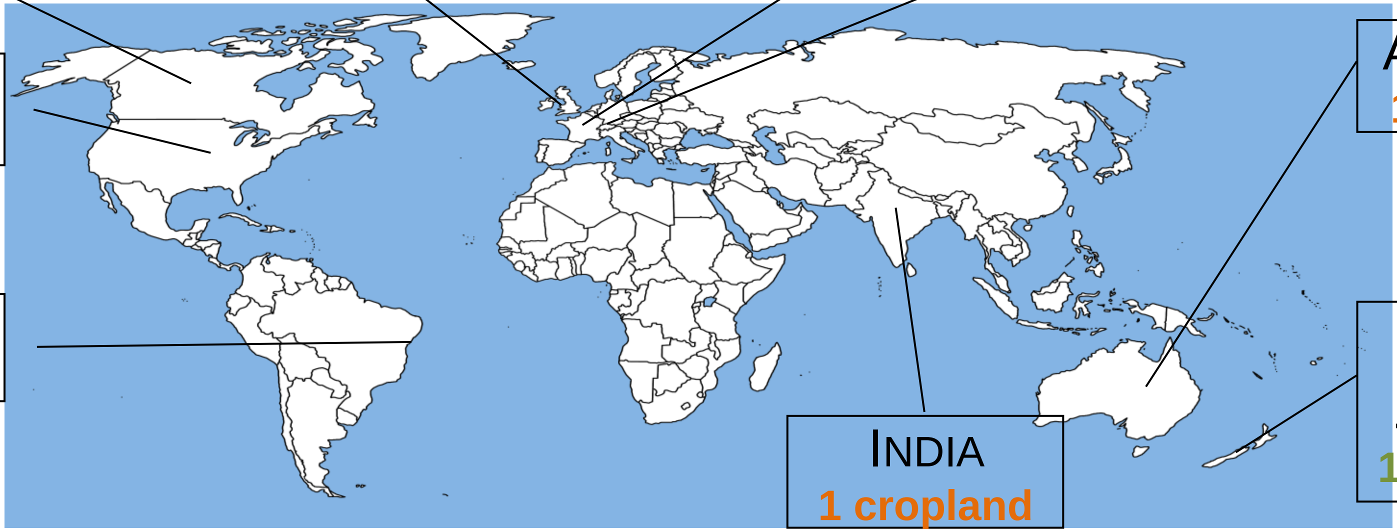
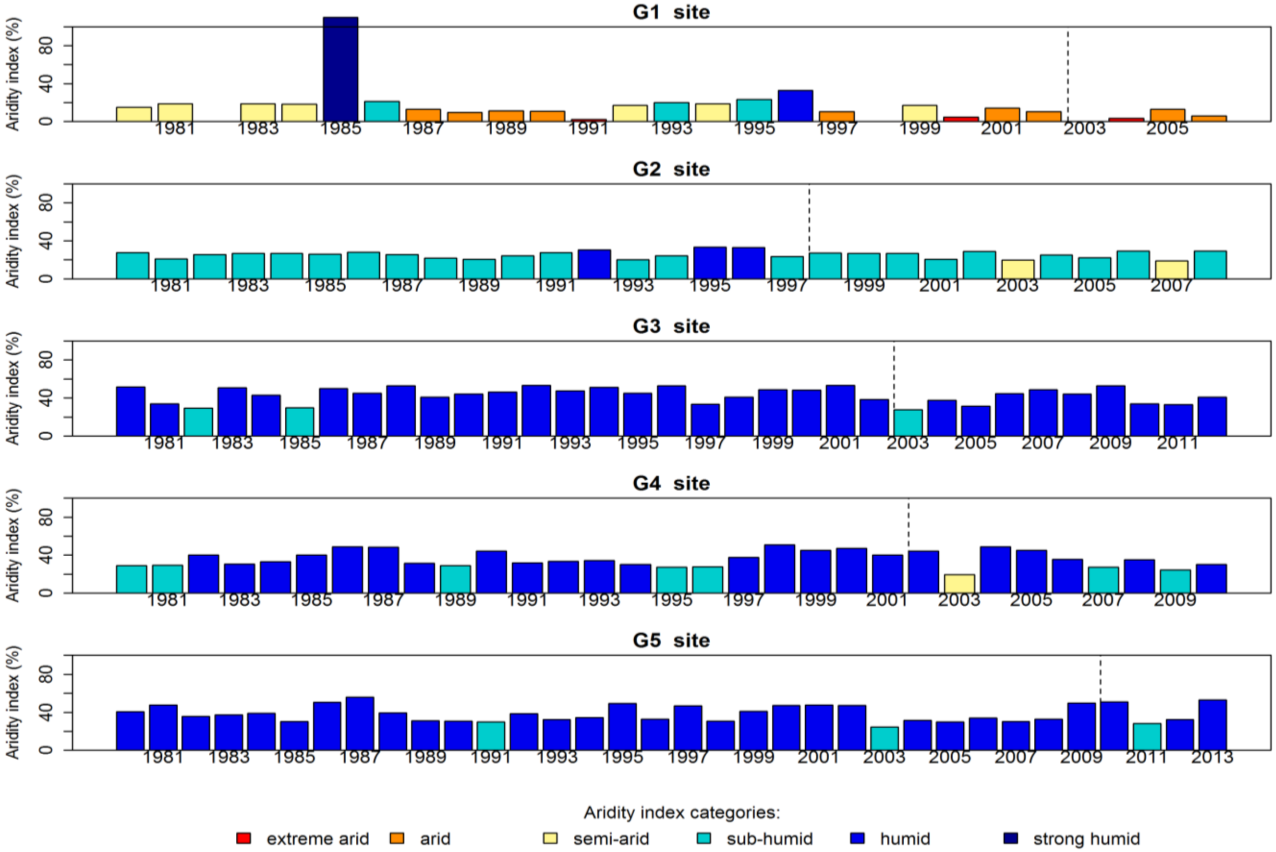
10 sites for model benchmarking



Providing extensive and high quality data sets for
Climate, Soil profile, Agricultural practices, Production, GHG emissions, C cycle, N cycle

Source: J.-F. Soussana *et al.,* 2016: Assessing simulation models for field scale projections of pasture and crop GHG emissions. GGAA, Melbourne

Meteorological conditions

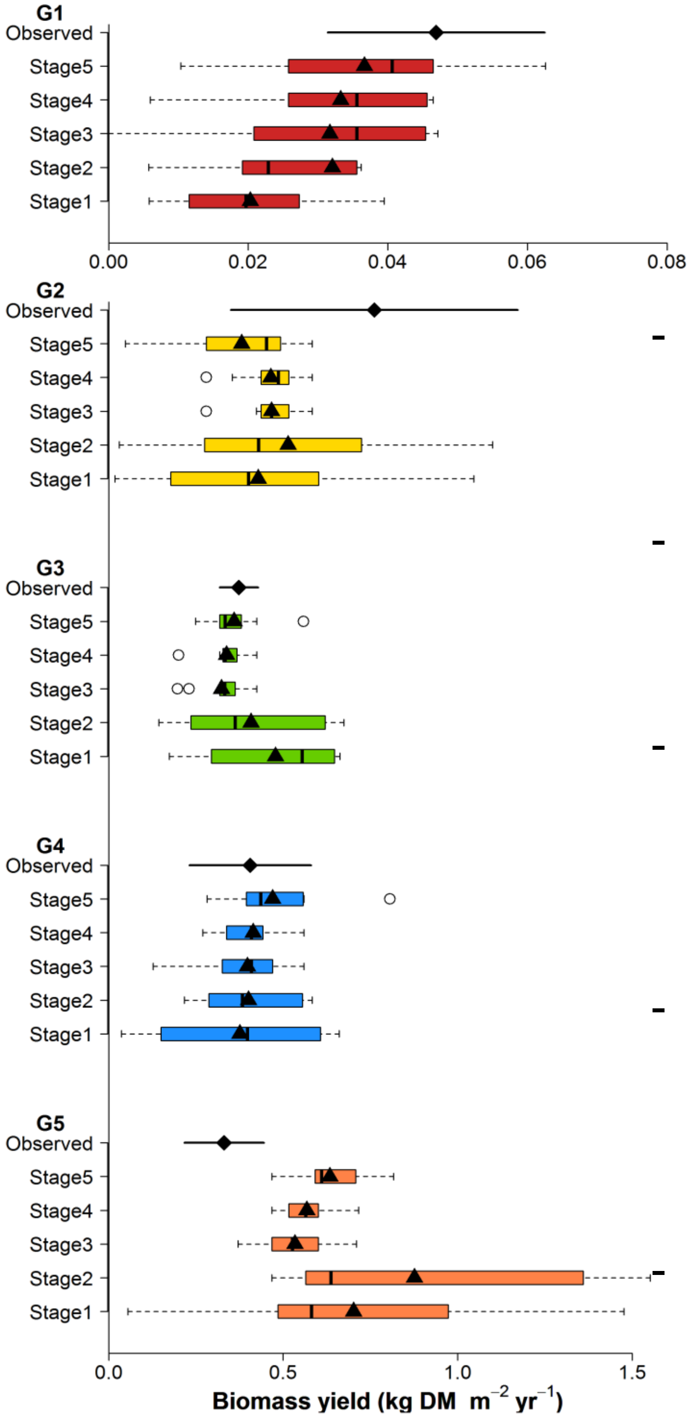


Aridity indexes at grassland (G1-5) sites. Dotted line separates the historical (left) and simulation (right) years. The De Martonne-Gottmann aridity index (De Martonne, 1942) was calculated for each site for historic and simulated period. The range is given by the by Diodato and Ceccarelli (2004):

- $b < 5$: extreme aridity;
- $5 \leq b \leq 14$: aridity;
- $15 \leq b \leq 19$: semi-aridity;
- $20 \leq b \leq 29$: sub-humidity;
- $30 \leq b \leq 59$: humidity;
- $b > 59$: strong humidity.

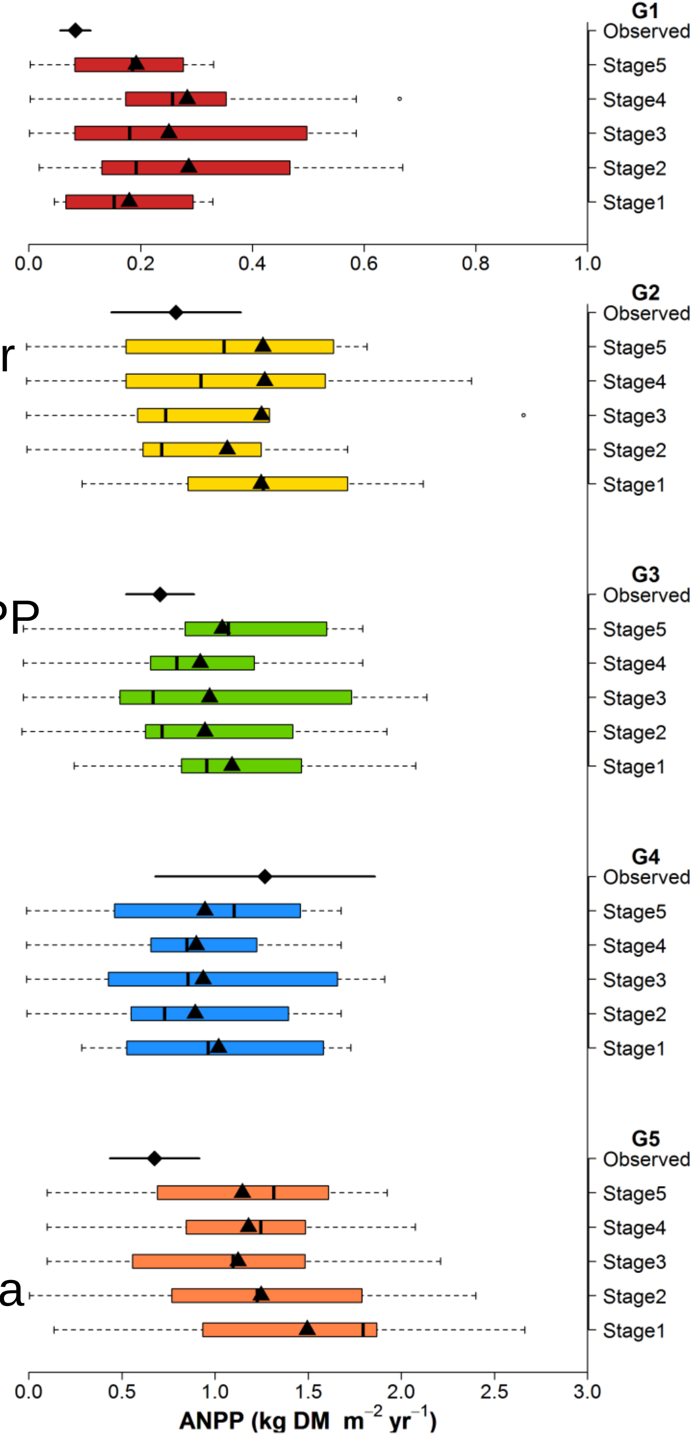
Description of data and simulation avalable for comparison across sites and models

Variable name	Unit	Observed sites						Model simulations										
		G1	G2	G3	G4	G5	M03	M05	M06	M07	M08	M14	M16	M21	M22	M23	M24	M28
Grassland production: intake or yield	kg DM m^{-2} d^{-1}	✔	✔	✔	✔	✔	✔	✖	✔	✖	✔	✔	✔	✔	✔	✔	✔	✔
Leaf Area Index	m^2 m^{-2}	✔	✖	✔	✔	✔	✔	✖	✔	✖	✖	✔	✔	✔	✔	✔	✔	✔
Above-ground Net Primary Production	kg DM m^{-2} d^{-1}	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	✔
Bellow-ground Net Primary Production	kg DM m^{-2} d^{-1}	✔	✖	✖	✖	✖	✔	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	✔
Gross Primary Production	kg C m^{-2} d^{-1}	✖	✖	✔	✔	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Net Primary Production	kg C m^{-2} d^{-1}	✖	✖	✖	✔	✖	✔	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	✔
Ecosystem Respiration	kg C m^{-2} d^{-1}	✖	✖	✔	✔	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Net Ecosystem Exchange	kg C m^{-2} d^{-1}	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Change in total soil organic carbon stock	kg C m^{-2} yr^{-1}	✔	✔	✔	✔	✖	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	✔	✔
Soil organic N_2O emissions	µg N-N_2O m^{-2} d^{-1}	✔	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✖	✖	✔	✔
Change in total soil organic nitrogen	g N m^{-2} yr^{-1}	✖	✔	✔	✔	✖	✔	✔	✔	✔	✖	✔	✔	✔	✖	✔	✔	✔
Enteric CH_4	g C-CH_4 m^{-2} d^{-1}	✔	✖	✔	✔	✔	✔	✖	✔	✖	✖	✖	✔	✔	✖	✔	✔	✖
CH_4 emissions	g C-CH_4 m^{-2} d^{-1}	✔	✖	✖	✔	✔	✖	✔	✔	✔	✔	✖	✖	✖	✖	✖	✔	✖
Nitrate leaching through soil profile	µg N-NO_3 m^{-2} d^{-1}	✖	✖	✔	✔	✖	✔	✖	✔	✖	✔	✔	✔	✔	✖	✖	✔	✔
Ammonia volatilization from soil	µg N-NO_3 m^{-2} d^{-1}	✖	✖	✖	✖	✖	✖	✔	✔	✔	✔	✔	✔	✔	✖	✖	✖	✖



Yield biomass & ANPP

- Yield biomass is better simulated than ANPP (G2 to G5)
- A general overestimation of ANPP measurements
- In general, calibrated models fit better to observations after Stage 2.
- Observed yield biomass shows a strong inter-annual variability
- ANPP simulation has a considerable uncertainty.



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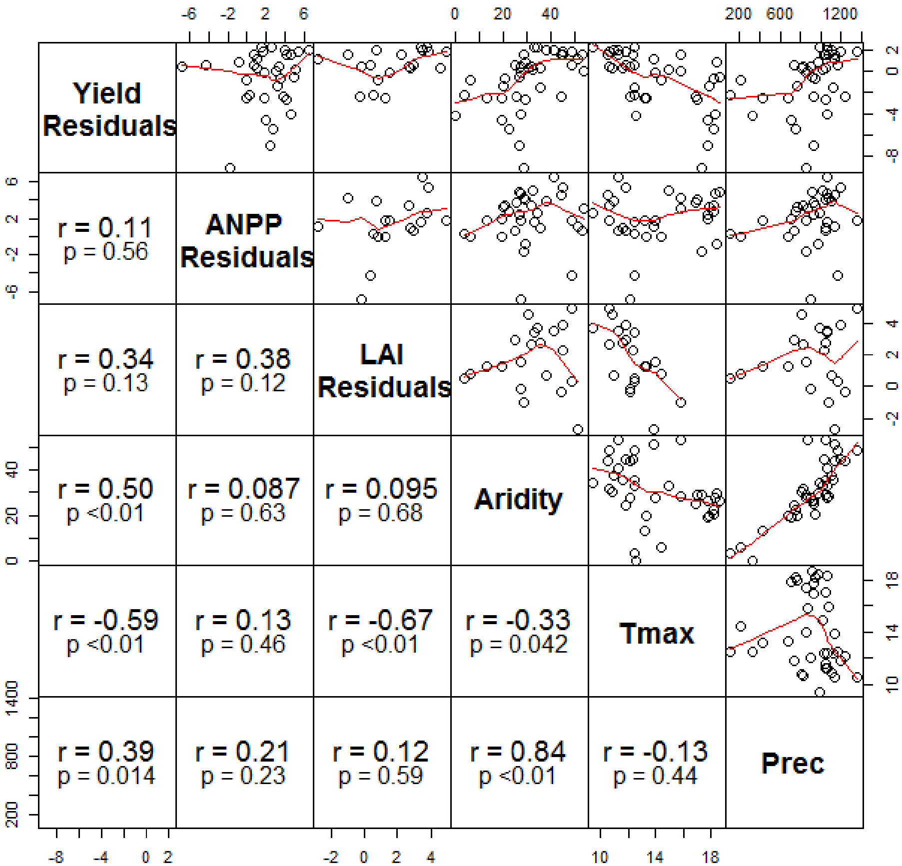
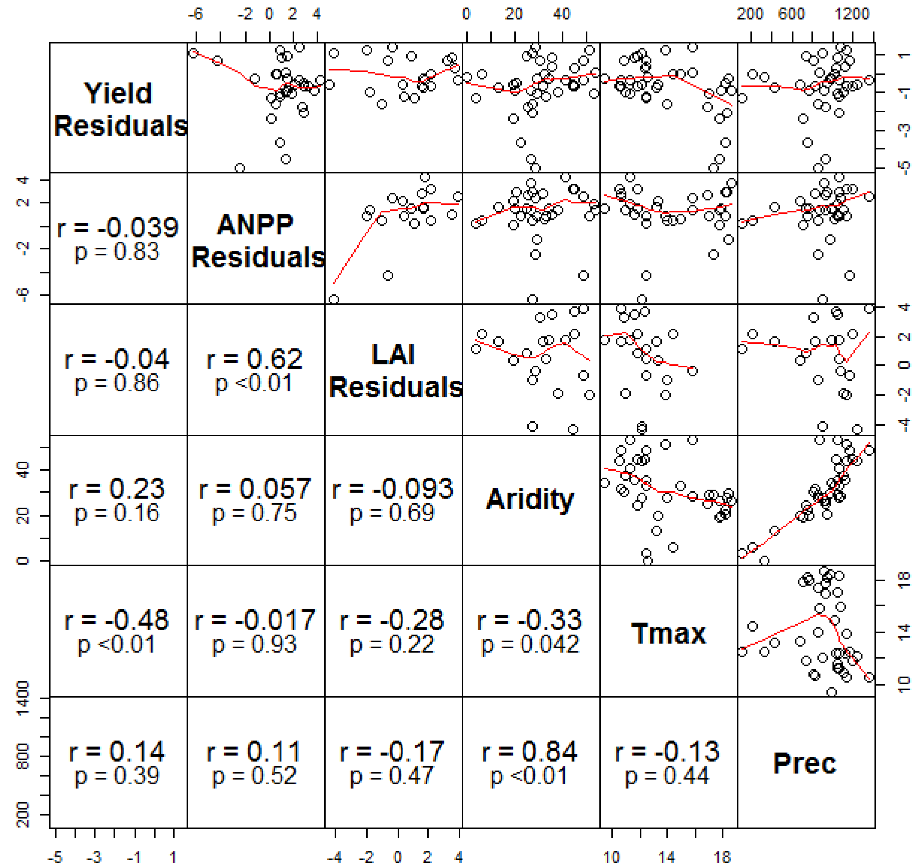
Stage1 simulation with MMM



Stage5 simulation with MMM



Pairwise scatterplots with loess smoothers (red lines) for the standardized residuals of simulated annual biomass yield and ANPP of the multi model median (MMM) of 12 models, aridity, maximum temperature (annual average) and precipitation (annual sum) across five sites in Stage 1 (left) and Stage 5 (right).

Model ensemble approach

- **Yields:**
  - Crop yields are better predicted than grassland DM offtake by grazing & mowing
  - This confirms AgMIP findings with crops of robust prediction of yields with multi-model medians

- **N_2O emissions:**
  - Potential of the multi-model mean approach in crops
  - Relative error of model ensemble still high, especially with grasslands
  - Frequency distributions poorly predicted by both single models and the ensemble in grasslands
- …

Why using a model ensemble?

- With few exceptions, no individual model had the same overall predictive ability as the model ensemble
- Best models in Stage 1 did not systematically perform better in Stage 5
- In general calibration required up to Stage 4, not necessarily Stage 5

Perspectives for GHG model intercomparison

Assess the potential of a smaller ensemble of fully calibrated models (e.g. 3-4) → to estimate the minimum number of models

Test mitigation (alternative management) options at the same sites (comparison with other experimental treatments)

Test the climate sensitivity of the models at the same sites (AgMIP, FACCE-JPI MACSUR)

Further test of calibrated model ensemble (Stage 5): with an additional year, and with new sites.

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Thank you for your attention!

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