

Coupling the land use decisions and carbon cycles of earth system and integrated assessment models





iESM and IA Boutique

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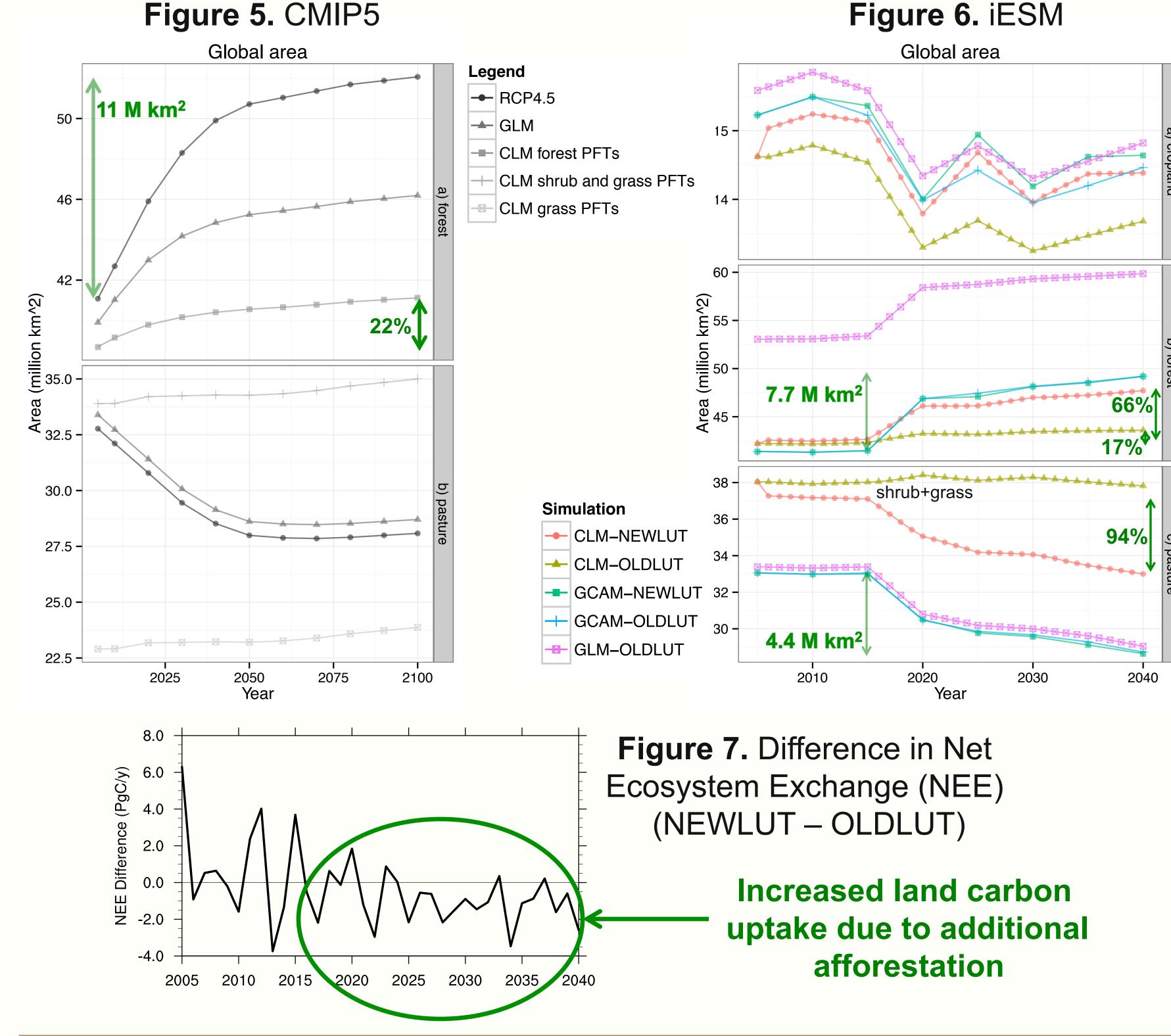
SUMMARY

- The integrated Earth System Model (iESM) is the first fully coupled model capable of examining two-way interactions between human and earth system processes
- Feedbacks of climate on terrestrial carbon are successfully passed from CESM to GCAM
- Net Primary Productivity (NPP) and Heterotrophic Respiration (HR) are effective proxies
- The forward coupling from GCAM to CESM, which is based on CMIP5, contains dramatic inconsistencies in land cover and land use
 - Only 22% of RCP4.5 afforestation by 2100 was simulated by CESM for CMIP5
- We have significantly improved the iESM land cover consistency through modification of the Land Use Translator (LUT)
 - The iESM simulated RCP4.5 afforestation increased from 17% to 66% of that prescribed by GCAM through 2040
 - This increases vegetation carbon gain by 19 PgC and decreases atmospheric CO2 gain by 8 ppmv from 2005 to 2040
- Further work is needed to implement consistent land cover and land use representations among IAMs and ESMs
 - This will ensure that ESMs are simulating the scenarios prescribed by IAMs

METHODS Figure 1. iESM land coupling CMIP5 iESM Climate feedbacks No land cover information! **Global Change Assessment Model** (GCAM) 16 plant functional types (0.5° maps) Annual land use aggregated to AEZ Filtered to exclude area, forest area, and used to modify and harvest C C densities land change artifacts **Global Land-use Model** Crop, pasture, primary, secondary HR Figure 2. New iESM Land Use and harvest area (0.5° maps Translator (LUT) **Land Use Translator** Get reference PFT-specific maps Forest harvest Crops Get current year crop and pasture data **Make Surface Data** Increase capped by amount of available land, including bare Resolution change Trees PFTs replace decreased crop PFT **Community Land Model** Increased crop PFT replaces tree PFTs until gone, then herbaceous PFTs until gone. then bare ground PF1 if Increase capped by amount o previous year tree and shrub Trees replace crops and pasture ncreased grass PFTs replace tree PFTs until gone, then shrub PFTs until gone herbaceous PFTs

Set current year

Figure 3. NPP is a good proxy for potential carbon stock Figure 4. Efficacy of method to filter out land change artifacts from climate feedback signal | Figure 4. Efficacy of method to filter out land change artifacts from climate feedback signal | Figure 5. CMIP5 | Figure 6. iESM



DISCUSSION

- Lack of consistency across models/components precludes robust ESM simulations of IAM generated scenarios
 - Afforestation is important for achieving the RCP4.5 climate stabilization target
 - Similar land cover inconsistencies exist in the CMIP5 archive
- Land cover mismatch significantly affects the global carbon cycle for RCP4.5
 - Linear extrapolation to include all prescribed afforestation by 2100 gives increases in vegetation carbon of 100 PgC and decreases in atmospheric CO₂ of 40 ppmv
- Land cover and land use need to be harmonized among ESMs and IAMs to provide robust comparisons and simulations of scenarios
 - IAM to ESM coupling is still incomplete, even after CMIP5 and iESM efforts to develop this coupling
 - ESM to IAM coupling is still limited by inconsistent carbon cycle representations (e.g. potential vs. actual carbon stock) and ESM land change artifacts