Irrigation modeling activities with CLM / CTSM

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Irrigation scheme in Community Land Model (CLM5) → Community Earth System Model (CESM2)

- Irrigation applied once per day (if needed) at **6am LT** for **4 hours**
- Irrigation amount D_{irrig}

Tunable parameter

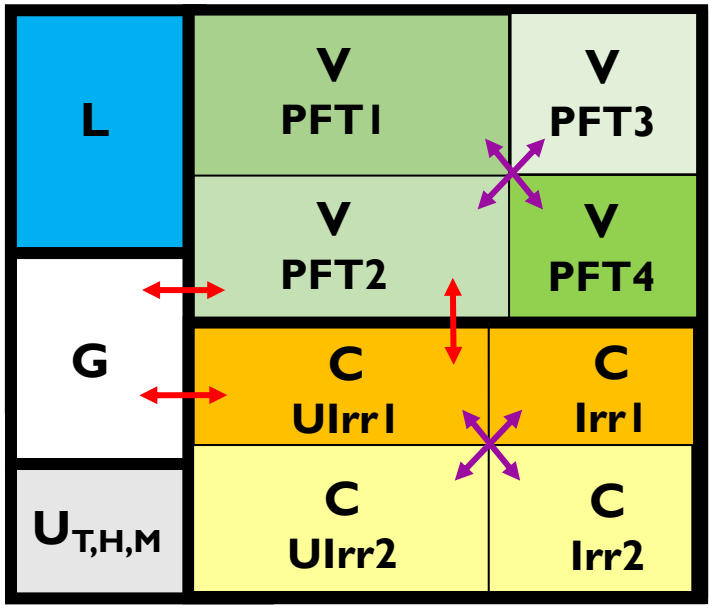
$$D_{irrig} = \begin{cases} w_{thresh} - w_{avail} & w_{thresh} > w_{avail} \\ 0 & w_{thresh} \leq w_{avail} \end{cases}$$

$$w_{thresh} = f_{thresh}\left(w_{target} - w_{wilt}\right) + w_{wilt}$$

where w_{target}, w_{avail} w_{wilt} calculated to **0.6m** depth

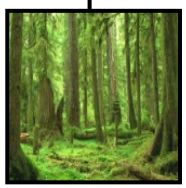
- f_{thresh} determines soil moisture threshold for irrigation
  - 1.0 (default) means irrigate when soil moisture below target
  - 0.0 means irrigate when soil moisture reaches wilting point
- Irrigation water applied directly to ground surface (i.e., drip irrigation)
- To conserve mass, irrigation water taken from river water storage; if not enough river water then:
  - water taken diffusely from ocean (default in CESM2)
  - irrigation water restricted by minimum river water limiter

Heterogeneity



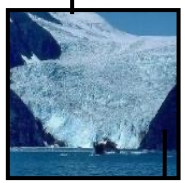
Gridcell

Landunit


Vegetated


Lake

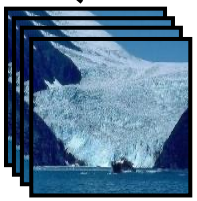
Urban


Glacier


Crop

Column


Soil


Elevation classes


Unirrig


Irrig


Unirrig


Irrig

Patch


PFT1


PFT2


PFT3


PFT4 …


Crop1


Crop1

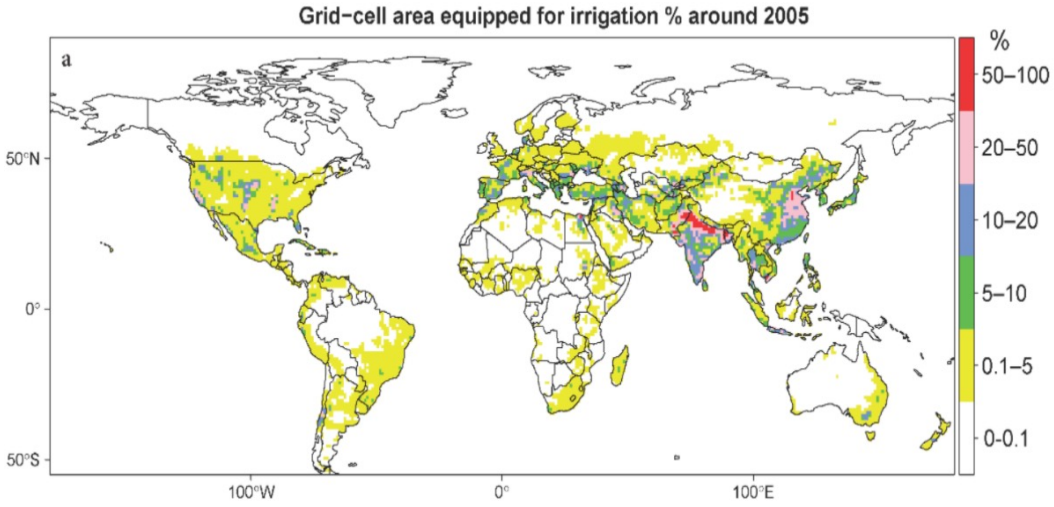

Crop2

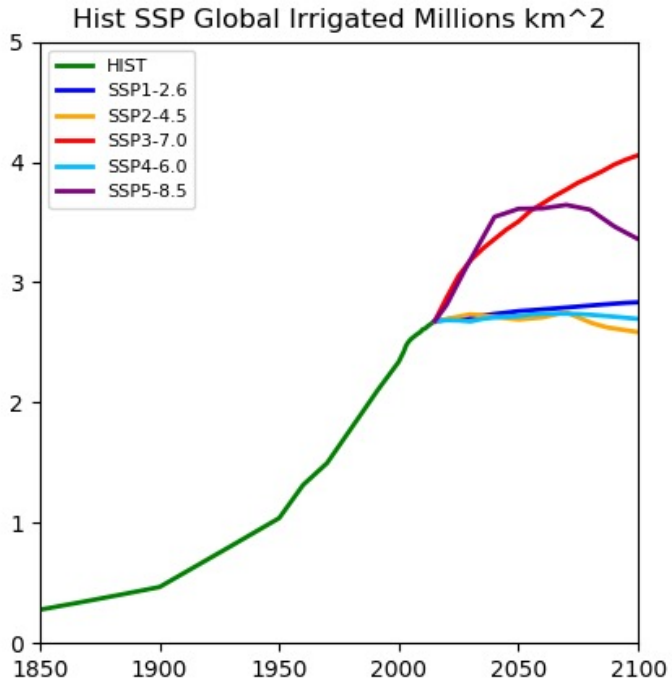

Crop2 …

Irrigation-equipped area
Historical and SSPs from LUH2

Land-use Harmonization (LUH2) for CMIP6 (0.25°, 850 to 2100)

Irrigation data from HYDE and IAMs

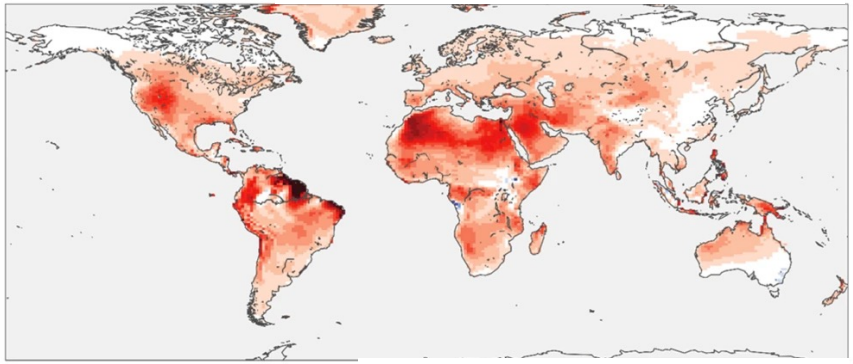




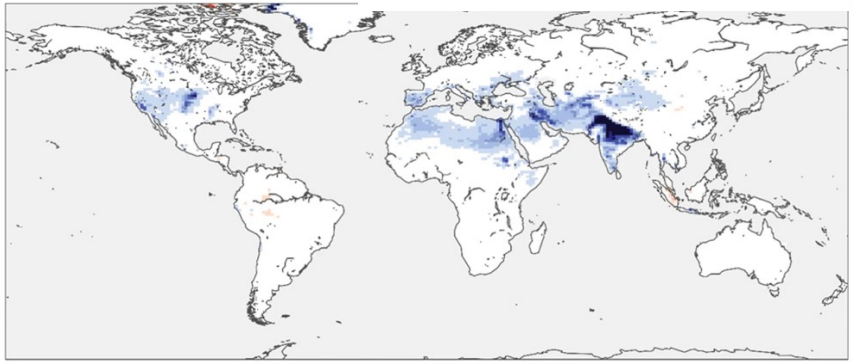
Hurtt et al. (2020)

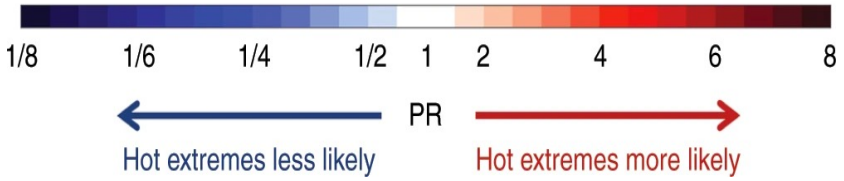
Impact of irrigation on heat extremes

All forcings except irrigation



Just irrigation expansion

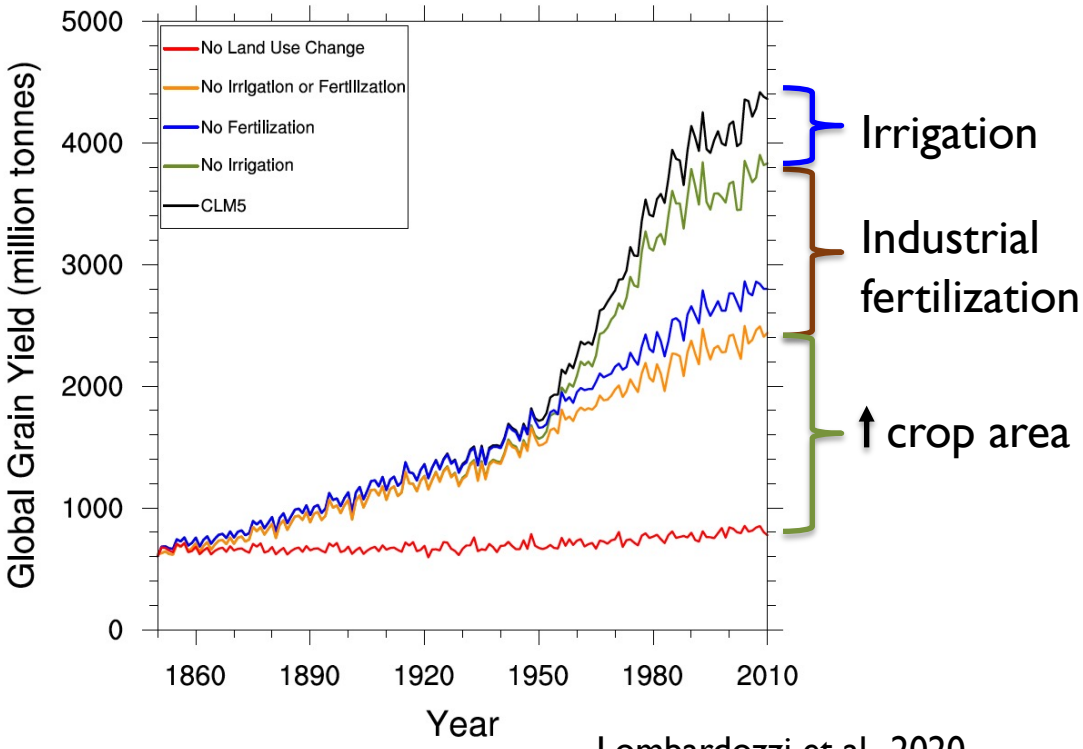




Thiery et al., 2020

Land-only land management experiments with CLM5

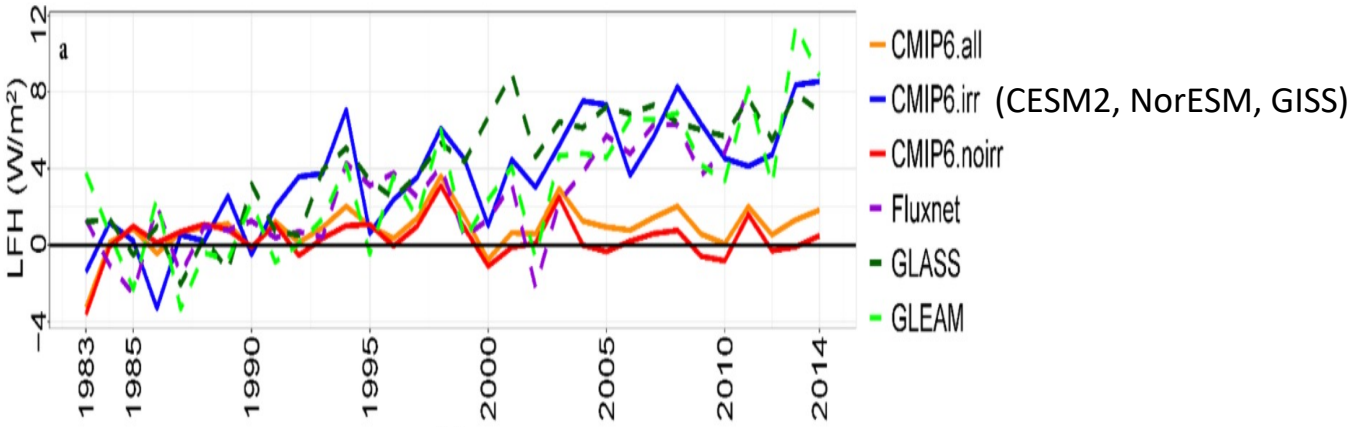
Crop Yield



Lombardozzi et al., 2020

Impact of agricultural management on annual CO2 amplitude trend (Lombardozzi et al, in review)

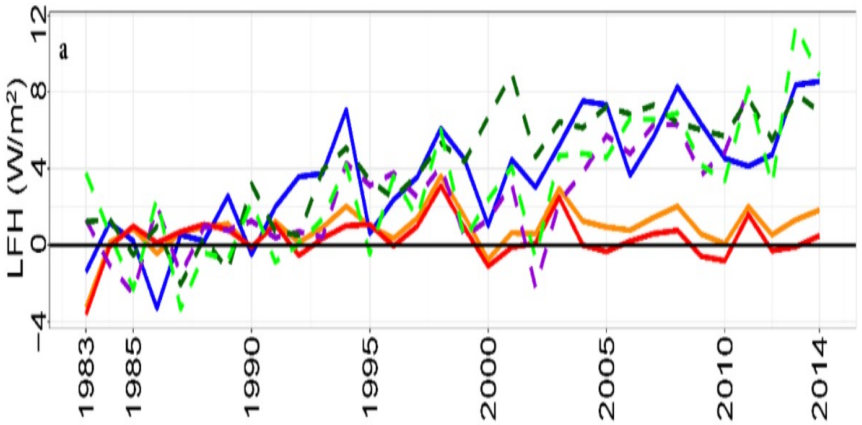
Irrigation impact in CMIP6 models

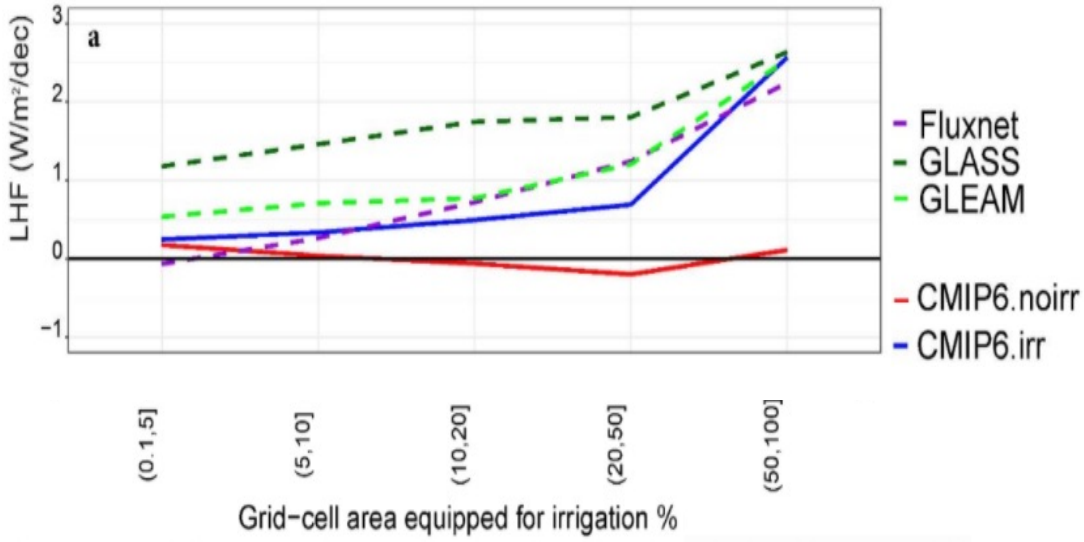


Data averaged for grid cells with 50-100% irrigation area

Al-Yaari et al., in review

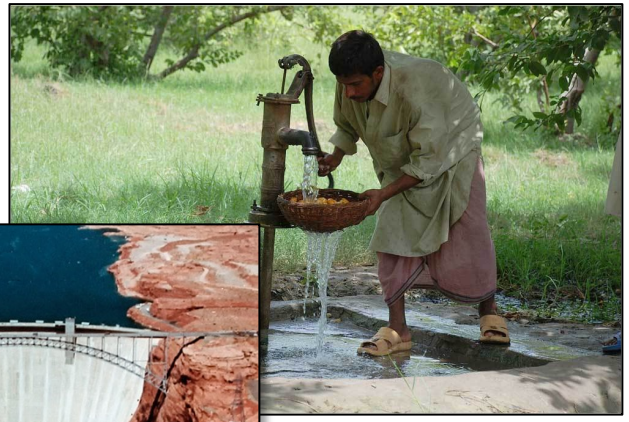
Irrigation impact in CMIP6 models



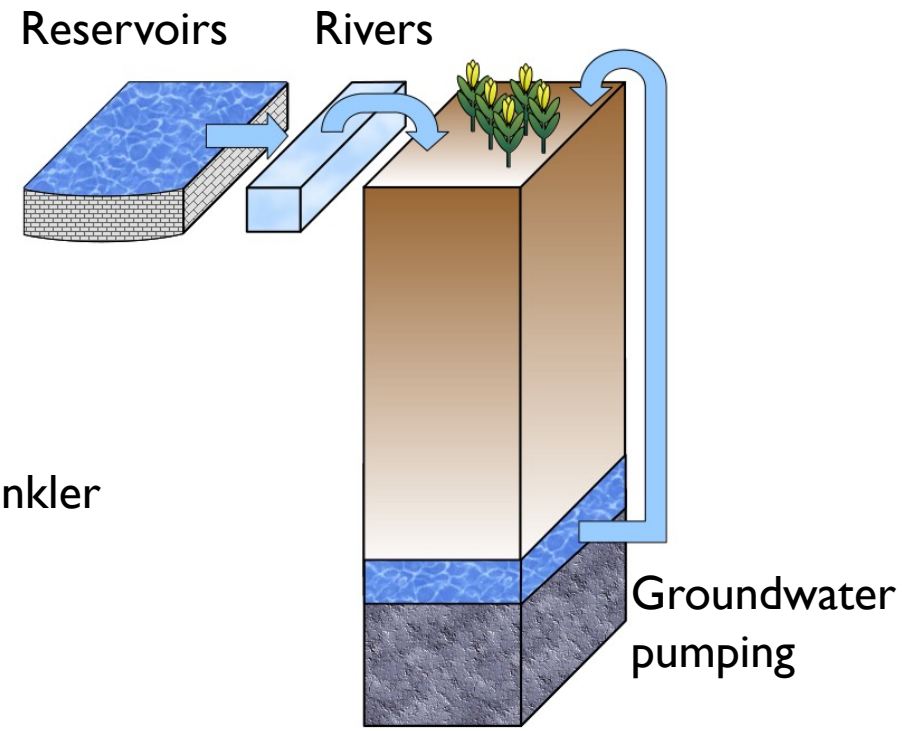


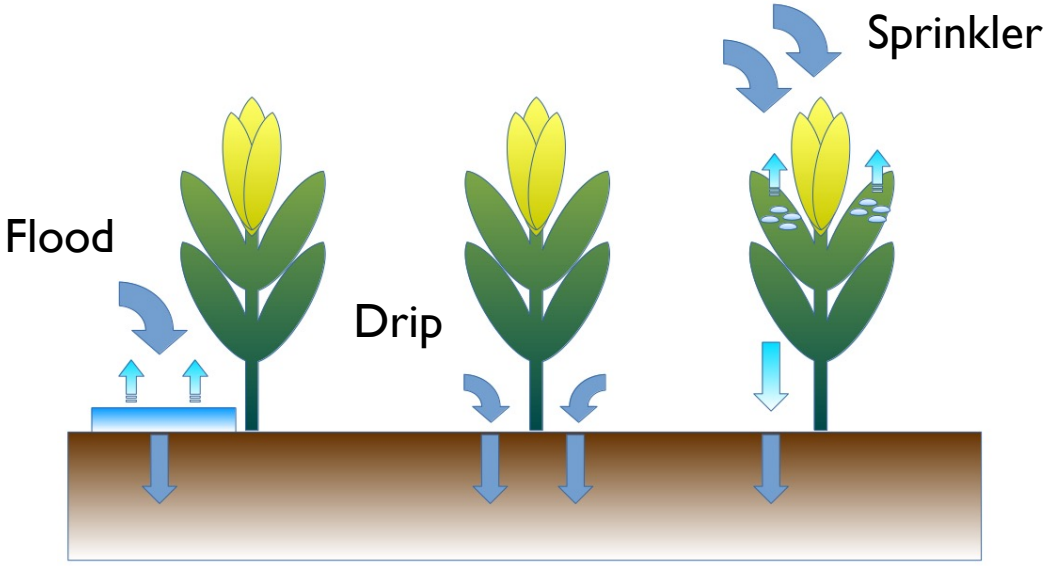
Al-Yaari et al., in review

Water management development beyond CLM5



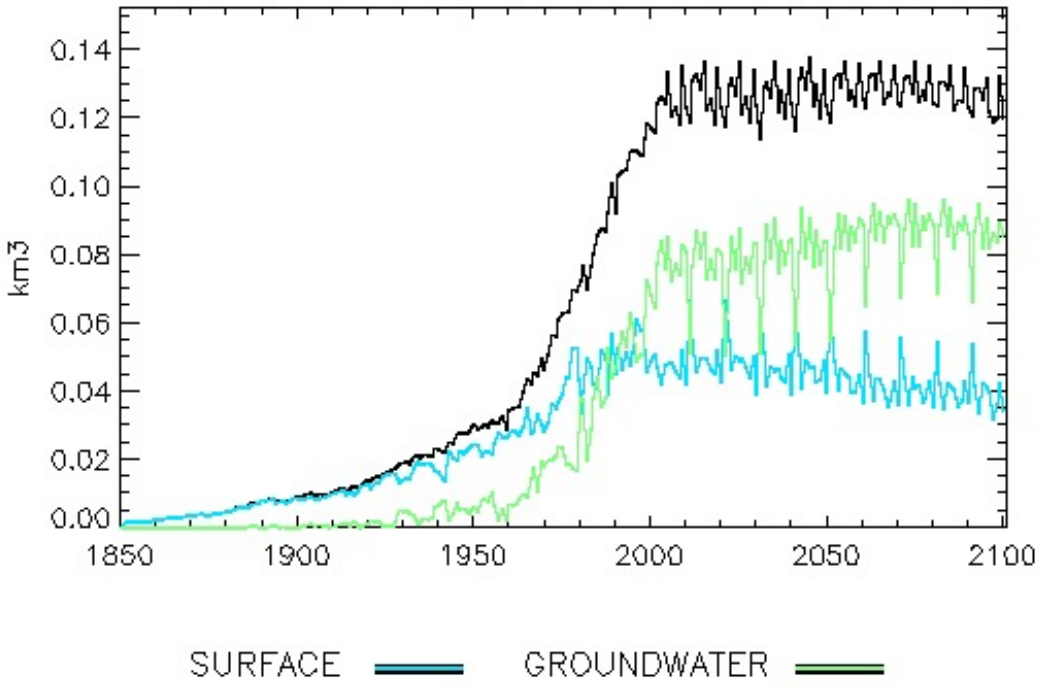
Alternative irrigation methods
Improved constraints on sources of irrigation water





More realistic treatment of sources of irrigation water

Annual irrigation
Northern India



Groundwater pumping

Can assess relative withdrawals from surface water versus groundwater

Need: Confined aquifer maps and water content

Water Resources Research

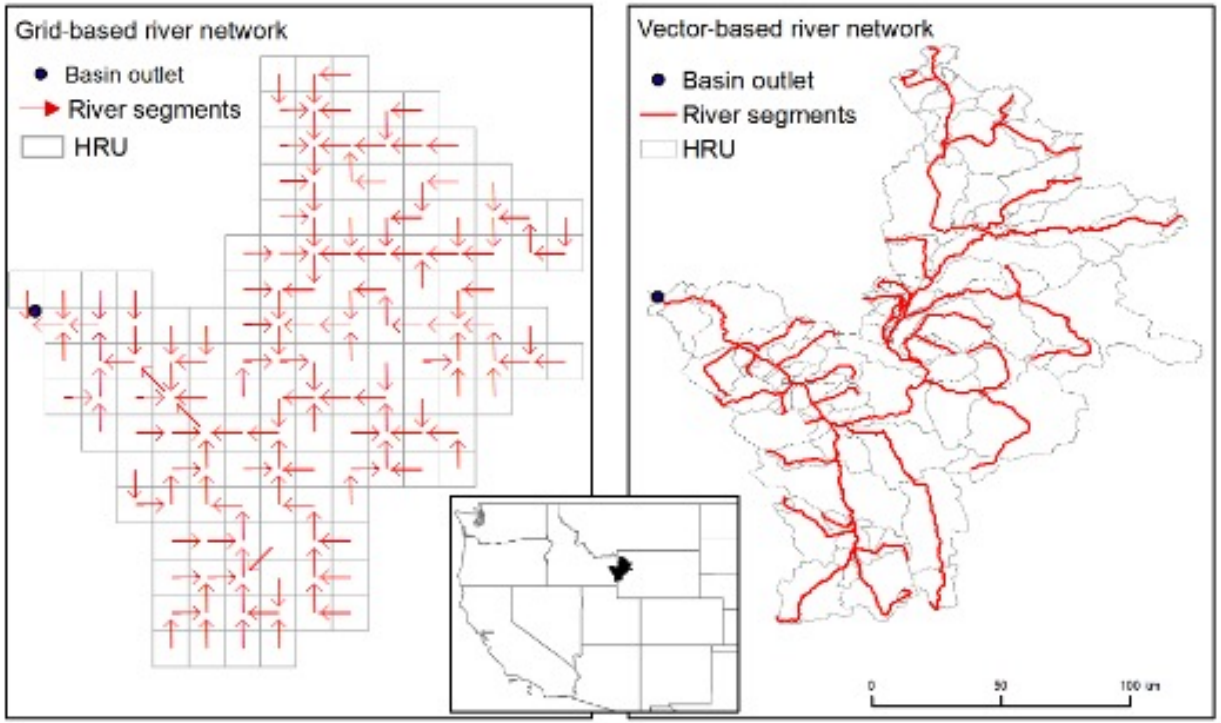
Representing Intercell Lateral Groundwater Flow and Aquifer Pumping in the Community Land Model

Farshid Felfelani[1], David M. Lawrence[2], and Yadu Pokhrel[1]

Connecting rivers and lakes, reservoir management

MOSART (Li et al., 2014)

mizuRoute (Mizukami et al., 2020)



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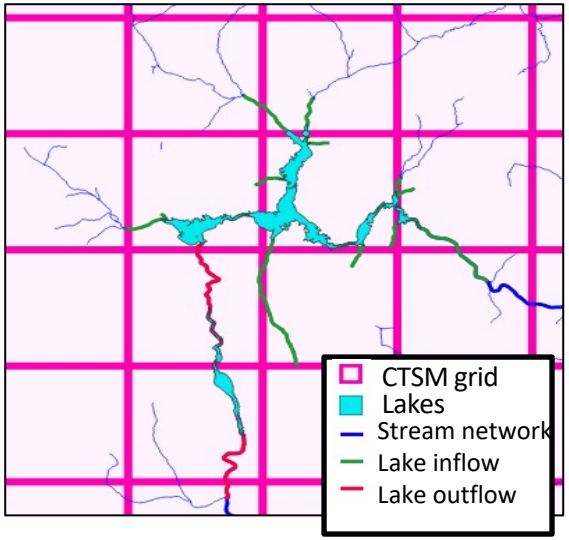
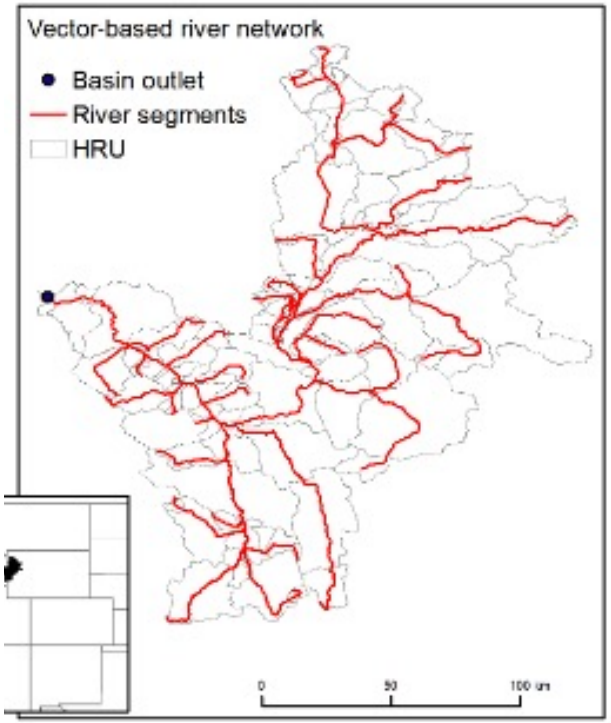
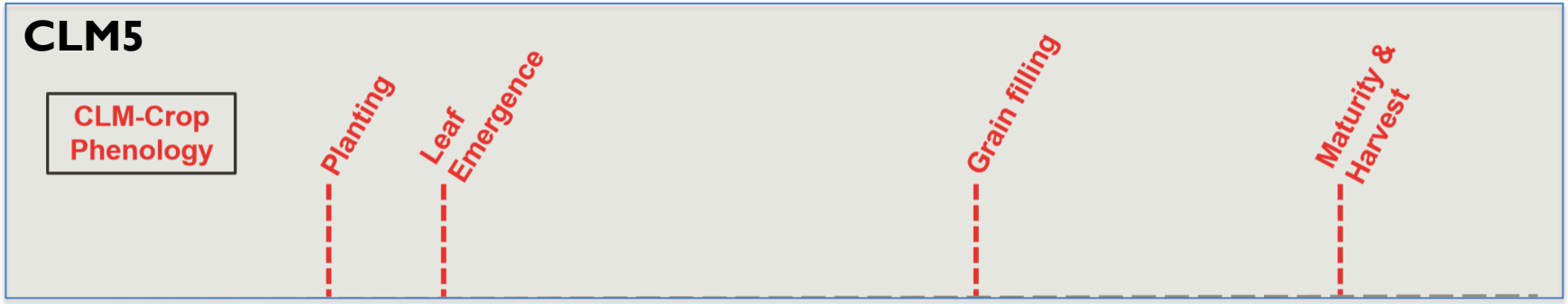




Vanderkelen et al., in prep

More advanced representation of crop phenological stages



(Peng et al., 2018, AFM)

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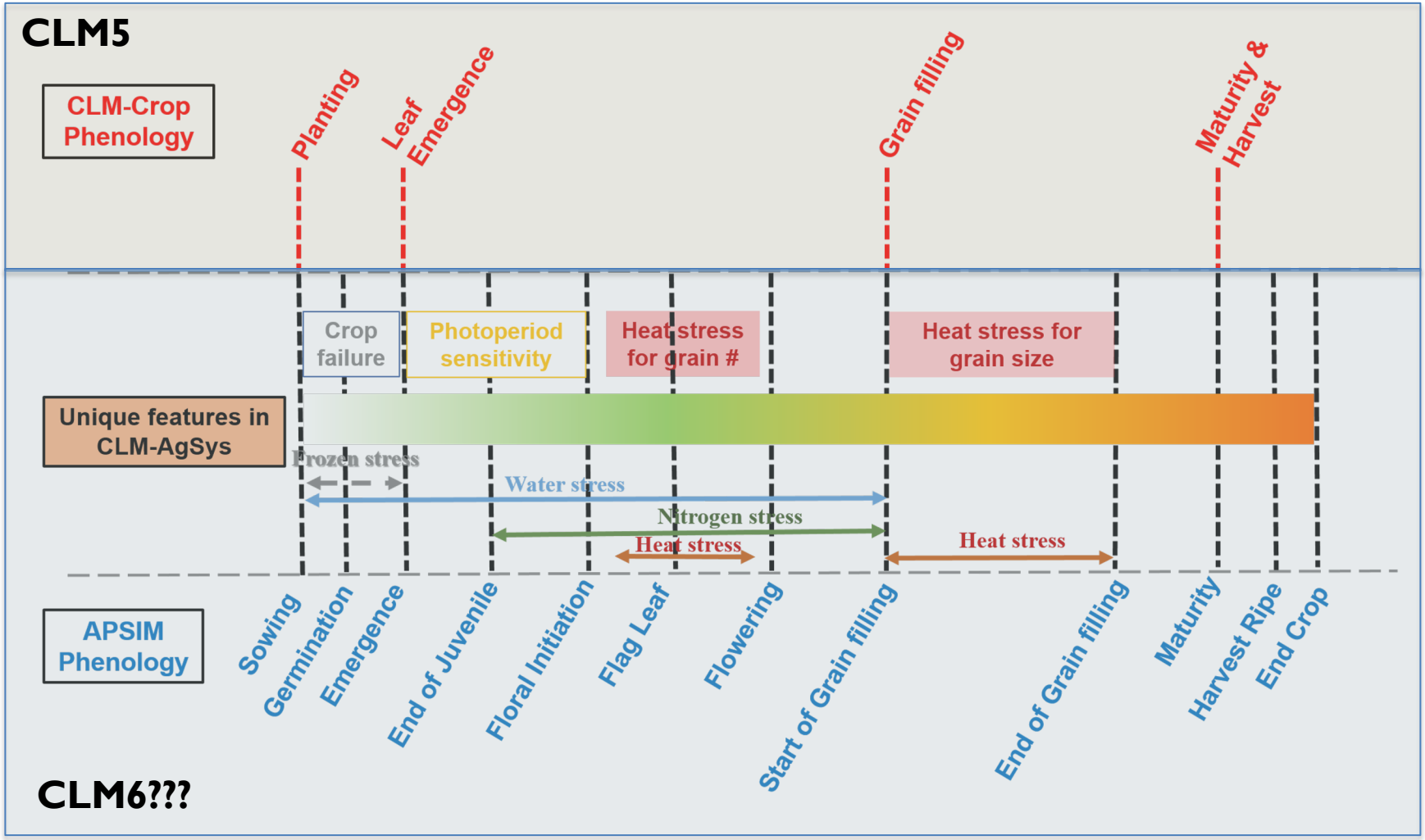
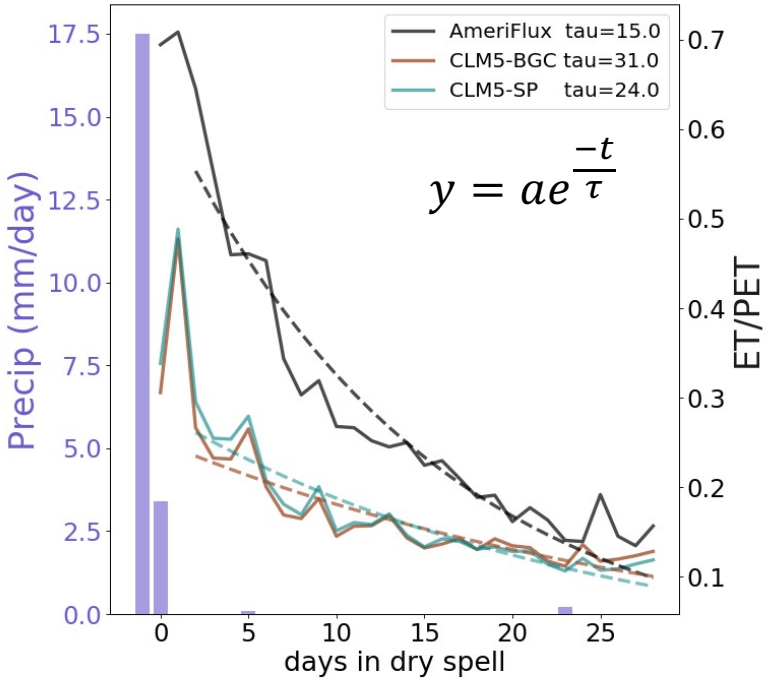


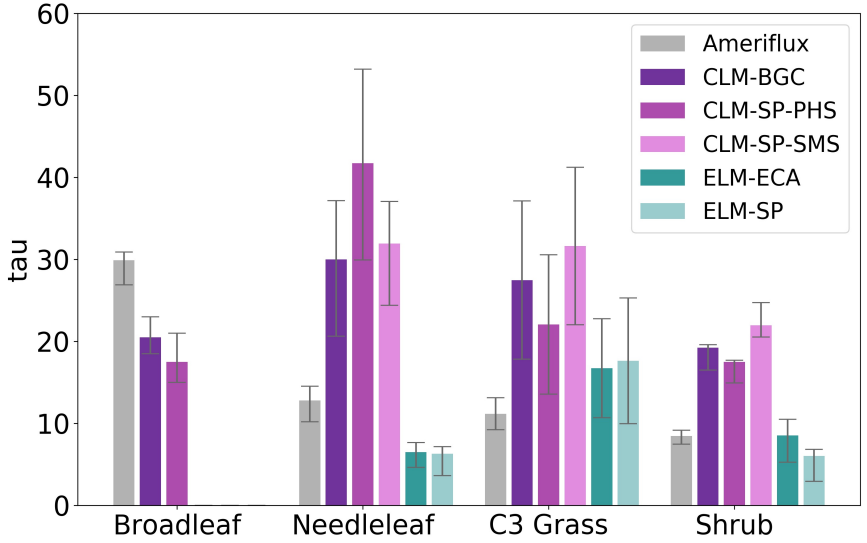
(Peng et al., 2018, AFM)

Improving soil hydrology and ET processes
Characteristic rates of ET recession

Identify events

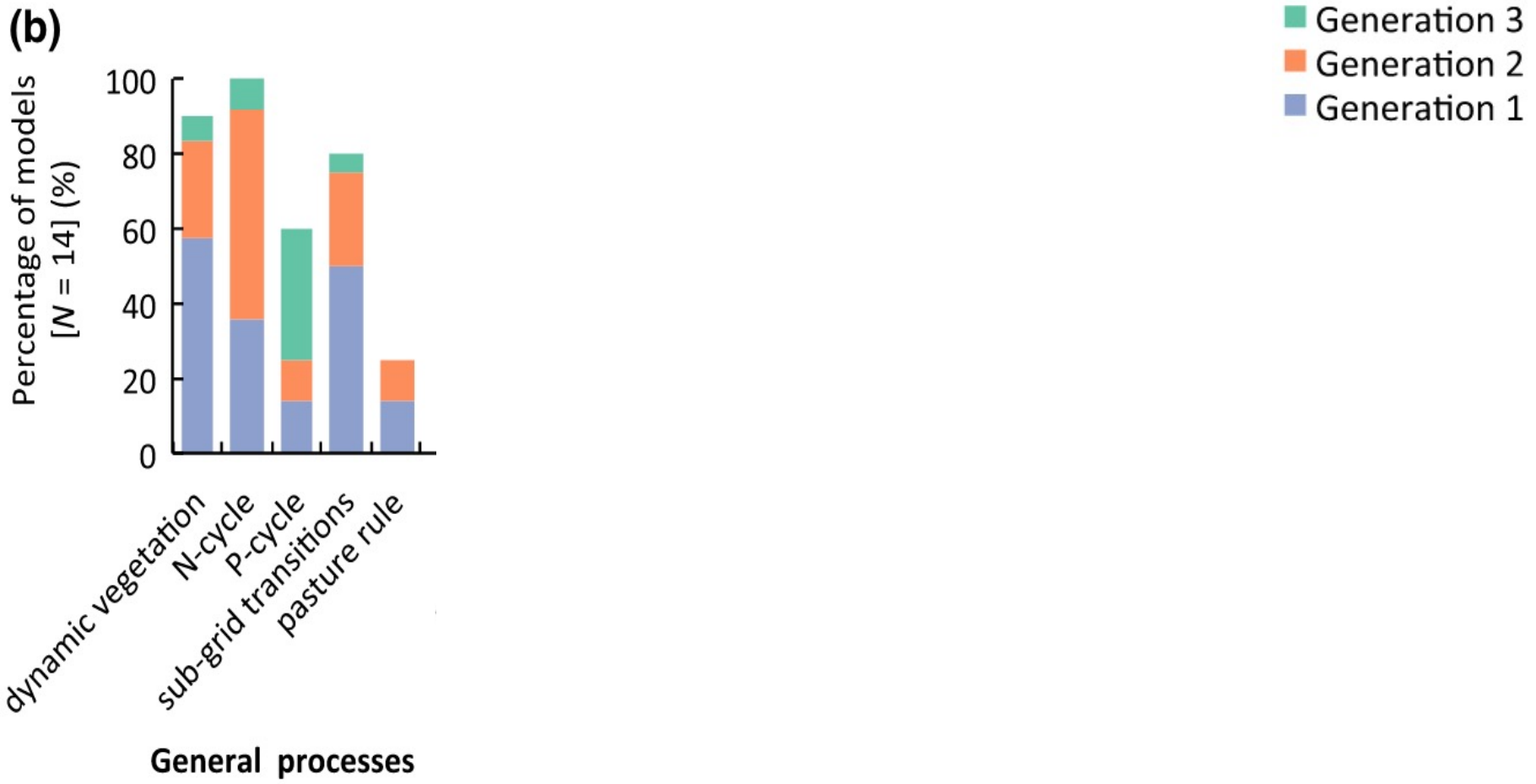


Comparing rates of ET recession during drydown in obs (Flux Tower sites) and models (after Martinez de la Torre et al., 2019)



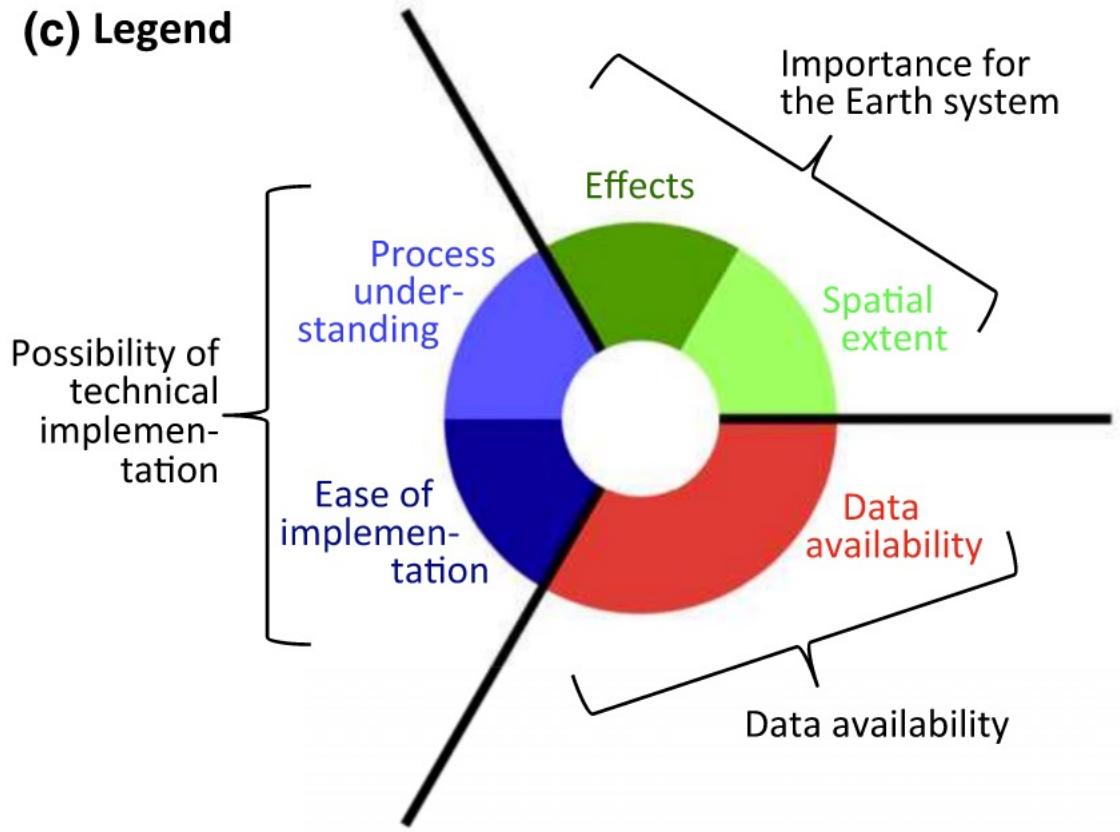
Slide courtesy Linnia Hawkins

Survey of modeling groups' progress and plans with respect to implementation of land management

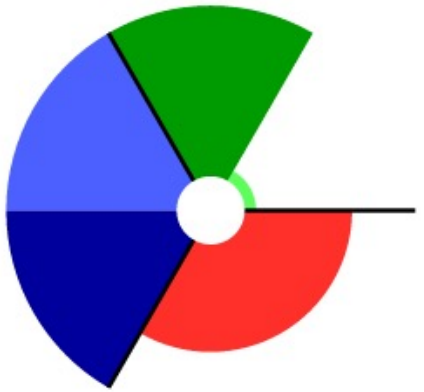


Pongratz et al., GCB, 2018

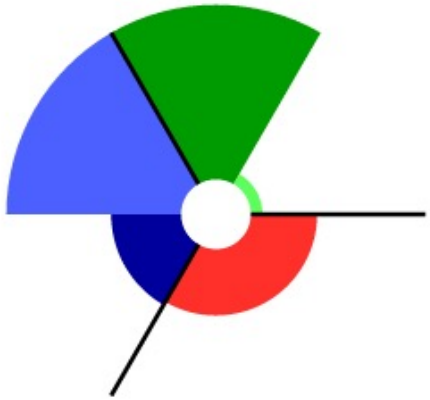
Importance and feasibility roadmap for land management processes



Irrigation (Simple)

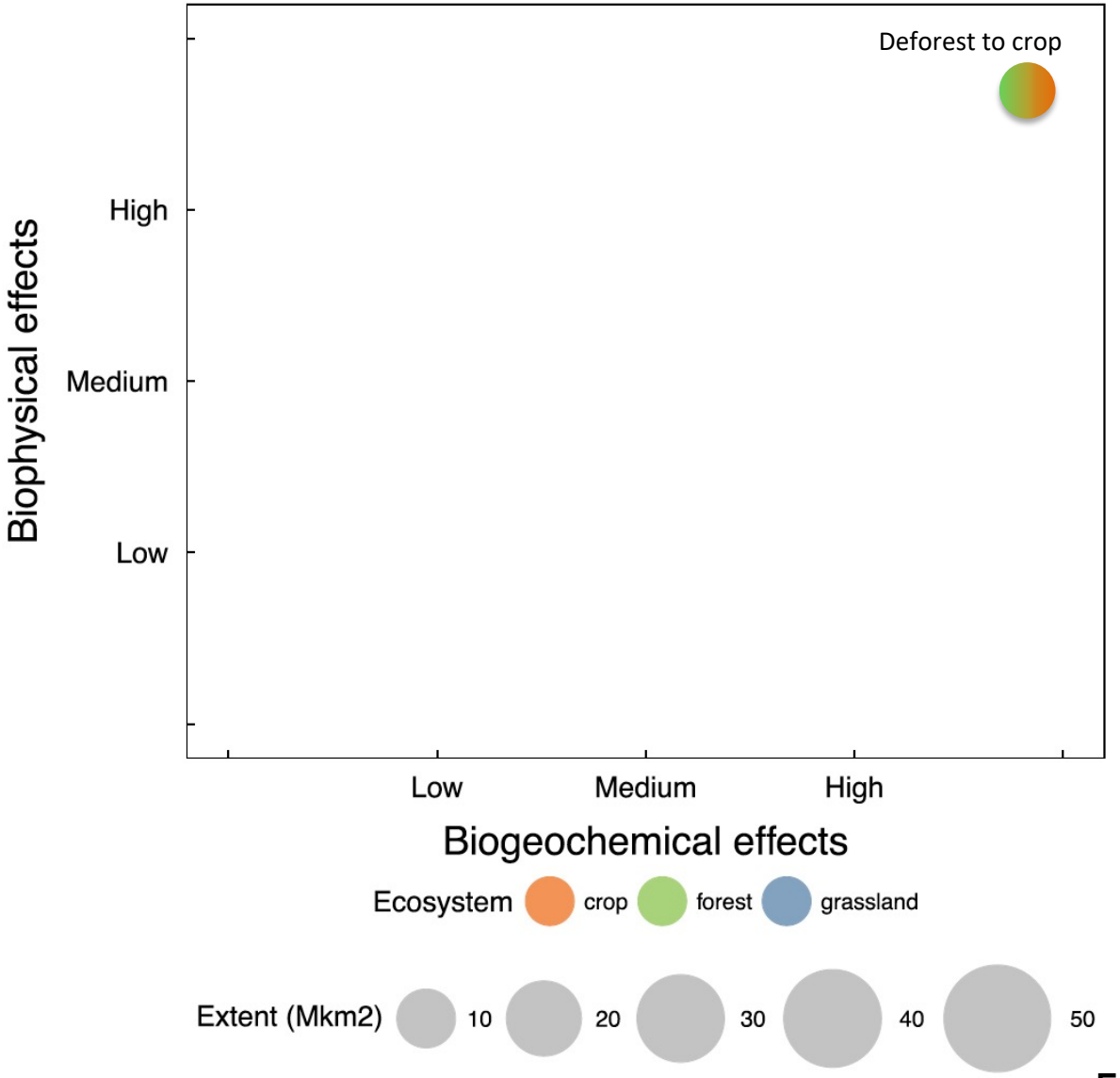


Irrigation (Comprehensive)



Pongratz et al., GCB, 2018

Synthesis of land management impacts



Erb et al., GCB, 2016

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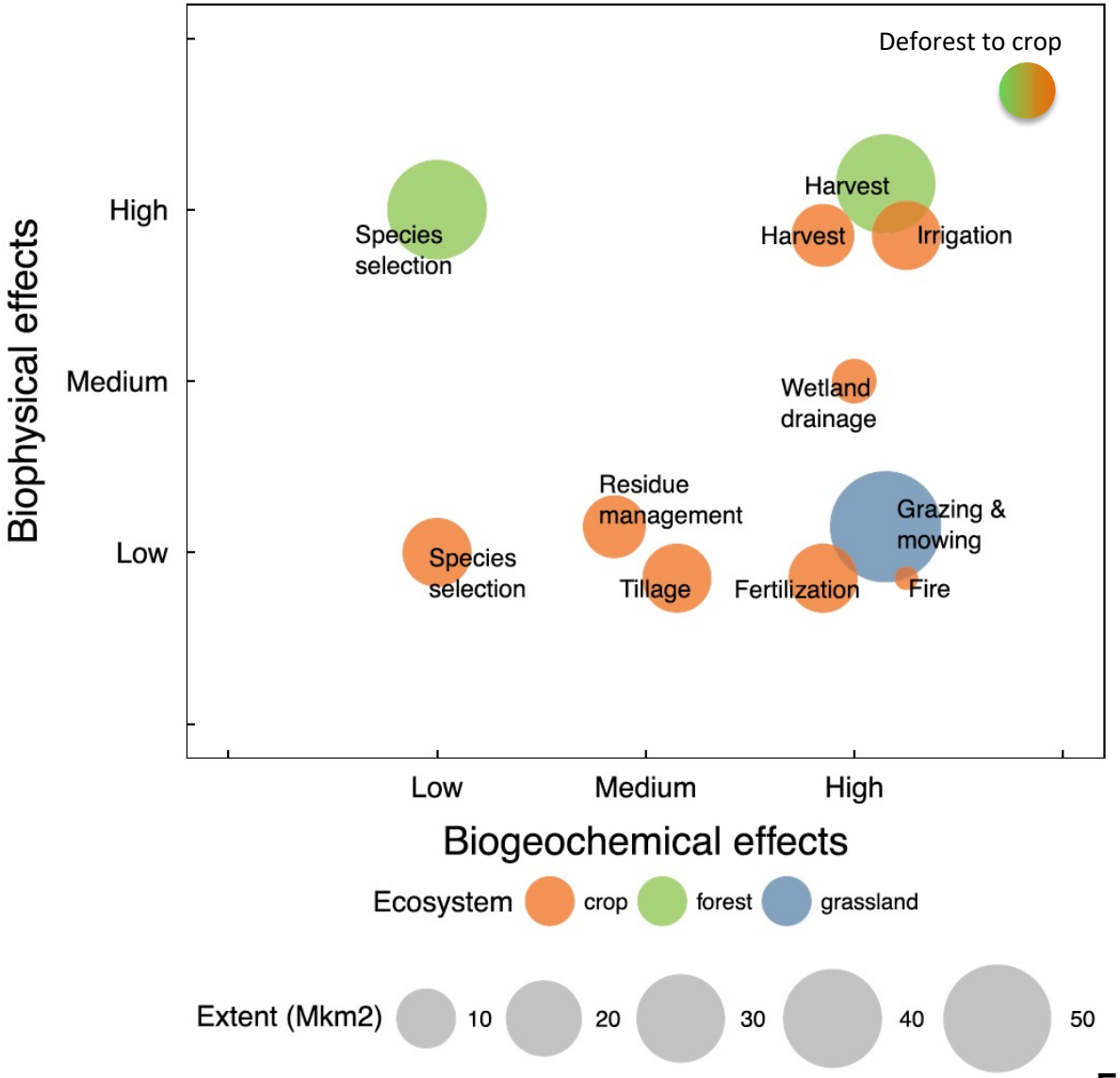
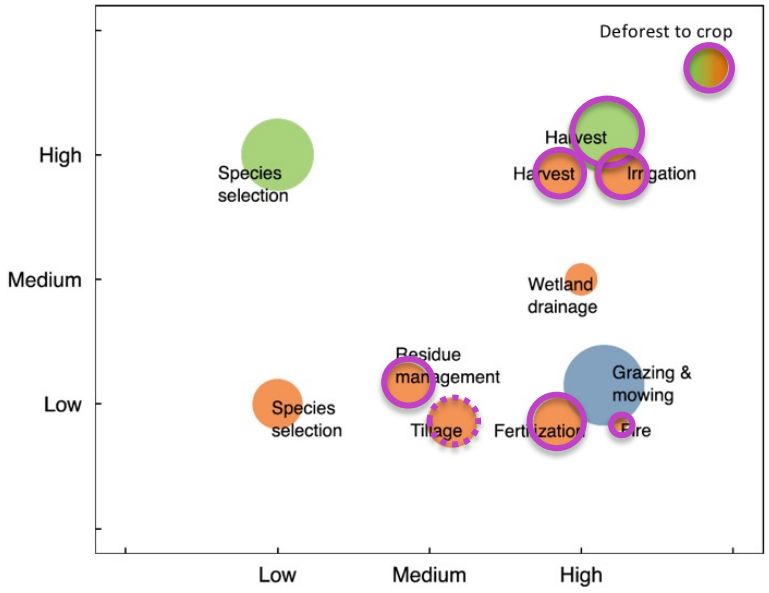


Erb et al., GCB, 2016

Land management in Community Land Model (CLM5)

Included in default CLM5

- Global crop model with 8 crop types; planting, grain fill, harvest, residue manage
- Crop irrigation
- Crop Industrial fertilization
- Wood harvest
- Urban environments
- Human fire ignition and suppression



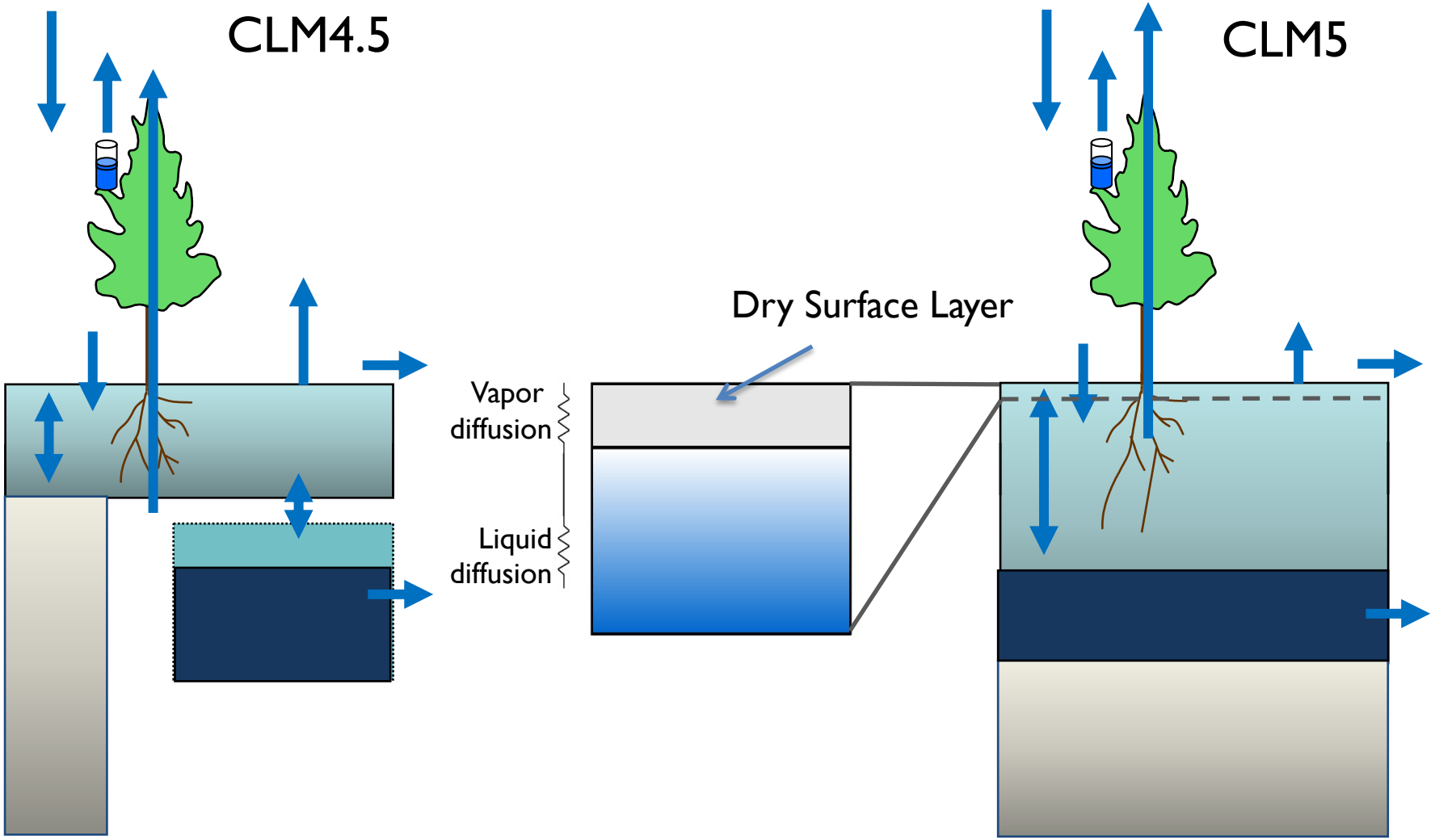
Corn* Winter wheat Sugarcane

Soy* Cotton Rice

* *Temperate and tropical varieties*

Fertilization Irrigation

CLM5: Soil hydrology updates



Swenson and Lawrence, 2014