

DFG Research Unit 1695 "Regional Climate Change"

# Coupling the land surface model Noah-MP with the generic crop growth model Gecros

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# Seasonal dynamics of energy fluxes at a winter wheat site



#### Wizemann et al., 2015. Zeitschrift für Meteorologie

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# Vegetation dynamics in Noah-MP (OptDynamicVeg = 1, 3 and 4)

# The vegetation dynamics is prescribed in look-up tables. The vegetation dynamics is "frozen".

Irrigated cropland															
	Dryland cropland					0									
117	LAIM	=	0.0,	0.0,	0.4,	0.4,	0.4,	0.0,	0.4,	1.0,	1.0,	1.0,	0.0,	0.0,	4.5,
118			0.0,	0.0,	0.5,	0.5,	0.5,	0.0,	0.5,	1.0,	1.0,	1.0,	0.0,	0.0,	4.5,
119			0.0,	0.0,	0.6,	0.6,	0.6,	0.0,	0.6,	1.0,	1.0,	1.0,	0.3,	0.0,	4.5,
120			0.0,	0.0,	0.7,	0.7,	0.7,	0.5,	0.7,	1.0,	1.5,	1.0,	1.2,	0.6,	4.5,
121			0.0,	1.0,	1.2,	1.2,	1.2,	1.5,	1.2,	1.0,	2.0,	1.0,	3.0,	1.2,	4.5,
122			0.0,	2.0,	3.0,	3.0,	3.0,	2.5,	3.0,	1.0,	2.5,	1.0,	4.7,	2.0,	4.5,
123			0.0,	3.0,	3.5,	3.5,	3.5,	3.5,	3.5,	1.0,	3.0,	1.0,	4.5,	2.6,	4.5,
124			0.0,	3.0,	1.5,	1.5,	1.5,	3.5,	1.5,	1.0,	2.5,	1.0,	3.4,	1.7,	4.5,
125			0.0,	1.5,	0.7,	0.7,	0.7,	2.0,	0.7,	1.0,	1.5,	1.0,	1.2,	1.0,	4.5,
126			0.0,	0.0,	0.6,	0.6,	0.6,	1.0,	0.6,	1.0,	1.0,	1.0,	0.3,	0.5,	4.5,
127			0.0,	0.0,	0.5,	0.5,	0.5,	0.0,	0.5,	1.0,	1.0,	1.0,	0.0,	0.2,	4.5,
128			0.0,	0.0,	0.4,	0.4,	0.4,	0.0,	0.4,	1.0,	1.0,	1.0,	0.0,	0.0,	4.5,
129			1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.		600507.0425		and a least		1000-100-100	Second State	61998-9619 56585	a na su da su d	1000000000	10-10-10-10-10-10-10-10-10-10-10-10-10-1	



# Vegetation dynamics in Noah-MP (OptDynamicVeg = 1, 3 and 4)

# Simplyfing assumptions:

- Phenological differences among crop types are not considered (e.g. wheat vs. maize)
- Each land cover type has a spatially uniform vegetation dynamics
- The vegetation dynamics does not depend on the weather conditions (→ "frozen" vegetation dynamics)



# The objective of the present study was

 to extend the land surface model Noah-MP by the generic and dynamic crop growth model Gecros

# This extensions allows

 simulating the development of two major crops of mid Europe (maize and winter wheat) in a weather-driven way and spatially explicit



# Characteristics of the crop growth model GECROS (Yin and van Laar, 2005)

- Crop model of the "Dutch school"
- Photosynthesis-based crop growth model (Farquhar model)
- The phenological development is computed from a temperature response function
- The stomatal resistance is a function of the photosynthesis.
- Two-leaf approach (sunlit and shaded leaves).
- The model computes the total leaf area index (TLAI) as well as the green leaf area index (GLAI).
- Noah-MP-Gecros was calibrated and validated over in total 16 • Universitat Seasons.



# Integration of the crop model GECROS with the land surface model NOAHMP



Ingwersen et al., 2018. Agricultural and Forest Meteorology



## Total leaf area index simulated with Noah-MP and Noah-MP-Gecros



Ingwersen et al., 2018. Agricultural and Forest Meteorology



### Latent heat fluxes simulated with Noah-MP and Noah-MP-Gecros for wheat





# Total leaf area index: WRF-Noah-MP-Gecros versus WRF-Noah-MP, April–August 2005



#### 1 Apr 2005

#### Warrach-Sagi, 2023. Personal communication 10



# **Reduction in temperature bias by Noah-MP-Gecros**



Warrach-Sagi et al., 2022. JGR Atmospheres 11

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# **Summary and Outlook**

- We successfully extended the land surface model Noah-MP by a dynamic crop growth component (Gecros) for wheat and maize.
- The new Noah-MP-Gecros enables simulating the development of wheat and maize in a weather-driven and spatially explicit way.
- The significantly improved cropland dynamics impacts the atmospheric model: Running WRF with Noah-MP-Gecros reduced the temperature bias by up 2.5°C.
- Since version WRF 4.1, which was released in April 2018, Noah-MP-Gecros is part of the offical WRF release.
- We intend to implement a refactored Gecros version into Noah-MP v5.0 until the end of 2023.



# Acknowledgments



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DFG Deutsche Forschungsgemeinschaft

Thank you for listening!

Michael Barlage from NOAA (Environmental Modeling Center, Maryland, USA) for technical support in implementing Gecros into WRF!





# Bias in monthly mean temperature with respect to HYRAS (German Weather Service)





# Leaf area index (LAI) evaluation: 5 June 2005

# Comparison with observational 5 x 5 km<sup>2</sup> gridded LAI data from European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)



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LAI [m2/m2]



# Model regions of the DFG Research Unit 1695 "Regional Climate Change"





# **Central study sites**

For the period April 2009 to July 2018 the following data were aquired:

- Half-hourly flux data on net radiation, latent heat, sensible heat and soil heat
- General meteorological data
- Soil data (water content, temperature, matric potential in 5 depths)
- Plant data (BBCH stage, LAI, biomass etc.) (Group of Prof. A. Fangmeier)







# Sensitivity study with the Weather Research and Forecasting (WRF) model



Noah-MP-Gecros was applied in winter crop grid cells, Noah-MP otherwise

Warrach-Sagi, 2018. Personal communication

Urban

Grasslands



## **Noah-MP-Gecros: Validation**



Ingwersen et al., 2018. Agricultural and Forest Meteorology



# Growth stages of wheat





# **Calibration runs for winter wheat**



Ingwersen et al., 2018. Agricultural and Forest Meteorology