COUPLING of A 3D ROOT SYSTEM ARCHITECTURE MODEL TO A 1D-CROP GROWTH MODEL FOR IMPROVED SIMULATION OF VERTICAL ROOT DISTRIBUTION AND SOIL WATER DYNAMICS.

[1,2]Mboh, Cho Miltin; [1]Gaiser, Thomas; [1]Ewert, Frank
[1]Institute of Crop Science and Resource Conservation
University of Bonn; Katzenburgweg 5, D 53115 Bonn, Germany.

[2]**E-mail:** cmboh@uni-bonn.de
http://www.lap.uni-bonn.de/

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Motivation and objectives

- Most 1D root growth models do not consider the root system architecture when simulating the RLD distribution
- This over-simplification of root growth may have significant consequences on simulated root water and nutrient uptake with a corresponding reflection on the simulated crop yields.
- The objective of this study is to examine if an improved representation of root growth in a 1D crop model can lead to better estimates of the simulated yield and above ground biomass.

Materials and Methods

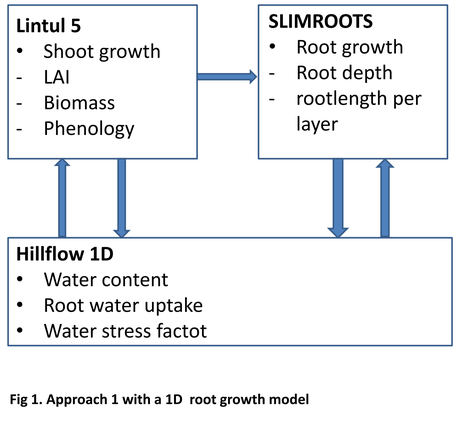


Fig 1. Approach 1 with a 1D root growth model

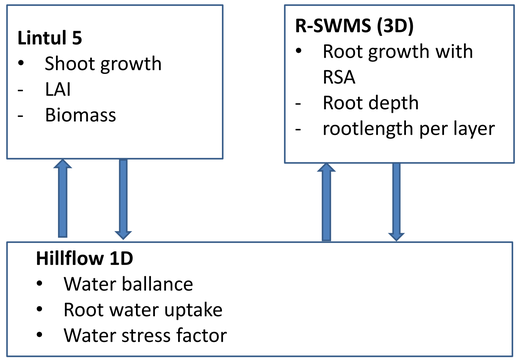


Fig2: Approach2 with improved root growth representation with a 3D root growth model

- Version 3.2 of the SIMPLACE (Gaiser et al.,2013) modeling framework, was used to couple Lintul5 (Van Ittersum et al., 2003) , SLIMROOTS (Addiscott and Whitmore, 1991) and Hillflow 1D (Bronstert and Plate, 1997)
- These models were forced with measured climatic, biophysical and soil data to simulate the growth of spring wheat in Klein-Altendorf in Germany. This constitutes the classical approach illustrated in Fig 1.
- R-SWMS (Javaux et al., 2008) a 3D model for simultaneous modeling of root growth, soil water fluxes and solute transport and uptake was coupled to Lintul5 and Hilflow 1D and calibrated against observed soil moisture contents and root length densities. Simulated root length density distributions from RSWMS are integrated into Hilfflow 1D as an improvement of root growth representation

LINTUL5

- Light use efficiency: 4.5 (g m^{-2} MJ^{-1})
- Specific leaf area : 0.036 (m^2g^{-1})
- Growing degree days until maturity: 1100 (◦C d)
- Relative growth rate of LAI in the early development stage : 0.018
- Anthesis DOY : 171 (20 June, 2010)
- Maturity DOY : 194 (July 13,2007)

SLIMROOTS/ RSWMS(Soma model)

- Maximum elongation rate of seminal roots per day: 3.3 (cm d^{-1})
- Maximum number of seminal roots: 6
- DailyDeadRootsStage(SLIMROOT): 1.2

Hillflow /RSWMS

Parmeters:	0-15	16-30	31 -45	46-90	91-150
Theta_r (cm^3cm^{-3})	0.010	0.08	0.090	0.090	0.012
Theta_s (cm^3cm^{-3})	0.44	0.42	0.410	0.410	0.435
Alpha (cm^{-1})	0.022	0.022	0.035	0.044	0.041
n [-]	1.438	1.504	1.376	1.436	1.628
Ks ($cmday^{-1}$)	47.53	321.9	95.23	35.60	240.0
Rho (gcm^{-3})	1.337	1.490	1.590	1.579	1.470

Theta_r: Residual moisture content
Theta_s: Saturation moisture content
Alpha and n are van Genuchten curve shape parameters
Ks is saturated hydraulic conductvity
Rho : bulk density

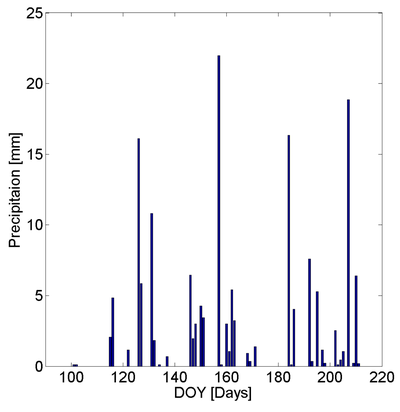
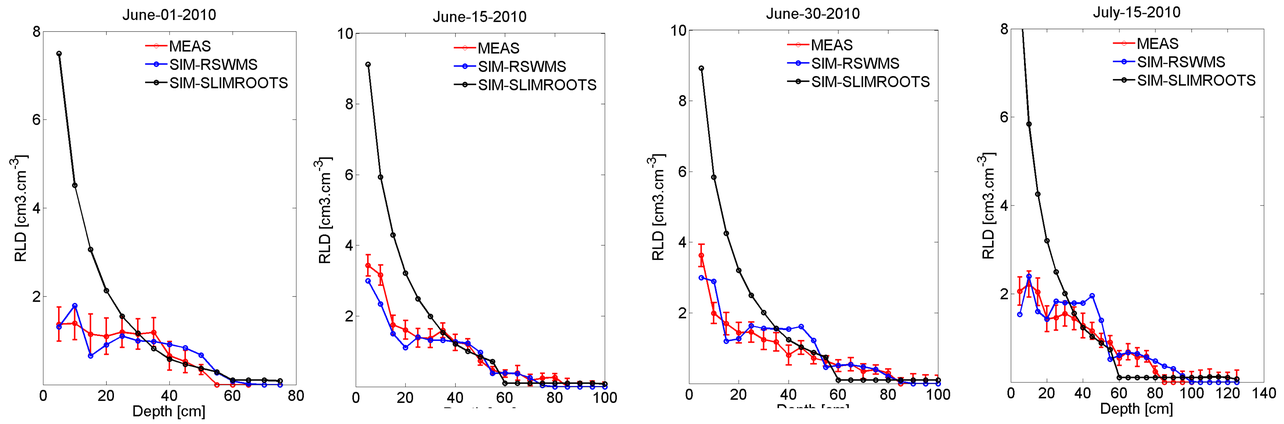
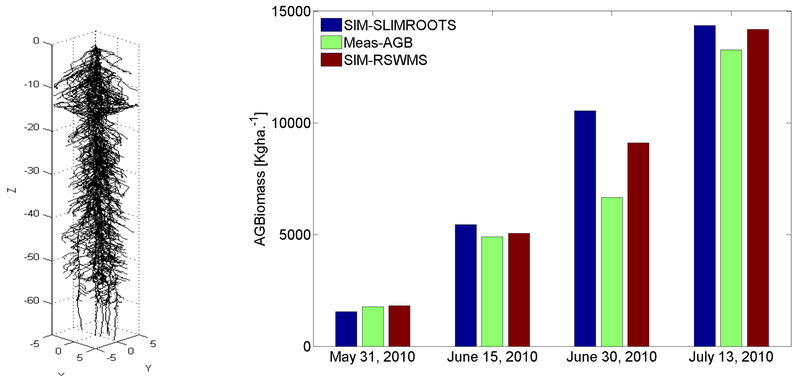
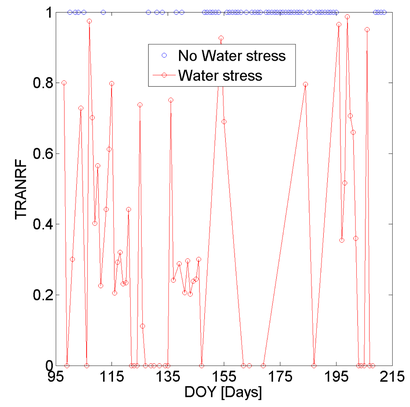


Fig3: Rainfall from planting to maturity

Results and Discussions and conclusions







- Rootlength densities simulated with RSWMS follow the trend of the observed root length density dynamics closer compared to SLIMROOTS
- RSWMS considers horizontal heterogeneity of water content and the root system architecture for the simulation of root length densities which is typically ignored in 1D approaches
- Both appraoches lead to good estimates of the above ground biomass (a slight improvement is obtained with SIM-RSWMS)
- The field plot was not nutrient limited and there was limited water stress during the critical phase of the growing season (DOY 171-190)

OutLook

- Simulations ignore the presence of biopores which might lead to better fits to the observed Root length density distributions if taken into consideration
- Nutrient limited field plots with biopores are envisaged for further understabding of the impact of the improvement of Root length density distribution on crop yields

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