Simulating soil-vegetation-atmosphere interactions with the ParFlow-CLM-COSMO modeling platform

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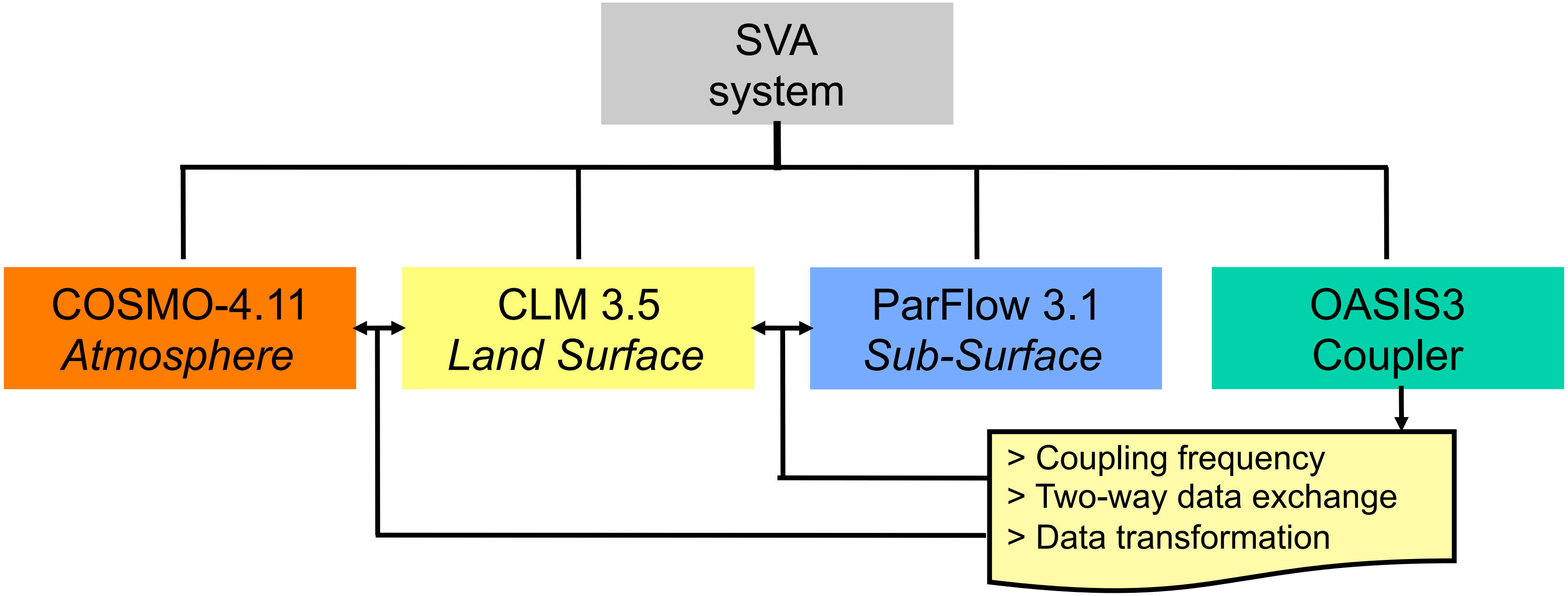
Presentation Outline

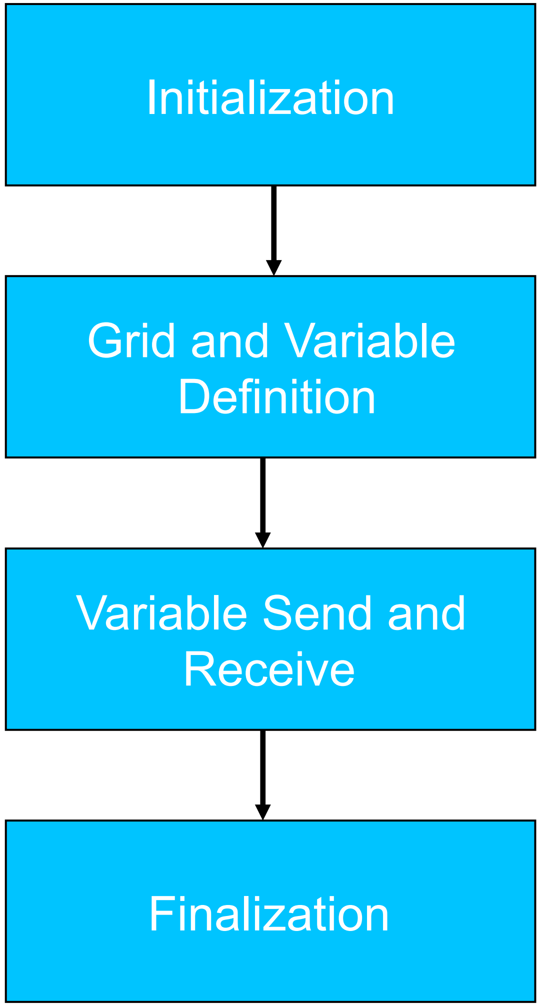
- Modular Soil Vegetation Atmosphere System (SVA).
- Interfacing OASIS3 in component models.
- Implementation of downscaling scheme in the OASIS3 coupler.
- Idealized Tests for CLM-ParFlow.

Modular Soil Vegetation Atmosphere system



- OASIS3 is the driver of the component model and manages the online coupling.
- COSMO-DE, CLM 3.5 and ParFlow runs as different executables linked to the OASIS libraries.
- The coupler is less code intrusive.
- Subcycling , data interpolation between different grids, temporal averaging possible with the OASIS coupler.

OASIS3 Interface



->Latitude / Longitude of grid centre and corners of 2D data.

->Variables to be exchanged

->Model Time Stepping
(Exchange variables based on specified coupling frequency)

Variable Exchange: COSMO and CLM

COSMO variables

•Air temperature (K) , Zonal and meridional wind (m/s), Sp. water vapour (kg/kg), Pressure (Pa) , Model height at lowest level (m), Downward direct and diffuse solar radiation (W/m2), Downward longwave radiation (W/m2), Convective precipitation rate of rain and snow (kg/m2*s), Grid-scale precipitation rate of rain, snow and graupel (kg/m2*s)

CLM variables

Sensible Heat Flux (W/m2), Latent Heat Flux (W/m2), Zonal Wind Stress (kg/m2*s), Meridional Wind Stress (W/m2), Upward long-wave radiation (W/m2), Albedo

In COSMO:

- Short-wave radiation is coupled via albedo send from CLM.
- Long-wave radiation is coupled by updating weighted surface temperature (t_g) using CLM upward long-wave flux.
- Momentum, heat and moisture fluxes coupled by updating the surface transfer coefficients (tch and tcm).

In CLM:

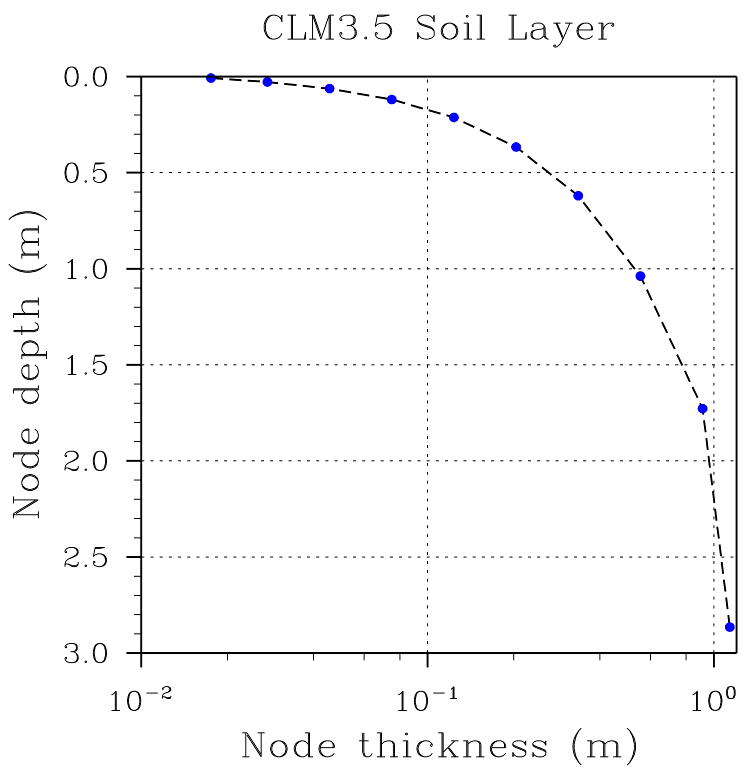
- Coupling is done by using the atmospheric driver routine used for running offline CLM simulation.

Variable Exchange: CLM and ParFlow

CLM

•Source/Sink flux (mm/s)

– Souce: Infiltration flux for first layer.
– Sink: Evapotranspiration flux multiplied by root-fraction at each soil level.



ParFlow

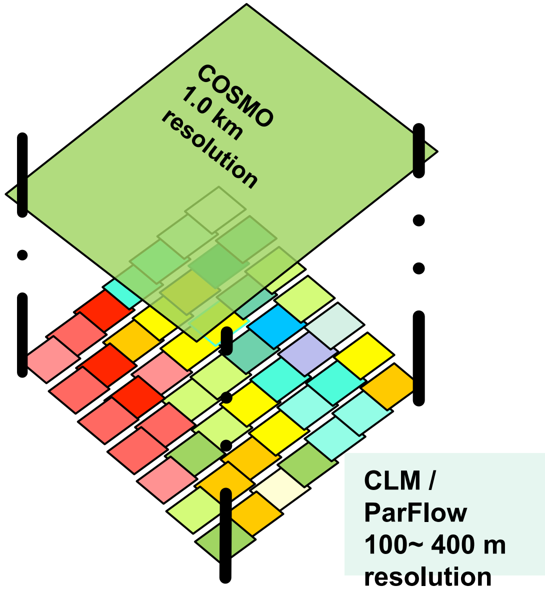
•Pressure head (mm)

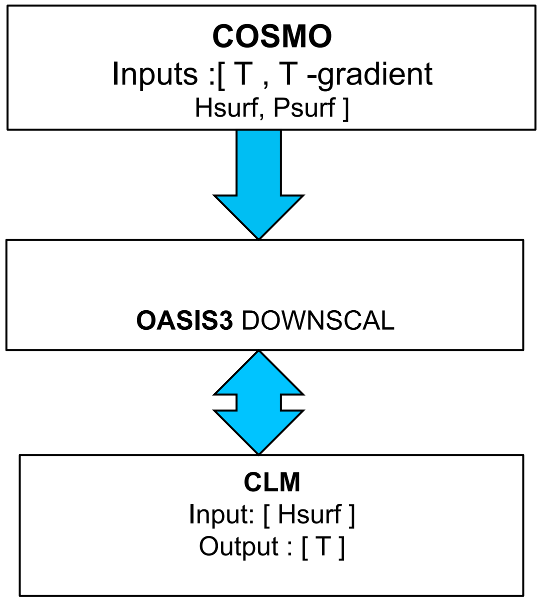
•Soil Saturation (fraction)

- CLM has only 10 soil levels (with exponentially increasing soil depth).
- ParFlow has flexible number of soil layers (constant /variable soil depth).
- Major changes in CLM for coupling:
  - Soil water physics /river routing turned off.
  - Soil depth (dz) / porosity consistent with ParFlow specification.
  - Soil Moisture provided by ParFlow. It includes effects of ponding, runoff and subsurface flow, including an explicitly resolved water table.

Implementation of Downscaling Scheme in OASIS3

- Instead of applying a constant atmospheric forcing over all land sub-pixels, a downscaling scheme is needed to account for the subgrid heterogeneity to apply a spatially variable forcing.
- Downscaling Algorithm (Schomburg et al. 2010) implemented in OASIS3
  - Increases the number of variables that need to be exchanged.



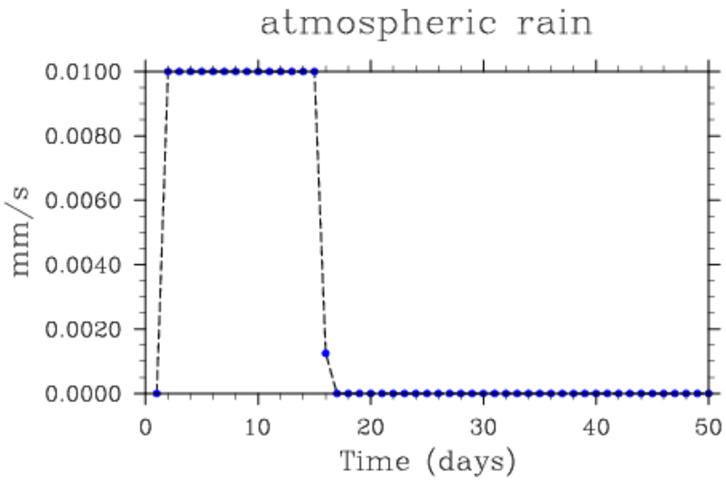


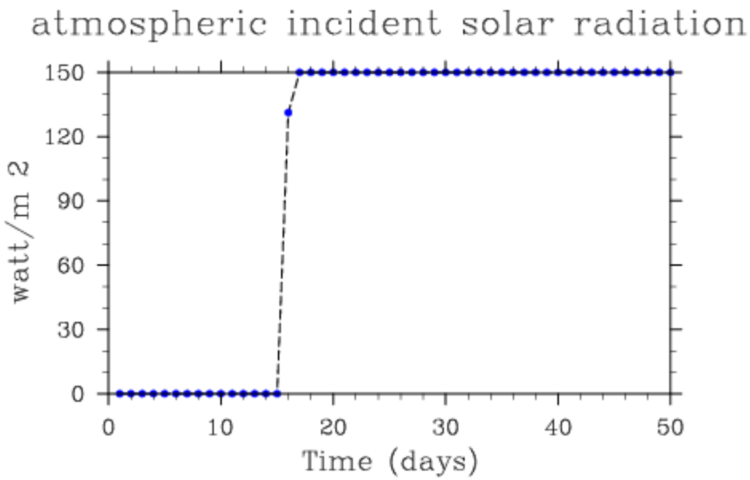
Idealized Tests: CLM and ParFlow

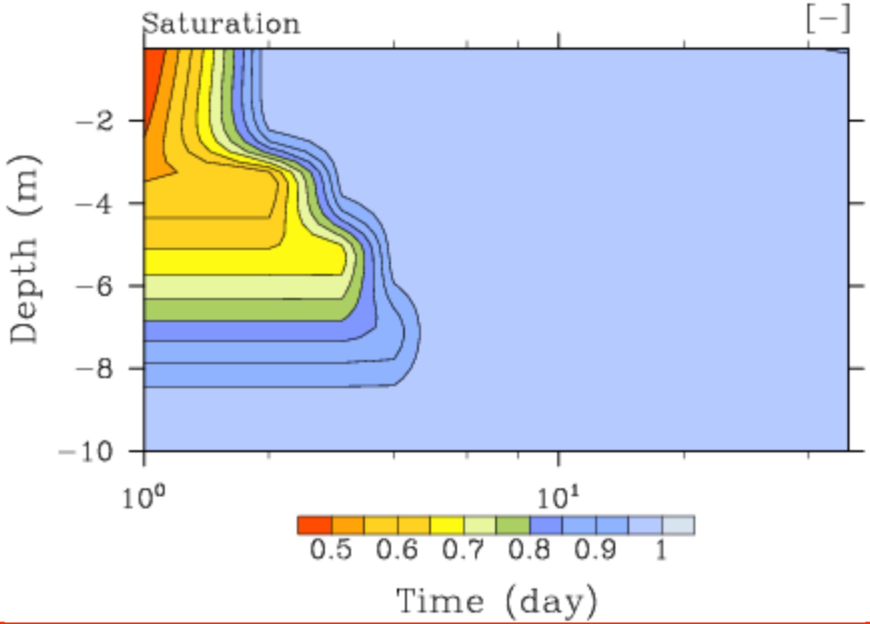
- Test 1 (Infiltration and Drying)
  - 50 day simulation, dt = 0.5 hr
  - Soil depth, dz = 0.25 cm
  - Number of layers in ParFlow, NZ= 40
  - Slope = 0.001 in X-direction
  - Porosity = 0.448,
  - Ksat = 0.01 m/hr,
  - Water Table Depth = -9.5m

- Test 2 (Flow routing)
  - 48 hour simulation, dt = 0.5 hr
  - Number of layers in ParFlow, NZ= 20
  - Ksat = 0.01 m/hr
  - Water Table Depth = -3.0m

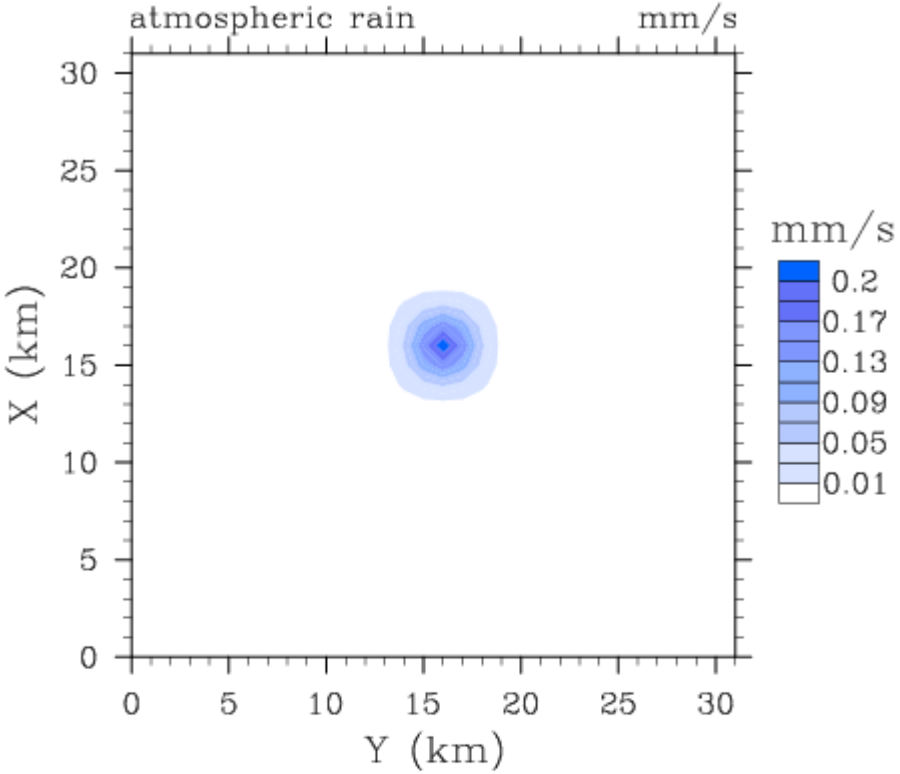
Idealized Test 1: Infiltration and Drying

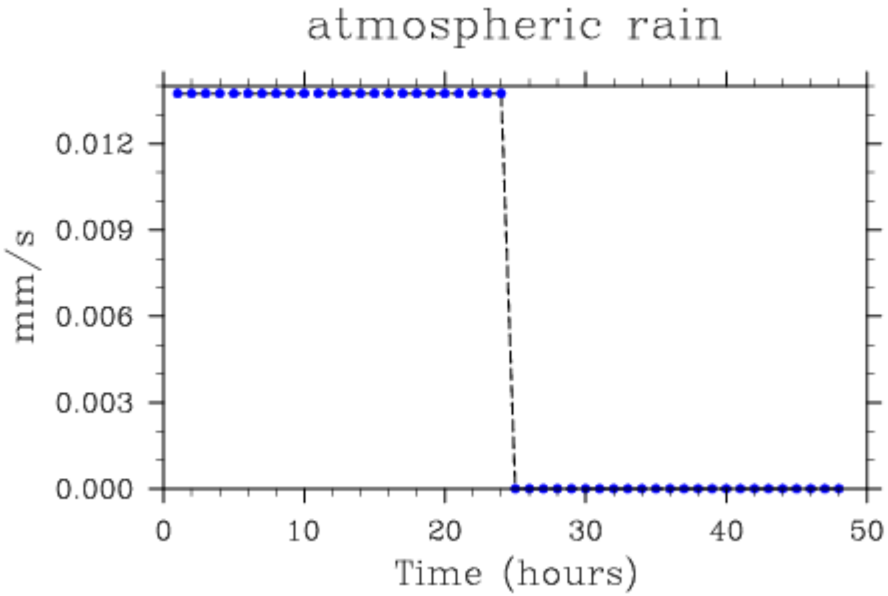






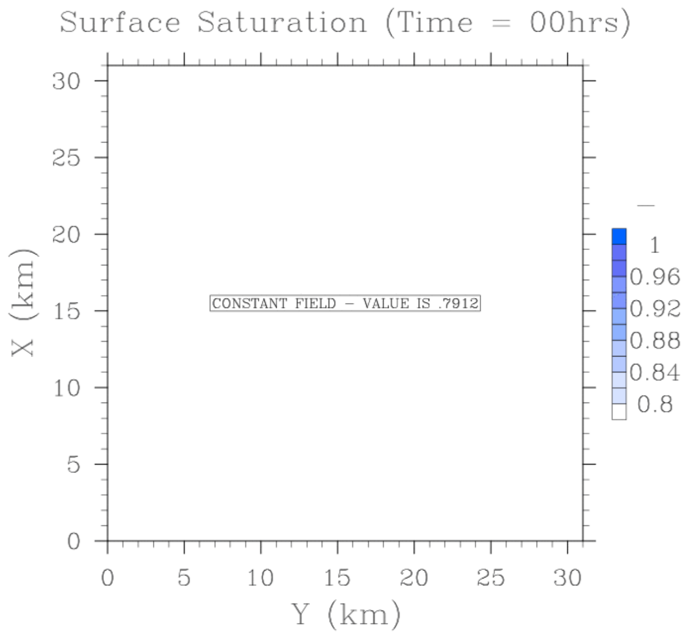
Idealized Test 2: Flow-routing

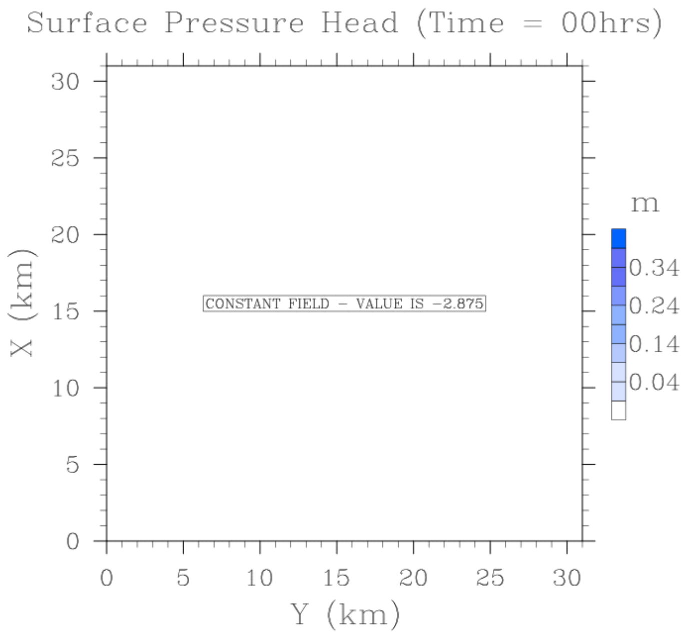




- NX =32, NY=32, NZ=20 (ParFlow)
- T = 300K, U=0.6m/s, Psrf=987.9 hPa, QV = 0.0055 kg/kg

Idealized Test 2: Flow Routing





Thank you.