TerrSysMP-DART Interface: An Integrated data assimilation platform for coupled atmosphere, land surface and groundwater model

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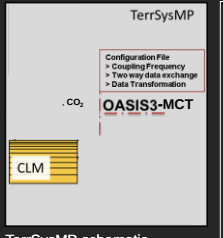
Motivation

- Development of TerrSysMP within the Collaborative Research Center TR32 to improve our understanding of patterns of energy, water and carbon fluxes and feedbacks in the terrestrial system.
- Need of data assimilation platform for better predictions and uncertainty estimates of states and fluxes of the terrestrial systems

The Data Assimilation Research Testbed (DART) provides:
- Community-based data assimilation (DA) capability.
- Easy to implement and customize with model/data needs.
- Platform for learning and teaching DA with each new models

Terrestrial System Modeling Platform (TerrSysMP)



TerrSysMP schematic (Shrestha et al. 2014) Gasper et al. 2014, Gasper et al. 2017;)

TerrSysMP
(Shrestha et al. 2014)

COSMO
Convection permitting configuration (COSMO-DE)
(Baldauf et al. 2011)

CLM
CLM3.5 (Oleson et al. 2008)

ParFlow
Integrated surface-groundwater flow model with terrain following co-ordinates
(Kollet and Maxwell 2006; Maxwell 2012)

OASIS3
External coupler with multiple executable approach
(Valcke 2013)

Shrestha P., M. Sulis, M. Masbou, S. Kollet, and C. Simmer, 2014: A Scale-Consistent Terrestrial Systems Modeling Platform Based on COSMO, CLM, and ParFlow. Mon. Wea. Rev., 142, 3466–3483

TerrSysMP-DART Interface

TerrSysMP is equipped with ensemble and model run manager system.
The interface operates in a cyclic sequential manner:
- TerrSysMP : Start/Restart of Ensemble Model Forecast
- DART : DA with selected model components

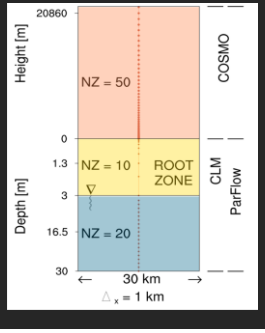
COSMO Interface
- Grid query, interpolations in native regular grids.
- Read/Write of COSMO binary restart files.

CLM Interface
- Existing interface available from the community-based effort.

ParFlow Interface
- Grid query, interpolations in regular geographic coordinates.
- Read/Write of ParFlow restart files.

Experiment Design

Weakly coupled DA (WCDA) for each model component in fully coupled semi-idealized test case.

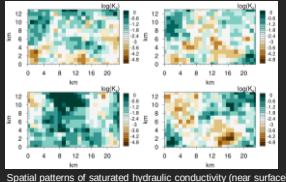


- 48 ensembles
- 5 sets of simulations
  1. Perfect Model Run (PM)
  2. OL run (OL)
  3. DA for COSMO (WCDA_cos)
  4. DA for CLM (WCDA_clm)
  5. DA for ParFlow (WCDA_pfl)
- Synthetic Observations* harvested from PM experiment
- Daily DA at 0000 UTC at 10 locations (2 zonal rows of 5 points)
- Cutoff radius ~ 125 km

Synthetic Observations*
ABL temperature (0.60 [K^2])
Soil temperature (0.10 [K^2])
Soil moisture (0.005 [-])

Experiment Design

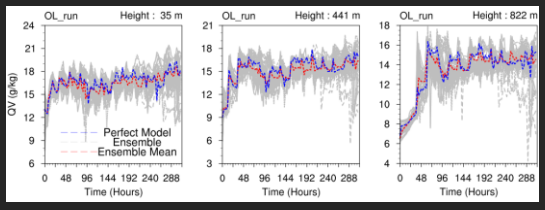
Uncertainty in soil-vegetation structure is generated using:
- Random Error Method
  Leaf Area Index, Soil Color, Clay Percentage
- Prescribed Variability
  Photosynthetic parameters, turbulent mixing length scale
- Spatially Correlated Method
  Hydraulic Conductivity



Spatial patterns of saturated hydraulic conductivity (near surface) of four different ensemble members obtained using the spatially correlated method in ParFlow (Tompson 1989)

Model Integration
- Land surface and groundwater model initialized from spinup
- Initial atmospheric sounding of air temperature and mixing ratio below 850 hPa perturbed using random error method temperature and moisture
- Model Integrated for 14 days
- Data output at 3 hourly intervals

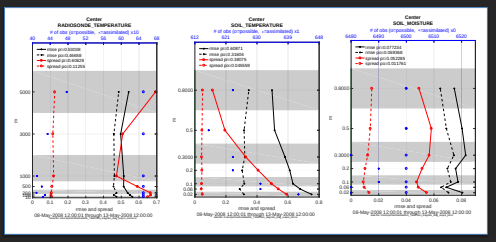
Results – Ensemble Spread from OL run



Model Level: 1 ~ 2 cm, 3 ~ 10 cm and 5 ~ 30 cm

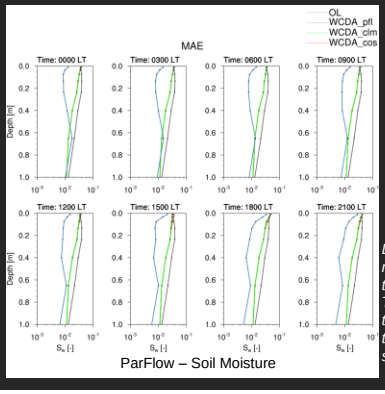
Results – Observation space diagnostics

WCDA_cos WCDA_clm WCDA_pfl



Vertical profile of time averaged response of prior and posterior rmse and ensemble spread.

Results – Mean Absolute Error (MAE)



ParFlow – Soil Moisture

Diurnal evolution of the mean absolute error for the ensemble mean. The vertical profiles are temporally averaged for the entire period of simulation.

Summary

- Assimilation of model states only improved the specific model components.
- Weaker improvements in soil temperature were also observed with assimilation of atmospheric air temperature through coupling.
- Land surface initial conditions and the radiosonde sounding used for the study could also potentially impact on the weakly coupled data assimilation.
- More tests are required to examine the affect of:
  - land surface initial conditions (dry to wet)
  - higher frequency of assimilation
  - cutoff radius
  - larger ensemble size

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