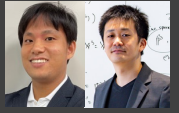


Investigating appropriate inflation methods for assimilating soil moisture data into a land surface model

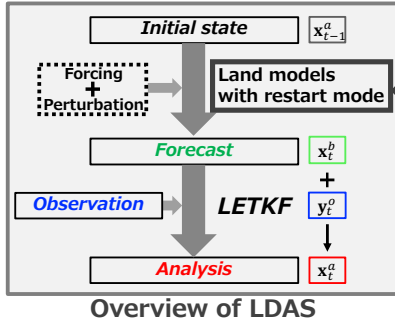


Daiya Shiojiri*, Shunji Kotsuki
IAAR, Chiba U.
(shiojiri.daiya@chiba-u.jp)

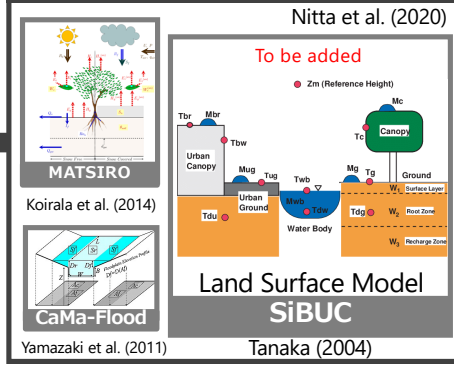


Objective

- ✓ To develop a land-DA system (LDAS) applicable to various land models
- ✓ To investigate inflation methods



Integrated Land Simulator (ILS)



Experimental design

- ✓ Assimilation of surface soil moisture (m^3/m^3)
- ✓ We also update soil moisture in the deeper soil layers (root zone and recharge zone)
- ✓ OSSE
 - True: SiBUC + GSWP3-W5E5
 - Test: SiBUC-LETKF + JRA55
 - Observation: True + $N(0, 0.05)$
- ✓ Assimilation interval: daily
- ✓ Ensemble size: 20
- ✓ Target grid: one grid in Kyoto, Japan
- ➔ Investigate appropriate inflation methods
- ✓ Perturbed forcing
- ✓ Relaxation to prior



Inflation: perturbed forcing (+ RTPP)

Same precipitation to all the ensembles

Different initial conditions → Same results (saturation)

Different precipitation to all the ensembles

Different initial conditions → Ensemble perturbation

Correlated random numbers $\epsilon_t \sim N(0, \sigma^2)$

Reichle et al. (2007)

	Prec	SWdn	LWdn
Prec	1	-0.8	0.5
SWdn	-0.8	1	-0.5
LWdn	0.5	-0.5	1

First-order auto regressive model $\epsilon_t \leftarrow AR1(\epsilon_{t-1})$

Multiplicative inflation $F \leftarrow F \cdot (1 + \epsilon_t)$

Additive inflation $F \leftarrow F + \epsilon_t$

Analysis ens. ptb. + Background ens. ptb.

RTPP: $Z_t^a \leftarrow (1 - \alpha_{RTPP})Z_t^a + \alpha_{RTPP}Z_t^b$

➔ Sensitivity analysis to σ_{pr}^2 and α_{RTPP}

Results: Assimilation of surface soil moisture

Inflation: only perturbed forcing

Sensitivity analysis

Rain inflation σ_{pr}^2 Changed from 0.1 to 1.5

RMSE takes minimum value at $\sigma_{pr}^2 = 1.0$

Assimilation result when $\sigma_{pr}^2 = 1.0$

Soil moisture = 1 (saturated)
Soil moisture is frequently saturated in some members.
= This may cause instability of assimilation.

True Analysis w/o DA

Soil moisture in the recharge zone (third layer)

Surface soil moisture assimilation Improves the accuracy of the soil moisture in a deeper layer

Perturbed forcing+ RTPP

Sensitivity analysis

Rain inflation σ_{pr}^2 Changed from 0.1 to 1.5

α_{RTPP} for RTPP Changed from 0 to 1.0

SM: soil moisture

Surface SM RMSE

SM in root zone RMSE

SM in recharge zone RMSE

Large σ_{pr}^2 / Small σ_{pr}^2

Small RTPP / Large RTPP

- ✓ RTPP may reduce rain inflation but its effect is limited.
- ✓ Soil moisture assimilation needs large rain inflation.
- $\sigma_{pr}^2 = 0.8 - 1.2$
- Unnatural precipitation can be generated.

Summary

- ✓ Developed an LDAS applicable to various land models
- ✓ Land-DA needs perturbed forcing as an inflation method.
- ✓ Large rain inflation improved the accuracy of soil moisture assimilation even when it caused unnatural precipitation.