Effect of the land surface hydrologic processes on land-air interactions in Taiwan using WRF-Noah and WRF-NoahMP

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Introduction

The land surface hydrologic processes such as surface/subsurface runoff and soil-groundwater interaction strongly affect soil moisture. To understand how the land surface hydrologic processes affect the land-air interactions in Taiwan, the WRF model coupled with two land surface models (Noah and Noah-MP) were applied. The major difference between the two LSMs is that a free drainage is specified as the lower boundary condition in Noah LSM while the Noah-MP considers the dynamic interactions between the soil and the aquifer. Noah-MP LSM adopts semi-tile approach to calculate energy fluxes from vegetated and bare land separately, while Noah LSM combines surface layer of vegetation and soil surface, over which surface energy fluxes are computed.

Model Configuration

Model configuration is shown in Table 1 and domain setup is shown is Fig 1. Three WRF experiments are conducted with different LSMs, with (1) Noah LSM, (2) Noah-MP LSM with MPr5.

Table.1 . WRF model configuration

WRFv3.9.1		
	Noah	MPr5
Simulation periods	2015/08/01 00UTC- 2015/08/10 00UTC	
Reanalysis data	NCEP FNL(0.25°x0.25°,6 hour)	
Resolution	15km(d01),3km(d02)	
Vertical levels	49(to 30 hpa)	
PBL scheme	YSU scheme	
Land surface model	Noah	Noah-MP (OPT_RUN=5)

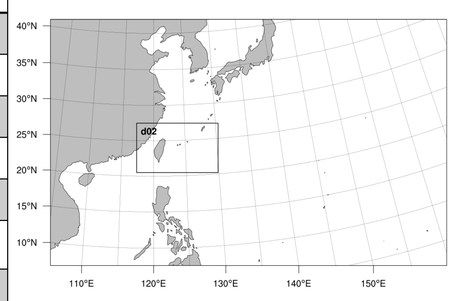

Fig.1. Domain setup.

Noah multi-parameterization options land surface model (Noah-MP) has several physical processes option to choose, such as dynamic vegetation, radiative transfer, runoff and groundwater, etc. The comparison between MPr1 and MPr5 is shown in Table 2.

Table.2 .Noah-MP options selected for MPr5 .

Noah-MP options	
	MPr5
Dynamic vegetation	Off (LAI from table, FVEG = maximum veg. fraction)
Stomatal resistance	Ball-Berry
Surface layer drag coefficient	Monin-Obukhov
Soil permeability	Linear effects, more permeable
Radiative transfer	Two-stream applied to vegetated fraction
Runoff and groundwater	Miguez-Macho & Fan groundwater scheme
Groundwater physics	Aquifer is dynamically determined depth below or within soil layers
Water table depth	Equilibrium water table depth provided by WPS3.9.1 Water table change with time
Water table change	Considers lateral flow of the aquifer and groundwater-river exchange

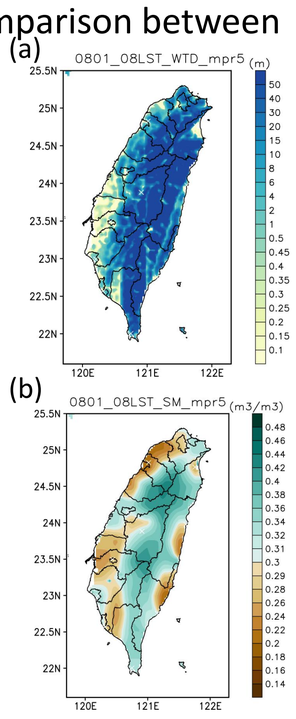

Fig.2. (a)WTD and (b) SM at the initial time.

Result

- Noah only considers free drainage and Noah-MP considers soil-groundwater interaction.
- The water table depth is shallower in southwestern Taiwan than in the central mountain area (Fig.3). The shallower water table would affect the soil moisture significantly in southwestern Taiwan (Fig.4).

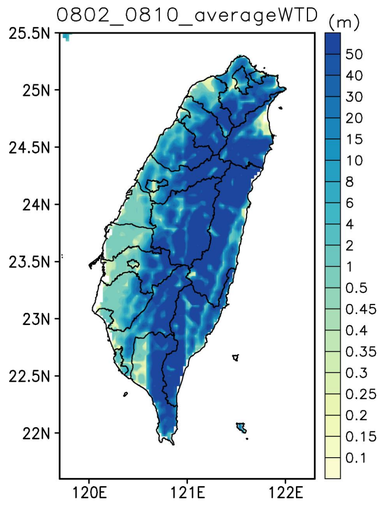

Fig.3. 08/02-08/10 average water table depth.

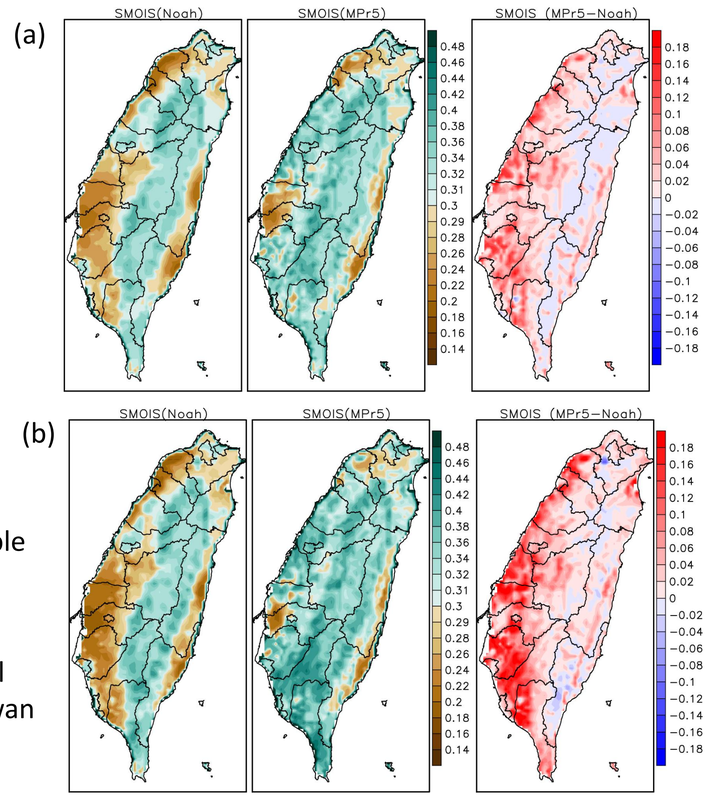

Fig.4.(a) 08/03 and (b) 08/05 daily average soil moisture. The higher soil moisture in the plain of western Taiwan than in the mountain area of central Taiwan.

- Soil moisture impacts the surface budget. MPr5 has groundwater – soil interaction which causes higher soil moisture and latent heat flux, especially in the plain of southwestern Taiwan (Fig.5).

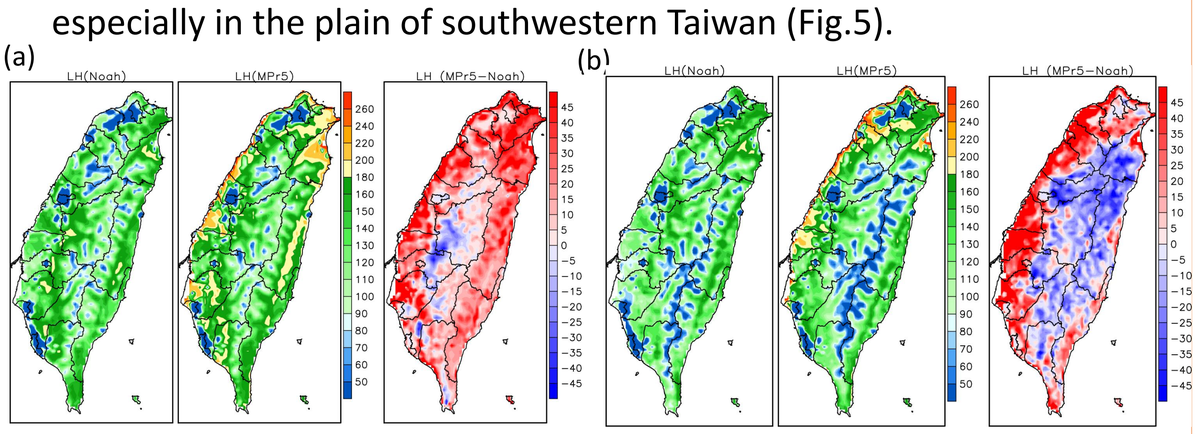

Fig.5.(a) 08/03 and (b) 08/05 daily average latent heat flux.

- MPr5 has higher latent heat flux which cause higher 2m mixing ratio and more accumulated rainfall.

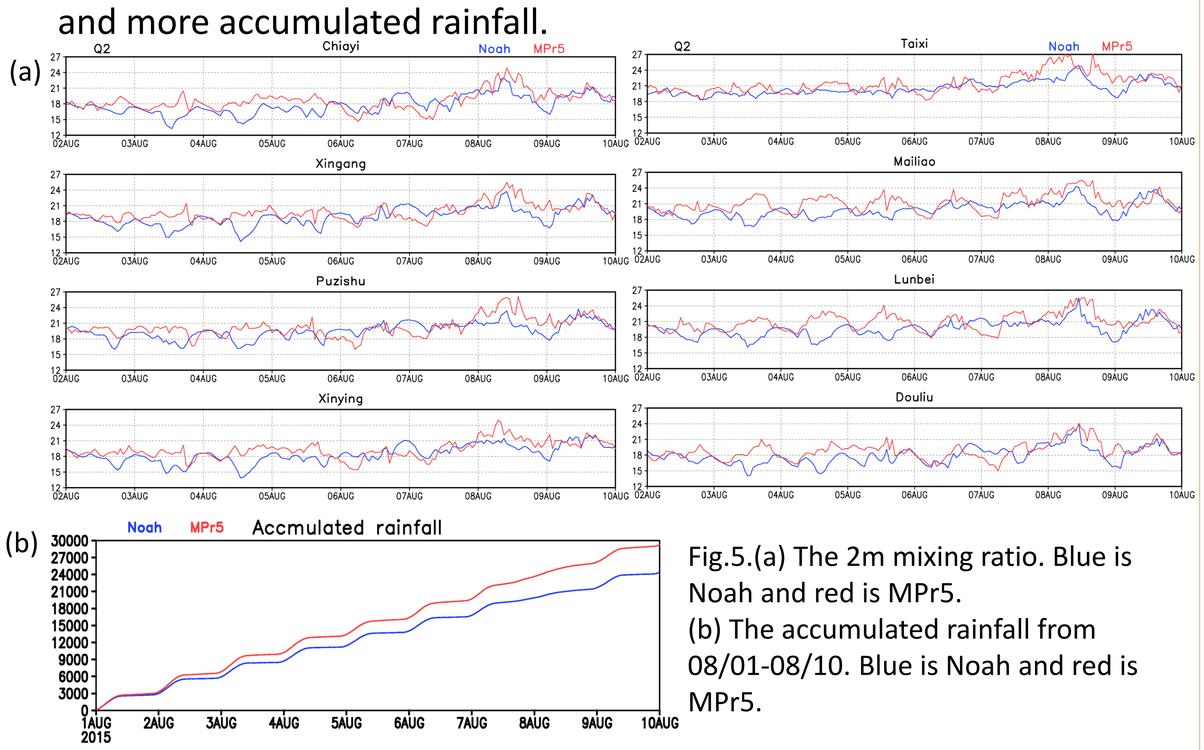

Fig.5.(a) The 2m mixing ratio. Blue is Noah and red is MPr5.
(b) The accumulated rainfall from 08/01-08/10. Blue is Noah and red is MPr5.

Summary

- The Noah has lower soil moisture because Noah only consider free drainage in the soil column.
- The Noah-MP with MPr5 option would consider the soil-groundwater interaction which results in higher soil moisture, higher latent heat flux and higher 2m mixing ratio. This result cause more rainfall with using Noah-MP LSM.
- Major problem of preliminary study is that **the soil moisture and WTD are unrelated at initial time.** To have a better understanding of impact of hydrologic process on land-air interactions, the soil conditions at the equilibrium stage is required for the soil moisture and WTD initialization process.

Future work

- An equilibrium soil moisture and an equilibrium water table depth is needed to drive the WRF simulations. So we will conduct **off-line Noah-MP LSM** to provide the equilibrium water table depth and soil moisture for WRF simulations in the future.
- Evaluate the simulation result with observation data and assess the impact of the hydrologic processes on simulated PBL characteristic and rainfall.

Reference

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- Fan,Y.,G.Miguez-Macho, C. P. Weaver, R . Wa lko, and A. Robock (2007), Incorporating water table dyna mics in climate modeling: 1. Water table observation and equilibrium water table simulations, *J. Geophys. Res*., **112**, D10125,doi:10.1029/2006JD008111.