Impact of vegetation on summer season precipitation over Central Mongolia

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Introduction

- Mongolia is situated in an arid and semi-arid zone in Northeast Asia. The southern part of the territory has a desert type climate. The Taiga forest covers the northern part of Mongolia, extending to Siberia in Russia (Sato et al., 2006).
- The 60-70% of the annual precipitation is observed during the summer season in Mongolia (Natsagdorj L, 2005).
- For any weather system to develop and sustain over land, the contribution of the land surface is primary concern. Change in vegetation fraction can induce major changes in the local effects such as local evaporation, surface radiation, etc., (Surya et al.,2009)
- Changes in vegetation greenness is strongly influence on regional climate through partitioning sensible and latent heat fluxes (Notaro et al., 2006).

Aim of study

- This study deals with the effects of vegetation in climate modeling over Mongolian region using the MM5 and WRF mesoscale model.
- The main objective of this study is to investigate the impact vegetation fraction derived from MODIS NDVI data versus that of prescribed climatological vegetation fraction on the simulation of the Mongolian summer season.
- The focus of this study is on summer season over the Central Mongolia, which has been identified by Standardized Precipitation Index (SPI).

Case of Study

- **Simulation period is selected June, July and August (JJA) of 2002 year, which is less than normal precipitation over central Mongolia.**

- **The Standardized Precipitation Index (SPI) is a relatively drought/dryness index based only on observed rainfall (McKee *et al.* (1993). The SPI defines standardized departure with respect to a rainfall probability distribution function.**

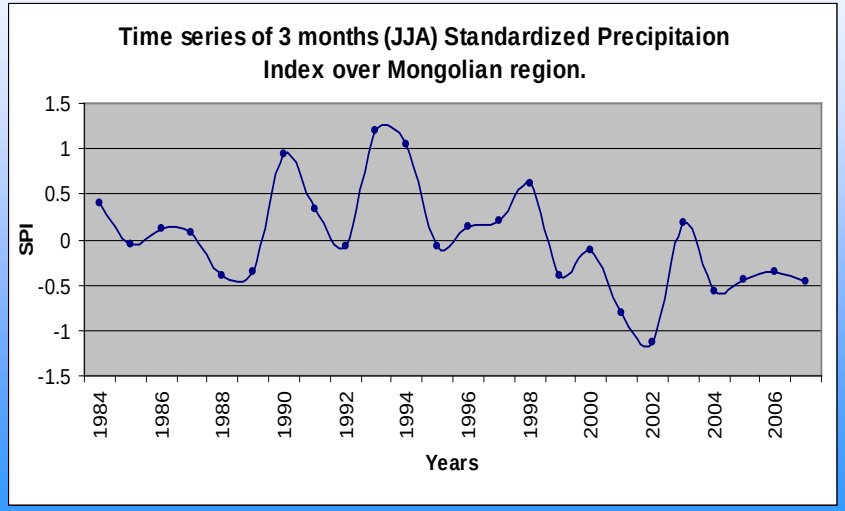
In statistics: SPI is usually calculated as.

$$SPI=(P-P_{aver})/St.Dev$$

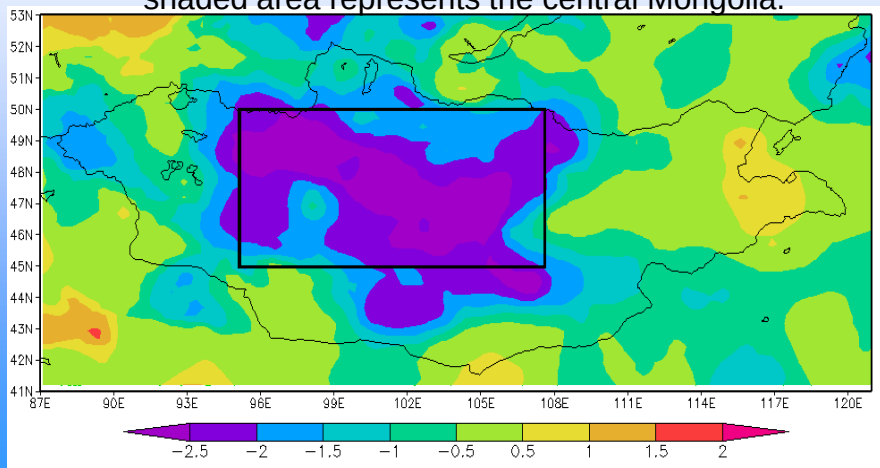
In this case

P-sum of precipitation of summer season
P_{aver}-mean of precipitation of summer season for observation period
St.Dev-standard deviation

SPI Values	
2.0+	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry



Spatial distribution of SPI in JJA 2002 over Mongolia, shaded area represents the central Mongolia.

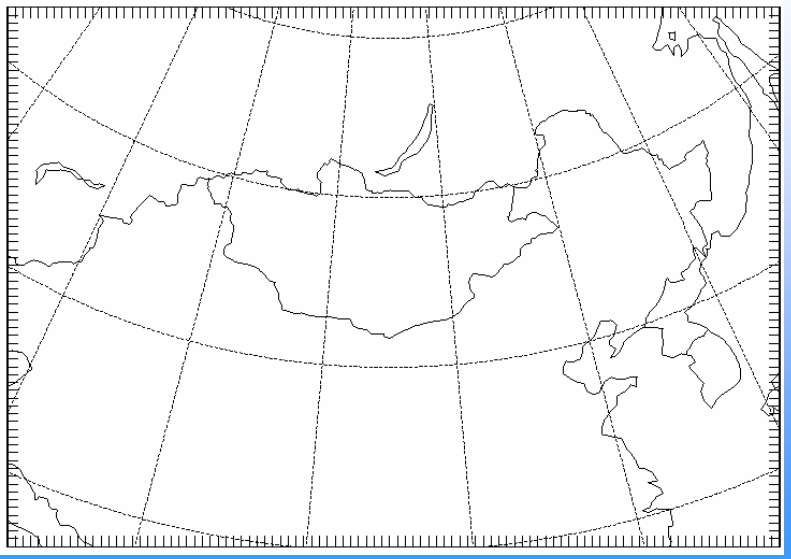


Experimental setup

In this study

- MM5 and WRF model are used.
- Models are simulated for 110 days starting from 00UTC of 15 May to 00UTC of 1 September 2002
- The simulations have been done separately using both vegetation fractions, prescribed climatological and derived MODIS NDVI.
- The simulated outputs obtained were compared with the observational and Reanalysis dataset.
- Similar parameterization schemes were chosen for MM5 and WRF model.

- MM5 and WRF model with prescribed climatological Vegetation fraction, herein after **MM5-Default, WRF-Default**
- MM5 and WRF model with MODIS NDVI derived Vegetation fraction, herein after **MM5-Modified, WRF-Modified**



- RRTM/Dudhia radiation
- MRF planetary boundary layer
- NOAH land surface model
- Kain-Fritsch cumulus scheme
- Microphysics scheme
  - Eta for WRF model
  - Reisner-1 for MM5 model
- Initial and boundary condition from NCEP FNL Analysis
- 45 km horizontal grid, 70x100 grid points

Vegetation Fraction

Vegetation fraction is the percent of solar insolation absorbed by green plant canopy.

MM5 and WRF model uses the 5 year climatological vegetation fraction.

- Linier formulation using NDVI value for GVF

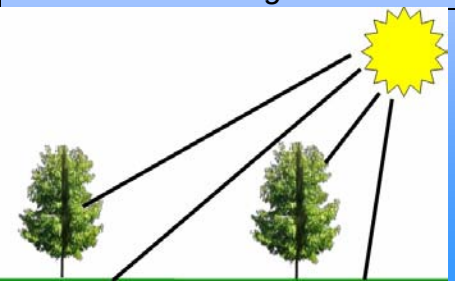
(Gutman and Ignatov (1998))

$$Fg = \frac{N - N_{Fg0}}{N_{Fg100} - N_{Fg0}}$$

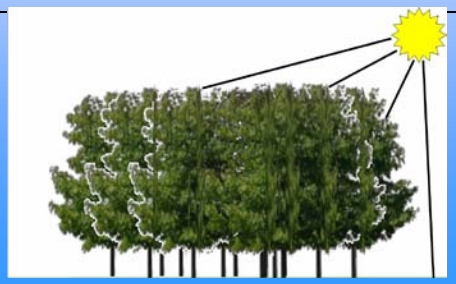
- Here, *N*-monthly maximum NDVI,

  N_{Fg100} the NDVI value for each veg.category, that corresponds to 100% vegetation cover.

  N_{Fg0}- the NDVI for barren or sparsely vegetated veg.category (N_{Fg0}=0.05)



20% VF.

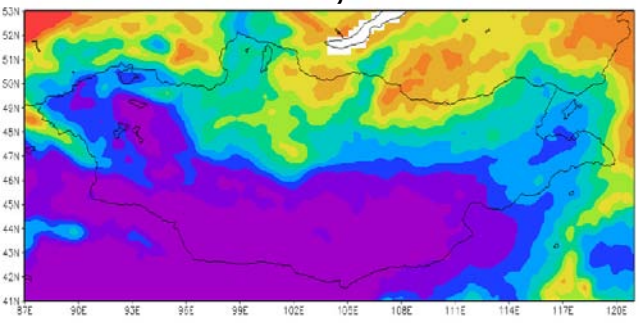


100% VF.

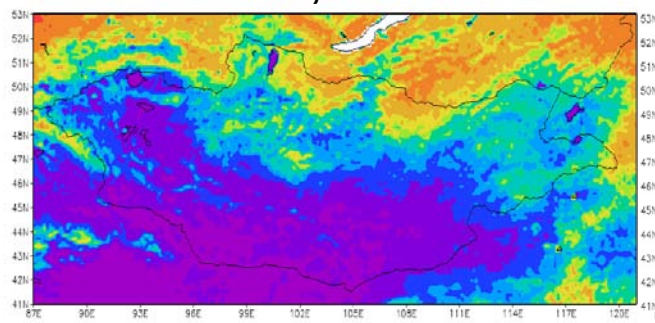
Vegetation Data

5 years climatological and MODIS derived vegetation fraction (%) and their differences for months over Mongolian region, 2002

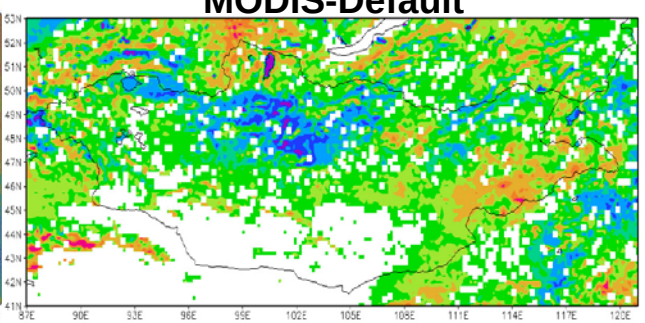
Default, June



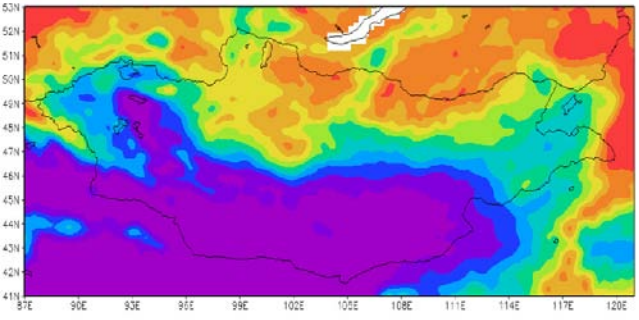
MODIS, June



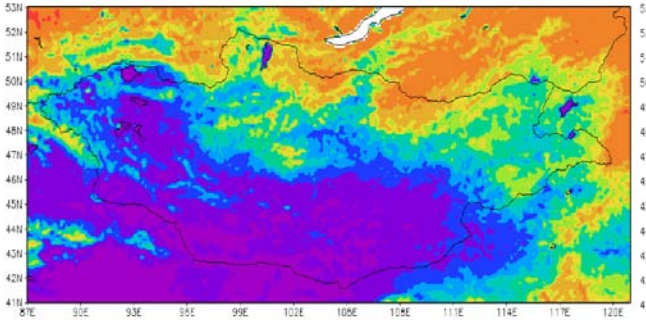
MODIS-Default



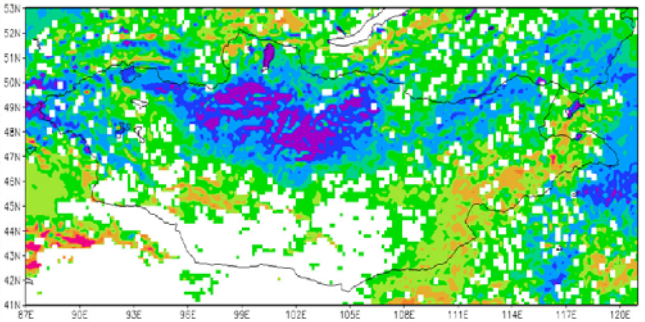
Default, July



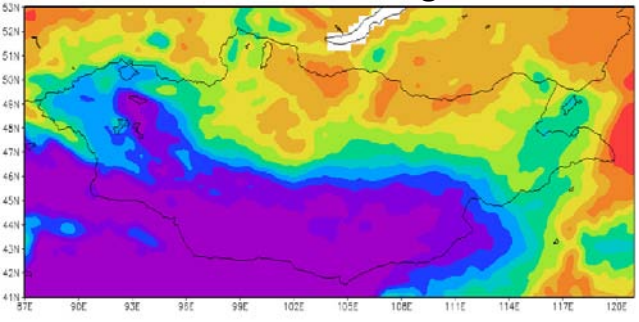
MODIS, July



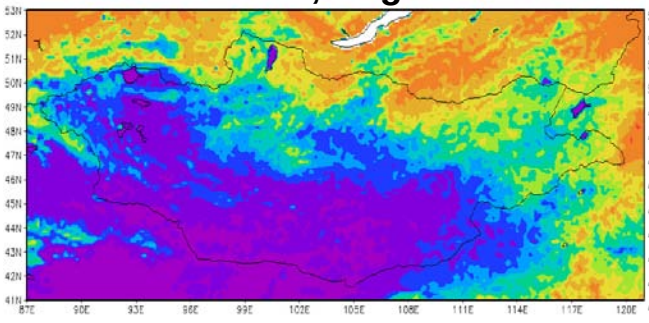
MODIS-Default



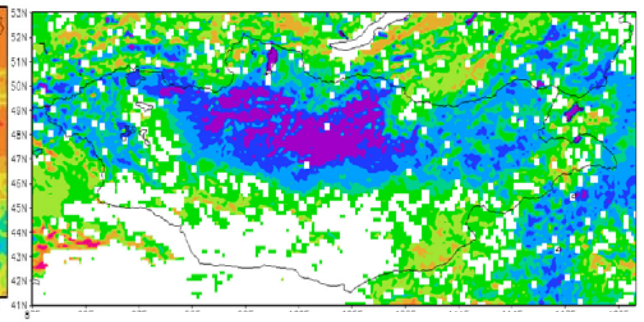
Default, August

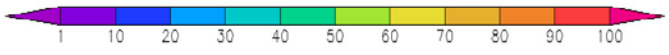


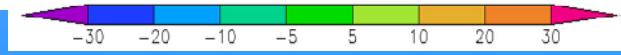
MODIS, August



MODIS-Default





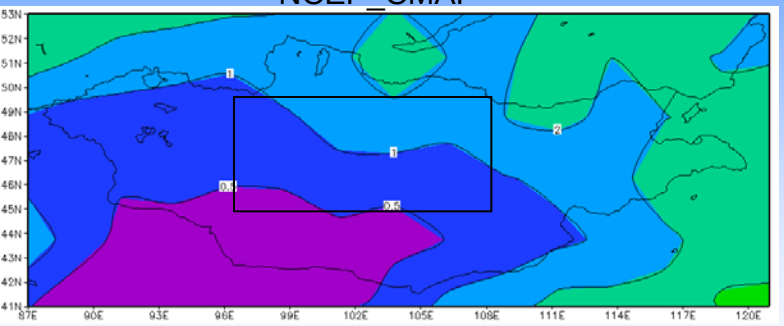


Results

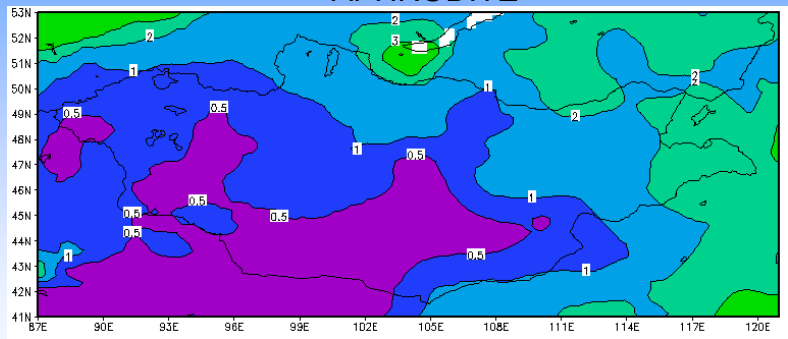
Observed and simulated precipitation in June, July, and August (JJA) 2002 over Mongolia.

Observed JJA precipitation from NCEP_CMAP and APHRODITE

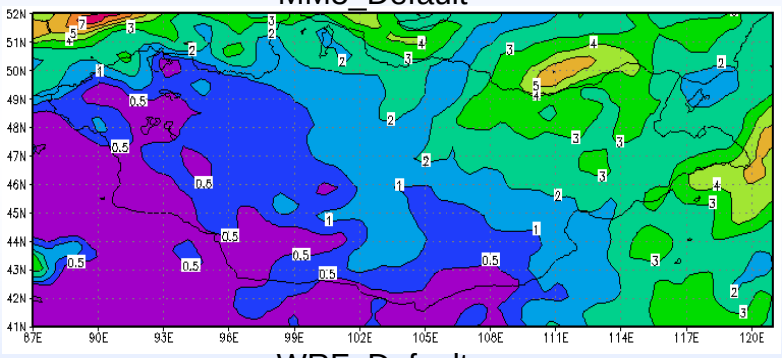
NCEP_CMAP



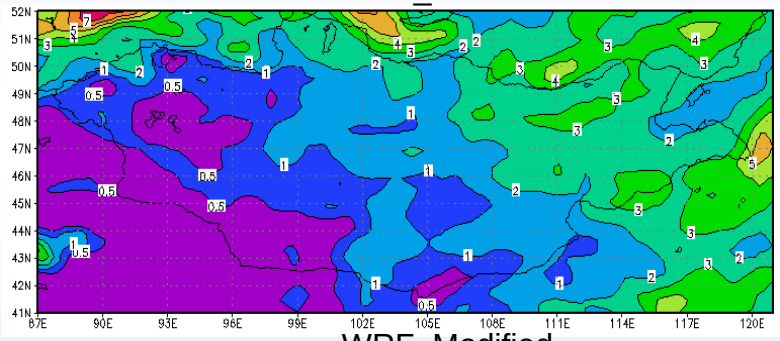
APHRODITE



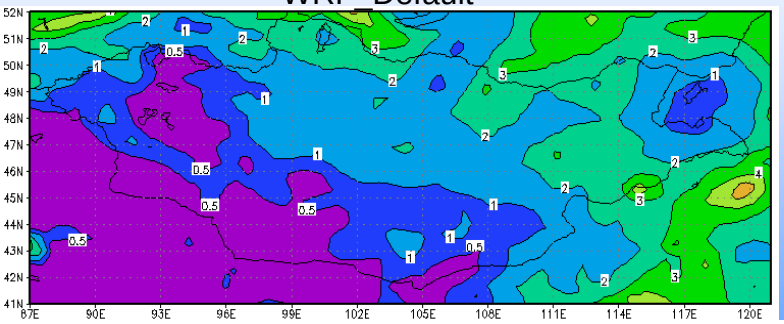
MM5_Default



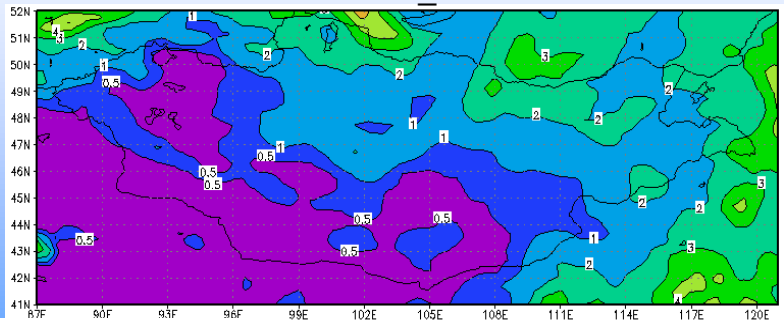
MM5_Modified



WRF_Default

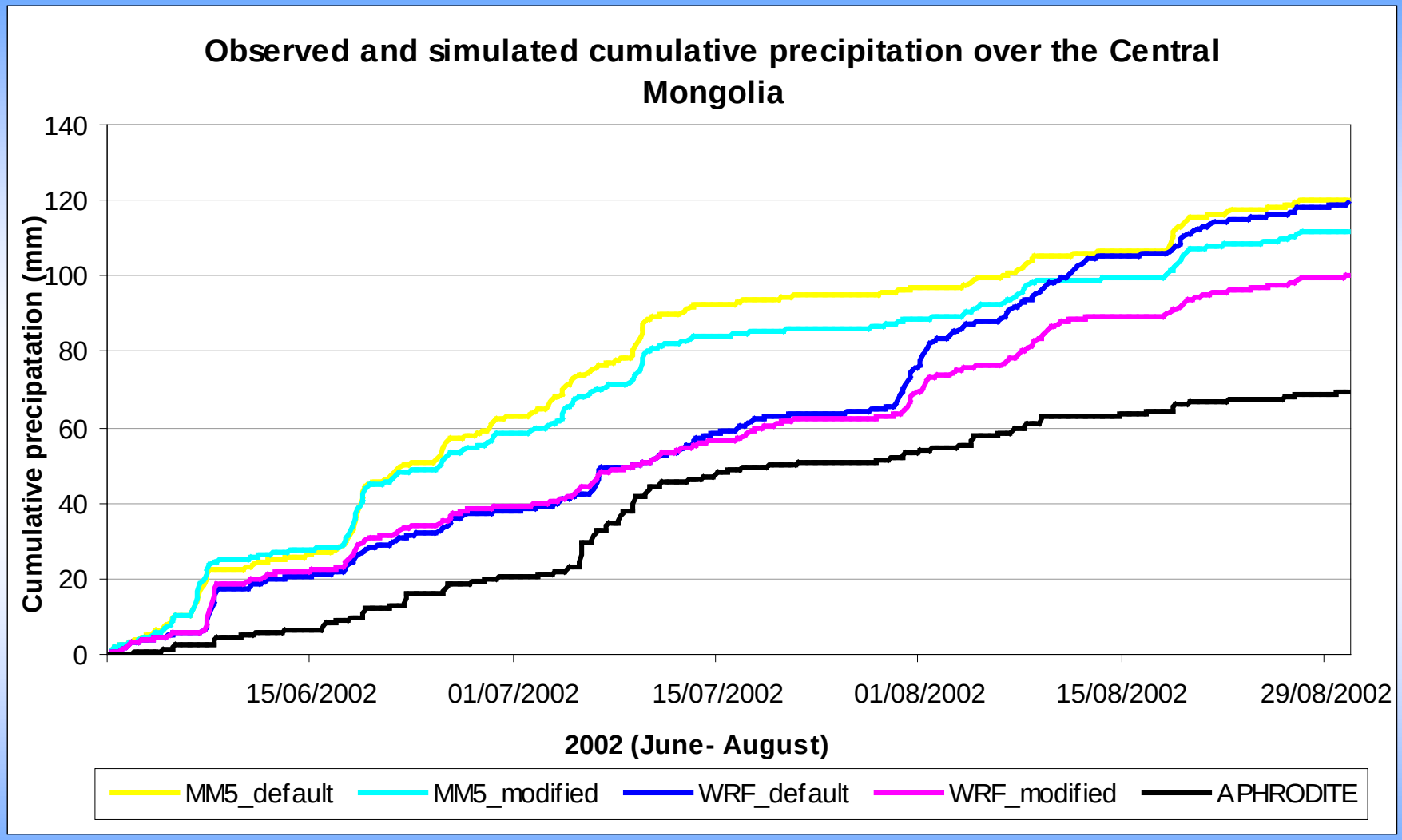


WRF_Modified



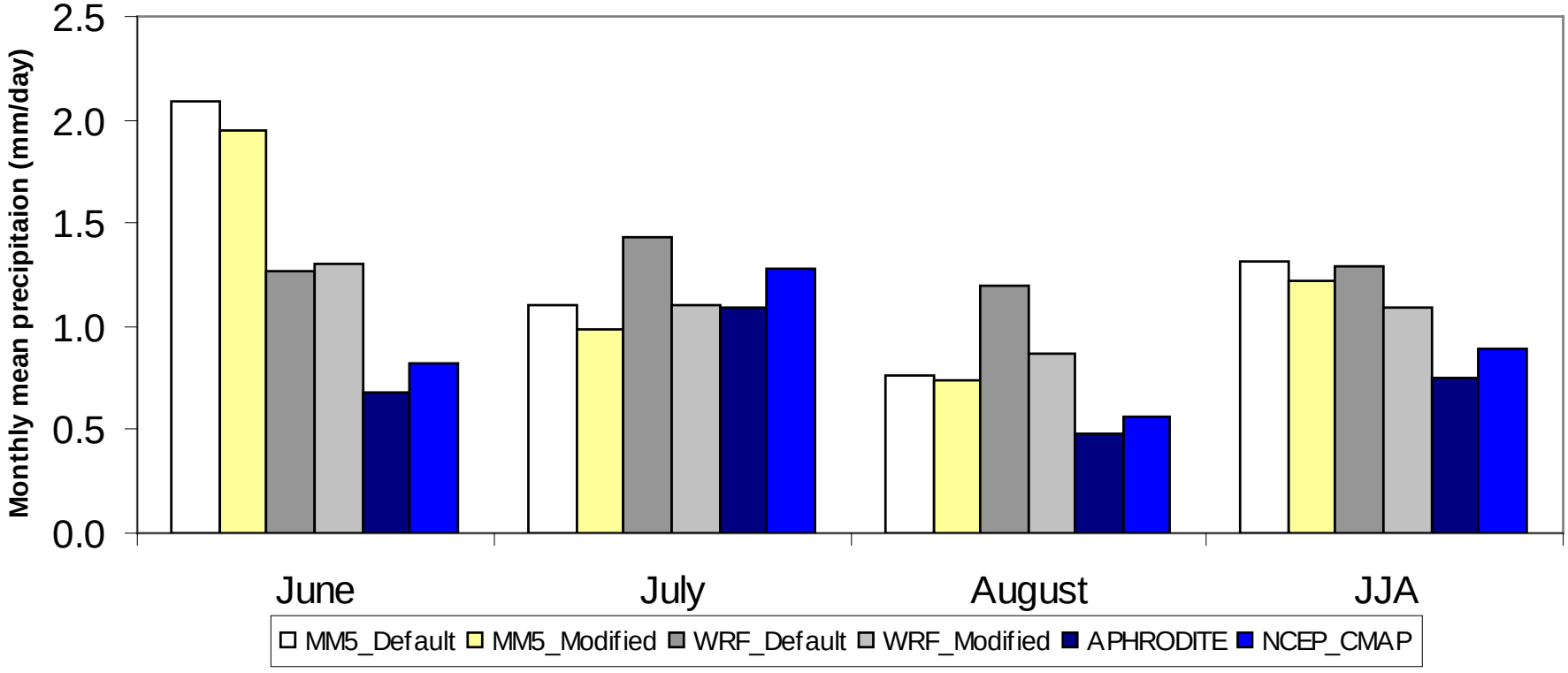
(mm/day)

The APHRODITE and NCEP CMAP data are used for comparison of the rainfall simulations.
APHRODITE-Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation (0.25x0.25)
CMAP -CPC Merged Analysis of Precipitation (2.5x2.5)

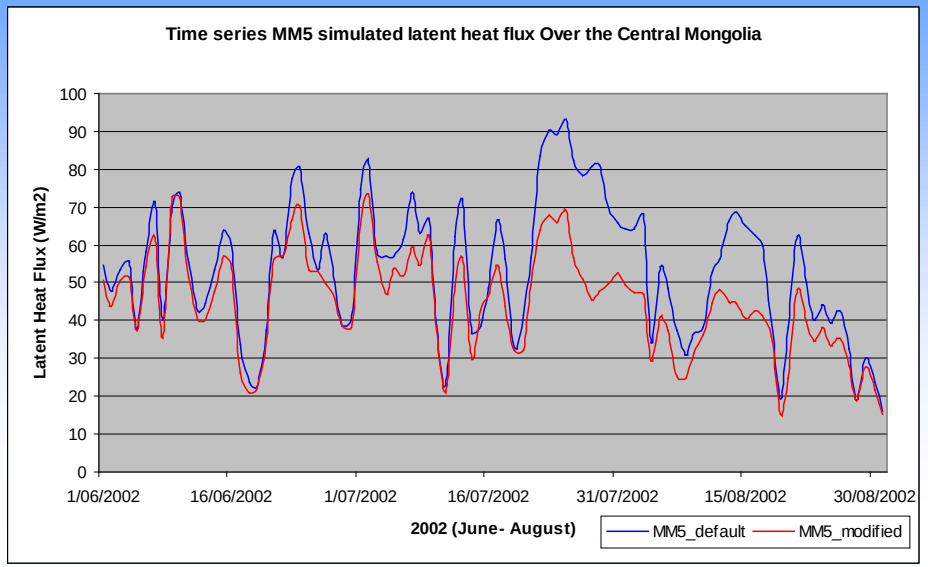


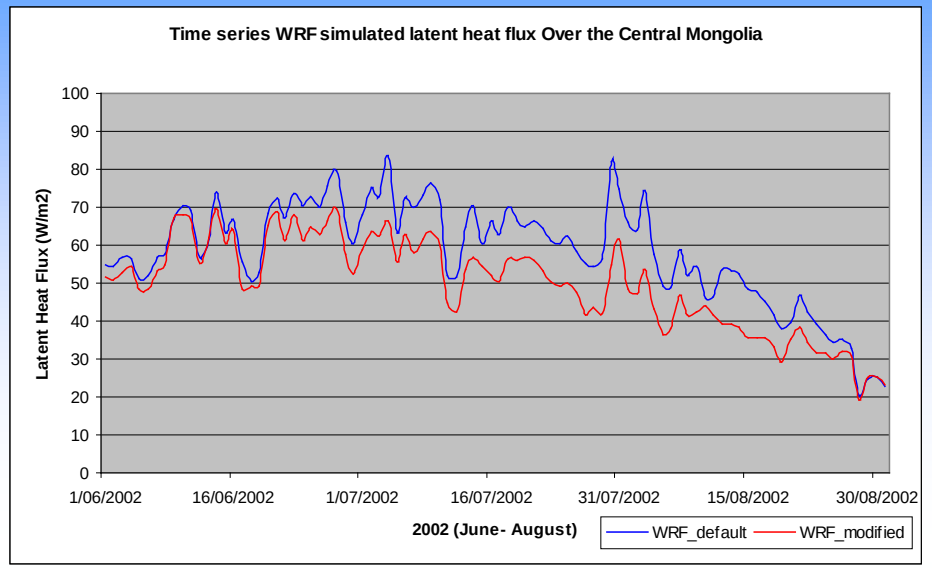
Decreased cumulative precipitation by both Modified simulations are 9% and 16% in MM5 and WRF, respectively.

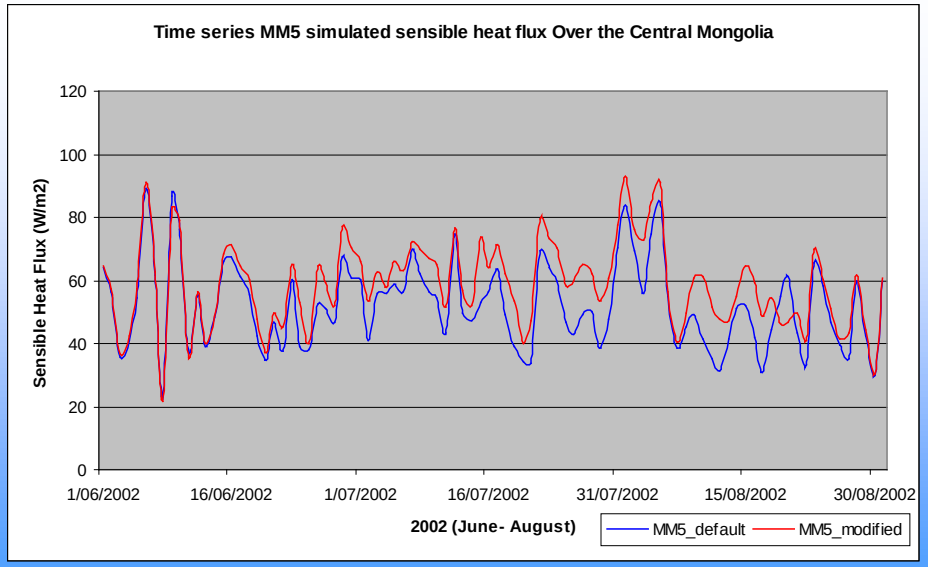
Observed and Simulated JJA and monthly mean precipitation over The Central Mongolia

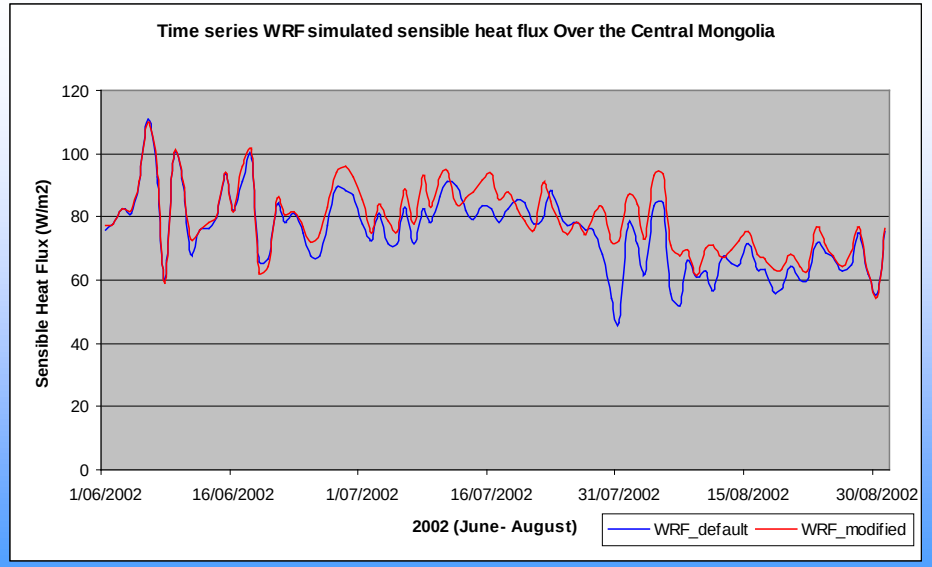


Comparison of simulated latent heat flux and sensible heat flux over the Central Mongolia



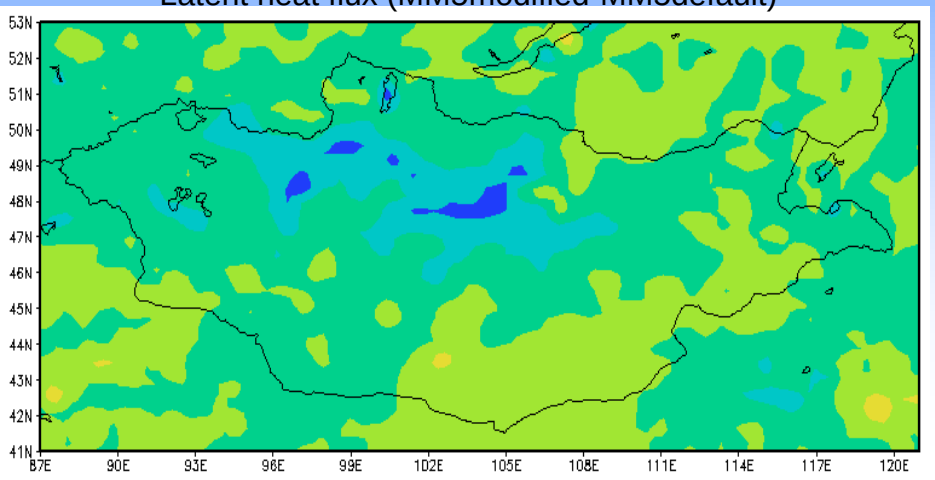




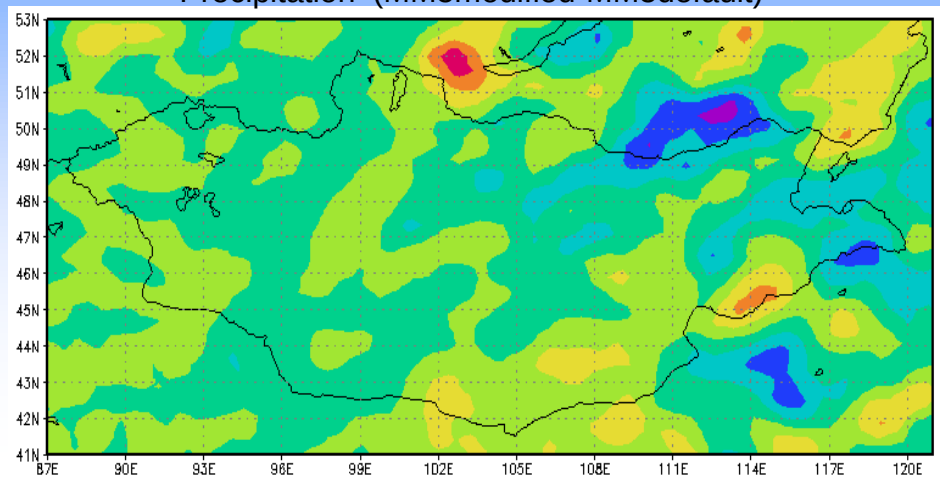


Map of differences in monthly average latent heat flux and precipitation between Default and Modified experiments. The domain covers the over Mongolia.

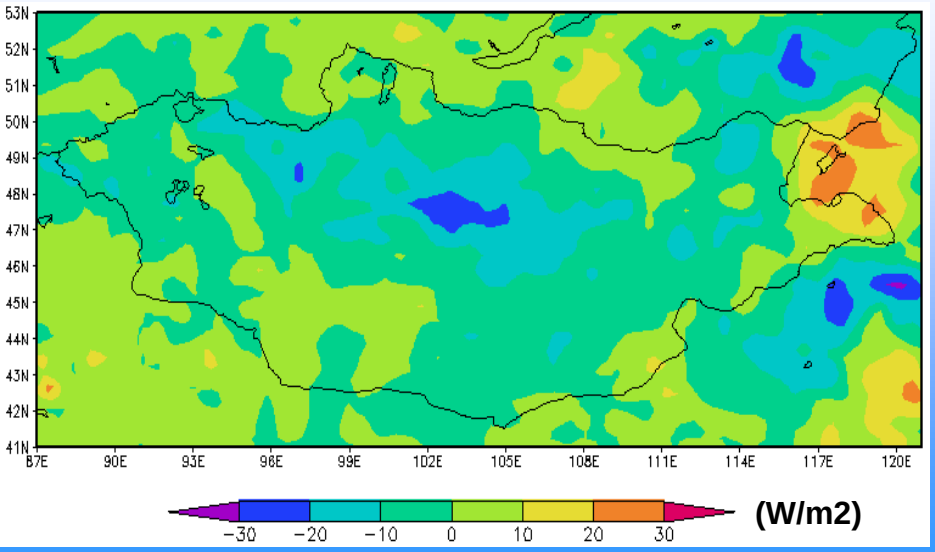
Latent heat flux (MM5modified-MM5default)



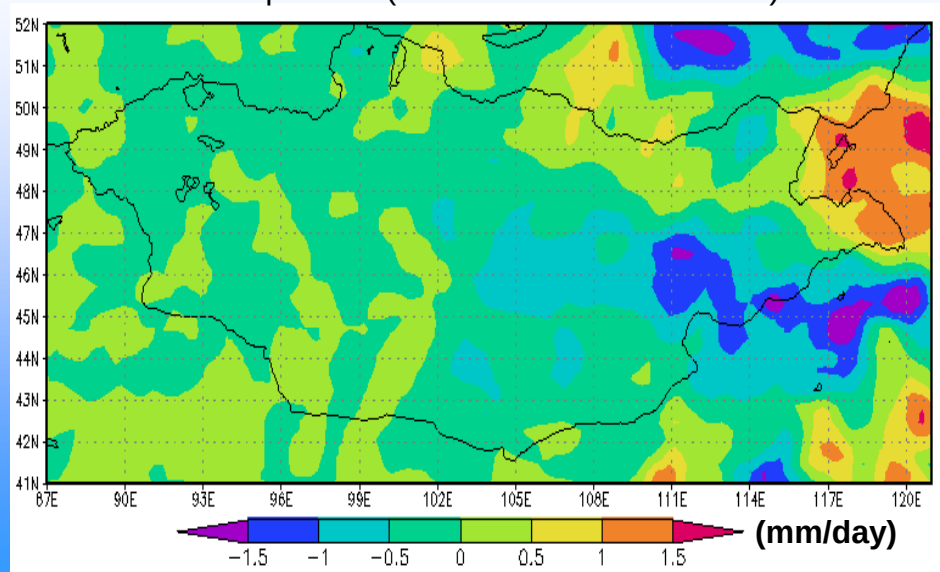
Precipitation (MM5modified-MM5default)



Latent heat flux (WRFmodified-WRFdefault)



Precipitation (WRFmodified-WRFdefault)



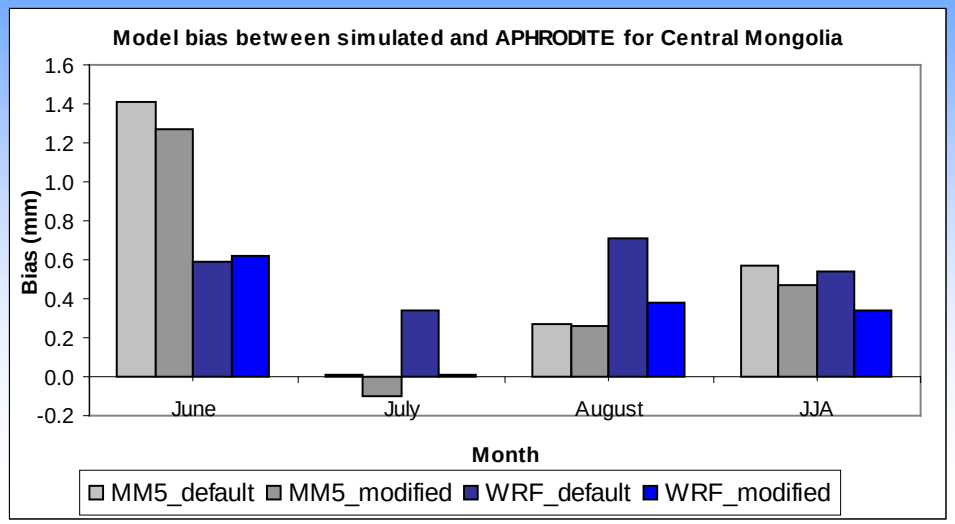
Water budget

Water budget over the Central Mongolia June, July, August 2002

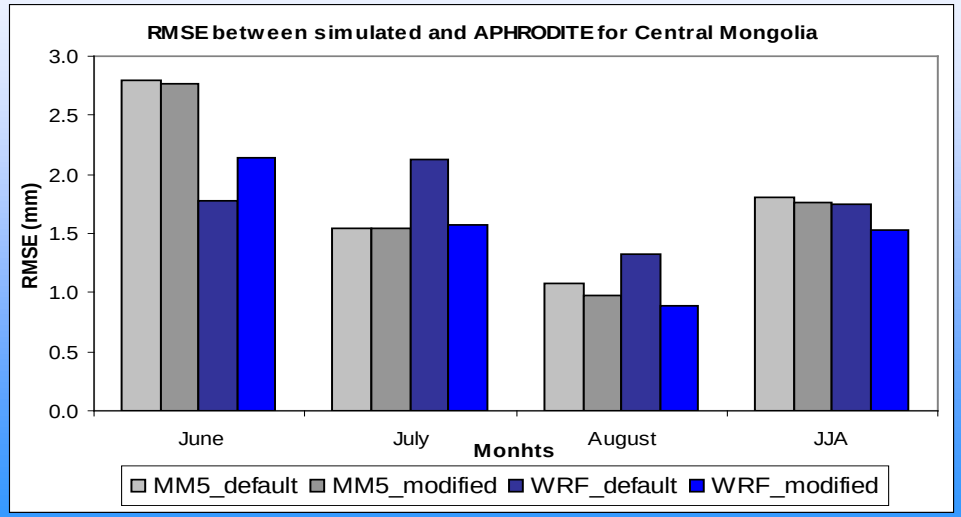
Variables	Precipitation (mm/day)	Calculated Evapotranspiration (mm/day)	Moisture Flux Convergence (mm/day)
MM5_Default	1.316	1.876	-0.237
MM5_Modified	1.224	1.557	-0.077
WRF_Default	1.295	2.013	-0.574
WRF_Modified	1.090	1.723	-0.842
NCEP Reanalysis	0.753*/0.882	1.991	-1.317

*** APHRODITE precipitation data**

Model bias of MM5 and WRF simulations using difference vegetation for JJA 2002



RMSE of MM5 and WRF simulations using difference vegetation for JJA 2002



Summary

- In this study shows that by changing the vegetation fraction in MM5 and WRF mesoscale model. The difference in the all experiments output is only due to the difference in the vegetation fraction.
- This period significant changes in precipitation simulations are observed both models. Model with MODIS derived vegetation fraction improves simulations of summer precipitation over the Central Mongolia. Simulated precipitation for WRF is better than for MM5. Default model produces more precipitation in comparison to observations.
- When MODIS derived vegetation fraction is included in the model, less precipitation generated by simulation correspond to lower latent heat flux and higher sensible heat flux.
- ET is an important water vapor source for summer precipitation. Mean evaporation exceeds mean precipitation with largest in JJA that this case 10-40 cm soil moisture is relatively dried over central Mongolia.
- Statistical parameters for WRF are slightly better than for the MM5.

  Finally WRF_modified simulation shows that lesser bias and RMSE and simulated rainfall is closer to observation.

Thank for your attention