North American and Global Land Data Assimilation Systems: Capability in Simulating Water and Energy Budget Over the U.S. Rocky Mountains and China Tibetan Region

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Background:

North American (NLDAS) and Global Land Data Assimilation Systems (GLDAS) were jointly developed by NOAA and NASA scientists in 1999, through the collaboration with several universities and other government agencies.

The NLDAS mainly focuses on continental US only although it includes southern Canada and northern Mexico. GLDAS includes two versions: NCEP/CFSR GLDAS and NASA GLDAS. The NCEP GLDAS version is a part of CFSR and CFS, and near future GFS. Its purpose is to provide optimal initial conditions to coupled model systems. The NASA GLDAS version mainly focuses on providing offline-simulated water, energy, and state variables to drought monitoring and water resource management community. In this point, NASA GLDAS is quite similar to NCEP NLDAS.

As there are more and more observations and references, the capacity of two systems in simulating water and energy budget in mountainous regions such as Rocky mountains and Tibetan Plateau needs to be evaluated although these regions are still challenging land surface modelling community.

Background (continue):

Major reasons: precipitation measurement errors (complex topography, rain & snow partitioning), snowpack, soil frozen and thaw processes, albedo (snow and snow free), very stable boundary layer etc.

NCEP NLDAS System: Operational Implementation at NCEP in August 2014

Four Models: Noah2.8, Mosaic, SAC, and VIC (version 4.0.3)
Region: US, S. Canada & N. Mexico, spatial resolution: 1/8 degree (~12-14 km), temporal resolution: one hour

NCEP GLDAS System: Operational Implementation at NCEP in April 2011

Noah2.7 only (CFSR forcing + [gauge, satellite & model precipitation])
Region: globe, spatial resolution: T382 ~ 38 km, temporal: hourly

NASA GLDAS System:

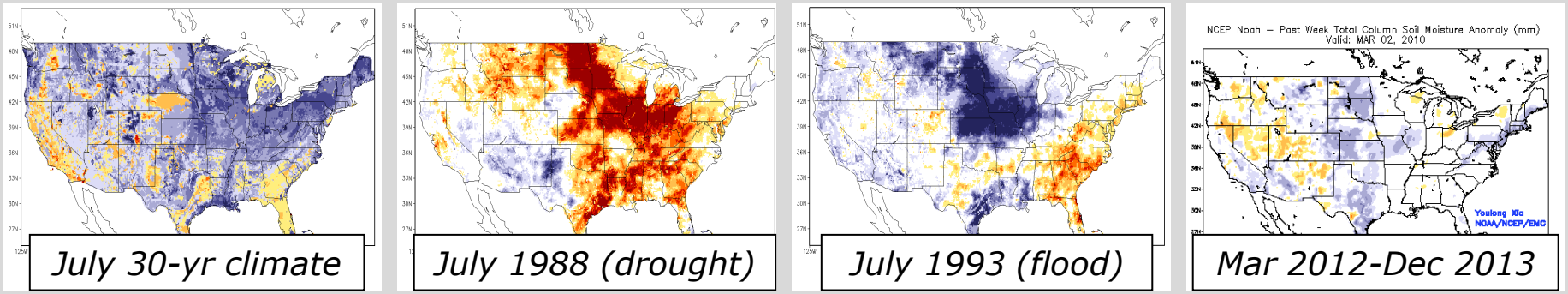
NASA GLDAS version 1 - CLM2, Mosaic, Noah2.7, VIC (one degree, 3 hourly)

NASA GLDAS version 2 – Noah3.3 (one degree, 3-hourly)
Gauge, satellite and reanalysis precipitation and air temperature

North American Land Data Assimilation System (NLDAS)
Operational at NCEP 05 August 2014

- **Land models**: Noah, SAC, VIC, Mosaic run in "uncoupled" mode.
- **Forcing**: NCEP Climate Prediction Center obs precip (gauge-based, radar/satellite disaggregatred), and atmospheric forcing from NCEP North American *Regional Climate Data Assimilation System.*
- **Output**: 1/8-deg. land & soil states, surface fluxes, runoff/streamflow.
- **Climatology** from land model assimilation runs for 30+ years provide **anomalies** used for **drought monitoring**; supports USDM, NIDIS etc.
- **Comprehensive evaluation** of **energy fluxes**, **water budget** and **state variables** using in situ and remotely-sensed data sets.
- **Evaluate** land-atmosphere **coupling metrics** for NLDAS climatology.
- NOAA/CPO/MAPP-supported partners: NCEP,NASA,***Princeton***,UW,NWC.

www.emc.ncep.noaa.gov/mmb/nldas ldas.gsfc.nasa.gov/nldas/NLDAS2valid.php



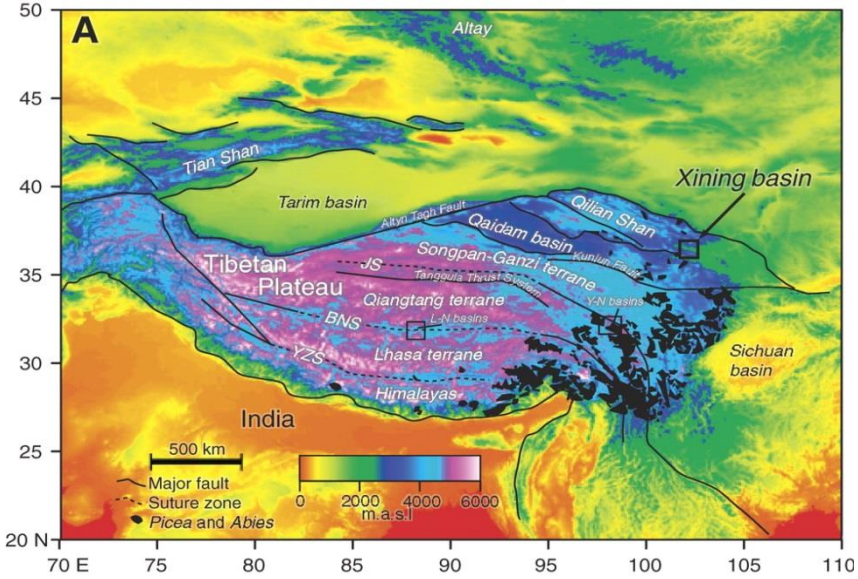
July 30-yr climate | *July 1988 (drought)* | *July 1993 (flood)* | *Mar 2012-Dec 2013*

NLDAS four-model ensemble monthly soil moisture anomaly

Selection of Two Example Regions

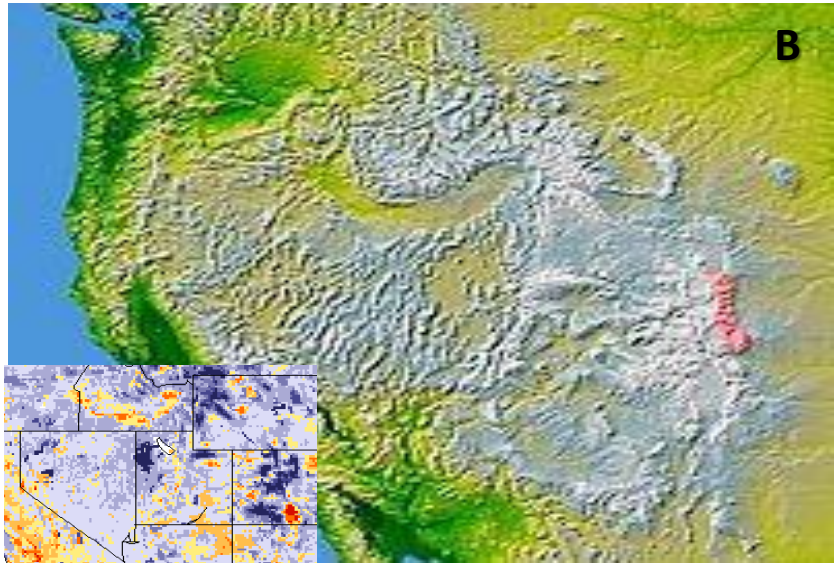
75-105°E, 25-40°N

Tibetan Plateau



120°W - 105°W, 35-45°N

Western US – Rocky Mountains



Observed and Reference Datasets

Water Budget

Snow Water Equivalent (SWE) Data: SNODAS (2004-2014)

Monthly Total Runoff (Q) Data: USGS HUC8 (1979-2014), GDRC (mean climatology)

Monthly ET: Gridded FLUXNET (Jan1982-Dec2008, Jung et al. 2009)

Energy Budget

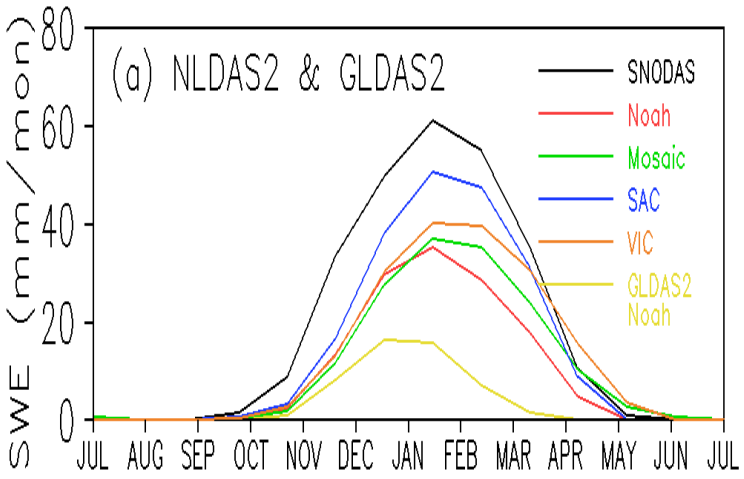
Monthly Radiation including downward and upward, shortwave and longwave: NASA SRB (Jul1983-Dec2007)

Monthly SH and LH: Gridded FLUXNET (Jan1982-Dec2008, Jung et al. 2009)

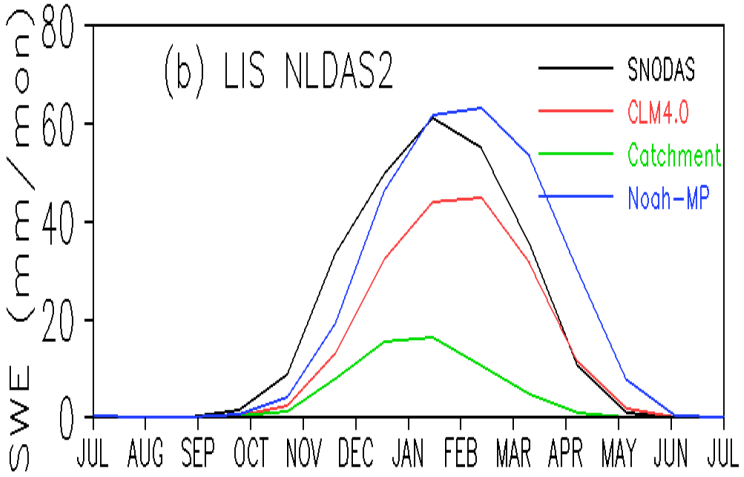
Result Analysis for Western US Rocky Mountains

SWE Comparison in US Rocky Mountains

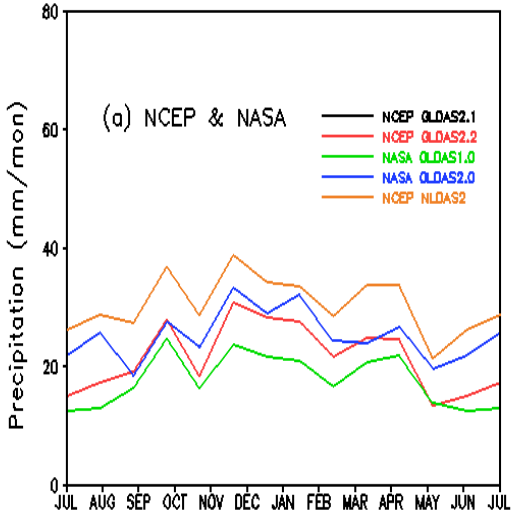
NCEP NLDAS & GLDAS

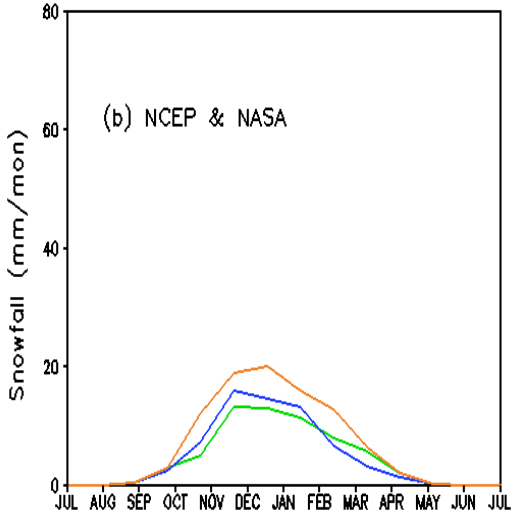


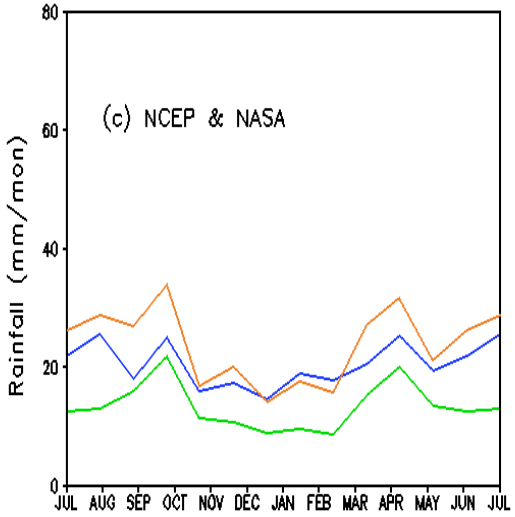
2004-2009 mean seasonal cycle

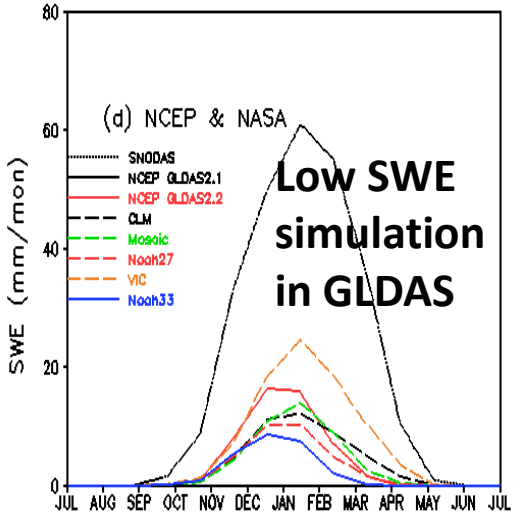


NCEP & NASA GLDAS



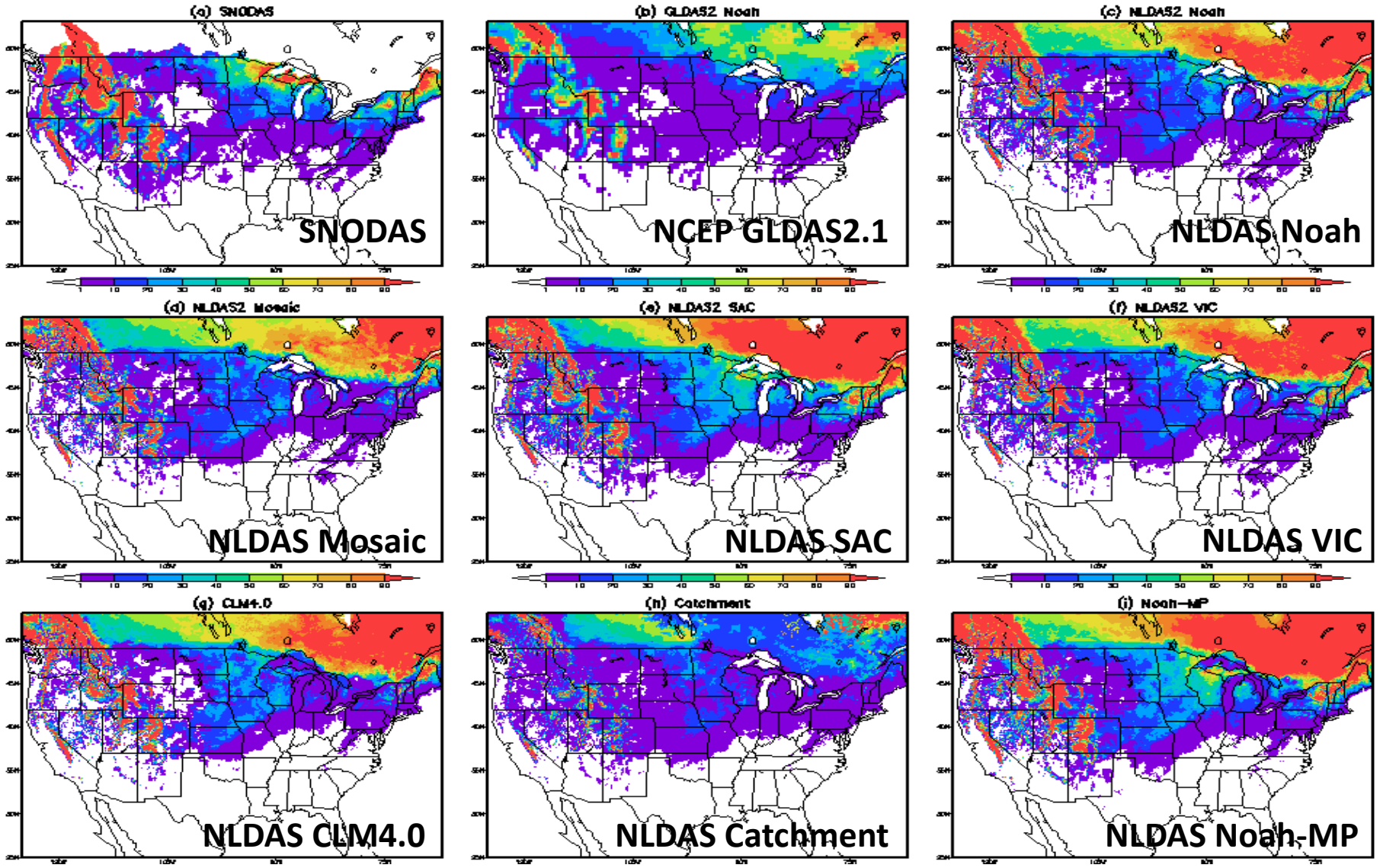






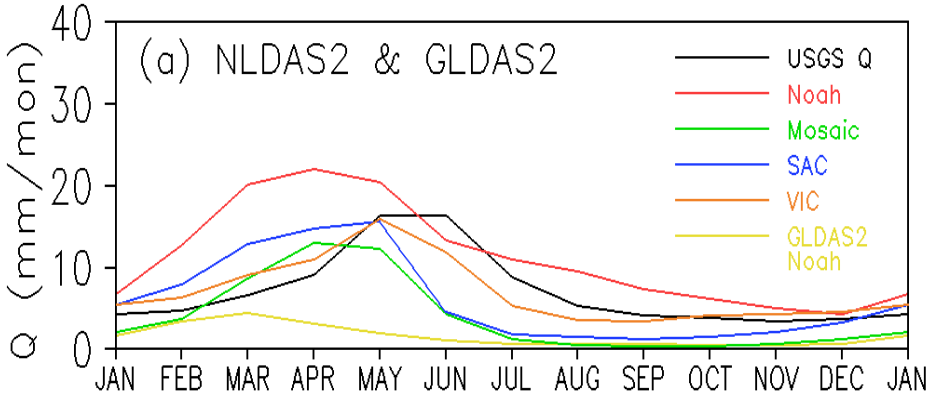
Reason: forcing, model, resolution

Comparison of Spatial Distribution for Mean January SWE SNODAS and NLDAS2 System, unit: mm, 2004-2009

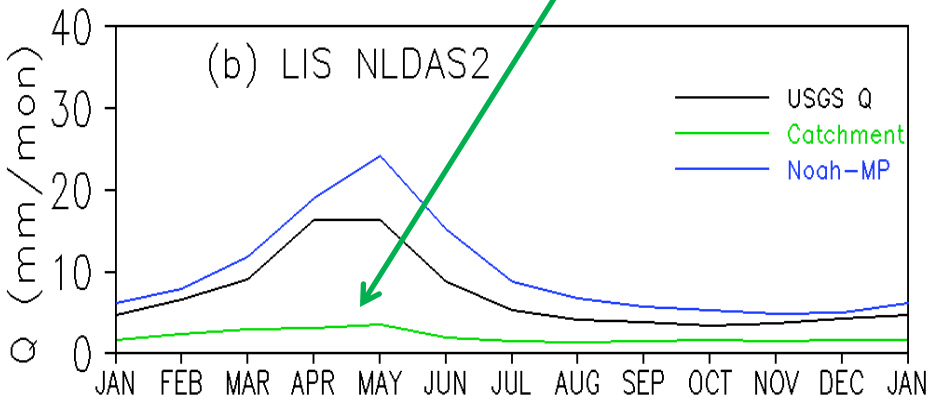


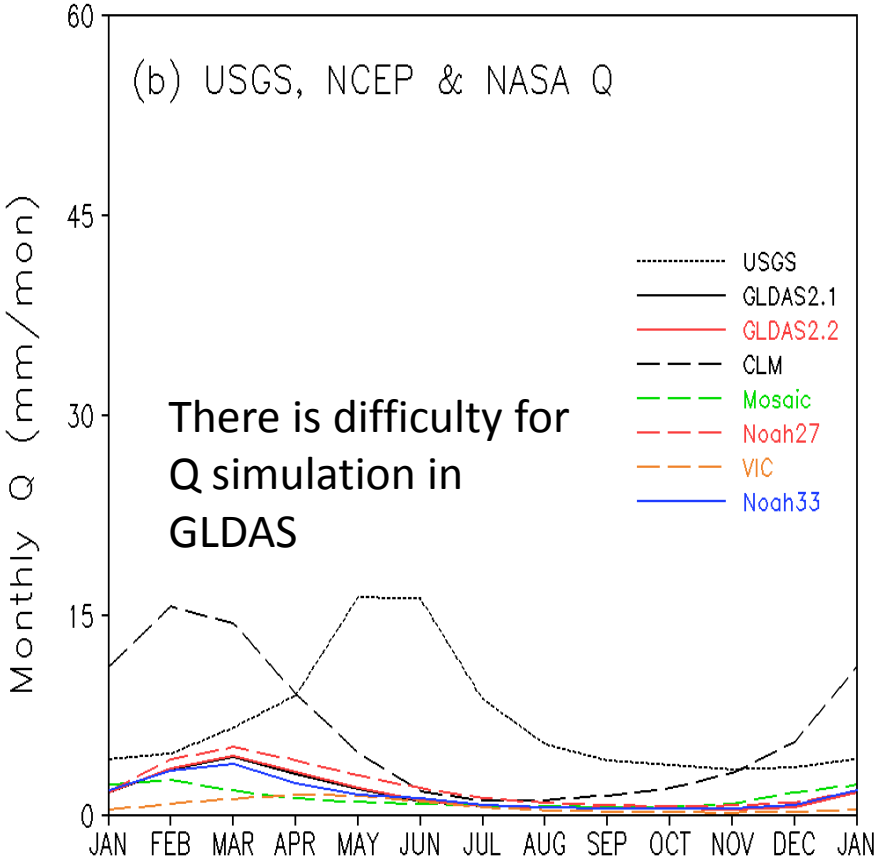
Comparison of Mean USGS and NLDAS, GLDAS Simulated Monthly Total Runoff for Western US Rocky Mountains

Calculated Period: January 1979 - December 2009

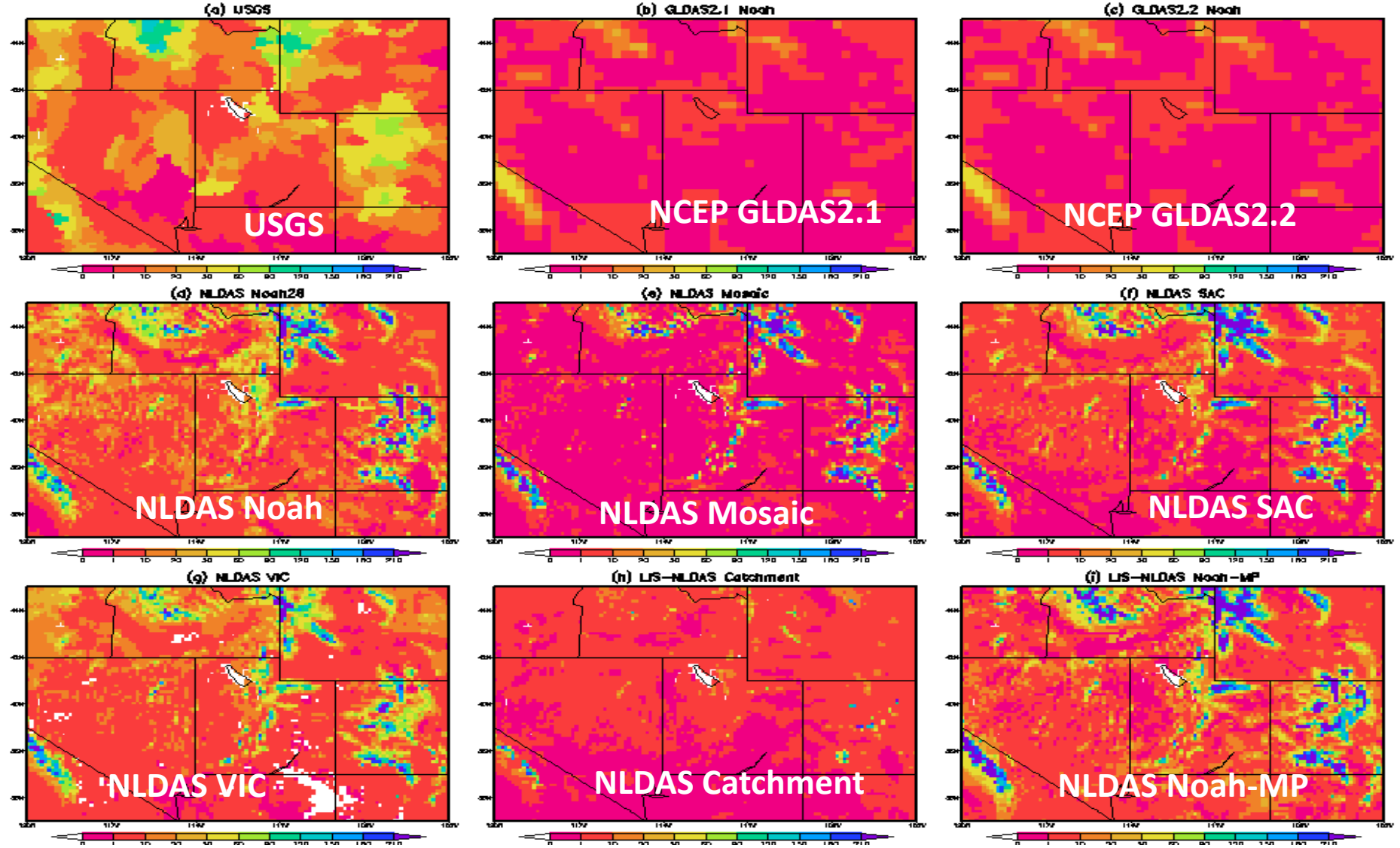


Low Q in Catchment

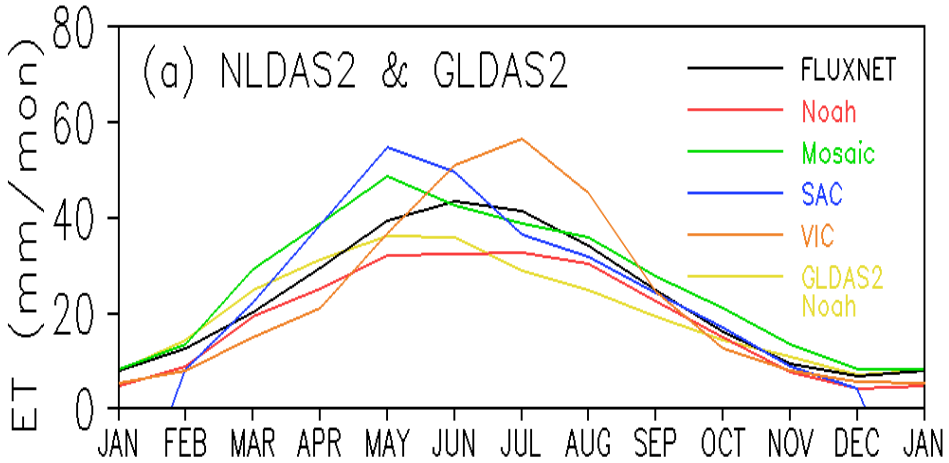


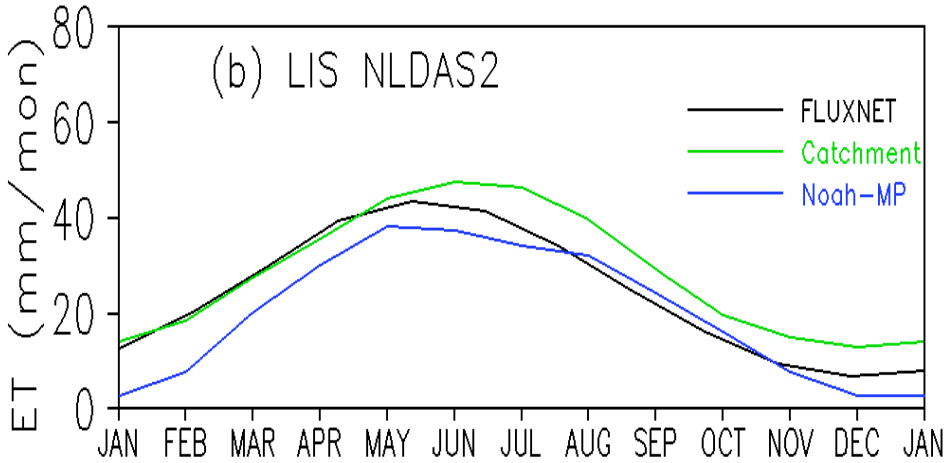


Mean May Total Runoff in Western US Rocky Mountains (Unit: mm/month, Jan1979-Dec2009)

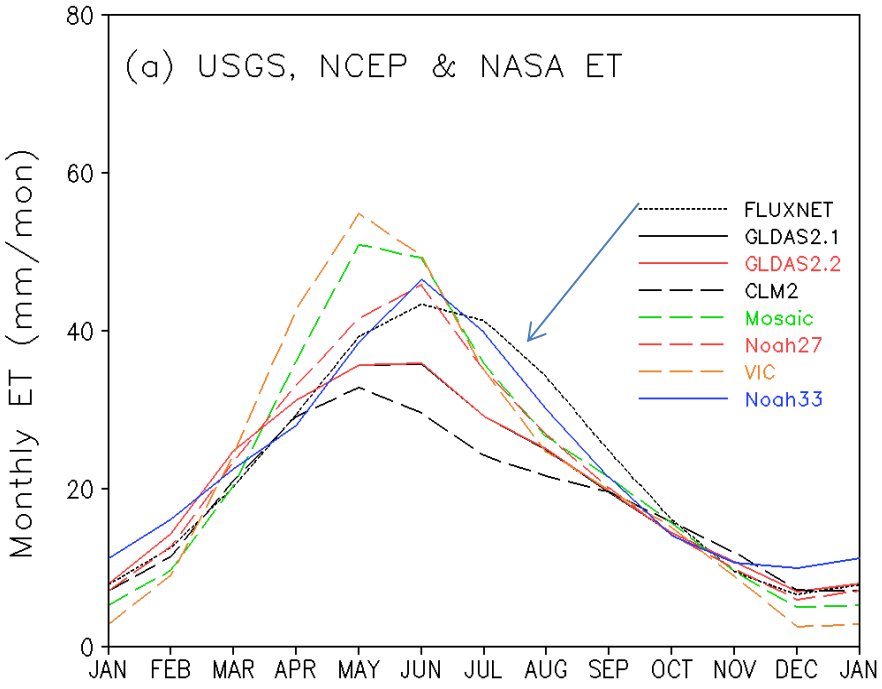


Mean Seasonal Cycle of FLUXNET ET and LDAS Systems averaged in western US Rocky Mountains

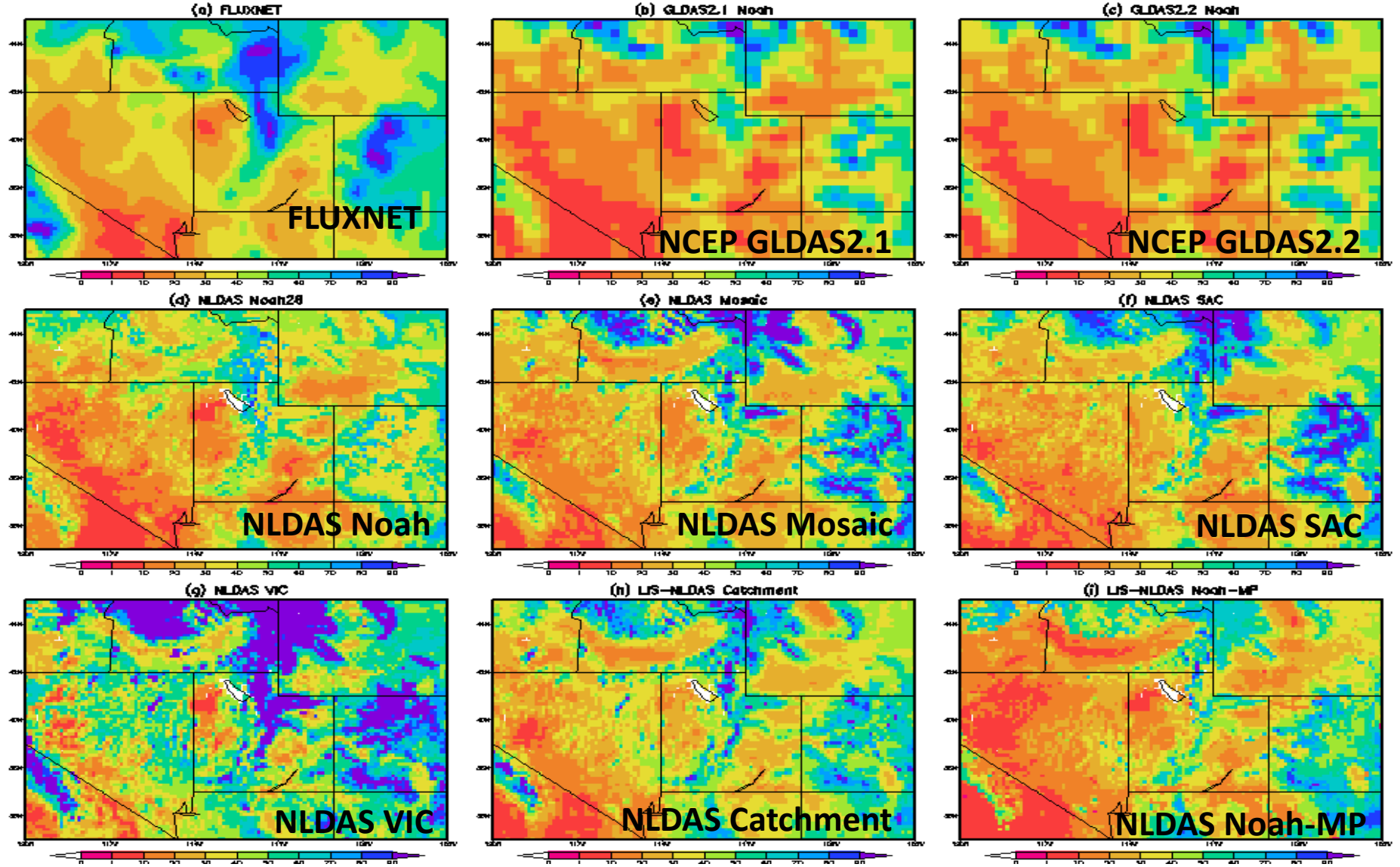




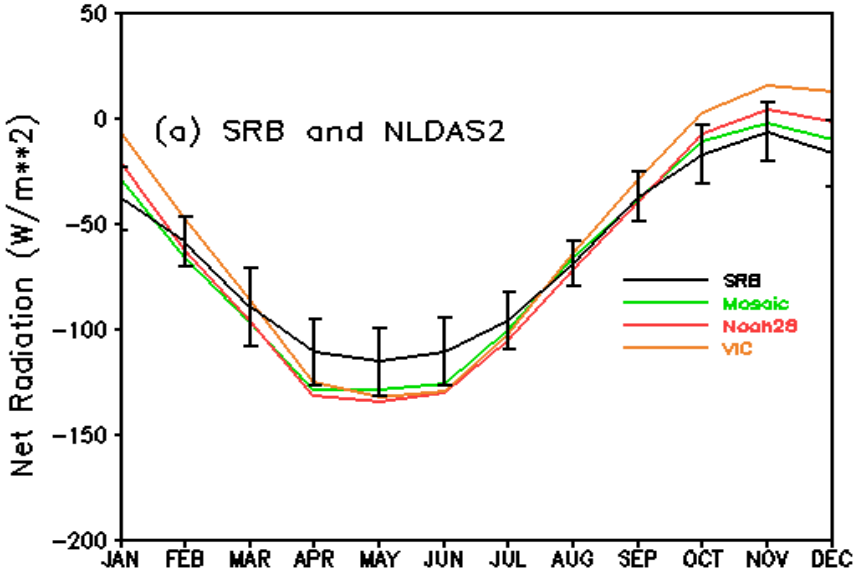
In general, NLDAS and GLDAS have similar performance although it is subjective to models and forcings.

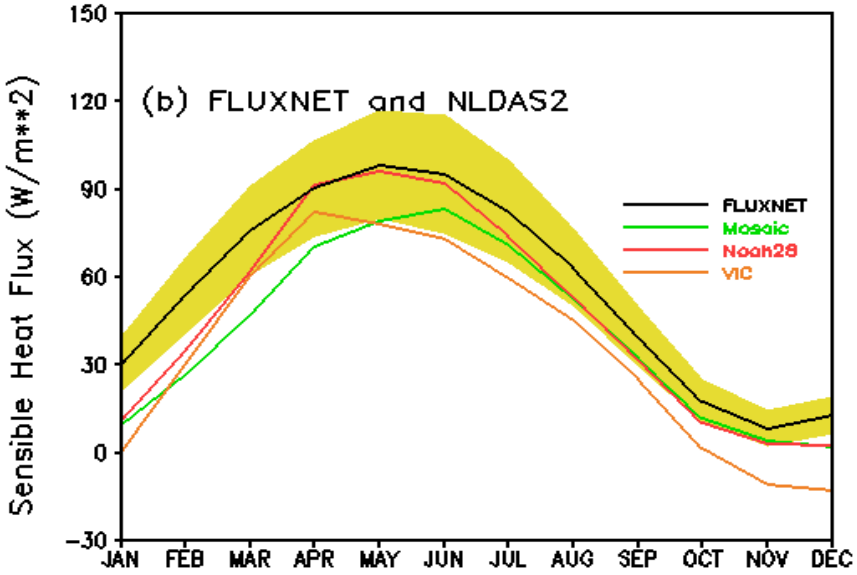


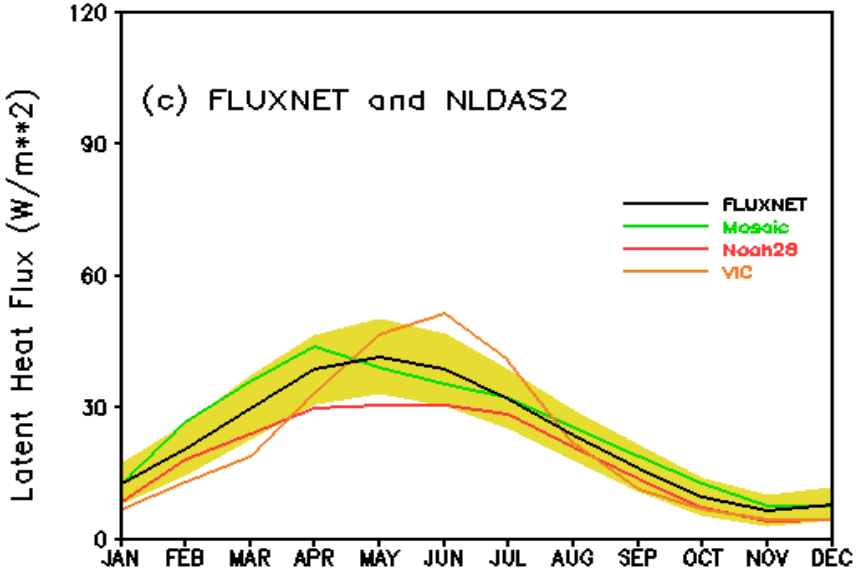
Comparison of NCEP LDAS Systems with Gridded FLUXNET Data – July Mean ET
Unit: mm/month, January 1982-December 2008

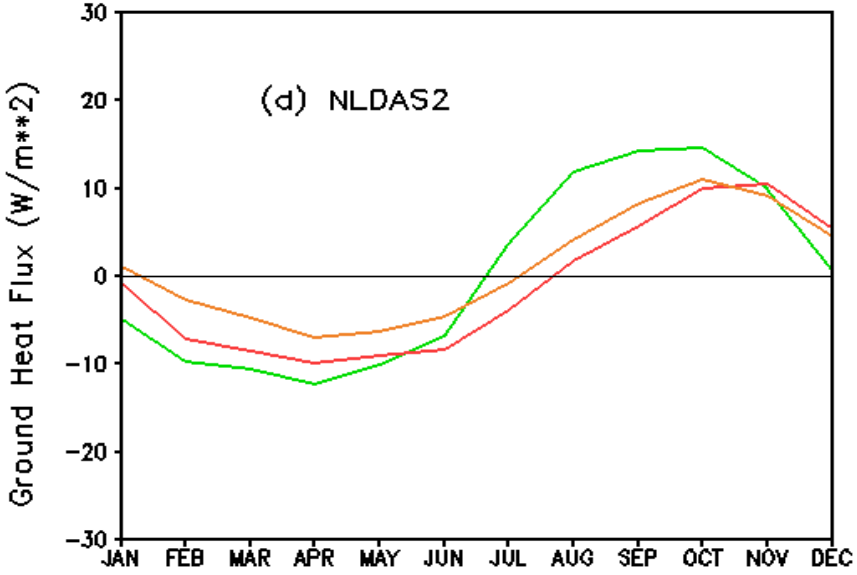


Mean Seasonal Cycles of Net Radiation, Sensible Heat Flux , Latent Heat Flux, and Ground Heat Flux over the Western US Rocky Mountains (1982-2008) - NLDAS

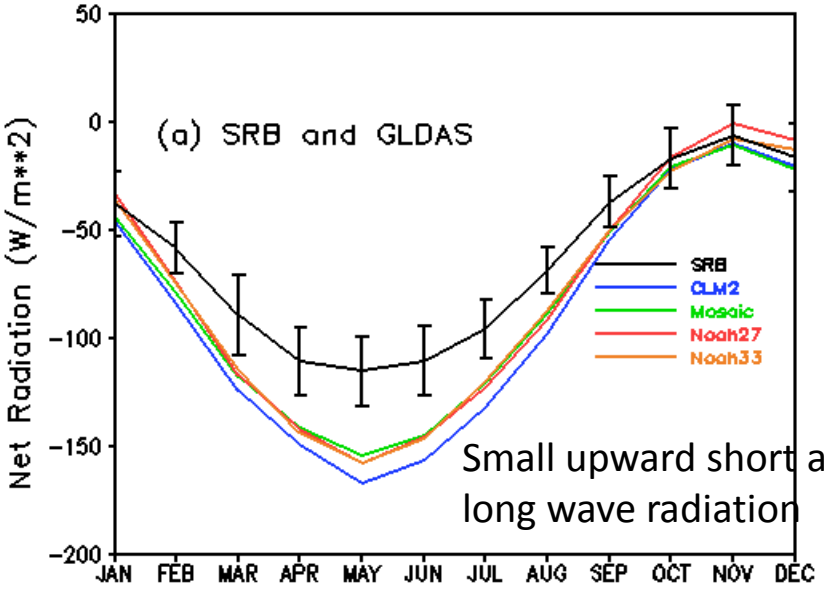


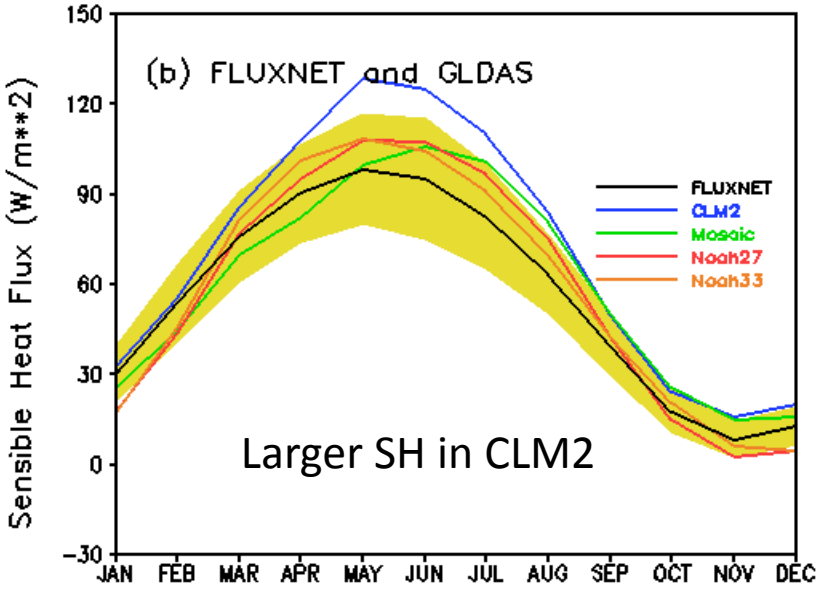


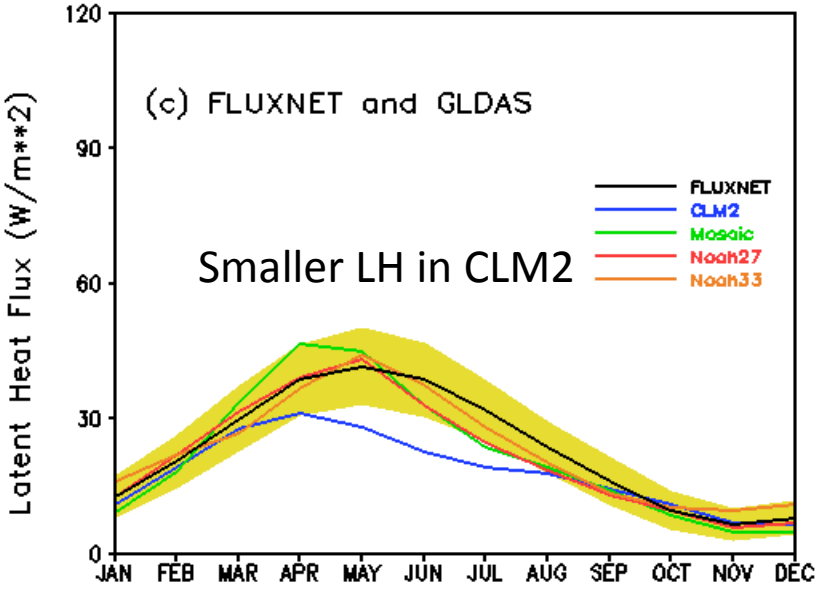


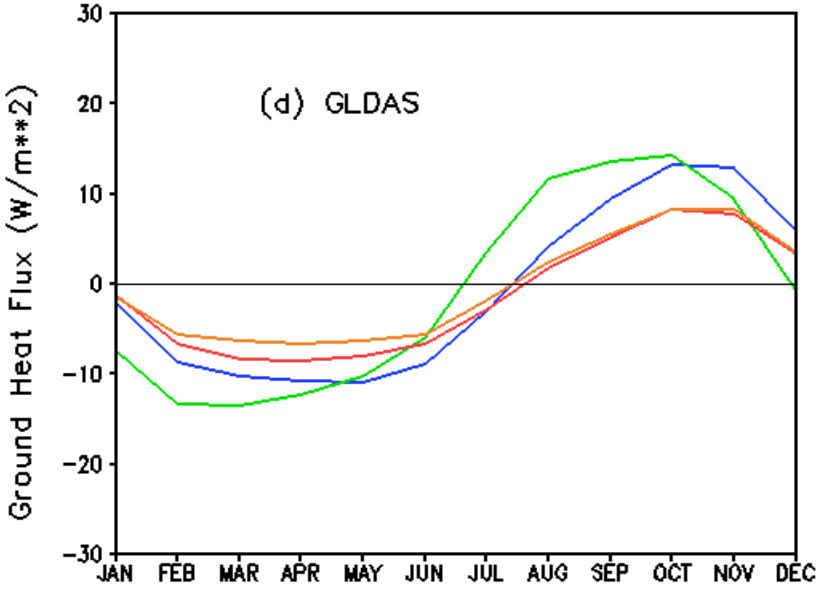


Mean Seasonal Cycles of Net Radiation, Sensible Heat Flux , Latent Heat Flux, and Ground Heat Flux over the Western US Rocky Mountains (1982-2008) – NASA GLDAS



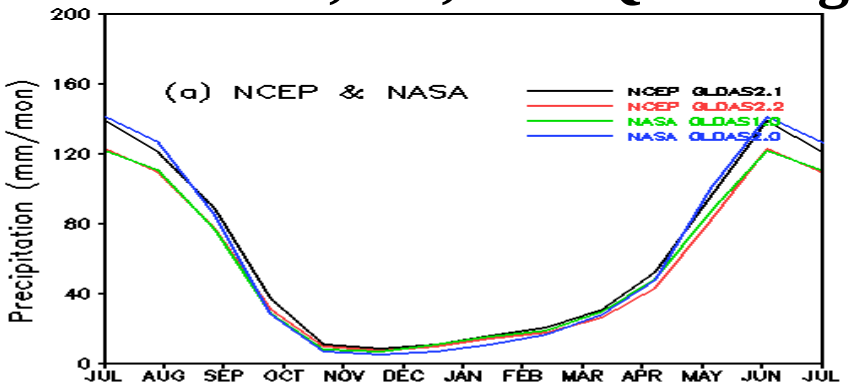


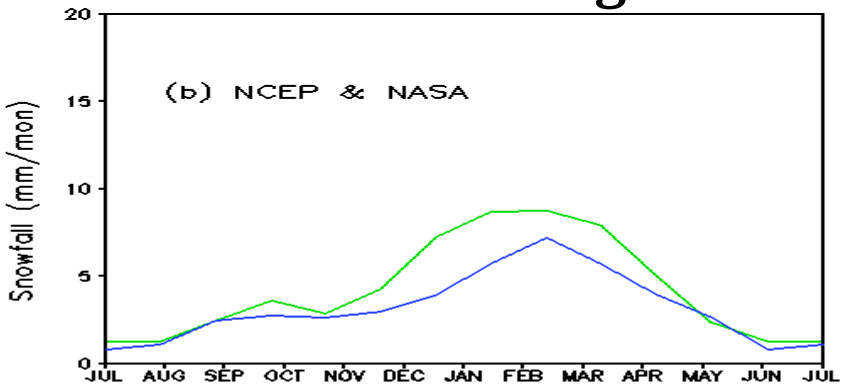


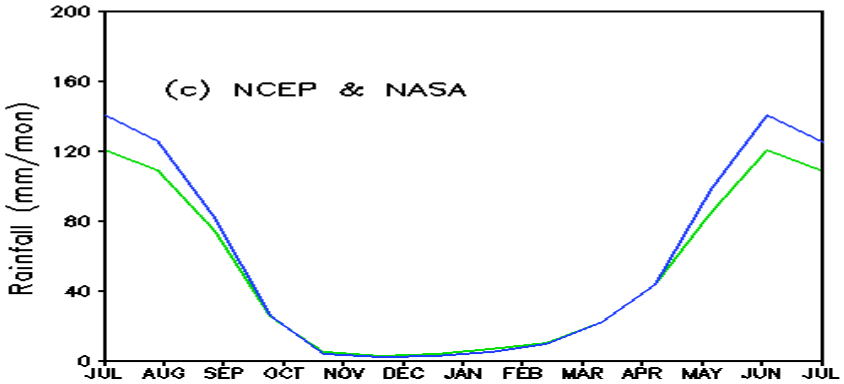


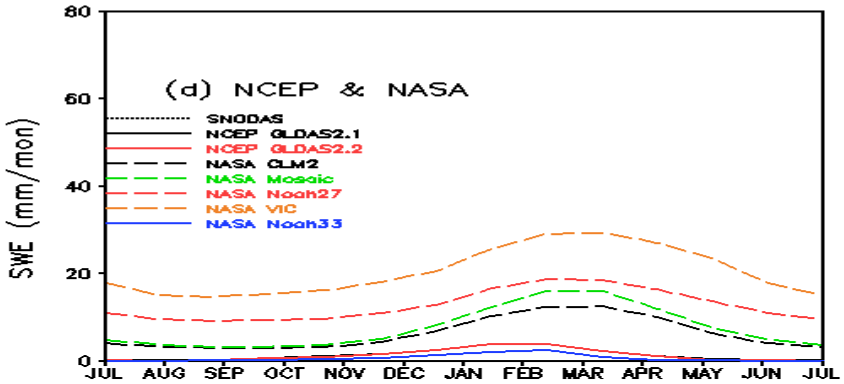
Result Analysis
for Tibetan Plateau

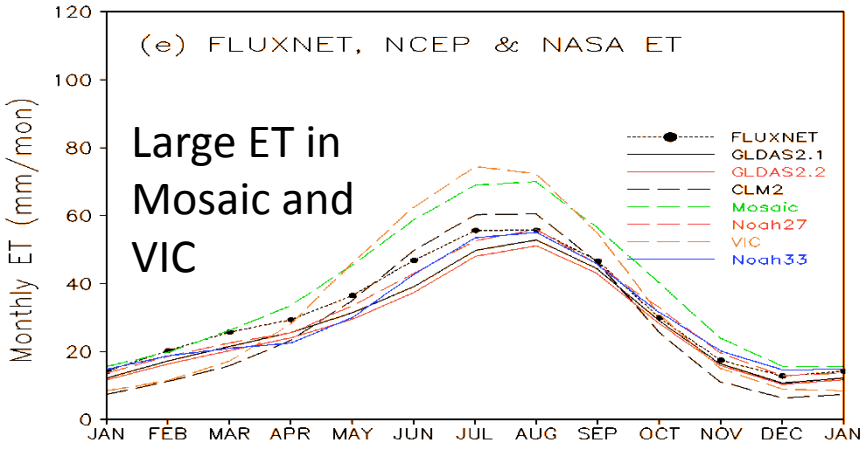
Mean Seasonal Cycle of Total Precipitation, Snowfall, Rainfall, SWE, ET, and Q Averaged in Tibetan Plateau Region

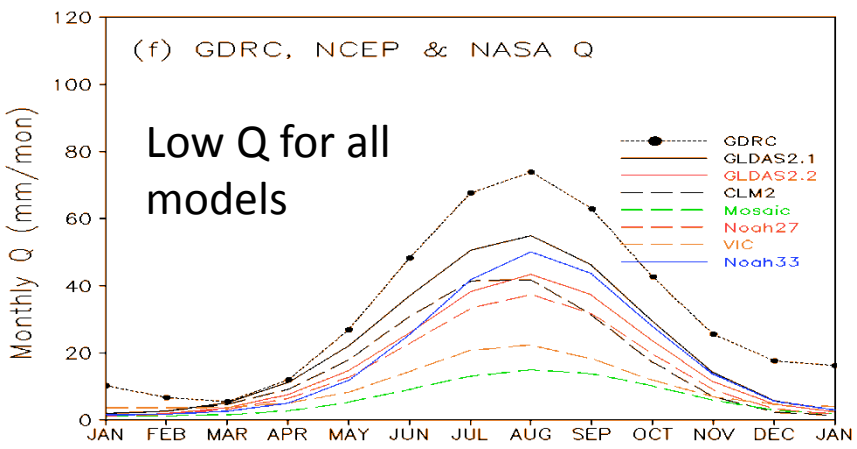




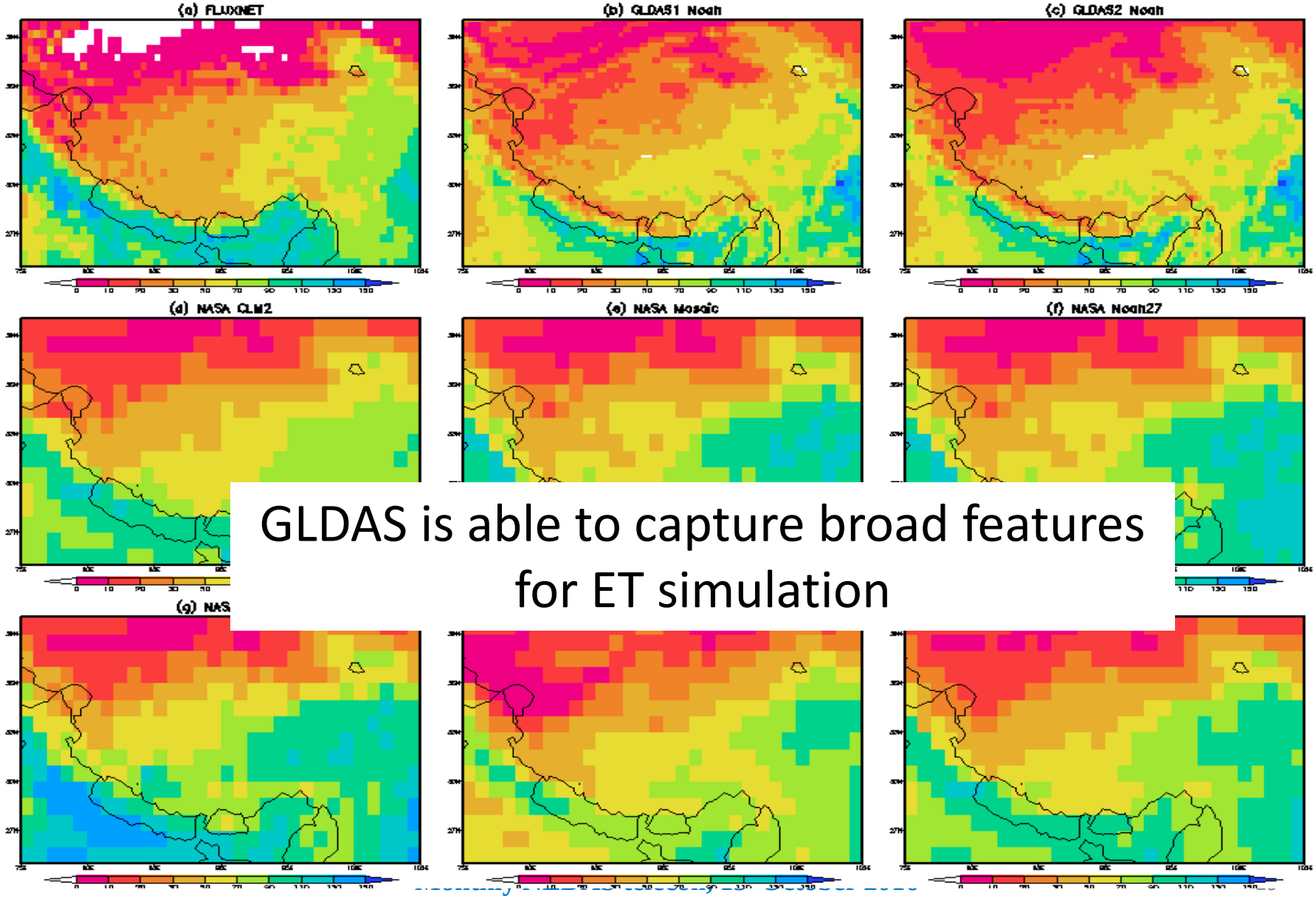






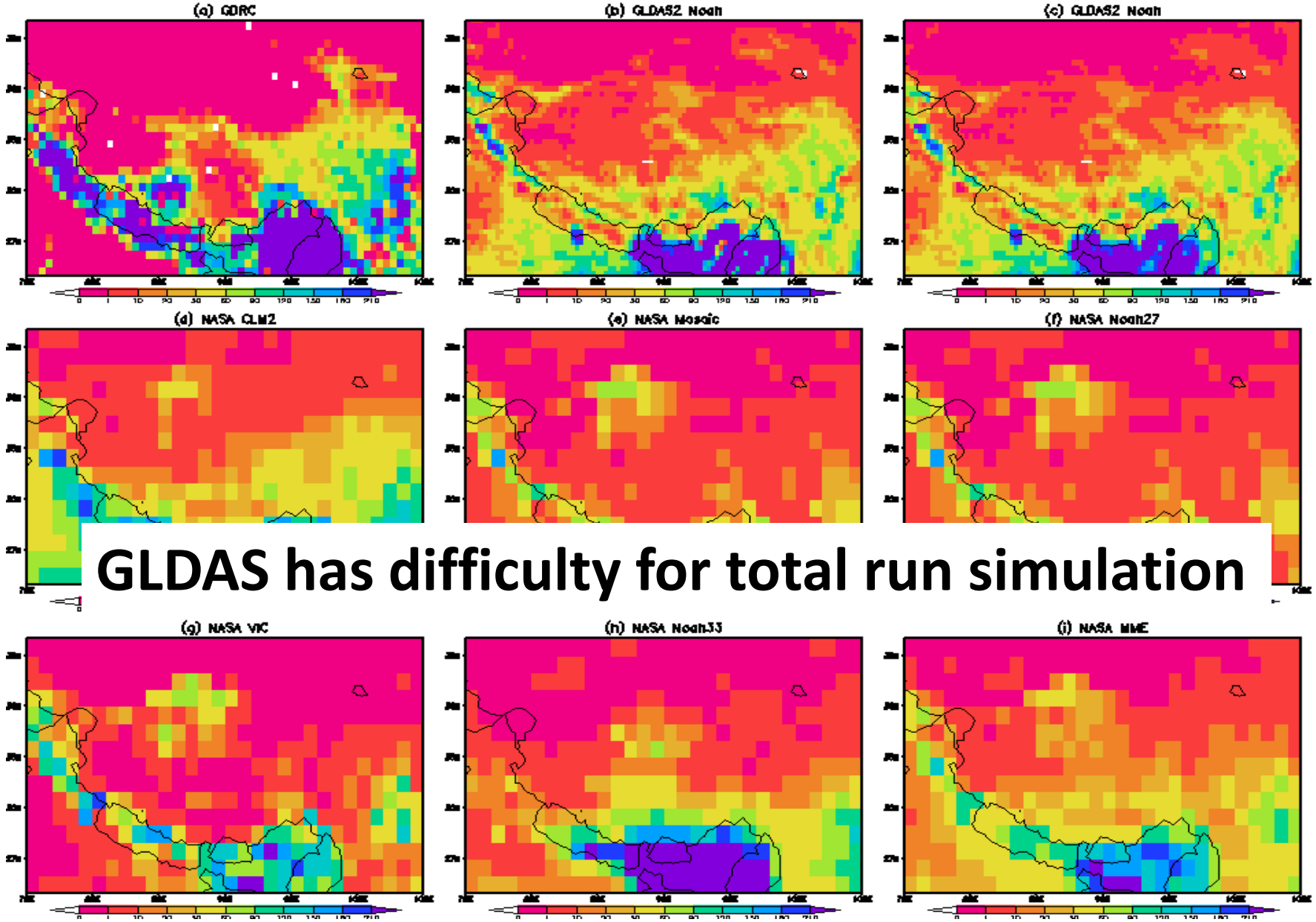


Mean July ET (1982-2008) from FLUXNET and GLDAS Systems (NCEP and NASA), unit: mm/month



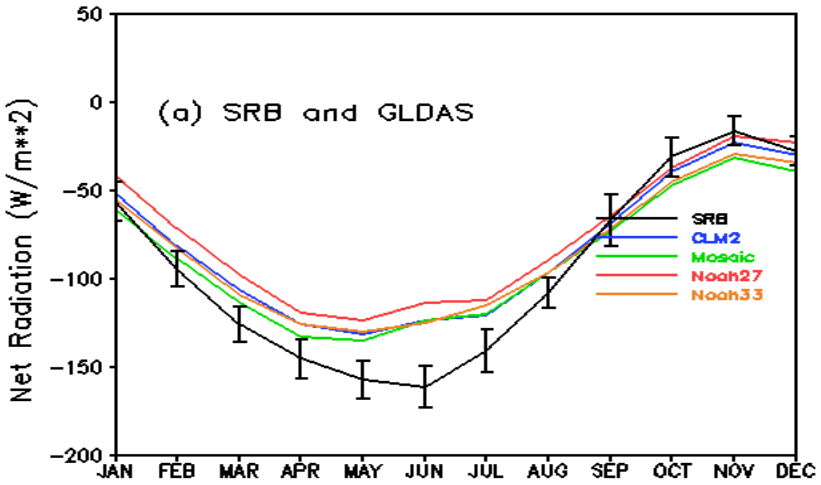
GLDAS is able to capture broad features for ET simulation

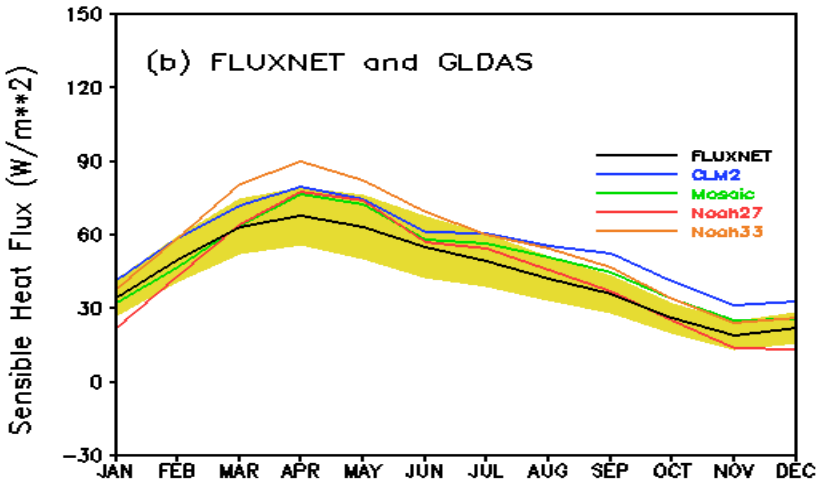
Mean July Q (1982-2008) from GDRC and GLDAS Systems (NCEP and NASA), unit: mm/month

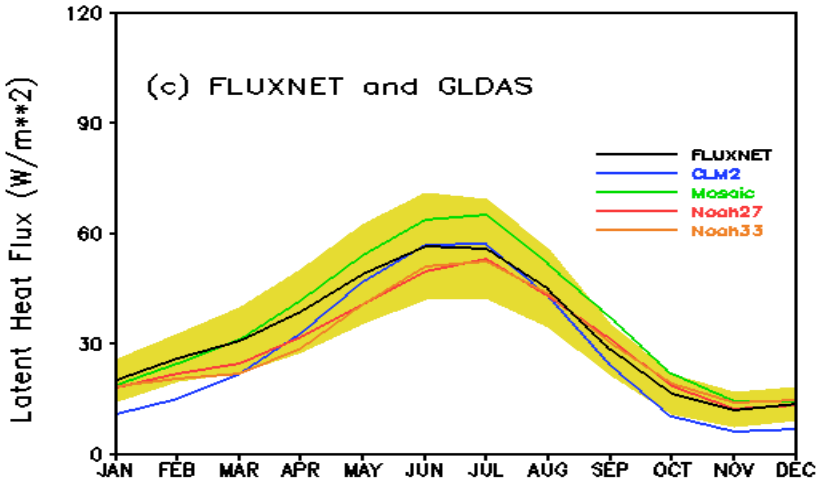


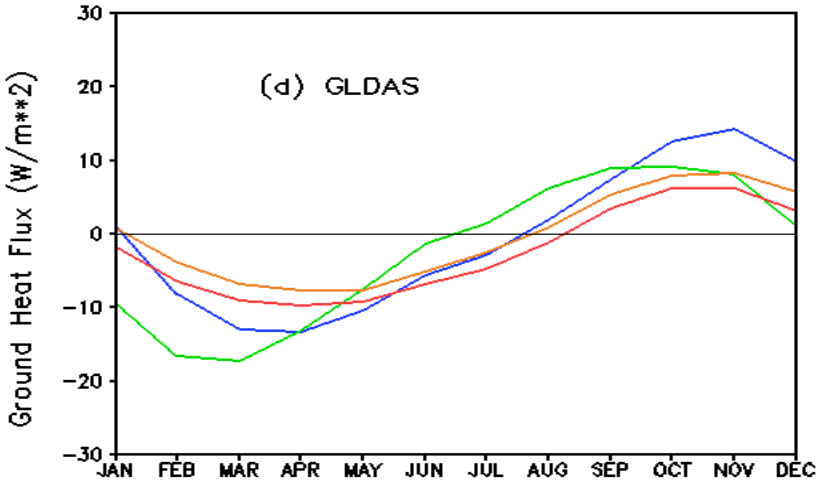
GLDAS has difficulty for total run simulation

Mean Seasonal Cycle of Net Radiation, Sensible Heat Flux, Latent Heat Flux and Ground Heat Flux Averaged from 1982-2008 for Tibetan Plateau Region

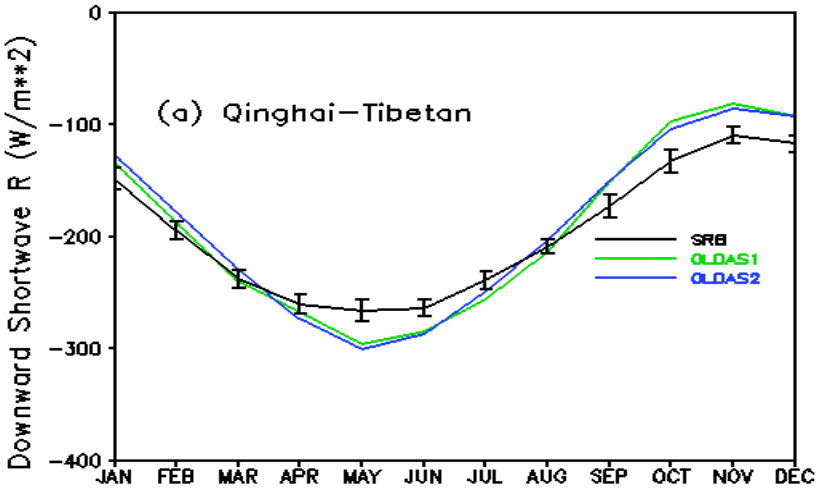


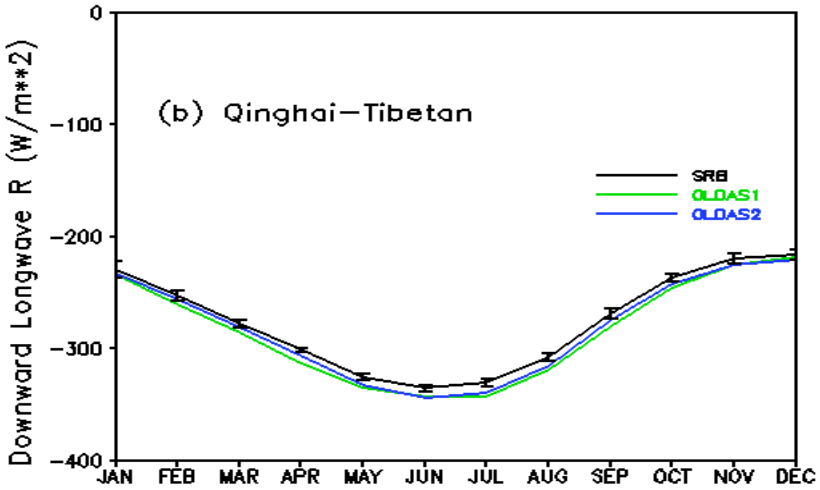


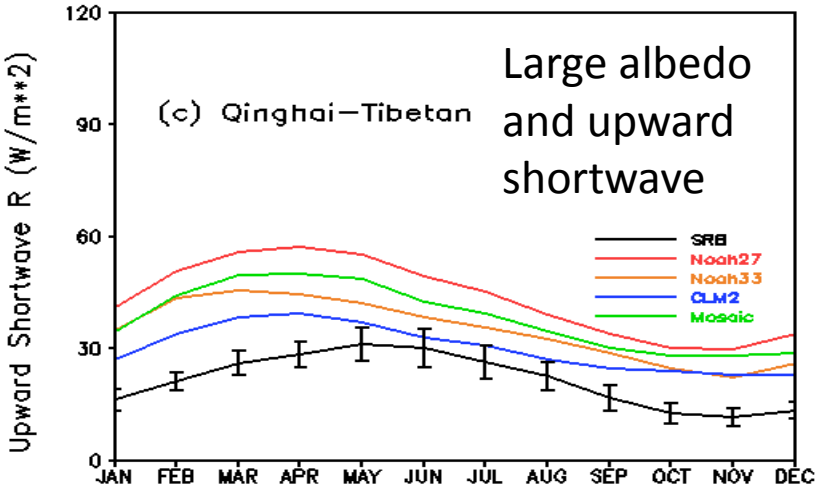


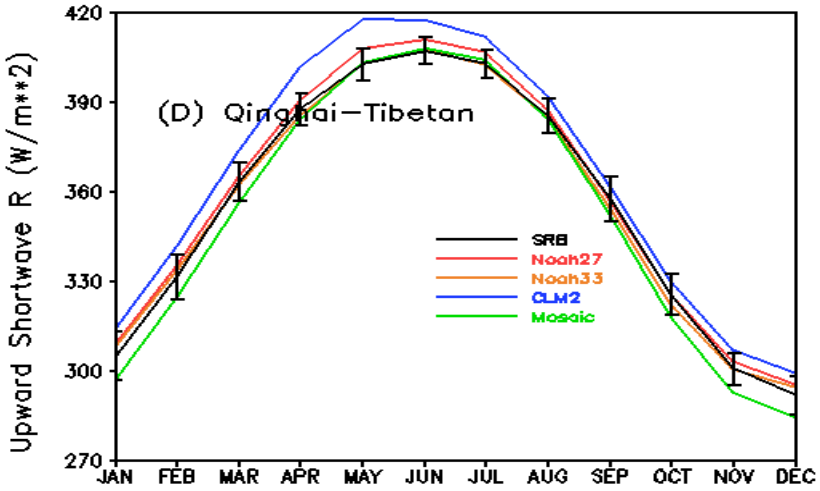


Mean Seasonal Cycle of Downward and Upward Shortwave (Longwave) Radiation Averaged from 1982-2008 for Tibetan Plateau Region

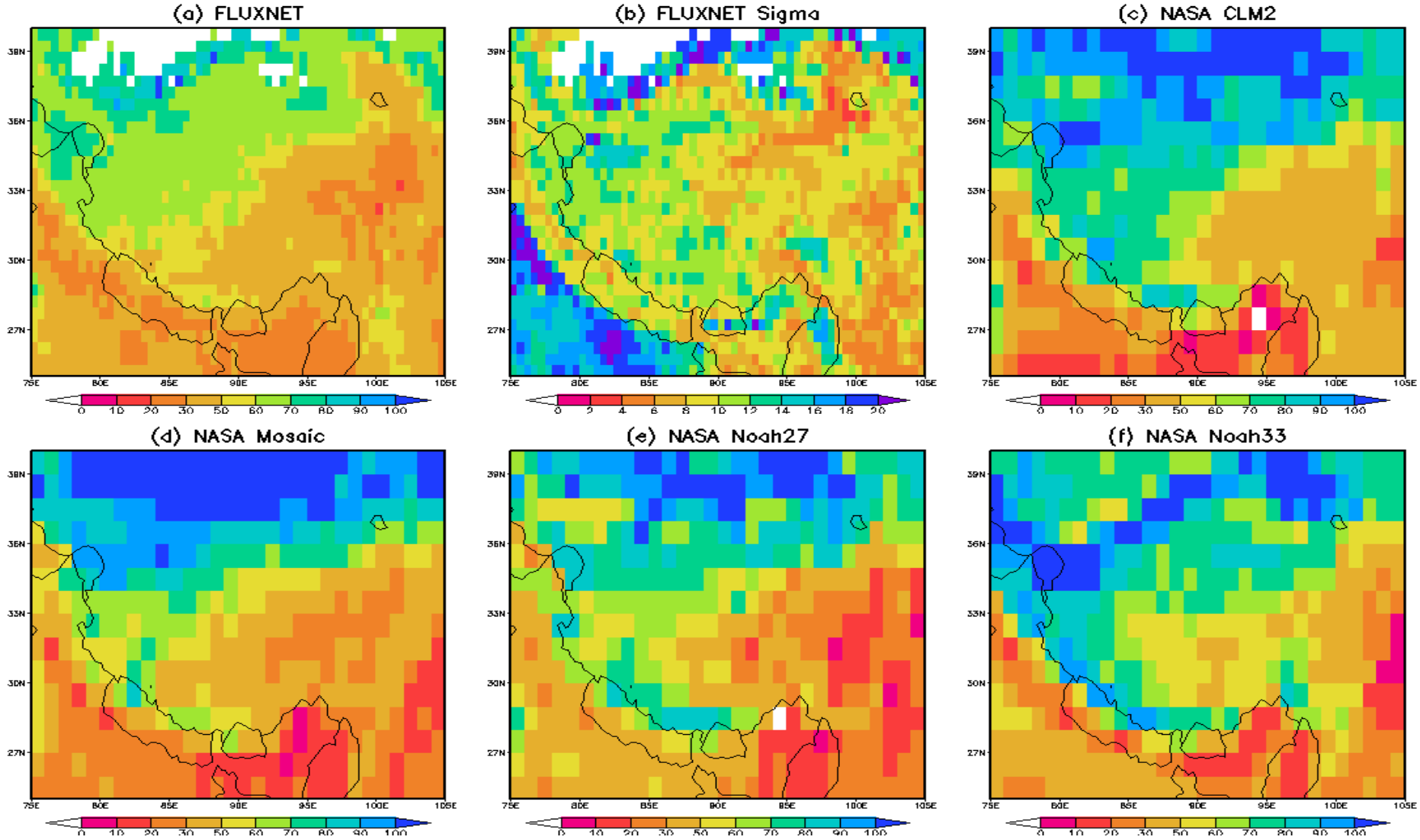








Mean July Sensible Heat Flux (unit: W/m^2) Averaged from 1982 to 2008: FLUXNET & NASA GLDAS



Conclusion

Both NCEP NLDAS/GLDAS and NASA GLDAS systems are evaluated against reference datasets over western US Rocky mountains and Tibetan Plateau.

The results show that:

Over Western US:

(1) NLDAS has better performance than GLDAS (NCEP & NASA) when compared with SNODAS and USGS Q. Spatial resolution may partially contributes to this difference. However, there are indeed large inter-model differences. GLDAS has difficulty to capture mean seasonal cycle and magnitude observed from USGS. For ET simulation, NLDAS and GLDAS performances are comparable.

(2) NLDAS and GLDAS can reasonably capture seasonal and spatial variability for various energy components with similar performance

Over China Tibetan Plateau:

GLDAS system shows reasonable performance and capability in simulating water and energy budget when compared with GDRC Q, gridded FLUXNET, and NASA SRB data although NCEP GLDAS has relatively better performance in simulating GDRC Q.

Thank you very much for your attention

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