Preliminary Comparison and Evaluation of Soil Moisture Produced in the NCEP Global Land Data Assimilation System (GLDAS)

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Background of the NCEP GLDAS

The offline land modeling system GLDAS was operationally implemented at NCEP in 2011 (*Meng et al., 2012*). Its main purpose is to provide land surface states such as soil moisture and temperature to the Climate Forecast System (CFS), including the CFS Reanalysis and Reforecast project and the CFS version 2, in support of seasonal analysis and forecasting at NCEP. As in traditional LDAS systems, GLDAS uses the CPC (Climate Prediction Center) Merged Analysis of Precipitation and NCEP's Global Data Assimilation System (GDAS) surface meteorological forcing to drive the Noah land model to produce soil moisture and soil temperature. In 2020, GLDAS was updated and extended to support the development of the Global Forecast System version 16 (GFSv16). Unlike the GLDAS used in the CFS, the updated GLDAS is forced by the CPC's 1/8th degree global gauge-based daily precipitation and GDAS surface meteorological forcing, and uses an updated MODIS (Moderate Resolution Imaging Spectroradiometer) IGBP (International Geosphere-Biosphere Programme) vegetation type and STATSGO (State Soil Geographic) soil type. The system was updated to a newer version of the NOAH Land Surface Model (LSM). It is run once a day to provide soil moisture and soil temperature initial conditions for GFS forecasts. Figure 1 shows how GLDAS was used in GDAS and GFSv16. It should be noted that GLDAS is not a data assimilation system, as neither in-situ observations nor satellite retrievals are assimilated into the NOAH LSM.

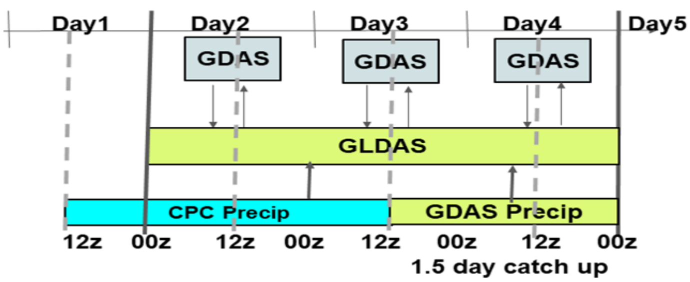

Figure 1. A diagram of the daily GLDAS run when the CPC precipitation and GDAS surface meteorological forcing are used. CPC daily precipitation observations are accumulated for a 12Z to 12Z cycle. GLDAS has a 1.5 day catch up as the CPC precipitation lags 1.5 days behind real time.

Reference Datasets and Evaluation Method

GLDAS soil moisture was evaluated by using multiple reference datasets including the operational GFSv15 model product, North American LDAS reanalysis product (NLDAS, *Xia et al., 2012*), Soil Moisture Operational Products System (SMOPS) satellite retrievals, and in-situ observations from the International Soil Moisture Network (ISMN). The NLDAS daily soil moisture simulated in the three land models has been comprehensively evaluated against in situ observations (*Xia et al., 2015*). In this study we compared and evaluated soil moisture for summertime (1 July - 31 August 2019) and wintertime (1 December 2019 – 31 January 2020) against our reference soil moisture products. We used time series comparisons of regional averages and station measurements, where stations were selected using the nearest neighbor method. A few examples are shown in the Results and Summary section below.

Results and Summary

Regionally averaged top 10 cm soil moisture was compared with the operational GFSv15 and NLDAS (Fig.2a), and SMOPS (Fig.2b). GLDAS is closer to NLDAS Noah and Mosaic than the GFSv15. GLDAS uses the same CPC gauge-based precipitation, while NLDAS uses the Regional Climate Data Assimilation System (RCDAS) surface meteorological forcing. The NLDAS evaluation results showed that VIC (Variable Infiltration Capacity) overestimates and Mosaic underestimates the observed soil moisture, while Noah is closer to the observations (*Xia et al., 2015*). Overall, GLDAS soil moisture in dry regions may tend to be even drier. The same result can be found when SMOS soil moisture was compared (Fig.2b). GLDAS soil moisture is outside of one-sigma standard deviation and tends to overestimate dryness when compared with GFSv15. In spite of these magnitude differences, GLDAS reasonably captures the daily variability of NLDAS and SMOPS soil moisture. GLDAS soil moisture was also compared with in-situ observations in Austin, TX (Fig.3a) and at Cochora Ranch, CA (Fig.3b). The results show that in the summer GLDAS soil moisture estimates are drier than the GFSv15 and in-situ observations, and in the winter GLDAS and GFSv15 estimates are closer to each other than to the observed soil moisture. There is a very large difference between the models and observations. The major reason for the dry soil moisture estimates may be due to lower precipitation amounts generated in GFSv16 and less observed precipitation when compared with precipitation generated in the operational GFS. In the summer, low precipitation results in less infiltration into soil, so the soil will become drier and drier until the wilting point is reached. However, the actual cause remains unclear and needs further investigation in the future. The large difference between the GLDAS and in-situ observations may come from (1) spatial scale mismatch, (2) soil type and related soil and hydrologic parameter differences, (3) vegetation type differences leading to different ET, (4) missing/misrepresenting physical processes, and (5) surface meteorological forcing errors. Nevertheless, comparison and evaluation of multiple references have shown that GLDAS reasonably captures the observed daily variability. Therefore, GLDAS was included in GFSv16 for an operational implementation at NCEP in March 2021.

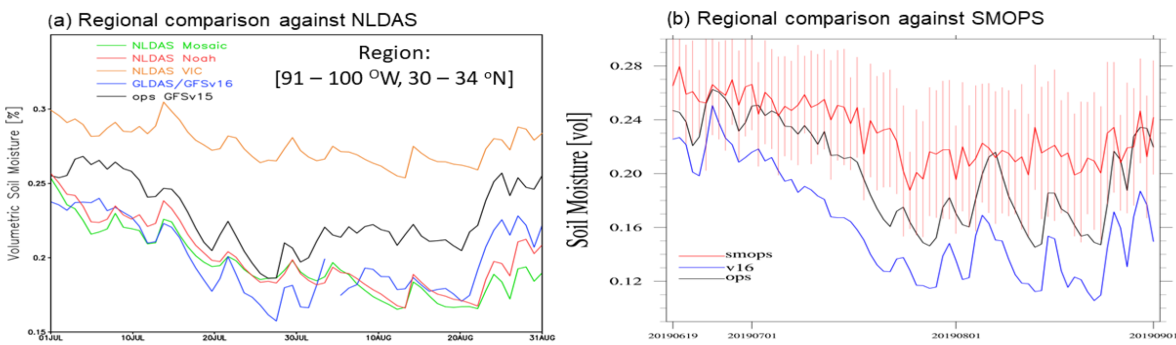

Figure 2. Regionally averaged top 10 cm GLDAS soil moisture comparison with ops GFSv15 (black line) and (a) NLDAS (Mosaic, Noah, VIC) and (b) SMOPS (red line). Vertical line is +/- 1 standard deviation representing SMOPS soil moisture variation.

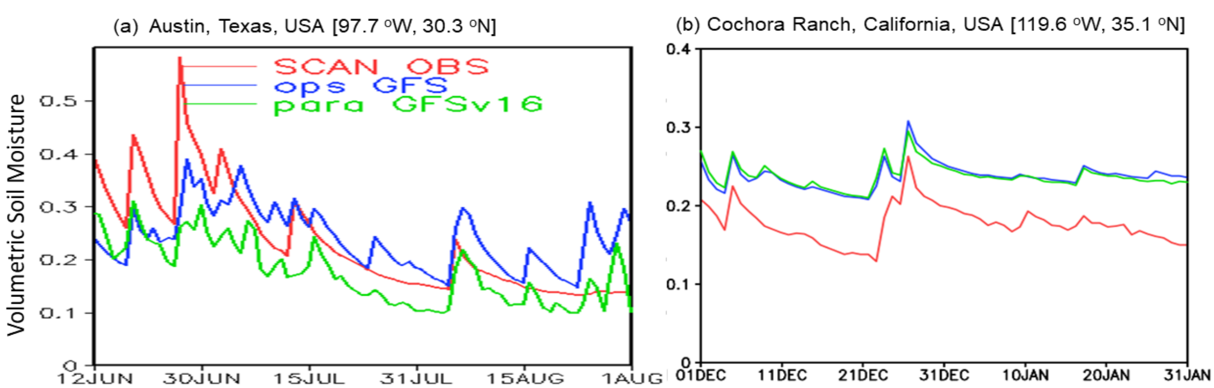

Figure 3**.** Comparison of top 10 cm GLDAS soil moisture with in-situ observations at Austin and Cochora Ranch. Soil Climate Analysis Network (SCAN) is included in ISMN and data is obtained from ISMN.

References

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