131 Precipitation Measurement Mission for Improved Forcing in Hyper-Resolution Land Surface Models

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Objectives

In this research, we aim to supplement the next generation of land surface models, at 'hyper-resolution', by creating and demonstrating the next generation high-resolution precipitation forcing combining dynamically downscaled reanalysis data and PMM observations.

Methodology

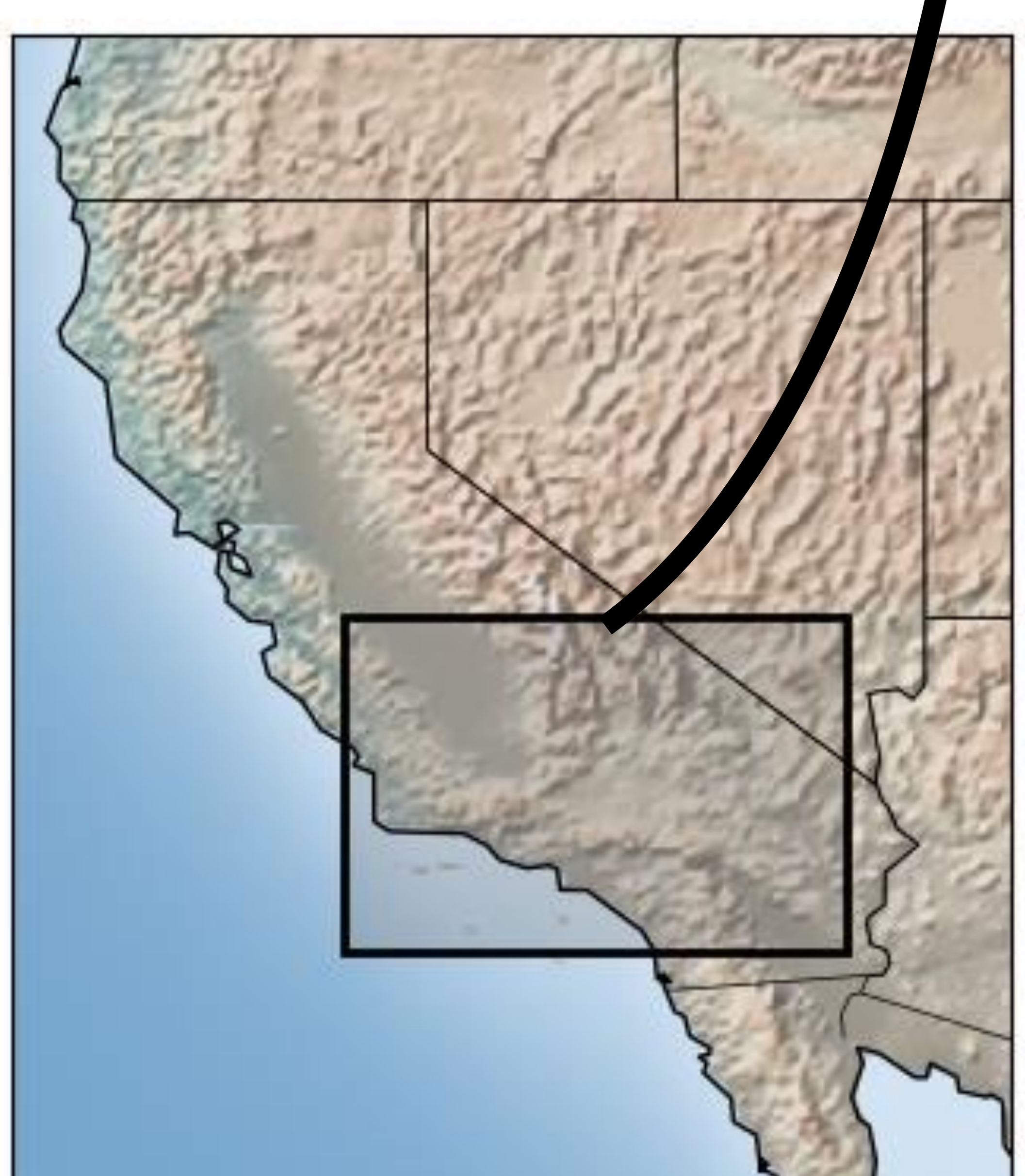
Spectral Nudging. State of the art atmospheric reanalysis data (e.g., JRA55, ERA-Interim, and MERRA) is available over global half to two degree grids for every 3 or 6 hours in near real time. Scale-selective bias correction (SSBC) scheme [Yoshimura and Kanamitsu, 2008] is proposed to disaggregate original reanalysis data using the Global/Regional Integrated Model system (GRIMs) [Hong et al. 2013]. Dynamic fields (i.e., vorticity) in the low frequency domain are constrained by original reanalysis data by using a spectral nudging scheme as follows:

$$f_{(\lambda,\phi)} = \sum_{m=-M}^{m=M} A_{(m,\phi)} e^{im\lambda}, \qquad with$$

$$A_{(m,\phi)} = \begin{cases} A_{RSM(m,\phi)} & \left(|m| > \dfrac{2\pi R_E \cos\phi}{L}\right) \\ \dfrac{1}{\alpha+1}\left[A_{RSM(m,\phi)} + \alpha A_{RA(m,\phi)}\right] & \left(|m| \le \dfrac{2\pi R_E \cos\phi}{L}\right) \end{cases},$$

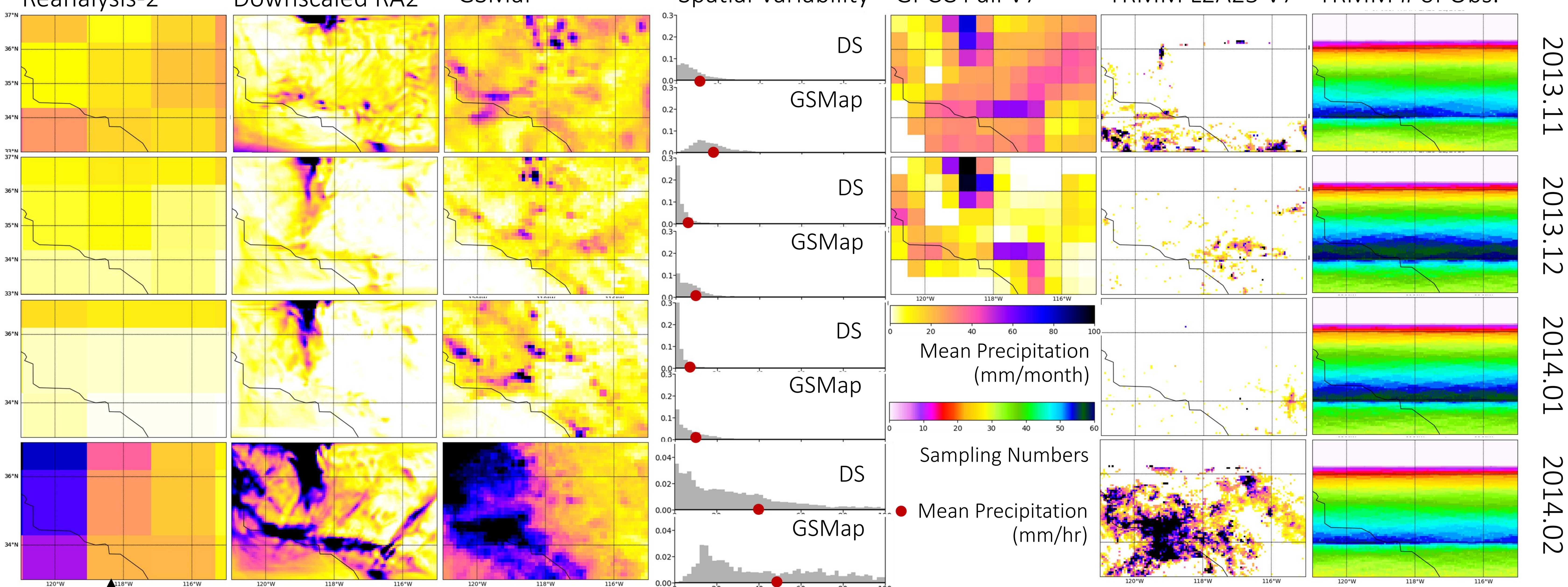
where f is a full field of physical variable, A is the Fourier coefficient, and the subscripts $GRIMs$ and RA indicate $GRIMs$ forecast and original atmospheric reanalysis, respectively. λ, ϕ, R_E, m, M, α, L indicate longitude, latitude, radius of the earth, wavenumber, truncation wave number, nudging coefficient and critical nudging scale where waves longer than L will be nudged.

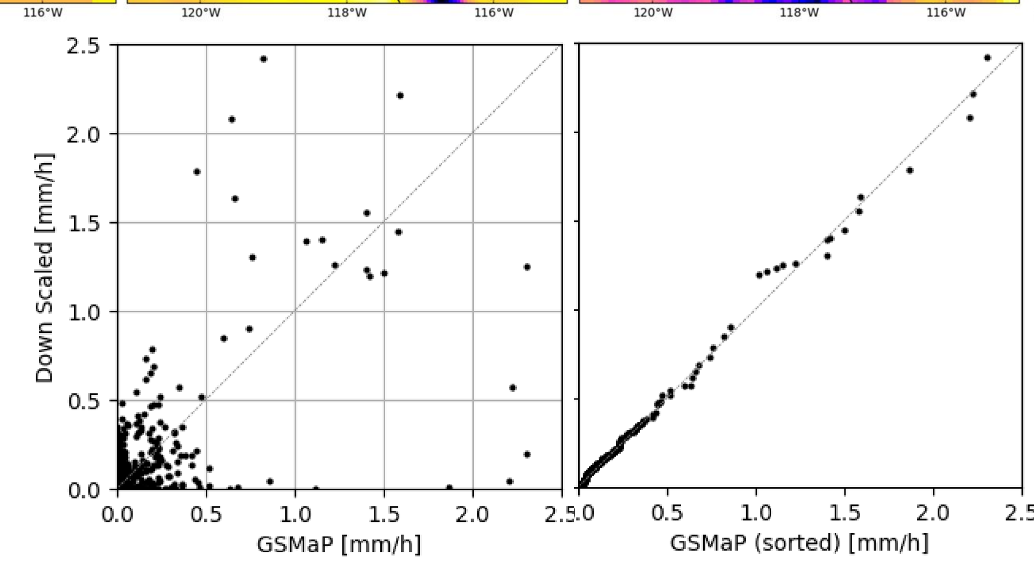
Downscaling Reanalysis Data. NCEP-DOE Reanalysis-2 has been downscaled from 2-degree & 6-hour original resolutions to 0.05 degree & 1-hour spatiotemporal resolution. Downscaling has been tested over Southern California regions for 2-year period (2013-2014). In analysis, only a wet season precipitation has been taken.



Test Area. Southern California
121°W–115°W × 33°N–37°N
(140 × 120 grid cells, each 0.05°)

Spatiotemporal Variability

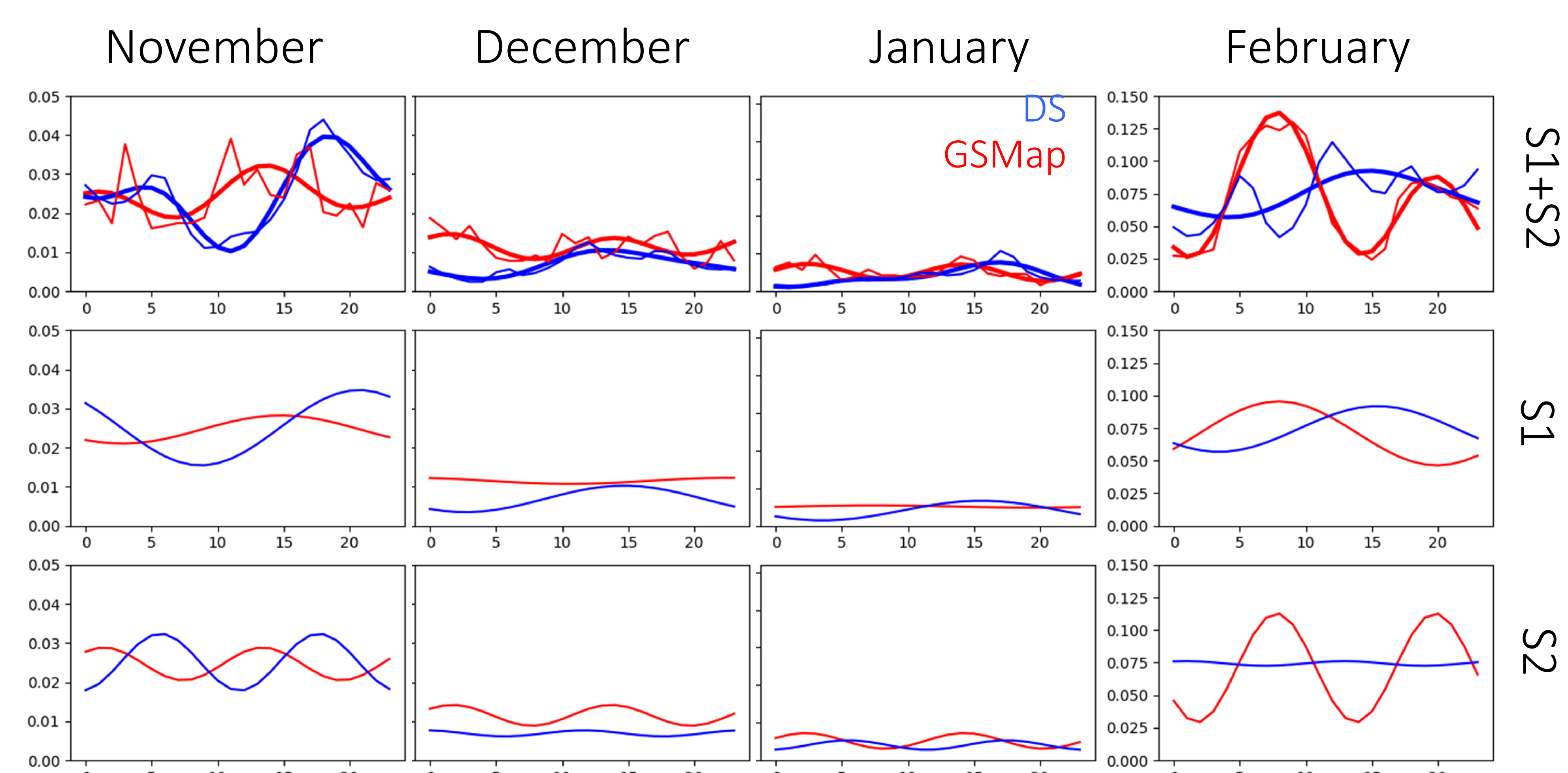




Intercomparison between different products. To evaluate the reproducibility of dynamically downscaled reanalysis precipitation comparing to different types of observation including in-situ observations and satellite retrievals. Optimal configuration of dynamical downscaling, different curves for vertical damping coefficient profiles and nudge scales for temperature and pressure should be tested. Also, different convective schemes (e.g., SAS, RAS, KF2) should be evaluated in terms of the reproducibility of diurnal cycles.

Diurnal Cycle

Harmonic Analysis. To evaluate how the dynamical downscaling method reproduces a diurnal cycle. The basic idea of harmonic analysis is to represent the fluctuations or variations in a time series by adding a series of sine and cosine functions. We will only focus on the first two harmonics (i.e., diurnal and sub-diurnal), which is known to have physical meaning and dominate the total precipitation [He et al. 2015].



$$y_t \sim \bar{y} + S_1 + S_2$$

$$S_k = A_k \cos\left(\frac{2\pi kt}{n}\right) + B_k \sin\left(\frac{2\pi kt}{n}\right)$$

$$A_k = \frac{2}{n}\sum_{t=1}^{n} y_t \cos\left(\frac{2\pi kt}{n}\right)$$

$$B_k = \frac{2}{n}\sum_{t=1}^{n} y_t \sin\left(\frac{2\pi kt}{n}\right)$$