

## A moderately coupled land data assimilation method (MCLDA) implemented in the NOAA Operational Weather Prediction Models - RAP and HRRR

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**Overview of Moderately Coupled Land DA (MCLDA)** approach in RAP and HRRR • Cycling of soil temperature/moisture, lake temperature and snow temperature/depth for balanced coupled initial state - unique in Rapid Refresh (RAP, 13-km) and High-Resolution Rapid Refresh (HRRR, 3-km). • MCLDA in GSI is a step towards coupling of soil DA with 3-d atmospheric DA. Increments for soil/snow temperature and soil moisture are derived from atmospheric surface analysis increments using empirical 1-d covariances (Benjamin et al, 2022, submitted to J. of Hydrometeorology) • Snow DA as part of MCLDA: updating snow cover from 4-km NESDIS Snow and Ice Analysis once per day - trim or build cycled snow depth. • MCLDA differs from the weakly coupled DA (WCDA) which uses a separate land data-assimilation system (LDAS) driven by 2-m temperature/humidity observations. The LDAS approach implemented in Canadian, French, ECMWF and other NWPcenter coupled DA. **Design of MCLDA used in RAP/HRRR for soil** temperature and moisture Soil temperature adjustment at the top 5 levels is based on the first-level air temperature increment:  $\Delta T_{s}(k) = \alpha(k) \cdot \Delta T_{a}$ (1)  $\Delta T_a$  - the atmosphere temperature analysis increment;  $\alpha(k)$  - the adjustment ratio for k<sup>th</sup> soil level: 0.6, ...., 0.2

Cooling up to  $\Delta T_s$  (k)=-2.0 × f × 0.6, where f = (1. + min(1.5, max(0., (T-283.0)/15.0)))*Warming* up to  $\Delta T_s(k) = 1.5 \text{ K}$ 

- Snow and sea-ice temperature adjustment uses Equation (1), but temperature cannot be warmed up above 273.15 K for snow and 271.4 K for sea ice.
- Soil moisture adjustment at the top 4 levels is based on the firstlevel relative humidity increment and applied if daytime and no snow on the ground:

 $\Delta \eta_{s}(k) = \alpha(k) \cdot \Delta Rh_{a}$ (2)

 $\Delta RH_a$  - the analysis increment of RH at the lowest model level;  $\Delta \eta_{s}(k)$  - the soil volumetric water content increment (-0.03< $\Delta \eta_{s}(k)$ < 0.03);  $\alpha(k)$  - the adjustment ratio for k<sup>th</sup> soil level: 0.2.... 0,.1.

• Soil moistening is applied when  $\Delta T_a < T_{crit}$  where  $T_{crit} = -0.15 K$ • Soil drying is applied when  $\Delta T_a > T_{crit}$ , where  $T_{crit} = 0.15 \text{ K}$ 

**Retrospective experiments for RAP with/without MCLDA** 

- 13-km RAP with cycled land/snow state
- Warm season: 18 July 17 August 2018
- Cold season: 1 February 1 March 2019



