Release Notes for the CSH V05 Level 3 gridded product (3HCSH)

5 July 2017

Changes from V04:

Major changes from V04 include the retrieval of latent heating (LH) over the entire GPM domain (i.e., 67N to 67S), not just the TRMM domain (i.e., 37N to 37S). However, the other remaining CSH products (i.e., eddy heating, microphysical and eddy moistening, and radiation) are still retrieved only over the TRMM domain.

All products are now retrieved at 80 vertical levels every 250 meters AGL starting at the surface (i.e., 0, 250, 500, etc.).

The retrievals for the Tropics (i.e., TRMM domain) are based upon an updated version of the previous CSH algorithm design (Tao et al. 2010). The algorithm still relies upon look-up-tables (LUTs) of model-simulated heating/moistening profiles generated from the Goddard Cumulus Ensemble Model (or GCE), a CRM, which are stored and mapped to satellite grids according to precipitation characteristics. In V04, the previous TRMM V7 CSH LUTs were used. Those LUTs were designed for 0.5 x 0.5 degree TRMM grids (versus the 0.25 x 0.25 degree GPM grids), so the GPM input data in V04 were pre-smoothed to accommodate the coarser resolution of the LUTs. In V05, the LUTs are generated at the GPM grid resolution (0.25 degrees) and are based on 2D multi-week simulations for 6 ocean (vs 5) and 4 land (vs 2) cases (**see Table 1**) using larger domains (512 vs 256 km) and an improved Goddard 4ICE (Lang et al. 2014; Tao et al. 2016) microphysics scheme that includes hail as well as a rain evaporation correction scheme (vs an improved Goddard 3ICE scheme). In addition to the same rain intensity (36) and stratiform fraction bins (20), the LUTs are further differentiated by two new metrics: mean echo top heights (5 bins: 0-2, 2-4, 4-6, 6-8, and above 8 km) and mean low-level (0-2 km) dBZ gradient (increasing or decreasing towards the surface).

Outside the Tropics (i.e., poleward of 37N and 37S), the LH retrievals are based upon a new cold season/ higher latitude algorithm that maps LH profiles based upon 6 NU-WRF (NASA-Unified Weather Research and Forecasting Model) simulations using the same improved 4ICE scheme for 3 eastern US synoptic snow storms and 3 West Coast atmospheric river events. The LUTs are constructed and mapped using the following domain average quantities: storm top heights (6 bins), freezing level (13 bins), max dBZ level (6 bins), dBZ gradient (2 bins), and composite dBZ intensity (90 bins, every 1 dBZ). As with the Tropics, the radar quantities are mean conditional values over each 0.25 x 0.25 degree GPM grid. A radar (composite) coverage factor is then used to scale the corresponding LUT conditional LH profile to obtain the GPM grid average value.

GCE cases for the Revised Tropical LUTs

LUT cases	Type	Location	Period	Duration
ARM 1997	Land	Southern Great Plains	June-July, 1997	29 days
ARM 2002	Land	Southern Great Plains	May-June, 2002	20 days
MC3E	**Land**	**Southern Great Plains**	**April-May, 2011**	**33 days**
GoAMAZON	**Land**	**Amazon Basin**	**Feb-March, 2014**	**40 days**
GATE	Ocean	Tropical Atlantic	Aug-Sept, 1974	20 days
KWAJEX	Ocean	Marshall Islands	July-Sept, 1999	52 days
SCSMEX	Ocean	South China Sea	May-June, 1998	45 days
TOGA COARE	Ocean	Equatorial West Pacific	November, 1992 - February, 1993	120 days
TWPICE	Ocean	Darwin, Australia	Jan-Feb, 2006	6 **(24) days**
DYNAMO	**Ocean**	**Equatorial Indian Ocean**	**Nov-Dec, 2011**	**31 days**

BOLD indicates new additional cases

Table 1

Caveats:

CSH retrievals are derived from Level 2 products from the Combined Radar-Radiometer Algorithm (CMB). Users are encouraged to check related CMB documentation.

CSH retrievals in the tropical TRMM domain are based upon GCE model simulations that do not include terrain. At higher latitudes, the CSH LUTs are based upon NU-WRF simulations that do include terrain. However, areas with domain heights above 500 m were screened out in the construction of the LUTs. Therefore, CSH retrievals both in the Tropics and at higher latitudes in areas with higher terrain should not be relied upon.

References:

Lang, S., W.-K. Tao, J.-D. Chern, D. Wu, and X. Li, 2014: Benefits of a 4th ice class in the simulated radar reflectivities of convective systems using a bulk microphysics scheme. *J. Atmos. Sci.,* **71**, 3583-3612. doi: http://dx.doi.org/10.1175/JAS-D-13-0330.1

Tao, W.-K., S. Lang, X. Zeng, S. Shige, and Y. Takayabu, 2010: Relating convective and stratiform rain to latent heating. *J. Climate.,* **23,** 1874-1893.

Tao, W.-K., D. Wu, S. Lang, J.-D. Chern, C. Peters-Lidard, A. Fridlind, and T. Matsui, 2016: High-resolution NU-WRF simulations of a deep convective-precipitation system during MC3E: Further Improvements and Comparisons between Goddard microphysics schemes and observations. *J. Geophy. Rev. Atmos*., **121**, 1278-1305, doi:10.1002/2015JD023986.