

The Next-Generation Goddard Convective-Stratiform Heating Algorithm



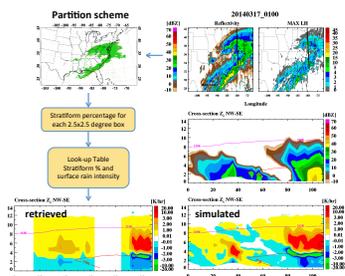
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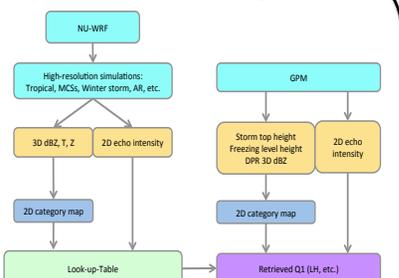
²Science Systems and Applications, Inc., Lanham, MD

Background

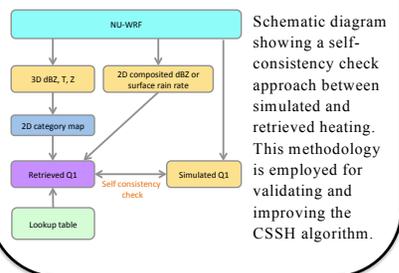
How to retrieve latent heating (LH) from satellite observations? In the current CSH algorithm, fine-binned look-up tables (LUTs) based on surface rain intensity and stratiform % are constructed from a compilation of several CRM simulations. The LUTs are then interfaced with comparable satellite observables to retrieve LH. However, for synoptic snow storms, stratiform % is almost always near 100%. Thus, more information is required to improve the CSH algorithm for GPM.



CSSH Flow Diagram



Schematic diagram for the new Goddard Convective Stratiform Synoptic Heating (CSSH) algorithm, utilizing NU-WRF-simulated variables corresponding to GPM satellite observables.

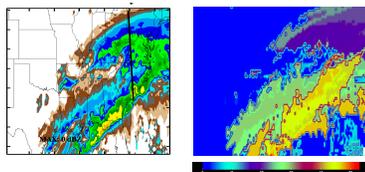


Schematic diagram showing a self-consistency check approach between simulated and retrieved heating. This methodology is employed for validating and improving the CSSH algorithm.

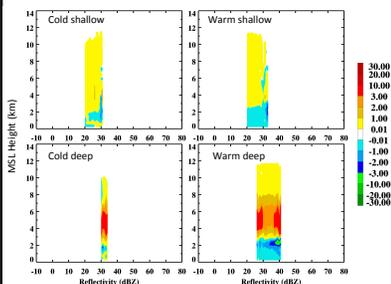
CSSH LUTs

The steps for constructing the CSSH LUTs include:

- Identify key variables (freezing level, echo top height, anvil, height of maximum dBZ) based on GPM observables.
- Construct bins for each of the key variables.
- Create heating tables for the categorized regions.



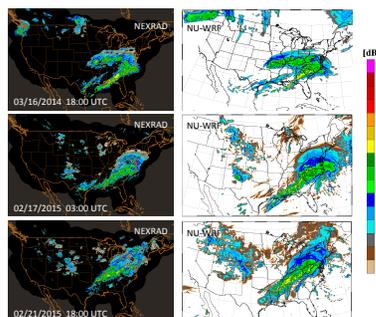
The left panel shows the composite NU-WRF dBZ field. The right panel shows the categorized regions at the same instant as the dBZ field. The category map is able to identify deep/shallow clouds, anvil regions, and cold/warm sectors, etc.



The above is an example showing LH profiles from only four regions out of the categorization map. The heating profiles vary widely among the four regions.

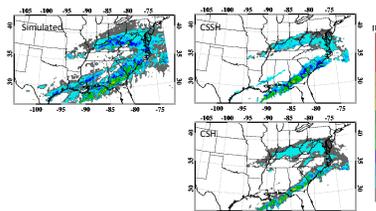
At the same time, the LH profiles are mostly consistent within each region across different dBZ intensities, thus the quasi-stratified features. The larger the differences between the regions, the more effective the categorization is, such that the LUTs will be more accurate in describing the LH features.

Winter Storm Cases



Composite radar reflectivity fields from NEXRAD observations and NU-WRF simulations using the new Goddard 4ICE bulk microphysics scheme for three winter storms. NU-WRF performs reasonably well in reproducing the shapes, intensities and locations of precipitation features for all three winter storms.

LH Evaluation

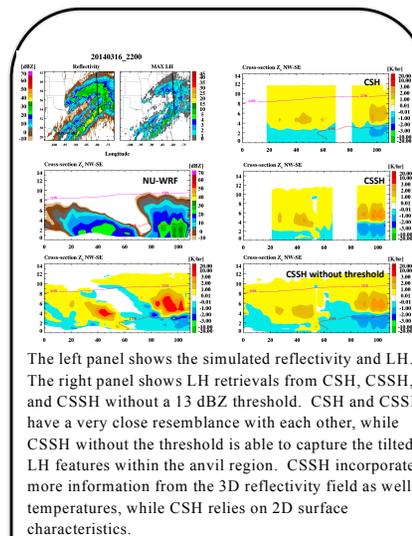


Retrieve for regions with reflectivity > 13 dBZ (20140316 22:00 UTC)

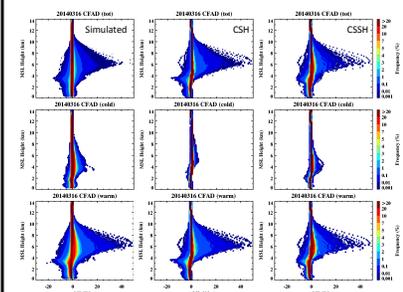
Instantaneous column maximum LH rates from NU-WRF simulations, and retrievals using the new CSSH and current CSH algorithms. Both CSSH and CSH capture the general heating pattern and intensities within the warm sector. CSSH did a slightly better job than CSH in the cold sector; however, both algorithms have weaker peak intensities in the cold sector than were actually simulated.

Summary

- The CSSH algorithm is being built upon the CSH to expand LH retrievals to include winter storm systems.
- New categories have been identified to link features in the satellite observables with associated LH structures.
- NU-WRF, upon which new LUTs will be based, did a reasonable job in simulating winter storms.
- CSSH improves the LH retrievals within the cold sector, but CSH does a better job for the warm sector.



The left panel shows the simulated reflectivity and LH. The right panel shows LH retrievals from CSH, CSSH, and CSSH without a 13 dBZ threshold. CSH and CSSH have a very close resemblance with each other, while CSSH without the threshold is able to capture the tilted LH features within the anvil region. CSSH incorporates more information from the 3D reflectivity field as well as temperatures, while CSH relies on 2D surface characteristics.



Contoured frequency with altitude diagrams (CFADs) for simulated and retrieved LH fields. CSH shows the lack of peak intensities in the cold sector for both heating and cooling, while CSSH does a better job there. Both CSH and CSSH are able to capture the general LH structure in the warm sector. CSH does a slightly better job at retrieving peak intensities than CSSH in the warm sector.

Di Wu, W.-K. Tao, and S. Lang (2016): The Next-Generation Goddard Convective-Stratiform Heating Algorithm, *J. Atmos. Sci.*, in preparation.