Assimilation of hyperspectral infrared radiances from the cloud-clearing methodology: Results from the 2017 Atlantic Tropical Cyclone season

E. L. McGrath-Spangler, N. Boukachaba, O. Reale, M. Ganeshan, W. McCarty, R. Gelaro, C. Barnet

Introduction and Motivation

Assimilation of cloud-affected radiances has the potential to dramatically improve numerical weather prediction systems, as has already been widely shown by use of all-sky microwave radiances. Assimilation of cloudy infrared (IR) radiances, however, lags far behind and only clear-sky radiances are used operationally, leaving data voids in dynamically sensitive areas, such as around tropical cyclones. This team has previously shown the positive benefit of assimilating cloud-cleared IR radiances from hyperspectral sensors (CCRs) and in this work applies the cloud-clearing methodology to generate fully customizable CCRs using an algorithm designed to be portable and reduce latency. These data are successfully assimilated in the Goddard Earth Observing System (GEOS) data assimilation system (DAS) for the 2017 Atlantic Hurricane season.

Locally-produced CCRs

Cloud-clearing removes cloud effects from a field of view (FOV) and derives the clear-sky equivalent radiances, allowing thermodynamic information from cloudy areas to be assimilated in an NWP system.

For AIRS and more recently with CrIS, this team modified the AIRS ST algorithm:

- Eliminated dependence on the neural network and instead uses the model background fields as the first guess
- Tailored the channel selection to the GEOS DAS
- Parallelized the code to increase speed

CCRs can now be customized to ANY modeling system for assimilation.

Results

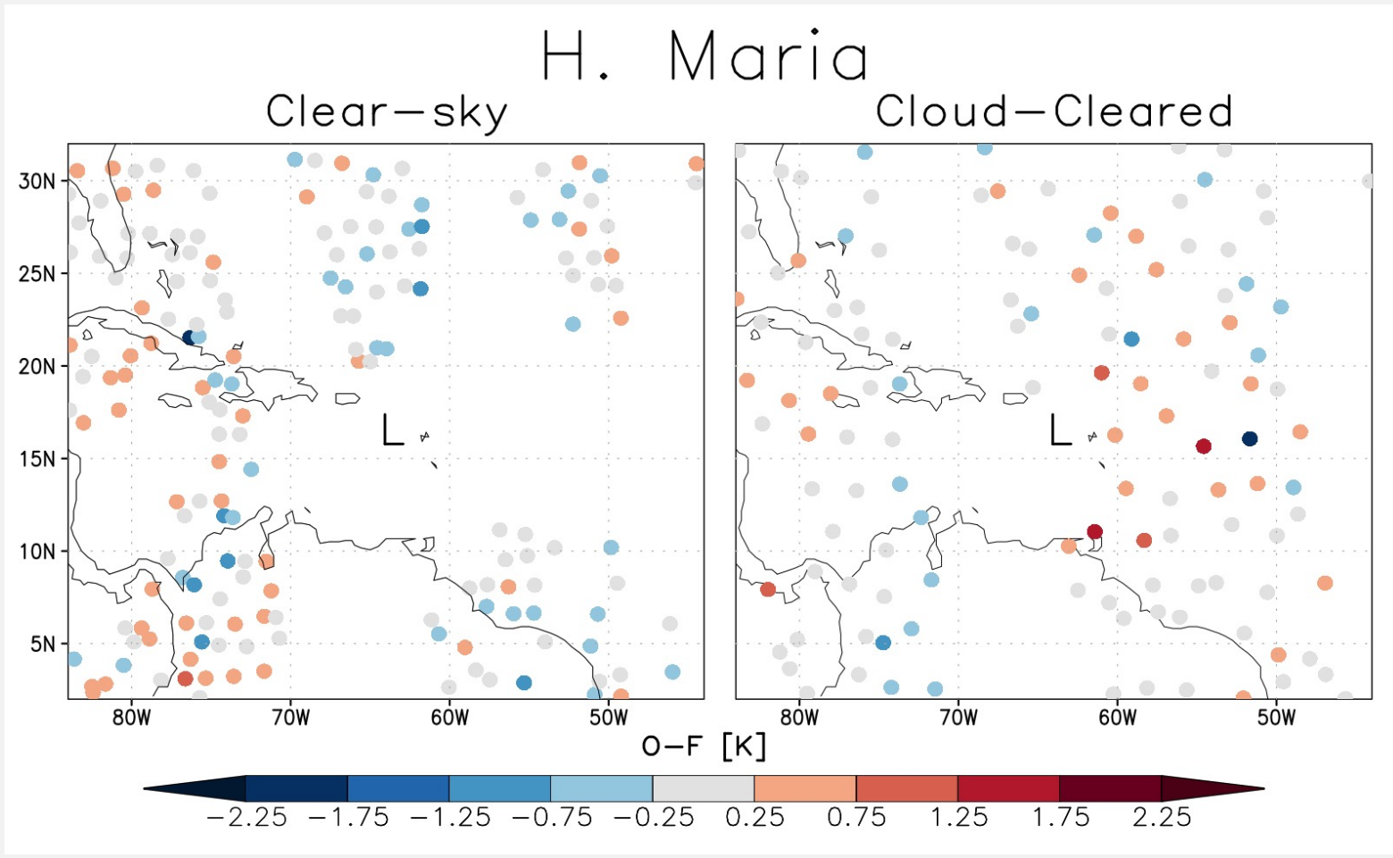

Fig. 1 Obs. minus Fcst. (O-F) temperature differences for AIRS channel 215 (~487-hPa). Circles indicate the location of assimilated radiances. CCRs must be thinned more aggressively than clear-sky due to greater information content and error correlation issues, resulting in a decrease in total assimilated radiances. CCRs can observe cloudy areas so more data are assimilated near the hurricane.

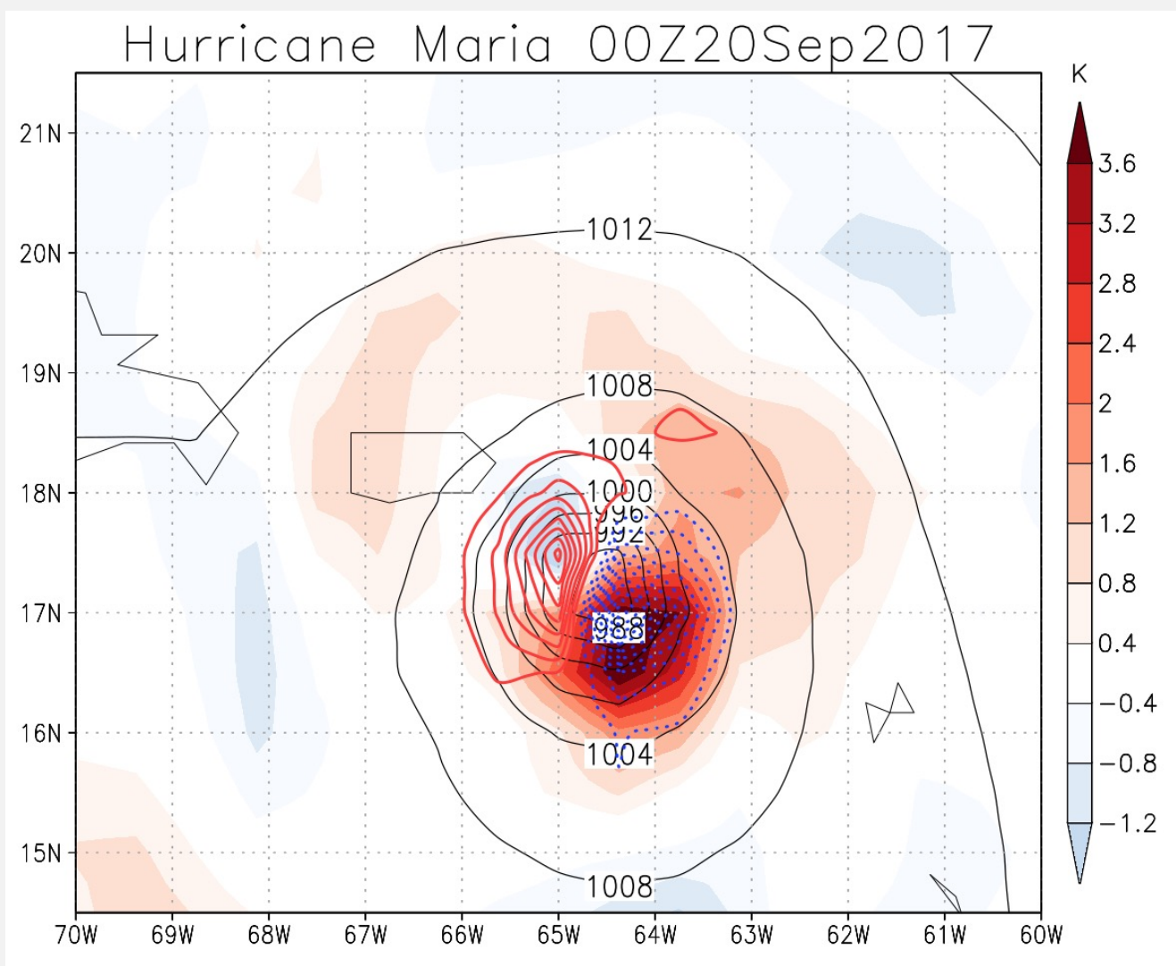

Fig. 2 200-hPa Cloud-cleared minus clear-sky temperature difference (K, shaded), clear-sky SLP (hPa, black contours) and cloud-cleared minus clear-sky SLP difference (hPa, red/blue contours). Assimilating CCRs results in an increased temperature at the top of the hurricane, which, through hydrostatic adjustment results in a lowering of the SLP and an intensification of the storm. This improves the overall representation of the hurricane.

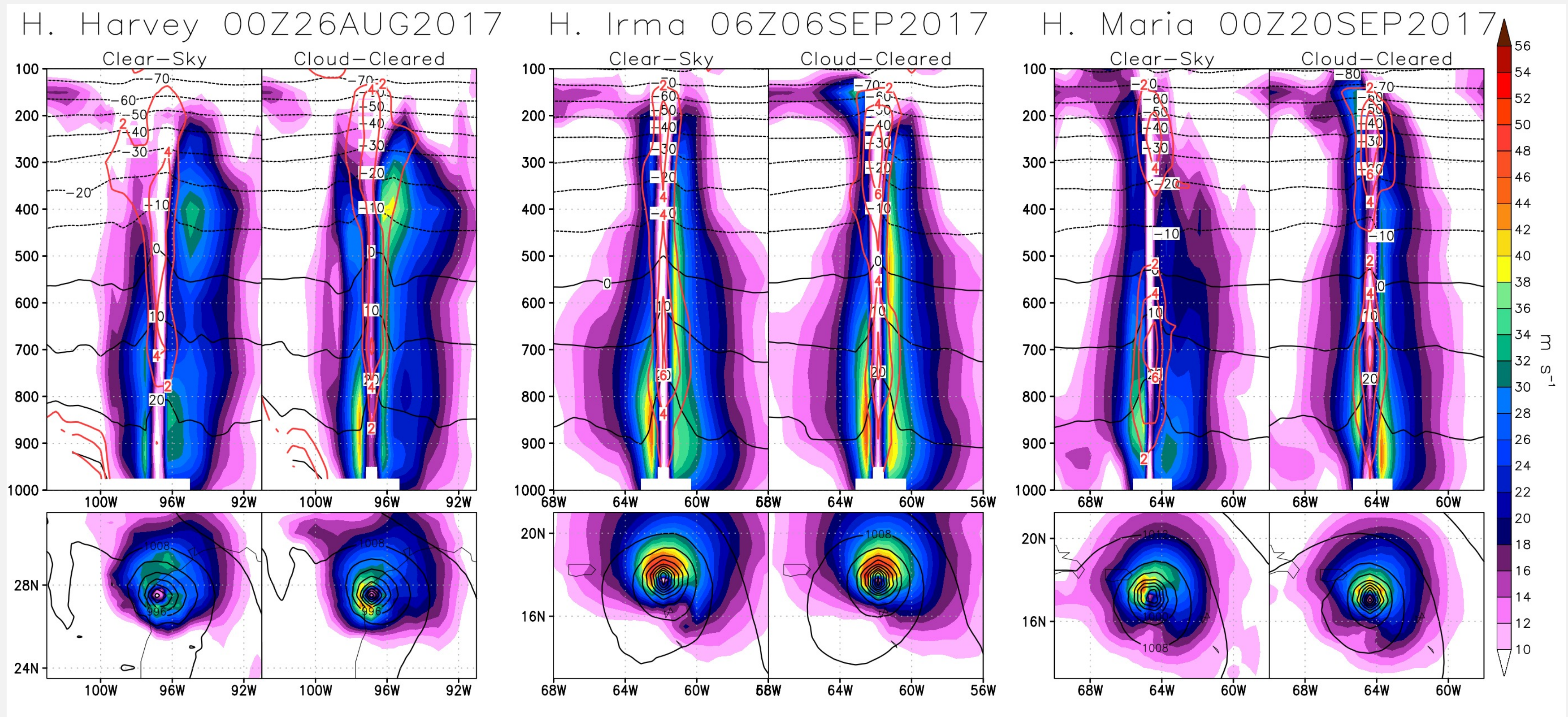

Fig. 3 Wind speed (m s^{-1}, shaded), temperature (ºC, black contours, top), temperature anomaly (ºC, red contours) and slp (hPa, black contours, bottom) for H. Harvey, Irma, and Maria each at maximum intensity. Using the mechanism described in Fig. 2, assimilation of CCRs relative to clear-sky radiances results in an improved horizontal and vertical structure with intensity increases. This includes a more compact eye, an increase in the wind speed, and a stronger warm core.

Summary and Future Work

In the absence of an available all-sky IR methodology, the use of cloud-cleared IR radiances is a viable option capable of improving the representation of tropical cyclones. The cloud-clearing algorithm was modified to allow customization and parallelized to reduce latency, permitting rapidly available and model-tailored CCRs to be assimilated in a near-real-time environment. This algorithm has been successfully applied to AIRS in the GEOS DAS and is currently being tested for CrIS hyperspectral infrared radiances with plans to extend to IASI.

E-mail: Erica.L.McGrath-Spangler@nasa.gov | *Web:* gmao.gsfc.nasa.gov

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