Hyperspectral Sounder Derived Severe Weather Indices

Elisabeth Weisz, William L. Smith Sr., Kathy Strabala, Hung-Lung Huang, Nadia Smith*

Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison

*Science & Technology Corp. (STC), Columbia, MD

AIRS (Atmospheric Infrared Sounder) on EOS-Aqua, IASI (Infrared Atmospheric Sounding Interferometer) on MetOp-A and MetOp-B and CrIS (Cross-track Infrared Sounder) on Suomi NPP provide high vertical resolution atmospheric temperature and humidity profiles from which severe weather indices such as the Lifted Index (LI) can be computed. These measures can be used to evaluate the atmospheric stability in the pre-convective storm environment within weather monitoring and forecasting operations.

The NOAA Unique Combined Atmospheric Processing System (NUCAPS) and the UW hyperspectral Dual-Regression (DR) algorithm are employed to investigate atmospheric instability associated with the severe weather outbreak on 11 May 2016. Both algorithms are available through the Community Satellite Processing Package (CSPP).

Results are shown from the CSSP DR algorithm as well from a research version that includes a de-aliasing (DA) step to correct for the vertical resolution alias error (Ref. 1). In general, the vertical structure of retrieved profiles, limited by the vertical resolving power of the radiance measurements, will be aliased towards the training-set mean. The vertical alias is the difference between a model profile (e.g., Global Data Assimilation System or GDAS, Rapid Refresh or RAP) and a simulated profile retrieval, derived from simulated radiances (which in turn were calculated from the model profile using PCRTM – Principal Component-based Radiative Transfer Model). The vertical alias is then removed from the DR profile retrieval obtained from the measured radiance spectrum. The de-aliased retrievals show fine-scale vertical temperature and water vapor features similar to the vertical structure of radiosonde observations.
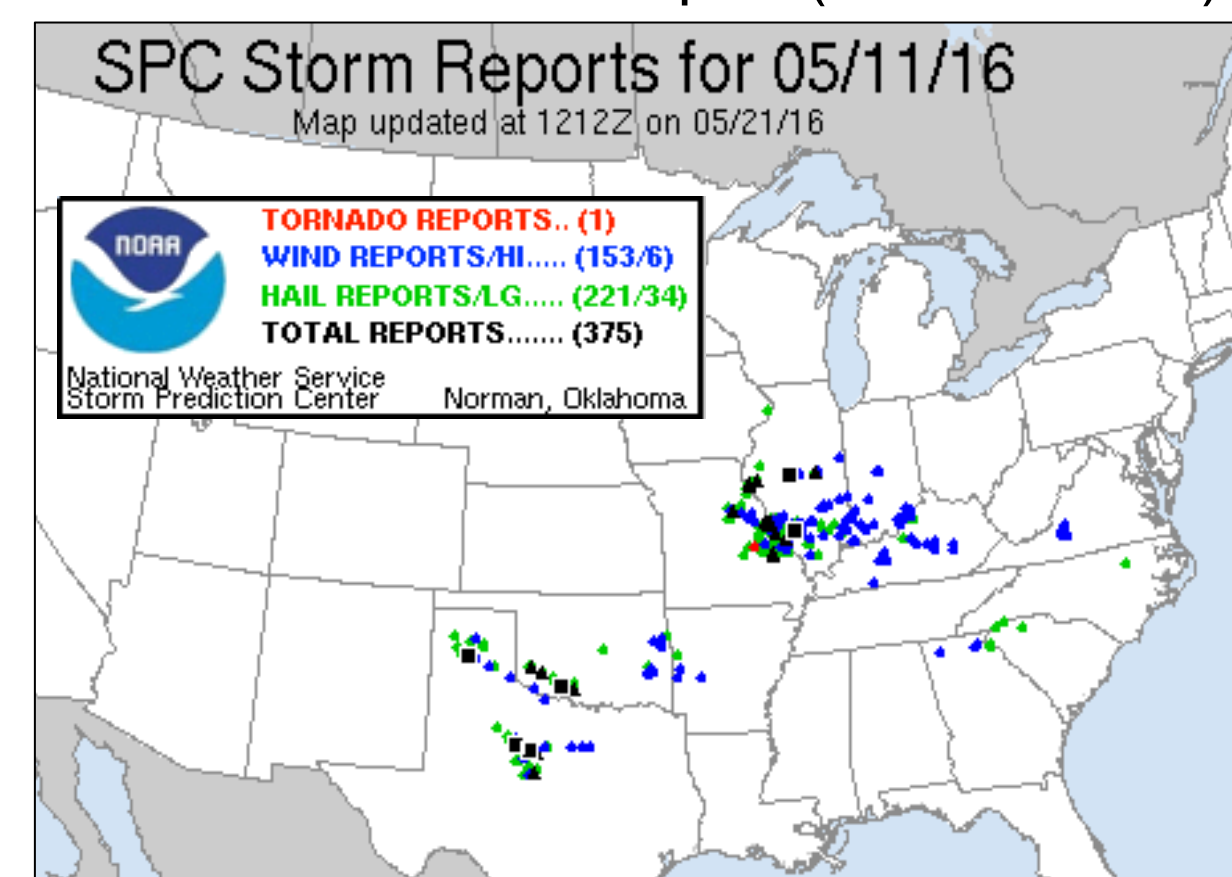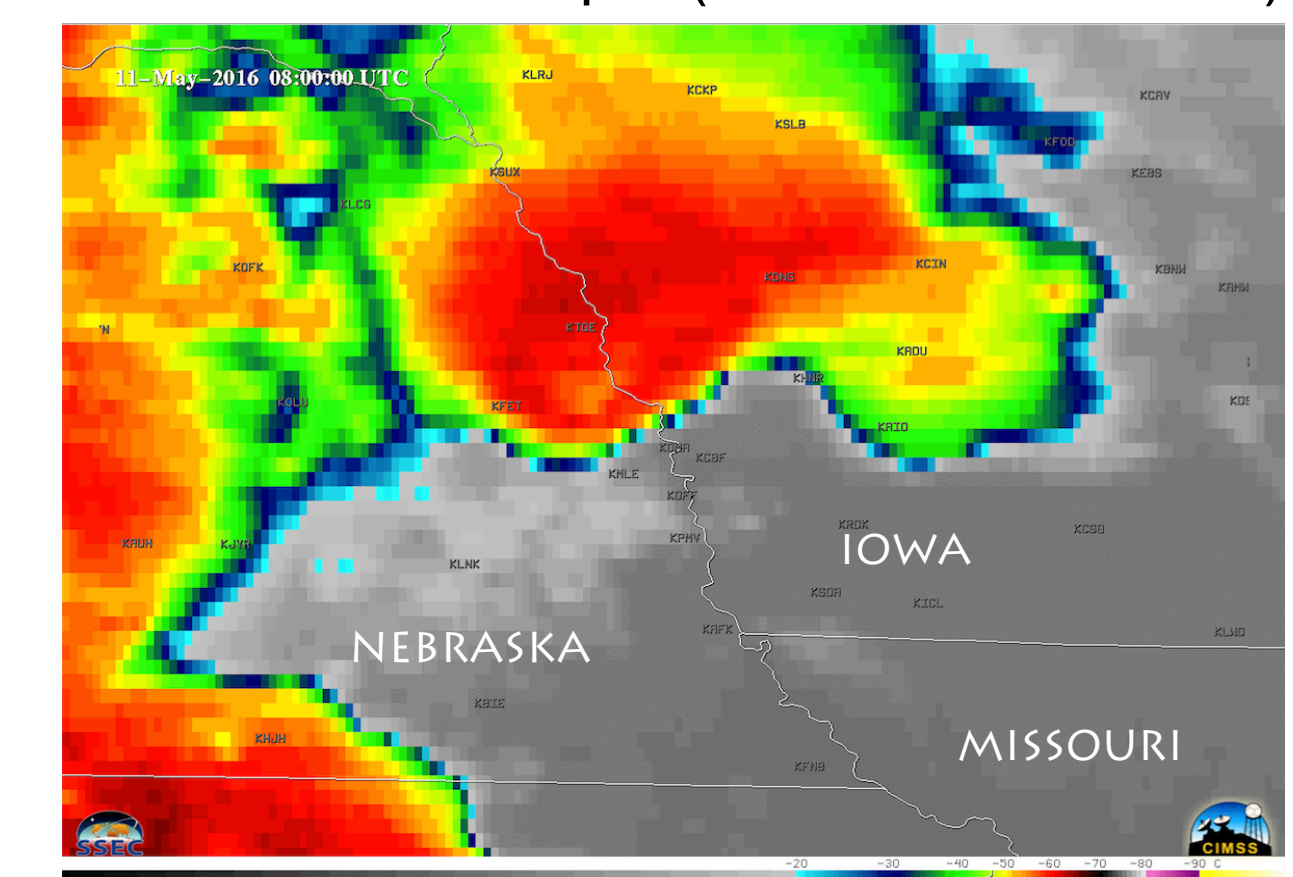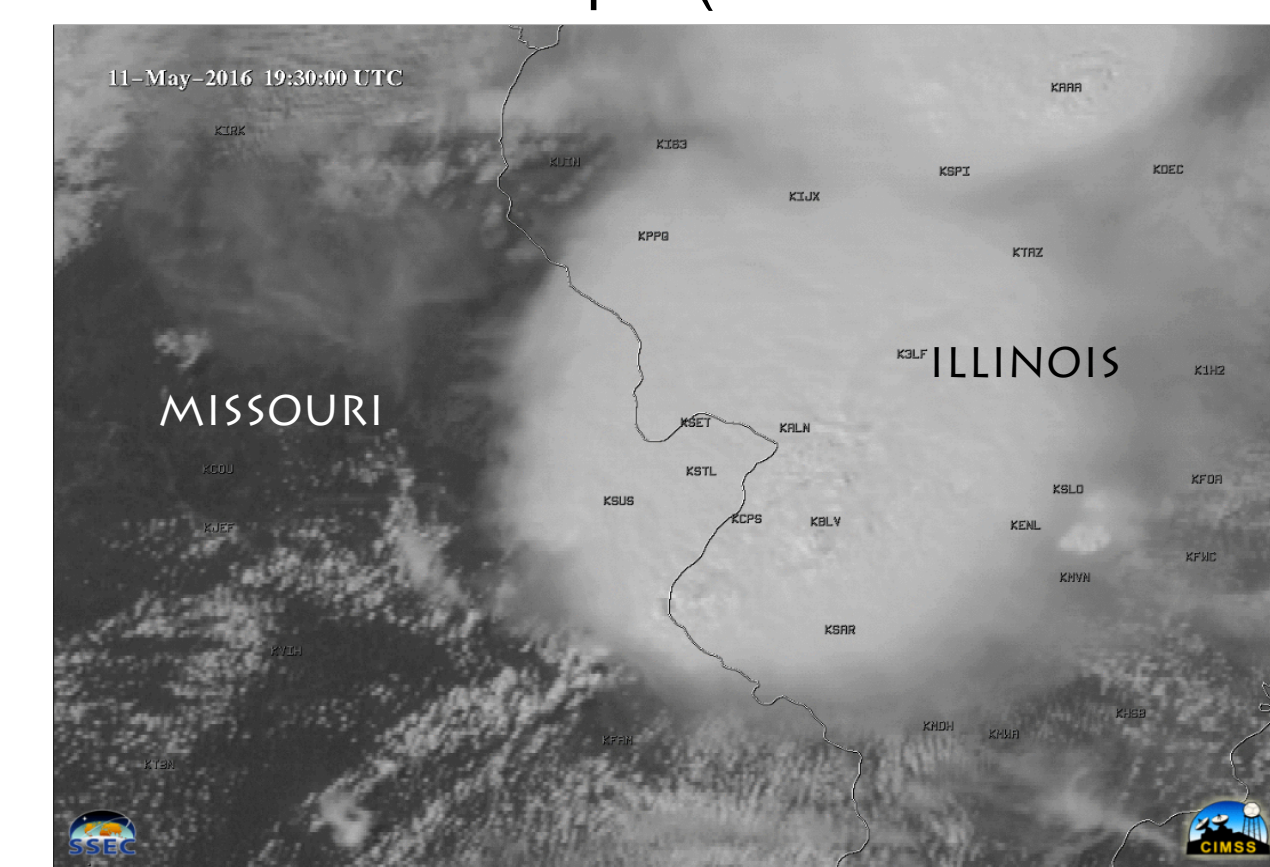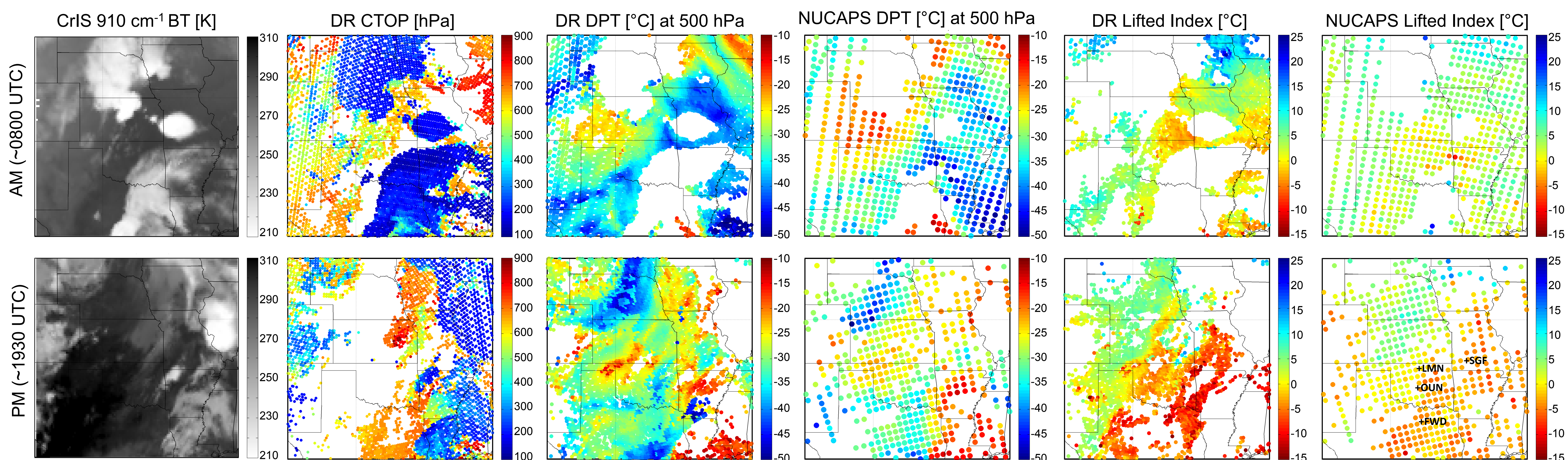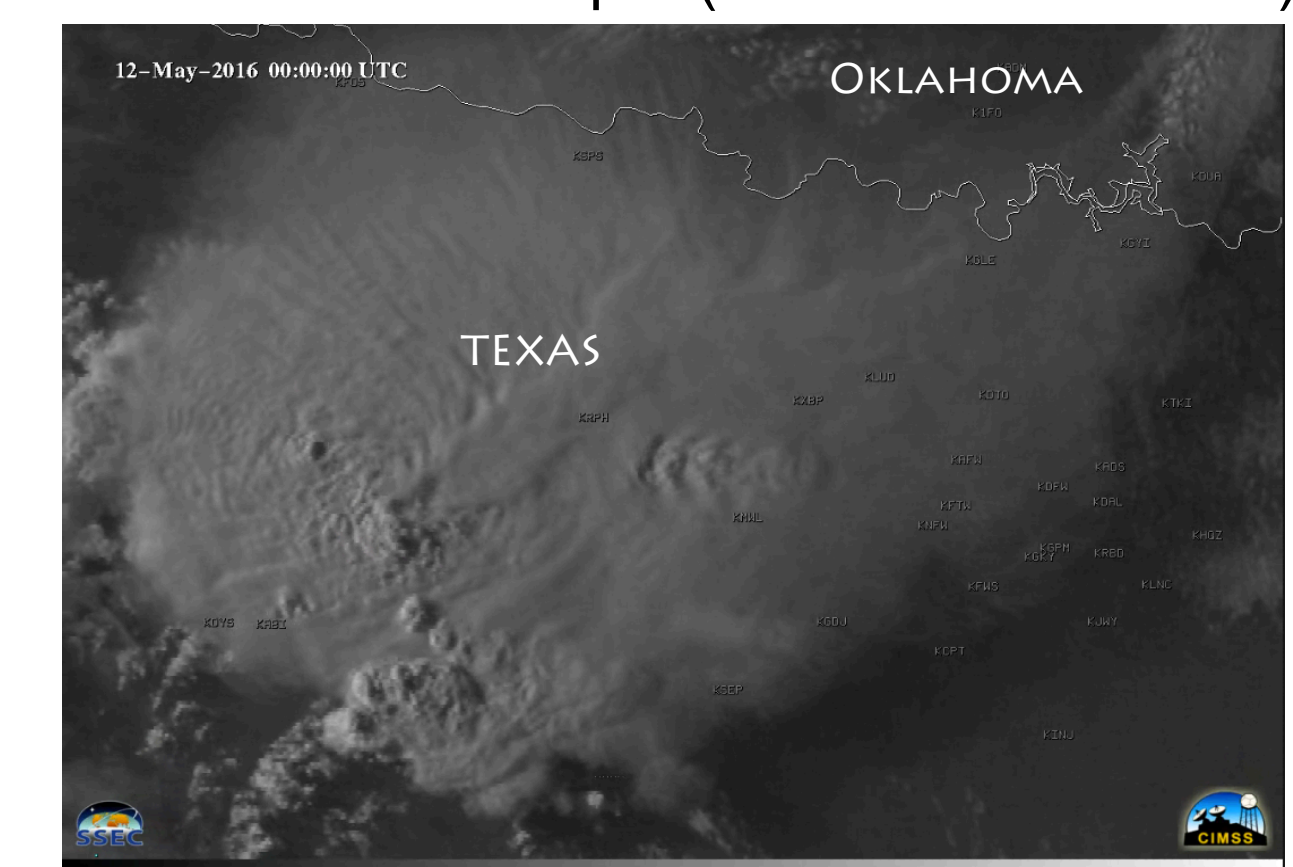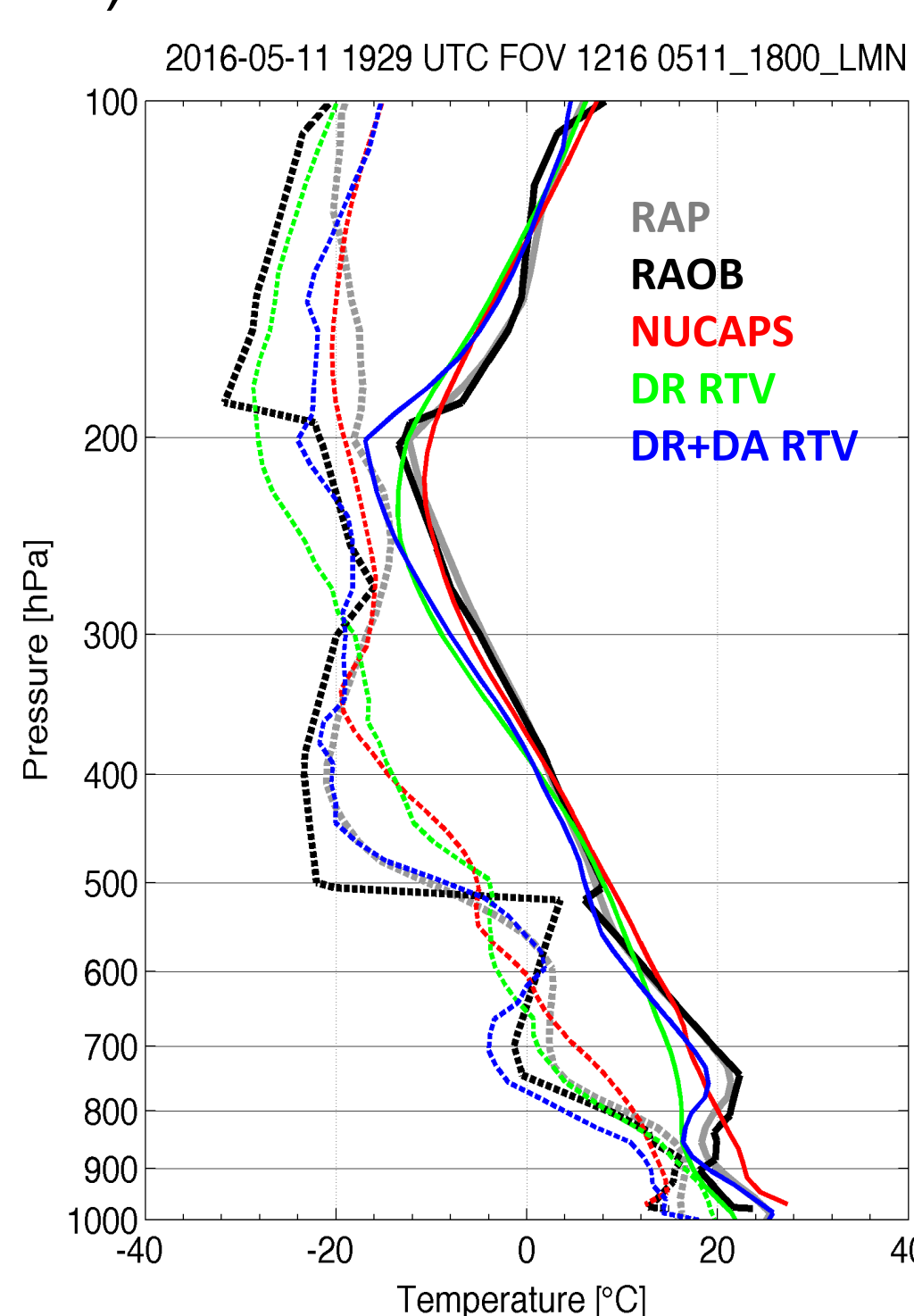

Figure 1. CrIS Brightness Temperatures (BT) at a window channel, Dual-Regression (DR) retrieved cloud top pressures (CTOP), DR and NUCAPS dewpoint temperature (DPT) at 500 hPa, as well as DR and NUCAPS Lifted Index. For the morning at approx. 03:00 CDT (top) and afternoon at approx. 14:30 CDT (bottom) S-NPP overpasses on 11 May 2016.
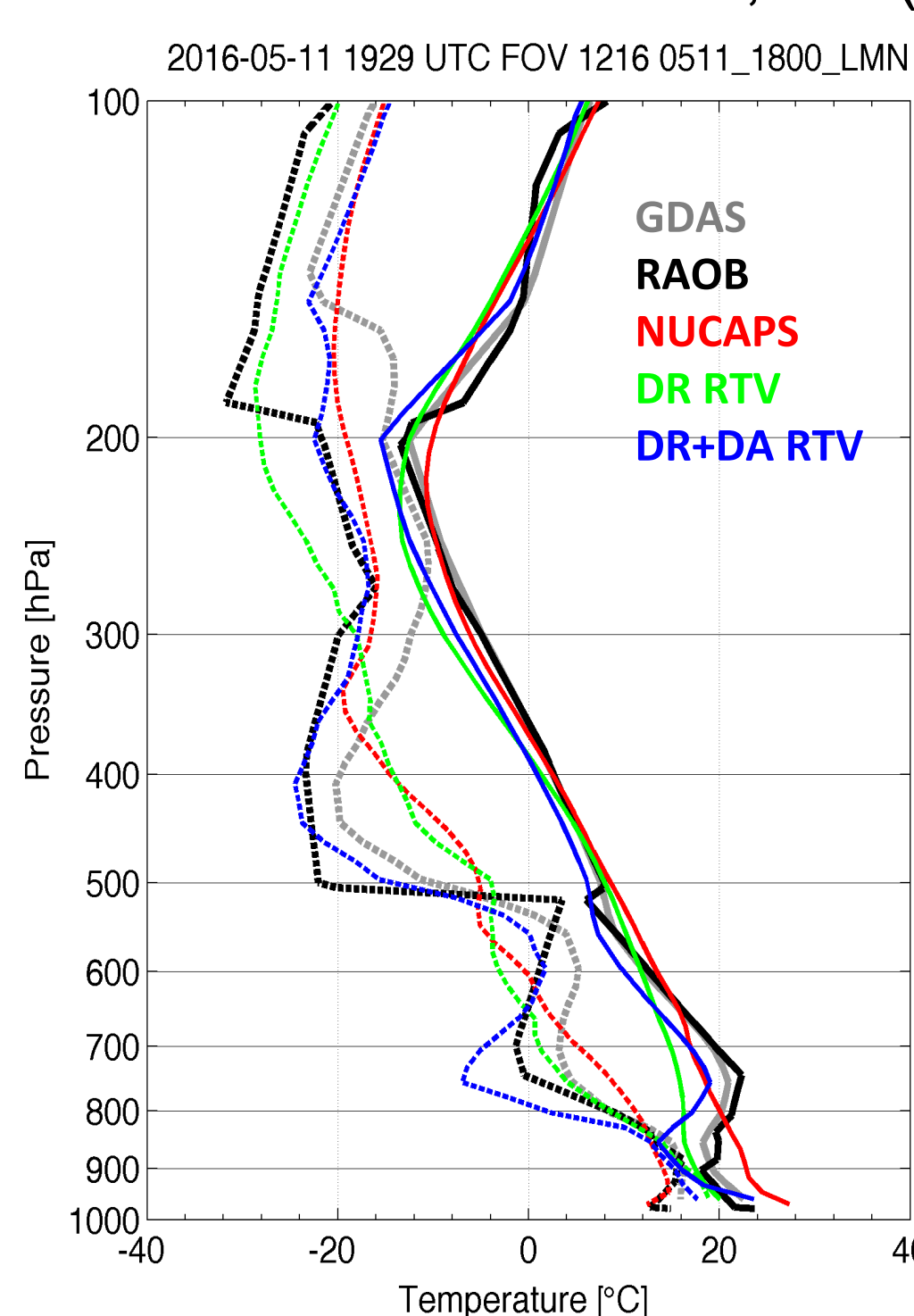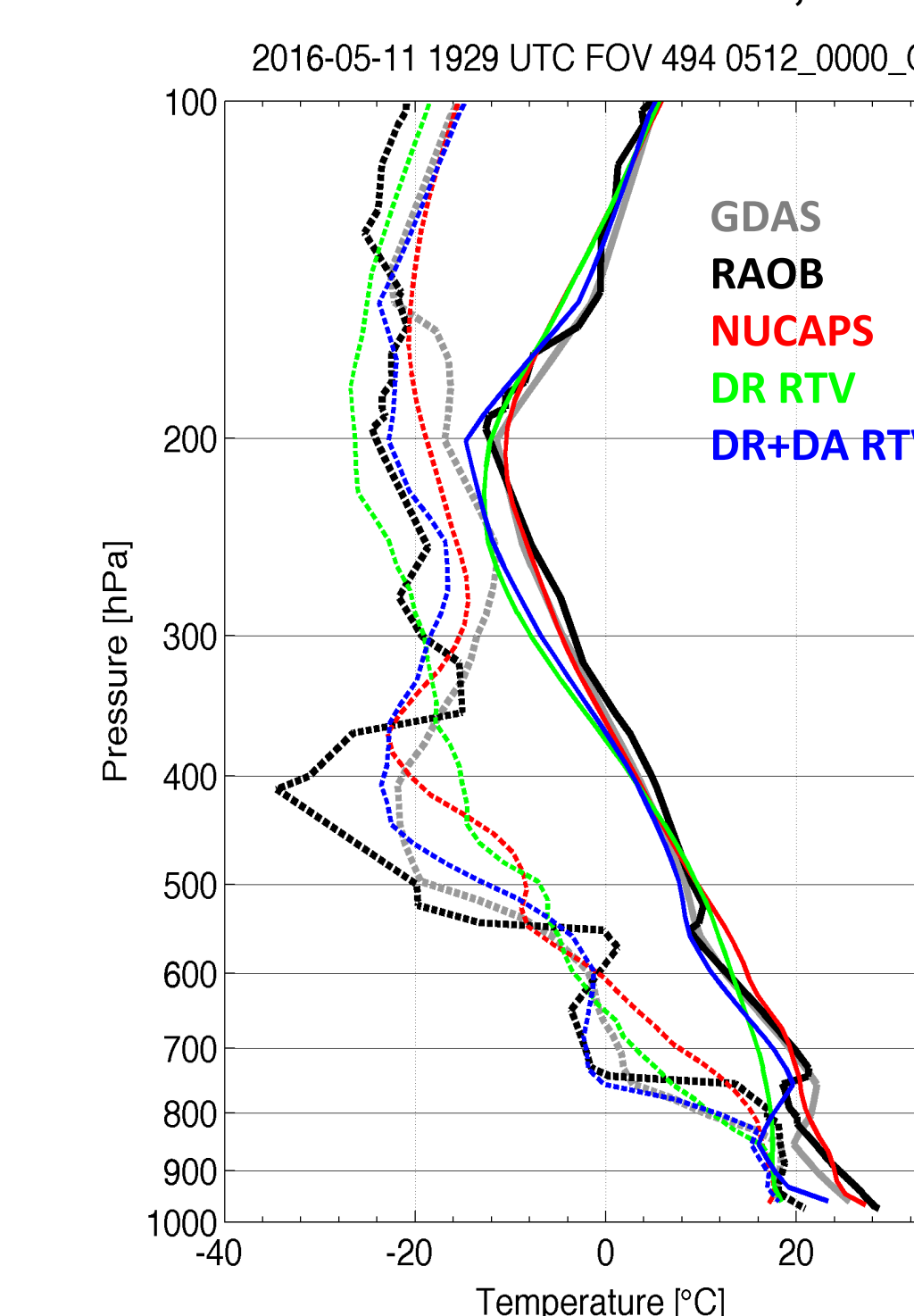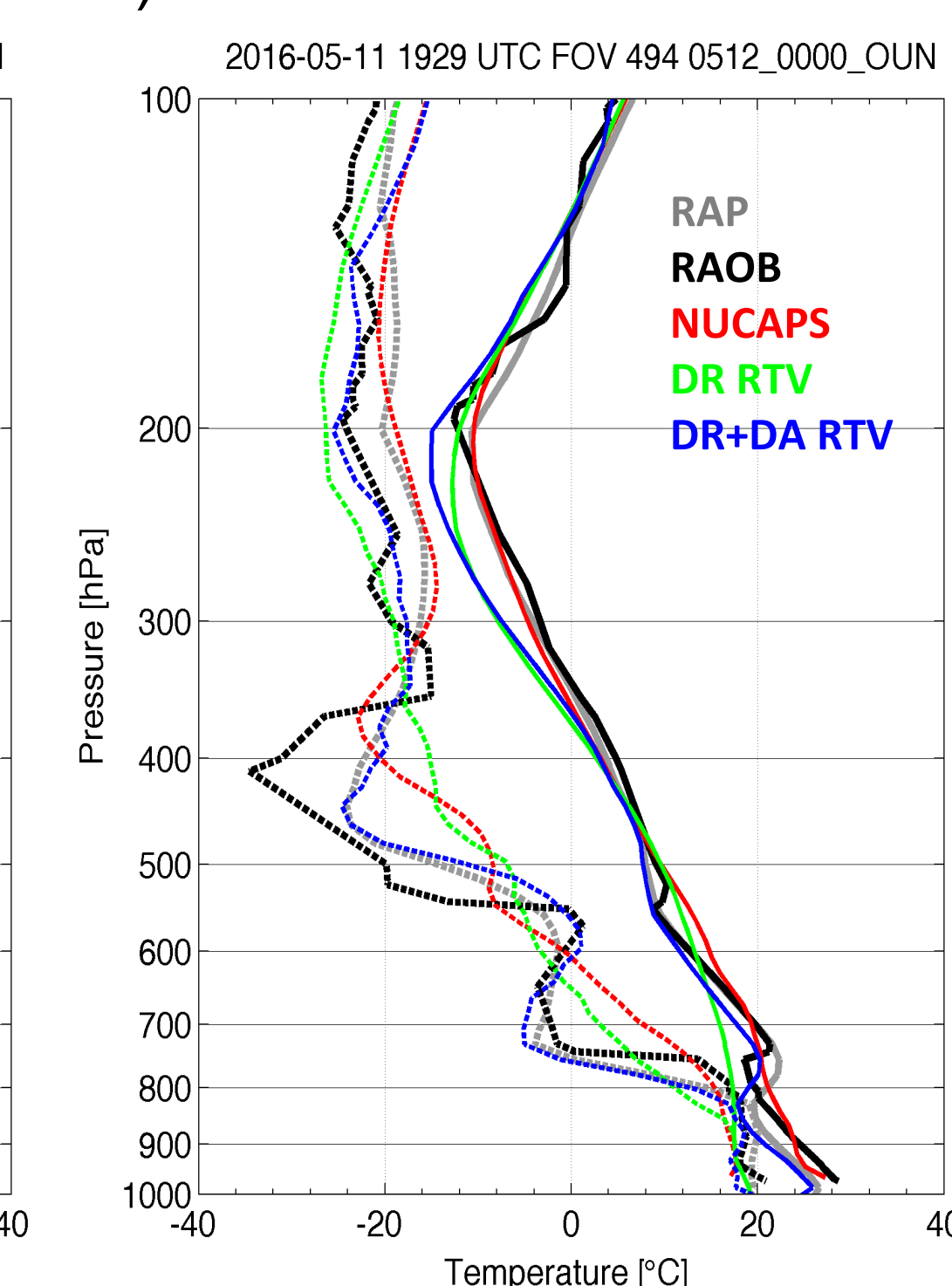

Figure 2. Co-located dewpoint (dashed) and temperature (solid) profiles in comparison with radiosonde observations (RAOB) at different weather stations. GDAS and RAP profiles, as used in the DR and DR+DA retrieval, are shown in gray on the left and right, respectively.

Station	Lifted Index [°C]						
	GDAS **DR** RAP		GDAS **DR+DA** RAP		NUCAPS	1800 **RAOB** 0000	
LMN Lamont, OK	-4.3	-5.7	-6.7	-10.8	-0.6	-1.7	-4.3
OUN Norman, OK	-1.4	-1.6	-5.5	-8.2	-4.1	--	-9.6
SGF Springfield, MO	-7.2	-8.5	-12.6	-12.9	-3.4	-7.0	-8.6
FWD Forth Worth, TX	--	--	--	-9.6	-2.8	--	-10.9
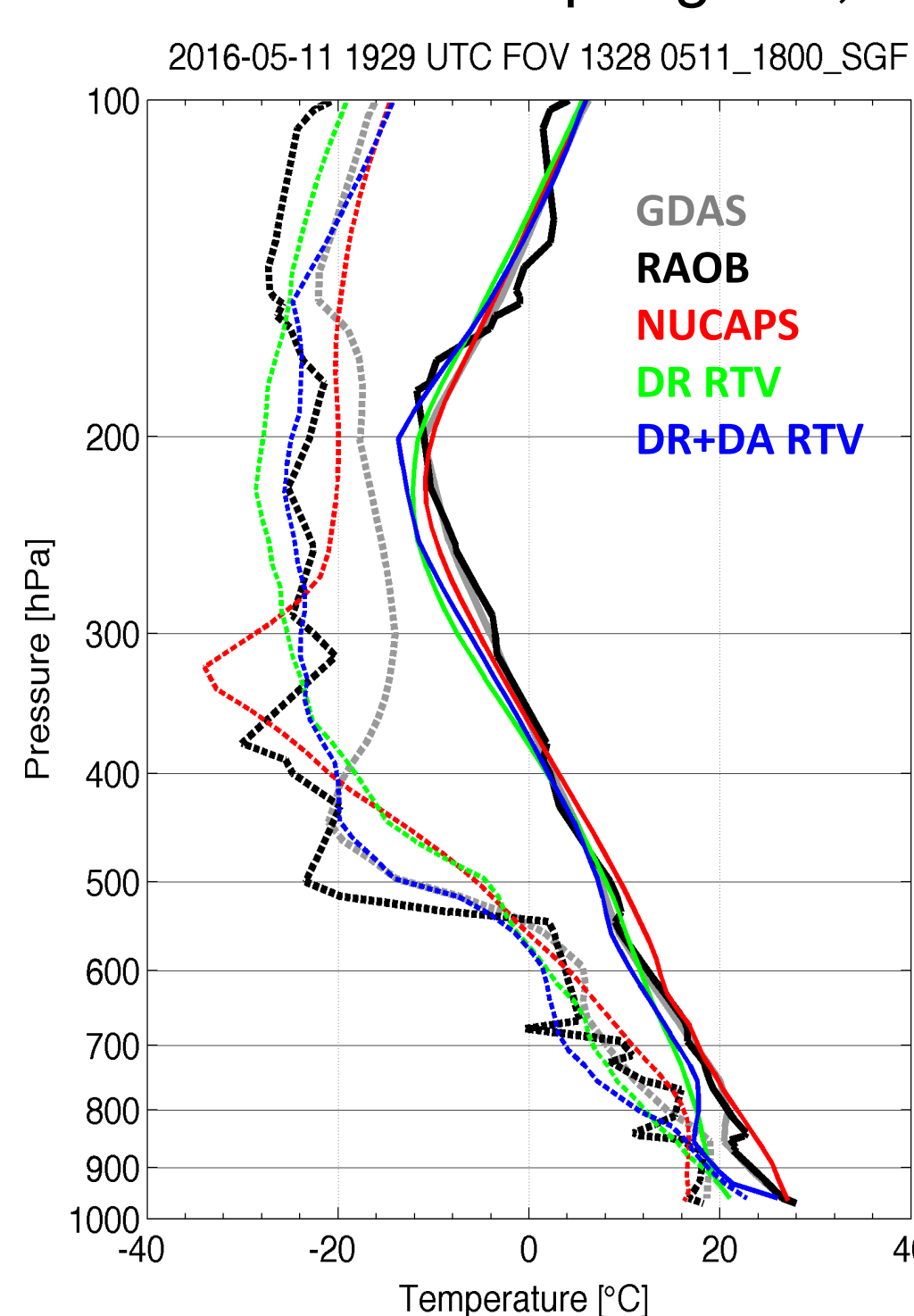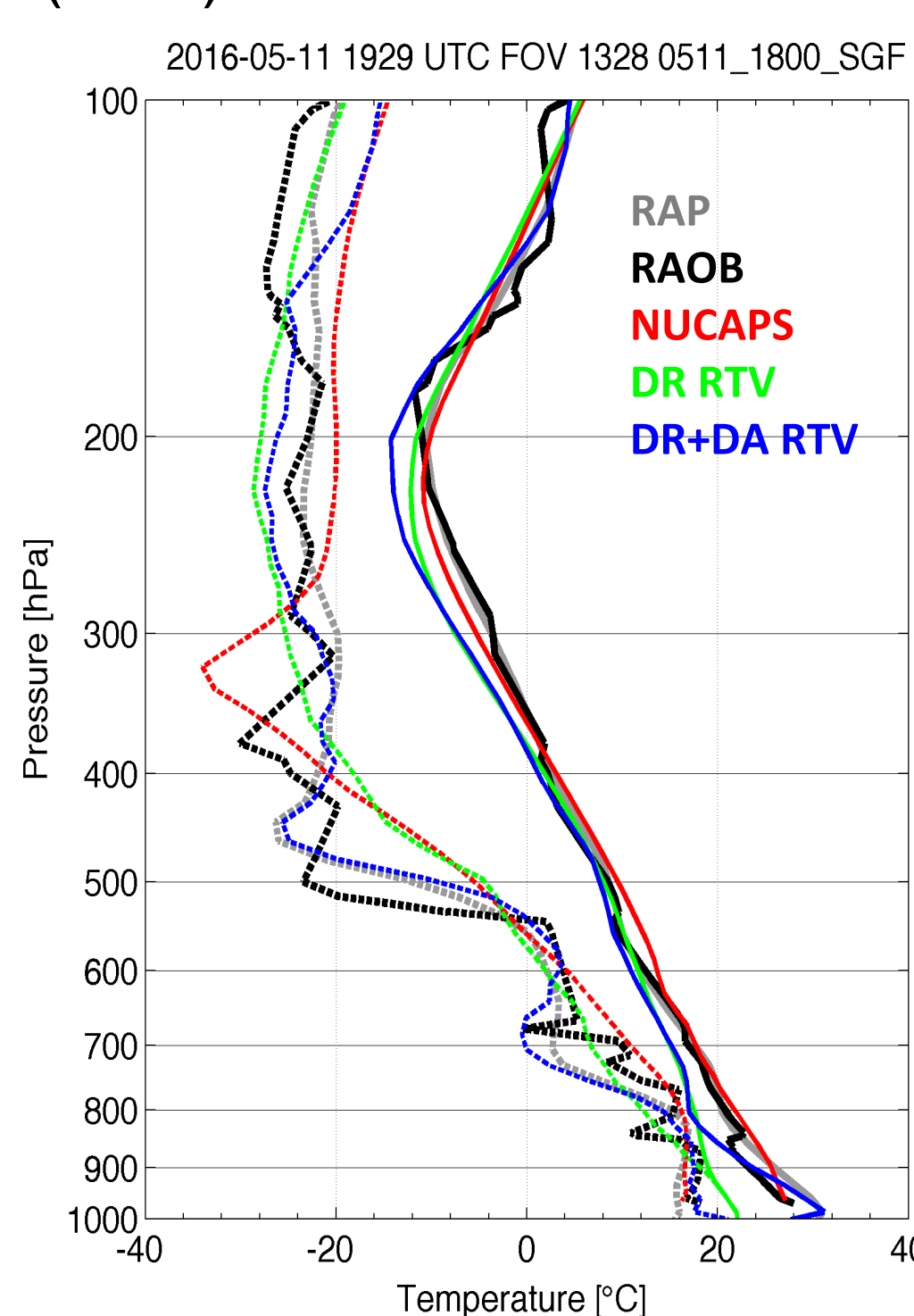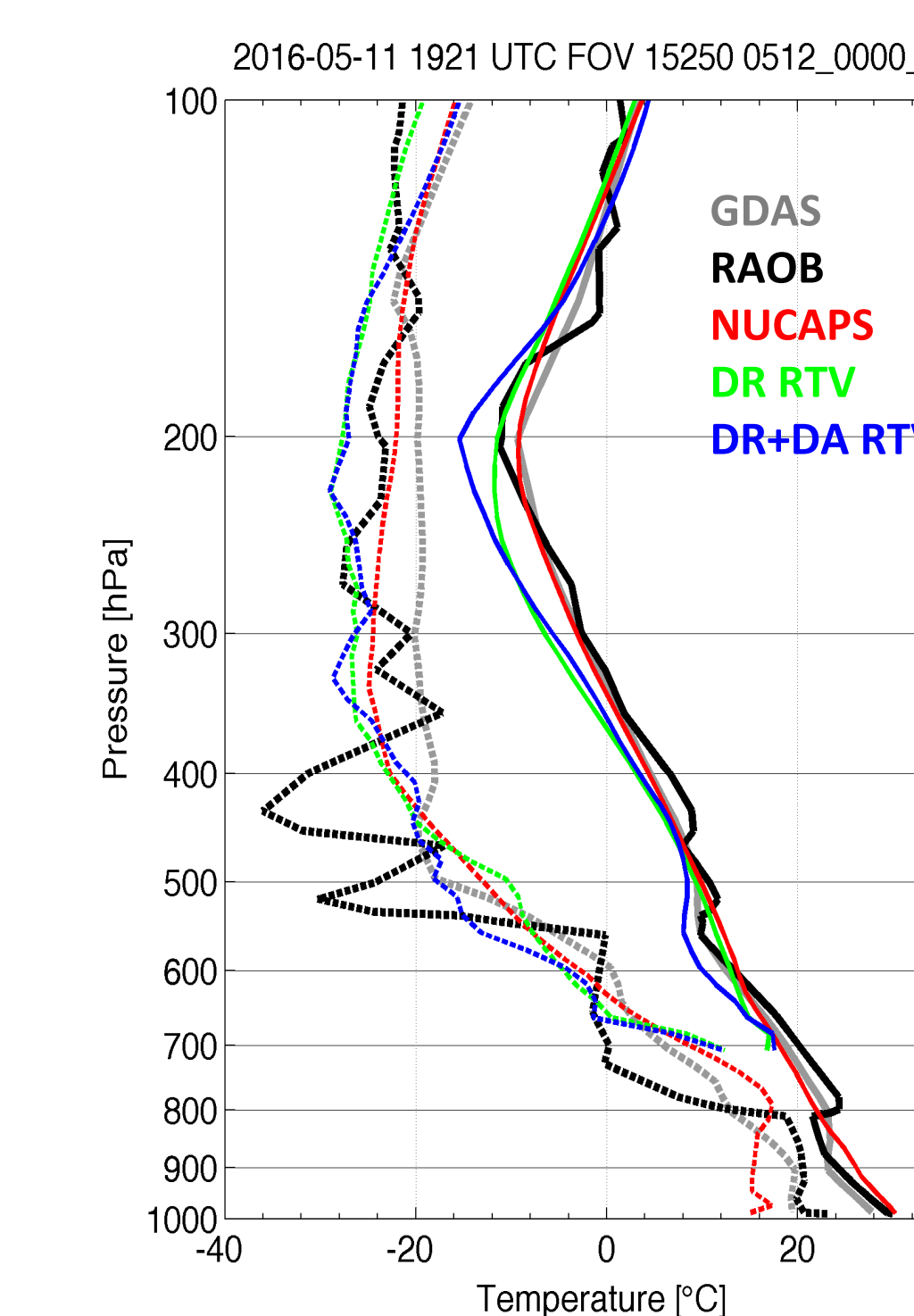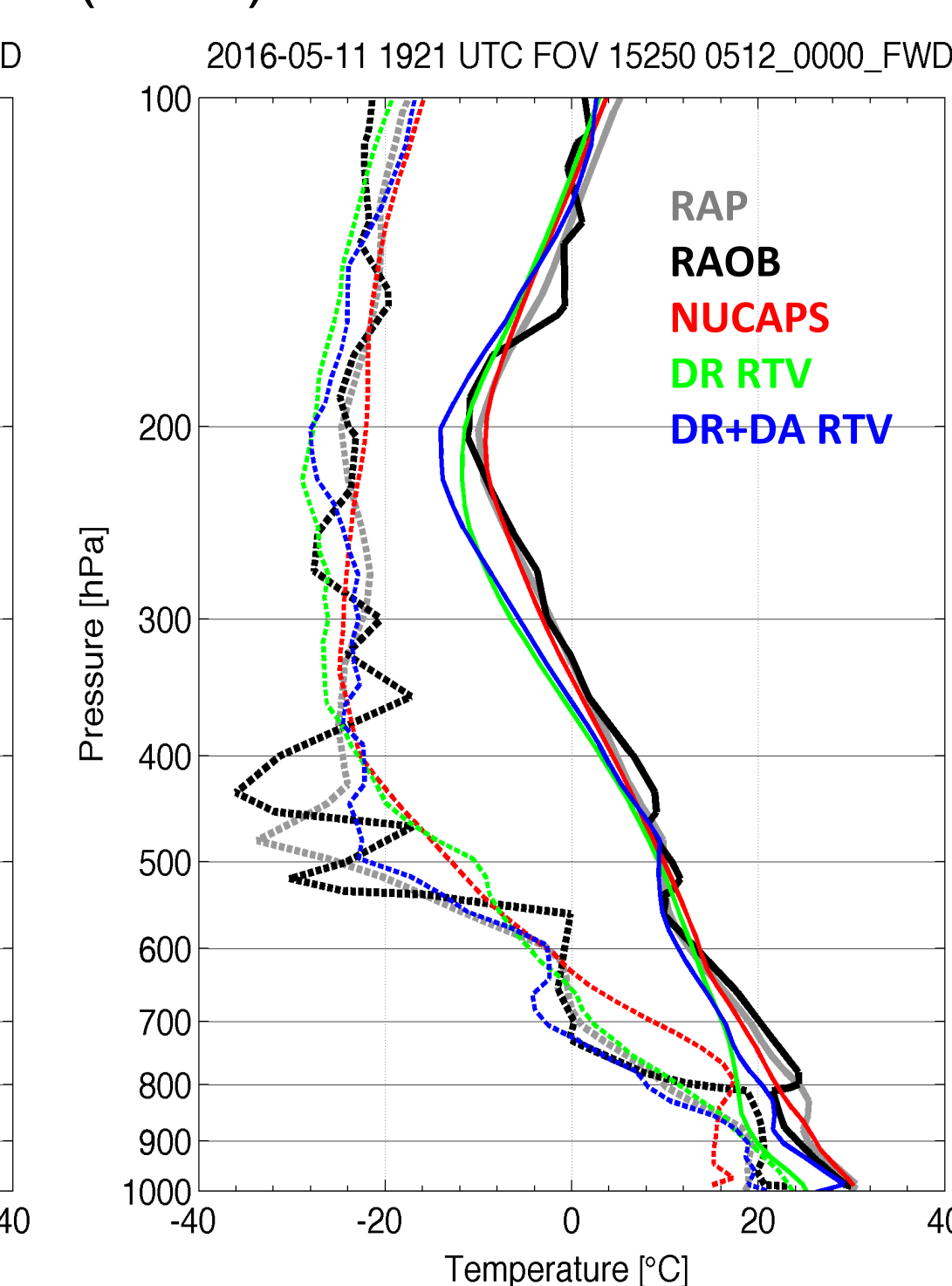
- NUCAPS, DR, and DR+DA retrievals prove valuable in the assessment of atmospheric conditions favorable to severe weather, and are found to complement the information from conventional surface and upper air data networks, satellite imagery and NWP models.

- DR and NUCAPS retrievals differ due to differences in algorithm design and methodology. For example, NUCAPS provides retrievals below most clouds due to the incorporation of microwave data, the DR allows for more details in the products due to its higher spatial resolution.

- DR retrievals which have been de-aliased show fine-scale vertical structure and compare better to radiosondes. The cold profile bias can be eliminated with a radiometric bias correction (e.g., similar to what NUCAPS uses). Overall, a positive impact is expected when these de-aliased retrieval profiles are assimilated in NWP models.

(1) W. L. Smith and E. Weisz (2017), "Dual-regression approach for high spatial resolution infrared soundings", Elsevier's MRW Comprehensive Remote Sensing.