A Module for Assimilating Hyperspectral Infrared Retrieved Profiles into the Gridpoint Statistical Interpolation System for Unique Forecasting Applications

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Background

- SPoRT has a history of assimilating hyperspectral infrared (IR) profiles into Gridpoint Statistical Interpolation (GSI) system for regional modeling studies utilizing the Weather Research and Forecasting (WRF) model
- Traditionally hyperspectral infrared radiance data are assimilated into global operational modeling systems
- The amount of radiance data assimilated is limited due to data thinning and because radiances are restricted to cloud-free fields of view
- The number of hyperspectral infrared profiles that can be assimilated is much higher
  - Partly cloudy scenes can be assimilated
  - Do not need to depend on a complex bias correction like radiance assimilation
- Satellite profiles are traditionally assimilated as rawinsonde observations and assigned rawinsonde errors which are unrepresentative for satellite profiles

Experiment Setup

- NOAA Unique CrIS and ATMS Processing System (NUCAPS) temperature and moisture retrievals are assimilated into the GSI system to demonstrate:
  - Assimilation of hyperspectral IR profiles with appropriate error characteristics other than radiosonde error
  - Generation of analysis increments and changes to the analysis fields as a result of assimilation
- Community WRF version 3.6.1 and GSI version 3.3 from Developmental Testbed Center
- 3 km domain with 13 km Rapid Refresh as boundary conditions
- Physics schemes similar to the Rapid Refresh and High Resolution Rapid Refresh
- NUCAPS temperature (t) and moisture (q) profiles appended to North American Model (NAM) prepbufr files
- This preliminary work only used conventional observations and NUCAPS; no other satellite data; future work will include assimilating more satellite data and radiances

GSI Changes

- NUCAPS profiles were appended to the NAM prepbufr file with a new code to distinguish them from radiosondes
  - Source code changes were not needed to assimilate the profiles
  - Changes were made to tables in the fix directory to assimilate the new data with appropriate error values
- The global_convinfo file contains prepbufr observation types and parameters for gross error checks
  - Added observation type t, q for code 179
- The nam_errtable.r3dv contains the errors for each prepbufr observation type for 33 vertical levels from 1100 hPa to 0 hPa
  - NUCAPS t, q RMS errors from Nalli et al. (2013) were added for observation type 179

NUCAPS Assimilation Results

- The default radiosonde errors (black line) in GSI are generally smaller than the Nalli et al. (2013) NUCAPS RMS errors for temperature (***Fig. 1***) and water vapor (***Fig. 2***)
- Hyperspectral IR profiles, especially temperature, have higher error values near the surface and tropopause
- Assigning appropriate error values can eliminate potential spurious innovations and analysis increments

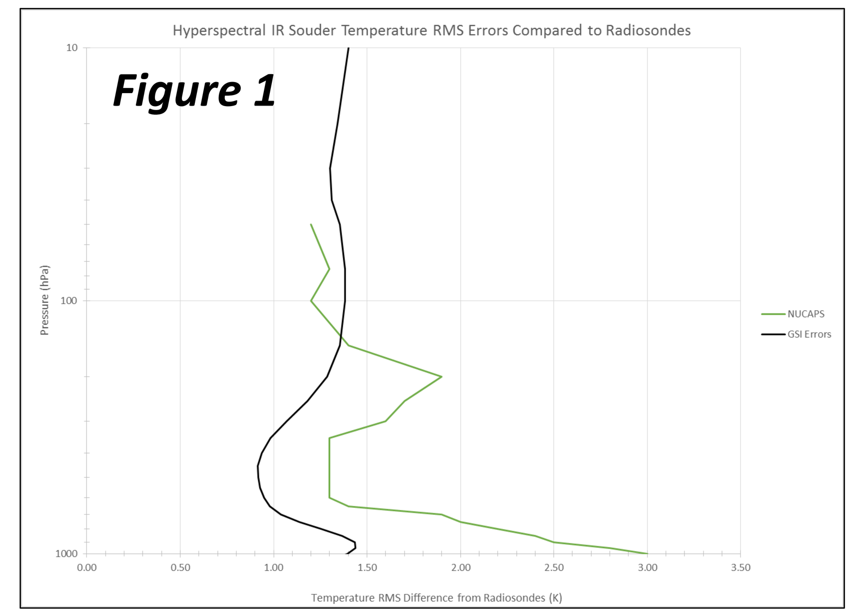

Figure 1

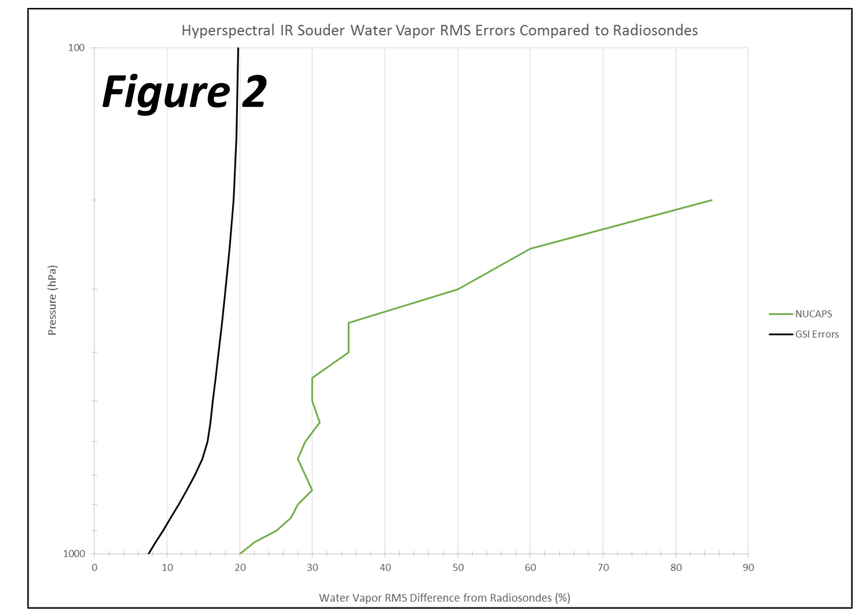

Figure 2

- ***Figure 3a*** shows the locations and color coded innovations where the NUCAPS profiles were assimilated at 850 hPa over a small sample domain
- Yellow/red (green/blue) regions represent locations where individual profiles are warmer (cooler) than the final temperature analysis
- Since innovations represent the observations – background ***Fig. 3a*** shows some profiles cool the temperature analysis by more than -2.0 K and others warm the analysis by more than 2.0 K

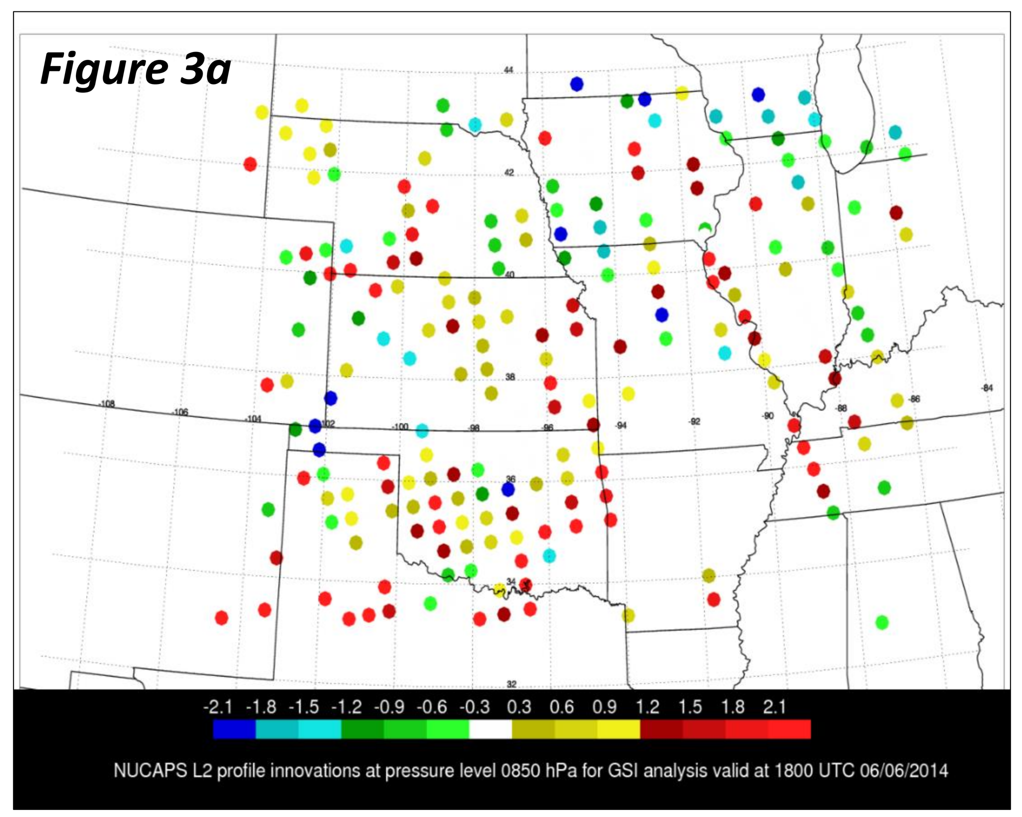

Figure 3a

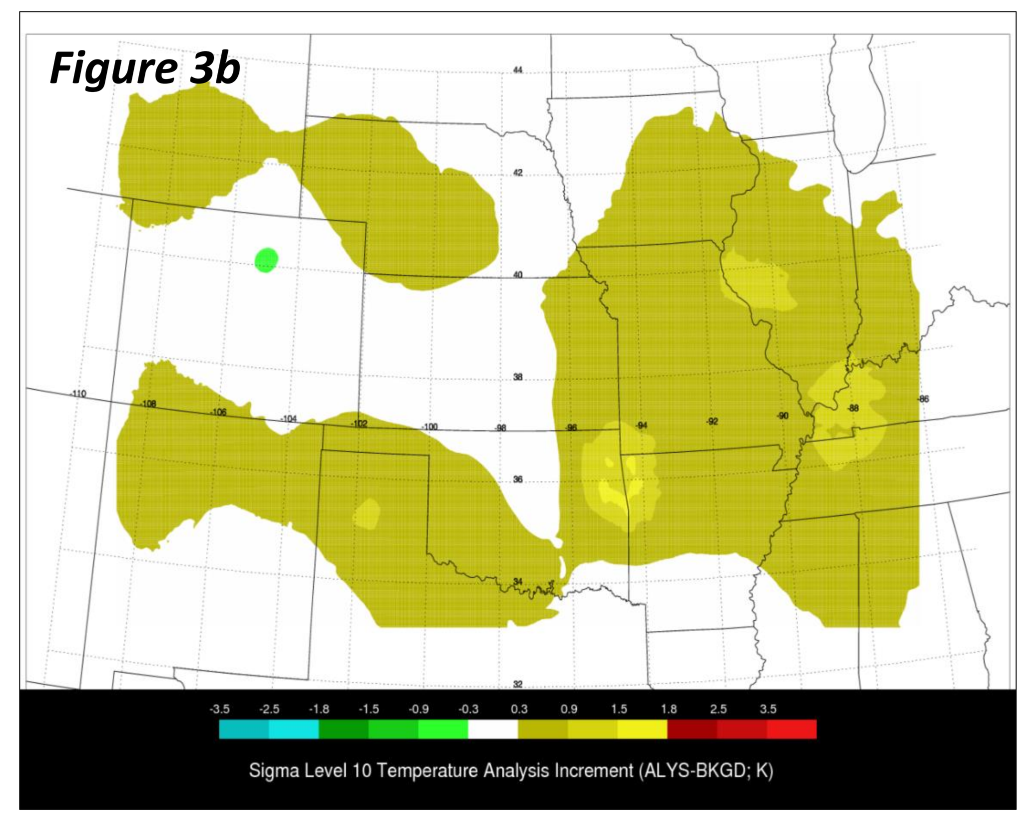

Figure 3b

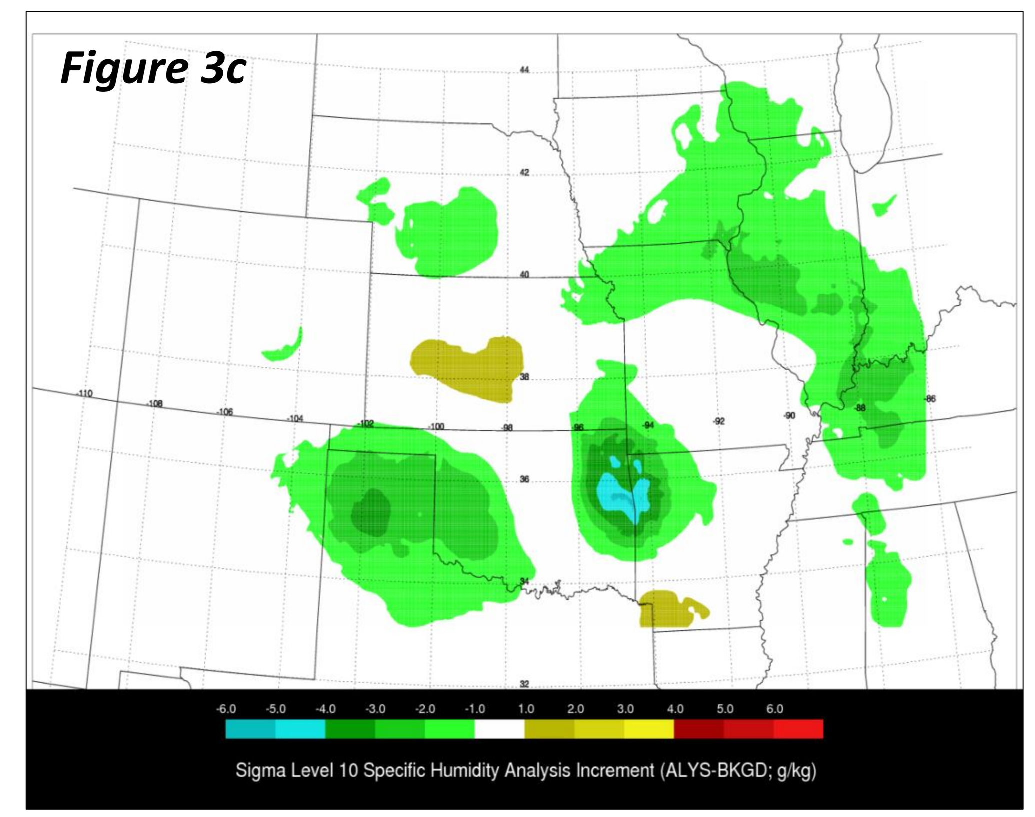

Figure 3c

- Analysis increments show how much and where the background fields have been modified by assimilating observations
- 850 hPa temperature analysis increments (***Fig. 3b***) show the new analysis is ~1 K warmer over portions of the domain
- 850 hPa moisture analysis increments (***Fig. 3c***) show multiple regions in the domain where the new analysis is more than 2.0 k/kg drier and only slightly more moist over part of Kansas and Arkansas

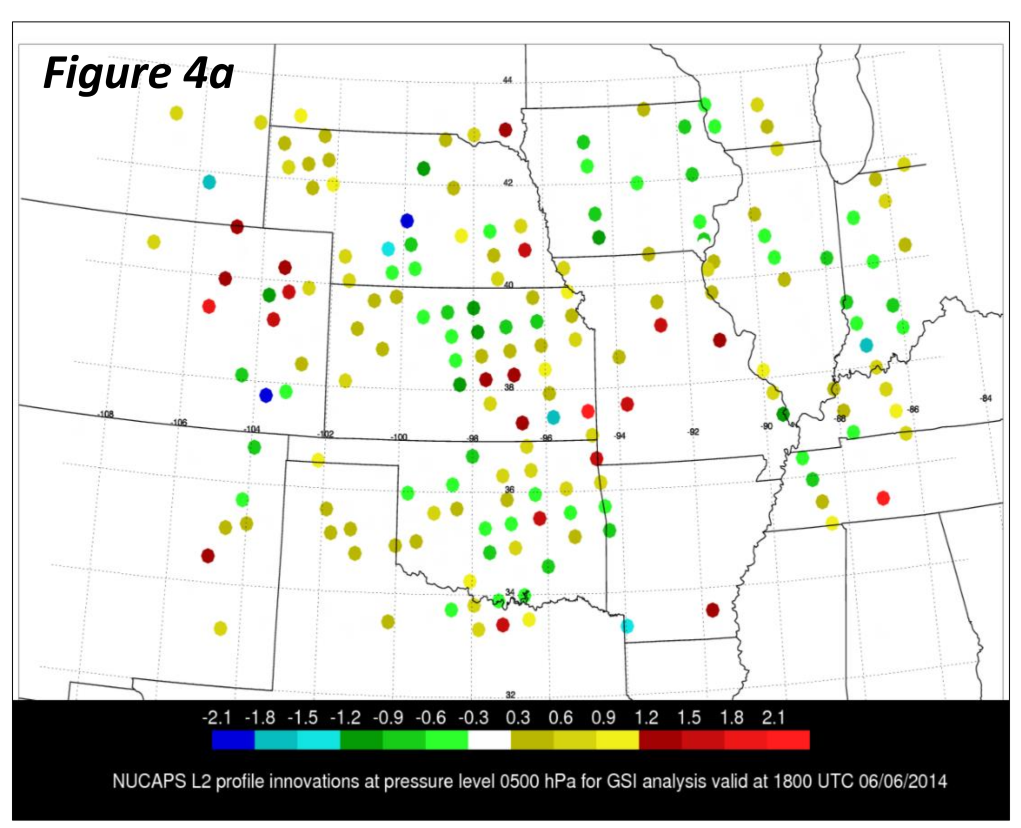

Figure 4a

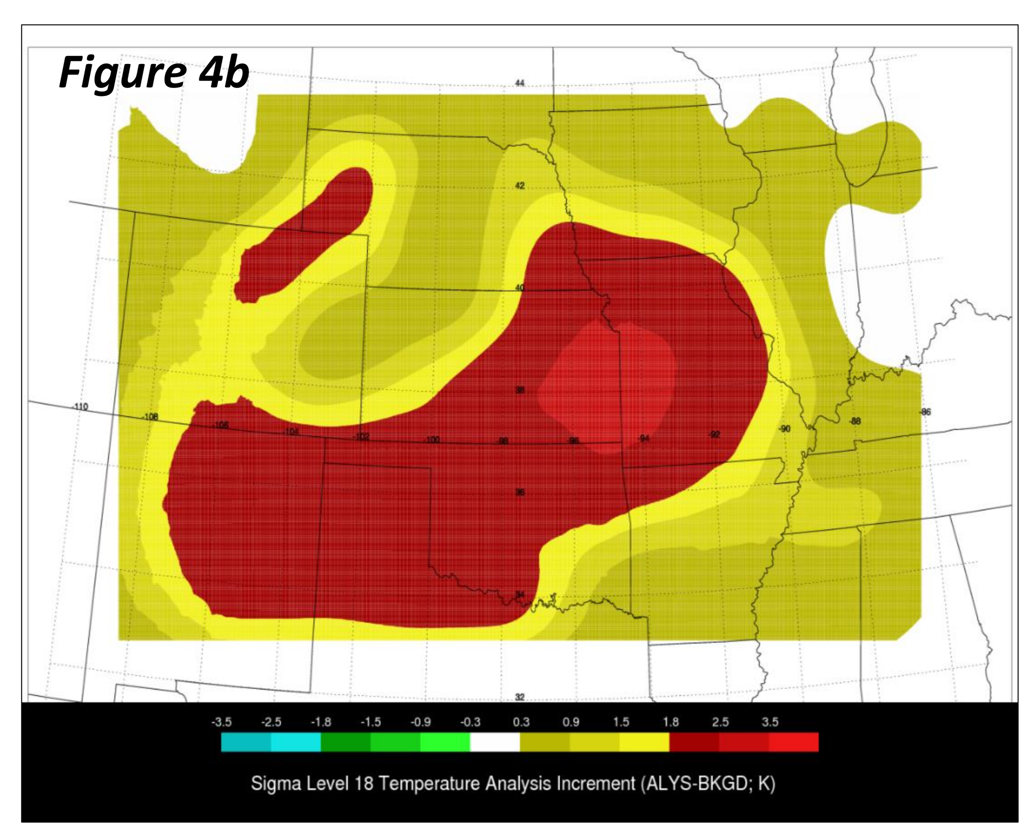

Figure 4b

- 500 hPa innovations (***Fig. 4a***) show each profile's individual impact on the temperature analysis varies between +/- 2.0 K
- 500 hPa temperature analysis increments show the new analysis is 1.8 K warmer than the original model background (***Fig. 4b***)
- There was no change in the 500 hPa moisture analysis field so the figure is not shown

Summary & Future Work

- ***Initial assimilation of NUCAPS profiles over a small test domain show:***
  - Hyperspectral IR profiles can be assimilated in GSI as a separate observation other than radiosondes with only changes to tables in the fix directory
  - Assimilation of profiles does produce changes to analysis fields and evidenced by:
    - Innovations larger than +/- 2.0 K are present and represent where individual profiles impact the final temperature analysis
    - The updated temperature analysis is warmer in the low- and mid-levels
    - The updated moisture analysis is modified more in the low levels and tends to be drier than the original model background
- This preliminary work to demonstrate the ability to assimilate hyperspectral infrared profiles distinct from radiosondes with representative error values with the GSI and WRF systems will lead to more experiments that show the impact of assimilating NUCAPS profiles on various forecasting applications
- ***Next steps include:***
  - Running GSI/WRF to produce control and assimilation simulations for a summer-time pre-frontal convection case
  - Comparing the control and experiment by verifying forecast fields using WRF MET Tools
    - Accumulated precipitation
    - Temperature and dew point temperature at 2 m, 850 hPa, and 500 hPa