Characterizing NUCAPS retrieval quality for CO and CH4: A step towards improving air chemistry applications

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Abstract: NOAA WP-3D aircraft measurements of pollutant gases over target sites were made during two dedicated field campaigns, SENEX (southeastern US) in 2013 and SONGNEX (Shale Oil and Natural Gas Nexus) in 2015. Together they provide high quality profile measurements with which to characterize trace gas retrievals from satellite nadir measurements. Of specific interest are the Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) NUCAPS products of Carbon Monoxide (CO) and Methane (CH4), neither of which have been well characterized before. In fact, CO retrieval products can reach operational quality only since the full-spectral-resolution capability was switched on for CrIS in December 2014. Given the scope and space-time extent of SENEX and SONGNEX, we aim to characterize NUCAPS CO/CH4 retrieval accuracy and precision for a number of different events over known source sites. With this we will learn how well NUCAPS products are able to depict horizontal and vertical transport of pollutant air masses. The results from this study will support two efforts specifically, that of trajectory-based forecasts of smoke dispersion as well as the improvement of chemical-transport models used in atmospheric research and air quality forecasting operations.

This 2015/2016 NOAA JPSS Paving Ground/Risk Reduction (PGRR) project is a collaborative effort combining expertise in satellite retrieval development (STC), airborne trace gas measurements (ESRL/CRES), and satellite trace gas validation (STAR/CIMSS) to characterize NUCAPS retrieval quality, with the goal of improving the accuracy of the NUCAPS daily global measurements of methane (CH4) and carbon monoxide (CO). This project addresses key recommendations from the 2014 CHEM Atmospheric Chemistry Data User’s Workshop Report (http://docs.lib.noaa.gov/noaa_documents/OAR/CPO/AC4/CrIS_workshop_2014.pdf) which concluded “that the current state of validation of the NUCAPS trace gas retrievals is insufficient for the use of these retrievals in most atmospheric chemistry applications” and recommended that the “CRS retrieval development community should closely coordinate with the project teams of upcoming field campaigns (aircraft, surface, balloon, etc.) on trace gas validation activities.”

The two primary periods chosen for NUCAPS evaluation are during the Southeast Nexus (SENEX) (http://crf.nova.noaa.gov/cdr/projects/SENEX/) and Shale Oil and Natural Gas Nexus (SONGNEX) (http://crf.nova.noaa.gov/cdr/projects/Songnex/) field campaigns. The majority of the 2013 SENEX and 2015 SONGNEX airborne observations occurred during the afternoons with nearest S-NPP coincidences during the PM (Ascending) orbits. NUCAPS quality control (QC) leads to lower yields in the PM orbits over land, particularly in the western US. This results in a limited set of aircraft/NUCAPS coincidences, particularly during the 2015 SONGNEX mission. Consequently, initial validation efforts focus on indirect validation using the Real-time Air Quality Modeling System (RAQMS, Pierce et al, 2007) as a transfer product to the NUCAPS retrievals. Direct comparisons between RAQMS and aircraft CO and CH4 are used to bias correct the RAQMS trace gas predictions, which are then directly compared to the NUCAPS retrievals over North America on each flight day. The RAQMS study is a precursor to more detailed indirect validation studies using high resolution nested RAQMS/WRF-CHEM simulations that more accurately represent the variability found in the aircraft measurements, particularly near source regions.

Future plans: These preliminary results use mean mid tropospheric CH4 and CO mixing ratios and do not account for the altitude dependence of the NUCAPS retrieval sensitivity, which requires averaging kernel (AK) information that is produced by the NUCAPS retrieval system but is currently not output. Once the AK information is provided we will account for the NUCAPS sensitivity by applying the AK to the coincident RAQMS CH4 and CO profiles, which will likely improve the results of these indirect validation efforts and possibly reduce the scan angle dependent bias identified in this study. We intend to further refine the NUCAPS quality control so that more trace gas retrievals are retained for the PM (Ascending) orbits, which will allow direct comparisons between the NUCAPS and insitu (with AK applied) CH4 and CO profiles.

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