Impact Analysis of LEO Hyperspectral Sensor IFOV size on the next generation NWP model forecast performance

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Motivation

To assess the forecast impact obtained from the assimilation of next generation CrIS observations with increased spatial resolution in a high resolution global model.

1. Observing Simulation System Experiment (OSSE)
   - Aim to assess the impact of a hypothetical data type on a forecast system.
   - Methodology (Figure 1)
     - Nature run.
     - Simulate existing observations.
     - Control run assimilating simulated existing observations.
     - Calibration.
     - Simulate candidate observations.
     - Perturbation run with the addition of simulated candidate observations.
     - Compare forecast skill between the control and perturbation run.

2. Nature Run (NR)
   - A long, uninterrupted forecast generated by state of the art numerical weather prediction (NWP) model at the highest resolution possible.
   - NASA GEOS-5 NR
     - Horizontal resolution: 7km.
     - Number of vertical levels: 72 extending up to 0.01hPa.
     - Period covers May 2005 to May 2007 (30 minutes write-out).

3. Simulation of conventional observations for existing observing systems
   - Noise free rawinsondes, surface profiler, scatterometer and GPSRO data simulated based on the location and time considered stored in BUFR files used by operational GFS for the same date.
   - Nearest time step, bilinear interpolation in the horizontal and log-linear interpolation in the vertical.
   - Surface pressure and station elevation follows NR topography.
   - GPSRO uses 2D bending angle forward model from EUMETSAT Radio Occultation Processing Package. (Figure 2 shows comparison between simulation and observed).
   - Errors added to simulated observations
     - Rawinsonde: vertically correlated errors added to T, q, u and v component of winds.
     - Other datasets – Non-correlated Gaussian random errors with standard deviation based on GSI observational error table.

4. Simulation of satellite observations for existing observing systems
   - Flying satellites in the NR.
   - Simulated radiances using CRTM 2.1.3 for the following sensors:
     (a) AMSU-A on NOAA-15, NOAA-18, NOAA-19, METOP-A, METOP-B and AQUA
     (b) MHS on NOAA-18, NOAA-19, METOP-A and METOP-B
     (c) HIRS-4 on METOP-A
     (d) AIRS on AQUA
     (e) IASI on METOP-A and METOP-B
     (f) CrIS on S-NPP (Figure 4)
   - Orbit simulator - Generate sensor geometry for the above list of sensors to be used for radiance simulation at any given set of start and end time. See Figure 3 for comparison between real and simulated orbits.
   - Errors added to simulated satellite observations – sum of Gaussian random error with standard deviation based on sensor NEDT and forward model error. No spatial and spectral correlations.

5. Assimilation System, NWP model and its configuration
   - GFS (mode) revision r44713 and GSI revision r42096
   - Global @ T1534 (~13km)
   - 80 Ensemble members

6. Experimental Design
   - Data denial experiments, model and bias correction spin-up: 1 April to 14 May 2014
   - Data type denied for calibration comparison are rawinsondes (Ps, T, q and uv), METOP-B AMSU-A and AIRS.