Continuity in Sounding Products from Multiple Platforms

Nadia Smith, Chris Barnet, Rebekah Esmaili and many others
NUCAPS

NOAA-Unique Combined Atmospheric Processing System
Operational at NOAA (2006–) for National Weather Service forecasters
IASI/AMSU (Metop-A/B/C) and CrIS/ATMS (SNPP/NOAA-20)

CLIMCAPS

Community Long-term Infrared Microwave Combined Atmospheric Processing System
Operational at NASA (2019–) for atmospheric research, studies and characterization
AIRS/AMSU (Aqua) and CrIS/ATMS (SNPP/NOAA-20)
Forecaster evaluation of NUCAPS at the NOAA Hazardous Weather Testbed 2019

**Hotspots**

- **Wherefore art thou Convection?** (May 9)
  - Forecaster used NUCAPS soundings to observing capping, which diagnosed why convection was delayed when compared to models in Houston, TX.

**Spatial Gradients**

- **NUCAPS Lapse Rates** (May 7)
  - Forecaster used gridded NUCAPS to see mid-level Lapse Rate across West Texas, which indicates convective potential. Values above reflect the drier air advancing east leading to steeper lapse rates.

**Vertical Structure**

- **TAE Mesoanalysis #1** (April 25)
  - Forecaster diagnosed building instability ahead of a line of convective storms. The warm “nose” can impact storm intensity due to decreased CAPE.

NUCAPS in National Weather Service Operations
National Weather Service Feedback

What would make NUCAPS more useful to you in future?

- "Improve the temporal availability"
- "More frequent satellite passes"
- "Need additional satellites that can provide higher frequency of NUCAPS soundings"

Smith N., et al. 2019, *Why operational meteorologists need more satellite soundings*
Creating a hyperspectral sounding continuity product

Sensitivity to a-priori assumptions
- Sensitivity to meteorology (e.g., clouds at 9:30 vs 1:30 am/pm)
- Sensitivity to seasonal and climate changes

Instruments are different
- Spectral resolution, sampling and noise
- Spatial sampling & co-registration of channels
- Degradation over time

Algorithm differences
- NOAA algorithms became operational ~1-2 year after launch and have asynchronous maintenance schedules (e.g., training datasets are different)
- 9:30/1:30 orbits co-location w/ in-situ is different (affects tuning/regression training and makes validation more difficult)

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Instruments</th>
<th>Overpass</th>
<th>Launch dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqua</td>
<td>AIRS, AMSU</td>
<td>1:30</td>
<td>2002</td>
</tr>
<tr>
<td>Metop</td>
<td>IASI, AMSU, MHS</td>
<td>9:30</td>
<td>2008, 2012, ...</td>
</tr>
<tr>
<td>S-NPP, JPSS</td>
<td>CrIS, ATMS</td>
<td>1:30</td>
<td>2011, 2017, ...</td>
</tr>
</tbody>
</table>
The information content of modern sounding instruments is **amazingly** similar.

For a global ensemble, AIRS, IASI, and CrIS each have ~100 degrees of freedom.

Even though AIRS, IASI, and CrIS have different number of channels, ILS, noise, etc.

The 1st 100 significant eigenvectors of radiance covariance for a set of focus days normalized at $\lambda(k=200)$.
Strong scene dependence of information content – CLIMCAPS NOAA-20
Sequential physical retrieval approach with channel selection allows us to decompose the spectrum into atmospheric parameters with uncorrelated information content.

Smith and Barnet, 2019, *Uncertainty characterization and propagation in CLIMCAPS*, doi.org/10.3390/rs11101227
Spatial patterns of information content from four retrieval parameters

We are able to remove/reduce spectral correlation of information content in retrieval parameters.
CLIMCAPS NOAA-20 AK diagonals Summer Daytime 5 Global Zones

CLIMCAPS Aqua AK diagonals Summer Daytime 5 Global Zones
CLIMCAPS made a SMALL change to FG water vapor profile (MERRA2) because the FG agreed with the measurements.

Here, we can have confidence in FG as approximation of true atmospheric state.
CLIMCAPS made a significant change to FG water vapor profile (MERRA2) because it did not agree with the measurements.

Here, we can have confidence in Retrieval as approximation of true atmospheric state.
Low SNR Small Departure

< 0.15 Ave Kern
<= 20% departure

CLIMCAPS made a SMALL change to FG water vapor profile (MERRA2) and measurement information content is low for this scene.

Here, we should interpret both FG and Retrieval with caution since we have limited knowledge of true state.

These cases typically occur in polar regions.
Low SNR
Large Departure

< 0.15 Ave Kern
> 20% departure

CLIMCAPS made a LARGE change to FG water vapor profile (MERRA2) despite low measurement information content for this scene.

Here, we should reject Retrieval since FG departure is NOT based on knowledge of true state.

These cases are typically rejected by QC filters
Smith and Barnet, 2019, *Diagnosing satellite sounding observations from multiple satellite platforms*, in prep
In summary...

**NUCAPS**
IASI/AMSU on *MetOp-A/B/C* + CrIS/ATMS on SNPP+NOAA20

**CLIMCAPS**
AIRS/AMSU on *Aqua* + CrIS/ATMS on SNPP+NOAA20

Multi-platform product continuity with scene-dependent uncertainty characterization, propagation and reporting to separate instrument effects, a-priori assumptions and real geophysical change