GOES IR Sounder – future perspective from current applications

Jun Li@, Tim Schmit#, Jaime Daniels#, Gary S. Wade#, Jinlong Li@, Zhenglong Li@, Chian-Yi Liu@, W. Paul Menzel#
(and many others)

ITSC-15, Maratea, Italy
4 - 10 October 2006

@Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin-Madison
#Center for Satellite Applications and Research
NESDIS/NOAA
Outline

• GOES-I(8)/P Sounders
• Selected Applications of Current GOES Sounder Products
• Transition from Current GOES IR Sounder to Geo Hyperspectral IR Sounder
• Future Perspective of Geo IR Hyperspectral IR Sounder
• Summary
Current GOES sounder obtains 18 broad spectral IR bands
**Description: GOES-I(8)/P Sounders**

- 19 channels (18 Infrared; 1 Visible)
- Spatial resolution: \(\sim 10\) km
- Hourly scanning over CONUS and adjacent waters
- Products include standard imagery and derived, Level-2 products

---

**GOES Sounder - 19 Channels**

**Typical GOES Sounder Scan Times**

- GOES-12: Caribbean sector 17:20 - 17:44 UTC
- GOES-12: East CONUS Sector 17:46 - 18:17 UTC
- GOES-10: N. Pacific sector 17:24 - 17:56 UTC
- GOES-10: West CONUS sector 18:01 - 18:22 UTC
<table>
<thead>
<tr>
<th><strong>GOES Sounder Product</strong></th>
<th><strong>Operational Use within the NWS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear-sky Radiances</td>
<td>Assimilation into NCEP operational regional &amp; global NWP models over water</td>
</tr>
<tr>
<td>Layer &amp; Total Precipitable Water</td>
<td>Assimilation into NCEP operational regional &amp; global NWP models; <strong>display and animation within</strong> NWS AWIPS for use by forecasters at NWS WFOs &amp; National Centers in forecasting precipitation and severe weather</td>
</tr>
<tr>
<td>Cloud-top retrievals (pressure, temperature, cloud amount)</td>
<td>Assimilation into NCEP operational regional NWP models; <strong>display and animation within</strong> NWS AWIPS for use by forecasters at NWS WFOs; <strong>supplement to</strong> NWS/ASOS cloud measurements for generation of total cloud cover product at NWS/ASOS sites</td>
</tr>
<tr>
<td>Surface skin temperature</td>
<td><strong>Image display and animation within</strong> NWS AWIPS for use by forecasters at NWS WFOs</td>
</tr>
<tr>
<td>Profiles of temp &amp; moisture</td>
<td><strong>Display (SKEW-Ts) within</strong> NWS AWIPS for use by forecasters at NWS WFOs in forecasting precipitation and severe weather</td>
</tr>
<tr>
<td>Atmospheric stability indices</td>
<td><strong>Image display and animation within</strong> NWS AWIPS for use by forecasters at NWS WFOs in forecasting precipitation and severe weather</td>
</tr>
<tr>
<td>Water Vapor Winds</td>
<td><strong>Image display and animation within</strong> NWS AWIPS for use by forecasters at NWS WFOs</td>
</tr>
</tbody>
</table>
Temperature & Moisture Profiles

- **Physical Retrieval** (Ma et al, 1999)
  - Short-term (< 12 hrs) GFS model forecasts provide first guess
  - Hourly surface observations, NCEP SST analysis provide boundary conditions
  - Computed at 40 levels
  - Pixel level retrievals

- **Distributed to AWIPS, NCEP**

- **Operational Applications**
  - **Nowcasting**
    - Aids in monitoring of vertical structure of temperature and moisture of the atmosphere
    - Fills in gaps between conventional observations
    - Convective potential and morphology
    - Situational awareness in pre-convective environments for potential watch/warning scenarios
View from space

Hourly LI indicates instability 5 hours before OK tornado 3 May 99

View from ground

530 CDT (2330 UTC)
April 13 – 14 hail storm case

April 13 - 14, 2006

Hail in my yard
23 UTC April 13, 2006
00 UTC April 14, 2006
01 UTC April 14, 2006

Classification

Super Cell

11um BT

Pressure (hPa)

Relative Humidity (%)
02 UTC April 14, 2006

Classification

Super Cell

11um BT

221

387

Pressure (Pa)

Relative Humidity (%)
NWS Forecast Office Assessment of GOES Sounder Atmospheric Instability

Summer 99 Forecaster assessment of usefulness of changes in hourly LI, CAPE, & CINH product for predicting location/timing of thunderstorms

Out of 248 valid weather cases:
- Significant Positive Impact (30%)
- Slight Positive Impact (49%)
- No Discernible Impact (19%)
- Slight Negative Impact (2%)
- Significant Negative Impact (0)

Figure from the National Weather Service, Office of Services
GOES Sounder Data and Products
Some Non-Operational Products

• **DPI Products** *(Not available on AWIPS, but via web pages, etc)*
  - **Downburst potential product**
    • Aids in monitoring and situational awareness in pre-convective environments
    • Assessment and short term forecasting of severe convective storm and downburst wind gust potential
  - **Convective Available Potential Energy (CAPE) DPI**
    • Aids in monitoring and situational awareness in pre-convective environments
  - **Convective Inhibition (CINH) DPI**
    • Aids in monitoring and situational awareness in pre-convective environments
  - **Layer Precipitable Water (PW) DPI**
    • Useful in tracking SW monsoon moisture
  - **700-500 MB Temperature Lapse Rate DPI**
    • Used to identify areas of elevated instability

• **Other Products**
  - Ozone
  - **Outgoing Longwave Radiation (OLR)**
OMI and GOES 12 (12 Feb 2006)

GOES ozone and OMI agree very well (Li et al. 2006, GRL)
Collaborative work from this project is also presented by John A. Knox of University of Georgia, the title of oral presentation is “GOES single FOV total column ozone: development and initial results” at the AMS2006 meeting held in Atlanta, GA

Use GOES Sounder ozone to study non-convective wind storm
Challenges: Current & Future

- GOES sounder data and products are well established in operational environments
  - Contribute to meeting NOAA mission goals
  - Demonstrated to have positive impact in nowcasting and NWP applications

Many challenges remain.....

- Need for new instruments
  - Faster scanning; adaptable scanning strategies
  - Improved vertical resolving power
    - Improved depiction of vertical distribution of moisture
  - Surface emissivity determination

- Need to reduce product latency
  - Streamlined product processing

- Improved product quality control & monitoring to assure the reliability of high quality products

- Getting experimental satellite products into the hands of NWS forecasters & NWP Centers
  - Especially those that have the potential to positively impact weather forecasts and services
Improved sounding retrievals give reasonable accuracy when compared with microwave radiometer TPW measurements.
Simulated TPW retrievals over CONUS with lifted index <0 (~300 independent cases)

RMS
0.48 cm
0.52 cm
0.44 cm
0.28 cm

(CIMSS/UW)
Simulated TPW retrievals over CONUS with lifted index <0 (~300 independent cases)

(CIMSS/UW)
<table>
<thead>
<tr>
<th></th>
<th><strong>Current</strong></th>
<th><strong>Future req.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage Rate</td>
<td>CONUS/hr</td>
<td>Sounding Disk/hr</td>
</tr>
<tr>
<td>Horizontal Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling Distance</td>
<td>10 km</td>
<td>5 - 10 km</td>
</tr>
<tr>
<td>Sounding FOR</td>
<td>30-50 km</td>
<td>10 km</td>
</tr>
<tr>
<td>Vertical Resolution</td>
<td>~3 km</td>
<td>1 km</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>2 deg. K</td>
<td>1 deg. K</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>20%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Different AIRS spectrum from one AIRS granule

Hyperspectral IR measurements provide detailed features on surface, atmosphere, clouds, dust, etc.
Hyperspectral IR measurements provide profile with high vertical resolution.

AIRS resolves absorption features in atmospheric windows enabling detection of temperature inversions – warming with height evident from spikes up.
Emissivity spectrum is retrievable from hyperspectral IR radiances
Hourly AIRS measurements within an approximate geostationary disk coverage area.

A geostationary hyperspectral sounder will provide full hourly disk coverage rather than the partial coverage available with polar orbiting sounders.
SEVIRI data from EUMETSAT

SEVIRI ozone agrees with OMI

OMI data from UW/CIMSS (CIMSS/UW)

SEVIRI data from EUMETSAT

SEVIRI ozone agrees with OMI

UW/CIMSS
Geo hyperspectral IR is able to provide hourly total ozone and tropospheric ozone profiles at high spatial resolution (better than 10 km) during both day and night time.
Summary

• Current GOES Sounder provides important products that have been used in NWP and short range forecasts and nowcasts
• ABI can be used together with forecast to continue the current GOES Sounder
• Geo hyperspectral IR sounder is needed to meet future NWP requirement
  – Depict large water vapor variations spatially and temporally
  – Improve thunderstorm over land
  – Emissivity determination over land
  – Low level inversion and cape inversion detection and retrieval