Aircraft weather observations: Impacts for regional NWP models

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Friends and Partners of Aviation Weather
NBAA Convention, Nov 2-3, 2016
Rapid Refresh and HRRR
NOAA hourly updated models

13km Rapid Refresh (RAP)

Version 3 -- NCEP
implement 23 Aug 2016
Version 4 – GSD
Planned NCEP – Early 2018

3km High Resolution Rapid Refresh (HRRR)

Version 2 – NCEP
implement 23 Aug 2016
Version 3 – GSD
Planned NCEP – Early 2018

Hourly updating ➔ maximize asynoptic observation use
<table>
<thead>
<tr>
<th>Hourly Observation Type</th>
<th>Variables Observed</th>
<th>Observation Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rawinsonde</td>
<td>Temperature, Humidity, Wind, Pressure</td>
<td>120</td>
</tr>
<tr>
<td>Profiler – 915 MHz</td>
<td>Wind, Virtual Temperature</td>
<td>20-30</td>
</tr>
<tr>
<td>Radar – VAD</td>
<td>Wind</td>
<td>125</td>
</tr>
<tr>
<td>Radar</td>
<td>Radial Velocity</td>
<td>125 radars</td>
</tr>
<tr>
<td>Radar reflectivity – CONUS</td>
<td>3-d refl → Rain, Snow, Graupel</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Lightning</td>
<td>(proxy reflectivity)</td>
<td>NLDN</td>
</tr>
<tr>
<td>Aircraft</td>
<td>Wind, Temperature</td>
<td>2,000 - 15,000</td>
</tr>
<tr>
<td>Aircraft - WVSS</td>
<td>Humidity</td>
<td>0 - 800</td>
</tr>
<tr>
<td>Surface/METAR</td>
<td>Temperature, Moisture, Wind, Pressure, Clouds, Visibility, Weather</td>
<td>2200 - 2500</td>
</tr>
<tr>
<td>Surface/Mesonet</td>
<td>Temperature, Moisture, Wind</td>
<td>~5K-12K</td>
</tr>
<tr>
<td>Buoys/ships</td>
<td>Wind, Pressure</td>
<td>200 - 400</td>
</tr>
<tr>
<td>GOES AMVs</td>
<td>Wind</td>
<td>2000 - 4000</td>
</tr>
<tr>
<td>AMSU/HIRS/MHS (RARS)</td>
<td>Radiances</td>
<td>1K-10K</td>
</tr>
<tr>
<td>GOES</td>
<td>Radiances</td>
<td>large</td>
</tr>
<tr>
<td>GOES cloud-top press/temp</td>
<td>Cloud Top Height</td>
<td>100,000</td>
</tr>
<tr>
<td>GPS – Precipitable water</td>
<td>Humidity</td>
<td>260</td>
</tr>
<tr>
<td>WindSat Scatterometer</td>
<td>Winds</td>
<td>2,000 – 10,000</td>
</tr>
</tbody>
</table>
Regional Observation Impact studies with RAP - GSD

- Observation gaps are major source in limiting forecast accuracy, even over US
- New RAP observation impact study covering 3 seasons, 8 observation types

<table>
<thead>
<tr>
<th>Rawinsonde</th>
<th>Aircraft obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radar reflectivity</td>
<td>VAD winds</td>
</tr>
<tr>
<td>Surface obs</td>
<td>GPS-Met</td>
</tr>
<tr>
<td>AMV (winds)</td>
<td>GOES clouds</td>
</tr>
</tbody>
</table>

- Aircraft data found to be most important observation type for wind, temperature and Relative humidity
  -- Ascent/descent observations both important
  -- Water vapor observations (about 1/8 total) improve RH forecast accuracy (WVSS only, no TAMDAR available to NOAA at this time)
Aircraft observations -- most important data source for weather prediction skill

Impact on WIND in 1000-100 hPa layer

Forecast degradation for withholding each obs type

- Aircraft obs most important for wind accuracy at all forecast lengths
- Significant impact also from rawinsonde, surface observations, GOES observations (likely from clearing of spurious convection)
Observation impact: Raob, Aircraft, GOES

Aircraft observations most important for all variable, times

20% Error reduction (normalized by 6-h fcst – 0-h anx difference)

Withhold:
- ALL Rawinsonde
- ALL Aircraft
- ALL Profiler
- ALL Radar Reflectivity
- ALL VAD winds
- ALL surface obs
- ALL GPS-Met PW
- GOES (clouds / winds)
Smoothed monthly aircraft obs counts

RUC
RAP

6-h upper-level Wind RMS error

Date

# of reports

Worldwide count

US count

Solid lines on Left Axis, Dashed lines on Right Axis

Based on reports received by the Canadian Meteorological Centre

http://www.wmo.int/pages/prog/www/GOS/ABO/data/statistics/aircraft_obs_cmc_mthly_ave_daily_reports_by_program.jpg
AMDAAR obs density -- global
FAA aircraft obs study -- ongoing  

(GSD, AvMet)

GOALS:

• Quantify gaps in airborne observations  
  (spatial, temporal, parameter, etc,)

• Identify most cost effective ways to obtain airborne data
AMDAR obs density -- time of day -- CONUS

Morning
12z – 18z

Afternoon
18z – 00z

Evening
00z – 06z

Overnight
06z – 12z
AMDAR obs density -- Ascending/descending -- CONUS
Color coded by vector difference from RAP background field

Amdar.noaa.gov
Regional Observation Impact studies with RAP - GSD

- Significant gap to achieve profiles every 300 km/3h
  -- achieving frequent aircraft profiles out of regional airports
  estimated to significantly improve forecast accuracy

- Ongoing airborne observation study sponsored by FAA (GSD, AvMet)

- 2017 article by James and Benjamin, MWR

How can we expand this coverage?

Ascent / descent Data for an entire day

0-15 kft
250 hPa RMS vector error vs. raobs over CONUS
RUC / RAP
2010-2015 – 6h forecasts

Steady progress in upper-level wind skill