THE NCAR-OSU YOPP-SH DATA IMPACT STUDY: UPDATE

Jordan G. Powers\textsuperscript{1}, Kevin W. Manning\textsuperscript{1}, and David H. Bromwich\textsuperscript{2}

\textsuperscript{1}Mesoscale and Microscale Meteorology Laboratory
National Center for Atmospheric Research
Boulder, Colorado, USA

\textsuperscript{2}Department of Geography and Byrd Polar and Climate Research Center
The Ohio State University
Columbus, Ohio, USA

14\textsuperscript{th} Workshop on Antarctic Meteorology and Climate
Charleston, South Carolina, USA
June 2019
Background

• **WMO Polar Prediction Project (PPP) (2013–2022)**
  – Goal: Promote research toward improved environmental prediction for the polar regions

• **YOPP Activity: YOPP–Southern Hemisphere (YOPP-SH)**
  – Focus: Observation & prediction in the high southern latitudes
  – Special Observing Period (SOP): November 2018–February 2019
  - ✓ Extra radiosondes
  - ✓ Enhanced surface AWS platforms
  - ✓ Drifting buoys
  - ✓ Ship obs: Oceanic, atmospheric
YOPP-SH SOP Data Impact Study

• Methodology: Conduct Model Forecast Experiments Adding Observations and Varying Data Assimilation Approaches

1) Add YOPP-SH SOP soundings in model initialization

*Do the YOPP-SH obs improve the forecasts significantly?*

2) Test new data assimilation (DA) methods for AMPS

*Can different DA approaches improve polar prediction in AMPS?*

• Framework: AMPS WRF Domains
  – 24-km (Southern Ocean) & 8-km (Antarctica) grids
Forecast Setups: Observation Sets

Standard Observations for AMPS WRF Forecasts

- Surface AWS and station reports (METAR, SYNOP, etc)
- Radiosondes
- Ships, buoys, aircraft
- Satellite measurements: Winds, temps, etc.
- GPSRO

Observation Sets for Experiments

1) STD Expts: Standard AMPS obs

2) STD + SOP Expts: Standard AMPS obs + SOP soundings

Issue: Identification of the extra/non-regular soundings attributable to the SOP
### Extra YOPP-SH Soundings

*Thanks to: Steve Colwell, BAS!*

<table>
<thead>
<tr>
<th>Site</th>
<th>Launches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboa</td>
<td>35</td>
</tr>
<tr>
<td>Agulhas II</td>
<td>15</td>
</tr>
<tr>
<td>Almirante Maximiano</td>
<td>20</td>
</tr>
<tr>
<td>Casey</td>
<td>91</td>
</tr>
<tr>
<td>Concordia</td>
<td>120</td>
</tr>
<tr>
<td>Davis</td>
<td>167</td>
</tr>
<tr>
<td>Dumont D'Urville</td>
<td>191</td>
</tr>
<tr>
<td>Escudero</td>
<td>86</td>
</tr>
<tr>
<td>Halley</td>
<td>63</td>
</tr>
<tr>
<td>Jang-Bogo</td>
<td>86</td>
</tr>
<tr>
<td>King Sejong</td>
<td>101</td>
</tr>
<tr>
<td>Mario Zucchelli</td>
<td>74</td>
</tr>
<tr>
<td>Macquarie</td>
<td>57</td>
</tr>
<tr>
<td>Mary Arctica</td>
<td>1</td>
</tr>
<tr>
<td>Mary Celeste*</td>
<td>21</td>
</tr>
<tr>
<td>Mawson</td>
<td>61</td>
</tr>
<tr>
<td>Mirnyj</td>
<td>93</td>
</tr>
<tr>
<td>Neumayer</td>
<td>257</td>
</tr>
<tr>
<td>Polarstern</td>
<td>118</td>
</tr>
<tr>
<td>Rothera</td>
<td>26</td>
</tr>
<tr>
<td>Shirase</td>
<td>20</td>
</tr>
<tr>
<td>Syowa</td>
<td>213</td>
</tr>
<tr>
<td>WAIS</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1945</strong></td>
</tr>
</tbody>
</table>

Not included: Dome Fuji

* = WDK38HS
Observation Acquisition: AMPS Data Sources During SOP

i) GTS
   – AMPS regular, real-time standard obs ingest source

ii) NCEP BUFR
   – BUFR= Binary Universal Form for the Representation of met data
   – Not QC’d
   – Sounding data: Full vertical resolution

iii) NCEP GFS PrepBUFR
    – Prepared BUFR: NCEP processed & QC’d BUFR
    – Sounding data: Reduced vertical resolution

iv) NCEP GDAS PrepBUFR
    – Data from NCEP’s Global Data Assimilation System
    – GDAS= DA system used by NCEP for GFS initialization
    – Sounding data: Reduced vertical res
    – Later cutoff time
YOPP-SH SOP Sonde Data Monitored for AMPS

- SOP Sonde AMPS Monitoring Page

www2.mmm.ucar.edu/rt/amps/status/prepbufr_raob_accounting.html

SOP Sonde Sites/Platforms

NB: Not all sites launched through the duration of the SOP.
### Ex: Radiosonde Data – 15 Jan 2019

#### Reports Received

<table>
<thead>
<tr>
<th>UTC</th>
<th>Neumayer</th>
<th>Scott</th>
<th>Halley</th>
<th>Frei</th>
<th>Rothera</th>
<th>Syowa</th>
<th>Mawson</th>
<th>Davis</th>
<th>Zhongshan</th>
<th>Mirnyj</th>
<th>Concordia</th>
<th>Dumont</th>
<th>Zucchelli</th>
<th>McMurdo</th>
<th>Macquarie</th>
<th>Polarstern</th>
<th>WDK38HS</th>
<th>WAIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- ○ ○: Source of data from NCEP
- ○: Report in low-level BUFR files but not in PREPBUFR files
- ●: Report in GDAS PREPBUFR file but not in GFS PREPBUFR file
WRF FORECAST EXPERIMENTS

• Period Forecasts
  – 72-h forecasts initialized 0000 & 1200 UTC each day
    15–30 November 2018 (spring)
    1–15 January 2019 (mid-summer)
    1–15 February 2019 (late summer)

• Event Forecasts
  – Cases of significant/noteworthy weather
    ♦ Major low impacting Ross Is. 3–4 Dec 2018
    ♦ Unusual ridge/flow over continent 18–22 Dec 2018
    ♦ Log fog/cloud period at WAIS causing flight aborts 8–9 Jan 2019
Case Study: Continent-Wide Ridge 18–22 Dec 2018

– Upper-level ridge: Flow crossing continent from QML to Ross Sea

400 mb analysis 00 UTC 20 Dec 2018 (Height interval= 60 m)

SLP/Precip 00 UTC 20 Dec 2018
72h AMPS WRF fcst
Case Study: Low Impacting McMurdo 3–4 Dec 2018

- Deep, strong low moving into Ross Sea from NW
- Strong winds and precip in Ross Is. region: Flight cancellations

500 mb analysis 00 UTC 4 Dec 2018
Height interval= 60 m
Cloud shaded

SLP/Precip 00 UTC 4 Dec
24h AMPS WRF fcst
Case Study: Low Impacting McMurdo 3–4 Dec 2018

Sfc wind gusts (kt) 00 UTC 4 Dec
24h AMPS WRF fcst

Phoenix Field Meteogram
00 UTC 3 Dec 2018 init
DA Experiment Methodology: Varied System Inputs from Different Forecast Ensembles

- AMPS WRF DA: Hybrid Ensemble/3D-Variational DA (3DEnVar)
  - Key system component: Background Error (BE) covariances
  - BE input types to 3DEnVar: (1) Static and (2) Ensemble

```
Obs (i) STD
(ii) STD + SOP
```

```
WRFDA 3DEnVar
```

```
WRF Analysis
```

```
WRF Forecast
```

Diagram:
- Background (WRF)
- Static BEs
- Ensemble BEs
- WRF Model forecast generation path (WRF Model forecast generation path)

The 2 ensembles to be run come into play here.
**Approach to DA Experiment Ensemble Input**

Run 2 WRF Ensembles $\Rightarrow$ 2 Ensemble BE Sets $\Rightarrow$

2 DA Setups $\Rightarrow$ 2 Different Forecast Analyses

- **Ensemble 1**
  
  Input: GFS Global Ensemble Forecasting System (GEFS) output used to initialize WRF ensemble

- **Ensemble 2**
  
  Input: Cycled WRF members w/member reanalysis via DA using the **DART** data assimilation system

**DART = Data Assimilation Research Testbed**

NCAR community system for *ensemble* data assimilation: Ensemble Kalman Filter (EnKF) technique
DA Approach Development and Testing

• **Testing of Cycled WRF Ensemble Completed**
  – Cycled WRF ensemble created and tested
    Period: 1 Nov 2017– 10 Dec 2017
  – WRF w/6-h cycling with DART DA
    
    *Results:* ✔ *Cycled system stable*
    ✔ *No forecast problems*

• **DART Configuration and Testing**
  – System applied to Antarctica: Code modified for WRF polar stereographic grid projections
    
    *Results:* ✔ *Error reductions in analyses*
    ✔ *Behavior reasonable*
Testing of DART: T Biases at RAOB Sites

Prior Bias = Background – Obs  \textit{Before DART DA}

Posterior Bias = Analysis – Obs  \textit{After DART DA}

Test Period: 1 Nov 2017–10 Dec 2017

T Bias Frequencies -- Prior

T Bias Frequencies -- Posterior
Summary: YOPP-SH Data Impact Study Update

• Experiment, Case, and Data Preparation
  – Target events/periods selected and case analyses begun
  – Data preparation
    ✓ Soundings compiled, formatted, and catalogued
    ✓ Sounding acquisition: “Thanks” to community (esp. BAS) on the efforts to collect and provide!

• DA and Ensemble Systems Setup
  – AMPS WRF cycling: Cycled system prepared, tested, stable
  – DART development
    ✓ Successfully applied for WRF over Antarctica
    ✓ Testing/tuning: Performance reasonable

*Experimental runs to begin soon!*