1. Objectives and Goals

- Evaluate two relatively high-resolution reanalysis datasets at ARM SGP, a well observed location in the continental mid latitudes

  - ARM Continuous Forcing has shown good agreement during IOPs (Xie et al. 2004)
  - Location should be one of the most constrained on the globe, making it easier to pick out parameterization issues that cause biases in the reanalyses
  - How well do reanalyses compare with ARM forcing in atmospheric state, precipitation, clouds, and the TOA/SFC radiation budget?
  - Are reanalysis forcing datasets for CRM/SCM studies feasible in the continental mid latitudes?

- Model parameterizations known to cause issues

- Horizontal advection much more important than in the tropics (limited NWP based forcing in the tropics, Hume and Jakob 2005)

2. Data and Methodology

- Three years (1999-2001) of ARM continuous forcing data compared to subsetted NARR and MERRA reanalyses

  - Datasets averaged to common temporal and spatial resolutions
  - Three-hourly
  - 180 km radius from ARM SGP Central Facility
  - Cloud information provided by GOES satellite (NASA VISSST, Minnis et al. 2001) and ARM MMCR (MACE PI product, Mace et al. 2006)

- Hourly/three-hourly cloud fractions derived following the methods in Kennedy et al. (2010) and Xi et al. (2010)

3. Atmospheric State (Reanalysis-ARM)

<table>
<thead>
<tr>
<th>NARR</th>
<th>YEAR</th>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆U (m/s)</td>
<td>0.42</td>
<td>0.35</td>
<td>0.46</td>
<td>0.42</td>
<td>0.41</td>
</tr>
<tr>
<td>∆V (m/s)</td>
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<td>0.13</td>
<td>-0.22</td>
<td>-0.2</td>
<td>0.29</td>
</tr>
<tr>
<td>∆Q (g/kg)</td>
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<td>0</td>
<td>0.01</td>
<td>-0.04</td>
<td>0.81</td>
</tr>
<tr>
<td>∆T (K)</td>
<td>0.34</td>
<td>0.26</td>
<td>0.23</td>
<td>0.26</td>
<td>0.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MERRA</th>
<th>YEAR</th>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆U (m/s)</td>
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<td>0.12</td>
<td>0.15</td>
<td>0.18</td>
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<tr>
<td>∆V (m/s)</td>
<td>0.03</td>
<td>-0.17</td>
<td>-0.3</td>
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<td>0.36</td>
</tr>
<tr>
<td>∆Q (g/kg)</td>
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<td>-0.8</td>
<td>-0.16</td>
<td>-0.25</td>
<td>-0.17</td>
</tr>
<tr>
<td>∆T (K)</td>
<td>0.22</td>
<td>0.07</td>
<td>0.32</td>
<td>0.04</td>
<td>0.25</td>
</tr>
<tr>
<td>∆P (mb/hr)</td>
<td>0.52</td>
<td>-0.13</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.07</td>
</tr>
</tbody>
</table>

4. Cloud Fraction, Precipitation, and Radiation Fluxes

- Radiation
  - ARM SFC radiative fluxes are within several W m⁻² of Dong et al. (2006) which studied a longer period
  - Of the two reanalyses, MERRA has better agreement overall with ARM, except for LW-down
  - NARR has significant positive biases for SW-down, SW-up, and LW-up. These are believed to be partly caused by the negative cloud bias, but also lack of extinction by aerosols and water vapor (clear-sky)

- Cloud Fraction
  - MERRA captures monthly variability but suffers from a monthly ~22mm bias.

5. Future work and Acknowledgments

- Further analysis of radiation flux biases to determine exact parameterization issues
  - NARR forcing for SCMC/CRF have already been developed for 1999-2001 and show promising results at ARM SGP. This may lead the way for longer-term decadal studies (Fig. 7).

- Summary
  - NARR has ~14-15% bias, but with a high correlation of 0.9 with ARM/GOES observations
  - MERRA agrees within ~3-4% of ARM/GOES, but its correlation is lower (0.78-0.86)
  - Precipitation
    - NARR has excellent agreement with ARM due to its assimilation of precipitation
    - MERRA captures monthly variability but suffers from a monthly ~22mm bias.
  - Radiation
    - ARM SFC radiative fluxes are within several W m⁻² of Dong et al. (2006) which studied a longer period
    - Of the two reanalyses, MERRA has better agreement overall with ARM, except for LW-down
  - NARR has significant positive biases for SW-down, SW-up, and LW-up. These are believed to be partly caused by the negative cloud bias, but also lack of extinction by aerosols and water vapor (clear-sky)
  - MERRA negative biases for LW-down are believed to be caused by the negative bias of water vapor (further investigation required)