NCEP Regional Reanalysis
NARR

Glenn K. Rutledge
NOMADS PI
NESDIS Data Archive Board Briefing

17 March 2004
Briefing Overview

• NARR Informational Briefing
  - NARR Overview
  - Improvements over Global Reanalysis
  - Domain / Resolution / Frequency
  - NCDC NARR: Ingest/Archive/Access
North American Regional Reanalysis (NARR): Background

- The NARR is an improved long term re-analysis of basic meteorological fields on a high resolution grid, that for the first time on any scale, includes precipitation.

- NCDC has agreed to archive most of these new data.

- This is an informational briefing for the DAB for
  - NARR availability with background information
  - Provide access information
NARR: Purpose

• Create a long-term set of consistent climate data on a regional scale on a North American domain

• Superior to NCEP/NCAR Global Reanalysis (GR) due to:
  – use of a regional model (the Eta model)
  – Advances in modeling and data assimilation since 1995, especially:
    • Precipitation assimilation
    • Direct assimilation of radiances
    • Land-surface model updates
ETA / NOAH LAND-SURFACE MODEL UPGRADES:

- Assimilation of Hourly Precipitation
  -- hourly 4-km radar/gage analysis (Stage IV)

- Cold Season Processes (Koren et al 1999)
  -- patchy snow cover
  -- frozen soil (new state variable)
  -- snow density (new state variable)

- Bare Soil Evaporation Refinements
  -- parameterize upper sfc crust cap on evap

- Soil Heat Flux
  -- new soil thermal conductivity
    (Peters-Lidard et al 1998)
  -- under snowpack (Lunardini, 1981)
  -- vegetation reduction of thermal cond.

- Surface Characterization
  -- maximum snow albedo database
    (Robinson & Kukla 1985)
  -- dynamic thermal roughness length refinements

- Vegetation
  -- deeper rooting depth in forests
  -- canopy resistance refinements
Domain Coverage of NARR
NARR: Data for Global

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Details</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiosondes</td>
<td>Temperature, winds, moisture</td>
<td>NCEP/NCAR Global Reanalysis (GR)</td>
</tr>
<tr>
<td>Dropsondes</td>
<td>Same as above</td>
<td>GR</td>
</tr>
<tr>
<td>Pibals</td>
<td>Wind</td>
<td>GR</td>
</tr>
<tr>
<td>Aircraft</td>
<td>Temp. and wind</td>
<td>GR</td>
</tr>
<tr>
<td>Surface</td>
<td>Pressure</td>
<td>GR</td>
</tr>
<tr>
<td>Cloud drift winds</td>
<td>Geostationary satellite</td>
<td>GR</td>
</tr>
</tbody>
</table>
## NARR: Data for Regional

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Details</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>CONUS (with PRISM), Mexico, Canada, CMAP over oceans</td>
<td>NCEP/CPC</td>
</tr>
<tr>
<td>TOVS-1B radiiances</td>
<td>Winds, precipitable water over oceans</td>
<td>NESDIS</td>
</tr>
<tr>
<td>Surface land</td>
<td>Wind, moisture</td>
<td>GR, TDL</td>
</tr>
<tr>
<td>COADS</td>
<td>Ship and buoy data</td>
<td>NCEP/EMC</td>
</tr>
<tr>
<td>Air Force Snow</td>
<td>Snow depth</td>
<td>COLA and NCEP/EMC</td>
</tr>
<tr>
<td>SST</td>
<td>1-degree Reynolds, with Great Lakes SSTs</td>
<td>NCEP/EMC, GLERL</td>
</tr>
<tr>
<td>Sea and lake ice</td>
<td>Contains data on Canadian lakes, Great Lakes</td>
<td>NCEP/EMC, GLERL, Canadian Ice Center</td>
</tr>
<tr>
<td>Tropical cyclones</td>
<td>Locations used for blocking of CMAP Precipitation</td>
<td>Lawrence Livermore National Laboratory</td>
</tr>
</tbody>
</table>
NARR Results: Upper-Air

• Compared both GR and RR against fits to raobs
• Root-mean-square (RMS) analysis fits significantly better for temperatures and vector wind speeds
• Wind speed improvement greatest in the upper troposphere, especially in winter
• First guess (3-hr forecast, pre-3DVAR) temperatures not always as favorable for RR compared to GR
• Relative humidity improved for RR for both analysis and first guess
NARR Results: Near Surface

- First guess, 1997: for temperatures, comparison against ship/buoy only. Surface temperature RMS improved both in winter and in summer.

- 1998: Surface temperatures RMS favorable for NARR in both winter and summer. RR biases closer to zero and little diurnal variation problem in summer.

- 10-m winds: RMS in NARR neither better nor worse compared to GR (remarkably similar!)

- Slow wind biases improved in NARR: just a little in winter, visibly in summer.
NARR Results: Precipitation

• Several sources of precipitation
  – CONUS data with PRISM (Mountain Mapper) to improve orographic effects
  – Canada
  – Mexico
  – CMAP (combination of satellite and gauge data) over oceans; CMAP is blocked:
    • Near central areas of hurricanes (7.5 by 7.5 deg)
    • Observed precipitation > 100 mm/day
    • A 15-degree “blending belt” between 27.5 and 42.5 N, with no CMAP north of 42.5 N
NARR Results: Precipitation (cont)

• Precipitation observations used to prescribe the latent heat profile in Eta

• Model uses given latent heat profile to simulate precipitation

• Resulting precipitation pattern looks very much like the observed precipitation pattern in both summer and winter
January 1997 Precipitation Results

OBS Precipitation (in) January 1997

GR Precipitation (in) January 1997
January 1997 Precipitation Results

OBS Precipitation (in) January 1997

NARR Precipitation (in) January 1997
July 1997 Precipitation Results
July 1997 Precipitation Results

OBS Precipitation (in) July 1997

NARR Precipitation (in) July 1997
NARR: Analysis System

- Precipitation assimilation in EDAS
- Revised 3DVAR to run using the satellite bias corrections for all the satellites
- Updated the RR’s land-surface model
- Ported the RR pilot system from the SGI Origin 3000 to the IBM-SP
NARR: System Design

- Fully cycled 3-hr EDAS
- Lateral boundary conditions supplied by GR2
- Forecasts to 72 hr every 2.5 days, using GR2 forecast boundary conditions
- Resolution: 32-km, 45 layers
- NARR time period: 1979-2003 Updated monthly
NARR: Data Acquisition and Processing

- Acquired precipitation dataset with use of PRISM (Mountain Mapper); disaggregated data to hourly
- Acquired TOVS-1B data for 1979-1997 time period
- Acquired Air Force snowdepth dataset
- Created a high-resolution sea-ice field
NARR: Archiving Overview

• Several archiving centers
  - National Climatic Data Center (10TB)
  - National Centers for Atmospheric Research *
  - San Diego Supercomputing Center **
  - Perhaps University of Maryland

* 7TB
** Ambitious amounts
NARR: Archive Data Volumes

AWIPS Grid 221

a) analysis files
   52 Mb single file
   420 Mb daily (8 times per day, every 3 hr)
   12.6 Gb monthly
   151 Gb yearly
   3.7 Tb entire RR period (25 years)

b) 3-hour first-guess forecast files
   58 Mb single file
   464 Mb daily (8 times per day, every 3 hr)
   14 Gb monthly
   168 Gb yearly
   4.1 Tb entire RR period (25 years)

c) Restart files
   265 Mb single file
   4.1 Gb daily (16 files per day; 8 analysis and 8 first-guess files, every 3 hr)
   130 Gb monthly
   1.5 Tb yearly
   37 Tb entire RR period (25 years)

Archive a) and b) only: 7.8TB + 2.2TB of restart = 10TB
NCDC: Data Ingest and Archive

- 10TB on HDSS and 7.8TB on NOMADS
  - No off-site backup

- Metadata: FGDC, COARDS, and XML
  - Dynamic XML and GrADs via NOMADS Infrastructure

- Serviced thru NOMADS – NOMADS is “NARR Ready”
  - Traditional ftp or Web browse/plot via NOMADS Web
  - NOMADS Distributed Access Services