

# North American Mesoscale (NAM) Analysis and Forecast System Characteristics

## Forecast Model Dynamics / Physics

Component		Comments/References
Infrastructure	NOAA Environmental Modeling System (NEMS)	<a href="http://www.emc.ncep.noaa.gov/index.php?branch=NEMS">http://www.emc.ncep.noaa.gov/index.php?branch=NEMS</a>
Dynamics	Non-Hydrostatic Multiscale Model on B-grid (NMMB)	<p>Janjic, Z., and R.L. Gall, 2012: Scientific documentation of the NCEP nonhydrostatic multiscale model on the B grid (NMMB). Part 1 Dynamics. NCAR Technical Note NCAR/TN-489+STR <a href="http://opensky.library.ucar.edu/collections/TECH-NOTE-000-000-000-857">http://opensky.library.ucar.edu/collections/TECH-NOTE-000-000-000-857</a></p> <p>Janjic, Z. I., J. P. Gerrity, Jr. and S. Nickovic, 2001: An Alternative Approach to Nonhydrostatic Modeling. <i>Monthly Weather Review</i>, Vol. <b>129</b>, 1164-1178.</p> <p>Janjic, Z. I., 2003: A Nonhydrostatic Model Based on a New Approach. <i>Meteorology and Atmospheric Physics</i>, <b>82</b>, 271-285. <a href="http://dx.doi.org/10.1007/s00703-001-0587-6">http://dx.doi.org/10.1007/s00703-001-0587-6</a></p> <p>Janjic, Z. I.: A unified model approach from meso to global scales. <i>Geophys. Res. Abstracts</i>, 7, SRef{ID: 1607{7962/gra/EGU05{A{05 582, 2005.</p> <p>Janjic, Z. I. and Black, T: A unified model approach from meso to global scales. <i>Geophys. Res. Abstracts</i>, 7, SRef{ID: 1607{7962/gra/EGU2007{A{05 025, 2007.</p> <p>Janjic, Z., Huang, H., and Lu, S.: A unified atmospheric model suitable for studying transport of mineral aerosols from meso to global scales, <i>IOP C. Ser. Earth Env.</i>, 7, 012011, <a href="http://iopscience.iop.org/1755-1315/7/1/012011/refs">http://iopscience.iop.org/1755-1315/7/1/012011/refs</a>, doi:10.1088/1755-1307/7/1/012011, 2009.</p> <p>Janjic, Z., 2010: Recent Advances in Global Nonhydrostatic Modeling at NCEP. Invited lecture at the ECMWF Workshop on Non-hydrostatic Modeling. November 2010, 14pp. ECMWF, Shinfield Park, Reading, Berkshire RG2 9AX, U.K.</p> <p><a href="http://dx.doi.org/10.1175/2010MWR3448.1">Janjic, Z., Janjic, T., and Vasic, R.: A Class of conservative fourth order advection schemes and impact of enhanced formal accuracy on extended range forecasts, <i>Mon. Weather Rev.</i>, 0, null, doi:10.1175/2010MWR3448.1, 2011.</a></p> <p>For changes with the 21 March 2017 NAM upgrade, see <a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/NMMB_Model_Changes_8-24-2016_v3.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/NMMB_Model_Changes_8-24-2016_v3.pptx</a></p>
Model Top Pressure and Vertical Characteristics	Hybrid sigma-pressure vertical coordinate	Figs. 1 and 2.

	2 mb model top pressure 60 vertical layers Bottom layer ~ 20 m	
Horizontal Resolution	12 km (parent N.American domain) 3 km CONUS nest 3 km Alaska nest 3 km Hawaii nest 3 km Puerto Rico nest Fire weather :1.5 km	Domain areal coverage : <a href="http://www.emc.ncep.noaa.gov/mmb/namgrids/namnests_domains.jpg">http://www.emc.ncep.noaa.gov/mmb/namgrids/namnests_domains.jpg</a> and Fig. 3. The fire weather nest can be placed anywhere inside the CONUS or Alaska nest; it is used for fire weather forecasting during the fire season and for severe weather events during other times of the year
Boundary Conditions	Parent domain : 6-h old GFS forecast, updated every 3-h Nest domains : Every model time step from parent domain	
Horizontal diffusion	Computed on hybrid surfaces	Nonlinear Smagorinsky-type  Janjic, Z.I.,1990: The step-mountain eta coordinate: Physical package. <i>Mon. Wea. Rev.</i> , <b>118</b> , 1429-1443.
Gravity wave drag (also includes mountain blocking)	Yes	Turned on for 12 km NAM parent domain only  Alpert, J., 2004: Sub-grid scale mountain blocking at NCEP. Proc. 20 <sup>th</sup> Conference on Weather on Analysis and Forecasting/17th Conference on Numerical Weather Prediction, American Meteorological Society. Seattle, WA. P2.4. [Available online at <a href="https://ams.confex.com/ams/pdfpapers/71011.pdf">https://ams.confex.com/ams/pdfpapers/71011.pdf</a> ].
Vertical diffusion	MYJ level 2.5 closure in free atmosphere	Janjic, Z. I., 2001: Nonsingular Implementation of the Mellor-Yamada Level 2.5 Scheme in the NCEP Meso model. NOAA/NWS/NCEP Office Note #437, 61 pp.
Land-surface	Noah LSM 20 MODIS-IGBP land use categories	<a href="http://www.emc.ncep.noaa.gov/annualreviews/day%201/05-EK-landsfc.pptx">http://www.emc.ncep.noaa.gov/annualreviews/day%201/05-EK-landsfc.pptx</a>  Ek, M. B., K. E. Mitchell, Y. Lin, E. Rogers, P. Grunmann, V. Koren, G. Gayno, and J. D. Tarpley, 2003: Implementation of Noah land surface model advances in the National Centers for Environmental Prediction operational mesoscale Eta model. <i>J. Geophys. Res.</i> , <b>108</b> (D22), 16, doi:10.1029/2002JD003296.
SST	NCEP 0.125 deg RTG_SST_HR	<a href="http://polar.ncep.noaa.gov/mmab/tpbs/operational.tpbs/RTG_SST_HR.pdf">http://polar.ncep.noaa.gov/mmab/tpbs/operational.tpbs/RTG_SST_HR.pdf</a> Updated once/day with new analysis at start of 00z NAM DA cycle
Snow/Sea ice	National Ice Center IMS snow cover/sea ice 577 <sup>th</sup> Weather Wing	<a href="http://www.emc.ncep.noaa.gov/jcsda/ggayno/snow/snow.txt">http://www.emc.ncep.noaa.gov/jcsda/ggayno/snow/snow.txt</a> Updated once/day at the start of the 00z NAM DA cycle

	(formerly AFWA) snow depth analysis	
Surface layer	NMM	
Boundary layer scheme	MYJ Level 2.5	<p>Janjic, Z. I.: The Step-mountain Eta Coordinate Model: Further developments of the convection, viscous sublayer and turbulence closure schemes, <i>Mon. Weather Rev.</i>, 122, 927– 945, 1994.</p> <p>Janjic, Z. I., 2001: Nonsingular implementation of the Mellor-Yamada level 2.5 scheme in the NCEP meso model. NCEP Office Note, 91 pp. [437].</p>
Shallow Convection	BMJ	<p>Janjic, Z. I.: The Step-mountain Eta Coordinate Model: Further developments of the convection, viscous sublayer and turbulence closure schemes, <i>Mon. Weather Rev.</i>, 122, 927– 945, 1994.</p> <p>Modified in the March 2017 NAM upgrade, see <a href="http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx</a></p> <p>Parameterized convection only run in 12 km NAM parent domain</p>
Deep Convection	BMJ	<p>Janjic, Z. I.: The Step-mountain Eta Coordinate Model: Further developments of the convection, viscous sublayer and turbulence closure schemes, <i>Mon. Weather Rev.</i>, 122, 927– 945, 1994.</p> <p>Modified in 21 March 2017 NAM upgrade, see: <a href="http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx</a></p> <p>Parameterized convection only run in 12 km NAM parent domain</p>
Gridscale clouds, precip microphysics	Ferrier-Aligo	<p>Aligo, E., and coauthors : High-Resolution NMMB Simulations of the 29 June 2012 Derecho, AMS 27<sup>th</sup> WAF/23rd NWP Conference, Atlanta, GA,, viewable at <a href="https://ams.confex.com/ams/94Annual/videogateway.cgi/id/26141?recordingid=26141">https://ams.confex.com/ams/94Annual/videogateway.cgi/id/26141?recordingid=26141</a></p> <p>Ferrier, B. S., W. Wang, and E. Colon, 2011: Evaluating cloud microphysics schemes in nested NMMB forecasts. <i>24th Conf. on Weather Analysis and Forecasting/20th Conf. on Numerical Weather Prediction</i>, Seattle, WA, Amer. Meteor. Soc.</p> <p>Ferrier, B. S., Y. Jin, Y. Lin, T. Black, E. Rogers, and G. DiMego, 2002: Implementation of a new grid-scale cloud and precipitation scheme in the NCEP Eta model. Preprints, <i>15th Conf. on Numerical Weather Prediction</i>, San Antonio, TX, Amer. Meteor. Soc., 280–283.</p> <p>Modified in 21 March 2017 NAM upgrade, see <a href="http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbppll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx</a></p>

		<p><a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/aligo_a_wc_8-24-2016.pptx">4 ScienceIT_brief_10Mar2017.final_expanded.pptx</a>  <a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/aligo_a_wc_8-24-2016.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/aligo_a_wc_8-24-2016.pptx</a></p> <p>Aligo, E., and coauthors, 2018: Modified NAM Microphysics for Forecasts of Deep Convective Storms. <i>Mon. Wea. Rev.</i>, 146, 4115-4153. Viewable at  <a href="https://journals.ametsoc.org/doi/pdf/10.1175/MWR-D-17-0277.1">https://journals.ametsoc.org/doi/pdf/10.1175/MWR-D-17-0277.1</a> or  <a href="https://www.emc.ncep.noaa.gov/users/Eric.Rogers/documents/Aligo_FAmicro_2018MWR.pdf">https://www.emc.ncep.noaa.gov/users/Eric.Rogers/documents/Aligo_FAmicro_2018MWR.pdf</a></p>
Shortwave Radiation	RRTM tuned for NMMB	<p>Rogers E., and coauthors, 2014: The NCEP North American Mesoscale (NAM) Analysis and Forecast System : Near-term plans and future evolution into a high-resolution ensemble, AMS 27<sup>th</sup> WAF/23rd NWP Conference, Atlanta, GA, viewable at  <a href="https://ams.confex.com/ams/94Annual/videogateway.cgi/id/26188?recordingid=26188">https://ams.confex.com/ams/94Annual/videogateway.cgi/id/26188?recordingid=26188</a></p> <p>Mlawer, E. J., S. J. Taubman, P. D. Brown, M. J. Iacono, and S. A. Clough, 1997: Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the long-wave. <i>J. Geophys. Res.</i>, <b>102</b>, 16 663–16 682.</p> <p>Modifications with the 21 Match 2107 NAM upgrade described:  <a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx">http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/NAMv4_ScienceIT_brief_10Mar2017.final_expanded.pptx</a></p>
Longwave Radiation	RRTM tuned for NMMB	<p>Iacono, M. J., J. S. Delamere, E. J. Mlawer, M. W. Shephard, S. A. Clough, and W. D. Collins, 2008: Radiative forcing by long-lived greenhouse gases: Calculations with the AER radiative transfer models. <i>J. Geophys. Res.</i>, <b>113</b>, D13103, doi:10.1029/2008JD009944.</p>
<b>Data Assimilation (Fig. 4)</b>		
Data Assimilation Method	Hybrid ensemble-3DVar version of NCEP Gridpoint Statistical Interpolation Analysis	<p><a href="http://www.dtcenter.org/com-GSI/users/index.php">http://www.dtcenter.org/com-GSI/users/index.php</a></p> <p>As of August 2014 NDAS/NAM GSI uses NCEP Global EnKF ensemble in background error covariance calculation</p> <p>Wu, W.-S., R. J. Purser, and D. F. Parrish, 2002: Three-dimensional variational analysis with spatially inhomogeneous covariances. <i>Mon. Wea. Rev.</i>, <b>130</b>, 2905–2916.</p> <p>Wang, X., 2010: Incorporating ensemble covariance in the gridpoint statistical interpolation variational minimization: A mathematical framework. <i>Mon. Wea. Rev.</i>, 138, 2990–2995.</p>

<p>Data Assimilation / Spin-up</p>	<p>Partial cycling NAM Data Assimilation (DA) 6-h spin-up from Global Data Assimilation System (GDAS) atmospheric states and NAM DA soil states</p>	<p>See Fig. 4 and schematic comparing NDAS vs GDAS at <a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/NDAS_vs_GDAS.pdf">http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/NDAS_vs_GDAS.pdf</a></p> <p>Partial cycling: Rogers, E., and Coauthors, 2009: The NCEP North American Mesoscale modeling system: Recent changes and future plans. Preprints, <i>23rd Conf. on Weather Analysis and Forecasting/19th Conf. on Numerical Weather Prediction</i>, Omaha, NE, Amer. Meteor. Soc., 2A.4. [Available online at <a href="http://ams.confex.com/ams/pdfpapers/154114.pdf">http://ams.confex.com/ams/pdfpapers/154114.pdf</a>].</p> <p>6-h spin-up consists of hourly GSI analyses and 1-h NMMB forecasts for the 12 km NAM parent and 3 km CONUS/Alaska nests with assimilation of radar/lightning data. NAM DA 1-h forecast valid at 00/06/12/18z used as first guess for 12 km parent and CONUS/Alaska nests analyses, non-cycled nests (Hawaii, Puerto Rico/Fire Weather) use 12 km parent for on-time analysis first guess</p> <p>All NAM forecasts (during data assimilation and 84-h forecast) are initialized with a diabatic digital filter</p>
<p>Data cutoff time</p>	<p>NAM analysis : T+70 min NAM DA cycle TM06 : T-150 min TM05 &amp; TM04 : T-120 min TM03 : T-90 min TM02 : T-27 min TM01 : T+18 min</p>	<p>T = NAM forecast cycle time (00/06/12/18z) TMXX = NAM data assimilation analysis rtimes; for example, "TM06" for the 12z NAM is valid at 06z.</p>
<p>Conventional observations assimilated</p>	<ul style="list-style-type: none"> <li>- Rawinsondes</li> <li>- Aircraft winds, temperature, moisture</li> <li>- Surface pressure. Wind. /temperature, moisture (including selected mesonets)</li> <li>- VAD wind profiles</li> <li>- Wind profilers</li> <li>- WSR-88D Doppler radial velocities</li> <li>- Radar reflectivity (used to computer temperature tendencies in daibatic digital filter)</li> </ul>	<p>Details on radar/lightning data assimilation are at : <a href="http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/radar_lightningDA_namv4.ppt">http://www.emc.ncep.noaa.gov/mmb/mmbpll/misc/namv4docs/radar_lightningDA_namv4.ppt</a></p>
<p>Satellite observations assimilated</p>	<ul style="list-style-type: none"> <li>- Cloud-drift winds from GOES and polar orbiting satellites</li> <li>- Radiances assimilated (using the Community Rapid Radiative Transfer Model) from GOES and polar orbiting satellites</li> <li>- GPS IPW data</li> <li>- Lightning data</li> </ul>	

Precipitation assimilated	- Merged Hourly Stage II/IV precipitation; drives NOAH land-surface physics during NAM DA cycle	<a href="http://www.emc.ncep.noaa.gov/mmb/ylin/docs/precip_assim.pdf">http://www.emc.ncep.noaa.gov/mmb/ylin/docs/precip_assim.pdf</a>
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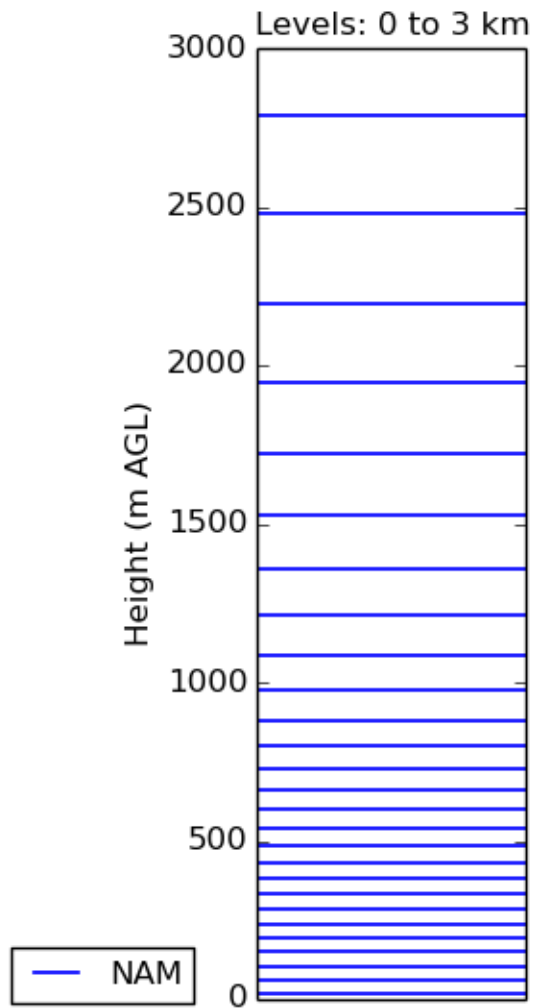


Fig. 1 NAM vertical levels from 0 m to 3 km AGL.

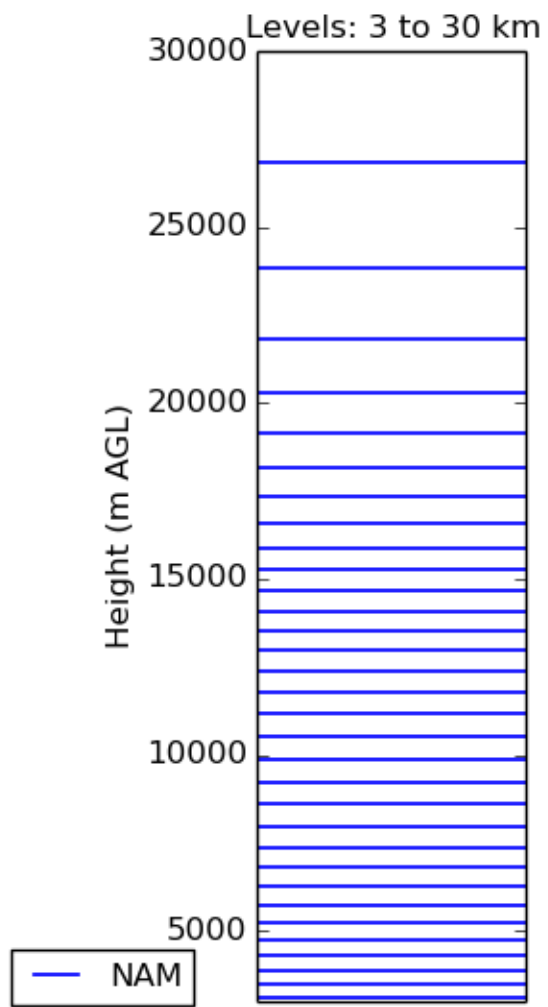
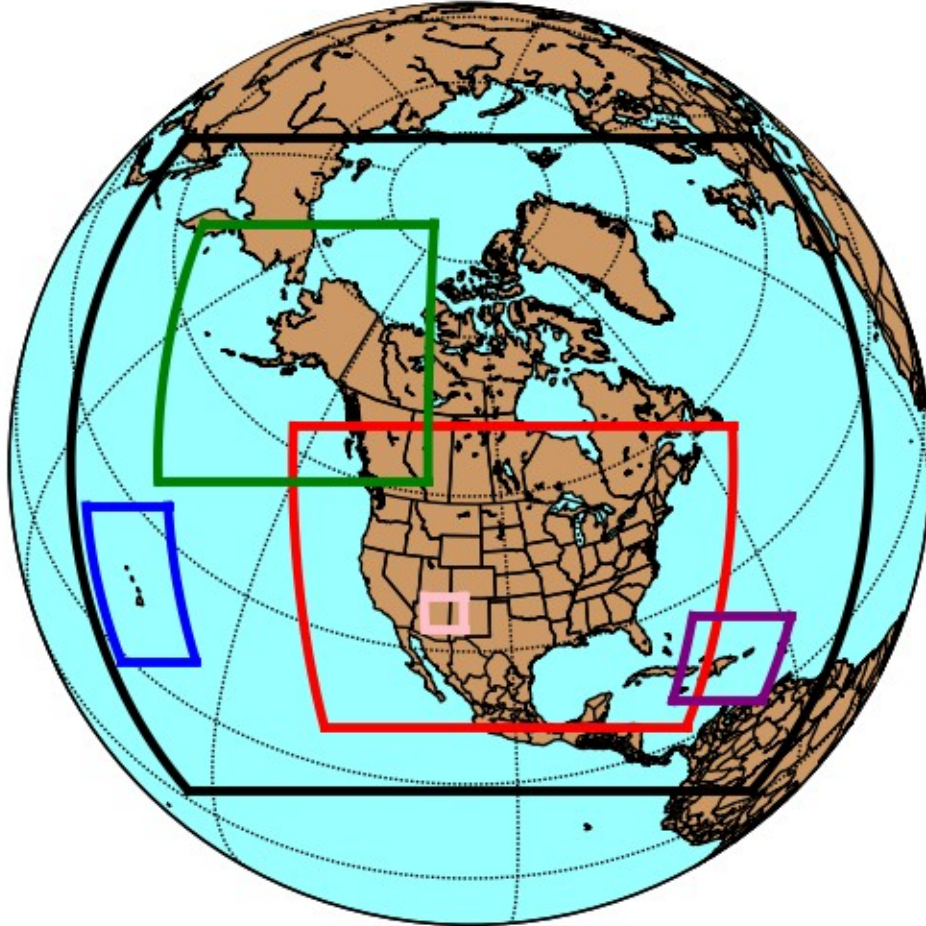


Fig. 2 NAM vertical levels from 3 km AGL to 30 km AGL.

### NMMB Domain Configuration



Parent dimensions:  $N_x = 954$   $N_y = 835$   $dx = 0.1260$   $dy = 0.1080$   
center lat = 54.00 center lon = -106.00

Fig. 3. NAM Parent 12 km (black), 3 km Alaska nest (green), 3 km CONUS nest (red), 3 km Hawaii nest (blue), 3 km Puerto Rico nest (Purple), and on-demand 1.5 km Fire WX nest computational domains.



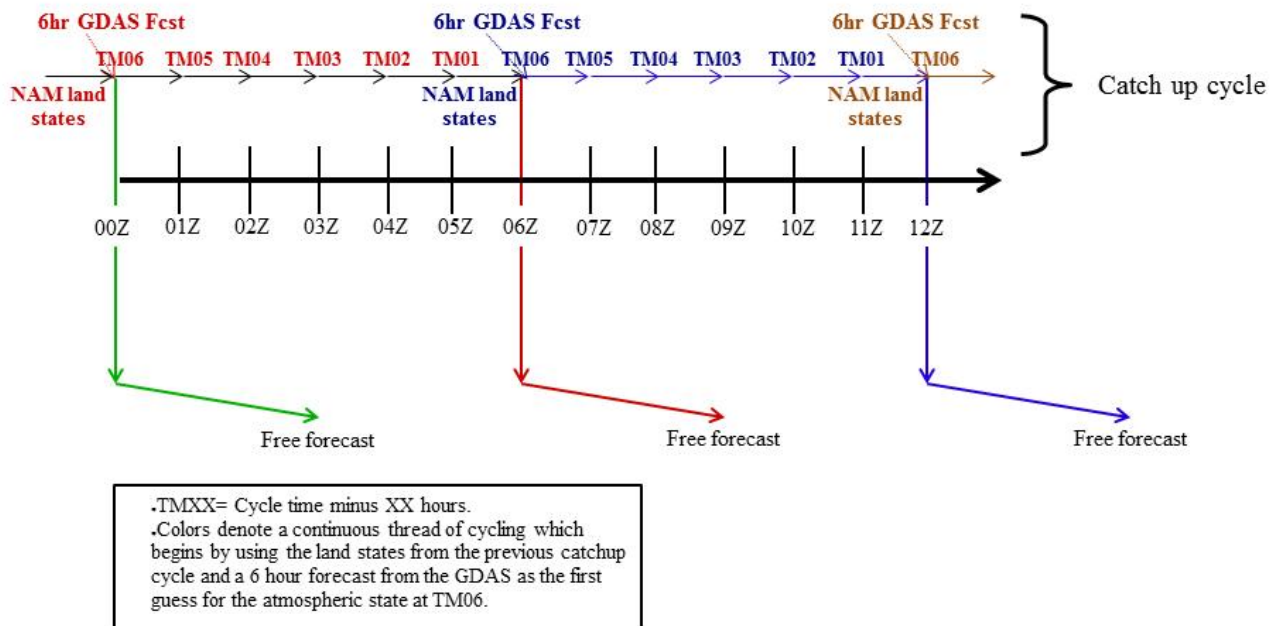


Fig. 4. NAM data assimilation (DA) cycling diagram. Each forecast cycle begins with a 6 hour analysis-forecast window during which analyses are conducted at one hour intervals (TM06, TM05, etc.). TM00 refers to the forecast initialization time (e.g. 00, 06, 12, or 18 UTC). At TM06 the first guess for the atmosphere is a 6 hour forecast from the GDAS. The land states are, however, still cycled from the previous NAM DA cycle. The 12 km NAM parent and 3 km CONUS/Alaska nests are run during the 6-h NAM DA cycle, the non-cycled nests (Hawaii, Puerto Rico, Fire Weather) and initialized using the TM00 first guess from the 12 km parent domain.