2.1 THE 12KM NORTH AMERICAN LAND DATA ASSIMILATION SYSTEM (NLDAS-E)

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1. INTRODUCTION

Land surface processes play an important role in the Earth system, governing exchanges of heat, moisture and momentum between the surface and atmosphere. Soil moisture, albedo, surface temperature, snow pack and runoff anomalies at various spatial and temporal scales greatly impact agriculture, large-scale water resource water management, and global weather patterns [Shukla and Mintz, 1982; Dirmeyer, 1997; Hall 1988]. Unfortunately, errors in land surface forcing, model physics and parameterizations can accumulate in the integrated land surface states of fully coupled Numerical Weather Prediction (NWP)-Land Surface Models (LSM). Because of this, accurate initialization of land surface conditions in such fully-coupled models is vital for short term to seasonal meteorological and hydrological prediction.

Land Data Assimilation Systems (LDAS), consisting of uncoupled LSMs forced by observations and unaffected by the biases that can accumulate in internally cycled systems, can be valuable sources of accurate initial land surface conditions for NWP models. Accuracy can be further improved with the assimilation of quantities such as soil moisture, surface temperature and snow depth and coverage, which acts to constrain unrealistic storages arising from errors in LSM physics or parameterizations. NWP model forecast accuracy should benefit from the use of such initial conditions, and this concept forms the central hypothesis of the 12km North American Land Data Assimilation System (NLDAS-E) project.

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2. PROJECT OVERVIEW

Building on the concepts discussed above, and on the success of the collaborative 1/8th degree North American Land Data Assimilation System (Mitchell et al., 2003), the NLDAS-E project centers on the initialization of the land surface fields of NCEP's mesoscale 12km coupled workstation Eta model (Rogers et al., 1996). Featuring multiple LSMs and assimilating multiple land surface quantities, this system will serve to supply the Eta model with accurate, unbiased and uncoupled initial land surface conditions on its native Arakawa E grid (Figures 1 and 2).

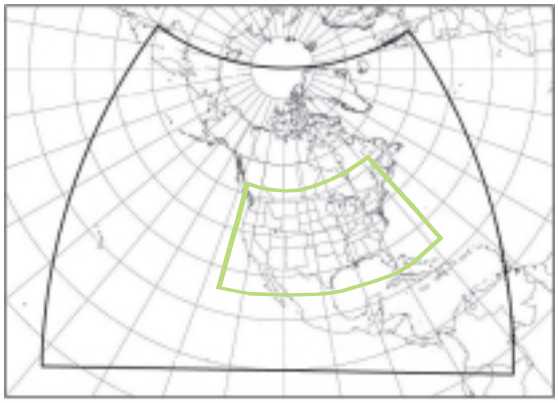

Figure 1. NLDAS-E (black) and NLDAS (green) domains.

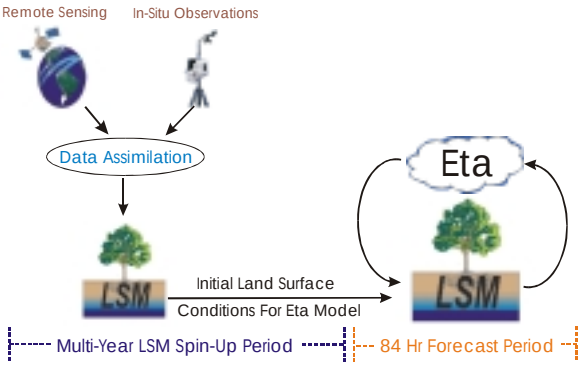

Figure 2. Overview of NLDAS-E system.

The NLDAS-E project is currently in the initial stages, and project goals include: 1) Generation of land surface states over the North American domain, with and without application of land data assimilation techniques, 2) Initialization of the NCEP workstation Eta model with uncoupled NLDAS-E states and internally cycled Eta land surface states, 3) Execution of ensemble forecasts using the NLDAS-E and Eta modeling systems. The system will make use of the Noah (Mitchell et al., 2000), CLM (Bonan et al. 2002) and Mosaic (Koster and Suarez, 1996) LSMs, and will utilize standard workstation Eta as well as high-resolution soil and vegetation fields in order to explore the impact that the use of such fields has on NWP forecasts. NLDAS-E research will:

- Improve understanding of the interaction between the land surface and the atmosphere from short- to medium-length time scales
- Create accurate, high resolution land surface data sets useful for future research and applications
- Improve the initialization of the Eta model in a way that may be adapted to additional NWP models in the future
- Improve forecast accuracy
- Continue NASA GSFC's efforts in the collaborative NLDAS project.

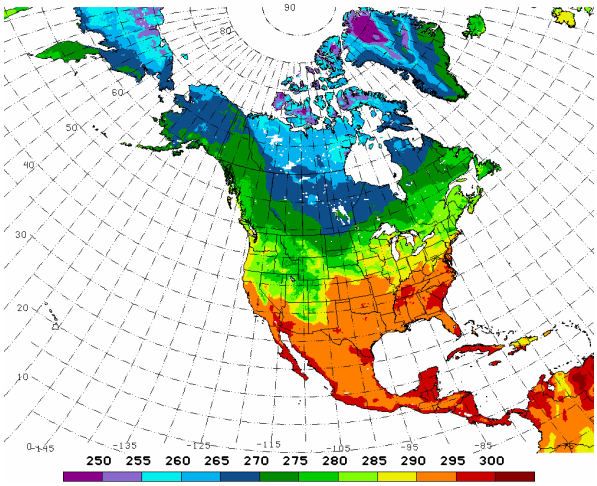

Figure 3. NLDAS-E layer 1 soil temperature (K) on January 1st, 2002 produced by the Noah LSM.

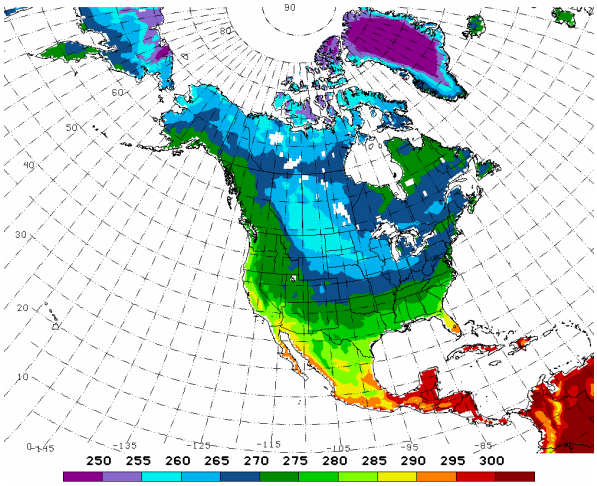

Figure 4. GLDAS layer 1 soil temperature (K) on January 1st, 2002 produced by the Noah LSM.

3. INITIAL RESULTS AND DATA

Land surface models used in the NLDAS-E system are recursively spun up for a period of 5 years in order to allow the model to reach equilibrium (Cosgrove et al., 2003). Specifically, models are forced with data from 2002, repeated in a yearly cycle for 5 years, before being allowed to progress into the 2003 model year from which Eta model initialization data will be drawn. 12km Noah LSM soil temperature data from the first year of this NLDAS-E spinup process are shown in Figure 3. A 1/2 degree Global LDAS soil temperature field from the same time period is shown in Figure 4. Such output will be used alongside the 12km data to initialize the Eta model. This makes possible the assessment of the impact on NWP model forecast accuracy of using model initialization data which differs in resolution from the NWP model being initialized.

As mentioned in Section 2, NLDAS-E will make use of both standard Eta land surface data sets, as well as recent, high-resolution data sets. Examples include the use of 1 degree SiB (Dorman and Sellers, 1989) versus 1km UMD AVHRR-based (Hansen et al., 2002) vegetation class data (Figure 5), as well as the use of 1 degree (Staub and Rosenzweig, 1987; Zobler 1986) versus 5-minute (Reynolds et al., 1999) soil texture data (Figure 6) based on the FAO soil map of the world.

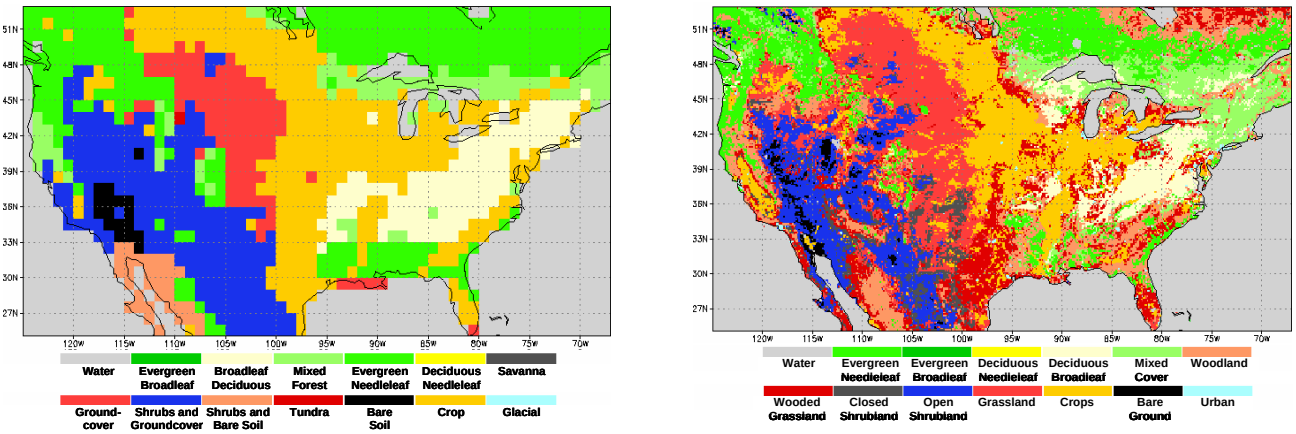

Figure 5. Vegetation class data used in the NLDAS-E project: One degree SiB vegetation classes (left) currently used in the operational Eta model, and 1km AVHRR-based UMD vegetation classes (right).

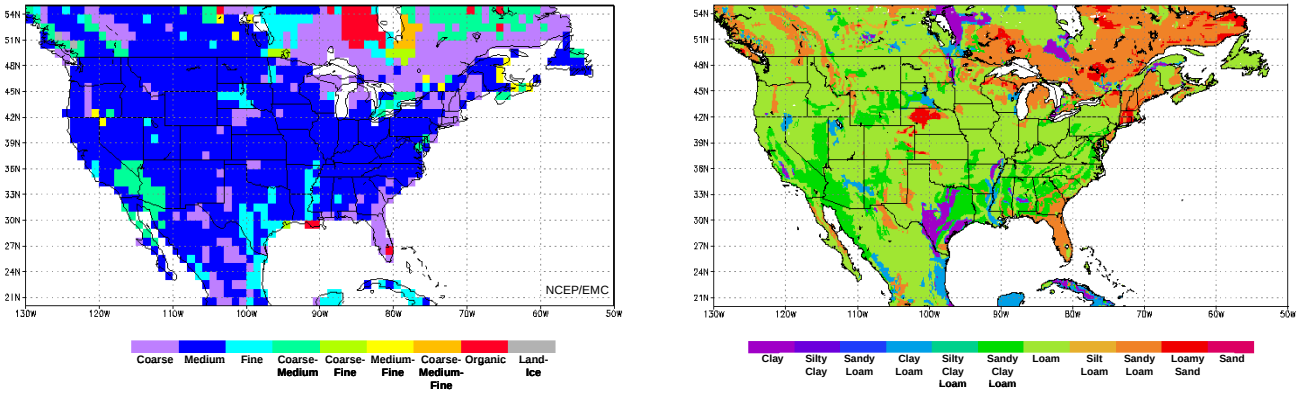

Figure 6. Soil class data used in the NLDAS-E project: One degree soil classes (Staub and Rosenzweig, 1987; Zobler 1986) (left) currently used in the operational Eta model, and 5 minute Reynolds et al. (1999) soil classes (right).

Short (out to 12 hours), medium (out to 36 hours) and long term (out to 84 hours) Eta model forecasts produced with initial conditions based on these data sets will be analyzed, with particular emphasis placed on validation of hourly 2 meter temperature and relative humidity, wind speed, precipitation, and soil moisture predictions.

4. ACKNOWLEDGMENTS

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5. REFERENCES

Bonan, G. B., K. W. Oleson, M. Vertenstein, S. Levis, X. B. Zeng, Y. J. Dai, R. E. Dickinson, and Z. L. Yang, 2002: The land surface climatology of the community land model coupled to the NCAR community climate model, *Journal of Climate*, **15(22)**, 3123-3149.

Cosgrove, B. A., D. Lohmann, K. E. Mitchell, P. R. Houser, E. F. Wood, J. C. Schaake, A. Robock, J. Sheffield, Q. Duan, L. Luo, R. W. Higgins, R. T. Pinker, J. D. Tarpley: 2003, Land surface model spin-up behavior in the North American Land Data Assimilation System (NLDAS), In Press, *J. Geophys. Res*.

Dirmeyer, P. A., 1997: Can seasonal climate simulation be improved by the GSWP soil wetness climatology? *Preprints 13th AMS Conference on Hydrology*, 169-171.

Dorman, J. L. and P. J. Sellers, 1989: A global climatology of albedo, roughness length and stomatal resistance for atmospheric general circulation models as represented by the simple biosphere model (SiB), *J. Applied Meteorology.*, **28(9)**, 833-855.

Hall, D. K., 1988: Assessment of polar climate change using satellite technology, *Reviews of Geophysics*, **26(1)**, 26-39.

Hansen, M. C., R. S. DeFries, J. R. G. Townshend, and R. Sohlberg, 2000: Global land cover classification at 1 km spatial resolution using a classification tree

approach, *International Journal of Remote Sensing*, **21**, 1331-1364.

Koster, R. D., and M. J. Suarez, 1996: Energy and Water Balance Calculations in the Mosaic LSM. *NASA Tech Memorandum 104606*, **9**.

Mitchell, K., Y. Lin, E. Rogers, C. Marshall, M. Ek, D. Lohmann, J. Schaake, D. Tarpley, P. Grunmann, G. Manikin, Q. Duan, and V. Koren, 2000: Recent GCIP-sponsored advancements in coupled land-surface modeling and data assimilation in the NCEP ETA mesoscale model, *Preprints, 15th AMS Conference on Hydrology*, 180-184.

Mitchell, K. E., D. Lohmann, P. R. Houser, E. F. Wood, J. C. Schaake, A. Robock, B. A. Cosgrove, J. Sheffield, Q. Duan, L. Luo, R. W. Higgins, R. T. Pinker, J. D. Tarpley, D. P. Lettenmaier , C. H. Marshall, J. K. Entin, M. Pan, W. Shi, V. Koren, J. Meng, B. H. Ramsay, and A. A. Bailey, 2003: The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system, In Press, *J. Geophys. Res., Atmospheres*.

Reynolds, C. A., T. J. Jackson, and W. J. Rawls, 1999: Estimating Available Water Content by Linking the FAO Soil Map of the World with Global Soil Profile Databases and Pedo-transfer Functions. Proceedings of the AGU 1999 Spring Conference, Boston, MA, May31-June 4, 1999.

Rogers, E., T. L. Black, D. G. Deaven, G. J. DiMego, Q. Zhao, M. Baldwin, N. W. Junker and Y. Lin, 1996: Changes to the operational "early" Eta analysis/forecast system at the National Centers for Environmental Prediction. *Wea. Forecasting*, **11**, 391-413.

Shukla, J. and Y. Mintz, 1982: Influence of land-surface evaporation on the Earth's climate. *Science*, **215**, 1498-1501.

Staub, B. and C. Rosenzweig, 1987: Global digital datasets of soil type, soil texture, surface slope, and other properties: documentation of archived data tape, *NASA Technical Memorandum #100685*.

Zobler, L., 1986: A world soil file for global climate modeling, *NASA Technical Memorandum #87802.*