Atmosphere-Biosphere Interactions at the Land Surface (Denning)

We will process a variety of EOS data to produce an hourly analysis of climatological and ecological variables at the land surface, on a 1° x 1° grid. The analysis will be based on the Simple Biosphere Model (SiB2, Sellers *et al* , 1996a), which has been adapted to run offline of a GCM by forcing it with observational data (Zhang *et al*, 1996; Denning *et al*, 1996a). Our analysis will produce user-level products (see **figure**) including the temperature and moisture of the soil (10 layers from the surface down to 6 m depth); evapotranspiration; canopy conductance; gross primary production; respiration by leaves, stems, roots, and soil microbes; net primary production; net CO_2 flux to the atmosphere; and the size of the organic matter pool in the soil. These will be generated by the model from forcing data that are interpolated in space and time from the DAO 4DDA product and MODIS output.

The EOS Data Assimilation System (DAS) will produce gridded fields of a complete suite of atmospheric data every three hours, on a 2.5° x 2.5° grid. These estimates are not purely observations, but are rather the output of an atmospheric GCM constrained by observations. We will interpolate the assimilated surface air temperature and dewpoint temperature, wind speed, sensible and latent heat fluxes, incident radiation, albedo, cloud, and precipitation fields onto a 1° x 1° grid by spherical interpolation. These 1° x 1° estimates will then be interpolated in time from the 3-hour assimilation product down to the 6-minute time step of the land surface model (SiB2), using the methods detailed in Zhang *et al* (1996). Such a short time step is necessary to maintain numerical stability in the land-surface energy flux calculations. SiB2 differs from the earlier version (SiB) in that the number of biome-specific parameters has been drastically reduced, with most physiological parameters determined from NDVI and FPAR (Sellers *et al* , 1996b). We will obtain these fields from the Goddard DAAC, and average them up to the 1° x 1° grid. Note that these data may need to be purchased at the marginal cost of their production and distribution.

SiB2 calculates the values of the following prognostic variables every 6 minutes, by methods detailed in Sellers *et al* (1996a): temperature of the vegetation canopy (T_C, the ground surface (T_G), and 10 layers of soil (T_S); the storage of water on canopy surface(W_C), ground surfaces (W_G), and within 10 layers of soil (W_S); snow water equivalent on the canopy (M_C) and on the ground (M_G); and the canopy-averaged stomatal conductance (g_c).the instantaneous rate of photosynthesis (Gross Primary Production, GPP). Canopy photosynthesis and transpiration are related through the parameterization of stomatal function which seeks to minimize water loss and maximize carbon gain within the constraints of available light and nitrogen, and subject to physiological stresses. Recent enhancements to the code include a multilayer soil thermodynamics and hydrology scheme (Denning *et al*, 1996b), based on the work of Bonan (1996). The model has been used to calculate the net exchange of CO_2 between the atmosphere and terrestrial ecosystems, within a climate model (Denning *et al* , 1996a), and as forced by offline meteorological variables (Zhang *et al* , 1996). We propose to extend this capability to produce near-real time "operational" estimates of the fluxes of energy, moisture, and carbon within the EOS data system.

SiB2 is now being modified to incorporate a carbon allocation scheme similar to that of Hunt *et al* (1996), which partitions photosynthate among canopy, stems, and roots. In addition, the multilayer soil physics parameterization described above has paved the way for SiB2 to be coupled to a belowground biogeochemistry module based on CASA (Potter *et al* , 1993; Field *et al* , 1995). The revised model will track changes to organic matter pools of various ages in each soil layer, according to local environmental conditions (temperature and moisture) in each layer. The new allocation and belowground BGC modules will allow photosynthate to be consumed by various ecosystem process (growth and maintenance respiration in canopy, stems, and roots, and microbial respiration in soils). We will use this capability to produce hourly maps of each component of ecosystem metabolism on the global 1° x 1° grid.

The products we develop will provide a detailed, mechanistic picture of the state of the vegetated land surface which is unprecedented in terms of spatial detail and temporal frequency. Possible end users of this suite of products are land managers, water resource specialists, meteorologists and weather forecasters, and farmers. Research uses include analysis of seasonal and interannual variability in land surface climate; initialization fields and boundary conditions for mesoscale meteorological models; and monitoring of the flux of CO_2 and carbon balance of the global land surface on diurnal, synoptic, seasonal, and interannual time scales.

References

Bonan, G. B., 1996. A land-surface model (LSM version 1.0) for ecological, hydrological, and atmospheric studies: technical description and user's guide. NCAR/TN-417+STR. Boulder, CO.

Denning, A. S., J. G. Collatz, C. Zhang, D. A. Randall, J. A. Berry, P. J. Sellers, G. D. Colello, and D. A. Dazlich, 1996. Simulations of terrestrial carbon metabolism and atmospheric CO_2 in a general circulation model. Part 1: Surface carbon fluxes. *Tellus*, **48B**, 521-542.

Denning, A. S., D. A. Dazlich, and D. A. Randall, 1996. Simulations of soil temperature, snowpack, and carbon fluxes with an atmospheric general circulation model. Presented at 1996 Fall Meeting of the American Geophysical Union **A32D-2**.

Field, C. B., J. T. Randerson, and C. M. Malmstrom, 1995. Global net primary production: Combining ecology and remote sensing. *Remote Sens. Environ.*, **51**, 74-88.

Hunt, E. R., S. C. Piper, R. Nemani, C. D. keeling, R. D. Otto, and S. W. Running, 1996. Global net carbon exchange and intra-annual atmospheric CO_2 concentrations predicted by an ecosystem process model and three-dimensional atmospheric transport model. *Global Biogeochem. Cycles*, **10**, 431-456.

Potter, C. S., J. T. Randerson, C. B. Field, P. A. Matson, P. M. Vitousek, H. A. Mooney, and S. A. Klooster, 1993: Terrestrial ecosystem production: A process-oriented model based on global satellite and surface data. *Global Biogeochem. Cycles*, **7**, 811-842.

Sellers, P.J., D.A. Randall, G.J. Collatz, J.A. Berry, C.B. Field, D.A, Dazlich, C. Zhang, G.D. Collelo and L. Bounoua, 1996, A Revised land surface parameterization (SiB2) for atmospheric GCMs. Part I: Model formulation. *Journal of Climate*, **9**, 676-705.

Sellers, P.J., S.O. Los, C.J. Tucker, C.O. Justice, D.A. Dazlich, G.J. Collatz and D.A. Randall, 1996, A Revised land surface parameterization (SiB2) for atmospheric GCMs. Part II: The generation of global fields of terrestrial biophysical parameters from satellite data. *Journal of Climate*, **9**, 706-737.

Zhang, C., D. A. Dazlich, D. A. Randall, P. J. Sellers, and A. S. Denning, 1996: Calculations of the global land surface energy, water, and c fluxes with an off-line version of SiB2. *Journal of Geophysical Research*, **101**, 19061-19075.