Climate Model Land Boundary Conditions from Satellite Data such as AVHRR

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Abstract

Satellite data over land can provide major improvements over past methods for boundary conditions, initialization/ 4DDA assimilation, and validation. I will address primarily the first topic. The boundary conditions commonly used by GCMs are dominant land cover(s), fractional bare soil over a grid square, albedo, surface roughness (from vegetation and smaller scale obstacles), and vegetation properties related to greenness. For land cover, the past descriptions were derived from national atlases at 1° or 0.5°. (Maureen Wilson, Elane Matthews, Jerry Olson) The satellite methods for land cover use 8-km NASA Pathfinder and 1-km 1992 AVHRR data. (Lovelock, EDC, Ruth Defries, U. Maryland). The latter takes clearly defined physical variables and combines them into two "orthogonal" variables that provide a maximum description of variance and classifies them into SiB land covers or into fractional trees, grass, or bare ground.

Satellite defines fractional cover at the subpixel scale. Early inferences assumed that all variations of NDVI for a given cover were bare soil (NOAA). Newer approaches are being developed.

Albedos are determined by the scattering from individual land elements down to leaves and by the geometric shading effects these elements impose on each other. GCMs need albedos that provide the partitioning of solar radiation absorption between each separately modeled land element. For example, many models distinguish between plant canopies rather than underlying soils and snow. However, satellites can, at best, provide the total surface albedo. Because of the large anisotropy (i.e., directionality) of scattering, a satellite measurement of radiation from a single direction gives only a rough estimate of albedo. The bi-directional reflectance distribution function (BRDF) must be determined integrated over view angles to get solar zenith dependent albedos. However, most satellite observations are from a nearly fixed view direction, so the BDRF shape can be uncertain. Some satellite estimates of albedo have been made, but whether they are

more accurate than past surface-based estimates is not evident. MODIS/MISR combination on the EOS AM platform should lead to major improvements in GCM albedo specification.

Surface roughness was, in the past, determined by using a few single plot numbers to determine a typical value of z_0/h, and a few measurements of canopy height h, to specify its value for a given land cover. To improve this with satellite data, we need to know a) a large climatology of what z_0 looks like for given vegetation covers as characterized by their heights and densities; b) a global measurement of h, which we may be able to infer from albedo or the contribution of optical shadowing to such but should be more accurate with canopy lidar; and c) a global measurement of z_0/h. We can use ground truth information to specify what it looks like typically. Satellite estimates of fraction of tall vegetation and sparse canopy roughness can be used to interpolate between or extrapolate surface measurements.

In terms of satellite data, AVHRR already gives a wonderful qualitative view of seasonally varying greenness through NDVI. It can be reasonably used to estimate FPAR, the fraction of visible radiation absorbed by the plants chlorophyll. Separating this into seasonal variations of fractional vegetation versus LAI or other plant greenness measures is more problematical, but this should be greatly advanced in the EOS era.

Skin temperature is a standard element of a GCM and measurable from its satellite sensed thermal emissions. However, there are currently a number of difficulties in relating satellite measurements of skin temperatures to models. These difficulties arise from differences between what a satellite sees and what models compute. One problem is cloud removal. Much of the time, satellite views can be "contaminated" by clouds, and high spatial resolutions are needed to minimize this problem. For temporal sampling, the high resolution measurements are from polar orbiters and, at best, are available twice a day. For the sun versus shade problem, land surface daytime emissions come from a variety of sunlight and shaded surfaces while modeled surfaces have always averaged the sun and shade. Because of various nonlinearities, e.g., sunny soils can be much drier than shaded soils, modeled fluxes may be inaccurate and modeled skin temperatures not easily related to real ones.