Application Note

Spatial and Temporal Sampling of Ecosystem Optical Properties with the UniSpec-DC

Satellite sensors (e.g. MODIS) provide large spatial patterns with regional or global coverage (Chen, 1999). However, the coarse resolution of satellite sensors are sometimes problematic, particularly for patchy landscapes (Turner et al., 2003). To properly validate and interpret satellite imagery, additional ground remotely sensed and biophysical data are needed. The **UniSpec-DC (**PP Systems, Amesbury, MA, USA) along with a mobile tram system can make a repeatable continuous measurement on the ecosystem optical properties. It can offer the ground level remotely sensed signal to validate the satellite measurement (Cheng et al., in press).

A research group directed by Dr. John A. Gamon at California State University has conducted long term studies at Sky Oaks Biological Field Station (run by San Diego State University). They have used a **UniSpec-DC** system along with a mobile tram system (Fig. 1) in collecting remotely sensed data for over 6 years. An automated tram system (based on the NOAA ATDD tram design, Baldocchi and Vogl 1996) was installed near the eddy tower. This system allowed researchers to collect spectral reflectance repeatedly over the diurnal (for studying solar angle effect on vegetation indices) and seasonal cycle (for studying the seasonal effects on the ecosystem processes). The tram was 100 m long (a dimension within the eddy covariance footprints). The tram track was mounted just above the top of the vegetation and the distance from the ground varies based on the topography. A dual channel spectrometer (**UniSpec-DC**) mounted in a motorized cart ran along the track and measured spectral reflectance at exactly 1 m intervals using a triggering system, in connection to an auxiliary port of the **UniSpec-DC** system with a DB9 straight connection. A fiber optic cable used as a foreoptic for the spectrometer was mounted on a boom at the side of the cart. With a field of view restrictor, this fiber provided an approximately 20° angle (adjustable as needed). This provided a view footprint of approximately 0.3 m at the top of the canopy and 1-2 meters at the ground surface (depending on the tram height, which varied with topography).

The spectrometers have a nominal spectral range from approximately 305 nm to 1135 nm with approximately 3 nm nominal bandwidth (10 nm full width, half max). Thus, for each measurement, the **UniSpec-DC** software program (UniSync 2.5) automatically collected 256 data points covering the entire spectral range for both upwelling and downwelling channels. This instrument allows measurements to be conducted under any weather conditions since the upwelling channel measures incoming solar irradiance while the downwelling channel measured reflected radiance. The spectral reflectance is calculated using a reference scan over a well leveled lambertian 99% reflectance panel (Spectralon, Labsphere Inc., North Sutton, NH, USA). The ratio of target scan and reference scan at earch wavelength corrected by sky condition is the reflectance at the wavelength. This procedure is represented by the following formula:

$$R_{target} = \frac{I_{upward}}{I_{99\% panel}} * \frac{I_{target}}{I_{upward}} \quad (1)$$

where R_{target} is the percent reflectance of the target, $I_{99\%panel}$ is the response of the downwelling sensor when positioned over the 99% reflectance panel, I_{target} is the response of the downwelling sensor when positioned over the target and I_{upward} is the response of the upwelling sensor measured at the same time as the 99% panel or target measurement (Sims et al., in press).

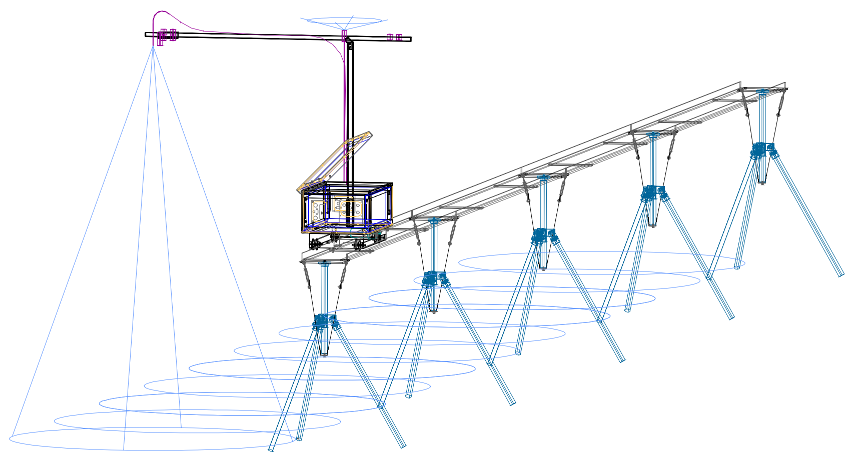

Fig. 1. Schematic and photo of tram system. A **UniSpec-DC** enables simultaneous sampling of upwelling and downwelling radiation (indicated by cones), providing “on-the-fly” correction for changing sky conditions needed for accurate calculation of spectral reflectance and vegetation indices. Drawing courtesy of Loren MacKinney (Dept. of Biological Sciences, California State University, Los Angeles).

Tram reflectance data were processed to reflectance using software (MultiSpec, available at http://vcsars.calstatela.edu/lab_documents/mspec.html) that interpolated wavebands to 1-nm intervals. Different vegetation indices were calculated by a specific formula based on the application. As an example for the note, the normalized difference vegetation index (NDVI) was calculated from the following formula:

$$NDVI = \frac{(R_{800} - R_{680})}{(R_{800} + R_{680})} \quad (2)$$

where R_x is the reflectance at wavelength x in nm.

In the very patchy site as sky Oaks, detailed information can be picked up by the system using remote sensing technique. The system can provide high repeatable result across the tramline (Fig. 2). The temporal pattern of the NDVI showed the striking effects of snowfall, drought, post-drought recovery, and wildfire on NDVI (Fig. 3). It is very important to understand this for the application of the remote sensing models.

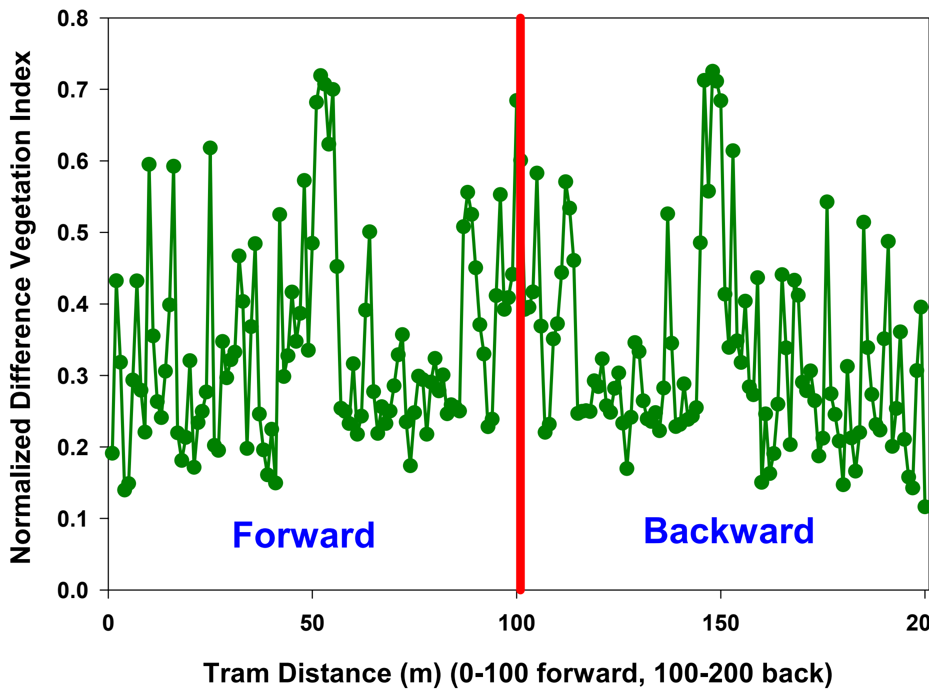

Fig. 2. Spatial pattern of the NDVI (calculated by spectral reflectance measured by **UniSpec-DC**) along the tram line (100 meter) at Sky Oaks Biological Field Station. Note the high repeatable pattern (symmetric back and forth, the red vertical line indicates the turning point). This also indicated that the ecosystem is very patchy.

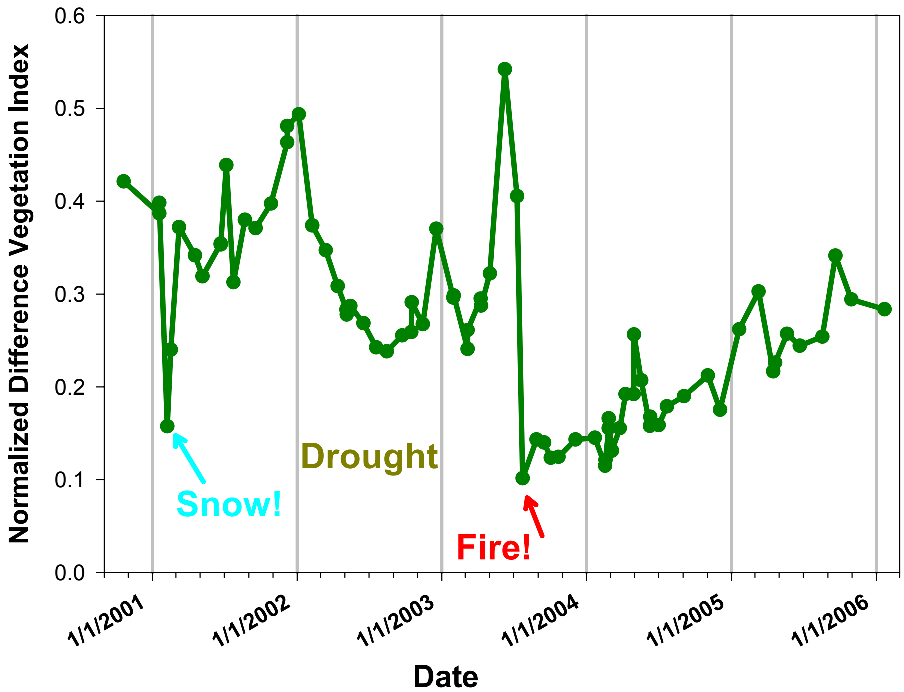

Fig. 3. Six year of midday NDVI (calculated by spectral reflectance measured by the **UniSpec-DC**) of tram measurements at Sky Oaks, CA. Note the system catches the strong seasonality of the chaparral ecosystem.

The **UniSpec-DC**, along with associated devices (e.g., tram system, aircraft or cable mounting system) can effectively monitor ecosystem processes as illustrated by NDVI in this note. This optical measurement can also help us to understand the ecosystem optical properties (e.g. solar angle effect and ecosystem BRDF properties). It is critical information for us to use link carbon and water vapor fluxes, and to interpret satellite remotely sensed data properly. The system can be also used for cross ecosystem analysis (one of the goals of Spectral Network (SpecNet)).

References:

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