Province of Québec, Canada – Study Site Description and Available Data Sets:

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The Québec Carbon LiDAR Project integrates six data sets, the same data sets described by Boudreau et al. (2008). These data sets include the Landsat Enhanced Thematic Mapper Plus (ETM+) land cover map of the Province, a digital map of the six vegetation zones, ground plots, GLAS data, SRTM (Shuttle Radar Topographic Mission) topographic data, and airborne profiling LiDAR data. The Landsat land cover mosaic and the vegetation zone map are used to stratify the Province. Data acquired by an airborne profiling LiDAR are used to tie ground plot observations to GLAS height and SRTM topographic measurements. The ground plot – GLAS pulse relationship is established (1) by flying the profiler over selected ground plots, (2) developing an equation to predict plot biomass as a function of profiling heights, (3) flying the profiler over selected, individual GLAS pulses, and then (4) developing an equation relating airborne laser estimates of biomass to GLAS measurements. The GLAS instrument, then, serves as the Provincial sampling tool to attribute each of the land cover classes in each vegetation zone with estimates of biomass/ha. The SRTM data is used to correct those GLAS measurements for the effects of topography. Each of these data sets is briefly described below.

Landsat Land Cover: Ninety-five Landsat scenes were mosaicked and classified using unsupervised clustering techniques to produce a 23-class land cover map of the Province

for that area south of the tree line, i.e., the northernmost black line in Figure 1. The Landsat imagery (1998 – 2003) was resampled to a 25 m grid. The 23 land cover classes are listed in the Figure 1 legend; the "cloud" and "no data" classes are assigned the same color.

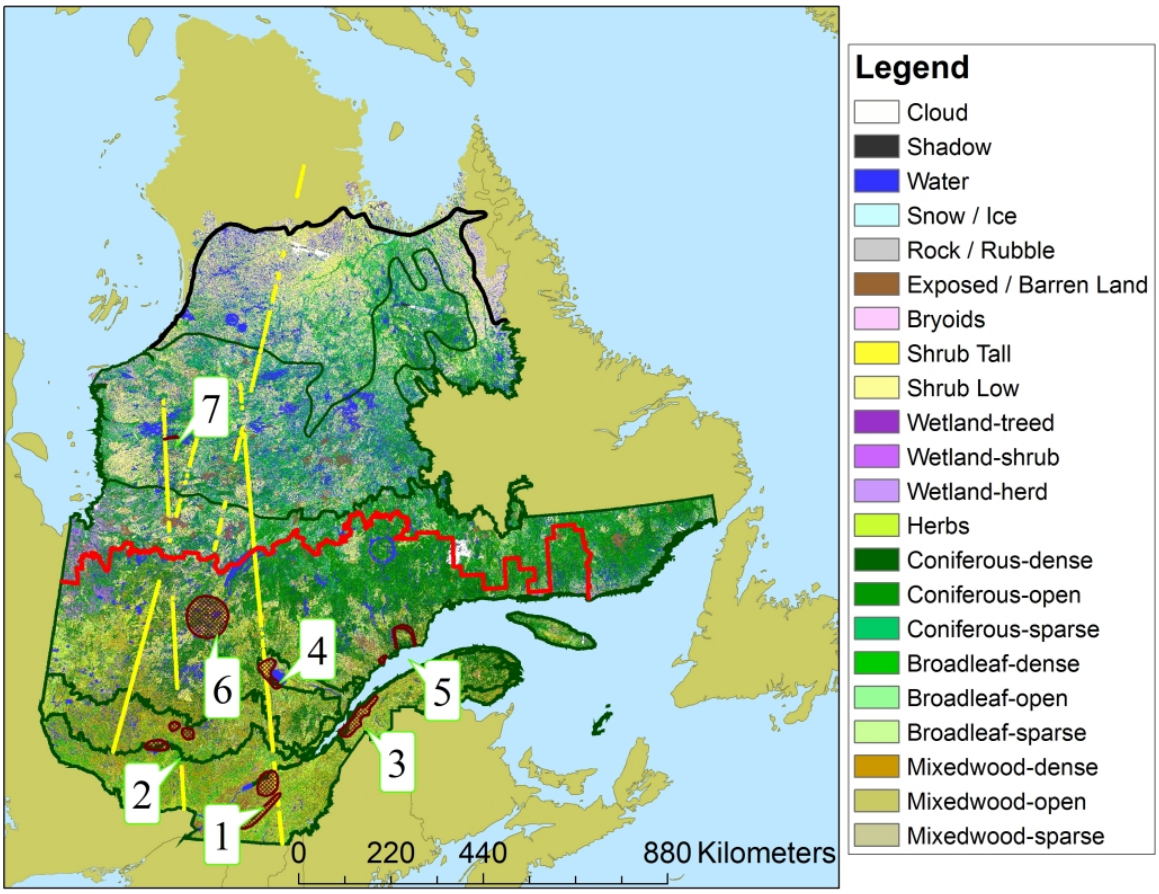

Figure 1. A Landsat ETM+ land cover map of the Province of Québec with six vegetation zones delineated, seven study areas (1-7) overflown by the PALS airborne profiler identified, and the four GLAS transects overflown by PALS plotted (yellow lines).

Vegetation Zone Map: A vector map divides the Province south of tree line, the northernmost black line in Figure 1, into six vegetation zones illustrated in Figure 1. These six zones include, from south to north,

- the Northern Hardwoods ecozone just north of the US border,

- the Mixedwood ecozone just north of the Northern Hardwoods, extending across much of the Gaspé Peninsula,

- the Southern Boreal forest south of the red line that separates the commercial, southern boreal forest from the noncommercial, northern boreal forest,

- the Northern Boreal forest just north of the red line,

- the Taiga, comprising much of the area east of the James Bay, and

- the Treed Tundra just south of the thick black line denoting treeline in the Province. The vegetation zones are defined by climatic factors and elevation, both of which drive tree species distributions (MRNFPQ 2003).

Ground Plots: Three hundred ground plots located in the Northern Temperate, Mixedwood, and southern (commercial) Boreal vegetation zones were selected from a list of 12,000+ Ministry of Natural Resources Québec (MRNFPQ) temporary sample plots (TSPs) measured between y2000 and y2004. Each circular, fixed-area plot encompasses 400 m^2 and has a plot radius of 11.28 m. The 300 TSPs were purposefully selected to cover, as best we could, as wide a range of biomass conditions, tree species conditions, and geography as possible in each of the vegetation zones. The 300 were clustered around 7 airports to facilitate flight logistics. Of these 300 pre-selected sites, 295 were actually measured at least once using the airborne LiDAR altimeter. The remaining 5 ground plots were not flown due to the presence of conditions that made low-altitude (200 m AGL) flight measurements difficult, e.g., proximity to steep terrain, proximity to antennas/towers, or restricted airspace. Moving south to north and referring to Figure 1, the seven airports include (1) Trois Rivières where 24 plots were flown, (2) Mont Laurier where 54 plots were flown, (3) Rivière du Loup – 18 plots flown, (4) Lac St. Jean – 61

plots flown, (5) Baie Comeau – 53 plots flown, (6)Chibougamau – 54 plots flown, and (7) Radisson - 31 plots flown. The 31 Radisson ground sites and 20 of the 54 Chibougamau sites were actually established and measured by the Canadian Forest Service (CFS) rather than by the MRNFPQ; the ground sampling setup and procedures were similar. The Radisson sites, at 53.8º N, 77.6º W, were the only sites located in noncommercial forest. All forests north of this site were, for the purposes of ground measurement, inaccessible – no roads.

Note: Access to the CFS and MRNFPQ ground plot locations and associated ground data were kindly provided by the CFS and MRNFPQ. If you need access to these ground data, you'll have to secure permission to use these data from the Canadian Forest Service and/or the Québec Ministry of Natural Resources. Nelson can provide contact information.

PALS Data

Ranging data from a profiling LiDAR, PALS (Portable Airborne Laser System, Nelson et al. 2003), were used to tie ground plot observations to the GLAS space LiDAR observations. PALS was flown over the ground plots and also over a subset of GLAS pulses. Using the ground plot crossings that passed the quality assessment filters, PALS height and crown closure measurements served as the independent variables in linear models to predict ground-measured total aboveground dry biomass. Once the ground-PALS model(s) was(were) developed, the model(s) could be used to predict biomass on those GLAS pulses intercepted by the PALS profiling LiDAR.

PALS data were nominally collected at 200 m AGL at 400 hz. The system employed a single return system (i.e., one ranging measurement per pulse) that

sequentially toggles between first and last returns. At a nominal flight speed of 97 knots, or 50 m/s, the system alternately acquired either a first or last return every 12.5 cm along the profiling track. In the post-processing phase, adjacent first and last returns were combined to produce a pseudo first/last return at 200 hz, with a post spacing of 25 cm. With a divergence of 1.7 mr and a 10 cm transmit lens, the system illuminates a spot on the ground 44 cm in diameter at 200 m AGL, so there's approximately 50% overlap between adjacent first/last returns.

ICESat GLAS Data

The GLAS – L2a data collect over Québec took place between September 27 and November 18, 2003 (Figure 2). Due to the limited life expectancy of the 3 lasers aboard the ICESat/GLAS instrument, one of the three lasers is turned on within time windows that, for the most part, reflect the interests of the ice, not the vegetation, community. L2a indicates that this particular data collect was made by the second of the three lasers; the "a" indicates that it is the first data collect made with laser #2. Laser power degrades with use (Abshire et al. 2005), so this initial laser 2 data acquisition found laser 2 at peak power, with an optimal signal to noise ratio. The dates are certainly not ideal from a vegetation standpoint given that some portion of the 138,010 pulses measured forest canopies under conditions that would affect the waveform returns and height measurements. Deciduous forests at different stages of senescence/leaf drop were measured along the N-S GLAS transect, resulting in increased pulse penetration and a downward bias to the canopy height measurements. Also, some unknown portion of the northerly GLAS height measurements may have been contaminated by recent snowfall,

decreasing canopy height measurements. No attempt was made to mitigate these unknown, downward biases.

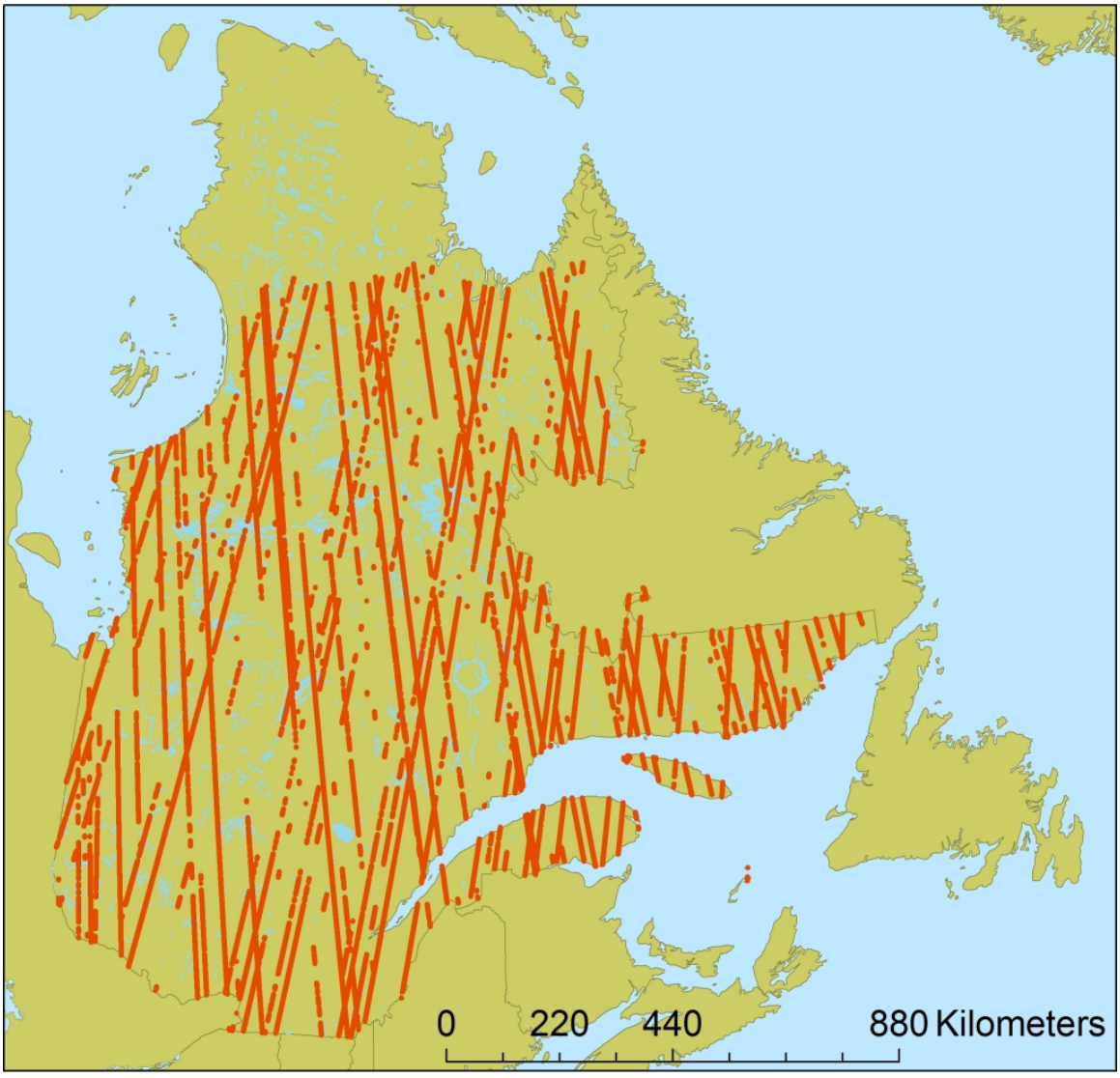

Figure 2. GLAS L2a orbits over Québec, September – November, 2003 (picture from Boudreau et al. 2008).

SRTM Data

SRTM data were collected during a shuttle mission in February 2000 (Figure 3). The C-band InSAR (Interferometric Synthetic Aperture Radar) digital topographic data

over Québec were used to infer local topography around individual GLAS pulses. The SRTM coverage extends to 60 degrees north; this coverage approximately coincides with the Québec treeline, which follows a convoluted E-W path between ~58-59º N latitude. The SRTM 90 m data were used to calculate the vertical range, in meters, and slope, in degrees, in a 3 x 3 pixel window centered on each GLAS pulse used in the analysis.

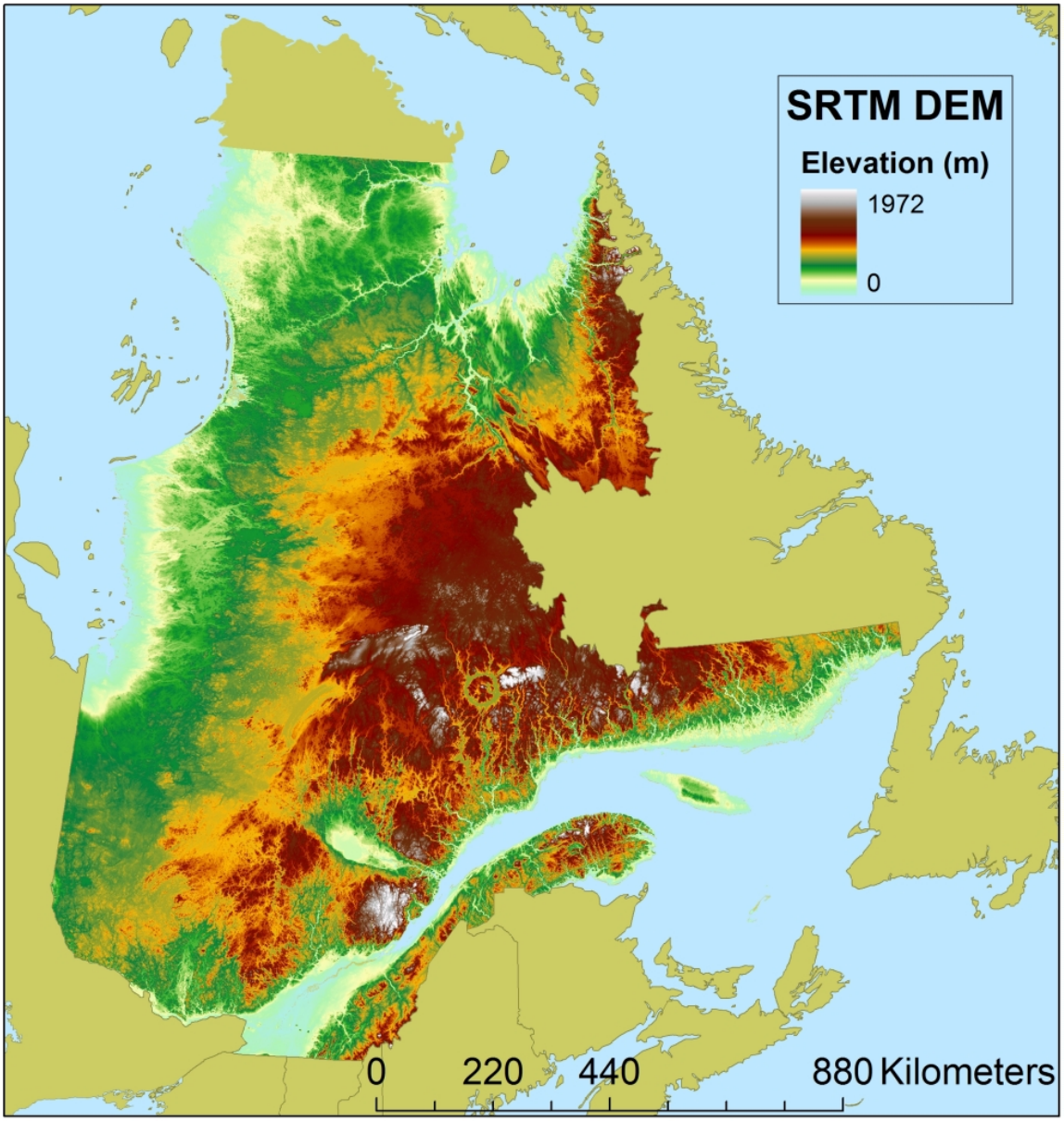

Figure 3. SRTM data used to characterize topography across Québec.

References

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