

Temperature Measurements in a Milagro Outrigger Detector

John A.J. Matthews and Bill Miller

johnm@phys.unm.edu

University of New Mexico

Albuquerque, NM 87131

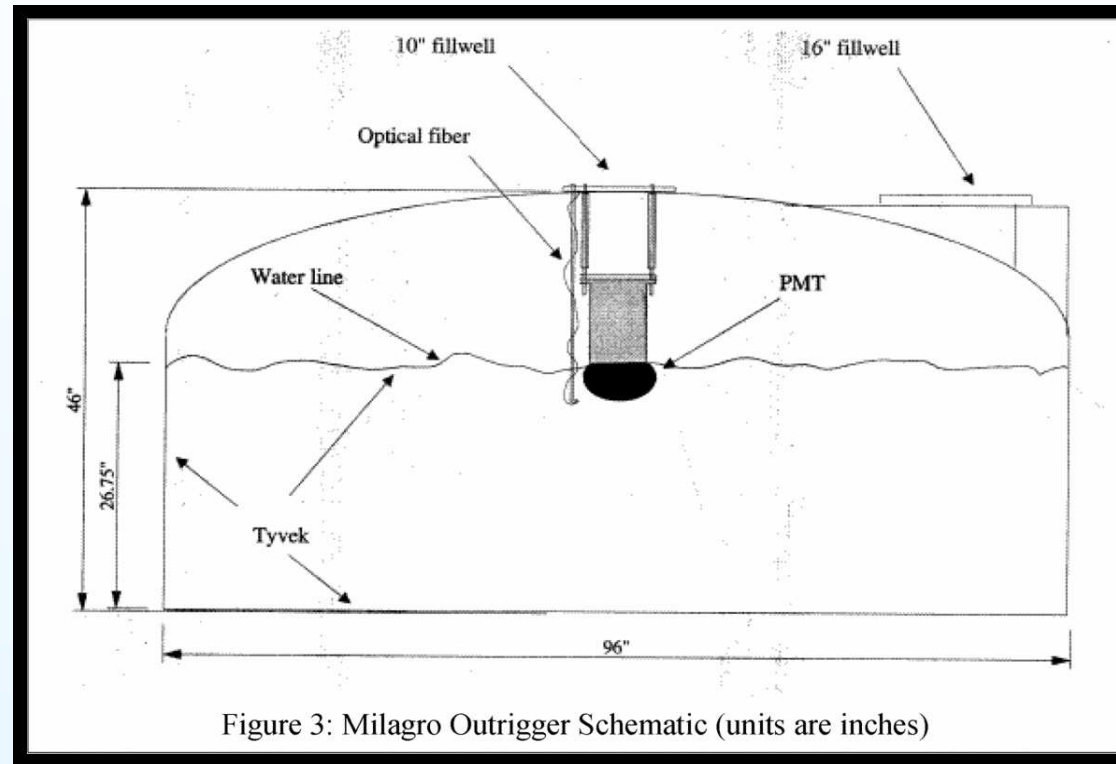
Where is ... Milagro?



The Milagro TeV γ -ray detector is at:

- Latitude 35.8 degrees, Longitude +106.67 west
- Elevation: 8650ft / 2650m

Outrigger detector ... Details & Dimensions



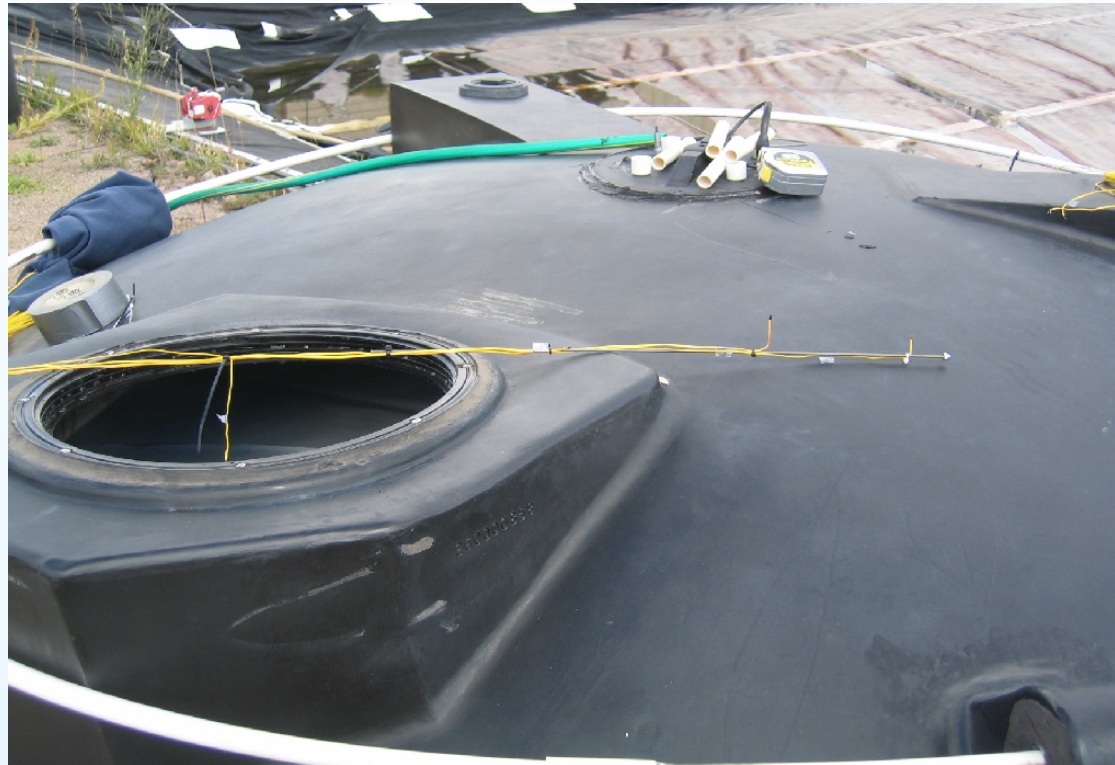
- One central PMT, enclosure $\sim 1/2$ -immersed, **only electronics: PMT-base**
- Water depth *typically* ~ 30 -inches (*i.e.* deeper than drawn)
- Smaller water volume and colder winter temperatures (than Auger South)
- In winter often “several inches of ice on water top surface/sides
... **but never close to freezing solid!**”

Outrigger detector ... Instrumented Sept. 2006



- Top fill port: 4 temperature sensors
- Hole *under* detector
~ 22"-deep with 2 temperature sensors:
one ~18"-(in) from tank edge [Ch 1] and one
~12"-(in) from tank edge [Ch 2]

In-tank ... string of 4 sensors



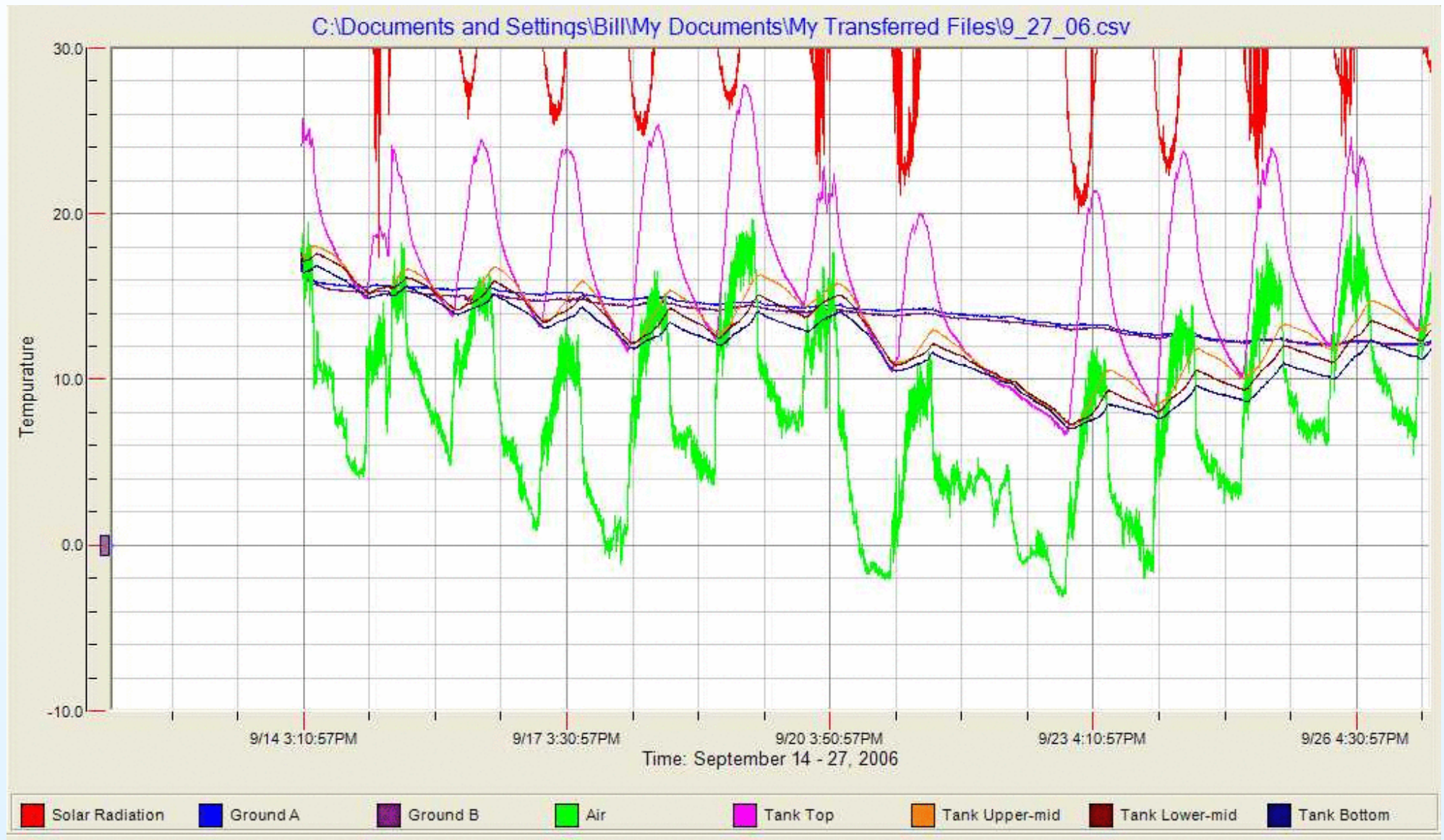
Thermocouple string:

- $\sim 13''$ in from the edge of the tank
- depths (below the surface of the water) of $<1''$ (*i.e.* "at the surface") [Ch 4], $14''$ below the surface [Ch 5], $22''$ below the surface [Ch 6] and $28.5''$ below the surface (*i.e.* about $1.5''$ above the bottom) [Ch 7]

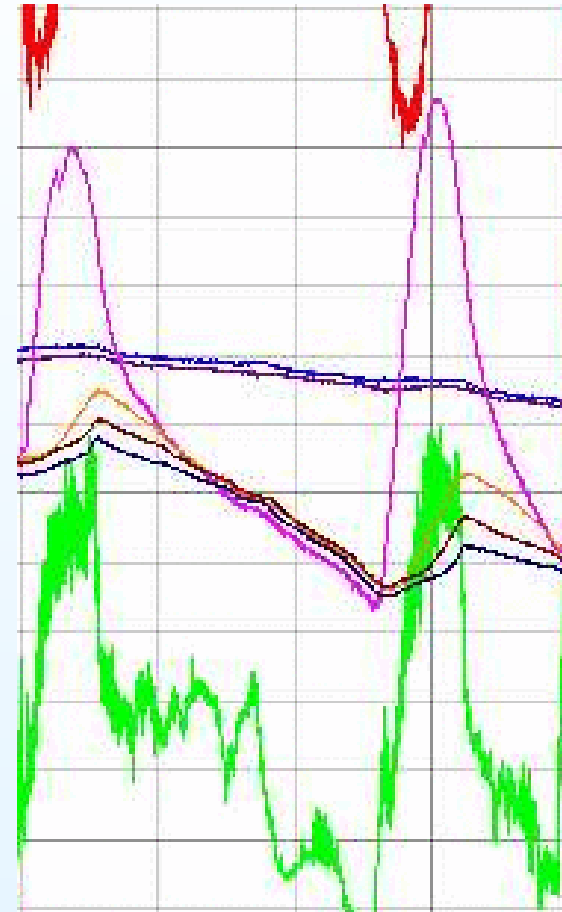
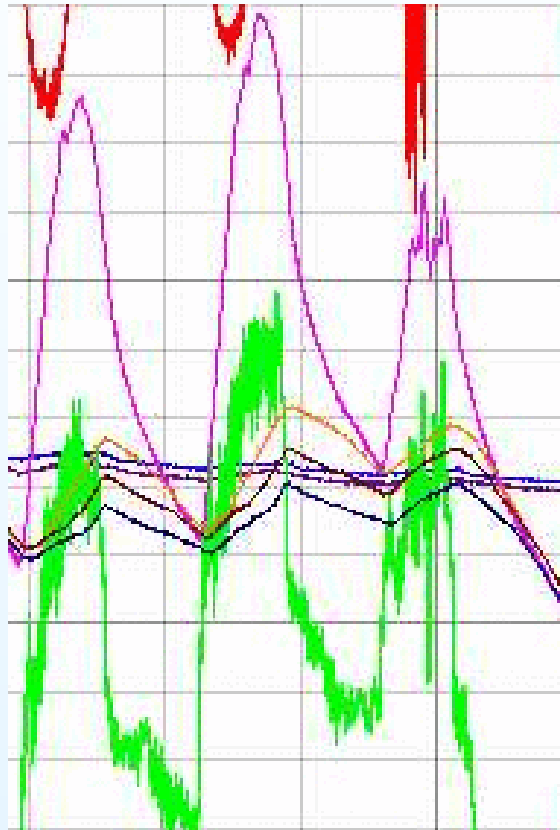
Ambient T [Ch 3] and Solar Sensors [Ch 0]



Sample at 1/minute ... mid to end Sept 2006



Tank temperature ... September 2006 details

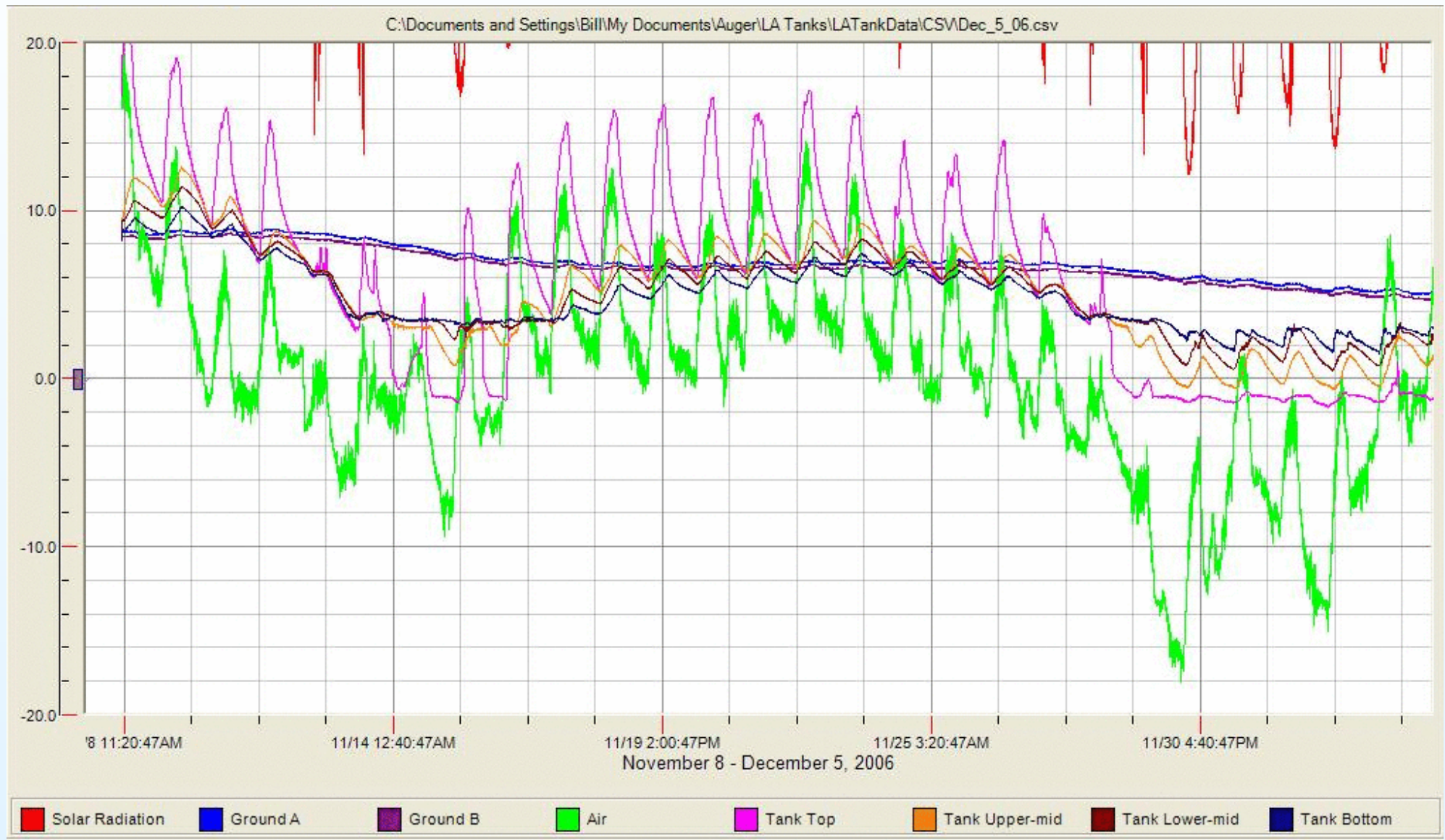


- [left plot] tank T-sensors show T-gradient: coolest (bottom=black) to warmest (top=violet) ... *large daily temperature variations* ... **not a good thing!**
- [right plot] but NO T-gradient on cloudy days!

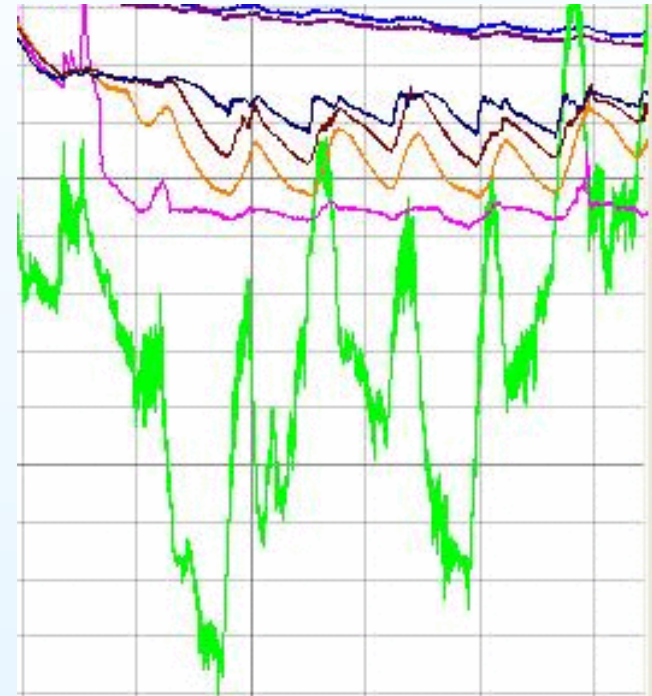
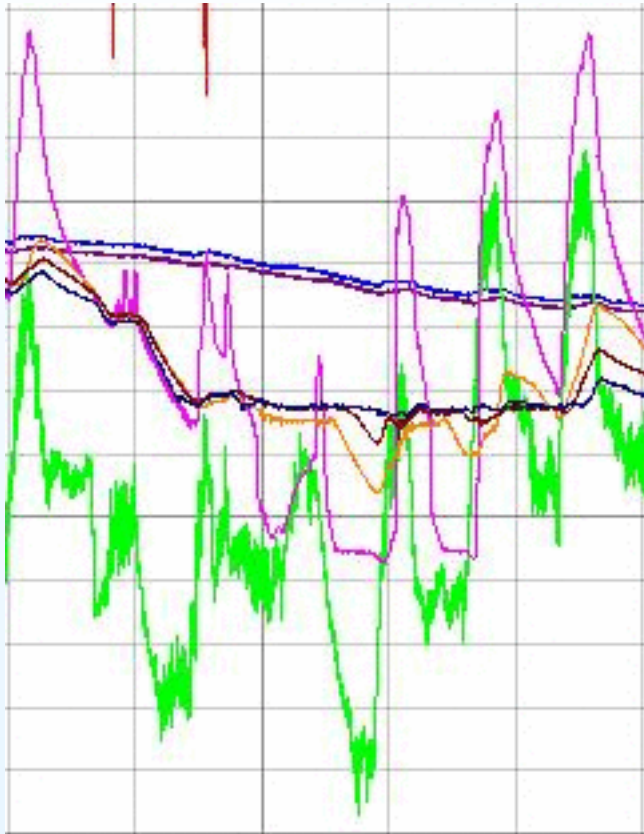
Upgrade ... solar panel + fix storm damage



Finally surface freezing ... in middle and late Nov



Tank temperature ... November 2006 details



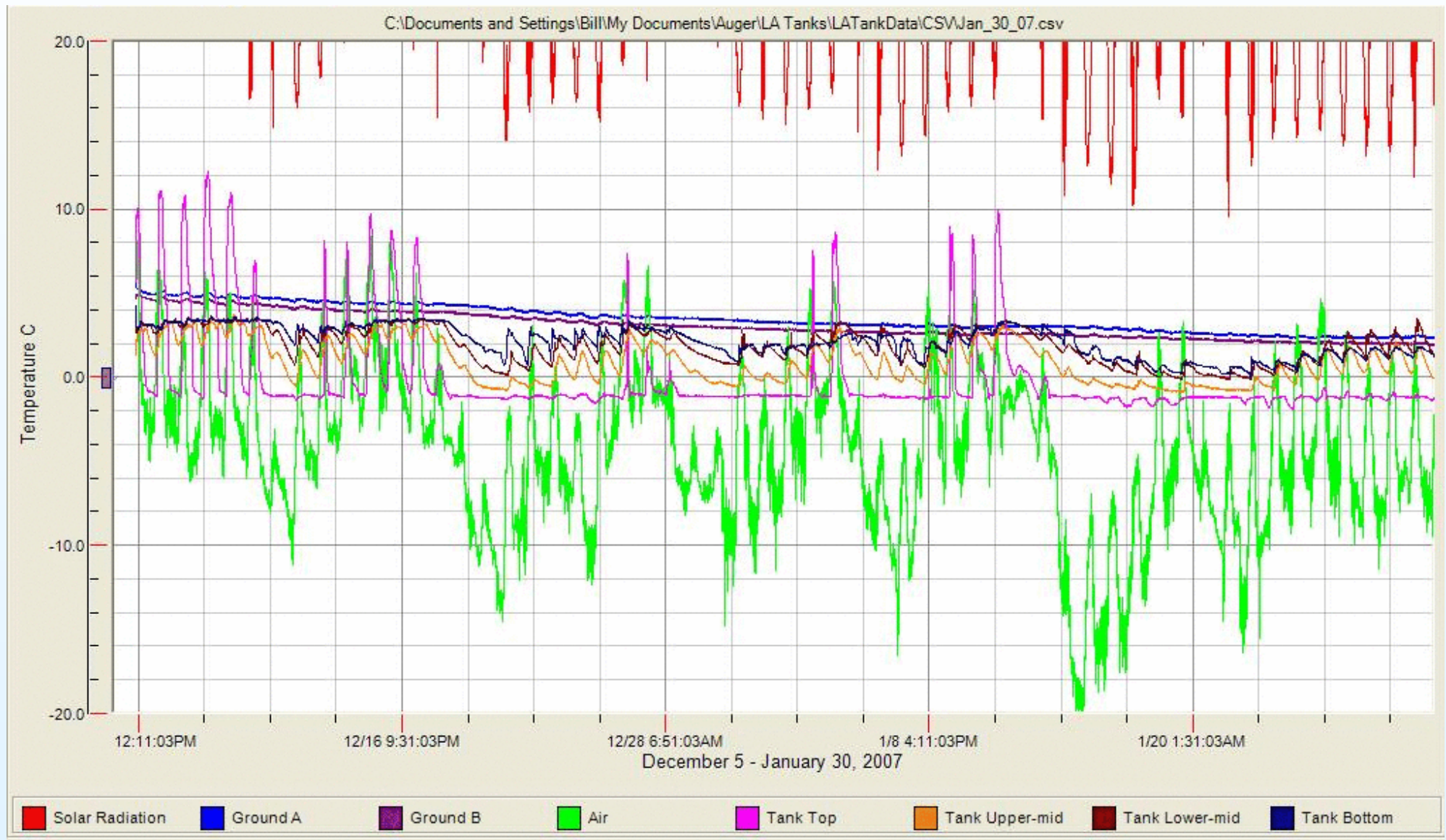
- [left plot] tank T-sensors show **inverted** T-gradient: coolest (top) to warmest (bottom) ... with top probably freezing at night and thawing during the day ... **not a good thing!**
- [right plot] now the top (**violet**) stays frozen day and night!

Then endless snows ... until late Jan 2007

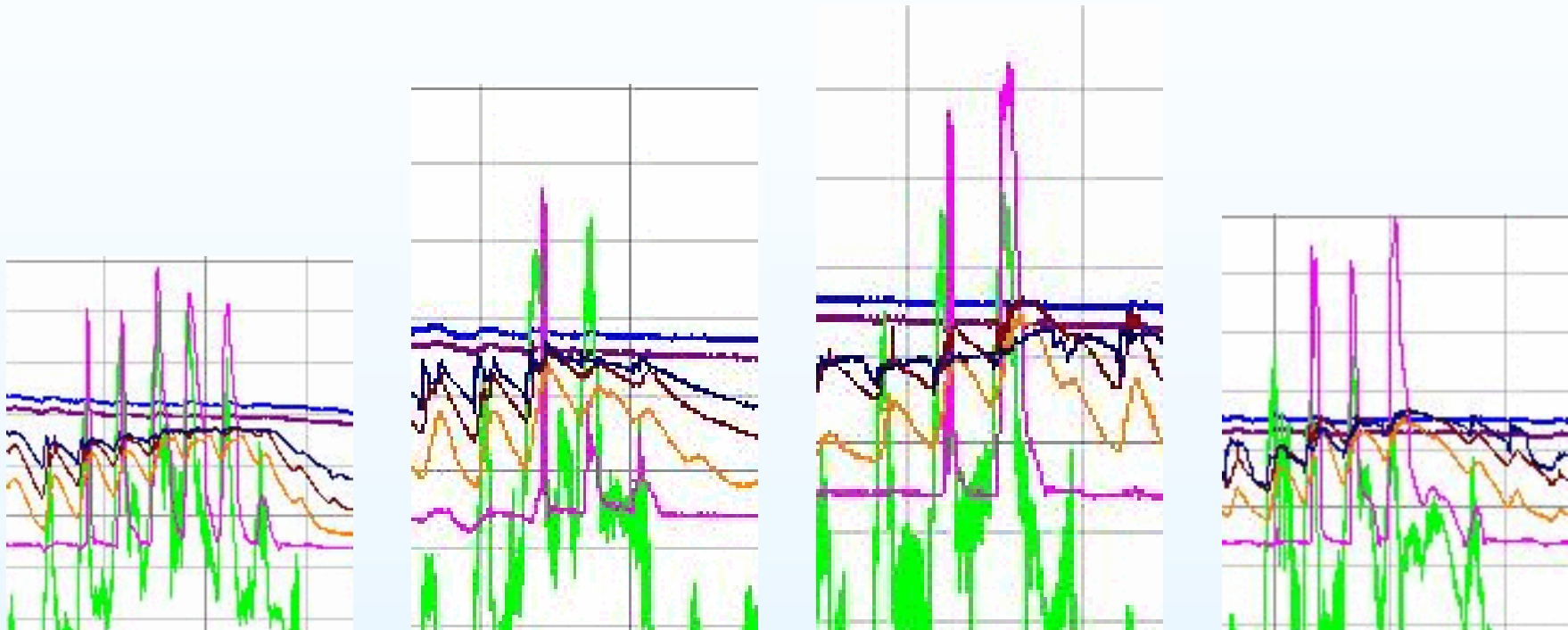


- Milagro experiences significant snow cover during the coldest months.
- Tanks in full sun have least snow (cover).
- Tanks in the shade (not shown) can be totally covered.

Then endless snows ... until late Jan 2007

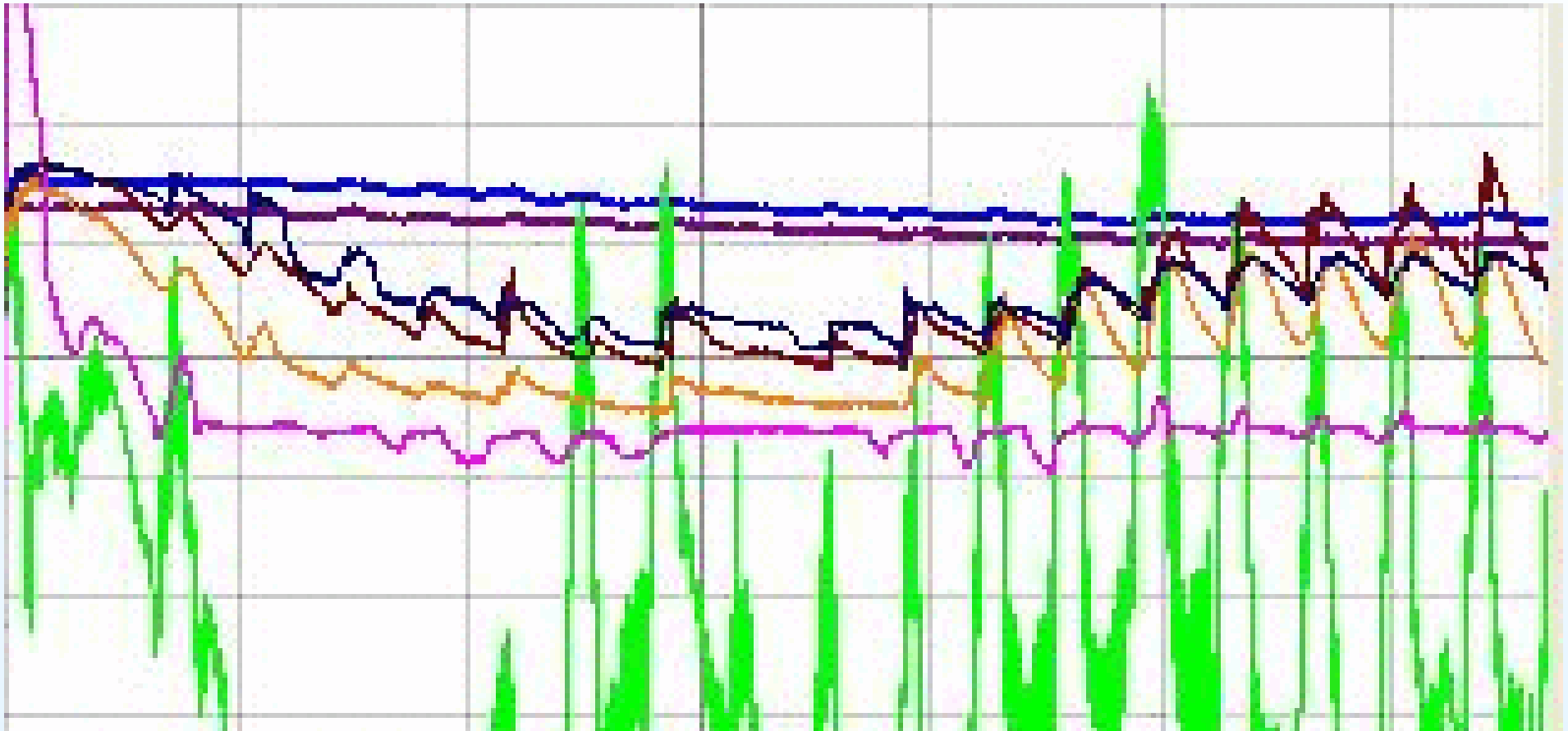


Tank temperature ... January 2007 details



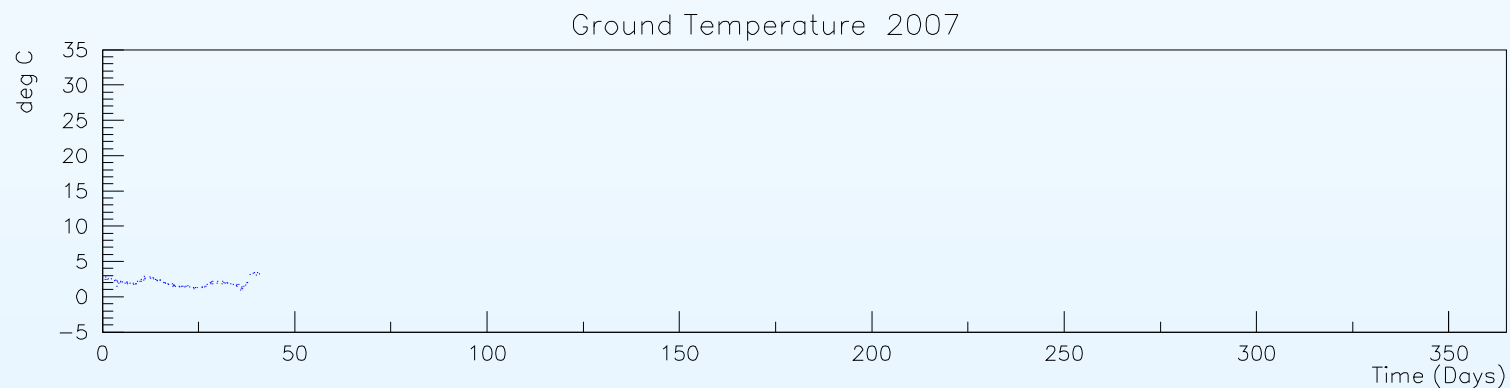
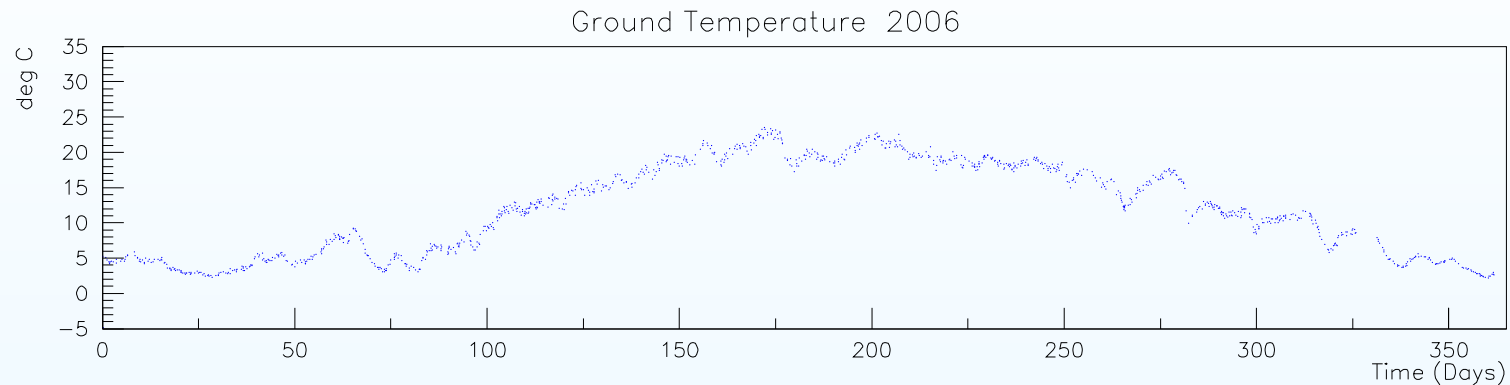
- **Note:** likely temperature offset of $\sim 1^\circ$ for all sensors
- Many (more) examples of tank surface (violet) night-time freezing followed by day-time warming
- Other depths in the tank (orange, brown and black) above freezing

Tank temperature ... January 2007 details



- Only **one** period of sustained freezing of the tank surface (**violet**)
- Middle of the tank (**orange**) close to 0° but probably above freezing
- **Ground temperatures remain above freezing** ($\sim 3^{\circ}\text{C}$)

Milagro ground temperature ... agree with our data!



- Milagro temperature sensor ~ 12 inches below the surface ... **not under a tank**
- Temperature record for 2006 **top**, and 2007 **bottom**
- **Ground temperatures remain above freezing: possibly a consequence of *typical* snow cover at Milagro during the coldest months.**

My own ... impressions!

- We observe large temperature variations in the tank ... especially near the top surface. Of these freezing:thawing is probably the most damaging to components in the tank. **Insulation of Auger North tanks should reduce these variations substantially!**
- The ground under the tanks remains *warm* ... and slowly varying in time (e.g. through Jan 30, 2007 the ground was warmer than the water!) **This, AND the typical snow cover at Milagro during the coldest months, may explain why: “the Milagro tanks are never close to freezing solid!”**
- Future plans: add insulation to Milagro outrigger tank in *steps*.
- Do we want to do some ground temperature studies in Lamar?