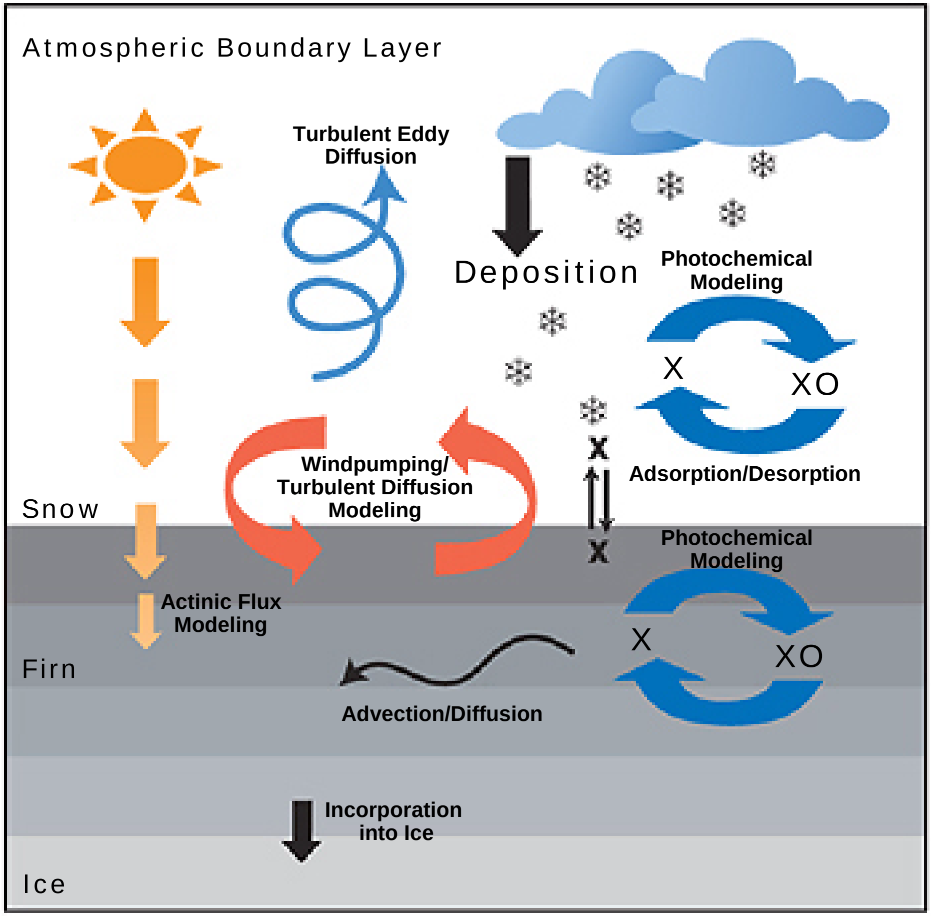
Atmosphere/Snow Exchange



It used to be thought . . .
that the steady accumulation of snow on polar glaciers preserved a perfect layer-cake record of the impurities in the atmosphere.

Today, we know . . .
this to be an extremely complex process. When sunlight shines onto the snow surface, temperature increases, releasing some of the impurities in the snow into the pore spaces.

More surprisingly, sunlight also breaks apart larger molecules into smaller, often more reactive, compounds. These compounds initiate a chain of additional reactions. Some reactive gases diffuse, both into the overlying air and deeper into the snow pack. Wind passing over the snow causes more vigorous mixing, again both in the snow and upward into the atmosphere.

All of these processes must be considered in order to understand the effect that snow photochemistry has on the chemistry of the overlying air and on the chemical record that is ultimately preserved in glacial ice.

How are we studying the snow photochemistry?

There are five major parts of our project:

- **Measuring radicals.**

Using a variety of techniques, we are measuring hydroxyl radical (OH, the "vacuum cleaner" of the atmosphere), hydroperoxyl radical (HO_2), and nitric oxide (NO). Some of these species are measured in the snow. Others are measured in the air above the snowpack.

- **Measuring chemicals that form radicals,**

including hydrogen peroxide (HOOH), formaldehyde (HCHO), nitrous acid (HONO), and nitric acid (HNO_3). These radical precursors are being measured on snow grains, in the air between the snow grains (firn air), and in the air that comes out of the snow. Since these chemicals form radicals in sunlight, understanding their concentrations and formation will help us understand the radical budgets at Summit.

- **Characterizing sunlight in the snowpack.**

As mentioned above, many of the species we are measuring are formed or destroyed by sunlight. In order to understand their rates of formation or destruction, we have to understand the amounts and wavelengths of light that penetrate the snowpack and how this varies with depth.

- **Determining the physical structure of the snowpack.**

Diffusion and winds blowing into and out of the snowpack play key roles in releasing chemicals from snow. In order to understand the speed of these processes, we are measuring the physical nature of the snow, including the sizes of snow grains, how tightly packed the snow is, and how temperature varies throughout the snowpack.

- **Putting it all together.**

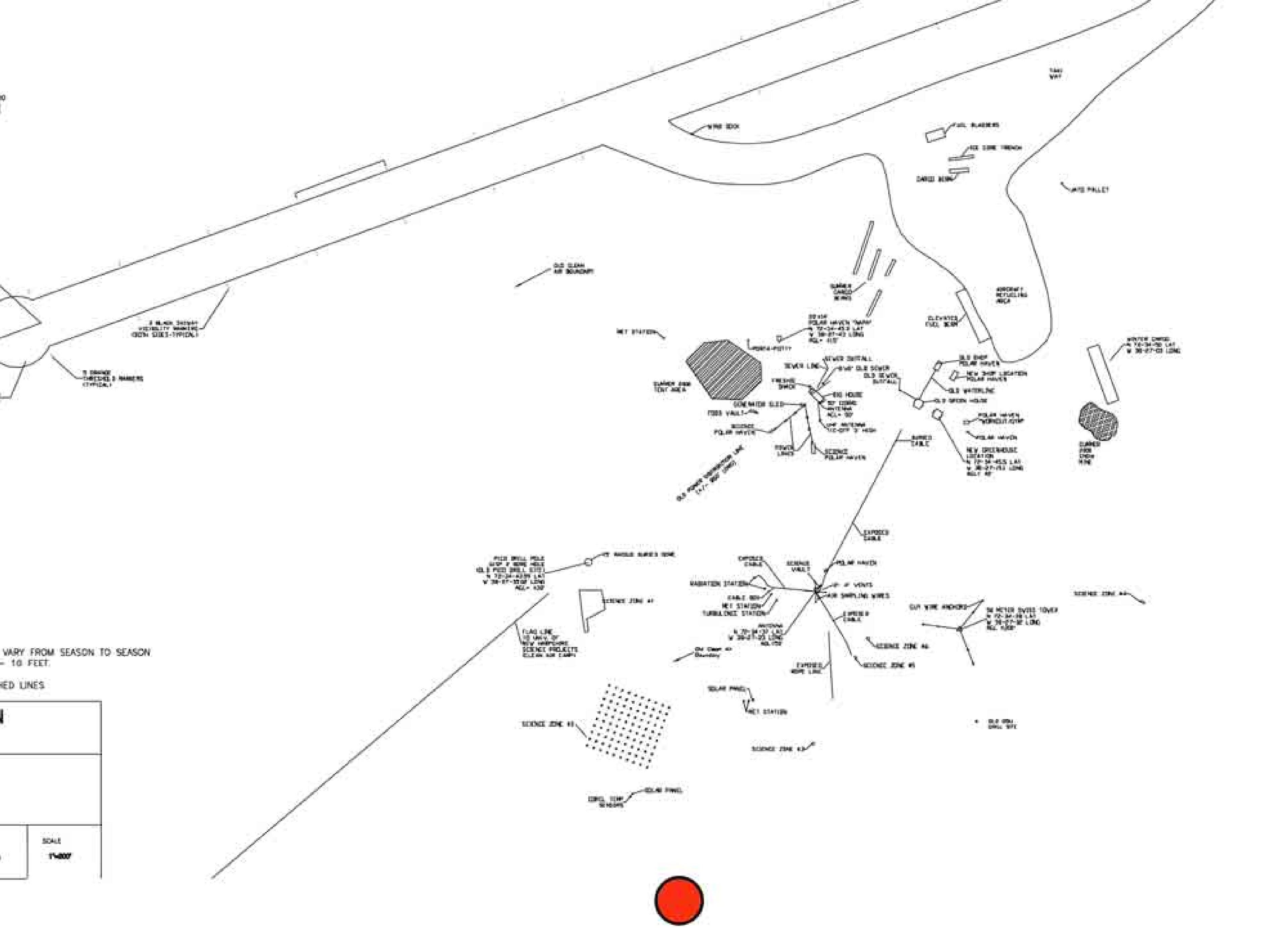
Our ultimate goal is to use our observations to create a model of photochemistry in the snowpack. This model would allow us to predict the impacts of snow reactions on the composition of the atmosphere, the snowpack, and resulting ice.

Summer '03/Spring '04 and ???

We have developed a special firn air sampling probe that allows simultaneous measurement of HONO, HNO_3, NO, HOOH, HCHO, HCOOH, CH_3COOH, NO, HO_2, $RONO_2$, and a long list of non-methanehydrocarbons in the air filling the pore spaces of snowpack. The top right photo shows this probe deployed in pristine snow, upwind of a specially-designed sampling bridge. The bridge allows snowsampling at least 3 m away from the nearest footprint.

At lower right, the probe is shaded to block direct visible and UV light. We also use large filters to block just UV light from reaching the snow around the probe. This close up view also shows a thermocouple array (orange wire) deployed to measure the temperature depth profile. The fiber optic cable (blue wire), visible at the top, is connected to one of the radiometers used to measure light levels in snow.

At left, a 2 m deep snowpit, showing over two years of snowpack.



WING SOCK
FUEL BLADDERS
ICE CORE TRENCH
CARGO BERM
AIRCRAFT REFUELING AREA
ELEVATED FUEL BERM
OLD CLEAN AIR BOUNDARY
MET STATION
GREENHOUSE
POLAR HAVEN "BARN"
SEWER OUTFALL
SEWER LINE
OLD SEWER OUTFALL
BIG HOUSE
GENERATOR SLED
POWER LINES
SCIENCE POLAR HAVEN
UHF ANTENNA
OLD SHOP POLAR HAVEN
NEW SHOP LOCATION POLAR HAVEN
OLD WATERLINE
OLD GREEN HOUSE
POLAR HAVEN
NEW GREENHOUSE LOCATION
BURIED CABLE
EXPOSED CABLE
SCIENCE VAULT
POLAR HAVEN
RADIATION STATION
CABLE BOX
MET STATION
TURBULENCE STATION
AIR SAMPLING WIRES
EXPOSED CABLE
SCIENCE ZONE #1
FLAG LINE
NEW HAMPSHIRE
SCIENCE PROJECTS
GUY WIRE ANCHORS
SCIENCE ZONE #6
SCIENCE ZONE #5
EXPOSED WIRE LINE
SOLAR PANEL
MET STATION
SCIENCE ZONE #3
SCIENCE ZONE #2
SOLAR PANEL
VARY FROM SEASON TO SEASON
- 10 FEET.
HED LINES
SCALE
1"=800'