

Antarctica

– a keystone to Earth history and processes, and –
a platform to observe the universe

- **Geology**
- **Ice sheets**
- **Southern Ocean**
- **Climate change**
- **Life in extremes**
- **'Mars lab'**
- **Universe**



IPY Mar 2007-2009

Prospects for dedicated research platform for Antarctic research are current research needs being met ?

SCIENCE REQUIREMENTS FOR A LONG-RANGE AIRCRAFT FOR ANTARCTIC RESEARCH

ASSESSING THE SCOPE OF MODIFICATIONS FOR AN LC-130 HERCULES



Site visit at NCAR's Research Aviation Facility, Jefferson County Airport, Breckenridge, Colorado December 18, 2004.

Report compiled by
Michael Siedinger, LDRD

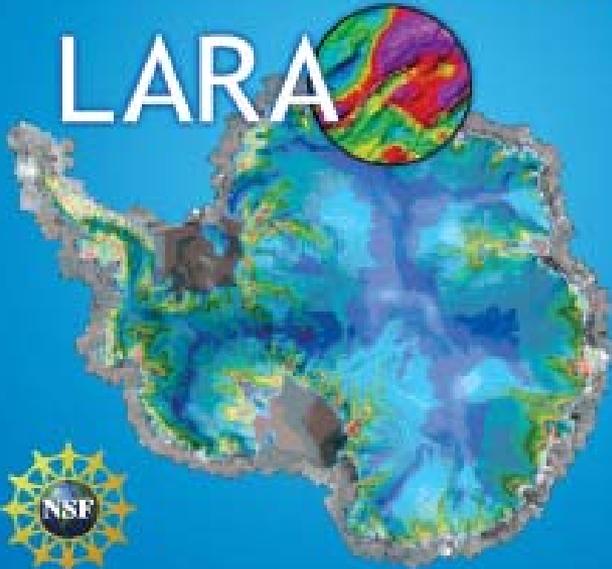
Based on notes by
Brian Davis, NSF/OPP



URL: <http://www.ice.danforth.edu/~msieding/LC130/>

Palmdale, April 27, 2004

SCIENTIFIC OPPORTUNITIES FOR A LONG-RANGE AIRCRAFT FOR RESEARCH IN ANTARCTICA



Sept 2004

Restore Deep Field LC-130 Operations

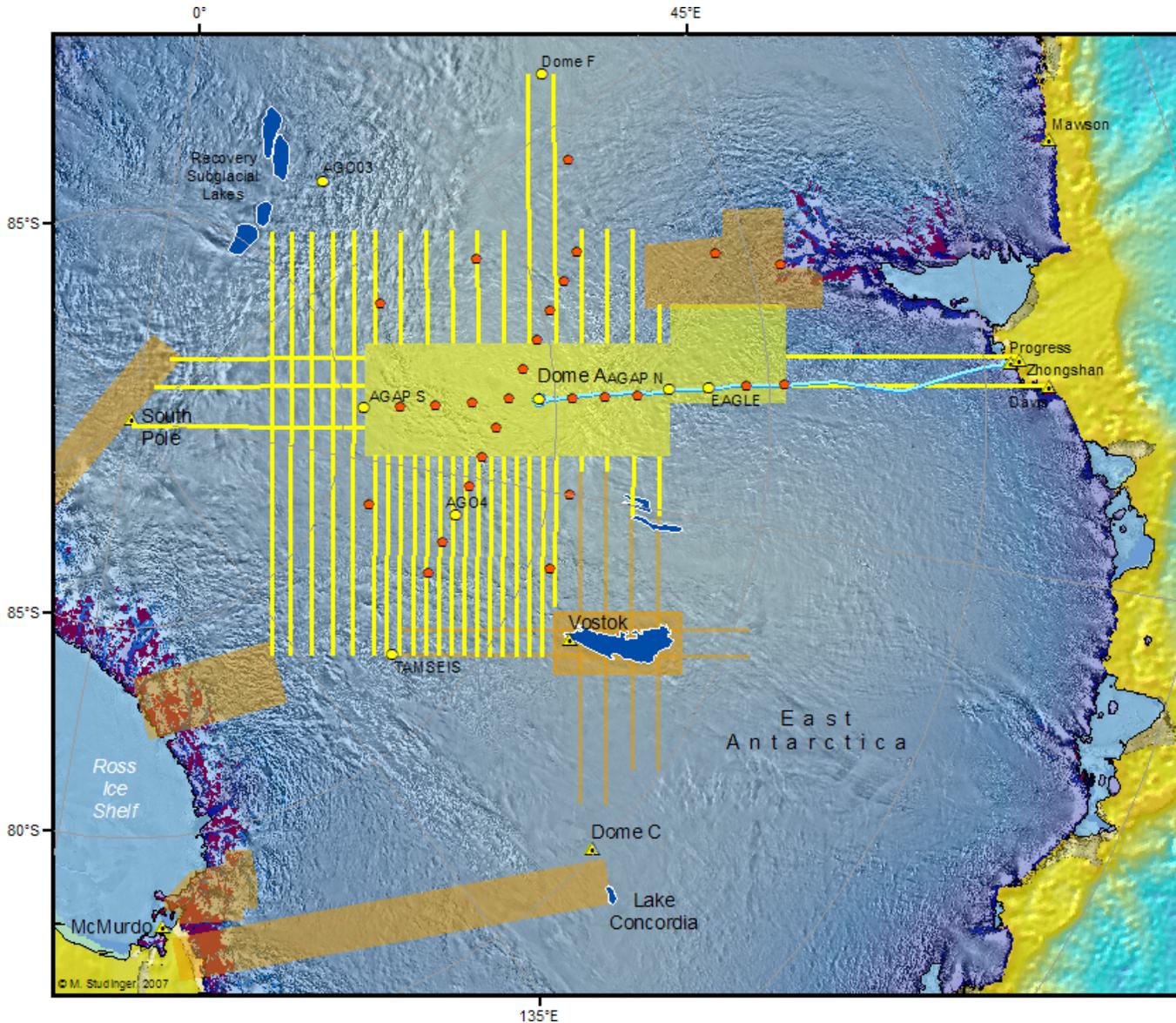
- **Motivation for convening the Workshop**
- **Completion of the new South Pole Station, and use of the South Pole Surface Traverse to assist in the re-supply, will provide the opportunity to re-allocate LC-130 capability to deep field science support**
- **Recognition of need to restore the expertise to operate LC-130's safely and effectively in support of remote field sites**
- **Results:**
 - **Committee of Antarctic glaciologists with expertise in remote sensing of snow to advise 109th AW**
 - **Timeline established to align grant awards with logistics planning**
 - **More efficient allocation of resources**
 - **Not every site is the same; combined science advice, remote sensing imagery, site history, and pilot expertise will provide information needed to better assess risk.**
 - **Improved capabilities will increase access to Antarctica by LC-130s**
 - **Ability to task LC-130s without long lead time. Possibly for immediate use in benign areas**
 - **Joint funding with Antarctic Sciences to create a GIS database for Antarctic Field, landing, and science field reports**
 - **Process began for 2007-08 season and is already starting for 2008-09 season**



Instrumented Twin Otter (Kenn Borek Air)







AGAP



Legend

- Field Camp or Fuel Cache
- ▲ Permanent Research Base
- Seismic Recording Site
- Traverse Route
- AGAP Aerogeophysics
- Aerogeophysical Survey
- Major Subglacial Lake
- Rock Outcrop
- Ice Shelf

Ice Surface Elevation [m]

High : 4400

Low : 0

Bedrock Elevation [m]

High : 4400

Low : -6800

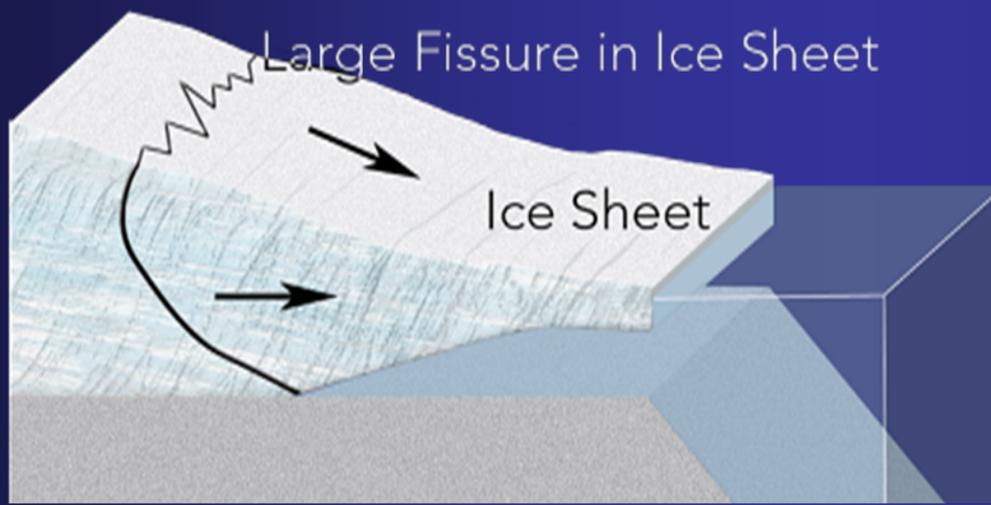
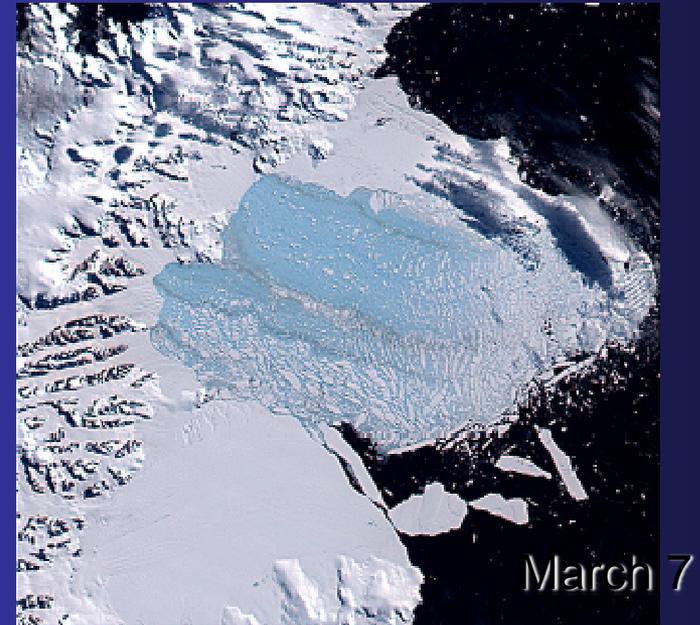
0 100 200 400 600

Kilometers

Map compilation:
Michael Studinger, LDEO

What if global temperature or sea level rises?

In 2002, an area the size of Rhode Island (3,250 km²) disintegrated over a few weeks. The ice was 200 m thick.

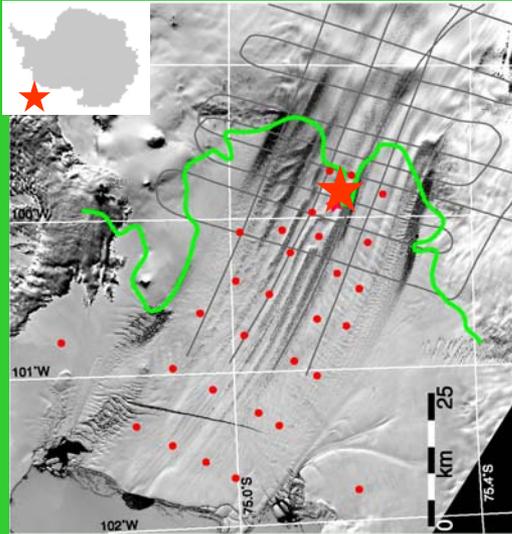


One possible scenario: rising sea level floats more ice sheet, detaching it from bedrock



Will ocean warming cause ice shelf collapse?

8 institutions, 13 investigators, 2 countries and 3 funding sources:



Four boreholes through 550-m thick ice shelf will permit video-camera exploration of sub-shelf environment and deployment of oceanographic profilers to measure water properties

Depth of ocean cavity beneath ice shelf at 29 seismic stations



Wind-powered Iridium phone transmits data and receives control commands for profilers



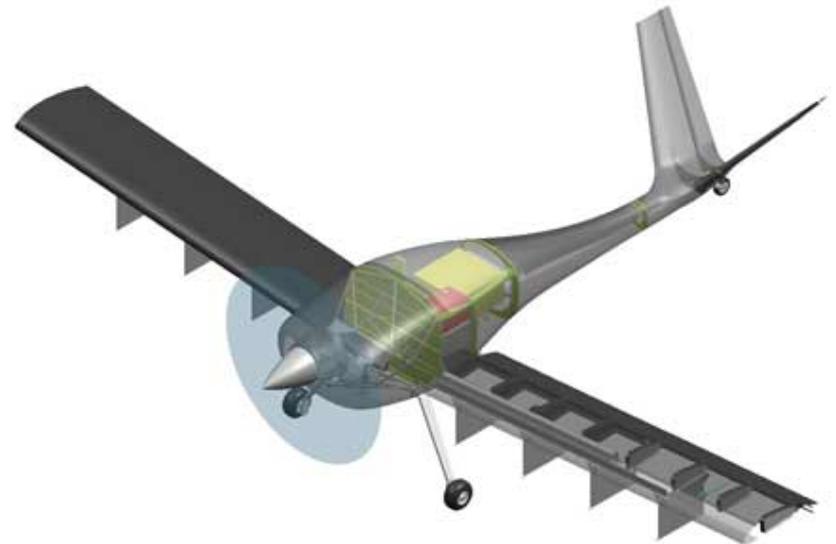
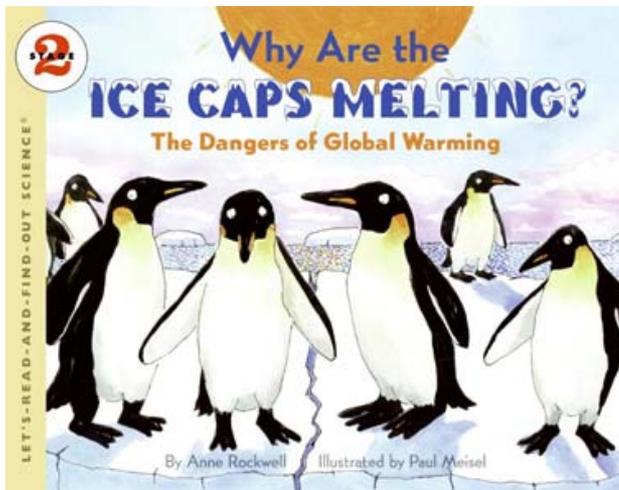
CReSIS

Center for Remote
Sensing of Ice Sheets

RADAR mapping of the ice sheets

NSF Science and Technology Center for:

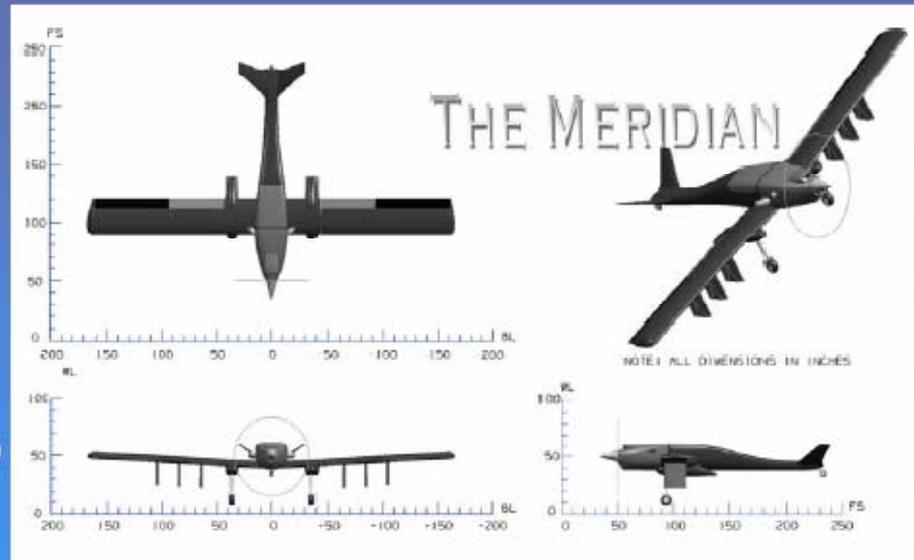
- Aerial RADAR and UAV development
- Ice sheet and glacier study
- Predict sea level change
- Specific outreach to Native Americans



<https://www.cresis.ku.edu/education/k-12.html>

Current UAV Design Concept

- Aircraft Summary:
 - $W_{TO} = 1,083$ lbs
 - $W_E = 618$ lbs
 - $W_F = 295$ lbs
 - $W_{PL} = 165$ lbs
 - Wingspan = 26.4 ft
 - Length = 17 ft
 - Range = 1,750 km (950 nm)
 - Endurance = 13 hours
- The most critical design requirements are:
 - Payload Integration (Antennae Size)
 - Takeoff/Landing Distance
 - Size limitations
 - Shipping
 - Hangar Size
 - Fuel Type
 - Cold Weather Requirements (Anti-icing)



UAV Prototype

- The Hawkeye aircraft is a successful demonstration of engineering, as well as integrated research/education and technology transfer.
- The Hawkeye was designed, analyzed and manufactured by 11 students in less than 3 months. The product is an industry quality aircraft, has met all expected performance goals, and is currently being transitioned to a commercial product.



Piccolo Applications



5 RnR UAVs With Piccolo (Courtesy RnR and Cloudcap)



4 Swarm UAVs (Courtesy ACR and Cloudcap)



Outlaw UAV With Piccolo (Courtesy Cloudcap)

Used by many small
businesses and
universities

Used by NASA and
Government research
facilities



Arerosonde – platform for both Arctic and Antarctic environmental studies

WINFLY Sept-Oct 2009

operate under IFR rules,
Class E air space, 100nm MCM
controller in direct contact with ATC

outside this – exclusion zone, or
filed flight plan.



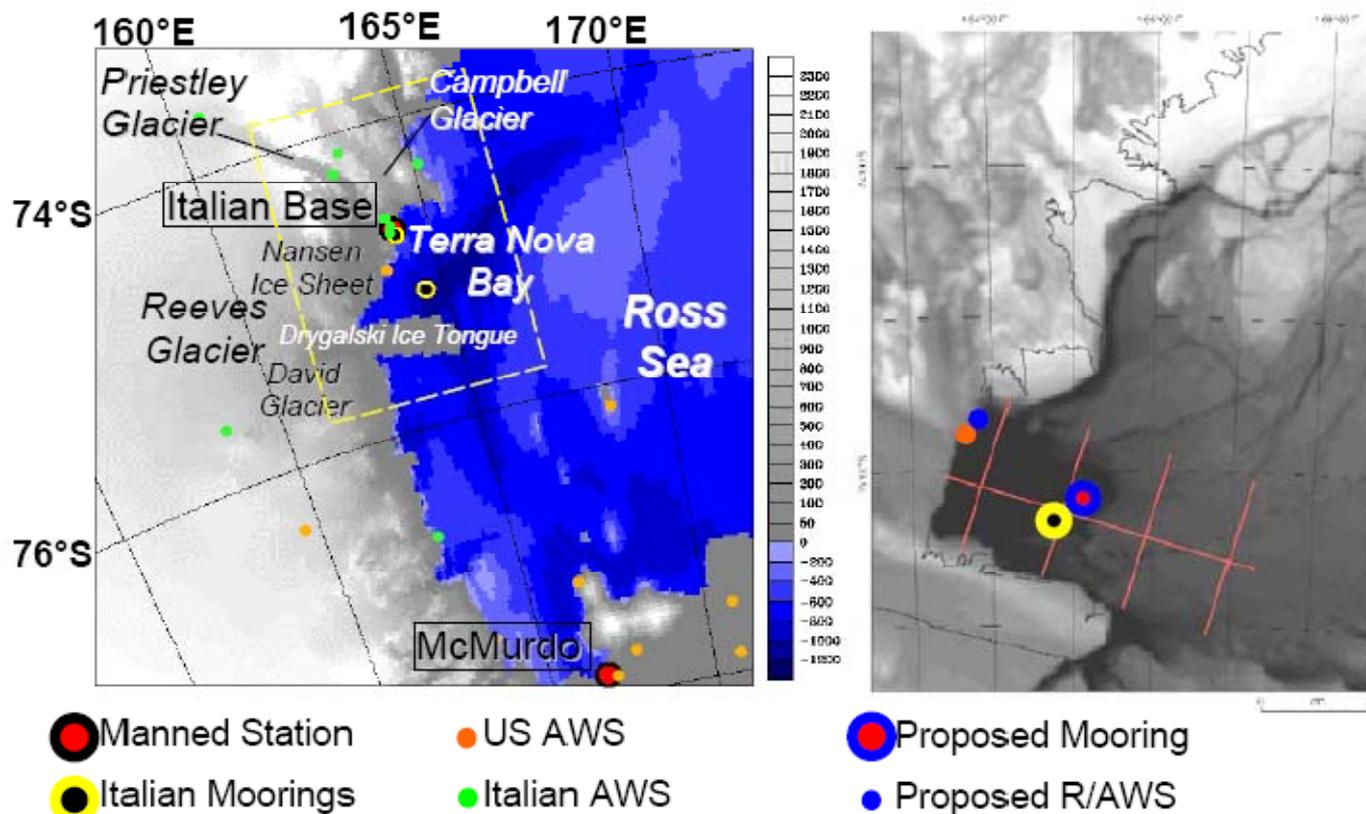


FIGURE 1. Left: southwestern Ross Sea including Terra Nova Bay region. Ice sheet topography is from the Radarsat Antarctic Mapping Project (Liu et al., 2001). Bathymetry is from unpublished bathymetry map by F.J. Davey and V.M. Stagpoole (pers. comm.). Topography and bathymetry are shown in units of m above sea level. Right: AVHRR Band 4 (infra-red) image of Terra Nova Bay polynya, 1 Oct. 1996, extracted from Hauser et al. (2002). The image roughly covers the dashed-boundary region at left. The scale at lower right corresponds to 40 km. Superimposed are locations of a proposed mooring, UAV flight tracks (orange lines), and R/AWS.

Long Duration Balloon Program

Scientific balloon payloads in a near space environment.

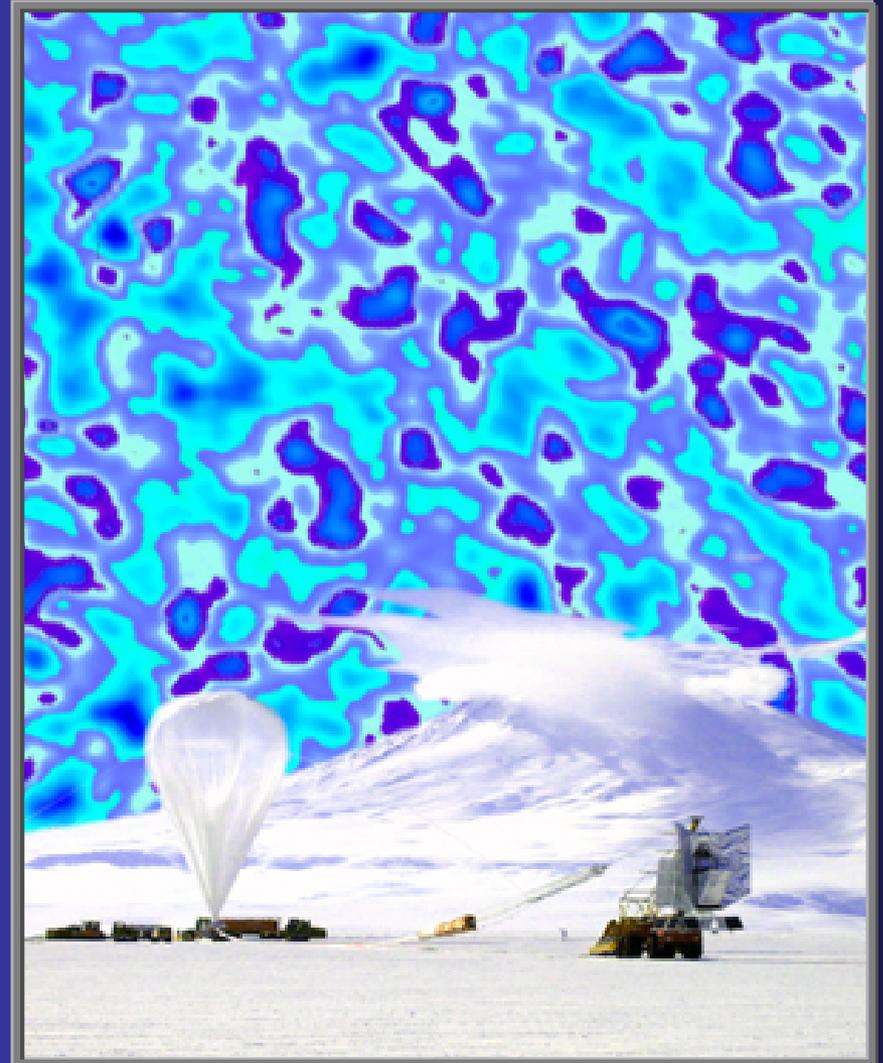
With NASA

- 2 flights/year thru 2009
- try 3 flights in 06/07

Circulation of polar vortex allows data collection for 2 weeks or more, versus 1-2 days in low latitudes.

Boomerang Mission Data

CMBR variation in sky





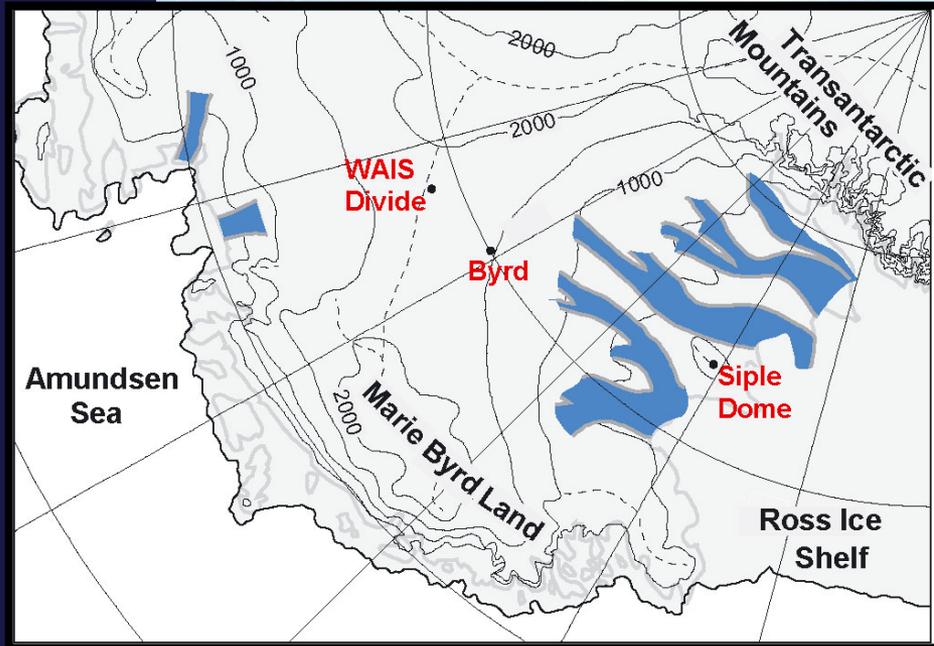
West Antarctic Ice Sheet (WAIS) Divide Coring

Do changes in greenhouse gases lead or lag changes in climate?

How stable is WAIS?

Interaction of the northern and southern hemispheres during major climate changes?

What lives in and under the ice?

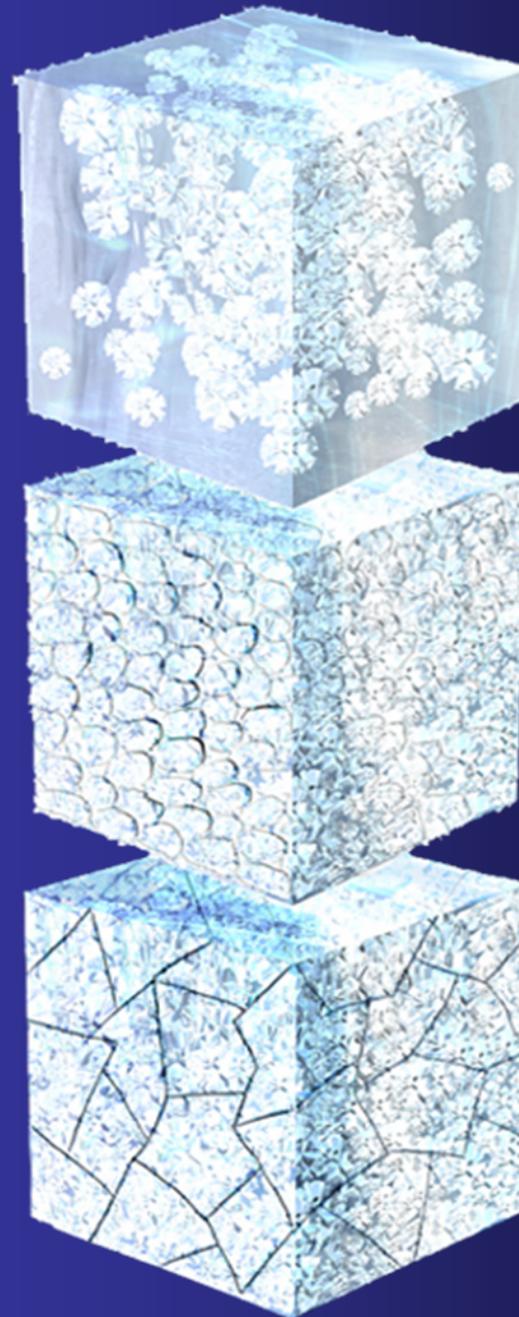


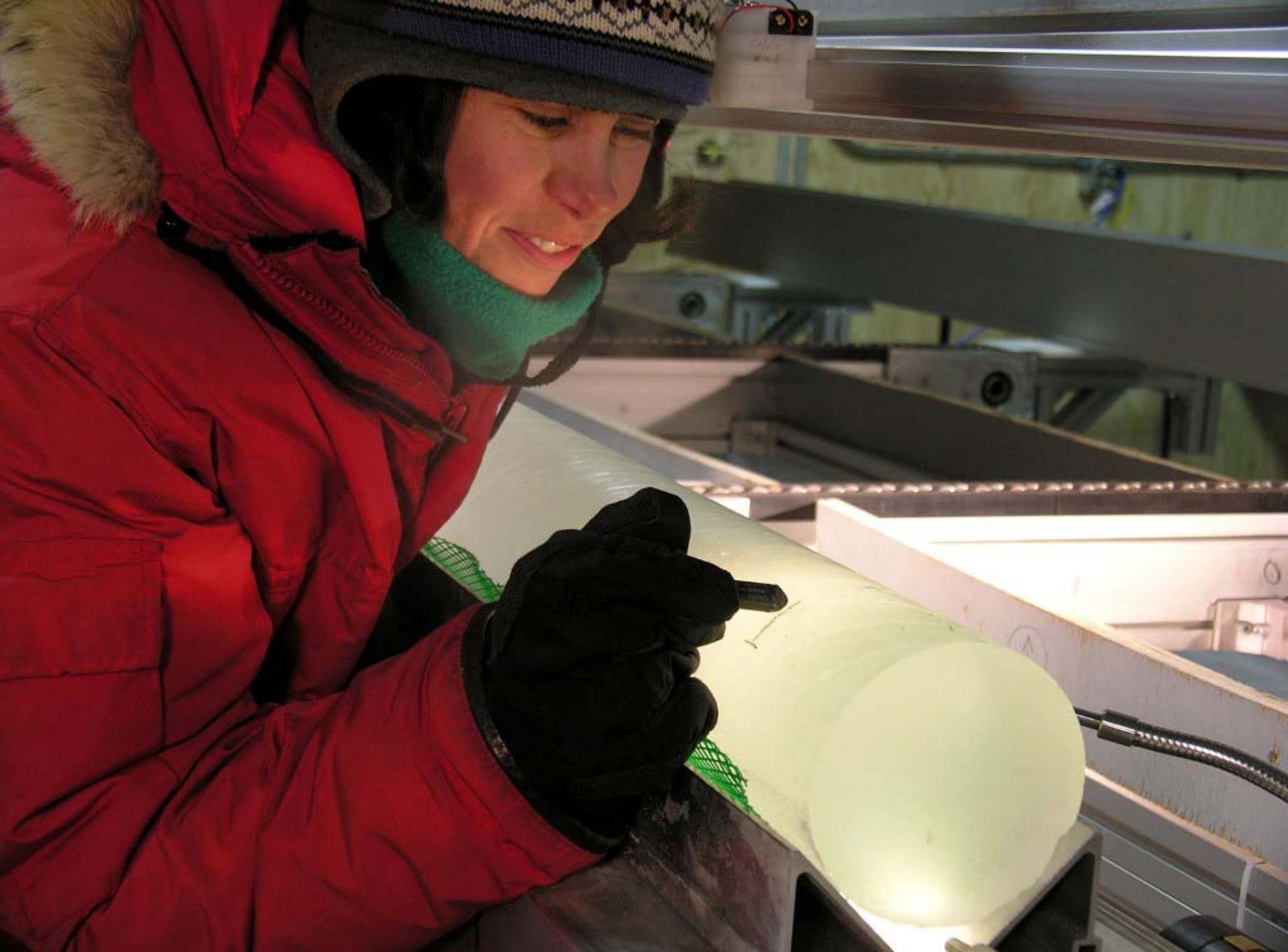
From snow to glacier:

Snowflakes pressed together
by weight of other snowflakes

More snow adds weight and
compresses flakes into small
spheres

Increasing depth and pressure
cause snow to become crystalline
ice; bluish from trapped air





Life in the cold and dark



How do organisms adapt to prolonged darkness?

Winter studies in the
McMurdo Dry Valleys

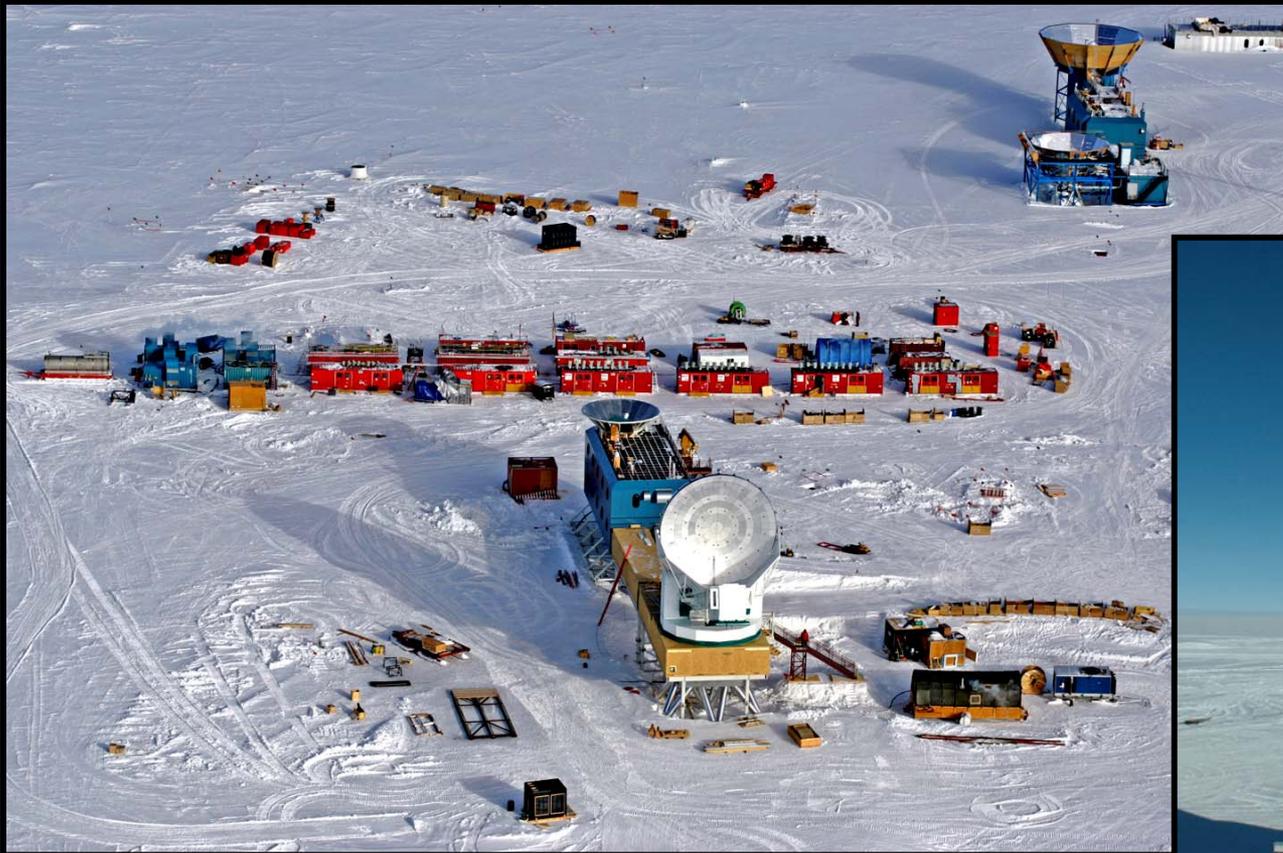


Amundsen-Scott South Pole Station, February 2007



South Pole Telescope

First Light Achieved! – Feb 2007

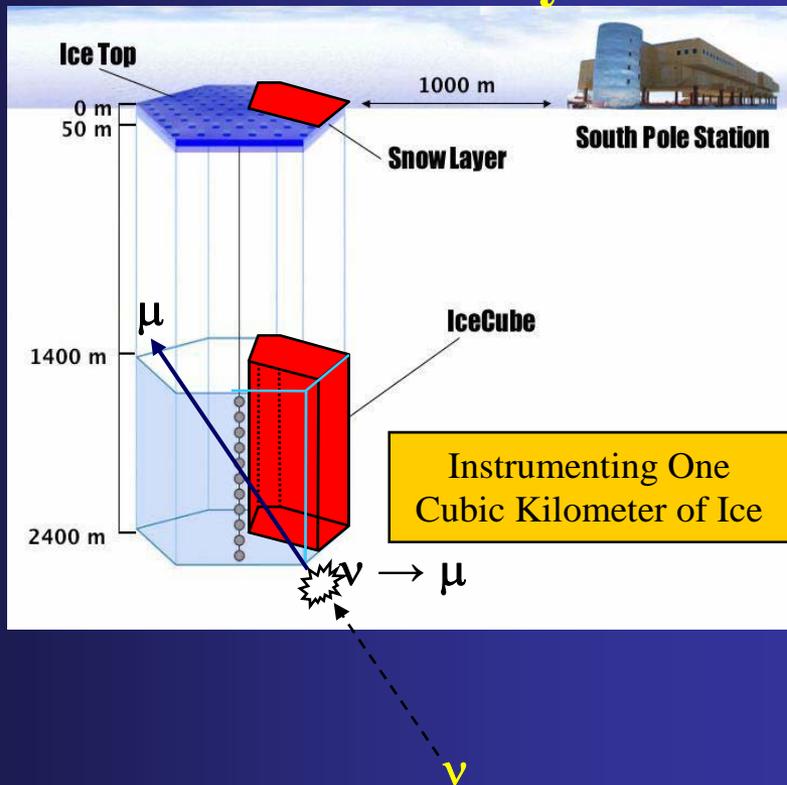


10m Sub-millimeter South Pole Telescope – first light achieved in Feb 2007

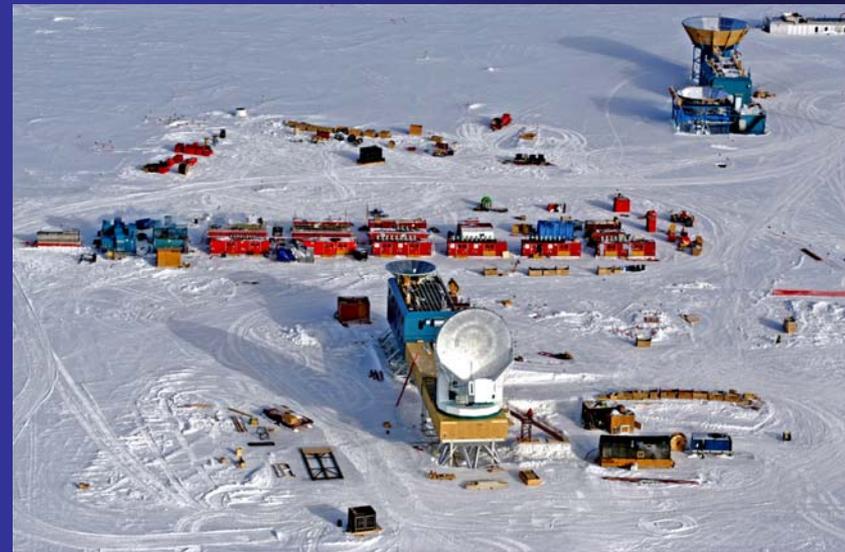
- Study Sunyaev-Zeldovich effect in CMB for clues to early galaxy formation
- Search for *Dark Matter* and *Dark Energy* for testing various cosmological models

Astrophysical Research at the South Pole

IceCube Neutrino Observatory



South Pole 10-Meter Telescope



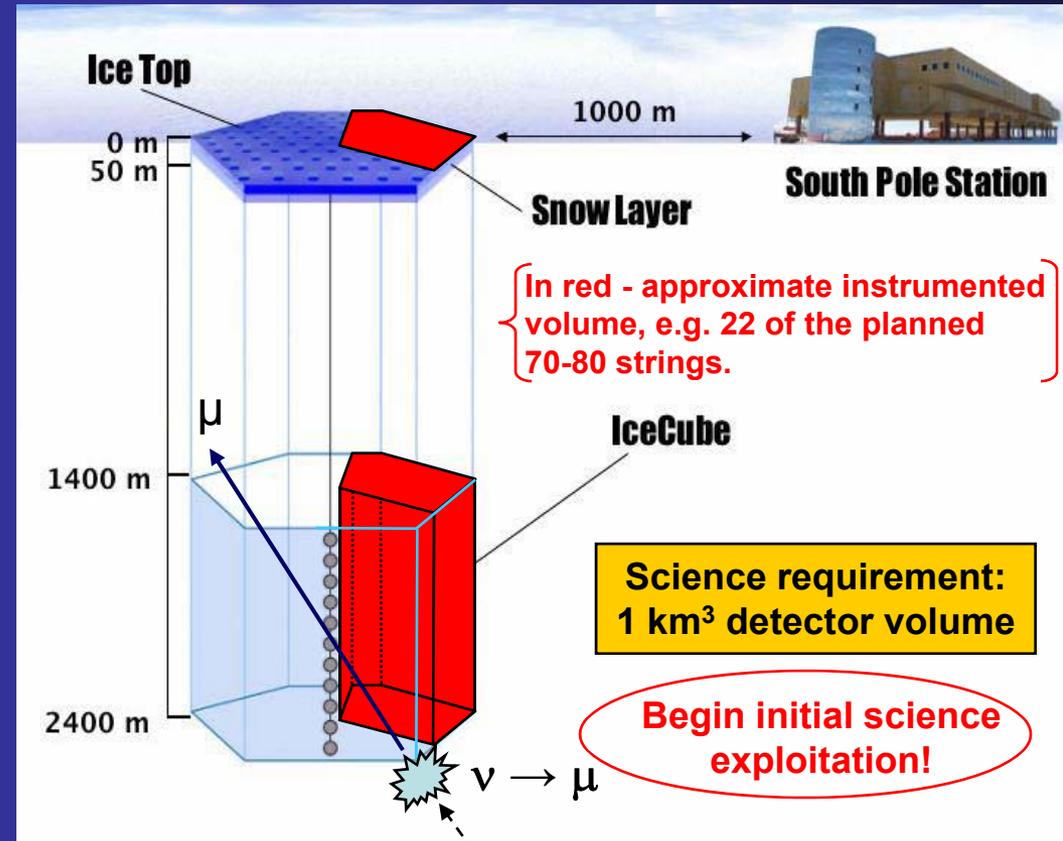
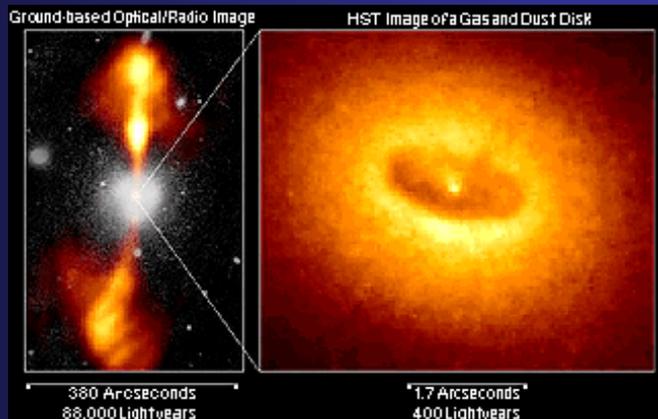
IceCube Project

Neutrino Observatory

Science:

- New window on the universe
- Search for astrophysical sources of high energy neutrinos (10^{11-18}eV)
- Probe objects at cosmological distances and high energy astrophysical processes

- Supermassive black holes
- Gamma ray bursts
- Dark matter
- High energy cosmic ray sources
- Properties of neutrinos



IceCube will occupy a volume of one cubic kilometer. Here we depict one of the 70-80 strings of optical modules (number and size not to scale). IceTop, located at the surface, comprises an array of sensors to detect air showers. It will be used to calibrate IceCube and to conduct research on high-energy cosmic rays.

Overland Traverse





2007-2008 Heavy Traverse Activities

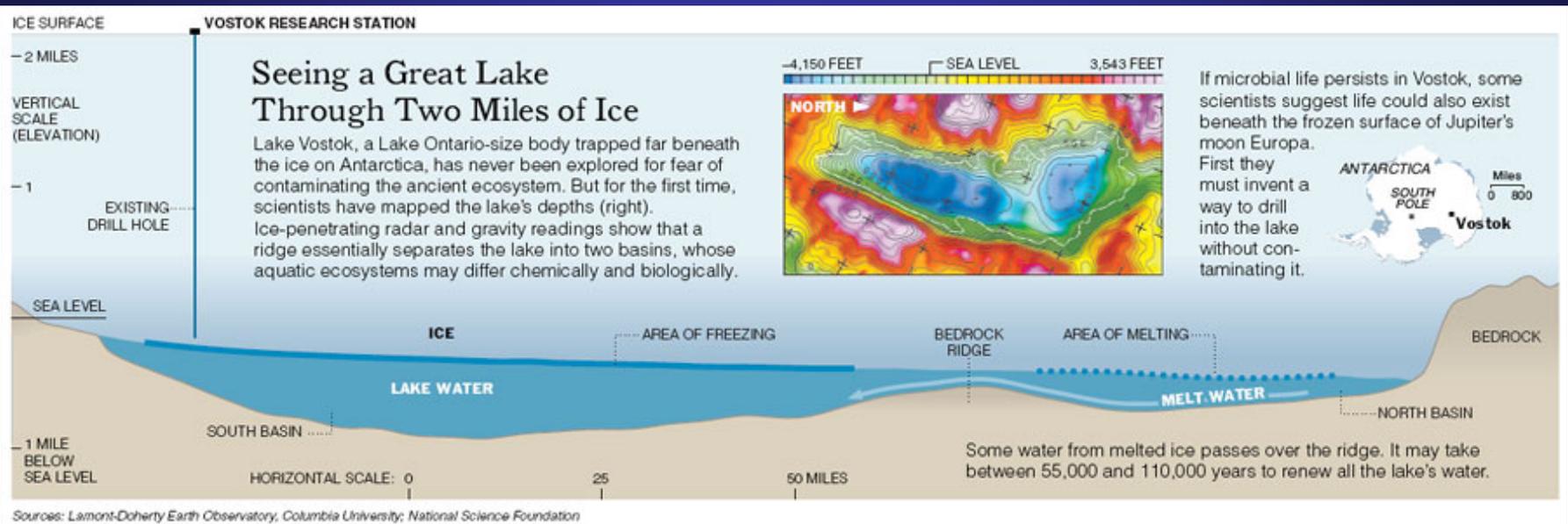
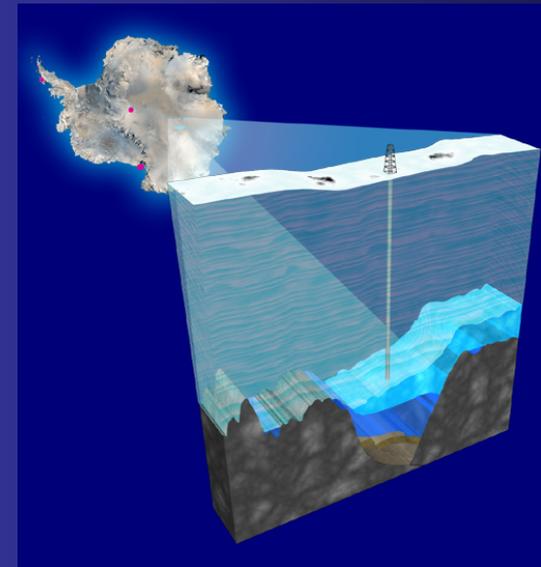
- **October (early) – Deliver and assemble production traverse fleet**
- **November (early) – Depart McMurdo performing trail maintenance along established route to South Pole**
- **November (late) – Cache 12k lb and 2k gal of fuel at 84.3° South, and prepare Twin Otter landing site for POLENET project**
- **December (late) – Complete trail maintenance, arrive at South Pole and deliver modest load of fuel and/or cargo**
- **January (mid) – Pick-up and remove of POLENET cache remains**

Subglacial Lake Vostok

Unexplored new class of environment on Earth

Probably has persisted for millions of years, though water cycles through the lake in 50-100 kyrs

Important analog for planetary science



Palmer Station



Wind Energy on Ross Island

- Purpose:
 - Decrease Fossil Fuel Req't for Ross Island via Renewable Wind energy
- Intent
 - AntNZ to capitalize Wind Energy production and provide electrical power to USAP-McMurdo Station as part of logistics resource sharing
- Scope: Stage 1
 - Establish a Proof-of-concept three turbine wind farm (1 MW) on Crater Hill, Ross Island
- Benefits
 - 10% Estimated reduction in fuel for power generation (122,300 gallons/yr)
 - NZ contribution to joint resource pool
 - Demonstrates Environmental commitment and stewardship

