

SECTION 1 – INTRODUCTION

SLIDE 1 – Title Slide

New Frontiers and Future Directions in Antarctic Science by Mahlon “Chuck” Kennicutt II, President Scientific Committee on Antarctic Research (SCAR)

I THANK THE ORGANIZERS FOR THE OPPORTUNITY TO SPEAK TO YOU TODAY ABOUT “**NEW FRONTIERS AND FUTURE DIRECTIONS IN ANTARCTIC SCIENCE**”.

AS THE WE CELEBRATE ON THE 50th ANNIVERSARY OF THE SIGNING OF THE ANTARCTIC TREATY AND THE SUCCESSES OF THE INTERNATIONAL POLAR YEAR, IT IS AN OPPORTUNE TIME TO REFLECT ON EMERGING THEMES IN ANTARCTIC SCIENCE.

THIS IS ONE OF THE MOST, IF NOT THE MOST, EXCITING TIMES FOR ANTARCTIC SCIENCE IN HISTORY. IN ADDITION, SOUND SCIENCE AND KNOWLEDGE–BASED ADVICE HAVE NEVER BEEN MORE CRITICAL TO THE POLICY COMMUNITY TO INFORM DECISION-MAKING AND TO SUPPORT COMPLEX ENVIRONMENTAL STEWARDSHIP AND CONSERVATION EFFORTS IN ANTARCTICA.

THE SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH (SCAR), AS AN INTERDISCIPLINARY, INTERNATIONAL SCIENTIFIC BODY OF THE INTERNATIONAL COUNCIL OF SCIENCE (ICSU), HAS BEEN A FACILITATOR AND CHAMPION OF ANTARCTIC SCIENCE FOR MORE THAN 50 YEARS DATING BACK TO THE BEGINNINGS OF THE ANTRCTIC TREATY.

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SLIDE 2 – Influences on Future Directions...

PREDICTING FUTURE DIRECTIONS IN ANTARCTIC SCIENCE IS DIFFICULT AS INVESTMENTS IN SCIENCE ARE DECIDED BY EACH NATION IN DIFFERING WAYS.

- INVESTMENTS IN SCIENCE ARE NATIONAL ENTERPRISES;

- PROCESSES FOR SETTING SCIENTIFIC PRIORITIES ARE HIGHLY VARIABLE AMONG NATIONS;
- FUTURE DIRECTIONS ARE DEPENDENT ON THE OUTCOME OF “IN-PROGRESS” RESEARCH;
- TRAJECTORIES CAN BE NON-LINEAR OR DISCONTINUOUS; AND
- TECHNOLOGY AND SCIENCE CAN BE DECOUPLED

Science can drive technology and technology can drive science

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SLIDE 3 – Antarctic Research in the 21st Century.....

LOOKING AT THE BROAD SWEEP OF ANTARCTIC SCIENCE, SEVERAL TRENDS ARE DISCERNABLE.

ANTARCTICA, AS A GEOGRAPHIC FOCUS FOR SCIENCE, IS UNIQUE IN THAT THE COMMUNITY OF SCIENTISTS AND RESEARCHERS THAT CONDUCT RESEARCH IN THE REGION COME FROM ALMOST ALL SCIENTIFIC DISCIPLINES.

21ST CENTURY ANTARCTIC SCIENCE WILL INCREASINGLY BE ASKED TO SOLVE MORE COMPLEX QUESTIONS THAT WILL REQUIRE SOPHISTICATED AND DIVERSE TECHNOLOGIES TO ANSWER.

IN THE 21ST CENTURY, AN EARTH SYSTEM SCIENCE APPROACH IS FUNDAMENTAL TO UNDERSTANDING ANTARCTICA’S PAST, PRESENT, AND FUTURE.

IN MOST INSTANCES, ANTARCTIC SCIENCE IN THE 21ST CENTURY WILL BE PURSUED WITHIN AN INTERDISCIPLINARY FRAMEWORK

21ST CENTURY ANTARCTIC SCIENCE WILL, GENERATE LARGE AND COMPLEX VOLUMES OF DIVERSE DATA AND INFORMATION - AND

21ST CENTURY ANTARCTIC SCIENCE WILL REQUIRE TRANSCONTINENTAL OR REGION-WIDE INVESTIGATIONS TO ADDRESS SCIENTIFIC QUESTIONS REQUIRING GREATER ACCESS TO ALL CORNERS OF THE CONTINENT THAN EVER BEFORE.

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SLIDE 4 - SCIENTIFIC THEMES

BASED ON REVIEWING THE IPY PROJECT DATABASE, A WIDE RANGE OF PLANNING DOCUMENTS, AND CONFERRING WITH LEADERS IN ANTARCTIC SCIENCE, AT LEAST NINE MAJOR EMERGING SCIENTIFIC THEMES ARE APPARENT:

- ANTARCTICA AND GLOBAL CLIMATE
- DECIPHERING PALEOCLIMATE
- ORGANISMS, ECOSYSTEMS AND BIODIVERSITY
- SUBGLACIAL AQUATIC ENVIRONMENTS
- EXPLORATION BENEATH THE ICE
- CRYOSPHERIC OBSERVING AND MODELING
- ICE SHEET DYNAMICS AND SEA LEVEL
- SOUTHERN OCEAN OBSERVING AND MODELING
- THE POLES AS A VANTAGE POINT

IN THE FOLLOWING PRESENTATION I WILL TAKE A FEW MINUTES TO REVIEW EACH OF THESE MAJOR THEMES AND HIGHLIGHT ON-GOING PROGRAMS AND PROJECTS THAT ARE ILLUSTRATIVE OF FUTURE DIRECTIONS.

REFLECTIVE OF THE TRULY INTEGRATED NATURE OF MODERN ANTARCTIC SCIENCE MANY SCIENTIFIC OBJECTIVES CROSS-CUT THESE SCIENTIFIC THEMES.

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SLIDE 5: ANTARCTICA AND GLOBAL CLIMATE

BY FAR THE MOST PERVASIVE THEME IN ANTARCTIC SCIENCE, TO NO ONE'S SURPRISE I AM SURE, IS CLIMATE CHANGE.

THE STUDY OF CLIMATE CHANGE IN THE REGION AND LINKAGES WITH THE GLOBAL CLIMATE SYSTEM WILL OCCUPY ANTARCTIC SCIENTISTS FOR MANY YEARS TO COME.

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SLIDE 6 - Antarctica and Global Climate

THE ANTARCTIC IS A CRITICALLY IMPORTANT PART OF THE EARTH SYSTEM.

THE CLIMATE, PHYSICAL AND BIOLOGICAL PROPERTIES OF THE CONTINENT, AND THE SURROUNDING OCEAN ARE CLOSELY COUPLED TO OTHER PARTS OF THE GLOBAL ENVIRONMENT BY THE OCEAN AND THE ATMOSPHERE.

ANTARCTICA CONTAINS 90% OF THE WORLD'S ICE AND 70% OF THE WORLD'S FRESH WATER, WHICH IS ENOUGH TO RAISE SEA LEVEL BY 63 M.

IT ALSO HOLDS HIGH RESOLUTION RECORDS OF PAST CLIMATE CHANGE AND SENSITIVE BIOLOGICAL INDICATORS OF CONTEMPORARY CHANGE.

FOR EXAMPLE, THE ANTARCTIC 'OZONE HOLE' WAS ONE OF THE MOST SIGNIFICANT SCIENTIFIC DISCOVERIES OF THE LAST CENTURY.

FOR THE LAST 30 YEARS THE OZONE HOLE HAS SHIELDED THE BULK OF THE ANTARCTIC FROM THE EFFECTS OF 'GLOBAL WARMING'.

THE SOUTHERN OCEAN IS WARMING AND THE ASSOCIATED ECOSYSTEMS ARE RESPONDING.

THERE HAS BEEN A RAPID EXPANSION OF PLANT COMMUNITIES ACROSS THE ANTARCTIC PENINSULA.

PARTS OF THE ANTARCTIC ARE LOSING ICE AT A RAPID RATE.

PALAEOCLIMATE STUDIES IN ANTARCTICA SHOW THE CURRENT CHANGES IN GLOBAL CLIMATE ARE UNUSUAL.

ASSUMING A DOUBLING OF GREENHOUSE GAS CONCENTRATIONS OVER THE NEXT CENTURY, ANTARCTICA IS EXPECTED TO WARM BY AROUND 3° C.

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SLIDE 7 - Antarctic Climate Change and the Environment

SCAR HAS JUST RELEASED A COMPREHENSIVE SYNTHESIS OF CURRENT UNDERSTANDING OF ANTARCTIC CLIMATE SCIENCE – ANTARCTIC CLIMATE CHANGE AND THE ENVIRONMENT (ACCE).

THIS VOLUME WILL BE WIDELY DISTRIBUTED AND IS AVAILABLE FROM THE SCAR WEB SITE.

THE ACCE REPORT CONCLUDES THAT A KEY OBJECTIVE FOR FUTURE ANTARCTIC CLIMATE STUDIES IS TO IMPROVE REPRESENTATIONS OF POLAR PROCESSES IN MODELS SO THAT MORE ACCURATE PREDICTIONS ARE PRODUCED.

HIGHER RESOLUTION GLOBAL MODELS, REGIONAL CLIMATE MODELS, AND ECOSYSTEM AND ICE SHEET MODELS ARE REQUIRED.

CLIMATE MODELS REQUIRE BETTER SIMULATION OF POLAR-SPECIFIC PROCESSES, SUCH AS SEA ICE AND THE ATMOSPHERIC BOUNDARY LAYER.

CLIMATE VARIABILITY IN THE POLAR REGIONS IS LARGER THAN IN OTHER PARTS OF THE WORLD AND IMPROVED MONITORING AND MORE DETAILED UNDERSTANDING OF PAST CLIMATE IS NEEDED IN ORDER TO DISCRIMINATE NATURAL VARIABILITY FROM ANTHROPOGENIC INFLUENCES.

THERE IS AN URGENT NEED TO ESTABLISH MARINE AND TERRESTRIAL BIOLOGICAL BASELINE MONITORING PROGRAMS IN ORDER TO UNDERSTAND PAST CHANGE AND TO ESTABLISH THE LINKS BETWEEN PHYSICAL AND BIOLOGICAL VARIABILITY.

THERE IS A REQUIREMENT FOR GREATER CROSS- AND INTRA-DISCIPLINARY OBSERVATIONAL EFFORTS AND MODELING STUDIES THAT WILL BE DISCUSSED LATER.

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SLIDE 8: DECIPHERING PAST CLIMATE CHANGE

IN ORDER TO BETTER UNDERSTAND CLIMATE VARIABILITY A DETAILED UNDERSTANDING OF PAST CLIMATE IS ESSENTIAL.

GAPS IN RECORDS OF PAST CLIMATE ARCHIVED IN ICE AND SEDIMENTARY CORES MUST BE FILLED.

THIS OBJECTIVE IS ACCOMPLISHED BY SEVERAL DIFFERING APPROACHES THAT INCREASE THE SPATIAL AND TEMPORAL COVERAGE OF CLIMATE RECORDS.

BECAUSE OF THE REMOTENESS OF THE CONTINENT, ANTARCTICA IS AN IDEAL LOCATION TO STUDY LOCAL-TO-GLOBAL SCALE CLIMATE CHANGE.

HOWEVER, THIS REMOTENESS HAS ALSO PREVENTED THE COLLECTION OF INSTRUMENTAL RECORDS, SIMILAR TO THOSE COLLECTED IN THE NORTHERN HEMISPHERE, THAT ARE REQUIRED TO ASSESS ANTARCTICA'S ROLE IN AND RESPONSE TO ENVIRONMENTAL AND CLIMATE CHANGE.

THE CONTINUED STUDY OF SURFACE AND NEAR-SURFACE ICE CORE RECORDS IS NECESSARY.

HIGH RESOLUTION ICE CORE RECORDS ARE THE MOST DIRECT WAY TO DOCUMENT CLIMATE WITH RESOLUTIONS AS FINE AS SEASONAL AND, POTENTIALLY, ON TIME SCALES AS LONG AS A MILLION YEARS.

FUNDAMENTAL ISSUES OF SPATIAL AND TEMPORAL CLIMATIC AND ENVIRONMENTAL VARIABILITY STILL NEED TO BE ADDRESSED BY DETERMINING THE SPATIAL VARIABILITY OF ANTARCTIC CLIMATE OVER THE LAST 200 YRS, AND WHERE THE DATA ARE AVAILABLE, THE LAST 1000 YEARS.

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SLIDE 9 - SEARCH FOR THE OLDEST ICE

HIGH RESOLUTION ICE CORE RECORDS ARE ALSO CRITICAL FOR ESTABLISHING SPATIAL GRADIENTS IN ICE CORE PROPERTIES AS A COMPLEMENT TO DEEP ICE CORE RECORDS THAT SUPPORT THE OBJECTIVE OF OBTAINING THE OLDEST ICE CORE RECORD IN ANTARCTICA.

THE SEARCH FOR A 1.5 MILLION YEAR RECORD OF CLIMATE AND GREENHOUSE GASES FROM ANTARCTICA WILL EXTEND KNOWLEDGE OF PAST CLIMATE CHANGE

MUCH AS THE EPICA ICE CORE SUPPLEMENTED THE VOSTOK ICE CORE CLIMATE RECORD.

COMPLEMENTARY TO ICE CORE RECORDS ARE CLIMATE RECORDS CONTAINED IN SEDIMENTARY SEQUENCES.

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SLIDE 10 - GAPS IN THE CLIMATE RECORD

RECOVERY AND INTERPRETATION OF SEDIMENTARY RECORDS OF CLIMATE CHANGE ARE THE OBJECTIVES OF SEVERAL MAJOR PROGRAMS INCLUDING ANDRILL, SHALDRILL, THE INTEGRATED OCEAN DRILLING PROGRAM, AND INTEGRATIVE SYNTHESIS PROGRAMS SUCH AS SCAR'S ANTARCTIC CLIMATE EVOLUTION (ACE) PROGRAM.

STUDIES OF THE GREENHOUSE WORLD 50 MILLION YEARS AGO, IMPLIES A HIGHER 'CLIMATE SENSITIVITY' THAN CURRENTLY ACCEPTED, SUGGESTING THE POTENTIAL FOR ADDITIONAL POSITIVE FEEDBACKS NOT CURRENTLY REPRESENTED IN CLIMATE MODELS.

KNOWLEDGE OF THE BEHAVIOUR OF POLAR REGIONS IN A HIGH-CO₂ WORLD STILL REMAINS ONE OF THE GREATEST UNCERTAINTIES IN PREDICTING FUTURE CLIMATE RESPONSE.

THERE IS CONTINUING NEED TO RECOVER ANTARCTIC GEOLOGICAL RECORDS BEYOND THE AGE-RANGE OF ICE CORES DATING AS FAR BACK AS 30 TO 50 MILLION YEARS AGO WHEN EARTH'S ATMOSPHERIC CO₂ WAS 2 TO 4 TIMES HIGHER THAN PRESENT – THE HIGH END OF INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE PROJECTIONS FOR 2100.

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MAJOR SCIENTIFIC OBJECTIVES IN THE GEOSCIENCES INCLUDE OBTAINING GEOLOGICAL RECORDS THAT SAMPLE PAST ANTARCTIC ICE SHEET DYNAMICS AND INTEGRATE CLIMATE AND ICE SHEET PROXY DATA WITH THE LATEST GENERATION OF COUPLED ICE SHEET-CLIMATE MODELS.

MUCH REMAINS TO BE ACCOMPLISHED IN THESE RESEARCH AREAS.

INVEST WHITE PAPER: GRANADA 12-13 SEPT. 2009

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SLIDE 11 – INTEGRATION OF CLIMATE RECORDS

AND FINALLY, IT WILL BE ESSENTIAL TO INTEGRATE SEDIMENTARY, ICE AND INSTRUMENTAL RECORDS OF CLIMATE CHANGE WITH CLIMATE AND ICE SHEET MODELS TO CONSTRAIN PREDICTIONS OF FUTURE CHANGE.

EACH TYPE OF CLIMATE RECORD CONTRIBUTES DIFFERING SPATIAL AND TEMPORAL REPOSITORIES OF PAST CLIMATE CHANGE THAT TOGETHER PROVIDE A COMPREHENSIVE PICTURE OF CLIMATE FORCINGS.

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SLIDE 12 – ANATRACTIC ORGANISMS, ECOSYSTEM AND BIODIVERSITY

RESEARCH DIRECTIONS IN THE LIFE SCIENCES WILL BUILD ON CURRENT RESEARCH BEING CONDUCTED BY PROGRAMS SUCH AS SCAR'S SCIENTIFIC RESEARCH PROGRAM – EVOLUTION AND BIODIVERSITY IN ANTARCTICA (EBA).

WHILE SIGNIFICANT ADVANCES HAVE BEEN MADE IN RECENT YEARS, ANTARCTICA'S BIOLOGICAL AND ECOLOGICAL DOMAINS REMAIN TO A LARGE EXTENT UNEXPLORED.

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SLIDE 13– CENSUS OF ANTARCTIC ORGANISMS

ANTARCTIC LIFE SCIENTISTS STRIVE TO UNDERSTAND THE EVOLUTION AND DIVERSITY OF LIFE IN ANTARCTICA TO DETERMINE HOW EVOLUTION AND BIODIVERSITY HAVE PRODUCED ANTARCTIC ECOSYSTEMS.

UNDERSTANDING OF ECOSYSTEM FUNCTIONING IS FUNDAMENTAL.

ONE OF THE MOST IMPORTANT RECENT DEVELOPMENTS IN LIFE SCIENCES IN THE ANTARCTIC IS THE INCREASE IN KNOWLEDGE OF BIODIVERSITY IN THE TERRESTRIAL AND MARINE SETTINGS, ESPECIALLY DEEP SEA.

WE ALSO KNOW THAT ORGANISMS AND BIODIVERSITY ARE BEGINNING TO CHANGE IN RESPONSE TO CLIMATE CHANGE.

THERE IS A GREAT NEED TO DESCRIBE THE LIVING RESIDENTS OF ANTARCTICA AND TO BETTER UNDERSTAND THEIR ORIGINS.

THERE IS ALSO A CRITICAL NEED TO BETTER UNDERSTAND NON-ENDEMIC SPECIES.

LIFE SCIENCES RESEARCH IN ANTARCTIC FOCUSES ON THREE MAIN ECOLOGICAL TOPICS THAT ARE IMPORTANT WORLD-WIDE: CHANGES IN HABITATS, LOSS OF BIODIVERSITY, AND THE EFFECT OF CLIMATE CHANGE

A FIRST STEP IN IMPROVING OUR BASIC UNDERSTANDING IS TO DOCUMENT WHAT ORGANISMS ARE PRESENT. AN EXCELLENT EXAMPLE OF ONE SUCH PROGRAM IS THE CENSUS OF ANTARCTIC MARINE LIFE - CAML.

CAML IS INVESTIGATING THE DISTRIBUTION AND ABUNDANCE OF ANTARCTICA'S MARINE BIODIVERSITY TO DEVELOP A BENCHMARK.

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SLIDE 14 –ADAPTATIONS, ECOSYSTEM FUNCTIONING, AND PHYSIOLOGY

LIFE SCIENCES RESEARCH IN ANTARCTIC HAS A LONG HISTORY OF STUDYING ADAPTATIONS, ECOSYSTEM FUNCTION AND STRUCTURE, AND THE PHYSIOLOGY IN THE UNIQUE ORGANISMS THAT INHABIT ANTARCTICA. MUCH RESEARCH ON THESE TOPICS IS EXPECTED TO CONTINUE TO ADDRESS BASIC QUESTIONS ABOUT:

- LIFE IN THE COLD AND DARK,
- LIFE IN SUBGLACIAL AQUATIC ENVIRONMENTS (WHICH I WILL RETURN TO), AND
- LIFE AT THE EXTREMES

RESEARCH OBJECTIVES WILL REQUIRE EXTENSION OF OBSERVATIONS BEYOND THE TRADITIONAL SUMMER SEASON AND THE APPLICATION OF MODERN METHODS IN MOLECULAR GENOMICS AND PROTEOMICS.

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SLIDE 15 – BIODIVERSITY AND BIOGEOGRAPHY

ANTARCTIC BIODIVERSITY AND BIOGEOGRAPHY WILL REMAIN A TOPIC OF HIGH INTEREST FOR YEARS TO COME.

AN EXEMPLARY PROGRAM IS THE SCAR-MARINE BIODIVERSITY INFORMATION NETWORK IS THE ANTARCTIC NODE FOR THE OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM (OBIS) AND IS A COMPANION PROJECT OF THE CENSUS OF MARINE LIFE (CAML) JUST DESCRIBED.

SCAR-MARBIN IS A DISTRIBUTED SYSTEM OF INTEROPERABLE DATABASES THAT COMPILES AND MANAGES EXISTING AND NEW INFORMATION ON ANTARCTIC MARINE BIODIVERSITY.

SUBSEQUENT TO THE LARSEN ICE SHEET COLLAPSE, THE FIRST OBSERVATIONS OF COLD SEEP COMMUNITIES IN ANTARCTIC WERE RECORDED.

THESE UNIQUE COMMUNITIES, AND POSSIBLY HYDROTHERMAL COMMUNITIES AND OTHERS, ARE BEING CONSIDERED AS POSSIBLE VULNERABLE MARINE AREAS THAT NEED SPECIAL PROTECTION. THESE SITES ALSO PRESENT OPPORTUNITIES TO STUDY UNUSAL ECOSYSTEMS THAT HAVE ONLY RECENTLY BEEN IDENTIFIED IN ANTARCTICA.

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SLIDE 16 - BIOLOGICAL COLONISATIONS AND EXTINCTIONS IN ANTARCTICA

TODAY ANTARCTICA IS ALMOST 99.7% COVERED BY PERMANENT ICE AND SNOW AND EVIDENCE SUGGESTS THAT AS RECENTLY AS THE LAST GLACIAL MAXIMUM ,

ICE SHEETS WERE BOTH THICKER AND MUCH MORE EXTENSIVE THAN THEY ARE NOW.

MOST IF NOT ALL OF THE CURRENTLY ICE-FREE GROUND WOULD HAVE BEEN OVER-RIDDEN BY ICE DURING PREVIOUS GLACIATIONS SUGGESTING THAT ANTARCTIC PRE-GLACIAL TERRESTRIAL LIFE WAS WIPED OUT BY SUCCESSIVE GLACIAL EVENTS.

THIS IN TURN SUGGESTS THAT MOST, POSSIBLY ALL, CONTEMPORARY TERRESTRIAL LIFE HAS COLONISED THE CONTINENT DURING SUBSEQUENT PERIODS OF GLACIAL RETREAT.

A COMBINATION OF RECENT BIOLOGICAL AND GEOLOGICAL COMPILED BY CONVEY ET AL. CHALLENGES THIS PARADIGM.

NEW AND COMPLEX CONCLUSIONS ABOUT TERRESTRIAL ANTARCTIC BIOGEOGRAPHY SUGGESTS GREATER REGIONALISATION AND EVOLUTIONARY ISOLATION THAN PREVIOUSLY SUSPECTED FOR CIRCUM- ANTARCTIC MARINE FAUNA.

THESE FINDINGS REQUIRE THE ADOPTION OF A NEW BIOLOGICAL PARADIGM WITHIN ANTARCTICA AND CHALLENGE CURRENT UNDERSTANDING OF ANTARCTIC GLACIAL HISTORY.

FUTURE RESEARCH THAT WILL FLOW FROM THESE INVESTIGATIONS WILL HAVE MAJOR IMPLICATIONS FOR UNDERSTANDING OF THE KEY ROLE OF ANTARCTICA IN THE EARTH SYSTEM.

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SLIDE 17 - SUBGLACIAL AQUATIC ENVIRONMENTS

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SLIDE 18 - Subglacial Aquatic Environments

THE STUDY AND EXPLORATION OF SUBGLACIAL AQUATIC ENVIRONMENTS IS AT ITS VERY BEGINNINGS. SUBGLACIAL AQUATIC ENVIRONMENT RESEARCH BY ITS VERY NATURE IS HIGHLY INTERDISCIPLINARY AND IS POISED TO FUNDAMENTALLY CHANGE OUR VIEW OF HOW ANTARCTICA RESPONDS AS PART OF THE EARTH SYSTEM.

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THE STUDY OF SUBGLACIAL AQUATIC ENVIRONMENTS WILL CONTRIBUTE TO A WIDE RANGE OF ANTARCTIC SCIENTIFIC TOPICS INCLUDING THE TECTONIC EVOLUTION AND HISTORY OF THE CONTINENT, THE IMPORTANCE OF SUBGLACIAL HYDROLOGY IN ICE SHEET AND ICE STREAM DYNAMICS, AND THE ADAPTATION OF MICROBIAL LIFE IN EXTREME ENVIRONMENTS.

IT IS ALSO CONJECTURED THAT THESE ENVIRONMENTS HOLD UNIQUE RECORDS OF PAST CLIMATE OF THE INTERIOR OF THE CONTINENT AND THAT OUTBURSTS OF SUBGLACIAL WATERS HAVE BEEN IMPORTANT PROCESSES OVER GEOLOGIC TIME.

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SLIDE 19 - MAJOR NATIONAL SAE PROGRAMS

THERE ARE 3 MAJOR SUBGLACIAL LAKE EXPLORATION PROGRAMS PROJECTING LAKE ENTRY AND SAMPLING IN 2011-2012.

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THESE PROJECTS INCLUDE THE LONG TERM STUDIES AT LAKE VOSTOK, THE STUDIES OF SUBGLACIAL LAKE ELLSWORTH AND COORDINATED STUDIES OF THE WHILLANS ICE STREAM.

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SECTION 20 – EXPLORATION BENEATH THE ICE

SEVERAL INTERNATIONAL, FIELD INTENSIVE PROGRAMS ARE EXPLORING THE ANTARCTIC CONTINENT HIDDEN BENEATH KILOMETERS OF ICE IN EAST ANTARCTICA.

THESE STUDIES USE A RANGE OF TECHNOLOGIES AND ARE PROVIDING A VIEW OF THE BASEMENT BENEATH THE ANTARCTIC ICE SHEET NEVER BEFORE SEEN.

THREE PROJECTS - AGAP, ICE CAP, AND POLENET HIGHLIGHT FUTURE DIRECTIONS IN ANTARCTIC GEOSCIENCES.

SLIDE 21- Exploring the Continent Beneath the Ice

FIRST, ANTARCTICA'S GAMBERTSEV PROVINCE – AGAP - IS EXPLORING THE HISTORY OF THE EAST ANTARCTIC ICE SHEET AND LITHOSPHERIC STRUCTURE OF THE GAMBURTSEV SUBGLACIAL MOUNTAINS - A MAJOR MOUNTAIN RANGE BURIED BY THE EAST ANTARCTICA ICE SHEET WHICH INCLUDES NUMEROUS SUBGLACIAL LAKES.

AGAP IS A MULTI-NATIONAL AND MULTI-DISCIPLINARY PROGRAM THAT INCLUDES AEROGEOPHYSICS, TRAVERSE PROGRAMS, PASSIVE SEISMIC EXPERIMENTS AND ICE CORE AND BEDROCK DRILLING.

THE OBJECTIVE IS TO BETTER UNDERSTAND THE TECTONIC ORIGIN OF THE GAMBERTSEV MOUNTAINS PROVIDING CRUCIAL NEW DATA FOR ICE SHEET AND CLIMATE MODELS.

FUNDAMENTAL QUESTIONS TO BE ADDRESSED INCLUDE:

- 1) WHAT ROLE DOES TOPOGRAPHY PLAY IN THE NUCLEATION OF CONTINENTAL ICE SHEETS?
- 2) HOW ARE MAJOR ELEVATED CONTINENTAL MASSIFS FORMED WITHIN INTRAPLATE SETTINGS BUT WITHOUT A STRAIGHTFORWARD PLATE TECTONIC MECHANISM?
- 3) HOW DO TECTONIC PROCESSES CONTROL THE FORMATION, DISTRIBUTION, AND STABILITY OF SUBGLACIAL LAKES?

4) WHERE IS THE OLDEST CLIMATE RECORD IN THE ANTARCTIC ICE SHEET?

SECONDLY, ICE AND CLIMATE EVOLUTION OF THE CENTRAL ANTARCTIC PLATE - ICECAP IS A COLLABORATIVE PROGRAM BETWEEN THE US, UK AND AUSTRALIA TO USE A MULTI-INSTRUMENTED LONG-RANGE AIRCRAFT OVER THREE AUSTRAL SUMMERS TO SURVEY PORTIONS OF THE EAST ANTARCTIC ICE SHEET.

ICECAP IS ACQUIRING AEROGEOPHYSICAL OBSERVATIONS TO DETERMINE ICE THICKNESS AND DATE INTERNAL LAYERS IN SUPPORT OF ICE SHEET MODELING, TO OBSERVE FLOW REGIME CHANGE RECORDED IN THE INTERNAL LAYERS AND TO STUDY CRUSTAL GEOLOGY AND SUBGLACIAL HYDROLOGICAL SYSTEMS FROM THE PERSPECTIVE OF PROCESSES CONTROLLING PAST AND FUTURE CHANGE IN THE EAST ANTARCTIC ICE SHEET.

AND FINALLY, THE POLAR EARTH OBSERVING NETWORK (POLENET) IS A COLLABORATIVE, INTERNATIONAL PROJECT TO UNDERSTAND HOW THE EARTH'S SURFACE RESPONDS TO CHANGES IN POLAR ICE SHEETS.

THE POLENET PROJECT IS COLLECTING GPS AND SEISMIC DATA FROM STATIONS AT REMOTE SITES SPANNING MUCH OF ANTARCTICA. INTEGRATED GPS AND SEISMIC MEASUREMENTS ARE USED TO MODEL HOW MUCH ICE HAS BEEN LOST OVER THE PAST 10,000 YEARS.

A COMBINATION OF GROUND-BASED AND SATELLITE DATA IS USED TO DETERMINE WHERE, AND AT WHAT RATE, THE ICE SHEETS ARE CHANGING IN RESPONSE TO RECENT CLIMATE CHANGE.

SLIDE 22 – CRYOSPHERIC OBSERVATIONS AND MODELLING

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SLIDE 23 – SATELLITE CRYOSPHERIC OBSERVATIONS

THE GLOBAL INTER-AGENCY IPY POLAR SNAPSHOT YEAR (GIIPSY) PROJECT COLLECTS DATA TO UNDERSTAND POLAR PROCESSES IN CLIMATE CHANGE, THE

CONTRIBUTION OF THE POLAR ICE SHEET TO SEA LEVEL, ICE SHEET AND OCEAN INTERACTIONS.

AN AMBITIOUS SCHEDULE OF MISSIONS OVER THE NEXT SEVERAL YEARS IS ALREADY PLANNED.

SATELLITE OBSERVATIONS SUPPORT A WIDE RANGE OF RESEARCH EFFORTS.

SLIDE 24 – West Antarctic Ice Sheet Evolution and Stability

SOME REGIONS OF ANTARCTICA, PARTICULARLY THE PENINSULA, HAVE WARMED RAPIDLY IN RECENT YEARS, CONTRIBUTING TO THE DISINTEGRATION OF ICE SHELVES AND ACCELERATING THE SLIDING OF GLACIERS.

THESE EVENTS HAVE FOCUSED ATTENTION ON THE STABILITY OF THE WEST ANTARCTIC ICE SHEET AS MUCH IF IT IS GROUNDED BELOW SEA LEVEL.

FOR EXAMPLE, THE WAIS DIVIDE ICE CORE WILL PROVIDE A SOUTHERN HEMISPHERE CLIMATE AND GREENHOUSE GAS RECORDS COMPARABLE IN TIME RESOLUTION AND DURATION TO THE GREENLAND ICE CORES.

THE WAIS DIVIDE ICE CORE WILL ALSO BE USED TO TEST MODELS OF WEST ANTARCTIC ICE SHEET HISTORY AND STABILITY.

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SLIDE 25 – ICE DYNAMICS AND SEA LEVEL

[CLICK]

SLIDE 26 – ICE SHEET MASS BALANCE

RECENT FINDINGS SUGGEST THAT FROM 1957 THROUGH 2006, TEMPERATURES ACROSS ANTARCTICA RISEN AN AVERAGE OF 0.2 DEGREES FAHRENHEIT PER DECADE, COMPARABLE TO GLOBAL WARMING RATES.

IN EAST ANTARCTICA, WHERE TEMPERATURES HAD BEEN THOUGHT TO BE FALLING RESEARCHERS HAVE FOUND A SLIGHT WARMING OVER THE LAST 50-YEAR S.

THIS ILLUSTRATION DEPICTS THE WARMING THAT SCIENTISTS HAVE DETERMINED HAS OCCURRED IN WEST ANTARCTICA DURING THE LAST 50 YEARS. THE DARK RED SHOWS THE AREA THAT HAS WARMED THE MOST.

THERE IS GROWING CONSENSUS THAT THE ANTARCTIC ICE SHEET IS EXPERIENCING NET MASS LOSS. THE LONG TERM TRENDS IN THESE DATA WILL BE OF INTEREST FOR YEARS TO COME.

SLIDE 27 – CRYOSPHERIC SEA LEVEL RISE

SEA LEVEL IS RISING IN RECENT YEARS MOSTLY DUE TO THERMAL EXPANSION OF THE WORLD'S OCEAN GLACIER MELT, AND LOSSES OF MASS FROM THE GREENLAND ICE SHEET.

HOWEVER, AS PREVIOUSLY NOTED THE ICE SHEETS OF ANTARCTIC AARE THE MAJOR GLOBAL RESEVOIR OF FRESH WATER AND REPRESENT BY FAR THE GREATEST POTENTIAL FOR SEA LEVEL RISE IN THE FUTURE.

THE STATUS OF AND TRENDS IN THE ANTARCTIC CRYOSPHERE WILL BE OF HIGH INTEREST FOR YEARS TO COME.

SLIDE 28 – SOUTHERN OCEAN OBSERVING AND MODELLING

SLIDE 29 – SOUTHERN OCEAN INSITU OBSERVATIONS AND MODELING

AS FOR ANTARCTICA'S CRYOSPHERE, A BETTER UNDERSTANDING OF THE SOUTHERN OCEAN IS CRTICAL TO ANTICIPATING AND PREDICTING RESPONSE TO CLIMATE CHANGE.

THE SOUTHERN OCEAN HAS A GLOBAL INFLUENCE AND THERE IS THE POTENTIAL FOR SIGNIFICANT FEEDBACKS.

THERE IS EVIDENCE THAT CHANGES IN THE SOUTHERN OCEAN ARE UNDERWAY BUT SPARSE OBSERVATIONS MAKE INTERPRETATIONS DIFFICULT.

SYSTEM-SCALE OBSERVATIONS OF THE SOUTHERN OCEAN ARE CRITICAL.

INTEGRATED MULTI-DISCIPLINARY OBSERVATIONS ARE NECESSARY TO UNDERSTAND AND ULTIMATELY PREDICT THE RESPONSE OF BIOTA TO CHANGES IN PHYSICAL DRIVERS.

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SLIDE 30 – SOUTHERN OCEAN OBSERVING SYSTEMS

AN INTEGRATED AND COORDINATED SOUTHERN OBSERVING SYSTEM IS IN ITS INFANCY. THE SYSTEM IS ENVISIONED AS BROADLY MULTI-DISCIPLINARY.

SOME ELEMENTS ARE ALREADY IN PLACE SUCH AS : (I) REPEAT HYDROGRAPHY (II) SHIPS OF OPPORTUNITY (III) ARGO FLOATS (VI) TAGGING OF MARINE MAMMALS (SEAOs ETC.) (V) SCAR CONTINUOUS PLANKTON RECORDER (VI) AND SATELLITES, E.G. SEAWIFS.

SLIDE 31 – SOUTHERN OCEAN ACIDIFICATION

OCEAN ACIDIFICATION DUE TO UPTAKE OF ATMOSPHERIC CARBON DIOXIDE CAN BE DELETERIOUS TO MANY MARINE ORGANISMS AND ECOSYSTEMS.

PREDICTED OCEAN ACIDIFICATION IS EXPECTED TO CAUSE MAJOR CHANGES IN NUTRIENTS, PHYTOPLANKTON DIVERSITY, BIODIVERSITY, BIOGEOCHEMICAL CYCLES, MARINE COMMUNITY STRUCTURE AND ROBUSTNESS, AND CALCIFICATION RATES WHILE REDUCING BEHAVIOURAL CAPACITY, GROWTH, PRODUCTION, LIFE SPAN, AND TOLERANCE TO ENVIRONMENTAL FLUCTUATIONS. FOLLOWING THIS GROWING PROBLEM WILL BE A MAJOR FOCUS OF RESEARCH FOR YEARS TO COME.

SLIDE 32 – THE POLES AS A VANTAGE POINT

SLIDE 33 Astronomy and Astrophysics

ANTARCTIC ASTRONOMY AND ASTROPHYSICS WILL ADDRESS FUNDAMENTAL QUESTIONS IN THE NEXT DECADE INCLUDING:

- LOCATING FIRST STARS, FIRST GALAXIES, REIONIZATION TOMOGRAPHY
- DEFINING THE NATURE OF THE DARK UNIVERSE
- DETECTING GRAVITY WAVES
- IDENTIFYING EXOPLANETS & THE FORMATION OF EXO-SOLAR SYSTEMS
- EXPLORING VARIATIONS IN FUNDAMENTAL CONSTANTS
- SEARCHING FOR EXTRA DIMENSIONS
- DEFINING THE TRANSIENT UNIVERSE

ONE PROGRAM, ICECUBE IS SEARCHING FOR NEUTRINOS FROM THE MOST VIOLENT ASTROPHYSICAL SOURCES: EVENTS LIKE EXPLODING STARS, GAMMA RAY BURSTS, AND CATAclysmic PHENOMENA INVOLVING BLACK HOLES AND NEUTRON STARS.

THE ICECUBE TELESCOPE COULD REVEAL THE PHYSICAL PROCESSES ASSOCIATED WITH THE ENIGMATIC ORIGIN OF THE HIGHEST ENERGY PARTICLES IN NATURE.

SLIDE 34 - Near-Earth Space Science

NEAR-EARTH SPACE (GEOSPACE) IS AN INTEGRAL PART OF THE EARTH SYSTEM, PROVIDING THE MATERIAL LINK BETWEEN THE SUN AND EARTH, PRIMARILY THROUGH THE POLAR REGIONS.

RESEARCH IN THIS AREA WILL CREATE AN INTEGRATED, QUANTITATIVE DESCRIPTION OF THE UPPER ATMOSPHERE OVER ANTARCTICA, AND ITS COUPLING TO THE GEOSPACE ENVIRONMENT.

SEVERAL MAJOR PROGRAMS ARE ILLUSTRATED:

SUPER DUAL AURORAL RADAR NETWORK AN INTERNATIONAL RADAR NETWORK WHICH STUDIES THE EARTH'S UPPER ATMOSPHERE, IONOSPHERE AND CONNECTION INTO SPACE.

SLIDE 35 – Summary

I HOPE THIS BRIEF REVIEW OF MAJOR THEMES IN ANTARCTIC SCIENCE OVER THE NEXT 10 TO 20 YEARS HAS ILLUSTRATED WHAT AN EXCITING AND PRODUCTIVE TIME IT IS FOR OUR COMMUNITY.

A COMBINATION OF SCIENTIFIC IDEAS AND SOCIETAL ISSUES WILL DRIVE FUTURE RESEARCH DIRECTIONS.

21ST CENTURY ANTARCTIC SCIENCE AND RESEARCH WILL ADDRESS COMPLEX QUESTIONS THAT REQUIRE HOLISTIC, INTERDISCIPLINARY, INTERNATIONAL, AND TECHNOLOGICALLY INTENSIVE SOLUTIONS THAT WILL OFTEN REQUIRE ACCESS TO ALL OF ANTARCTICA.

THE NEED FOR ACCESS TO DATA AND DATA SHARING WILL INCREASE AS WELL AS THE NECESSITY FOR EVER MORE SOPHISTICATED DATA AND INFORMATION INFRASTRUCTURE TO COLLECT, STORE, ARCHIVE AND SYNTHESIZE THE VAST AMOUNTS OF DATA THAT WILL BE GENERATED.

THERE ARE GREAT OPPORTUNITIES FOR COORDINATION, PARTNERSHIPS, AND SYNERGY THAT BUILD ON THE HISTORICAL INTERNATIONAL PARTNERSHIPS THAT EPITOMIZE ANTARCTIC SCIENCE.

WHERE OUR COMMUNITY WILL BE IN 10 OR 20 YEARS IS ONLY LIMITED BY OUR IMAGINATION AS THE FUTURE IS IN OUR HANDS!

THANK YOU!!!!



THANK YOU!!!!

SLIDE 36 – Thank you for your Attention!