

A Selection of Current NASA and other Space Related Work in Christchurch and the Antarctic with Ideas for the Future

Zaheer Abbas Ali

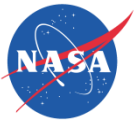
Extreme Environments - from the Antarctic to Space

New Zealand Tech Week

Christchurch, New Zealand

24 May 2018





Outline



- A brief (extremely) overview of NASA missions and how they relate to Christchurch and the Antarctic
- Airborne missions operating out of Christchurch
 - SOFIA
 - DC-8
 - ER-2
 - Super Pressure Balloons
- Uses of the Antarctic by NASA and others – examples
 - Mega dunes – a Mars topological analog in the Antarctic
 - The Don Juan Pond – Geology, geography and weather interaction analog to Mars
 - Jurisdictional Analog for a Mars Station
 - Human Research Program
 - Balloons on Ice
- Looking Forward
 - Europa mission tests
 - Technology test beds for Lunar/Martian stations
 - Earth science





Airborne Missions Operating out of Christchurch





Airborne Astronomy: The Stratospheric Observatory for Infrared Astronomy (SOFIA)



- A 747-SP modified by NASA to have a 2.5 meter telescope inside.
- Flies above the water vapor of Earth's atmosphere to observe the night sky, capturing 99.99% of the infrared spectrum
- Studies star formation, interstellar clouds and dust, planets, Kuiper objects
- During Southern Hemisphere winter the Galactic Center can be observed for the entire 10 hour flight, while in the North it is observable for only 1-4 hours
- Excellent facilities, a world class city, dry skies and perfect stellar positioning bring us back to Christchurch every year



Image: Shawn Granen





Airborne Science: The DC-8 an Experimenter's Flying Platform



- A flying laboratory capable of looking up, out, and down, both optically and for gas/particle sampling
- Carries out environmental, atmospheric, and earth science
- Christchurch provides
 - Access to the Antarctic
 - English speaking first world conditions
 - Excellent logistical and technical aircraft support
 - Collaborations





ER-2, Science from Extreme Altitude



- Operates from 40,000-70,000 ft.
- Environmental and atmospheric science
- Satellite sensor development and simulation
- Overfly weather to look down on special events
- O-zone loss studies from the Southern Hemisphere
- Christchurch offers good facilities, technical services, ease of shipments, access to Antarctic



- Relatively low cost, heavy-lift balloons are launch vehicles used to test and validate new technologies and science instruments for costlier, higher-risk follow-on spaceflight missions
- Queenstown Airport Corporation leased area to NASA for 10 years
- NASA built gravel launch pad
- Why Wanaka?
 - Latitude, provides access to Southern Hemisphere targets
 - Fewer crossings over populated areas
 - launch into the southern hemisphere's stratospheric winter cyclone which develops in fall
 - Predictable diurnal cycles
- Wind can be an issue from this site



The Super Pressure Balloon, carrying the International Extreme Universe Space Observatory payload, launching from Wanaka Airport

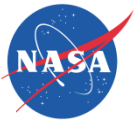
More info:

<https://www.nasa.gov/feature/wallops/2017/nasas-super-pressure-balloon-takes-flight-from-new-zealand>

- Logistics, facilities, shipping, and amenities in Christchurch are critical
- Access to Antarctica and the Galactic Center provide unique science cases
- Latitude
- Isolation
- Seasonal effects



SOFIA on the parked at Christchurch Airport
Image: Zaheer Ali



Space Related Work In Antarctica

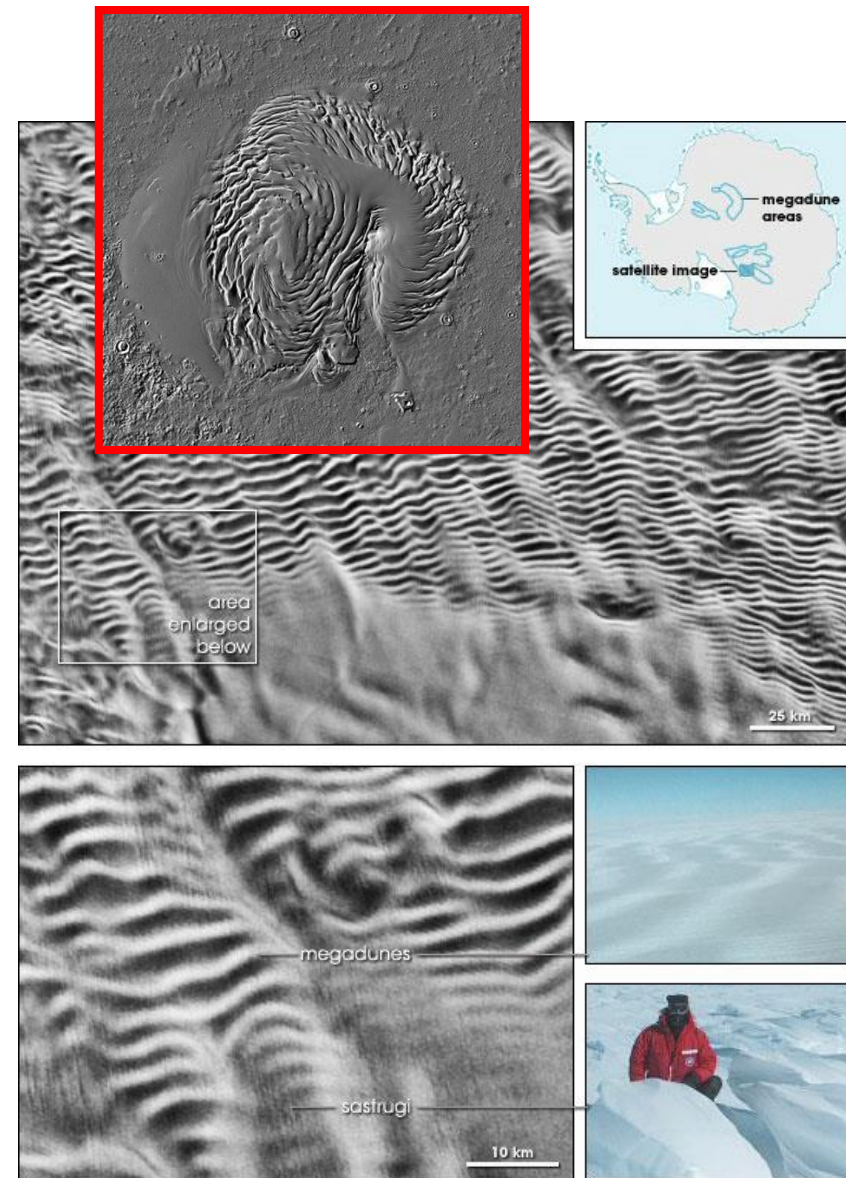
A Few Examples



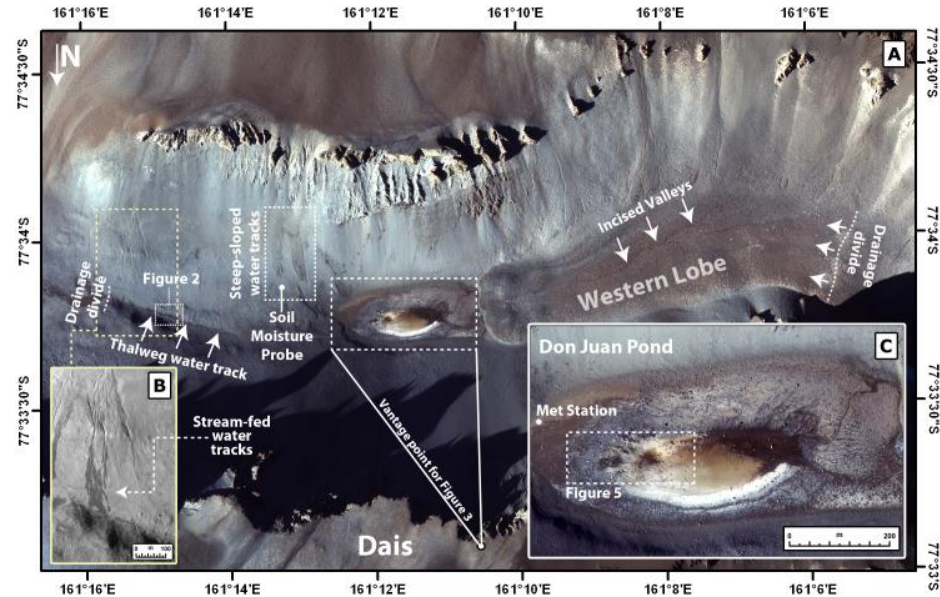
- Antarctic megadunes are long, undulating waves in the surface of the ice sheet
- Rippling in Martian North Pole Ice Cap has analogs to Antarctic megadunes
 - similar texture and morphology
 - presence of snow megadunes, shaped by katabatic winds, implies that the Martian North Pole has a frigid and icy but dry climate much like the Antarctic Plateau
 - Suggests interaction between the icy cap and the planet's atmosphere

Fahnestock, M. A., T. A. Scambos, C. A. Shuman, R. J. Athern, D. P. Winebrenner, and R. Kwok. 2000. Snow megadune fields on the East Antarctic Plateau: extreme atmosphere-ice interaction. *Geophysical Research Letters* 27(22): 3,719-3,722. [doi:10.1029/1999/GL011248](https://doi.org/10.1029/1999/GL011248).

Herny, C., M. Massé, O. Bourgeois, S. Carpy, S. Le Mouélic, T. Appéré, I. B. Smith, A. Spiga, and S. Rodriguez. 2014. Sedimentation waves on the Martian North Polar Cap: Analogy with megadunes in Antarctica. *Earth and Planetary Science Letters* 403: 56-66. [doi:10.1016/j.epsl.2014.06.033](https://doi.org/10.1016/j.epsl.2014.06.033).



- The saltiest water on Earth and amazingly pure
- The source of the water is disputed: deliquescence or ground water?
- The existence of a regional groundwater flow system beneath DJP has implications for water and solute budgets in cold desert ecosystems, and may provide clues for the formation of groundwater and aqueous flows on Mars
- If this water contains life could or did hypersaline water on Mars contain life?
- Sites such as this allow scientists to learn about how water, ice, weather, and topology may interact on Mars



A NASA satellite image of Don Juan Pond.

Dickson, J. L., Head, J. W., Levy, J. S., & Marchant, D. R. (2013). Don Juan Pond, Antarctica: Near-surface CaCl_2 -brine feeding Earth's most saline lake and implications for Mars. *Scientific Reports*, 3, 1166. <http://doi.org/10.1038/srep01166>

J.D. Toner, D.C. Catling, R.S. Sletten, The geochemistry of Don Juan Pond: Evidence for a deep groundwater flow system in Wright Valley, Antarctica, *Earth and Planetary Science Letters*, Volume 474, 2017, Pages 190-197, ISSN 0012-821X, <https://doi.org/10.1016/j.epsl.2017.06.039>.



Antarctica as a Jurisdictional Analog for a Mars Station



- What laws will govern humans on Mars or the Moon?
- Space law has always supported the position that objects and stations placed on celestial bodies are to remain under national ownership, jurisdiction and control
- The closest practical analogies to a future Mars station in current jurisdictional terms would be the Antarctic stations maintained by Antarctic claimant states
- Isolation experiments could reveal a preference for a more democratic and less hierarchical regime for modern space stations
- What can we take to space from Antarctic treaty negotiations?
- What will we have to invent?





White Mars: NASA's Human Research Program Funds Studies to be done in Antarctica



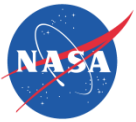
- Done both in stations and in training camps
- Specific astronaut training and experiences as well as academic studies
- Topics range from health and wellness to tools and vehicles
- Dr. Candice Alfano, University of Houston: psychologically analyze people who work in Antarctica for long periods of time (funded 2016)
 - “It’s relatively simple to place subjects in isolation or confinement for the purpose of studying mood and behavior, but the extreme environment element is harder to find.”
- David Dinges, University of Pennsylvania: NSCOR for Evaluating Risk Factors and Biomarkers for Adaptation and Resilience to Spaceflight: Emotional Valence and Social Processes in ICC/ICE Environment (funded 2017)
 - experimental studies to identify biological domains and behavioral domains that relate to individual adaptation and resiliency in spaceflight-relevant confined and extreme environments such as the Neumayer Research Station in Antarctica.



Training camp set up on the foot hills of Mt. Erebus near McMurdo Station in the Antarctic.

<https://www.nasa.gov/feature/nasa-selects-seven-proposals-to-support-astronaut-health-on-missions-to-mars>





NASA High Altitude Balloon Missions



- Inexpensive (relatively) means of getting payloads to the brink of space
- Minimal atmospheric effects
- Summer insolation makes power easier
- Winter dark skies allow continuous observations
- Circumpolar winds high in the stratosphere carry balloons steadily and predictably around the pole
- Multiple missions: ANITA, BACCUS, STO-II, SuperTIGER, GUSTO (2021)
- Balloon tracking:
<https://www.csbf.nasa.gov/antarctica/ice.htm>
- NASA Balloons:
<https://www.nasa.gov/scientificballoons>



Above: The Antarctic Impulsive Transient Antenna (ANITA) from the University of Hawaii at Manoa was launched from Antarctica's Ross Ice Shelf near McMurdo Station

Below: The Boron And Carbon Cosmic rays in the Upper Stratosphere (BACCUS) was also launched near McMurdo



- Location, location, location
- Christchurch is an ideal transition point
- Topology matters
- Analogs exist for multiple non-earth missions; both human and environmental
- Seasonal extremes can be exploited
- Circumpolar winds are your friends
- Isolation of experiments provides opportunity
- The radiation environment is unique



Another view of ANITA being prepared for launch from the ice.



Looking Forward



- Possible testing of Europa lander and submarine concepts
- Continuing testing and development of habitat, agriculture, equipment, transportation and other technology for analogs to Lunar and Martian conditions
- Additional airborne missions both with aircraft and balloons
- New ways to test human factors in extreme environments
- Is there a database of sites on Antarctica with analogs to Mars, the Moon, or other possible landing sites in our solar system?
- Can the University of Canterbury forge more collaborations?
- Can Christchurch leverage Mt. John observatory?
- Taking advantage of seasonal extremes in Southern Hemisphere, both in Antarctica and from New Zealand itself.



Image: Zaheer Ali

Thank you for you attention!

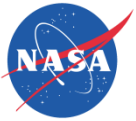
zaheer.a.ali@nasa.gov

<https://www.linkedin.com/in/zaali/>

+1 650 933 3376

Note: All unattributed images taken from NASA mission pages.

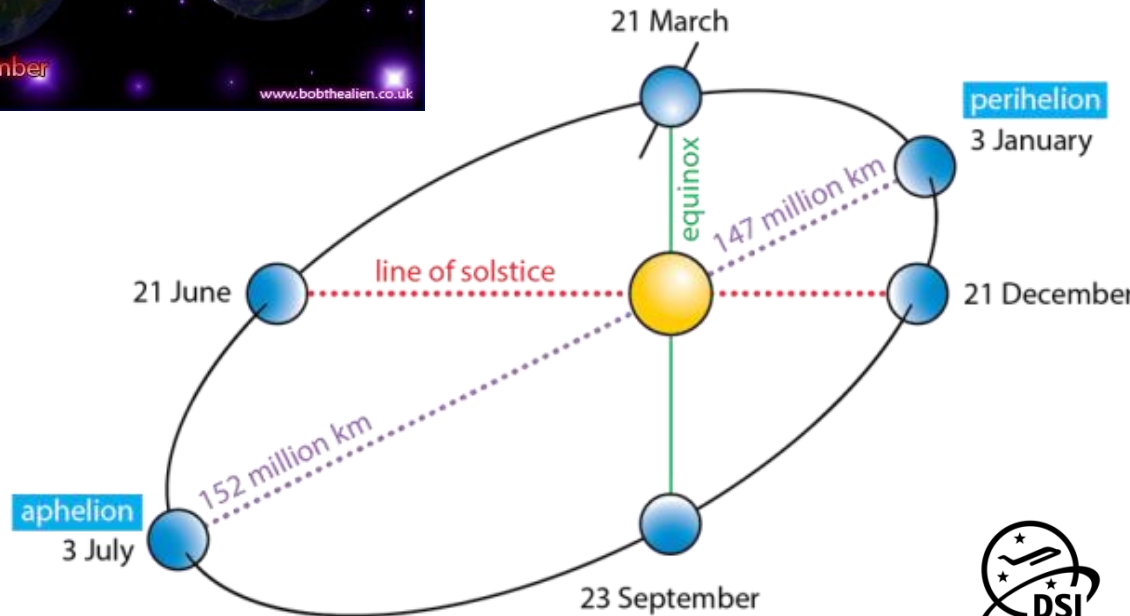
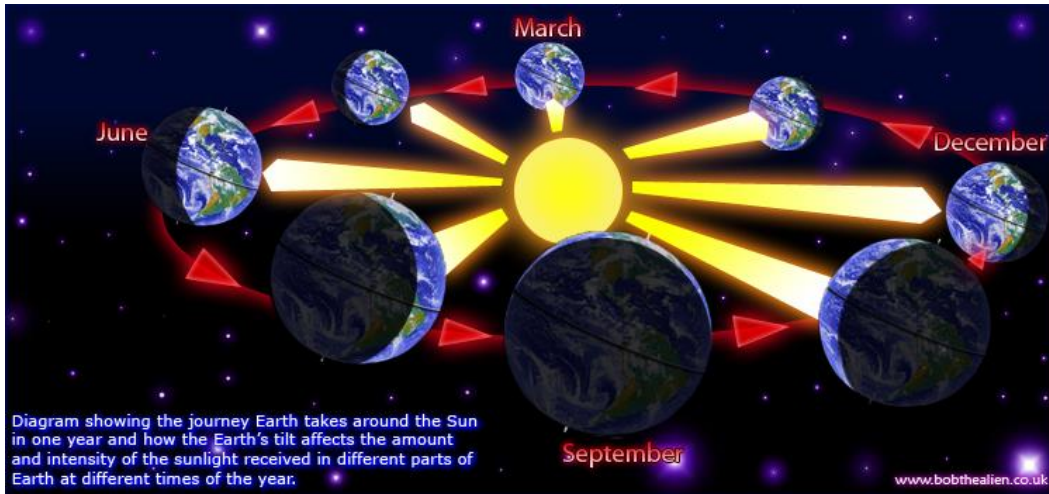




Back-Up Slides



What part of the sky can we see when?



- One of the biggest astronomical efforts in Antarctica is actually taking place under the ice. IceCube is an array of ultra-sensitive light detectors buried a mile deep into the Antarctic ice sheet. These detectors can spot the passage of high-energy neutrinos, particles created by the most violent events in the universe, allowing astronomers to see impossibly distant cosmic events by detecting the neutrinos they create
- Isolated environment
- No background



Blue light sensor from neutrino ice interaction



South Pole Communications as a Proving Ground for Deep Space



- NASA used a selfie taken outside Antarctica's McMurdo Station at the bottom of the world and sent to the International Space Station to show off a new technology called Disruption Tolerant Networking (DTN)
- This works similar to the internet – data is sent from node to node in packets, however, with DTN, if there is an interruption the node stores the data until reconnected
- DTN from McMurdo sent an image to White Sands via the repurposed Tracking and Data Relay Satellite; that was then relayed via DTN to NASA Marshall
- DTN is open source software



Near McMurdo Station





Satellite Proving



- IceSat and IceSat-2
- Scientists trekked across the Antarctic to proof/calibrate measurements by the proposed satellite systems

