

# Monitoring Landscapes on Oceanic Islands: Sub-meter Imaging from IKONOS and QuickBird

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JACIE Presentation, May 2003



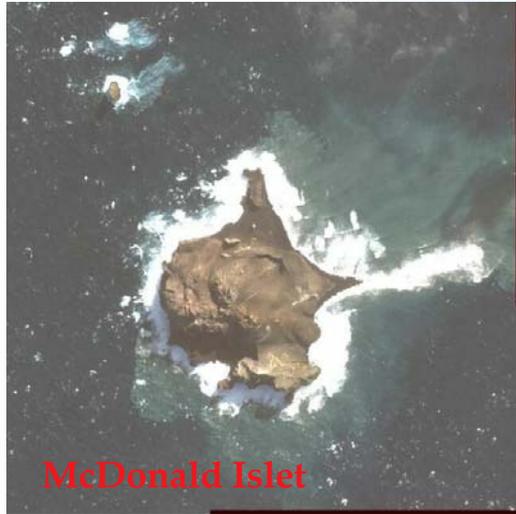


# Outline

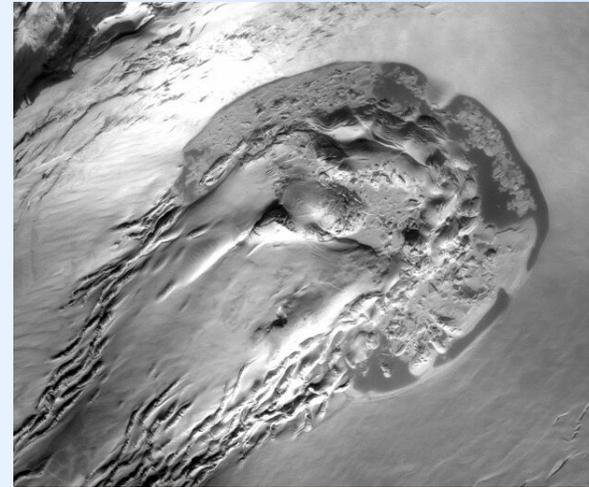
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- **Oceanic Islands: *Why Monitor them?***
  - Sensitive landscapes are microcosm for larger systems
  - Extremely Responsive to any forcings (change annually)
  - Diverse set of fragile landscapes, many with ice-cover
- **Index Set of Oceanic Islands:**
  - From Ice-covered islands to active volcanic islets
- **Establishing Context: Landsat 7 ETM+ and SRTM topography**
  - Context for monitoring many tens of islands (time series)
- **Landsat 7 shows Sub-meter Satellites where the “action” is:**
  - Targeted monitoring at sub-meter resolution:
    - IKONOS and QUICKBIRD
- **EXAMPLES: Case studies underway , i.e. *McDonald vs Surtsey***
- **Training Ground for sub-meter imaging of Martian landscapes**
- **Summary**

# Examples of Island Monitoring Sites



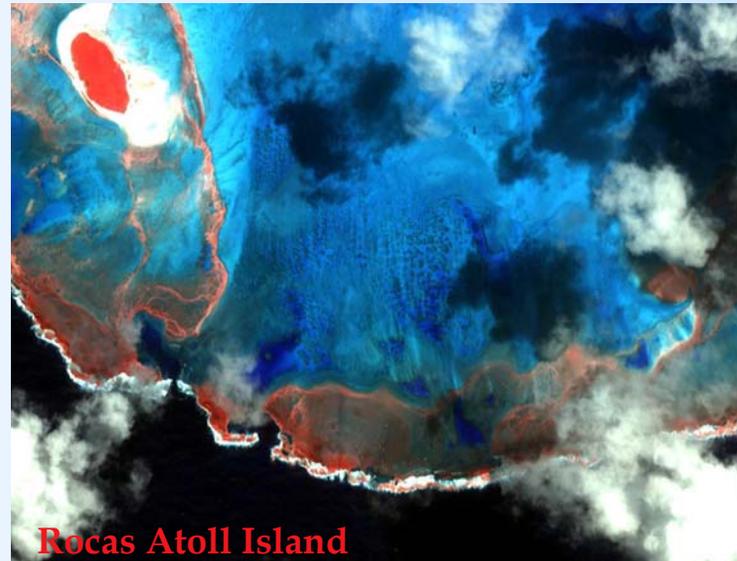
McDonald Islet



Sigketil, Iceland



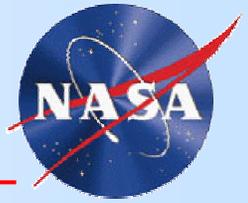
Surtsey Island



Rocas Atoll Island

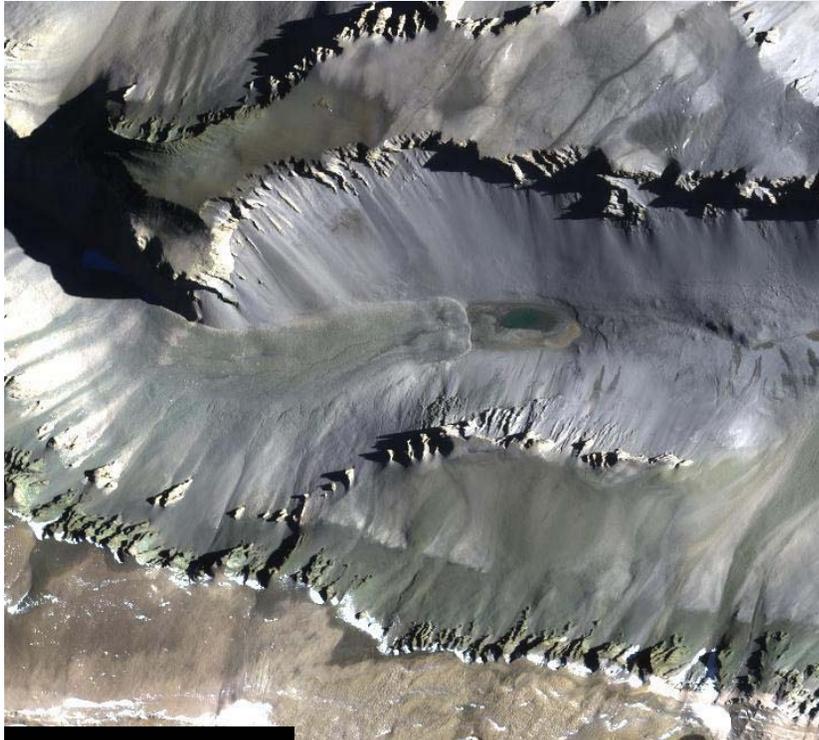
# Analogues to Mars

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- *Ikonos* and *Quickbird* imaging of “Mars analogues”
- Successful acquisition of images of Antarctic Dry Valleys in early 2003 by both systems
- Additional SDB-archive images of Atacama desert also useful analogues to Mars
- Sub-glacial volcanic eruption site provides training ground for processes that probably occurred on Mars
- Mars Science community now engaged using these datasets
- Recent Mars Global Surveyor MOC Image Motion Compensation (IMC) experiment achieved 60 cm/pixel
- NASA 2005 MRO mission carries a Quickbird-like “HiRISE” imaging experiment with 25-30 cm/pixel
- Valuable inter-Enterprise science activity : “One NASA”

# Mars On Earth and Earth on Mars

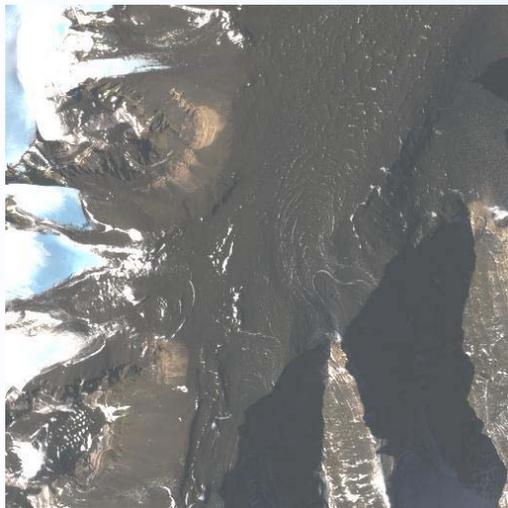


**Don Juan Pond, Antarctic Dry Valleys**

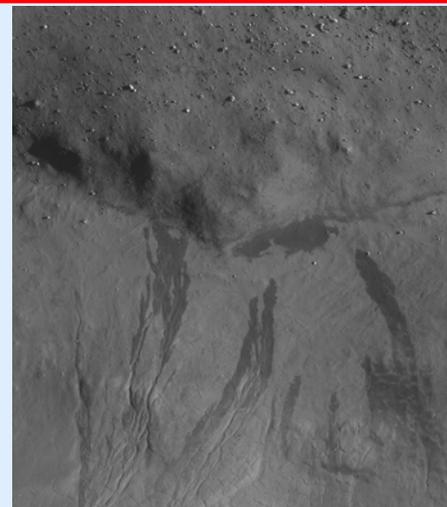


**2003 Mars Exploration Rover**

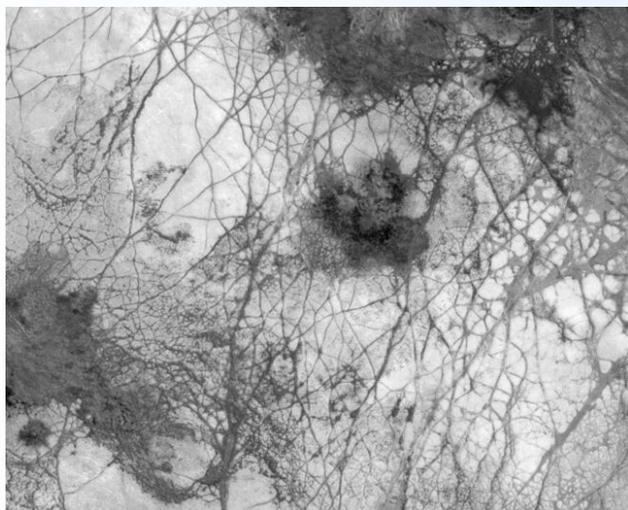
# Mars on Earth: Unfolding stories...



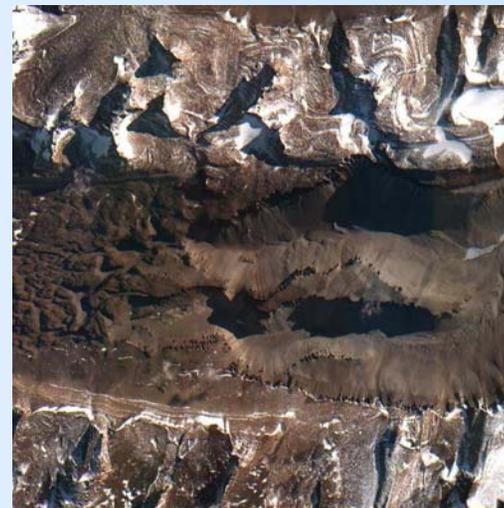
**Mullins Dry Valley (Ikonos)**



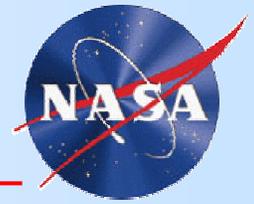
**Gullies near Don Juan pond (Ik)**



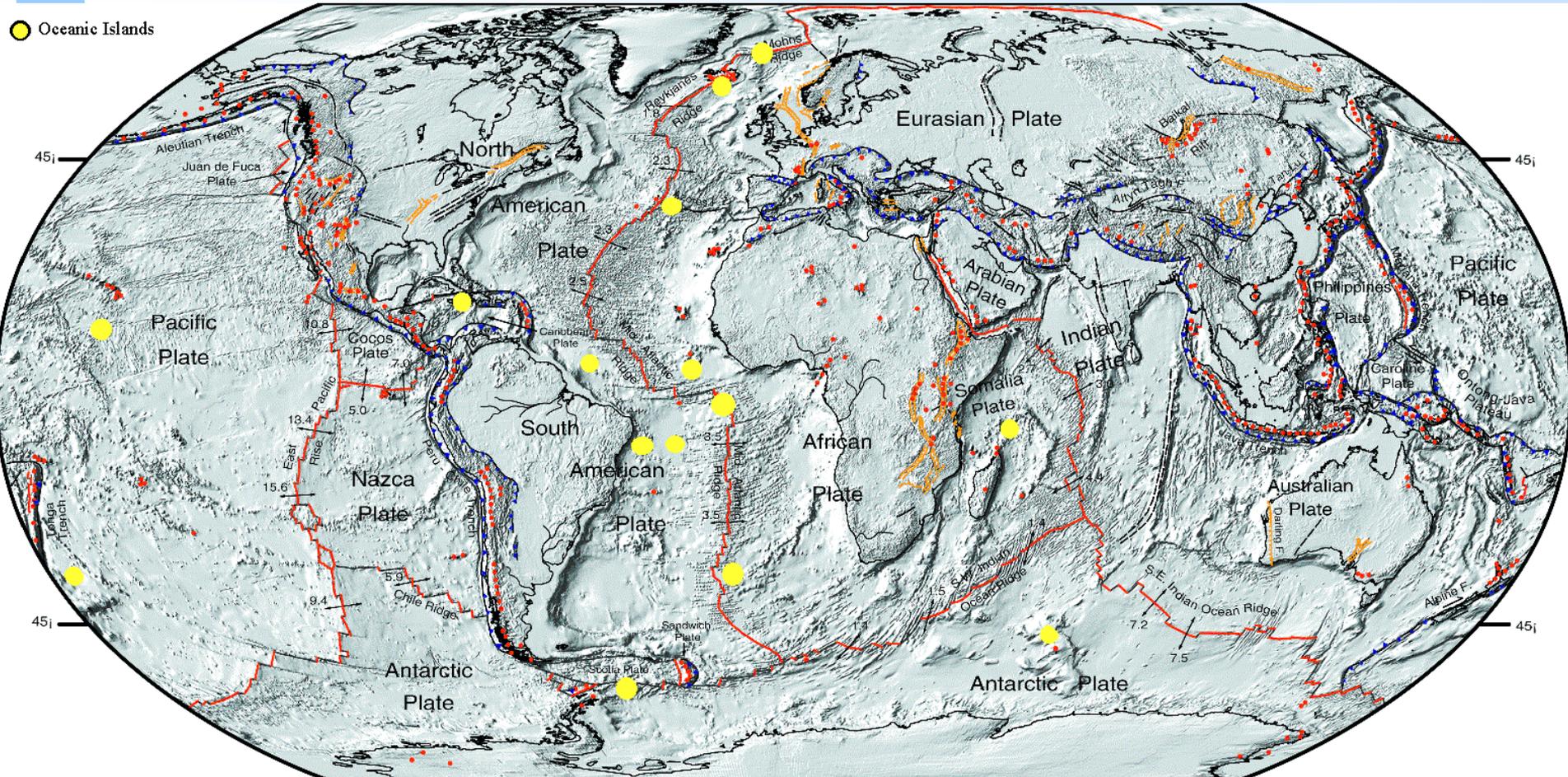
**Atacama Evaporites (Qb)**



**Upper Wright Dry Valley (QB)**



# Map of Islands on Earth

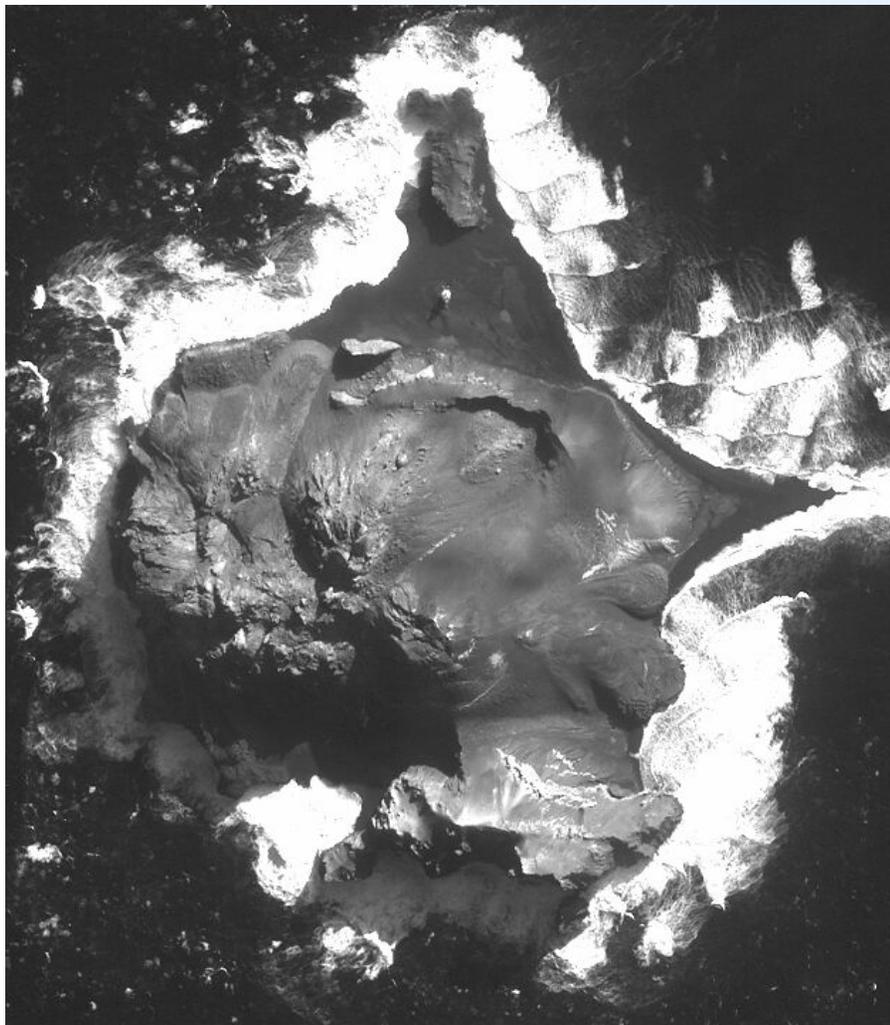


New Target: *Montagu Island*, S. Sandwich (2003 Eruption)

# Important Examples for Monitoring : 2002-2003



Ocean Island Monitoring

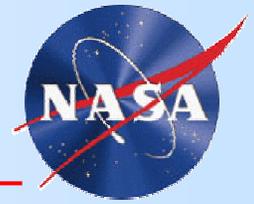


McDonald Islet, Australia (Ikonos)



Surtsey, Iceland (Quickbird)

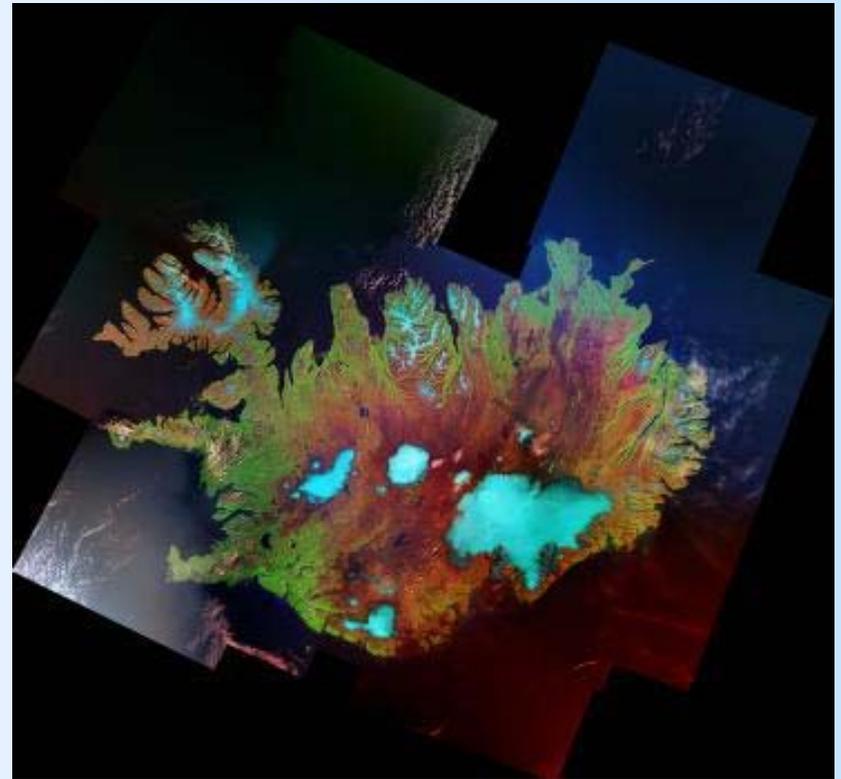
# Emerging Opportunities: 2002-2003



Ocean Island Monitoring



**Ikonos View of Corvo, Azores**



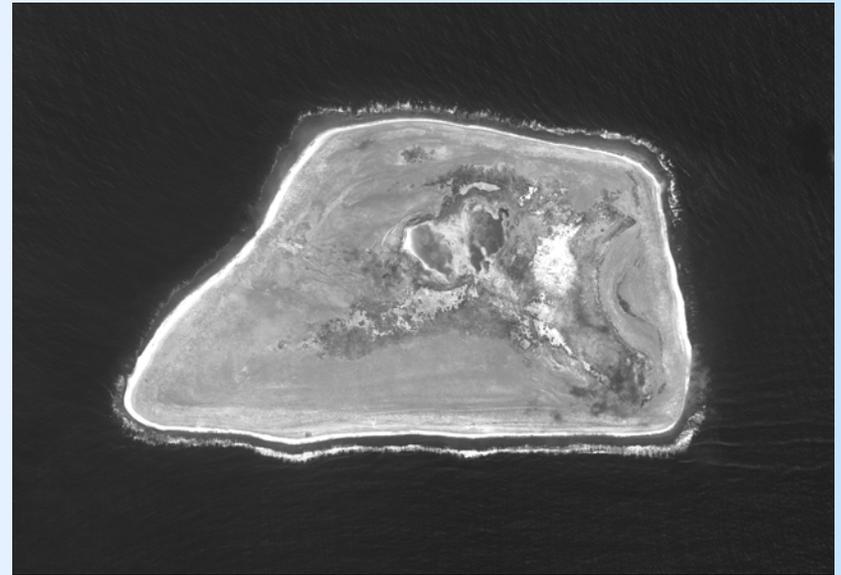
**Landsat Mosaic of Iceland**

# New Opportunities...

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**Heron Reef, Australia**



**Jarvis Atoll, Pacific (US)**

# Tracking Small Island Responses...



**Inaccessible, UK (Ikonos)**



**McDonald 2003 (Quickbird)**

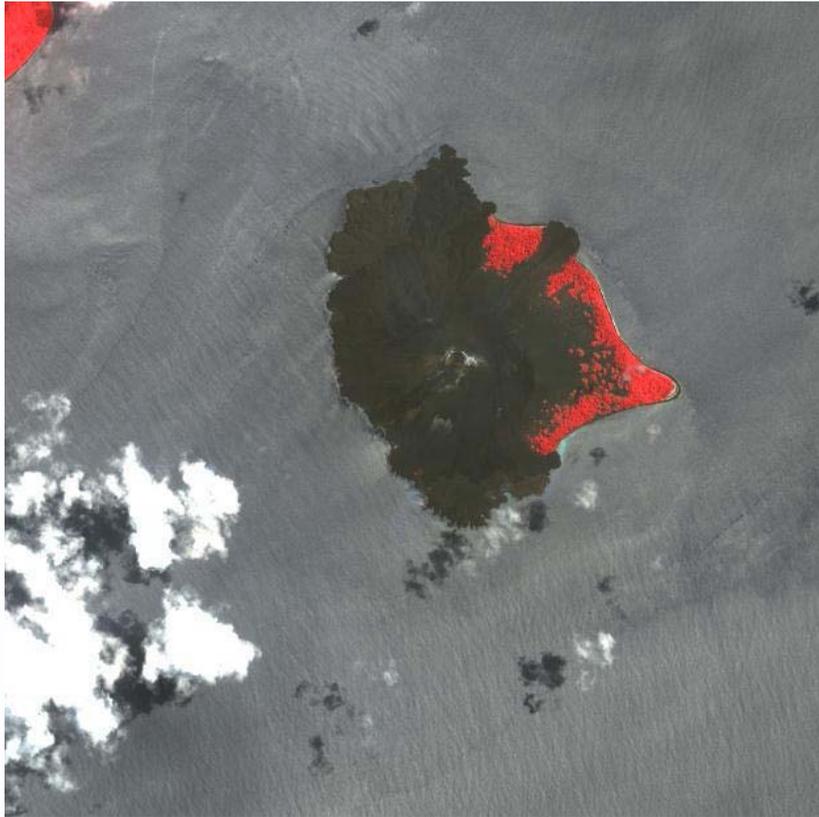
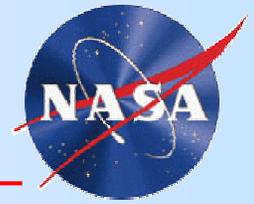


**Trindade, Brazil (Ikonos)**

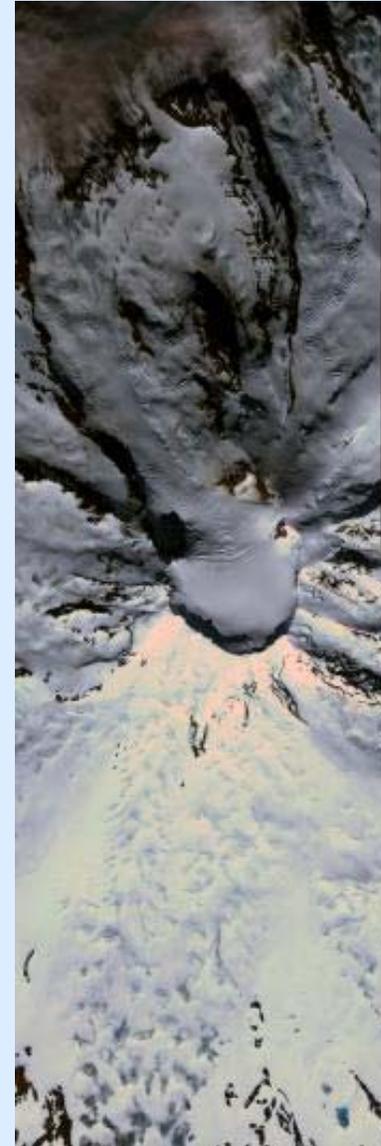


**Surtsey 2002 (Quickbird)**

# New Vistas...ever-changing



Anak Krakatau 2003 (*Ikonos*)



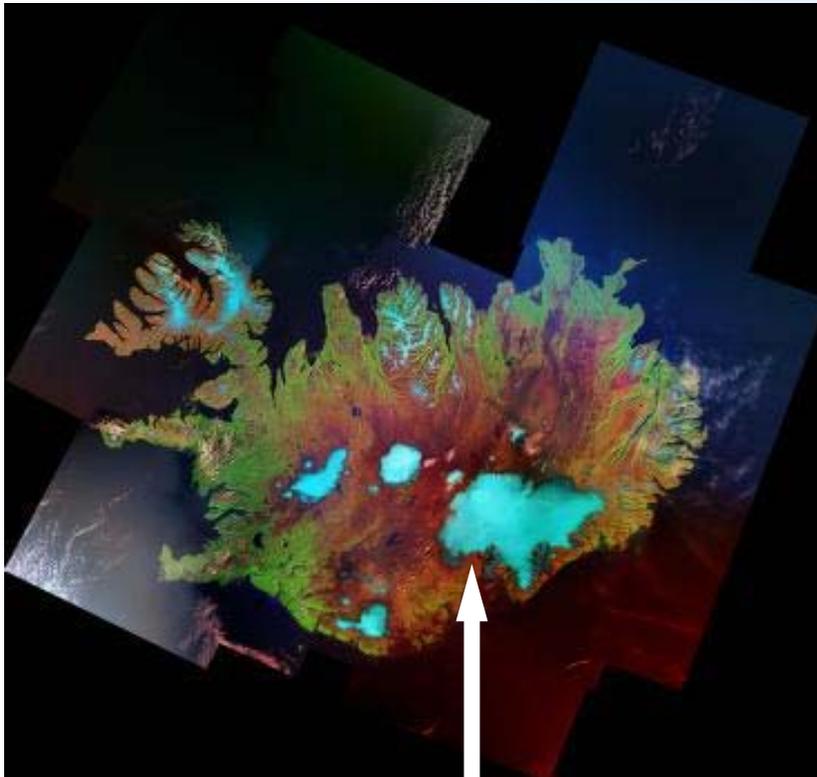
Jan Mayen:  
Beerenberg  
Volcano  
(*Ikonos*)

# Index Islands under study with Ikonos and QuickBird (SRTM)



Island Name	Location	Comments
Surtsey	N. Atlantic, Iceland	Time series analysis underway with comparison with laser DEMs
McDonald	Indian Ocean	Time series analysis (comparison with Surtsey) : erupted 2001
Sigketil, Iceland	Atop Vatnajokull	Impact of 2002 sub-glacial eruption
Rocas Atoll	Equatorial Atlantic	Time series analysis, Sea-level changes, etc.
Anak Krakatau	East Indies	Coastline analysis, landcover changes
Trindade	Central Atlantic	Time-series analysis, mass-wasting
Corvo, Azores	Central Atlantic	Coastal erosion, sea-level effects, landcover
Tristan da Cunha	South Atlantic	Sea-level, erosion of 1961 eruptives, gullying snow-cover effects at summit
Bouvet	South Atlantic	Ice-cover change, coastal erosion, sea-level comparison with Radarsat time series
Kerguelen	S. Indian Ocean	Ice-cover change, coastal erosion, landcover comparison with Radarsat SAR, L-7 time series
Deception	S. Shetlands	Ice-cover change, active volcanism, erosion comparison with Radarsat SAR time series
Fogo, Cape Verdes	Central Atlantic	Post-eruption erosion, sea-level, landcover
Jan Mayen	Arctic Ocean	Ice-cover change and dynamics, coastal erosion comparison with Radarsat, L7 time-series

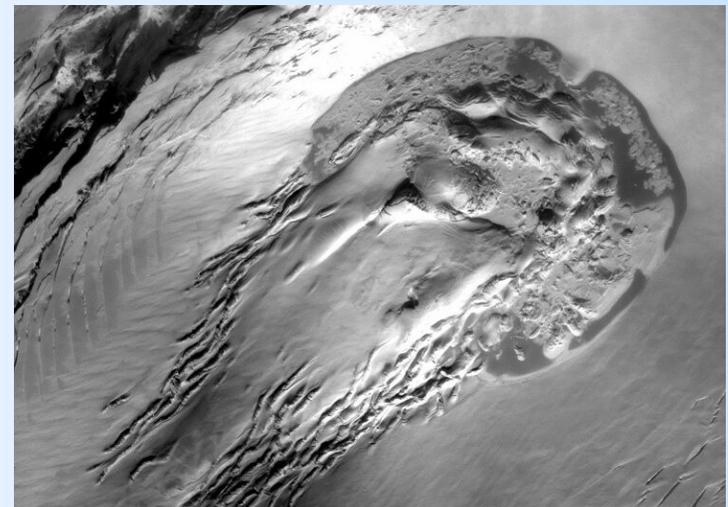
# Witnessing the “Unseen”: Summer 2002 Sub-glacial Eruption



Iceland TM Mosaic: Vatnajokull



Landsat 7 before and after ...



Ikonos view of “ketil” post-eruption



# Surtsey, Iceland

Ocean Island Monitoring



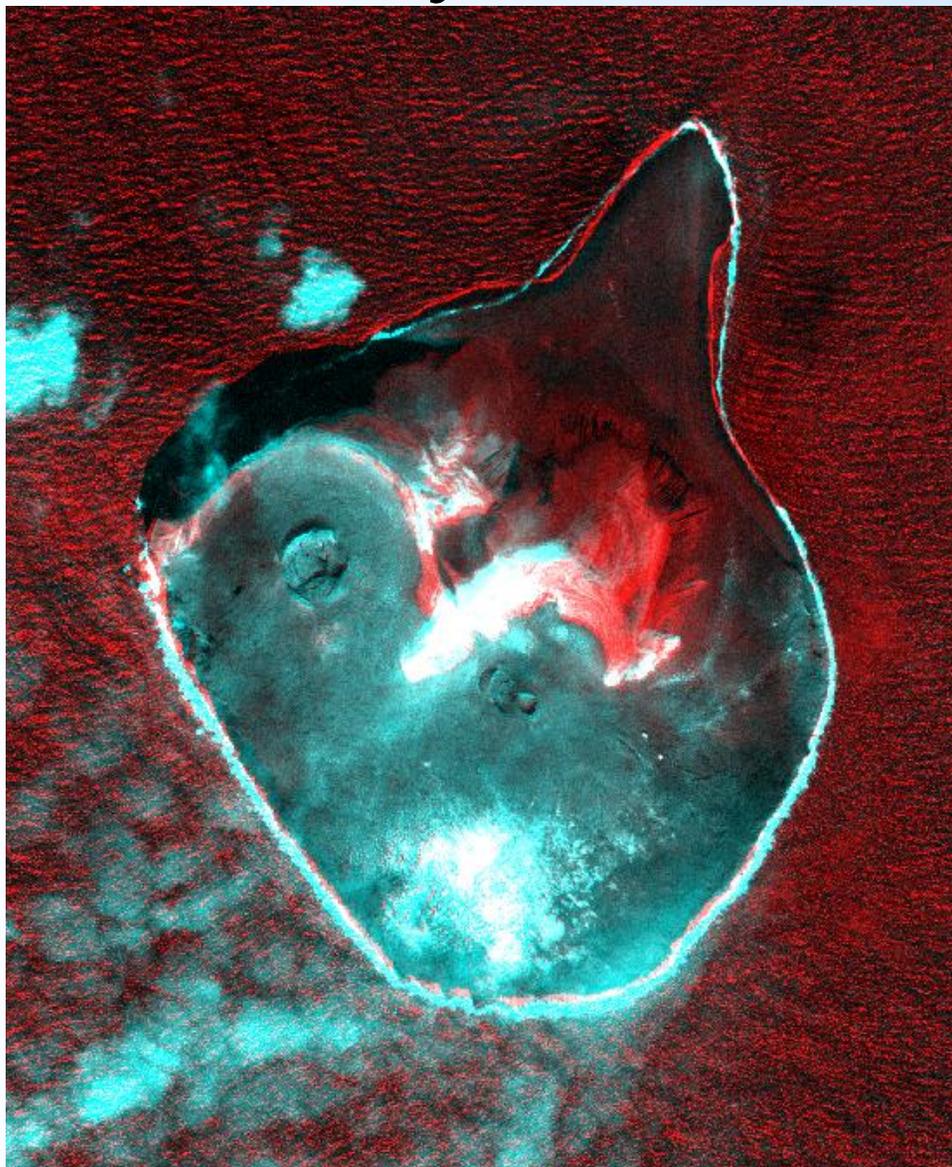
8/14/00



6/12/01



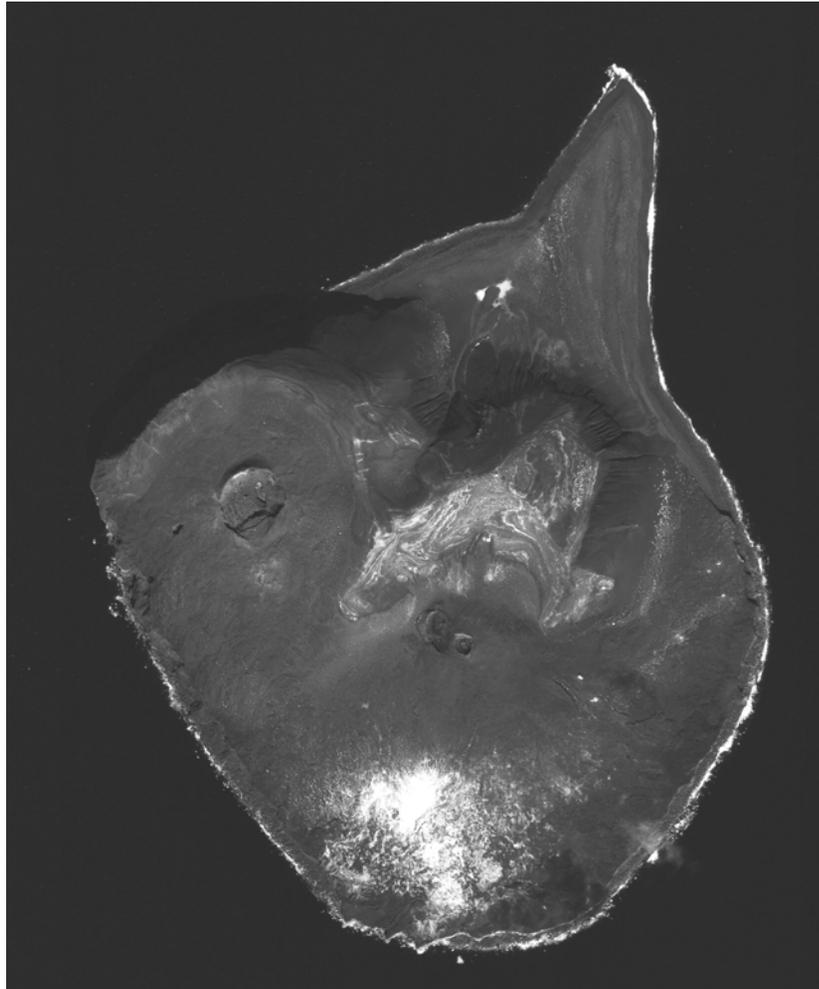
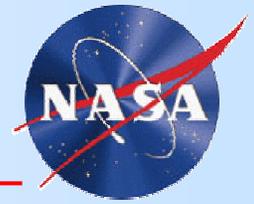
# Surtsey, Iceland



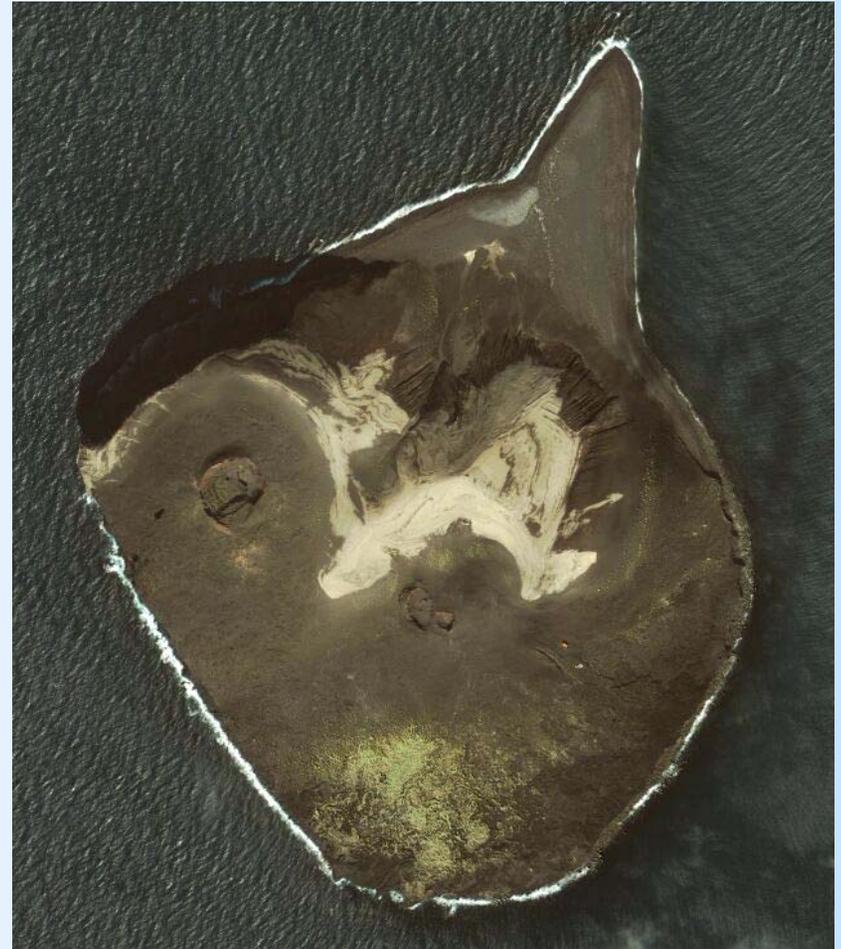
**Time-Series  
Analysis**

**IKONOS: 1~m pan  
Blue: 8/14/00  
Red: 6/12/01**

# Surtsey 2002: Ikonos vs Quickbird



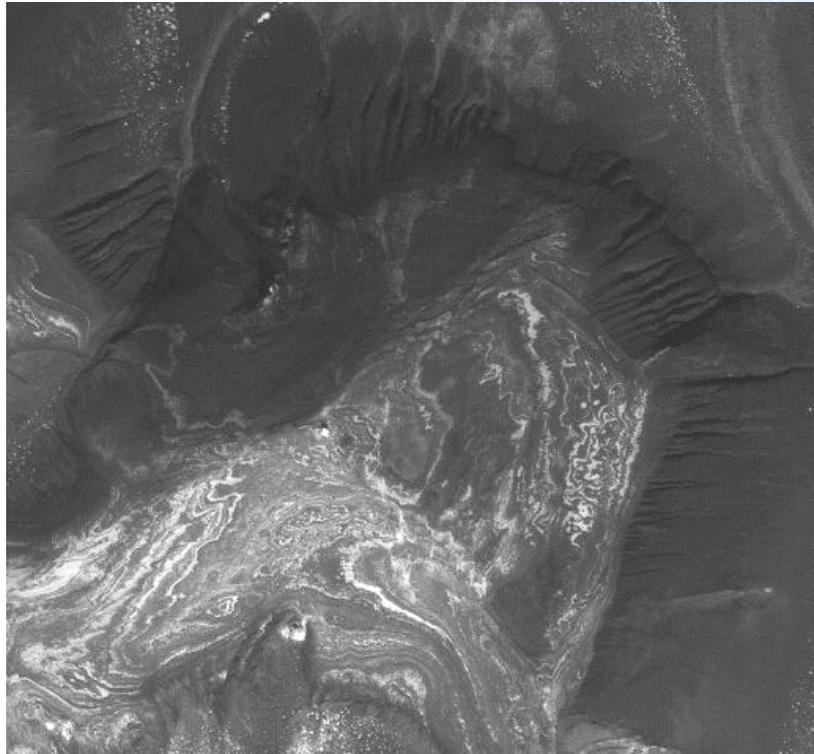
Surtsey 2002: IKONOS (86 cm)



Surtsey 2002: QuickBird (60cm)

# SURTSEY: tracking changes

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IKONOS Aug. 2002 pan

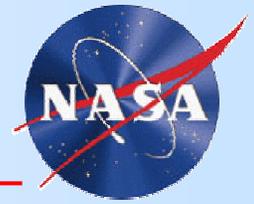


QuickBird: Sept. '02 pan-sharpened

**In Process: registration to 2m  
per grid cell DEM for 3D analysis**

# Multi-Temporal Studies: *McDonald Islet* after the 2001 Eruption

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McDonald (Sept.'02): Ikonos



McDonald (April '03): Quickbird

# McDonald post eruption...

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East Spit (Ikonos Sept. 2002)



East Spit (QuickBird, April 2003)

Redeposition along the "ness" as at Surtsey

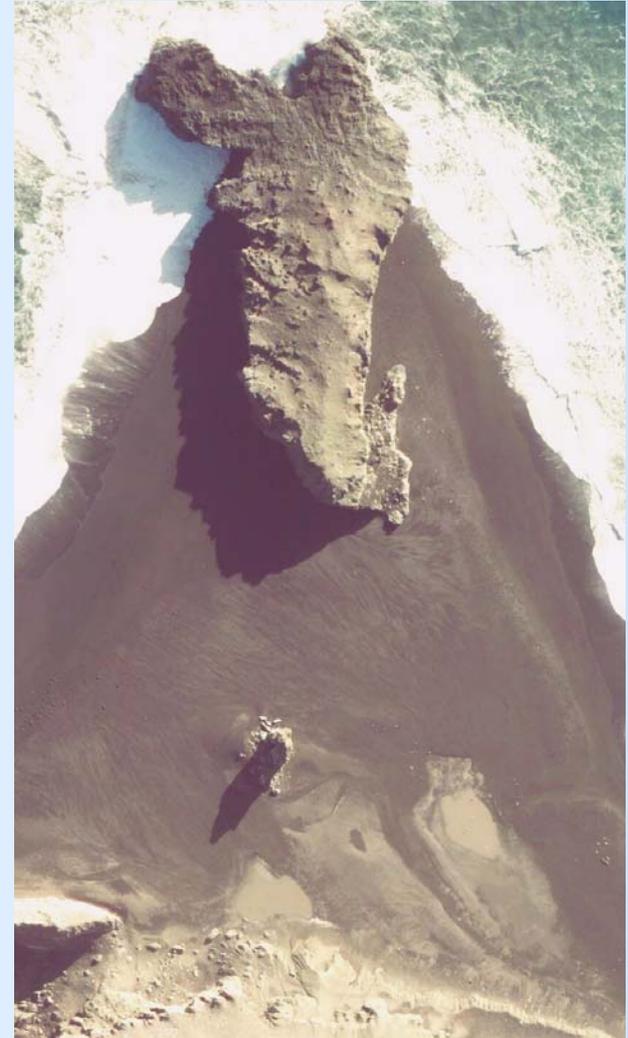
# McDonald post-eruption cont'd



Ocean Island Monitoring



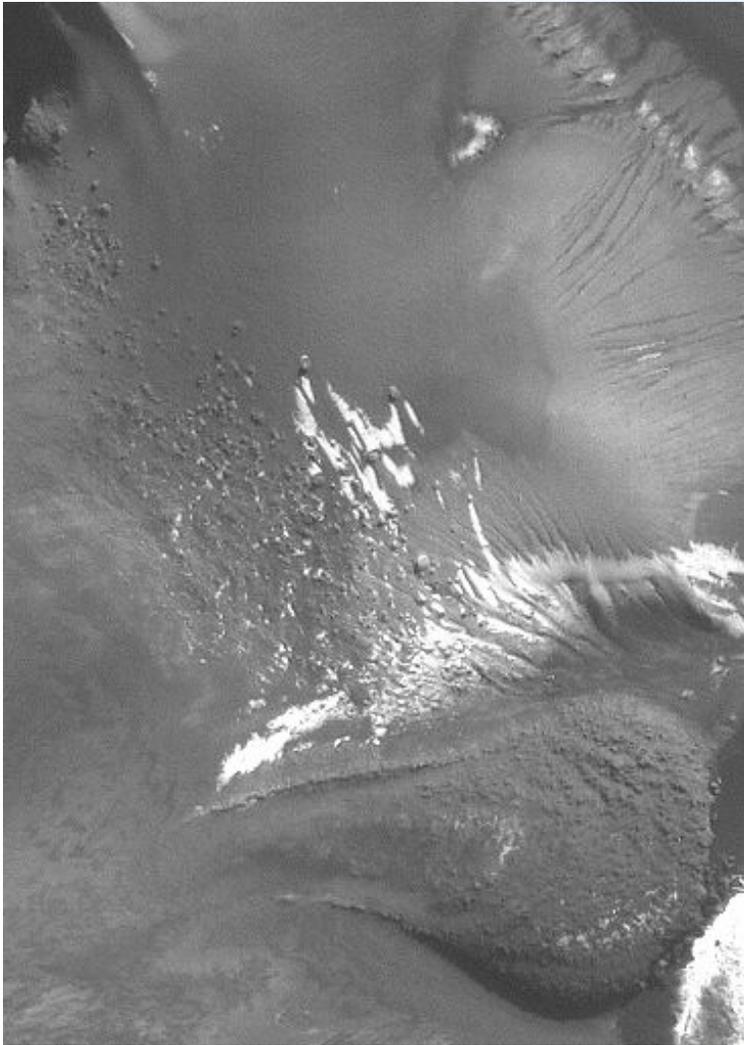
Northern Ness (Ikonos, Sept. 2002)



Northern Ness (Qb, April 2003)

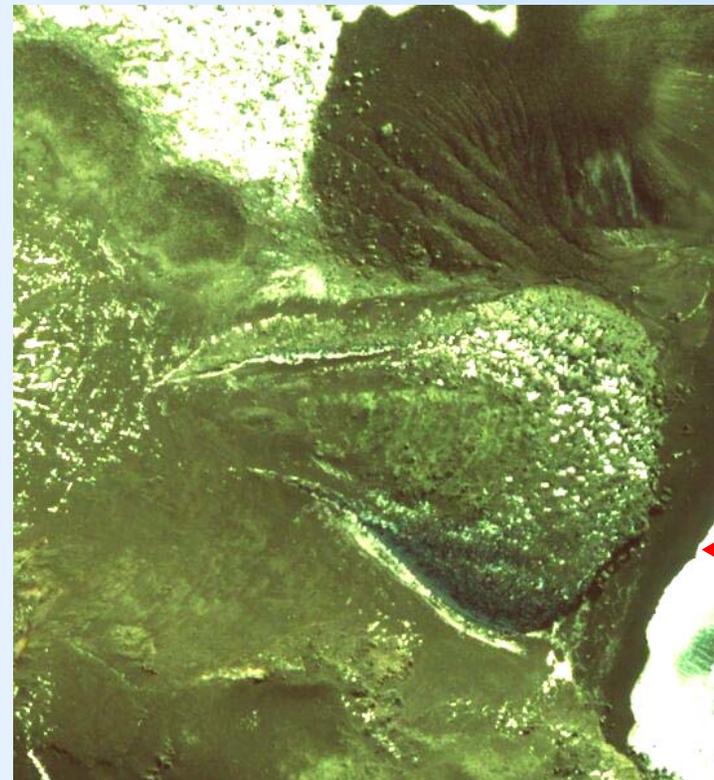


# McDonald: Lavas



Ikonos, Sept. 2002: new lavas

Quickbird, April 2003: lavas

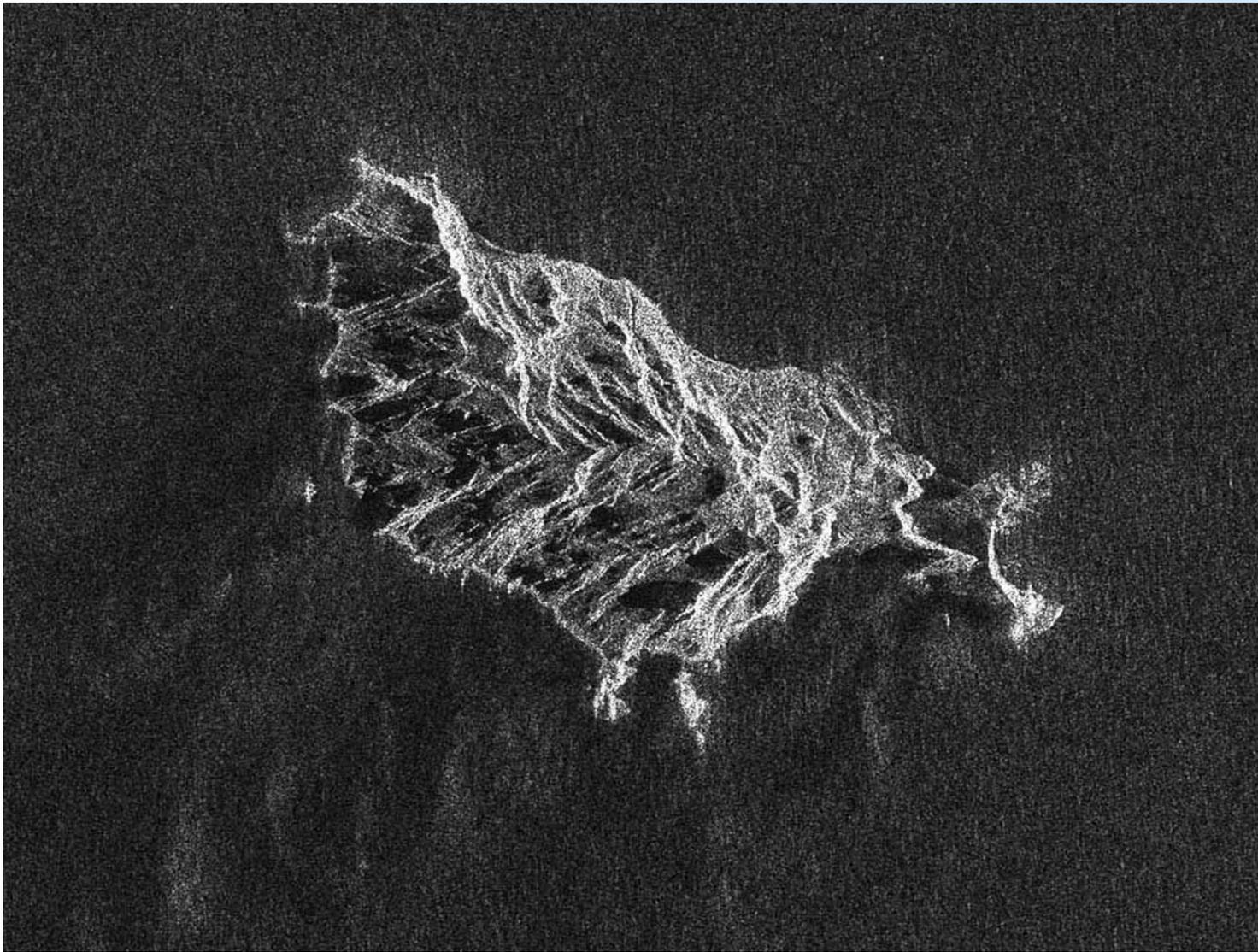


New beach

# Trindade, Brazil RADARSAT SAR



Ocean Island Monitoring



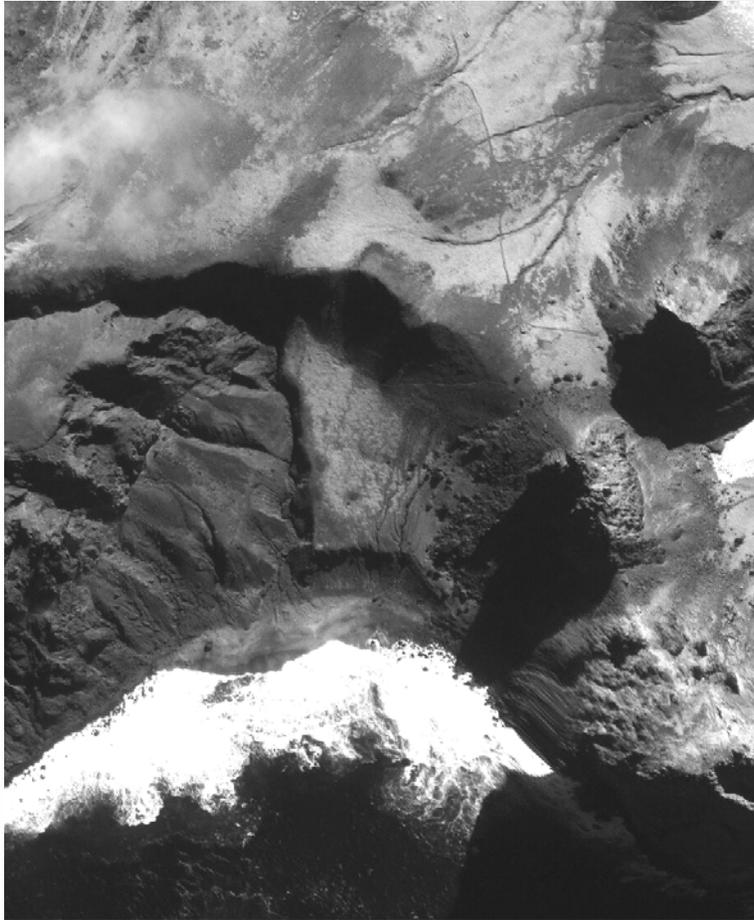
# Trindade, Brazil



Rare  
Tree Fern  
Forests  
(now  
Protected)



# Trindade: comparisons...



Ikonos (2002) : SE Coast



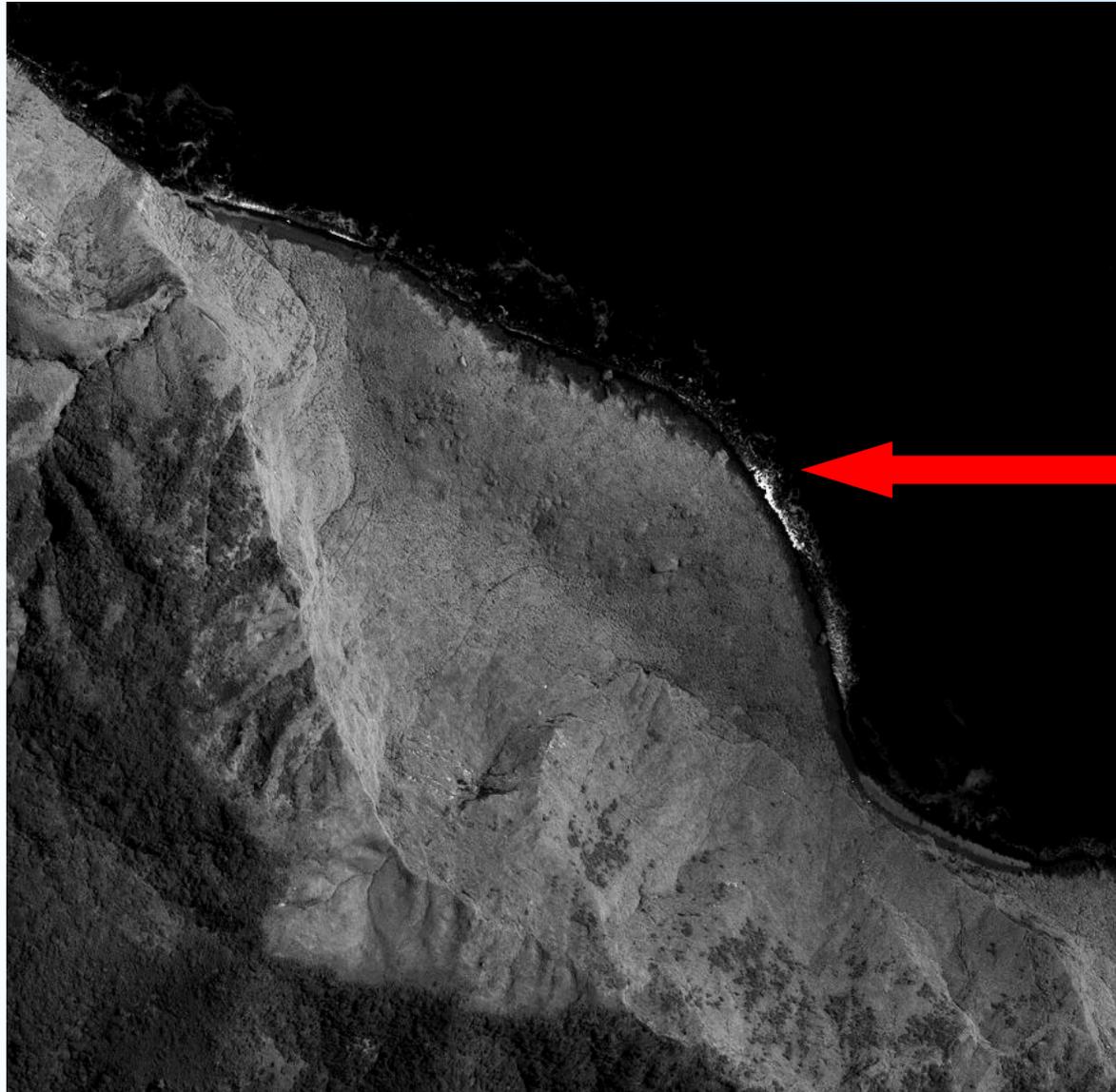
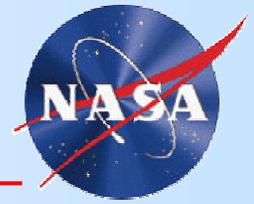
Ikonos (2003): SE Coast

**Tracking Mass Wasting and gully erosion...**

# *Inaccessible* (near Tristan da Cunha)



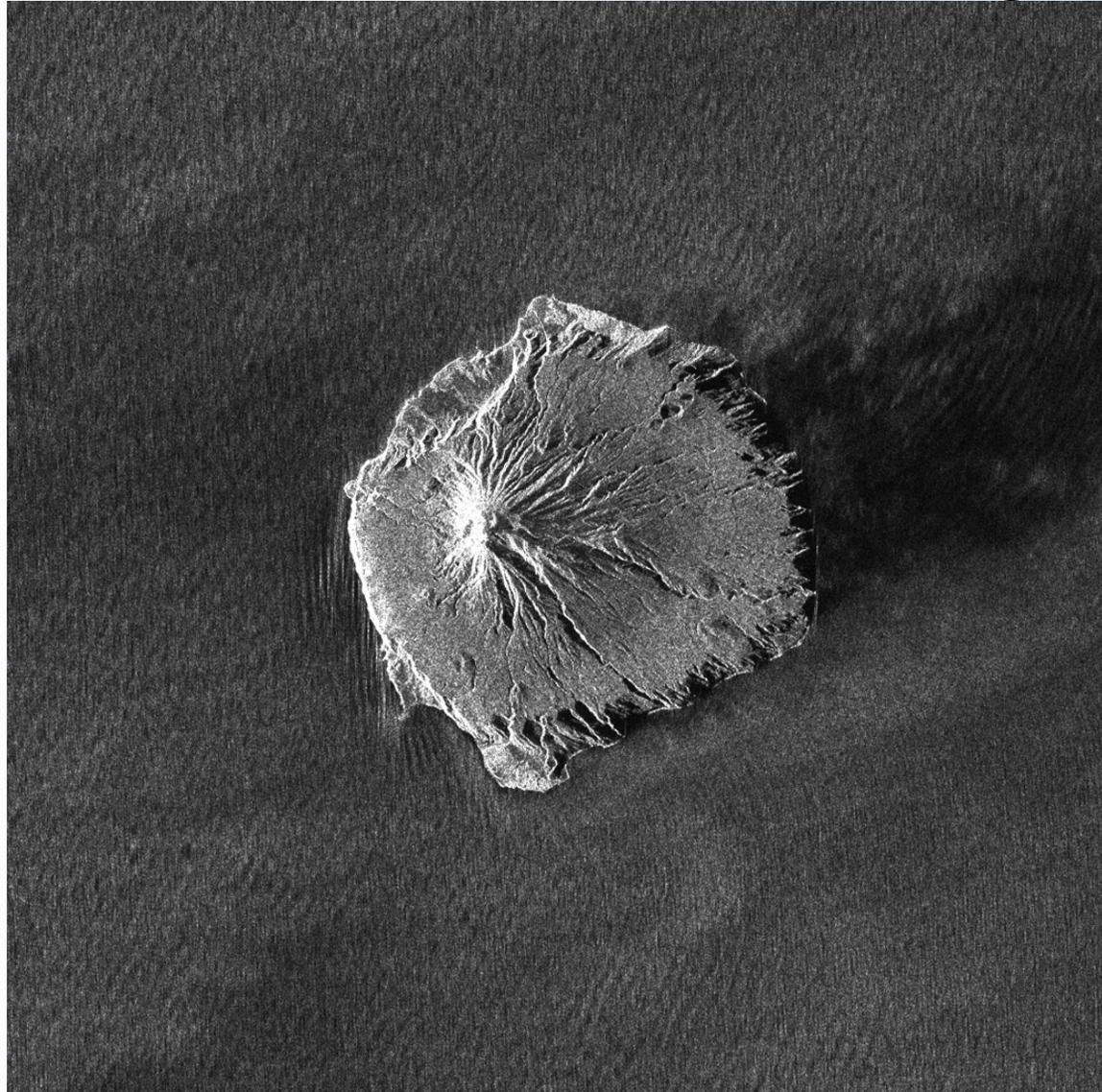
# *Inaccessible:* NE Coastal slump scars



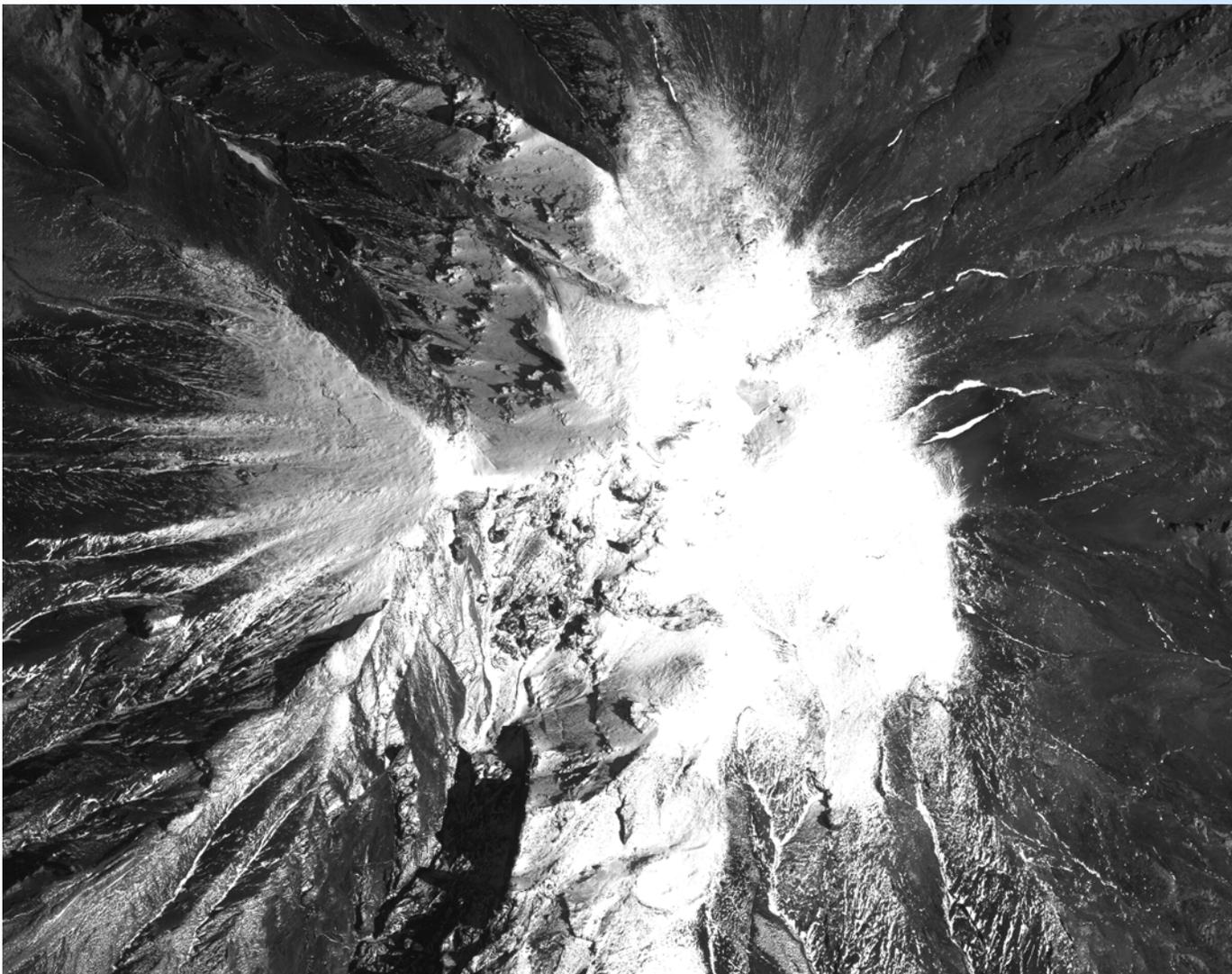
**Slump  
Terrace**

**Ikonos, 2003**

# Tristan da Cunha RADARSAT Context Image



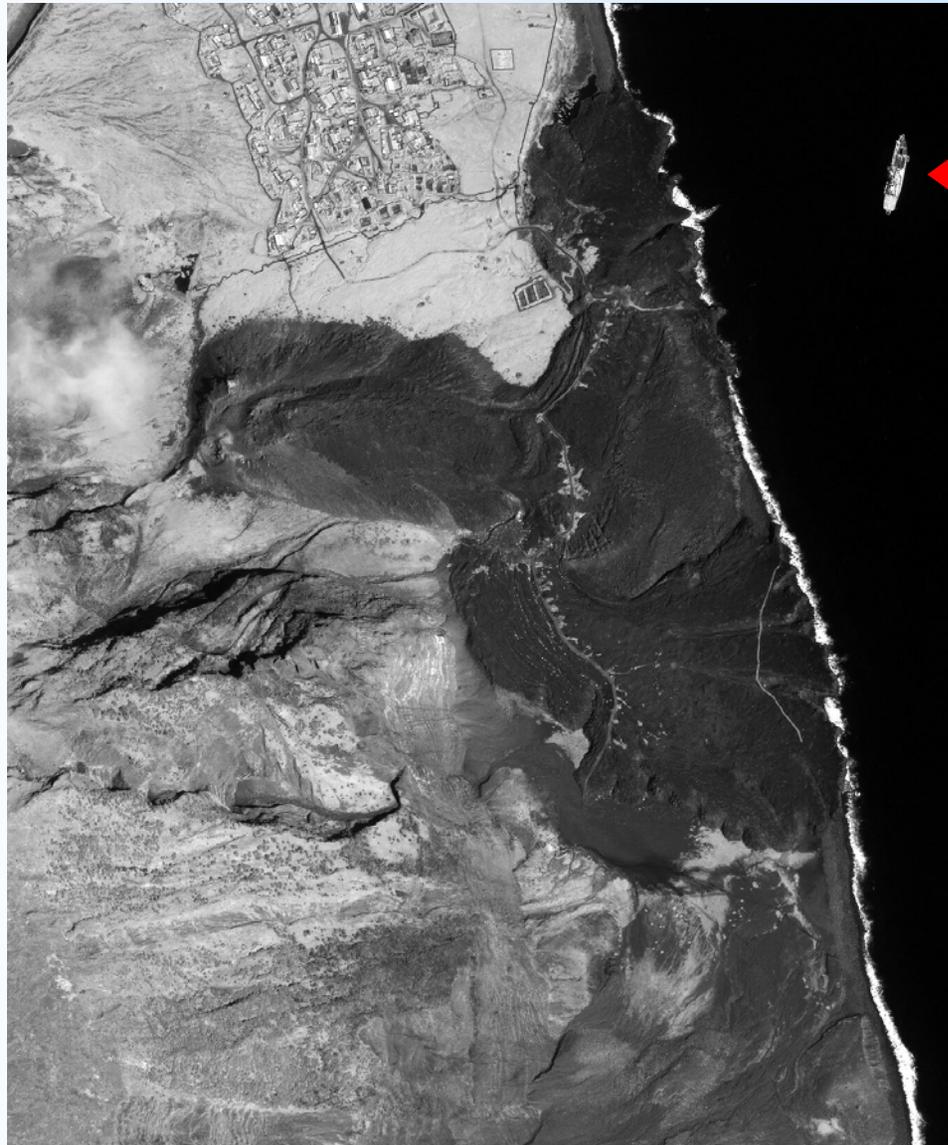
# Tristan da Cunha...



Ikonos, 2001

**Summit Snowpack and signs of Paleo-glaciers**

# Tristan da Cunha: 1960's lavas



Ship

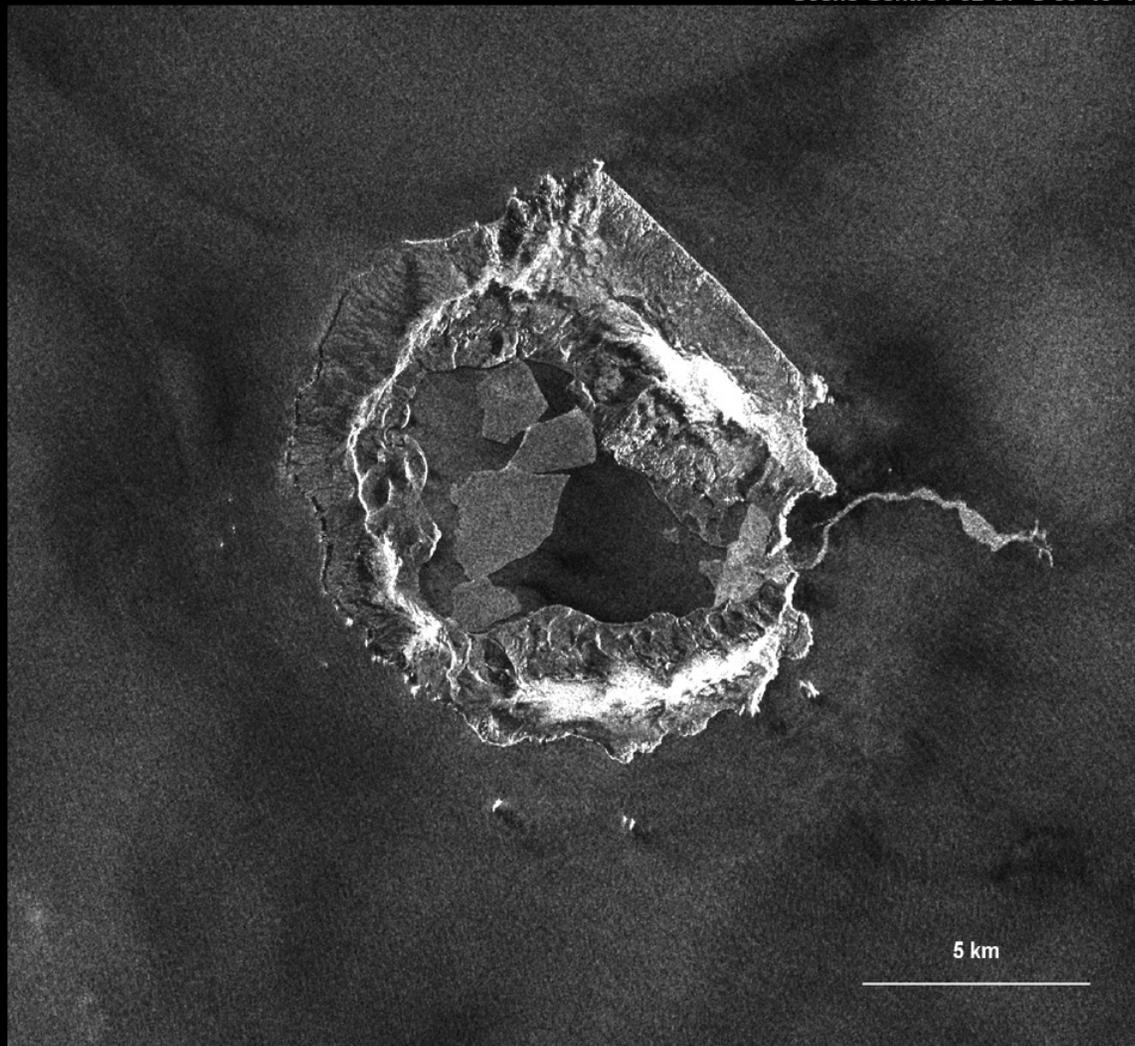
Ikonos, 2001

# Deception Island: RADARSAT Context Image (S. Shetlands)



RADARSAT BACKGROUND MISSION

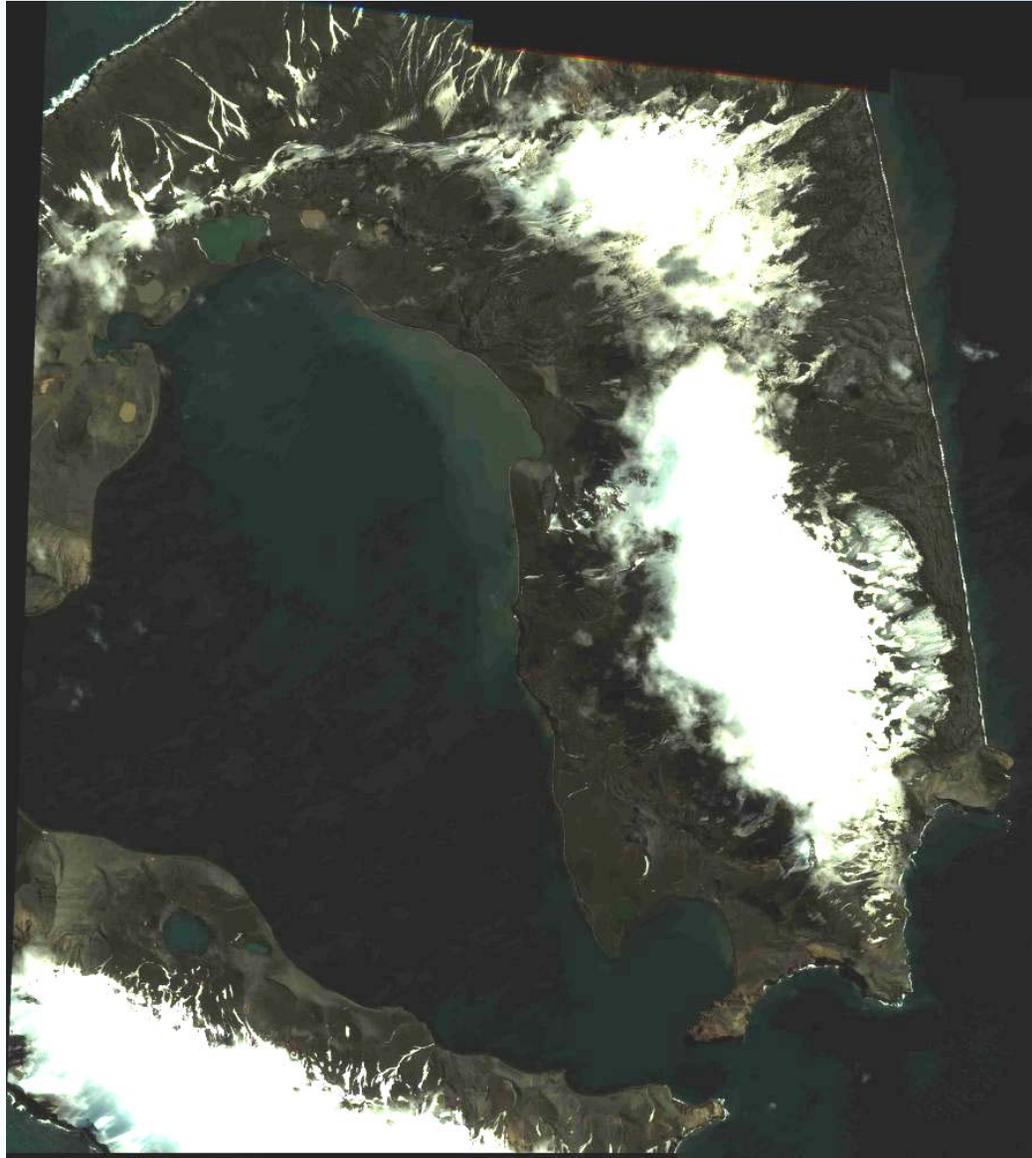
Deception Island  
Scene Centre : 62°57' S 60°40' W



© Canadian Space Agency / Agence spatiale canadienne, 1998

RADARSAT 1 Standard 5 Descending Image, acquired on November 21, 1998  
covering approximately 25 km X 25 km.

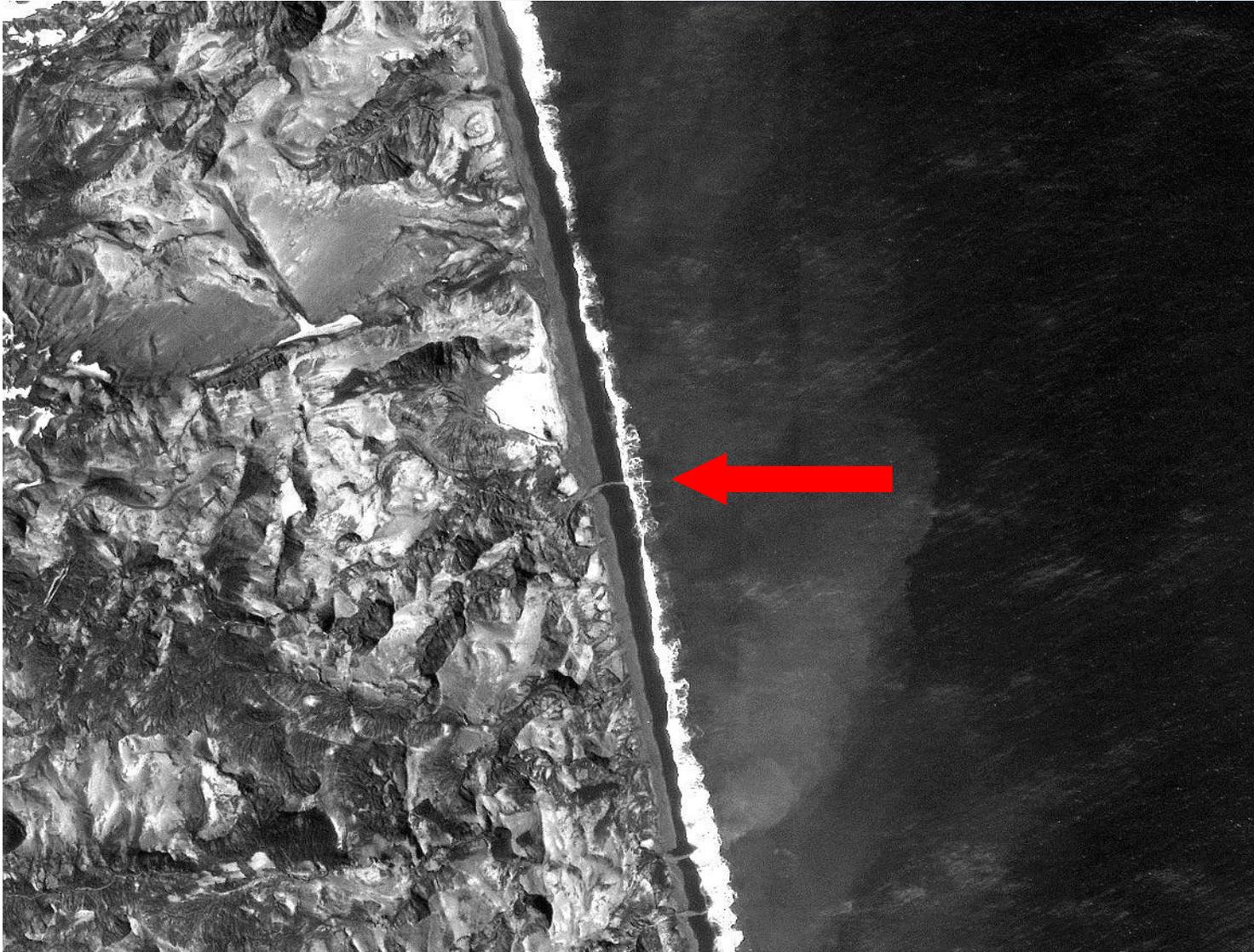
# Deception IKONOS Context Image



# ENE Straight Coast of Deception Island



Ocean Island Monitoring

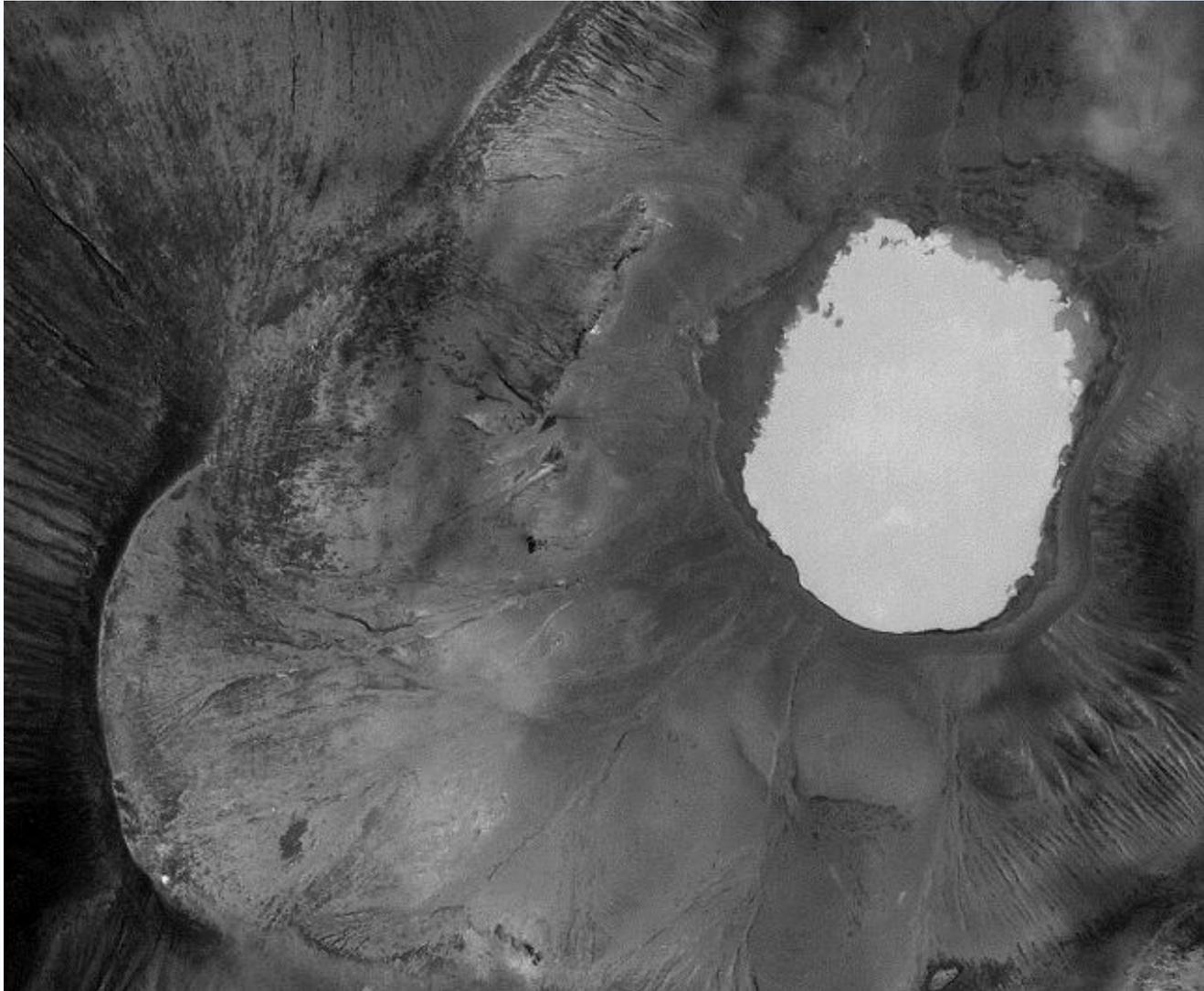
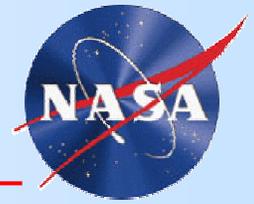


Runoff  
from glacier  
melt and  
retreat

Ikonos,  
2001

# Deception: ongoing studies

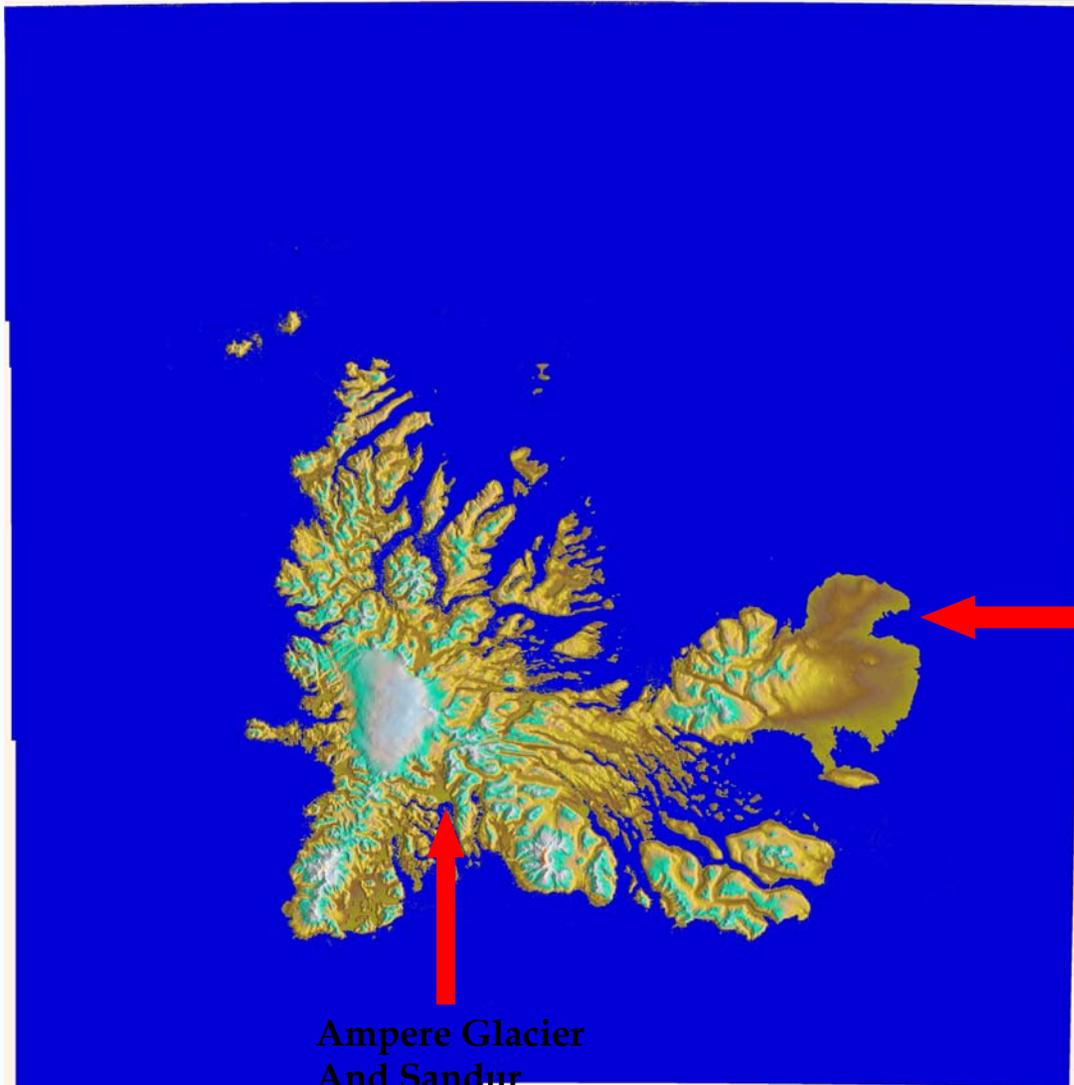
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Recession of ice-cover in maar crater lake: Ikonos 2002



# Iles Kerguelen: SRTM



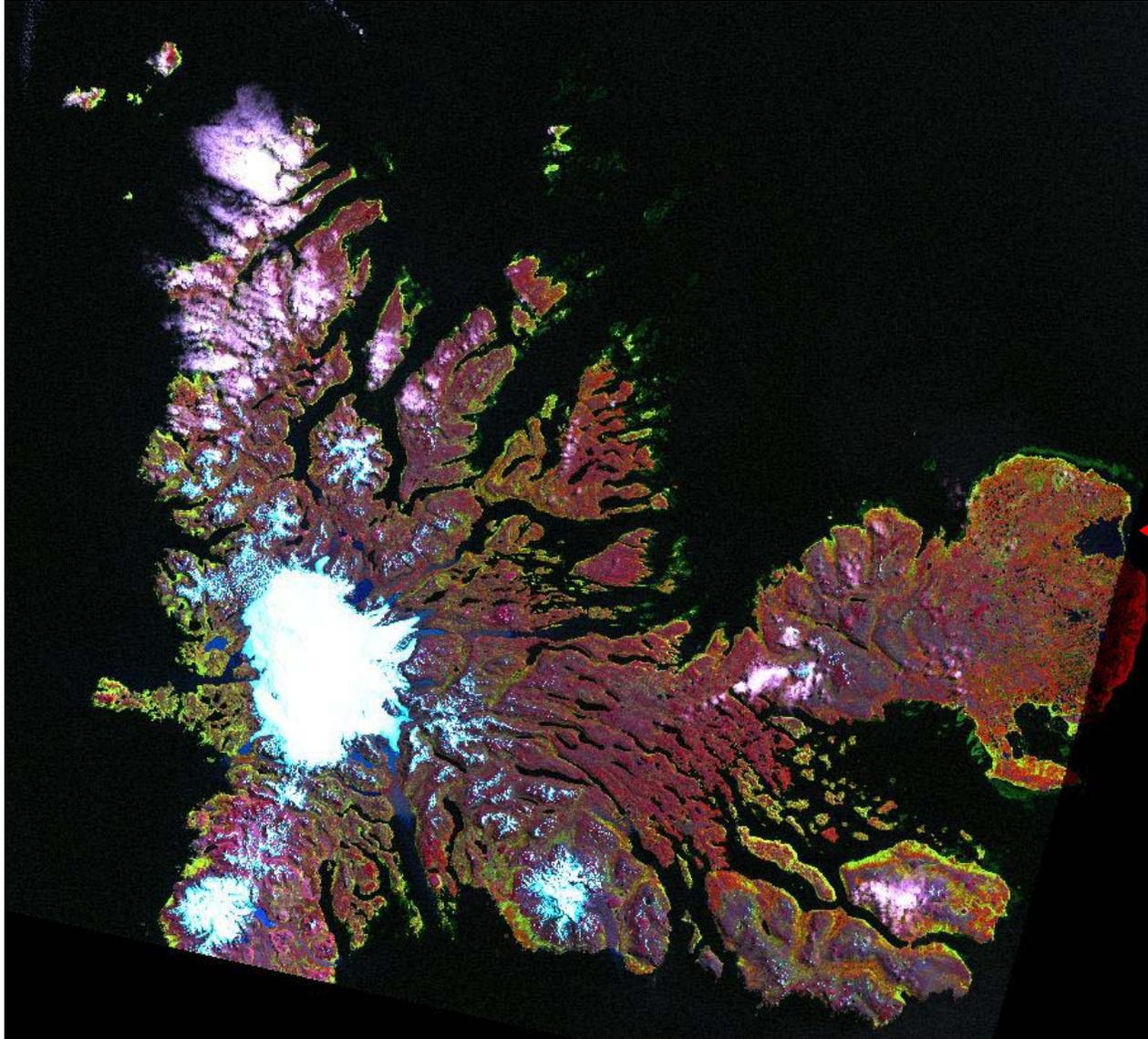
Ampere Glacier  
And Sandur

Lac  
Marville

# Kerguelen Landsat-7 Context Image



Ocean Island Monitoring

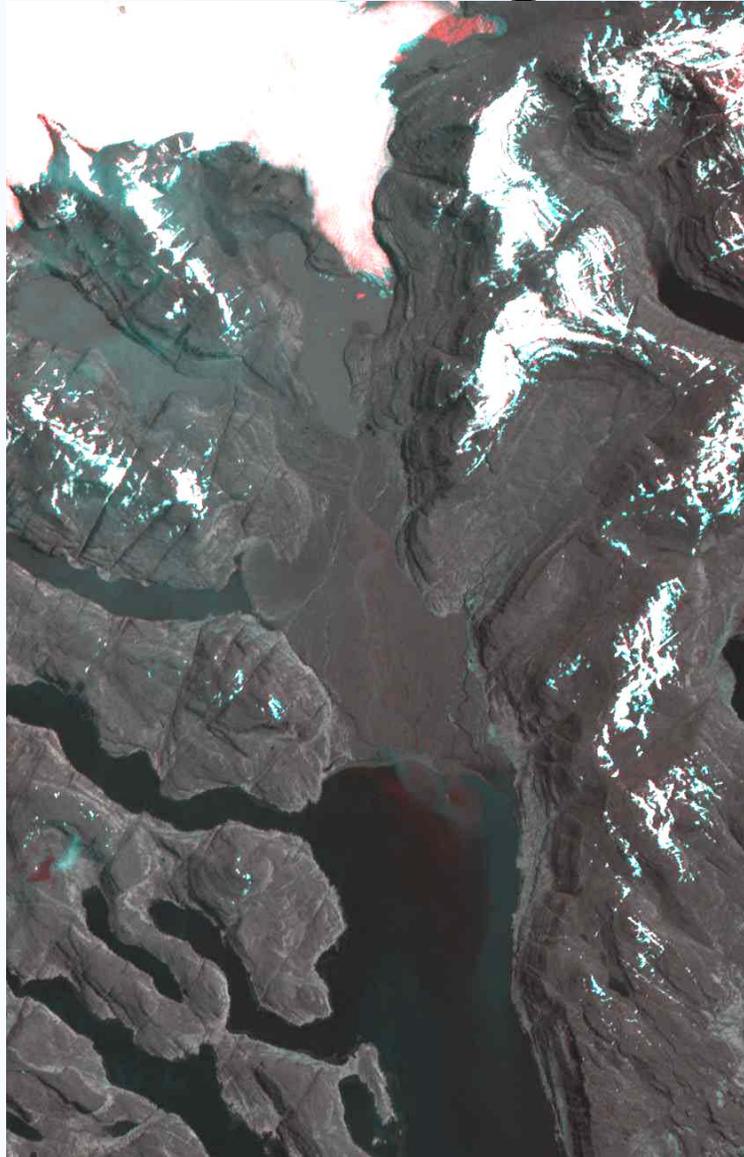


Lac  
Marville

11/27/01

# Kerguelen: Ampere Glacier, Sandur, Cook Icecap recession...

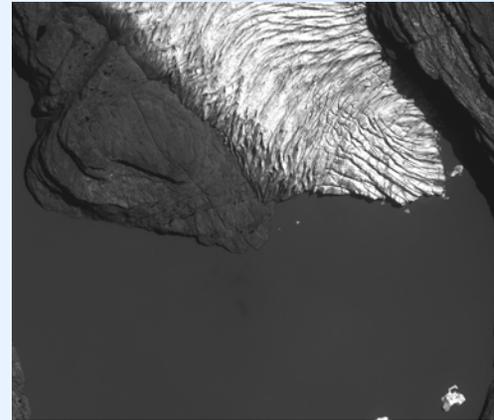
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Landsat-7



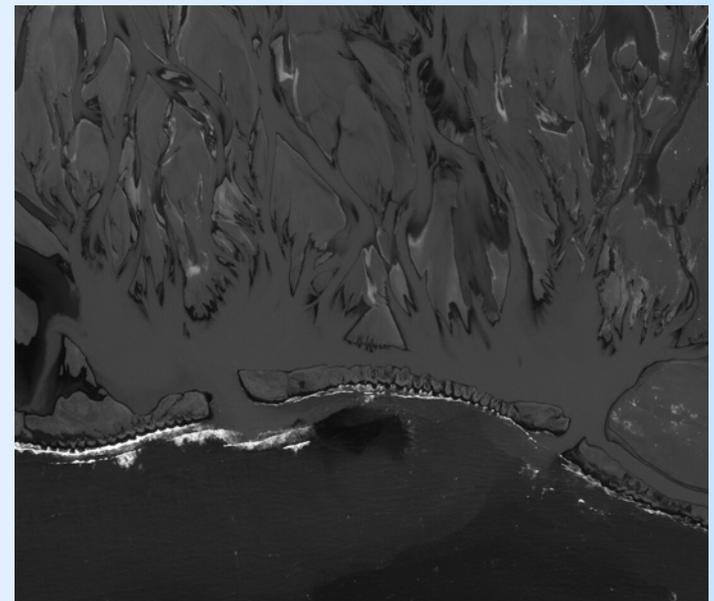
# Changing Ice-cover: *Kerguelen*



IKONOS  
Images  
2003

Ampere Glacier Terminus

Ampere Glacier Sandur



Distal Sandur from Ampere Recession

# Evolving Lac Marville: Eastern Kerguelen (France)



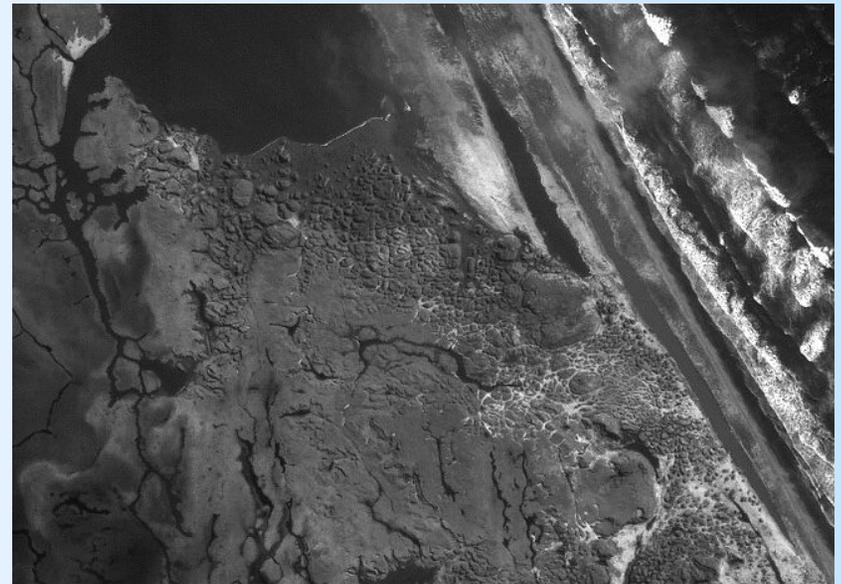
**Breakthrough**

Ikonos, 2002

# KERGUELEN: Lac Marville



Breakthrough from Lake to Indian ocean



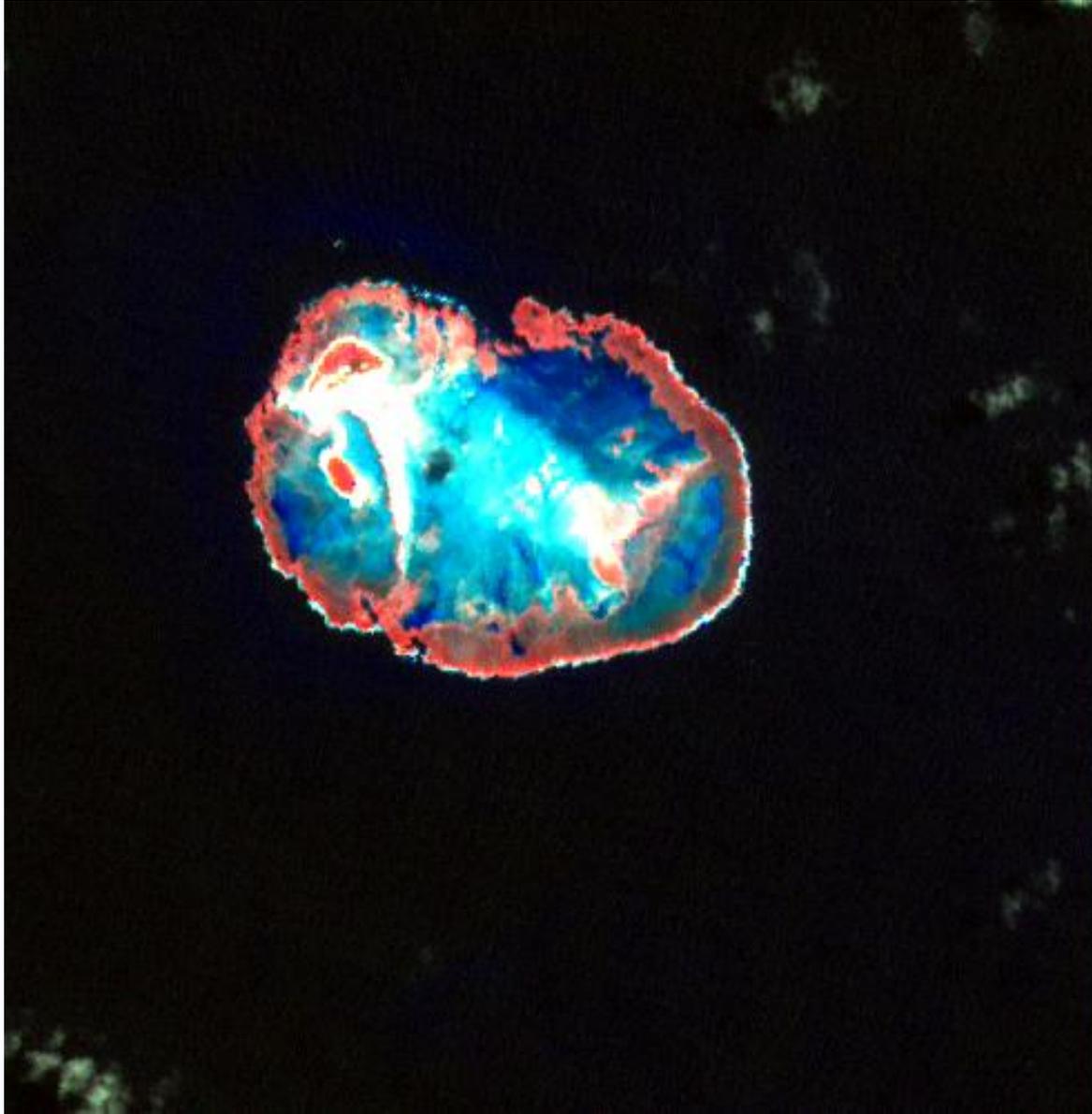
"Botryoidal terrain" at South End of Lake

Ikonos Images: 2002

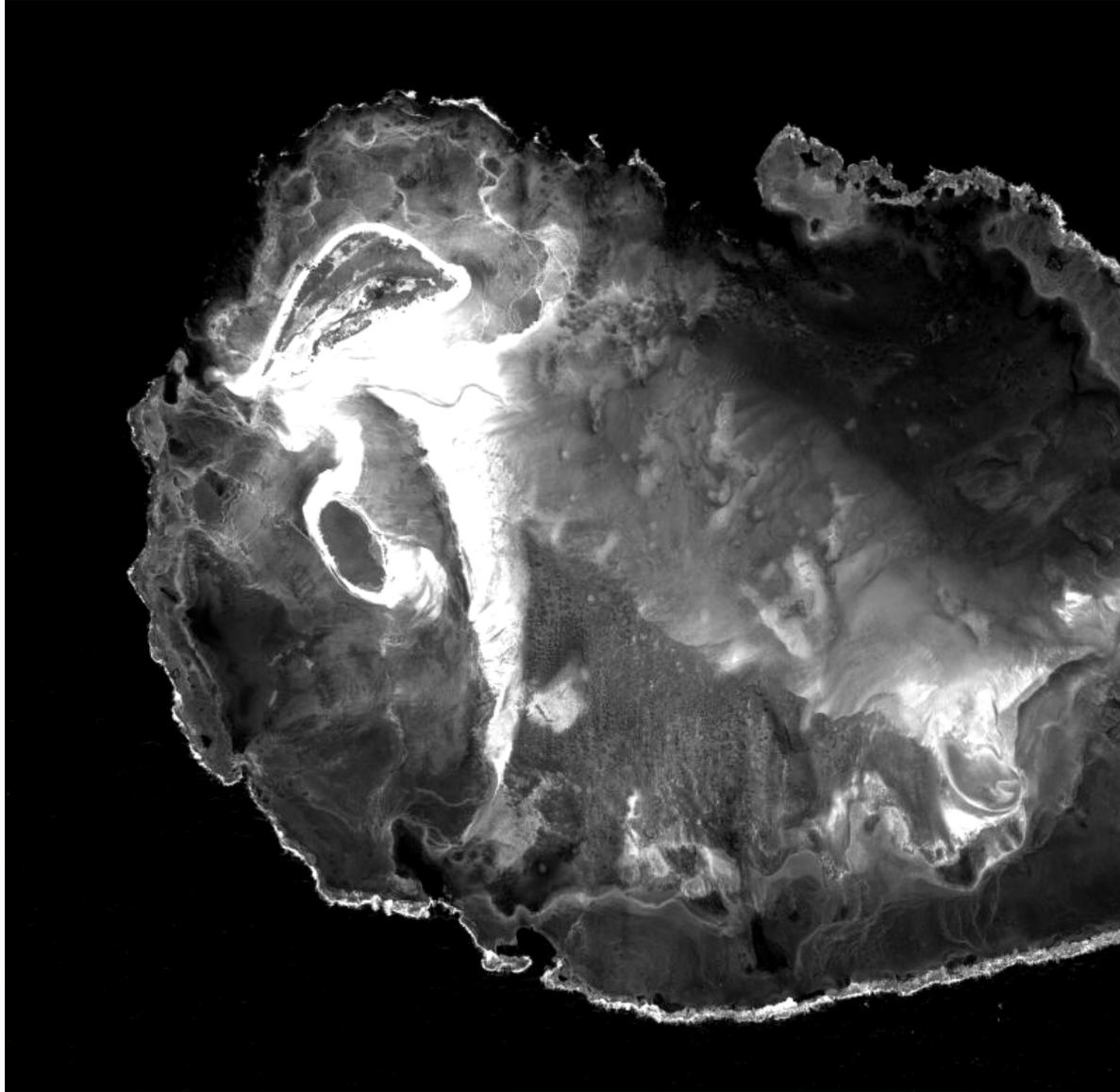
# Rocas Atoll Island Landsat-7 Context Image



Ocean Island Monitoring



# Rocas Atoll: Ikonos 2002



# Rocas 2002: Evolving S. Coast



Ocean Island Monitoring

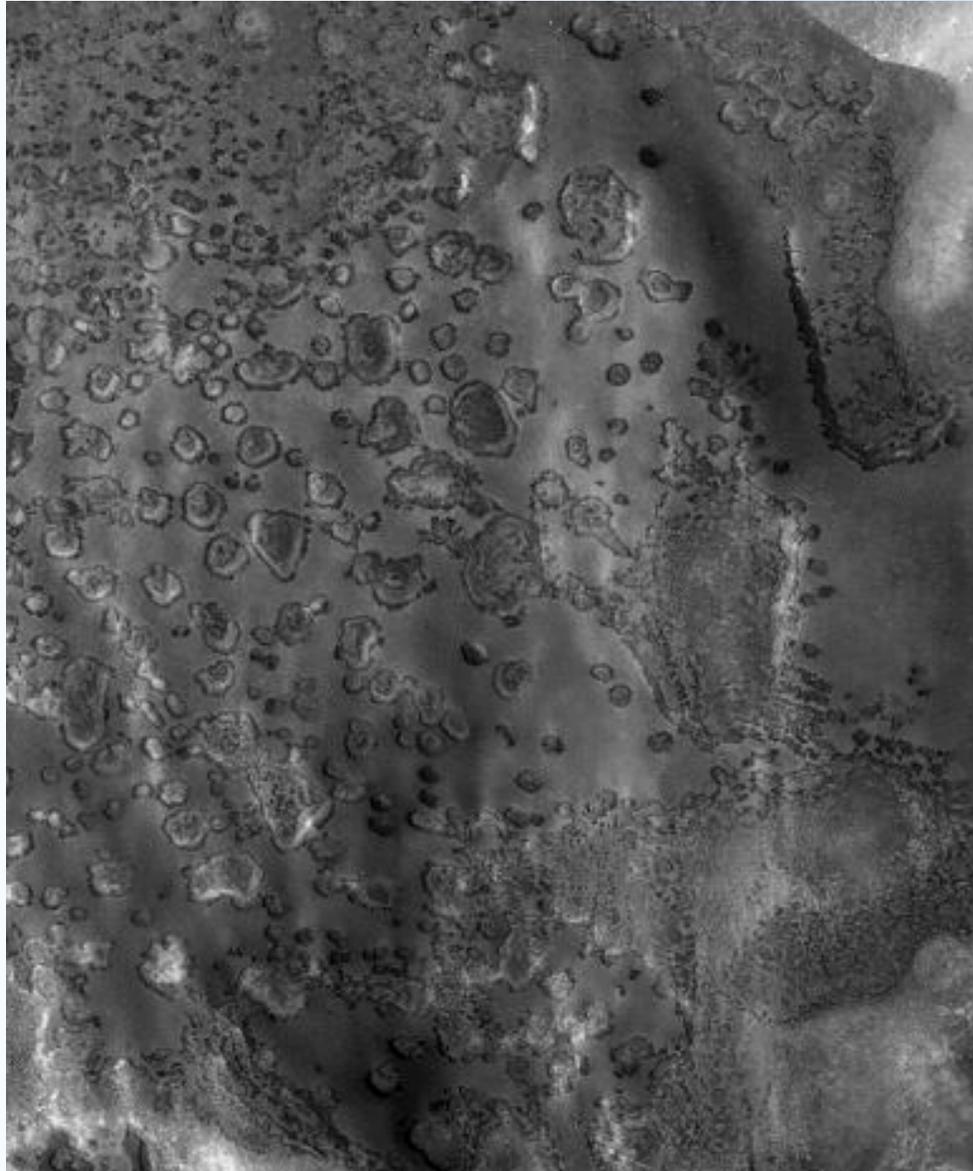
Roches  
Champignons



# Rocas Atoll: Atlantic Algal Reef

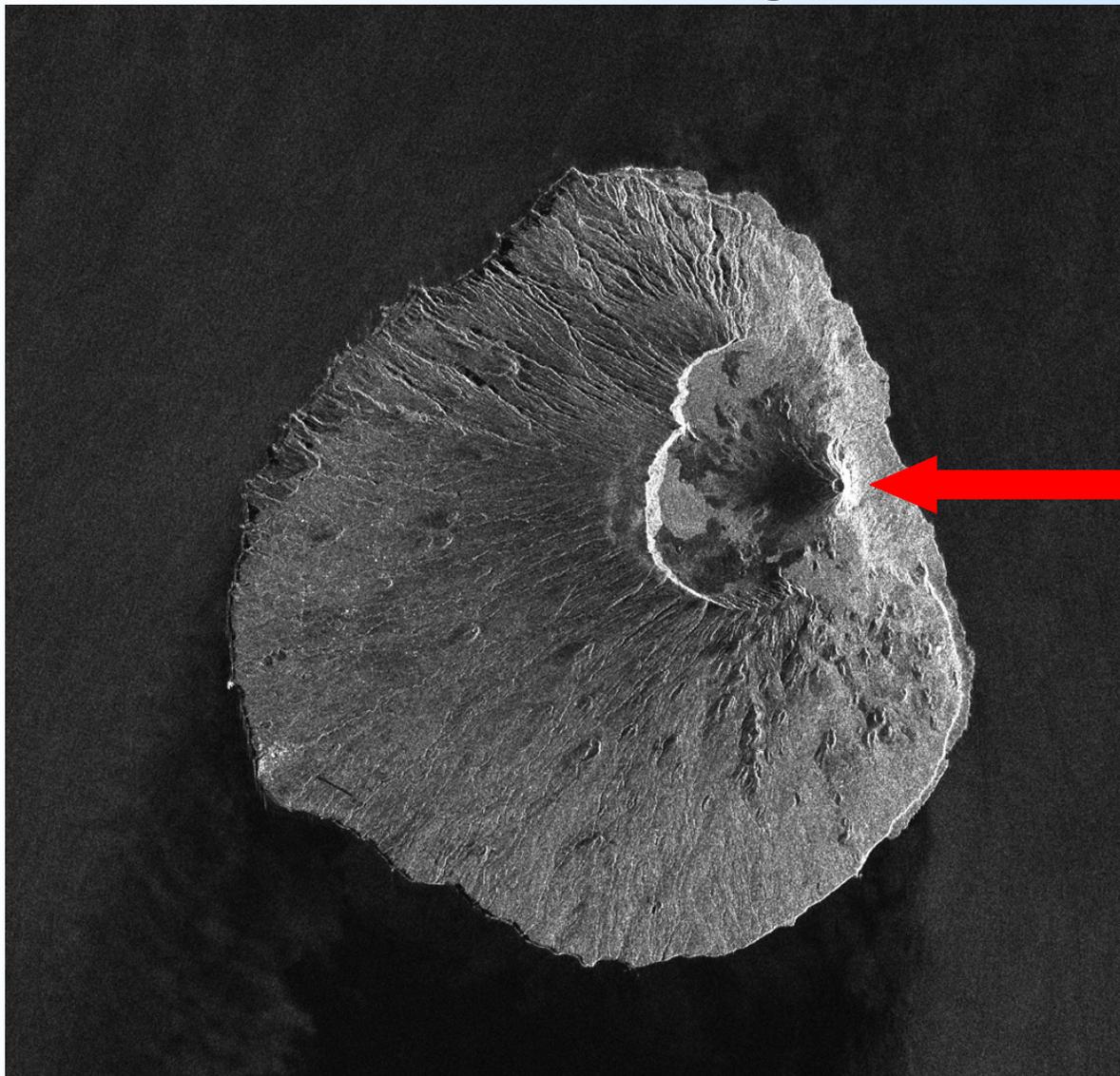


**Evolving  
Roches  
Champignons**



Ikonos, 2002

# Fogo Island RADARSAT Context Image

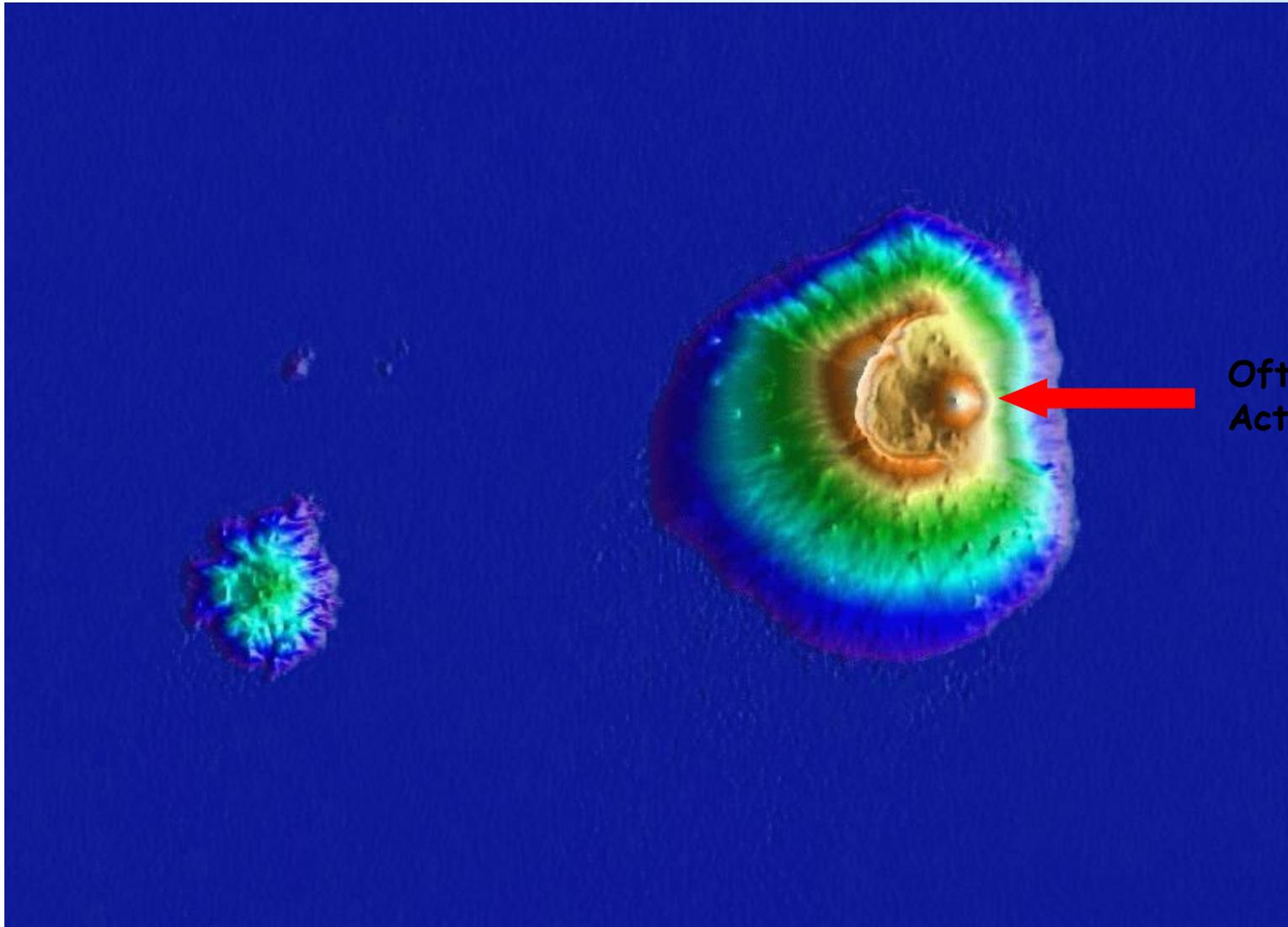


Primary Vent

# FOGO: SRTM Topography



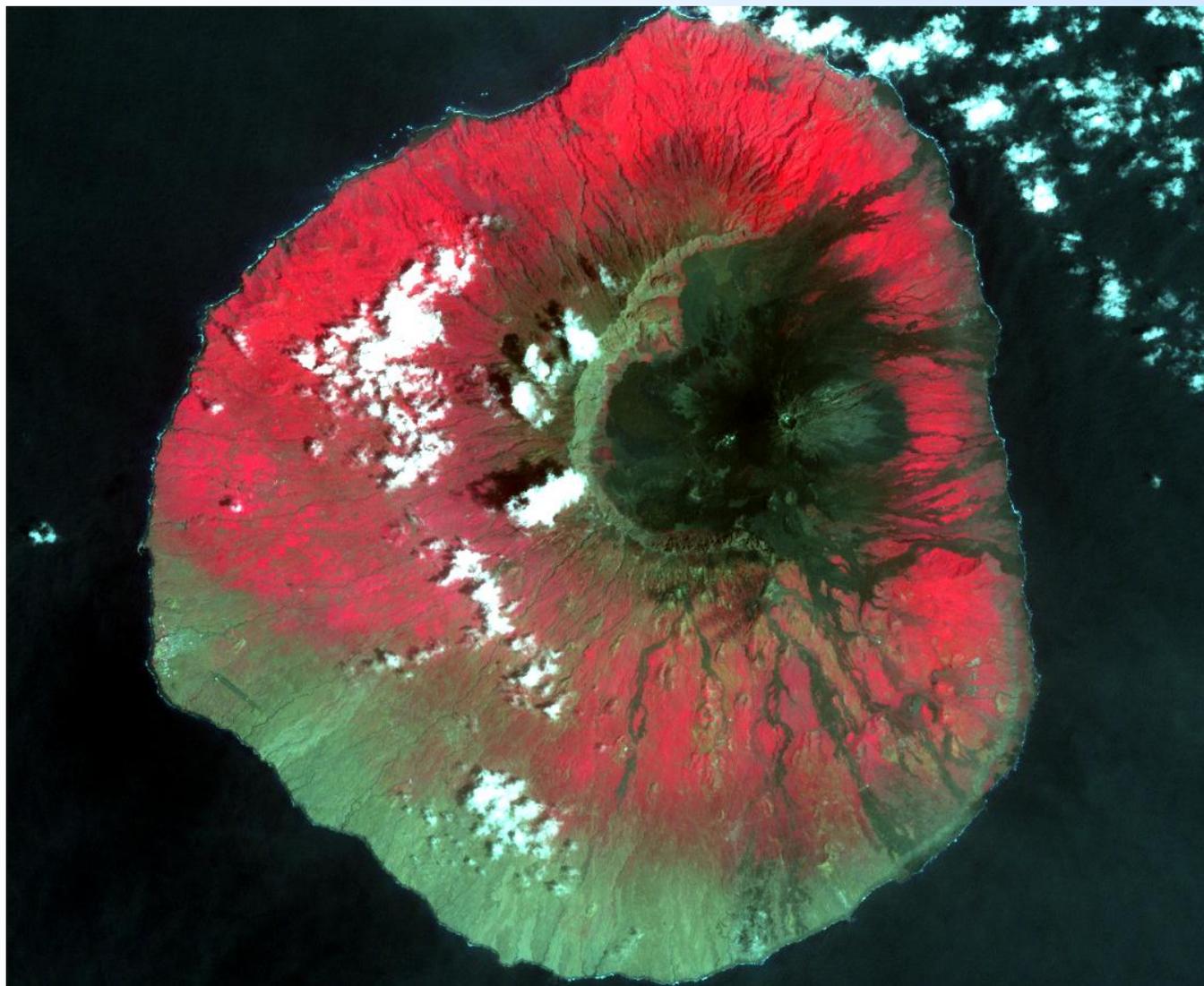
Ocean Island Monitoring



Often  
Active Cone



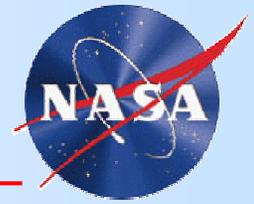
# Fogo Island



Landsat-7: 543

9/20/99

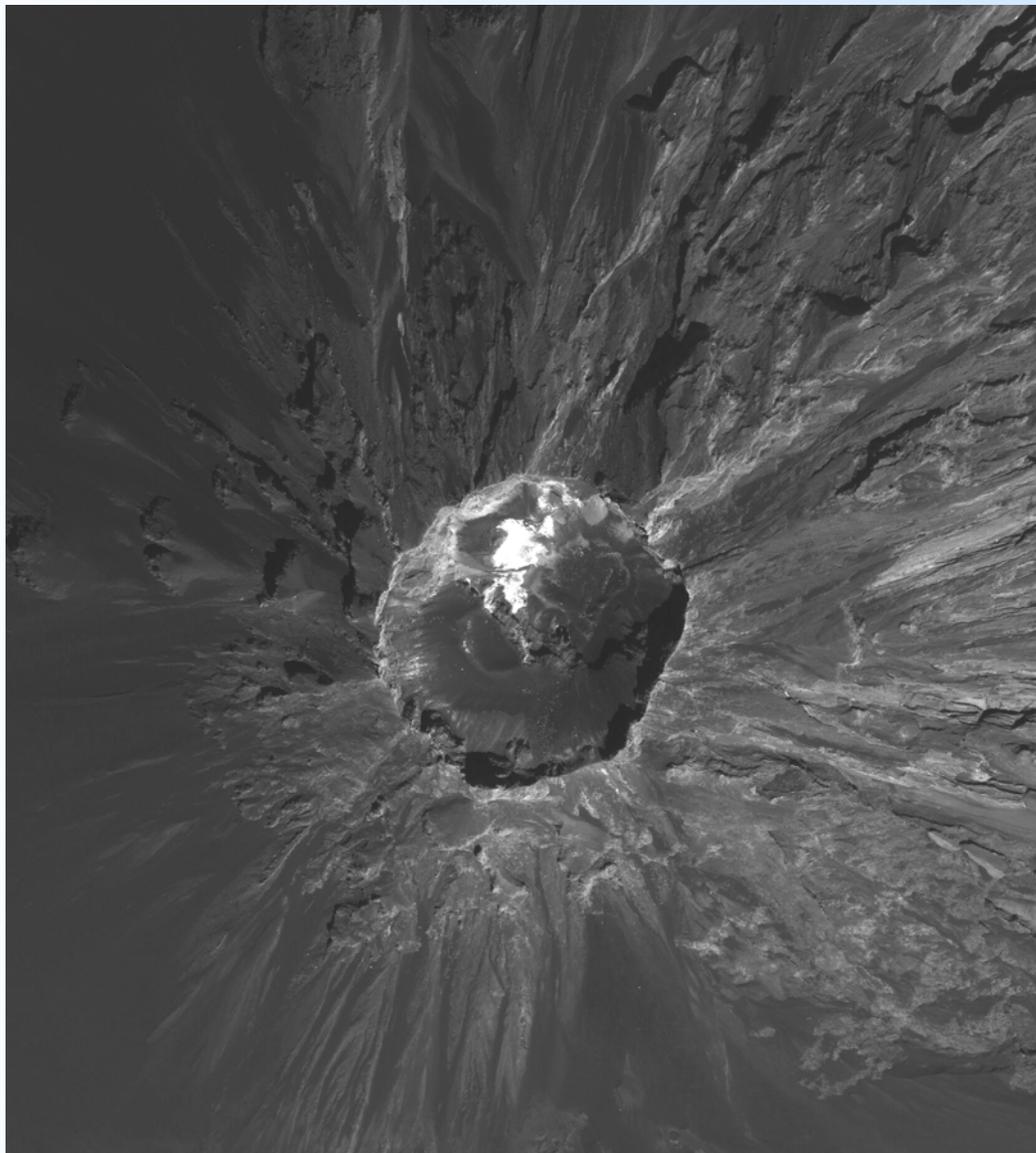
# FOGO, Cape Verdes: Caldera



1995 Vent and lavas



# FOGO: primary vent tracking...

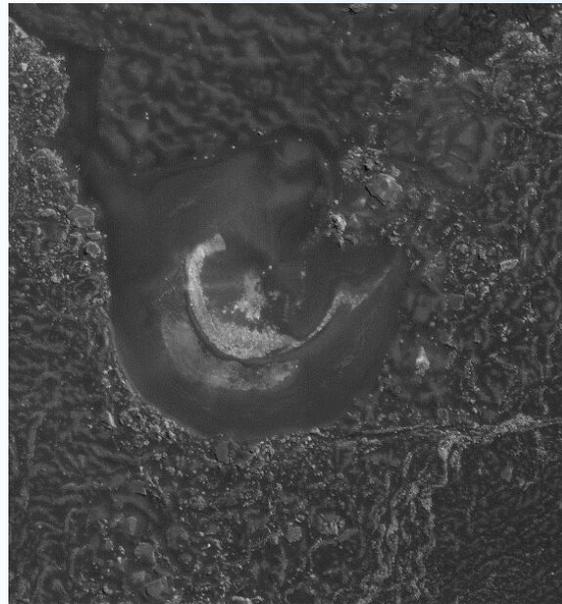


**Vent with active  
Fumaroles**

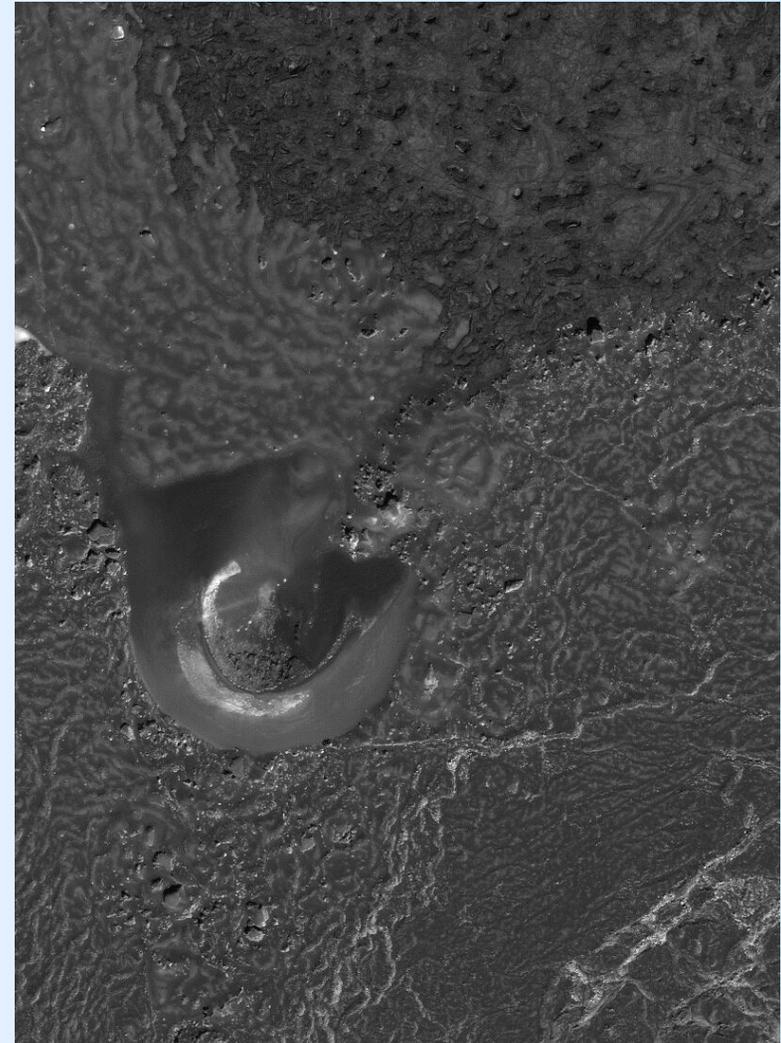
# Fogo: Post-eruption changes



Tracking erosion and landcover  
Variations at sub-meter scales...



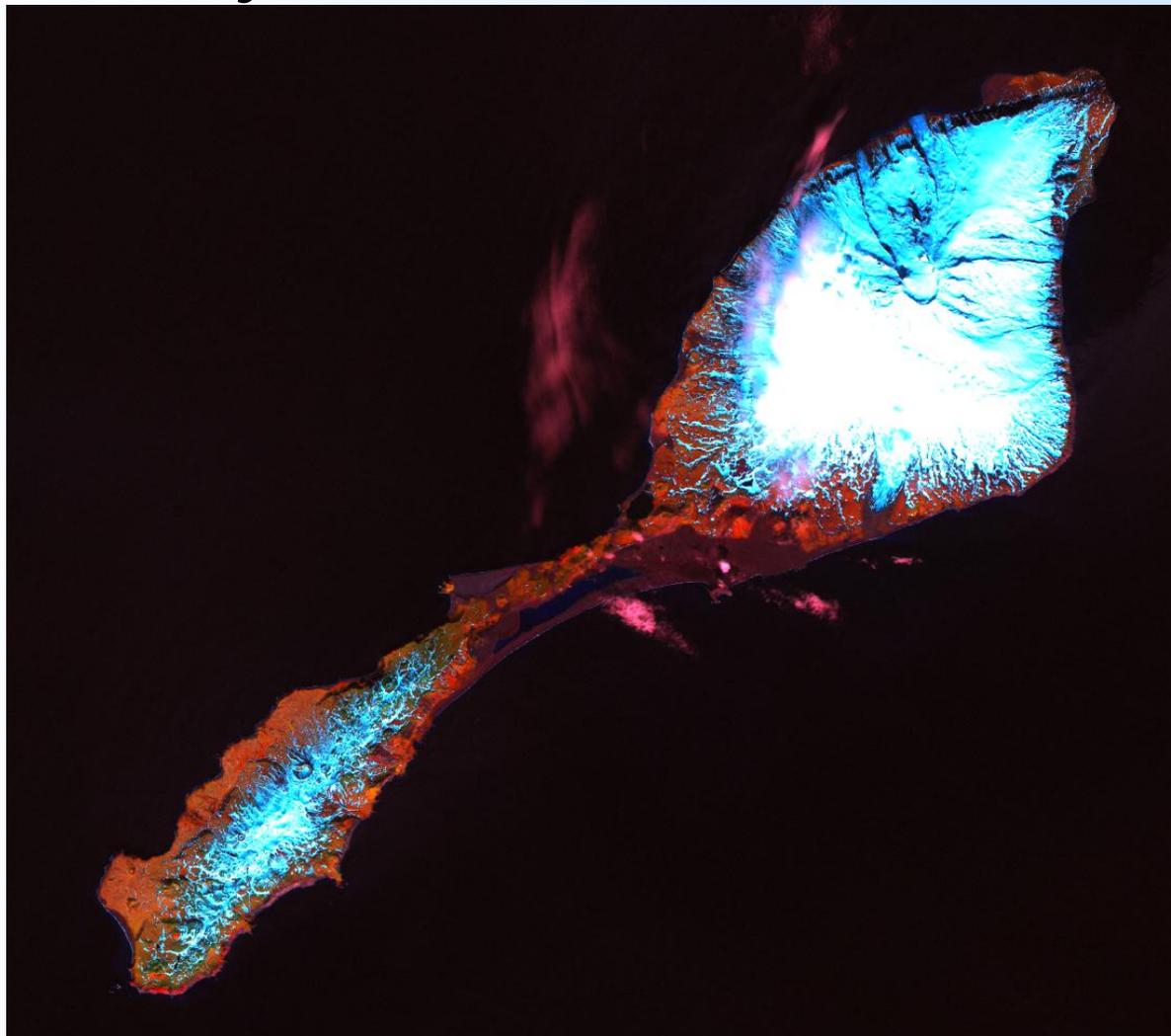
2001 Ikonos Image  
of the 1995 vent



2003 Ikonos Image of '95 vent



# Jan Mayen Island, North Atlantic

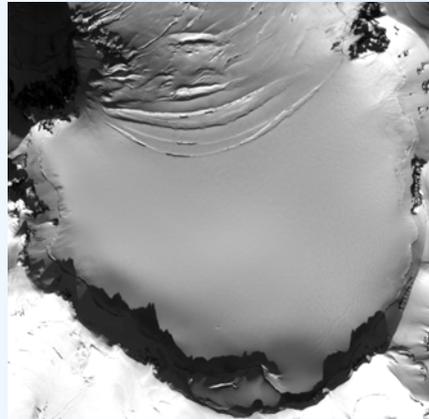


Landsat 7 Context image

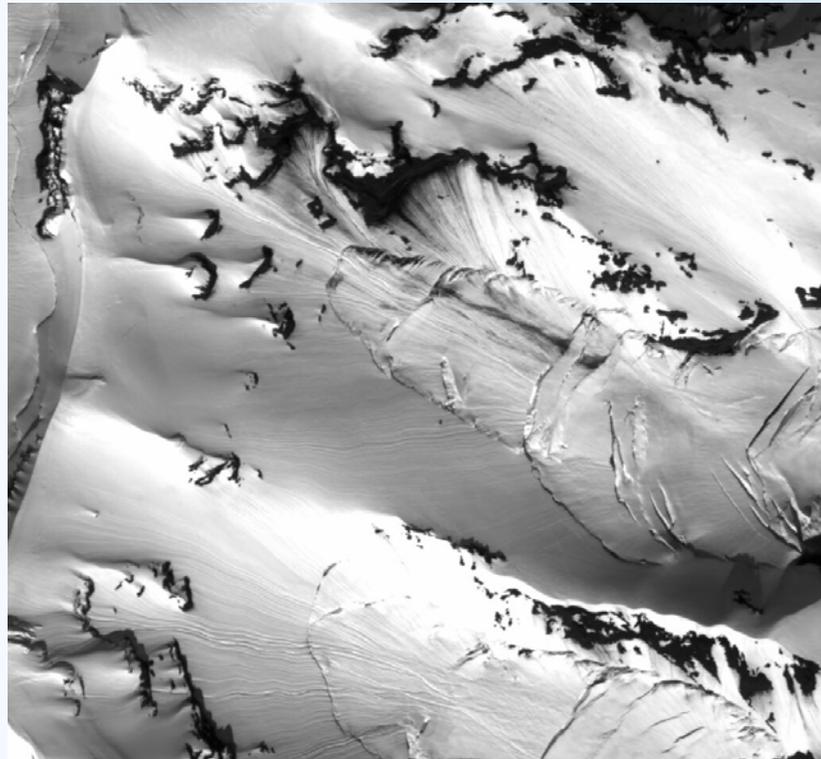
# Jan Mayen: Beerenberg 2002



Jan Mayen:  
Beerenberg



Summit crater of Beerenberg:  
Source of main outlet glacier



East flank:  
Avalanching due  
to mass wasting

# BOUVETOYA (S. Atlantic)

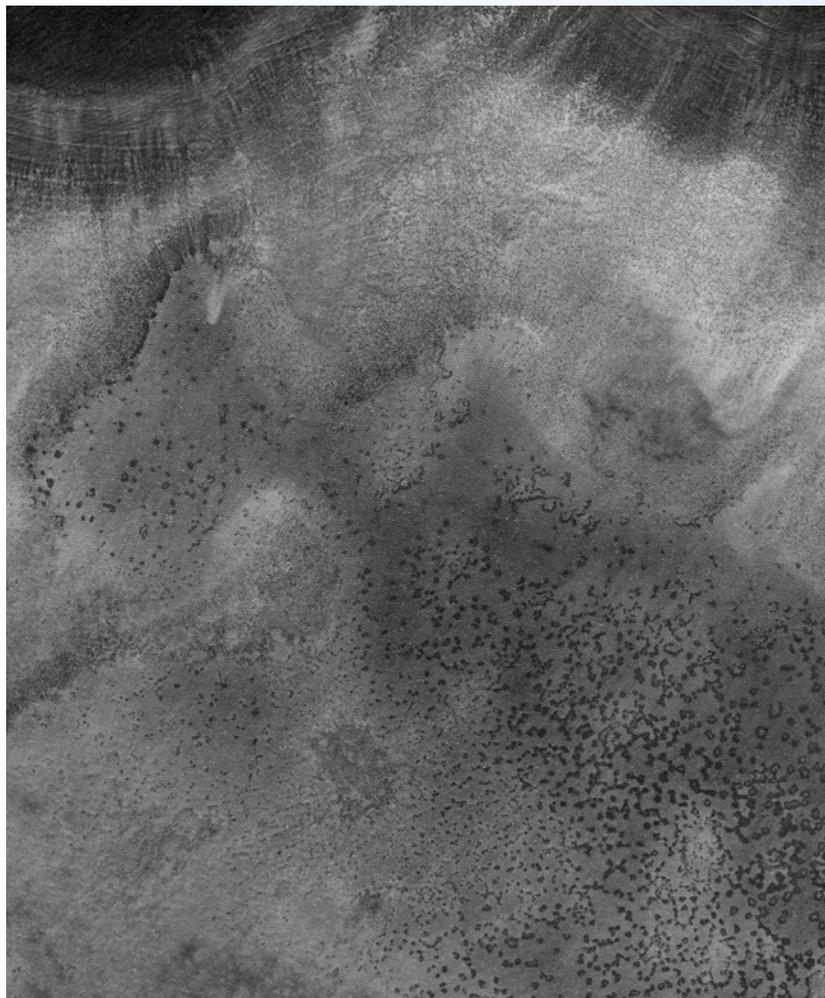


West Edge of  
Subglacial Caldera

Ikonos, 2002

# More to come...

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Submerged Heron Reef (*Ikonos*)



Eroding margin of Selvagens (*Quickbird*)



# Ongoing Studies

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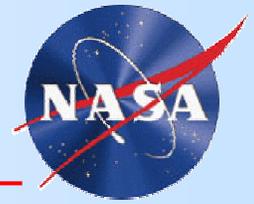
- **Bouvet Island (S. Atlantic):** Ice-cover changes under analysis
- **Jan Mayen Island (N. Atlantic):** Acquired in 2002
  - Require second time-step in 2003-2004 for change detection
- **New Island Imaging Requests** for additional time steps for Key Islands [*Surtsey, McDonald, Montagu, Sigketil, etc.*] needed...
- **Additional "Benchmark Islands" Acquired by SDP in 2002-2003:**
  - Kerguelen (Ampere glacier terminus, Lac Marville)
  - Rocas (2<sup>nd</sup> time step)
  - Corvo (Azores)
  - Selvagens (QB and Ikonos)
  - Gough
  - Niuafo'ou (Tonga)
  - Jarvis (phosphate atoll)
  - Anak Krakatau
  - McDonald (Indian Ocean)



# Summary

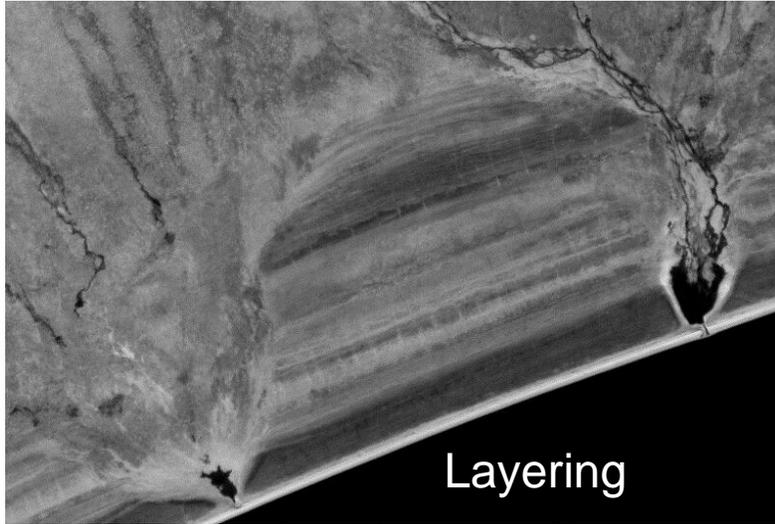
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- Established 1<sup>st</sup> Sub-meter Imaging Time Steps ( $t_0$ ) for ~ 20 Oceanic Islands (some 2<sup>nd</sup> time steps)
  - Identified Targets on Basis of Ongoing Landsat 7 Monitoring Program (and Radarsat SAR background mission)
- Demonstrated Detection of Key indicators in IKONOS Images:
  - Roches Champignons and their evolution
  - Recent eruptives (lavas and tephra)
  - Sub-glacial eruption effects (cauldrons)
  - Receding Ice Cover
- Discovered evidence of *unseen* 2001 eruption on McDonald
- Identified surface manifestation of sub-glacial eruption (Iceland)
- Measured AREAL changes at Surtsey Island (interannual)
- Observed breakthrough of Lac Marville on Kerguelen
- IKONOS DEM's Potentially Valuable for Volumetric Erosional Studies when compared with SRTM ones (ongoing work!)
- Value of Landsat 7 time series to direct sub-meter Imaging Demonstrated (by QuickBird and IKONOS)
- Demonstrated need for additional time steps for several islands



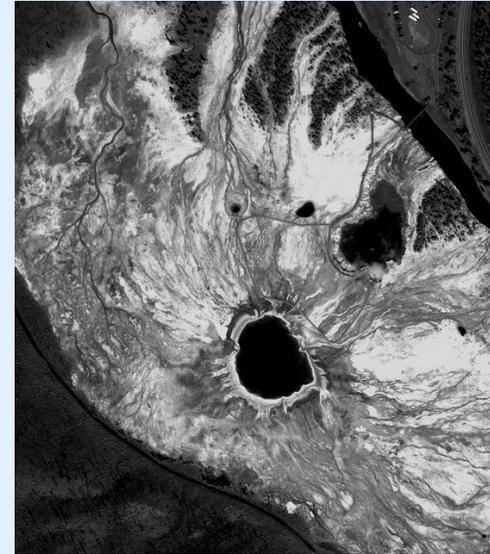
# Analogues to Mars...

Ocean Island Monitoring



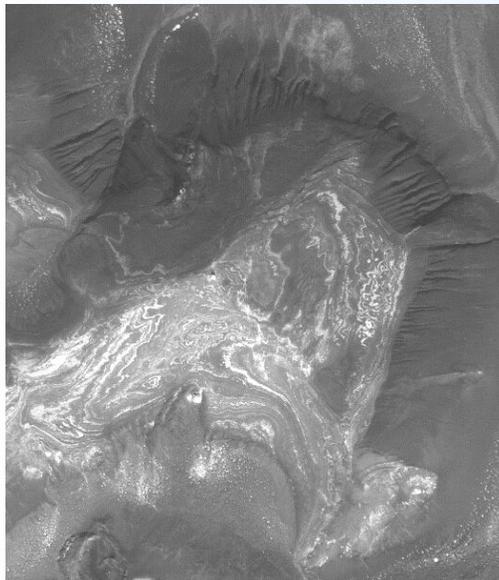
Layering

Crater lake sediments, Siberia

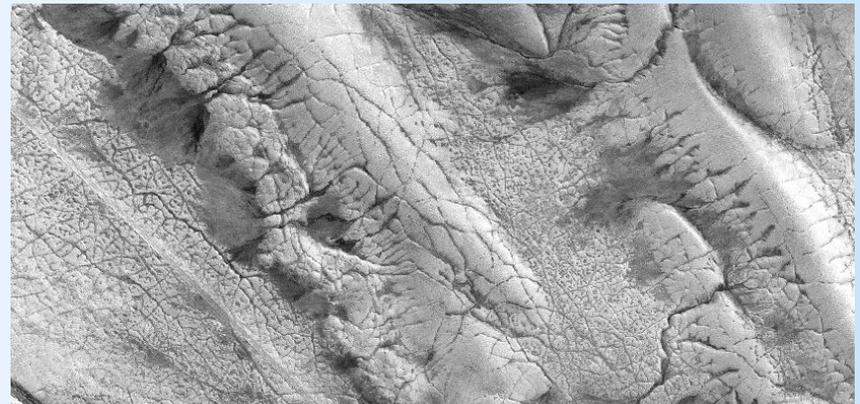


Vents

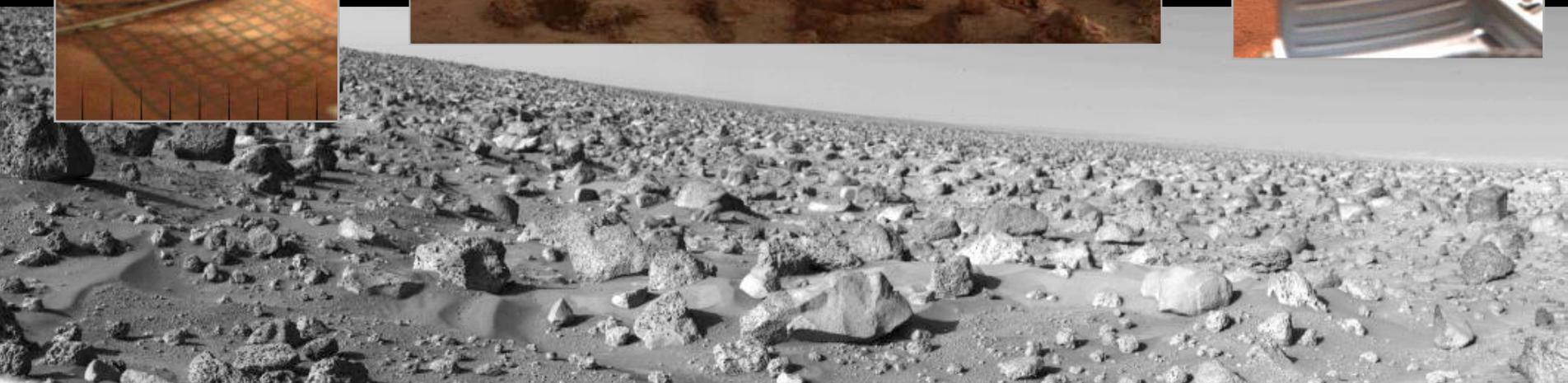
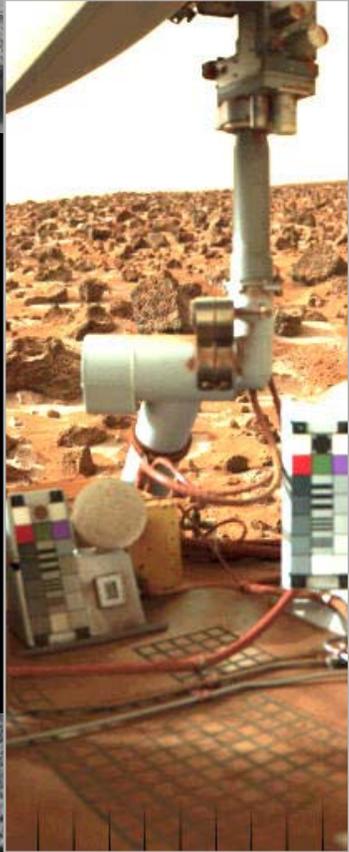
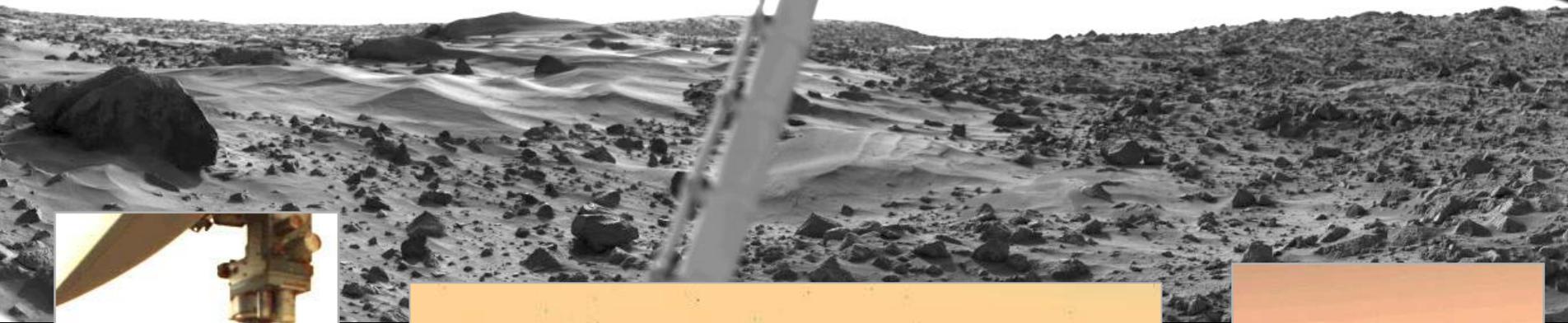
Yellowstone Hydrothermal systems



Gullies



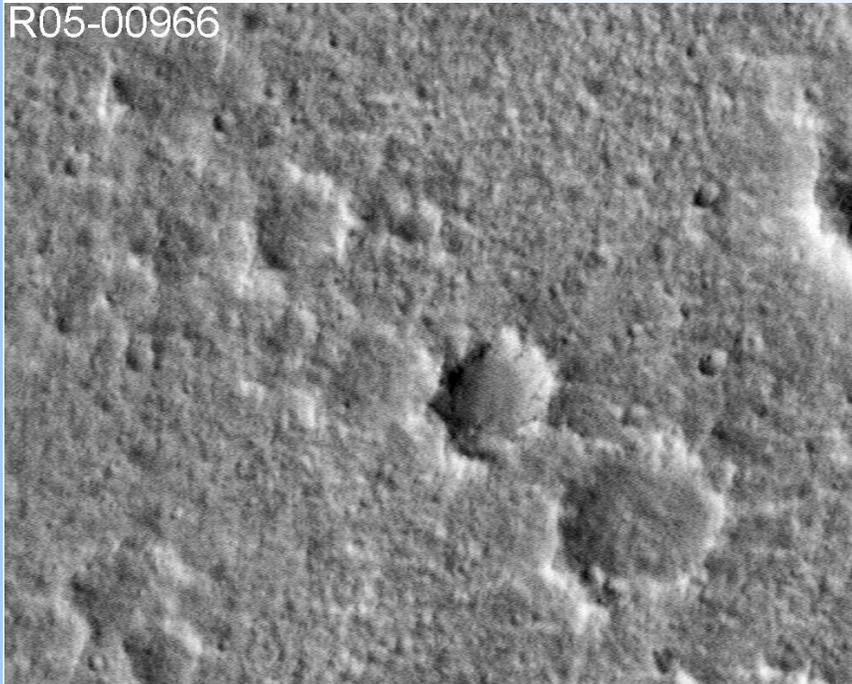
Evaporites



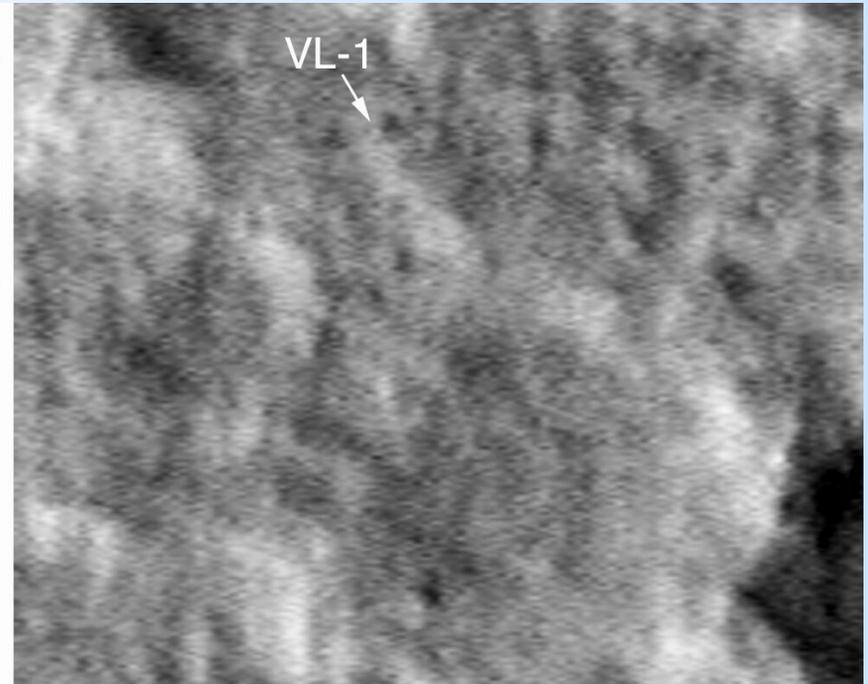
# Sub-meter imaging of Mars...



Ocean Island Monitoring



60 cm/pixel GSD Image of VL-1 Site

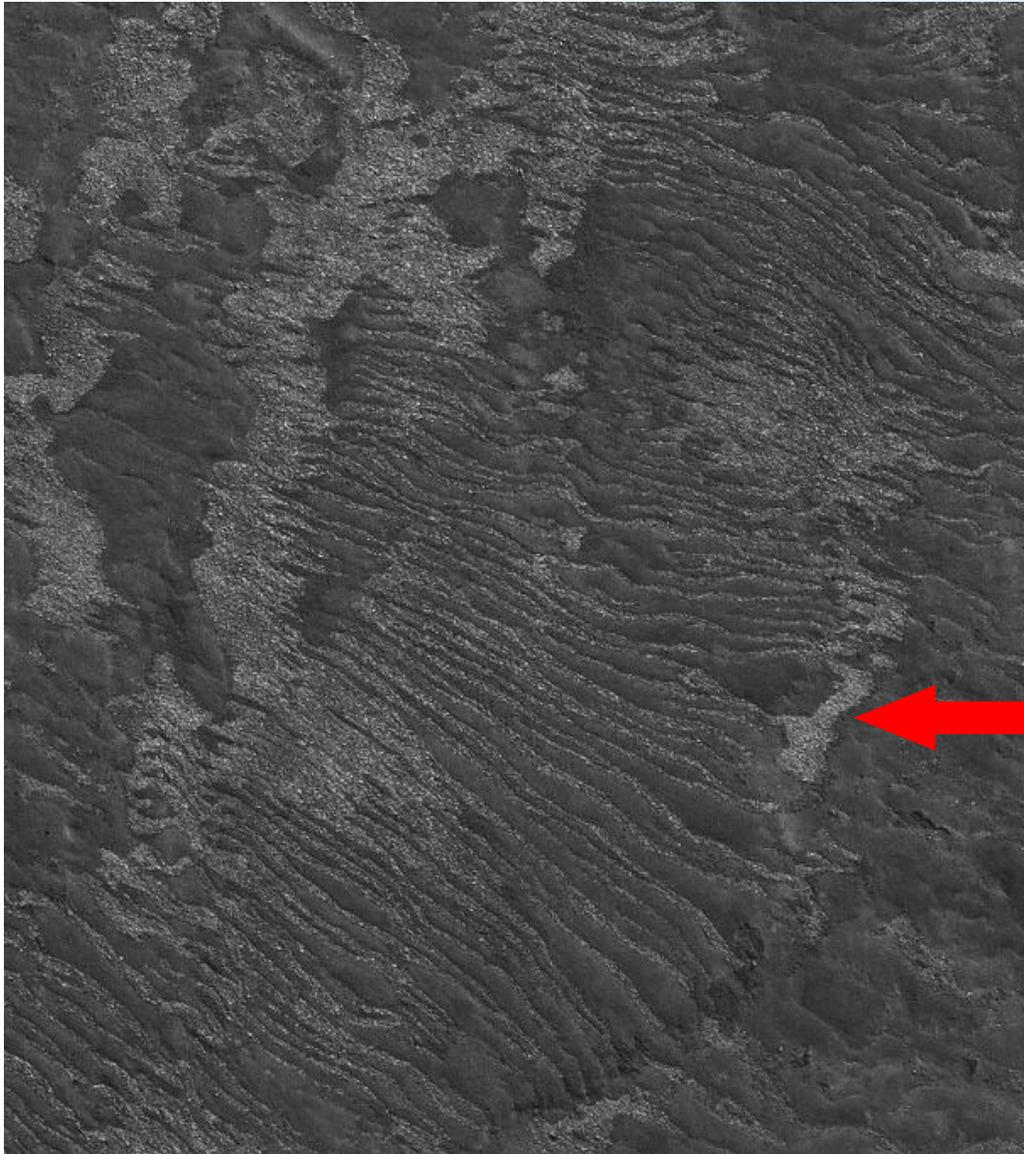


Enlargement of area showing VL-1 lander

**MGS/MOC Image Motion Compensation Experiment**



# Seeing rocks from Space...



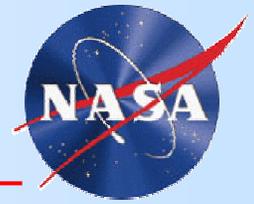
Meter-scale boulders:  
"Stone Runs" of the  
Falkland Islands  
as seen by IKONOS



**Boulders**

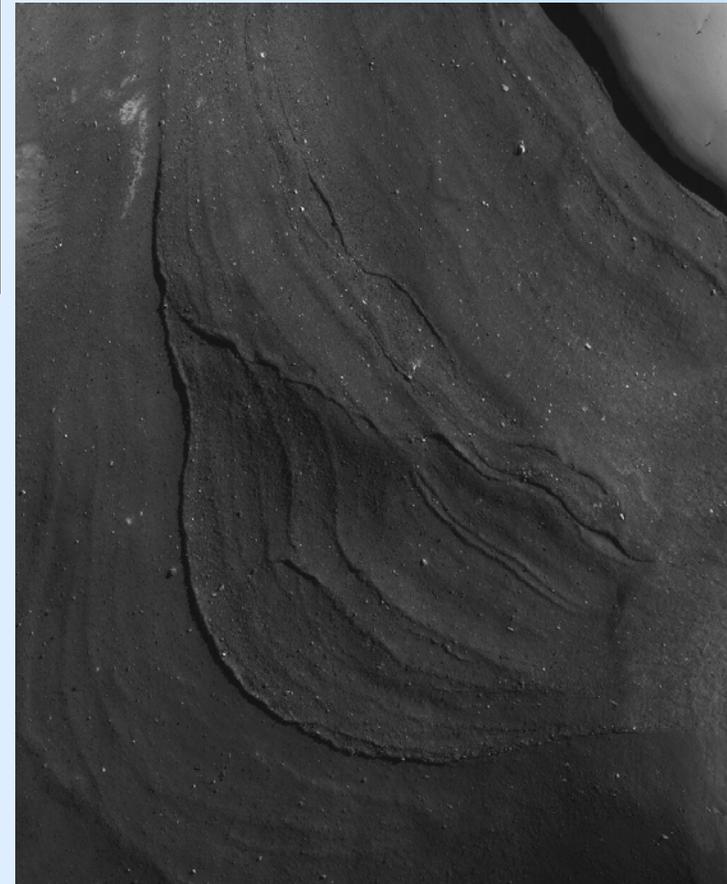
Measuring clastic  
Sedimentary debris will  
Be important for Mars  
(2005 MRO mission)

# Mars: Using Earth Analogues



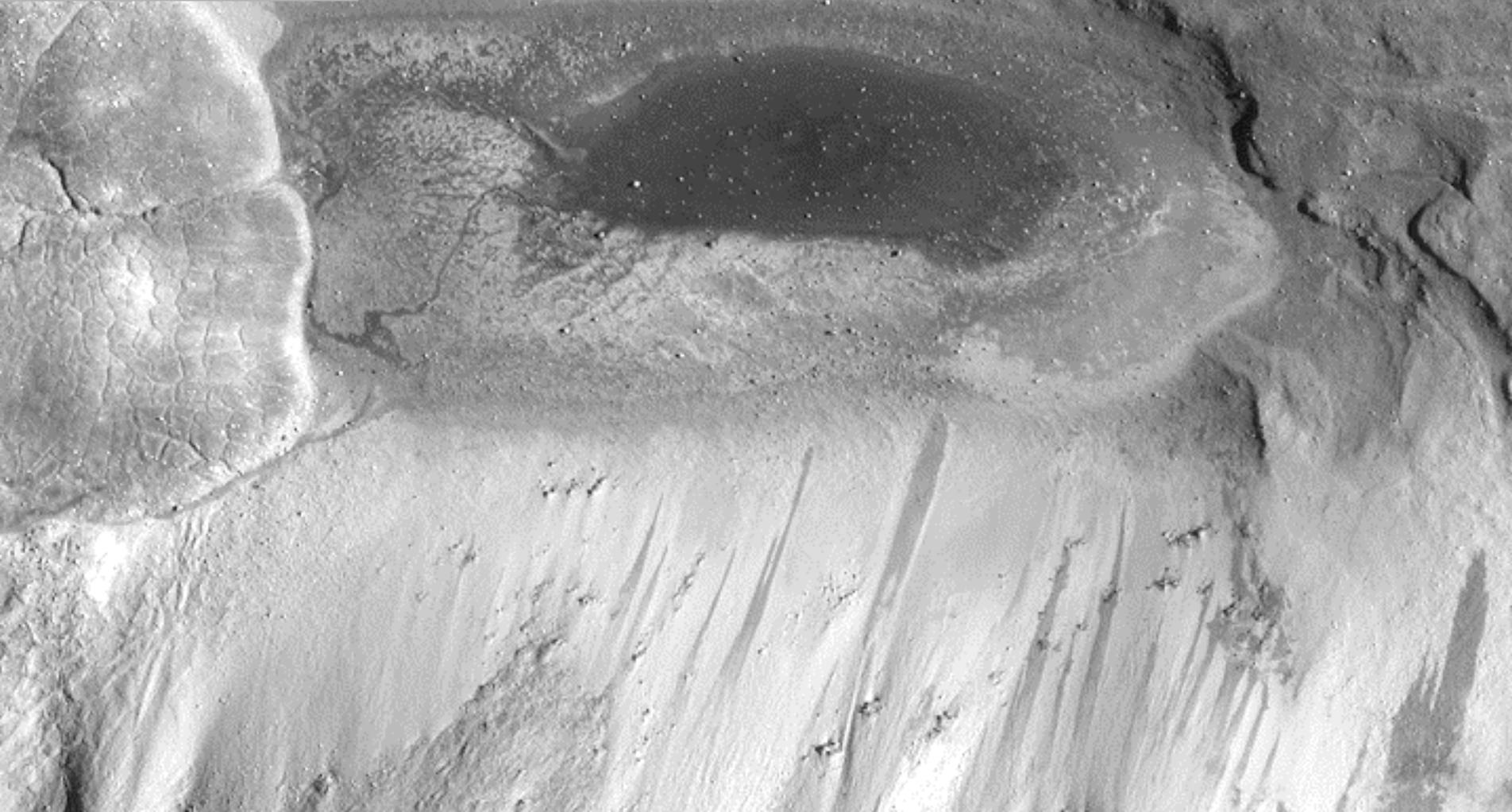
Mars Polar Crater with "moraines"?  
(Odyssey THEMIS + MGS/MOLA)

Lower Arena Dry Valley:  
Sublimation Moraines (Ikonos)

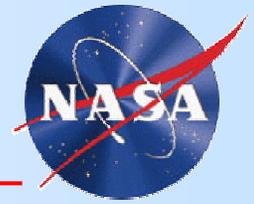


**Are there Sublimation Moraines  
On Mars?**

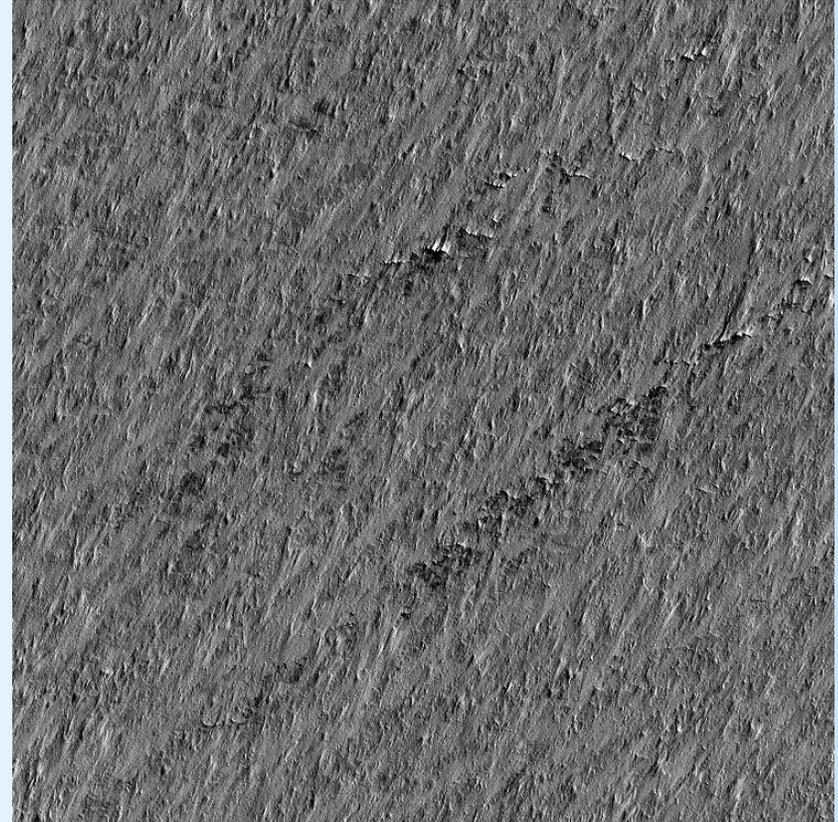
# Hypersaline Pond in Antarctic Dry Valleys



# Finding Meteorites from Space?



Allan Hills, Antarctica (synoptic)



Full IKONOS resolution of rocks in ice



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