The Flora of Antarctica and South Georga

Jonathan Shanklin

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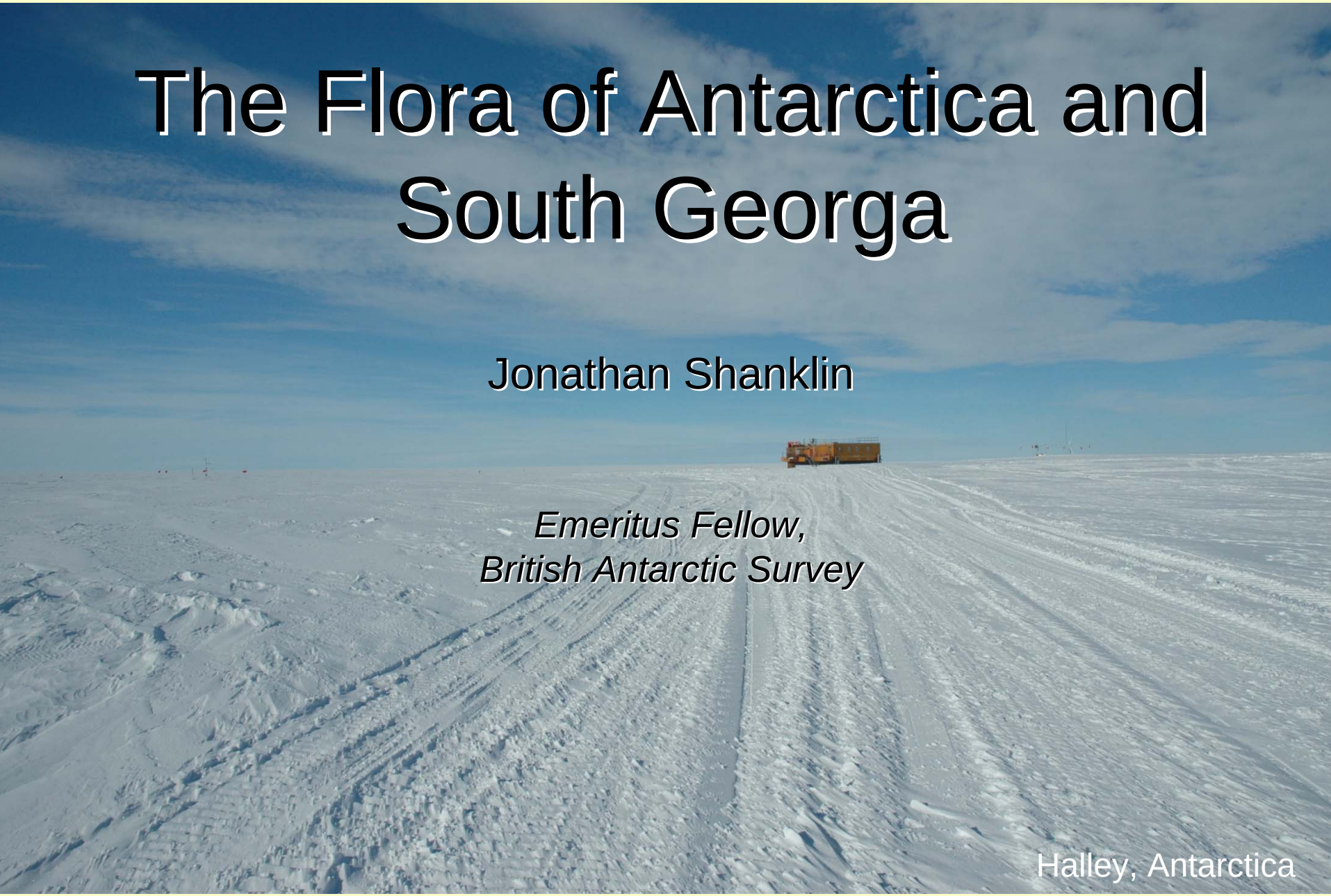
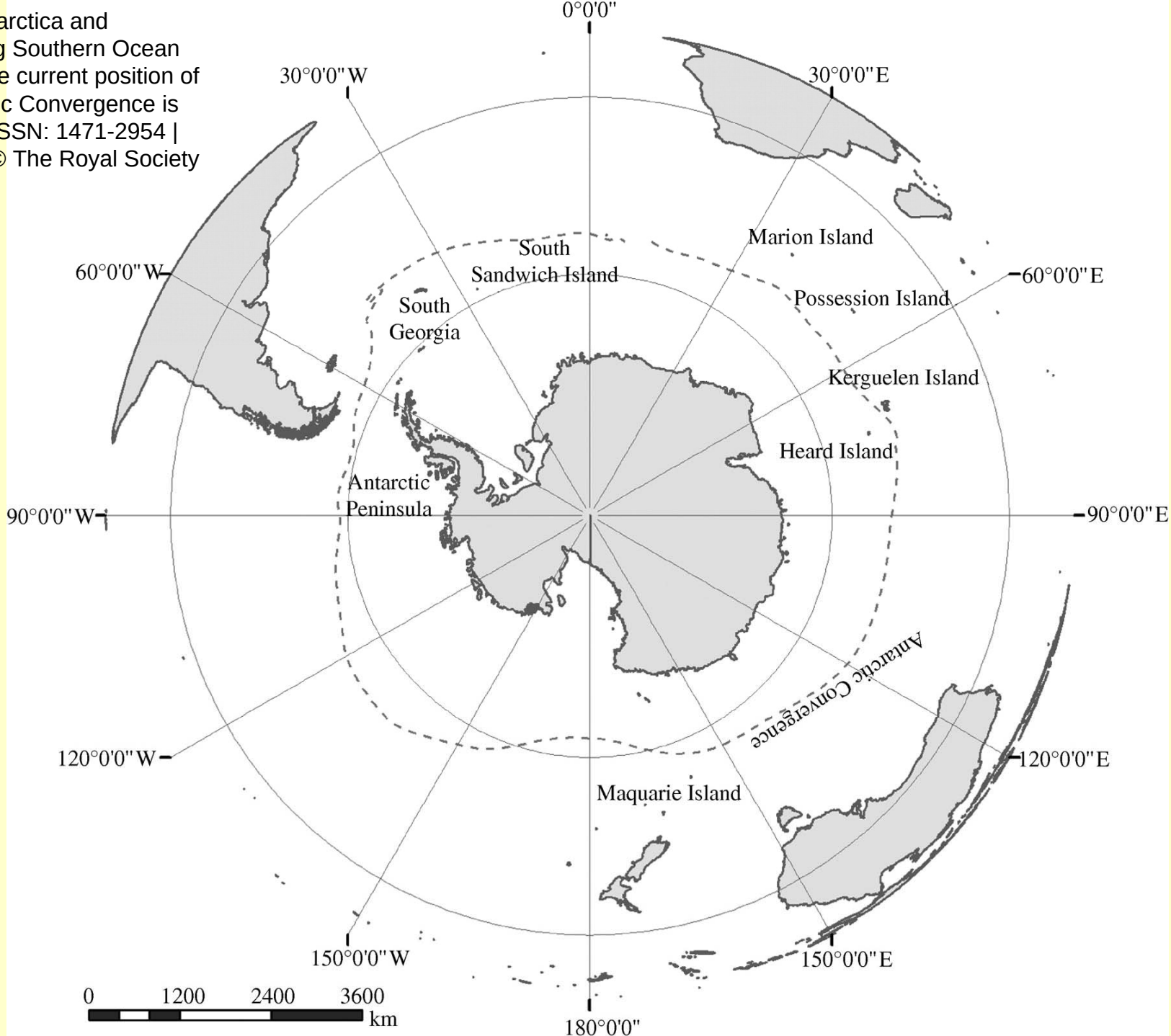
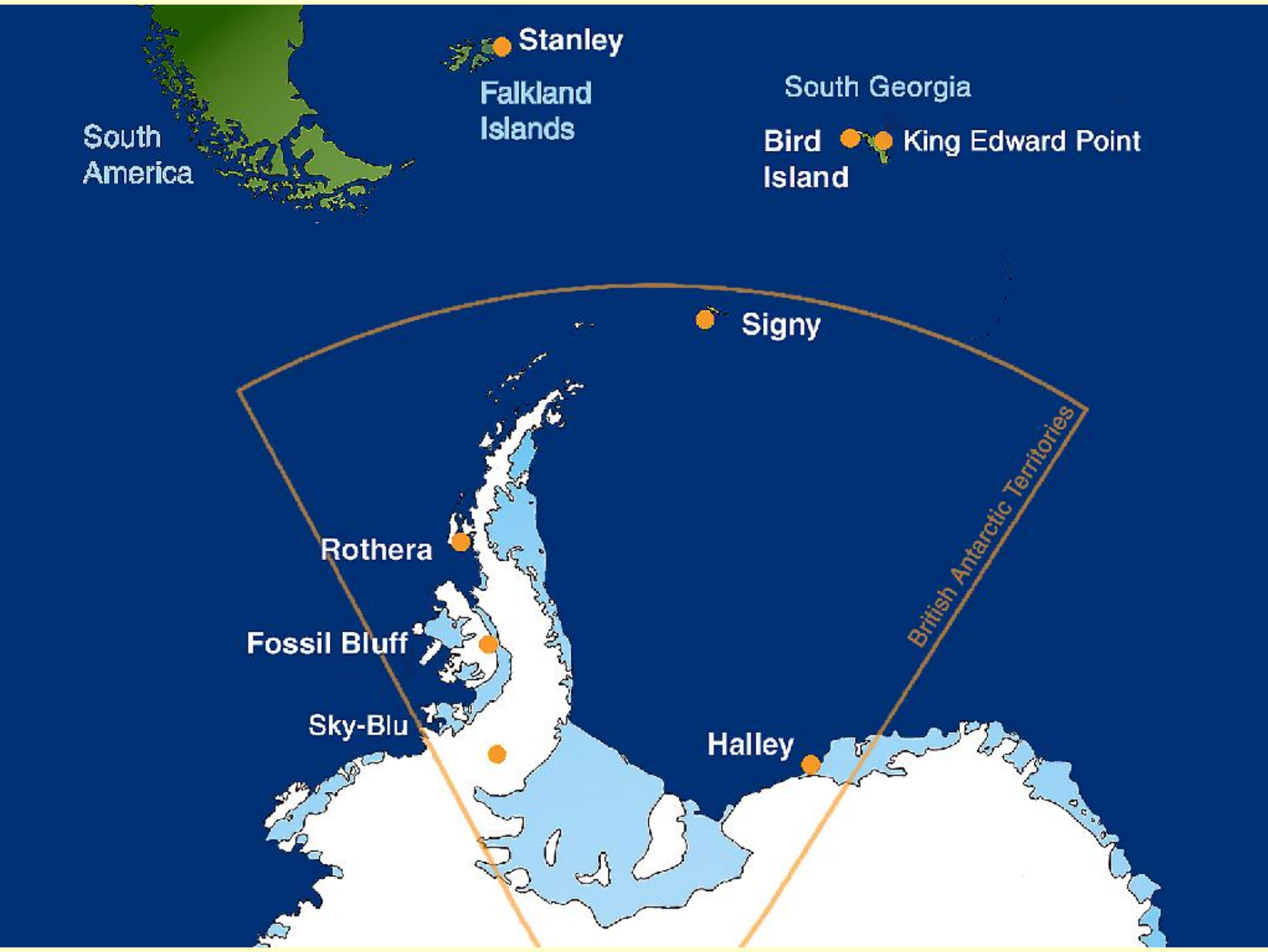
British Antarctic Survey



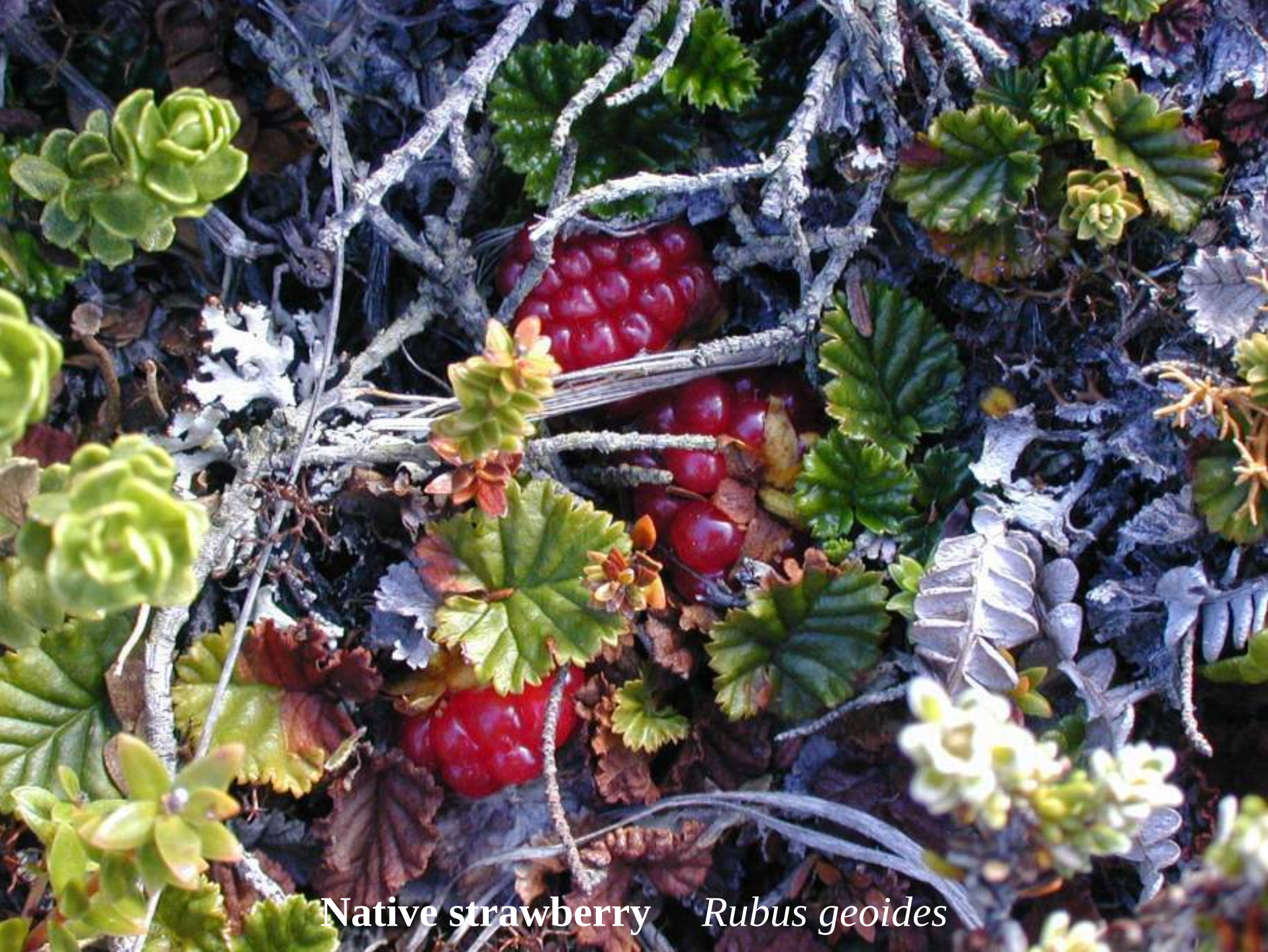


Map of Antarctica and surrounding Southern Ocean Islands. The current position of the Antarctic Convergence is indicated. ISSN: 1471-2954 |


Stanley
Falkland Islands
South America
South Georgia
Bird Island
King Edward Point
Signy
Rothera
Fossil Bluff
Sky-Blu
Halley
British Antarctic Territories


British Antarctic Survey
Cambridge, UK
RAF Brize Norton
Boscombe Down Airport
Calgary, Canada
BAS Aircraft
1 x Dash-7, 4 x Twin Otter
~10 day route to
Rothera Research Station
NORTH ATLANTIC OCEAN
Madrid, Spain
RRS
James Clark Ross
~38 days passage to
Rothera Research Station
Lan Chile
(commercial)
~2 day route from UK
to Falkland Islands
MOD Airbridge
~1 day flying from UK
to Falkland Islands
Cozumel, Mexico
RRS
Ernest Shackleton
~40 days passage to
Halley Research Station
Africa
BAS Aircraft
Secondary Route
South America
Ascension Island
BAS Aircraft
Primary Route
Montevideo, Uruguay
SOUTH ATLANTIC OCEAN
Santiago, Chile
Cape Town, South Africa
Halley VI Build
Charter Ship
Falkland Islands
Bird Island
South Georgia
Signy Island
Punta Arenas, Chile
WEDDELL SEA
Rothera
Research Station
Adelaide Island
Halley
Research
Station
Brunt Ice Shelf
DROMLAN Route
~2 day route to
Halley Research Station
Antarctica


Berry lobelia *Pratia repens*



Native strawberry *Rubus geoides*


Dusen's Moonwort
Botrychium dusenii

Lady's slipper *Calceolaria fothergillii* [Endemic]

Woolly ragwort *Senecio littoralis* [Endemic]

Coastal nassauvia
Nassauvia gaudichaudii

*[*Endemic*]*

Buckshorn plantain *Plantago coronopus*

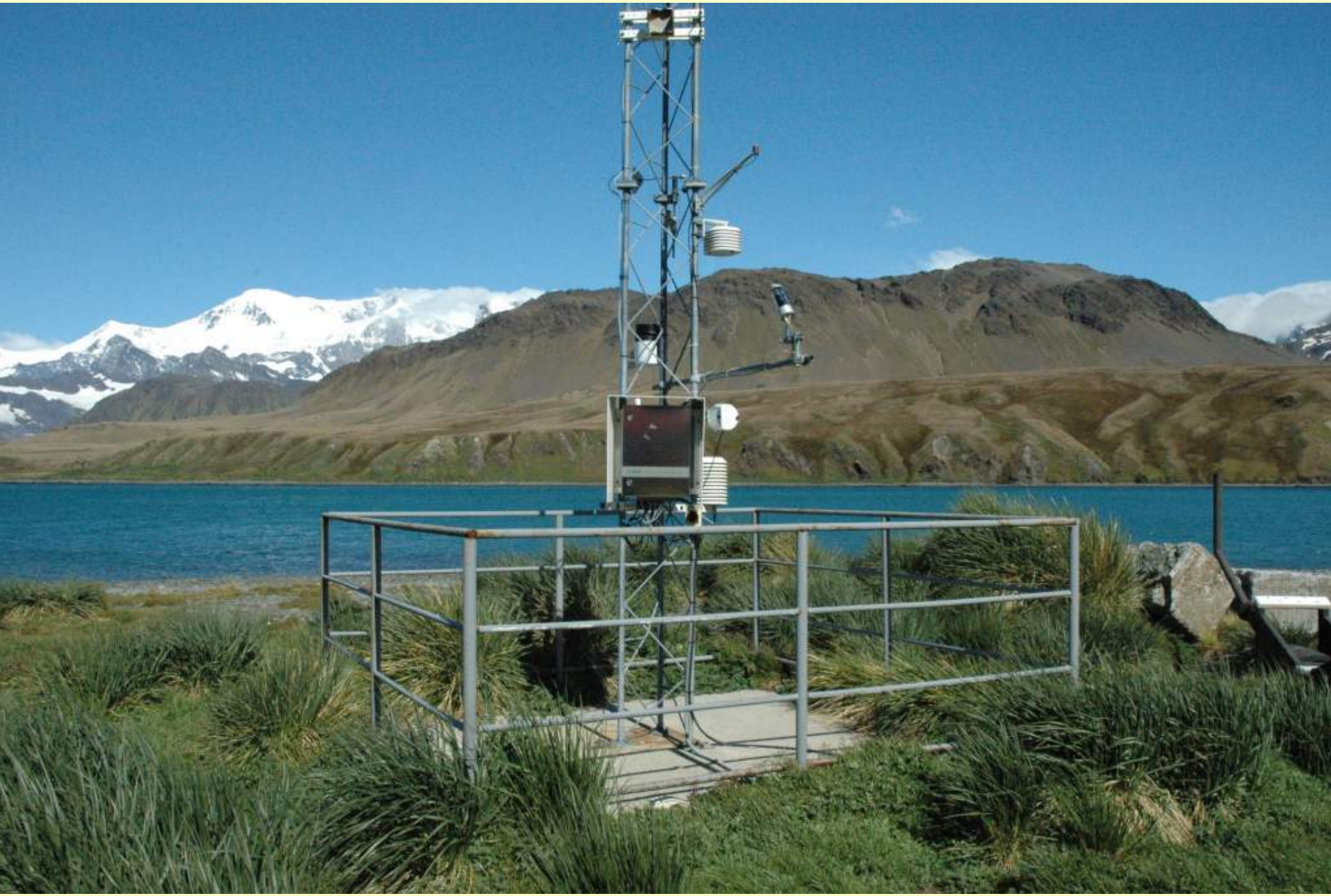
Watercress *Rorripa nasturtium-aquaticum*


FISHERY PATROL

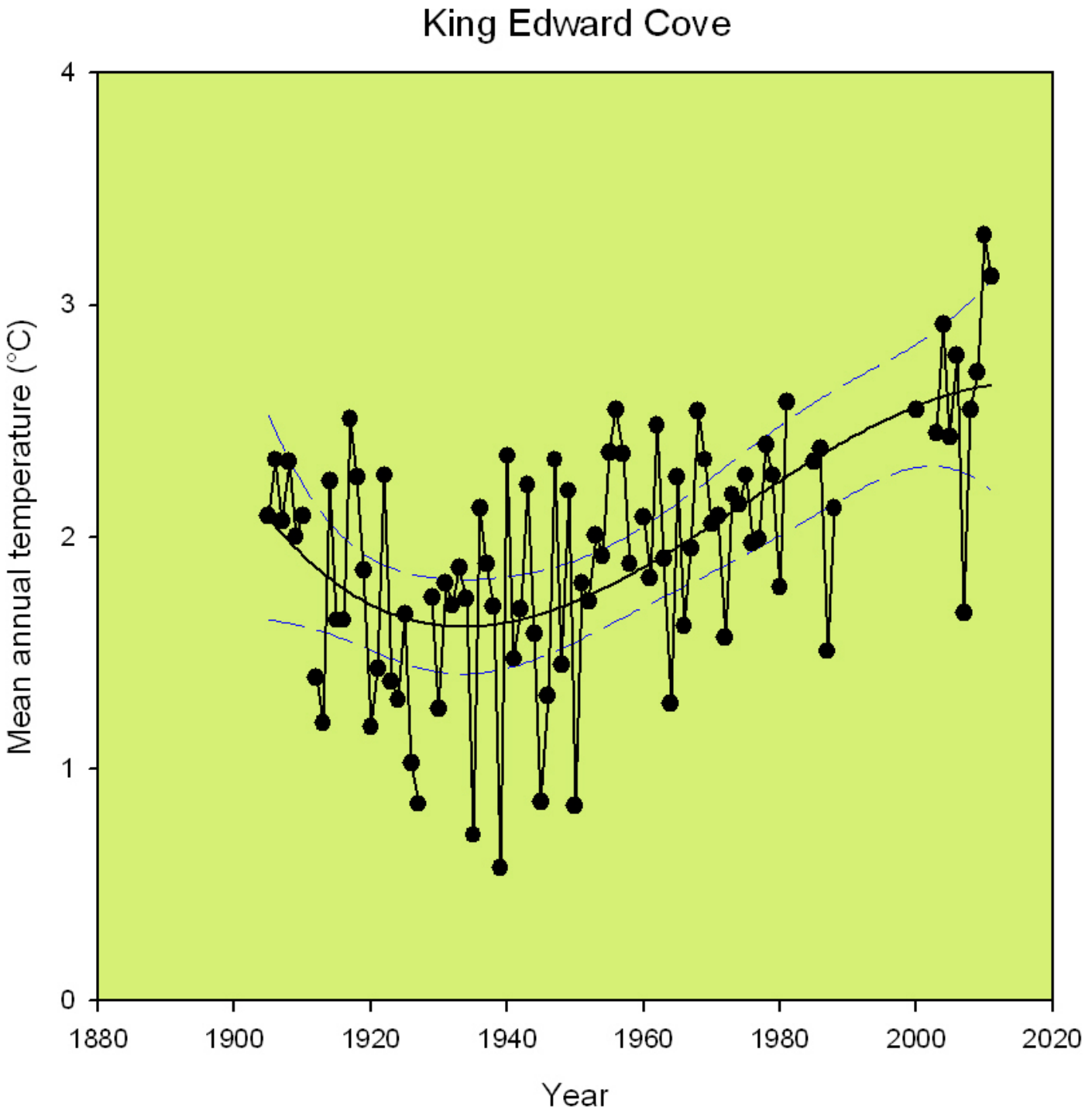

Bird Island
Prince Olav Harbour
Leith Harbour
Stromness
Husvik
King Edward Point
GRYTVIKEN
Godthul
Ocean Harbour
SOUTH ATLANTIC
Scotia Sea
SOUTH GEORGIA
Historical and Modern Settlements
20 km

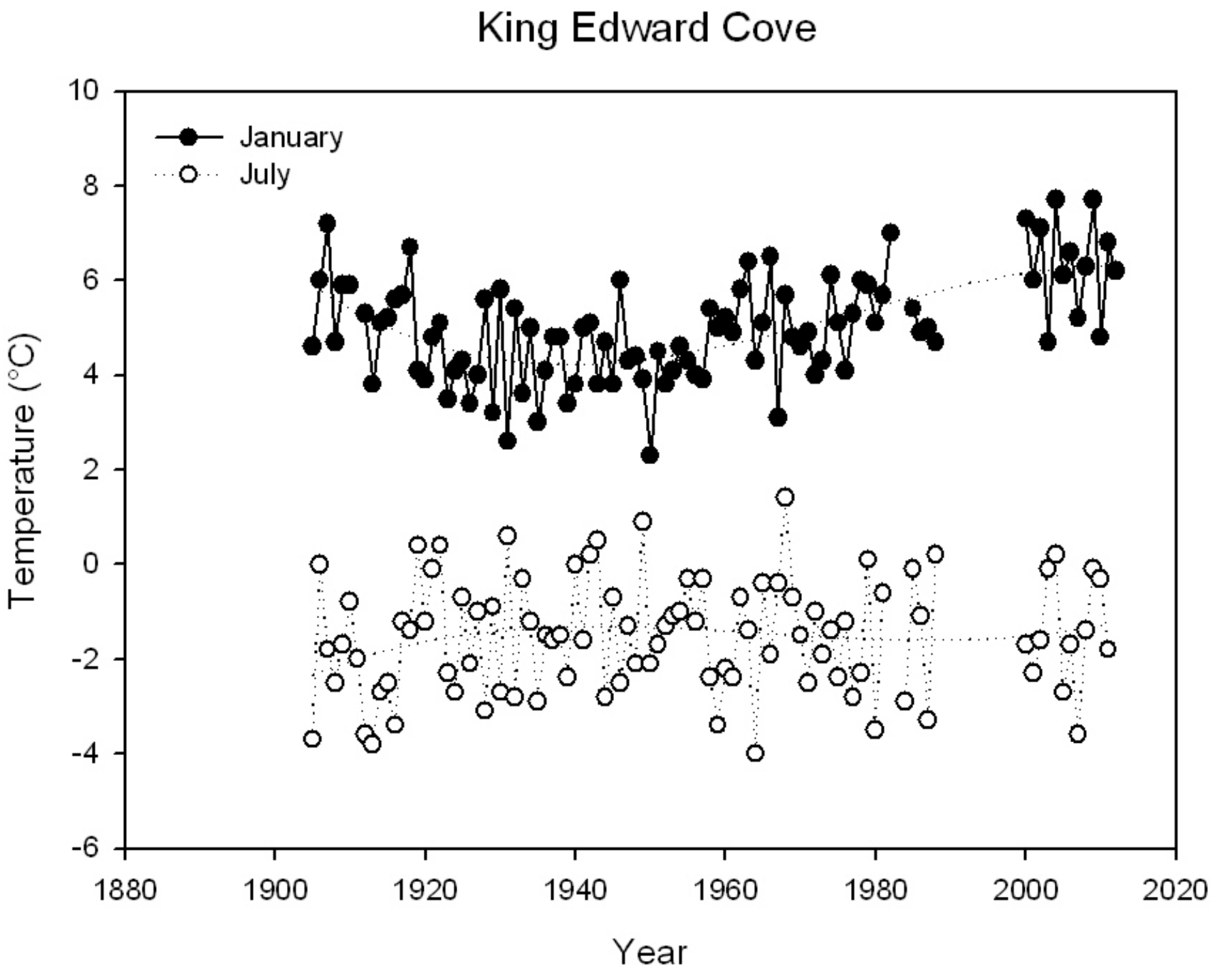

MILOS 520

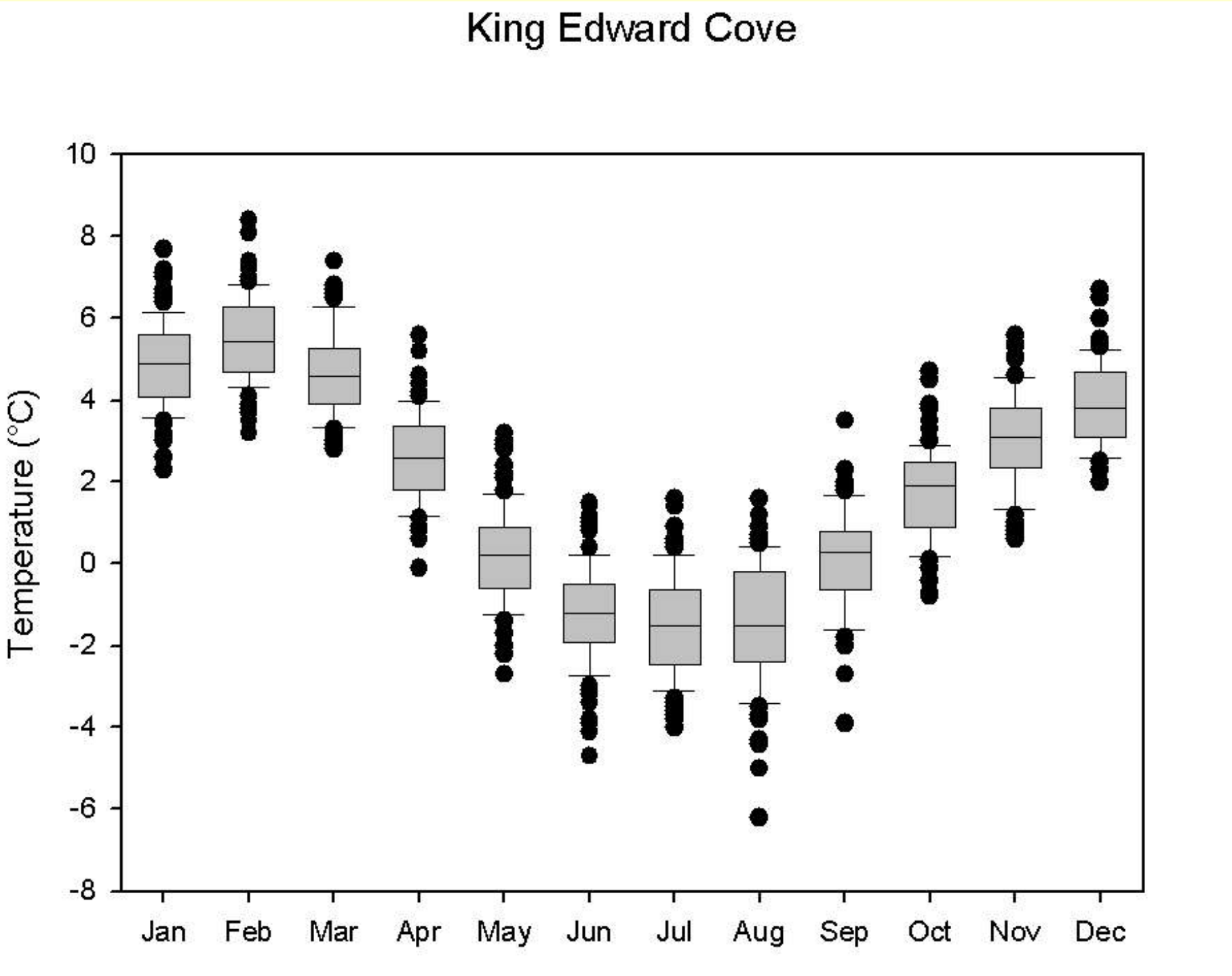
Annual Meadow Grass *Poa annua*



Weather station surrounded by **Tussac** *Poa flabellata*


King Edward Cove
Mean annual temperature (°C)
0
1
2
3
4
1880
1900
1920
1940
1960
1980
2000
2020
Year


King Edward Cove
January
July
Temperature (°C)
10
8
6
4
2
0
-2
-4
-6
1880
1900
1920
1940
1960
1980
2000
2020
Year


King Edward Cove
Temperature (°C)
10
8
6
4
2
0
-2
-4
-6
-8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Yarrow *Achillea millefolium*

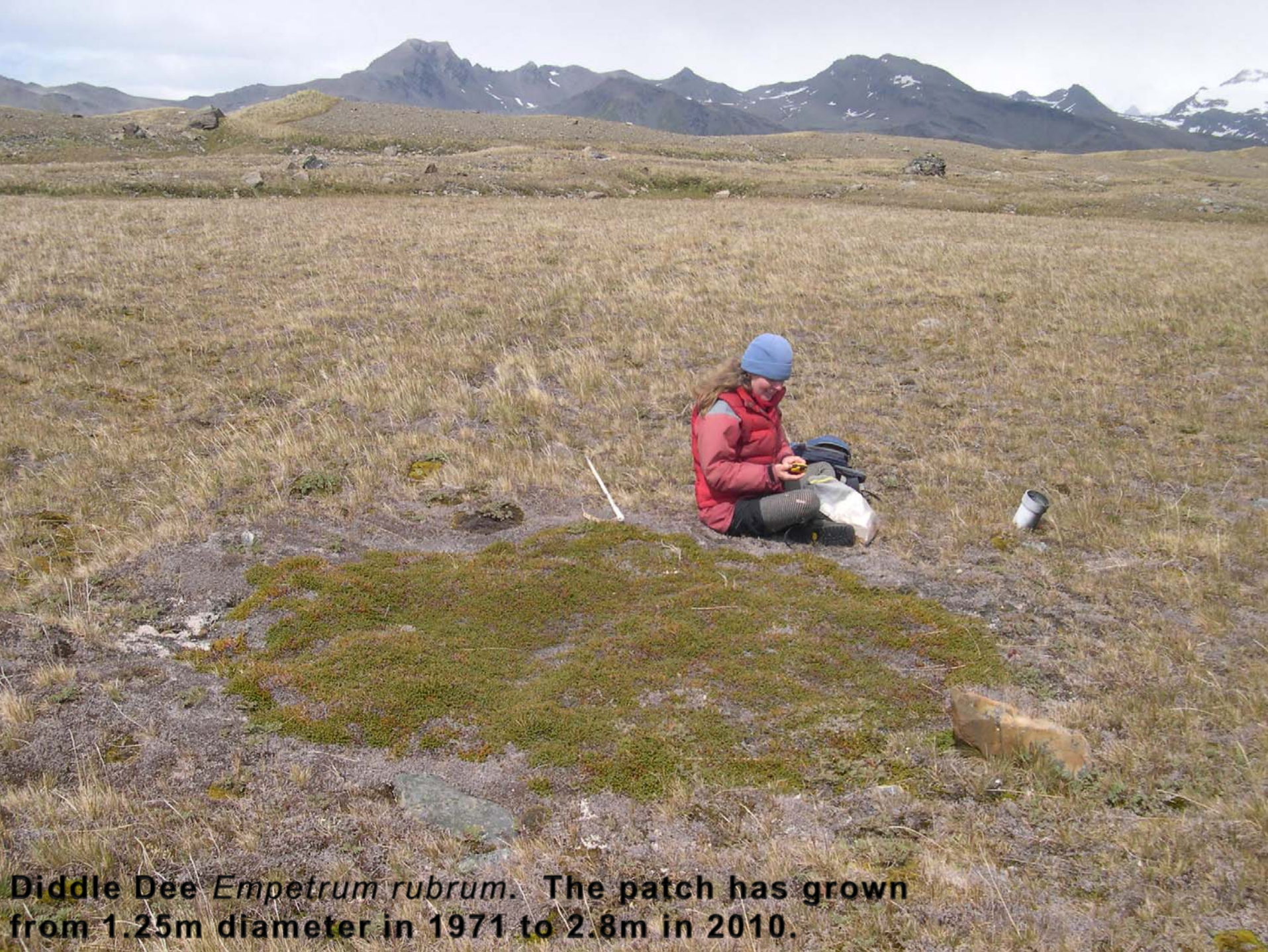
Cow Parsley *Anthriscus sylvestris*

Creeping Buttercup *Ranunculus repens*

Tufted Hair-grass *Deschampsia cespitosa*

Curled Dock *Rumex crispus*

Sheep's Sorrel *Rumex acetosella*



Diddle Dee *Empetrum rubrum*. The patch has grown from 1.25m diameter in 1971 to 2.8m in 2010.


Brittle bladder fern
Crystopteris fragilis

Adder's-tongue *Ophioglossum crotalophoroides*

Falkland filmy-fern *Hymenophyllum falklandicum*,
with **Lesser Prickly Burr** *Acaena tenera*

Strap Fern
Grammitis poeppigiana


Prickly burr or burnet
Acaena magellanica

Acaena magellanica x tenera
[Endemic]

Antarctic water-starwort
Callitriche antarctica

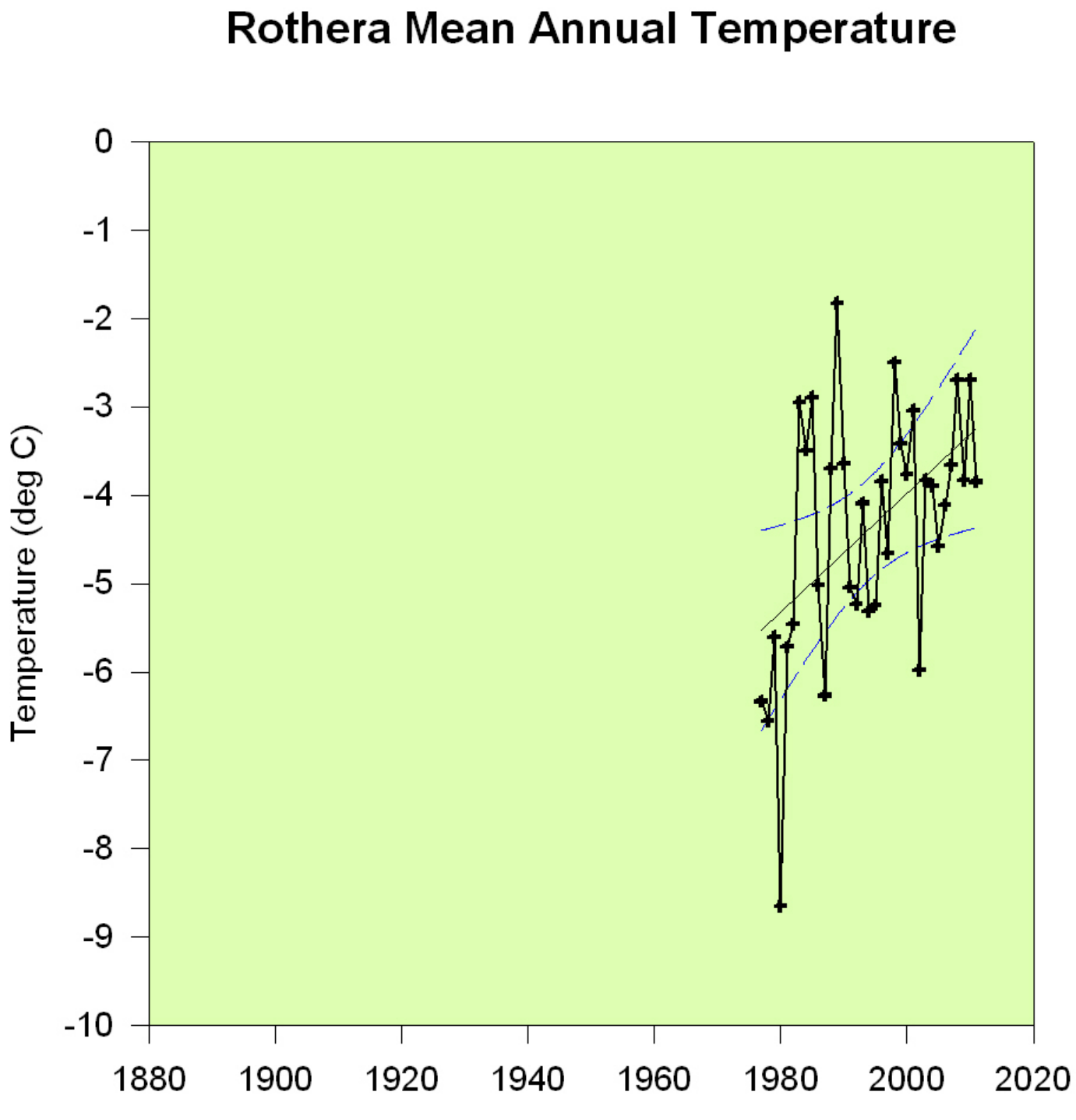
also a liverwort *Riccardia* sp.

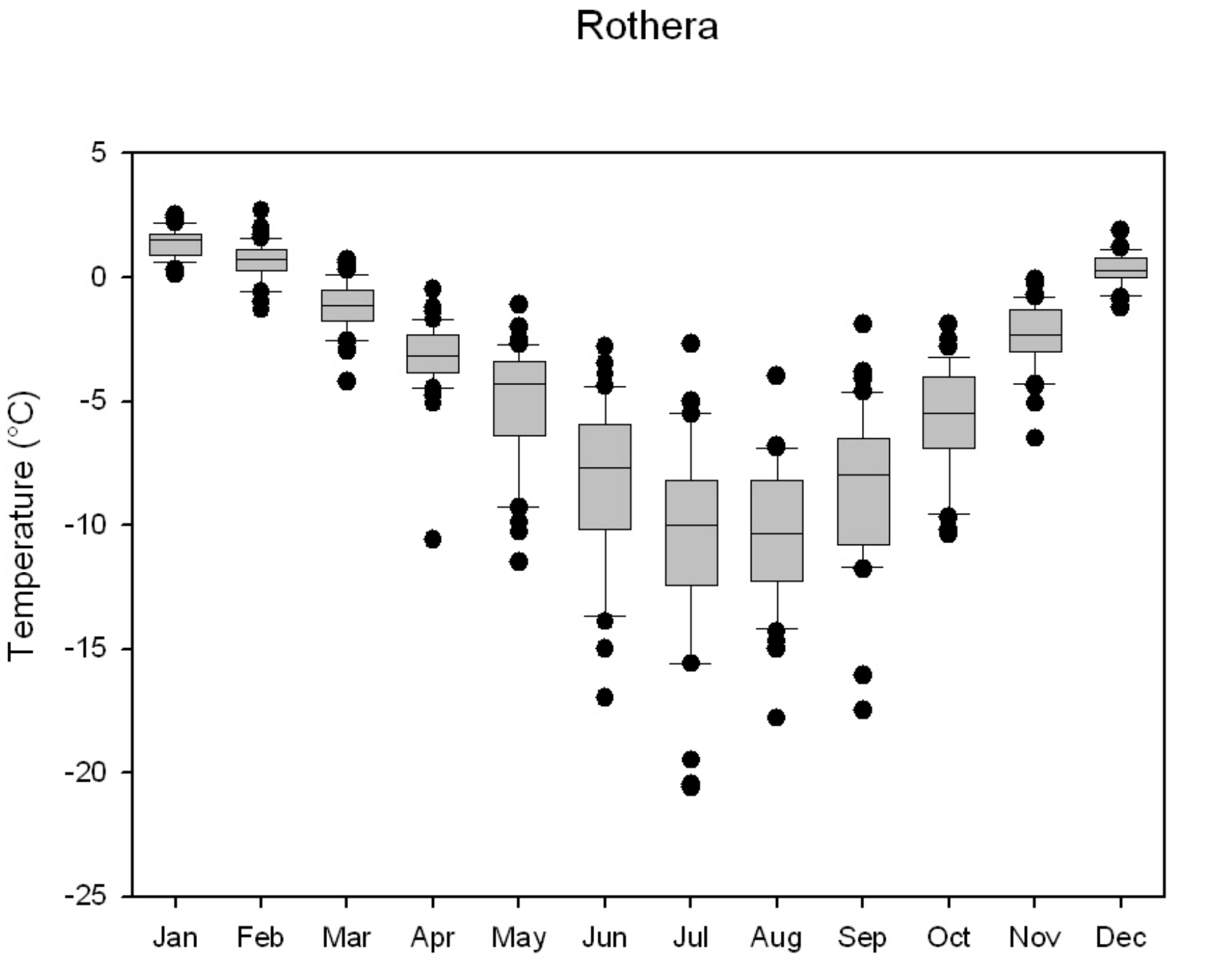
Antarctic bedstraw
Galium antarcticum

Mat Grass *Nardus stricta*

Cock's Foot ***Dactylis glomerata*** **with Alpine Catstail** ***Phleum alpinum***

Scurvey Grass *Cardamine cf glacialis*

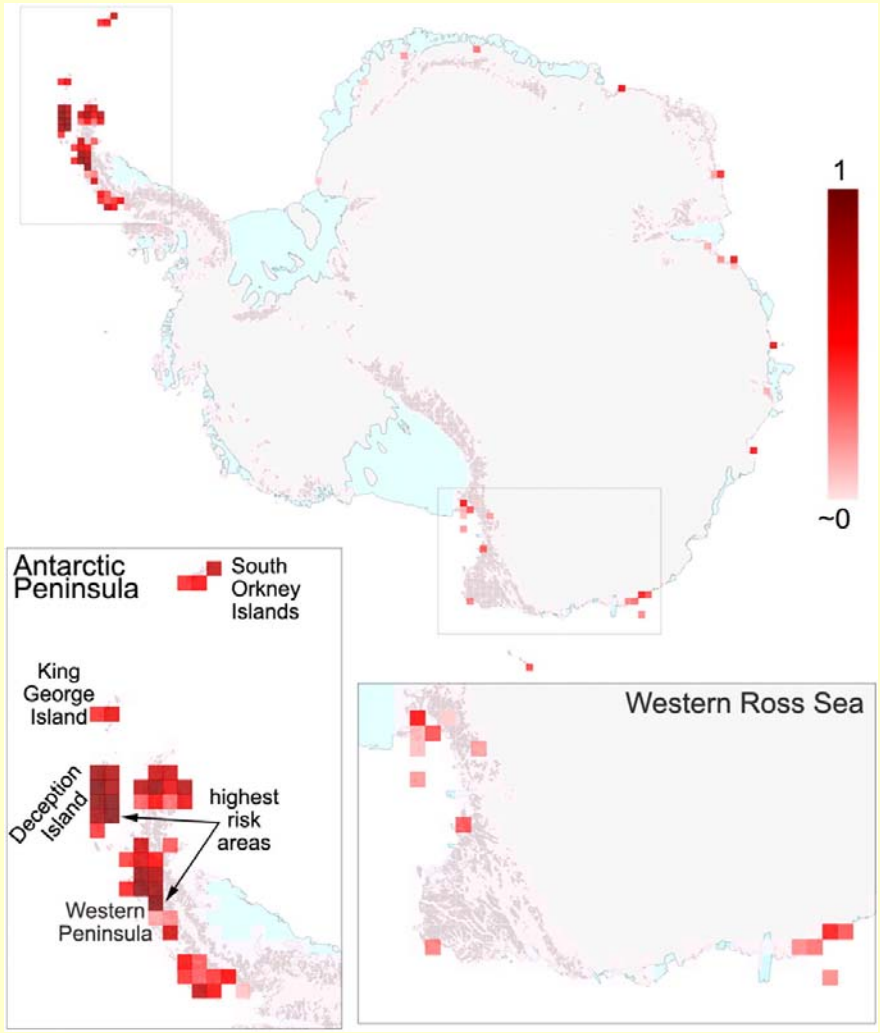

Rothera Mean Annual Temperature
Temperature (deg C)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
1880
1900
1920
1940
1960
1980
2000
2020


Rothera
Temperature (°C)
5
0
-5
-10
-15
-20
-25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

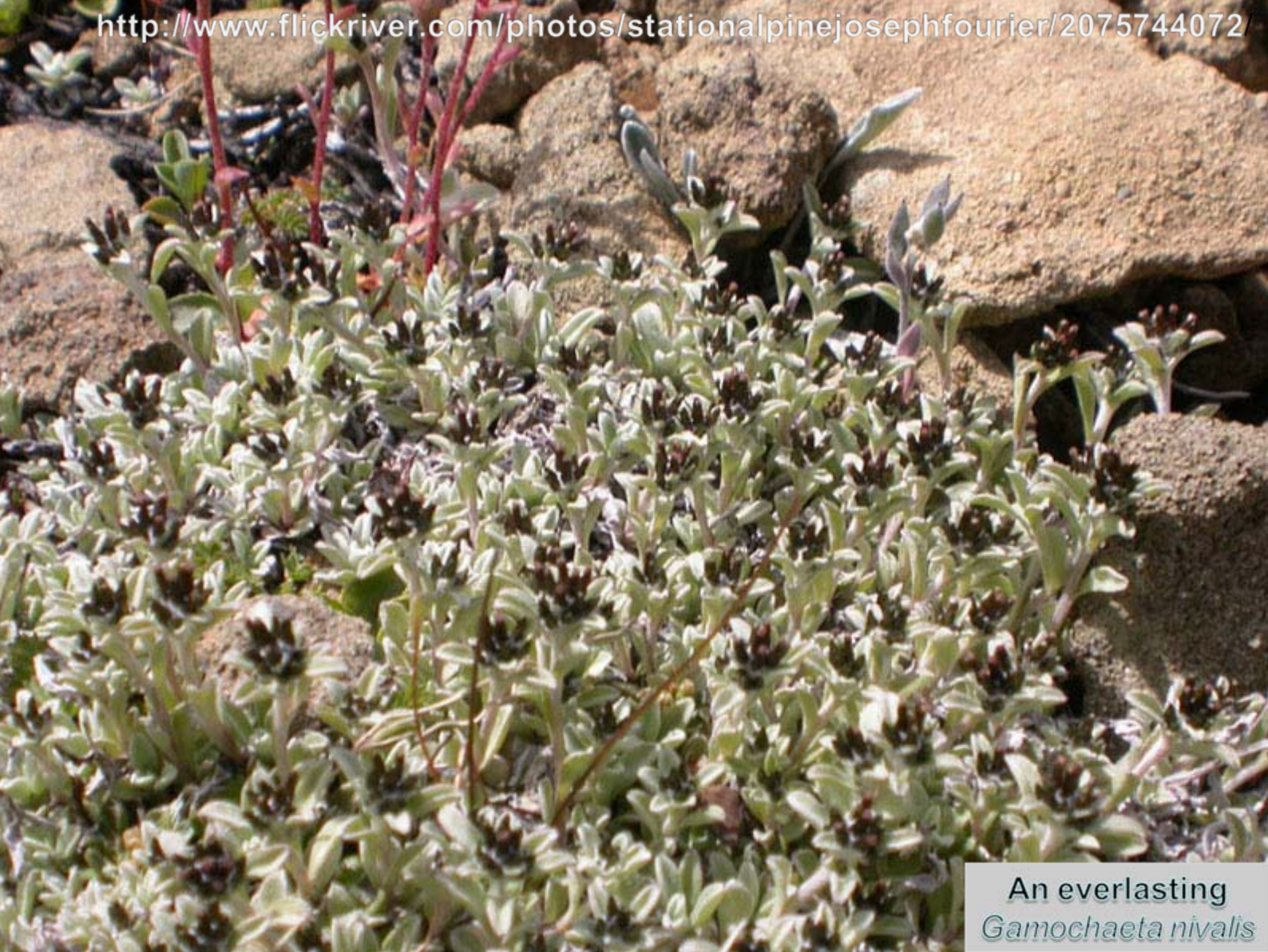
Antarctic Hair-grass *Deschampsia antarctica*

Antarctic Pearlwort *Colobanthus quitensis*

Relative risk of alien vascular plants establishing in Antarctica.



Chown S L et al. PNAS 2012;109:4938-4943

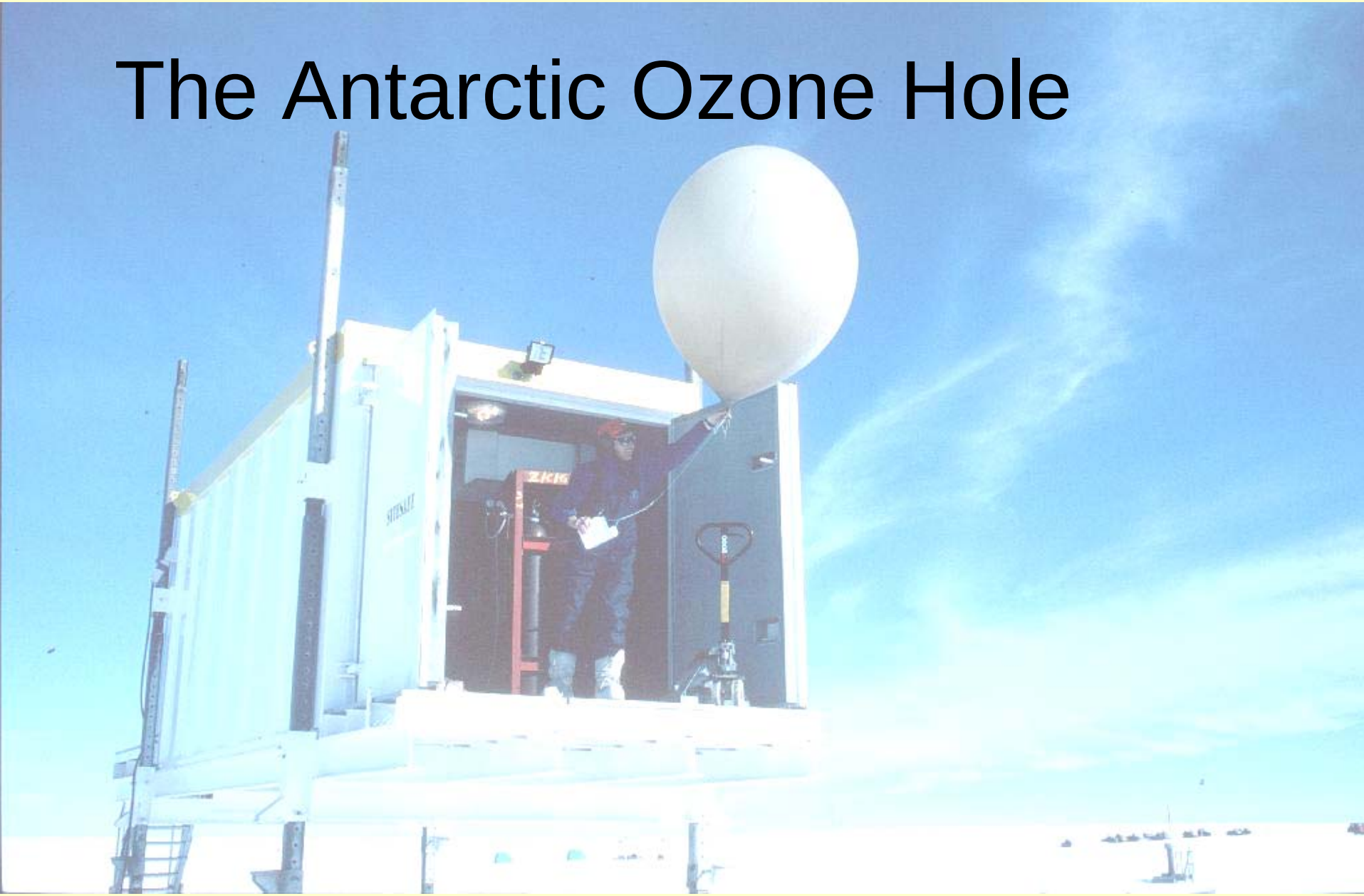


An everlasting
Gamochaeta nivalis

Hairy Chocolate Flower
Nassauvia magellanica

http://www.helsinki.fi/~jhyvonen/PB/N/N.html

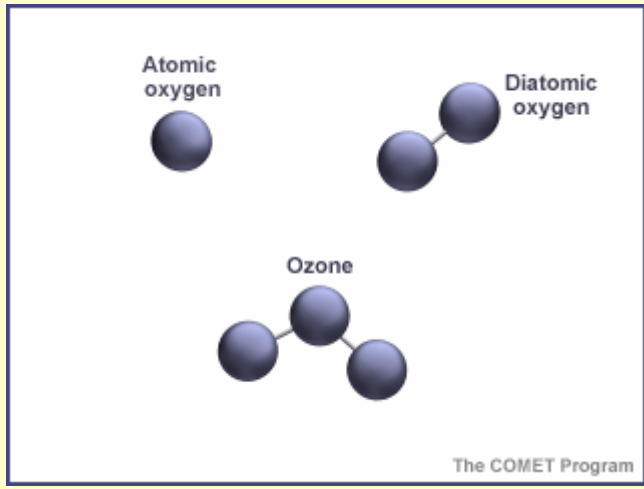
The Antarctic Ozone Hole



What is ozone ?

Air is a mixture of oxygen and nitrogen, which has the oxygen as pairs of oxygen atoms, making an oxygen molecule : O_2

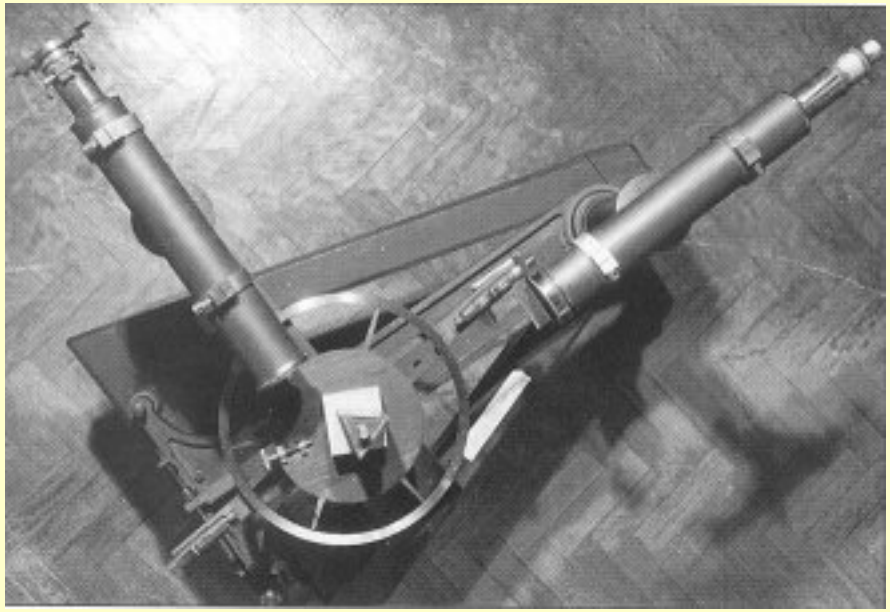
Ozone is created from oxygen in the air by sunlight breaking apart oxygen molecules to liberate oxygen atoms. One of these reacts with another oxygen molecule to make ozone : O_3 .



Ozone was discovered in 1840 by a German chemist working in Switzerland.

He was experimenting on the electrolysis of water

Christian Schonbein (1799 – 1868)



Spectrograph used by Sir Walter Hartley

Alfred Cornu

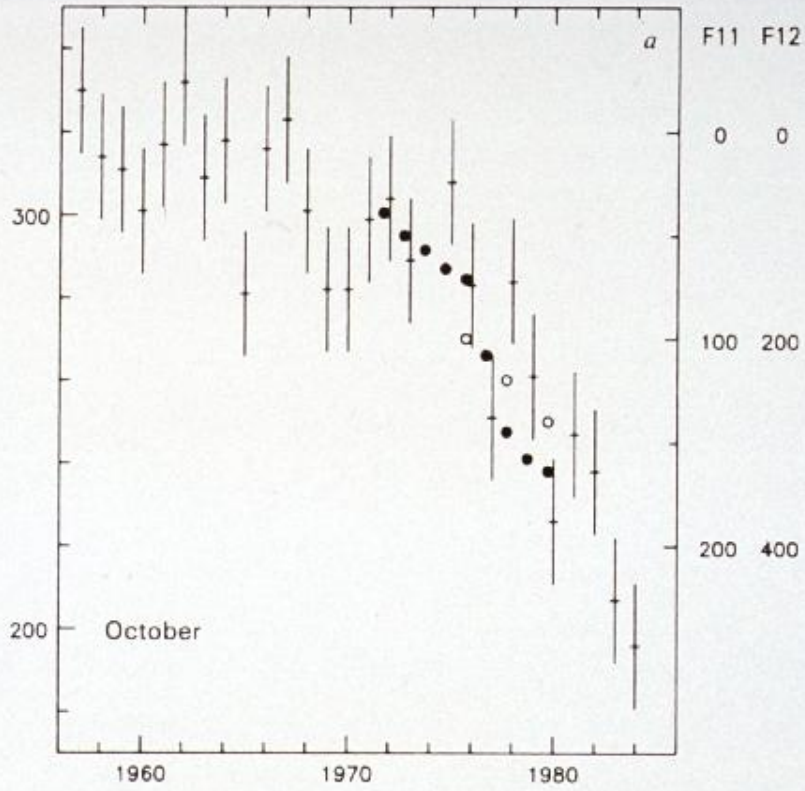
Around 1880, Cornu suggested that the uv cut-off in stellar spectra was due to ozone, and Hartley hypothesised that ozone was present in the atmosphere.


G-ELDSWORTH

Large losses of total ozone in Antarctica reveal seasonal ClO_x/NO_x interaction

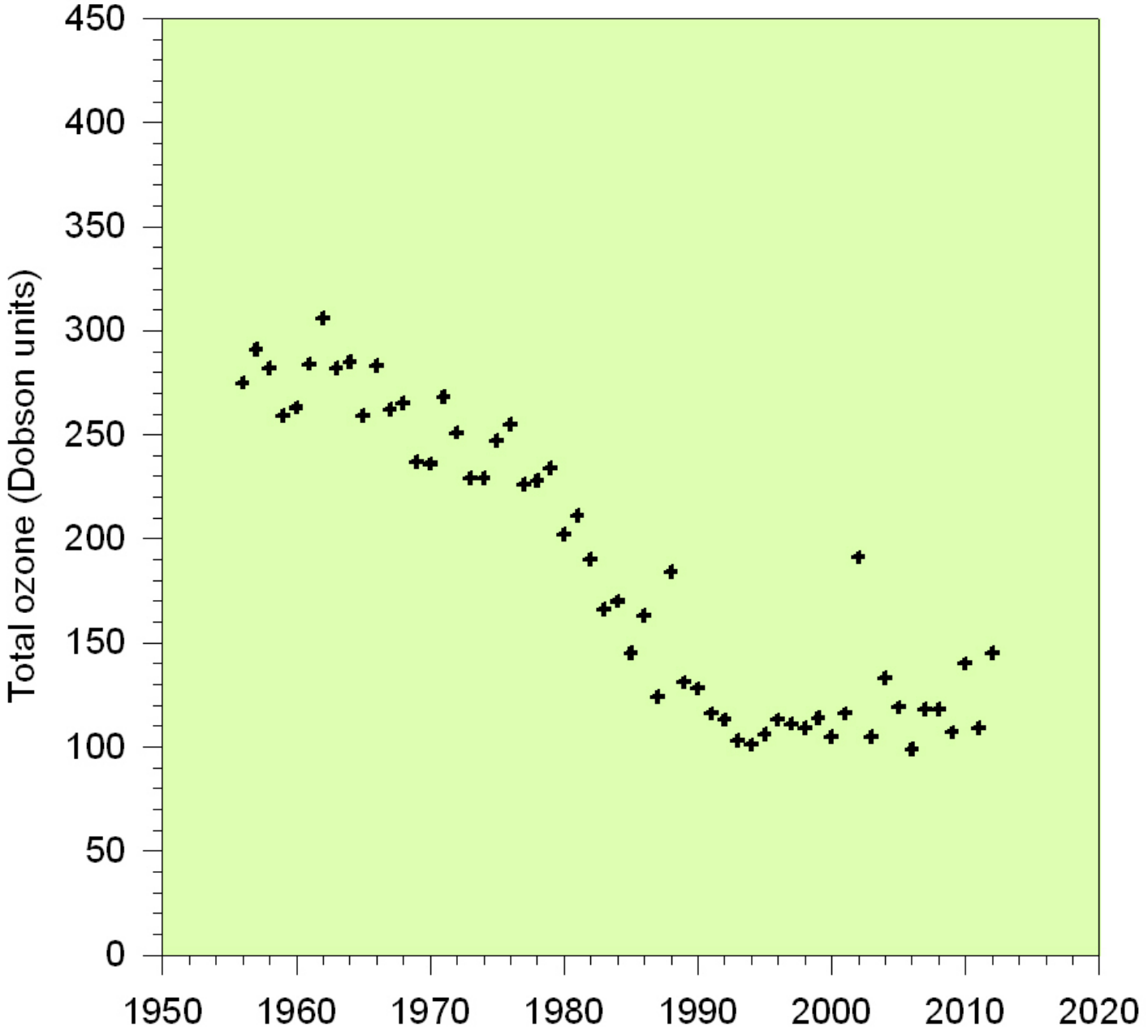
J. C. Farman, B. G. Gardiner & J. D. Shanklin

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

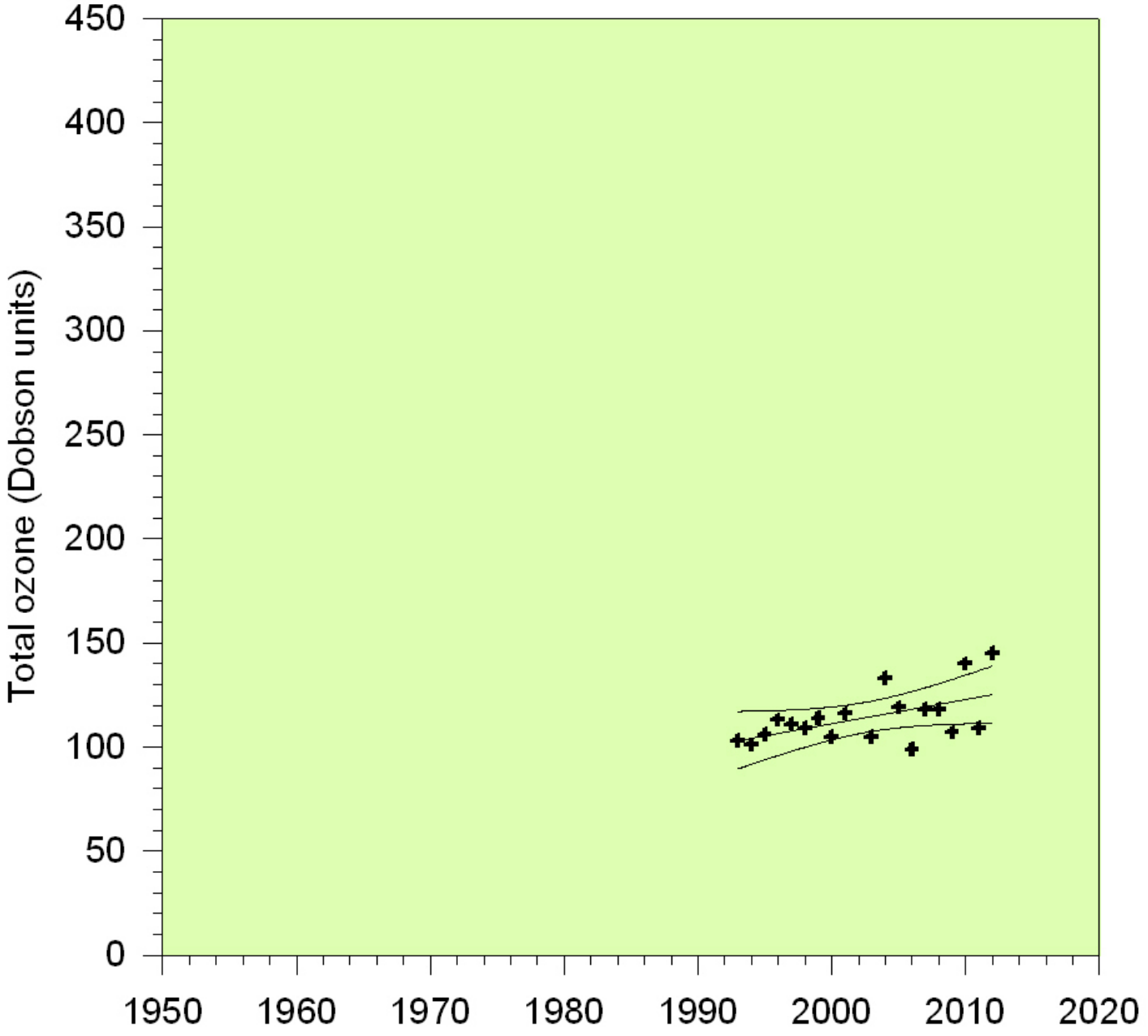


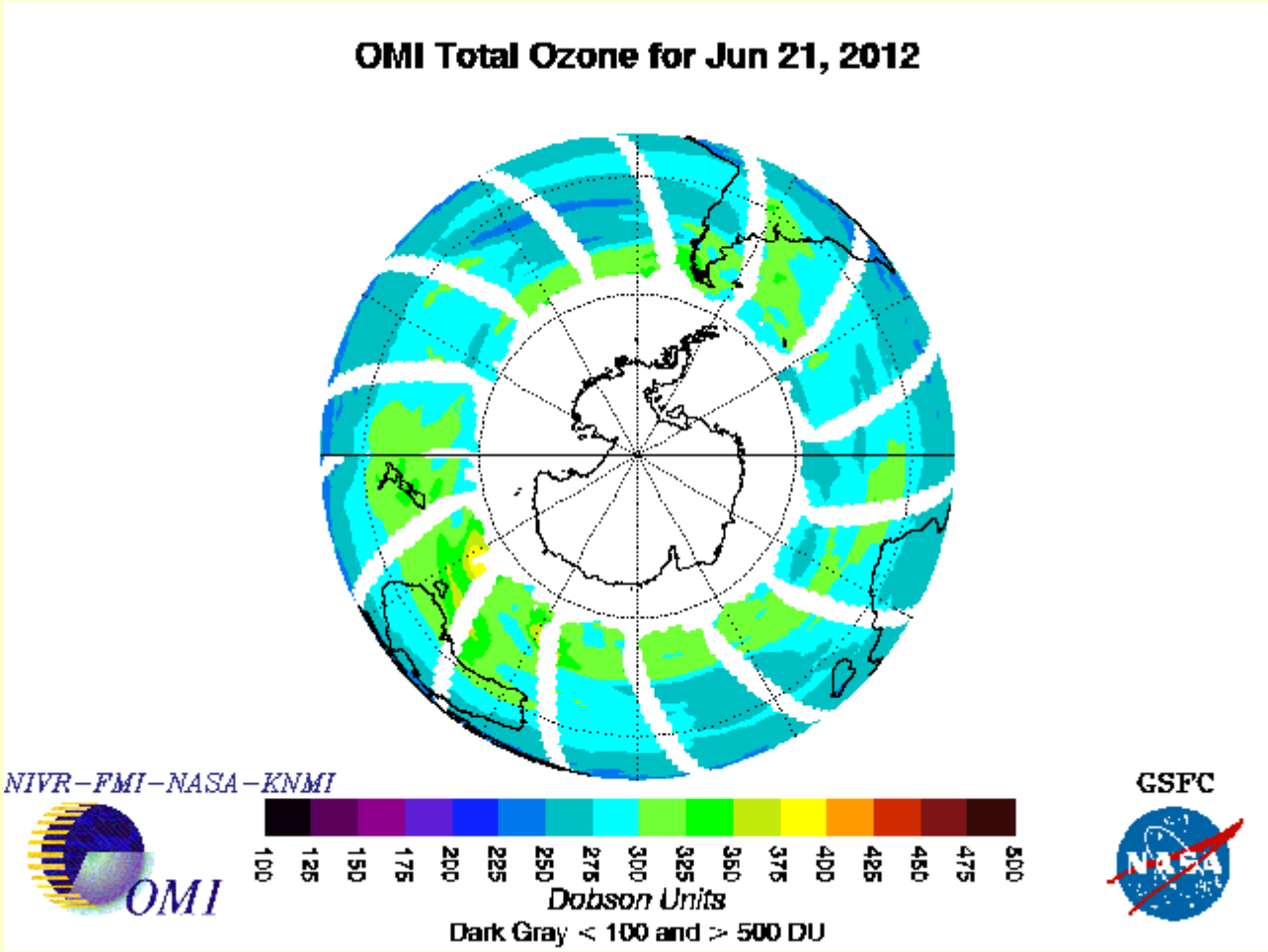
Recent attempts[1,2] to consolidate assessments of the effect of human activities on stratospheric ozone (O_3) using one-dimensional models for 30° N have suggested that perturbations of total O_3 will remain small for at least the next decade. Results from such models are often accepted by default as global estimates[3]. The inadequacy of this approach is here made evident by observations that the spring values of total O_3 in Antarctica have now fallen considerably. The circulation in the lower stratosphere is apparently unchanged, and possible chemical causes must be considered.

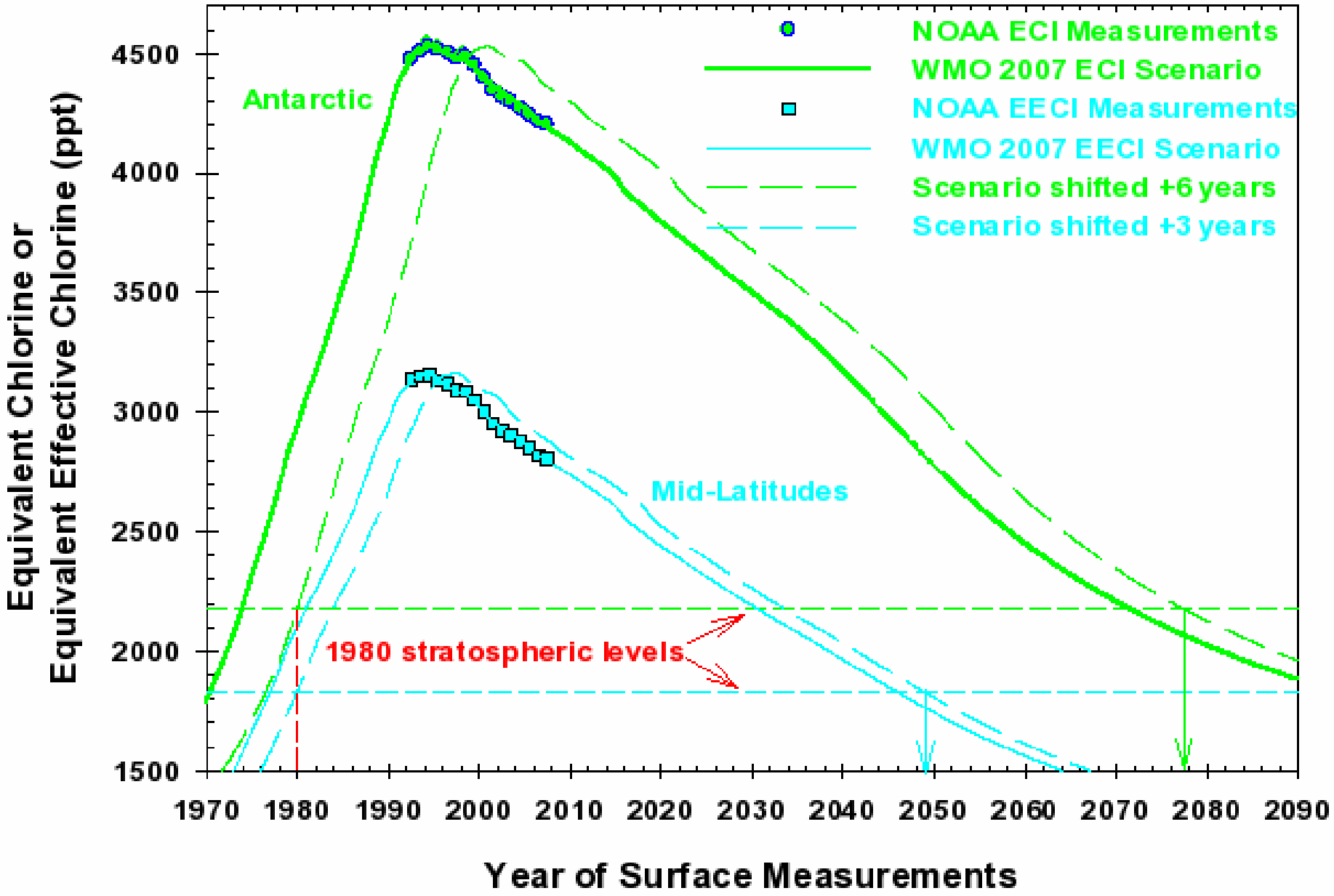
Minimum October ozone at Halley



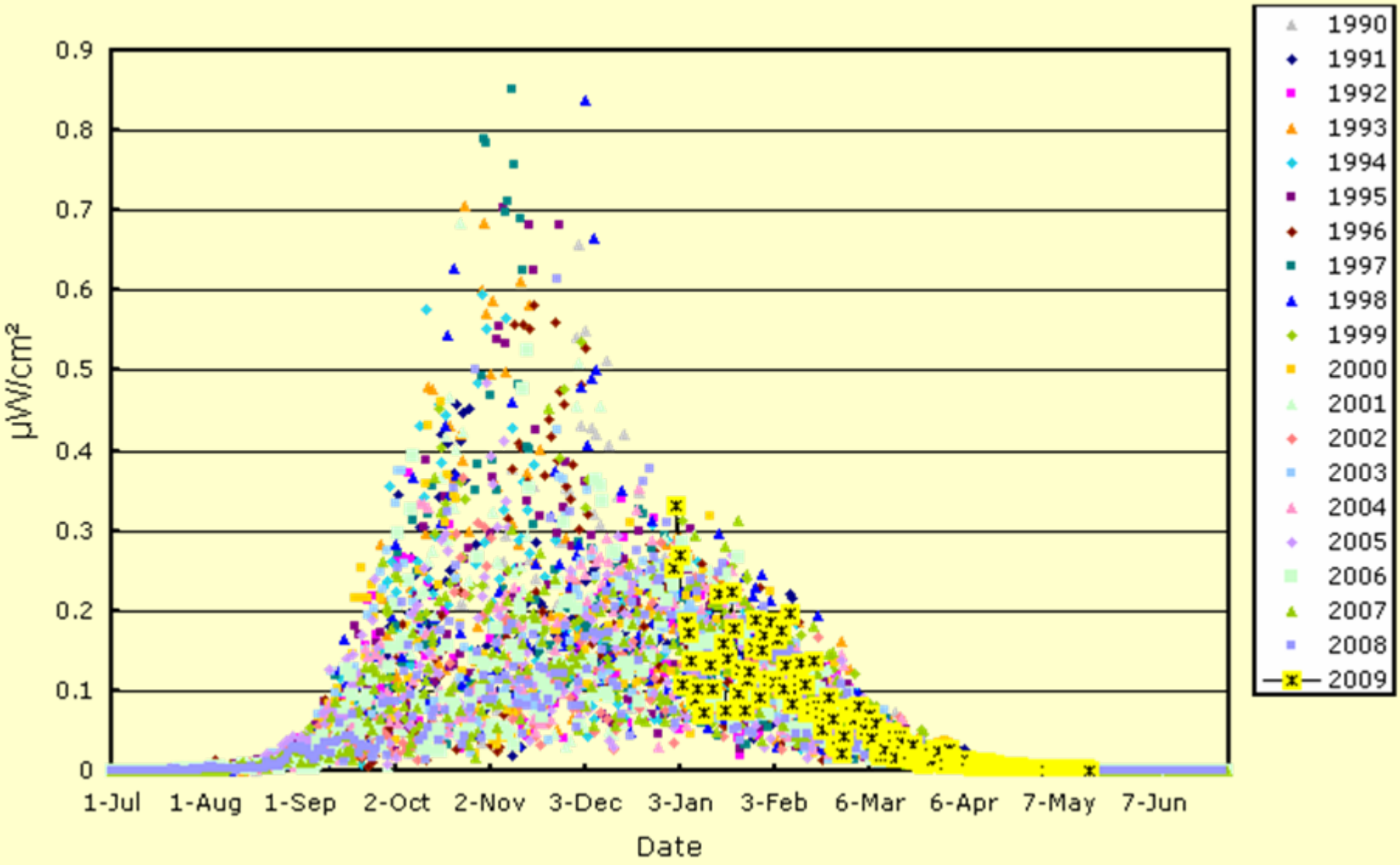
Minimum October ozone at Halley

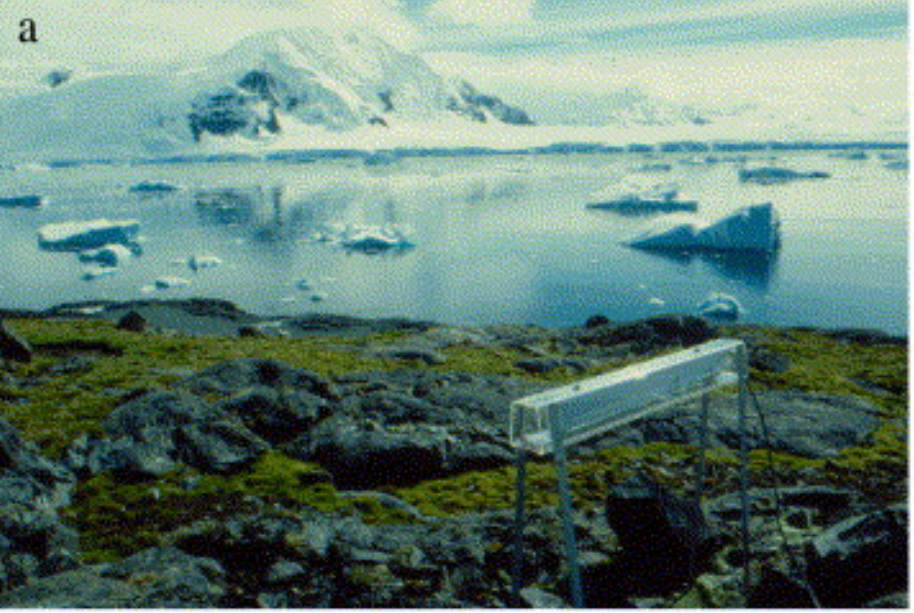


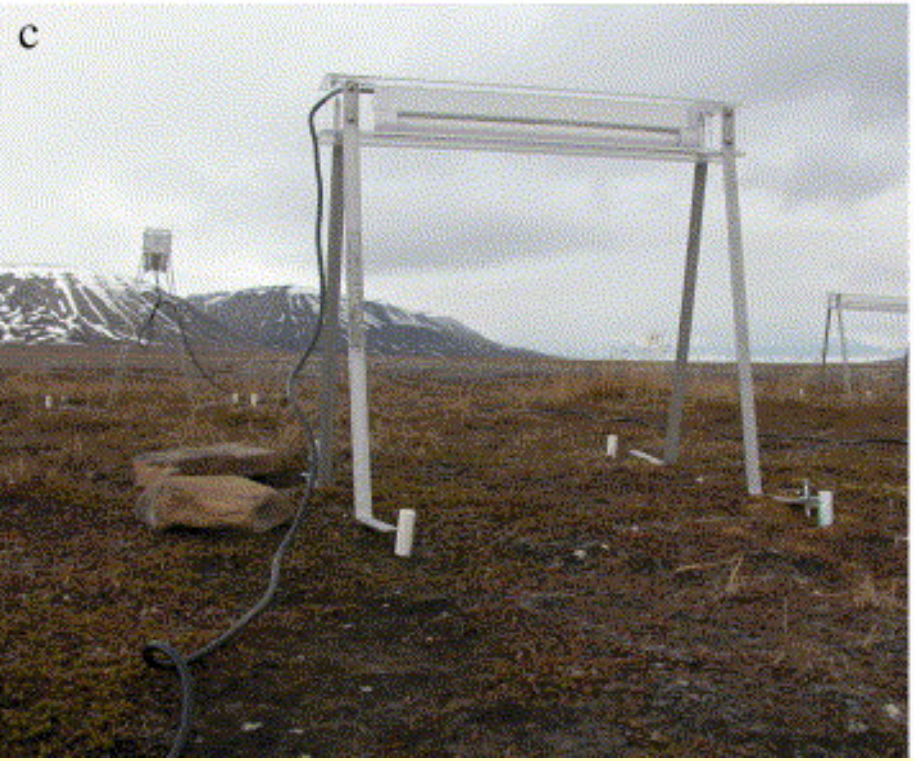

OMI Total Ozone for Jun 21, 2012
NIVR–FMI–NASA–KNMI
OMI
100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500
Dobson Units
Dark Gray < 100 and > 500 DU
GSFC
NASA


NOAA ECl Measurements
WMO 2007 ECl Scenario
NOAA EECl Measurements
WMO 2007 EECl Scenario
Scenario shifted +6 years
Scenario shifted +3 years
Antarctic
Mid-Latitudes
1980 stratospheric levels
Equivalent Chlorine or
Equivalent Effective Chlorine (ppt)
4500
4000
3500
3000
2500
2000
1500
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
Year of Surface Measurements

Palmer Station, Antarctica (64°46' S, 64°03' W)
Setlow's DNA Dose Weighted Irradiance
Local Apparent Noon

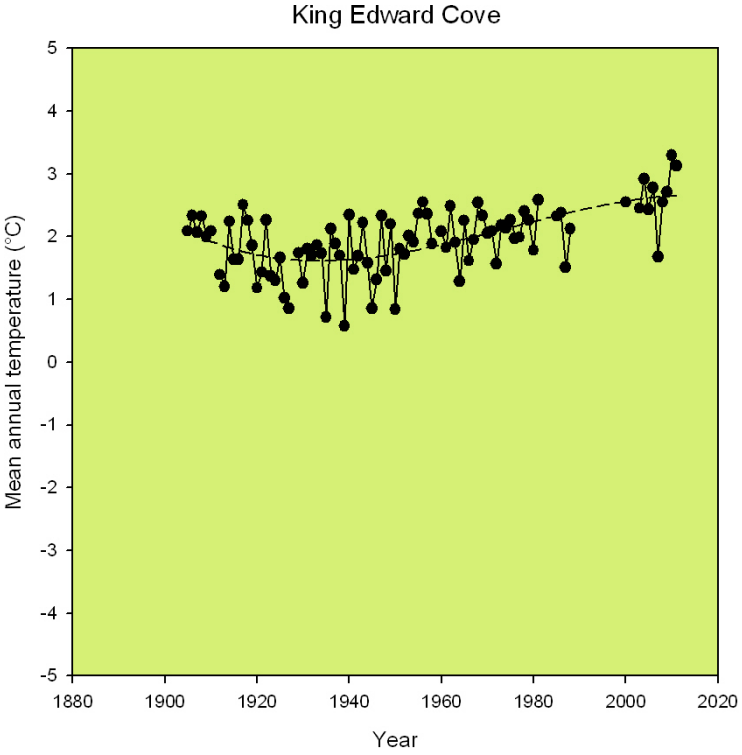


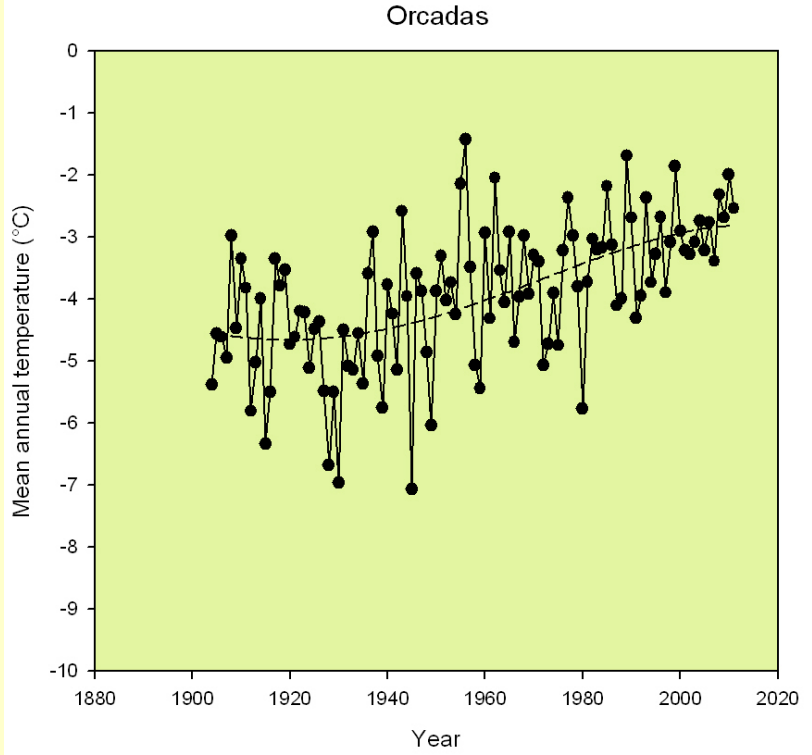


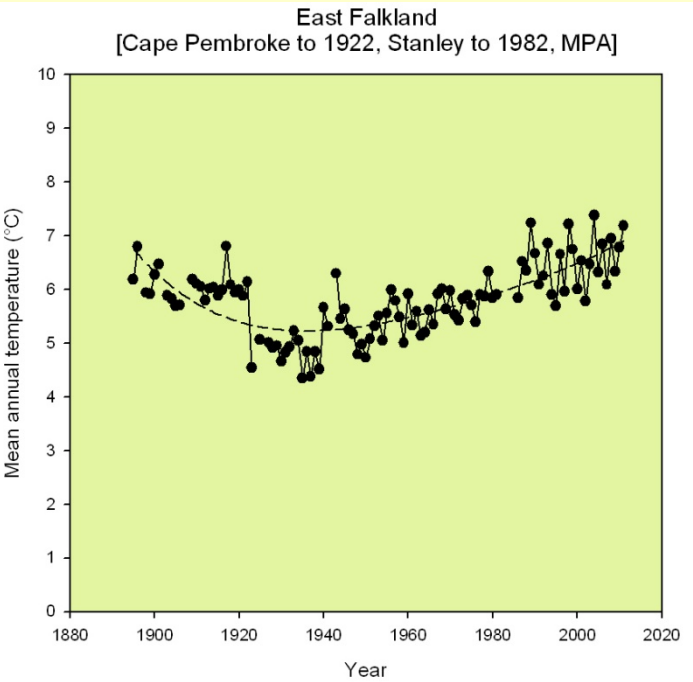


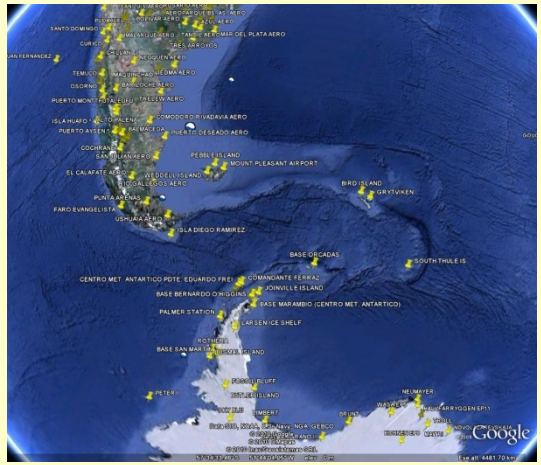
http://dx.doi.org/10.1016/j.envpol.2005.01.048

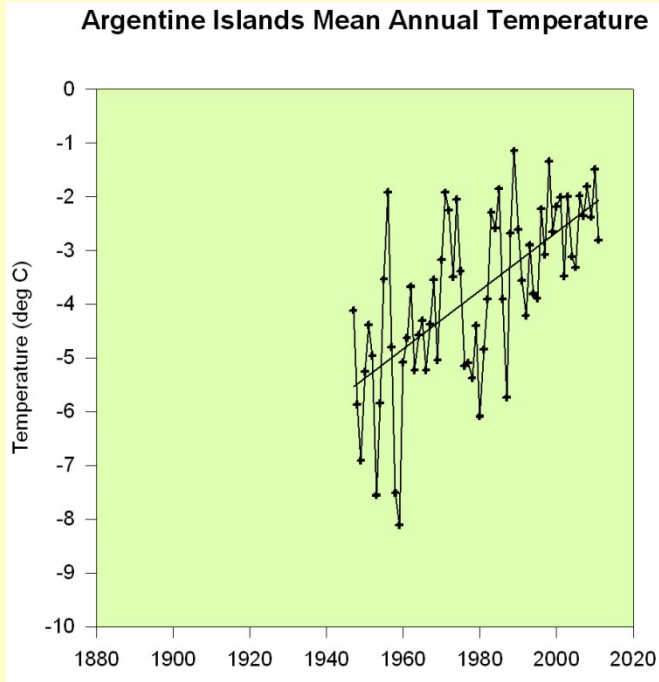
Climate

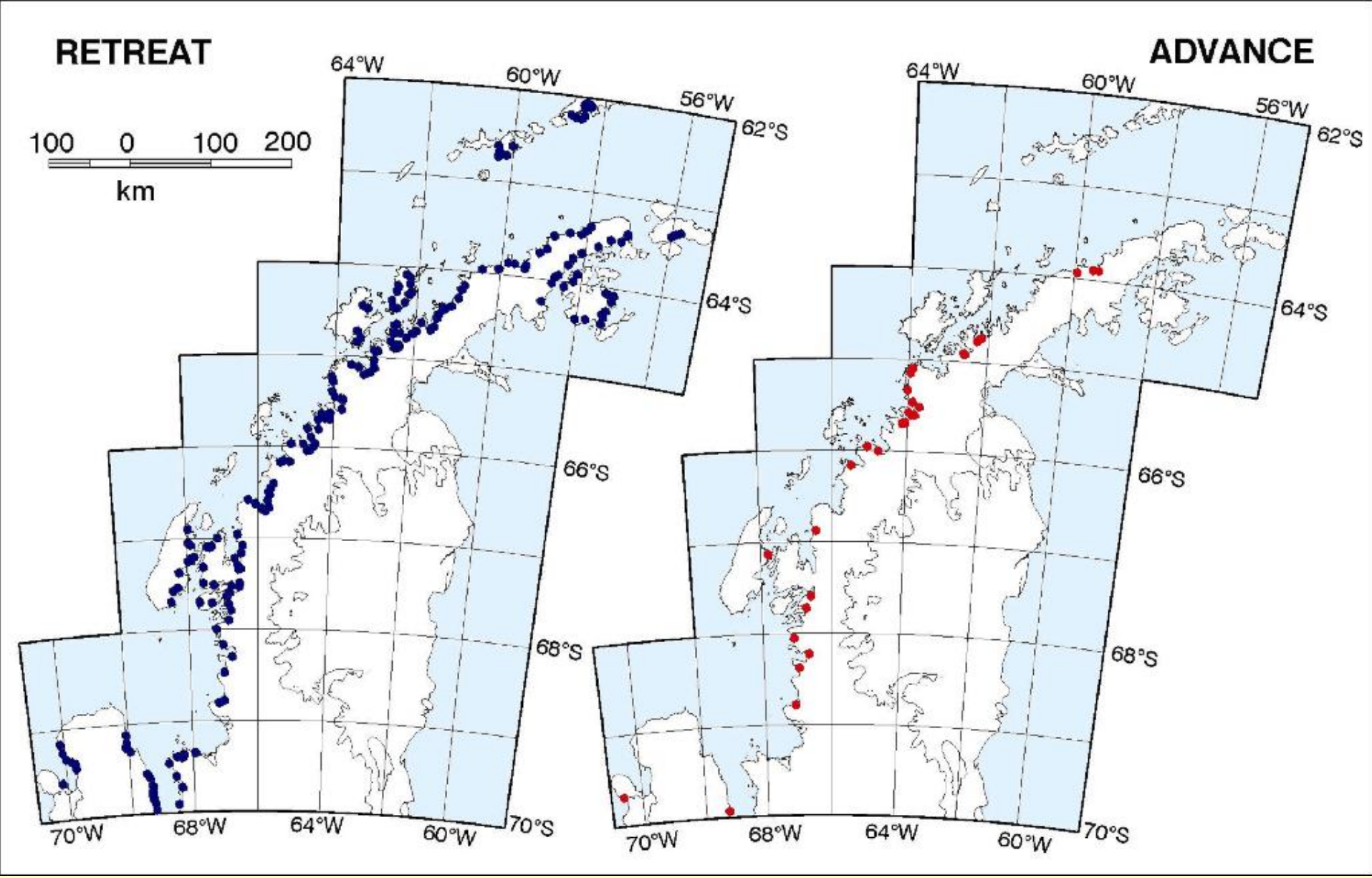

King Edward Cove
Mean annual temperature (°C)
Year
5
4
3
2
1
0
-1
-2
-3
-4
-5
1880
1900
1920
1940
1960
1980
2000
2020


Orcadas
Mean annual temperature (°C)
Year
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
1880
1900
1920
1940
1960
1980
2000
2020

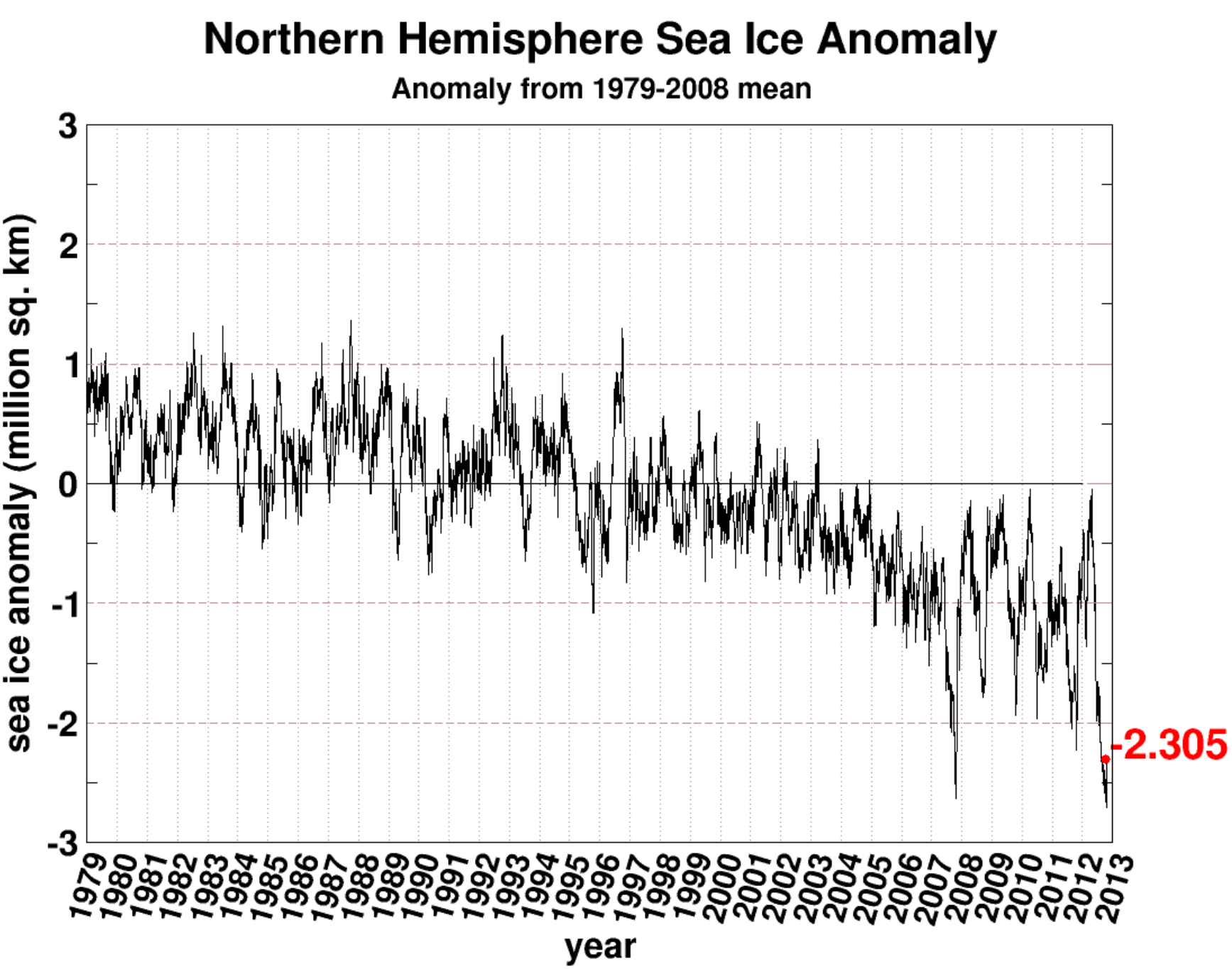

East Falkland
[Cape Pembroke to 1922, Stanley to 1982, MPA]
Mean annual temperature (°C)
Year
10
9
8
7
6
5
4
3
2
1
0
1880
1900
1920
1940
1960
1980
2000
2020

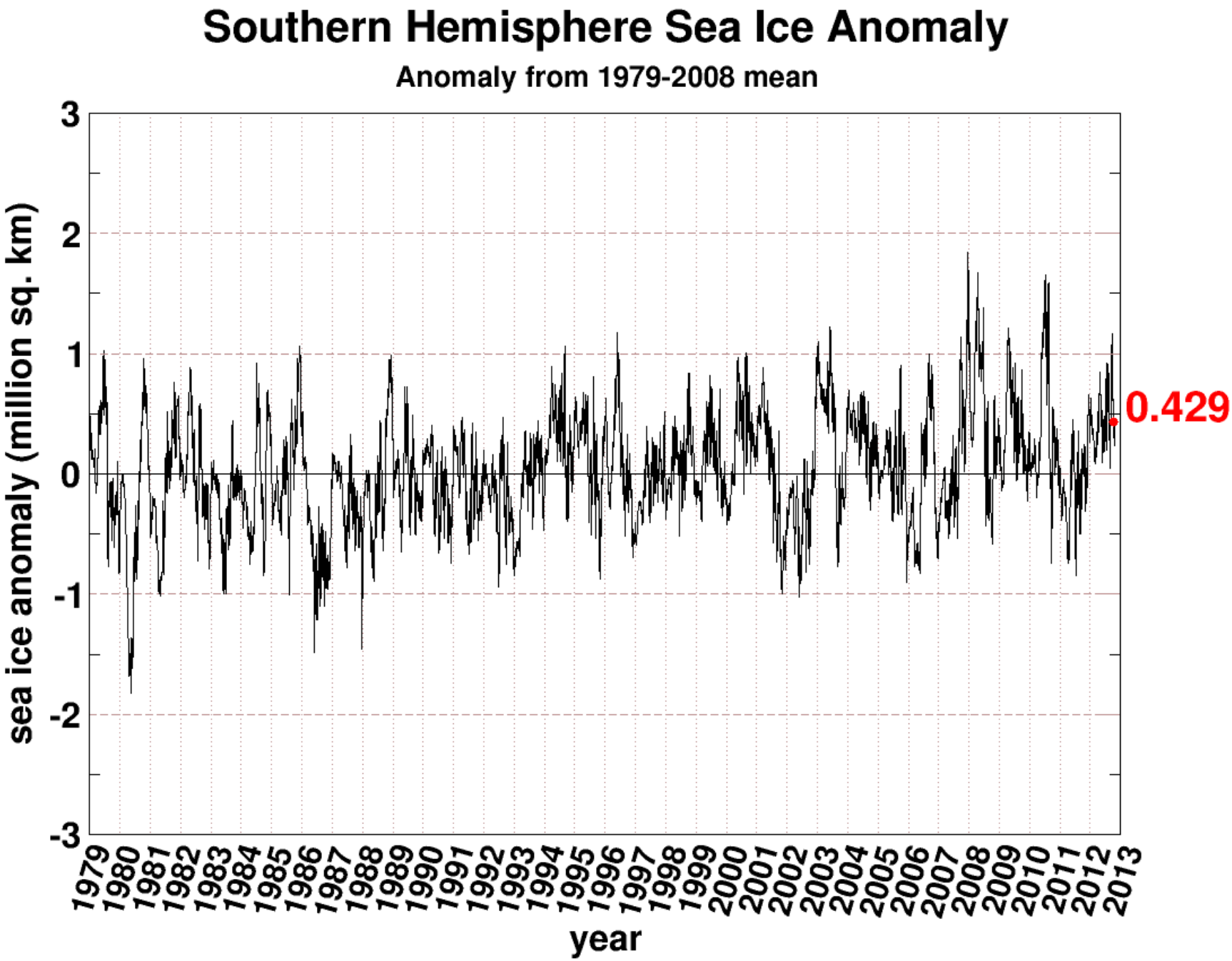

BASE ORCADAS
SOUTH THULE IS
BIRD ISLAND
GRYTVIKEN
PEBBLE ISLAND
MOUNT PLEASANT AIRPORT
ISLA DIEGO RAMIREZ
BASE BERNARDO O'HIGGINS
PALMER STATION
LARSEN ICE SHELF
NEUMAYER
Google

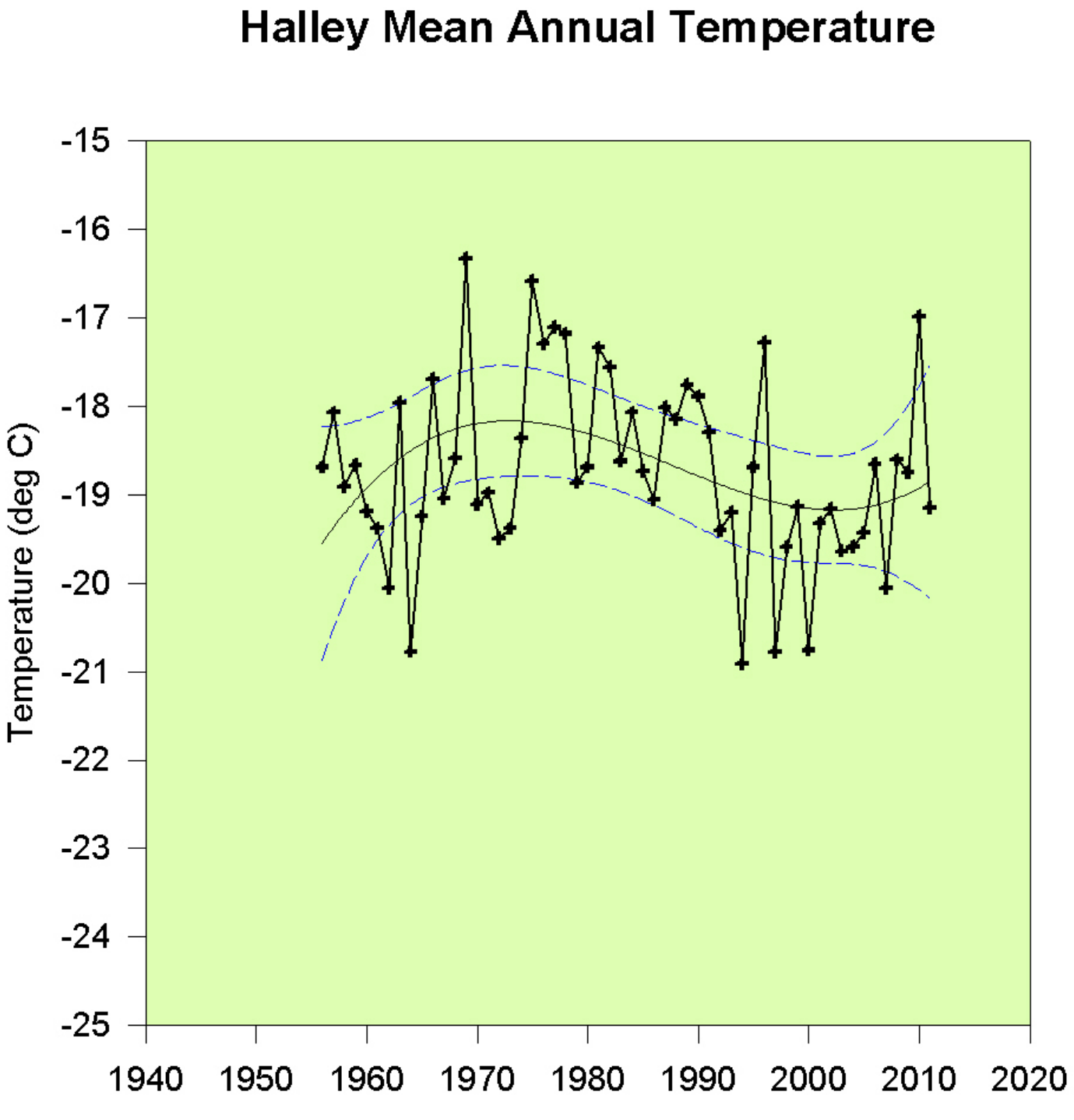

Argentine Islands Mean Annual Temperature
Temperature (deg C)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
1880
1900
1920
1940
1960
1980
2000
2020

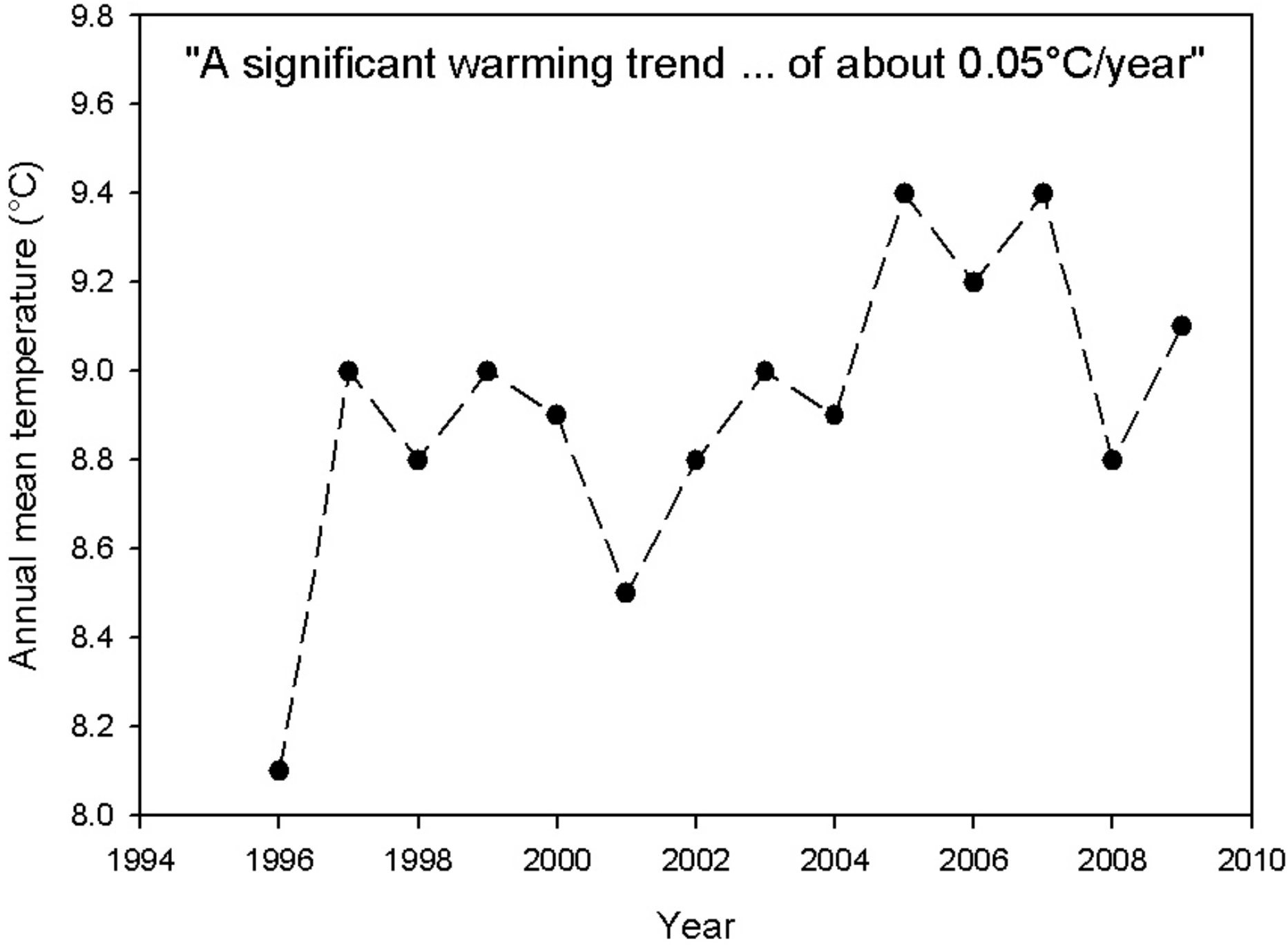


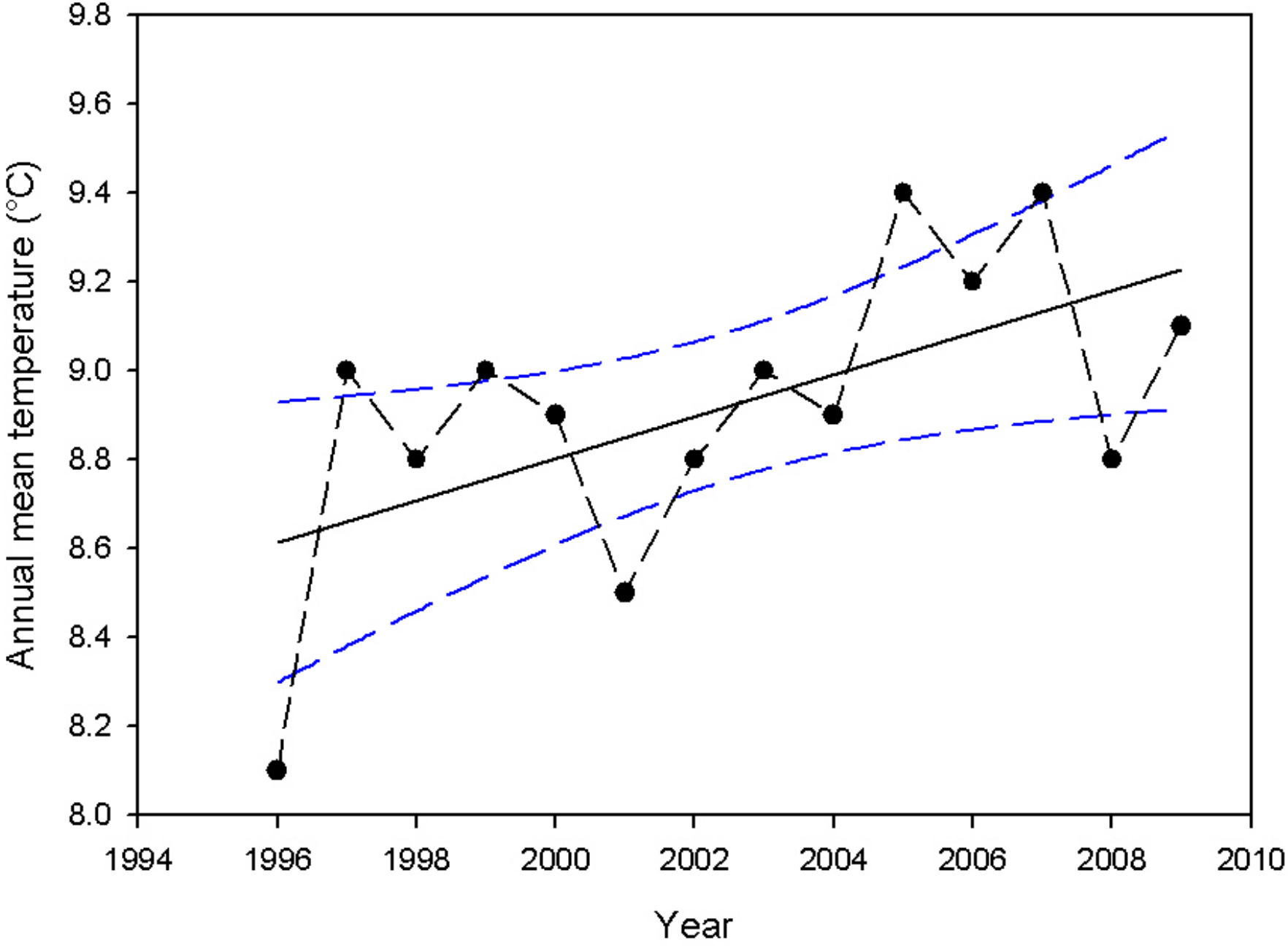
87% of glaciers are retreating in this area

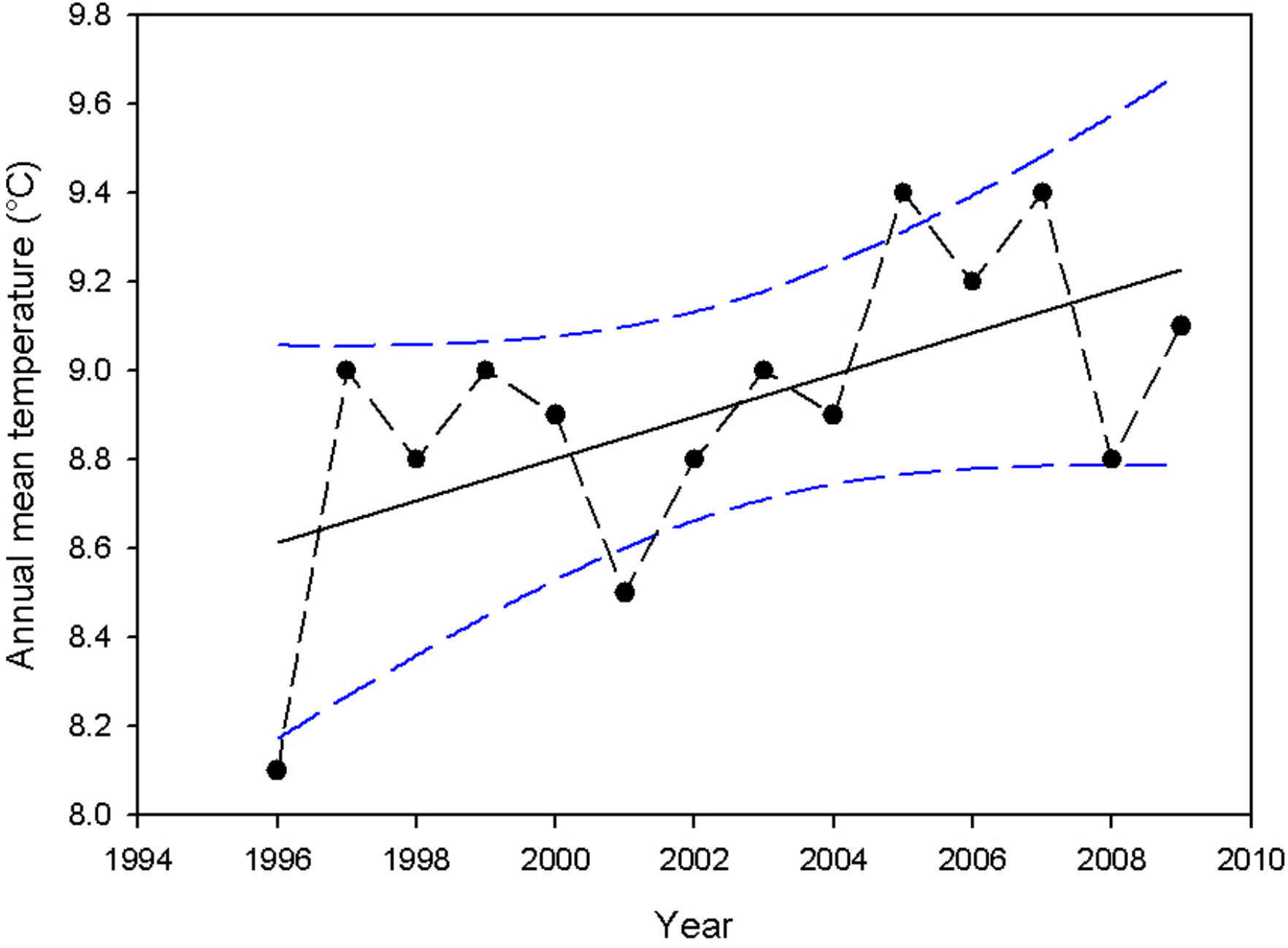

Northern Hemisphere Sea Ice Anomaly
Anomaly from 1979-2008 mean
sea ice anomaly (million sq. km)
3
2
1
0
-1
-2
-3
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
year
-2.305

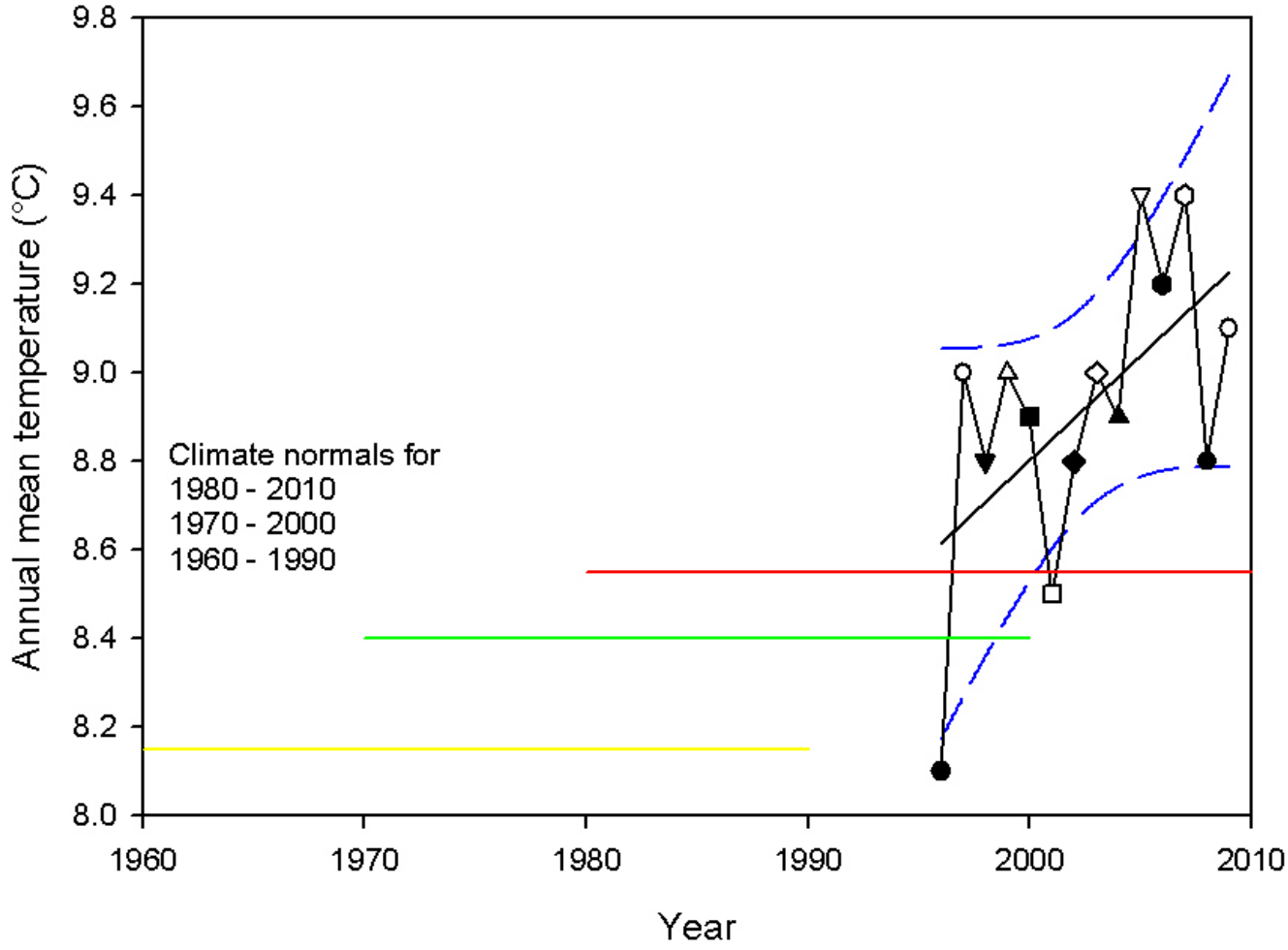

Southern Hemisphere Sea Ice Anomaly
Anomaly from 1979-2008 mean
sea ice anomaly (million sq. km)
3
2
1
0
-1
-2
-3
0.429
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
year


Halley Mean Annual Temperature
Temperature (deg C)
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24
-25
1940
1950
1960
1970
1980
1990
2000
2010
2020


"A significant warming trend ... of about 0.05°C/year"
Annual mean temperature (°C)
9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year


9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
Annual mean temperature (°C)
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

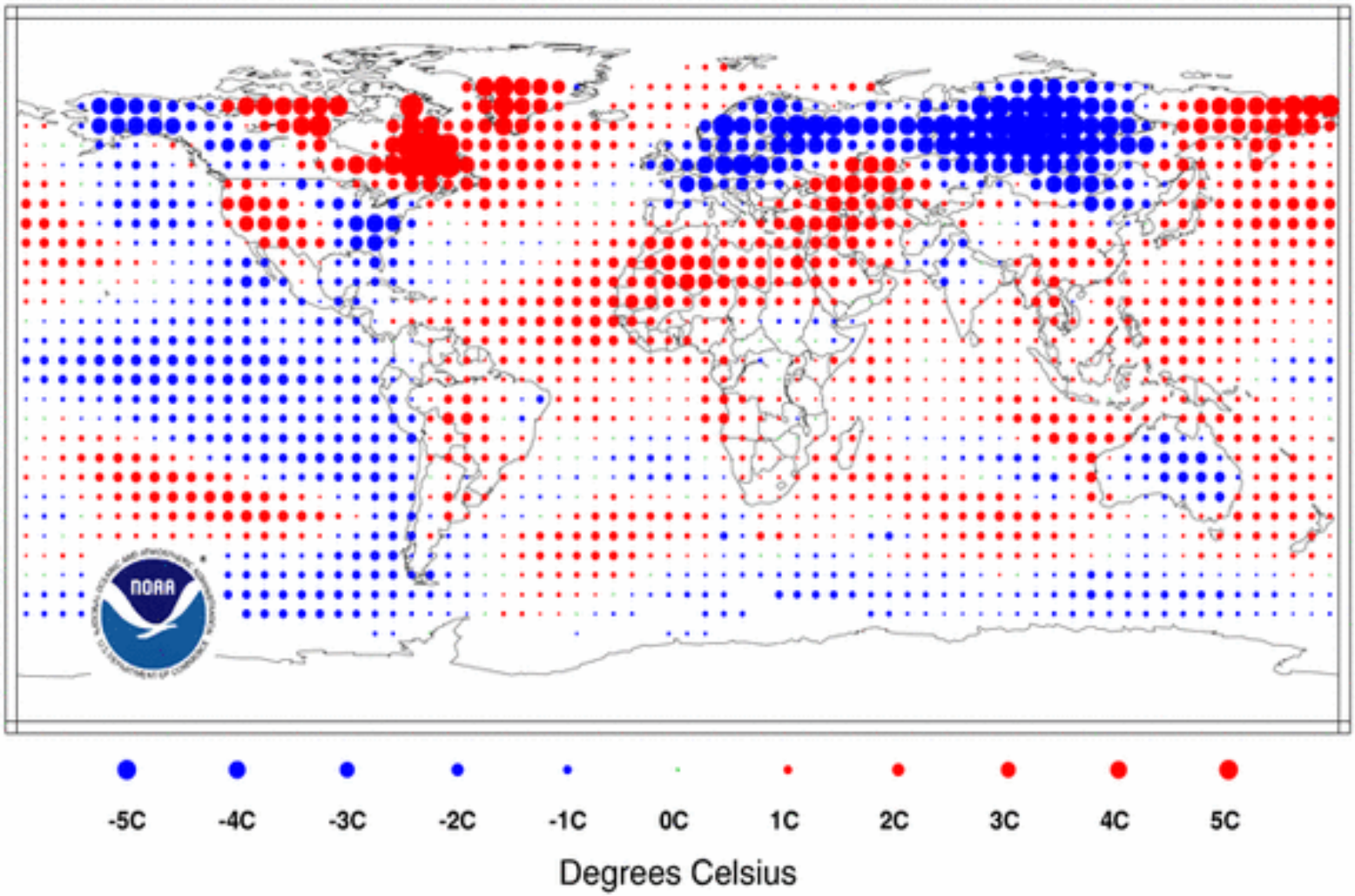

9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
Annual mean temperature (°C)
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

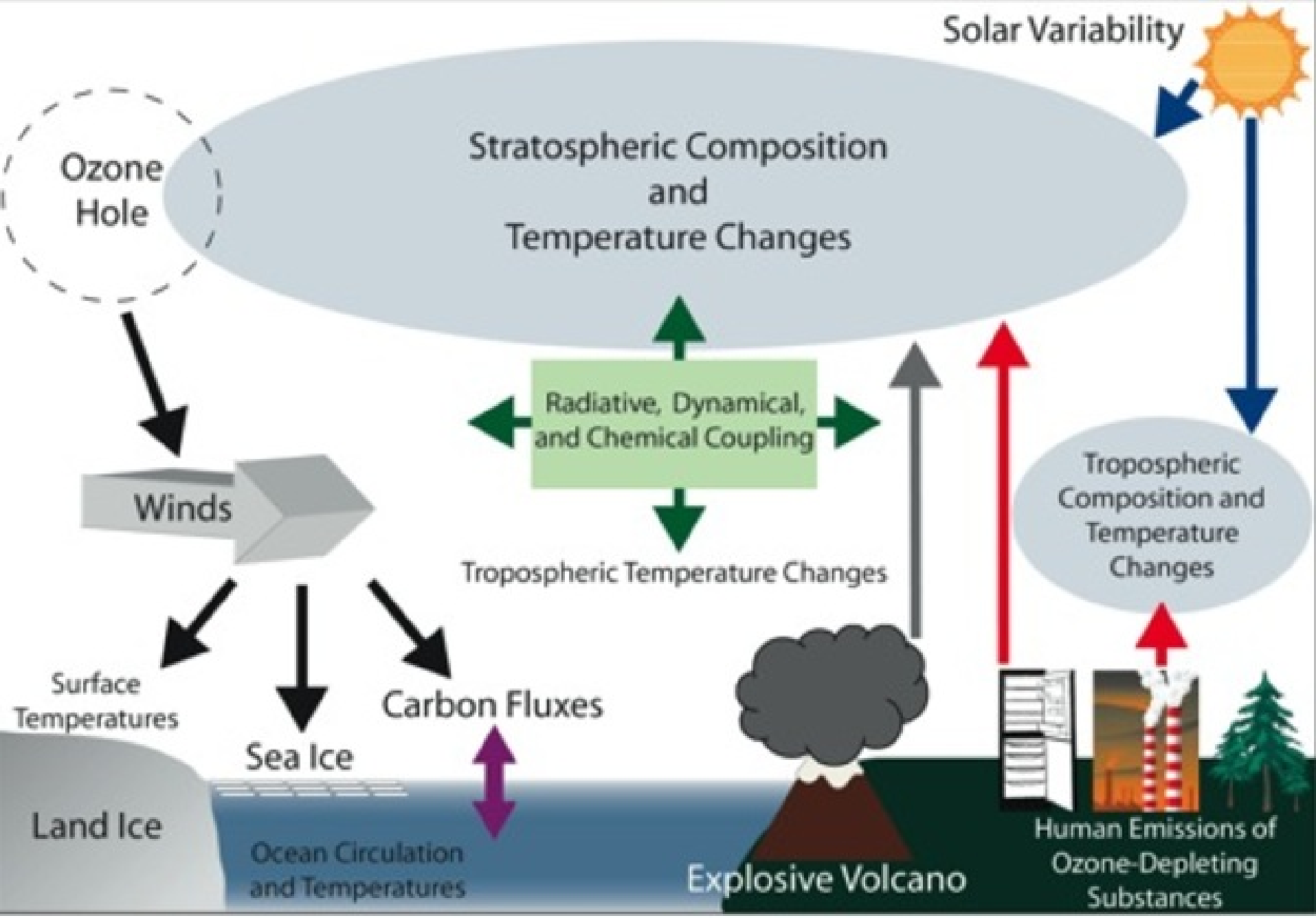

Annual mean temperature (°C)
9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
Climate normals for
1980 - 2010
1970 - 2000
1960 - 1990
1960
1970
1980
1990
2000
2010
Year

Temperature Anomalies December 2010

(with respect to a 1971-2000 base period)

National Climatic Data Center/NESDIS/NOAA

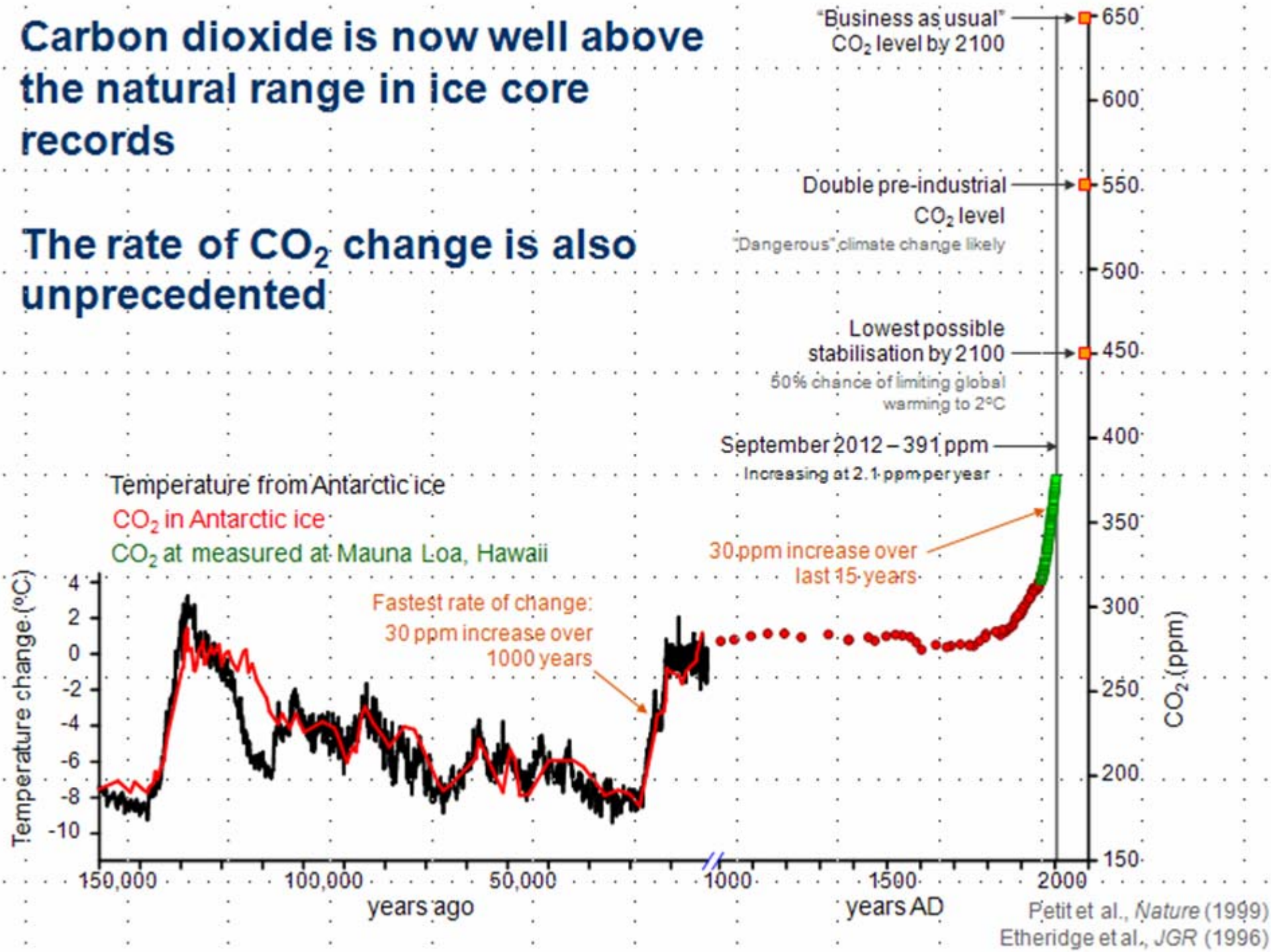




The climate system is complex, meaning that the ozone hole does indirectly alter the surface temperature and climate of the Earth. *WMO/UNEP Scientific Assessment of Ozone Depletion 2010*

Carbon dioxide is now well above the natural range in ice core records

The rate of CO_2 change is also unprecedented



Petit et al., *Nature* (1999)
Etheridge et al., *JGR* (1996)

Cretaceous forest 120 Million years ago on the Antarctic Peninsula. Reconstruction based on PhD work of Jodie Howe, University of Leeds/BAS, painted by Robert Nichols.


QUESTIONS ?
See http://www.antarctica.ac.uk/met/jds/ for more information