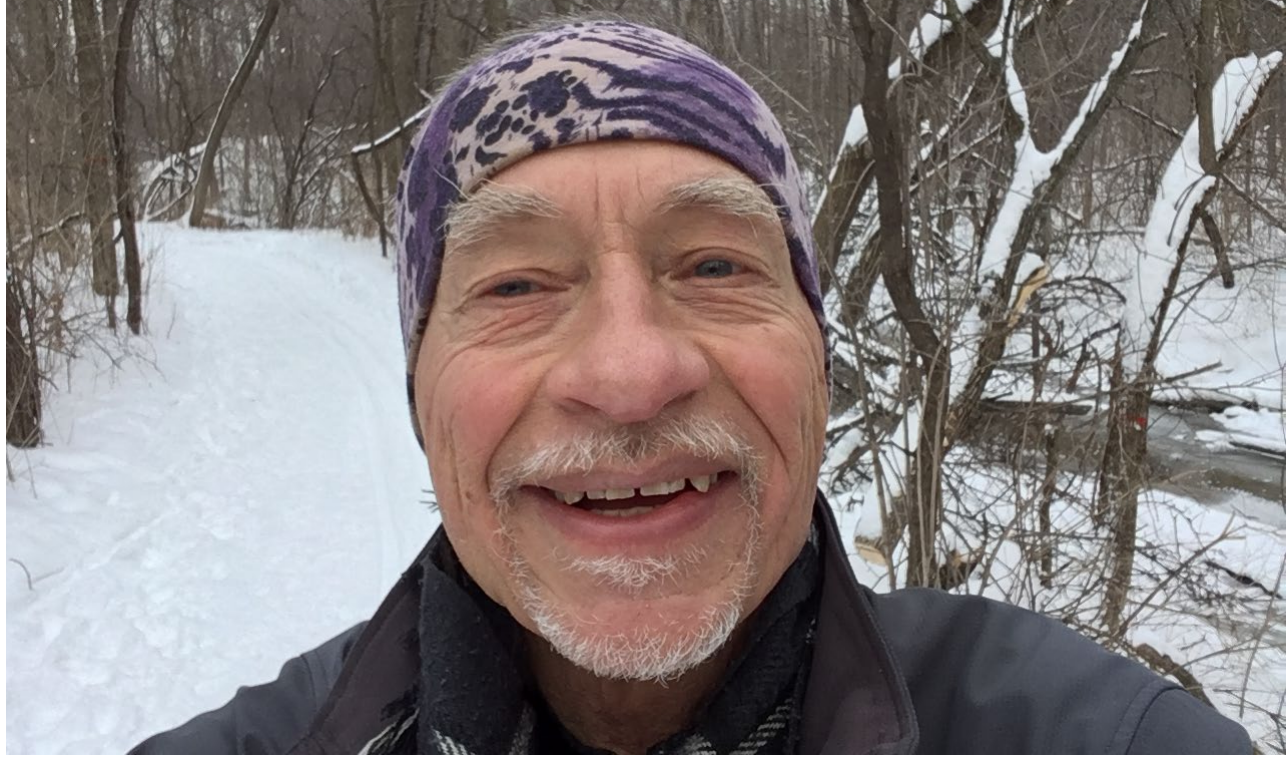
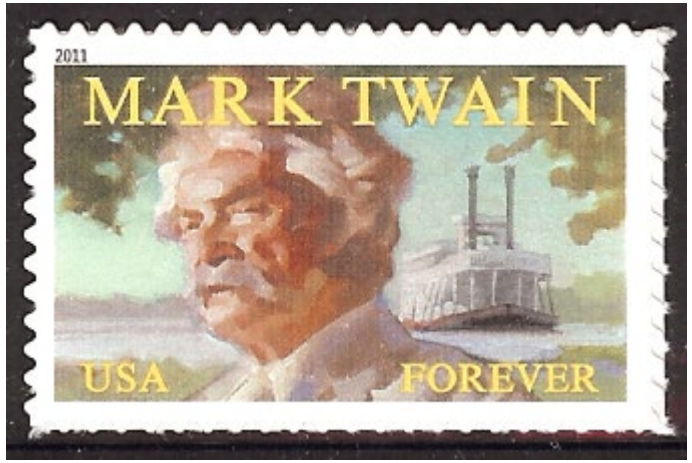


Garry Toth

GeoPhilately Workshop – 19 March 2022

An Introduction to Meteorology and Space Weather in Philately

Part 1 – Meteorology (includes Weather and Climate)



Geophysics / Earth Sciences include meteorology

International Cooperation – the IPYs (International Polar Years)

1st IPY – 1882-1883 – 100th anniversary

2nd IPY – 1932-1933

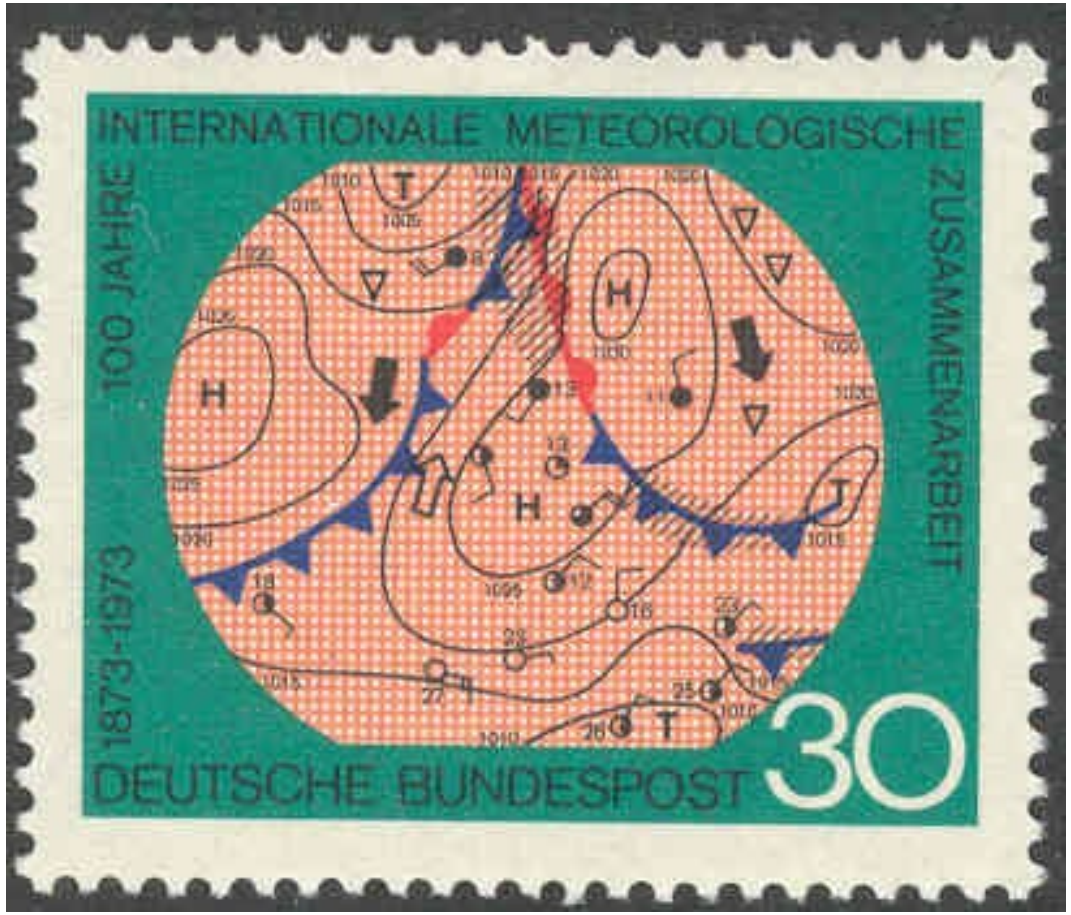
3rd and 4th IPYs (3rd IPY is the IGY – the International Geophysical Year)

3rd IPY – 1957-1958

4th IPY – 2007-2008

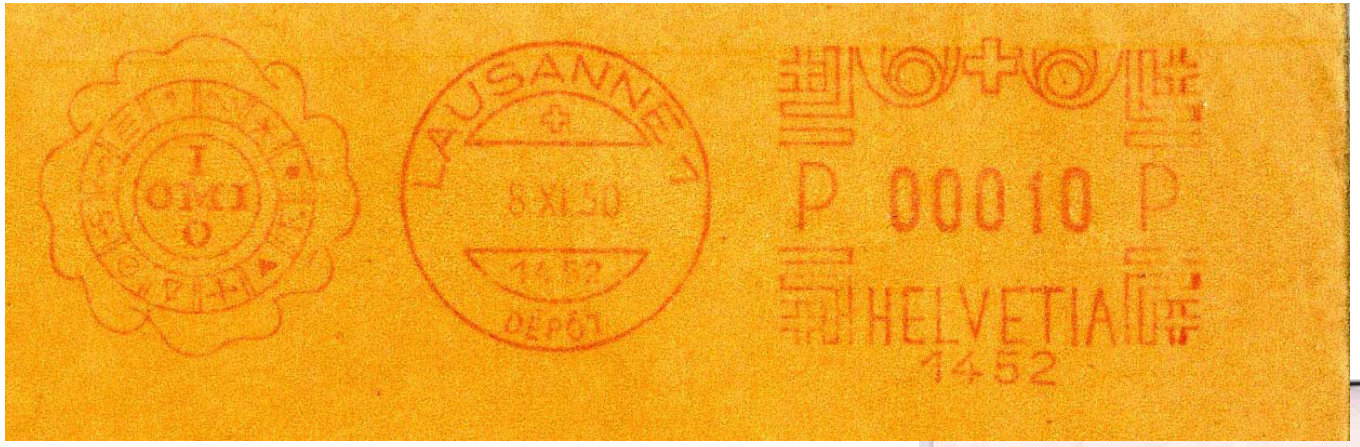
World Meteorological Organization (WMO) (originally IMO – International Meteorological Organization)

100th anniversary IMO/WMO, in 1973

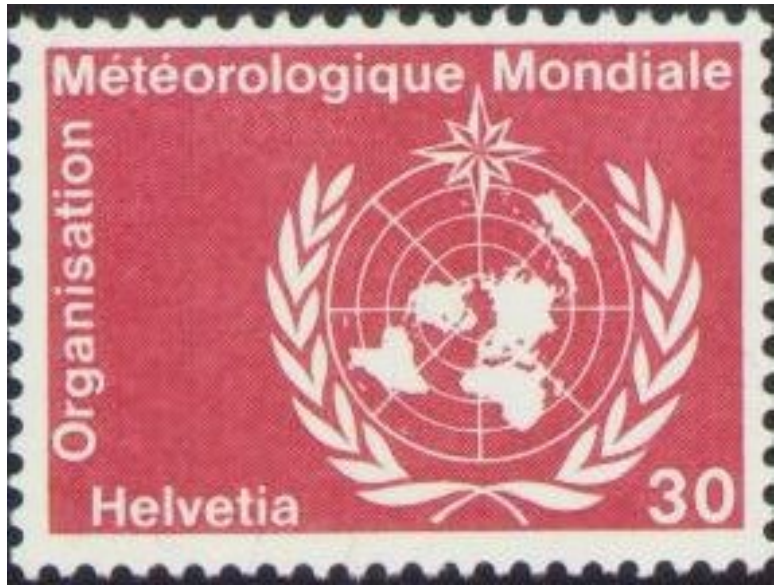


World Meteorological Day – each 23 March since 1961

The IMO became the WMO (the World Meteorological Organization) in 1950



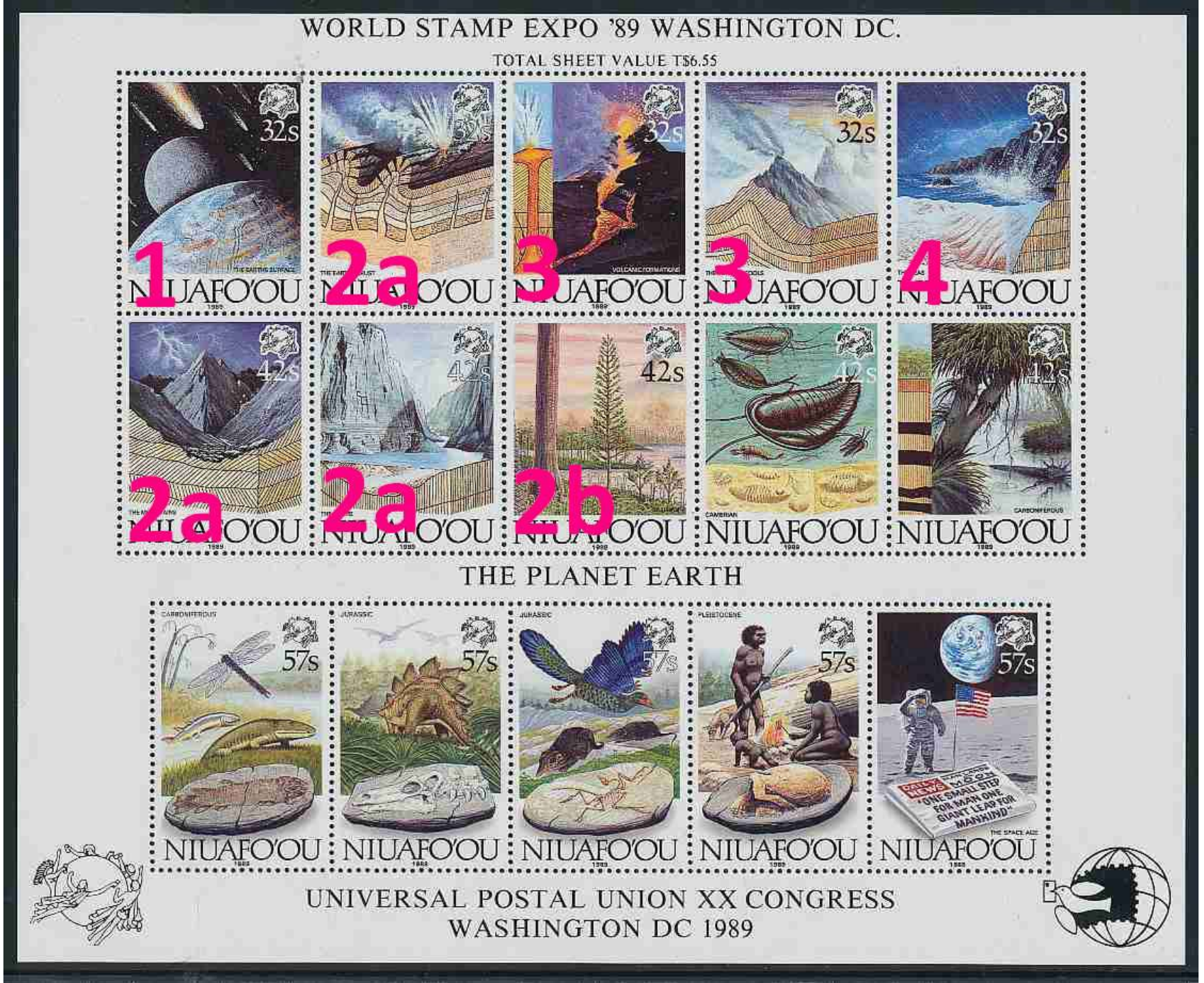
WMO logo



WMO 50th Anniversary (in 2000)

Some elements of geophysics related to meteorology

1. Asteroid/Meteorite strike
2. Continental Drift
3. Vulcanism
4. Oceans



Alvarez theory - ~10 km diameter meteorite (asteroid) impact

65 million years ago

Changed climate

Chicxulub crater (Yucatan)

Alvarez (father & son) – iridium layer at Cretaceous-Tertiary (K-T) boundary

→ K-T extinction event

Continental Drift & Climate Change

Wegener – meteorologist who developed continental drift theory

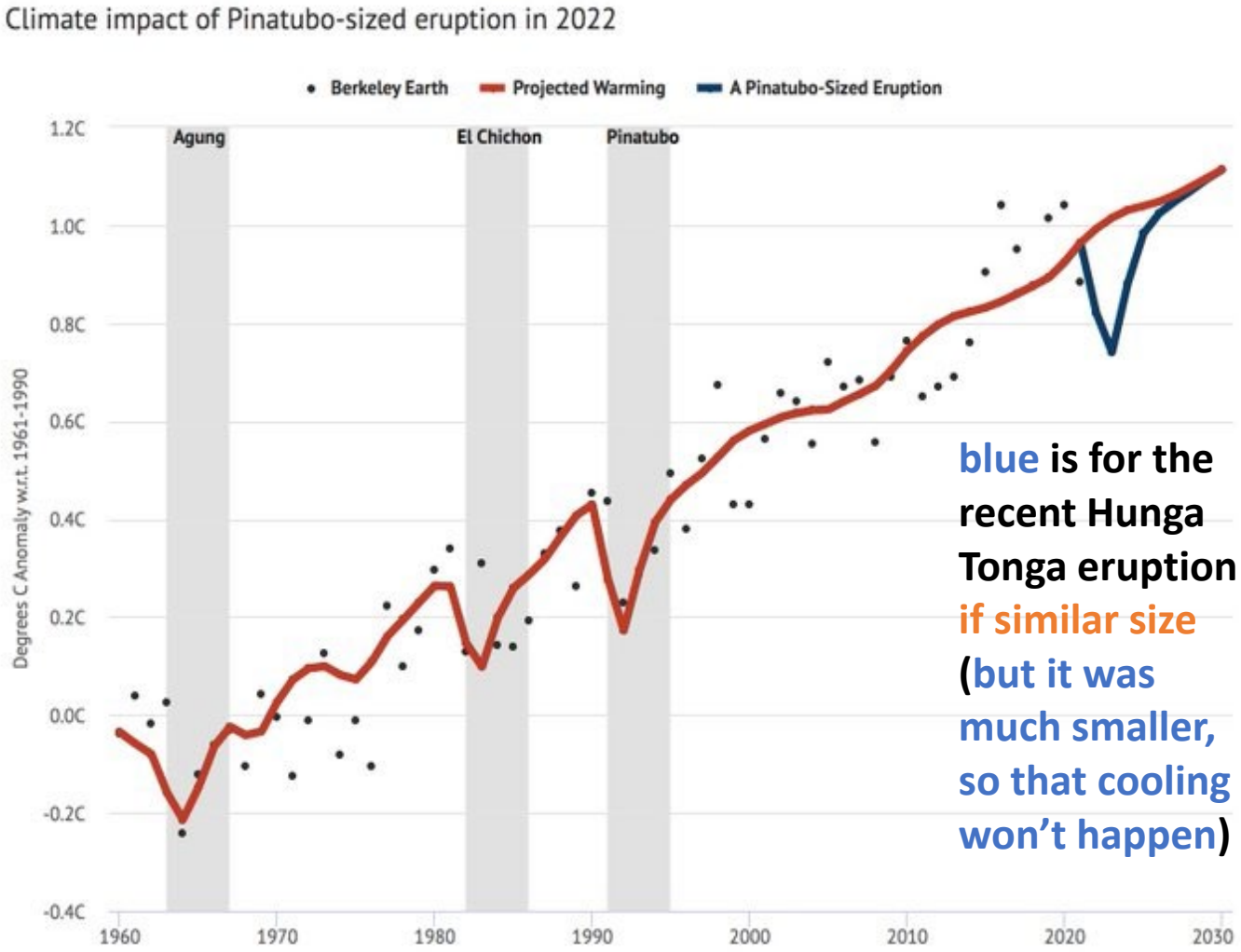
The disastrous Scott South Pole expedition collected fossilized Glossopteris leaves, recovered after their bodies were found. From a warm and wet climate, they were one piece of evidence supporting the idea of continental drift

Major Volcanic Eruptions in Recorded History

Tambora's eruption in 1815 was followed in 1816 by what was called in some areas a "year without summer". Krakatoa's eruption in 1883 also had significant climate effects.

Recent Large Eruptions

Climate impact (~0.2°C of cooling for ~3 yr) of Pinatubo, Agung and El Chichón (1982) – dotted observations and red model forecasts



blue is for the recent Hunga Tonga eruption if similar size (but it was much smaller, so that cooling won't happen)

Agung (1963)

Pinatubo (1992)

Volcanoes and Aviation

Eruption seen from ISS (Cleveland Volcano, Aleutians, 23 May 2006)

Volcanoes and airplanes don't mix!

Two volcanoes that caused aviation problems and closed airspace

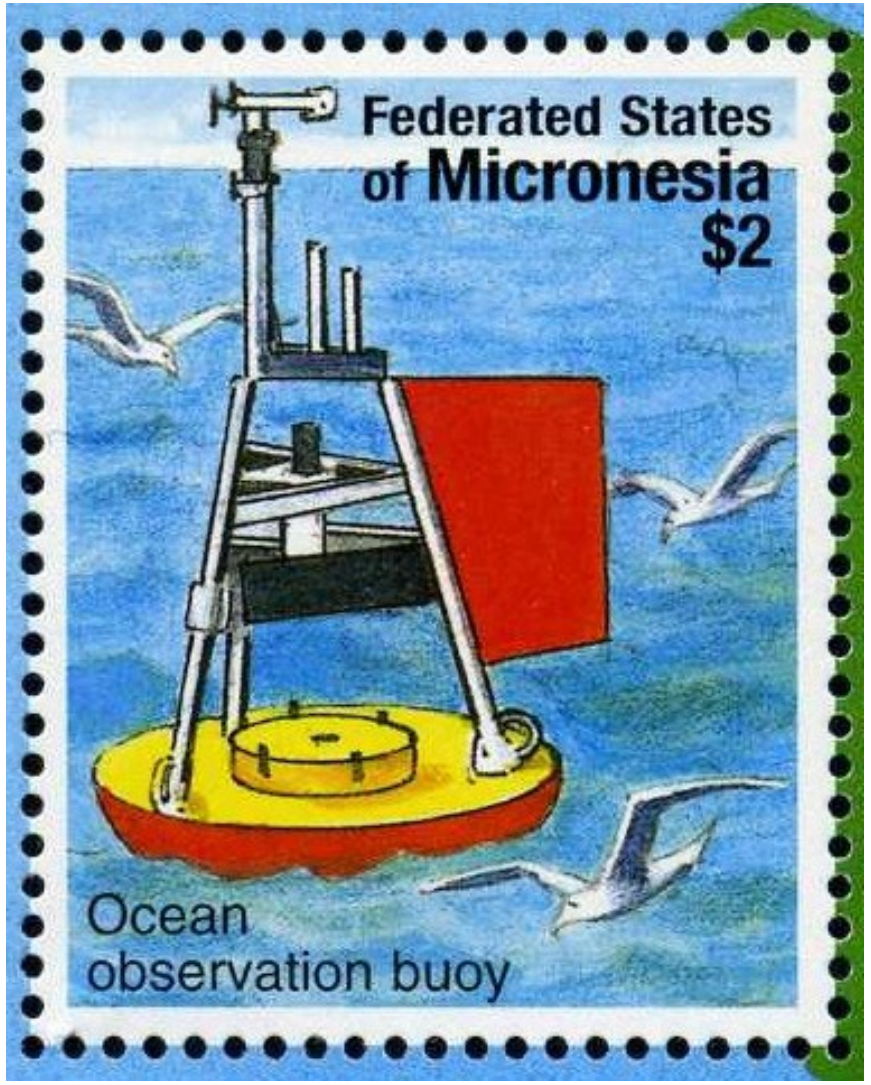
Mt. St. Helen's, Washington State (18 May 1980 eruption)

Eyjafjallajokull (Iceland, April 2010 eruption)

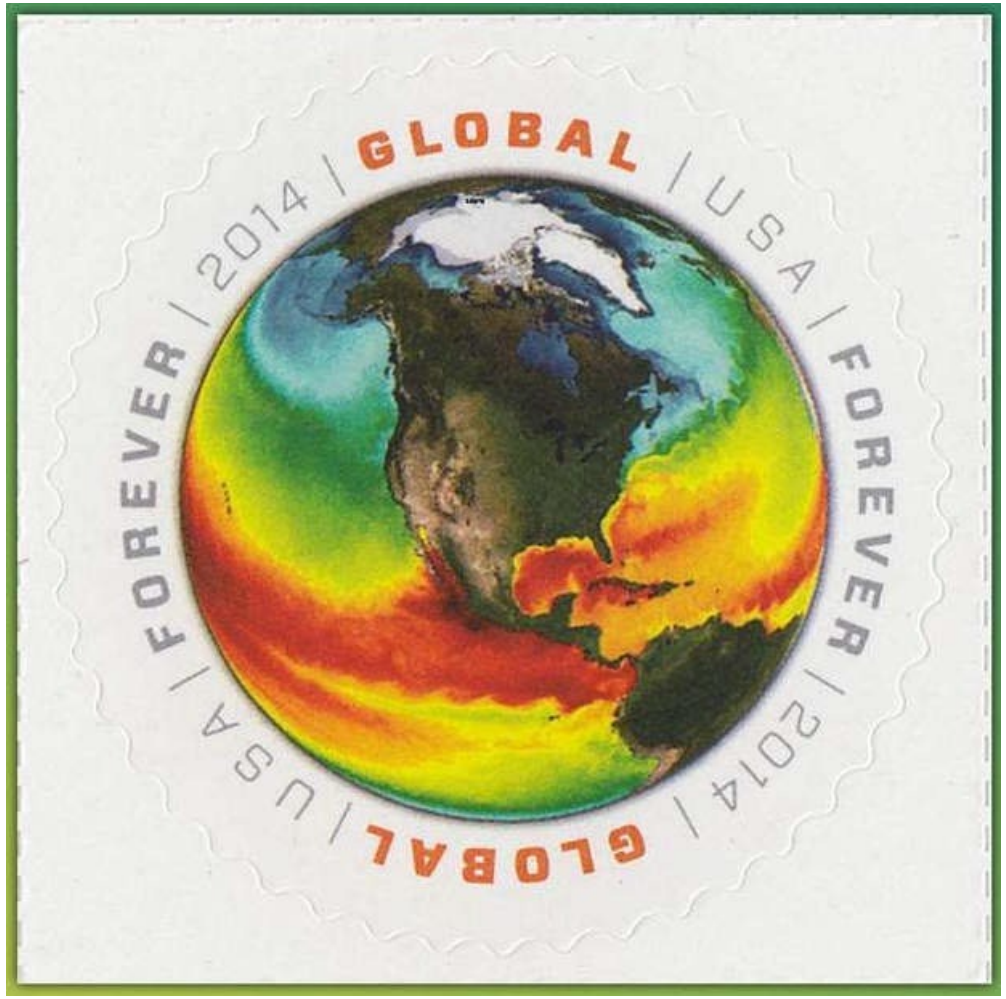
Ocean SST

Satellite observations

Weather buoy observations

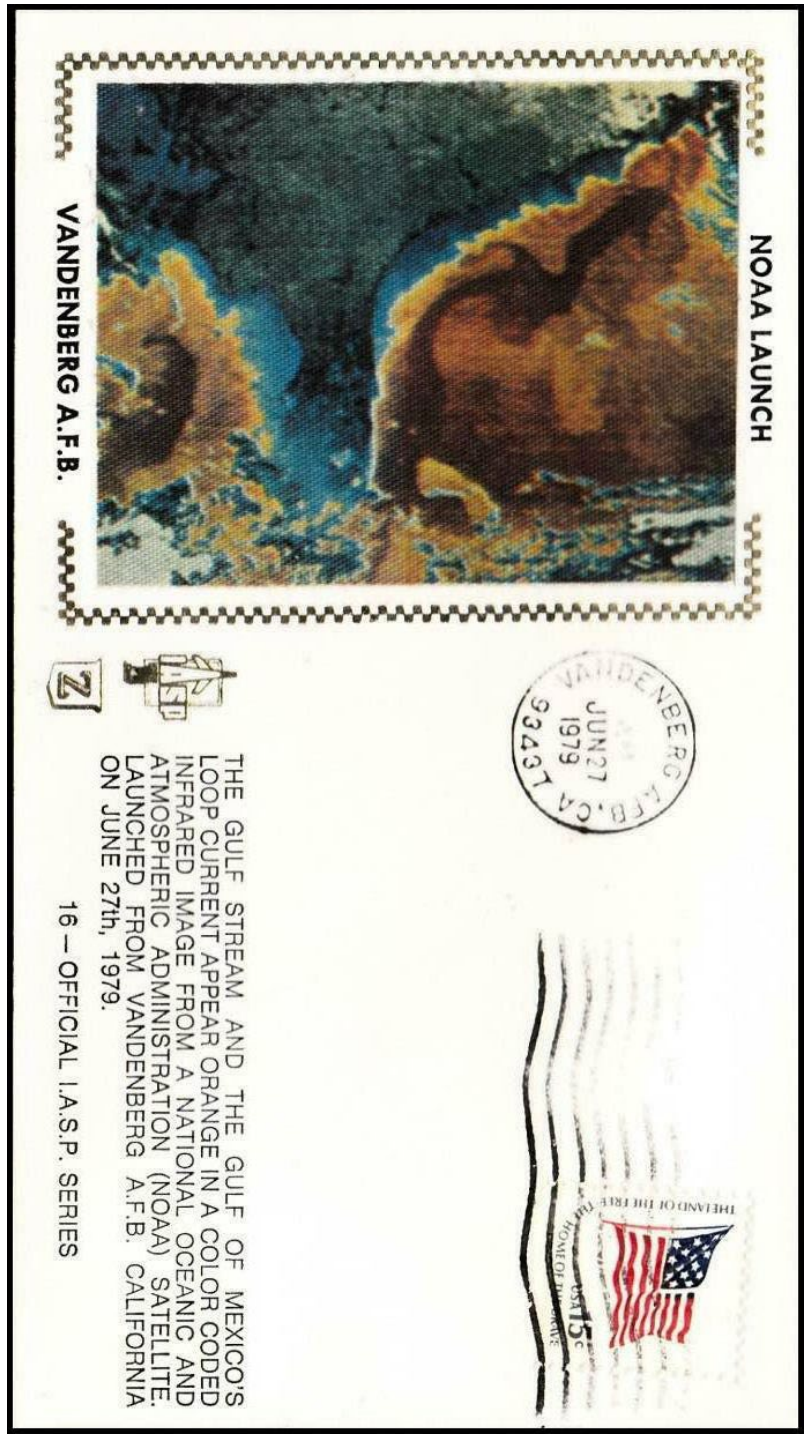


Sea Surface Temperatures (SSTs)



SST anomalies (in this map, with El Niño off Peru)

Warm **Gulf Stream** (and **Gulf of Mexico Loop Current**) seen from space (by NOAA-6)

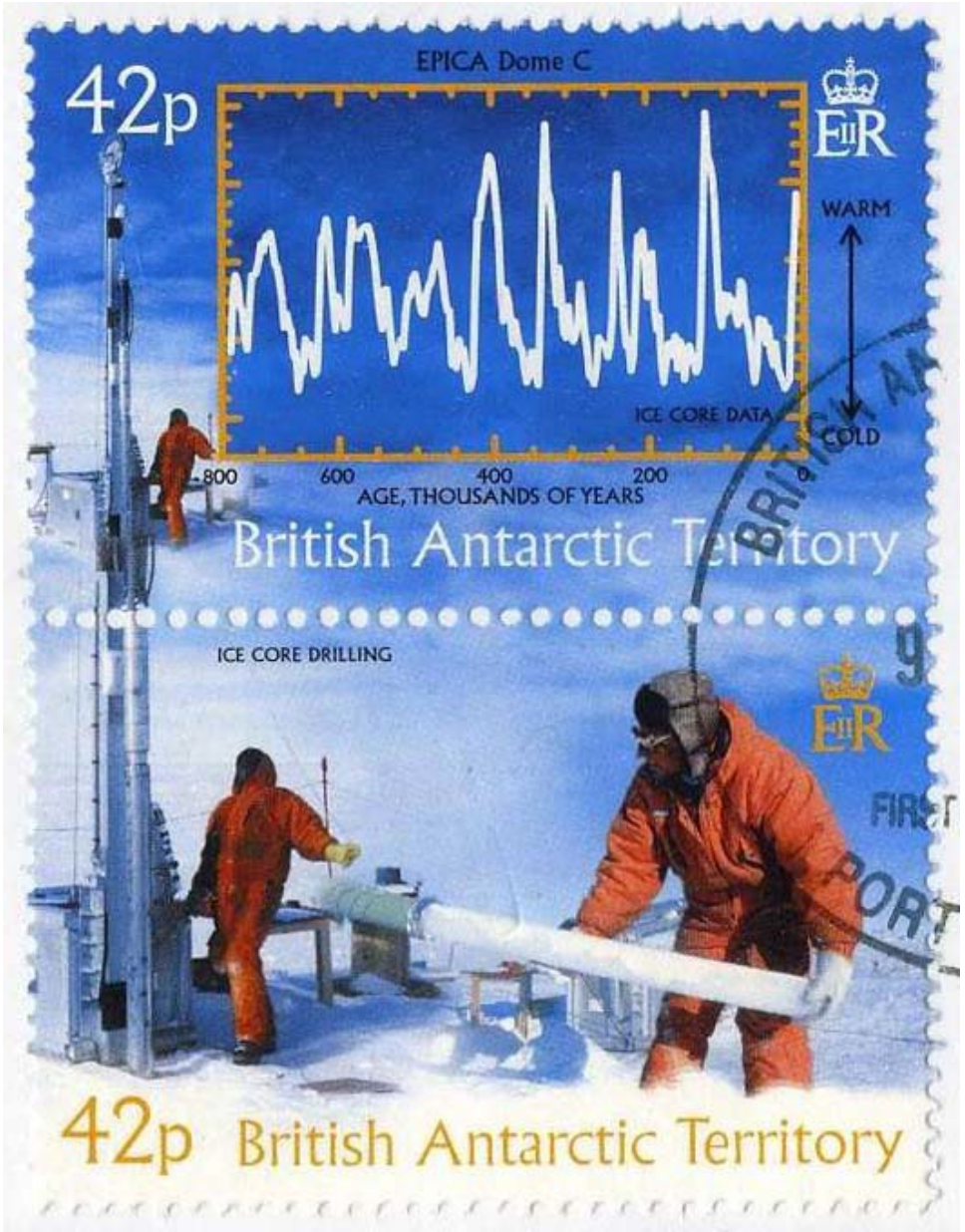


In 1769, Benjamin Franklin published the first known map of the Gulf Stream

FIG. 173.—FRANKLIN'S CHART OF THE GULF STREAM.

Glaciology and Ice Coring

Historical temperatures can be estimated from ice cores



Glaciology, Ice Coring and Snowflake

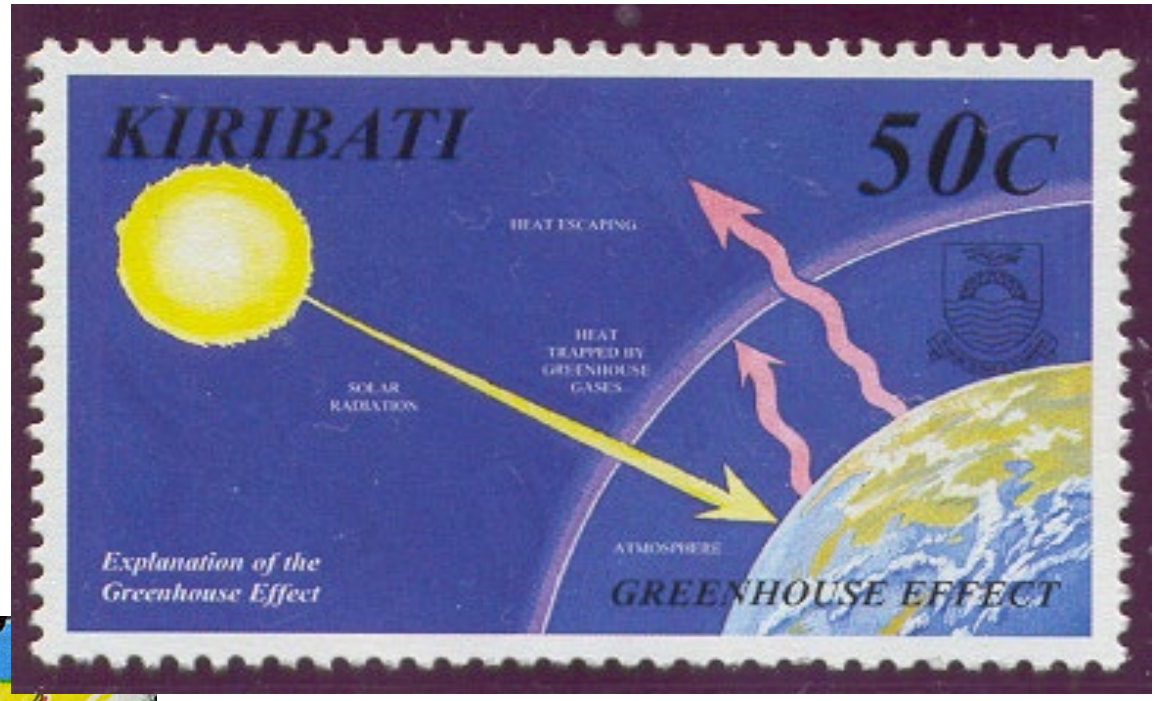
Ocean Floor Sediment Coring

Ocean sediment “coring for past climate changes”

Ocean sediment coring and continental drift

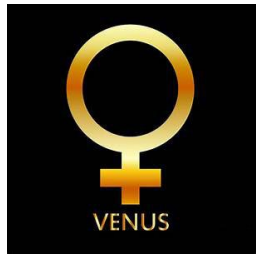
Global Warming and Climate Change

~1825 – Fourier - 1st to present the idea of the atmosphere as an "insulator" (the atmospheric "greenhouse effect")



Atmosphere traps some outgoing L/W radiation. More greenhouse gases → more trapping → temperature rises

Venus – extreme greenhouse effect – surface temperature ~462° C



Fossil fuel burning increases CO2 in Earth's atmosphere

Global Warming

Forecast

Observed

Arrhenius – 1896 – 1st forecast of warming due to CO2 release

Some Impacts of Global Warming and Climate Change

Sea level rise, flooding and coastal erosion

Heat waves

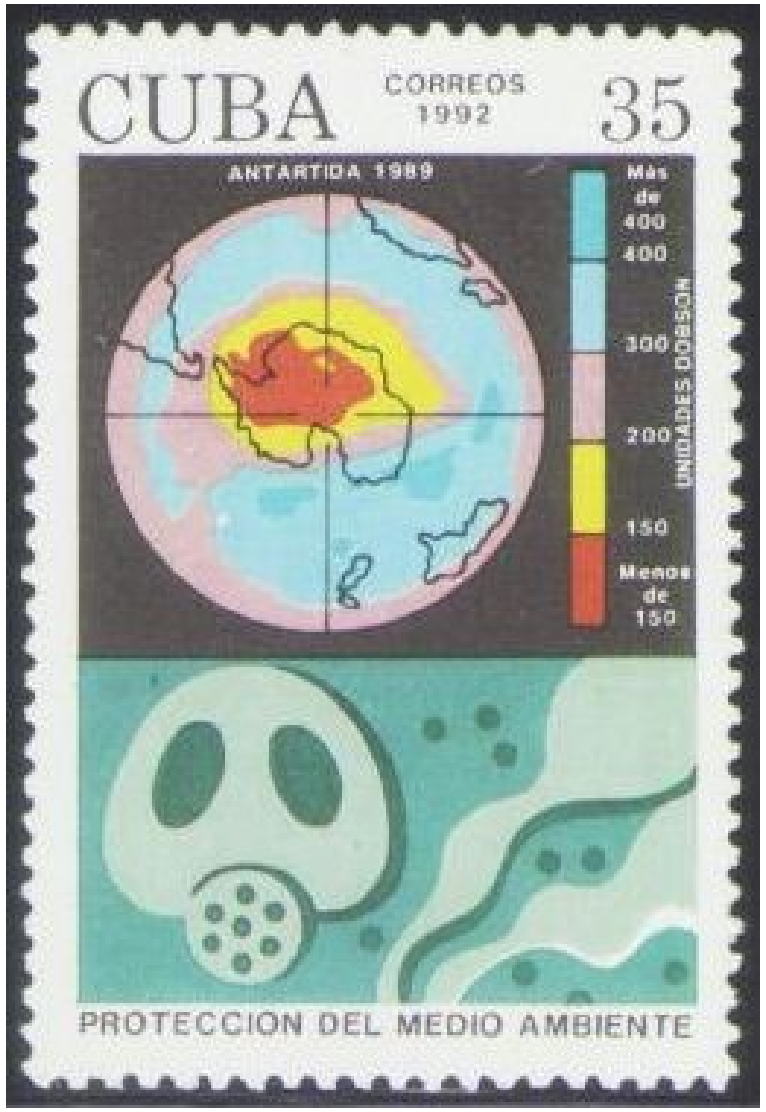
Drought

Wildfires (in forests, but also in built-up areas)

Health effects (e.g. due to heat waves, poor air quality, changing patterns of disease and migration of insects, severe weather, etc)

Ozone

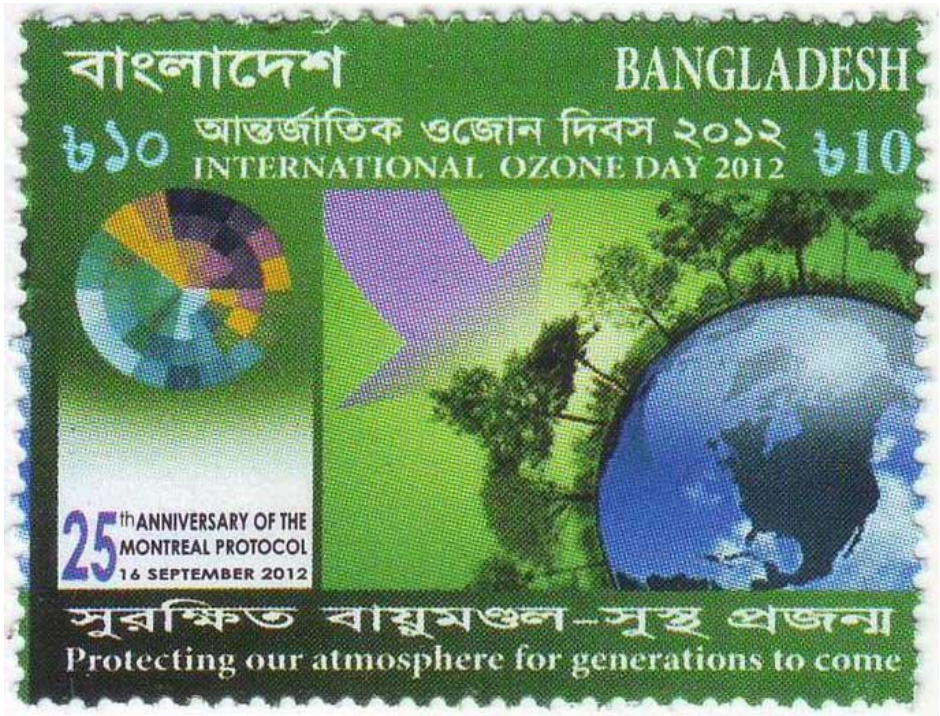
Antarctic ozone hole



Molina and ozone equation

Healing the hole – 1987 Montréal Protocol – phase out CFCs

Also, World Ozone day, each year on 16 September



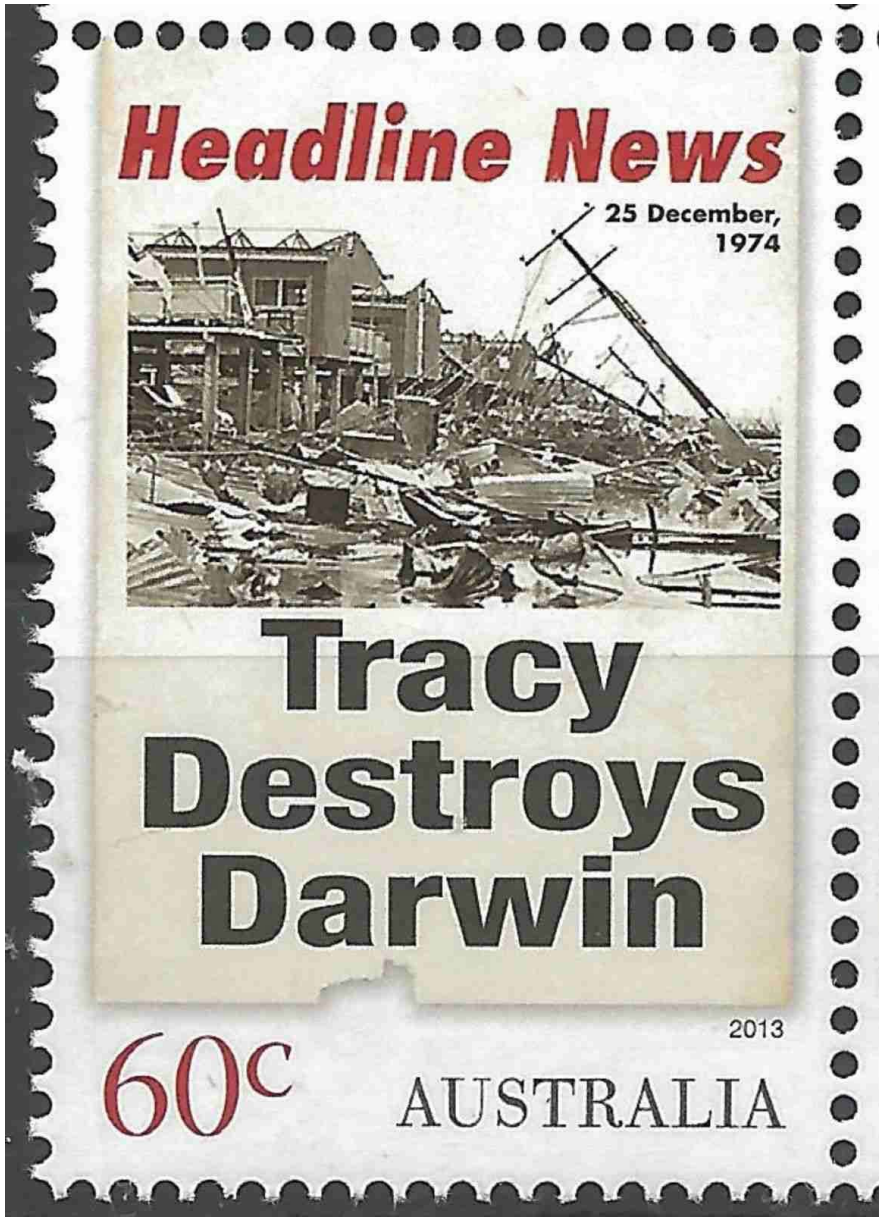
Ice Ages

16,000 BC - maximum glaciation and minimum sea level

1930s – Milankovic – mathematical relationships between the cycles of the Ice Ages and changes in Earth's orbital eccentricity, axial tilt and precession

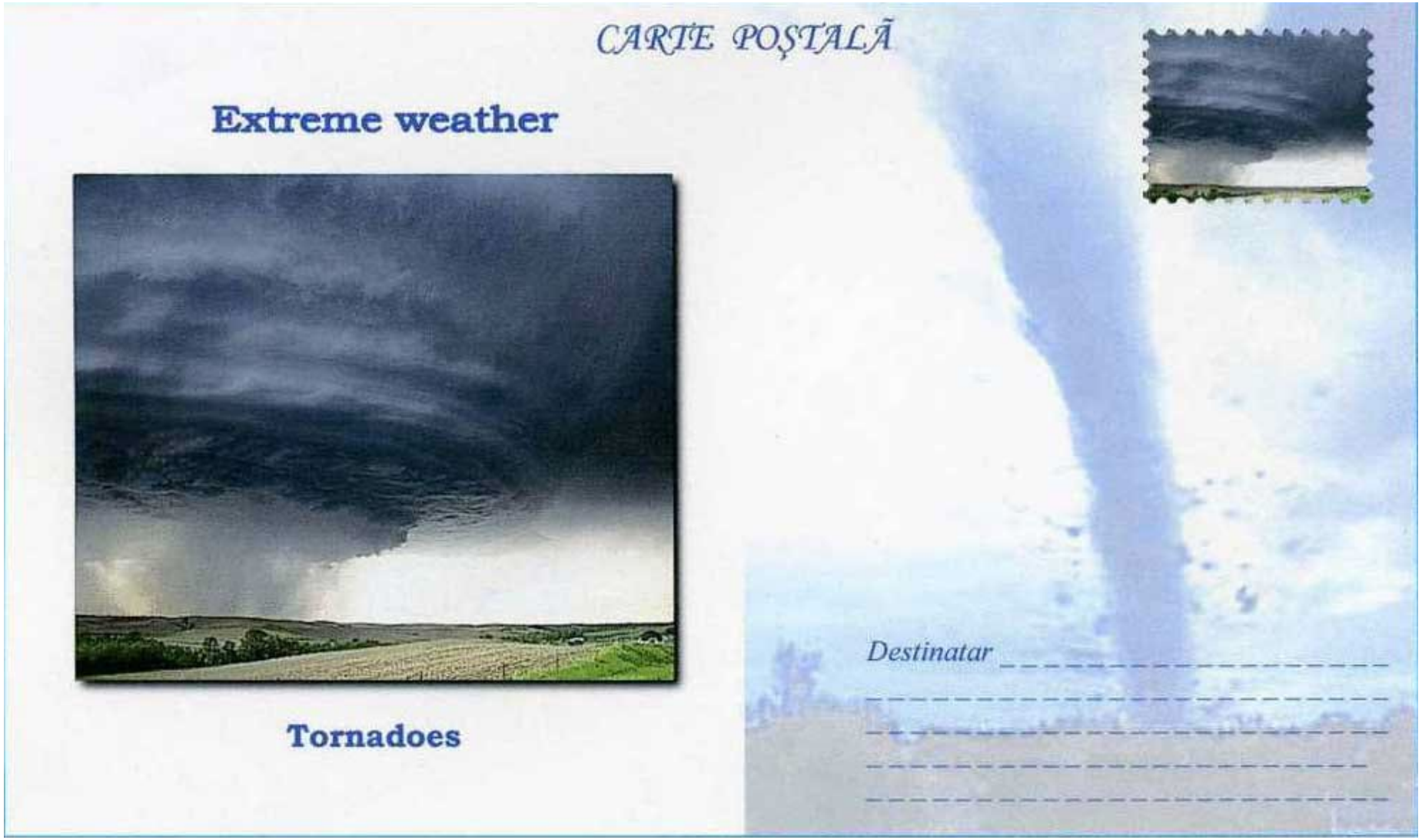
Some Storms 1

Hurricanes/Typhoons/Cyclones



Some Storms 2

Tornadoes



Some Storms 3

Windstorm

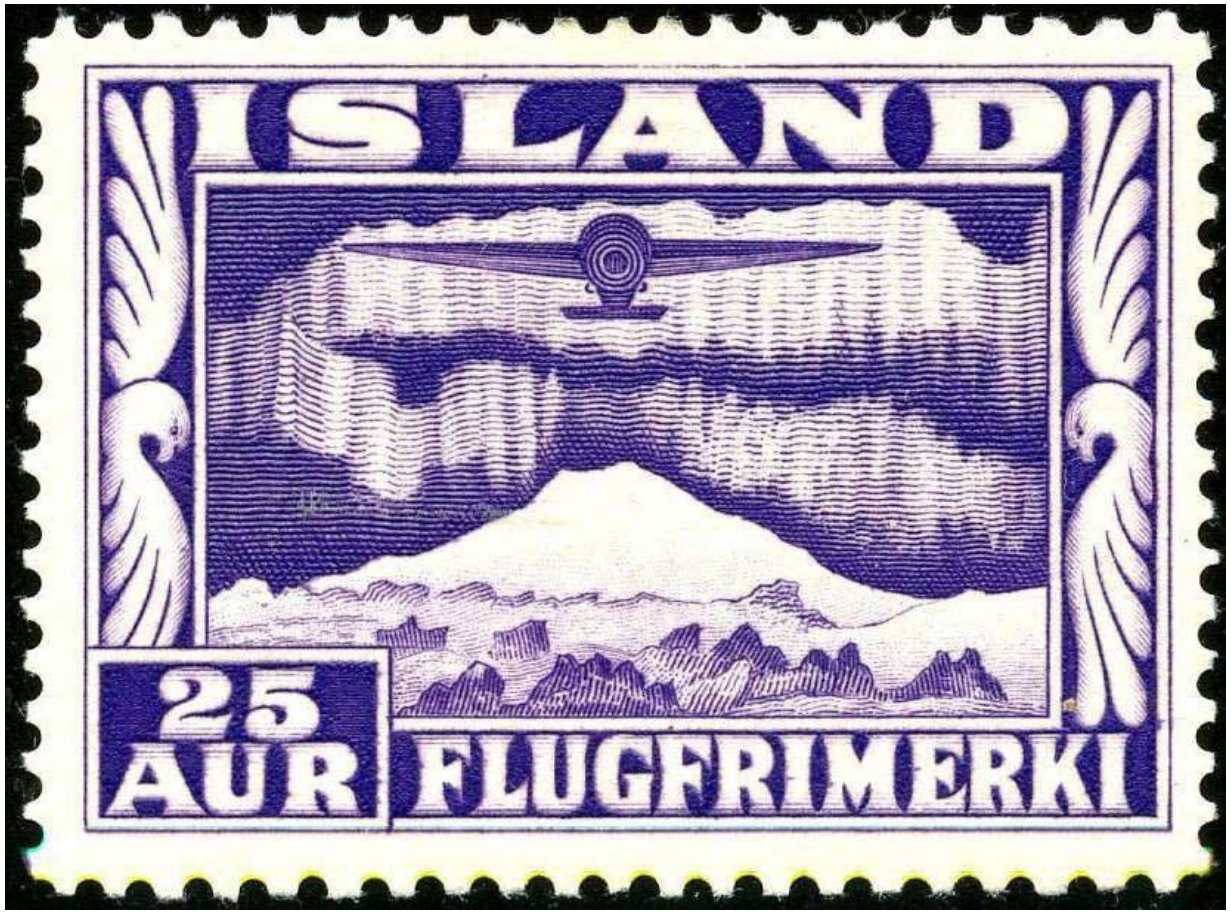
Blizzard (US *Scott* 292, year 1898)

Part 2 – Space Weather

- The effects of “storms” of solar energy and particles on Earth’s atmosphere, on its biology and technology, and on the near-Earth space environment
- “near Earth” – as far as the Moon
- Such effects also exist elsewhere in solar system (e.g. deep space, other planets)

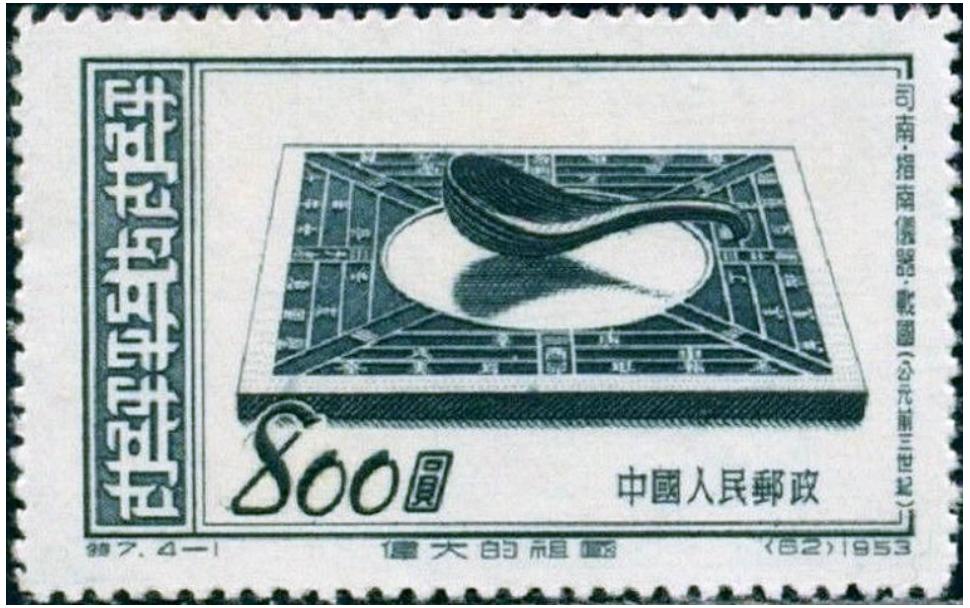
The auroras symbolize space weather

Iceland *Scott* C17, year 1934



Antecedents 1 – Earth magnetism

An early Chinese compass (ca 400 BC) – magnetized iron spoon on bronze plate



Halley's map of lines of magnetic variation of the compass (1701)

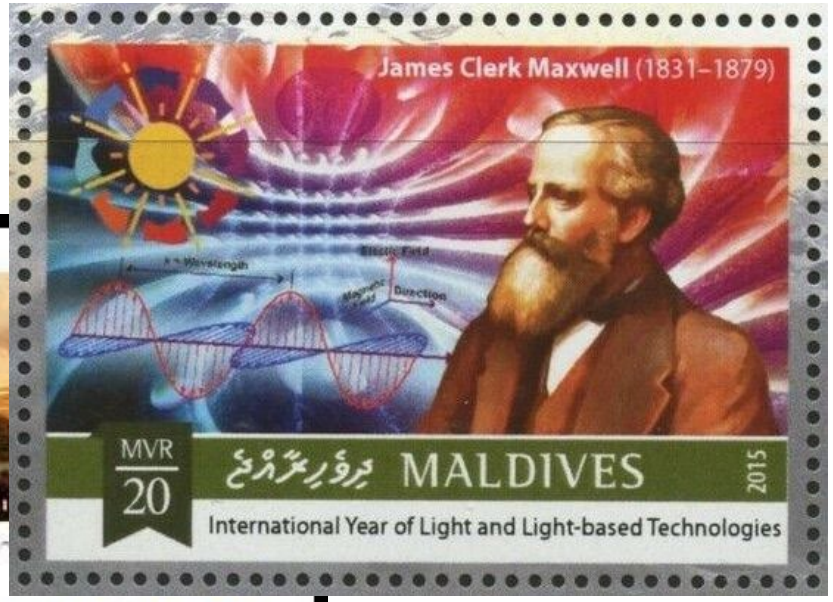
Antecedents 2 - Auroras

Angels in the sky?

Spirits of the Dead in the sky, playing a ball game with a walrus head?

Von Humboldt -1805 – observed strong variations of the magnetic field in the presence of auroras → term "***Magnetischer Sturm***". BUT was its origin terrestrial or external?

The Carrington Event



Magnetic & electric fields

What relation to solar storms and auroras?

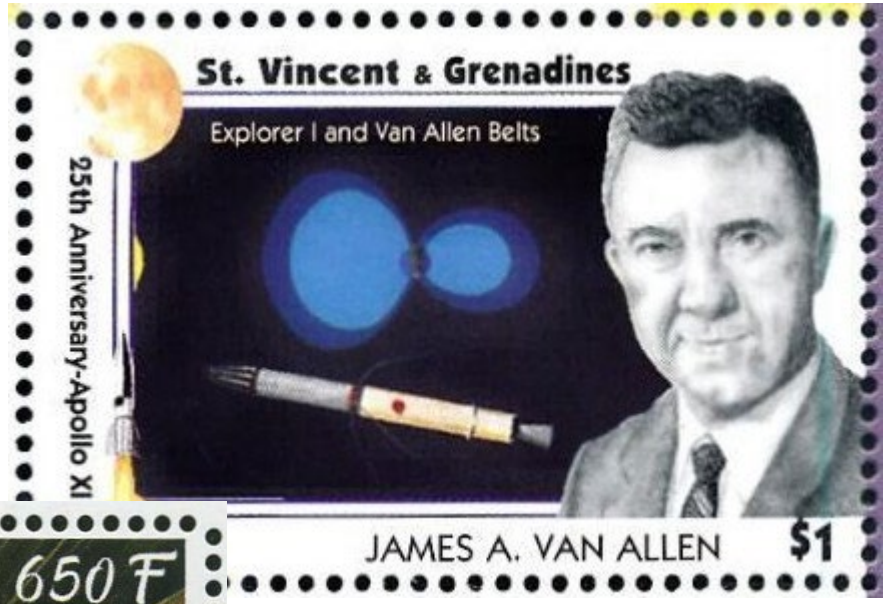
Earth-based research →

Some balloons & rockets →

IGY & Space Age satellites

The Space Age – A Great Leap Forward in Space Weather

Sputnik-1: begin the Space Age

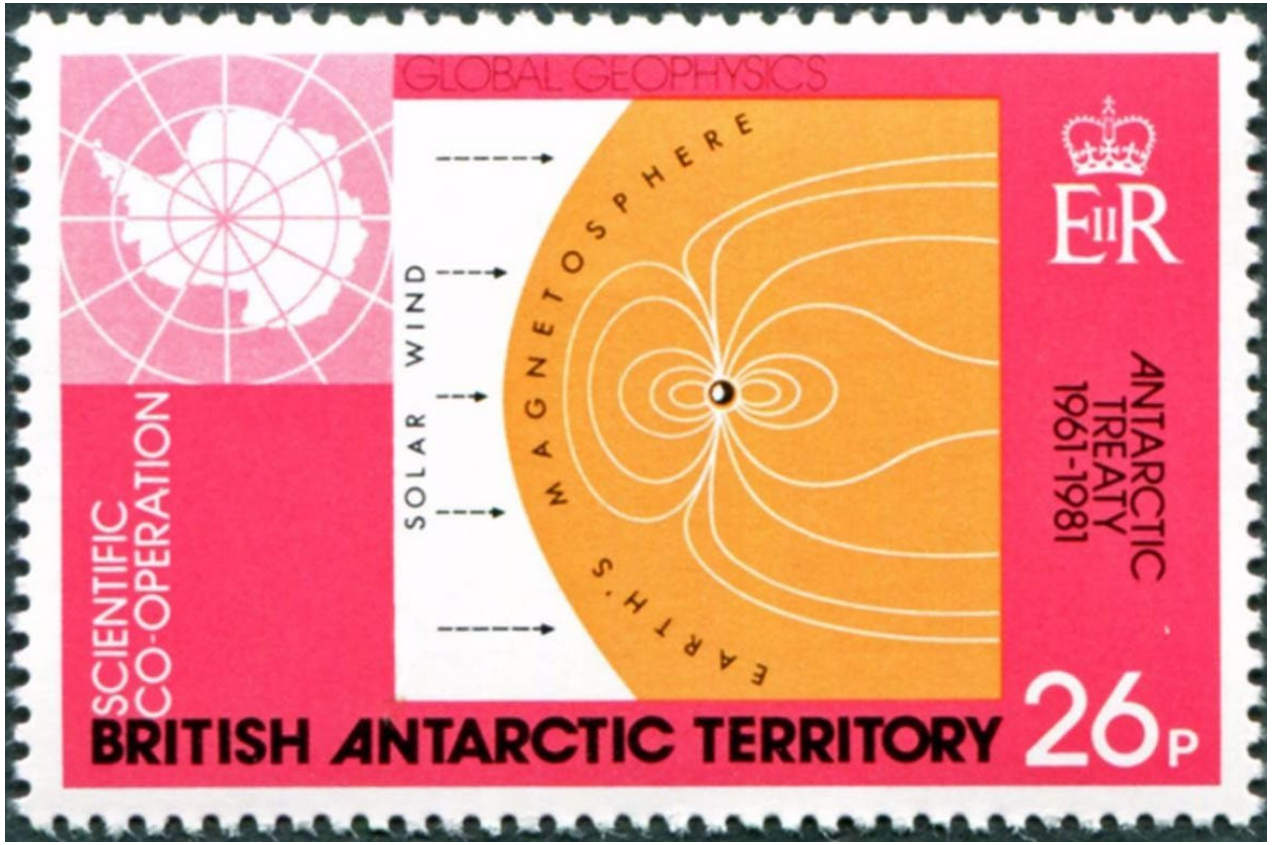


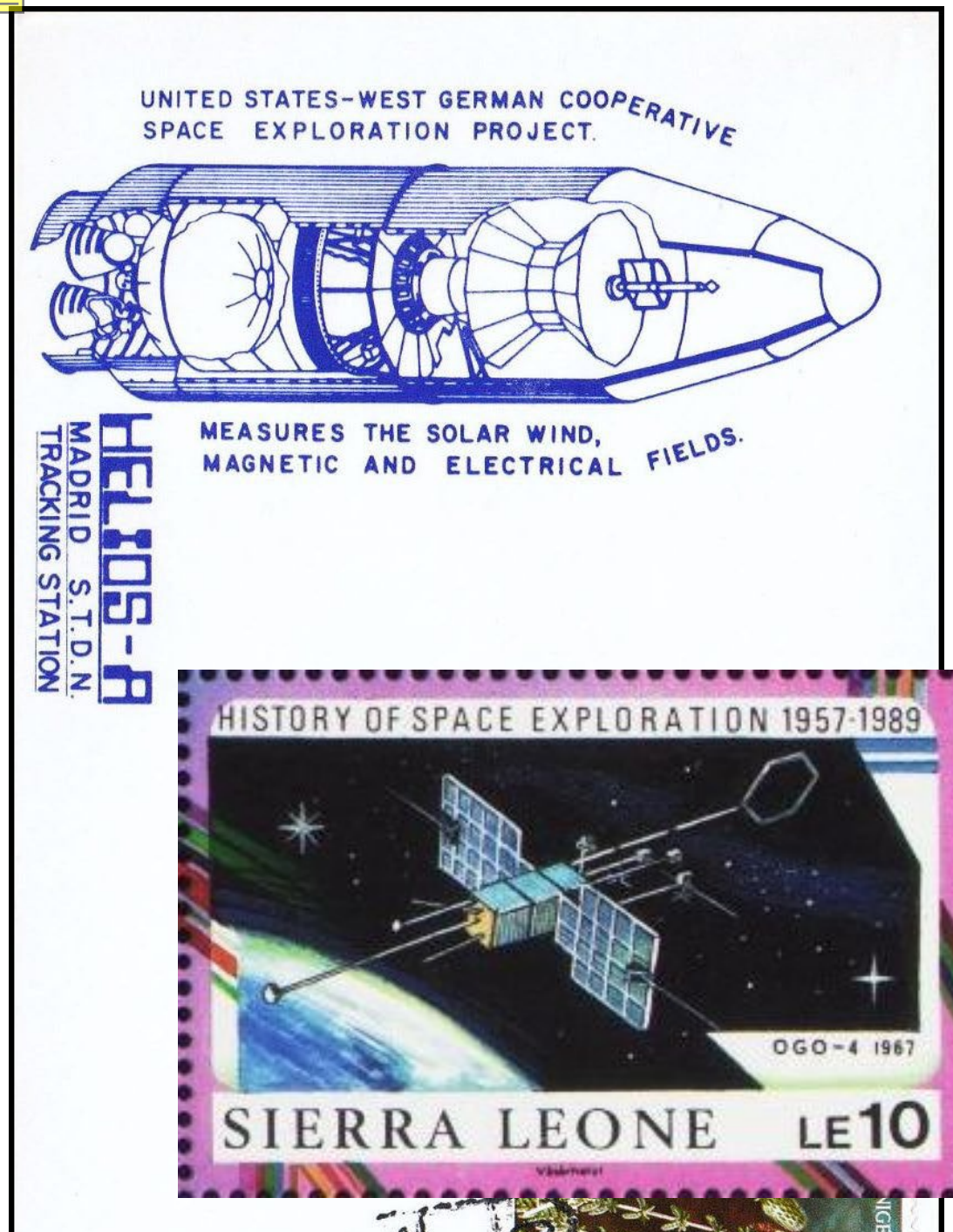
Explorer-1 discovers the Van Allen Radiation Belts – 31 Jan, 1958)

Mariner-2 discovers the solar wind in 1962

Solar Wind – stream of charged particles from the Sun; average 400 km/s (1.5 million km/h); ~4 days Sun-Earth but can be MUCH faster – 17 hr in the Carrington event

The Magnetosphere





Helios-1 was launched in 1974, and OGO-4 in 1967

Solar storms → Energetic solar wind → Complex interactions in the magnetosphere among that solar wind & magnetic & electric effects → geomagnetic storm → energetic particles accelerated into polar regions → Auroras

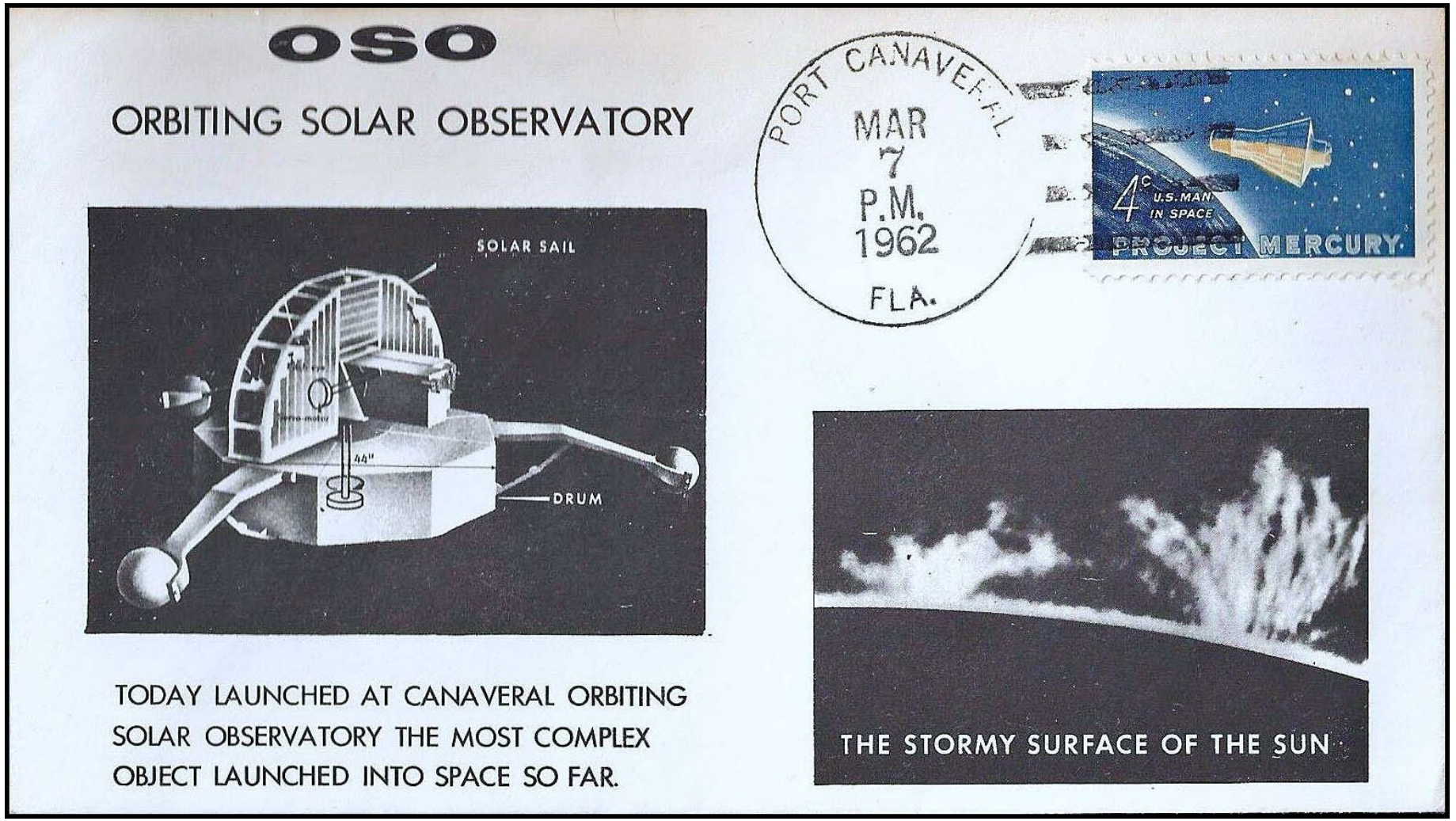
Auroral research – involves the study of high-energy solar particles in polar regions

e.g. by satellites such as ESRO-4 and Swedish Viking, and by research rockets

Auroral research rocket

Swedish Viking satellite (launched in 1986)

OSO-1 – An Early Solar-Observing Satellite



Biological effect of space radiation levels – for Apollo program – Explorer-35

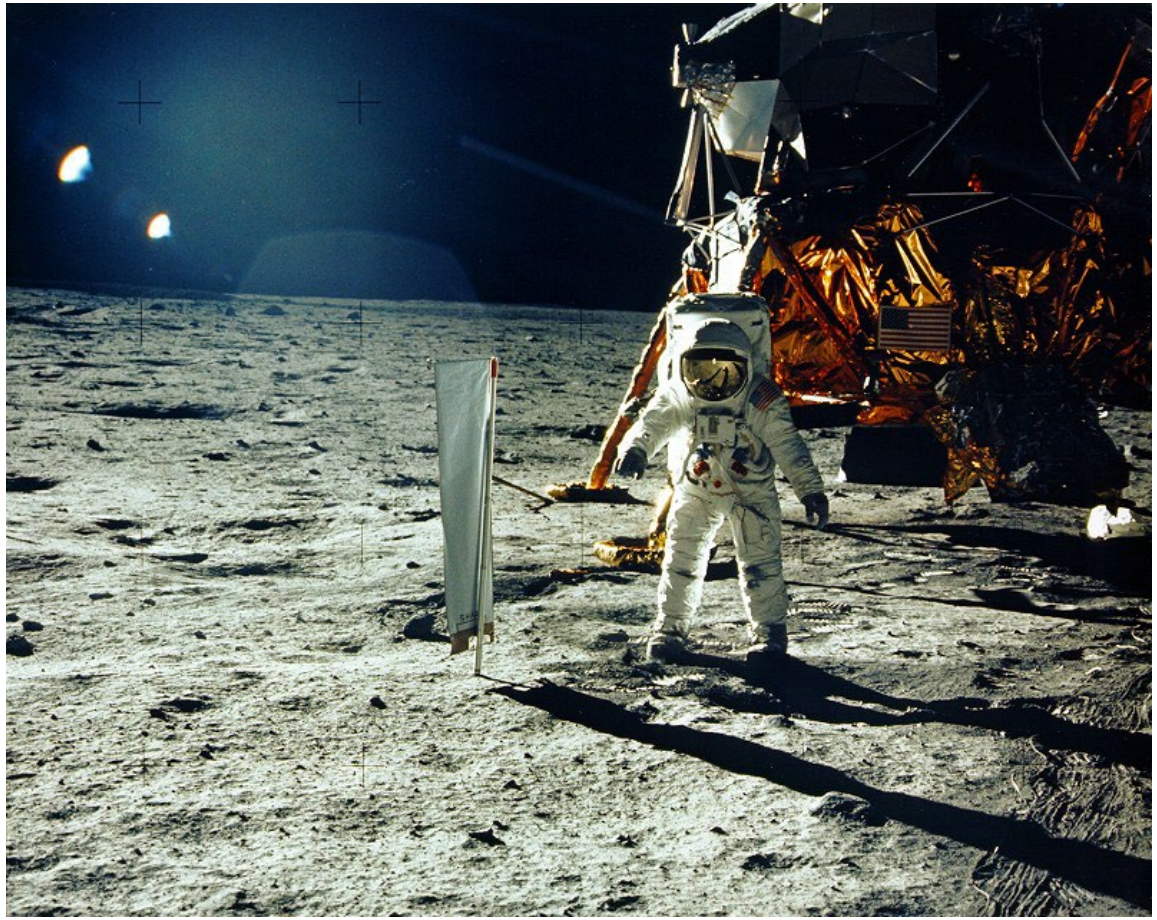
Explorer 35, launched in 1967, was one of 10 Interplanetary Monitoring Platforms that made notable discoveries about the solar wind and the Earth's magnetospheric tail. *(NASA)*

njm

Solar Wind Composition Experiment (SWCE)

Buzz Aldrin beside the SWCE (Apollo-11)

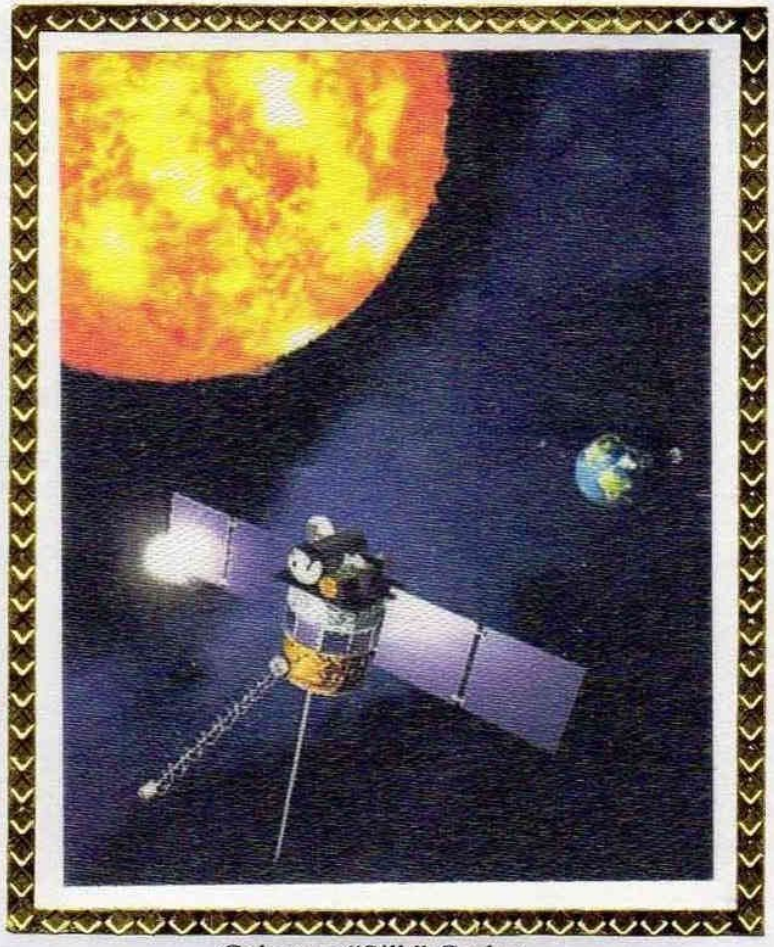
Stamp design based on this photo



Two operational Solar & Space Weather Observing Satellites

DSCOVR

SOHO



Colorano "Silk" Cachet

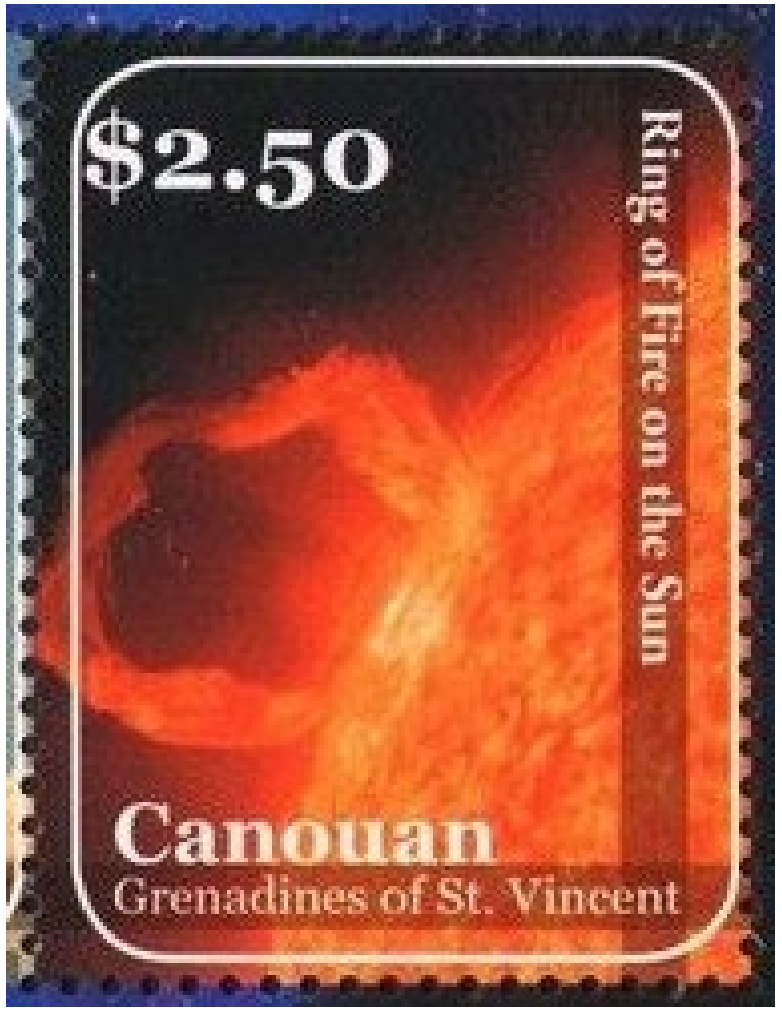
CAPE CANAVERAL
FEB 11 2015
USPS-FL-32920

DEEP SPACE CLIMATE OBSERVATORY (DSC
DSCOVR is the result of a partnership between
NASA and the United States Air Force and will
to observe and provide advanced warning of ext
emissions from the sun which can affect power grids,
communications systems, and satellites close to Earth.

SOlar **H**eliospheric **O**bservatory

Major Space Weather Storms – and Impacts

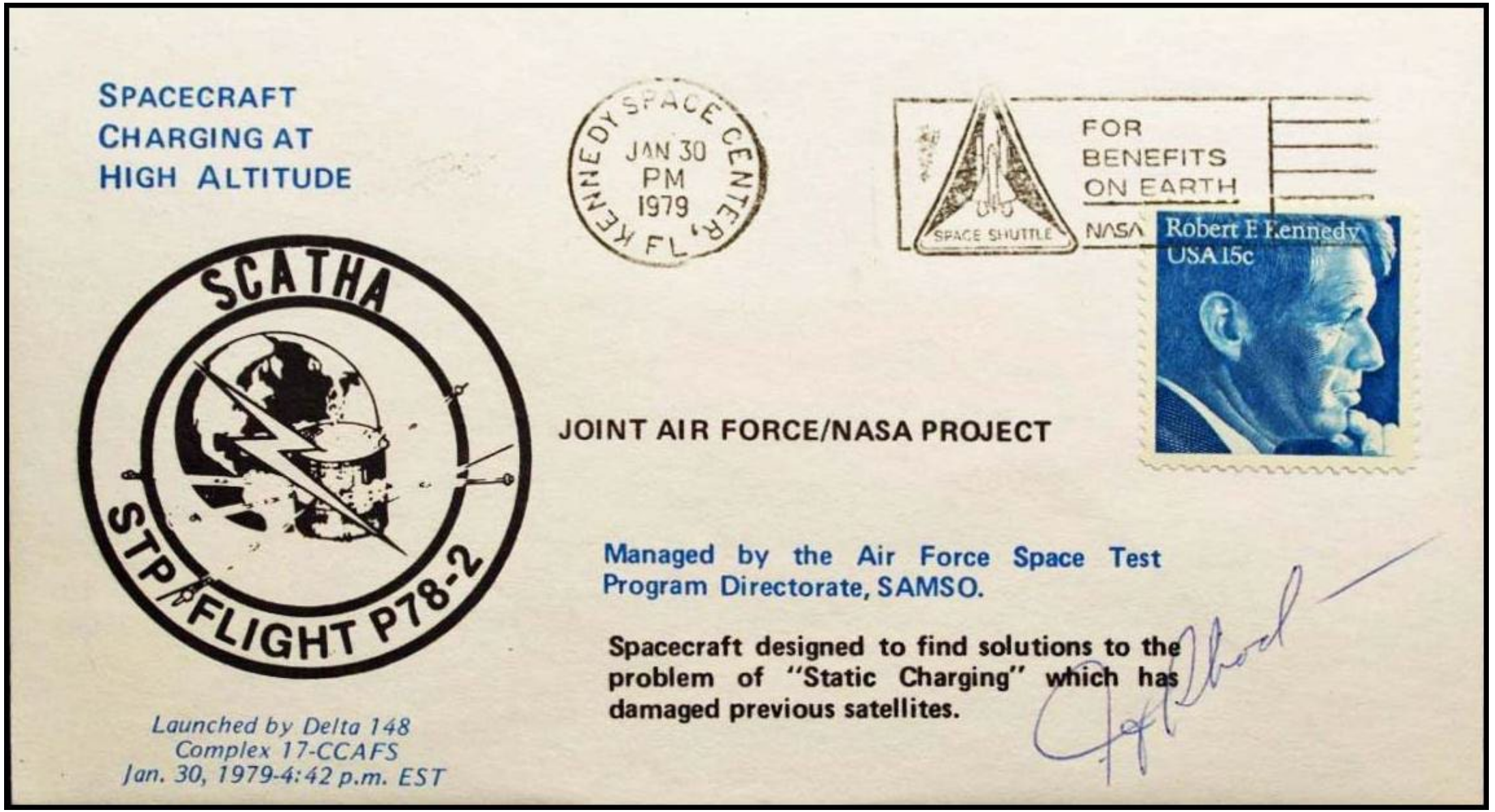
Solar Flares



CMEs (Coronal Mass Ejections)

- Biological
- Telecommunications
- Aviation (ATC, navaids, landing aids)
- Navigation (e.g. 13 Dec 2006 – GPS outage on sunlit side of Earth)
- Power grids (e.g. QC 13 Mar 1989)
- Satellites (anomalies, damage and even loss, or orbital decay)
- Auroras

Impacts - Damage to Satellites due to Electrical Charging and Static Effects



Impacts - Ionospheric effects (radio transmission and communications)

Impacts - Loss of Satellites due to Atmospheric Density Effects

SpaceX to lose as many as 40 Starlink satellites due to space storm

PUBLISHED WED, FEB 9 2022•10:53 AM EST | UPDATED WED, FEB 9 2022•6:42 PM EST

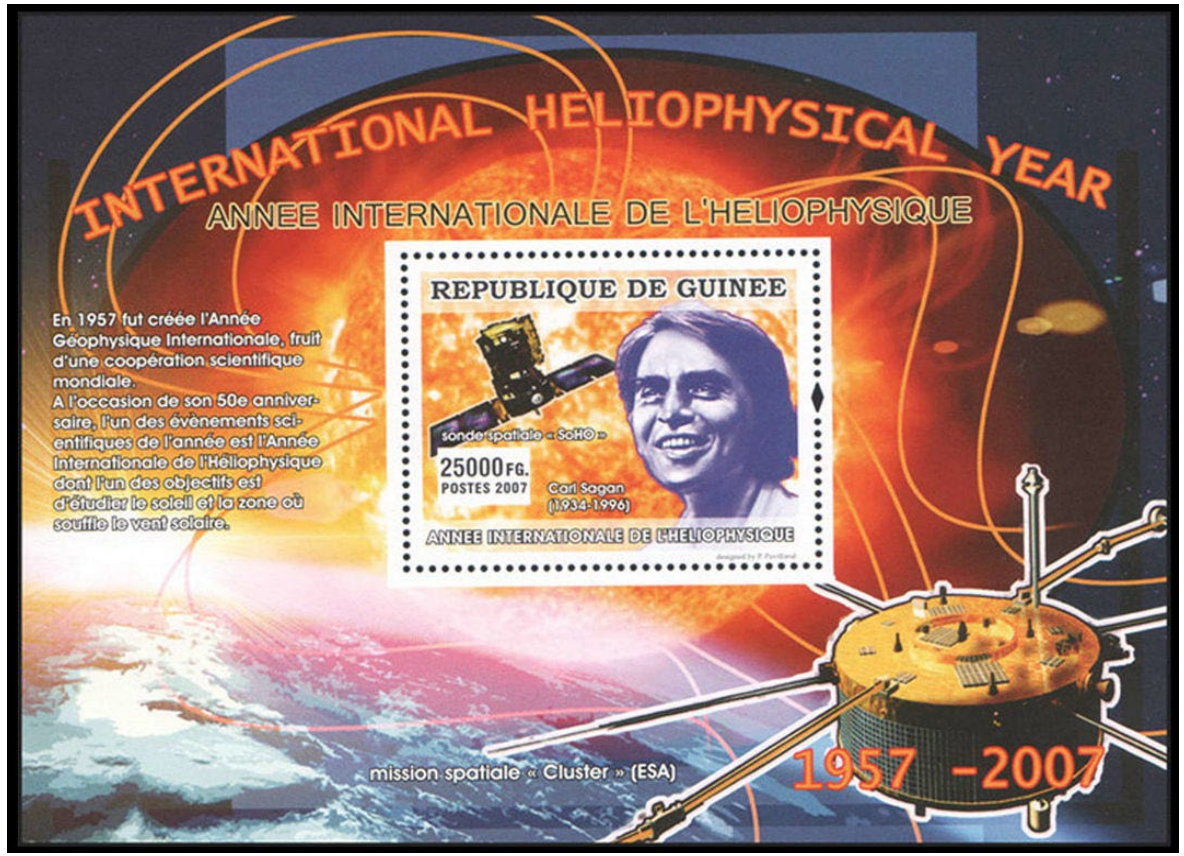
Michael Sheetz
@THESHEETZTWEETZ

KEY POINTS

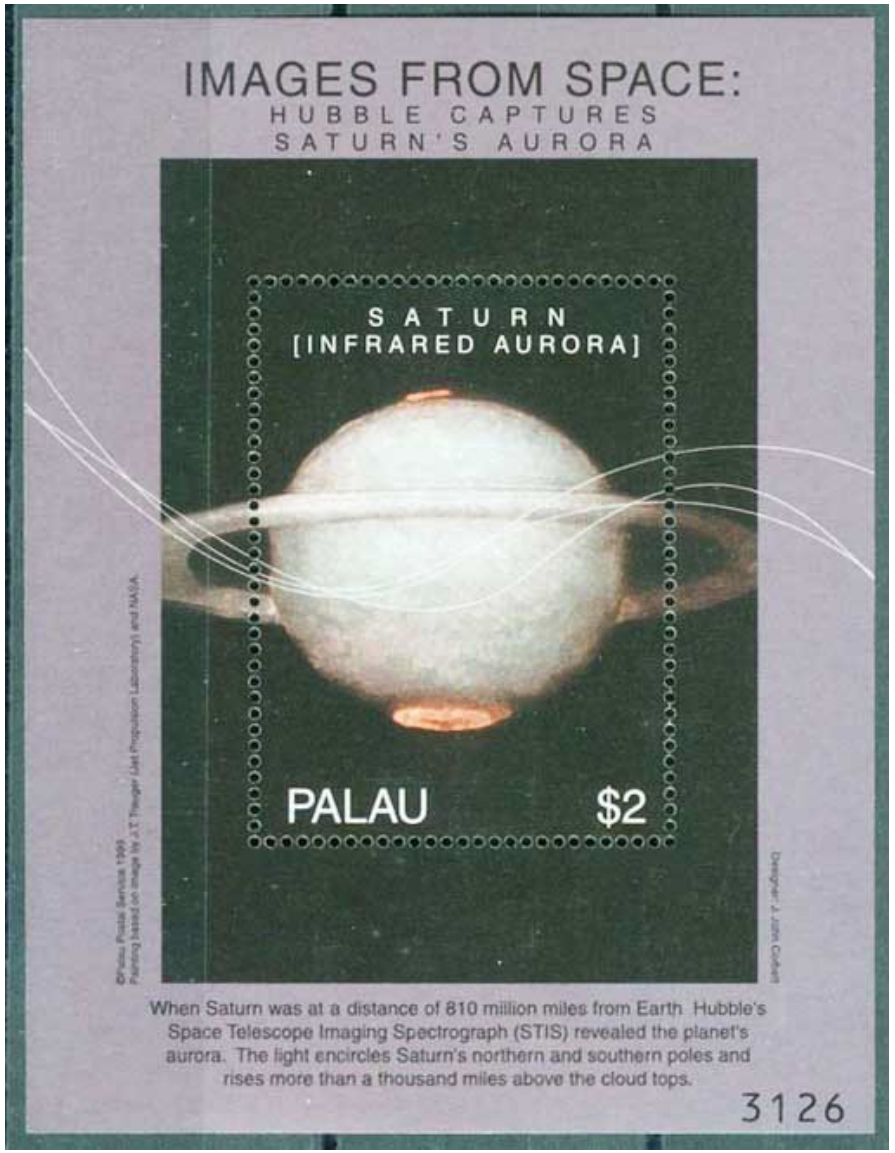
- Elon Musk's SpaceX expects to lose nearly an entire launch's worth of Starlink satellites after a storm created by the sun struck the Earth's atmosphere.
- The company launched 49 Starlink satellites on Feb. 3, but "up to 40 of the satellites" will be lost due to this geomagnetic storm.
- SpaceX does not disclose the exact cost of its Starlink satellites or its Falcon 9 launches – but losing the majority of the mission could be a financial hit upward of $50 million, based on previous statements from company leadership.

Closing Space Weather Stamp Images

IHY (2007)



Saturn aurora



Hillger & Toth Weather and Climate Philately website

https://rammb.cira.colostate.edu/dev/hillger/index.html

Collective Philatelic Works
(of Two Meteorologists)

This page has links to the collective philatelic works (in the topic areas below) of two meteorologists, **Don Hillger** (USA) and **Garry Toth** (Canada). Our goal, since 2001, has been to build an online catalog of topics of interest to the authors, to make it available to, and shared with anyone interested. This is a work in progress, and completeness is our goal, except where specific exceptions are noted. If readers know of additional information or images in these areas, please contact the authors using the e-mail addresses in the link at the bottom of this page.

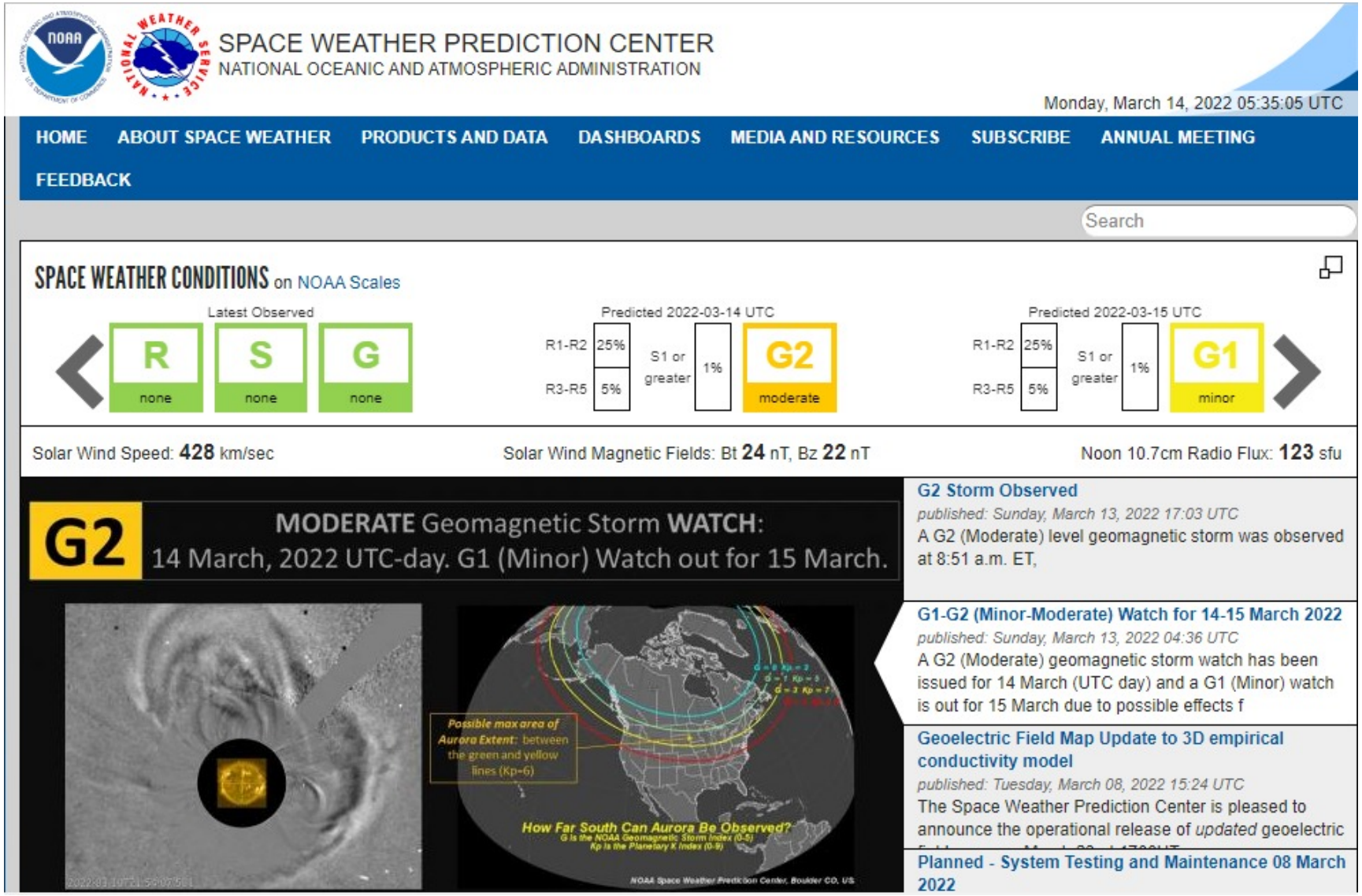
Collective Philatelic Works (of Two Meteorologists)	
	**Weather and Climate Philately**
	**Un-Manned Satellite Philately**

The Philately of Space Weather – Toth & Hillger references

1. Web page https://rammb.cira.colostate.edu/dev/hillger/space-wx.htm

2. Space Weather Handbook (Toth and Hillger) available through the ATA as Handbook 166E, or in DVD format

https://www.swpc.noaa.gov



End

Thanks for listening.

Questions?