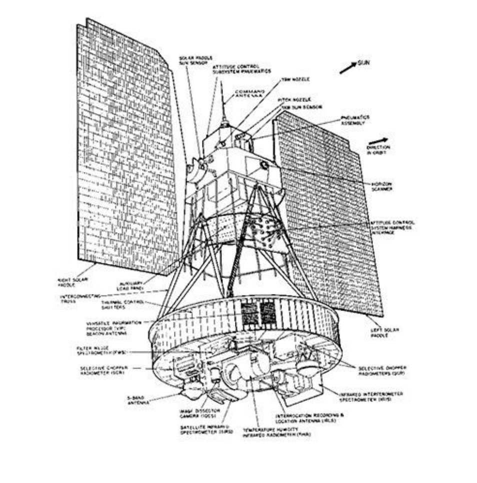
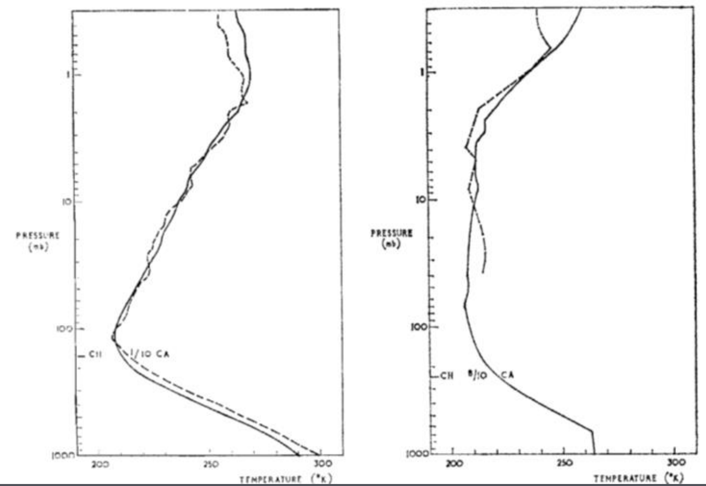
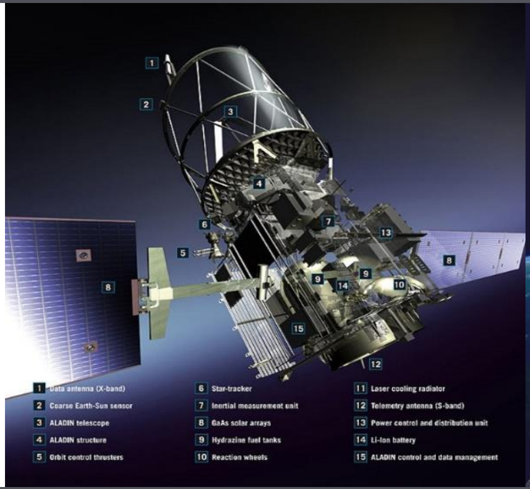
Department of Meteorology

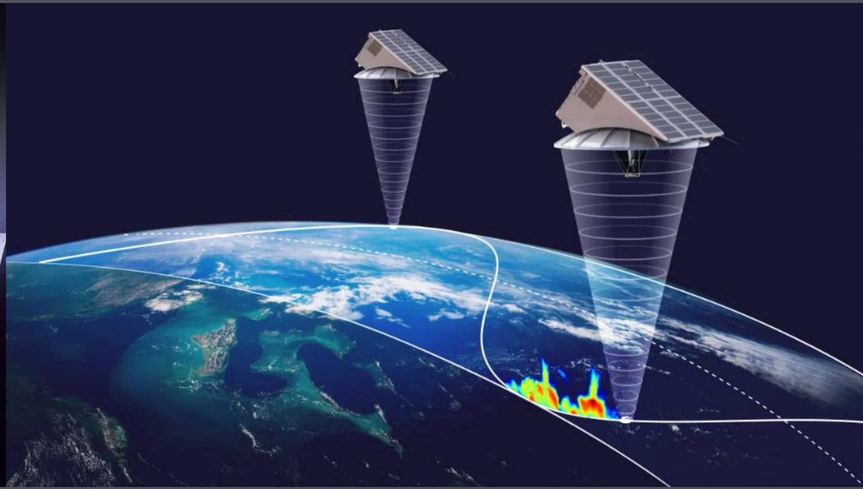
University of Reading

Looking ahead Towards Celebrating 150 years of Remote Sensing Observations









Thorwald Stein (t.h.m.stein@reading.ac.uk)

Celebrating 150 years of the Quarterly Journal of the Royal Meteorological Society

Wednesday 13 September 2023

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Remote Sensing in the Quarterly Journal of the Royal Meteorological Society

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Meteorology, Atmospheric science, Applied meteorology, Physical oceanography, Forecasting, Climatology, Oceanography, Geophysical fluid dynamics, Planetary atmospheres, Climate modelling, Climate prediction, Climate change, Ocean and climate models, Hydrometeorology, Atmospheric composition, Air quality, Cloud physics, Boundary Layer, Troposphere, Stratosphere, General circulation, Field observations, Satellite observations, Numerical weather prediction, Data assimilation, Atmosphere ocean dynamics, Land atmosphere interaction, Dynamical meteorology, Ocean atmosphere systems

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Volume 76 (1950)
A big year for radar?

The size distribution of raindrops

By A. C. BEST, M.Sc.
(*Meteorological Office, London*)

(Manuscript received 22 July 1949)

1. Introduction

During recent years the drop size distribution in rain has acquired increased importance as a result of the use of radar equipment to locate precipitation. The radar signal received from precipitation is exceedingly sensitive to the size of the drops.

The bright band — a phenomenon associated with radar echoes from falling rain

By J. E. N. HOOPER and A. A. KIPPAX

(Manuscript communicated by A. C. Best, M.Sc., 18 May 1949)

Summary

Frontal rain when illuminated by radar transmission gives rise to echoes which exhibit a characteristic layer of greater intensity near to the freezing level. Observations which establish the height of this layer or " bright band," relative to that of the freezing level, are described. Measurements of the terminal velocities of snowflakes of known mass, a factor of importance in support of a possible explanation of the phenomenon, are also given.

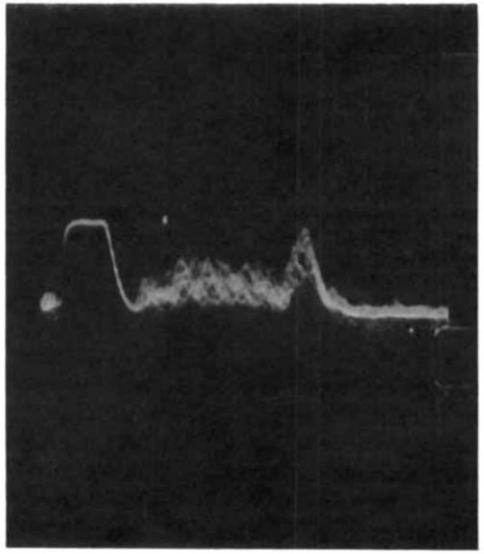


Figure 1. Photograph of Radar A scope during precipitation showing :
(i) ground ray,
(ii) echoes from rain,
(iii) bright band echo, and
(iv) very small echoes from above bright band

The temperatures at the tops of radar echoes associated with various cloud systems

By R. F. JONES
Meteorological Office, London

(Manuscript received 3 October 1949)

Summary

Evidence is produced to support the belief that temperatures at the tops of weather echoes are an indication of the relative strengths of the vertical currents within the echoes. Two types of weather echo are indicated according as the vertical currents are strong or weak, giving support to a theory for two different methods for the production of water drops of raindrop size in the atmosphere.

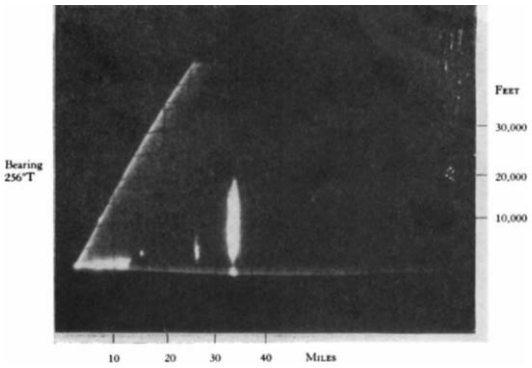


Figure 3. 30 May 1949. 13.48 G.M.T. This is a typical cumulonimbus echo with a top at −29°F. Note the clear cut vertical edges indicating a " solid " type of vertical current. The persistence of form of an echo of this type suggests that, although the vertical current is strong, it is not subject to violent changes in value.

Volume 87 (1961)
A big year for satellite?

Satellite cloud pictures of a cyclone over the Atlantic Ocean

By S. FRITZ
Meteorological Satellite Laboratory, U.S. Weather Bureau, Washington

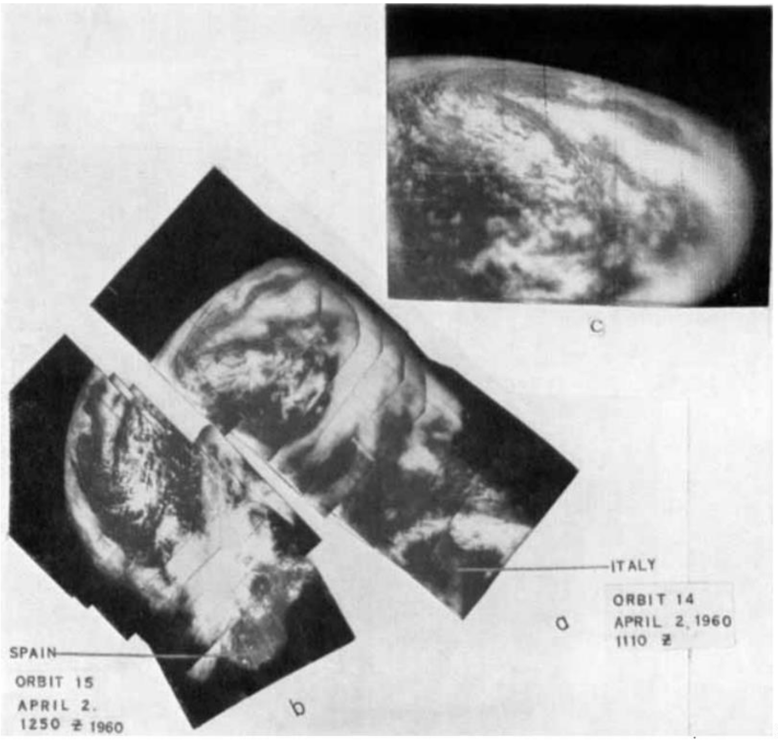


Figure 1. (a) Composite of frames photographed at about 1110 GMT, 2 April 1960, showing stratiform cloud surrounding cumuliform cloud in an Atlantic Ocean vortex. Italy appears just below an extensive bright area in the picture; this bright area is the snow-covered Alps. (b) Composite of frames photographed at about 1250 GMT, 2 April 1960, showing the same Atlantic Ocean storm, 100 min later. The eastern part of Spain is nearly cloudless. (c) Single frame showing continuous stratiform cloud.

Satellites and the earth's outer atmosphere

By D. G. KING-HELE
Royal Aircraft Establishment, Farnborough

Satellites are also adding to our knowledge of the lower atmosphere, through cloud-photographs like those taken by the highly successful Tiros. These weather satellites will probably do more to advance meteorology than will mere knowledge of conditions in the upper atmosphere, and they will also have a greater impact on everyday life : for example, operational weather satellites would have provided warning of the two cyclones which struck East Pakistan in October 1960, and might thereby have saved many of the 18,000 lives lost. But apart from this brief acknowledgment of their importance, I shall not discuss weather satellites here.

My plan is first to look at the atmosphere in general and then to describe, in turn, the successive layers of the outer atmosphere.

Classic Papers and Remote Sensing

- The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)
- On the predictability of the interannual behaviour of the Madden-Julian Oscillation and its relationship with El Niño (Slingo et al. 1999)
- The sting at the end of the tail: Damaging winds associated with extratropical cyclones (Browning, 2004)
- The Indian drought of 2002—a sub-seasonal phenomenon? (Bhat, 2006)
- The ERA5 global reanalysis (Hersbach et al., 2020)

The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)

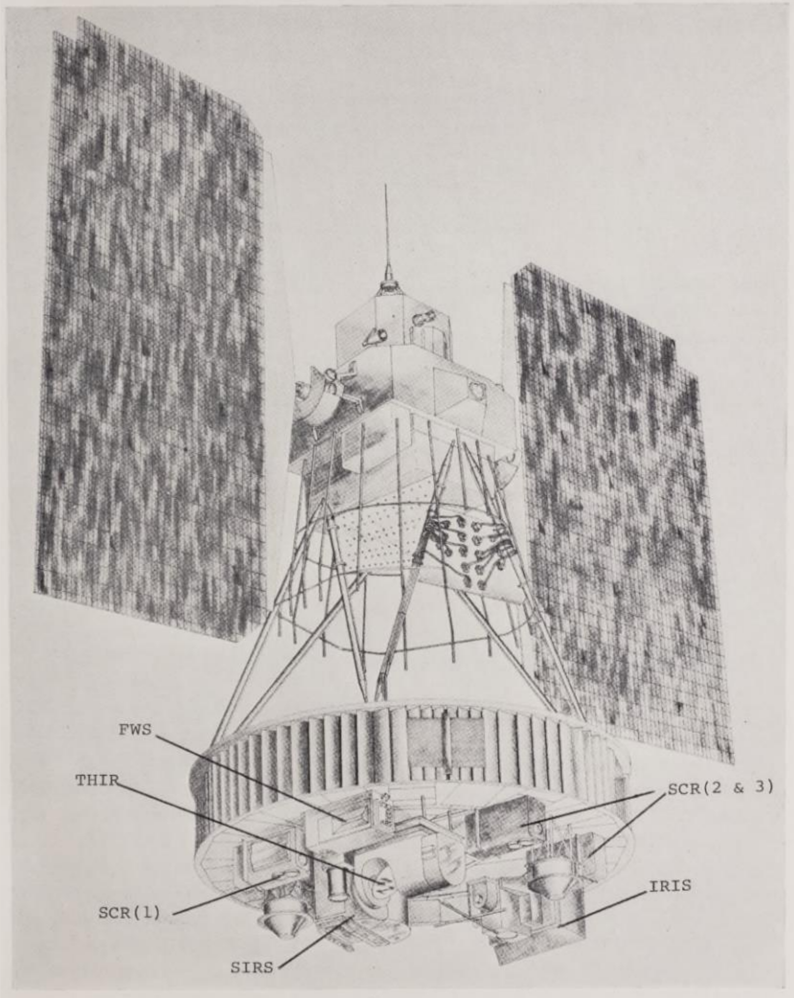


FIGURE 7. Nimbus D spacecraft.

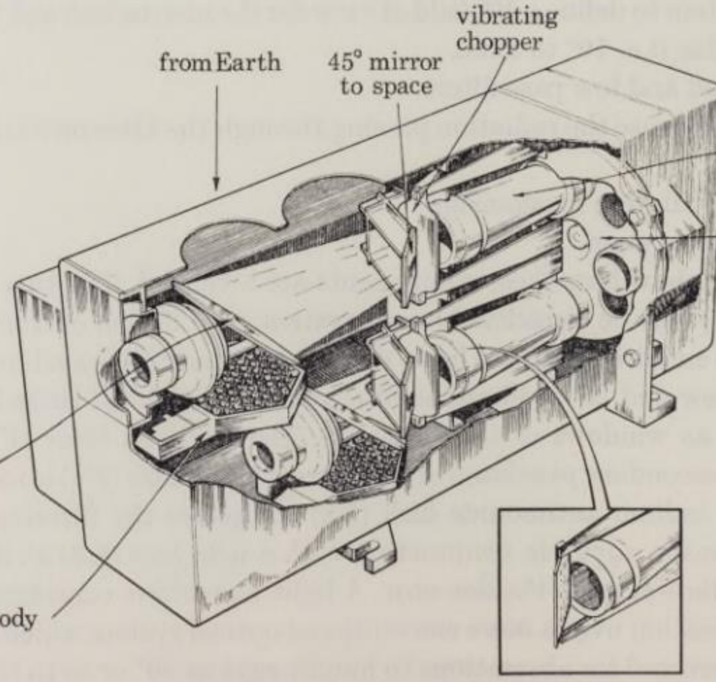
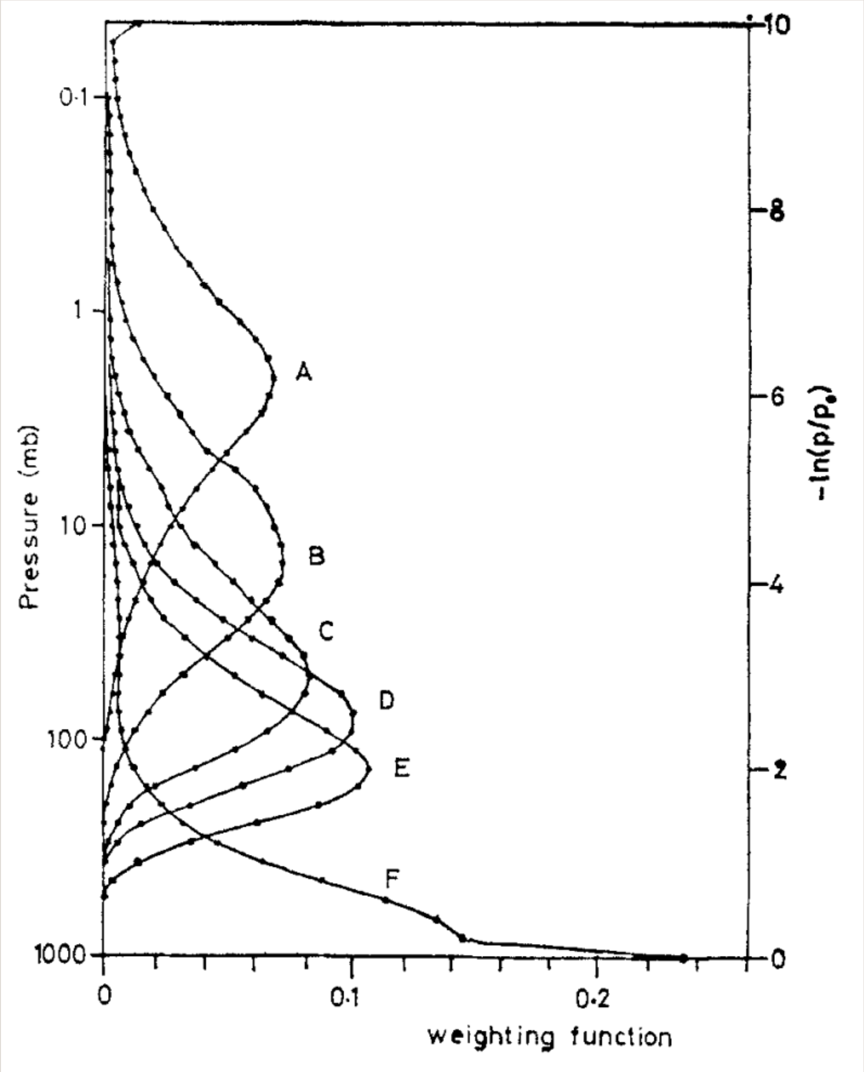


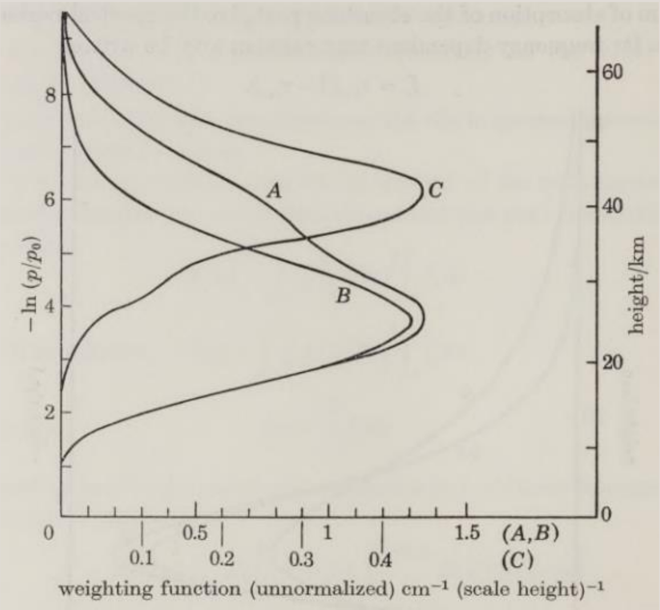
FIGURE 9. Perspective diagram of single-cell radiometer housing (two channels). Inset, part view of double cell unit.

Remote sounding of atmospheric temperature from satellites II. The selective chopper radiometer for Nimbus D (Abel et al., 1970, Proc.Roy.Soc.Lon.A)

The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)



- Radiometers for atmospheric sounding
- Operates near 15 micron CO_2 absorption band
- Normal operation would allow maximum height of temperature sounding of 25 km.
- “Chopping” technique allows height of 48km!



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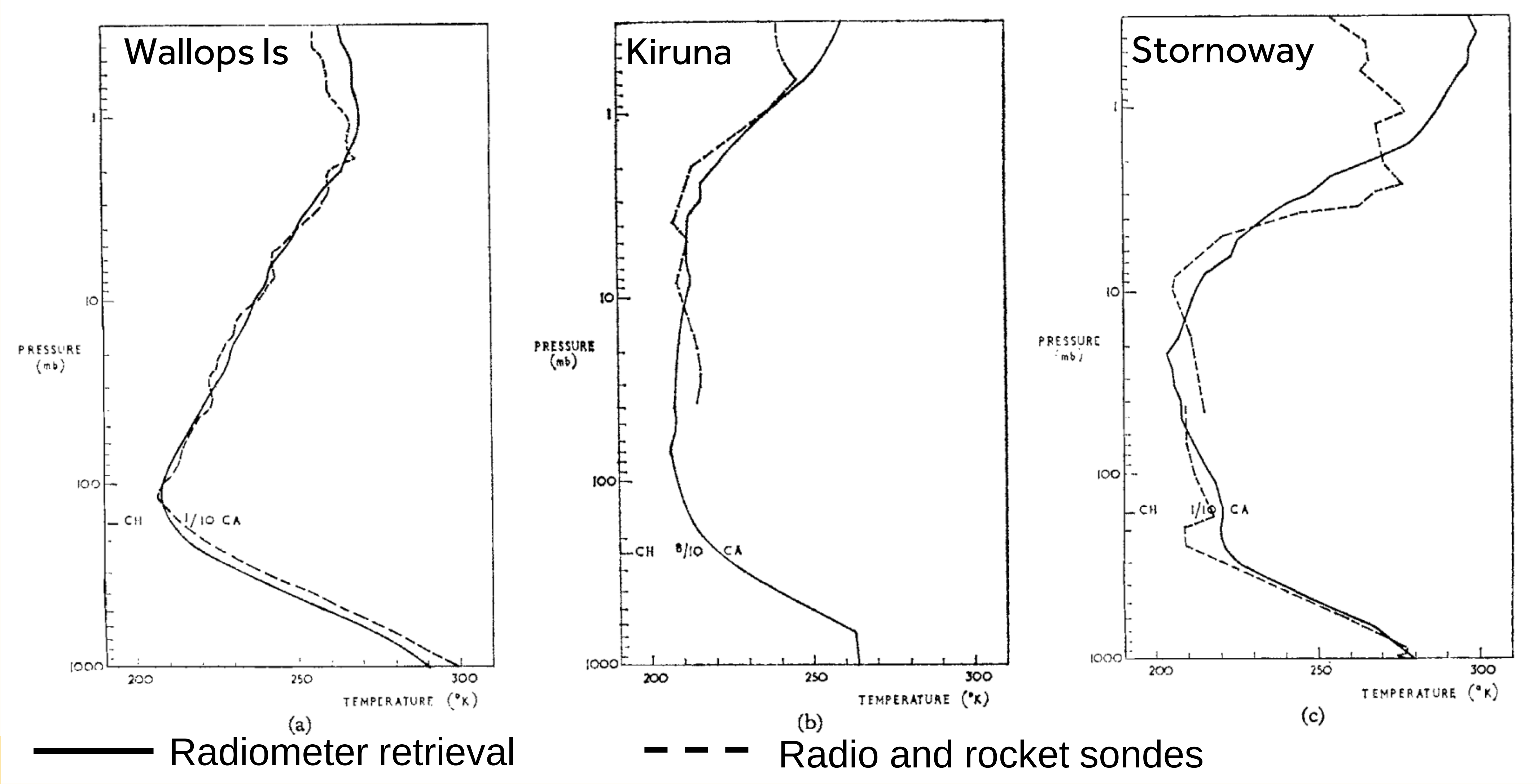
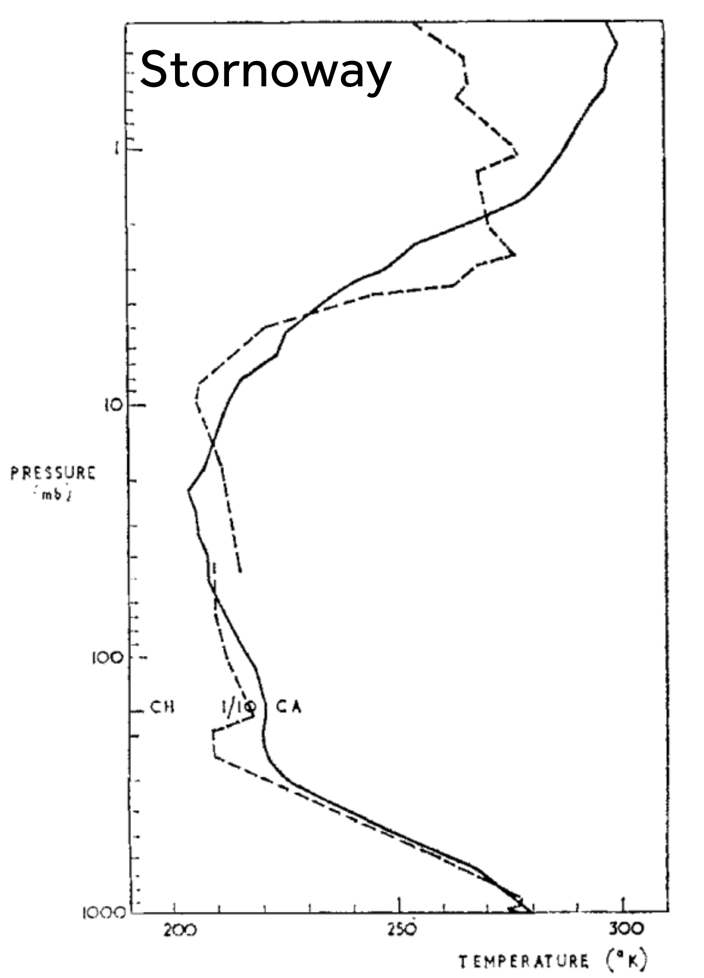


The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)

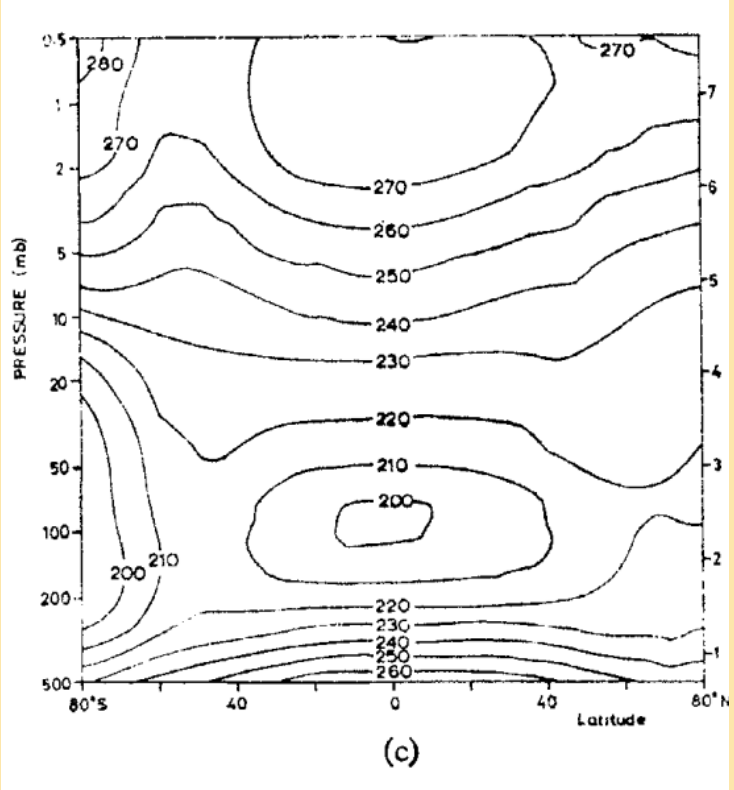
As an example of a poor retrieval we include Fig. 10(c). Again both atmospheres are consistent with the observed radiances; indeed in the lower troposphere they are very similar. Above 40 km, however, they are strikingly different. The soundings are taken through a strong mid-winter warming which produced the very unusual temperature structure revealed by the South Uist rocket. Such structures are rare in the statistics. Consequently the retrieval method finds a profile consistent with the observations but with greater probability of occurrence.

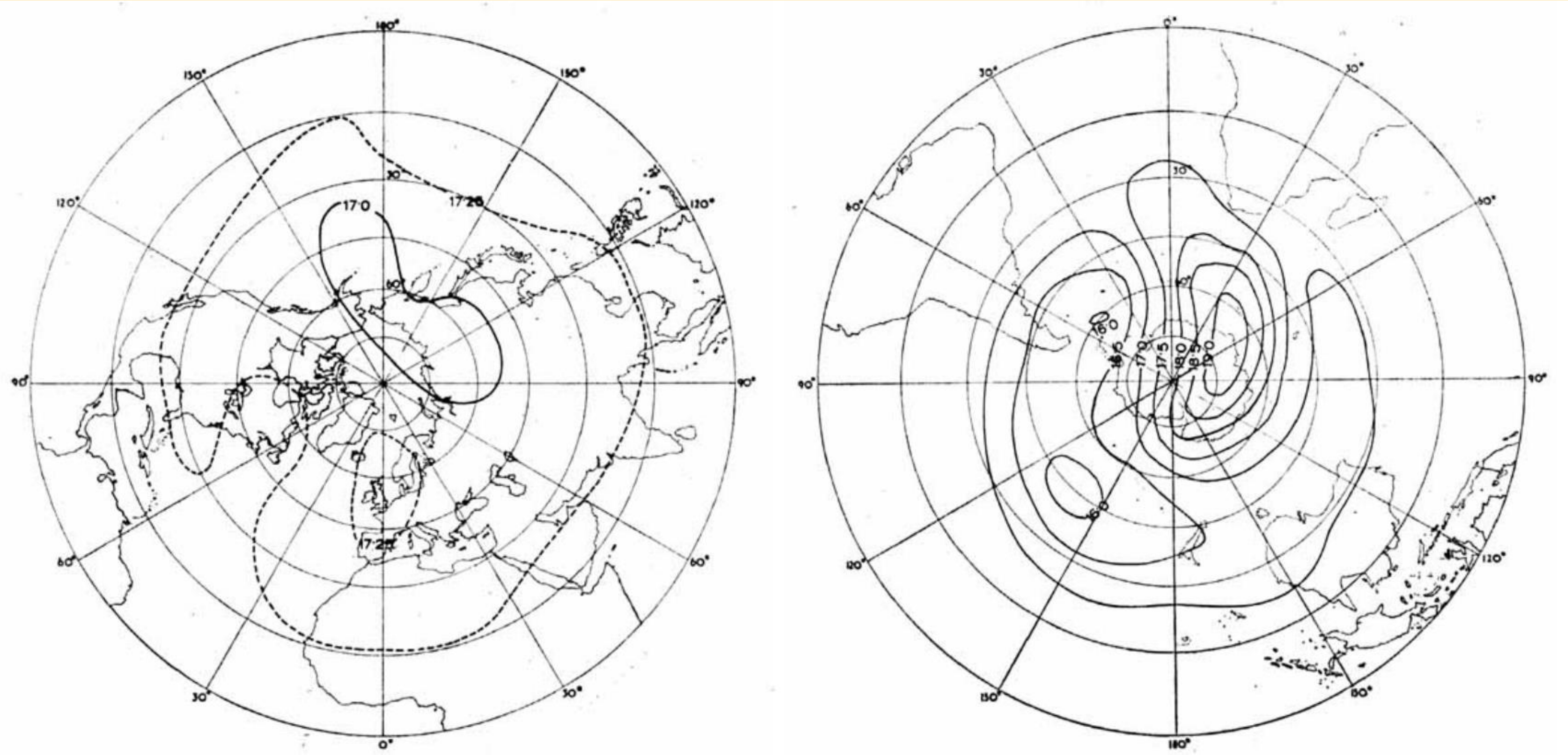


(c)

Radiometer retrieval — — — Radio and rocket sondes

The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)





Meridional cross-section of zonally averaged temperatures 18 September 1970

Thickness of 10-1mb pressure surfaces 5 September 1970

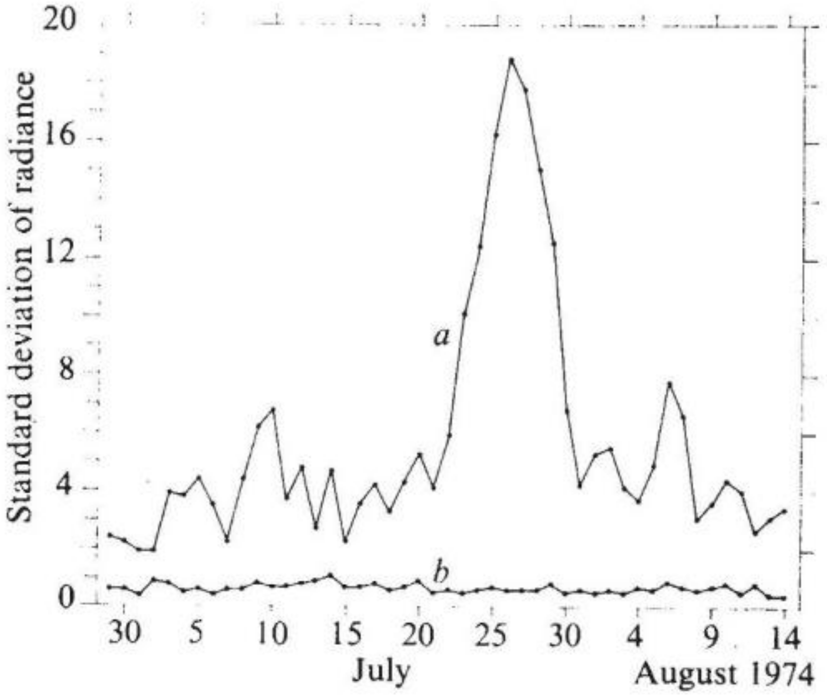
The first year of the selective chopper radiometer on Nimbus 4 (Barnett et al. 1972)

Large sudden warming in the Southern Hemisphere

LARGE and rapid temperature changes, 'sudden warmings', can occur in the stratosphere during winter[1]. They are hemispheric-scale phenomena, and, until recently, were supposed to be much weaker in the Southern Hemisphere winter than in the Northern Hemisphere winter. But during July 1974 a warming occurred in the Southern Hemisphere which was more intense in the initial phase than any of the three very large warmings of the past four Northern Hemisphere winters. The relatively early date of this warming (most large warmings in the Southern Hemisphere occur after late August at the end of the winter), its failure to produce the large heating of the polar cap which normally occurs in the Northern Hemisphere after such intense initial activity, and the large associated cooling in the tropics and Northern Hemisphere are further reasons for regarding this as a significant event.

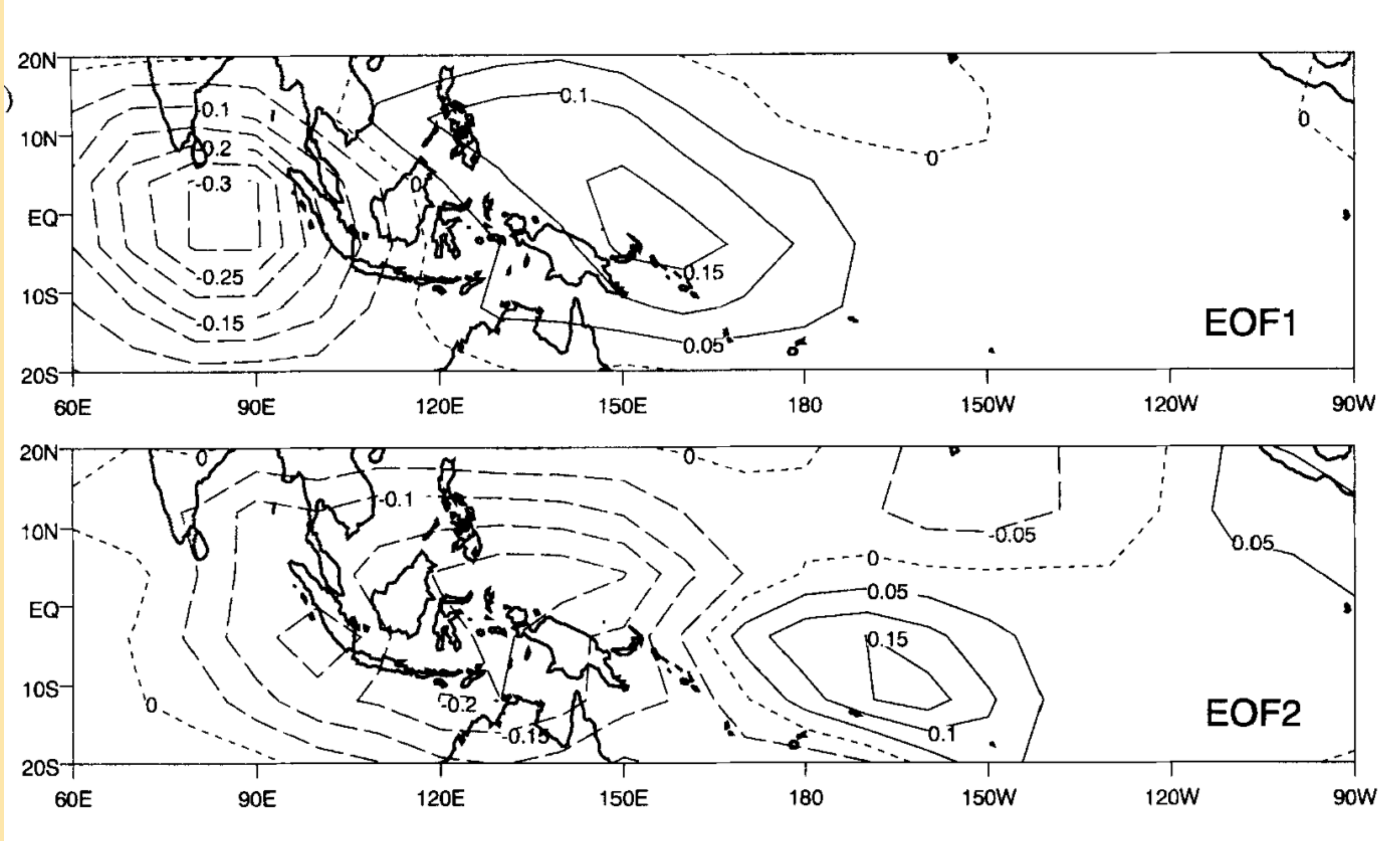
Measurements by the Selective Chopper Radiometer (SCR)[2–5] carried by Nimbus 5, give continuous coverage of atmospheric temperature between 80°S and 80°N. Uninterrupted measurements of a layer approximately 20 km thick and centred near 150 Pa (1.5 mbar) (~45 km near the stratopause) have been made since April 1970 using this instrument or its predecessor on Nimbus 4. Both instruments operate by measuring thermal emission from atmospheric carbon dioxide in the 15-μm band in the infrared, using cells of carbon dioxide acting as filters in series with interference filters. The satellites are in Sun-synchronous polar orbits, passing over most places near local noon and midnight; the orbits are 26.8° longitude apart.

Fig. 1 Standard deviation of channel B23 radiance (mW m^{-2} sr^{-1} $(cm^{-1})^{-1}$) around latitude circles. This channel measures emission from the upper stratosphere. *a*, 60°S; *b*, Equator.



Large sudden warming in the Southern Hemisphere (Barnett, 1975, Nature)

On the predictability of the interannual behaviour of the Madden-Julian Oscillation and its relationship with El Niño (Slingo et al. 1999)



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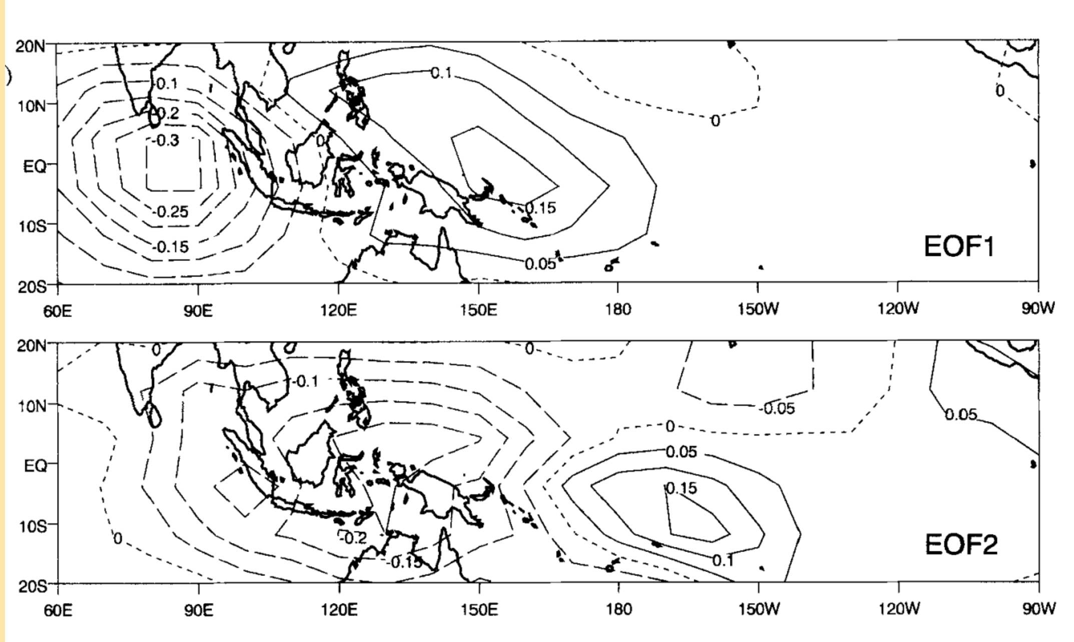
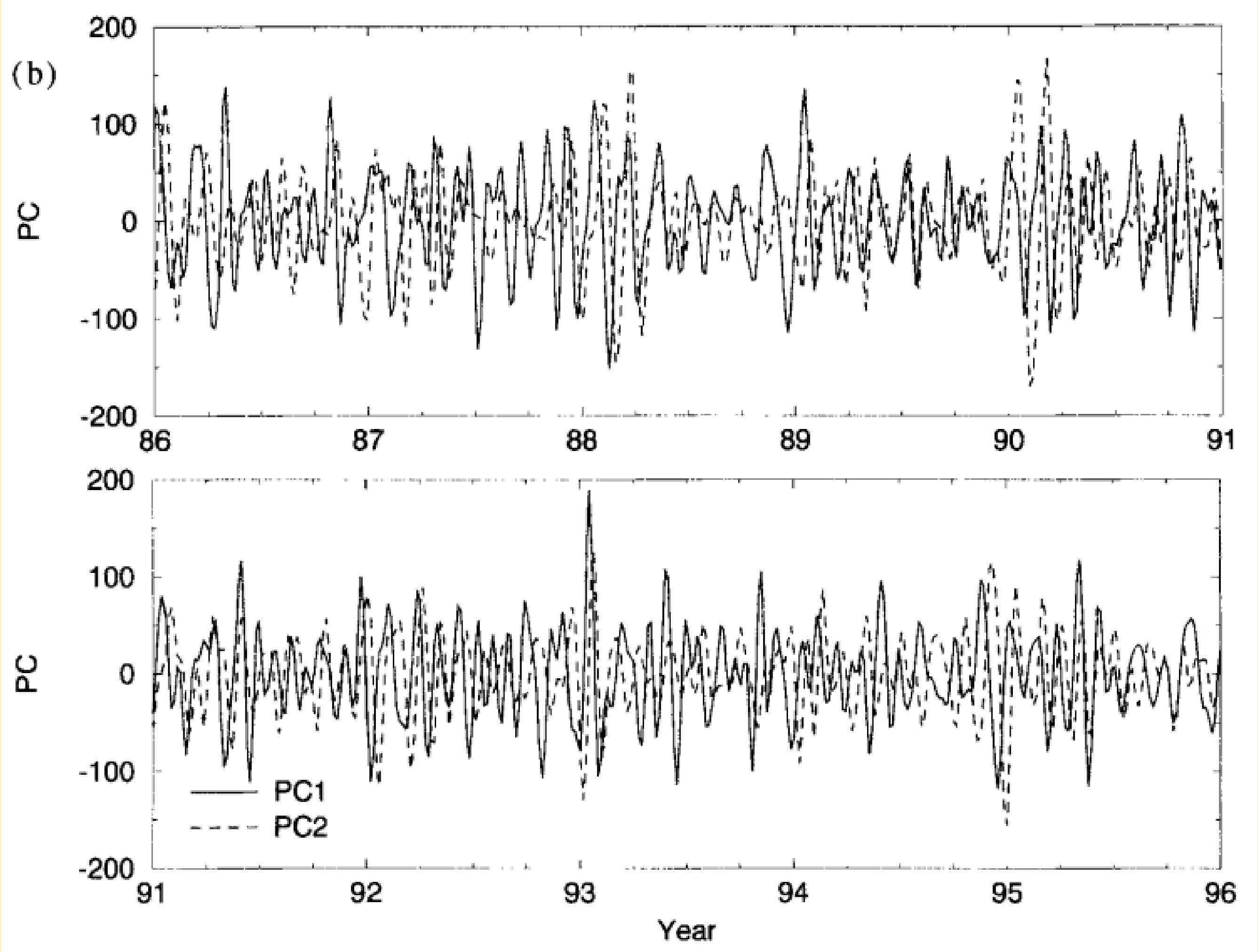
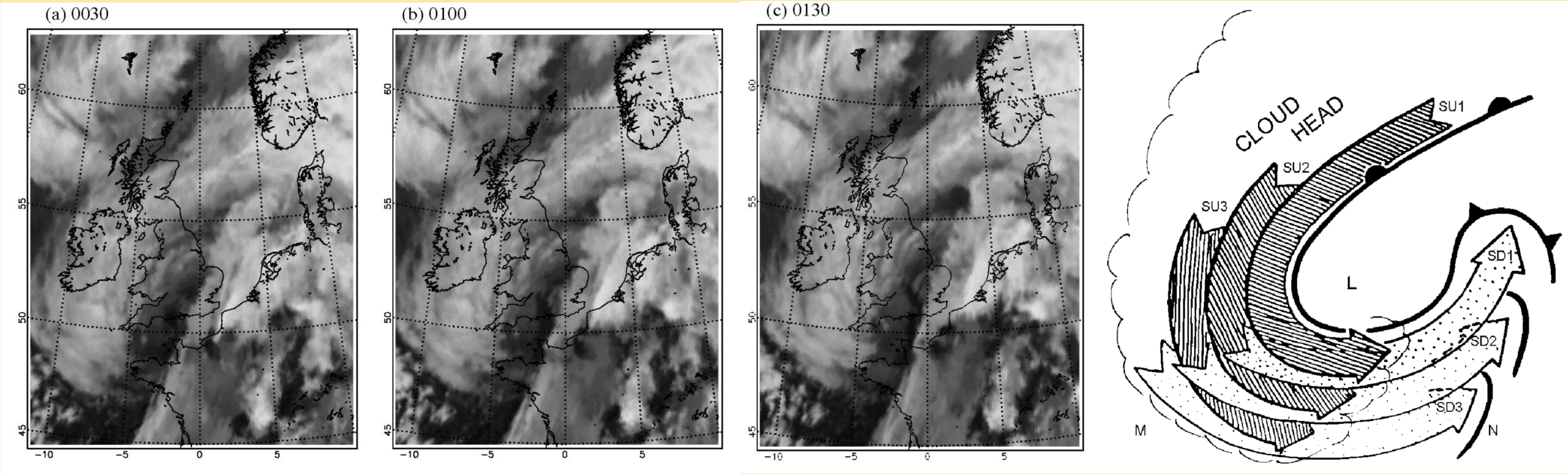




The sting at the end of the tail: Damaging winds associated with extratropical cyclones (Browning, 2004)



"The circumstantial evidence from the observational study leads one to hypothesize that the mesoscale circulations and the associated evaporative heat sinks may play an active role in strengthening the damaging winds. Regardless of how important this role may be, the evolution of the cloud pattern seen in satellite imagery is a useful tool for nowcasting the occurrence and location of the worst winds."

Looking ahead towards 150 years?

University of Reading

I. Explore more aspects of the Earth system

II. Measure key variables for data assimilation, more often, at greater extent

III. Low-cost opportunities (and commercialisation)

Looking ahead to 150 years?
I: Monitor more aspects of the Earth system

The FLuorescence EXplorer (FLEX)

- ESA Earth Explorer mission
- Expected launch 2025
- Measures Solar Induced Fluorescence (SIF)

"The reason we're interested in SIF is that it's a direct measurement of one the biochemical processes that is involved in photosynthesis. We hope it will shed new light on the global carbon cycle. The fluoresced photons have literally been bouncing around inside the photochemical machinery of plants. Traditional EO techniques use much more indirect measurements (i.e. how green the plants are) and don't provide much process level insight. The promise of SIF is that it will provide that insight."

(Tristan Quaife)

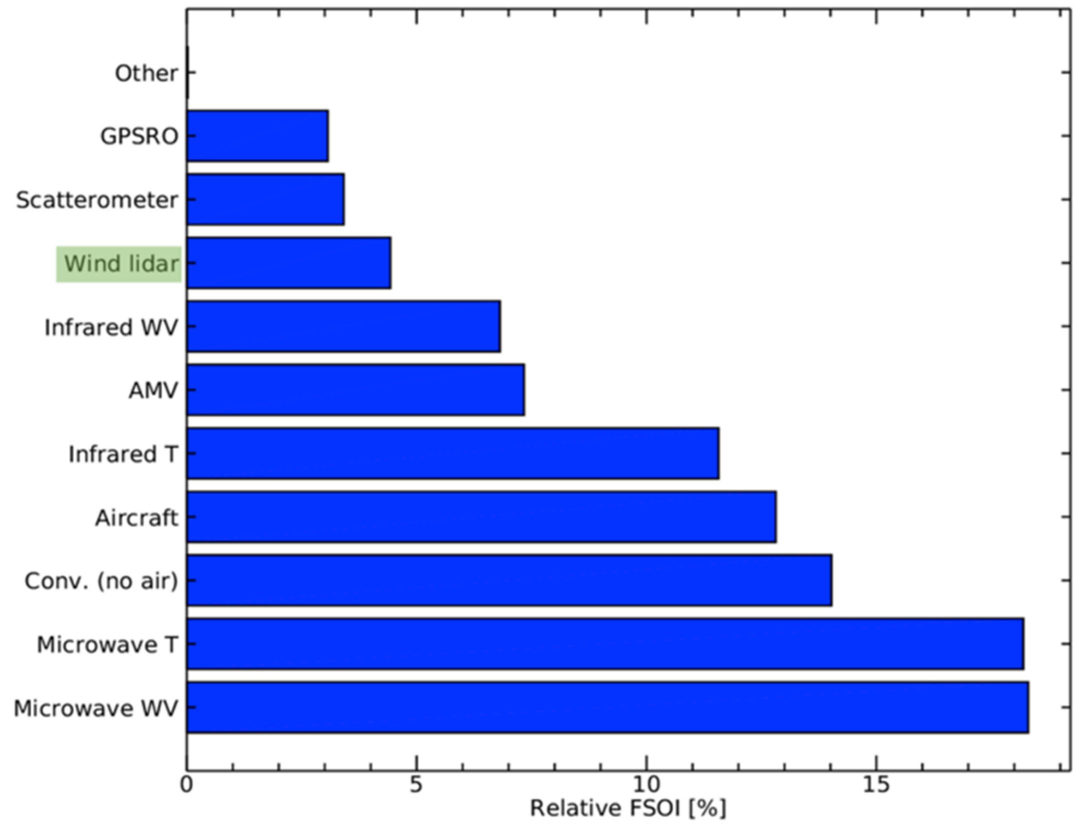
https://earth.esa.int/eogateway/documents/20142/1898959/FLEX-concept-1920x1080.jpg

Looking ahead to 150 years?
II: Data assimilation as a primary objective

Wind Velocity Radar Nephoscope (WIVERN, Illingworth et al. 2018, BAMS)

- ESA Earth Explorer mission (tbc)
- Expected launch 2031-32
- Measures winds in cloud

The AEOLUS mission, which carried a Doppler lidar, had a forecast sensitivity impact (FSOI) of 4% - from a single instrument! Compared to 13% from all aircraft.



Rennie and Larsen (2020) "Assessment of the Impact of Aeolus Doppler Wind Lidar Observations for Use in Numerical Weather Prediction at ECMWF." *EGU2020/EGU2020-5340*

Looking ahead to 150 years?
III: Low-cost successes leading to commercialisation

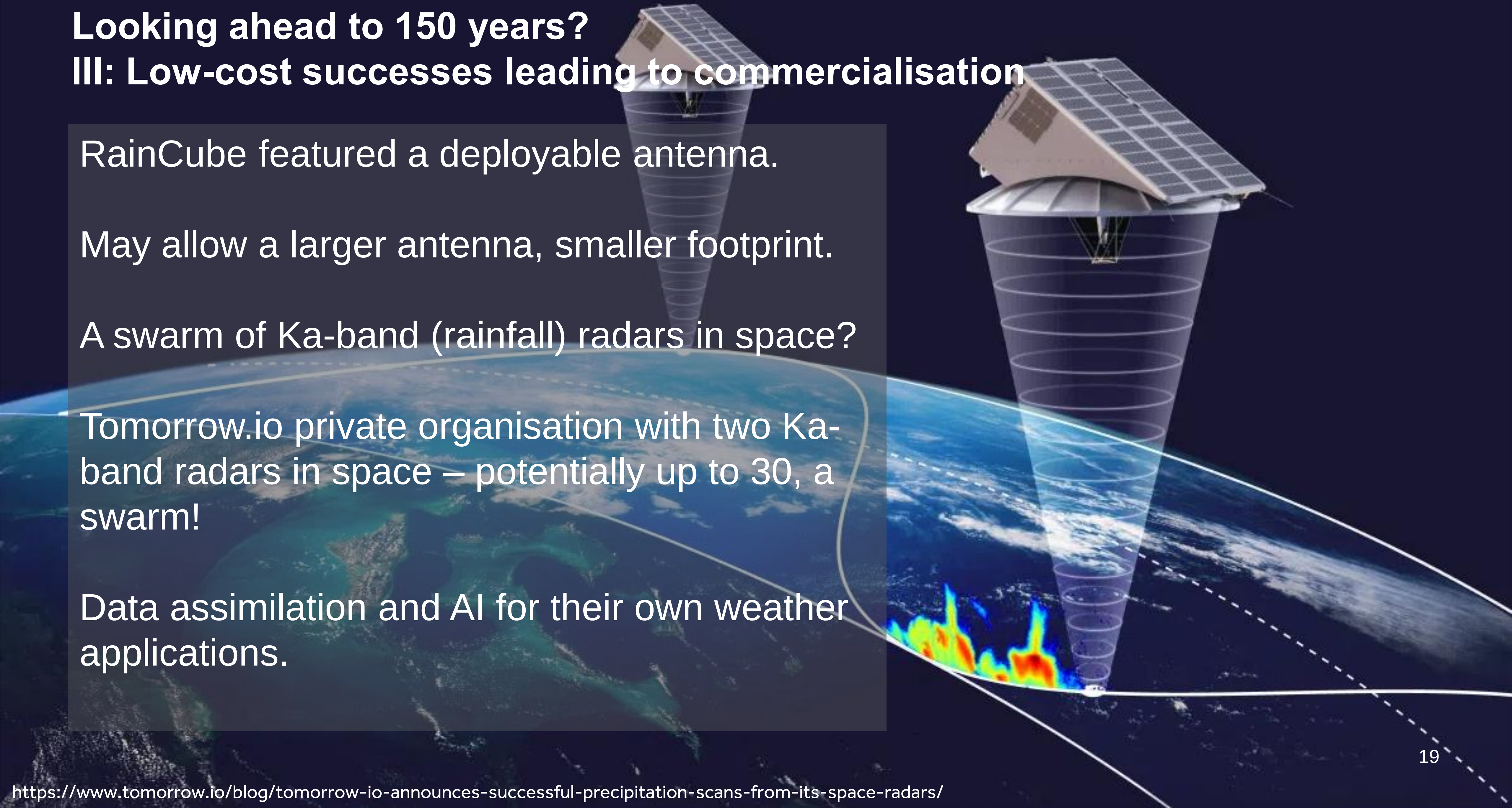
RainCube featured a deployable antenna.

May allow a larger antenna, smaller footprint.

A swarm of Ka-band (rainfall) radars in space?

Tomorrow.io private organisation with two Ka-band radars in space – potentially up to 30, a swarm!

Data assimilation and AI for their own weather applications.



https://www.tomorrow.io/blog/tomorrow-io-announces-successful-precipitation-scans-from-its-space-radars/


ROYAL METEOROLOGICAL SOCIETY
TOWER OF THE WINDS
ATHENS