- At the top of cumulus clouds to form a 'cap-cloud' (pileous cloud).

- With a 'metallic grey' colour.

4. If cumulus cloud below a cap-cloud evaporates or disperses the lenticular cap can descend (sink). They can remain poised or slowly wavering above hills. Lenticular effects can form with several basic cloud types, e.g. Altocumulus Lenticularis, Cumulus Pileus, Strato-Cumulus Lenticularis etc.

5. Some photographs (for example, at Figure 2) show that lenticularis clouds (or 'wave clouds') can appear as billows (i.e. ovals/lens-shaped discs with a hole in the centre) and also with laminated appearance. Pileous laminations occur when humid layers are sandwiched between dry air layers. At Figure 5 little imagination is required to describe 'a dome on top'. When the top of a wave-cloud is 'bow-shaped' and smooth, this usually indicates that the air above is stable and dry. The size of lenticularis clouds may extend for kilometres. However, small ones seen edge-on may give the impression of much smaller discs. These formations often appear to the leeward side of high ground. The typical reported altitude might be 3000-6500 metres.

MAMMA

6. These protuberances occur when small-scale convection changes cause portions of cloud to sink in clear air below a cloud formation. The sinking elements mix with the clear air and usually evaporate. However, if they contain rain or snow crystals, the shapes shown at Figure 6 can occur. These particularly occur beneath the thick clouds associated with thunderstorms. Mamma can also occur at the lower ends of cirrus cloud formations.

NOCTILUCENT CLOUDS

7. Noctilucent clouds have the appearance of decayed cirrus but are typically at 80Km altitude in the stratosphere. They can shine for an hour or so after sunset but they are not seen if the sun is above the horizon. If the sun is more than ~16° below the horizon noctilucent effects cannot be seen. Normally noctilucent clouds appear between May and August at latitudes 50°-70°N. (This includes UKADR latitudes). It is reported that these may be caused by dust particles which catch the lower stratosphere during volcanic eruptions, or due to dust produced in the solar system by collisions among minor planets. Noctilucent effects can also be caused by terrestrial-based light sources shining on the underside of disc-shaped or laminar clouds. Noctilucent clouds are the highest clouds in the atmosphere.

MOTHER OF PEARL CLOUDS

8. 'Mother of Pearl' formations (Figure 9) are rare but can be seen in Scotland occasionally between November and March. They have iridescent bands of colour, lit by sunlight in a twilight sky (limiting the time of occurrence). They occur only at altitudes of the order 22-30Km and probably comprise super-cooled droplets with ice crystals.

DUST DEVILS, TORNADOES & WATER SPOUTS

9. These occur in unstable layers of dry air over hot ground. They are visible because of the dust (which may rotate in

either direction) and often have a hollow centre. Water spouts occur similarly at sea. Tornadoes are predominantly cyclonic in rotation. All three phenomena move at prevailing wind-speed.

CONDENSATION & DISSIPATION TRAILS

10. 'Contrails' and 'Distrails' are well known visual effects in the sky. Drawn into aerodynamic vortices (i.e. wing-tip vortices), these can fragment to provide unusual visual phenomena. Distrails are formed when an aircraft flies in relatively dry air just above a thin layer of cloud such that the down-wash penetrates the layer. This can produce a series of 'holes'. Pendulous blobs (with the probable appearance of spheres) can occur.

GLORY & CORONAS

11. Coronas are colourful concentric rings centred on bright light sources. They are caused by water droplets or ice crystals of relatively uniform size. However, observers in both Texas and Finland have reported coronas caused by pollen particles. Coronas can be distinguished from halos in that they commonly have a radius angle of 22 degrees, although the extremes reported for halos have boundaries of 4 to 46 degrees. The key filter to use in UAP identification is that coronas are always centred on a bright object. Figure 7(a) shows the shadow of a crucial peak thrown onto mist. The observer (on the peak) is surrounded by a multicoloured 'Glory' of corona rings. In fact until the advent of aircraft only mountaineers could observe the effect. This is due to the refraction and diffraction of light by the mist droplets. This effect can also be seen from aircraft when their shadow falls on droplet clouds. On the ground it is especially noticeable in hilly country, when air close to the ground cools and flows into valleys overnight. Some of the ice particles in cirrus wave clouds at temperatures of -40 to -50 degrees C, apparently form faceted uni-axial polyhedral crystals, while others resemble spheres. It is well known that 'Glory' results from the interference of light rays back-scattered from internally reflected and circumferential ray paths (the latter is unique to spheres).

12. As seen at Figure 7(b), the incident ray couples to a sphere as a surface wave, is critically refracted into the sphere, reflects, and is critically refracted back to the surface, spends a short period as a surface wave and is directed back towards the original source. A curved wavefront is formed by exciting the rays to the right and left of the glory ray. Rotating this curved wavefront (Figure 7(c)), through an angle (Π), as directed by spherical geometry, reveals that a wavefront shape associated with the Glory is a toroid. Propagation of this wavefront to a far field gives rise to a strong axial focusing, because the infinite number of rays from the ring around the flat part of the wavefront all go in the same direction. As soon as the observer moves off the exact back-scattered axis, only two rays contribute to the scattering and it is the interference between the left and right rays of the toroidal wavefront that produces the 'Glory'.

HALOS & ARCS

13. A halo is observed when looking at the sun through high altitude cirro-stratus (which is several thousand feet deep and composed of non-spherical ice crystals - which have also recently been suspected of producing 'Glories'. It is a cloud type which readily forms aircraft condensation trails). The halo angular radius (i.e. half

angle) is said to be 22°. Halos from the sun can be either above or below the horizon. Halo activity is persistent and is known to many of the public, however it results in some UAP reports. Over a 40 year period (Netherlands) it was noted that average halo conditions existed for 227 days of the year, peaking in 1972, when 300 days were recorded.

13. On other days conditions existed for other parhelian and circumzenithal events. Halo Arcs occur at low solar elevations and are caused by pyramidal crystals and occur when they fall through the air with certain axes vertically orientated. Halo rings of unusual radii can be produced when their faces are not in random orientation. From those in random orientation six concentric odd-radii halos should result at 9, 18.3, 19.9, 22.9, and 23.8 degrees. Each of these six halo types has been imaged this century, but most of the 12 (yet undiscovered) forms are, at most solar elevations, completely below the horizon and thus only visible from airborne platforms in cool climates. The 12 halos divide into 32 individual arcs in the sky, of which only ten, so far, have been photographed. Halos still escape a complete understanding. In particular, ice particles with pyramidal ends are suspected of producing bright arcs of dimension of odd radius halos. It should be noted that some effects can be related to the polarisation of observers' sun-glasses!

Although the photograph at Figure 13 is artificially produced by light passing through a single vertically orientated hexagonal ice crystal (the parhelic spots shown are the actual projection on a wall), it is noted that these shapes are markedly similar to some UAP reports where 'multiple balls' are described.

SUN DOGS

14. A 'sun dog' (parhelian) is a mock sun, a parhalion. (See also para.20 and Figure 14)

St. ELMO's FIRE

15. This is commonly mis-identified as ball (or bead) lighting. It has been reported for thousands of years and is a corona discharge from a 'grounded' point in a strong electric field, hence, it is usually observed as a glowing object hovering over an earthed object before or during a thunderstorm. It is commonly blue or blue-white in appearance and about the size of a large orange. However, much larger diameters - up to 30cm - have been seen. It decays silently, sometimes slowly and sometimes suddenly, with a lifetime of (usually) many seconds, which may extend to minutes. A characteristic distinction between St. Elmo's Fire and Ball/Bead lighting is that the latter has motion. The exception is when St. Elmo's Fire moves along a conductor.

BIRDS

15. Small flocks of birds (e.g. gulls) can be reported at night as UAPs. Their reflective under-bellies can be seen in triangular formation. Because no sound may be heard this increases the likelihood of an unwary observer, who may only see the birds for a few seconds as they wheel; producing a brief visual reflection. In bright sunlight seagulls have high reflectivity. The specular reflection from the body reported as 'bluish white' observes the fact that it is a bird as the bright flash obscures the wings. Clusters of sightings tend to occur in areas of 'greatest watchfulness' - for example near airfields and population centres. The radar echoing area (i.e. RCS) of birds is

briefly considered at Volume 3 as a source of radar false alarms in the UAP context. Certain areas of the UKADR[1] (e.g. breeding areas) are prone to the presence of birds concentrations, shown at Figures 10 to 13, and are therefore more likely to be areas where UAP are mis-reported.

MOTHS

16. Clouds of large moths, usually in some country areas, can briefly reflect light and appear as a 'vehicle'. Swarms of spruce budworm moths are said to be luminous.

SOLAR RADIATION

17. LAZAREV, [2] writing in the Journal of Optical Technology, explains the 'outbreak in Flying Saucers' (in Brazil and S. Africa) by "atmospheric optical phenomena which manifest themselves especially distinctively at twilight, near the visible horizon of the earth".

18. It is claimed that this is associated with the increase of optically active air mass, coincident with sharp reduction of the brightness of the atmosphere combined with the enhanced contrast of the phenomenon against the twilight background. In particular (in the locations mentioned above) these formations were observed over volcanic areas and faded after a time. This is attributed to Fresnel reflection from clouds of heated gases (air, CO_2, water vapour, volcanic sulphurous gases, aerosols etc.). Sometimes these ring-like formations were observed for several minutes.

19. Lazarev has also reported the entry of a snowball core (of a minicomet) into the atmosphere (26 September, 1990) and possibly again on 20 June, 1992 (at the MIR orbital complex). The frequency of occurrence of cores of minicomets into the earth's atmosphere (observed from space-station MIR) is assessed at ~20 per minute.

SUN PILLARS & LIGHT PILLARS

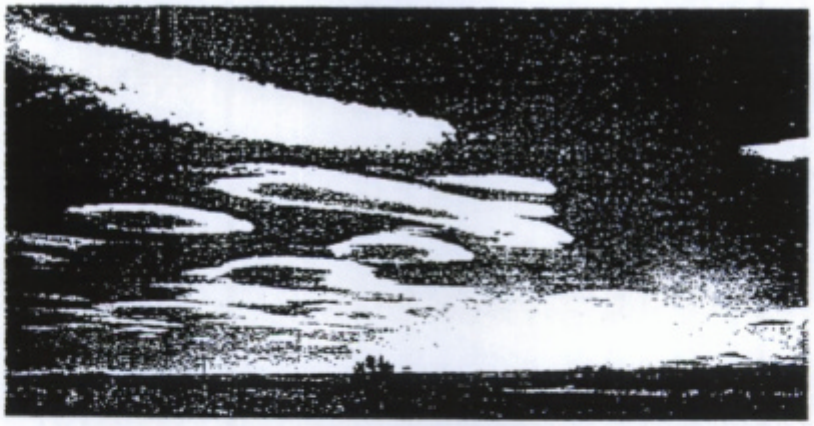
20. A vertical column of light can sometimes be seen either below or above the sun, usually when the sun is at low elevation angles. Sun pillars are produced when correctly orientated ice crystals reflect sunlight or when hexagonal columnar ice crystals fall through the air with their long axes orientated horizontally. Example Sun Pillars and Sun Dogs are shown at Figures 14 to 16. Light Pillars are similarly formed from strong light sources other than the sun. It is possible to observe Light Pillars which do not reach to the ground - another source of UAP activity with 'searchlights' beaming downwards.

[1] UK Military Low Flying Handbook (NATO Restricted) Edition 82 Dec, 1997.

[2] A I Lazarev, State Optical Institute, All Russia Scientific Centre, St Petersburgh. 1997.

Australian National Antarctic Research Expedition

FIGURE 1: LAMINATED CLOUD [1]



L. Larsson

FIGURE 2: LENTICULAR CLOUD [1]

[1] "Cloud Study". Ludlam and Scorer, Muray 1960

FIGURE 3: LENTICULAR CLOUD

FIGURE 4: LENTICULAR CLOUD

FIGURE 5: PILEOUS LAMINATED CLOUD [1]

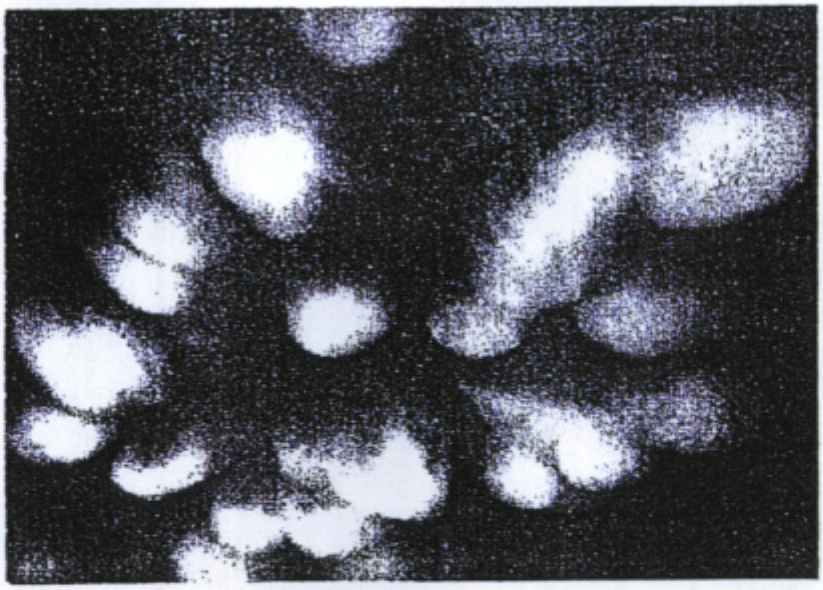
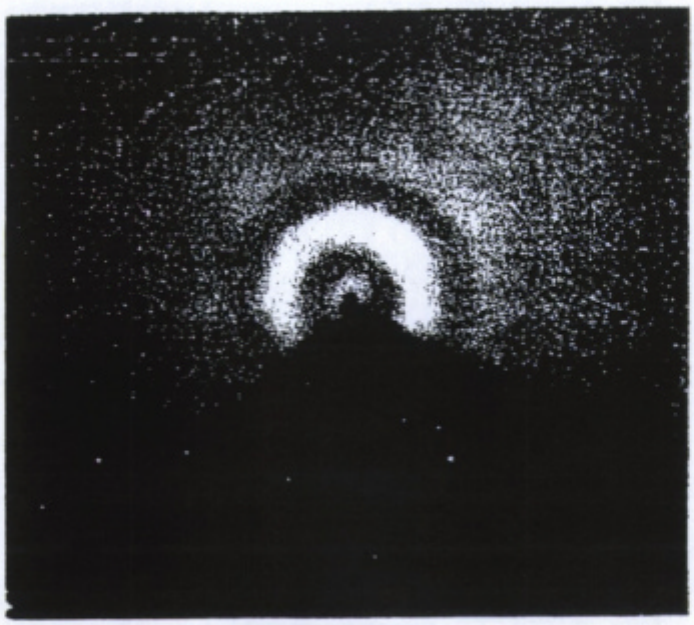


FIGURE 6: MAMMA [1]

R. S. Scorer



J. E. Tinkler

FIGURE 7(a): GLORY [1]

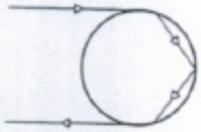


FIGURE 7 (b): LIGHT PATH

FIGURE 7(c): TOROID

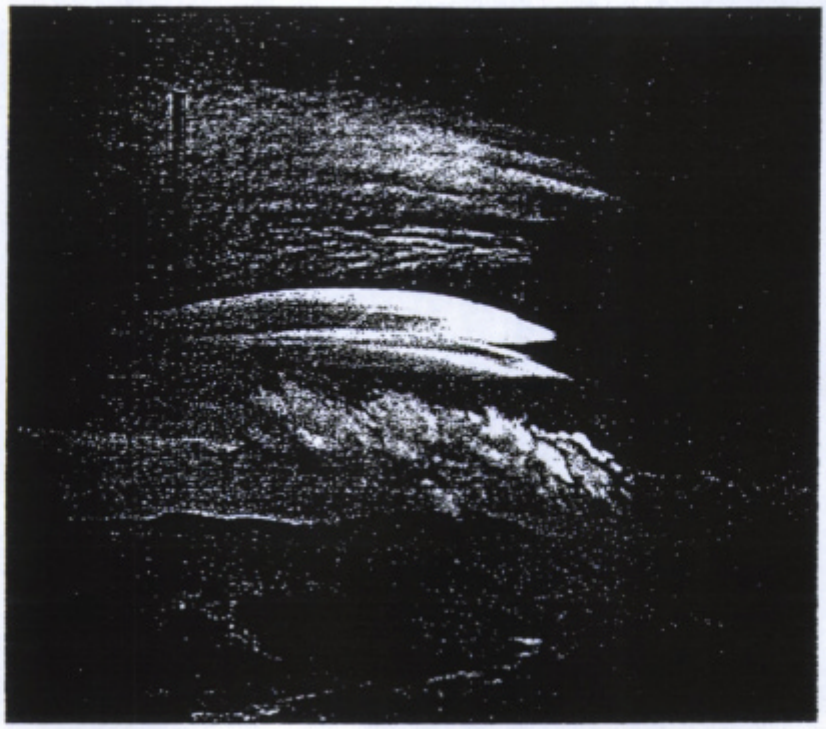


FIGURE 8: ROTOR CLOUD UK [1]

Carl Störmer

FIGURE 9: 'MOTHER OF PEARL'

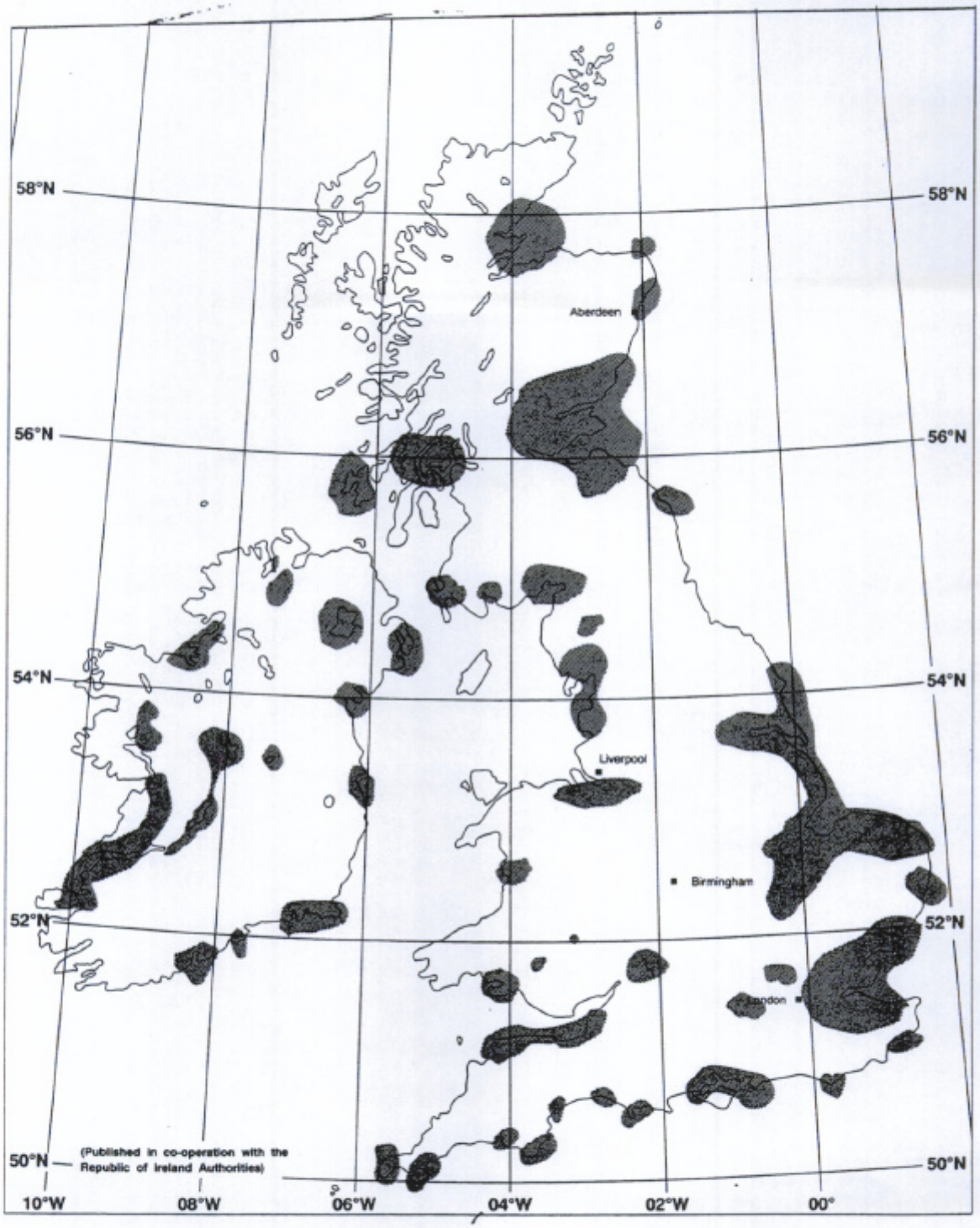


FIGURE 10: BIRD CONCENTRATION AREAS(Aug-Feb)

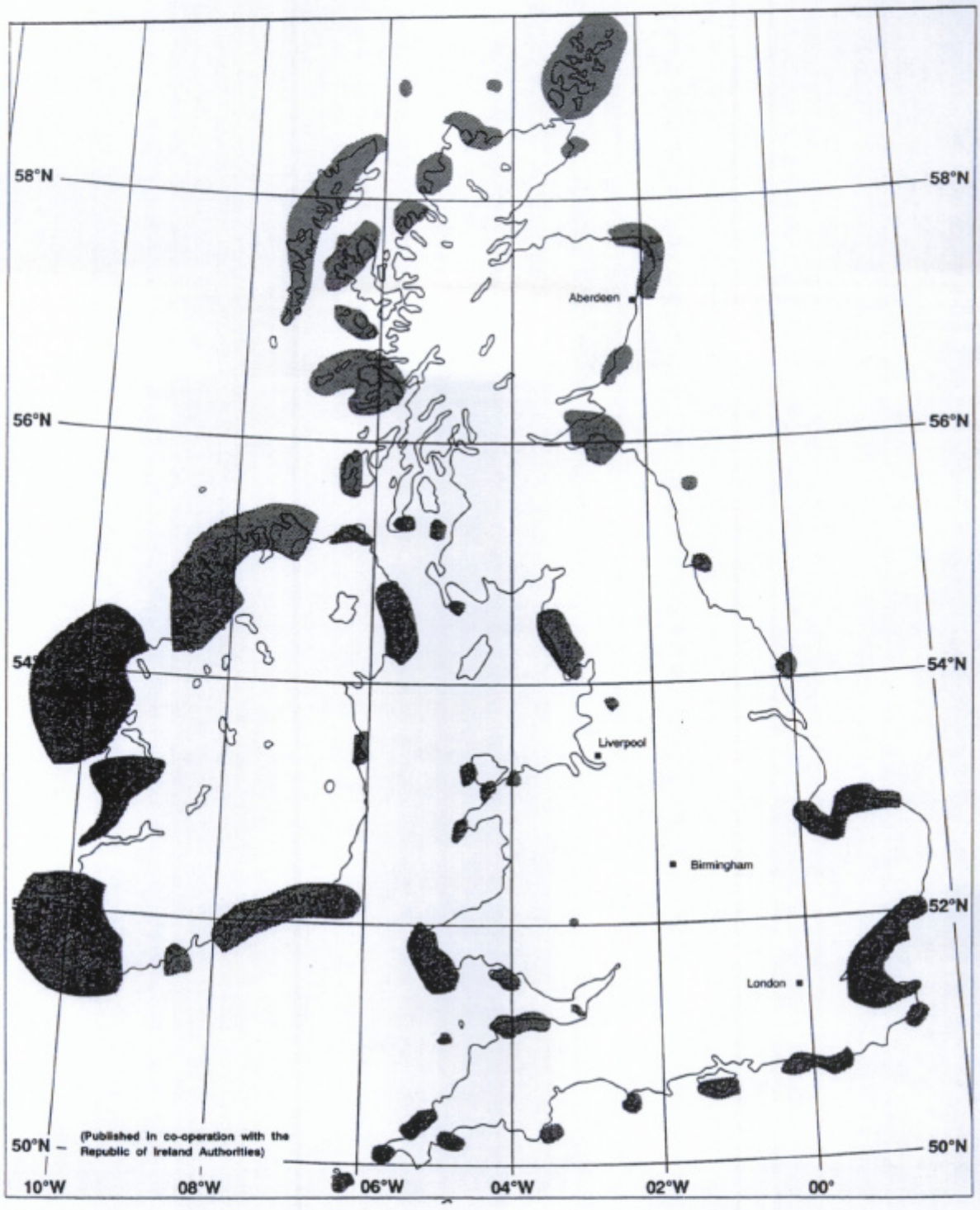


FIGURE 11: BIRD CONCENTRATION AREAS (Mar-Jul)

FIGURE 12: MAJOR SEABIRD AREAS -SCOTLAND

FIGURE 13: SEVEN SOLAR IMAGES FROM ICE CRYSTAL

FIGURE 14: SUN PILLAR & SUN DOG (R GREENLER)

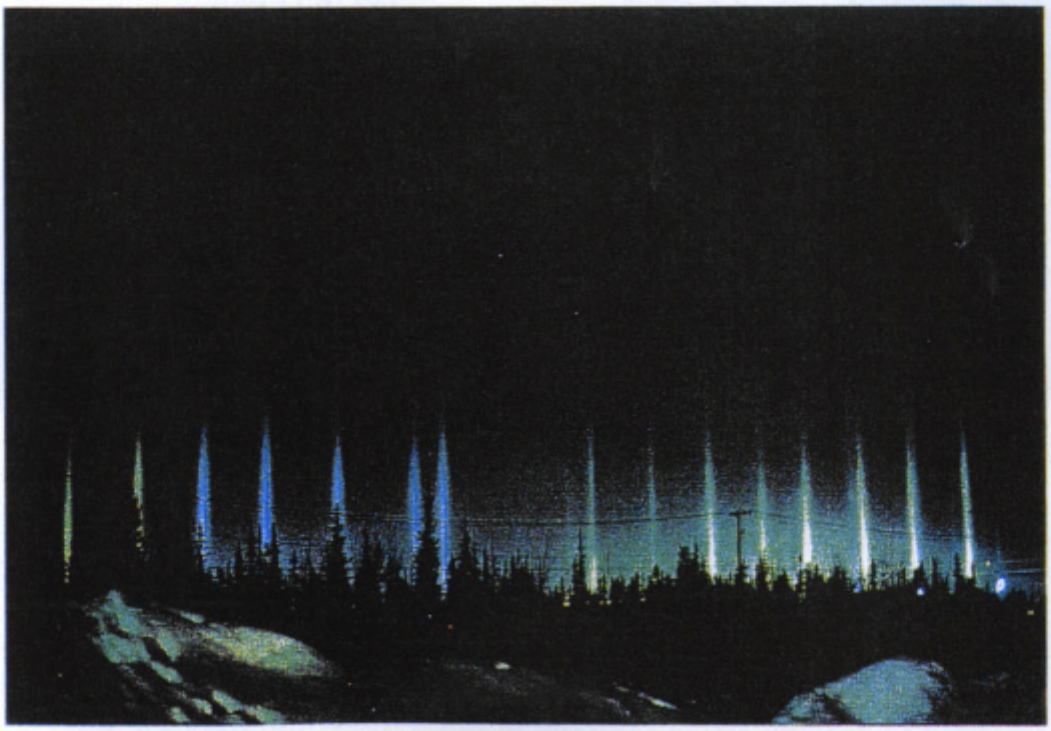


FIGURE 15: MULTIPLE LIGHT PILLAR DISPLAY (W TAPE)

FIGURE 16: LIGHT PILLAR (P PARVIAINEN)

WORKING PAPER NO. 14

METEOROLOGICAL BALLOONS