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Radar: A Useful Remote Tool in Biodiversity Research, Habitat Quality Assessment, Pest Control and Pollution Surveillance

Ommo Hüppop*

Institute of Avian Research "Vogelwarte Helgoland", Wilhelmshaven, Germany

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***Corresponding author:** Ommo Hüppop, Institute of Avian Research "Vogelwarte Helgoland", Wilhelmshaven, Germany

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Mini Review

Ecologists, conservationists and institutions working on pest controls or on monitoring and persecuting environmental pollutions but also hydrologists, geologists, oceanographers and others use a broad variety of modern remote sensing techniques for their daily work, including various radar applications [1-3]. "Radar" is an acronym for "Radio Detection and Ranging" which essentially means the transmission of electromagnetic waves and the reception of their echoes to retrieve information about the target [4-6]. From the 1920s on, radar was initially developed as a tool for military purposes to detect aircraft and ships. Later, it became obvious that radar can also be usefully applied to non-military objectives such as meteorological observations and weather forecasts [5] as well as aerial movements of birds, bats and insects [4,6,7]. An amazing variety of radars was applied in aeroecology [6-8], biological conservation [9] but also in insect pest control [6,10] and other areas. Namely, with the continent-wide availability of weather radar data [8,11], a real renaissance of radar in aeroecology started in the last decade.

While early radar equipment was huge and only suited to be operated stationary to detect and track moving targets, perpetual miniaturization enabled a kind of reversion of this principle, i.e. the operation of air-borne radars used for different kinds of remote surface sensing from aircraft, shuttles or satellites. Many different remote sensing radar types were developed, providing a wide variety of configurations, frequency bands and polarizations [1,2,12,13].

Side Looking Airborne Radar (SLAR) was developed as early as the 1950s. Scanning was achieved by a fixed radar beam point ed to the side with the aircraft's motion moving the beam across the land. Hence, images shot by SLAR are poor in azimuth resolution. In order to obtain high-resolution images, one had to resort either to a very large antenna or to employ radar wavelengths so short that the radar must contend with severe attenuation in the atmosphere [12]. In contrast, Synthetic Aperture Radar (SAR), which is operational for earth observation since 1978, can produce high-resolution radar images of the land surface characteristics insensitive to cloud interference – a major issue in remote sensing with optical sensors – by using the forward motion of the aircraft or satellite to 'synthesize' a very long antenna. Thus, SAR allows the use of longer wavelengths and reasonably sized antennas [1,12]. SAR is broadly used for remote sensing in forestry (forest structure and diversity, tree biomass, height, species, plantation and deforestation, forest fire monitoring) and agriculture (crop classification, plantation acreage, growth, harvest and disaster, soil moisture). Archived radar images allow monitoring as well as long-term tracking of changes and losses of habitats and biodiversity over larger areas and habitat types including endangered landscapes such as tropical rain, mangrove, swamp and other forests [2,3,13], intertidal mudflats, moorlands, bogs and other wetlands [14,15] but also large scale quantification of agricultural land-use intensity across human-dominated landscapes [16]. Analyses of SAR imagery will also be further developed to estimate soil moisture, which is relevant, e.g., to egg development in locust outbreaks [10] and thus improve prediction of pest insect outbreaks (which could help to reduce the use of pesticides harmful to biodiversity).

Radar sensors on satellites and aircraft also meet most requirements needed for tracking and predicting oil and other marine slicks at various resolutions, over wide areas and at frequent intervals. For detecting such pollutants on water, radar imagers have the advantage of not being bothered by cloud cover and other atmospheric effects [1,17]. Detection of oil spills by radar systems is based on the dampening effect oil has on surface waves which offers the unique potential for large area searches, both during day and night as well as during foul weather [17,18]. In Europe, satellite SAR system-based oil spill detection is a near real-time service by the European Marine Safety Agency, which provides alerts of oil spill occurrences [18].

Due to its all-weather capabilities, its image acquisition capacity during both day and night and the extraction of the three-dimensional structure of habitats, radar often offers better alternatives for many questions compared to optical imagery. Regrettably, radar data access and availability are limited, often costly and only a few sensors allow continuous high-resolution long-term monitoring over larger areas [2,3]. One recent example worth to be highlighted is the Sentinel-1 mission launched by the European Space Agency in 2014 with its unprecedented combination of high spatial resolution, high revisit frequencies, complete geographic coverage and open-access of the data [13]. With easier, and hopefully free, availability of radar (and other) remote sensing data, area-wide biodiversity research and many facets of biological conservation will increasingly benefit from a fruitful cooperation between these communities [2,13,18].

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