ASSESSMENT OF SEA BREEZE CHARACTERISTICS FROM SODAR ECHOGRAMS

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ABSTRACT

The SODAR echograms extracted from SODAR have been used to estimate the various meteorological parameters such as vertical wind profiles, temperature profiles to observe the lower atmospheric phenomenon like sea breeze characteristics, height of Atmospheric Boundary Layer, Temperature inversions etc. In this paper the characteristics of sea breeze circulation are studied from SODAR echograms.

Keywords: SODAR echograms, Sea breeze characteristics.

1. INTRODUCTION

The concentration of interest in the sea breeze flow is not surprising since it affects the coastal weather which plays major role on the life style of population living in coastal areas. Generally, the sea breeze develops when the mean temperature difference between the two air masses overlying coastal waters and coastal land is sufficient to create a density (and therefore pressure) gradient. The resulting land–sea temperature difference increases during the day and produces a land–sea surface pressure difference at low levels in the atmosphere, which results in the development of the sea breeze circulation (Simpson 1994). The sea breeze generally begins before noon and reaches their greatest intensity in the mid afternoon hours. The scale of sea breeze depends upon the location and time of the year. The sea breeze is usually accompanied by a decrease in temperature and a corresponding increase in atmospheric humidity. The onset of the sea breeze is sometimes marked by a sudden squall, resembling a minor cold front at inland boundary of the sea-breeze circulation (Simpson et al. 1977). If the synoptic gradient flow opposes it, that is, if the overland winds are offshore, interaction with this onshore gradient flow will form a sea-breeze front. As sea breeze front penetrates over land there is drop in Drop in air temperature (8-11°C), increase in humidity levels, significant change in wind direction or speed, triggers the mechanism of afternoon thunder storm formation, formation of convective clouds, advection of sea fog onto the coast, influences the pollution plume direction and diffusion in coastal regionand formation of thermal internal boundary layer.

The sea-breeze front can be identified by remote sensing, especially on visible satellite images. Sound Detection And Ranging (SODAR) is one of the remote sensing instruments for continuous monitoring of the lower atmosphere. It works on the same lines of typical radar, whose acronym is radio detection and ranging. An English physicist Tyndall (1874) was the first who observed sound scattering from turbulence when studying the propagation of acoustic signals through
the sea fog to determine the potentialities of acoustic beacons. A packet of sound at some frequency with some magnitude is sent into the atmosphere, mostly vertically or titled 15°- 30° off from vertical, at repeated time intervals. The SODAR system principally uses sound wave scattering by atmospheric inhomogenieties (McAllister 1968, Little 1969). The vertically (or tilted) sound propagating in the atmosphere gets backscattered from small scale temperature fluctuations spaced at half the wavelength of the sound. Immediately after transmission, the system is set in the receiving mode to receive backscattered echoes due to the atmospheric temperature and velocity inhomogenieties.

These backscattered echoes are detected, digitized and stored subsequently in the permanent storage devices of the computer and are displayed as facsimile pictures. This instrument finds applications in the areas of fog monitoring, air pollution monitoring and air quality measurement. The SODAR is operated on a regular basis and the SODAR data is recorded on facsimile recorder.

2. Sea breeze Characteristics and classification of SODAR echograms

The sea breeze occurs most frequently in the tropical zones where the higher temperatures and weaker predominant winds which help the development of sea breeze. In the temperate zones sea breeze occurs in the spring and summer and the land breeze occur in the cold seasons. The landward penetration of sea breeze reaches 15 to 50km in the temperate zone and 50 to 65km in the tropics. The vertical extent of the sea breeze is about 1 to 2km over the land. Sea breeze in the middle latitudes can be strong particularly in summer but at lower latitudes it can be strong at any time of the year. The strength of sea breeze depends on the difference in temperatures over the sea and land surfaces. The onset and decay pattern of sea breeze circulation is different at different coastal areas because of the difference of latitude, sea surface temperature, topography and other circumferences. The nocturnal breeze (land breeze) is shallower and weaker than the day time sea breeze. When the sea breeze circulation prevails on land, changes in the temperature structure, humidity and roughness occur in the air adjacent to the coast and lead to formation of a thermal internal boundary layer (TIBL) (Stull 1988). This effectively reduces the mixing height in the coastal regions in the daytime. Land–sea breeze circulation and TIBL are the two important phenomena that influence the pollution plume direction and diffusion in coastal regions. Many factors such as topography, synoptic flow and latitude are shown to influence the evolution and characteristics of sea breeze.

Different studies have been discussed on the SODAR echogram structures. Choudhury and Mitra (2004) were proposed a SODAR structure classification model using a neural network for six different structures as convective plumes, inversion with flat top, inversion with small spike, inversion with tall spike, rising inversion and rising inversion with convective plumes.
3. SODAR data-Assessment of sea breeze Characteristics

Some of SODAR echograms collected from the SODAR system installed on the top of the building of Physics department, Andhra University, Visakhapatnam, India to capture the typical characteristics of sea breeze circulation are presented in this study.

Fig: 1 SODAR echogram - the structure of thermal plumes

Fig: 2 SODAR echogram - thermal plume structures before sea breeze.

The SODAR echograms were obtained during the occurrence of sea breeze at Visakhapatnam. The primary characteristics of the acoustic radar (SODAR) record that indicated the presence of sea breeze are:

When the winds are light and offshore, and the day is bright and sunny, vertically oriented intermittent scattering regions extending to few hundred meters
are seen on the sodar facsimile record (Fig: 1 and Fig: 2). The intermittent scattering regions are also called ‘spike echoes’ because they appear as vertical intermittent spikes or ‘grass’ rising from the ground (Russell and Uthe, 1978a; 1978b). This type of record is characteristic of convective activity associated with a low-level super adiabatic (unstable) layer generated by surface heating of the ground due to incoming solar radiation represents the atmospheric pattern before arrival of sea breeze.

![SODAR echogram- onset of sea breeze structure](image)

The limited vertical extent and temporal coherence of the echo region. This type of record is indicative of a stable region limiting the vertical development of turbulent scattering region. As the sea breeze front moved inland, an elevated layer within the height range of between 100 - 500 m is observed (Fig: 3).

As the day progresses with strong solar heating, due to the temperature gradient between land and sea develops sea breeze by suppressing the thermal plumes towards the ground. It is observed a strengthened sea breeze in Fig: 4 with increase in separation between ground layer and above the’ no echo’ region, called inversion layer. From this echo gram, the vertical extent of sea breeze (about 260m) and the TIBL height (about 168m) is estimated approximately. As the sunset occurred it is observed the decrease in temperature gradient causes the decrease in convective pluming activity (Fig: 5) and a stable ground layer with a few metres about 70m above the ground represents the decay of sea breeze.
5. CONCLUSION

It is observe that the acoustic remote sensing has great importance in capturing the various structures of sea breeze circulation. In this study SODAR echograms assessed the sea breeze characteristics with the convective plume structure analysis. These SODAR echograms can also provide the reliable information about the other atmospheric phenomenon such as atmospheric boundary layer processes and
thunderstorm activities etc. Finally, this study holds promise for researchers can do their research in the domains of atmospheric sciences, remote sensing, microwave propagation, civil aviation, air pollution, and meteorology for attaining the agreeable results.

6. References


