# Dynasonde 21 Data Processing: Principles and First Results Obtained with the new 8-Channel HF Radar System at Wallops Island, Virginia


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## Summary


*Dynasonde* is a generic name for a unique ideology of ionospheric radio sounding which commenced development in the mid 60's at NOAA's forerunner in Boulder, Colorado, the Institute for Telecommunication Sciences and Aeronomy. The name itself was chosen in 1969 to denote "a system competent to sound the full range of dynamic variation of the ionosphere" [1]. The distinguishing properties of this ideology are:

a) *Limited impact to other uses of the radio spectrum.* The Dynasonde avoids application of long sequences of pulses at the same base frequency. Instead, short sequences (3 to 8) of narrowband (30 kHz) pulses are used. In these pulse sets the radio frequencies are slightly offset (by 1-4 kHz) from the base frequency in a carefully designed pattern to enable precision range measurements (to within a few meters) by the Stationary Phase principle.

b) *Direct attention to physical properties of the raw data*. Mathematical procedures which can have undesirable consequences, such as Fourier transforms, pulse coding, or coherent summation, are not used. Instead, the phase and amplitude of received signals (from raw I&Q) are used directly. As a consequence, low-level Dynasonde data processing yields excellent statistics of recognized echoes characterized by accurate physical parameters, each with its individual error estimate. The same echo recognition and characterization process rejects false echoes and noise.

c) *Diverse and sophisticated methods of higher-level data processing.* Owing to the quality and the quantity of the echoes, an autonomous classification of the echoes into traces is accomplished; subsequent inversion procedures address the appropriate traces more efficiently. Another important benefit of the Dynasonde data analysis is its use of physics-based criteria rather than using indirect procedures (such as image processing). Unique Dynasonde products include: dependable autonomous scaling of standard ionospheric parameters, 3-D plasma density inversion (NeXtYZ), small-scale irregularity diagnostics, and vector velocities, all obtained directly from ionogram data.

Development of Dynasonde methods has benefited continuously from the excellent hardware design of NOAA's last HF Radar, circa 1975-1983 [2]. Significant features of the old hardware included high-resolution receivers with wide dynamic range I&Q digital output; extensive calibration capabilities; careful attention to minimizing radiated interference; excellent linear performance throughout signal generation, transmitter amplification, antenna characteristics, receiver qualities, and digital data definition. The new HF Radar designed by Scion Associates Inc. and recently installed at NASA's Wallops Flight Facility in Virginia, builds upon success of the old instrument, adding many new features [3,4]. It is a fully digital radar system that allows very flexible programming. For the first time in Dynasonde practice it provides as many parallel receivers as receiving antennas (8 each). This means that the frequency-time (group range, Doppler) and spatial (echolocations, polarization) partitions of the total measurement activity, are solved for by independent least-squares solutions.

Dynasonde 21 is a comprehensive software suite that integrates all of the Dynasonde data analysis methods. It has been tested in a multi-year real-time operation with the data from old Dynasondes. Since November 2007, real-time data produced by the new radar at Wallops are processed with this software. We report in this paper the features of the data analysis that were made possible by the new radar system at Wallops, and its first results (see illustration in Fig. 1).

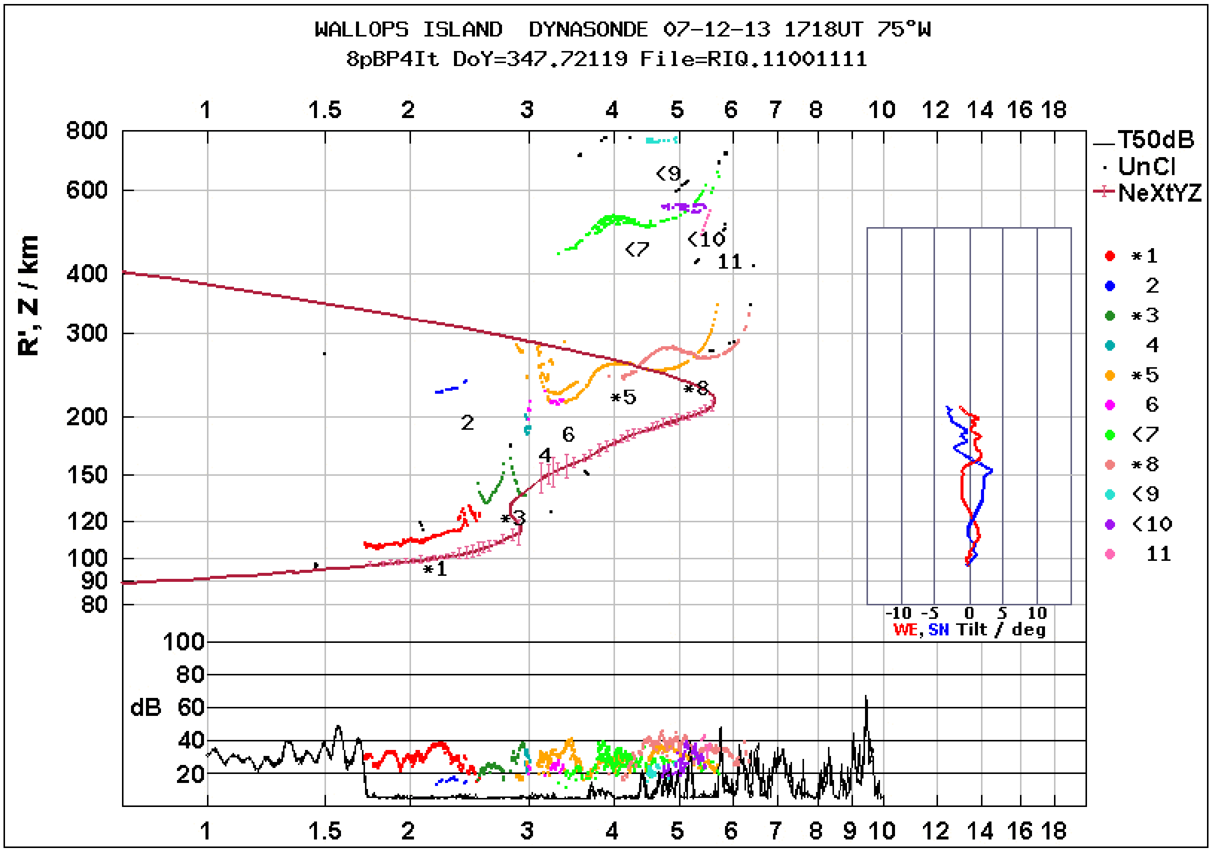


Figure 1. Top panel of a standard Dynasonde 21 ionogram image. Observed echo group range *R*' and computed vertical profile *Z* by NeXtYZ *vs* radio and plasma frequency (in MHz) respectively, on log scales. Colors and trace numbers identify echo classes: those marked with '*' are selected for profile inversion; those marked with '<' are rejected for NeXtYZ. Insert shows East-West (red) and North-South (blue) components of NeXtYZ "Wedge-Stratified Model" (WSM) tilts *vs Z*. Error bars respond to WSM fitting of O and X data. Echo amplitude (dB) panel also shows measured noise level (black curve). Near noon local time; radar is operating at a reduced power; moderate absorption shows mainly local broadcast stations in noise data; flawless trace selection. Error bars on profile show effect of medium-scale structure just above 3 MHz.

## References

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