

## Modern F-K Filters

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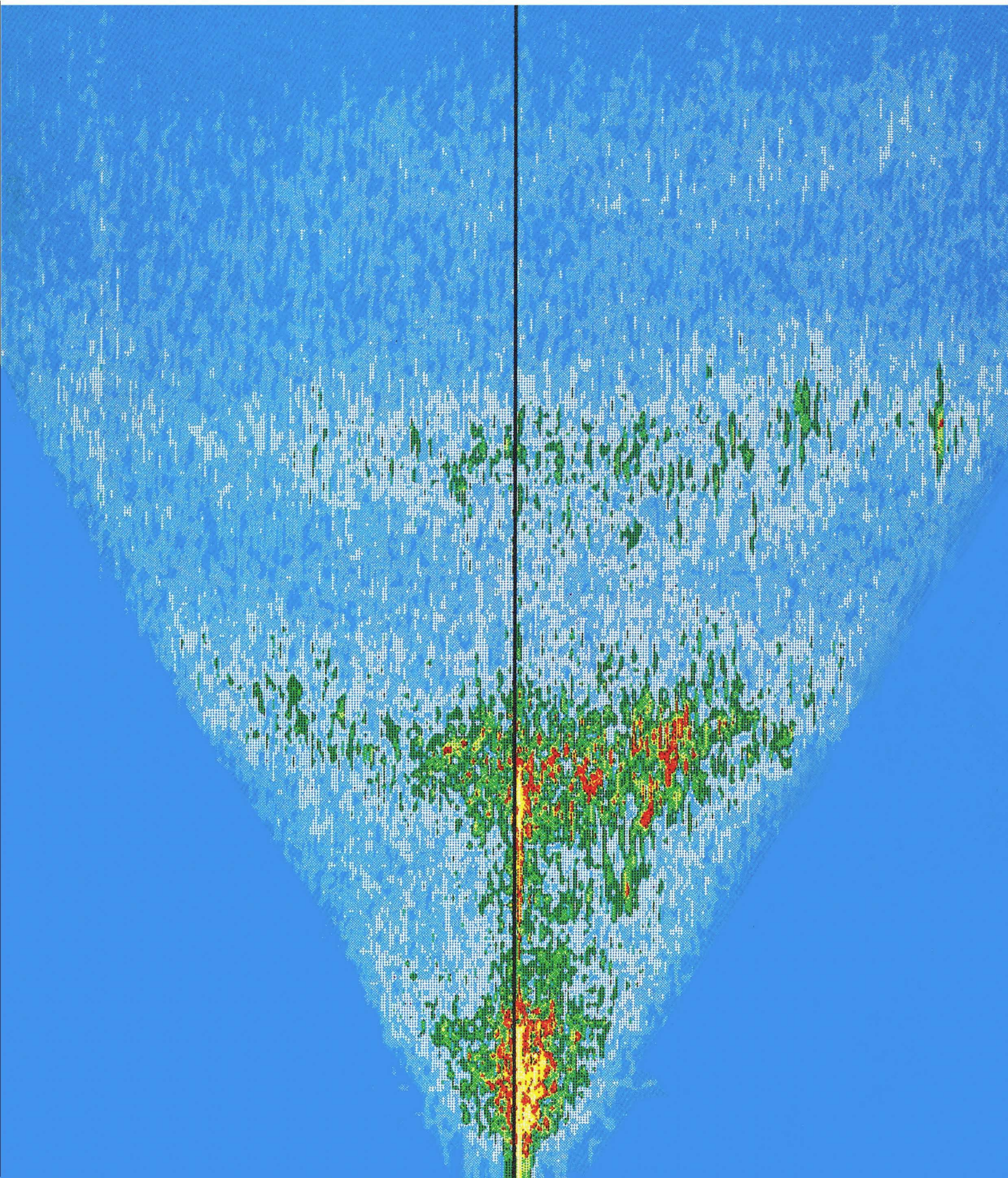
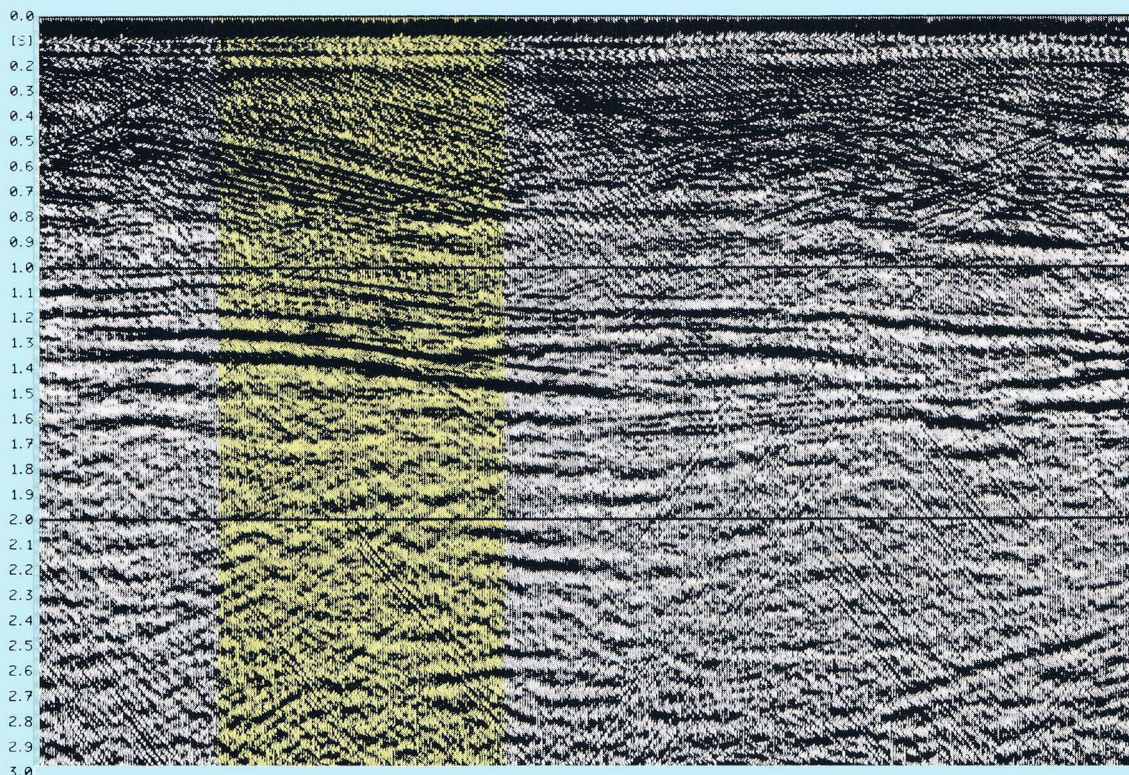




Fig. 1 a:  
Stacked Section (input)



Seismic data are often contaminated by coherent noise events aligned along steeply dipping straight lines in varying directions as, e.g., indicated in the stacked sections of figs. 1a and 2a. They can emanate from scattered waves from near surface anomalies, cable noise, reflected refractions, direct waves etc.

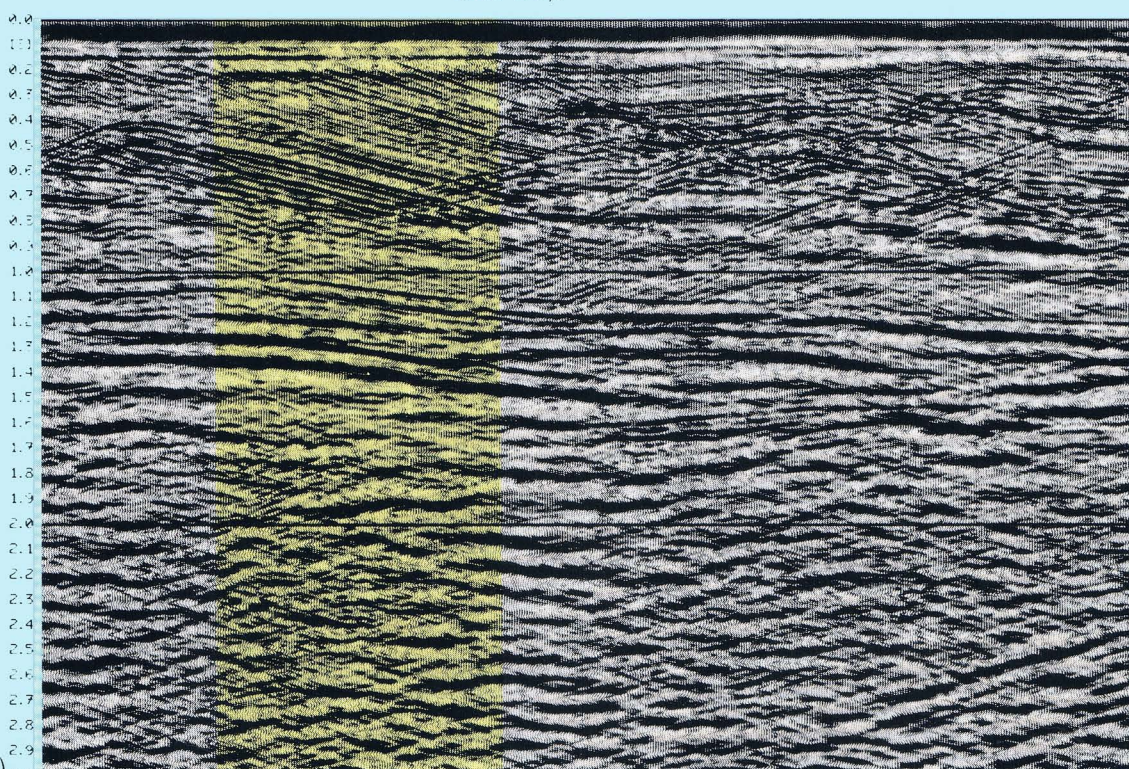
As is well known, coherent noise affects the efficiency of certain processing steps such as deconvolution and migration; for this reason fan filtering was introduced at the very beginning of seismic data processing. However, the design and implementation of effective filter operators has become problematic in many cases with respect to the character of output data or computational effort.

The transformation of  $x$ - $t$  data to the frequency wave number domain allows the proper separation of noise

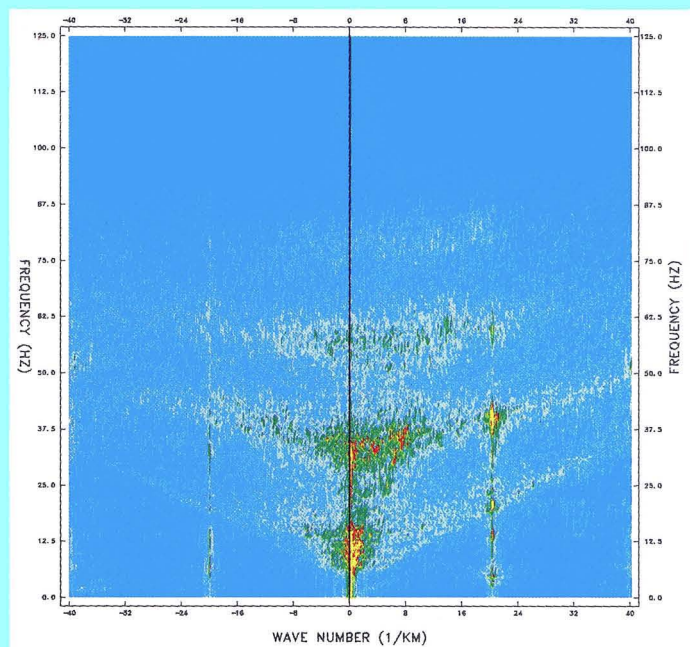
events from useful seismic signals. The analysis of these F-K spectra easily defines the type of filter operator to be applied. A special **separation technique** provides a variety of **fast single-channel filter operators** optimally designed for effective noise attenuation.

Representative data of the stacked sections in figs. 1a and 2a, as marked by the yellow time gates, have been transformed to the F-K domain, resulting in the corresponding spectra shown in figs. 1b and 2b. Appropriate narrow rejection filters of triangular and trapezoidal geometry, illustrated by the operator displays of figs. 1c and 2c, effectively attenuate the coherent noise, as shown in the output sections of figs. 1d and 2d respectively. The effectivity of the results can be proved by F-K spectra calculated in the same time gates (figs. 1e and 2e).

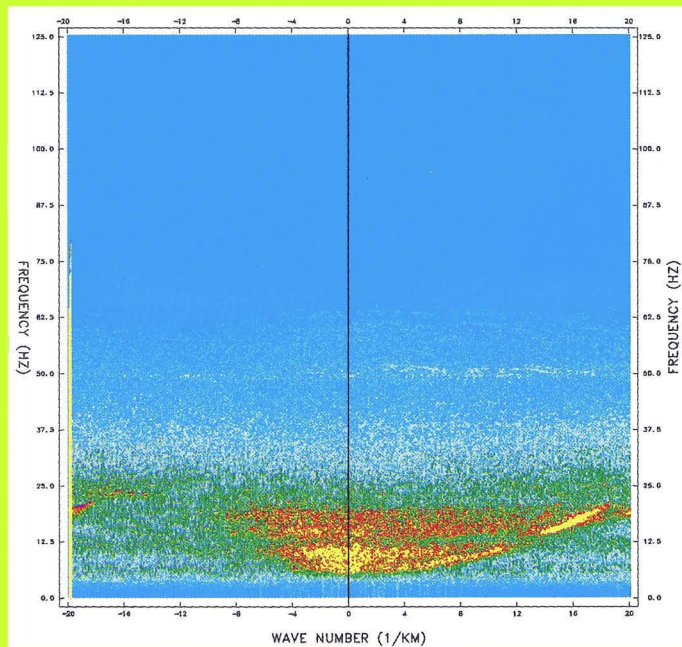
Fig. 1 d:  
Stacked Section (output)



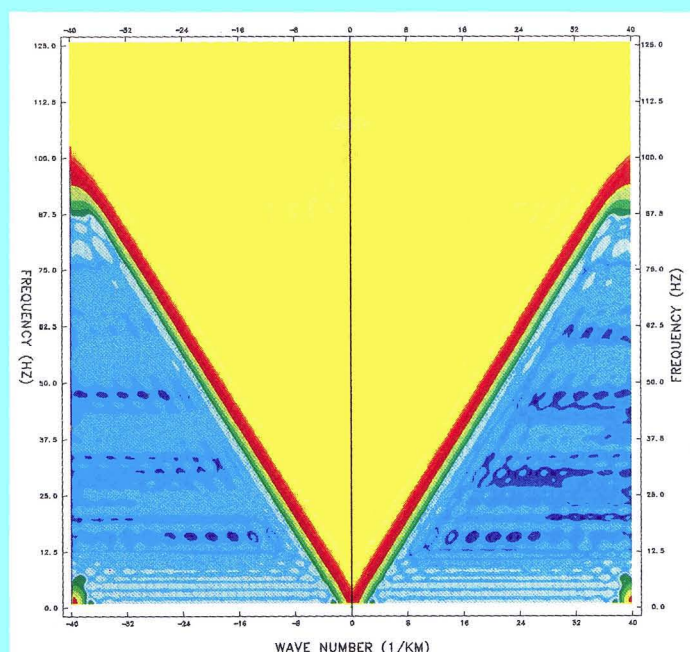




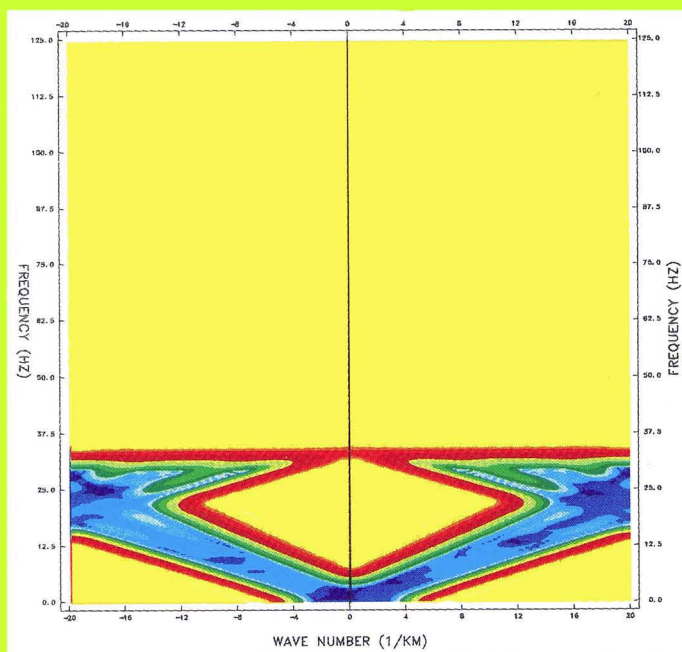
**Fig. 1b: F-K Spectrum of yellow window (fig. 1a)**



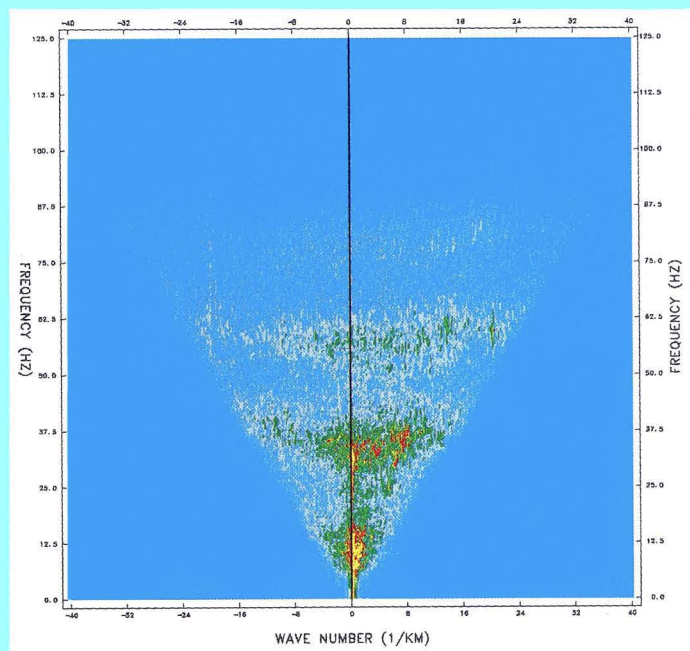
**Fig. 2b: F-K Spectrum of yellow window (fig. 2a)**



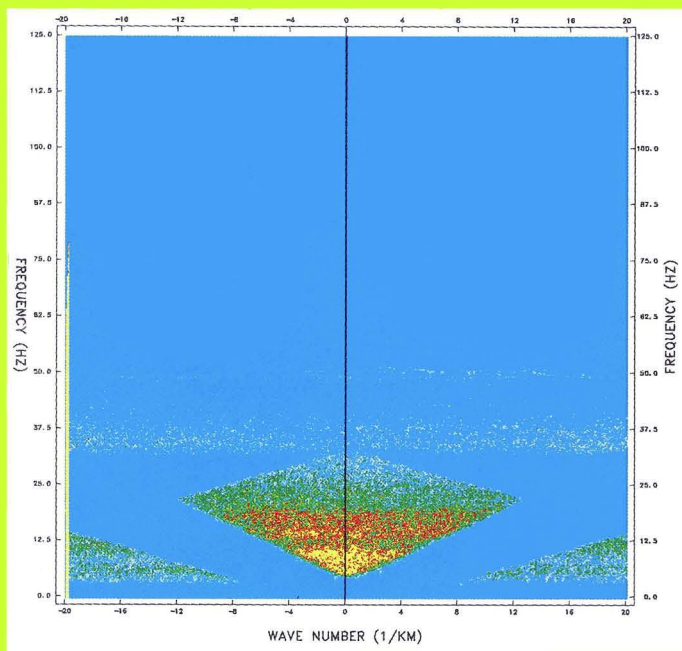
**Fig. 1c: Triangular Rejection Filter Operator**



**Fig. 2c: Trapezoidal Rejection Filter Operator**

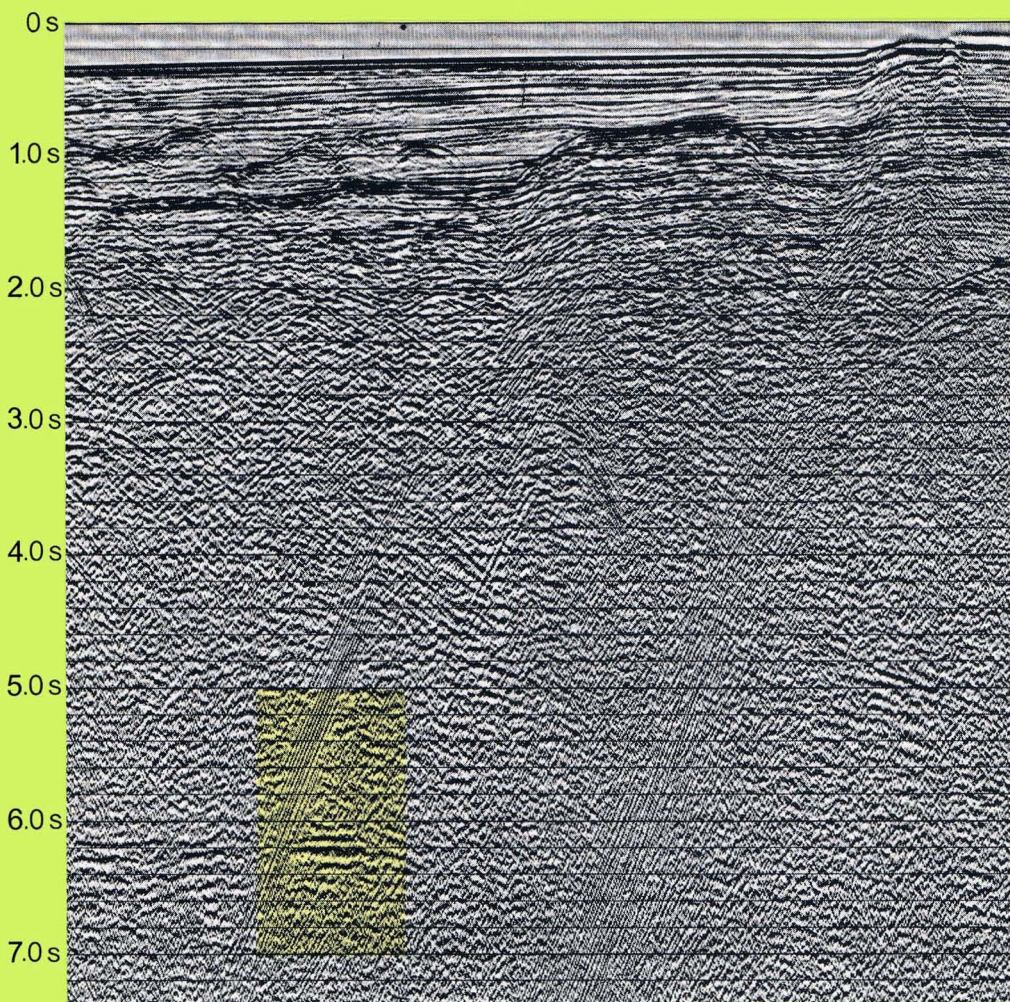


**Fig. 1e: F-K Spectrum of yellow window (fig. 1d)**



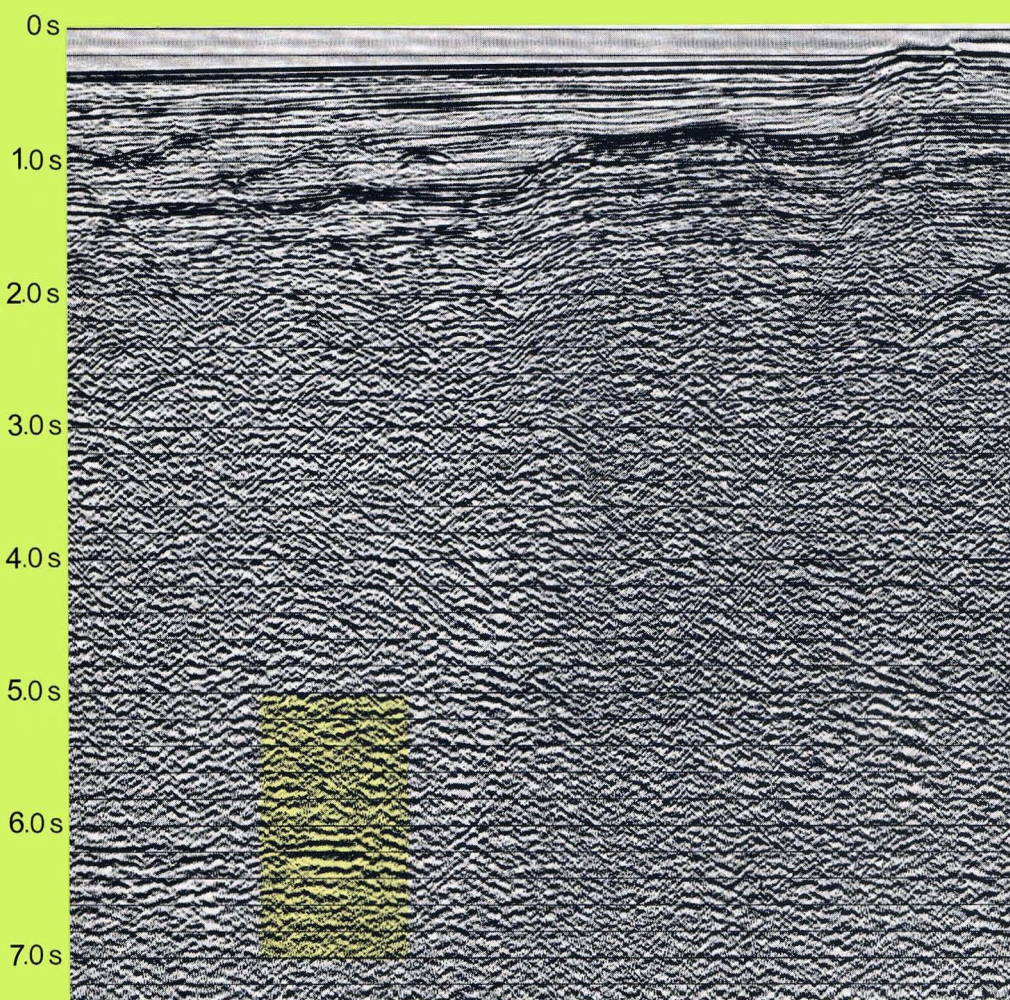
**Fig. 2e: F-K Spectrum of yellow window (fig. 2d)**





**Fig. 2a: Stacked Section (input)**

The most important feature of this **Separated Design Method** is the fact that all operations are derived from single-channel-operators whose design by mathematically rigorous methods is a tractable problem in contrast to direct multichannel design. Thus, all transition domains of the resulting fan filter are fully predictable and can be varied over a wide range of user parameters.



**Fig. 2d: Stacked Section (output)**

#### **Advantages of Separated Design over Conventional Design**

- Pass ripple below 1.5%
- Rejection better than  $-40$  db
- Smooth transition flanks with overshoot below 1.5%
- Nominal size of transition zone is kept within 5% accuracy
- Well defined "apex"
- Fast filter algorithms, which can be applied economically even before stack.



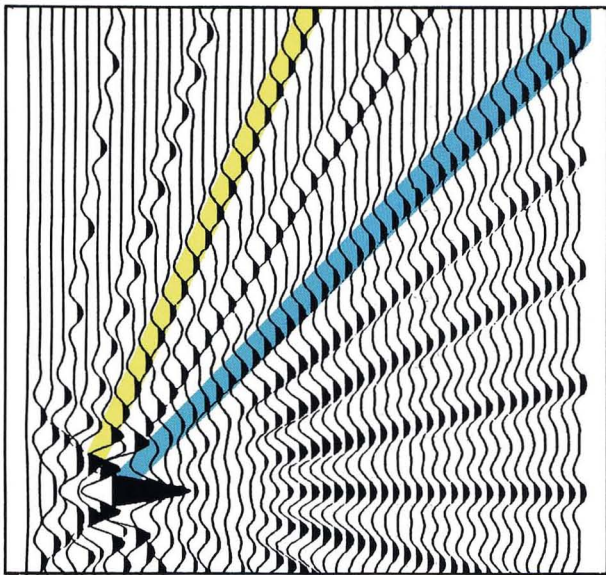


Fig. 3a: Synthetic Data (input)

Figs. 3a–e illustrate the effect of various filters on synthetic data with corresponding displays of the operators and F-K spectra after filter application. In fig. 3a the input data used for this demonstration, a group of various dipping events, are shown. Fig. 3b represents the corresponding F-K spectrum.

Fig. 3c gives the output of a **triangular separated fan rejector** set to eliminate the blue event. A complete elimination without any effect on the neighbouring events can be achieved. Such narrow reject settings are impracticable with the classical truncated operator.

The success of any triangular rejector, however, is no longer feasible for the yellow event, where some aliased energy remains (fig. 3d). In this region, typical direct water waves may be expected. Only a narrow **trapezoidal filter of the aliased type**, fig. 3e, is able to eliminate this event without visible impact on other events.

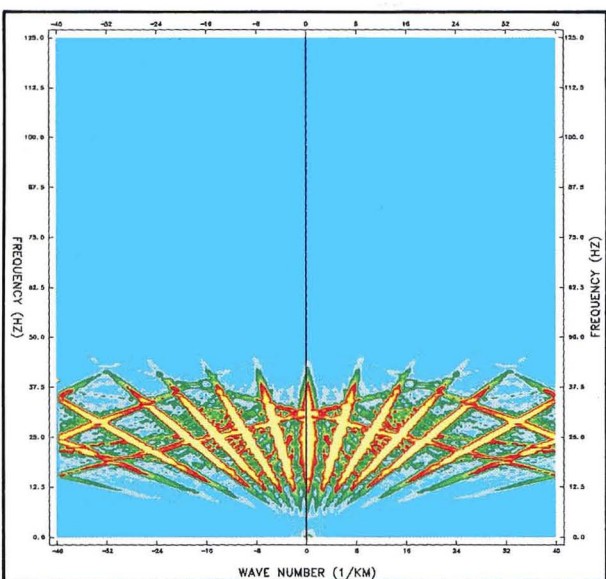


Fig. 3b: F-K Spectrum of input data

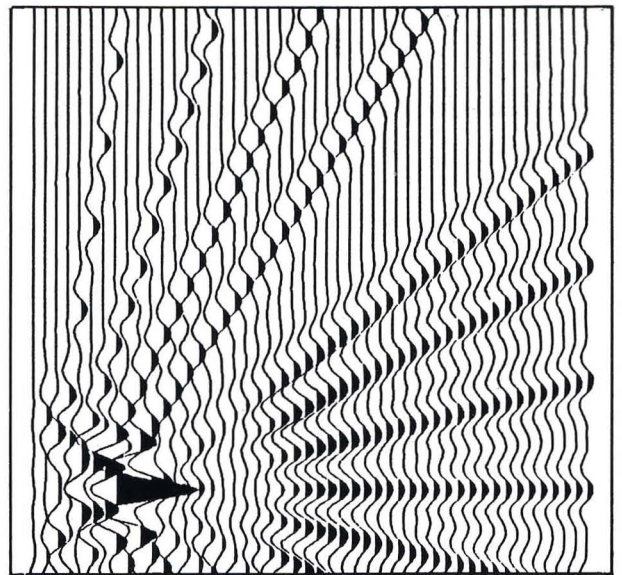


Fig. 3c1: Result of triangular rejection filter

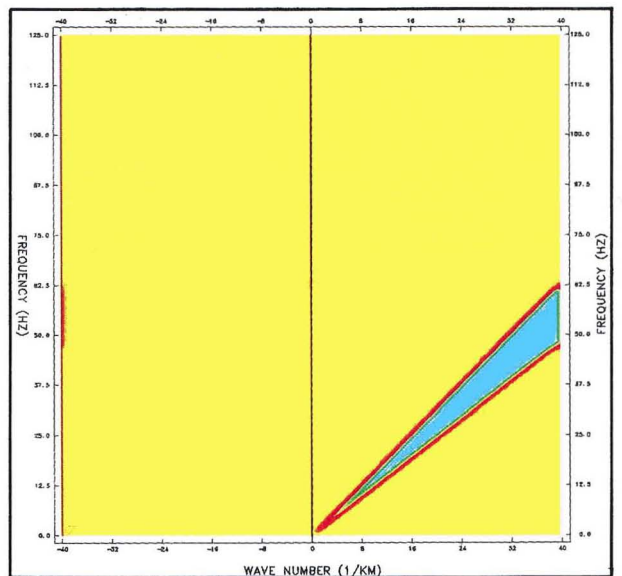


Fig. 3c2: Triangular Filter Operator

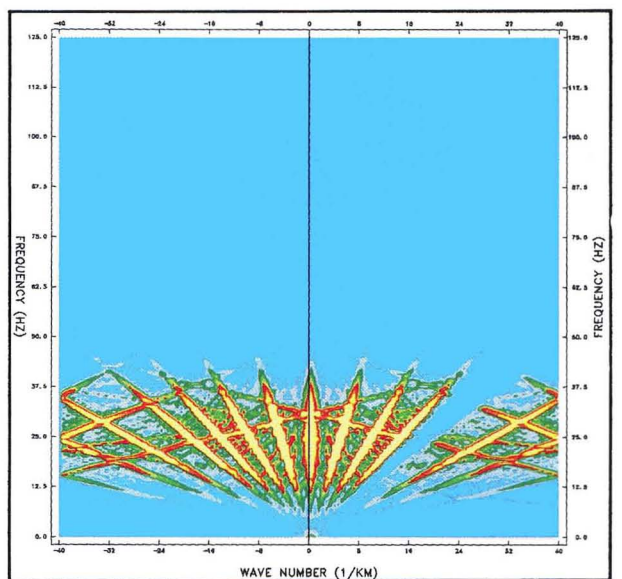
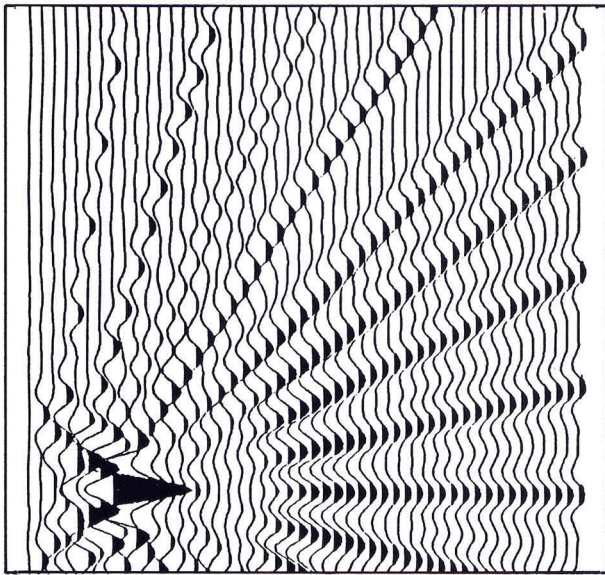
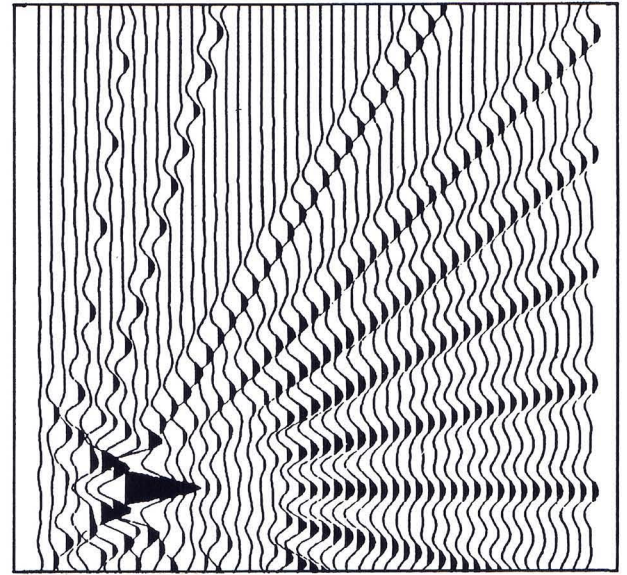


Fig. 3c3: F-K Spectrum of filtered data

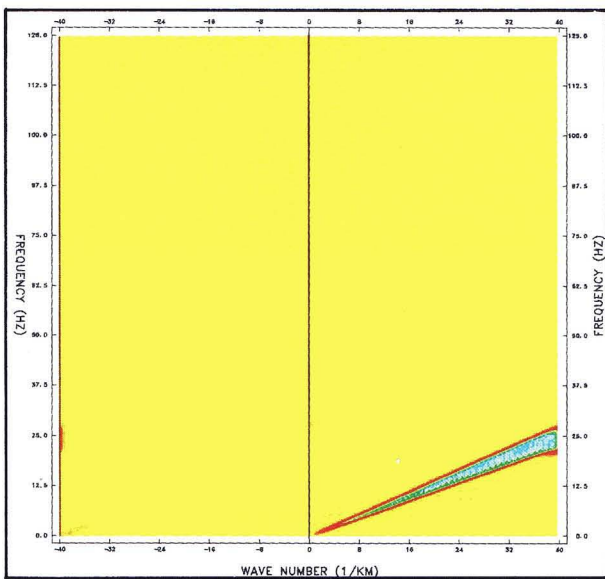




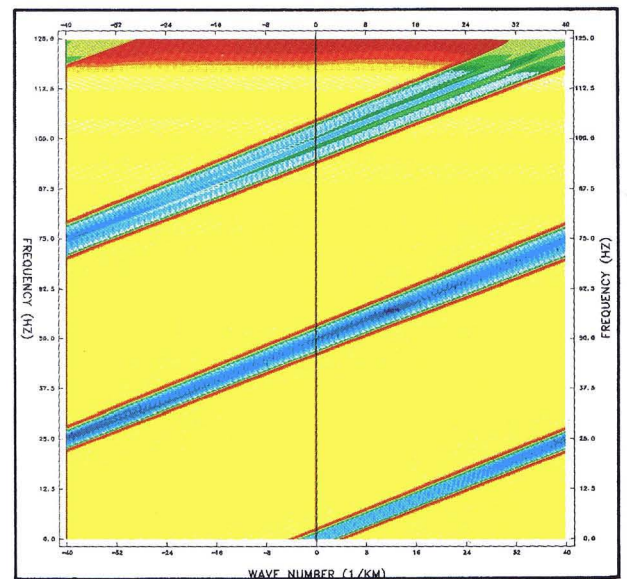
**Fig. 3d1: Result of triangular rejection filter**



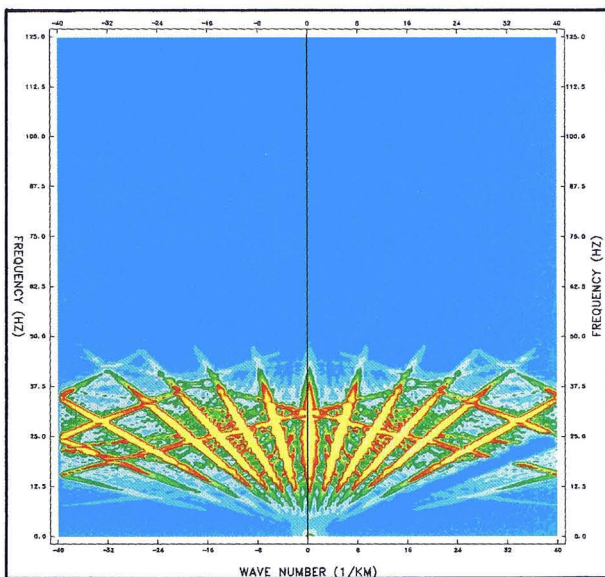
**Fig. 3e1: Result of aliased trapezoidal rejection filter**



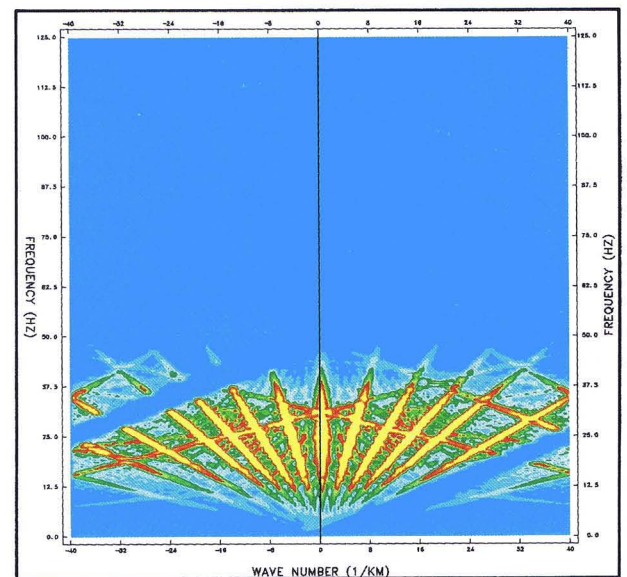
**Fig. 3d2: Triangular Filter Operator**



**Fig. 3e2: Aliased Trapezoidal Filter Operator**



**Fig. 3d3: F-K Spectrum of filtered data**



**Fig. 3e3: F-K Spectrum of filtered data**



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