The cross-correlation algorithm [1] is a numerical method used to estimate the motion of features between two frames in image sequences. Prior to this research, it was applied to real aerosol lidar for wind measurements [2, 3]. However, an evaluation of the cross-correlation algorithm involving precise control of aerosol features and flow fields has not been performed. Therefore, we have evaluated performance of the cross-correlation algorithm using synthetic backscatter images and flow fields. The results show that the cross-correlation algorithm provides reliable displacement vectors if the flow is uniform, but the performance of the cross-correlation algorithm decreases as non-uniformity of the flow fields increases.

Tests of the Cross-Correlation Algorithm Using Synthetic Backscatter Lidar Images and Wind Fields

Masaki Hamada, Pierre Dérian and Shane D. Mayor, Department of Geologic and Environmental Sciences, California State University, Chico, U.S.A.
e-mail: mhamada1@mail.csuchico.edu, pderian@csuchico.edu, smayor@csuchico.edu

Non-uniformity of the flow fields increases the cross-correlation algorithm using synthetic backscatter images and flow fields. The results show that the cross-correlation algorithm provides reliable displacement vectors if the flow is uniform, but the performance of the cross-correlation algorithm decreases as non-uniformity of the flow fields increases.

Methodology

We create a synthetic backscatter image in computer using Interactive Data Language (IDL). This is done by two-dimensional array filled with random numbers and smoothing the array with a twodimensional moving average. Then, we randomly place Gaussian features in the array and diffuse the features using turbulent fluctuation fields [4, 5]. We call this array “Block 1.”

Next we create a two-dimensional, two-component, velocity field \((u', v')\) by sum of an analytical function of flow field and a turbulent fluctuation field \((u', v')\) based on the model of Jacob Mann [4, 5].

Then, we move each pixel in “Block 1” to a new location according to the velocity at that pixel location. An image of the displaced pixel distribution is formed by applying a bicubic interpolation. The new image with displaced features is referred to as “Block 2.”

The cross-correlation algorithm is applied to the images to estimate the displacement vector.

To make a better approximation of the displacement vector, we move the “Block 2” according to the initial estimation of the displacement vector, and apply the cross-correlation algorithm again (multi-pass approach). In this case, we use a polynomial fit to estimate the subpixel fluctuation of the displacement vector.

Finally we add the initial estimate of the displacement vector and the subpixel fluctuation of the displacement vector to get the resultant displacement vector.

Why Use Synthetic Backscatter Images?
We cannot control the backscatter images generated by aerosols. Therefore, we used synthetic backscatter images; we call this method the multi-pass approach. In this method, we use a polynomial fit to estimate the subpixel fluctuation of the displacement vector.

To test the method, we used three different velocity fields: uniform, uniform with turbulent fluctuations, and divergent with turbulent fluctuations. The results show that the cross-correlation algorithm provides reliable displacement vectors if the flow is uniform. However, because the cross-correlation algorithm only results in one displacement vector for the entire block, information that could describe non-uniformity is not retrieved. As a result, this method cannot control the subpixel fluctuation of the displacement vector.

Conclusion

The results show that the cross-correlation algorithm provides reliable displacement vectors if the flow is uniform. However, because the cross-correlation algorithm only results in one displacement vector for the entire block, information that could describe non-uniformity is not retrieved. As a result, ambiguity increases, and the performance of the cross-correlation algorithm decreases as non-uniformity of the flow fields increases.

References


"This work was supported by NSF AGS 1228464."