Comments on "Landsat-7 Reveals More Than Just Surface Features in Remote Areas of the Globe"

The cover the May 2000 *Bulletin of the American Meteorological Society* (DeFelice et al. 2000) interested me because I published the first description and study of island-generated von Karman vortex streets in the 1960s (see Hubert and Krueger 1962; Chopra and Hubert 1965). The eddies I studied were generated by the Canary Islands just west of Africa.

I offer the following with the hope it will assist the authors in their further study.

While such vortex streets are "rarely observed" (DeFelice et al. 2000), they are common in the regions where the necessary conditions are prevalent. The necessary conditions are (i) a strong, low-lying inversion that enforces horizontal (two-dimensional) air motion on the scale involved here; and (ii) an obstacle that extends through the entire stratum of the air involved. A smooth surface—little roughness turbulence—is probably also a requirement, to ensure laminar flow.

These conditions exist most of the time in the eastern-equatorward limb of oceanic anticyclones where strong, low-level subsidence inversions are common. Then all we need is a tall island, and enough wind to supply the energy!

Low-level inversions also exist when cold continental air flows over warm oceans. The Japanese geostationary satellite pictured such vortices downwind from an island off the Asiatic coast during a strong polar outbreak.

Scale is probably critical: the obstacle's horizontal size must be large relative to fluid depth, and those dimensions, in turn, must be large relative to the small-scale turbulence. Small-scale turbulence plays the role of viscosity in the atmosphere vis a vis molecular viscosity in the laboratory.

Eddy viscosity is variable and difficult to estimate—a sticky problem in applying fluid theory to the atmosphere. Its poorly known value is probably the basis of the differences between laboratory and atmospheric Karman vortices (e.g., h/l ratio, Reynolds numbers, etc.).

Now, a note of dissent. I cannot accept the authors' conjecture that the cloud-free centers of the vortices on the right are caused by an effect quite different from that on the left!

The pictures show identical cloud-free centers on both sides, so it is more logical to attribute the effect to a common mechanism. While downward motion is consistent with clearing, the authors' "explanation" of clearing in the ascending centers is, in my opinion, bizarre.

A more logical hypothesis calls for descending motion at the center of all vortices. Perhaps centripetal acceleration in each vortex produces horizontal divergence at cloud level that "pulls down" drier air from the inversion strata. Such a hypothesis is also consistent with the downstream disappearance of clear centers: as vortex circulation weakens, the clear centers disappear. The atmosphere above the inversion is very dry; consequently, it would require very little mixing with the stratus clouds to evaporate them. I suspect vertical mixing also accounts for clearing on the windward side of the island.

References

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Reply

We appreciate our colleague's interesting comment (Hubert 2001) on the Alejandro Selkirk vortex scene from *Landsat-7*. Our discussion of the flow pattern employed larger-scale principles that do not readily transfer to the scale of the individual vortices as implied in our oversimplified discussion. It is very likely that the vortices are responsible for creating their cloud-free centers as suggested. But do we have the wind force balance present to support this hypothesis? Clearly the vortices are not in equilibrium. It is also possible that the clear centers are caused by the momentum creating the vortices, which encircle the clear air around the island. So, to explain the vortex centers, one just needs to explain why the island is (at least partially) clear.

However, we concede to the reality that a fully satisfactory explanation of this flow may not exist until the local winds, water vapor, and temperature fields are known. How local temperature and/or pressure gradients impact the cloudiness and clearness over the island requires a good 3D model of the island. Local measurements of temperature, pressure, wind field, water vapor, and cloud liquid are needed to verify such a model.

We initiate the data gathering effort with the QuikSCAT-retrieved general wind field for the vortex street area (Fig. 1). The QuikSCAT winds are anticyclonic and are given on a much larger scale than the individual vortices. The usual subtropical oceanic high-pressure center occurs west of the island. Figure 1 indicates that the general wind field curves slightly leftward, toward the oceanic high pressure, as does the overall vortex street direction (as "seen" by Landsat sensors), thus confirming general knowledge that the Coriolis force is important on the much larger scale of the whole vortex street, though saying nothing about its importance in the individual vortex spins.

We would also like to note that Jensen and Agee (1978) provide additional insights, as well as some others who have studied this phenomenon since 1978.

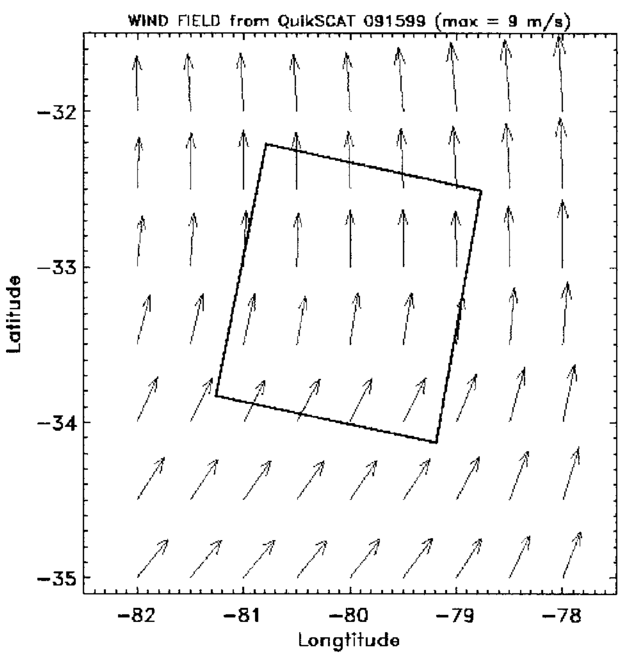

FIG. 1. QuikSCAT wind field for 15 Sep 1999 for the vicinity of the Alejandro Selkirk Karman vortex street. The box represents the area covered by the original *Landsat-7* 185 × 185 km scene. The vortex lies within the leftmost portion of the rectangle with the island situated at −33.75° lat, −80.75° long.

References

Hubert, L. F., 2001: Comments on "Landsat-7 Reveals More Than Just Surface Features in Remote Areas of the Globe." *Bull. Amer. Meteor. Soc.*, **82,** 313.

Jenson, N. E., and E. M. Agee, 1978: Vortex cloud street during AMTEX 75. *Tellus*, **30,** 517–523.

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