

TOPIC

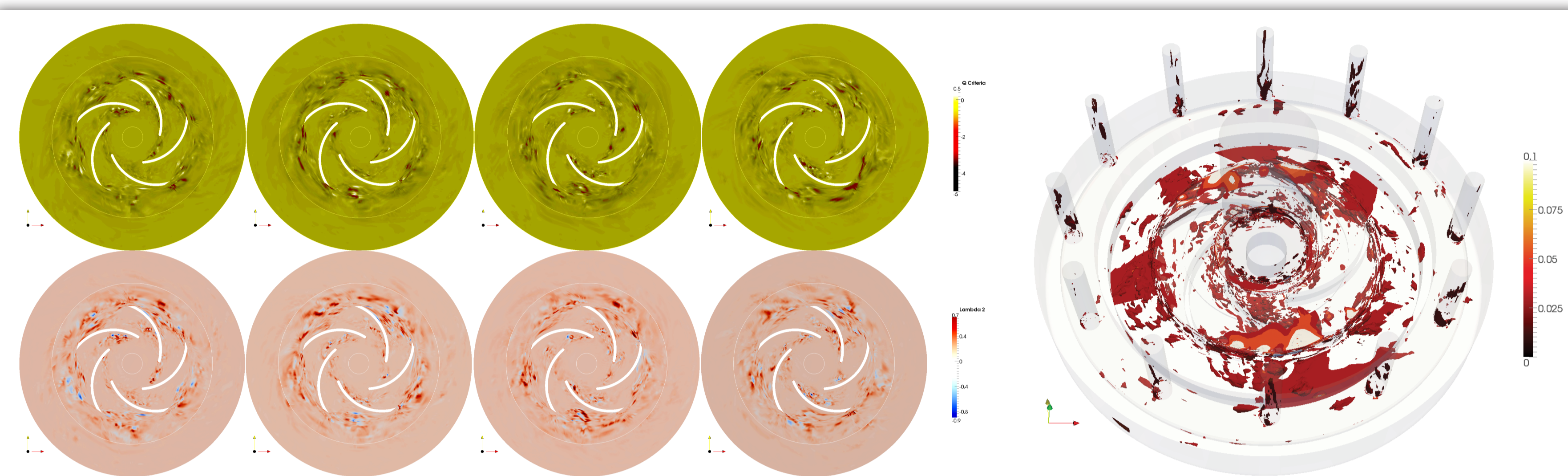
We present our results analyzing a centrifugal pump as a part of the IEEE Visualization Contest 2011. The given data set represents a high resolution simulation of a centrifugal pump operating below optimal speed settings. Our goal is to find suitable visualization techniques to identify areas of recirculation that impede the effectiveness of the pump in practical application. We split our analysis into three parts based on the

functional behavior of the pump and applied a set of local and integration based techniques to communicate flow transport in different regions of the data set. Based on this we will present a direct comparison of a set of common vortex extractors and more recent approaches and discuss their applicability. Further, we will show that integration based methods are well suited to capture the complex time-dependent behavior of the flow within the given time interval.

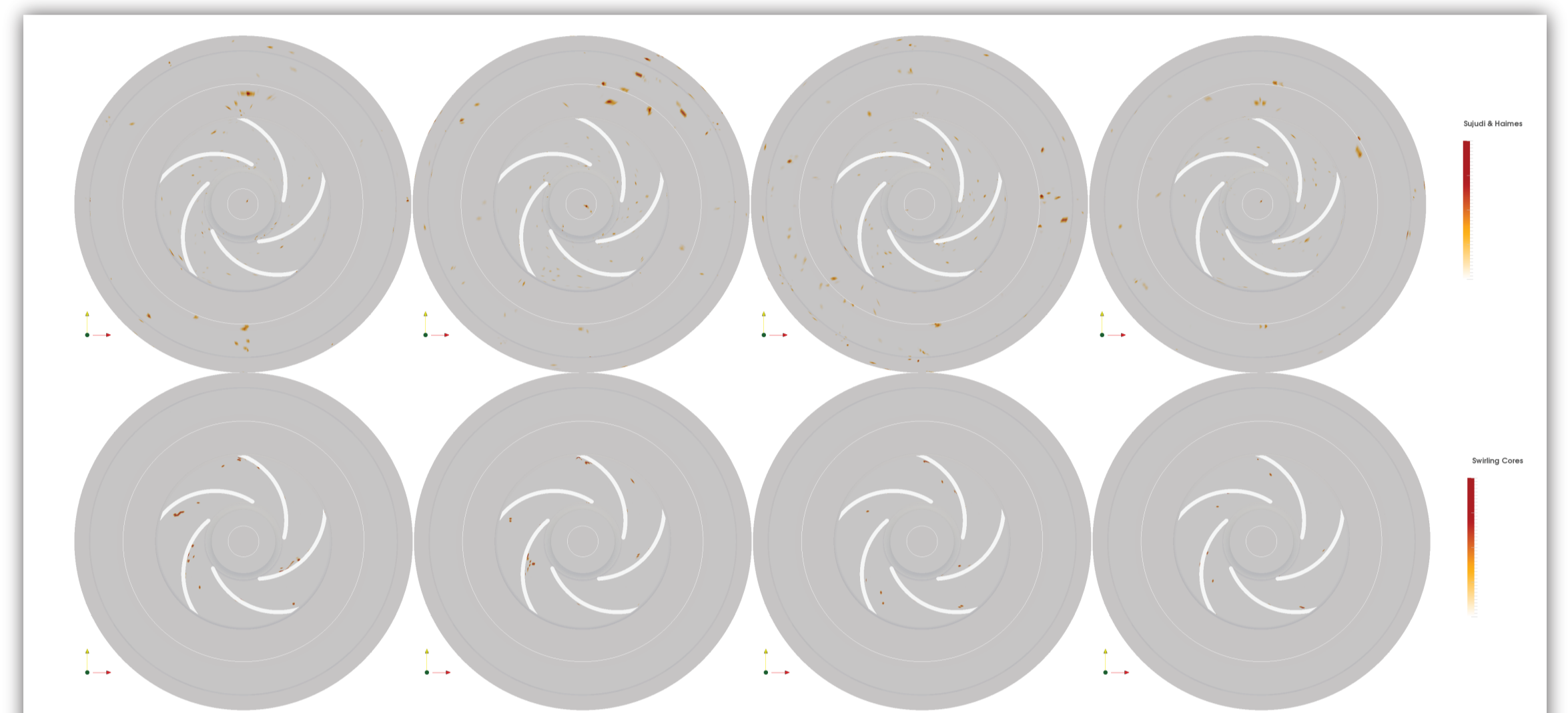


Geometry of the centrifugal pump and flow directions

LOCAL METHODS

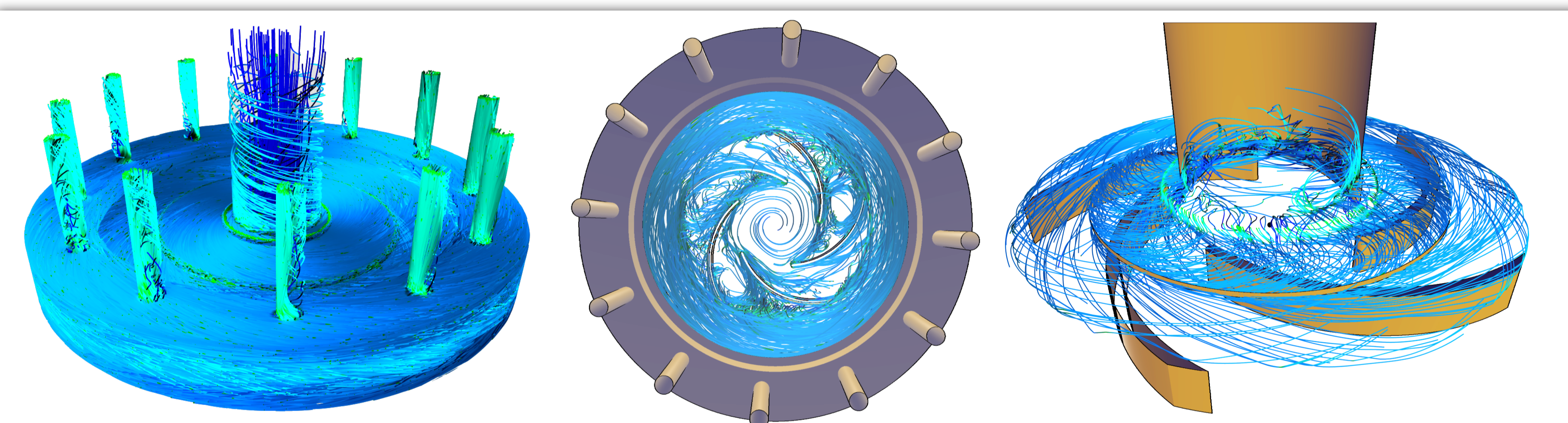


Region-based vortex detectors: Level sets of the Q criterion and the λ_2 criterion represent the hull of vortical structures. Both techniques are Galilean invariant.

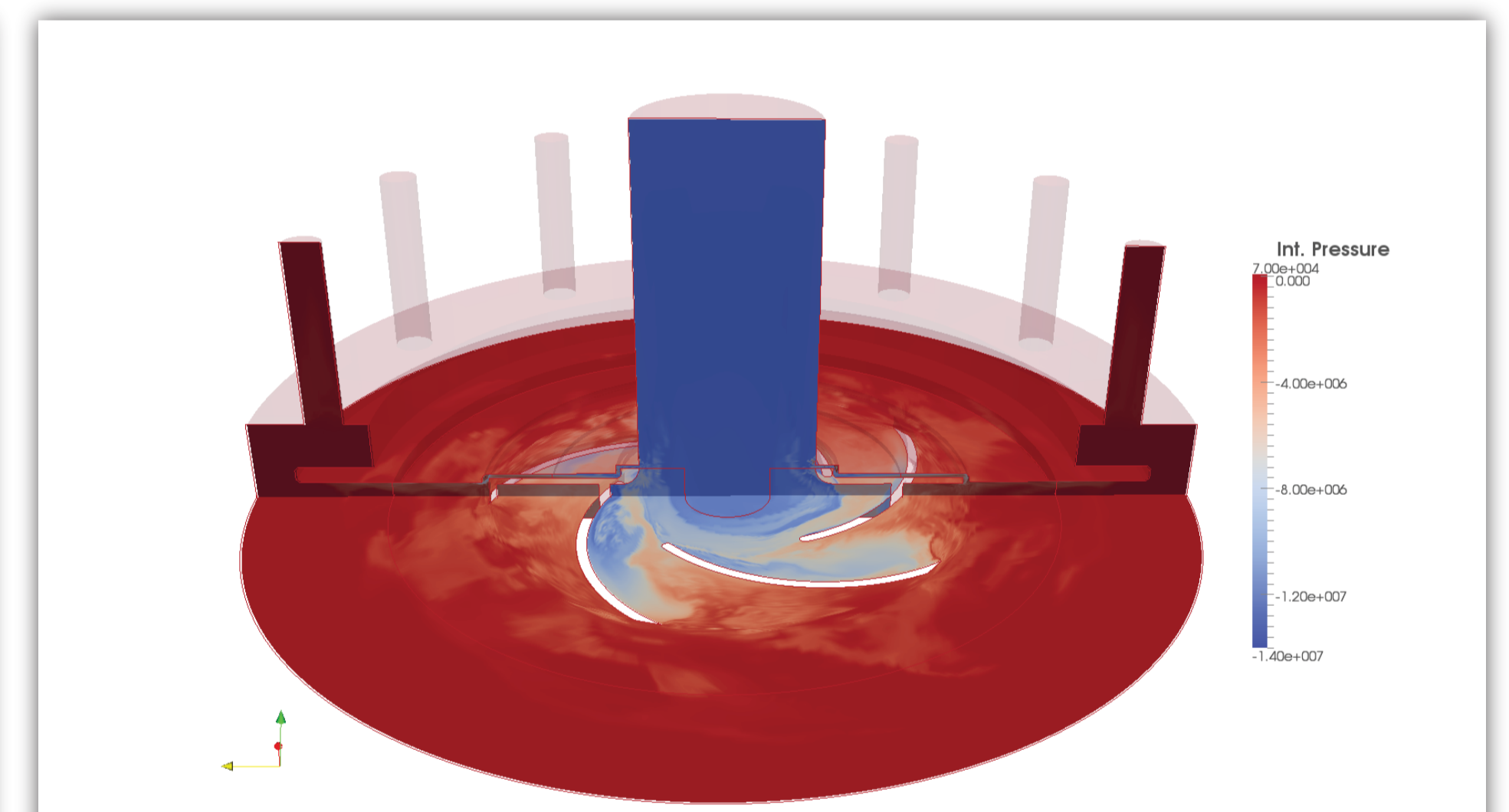


Vortex core detectors: The method by Sujudi and Haines and the cores of swirling particle motion extract vortex centers.

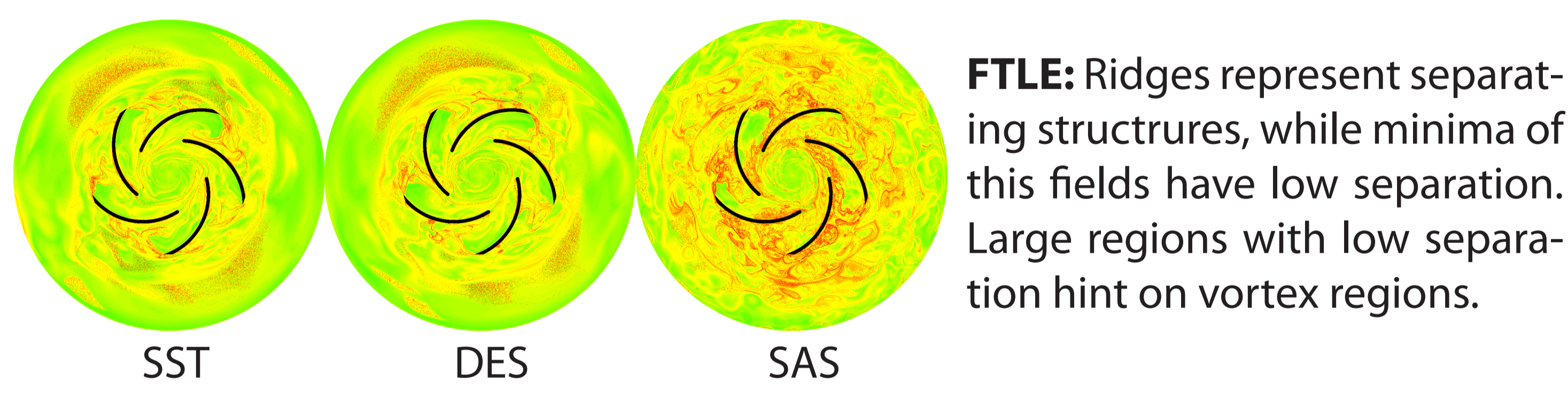
GLOBAL METHODS



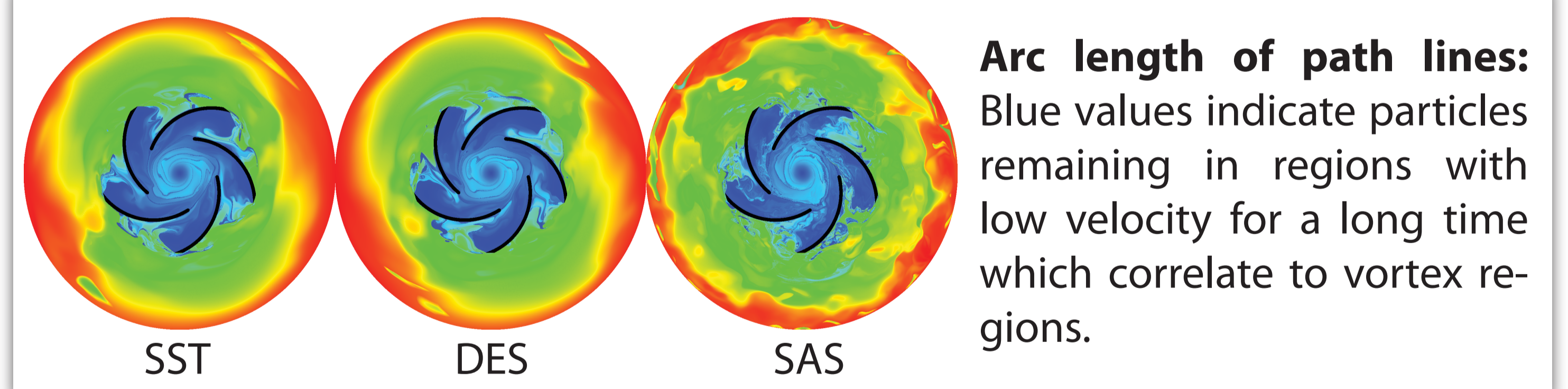
Path lines track particle movements over the complete given time interval color coded by the z-direction. Dark blue represents downward and light blue upward particle motion.



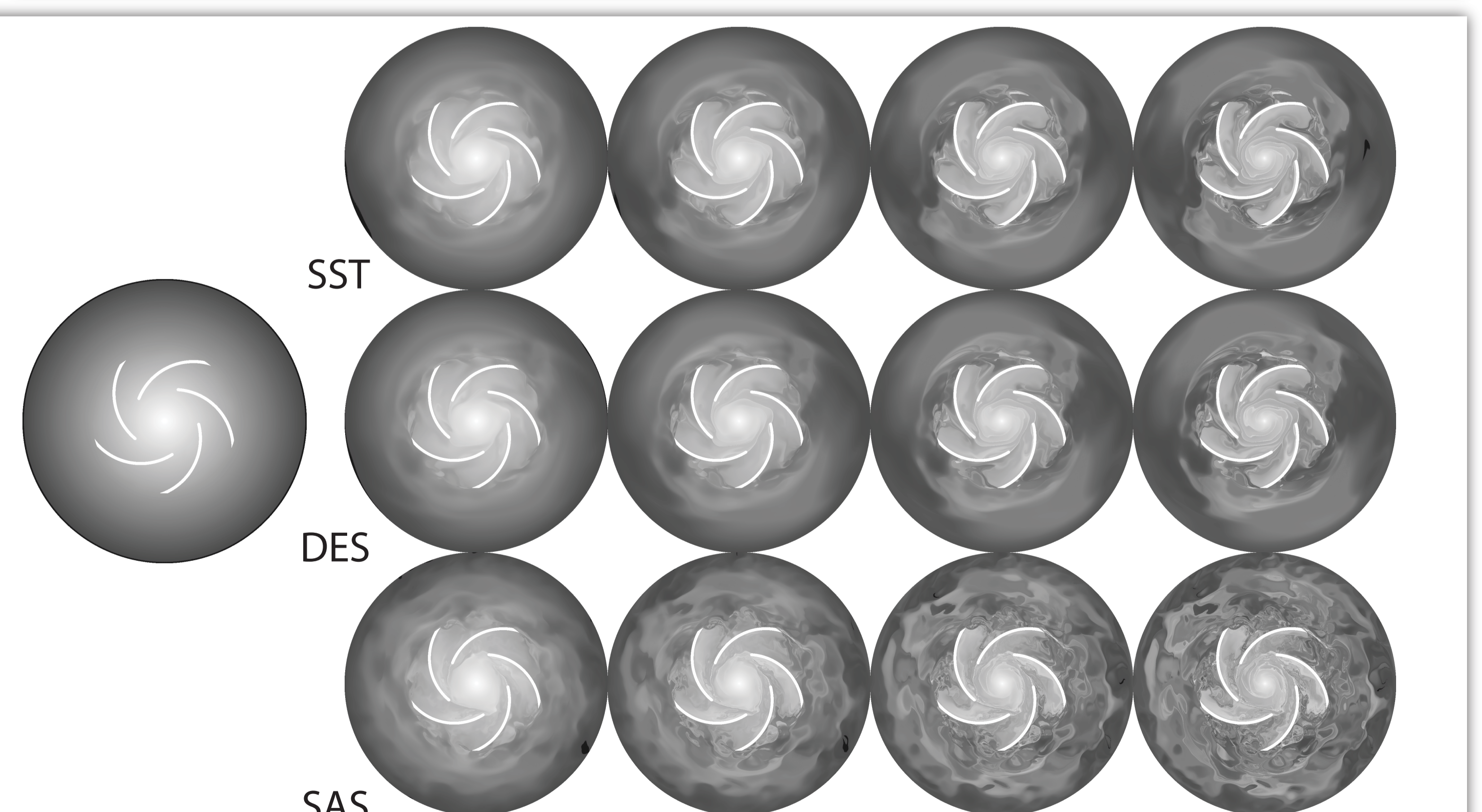
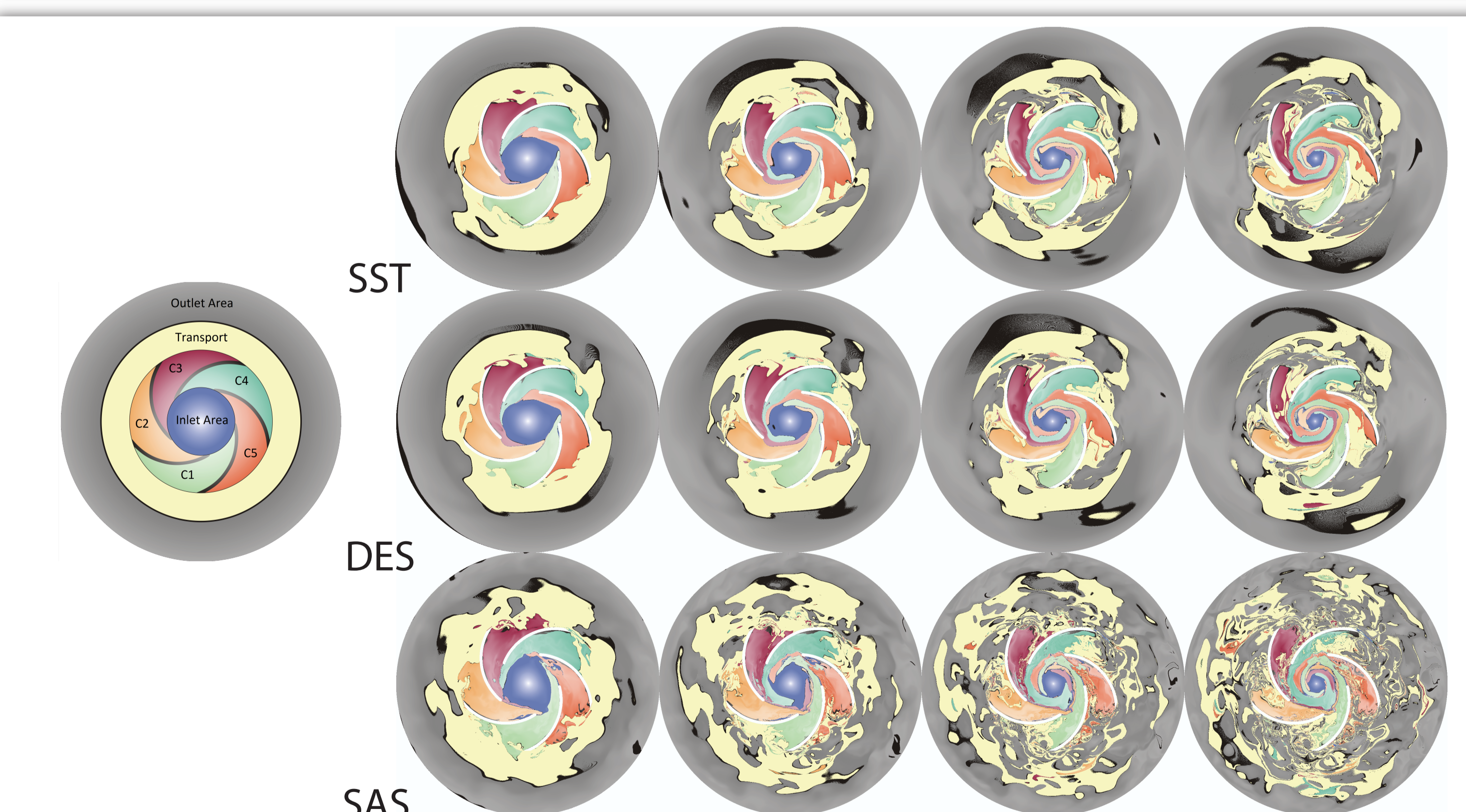
Integrated pressure on path lines: Minima of this field indicate vortex regions.



FTLE: Ridges represent separating structures, while minima of this fields have low separation. Large regions with low separation hint on vortex regions.



Arc length of path lines: Blue values indicate particles remaining in regions with low velocity for a long time which correlate to vortex regions.



Texture Advection: Path lines are used to lookup color information in the reference texture. This captures the transport behavior inside the channel regions.