

Figure D.6: Distributions of the vertical velocity fluctuations ( $v'/\overline{U}_{tot}$ ) inside the surface film for impingement of a spray, generated by the ultrasonic US10 (a-d) and US20 (e-f) nozzles, without carrier gas, for two different volume flows of 150 mL/min and 200 mL/min at the axial positions  $z = 48.8$  mm (left) and  $z = 110$  mm (right) for US10 and at  $z = 61.3$  mm (left) and  $z = 122.5$  mm (right) for US20

## D.3 Radial distributions of Reynolds tensions

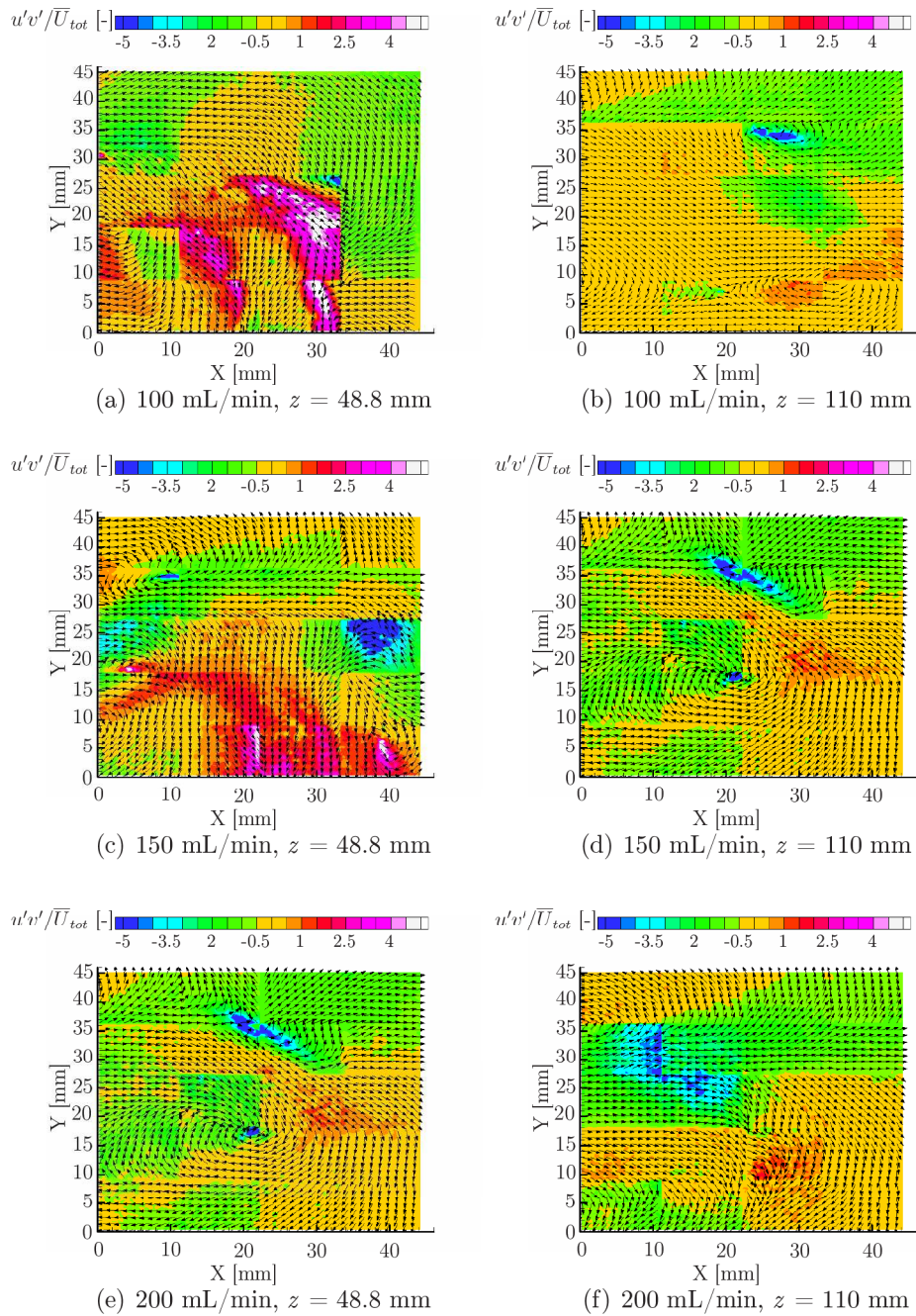


Figure D.7: Distributions of the Reynolds tensions ( $u'v'/\overline{U}_{tot}$ ) inside the surface film for impingement of a spray, generated by the ultrasonic US10 nozzle, applied with pressurized air at 0.604 bar, for different volume flows between 100 mL/min and 200 mL/min at the axial positions  $z = 48.8$  mm (left) and  $z = 110$  mm (right)

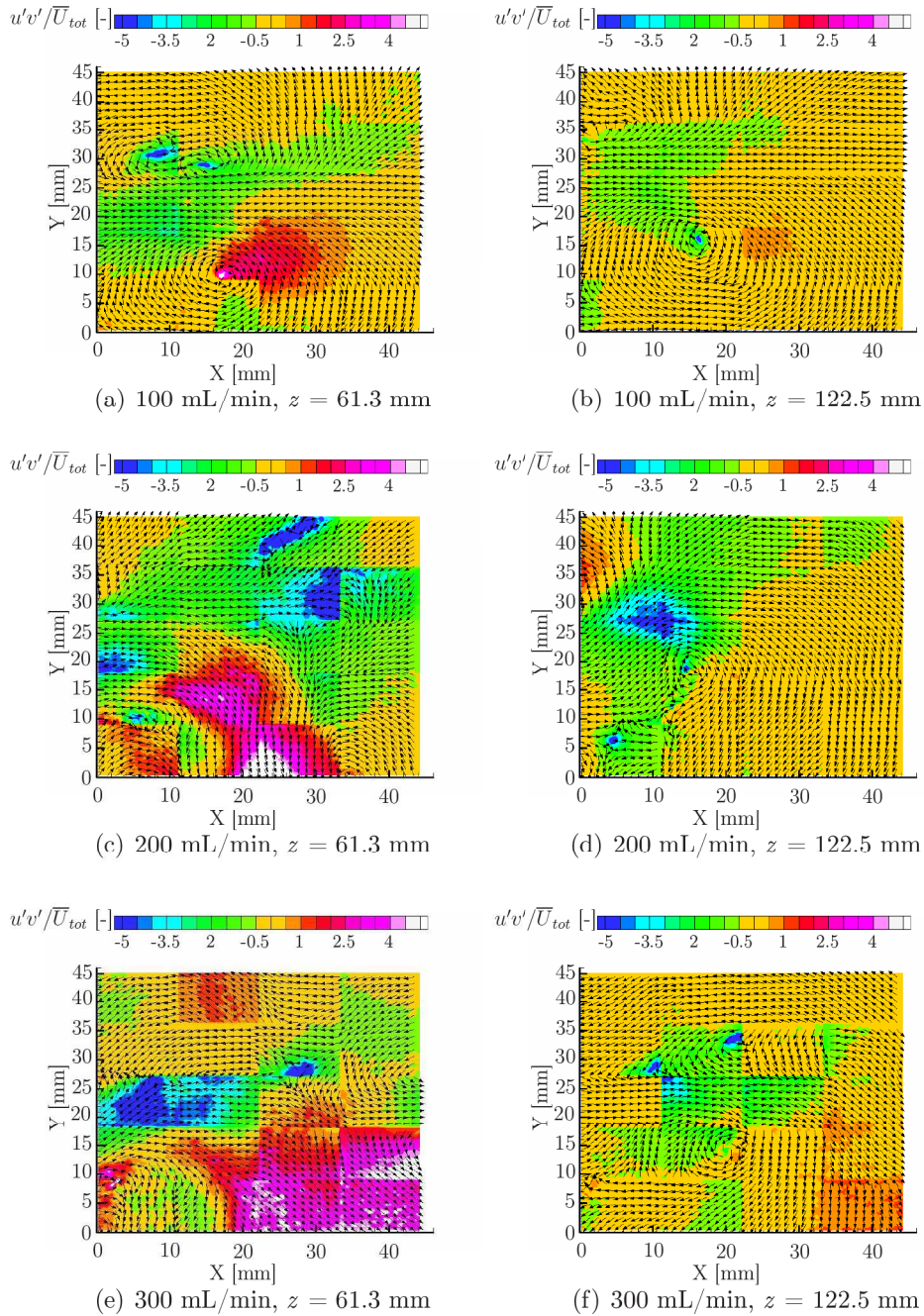


Figure D.8: Distributions of the Reynolds tensions ( $u'v'/\overline{U}_{tot}$ ) inside the surface film for impingement of a spray, generated by the ultrasonic US20 nozzle, applied with pressurized air at 0.604 bar, for different volume flows between 100 mL/min and 300 mL/min at the axial positions  $z = 61.3$  mm (left) and  $z = 122.5$  mm (right)

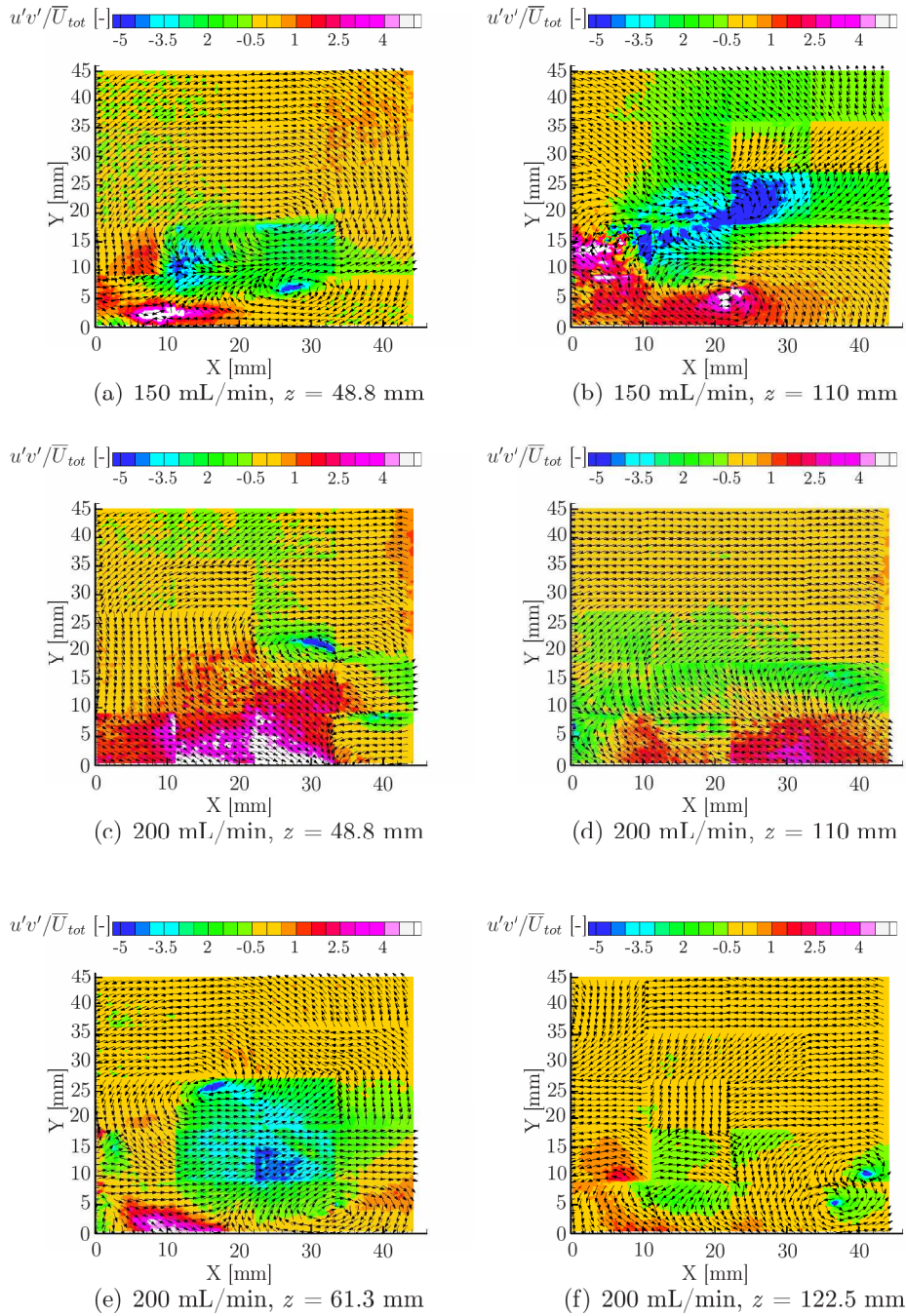


Figure D.9: Distributions of the Reynolds tensions ( $u'v'/\bar{U}_{tot}$ ) inside the surface film for impingement of a spray, generated by the ultrasonic US10 (a-d) and US20 (e-f) nozzles, without carrier gas, for two different volume flows of 150 mL/min and 200 mL/min at the axial positions  $z = 48.8$  mm (left) and  $z = 110$  mm (right) for US10 and at  $z = 61.3$  mm (left) and  $z = 122.5$  mm (right) for US20

# Appendix E

## Validation of the velocity computation algorithm for PIV analysis

In this appendix the results are shown of the validation study for the velocity computation algorithm. This algorithm is part of the image processing toolbox, that calculates mean velocity distributions and its fluctuations at different depths inside the three-dimensional investigated volume out of tracer particle image recordings, as presented in §(8.3). The validation is done in such a way, that recordings of tracer particle images are generated synthetically in Matlab. These recordings represent a known uniform flow and it is checked whether the velocity computation algorithm calculates the exact same velocity field and how large the fluctuations in the flow, generated by the algorithm itself, are. Two different flows are investigated: a translational flow and a solid body rotational flow. Different seeding densities are investigated, to see the influence of the amount of tracer particles in the images.

### E.1 Mean and statistical velocity fields of a synthetical translational flow

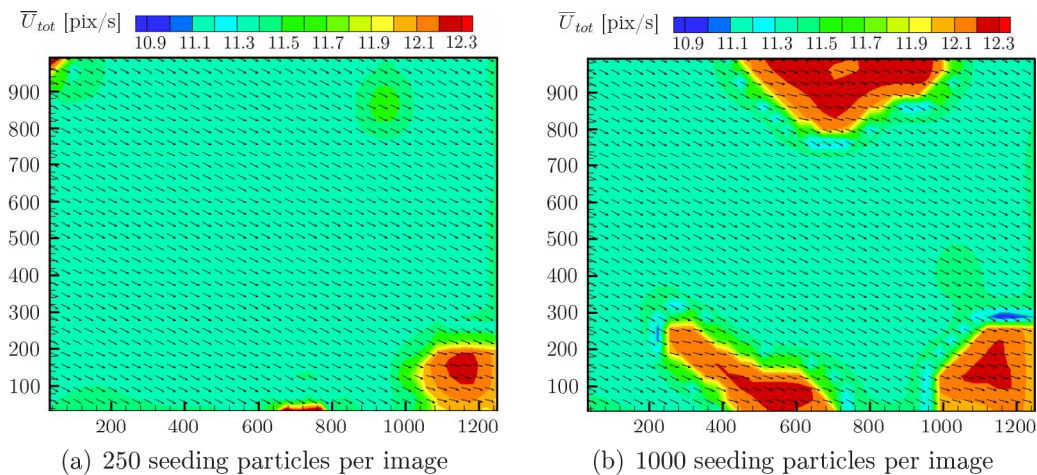


Figure E.1: Mean velocity field for a uniform translational input flow of  $\bar{U}_{tot} = \sqrt{125}$  for two different seeding densities of 250 and 1000 tracer particles per image

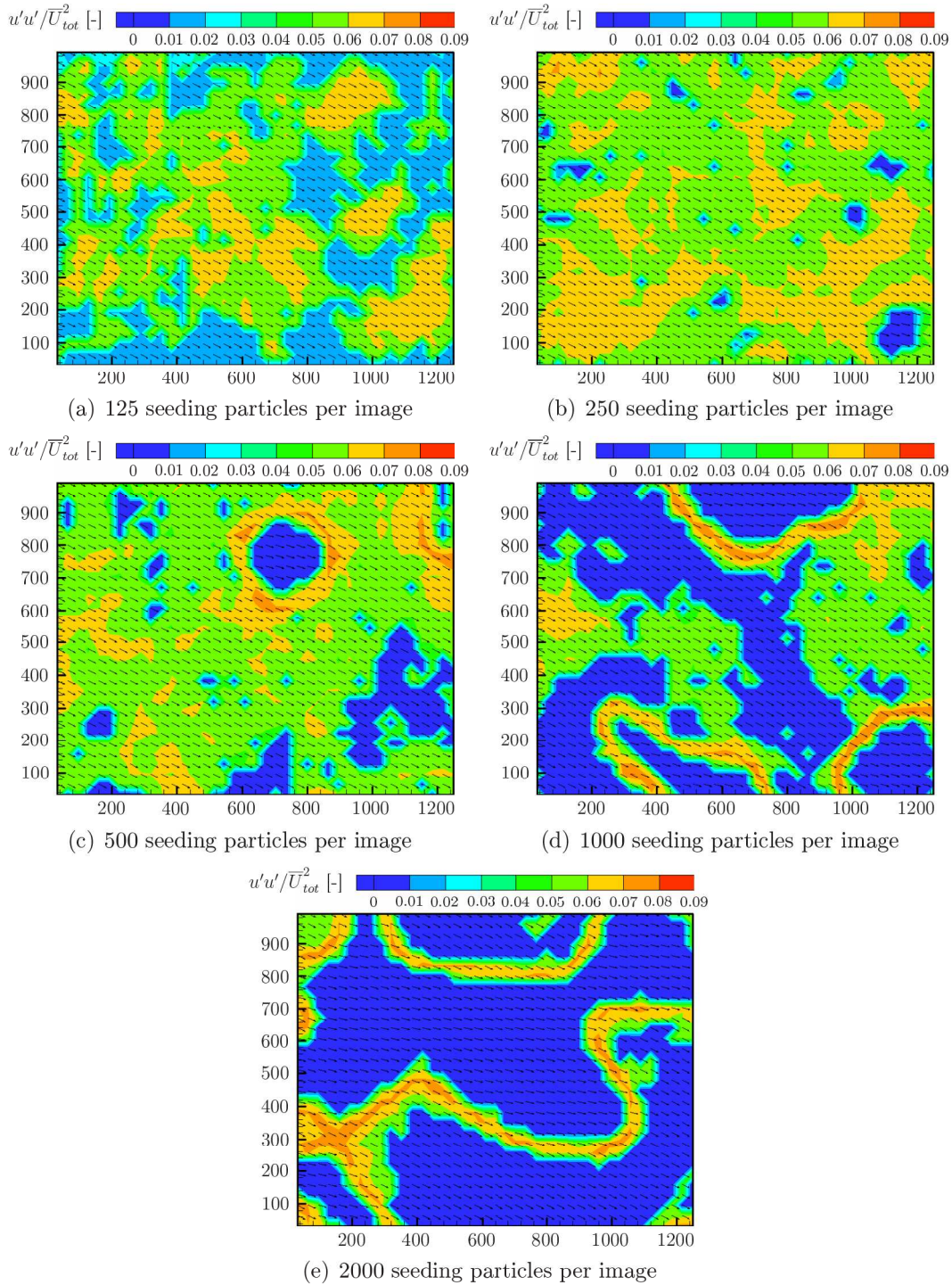


Figure E.2: Distributions of the horizontal velocity fluctuations ( $u'u'/\overline{U}_{tot}^2$ ) for a uniform translational input flow of  $\overline{U}_{tot} = \sqrt{125}$  for different seedings densities between 125 and 2000 tracer particles per image

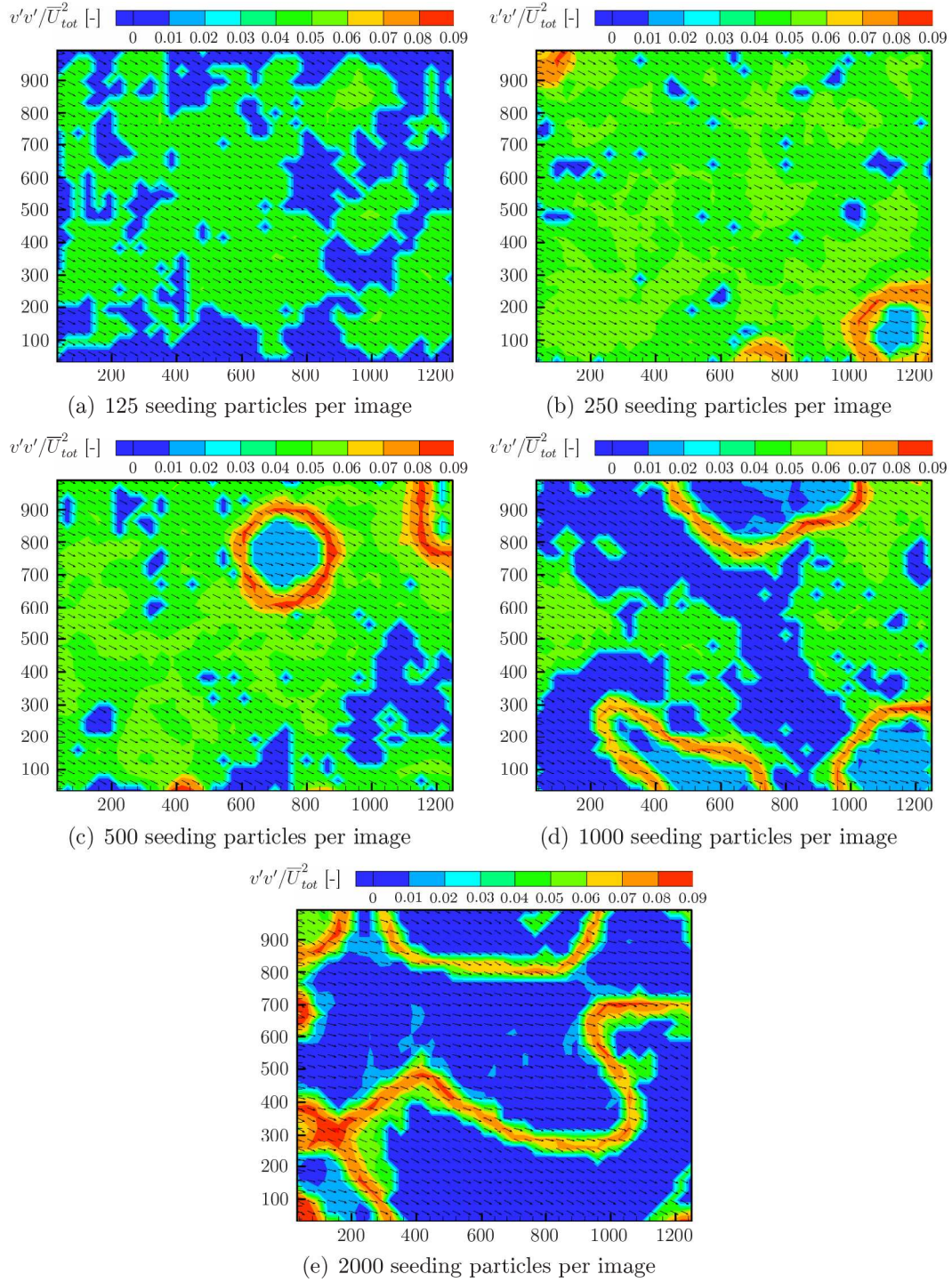


Figure E.3: Distributions of the vertical velocity fluctuations ( $v'v'/\overline{U}_{tot}^2$ ) for a uniform translational input flow of  $\overline{U}_{tot} = \sqrt{125}$  for different seedings densities between 125 and 2000 tracer particles per image

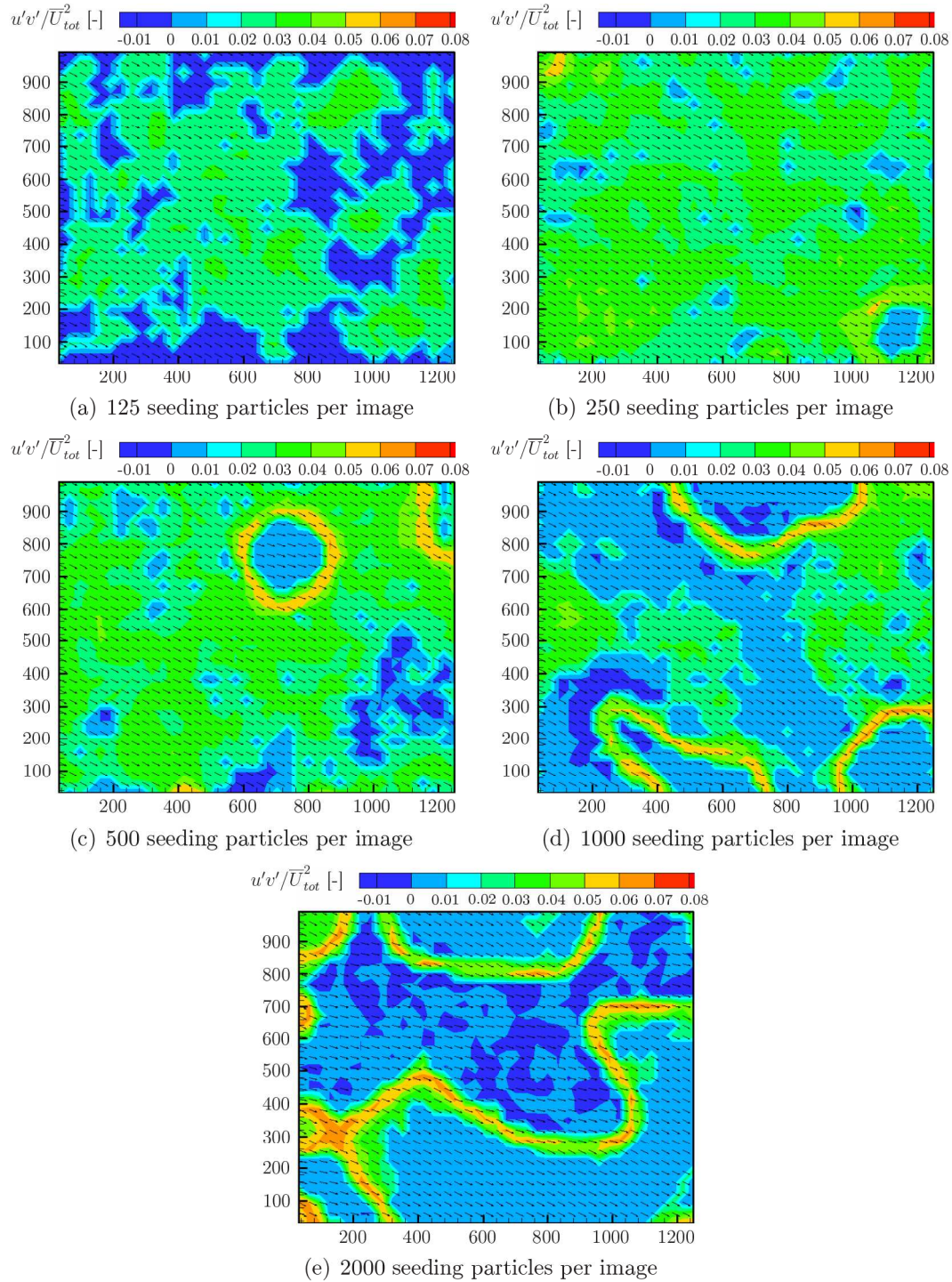


Figure E.4: Distributions of the Reynolds tensors ( $u'v'/\overline{U}_{tot}^2$ ) for a uniform translational input flow of  $\overline{U}_{tot} = \sqrt{125}$  for different seedings densities between 125 and 2000 tracer particles per image



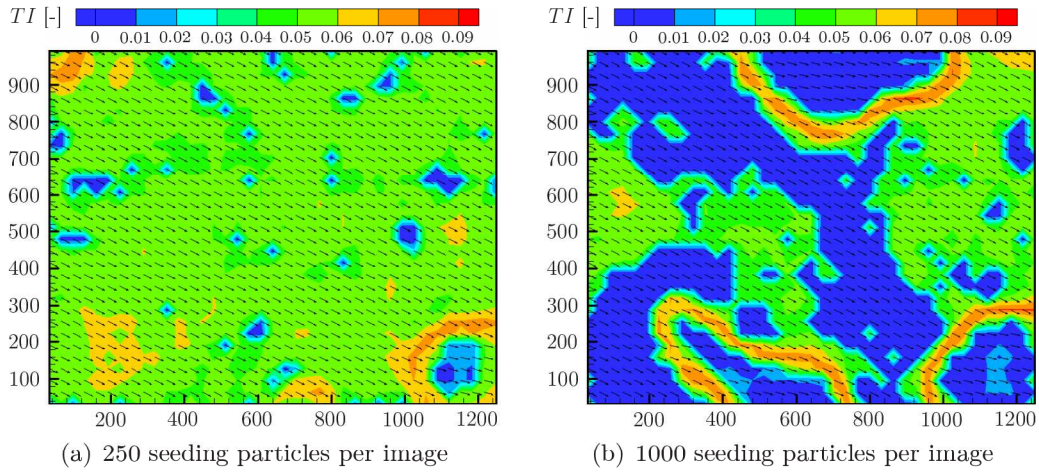


Figure E.5: Distributions of the turbulence intensity for a uniform translational flow of  $\bar{U}_{tot} = \sqrt{125}$  for two different seedings densities of 250 and 1000 tracer particles per image

## E.2 Mean and statistical velocity fields of a synthetical solid body rotational flow

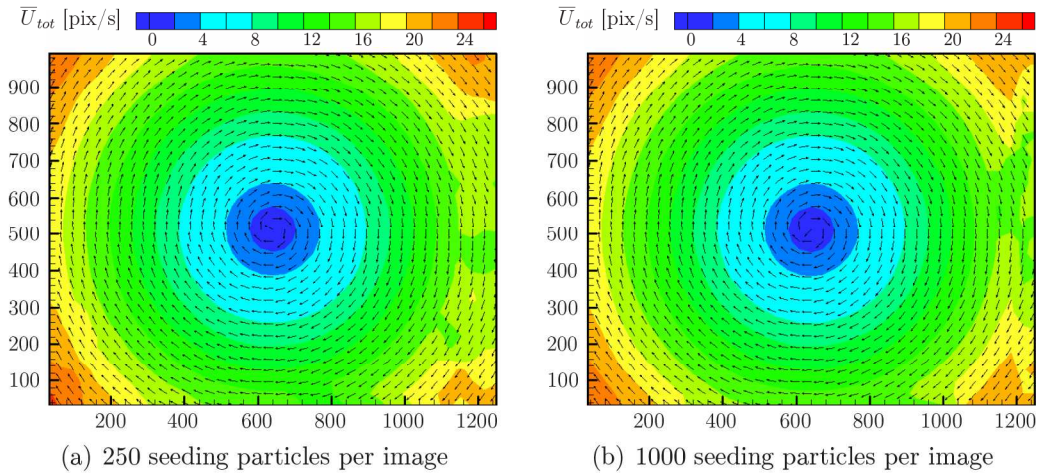


Figure E.6: Mean velocity field for a uniform solid body rotational flow input flow of  $\bar{U}_{tot} = 3.1416 \cdot 10^{-2}R$  for two different seedings densities of 250 and 1000 tracer particles per image

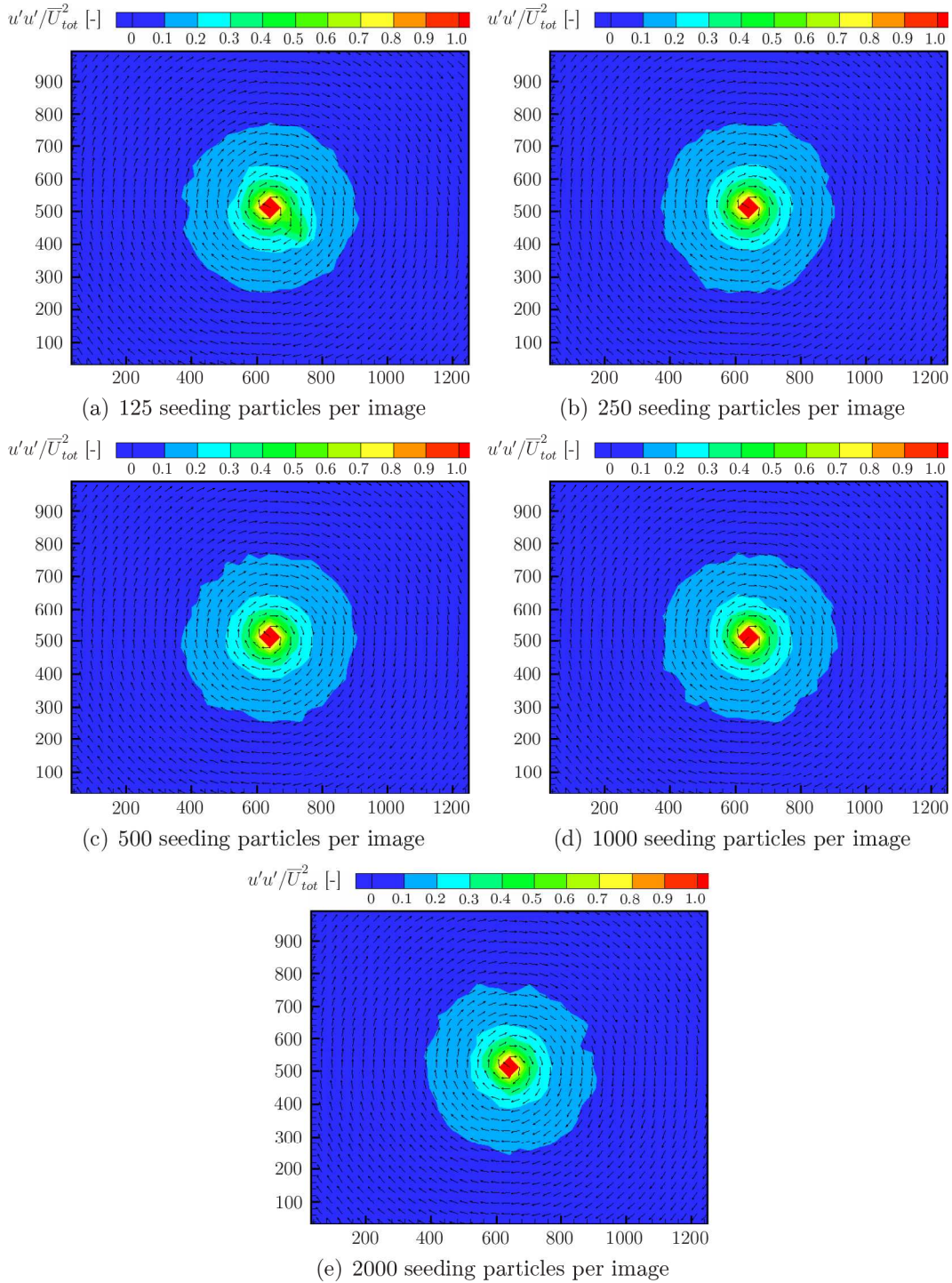


Figure E.7: Distributions of the horizontal velocity fluctuations ( $u'u'/\bar{U}_{tot}^2$ ) for a uniform solid body rotational flow of  $\bar{U}_{tot} = 3.1416 \cdot 10^{-2}R$  for different seedings densities between 125 and 2000 tracer particles per image

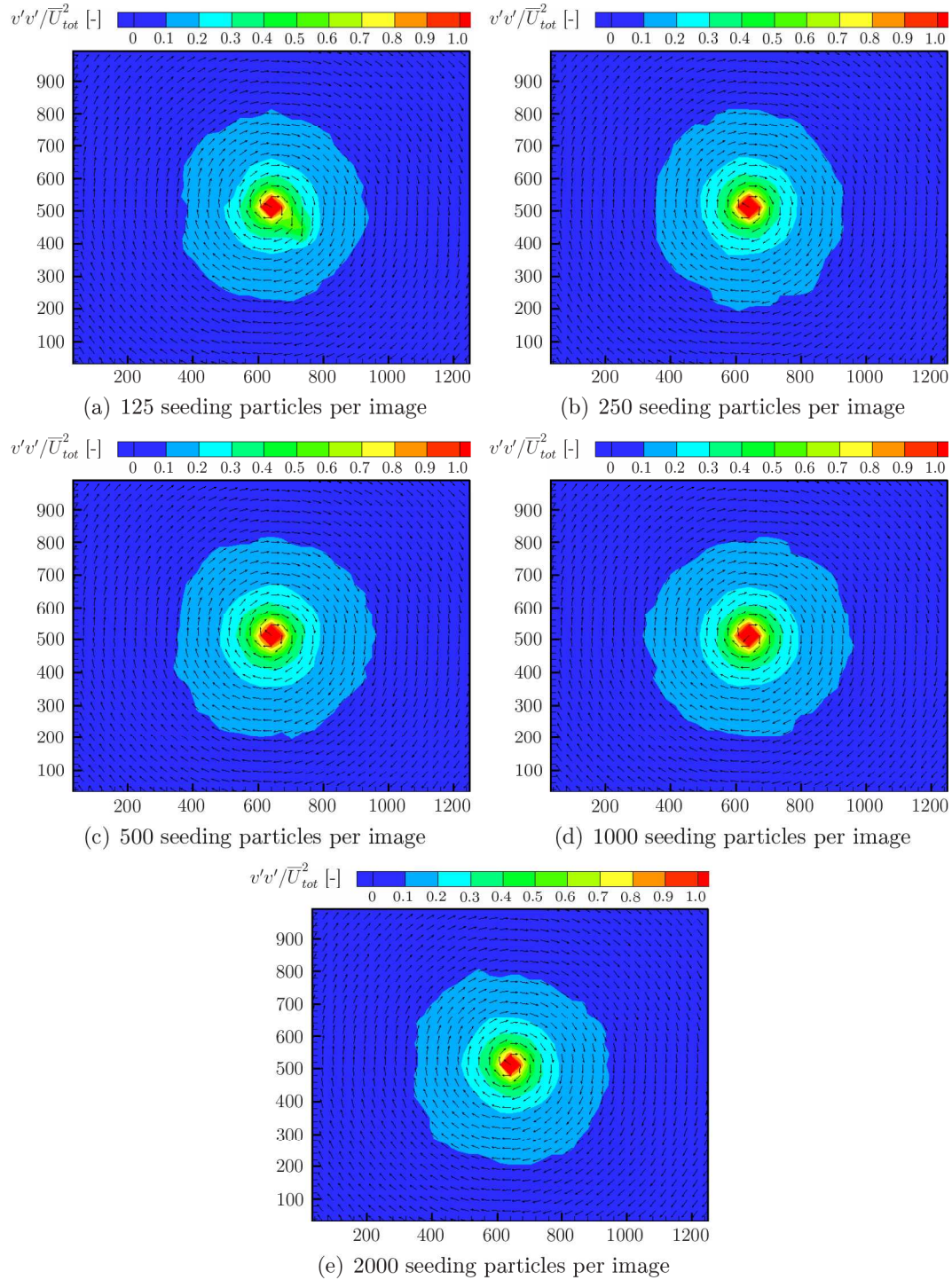


Figure E.8: Distributions of the vertical velocity fluctuations ( $v'v'/\bar{U}_{tot}^2$ ) for a uniform solid body rotational flow of  $\bar{U}_{tot} = 3.1416 \cdot 10^{-2}R$  for different seedings densities between 125 and 2000 tracer particles per image

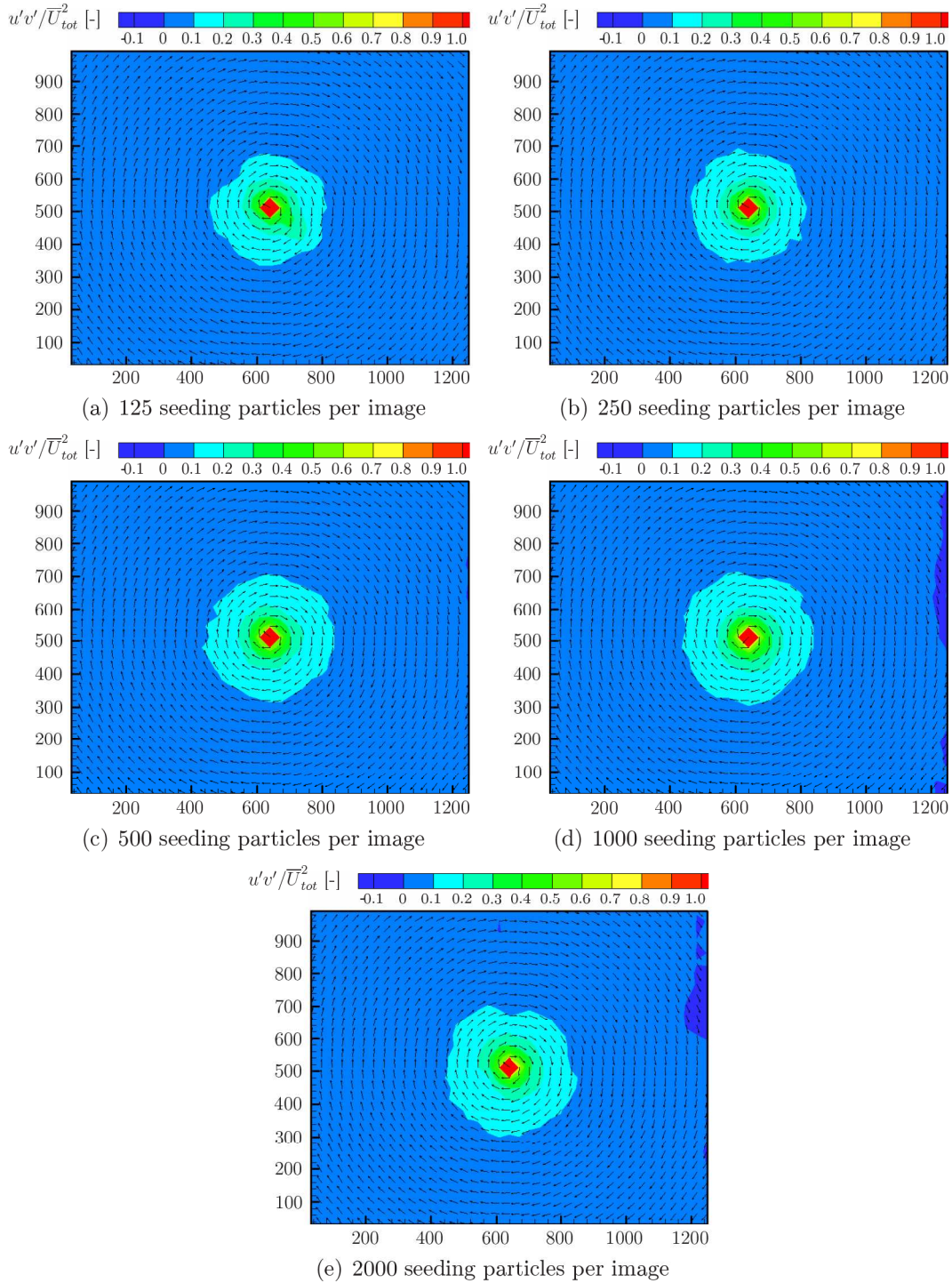


Figure E.9: Distributions of the Reynolds tensions ( $u'v'/\overline{U}_{tot}^2$ ) for a uniform solid body rotational flow of  $\overline{U}_{tot} = 3.1416 \cdot 10^{-2}R$  for different seedings densities between 125 and 2000 tracer particles per image

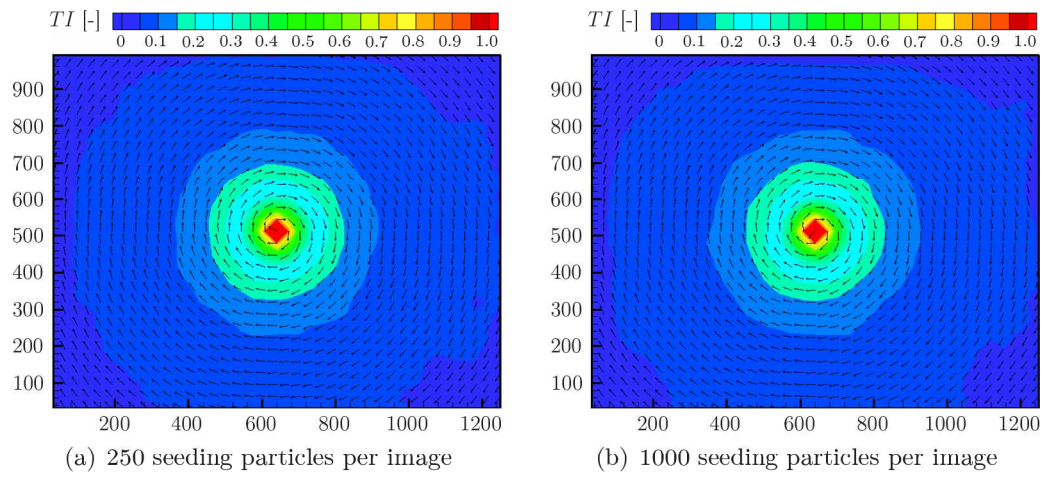


Figure E.10: Distributions of the turbulence intensity for a uniform solid body rotational flow of  $\bar{U}_{tot} = 3.1416 \cdot 10^{-2}R$  for two different seedings densities of 250 and 1000 tracer particles per image

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# Resume

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