Supplementary Material

1. Sensitivity analysis for the Total Grain Size Distribution (TGSD)

In this supplementary material we present the results of an analysis on the effects of the TGDS on lahar dynamics. We take as reference simulation one of the simulations used in the hazard study, for which the initial TGSD is defined as the linear combination of two Weibull distributions with a weight p=0.339. We then performed 5 simulations varying the weight *p* from 0 (resulting in the finest-grain size Weibull only) to 1 (resulting in the coarsest-grain size Weibull only). The different TGSDs are presented in Fig. SM1.

The corresponding simulated results are given in the following figures:

- deposit thickness after 24 hours from the flow onset in Fig. SM2;
- maximum flow thickness during 24 hours from the flow onset in Fig. SM3;
- maximum dynamic pressure with a flow thickness of at least 0.1m during 24 hours from the flow onset in Fig. SM4;
- maximum dynamic pressure with a flow thickness of at least 0.5 m during 24 hours from the flow onset in Fig. SM5;
- maximum dynamic pressure with a flow thickness of at least 1m during 24 hours from the flow onset in Fig. SM6.

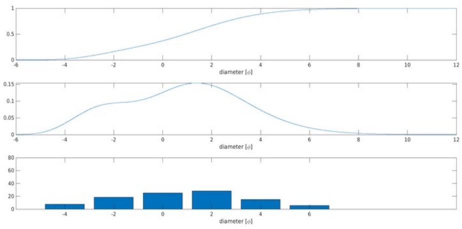
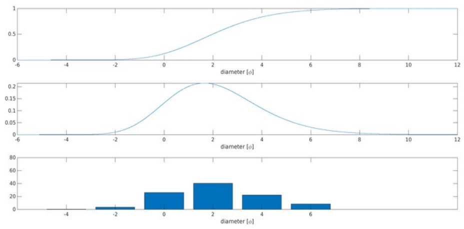
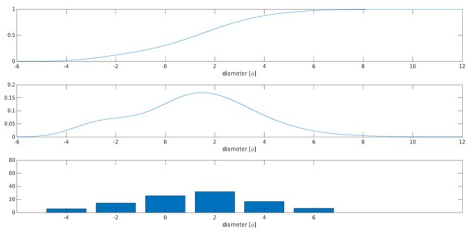
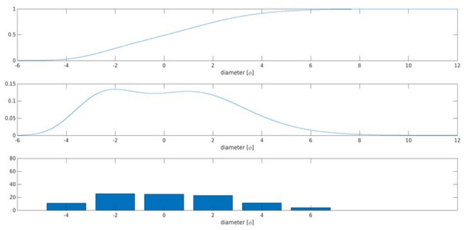
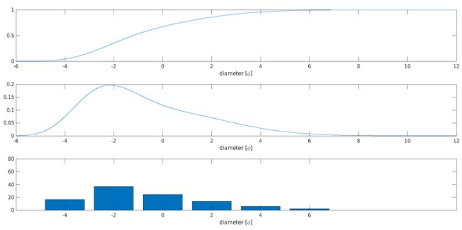
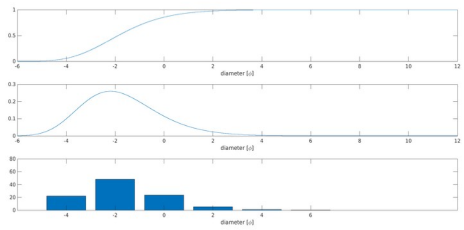
p=0.339 	p=0.0 
p=0.25 	p=0.5 
p=0.75 	p=1.0 

Figure SM1. TGSDs investigated: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

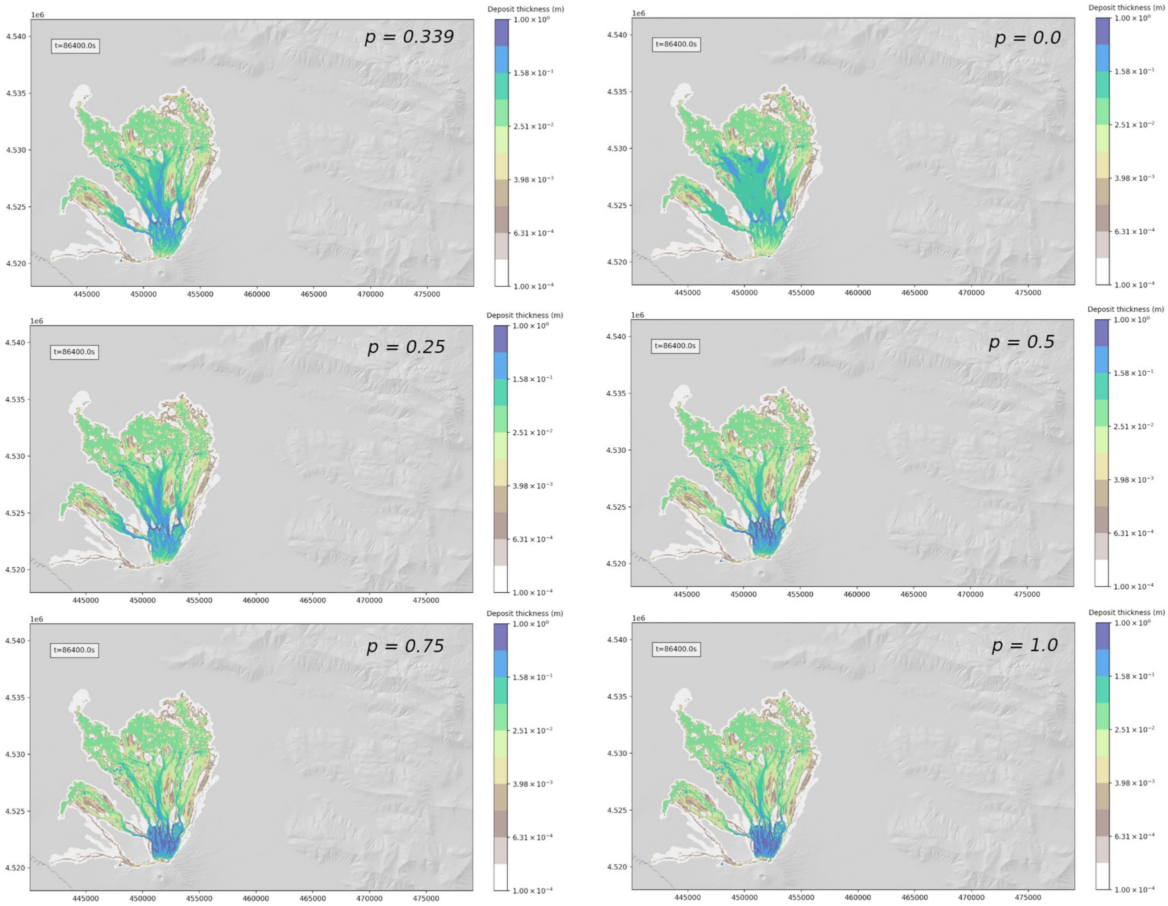


Figure SM2. Flow thickness 24h from the mobilization of the lahar for: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

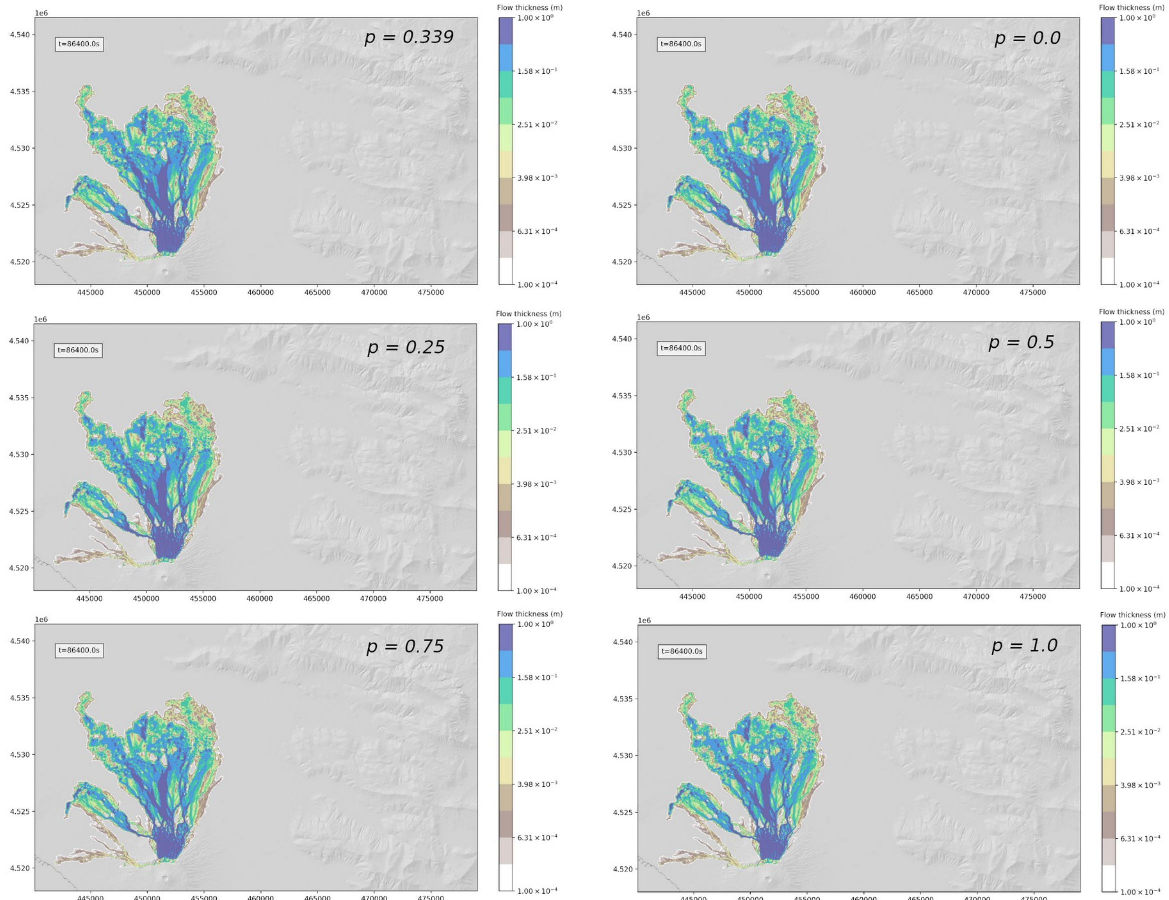


Figure SM3. Maximum flow thickness during 24h from the mobilization of the lahar for: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

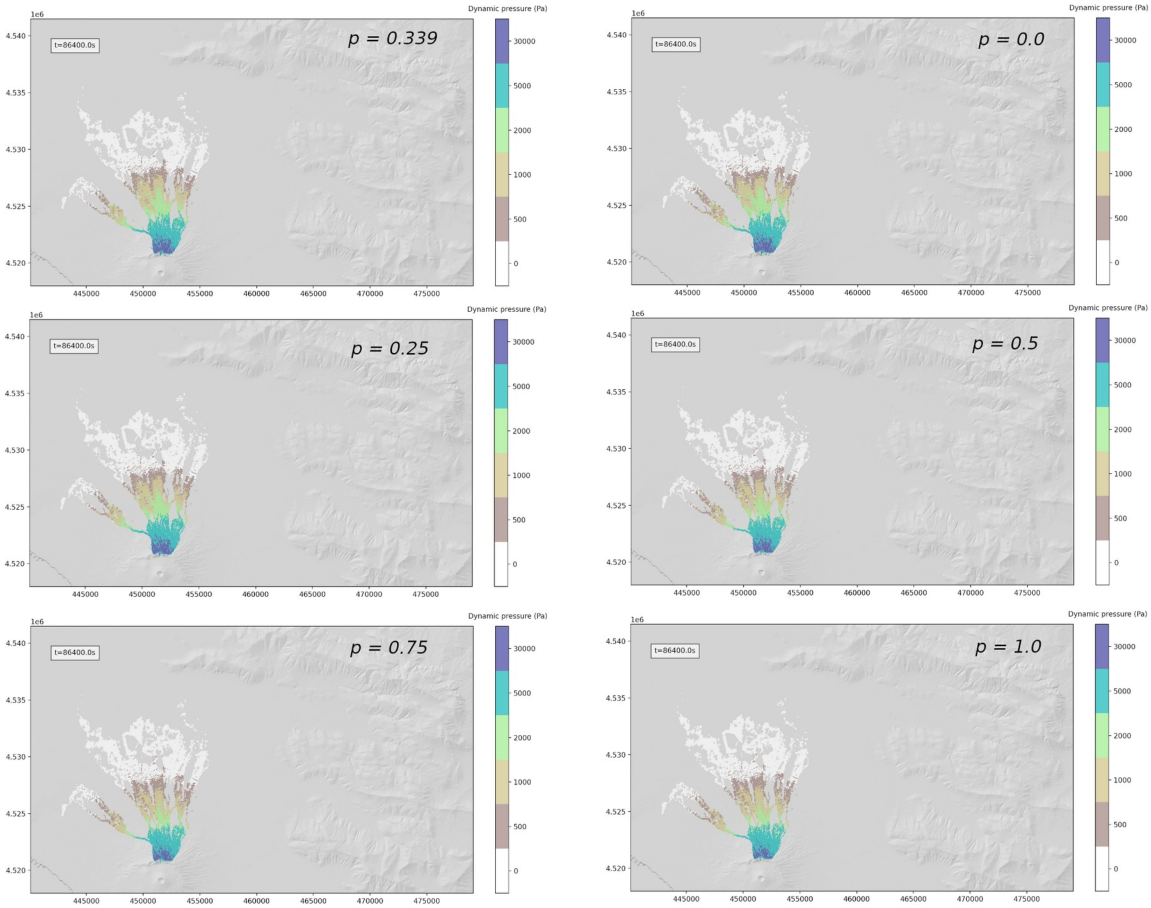


Figure SM4. Maximum dynamic pressure reached, in each pixel, with a flow thickness of at least 0.1m, for: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

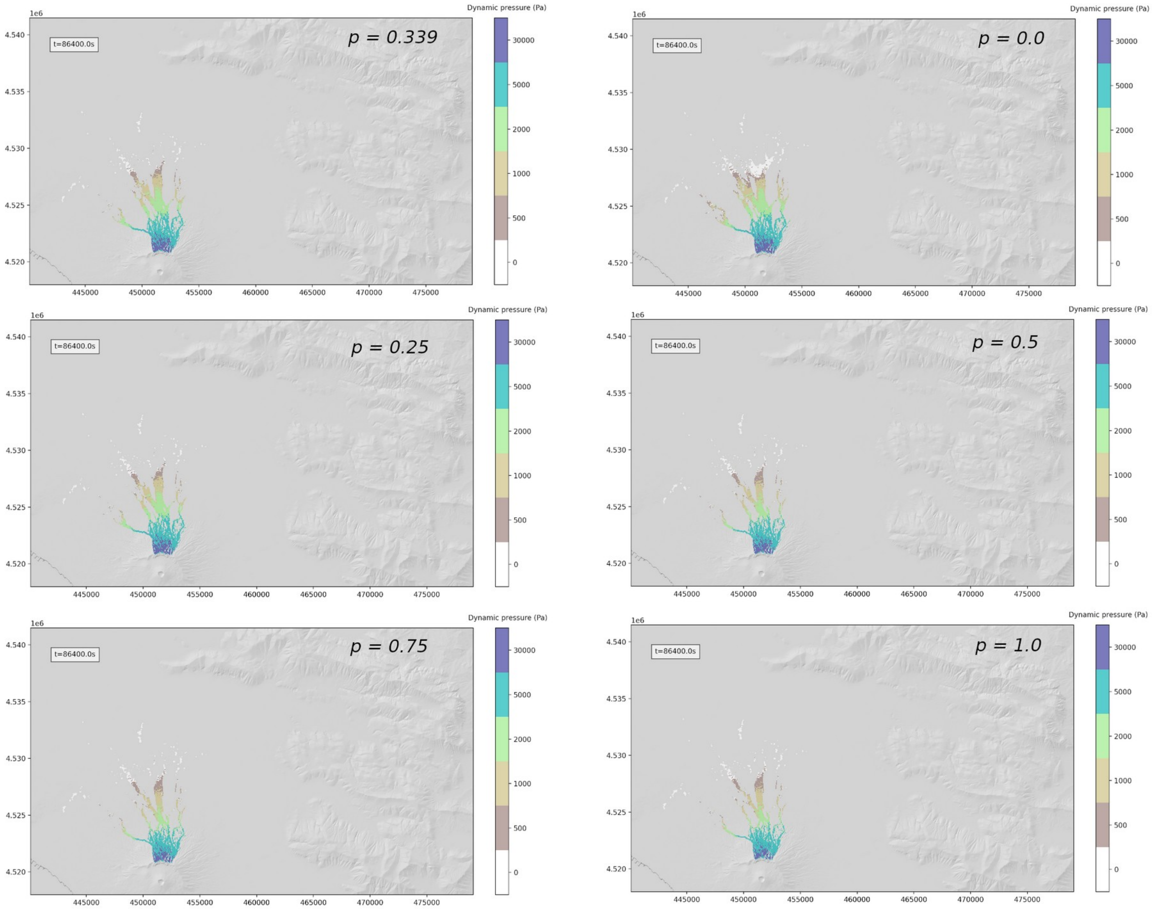


Figure SM5. Maximum dynamic pressure reached, in each pixel, with a flow thickness of at least 0.5m, for: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

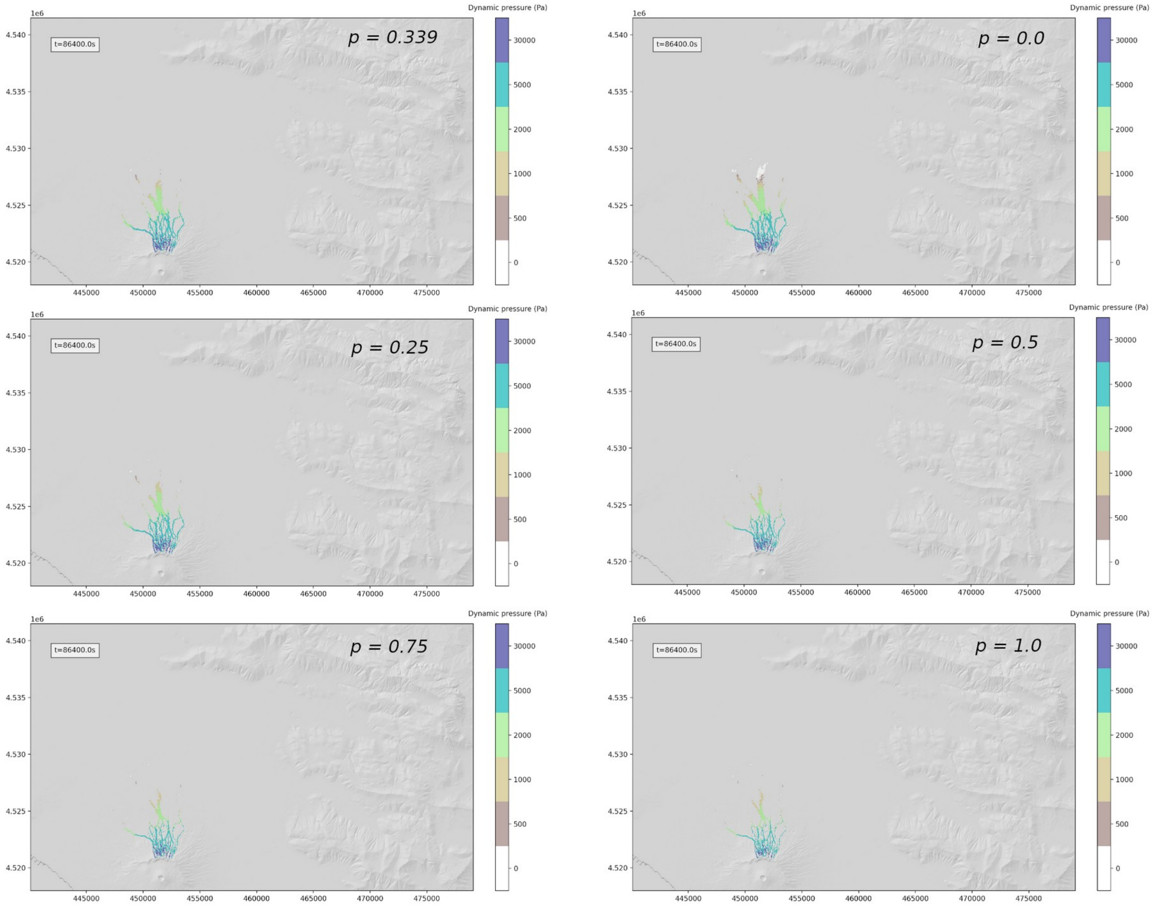


Figure SM6. Maximum dynamic pressure reached, in each pixel, with a flow thickness of at least 1m, for: (top-left) p=0.339 – reference simulation; (top-right) p=0.0; (middle-left) p=0.25; (middle-right) p=0.5; (bottom-left) p=0.75; (bottom-right) p=1.0.

2. Probability maps for different thresholds in maximum flow thickness, maximum flow thickness hazard maps for different thresholds in probability, and probability maps for joint threshold pairs in flow thickness and dynamic pressure

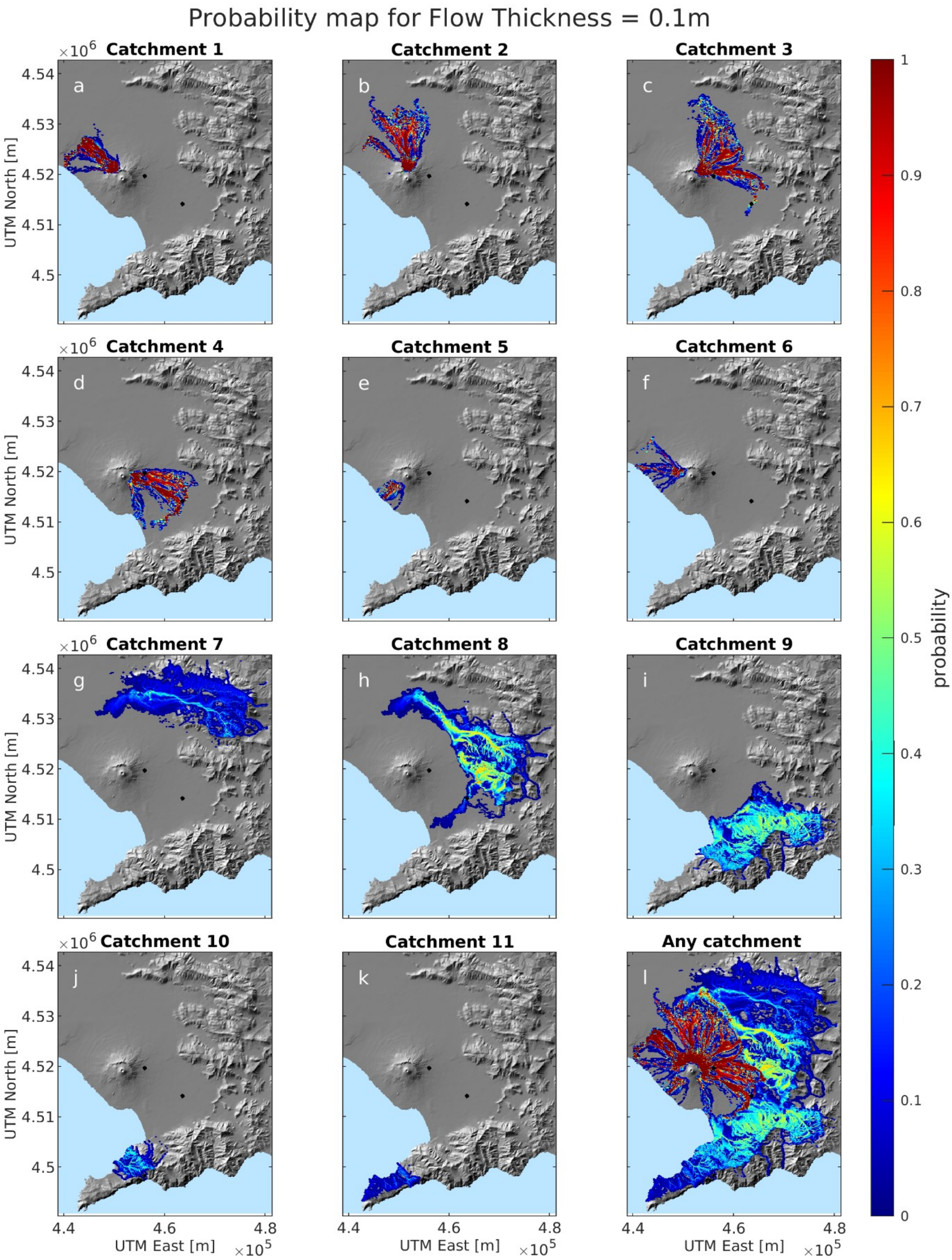


Figure SM7: Probability maps for maximum flow thickness larger than 0.1 m

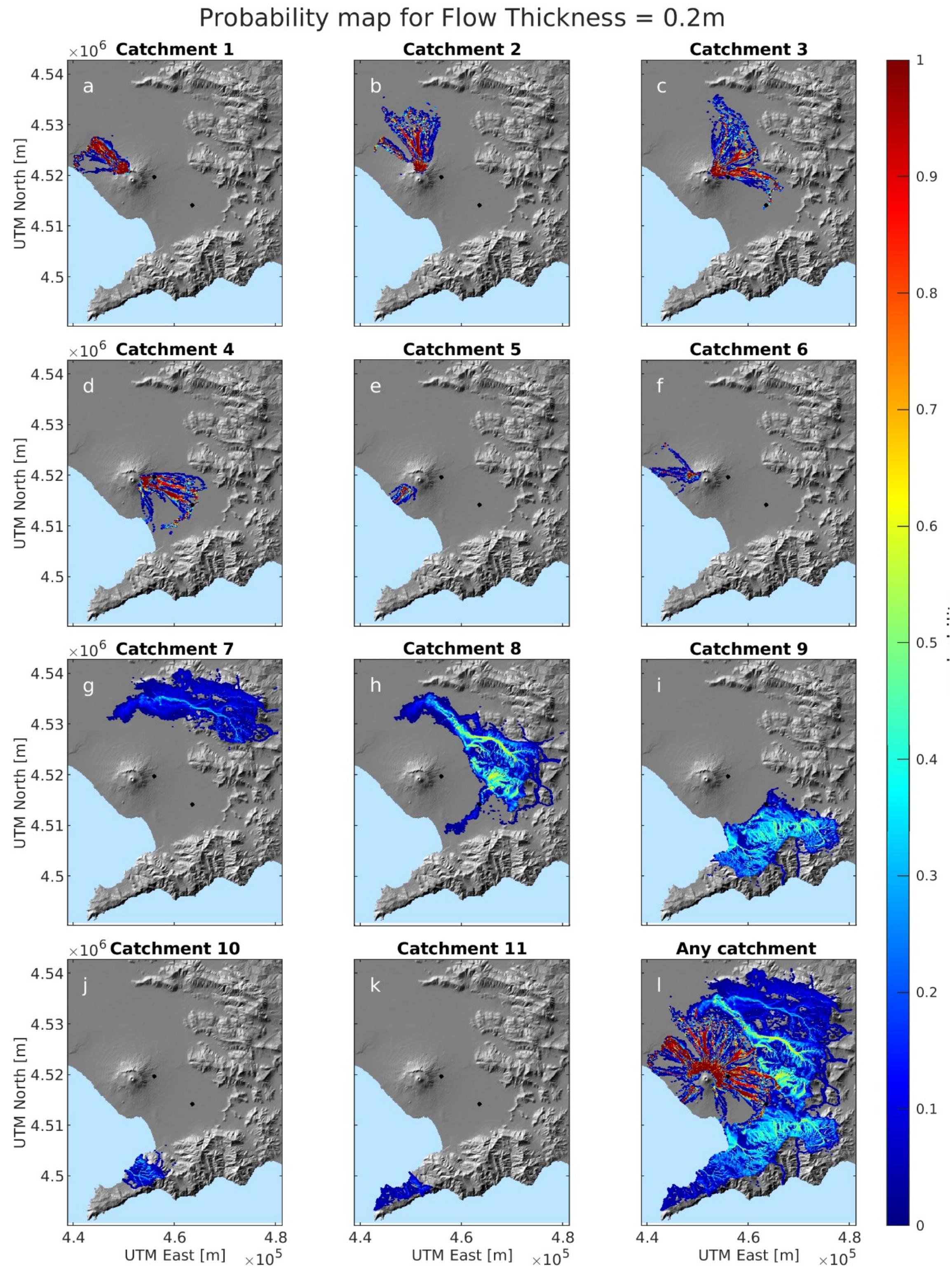


Figure SM8: Probability maps for maximum flow thickness larger than 0.2m

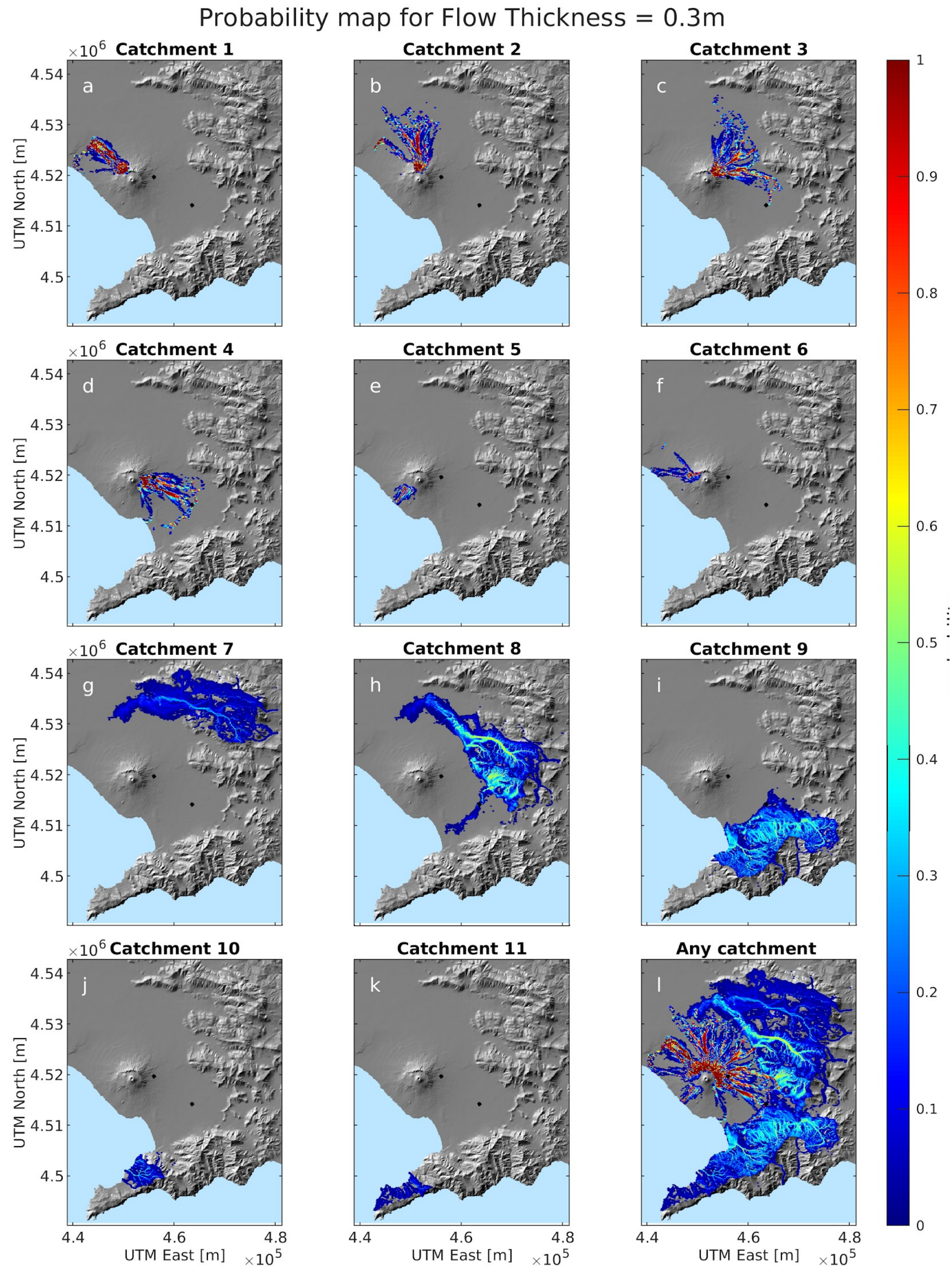


Figure SM9: Probability maps for maximum flow thickness larger than 0.3 m

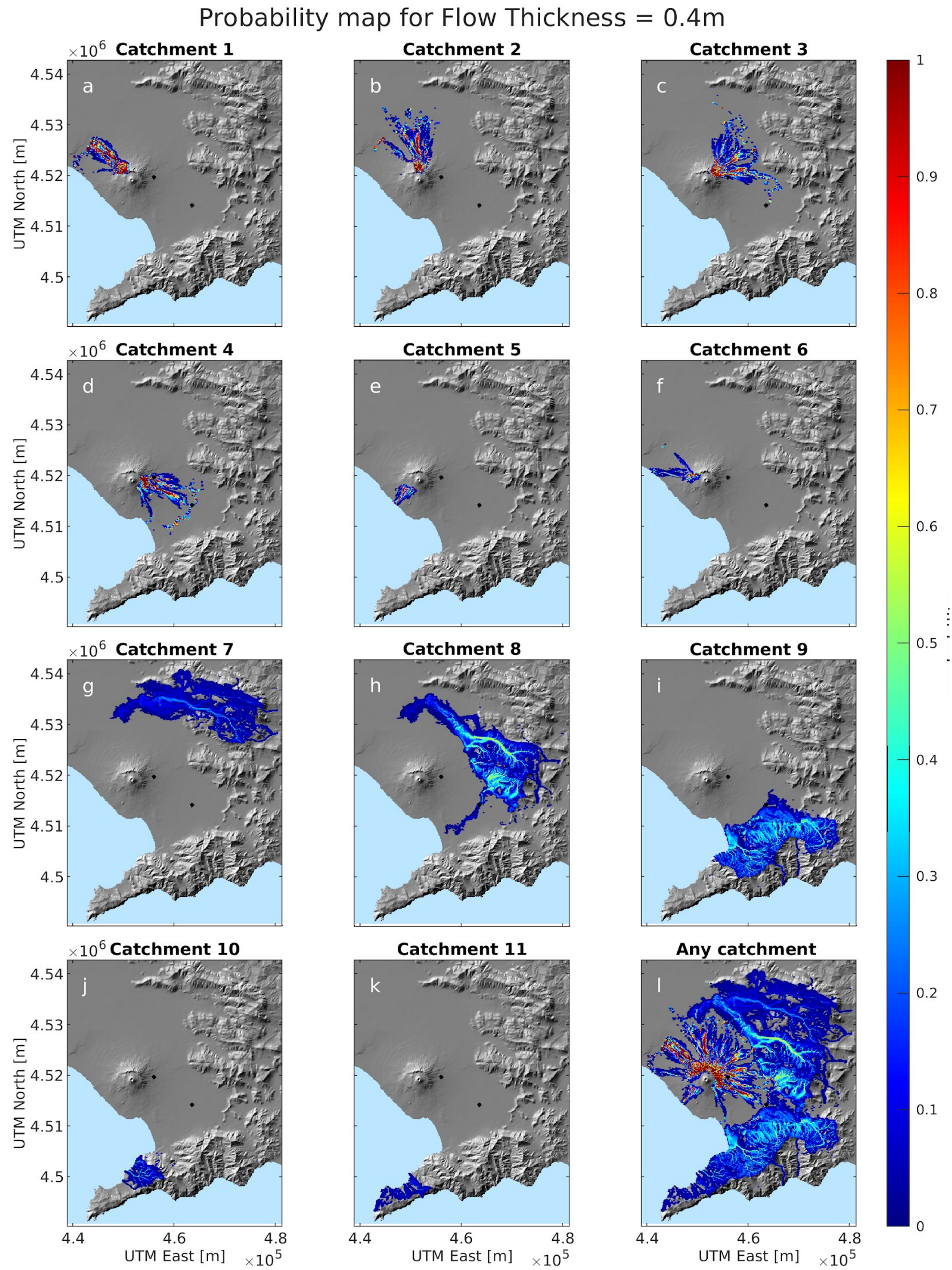


Figure SM10: Probability maps for maximum flow thickness larger than 0.4 m

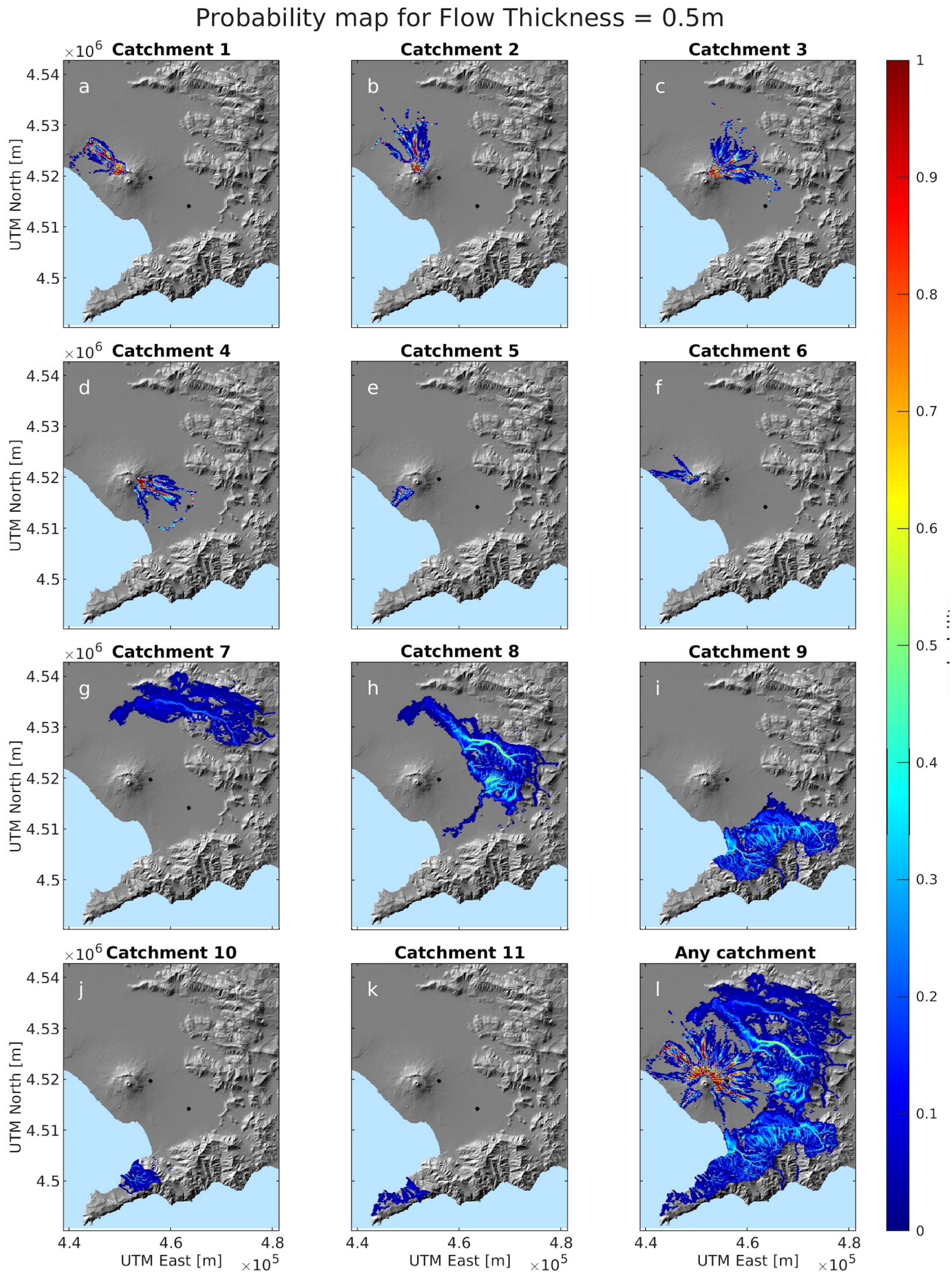


Figure SM11: Probability maps for maximum flow thickness larger than 0.5 m

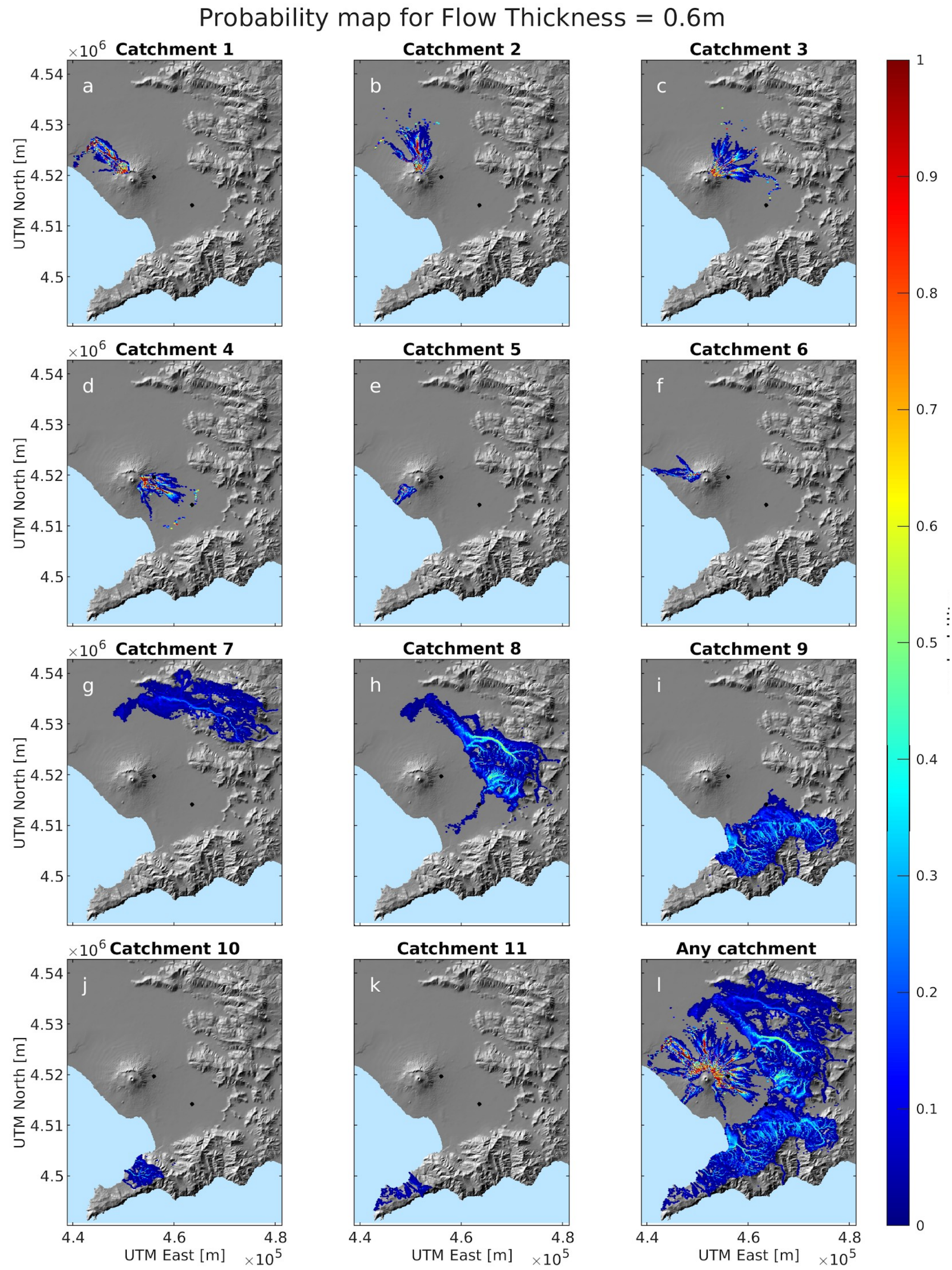


Figure SM12: Probability maps for maximum flow thickness larger than 0.6 m

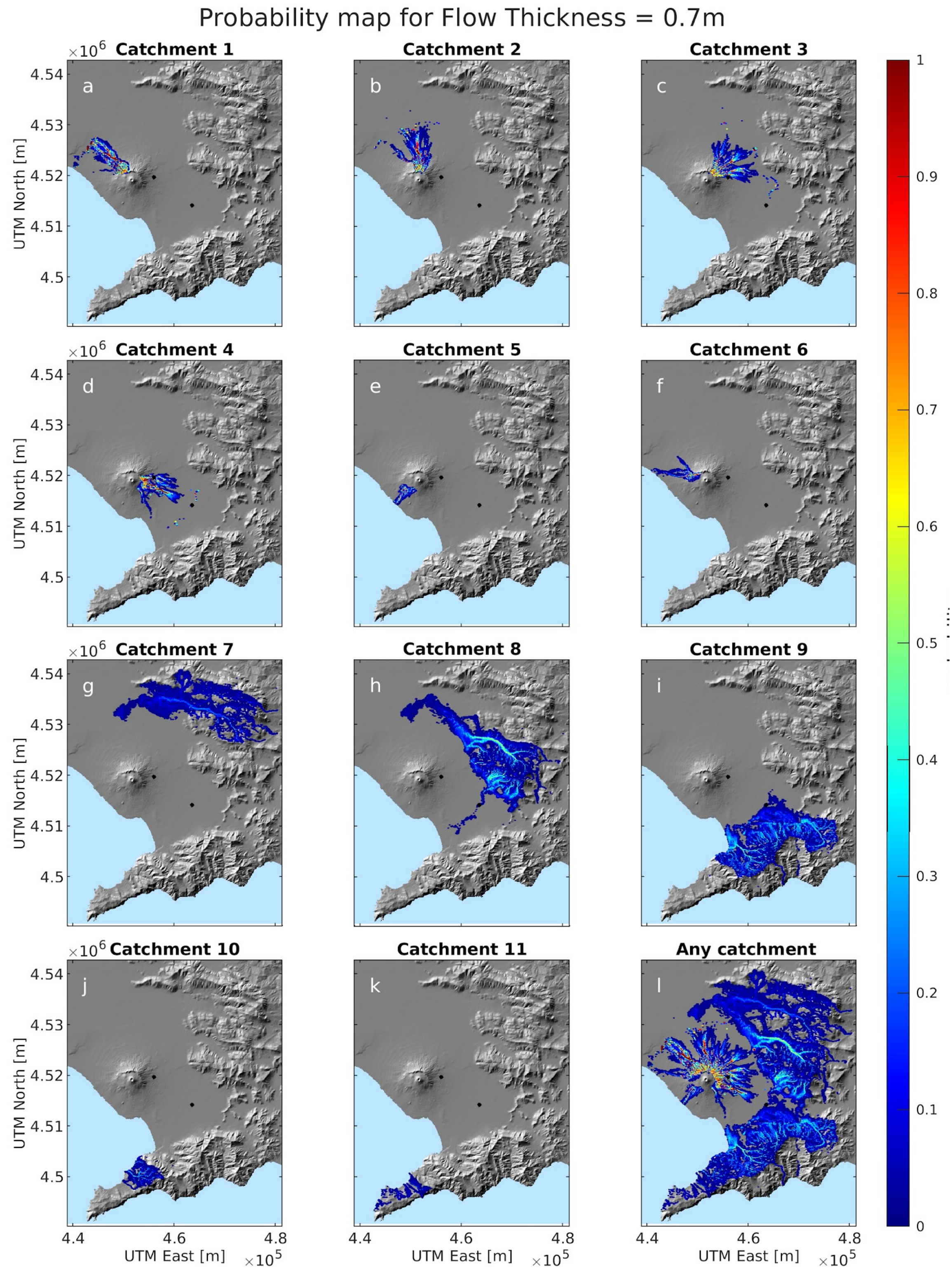


Figure SM13: Probability maps for maximum flow thickness larger than 0.7 m

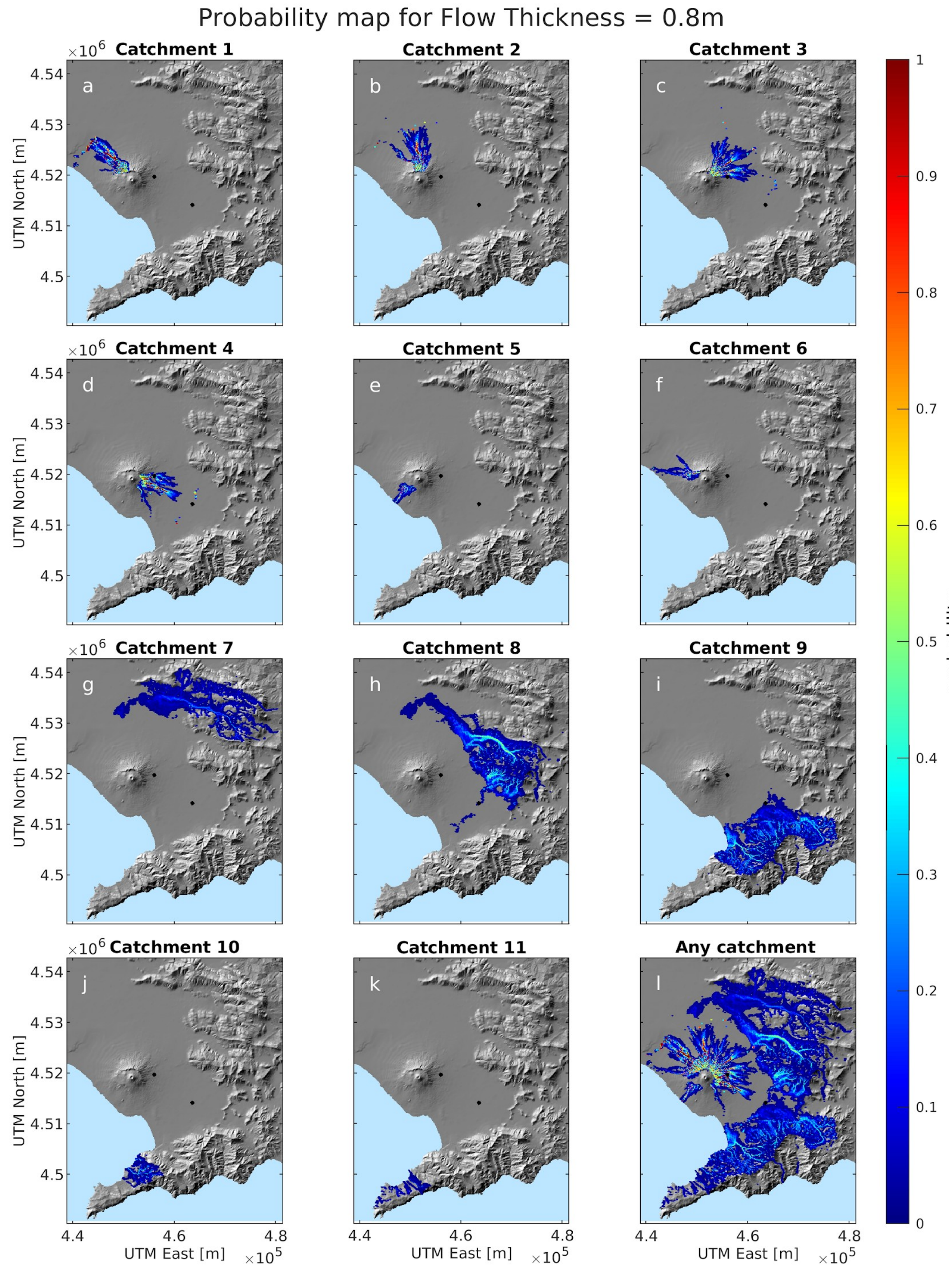


Figure SM14: Probability maps for maximum flow thickness larger than 0.8 m

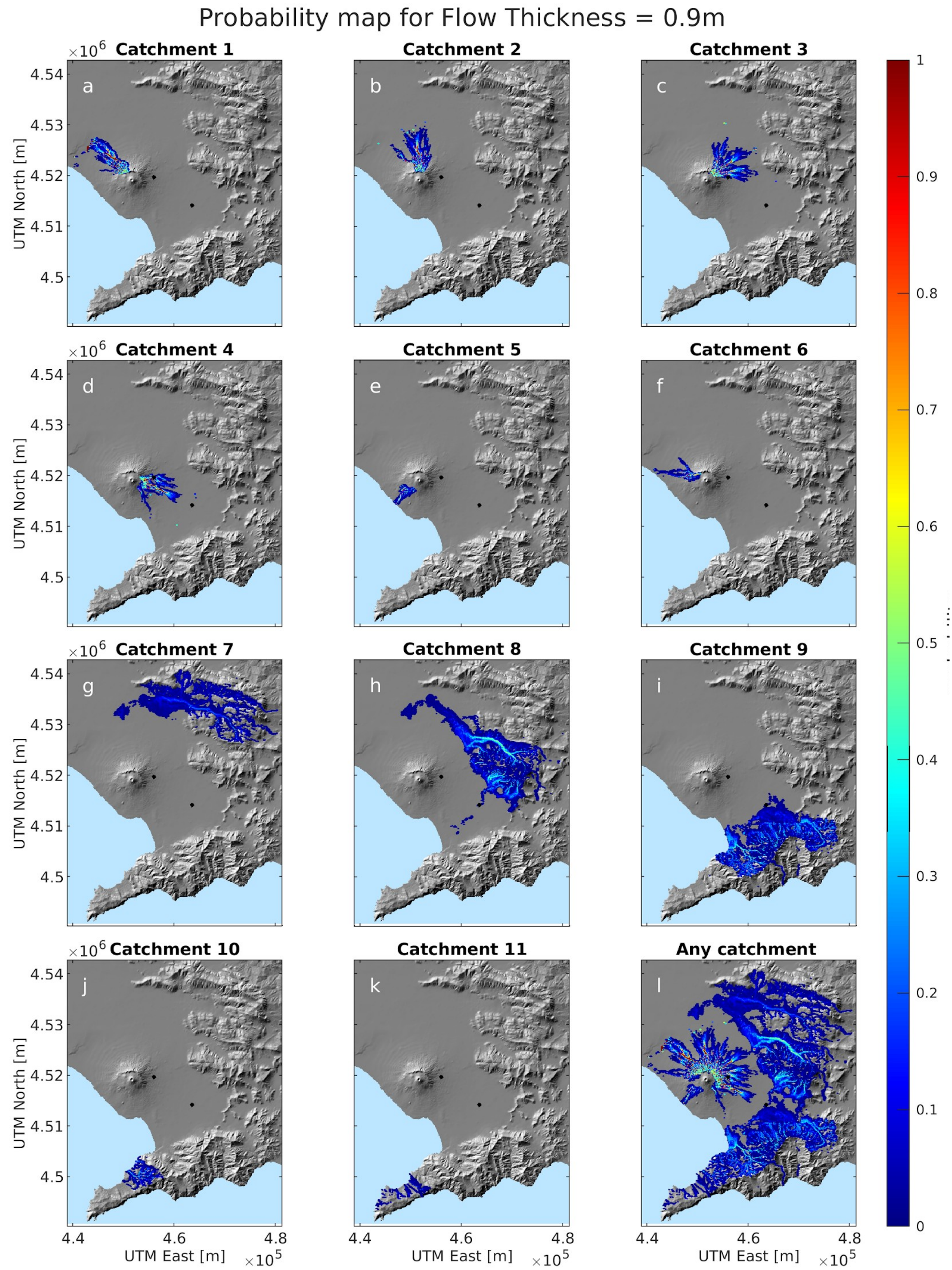


Figure SM15: Probability maps for maximum flow thickness larger than 0.9 m

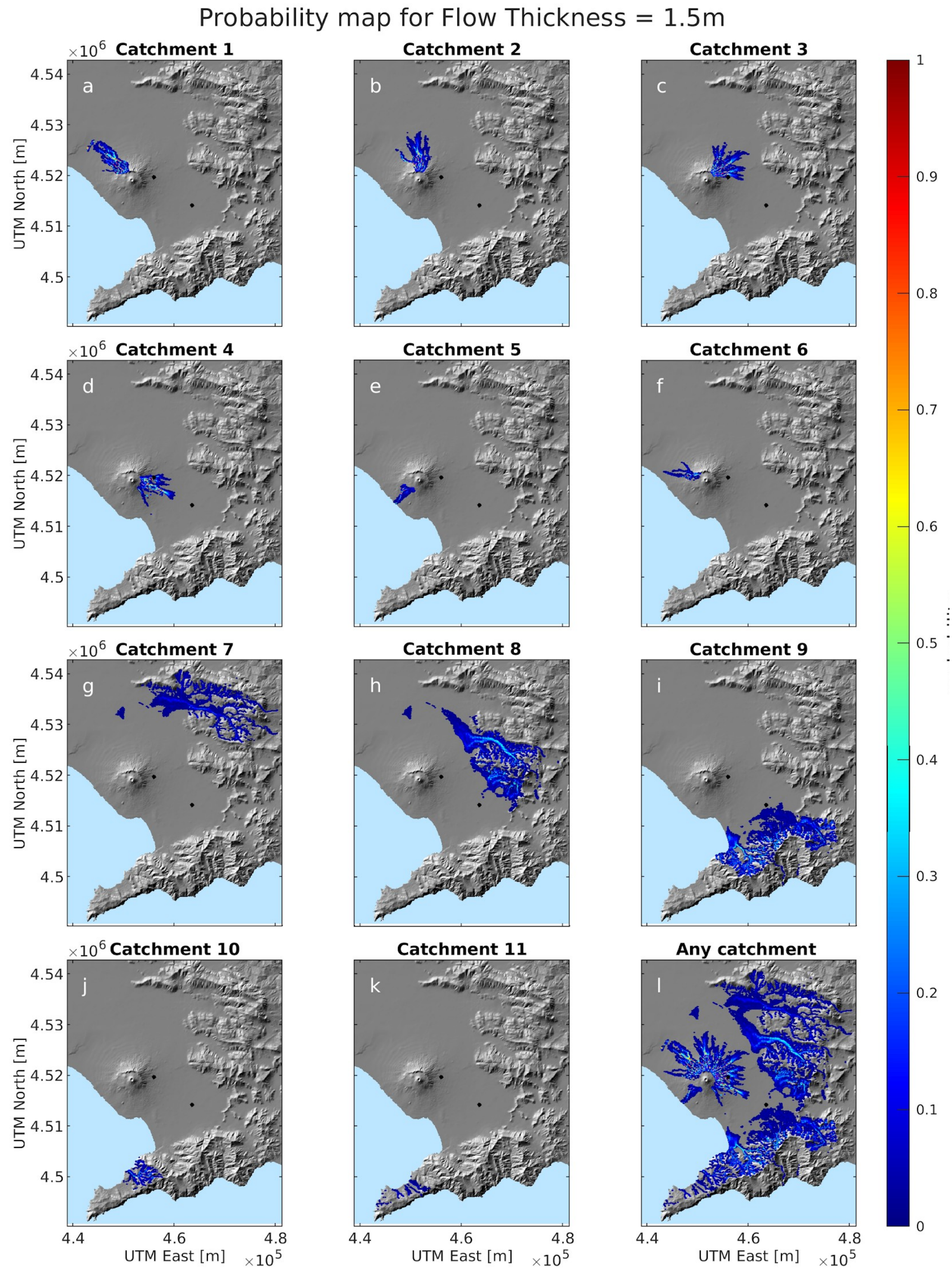


Figure SM16: Probability maps for maximum flow thickness larger than 1.5 m

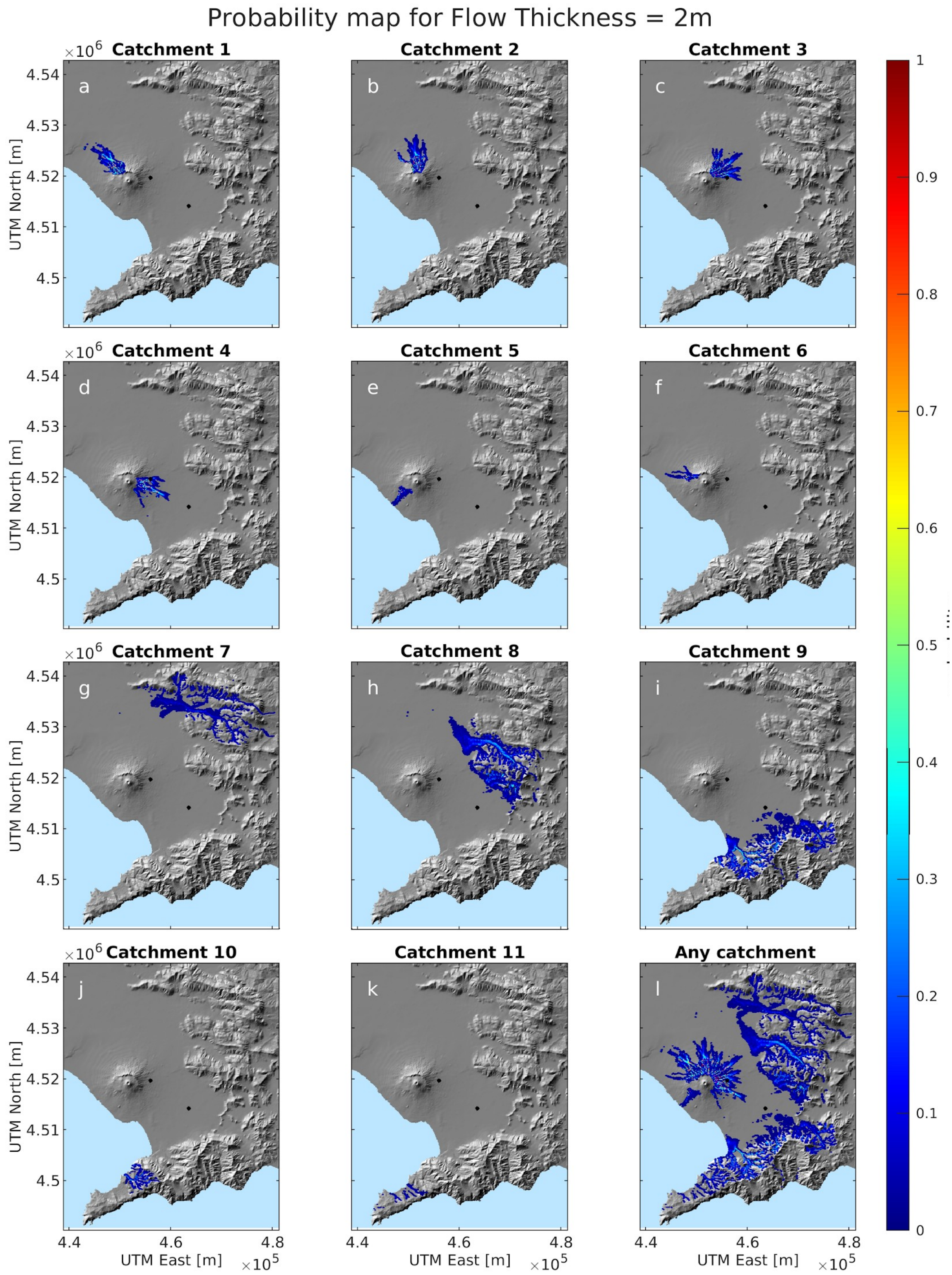


Figure SM17: Probability maps for maximum flow thickness larger than 2 m

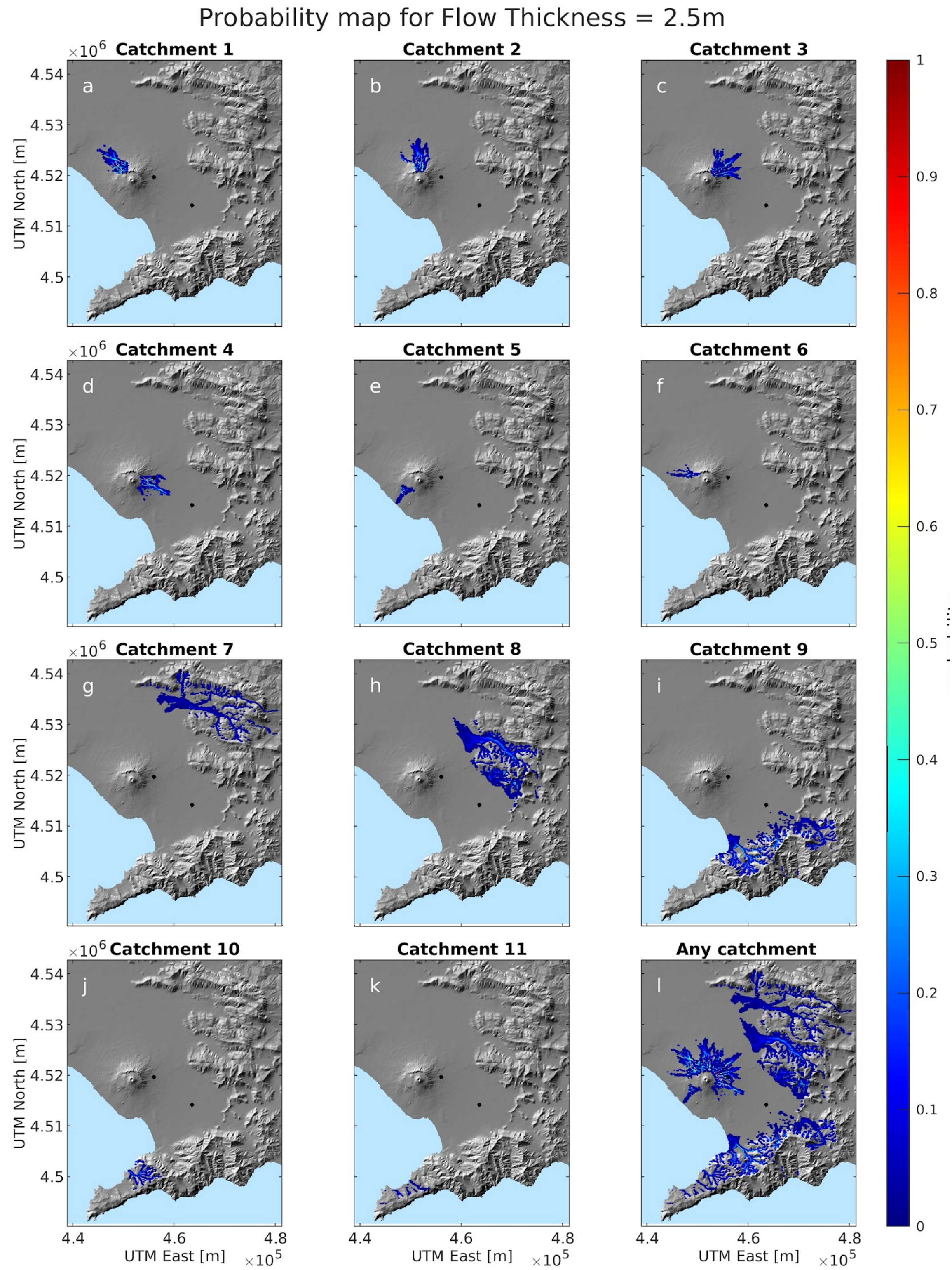


Figure SM18: Probability maps for maximum flow thickness larger than 2.5 m

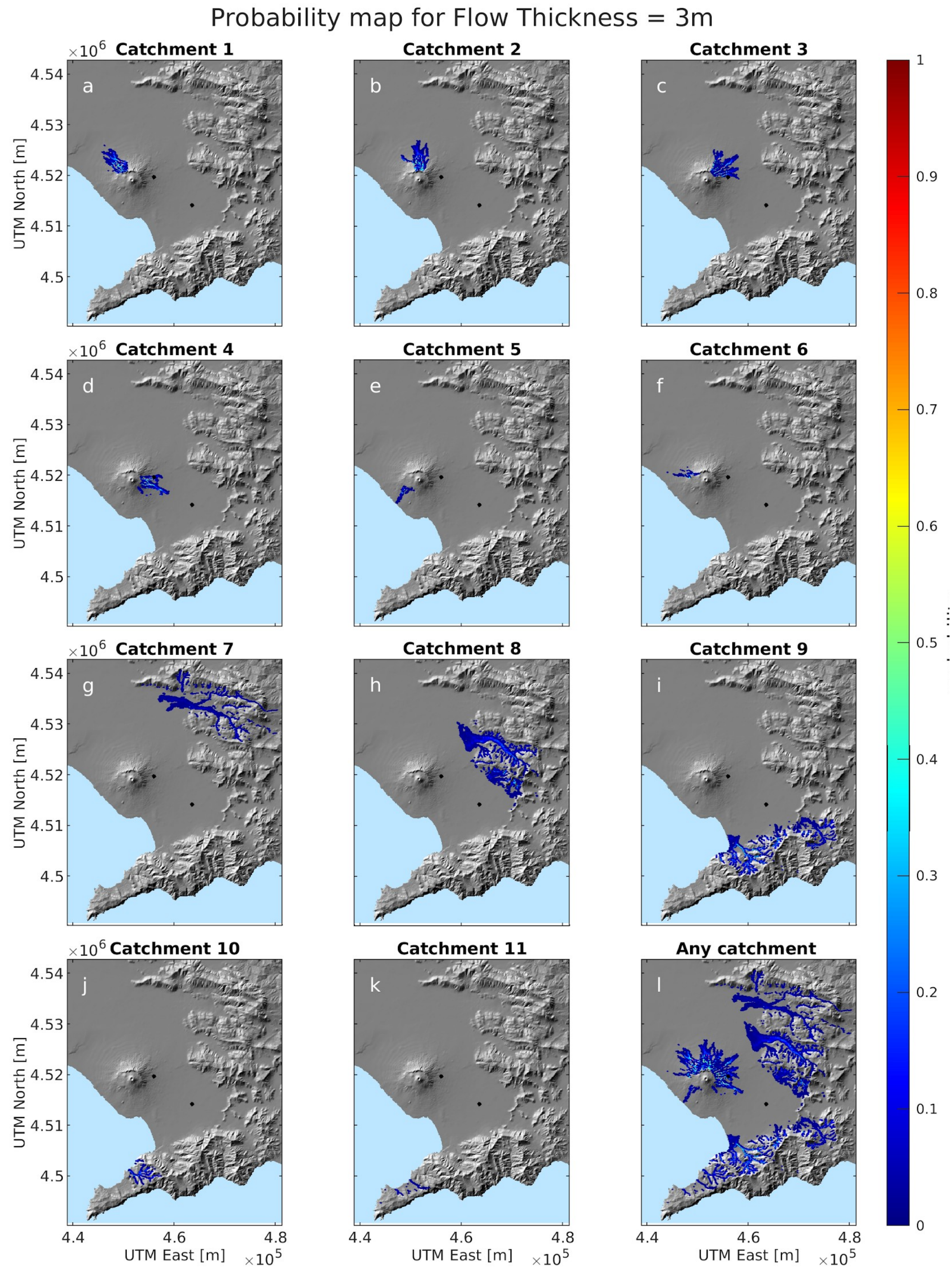


Figure SM19: Probability maps for maximum flow thickness larger than 3 m

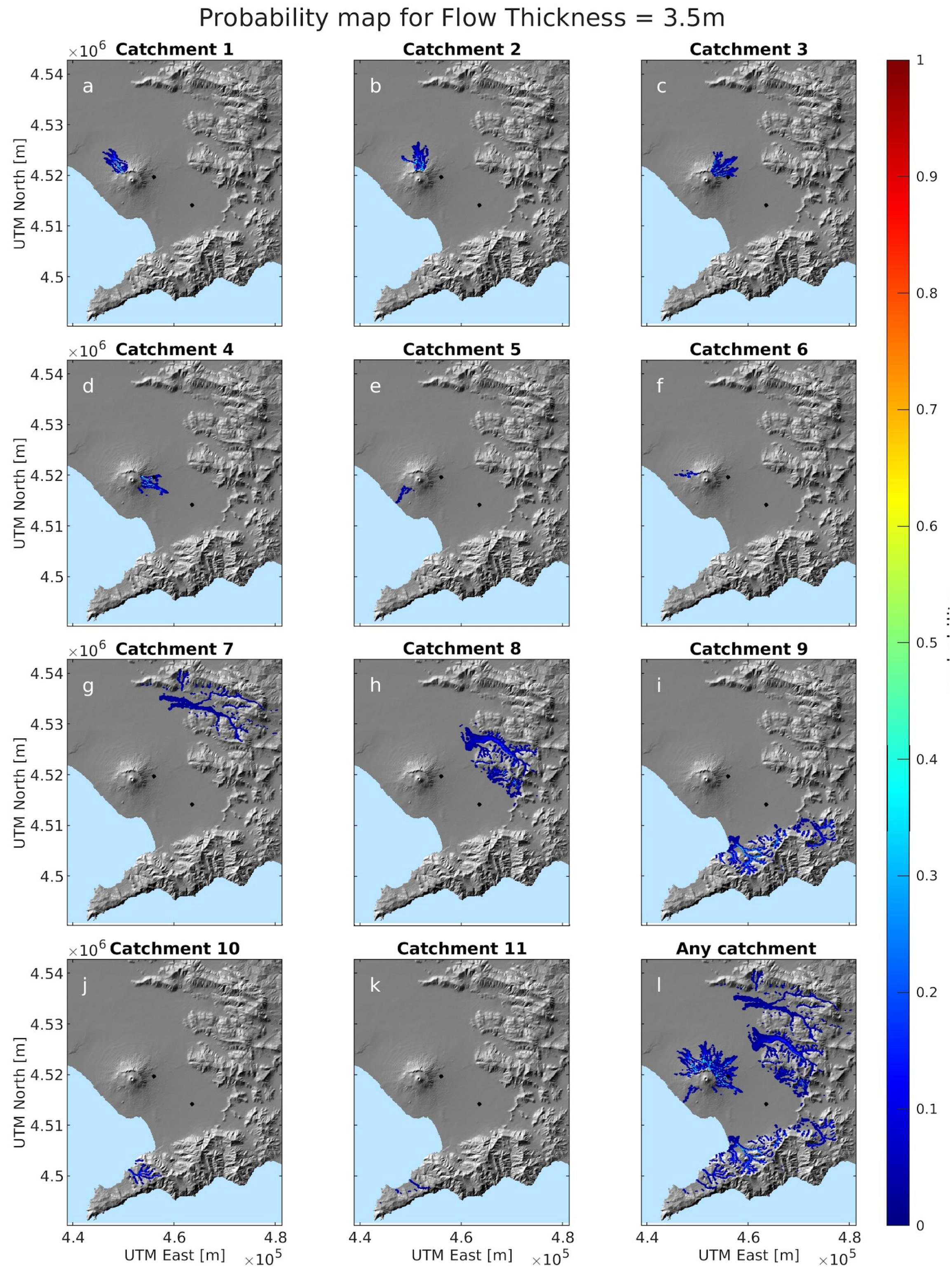


Figure SM20: Probability maps for maximum flow thickness larger than 3.5 m

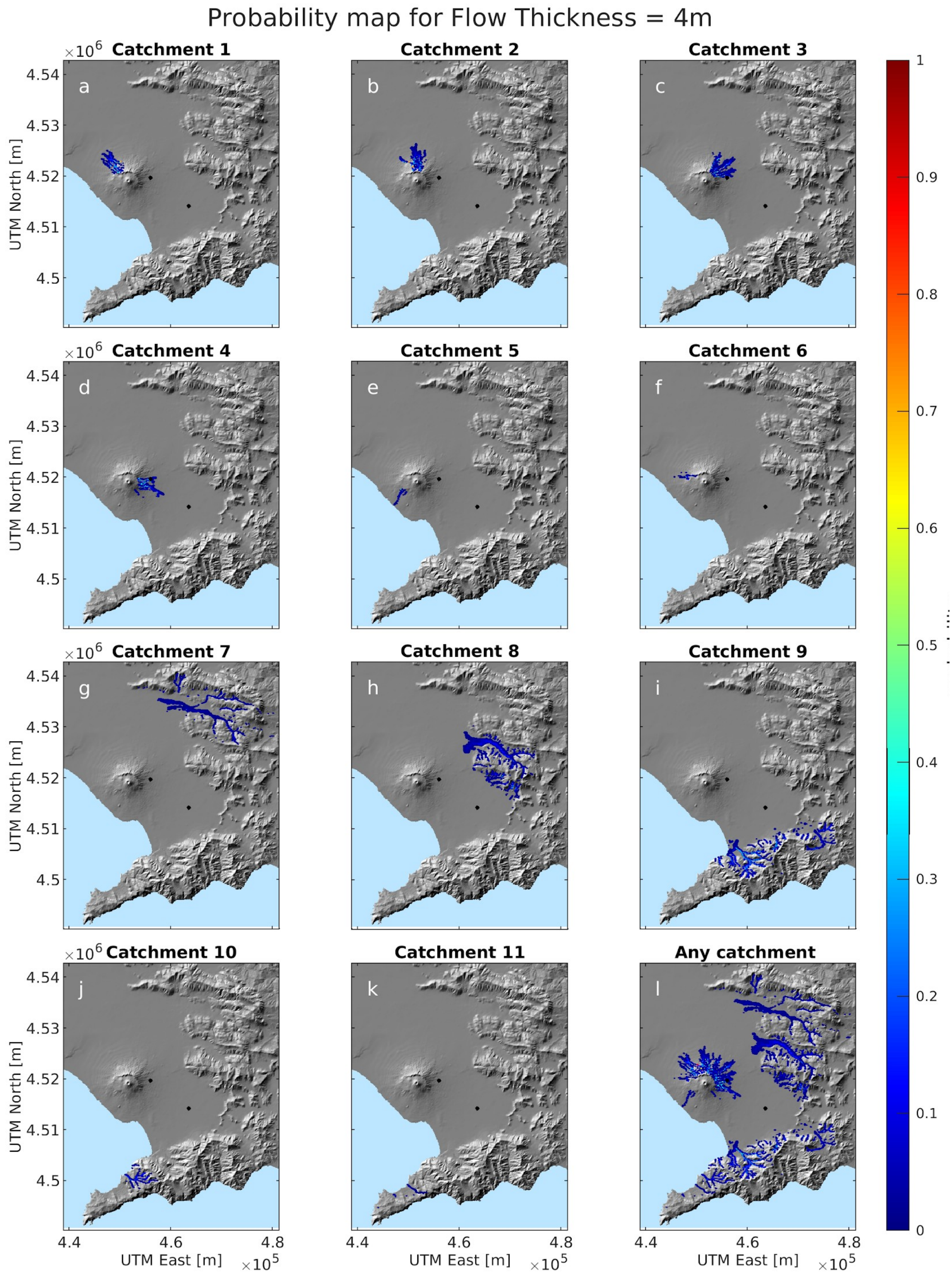


Figure SM21: Probability maps for maximum flow thickness larger than 4 m

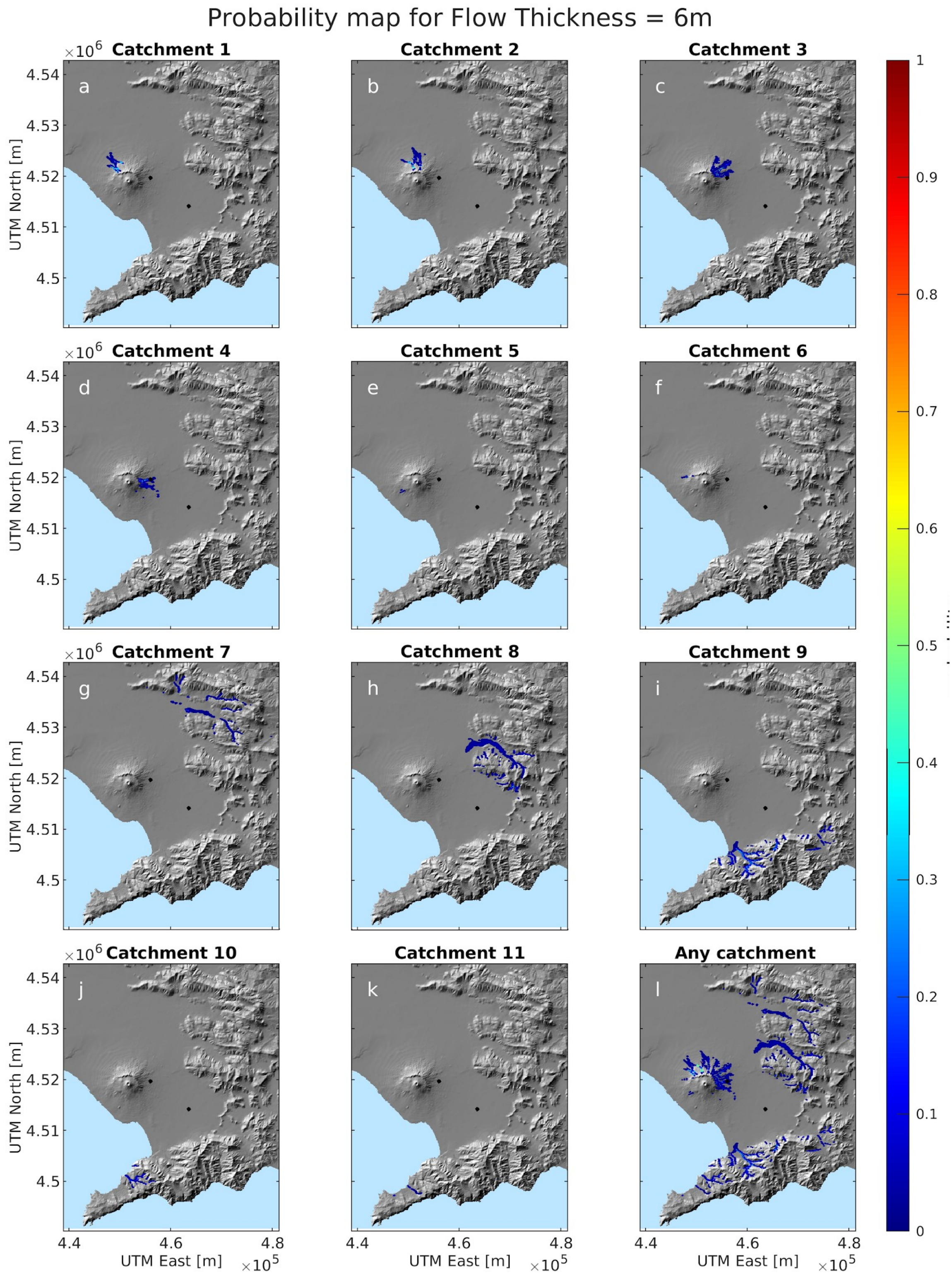


Figure SM22: Probability maps for maximum flow thickness larger than 6 m

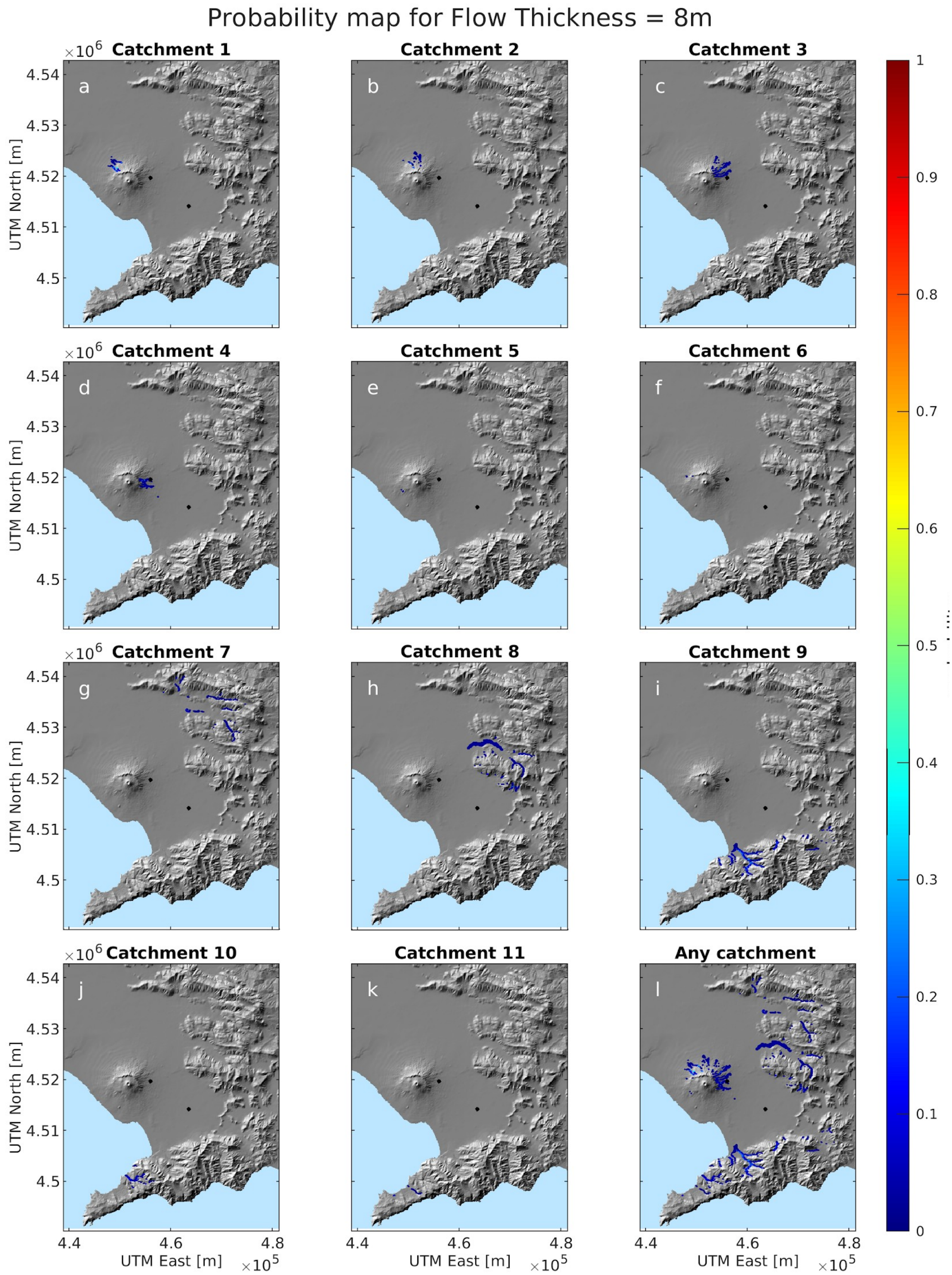


Figure SM23: Probability maps for maximum flow thickness larger than 8 m

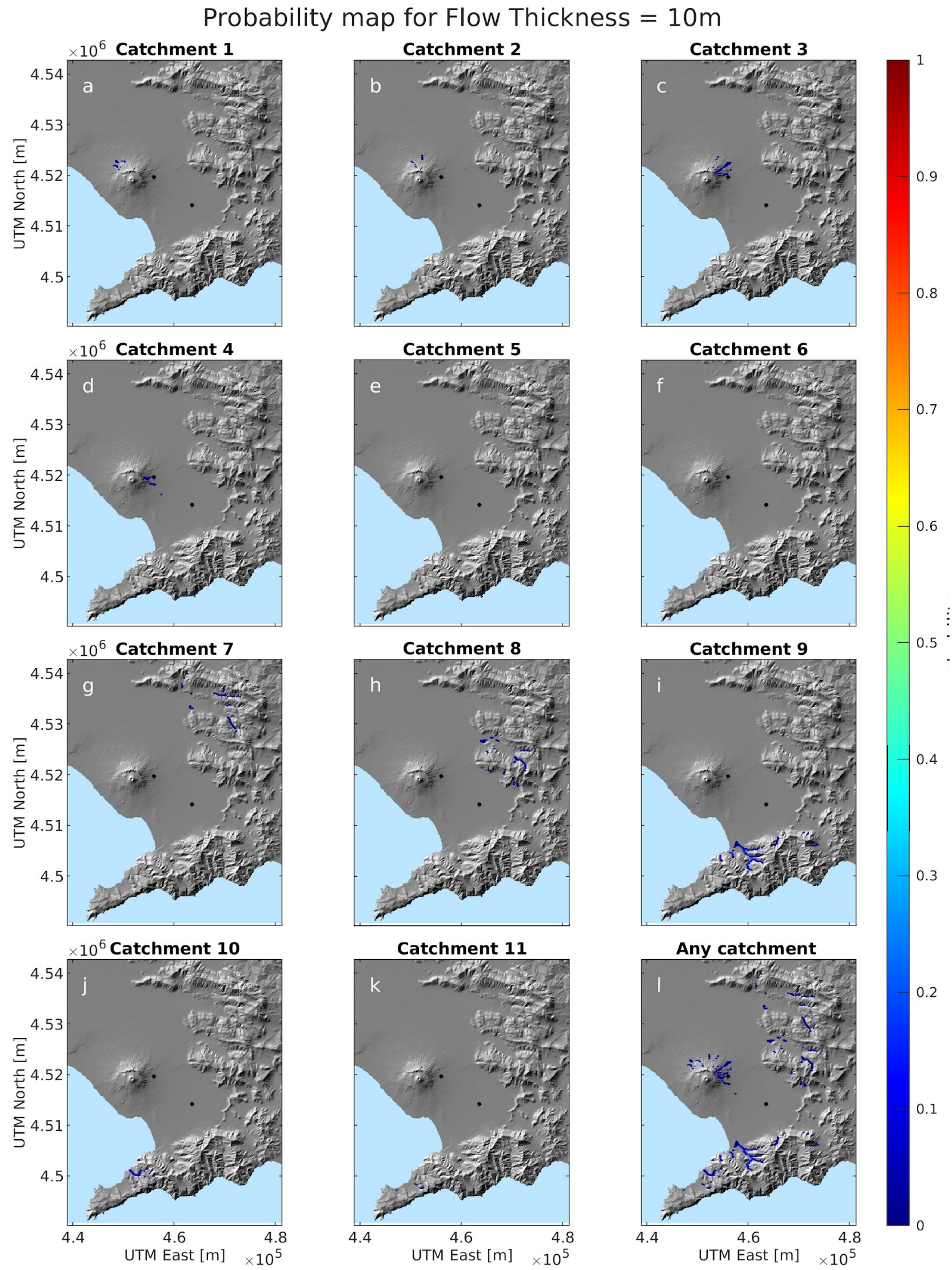


Figure SM24: Probability maps for maximum flow thickness larger than 10 m

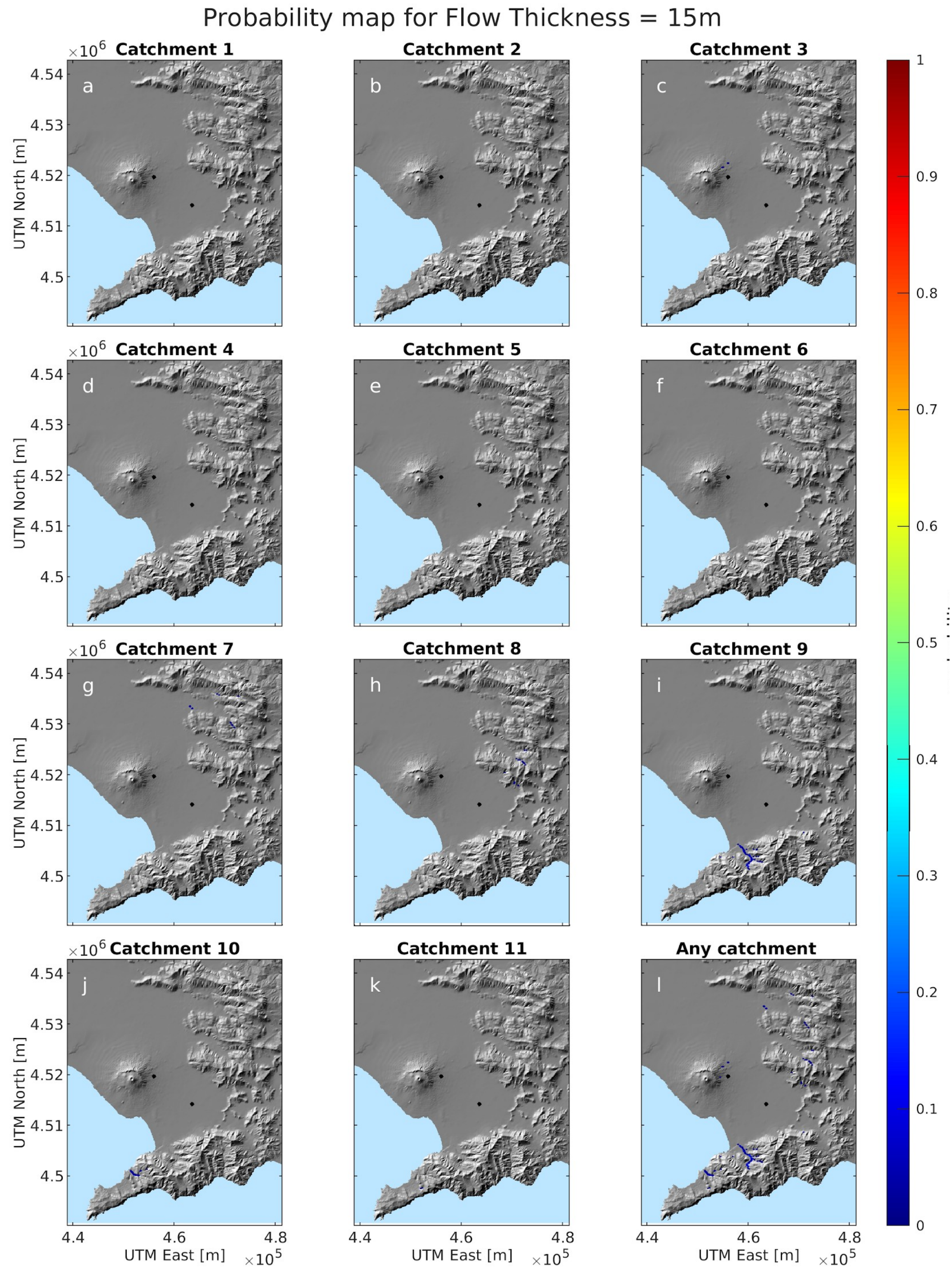


Figure SM25: Probability maps for maximum flow thickness larger than 15 m

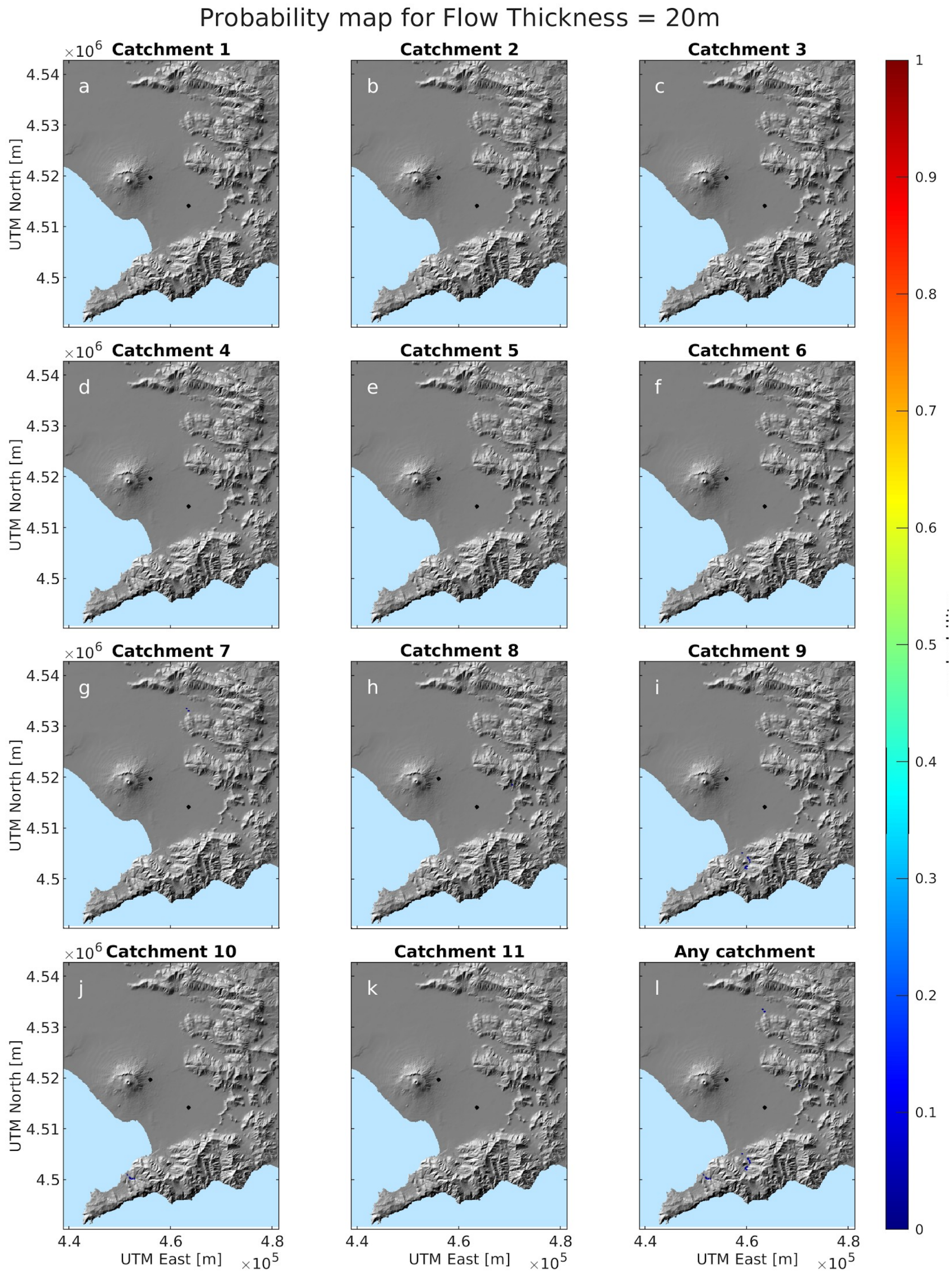


Figure SM26: Probability maps for maximum flow thickness larger than 20 m

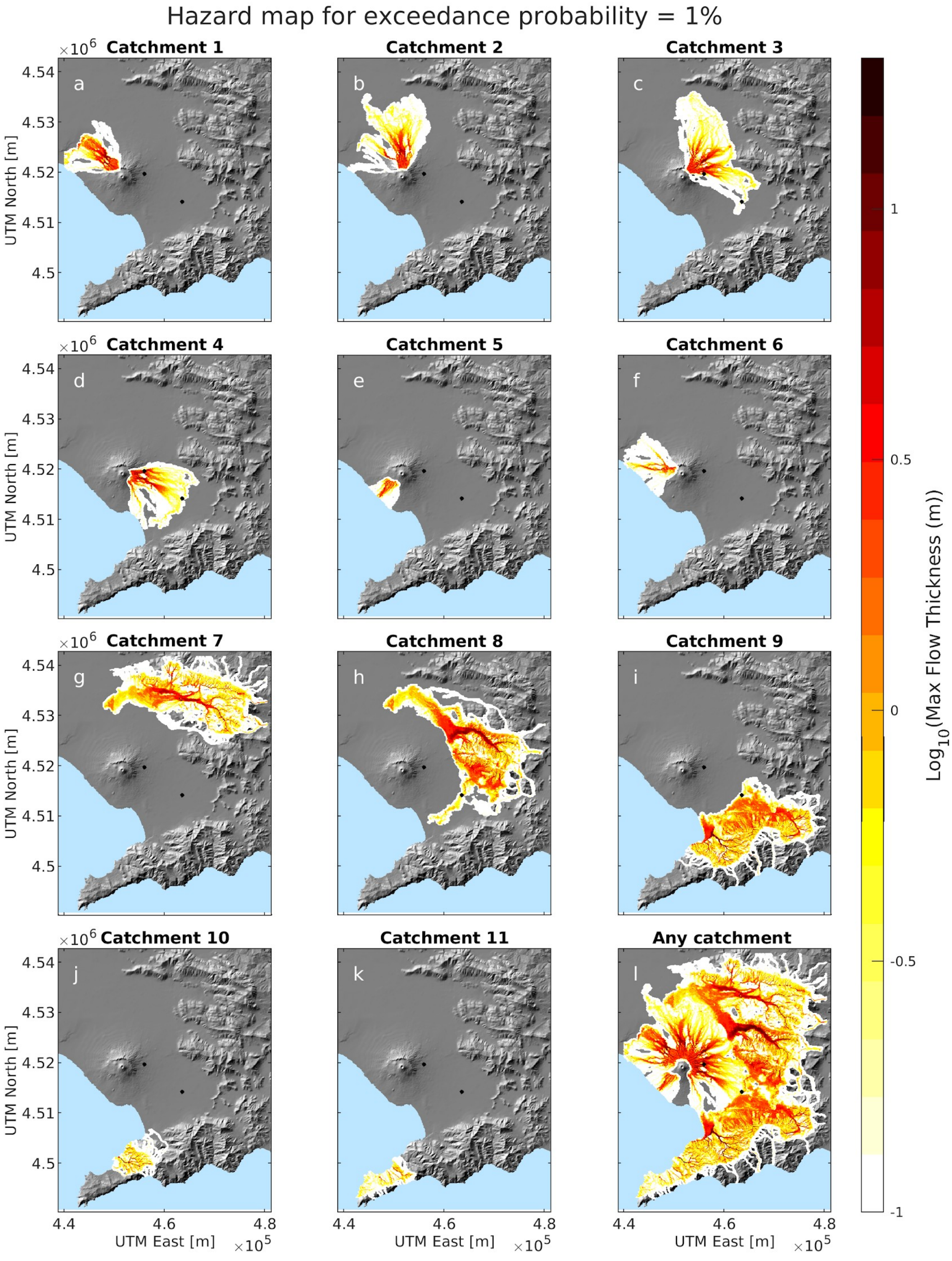


Figure SM27: 1% hazard maps in maximum flow thickness

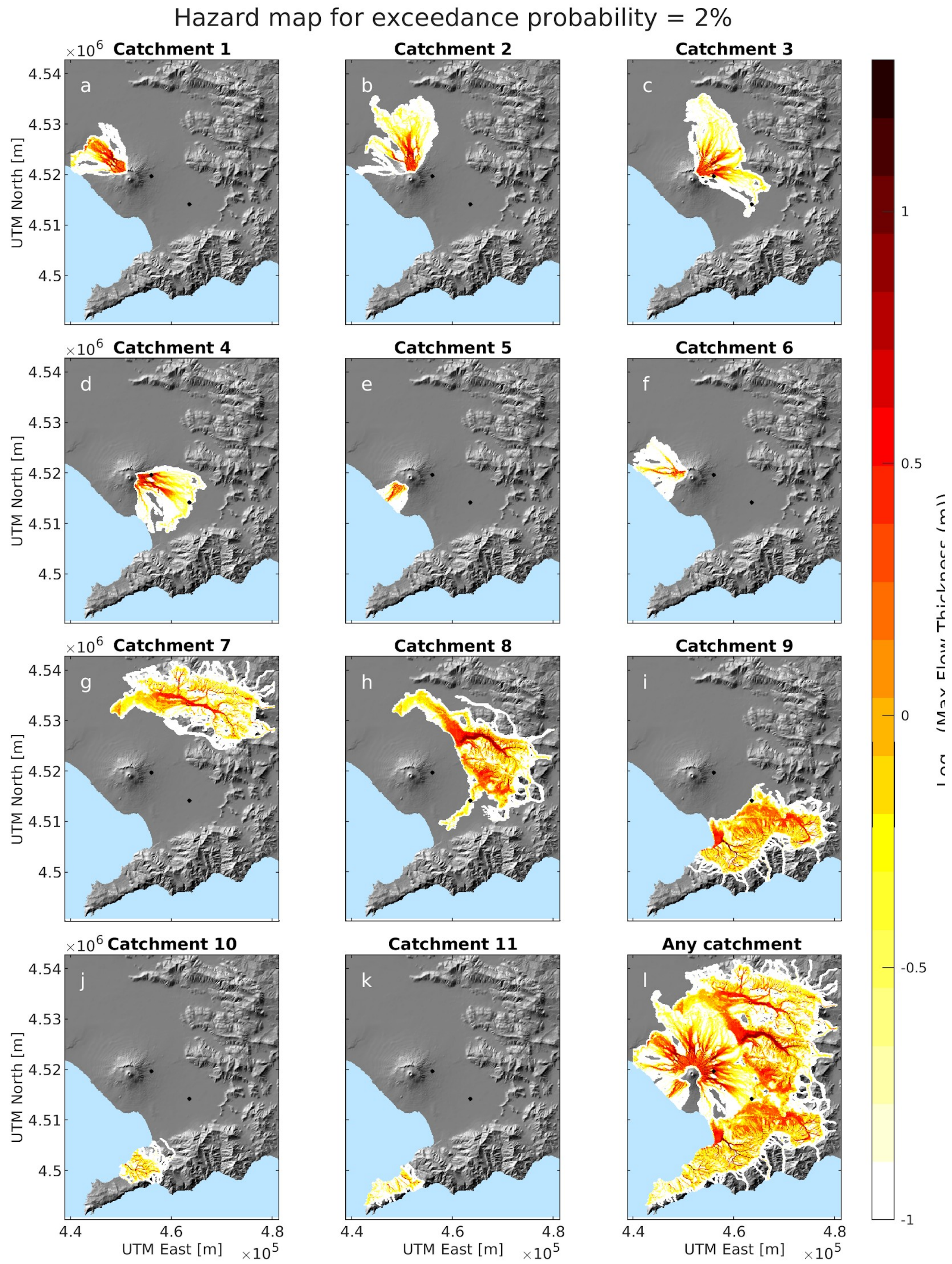


Figure SM28: 2% hazard maps in maximum flow thickness

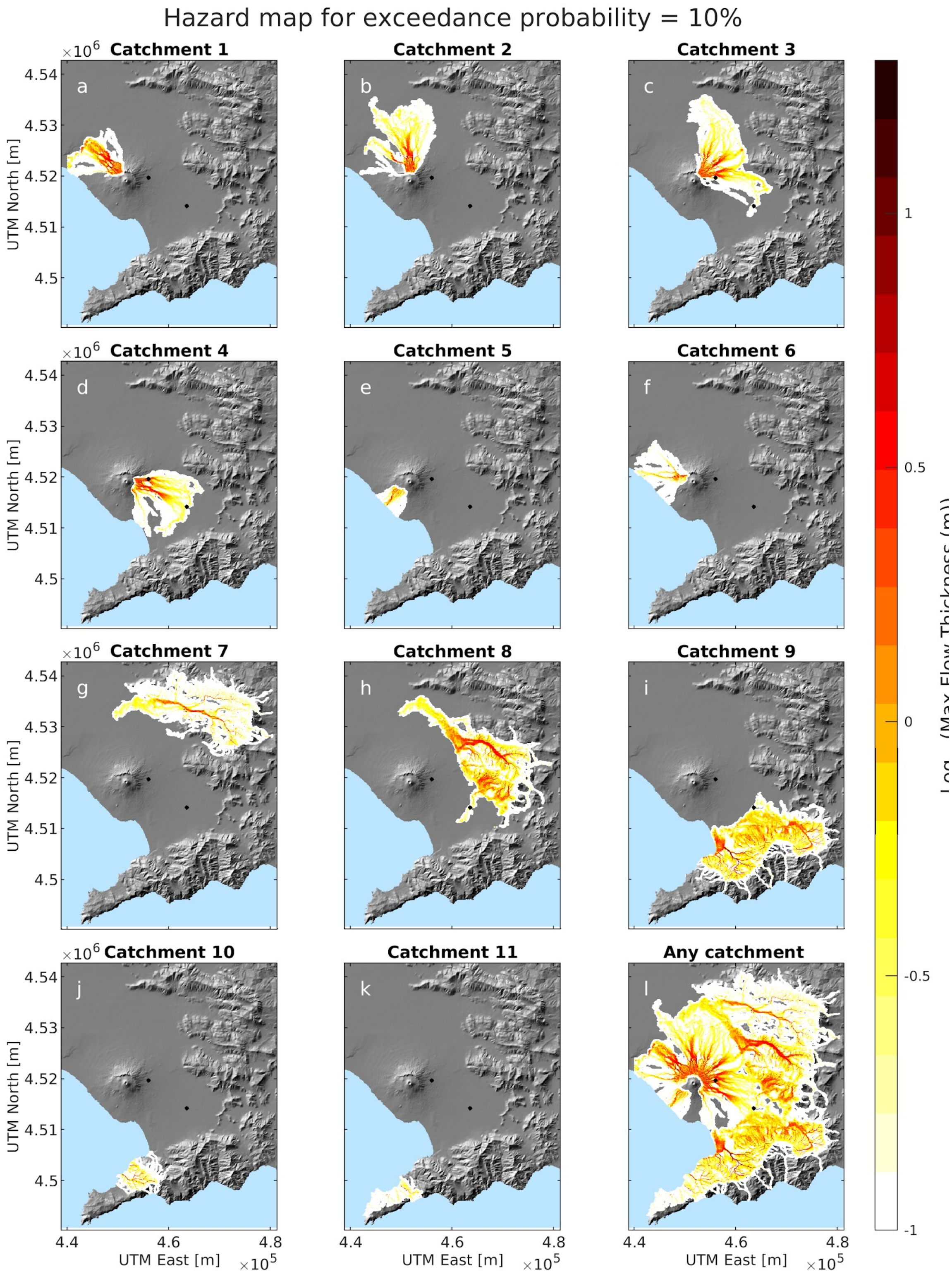


Figure SM29: 10% hazard maps in maximum flow thickness

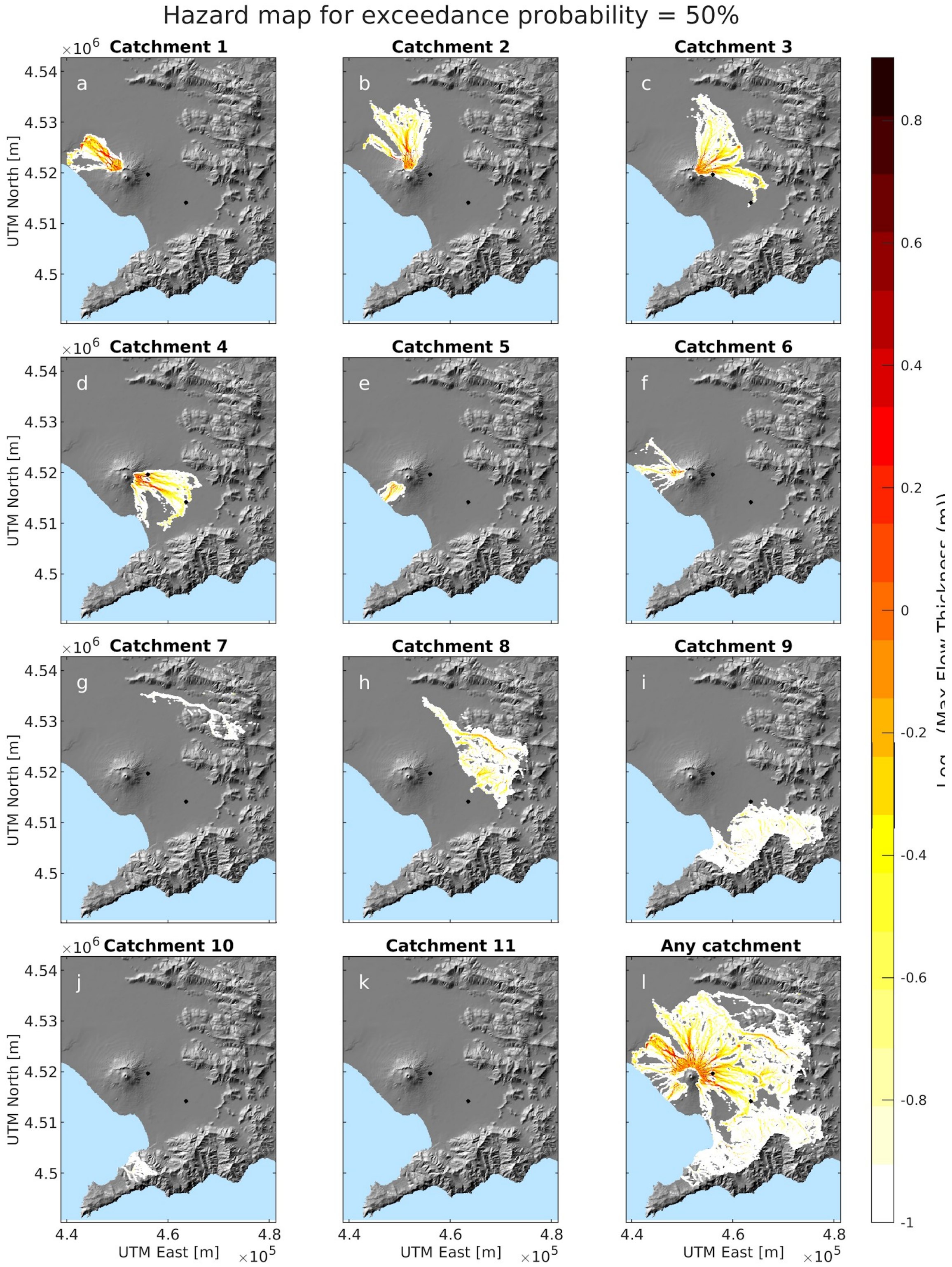


Figure SM30: 50% hazard maps in maximum flow thickness

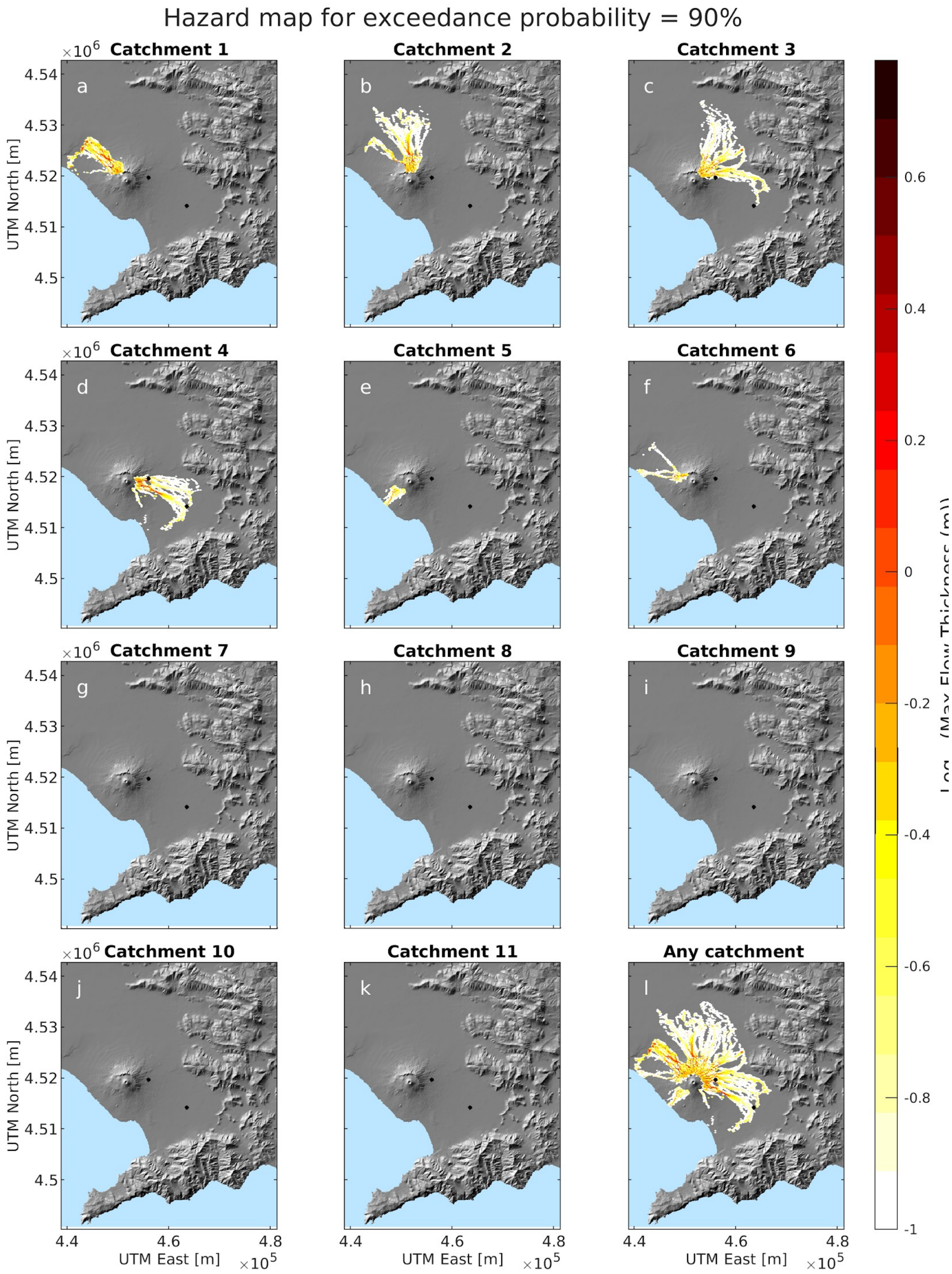


Figure SM31: 90% hazard maps in maximum flow thickness

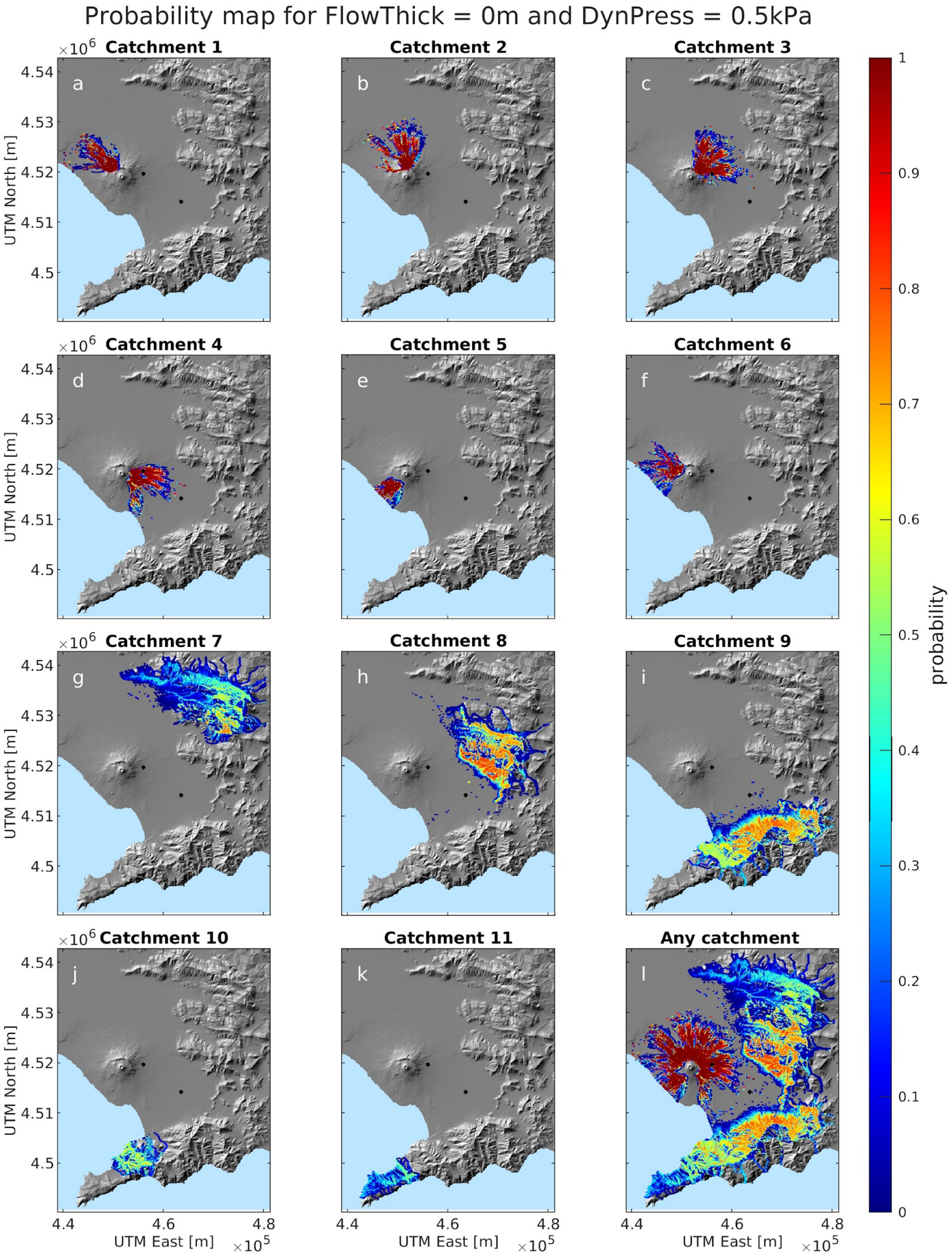


Figure SM32: Probability maps for dynamic pressure larger than 0.5 kPa

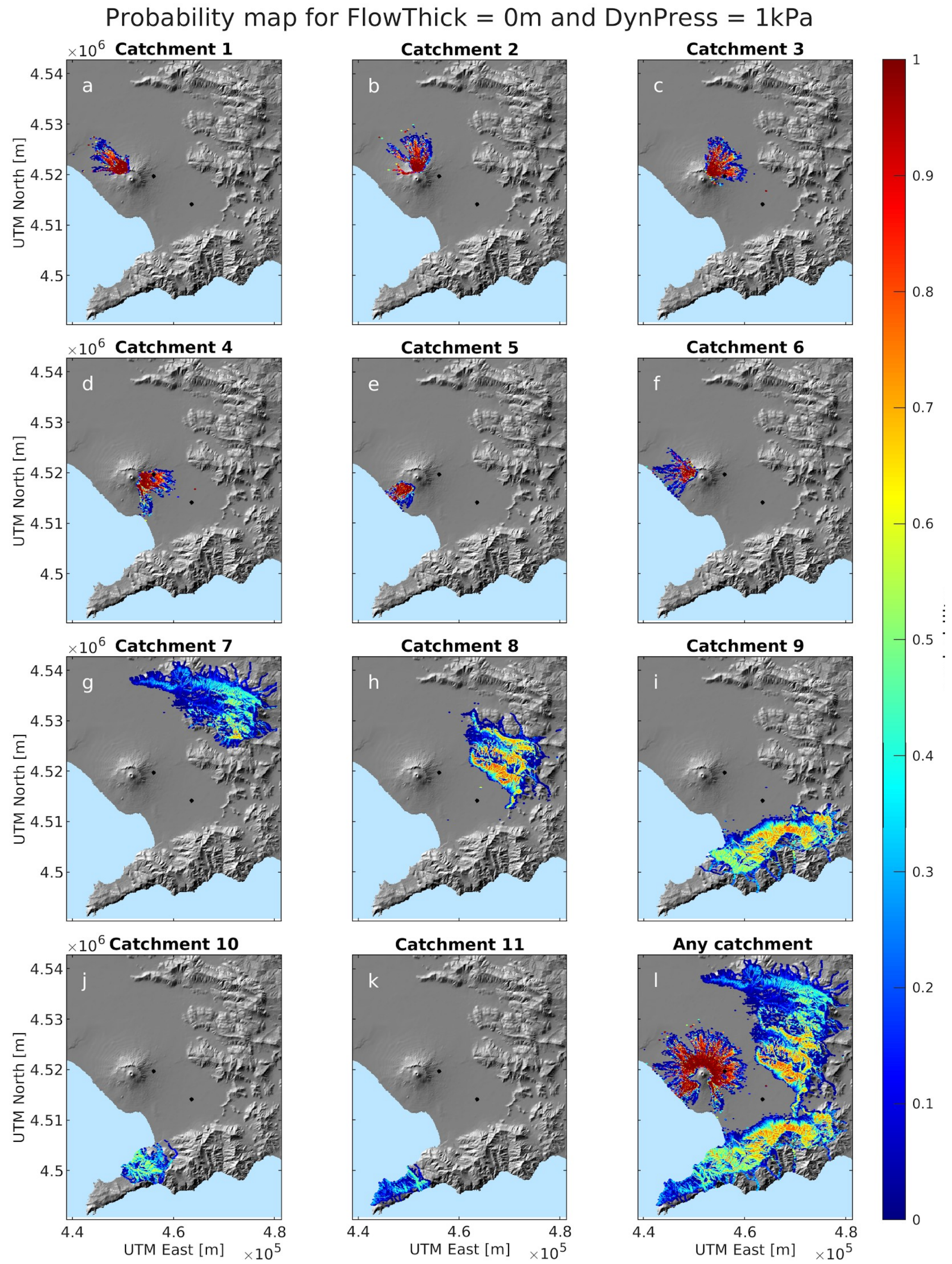


Figure SM33: Probability maps for dynamic pressure larger than 1 kPa

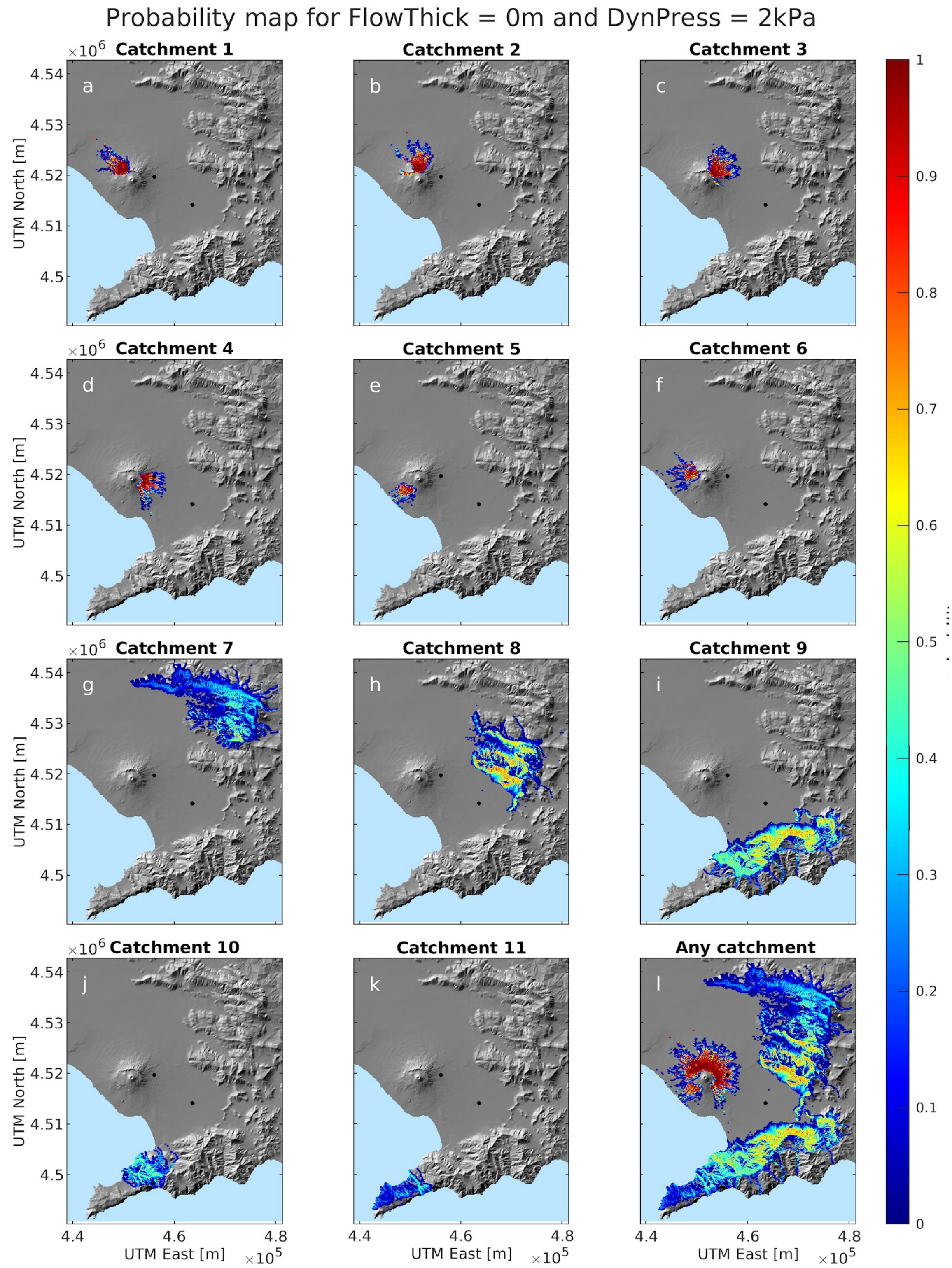


Figure SM34: Probability maps for dynamic pressure larger than 2 kPa

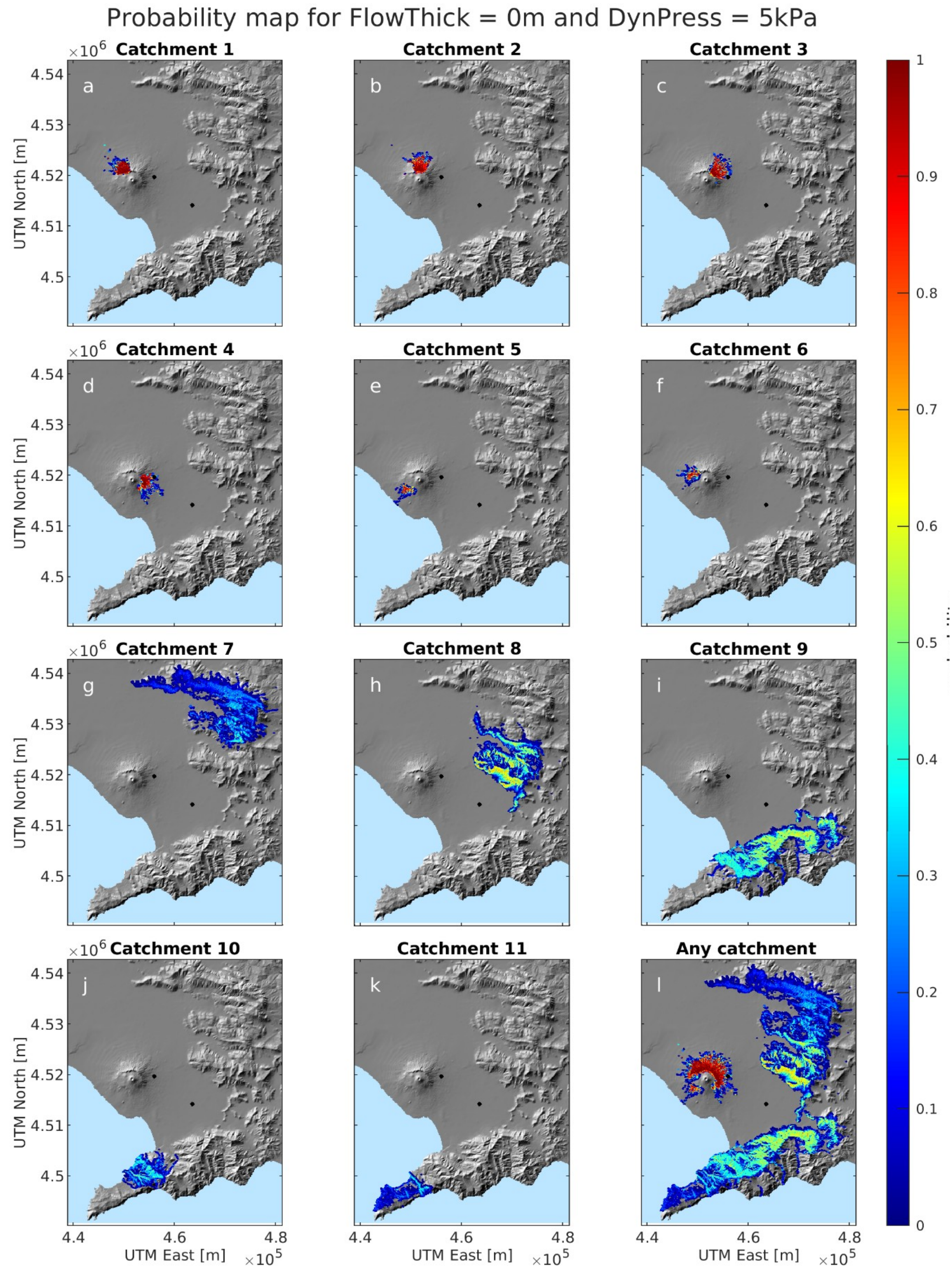


Figure SM35: Probability maps for dynamic pressure larger than 5 kPa

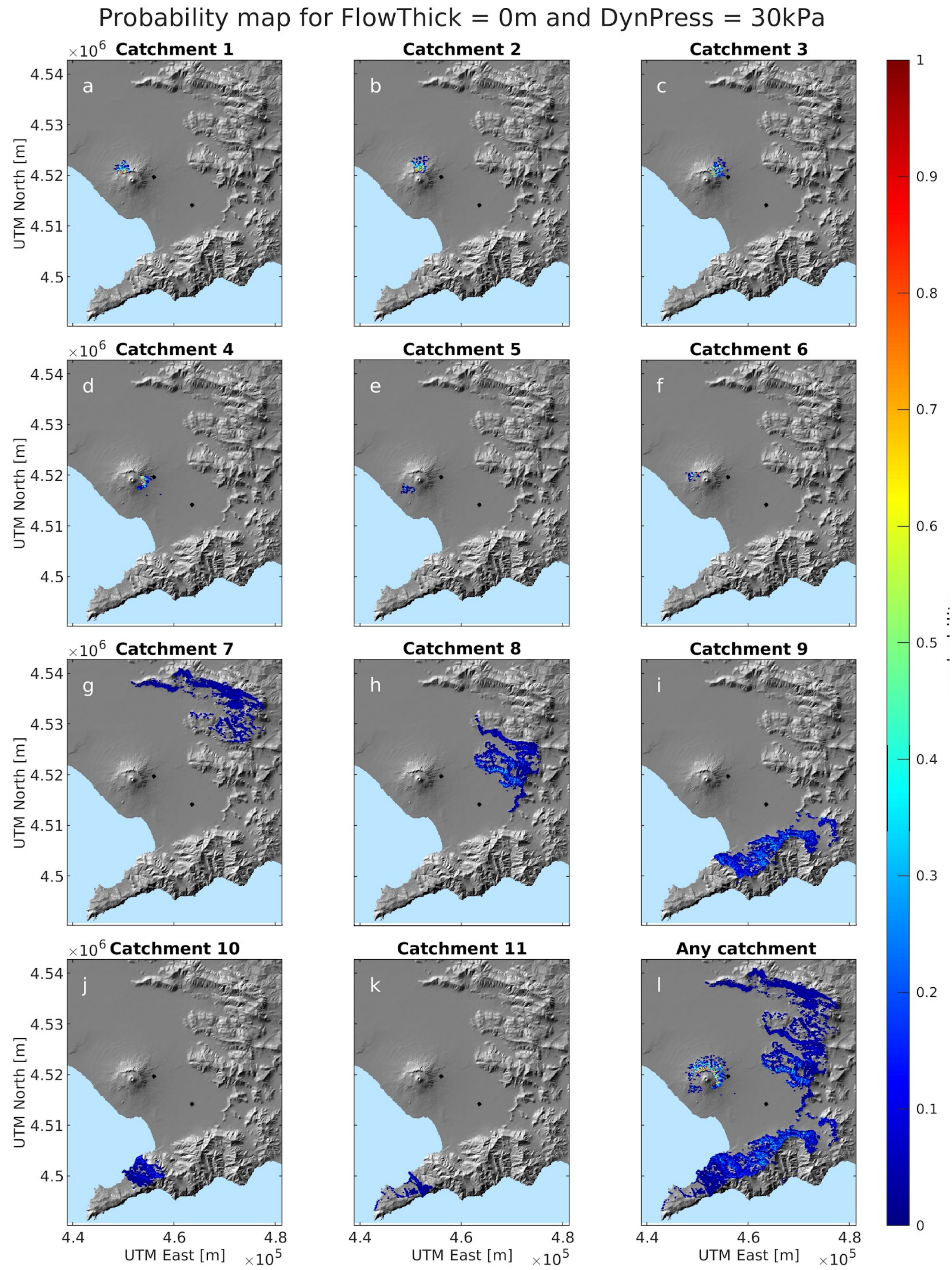


Figure SM36: Probability maps for dynamic pressure larger than 30 kPa

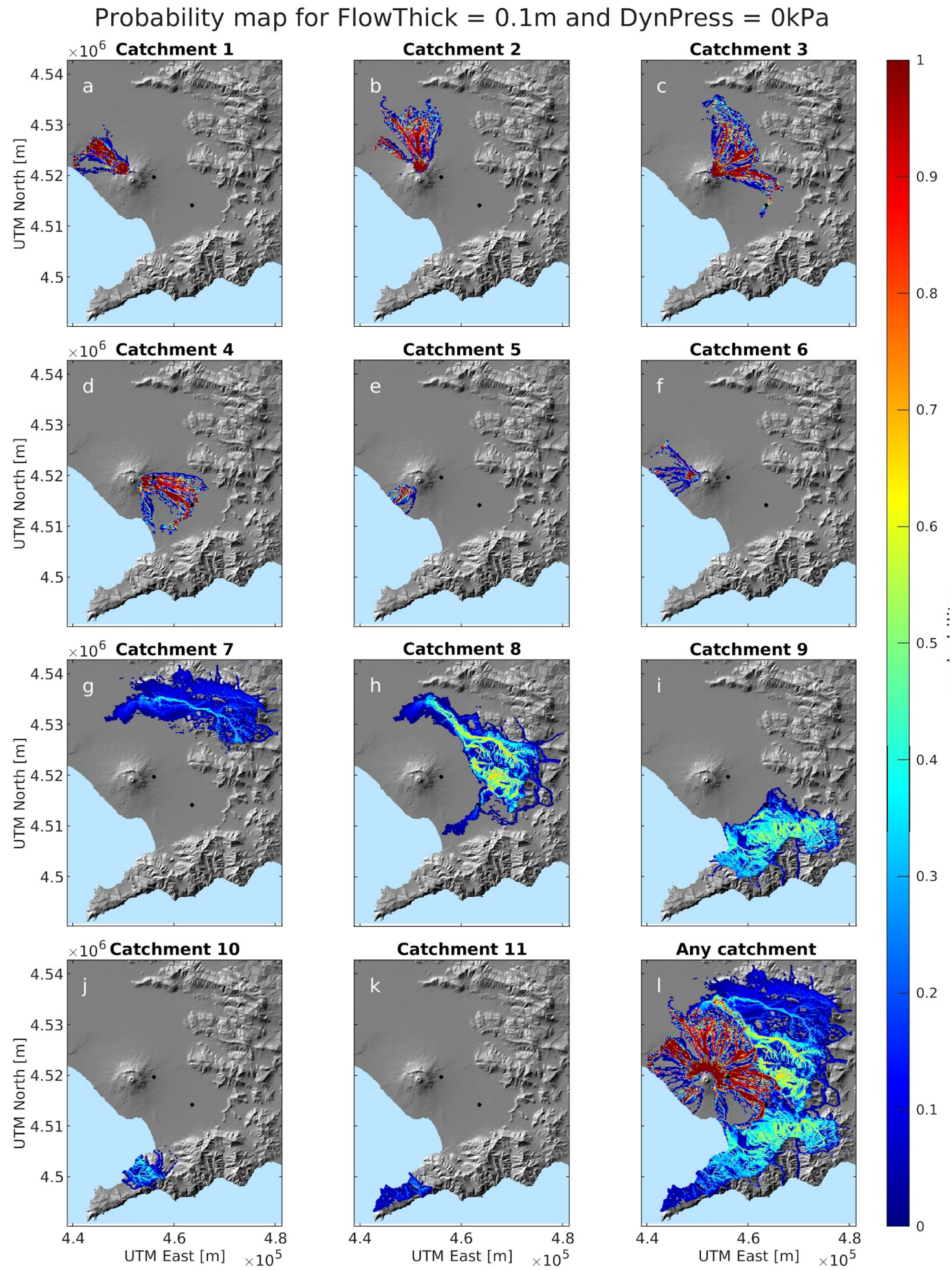


Figure SM37: Probability maps for overcoming a maximum flow thickness of 0.1 m

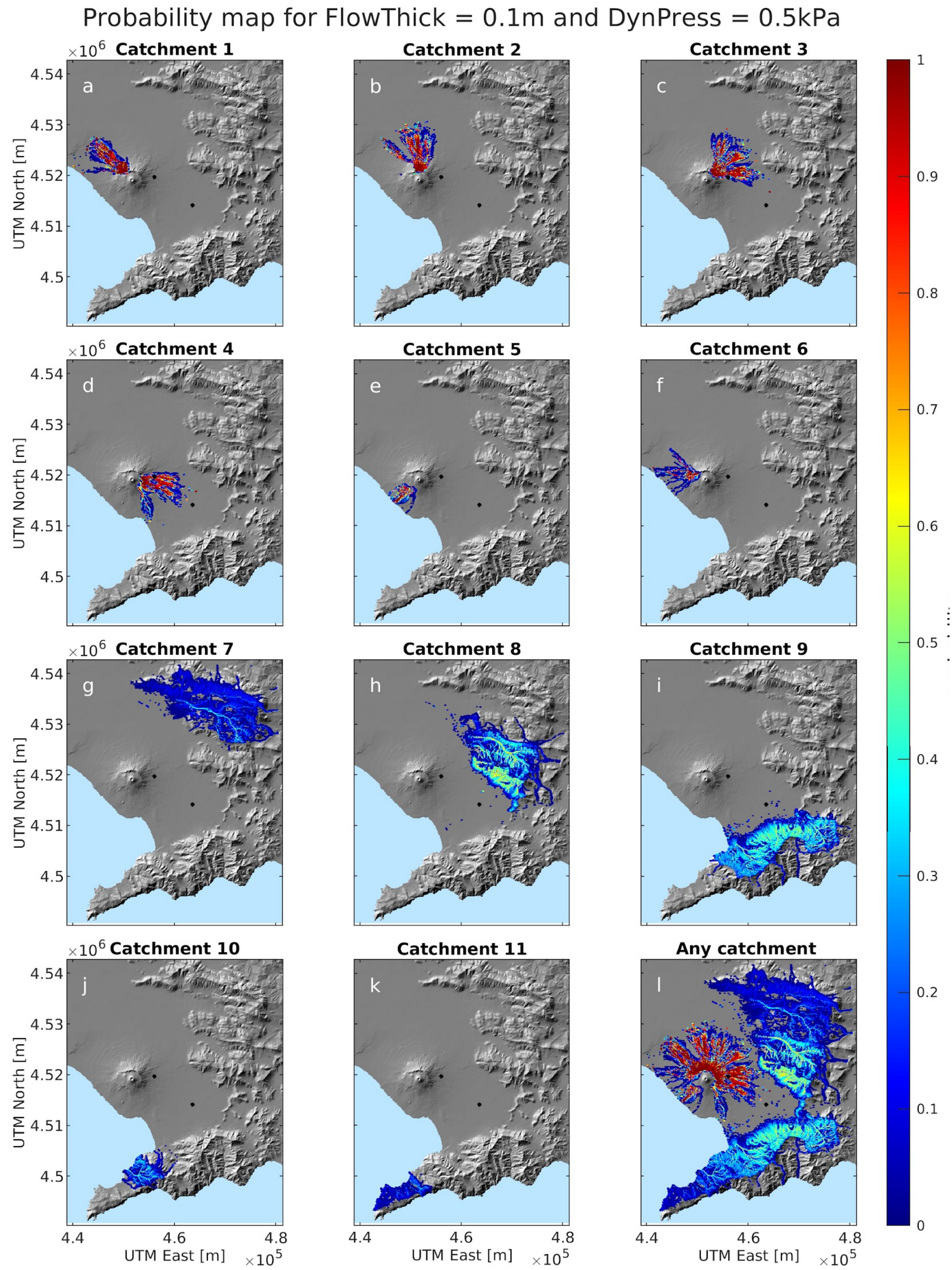


Figure SM38: Probability maps for simultaneously overcoming a maximum flow thickness of 0.1 m and a dynamic pressure of 0.5kPa

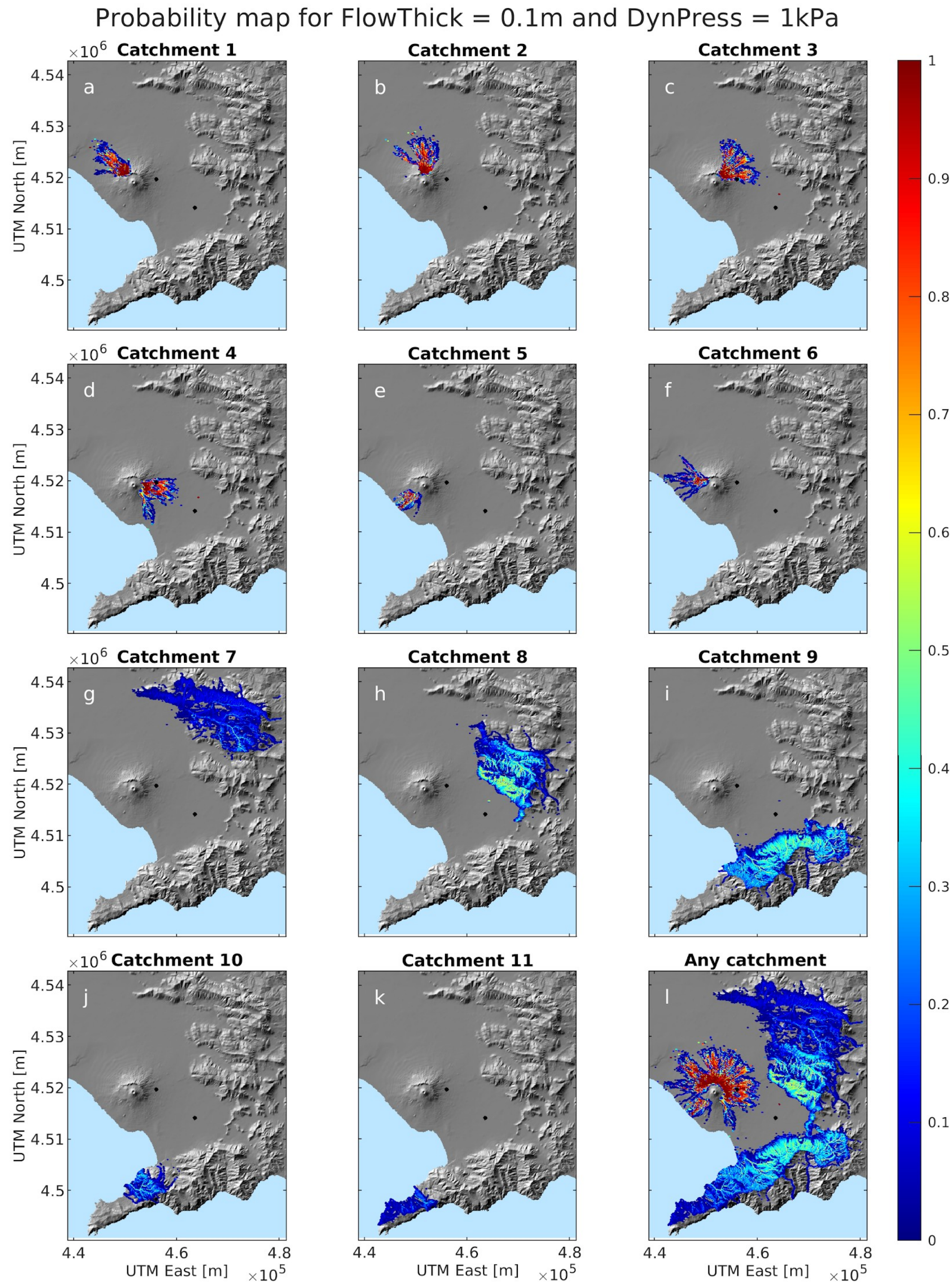


Figure SM39: Probability maps for simultaneously overcoming a maximum flow thickness of 0.1 m and a dynamic pressure of 1kPa

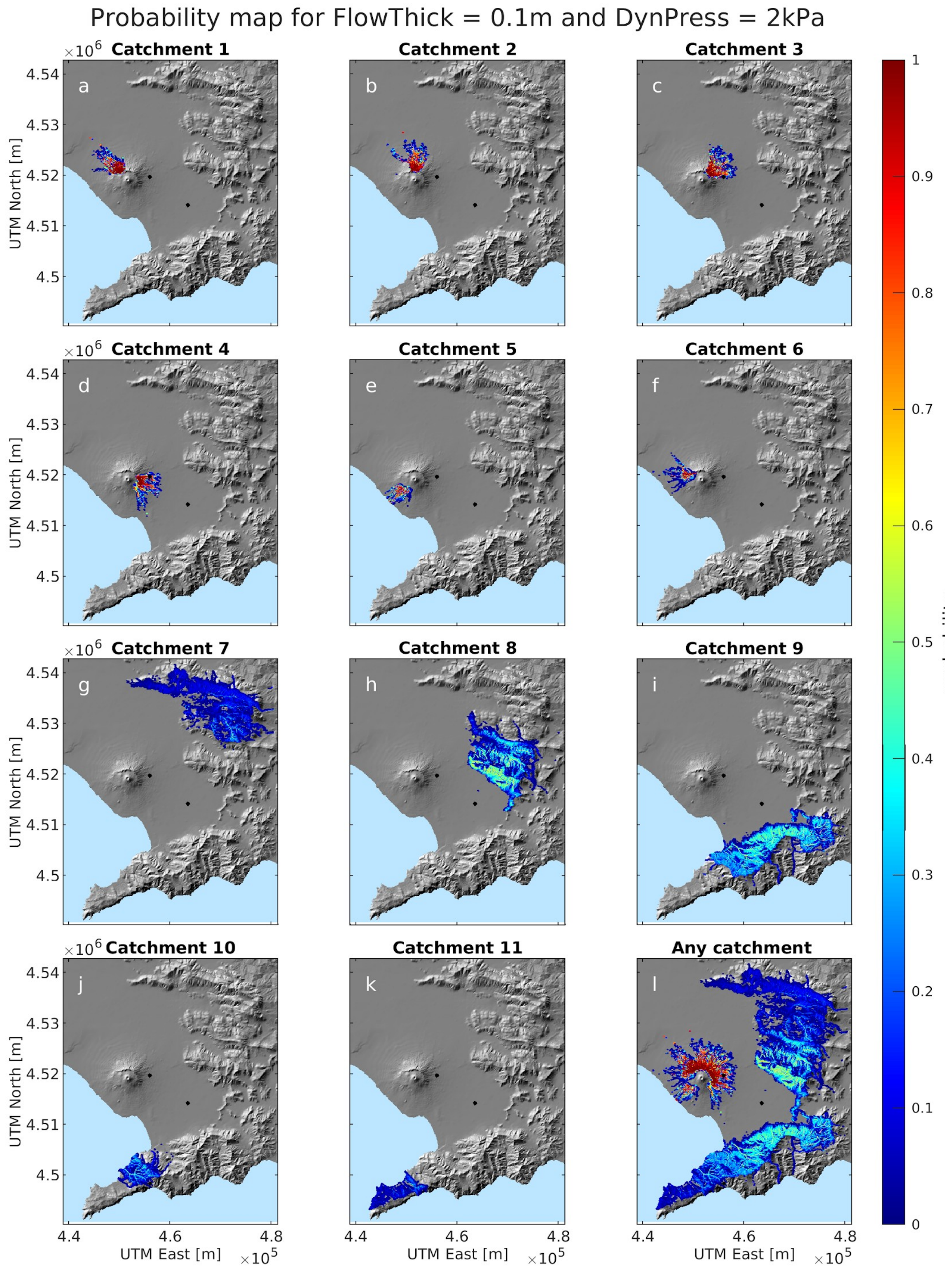


Figure SM40: Probability maps for simultaneously overcoming a maximum flow thickness of 0.1 m and a dynamic pressure of 2kPa

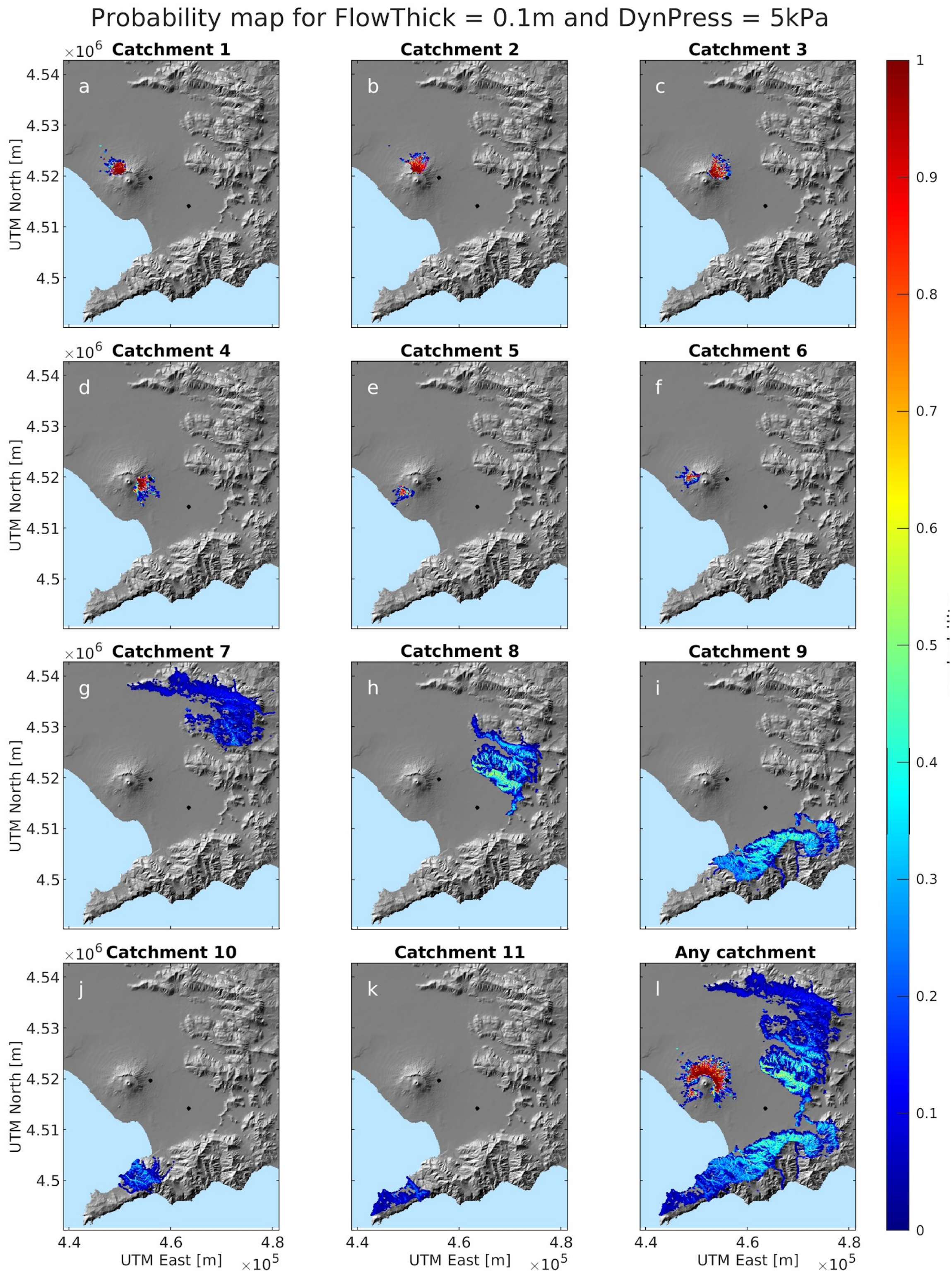


Figure SM41: Probability maps for simultaneously overcoming a maximum flow thickness of 0.1 m and a dynamic pressure of 5kPa

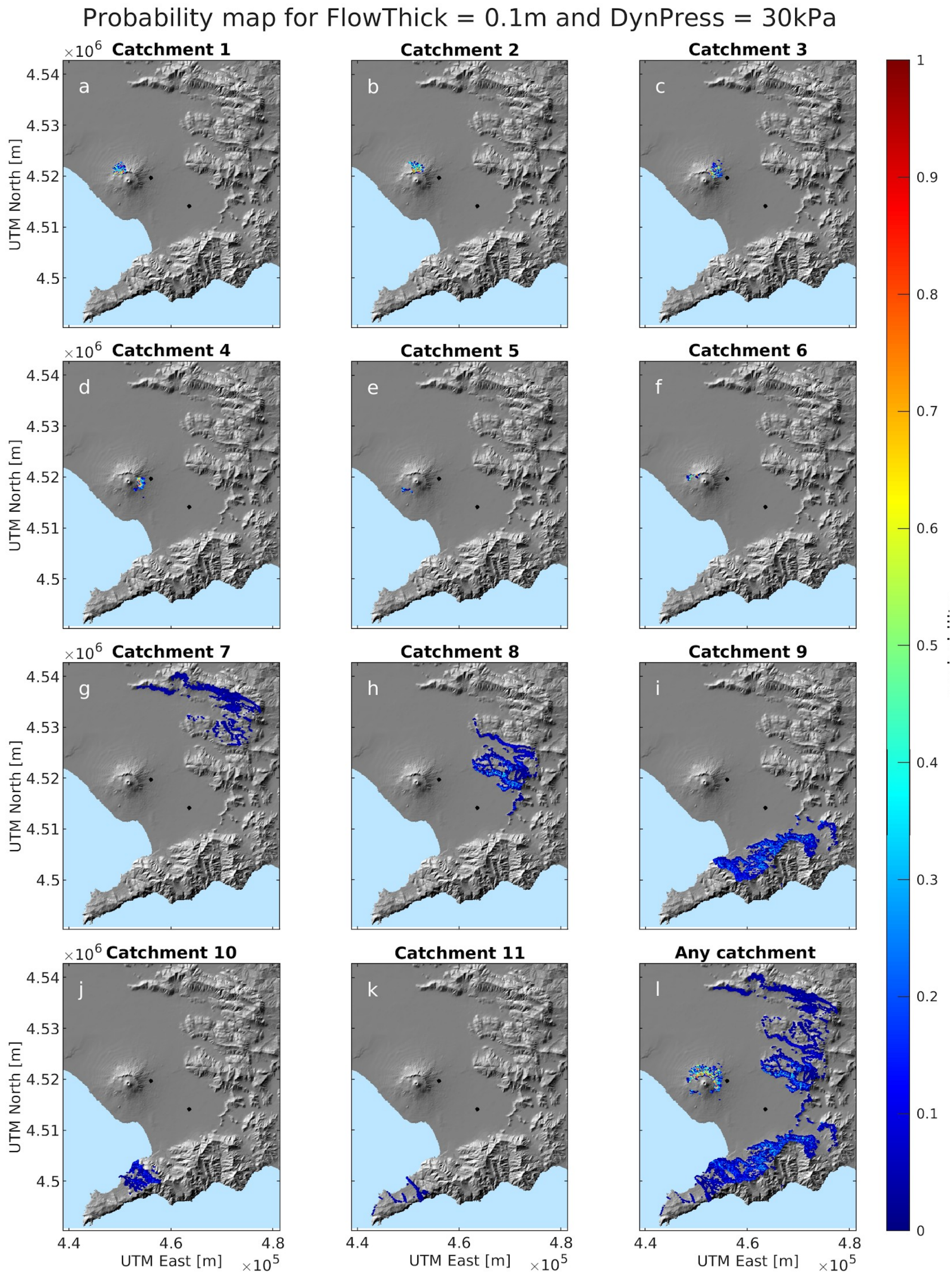


Figure SM42: Probability maps for simultaneously overcoming a maximum flow thickness of 0.1 m and a dynamic pressure of 30kPa

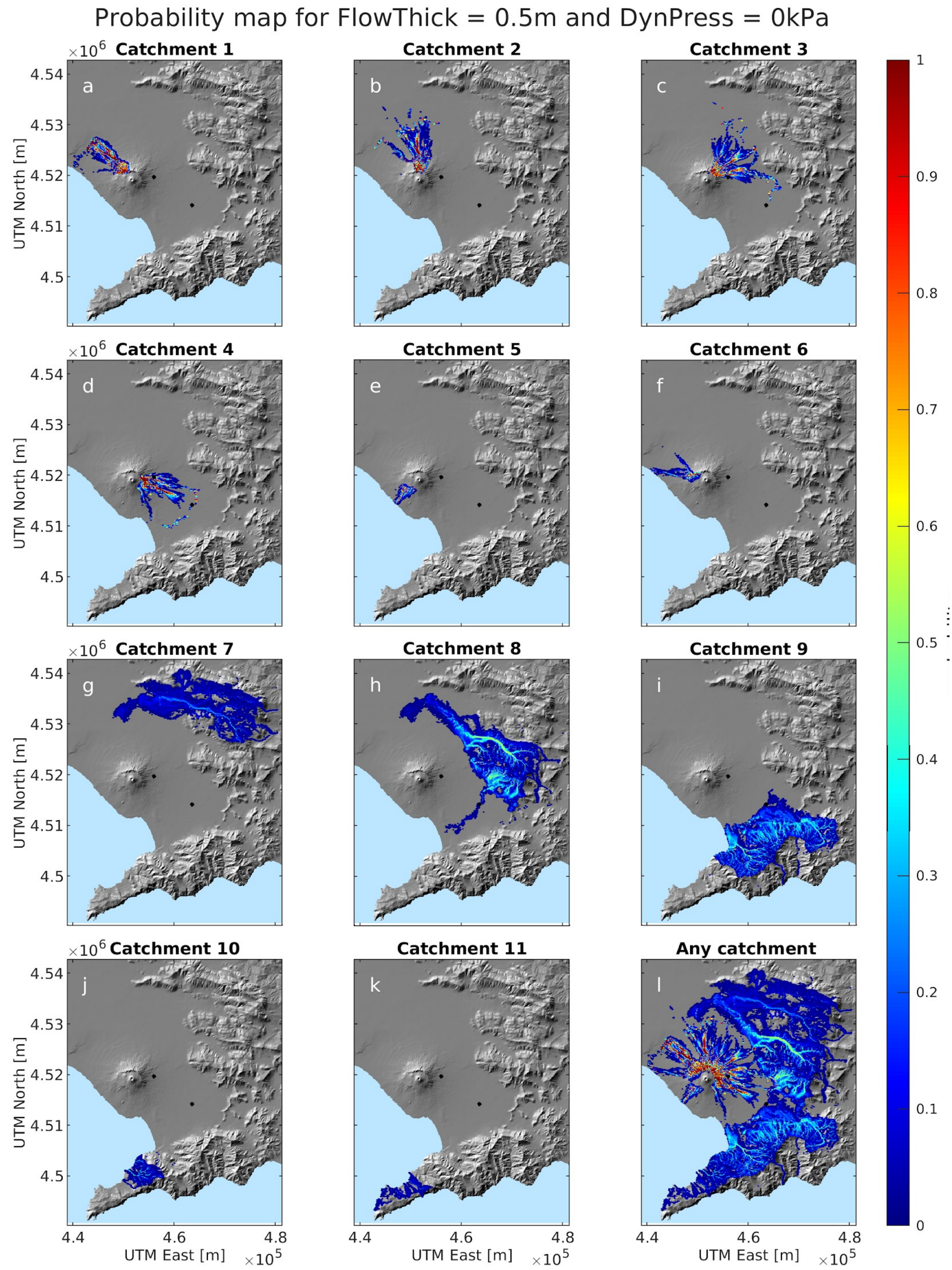


Figure SM43: Probability maps for overcoming a maximum flow thickness of 0.5 m

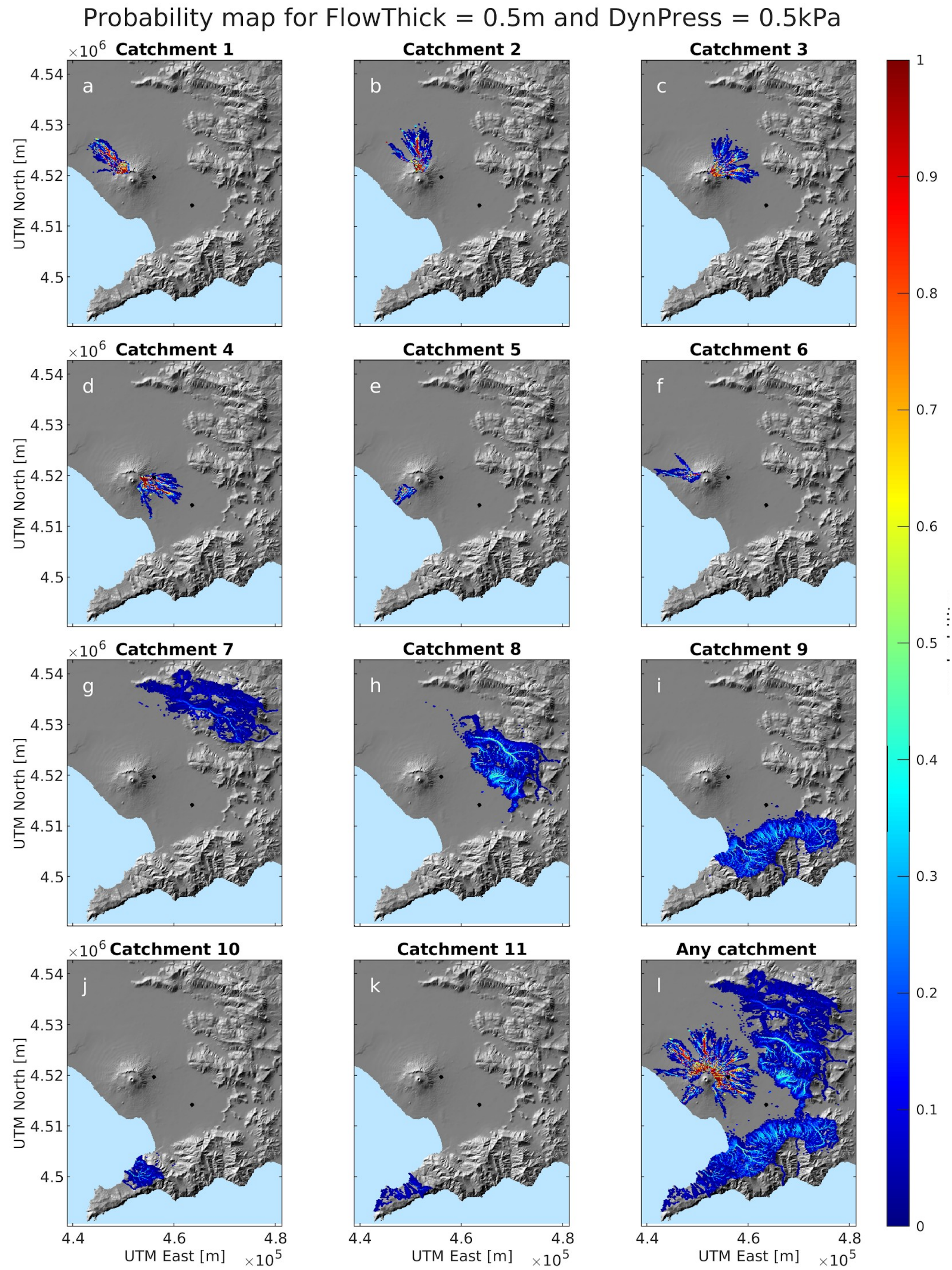


Figure SM44: Probability maps for simultaneously overcoming a maximum flow thickness of 0.5 m and a dynamic pressure of 0.5kPa

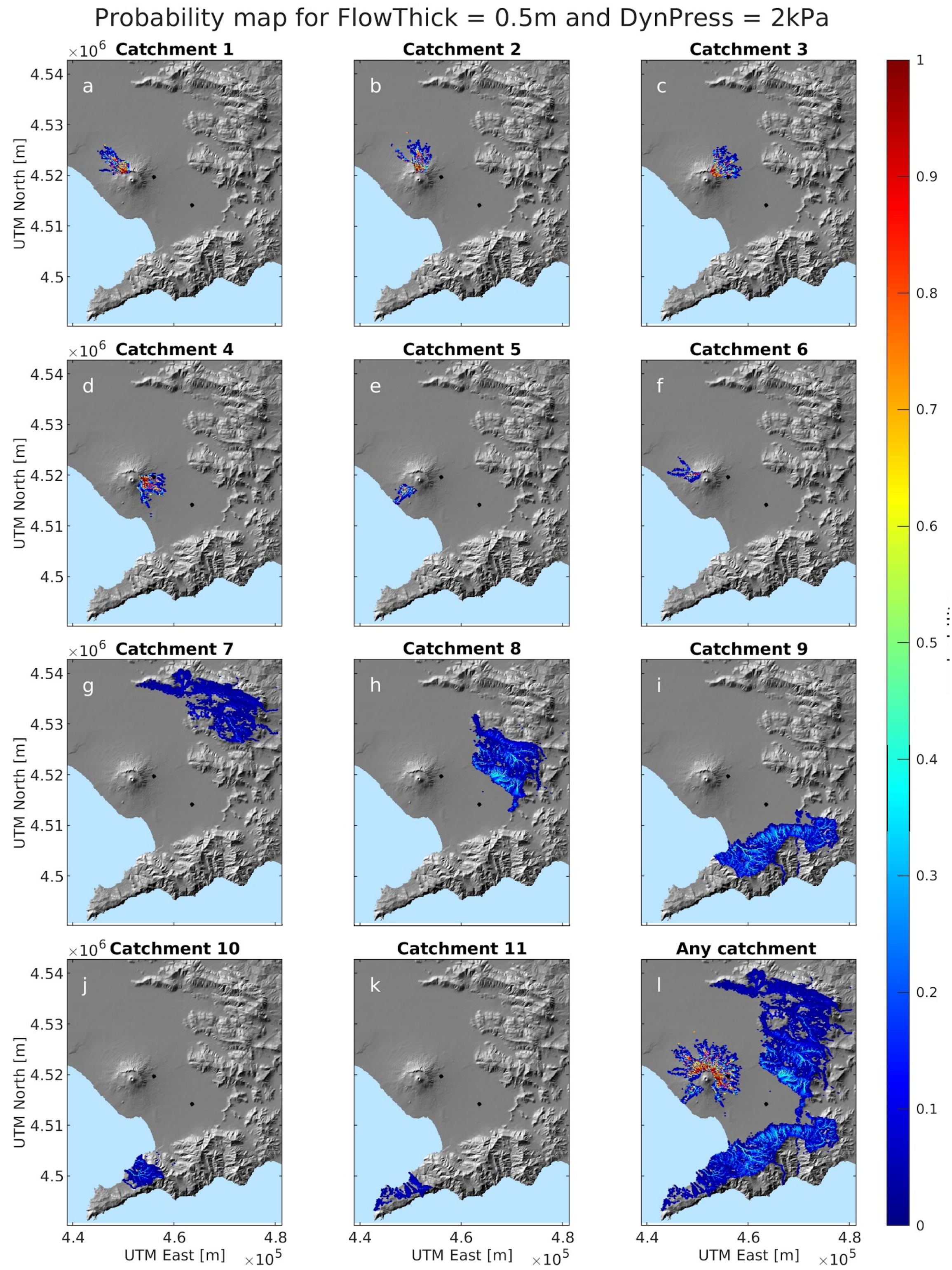


Figure SM45: Probability maps for simultaneously overcoming a maximum flow thickness of 0.5 m and a dynamic pressure of 2 kPa

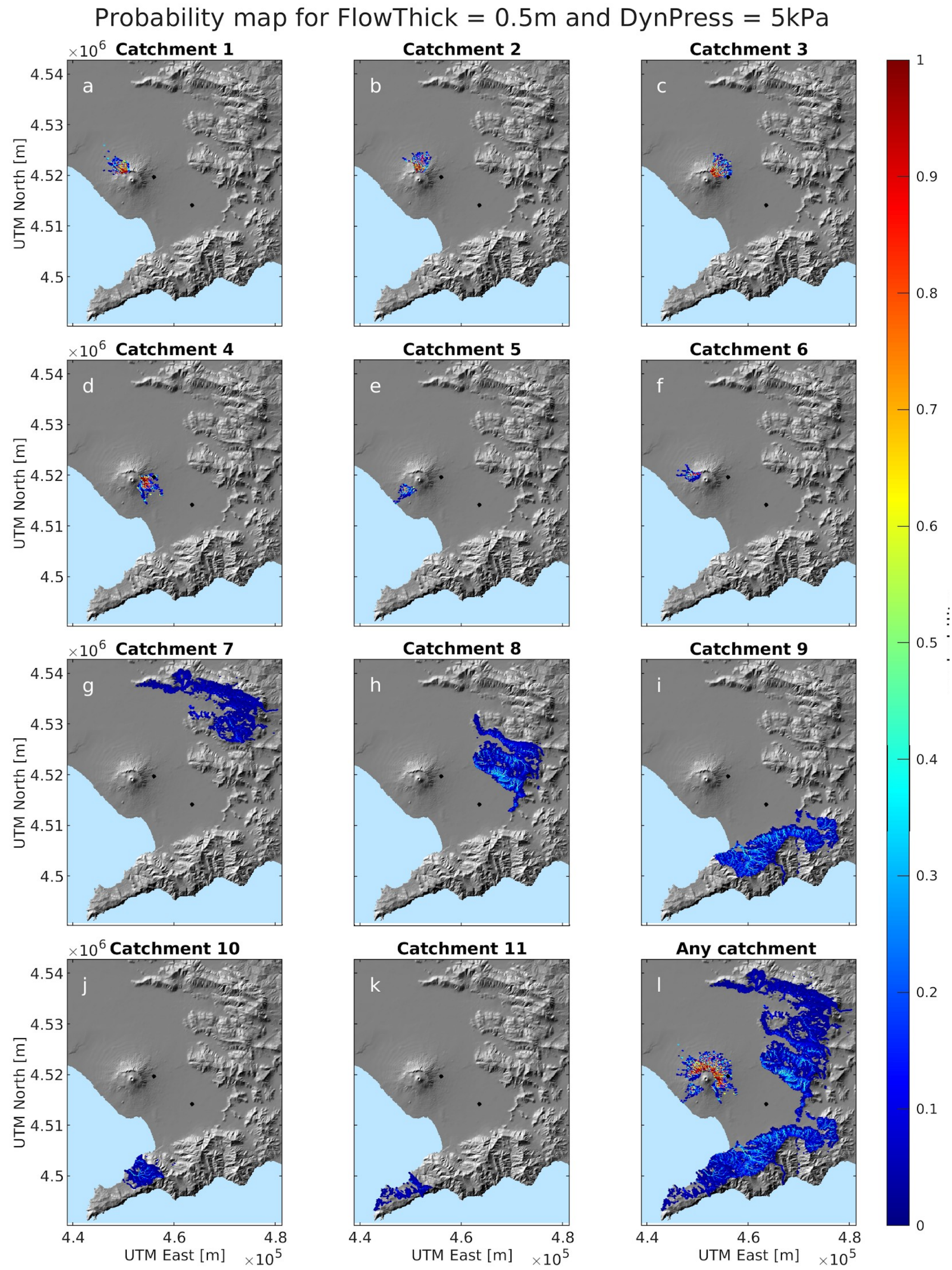


Figure SM46: Probability maps for simultaneously overcoming a maximum flow thickness of 0.5 m and a dynamic pressure of 5 kPa

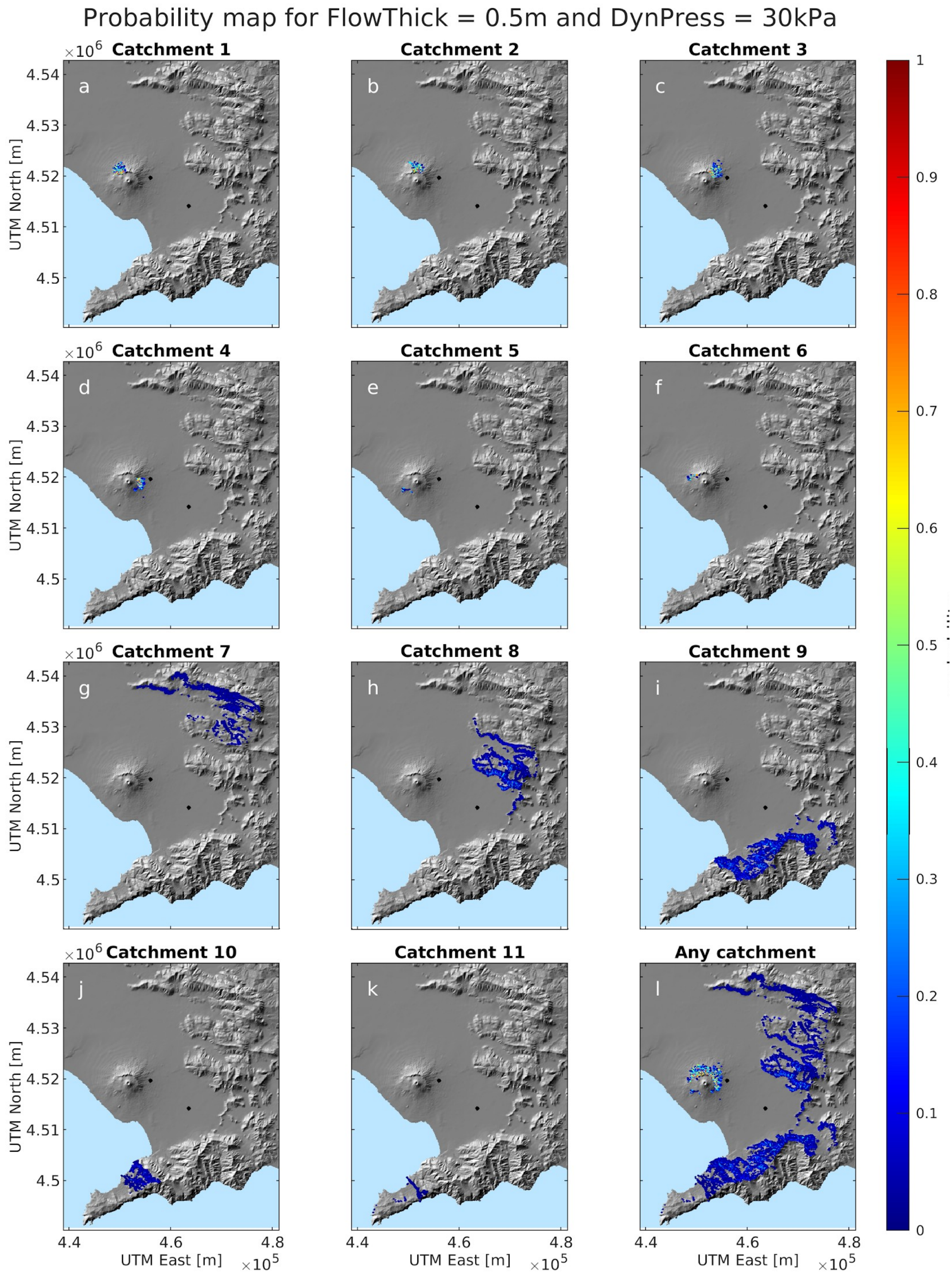


Figure SM47: Probability maps for simultaneously overcoming a maximum flow thickness of 0.5 m and a dynamic pressure of 30 kPa

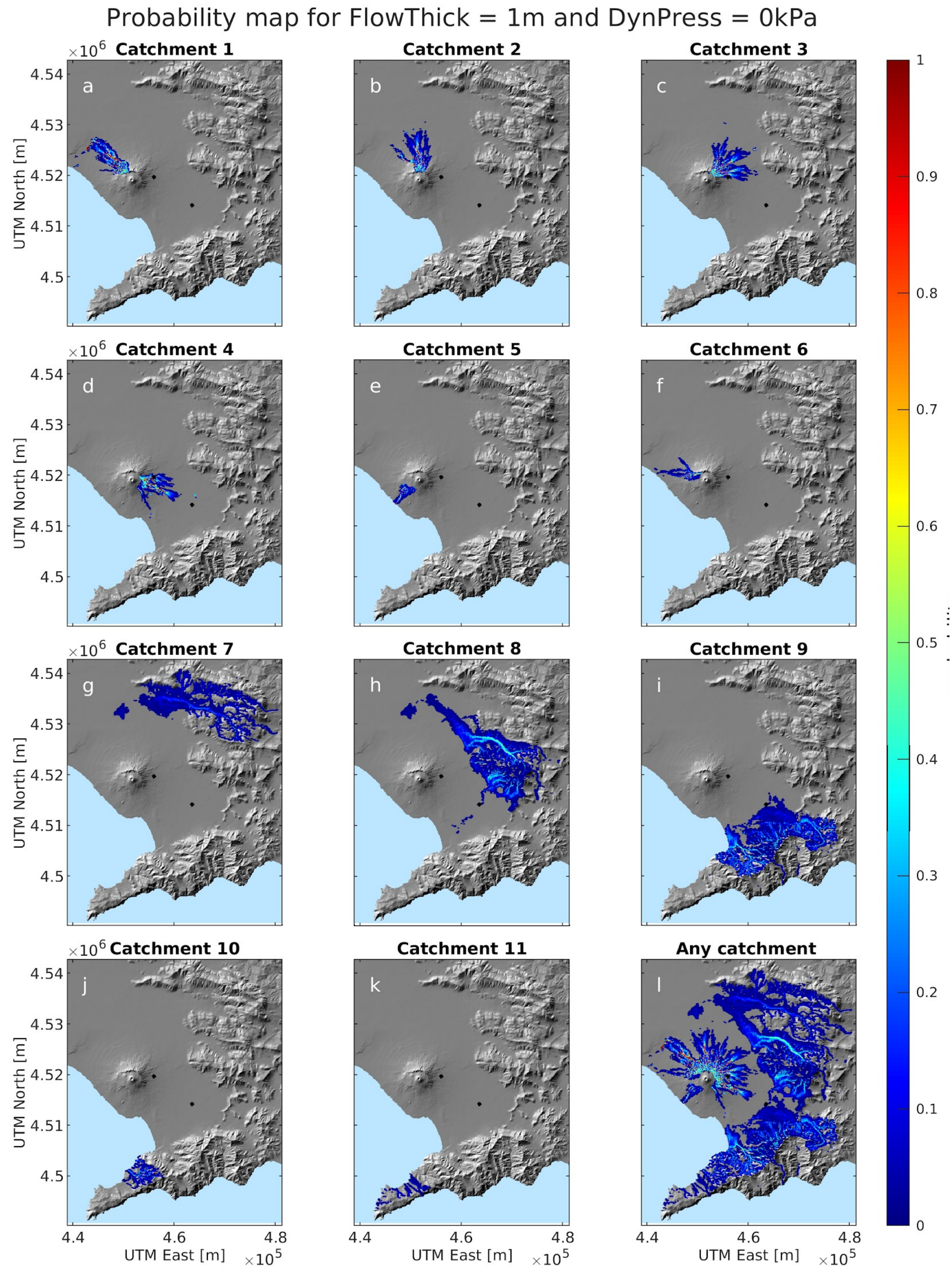


Figure SM48: Probability maps for overcoming a maximum flow thickness of 1 m

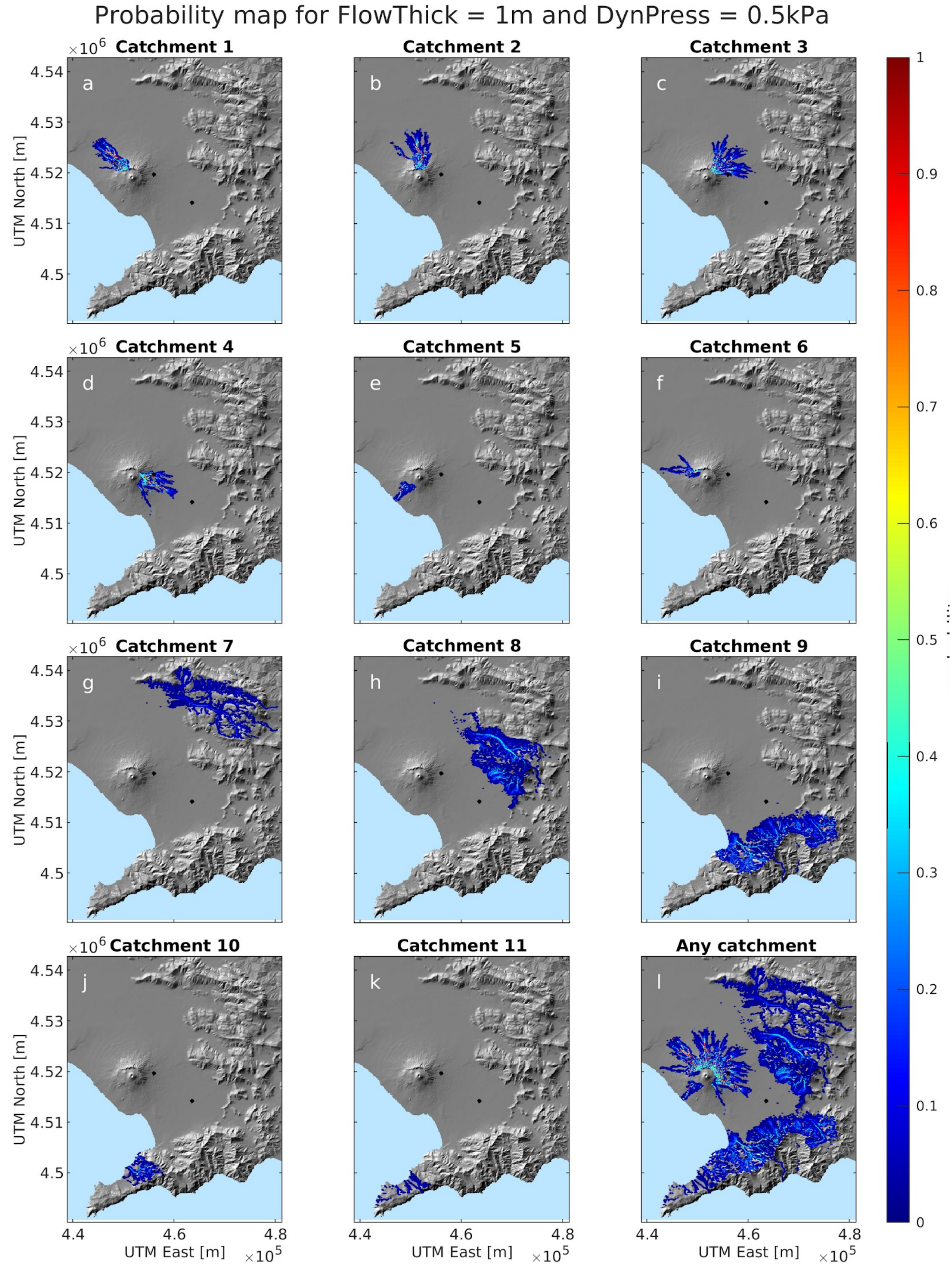


Figure SM49: Probability maps for simultaneously overcoming a maximum flow thickness of 1 m and a dynamic pressure of 0.5 kPa

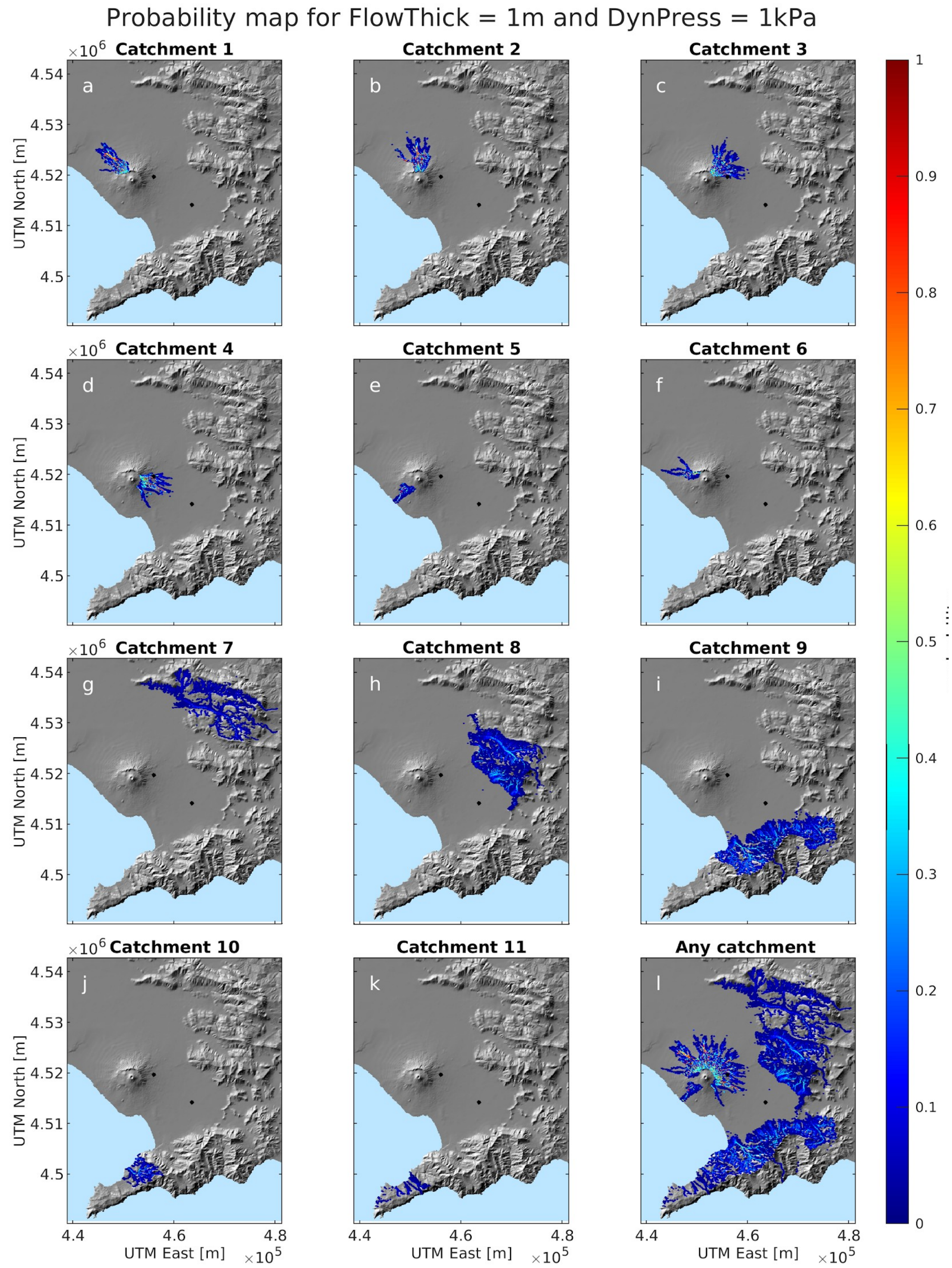


Figure SM50: Probability maps for simultaneously overcoming a maximum flow thickness of 1 m and a dynamic pressure of 1 kPa

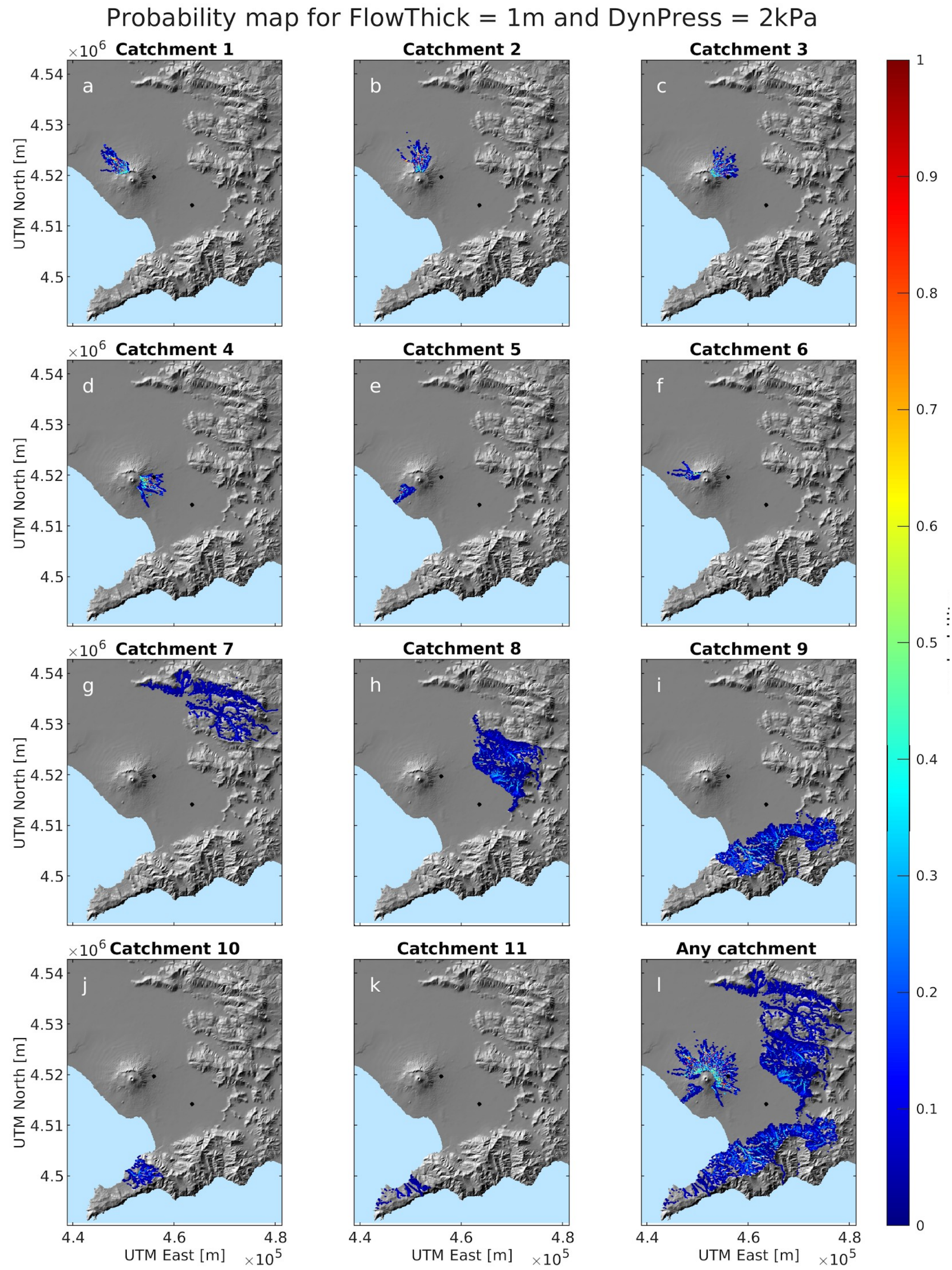


Figure SM51: Probability maps for simultaneously overcoming a maximum flow thickness of 1 m and a dynamic pressure of 2 kPa

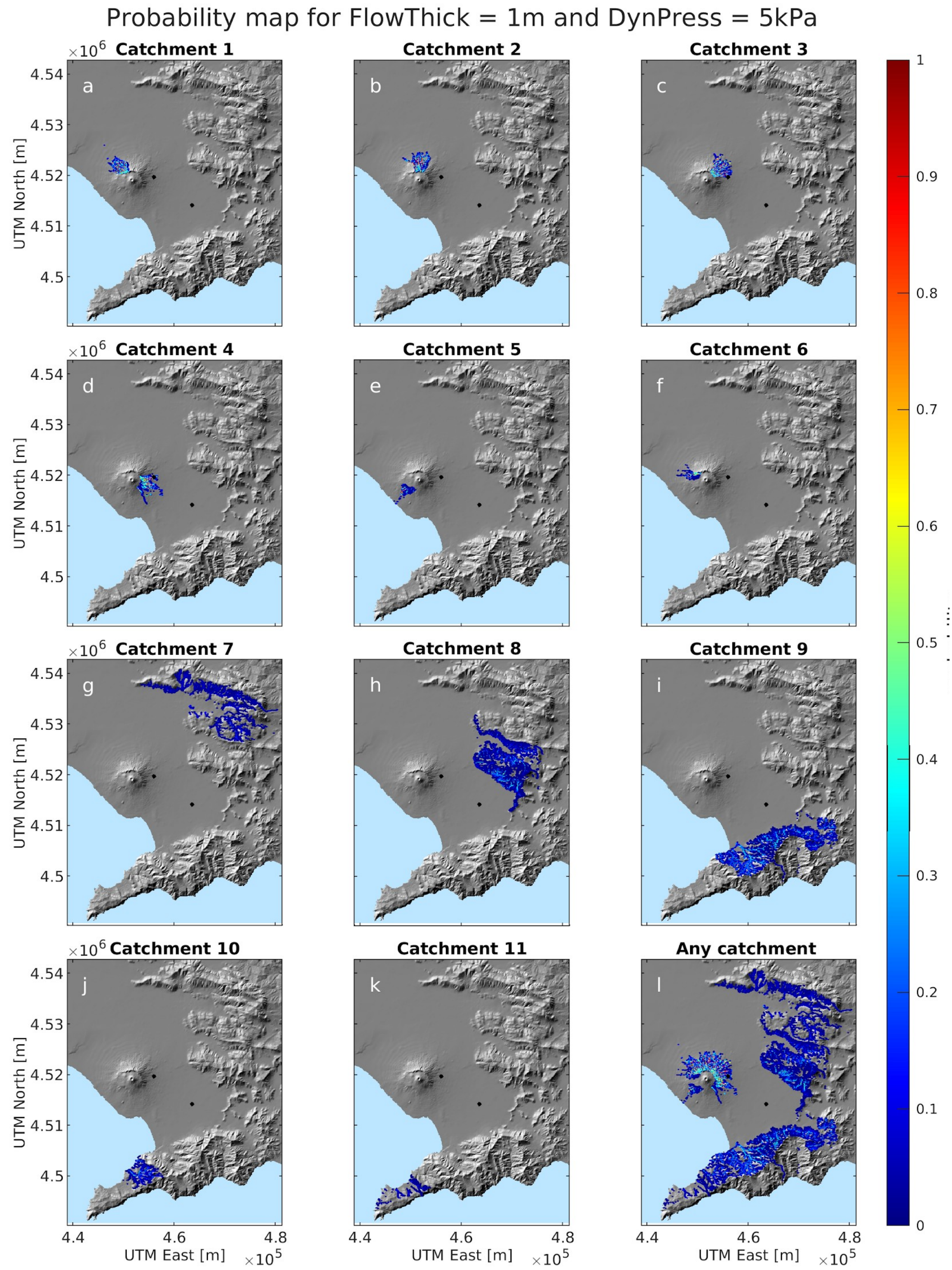


Figure SM52: Probability maps for simultaneously overcoming a maximum flow thickness of 1 m and a dynamic pressure of 5 kPa

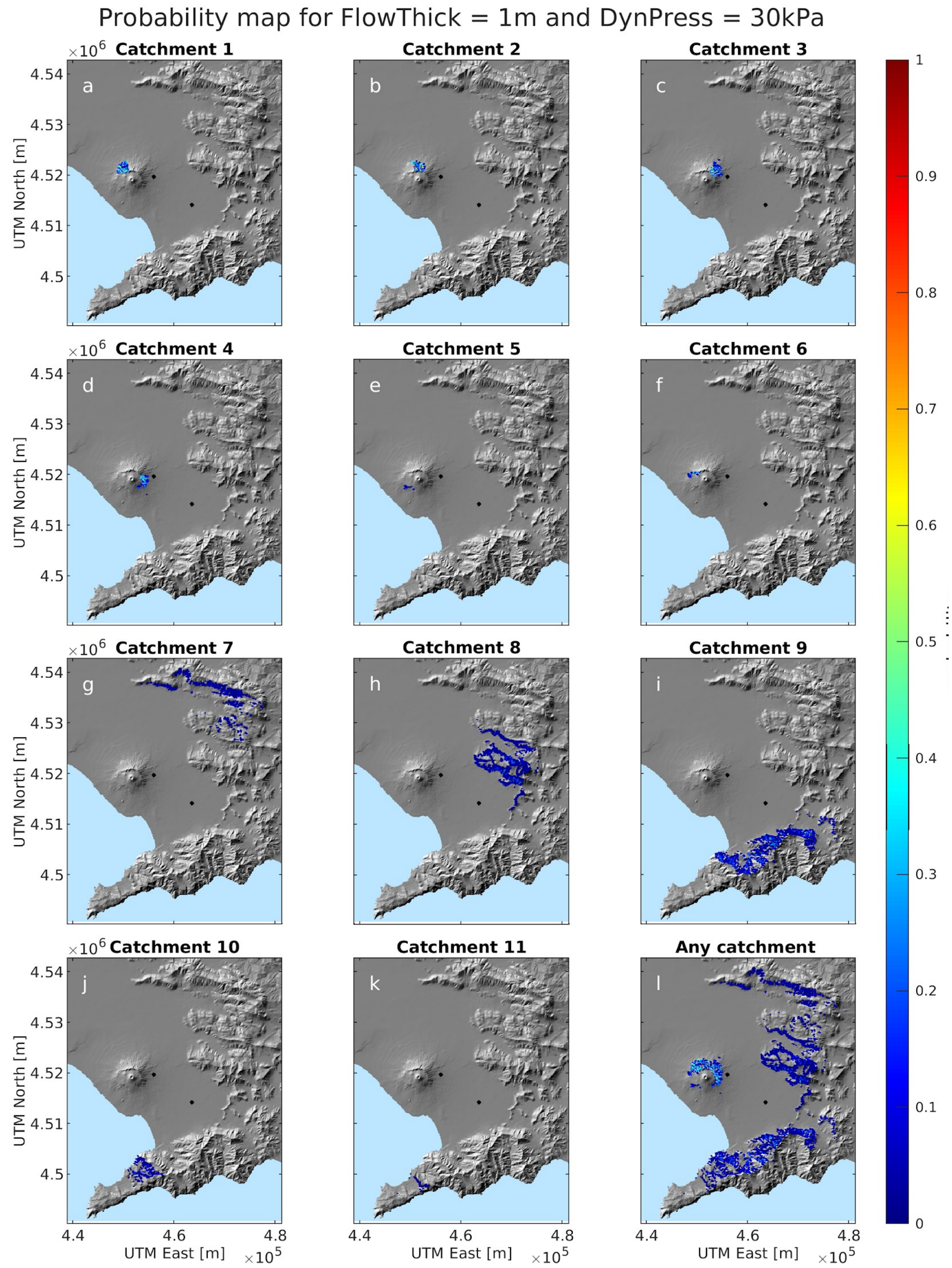


Figure SM53: Probability maps for simultaneously overcoming a maximum flow thickness of 1 m and a dynamic pressure of 30 kPa

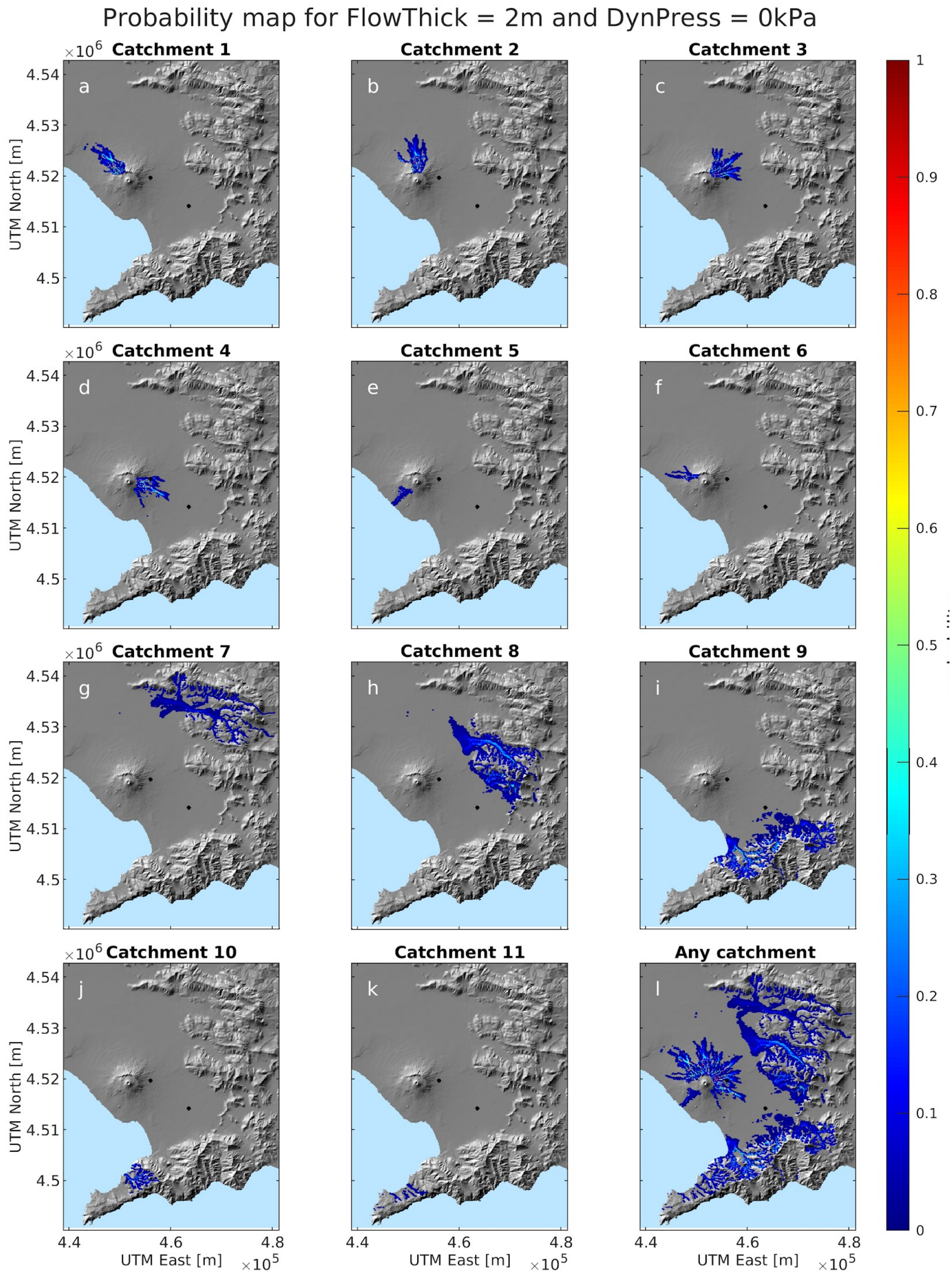


Figure SM54: Probability maps for overcoming a maximum flow thickness of 2 m

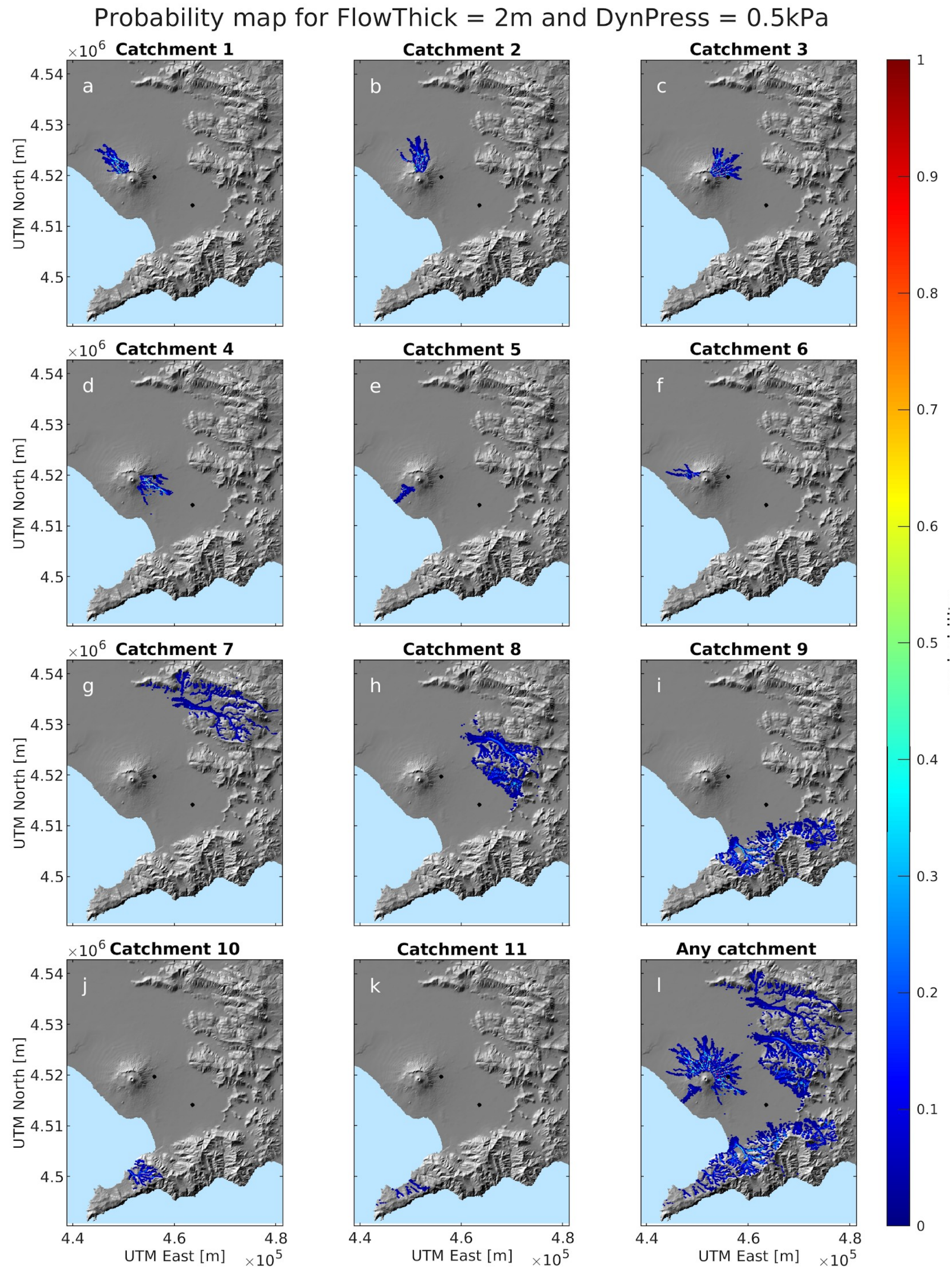


Figure SM55: Probability maps for simultaneously overcoming a maximum flow thickness of 2 m and a dynamic pressure of 0.5 kPa

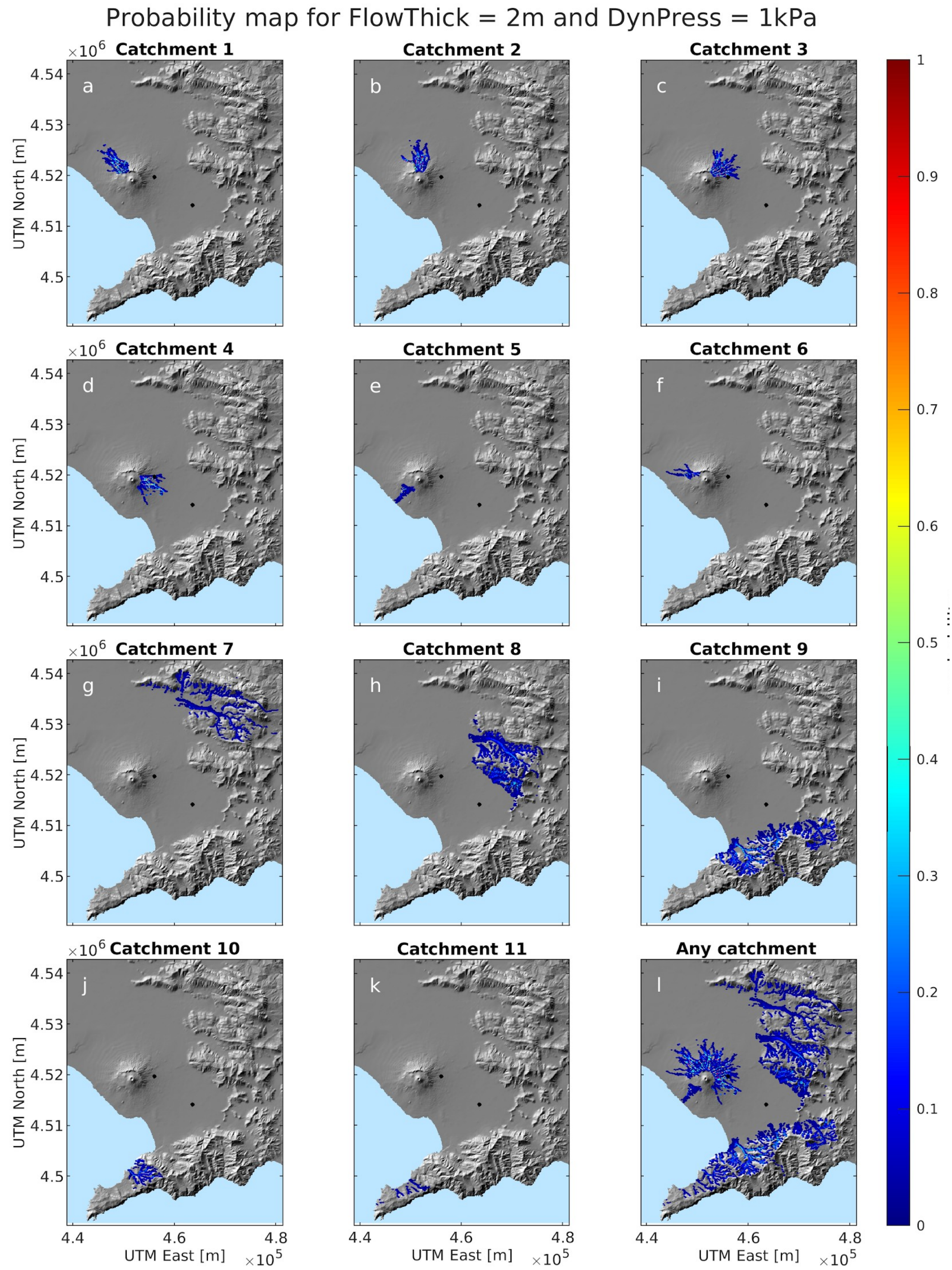


Figure SM56: Probability maps for simultaneously overcoming a maximum flow thickness of 2 m and a dynamic pressure of 1 kPa

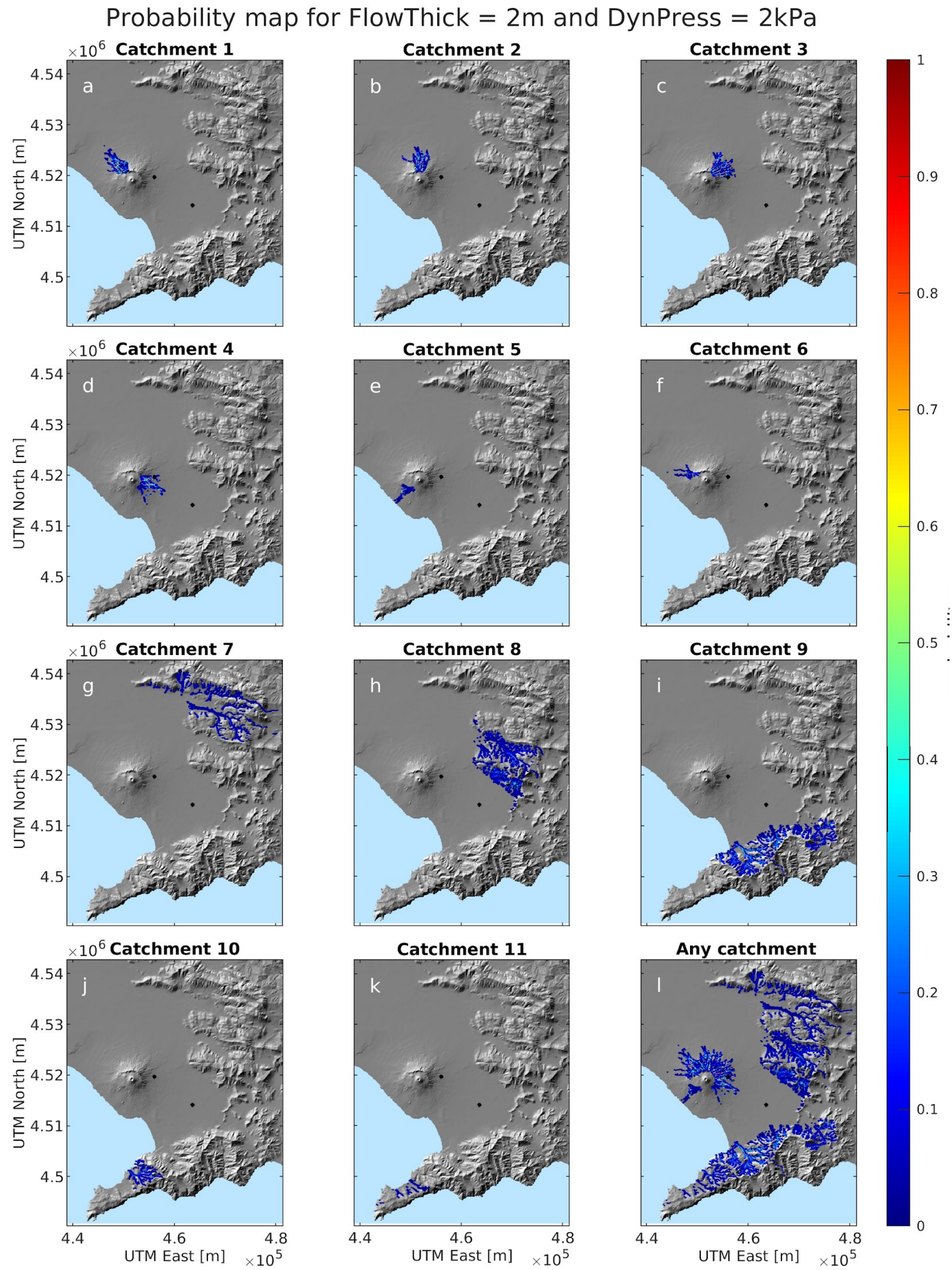


Figure SM57: Probability maps for simultaneously overcoming a maximum flow thickness of 2 m and a dynamic pressure of 2 kPa

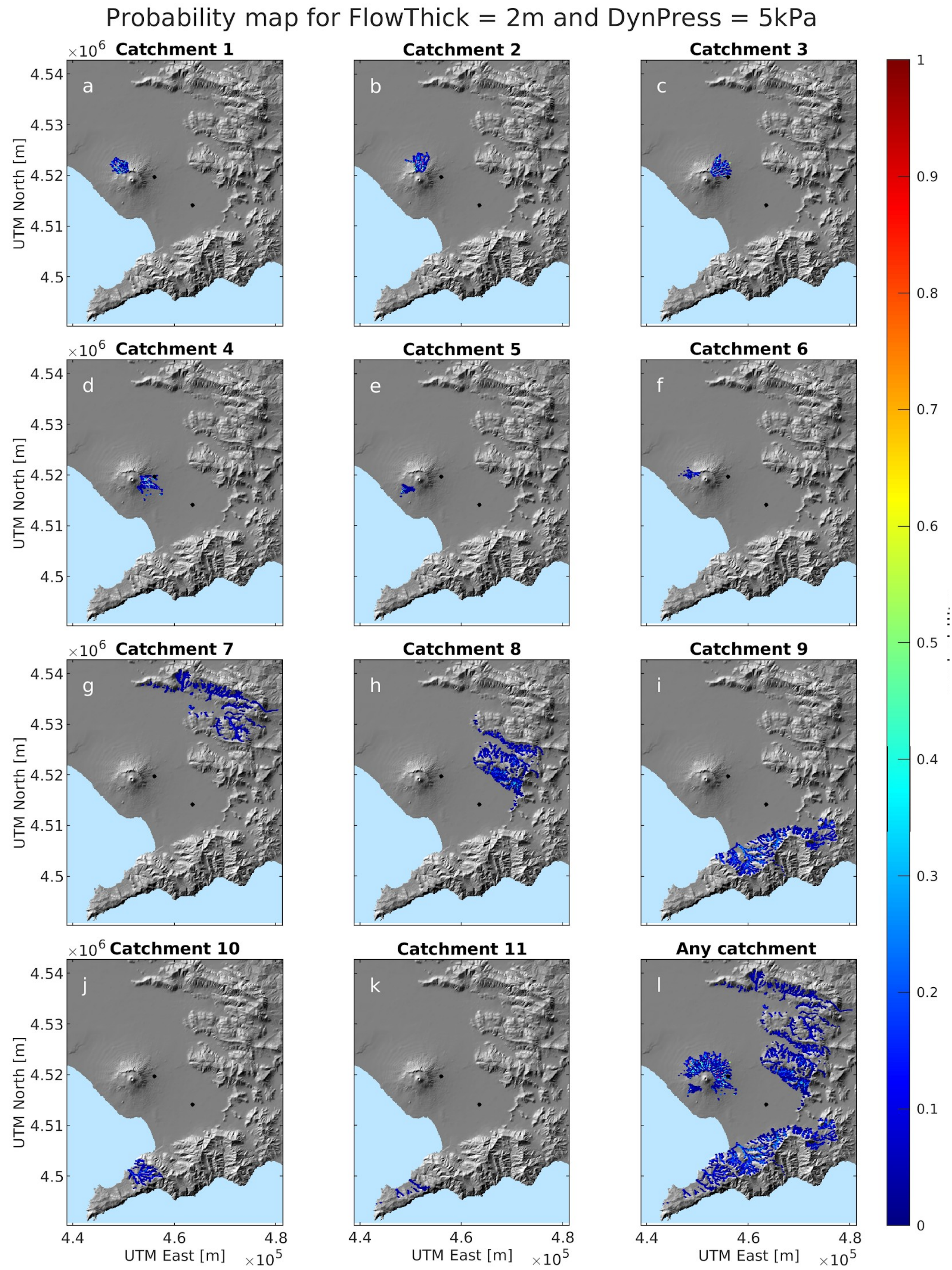


Figure SM58: Probability maps for simultaneously overcoming a maximum flow thickness of 2 m and a dynamic pressure of 5 kPa

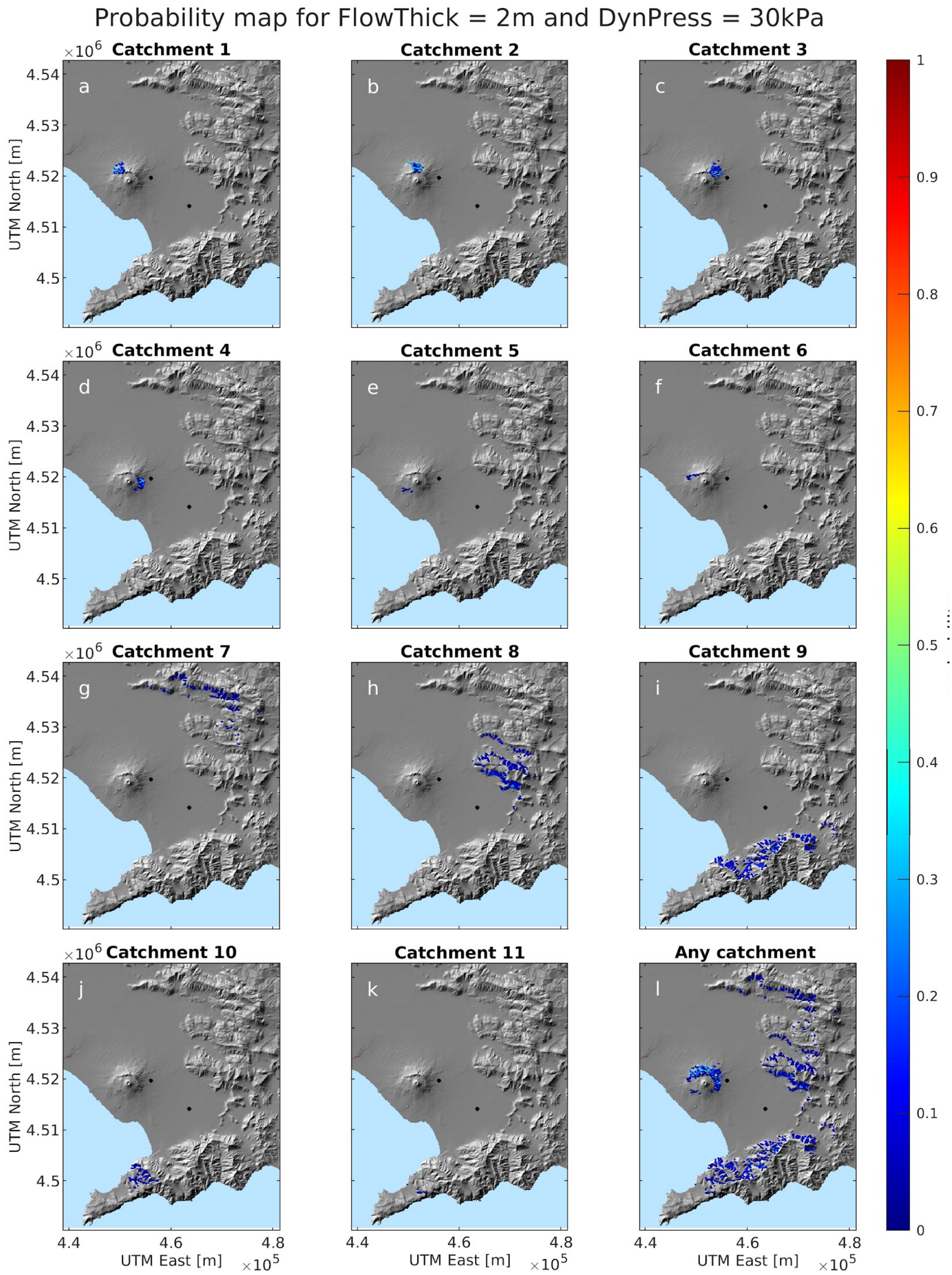


Figure SM59: Probability maps for simultaneously overcoming a maximum flow thickness of 2 m and a dynamic pressure of 30 kPa

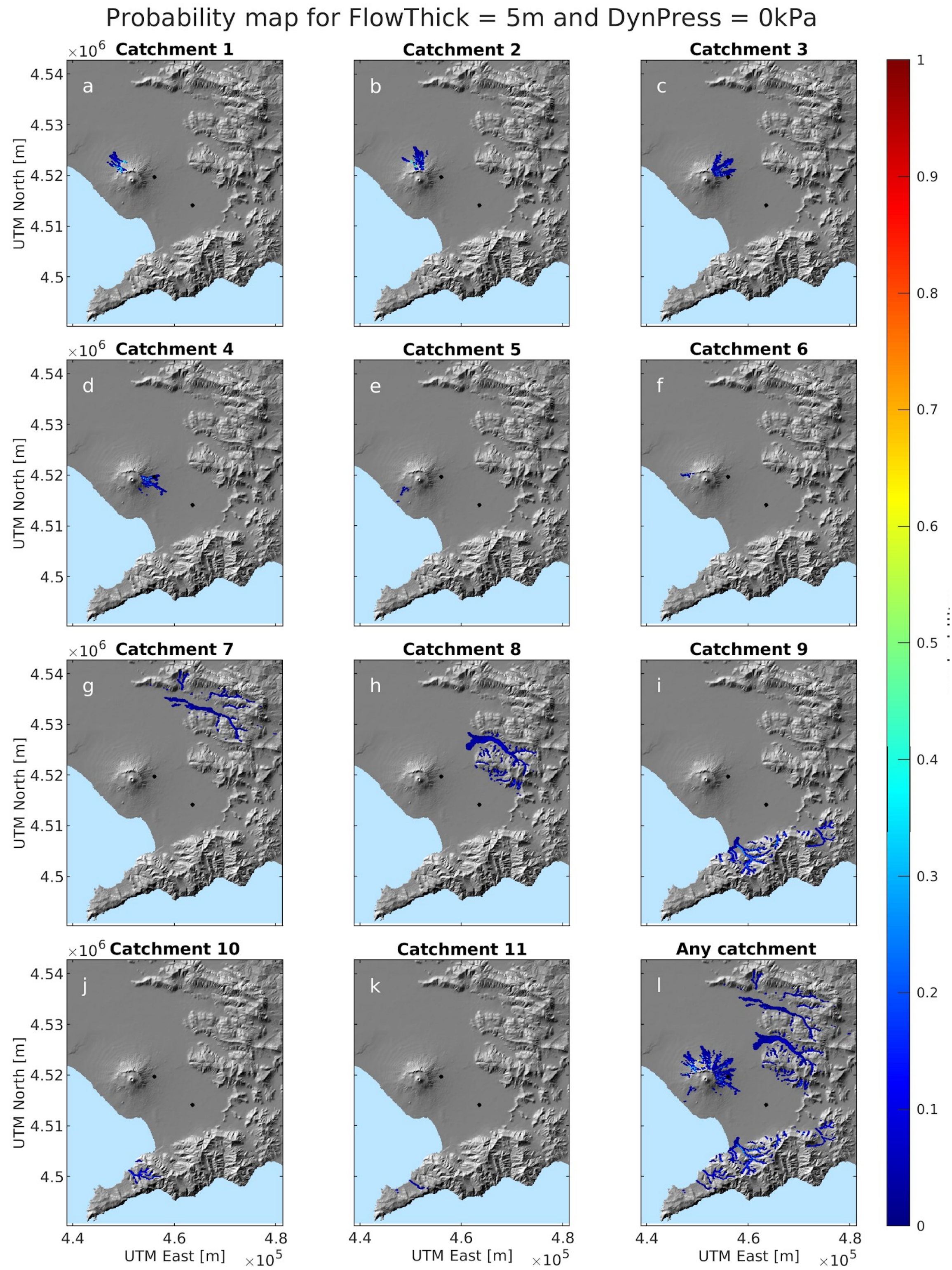


Figure SM60: Probability maps for overcoming a maximum flow thickness of 5 m

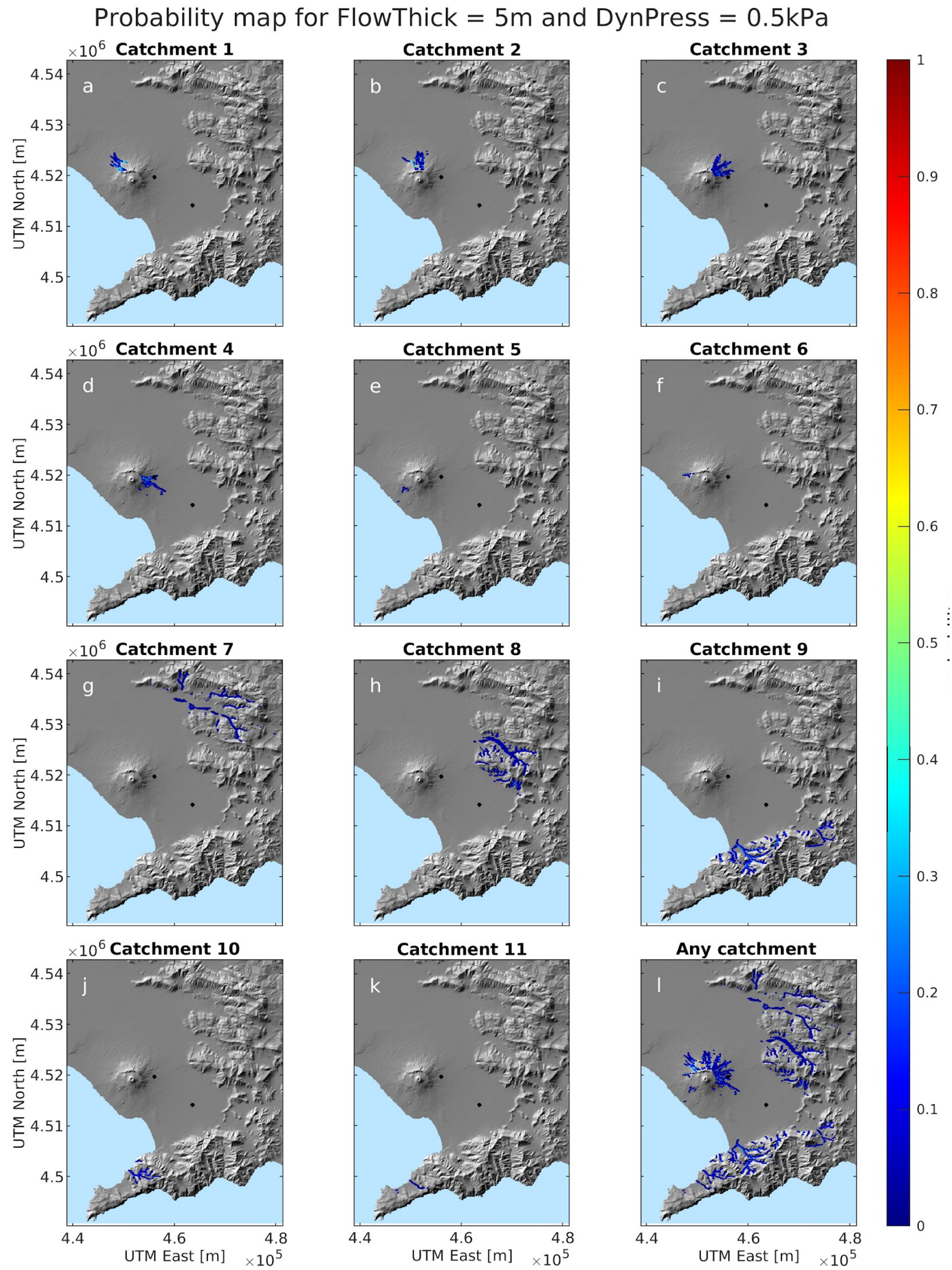


Figure SM61: Probability maps for simultaneously overcoming a maximum flow thickness of 5 m and a dynamic pressure of 0.5 kPa

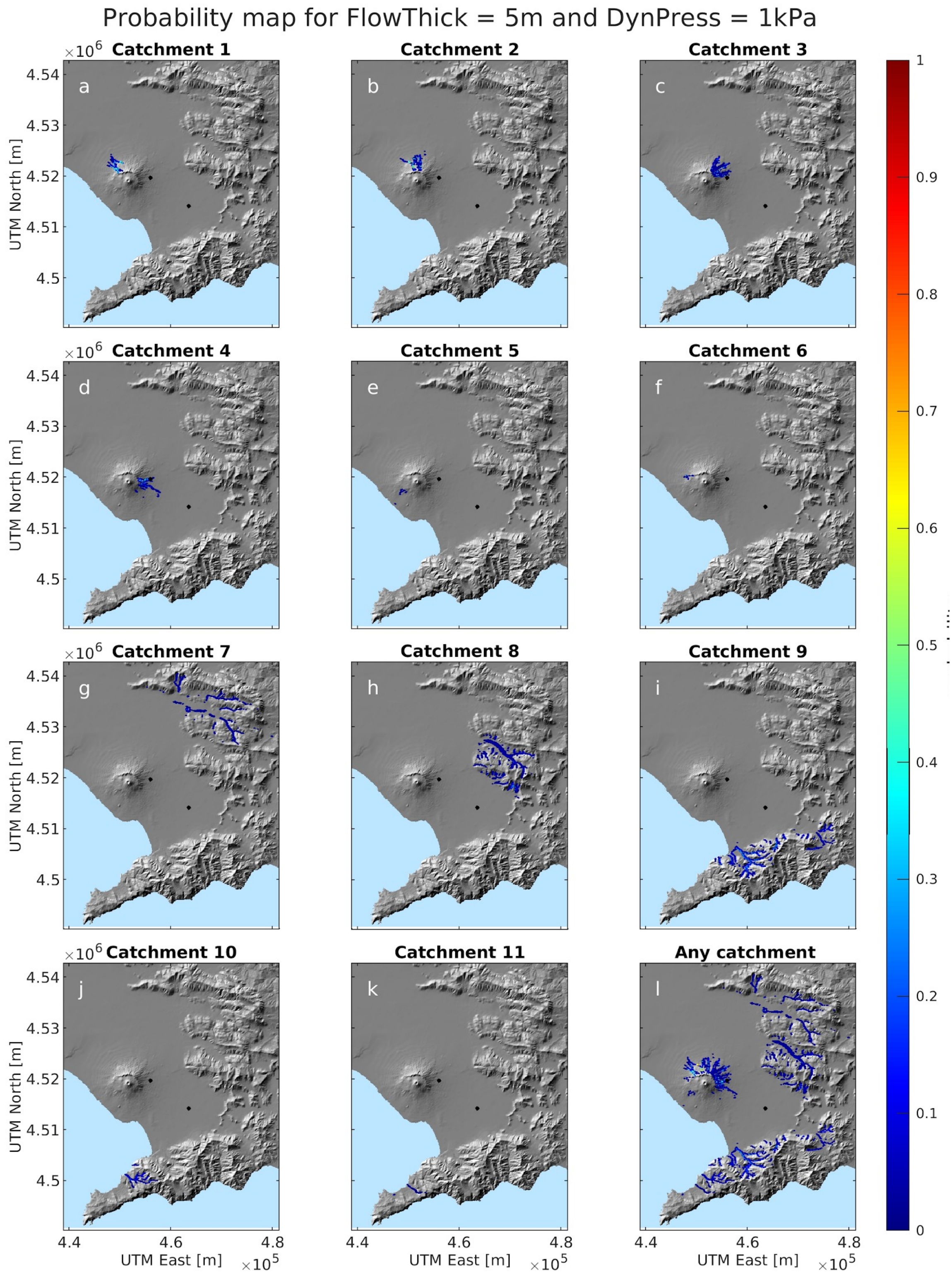


Figure SM62: Probability maps for simultaneously overcoming a maximum flow thickness of 5 m and a dynamic pressure of 1 kPa

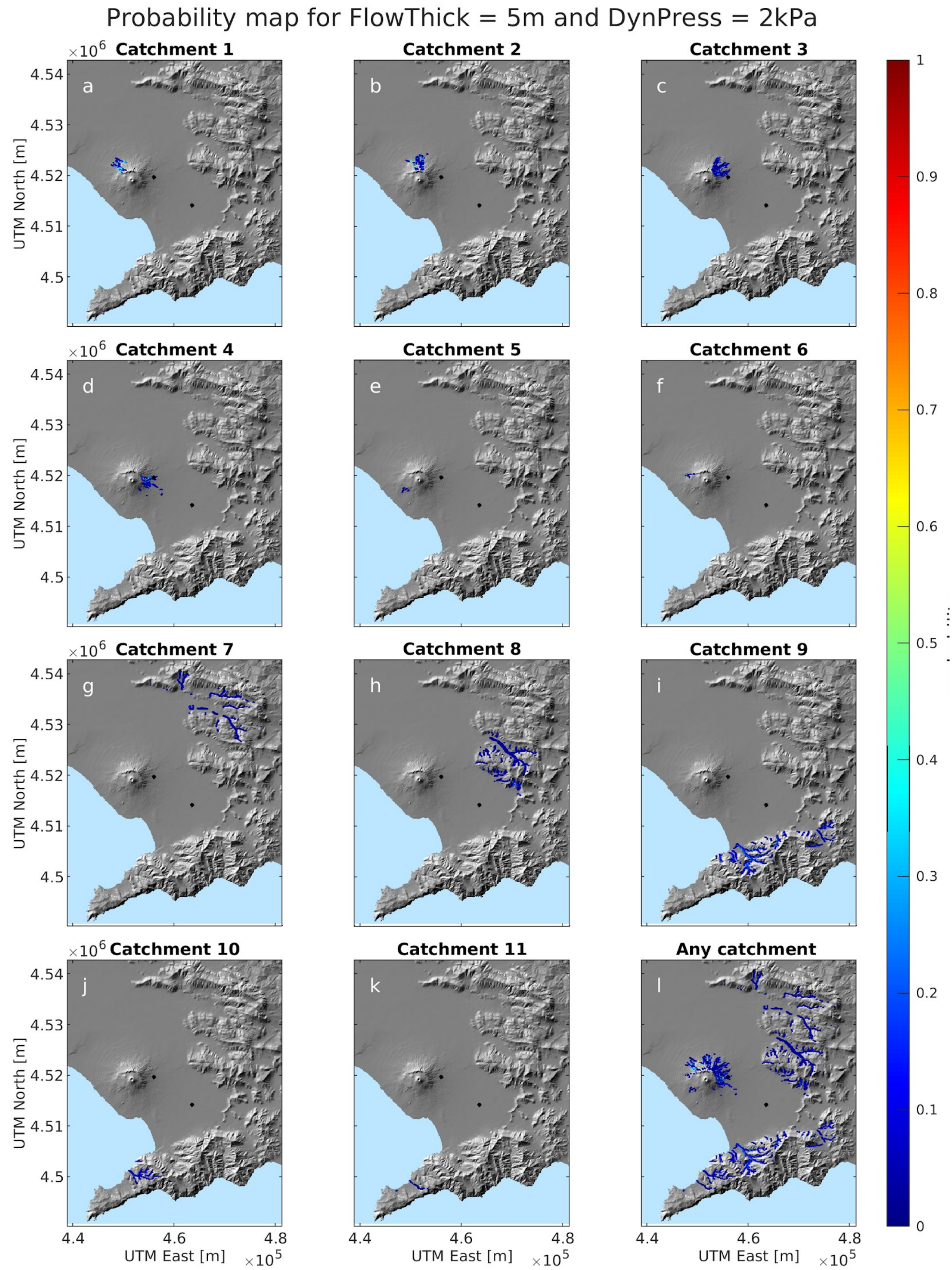


Figure SM63: Probability maps for simultaneously overcoming a maximum flow thickness of 5 m and a dynamic pressure of 2 kPa

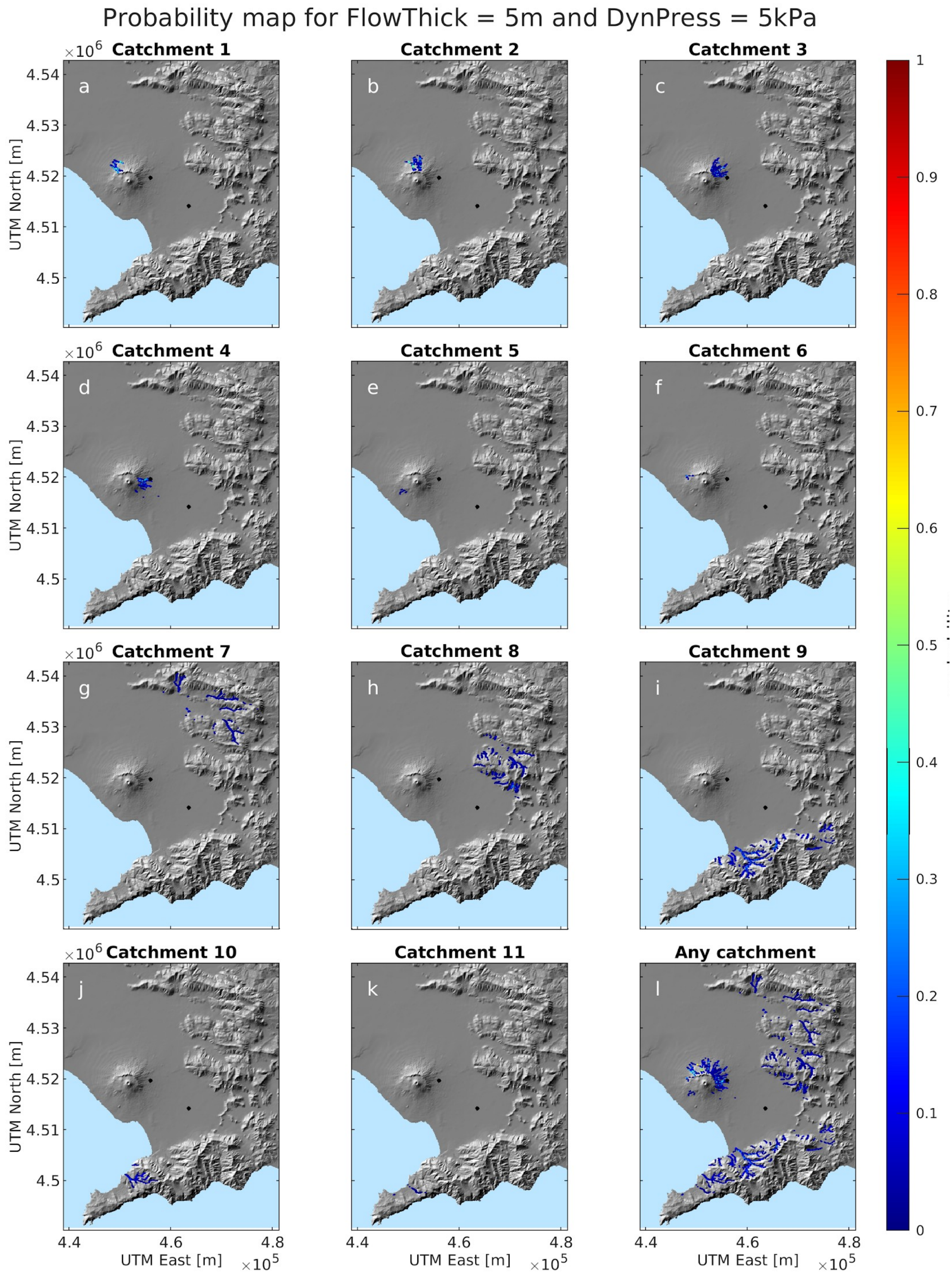


Figure SM64: Probability maps for simultaneously overcoming a maximum flow thickness of 5 m and a dynamic pressure of 5 kPa

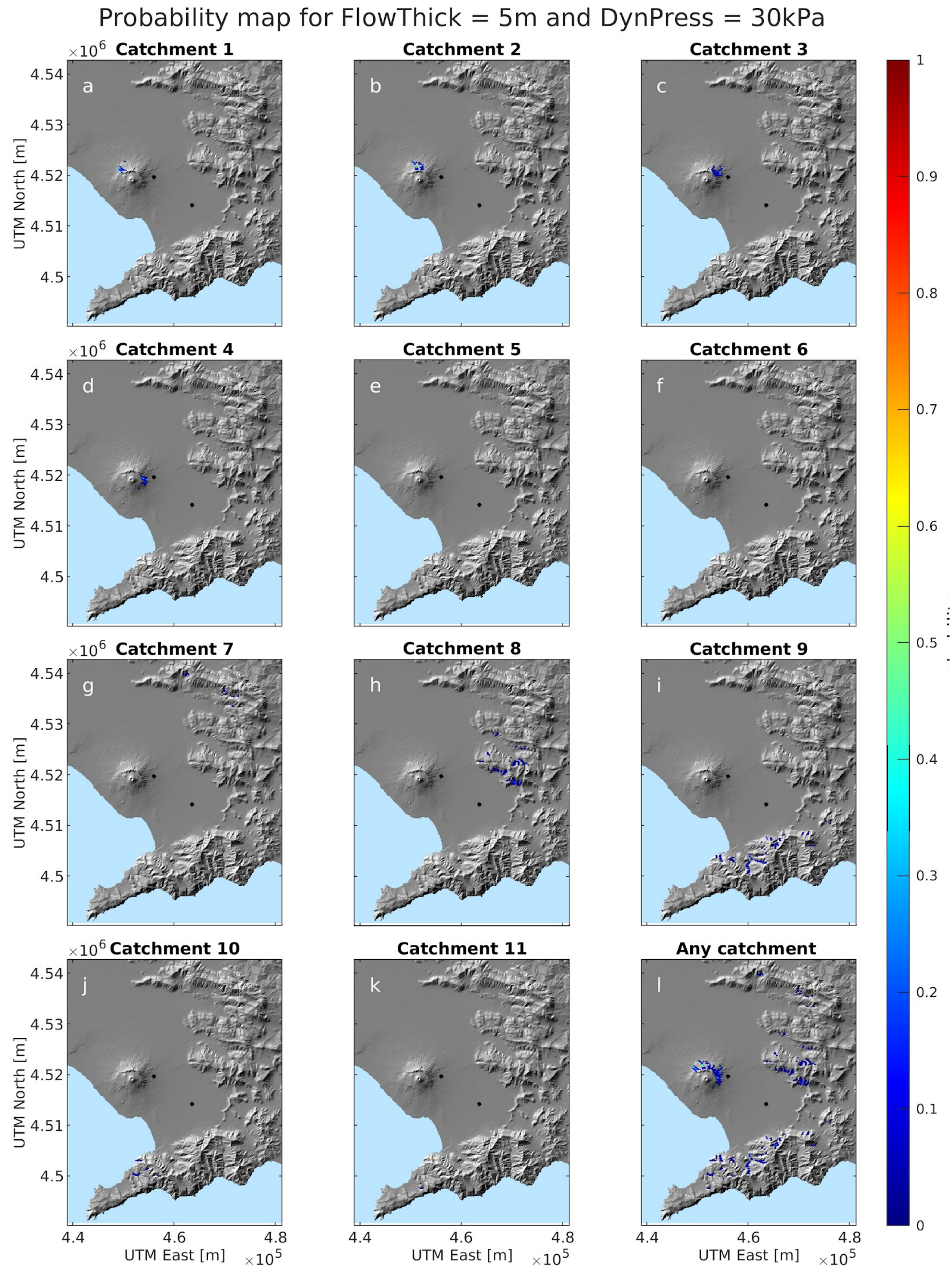


Figure SM: Probability maps for simultaneously overcoming a maximum flow thickness of 5 m and a dynamic pressure of 30 kPa