Practical handling of release area uncertainties in avalanche simulations

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INTRO:

- **Observed behavior in simulations:**
  - **Decrease in release area altitude → increase in runout**
  - **Doesn't fit with simple physical models**
- **Probabilistic analysis with SamosAT to identify and examine uncertainties and the source for this behavior**
- **Displaying result variability related to initial mass/altitude/entrainment uncertainty**

METHODS

1. 3 operational scenarios to evaluate uncertainties:
   - **Mass:** Release depth variation around **Reference** $\Delta d_{rel} = \pm 0.50\ m$
   - **Altitude:** Lowering release area altitude
   - **Entrainment:** Mass uptake along track
2. Evaluation of:
   - Maximum velocity $\vec{v}$
   - Maximum flow depth d
   - Runout length r (pressure based → 1 kPa)
   - Two-dimensional frequency distribution (**Probability Map**)

RESULTS

- Result range in scenarios:
  - $\vec{\boldsymbol{v}}$: ± 5 m/s
  - $\boldsymbol{d}$: ± 3 m
  - $\boldsymbol{r}$: ± 50 m
- Compensation of release area uncertainties through **Mass Scenario** ($\Delta d_{rel} = \pm 0.50\ m$) possible
- Different results for **Altitude Scenario**:
  - Channelization → higher $\vec{\boldsymbol{v}}, \boldsymbol{d}$ and $\boldsymbol{r}$ (e.g. Kerngraben avalanche)
  - Open terrain → reduced $\boldsymbol{r}$ (e.g. Schreckenmaehder avalanche)
- **Entrainment Scenario** mostly covered by d_{rel} variation (**Mass Scenario**)

CONCLUSION

1. **Runout length, velocity and flow depth** mainly influenced by:
   - Topography at transition zone
   - Spatial and temporal differences in mass distribution along the avalanche track and
   - Location of release area
2. Although release area definition of vital importance, **Probability Maps** depicting **Mass Scenario** usually allow to cover results ranges associated with other scenarios (Altitude / Entrainment)

Identifying, Quantifying & Handling of release area **uncertainties** in **avalanche simulations**

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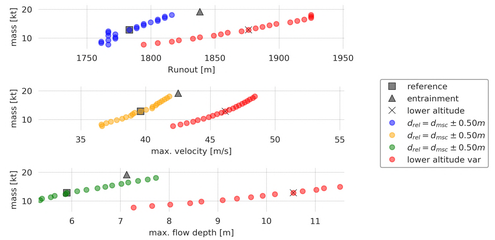
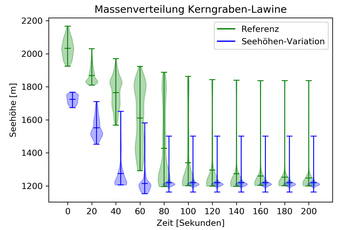
Kerngraben avalanche (channelized)



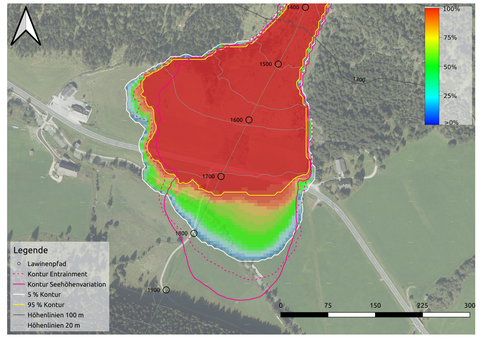
Development of runout length (blue), max. velocity (yellow) and flow depth (green) for the Kerngraben avalanche. X represents **Altitude Scenario**. The triangle represents the **Entrainment Scenario**. The red dots in each graph show an **additional Mass Scenario** over the **Altitude Scenario**.



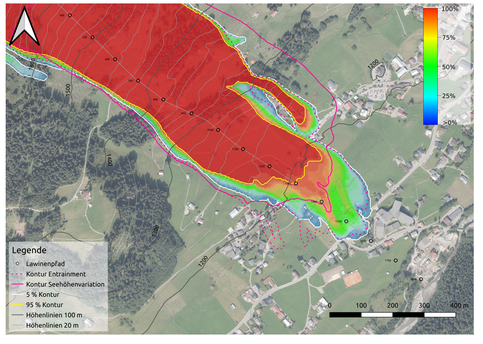
Chronological sequence of mass distribution for the Kerngraben avalanche. Compact entrance of initial mass into channelization leads to higher flow depth. Reduced turbulent friction causes higher acceleration. This results in higher velocity and runout length. Green represents the **Reference** simulation, blue the **Altitude Scenario**. Channelization between 1600 – 1250 m a.s.l.

Probability Maps: spatial distribution with 3 scenarios:

- **Mass Scenario:**
  - Colour Bar: Displays how many Simulations have a peak pressure higher then 1 kPa
  - White line → 5 % quantile of **Mass Scenario**
  - Yellow line → 95 % quantile of **Mass Scenario**
- **Altitude Scenario:** Magenta line
- **Entrainment Scenario:** Dashed magenta line
- Grey line represents the avalanche track with runout values.

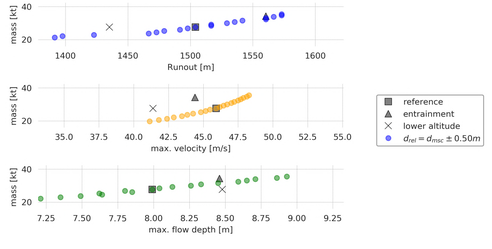


Probability Map for Kerngraben avalanche

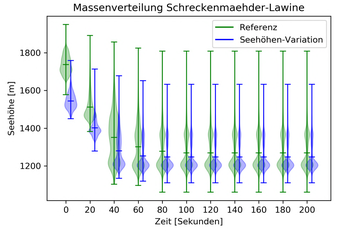


Probability Map for Schreckenmaehder avalanche

Schreckenmaehder avalanche (open terrain)



Development of runout length (blue), max. velocity (yellow) and flow depth (green) for the Schreckenmaehder avalanche. X represents **Altitude Scenario**. The triangle represents the **Entrainment Scenario**.



Chronological sequence of mass distribution for the Schreckenmaehder avalanche. Terrain in transition zone continuously open. Green represents the **Reference** simulation, blue the **Altitude Scenario**.