Representation of Source and Receptor Heights in Steep Terrain Dispersion Modelling

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Introduction

Trinity Consultants Australia

Introduction

Why Terrain Resolution is a Modelling Problem

- Model terrain grids can smooth out real, steep terrain features
- Terrain smoothing can materially change predicted concentrations
- CALPUFF, AERMOD and GRAL each handle terrain differently

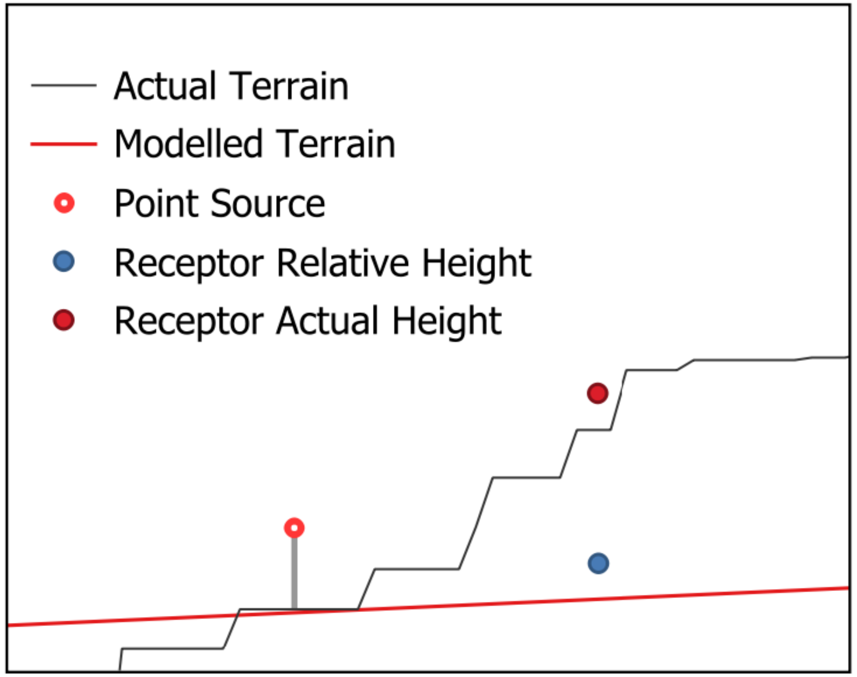
The Key Question

?

Should source and receptor height follow the model's terrain or the real terrain?

Relative Height vs. Actual Height

	Relative Height	Actual Height
Reference Surface	The model's own smoothed terrain grid	True ground elevation
Geometric Accuracy	Approximate	Accurate
Plume Centreline Consistency?	Yes	Most likely not



The plume itself follows the modelled terrain, so a geometrically accurate height can be physically inconsistent with the model

Three Models, Three Ways of Seeing Terrain

Model	Terrain Treatment	Key Limitation
CALPUFF	3D wind field generated by CALMET over smoothed terrain	Terrain features below CALMET's grid resolution are absent from the simulated wind field
AERMOD	AERMAP assign actual DEM elevations to each source/receptor; no 3D wind field	Steady-state Gaussian plume, not recommended in complex terrain
GRAL	High-resolution 3D wind field	Still grid limited, but far finer resolution than CALMET

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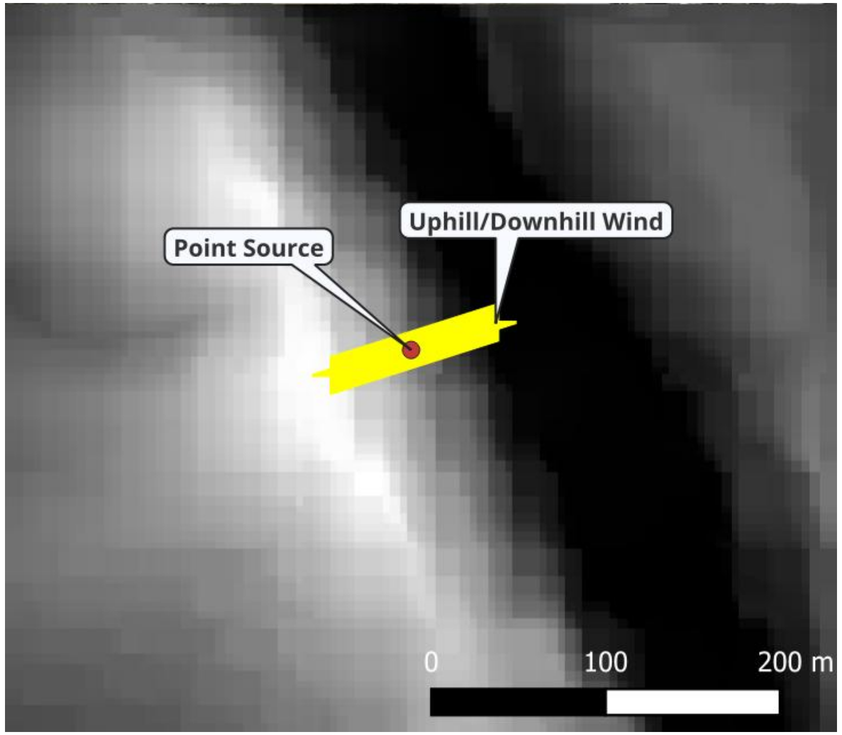
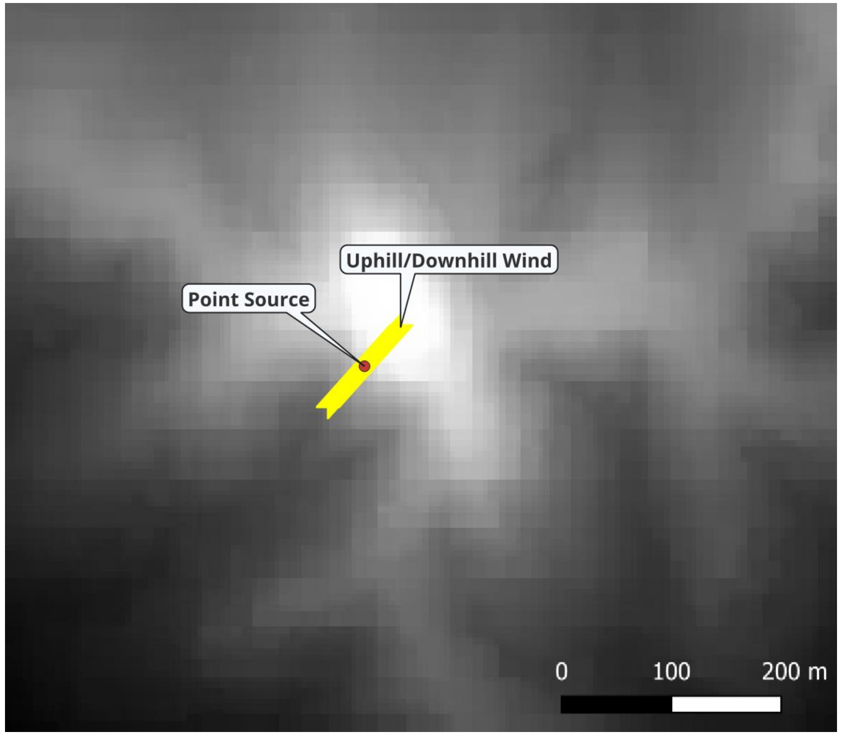
Methodology

Two Scenarios: Ridge and Hill

Both locations present complex terrain features finer than the CALMET grid resolution



Ridge Scenario



Hill Scenario

Meteorology

1 TAPM

2 CALMET

3 Scenario Extraction

12 meteorological conditions per scenario:

2 flow directions (upslope/downslope) x 3 stability classes (stable, neutral, unstable) x 2 wind speeds (low/high)

Downstream Processing by Model

CALPUFF	• Used CALMET output directly as meteorological input for each scenario.
GRAL	• GRAMM ran independently for each scenario and wind condition.
AERMOD	• TAPM and CALMET outputs used to construct the surface and profile files.

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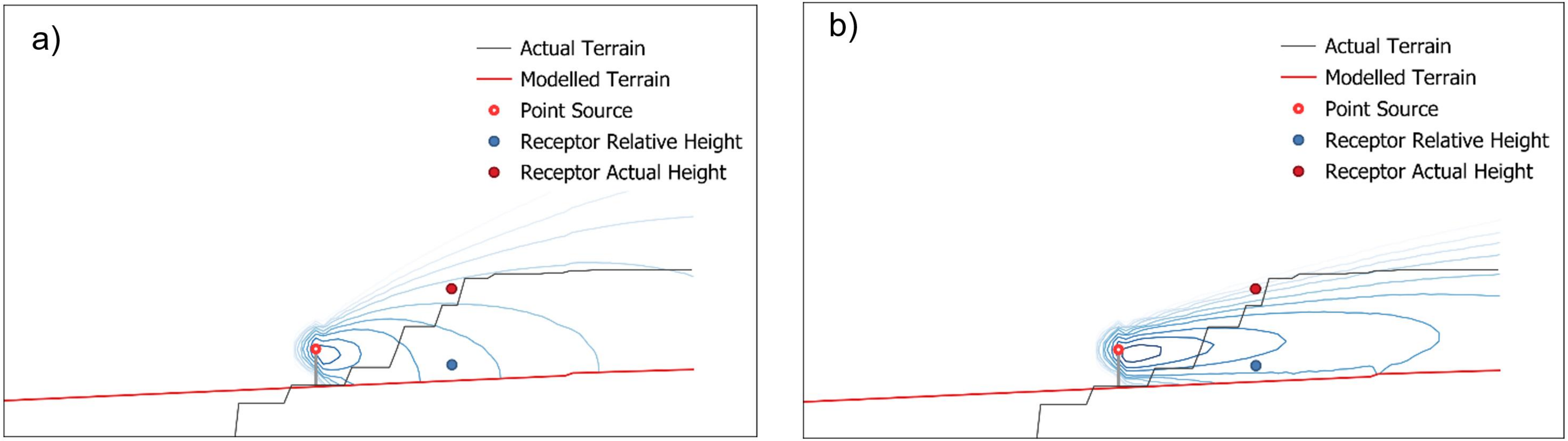
Results

CALPUFF Results



Calpuff vertical cross-sections, hill site: (a) unstable, (b) stable

Scenario	Terrain Height Difference (m)	Concentration Ratio (Relative Height / Actual Height)
Hill - Unstable	10	5
Hill - Stable	10	34

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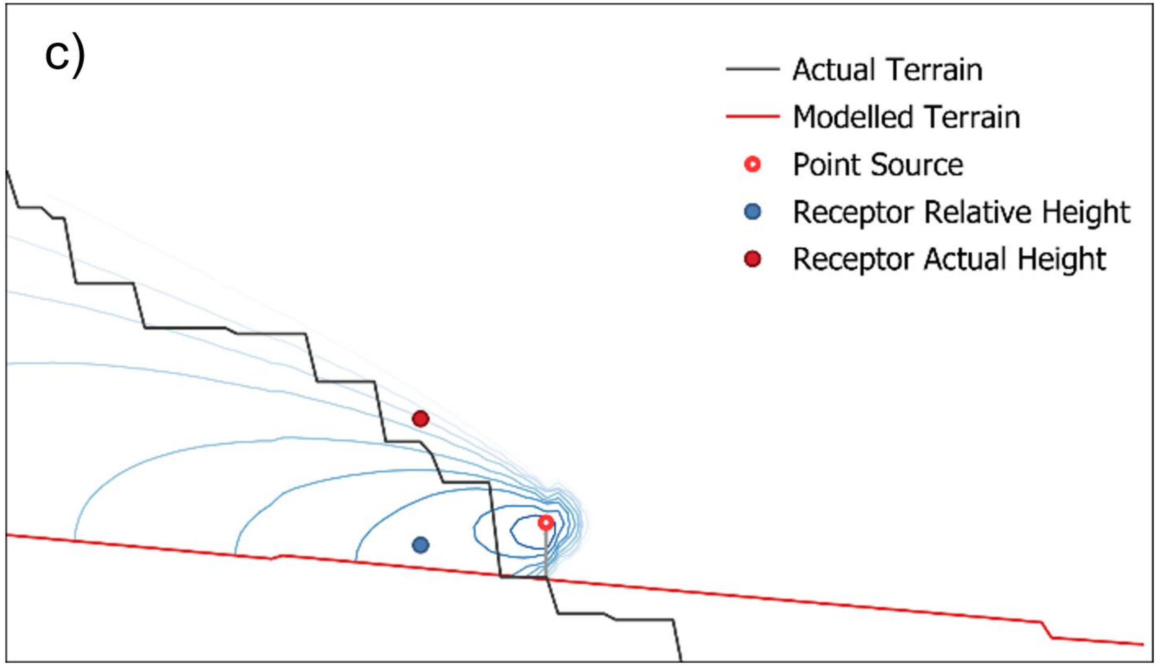
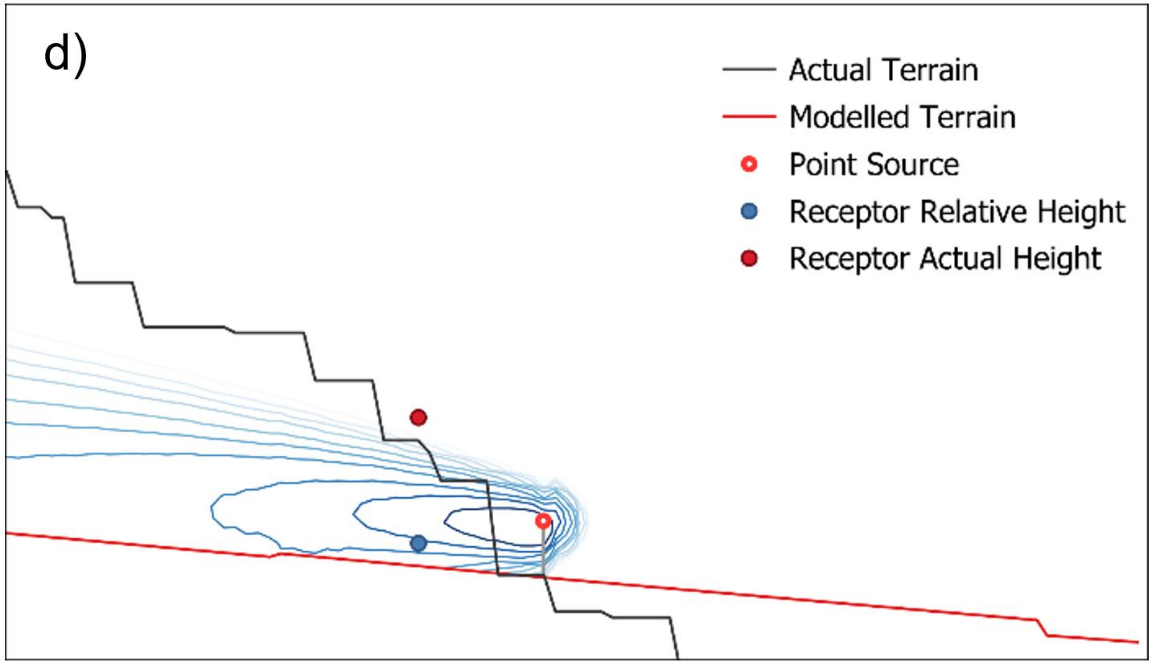
CALPUFF Results





Calpuff vertical cross-sections, ridge site: (c) unstable, (d) stable

Scenario	Terrain Height Difference (m)	Concentration Ratio (Relative Height / Actual Height)
Ridge - Unstable	11	30
Ridge - Stable	11	25,487

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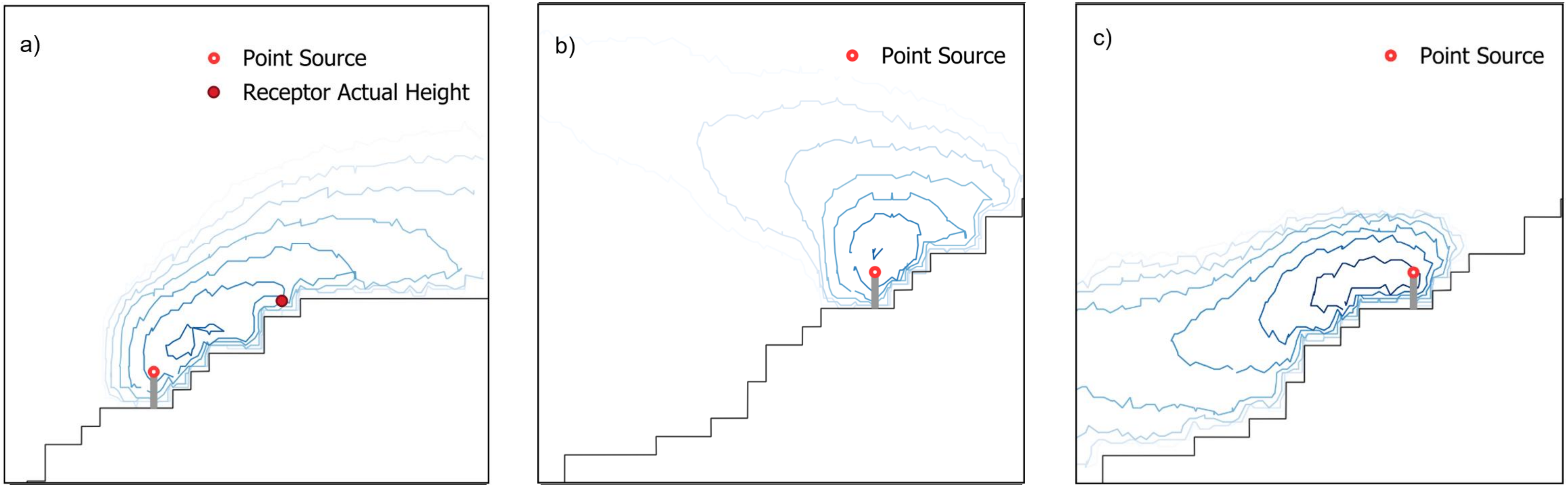
GRAL Results



GRAL vertical cross-sections, hill site: (a) unstable upslope, (b) calm conditions and (c) stable downslope

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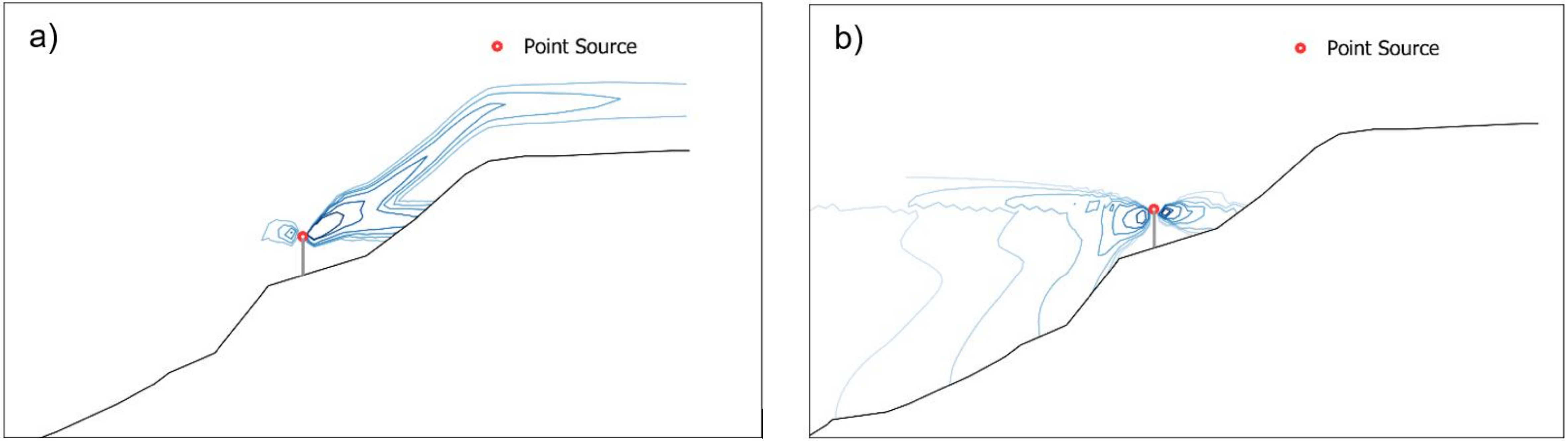
Results

AERMOD Results



AERMOD vertical cross-sections, hill site: (a) stable upslope and (b) stable downslope

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Conclusions and Recommendations

Conclusions

Summary of Findings

CALPUFF	Plume follows smoothed CALMET terrain. Geometric height corrections may move a receptor to the wrong side of the plume that is simulated in the model.
GRAL	Resolved actual terrain, producing a more physically realistic plume.
AERMOD	Uses actual terrain elevations, however, the concentration distribution near the surface is a product of the mathematical weighting between the two plume states, not a simulation of the actual flow pattern.

Conclusions

Recommendations

1

In steep terrain, model selection is critical. Models that resolve 3D flow over terrain (e.g. GRAL/GRAMM) provide more realistic results than Gaussian or coarse grid approaches.

2

Terrain resolution should be sufficient to capture key topographic features. Where this is not achievable, the implications of terrain smoothing should be explicitly assessed.

3

For models using gridded terrain (e.g. CALPUFF), source and receptor heights should generally be defined relative to the modelled terrain, ensuring consistency with the wind field and plume pathway.

4

Conduct supplementary sensitivity runs with adjusted height receptors where appropriate.

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Thank you

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