Orographic Flow over an Active Volcano

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• **Aims of research**
  – Study the effect an active but non-erupting volcano has in the orographic flow and rainfall

• **Existing literature**
  – Flow over hills
  – Effect of boundary layer
  – Effect of heated terrain
  – Orographic rainfall

• **Methodology**
  – Use WRF to study:
    • Idealised simulations
    • Case study analysis
• Type of volcanoes studied
  – Dome building (High viscosity magma)
• What is a volcanic dome
  – Quickly solidifying lava acting as a tap
  – ST values ranging from 320-600K
• Rainfall can trigger volcanic hazards
  – Pyroclastic flows/ Eruptions
  – Lahars
• Dome in simulations
  – Small number of grid points set at average temperature

(Macfarlane et al, 2006)
• **Domain**
  – $\delta x=500m$
  – 150 x 150 x 70 grid points

• **Gaussian hill**
  – 1km height
  – 10km half-width

• **Idealised atmosphere**
  – Brunt-Väisälä frequency $N=0.01s^{-1}$
  – Wind constant with height
  – Experiments ranging from 2ms$^{-1}$ to 15ms$^{-1}$ (Fr=0.2-1.5)

• **Surface temperature anomaly**
  – Experiments ranging from 0 to 40K

• **Boundary layer**
Results (Fr=1 Case)

Across middle

Lines: Theta
Contours: W
Purple: BLH

At h=200m
• **Domain**
  - 300 x 150 x 70 grid points

• **Sea before and after the hill**

• **Semi-realistic atmospheric structure**
  - Inversion at 2km height with varying strength
  - Wind height dependant
  - Experiments run for 15ms$^{-1}$

• **Surface temperature anomaly**
  - Experiments for 0 and 40K
Results (Strong Inversion Case)

Control

Heated (40K)

Across middle

Lines: Theta
Contours: W
Purple: PBLH
Thick: Clouds

Rainfall

Average Rainfall (mm/day)
Results (Weak Inversion Case)

Control

Heated (40K)

Across middle

Lines: Theta
Contours: W
Purple: BLH
Thick: Clouds

Rainfall
Conclusions

• The temperature anomaly drastically alters the flow pattern
  – Introduction of a convective plume near the anomaly

• Can act to trigger localised deep convection
  – Very sensitive to atmospheric conditions
    • Humidity above the inversion
    • Characteristics of the inversion (height, strength)
    • CAPE
Next Steps

• Specify the necessary conditions for the deep convective rainfall
• Investigate the possibility of non-localised convection
• Higher resolution runs to analyse the plume
• Real topography/ Case studies
Thank you for your time

• Questions?