Katabatic drainage flow characteristics on a low-angle slope around Arizona‘s Meteor Crater

Norbert Kalthoff[(1)], Bianca Adler[(1)], Manuela Lehner[(2)], C. David Whiteman[(2)], Sebastian W. Hoch[(2)]

[(1)] Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT)

[(2)] Department of Atmospheric Sciences, University of Utah

Introduction

- Katabatic drainage flows regularly develop on the low-angle slope (~1°) outside Arizona‘s Meteor Crater during clear, quiescent nights
- Their characteristics are decisive for downslope-windstorm-type flows inside the crater

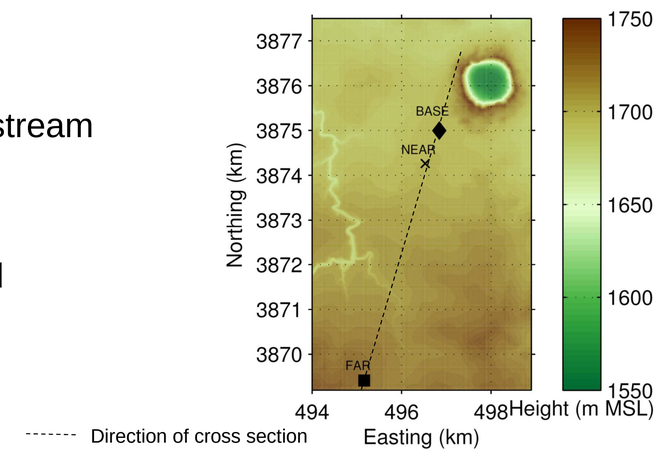
Research questions

1. What is the horizontal and vertical structure of the drainage flows? How do they evolve with time?
2. What are the processes controlling the drainage-flow characteristics?

Used data

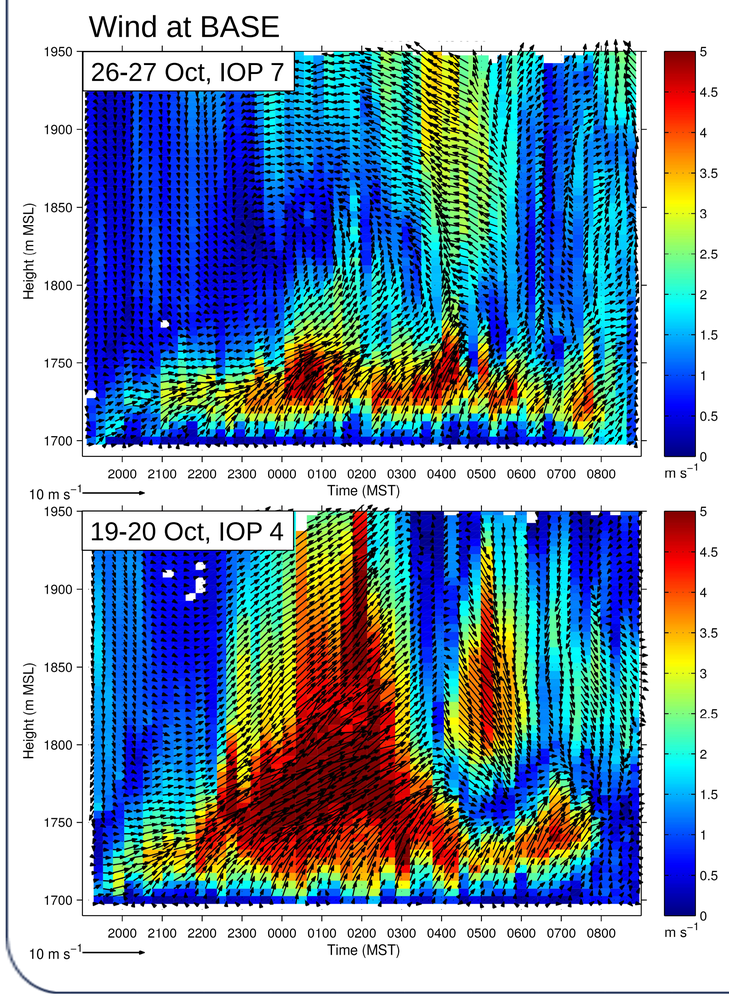
From METCRAX II field campaign in October 2013 available data on plain upstream of the crater are from:

- Sodar (FAR)
- 50-m tower (NEAR) and
- Tethersondes (BASE)



Spatio-temporal evolution of drainage flows

Wind at BASE



Drainage flow with jet-like profile evolves

Onset: 1900 - 2000 MST
Decay: 0700 - 0800 MST

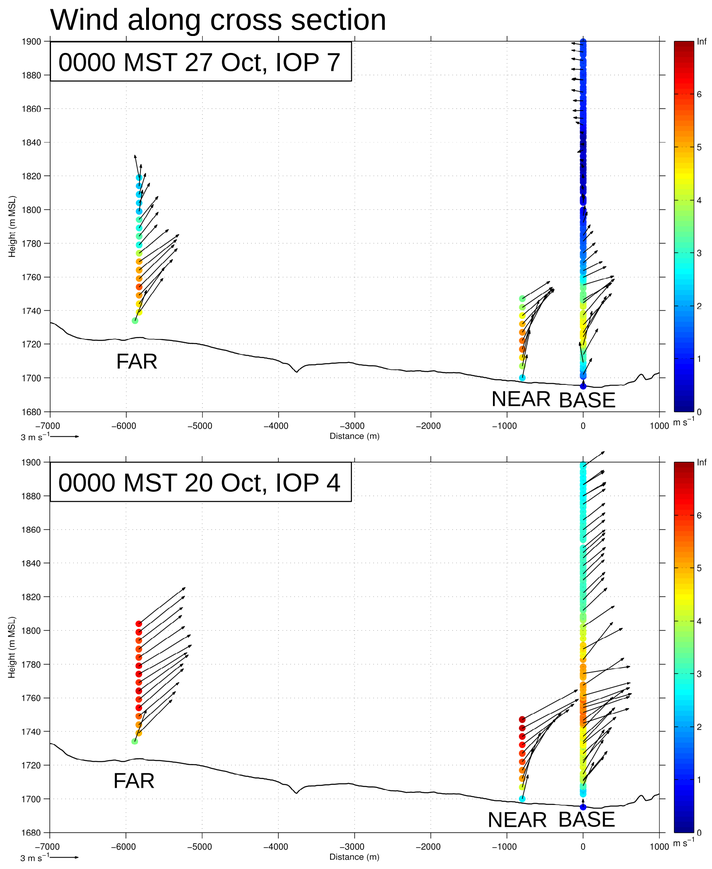
“Shallow” drainage flow (IOPs 1, 6 and 7)

Depth: ~ 100 m
Max. wind speed: ~ 6 m s^{-1}
Height of max. wind speed: 20 - 25 m

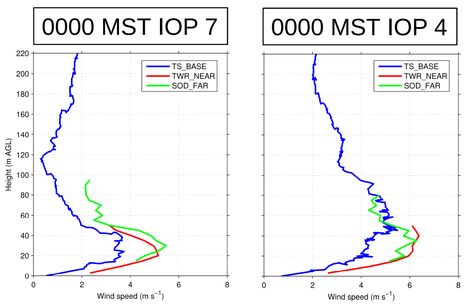
“Deep” drainage flow (IOPs 3 and 4)

Depth: > 200 m
Max. wind speed: > 8 m s^{-1}
Height of max. wind speed: > 50 m

Wind along cross section



Terrain-following wind speed profiles



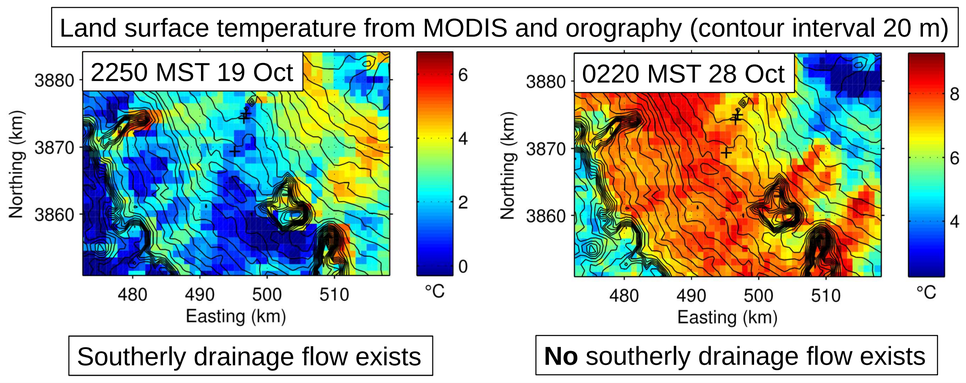
- Main characteristics (depth, strength, direction) of drainage flows similar along the slope during each night
- Southerly flow near the surface turning to south-westerly flow with height

Processes controlling drainage-flow characteristics

Direction of drainage flows

- South-westerly drainage flow due to mesoscale orographic gradient
- Southerly drainage flow near the surface due to locally enhanced southerly orographic gradient and cold air pooling behind mesas south-east of the crater

Land surface temperature from MODIS and orography (contour interval 20 m)



Southerly drainage flow exists

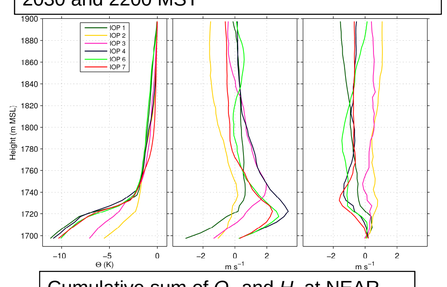
No southerly drainage flow exists

Depth of drainage flows

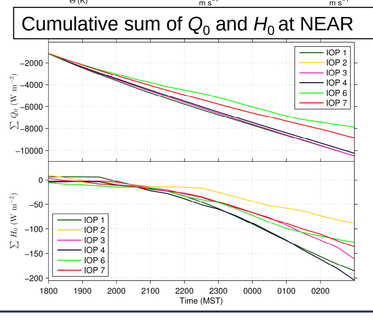
- Ambient stratification most stable during IOPs 1 and 6
- No systematic differences in ambient wind (observations and ECMWF analysis)
- Net radiation most negative during IOPs 1, 2, 3 and 4
- Surface sensible heat flux most negative during IOPs 1 and 4

→ Deep drainage flow evolves only when surface cooling is strong AND ambient stratification is weak (IOPs 3 and 4)

Profiles of Θ and downslope and cross-slope wind components at BASE averaged between 2030 and 2200 MST



Cumulative sum of Q_0 and H_0 at NEAR



Summary

- Drainage-flow depth (deep or shallow) strongly depends on ambient stratification and net radiation
- Direction of drainage flow influenced by local and mesoscale orographic gradient (southerly flow near the surface turning to south-westerly with height)

Funding agencies: National Science Foundation AGS-1160730 and International Bureau of BMBF under grant 01 DM 13002