METCRAIX II
An upcoming field investigation of downslope-windstorm-type flows on the inner sidewall of Arizona's Meteor Crater

Arizona’s Barringer Meteor Crater

Diameter: 1.2 km
Depth: 170 m
Plain-rim: 30-50 m
Nighttime drainage flows approach the crater from the Mogollon Rim

Model:
4-6 m/s < 50 m

Observations:
5-8 m/s, 35 m
• During METCRAX-I in 2006 we found that intermittent downslope-windstorm-type flows developed over the crater’s SW sidewall on clear, undisturbed nights. (See Adler et al. 2012)

• A new experiment, called METCRAX II, will be investigating these flows. Laboratory-like experiment – continuous observations of approach flow and response of crater atmosphere.
Experimental Goal

Improve understanding of hydraulic-analog atmospheric flows that produce downslope-windstorm-type events.

The overall research program will combine modeling with field research to improve understanding of these flows.

This presentation will focus on the design of a field program to investigate katabatically driven hydraulic-type flows at Arizona's Meteor Crater in a one-month experiment scheduled for October 2013.
Equipment placement - Sites A through E

**Site A**
- Far upwind

**Site B**
- Flow field/stratification impinging on crater topography

**Site C**
- Flow field/stratification at rim

**Site D**
- In-Crater response

**Site E**
- Vantage point to remotely sense crater response
Flow upwind of Crater

More Model results this afternoon in the talk by Manuela Lehner!
Flow and temperature structure upwind of Crater

- Radar Wind Profiler
- SoDAR / RASS
- Wind-Profiling LiDAR
- Scanning Doppler LiDAR
Cold air damming upwind of crater

Hobo temperature data loggers

Mobile tethersonde
Between sites B and C
Flow splitting around the crater

6 Automatic Weather Stations

Scanning Doppler Wind LiDAR

Site B LiDAR
Warm-Air Intrusions & Wind Field in Crater
Temperature in Crater Basin

0-400 m AGL
Warm-Air Intrusions & TKE

Variable Extent of Warm-Air Intrusion

Effect on near-surface turbulence

“Mini-PAM / AWS”: 1 level: Pressure, Sonic, T/RH
Warm-Air Intrusions & Pressure Field

Variable Extent of Warm-Air Intrusion
Summary

• METCRAX II, October 2013, will investigate katabatically driven hydraulic flows over the rim of Meteor Crater that produce warm air intrusions and hydraulic jumps.

• Unusual field equipment resources: 3 LiDARs and 2 tall towers

• Selected science issues:
  • evolution of 3-D structure
  • controlling upstream parameters
  • evaluation of existing theories
  • modeling
Project personnel - METCRAX II

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Questions?
Warm-Air Intrusions
Warm-Air Intrusions & LiDAR siting

LiDAR Siting

• Sites and ranges

• Alignment & geometry

RHI – co-plane or virtual towers?
Warm-Air Intrusions & LiDAR siting

- Sites and ranges in co-planar geometry
- 70-100 m blind spot
- 1000 m range
- 1-2 min / scan

Cross section through SW-Gap, Azi.: 22.5 deg
Meso-scale drainage flow formation & evolution

- Full Energy Balance along the slope: PAMs at A, B
- Mini-SoDAR observations A, B
- Temperature profile at B (50 m tower, RASS, Tethersonde)

Pulsations & changes in wind speeds, direction, stability

~ 5.5 km
What is so special about Meteor Crater?

- Near-circular basin
- Surrounded by a uniform plain sloping upwards to the SW with 2% slope
- Uniform rim height - no major saddles or passes

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10m wind speed & direction

Sensible & latent heat fluxes; momentum flux; \{u',v',w',tc',q'\}

2m P, T, RH

PC-104 Linux data system

12 V solar-charged batteries

Flux-PAM Instrumentation

2.4 GHz radio
K&Z CG4’s
K&Z CM21s
Soil measurements
Logistics
Synoptic situation & weather pattern

- Radiosondes Flagstaff NWS & (ISS- GAUSS)
- Wind Profiler / RASS (ISS)
ISFS Instrumentation

Profile Towers at sites B (50m) & C (40m)

Sonic Anemometers & \{T,RH\} at 5m height intervals
Meso-scale drainage flow formation & evolution

METCRAK 1.5: Jet nose : 6-8 m/s at 30 m AGL
The Meteor Crater

A near-circular basin with a diameter of 1.2 km and a depth of 170 m. The crater's rim projects 30-50 m above an extensive surrounding plain, which is tilted upward to the southwest.

During clear undisturbed nights, a shallow mesoscale drainage flow comes down this plain from a collection of plateaus and mesas (the Mogollon Rim) to interact with the crater topography. Hydraulic flows over the crater's rim lead to occasional downslope-windstorm-type events on the inner southwest sidewall of the crater, and a hydraulic jump sometimes forms locally over the sidewall. These katabatically driven events were discovered serendipitously in a previous field program at the crater, but the characteristics of the flows were not well observed with the instruments deployed during those experiments.
Warm-Air Intrusions & Pressure Field

Variable Extent of Warm-Air Intrusion

Pressure sensor

PAM