Surface Energy Balance Measurements and Subsurface Properties during MATERHORN

Sebastian W. Hoch, Derek Jensen, Jeff Massey, Eric Pardyjak
all other MATERHORN-X participants
Introduction

Land surface contrasts

Topography

Land-Atmosphere energy exchange

Synoptic forcing

Boundary Layer Evolution

Circulation patterns

High albedo

Lower albedo

PLAYA

EFS SITE

upwind tethersonde & radiosonde

GRANITE MTN.

SLOPE EFS SITE

Slope Flow Experiment
Gap Flows

Meso-scale nighttime down-valley & daytime up-valley flows

SAGEBRUSH FLATS EFS SITE

SAGEBRUSH

SARPCE SAGEBRUSH

DUGWAY RANGE

32 m tower

Tethersonde

downwind tethersonde

EFS Site
Google Earth™ imagery of Dugway Proving Ground, UT.
Radiation Balance

\[ NR = SW_{\downarrow} + SW_{\uparrow} + LW_{\downarrow} + LW_{\uparrow} = (1-\alpha) SW_{\downarrow} + LW_{\downarrow} + LW_{\uparrow} = SW^* + LW^* \]

Surface Energy Balance

\[ NR + H + L_vE + G = \text{Residual} \]

Eddy-Covariance measurements of Sensible Heat flux (H) and Latent Heat Flux (\(L_vE\)) ; CSAT3 and IRGAsonde - Derek Jensen
Subsurface Heat Flux / Soil Thermal Properties
at EFS Sagebrush, EFS Playa, EFS Slope/ES5

Surface

- Heat Flux Plates
  5 cm; 2 x
  Hukseflux HFP-SC

- Water Content
  Reflectometer
  (7, 25, 70 cm)
  Campbell Sci. CS650

- Thermocouple
  (8 levels)
  Omega, custom built

- Averaging thermocouple
  Campbell Sci, TC-AV

- Thermal Properties Sensor
  (1-3 sensors)
  Hukseflux TP01
Campbell Scientific CS650 / CS655 water content reflectometer

Hukseflux TP01 thermal property sensor

Hukseflux HFP01-SC self-calibration heat flux plate

© Campbell Scientific

© Hukseflux thermal sensors

Surface

0 cm
1
2.5
5 cm
10 cm
15 cm
25 cm
70 cm

Heat Flux Plates 5 cm; 2 x Hukseflux HFP-SC
Water Content Reflectometer (7, 25, 70 cm) Campbell Sci. CS650
Thermocouple (8 levels) Omega, custom built
Averaging thermocouple Campbell Sci, TC-AV
Thermal Properties Sensor (1-3 sensors) Hukseflux TP01
Ground heat flux
Calculation & QC

Sum of
1) Flux at heat flux plate (self calibrated at midnight / power outage corrected)
2) Heat storage change above flux plate (calculated for individual layers); Volumetric heat capacity from TP01 sensor

Radiation QC
Correction for positive and negative night-time offsets

Turbulent Fluxes QC
See UTESpac / Derek Jensen
Results

• Two days (18-19 Oct 2012) during the Fall campaign / Two days during Spring campaign (2-3 May 2013)

• EFS-Sagebrush site vs EFS-Playa site

• WRF model results (tuned by using observed albedo values); Massey at al. 2014 soil parameterization and moisture (fix night time warm bias; silt loam sites)

• Surface radiation balance

• Surface energy balance \[ NR + H + L_v E + G = \text{Residual} \]
Albedo differences among the sites are the main cause of variations in shortwave energy input. Differences are more pronounced in spring, as albedo values are then lower at Sagebrush and higher at Playa than in the fall.

In the fall, the (smaller) effect of the albedo differences is compensated by higher longwave emission at Sagebrush, and net radiation differences are higher at night than during the day. In spring, daytime net radiation at Sagebrush exceeds values observed at Playa.
- Especially in Spring, WRF under-predicts daytime temperatures at both sites (cold bias), under-predicts night-time temperatures at Playa (cold bias).
- Specular reflectance plays a role at Playa and leads to a pronounced diurnal cycle of albedo.
- Albedo at Playa varies with thermal conductivity (proxy for soil moisture).
- Ground heat flux very important at both sites
- Model seems to over-predicts magnitude of sensible heat flux (H) and latent heat flux (L_vE)
- Ground heat flux (G) at Playa is well captured / slight over-prediction at Sagebrush
The energy balance is closed at night.

A significant residual term remains during daytime when observations do not close the energy balance. WRF simulations show a higher sensible heat flux than observations, closing the balance.

Representativeness of albedo?
... a word about ...

RADIOSONDES & QC

- Issue with reprocessing software
- Moisture error introduced
- Currently working with GRAW technicians to solve the issue
Moisture error
Acknowledgements

- Office of Naval Research ONR
- Dugway Proving Ground
- All MATERHORN participants
<table>
<thead>
<tr>
<th>Site</th>
<th>EFS-Sagebrush</th>
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<th>EFS-Playa</th>
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<tbody>
<tr>
<td>Season</td>
<td>Fall</td>
<td>Spring</td>
<td>Fall</td>
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<tr>
<td>Albedo [-]</td>
<td>0.27</td>
<td>0.24</td>
<td>0.31</td>
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<tr>
<td>Thermal</td>
<td>0.59</td>
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<tr>
<td>[W m(^{-1})</td>
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<tr>
<td>K(^{-1})]</td>
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<tr>
<td>Roughness, (z_0) [m]</td>
<td>0.24</td>
<td></td>
<td>6 x 10(^{-4})</td>
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