Simulation of the land-atmosphere exchange during persistent cold air pool events in Salt Lake Valley, Utah

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Introduction

- PCAPs are characterized by stable ABL conditions
- PCAPs are accompanied by elevated air pollution concentrations due to limited mixing and low PBLH
- WRF does not give satisfactory results
- Land-atmosphere interaction is pivotal for meteorology simulation (it might hold the key!)

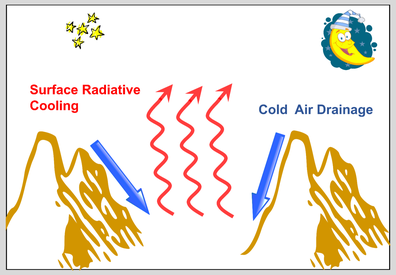


Figure 1 Cold air pools are topographic depression with cold air

Data and Methods

- The Persistent Cold Air Pool Study, 2010-2011,Utah (PI: Whiteman, UU)

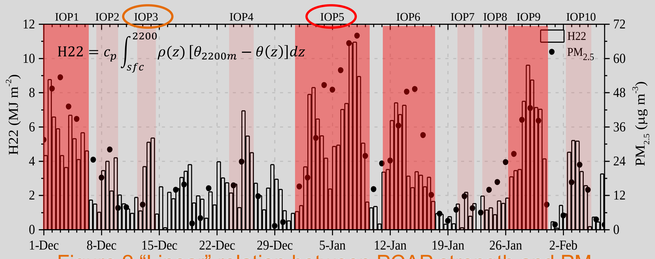
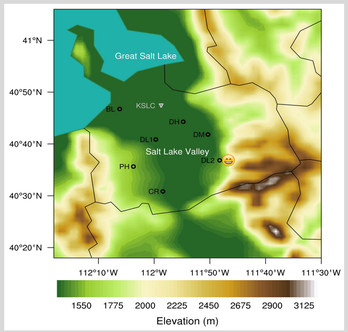


Figure 2 “Linear” relation between PCAP strength and $PM_{2.5}$



- Three domains, dx/dy=0.48 km
- NAM reanalysis data (12km) with 3 hr forecasting dataset
- Three sensitivity experiments for two IOPs, using ACM2, YSU, MYJ, and MYNN PBL schemes

Figure 3 Obs data from site DL2 is used in our case study

Weak PCAP (IOP3)

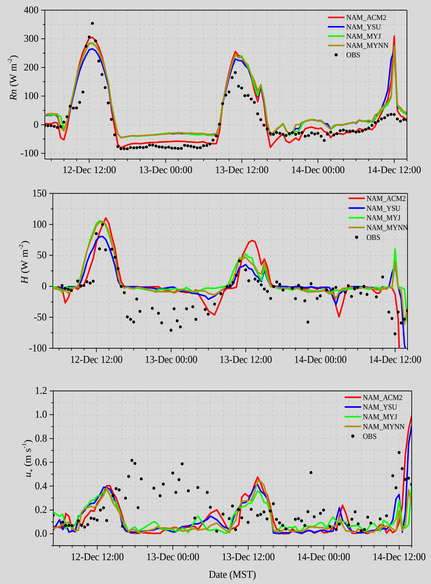


Figure 4

- Noah LSM produced higher background surface albedo than Pleim-Xiu LSM
- Net radiation was overestimated (higher *DSR* and lower *ULR*)
- Variations of turbulent fluxes during the weak PCAP were captured by the model
- Failure of modeling the mountain flow can underestimate |*H*|

Strong PCAP (IOP5)

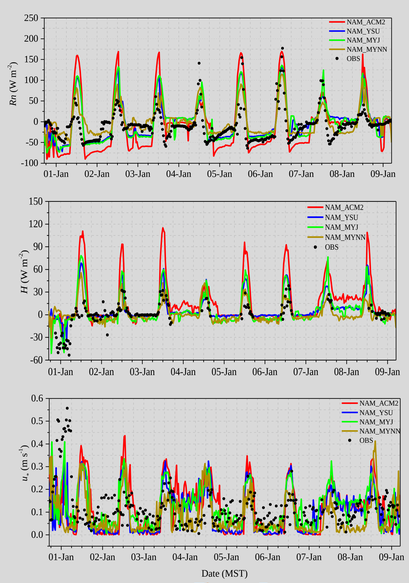


Figure 5

- The model simulated lower surface albedo during snow coverage
- Net radiation was overestimated (lower *USR* and lower *ULR*)
- Model performance degraded during the strong PCAP
- NAM_MYNN performed best in simulating surface turbulent fluxes

Surface Exchange Coeff.

$$H = -\rho c_p CH(\theta_a - \theta_0) \quad (1)$$

$$CH = \frac{ku_*}{ln\left(\frac{z}{z_{0h}}\right) - \psi_h\left(\frac{z}{L}, \frac{z_{0h}}{L}\right)} \quad (2)$$

- Major underestimation of ϕ_h in the stability range of $0.025 < \zeta \leq 1.0$
- Almost inverse behavior of ϕ_h versus ζ
- Overall overestimation of *CH* in models

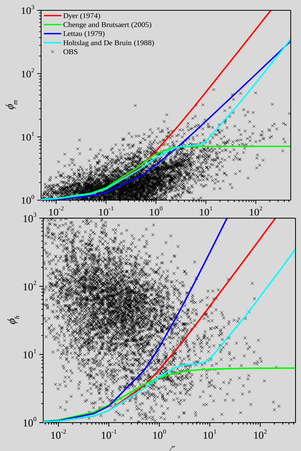


Figure 6

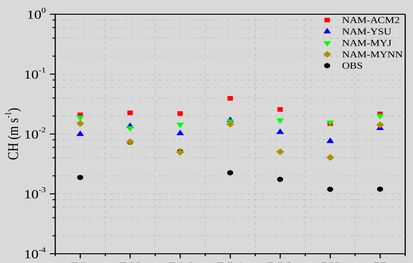


Figure 7

- Spatial variation of the *CH* discrepancies

Conclusions

- The model performance in simulating surface energy fluxes degraded in the strong PCAP compared to the weak PCAP.
- The overestimated surface sensible and latent heat fluxes during the strong PCAP was related to the overestimated net radiation and soil moisture.
- The NAM_MYNN case produced the least bias in both net radiation and surface turbulent fluxes for the strong PCAP.
- The underestimation of non-dimensional vertical temperature gradient in stability functions based on the Monin-Obukhov theory was responsible for the *CH* discrepancies in the WRF model.

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