**Introduction**

- Utah residents in basins susceptible to cold air pools (CAPs) often affected by: (1) high wintertime ozone concentrations due to oil and gas development; (2) high particulate concentrations in urban areas
- CAPs are difficult to simulate correctly
- Research underway at the University of Utah and Utah Division of Air Quality to improve modeling capabilities

**Land Use Sensitivity**

- 3 nested domains (12, 4 and 1.33 km)
- Simulations studies focus on innermost domain
- 40 eta (terrain following) vertical levels
- YSU PBL scheme
- No nudging
- Thompson bulk or WRF Single Moment (WSM) microphysics schemes
- USGS, MODIS, or NLCD 2006 land use

**Microphysics Sensitivity**

- WRF model runs are sensitive to land use and issues arise from the following:
  - Land use categories (different snow heights cover certain vegetation vs different land use)
  - Year of data set (varying Great Salt Lake size and outdated representation)
  - Modeling of cold air pools is highly sensitive to initialization time
  - Initialize before the cold air pool onset in order to let the model simulate the CAP build-up
  - NAM meteorological input fields poor first guess
  - Microphysics scheme and cloud cover
  - Less spurious cloud cover when WSM3 scheme used compared to Thompson, but that is not a general solution (see also Neemann et al. 2014)
  - Enhanced nighttime cooling with less clouds

**Future Work**

- Simulating partial CAP mix-outs
- Testing ice fog and aerosol-aware Thompson microphysics schemes to improve modeled clouds (Kim et al. 2014; Thompson & Eidhammer 2014)
- Targeted large-eddy simulations
- More research regarding albedo snow interaction w/ vegetation, land use, and initialization

**References**

White et al., 2015: Laser ceilometer investigation of persistent wintertime cold-air pools in Utah’s Salt Lake Valley, submitted to Journal of Applied Meteorology and Climatology

**Summary**

- Differences in Great Salt Lake size cause the largest differences between runs, but so do differences in land use categorization.

**Initialization Sensitivity**

- IOP5 Simulation Period:
  - 00 UTC 1 Jan, 2011 to 00 UTC 10 Jan 2011
  - Figure 1: Panel 1: ceilometer back scatter during PCAPS (PCAPS), 1–10 Jan 2011. Panel 2: PM$_{2.5}$ concentration at the center of the Salt Lake Valley, data courtesy of USGS (James et al. 2013, Young & Whiteman 2015)

**Figure 2**

- Map of three WRF domains. Pictured are those of USGS, MODIS, and NLCD land use respectively.

**Figure 3**

- Map of terrain height (m) in WRF domain 3 plotted with location of station sites used for validation.

**Figure 4**

- Maps of land use type by category for WRF model domain 3. Pictured are those of NLCD, MODIS, and NLCD land use respectively.

**Figure 5**

- Time series of temperature and relative humidity at Vernal (VER), left, and Salt Lake City (SLC), right, from observations and USGS, MODIS, and NLCD WRF model runs.

**Figure 6**

- Average 2 m temperature of domain 3 from 1-9 Jan 2011, USGS run minus MODIS run.

**Figure 7**

- Average albedo of domain 3 from 1-9 Jan 2011, USGS run minus MODIS run.

**Figure 8**

- Time-height diagram of potential temperature in the Salt Lake basin for the USGS run from 1-9 Jan 2011. Pictured are the first 20 vertical levels from the WRF model run. Black contours plotted every 5 K. 

**Figure 9**

- Time series of temperature and relative humidity at Vernal (VER) from observations and USGS and early initialization WRF model runs.

**Figure 10**

- Differences in Great Salt Lake size cause the largest differences between runs, but so do differences in land use categorization.

**Figure 11**

- Time-height diagram of potential temperature difference (K) due to initialization data. WRF run minus NAM initial condition.

**Figure 12**

- Time-height diagram of potential temperature difference (K) from observations and WRF and early initialization runs.

**Figure 13**

- Time-height diagram of difference in temperature between early initialization and USGS run in central Uintah Basin.

**Figure 14**

- Time-height diagram of potential temperature difference (K) due to initialization data. WRF run minus NAM initial condition.

**Figure 15**

- Average 2 m temperature of domain 3 from 00 UTC 1 Jan to 00 UTC 9 Jan 2011, early initialization run minus USGS run.

**Figure 16**

- Time-height of cloud mixing ratio (g/kg) in central Uintah Basin, early initialization run.

**Figure 17**

- Time-height of cloud mixing ratio (g/kg) in central Uintah Basin, WRF run.