Thermally-forced Circulations

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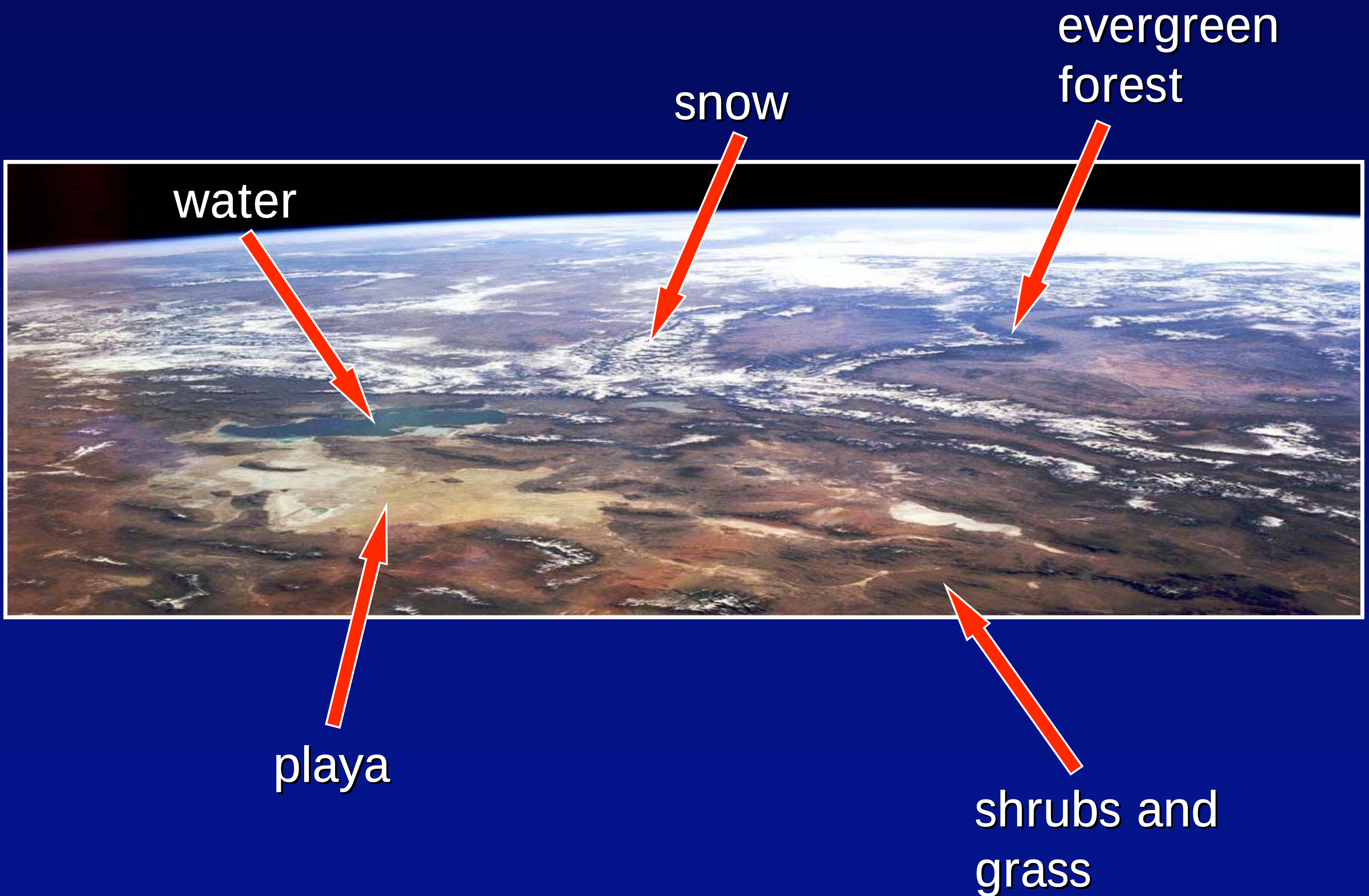
26 Jul 2005

Thermally-driven Winds: Some Basic Concepts

- A class of mesoscale circulations driven by horizontal gradients in surface heating or cooling.
  - Land-water contrasts.
  - Elevated terrain.
  - Urban-rural contrasts.
  - Contrasts in ground wetness.
  - Snow cover contrasts.
  - Variations in cloud shadowing.
  - Contrasts in ground brightness and vegetation.

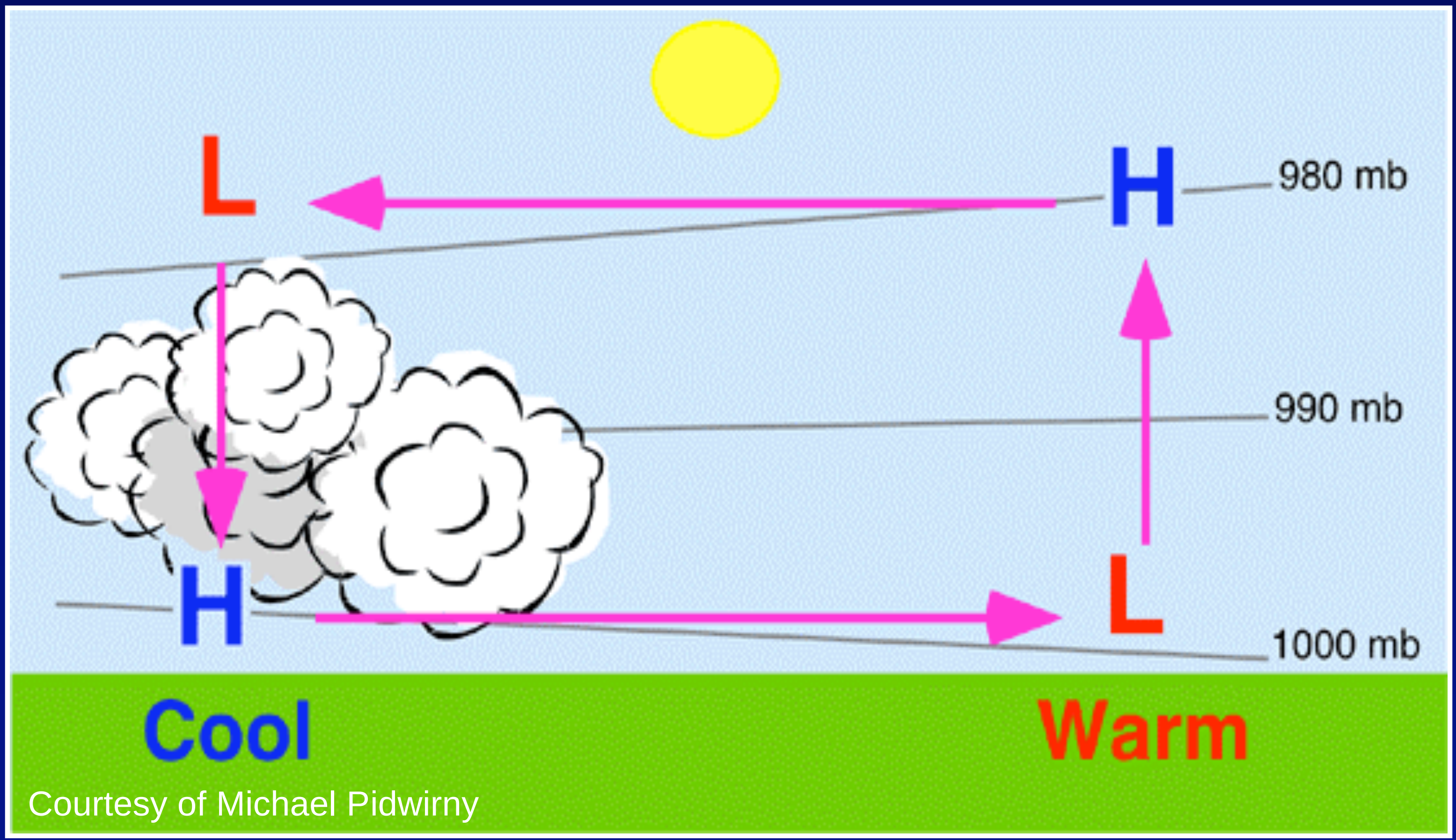
Landscape Contrasts over Northern Utah



Basic Concepts (Cont'd)

- Thermally-driven winds dominate when the large-scale flow is weak.
- These flows usually evolve in the same way from one day to the next (i.e., they are highly repeatable).
  - Fairly easy to predict the onset and cessation of thermally-forced flows, and their impact on the sensible weather.

Direct Thermal Circulation



Two Basic Types of Thermally-forced Air Flows

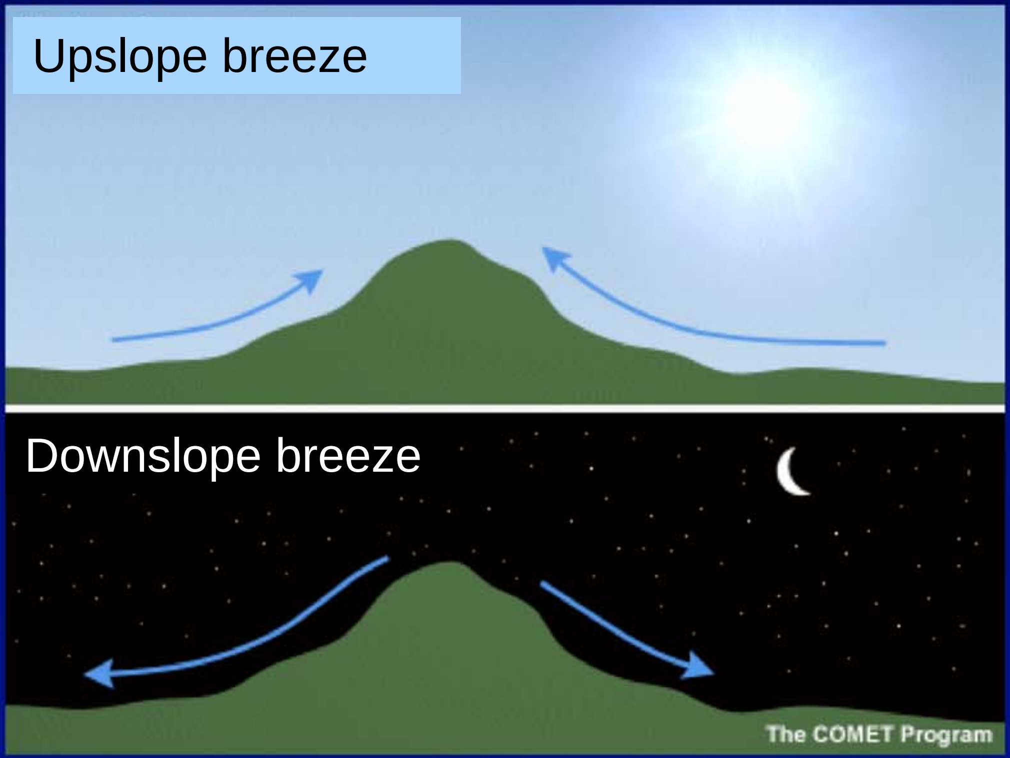
i. Breezes generated by surface heating contrasts (e.g., sea/lake breeze).

ii. Diurnal mountain winds.

Diurnal Mountain Winds

- A diurnal wind pattern that routinely develops along mountain slopes.
- Produced by horizontal contrasts in temperature that develop everyday in complex terrain.

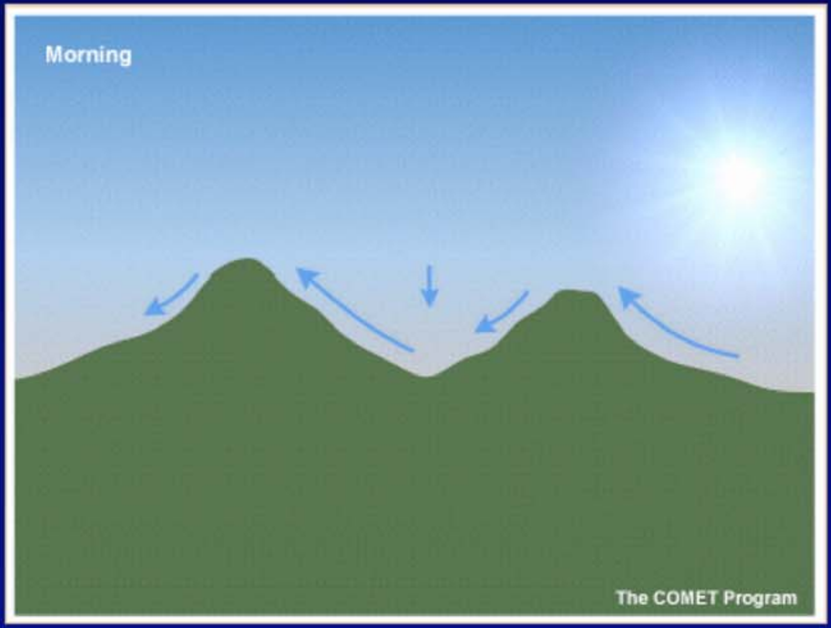
Slope Winds

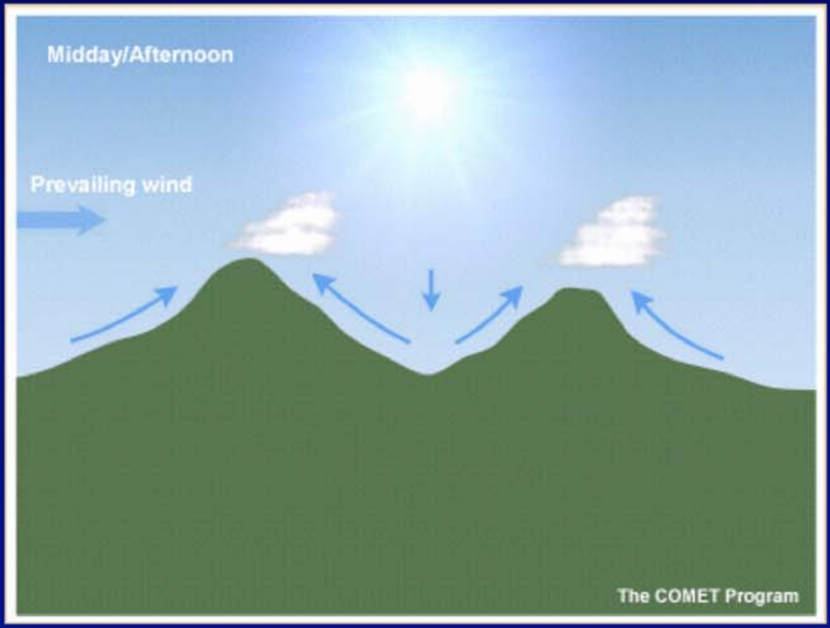


Evolution of Upslope Flow

Morning

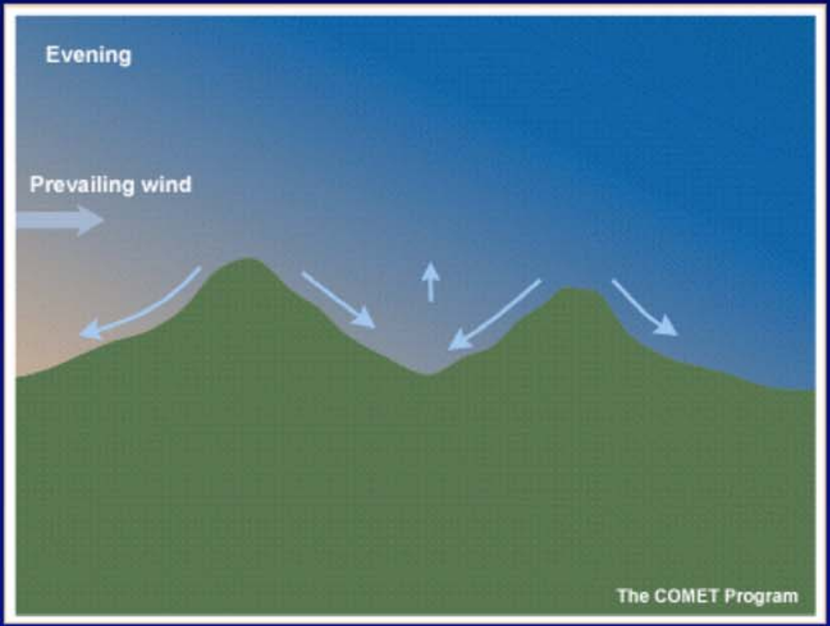
Afternoon





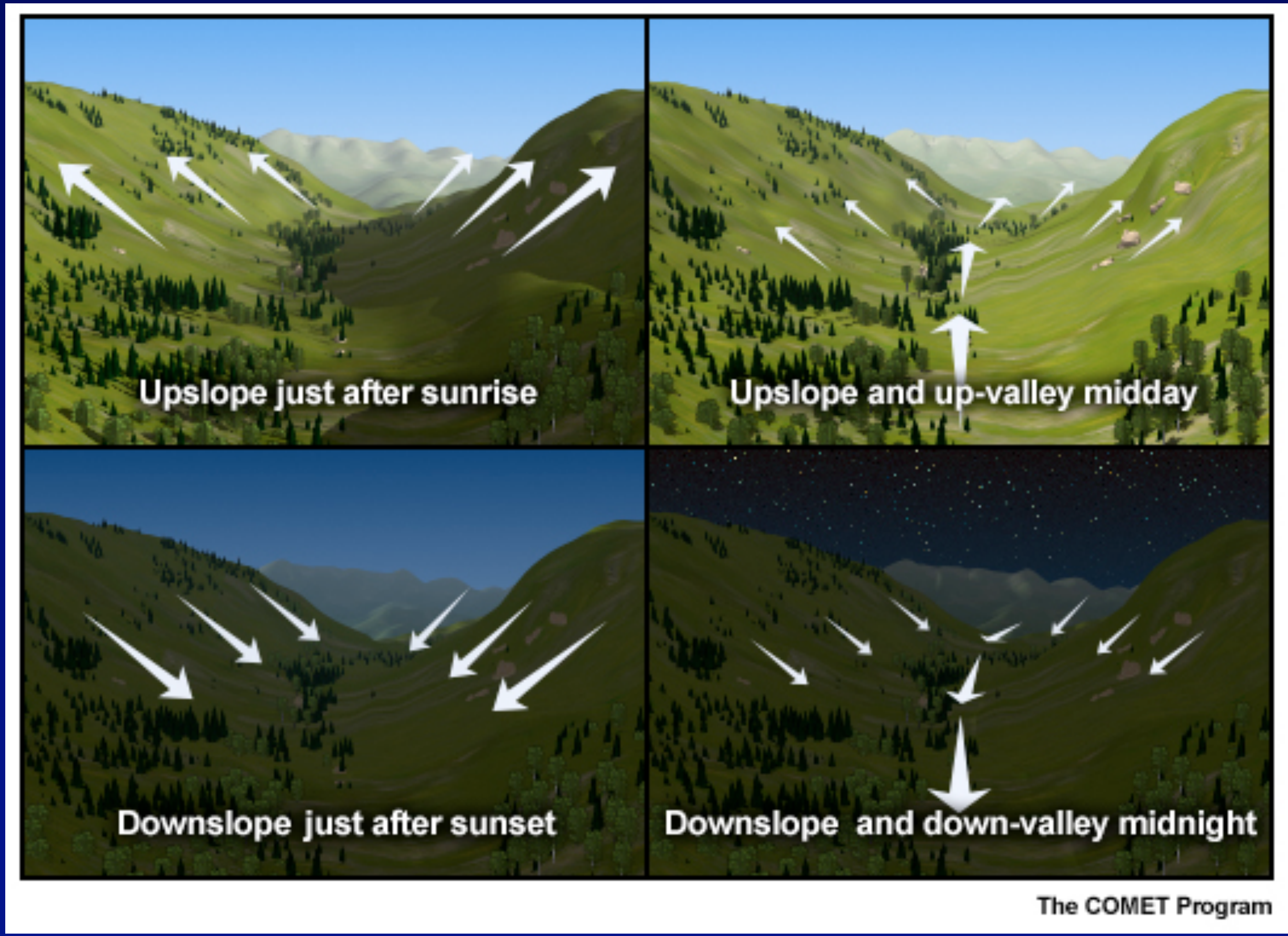
Evolution of Downslope Flow

Evening



Late night

The Slope-Valley Wind System



Using CPCS for Long-Horizon Planning

Test scenario 1:

The Chemical Test Division at DPG wants to study the properties of a heavier-than-air toxic industrial chemical (TIC). Specifically, they want to know how quickly clouds of TIC spread out during calm (or nearly calm) and statically stable conditions, and how long it takes clouds of TIC to completely dissipate under such conditions.

Using CPCS for Long-Horizon Planning

Test requirements:

- Will take place at DPG near SAMS 4.
- Must run 3 trials, and each trial takes 4 hours to complete.
- Trials must be done during nighttime (when statically stable conditions are most likely to exist).
- No winds above 2 m s^{-1}.
- No precipitation.

CPCS Demo

CPCS Web tool

Using CPCS for Long-Horizon Planning

Test scenario 2:

A weapons manufacturer wants to test a new ammunition at ATC. They need 10 days of testing, and testing is only done during normal business hours. They will use cameras to observe the rounds as they pass through the air. At high temperatures the gun barrels bend slightly (a Big No No).

Using CPCS for Long-Horizon Planning

Test requirements:

- Will take place at ATC near SAMS 7.
- Tests are done between 08:00 and 17:00 LT.
- Air temp. cannot be greater than 100 degF.
- Test range uses a firing direction of 26 deg.
- Maximum tolerable cross wind is 5 m s^{-1}.
- No precipitation.

CPCS Demo

CPCS Web tool

Further Reading

COMET Program cited. , 2001: Thermally Forced Circulation I: Sea Breezes. [Available online at http://meted.ucar.edu/mesoprim/seabreez/.].

COMET Program cited. , 2002: Thermally Forced Circulation II: Mountain/Valley Breezes. [Available online at http://meted.ucar.edu/mesoprim/mtnval/.].

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Stewart, J. Q., Whiteman C. D., Steenburgh W. J., and Bian X., 2002: A climatological study of thermally driven wind systems of the U.S. Intermountain West. *Bull. Amer. Meteor. Soc.*, **83**, 699-708.

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