Name:

Project: 'TOM: Teaching flow Over Mountains'
Deadline 29 April 2011, 2pm; 62 points

Concept of orographic precipitation:

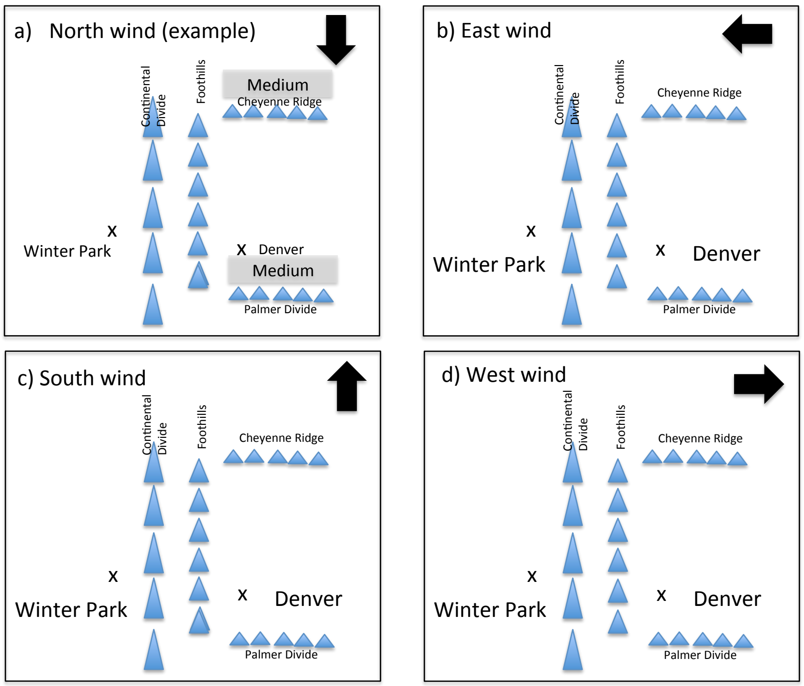

Figure 1: Schematic illustrating the topography around Denver (blue mountains) and the dominant wind flow (thick black arrows).

1) Use Fig. 1 to answer the following questions. **(8 points)**
   a. Highlight the regions in Fig. 1b, c, and d where you would expect precipitation (rain or snow) to occur. An example of the precipitation distribution for a northerly wind across the entire region is shown in Fig. 1a.

   b. Indicate in Fig. 1b, 1c, and 1d if you would expect high or low precipitation amounts and explain why.

c. List other meteorological parameters (beside wind) that determine the intensity of the precipitation.

Precipitation climatology in March:

Go to the ATOC weather statistic site (http://foehn.colorado.edu/weather/paos1/monthly_stats.html), read out the precipitation values for March 2008, 2009, 2010, 2011 and complete the graph in Fig. 2. (**4 points**)

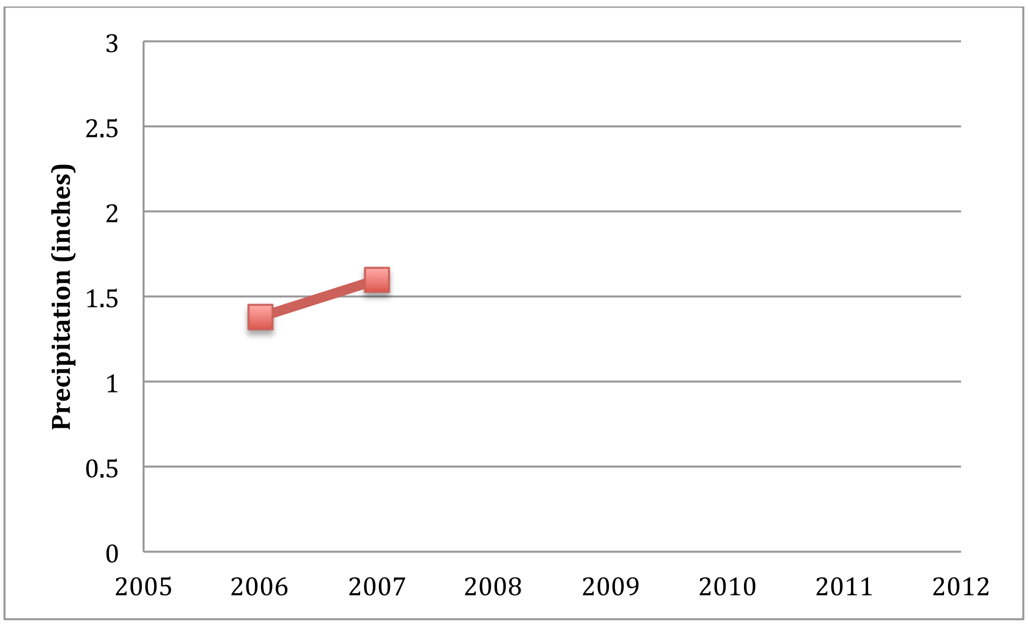

Figure 2: Accumulated precipitation (in inches) in March 2006 and 2011.

For the following questions use images and animations posted at
http://rain.colorado.edu/TOM-data

Environmental conditions during TOM (3 April 2000 UTC - 4 April 0500 UTC):

2) Use the Denver sounding on 3 April 12Z and 4 April 00Z to answer the following questions. (**6 points**)
    a. Describe the vertical profiles of temperature, moisture and wind at 12Z.

    b. Describe how the temperature, moisture and wind changed over 12 hours. Compare the vertical profiles of temperature, moisture and wind at 12 Z with observations at 00Z.

3) Choose a set of images showing surface observations (temperature, dew point, pressure, wind) which covers the time of the TOM experiment (3 April 2000 UTC – 4 April 0500 UTC). Please write down which station you used. (**6 points**)
   a. Describe the changes in temperature, moisture and wind before and during the TOM experiment.

   b. Based on the surface observations can you identify a surface front? Describe the parameters that you use to identify the front and how they changed with time. At what time did the surface front passes the station?

TOM Radar setup:

4) Figure 3 shows topography and radar reflectivity measured by the rapid-scan DOW radar on 4 April at 0056 UTC. At the time the radar image was taken there was no precipitation in the area. The reflections you see on the radar image (Fig. 3b) are all related to obstacles. Use the images and answer the following questions. (**17 points**)

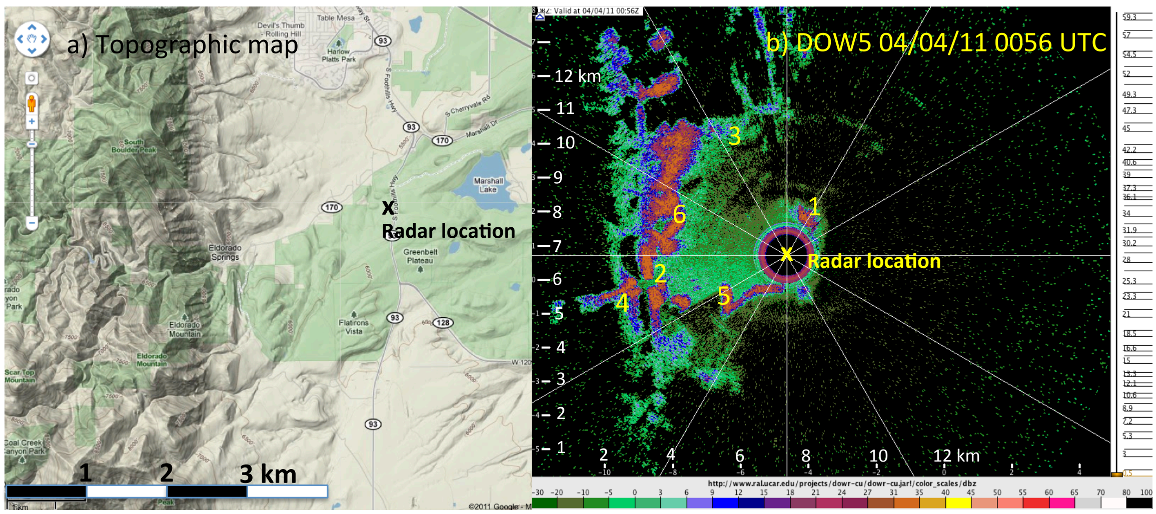

Figure 3: a) Topographic map of south of Boulder near the rapid-scan DOW5 location and b) radar reflectivity (color-coded) measured by the rapid-scan DOW. The radar location is indicated by the x symbol.

a. At what time (date and local time) was the radar image taken?

b. Place the appropriate numbers shown in the radar image in Fig. 3b to the topographic features in Fig. 3a.

c. What is the distance between the radar and the mouth of Eldorado Canyon? The distances in km are indicated as white numbers on the bottom of Fig. 3a.

d. Most radars start scanning at 0.5 degrees elevation angle. However, with increasing distance from the radar, the radar beam will be located higher above the ground (Fig. 4b). Feature that occur close to the ground are often important for the evolution of severe weather but most radar cannot observe these feature because the radar beam is just too far away from the ground. The following exercise will show the differences. Use the trigonometric identities in Fig. 4a to calculate the height of the radar beam above ground level (see Opposite O in Fig. 4a).

   a. What is the height of the rapid-scan DOW radar beam at 0.5 degrees elevations (see Angle x in Fig. 4a) above ground at the mouth of Eldorado Canyon? Assume that the distance between the rapid scan DOW radar and the Canyon is 3 km (see Adjacent A in Fig. 4a; orange triangle in Fig. 4b).

Answer:
1? Rapid-scan Dow: The radar beam will be __________km above ground level (AGL) when scanning at 0.5 degree elevation angle.

b. What is the height of the WSR-88D radar beam at 0.5 degrees elevations (see Angle x in Fig. 4a) above ground at the mouth of Eldorado Canyon? The distance between the WSR-88D Denver radar and the Canyon is 60 km (see Adjacent A in Fig. 4a; blue triangle in Fig. 4b).

Answer:
2? WSR-88D Denver: The radar beam will be __________km above ground level (AGL) when scanning at 0.5 degree elevation angle.

c. Use the height of the WSR-88D 0.5 deg elevation angle (2?) and determine the elevation angle. This time the Opposite (O) and Adjacent (A) are given,

d.

Answer:
3? Rapid-scan DOW: In order to scan up to 2?______ km AGL the rapid-scan DOW needs to have an elevation angle of _______degree.

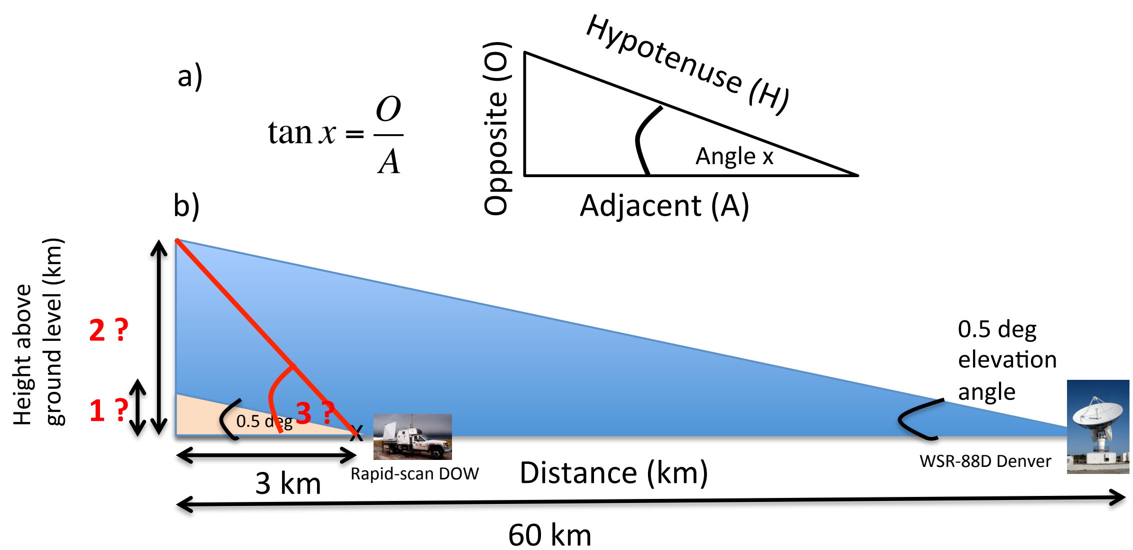

Figure 4: a) Trigonometric identities and b) schematic of the problem.

TOM - Interpreting radar images

5) To answer the following questions use the WSR-88D radar reflectivity loops at 0.5 degrees elevation (WSR-88D reflectivity zoom version) and rapid-scan DOW reflectivity loops at 4.1deg elevation (DOW reflectivity). (**21 points**)

a. How do the reflectivity and Doppler velocities measured in the snow differ from the reflectivity and the Doppler velocity from the mountains? Use the

WSR-88D reflectivity and Doppler velocity data to answer this question (zoomed versions).

b. Use the WSR-88D radar loops and read the reflectivity range of the precipitation that occur around the rapid-scan radar site. Make sure that you only consider reflections from rain or snow and NOT from the mountains.

	Begin/end time (UTC)	**Reflectivity precipitation NWR-88D**
Event#1	1630-1900 UTC	5-40 dBZ
Event#2	2030-2210 UTC	
Event#3	2340-0124 UTC	
Event#4	0320-0440 UTC	

c. Describe differences between images taken by the NWR-88D and the rapid scan DOW during 0320-0440 UTC (spatial range, spatial and temporal resolution)? Can you identify features (enhance reflectivity line, no reflectivity) in one image that do not show up in the other, i.e., what do we see/what do we miss? Use the movies from the rapid-scan DOW at 6.3deg elevation angle.