

An Overview of Air Quality and Atmospheric Change



The Air We Breathe...

Think of the world as a basketball. The atmosphere is then merely a piece of paper covering the ball!



The *Troposphere* is the lowest layer in the atmosphere--where we live and breathe

The weight of the molecules in the atmosphere creates air pressure. Thus, air pressure is greatest at the surface, and at sea level (or below), and is less at higher elevations



The Air We Breathe...

Major Components of the Atmosphere:

- 78% Nitrogen (N_2)
- 20.95% Oxygen (O_2)
- 0.93% Argon (Ar)
- 0.04% Carbon Dioxide (CO_2)
- 1% Water Vapor (H_2O)
- < 0.08% other trace gases

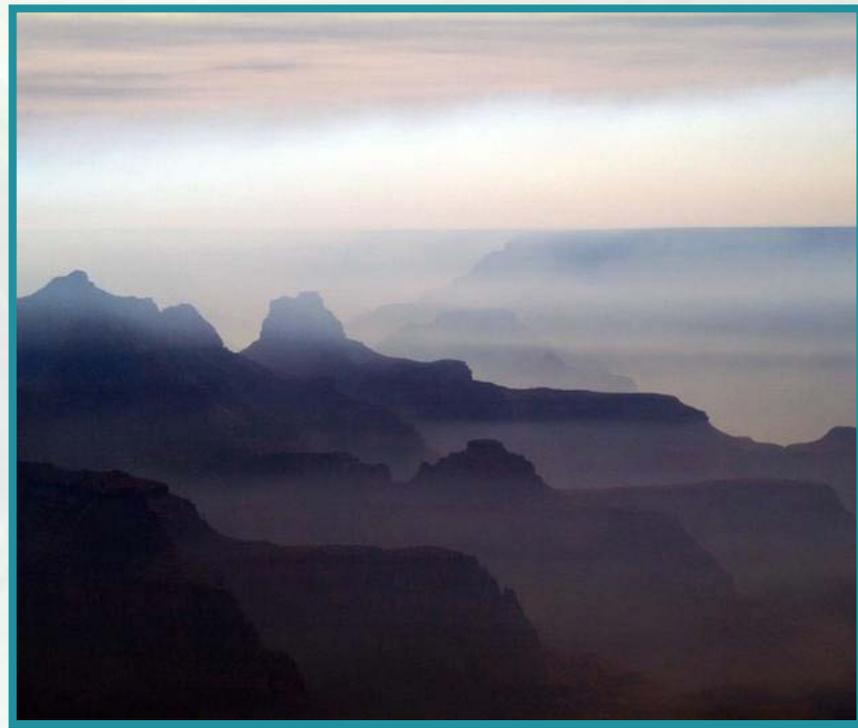
It is these trace gases that impact our health and drive atmospheric chemistry





What is *Air Quality*?

Air quality is the condition of the air expressed in terms of the concentration of pollutants relative to established baseline values





Key Ingredients for Air Quality Issues

Emissions

What is put into the atmosphere

Meteorology

Determines what happens to emissions

Topography

Puts a framework on the issue



Emissions and Meteorology

Important points about emissions:

Amount

Type

Source type (point or non-point)

Other emissions, and pollutants in the atmosphere

Once pollutants are emitted into the atmosphere, what happens to them is largely controlled by the weather



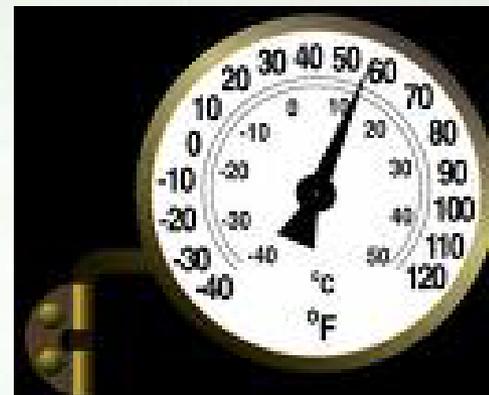
Significant Meteorological Factors influencing Air Quality

- **Temperature**
- **Solar radiation (sunlight)**
- **Wind (speed and direction)**
- **Precipitation**
- **Atmospheric moisture content (humidity)**



Temperature Controls on Air Quality

- Ozone (O_3) is formed preferentially in warm temperatures with bright sunlight (for given VOC and NO_x values)
- Volatile Organic Compounds (VOCs, which can help form ozone, and can be odorous) can result from pesticide volatilization that occurs more in warmer temperatures
- Ammonia generally forms at greater rates in warmer temperatures





Vertical Temperature Profile and *Inversions*

Vertical temperature profile: The change of temperature with height in the atmosphere

Very important for Air Quality! Issue of Atmospheric Stability

Change of temperature w/ height = “Lapse Rate”. Typical rate about 5.5F *decrease* / 1000 feet →

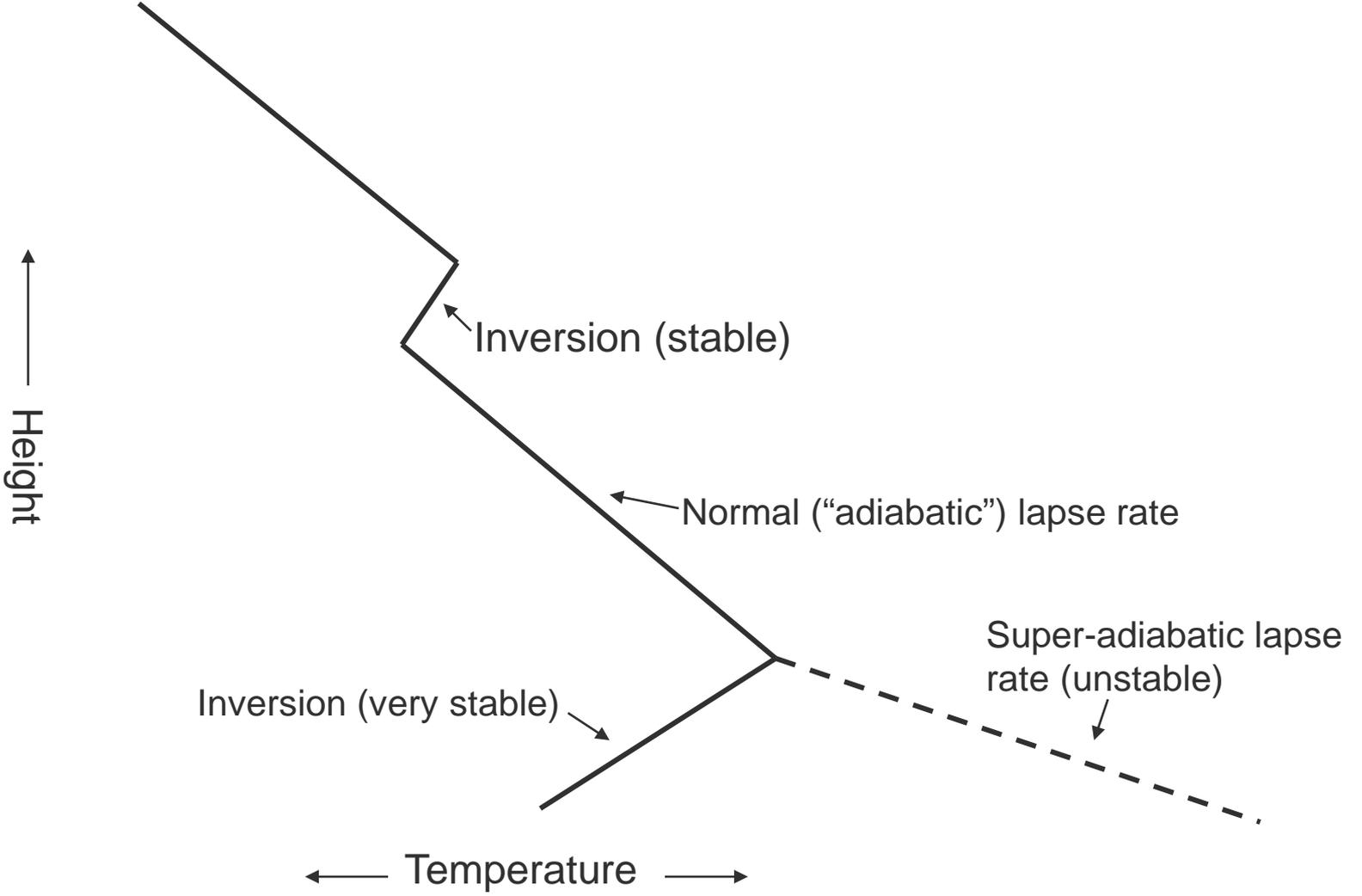
Strong surface heating (summer) or “adiabatic warming” (Chinooks) = Large *positive* lapse rate (can be *unstable*)

Strong surface cooling relative to above can lead to *inversions* (very *stable* atmosphere). Very warm air aloft can also create inversions

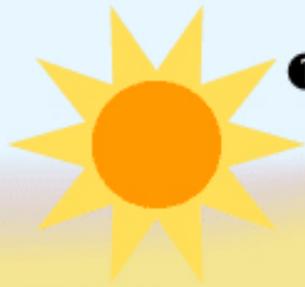
Vertical temperature profile is altered: temperatures *increase* with height

Result: Stagnant conditions, with very little vertical mixing

Common in colder months, but also in warm season in Southeast



Calm winds and the inversion result in poor air quality.



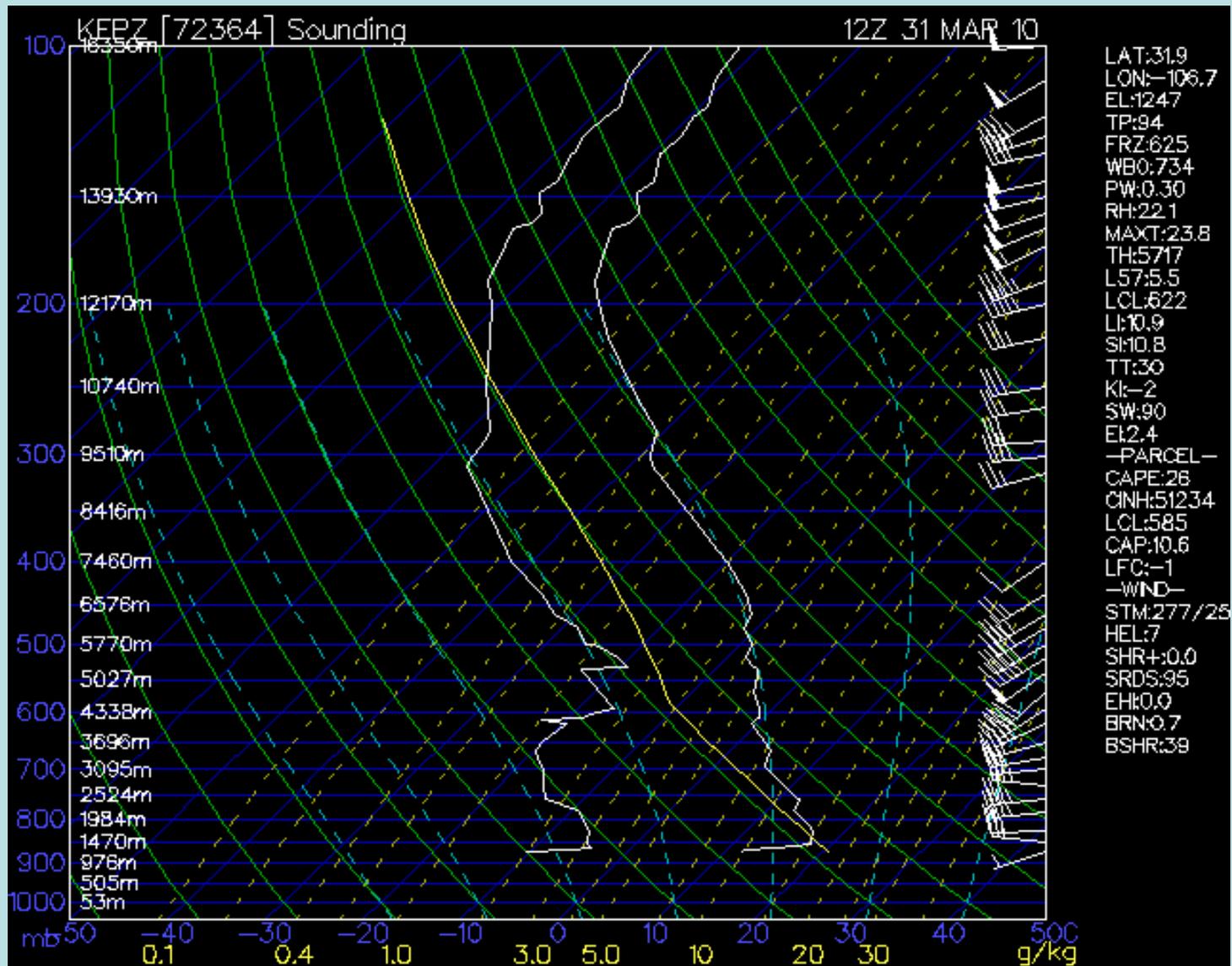
① The winter sun, low in the sky, supplies less warmth to the Earth's surface.

② Warmer air aloft acts as a lid and holds cold air near the ground.

③ Pollution from wood fires and cars are trapped by the inversion.

④ Mountains can increase the strength of valley inversions





Morning “sounding,” El Paso, 6 am, Wednesday March 31, 2010. Note the inversion (right white line). What is the approx. level of this inversion?



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Influence of Wind on Air Quality

Windy conditions can cause wind erosion and stir up dust (particulate matter). It can also transport dust, or other pollutants (smoke, chemicals, etc.), sometimes great distances





Winds: Important for Transport, Dispersion

Wind Roses depict frequency of winds from various directions and classes of speed

See:

<http://www.wcc.nrcs.usda.gov/climate/windrose.html>

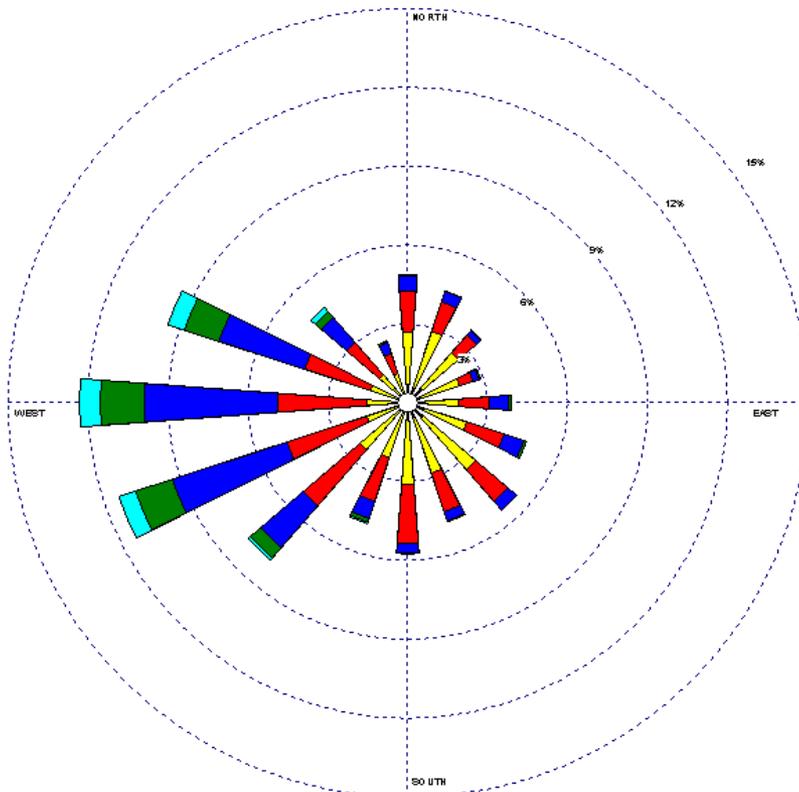
Winds are always indicated FROM the direction of flow

Wind roses show directional and speed frequencies (usually 16 directions and 5-6 categories of speed)

Wind roses are typically for given month, or for whole year. For site above, they are for each month, based on 30 years of data

WIND ROSE PLOT

Station #23044 - EL PASO INT'L ARPT, TX



<p>Wind Speed (m/s)</p> <ul style="list-style-type: none"> > 11.05 8.49 - 11.05 5.40 - 8.49 3.34 - 5.40 1.20 - 3.34 0.51 - 1.20 	<p>MODELER Sara West</p>	<p>DATE 8/29/2002</p>	<p>COMPANY NAME USDA-ARS</p>	
	<p>DISPLAY Wind Speed</p>	<p>UNIT m/s</p>	<p>COMMENTS</p>	
	<p>AVG. WIND SPEED 4.72 m/s</p>	<p>CALC WINDS 6.32%</p>		
	<p>ORIENTATION Direction (blowing from)</p>	<p>PLOT YEAR-DATETIME 1961 Apr 1 - Apr 30 Midnight - 11 PM</p>		

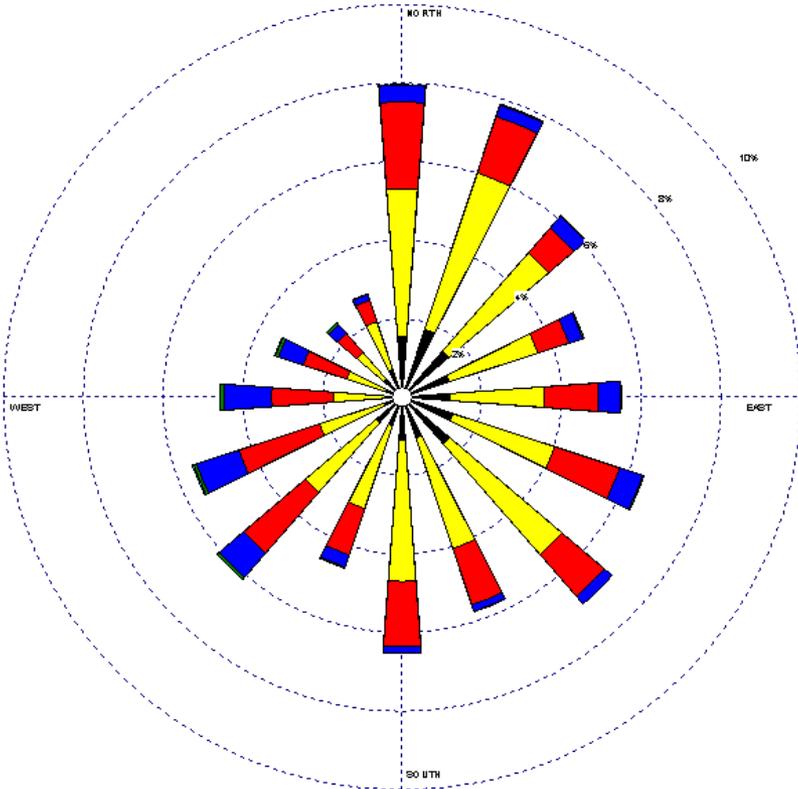
Wind Rose

April

El Paso

WIND ROSE PLOT

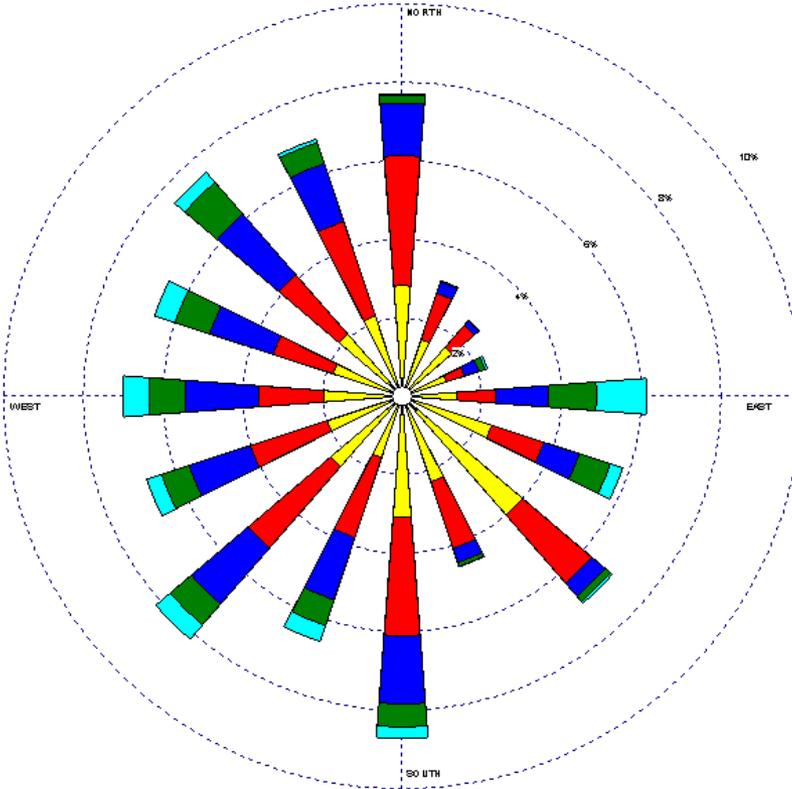
Station #23044 - EL PASO INT'L ARPT, TX



<p>Wind Speed (m/s)</p> <ul style="list-style-type: none"> ■ > 11.06 ■ 8.49 - 11.06 ■ 5.40 - 8.49 ■ 3.34 - 5.40 ■ 1.20 - 3.34 ■ 0.51 - 1.20 	<p>MODELER Sara West</p>	<p>DATE 8/29/2002</p>	<p>COMPANY NAME USDA-ARS</p>	
	<p>DISPLAY Wind Speed</p>	<p>UNIT m/s</p>	<p>COMMENTS</p>	
	<p>AVG. WIND SPEED 3.18 m/s</p>	<p>CALM WINDS 12.61%</p>		
	<p>ORIENTATION Direction (blowing from)</p>	<p>PLOT YEAR-DATE-TIME 1961 Oct 1 - Oct 31 Midnight - 11 PM</p>		

Wind Rose October El Paso

WIND ROSE PLOT
 Station #23050 - ALBUQUERQUE INT'L ARPT, NM

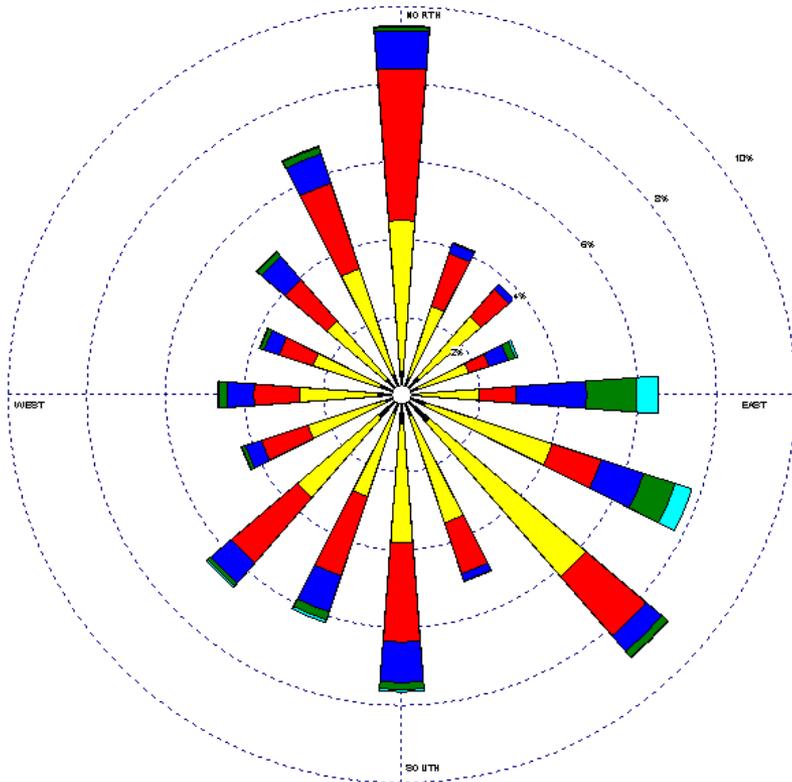


Wind Speed (m/s) 	MODELER Sara West	DATE 9/4/2002	COMPANY NAME USDA-ARS
	DISPLAY Wind Speed	UNIT m/s	COMMENTS
	AVG. WIND SPEED 5.07 m/s	CALM WINDS 2.73%	
	DIRECTION Direction (blowing from)	PLOT YEAR-DATE-TIME 1961 Apr 1 - Apr 30 Midnight - 11 PM	

Wind Rose April Albuquerque

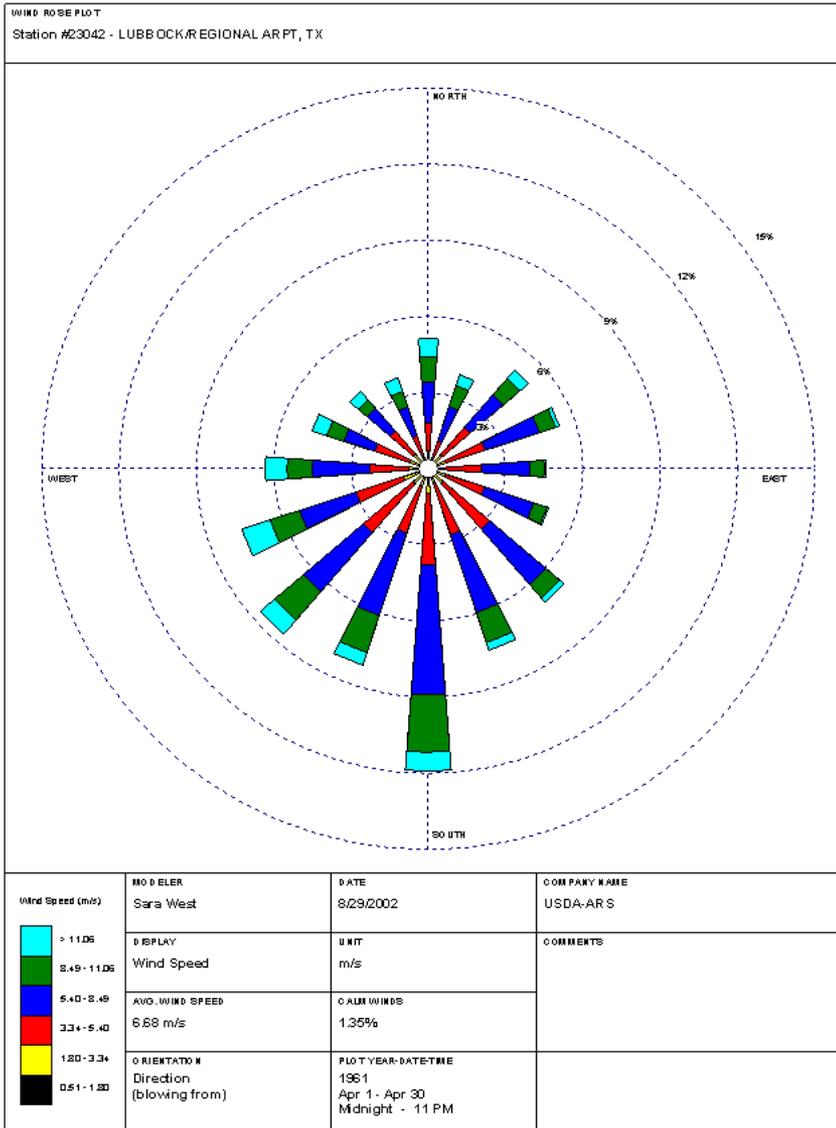
WIND ROSE PLOT

Station #23050 - ALBUQUERQUE INT'L ARPT, NM



<p>Wind Speed (m/s)</p> <ul style="list-style-type: none"> > 11.06 8.49 - 11.06 5.40 - 8.49 3.34 - 5.40 1.20 - 3.34 0.51 - 1.20 	<p>MODELER Sara West</p>	<p>DATE 9/4/2002</p>	<p>COMPANY NAME USDA-ARS</p>	
	<p>DISPLAY Wind Speed</p>	<p>UNIT m/s</p>	<p>COMMENTS</p>	
	<p>AVG. WIND SPEED 3.88 m/s</p>	<p>CALM WINDS 6.41%</p>		
	<p>ORIENTATION Direction (blowing from)</p>	<p>PLOT YEAR-DATE-TIME 1961 Oct 1 - Oct 31 Midnight - 11 PM</p>		

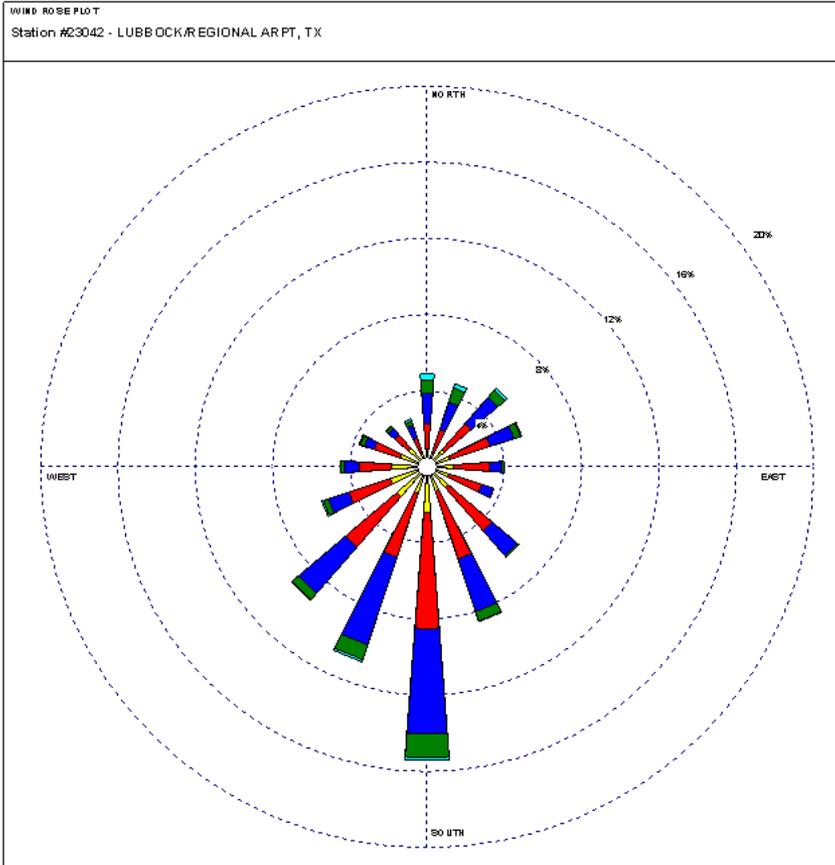
Wind Rose October Albuquerque



Wind Rose

April

Lubbock

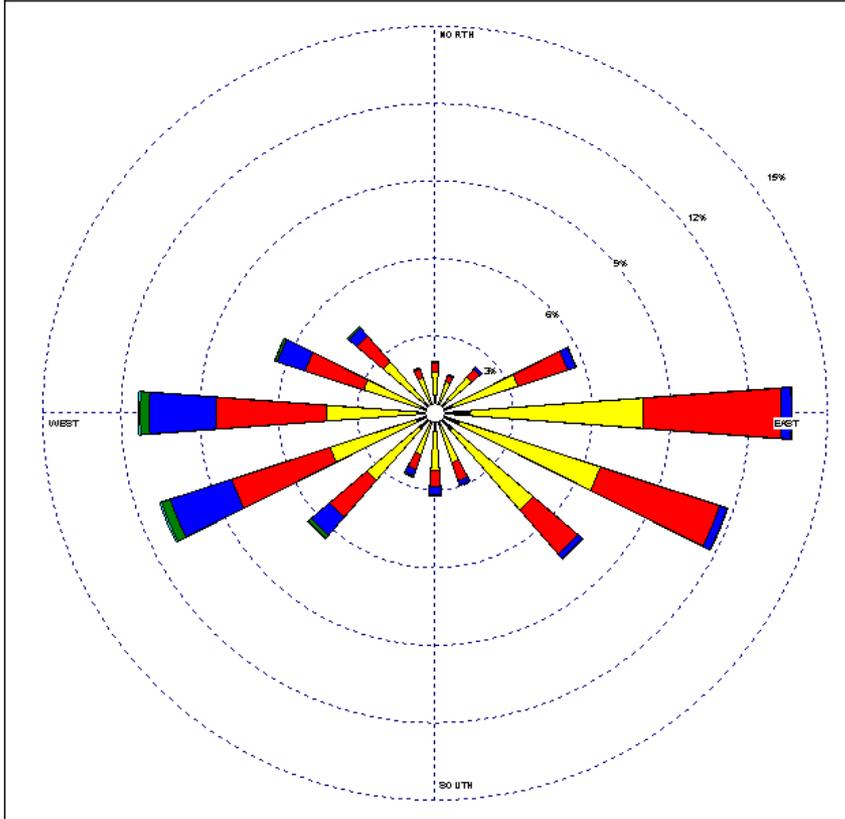


Wind Rose October Lubbock

Wind Speed (m/s) 	NO. OF ELER Sara West	DATE 8/29/2002	COMPANY NAME USDA-ARS
	DISPLAY Wind Speed	UNIT m/s	COMMENTS
	AVG. WIND SPEED 5.14 m/s	CALM WINDS 2.50%	
	ORIENTATION Direction (blowing from)	PLOT YEAR-DATETIME 1961 Oct 1 - Oct 31 Midnight - 11 PM	

WIND ROSE PLOT

Station #23183 - PHOENIX/SKY HARBOR INT'L ARPT, AZ

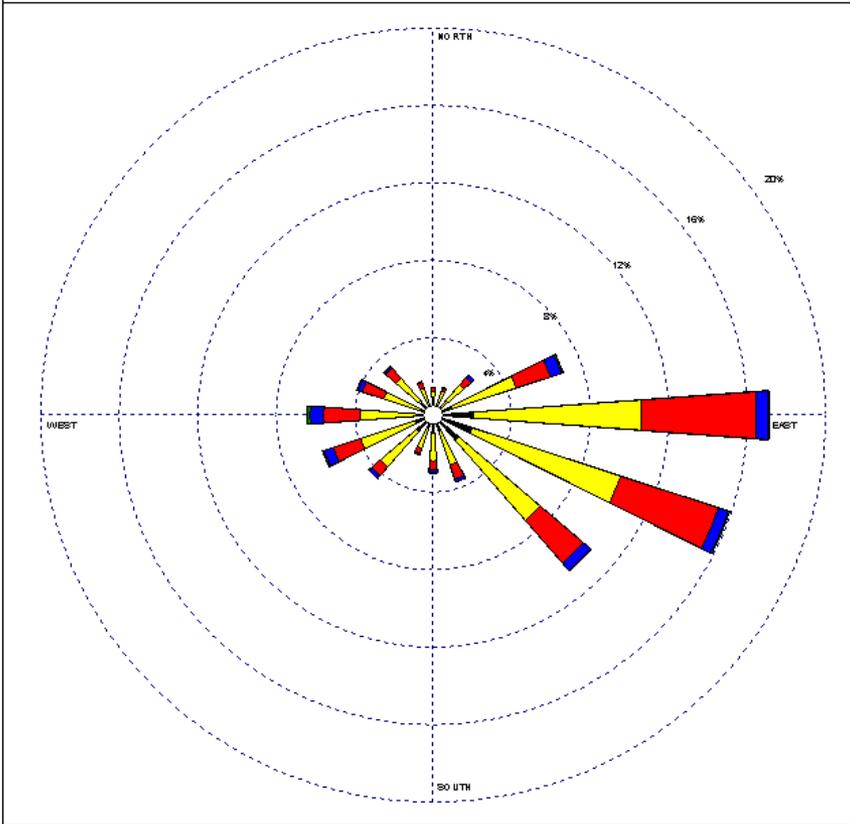


<p>Wind Speed (m/s)</p> <ul style="list-style-type: none"> > 11.06 8.49 - 11.06 5.40 - 8.49 3.34 - 5.40 1.20 - 3.34 0.51 - 1.20 	<p>MODELER Sara West</p>	<p>DATE 9/4/2002</p>	<p>COMPANY NAME USDA-ARS</p>	
	<p>DISPLAY Wind Speed</p>	<p>UNIT m/s</p>	<p>COMMENTS</p>	
	<p>AVG. WIND SPEED 3.53 m/s</p>	<p>CALM WINDS 5.02%</p>		
	<p>ORIENTATION Direction (blowing from)</p>	<p>PLOT YEAR-DATETIME 1961 Apr 1 - Apr 30 Midnight - 11 PM</p>		

Wind Rose April Phoenix

WIND ROSE PLOT

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<p>Wind Speed (m/s)</p> <ul style="list-style-type: none"> > 11.06 8.49 - 11.06 5.40 - 8.49 3.34 - 5.40 1.20 - 3.34 0.51 - 1.20 	<p>MODELER Sara West</p>	<p>DATE 9/4/2002</p>	<p>COMPANY NAME USDA-ARS</p>	
	<p>DISPLAY Wind Speed</p>	<p>UNIT m/s</p>	<p>COMMENTS</p>	
	<p>AVG. WIND SPEED 3.05 m/s</p>	<p>CALM WINDS 8.71%</p>		
	<p>ORIENTATION Direction (blowing from)</p>	<p>FLY YEAR-DATETIME 1961 Oct 1 - Oct 31 Midnight - 11 PM</p>		

Wind Rose October Phoenix



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- Temperature
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Precipitation Impacts on Air Quality

Precipitation can clean the air, but in so doing “wet deposition” of particulates and other pollutants can occur, impacting water and soil quality, plants, etc.





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Topography-Air Quality Relationships

Topography is a critical factor in Air Quality:

- Helps define *airsheds*
- Directs wind direction and speed
- Creates microclimates
 - ▶ Valleys: Colder at night (and sometimes even in day in winter);
More inversions
 - ◆ Orientation important w.r.t sun, large scale flow, etc.
 - ◆ Valley Winds: Up valley during day; Down valley during night



Airsheds

“An *airshed* is a part of the atmosphere that behaves in a coherent way with respect to the dispersion of emissions. It typically forms an analytical or management unit. Also: A geographic boundary for air quality standards.”

- ▶ Scale is important!
 - ◆ For some issues, very local airshed (odors)
 - ◆ For some issues, regional airshed (ozone)
 - ◆ For some issues, global concern (GHGs)

Think about all of these scales when addressing air quality issues

Local Topography and Climate



Maricopa County PM10 Nonattainment Area

