Introduction to Air Pollution

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Outline

- Important Air Quality Regulations
  - Clean Air Act and Amendments
  - Others
- Methods for Quantifying Pollutants
- Air Pollution Control
- Field Trip to Bondville Atmospheric Environmental Research Station (BEARS)
- Summary

Air Pollutant Regulations

- **Regulations Prior to 1970 (1955, 1963, 1967)**
  - Provided funds to research air pollution monitoring and abatement techniques
  - Began to develop emission inventories for select pollutants

Air Pollutant Regulations

- **Clean Air Act (1970)** – Created federal regulations on emissions for select contaminants from stationary and mobile sources
  - National Ambient Air Quality Standards (NAAQS)
  - State Implementation Plans (SIP)
  - New Source Performance Standards (NSPS)
  - National Emission Standards for Hazardous Air Pollutants (NESHAPs)
- Contributed to the development of the US EPA
- Small amendments made in 1977

Air Pollutant Regulations

- **Clean Air Act Amendments (1977)** – Updates to the previous CAAA that address specific air quality issues
  - States must submit revised SIPs
  - Classification of areas with respect to NAAQS
  - Establish policies for non-attainment areas
  - New major facilities must apply specific standards
  - Good Engineering Practice for stack height

Air Pollutant Regulations

- **Clean Air Act Amendments (1990)** – Updates to the initial Clean Air Act that address specific problems and increased ability to control and detect pollutants
  - Control of Acid Rain
  - Control of Hazardous Air Pollutants
  - Control of Ozone Depleting Chemicals
  - New Requirements for Motor Vehicles
  - New Permitting Requirements for Sources

National Ambient Air Quality Standards

- Standards set for the six criteria air pollutants

- **Primary Standard –** Protection of health
- **Secondary Standard –** Protection of welfare

  – Pollutant Concentrations

  – Averaging Times – Average pollutant concentration during a given amount of time (to remove outliers)

National Ambient Air Quality Standards

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: US EPA

Monitoring/Measuring Air Pollutants

- **What Effects an Air Pollutant's Concentration?**
  - Location of Source Compared to Receptor (x, y, z)
  - Type of Source (stationary, mobile, area)
  - Source Strength
  - Atmospheric Conditions
    - Wind Speed/Direction
    - Precipitation
    - Atmospheric Stability

Gaussian Dispersion Model

Determining contaminant concentrations resulting from a stationary pollutant source…

$$C_{(x,y,z)} = \frac{Q}{2\pi u_g \sigma_y \sigma_z}\left\{\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Q = Source Strength (mass / time)

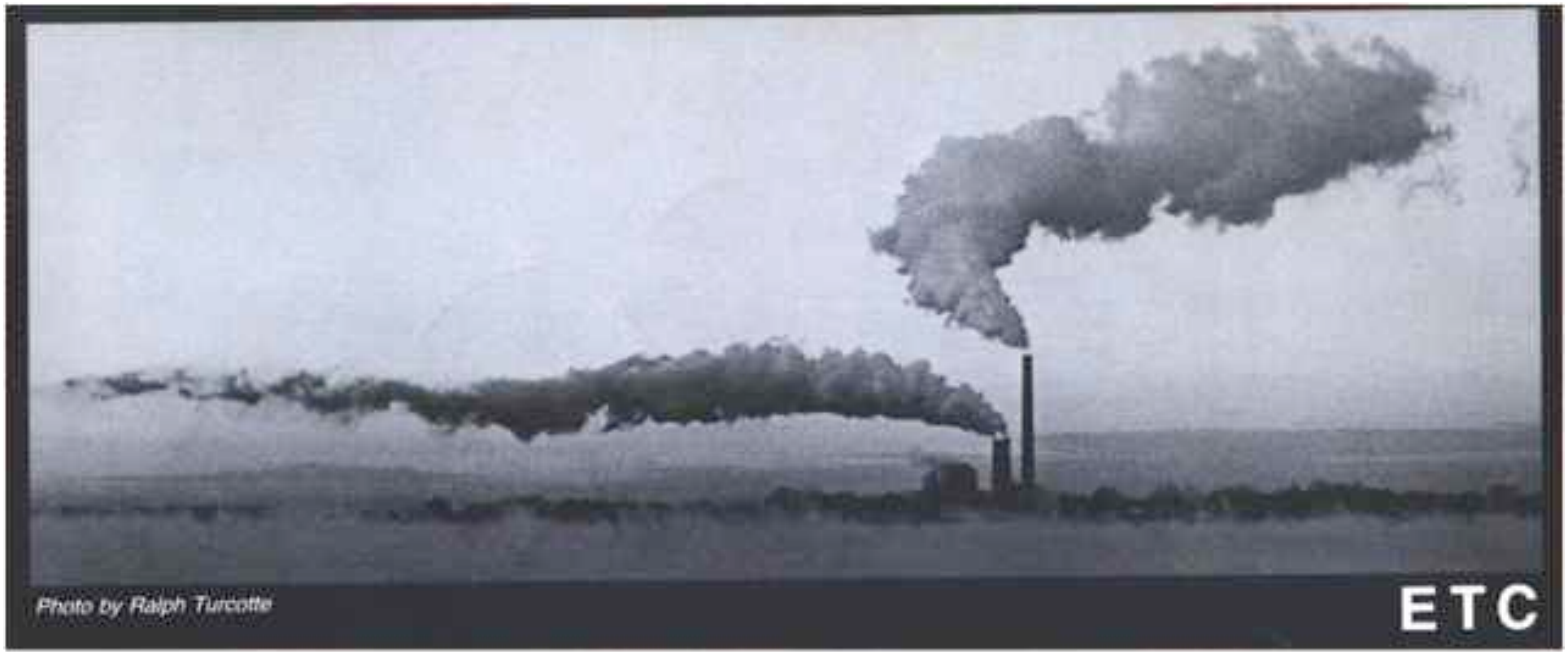
$\mathbf{u_g}$ = Wind Speed (length / time)

$\boldsymbol{\sigma_y}$ **and** $\boldsymbol{\sigma_z}$ = Parameters Describing the Weather Conditions (length)

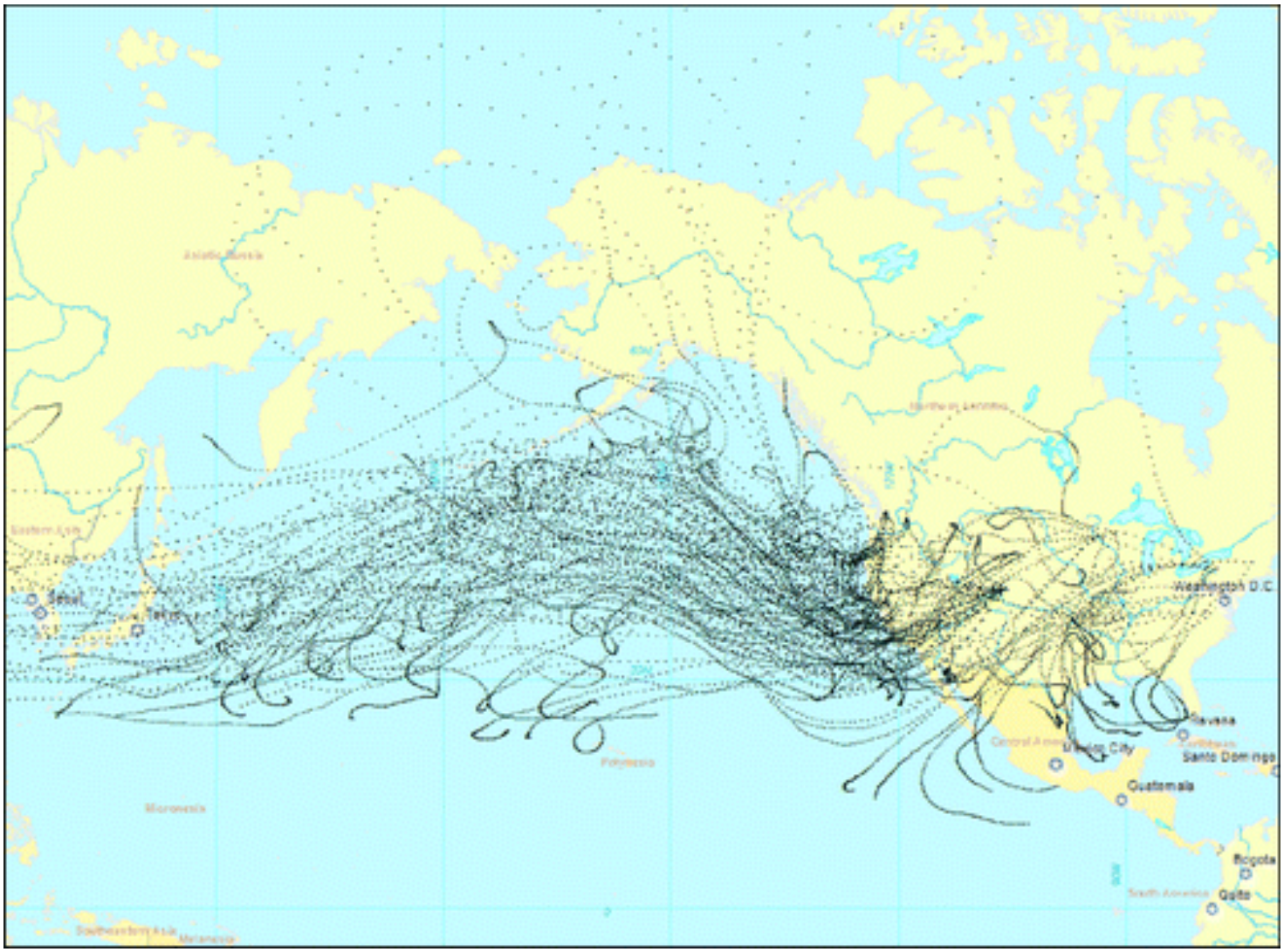
(x, y, z) = Position of Interest

H = Height of Pollutant Source (length)

Atmospheric Conditions Impact Pollutant Dispersion

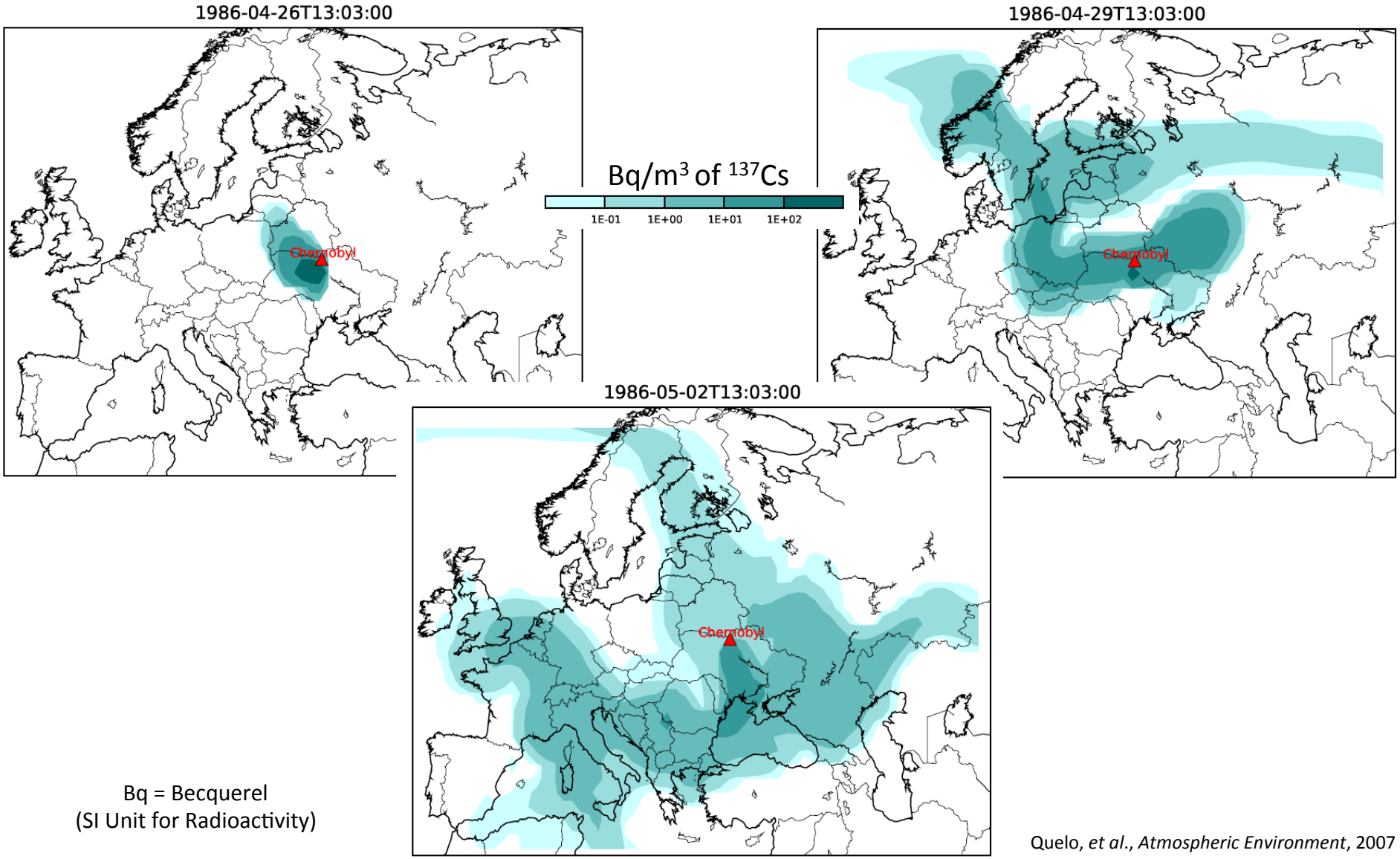


Radioactive Materials from Fukushima Detected at Sites in the USA



Weatherbee, *et al.*, *Environmental Science and Technology*, 2012

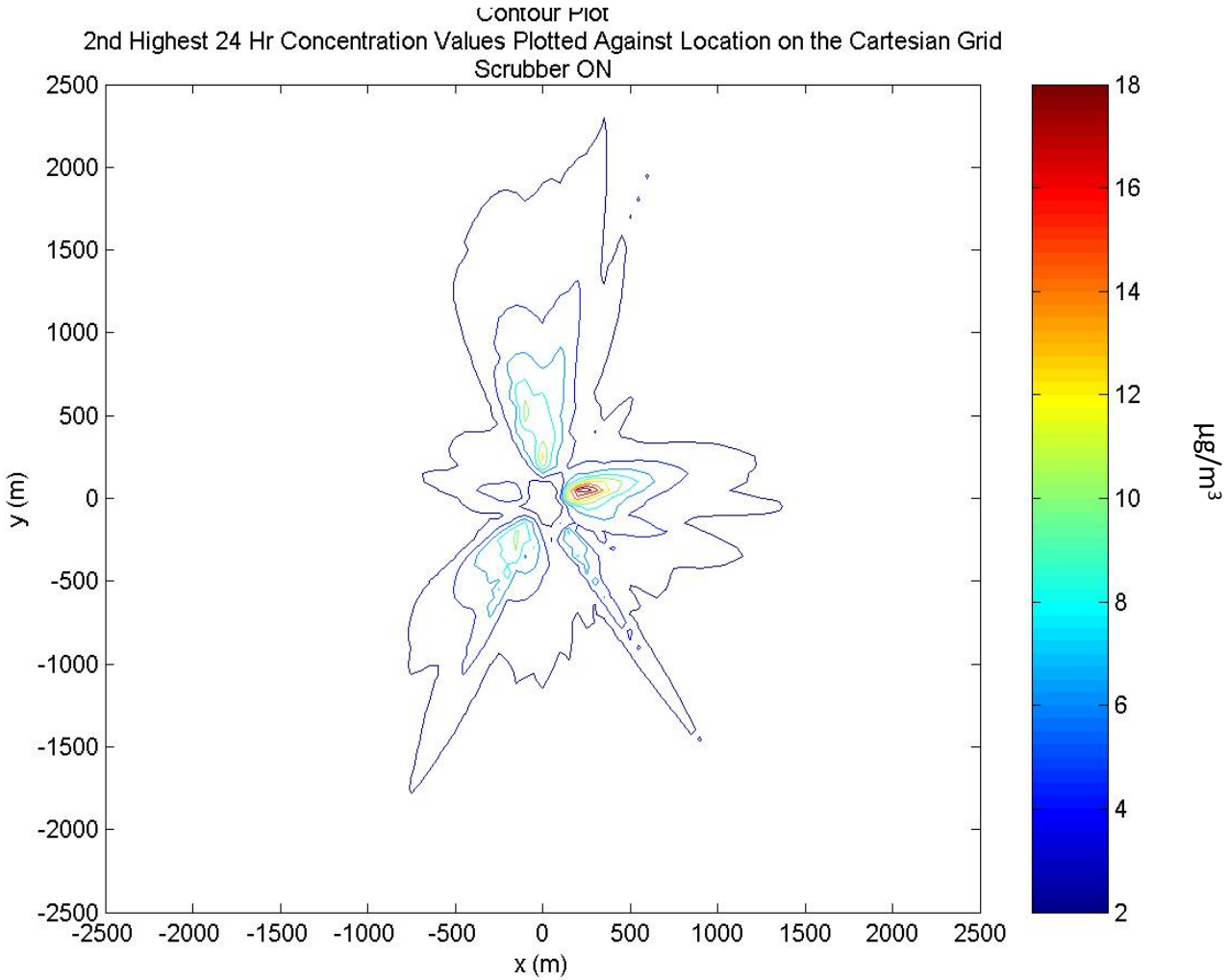
Radiation Dispersion (and decay) from the Chernobyl Disaster



Bq = Becquerel
(SI Unit for Radioactivity)

Quelo, *et al.*, *Atmospheric Environment*, 2007

Sulfur Dioxide Emissions from **Abbott Power Plant**



- AERMOD model from EPA

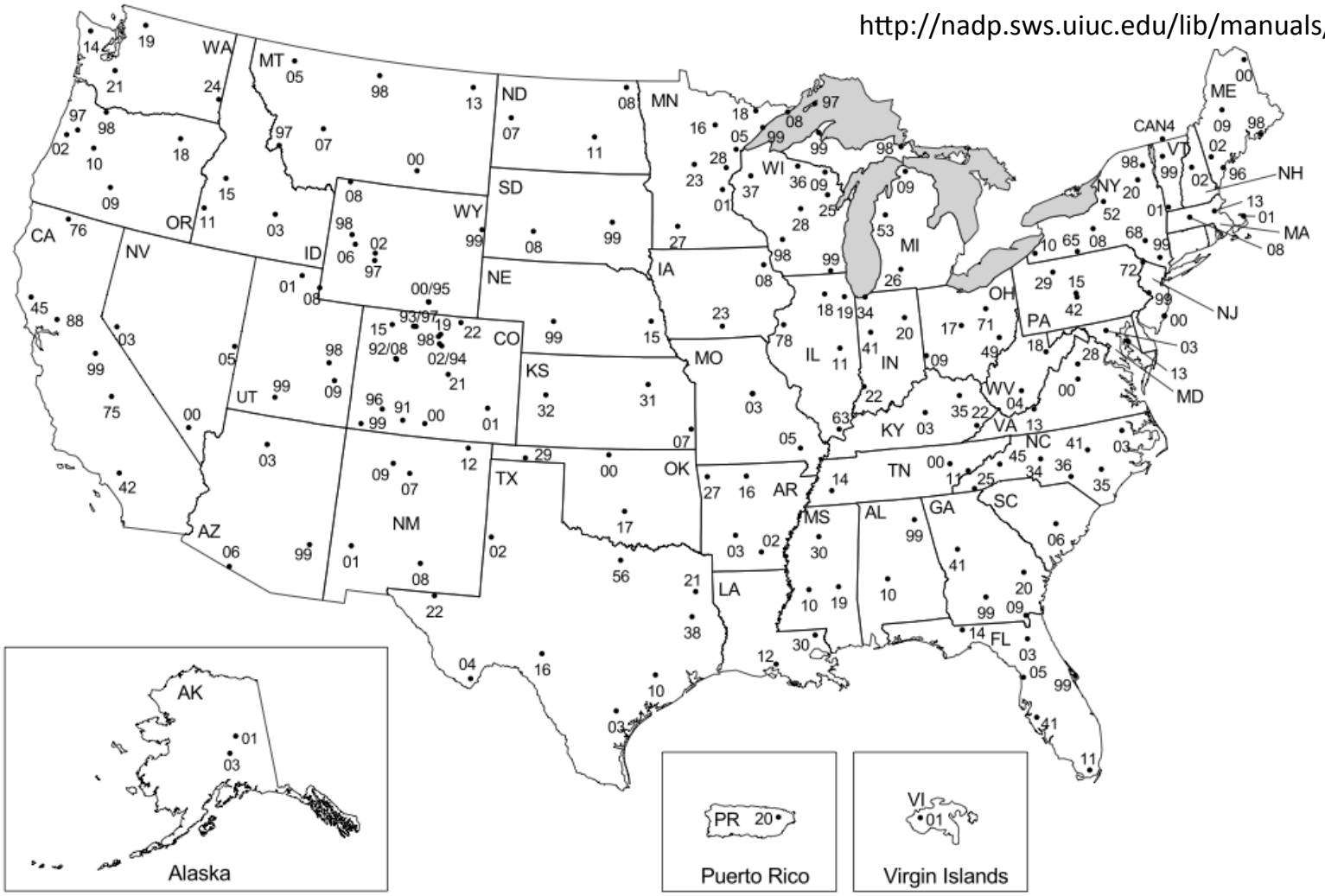
Types of Air Pollutant Monitoring

Outdoor Ambient Monitoring is the systematic, long-term assessment of pollutant levels by measuring the quantity and types of pollutants in the outdoor air.

Emissions Measurement is the process of monitoring particulate and gaseous emissions from specific sources.

National Trends Network Measurement Sites

http://nadp.sws.uiuc.edu/lib/manuals/opman.pdf



IL 11 = Bondville, IL – Tour of this site next week!

Ambient Atmospheric Sampling at Bondville Environmental Atmospheric Research Site

Ambient Atmospheric Sampling at Bondville Environmental Atmospheric Research Site

- Basic Air Quality
  - Sulfur dioxide, ozone, particulate matter, organics
- Precipitation Chemistry
  - Major ions, mercury, event based longer term sampling
- Long-Term Climate
  - National Weather Service site
- On-Site Meteorology
  - Wind velocity, air and soil temperatures, dew point temperature, pressure, radiation
- Atmospheric Visibility
- Solar Physics
- Continuous Particulate Monitoring using Chromatographic Methods

Sampling Platforms – Ships

NOAA Research Vessel: Ronald H. Brown

http://www.moc.noaa.gov/rb/

Sampling Platforms – Aircraft

NOAA DHC-6 Twin Otter Aircraft

http://www.noaanews.noaa.gov/stories2009/20090112_twinotter.html

Balloon

http://www.ncdc.noaa.gov/weather-balloon-data

Satellites

http://www.nasa.gov/vision/earth/lookingatearth/earthweek.html

Sampling Platforms – Personal Samplers

http://www.munroinstruments.co.uk/Environmental/contents/en-us/d27_Standard_Personal_Air_Samplers.html

Stack Sampling

Air Pollution Control

- Major Techniques
  - **Adsorption** – Adhesion of a contaminant to the surface of a solid
    - Volatile Organic Compounds
    - Mercury
  - **Absorption** – Concentration of a contaminant into the bulk of another solid or liquid
    - Sulfur Dioxide
    - Carbon Dioxide (?)
  - **Filtration** – Removing solids/liquids from a gas stream by imposing an impenetrable barrier
    - Particulate Matter
  - **Catalytic Destruction** – Conversion of a contaminant to an inert compound via catalytic processes
    - Nitrogen Oxides (Catalytic Reduction to N_2)

Next Week… (Thursday)

- Tour of Bondville Environmental and Atmospheric Research Site (BEARS)