Consolidated Code Prototype Atmospheric Engine

Pacific Northwest NATIONAL LABORATORY
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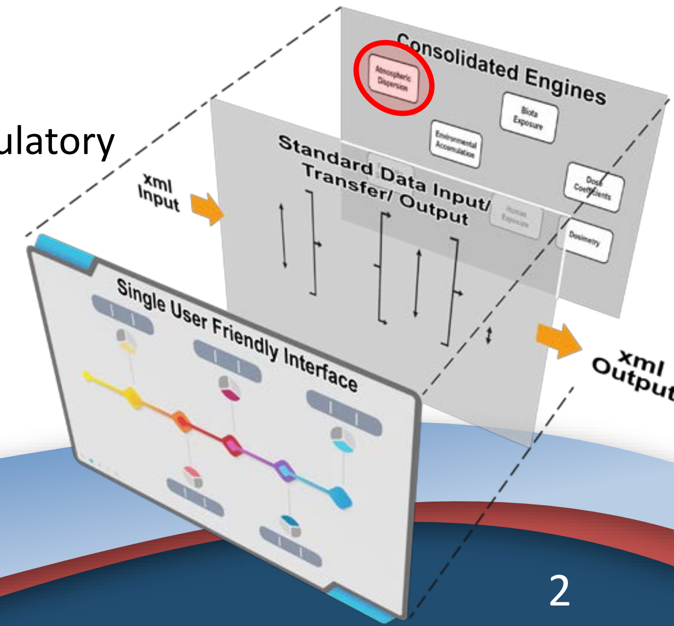
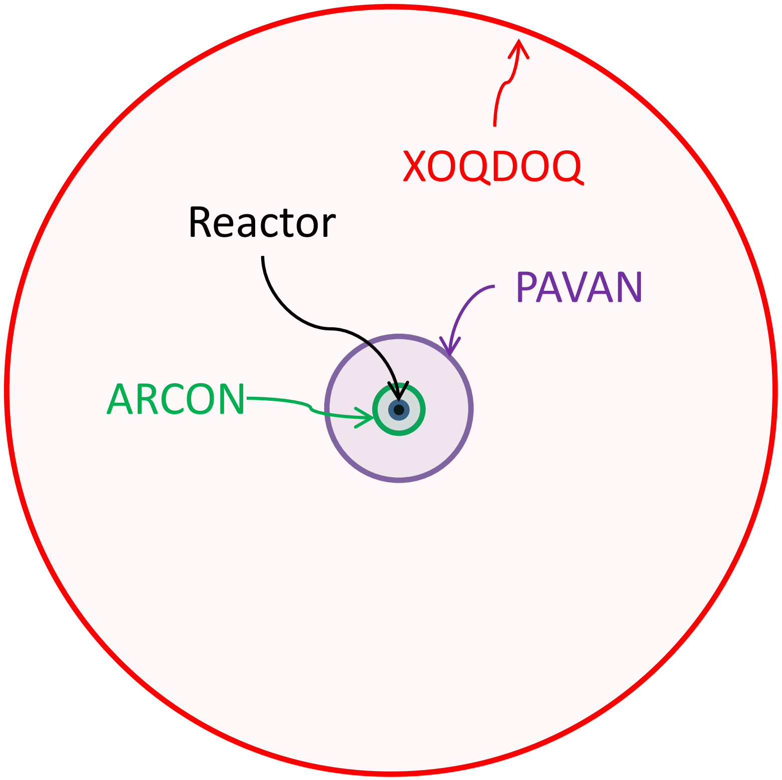
Goals of the Prototype

- Modernize codes, increase efficiency, and to allow for easy maintenance and future modifications
- Demonstrate the concept of three “Pillars”
- Consolidate the atmospheric codes into a single “engine”
- Build a flexible data transfer system with XML
- Incorporate scientific improvements for atmospheric dispersion
  - Direct measurements of turbulence
  - Similarity theory – currently implemented in USEPA regulatory models (e.g., AERMOD)



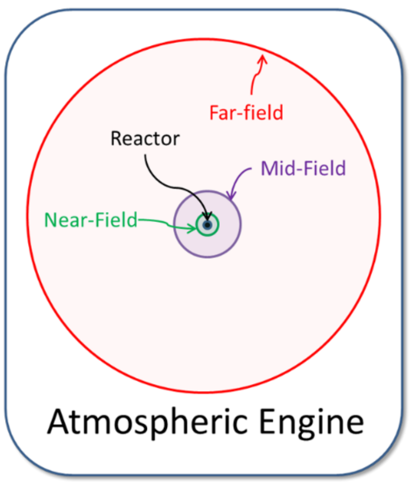
Current Atmospheric Dispersion Codes

- Three distance scales to consider:
  - ARCON: Near-field (~100s meters); design basis accidents (DBA's) at the control room (CR) and technical support center (TSC).
  - PAVAN: Mid-field (~10 km); DBA's at the exclusion area boundary (EAB) and low population zone (LPZ).
  - XOQDOQ: Far-field (out to ~80 km); normal effluent releases for sensitive receptors and population.



Atmospheric Dispersion "Engine"

- A single "atmospheric engine" would perform the same calculations in ARCON, PAVAN, and XOQDOQ that are currently used for reviewing reactor license applications.
- The methods implemented in the "atmospheric engine" would meet the requirements for near-, mid-, and far-field dispersion calculations.



	Consolidated Atmospheric Module Choices			
Current Code	**Meteorology**	**Source**	**Dispersion**	**Receptor**
ARCON PAVAN XOQDOQ	Wind Speed/Direction - Hourly - Joint Frequency Distribution Temperature Turbulence - Pasquill-Gifford - Desert Curves - Direct Measurement Wind Measurement Heights	Ground Level, Elevated or mixed-mode Type: ground, vent, or stack Height (vent or stack release) - Vent or stack release - Plume rise (momentum/buoyancy) - Effective height (topography) Building area (ground or vent release) Vertical velocity, stack flow, and radius Terrain Height Plume Decay/Depletion Modified χ/Q for recirc or stagnation	Puff Plume Meander Entrainment	Direction to the Source Distance to Receptor Height Elevation Difference

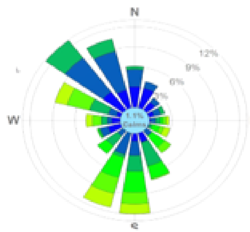
Prototype Development Concept

Select Dispersion Distance

- ❑ Near-field (RG1.194)
- ❑ Mid-field (RG1.145)
- ❑ Far-field (RG1.111)

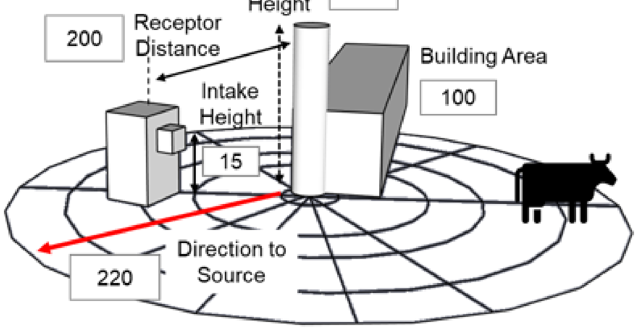
Import Meteorology

Upload met file (RG1.23 format)	Example_met.csv
Wind Sensor Height	2.0
Surface Roughness	0.2

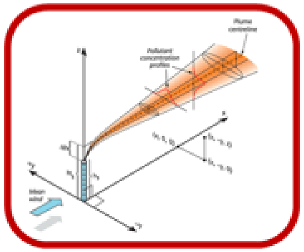


Import Terrain

Source-Receptor



Atmospheric Dispersion Engine



Source Info

❑ Ground Level	Vertical Velocity (m/s)	5.0
❑ Vent Release	Stack Flow (m^3/s)	15.7
❑ Elevated Stack	Stack Radius (m)	1.3
❑ Diffused Source		

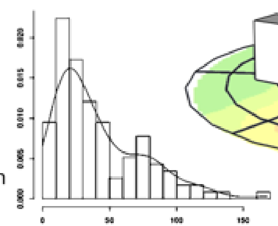
Output Options

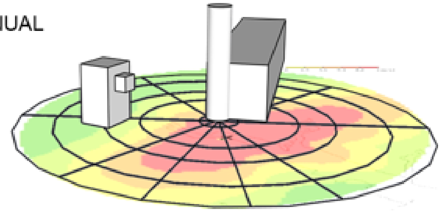
Averaging Time

❑ 2 HR ❑ 8 HR ❑ ANNUAL

Generate Reports

95% X/Q distribution



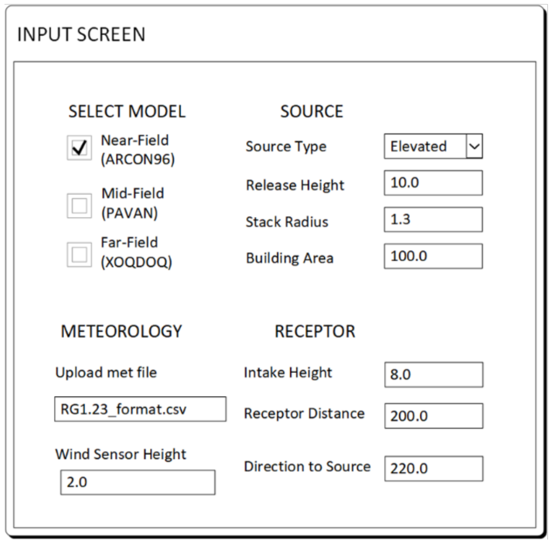


New Planned Features

- Interactive interface with an underlying code that reduces the burden on the user with minimum input
- Users do not need to externally calculate stability
  - Internal routines to compute stability classes based on ΔT or σ_θ
- Users do not need to generate joint frequency distribution (JFD) of meteorological data
  - Input standard hourly meteorological data in the RG 1.23 format
  - User customized format
- Additional options to estimate diffusion
- Features to export and visualize output

XML Data Transfer

User Interface



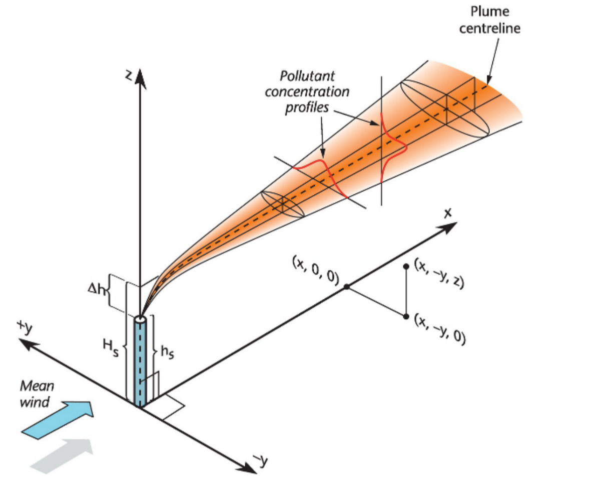
XML Implementation

```xml
<?xml version="1.0"?>
<input>
    <modeltype>near-field</modeltype>
    <sourceinfo>
        <type>Elevated</type>
        <stackHeight>10.0</stackHeight>
        <radius>1.3</radius>
        <buildingArea>100.0</buildingArea>
    </sourceinfo>
    <receptorinfo>
        <intakeHeight>8.0</intakeHeight>
        <distance>200.0</distance>
        <direction>220.0</direction>
    </receptorinfo>
    <metinfo>
        <metfile>"RG1.23_format.csv"</metfile>
        <sensorHeight>2.0</sensorHeight>
    </metinfo>
</input>
```

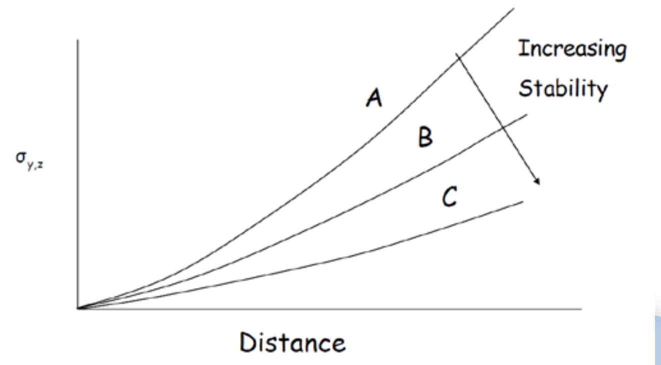
- Currently, fixed format text files (card input) is rigid and difficult to modify
- XML would make data input universal and adaptable
- XML easily allows new data to be added (or removed) and do not affect the underlying code

Diffusion Coefficients

- Gaussian plume model is the workhorse for dispersion calculations
- Why so popular?
  - Produces reasonable results
  - Easy mathematics
  - Quick running
  - Results consistent with “averaged” turbulence



- Dispersion model will be designed to allow calculations of σ_y and σ_z using three options:
  - Pasquill-Gifford (P-G) coefficients based on stability category
  - Dispersion coefficients computed from measured turbulence (σ_θ/σ_v and σ_e/σ_w)
  - Dispersion coefficients from internally calculated micrometeorological variables based on similarity theory



P-G Method Technical Basis

- Based on experimental measurements
  - Project Prairie Grass, 1956
  - Seventy, 10-minute SO_2 releases
  - 0.5 m release height
- Idealized conditions:
  - Nebraska = Flat terrain, open country
  - Homogenous, 5-6 cm grassy surface
  - July-August summer season
  - Daytime and nighttime
  - Wind speed > 2 m/s
- Measurement locations:
  - Sampling arcs downwind to 800 m
  - Vertical height at 1.5 m

P-G Limitations

- Represent a finite number of atmospheric conditions
- Goes directly to dispersion without explicit use of turbulence
- It applies primarily to near surface releases
- Actual diffusion coefficients can be 2 to 10 times greater than P-G estimates
- However, simple to use and found in most regulatory models
  - Environmental Protection Agency (EPA) ISC
  - Nuclear Regulatory Commission (NRC) PAVAN and XOQDOQ

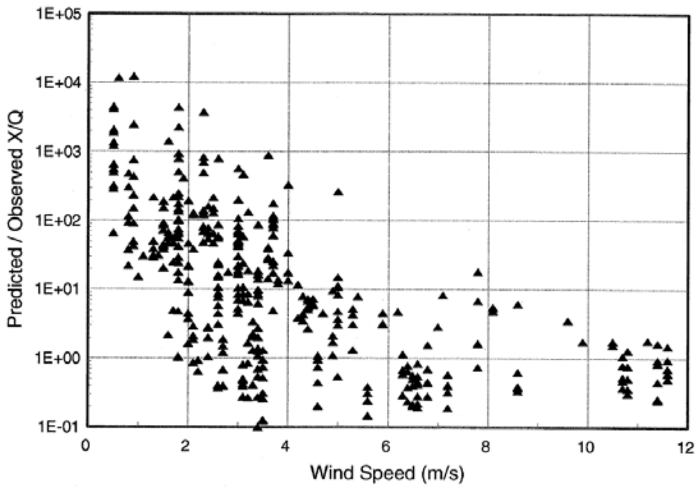
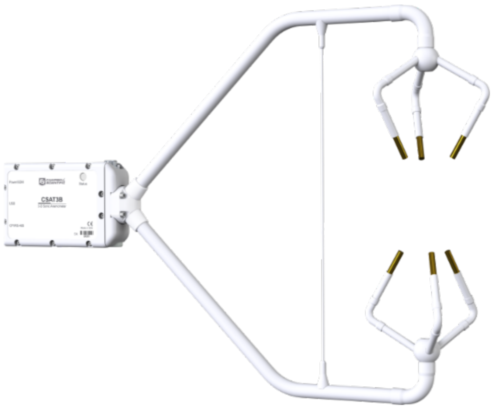


Figure shows the ratios of concentrations predicted by an open-terrain dispersion model (using P-G coefficients only) to observed centerline concentrations in wakes as a function of wind speed (Ramsdell & Fosmire, 1990)

Advanced Diffusion Methods

- Non-LWRs may be located anywhere
- A better approach would be to use direct measurements of turbulence
  - Present-day wind instrumentation (e.g., 3-D sonic anemometer) can measure turbulent fluctuations of horizontal and vertical wind
    - Minimal flow distortion
    - Withstand harsh weather conditions
  - Diffusion coefficients can be directly calculated using “known” functions (e.g., Hanna 1982, Irwin 1980) that relate turbulence measurements to diffusion
  - Diffusion coefficients would be truly representative of the site and not be “binned” by discrete stability classes



Campbell Scientific Sonic Anemometer

Questions?

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