Air Quality Modelling for Multimedia Assessments and Associated Challenges

Mervyn Davies

March 14th 2013

One Team. Infinite Solutions

Stantec

What is an Air Quality Model?

- Provides a scientific link between an emission source and associated ambient concentrations and deposition.
- Uses mathematical relationships to simulate transport, dispersion, chemical transformation, and wet and dry deposition processes in the atmosphere.
- Air is one of the key pathways from sources to receptors.

Why Air Quality Models?

- **Past Conditions**
  - Forensic analysis
- **Existing Conditions**
  - Fill in the gaps between monitoring stations
  - Provide predictions for parameters not monitored
  - To discriminate source contributions
- **Future Conditions**
  - Examine air quality changes before a facility is built
  - Examine future year changes
  - Examine the effects of management actions

Spatial Scales

- **Single facility**
  - 20 by 20 km to 50 by 50 km
- **Air Shed**
  - 100 by 100 km
- **Regional (e.g., NE Alberta)**
  - 300 by 700 km
- **Provincial**
  - 700 by 1200 km
- **Western Canada**
  - 1500 by 2500 km

Temporal Scales

- **Seconds to minutes**
  - Unplanned toxic and flammable releases
  - Quantitative risk and odour assessments
- **Short-term (Acute)**
  - 1-h to 24-h
  - Vegetation/human health
- **Long-term (Chronic)**
  - Annual to five-year modelling
  - Lifetime exposure
  - 100 year

Status of Air Quality Models

- **Air quality simulation models are mature**
  - Have been around since the mid 1970s
  - Continue to evolve
- **Alberta benefiting from the US generosity**
  - Public domain model codes, documentation, performance studies, and user groups are available
- **Alberta models**
  - Replaced by US EPA models due to resource challenges
  - Provides guidance on the application of these models
- **Environment Canada Models**
  - Not in public domain

Past Provincial Efforts

GLCGEN/FRQDTN

- An Alberta air quality model developed in 1981.
- Provided an internal weighting function to reduce/remove contribution when receptor sensitivity was reduced.
- Never really used on an operational basis due to computer platform complexities.

GASCON2

- An Alberta model to evaluate hazards and risks associated with unplanned sour gas releases.
- One copy was sold.

Air Quality Model Inputs

- Source and emission inventory
  - From industry, ESRD, EC and consultant databases
- Hourly meteorological data
  - From surface measurements and meteorological models
- Topographical data
  - From digital elevation models
- Land cover properties
  - From land use class models.
- Ambient concentration data
  - From ambient air quality monitoring stations

Air Quality Model Outputs

- Ambient concentrations
- Wet deposition
- Dry deposition
- Total deposition
- Primary emissions
- Secondary pollutants
- 1-h, 24-h, month, annual averages
- Hourly time series
- Frequency of exceeding a threshold

Receptor locations

- **Coordinate system**
  - UTM NAD 83
  - Lambert conformal conic projection
- **Nested Cartesian grid systems**
  - Spacing
- **Discrete Locations**
  - Monitoring stations
  - Community locations
  - Identified lakes
- Can examine 10,000 to 20,000 receptors

Human Exposure Assessments

- **Hazard and QRA modelling for land use planning**
  - Setbacks between industry and residences
- **Endpoints:**
  - Nuisance(e.g., odours)
  - Mild irritation
  - Respiratory
  - Neurological
  - Reproduction and development
  - Imunotoxicity
- **Acute and chronic exposures**

Environmental Assessments

- Vegetation: direct
- Livestock and wildlife: direct
- Soils: deposition
  - Vegetation
- Water bodies: deposition
  - Fish
- Food chain
  - Relates back to human exposures

Technical Challenges

- **Model Input**
  - Emission inventory
- **Model Assumptions**
  - Northern latitudes/Cold winters
    - Is the chemistry still valid?
    - Gas/particle phase distribution still valid?
  - Extrapolation of default parameters
    - Land cover properties
    - Seasonal variations

Ambient Monitoring

Modelling and monitoring complement one another; one is not a replacement for the other.

- Monitoring provides a gauge of model performance.
- Desirable to have concentration and deposition data.
- No one wants to locate ozone monitors downwind of large emission sources.
- Gaps in deposition monitoring. Recommendations have been put forward; does not appear to be any action.

Technical Challenges

- **Source and emission inventory**
  - Data not well documented
  - Industry data for existing operations often difficult to obtain
  - Industry data for future operations incorporate conservative assumptions
  - Emission databases often treated by industry and regulators as proprietary
  - Biogenic sources often not included

Process Challenges

- **Environmental zones in Alberta defined by river/drainage basis**
  - Do not fit into an airshed definition
  - CASA airsheds and provincial regions do not match
- **Divergence of regulatory application and land-use planning model approaches**
  - May lead to conflicting predictions
  - Want consistency from a public record perspective

Communication

"**Functional** multidisciplinary communication is essential"

- Is the overall objective defined?
- Have the end users defined what is required?
- Have receptor locations been defined?

- Have model limitations been communicated to end-user?
- Has end-user had discussions with the modeller to confirm appropriate assumptions?

CMO Scope?

- What “air” models will be addressed by the CMO?
  - Computational Fluid Dynamic models?
  - Hazard and quantitative risk models?
  - Visibility/haze models?
  - Odour models?
  - Noise models?
  - Light trespass models?
  - EMF from power lines?
- What’s included, what’s excluded?

CMO Scope?

- Will the CMO only address models if there is an “integrated environmental” component?
- Will the CMO include human health as well as environmental modelling endpoints?
- Will the CMO address local, regional and provincial scale issues where modelling can be adopted to resolve issues?
- Linkages to other tools (e.g., monitoring)?

CMO Scope?

- Does the CMO have a model and modeller inventory for the province?
  - Regulatory, academic, and private sectors?
  - Regulatory and no-regulatory applications?
- How will the CMO determine the appropriate selection and application of models?
  - Regulatory, academic, and private sector inputs?
  - Alberta and non-Alberta inputs?
- How will the CMO promote and support model use?
  - Regulatory, academic, and private sectors?
  - Workshops, websites, publications?

CMO Scope?

- How will the CMO act as a warehouse for models?
  - Public domain vs. commercial models?
  - Model guidance or directives re the application?
    - Will future AQMG come from the CMO?
  - Common input data?
    - How will ensure these are updated on a timely manner?
    - How will you ensure they are Alberta specific?
- How will CMO obtain feedback on modelling applications?
  - What is the indicator that the modelling is being done appropriately?
  - Review regulatory applications?
  - Review industry association assessments?

CMO Scope?

- Will the CMO be setup as a support AESRD department like RMD was? Or will it be at arm's length like CASA?
- Will the CMO resources have sufficient resources to be functional?
- Will the CMO activities be open and transparent?
  - Never trust a breakfast cereal box that says "nutritious"!
- Recipe for success (?):
  - Communication!
  - Communication!
  - communication!