HOW HEALTH RELATED ISSUES ARE LIKELY TO DRIVE DISPERSION MODELING OVER THE NEXT DECADE

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Agenda

- Historical Perspective of Air Pollution
  - Through Art
  - Through Time
- Evolution of Dispersion Models and Techniques
- What We Know…and What We Don't Know

Historical Perspective of Air Pollution – Through Art

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THE LACKAWANNA VALLEY, 1856 - George Innes

SUNSET: CORNFIELDS NEAR ARLES, 1888 - Vincent Van Gogh

THE RIVER OISE NEAR POINTOISE, 1873 - Camillie Pissarro

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GARE ST. LAZARRE - Claude Monet

THE WATERLOO BRIDGE, London -1900 - Claude Monet

EAST RIVER FROM THE THIRTIETH STORY OF THE SHELTON HOTEL, NEW YORK, 1928 Georgia O'Keefe

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Historical Perspective of Air Pollution – Through Time

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1960s

- General recognition of problems
  - Concern developed about health effects
  - Studies defined “safe concentrations” for the general public
    - Idea paralleled industrial hygiene which defined a “safe level” for healthy workers
  - Local regulations developed
  - Benefits of natural gas instead of coal for comfort heating and for industrial sources became apparent

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1970s

- US Clean Air Act of 1970
  - National law was needed because localities implementing rules would be disadvantaged with respect to economic development. A national level playing field needed.
- Air Quality Standards of 1971
  - Criteria Documents based on primary effects – idea there was a "bright line"

1970s

- First point source models developed
  - Model accuracy became a major issue
- Protection afforded by a standard is dependent on format of standard –
  - Second highest one hour value = 80% of highest high one hour value
  - 25th highest one-hour value = 55% of highest one hour value
  - 99th percentile (88th highest) = 40% of highest
  - 98th percentile (177th highest) = 25% of highest
- Form of standard affects what is “safe”

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1970s onward

- 1974 - Supreme Court ruled air quality could only get incrementally dirty
- 1977 – Clean Air Act amendments codified and expanded the Court decision
- Modeling became the only way to track the increments
- Models could handle multiple sources and by 1980 included downwash

1980s

- Discovery of uneven distributions of updrafts and downdrafts under daylight conditions
  - Physics of this captured starting in 1986 and expanding greatly in the 1990s – TUPOS, AERMOD, OML, ADMS, and others
- First large-scale grid models that included chemistry packages and cell-specific wind fields

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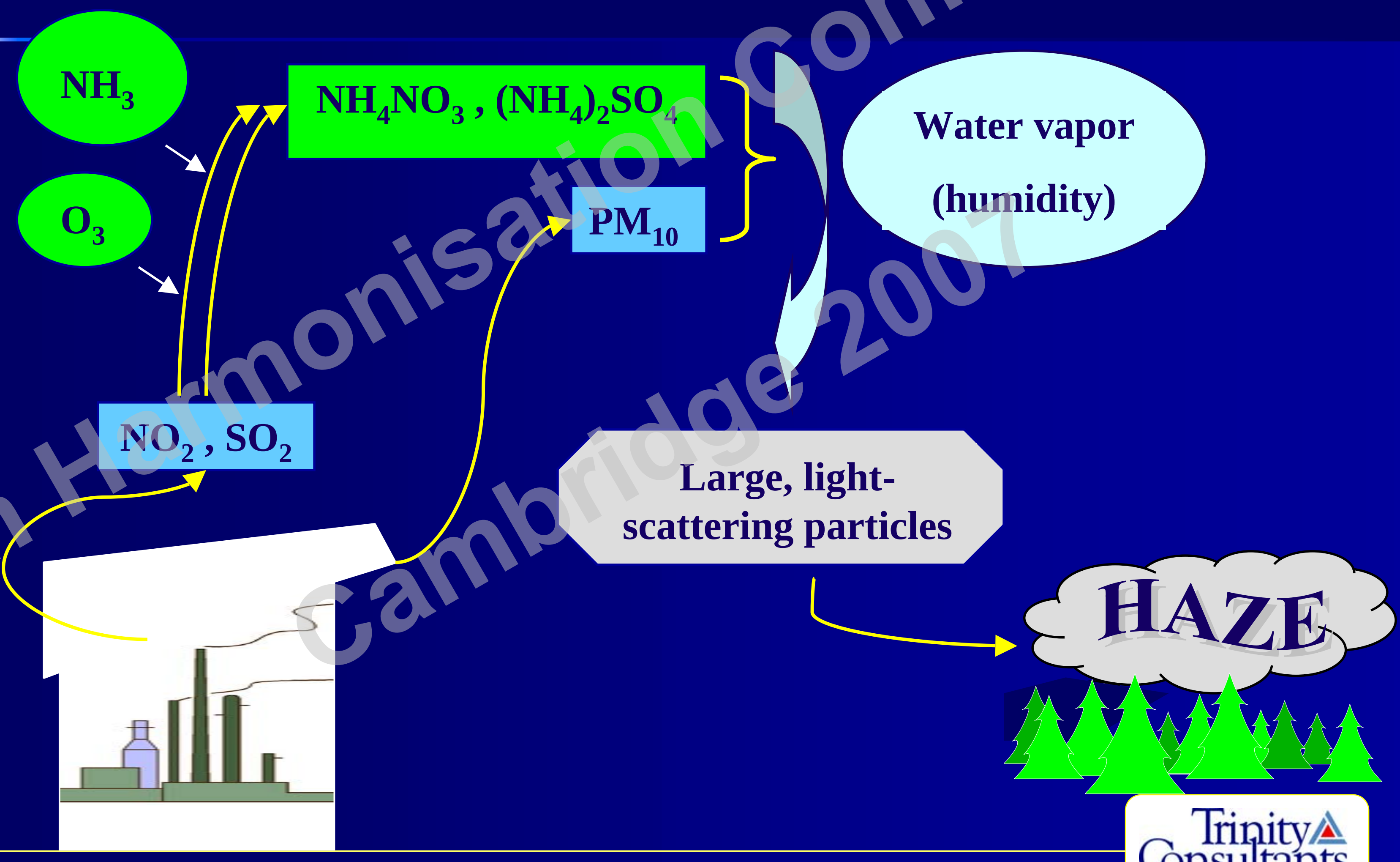
SKY ABOVE CLOUDS II, 1963 - Georgia O’Keefe

1990s

- With improved air quality and a reduction in cigarette smoking subtle effects noticed
- First, ozone was thought to be important
- Recently, ammonia substances appear more important
- Both are formed through gas-phase reactions

Regional Haze Formation



What We Would Like to Know...

How clean is "clean"?
How safe is "safe"?
How much is enough?

1990s and 2000s

- US begins regulating fine particles through regional haze rules – an outgrowth of visibility and epidemiological studies
- EU recognizes health effects of ammonia substances as being more important than ozone and proposes some new policies

Evolution of Dispersion Models and Techniques

Past Modeling Paradigm

- Industrial Source Complex (ISCST3)
  - Workhorse model for past decade
  - Gaussian, steady-state formulation
  - Analyzed "stable" pollutants
  - PGT stability-based dispersion
  - Simple meteorological input
  - Primitive complex terrain treatment
  - Deficient in downwash representation

Emerging Dispersion Models

- **P**lume **RI**se **M**odel **E**nhancements (PRIME)
  - – Considerable improvements in downwash/cavity modeling
- **A**MS/**E**PA **R**egulatory **MOD**el (AERMOD)
  - – Gaussian and steady-state like ISC3, but with notable improvements in parameterization of dispersion and treatment of terrain

Emerging Dispersion Models

- CALPUFF
  - Formal recommendation is for LRT modeling (from 50 to more than 200 km) for all source types
  - Also suitable for SRT modeling in “complex wind” situations
  - Dynamic, Lagrangian, ‘Puff’ modeling paradigm
  - CALPUFF is an advanced non-steady-state modeling system with sophisticated treatments of meteorological conditions, terrain, and chemical transformation and deposition

Dispersion Modeling Overview

- Looking to the Future
  - Implementation timeline
  - Obstacles to implementation
  - Planning for new paradigms

20th Century Knowledge

- Cannot define a “bright line” of no health effects – air is simply better or worse
- There are no “stable” air pollutants. All pollutants – except possibly for wind-blown soil – react in the atmosphere
- Absolute accuracy of a model may be less important than the widespread acceptance that a specific model is the “best we can do.” Analysis of increments may be more important.

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21st Century Knowledge

- Fine particles are formed by gas-phase reactions in the atmosphere
- Two types of reactions found to date:
  - Ozone, a tracer of photochemical oxidants, generally of concern within 50 km of a source
  - Fine particles (mostly ammonia based) generally of concern as far as 400 km from source
- Fine particles affect more people than ozone
- Background – even intercontinental – is important

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21st Century Modeling

- Models for individual sources appear to have reached optimum development
- Opportunities for a dramatic increase in predictive capability appears somewhat limited and *may not be worth the effort*
- Most site-specific issues have been addressed in developed countries but individual source models useful in developing and undeveloped countries

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21st Century Modeling

- Regional and Continental models likely to be focus in future
- Require ability to compute wind speed and direction as well as turbulence at multiple levels throughout the modeling domain
- Require ability to compute ~100 chemical reactions involved in organic and inorganic particle formation
- Validation will not be generic but will be site specific using monitored data

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35 years

- Conclusions:
  - No “bright line” simply better and worse
  - Fine particles tied to health effects with ammonia substances have greater – and longer distance – effects than ozone
  - Models for individual sources appear to have reached optimum development
  - Future needs will focus on models that include variable meteorology, chemistry packages. Validation issues will be immense

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Questions?

How clean is "clean"?
How safe is "safe"?
How much is enough?