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The International Most Advanced Atmospheric EIA Technology and Development Trends
国际先进大气环境影响评价技术与发展趋势

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The First National Workshop on Atmospheric Environmental Impact Assessment
Harbin , December 2010

Contents
内容

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- The latest trends in international EIA practice
- 国际环境影响评价最新趋势

- Difference between UK and US models - ADMS, Aermod, CALPUFF - how to explain and deal with the difference in results:
- 英国模型与美国模型的不同– **ADMS, Aermod和CALPUFF**——如何解释/理解结果的差异

- Future direction and some research projects
- 未来发展方向与相关研究项目

Trends in International EIA Practice
国际环境影响评价工作的发展趋势

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European Legislation

EIA Directive (85/337/EEC) and amendments

- Sets procedures for undertaking EIA
- Environmental effects considered can include: air quality, water, noise, fauna , flora, soil, population, landscape, cultural heritage

欧洲法规

欧共体85/337号指令及修正案

- 规定环境影响评价实施的程序
- 需要考虑的环境影响因素包括：空气质量、水、噪声、动物群、植物群、土壤、污染、景观、文化遗产

Trends in International EIA Practice
国际环境影响评价工作的发展趋势

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UK implementation of EIA directive
Air Quality

Ambient Air Quality Directive 2008 (208/50/EC) – 'Ambient Air Quality and Clean Air for Europe'

- Defines limit values for key pollutants: SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, O_3, heavy metals, PAHs

环境影响评价指令在英国的实施
空气质量

环境空气质量指令2008 (208/50/EC) — "欧洲环境空气质量与清洁空气"

- 规定主要污染物的浓度限值： **SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, O_3, 重金属, PAHs**（多环芳烃）

Trends in International EIA Practice
国际环境影响评价工作的发展趋势

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UK implementation of Air Quality Directive
- UK National Air Quality Strategy
- Local air quality management (LAQM)
- Air quality management areas (AQMA)

空气质量指令在英国的实施
- 英国国家空气质量战略
- 地方空气质量管理（LAQM）
- 空气质量管理区（AQMA）

Air quality is a material consideration (development could be turned down on AQ failure alone)

空气质量是环境影响评价中一个非常重要的考虑因素（项目开发可能仅因为空气质量的原因而被终止）

ADMS used widely for and on behalf of government departments in UK and Europe for regulatory applications

在英国和欧洲，ADMS广泛应用于政府部门的管理工作

Atmospheric dispersion models for EIA in China
中国大气环境影响评价导则推荐大气扩散模型

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- ***ADMS*** (CERC UK, sponsored by government and regulatory authorities) and ***AERMOD*** (US EPA)
  - range typically from metres up to 50-100km
  - broadly similar principles regarding the boundary-layer structure and dispersion modelling

- ***ADMS*** **(CERC 英国, 由英国政府和相关机构赞助开发)，** ***AERMOD*** **(美国环境保护署，EPA)**
  - 模拟范围可从几米精度到 50-100公里
  - 在边界层结构和扩散模型方面的原理大致相似

Atmospheric dispersion models for EIA in China
中国大气环境影响评价导则推荐大气扩散模型

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- but significantly different in detail regarding the meteorology pre-processing and the dispersion algorithms

→ ***very different predictions of pollutant concentrations in some situations*** **–** for example when effects of complex terrain are modelled

- 但在气象预处理和扩散公式细节方面有很多显著的差异

→ *在某些情景下污染物浓度预测值差异较大* **–** 例如当考虑复杂地形影响时

- *CALPUFF* (US EPA)
  - for longer range modelling
  - 更大尺度范围的模拟

Model features: ADMS, AERMOD, CALPUFF
模型特点：ADMS、AERMOD和CALPUFF

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MODEL FEATURE 模型特点	ADMS	AERMOD	CALPUFF
APPLICATIONS	Up to 50km from sources; local and urban scale.	Up to 50km from sources.	Local and Regional Pollution Impacts.
应用范围	距离污染源达到50公里；局地与城市范围	距离污染源**50**公里	考虑局地与区域污染影响
SOURCE TYPES	Point, line (including road, rail), area, volume, grid, jet.	Point, line, volume and area sources.	Point, line, volume, area
污染源类型	点源、线源（包括道路、铁路）、面源、体源、网格源和喷射源 (仅限ADMS4)	点源、线源、面源和体源	点源、线源、面源和体源
METEOROLOGY	ADMS Met Pre-processor	AERMET Pre-processor	CALMET Pre-processor
气象处理	**ADMS** 气象预处理	**AERMET**预处理	**CALMET**预处理

Model features: ADMS, AERMOD, CALPUFF 模型特点：ADMS、AERMOD和CALPUFF

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MODEL FEATURE 模型特点	ADMS	AERMOD	CALPUFF
DISPERSION: Boundary layer structure	h, L_{MO} scaling	h, L_{MO} scaling	h, L_{MO} scaling
扩散：边界层结构	边界层高度、**Monin-Obukhov**长度范围	边界层高度、**Monin-Obukhov**长度范围	边界层高度、**Monin-Obukhov**长度范围
DISPERSION: Plume rise	Advanced integr al model	Briggs empirical expressions	Briggs empirical expressions
扩散：烟羽抬升	高级的积分模型	**Briggs** 经验公式	**Briggs** 经验公式
DISPERSION: Concentration distribution	Advanced Gaussian plume and puff model	Advanced Gaussian plume model	Non-steady Gaussian puff model
扩散：浓度分布	高级高斯烟羽和烟团模型	高级高斯烟羽模型	非稳定高斯烟团模型

Model features: ADMS, AERMOD, CALPUFF 模型特点：ADMS、AERMOD和CALPUFF

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MODEL FEATURE 模型特点	ADMS	AERMOD	CALPUFF
COMPLEX EFFECTS: Buildings	Uses flow model with near and main building wakes.	Uses PRIME buildings model.	Based on ISC building model.
复杂影响：建筑物	采用考虑近距离尾迹与主要建筑物尾迹的气流模型	采用**PRIME**建筑物模型	基于**ISC**建筑物模型
COMPLEX EFFECTS: Complex terrain	Based on calculation of flow field and turbulence filed by FLOWSTAR model.	Interpolation between terrain following solution and stable flow impaction solution.	Effects of complex flow input via meteorological fields.
复杂影响：复杂地形	基于**FLOWSTAR**模型中的流场与湍流场计算.	对地形响应型烟羽和稳定条件下烟羽直接撞击山坡两种极端情况的插值	考虑由输入气象场数据得到的复杂气流的作用

Model features: ADMS, AERMOD, CALPUFF 模型特点：ADMS、AERMOD和CALPUFF

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MODEL FEATURE 模型特点	ADMS	AERMOD	CALPUFF
COMPLEX EFFECTS: Wet Deposition Dry Deposition	YES Includes advanced falling drop method for wet deposition	YES	YES
复杂影响：湿沉降 干沉降	考虑 湿沉降中包括了先进的落滴法	考虑	考虑
COMPLEX EFFECTS: Chemistry	GRS (Generic Reactio n Scheme) 8 reaction scheme for NO_x chemistry, parameterised sulphate chemistry.	Ozone limiting model, assumes maximum conversion of NO to NO_2.	NO_x and SO_2 chemistry for particle generation.
复杂影响：化学反应	**GRS** 化学方法，包括 **8** 个化学反应方程来描述 NO_x化学反应、参数化的硫酸盐反应	臭氧限制模型，假定**NO**转化为NO_2的最大转化率	**NO_x and SO_2** 生成颗粒物的化学反应

ADMS and AERMOD ADMS 与 AERMOD

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- Need to understand differences between ADMS and AERMOD in order to deal with the differences modelled concentrations
- 需要通过了解**ADMS**模型与**AERMOD**模型之间的区别，以更好地处理模拟结果的差异

- ADMS and AERMOD are compared on an almost identical basis through a hybrid model
  - meteorological and source input data used by each model can be made identical
- 通过一个混合模型在基本一致的条件下比较**ADMS** 与 **AERMOD**
  - 两个模型输入的气象与污染源数据设定为一致

Boundary Layer Structure
边界层结构

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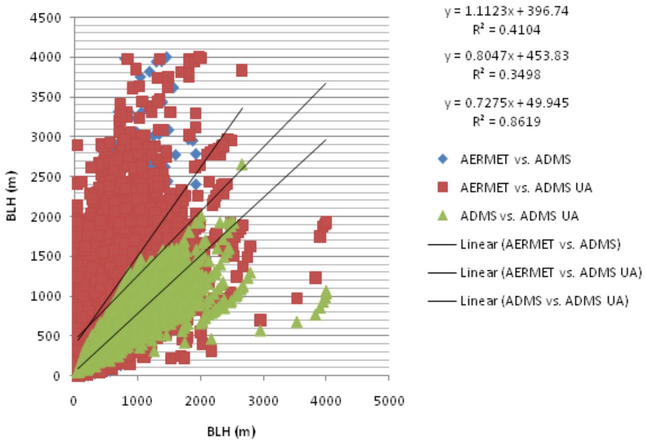
- Large differences in **boundary layer heights**.
- 边界层高度有很大差异



Blue: **AERMET vs ADMS;**
RED: **AERMET vs ADMS with upper air.**
Green: **ADMS vs ADMS with upper air;**

蓝色: **AERMET vs ADMS;**
红色: **ADMS vs ADMS (考虑高空气象);**
绿色: **ADMS vs (考虑高空气象);**

Flat Terrain : atmospheric dispersion
平坦地形：大气扩散

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ADMS and AERMOD both use advanced Gaussian-type plume models;

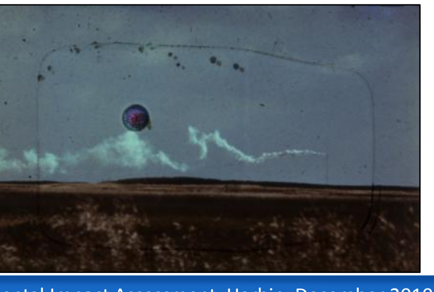
plume spread parameters σ_z and σ_y calculated from local mean flow, turbulence and stability (differences in detail);

ADMS uses a more physics-based approach / *AERMOD uses a more empirically based approach*

ADMS 与AERMOD 都采用高级的高斯烟羽模型;

均由当地平均流、湍流和稳定性计算烟羽扩散参数s_z 和 s_y（细节有区别）

ADMS采用更基于物理学的方法/ ***AERMOD 采用更基于经验性的方法***



Plume rise
烟羽抬升

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Contribution from momentum and buoyancy fluxes
- ADMS uses integral plume rise model
- AERMOD uses analytical formulation (Briggs)

May be large differences in predicted plume rise

由动力和浮力通量形成
- ADMS 采用积分烟羽抬升模型
- AEDMOD采用分析方法（Briggs）

烟羽抬升预测结果可能会有很大的差别

Flat terrain: ADMS AERMOD comparison short term averages
平坦地形： ADMS 与AERMOD短期平均浓度比较

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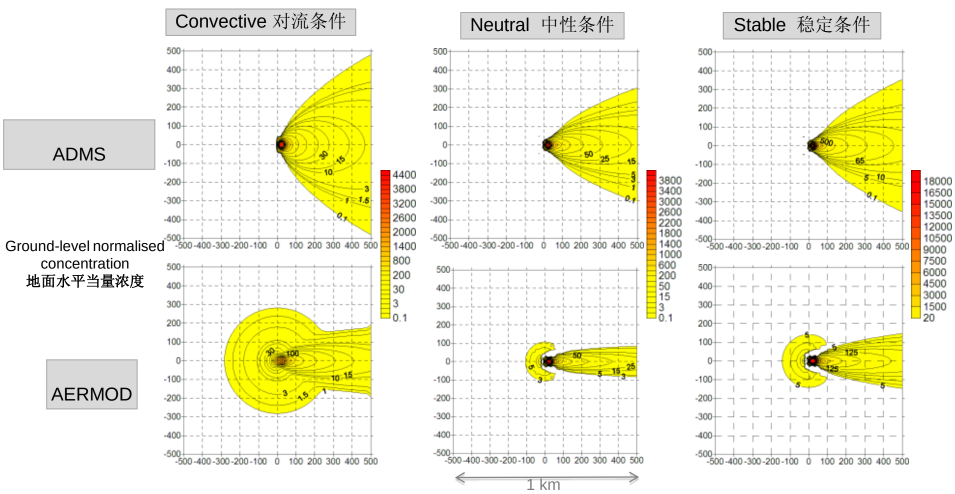
- Low level source (0 m), no plume rise
- 地面源（0米），无烟羽抬升



Flat terrain: ADMS AERMOD comparison long term averages
平坦地形： ADMS 与AERMOD长期平均浓度比较

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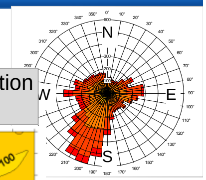
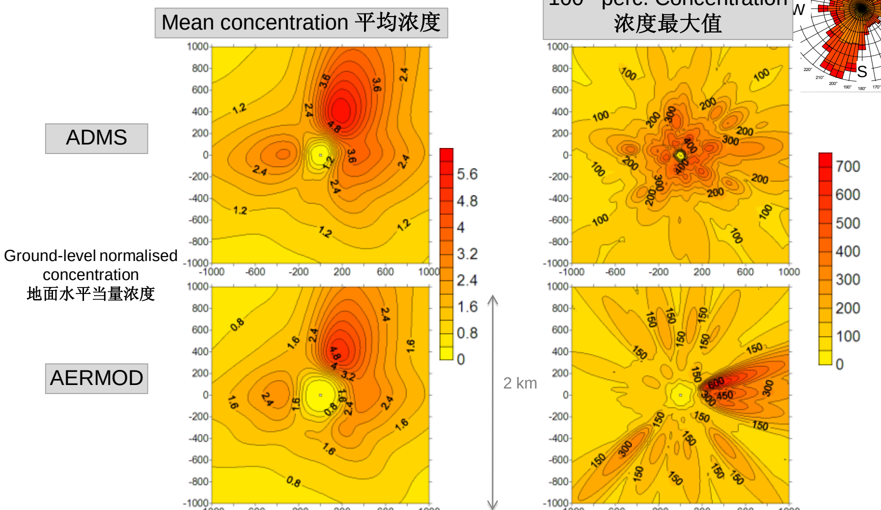
- **Industrial source (50 m), plume rise**
- 工业源（50米），烟羽抬升





Flat terrain: ADMS AERMOD comparison long term averages
平坦地形： ADMS 与AERMOD长期平均浓度比较

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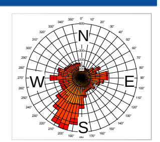
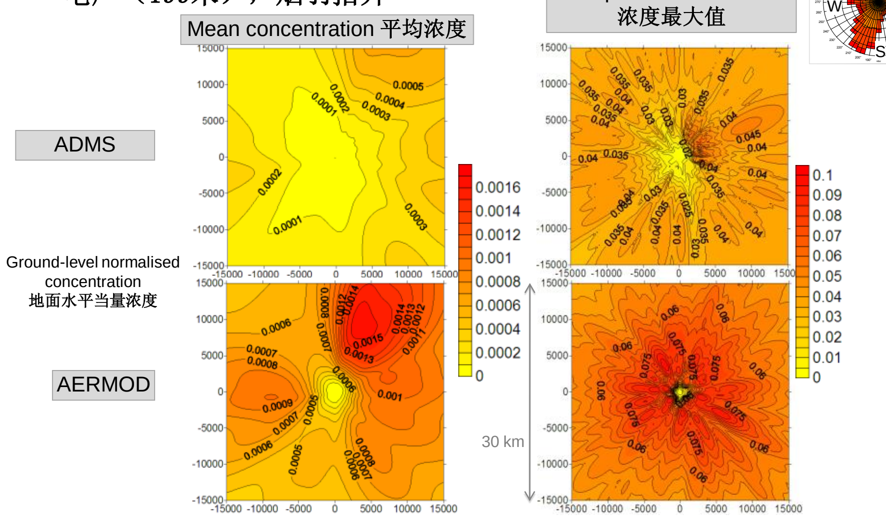
- Power station (199 m), plume rise
- 电厂（199米），烟羽抬升





The effects of buildings on dispersion
建筑物对扩散的影响

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The effects of buildings on dispersion
建筑物对扩散的影响

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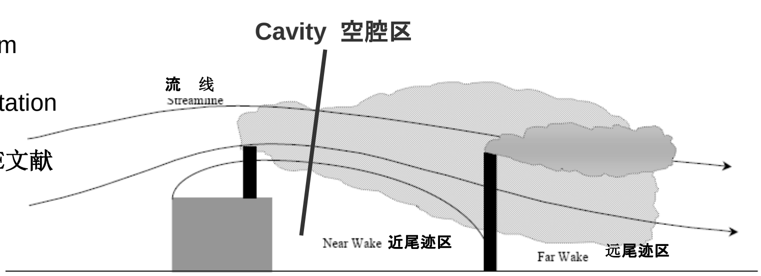
- ADMS and AERMOD modelling approaches include:
  - Near wake (cavity)
  - Main wake (descending streamlines)
  - Two plume approach
- Differences in detail
  - For example ADMS includes effects of angle of wind to building

- **ADMS 和AERMOD 采用的模拟方法如下:**
  - 近距离尾迹（空腔区）
  - 主尾迹（下行流线）
  - 两种烟羽方式
- 细节不同
  - 例如ADMS会考虑到风作用于建筑物的角度

Figure from PRIME Documentation

摘自PRIME文献



Building effects: ADMS and AERMOD 建筑物影响 comparison with wind tunnel data 与风洞实验数据对比

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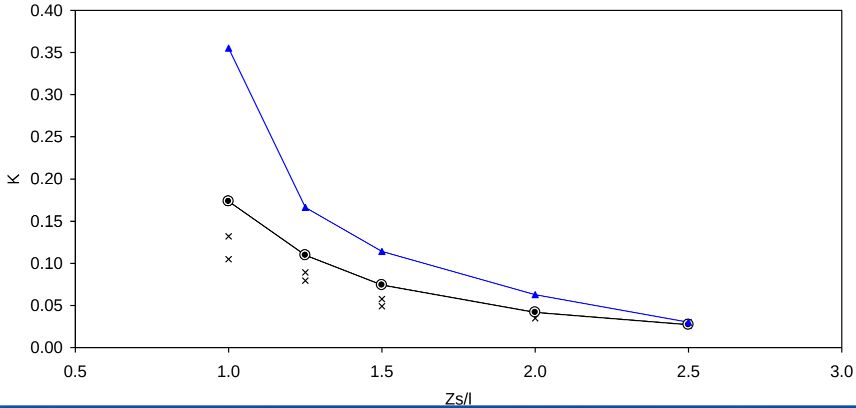
- Maximum ground level concentration (K) as a function of source height (Z_S); the angle of the building to the wind is zero, x: (Robins and Castro wind tunnel data),
- 最大地面浓度(K)是污染源高度(Z_S)的函数， 污染源与风速的夹角为0
- **x (Robins 与 Castro 风洞实验数据)** ▲ AERMOD; ⊙ ADMS



Flow and dispersion over complex terrain 复杂地形下气流运动与污染物扩散

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Flow and dispersion over complex terrain
复杂地形下气流运动与污染物扩散

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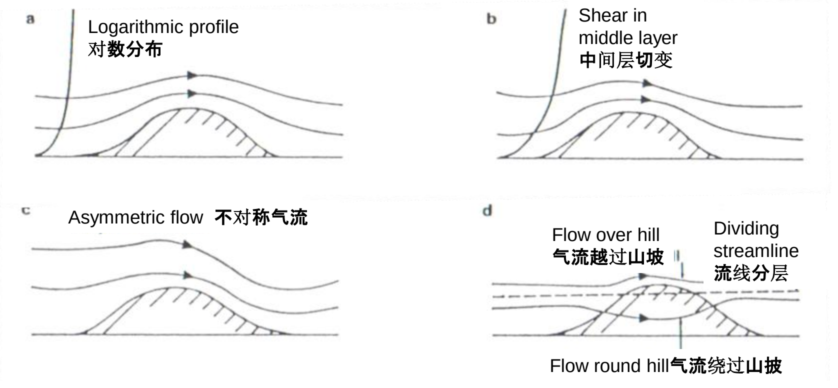
- The impact of stability on flow
- 稳定性对气流运动的影响



Flow patterns over a 3-dimensional hill for a. neutral flow b. weak stratification c. moderate stratification, and d. strong stratification.
气流流过 3D山坡的不同方式 a. 中性气流 b.弱层化 c.中度层化 d. 强层化

Flow and dispersion over complex terrain——Hill wakes
复杂定性对扩散的影响——山坡尾迹

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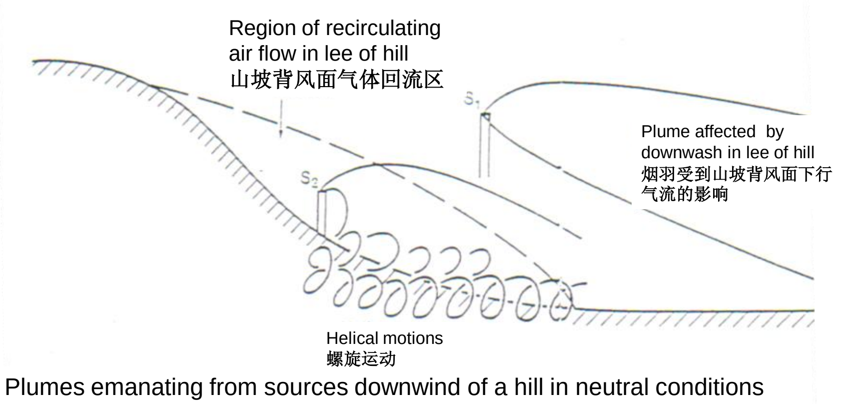
- Terrain-affected dispersion from sources in the lee (downwind) of a hill
- 地形对山坡背风面（下风向）污染源的影响



Plumes emanating from sources downwind of a hill in neutral conditions
中性条件下山坡下风方向污染源排放烟羽

Flow and dispersion over complex terrain Treatment in ADMS and AERMOD 复杂地形条件下ADMS与AERMOD中气流运动与大气扩散处理方式

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- ADMS uses two stage process

  (i) calculates mean flow and turbulence over complex terrain using established and validated flow model (FLOWSTAR)

  (ii) calculates dispersion of pollutants using the flow field
- ADMS includes the effect of varying terrain height and varying surface roughness and effects of stratification
- ADMS allows for effects of hill wakes

- **ADMS采用两步处理方式**

  (i) 应用已经过验证的气流模型**(FLOWSTAR)**计算复杂地形条件下的平流与湍流

  (ii) 利用得到的流场数据计算污染物扩散
- **ADMS**考虑地形与地表粗糙度变化以及层化效应的影响
- **ADMS** 考虑山坡尾迹效应

The First National Workshop on Atmospheric Environmental Impact Assessment, Harbin, December 2010

Flow and dispersion over complex terrain Treatment in ADMS and AERMOD 复杂地形条件下ADMS与AERMOD中气流运动与大气扩散处理方式

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- AERMOD uses simple one stage process to calculate pollutant concentrations (it does not calculate flow field)
- AERMOD solution is weighted average of terrain following solution (no impact of terrain in neutral flow) and very stable solution (plume impaction)

- AERMOD 采用简单的一步处理方式直接计算污染物浓度（不计算流场）
- AERMOD的方法是计算两种极端情况下的加权平均——气流流过地形型烟羽（不考虑中性条件下地形的影响）和非常稳定条件下（烟羽缩紧）

Flow and dispersion over complex terrain
Example flow field and dispersion in ADMS
复杂地形条件下气流运动与大气扩散——ADMS中风场与扩散示例

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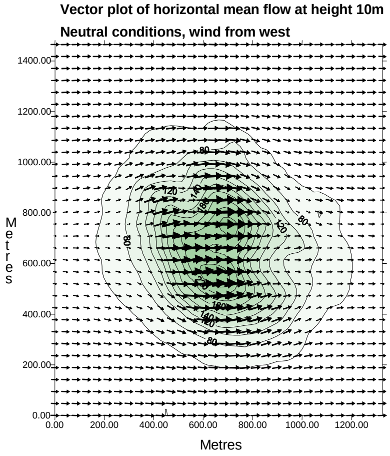
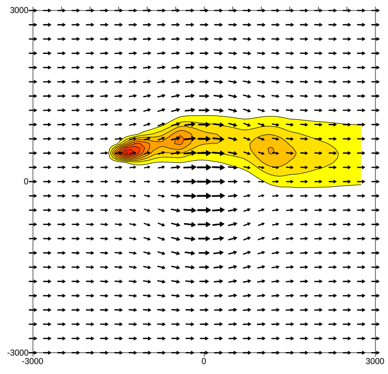


Example of calculated ADMS flow field
ADMS流场计算示例



Example of plume over complex terrain
复杂地形条件下烟羽示例

Flow and dispersion over complex terrain: AERMOD approach
复杂地形条件下气流运动与大气扩散——AERMOD采用方法

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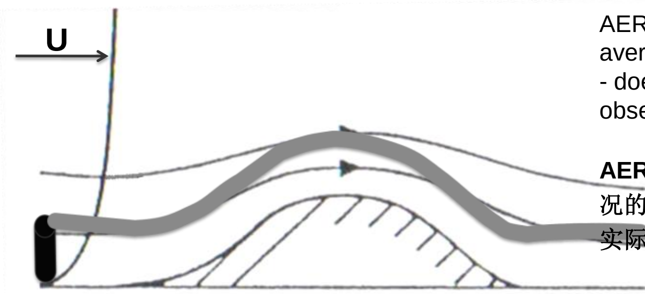
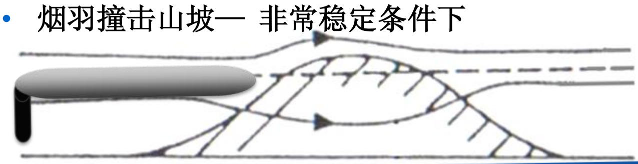
- Terrain-following – hills have no effect in neutral flow
- 气流流过山坡— 山坡对中性气流没有影响



AERMOD solution is weighted average of two extremes
- does not correspond well to observed flows

AERMOD的方法是两种极端情况的加权平均— 不能很好地与实际观测的气流情况吻合

- Plume impaction – very stable
- 烟羽撞击山坡— 非常稳定条件下



Flow and dispersion over complex terrain
ADMS v AERMOD comparison with wind tunnel data – neutral flow
ADMS 与 AERMOD结果与风洞试验数据比较— 中性气流

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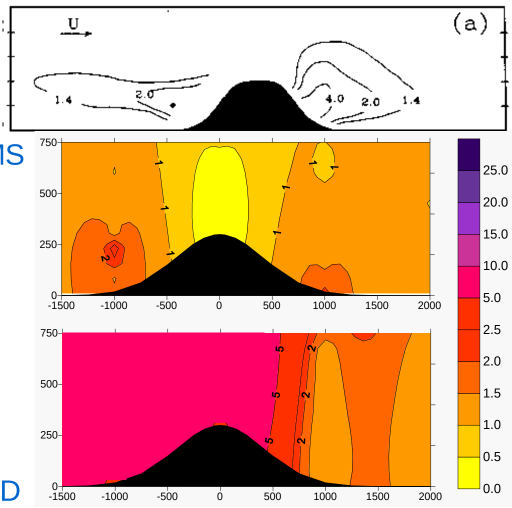
US EPA Wind Tunnel Data
Lawson, Snyder and Thompson (1989)

美国EPA风洞试验数据

Ratio of complex terrain to flat terrain maximum concentrations as function of stack height and location
复杂地形与平坦地形下最大浓度值的比值是烟囱高度与位置的函数

AERMOD does not model wake effect
AERMOD不考虑尾迹效应



Flow and dispersion over complex terrain: Clifty Creek experiment
复杂地形条件下气流运动与污染物扩散： Clifty Creek 实验

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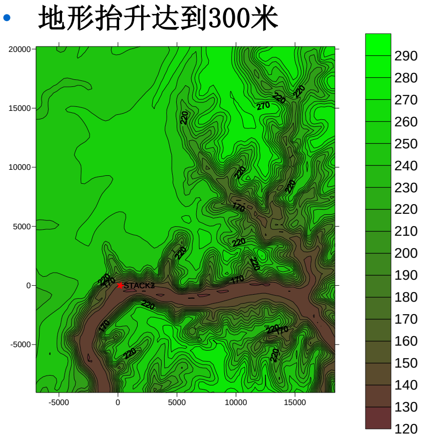
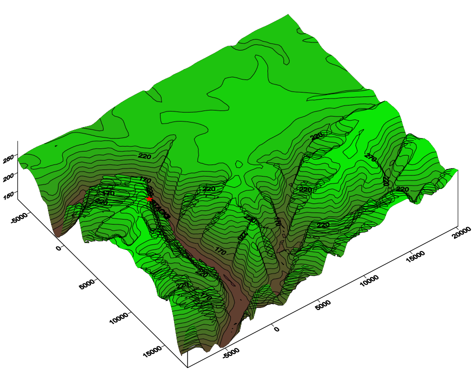
- Clifty Creek field experiment, US, heights of three stacks 208m
- Terrain rising to almost 300m
- **美国 Clifty Creek风场实验，三个高度为208米的烟囱**
- 地形抬升达到300米





Flow and dispersion over complex terrain: Clifty Creek, calculated annual averages 年均浓度计算结果

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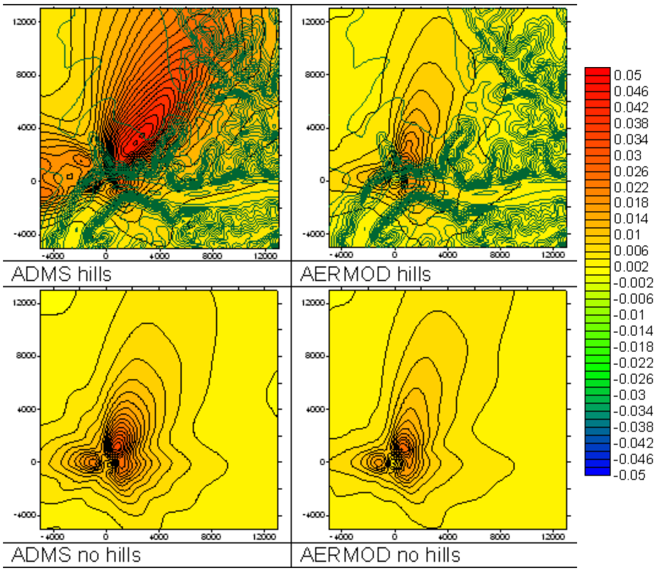
The deep valley affects the flow and hence dispersion in ADMS but not in AERMOD

在**ADMS**中，深谷地形影响气流运动进而影响污染物的扩散，但在AERMOD中浓度扩散不受到深谷的影响



Flow and dispersion over complex terrain: Ribblesdale modelling Ribblesdale 水泥厂模拟

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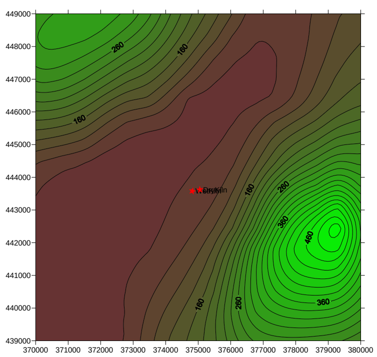
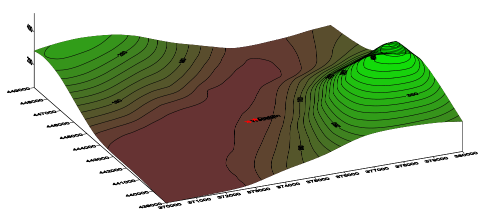
- Ribblesdale, UK
- Cement works with wet and dry kil n – stack heights 92m and 104m

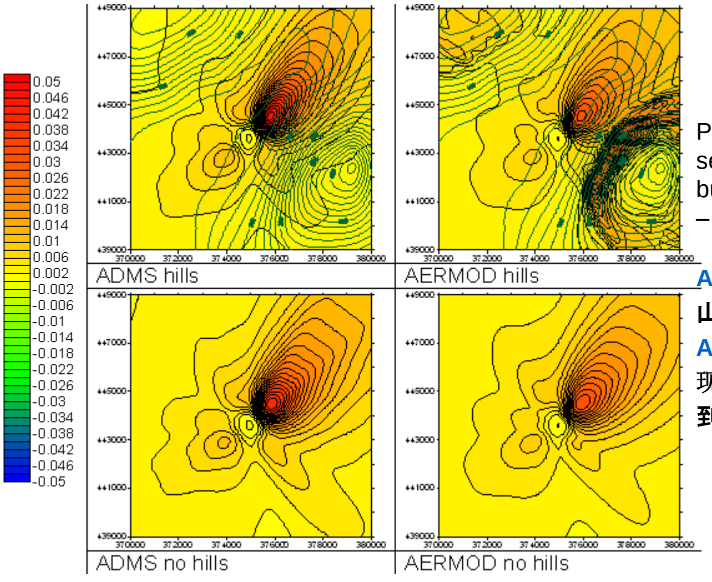
- 英国**Ribblesdale** 案例
- 水泥厂拥有湿式和干式窑，烟囱高度分别为92米和104米





Flow and dispersion over complex terrain: Ribblesdale, calculated annual averages Ribblesdale 案例年均浓度计算结果

CERC



Plume impaction very severe in AERMOD but not in ADMS – it is rarely observed

AERMOD中烟羽撞击山坡现象非常明显，而ADMS中则不 ——该现象在实际中很少观察到

Flow and dispersion over complex terrain: Ribblesdale modelling Ribblesdale案例

CERC

- Maximum (and minimum) values for the average and maximum normalised concentrations for the Ribblesdale case.
- Ribblesdale案例中平均和最大当量浓度的最大（和最小）值

	Average (μs/m³) 平均浓度(μs/m³)	Maximum (μs/m³) 最大值(μs/m³)
ADMS hills ADMS考虑复杂地形	0.0470	1.01
ADMS no hills ADMS平坦地形	0.0417	0.90
AERMOD hills AERMOD考虑复杂地形	0.0518	10.36
AERMOD no hills AERMOD平坦地形	0.0316	0.54

Flow and dispersion over complex terrain: Difference between Clifty Creek and Ribblesdale modellings Clifty Creek与Ribblesdale案例区别

CERC

- At Clifty Creek a deep steep valley is carved out of a plain
  – the flow in the valley is 'cut-off' from ambient flow and the effective stack height is much reduced as predicted by ADMS
- At Ribblesdale stack is in wide valley with rounded hills
  - AERMOD predicts plume impaction onto hillside but this is not observed

- **Clifty Creek**案例中，地形为平原地形中深嵌的陡峭山谷
  –山谷中的气流被周围的气流切断，在ADMS预测方法中烟囱有效高度将大大降低
- **Ribblesdale**案例中烟囱位于周围环山的宽阔山谷中
  – **AERMOD**预测会产生烟羽撞击山坡现象——与实际观测不符

ADMS and AERMOD Dealing with model differences 如何处理模型差异

CERC

- **Main drivers of model differences**
  - Boundary layer height (BLH)
  - Plume rise modules (PR)
  - Complex terrain modules

- 导致模型结果差异的主要原因
  - 边界层高度(BLH)
  - 烟羽抬升模块(PR)
  - 复杂地形模块

ADMS and AERMOD
Dealing with model differences 如何处理模型差异

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- **Concentrations over flat terrain**
  If ADMS and AERMOD predict markedly different concentrations (and one model predicts exceedence of air quality standard), use model diagnostics/output to check if BLH and PR appear realistic (for example BLH may appear unrealistically high). Adjust BLH or use model with more realistic BLH and PR.

- 平坦地形下浓度
  如果ADMS与Aermod 模拟浓度结果差别明显（有一个模型预测值超过空气质量标准），使用模型诊断/输出方法检查边界层高度和烟羽抬升是否正常（例如边界层高度是否出现不正常的偏高现象）。如果出现这样情况对边界层高度进行调整，或在模型中使用与实际更为相符的边界层高度与烟羽抬升

ADMS and AERMOD-Dealing with model differences
ADMS 与 AERMOD - 如何对待模型差异

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- **Concentrations with building effects**
  ADMS and AERMOD have quite similar approach. If marked differences and one model exceeds air quality standard check specified building geometry, BLH and PR for realistic values. Adjust building geometry and/or BLH or use model with more realistic BLH and PR.

- 建筑物对浓度的影响
  ADMS与**AERMOD**处理建筑物的方法非常相似。如果结果出现显著的差异并且一种模型模拟值超标时，检查指定建筑物的几何尺寸、边界层高度和烟羽抬升是否与实际相符。调整建筑物几何尺寸和/或边界层高度与烟羽抬升，使其与实际更为相符。

ADMS and AERMOD-Dealing with model differences ADMS 与 AERMOD - 如何对待模型差异

CERC

- **Concentrations over complex terrain**

  If ADMS and AERMOD predict markedly different concentrations (and one model predicts exceedence of air quality standard) check plume rise and boundary layer height as above then if:

  (i) AERMOD greater than ADMS and terrain higher than stack height and exceedence on windward side of hill, ADMS likely to give more accurate predictions;

- 复杂地形下浓度

  如果**ADMS**与**Aermod** 模拟结果差异显著（并且有一个模型预测值超过空气质量标准），除按上述方法检查烟羽抬升与边界层高度外：

  (i) **AERMOD** 预测浓度高于**ADMS**，并且地形高度高于烟囱高度，超标区域位于山坡迎风面，**ADMS** 预测结果可能更为准确

ADMS and AERMOD-Dealing with model differences ADMS 与 AERMOD - 如何对待模型差异

CERC

(ii) ADMS greater than AERMOD and terrain higher than stack height and exceedence on leeward side hill (in hill wake), ADMS likely to give more accurate predictions;

(ii) ADMS 预测浓度高于**AERMOD**，并且地形高度高于烟囱高度，超标区域位于山坡背风面时（在山坡尾迹区）， **ADMS**预测结果可能更为准确

(iii) if stack exit higher than terrain height, ADMS likely to give more accurate predictions.

(iii)**如果**烟囱出口高度高于地形时， ADMS预测结果可能更为准确

Future Directions:
未来发展方向

CERC

- Modeling plays an increasingly important role for EIA

-Not looking at one single issue, but more comprehensive approach. e.g. industrial and roads sources combined etc.

- **模型模拟在环境影响评价中的作用越来越重要**

- 所应对的问题不再单一化，而是越来越综合全面，例如将工业源和道路源结合考虑等

- Linkage to climate change
- 与气候变化相联系

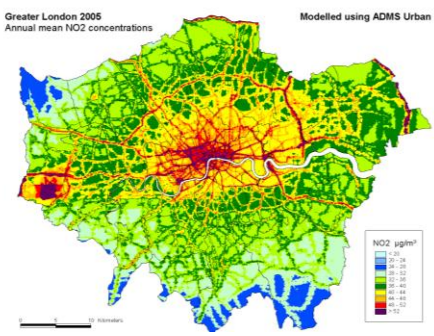
Road traffic sources
道路交通源

CERC

- ADMS includes specific algorithms for road traffic sources
  - vehicle induced turbulence
  - effects of street canyons
  - effects of sound barriers
  - vehicle emission factors

- ADMS包括专门的计算道路交通源的算法
  - 机动车导致湍流
  - 街道窄谷作用
  - 隔声屏效应
  - 机动车排污因子

ADMS calculated contours of Annual mean NO_2 across London
ADMS计算NO_2年均浓度等值图



- AERMOD has no specific treatment of road traffic emissions
- AERMOD没有专门的针对道路交通排放的算法

Model development and some other projects 模型开发与相关项目

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- Models are undergoing continuous development to reflect new science and issues:
  - for example ADMS is being developed to calculate the effect of wind farms on dispersion and industrial structures on efficiency of nearby wind farms;
  - models are been used in health impact studies taking account of population exposure.

- 模型正在进行后续开发，将针对下列新的领域与问题：
  - 例如正在进行ADMS的进一步开发，以应用于计算风力发电厂对扩散的影响和工业结构对附近风力发电厂能效的影响
  - 应用于人群暴露对人体健康影响的研究

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Model development and some other projects 模型开发与相关项目

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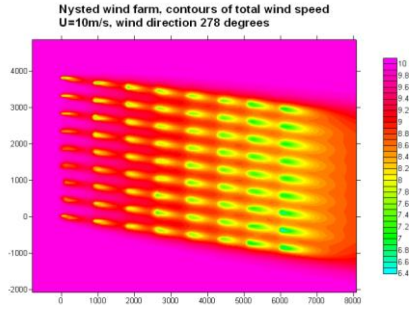
Wind speed calculated in the in the Nysted offshore wind farm with modified version of ADMS complex terrain and concentration fluctuation module

应用改进的ADMS模型复杂地形与浓度波动模块计算的位于海边的Nysted 风力发电厂风速



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ADMS-Airports
ADMS-机场

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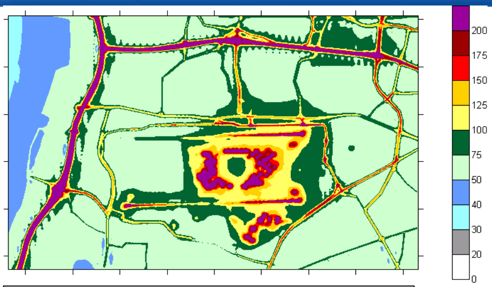

•Figure: annual average NO_X µg/m³ near to Heathrow Airport, 2002

- **2006 ADMS-Airport first version released**
  - **part of the Project for the Sustainable**
  - **Development of Heathrow, Adding Capacity**
  - **UK Department of Transport declared ADMS-Airport the best model !**
  - **Staff trained in handling protestors ahead of public meetings**
- **2006** 年ADMS机场第一版正式发布
  - 作为希斯罗机场可持续发展项目（运力增加 ）的一部分
  - 英国交通部宣布ADMS-机场为最佳模型！
  - 公开听证会召开前的员工培训， 例如如何应对抗议者

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ADMS Star – emergency response model

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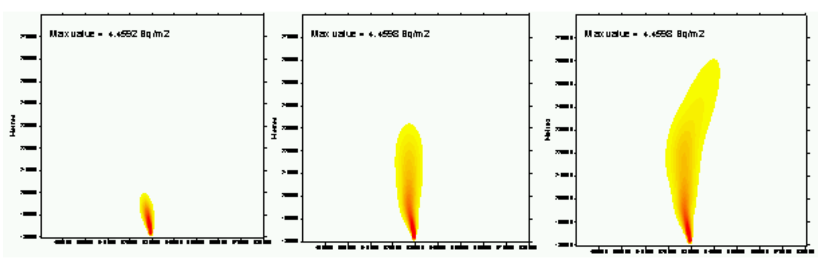
ADMSSTAR emergency response model for the UK Food Standards Agency
- uses puff model

为英国食品标准局开发的应急响应模型ADMSSTAR
- 采用烟团模型



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Thank you for your attention!

谢　谢！

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