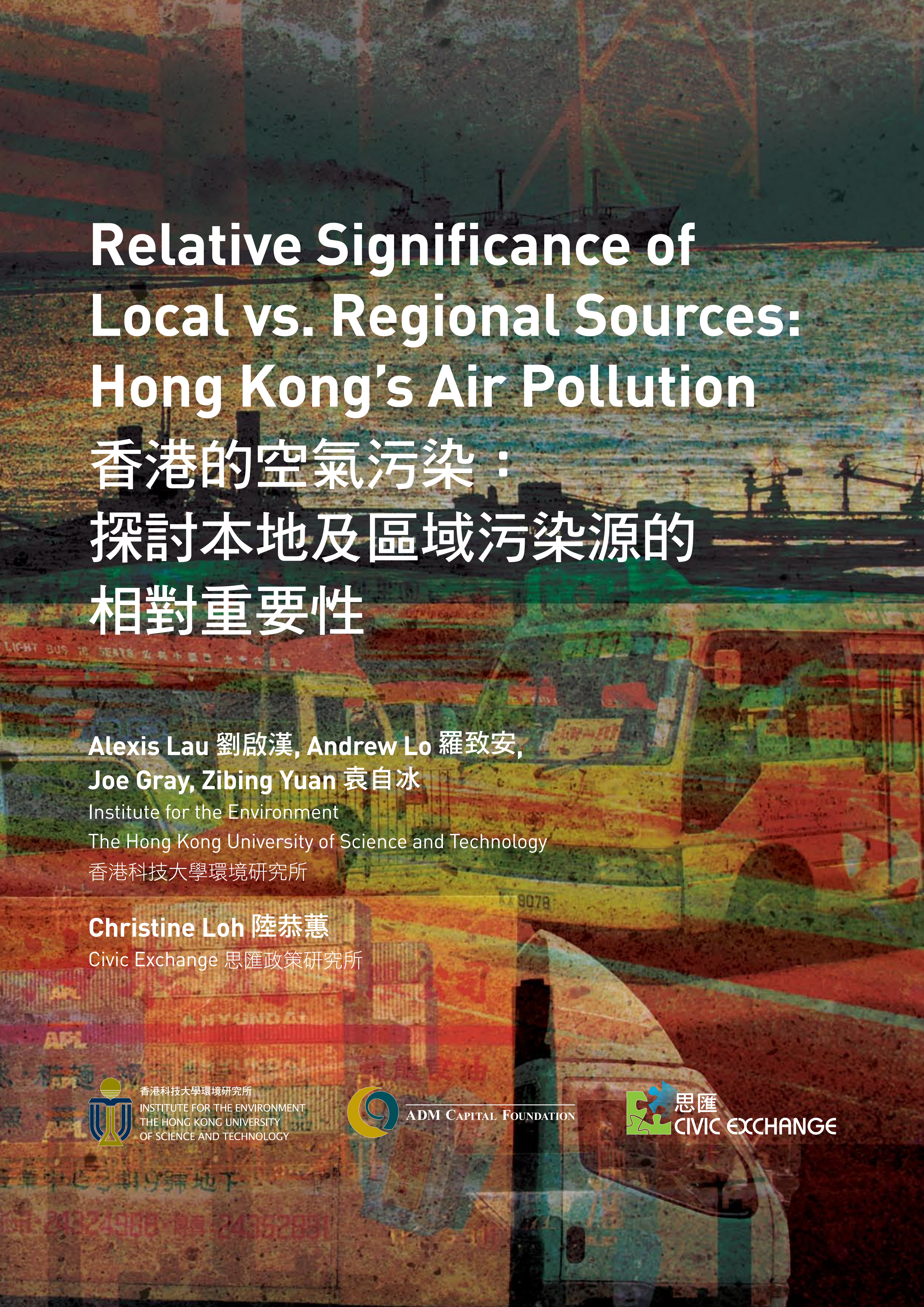

Relative Significance of Local vs. Regional Sources: Hong Kong's Air Pollution

香港的空氣污染：探討本地及區域污染源的相對重要性

Alexis Lau 劉啟漢, Andrew Lo 羅致安, Joe Gray, Zibing Yuan 袁自冰
Institute for the Environment
The Hong Kong University of Science and Technology
香港科技大學環境研究所

Christine Loh 陸恭蕙
Civic Exchange 思匯政策研究所

香港科技大學環境研究所
INSTITUTE FOR THE ENVIRONMENT
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Relative Significance of Local vs. Regional Sources: Hong Kong's Air Pollution

1 Background

No matter how one chooses to measure it, the air quality in Hong Kong and the Pearl River Delta has deteriorated rapidly over the past 20 years. For the layman, the distance one can see is a good indicator of air quality. The deterioration of Hong Kong's air quality has resulted in a steady increase in the number of hazy days. (Figure 1)

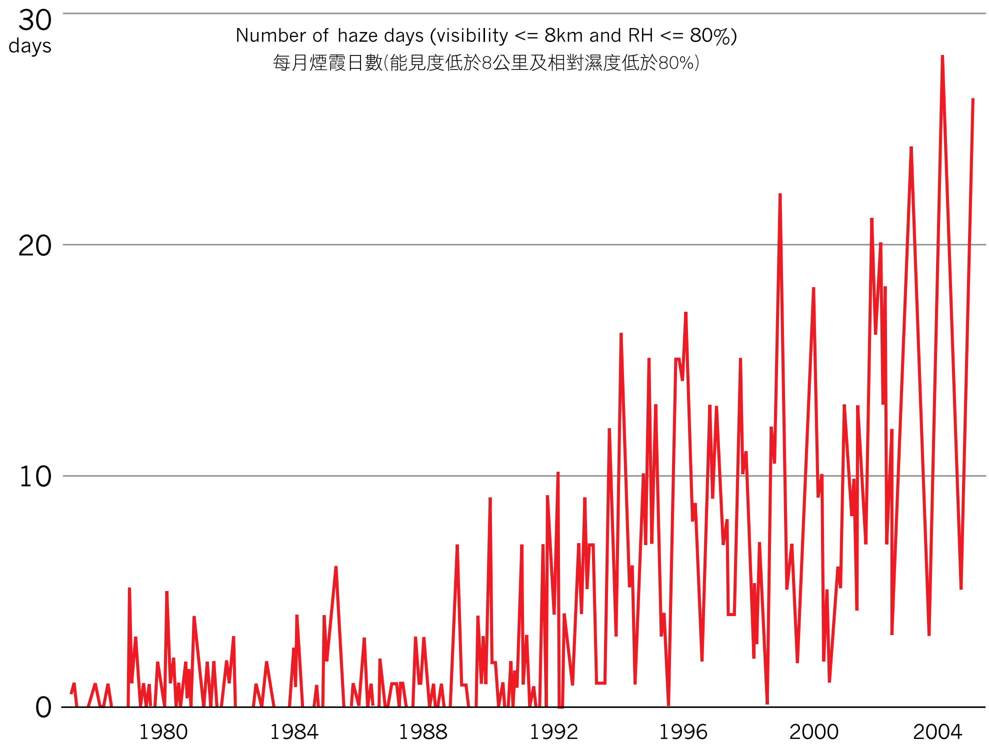

Figure 1: Monthly number of hazy days

As the air quality grows worse, questions arise about where the pollution is coming from, and what can be done about it. How significant are local and regional pollution sources for Hong Kong's air quality? The answer to this question is complex, and in fact can be quite different depending on how one approaches the problem.

In this report, we first summarize the results from two traditional approaches – one based on total emissions in terms of tonnage and another based on receptor source apportionment in terms of mass concentration. We then introduce our new approach, which gives a time-based perspective. It answers the question of how many days in a year Hong Kong's air quality is affected by regional and local emissions respectively. This type of analysis has not been undertaken in Hong Kong before.

Using 2006 data, we found that regional sources are the primary influence on Hong Kong's air 132 days (approximately 36% of the time) while local sources are the crucial factor on 192 days (nearly 53% of the time). Based on these results, it is clear that reducing emissions of air pollutants in Hong Kong would have a significant positive impact on local air quality, which would in turn improve public health.

The results of this study are important to policy makers and the public because they show that:

1. By taking more environmental responsibility locally, Hong Kong can do much more to improve air quality and therefore public health.
2. There is no reason for Hong Kong to feel debilitated by the belief that on its own it cannot make substantial improvement to the city's air quality.

To conclude, we offer broad policy recommendations as to how local emissions can be reduced. We believe that there are a number of potentially effective solutions that can be implemented relatively quickly. In particular, we recommend that Hong Kong adopt and enforce the World Health Organization's (2006) global air quality guidelines, and devise a comprehensive energy policy.

2 Scientific Approaches to Emissions Measurement

2.1 Total Emission Method

The total emission method is useful on a regional scale to depict the volumes in terms of tonnage emitted from different sources. It has been used in the Greater Pearl River Delta for many studies.

In a study based on 1997 data, CH2M Hill (2002) analysed the emission inventory for the Hong Kong Special Administrative Region (HKSAR) and the Pearl River Delta Economic Zone (PRDEZ). In that government-sponsored joint study, emission source types were grouped into four major sectors: energy, industry, transportation, and Volatile Organic Compound (VOC)-containing products. The analysis results showed that the PRDEZ contributed 88% of VOC, 95% of Respirable Suspended Particulates (RSP or PM_{10}), 80% of Nitrogen Oxides (NO_x), and 87% of Sulphur Dioxide (SO_2) to the region in the base year of 1997. (Figure 2)

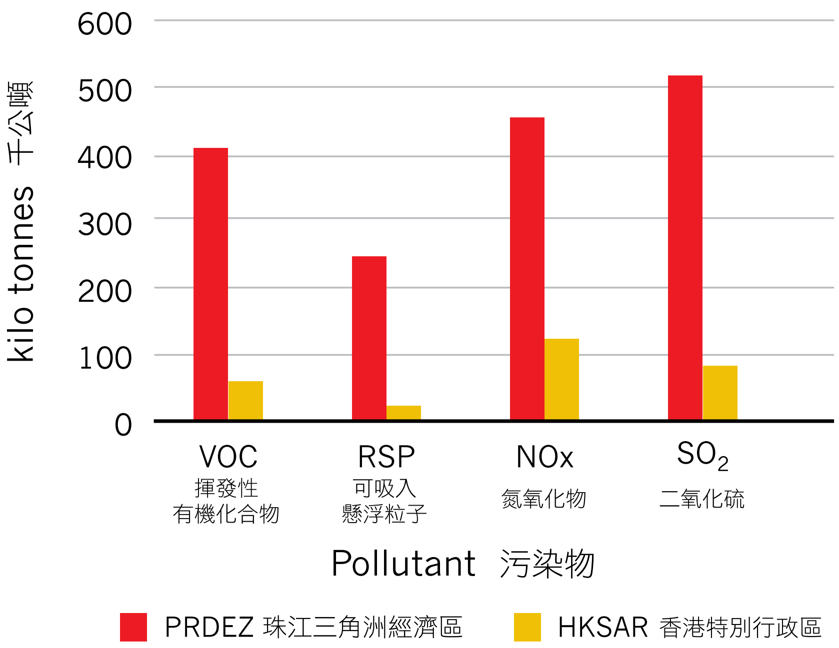

Figure 2: PRD vs. HK: total emission of specific pollutants

It should be noted that the above percentages are emissions contributions to the entire region. Since the PRDEZ is the geographically larger area, with higher population, and an industrial production zone, its emissions contributions are higher than that of the HKSAR.

Without a detailed regional air quality model to describe the flow characteristics of pollutants emitted from PRDEZ, it is difficult to give a quantitative estimate on its contribution to pollution levels in the HKSAR (Lo et al, 2006). However, one may interpret from such large percentages that the regional impact far overshadows local contributions for all four types of pollutants in the HKSAR.

2.2 Source Apportionment Method

This approach relies on a large amount of chemically speciated data (i.e. data showing the chemical composition of particulates) measured at air monitoring stations. Receptor models are applied to apportion the measured speciated data into groups through statistical identification of intrinsic features of the data, and to estimate the contributions from each group in each time slice. The derived groups, with similar component abundances to the known source signatures, are regarded as source profiles.

This method relies on expert judgment to identify the emission sources. To draw useful conclusions using this method, researchers must have an in-depth understanding of prevailing environmental conditions and must scrutinise environmental data. Yuan et al. (2006) conducted a study in which they applied the two commonly used receptor models – Unmix and Positive Matrix Factorization – to the speciated dataset collected from 1998 to 2002 at air quality monitoring stations around the HKSAR by the Environmental Protection Department. Nine major sources were identified. By examining the temporal and spatial distribution of source contributions, these sources were then classified as 'local' or 'regional'. It was concluded that in terms of mass concentration, regional sources from the PRDEZ accounted for approximately 60% of the pollution level in the HKSAR in annual average terms, but that this percentage would rise to 70% in wintertime.

3. Time-based Apportionment Method (number of days)

Numerous earlier studies (EPD 2006, Yuan et al. 2006) have shown that the average concentrations for most pollutants in Hong Kong are higher during winter than summer. This is partly related to the fact that there are more days dominated by the regional air mass in the winter and pollutant concentrations during these events are typically higher than when the local air mass dominates.

3.1 Data sets used

The data used in this study include:

- Hourly criteria gas concentrations from the 14 air quality monitoring stations operated by the Hong Kong Environmental Protection Department
- Wind and other meteorological data measured by the Hong Kong Observatory
- Regional Air Pollution Index[1] from the Regional Air Quality Monitoring Network operated by the Guangdong Environmental Protection Bureau and the Hong Kong Environment Protection Department
- Meteorological and air quality observations made by the Hong Kong University Science and Technology and other organizations around the Pearl River Delta

1 Available at http://www.gdepb.gov.cn/raqi

- Satellite-derived aerosol optical depth and surface extinction coefficient distribution; and three-dimensional flow field derived from near real-time MM5 runs operated by the Hong Kong University of Science and Technology[2].

3.2 Methodology

In this study, the time-based apportionment method identified, for each day in 2006, the likely source or region (i.e. the geographical area) that influenced the HKSAR's air quality.

Careful inspection of all of the data enabled us to identify 6 'modes' of pollution characteristics that may be said to be the most generally dominant mode on any one day. The modes identified were:

- Regional West
- Regional All
- Regional East
- Local Vehicle / Power Plants
- Local Vehicle / Marine
- Low Pollution

For details of each of the individual mode analysis, see Appendix II.

Days with SO_2 concentrations below 20 $\mu g/m^3$ at more that 11 of the 14 stations were flagged *Low Pollution*, as it is more difficult to positively identify sources on these days.

Subsequently, the weather conditions and spatial pollution pattern of SO_2 were assessed daily to determine which region in the Greater PRD, including Hong Kong, was the most influential. Sulphur dioxide was used as the tracer in this study because its sources in the Greater PRD region are well known and its chemical paths in the atmosphere are also relatively well understood, making source and mode identification easier than using other pollutant species. Sulphur dioxide is also a good tracer as its production is indicative of the production of other critical pollutants such as secondary particulates.

The current method has the drawback that some of Hong Kong's local pollution sources such as the power stations may also contribute significantly to the pollution level on some of the days flagged as either Regional All or Regional West. This is because some of Hong Kong's local emitted pollutants may be transported into the greater Pearl River Delta area, mixed in the regional land-sea breeze circulate with regional pollutants and returned into Hong Kong's air shed (Lo et al, 2006). This is unavoidable because the current methodology is based on the identification of air mass, and on these days emissions from local power plants are mixed into the regional air mass before it returns to Hong Kong. So while it is estimated that these days are dominated by regional emissions, it must be noted that emissions from local power plants may also contribute to this mixed air mass.

2 See http://envf.ust.hk/dataview

3.3 Results and Discussion

When the data is grouped by month and mode (local, regional or low pollution), it shows that while the Pearl River Delta affects Hong Kong's air pollution in winter (November – March), it is local sources (including vehicles, marine and power plants) that play the biggest role through summer (April – August), see Appendix I for a full summary of the data grouped by month and mode. Low pollution days are slightly less common in winter but are generally spread across the whole year.

Overall, we find at that regional sources are the primary influence on Hong Kong's air 132 days a year (approximately 36% of the time) while local sources are the crucial factor nearly 53% of the time (on 192 days), see Figure 3 and Appendix II for the percentages for each mode grouped by month.

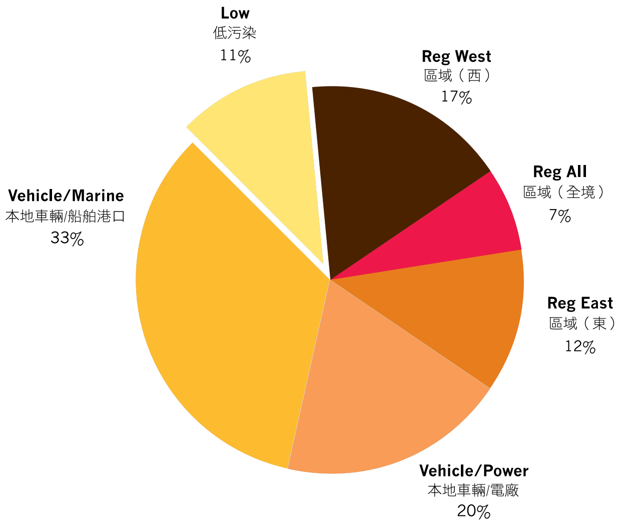

Figure 3: percentage of total days of the year that each mode was dominant

This leads us to conclude that Hong Kong can indeed control the source of its air pollution problem more often than not. Reducing local emissions in the transport (both road and marine) and power sectors would substantially improve the HKSAR's air quality.

We believe that the results of this study are important to policy makers and the public for two key reasons:

1. By taking more environmental responsibility locally, Hong Kong can do much more to improve air quality and therefore public health.
2. There is no reason for Hong Kong to feel debilitated by the belief that on its own it cannot make substantial improvement to the city's air quality.

In other words, Hong Kong has no excuse not to act with determination and speed to clean up its own emissions on the basis that the majority of the pollution arises from elsewhere.

It is also clear that the Greater Pearl River Delta plays a significant role in Hong Kong's air pollution problems. Total emissions from the Pearl River Delta far outweigh those from local sources. On days when Hong Kong's air quality is under the influence of the Pearl River Delta, the air quality is likely to be worse than when under the influence of local sources. This means that Hong Kong and its neighbours must continue to set joint reduction targets that will reduce overall regional pollution and lead to a cleaner future for all its citizens.

4. General Policy Recommendations

4.1 General Recommendations

- **Urgency:** In view of the fact that the health of citizens is being affected by HKSAR's air quality on a daily basis, urgent and comprehensive policy actions are required.
- **Goals and Priority:** For the success of the Chief Executive's Action Blue Sky, well-targeted and ambitious policy goals and priorities must be set at the highest level of government.
- **Coordination within government:** Air pollution arises from various sources which are regulated by different laws, measures and government authorities. Therefore, the making, implementation and review of policy must be well coordinated among the principal officials, bureaux and departments to ensure optimal results.
- **Concurrent actions:** For the greatest gains, comprehensive and concurrent actions must be taken not only within government but also improving regulation of industry sectors, and building public awareness.

4.2 Specific policy foci

We recommend that the following areas be key foci for action:

- **Target major emissions sources:** These must include the power, land transportation, marine transportation and logistics sectors. While the power sector is the largest emissions sector in terms of total quantity, our new research shows that by controlling the land and marine transportation sectors, as well as the logistics sector, solid gains can be made to reduce the impact of air pollution on Hong Kong residents.
- **Sharpen essential policy tools:** The HKSAR Government must use effective policy tools. The essential tools are to (a) adopt and enforce the World Health Organisation's 2006 global air quality guidelines; and (b) devise a comprehensive energy policy.

4.3 Effective policy tools

Without effective policy tools, policies are unlikely to generate the best outcomes. In other words, these tools provide goal-setting and priority-setting focus thereby showing the way to what actions need to be taken.

4.3.1 Standards influence regulation of emissions: The World Health Organization's 2006 global air quality guidelines are set to reflect the latest medical knowledge about the impact of air pollution on health. A loose set of standards represent a license to pollute. This is the situation today with Hong Kong's current Air Quality Objectives. We appreciate that the HKSAR Government has already launched an 18-month review but immediate adoption of the WHO guidelines would galvanize a comprehensive plan to reverse the public health crisis Hong Kong faces today.

4.3.2 A cross-cutting energy policy helps to maximise emissions reduction: There is no coherent across-the-board energy policy today in Hong Kong. This is a substantial area of discussion. For now, we will just point to some issues for illustration:

- **Energy efficiency:** To achieve energy efficiency gains, the HKSAR government will need to take a range of actions including recalibrating the Schemes of Control to reward efficiency (the Schemes of Control are being renegotiated, as they expire in 2008, and important opportunities may be lost without urgent attention now); and reforming building codes.
- **Lowering emissions from power generation:** Once the power plants in Hong Kong have been retrofitted with flue gas desulphurization FGD in the coming few years, further substantial emissions reduction gains may only be achieved through changing the fuel mix, such as to use more natural gas.

- **Energy security:** The HKSAR Government needs to consider what energy security risks there are for Hong Kong and how they may be dealt in the medium, longer-term future.

5. Dealing with emissions from transport, marine and logistics sectors

There is a range of possible methods to control and reduce emissions from the transportation, marine and logistics sectors. Some ideas include:

5.1 Vehicular

- Get pre-Euro, Euro I and Euro II vehicles off the road – consider (i) introducing a phase-out scheme; and (ii) complementing the phase-out with traffic management methods (e.g. road charging, restrict entry into low emissions zones)
- Make biodiesel available;
- Lower first registration charge for low-emission vehicles and charge a higher annual licence fee for high-emission vehicles;
- Expand rail infrastructure and coordinate rail and bus feeder services better; and
- Manage density and traffic flow to reduce "street canyon effect".

5.2 Marine

- In the short term, establish voluntary schemes that would encourage lower emissions from all waterborne crafts and terminal footprint such as:
  - Slow down ships when approaching and leaving port – the HKSAR Government can start with its own fleet;
  - Reduce land-based emissions at port – e.g. container stackers use ULSD;
  - Switch fuel to lower sulphur fuels for local craft and for auxiliary engines of ocean-going ships when along side – the HKSAR Government can require its own fleet to use cleaner gasoil;
- Retrofit engines of local crafts;
- Switch to shore-side power for ships when along side;
- Promote the use of shipping fuels with a 1% sulphur cap worldwide;
- Collaborate with Shenzhen and Guangdong to operate 'green port' policies

香港的空氣污染：
探討本地及區域污染源的
相對重要性

1 背景

我們無論選擇以哪種方法量度空氣質量，都會得出以下的結論：香港及珠江三角洲的空氣質量在過去二十年間迅速變壞。對一般人士來說，能見度是一個反映空氣質量的理想指標。香港空氣質量惡化，同時令煙霞日數穩步上升。（見圖1）

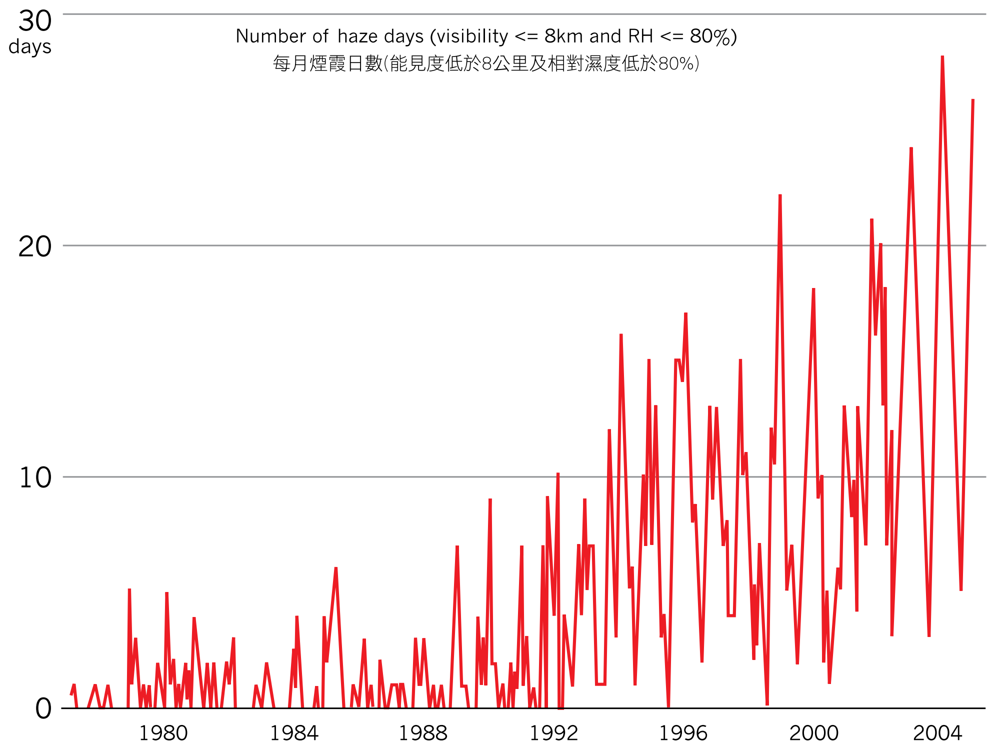

圖1：每月煙霞日數

當空氣質量持續惡化，隨之而來的問題包括：污染從何而來？我們可以採取什麼措施？本地及區域污染源對於香港空氣污染問題分別有多重要？其中，最後一個問題的答案是非常複雜的。事實上，由於分析這個問題的方法可能因人而異，因此各人的答案亦將有所不同。

傳統上，量度空氣污染的方法有二：其一是以污染物的重量作基礎，量度總排放量；其二是按污染物的質量濃度，進行污染源解析。我們在以下篇幅將會首先概述以上述兩種方法進行研究所得出的結果。然後，我們會介紹一種以時間作基礎，研究空氣污染的新方法。這種分析方法在香港是前所未有的。它可以幫助我們瞭解在一年當中，香港的空氣質量有多少天是受區域性排放影響，而又有多少天主要是受本地排放影響。

我們的研究分析了2006年的數據，發現香港的空氣質量主要受區域性污染源影響的日數，是每年132日（以時間計算約佔36%）；本地污染源作為主要原兇的日數，則達到每年192日（約佔53%）。以上研究結果讓我們清楚知道，減少香港空氣污染物的排放，將可以明顯改善本地空氣質量，從而改善公眾健康。

本項目的研究成果對政策制定者和公眾人士都至為重要，因為研究結果指出：

1. 香港只要在本地環境問題上作出更大承擔，就能進一步改善空氣質量及公眾健康。
2. 香港不能單靠自身努力，改善本地空氣質量的想法是錯誤的。我們不應受這個想法影響而感到無能為力。

最後，我們提出幾項減少本地污染物排放的政策建議，作為報告的終結。我們相信有一些具成效的措施，是可以在較短時間

內開始實施的。其中，我們建議香港採納和執行世界衛生組織（2006）的全球空氣質量指引，以及訂立一套全面的能源政策。

2 量度污染物排放的科學方法

2.1 總排放量方法

總排放量方法適用於在區域範圍內，描述不同污染源的排放量。不少研究大珠三角地區的項目都採用了這種方法。

在2002年，西圖國際（中國）有限公司根據1997年的資料，就香港特別行政區及珠江三角洲經濟區的排放清單進行了分析。這項由香港及廣東省兩地政府提供撥款的聯合研究，把污染物排放源歸納為四個主要類別，包括能源、工業源、汽車和含揮發性有機化合物產品。研究結果顯示，珠三角經濟區在1997年（研究基準年）的污染物排放量佔整個區域的比例分別是：揮發性有機化合物佔88%，可吸入懸浮粒子佔95%，氮氧化物佔80%，以及二氧化硫佔87%。（見圖2）

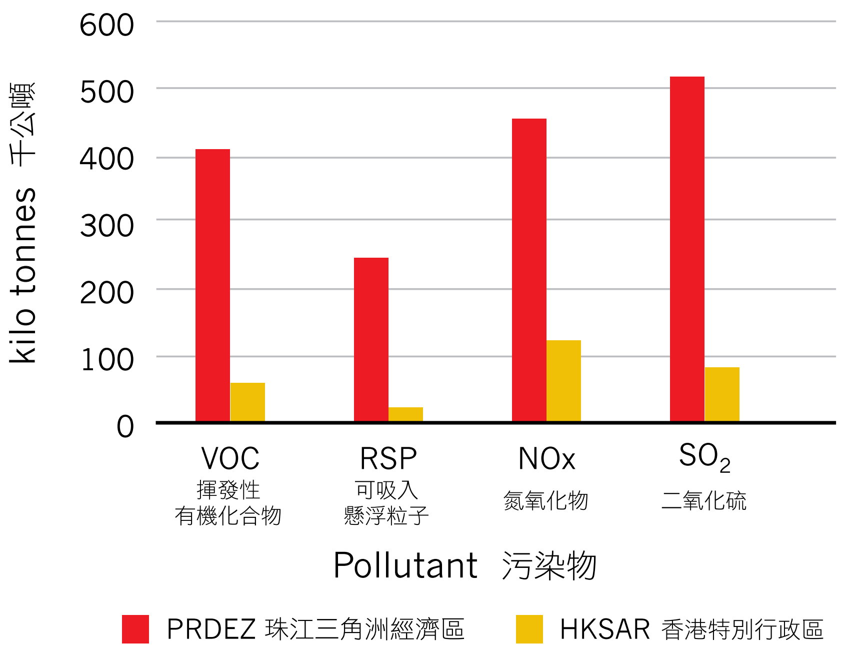

圖2：個別污染物的排放總量：珠江三角洲與香港的比較

讀者必須留意：上述百分率所反映的是珠三角經濟區排放量佔整個地區的比重。珠三角經濟區由於幅員較廣，人口較多，再加上是一個工業生產區，污染物排放量在地區的比重自然高於香港。

由於目前欠缺一個區域性空氣質量模型，講解源於珠三角經濟區的污染物的流動特性，因此，要估量當地對香港空氣污染水平的影響，將會是十分困難的（盧俊峰等人，2006年）。可是，上述的高百分率可能會令人覺得，區域性因素對香港四種污染物的影響，遠遠蓋過了本地因素的重要性。

2.2 源解析方法

源解析方法需依靠大量從空氣監測站錄得的化學分類數據（即顯示粒子化學成分的資料）。研究人員配合受體模型的應用，以統計識別方法分析數據特徵，把數據分配成不同類別，從而估算每個類別在每個時段的影響。這些類別一般稱為污染源成分譜，每個類別都顯示出大量相類似的污染源特徵。

源解析方法同時要依靠研究人員的專門判斷，對污染源進行識別。研究人員必須對區內最主要的環境狀況有深入瞭解，以及能細讀環境數據，才能以源解析方法得出實用的結論。袁自冰等人（2006年）採用了Unmix及正矩陣因數分解（Positive Matrix Factorization）這兩個常用的受體模型，分析由香港環境保護署自1998至2002年間在空氣質量監測站收集的化學分類數據。這項研究識別出九個主要污染源，並根據時空分佈的分析，把污染源劃分為「本地」或「區域」類別。研究結論指出，假若以污染物的質量濃度計算，來自珠三角經濟區的污染物約佔香港年平均污染水平的60%。在冬季，這個百分率可能會上升至70%。

3 時解析方法（日數）

多個早期的研究（環保署2006年，袁自冰等人2006年）分別指出，香港大多數污染物的平均濃度，一般是冬季高於夏季。其中部分原因是在冬季時分，我們有較多污染日子是由區域性氣團主導的，而當這種情況出現的時候，污染物濃度一般要比由本地氣團主導的時候為高。

3.1 採用的資料

本研究使用以下資料：

- 香港環境保護署14個空氣質量監測站提供的每小時標準污染物濃度資料
- 香港天文臺量度的風及其他氣象資料
- 廣東省環保局及香港環保署共同合作的粵港珠三角聯合空氣監測網絡提供珠三角區域空氣質量指數[1]
- 香港科技大學及其他組織提供的氣象及空氣質量資料
- 香港科技大學應用衛星資料識別氣溶膠光學厚度及表面消光系數分佈，以及由近即時MM5模式運算所得的三維流場[2]

3.2 研究方法

在本研究過程當中，我們以時解析方法分析2006年的每一天，從而識別當日最有可能影響香港空氣質量的污染源或區域。

在仔細審閱所有資料之後，我們識別出六種有明顯特徵的污染模式如下：

- 區域（西）
- 區域（全境）
- 區域（東）
- 本地車輛/電廠
- 本地車輛/船舶港口
- 低污染

請參閱附錄2，參考個別污染模式的詳細分析。

當14個空氣監測站中有最少12個的二氧化硫濃度讀數低於20毫克/立方米的時候，我們將很難有信心地識別當日的污染源。因此，我們會把這些日子定為「低污染」的日子。

我們隨後會為其他日子，評估天氣狀況及二氧化硫的污染分佈情況，決定大珠三角地區內哪一個區域（包括香港）對本港的空氣質量產生最大的影響。我們在這項研究當中選用二氧化硫作為追蹤氣體，因為我們對二氧化硫在大珠三角地區的污染源有相當的認識，亦大致明白它在大氣中的化學路徑。相對於其他污染物類別，二氧化硫令我們較容易辨別污染源和污染模式。二氧化硫是理想的追蹤氣體的另一個原因是，它的形成對於其他主要污染物如次生粒子的形成，有著指標性的作用。

1 請瀏覽 http://www.gdepb.gov.cn/raqi

2 見 http://envf.ust.hk/dataview

然而，這種方法亦有其不足之處。在一些被我們界定為主要受「區域（全境）」或「區域（西）」污染源影響的日子，香港的污染源如電廠亦可能是導致污染問題的重要原因之一，因為部分在香港境內排放的污染物可能會被吹到大珠三角地區，因區域性海陸風的緣故跟其他在區內排放的污染物混和，然後再被帶回香港（盧俊峰等人，2006年）。這種情況是難以避免的，因為我們目前使用的研究方法是針對空氣團的識別，而在上述日子中，本地電廠排放的污染物將會混在區域性氣團當中，再返回香港。因此，這些日子雖然被認定主要是受區域性污染源影響，但本地電廠亦可能貢獻了部分污染物，這一點讀者們務必注意。

3.3 研究成果及討論

我們把分析資料按月份和污染模式（本地、區域或低污染）分類。結果顯示，在冬季（十一月至三月），香港的空氣污染主要受珠三角的影響；在夏季（四月至八月），本地污染源（包括汽車、船舶、港口和電廠）的影響則較為重要。「低污染」日子較少在冬季出現，但一般而言，它的全年分佈卻相當平均。附錄1提供了一份按月及污染模式分類的資料分析概覽。

總的來說，我們發現在2006年，香港空氣質量主要受區域性污染源影響的日數有132天（約36%）。有接近53%的日子（即192日）則主要受本地污染源影響。有關每一種污染模式的按月分佈，請參見圖3及附錄2。

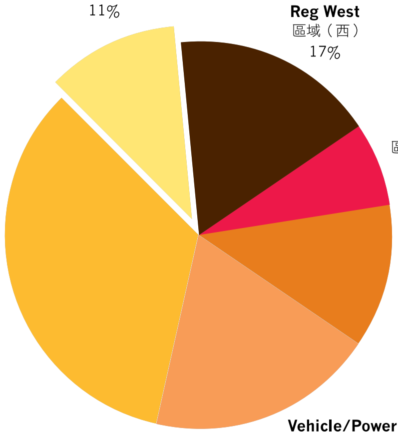

圖3：每種污染模式主導的日數（百分率）

根據以上結果，我們得出這樣的結論：以日子計算，香港有很多空間（而非沒有空間）控制導致本地污染的主要源頭。減少本地交通（包括道路交通、船舶和港口）污染和電廠污染，將能大大改善香港的空氣質量。

我們基於兩個重要原因，深信本研究項目的結果對政策制定者和公眾人士皆極為重要：

1. 研究結果指出，香港只要在本地環境問題上作出更大承擔，就能進一步改善空氣質量及公眾健康。
2. 研究結果同時令我們相信，香港不能單靠自身努力，改善本地空氣質量的想法是錯誤的。我們不應受這個想法影響而感到無能為力。

換言之，香港不能再以大部分污染物來自境外為理由藉辭推搪，因而不拿出決心和效率，減少本地的污染物排放。

我們同樣清楚知道，大珠三角地區在香港的空氣污染問題上，扮演著重要角色。來自珠三角的污染物總排放量遠超出本地污染源。在香港空氣主要受珠三角因素影響的日子，空氣質量很有可能較受本地因素影響的日子差。這代表香港及其鄰近地區必須繼續攜手合作，訂立共同的減排目標，為減少整體區域性污染，以至在將來為整個地區的居民帶來潔淨的環境作出努力。

4 一般政策建議

4.1 一般建議

- **急切性：**鑒於市民的健康每一天都受到香港空氣質量的威脅，我們急需制訂即時及全面的政策措施。
- **目標及優先處理事項：**要確保行政長官的「藍天行動」成功，特區政府的最高決策機構必須訂立適當及有抱負的政策目標和優先次序。
- **協調政府機關：**空氣污染來自不同的污染源。這些污染源各自受不同的法例、措施及政府部門監管。因此，政府務必妥善協調主要官員、政策局和各部門之間的合作，以確保政策的訂立、施行及檢討能達到最佳效果。
- **同步推行各項措施：**以達到最大成效，政府一方面需要全面地及同步地推出不同的措施，另一方面亦要尋求改善與不同行業有關的條例，和建立市民大眾對空氣質量的關注。

4.2 具體政策焦點

我們提出下列幾個範疇，作為行動的重要焦點：

- **以主要排放源頭作目標：**當中定必包括電廠、道路交通、海上交通及物流業。雖然以總排放量計算，電廠是最大的污染源，但我們的研究顯示，妥善管制道路和海上交通，以及物流業的污染情況，將能在減少空氣污染對市民健康的影響方面，取得實質的成效。
- **加強主要政策的力度：**香港特區政府必須採用具成效的政策工具。這些工具包括（a）採納及執行世界衛生組織的全球空氣質量指引，以及（b）訂立一套全面的能源政策。

4.3 具成效的政策工具

欠缺有效的政策工具作配合，政策的推行將難以取得最佳效果。換句話說，這些工具提供了訂立目標和優先次序的焦點，從而讓政府更容易找出需要推行的措施。

4.3.1　空氣質量標準影響到污染物排放的規管：世界衛生組織訂立全球空氣質量指引的目的是，反映有關空氣污染對人體健康影響的最新醫學知識。太寬鬆的標準只會成為污染者的護身符，而這正是目前香港空氣質素指標的問題所在。我們對於香港特區政府已啟動為期十八個月的空氣質素指標檢討感到欣慰，但即時採用世衛指引卻能激起訂立全面空氣管理計畫的決心，扭轉目前香港面對的公眾健康危機。

4.3.2　全面的能源政策將有助於提高減排的成效：香港現時欠缺一個全面而又內容協調的能源政策。這將會是一個主要的討論議題。我們謹此提出幾點稍作說明：

- **能源效益：**要成功提高能源效益，香港特區政府需要採取一系列措施，包括透過管制計畫獎勵能源效益（兩電的《管制計劃協議》將於2008年屆滿，政府目前正跟兩家電力公司進行磋商。假如政府不即時提出能源效益方面的關注，我們有可能失去一個難得的機遇），以及就建築守則進行改革。
- **降低電力發電的廢氣排放：**當香港的電廠在未來數年陸續完成加裝煙氣脫硫系統之後，香港只能透過改變燃料組合，例如使用更多天然氣，以進一步大幅減少污染物排放。
- **保持能源供應穩定：**香港特區政府必須考慮香港能源供應的風險，以及如何在中期及長期處理這個問題。

5 處理交通、航運及物流業的廢氣排放問題

我們提出一系列可行的辦法，控制和減少來自交通、航運及物流業的廢氣排放，部分建議包括：

5.1 車輛

- 禁止歐盟前期、一期及二期車輛使用道路，並考慮(i)推出分階段車輛淘汰計畫，以及(ii)以交通管理措施，配合分階段車輛淘汰安排（例如：道路收費、限制車輛進入低排放區等）
- 供應生化柴油
- 調低「低排放」車輛的首次登記稅，和調高「高排放」車輛的牌照年費
- 擴建鐵路系統，以及更有效地協調鐵路和接駁巴士服務
- 管理城市發展密度和交通流量，減少「街道峽谷效應」

5.2 航運

- 在短期內設立自願計畫，鼓勵所有船隻減少排放，以及鼓勵碼頭減低污染足跡，例如：
  - 減低港內船隻進出港口時的航行速度 — 香港政府應鼓勵政府船隻帶頭響應
  - 訂立目標，減少碼頭範圍內的廢氣排放 — 例如要求貨櫃堆積機使用超低硫柴油
  - 要求本地船隻，以及遠洋船隻靠岸後使用備用引擎時改用低硫燃料 — 香港政府可以要求政府船隻使用潔淨的汽油；此外，政府應該協助本地提供潔淨汽油，讓其他船隻使用
- 為本地船隻引擎加裝減排裝置
- 提供配套，讓船隻在泊岸後改用岸電
- 鼓勵全球航運業界使用含硫量不高於百分之一的蒸餾油作為船用燃料
- 與深圳及廣東省合作，推行環保港口政策

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Appendix I 附錄1

	Reg West 區域（西）		Reg All 區域（全境）		Reg East 區域（東）		Vehicle/Power 本地車輛 / 電廠		Vehicle/Marine 本地車輛/船舶港口		Low 低污染	
Jan 一月	12	(38.7%)	2	(6.5%)	0	(0.0%)	3	(9.7%)	12	(38.7%)	2	(6.5%)
Feb 二月	8	(28.6%)	3	(10.7%)	1	(3.6%)	1	(3.6%)	9	(32.1%)	6	(21.4%)
Mar 三月	10	(32.3%)	3	(9.7%)	3	(9.7%)	7	(22.6%)	7	(22.6%)	1	(3.2%)
Apr 四月	4	(13.3%)	1	(3.3%)	2	(6.7%)	7	(23.3%)	16	(53.3%)	0	(0.0%)
May 五月	2	(6.5%)	4	(12.9%)	2	(6.5%)	8	(25.8%)	12	(38.7%)	3	(9.7%)
Jun 六月	1	(3.3%)	0	(0.0%)	0	(0.0%)	10	(33.3%)	16	(53.3%)	3	(10.0%)
Jul 七月	0	(0.0%)	4	(12.9%)	0	(0.0%)	11	(35.5%)	12	(38.7%)	4	(12.9%)
Aug 八月	1	(3.2%)	2	(6.5%)	3	(9.7%)	11	(35.5%)	7	(22.6%)	7	(22.6%)
Sep 九月	5	(16.7%)	3	(10.0%)	8	(26.7%)	3	(10.0%)	5	(16.7%)	6	(20.0%)
Oct 十月	4	(12.9%)	1	(3.2%)	2	(6.5%)	5	(16.1%)	14	(45.2%)	5	(16.1%)
Nov 十一月	7	(23.3%)	3	(10.0%)	11	(36.7%)	2	(6.7%)	5	(16.7%)	2	(6.7%)
Dec 十二月	7	(22.6%)	1	(3.2%)	12	(38.7%)	3	(9.7%)	6	(19.4%)	2	(6.5%)
TOTAL 總計	**61**	**(17%)**	**27**	**(7%)**	**44**	**(12%)**	**71**	**(20%)**	**121**	**(33%)**	**41**	**(11%)**

Table 1: Number of days each mode was identified per month (percentages in brackets).
表1：每種污染模式按月出現次數（括弧內是百分率）

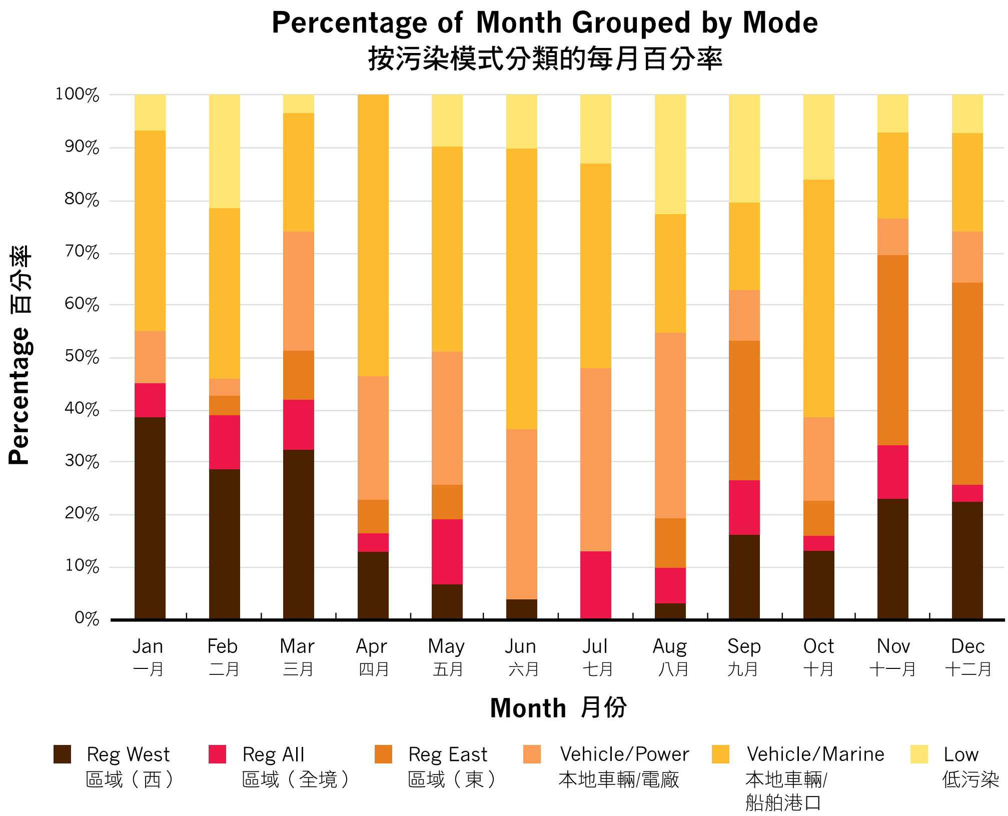

Figure 4: Graph of percentage each mode influenced each month
圖4：每種污染模式按月影響力比較

	Regional 區域污染源		Local 本地污染源		Low Pollution 低污染	
Jan 一月	14	(45.2%)	15	(48.4%)	2	(6.5%)
Feb 二月	12	(42.9%)	10	(35.7%)	6	(21.4%)
Mar 三月	16	(51.6%)	14	(45.2%)	1	(3.2%)
Apr 四月	7	(23.3%)	23	(76.7%)	0	(0.0%)
May 五月	8	(25.8%)	20	(64.5%)	3	(9.7%)
Jun 六月	1	(3.3%)	26	(86.7%)	3	(10.0%)
Jul 七月	4	(12.9%)	23	(74.2%)	4	(12.9%)
Aug 八月	6	(19.4%)	18	(58.1%)	7	(22.6%)
Sep 九月	16	(53.3%)	8	(26.7%)	6	(20.0%)
Oct 十月	7	(22.6%)	19	(61.3%)	5	(16.1%)
Nov 十一月	21	(70.0%)	7	(23.3%)	2	(6.7%)
Dec 十二月	20	(64.5%)	9	(29.0%)	2	(6.5%)
TOTAL 總計	**132**	**(36%)**	**192**	**(53%)**	**41**	**(11%)**

Table 2: Days the major influence grouped by month (percentages in brackets).

表2：主要污染模式按月出現次數（括弧內是百分率）

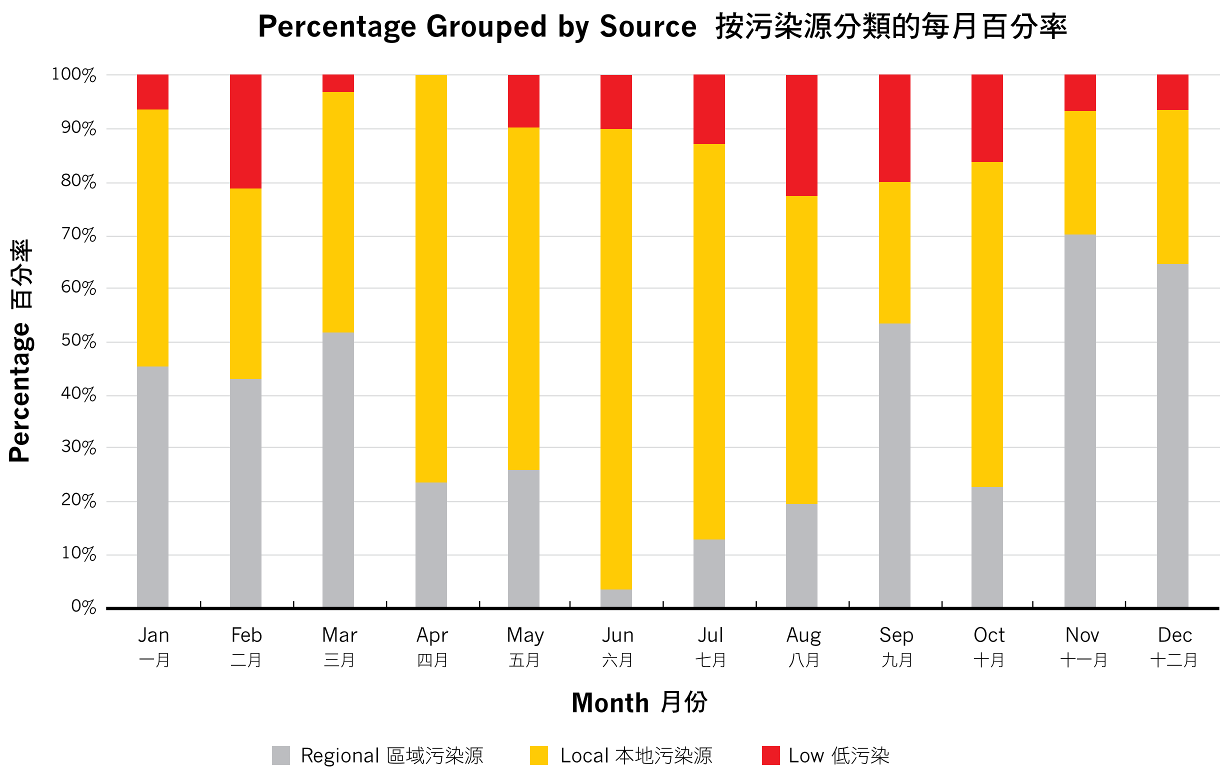

Figure 5: Graph of percentage each source was the major influence grouped by month

圖5：主要污染模式按月影響力比較

Appendix II: Analysis of individual modes
附錄2：個別污染模式分析

Regional West

The mode Regional West describes the condition when the HKSAR's air pollution is derived mainly from the PRD region to the west and northwest of Hong Kong. Figure 6 is an example of the pollution levels across the region on a typical day that is dominated by the Regional West mode. Figure 6 shows the heavy pollution along the western edge of Hong Kong with relatively good air quality for the majority of the rest of Hong Kong. Figure 7 and Figure 8 show the typical wind vector map and SO2 levels during a Regional West mode. This condition was identified as being the major influence on the HKSAR's air quality for an annual average of 61 days per year, or just under 17% of the year.

區域（西）

區域（西）污染模式指出香港的空氣污染主要源自珠三角地區，而受影響的範圍則集中在香港的西部及西北部。圖6顯示在一個由區域（西）污染模式主導的典型日子，珠三角地區的的整體污染情況。我們亦可以從圖六看到香港西面邊緣地帶嚴重的污染情況，而香港其他地區的空氣質量則相對良好。此外，圖7和圖8分別顯示在區域（西）污染模式下的典型風矢圖和二氧化硫水平。我們把這種污染情況識別為影響香港空氣質量最重要因素的日子，是平均每年61日或佔全年17%的時間。

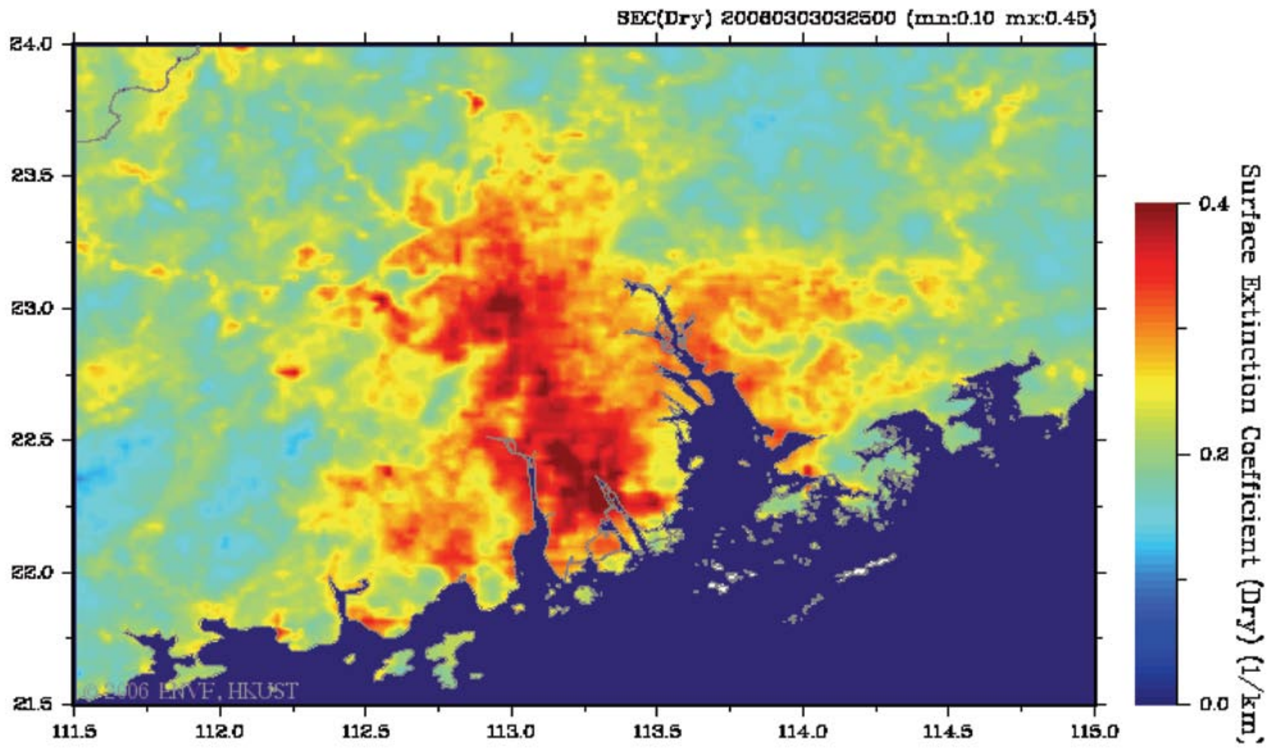

Figure 6: Surface Extinction Coefficient Map of the PRD during a Regional West mode.
圖6：區域（西）污染模式下的珠三角表面消光系數分佈圖

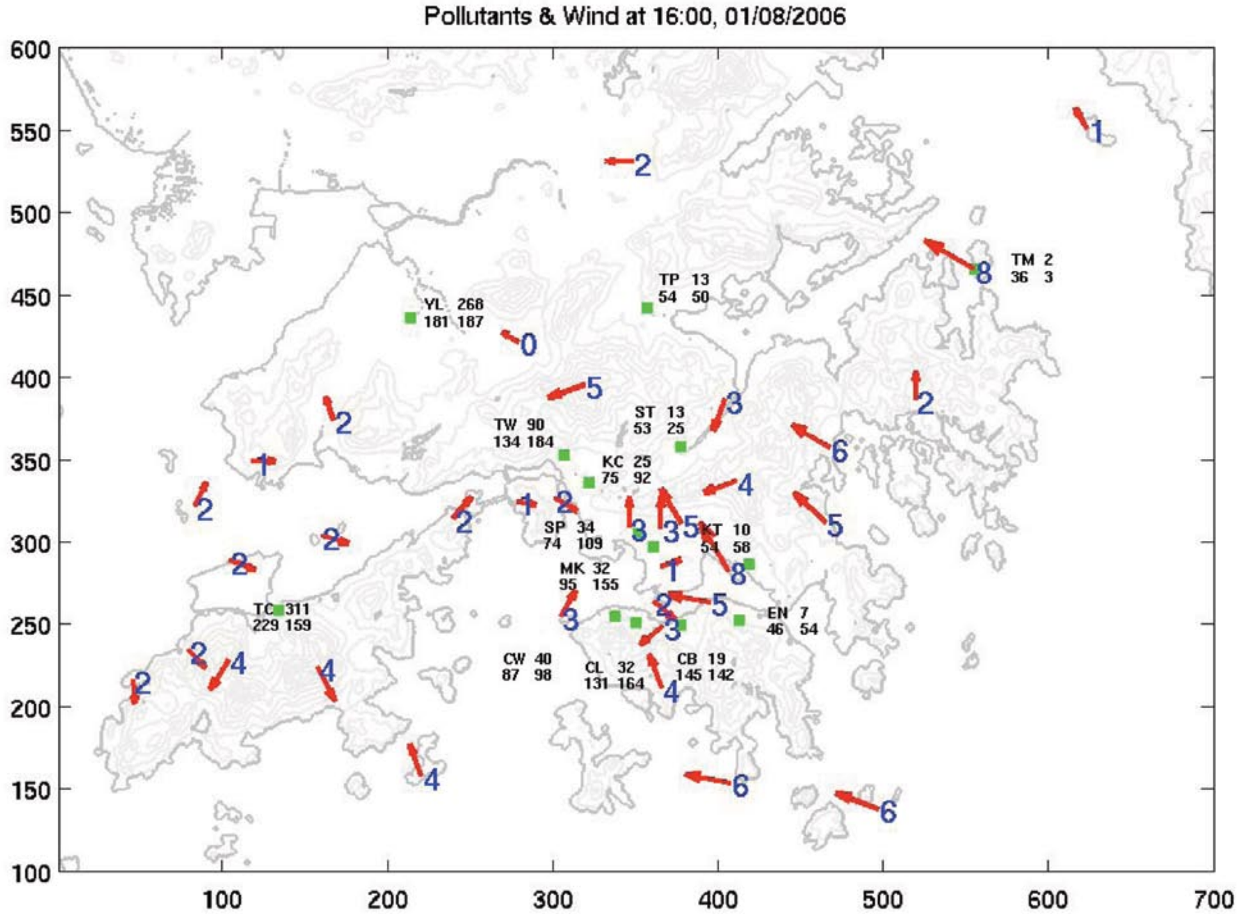

Figure 7: Wind Vector Map during a typical Regional West mode. Red arrows represent the wind direction at the corresponding wind stations. Green dots are the locations of the Air Quality Monitoring Stations (AQMS), Black number are the pollution concentrations in μg/m^3 at the corresponding AQMS: SO_2 (top right) RSP (bottom left and NO_2 Bottom right)

圖7：區域（西）污染模式下的風矢圖
紅色箭頭代表測風站錄得的風向，綠點代表空氣質量監測站的位置，黑色數字是監測站錄得的二氧化硫（右上）、可吸入懸浮粒子（左下）和二氧化氮（右下）濃度讀數（毫克/立方米）

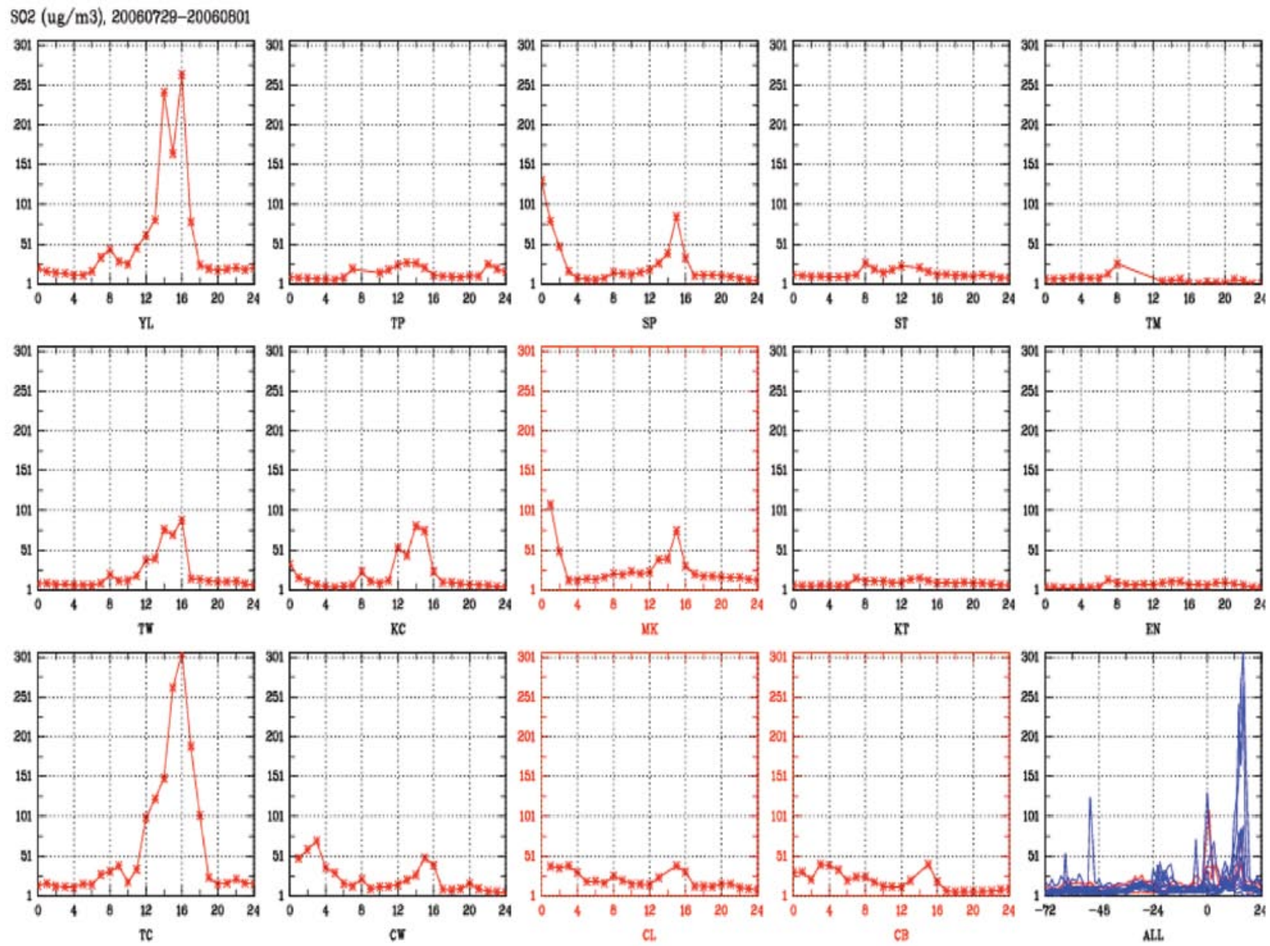

Figure 8: SO_2 levels during a typical Regional West mode. Going from top to bottom and left to right, the stations are Yuen Long (YL), Tsuen Wan (TW), Tung Chung (TC), Tai Po (TP), Kwai Chung (KC), Central/Western (CW), Sham Sui Po (SP), Mong Kok (MK), Central (CL), Sha Tin (ST), Kwun Tong (KT), Causeway Bay (CB), Tap Mun (TM) and Eastern (EN). The last panel summarizes the variation of SO_2 at all the 14 stations.

圖8：典型區域（西）污染模式下的二氧化硫水平
由上而下再由左至右，各個空氣監測站分別是：元朗（YL），荃灣（TW），東涌（TC），大埔（TP），葵涌（KC），中西區（CW），深水埗（SP），旺角（MK），中環（CL），沙田（ST），觀塘（KT），銅鑼灣（CB），塔門（TM）和東區（EN）。最後一張圖概括了十四個站的二氧化硫水平變化

Regional East

As the region to Hong Kong's east is not as heavily developed as its west, we had thought that there may not be clear signature of polluted air masses coming from the east or northeast despite prevailing winds often coming from an east or north-easterly direction. Days dominated by this mode usually showed a prevailing easterly or north-easterly flow across Hong Kong with significant SO_2 levels in Tap Mun and Tai Po. This mode was identified on 44 days of the year on average making roughly 12% of the time. This result shows that emissions to the east and northeast of Hong Kong definitely play a role in the HKSAR's air quality. With the upcoming developments in Yantian port and Huizhou Daya Bay Economic and Technological Development Zone, emissions to the east and northeast may have a larger role for HKSAR's air quality in the future. Figure 9 and Figure 10 show the typical wind vector map and SO_2 levels during a Regional East mode.

區域（東）

雖然香港的盛行風主要從東面或東北面吹來，但由於香港以東地區並未如香港以西地區發展迅速，因此我們最初假設來自東面或東北面的氣團，很可能沒有清晰的污染特徵。然而，我們在區域(東)污染模式主導的日子裏，經常發現一股由東面或東北面吹來的氣流，為塔門及大埔帶來甚高的二氧化硫水平。這種污染模式在2006年一共出現了44天，又或是大約12%的時間。這肯定說明香港以東或東北方向的污染源，同樣會對香港的空氣質量造成影響。考慮到鹽田港和惠州大亞灣經濟技術開發區的未來發展，我們覺得香港東面和東北面的污染源有可能在將來對香港的空氣質量，帶來更大程度上的影響。圖9和圖10分別顯示在區域（東）污染模式下的典型風矢圖和二氧化硫水平。

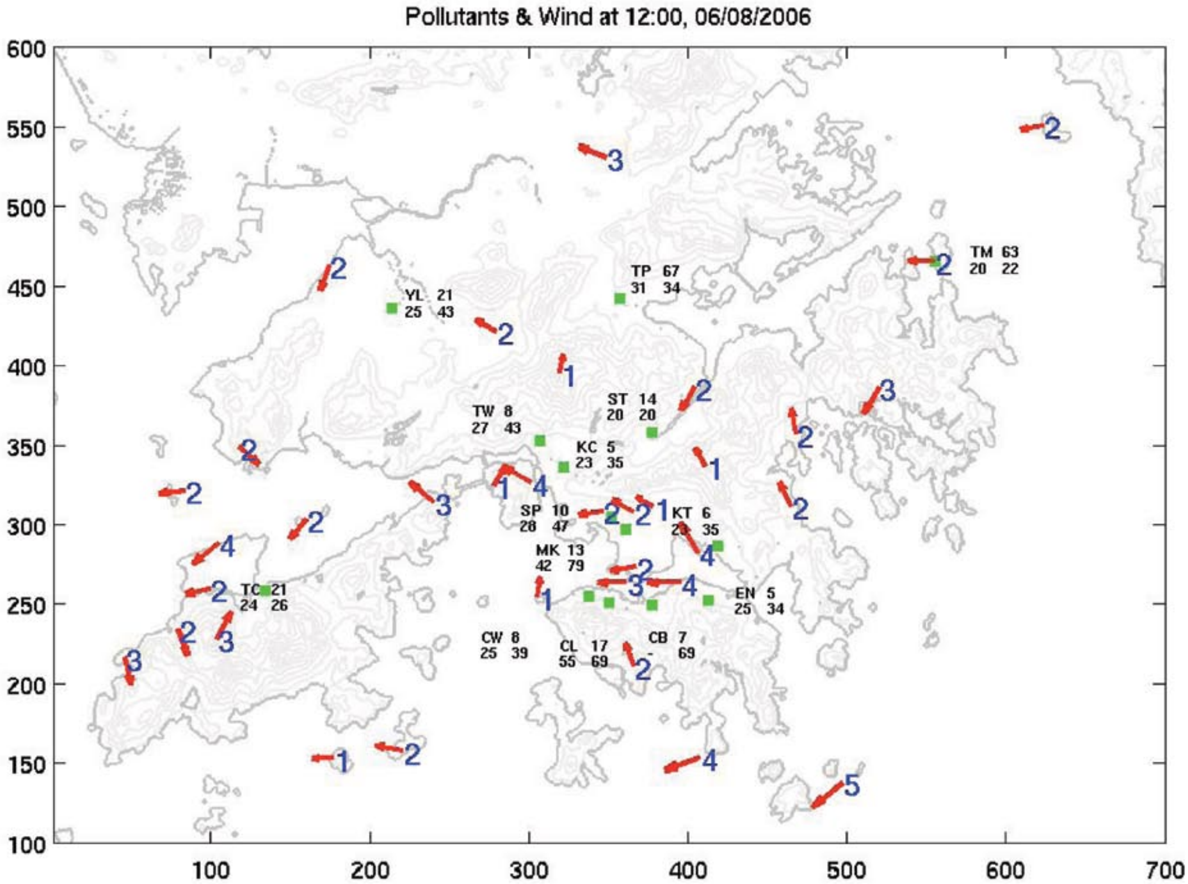

Figure 9: Wind Vector Map during a typical Regional East mode

圖9：區域（東）污染模式下的風矢圖

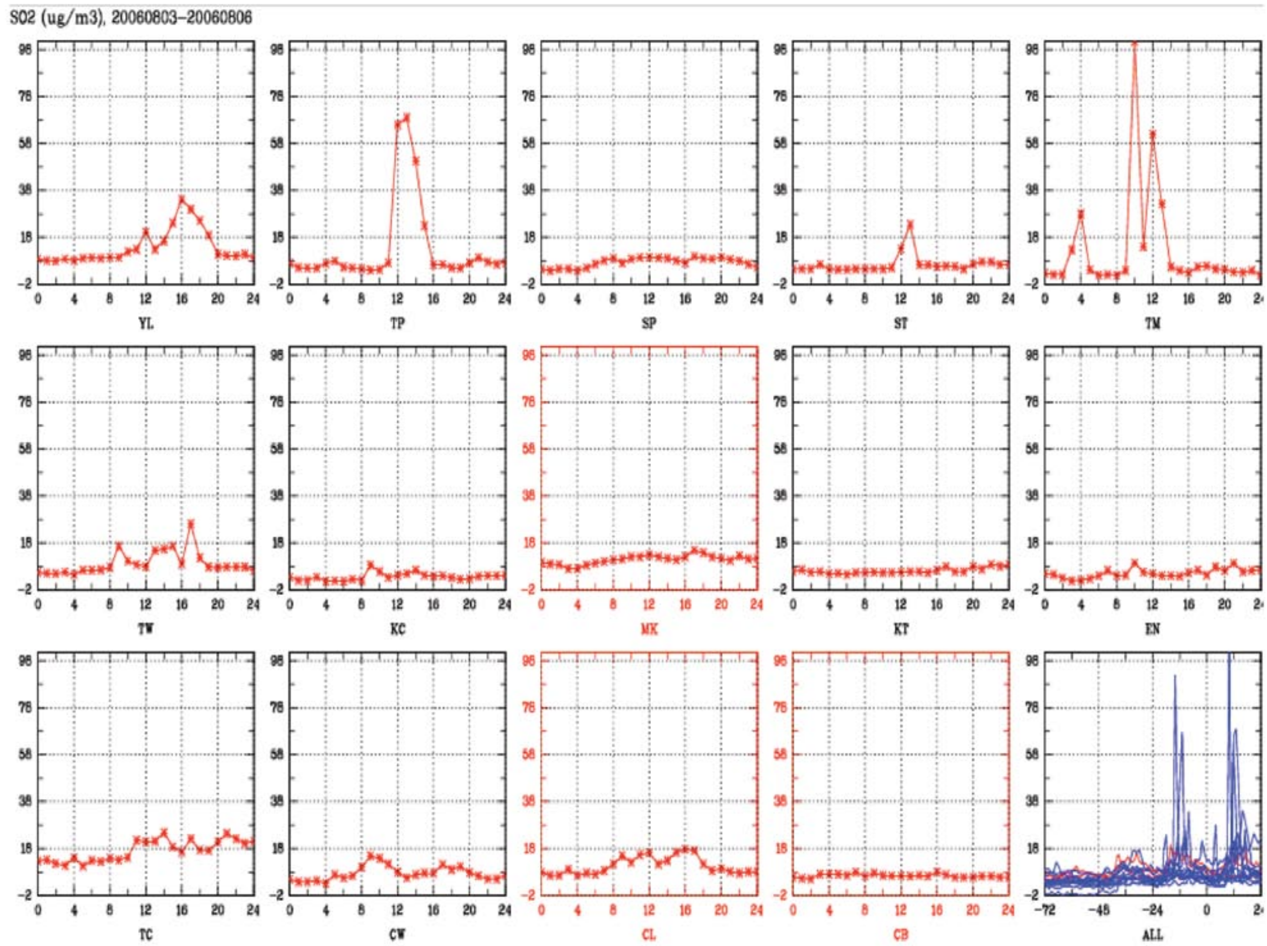

Figure 10: SO_2 levels during a typical Regional East mode

圖10：典型區域（東）污染模式下的二氧化硫水平

Regional All

This mode represents conditions where the air quality throughout the HKSAR is under region influence. These Regional All modes can have the highest concentration of pollutants and the highest air pollution index (API's). Figure 11 and Figure 12 show the conditions on a typical day identified as a Regional All mode. Figure 11 shows a typical wind map in Hong Kong. Figure 12 shows SO_2 levels at monitoring stations across Hong Kong. Analysis showed that Regional All was the dominant mode only 7% of the time or 27 days a year.

區域（全境）

這個污染模式表示香港境內所有地區的空氣質量都受到區域性因素的影響。我們在這種模式下，可以找到最高的污染物濃度和最高的空氣污染指素。圖11及圖12分別反映了典型區域（全境）污染模式的情況。圖11是一個香港全境的風矢圖，而圖12則顯示了香港空氣監測站的二氧化硫水平。我們的分析指出，每年只有7%的時間或27日是由區域（全境）污染模式作主導的。

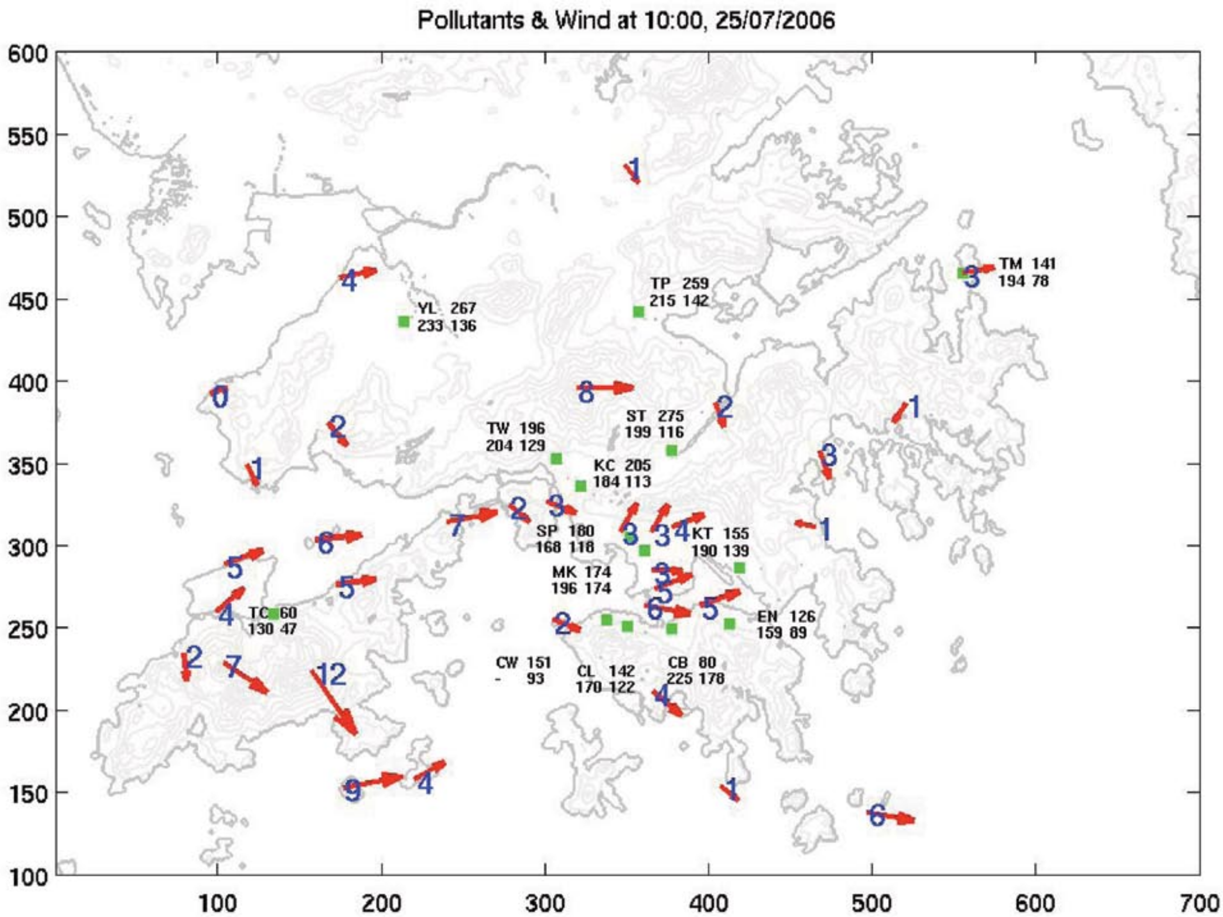

Figure 11: Wind vector map of Hong Kong during a Regional All event

圖11：區域（全境）污染模式下的風矢圖

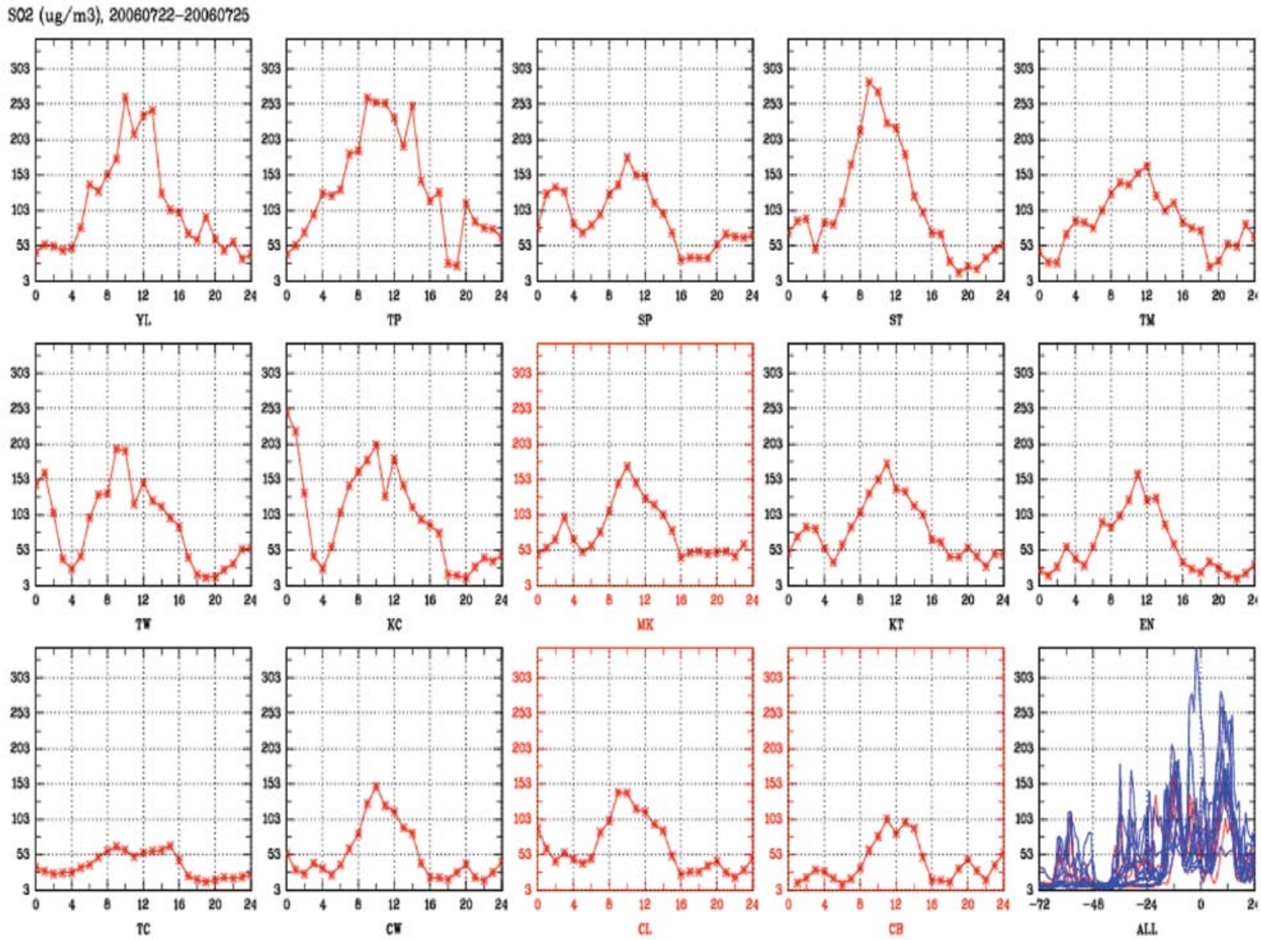

Figure 12: SO_2 levels during a typical Regional All mode
圖12：區域（全境）污染模式下的二氧化硫水平

Local Vehicle / Power Plant

Using SO_2 as an air mass tracer, two different modes (Power Plants and Marine) could be identified on days when HKSAR's air quality was dominated by local sources. Nevertheless, SO_2 is not a good tracer for local vehicular emissions because of our use of ultra-low sulphur fuels. This was not a significant drawback for our current objective. Since dispersion for on-road vehicular emission was likely to be less effective than for power plants or marine vessels, vehicular traffic was identified as a major factor and included in both modes.

The first local mode is a combination of local vehicle sources and power stations. This mode is associated with weak to moderate winds, and higher pollutant levels can be seen both in the city centres and at monitoring station near to either power station. This mode was identified as active around 19% of the time analysed, or 71 days of the year. Examples of this mode are shown in Figures 13 to 16.

本地車輛/電廠

我們使用二氧化硫作為氣團追蹤氣體，讓我們可以在本地污染源主導的日子當中，辨別出兩個不同的污染模式（電廠及船舶港口）。可是，本地有不少車輛使用超低硫柴油，因此二氧化硫並非一個追蹤本地車輛污染的理想工具。然而，這個缺點並不會影響本研究的目的。由於道路交通的排放物比電廠或船舶的排放物較難吹散，我們於是把車輛定為主要因素，並且讓它同時出現在兩種污染模式之中。

第一個本地污染模式是車輛和電廠的混合體。這種模式通常發生在風力微弱至一般的日子。我們可以在市中心和鄰近電廠的監測站，錄得十分高的污染水平。研究發現這種污染模式的出現日次共有71日，或約佔19%的時間。我們可以透過圖13至圖16，瞭解本地車輛/電廠污染模式的特性。

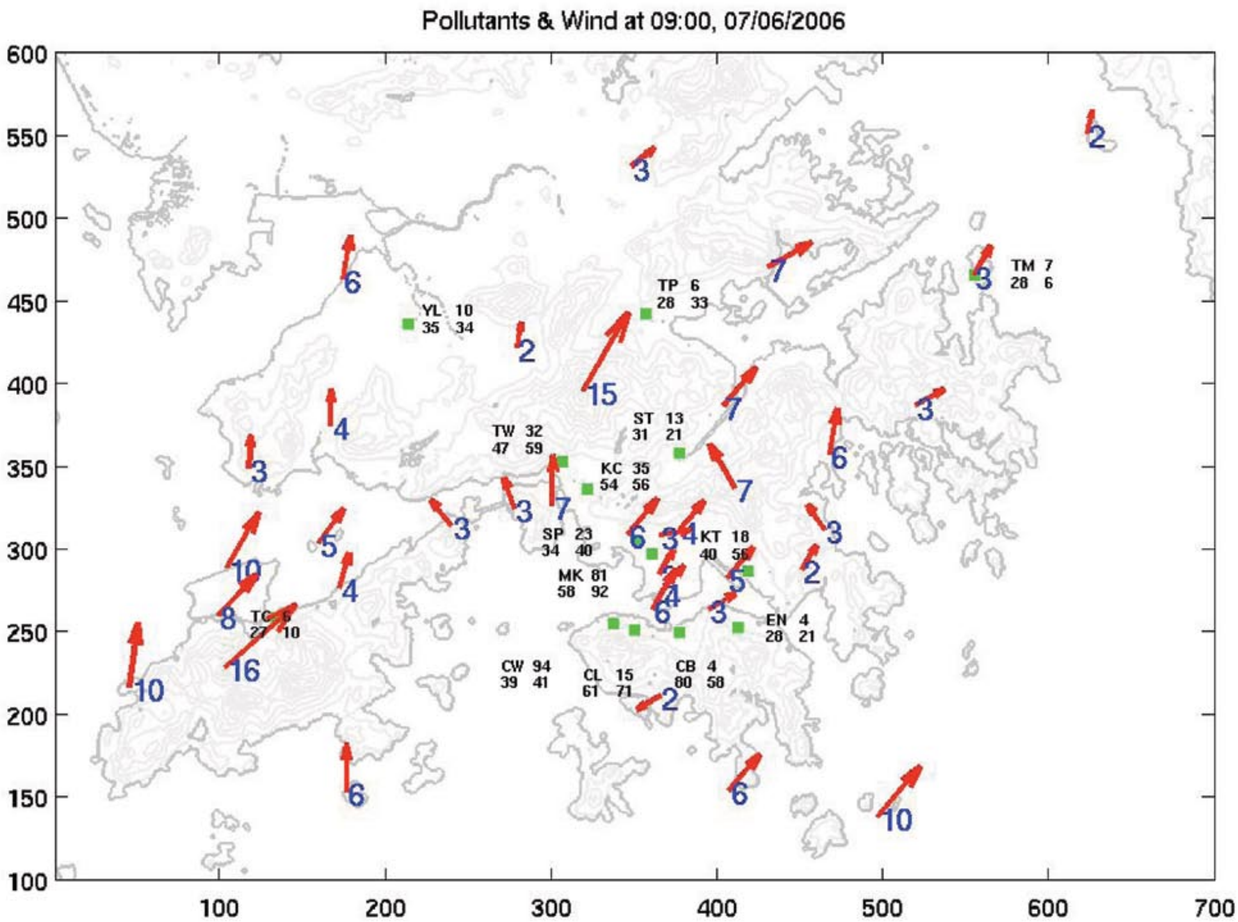

Figure 13: Wind Vector Map during a typical Local Vehicle / Power Plant mode
圖13：本地車輛/電廠污染模式下的風矢圖（例一）

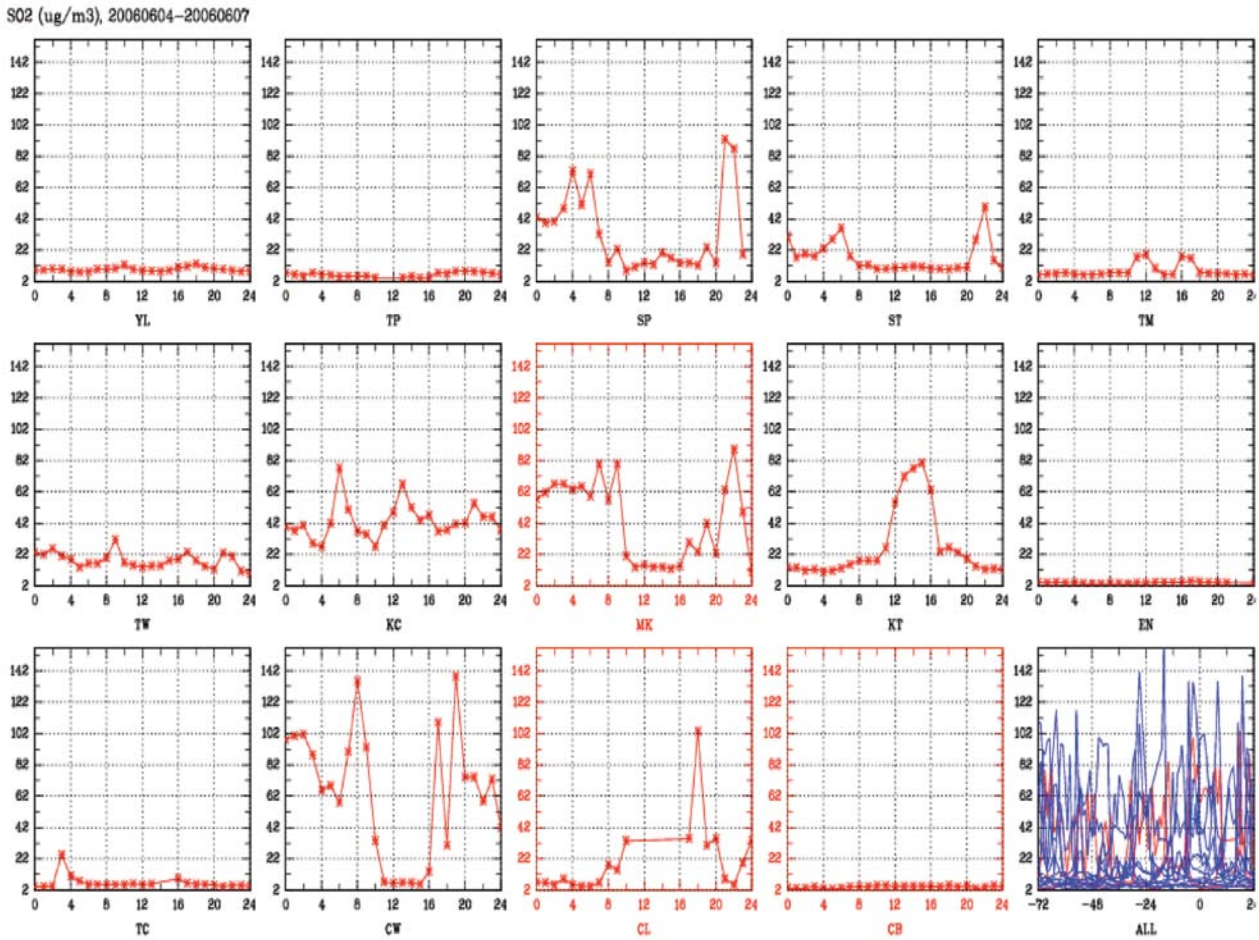

Figure 14: SO_2 levels during a typical Local Vehicle / Power Plant mode
圖14：本地車輛/電廠污染模式下的二氧化硫水平（例一）

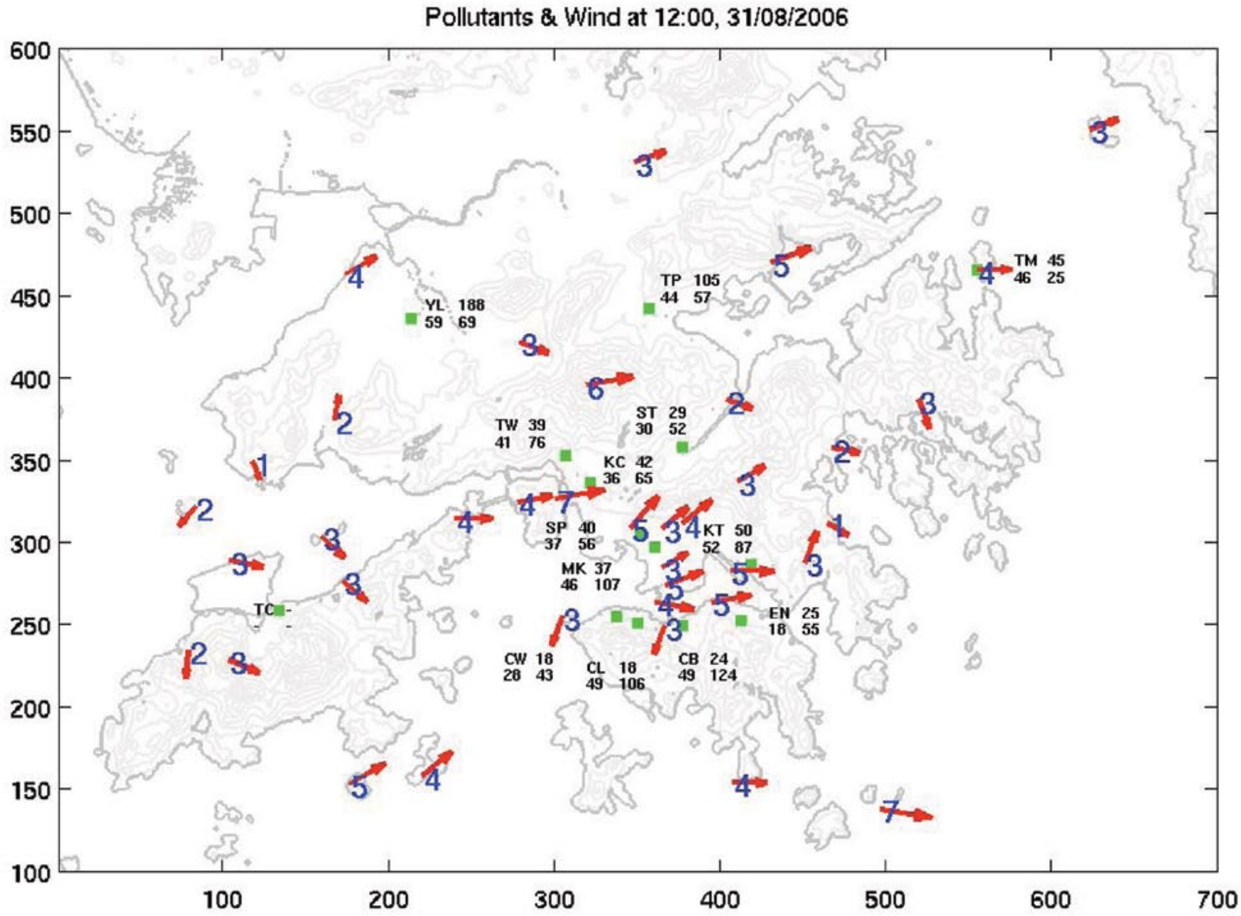

Figure 15: Wind Vector Map during another typical Local Vehicle / Power Plant mode

圖15：本地車輛/電廠污染模式下的風矢圖（例二）

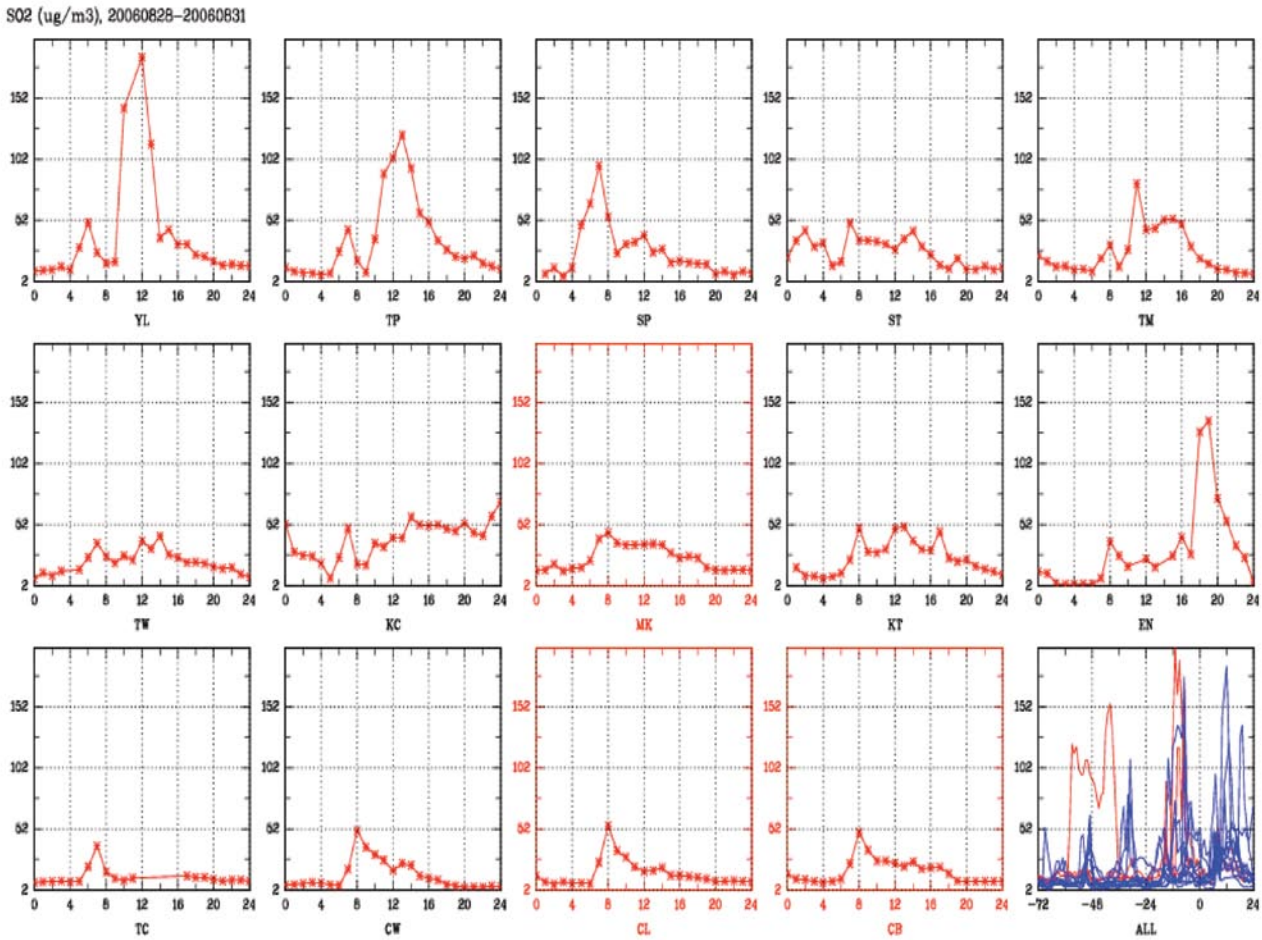

Figure 16: SO_2 levels during another typical Local Vehicle / Power Plant mode
圖16：本地車輛/電廠污染模式下的二氧化硫水平（例二）

Local Vehicle / Marine

This is the other mode dominated by the HKSAR's local sources. As discussed above, vehicular sources play a major role in this mode as well but are partnered by emissions from Hong Kong's marine sector. While much thought has been put into reducing the SO_2 emissions from on-land vehicles, such as the move to ultra-low sulphur diesel and the change of diesel to liquefied petroleum gas LPG taxi, not many regulations have been forced upon marine vessels while they are in Hong Kong's territorial waters and especially terminals and port area. This mode is linked to weak winds from directions other than north or northwest and consistently high SO_2 levels at the monitoring stations near to the city's marine freight handling regions (Lau et al, 2005). Figure 17 shows the wind vector map with generally southerly prevailing conditions and shows low pollution levels at Yuen Long and Tap Mun and elevated levels around Victoria Harbour with consistently high readings at Kwai Chung. This mode was identified as being dominant 121 days of the year or just over 33% of the time.

本地車輛/船舶港口

這是另一個由本地污染源支配的污染模式。如上文所指，車輛污染的影響非常重要，但這個污染模式同時反映出船舶及港口污染的情況。一方面政府投放不少資源減少道路交通的二氧化硫排放量，包括推行使用超低硫柴油以及柴油的士轉換石油氣的士計畫；另一方面，政府卻少有透過法規，管制停泊在香港水域，尤其是在碼頭及港口範圍的船隻的排污情況。本地車輛/船舶港口污染模式與微弱風力有關（西風或西北風除外）。再者，市區內貨物處理區附近的空氣監測站，經常錄得甚高的二氧化硫濃度水平（劉啟漢等人，2005年）。我們可以根據圖17的風矢圖，看到南風的影響，元朗和塔門偏低的污染水平，維多利亞港兩岸偏高的污染情況，以及葵涌長期高企的讀數。我們的分析發現，這個污染模式影響最強的日子共有121日，或相等於全年三分之一左右的時間。

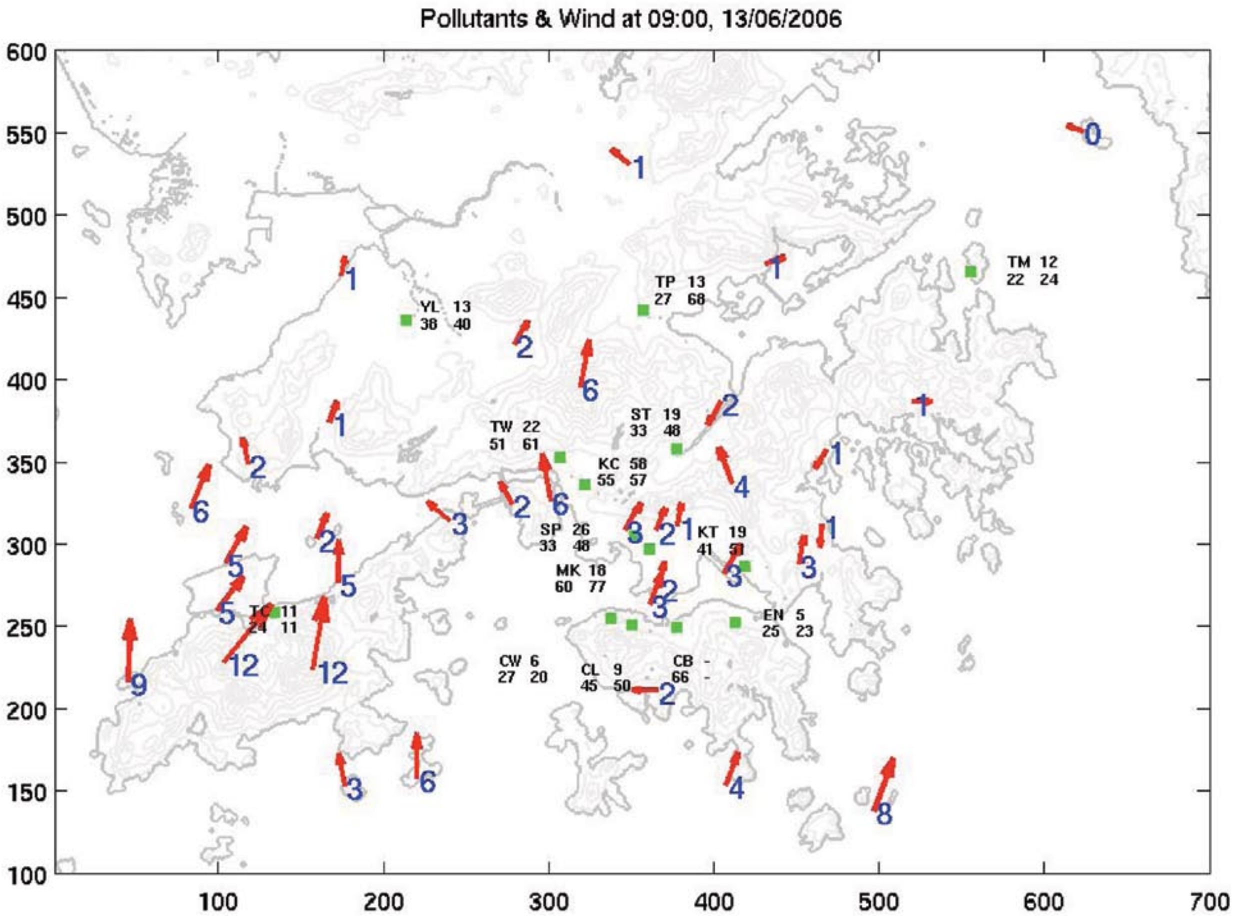

Figure 17: Wind Vector Map during a typical Local Vehicle / Marine mode

圖17：本地車輛/船舶港口污染模式下的風矢圖

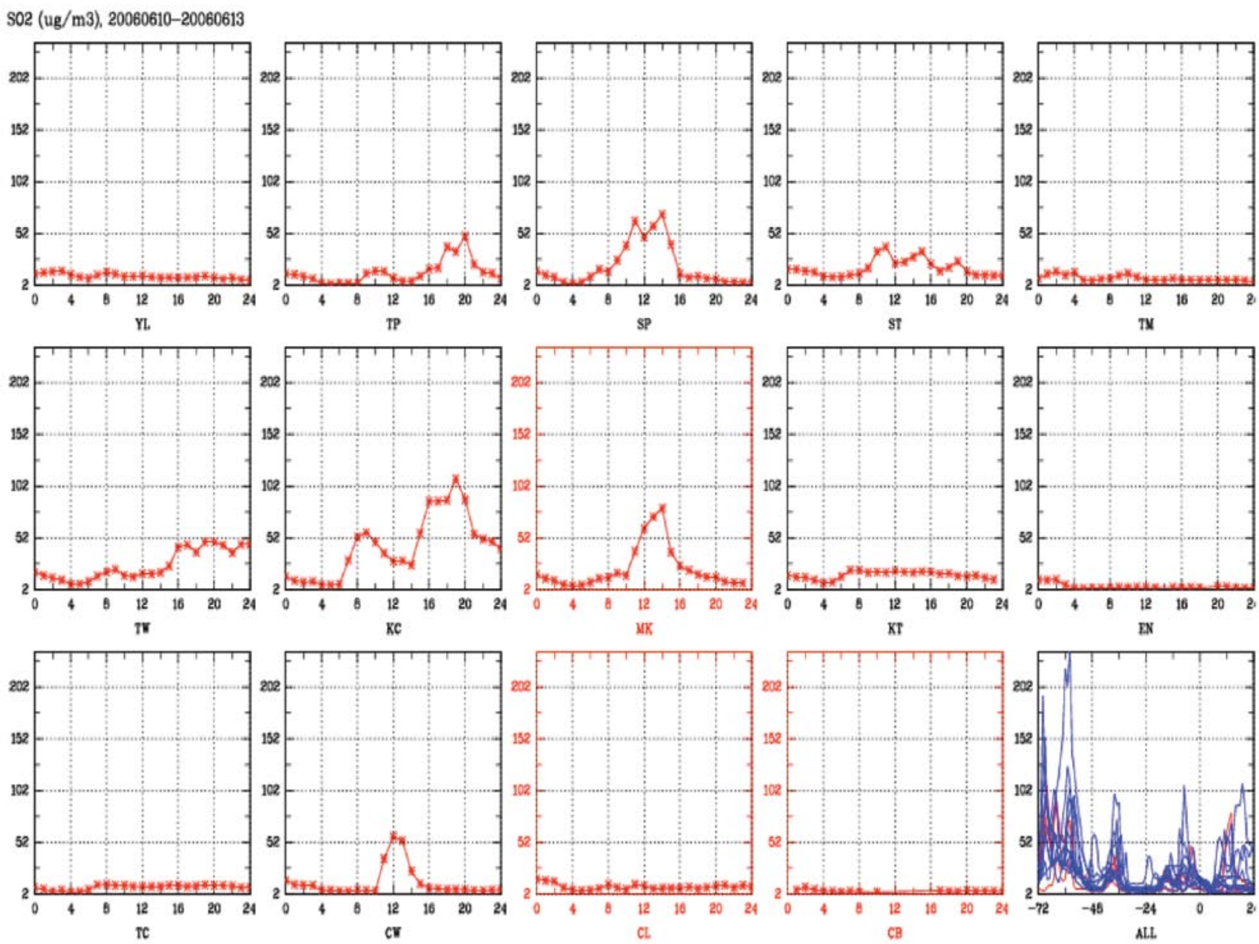

Figure 18: SO_2 levels during a typical Local Vehicle / Marine mode
圖18：本地車輛/船舶港口污染模式下的二氧化硫水平

Low Pollution

This mode is identified as any day where SO_2 levels were low levels across Hong Kong. This mode was used because of the difficultly in identifying dominant sources on days with low pollution levels. The wind over these days is typically stronger, and 41 days of the year or just over 11% of the time was flagged as low pollution days.

低污染

當全港的空氣監測站都同樣錄得低二氧化硫水平，我們便會把這些日子定為低污染模式。這種模式一般用於污染低而又難於辨別主要污染源的日子。一般而言，這些日子的風力十分之強。我們發現在一年當中，有41日或略高於11%的時間是屬於低污染的日子。

香港科技大學環境研究所
INSTITUTE FOR THE ENVIRONMENT
THE HONG KONG UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institute for the Environment
The Hong Kong University of Science and Technology
Clear Water Bay
Kowloon, Hong Kong

Tel: (852) 2358 6901
Fax: (852) 2385 1582

ienv.ust.hk

思匯
CIVIC EXCHANGE

Civic Exchange
Room 701 Hoseinee House
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