Methodology for the creation of meteorological datasets for Local Air Quality modelling at airports

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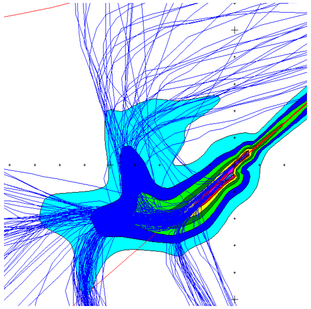
About ENVISA

Noise Studies

ENHANCE

Environmental Impact Assessment of CDA

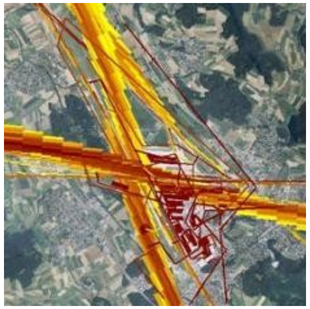


Global Emissions & Local Air Quality

AEM, ALAQS

CAEP Goals Assessment

Environmental Impact of Delays



Economics & Sustainability

Cost Benefit Analyses

Environmental Tradeoffs

Overview of the presentation

1. Data requirements for Local Air Quality studies at airports
2. Three sources of meteorological data
   - Monitored data (METAR)
   - Numerical weather prediction models (WRF)
   - Archived data (Re-Analysis)
3. Methodology to create datasets for Local Air Quality studies
4. Case study: two airports in south-east England

Basic data for dispersion model

- Emission inventory results (time + space)
- Topography
- Chemistry
- Key meteorological data
  - Wind speed and direction (straightforward)
  - Temperature, pressure, humidity (depending on the dispersion model)
  - **Stability** (not directly measured !)

Three ways to obtain meteo data

1. METAR data - from monitoring stations located at airports (generated for aviation purposes, but very suitable for air quality studies)
2. WRF - from numerical weather models (high expertise of meteorology required)
3. Re-Analysis - from long term / large scale archived data

1. METAR Aviation Weather Reports

- from the French "METéorologique Aviation Régulière".
- Routine weather report from airports

PROS	CONS
Very detailed monitoring - most METAR reports in the EU are half-hourly	Available only for airport opening hours (i.e. no data overnight)
Generated by automated sites	Stability must be calculated using other parameters
Usually reviewed by certified weather forecasters prior to being transmitted	Local scale only

1. METAR Weather Components

- Wind speed and direction
- Visibility
- RVR (Runway Visual Range)
- Cloud cover
- Temperature / Dew Point
- QNH (barometric pressure extrapolated to sea level)
- Recent weather
- Wind shear
- Trend

1. METAR Example: CROATIA

- METAR LDDU 171230Z 25008KT 210V310 9999 BKN043 20/04 Q1013 NOSIG
- METAR LDOS 171230Z 29006KT 9999 BKN030 11/05 Q1018 NOSIG
- METAR LDPL 171230Z 13005KT 000V360 9999 FEW055 19/03 Q1018 NOSIG
- METAR LDRI 171230Z VRB02KT 9999 FEW047 19/02 Q1018 NOSIG
- METAR LDSP 171230Z 07006KT 020V130 CAVOK 20/02 Q1015 NOSIG
- METAR LDZD 171230Z VRB06KT 9999 FEW050 20/03 Q1017 NOSIG
- METAR LDZA 171230Z VRB03KT CAVOK 16/02 Q1019 NOSIG

Extracted from NOAA METAR Data Access Web Site:

http://weather.noaa.gov/weather/metar.shtml

1. METAR Example Decoded Part A

- More comprehensively…

ICAO	Station Name	Country	Location	Elevation	Time	Temperature	Dew Point	RH	Wind
LDDU	Dubrovnik-Cilipi	Croatia	42-34N 018-16E	170m	17 / 12:30Z	20.0°C	4.0°C	35%	WSW (250 degrees) at 4 m/s
LDOS	Osijek	Croatia	45-28N 018-49E	89m	17 / 12:30Z	11.0°C	5.0°C	66%	WNW (290 degrees) at 3 m/s
LDPL	Pula	Croatia	44-53N 013-55E	63m	17 / 12:30Z	19.0°C	3.0°C	35%	SE (130 degrees) at 3 m/s
LDRI	Rijeka/Omisalj	Croatia	45-13N 014-34E	85m	17 / 12:30Z	19.0°C	2.0°C	32%	Variable at 1 m/s
LDSP	Split/Kastel Sta	Croatia	43-31N 016-18E	21m	17 / 12:30Z	20.0°C	2.0°C	30%	ENE (70 degrees) at 3 m/s
LDZD	Zadar/Zemunik	Croatia	44-06N 015-22E	84m	17 / 12:30Z	20.0°C	3.0°C	32%	Variable at 3 m/s
LDZA	Zagreb/Pleso	Croatia	45-43N 016-04E	110m	17 / 12:30Z	16.0°C	2.0°C	39%	Variable at 2 m/s

1. METAR Example Decoded Part B

ICAO	Station Name	Country	Visibility	Pressure	Sky Condition	Weather	Remarks	Heat Index	Wind Chill
LDDU	Dubrovnik-Cilipi	Croatia	> 10000m	1012.9 mb	Broken clouds at 1300m			N/A	N/A
LDOS	Osijek	Croatia	> 10000m	1017.9 mb	Broken clouds at 910m			N/A	N/A
LDPL	Pula	Croatia	> 10000m	1017.9 mb	Few clouds at 1700m			N/A	N/A
LDRI	Rijeka/Omisalj	Croatia	> 10000m	1017.9 mb	Few clouds at 1400m			N/A	N/A
LDSP	Split/Kastel Sta	Croatia	> 10000m	1014.9 mb				N/A	N/A
LDZD	Zadar/Zemunik	Croatia	> 10000m	1016.9 mb	Few clouds at 1500m			N/A	N/A
LDZA	Zagreb/Pleso	Croatia	> 10000m	1019.0 mb				N/A	N/A

Deriving stability from observed data

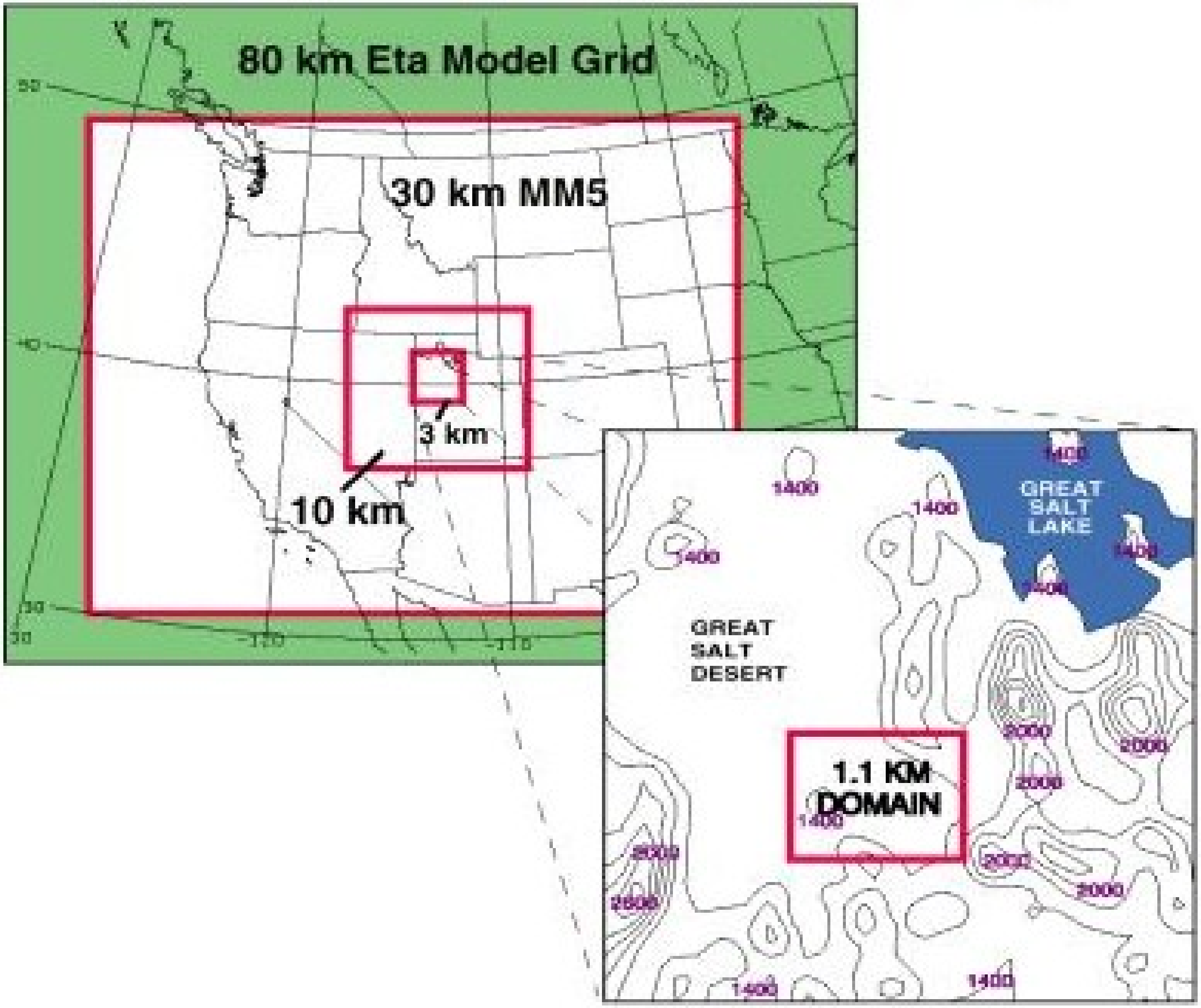
- Stability is generally not monitored, so it must be derived from other observed parameters
- Stability is based on the "Turner method" which is recommended by the US Environmental Protection Agency
- The Pasquill-Gifford stability classes (A 'very unstable' to G 'very stable') are calculated based on the following variables:
  - wind speed
  - cloud cover (sky condition)
  - sun angle (time of day, latitude of airport)

2. MM5 Weather Model

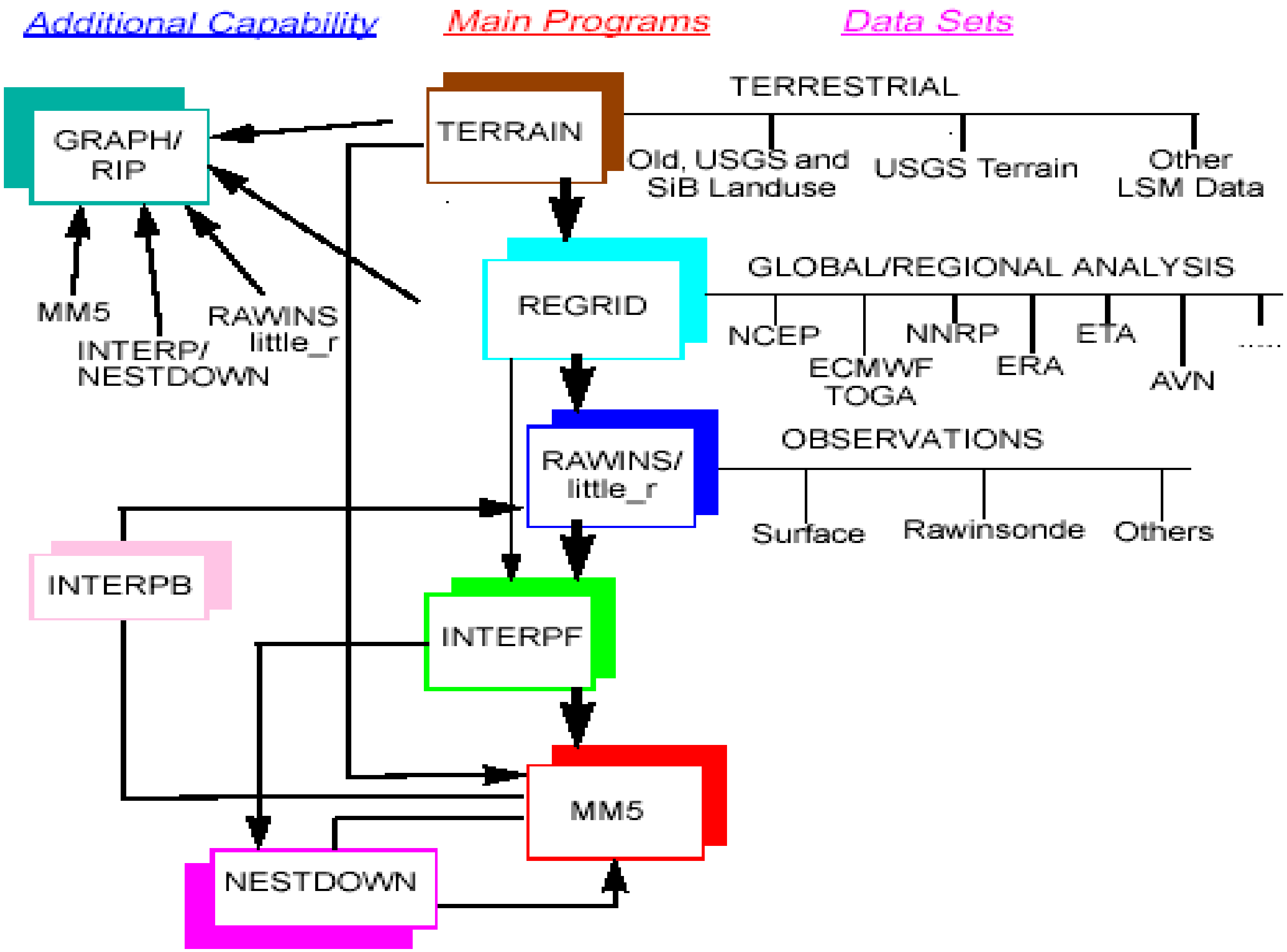
- Meso-scale numerical weather prediction model
- From the US National Center for Atmospheric Research
- Free community model used by over 400 institutions in 30 countries

PROS	CONS
Used for weather prediction and weather data collection	Needs a high level of expertise in meteorology
Very accurate data on a very fine spatial and temporal grid	High computing time
Data available in 3D gridded format for sophisticated models	Complex input data (terrain, meteo) + format
Stability explicitly available	

MM5 Domain Configuration



The MM5 Modeling System Flow Chart



2. Mandatory MM5 Input Requirements

- **Gridded** 2D fields (surface data): sea-level pressure, sea-surface temperature, snow cover, sea ice cover, soil temperature, soil moisture

- **Gridded** 3D fields (upper air data): temperature, wind speed and direction, pressure, relative humidity, etc.

Note: Can Use NCEP/NCAR REANALYSIS 2 DATA SET

2. Observational Data for MM5

- **Optional** data
- Upper air observations: pressure, height, temperature, humidity, wind speed and direction (e.g. balloons and aircraft)
- Surface observations: winds, cloud cover, precipitation, maximum and minimum temperature (e.g. airports, weather stations, ships, buoys)

Note: can use METAR for surface data

2. MM5 Model Output: 2D Fields

- Cloud ceiling
- Accumulated precipitation
- Planetary boundary layer height
- Surface evaporation
- Soil moisture/temperature
- Surface/underground runoff
- Snow depth
- Surface roughness/friction
- Flight regulation (VFR, MVFR, IFR, LIFR) via post-processor
- Etc.

There are hundreds of fields available !

2. MM5 Model Output: 3D Fields

- Wind speed and direction
- Vertical wind shear
- Temperature
- Relative humidity
- Pressure
- Cloud/rain/snow/ice water content
- Radiation fluxes
- Clear air turbulence via post-processor
- Etc.

There are hundreds of fields available !

2. WRF Weather Model (New MM5)

- “Weather Research and Forecasting”
- Co-developed by research and operational communities
  - ARW core “Advanced Research WRF”
  - NMM core “Nonhydrostatic Mesoscale Model”
- Supersedes MM5
- Freely available

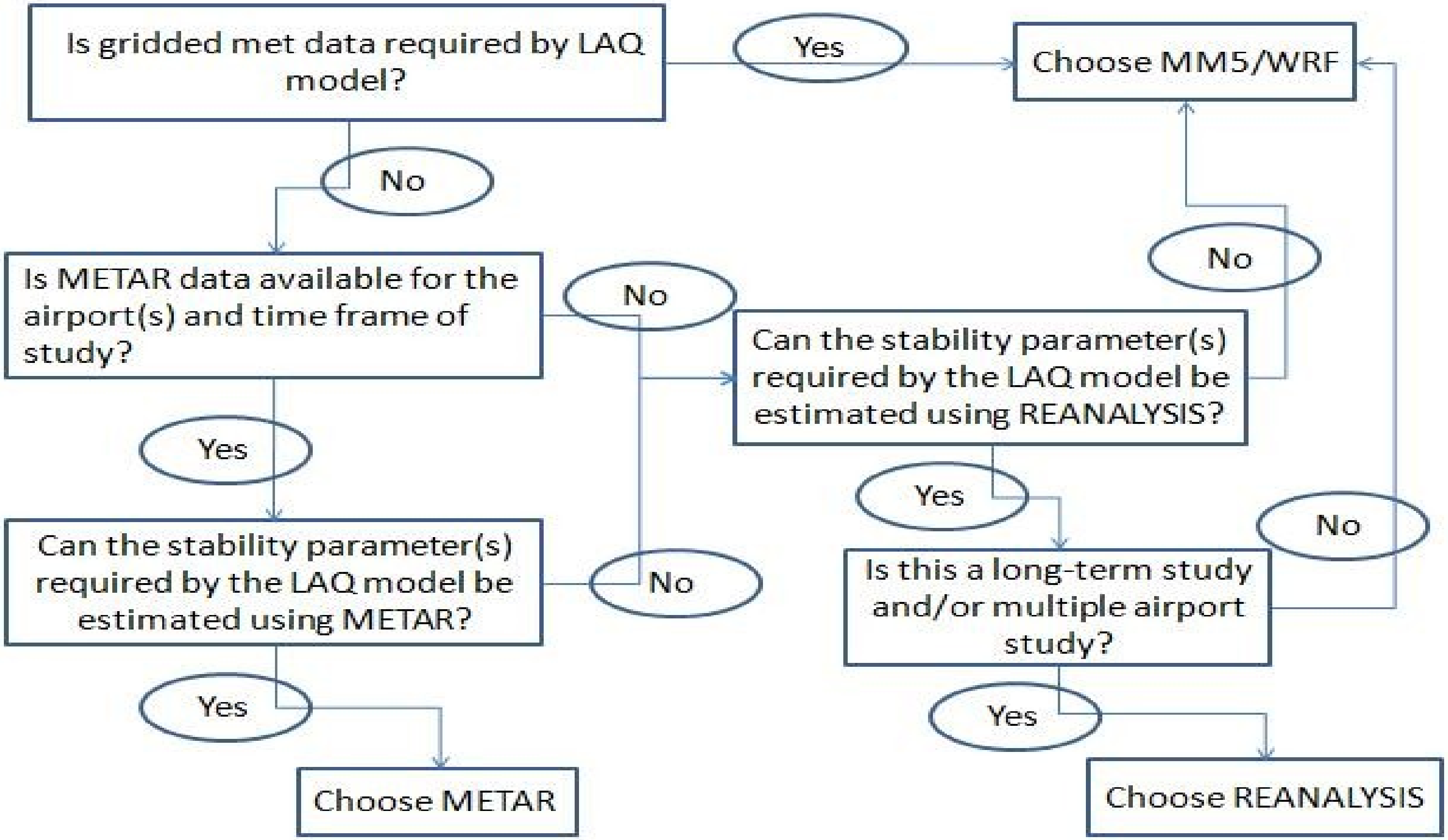
3. Re-Analysis data

- From two US National Centers:
  - for Environmental Prediction NCEP
  - for Atmospheric Research NCAR
- Analysis / forecast system prepares re-analysis data
- Over 80 different variables (temperature, relative humidity, U and V wind components, etc.)
- 17 pressure levels (heights)
- 2.5 x 2.5 degree grids, 4 times daily
- Diagnostic terms (radiative heating, convective heating, etc.) and accumulative variables (precipitation rate, etc.)

3. Re-Analysis data

PROS	CONS
Data available since 1948	Fixed spatial and temporal resolution . Data must be interpolated to be used in dispersion models.
Great set of information available (80 different variables)	Very coarse resolution (2.5 x 2.5 degree grid, 4 times a day)
Large datasets can be extracted quickly	Stability must be calculated based on other parameters
"Good guess" meteo data	

Method to choose meteo data source

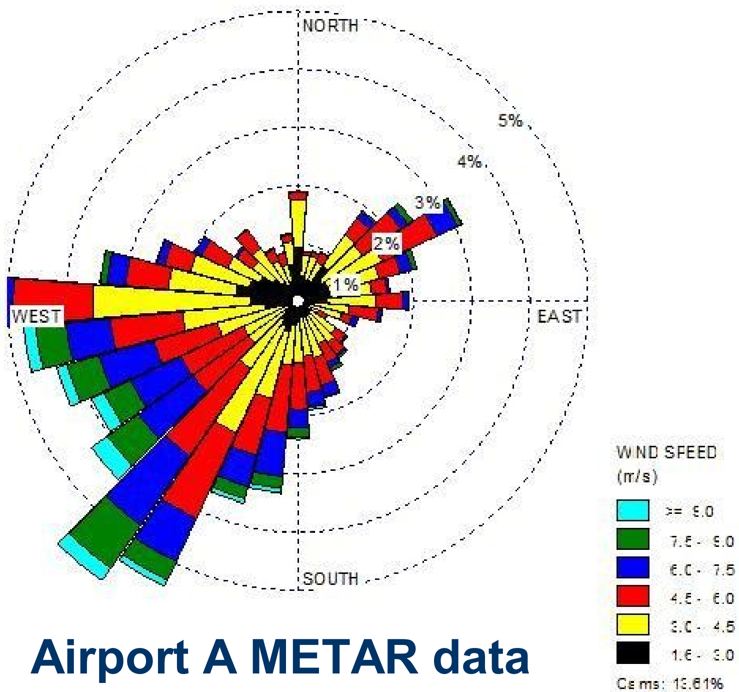


Case study at two airports

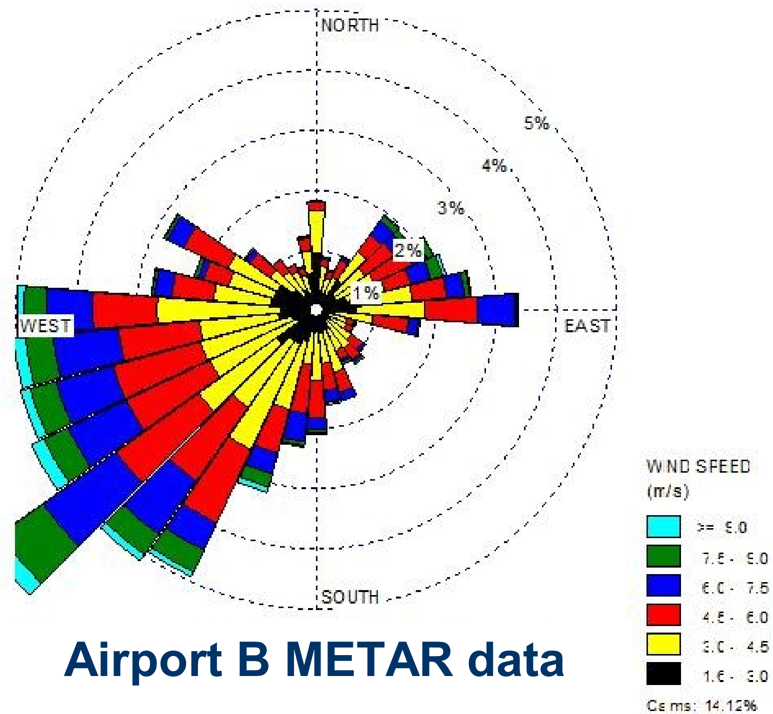
- Two airports in the same region: south-east England
- Distance between airports ~20 km
- For both airports, METAR data was available from the airport weather station
  - At airport A, reports were issued every 30 minutes
  - At airport B, reports were issued every hour but **only for day-time**

Approach followed (1)

Comparison of meteo data at airport A and airport B for common open hours for wind speed, direction and calculated stability.



Airport A METAR data

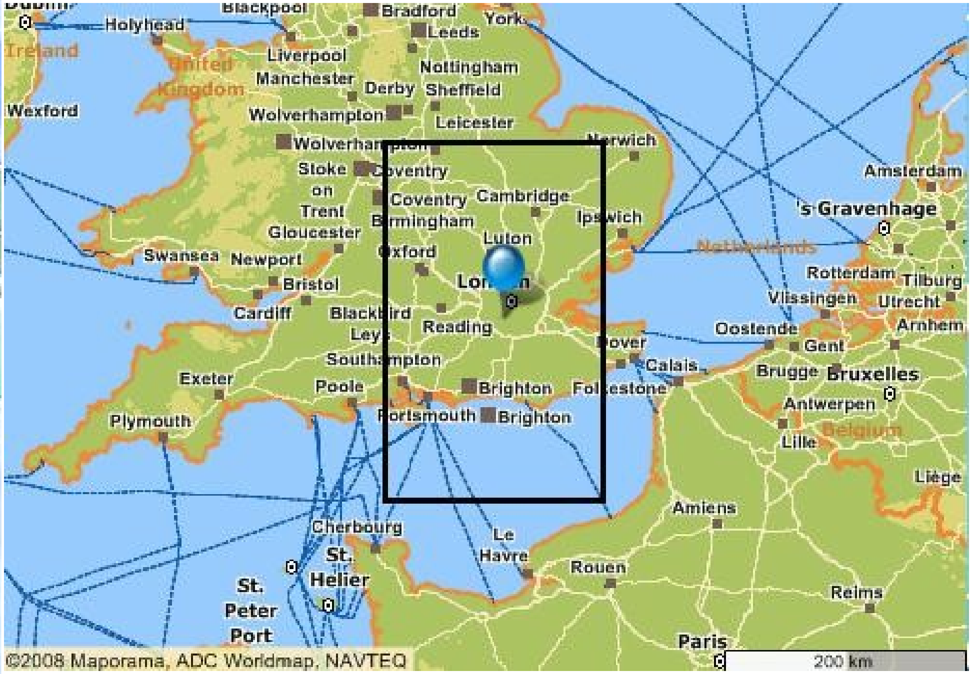


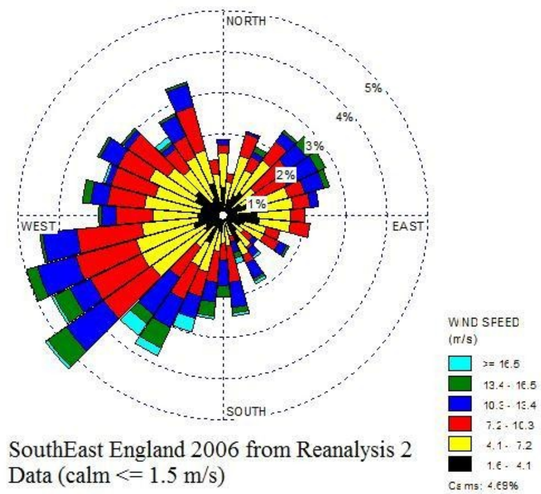
Airport B METAR data

Approach followed (2)

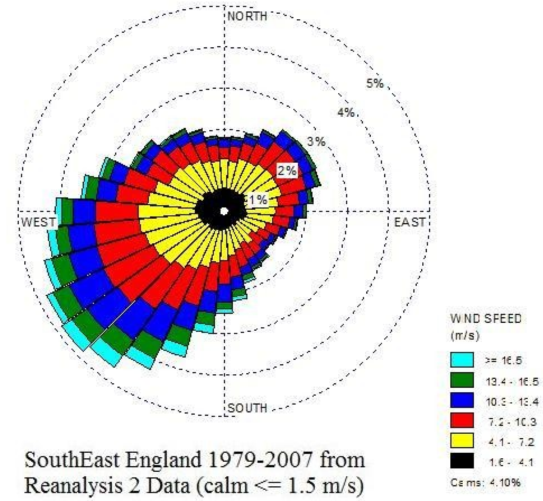
- Since differences in wind speed, in direction frequencies and in stability classes were small, it was decided to use the METAR data from airport A to estimate the meteo at airport B during the missing hours
- This was also valid because the two airports were fairly close to each other

Re-analysis data for S-E England





SouthEast England 2006 from Reanalysis 2 Data (calm <= 1.5 m/s)



SouthEast England 1979-2007 from Reanalysis 2 Data (calm <= 1.5 m/s)

Re-analysis data

- Was also used to validate the results of the local air quality studies for policy usage
- Trends of the period 1979-2007 were compared with the year 2006 only
- The results showed that 2006 could be considered as a "standard year" because no particular extreme weather event suggest it was abnormal
- Therefore, the dispersion results (i.e. concentrations) were considered to be "standard" (from the met. point of view)

Conclusion

1. Detailed monitored data (METAR) should be preferred for airport air quality studies
2. If no METAR reports exist at one airport, then airports in the surrounding area should be investigated
3. Otherwise, use data from Numerical Weather Prediction models (or in the worst case, Re-analysis data)
4. Re-analysis data is best used to validate that the meteorological conditions of the dispersion period are not exceptional

Web references

METAR Data Access Web Site:
http://weather.noaa.gov/weather/metar.shtml

Turner Method:
http://www.webmet.com/met_monitoring/641.html

MM5 model:
http://www.mmm.ucar.edu/mm5/

WRF model:
http://www.wrf-model.org/index.php

NCEP/NCAR Re-Analysis:
http://www.cdc.noaa.gov/cdc/data.ncep.reanalysis2.html

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Thank you for your attention!

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