How can non-exhaust motorsports events improve urban air quality with hyper-local monitoring?

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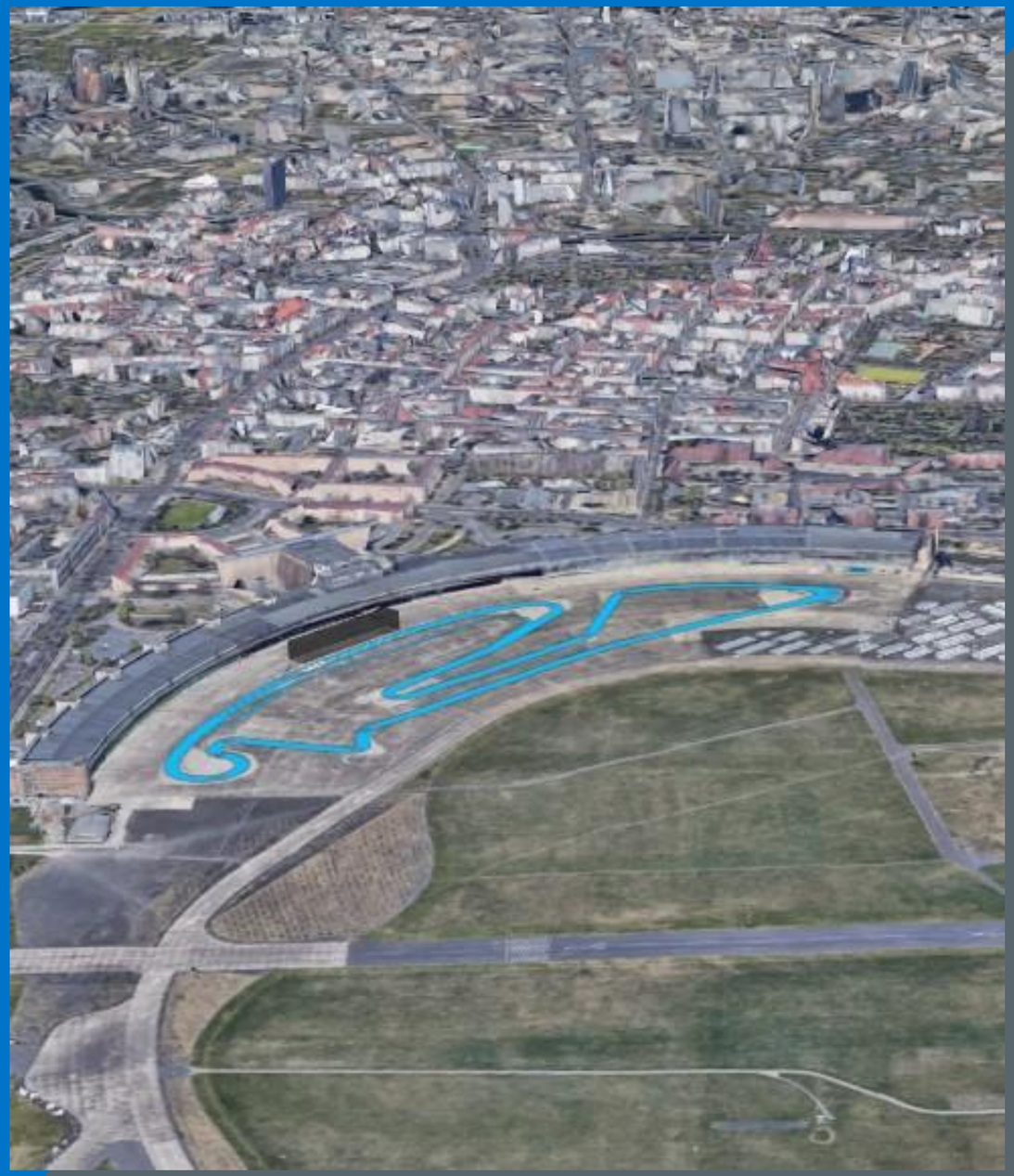
PART 1.

Getting started



FORMULA-E Introduction

#BeatAirPollution

ABB FORMULA E
FIA WORLD CHAMPIONSHIP

Formula E exists to promote the adoption of electric mobility and alternative energy solutions to help reduce air pollution and fight climate change.

ELECTRIC

EVERY CAR, TRUCK, BOAT, TRAIN AND PLANE IS ELECTRIC

CLEAN

CELLS CHARGED USING RENEWABLE ENERGY SOURCES

CONNECTED

SAFER ROADS WITH DATA SHARING BETWEEN CARS

SHARED

CAR SHARING FLEETS AND COLLEAGUES TRAVELLING TOGETHER

AUTONOMOUS

SELF-DRIVING CARS PROMOTING PRODUCTIVITY

The event

Location

Berlin (Germany)
11-15 August 2021

Berlin Tempelhof Airport

Methodology & Approach

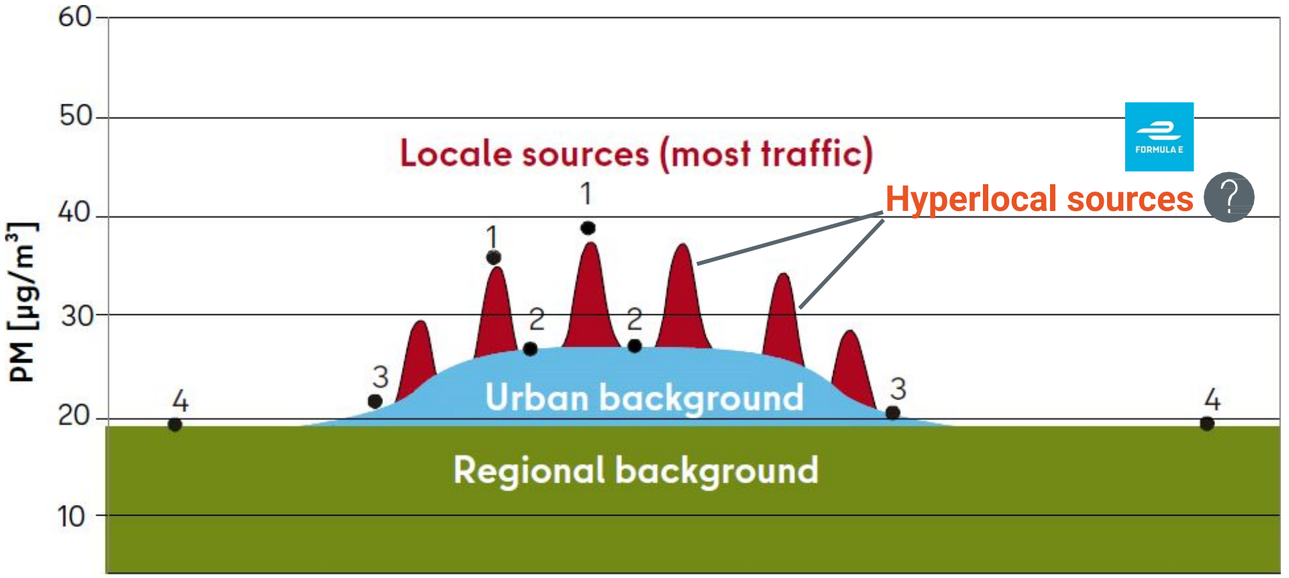


Figure 5.1: Schematic diagram of the distribution of ambient air pollution in Berlin and the surrounding area by region of origin, using the example of particulate matter PM

- What is the impact of the event on the local conditions? Was there an event increment caused by Berlin E-Prix?
- What are the transboundary, regional, city and street emission sources (under control of the organization and outside the control) incrementing the air pollution?
- What's the personal exposure of the sensitive receptors (visitors, staff, pilots)?

Methodology & Approach

Sensitive Receptors

- **VISITORS**
- **STAFF**
- **TEAMS & PILOTS**

Parameters

- **Conventional pollutants** (PM_1, $PM_{2.5}$, PM_{10}, NO_2, NO, CO, O_3)
- **Emerging parameters** (Total VOCs and diesel/black carbon)
- **Meteorological:** Temperature, Humidity, WBGT

Monitoring Goals

- Measure outdoor air quality **before, during and after the** event
- **Compare results** with national and international air quality standards.
- Identify the major **air pollution sources**.

Best Fit monitoring approach

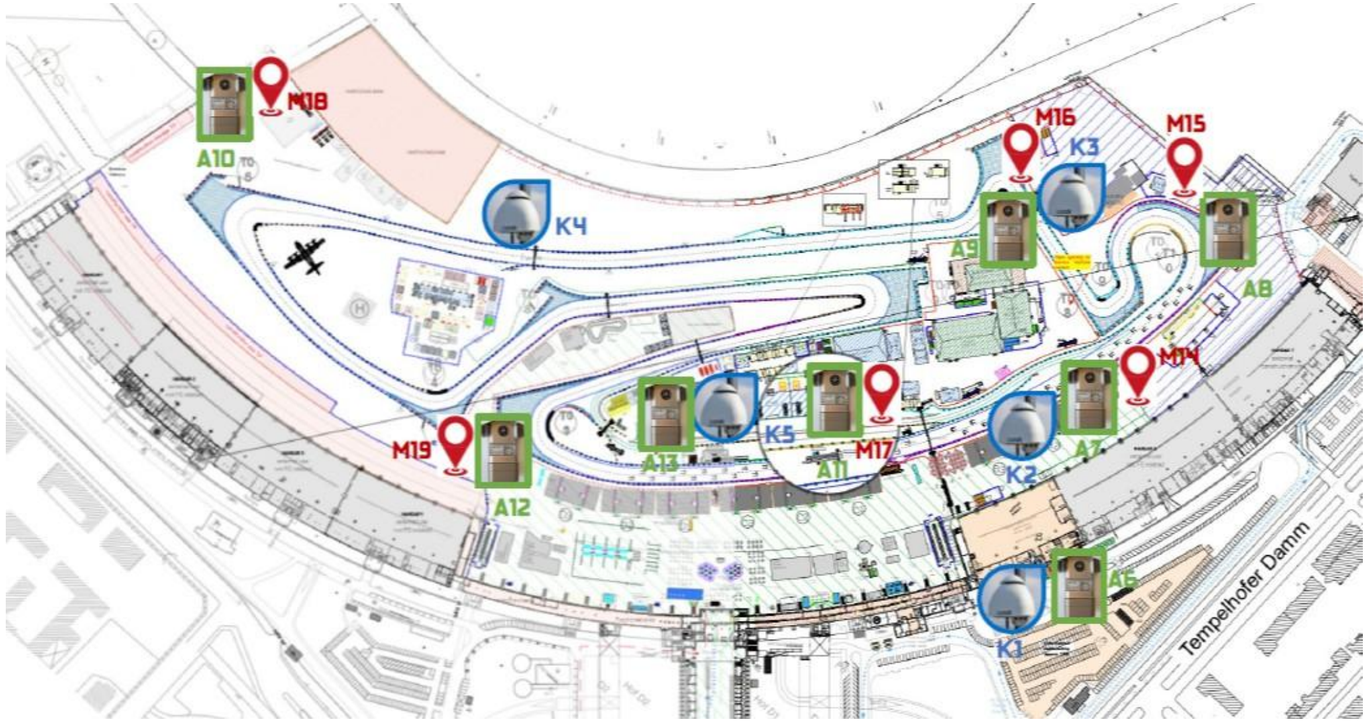
- Dense, distributed stationary **hybrid network**.
- **Mobile monitoring** to identify unknown or suspected emission sources (hotspots)

PART 2.

Planning & Delivering

Designing an hyper-local Air Quality network

28 data sources
131 sensors
50,000 datapoints



Reference Stations: Berlin Air Quality Monitoring Network

Kunak Air: 5 sensor-systems + solar panel + anemometer

Airly devices: 8 sensor-systems + main network power mode

Sentinel 5P satellite images

Identifying hyper-local sources

Traffic (NOx/PMs)

HOW DO I GET TO THE BERLIN E-PRIX AT TEMPELHOF AIRPORT?

As there are no parking spaces available and also in terms of sustainability, it is recommended to arrive by bike or to use the public transport: Underground line U6 / 'Platz der Luftbrücke' or bus line 104 and 248 or S-Bahn station

Fuel based generators (NOx/PMs)

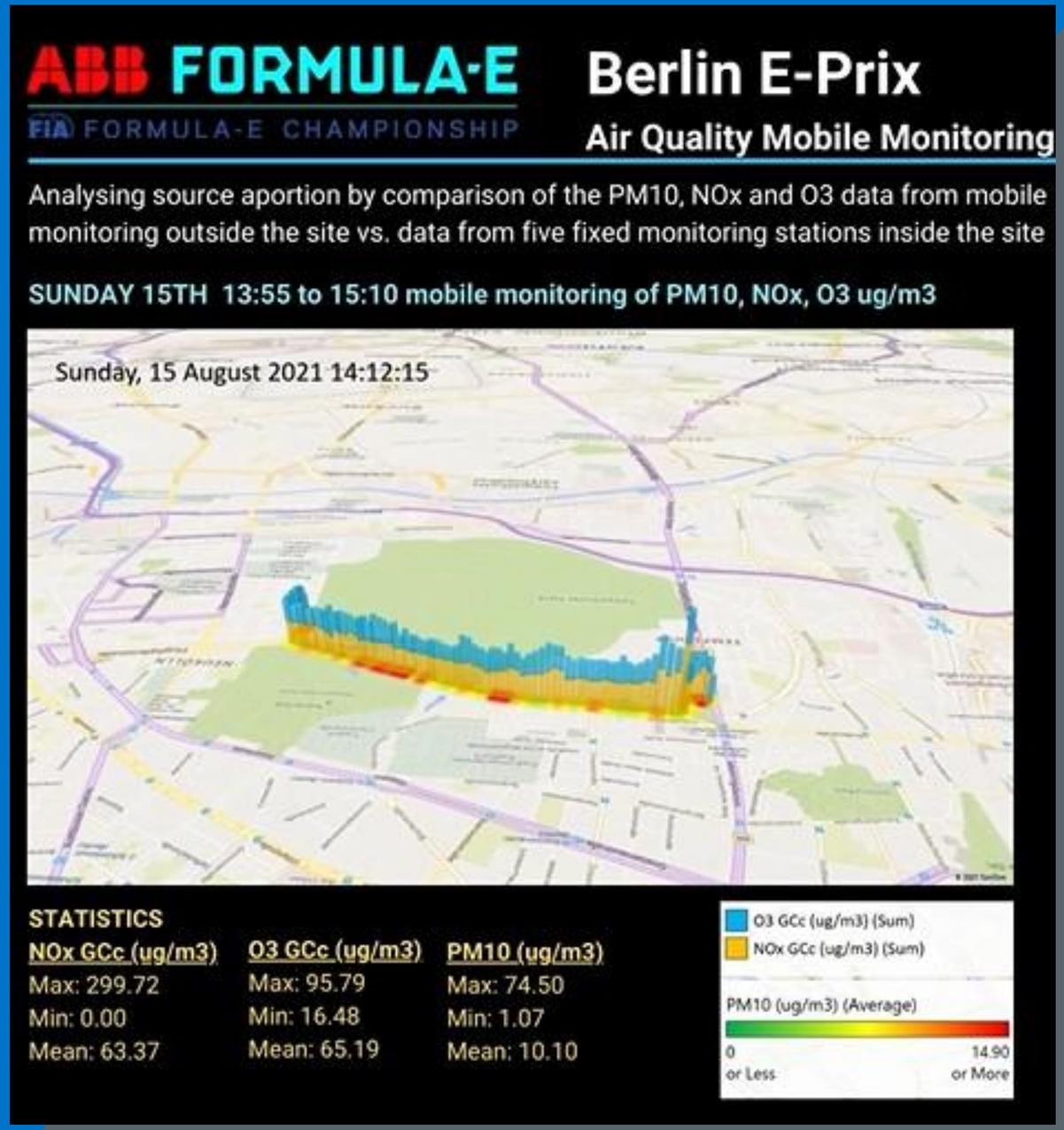
Overlay vehicles (NOx/PMs)

Garages (VOCs)

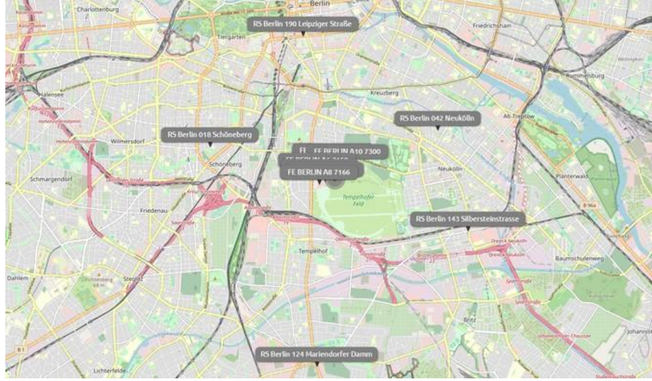
Abrasion/resuspension (PMs)

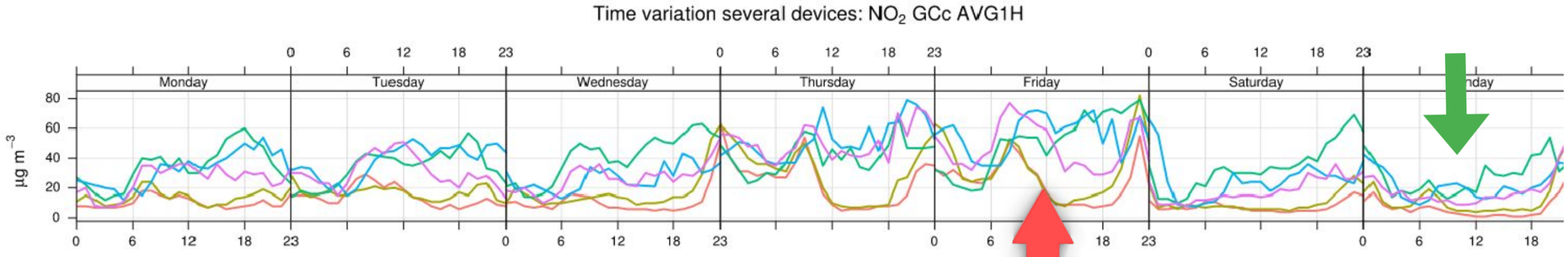
PART 3.

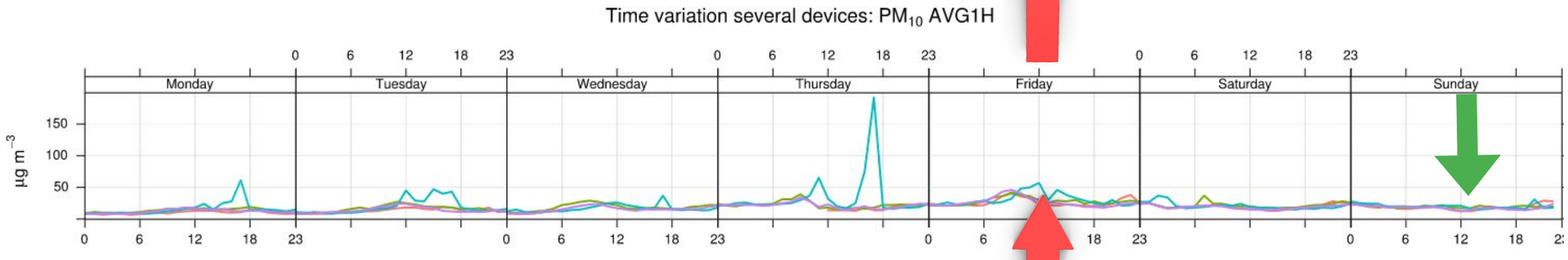
Making sense of the data

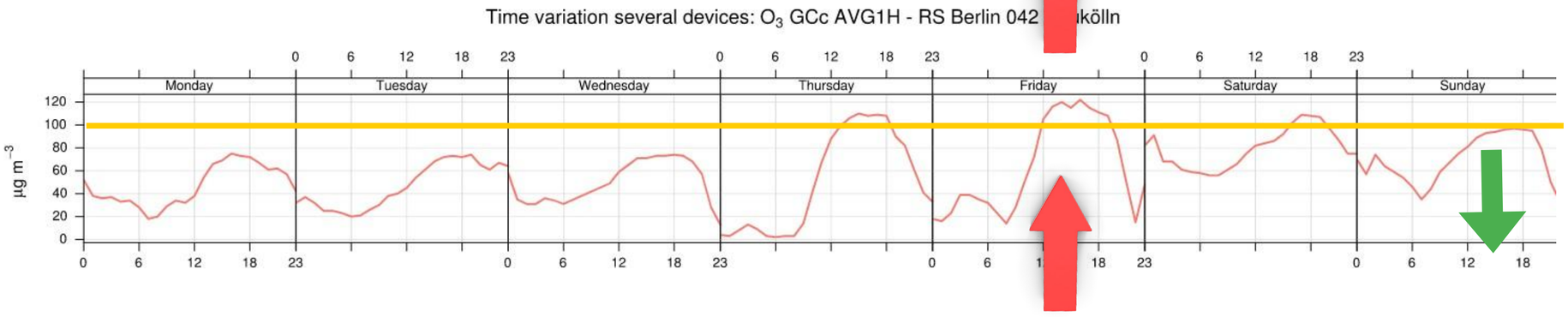


Looking temporal trends of RS network



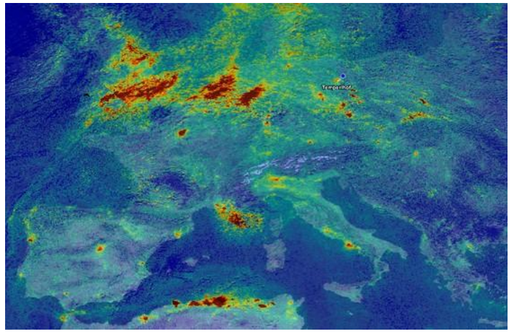
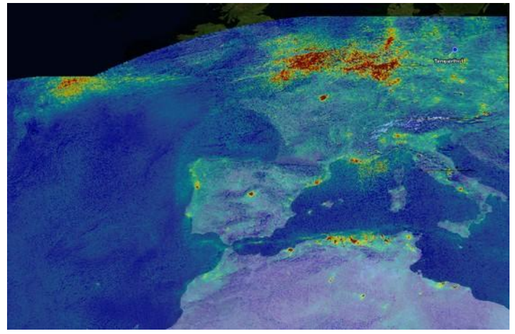
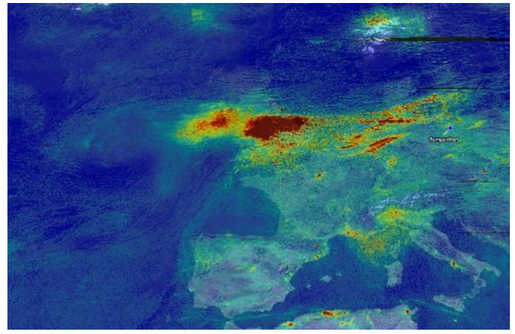
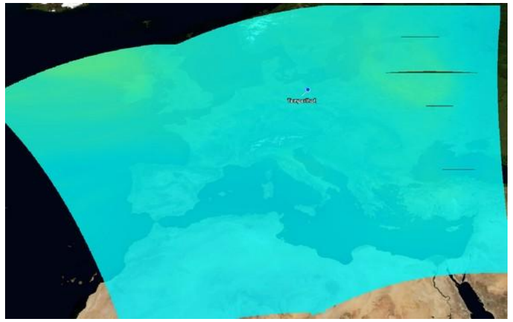
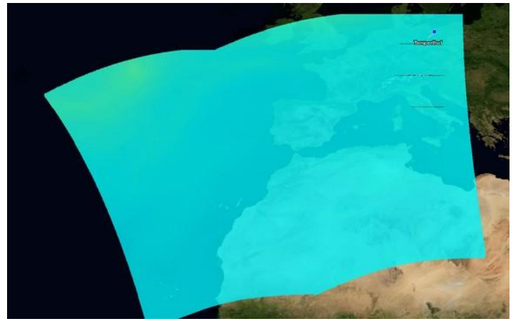
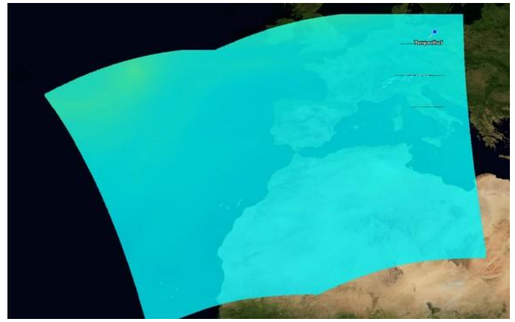
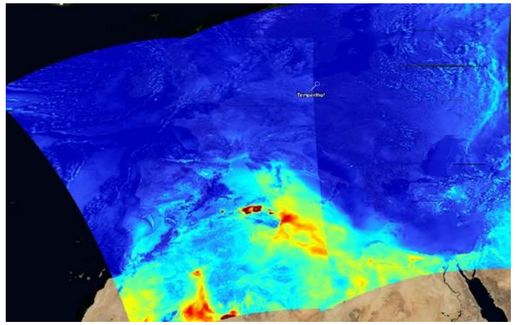
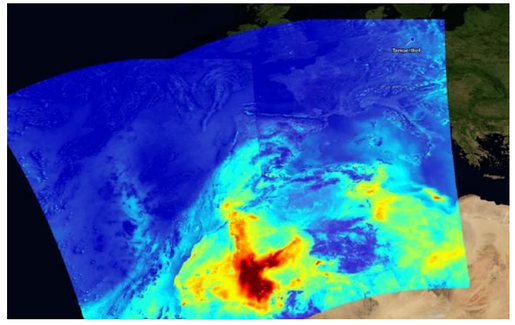
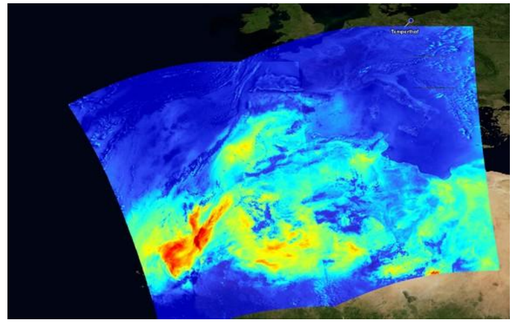






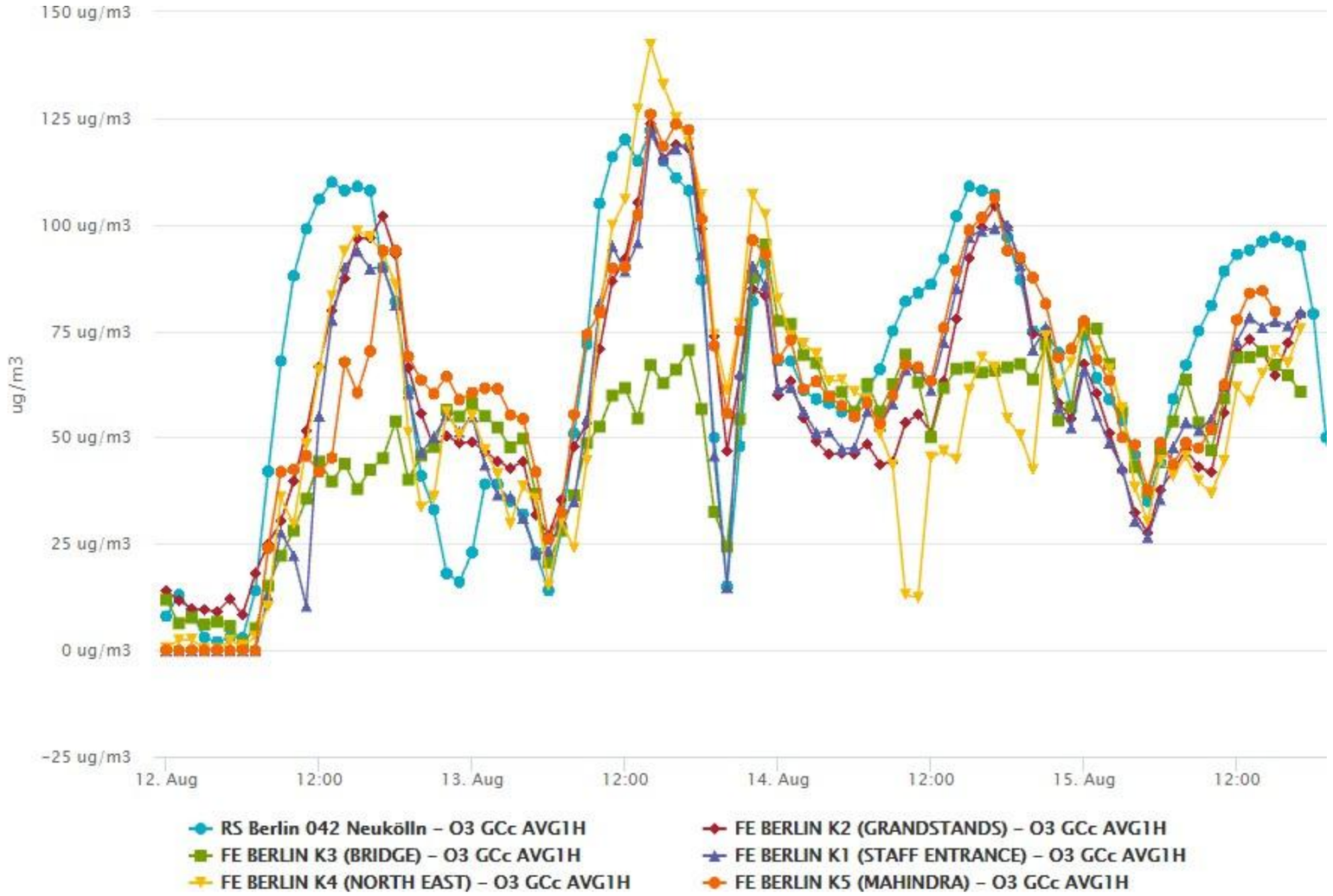
O_3 WHO Limit Value

Looking at satellite data - SENTINEL 5P

	12th August	13th August	14th August
NO2			
O3			
Aerosols			

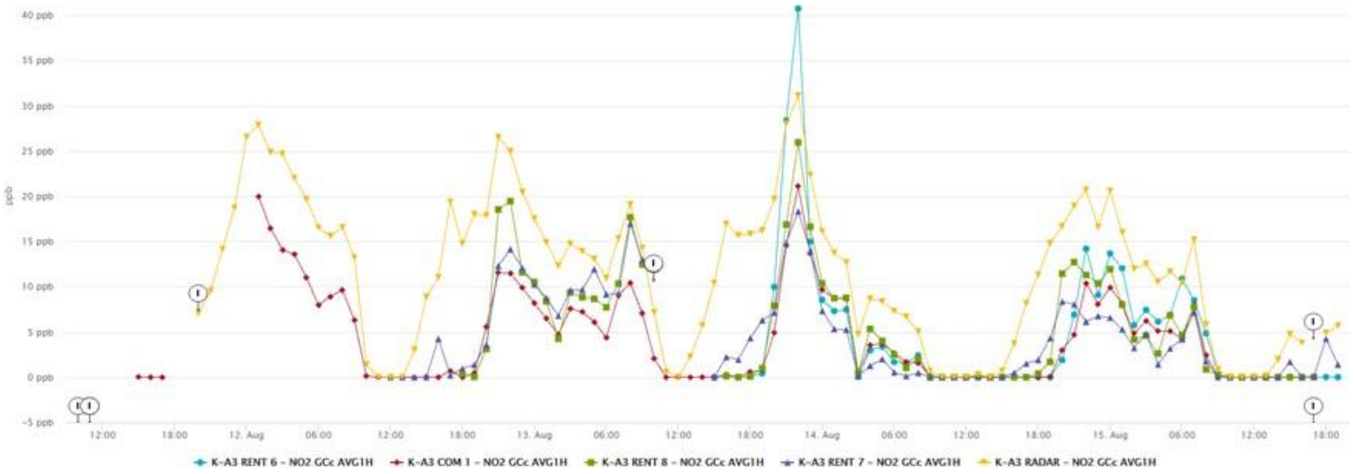
QA&QC of sensor-based AQ stations

Using Ozone for accuracy test: Kunak vs. Reference Station

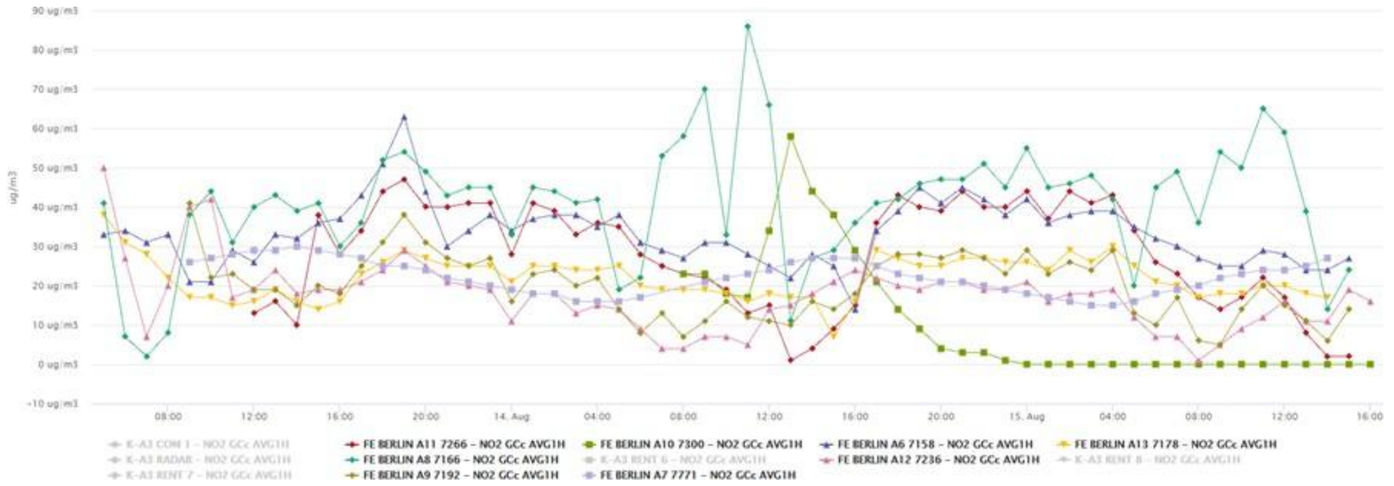


QA&QC of sensor-based AQ stations

Looking at Kunak NO2 vs. Airly NO2



- Factory calibrated against reference standards
- Remote baseline correction
- Clear NO_2 urban trends



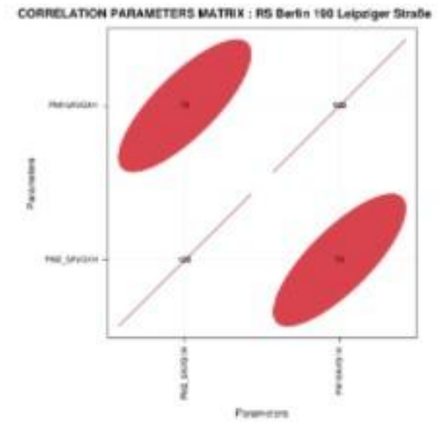
- Machine Learning Calibration *in situ*
- No clear trends...

but emission sources identification

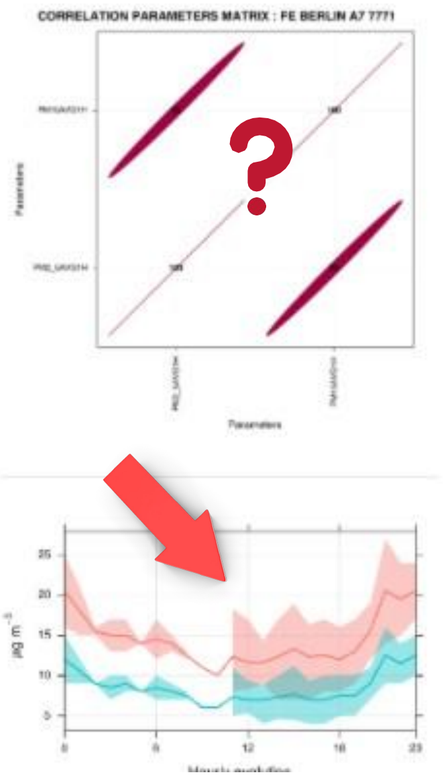
QA&QC of sensor-based AQ stations

Looking into $PM_{2.5}$ and PM_{10} size distribution

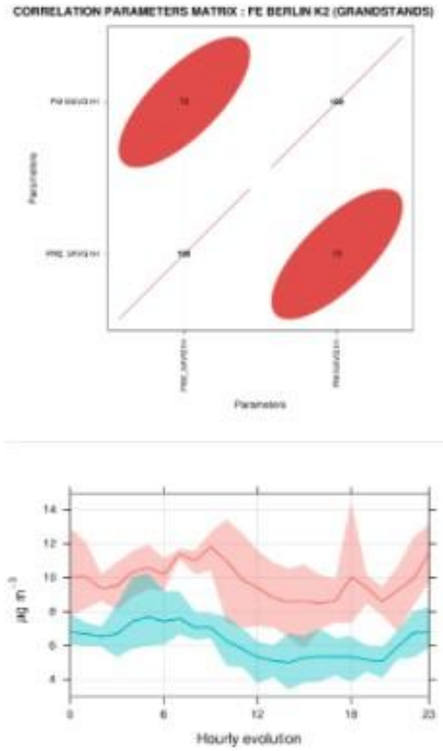
Berlin RS



Airly



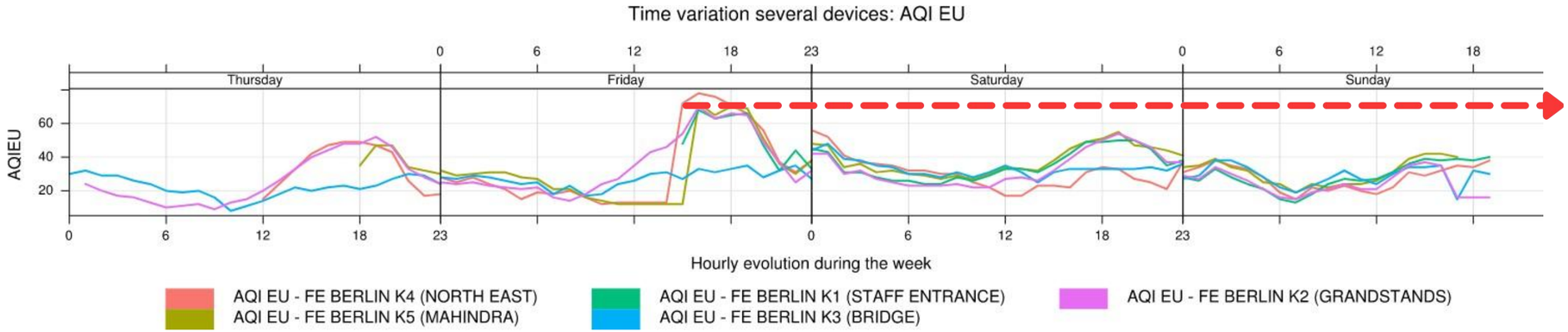
Kunak AIR



- The distribution of $PM_{2.5}$ and PM_{10} values are correlated to some extent…
  but should not be so near 100%.
- This might imply that the values for PM_{10} are estimated but not measured.

Comparison with international standards

Looking into European AQI values

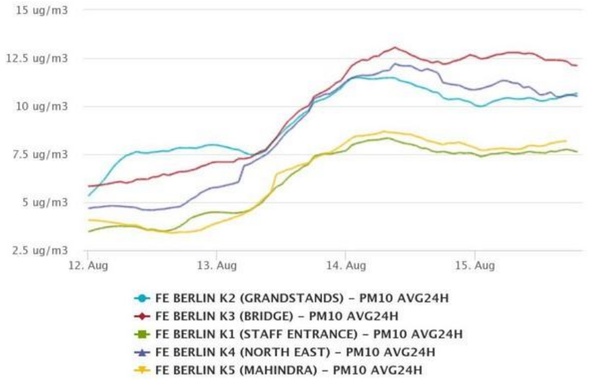


EXTREMELY POOR 126 - 200	May cause respiratory issues in healthy people, and serious health issues in people with lung/heart disease.
VERY POOR 101 - 125	The pollution level has reached a critical level. Even healthy people may show symptoms for short exposures.
POOR 76-100	Effects can be immediately felt by individuals at risk. Everybody feels the effects of prolonged exposure.
MODERATE 51-75	The air has reached a high level of pollution. Higher than the maximum limit for 24 hours established by WHO.
FAIR 26-50	The air is moderately polluted. A long-term exposure constitutes a health risk.
GOOD 0-25	The air is pure, ideal for outdoor activities.

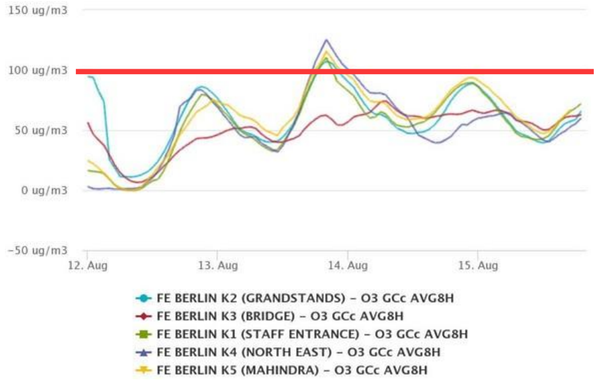
European and WHO standards

$PM_{2.5}$ 24h average
(WHO limit=25ug/m^3)

PM_{10} 24h Average
(WHO limit=50ug/m^3)



O_3 8h Average
(WHO limit=100ug/m^3)



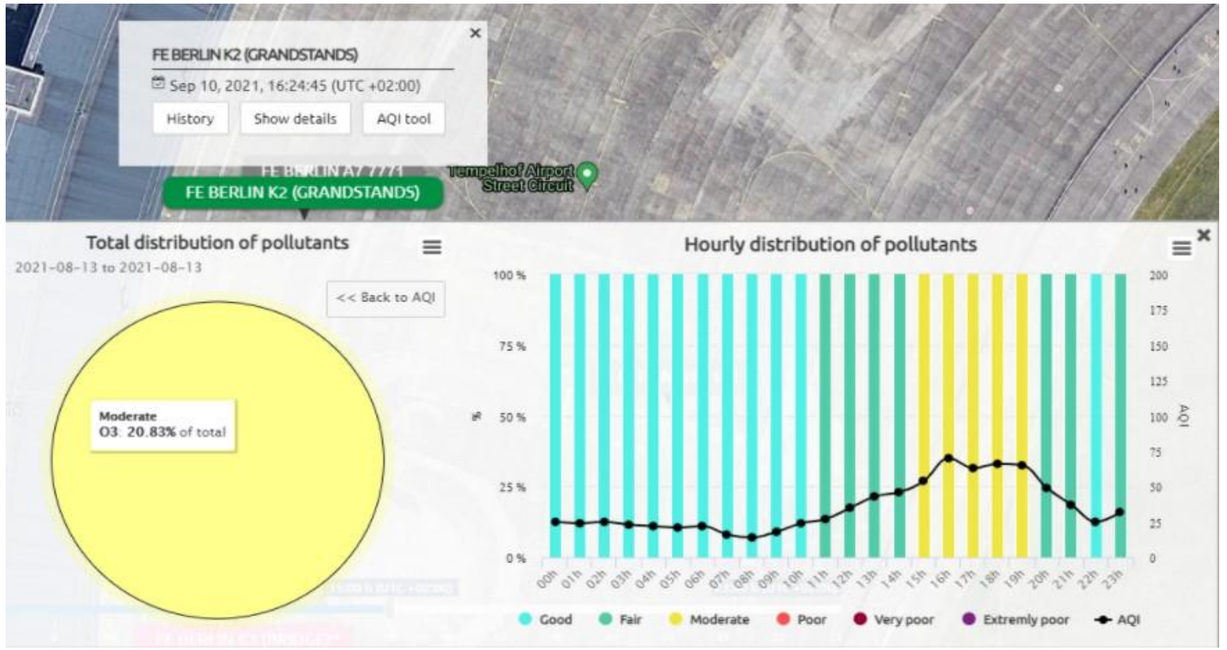
Whats the main source of O_3 exceedances of limit values?

Pollution Rose of O_3

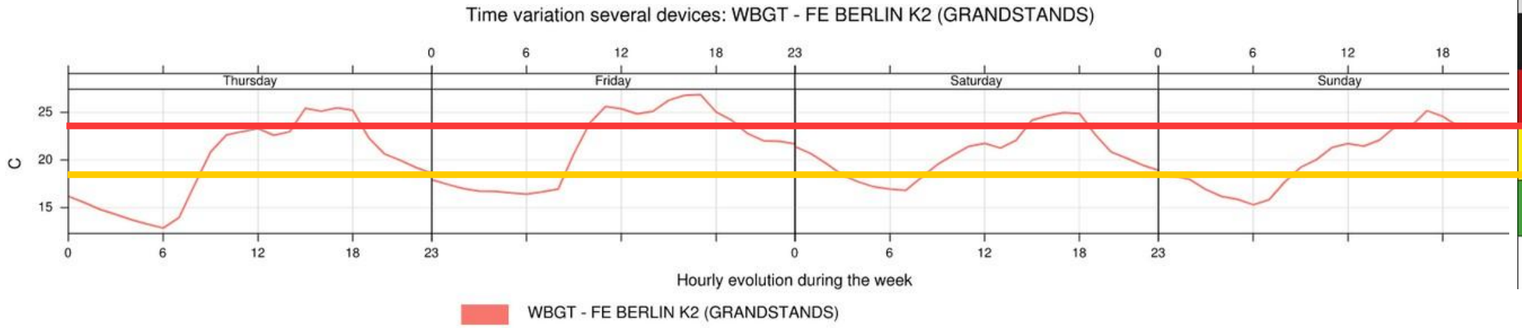
Targeting Visitors

Granstands Kunak AIR unit

EU AQI Moderate - due to O_3



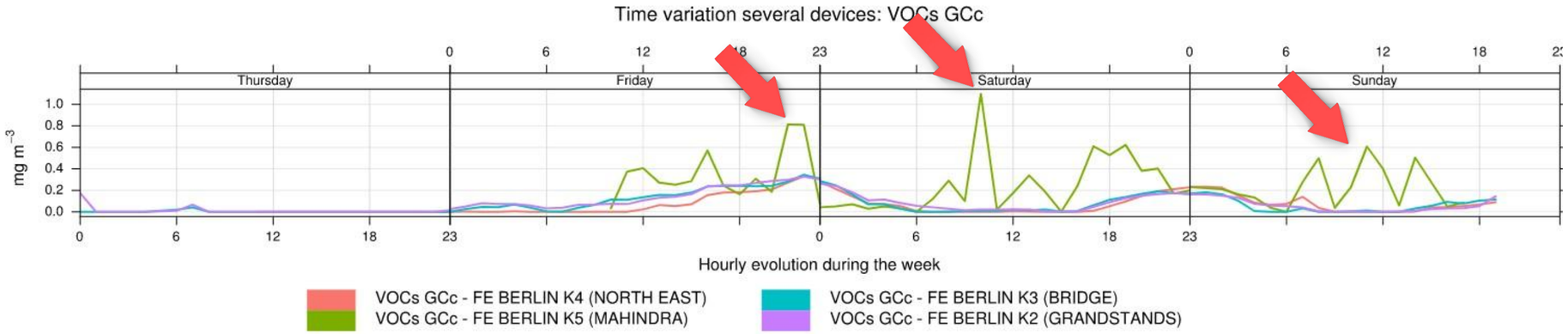
Wet Bulb Globe Tempeature

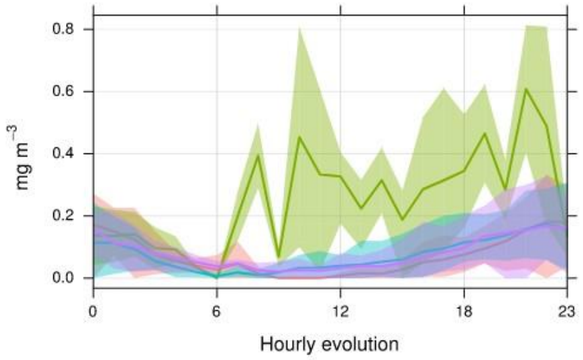


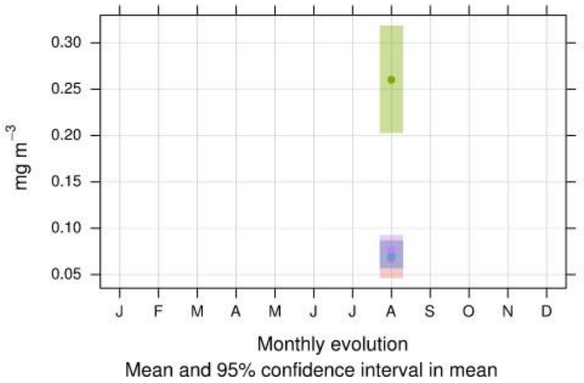
Warning flag	Risk	of	WBGT (°C)
	Extreme	Overheating	> 28.0 °C
	High		23.1 °C - 28.0 °C
	Moderate		18.1 °C - 23.0 °C
	Low		10.1 °C - 18.0 °C
	Increased	Hypothermia	≤ 10.0 °C

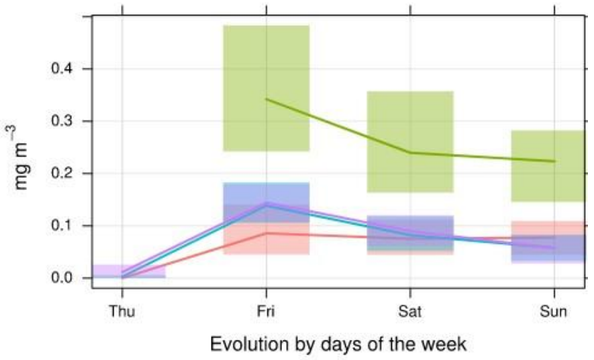
Targeting Formula-E Teams & Pilots

Garage Kunak AIR unit





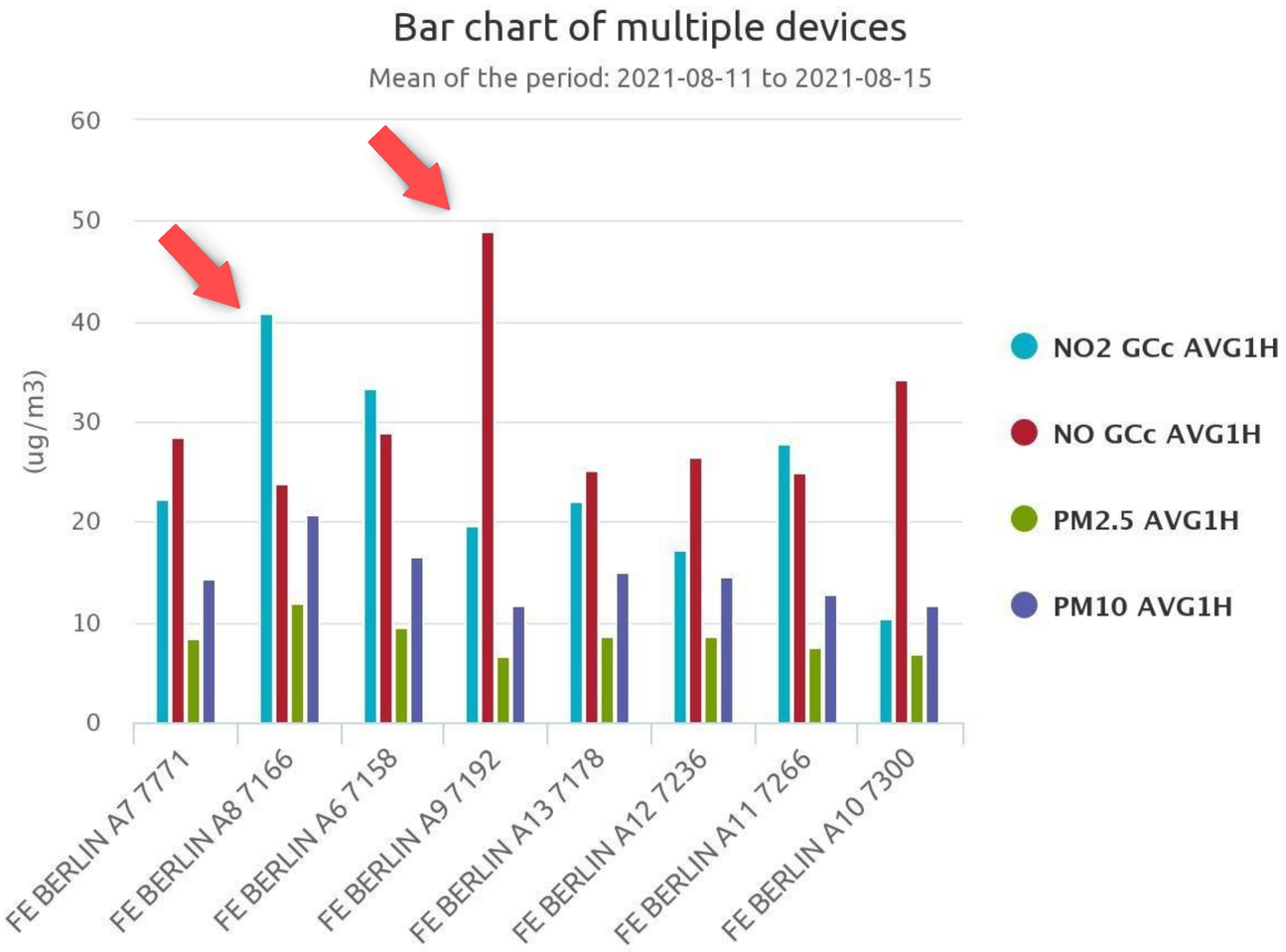




Sun Exposure: VOCs >> O3

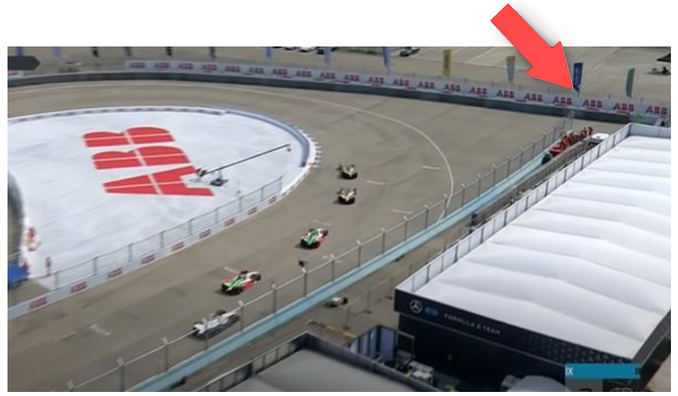
Targeting Staff

Looking into maximum values of Airly units



NO2

Van started during the races

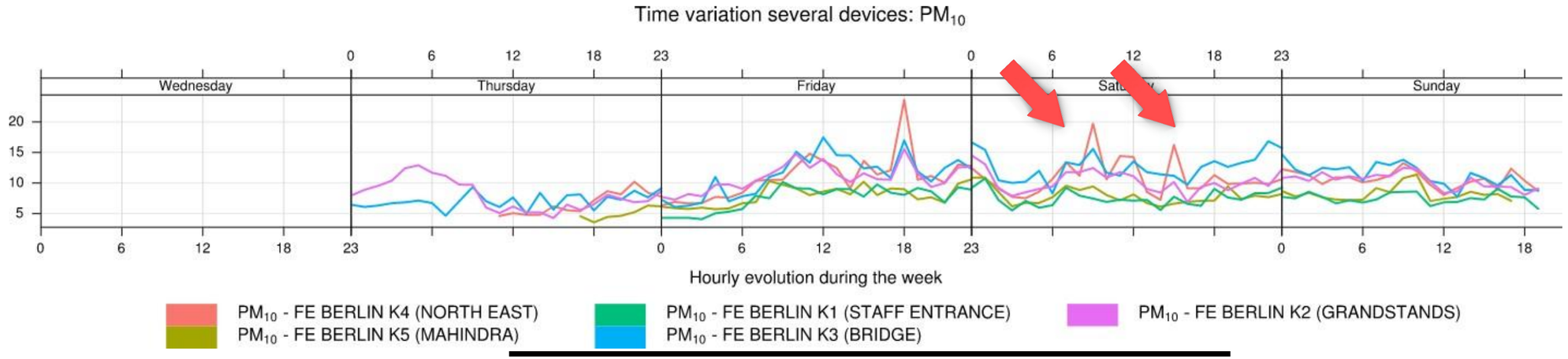


NO

Generators with biodiesel

Targeting abrasion/resusponesion of Particles

Kunak units



SATURDAY 14 AUGUST					
05:47				SUNRISE	
	06:30			Parc Fermé opens	Team garages
07:30	07:40	00:10	FIA	Track Inspection lap	Track
07:40	07:50	00:10	FIA	Medical Inspection	Track
07:50	08:00	00:10	FIA	Closing lap	Track
08:00	**08:30**	**00:30**	**FORMULA E**	**FREE PRACTICE 2**	***Track***
08:45	09:45	01:00	Promotor activity	Track activity	Track
09:53	10:00	00:07	FIA	Closing lap	Track
09:55				Pre-qualifying Parc Fermé	
10:00	**10:04**	**00:04**	**FORMULA E**	**QUALIFYING GROUP 1**	***Track***
10:08	**10:12**	**00:04**	**FORMULA E**	**QUALIFYING GROUP 2**	***Track***
10:16	**10:20**	**00:04**	**FORMULA E**	**QUALIFYING GROUP 3**	***Track***
10:24	**10:28**	**00:04**	**FORMULA E**	**QUALIFYING GROUP 4**	***Track***
10:37	**10:57**	**00:20**	**FORMULA E**	**SUPER POLE (Top 6)**	***Track***
11:10	13:00	01:50	Promotor activity	Track activity	Track
13:00	13:10	00:10	FIA	Medical Inspection	Track
13:18	13:23	00:05	FIA	Closing lap	Track
13:23			FORMULA E	Pit lane opens	Track
13:33			FORMULA E	Pit lane closes	Track
13:33	13:53	00:20		Grid visit by VIP Guests	Grid
13:53			FORMULA E	10' board	Grid
13:58			FORMULA E	5' board	Grid
14:00			FORMULA E	3' board	Grid
14:02			FORMULA E	1' board	Grid
14:02:45			FORMULA E	15" board	Grid
14:03			FORMULA E	Grid positioning	Grid
≈14:04			**FORMULA E**	**RACE (45' + 1 lap)**	***Track***
15:00			FORMULA E	Podium ceremony	Podium
15:25	15:40		FORMULA E	Press Conference (top 3 drivers)	Media Centre
15:40	16:10		FORMULA E	Media pen (all drivers)	Media Centre
23:00				Cars under Parc Fermé	Team garages
20:33				SUNSET	

ABB FORMULA-E
FIA FORMULA-E CHAMPIONSHIP

Berlin E-Prix

Air Quality Mobile Monitoring

Powered by: kunak SENSING ANYWHERE

FORMULA E

Comparison of the PM 10 values from three different days, from a mobile sensor

SATURDAY 14TH

THURSDAY 12TH

SUNDAY 15TH

STATISTICS FOR SATURDAY

FE BERLIN MOBILE (BUGGY) - PM10 (ug/m3)
Max: 20.56
Min: 1.32
Mean: 5.88

LEGEND

PM10 (ug/m3) (Average)

0.59 or Less — 15.00 or More

PART 4.

Data to action

Learnings

1

Source Identification & Macro-sitting

Understand the AQ data from the location, surveys, meetings, videos, pics

2

Micro-sitting

Follow guidelines from EU DIRECTIVE

3

Powering units Stabilization Calibration

Plan in advance.
Follow instructions of manufactures
Consider easy Plug&Play units

Preliminary Conclusions

1. A multi-stakeholder approach and using a **hybrid monitoring network** are key for Air Quality management in sports events.

2. **Hyperlocal indicative monitoring** has filled the data gap.

3. Air Quality conditions at Berlin E-Prix **met international standards**. Local conditions were determinant at times when the conditions worsened.

4. The **Impact** on Sensitive Receptors was **dynamic and low**.

5. Berlin E-Prix was **not a significant source** of incremented **air pollution** during the event