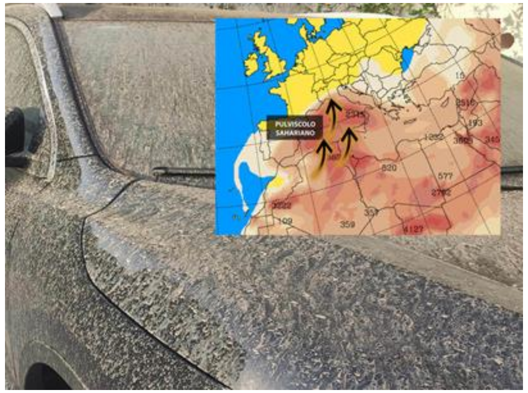
XI giornata della modellistica in aria(net)
Milano, 11 aprile 2024

Emissioni naturali in SURFPRO 5.1.1
polveri desertiche e pollini



Camillo Silibello

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Emissioni naturali: pollini

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Surfpro 5.1.1 documentation

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Dry deposition
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Natural Emission tables
Biogenic - Emissions
Dust - Emissions
Pollen - Emissions

Pollen - Emissions

To estimate pollens emissions from pollen of alder,birch, grass, olive, 5 groups of mugwort species, and ragweed following files have to be provided to SURFPro (following labels in the *Initialization file*):

```
ALDER_FILE = ./datasets/Alder.efi_esa.nc
BIRCH_FILE = ./datasets/Birch.efi_esa.nc
GRASS_FILE = ./datasets/Grass.EU_LCZ.nc
OLIVE_FILE = ./datasets/Olive.corine.nc
RAGWEED_FILE = ./datasets/Ragweed.nc
MUGWORT_FILE = ../datasets/Mugwort.CAMS.nc
```

The ALDER_FILE must containing following information:

```
field              Units
landcover_alder    (%)
correction_alder   (adim)
scale_factor_alder (adim)
Hc_start_alder     (° day)
Hc_end_alder       (° day)
```

The BIRCH_FILE must containing following information:

```
field              Units
landcover_birch    (%)
correction_birch   (adim)
scale_factor_birch (adim)
Hc_start_birch     (° day)
```

The GRASS_FILE must containing following information:

```
field              Units
landcover_grass    (%)
correction_grass   (adim)
start_season_grass (Julian day)
end_season_grass   (Julian day)
```

v5.1.1 - latest

Possiamo darvi il nostro supporto alla preparazione di questi file in particolare per quanto riguarda i campi «landcover_xxxxx»:

- rigrigliatura dei corrispondenti campi disponibili a scala europea (≈ 10 km di risoluzione spaziale)
- In alternativa, utilizzo di dati locali e/o disponibili a maggiore risoluzione spaziale:
  - **Erba** e **Olivo**: Corine Land Cover (CLC), shapefile liv. III e IV;
  - **Betulla** e **Ontano**: carte forestali europee in formato raster (FISE – Forest Information System for Europe);
  - **Ambrosia**: Inventario nazionale delle sorgenti di polline di Ambrosia in formato shape (Bonini et al., 2018).

Applicazione preliminare Regione Veneto ((Univ. Verona), maggiori informazioni: www.isprambiente.gov.it/it/events/giornata-nazionale-del-polline-2024, www.youtube.com/watch?v=WbN6Mys67QM)

Emissioni naturali: polveri minerali

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Dust - Emissions

Using Foroutan *et al.* (2017) scheme (with other parameterizations) it is mandatory to provide the soil texture. This information is contained in the *Initialization file* (TOPSOIL_FILE label, soiltexture field) and can be provided by WRF model.

Other optional information, but strongly recommended, to be provided are the soil moisture (*Initialization file*, TOPSOIL_FILE label, SM_1 field) and LAI data.

Topsoil classes

```
#  Class
1  Sand
2  Loamy Sand
3  Sandy Loam
4  Silt Loam
5  Silt
6  Loam
7  Sandy Clay Loam
8  Silty Clay Loam
9  Clay Loam
10 Sandy Clay
11 Silty Clay
12 Clay
13 Organic Material
14 Water
15 BedRock
```

Es. file meteo prodotto da WRF:

- 2D variables: REL, VGTYP, **soiltexture, LAI,** TCC, PREC, SST, TOTRAD, NETRAD, **SM_1,** U10m, V10m;
- 3D variables: PHI, U, V, W, T, P, RH, DIV.

Pollen - Emissions

To estimate pollens emissions from pollen of alder,birch, grass, olive, 5 groups of mugwort species, and ragweed following files have to be provided to SURFPro (following labels in the *Initialization file*):

```
ALDER_FILE = ./datasets/Alder.efi_esa.nc
BIRCH_FILE = ./datasets/Birch.efi_esa.nc
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```


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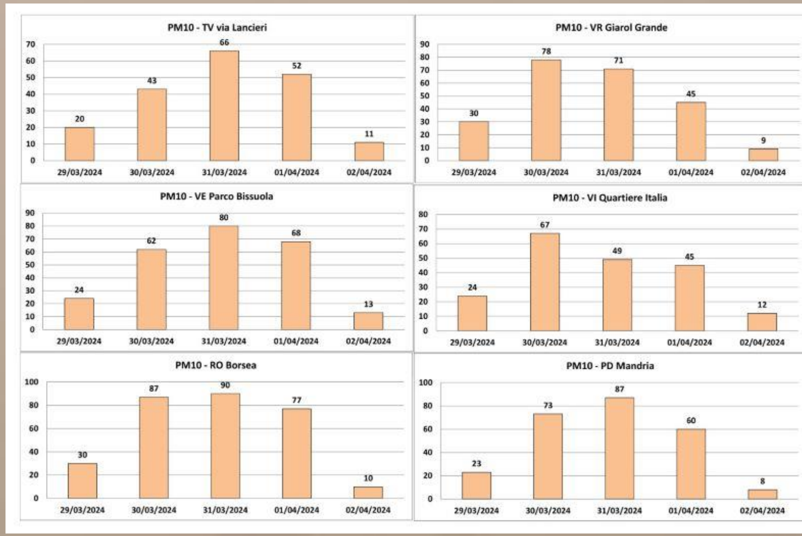
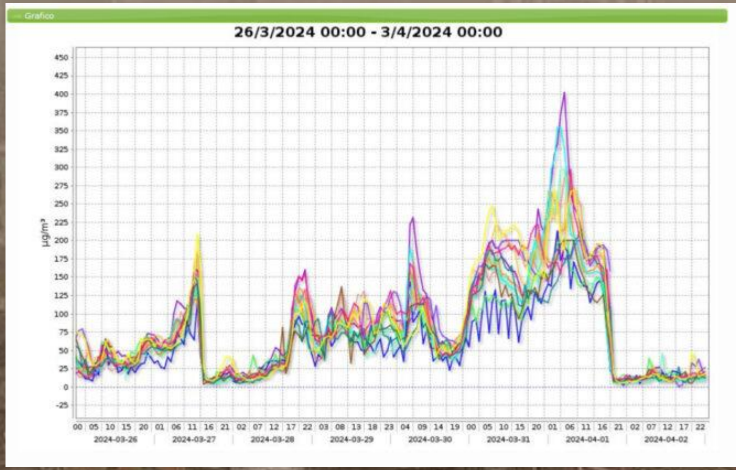
```
!============================================================================
! Biogenic/natural emissions
!============================================================================

IOUTBIOVOC = 0    ! (optional) (0/1/2) = flag to activate biogenic VOC emissions module
                  !            (1 - simple module;
                  !             2 - MEGAN module)
IOUTBIODUST = 3   ! (0/1/2/3) = flag to activate natural dust emissions module
                  !             (1 - Vautard et al.;
                  !              2 - Foroutan et al.;
                  !              3 - Foroutan et al. + Marticorena et al., Klose et al.)
IOUTBIOSSALT = 0 ! (optional) (0/1) = flag to activate sea salt emissions module
IOUTBIOHMS = 0    ! (optional) (0/1) = flag to activate HMs emissions module from Topsoil and sea
IOUTBIONH3 = 0    ! (optional) (0/1) = flag to activate natural NH3 emissions module
IOUTBIONO = 0     ! (optional) (0/1) = flag to activate natural NO emissions from soils module+
IOUTPOLLEN = 1    ! (optional) (0/1) = flag to activate pollen emissions

!============================================================================
! New natural dust emission module parameters
! (Foroutan et al., 2017; Klose et al., 2021)
!============================================================================
FECAN_CF1 = 1.0         ! soil moisture scaling (typically =< 1)
FECAN_CF2 = 1.75        ! Fecan coefficient (typically >= 1)
                        ! recommended to use either FECAN_CF1 or FECAN_CF2 and not both at the same
                        ! (Klose et al., 2021, eq. 19)

Z0MIN = 0. 0. 0. 0. ! minimum aeolian roughness (m) for four emitting land cover types:
                    ! shrubland, shrub/grass, cropland, barren/sparsely veg.
                    ! WBDUST values: Z0MIN = (/0.05, 0.04, 0.02, 0.01/)
                    ! WBDUST ones lead to high emissions

EROPOT =0.13 0.33 1.00 0.10 ! erodible potential of four soil components:
                            ! Coarse sand, Fine-medium sand, Silt, Clay
                            ! CMAQ values: EROPOT = (/0.12, 0.12, 1.00, 0.08/)

EP_METHOD = 2   ! flag to consider erodible potential (1/2 = 1: as CMAQ; 2: as WBDUST)

FRYREAR = 0     ! (0/1) flag to use Fryrear et al. (1994) formula insted to compute the erodible po
                ! sd_ep = (29.09 + 31. * sandf + 17. * siltf + 33. * sandf / clayf) / 100
                ! sandf is the sum of coarse and fine-medium sand fractions
                ! if (FRYREAR == 1 .and. EP_METHOD == 2) -> FRYREAR forced to 0

!============================================================================
! Output variable flags  (1 = save; 0 = do not save)
!============================================================================

ALB_FLAG = 1       ! (optional) albedo
Z0_FLAG = 0        ! (optional) z0 and canopy height
BR_FLAG = 0        ! (optional) Bowen ratio
```

Veneto

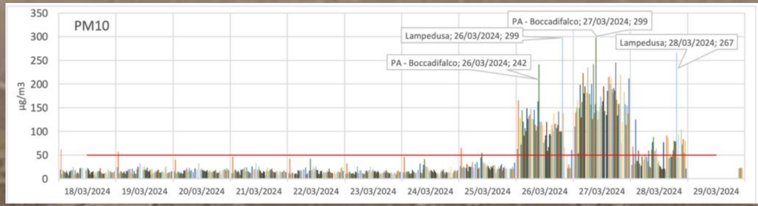


A partire da **lunedì 25 marzo fino a lunedì 1 aprile** una parte consistente del territorio italiano è stato interessato da un importante **afflusso di polveri provenienti dal Sahara**, in corrispondenza del quale **molte stazioni di monitoraggio del SNPA hanno rilevato concentrazioni elevate di particolato atmosferico**.

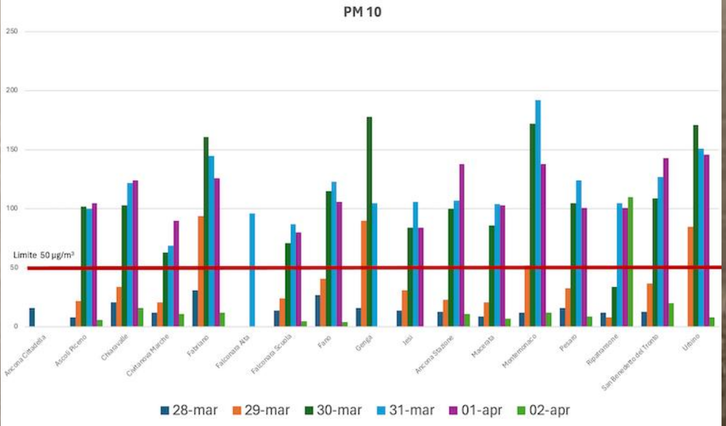
Campania



Sicilia



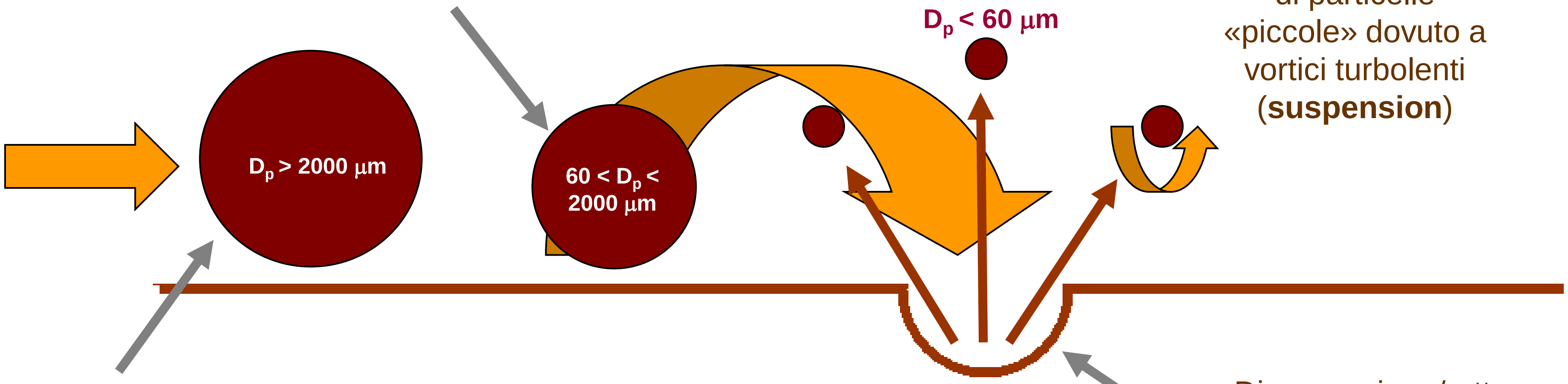
Marche



Emissione di polveri (teoria)

Sollevamento di particelle «grandi» dovuto al «wind shear» (**saltation**)

Trasporto verso l'alto di particelle «piccole» dovuto a vortici turbolenti (**suspension**)



Sandblasting (bombardamento)

Particelle troppo grandi o troppo pesanti per essere sollevate dalla superficie, rotolano e strisciano lungo la superficie (**creep**)

Disgregazione/rottura degli aggregati e produzione di particelle di polvere «piccole»

Schema di emissione di polveri (in CMAQ e CAMx)

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AGU PUBLICATIONS

Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1002/2016MS000823

Key Points:
- A new windblown dust emission treatment is incorporated in CMAQ model
- The model incorporates a new dynamic relation for the surface roughness length
- The CMAQ model with the new windblown dust treatment shows close agreement with observations

Supporting Information:
- Supporting Information S1

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Development and evaluation of a physics-based windblown dust emission scheme implemented in the CMAQ modeling system

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[1]Computational Exposure Division, National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, USA

Abstract A new windblown dust emission treatment was incorporated in the Community Multiscale Air Quality (CMAQ) modeling system. This new model treatment has been built upon previously developed physics-based parameterization schemes from the literature. A distinct and novel feature of this scheme, however, is the incorporation of a newly developed dynamic relation for the surface roughness length relevant to small-scale dust generation processes. Through this implementation, the effect of nonerodible elements on the local flow acceleration, drag partitioning, and surface coverage protection is modeled in a physically based and consistent manner. Careful attention is paid in integrating the new windblown dust treatment in the CMAQ model to ensure that the required input parameters are correctly configured. To test the performance of the new dust module in CMAQ, the entire year 2011 is simulated for the continental United States, with particular emphasis on the southwestern United States (SWUS) where windblown dust concentrations are relatively large. Overall, the model shows good performance with the daily mean bias of soil concentrations fluctuating in the range of ±1 μg m^{-3} for the entire year. Springtime soil concentrations are in quite good agreement (normalized mean bias of 8.3%) with observations, while moderate to high underestimation of soil concentration is seen in the summertime. The latter is attributed to the issue of representing the convective dust storms in summertime. Evaluations against observations for seven elevated dust events in the SWUS indicate that the new windblown dust treatment is capable of capturing spatial and temporal characteristics of dust outbreaks.

I fattori determinanti per la stima di emissione di polveri minerali sono:

- Tipologia/tessitura del terreno;
- Erodibilità del suolo;
- Turbolenza superficiale e del boundary layer (u*);
- Umidità del suolo (f_m) e Rugosità superficiale (surface roughness, f_r)

Tessitura del suolo

La frazione inorganica di un suolo è costituita da particelle aventi dimensioni diverse. Alle particelle con dimensioni superiori a 2 mm si dà il nome di " scheletro", mentre la frazione formata da particelle con diametro inferiore a 2 mm è denominata "terra fine" . La terra fine è quella di nostro interesse ed è costituita da sabbia, limo e argilla.

Il modello di emissione adottato prende in esame quattro classi dimensionali per la polvere minerale:

Sabbia grossolana, Sabbia medio-fine, Limo, Argilla.

Table 2. Composition of Each Soil Type

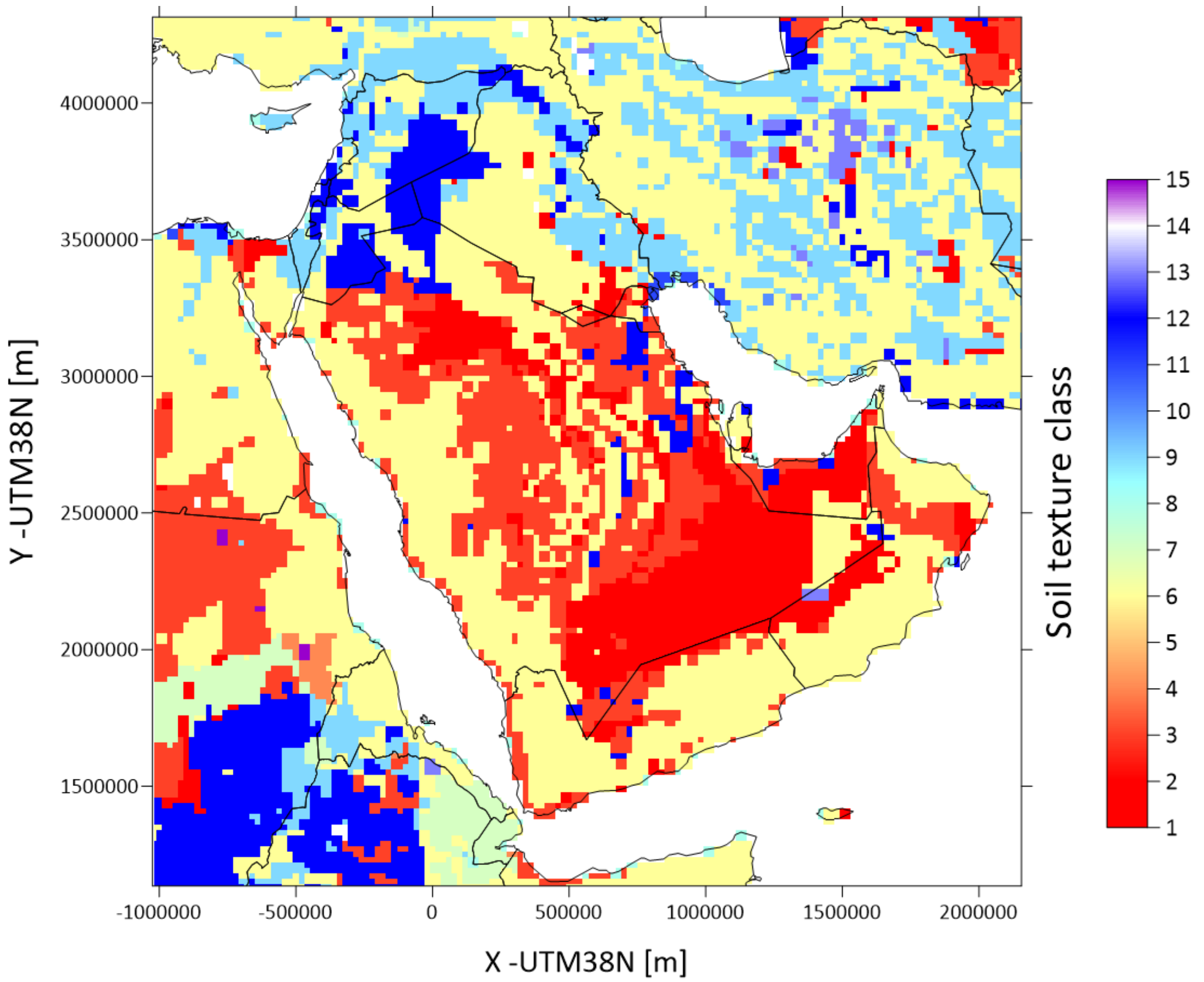
Number	Soil Type	% Coarse Sand $D = 690\ \mu m$ $\sigma = 1.6$	% Fine-Medium Sand $D = 210\ \mu m$ $\sigma = 1.6$	% Silt $D = 125\ \mu m$ $\sigma = 1.8$	% Clay $D = 2\ \mu m$ $\sigma = 2.0$
1	Sand	46	46	5	3
2	Loamy sand	41	41	~~18~~ 12	~~0~~ 6
3	Sandy loam	29	29	32	10
4	Silt loam	0	17	70	13
5	Silt	0	10	85	5
6	Loam	0	43	39	18
7	Sandy clay loam	29	29	15	27
8	Silty clay loam	0	10	56	34
9	Clay loam	0	32	34	34
10	Sandy clay	0	52	6	42
11	Silty clay	0	6	47	47
12	Clay	0	22	20	58

Class No.	Soil Texture Class	Class Abbreviation	% Sand	% Silt	% Clay
1	Sand	S	92	5	3
2	Loamy Sand	LS	82	12	6
3	Sandy Loam	SL	58	32	10
4	Silt Loam	SiL	17	70	13
5	Silt	Si	10	85	5
6	Loam	L	43	39	18
7	Sandy Clay Loam	SCL	58	15	27
8	Silty Clay Loam	SiCL	10	56	34
9	Clay Loam	CL	32	34	34
10	Sandy Clay	SC	52	6	42
11	Silty Clay	SiC	6	47	47
12	Clay	C	22	20	58
13	Organic Materials	OM	0	0	0
14	Water	W	0	0	0
15	Bedrock	BR	0	0	0
16	Other	O	0	0	0

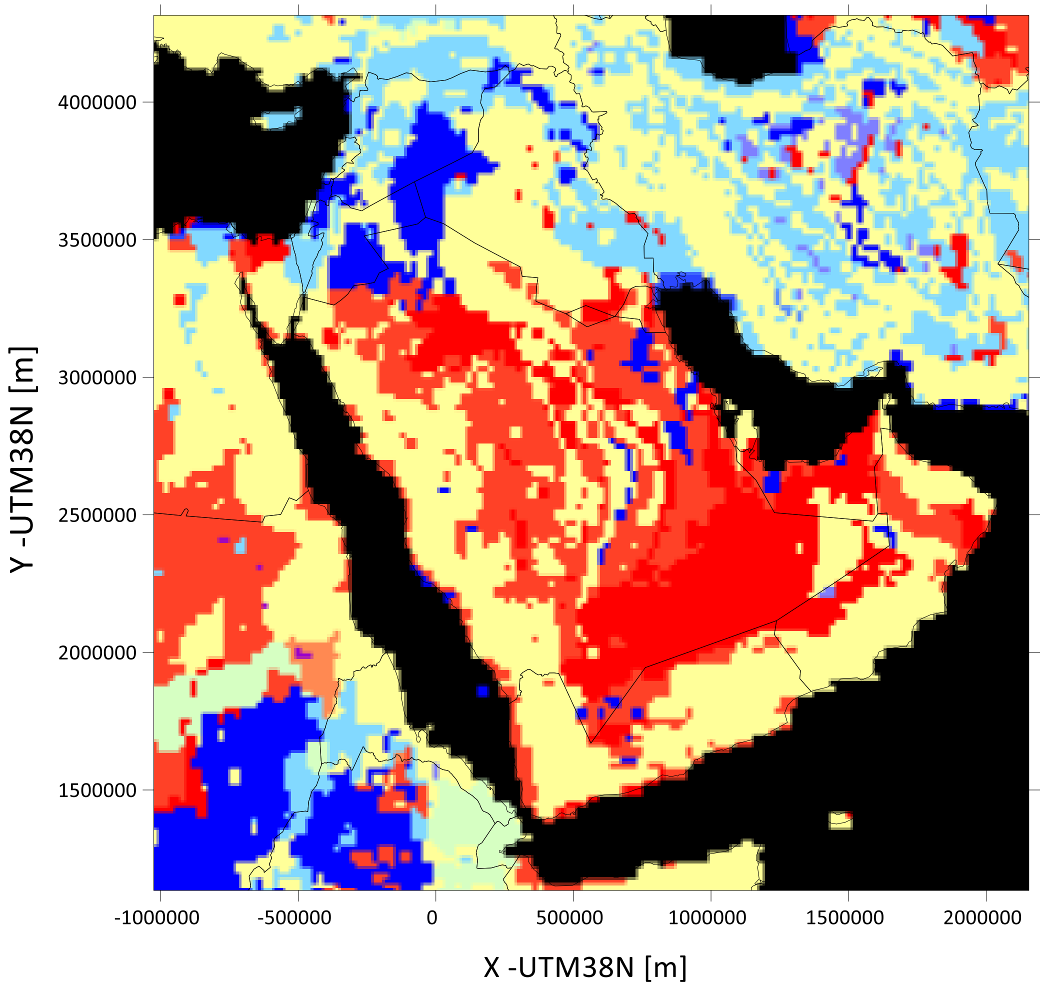
http://www.soilinfo.psu.edu/index.cgi?soil_data&conus&data_cov&fract&methods

Applicazione preliminare alla penisola Arabica (anno 2022)

Tessitura del suolo



From WRF, Water assigned to class 14



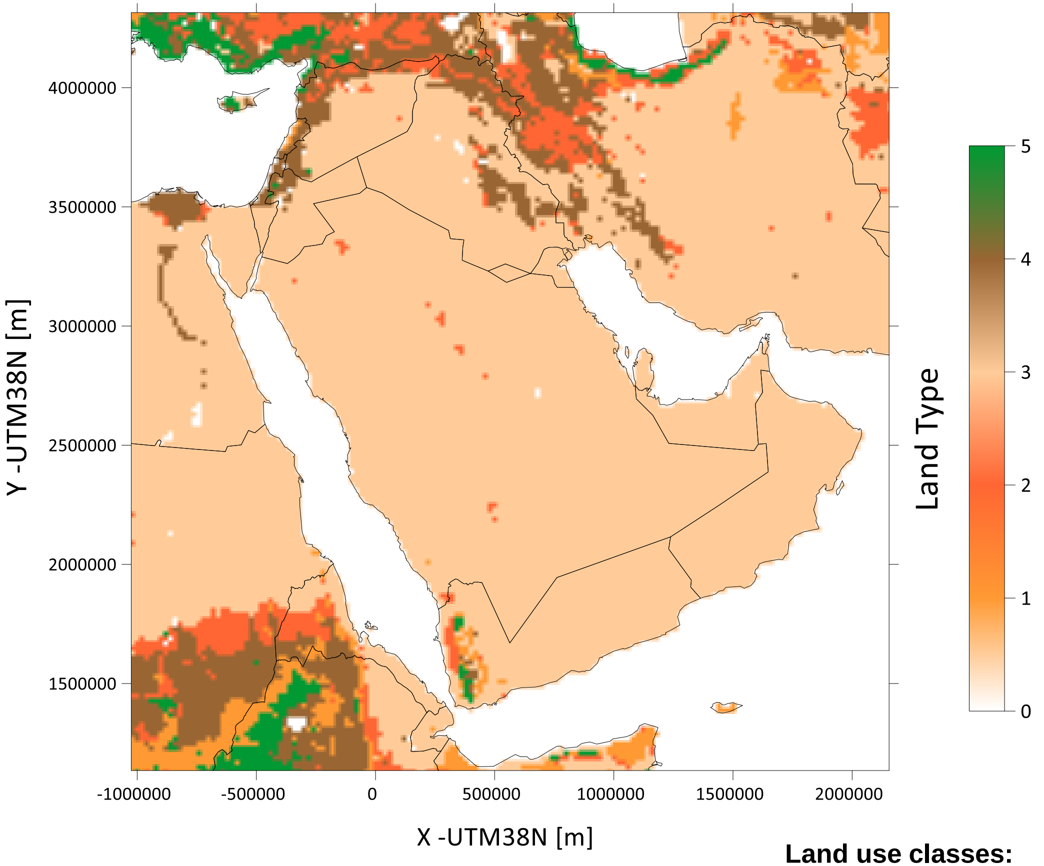
From GLDAS

Erodibilità del suolo/classi di uso del suolo

La frazione di copertura vegetale (Av) riduce il tasso di erosione del suolo, nel modello sono considerate le seguenti classi di uso del suolo effettivamente erodibili:

- Shrubland;
- Shrub/grass;
- Barren/sparsely vegetated;
- Cropland

Urban fabric	NOT ERODIBLE
Industrial commercial and transport units	NOT ERODIBLE
Airports	NOT ERODIBLE
Other artificial surfaces	NOT ERODIBLE
Arable land (non-irrigated and permanently irrigated)	CROPLAND
Rice fields	NOT ERODIBLE
Permanent crops	CROPLAND
Pastures	SRUB/GRASS
Heterogeneous agricultural areas	CROPLAND
Broad-leaved forest	VEGETATION (AV)
Coniferous forest	VEGETATION (AV)
Mixed forest	VEGETATION (AV)
Natural grassland	SRUB/GRASS
Shrubs and heathland	SHRUBLANDS
Beaches dunes and sand plains	BARREN OR SPARSELY VEGETATED
Bare rock	BARREN OR SPARSELY VEGETATED
Sparsely vegetated areas	BARREN OR SPARSELY VEGETATED
Glaciers and perpetual snow	NOT ERODIBLE
Inland wetlands	NOT ERODIBLE
Coastal wetlands	NOT ERODIBLE
Sea and ocean	NOT ERODIBLE
Other Water bodies	NOT ERODIBLE

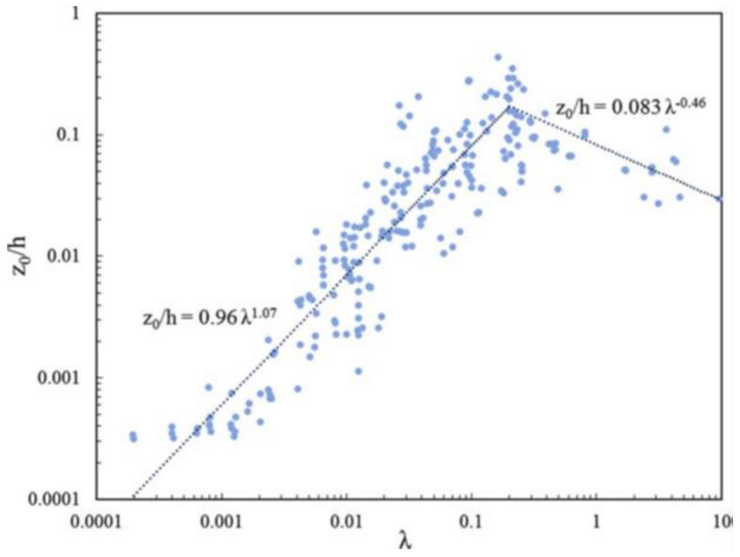


Land use classes:
0 = not considered
1 = SHRUBLANDS
2 = SRUB/GRASS
3 = BARREN OR SPARSELY VEGETATED
4 = CROPLAND
5 = VEGETATION

u^* e valore di soglia per $u_{*,t}$

u_* (m s^{-1}) è il parametro fondamentale per il calcolo delle emissioni di polveri minerali:

$$u_* = \frac{\kappa u_z}{\ln\left(\frac{z}{z_0}\right)}$$



u_z è la velocità del vento alla quota z (tipicamente 10 m), k è la costante di von Karman e z_0 è la lunghezza di rugosità eolica superficiale e rappresenta la vulnerabilità della superficie all'erosione eolica.

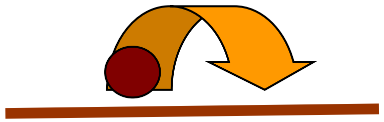
z_0 viene calcolata in funzione dell'uso del suolo utilizzando i valori di densità totale di rugosità λ e di altezza effettiva degli elementi di rugosità h stimati sulla base di parametri tabulati (uso del suolo) e della frazione di copertura vegetale (Av).

$u_{*,t0}$ è la soglia per la velocità di attrito sotto la quale non avviene il sollevamento di polvere [Shao et al., 2011]:

$$u_{*,t0}(D) = \sqrt{A_N\left(\frac{\rho_p g D}{\rho_a} + \frac{\Gamma}{\rho_a D}\right)}$$

dove A_N =0.0123 e Γ= 1.65 10^{-4} g s^{-2}, D è il è il diametro delle particelle del terreno, g l'accelerazione di gravità e ρ_p e ρ_a sono rispettivamente la densità delle particelle (2650 g m^{-3}) e dell'aria (1227 g m^{-3}). Per considerare gli effetti dell'umidità del suolo e della rugosità superficiale, viene considerata la relazione $u_{*,t} = u_{*,t0}\ f_m\ f_r$ dove f_m e f_r sono i fattori di correzione rispettivamente per l'umidità del suolo e la rugosità superficiale-

Flusso orizzontale (saltation) e verticale (sandblasting)

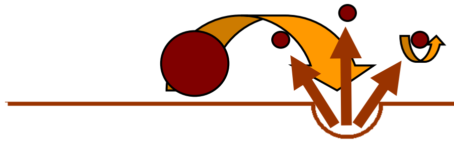


saltation

A seconda della tessitura e tipologia terreno, possono essere emesse quattro particelle di terreno (sabbia grossolana, sabbia medio-fine, limo e argilla). Il flusso orizzontale (saltazione, g m^{-1} s^{-1}) per ciascuna particella è dato dalla seguente relazione (unità MKS):

$$F_H(D)=\begin{cases} c\dfrac{\rho_a}{g}u_*^3\left(1-\dfrac{u_{*,t}(D)}{u_*}\right)\left(1+\dfrac{u_{*,t}(D)}{u_*}\right)^2, & u_{*,t}<u_* \\ 0, & u_{*,t}\geq u_* \end{cases}$$

dove *c* è una costante pari a 1



sandblasting

Dopo aver colpito la superficie, le particelle determinano la disgregazione/rottura del suolo e la produzione di particelle di polvere «piccole» che vengono espulse verso l'alto. Il flusso di massa delle particelle di polvere generato da questo processo, noto come flusso verticale ($F_{V,tot}$, g m^{-2} s^{-1}), è proporzionale al flusso orizzontale $F_{H,tot}$ [Shao et al., 1993; Marticorena e Bergametti, 1995].

$$F_{V,tot}= \alpha \; F_{H,tot}$$

α (m^{-1}) è detta efficienza di massa di sabbiatura

Dust emission module in SURFPro

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Two option have been implemented:

1. Foroutan *et al.*, 2017 (**IOUTBIODUST = 2**);
2. Marticorena *et al.* algorithms for z_0 (2006) and $u_{*,t}$ (1995) with Klose et al. 2011 integrations (IOUTBIODUST = 3).

….

IOUTBIODUST = 2 (0/1/2/3) = flag to activate natural dust emissions module (1 - Vautard et al.; 2 - Foroutan et al.;
3 - Marticorena et al., Klose et al.)

…

!==

! New natural dust emission module parameters

! (Foroutan et al., 2017 / Marticorena et al. (1995, 2006) and Klose et al., 2021)

!==

FECAN_CF1 = 1.0 (soil moisture scaling (typically =< 1)

FECAN_CF2 = 1.75 (Fecan coefficient (typically >= 1)

Z0MIN = 0. 0. 0. 0. minimum aeolian z0 (m) for four emitting land cover types: shrubland, shrub/grass, cropland,
barren/sparsely vegetated

EROPOT = 0.13 0.33 1.00 0.10 erodible potential of four soil components: Coarse sand, Fine-medium sand, Silt, Clay

SD_EP_METHOD = 1 (1/2) flag to use the average emission potential (1 as CMAQ)
or the soil component value (2 as WBDUST)

FRYREAR = 0 (0/1) flag to use Fryrear et al. (1994) formula to compute the average erodible potential (1)

Following additional files must/should be provided:

- **TOPSOIL_FILE** = <soilfile> (mandatory using IOUTBIODUST = 2 or 3, from WRF or FAO soil texture dataset)
- **SOILM_FILE** = <soilmfile> (optional) 2D volumetric soil moisture if not provided uniform scalar values for the gravimetric soil moisture (kg/kg) are considered according to the climate index (dry, 0.001; normal, 0.05; wet,0.1);

Simulations

Common parameters

- **TOPSOIL_FILE:** *from WRF*
- **SOILM_FILE:** *from WRF*
- **IOUTBIODUST=2/3** ⇒ Foroutan *et al.* (2017) (IOUTBIODUST=2); Marticorena *et al.* (1995 and 2006) and Klose et al.(2021 (IOUTBIODUST=3)
- **FECAN_CF1 = 1.0** (soil moisture scaling (typically =< 1)
- **FRYREAR = 0** (do not use Fryrear et al. (1994) formula to compute the average erodible potential)
- **EP_METHOD = 2** flag to consider erodible potential (1/2 = 1: as CMAQ; 2: as WBDUST)EP_MET

- **run0**:
  - **FECAN_CF2 = 1.75** (Fecan coefficient (typically >= 1, NMMB suggested value)
  - **Z0MIN = 0. 0. 0. 0.** minimum aeolian roughness (m) for four emitting land cover types: shrub., shrub/grass, crops; barren/sparsely veg.
  - **EROPOT = 0.13 0.33 1.00 0.10** CMAQ erodible potential of four soil components: Coarse sand, Fine-medium sand, Silt, Clay

- **run1 (as run0)**:
  - **FECAN_CF2 = 5.** Zender et al. suggested value

- **run2 (as run0)**:
  - **FECAN_CF2 = 5.** Zender et al. suggested value
  - **EROPOT = 1.0 1.0 1.0 1.0**

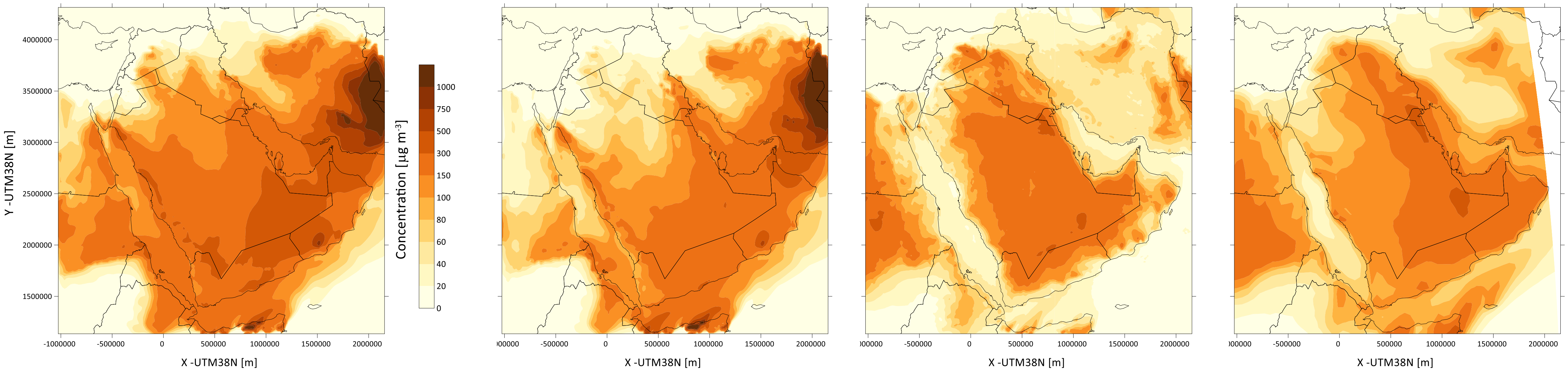
- **run3 (as run0)**:
  - **FECAN_CF2 = 5.** Zender et al. suggested value
  - **Z0MIN = 0.0001 0.0001 0.0001 0.0001**

- **run4 (as run0)**:
  - **FECAN_CF2 = 5.** Zender et al. suggested value
  - **EROPOT = 1.0 1.0 1.0 1.0**
  - **Z0MIN = 0.0001 0.0001 0.0001 0.0001**

Comparison with BSC/NMMB and ensemble models (PM_{10})

A SUEZ company

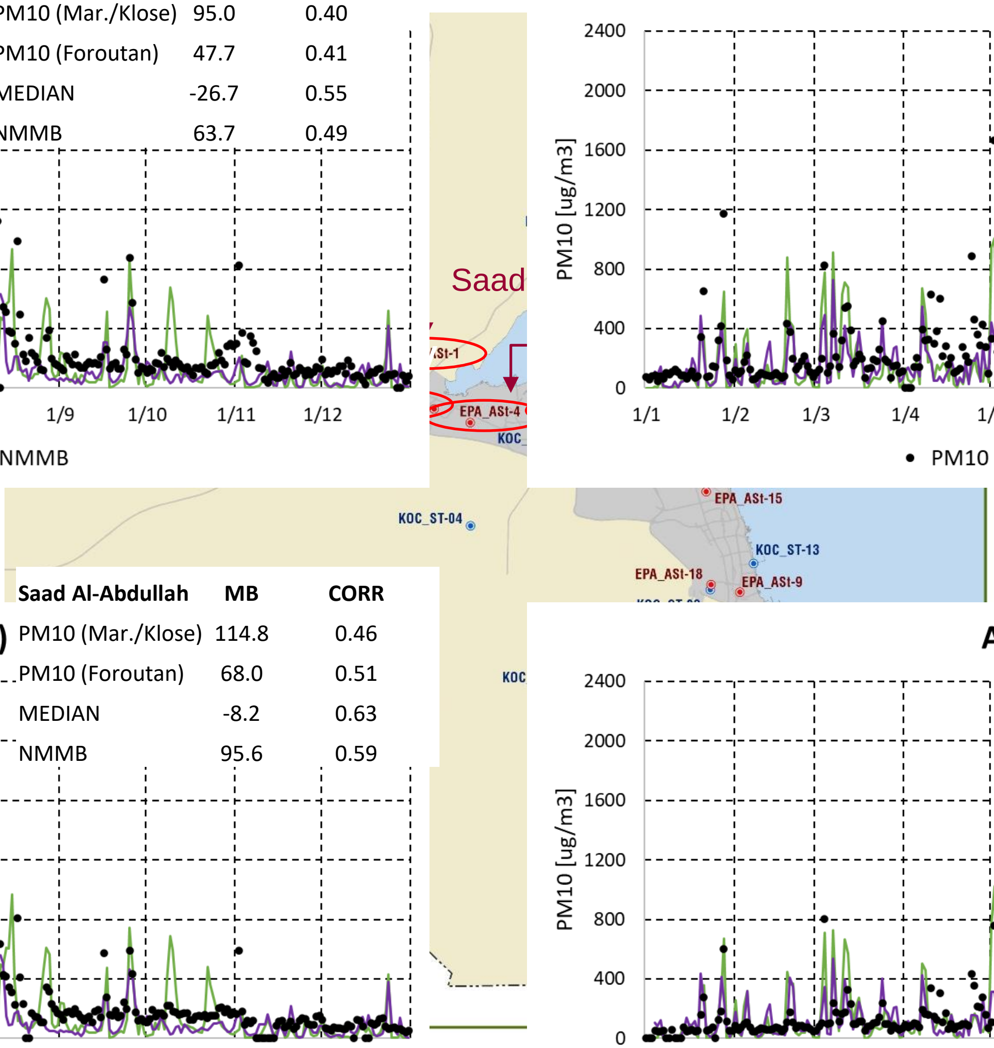
June - run4



Foroutan et al. | **Marticorena & Klose** | **BSC/NMMB** | **Median**

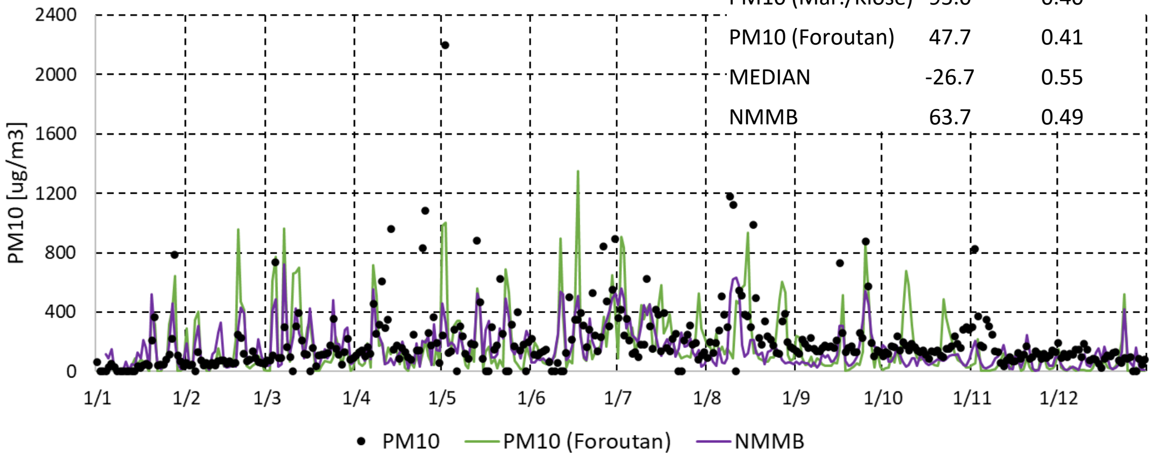
PM_{10} Comparison with observations (run4 test)

ARIANET A suez company



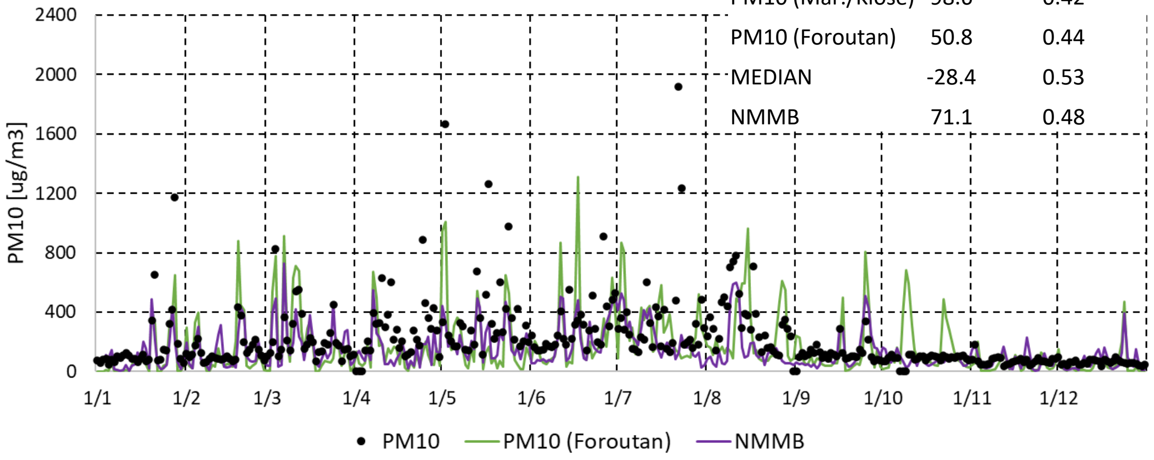
Al-Mutla (run4)

Al-Mutla	MB	CORR
PM10 (Mar./Klose)	95.0	0.40
PM10 (Foroutan)	47.7	0.41
MEDIAN	-26.7	0.55
NMMB	63.7	0.49



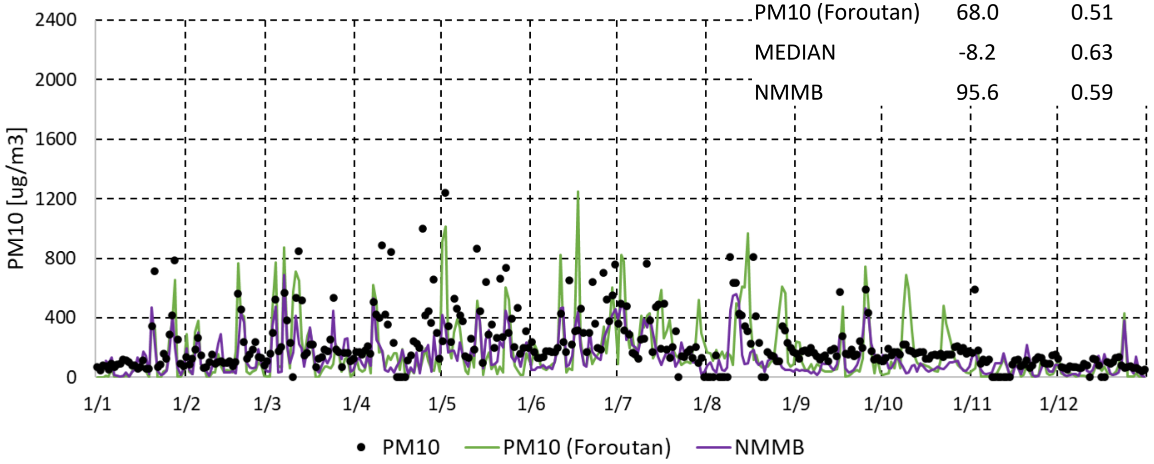
Al-Jahra (run4)

Al-Jahra	MB	CORR
PM10 (Mar./Klose)	98.6	0.42
PM10 (Foroutan)	50.8	0.44
MEDIAN	-28.4	0.53
NMMB	71.1	0.48



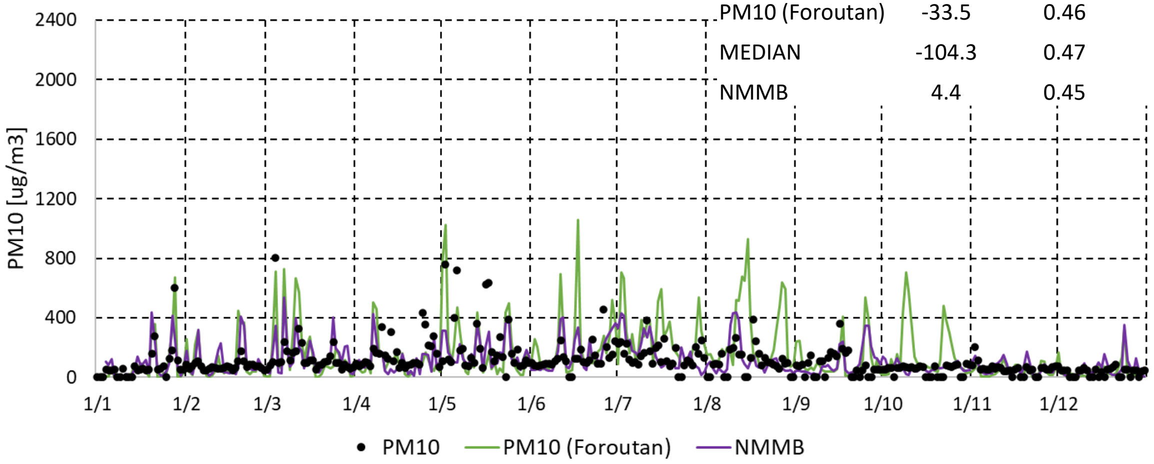
Saad Al-Abdullah (run4)

Saad Al-Abdullah	MB	CORR
PM10 (Mar./Klose)	114.8	0.46
PM10 (Foroutan)	68.0	0.51
MEDIAN	-8.2	0.63
NMMB	95.6	0.59



Al-Shuwaikh (run4)

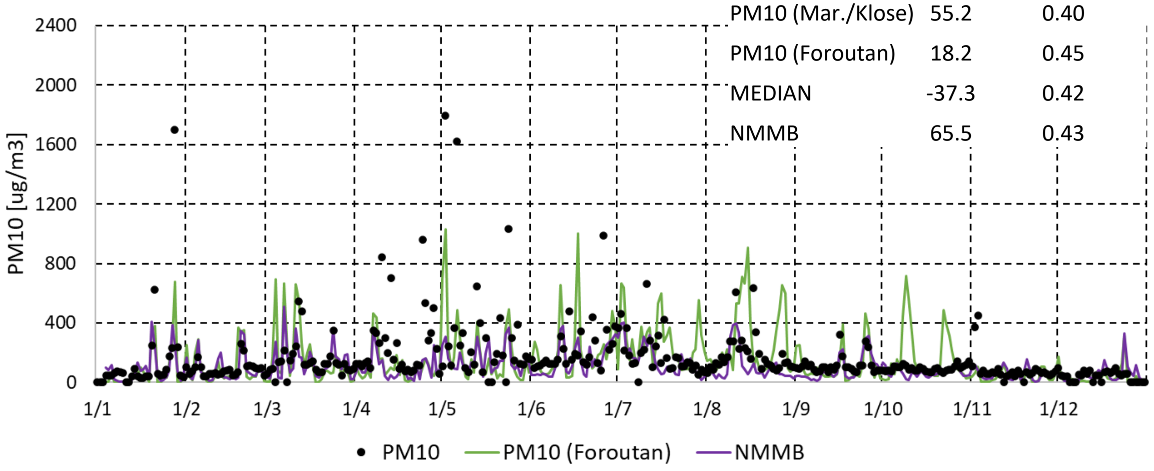
Al-Shuwaikh	MB	CORR
PM10 (Mar./Klose)	8.3	0.40
PM10 (Foroutan)	-33.5	0.46
MEDIAN	-104.3	0.47
NMMB	4.4	0.45



PM_{10} Comparison with observations (run4 test)

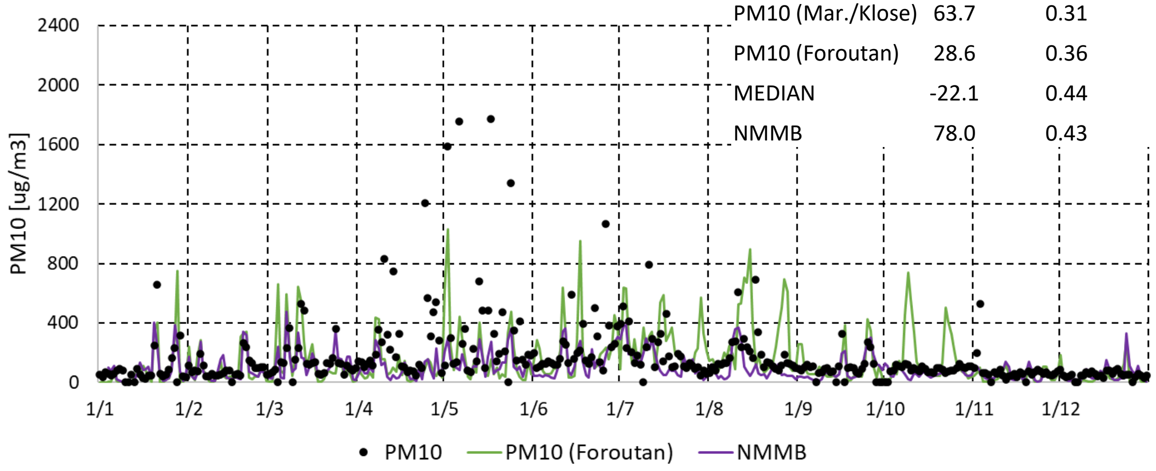
Al-Salam (run4)

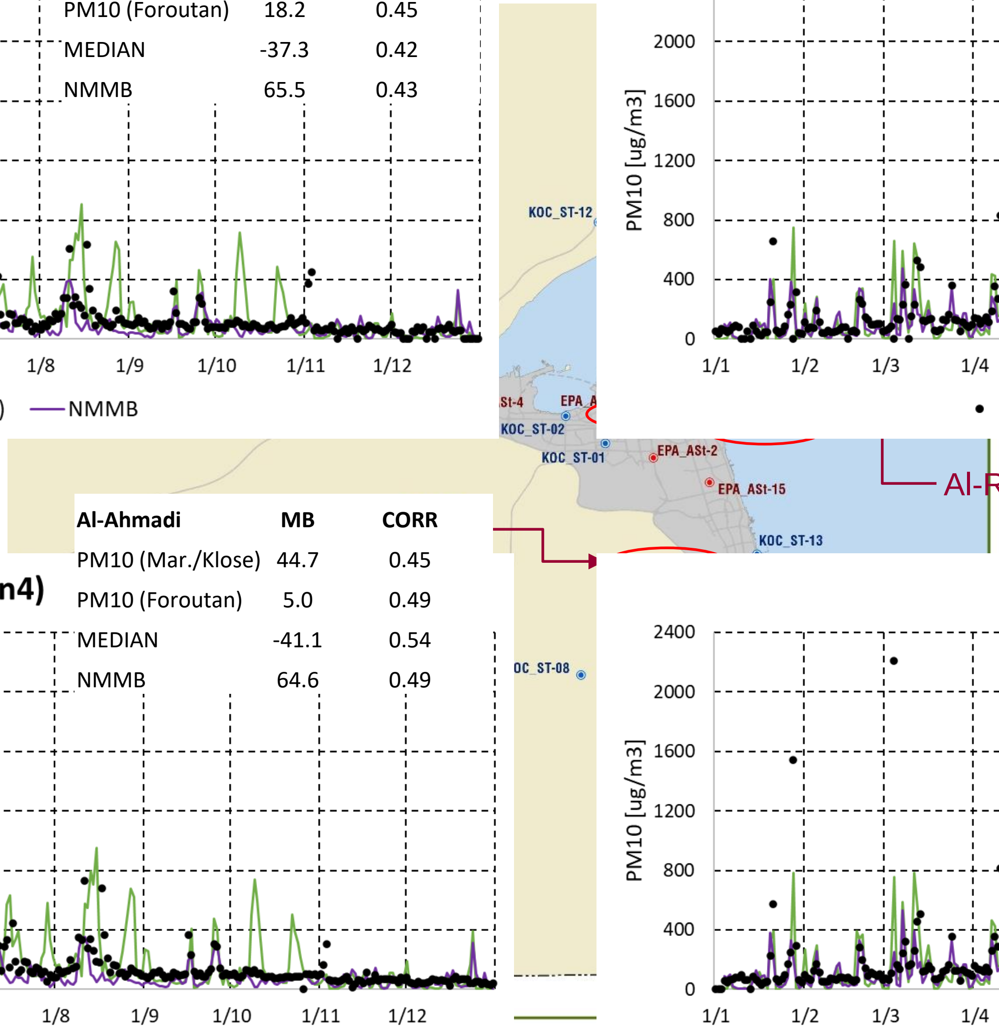
Al-Salam	MB	CORR
PM10 (Mar./Klose)	55.2	0.40
PM10 (Foroutan)	18.2	0.45
MEDIAN	-37.3	0.42
NMMB	65.5	0.43



Al-Rumaithiya (run4)

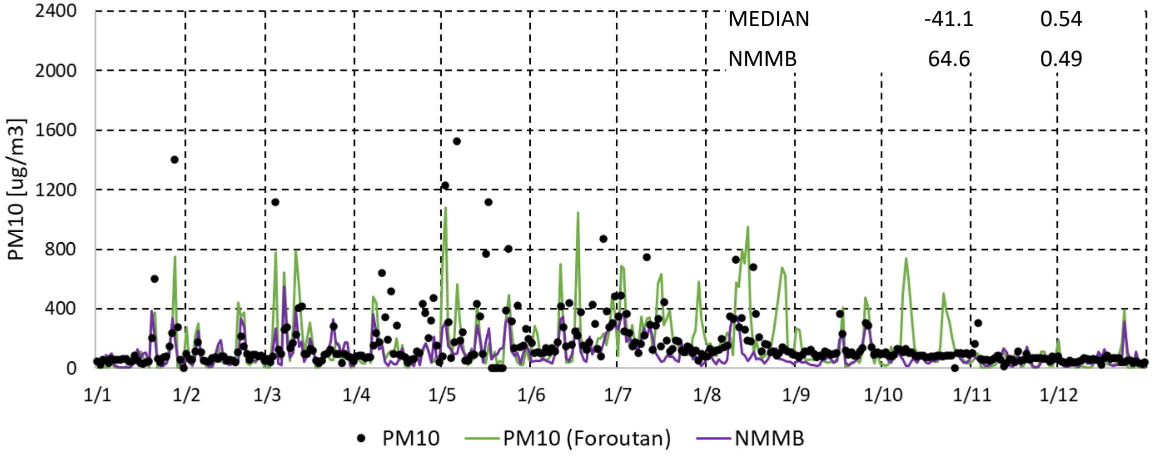
Al-Rumaithiya	MB	CORR
PM10 (Mar./Klose)	63.7	0.31
PM10 (Foroutan)	28.6	0.36
MEDIAN	-22.1	0.44
NMMB	78.0	0.43





Al-Ahmadi (run4)

Al-Ahmadi	MB	CORR
PM10 (Mar./Klose)	44.7	0.45
PM10 (Foroutan)	5.0	0.49
MEDIAN	-41.1	0.54
NMMB	64.6	0.49



Al-Fahaheel (run4)

Al-Fahaheel	MB	CORR
PM10 (Mar./Klose)	84.4	0.36
PM10 (Foroutan)	45.4	0.40
MEDIAN	2.5	0.46
NMMB	107.2	0.45