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EXCELENCIA SEVERO OCHOA

High-resolution SDS forecast requirements for the Middle East

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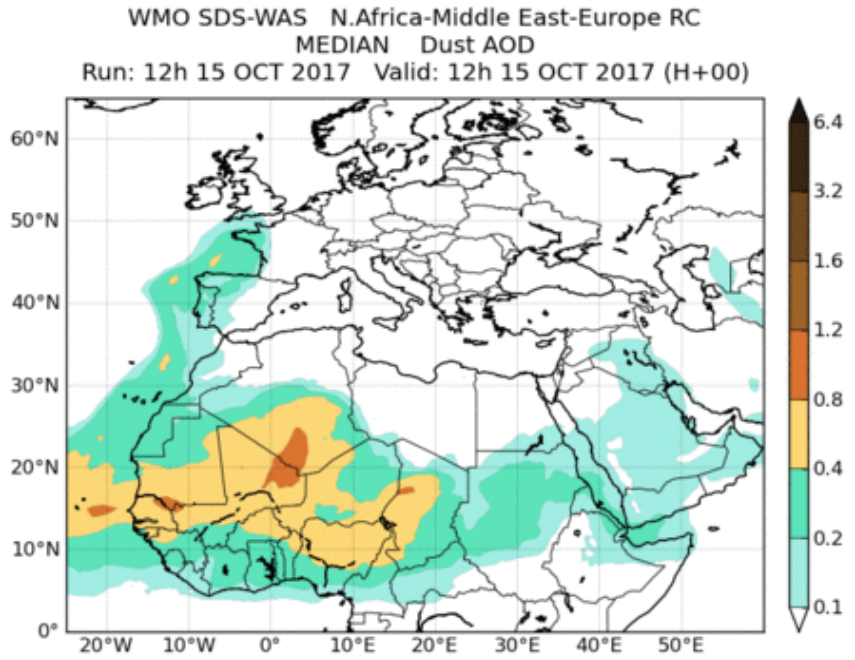
5th International Workshop on SDS, 23-25 October 2017, Istanbul

Dust forecasts: SDS-WAS Multi-model

SDS-WAS product

12 Global – Regional models
(from ~ 100 to 10 km)

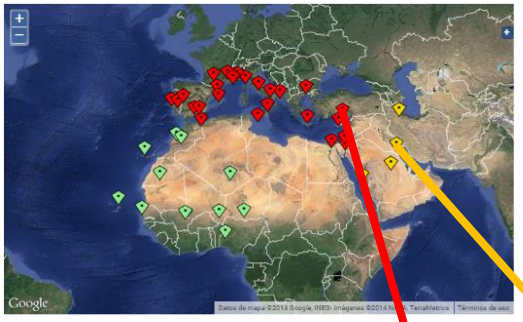


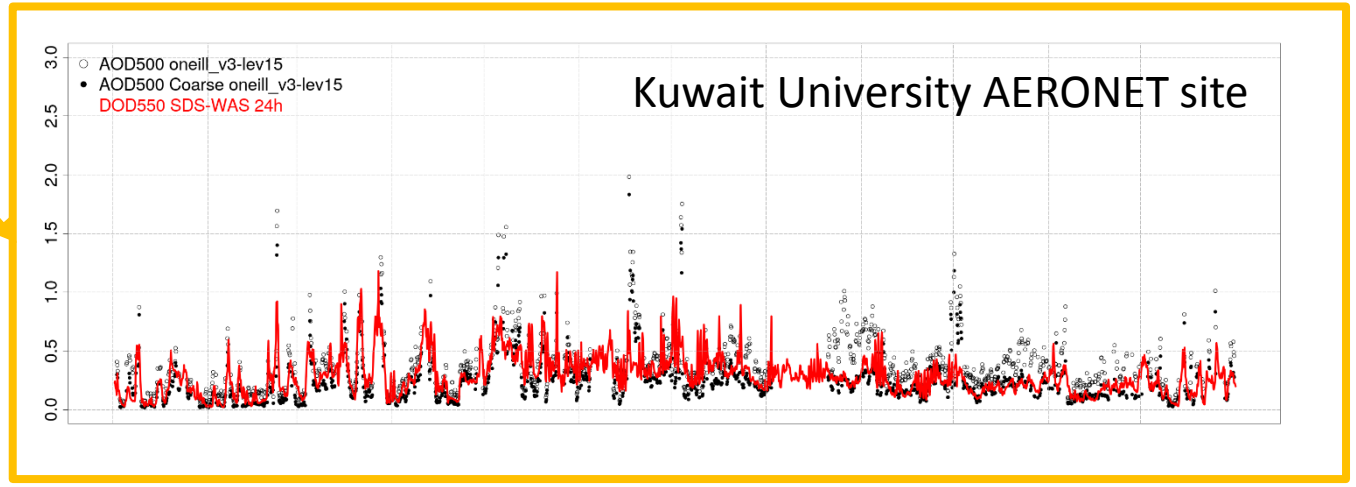
Dust forecasts: SDS-WAS Multi-model

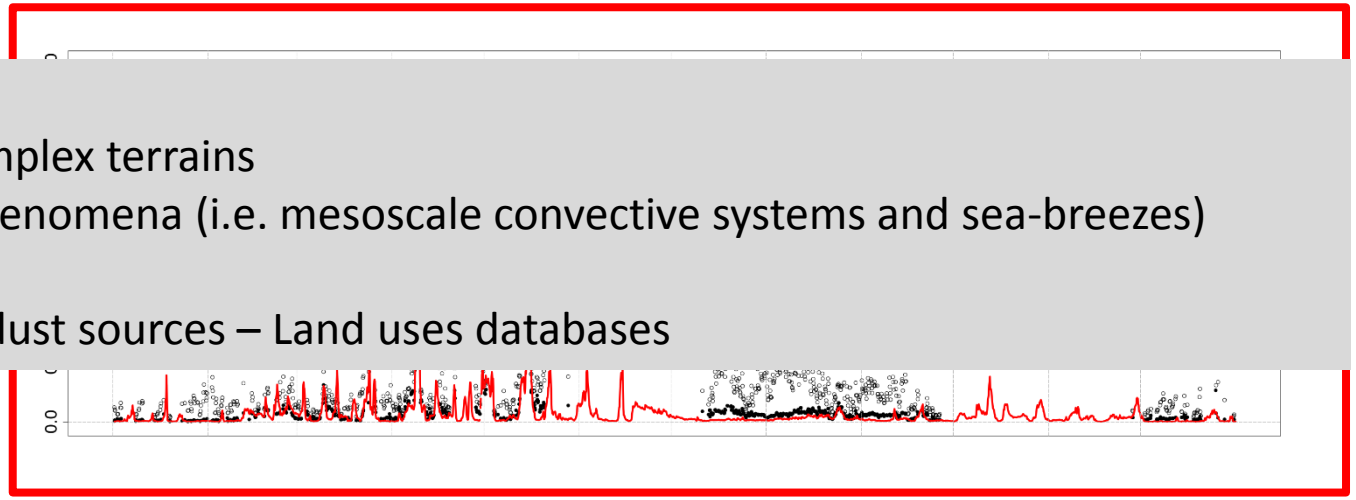
Dust-filtered AERONET evaluation for 2016

	NDATA	r	RMSE	MB	MAE
Directsun Version 3 Level 1.5 (dust filter based on AE < 0.75 is DOD and AE > 1.2 DOD = 0)					
Sahel/Sahara	8104	0.78	0.27	-0.12	0.15
Middle East	1744	0.63	0.22	-0.07	0.15
Mediterranean	10469	0.85	0.08	-0.02	0.05
All sites	20795	0.84	0.19	-0.06	0.10
O'Neill Version 3 Level 1.5 (only coarse fraction)					
Sahel/Sahara	4599	0.80	0.17	-0.02	0.09
Middle East	2272	0.64	0.15	0.01	0.08
Mediterranean	13318	0.84	0.06	-0.02	0.04
All sites	20189	0.83	0.11	-0.02	0.06

Dust forecasts: SDS-WAS Multi-model







Meteorolgy

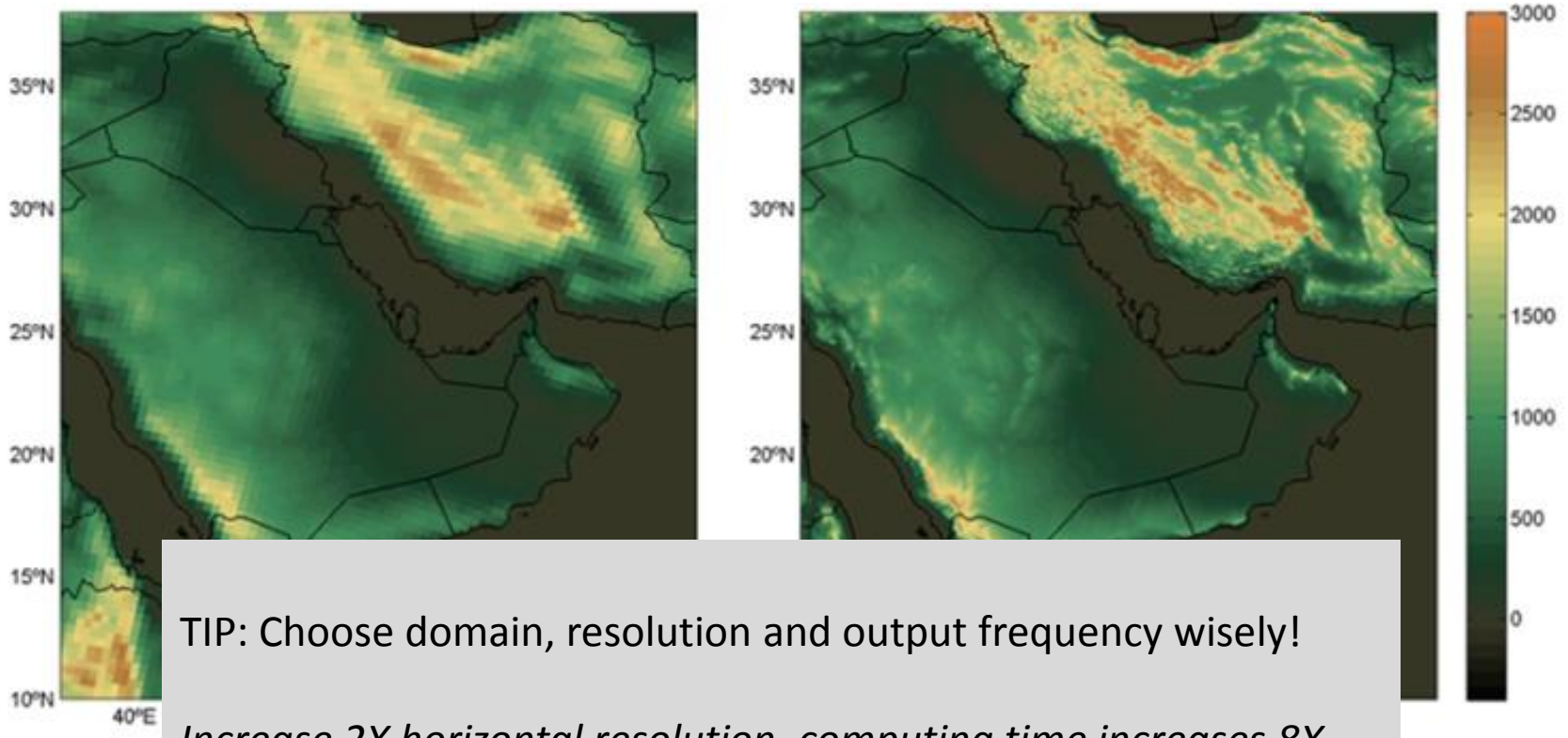
Topography - Complex terrains

Smaller-scales phenomena (i.e. mesoscale convective systems and sea-breezes)

Dust emissions

Identification of dust sources – Land uses databases

Topographical impacts on dust transport



TIP: Choose domain, resolution and output frequency wisely!

Increase 2X horizontal resolution, computing time increases 8X (on the same number of processors).

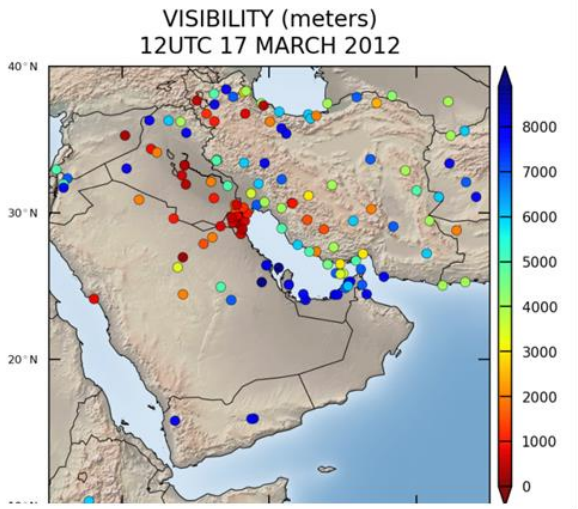
→ Double the number of vertical levels is additional 2X.

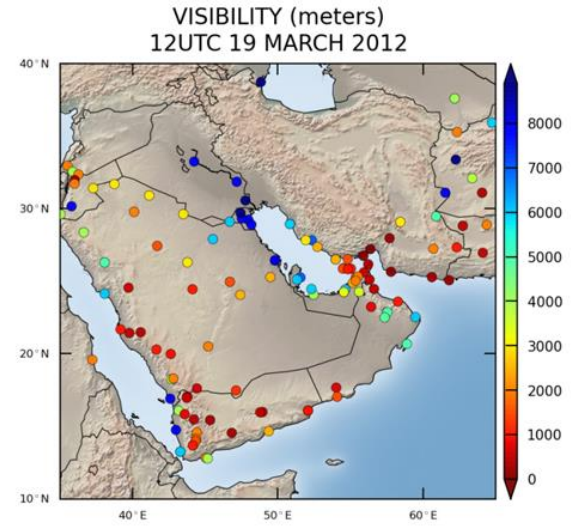
Two simula … MB-MONARCH … cinity of complex te…

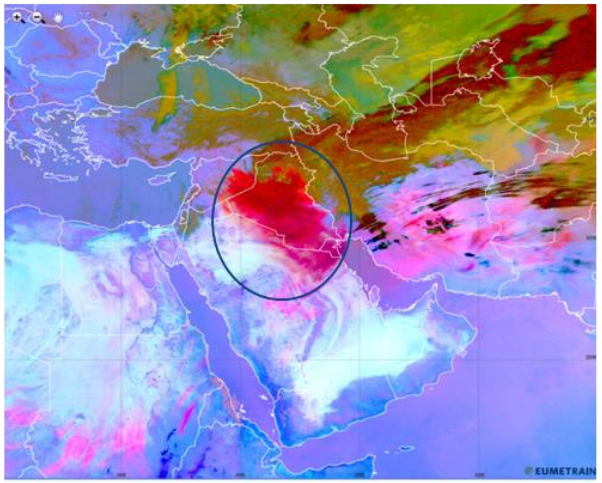
Model configuration: LR (0.33º, ~33km), HR (0.03º, ~3km), 40 levels, FNL as meteo. Initial conditions
Forecast time: 10 – 21 March 2012

(Basart et al., Aeolian Research, 2016)

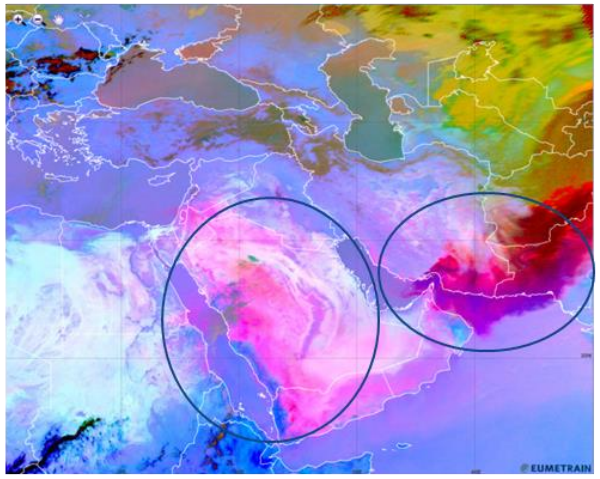
Topographical impacts on transport
Dust event on March 2012







Dust emission in Iraq



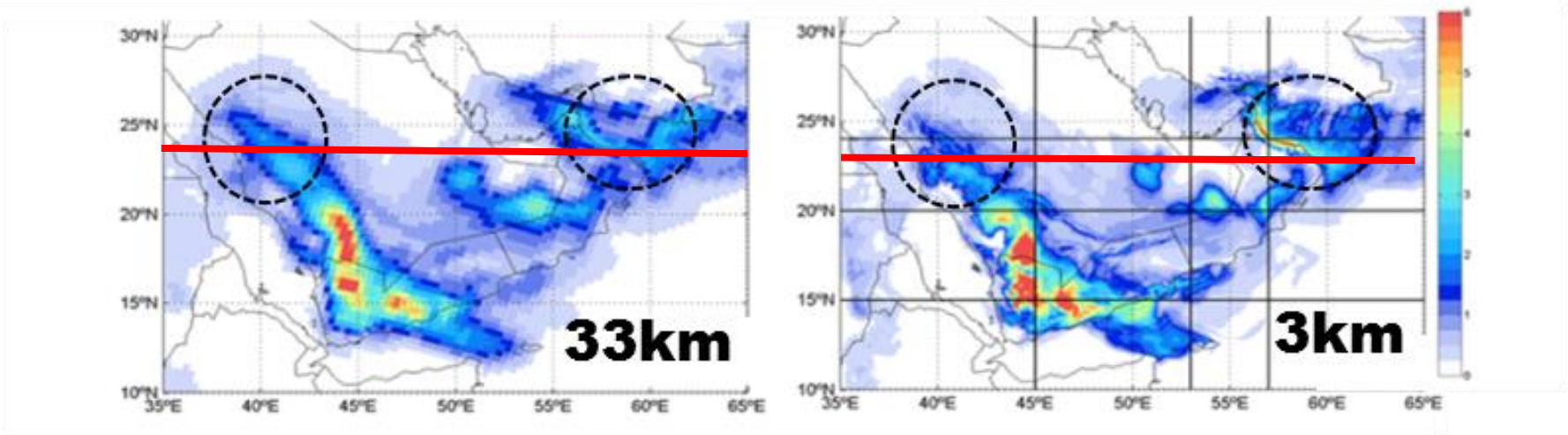
Dust from Iran and Afganisthan/Iran border reaches Oman coasts

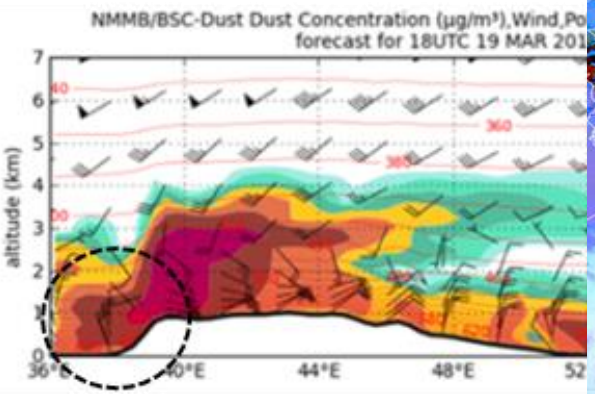
Dust from Iraq reaches Yemen

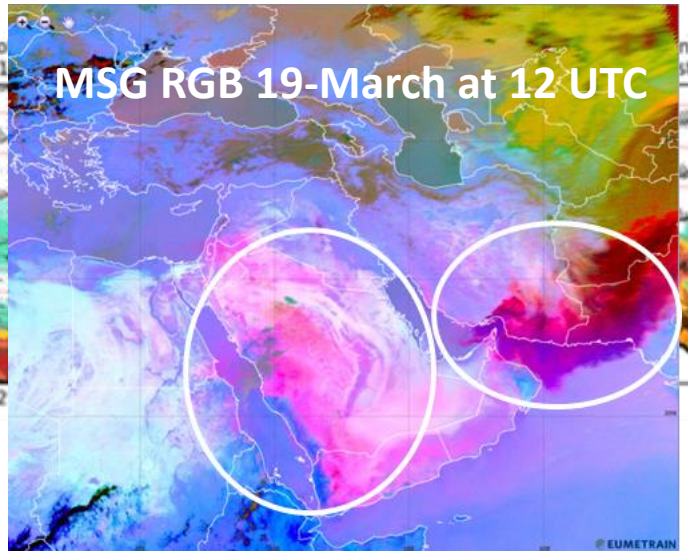
(Basart et al., Aeolian Research, 2016)

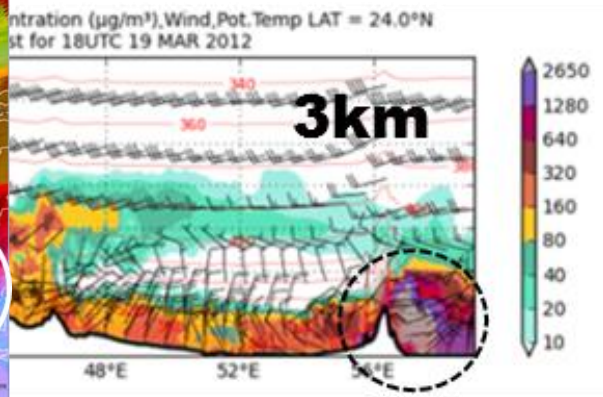
Topographical impacts on dust transport

NMMB/BSC-Dust 19-March-2012 18UTC





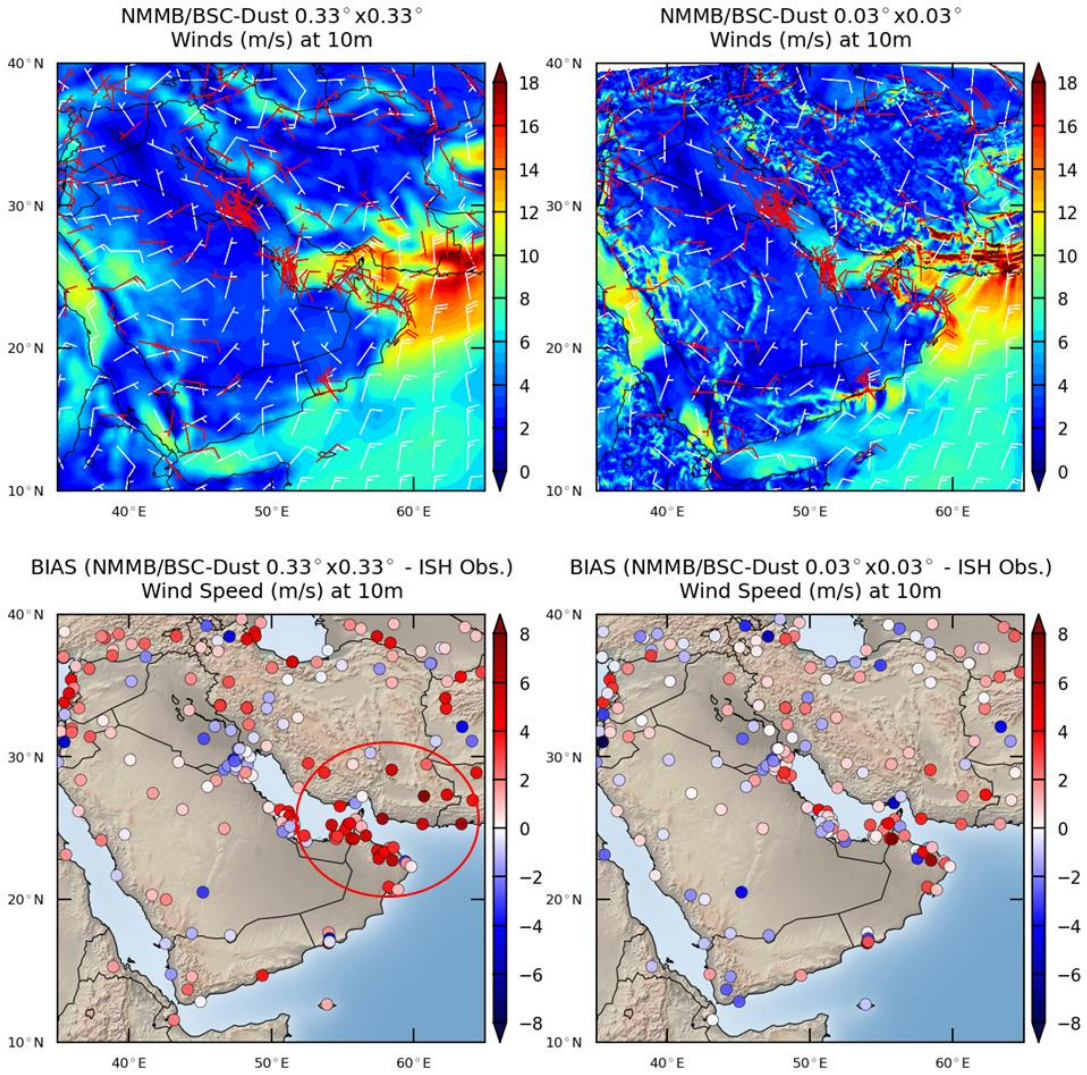




(Basart et al., Aeolian Research, 2016)

Topographical impacts on dust transport

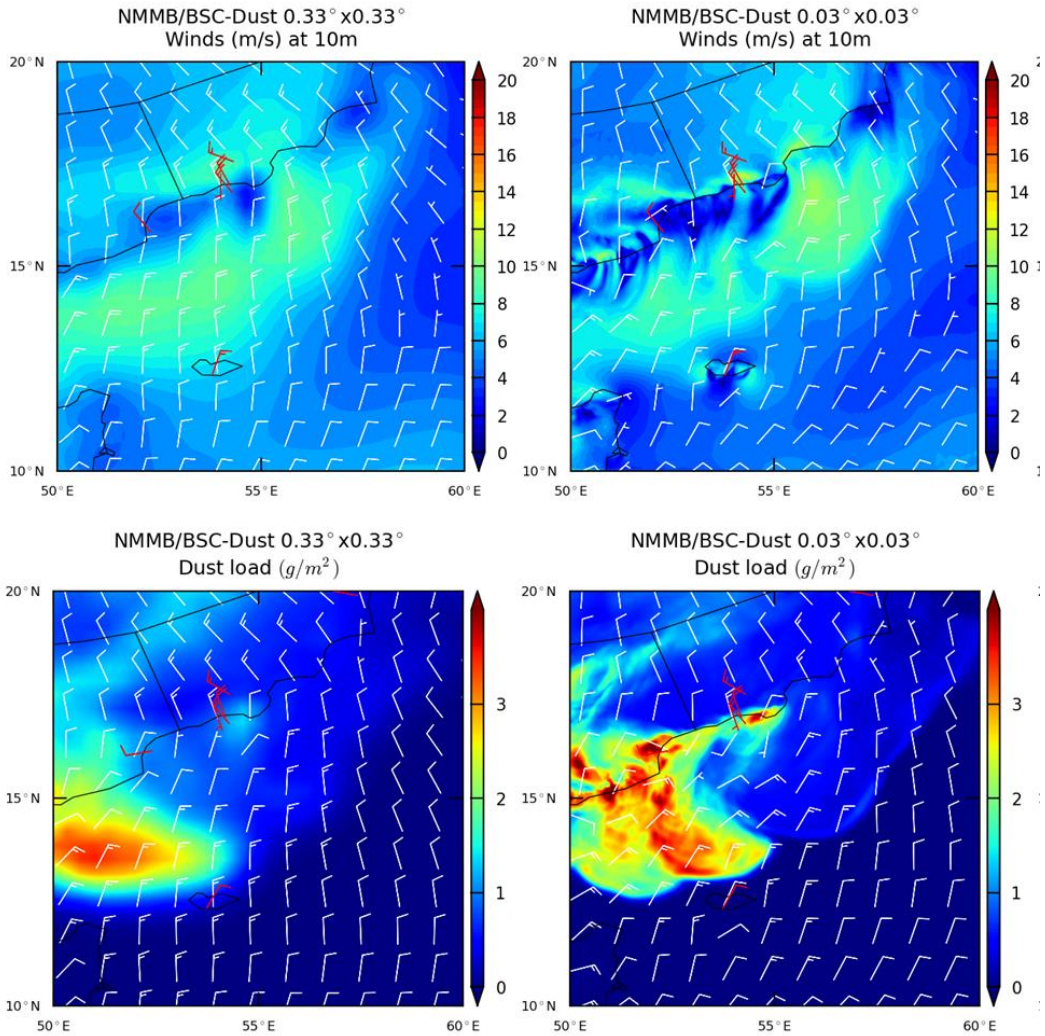
NMMB/BSC-Dust 19-March-2012 21UTC

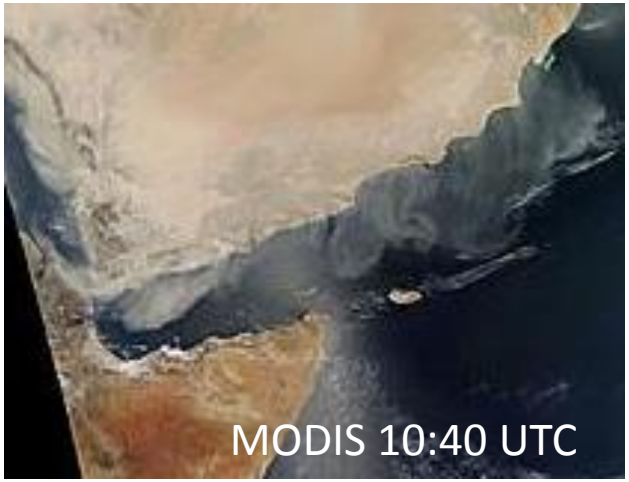


(Basart et al., Aeolian Research, 2016)

Topographical impacts on dust transport

NMMB/BSC-Dust 20-March-2012 12UTC





(Basart et al., Aeolian Research, 2016)

Iranian Haboob: Teheran 2nd June 2014

Ongoing SDS-WAS Study Case

The event was local (several 100km), intense (several 1000μg/m^3 PM10) & short lived (few hours) dust storms

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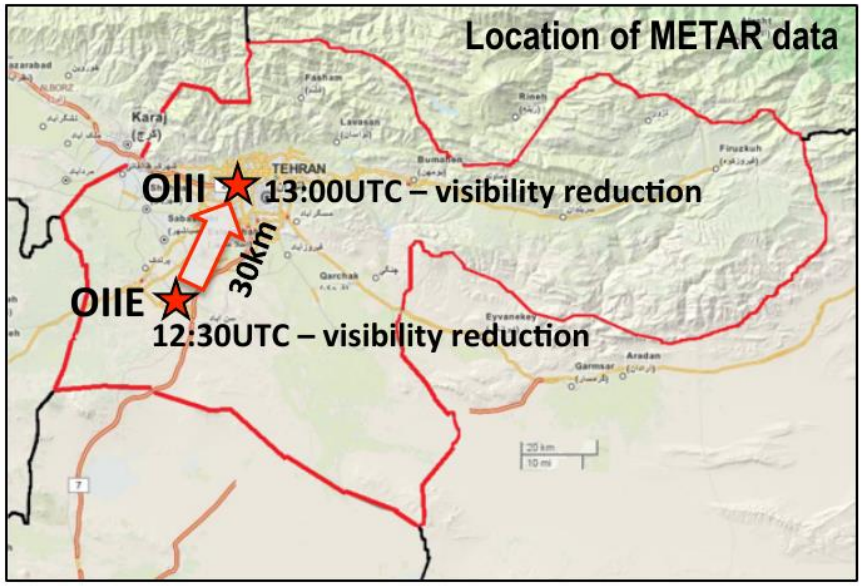
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

Information from reports

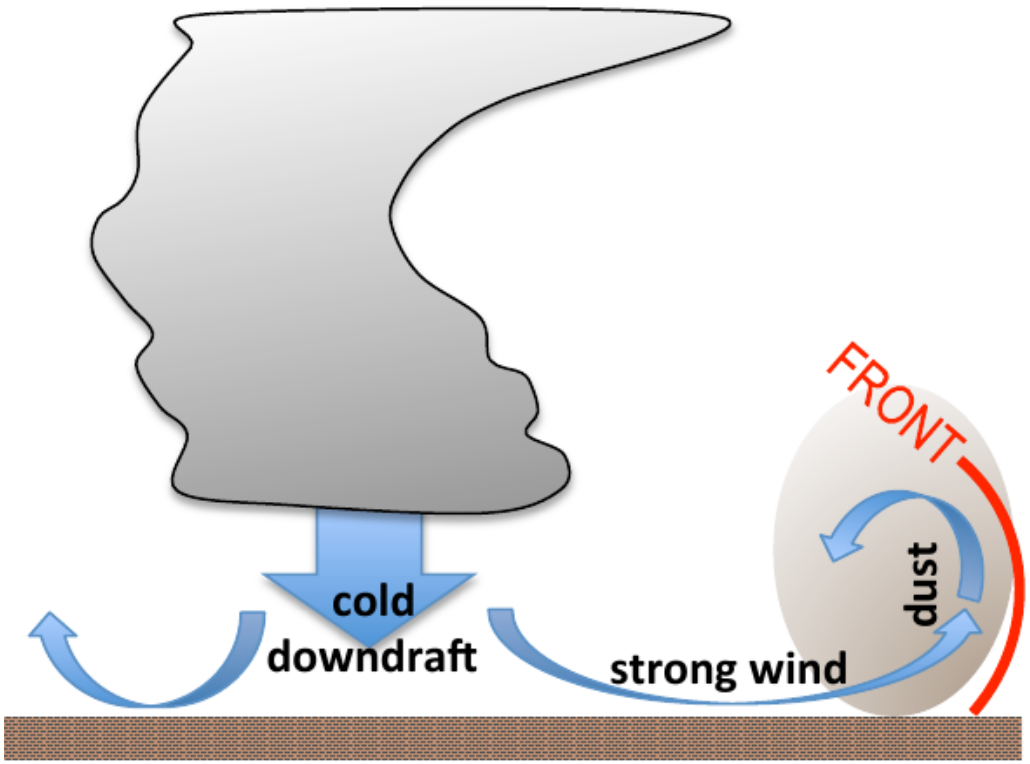
- reached city at 5.30 p.m. local time;
- passing of the sand storm over the fixed site lasted about 15min;
- storm duration less than 2h;
- reduction of visibility to ~10m; wind velocity reached 110 km/h;
- temperature dropped from 33 to 18ºC in several min;
- at least 5 deaths, 82 injured; multiple vehicle collision;



(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

Intensive cold downbursts from convective cells produced high velocity surface wind, creating cold front which was lifting, mixing and pushing dust towards the city;

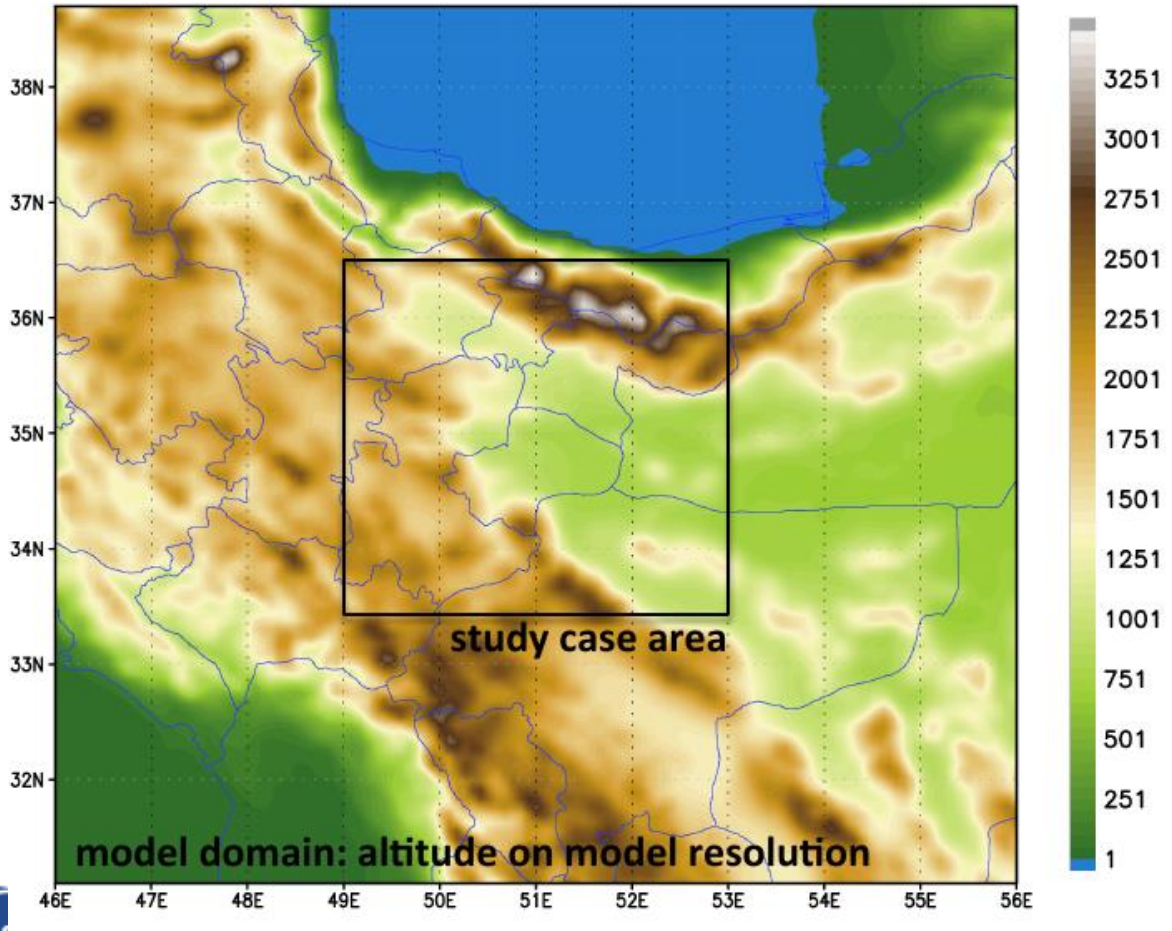


Expected: high wind speed, drop in temperature, rise in humidity, rise in pressure, reduction of visibility.

(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

DREAM – SEEVCCC: NMME atmospheric driver (Vukovic et al. 2014 – HR simulation)
(Perez et al. 2006, Nickovic 2001)
Model domain: lat 31N-39N, lon 46E-56E; Model resolution: 1/40 horizontal (~4km); 60 vertical levels
Forecast time: 12UTC 01 June 2014 – 00UTC 03 June 2014 (36h)
Time of the event: about 12-15 UTC 02 June 2014

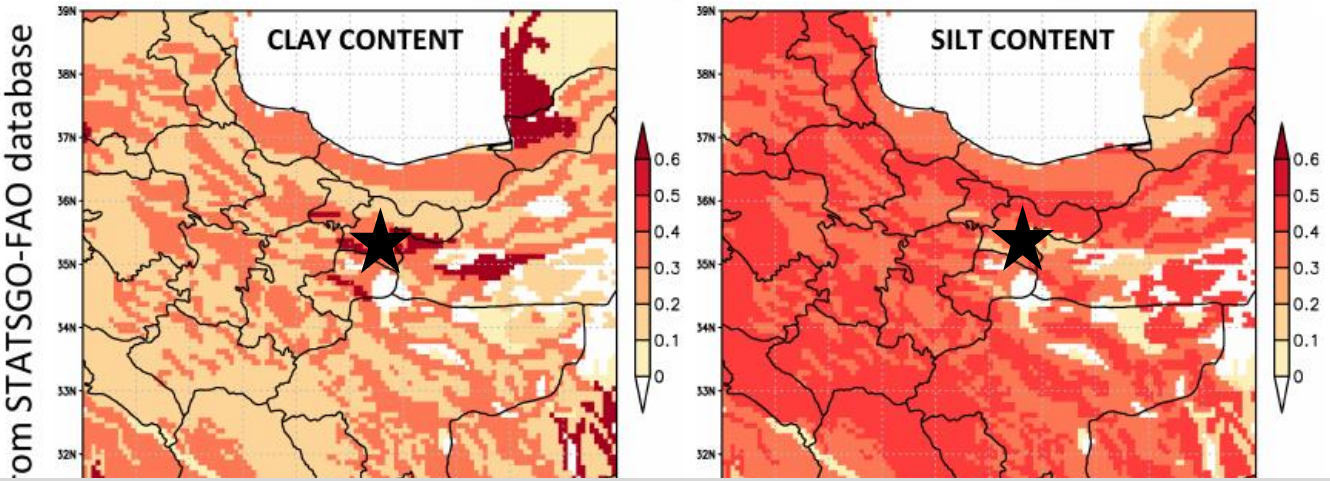


The main goal:
To create tool for forecast of intense local short lived dust storms in service of warning system.

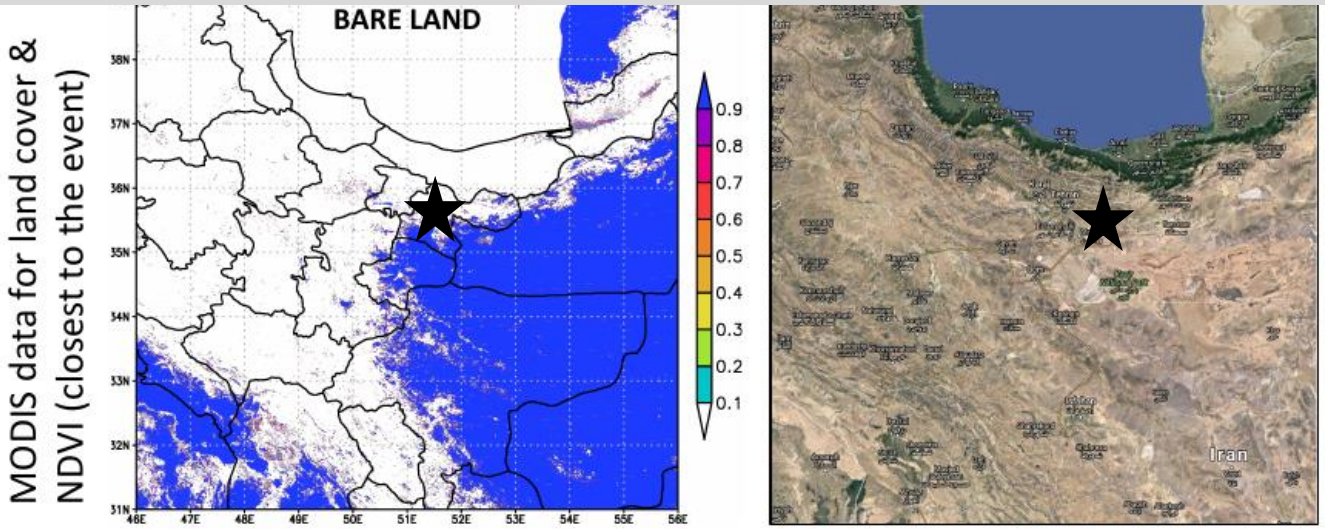
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

clay size particles source potential = (clay content)*(bare land)
silt size particles source potential = (silt content)*(bare land)



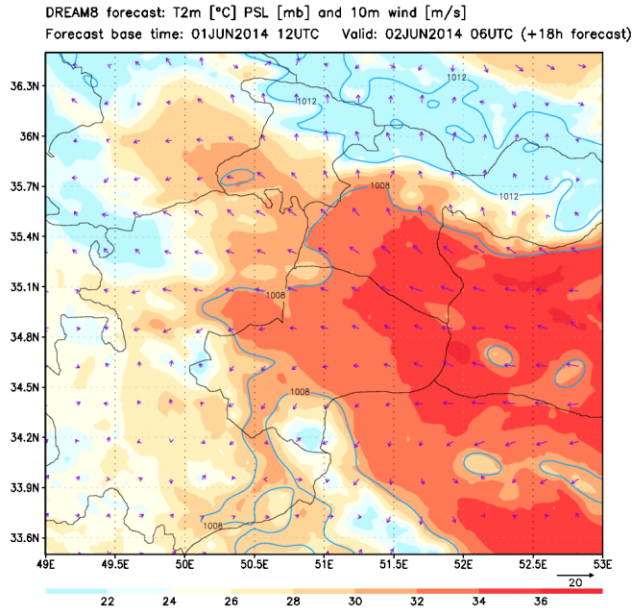
High-resolution dust modelling ↔ High-resolution updated land databases

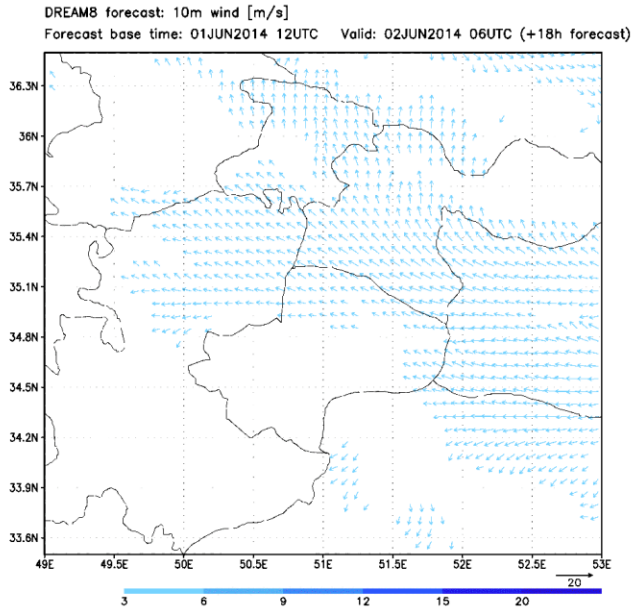


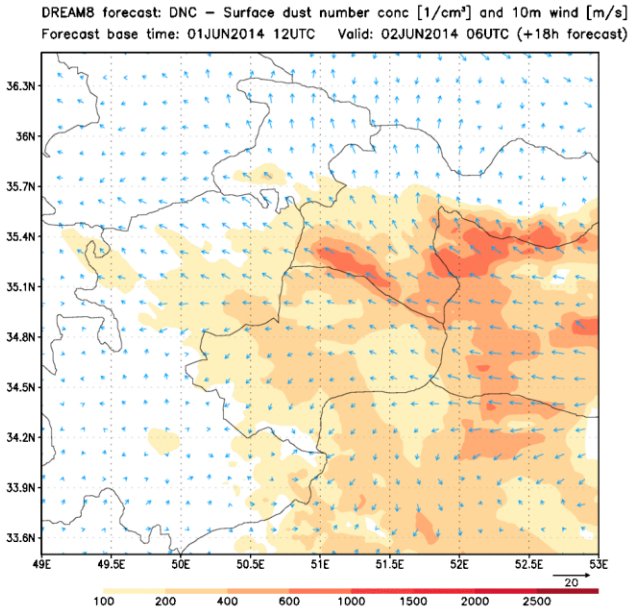
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

NMME-DREAM (SEEVCCC) simulation results for the period 06-20 UTC 2014







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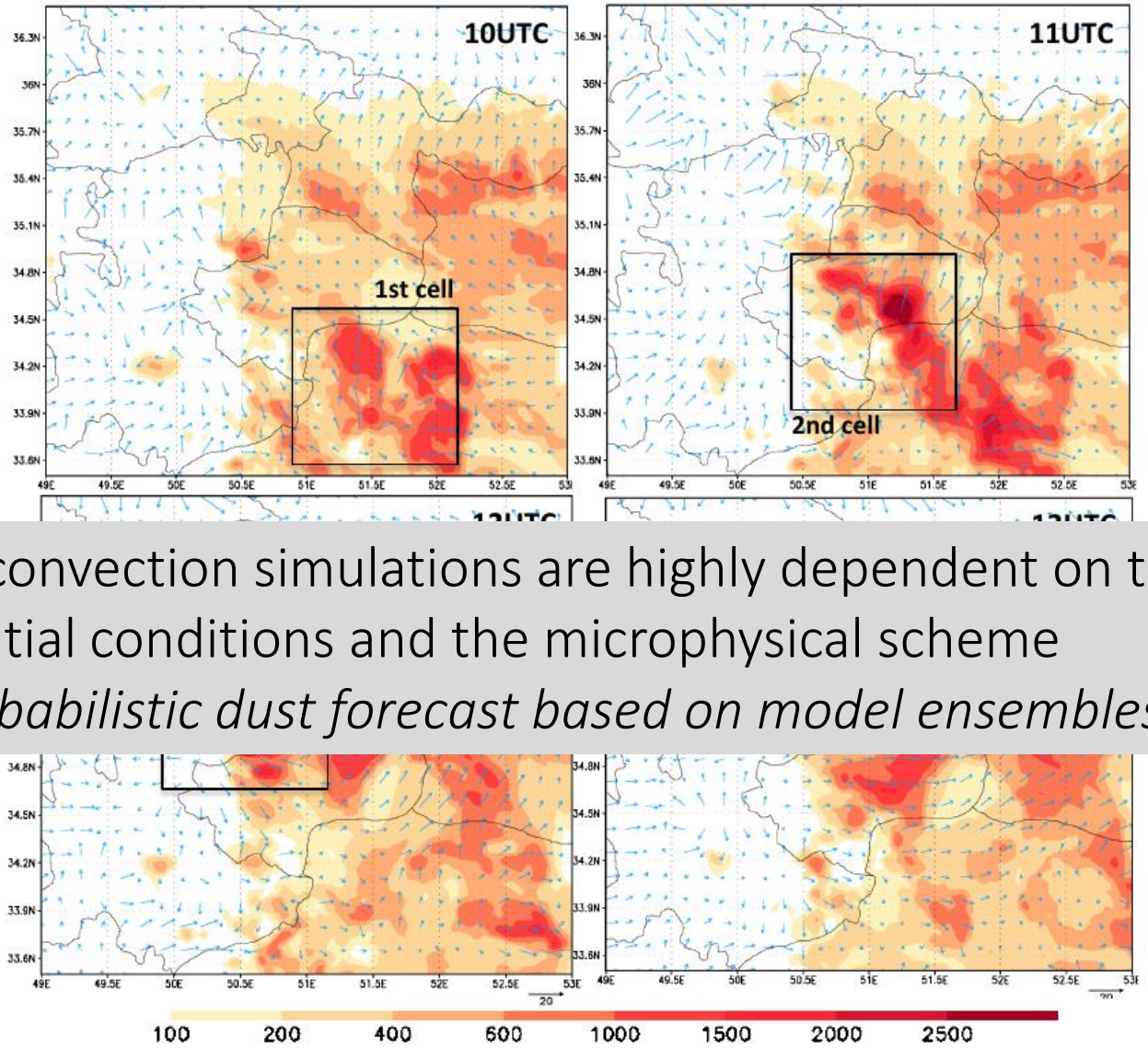
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

DNC
(surface)
Dust Number
Concentration
number of dust particles in cm^3

Dust uplift and transport controlled with three main cells.

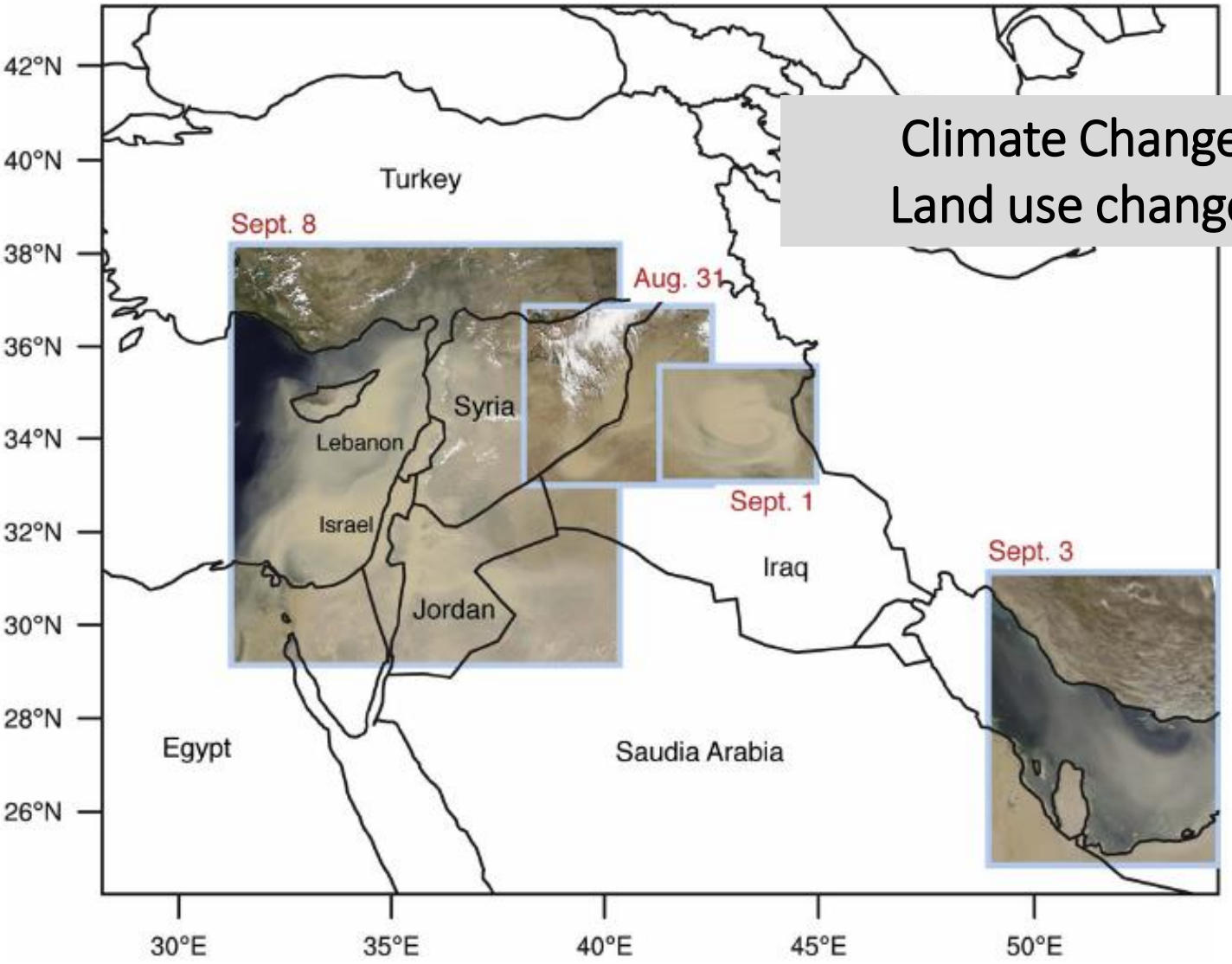


Explicit convection simulations are highly dependent on the initial conditions and the microphysical scheme

→ *Probabilistic dust forecast based on model ensembles*

(Vukovic et al., in preparation)

Exceptional dust event on September 2015



Climate Change?
Land use change?

Extracted from (Parolari et al., 2016)

Exceptional dust event on September 2015

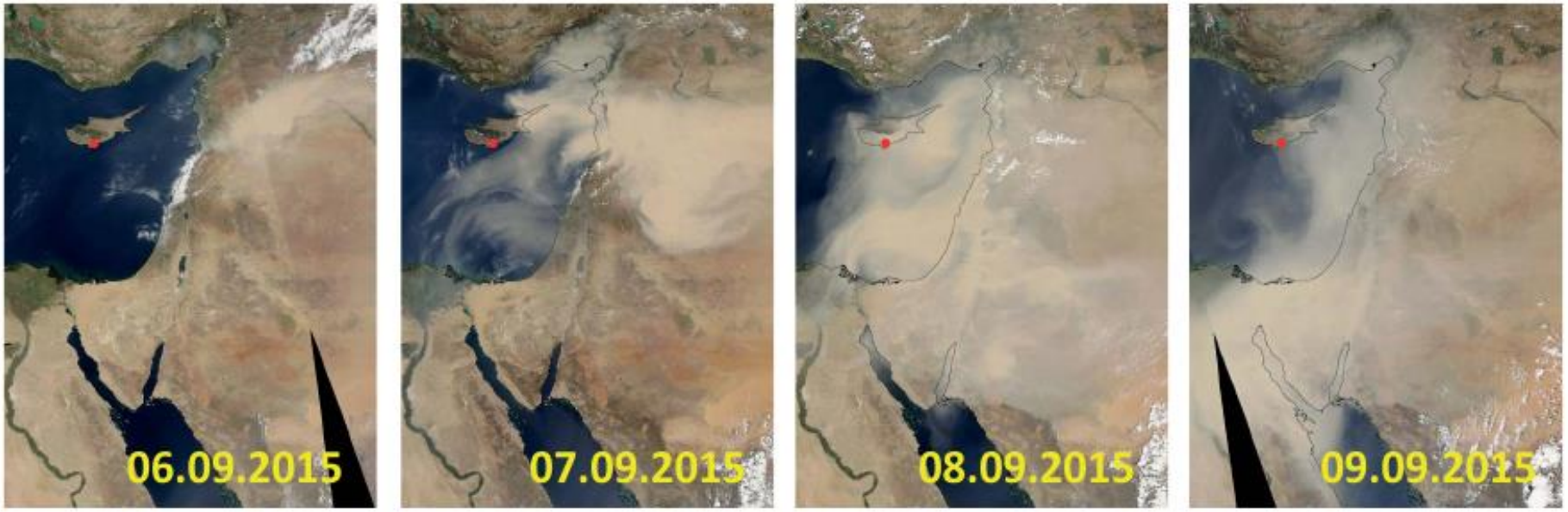
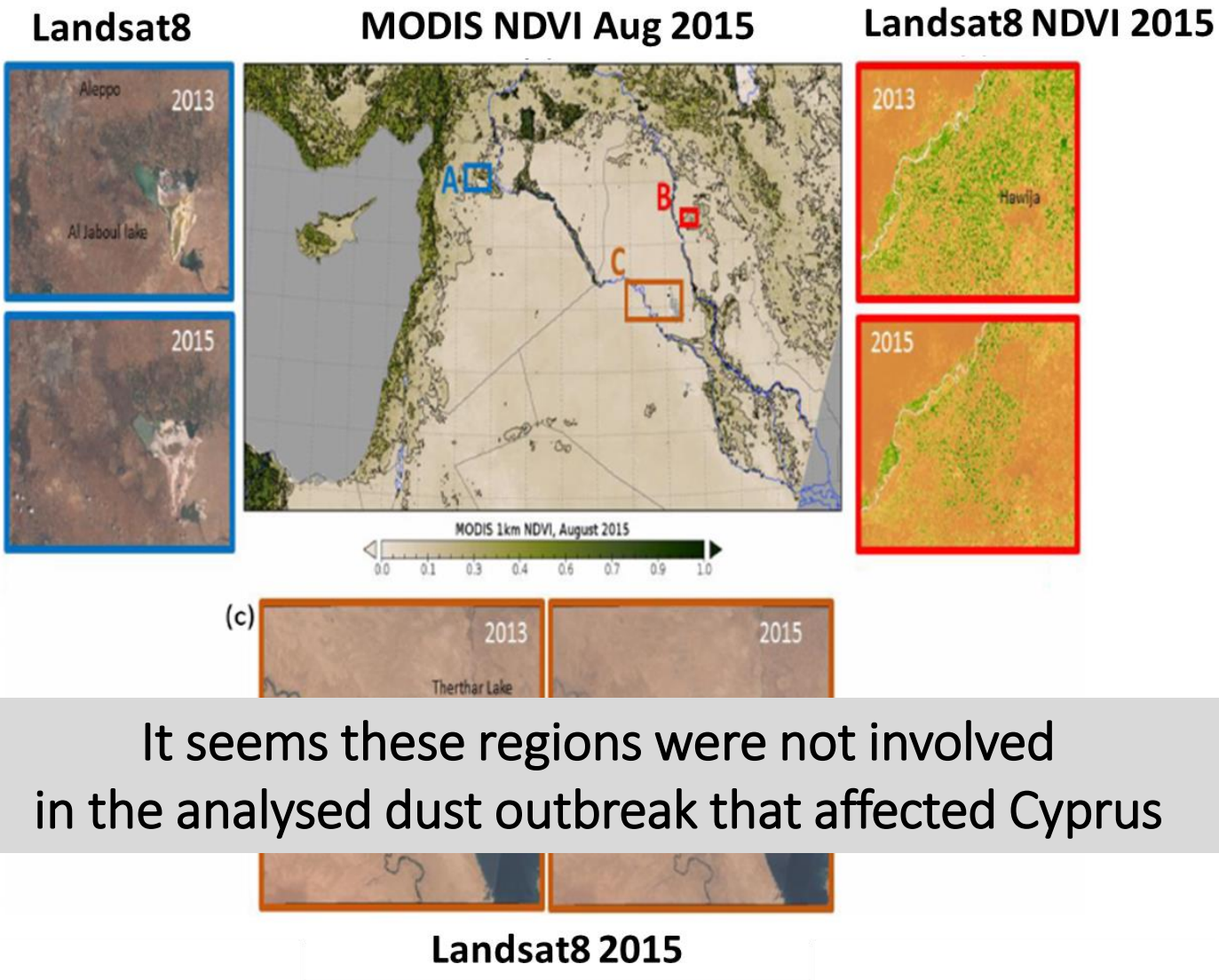


Figure 2. Dust outbreak towards Cyprus in September 2015 as seen from space (aqua-MODIS, 10:30–11:30 UTC overpasses, 13:30–14:30 EEST, Eastern European Summer Time). Red points indicate Limassol.

Extracted from (Mamouri et al., 2016)

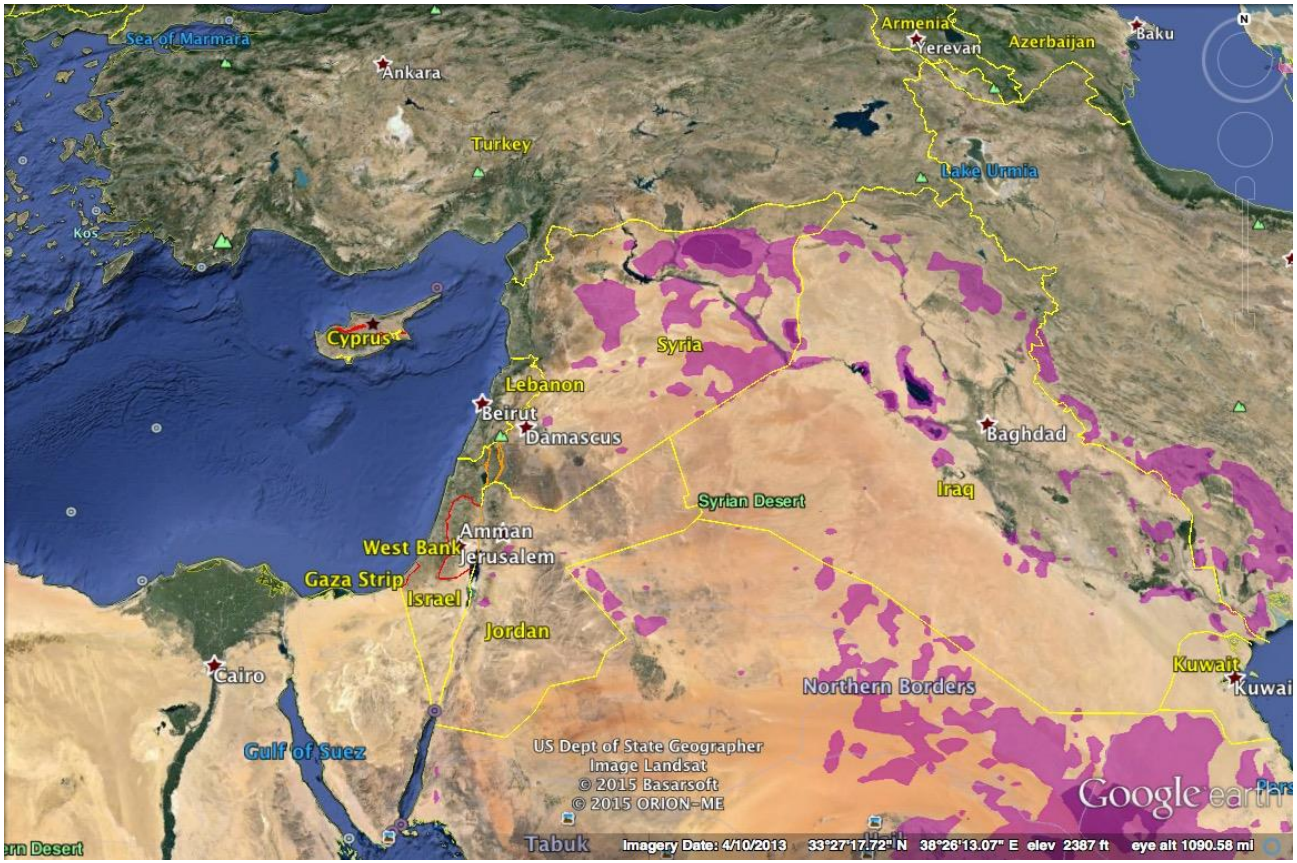
Exceptional dust event on September 2015



It seems these regions were not involved
in the analysed dust outbreak that affected Cyprus

Extracted from (Solomon et al., 2017)

Exceptional dust event on September 2015



*Frequency of dust storms over **agriculture** derived from MODIS Deep Blue (Ginoux et al., Rev Geophys., 2012). Highest frequency where the storm originated.*

Extracted from (Ginoux et al., 2012)

Exceptional dust event on September 2015

First cold-pool outflow, heat low and Eastern Mediterranean sea-breeze

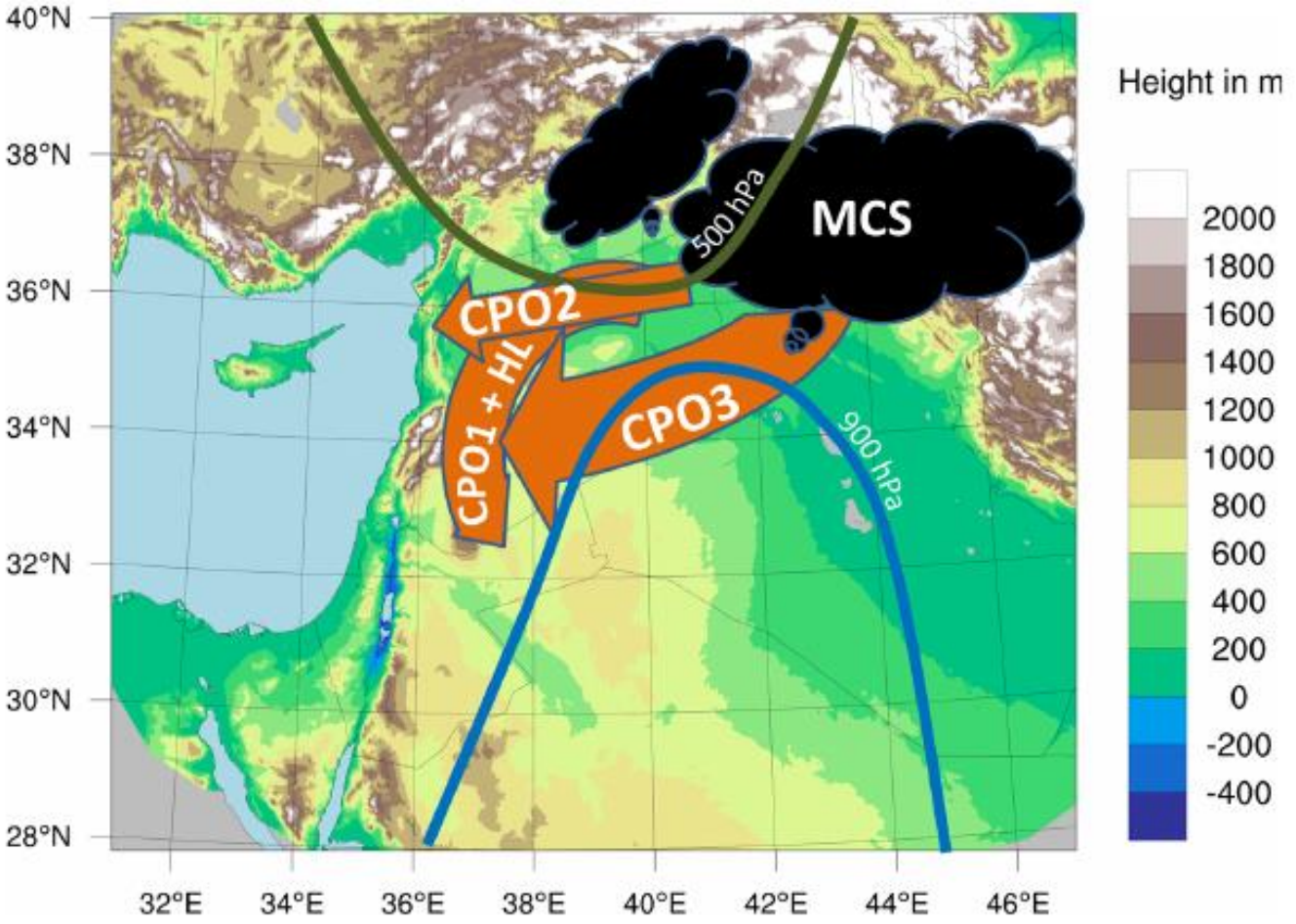
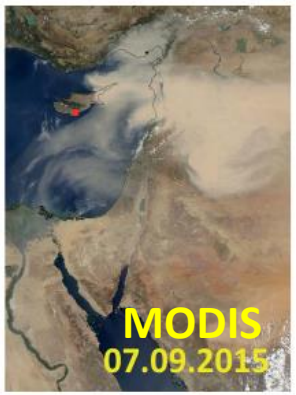
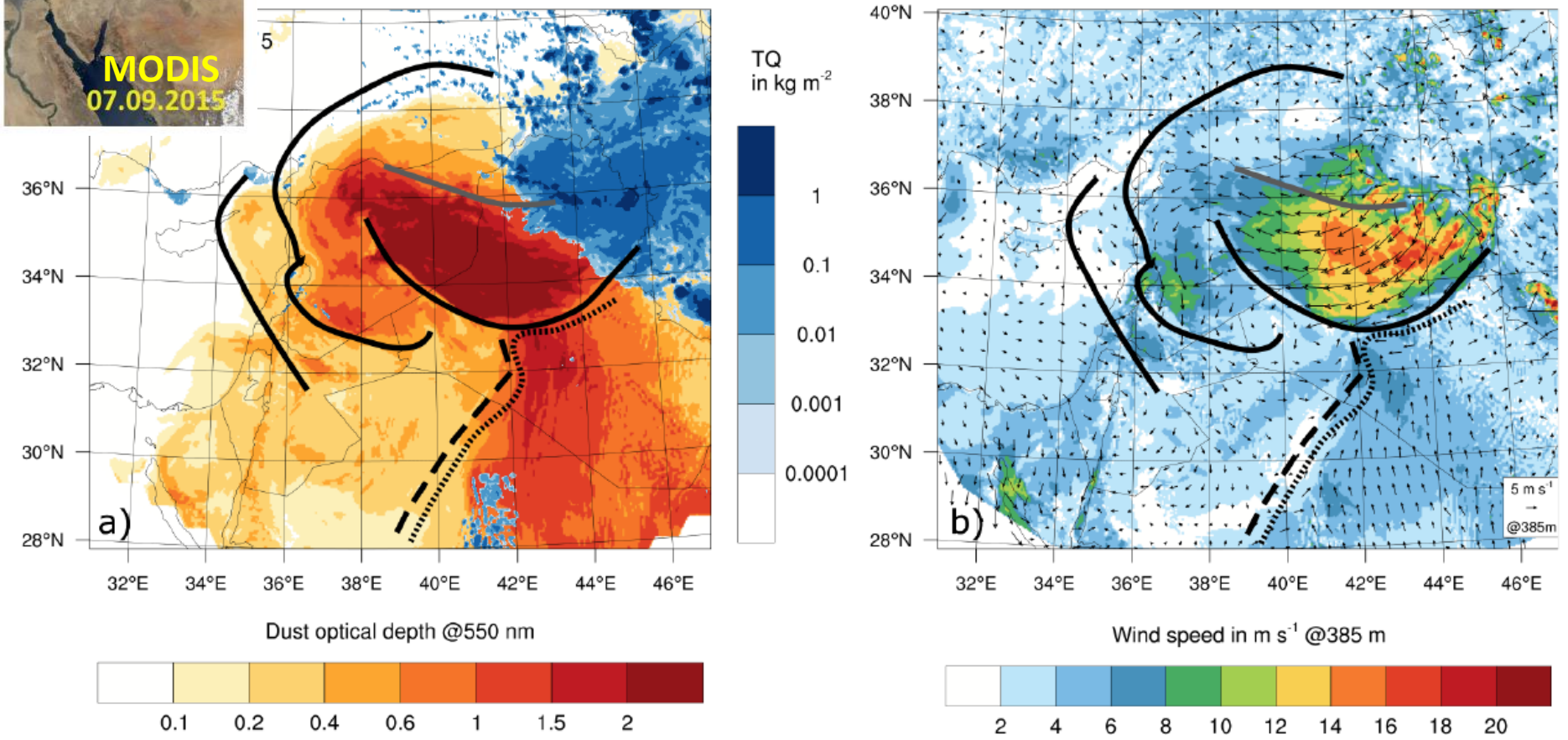


Figure extracted from (Gasch et al., 2017)

Exceptional dust event on September 2015



ICON-ART at 10UTC 7 September
(global-parent domain usign IFS as initial conditions provides boundaris to 4 nested domains at 2.5km)



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Extracted from (Gasch et al., 2017)

Summary and conclusions

Why high-resolution dust modelling for the Middle East?

- To improve the representation of the topography of the region
  - ✓ *This will improve the meteorological and dust forecasts*
- To better predict smaller scale sand and dust storms
  - ✓ *Convective dust storms requires explicity convection (< 4km)*

Towards high-resolution forecasts: Modelling requirements

- A non-hydrostactic model capable to run in HPC platforms
- High-resolution and update land surface databases
  - ✓ *Identification of dust sources*
- Dust ground-based and satellite observations
  - ✓ *Model Evaluation and Data Assimilation*
- Probabilistic forecasting of smaller scale SDS – Model Ensembles
  - ✓ to constrain the uncertainty associated to the dust forecasts: *initial conditions, microphysic scheme, …*

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Thank you

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