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EXCELENCIA SEVERO OCHOA

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Dustpredictionmodels

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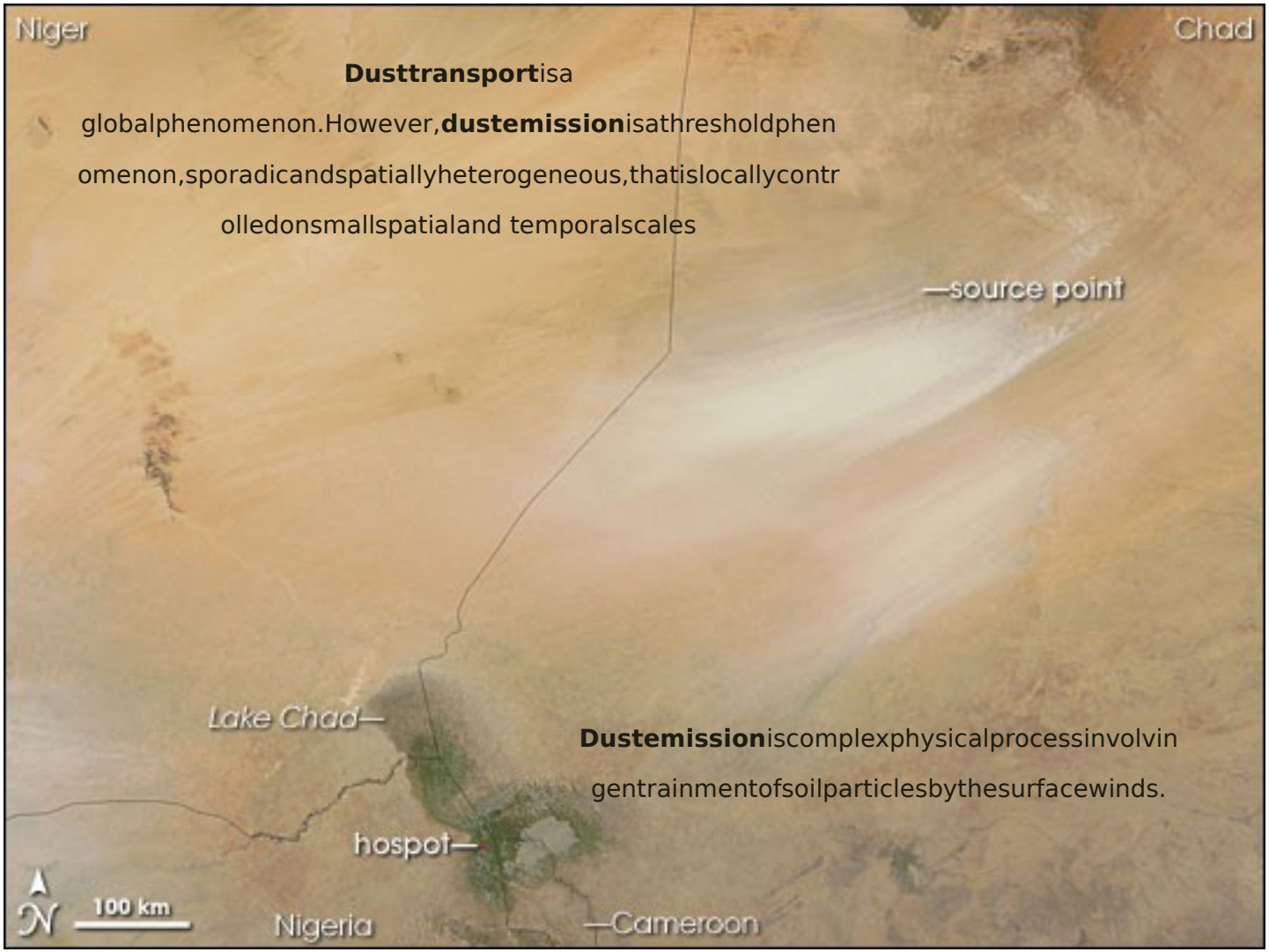
EarthSciencesDepartment, BarcelonaSupercomputingCenter

1st Africa/Middle-East Expert Meeting and Workshop on the health impact of airborne dust

Amman,Jordan,2nd November2015

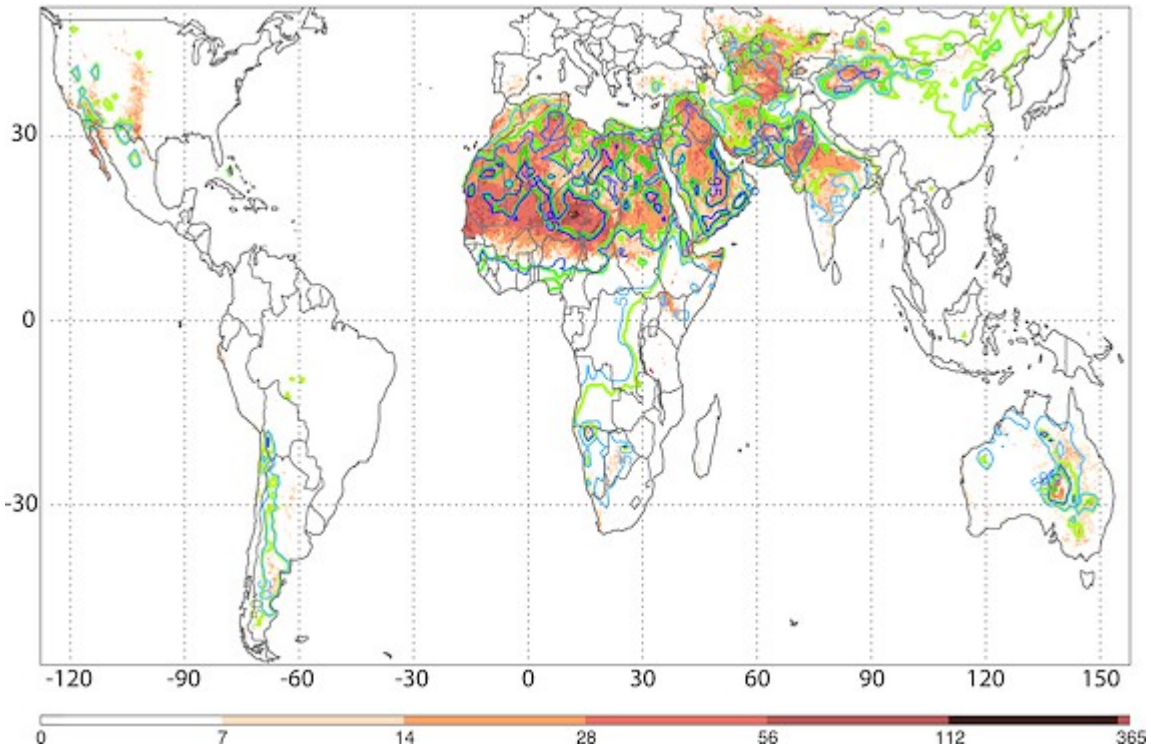
Questions will be welcome!

Dust cycle and associated processes



Dust cycle and associated processes

Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products (extracted fromGinouxet al., 2012)



Naturaldustsourcesgloballyaccountfor75% ofemissions;anthropogenicsourcesaccountfor25%.

Dust cycle and associated processes

Types of dust storms:

Synopticduststorms(largescaleweathersystems)

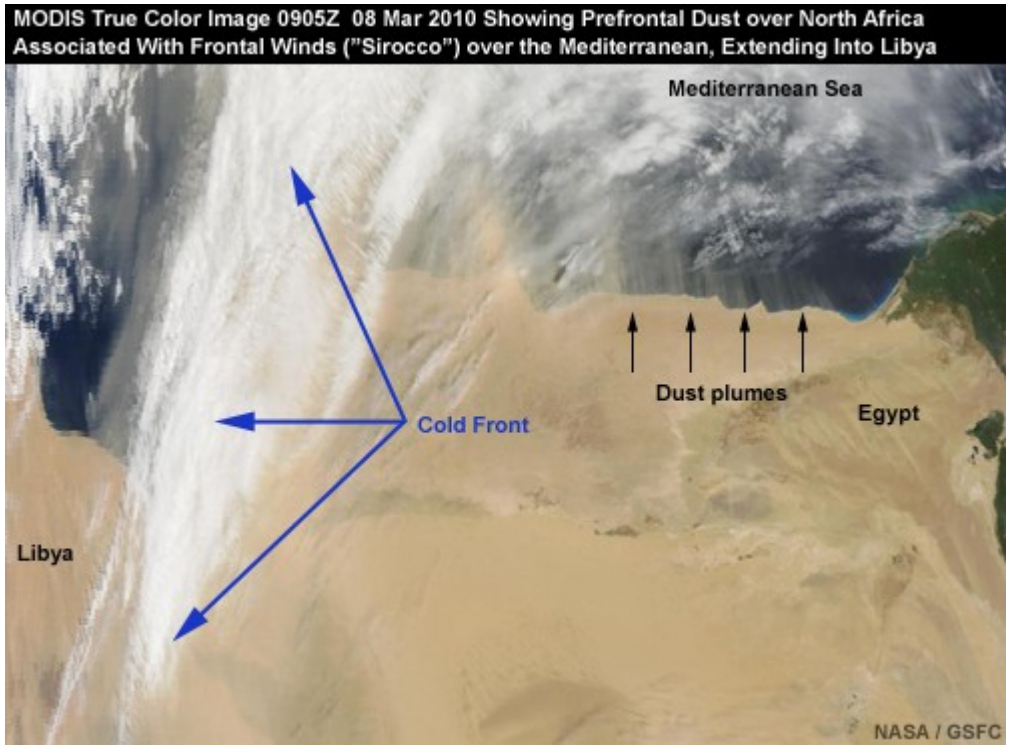
- Prefrontalwinds
- Postprontalwinds
- Large-scaleTradewinds
- …

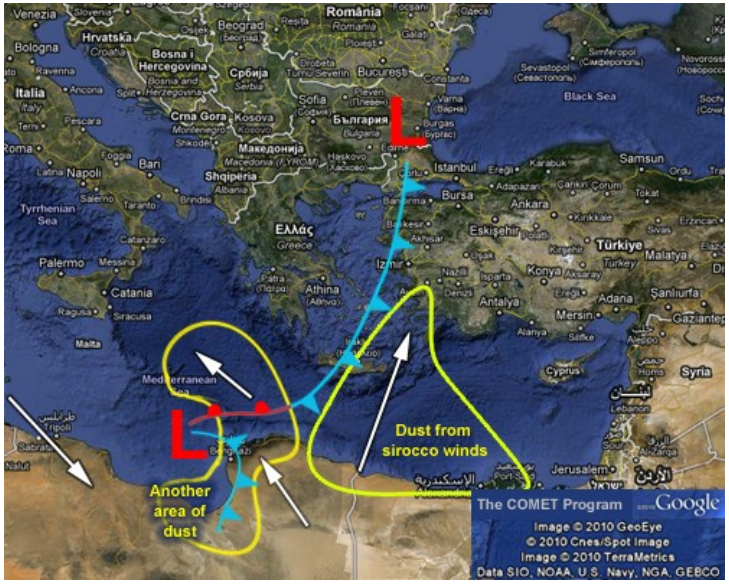
Mesoscaleduststorms

- Downslopewinds
- Gapflow
- ConvectionandHaboobs
- Inversiondownburststorms
- …

Dust cycle and associated processes

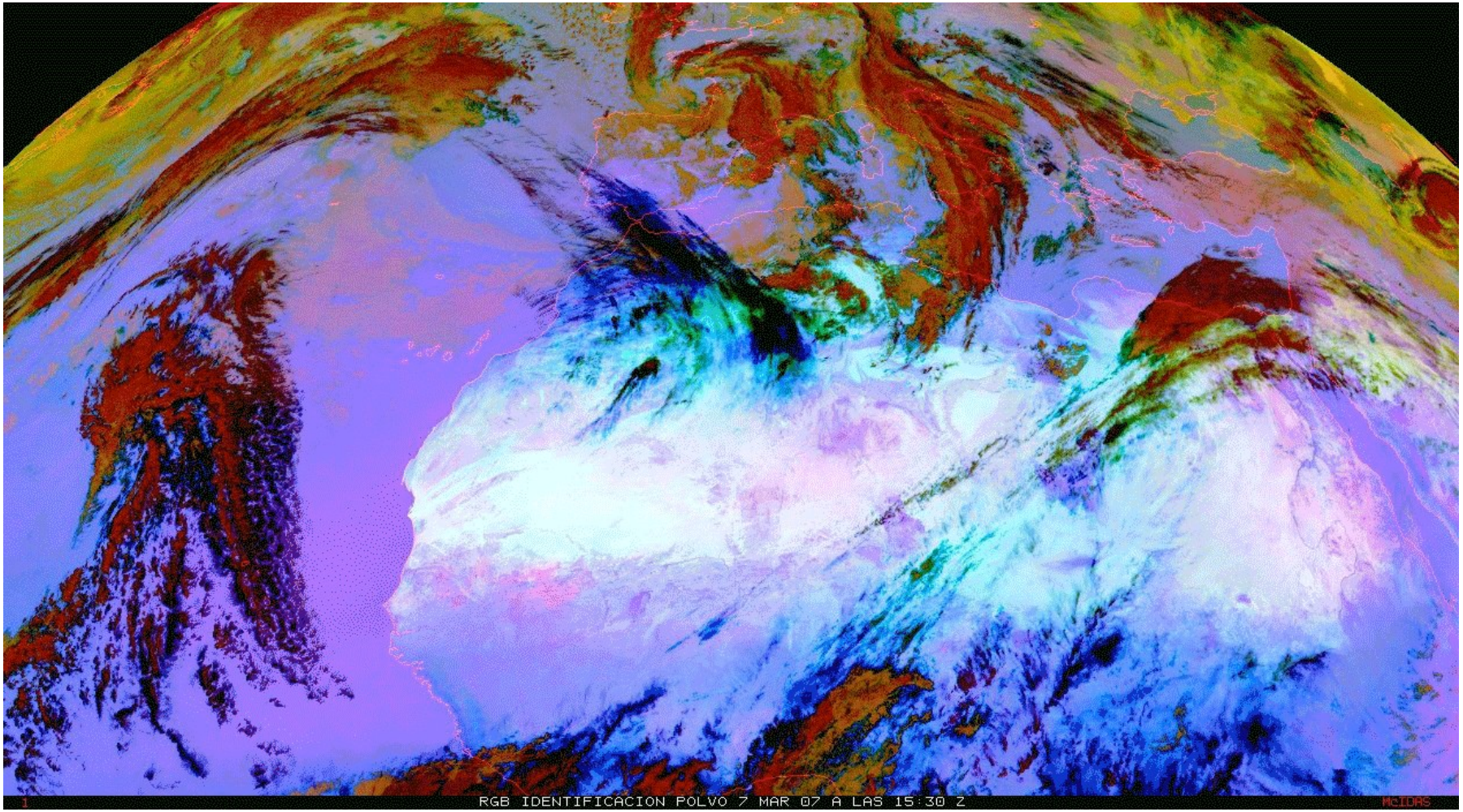
Synopticduststorms: Pre-frontal





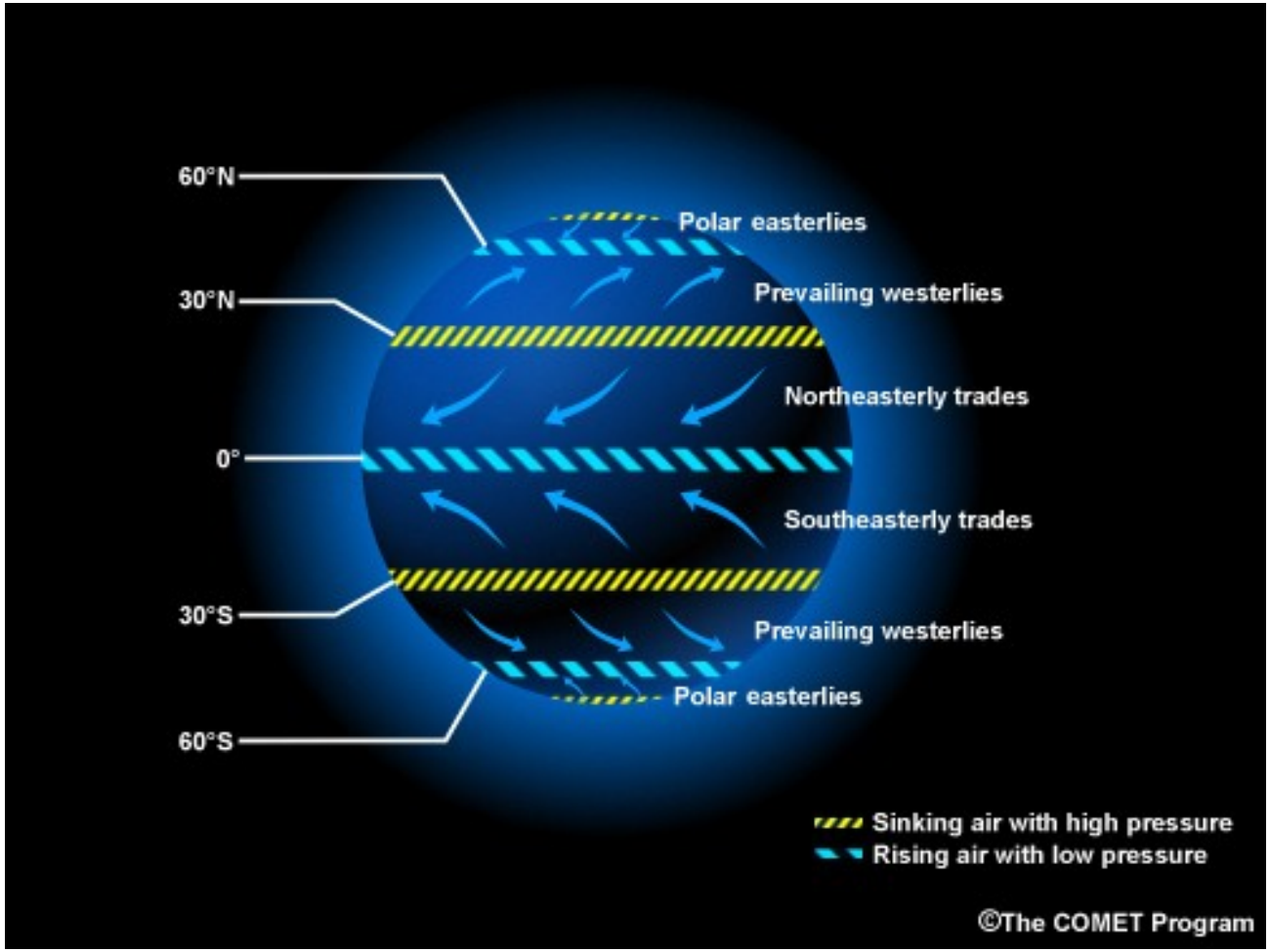
Dust cycle and associated processes

Synopticdusts storms: Post-frontal



Dust cycle and associated processes

Synopticdusttorms:Large-scaletradewinds



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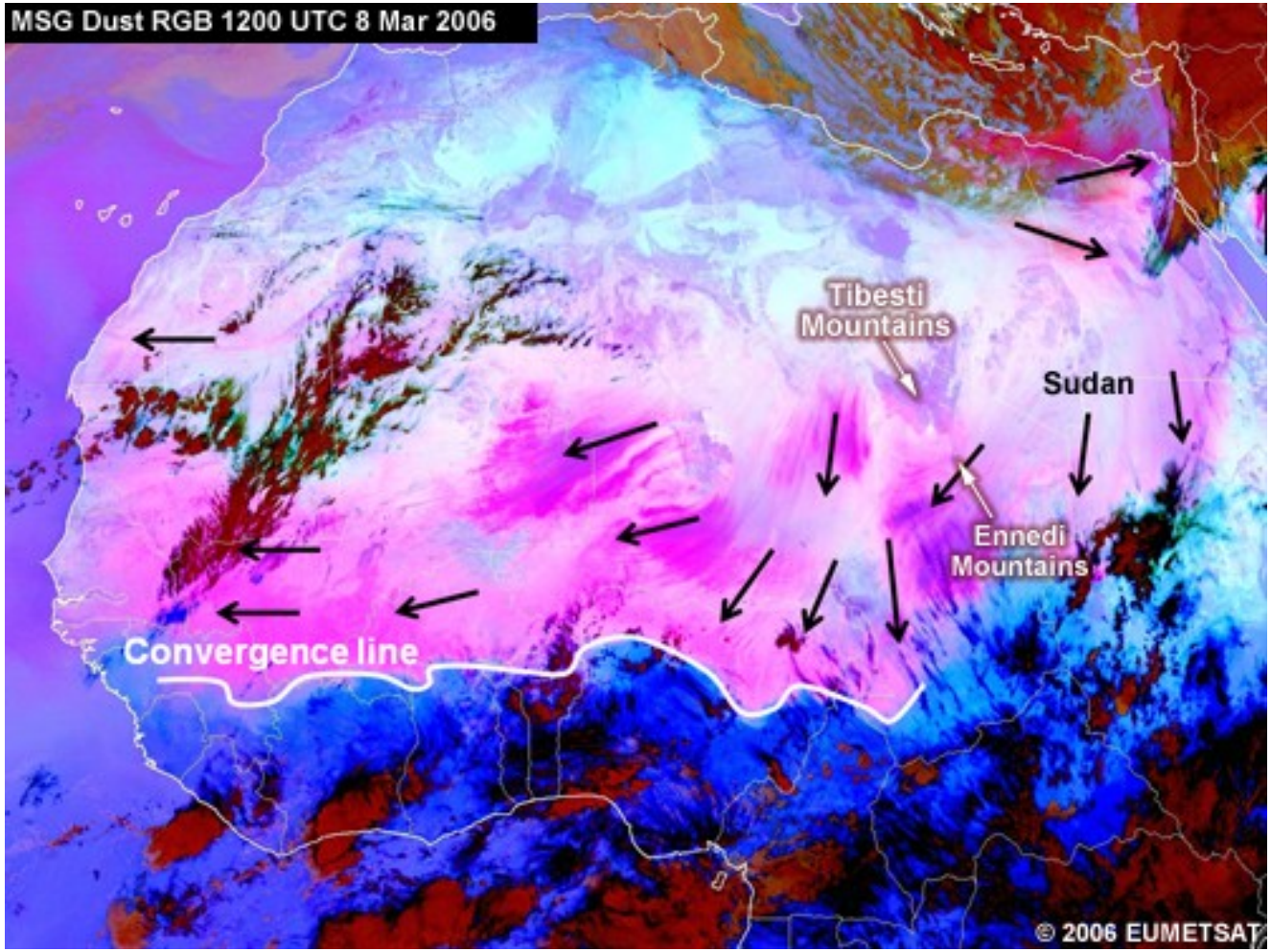
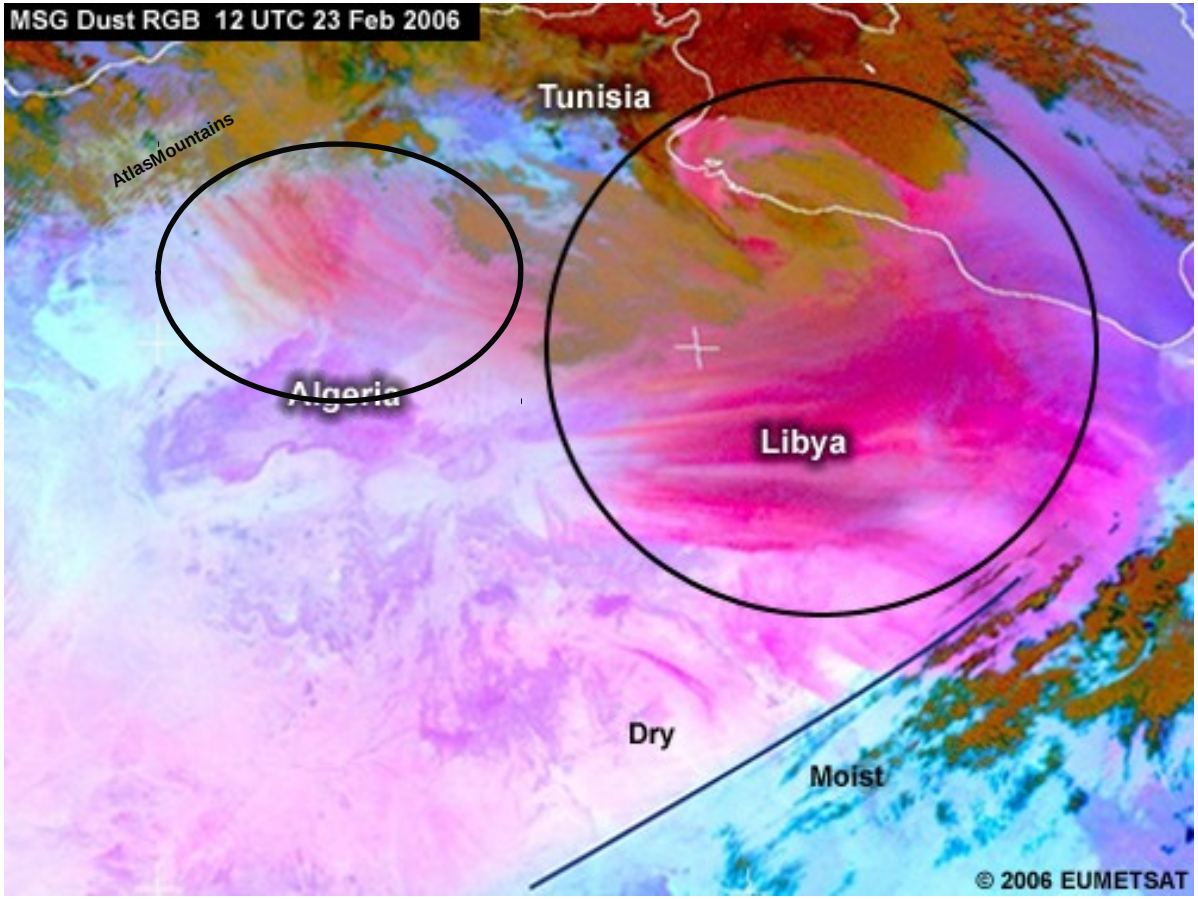
Dust cycle and associated processes

Synopticduststorms:Large-scaletradewinds



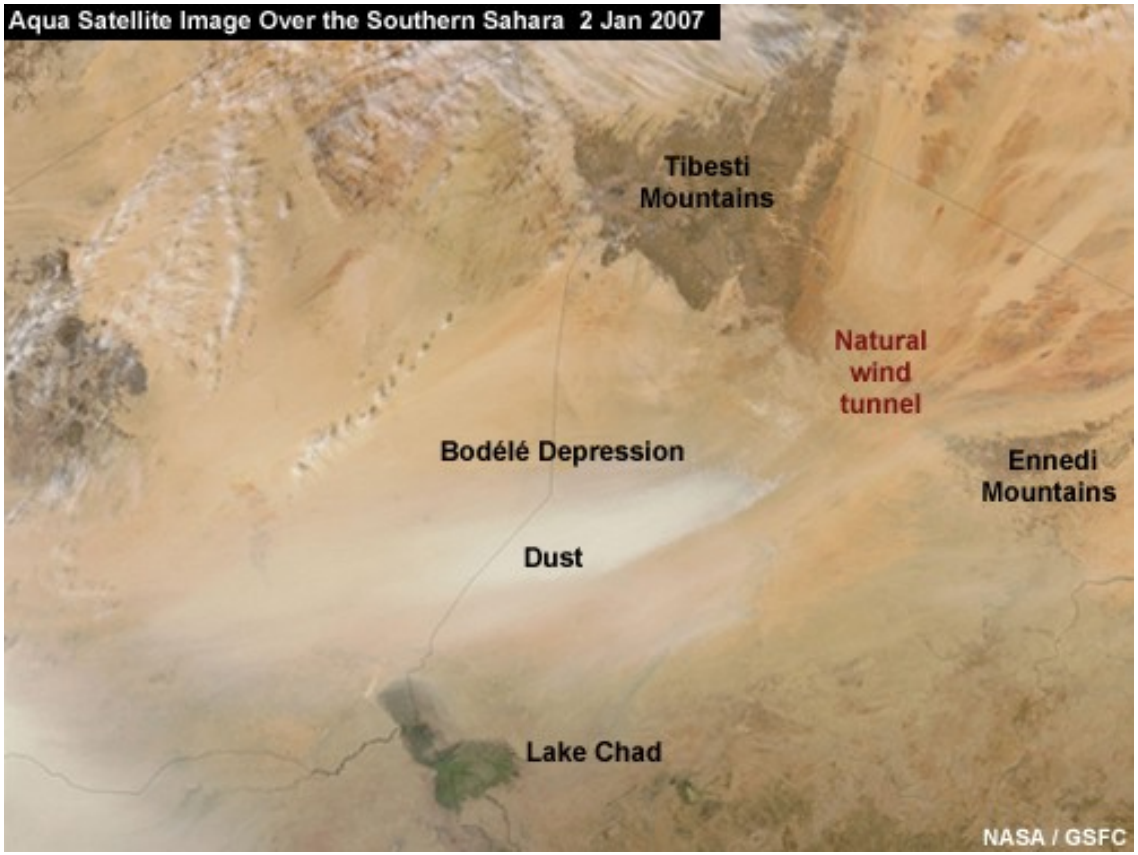
Dust cycle and associated processes

Mesoscaledustst orms:Downslopewinds



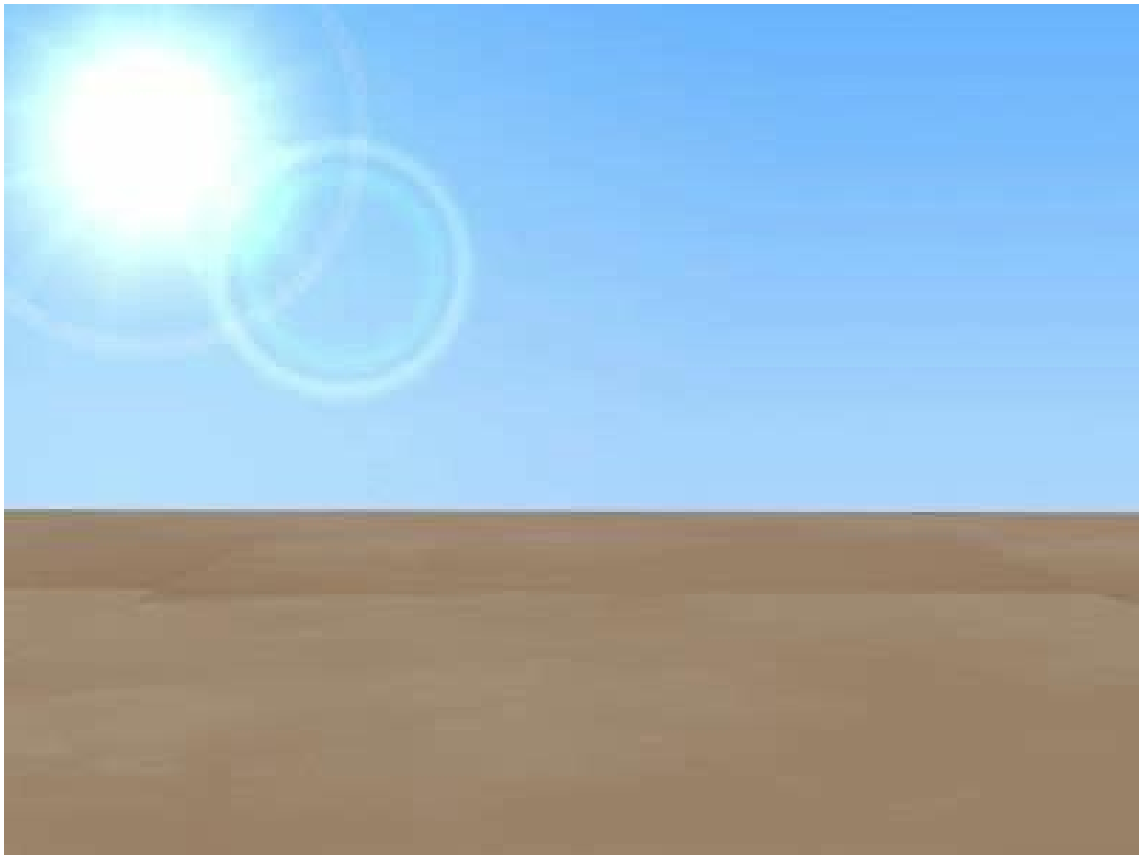
Dust cycle and associated processes

Mesoscaledustst orms: Gapflow



Dust cycle and associated processes

Mesoscaleduststorms:Dustdevils(convection)



MoviefromtheCOMETprogramat http://meted.ucar.edu/ oftheUniversityCorporationforAtmosphericResearch(UCAR)

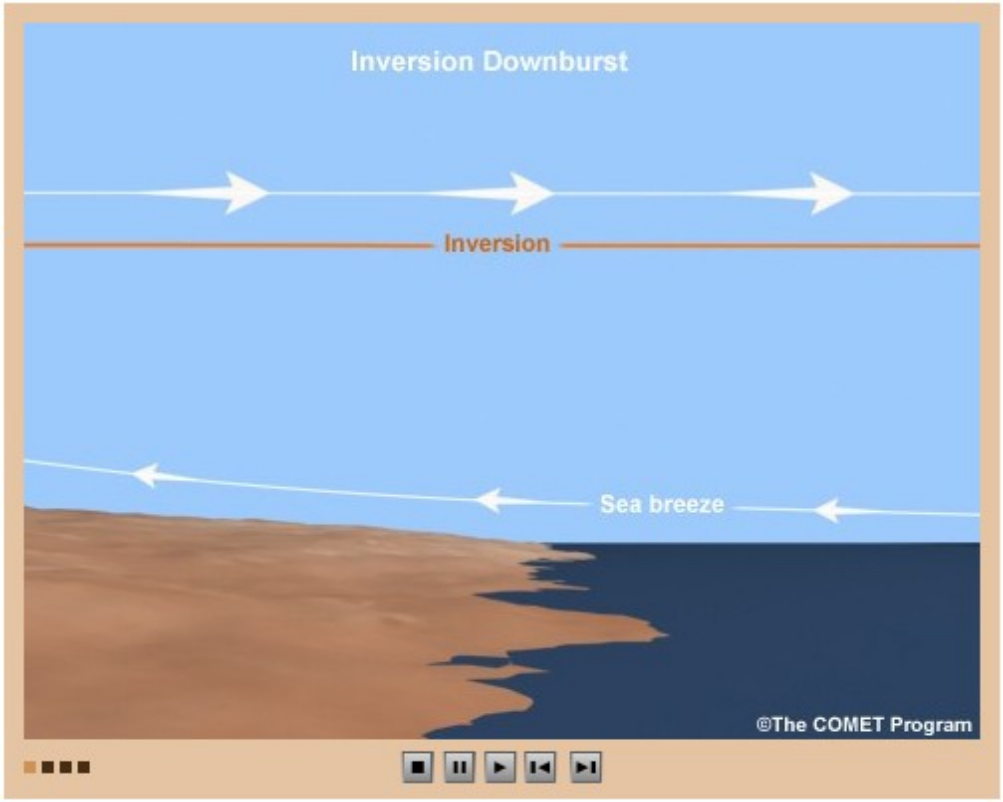
Dust cycle and associated processes

Mesoscale dust storms: Haboobs

MoviefromtheCOMETprogramat http://meted.ucar.edu/ oftheUniversityCorporationforAtmosphericResearch(UCAR)

Dust cycle and associated processes

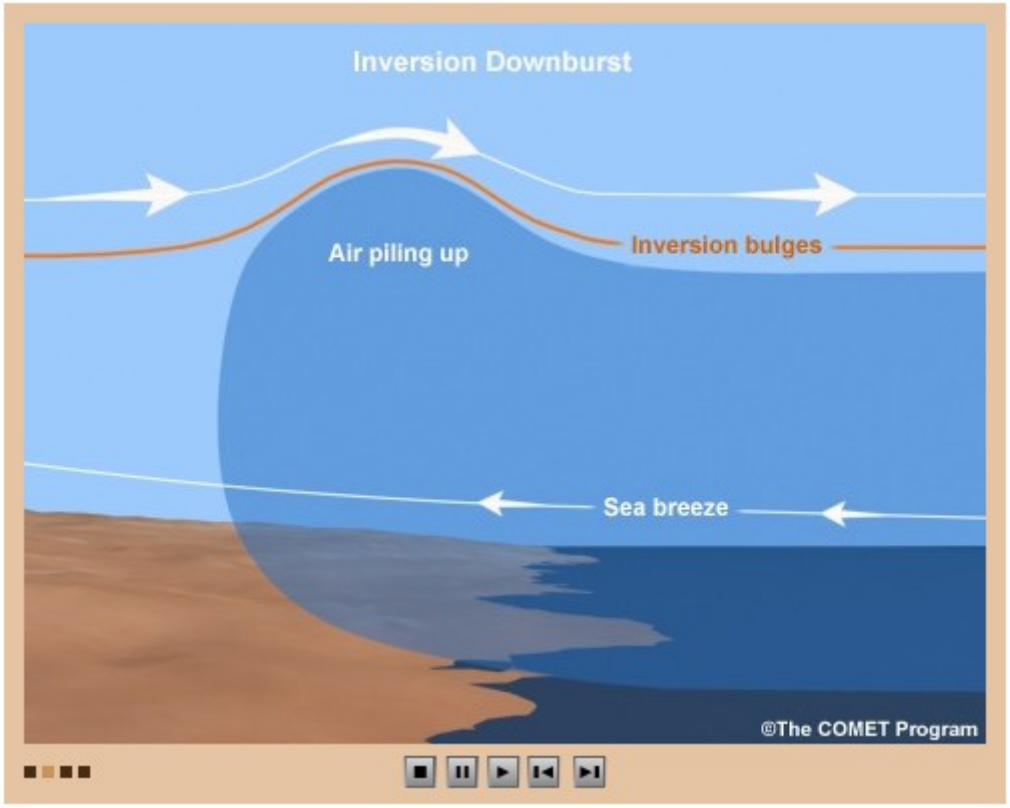
Mesoscale dust storms: Inversion downbursts



MoviefromtheCOMETprogramat http://meted.ucar.edu/ oftheUniversityCorporationforAtmosphericResearch(UCAR)

Dust cycle and associated processes

Mesoscale dust storms: Inversion downbursts



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Dust cycle and associated processes

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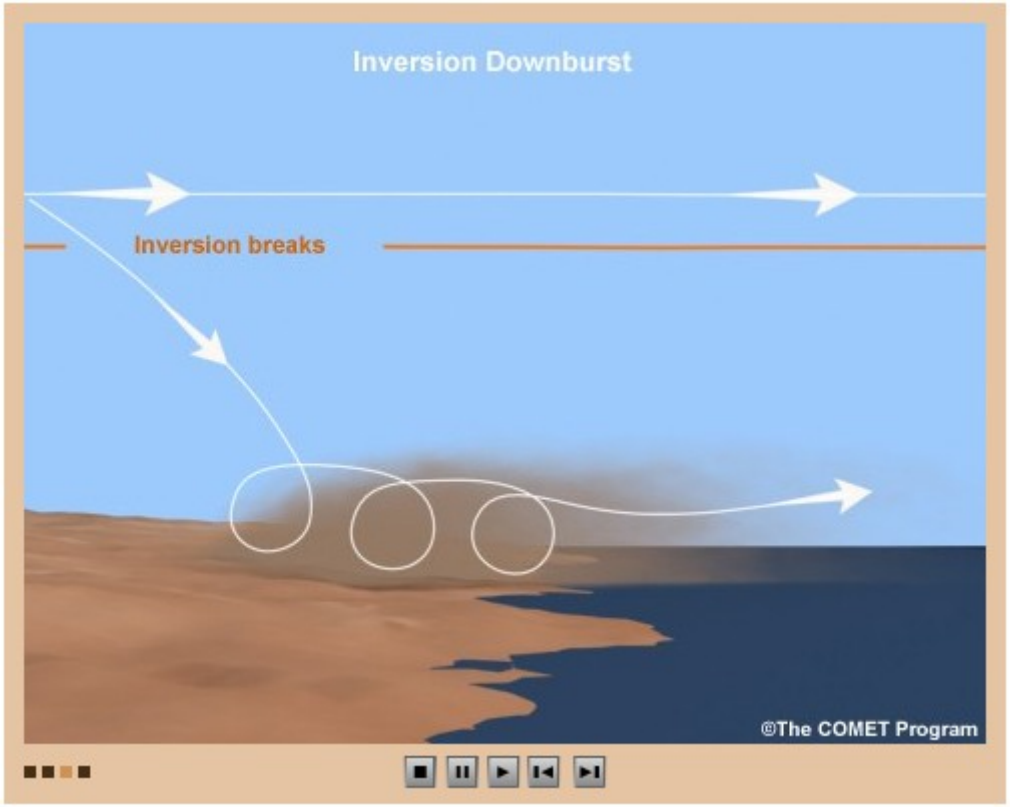

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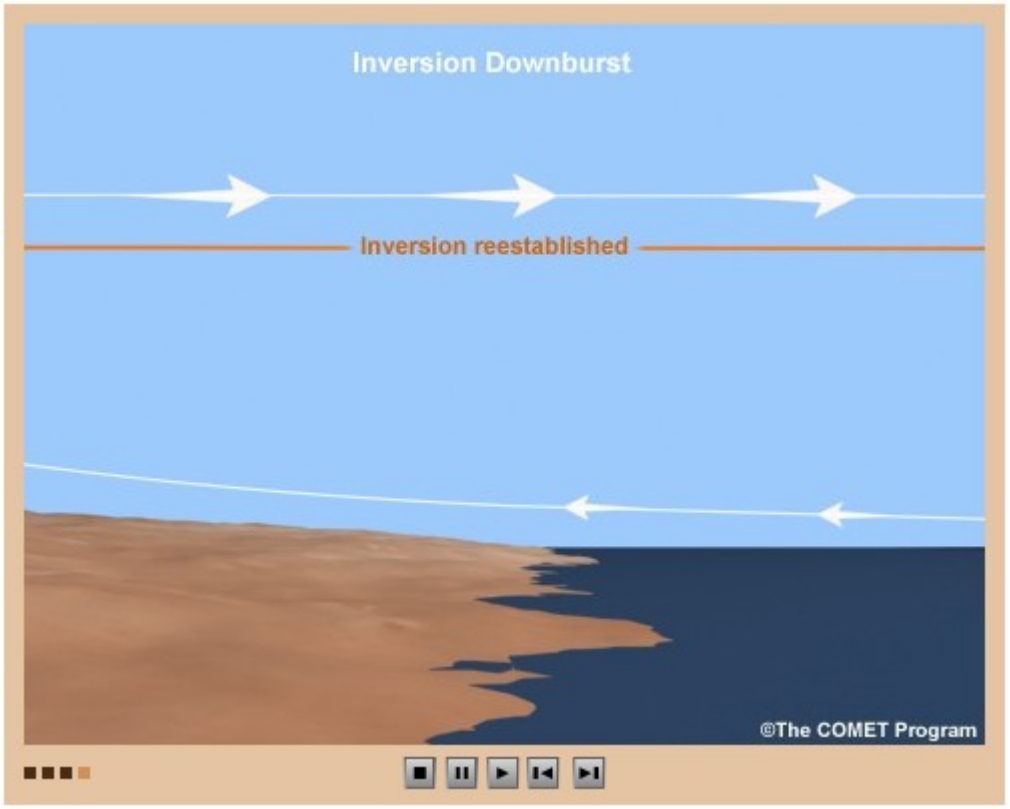
Dust cycle and associated processes

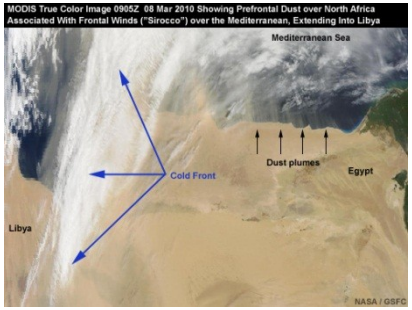
Mesoscaleduststorms:Inversiondownbursts



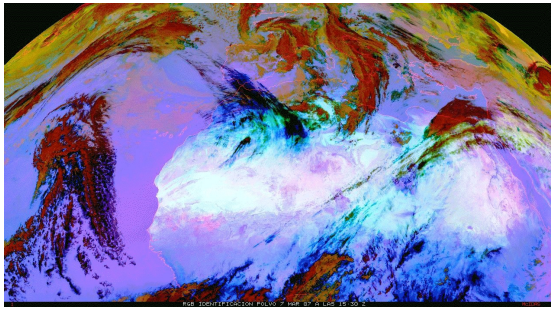
MoviefromtheCOMETprogramat http://meted.ucar.edu/ oftheUniversityCorporationforAtmosphericResearch(UCAR)

Dust cycle and associatedprocesses: Types of dust storms

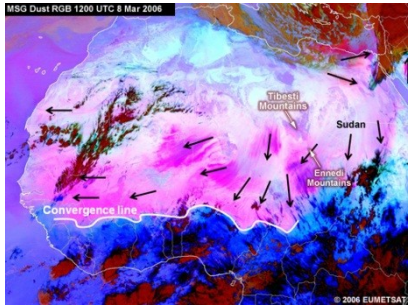
Synopticduststorms(largescaleweathersystems)



Pre-frontalwinds

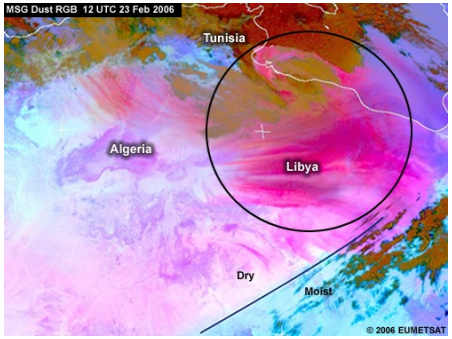


Post-frontalwinds

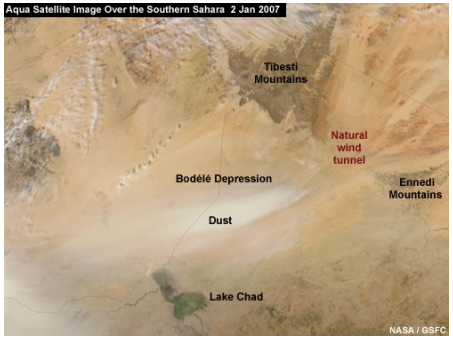


Large-scaletrade winds

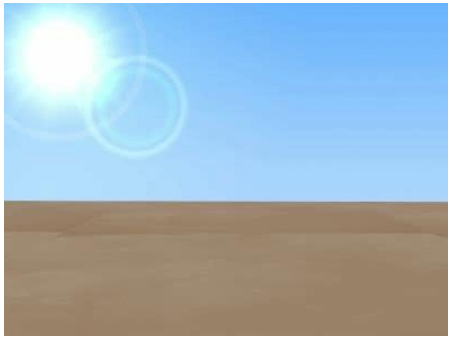
Mesoscaleduststorms



Downslopewinds



Gapflow

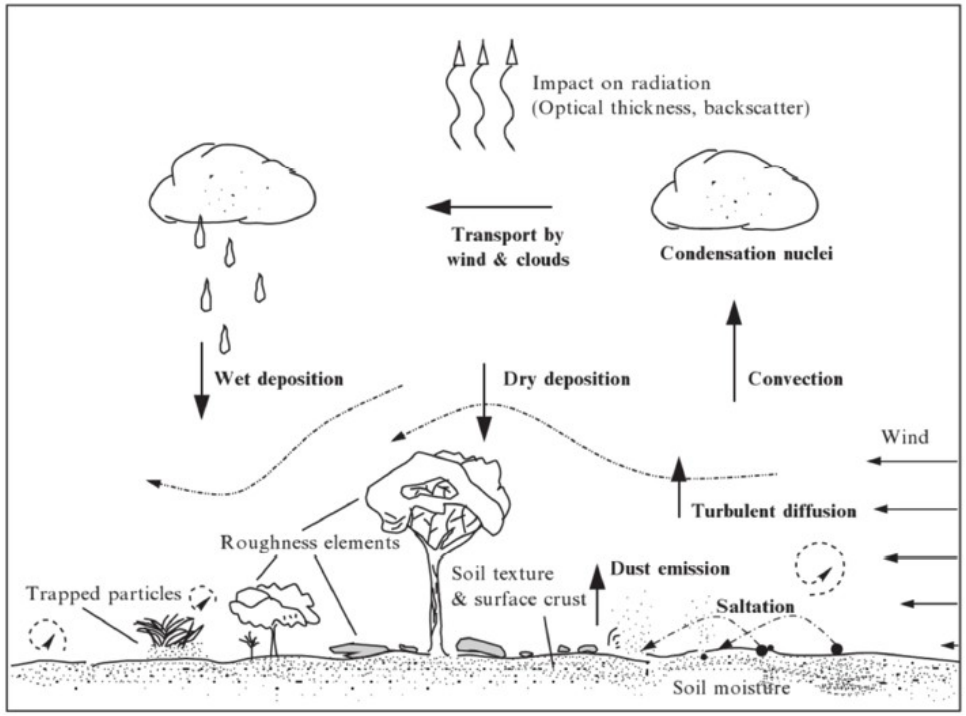


Convection& Inversiondownbursts

Haboobs

Dustforecasting models

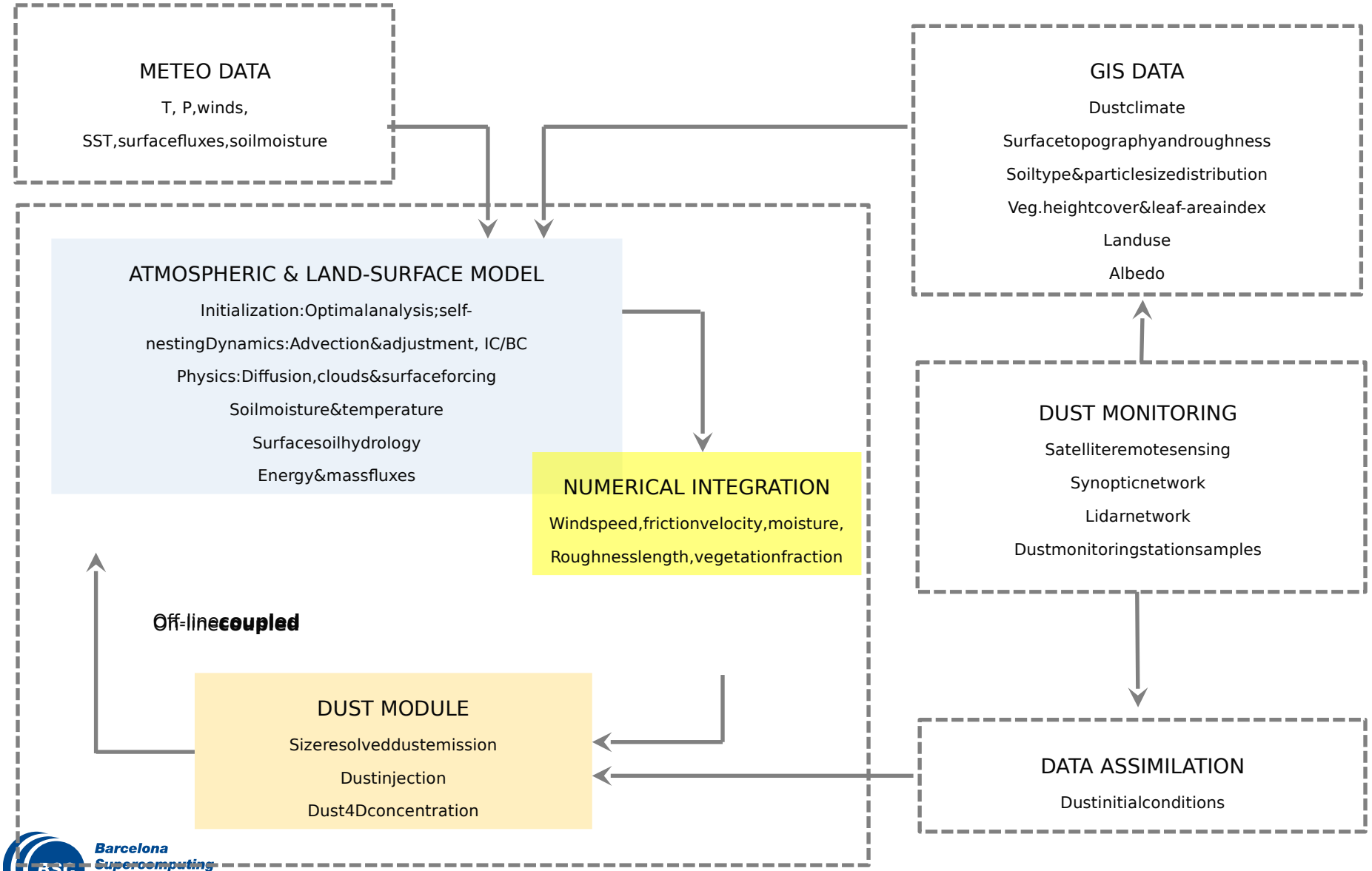
Dustmodelsare a mathematicalrepresentation of atmospheric dust cycle.



Extracted from Shao (2008)

- ✓ *To complement dust-related observations, filling the temporal and spatial gaps of themeasurements.*
- ✓ *To help us to understand the dust processes and their interaction with climate andecosystems.*
- ✓ *To predict the impact of dust on surface level concentrations used as* ***SHORT-TERMFORECASTING TOOLS*** *(3-5 days ahead)*

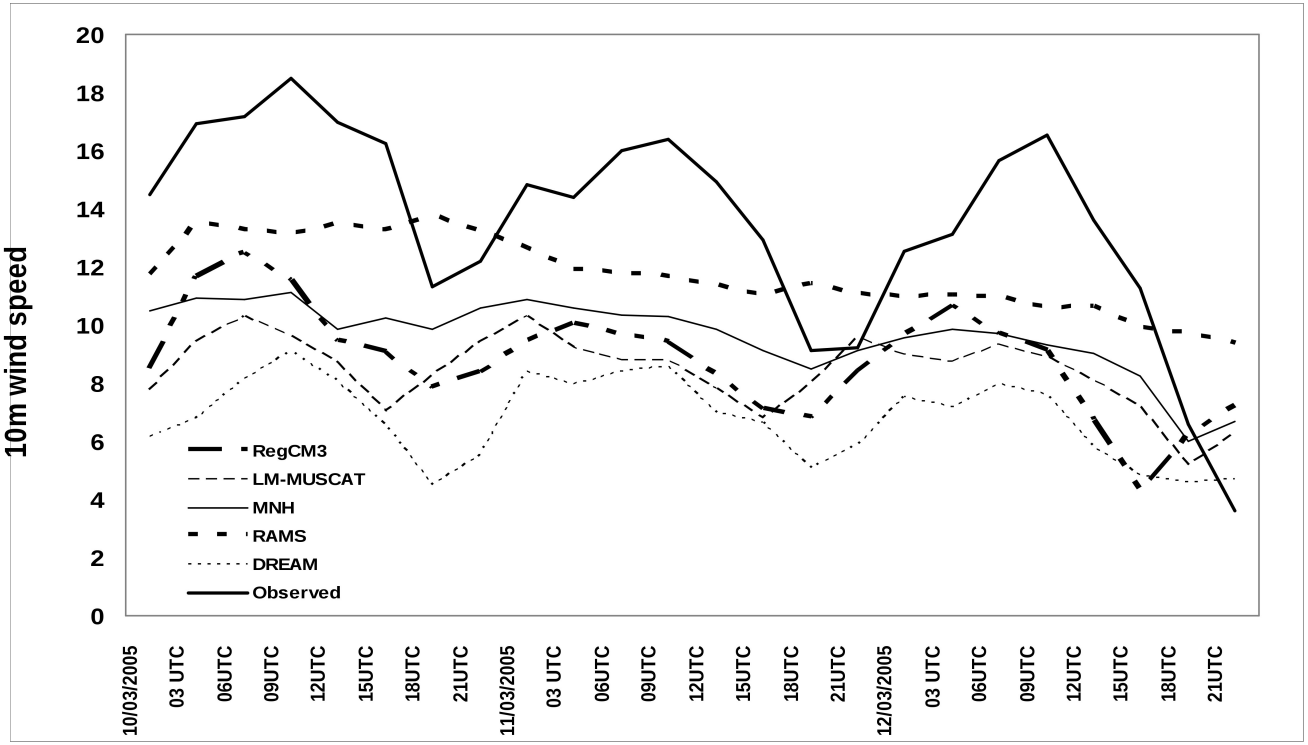
Dust forecasting models



Dust forecastingmodels

Experimentalcampaigns: BODEX 2005 (Toddetal.2008, JGR)

First regional model intercomparison in the Bodélé hot spot



Strongdifferencesbetweenmodels!!!!→**Meteorology**and**emissionscheme**

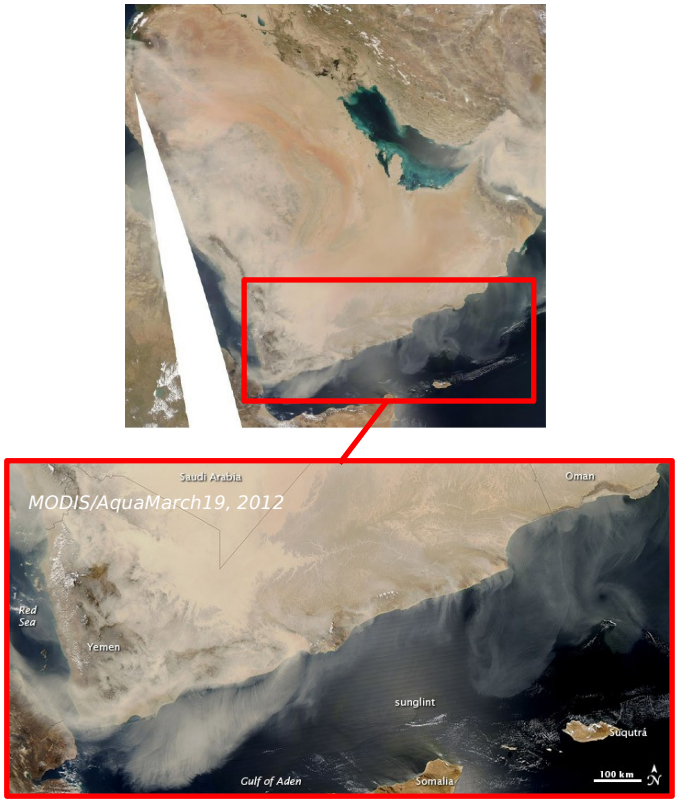
Dust forecasting models

March 2012, West Asia

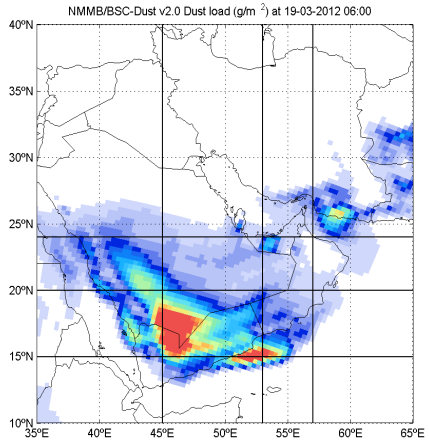
Dust forecasting models

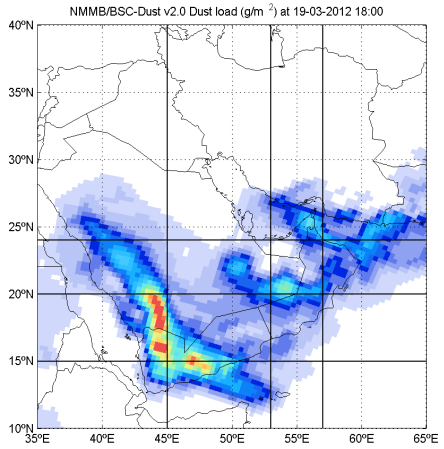
Impactofthetopographyondusttransport

Theimpact of model resolution in dust propagation in a complex terrain region such as WestAsia: ***19th March2012***

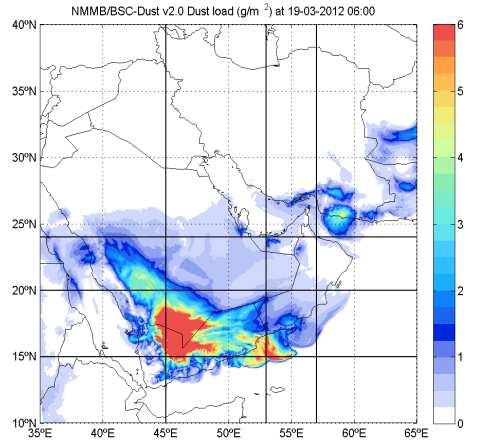


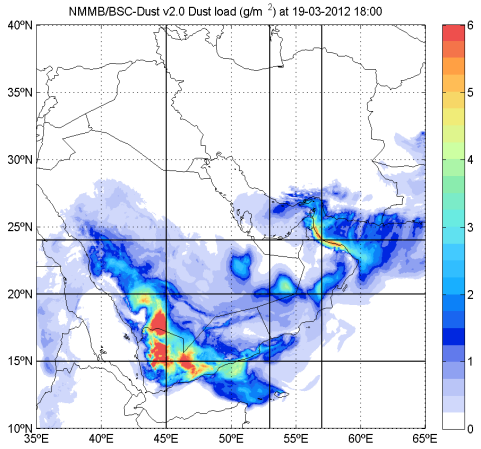
Exp. 0.33º x 0.33º





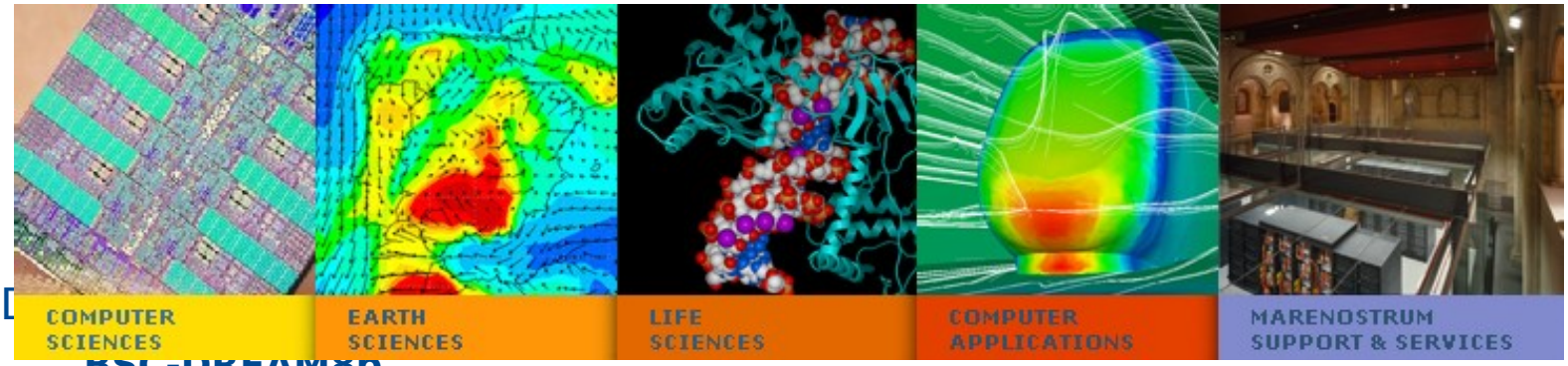
Exp. 0.03º x 0.03º





Basart andBaldasano,submittedtoAeolianResearch

ES-BSC: Mineral Dust Modelling



- **BSC-DREAM8b**

  http://www.bsc.es/projects/earthscience/BSC-DREAM/

- **NMMB/BSC-Dust:**

  http://www.bsc.es/projects/earthscience/NMMB-BSC-DUST/

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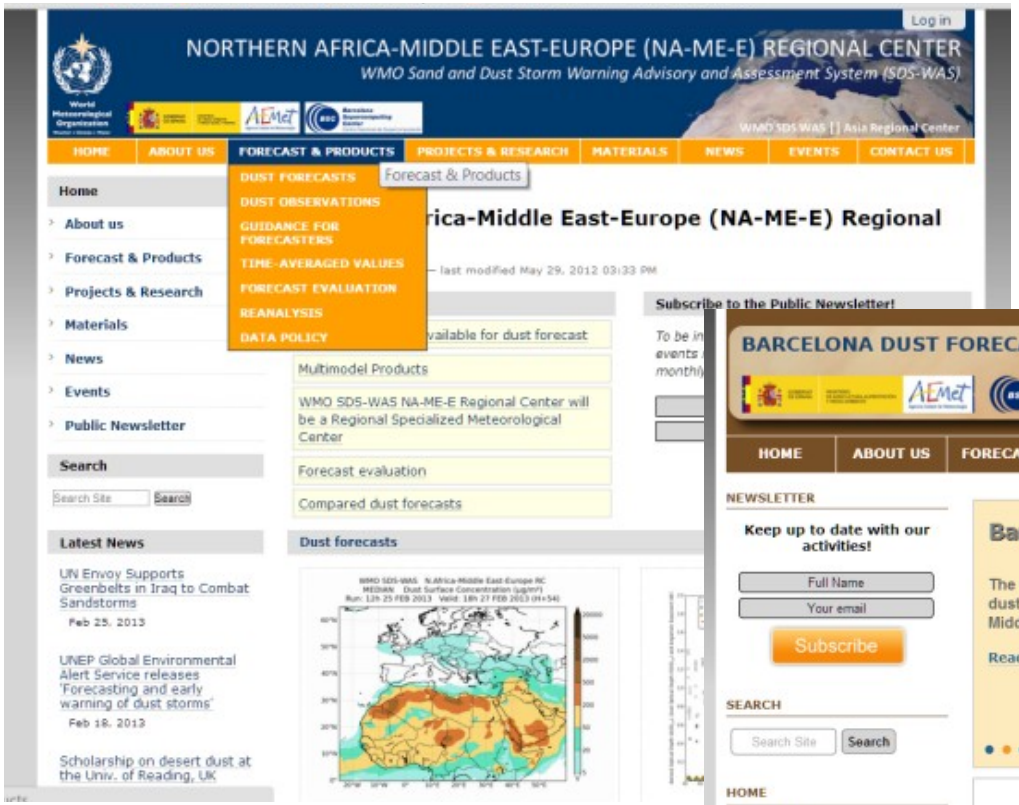
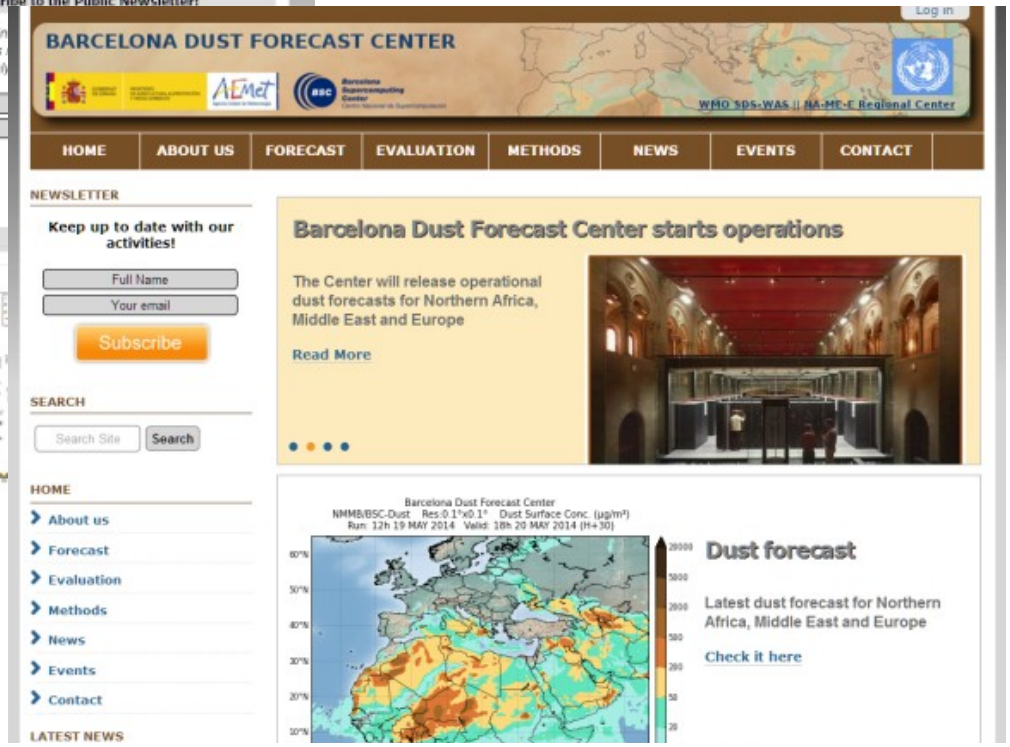
ES-BSC: WMO Dust Centers





RESEARCH

http://sds-was.aemet.es/

OPERATIONAL

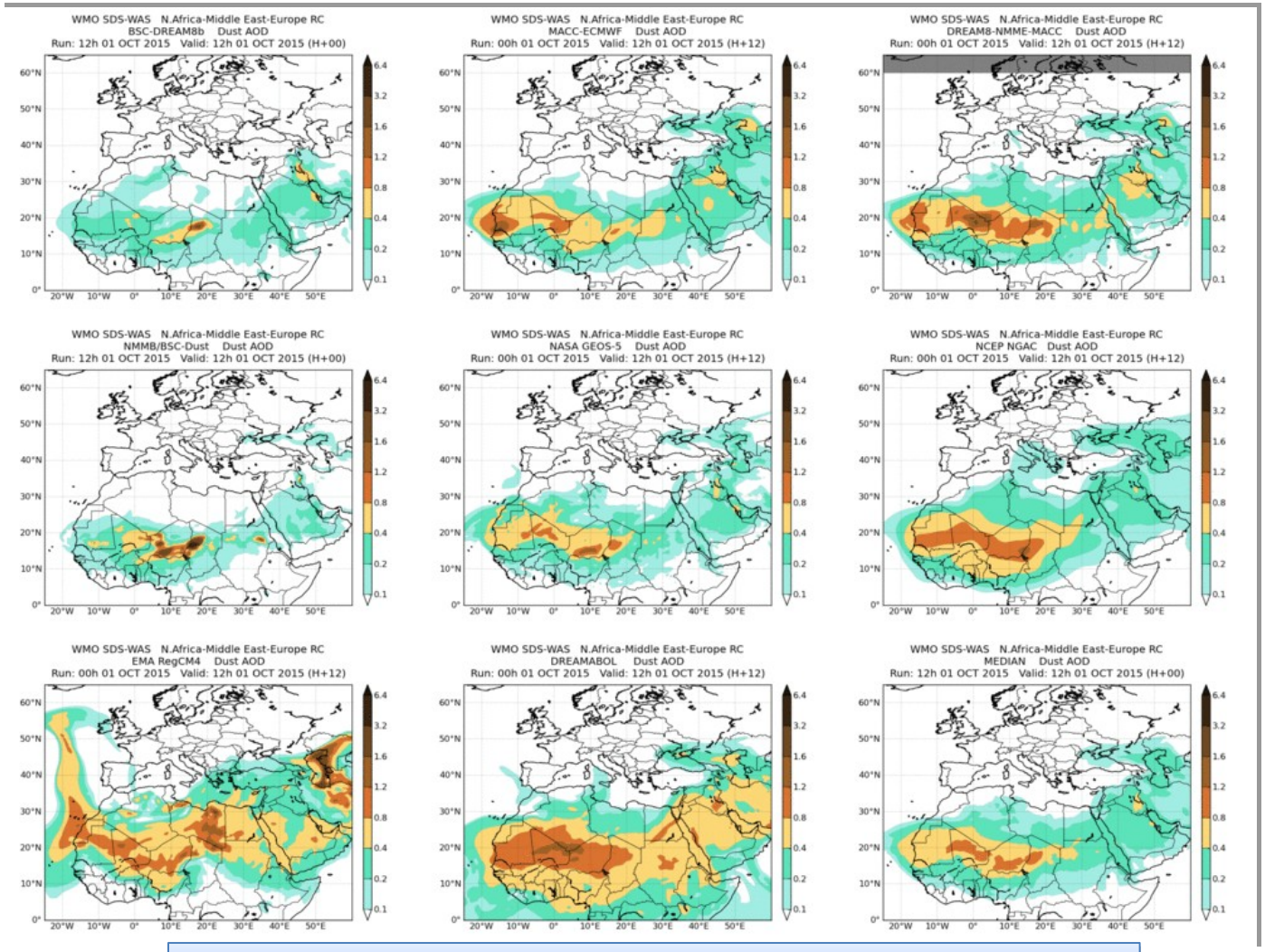
http://dust.aemet.es/

SDS-WAS NA-ME-ERC (http://sds-was.aemet.es/)

SDS-WAS:Dustmodels

MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
MACC	00	Global	MODIS AOD
DREAM-NMME-MACC	12	Regional	MACCanalysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODISreflectances
NGAC	00	Global	No
EMA REG CM4	12	Regional	No
DREAMABOL	12	Regional	No

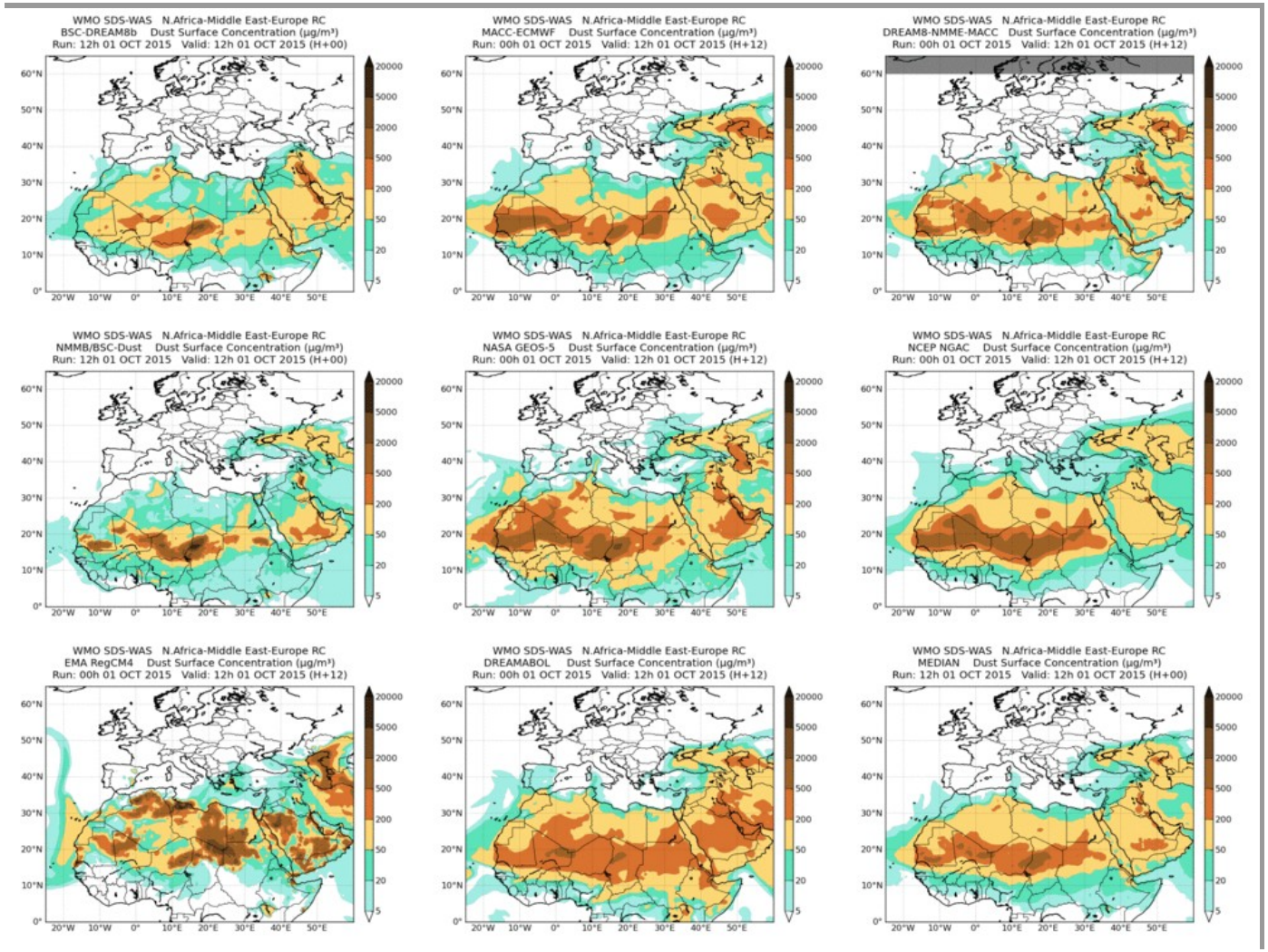
SDS-WAS:AODjointvisualization



AOD at 550nm

from1-Oct-2015 12:00 to 3-Oct-2015 00:00

SDS-WAS:Surfaceconcentrationjointvisualization

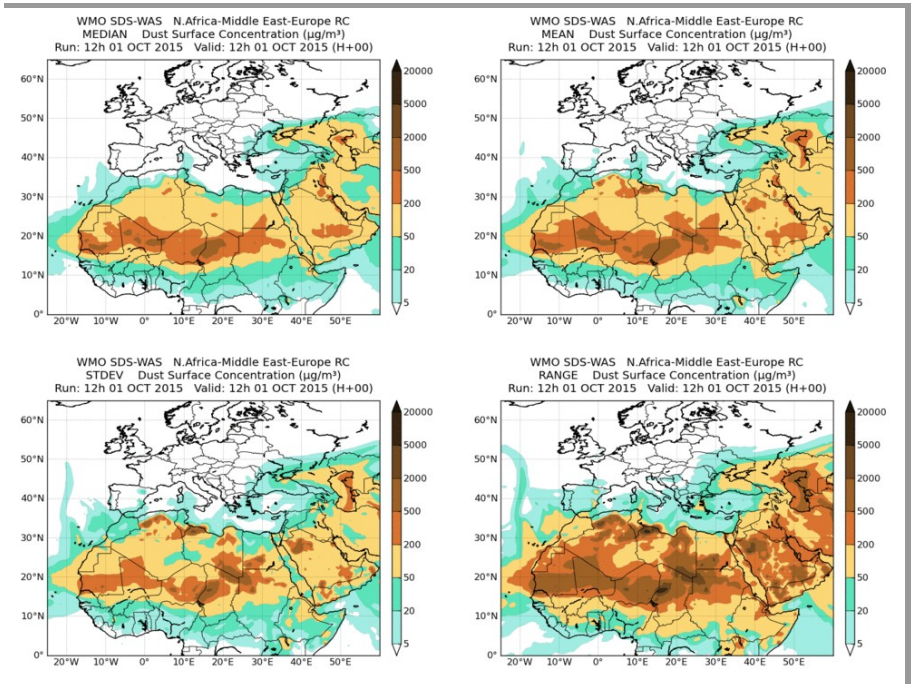


Surfaceconcentrationat 550nm

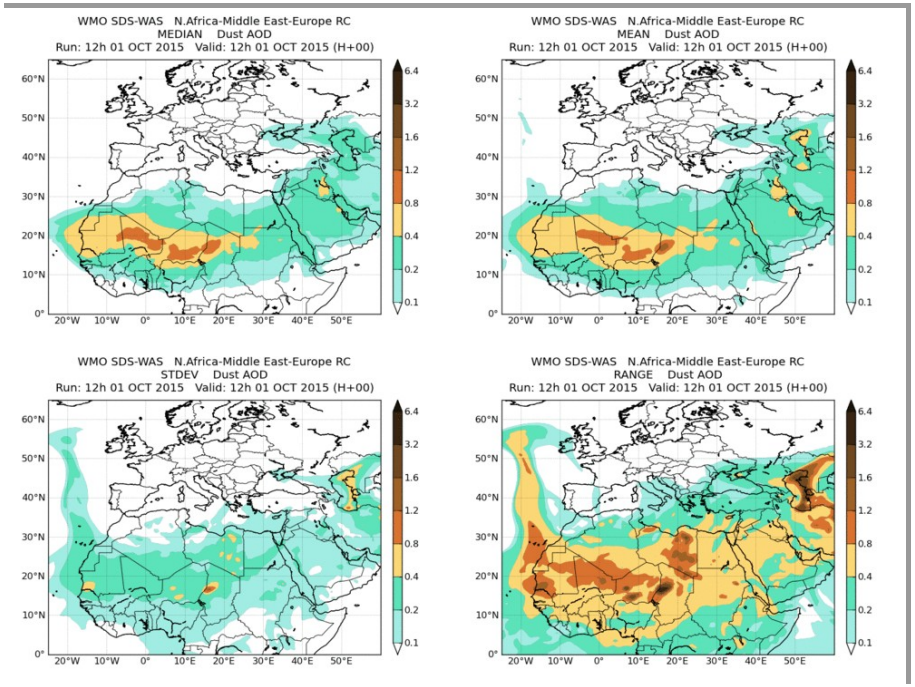
from1-Oct-2015 12:00 to 3-Oct-2015 00:00

SDS-WAS:Generationofmulti-modelproducts

Surfaceconcentration



AOD at 550nm



from1-Oct-2015 12:00 to 3-Oct-2015 00:00

Modeloutputs are bi-linearly interpolated to a common0.5ºx0.5ºgrid mesh.Then, differentmulti-model products aregenerated:

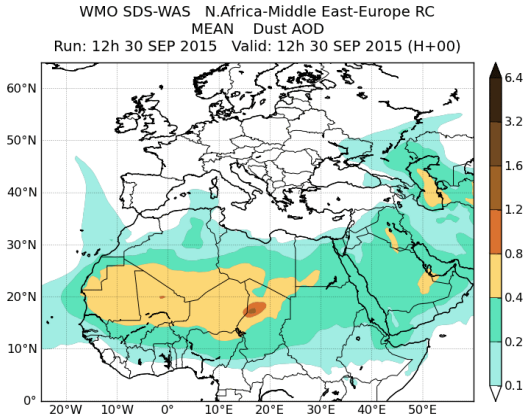
CENTRALITY: median - mean

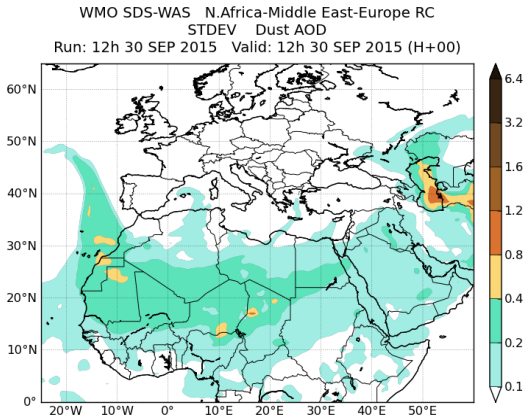
SPREAD:standard deviation – range of variation

SDS-WAS:Generationofmulti-modelproducts

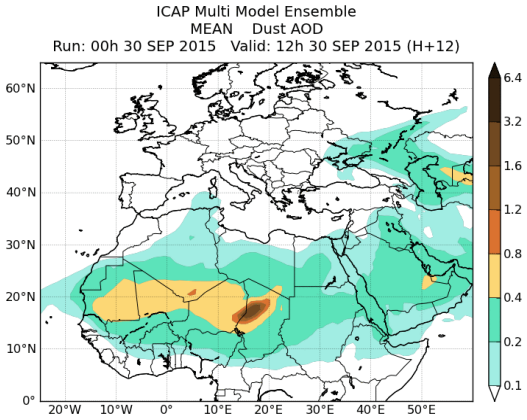
SDS-WAS and ICAPmulti-modelproducts

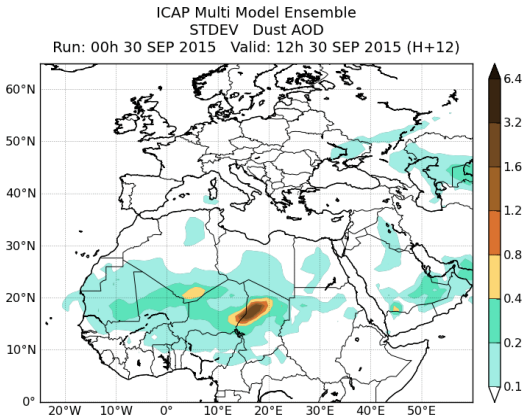
SDS-WAS





ICAP



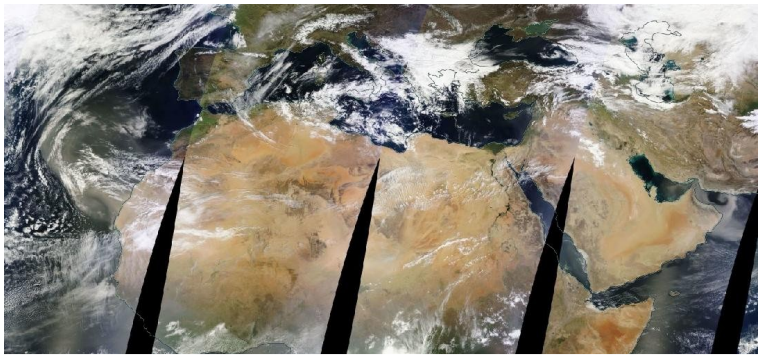


AOD at 550nm

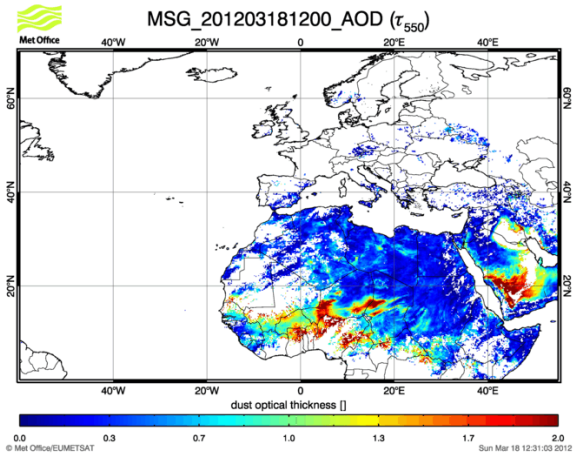
from1-Oct-2015 12:00 to 3-Oct-2015 00:00

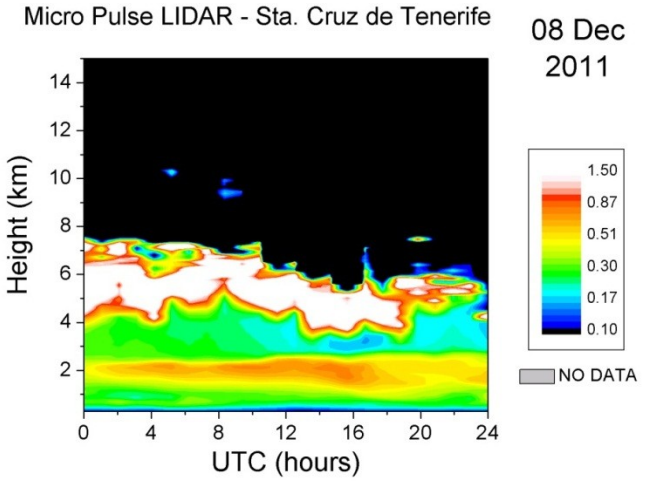
Newsourcesof dataformodelevaluation

- Visibility
- MSG/SEVIRI
- MODIS
- OMI
- CALIPSO
- PARASOL
- MPLNET
- PM_{10}

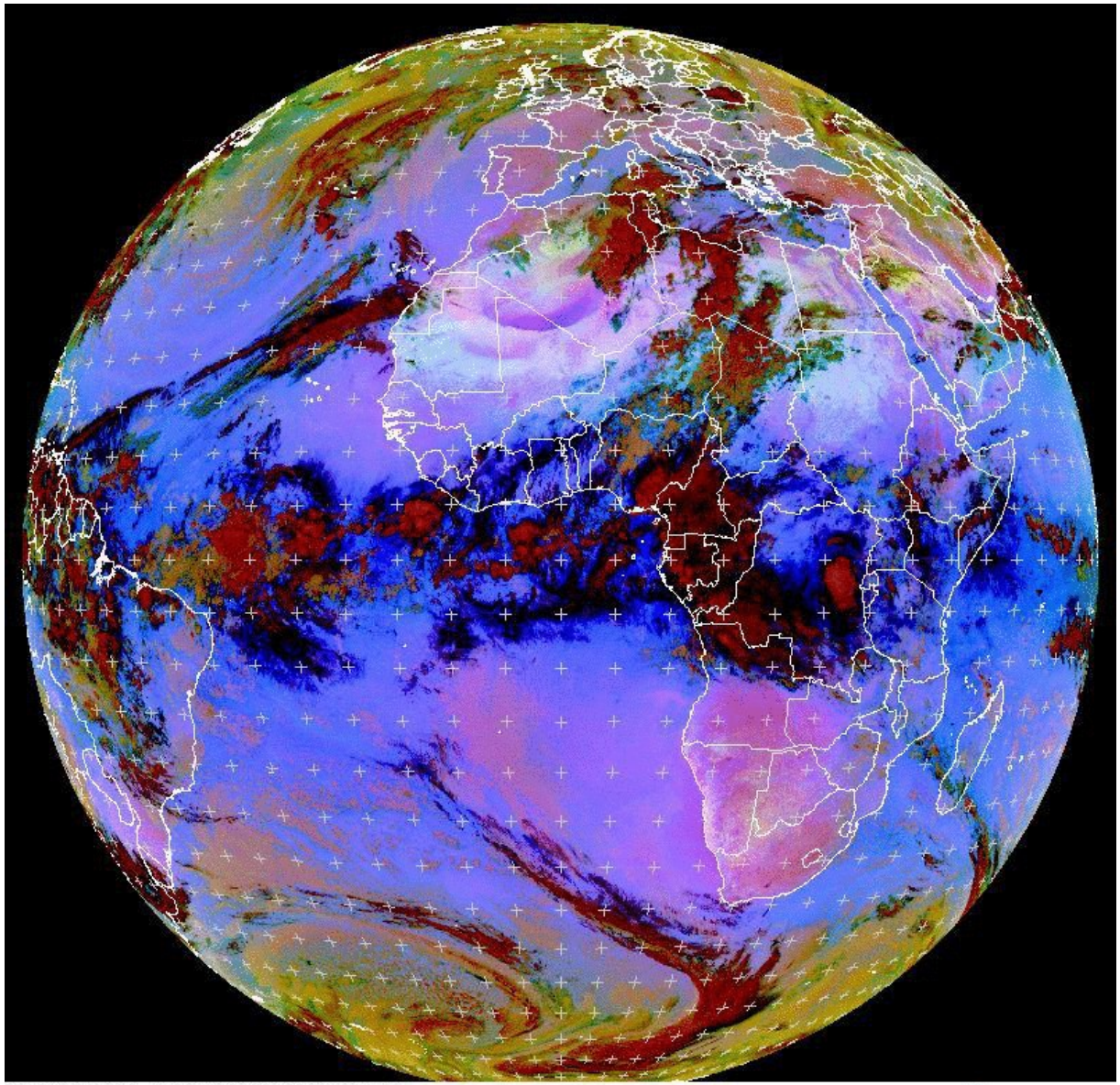


MODIS composite 8thMarch 2015 from EOSDIS World Viewer



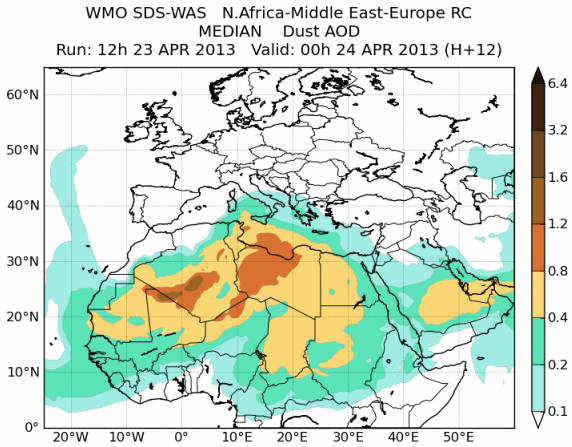


SDS-WAS: NRTEvaluationusingsatelliteaerosolproducts

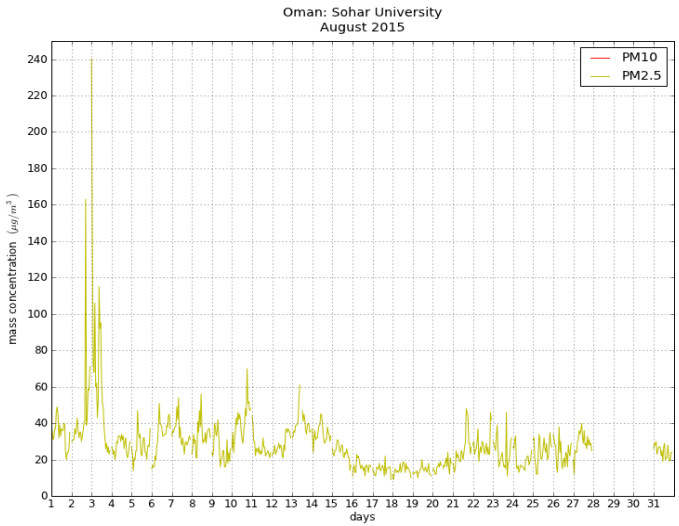


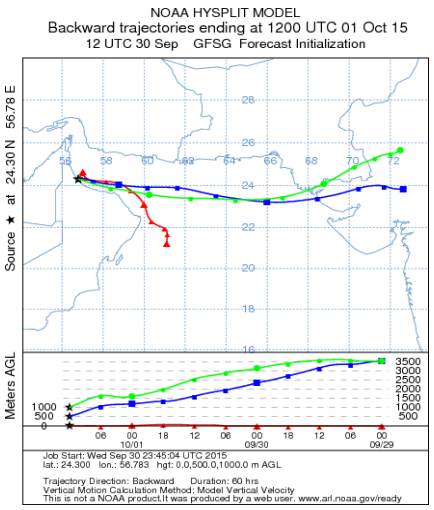
EUMETSAT

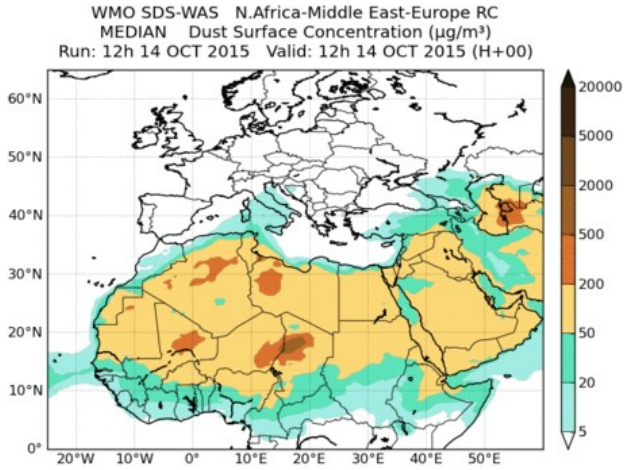
24 April 2013



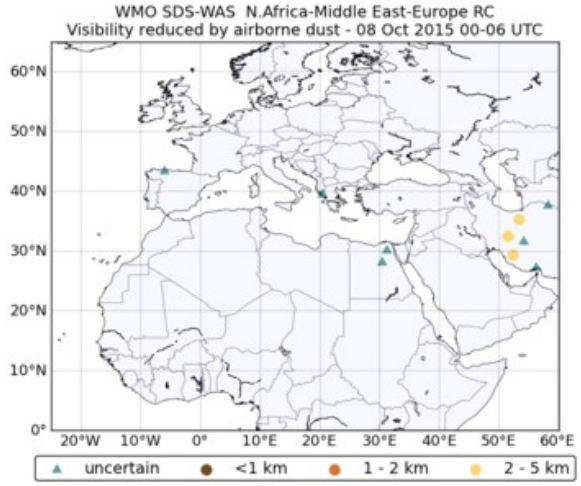
SDS-WAS: NRTEvaluationusingsurfaceconcentration

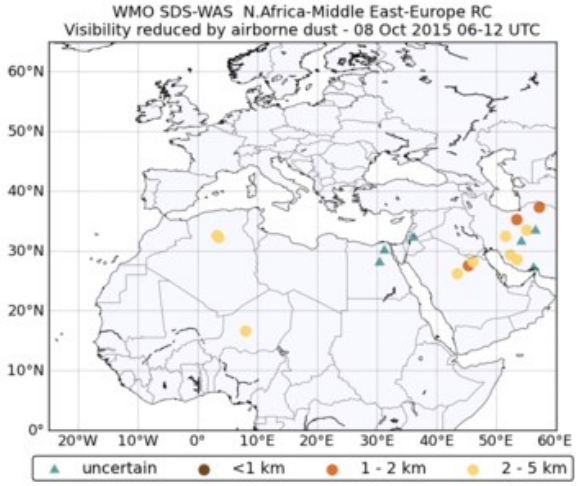


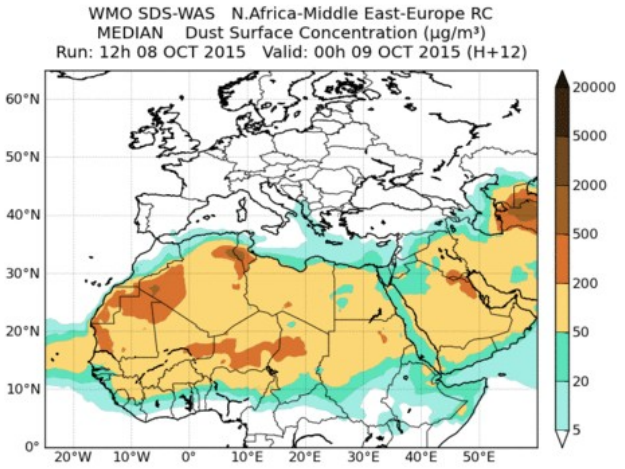


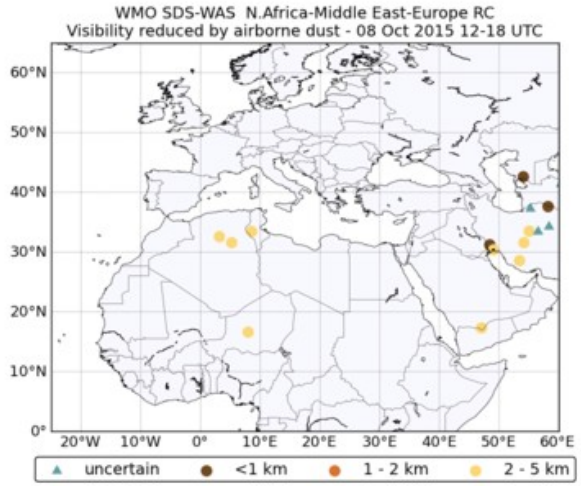


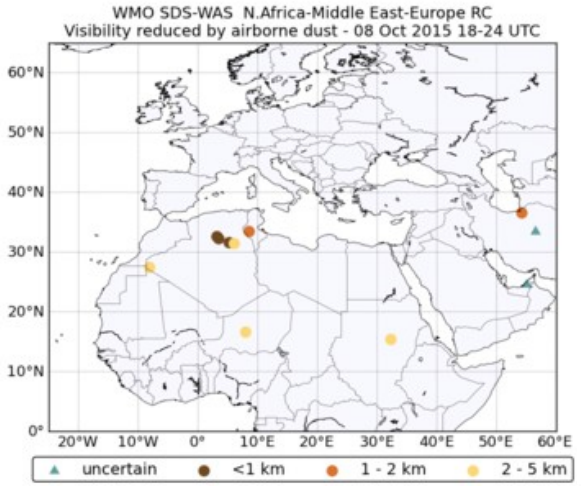
SDS-WAS: NRTEvaluationusingVISIBILITY data

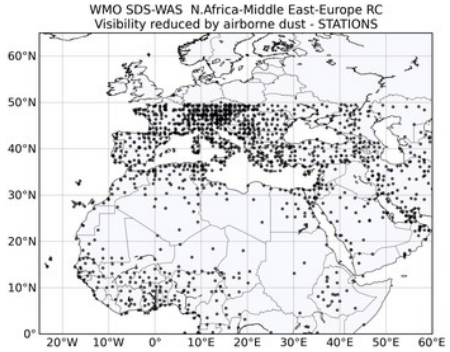






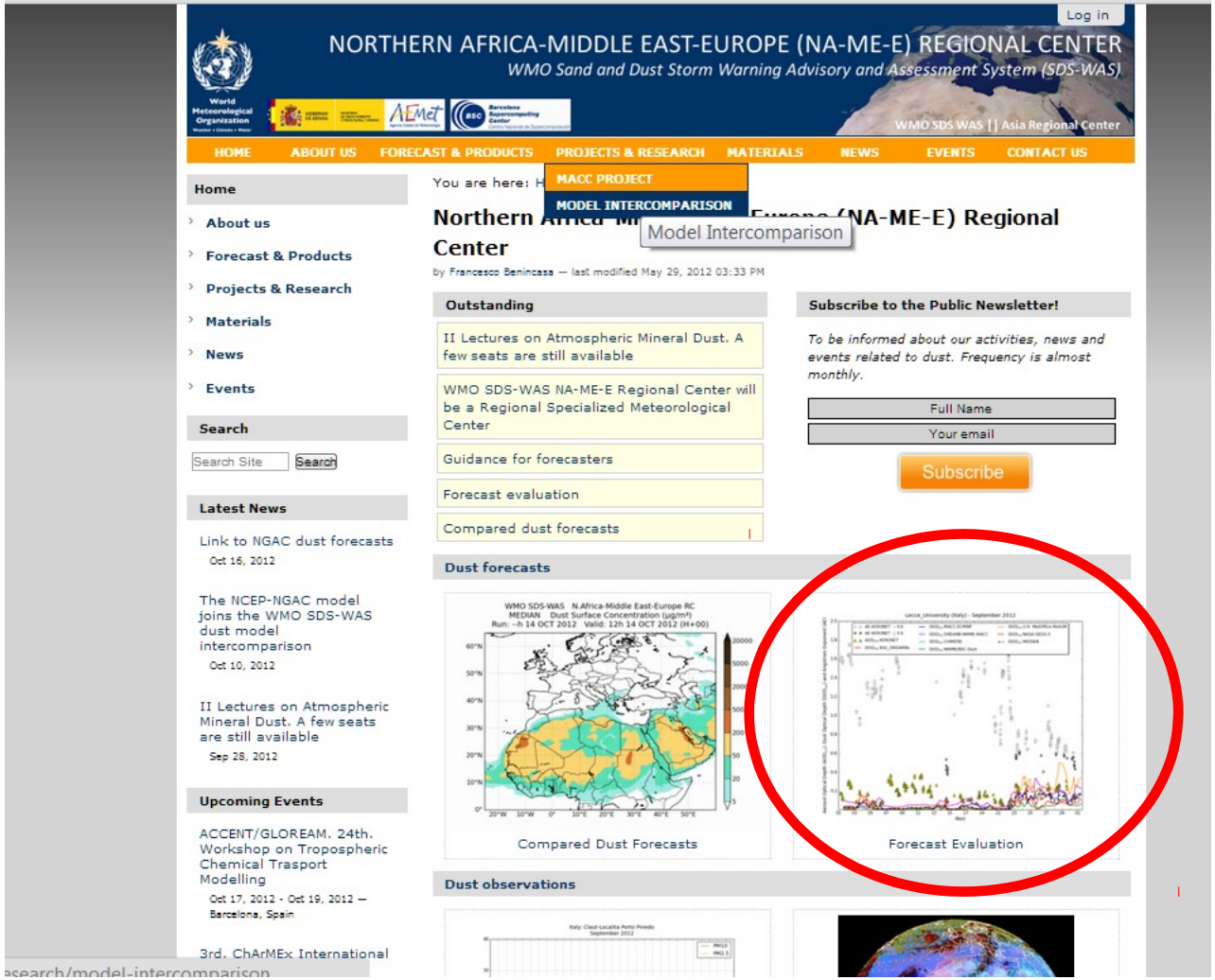






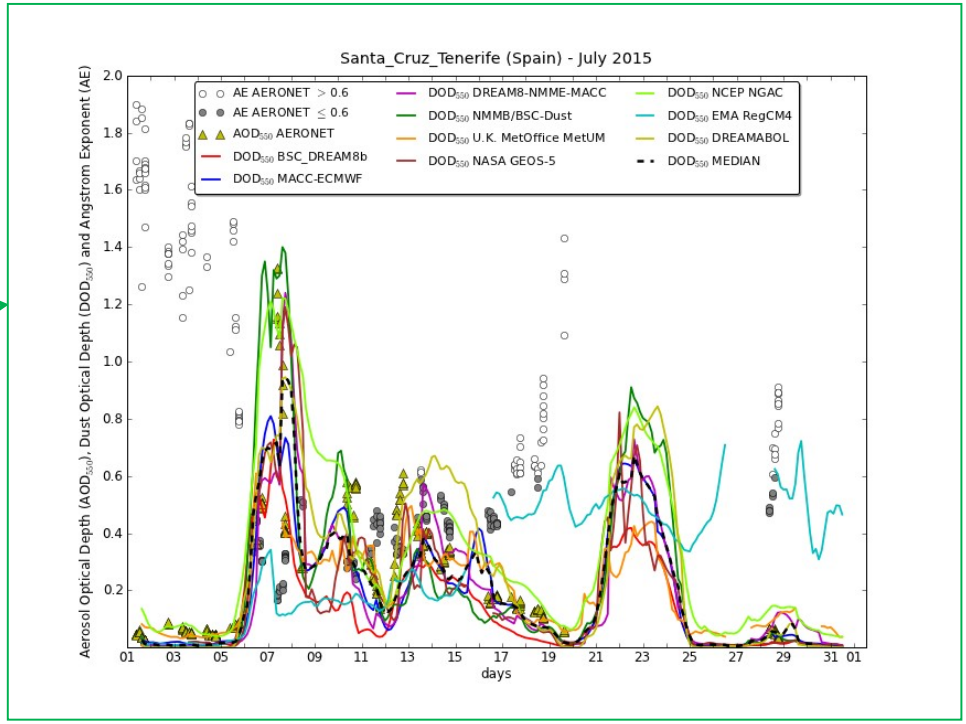
VISIBILITYon8-Oct-2015

SDS-WAS:NRTEvaluationusingAERONET



http://sds-was.aemet.es

SDS-WAS: NRTEvaluationusingAERONET



Model evaluationmetrics (bias, correlation, RMSE and FGE) are calculated:

- By regions: NA-ME-E, Sahel/Sahara, Middle East and Mediterranean
- By time periods: monthly, seasonal and annual

SDS-WAS: NRTEvaluationusingAERONET

Annual scores

by Francesco Benincasa — last modified Nov 27, 2014 11:52 AM

Date: - Select Year -

Jan 2014 - Dec 2014. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

BIAS

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN
Sahel/Sahara show stations	-0.23	-0.07	-0.08	-0.13	-0.07	-0.12	-0.01	0.32	-0.09	-0.10
Middle East show stations	-0.16	0.00	0.07	-0.14	-0.04	-0.12	-0.09	0.53	-0.02	-0.06
Mediterranean show stations	-0.18	-0.11	-0.10	-0.18	-0.10	-0.15	-0.08	0.11	-0.10	-0.13
TOTAL	-0.21	-0.08	-0.08	-0.15	-0.08	-0.13	-0.04	0.24	-0.09	-0.11

ROOT MEAN SQUARE ERROR

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN
Sahel/Sahara show stations	0.40	0.32	0.35	0.36	0.31	0.33	0.30	0.69	0.38	0.31
Middle East show stations	0.26	0.23	0.24	0.25	0.21	0.24	0.25	0.67	0.20	0.22
Mediterranean show stations	0.30	0.27	0.29	0.29	0.25	0.27	0.26	0.49	0.26	0.26
TOTAL	0.36	0.30	0.33	0.33	0.29	0.31	0.28	0.62	0.33	0.29

CORRELATION COEFFICIENT

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN

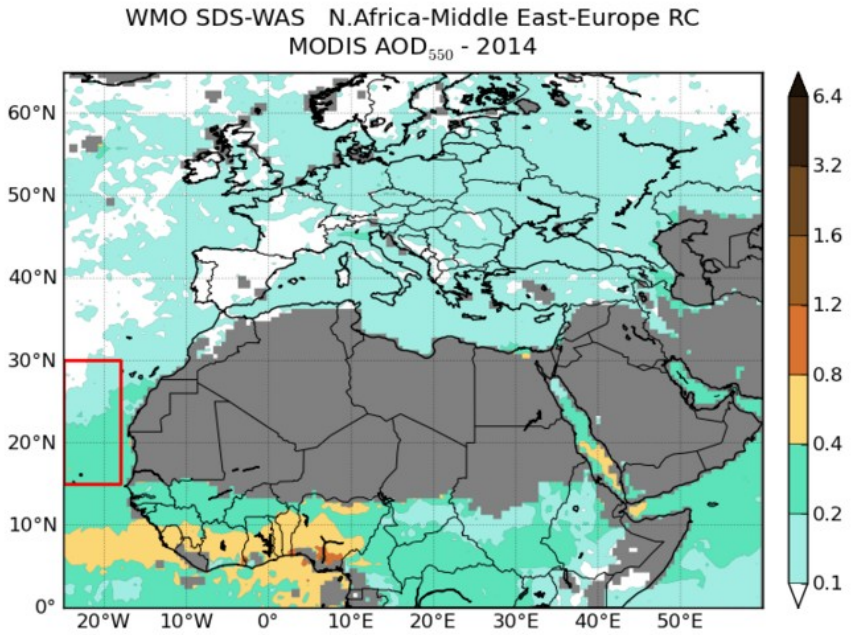
A set ofevaluationmetricsareselected:

- Bias
- RMSE
- correlationcoefficient
- FGE

Calculationsevaluationmetricsare donefor:

- monthly/seasonal/annual
- sitesandregions

SDS-WAS: NRTEvaluationusingMODIS



Download full image

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.14	0.20	0.72	1.07	22154
NMMB/BSC-Dust	-0.13	0.18	0.79	1.09	22154
NCEP NGAC	0.04	0.15	0.81	0.59	21608
EMA RegCM4	-0.04	0.37	0.26	1.09	13300
DREAMABOL	-0.04	0.17	0.69	0.92	13611

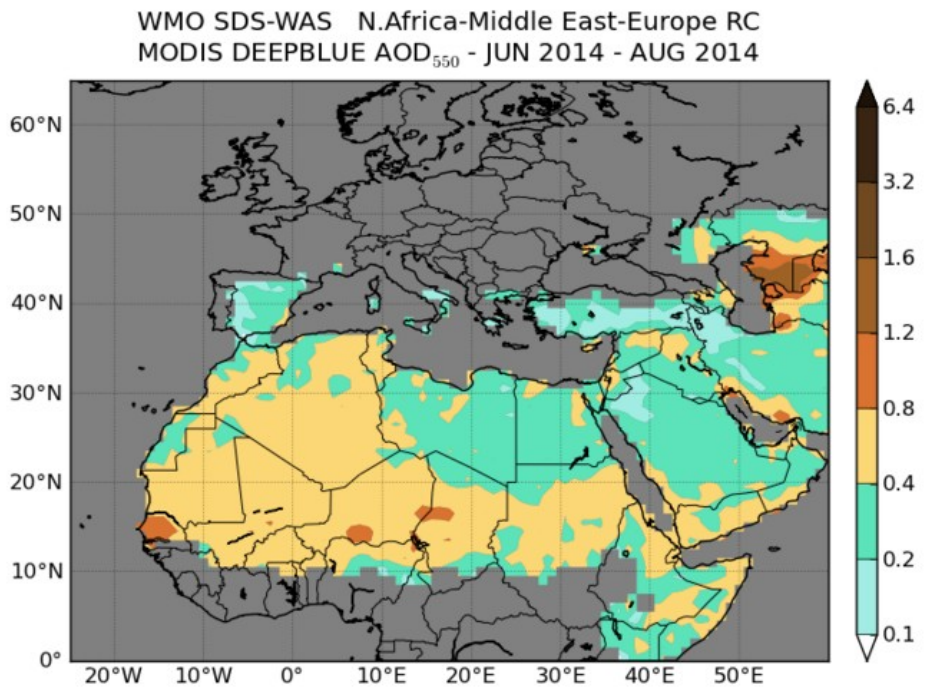
A set ofevaluationmetricsareselected:

- Bias
- RMSE
- correlationcoefficient
- FGE

Calculationsevaluationmetricsare donefor:

- monthly/seasonal/annual

SDS-WAS: NRTEvaluationusingMODISDeepBlue



Download full image

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.17	0.35	0.26	0.84	100952
NMMB/BSC-Dust	-0.12	0.39	0.32	0.84	100952
NCEP NGAC	-0.01	0.31	0.39	0.59	99159
EMA RegCM4	0.48	0.95	0.19	0.97	88666
DREAMABOL	0.07	0.34	0.36	0.71	64441

A set ofevaluationmetricsareselected:

- Bias
- RMSE
- correlationcoefficient
- FGE

Calculationsevaluationmetricsare donefor:

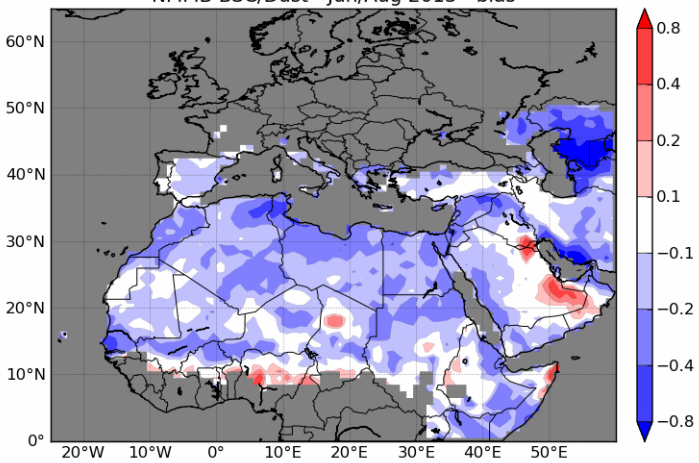
- monthly/seasonal/annual

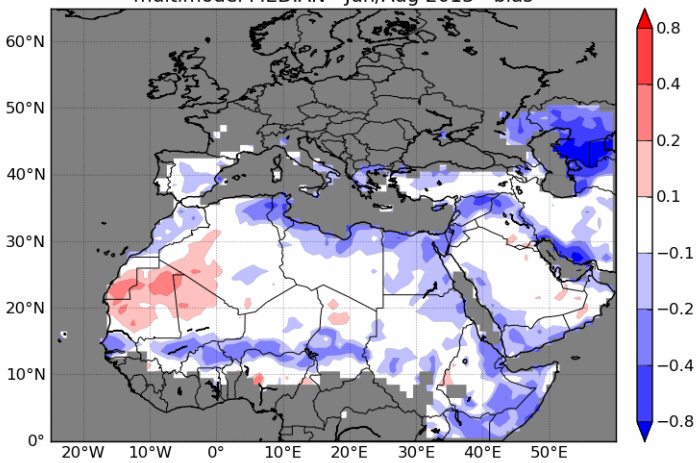
SDS-WAS: NRTEvaluationusingMODISDeepBlue

NMMB-BSC/Dust

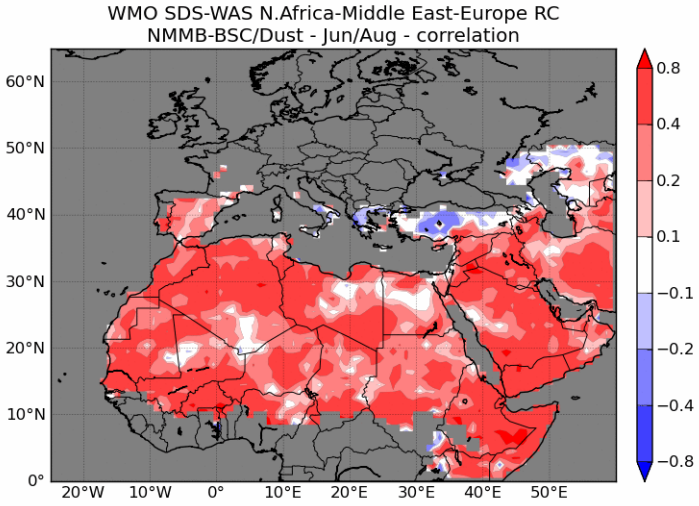
MultimodelMEDIAN

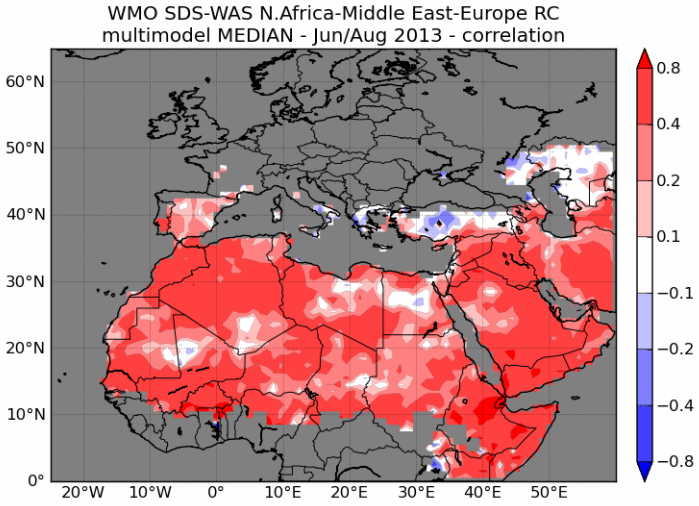
MB





Correlation



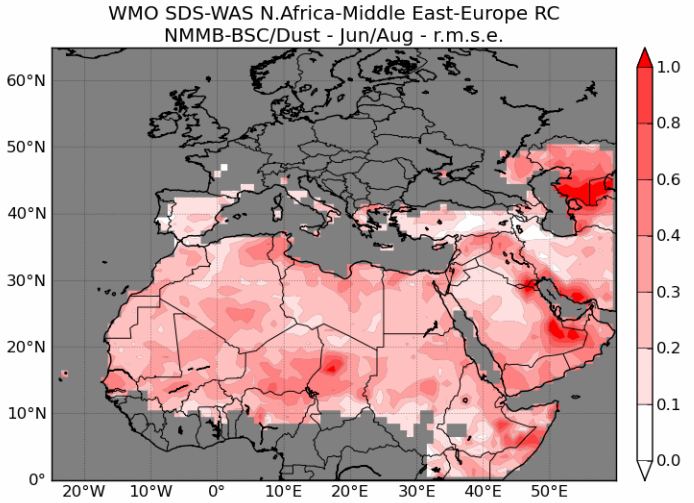


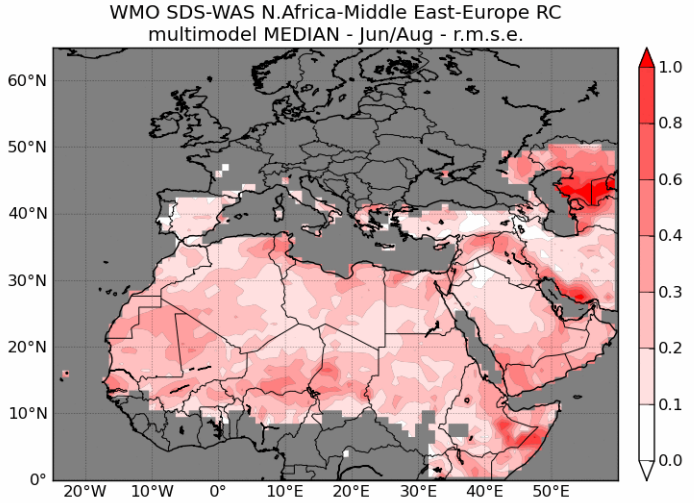
SDS-WAS: NRTEvaluationusingMODISDeepBlue

NMMB-BSC/Dust

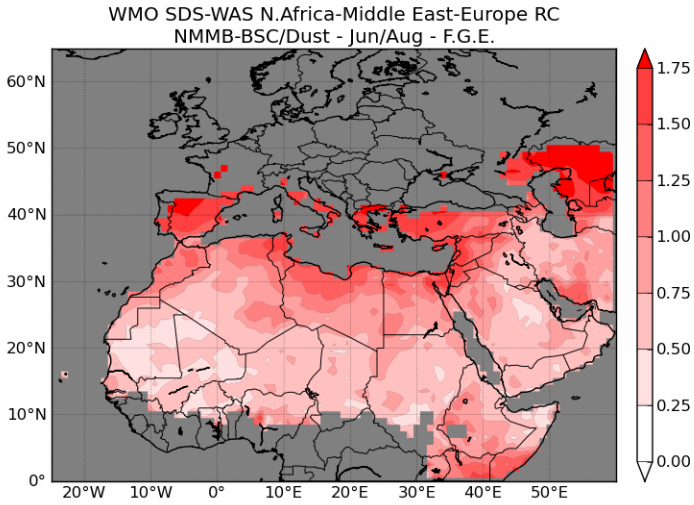
MultimodelMEDIAN

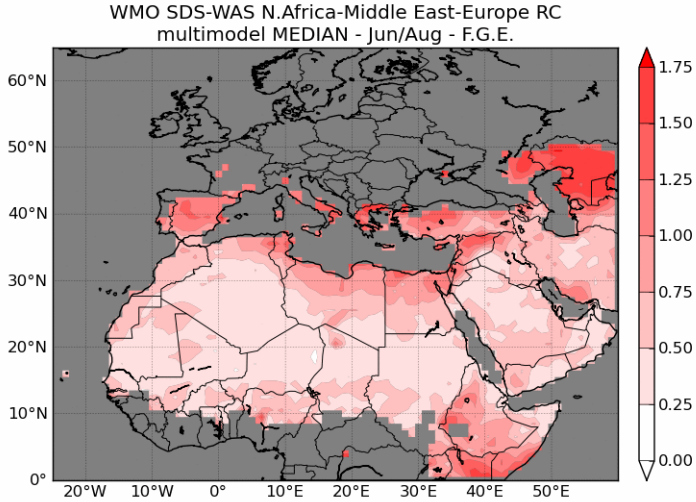
RMSE





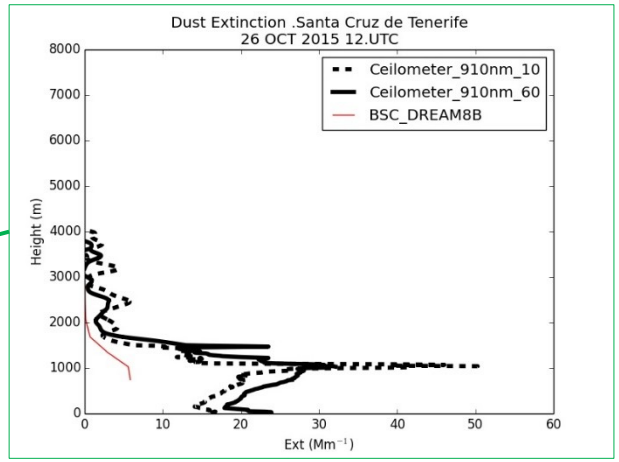
FGE

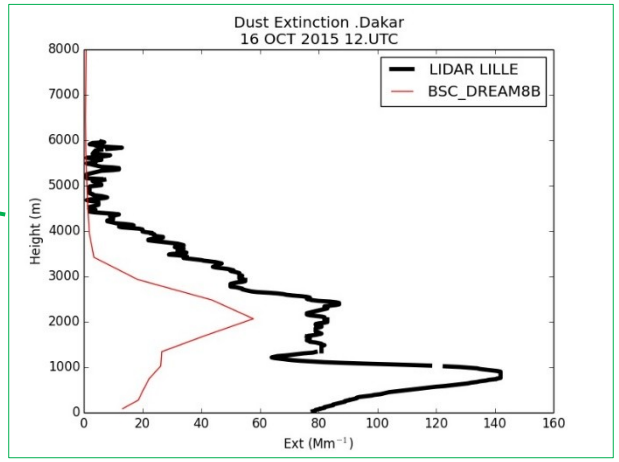




SDS-WAS:EvaluationusingLIDAR/Ceilometersdata

Université de Lille 1 SCIENCES ET TECHNOLOGIES





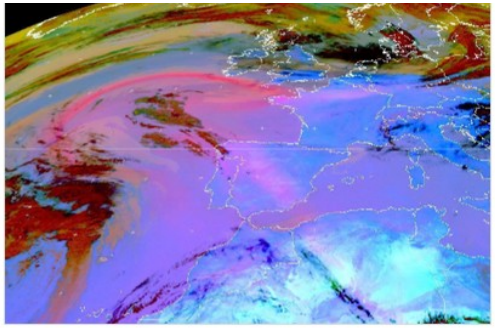
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

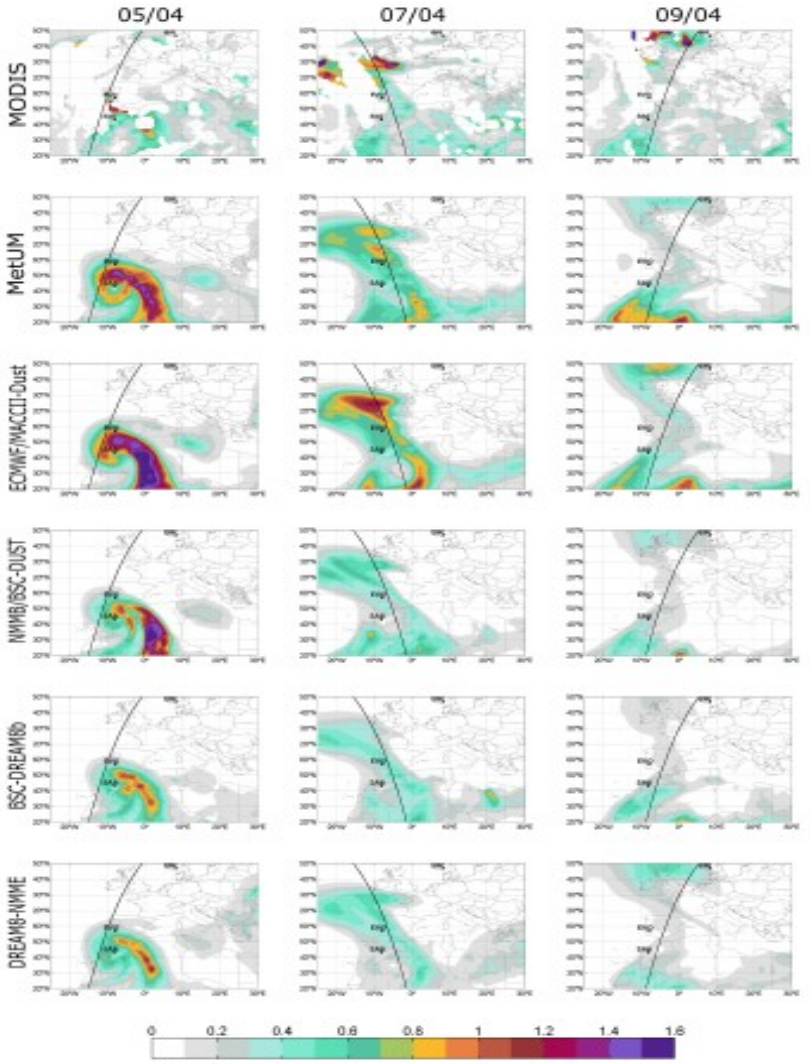
SDS-WAS:Modelintercomparison

http://sds-was.aemet.es

SDS-WAS:Modelintercomparison

Studyof adustoutbreakoverEuropeinApril2011

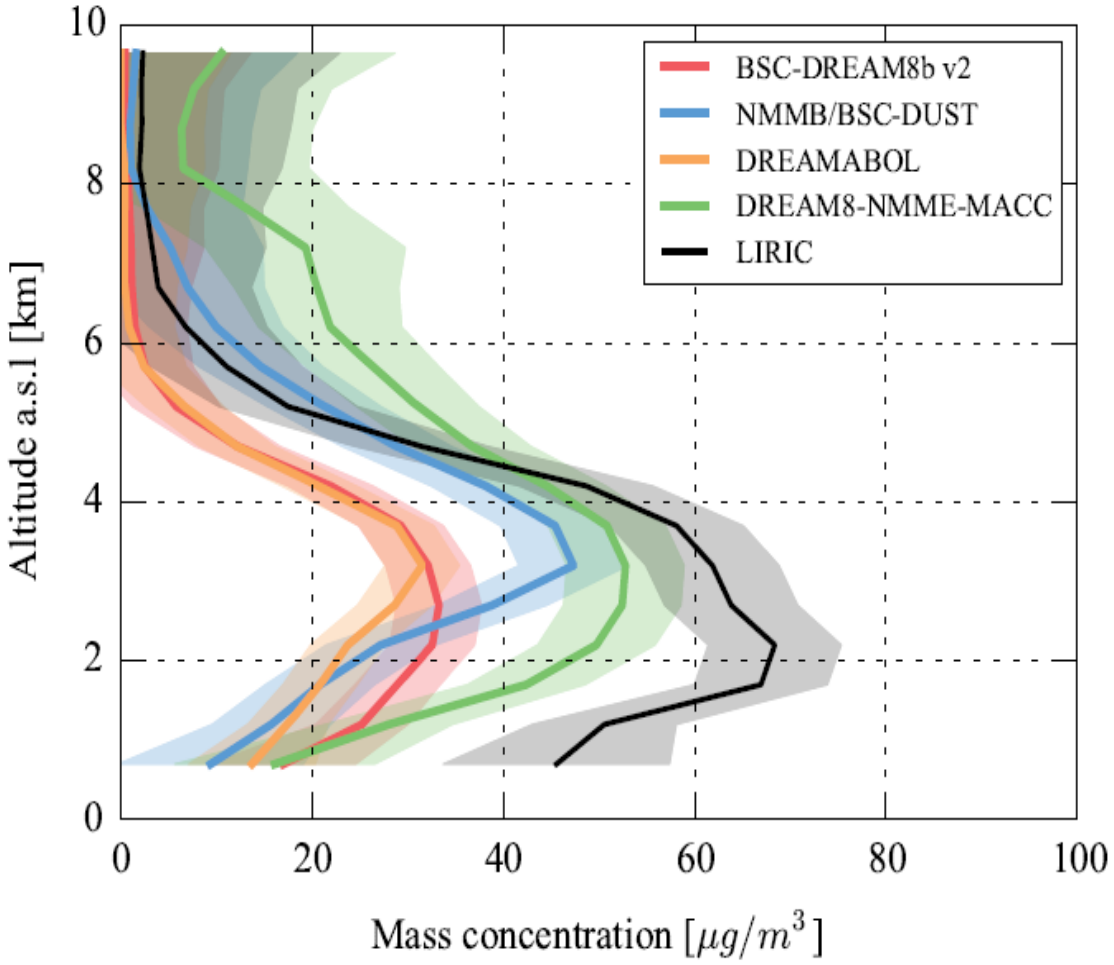




(Huneeuset al., 2015, ACPD)

SDS-WAS:Modelintercomparison

EARLINET verticalprofiles2011-2013



(Binitieglouet al., 2015, AMT)

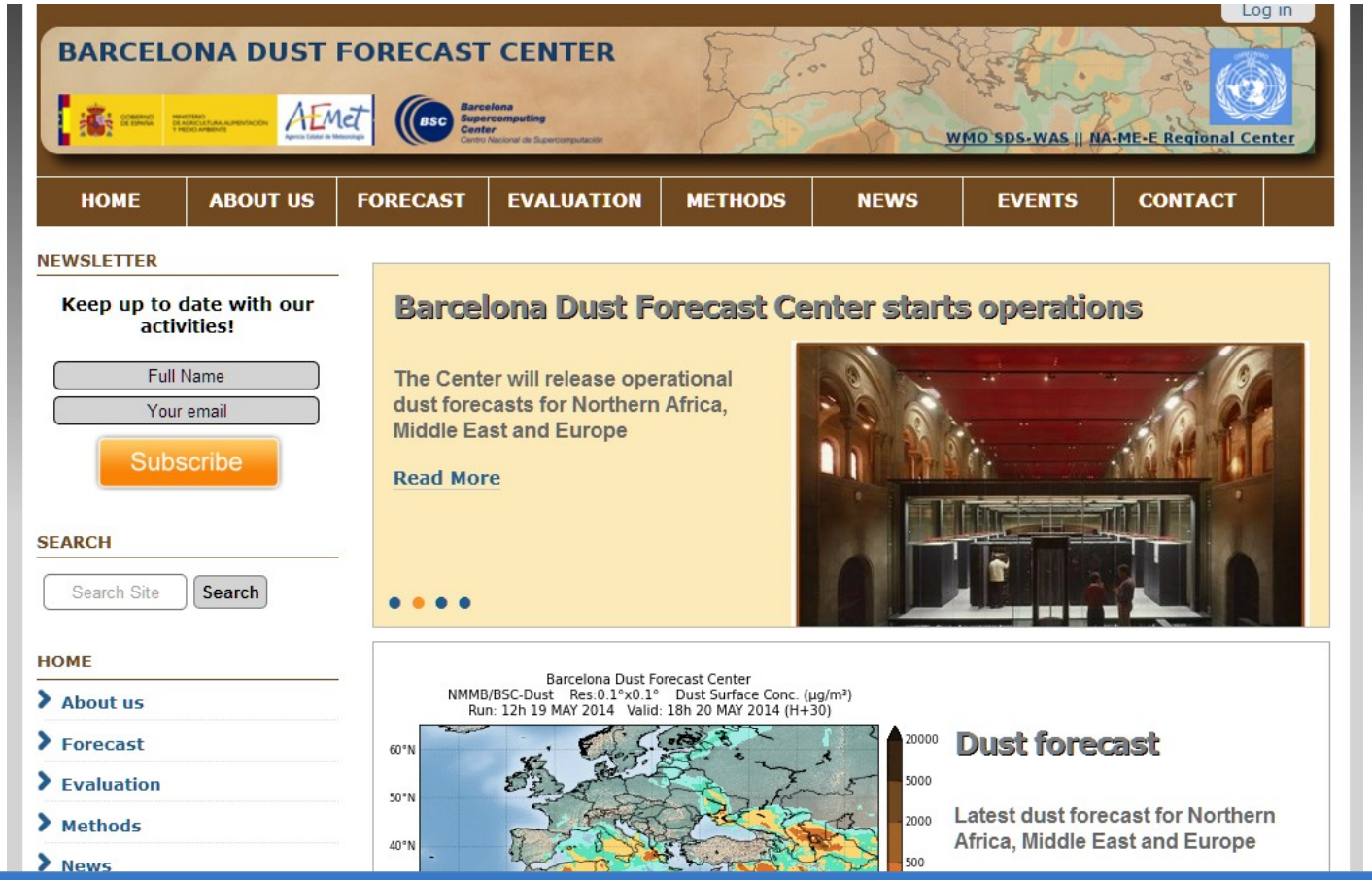
Studyof ahaboobinIranin 2014

Case studyof the small-scale extreme dust storm occurred in**Tehran**on**2nd June 2014**, at 5:30 PM local time, lasting less than 2 hours according to public evidence.

Basedon public news, the dust storm caused several deaths, reduction of visibility to several tenths meters in the city, and adverse disturbance of the public traffic. The blowing wind reached 110 km/h.

Contact: SlobodanNickovic(nickovic@gmail.com)

Barcelona DustForecasting Center (http://dust.aemet.es/)



First SpecializedCenterfor Mineral Dust Prediction ofWMO

NMMB/BSC-Dust*selected to provide operational forecasts at high resolution (10km) for NAMEE region*

BDFC (http://dust.aemet.es/)

DustOpticalDepthat 550nm

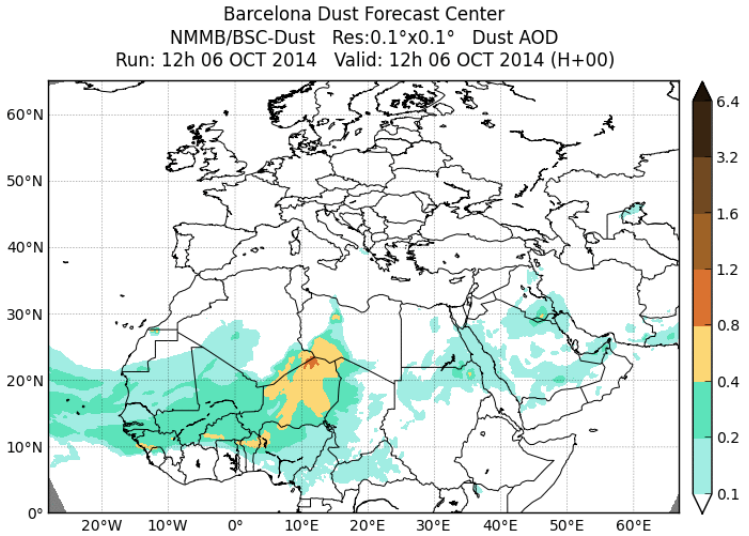
DustDryDeposition

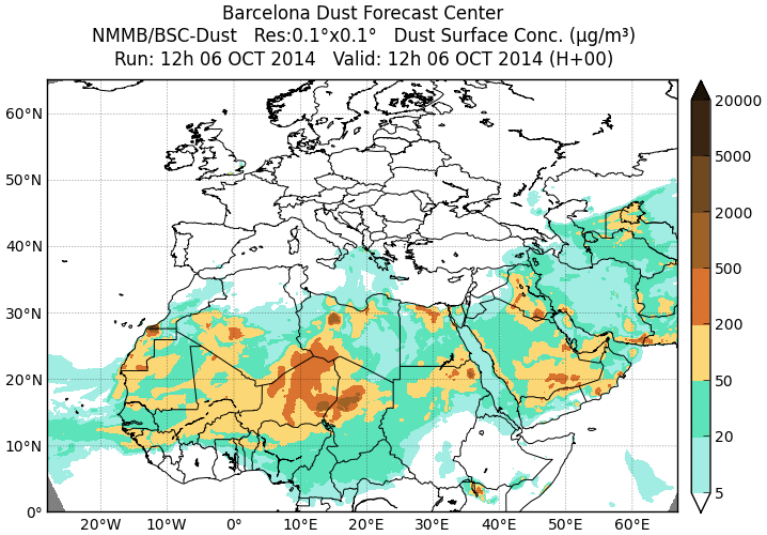
DustLoad

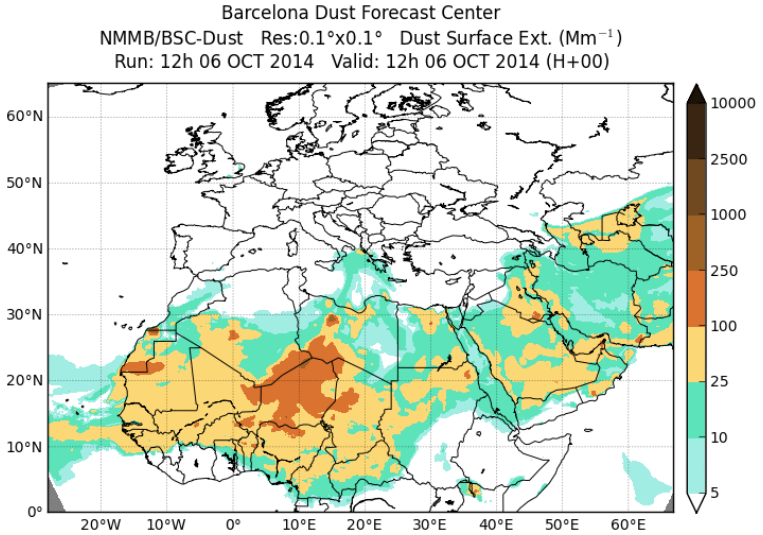
DustSurfaceConcentration

DustSurfaceExtinctionat 550nm

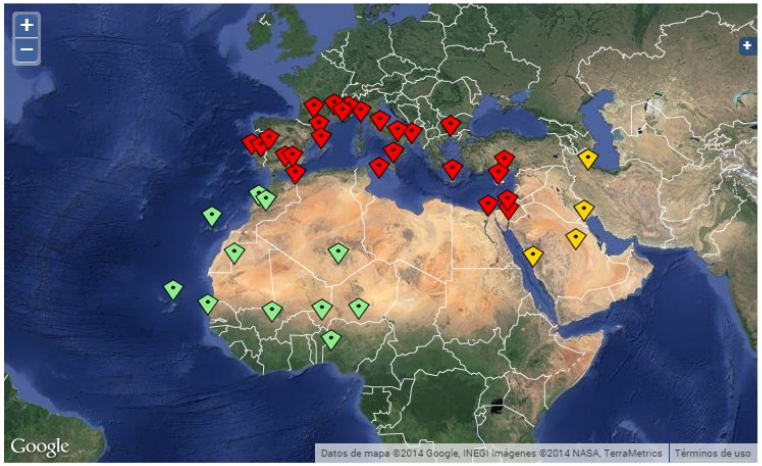
DustWetDeposition







BDFC:NRTEvaluationusingAERONET



A set ofevaluationmetricsareselected:

- Bias
- RMSE
- correlationcoefficient
- FGE

Calculationsevaluationmetricsare donefor:

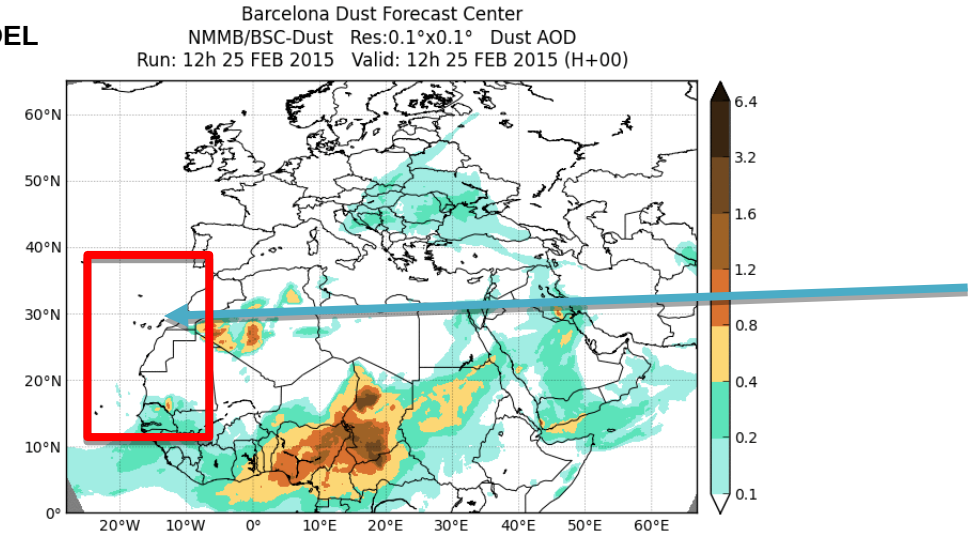
- monthly/seasonal/annual
- sitesandregions

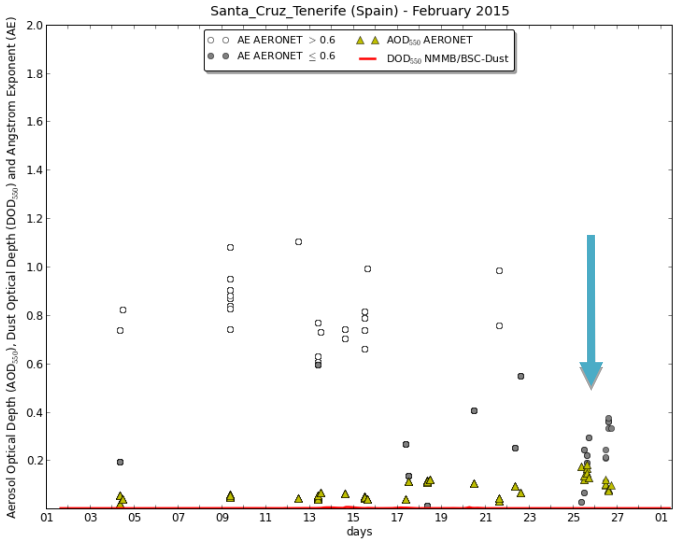
Jan 2014 - Dec 2014. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
Sahel/Sahara show stations	-0.12	0.38	0.51	0.75	7427
Middle East show stations	-0.10	0.27	0.39	0.64	112
Mediterranean show stations	-0.19	0.30	0.46	1.34	4623
TOTAL	-0.15	0.35	0.52	0.98	12162

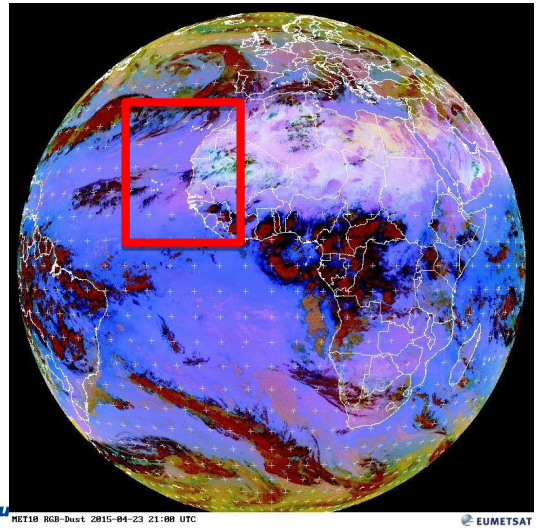
CanaryIslands dust eventFebruary 2015

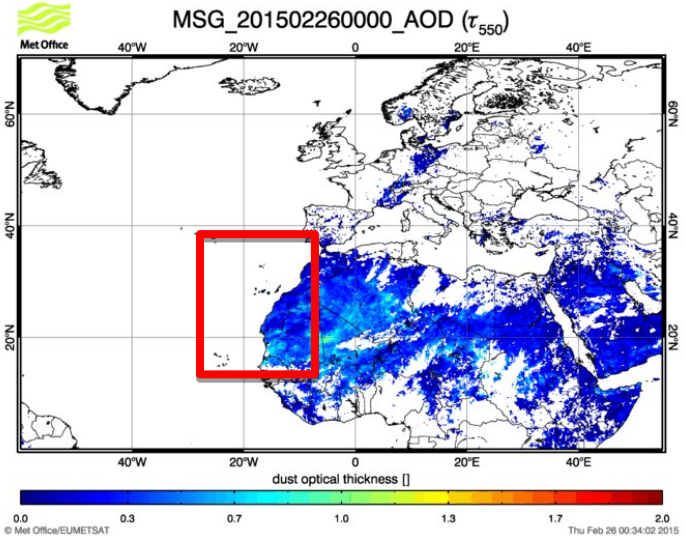
MODEL





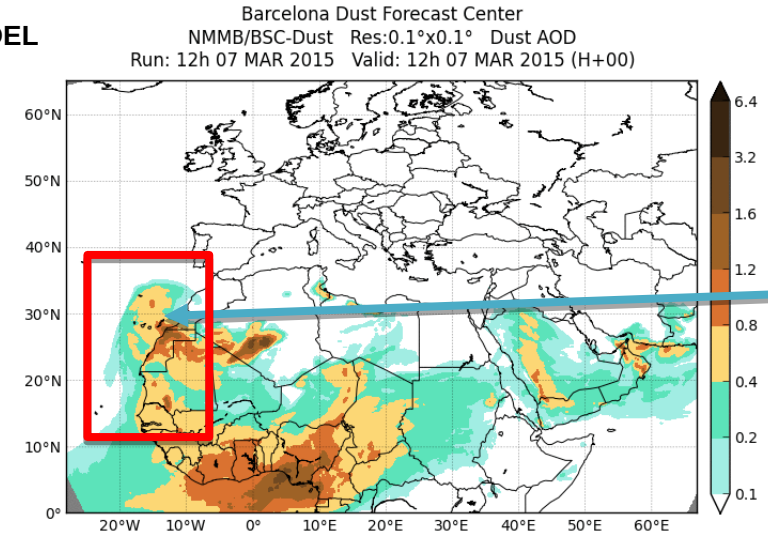
OBSERVATIONS

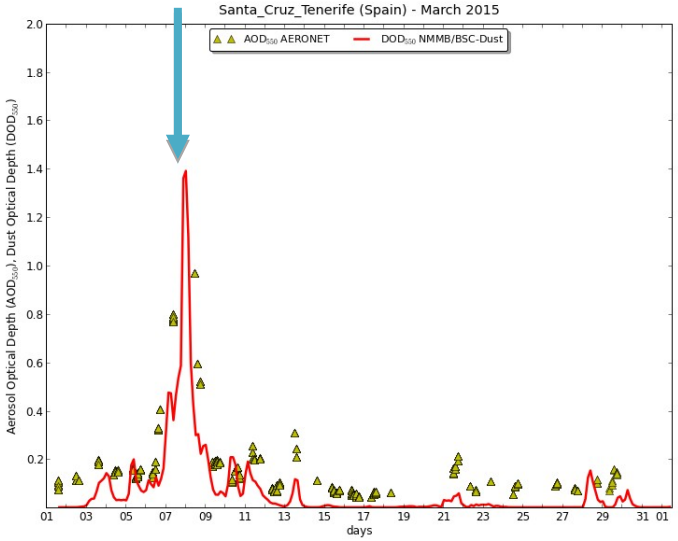




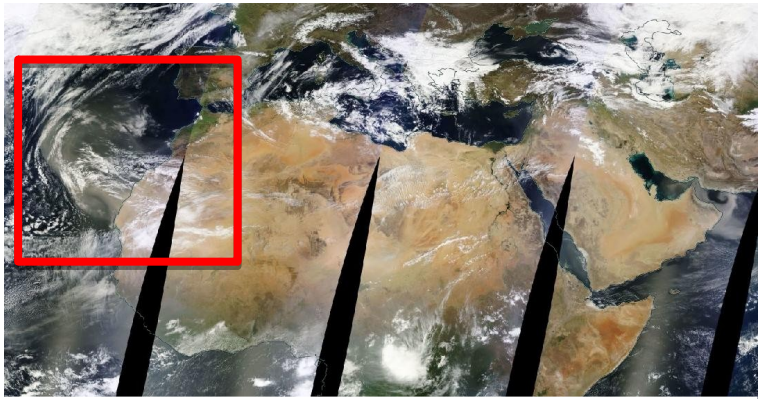
CanaryIslands dust event March 2015

MODEL



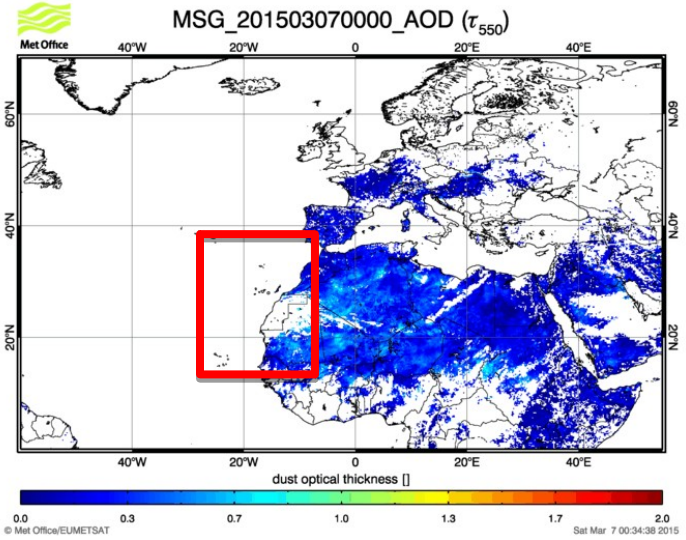


OBSERVATIONS



MODIS composite 8th March

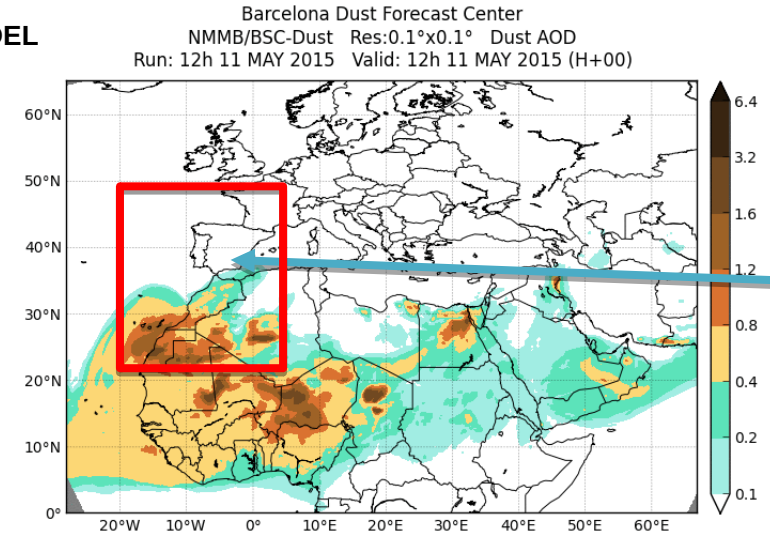
from EOSDIS World Viewer

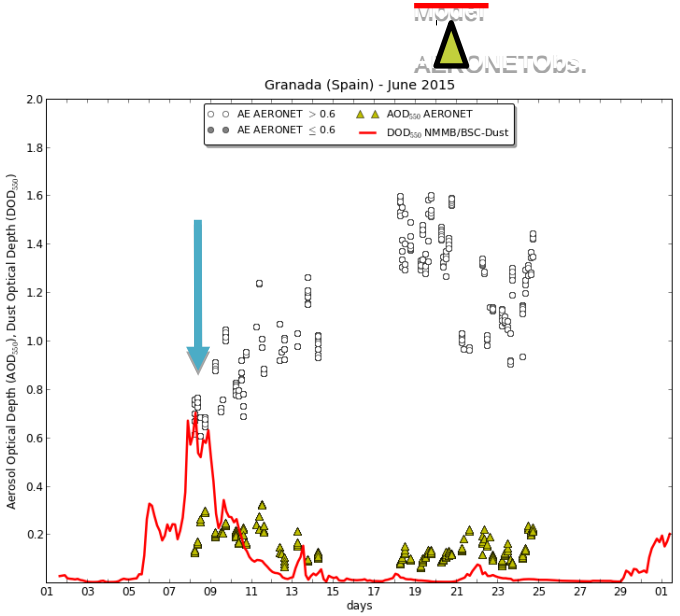


BSC Center
Centro Nacional de Supercomputación

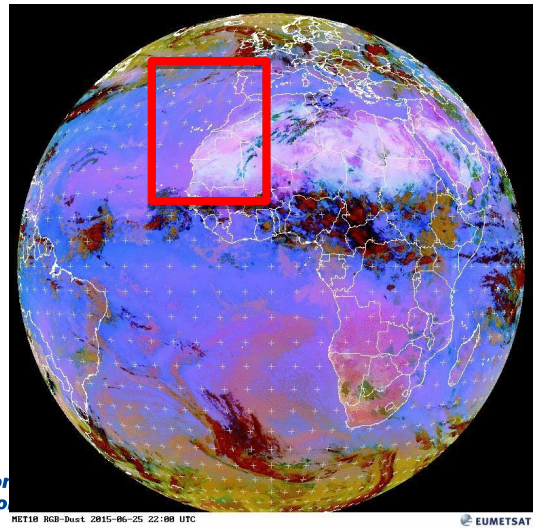
Europedust eventJune 2015

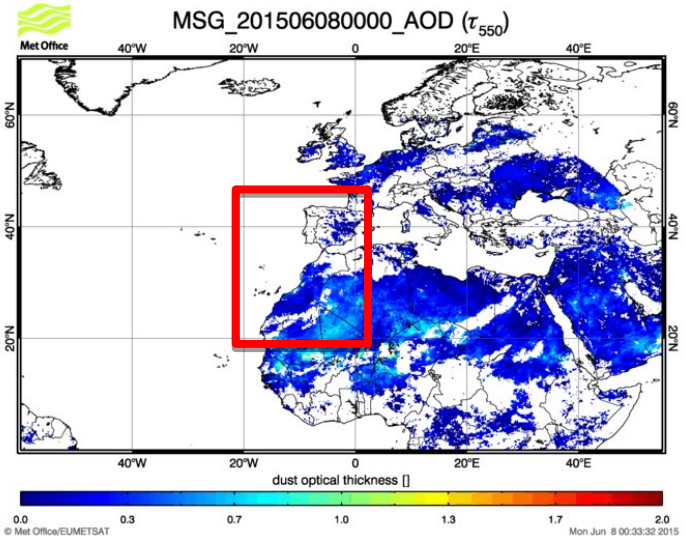
MODEL





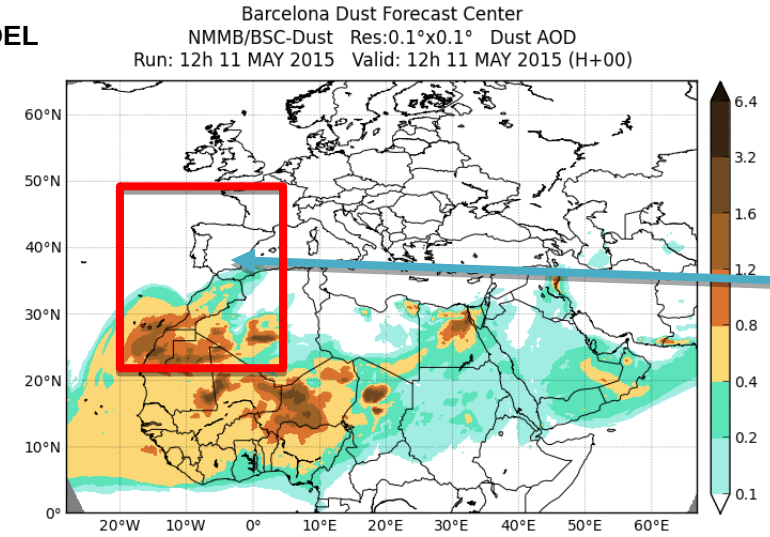
OBSERVATIONS

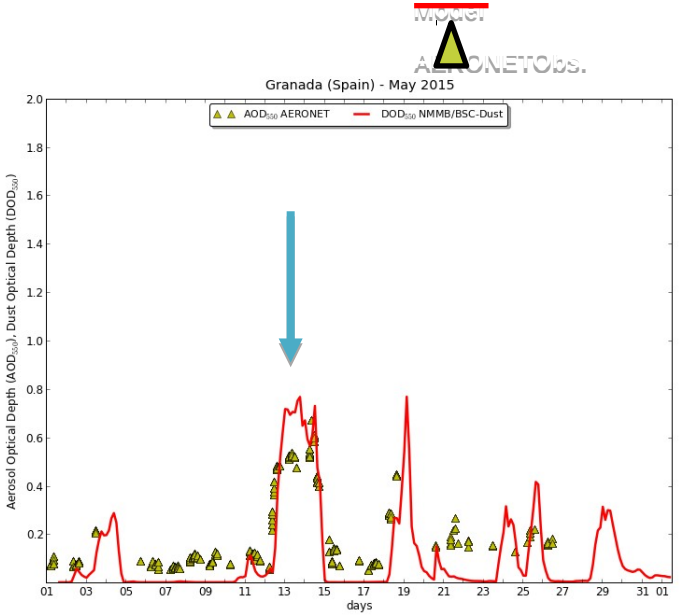




Europedust eventMay2015

MODEL





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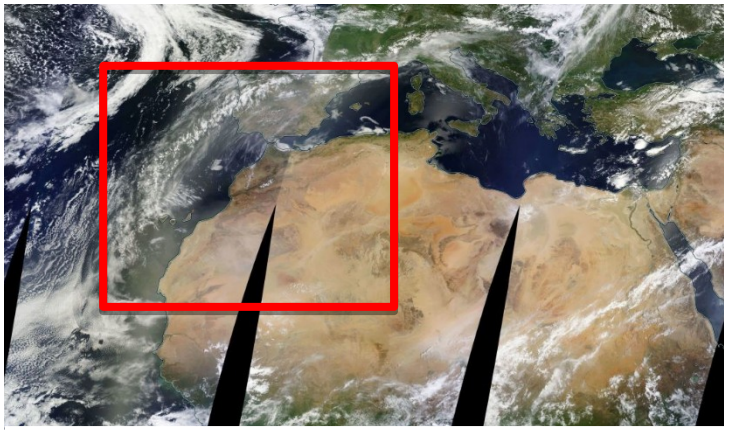
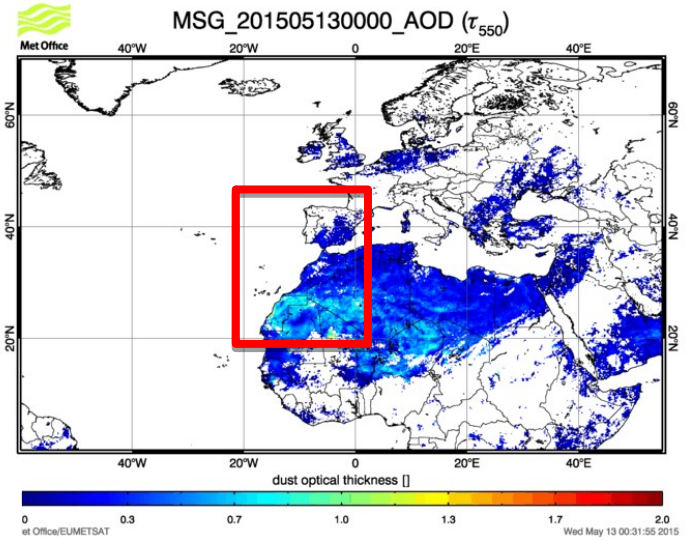


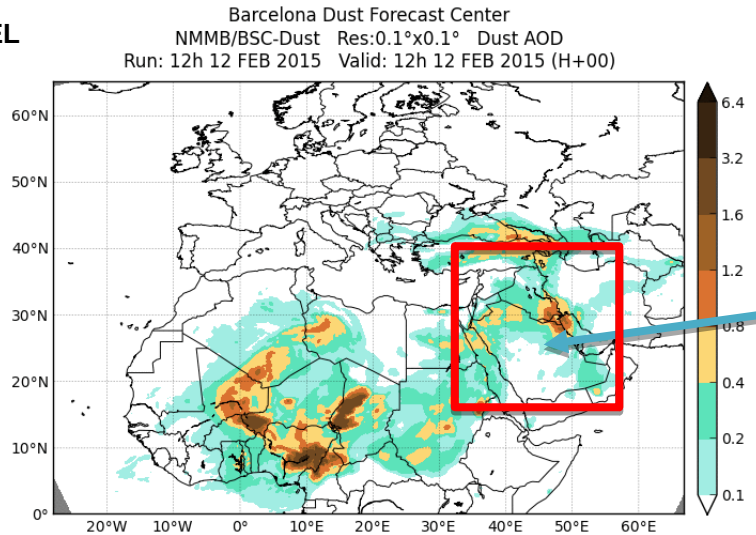
MODIS composite 13th May

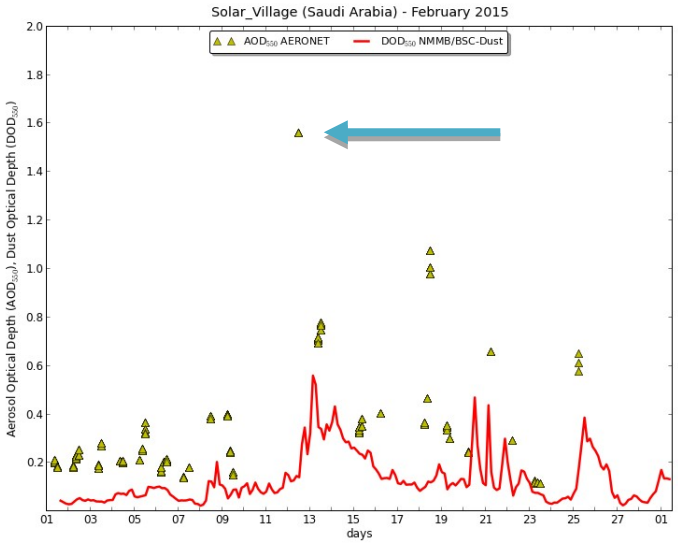
from EOSDIS World Viewer



Arabian dust event February 2015

MODEL





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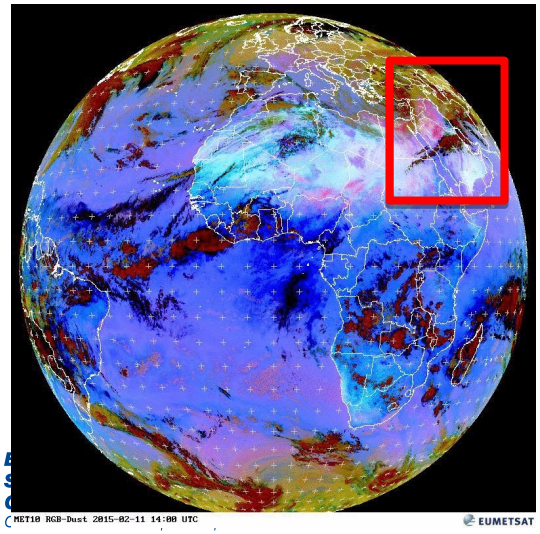
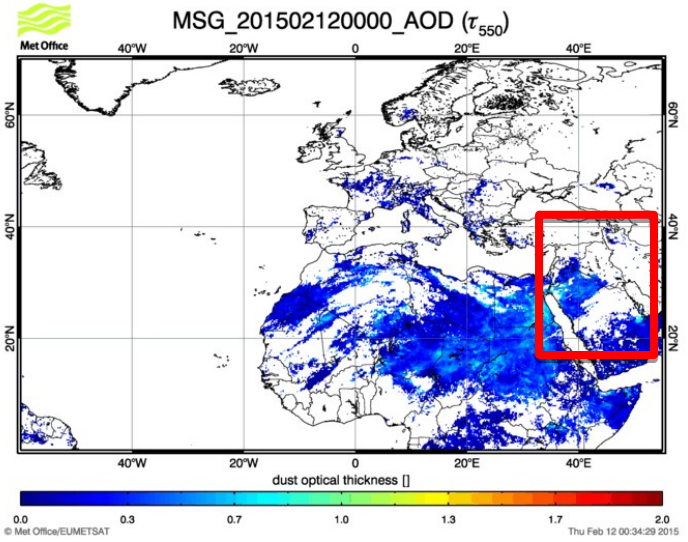
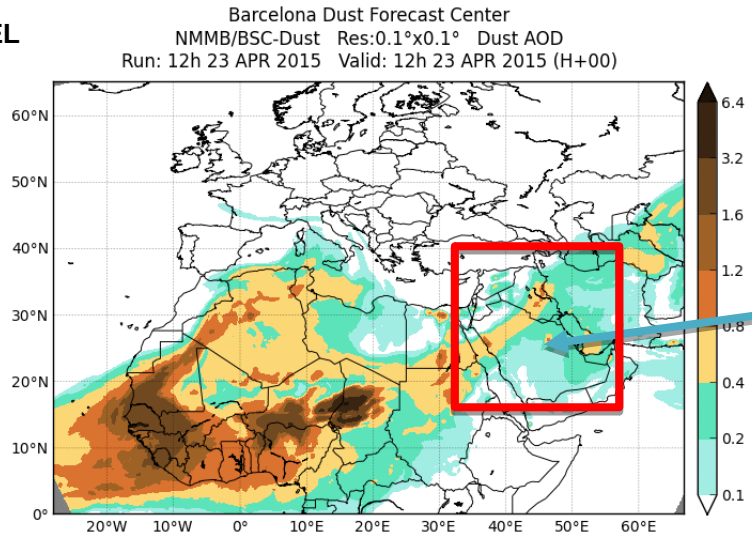
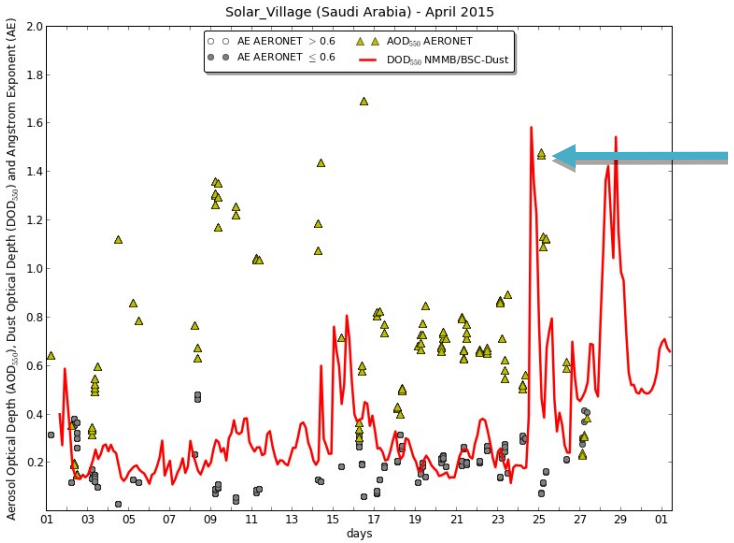




Arabian dust event Abril 2015

MODEL





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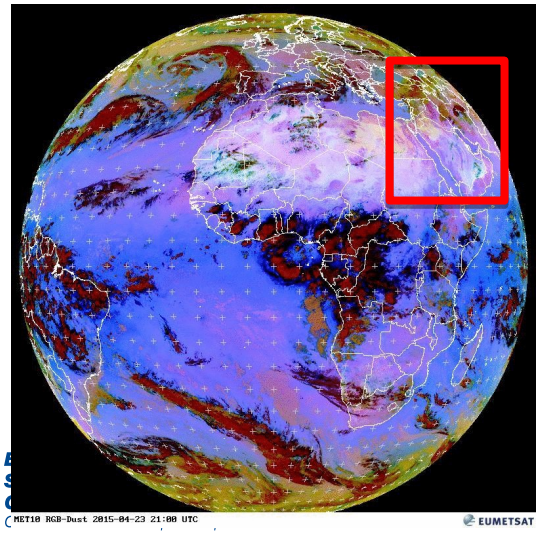
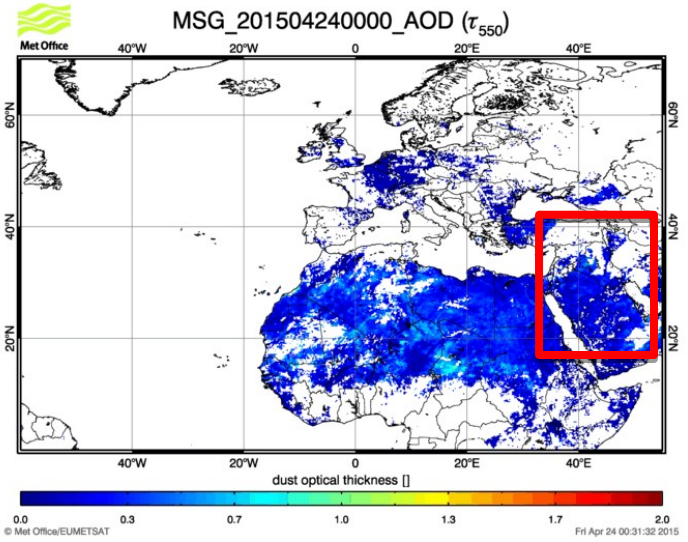
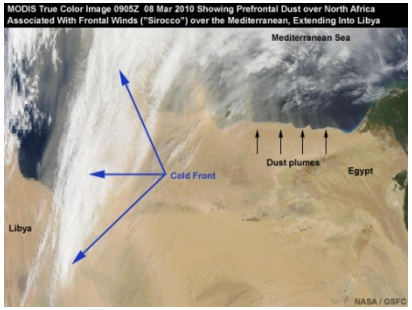
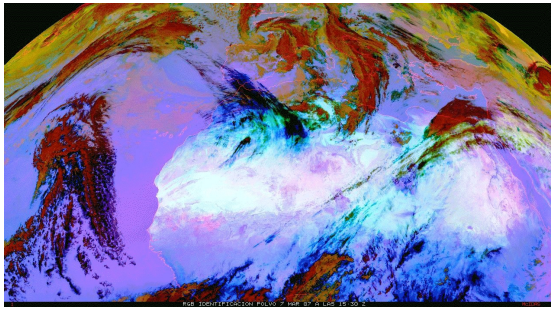


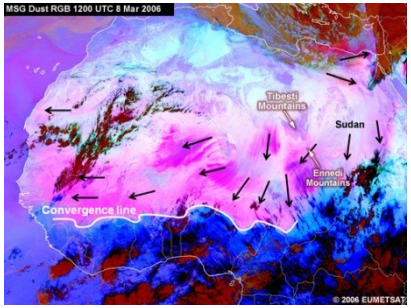


Dust cycle and associatedprocesses: Types of dust storms

Synopticduststorms(largescaleweathersystems) **Wellcapturedbymodels.**

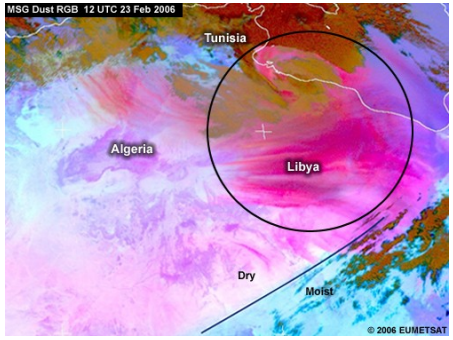


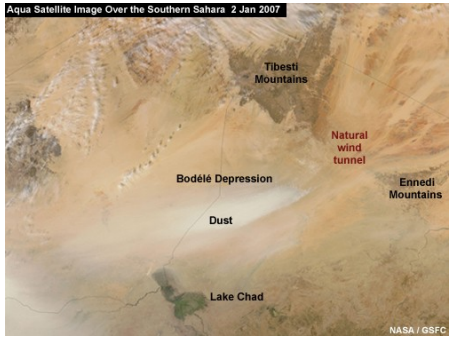


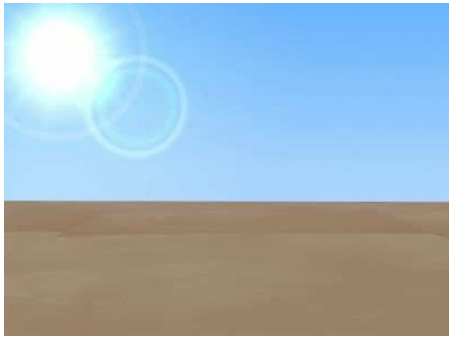


Pre-frontalwinds *Post-frontalwinds* *Large-scaletrade winds*

Mesoscaleduststorms **Poorlycapturedbymodels.Sometypesimprovein regionalmodels.**







Downslopewinds *Gapflow* *Convection& Inversiondownbursts* *Haboobs*

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Centro Nacional de Supercomputación

1st Africa/Middle-East Expert Meeting and Workshop on the health impact of airborne dust

Amman,Jordan,2nd November2015

Thankyou غراسياس

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