11th International Conference on
Air Quality - Science and Application
Thursday 15 March 2018

DESCRIBING AIR QUALITY–CLIMATE INTERACTIONS WITHIN THE REPAIR PROJECT

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GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Motivation and Objectives

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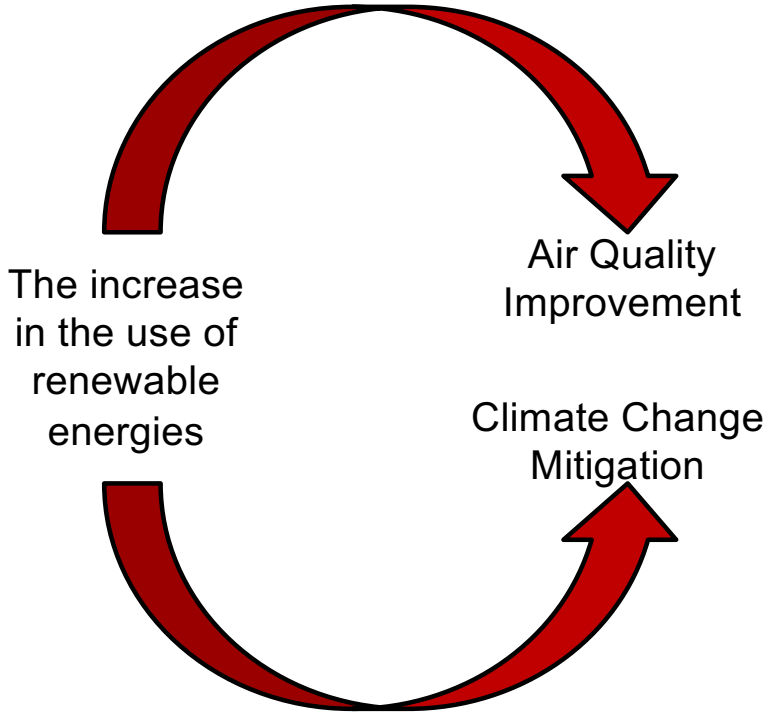
Air quality-climate interactions and their impact on renewable energies under climate change scenarios (REPAIR)



Objectives

To study the impact of the air quality-climate interactions (AQCI) and potential future emission reductions due to the increased use of renewable energies (including wind and solar) on climate change in Europe through its mitigating role in radiative forcing and air quality.

The REPAIR project is a Spanish competitive-funded initiative. The objectives of the REPAIR proposal are decisively comprised in the goals of the Horizon 2020 programme, since it will provide science-based information.

WP2. Modelling System

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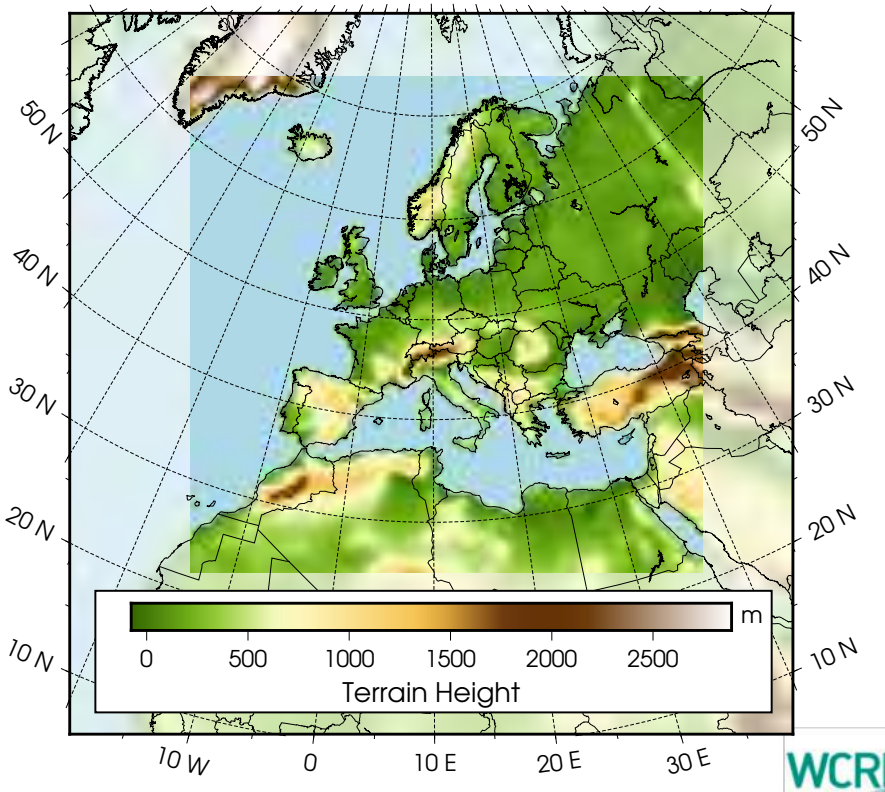
Simulation Matrix (Scenarios)				
Code	**Model**	**IC/BC**	**Emiss**	**Period**
REA	WRF	ERA-20C	-	1991-2010
REA-CHEM_P	WRF-Chem	ERA-20C	EDGAR-HTAP	1991-2010
PRE	WRF	EC6-20C3M	-	1991-2010
PRE-CHEM_P	WRF-Chem	EC6-20C3M	EDGAR-HTAP	1991-2010
FUT85	WRF	EC6-RCP8.5	-	2031-2050
FUT85-CHEM_P	WRF-Chem	EC-RCP8.5	EDGAR-HTAP	2031-2050
FUT85-CHEM_F	WRF-Chem	EC-RCP8.5	EDGAR-HTAP fut	2031-2050
FUT85-CHEM_R	WRF-Chem	EC-RCP8.5	EDGAR-HTAP fut + ALT8.5	2031-2050

Domain 1 (1.32º) → Total Saharan dust intrusions capture

Domain 2 (0.44º) → EuroCORDEX



WCRP CORDEX

WP2. Modelling System

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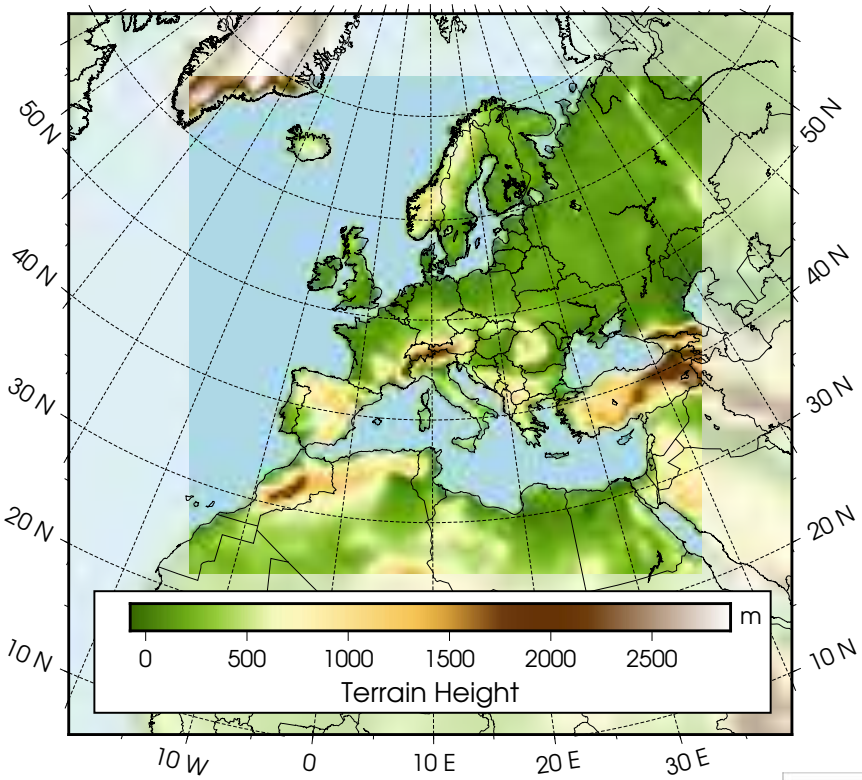
Model configuration	
Parameterization	**Reference**
Physics	
Microphysic	Lin
Radiation (SW & LW)	RRTM
Planetary Boundary Layer	YSU
Cumulus	Kain-Fritsch
Soil option	Noah
Chemistry	
Gas-phase	RACM-KPP
Aerosol	GOCART
Photolysis	Fast-J
Biogenic emissions	MEGAN
Dry deposition	Wesely
Wet deposition	Wet deposition + Grid-scale wet deposition

Domain 1 (1.32º) → Total Saharan dust intrusions capture

Domain 2 (0.44º) → EuroCORDEX



WCRP CORDEX

WP3. Present-day climatologies (2001-2010): REA-CHEM_P

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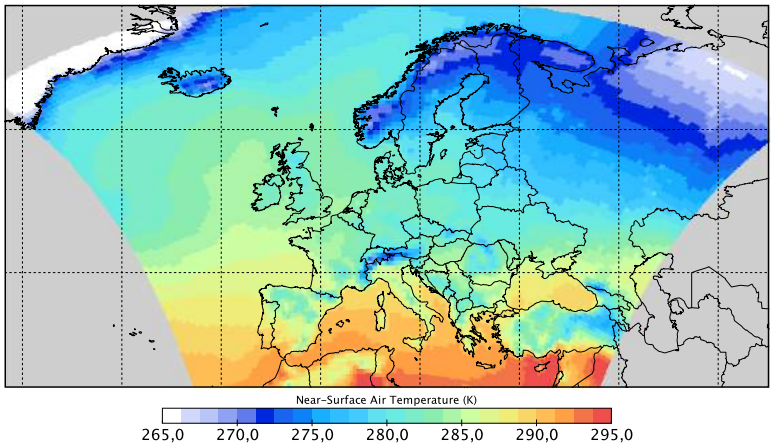
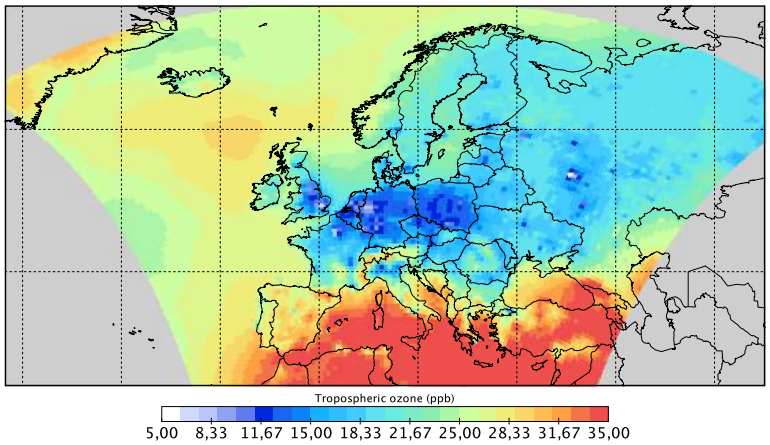
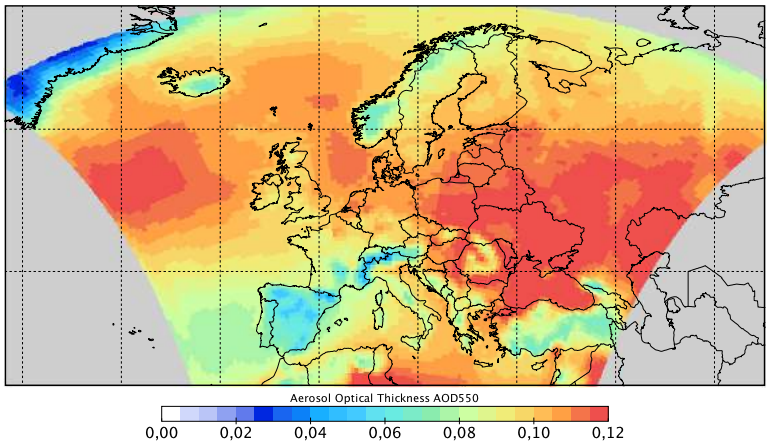
Near-Surface Air Temperature



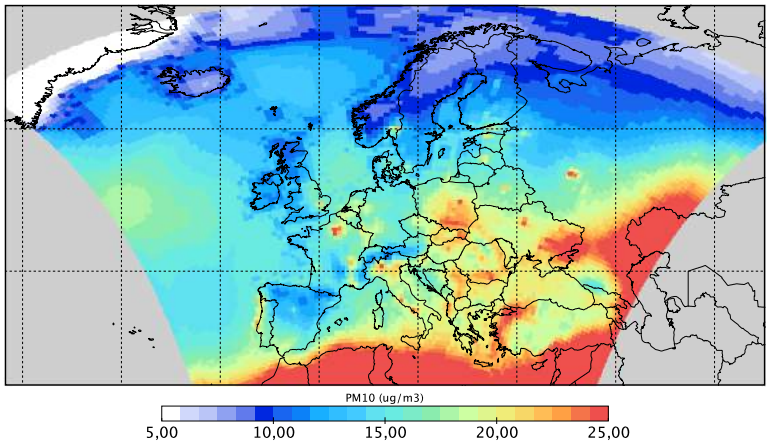
Tropospheric ozone



Aerosol Optical Depth at 550nm



Particulate Matter PM_{10}



WP3. Present-day climatologies (2001-2010): REA-CHEM_P

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Evaluation against…				
Variable	**Observation**	**Temporal resolution**	**Spatial resolution**	**Reference**
NO_2	OMI/Aura NO_2 Tropospheric Column	Daily L3	Global (0.25º)	Krotkov, N.A. (2013), OMI/Aura NO2 Cloud-Screened Total and Tropospheric Column L3 Global Gridded 0.25, NASA GSFC, GES DISC, 10.5067/Aura/OMI/DATA3007
O_3	Gridded data observations	MDA8	Europe (1º)	Schnell, J., et al.: Skill in forecasting extreme ozone pollution episodes with a global atmospheric chemistry model, Atmos. Chem. Phys., 14, 7721-7739, https://doi.org/10.5194/acp-14-7721-2014, 2014.
PM_{10}	Gridded data observations	Daily	Europe (1º)	Provided by J. Schnell. Methodology analogous to: Schnell, et al., 2014.
AOD	MODIS L2	Daily from L2	Global (10 km)	Levy, R., Hsu, C., et al., 2015. MODIS Atmosphere L2 Aerosol Product. NASA MODIS Adaptive Processing System, GSFCnter, USA
Near-Surface Air Temperature	E-OBS (v16.0)	Daily	Europe (0.5º)	Haylock, M. R., et al., 2008. A European daily high-resolution gridded data set of surface temperature and precipitation for 1950-2006. Journal of Geophysical Research: Atmospheres, 113: D20119. DOI: 10.1029/2008JD010201.
Precipitation	E-OBS (v16.0)	Daily	Europe (0.5º)	Haylock, M. R., et al., 2008.

WP3. Present climatologies (2004-2010): Evaluation NO_2 (REA-CHEM_P)

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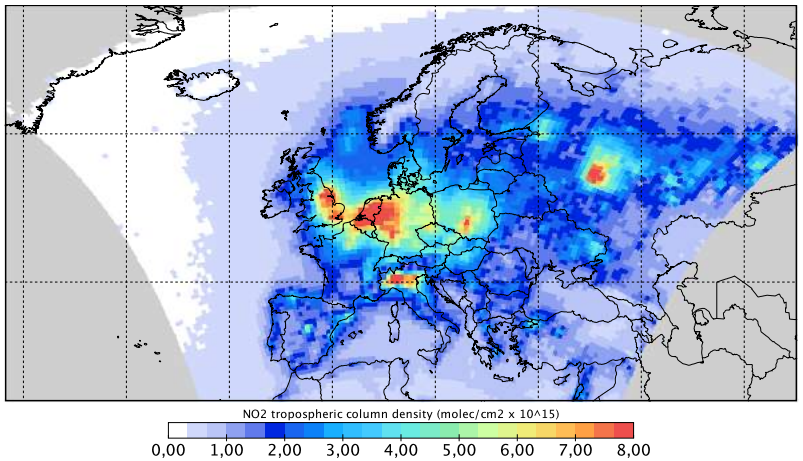
NO_2 tropospheric column from OMI-L3 (Daily)

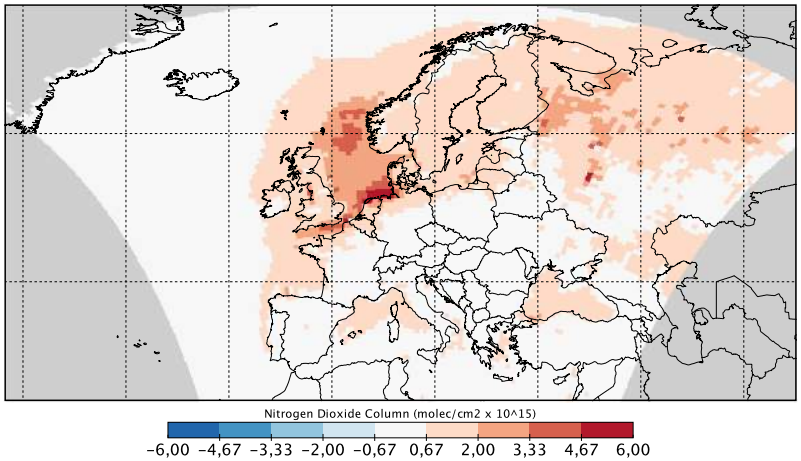


◀ OMI/Aura NO2 Cloud-Screened Total and Tropospheric Column Daily L3 Global 0.25deg

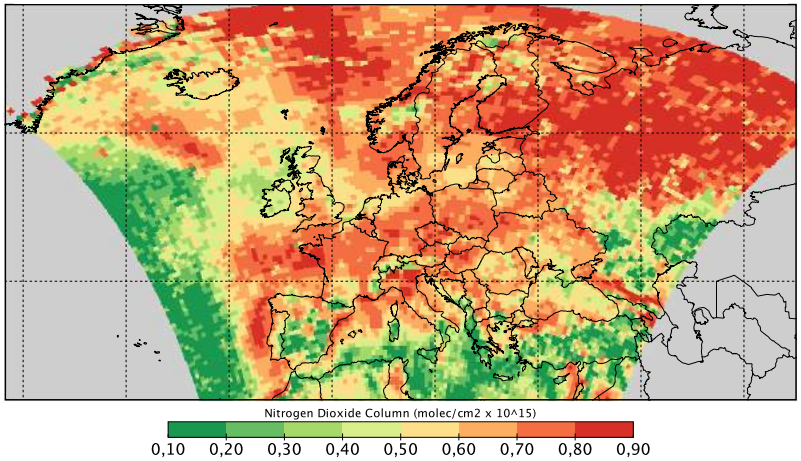
Overestimation of NO_2 levels over the sea

Low correlations over the Mediterranean Basin

Daily BIAS NO_2



Daily correlation NO_2



WP3. Present climatologies (Summer 2001-2010): Evaluation O_3 during summer (REA_CHEM_P)

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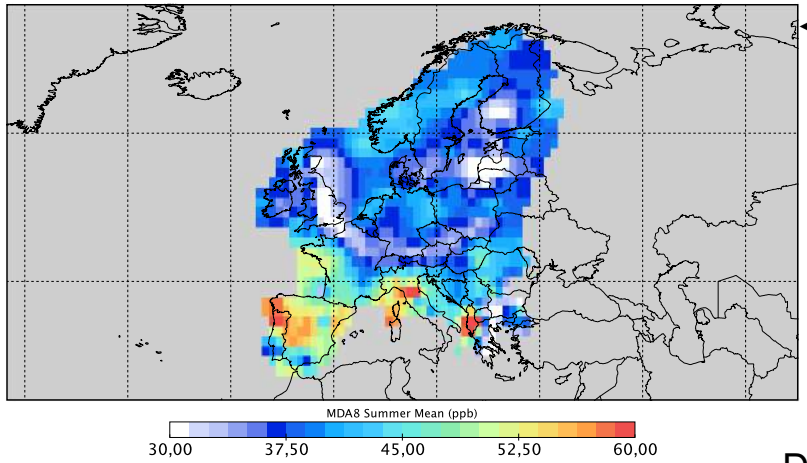
Summer MDA8 Tropospheric O_3 from Schnell et al (2014)

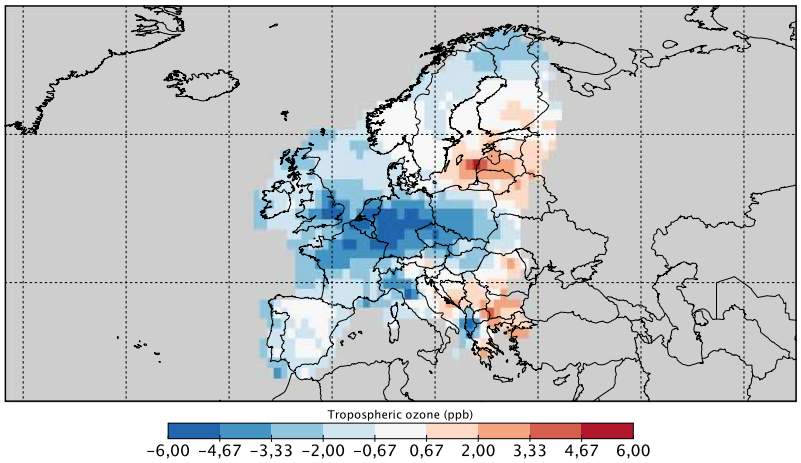


Schnell, J. L., Holmes, C. D., Jangam, A., and Prather, M. J.: Skill in forecasting extreme ozone pollution episodes with a global atmospheric chemistry model, Atmos. Chem. Phys., 14, 7721-7739, https://doi.org/10.5194/acp-14-7721-2014, 2014.

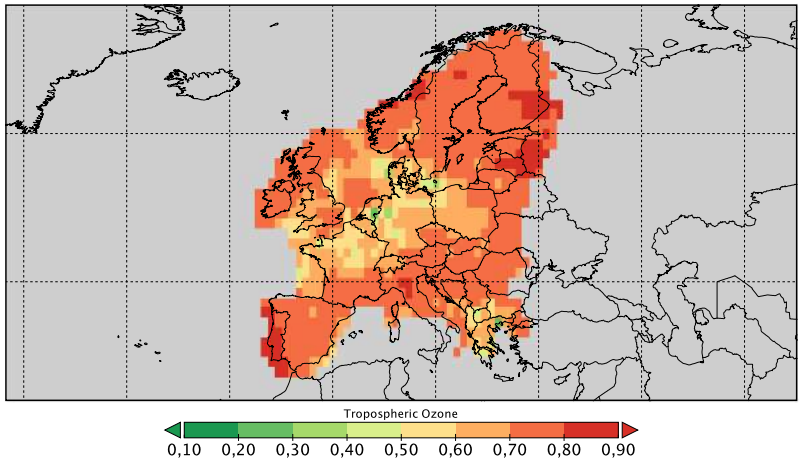
A general underestimation. Low biases over the IP

Higher correlation values during summer

BIAS MDA8 O_3



Daily correlation MDA8 O_3



WP3. Present climatologies (2003-2010): Evaluation PM_{10} (REA_CHEM_P)

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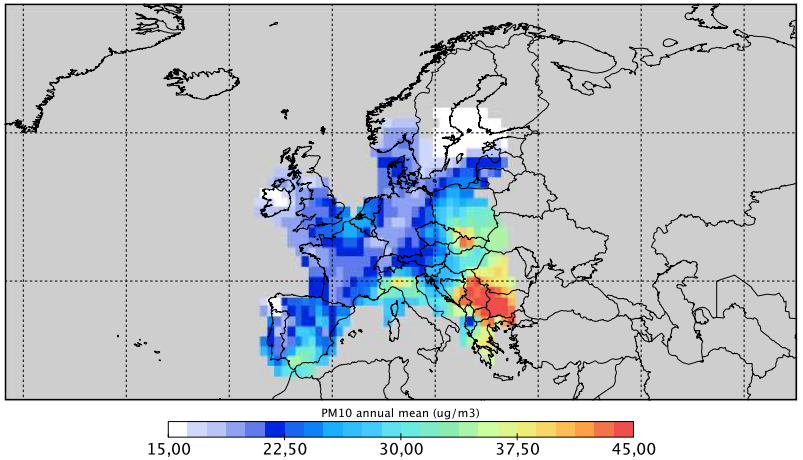
PM_{10} (J. Schenell, personal communication)

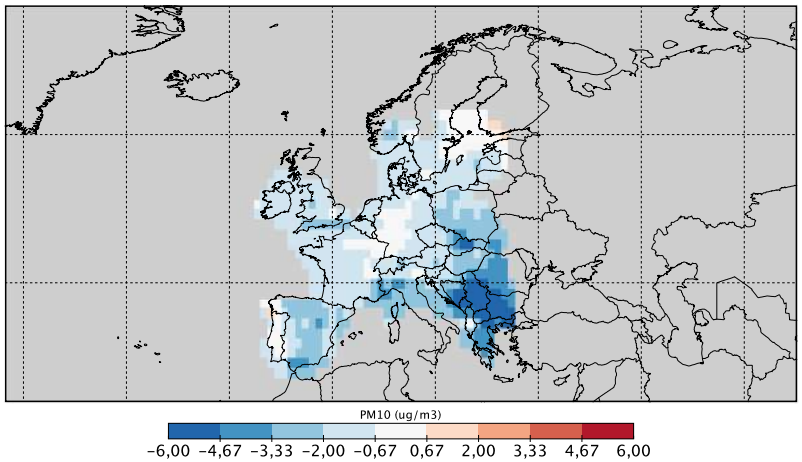


Methodology analogous to: Schnell, et al., 2014. Personal communication of J. Schnell.

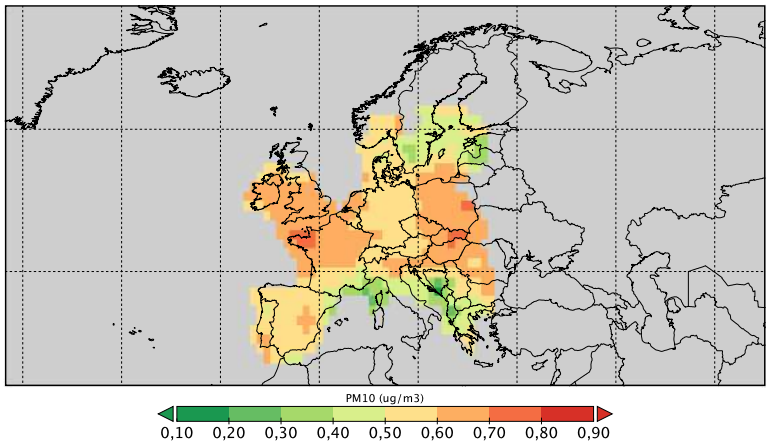
A general underestimation, larger bias over Balkan peninsula

Low correlation over the south of the domain → lower stations density

BIAS PM_{10}



Daily correlation PM_{10}



WP3. Present-day climatologies: WRF (REA) vs. WRF-Chem (REA_CHEM_P)

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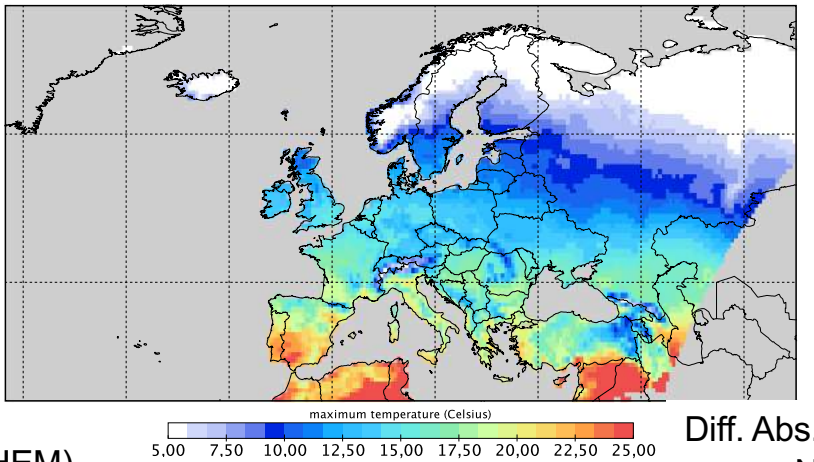
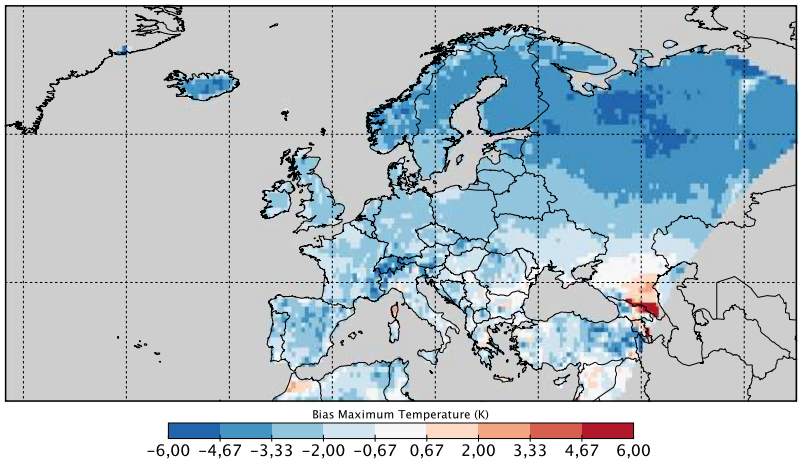
Maximum Temperature (E-OBS)



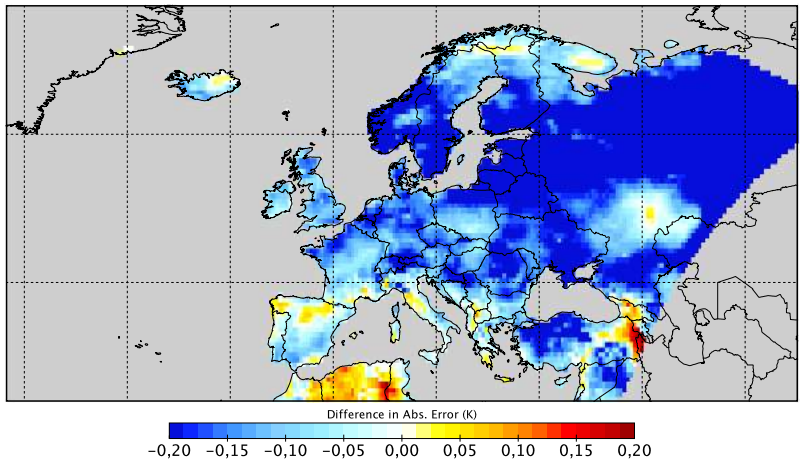
Underestimation of maximum temperature, higher over the north

Generally, lower absolute error in CHEM simulation (in blue)

Temp. BIAS (NO-CHEM)



Diff. Abs. Error (CHEM vs NO-Chem)



WP3. Present-day climatologies: WRF (REA) vs. WRF-Chem (REA_CHEM_P)

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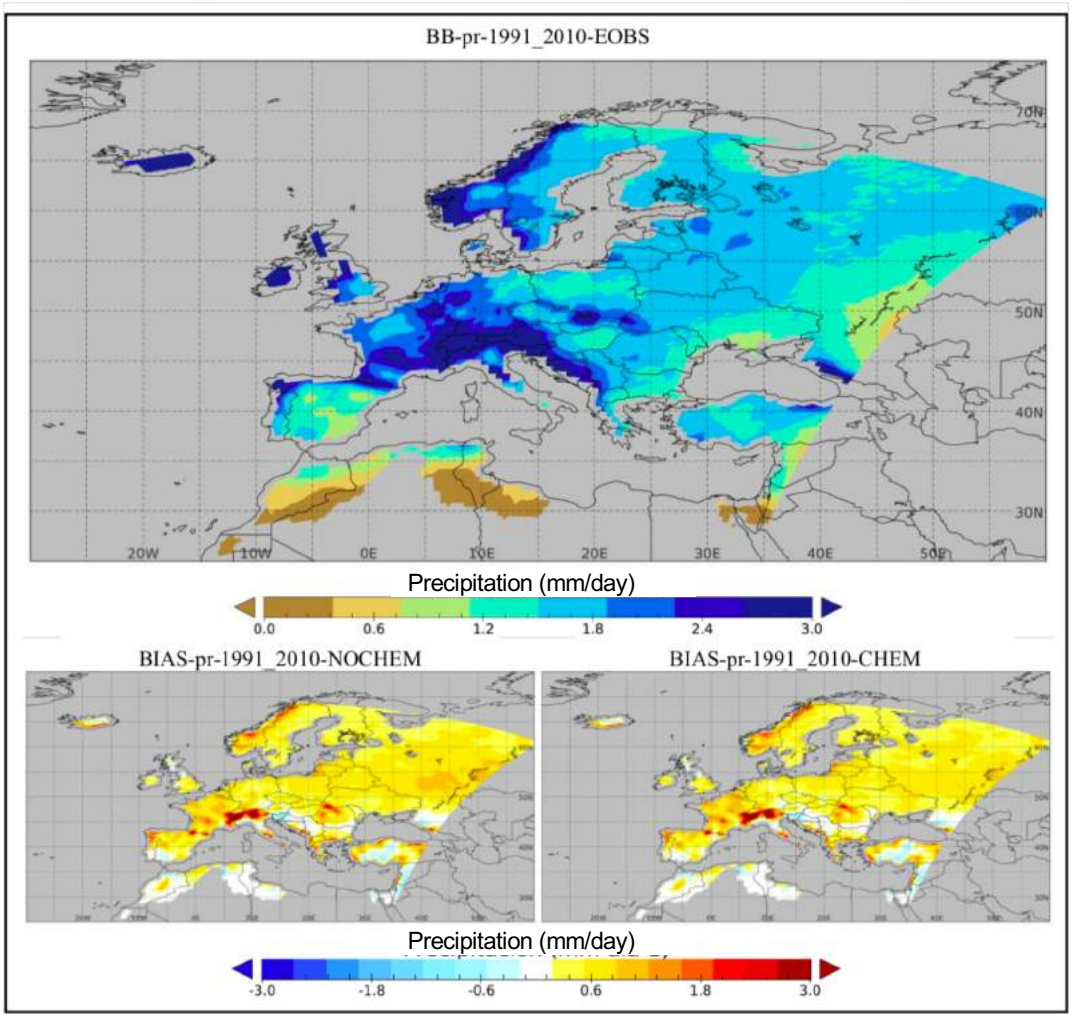
Precipitation

Mean	Media (mm/day)	BIAS (mm/day)	% BIAS
E-OBS	1.58	-	-
WRF	1.73	0.51	32.28
WRF-Chem	1.71	0.47	29.75

Number of consecutive wet days

ECACWD	Mean (days)	BIAS (days)	% BIAS
E-OBS	13.65	-	-
WRF	-	2.72	19.93
WRF-Chem	-	2.56	18.75



WP4. CLIMATE CHANGE PROJECTIONS:
Impact of evolving greenhouse gas forcing on the warming signal in regional climate model experiments

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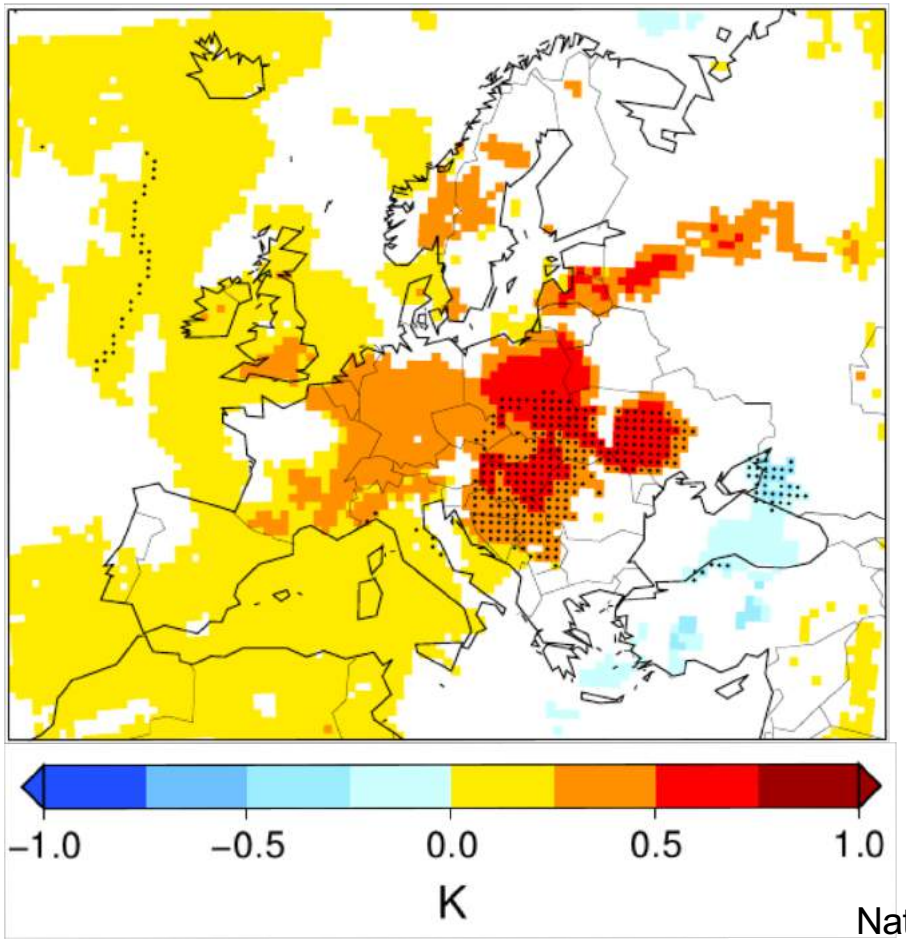

◀ Impact of including the evolving GHG forcing in regional climate simulations on the temperature projections under 1.5ºC global warming.

The **inclusion of the GHG forcing in regional climate model experiments** is a non-regulated, non-documented practice.

Its significant impact on the simulated regional warming trends even **doubles the climate change signals** under 1.5ºC global warming (see points in the figure).

Nature Communications (2018), in press, DOI: 10.1038/s41467-018-03527-y

WP4. CLIMATE CHANGE PROJECTIONS: RCP 8.5

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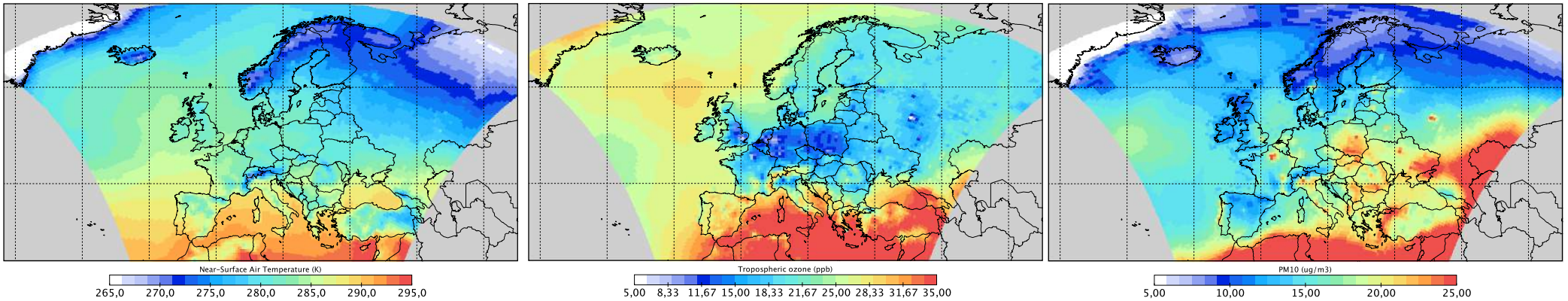
Near-Surface Air Temperature

Tropospheric Ozone

Particulate Matter PM_{10}

PRE_CHEM_P



Near-Surface Air Temperature (RCP8.5 vs 20C3M)

Tropospheric ozone (RCP8.5 vs. 20C3M)

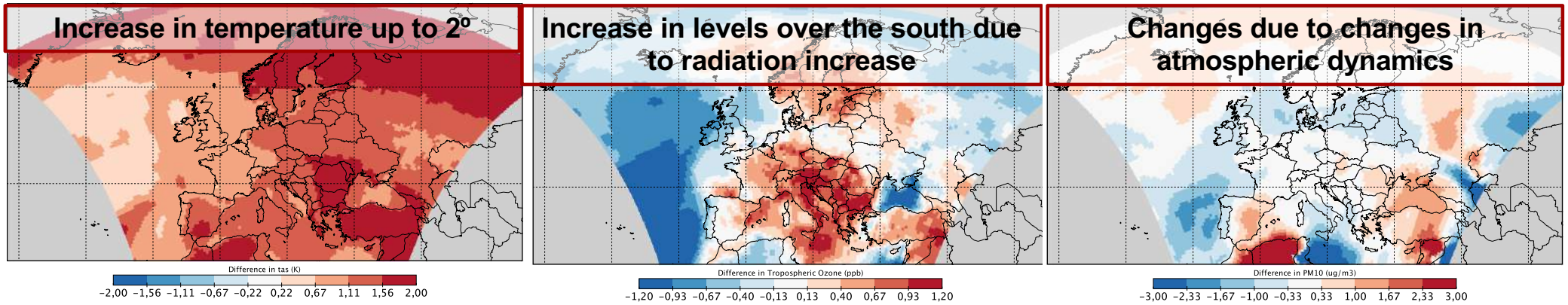
PM10 (RCP8.5 vs. 20C3M)

FUT85-CHEM_P vs PRE_CHEM_P

Increase in temperature up to 2º

Increase in levels over the south due to radiation increase

Changes due to changes in atmospheric dynamics



Summary and Conclusions

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- WP2. The evaluation of the air quality variables indicates a good representation of:
  - NO_2: low BIAS over Europe but lower correlation values over the Mediterranean Basin.
  - O_3 during summer: a general overestimation of MDA8 levels but really high temporal correlation
  - PM_{10}: a general underestimation of the levels. Low temporal correlation may due to low density of station.

- WP3. Both, air-surface temperature and precipitation, the model representation improves when aerosol-radiation-clouds interactions are taken into account.

- WP4. Future climate projection under the RCP8.5 scenario indicate:
  - Regional climate change projection should include GHG variations.
  - An increase in temperatures and radiation and changes in PM_{10} due to atmospheric dynamic.

Future Works: CLIMATE PROJECTIONS INCLUDING RENEWABLE ENERGIES AND THEIR IMPACT ON EMISSIONS (WP5)

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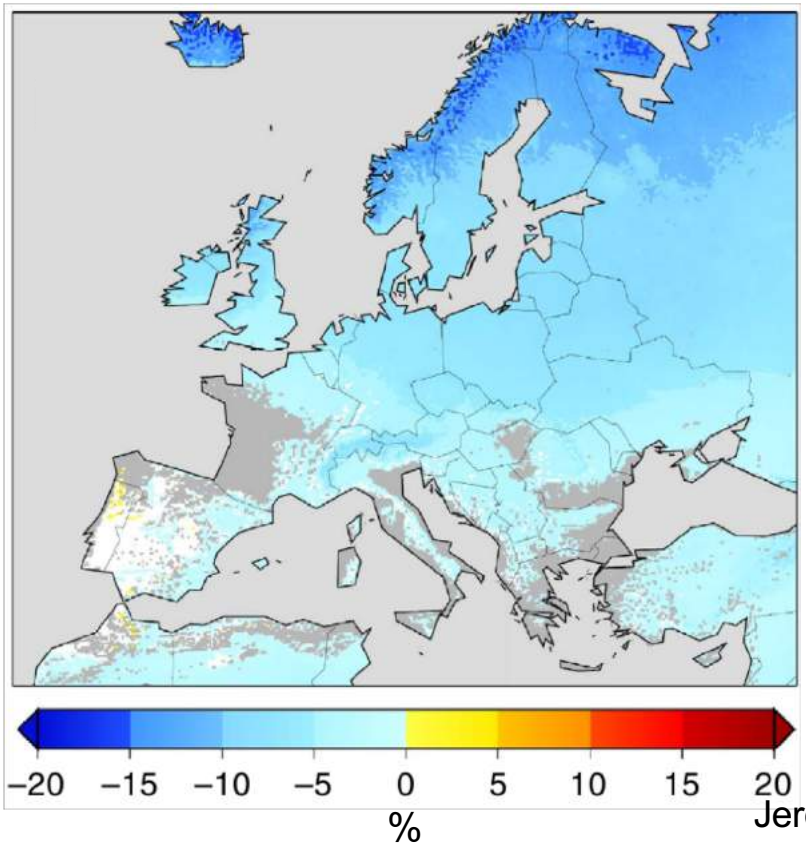
The impact of climate change on photovoltaic power generation in Europe



◀ Changes in PV power generation potential for the end of this century (expressed in % with respect to present-day estimates) as displayed by the ensemble mean of a set of Euro-Cordex simulations.

None of current Euro-Cordex simulations includes ARI or ACI dynamically, hence the **effect of atmospheric aerosols** is missing in the currently available **projections for the renewable resource**. REPAIR will allow to elucidate so, by applying the same methodology described in this paper to the new set of simulations from REPAIR.

Jerez et al 2015, Nature Communications, 6:10014, DOI: 10.1038/ncomms10014

Acknowledgments:

- We acknowledge the funding of **REPAIR-CGL2014-59677-R** project (Spanish Ministry of Science and Innovation and FEDER program of the European Union).
- Laura Palacios-Peña the FPU scholarship (Ref. FPU14/05505).

THANK YOU FOR YOUR ATTENTION

REPAIR Tasks

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The REPAIR project is a Spanish competitive-funded initiative. The objectives of the REPAIR proposal are decisively comprised in the goals of the Horizon 2020 programme, since it will provide science-based information. Moreover, this project is going to contribute to the Euro-CORDEX initiative, special emphasis is put in the two WP related to management and dissemination:

- **WP1. COORDINATION AND MANAGEMENT OF THE PROJECT**
- WP2. DEFINITION OF THE MODELLING SYSTEM, SCENARIOS AND DATA NEEDED
- WP3. GENERATION AND EVALUATION OF PRESENT-DAY CLIMATOLOGIES
- WP4. CLIMATE CHANGE PROJECTIONS
- WP5. CLIMATE PROJECTIONS INCLUDING RENEWABLE ENERGIES AND THEIR IMPACT ON EMISSIONS
- **WP6. DISSEMINATION AND EXPLOITATION OF THE RESULTS OF THE PROJECT**

WP3. Present climatologies (2001-2010): Evaluation O_3 (REA_CHEM_P)

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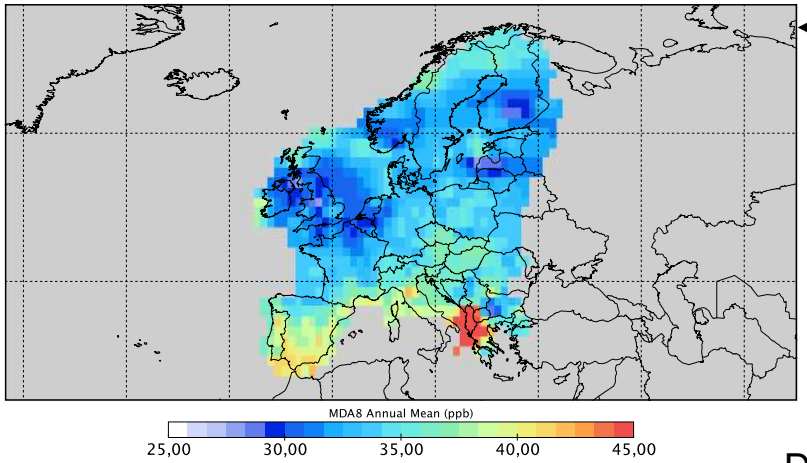
MDA8 Tropospheric O_3 from Schnell et al (2014)

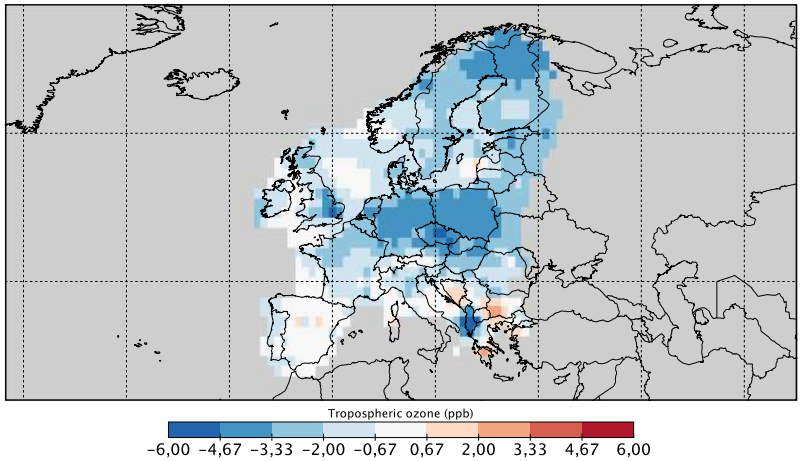


Schnell, J. L., Holmes, C. D., Jangam, A., and Prather, M. J.: Skill in forecasting extreme ozone pollution episodes with a global atmospheric chemistry model, Atmos. Chem. Phys., 14, 7721-7739, https://doi.org/10.5194/acp-14-7721-2014, 2014.

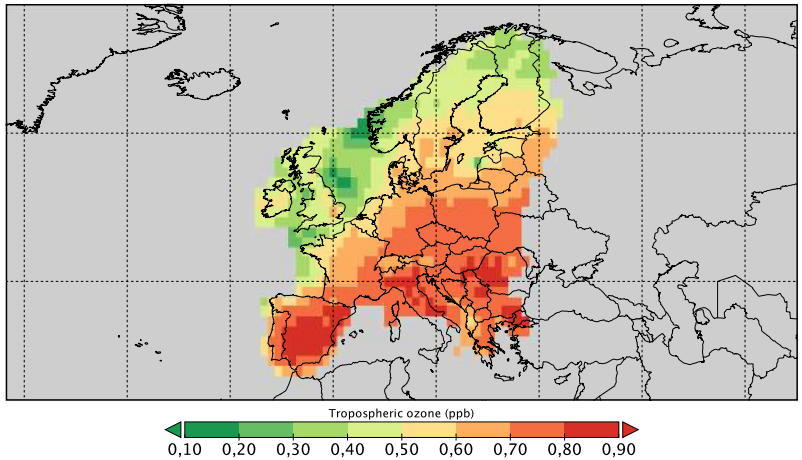
A general underestimation. Low biases over the IP

High correlation over the most of the domain (> 0.8)

BIAS MDA8 O_3



Daily correlation MDA8 O_3



WP3. Present climatologies (2003-2010): Evaluation AOD (REA_CHEM_P)

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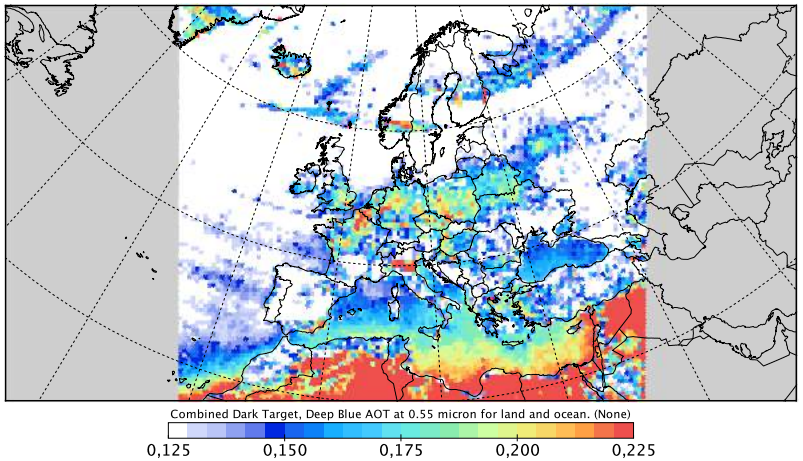
AOD (MODIS L2)

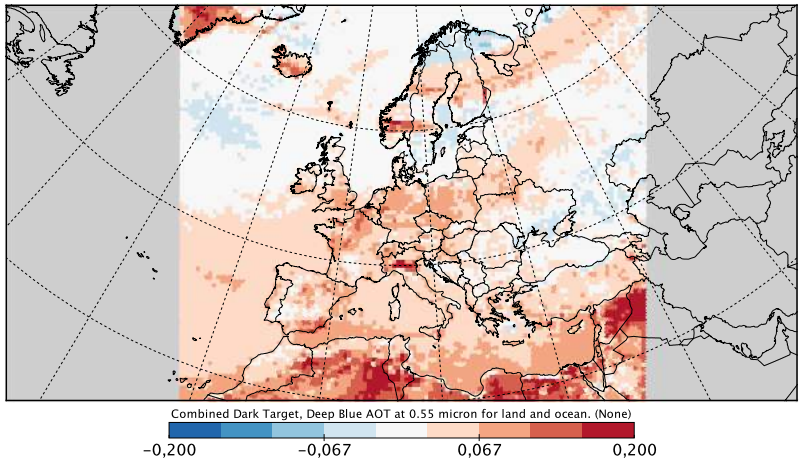


Observations: MODIS Atmosphere L2 Aerosol Product

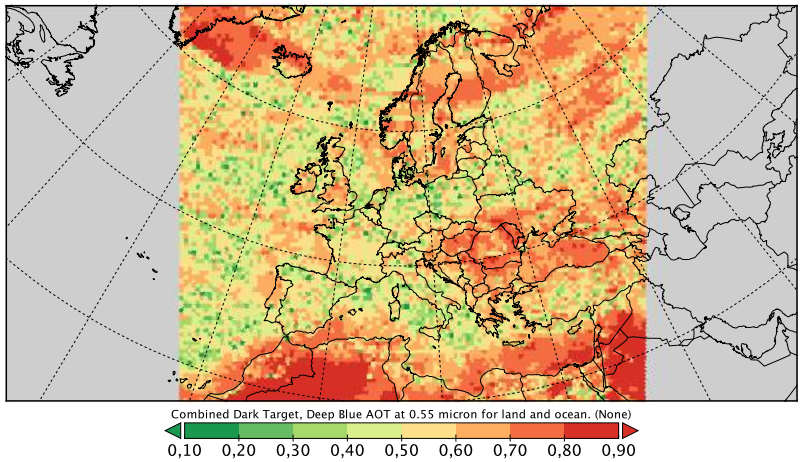
A general overestimation, specially over southern domain

In general, temporal correlation > 0.5
High values over the south of the domain

BIAS AOD



Daily correlation AOD



WP3. Present-day climatologies: WRF (REA) vs. WRF-Chem (REA_CHEM_P)

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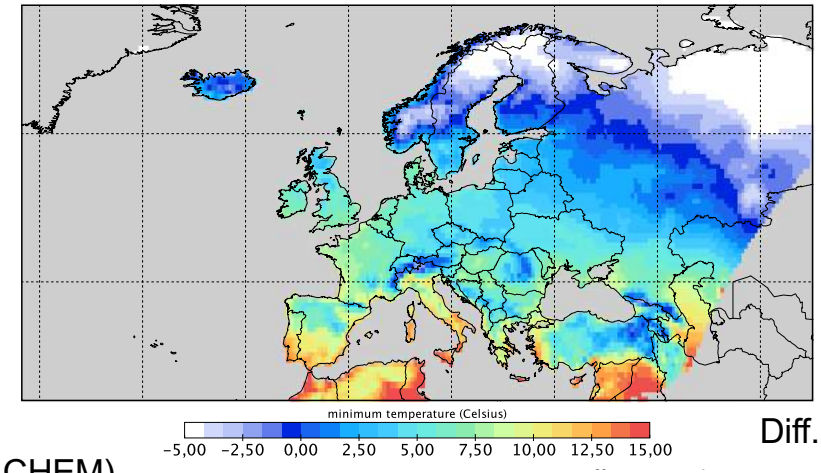
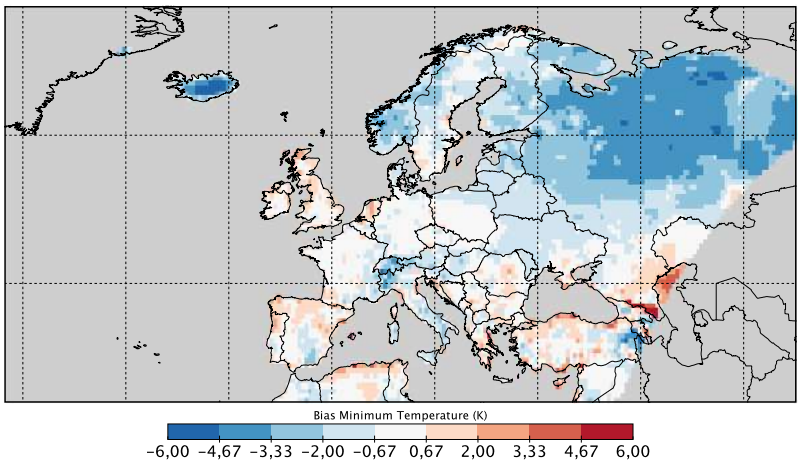
Minimum Temperature (E-OBS)



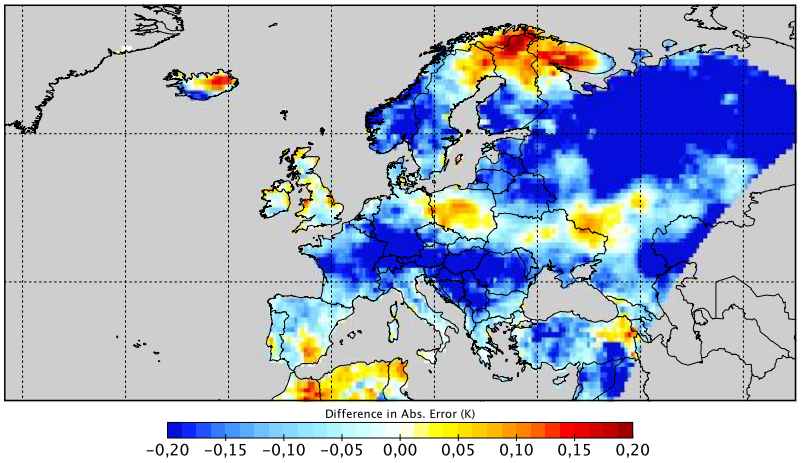
Underestimation of minimum temperature but lower than maximum

Lower improvement than for maximum temperature

Temp. BIAS (NO-CHEM)



Diff. Abs. Error (CHEM vs NO-Chem)



WP3. Present-day climatologies: WRF (REA) vs. WRF-Chem (REA_CHEM_P)

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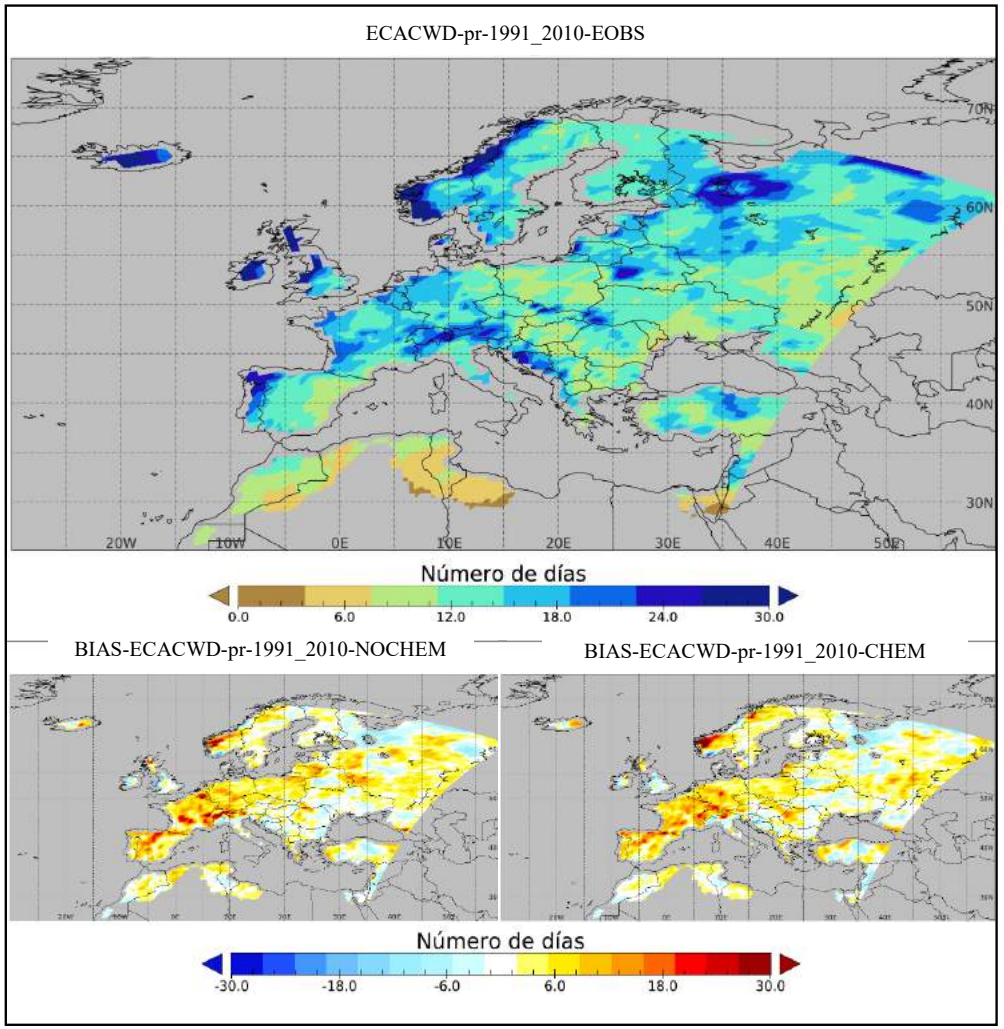
ECACWD (Number of consecutive wet days)

ECACWD	Mean (days)	BIAS (days)	% BIAS
E-OBS	13.65	-	-
WRF	-	2.72	19.93
WRF-Chem	-	2.56	18.75



HEM_P)

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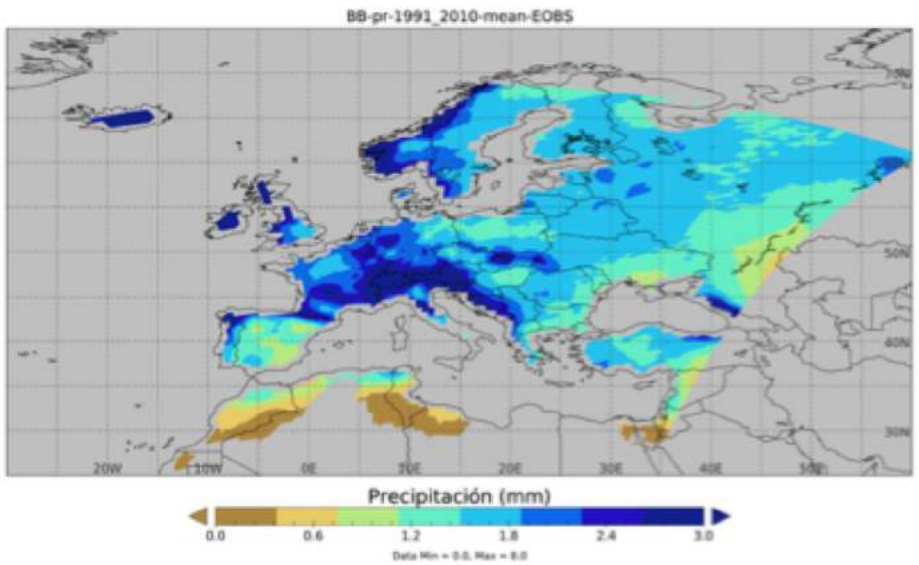

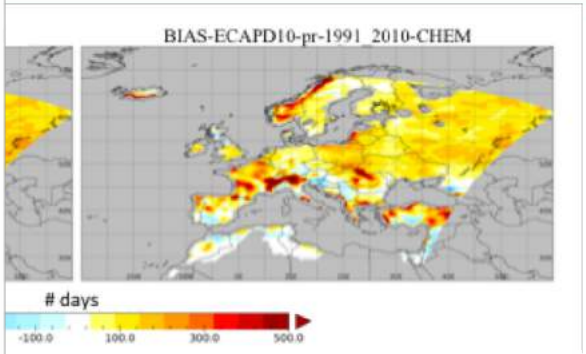

BIAS (days)	% BIAS
-	-
106.83	43.85
101.24	41.55

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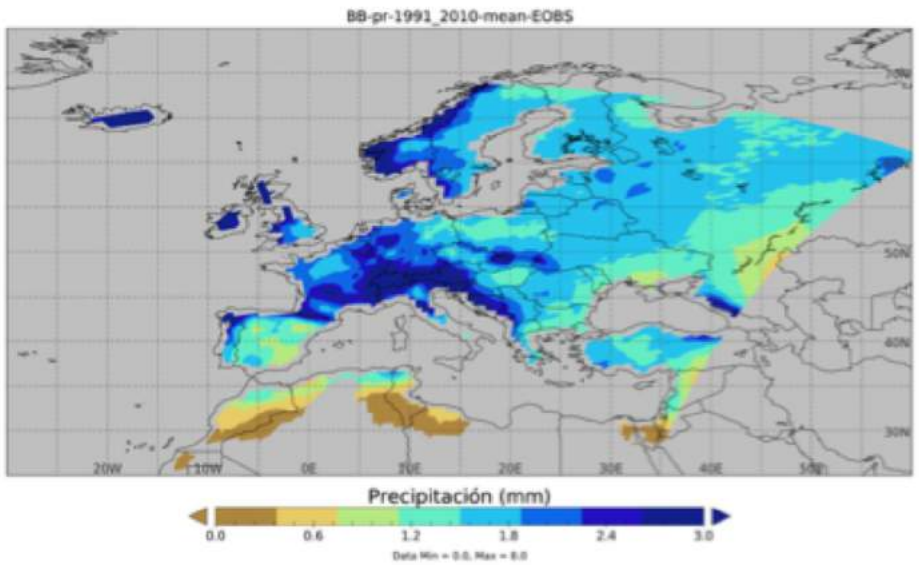
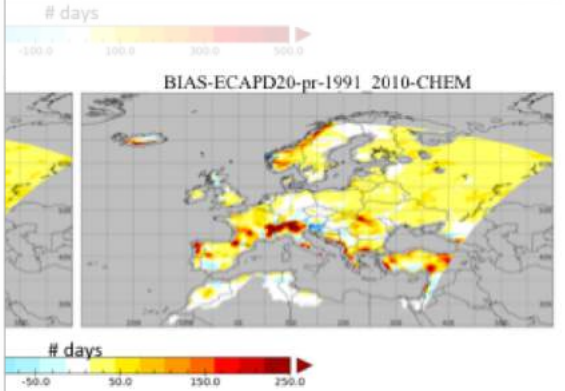


BIAS (days)	% BIAS
-	-
35.22	77.58
32.32	75.59



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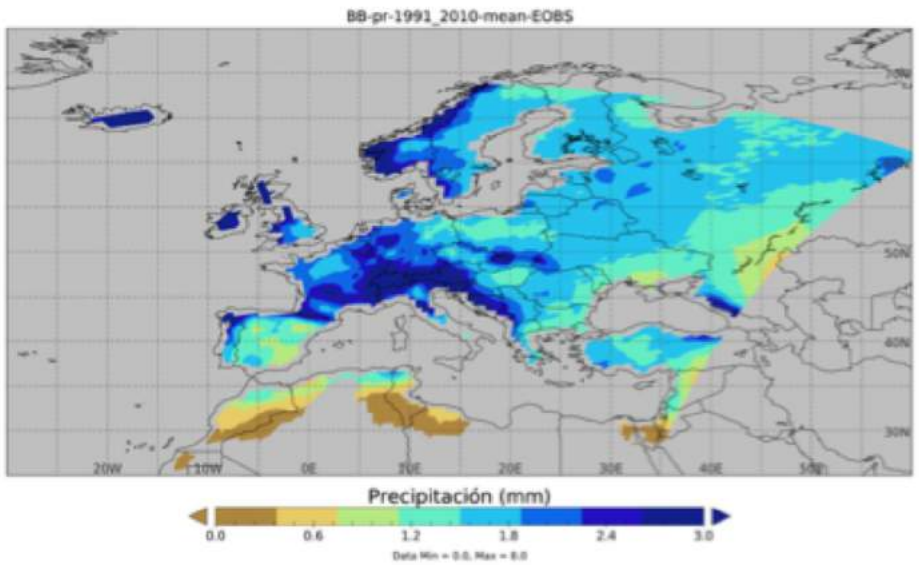

BIAS (day)	% BIAS
-	-
15.38	136.35
15.38	136.35