Dependence of past air pollution on meteorology over Europe

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Motivation and aim

”Gain knowledge of the variability and trends in air pollution over a longer time period caused by variability and change in climate”

Motivation:

- How representative chosen years are in for example IAM (CAFE) and measurement campaigns.
- Impact of climate change on air pollution

Method – concept of choosing meteorology

Climatological data

Pro

- No real time boundaries (can do future and long past scenarios)

Con

- Difficult to capture all physical processes

Reanalysis data

Pro

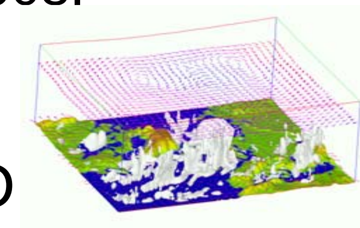
- Bound by observations (closer to reality, variability at least fairly good)

Con

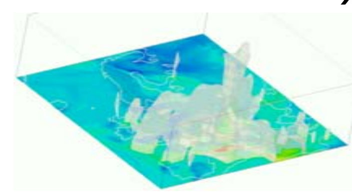
- Only past scenarios are possible

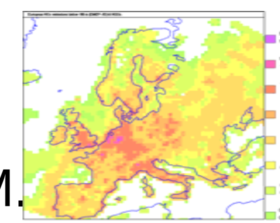
Method - details

1. Reanalysis data: ERA40. Time period 1958-2001.
   - Also in part adding operational data for 2002-2003.
   - 6 hour, 125x125 km, lowest 21 levels



2. CTM: MATCH. Regional scale Eulerian 3D
   - Photochemistry (70 chem comp, 130 reactions), sea salt, isoprene emission.
   - 44x44 km, 21 layers

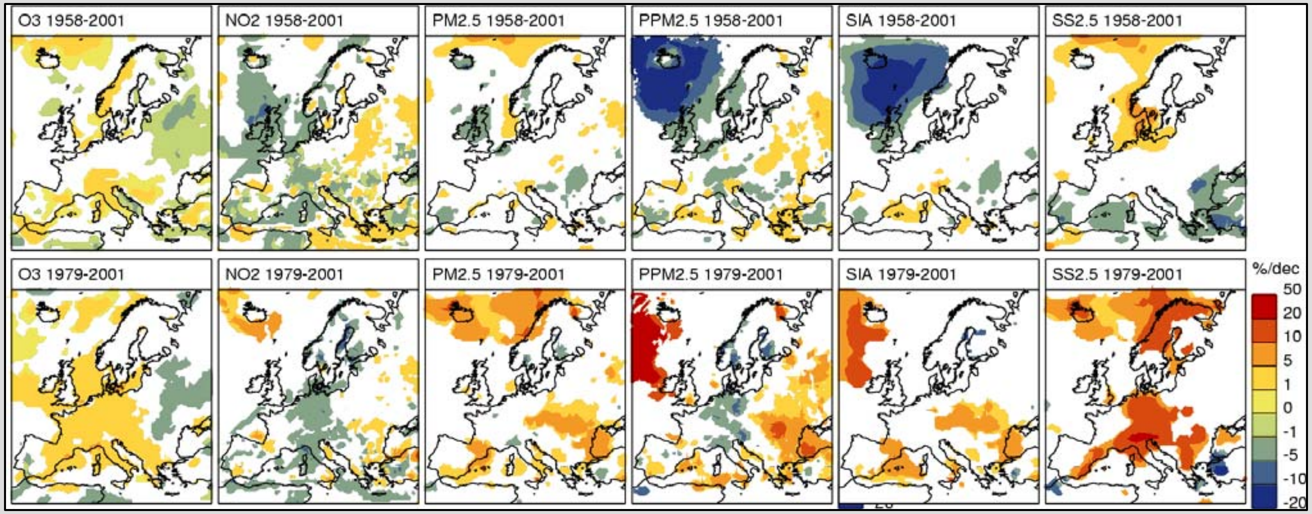




3. Emissions: EMEP expert of 2000.
   - 50x50 km, NOx, SOx, NMVOC, CO, NH3, prim PM.

4. Monthly/seasonally varying boundary conditions.

Trends in air pollution due to meteorology



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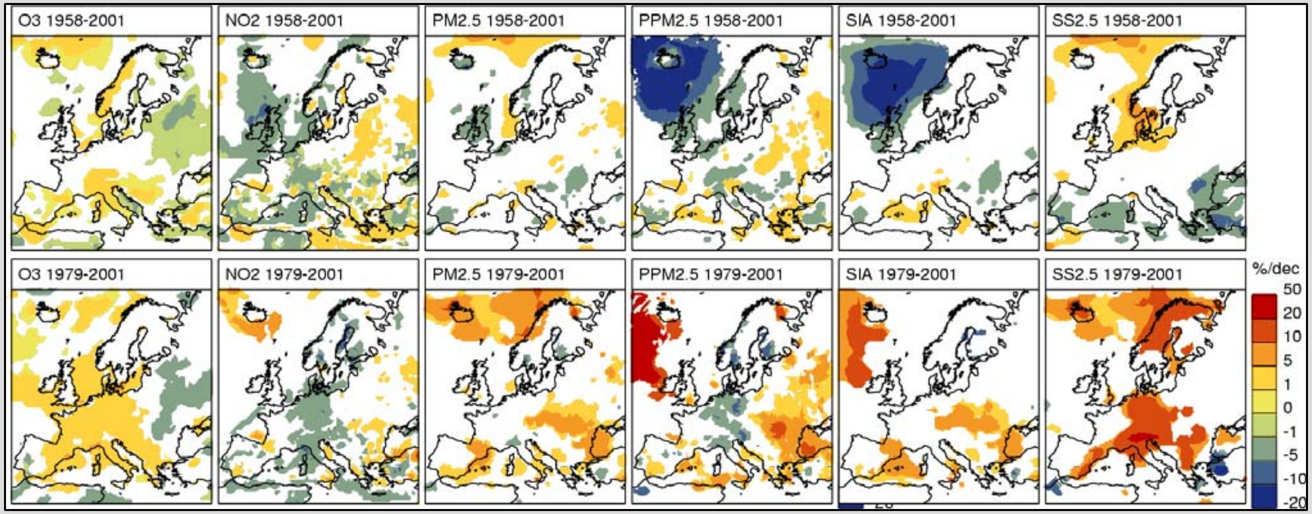
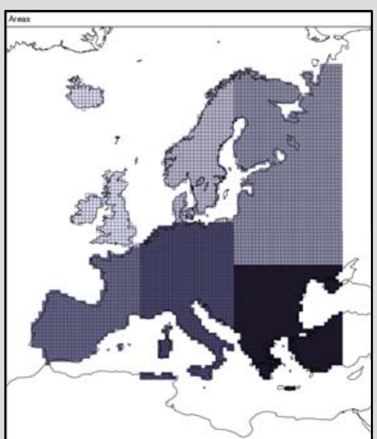
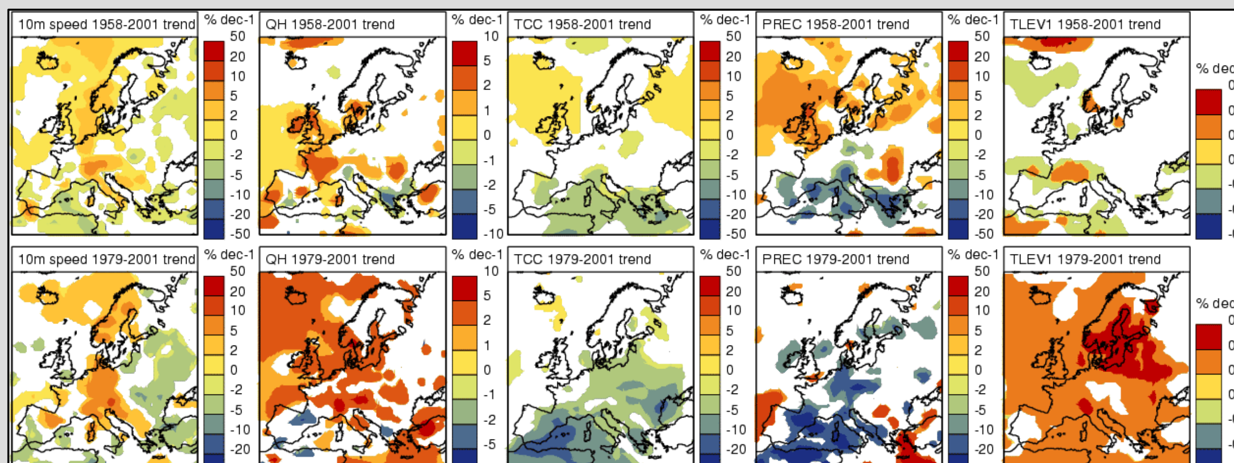
Reason for trends and variability in air pollution







Trends put into perspective

Comparison of simulated trends to emission reductions and observed changes in air pollutants

Reduction (emission)

- NO_x: 30%, SO_2: 70%,
- NMVOC: 35%, NH_3: 25%
- Time period: 1980-2000

Concentration changes:

- Bg O_3: +0.5 ppbv yr^{-1}
- SO_2: 50-90%
- SO_4^{2-}: 50-75%
- NO3-: 20-60%

Simulated trend

O_3: -0.1 to 0.2 ppbv yr^{-1}
(-5% - 5% dec^{-1})

NO2: -0.05 to 0.05 ppbv yr^{-1}
(-5% - 10% dec^{-1})

SIA: -0.1 to 1 $\mu g\ m^{-3}$
(-5% - 20% dec^{-1})

Discussion and Future work

1. Inter-continental transport, stratospheric ozone
   - meteorological variability (and/or emission changes) at other places, how does that affect the situation
   - Nesting to global model
2. Trends and variability when using varying emission
   - Can we capture real variation and trends?
   - Divide into 3-4 different contributions: inter-hemispheric (2), emission related and climate related
3. A deeper analysis into reason for changes
   - changes in transport patterns?
4. Redo analysis when improved and (perhaps) elongated reanalysis data arrives.
   - Problems: precipitation bias due to change in observation data
5. Reanalysis using reanalysis meteorological data and observed air pollution.

Implications

1. Variability on all time scales:
   - Continously (and preferrably well spatially distributed) monitor air pollutants.
   - Important to re-think the choice of representative years in modelling (e.g. IAM) in the future
2. Trends in measurement data is not only affected by emissions.
   - Climate variability, possibly inter-continental transport.
3. Follow-up studies with new re-analysis data, varying emissions and contribution from inter-continental transport.
4. In deciding on emission reductions for the future climate change induced changes of air pollutants need to be considered.

Thank you for listening!

For further questions and/or material and/or suggestions for future cooperation contact me at:
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Andersson, C., Langner, J. and Bergström, R., 2007. Tellus 59B, 77-98.

Andersson, C. and Langner, J., 2007. Focus: Water, Air and Soil Pollution, doi: 10.1007/s11267-006-9088-4

Comparison to measurements

- Overall underestimation of PM (10-80 %)
- Perfomance is good compared to other regional scale models (van Loon et al., 2003)

	PM10					PM2.5				
	OBS mean	MATCH mean	bias	corr	#meas	OBS mean	MATCH mean	bias	corr	#meas
global	14.43	6.40	-55.63	0.56	5079	11.36	5.22	-54.01	0.56	1676
CH02	20.59	6.37	-69.05	0.59	341	15.88	5.99	-62.31	0.53	347
CH03	18.79	5.57	-70.37	0.53	355	*	*	*	*	*
CH04	12.88	6.88	-46.58	0.62	315	8.69	6.52	-24.95	0.64	341
CH05	11.79	6.08	-48.38	0.58	360	*	*	*	*	*
DE01	19.72	5.91	-70.04	0.70	348	*	*	*	*	*
DE02	16.46	7.95	-51.69	0.71	343	11.87	7.77	-34.52	0.66	278
DE03	8.13	7.09	-12.80	0.58	349	*	*	*	*	*
DE04	14.42	8.54	-40.77	0.73	356	*	*	*	*	*
DE05	10.54	8.48	-19.53	0.60	364	*	*	*	*	*
DE07	14.57	6.85	-53.00	0.62	364	*	*	*	*	*
DE08	12.51	7.88	-37.06	0.73	364	*	*	*	*	*
DE09	17.02	6.91	-59.40	0.61	363	*	*	*	*	*
SE12	12.58	2.63	-79.05	0.63	263	9.81	2.53	-74.19	0.60	273
SE41	12.24	3.66	-70.06	0.75	134	11.16	3.54	-68.23	0.75	136
SE42	13.49	4.58	-66.09	0.62	162	10.51	4.75	-54.80	0.65	151
SE44	13.58	2.77	-79.62	0.64	298	9.87	2.69	-72.76	0.65	150

	Global					Spatial				
	OBS mean	MATCH mean	%bias	corr	#cases	OBS mean	MATCH mean	%bias	corr	#cases
O3 mean(h)	32.29	29.19	-9.6	0.59	842706	32.62	29.30	-10.2	0.46	106
O3 max(d)	42.70	37.93	-11.2	0.72	36059	43.05	38.10	-11.5	0.63	106
Na+	0.59	0.65	9.5	0.59	7458	0.70	0.67	-4.4	0.53	8
SO2	0.94	1.21	28.5	0.35	29537	0.95	1.32	39.5	0.51	88
SO42-	0.76	0.70	-8.1	0.294	26365	0.77	0.71	-7.8	0.73	82
NO2	2.07	1.86	-10.1	0.485	22688	2.11	2.06	-2.4	0.61	68
NO3-	0.51	0.48	-5.1	0.503	6725	0.49	0.47	-4.0	0.87	20
HNO3+NO3	0.45	0.45	0.3	0.393	13424	0.46	0.46	0.3	0.75	40
NH4+	0.87	1.00	14.3	0.443	8149	0.84	0.96	14.4	0.71	25
NH3+NH4	1.23	1.12	-9.2	0.55	13656	1.25	1.13	-9.3	0.72	41
SO4-wet	40.54	40.20	-0.8	0.401	905	40.49	39.97	-1.3	0.57	78
NO3-wet	27.44	23.01	-16.2	0.37	905	27.04	23.03	-14.8	0.56	78
NH4-wet	30.06	25.03	-16.7	0.296	905	29.77	25.07	-15.8	0.47	78