Norwegian Meteorological Institute

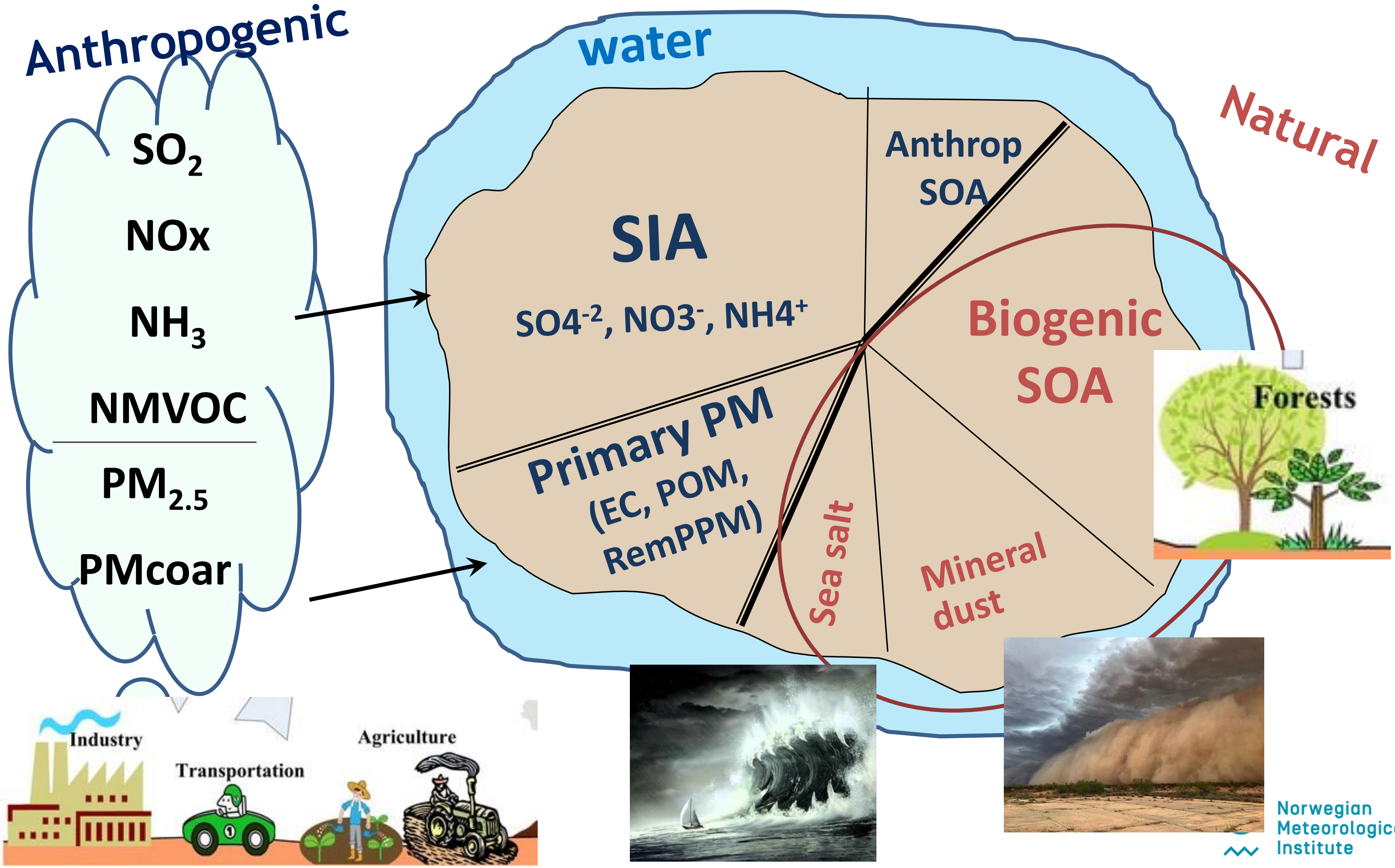
Aerosols

in the EMEP MSC-W model

EMEP MSC-W model training course
29-30 April 2019

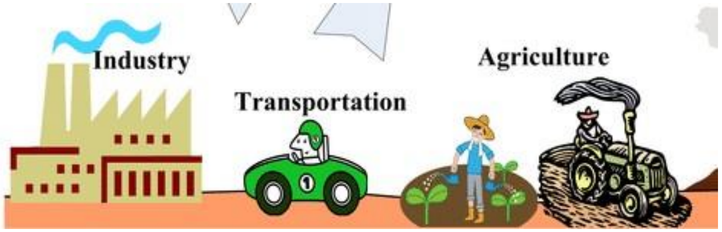
Particulate Matter (PM)

artistic representation of an EMEP MSC-W particle



The model calculates mass concentrations of the aerosol components in fine and coarse fractions

Primary anthropogenic



emissplit.defaults/specials.pm25
emissplit.defaults/specials.pmco

PPM2.5 = **[** EC_new +EC_age (elemental carbon) *)
+ POM (primary organic matter) + Remaining PPM **]_F**

coarse PPM = [EC + POM + Remaining PPM**]_C**

***) in emissions EC_new/EC_old = 80/20%**

Diff equations in **CM_Reactions2.inc**

Norwegian Meteorological Institute

Secondary inorganic aerosols (SIA)

SO_4 : SO_2 oxidation homogeneous by OH; in clouds by H_2O_2 and O_3 (pH depend – **Aqueous_mod.f90**)

Diff equations in **CM_Reactions2.inc**

NO_3 & NH_4 (thermodyn equilibrium with HNO3-NH3) – **MARS_mod.f90**

eqsam4clim is under testing (includes also Na^+, Cl^+, Ca^{2+}, Mg^{2+}, K^+, organic acids)

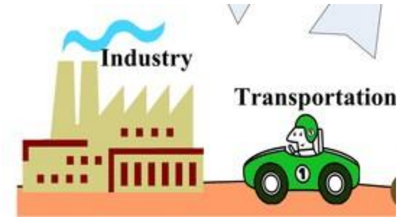
coarse NO3 (on surfaces of sea salt and mineral dust) reaction probability 0.01 for SS and 0.02 for Dust

Diff equations in **CM_Reactions2.inc**

Norwegian Meteorological Institute

SOA (secondary organic aerosol)

anthropogenic/biogenic……



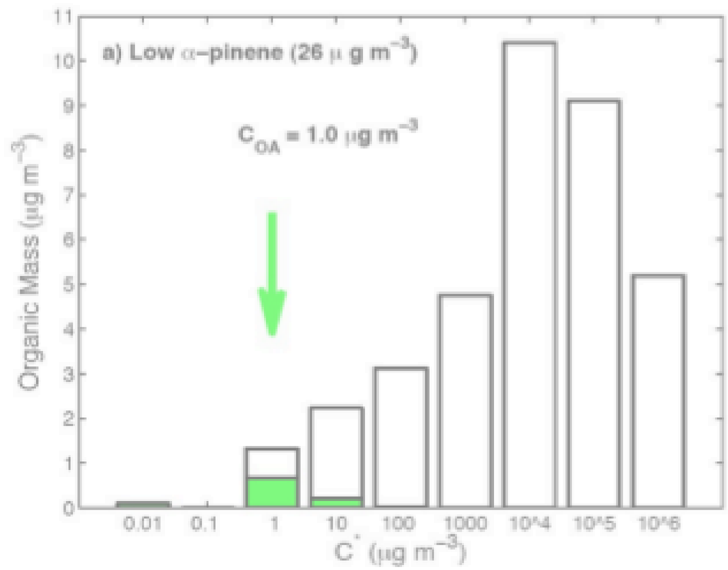
- Volatility Basis Set (Donahue and colleages)

- Gas-Particle partitioning:

$$\frac{A_i}{G_i} = \frac{C_{OA}}{C_i^*}$$

where

- C_i^* is saturation concentration, $= f$(Vapour pressure)



Units in output for

OM, ASOA/BSOA, VOC…

OM25 = POM25 + SOA

POM_C

ug - gases & particles

ug_PM - particles in ug/m3

ugC_PM - particles in ugC/m3

Sea salt aerosols

The source function for sea salt production is a product of the whitecap area fraction and the shape function (describing the dependence of sea spray flux per unit white-cap area): Monahan et al. (1986) & Mårtensson et al. (2003)

Whitecap coverage: in addition to scheme Monahan and O'Muircheartaigh (1980), two more alternative schemes are implemented: Norris et al. (Ocean Sci., 9, 2013) and Callaghan et al. (Geophys. Res. Lett., 35, 2008)).

Config_module.f90 **WHITECAPS = 'Callagan' (or 'Norris', 'Monah')**

SeaSalt_mod.f90 Sea spray as f(U10m, SST) in 10 size fractions, aggregated to fine and coarse SS

Mineral dust: DustProd_mod.f90

- road dust (DUST_ROAD) - based on TNO scheme
- windblown (DUST_WB)- online, f(U*, soil moisture, …))
- Saharan (DUST_SAH) - Boundary conditions (EMEP global run 2012-2016)

Norwegian Meteorological Institute

Dry Deposition

Drydep_mod.f90 Venkatram & Pleim (AE, 1999)

$$v_d = \frac{v_s}{(1-e^{-r v_s})} \qquad r = r_a + r_s = r_a + 1/v_{ds}$$

Aero_Vds_mod.f90

Petroff et al (2008)-based for forest

Wesely (1985)- based for other land covers

Enhancement Factor 3 for ammonium nitrate

Wet Deposition **Aqueous_n_WetDep_mod.f90**

In-cloud - scavenging ratios (solubility dependent)

Below-cloud - size-dependent collection efficiency

CM_WetDep.inc GasParticleCoeffs_mod.f90

$PM_{2.5}$ & PM_{10}

- Policy relevant metrics for air quality

- Output:

PM25 and PM10 - (sum of) dry aerosol mass

PM25_rh50 and PM10_rh50 - added PM water at Rh = 50% and T=20C (conditioning of PM filter samples prior weighing in gravimetric method)

Used for comparison with observations, assessments, source-receptor tables…

Norwegian Meteorological Institute

Output: PM2.5_rh50 and PM10_rh50 (at RelHum=50%)

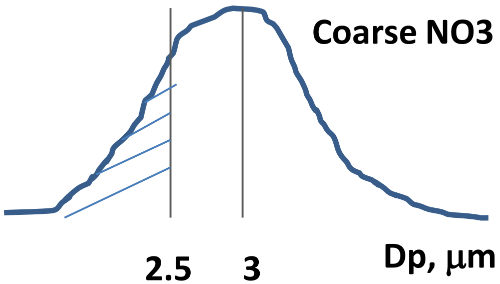
CM_ChemGroups_ml.f90

PMFINE_GROUP = (/ SO4, NO3_F, NH4_F, EC_F_WOOD_NEW, EC_F_WOOD_AGE, EC_F_FFUEL_NEW, EC_F_FFUEL_AGE, PART_OM_F, REMPPM25, FFIRE_BC, FFIRE_REMPPM25, SEASALT_F, DUST_ROAD_F, DUST_WB_F, DUST_SAH_F /)

PM10_GROUP = (/ SO4, NO3_F, NO3_C, NH4_F, PART_OM_F, POM_C_FFUEL, EC_F_WOOD_NEW, EC_F_WOOD_AGE, EC_C_WOOD, EC_F_FFUEL_NEW, EC_F_FFUEL_AGE, EC_C_FFUEL, REMPPM25, REMPPM_C, FFIRE_BC, FFIRE_REMPPM25, SEASALT_F, SEASALT_C, DUST_ROAD_F, DUST_ROAD_C, DUST_WB_F, DUST_WB_C, DUST_SAH_F, DUST_SAH_C /)

Derived_ml.f90

```
select case(nint(AERO%DpgV(2)*1e7))
case(25);    fracPM25=0.37
case(30);    fracPM25=0.27       endselect
```



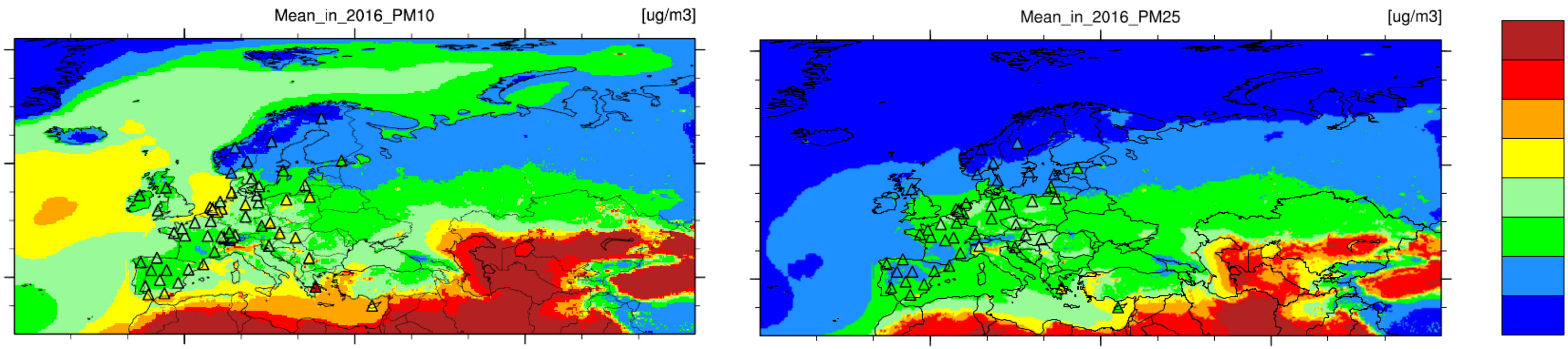
case ("PM25_rh50")

```
d_2d( n, i,j,IOU_INST) =
    d_2d(ind_pmfine ,i,j,IOU_INST) + d_2d(ind_pmwater,i,j,IOU_INST)
    + fracPM25 * ( xn_adv(iadv_NO3_C,i,j,KMAX_MID) * ug_NO3_C )
    * cfac(iadv_NO3_C,i,j) * density(i,j)
```

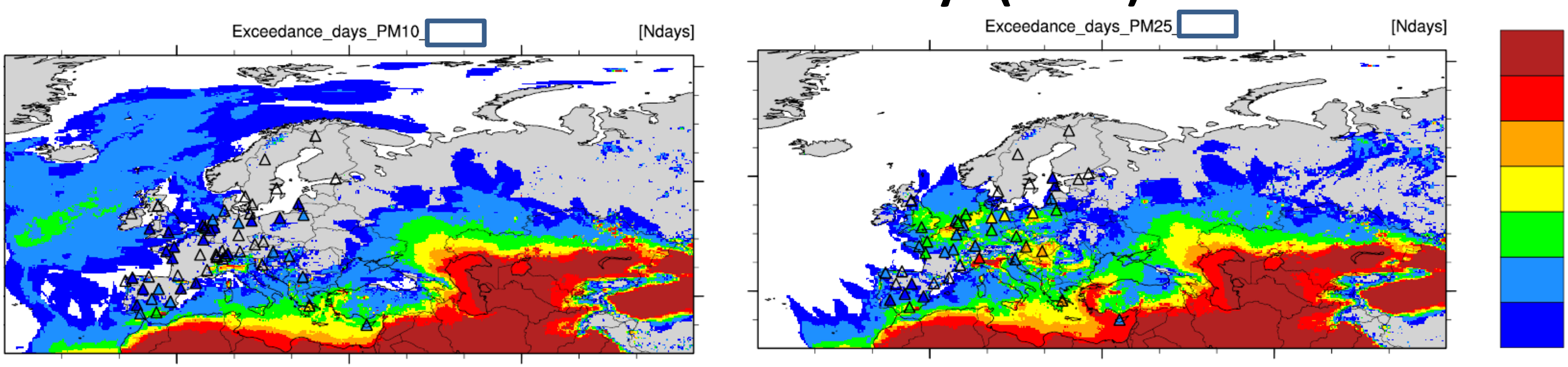
Norwegian Meteorological Institute

Some examples of PM level annual assessment (EMEP Report 1/2018)

Annual mean PM_{10} and $PM_{2.5}$ (2016)



and Exceedance days (2016)



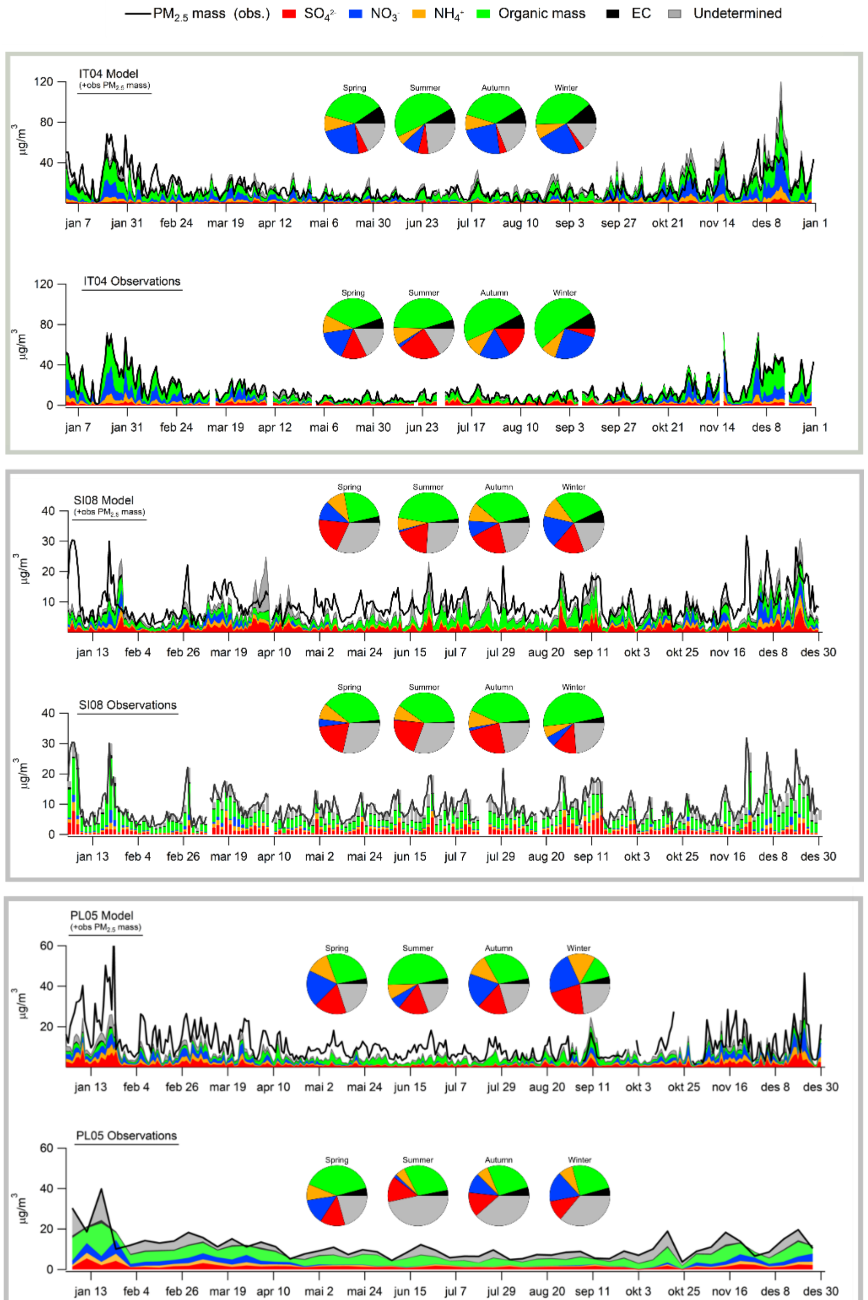
of EU's critical value of 50 ug/m3

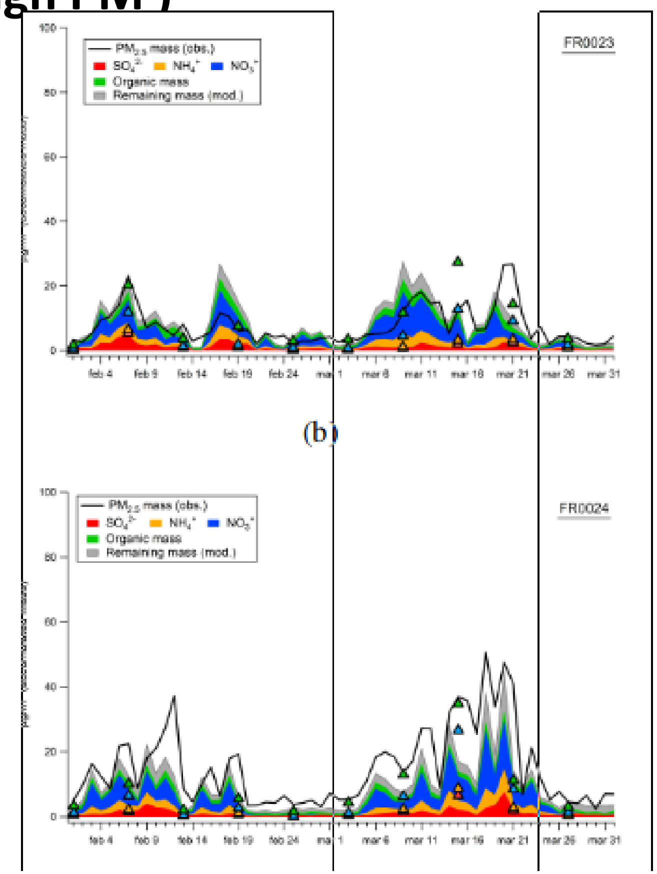
of WHO AQG of 25 ug/m3

Norwegian Meteorological Institute

Analysis of PM episodes in 2016 and 2015

Different aerosol types were dominating during the episodes, indicating that different sources were responsible for high PM)

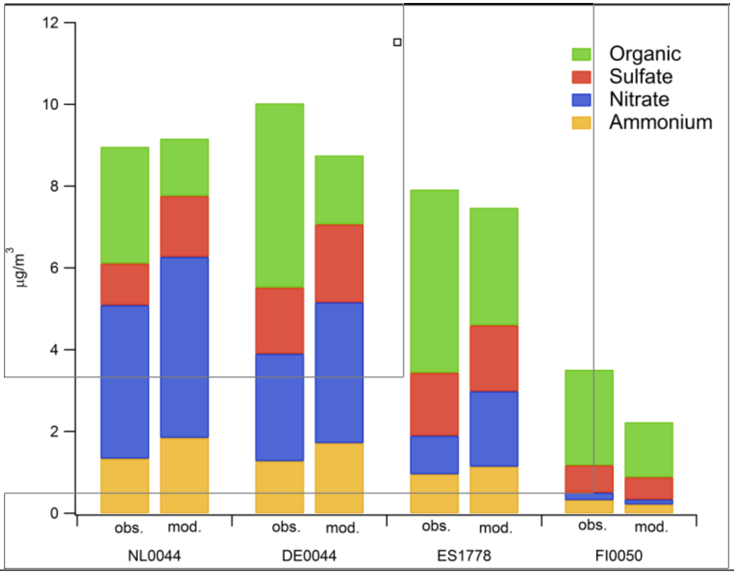


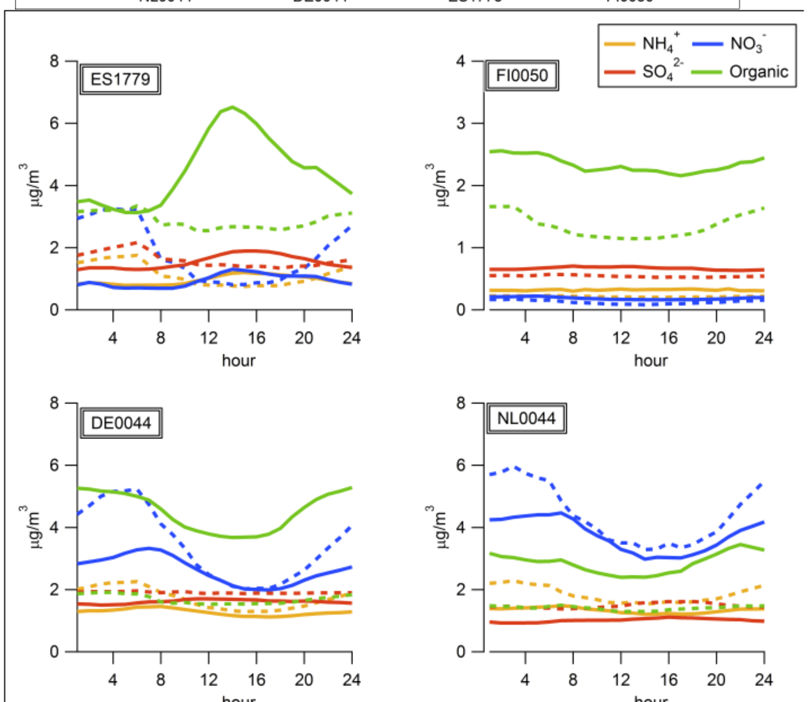


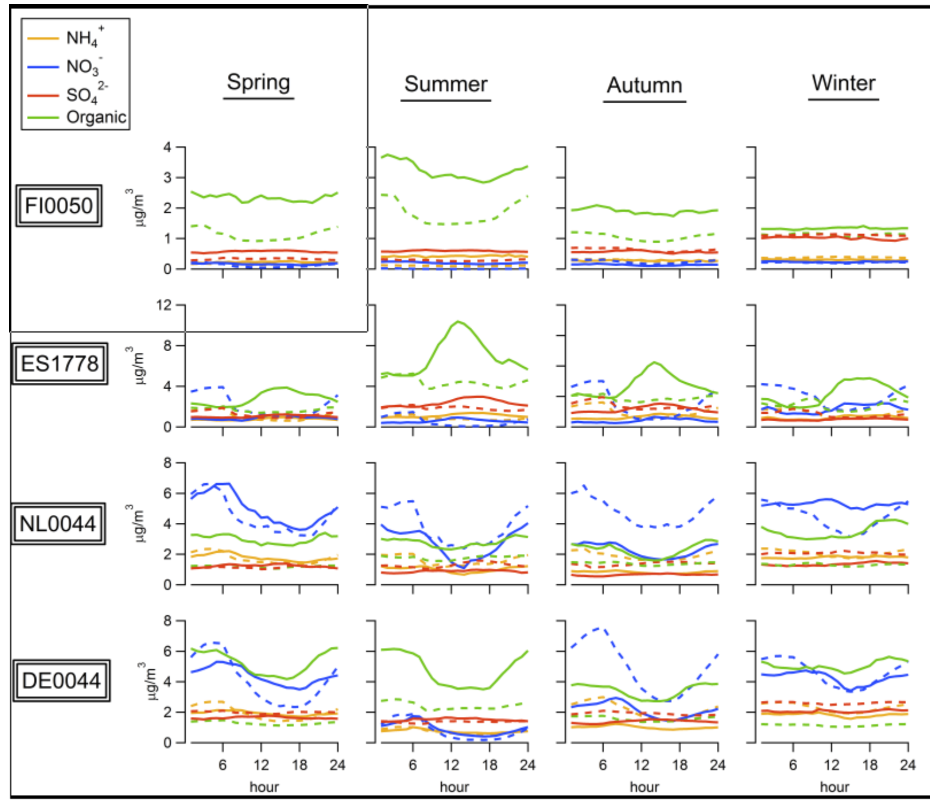
Norwegian Meteorological Institute

Aerosol evaluation with ACSM

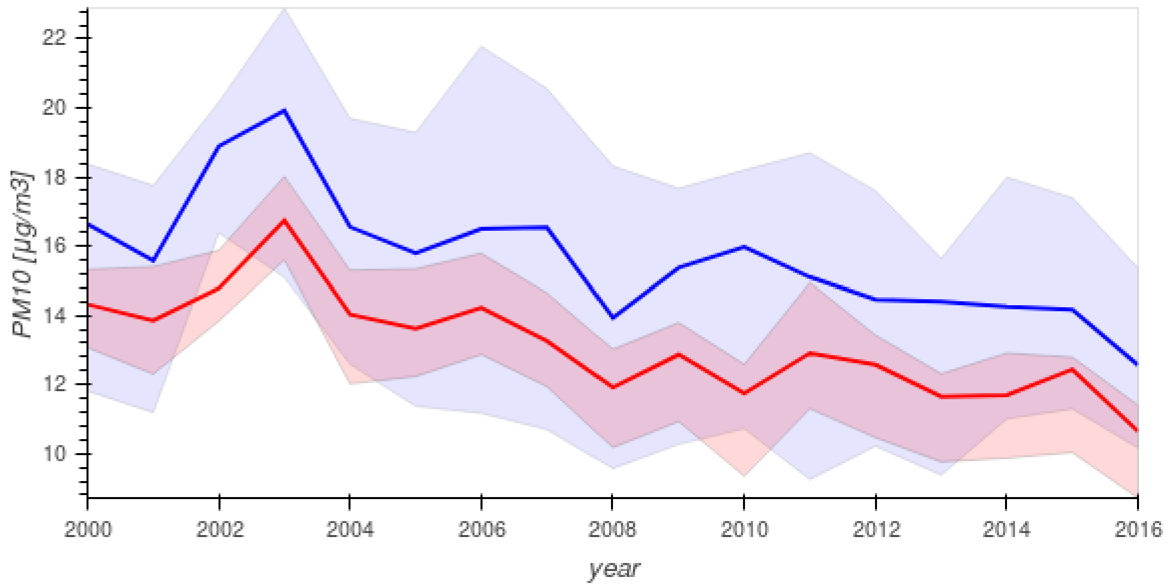
(aerosol chemical speciation monitor)

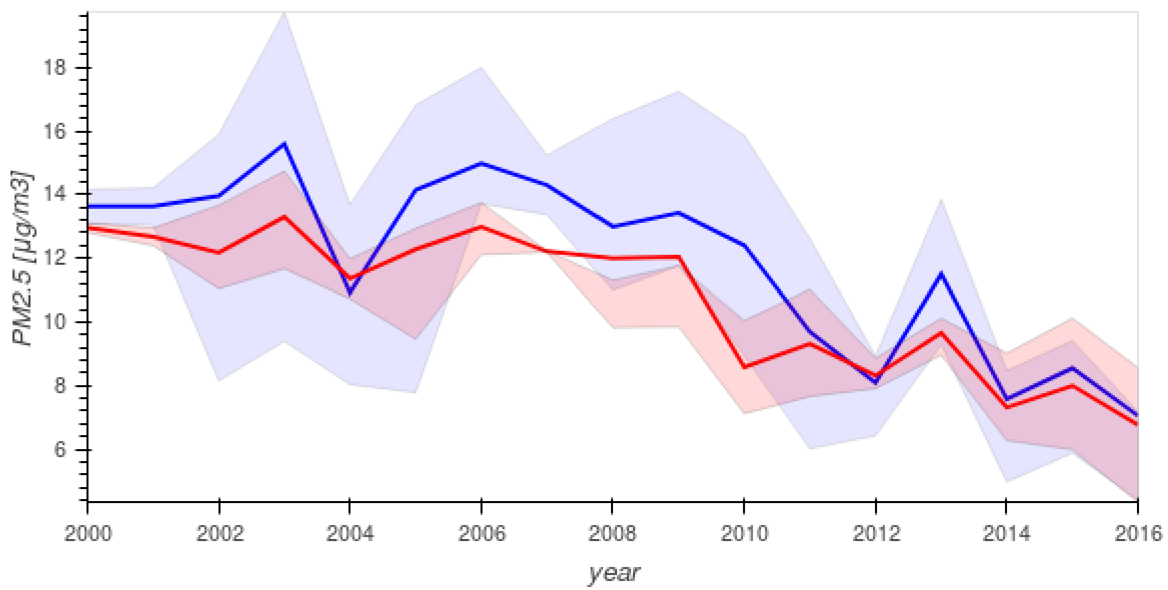






PM trends at EMEP sites **(mean, 25 and 75 %-tiles)**





See EMEP Report 1/2018

Norwegian Meteorological Institute

Aerosol extinction & Optical Depth

- 3-D aerosol concentrations
- Specific Extinction Efficiencies (Q_i) for the individual aerosol components (OPAC; Hess et al, 1998)
- Effective cross-sections implicitly accounting for the effect of relative humidity – tabulated based on Chin et al. (2002)

AOD_PM_mod.f90

calculates 3-D extinction and AOD for 9 wave lengths
for individual aerosol types

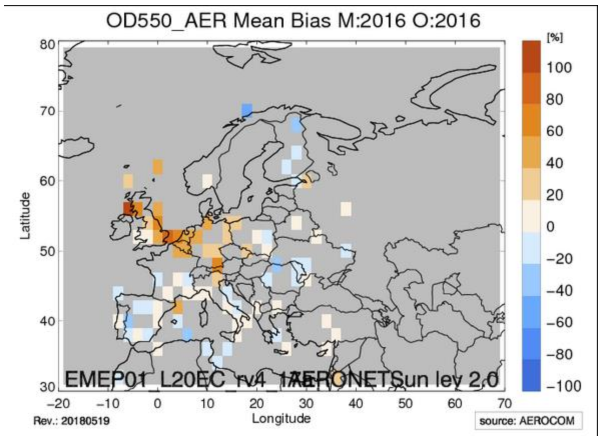
Ask for output in **config_emep.nml**

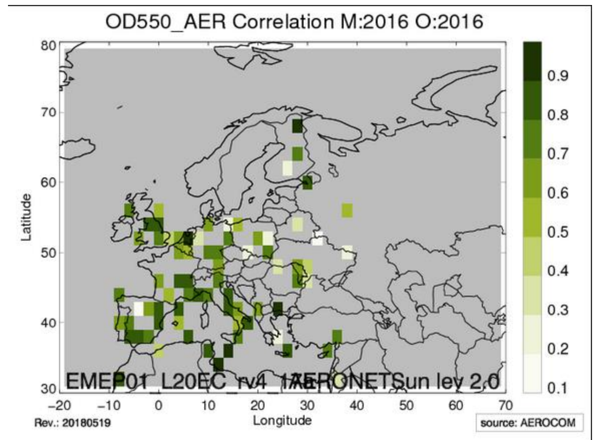
```
'AOD'   ,' ' ,  '350nm','AOD:GROUP','MISC', 4,     AOD_350nm
'AOD'   ,' ' ,  '550nm','AOD:GROUP','MISC', 4,     AOD_550nm
'DUST'  ,' ' ,  '550nm','AOD:GROUP','MISC', 4,     AOD_DUST_350nm
'EXT'   ,'1/m', '550nm','EXT:GROUP','MISC', 3,     EXT_550nm
```

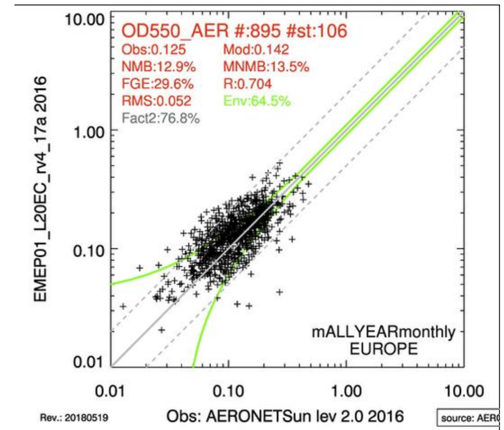
Remember to turn on AOD calculations: USE%AOD = True

Norwegian Meteorological Institute

Evaluation with AERONET AOD (2016) and EARLINET climatological extinction profiles



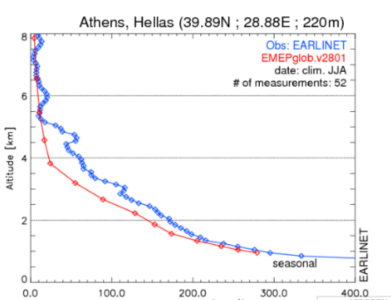


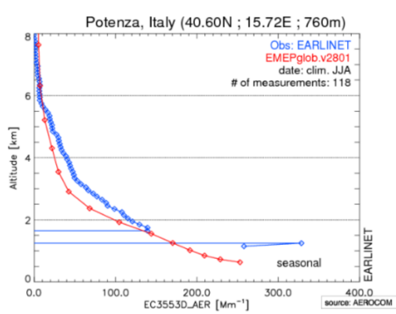


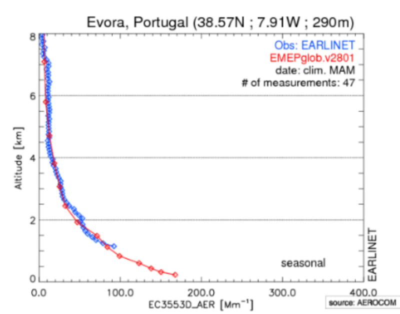
EARLINET climatology

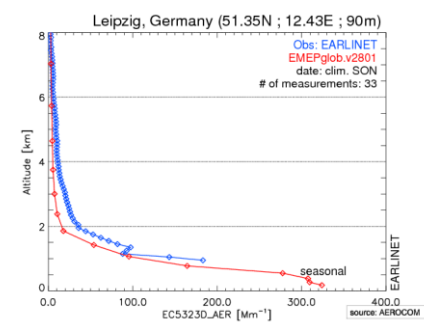
355 nm

532 nm









Anything I've forgotten?