How does aerosol dry deposition affect global crop yields?

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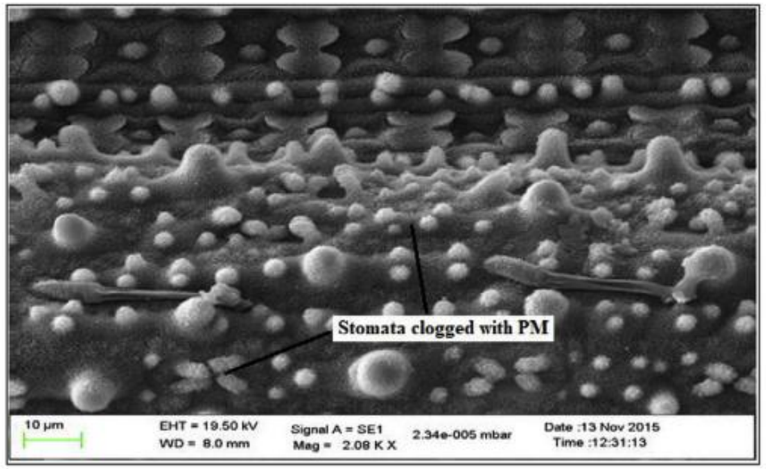
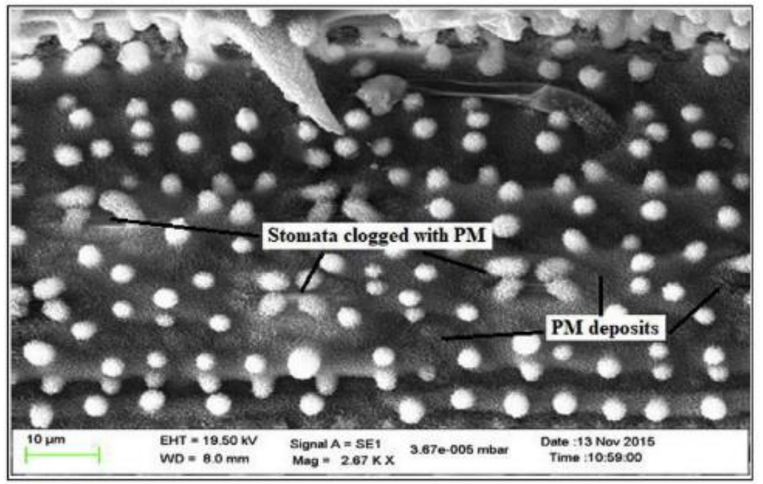
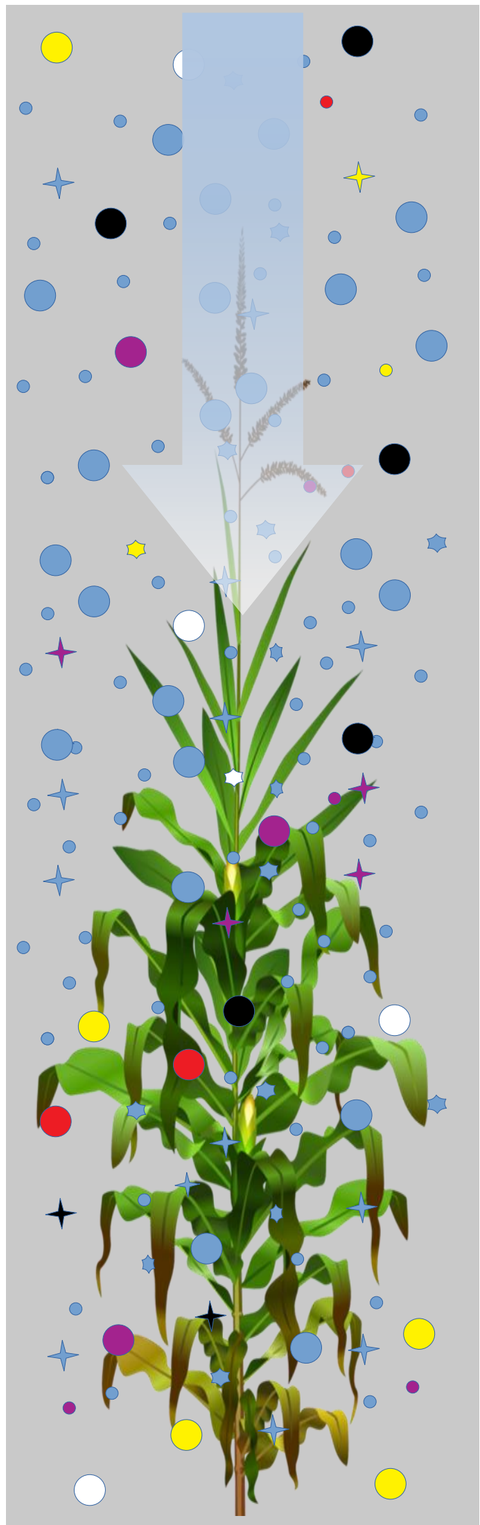
Direct Effect of Aerosol on Crops

- Aerosol is deposited to crop leaves
- This reduces incoming PAR, likely reducing yields
- It also reduces stomatal conductance and increases leaf temperature





Mina et al 2018 Fig. 3



Core Principles

- Bergin 2001 initial parameterisation
- Canopy layers
- Washoff

$$PM_W = \left(\frac{V_d C_p}{LAI/i}\right)\text{*W}$$

Equation 1: PM Accumulation

$$T_{PAR} = 1 - PM_W(E_{abs} + E_{scat}\ \beta)$$

Equation 2: PAR reduction

Progress since July Meeting

Code Development

- JULES vn5.4 Branch with accumulation, PAR absorption impact and wash off versions
- New namelist options

Model Runs and testing

- Range of bugs identified and corrected
- Single site tests to tune model
- Initial gridded simulations
- Emergent properties

Coding and Namelist Options

- Inserted accumulation code located in own PM accumulation module
- Further modifications in surface and crop modules to facilitate accumulation and consequent reductions in photosynthesis
- Surface
- pm_dep_mod.f90
- Physiol_jls_mod.f90
- Sf_stom_jls_mod.f90
- Vegetation
- Crop_mod.f90

Namelist Options

[namelist:jules_pm]

l_pm=.true.

pm_model=1

l_washoff_type=1

Data_end='2003-12-31 23:00:00'

Data_period=3600

Data_start='1995-01-01 00:00:00'

Nfiles=1

file='Aerosol_0.25vd.txt'

nvars=4

Var='fm','eabs','escat','beta'

Var_name='fm','eabs','escat','beta'

Interp=6*'nf'

Potential Emergent Features & Further Development Work

DEPOSITION EFFECTS MAGNIFIED DURING EARLY CROP GROWTH

IMPORTANCE OF WASH OFF TUNING

“STICKINESS” OF PLANT LEAVES

Upcoming Simulations

Single site simulations

- Tuning of model and testing of yield accuracy
  - IARI - India
  - Mashhad - Iran
  - Mead, Nebraska - USA

Global Simulations

- Global impacts of deposition on Wheat, Rice and Maize yields
  - 1995-2003
  - 2011-2015

Regional simulations

- Composition effects
  - China

PM reduces light intensity, which reduces maize yields...

...but PM also increases light quality, which can increase maize yields.

On the North China Plain, the impacts of reducing light intensity, outweigh those of increasing diffuse fraction. This reduces maize yields.

These changes to light intensity and quality have the greatest impact during the early reproductive stage of the maize growth cycle.

Reducing PM across China could increase the country's maize yields by as much as 8Mt

Temporal Variability in the Impacts of Particulate Matter on Crop Yields on the North China Plain

10.1016/j.scitotenv.2021.145135