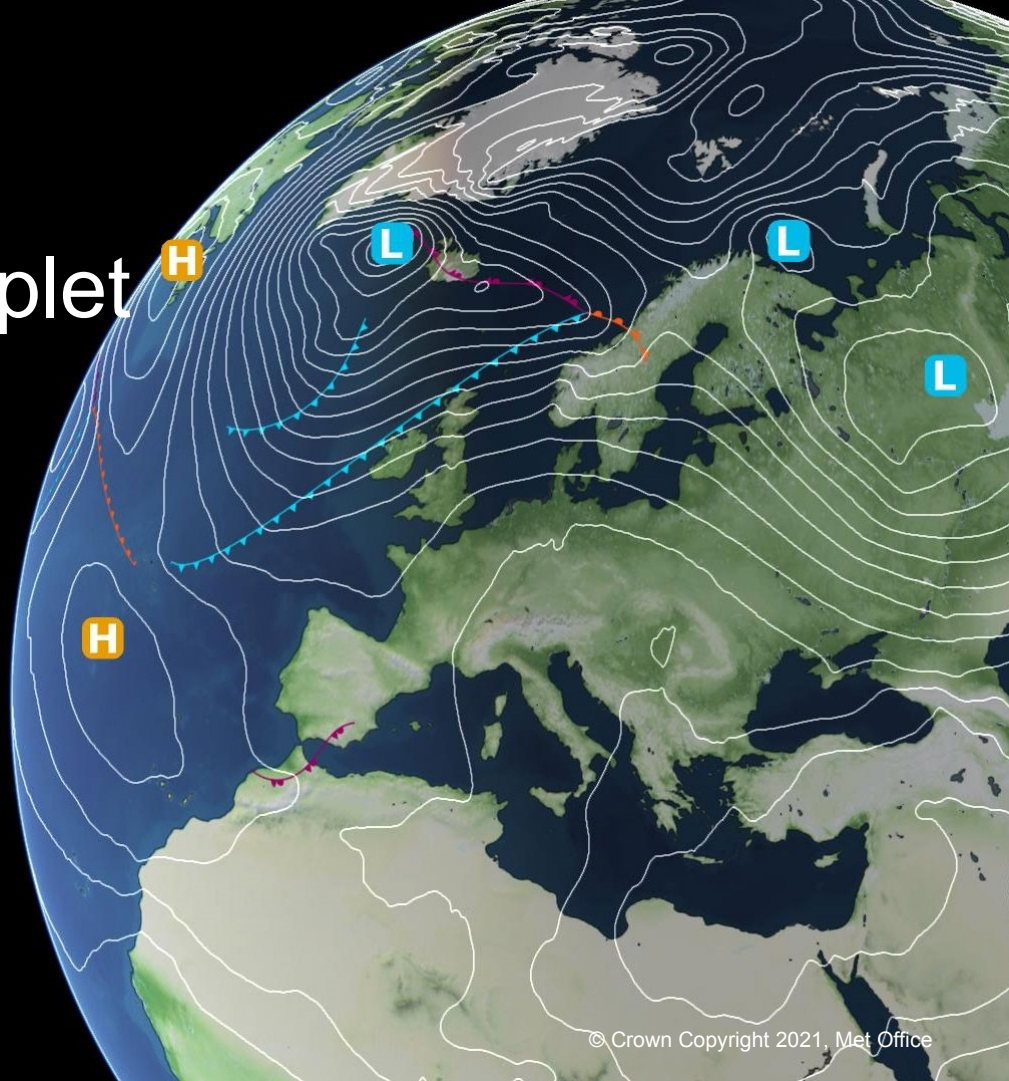# Observations of fog droplet deposition at Le Couye during SOFOG3D

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Outline

Met Office

(1) Fog droplet deposition has been studied at Le Couye using dewmeter data and DMT FM120 fog spectrometer data, during SOFOG3D

(2) Gravitational deposition rate has been estimated and compared to the total water deposition rate

(3) Liquid water content has been compared to total water deposition rate.

(4) A multiple regression of turbulent, advective and gravitational settling terms has been made against observed deposition

(5) Twelve cases analysed, including radiation and stratus fogs

(6) Conclusions and Further work

Primary Instrumentation used
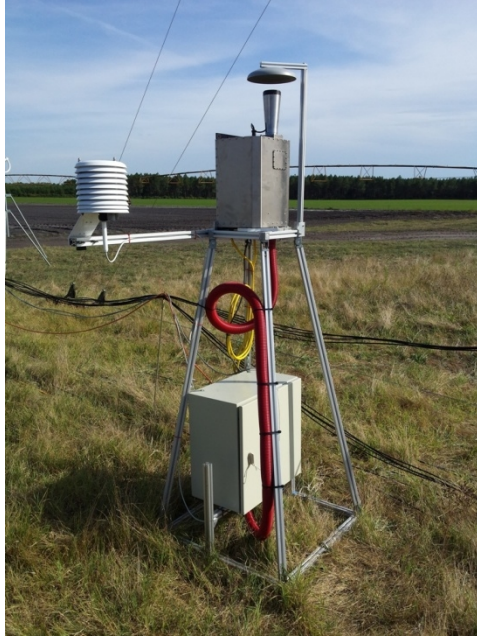
DMT FM120 spectrometer

Cardington dewmeters (natural canopy used when possible)

Gill HS50 sonic anemometers at 2m agl

Overview of Instrumentation

≋ Met Office   Gravitational settling and dewmeter

Graviational settling estimated from
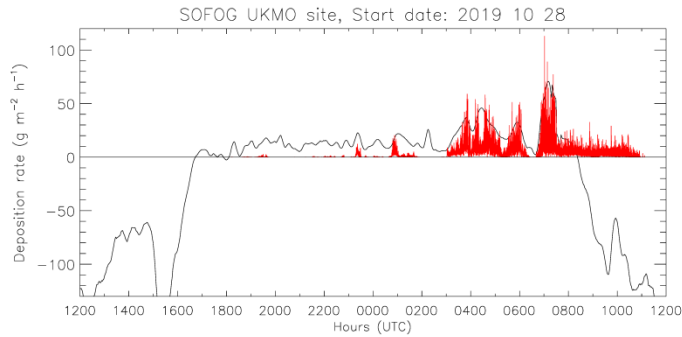Stoke's law:

$$V_t = \frac{\rho_p D^2 g}{18\,\mu}$$

Corrections for air
temperature and pressure
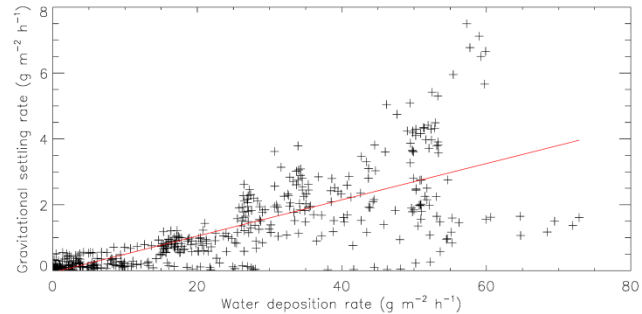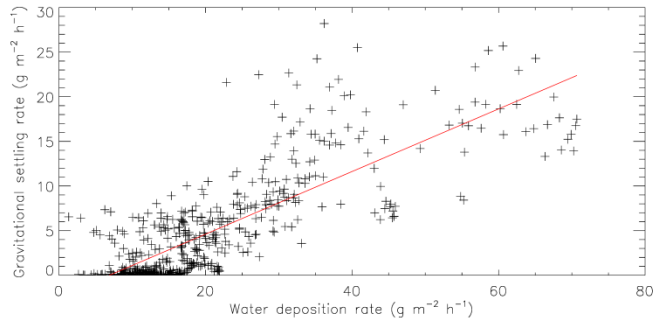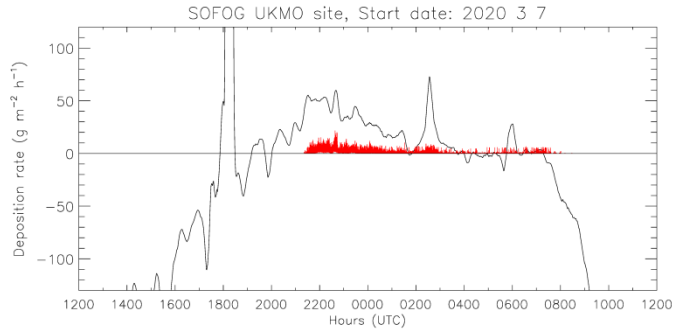applied

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Dewmeters measure the following processes

1) Hygroscopic adsorption
2) Dewfall
3) Gravitational Droplet settling
4) Turbulent droplet deposition
5) Capture by ventilation

4) and 5) can be taken together as the as
   'dynamic' deposition

Results - examples

Shallow radiation fog, m= d_g/d_t =0.35

Advective stratus fog, m= d_g/d_t =0.06

Red line denotes fitted gradient, d_g/d_t

Does the ratio of d_g/d_t vary with the level of turbulence?

Averaged results over 12 fog episodes

|	All data	'High' turbulence	'Low' turbulence
Mean, m	0.14	0.11	0.22
n	12	9	8
Std. Dev.	0.11	0.08	0.12
Std. Err.	0.03	0.01	0.02

Data were filtered according to turbulence level (ww, vertical velocity variance) : - high or low. Threshold=0.003 m^2s^2

Results show low turbulence regimes have a significantly higher value of, m, i.e. there is relatively more gravitational settling in the lower turbulent regimes – these tend to be the shallow stable fogs
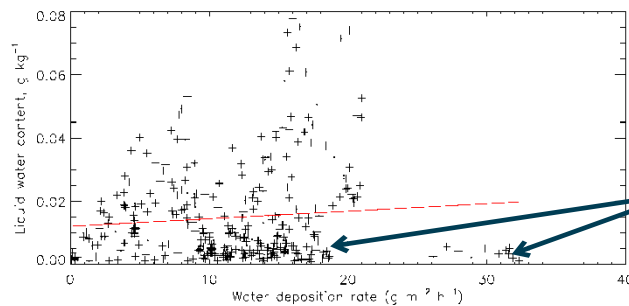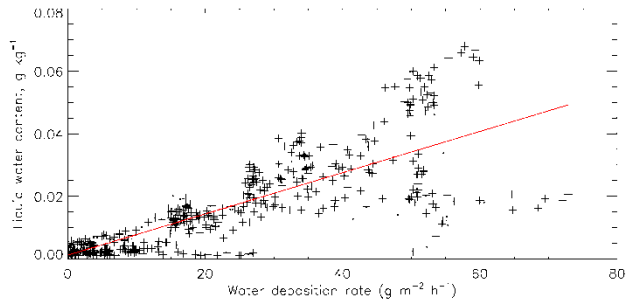
Other threshold values tested – gradients differed but significance in difference between high and low regimes unchanged

Can we relate LWC to the measured water deposition?

Good example (stratus fog)
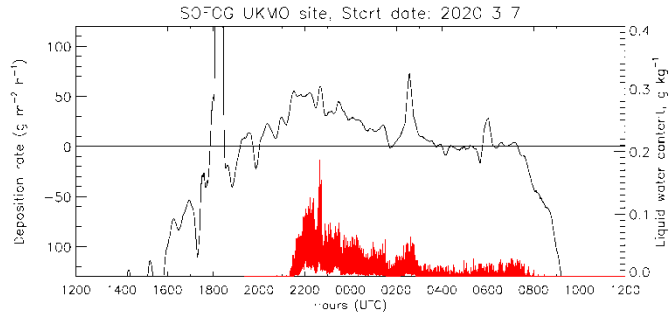
Not-so-good example (thin radiation fog)
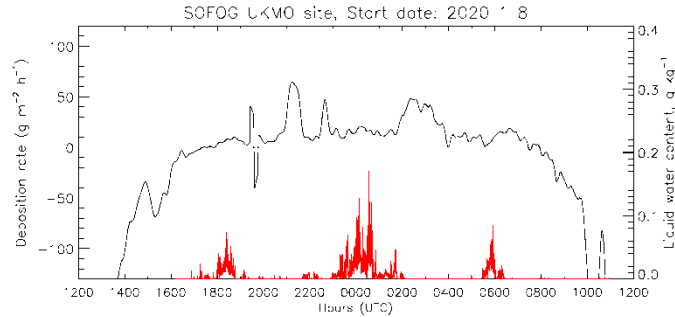
Data 'contaminated' by continued dewfall in fog?

Averaged LWC results over 8 fog episodes

Mean, m (lwc/d_d)	0.0017
n	8
Std. dev.	0.0012
Std. err.	0.0004

- The high standard deviation indicates no universal relationship for all cases

Multiple regression

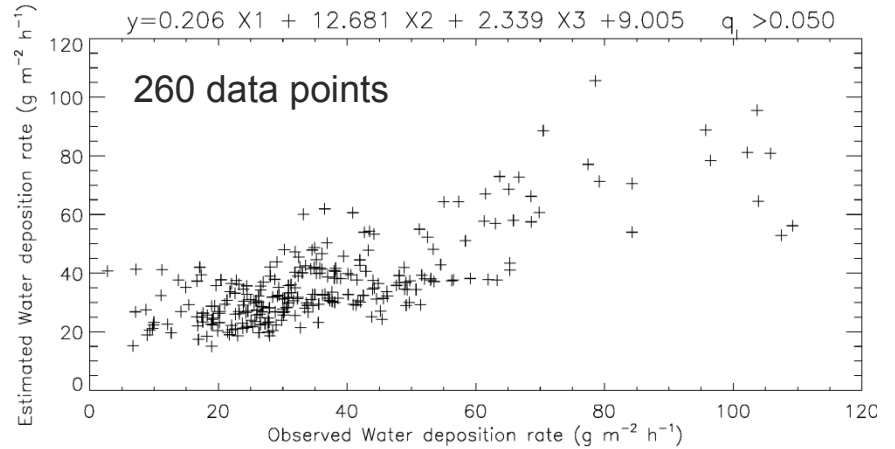Does regressing turbulent, gravitational and ventillation terms produce a better result?

Above terms were regressed against observed droplet deposition rate from dewmeters, to achieve the following:

$$\frac{dq_d}{dt} = x1. q_l. \sigma_w + x2. U + x3. q_g + C$$

q_l is liquid water from FM120, σ_w the vertical velocity standard deviation at 2m, U the mean wind at 2m and q_g is the gravitational settling rate.

• We expect, *C*, to be zero in a perfect regression, then the terms *x1* etc represent the relative importance of the individual processes.

Multiple regression - Results

$y=0.303\ X1 + 2.475\ X2 + 2.405\ X3 + 10.640 \qquad q_l > 0.001$

1074 data points

$y=0.206\ X1 + 12.681\ X2 + 2.339\ X3 + 9.005 \qquad q_l > 0.050$
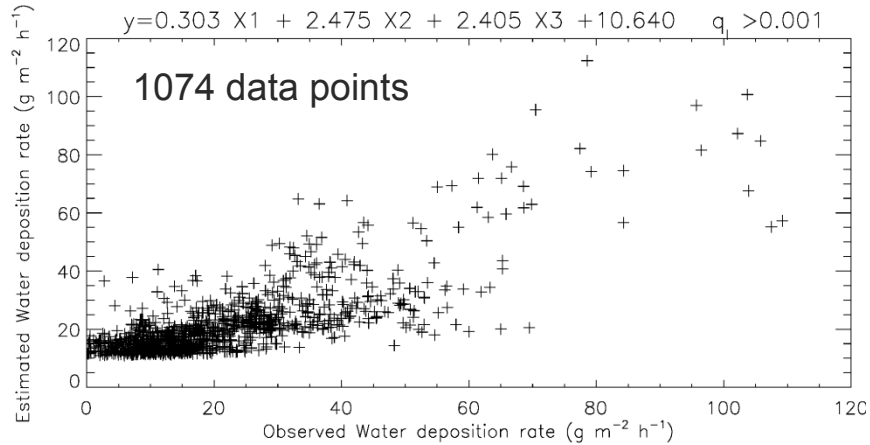
260 data points

- Two filter values shown for q_l >0.001 and >0.05 gm^{-3} to examine possible dew contamination

- All available data used from all 12 cases (IDL REGRESS function used)

- Data points are 5 minute averages

Multiple regression – Stats

coefficients	ql > 0.001			ql>0.05		
	X1	X2	X3	X1	X2	X3
value	0.30	2.48	2.41	0.21	12.68	2.34
σ_X	0.04	0.65	0.11	0.07	3.45	0.19
R	0.64	-0.10	0.75	0.57	0.02	0.72

- Error metrics and 'fit' slightly better for all data regression
- Gravitational settling is strongest term
- Advective component is very weak

Conclusions and Further Work

- Analysis shows that the gravitational deposition of fog droplets is a small fraction (0.14) of the total water deposition during these fog cases

- The fraction of gravitational deposition is greater for cases where the turbulence intensity is lower – these typically are shallow stable radiation fogs (0.22, compared to 0.11 when ww>0.003 m^2s^2)

- The liquid water content shows weak proportionality with the total water deposition in fog.

- However, a multiple regression of deposition terms shows reasonable proportionality with observations.

- Gravitational term shows the highest correlation

- Ventilation term shows lowest correlation and appears to be insignificant for this canopy type

Further work?

- Include data from Jachere site where possible

- With additional data, is it possible to repeat the analysis but for other canopy types (e.g. Trees)

Any Questions?

Conclusions and further work