

Modelling the atmospheric chlorine 36 dry deposition on grass using micrometeorology

D. Sourabie¹, D. Hebert¹, L. Benedetti², E. Vitorge³, B. Lourino Cabana⁴, V. Guillou², D. Maro¹

¹*Institute for Radioprotection and Nuclear Safety (IRSN), PSE-ENV/SRTE/LRC, Cherbourg-Octeville, 50130, France*

²*Univ. Aix-Marseille, CNRS, IRD, INRAE, Coll. France, UM 34 CEREGE, Aix-en-Provence, 13545, France*

³*EDF – DPNT – DIPDE - DEE – Environment department, Villeurbanne, 69100, France*

⁴*EDF R&D LNHE - National Laboratory of Hydraulics and Environment, Chatou, 78401, France*



Chlorine radioactive isotope

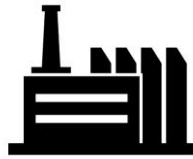
Long-lived radionuclide ($t = 301,000$ years)

Activity = $1,22 \times 10^9$ Bq.g⁻¹



*High solubility
and
bioavailability*

(Bastviken et al., 2013)



*Natural
and
antropogenic
sources*

(Pupier et al., 2016)



*Lack of data on his
fate and
dosimetric impact*

(Tanaka and Thiry, 2019)

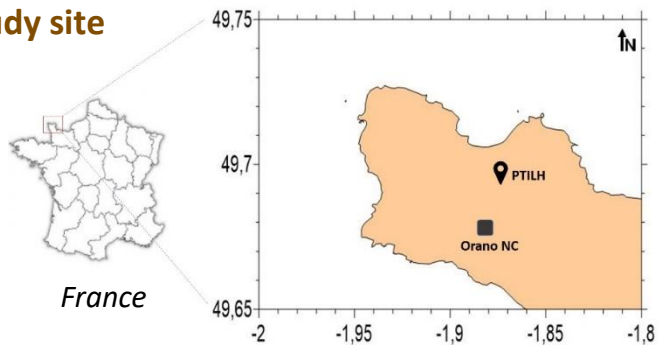
(Le Dizès and Gonze, 2019)



*Wet and dry
deposition*

(Lazarev, 2003)

Study site

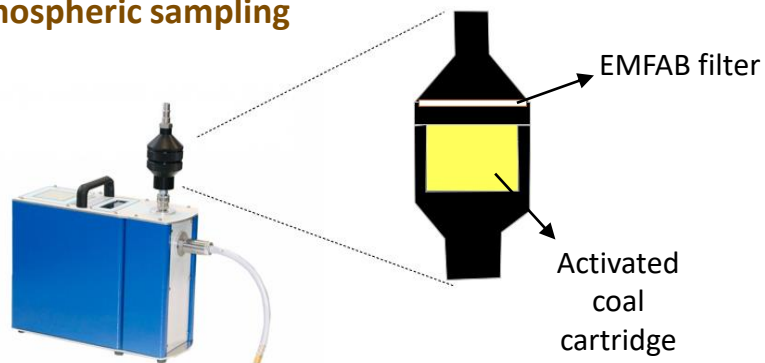


PTILH : IRSNA La Hague technical platform
Orano NC : Nuclear fuels reprocessing plant

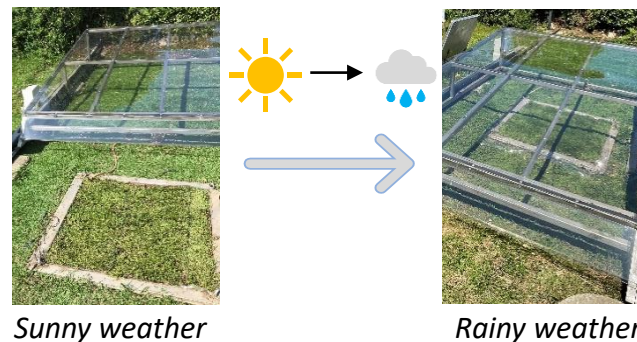
Monitoring of weather parameters



Atmospheric sampling

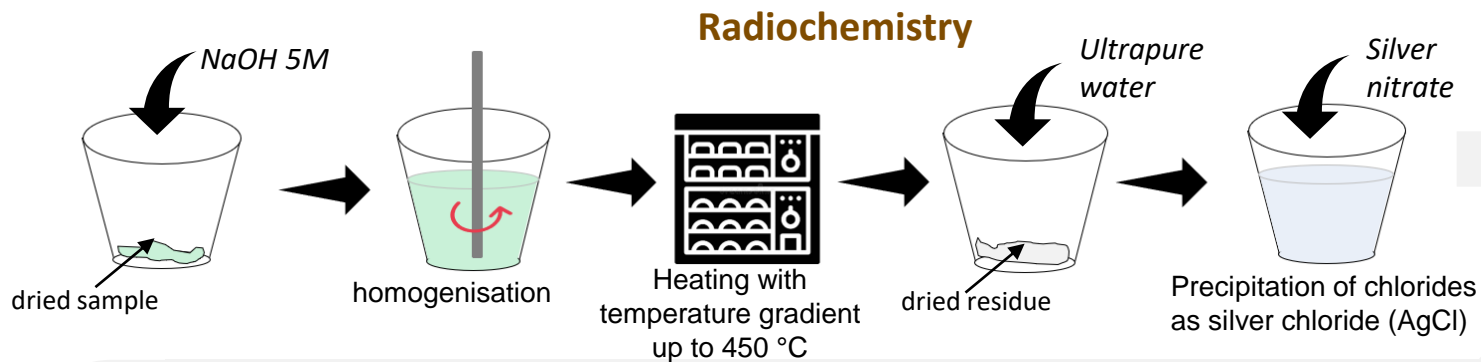


Grass sampling



Sunny weather

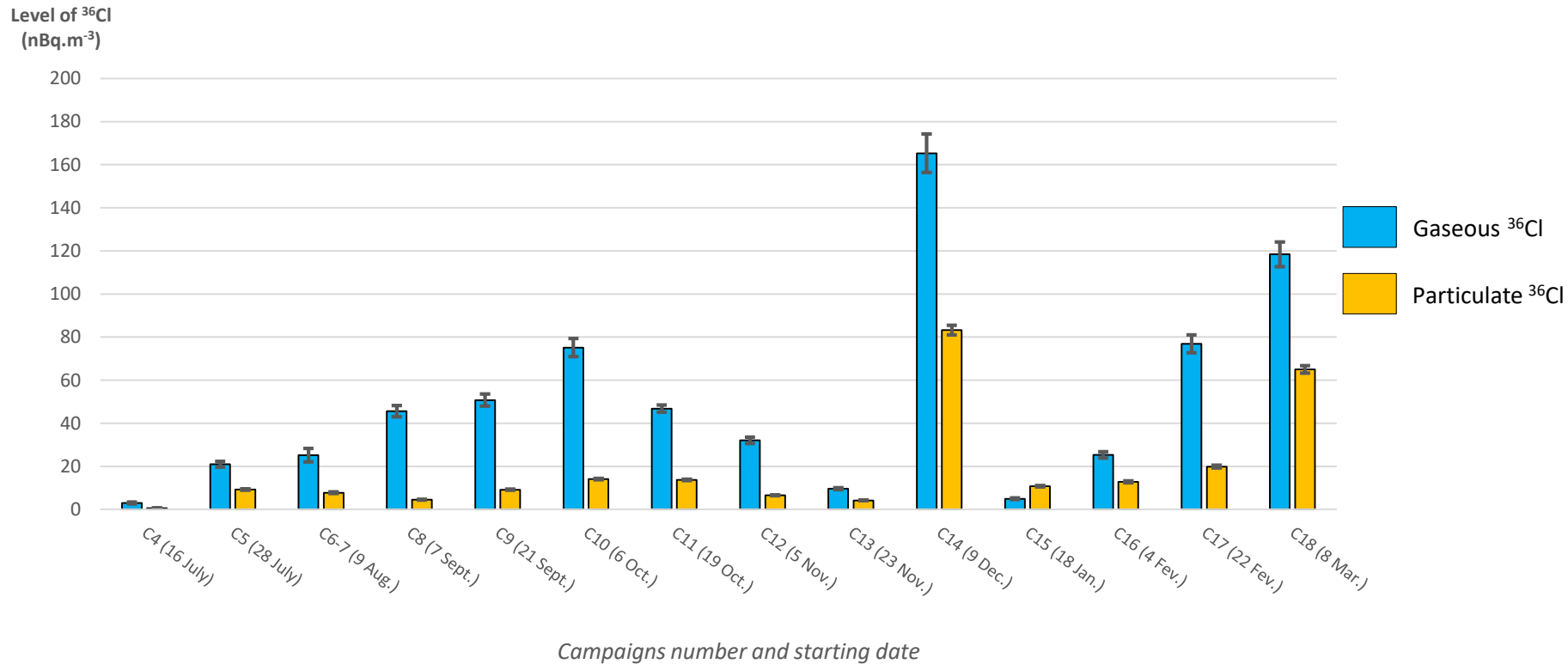
Rainy weather



Accelerated Mass spectrometer (**AMS**) - *Accelerator for Environmental, Earth and Risk Sciences (ASTER)*

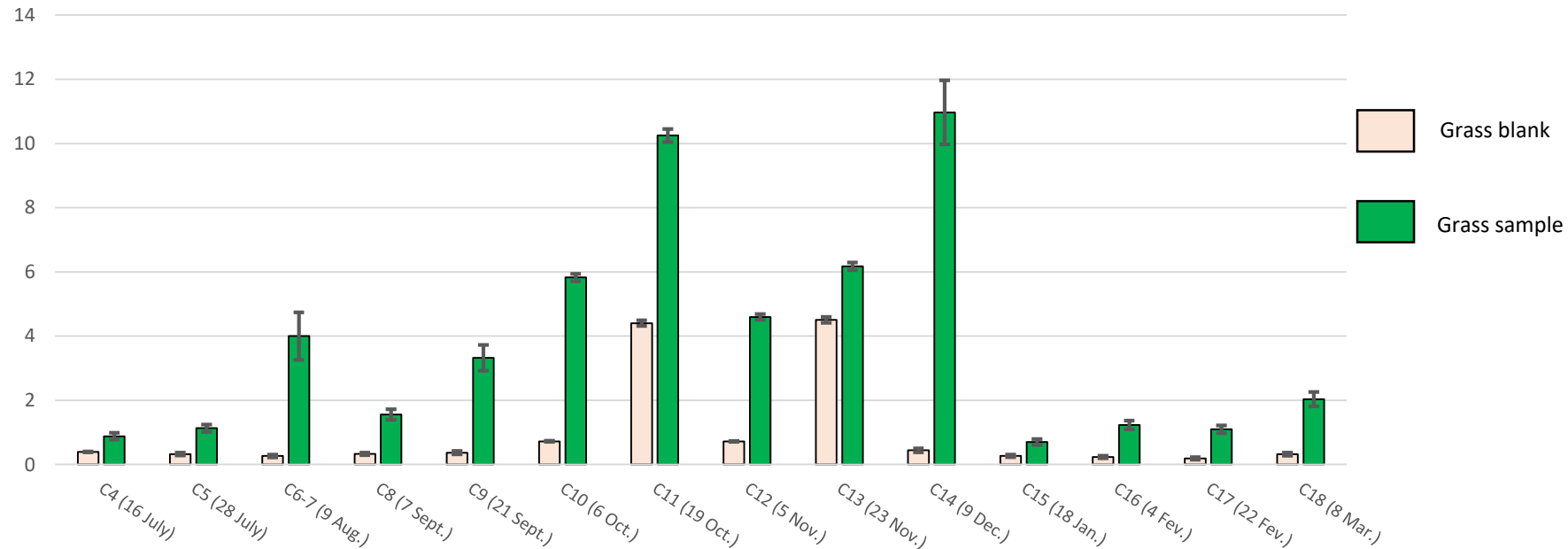


Atmospheric chlorine 36

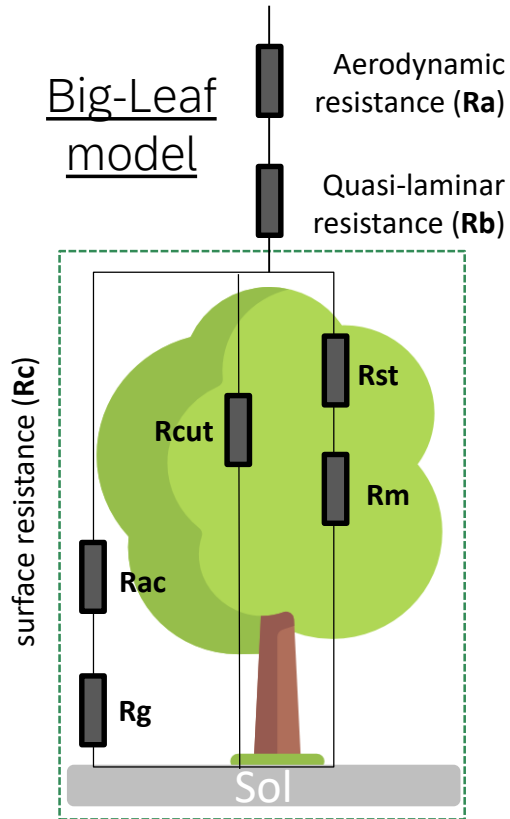


Chlorine 36 in grass samples

Levels of ^{36}Cl
($\mu\text{Bq}\cdot\text{g}^{-1}$)



Campaigns number and starting date

Modelling gaseous ^{36}Cl 

(adapted from Zhang et al., 2003)

$$v_d = \frac{1}{\Sigma R}$$

$$v_d = \frac{1}{R_a + R_b + R_c}$$

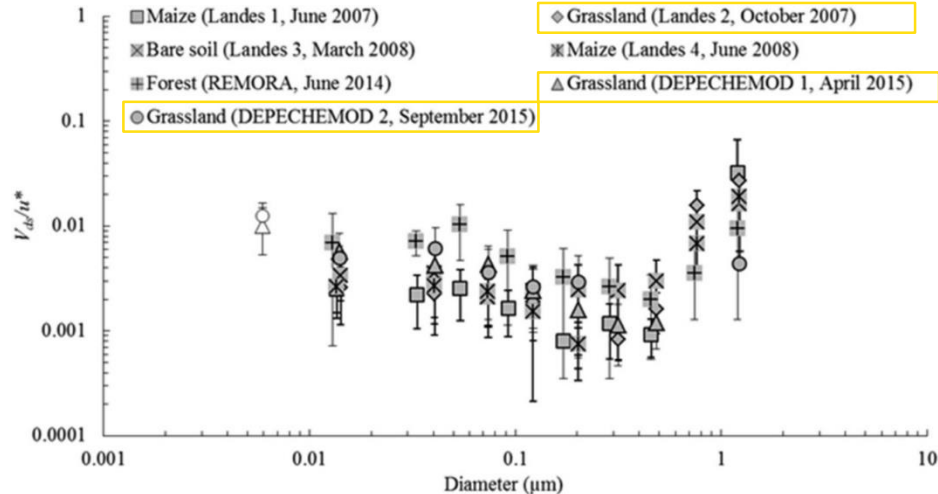
- ⚡— **Aerodynamic resistance (R_a)** is the resistance to turbulent transport of matter through the atmospheric surface layer. It is common to all gases
- ⚡— **Quasi-laminar resistance (R_b)** is the resistance to material transfer at the latter layer to the surface. This resistance is due to molecular diffusion in the thin sub-layer near a flat rough surface
- ⚡— **Canopy or surface resistance (R_c)** is the total resistance to gas transfer at the surface and at the substrate. Surface resistance refers to the resistance at the sheet level

Modelling particulate ^{36}Cl

- Diameter of the particle (d_p)
- Atmospheric stability ($1/L$)
- Air friction velocity (u^*)



Particles dry
deposition velocity



Surface dry deposition rates normalized by u^* for neutral and stable conditions as a function of geometric particle diameter

(Pellerin et al., 2017)

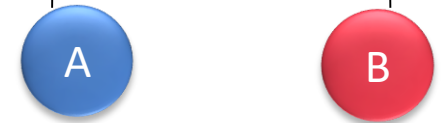


Low pressure
Impactor (LPI) DEKATI



$D_{\text{particles}} = 0,48 \mu\text{m}$

Particles
diameter



If stable or neutral atmosphere

$$\frac{v_d}{u^*} = A$$

If unstable atmosphere

$$\frac{v_d}{u^*} = A \left(1 + \left(\frac{B}{L} \right)^{\frac{2}{3}} \right)$$

(Damay et al., 2009)

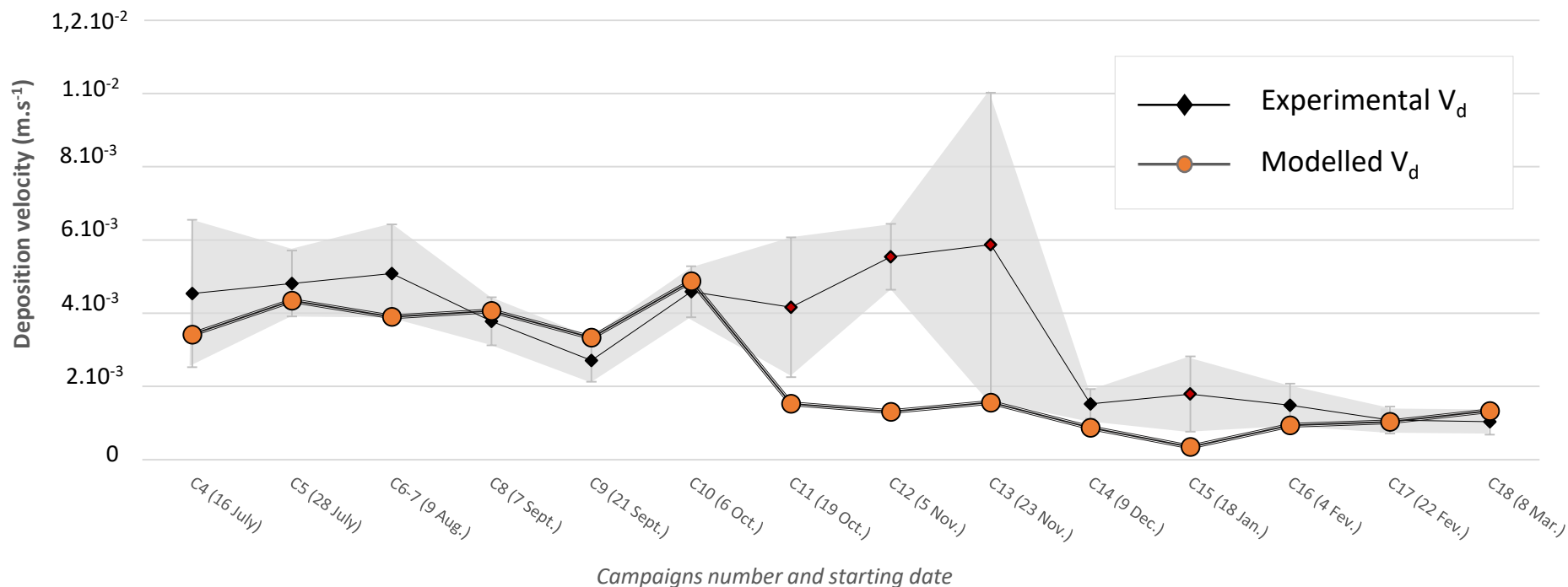
(Pellerin et al., 2017)

Experimental and modelled dry deposition velocities


$$Vd_{\text{gas}} = 3.10^{-4} \sim 5.10^{-3} \text{ m.s}^{-1}$$

$$Vd_{\text{particles}} = 6.10^{-5} \sim 9.10^{-4} \text{ m.s}^{-1}$$


$^{36}\text{Cl}_{\text{gaz}} > 97\%$ of deposits




Take-home messages



Dry deposition velocities of ^{36}Cl on grass vary with the season and parameters related to atmospheric turbulence



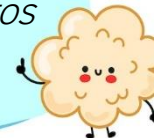
The deposition models: Big-leaf for gaseous ^{36}Cl and Damay-Pellerin for particulate ^{36}Cl developed can provide a good estimate of dry deposition



^{36}Cl deposits are dominated by the gaseous fraction but particulate ^{36}Cl with larger diameter may question this trend

Thanks for your attention!

More infos



Abstract



Project



Contact



Deo-Gratias SOURABIE
IRSN/France
deo-gratias-kily.sourabie@irsn.fr
Tél. : +33 (0)2 33 01 41 00