Cloud diagnosis impact on deposition modelling applied to the Fukushima accident

Arnaud Quérel, Denis Quélo, Yelva Roustan, Anne Mathieu

Cloud diagnosis impact on deposition modelling applied to the Fukushima accident.

Arnaud Quérel[1,2], Denis Quélo[1], Yelva Roustan[3], Anne Mathieu[1]

[1] Institute for Radiological Protection and Nuclear Safety (IRSN), PRP-CRI, SESUC, BMCA, Fontenay-Aux-Roses, France

[2] Strathom Energie, Paris, France

[3] CEREA, École des Ponts ParisTech - EDF R&D, Marne-la-Vallée, France

In case of a nuclear accident, they are two phases concerning the dispersion of radioactive materials:

1. **Forecast: Anticipating the consequences of an atmospheric release of radioactive material.**
2. **Aftermath: Understand the soil contamination and the possible harm suffered by the populations during the event.**

Wet deposition modeling is important to achieve these goals. The cloud diagnosis is a key issue for wet deposition modelling since it allows distinguishing between two processes:

- **in-cloud scavenging: the collection of radioactive particles into the cloud**
- **below-cloud scavenging: the removal of radioactive material due to the falling drops.**

Which cloud diagnosis to use for the atmospheric transport models ?

Case study: the Fukushima accident

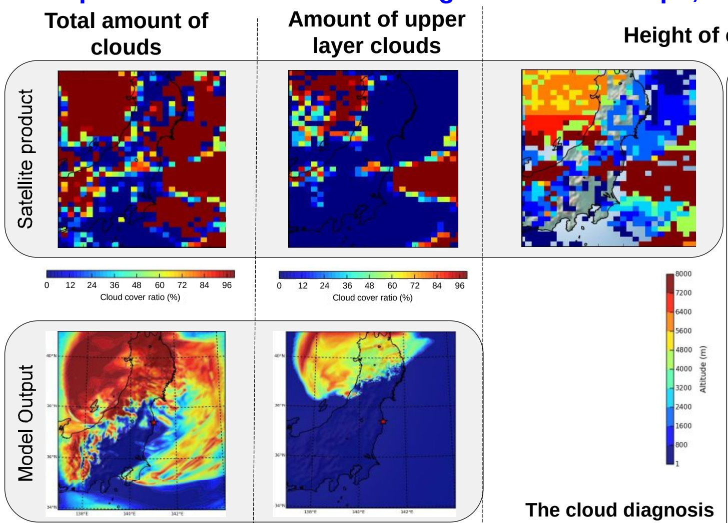
Models cannot currently reproduce the Fukushima accident in a completely satisfactory manner. One of the potential improvement may concern the cloud diagnosis on this case. The period studied is around the 15 of March 2011; This is the period where the largest deposits occurred and several cloud observations were available. The meteorological model used here is a 3km/10min resolution simulation provided by JMA. To model wet deposition, the variables of interest are:

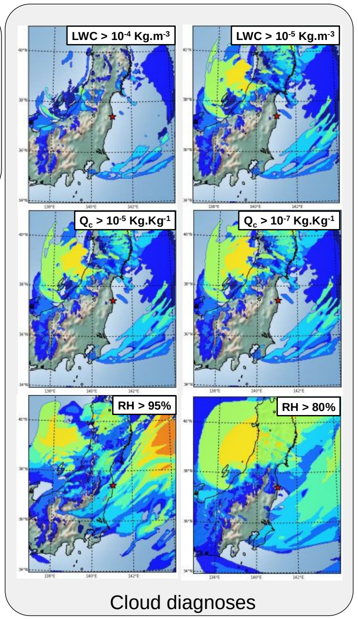
	Cloud fraction	Cloud base and top	Precipitations**
Observations	Satellite product (Himawari, METSAT2)	Satellite product (for the cloud top) (Himawari) Ceilometer (for cloud base)	Radar, rain gauge, radar/rain gauge-analyzed precipitation (RAP, Saito et al., 2015)
Meteorological model	Simulation output	Diagnosed* with help of simulation output	Simulation output

*Cloud diagnoses: Relative humidity, Liquid Water Content (LWC) and cloud water mixing ratio (Q_C) are used for diagnoses. Two thresholds are used for each diagnosis.

**Precipitations are only used here to verify the consistency with cloud presence.

Comparison of observed and diagnosed cloud maps, the 16th March 00:00





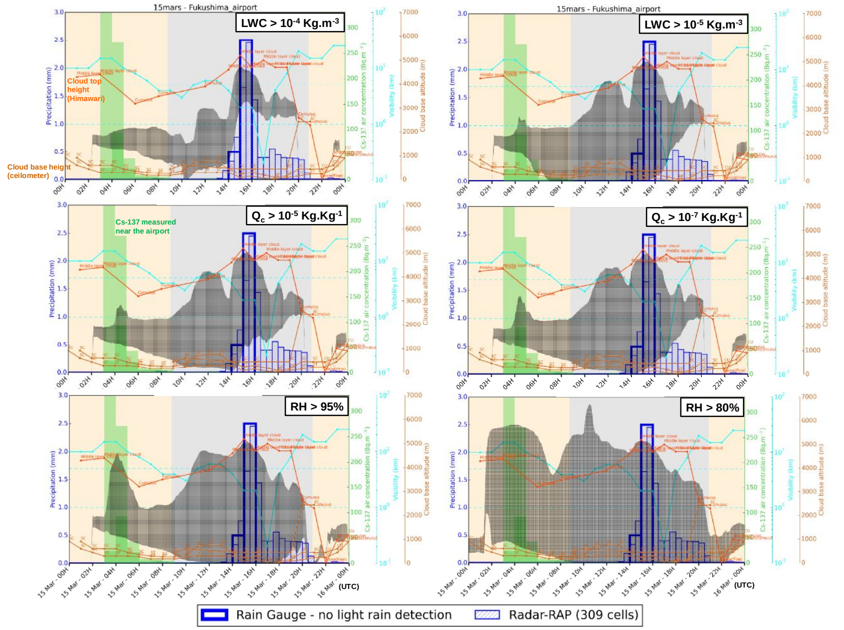
Cloud diagnoses

In this case, the meteorological model does fairly reproduce the cloud cover for low and middle layer. Upper layer clouds are not well reproduced. But, these types of clouds are not important for deposition modelling.

The cloud diagnosis has a strong impact. The diagnosis using LWC with a threshold at 10^{-4} Kg.m^{-3} is the worst one.

Comparison between observation and diagnosis at one station

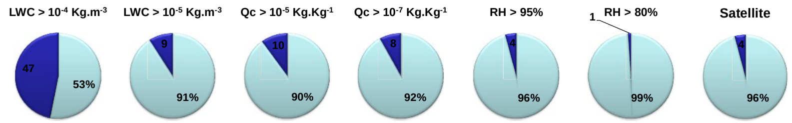
At the Fukushima airport, a deposit as large as 36 kBq.m^{-2} of Cs-137 was measured. Both dry and wet deposition were probably involved since a raining event occurred on the 15th of March when the plume was passing nearby.



At this station, cloud thickness is very sensitive to the cloud diagnosis, contrary to the cloud presence. Relative humidity at 80% and LWC at 10^{-4} Kg.m^{-3} give poor performances.

Radar RAP vs cloud diagnosis

Is there cloud above the rainfall observed by radar?



LWC at 10^{-4} Kg.m^{-3} is not usable. Other diagnosis are equally coherent with RAP data, satellite diagnosis include. The RH 80% is the best one, but only due to its cloud overestimation.

Cloud diagnosis choice have a major impact to the volume of the atmosphere considered as "in-cloud". Then, the repartition between in-cloud and below-cloud may be strongly impacted by the cloud diagnosis. Cloud water mixing ratio (Q_C) is the most interesting variable, which describes only the cloud water. Q_c provides satisfactory results and is not sensitive to the threshold. We therefore recommend to use Q_c to distinguish in-cloud and below-cloud scavenging in the atmospheric transport modelling.

Thanks to Dr Sekiyama and Dr Kajino for the Himawari, AMeDAS and meteorological modelling data providing.
Thanks to Japan Meteorological Agency Sendai Airport Observatory to the Grant-in-Aid for Scientific Research on Innovative Areas ISET-R modeling team and Pr Tsuruta for Fukushima airport data.

Saito, K., Shimbori, T., Draxler, R., 2015. JMA's regional atmospheric transport model calculations for the WMO technical task team on meteorological analyses for Fukushima Daiichi Nuclear Power Plant accident. Journal of Environmental Radioactivity 139, 185–199. doi:10.1016/j.jenvrad.2014.02.007