Deep Learning weather uncertainty quantification for EO satellite mission planning

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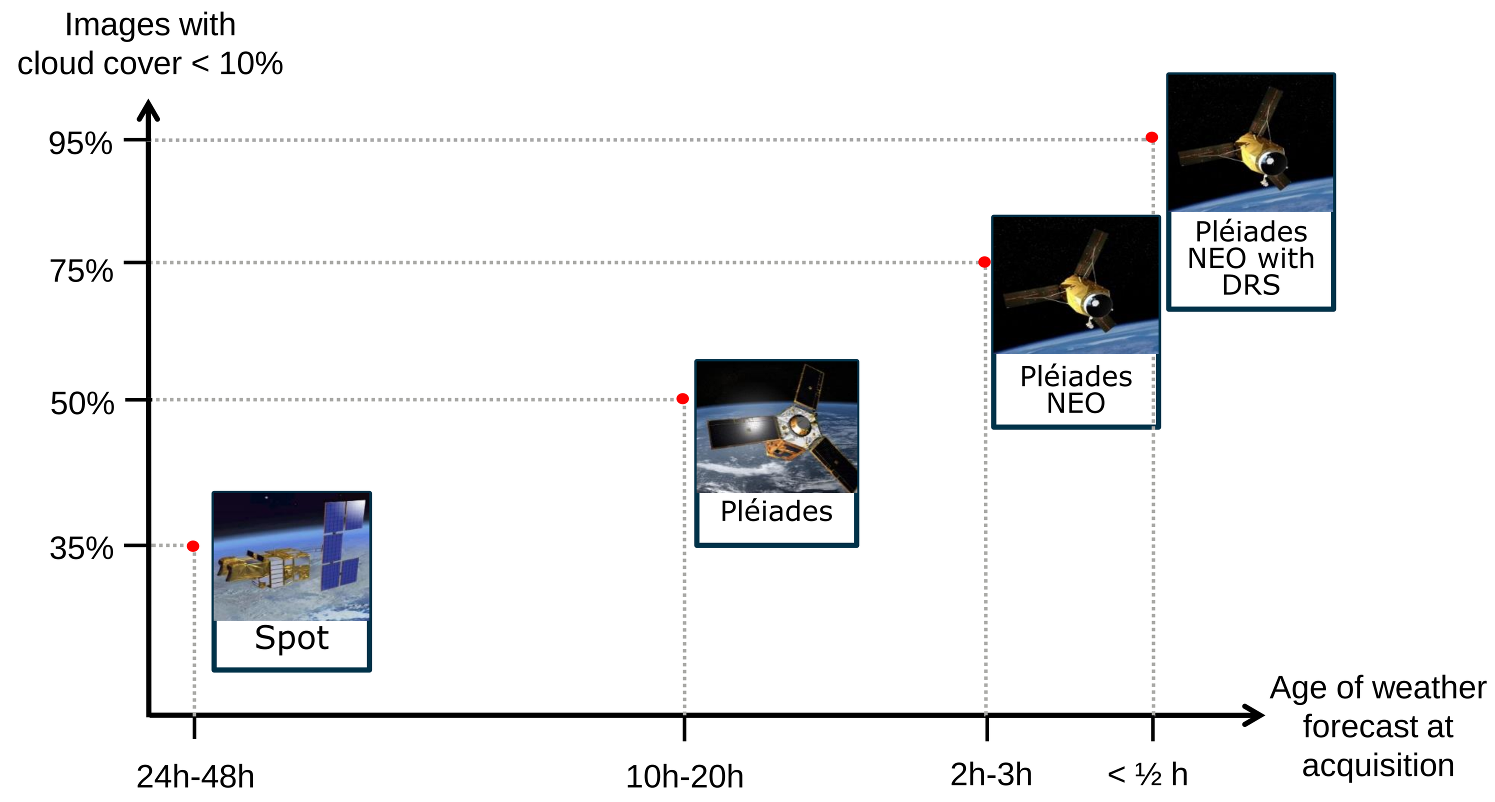
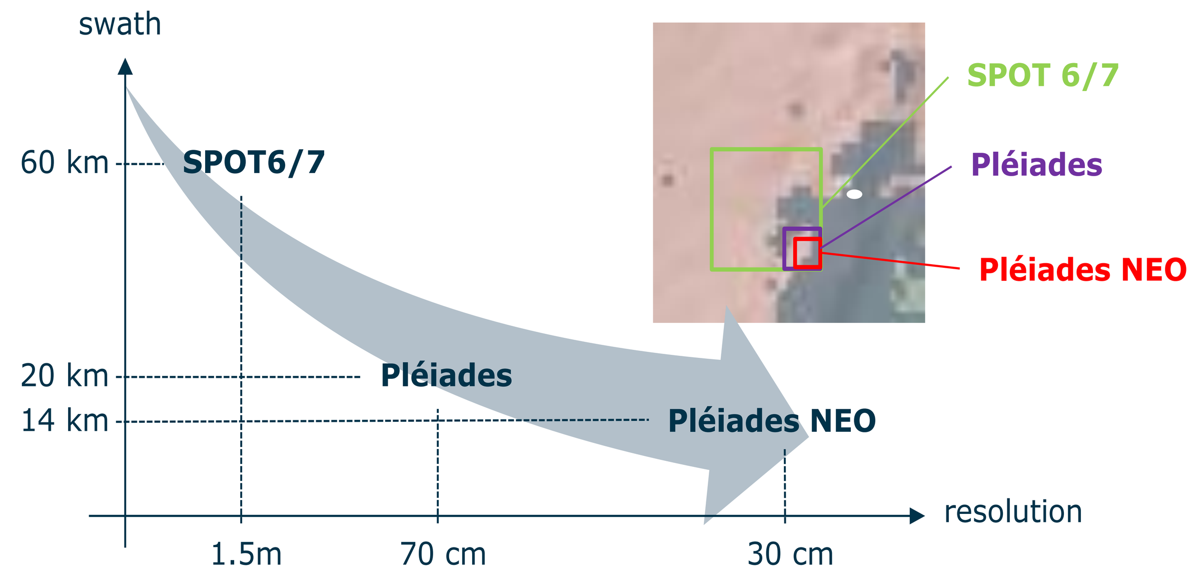
Trends for Very High Resolution (VHR), Agile Earth Observation Satellite (AEOS) Mission Planning

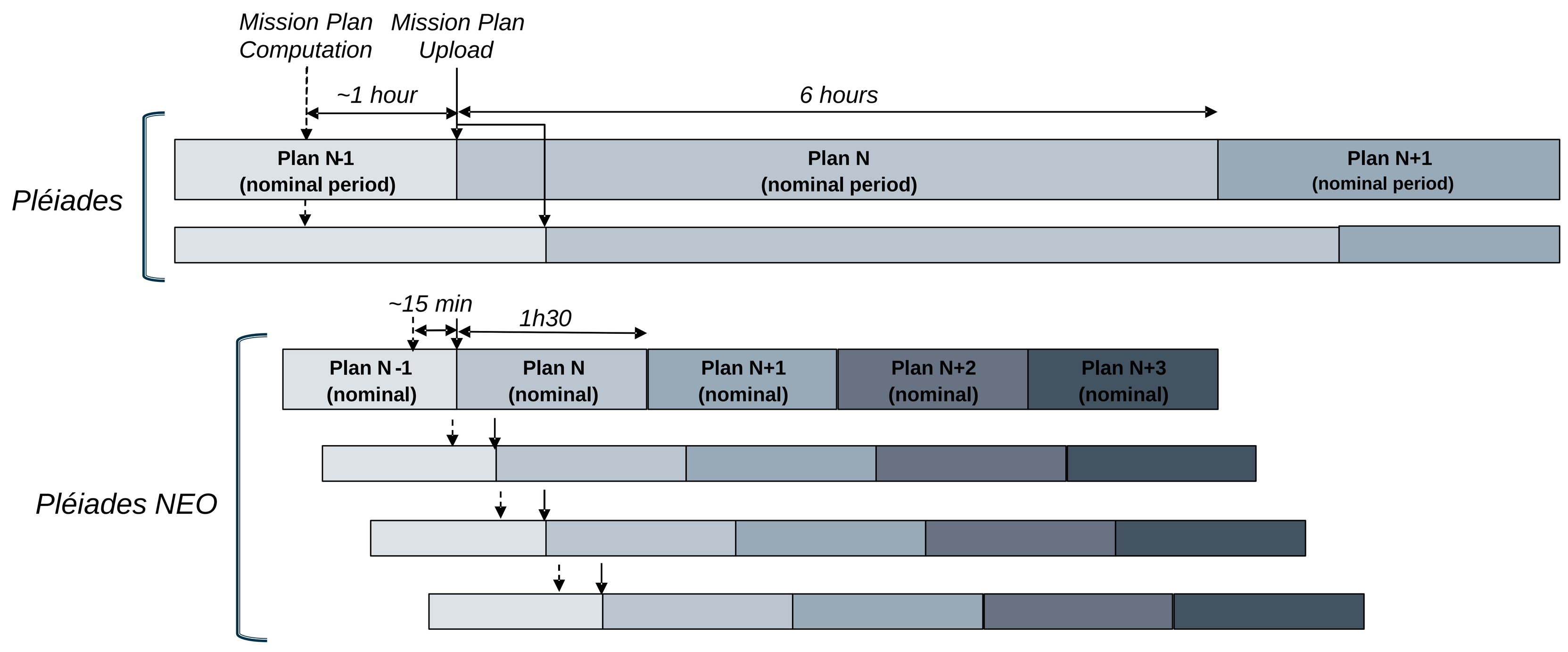
Ageing of weather forecast, together with the spatial and temporal resolution of weather data, have a high impact on the efficiency of Earth Observation satellites.

The next-generation of VHR AEOS (such as the Pléiades NEO system) feature **higher resolution**, a **reduced swath** and their acquisition and download plans are computed much **more frequently**. Therefore they rely more and more on **short-term cloud cover nowcasting** with improve accuracy and a finer resolution.

Nowcasting techniques (based on motion field extrapolation) usually provide a deterministic prediction of cloud cover but the **uncertainty** of the prediction is usually unknown.

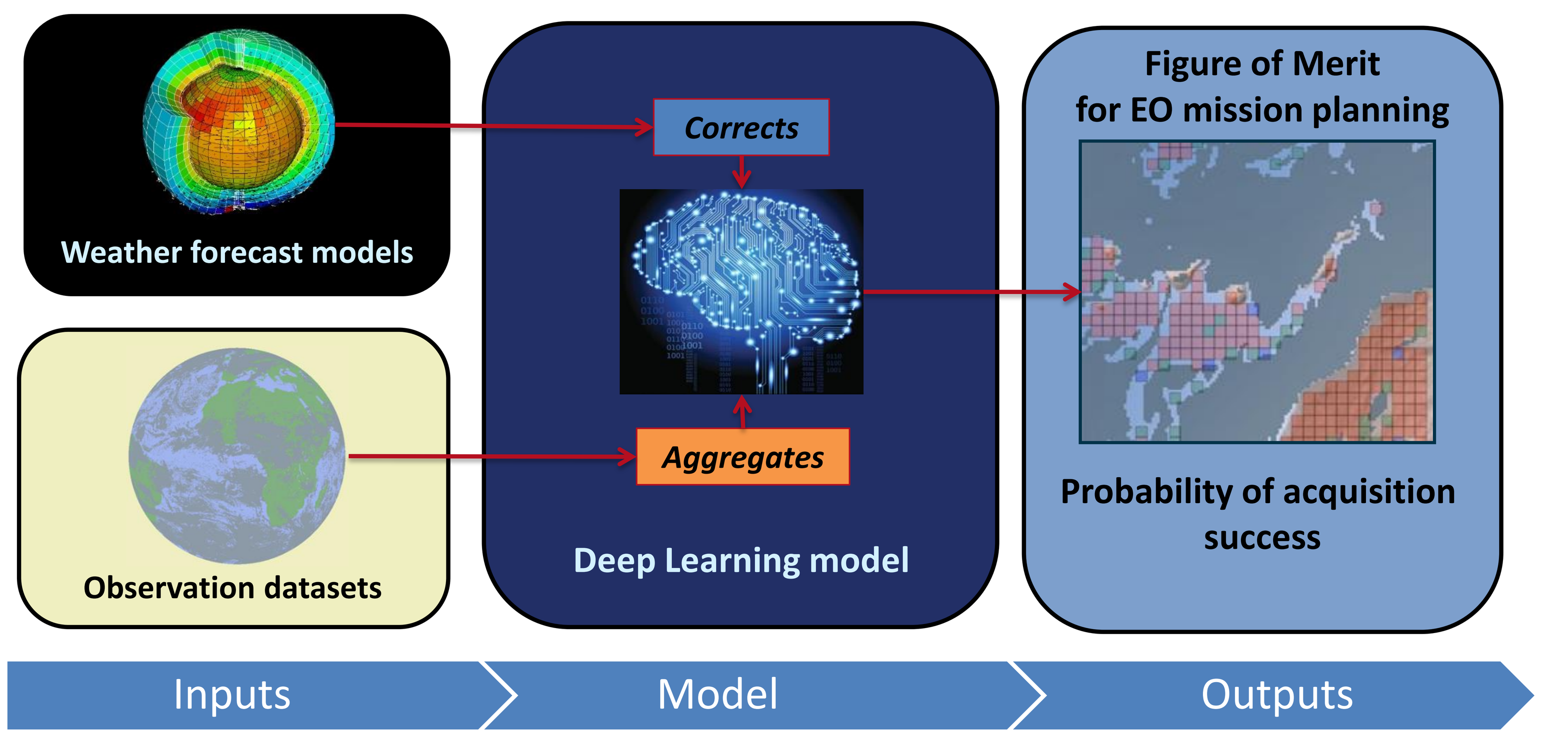


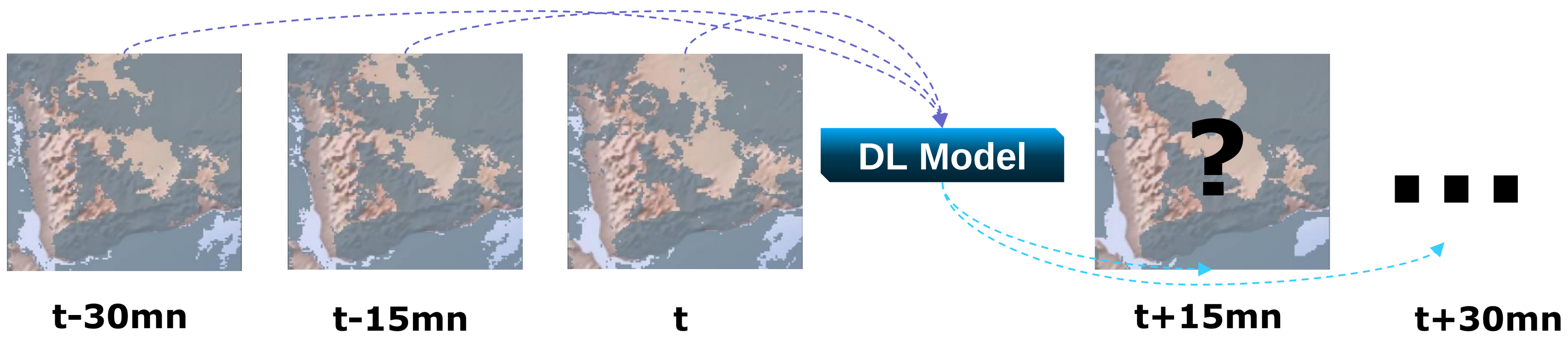




Deep Learning to improve the quality and capture the uncertainty of cloud cover forecasts

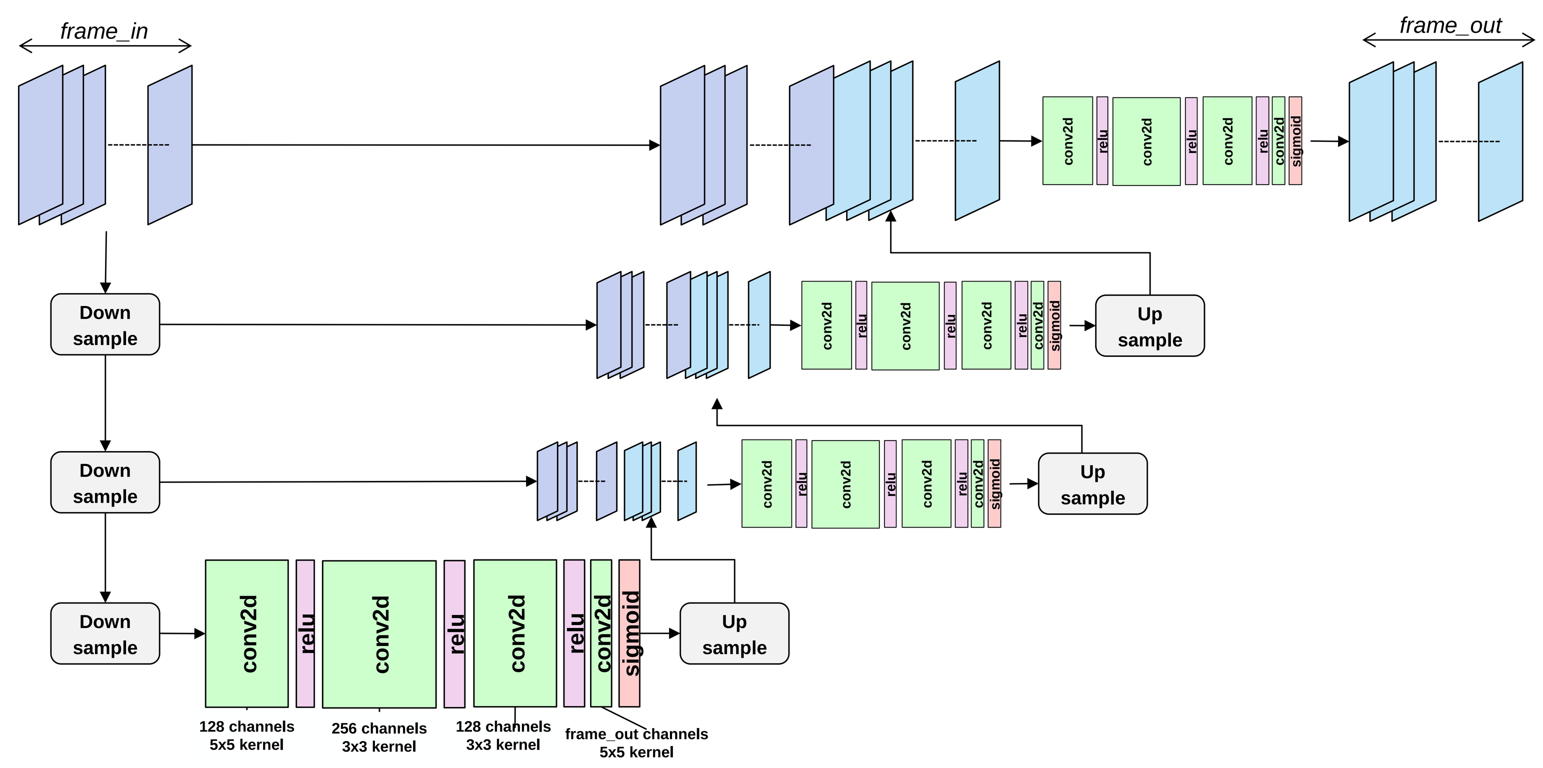
A tailored Deep Learning model can ingest the **latest cloud cover observations** together with **predictions of classical nowcasting techniques** to estimate the probability of acquisition success of the candidate meshes to be acquired by the EO satellite.





Datasets archived at ECMWF, providing **historical** records and re-analyses worldwide for both cloud cover observation and forecast, can be used to **train** the model.

Recurrent convolutional multi-scale models, already popular for next frames prediction in video sequences, are well adapted to our needs.



Deep Learning to improve the quality and capture the uncertainty of cloud cover forecasts

The solution has first been compared to a naive **persistent observation** technique in terms of Hit Rate and False Alarm Rate regarding acquisition success.

Next, through a **realistic mission planning simulation**, we have assessed the impact of ranking candidate acquisition based on the probability of success estimated by the model against a **classical approach** relying on the forecasted percentage of clear sky.

Legacy weather ranking	DL-based weather ranking
Raw clear sky percentage forecasted at the position and date of the acquisition	Estimated probability of success at the position and date of the acquisition
score(t, lat, lon) = 1-TCC$_{forecast}(t, lat, lon)$	score$(t, lat, lon) = f_{DL}(t, lat, lon) \sim p(TCC_{real} < 10\%)$
75% of validation success	85% of validation success