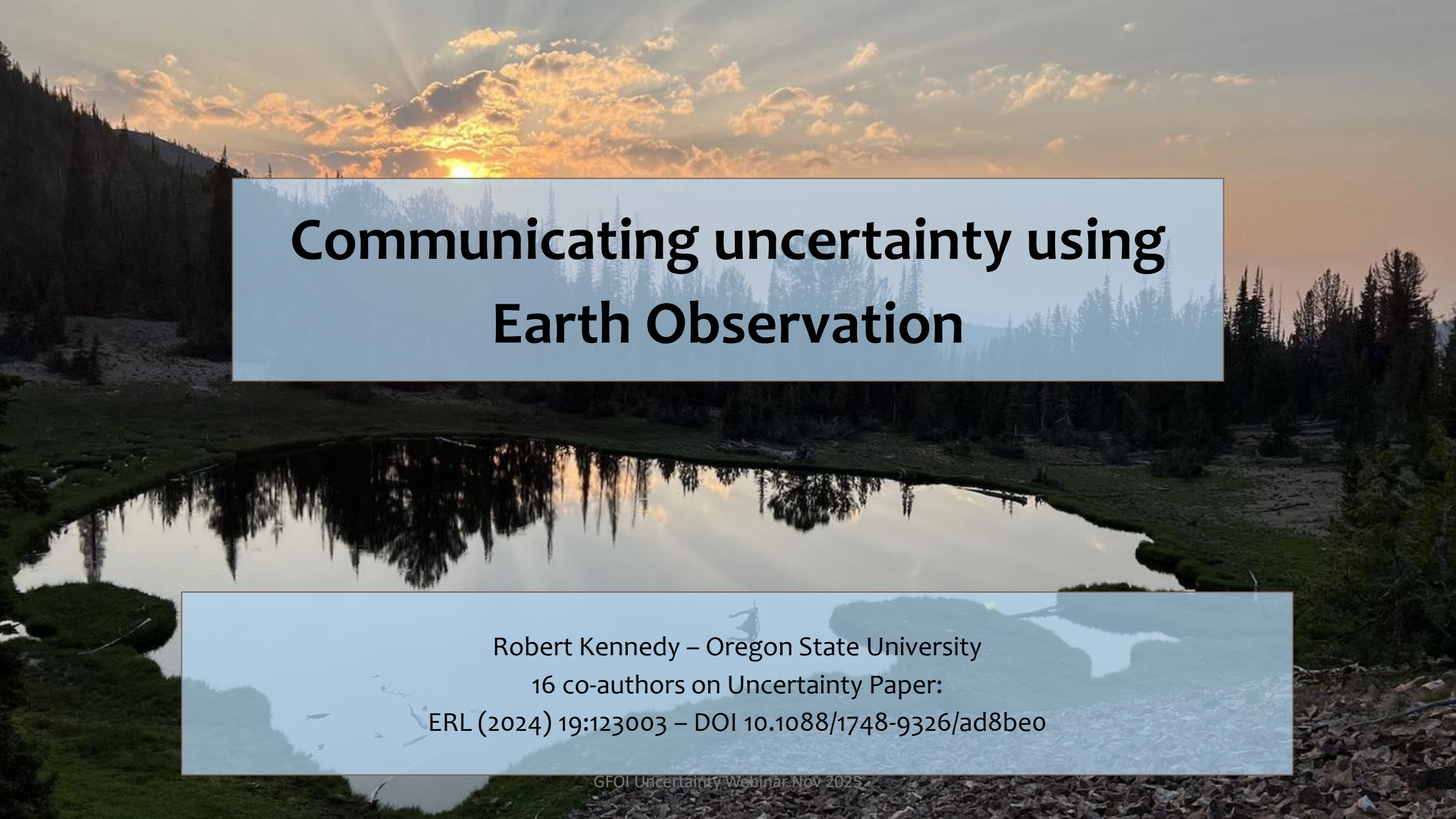




Communicating uncertainty using Earth Observation

Robert Kennedy – Oregon State University
16 co-authors on Uncertainty Paper:
ERL (2024) 19:123003 – DOI [10.1088/1748-9326/ad8be0](https://doi.org/10.1088/1748-9326/ad8be0)

Uncertainty

“....any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system.”
(Walker et al., 2003)

Walker, W.E., Harremoes, P., Rotmans, J., Sluijs, J.P. van der, Asselt, M.B.A. van, Janssen, P., Krauss, M.P.K. von, 2003. *Defining Uncertainty: A Conceptual Basis for Uncertainty Management in Model-Based Decision Support*. Integr. Assess. J. 4 (1): 5-17.

Uncertainty

Aleatoric

We can't know the system perfectly because of random (stochastic) effects.

Epistemic

There are parts of the system that we just don't understand or know about.

Uncertainty: Many Frameworks*

Arises in different places in production of knowledge

Has different severities

Includes “aleatoric” and “epistemic” components

* Bevan, L.D., 2022. The ambiguities of uncertainty: A review of uncertainty frameworks relevant to the assessment of environmental change. *Futures* 137, 102919.
<https://doi.org/10.1016/j.futures.2022.102919>

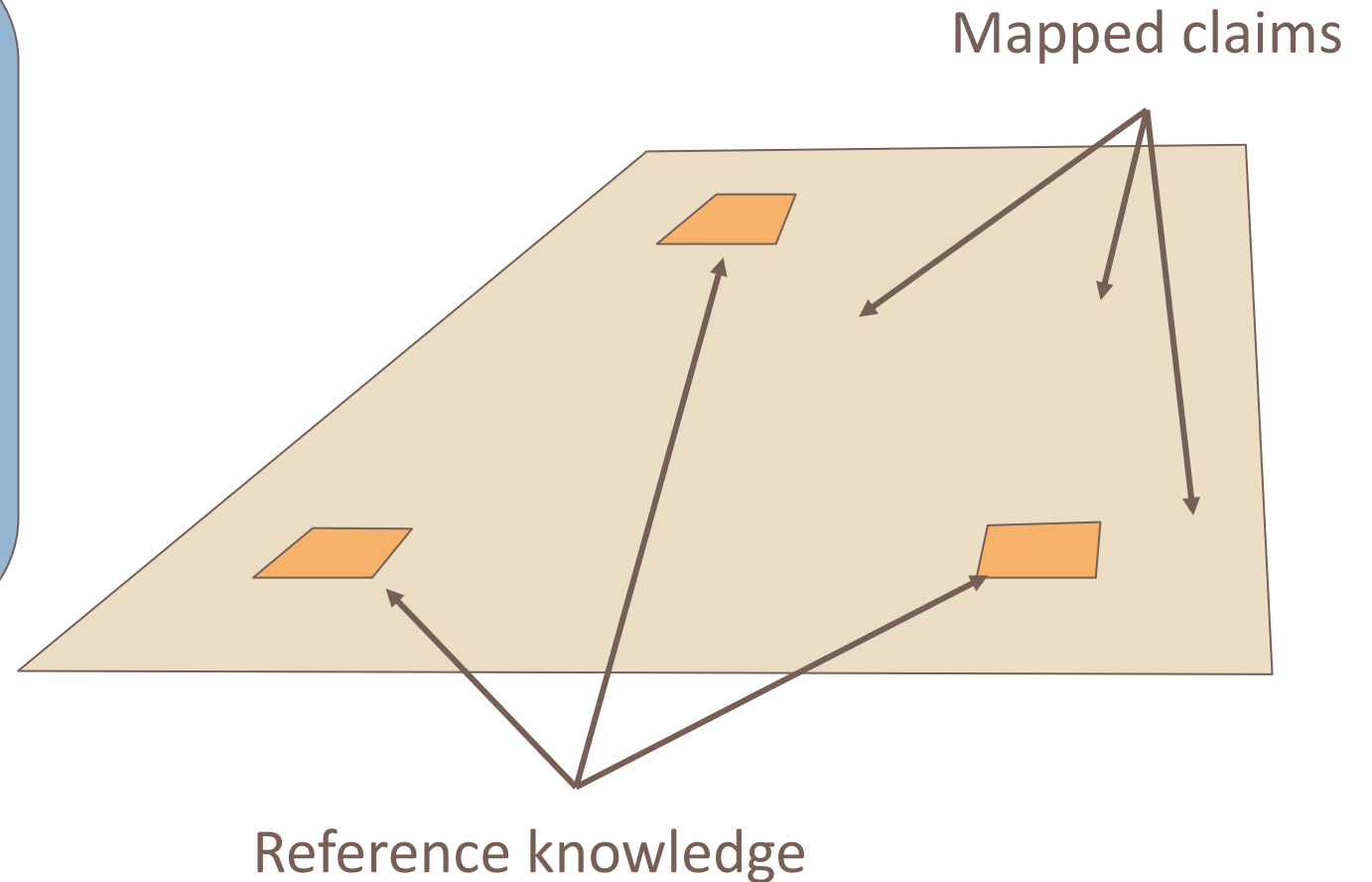
Uncertainty in Maps: Special!!

Every mapped claim (every pixel) has uncertainty:
an uncertainty surface → A Map!!!

If your map and my map do not consider the
same sources of uncertainty,
our uncertainty surfaces may not agree.

Uncertainty: Geospatial

We make claims in places for which we have no direct knowledge



Our approach

Relax disciplinary definitions to find common themes

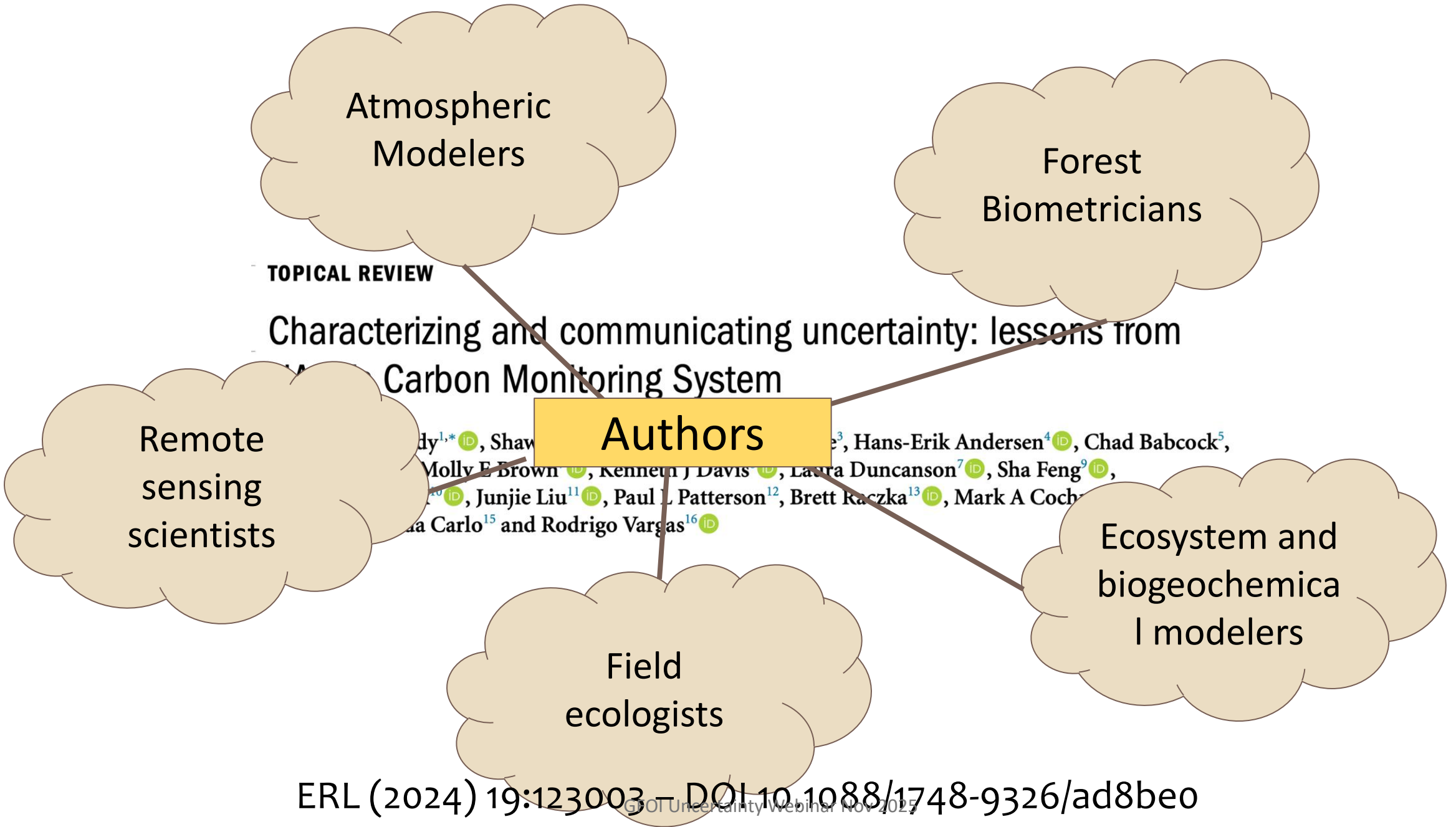
Develop generalized workflow for all projects

Build uncertainty framework

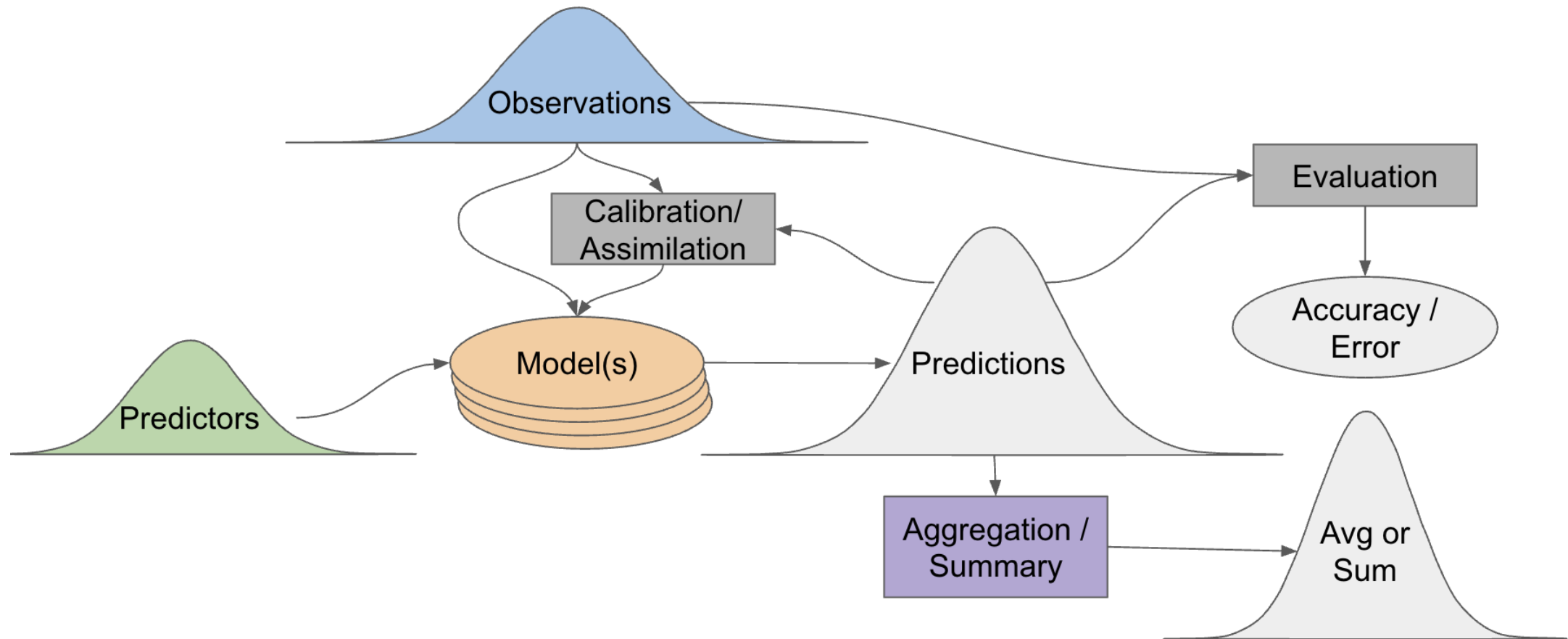
Terminology

Table 1. Generalized terminology used in this paper and its relationship to related terms found in common parlance or in discipline-specific cases.

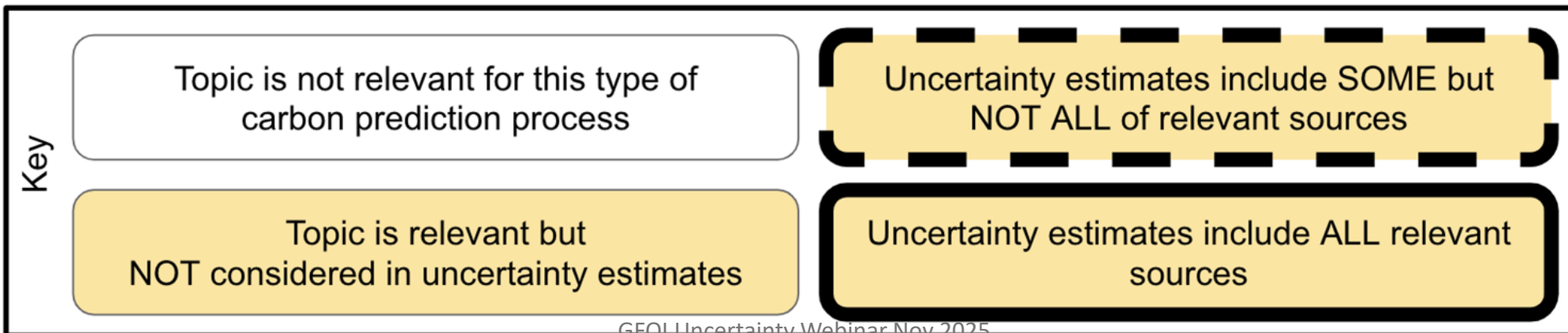
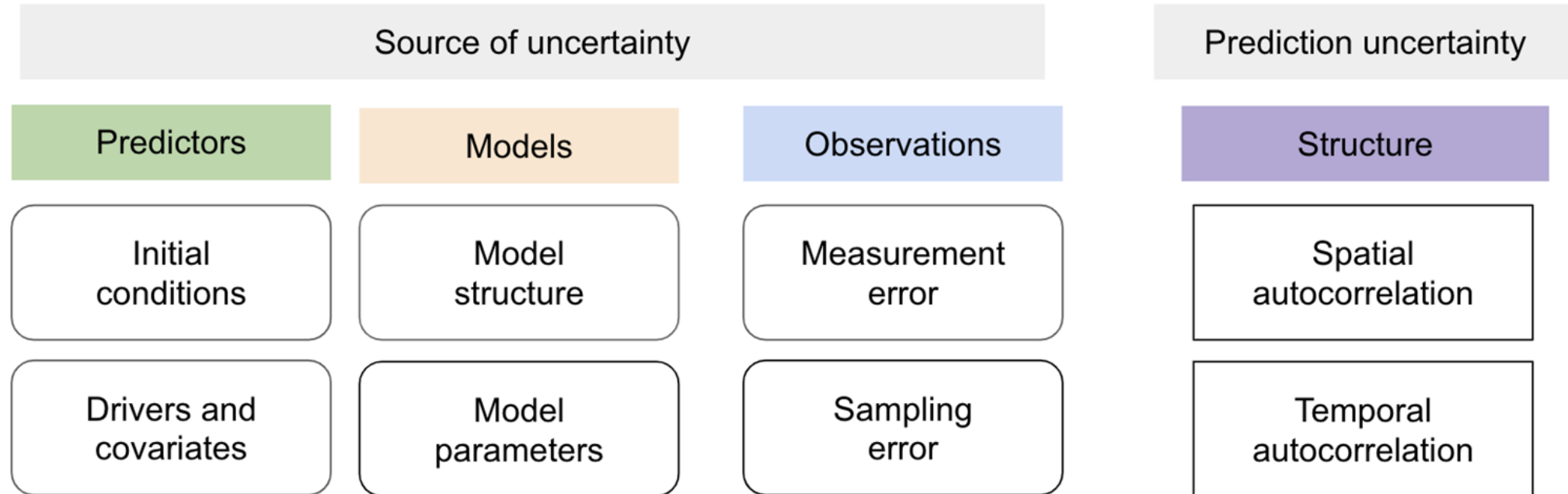
Term used in this framework	Definition	Alternative or discipline-specific related terms
Carbon-related attribute	True carbon state or flux characteristics of a real-world system	Atmospheric carbon mixing ratio, terrestrial forest carbon, marine dissolved carbon, etc.
Observation	A measurement of the carbon-related attribute of interest for a specific place and time	Measurement, data
Prediction	A quantitative claim about a carbon-related attribute for a specific place and time	Estimate, output, forecast, hindcast
Predictor	A characteristic of the real-world system that is thought to help predict the carbon-related attribute of interest	Ancillary variable, explanatory variable, driver variable, feature
Model	A conceptual, statistical, or mechanistic tool to translate predictors and/or observations into predictions	Linear regression, terrestrial ecosystem models, atmospheric transport models, machine learning
Error	The difference between the true value of a carbon-related attribute and either the prediction or observation	Standard deviation, variability, bias, root mean square error
Uncertainty	A characterization of the spread or distribution of potential values for the carbon-related attribute	Standard error, variance. Inverse or opposite of: accuracy, confidence, precision.



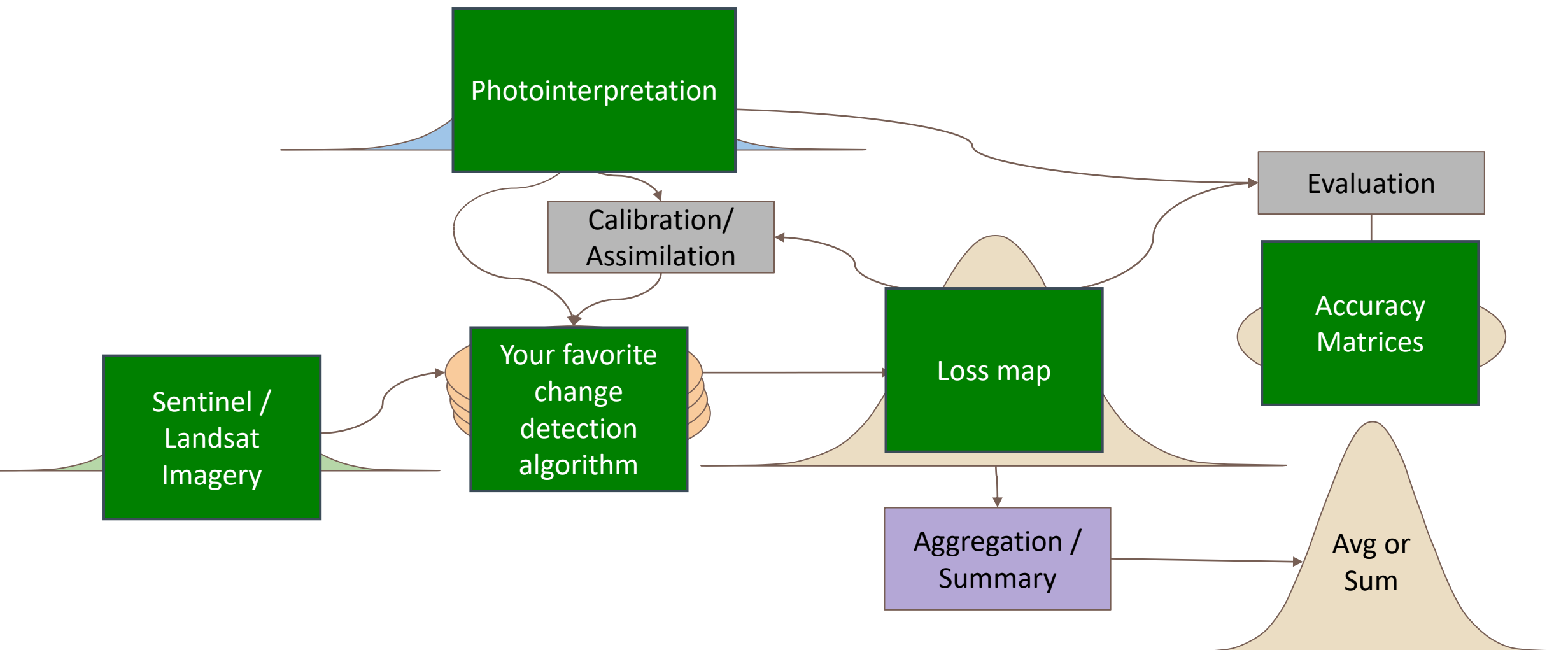
Generalized Workflow for ... everything?

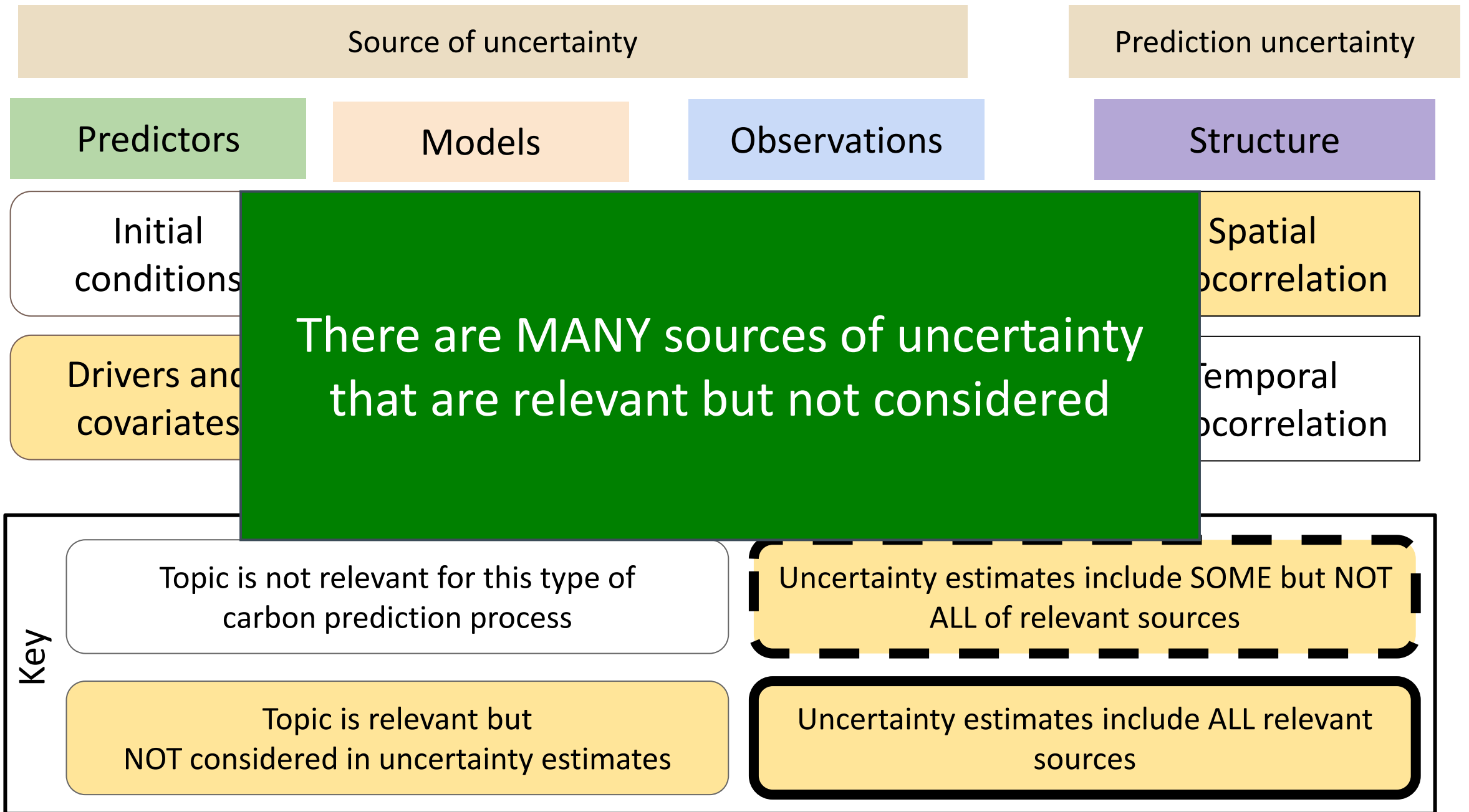


The Uncertainty Framework

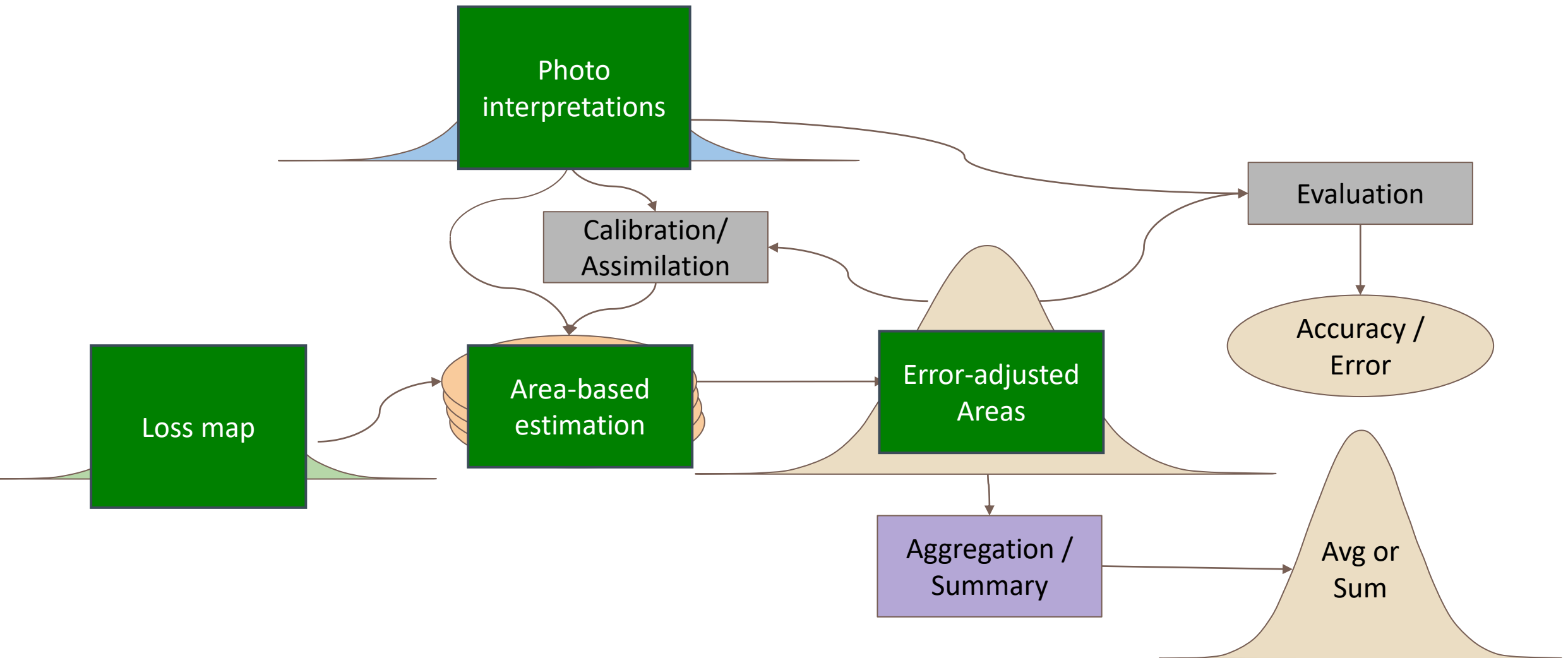


Example: Pixel-counting reporting





Example: Area-based estimation



Source of uncertainty

Because we have shifted to a design-based sample, uncertainty in drivers, etc. are no longer important

We have accounted for sampling error, but not measurement error in reference data

Prediction uncertainty

The design-based approach also does not need to worry about these factors for its error estimation

Key

Topic is not relevant for this type of carbon prediction process

Topic is relevant but NOT considered in uncertainty estimates

Uncertainty estimates include SOME but NOT ALL of relevant sources

Uncertainty estimates include ALL relevant sources

Uncertainty: Take-homes

Uncertainty arises in different places
in production of knowledge

Spatial maps make many claims
about unknown locations

It is important to communicate
what types of uncertainty you considered,
and which types you did NOT consider