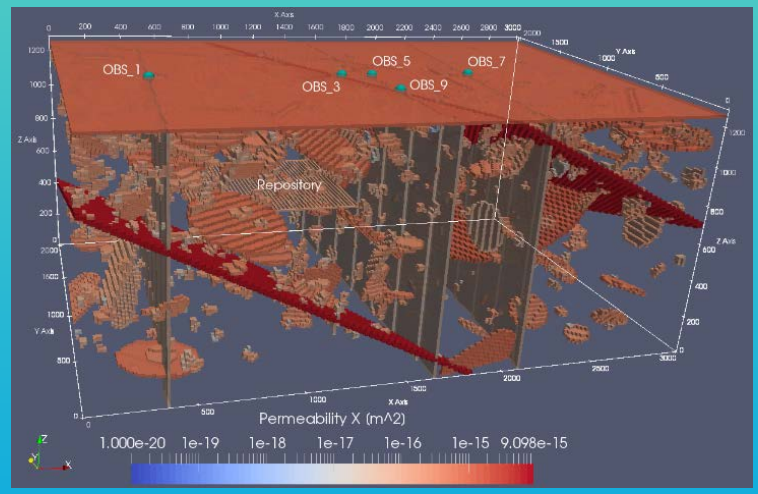


Geologic Disposal Safety Assessment - Biosphere Model Development

NWTRB Meeting
November 3rd-4th, 2021
PNNL-SA-167854

Caitlin Condon
Bruce Napier
Saikat Ghosh

Pacific Northwest National Laboratory

Outline

- Biosphere Modeling as part of the Geologic Disposal Safety Assessment (GDSA) Program
- Existing Biosphere/Dosimetry Models
- International Recommendations for Biosphere Modeling
- Needs of a Repository Biosphere Model
- Design and Function of the Biosphere Model

GDSA Biosphere Model

- New Capability for GDSA
  - Calculate dose to potential receptors in the biosphere for a geologic repository scenario as modeled by PFLOTRAN

Andrea Starr | Pacific Northwest National Laboratory

Existing Biosphere/Dosimetry Models

- WIPP (Waste Isolation Pilot Plant)
  - Biosphere model established set release scenarios and simulated human exposure pathways (DOE 1980)
- ERMYN (Environmental Radiation Model for Yucca Mountain Nevada)
  - Dose to the reasonably maximally exposed individual (RMEI) in the Amargosa Valley from releases through groundwater or an erupting volcano (DOE 2007)
  - Previously reviewed by the International Atomic Energy Agency
- GENII
  - NQA-1, PNNL developed environmental transport code, capable of handling diverse source terms and scenarios (Napier 2012)
  - Previously reviewed by the National Academies of Science
- RESRAD (RESidual RADioactive Materials Assessment Code)
  - Code for assessing human and biota exposure from environmental contamination (Yu, Gnanapragasam et al. 2019)

International Guidance

- International Atomic Energy Agency (IAEA)
  - BIOMASS
  - MODARIA I & II
  - MEREIA

- BIOPROTA – International collaboration that addresses modeling assumptions and sources of uncertainty in the long-term assessment of releases from radioactive waste management (collaborates with MODARIA WG 6) (BIOPROTA 2018)
  - Simplify biosphere models for longer time frames
  - Climate change can be treated as an input variable
  - Compartment modeling for Biosphere representation

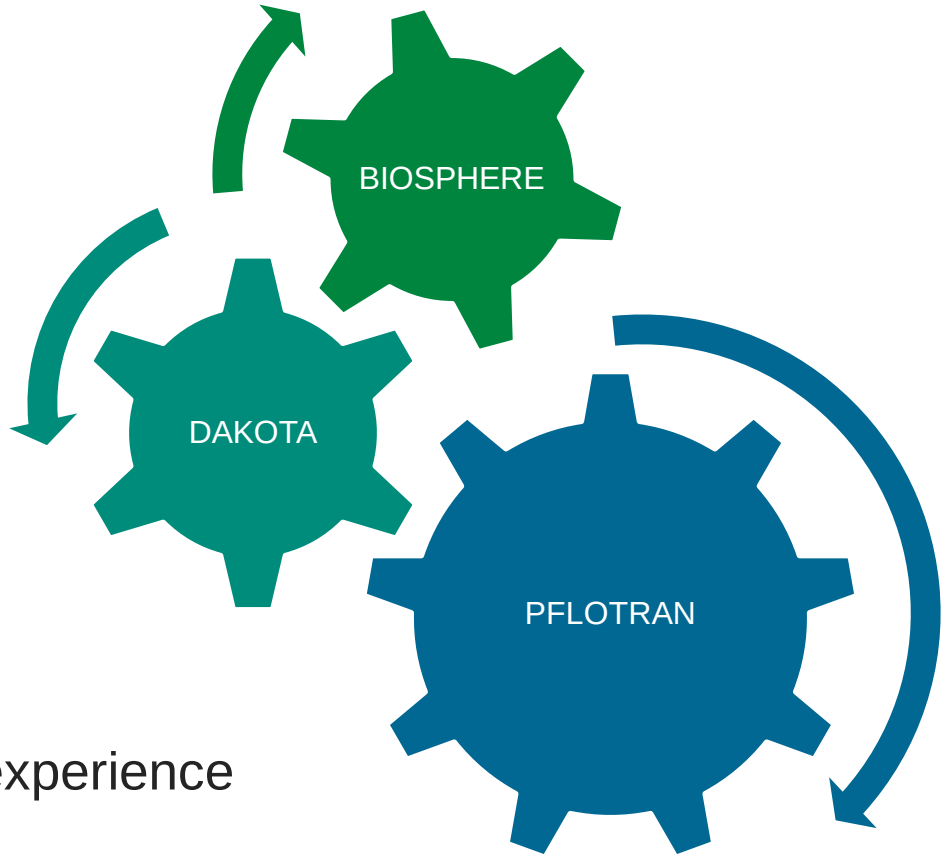
FEPs

- Nuclear Energy Agency (NEA)
- Features, Events, and Processes (FEPs) related to long-term safety or performance of a geologic repository
- FEP Group 5 – Biosphere factors
  - Examples:
    - Surface environment (5.1)
      - Vegetation (5.1.9)
      - Climate and weather (5.1.11)
    - Human characteristics and behavior (5.2)

(NEA 2019)

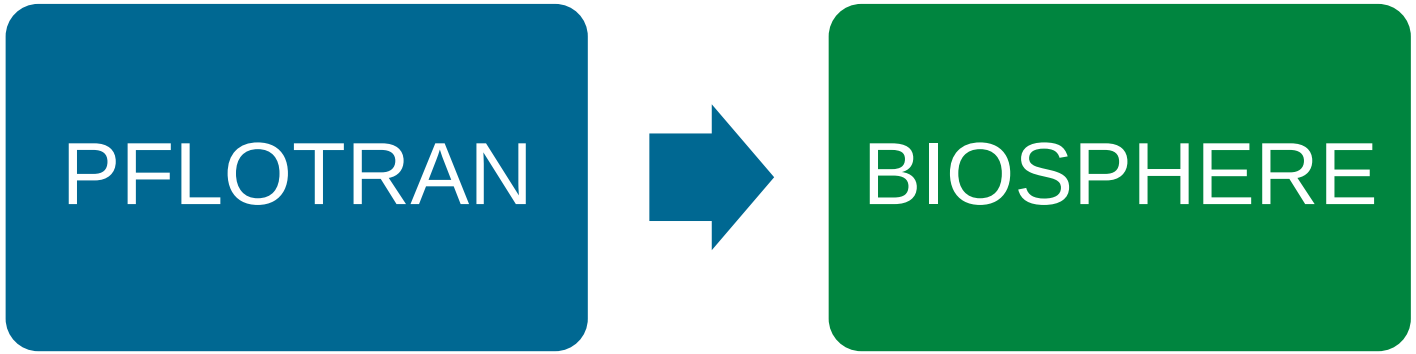
Biosphere Model Requirements

- Compatible with PFLOTRAN
  - Compatible coding style and language
- Open Source
  - Transparency
  - Tool for stakeholders and decision makers
- Flexible
  - Capable of modeling a variety of locations
  - Capable of modeling a variety of climate states
  - Capable of handling a scenario location which may experience multiple climate states during the period of interest
  - Capable of growth (i.e., including non-human biota in future)

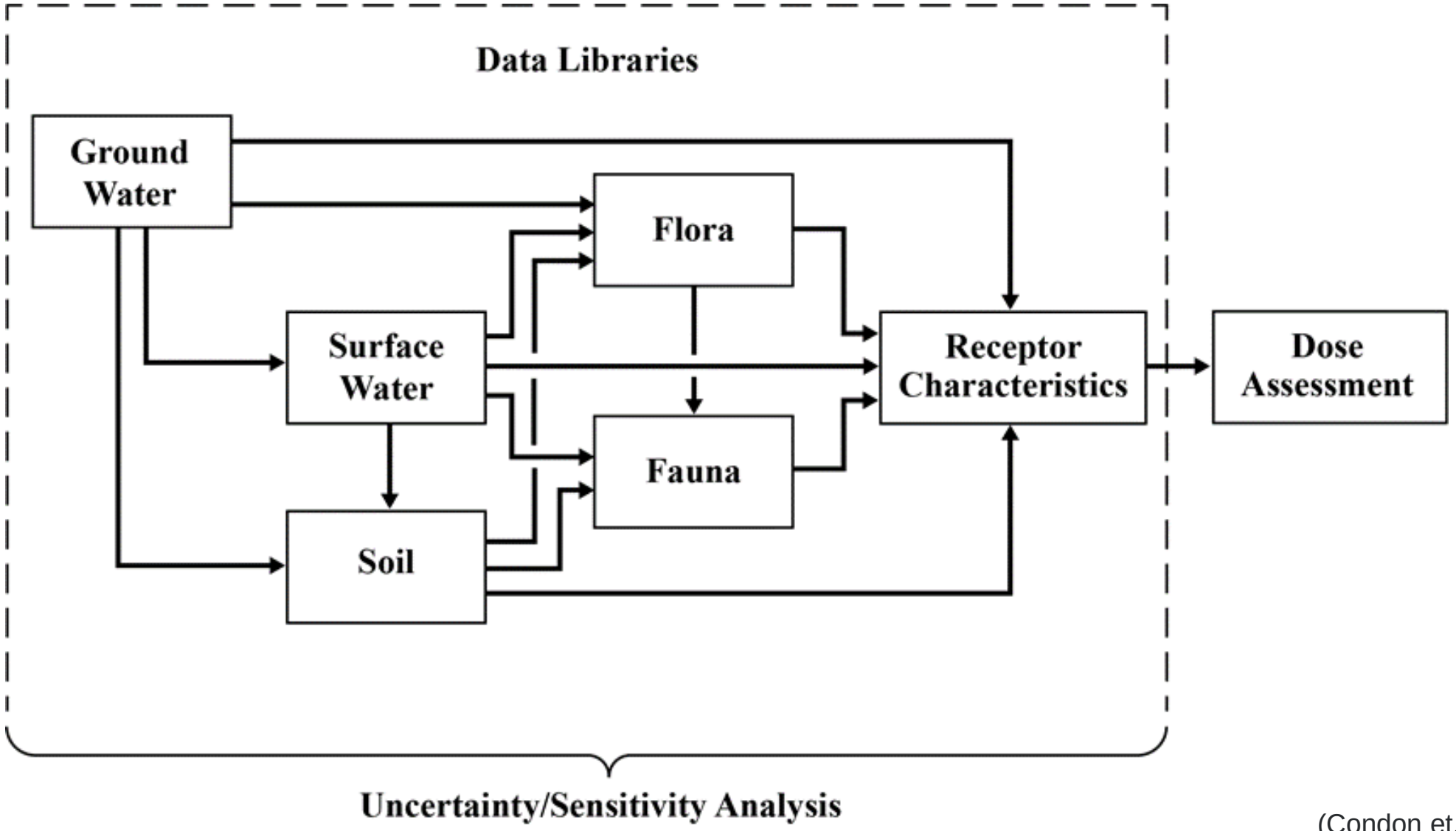


Connection to PFLOTRAN

- **1-way coupling**
- PFLOTRAN output = Biosphere Model Input
- Radionuclide concentration in mol/L over the time period of interest in groundwater



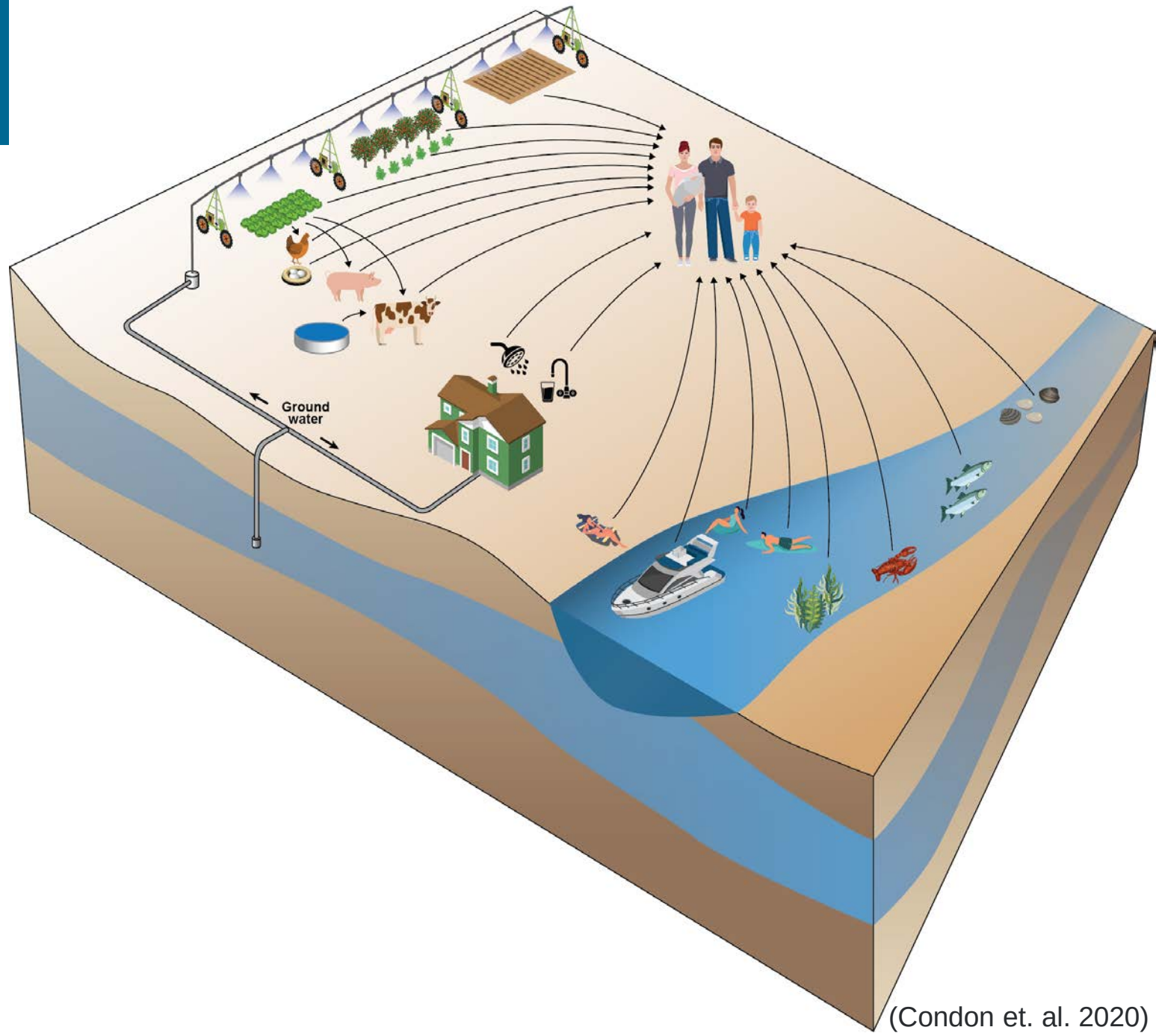
Function of the Biosphere Model



(Condon et. al. 2020)

Proposed Biosphere Model

- Conceptual model example of GDSA Biosphere receptors
  - Ingestion dose
  - Inhalation dose
  - External dose
- Reasonably maximally exposed individual (RMEI)



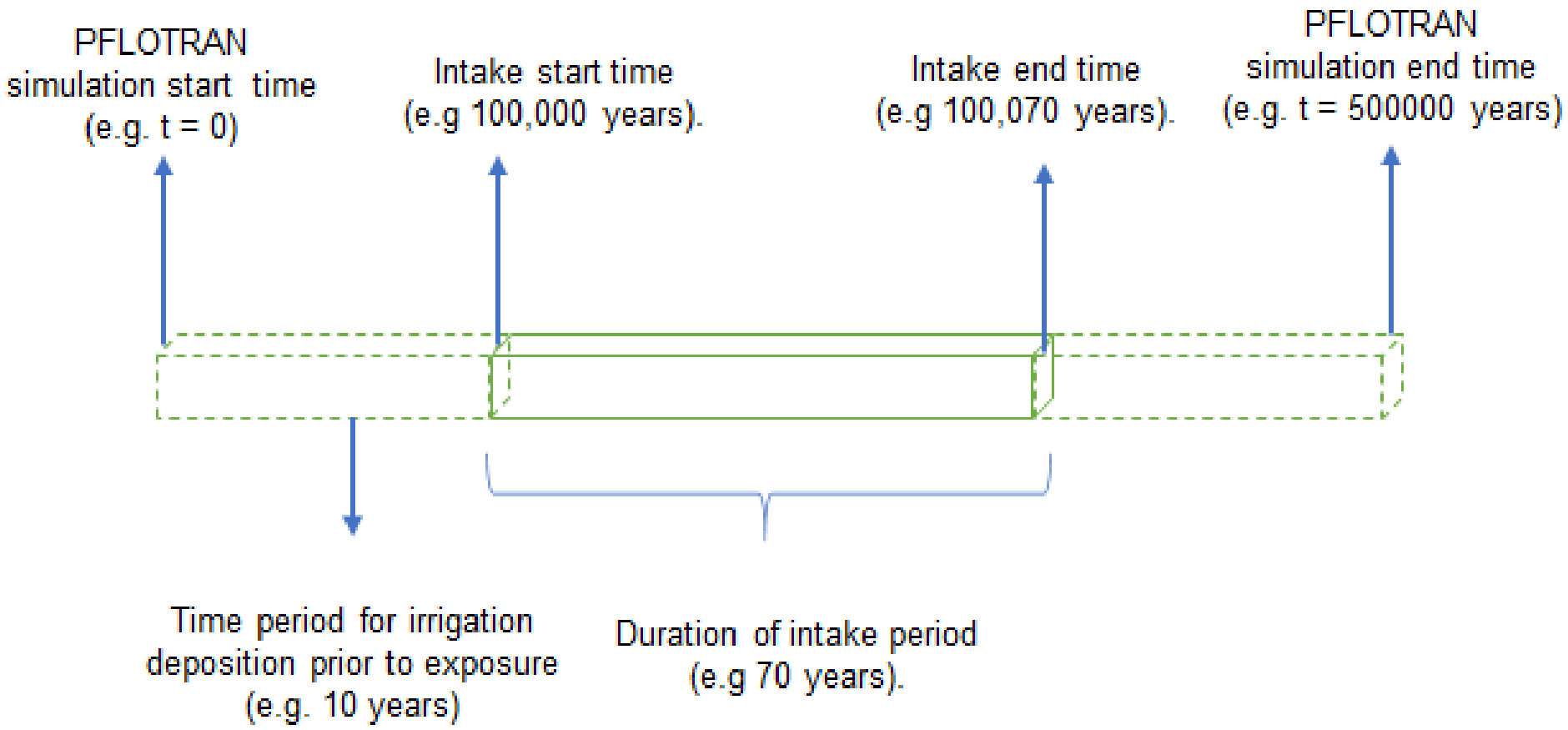
(Condon et. al. 2020)

RMEI

- Reasonable maximally exposed individual
- Conservative dose assessment
- Allows flexibility in receptor characteristics

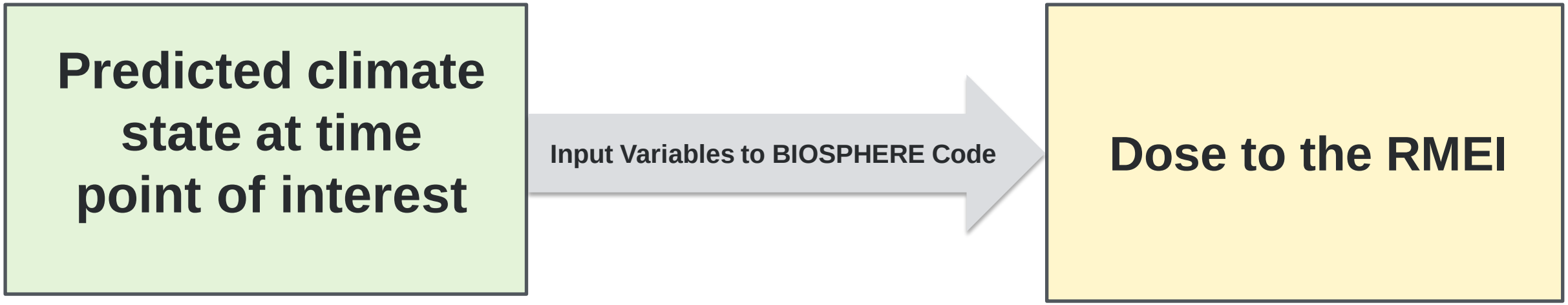
Receptor Exposure

- Receptor exposure timeline
  - Annual Doses over 70-year lifetime

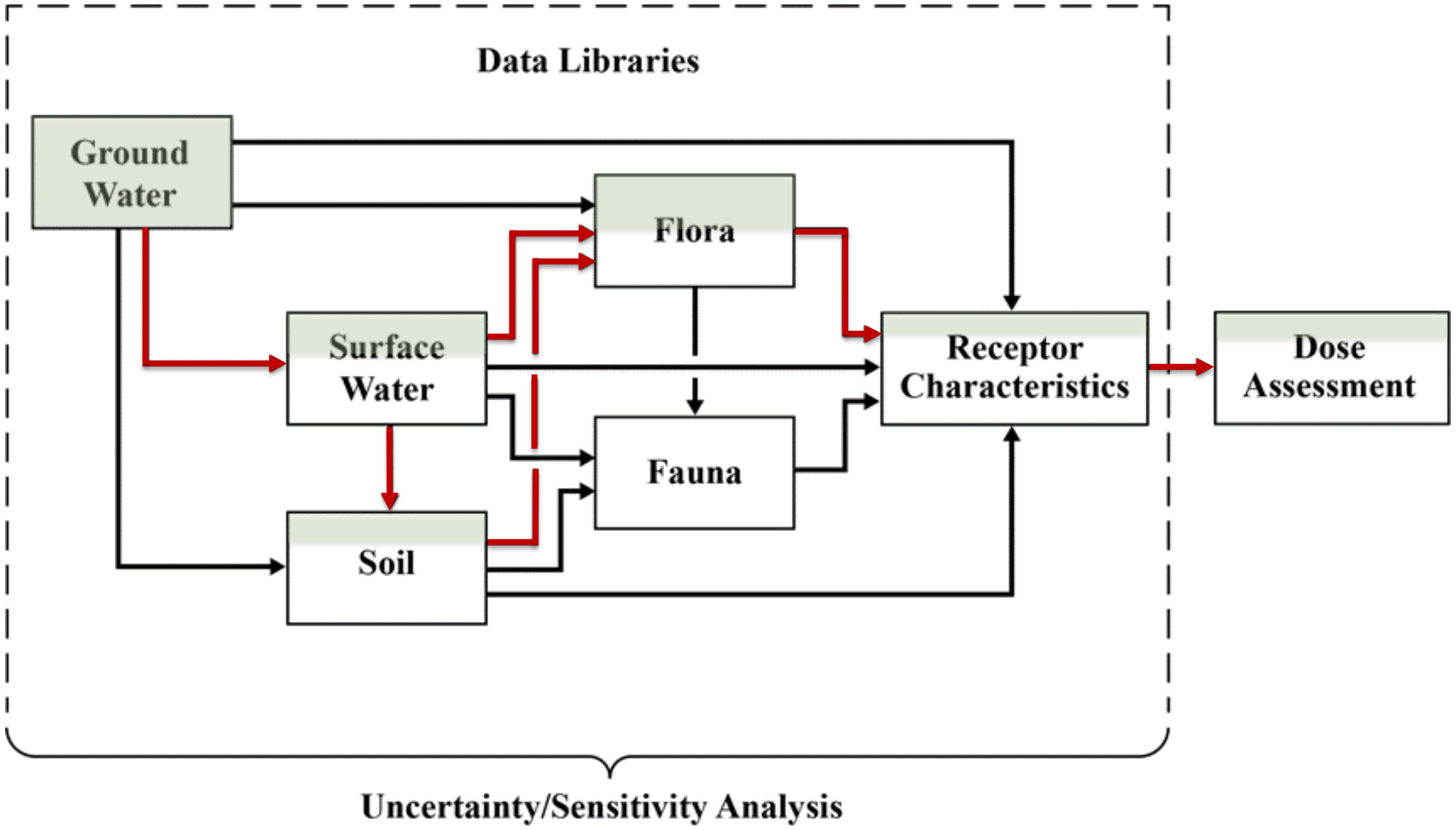


Receptor Exposure

- Climate state is defined by location and time periods of interest
- Climate as an input variable (i.e., precipitation rates)



Function of the Prototype Biosphere Model



Future Work

Continued development of the GDSA Biosphere model to include all exposure pathways identified in the GDSA Biosphere Model Software Requirements Document

Source Term	Exposure Pathway	Exposure Route
Groundwater ✓	Drinking Water	Ingestion
	Water Volatilization	Inhalation
	Shower Water Ingestion	Ingestion
	Irrigated Food Crops ✓	**Ingestion** ✓
	Irrigation/Animal Products	Ingestion
	Irrigated Ground Exposure	External
Surface Water	Drinking Water	Ingestion
	Water Volatilization	Inhalation
	Shower Water Ingestion	Ingestion
	Irrigated Food Crops ✓	**Ingestion** ✓
	Irrigation/Animal Products	Ingestion
	Irrigated Ground Exposure	External
	Swimming	External
	Swimming Water Ingestion	Ingestion
	Boating	External
	Shoreline Sediment	External
	Aquatic Foods	Ingestion
Soil	Soil Resuspension	Inhalation
	Soil Ingestion	Ingestion
	Ground Exposure	External

Questions?

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