

Science in the marketplace: Setting the trajectory for safe and verifiable ocean-based CDR

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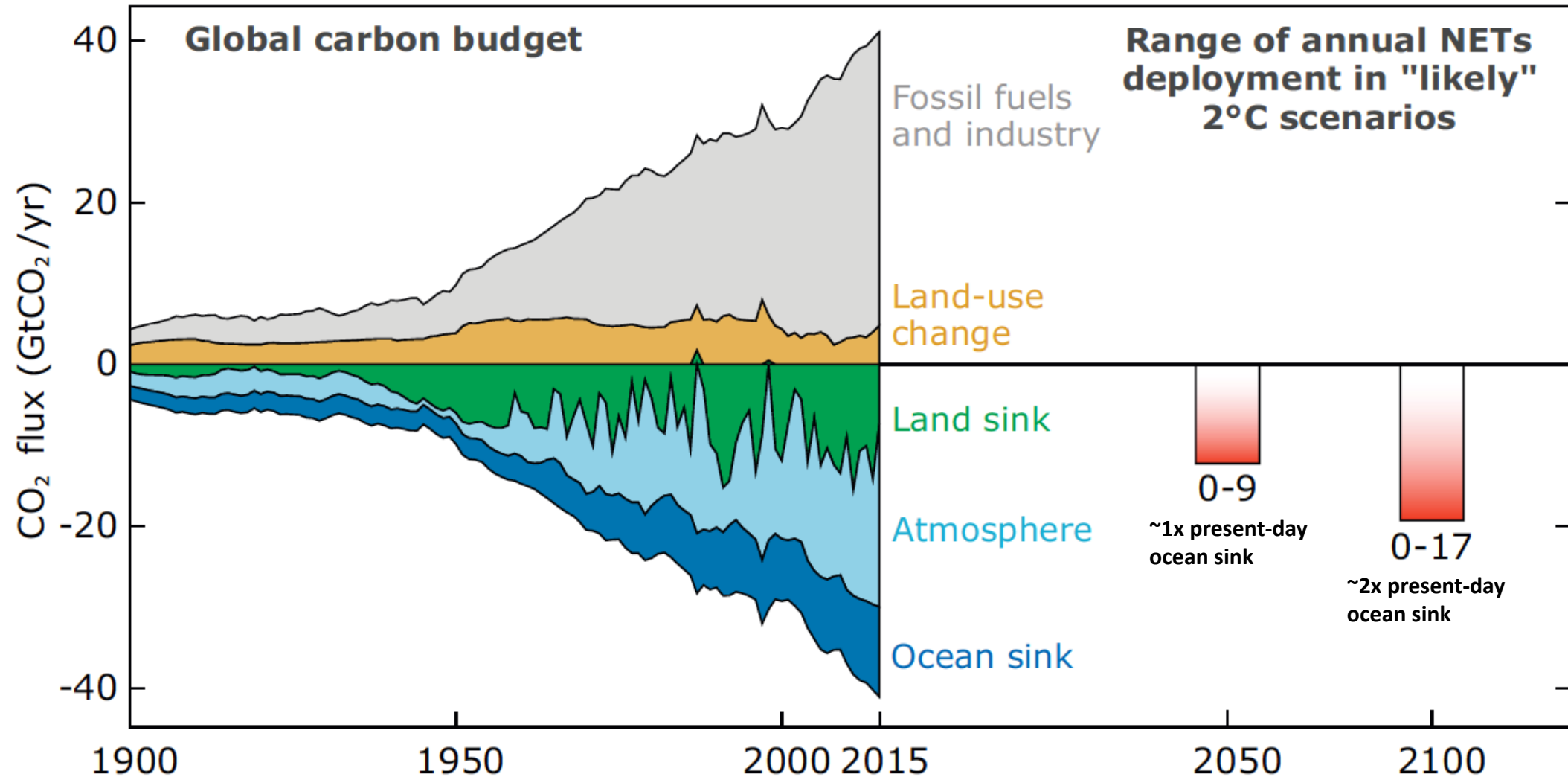
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The carbon removal quantities required are daunting

Global carbon budget as context for Negative Emissions Technologies (NETs) deployments



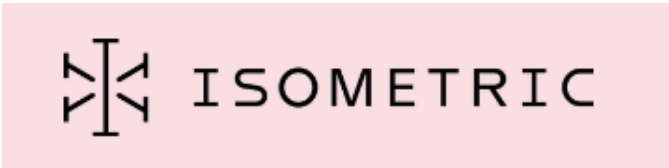
Private sector is moving, investments flowing into mCDR

CDR Buyer



Frontier is an advance market commitment to buy \$925M of permanent carbon removal between 2022 and 2030

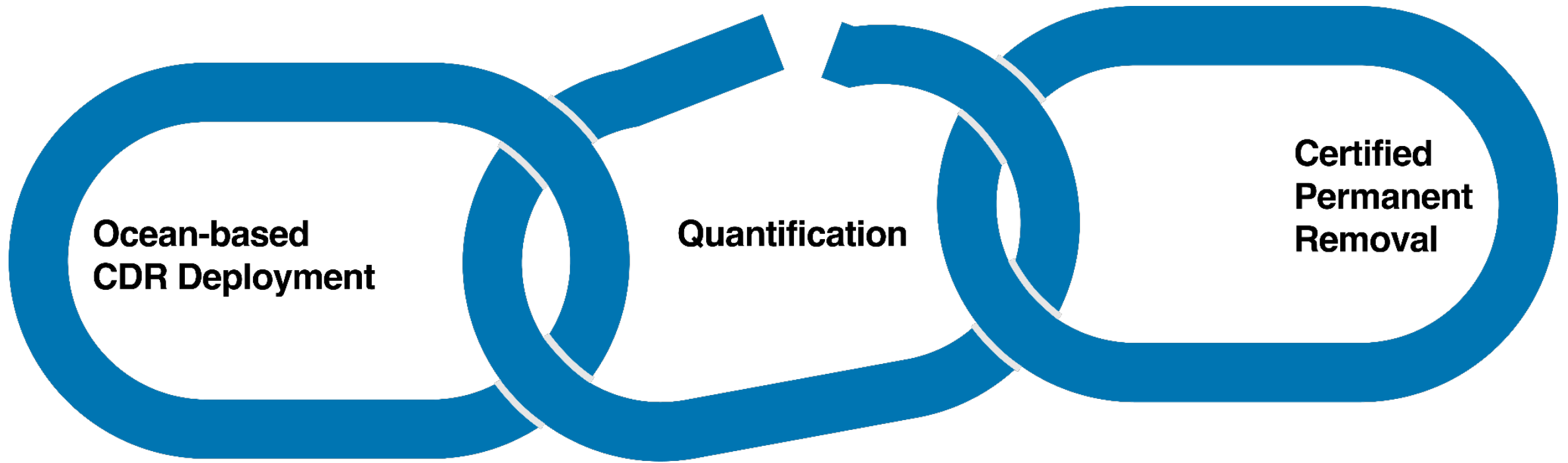
CDR Verifier



mCDR Suppliers



Quantification is a requirement for functional carbon markets



**This is the
pivotal decade**



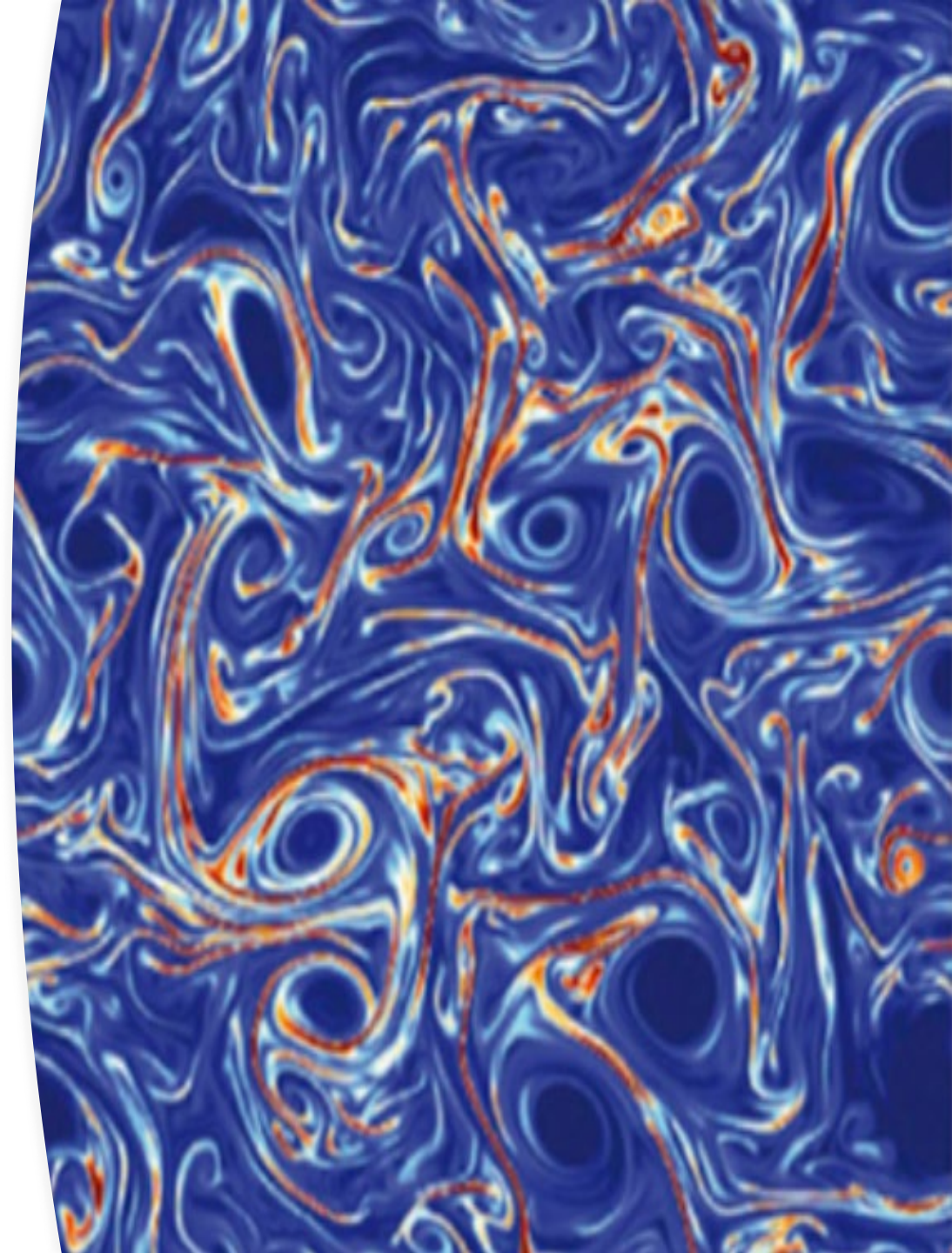
Gating criteria

Deployments of mCDR technologies must demonstrate

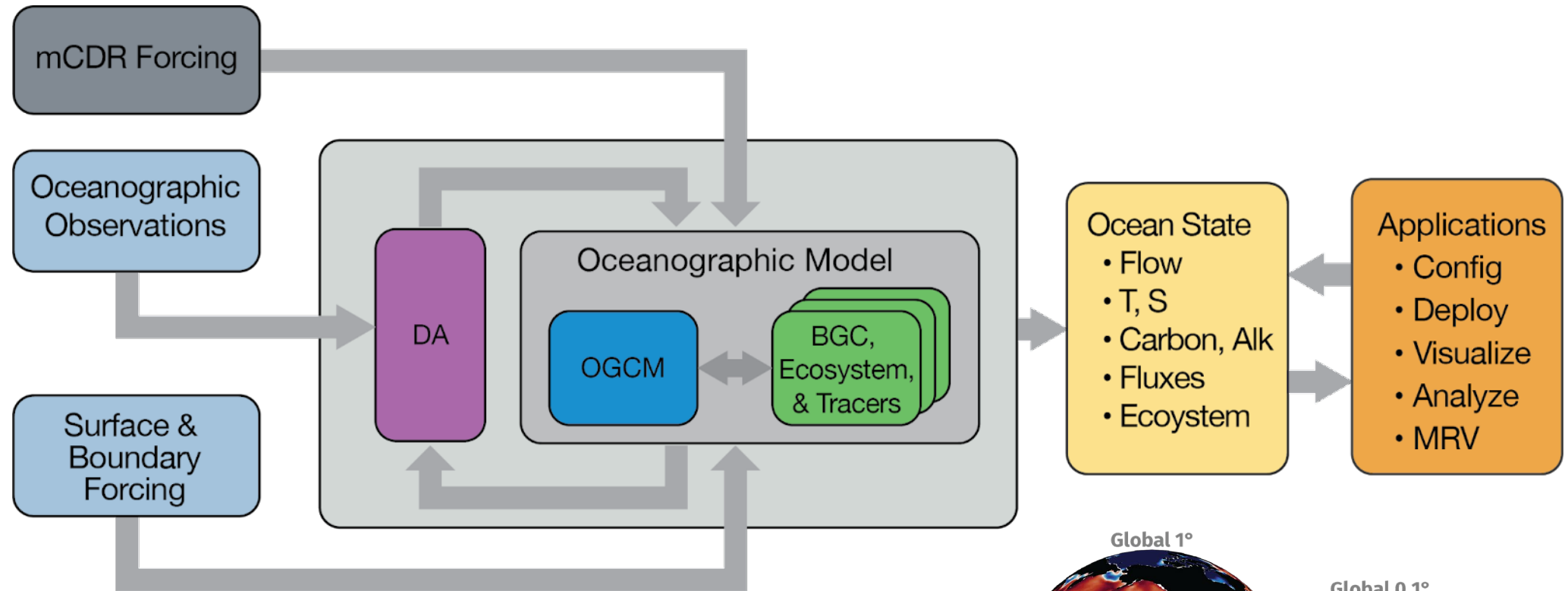
Ecological Safety	Risk of negative environmental consequences are acceptable and can be monitored on an ongoing basis
Net negativity	Certain to produce a net reduction in atmospheric CO ₂ (or radiative forcing)
Verifiability	Has a path to using scientifically rigorous and transparent methods for monitoring and verification

Challenges to CDR quantification

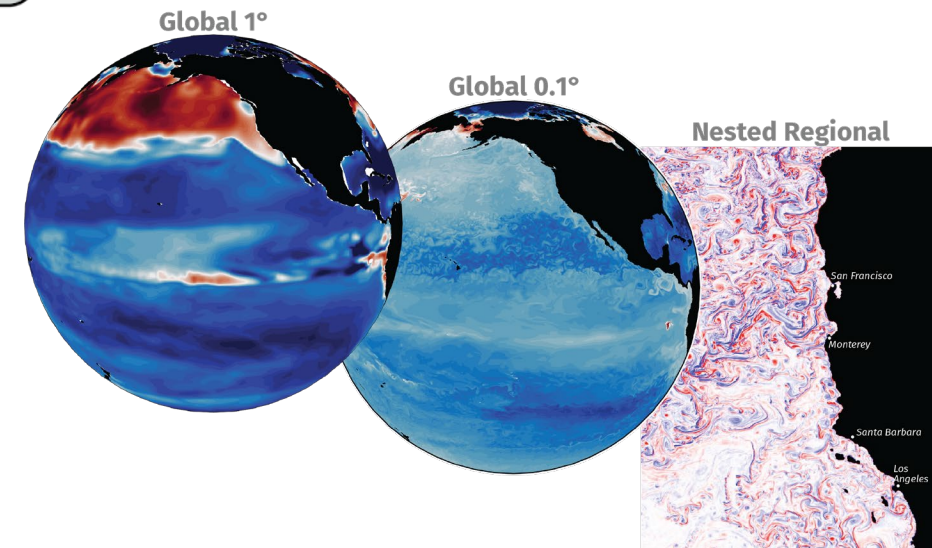
- Complex baselines
 - Establishing counterfactual baseline is needed to assess additionality
- Large spatiotemporal scales
 - Slow CO₂ equilibration timescale
 - Large-scale overturning circulation
- Unfavorable signal-to-noise ratios
 - Analytical precision
 - Dynamic variability
- Unknown unknowns
 - Ecosystem compensation



Software systems for mCDR & MRV decision support

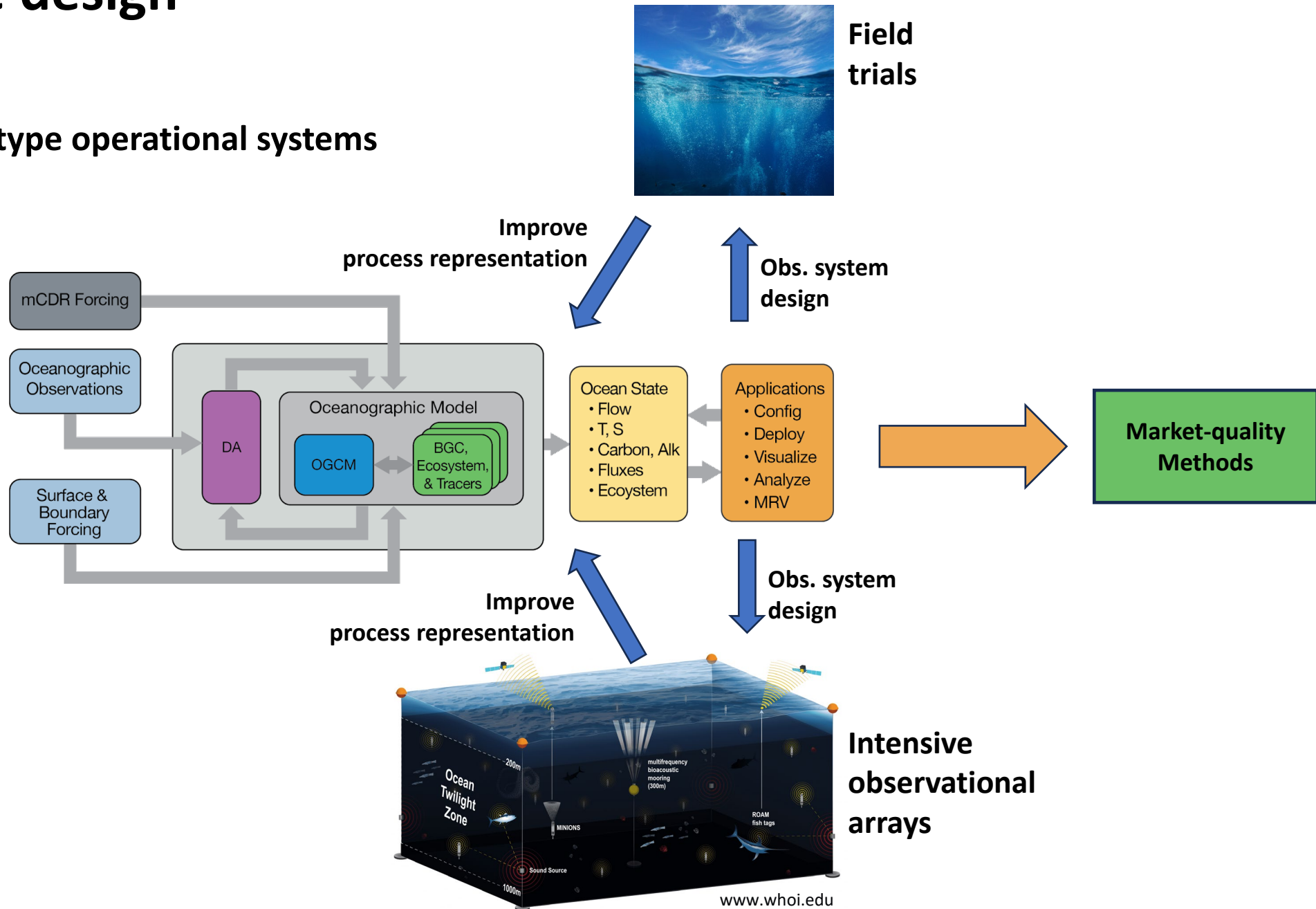


Building the tools needed to ensure safe and effective ocean-based carbon dioxide removal



Iterative design

Prototype operational systems



Pragmatic targets for MRV systems

Good enough: Scientifically credible and transparent estimates of net carbon removal, durability, and *uncertainties*

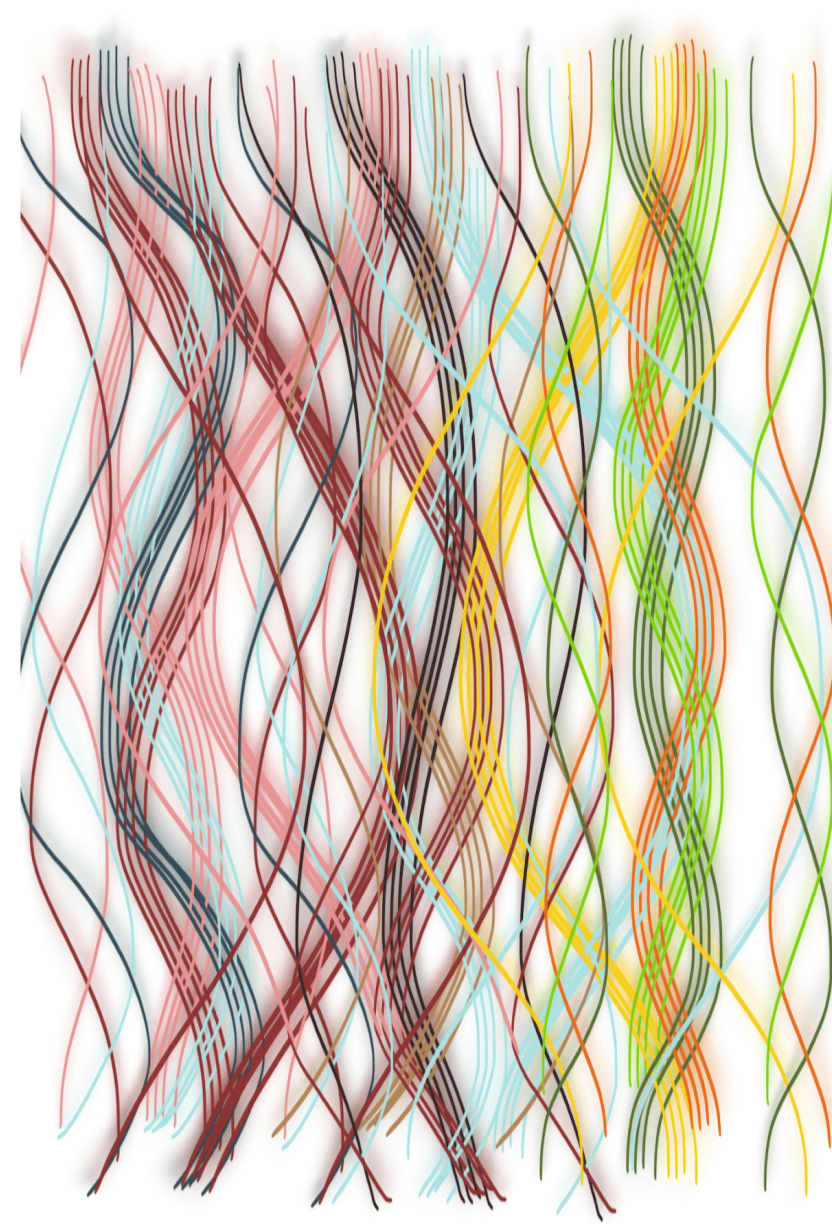
Fast enough: Decision-support applications can be deployed quickly enough to support mCDR companies

Cheap enough: The cost of applying MRV methods is acceptably low in the context of carbon removal markets

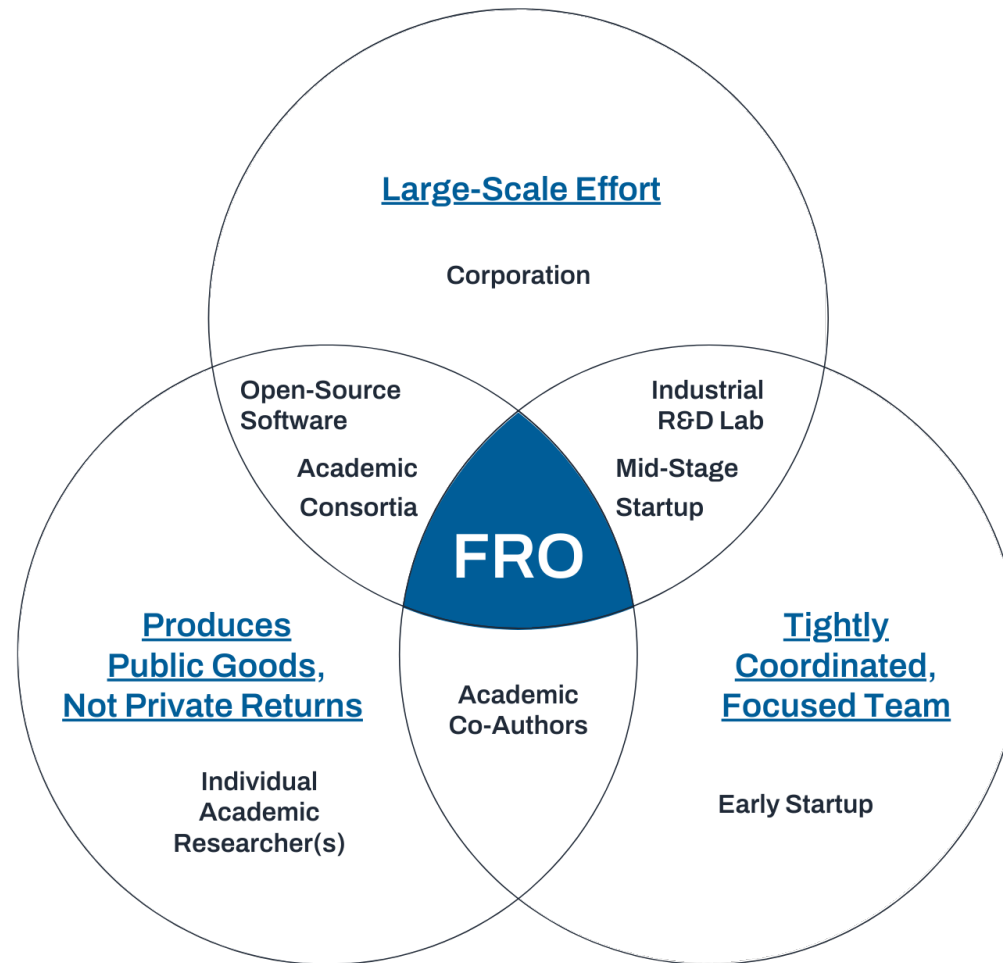
Diverse enough: Systems to support the quantification of multiple promising mCDR paths

Safe enough: Ecosystem impacts can be robustly assessed and valued relative to baselines without intervention

Getting better: The system can evolve and improve, tracking the evolving state of science



Introducing inflection points: Focused Research Organization (FRO)



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