

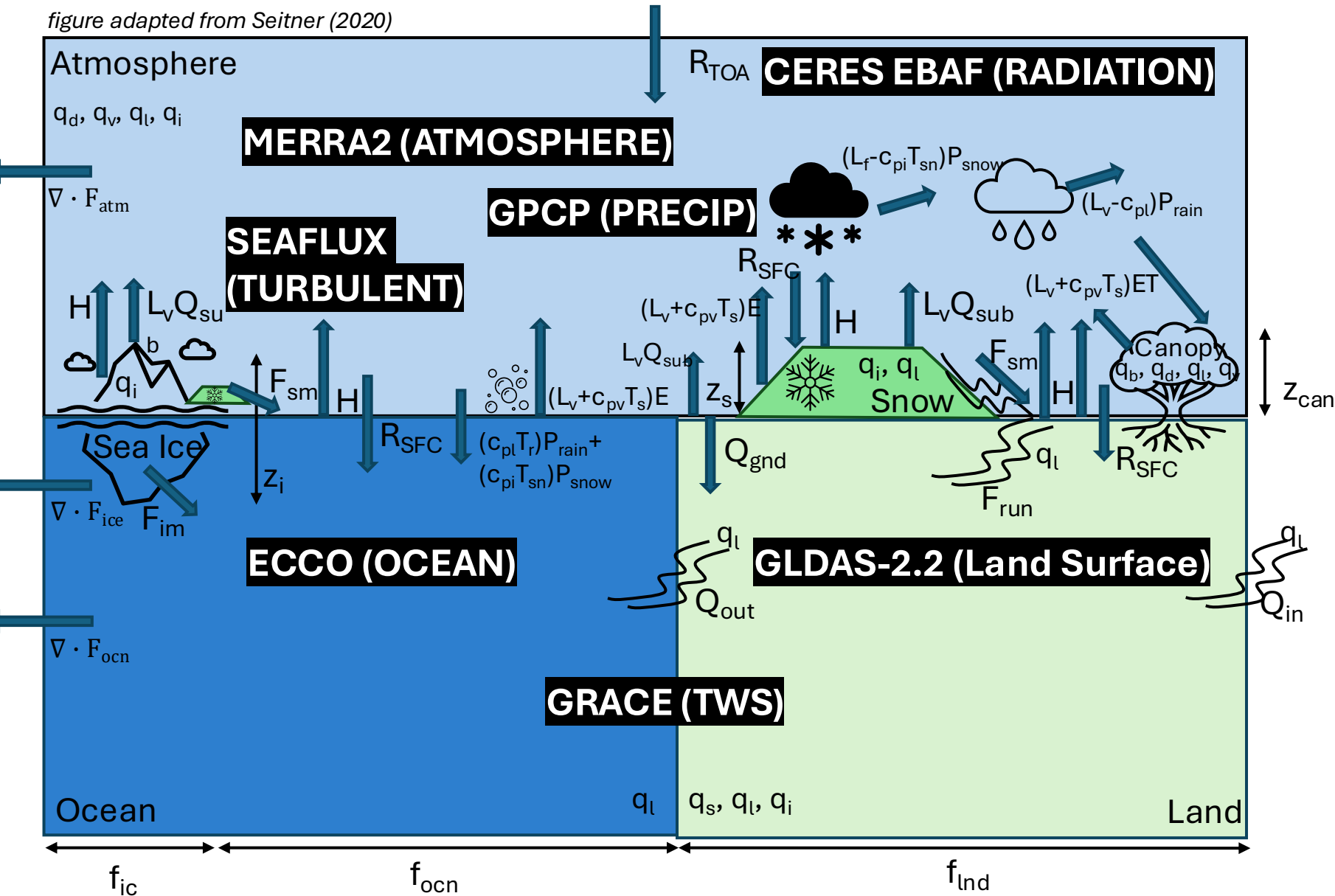
Advancing Consistent Earth System Water and Energy Budgets for Science and Applications

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Key Takeaway: The hard part isn't the budget. It's the uncertainty.

NEWS-IA: Consistent, Coupled Budgets

figure adapted from Seitner (2020)



- Objectively optimized, coupled atmosphere–ocean–land–cryosphere water **and** energy budgets
- Monthly, 2002–2017
- 25 regions, 25+ components
- Storage change, interannual variability, region-to-region transports
- *Successor to the 2015 NEWS climatology (600+ citations) and NEWTE_x*

NEWS-IA Core and NEWS Team

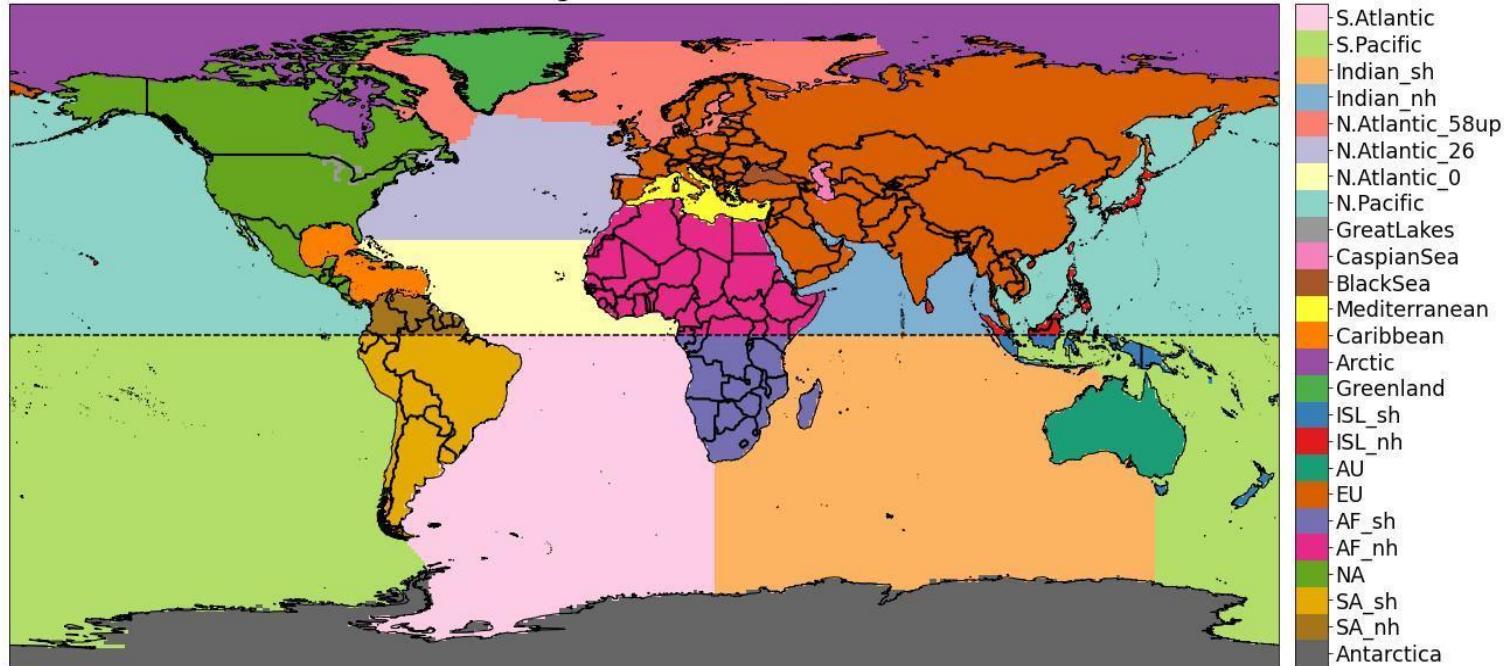
NEWS-IA Core: Supports the core optimization to produce analysis and implement advances

NEWS Team (ROSES): Works with NEWS Core to advance datasets, techniques, and science application

Relationship to NEWS-IA Core	Who	What
New independent information	Stephen Good (OSU)	Water isotopes — satellite + ground networks
	Lisan Yu (WHOI)	Ocean closure; OAFlux2 turbulent + radiative
Consistency conventions	Gavin Schmidt (GISS)	Gauge-invariant vs. gauge-variant energy fluxes
Fitness for purpose	Hugo Lee (JPL)	NEWS-IA as reference for CMIP6/7 evaluation
	Guojun Gu (UMD)	Interannual–decadal variability and trends; GPCP

NEWS Regions and Optimization

NEWTex Regional Mask, 1.0° x 1.0°



**25+ components × 25 regions
× every month**

**NEWS-IA analysis is
determined by applying
budget constraints and the
optimum depends entirely
on the *relative uncertainties*
we assign.**

$$\begin{aligned}
 p(\boldsymbol{\theta}) p(\mathbf{y}_{r1} \dots \mathbf{y}_{rK} | \boldsymbol{\theta}) = & (2\pi)^{-\frac{J}{2}} |\boldsymbol{\Theta}|^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} (\boldsymbol{\theta} - \bar{\boldsymbol{\theta}})^T \boldsymbol{\Theta}^{-1} (\boldsymbol{\theta} - \bar{\boldsymbol{\theta}}) \right\} \\
 & \times \prod_{k=1}^K (2\pi)^{-\frac{M}{2}} |\mathbf{C}_k \mathbf{B}_k \mathbf{C}_k^T + \mathbf{R}_k|^{-\frac{1}{2}} \\
 & \times \exp \left\{ -\frac{1}{2} (\mathbf{y}_{rk} - \mathbf{C}_k \mathbf{x}_{csk}(\boldsymbol{\theta}))^T (\mathbf{C}_k \mathbf{B}_k \mathbf{C}_k^T + \mathbf{R}_k)^{-1} (\mathbf{y}_{rk} - \mathbf{C}_k \mathbf{x}_{csk}(\boldsymbol{\theta})) \right\}
 \end{aligned}$$

Consistent, Coupled Budgets and Uncertainties

Current Gate: Assigning Consistent Uncertainties

	SME Assignment	MTC / 3CH
Gives you	Absolute magnitudes; encodes instrument and process knowledge	Relative error magnitudes — what the estimator needs
Works when	N = 1 or 2 products. Sometimes the only option	$N \geq 3$ with independent errors
Scaling	Not to $25 \times 25 \times$ Monthly beyond flat percentages	Yes — and spread across triplets is itself diagnostic
Fails by	Incommensurate across variables and experts; no seasonality or regionality	Independence asserted, never measured. Linearity, stationarity. Conditional and systematic errors survive

Addressing Systematic and Random Uncertainties

Analyses reveal systematic uncertainties: modeled via additive bias — exploring multiplicative bias

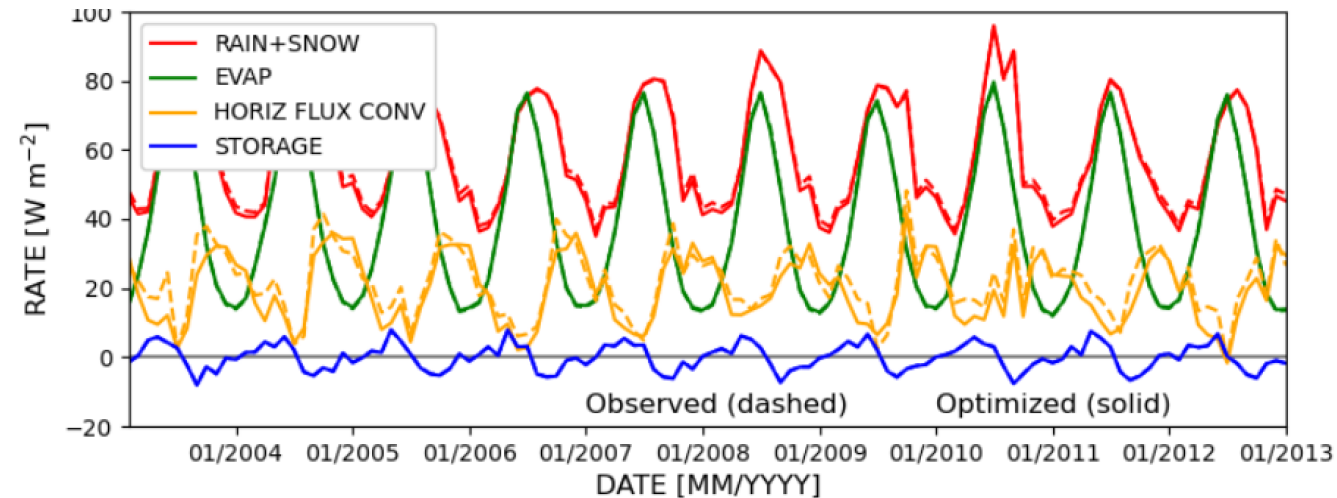
Using MTC (when available) to characterize random uncertainties

Dashboard Developed for MTC Analyses

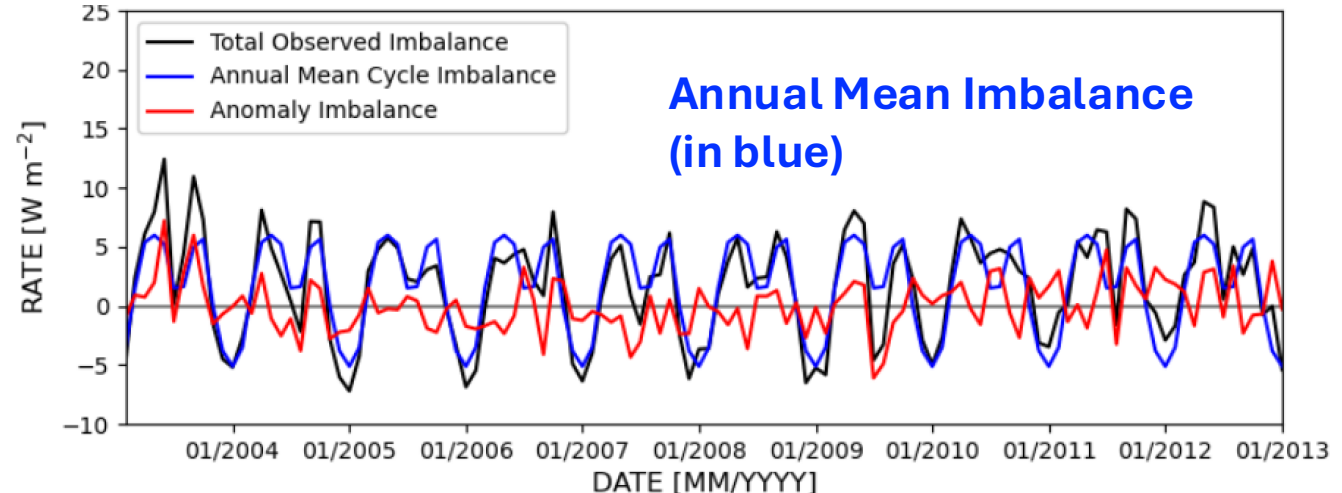
MTC Parameters Table

Product ▲	Random Error (W/m ²) ▲	Additive Scaling (W/m ²) ▲	Multiplicative Scaling (relative) ▲
ERA5	2.058	-2.169	0.884
GEOSIT	1.832	-3.595	0.786
MERRA2	0.000	0.000	1.000

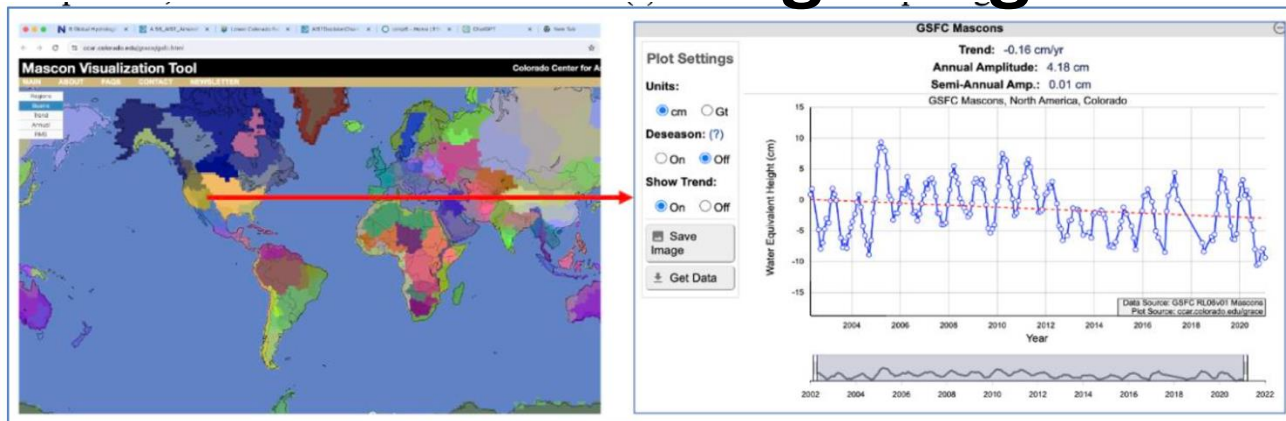
North America Atmospheric Water Cycle Components



North America Atmospheric Water Cycle Imbalances



Terrestrial Water Budget Digital Twin



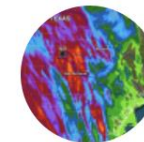
Optimization

NEWS-IA

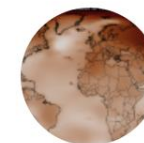
Feedback

EMN

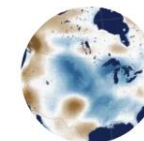
Inputs



GEOS



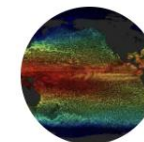
ModelE



LIS



ISSM



ECCO

The NEWS-IA should be tightly coupled to IMVI activities through use as inputs and opportunities for feedback on E&W consistency

The NEWS-IA optimization is a transferrable asset to other focused activities

How you can help

Contribution	What it Looks Like	Happening Now
Term	An independent product for a weakly constrained component	OaFLux Version 2
Constraint	An observation that constrains partitioning, not just magnitude	Water isotopes
Conventions	Gauge-invariance, masks and land fractions, uncertainty specification	Gauge-invariant energy fluxes
Test	Use NEWS-IA as reference — and tell us where it fails	CMIP6/7 evaluation; decadal precipitation trends
Domain Application	Take the optimization to your basin, your twin, your system	AIST TWB Digital Twin; Regional Applications