CSQ-43

Question	Knowledge Advancement Objectives	Geophysical Observables	Measurement Requirements	Tools & Models
What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. A). Advance f**orcing-feedback understanding**: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	All variables in coupling of the energy and water cycles with the carbon cycle: observation and description of photosynthesis in response to changes in temperature, CO_2 concentration and water stress	Field scale (hm -km) at half hourly time step; Better than 10% uncertainty (currently 20%) in fluxes (sensible, latent heat, and carbon fluxes – Gross Primary Productivity and Net Ecosystem Exchange)	Retrieval algorithms for reflectance (albedo), vegetation parameters, LST, fluorescence, and SM, VWC, WV (profile of relative air humidity); Coupled model of energy, water and carbon process in ESM and DTE (coupled surface and atmospheric models); Validation by in-situ flux observations (e.g. Fluxnet)
	B). Quantify **role of surface and UTLS forcings in ABL processes**: - role of sensible and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	Surface observables: same as above; UTLS observable: T, P, u, q (temperature, pressure, wind and specific humidity)	UTLS: km – 10km at half hourly step profile (T,P, u, q)	Validation by radiosoundings; Reanalysis based on data assimilation

	C). Quantify **circulation controls:** influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Simultaneous observation of surface and atmospheric variables: radiation fluxes, LST, SM as well as clouds and precipitation patterns	10 – 100km at half hourly step	Comparison to reanalysis; CDR (climate data records)
	D). Quantify **land-atmosphere interactions**: What are the role of land surface-atmospheric interactions in the water, energy and carbon budgets across spatiotemporal scales?	Multiscale observations of radiation, heat, water and carbon fluxes (H, LE, CO2 - sensible, latent and carbon fluxes) and surface states (albedo, LST, LST, SM, VWC)	hm – 10km at half hourly step	Comparison to 3D lidar observation at super observation sites; LES (large eddy simulation); ML algorithms

Narrative: What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?

We need to be able to quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales.

The coupling of the energy and water cycles with the carbon cycle need to be pursued by including the observation and description of photosynthesis as a major component of the whole system, such that we can better close the water budget over land, provide improved information for water availability and quality for decision making for water, energy and food security and for initializing and assessing climate predictions across multiple time scales and at the relevant adaptation scales (e.g. political and administrative regions). Detecting and attributing past changes in the water cycle due to either changing greenhouse gasses or land and water use changes will be essential to advance our prediction capability and tools for devising adaptation alternatives to these changes.

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