Appendix B. CCSP's Earth Climate System Observations

This table provides a summary of "State" and "Forcing/Feedback" variables for the major components of the Earth system for which observations are required. It is adapted from: *Climate Change Science Program Strategic Plan Chapter 12. Observing and Monitoring the Climate System*, published by the U.S. Climate Change Science Program, Washington, DC 20006. Only measurements identified for space-based instruments are shown here. Many of these ECVs require *in situ* observational networks to ensure reliable and validated retrievals from space-based sensors.

(1) Atmosphere

STATE VARIABLES	**EXTERNAL FORCING OR FEEDBACK VARIABLES**
• wind • upper air temperature • surface air temperature • sea-level pressure (l) • upper air water vapor • surface air humidity/water vapor • precipitation • clouds • liquid water content	• sea surface temperature • land surface soil moisture/temperature • land surface structure and topography • land surface vegetation • CO_2 and other greenhouse gases, ozone and chemistry, aerosols • evaporation and evapotranspiration • snow/ice cover • shortwave and longwave surface radiation budget • solar irradiance and shortwave/longwave radiation budget

(2) Ocean

STATE VARIABLES	**EXTERNAL FORCING OR FEEDBACK VARIABLES**
• upper ocean currents • sea surface temperature • sea-level/surface topography • sea surface salinity • sea ice • wave characteristics • ocean biomass/phytoplankton	• ocean surface wind and wind stress • incoming surface shortwave radiation • downwelling longwave radiation • surface air temperature/humidity • precipitation (freshwater/salinity flux) • evaporation • freshwater flux from rivers and ice melt • organic and inorganic effluents (into ocean) • biomass and standing stock • coastal zones/margins

(3) Terrestrial

STATE VARIABLES	EXTERNAL FORCING OR FEEDBACK VARIABLES
• topography/elevation • land cover • leaf area index • soil moisture/wetness • soil structure/type • vegetation/biomass vigor • water runoff • surface ground temperature • snow/ice cover • subsurface temperature and moisture • land use • lakes and reservoirs • rivers and river flow • glaciers and ice sheets • water turbidity, nitrogen, phosphorus, dissolved oxygen	• incoming shortwave radiation • net downwelling longwave radiation • fraction of absorbed photosynthetically active radiation • surface air temperature and humidity • albedo • evaporation and evapotranspiration • precipitation • land use and land-use practices • deforestation • human impacts—land degradation • erosion, sediment transport • fire occurrence • volcanic effects (on surface) • biodiversity • Earthquakes, tectonic motions • coastal zones/margins

GCOS' Essential Climate Variables (ECVs)

The Global Climate Observing System recently found that there remain serious deficiencies in the ability of the current global climate observing systems to meet the observational needs of the UNFCCC. In response, GCOS published a list of Essential Climate Variables (ECVs) – variables that are both currently feasible for global implementation and have a high impact on United Nations Framework Convention on Climate Change (UNFCCC) requirements. It concludes that achieving global coverage and climate-quality observations for ECVs is essential to ensure that the needs of the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC) for systematic climate information are addressed.

Domain	Essential Climate Variables	
Atmospheric (over land, sea and ice)	**Surface:**	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapor.
	Upper-air:	Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.
	Composition:	Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases[1], Aerosol properties.
Oceanic	**Surface:**	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.
	Sub-surface:	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.

[1] Including nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs).

Terrestrial[2]	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance.

From: *The Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC, GCOS-82, April 2003 (WMO/TD No. 1143).*

[2] Includes runoff (m^3 s^{-1}), ground water extraction rates (m^3 yr^{-1}) and location, snow cover extent (km^2) and duration, snow depth (cm), glacier/ice cap inventory and mass balance (kg m^{-2} yr^{-1}), glacier length (m), ice sheet mass balance (kg m^{-2} yr^{-1}) and extent (km^2), permafrost extent (km^2), temperature profiles and active layer thickness, above ground biomass (t/ha), burnt area (ha), date and location of active fire, burn efficiency (%vegetation burned/unit area).