Integrated Global Monitoring

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The combination of anthropogenic effects on planetary systems such as the atmosphere, biosphere, and hydrosphere now requires systematic management of the resulting Technosphere (Turner, 2011). A new form of planetary stewardship is essential in managing the Technosphere. Effective governance relies on the coordinated, persistent, and rigorous Global Earth Monitoring System (Turner, 2011). Consistent monitoring allows societies to assess environmental change, evaluate policy effectiveness, or anticipate tipping points.

Part of this important monitoring system is remote sensing. Remote sensing offers synoptic, repeatable measurements of environmental change over large scales. For example, the Landsat series provides consistent spatial and temporal coverage that allows for detailed tracking of heterogeneous landscapes and disturbances such as deforestation. This can allow researchers to quantify global Gross Forest Cover Loss (GFCL) (Hansen et al., 2010). Remote sensing also allows for estimating process rates such as global net primary production (NPP) (Turner, 2011). Satellite missions using spectrometers to estimate abundance of CO_2 in an atmospheric column can be used in inverse flux modeling to estimate sources and sinks of CO_2 on Earth’s surface. This is an essential tool for verifying national emissions reports under international agreements.

Satellites alone can’t fully capture the dynamic processes of the Technosphere. Turner (2011) and Reichstein et al. (2007) highlight the importance of *in situ* measurements. The FLUXNET network provides continuous, local-scale measurements of CO2 and water exchange between ecosystems and the atmosphere. This offers insight into crucial trends and serves as a basis for validating carbon cycle processes (Reichstein et al., 2007; Turner, 2011). The combined use of satellite data and tower observations allows for greater precision on diagnosing climate impacts. For example, the joint analysis of FLUXNET data and remote sensing during the 2003

European heatwave showed a negative anomaly in NPP. The ground base data revealed that the decline in NPP was caused by water limitation or drought stress, rather than high temperatures (Reichstein et al., 2007). This example highlights the limitations of remote sensing, not accurately reflecting the changes, further proving that an integrated system that coordinates multiple systems can be the most efficient and accurate.

Turner (2025) warns that political volatility threatens cooperation and continuation of global monitoring such as the Orbital Carbon Observatory (OCO). Defunding such missions would leave policymakers blind to critical components of the global carbon cycle. This fragility reflects a broader challenge of global monitoring: it is fragmented, underfunded, and institutionally weak. Organizations such as UN Environment Programme (UNEP) and Global Earth Observations (GEO) advocate for integrated global monitoring but struggle to maintain support. Traditional methodologies such as the Food and Agricultural Organization's (FAO) Forest Resource Assessment (FRA) are problematic in that they lack consistency across nations. Remote sensing offers the ability to establish globally consistent and spatially explicit characterizations of forest cover changes (Hansen et al., 2010).

The management of the Technosphere requires a permanent, internationally coordinated monitoring system that integrates remote sensing, ground observations, and ecological modeling. A system with these qualities could provide critical knowledge required to verify compliance, assess impacts, and manage the Technosphere from dangerous trajectories (Turner, 2025).

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