The Terrestrial Carbon Cycle and the EC-ESA Earth System Science Initiative

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Key issues in carbon cycle research

❑ **Improve predictive capabilities for future trends under varying scenarios**

  ✓ Need to rely on dynamical evolution models (mechanistic ?)
  ✓ Feedback loops in vegetation response to multiple stress factors
  ✓ Understand the inter-annual variability in carbon storage versus GPP

❑ **Identify where we can reduce uncertainties and where not**

  ✓ Processes not accessible by means of direct observables
  ✓ Systematic versus random variability and consistent error propagation
  ✓ Characterization of statistical distribution functions of key variables
  ✓ Correlations among inputs (measurements) versus covariance in model parameters and coupling/feedbacks among processes

Where are we today?

❑ **Are we doing a proper, consistent and scientifically sound exploitation of EO data?**

  ✓ Not, at least in some cases exploitation is not even correct
  ✓ Integration of multiple data sources still very preliminary
  ✓ Consistency in time series and proper uncertainty estimates
  ✓ Exploitation of multi-resolution / multiscale approaches

❑ **Are current models able to ingest EO data correctly?**

  ✓ In most cases, EO data used as "proxy" for something in the model (weak constraint). Usage with direct physical meaning as a model variable (strong constraint) requires better characterization of EO data (realistic uncertainties) and probably significant model adaptations.

❑ **Relevant achievements**

- ✓ Improved representation of land cover dynamics (seasonal versus multi-annual) thanks to Sentinel-2 / Sentinel-1 time series, even at large scales
- ✓ Initial exploitation of new data (like vegetation fluorescence) and multi-source EO data integration, including also ground networks

❑ **Remaining goals**

- ✓ Make the models more adapted to handle EO data as true inputs instead of proxys
- ✓ Realistic estimation of true uncertainties

❑ **Key priorities**

- ✓ Get ready for combined BIOMASS / FLEX / Sentinels+ exploitation inside ESA *Terrestrial Carbon Constellation* before 2025 → Specific actions needed very soon