

Cycles and Budgets

A joint effort by WCRP and GCOS to establish the state of the art in closing the cycles for the conservative quantities in the Earth system.

.Jan Polcher, Han Dolman and Detlef Stammer

.With the support of GCOS and WCRP's offices : Hindumathi Kulaiappan & Caterina Tassone.

Some fundamentals

For a conservative quantity ρ we can write the basic equation :

$$\frac{\partial \rho}{\partial t} + \nabla \cdot f = \sigma$$

Where f is the flux of ρ and σ the sink and source terms.

To use this equation two basic assumptions are needed :

- Over which domain will the divergence be estimated ?
- What is the appropriate time scale for changes of ρ over the domain ?

The continuity equation is axiomatic : it defines conservative quantities :

- Models integrate it in their definition of space and time

• Some variables are derived from observations using it

Error considerations

- Systemic errors :

- Caused by ill defined space and time domains, or
- Uncounted processes.

- Estimation errors :

- Due to the definition of observed variables, or
- Errors in the estimation of these variables.

- The global balance (ocean, land, atmosphere and cryosphere) is the simplest definition :

- Without estimation errors, EEI should see geothermal fluxes !

• Understanding both errors and quantifying accuracy are essential to detecting changes in the cycles.

The questionnaire

The following topics were explored to understand the assumptions made in previous cycle quantification :

- Time and space domain used to quantify the cycle.

- Dominant method used to estimate closure :

 - Only observation based,

 - Observation and model merger,

 - Fluxes obtained with statistical and AI methods,

 - Meteorological re-analysis.

- Error considerations

- Evaluation of the results by the authors

Outcome of the questionnaire

Answers for only 3 cycles were obtained. In some cases the questionnaire was incomplete or key information (reference !) were missing.

.Energy : 10 answers with 6 significant :

-4 for ocean, 1 each for atmosphere and land.

.Water : 19 answers and 7 exploitable :

-2 cover the global water cycle, 5 for catchments from continental to small.

-2 studies deal with the land/ocean coupling.

.Carbon : 5 answers with only 1 which can be analyzed :

-The globe and all reservoirs were analyzed.

The analysis needs to be refined

- Missing studies need to be added.
- Analyze the references given to evaluate the following issues :
 - Usage of the stationarity hypothesis ($\frac{\partial \rho}{\partial t} = 0$)
 - Fluxes obtained from the continuity equation itself.
 - Details of error analysis : separation of the two error types.
- It is clear to GCOS and WCRP that more research on cycle quantification is needed and the priorities need to be identified.

Proposed workshop for 22 & 23rd of June

• Two aspects will be explored for our 3 cycles :

- Day 1 : The state of our knowledge on each cycle.

- Day 2 : How do we integrate the coupling between cycles and transfer expertise.

• The state of knowledge will be explored through the following questions addressed to keynote speakers:

- Definition of the system to be closed

- Stationarity hypothesis

- Missing processes

- Error definition and estimation

- Accuracy needed for trend estimates.

Expected outcome from the workshop

- Establish the state of the art for each of the cycle.
- How can the interactions between cycles be exploited ?
- What needs to be achieved in terms of accuracy and precision to quantify trends or shifts in the cycles.
- Can observational priorities and qualities be identified ?
- Can we formulate some good practices for cycle & budget studies ?

Current list of participants

- .1 Wouter Dorigo
- .2 Megan Cronin
- .3 Sabrina Speich
- .4 Toste Tanhua
- .5 Karina von Schuckmann
- .6 ~~Tristan l'Ecuyer~~
- .7 Benoit Meyssignac
- .8 Lijing Cheng
- .9 Howard Wheeler
- .10 Thomas Haine
- .11 ~~Hollmann Rainer~~
- .12 Philippe Ciais
- .13 Detlef Stammer
- .14 Jan Polcher
- .15 Anna Maria
- .16 Han Dolman
- .17 Caterina Tassone
- .18 Hindumathi Kulaiappan Palanisamy
- .19 Lai-Yung (Ruby) Leung