CART - the Constituent Oriented Age and Residence time Theory

A holistic approach to the understanding of the results of complex marine models

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http://www.climate.be/CART
Motivation

• Make sense of the huge amounts of results produced by complex numerical models;
• Not ignore 99 % of the information (space-time slices of the output) ;
• Drastically reduce the amount of data
• End-users require simple answers / figures

⇒ Holistic methods : Statistics and timescale analyses taking into account all/most of the results and all the processes.
Characteristic time scales

Residence time, turnover time, age, transit time, renewal time, flushing time, . . .

Aim: Quantify the renewal of water masses or input and output of contaminants

⇒ Relevant diagnostic for the dynamics of water masses
⇒ Relevant diagnostic for pollution issues
⇒ Relevant diagnostic for eutrophication problems
⇒ . . .
Common approaches (1)

- Flushing time:
  \[ \tau = \frac{\text{Volume}}{\text{Flux}} \]
  + tidal prism and Knudsen estimates

- e-folding time:
  \[ M(t) = M_0 \exp \left( -\frac{t}{\tau} \right) \]
Common approaches (2)

• Correlation time scale:

\[
\tau(x) = \arg\max_\theta \frac{\langle S(t)C(x, t + \theta) \rangle}{\sqrt{\langle S(t)^2 \rangle} \sqrt{\langle C(x, t)^2 \rangle}}
\]

where \( S(t) = \) concentration at the source or incoming flux.

• Radio-age:

Assume \( C_\gamma(t) \propto e^{-\gamma t} \), then

\[
\tilde{a}_\gamma(x, t) = \frac{1}{\gamma} \ln \frac{C_0(x, t)}{C_\gamma(x, t)}
\]
Problems / issues

- Definitions are often unclear / confusion of concepts;
- Diffusion is not properly taken into account;
- Space and/or time dependency;
- Oversimplification of the dynamics;
- A single time scale to describe different tracers.
Some definitions

- Age = $t - t_{in}$
- Residence time = $t_{out} - t$
- Transit time = $t_{out} - t_{in}$