EGU 2012

Toward unified ice core chronologies with the DatIce tool

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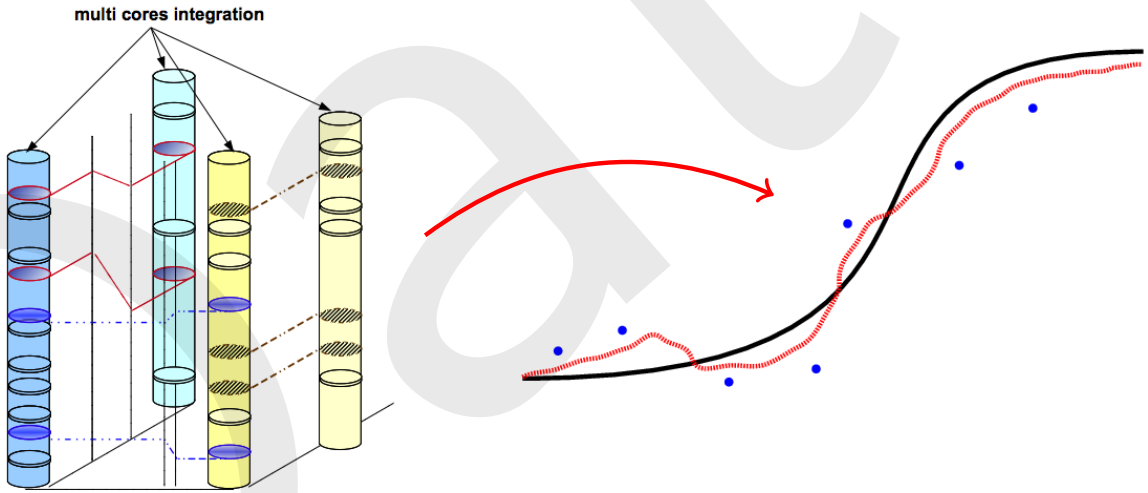
Objectives

- Present the DatIce software tool
  - This tool implements an inverse method for multiple ice cores dating
  - It provides an improved chronology, using a prior chronology and independent observations
  - This tool is available to the scientific community



- This talk is NOT a presentation on paleoclimatology

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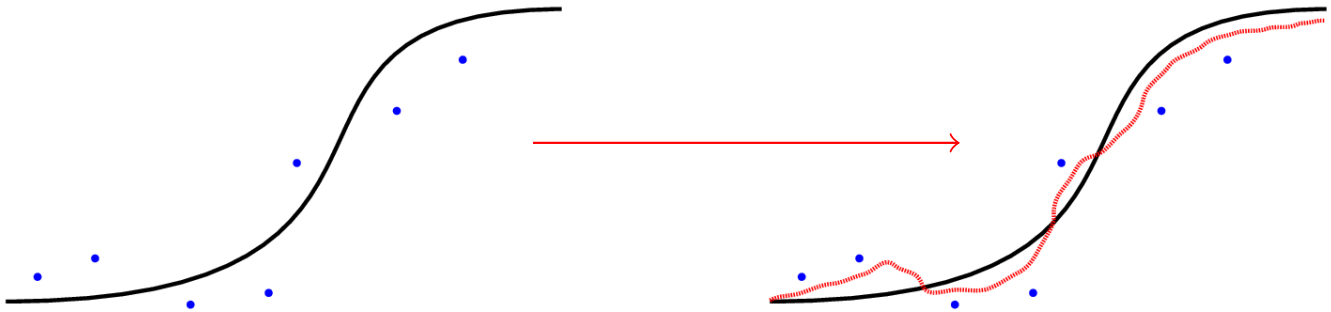
Mathematical formalism

We want to use data from **previous chronology** and observation markers to get a new chronology.



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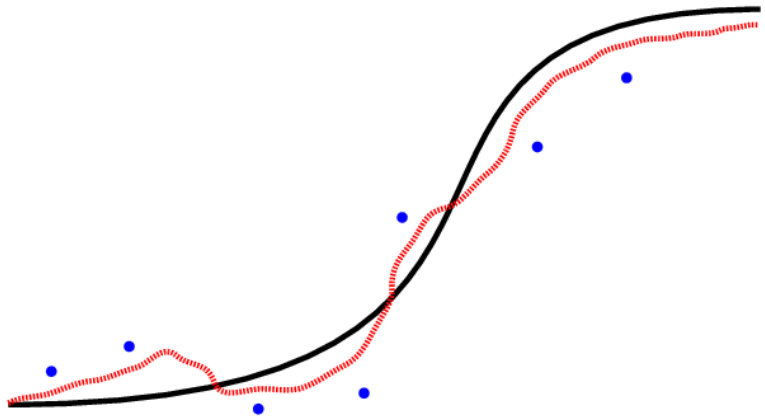
Mathematical formalism

X : unknwon vector representing a chronology

$$J(X) = \underbrace{\left|\left|X - \mathbf{X^b}\right|\right|^2_B}_{\text{misfit to the } \textbf{background}} + \underbrace{||h(X) - \mathbf{Y^o}||^2_R}_{\text{misfit to observations}}$$

We are looking for X^a, "the best new chronology" that minimizes the J function.



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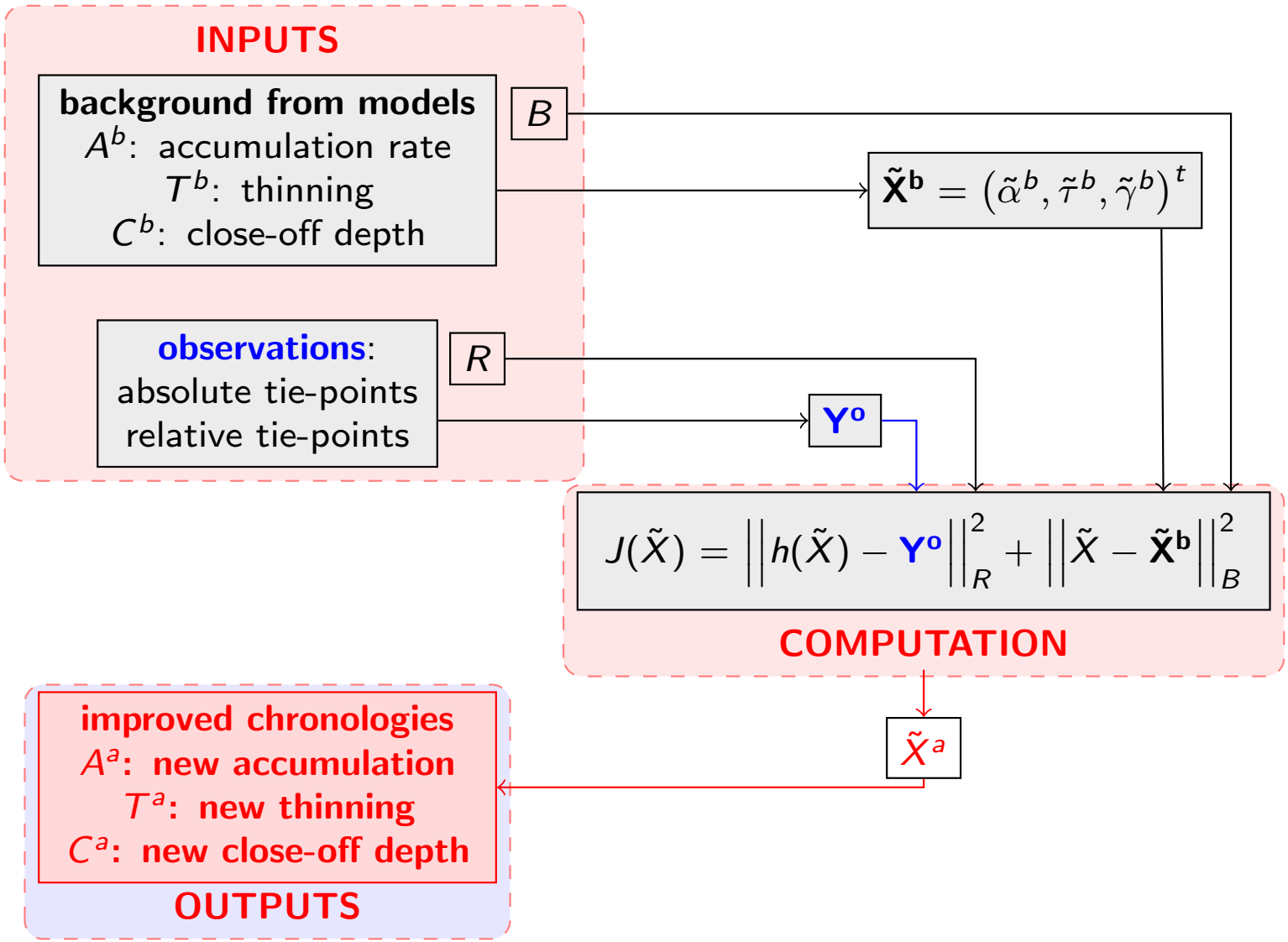
Data flow chart



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Background inputs
Background error covariance matrix

The background error covariance matrix B gives us information about the background chronology **error** and appears in the cost function:

$$||X - \mathbf{X^b}||^2_B = (X - \mathbf{X^b})^t \; B^{-1} \; (X - \mathbf{X^b})$$

B is very often poorly known and it is therefore modeled.

Available options in DatIce are diagonal matrix and block diagonal matrix. Users must provide standard deviation and correlation profiles.

$$B = \begin{pmatrix} \ddots & & \\ & \ddots & \\ & & \ddots \end{pmatrix} \quad \text{or} \quad B = \begin{pmatrix} \boxed{B_\alpha} & & \\ & \boxed{B_\tau} & \\ & & \boxed{B_\gamma} \end{pmatrix}$$

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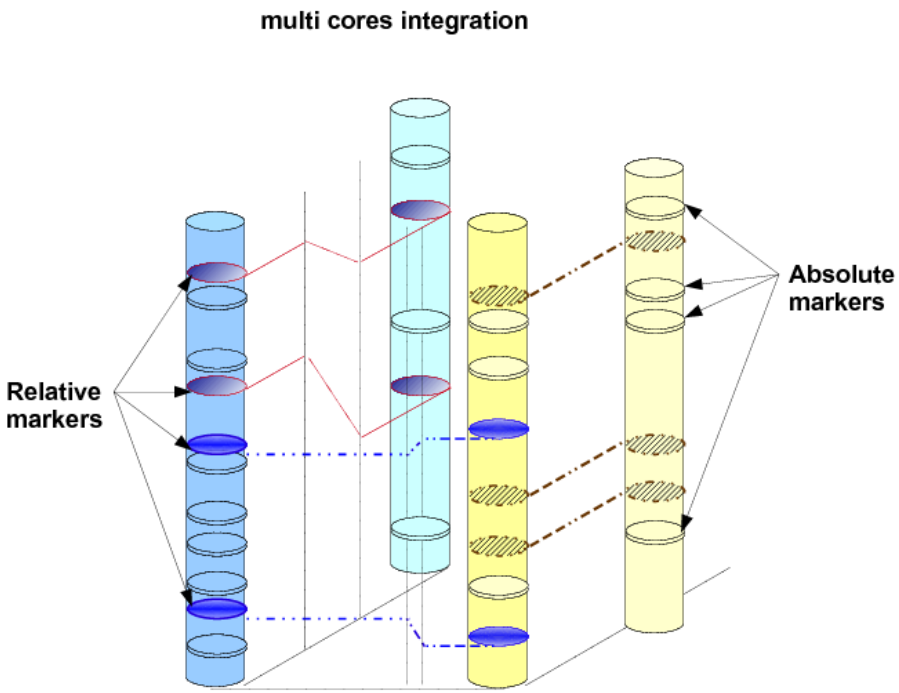
Observation inputs

DatIce tool handles two kinds of observations:

- absolute tie-points: ice and gas ages markers, thinning and delta-depth correction markers.
- relative tie-points: ice and gas stratigraphic links, ice age difference markers.

The observation covariance error matrix R is the B analogue for observations errors.

$$||h(X) - \mathbf{Y^o}||^2_R = (h(X) - \mathbf{Y^o})^t \; R^{-1} \; (h(X) - \mathbf{Y^o})$$



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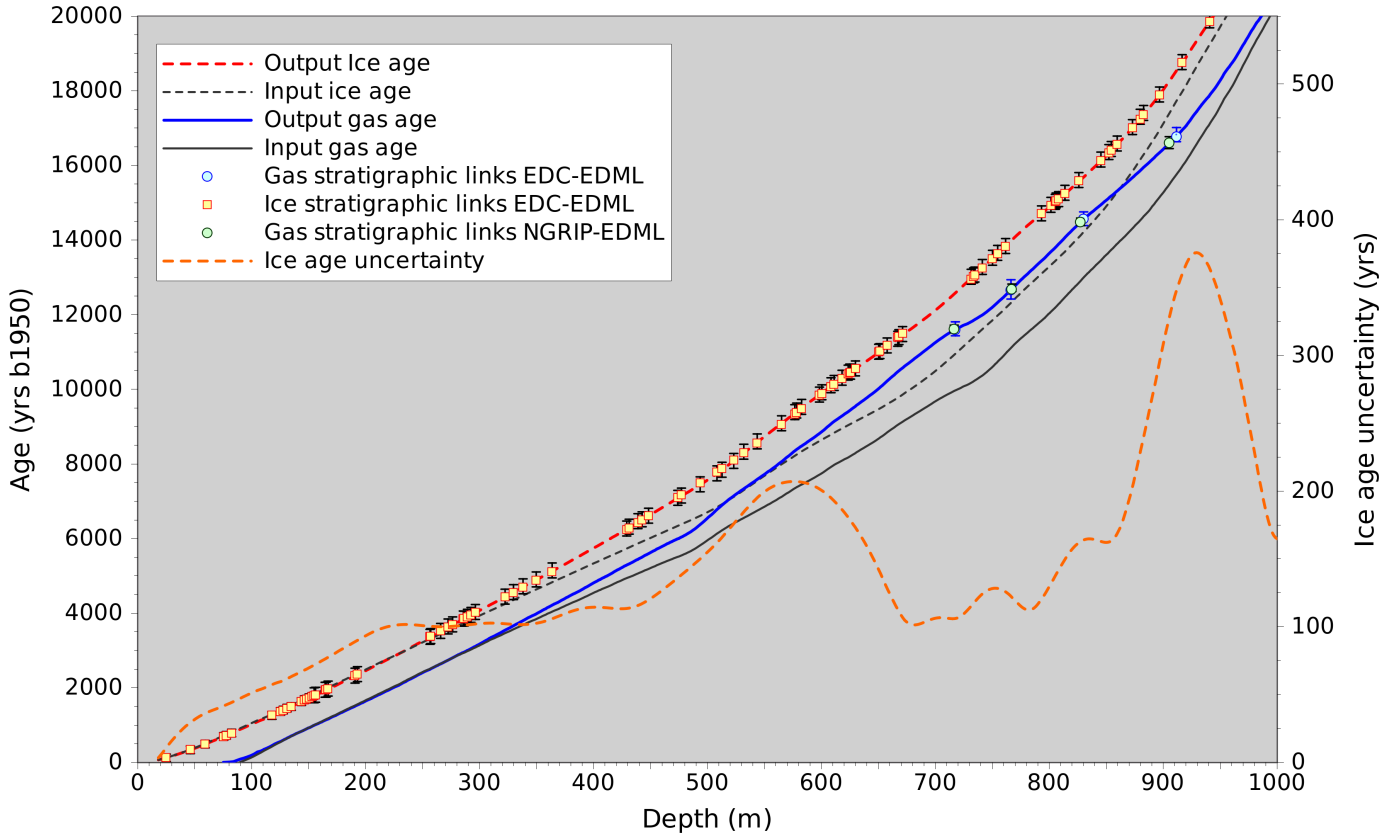
Outputs

After the minimization step we get corrections coefficients $\tilde{X} = (\tilde{\alpha}, \tilde{\tau}, \tilde{\gamma})^t$ that will allow us to determine the new chronology.

$A^a = \alpha^a \mathbf{A}^b$: new accumulation, $T^a = \tau^a \mathbf{T}^b$: new thinning, $C^a = \gamma^a \mathbf{C}^b$: new CODIE.



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Input and output files extracts

Background

```
depth    relative density    accumulation rate    thinning function    delta-depth    CODIE
...
 147          0.989               2.2289               0.92505             -1            -1
 148          0.989               2.22                 0.92455             -1            -1
 149          0.989               2.2031               0.92404             -1            -1
 150          0.989               2.1866               0.92354          65.856383     71.270056
 151          0.99                2.1699               0.92303          65.820846     71.270163
...
```

Ice age markers

```
depth        age in years BP (b1950)    uncertainty in years (1 sigma)
...
 3166.87          767679                        5090                      2001    2002
 3180.6           787736                        6000                      2000
 3189.83          797460                        6010
```

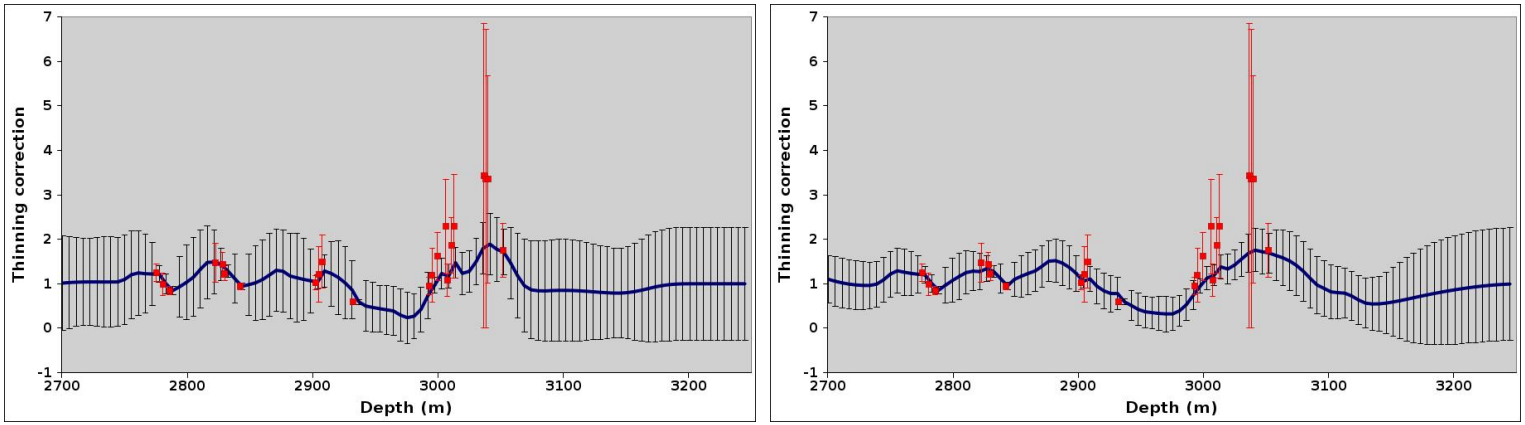
Outputs

real depth (m)	α^a	τ^a	A^b m.yr^{-1}	T^b	A^a m.yr^{-1}	T^a
0	1.04928	1.00099	0.03099	1.00006	0.0295346	0.999071

Ψ^b yr	Ψ^a yr	σ^{α^a}	σ^{τ^a}	σ^{Ψ^a} yr	$\tilde{\alpha}^a$	$\sigma^{\tilde{\alpha}^a}$	$\tilde{\tau}^a$	$\sigma^{\tilde{tau}^a}$
-55	-55	0.135227	0.0366051	1.66132	0.048101	0.128876	0.000989775	0.0365689

On going work
A posteriori diagnostics

Choosing the good coefficients for B (and R) still remains a great challenge.



We are currently working on an automatic statistic procedure to calibrate B and R.
For instance, we expect:

$$E[J(\tilde{X}^a)] = p \qquad (p\text{: number of observations})$$

Talagrand, ECMFW workshop, 1999 and Desroziers et al, 2009

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DatIce code

- v1.0
- Fortran 90
- ascii input format
- ascii and netcdf output format
- http://datice.gforge.inria.fr
- next talk from Lucie Bazin will present new DatIce applications.

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