Diagnosing **Lagrangian** aspects of the atmospheric circulation by **Eulerian tracer advection** with relaxation

by Amelie Mayer & Volkmar Wirth

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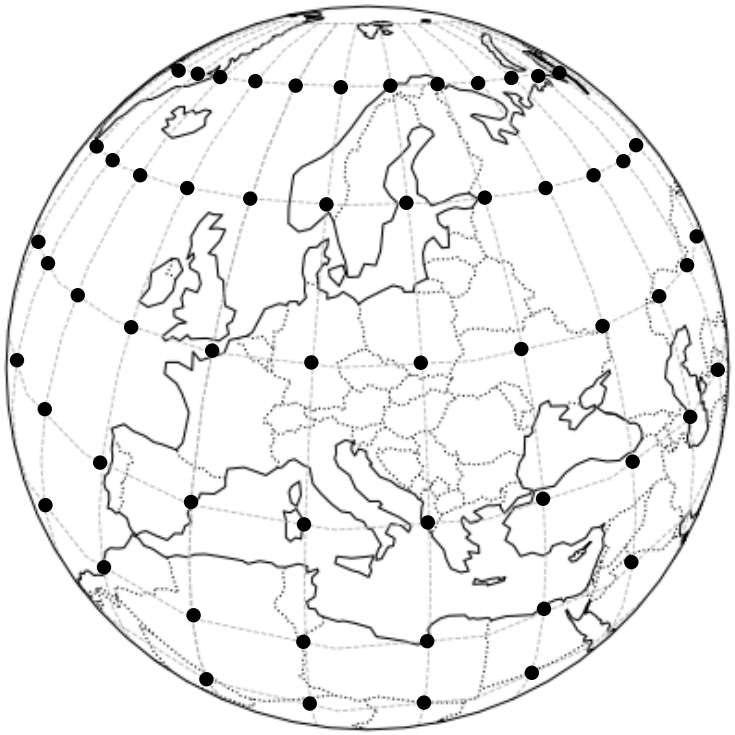
27 May 2022, EGU
CL 2.3: Synoptic climatology: methods and applications

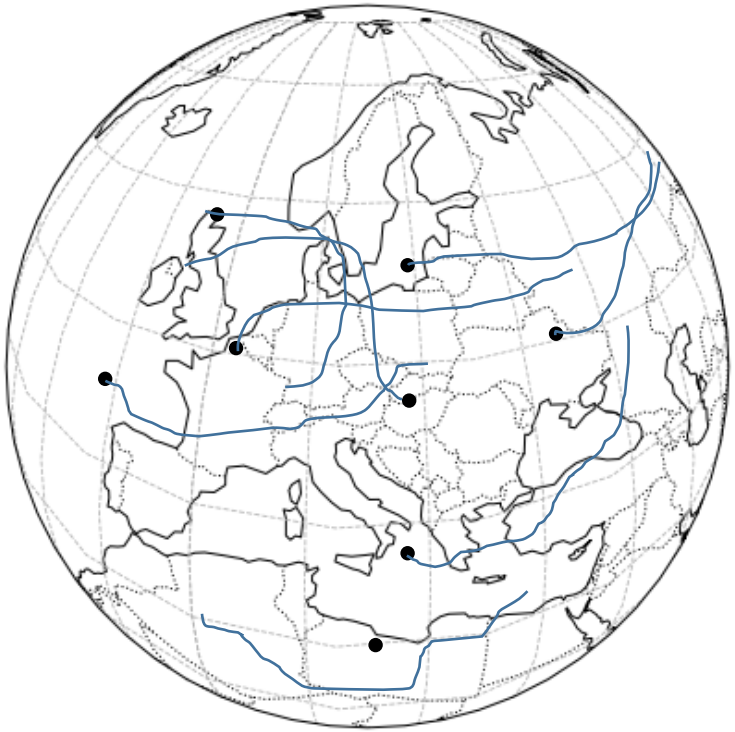
The idea: Combining two perspectives

Eulerian representation



convenient from a diagnostic point of view

Lagrangian representation



physically more meaningful

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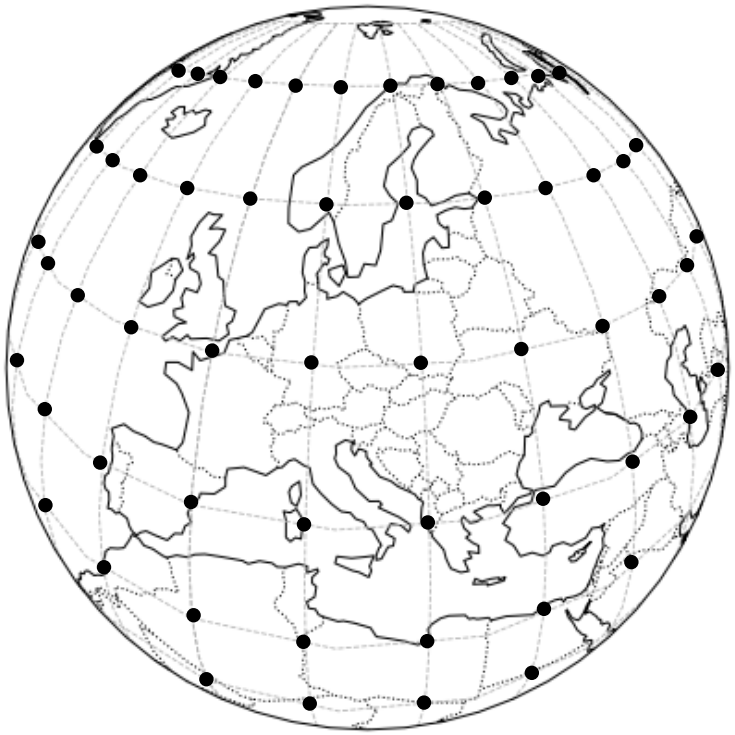

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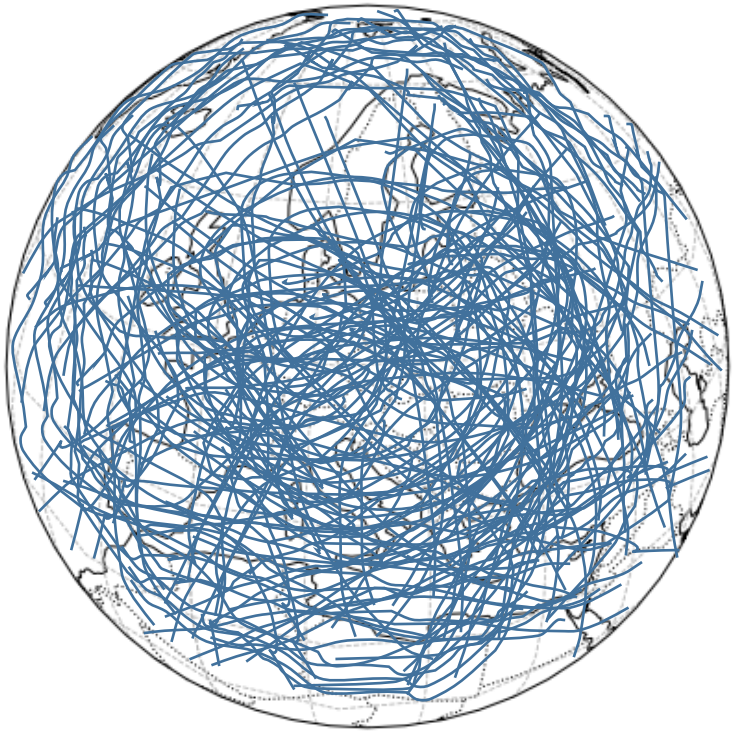

physically more meaningful

The method: Tracer advection with relaxation ...

Consider e.g. the tracer X to be **latitude**.

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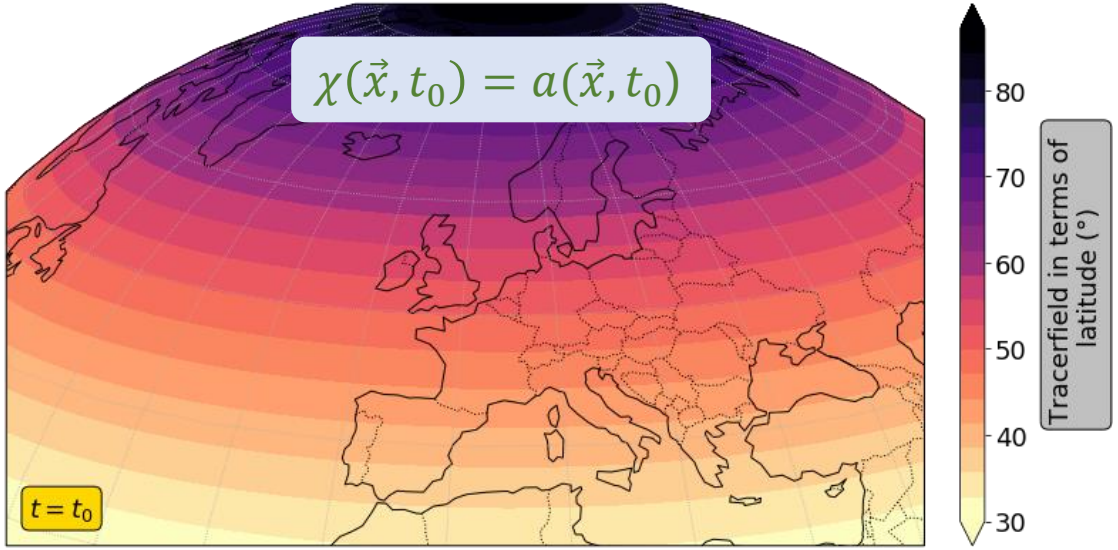
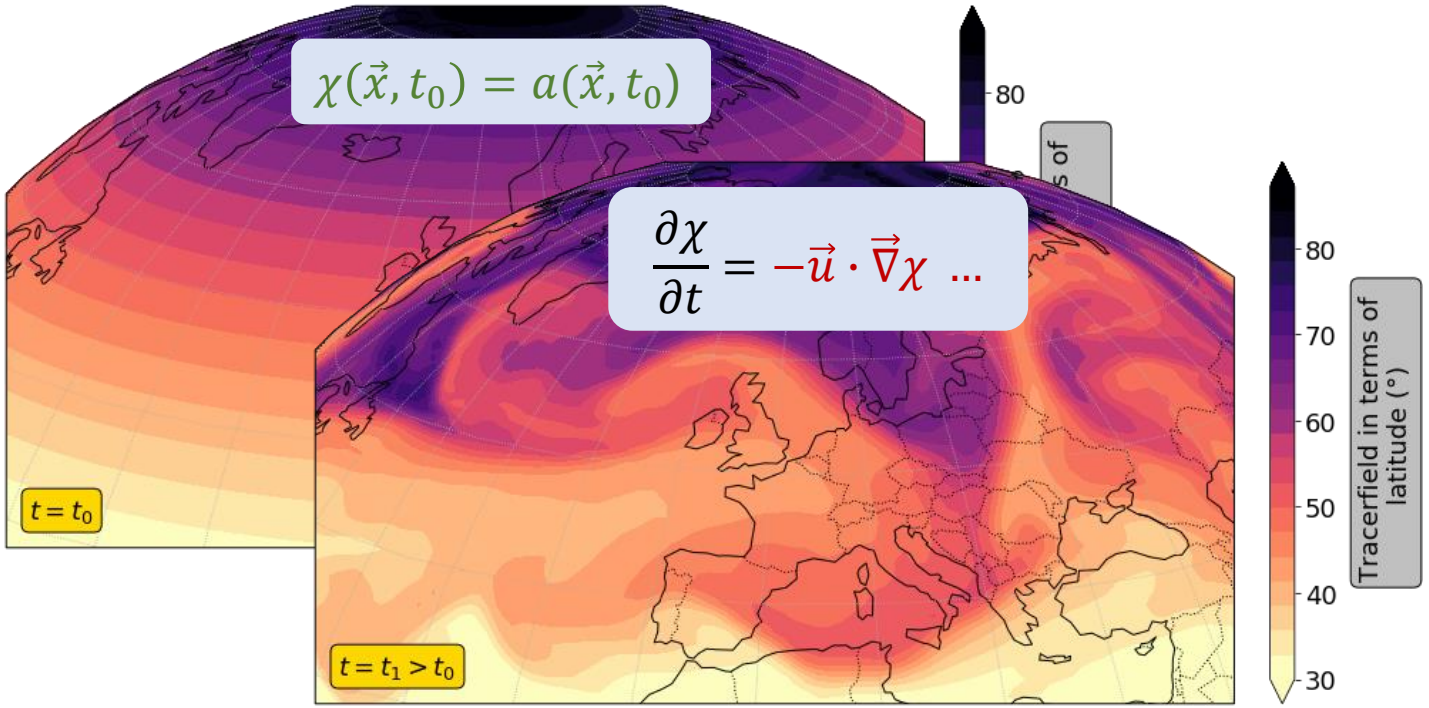
Consider e.g. the tracer *X* to be **latitude**.



We **once (!) initialize** the tracer field *X* with its current latitudes.

The method: Tracer advection with relaxation ...

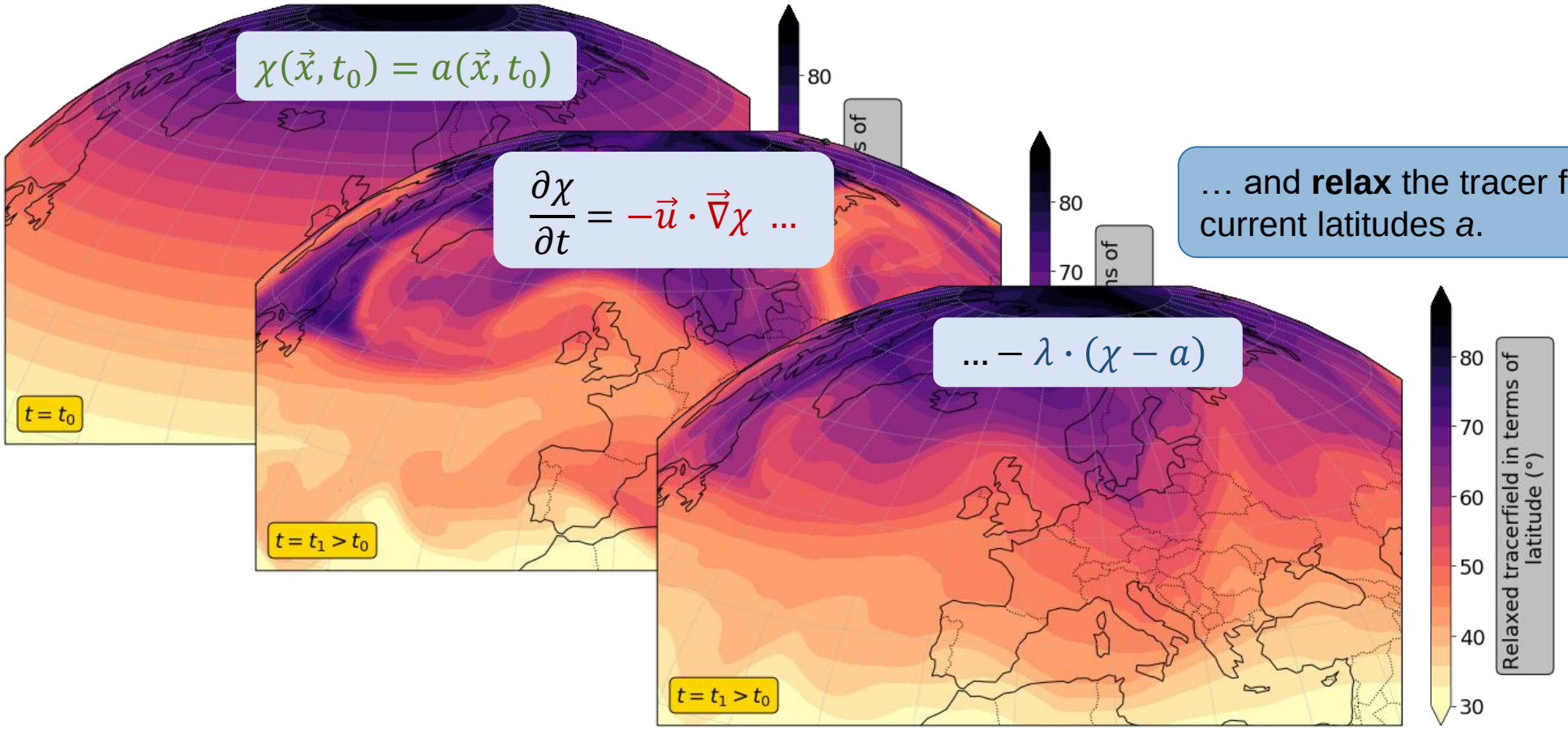
Consider e.g. the tracer *X* to be **latitude**.



In each timestep we passively **advect** the tracer field *X* with a given 3D wind field *u* ...

The method: Tracer advection with relaxation ...

Consider e.g. the tracer *X* to be **latitude**.



… and **relax** the tracer field *X* to its current latitudes *a*.

The method: Tracer advection with relaxation ...

Consider e.g. the tracer *X* to be **latitude**.

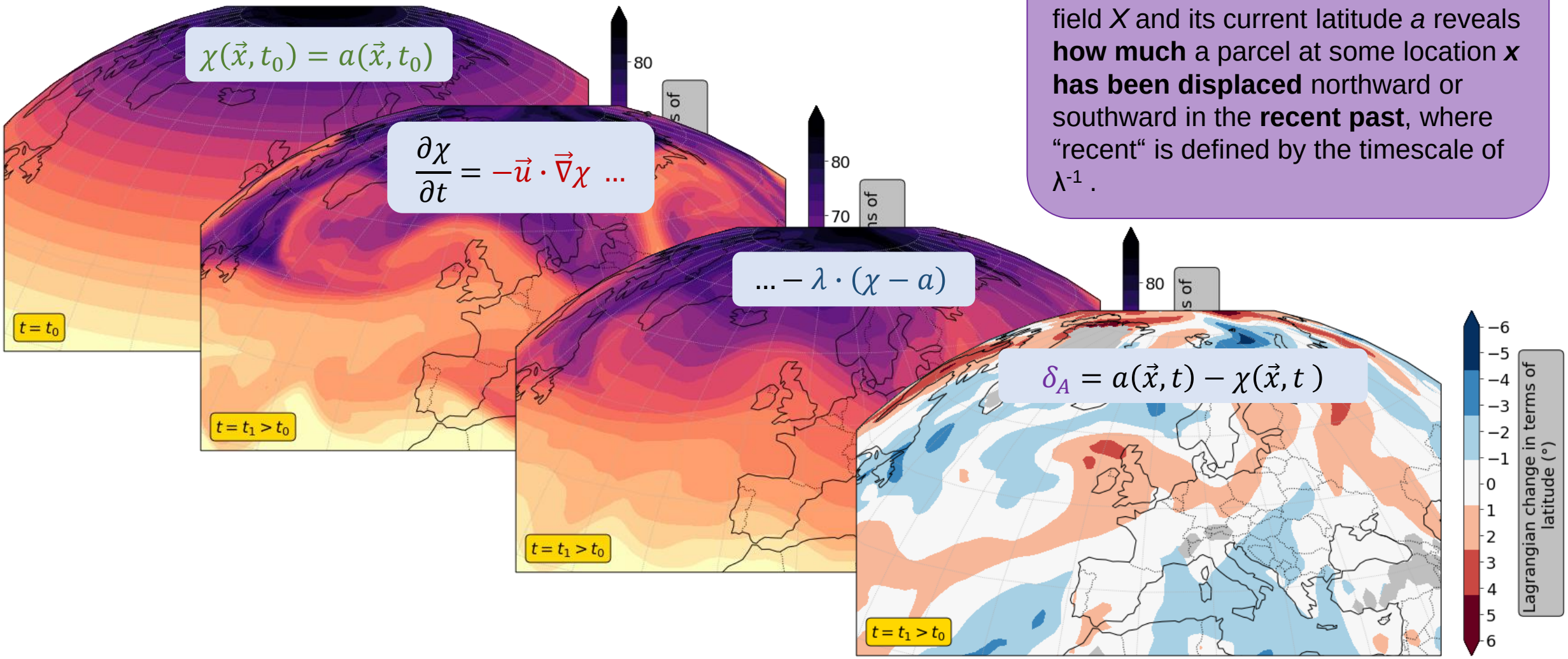
$\chi(\vec{x}, t_0) = a(\vec{x}, t_0)$

$\frac{\partial \chi}{\partial t} = -\vec{u} \cdot \vec{\nabla}\chi \ \ldots$

$\ldots - \lambda \cdot (\chi - a)$

$\delta_A = a(\vec{x}, t) - \chi(\vec{x}, t\,)$

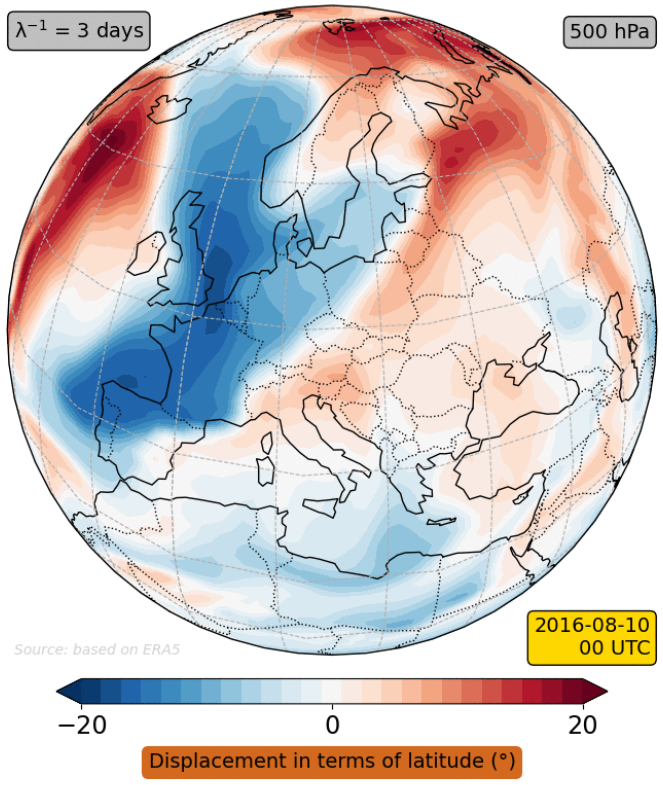
The **difference δ** between the tracer field *X* and its current latitude *a* reveals **how much** a parcel at some location ***x*** **has been displaced** northward or southward in the **recent past**, where "recent" is defined by the timescale of λ^{-1} .

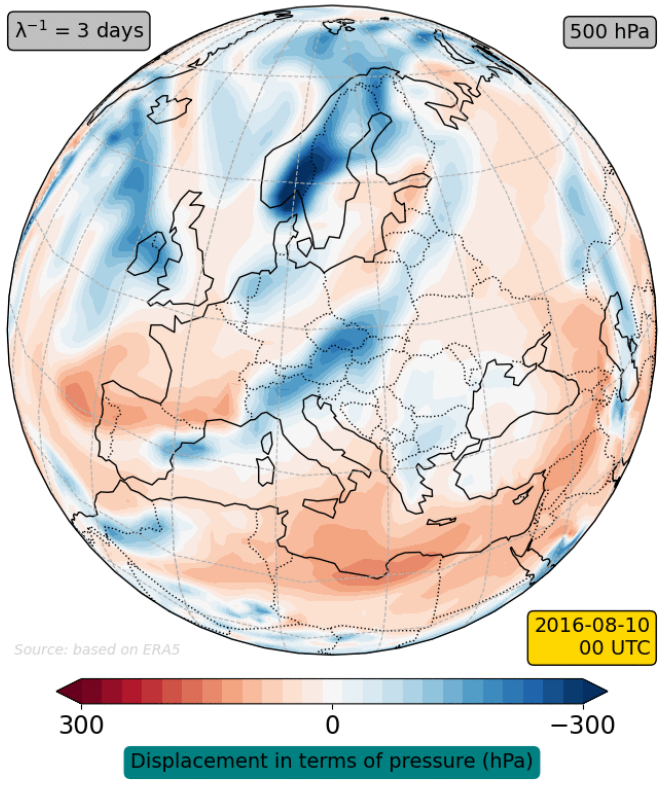


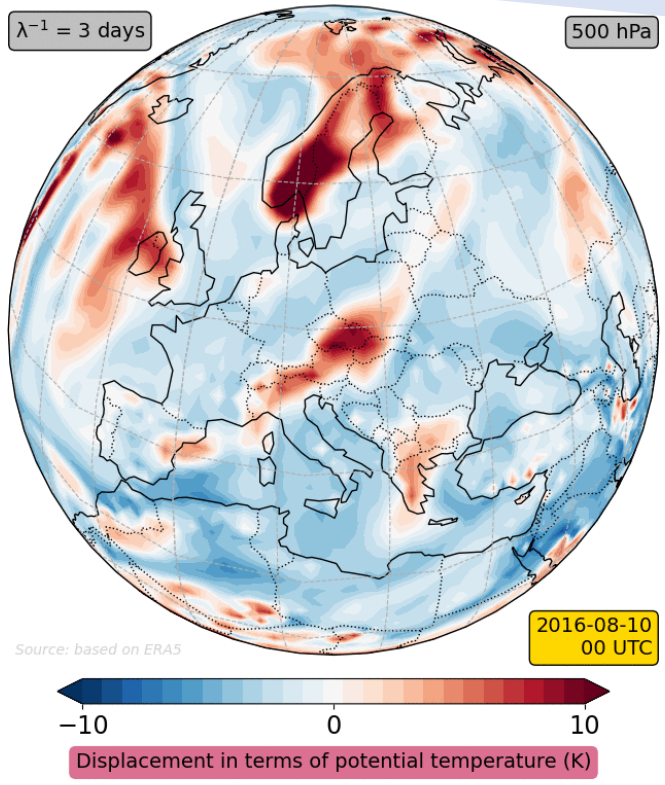
The output: Fields of Lagrangian changes ...

The fields show, how much air masses …

The beauty: Lagrangian information on Eulerian grid!







… moved northward/southward

… ascended/descended

… diabatically warmed/cooled

… allow for computing climatologies

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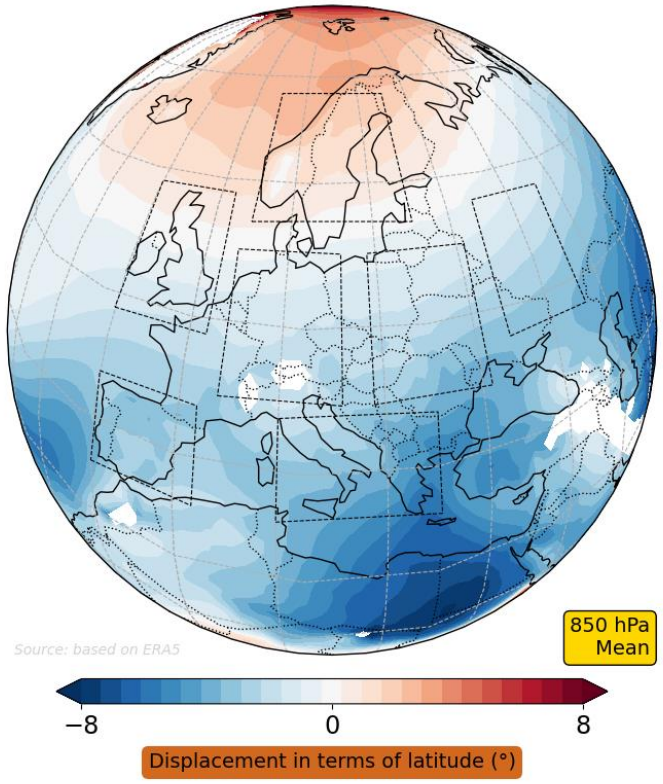

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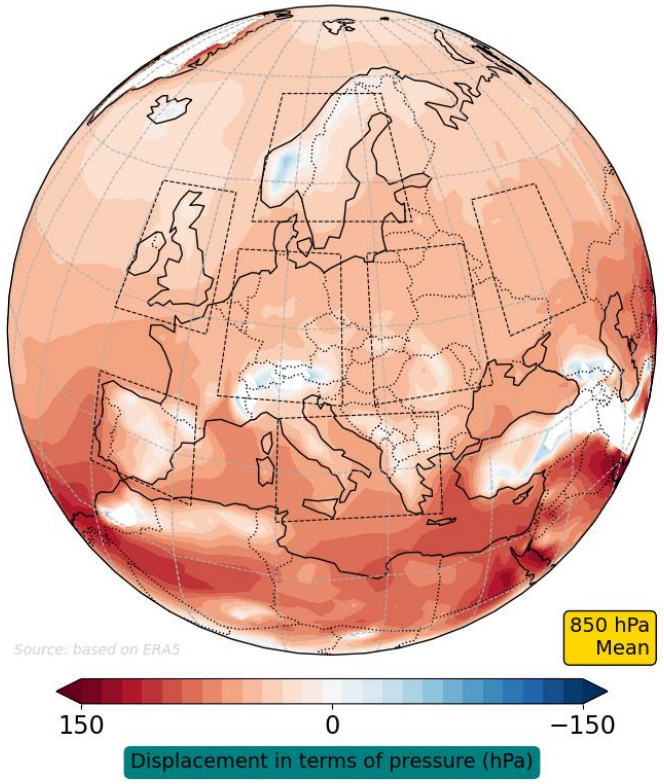

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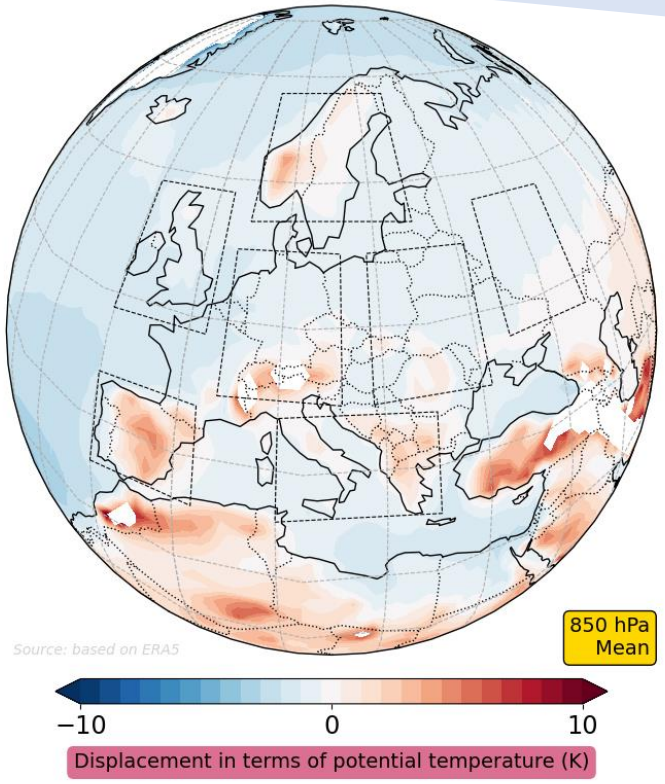

… diabatically warmed/cooled

Eulerian tracer advection with relaxation …

… provides essential **Lagrangian information** for each gridpoint at any timestep without computing (millions of!) trajectories.

… allows one to **analyse large data sets** in a straightforward manner.

… could be particularly **useful** in the field of **synoptic climatology**.

Thank you for your attention!

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Mayer and Wirth: Lagrangian description of the atmospheric flow from Eulerian tracer advection with relaxation
Under review (QJRMetS)