DATA ASSIMILATION FOR THE TIME-DEPENDENT RECONSTRUCTION OF CONTINENTS.

**Aim**
Assimilate Paleomagnetic data to reconstruct the motion of continents over the last hundreds of Myr, while preserving basic geodynamical principles.

**Motivation**
- Using plate tectonic theory, we can integrate a wide range of geological and geophysical observations to produce kinematic plate tectonic reconstructions. These reconstructions are built via a largely manual process of integrating many individual time-dependent, regional tectonic histories into a geographically self-consistent model, making the quantitative estimation of uncertainties very complex.

Here, we demonstrate a first step to building a data assimilation framework for plate tectonic reconstructions: we apply a particle filter to reconstruct time-dependent continental configurations and motions.

**The Forward Model**
Continents motions are solid body rotations:

At each timestep, we compute the rotation of each continent during the time interval (here 1 Myr). This rotation is determined by 3 parameters:

- $D_0$, the distance from continent centroid to the Euler pole (pole of rotation)
- $V_c$, the velocity of the continent's centroid
- $T_s$, the fraction of the current rotation to be kept for the next rotation.

Composition of the Random drift for each continent: $D_0$, $V_c$, and $T_s$ are random variables. Each of them follows a beta function. We choose the parameters $(a, b)$ of those beta functions to fit the following geodynamical constraints:

- $max |a| = 18$ centimeters maximum, made $c = 5.3$ centimeters
- $D_0$ is related to spin vs translation motions for continents: made at 10000 km.
- $T_s$: how often the continents change drastically their trajectory.

Collision rules:
- If during a timestep, two continents overlap each other, the two bodies deformed and are rotated together.

**Example Random Drift Scenario**

Database of inclination and declination of the magnetic field fossilized in rocks.

Uncertainties modelled with Fisher statistics:

$\mathcal{F}_\theta (\mathbf{x}_t) = C(\mathbf{x}_t) \exp(\mathbf{h}^T \mathbf{H}_t \mathbf{h})$

with $C(\mathbf{x}_t) = \frac{2\pi e^{-0.5}}{\pi e^{-0.5}}$

North America paleopoles computed from the inclination declination database used in Tetley (2018), dated from 0.5 to 300 Myrs.

**Data Assimilation Method**

**Observations**

Aims:
- Estimate the trajectory of continents for at least 130 Myrs.
- Further development of data assimilation framework for paleomagnetic data.

**Preliminary Tests**

### Synthetic experiment

Synthetic experiment

- Time (Myrs)
- Distance Pole-Centroid (km)
- Declination
- Centroid velocity, cm/yr

1. True
2. Estimated with 100 particles
3. Estimated with 1000 particles
4. Estimated with 10 000 particles

**Conclusions**
- We have developed a data assimilation framework for paleomagnetic data:
  - based on the Particle Filter,
  - with a continental drift model consistent with basic geodynamics rules,
  - where the uncertainties on observations are taken into account.
- For single continent synthetic experiments, a number of particles of ca. 10000 allows us to estimate the trajectory of continents for at least 130 Myrs.

**The Way Forward**
- Perform synthetic tests with data at multiple sites and on different continents
- Optimize forward code to allow for more particles
- Test different resampling techniques, while concerning geodynamical constraints.

**References**