The mantle's drapes: 30 years of global tomography

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Drapes work

Michel-Ange [beginning XVIe]

Reveal the complexity which includes
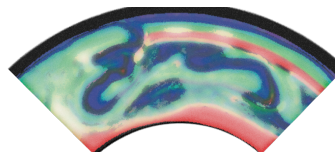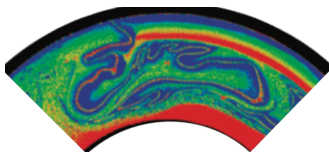
- Various amplitudes
- Various scales
- Various texture

Drapes work

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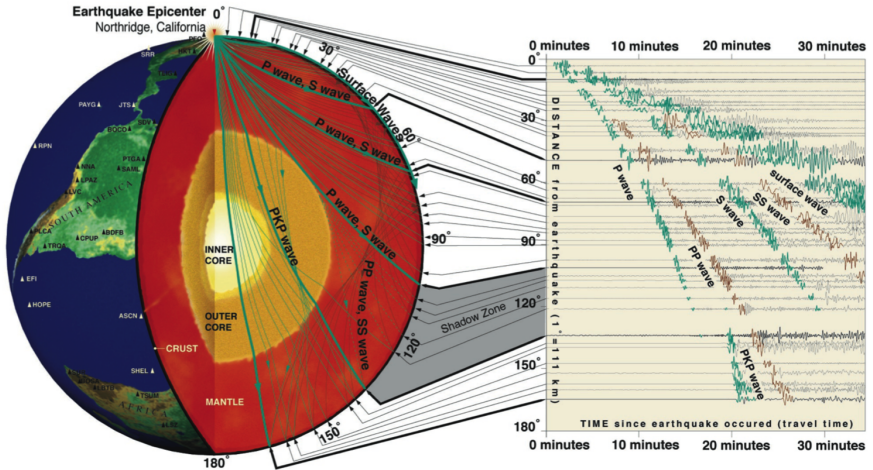
- Various amplitudes
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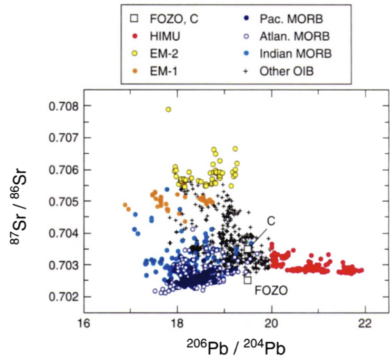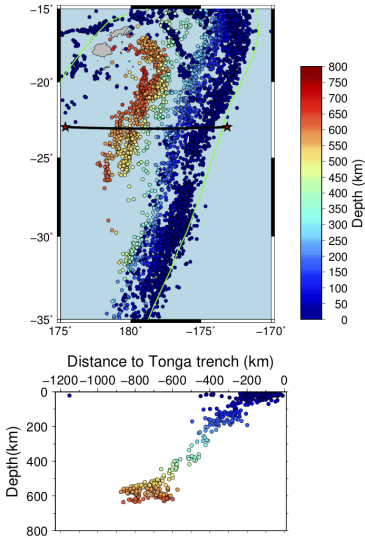- Various texture

Ballmer et al. [2015]

We aim to do the same with tomography

How to study the deep Earth ?

IRIS.EDU

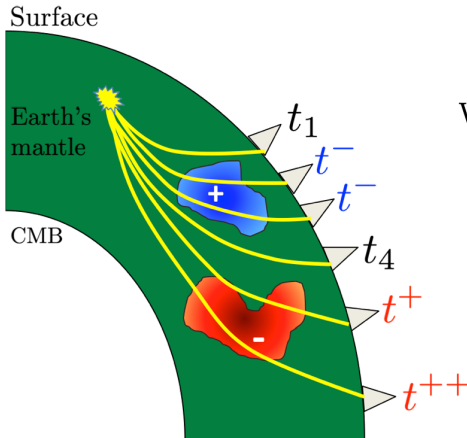# Evidences for a heterogeneous Earth's mantle

Hofmann [1997]

Tomography principle

Tomography principle

40th anniversary GEOSCOPE June 29$^{\text{th}}$ 2022   5/21

Introduction
○○○○

Method
●○○○○

Results
○○○○○○

Challenges
○○○

Availability
○

What is the future ?
○
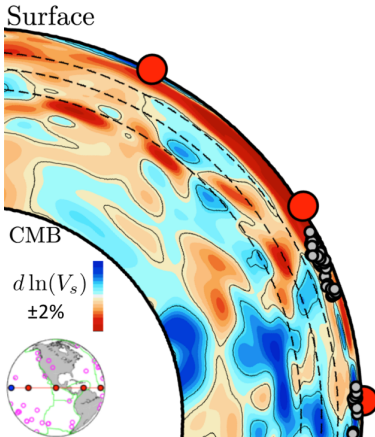
Model (m)
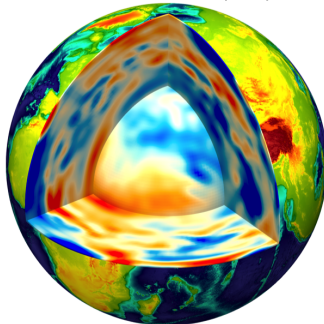
Forward problem
$d = g(m) + \epsilon$

Data (d)
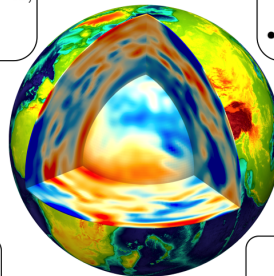
Time (min)

Inverse problem
$m = ... ?$
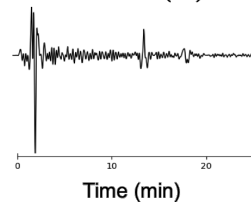
PARAMETRIZATION
- Spherical harmonics,
  spherical splines, radial splines,
- Velocity, anisotropy

SEISMIC DATA
- Normal modes, surface waves
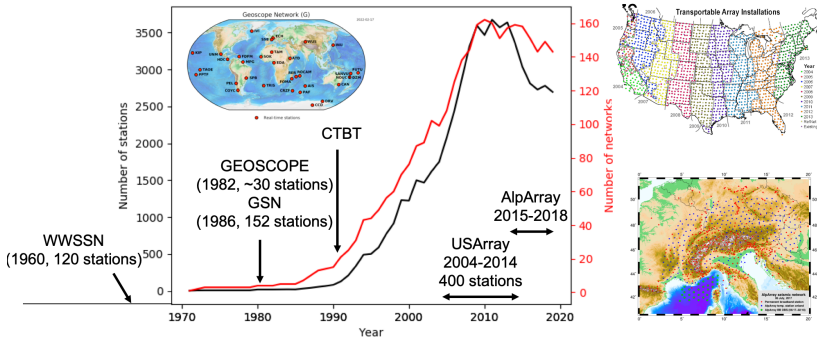 and body waves
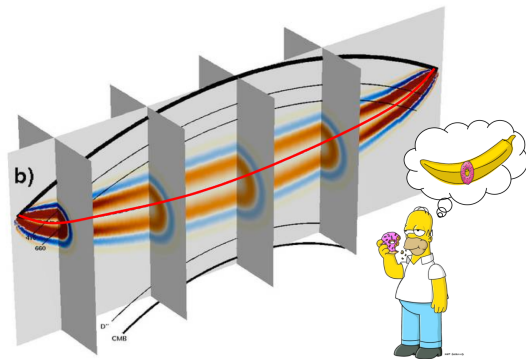- Measurements or waveforms

REGULARIZATION
Damping parameter
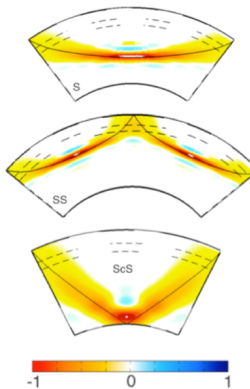
THEORY
Ray theory or finite frequency kernels

Networks

Theory

Zaroli et al. [2010]

Introduction
○○○○

Method
○○○●○

Results
○○○○○○

Challenges
○○○

Availability
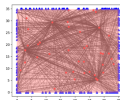○

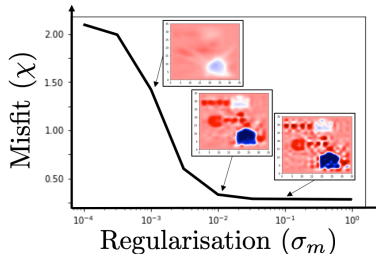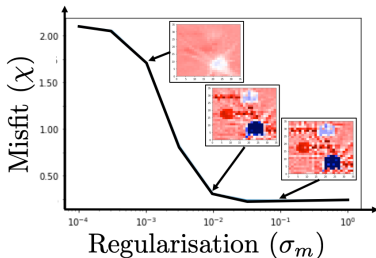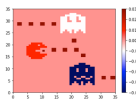What is the future ?
○

Theory

Durand et al. [2017]
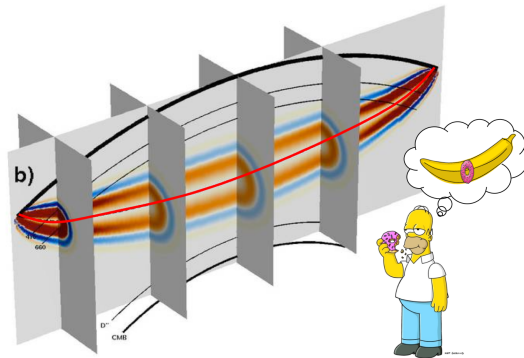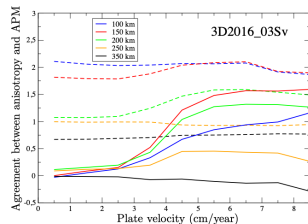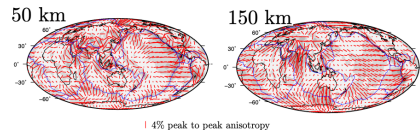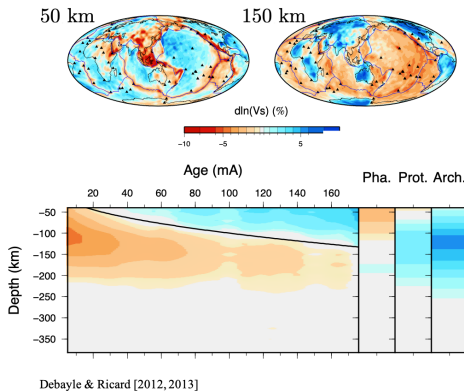

Zaroli et al. [2010]

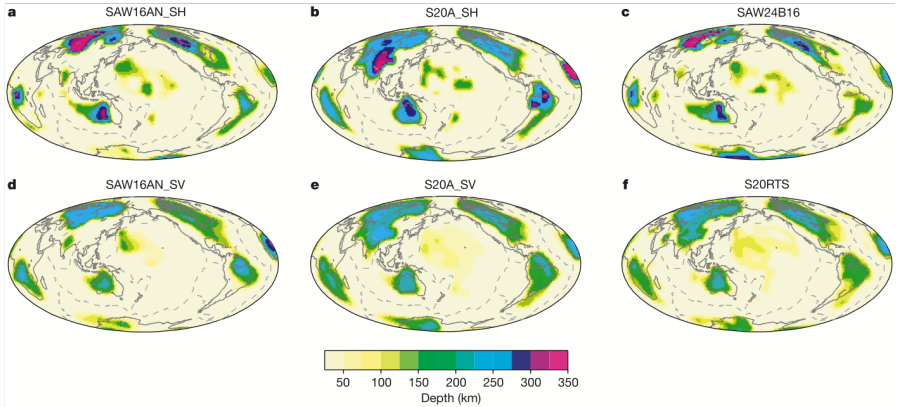# Regularization, parametrization

A priori model   True model

Oceanic lithosphere and cratons

50 km   150 km

dln(Vs) (%)

−10   −5   5

50 km   150 km

4% peak to peak anisotropy

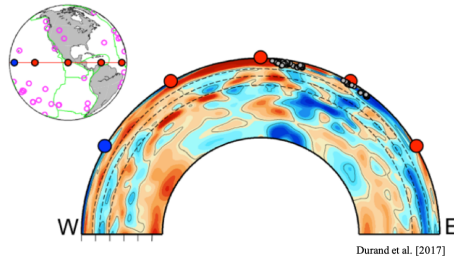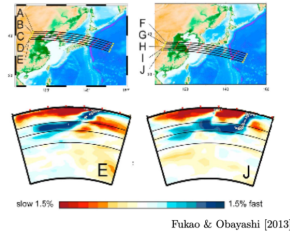Age (mA)

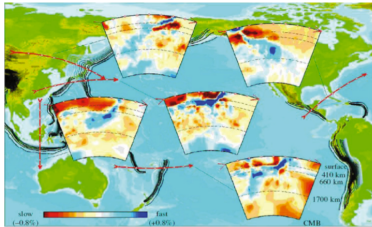Pha. Prot. Arch.

Debayle & Ricard [2012, 2013]

3D2016_03Sv

Oceanic lithosphere and cratons

Gung et al. [2003]
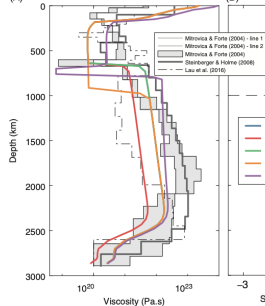
Imaging slabs
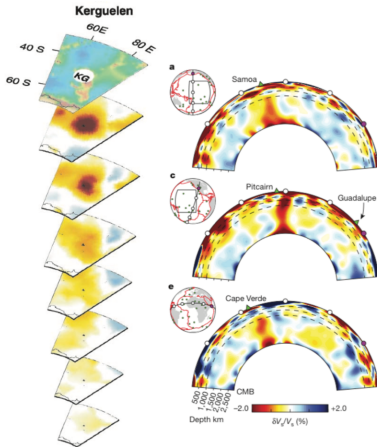

Karason & van der Hilst [2001]

Fukao & Obayashi [2013]

Durand et al. [2017]

Upper-lower mantle transition
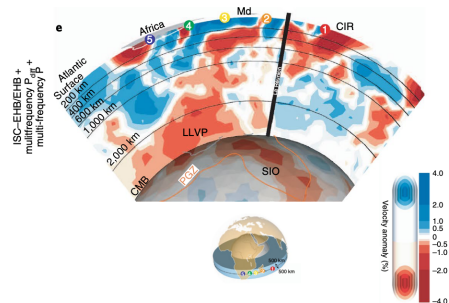

Rudolph et al. [2021]
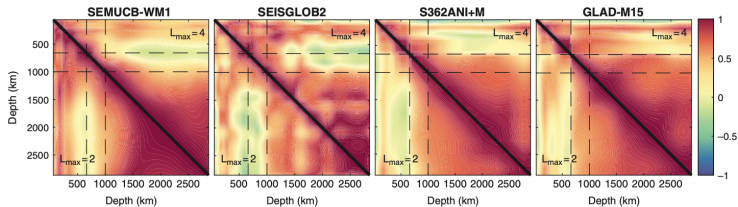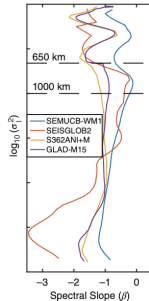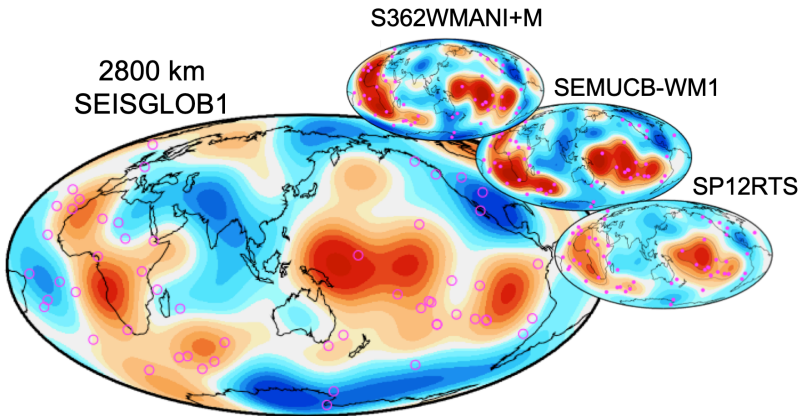
Mantle plumes

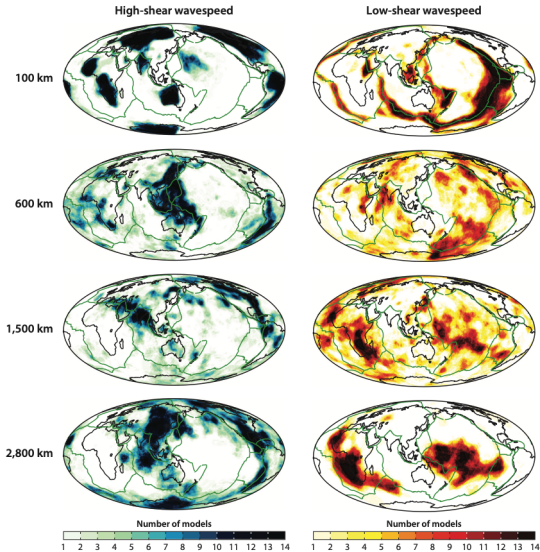Montelli et al. [2004]   French & Romanowicz [2015]   Tsekhmistrenko et al. [2021]

LLSVPs

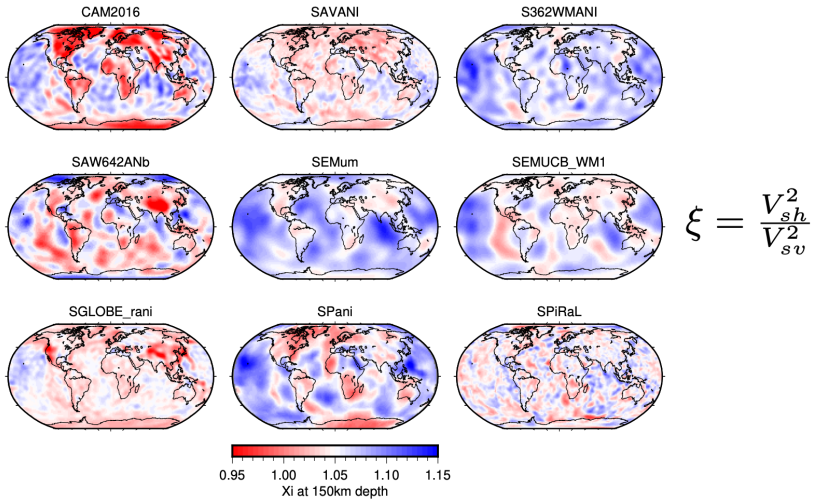# Comparison of shear wave velocity models

Ritsema & Lekic [2020]
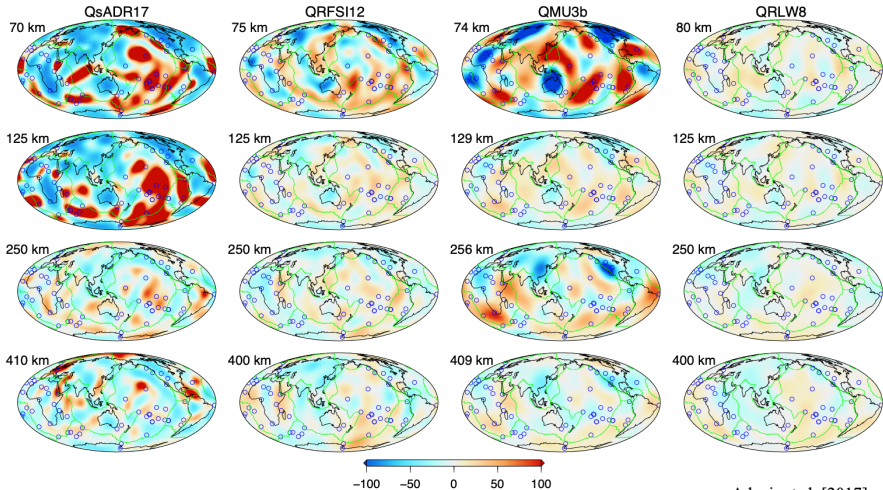
Radial anisotropy

$$\xi = \frac{V_{sh}^2}{V_{sv}^2}$$

Attenuation

$$x(t) = Ae^{-\omega_0 t/2Q} \sin(\omega_0 t)$$

Q = 10 ~ ΔE/E = 66%
Q = 100 ~ ΔE/E = 6%
Q = ∞

Elasticity
Elastic moduli
κ,μ

Anelasticity
Quality factors
$Q_\kappa(\omega) \gg Q_\mu(\omega)$
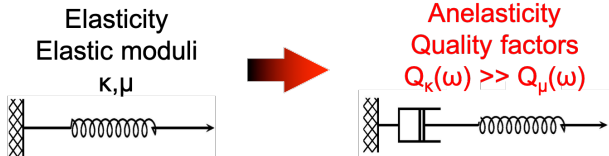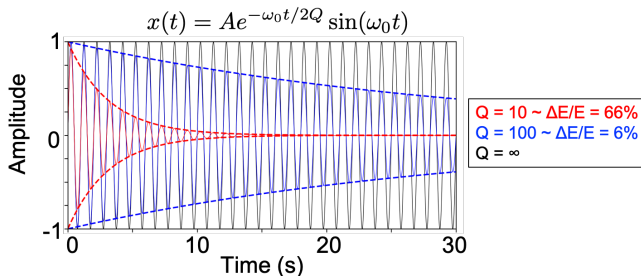
Attenuation

Adenis et al. [2017]

3D reference mantle model

Moulik et al. [2022]
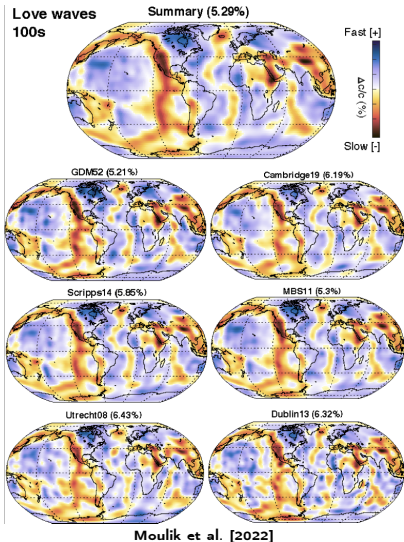
The aim of the project is to develop a 3D seismic reference model (REM-3D) for the Earth's mantle, parameterized in terms of V_s, V_p, ρ, and radial anisotropy. REM-3D will come with uncertainty estimates.
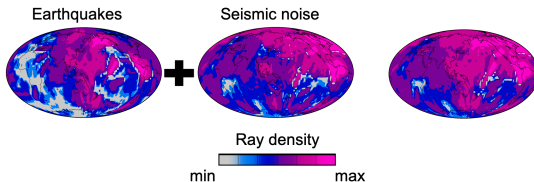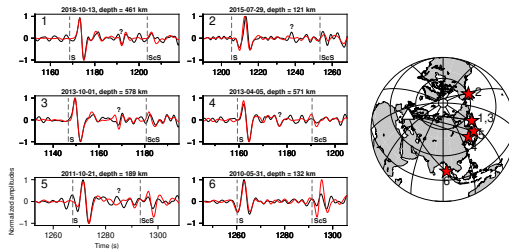
Where to find the models and how to plot them

- IRIS EMC : `https://ds.iris.edu/ds/products/emc-earthmodels/`
- SeisTomoPy : `https://github.com/stephaniedurand/SeisTomoPy_V3`
- Submachine : `https://www.earth.ox.ac.uk/~smachine/cgi/index.php`

What is the future ?

- The use of ambient noise to enlarge the coverage in the deep mantle

- New data with the rotational sensors

- Bayesian approach