The coupling transition depth in subduction zones: rheologically controlled and not constant

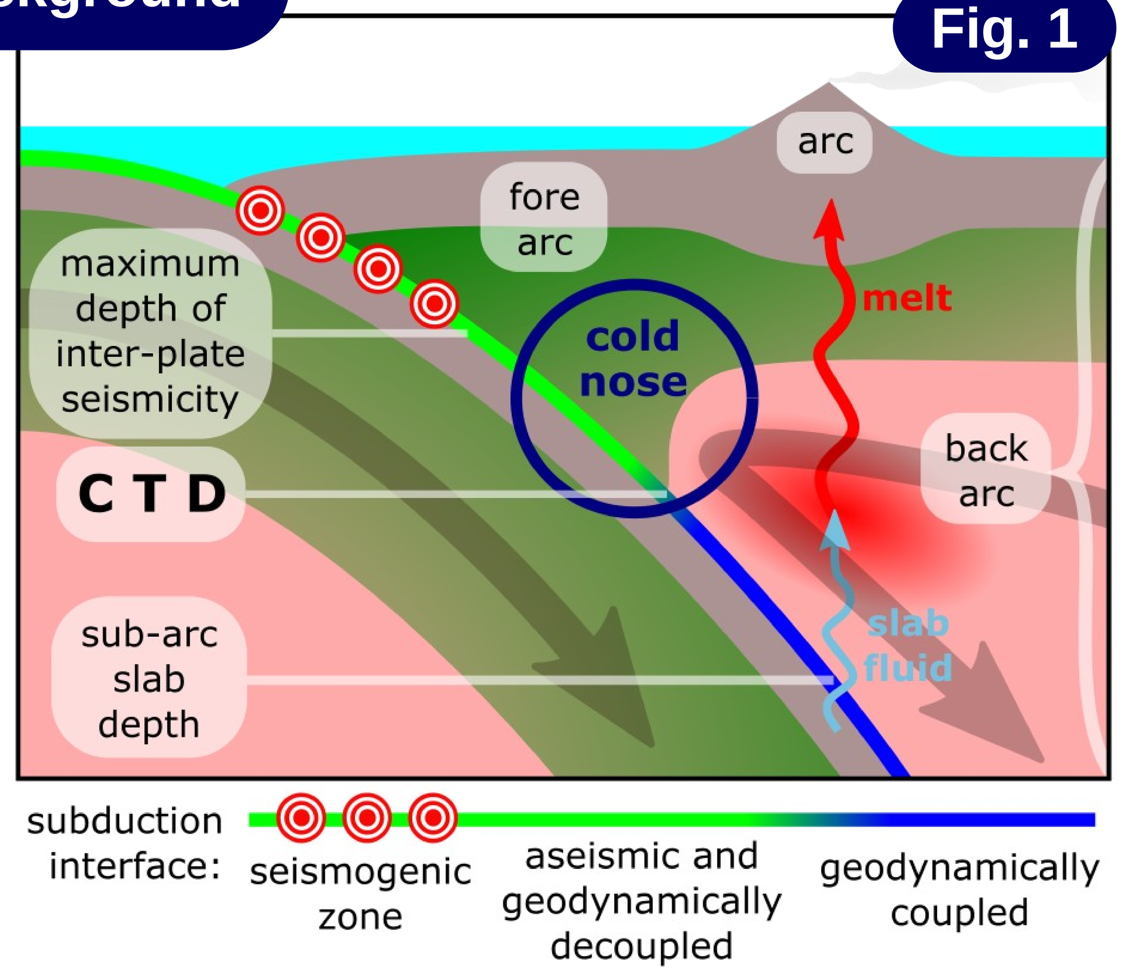
Ben Maunder[1] Saskia Goes[1] Jeroen van Hunen[2]

1. Imperial College London, South Kensington, UK
2. Durham University, Durham, UK

Email: **ben.maunder@imperial.ac.uk**

Background

Fig. 1



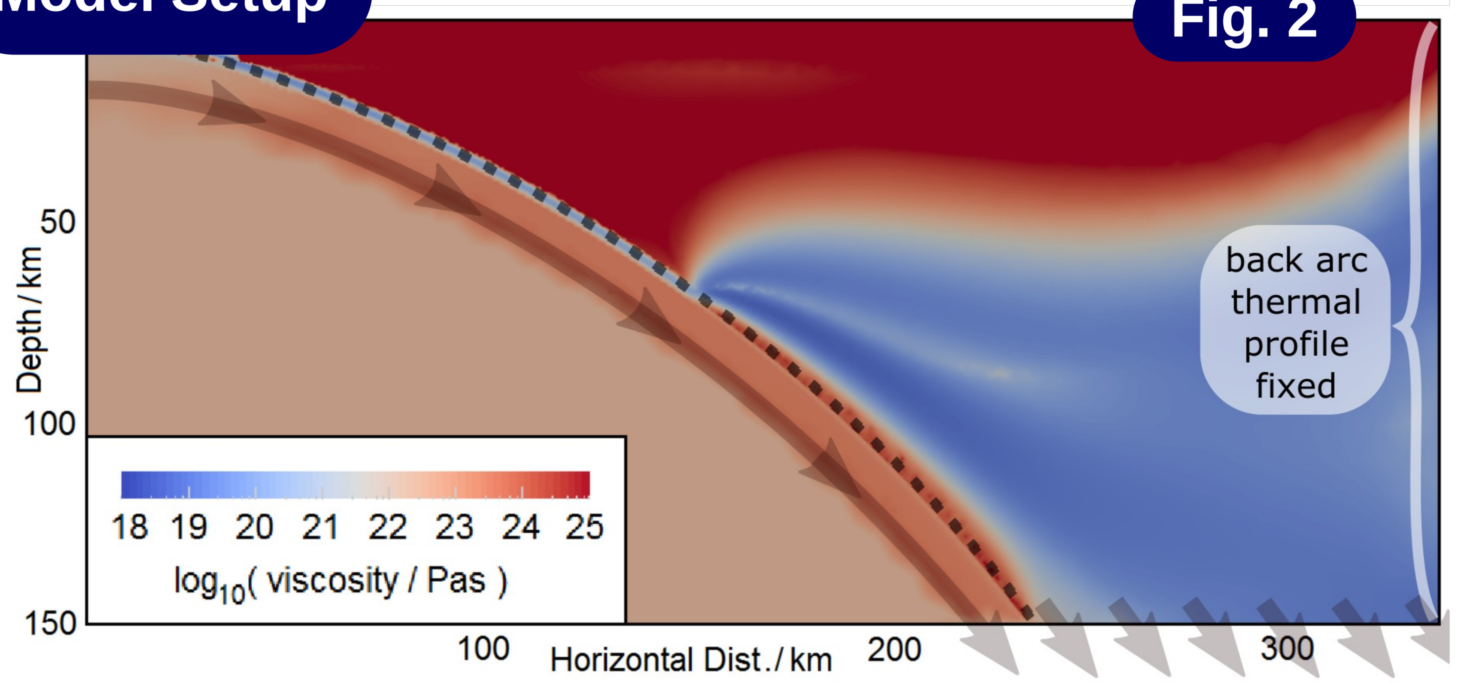
The subduction zone coupling transition depth, or **CTD**, marks the transition from frictional/ductile decoupling between the two plates to viscous coupling between the subducting plate and convecting mantle.

This depth plays an important role in the state of stress, earthquake potential, and the location of the volcanic arc.

Based on previous studies of heat flow and seismic structure of circum-Pacific subduction zones, the CTD has been inferred to be at a constant 70-80 km. A mechanism for the CTD and its constant depth has remained elusive.

Model Setup

Fig. 2



2D kinematic (fixed geometry) model.

Mantle rheology visco-plastic and within the range of laboratory experiments.

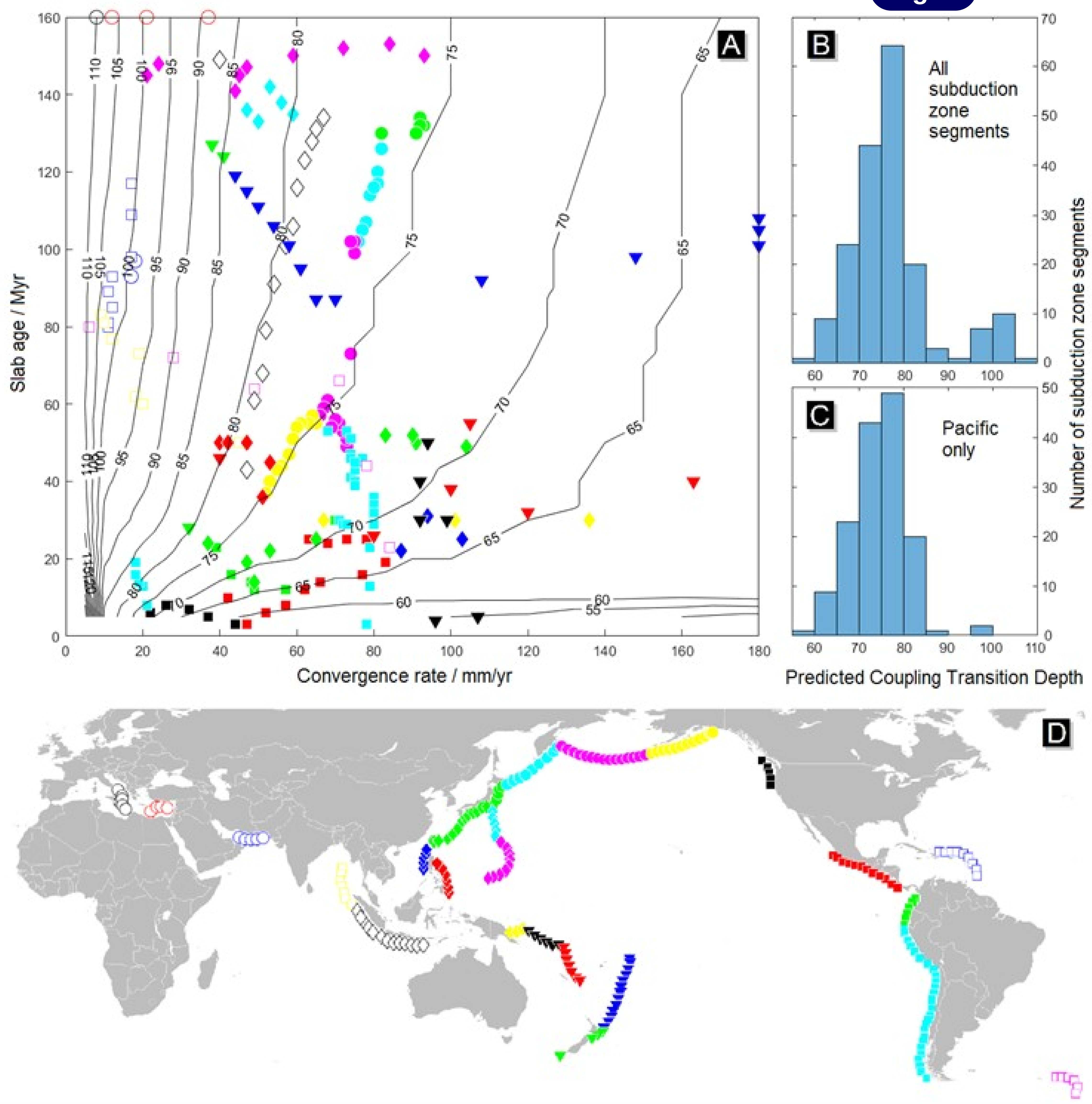
2 km thick and continuous "weak layer" on top of slab (dashed line) given a lower friction co-efficient to surrounding mantle.

Strain-rate measured through middle of this layer. It is observed to drop abruptly at a certain depth: the CTD.

Over time (of order 10 Myr) the CTD stabilises at **"stable CTD"** for the model.

CTD Dependence on Convergence Rate and Slab Age

Fig. 3



255 models run with different slab ages and convergence rates spanning the parameter space in panel A.

Contours are our predicted CTD for a given convergence rate and slab age and are plotted using the stable CTD of each model.

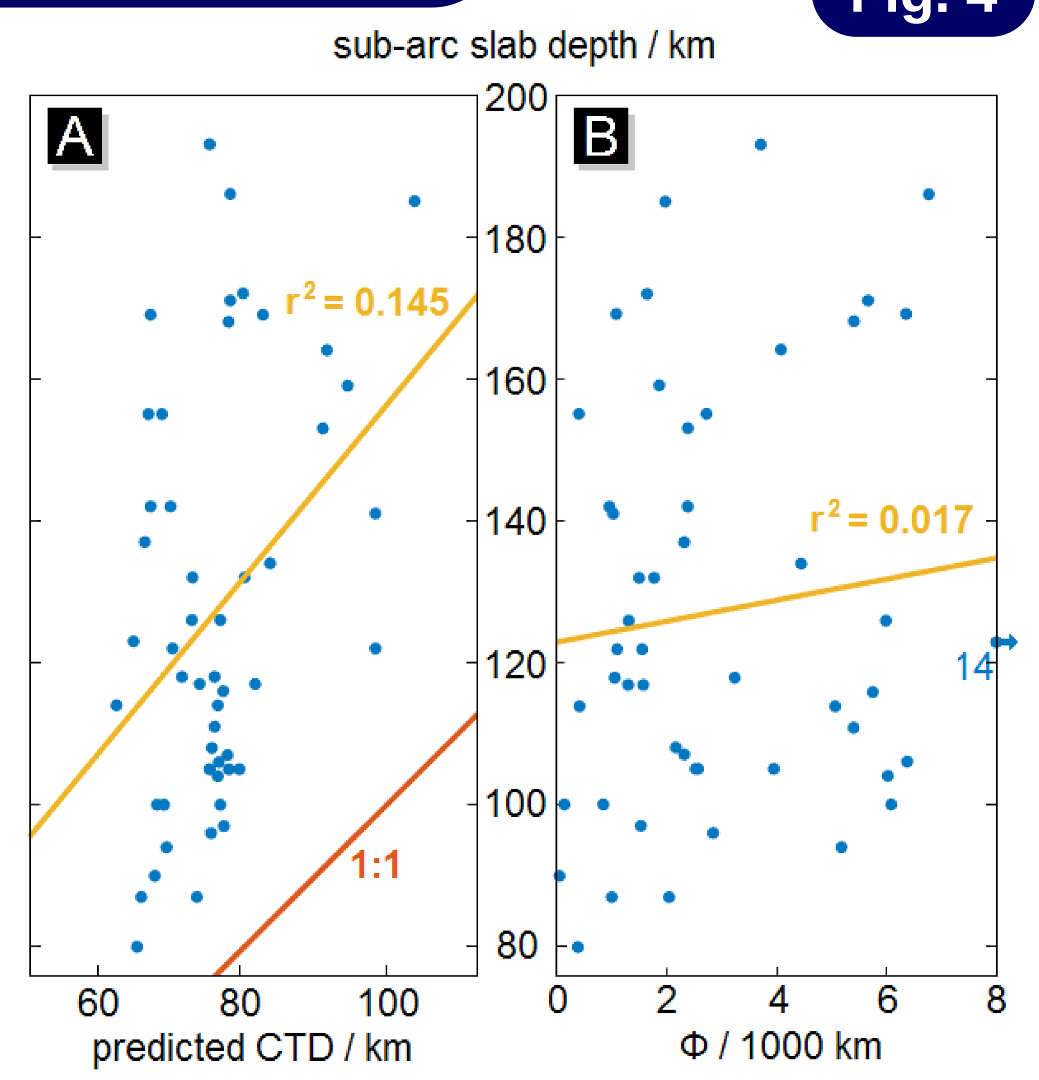
All subduction zone segments in panel D (Heuret and Lallemand 2005) are also plotted.

83% of all subduction zone segments are predicted to have CTDs that lie in the 65-85 km range (panel B).
91% if only Pacific segments are considered (panel C).

Note: back-arc thermal profile (Fig 2.) was also varied but observed to have a negligible effect on the stable CTD.

Sub-arc Slab Depth

Fig. 4



Each blue dot is a whole subduction zone, data is taken from Syracuse et al. (2011)

Sub-arc slab depth is likely dependent on CTD as it is dependent on where the slab loses its fluid (Fig. 1).

There is indeed a slight correlation between the sub-arc slab depth and our predicted CTD.

There is no correlation between sub-arc slab depth and slab thermal parameter (Φ) as previously noted.

Optimal Friction Coefficient

The whole study was conducted for different values of the friction co-efficient of the weak-layer.

A value of 0.065 appears to be optimal in putting the most subduction zone segments in the observed 65-85 km range for predicted CTD.

Results and conclusions are relatively robust with regards to the method used to calculate real world convergence rate (1 & 2 = plate deformation considered; 2 & 4 = only trench-normal velocities taken).

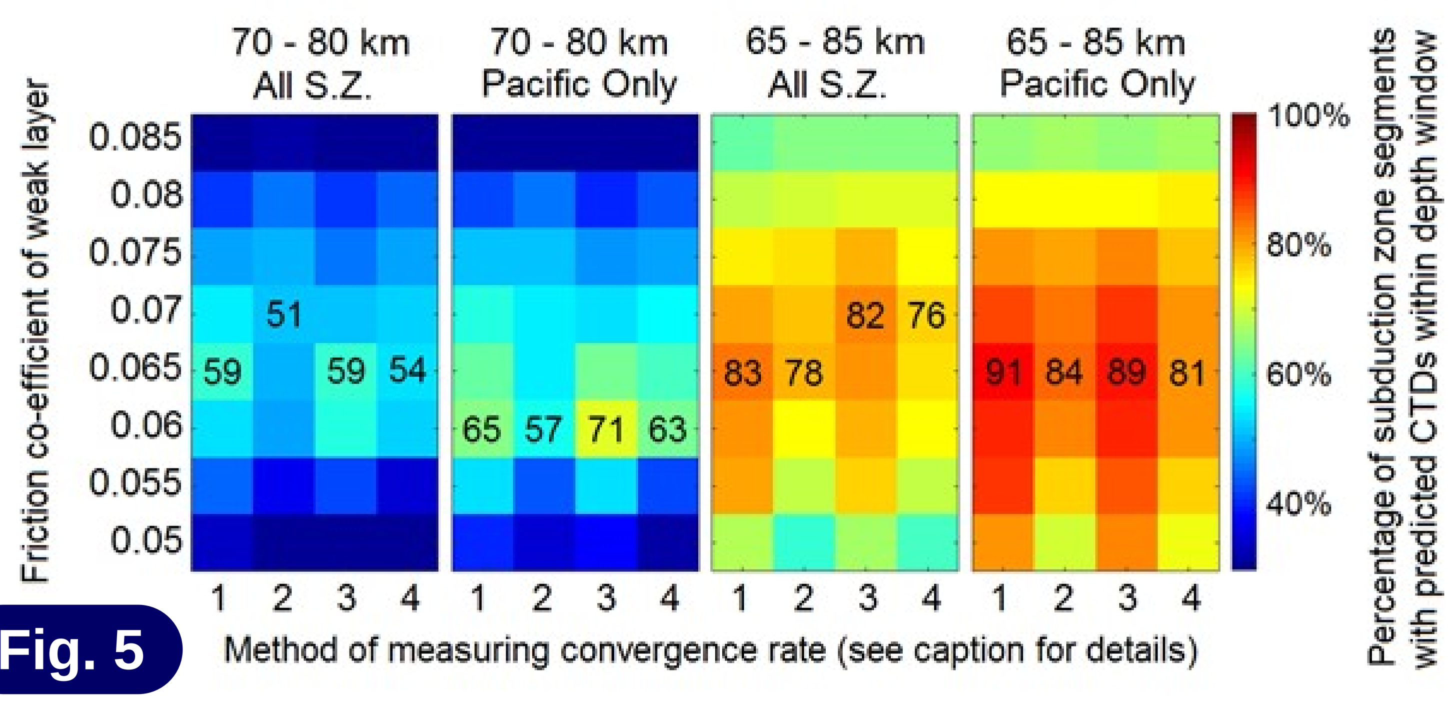


Fig. 5

Conclusions

- CTD decreases with convergence rate and increases with slab age
- However, we predict that ~90% of Pacific subduction segments have a uniform CTD of 65-85 km
- Certain subduction zones predicted to have a deep CTD **(e.g. Lesser Antilles)**