Anisotropic shear wave velocity structure in the D-double-prime layer beneath Antarctic Ocean

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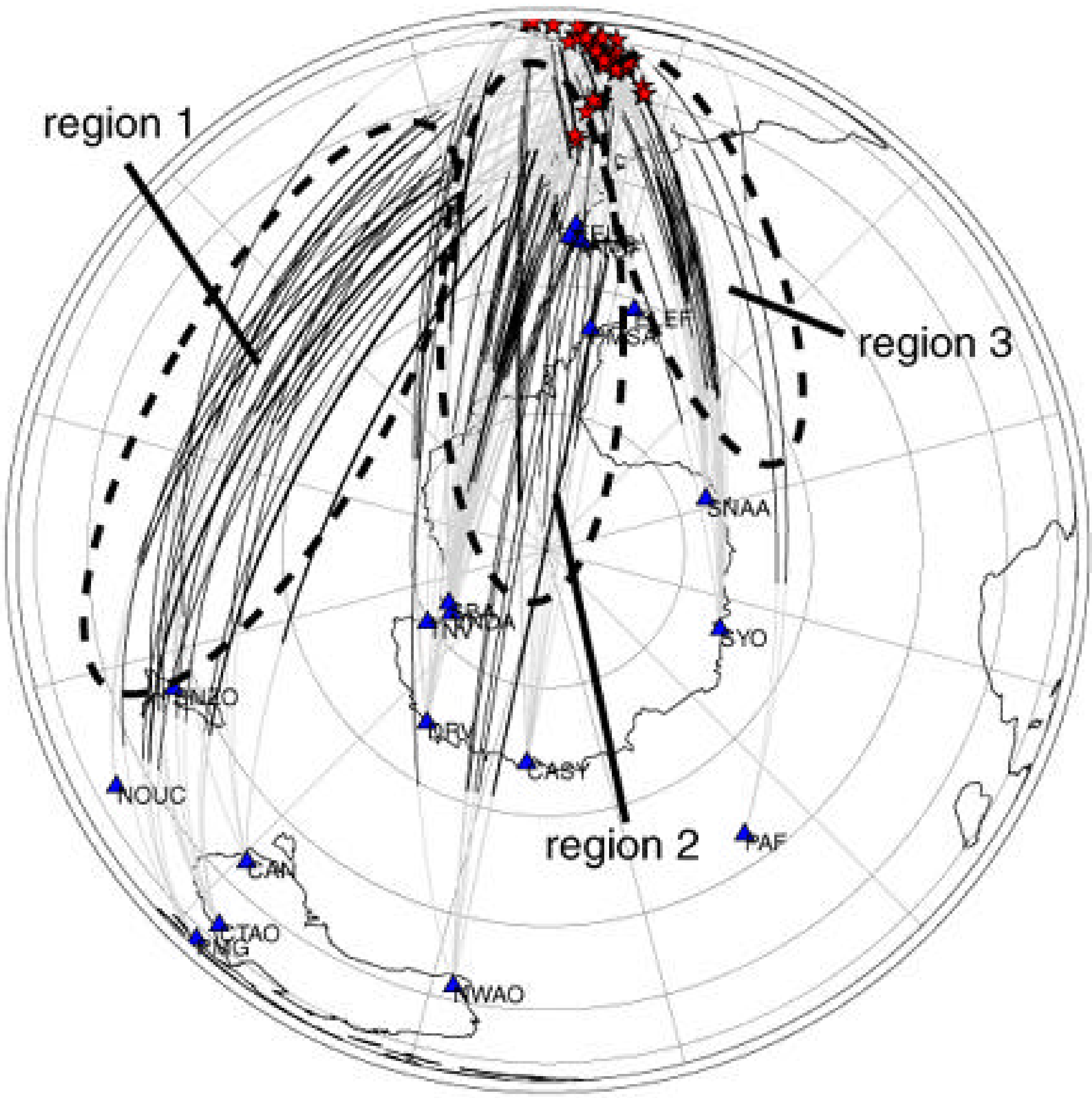
We analyze seismograms from 54 deep earthquakes in South America from 1990 to 2004 recorded by 21 broad-band seismographic stations located in New Zealand, South America, Antarctica and Australia (Figure 1) to study the anisotropy and velocity structure of shear waves in the D-double-prime layer beneath the Antarctic Ocean. Their source-receiver distances are in the range of 60-135 degree. We apply two corrections to the observed waveforms before the analysis. One is for the upper mantle anisotropy using SKS splitting parameter (Silver and Chan, 1991) and the other for the heterogeneity of the shear wave velocity in the upper- and mid-mantle mantle using the 3-D tomographic mantle shear velocity structure model S16U6L8 obtained by Liu and Dziewonski (1998). After the corrections, we rotate the waveform data of the two horizontal components to the radial (SV) and transverse (SH) components of the shear wave signals. Then times of phase onsets are read on the seismograms.

We measure SV-SH differential travel times (dTSV-SH) of ScS in the range of 60-83 degree and those of S (Sdiff) splitting of beyond 83 degree. We observe that SH component arrive earlier than SV for S, Sdiff and ScS waves passing through the high velocity regions of S16U6L8 model. In contrast, we observe VSV fast anisotropy for shear waves through the low velocity regions. A variation of dTSV-SH of 2-6 s implies that VSH is different from VSV for 1.5-4.5% in the D-double-prime layer. The region 1 is a low to high velocity transition zone from source sides to stations. As the velocity increases, the anisotropy of the D-double-prime layer changes VSV fast to VSH fast. Such a variation was reported in the Atlantic Ocean (Garnero and Lay, 2003). A large-scale lateral variation in anisotropy suggests the existence of different type of anisotropy in the D-double-prime layer. The regions 2 and 3 correspond to the high velocity regions at the CMB. We generally observe VSH fast anisotropy, while there is small-scale heterogeneity (a few hundred km) in these region.

The SV-SH differential travel times mentioned above indicate the existence of the shear wave velocity anisotropy in the D-double-prime layer beneath the Antarctic Ocean. In this study, we use differential travel times and waveforms to constrain the anisotropic velocity structure in the lowermost mantle beneath the Antarctic Ocean. We calculate synthetic waveforms using the Direct Solution Method (DSM: Takeuchi et al, 1996). PREM (Dziewonski and Anderson, 1981) and SP6 (Morelli and Dziewonski, 1993) are adopted as reference models. SH waveforms show D-double-prime reflector (SdS) between S and ScS at 65-92 degree in Region 2 and 3. We also observe sSdS phase between sS and sScS at the same range. We perform waveform modeling and the differential travel time analysis among S, ScS and SKS phases to explain the observations. Although trade-off exist in the depth of D-double-prime discontinuity, the degrees of velocity jump and D-double-prime anisotropy, we consider that the D-double-prime layer in the region 2 and 3 has 1.5-3.0% velocity discontinuity at the depth of 2600(+/-)50km.

The thick D-double-prime layer beneath the Antarctic Ocean can be possibly attributed to subducted material which started ~150 Ma (Richards and Engebreston, 1992). Since this study region is older subduction than Alaska and Caribbean Sea, we consider that the paleo-slab constitutes the thick D-double-prime layer and develops LPO transverse isotropy due to shear strain in the D-double-prime layer.



region 1
region 3
region 2
SNAA
SYO
CASY
NOUC
PAF
SNZO
CTAO
NWAO