3D-SCS: Three-dimensional lithospheric-scale structural and density model of the South China Sea

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1. Licence

2. Citation

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The data are supplementary material to:

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3. Data Description

3.1. Abstract

We present a comprehensive 3D lithospheric-scale model of the South China Sea region (SCS), which reveals the structural configuration of the area. This model delineates seven distinct geological units: (1) seawater, (2) sedimentary cover, (3) continental crystalline crust, (4) oceanic crust, (5) upper lithospheric mantle, (6) lower lithospheric mantle, and (7) sub-lithospheric mantle. The model covers an area of 960 km × 1260 km and reach down to a depth of 250 km. It is provided as uniformly spaced grids with 10 km intervals for each unit. The geometries and density distributions within the crust have been compiled and interpolated from a variety of datasets, predominantly seismic data (see section 6). To eliminate boundary effects, the model boundaries have been extended by more than 500 km in all horizontal directions, incorporating additional constraining data from the extended region. Additionally, we provide gridded gravity field data, a density voxel cube for the sub-lithospheric mantle, and relevant tomography data. Notably, the density of the lower lithospheric mantle was derived from 3D gravity inversion modeling.

3.2. Model area

Model coordinates are given in UTM map projection (UTM Zone 50N)
Datum: World Geodetic System 1984
Unit: m

Model bounds in UTM_Zone_50N:
Easting: from -120000 m to 840000 m
Northing: from 1060000 m to 2320000 m

Model bounds in longitude/latitude (WGS 84):
Longitude: from 111.1°E to 120.3°E
Latitude: from 9.5°N to 20.9°N

Extended model bounds in UTM_Zone_50N:
Easting: from -1130000 m to 1750000 m
Northing: from 0 m to 3360000 m

4. Methods

Topography and bathymetry data were obtained from the ETOPO_2022 dataset (NOAA National Centers for Environmental Information, 2022). Then, we integrated reflection and refraction seismic profiles (Table 1 and 2) to constrain the sediment base and the Moho interface, and where seismic profiles were lacking, we used a global crustal model-ECM1 (Mooney et al., 2023) to fill gaps.

To derive sediment thickness from Multi-Channel Seismic (MCS) reflection data (as listed in Table 1, section 6), the two-way travel time (TWT) was converted to depth below the seafloor using specific time-depth conversion formulas (Table 3). For the Moho interface, the TWT within the crystalline crust layer is converted to depth below sediment basement by using the time-depth relationship established by Huang et al. (2023) (Table 3), which is based on velocity-depth profiles from seismic refraction data in the SCS. Additionally, the Ocean Bottom Seismometer (OBS) refraction data (Table 2), presented in depth terms, were extracted directly through digitization. For the upper mantle, we converted the Vs tomography data of Tang & Zheng (2013) into mantle temperature using the method of Priestley & McKenzie (2006) and defined the depth of the 1300°C isotherm as the Lithosphere-Asthenosphere Boundary (LAB).

To enhance the gravity response of our 3D density models, we referenced the free-air gravity disturbance at an altitude of 6 km above sea level, as derived from the EIGEN-6C4 model (Förste et al., 2014; Ince et al., 2019), a global gravity model that combines satellite and terrestrial data sources. We selected a height of 6 km that is above the highest topographical point of the model in order to ensure that all gravity observations are outside the subsurface space of relevant mass variations.

5. File description

5.1. File inventory

Files are subdivided into five categories:

1. Structural interface and density
2. Gravity data
3. Density for the lower lithospheric mantle
4. Density voxel cube for the sub-lithospheric mantle
5. Tomography data

5.1.1. Structural interface files and density for each unit

There are seven structural interface files that correspond to the top surfaces of 7 model layers:

Filename	Layer	Layer density (kg/m^3)
2024-031_Yan_01_top_water.xyz	water	1030
2024-031_Yan_02_top_sediment.xyz	sediment	2400
2024-031_Yan_03_top_oceanic_crust.xyz	oceanic crust	2900
2024-031_Yan_04_top_continent_crust.xyz	continent crust	2800
2024-031_Yan_05_top_upper_lithos_mantle.xyz	upper lithospheric mantle	3300
2024-031_Yan_06_top_lower_lithos_mantle.xyz	lower lithospheric mantle	3300*
2024-031_Yan_07_top_sublithos_mantle.xyz	sub-lithospheric mantle	Voxel cube#

**Density values for the lower lithospheric mantle are given for reference, the actual density distribution for the lower lithospheric mantle is represented by the file 2024-031_Yan_D_lower_lithospheric_mantle.xyz*

#The actual 3D density distribution in sub-lithospheric mantle is represented by the file 2024-031_Yan_D_Tang_Zheng_20-250km.vxo

5.1.2. Gravity data file

There is 1 gravity data file: 2024-031_Yan_G_EIGEN-6C4_10km_disturbance_6km.xyz

5.1.3. Density file for lower lithospheric mantle

There is 1 density file for lower lithospheric mantle: 024_001_Yan_D_lower_lithospheric_mantle.xyz

5.1.4. Density voxel cube file for the sub-lithospheric mantle below the LAB

There is 1 density voxel cube file: 2024-031_Yan_D_Tang_Zheng_20-250km.vxo

5.1.5. Tomography data file

There is 1 tomography file with information on the shear-wave velocity distribution: 2024-031_Yan_Vs_Tang_Zheng.xyz

6. Tables of seismic data

Table 1. Published MCS profiles

Name of Seismic Lines in reference	Type	Location	Available information	Reference
L1, 2, 3, 4, 5	MCS	NW Margin	Basement, Moho	Gao et al. (2016)
11e882, 11e005, 11e115, 06e286, 11e335	MCS	NW Margin	Basement, Moho	Lei & Ren, (2016)
L5, 6, 8	MCS	NW Margin	Basement, Moho	Lei et al. (2020)
Fig.4, 5, 6, 7, 8	MCS	NW Margin	Basement	Mao et al. (2015)
Fig.2	MCS	NW Margin	Basement, Moho	Wang et al. (2020)
L1, L2, L3	MCS	NW Margin	Basement	Zhao et al. (2018a)
Line 1	MCS	NW Margin	Basement, Moho	Zhao et al. (2018b)
L1, 2, 3, 4, 5	MCS	NW Margin	Basement, Moho	Qiu et al. (2014)
fig.17, 18	MCS	Northern Margin	Basement, Moho	Zhang et al. (2016)
XX’	MCS	Northern Margin	Basement, Moho	Deng et al. (2020)
Fig.9	MCS	Northern Margin	Basement	Ding et al. (2013)
L1, 2, 3, 4	MCS	Northern Margin	Basement, Moho	Gao et al. (2015)
S1, 2, 3	MCS	Northern Margin	Basement	Guo et al. (2016a)
L4, 6, 8	MCS	Northern Margin	Basement, Moho	Hu et al. (2009)
L5, 6	MCS	NE Margin	Basement	Lei et al. (2018)
ZJK2012-1-2	MCS	Northern Margin	Basement, Moho	Lei et al. (2019a)
ZJK2012-3	MCS	NE Margin	Basement	Lei et al. (2019b)
L1, 2, 4	MCS	Northern Margin	Basement	Leyla et al. (2015)
Fig.5	MCS	Northern Margin	Basement, Moho	Li et al. (2022)
S1, 2, 3	MCS	Northern Margin	Basement	Sun et al. (2014a)
Fig.10	MCS	NE Margin	Basement	Wu et al. (2014)
AB; CD	MCS	Northern Margin	Basement	Xie et al. (2019)
L3, 8	MCS	Northern Margin	Basement	Xie et al. (2021)
Fig.2	MCS	Northern Margin	Basement, Moho	Zhang et al. (2021)
AA’, CC’, EE’, GG’	MCS	Northern Margin	Basement, Moho	Zhao et al. (2020a)
Fig.1e, 1d	MCS	Northern Margin	Basement	Zhao et al. (2020b)
P1, 2, 3	MCS	Northern Margin	Basement	Zhu et al. (2012)
Line 01, 02, 03	MCS	Northern Margin	Basement	Dong et al. (2008)
BB’	MCS	Northern Margin	Basement	Sun et al. (2014b)
MCS693-6, 693-4, 693-3, 693-1, 689-3a, 689-4	MCS	NE Margin	Basement	Ku & Hsu, (2009)
973G	MCS	NE Margin	Basement	Li et al. (2007)
A, B, E	MCS	NE Margin	Basement	Li et al. (2008)
T1, T2, T3	MCS	NE Margin	Basement, Moho	Wen et al. (2021)
MCS645-4, 645-3, 645-2, 645-1, 689-1, 689-4b, 689-3a, ACT111, ACT110, 108, 105, 099a, 103, 101,	MCS	NE Margin	Basement	Yeh & Hsu, (2004)
MGL0905-04, 0905-05, 0905-25A, 0908-04	MCS	NE Margin	Basement, Moho	Yeh et al. (2012)

Line1, 2	MCS	NW Margin	Basement	Gao et al. (2023)
SO27-04	MCS	SW Margin	Basement	Ding et al. (2013)
NH973-2	MCS	S Margin	Basement	Ding et al. (2014)
DPS93-2	MCS	S Margin	Basement	Ding et al. (2015)
BGR01-01, 01-02, 01-10, 01-06, 01-07	MCS, OBS (01-07)	SW Margin	Basement, Moho (01-07)	Franke et al. (2008)
BGR08-104, 08-109	MCS	SE Margin	Basement, Moho	Franke et al. (2011)
AB, CD, ST, QR, EF, GH, KL, YZ,	MCS	SW Margin	Basement	Hutchison, (2010)
L1, 2, 3, 4, 5, 6, 7, 8	MCS	SW Margin	Basement	Peng et al. (2019)
S1, S2	MCS	SE Margin	Basement, Moho	Peng et al. (2020)
Fig.3, 4a, 4b, 6	MCS	SW Margin	Basement, Moho (4a, 4b)	Steuer et al. (2014)
Fig.4, 5, 6, 7A, 7B, 8	MCS	SE Margin	Basement, Moho (6, 7A, 7B, 8)	Tong et al. (2019)
L1, 2, 3	MCS	S Margin	Basement	Wang et al. (2022)
AA’	MCS	S Margin	Basement	Xu et al. (2019)
DZ02	MCS	SW Margin	Basement	Zhang J-L et al. (2020)
M17B	MCS	S Margin	Basement, Moho	Zhang Y-X et al. (2020)
90N09, 94N07	MCS	S Margin	Basement	Sun et al. (2011)
HYML320, HYM390, HYM1010	MCS	ESB	Basement	Zhao et al. (2022)
CGN-1	MCS	NWSB	Basement, Moho	Chao et al. (2021)
Line A, B, C, D, E, F, G	MCS	NWSB	Basement, Moho	Chao et al. (2022)
nw1, nw2, nw3	MCS	NWSB	Basement	Song et al. (2019)
SO49-17, SO49-18, SO49-25, 97303	MCS	NWSB	Basement	Wu et al. (2020)
Line7, 9	MCS	SWSB, ESB	Basement	Cao et al. (2017)
CFT-N	MCS	NW Margin, SWSB	Basement, Moho	Chang et al. (2022)
N3, 7, 10, 16, 973-1	MCS	SWSB	Basement	Ding et al. (2016)
Line A, B	MCS	SWSB	Basement, Moho (A)	Luo et al. (2021)
Line PKGE 09_09, PKBE 09_08, PKI09_11, PKG09_03, PKG09_09, PKBE09 08_57	MCS	NW Margin	Basement, Moho	Savva et al. (2013)
SO49-22, SO49-23	MCS	SWSB	Basement	Wu et al. (2018)
Z1	MCS	SWSB	Basement	Wang et al. (2021)
N3, N4	MCS	ESB	Basement, Moho	Ding et al. (2018)
N2	MCS	NE Margin	Basement, Moho	Ding et al. (2020)
BC, DE, FG	MCS	ESB	Basement	Li et al. (2008)

Note: *MCS, Multi-channel Seismic; OBS, Ocean Bottom Seismometer; ESB, East Sub-basin; NWSB, Northwest Sub-basin; SWSB, Southwest Sub-basin*

Table 2. Published OBS profiles

Name of Seismic Lines in reference	Location	Available information	Reference
ESP-W	NW margin	Basement, Moho	Nissen et al. (1995)
OBH-IV	NW margin	Basement, Moho	Qiu et al. (2001)
OBS2006-1	NW margin	Basement, Moho	Wu et al. (2012)
OBS2006-2	NW margin	Basement, Moho	Wang et al. (2020)
OBS2011-1	NW margin	Basement, Moho	Huang et al. (2019)
OBS2013-1	NW margin	Basement, Moho	Huang et al. (2021)
OBS2013-3	NW margin	Basement, Moho	Guo et al. (2016b)
OBS2017-2	NW margin	Basement, Moho	Li et al. (2021)
OBS2011-2	NW margin	Basement, Moho	Xia et al. (2022)
OBS2010-1	NE margin	Basement, Moho	Cao et al. (2014)
OBS2010-2	NE margin	Basement, Moho	Zhu et al. (2018)
L2 & OBS2015-3D	NE margin	Basement, Moho	Lv et al. (2020)
OBS1993	NE margin	Basement, Moho	Yan et al. (2001)
OBS2006-3	NE margin	Basement, Moho	Wei et al. (2011)
OBS2001	NE margin	Basement, Moho	Wang et al. (2006)
T3	NE margin	Basement, Moho	Lester et al., (2014)
MGL0905_10 & MGL0908_3	NE margin	Basement, Moho	McIntosh et al. (2014)
OBS2012	NE margin	Basement, Moho	Wan et al. (2017)
OBS2014-3D (NS5, NS7, NS8)	NE margin	Basement, Moho	Fan et al., (2019)
OBS2015-1	NE margin	Basement, Moho	Li et al. (2017)
OBS2016-2	NE margin	Basement, Moho	Wan et al. (2019)
OBS2019-1	NE margin	Basement, Moho	Liu et al. (2021)
MGL0905_27	MT	Basement, Moho	Lester et al. (2013)
Line T1 (MGL0905_25A) & Line T2 (MGL0902_23)	MT	Basement, Moho	Eakin et al. (2014)
T4A & T2933	MT	Basement, Moho	McIntosh et al. (2013)
OBS2015-2	MT	Basement, Moho	Liu et al. (2018)
OBS973-1	South margin	Basement, Moho	Qiu et al. (2011)
OBS973-2	South margin	Basement, Moho	Ruan et al. (2011)
PR1 & PR2	NW/South margin, SWSB	Basement, Moho	Pichot et al. (2014)
DZ01	SW margin	Basement, Moho	Wei et al. (2020)
OBS2010-3D-T1	ESB	Basement, Moho	Zhang J et al. (2020)
OBS2011-3D-P4	ESB	Basement, Moho	Zhao et al. (2018)
OBS2013-ZN, OBS2014-ZN	ESB	Basement, Moho	Ruan et al. (2016)

Table 3. Time-to-depth conversion information for MCS reflection data.

Strata	Region	Time to depth formula	Unit (t, z)	Reference
Sedimentary	ESB	$z = 0.000188295\ t^2 + 0.695896\ t$	ms, m b.s.f[a]	Li et al. (2015)
Sedimentary	SWSB	$z = 0.000152626\ t^2 + 0.714658\ t$	ms, m b.s.f	Li et al. (2015)
Sedimentary	NWSB	$z = 0.0003\ t^2 + 0.7155\ t - 2.4959$	ms, m b.s.f	Sun et al. (2018)
Sedimentary	Continental Margin	$z = 946\ t^{1.447} + 124$	s, m b.s.f	Zhou et al. (2008)
Crystalline crust	SCS	$z = 0.1801t^2+2.8533t–0.5807$	ms, km b.s.b[b]	Huang et al. (2023)

a: *b.s.f, below seafloor;* ***b:*** *b.s.b, below sediment basement.*

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