Constraining mantle volatiles in Fiordland and Puysegur with an MT experiment

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Mini-Workshop for the South Island,
New Zealand Primary Site coordination

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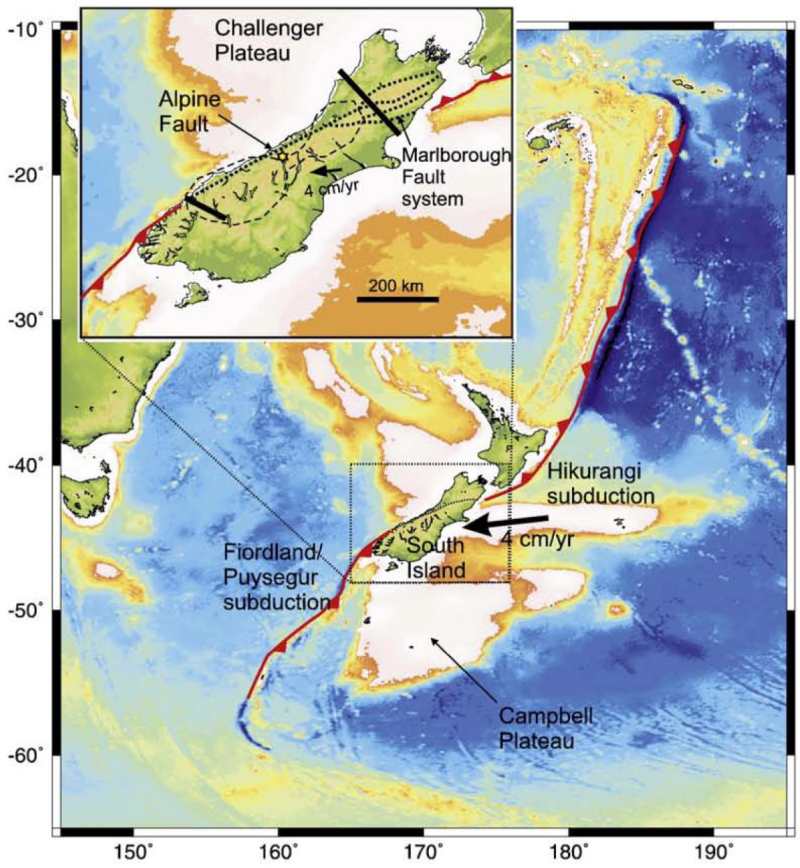
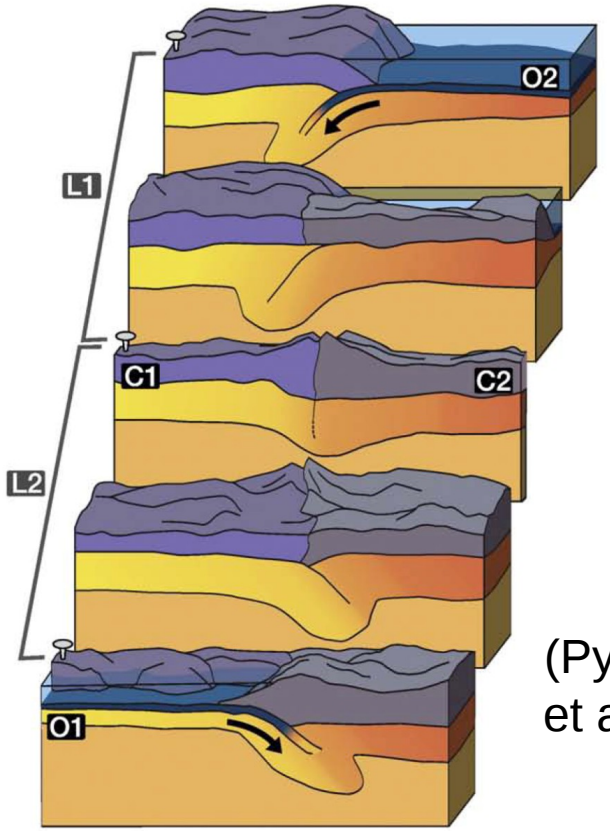
THE UNIVERSITY OF UTAH

DEPARTMENT OF MATHEMATICS
COLLEGE OF SCIENCE | THE UNIVERSITY OF UTAH

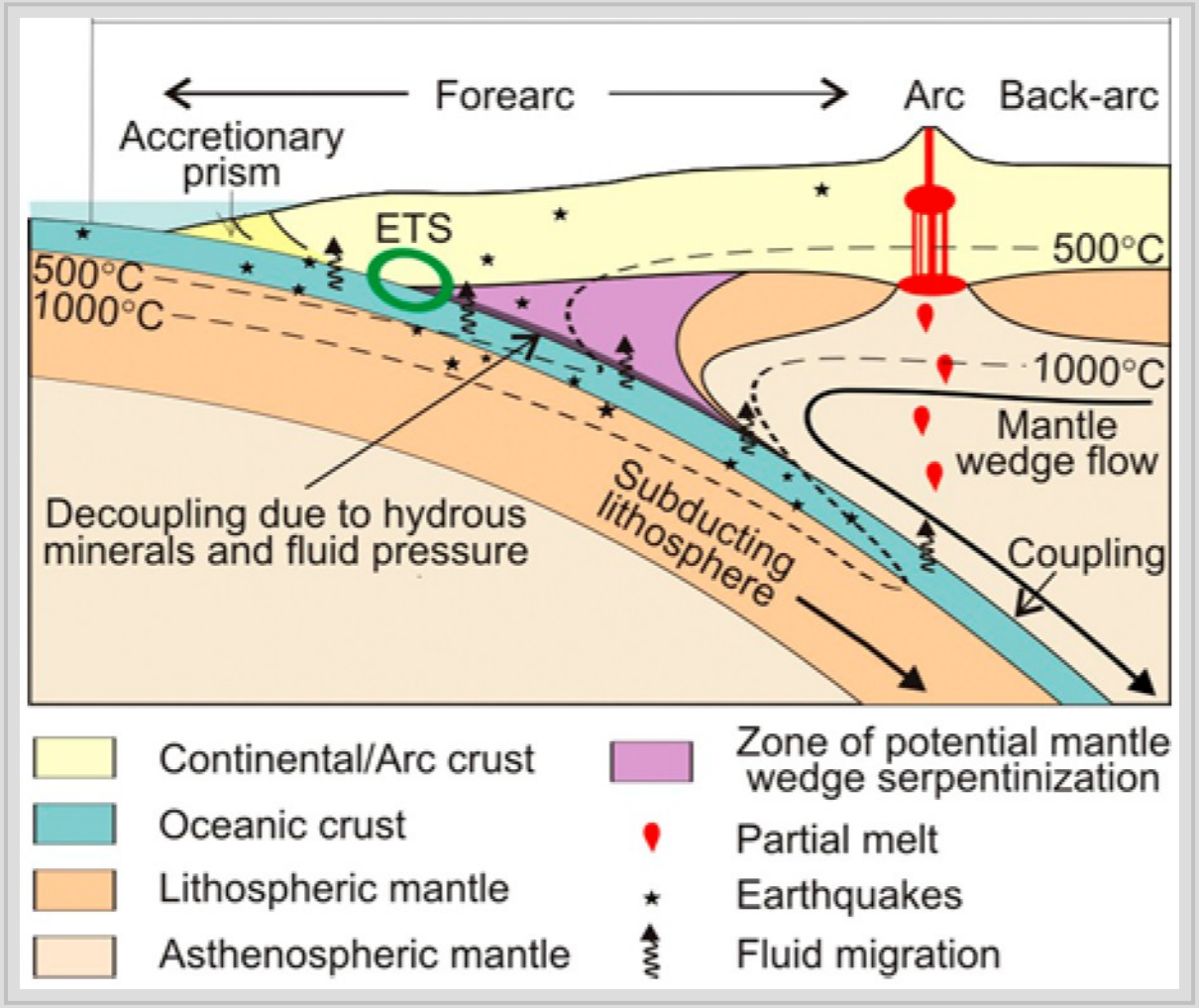




(Pysklywec et al., 2010)

New Zealand: A Subduction Scissor

- Highly oblique convergence has induced opposing subduction zones
- Puysegur/Fiordland subduction incipient with solitary arc volcano (Sol. Is)
- Ideal to study initiation of plate eclogitization, hot mantle wedge process

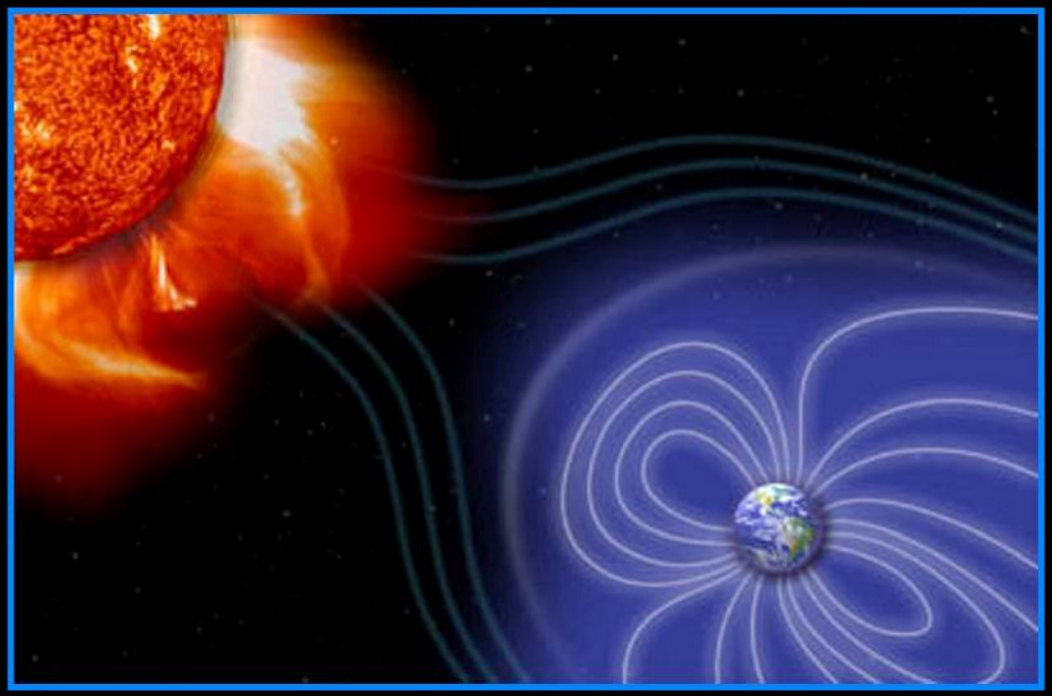


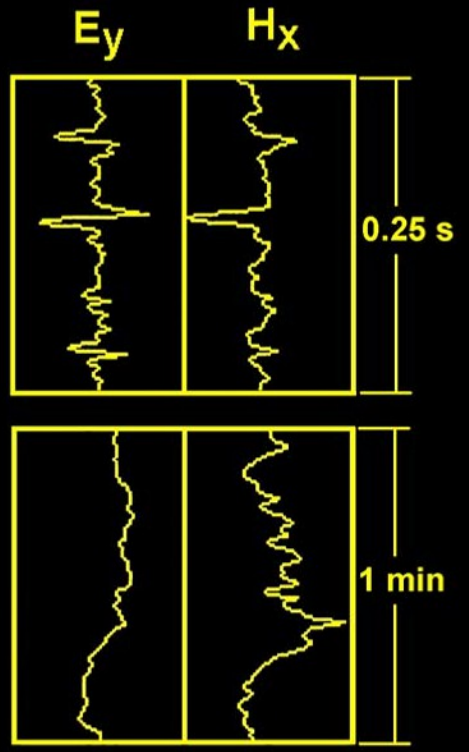
(Wada and Wang, 2009)

Mature Subduction: Fluids, Melting and Thermal Regime

- Classic 2D view at depth exhibits subducted hydrous mineral breakdown, circulating high-T mantle wedge, subduction fluid flux melting to form arc
- Unclear when these processes develop during subduction initiation

Source Fields for the Magnetotelluric Method

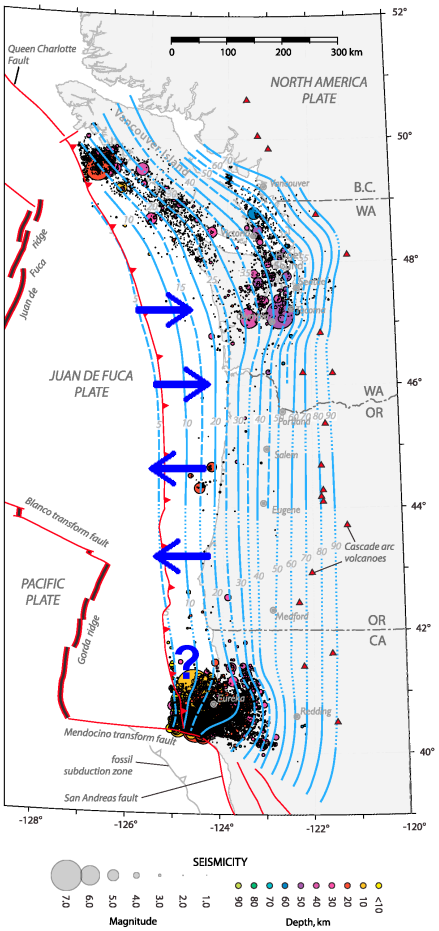


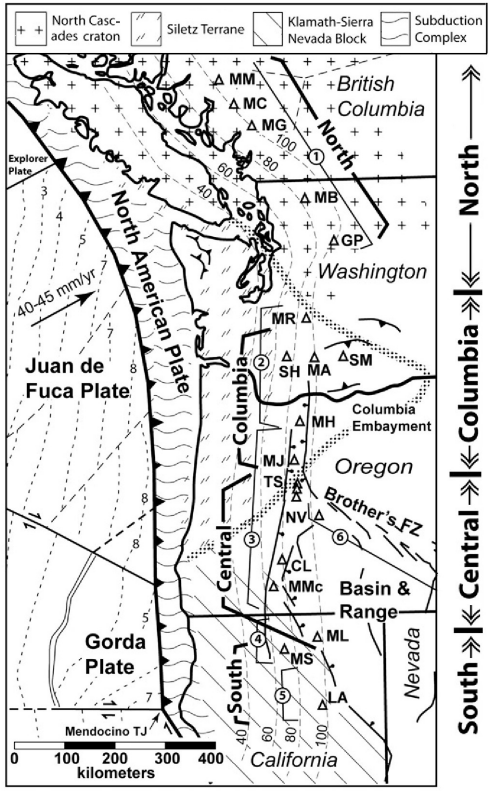


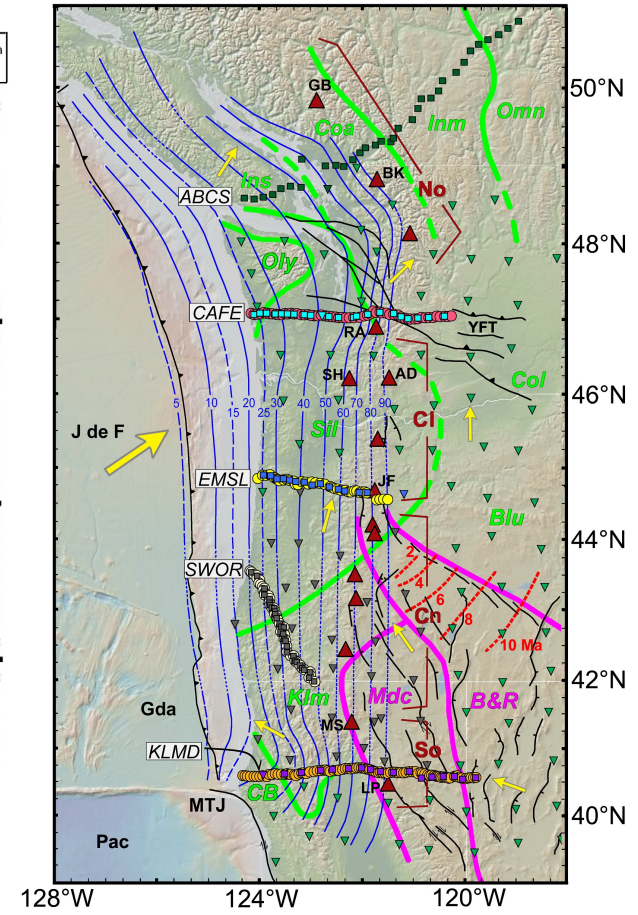
Regional and Global Lightning Activity for f > 1 Hz
Solar Wind-Magnetospheric Interactions for f < 1 Hz

ETS Segments (Brudzinski and James, 2007)

Transect MT (Wannamaker et al, 2014)



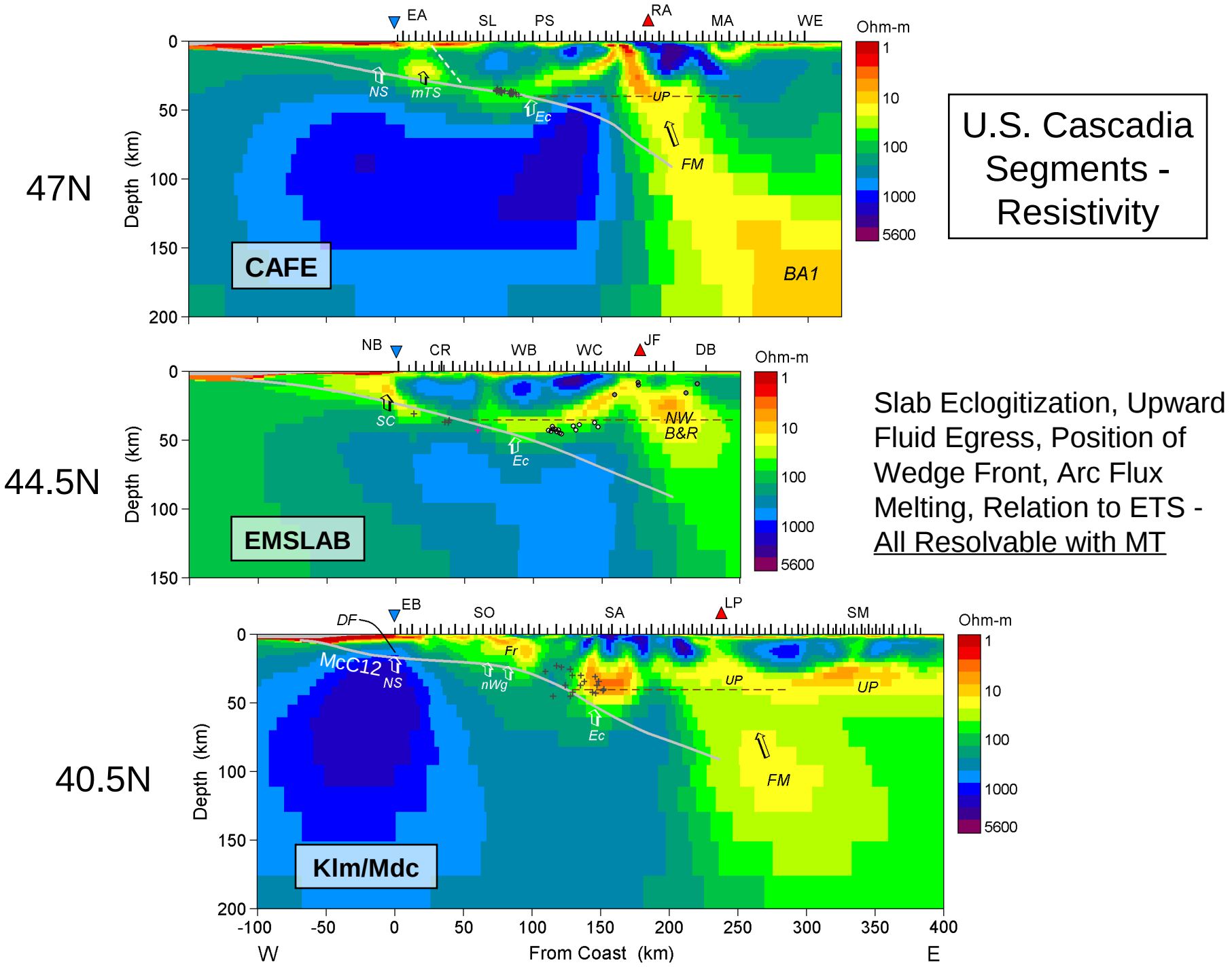


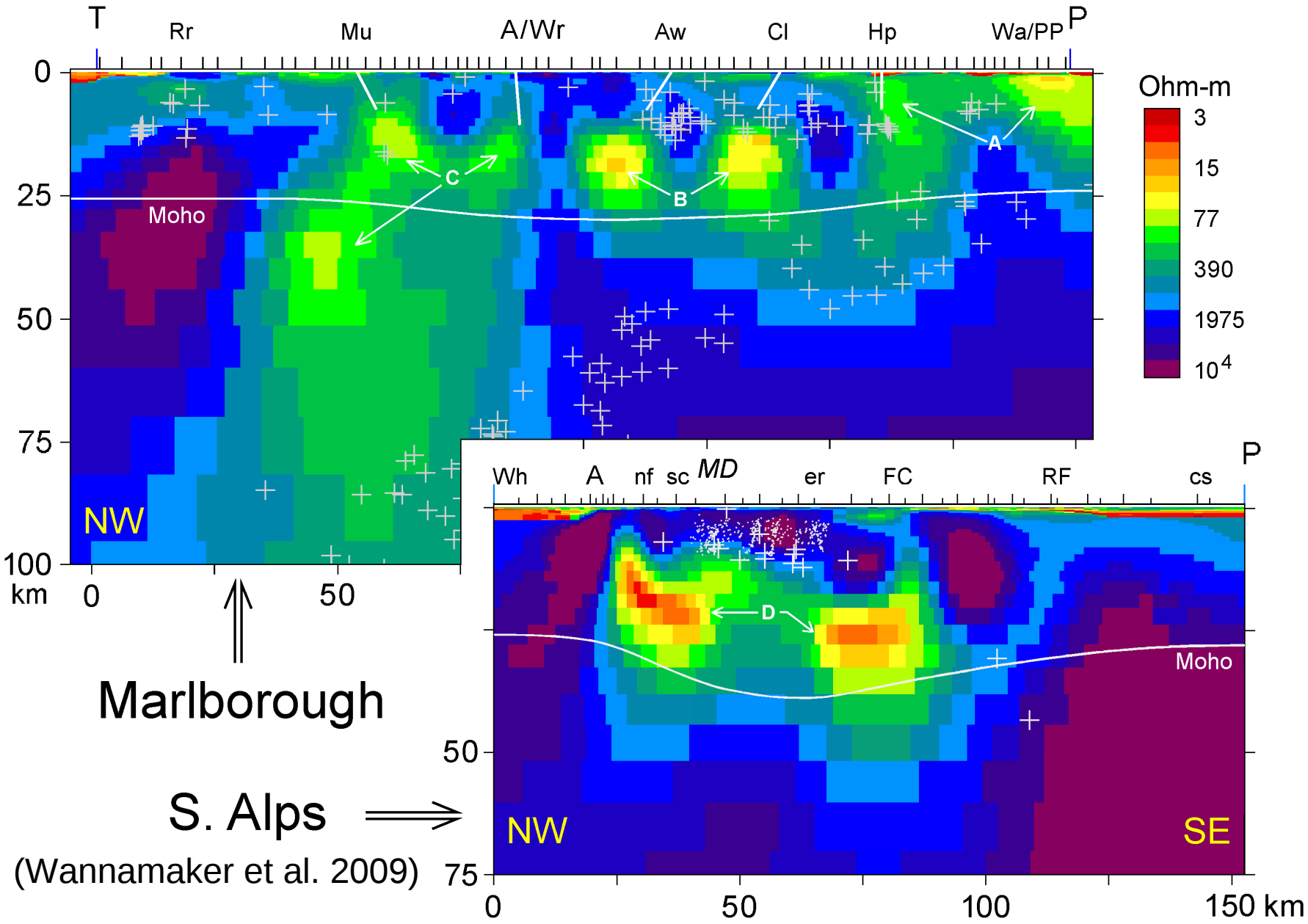


Arc Magma Segments (Schmidt et al, 2008)

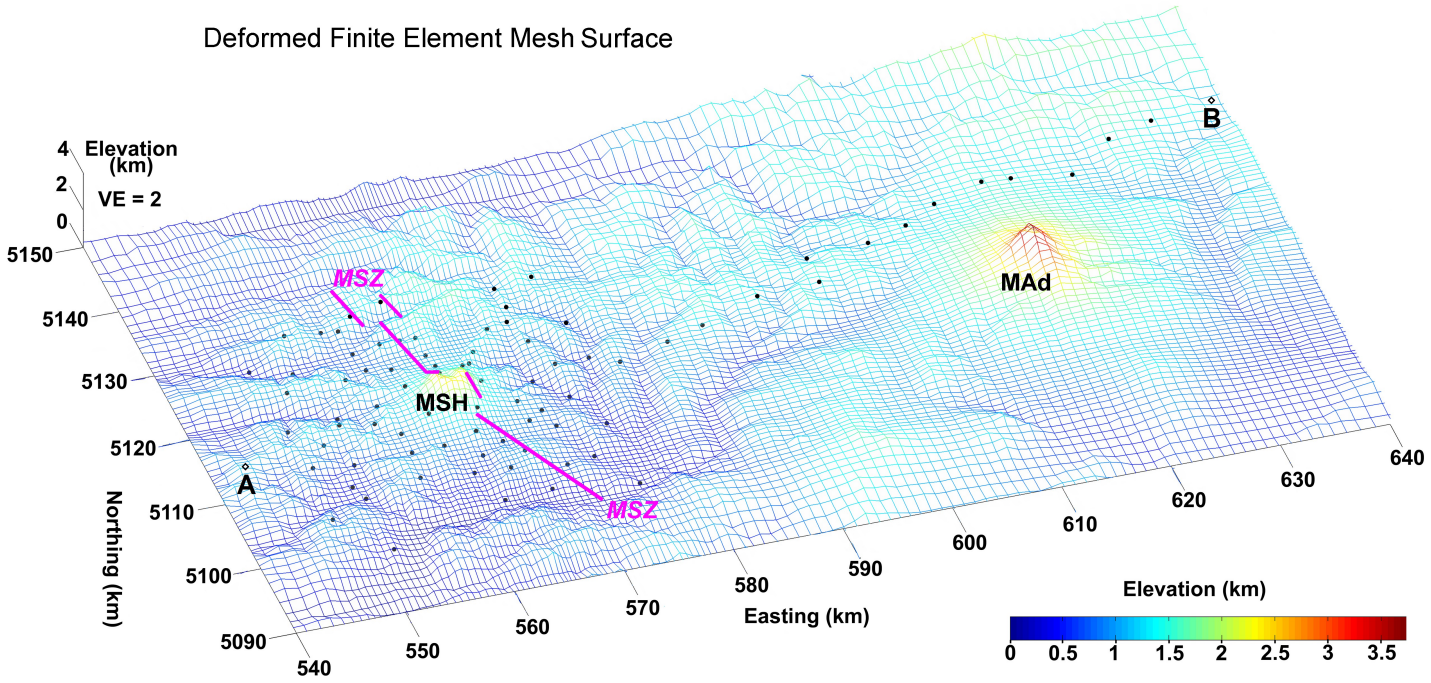
Slab Depth Contours & Prism Thrust Verg. (McCrory et al, 2012; Gulich et al, 1998)

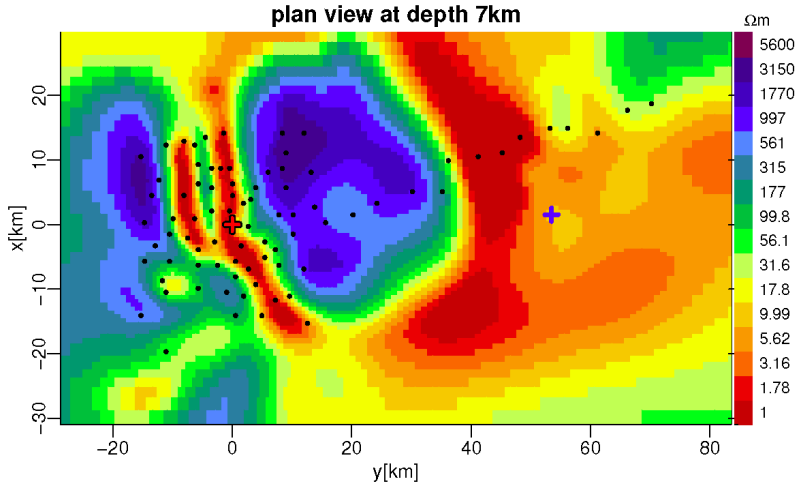
Segmentation of Seismicity, Plate Locking, ETS, and Arc Magmatism in Cascadia Investigated with MT

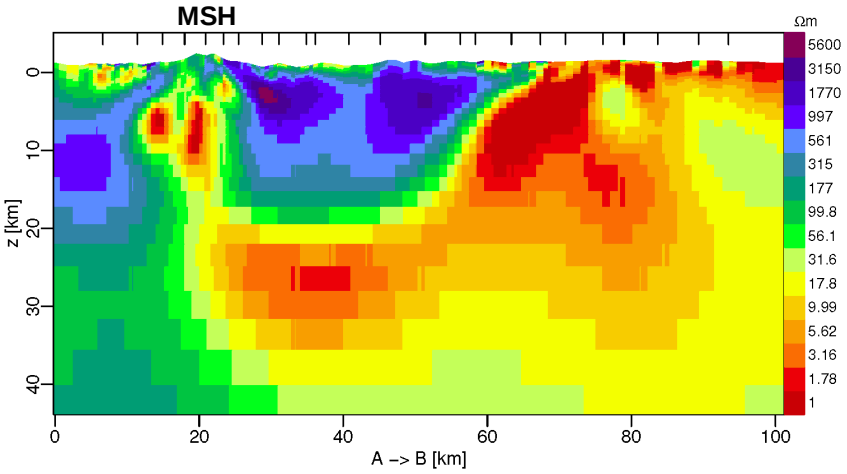

47N
EA
SL
PS
RA
MA
WE
Ohm-m
1
10
100
1000
5600
Depth (km)
0
50
100
150
200
NS
mTS
Ec
UP
FM
CAFE
BA1
U.S. Cascadia Segments - Resistivity
44.5N
NB
CR
WB
WC
JF
DB
SC
NW B&R
EMSLAB
Slab Eclogitization, Upward Fluid Egress, Position of Wedge Front, Arc Flux Melting, Relation to ETS - All Resolvable with MT
40.5N
EB
SO
SA
LP
SM
DF
McC12
Fr
nWg
Klm/Mdc
-100
-50
0
50
100
150
200
250
300
350
400
W
From Coast (km)
E



Crustal-Scale Fluid Evolution and Transport in Transpression

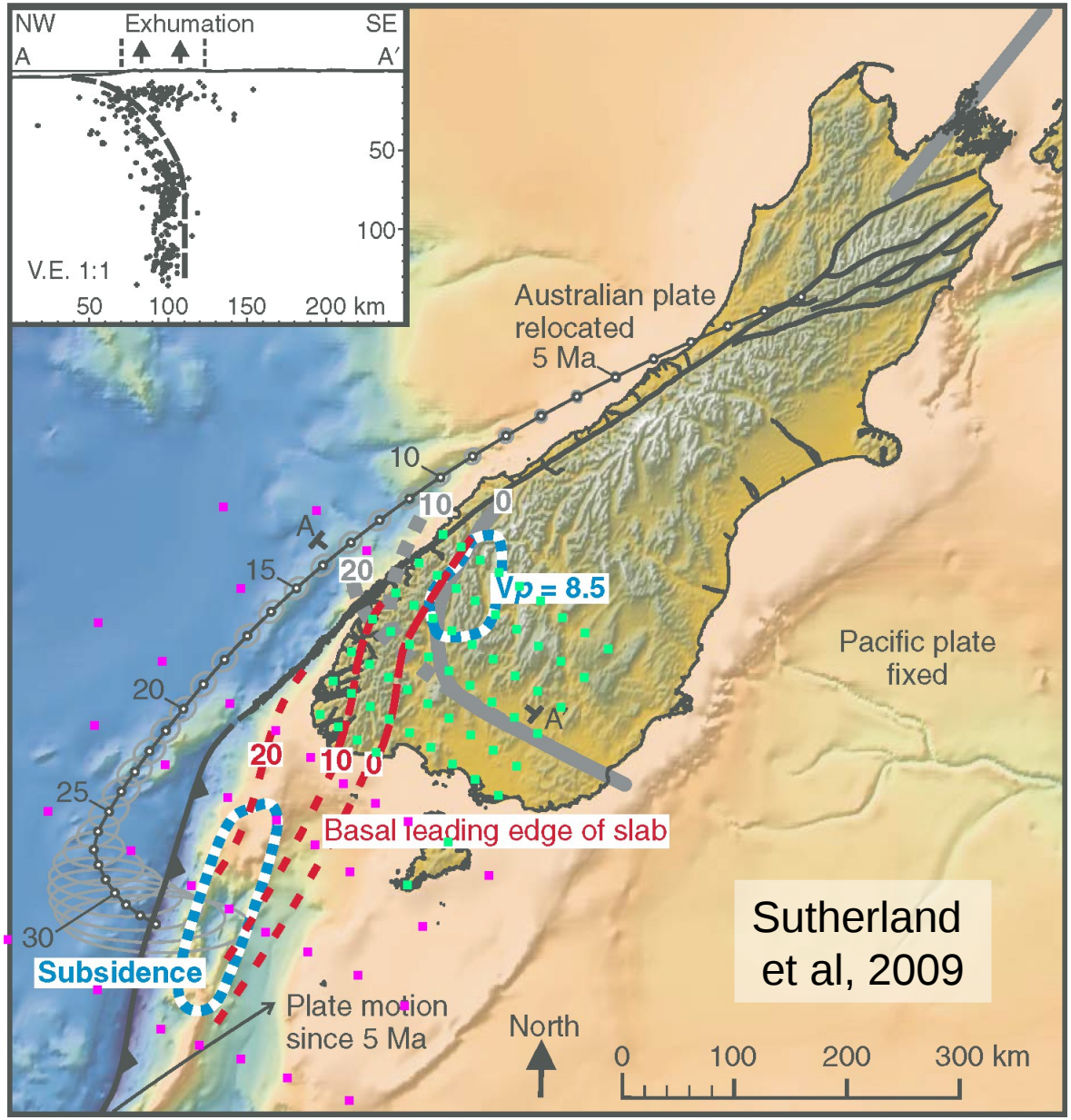




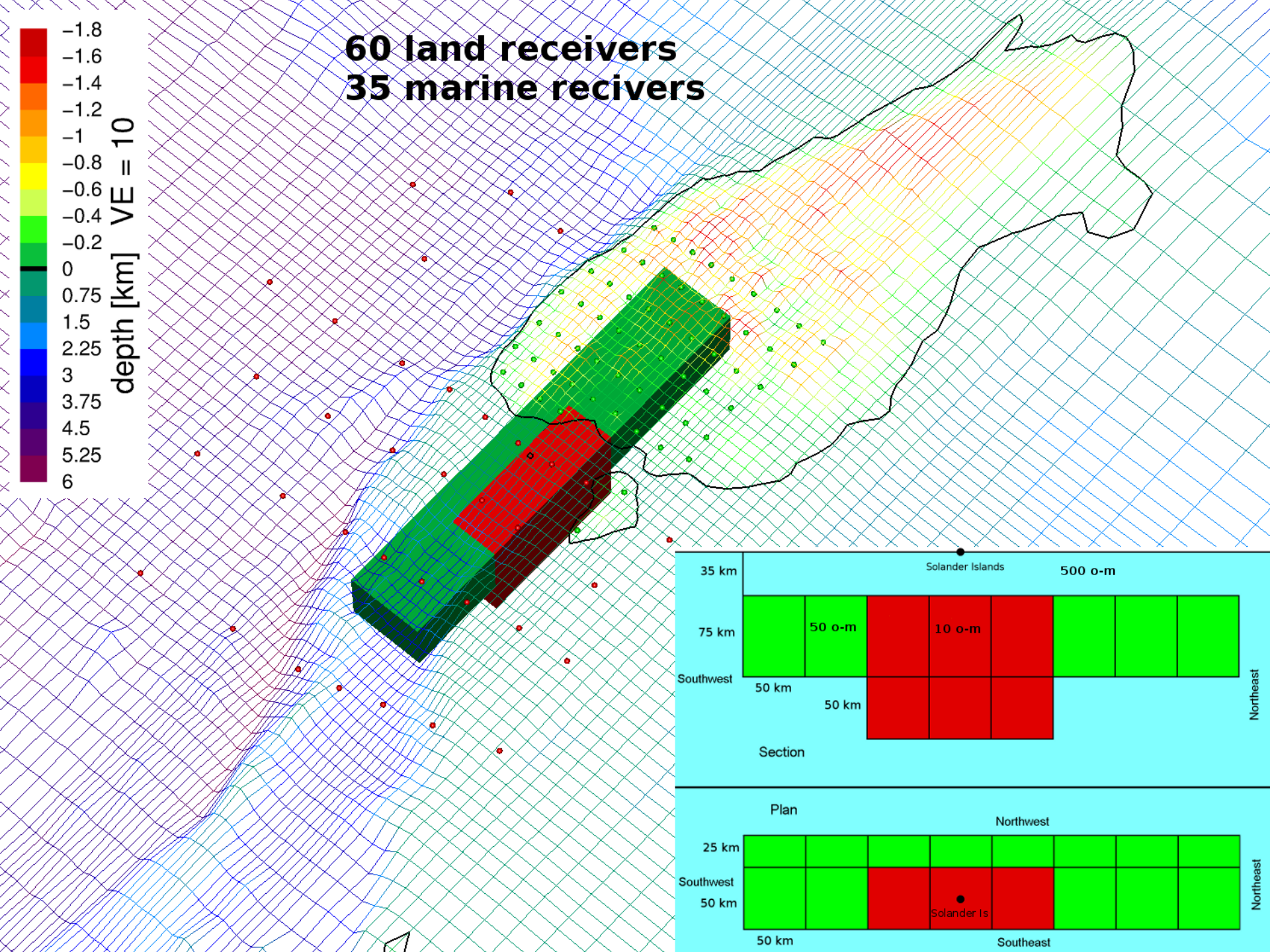


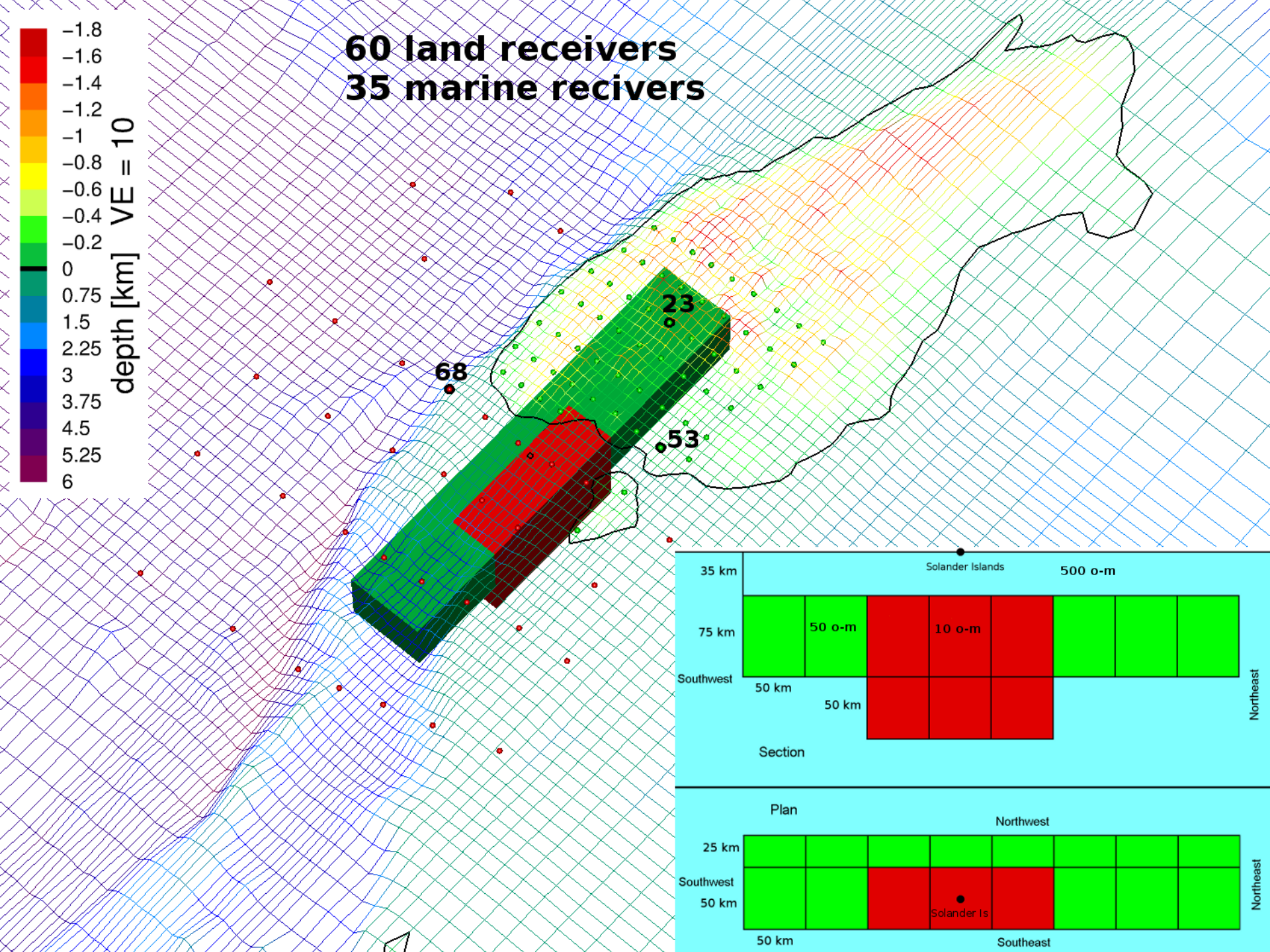
Plan and Section Views Through 3D MT Inversion of Mt St Helens Data

Produced using Deformable Edge Finite Element Algorithm (Kordy, Wannamaker, et al., 2014)



Potential MT Station Distribution, Puysegur-Fiordland


60 land receivers
35 marine recivers
depth [km] VE = 10
−1.8
−1.6
−1.4
−1.2
−1
−0.8
−0.6
−0.4
−0.2
0
0.75
1.5
2.25
3
3.75
4.5
5.25
6
Solander Islands
500 o-m
35 km
75 km
50 o-m
10 o-m
Southwest
50 km
50 km
Northeast
Section
Plan
Northwest
25 km
Southwest
50 km
Solander Is
50 km
Southeast
Northeast


60 land receivers
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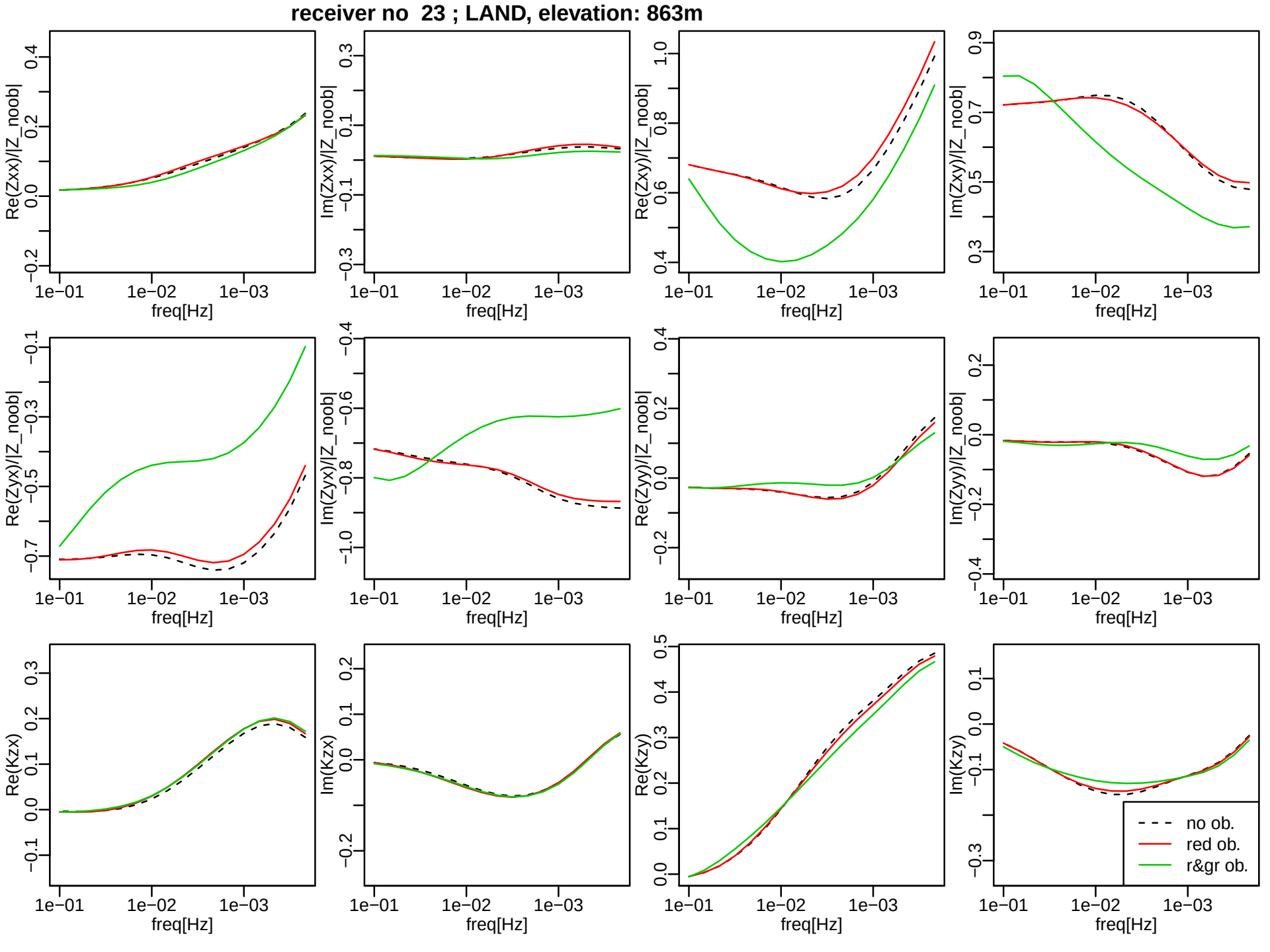
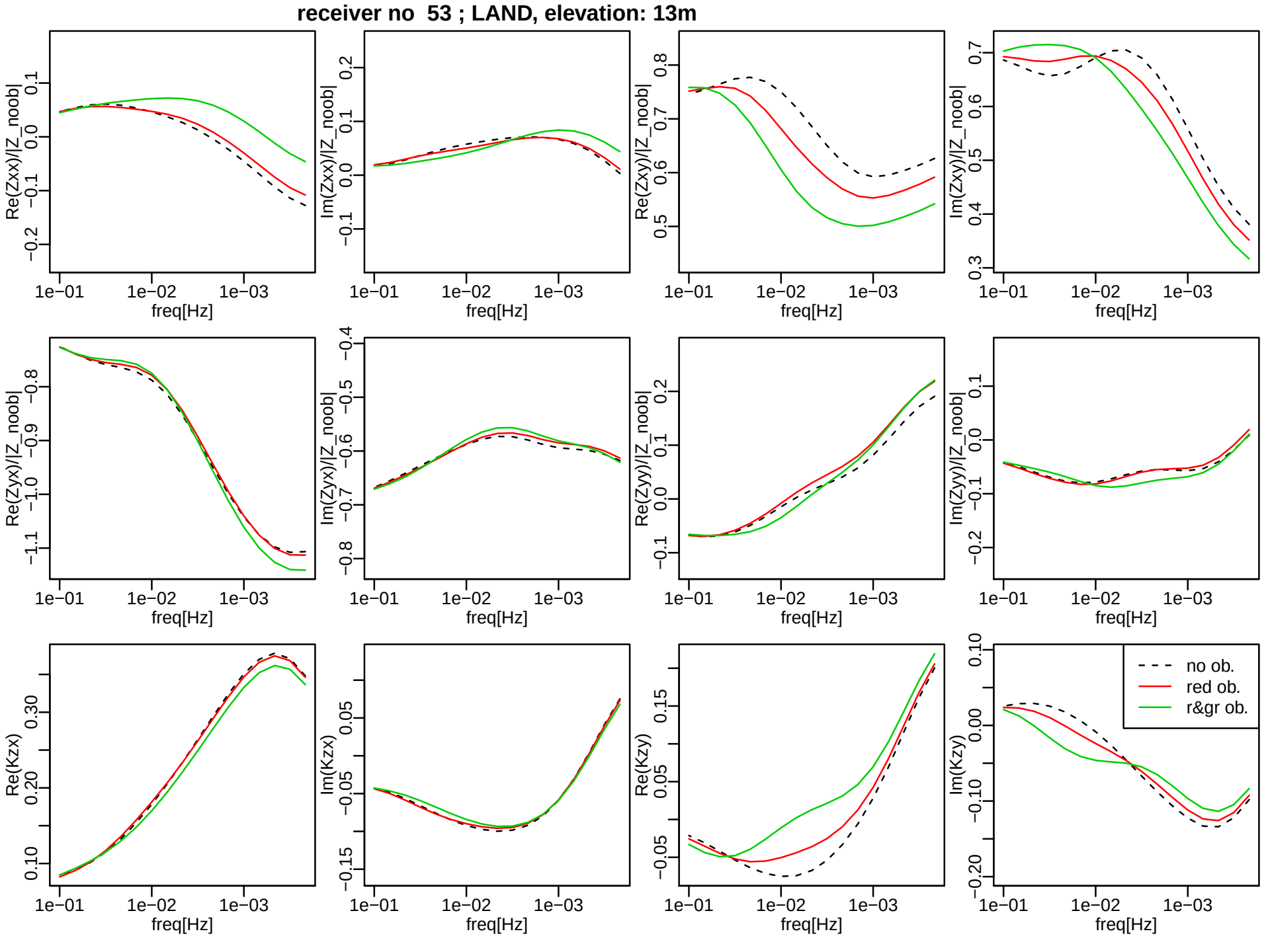
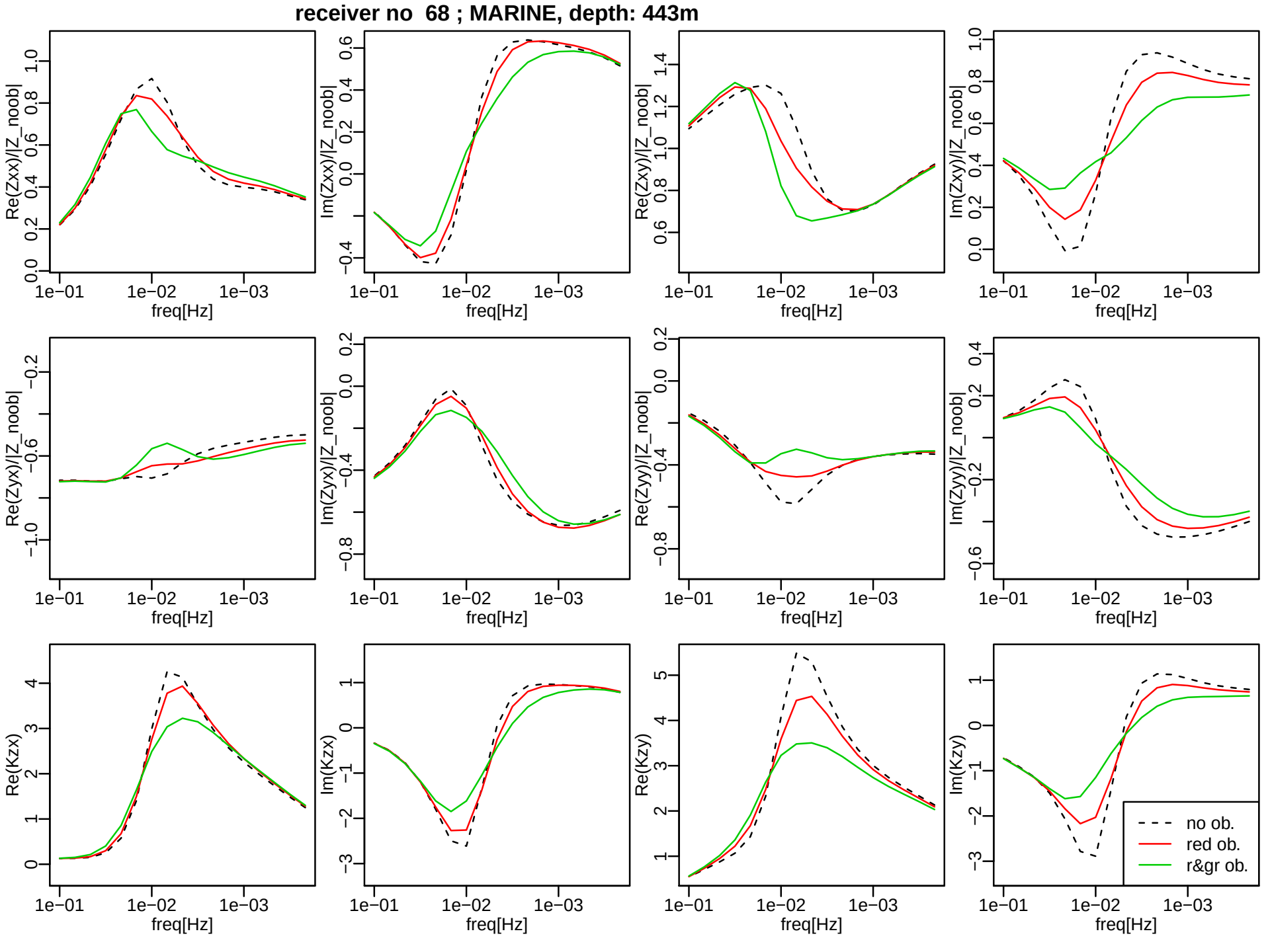
depth [km] VE = 10
−1.8
−1.6
−1.4
−1.2
−1
−0.8
−0.6
−0.4
−0.2
0
0.75
1.5
2.25
3
3.75
4.5
5.25
6
23
68
53
Solander Islands
500 o-m
35 km
75 km
50 o-m
10 o-m
Southwest
Northeast
50 km
50 km
Section
Plan
Northwest
25 km
Southwest
50 km
Solander Is
Northeast
50 km
Southeast


receiver no 23 ; LAND, elevation: 863m
Re(Zxx)/|Z_noob|
Im(Zxx)/|Z_noob|
Re(Zxy)/|Z_noob|
Im(Zxy)/|Z_noob|
Re(Zyx)/|Z_noob|
Im(Zyx)/|Z_noob|
Re(Zyy)/|Z_noob|
Im(Zyy)/|Z_noob|
Re(Kzx)
Im(Kzx)
Re(Kzy)
Im(Kzy)
freq[Hz]
1e−01
1e−02
1e−03
no ob.
red ob.
r&gr ob.


receiver no 53 ; LAND, elevation: 13m
Re(Zxx)/|Z_noob|
Im(Zxx)/|Z_noob|
Re(Zxy)/|Z_noob|
Im(Zxy)/|Z_noob|
Re(Zyx)/|Z_noob|
Im(Zyx)/|Z_noob|
Re(Zyy)/|Z_noob|
Im(Zyy)/|Z_noob|
Re(Kzx)
Im(Kzx)
Re(Kzy)
Im(Kzy)
freq[Hz]
1e−01
1e−02
1e−03
no ob.
red ob.
r&gr ob.


receiver no 68 ; MARINE, depth: 443m
Re(Zxx)/|Z_noob|
Im(Zxx)/|Z_noob|
Re(Zxy)/|Z_noob|
Im(Zxy)/|Z_noob|
Re(Zyx)/|Z_noob|
Im(Zyx)/|Z_noob|
Re(Zyy)/|Z_noob|
Im(Zyy)/|Z_noob|
Re(Kzx)
Im(Kzx)
Re(Kzy)
Im(Kzy)
freq[Hz]
1e−01
1e−02
1e−03
no ob.
red ob.
r&gr ob.

Conclusions

- Puysegur/Fiordland subduction system a compelling candidate for birth of subduction system.
- When do eclogitization fluids begin releasing?
- When does circulating mantle wedge form?
- How are those affected by prior lithosphere variations (i.e. transition to Fiordland?
- Previous MT campaigns show strong effect of subduction processes on conductivity variation.
- Start of eclogitization and ETS, fluid egress, position of wedge front, arc flux melting all resolvable with MT.
- Thermal/fluid/melt inferences complement seismology.
- Pertinent subduction processes affect MT in the 10-10000 s period range; responses strongly anomalous.
- Wedge melting separable from broader fluidization.
- Strongly 3D geometry, requires land/seafloor deployment.