Are Post-Glacial Rebound Model Predictions Consistent with the Global Space-Geodetic Secular Velocity Field?

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Are Post-Glacial Rebound Model Predictions Consistent with the Global Space-Geodetic Secular Velocity Field?

- Comparison of PGS model predictions
- The secular velocity fields
- Separating rigid body motion from PGS
- Is there consistency between observation and model predictions?

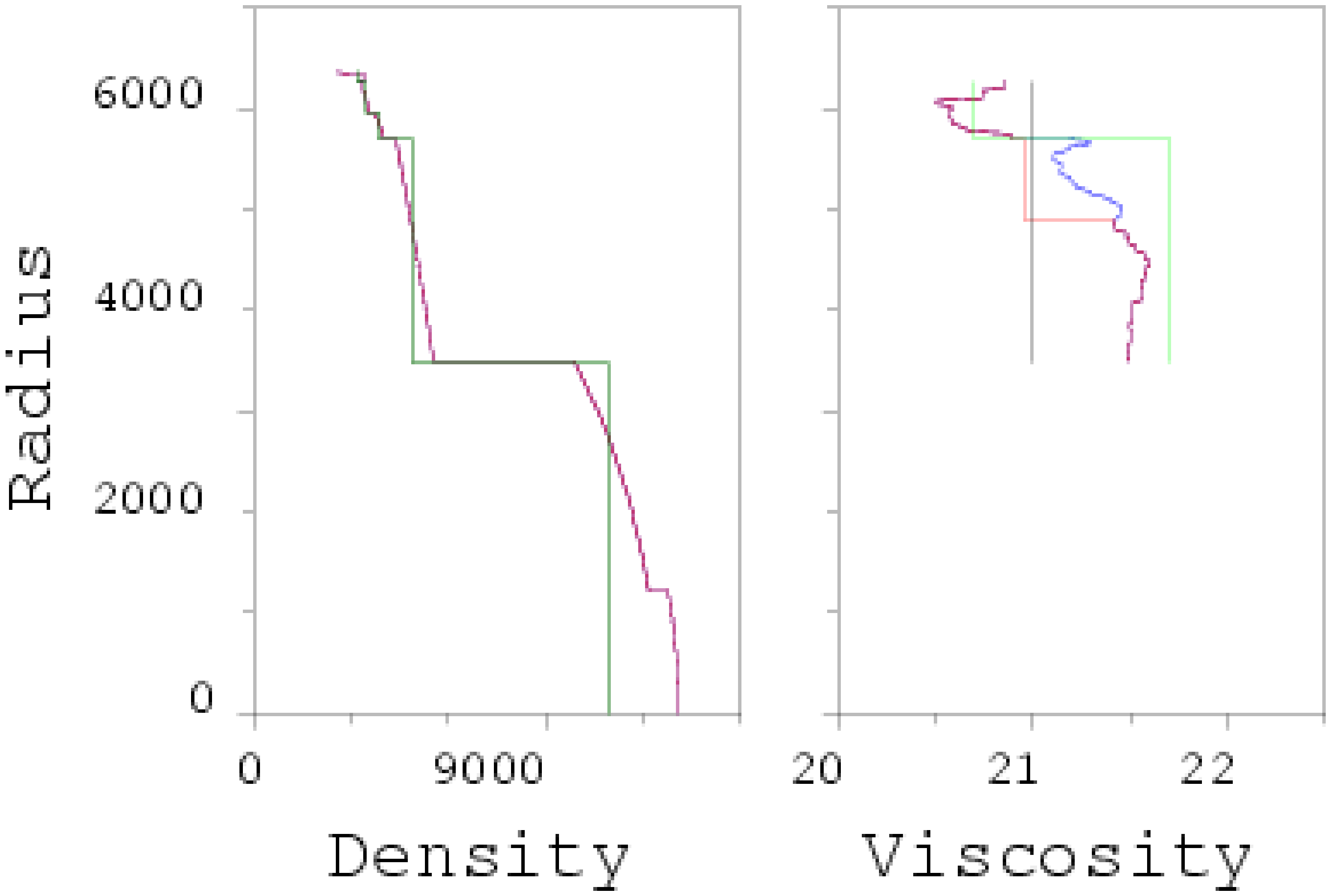
Comparison of Post-Glacial Rebound Model Predictions

Submission of PGR predictions to the IERS Special Bureau for Loading. Available at http://www.sbl.statkart.no.

Model	Author	Ice	Earth
VM2	Peltier (2004,2005)	ICE-5G V2	Depth-dependent parameters, 90 km lithosphere
VM4	Peltier (2004,2005)	ICE-5G V2	Same as VM2 but lower viscosity in upper mantle
REF	Schotman et al. (2005)	ICE-3G	5 homogeneous layers, 98 km lithosphere, higher viscosity in lower mantle
ALT	Schotman et al. (2005)	mod. ICE-3G	Same as REF, but homogeneous viscosity in mantle
JXM	Mitrovica (Milne et al., 1999)	ICE-3G	4 homogeneous layers, 120 km lithosphere, high viscosity in lower mantle.

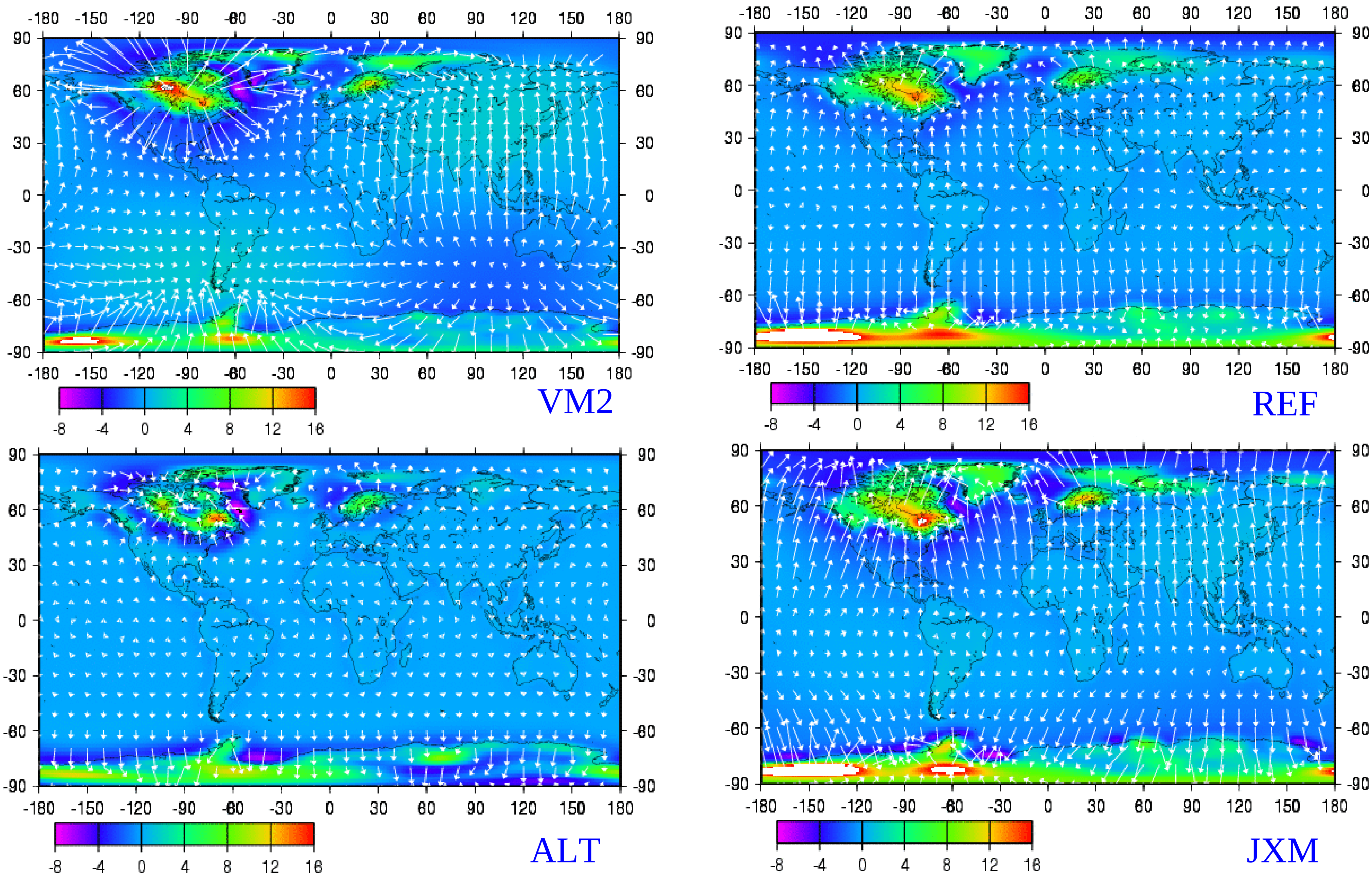
All models are spherically symmetric.

Comparison of Post-Glacial Rebound Model Predictions



Comparison of Post-Glacial Rebound Model Predictions

3-D displacements



Comparison of Post-Glacial Rebound Model Predictions

Cross correlations

Up Component:

	VM2	VM4	REF	ALT	JXM
VM2	1.000	0.959	0.737	0.609	0.808
VM4	0.959	1.000	0.618	0.579	0.715
REF	0.737	0.618	1.000	0.663	0.956
ALT	0.609	0.579	0.663	1.000	0.689
JXM	0.808	0.715	0.956	0.689	1.000

Horizontal displacement vectors:

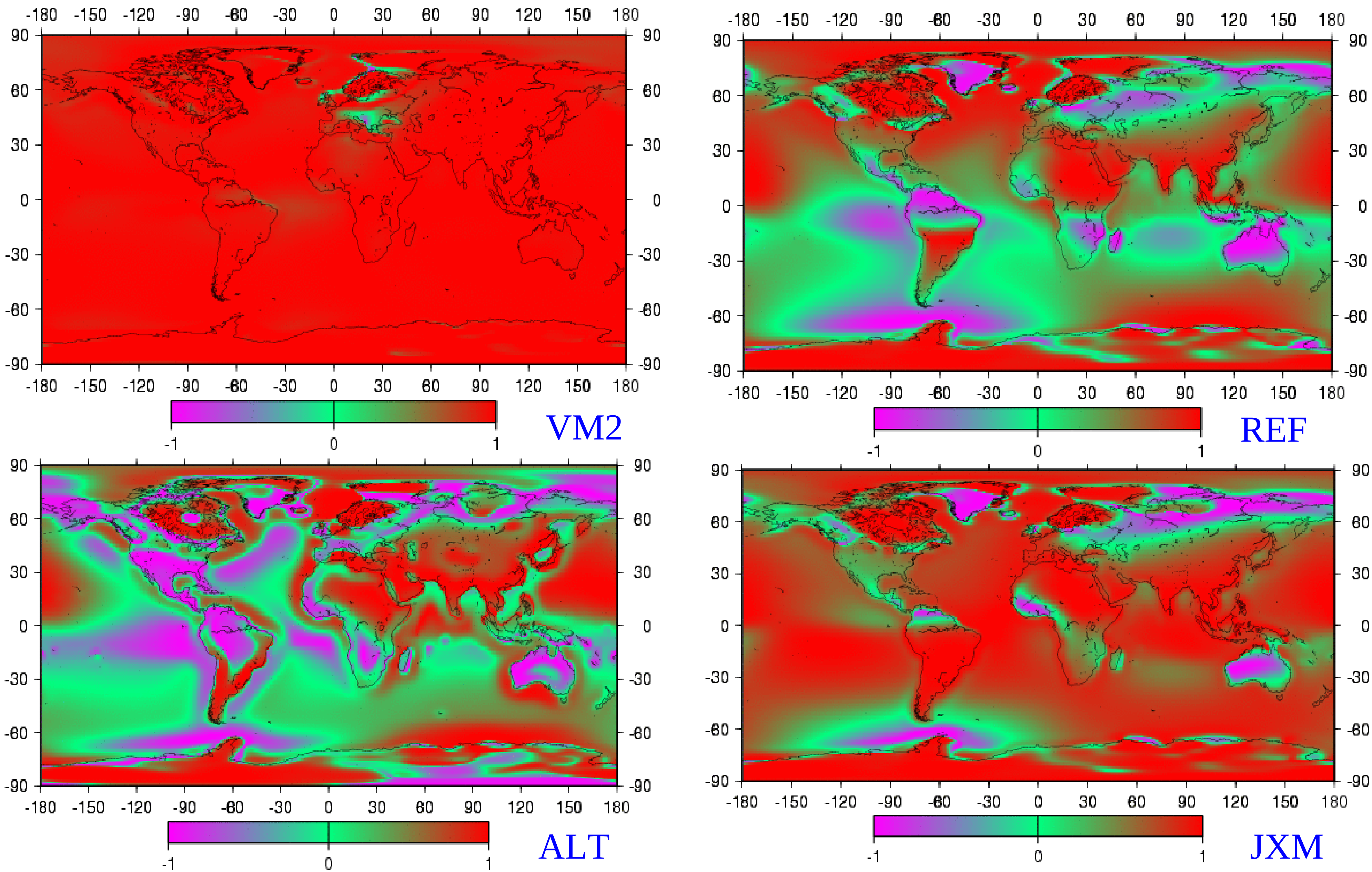
	VM2	VM4	REF	ALT	JXM
VM2	1.000	0.947	0.279	-0.252	0.368
VM4	0.947	1.000	0.124	-0.412	0.132
REF	0.279	0.124	1.000	0.551	0.811
ALT	-0.252	-0.412	0.551	1.000	0.673
JXM	0.368	0.132	0.811	0.673	1.000

3-D displacement vectors:

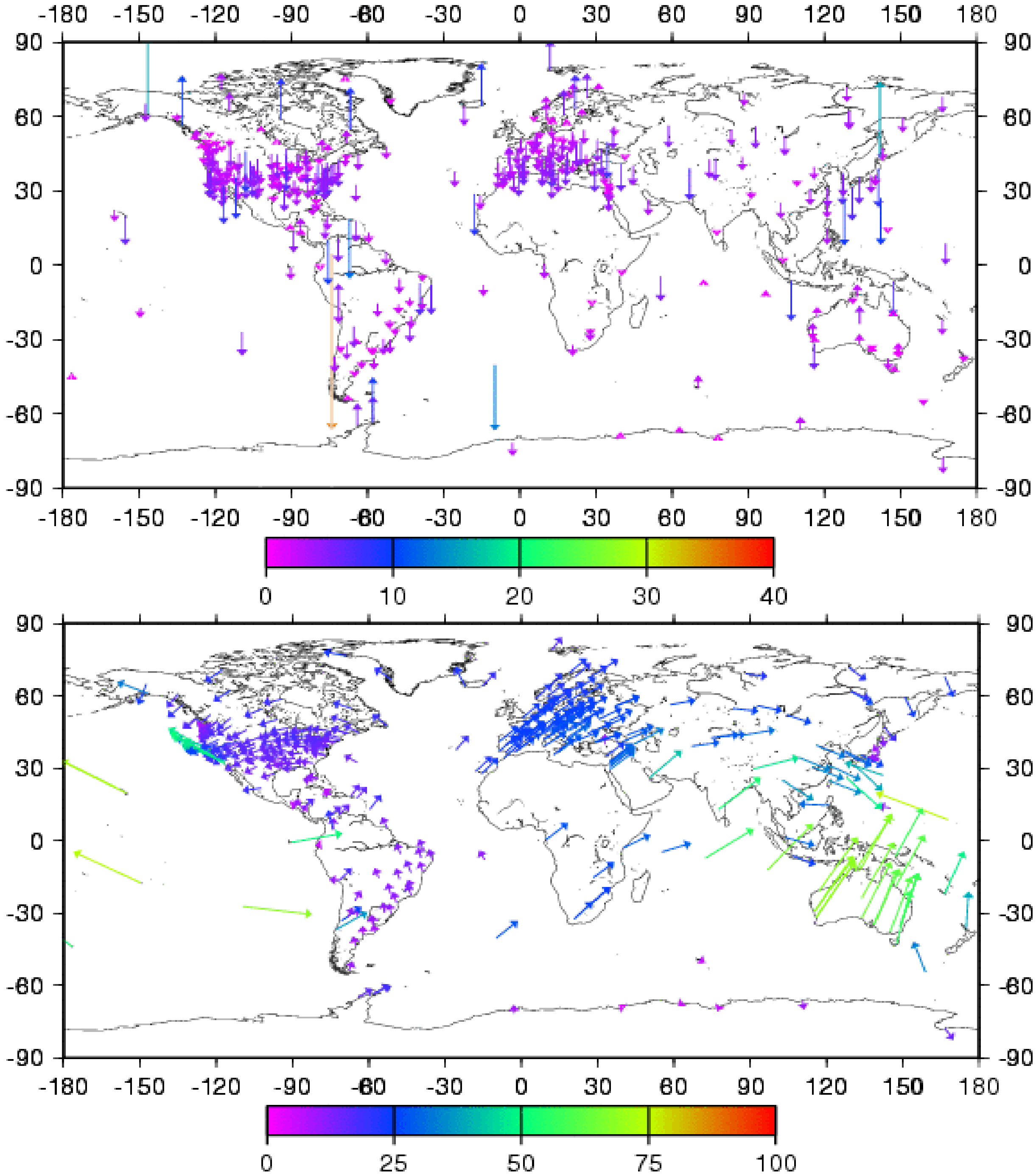
	VM2	VM4	REF	ALT	JXM
VM2	1.000	0.955	0.637	0.447	0.712
VM4	0.955	1.000	0.504	0.382	0.580
REF	0.637	0.504	1.000	0.652	0.929
ALT	0.447	0.382	0.652	1.000	0.679
JXM	0.712	0.580	0.929	0.679	1.000

Comparison of Post-Glacial Rebound Model Predictions

Normalized Scalar Product of 3-D Displacements for VM4 and the Other Models



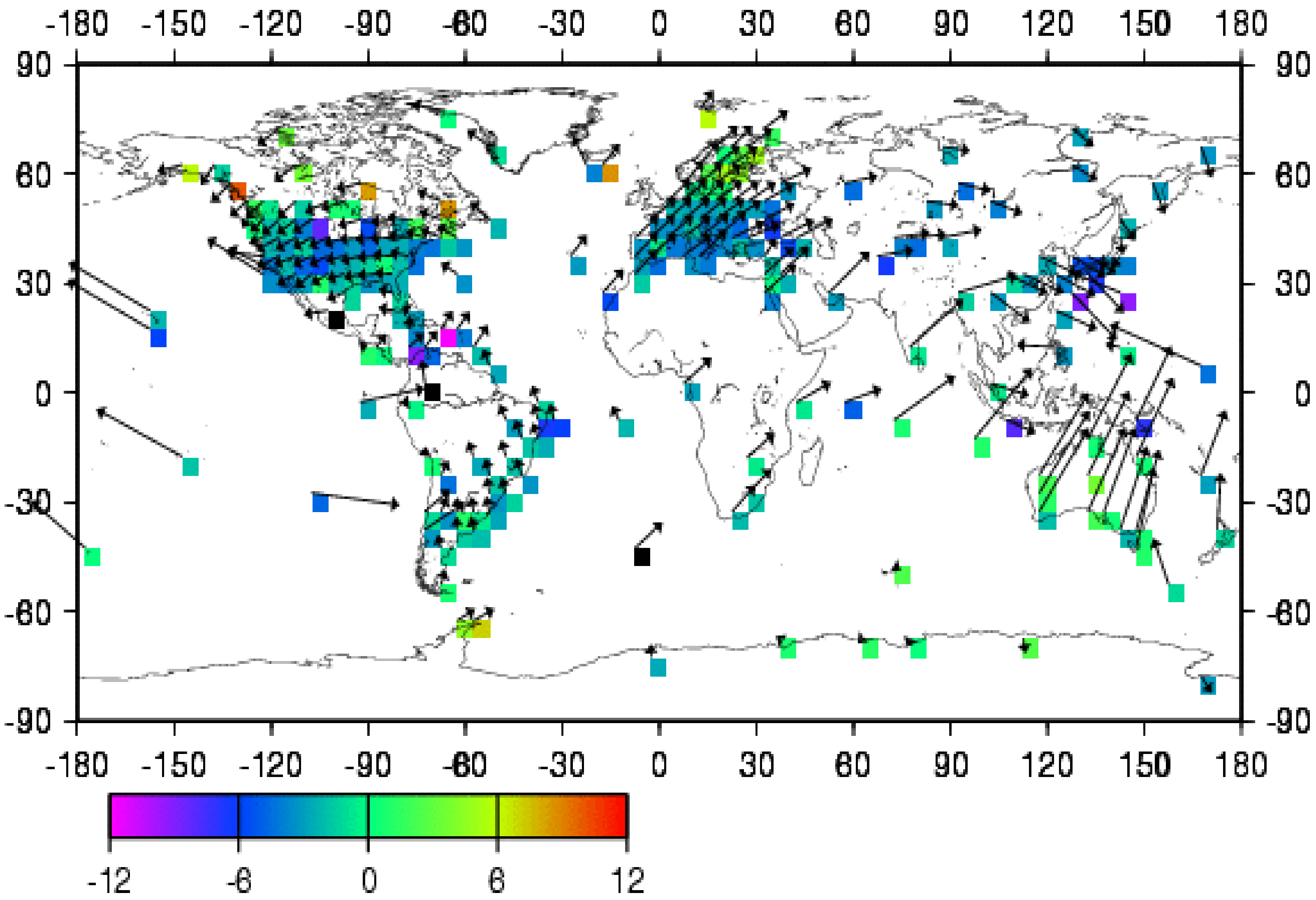
The Secular Velocity Field



- Total of 376 points
- Combination of weekly global and regional solutions provide by IGS analysis centers
- 1999 - 2005

The Secular Velocity Field

- 5 X 5 degrees
- Total of 222 grids elements
- 78 elements with multiple values



Separating rigid body motion from PGS

Standard approach:

$$\vec{V}(\vec{X}) = \vec{\Omega} \times \vec{X}$$

$\vec{V}$: secular velocity,
$\vec{X}$: position,
$\vec{\Omega}$: rigid plate rotation.

Plag et al. (2002):

$$\vec{V}(\vec{X}) = \vec{\Omega} \times \vec{X} + \sum_{i=1}^{N} \vec{V}_i(\vec{X})$$

$\vec{V}_i$: velocity due to i-th geophyscial processes.

Kierulf et al. (2003): Significantly improved velocity field for Eurasian plate if PGR is taken into account.

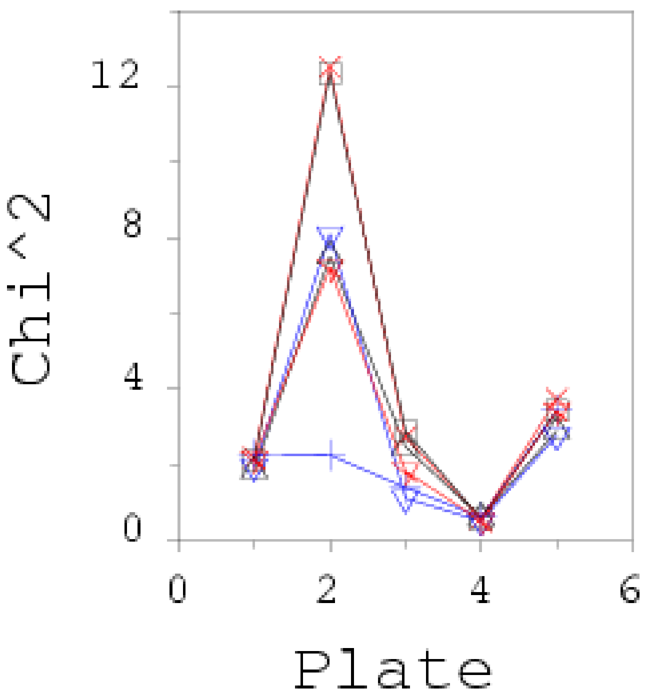
Here: Extension to more PGR predictions and all major plates.

$$\vec{V}_{\text{horizontal}} = \vec{\Omega} \times \vec{X} + \gamma \cdot \vec{V}^{(\text{PGR})}_{\text{horizontal}}$$

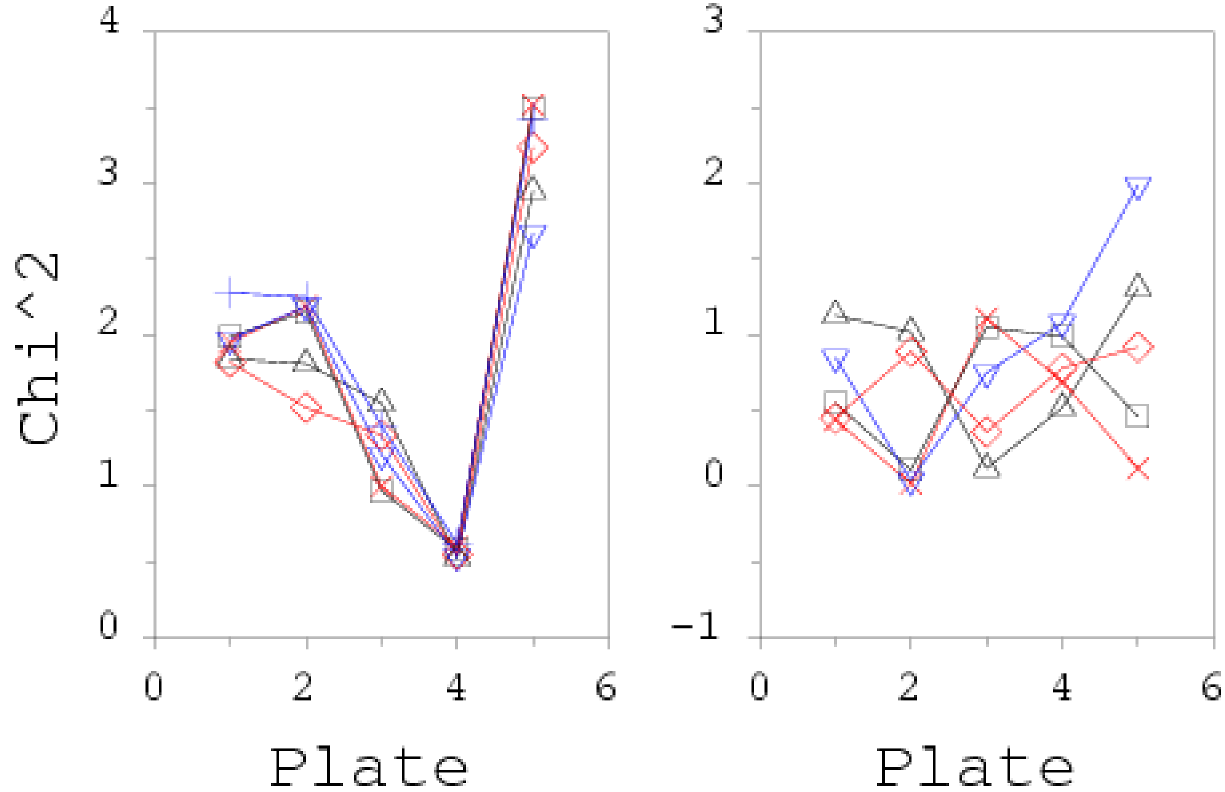
We consider three cases:
(1) no PGR, (2) γ fixed to 1, (3) γ and $\vec{\Omega}$ estimated.

Separating rigid body motion from PGS

Unscaled



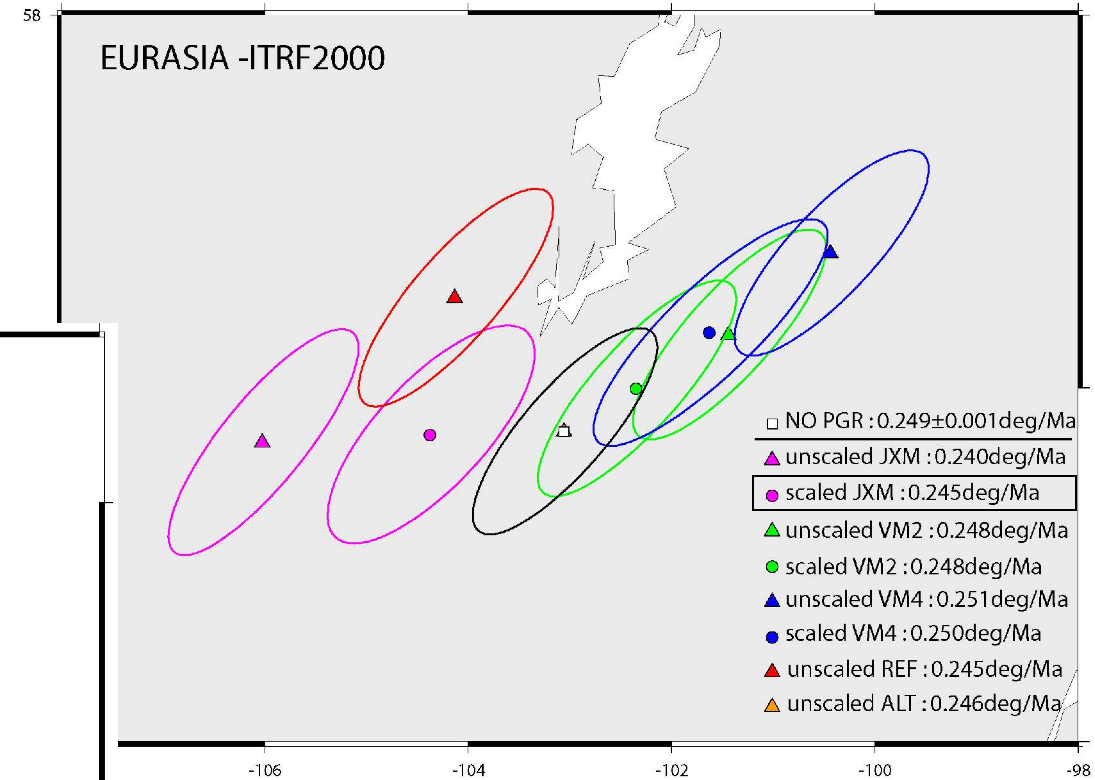
Scaled

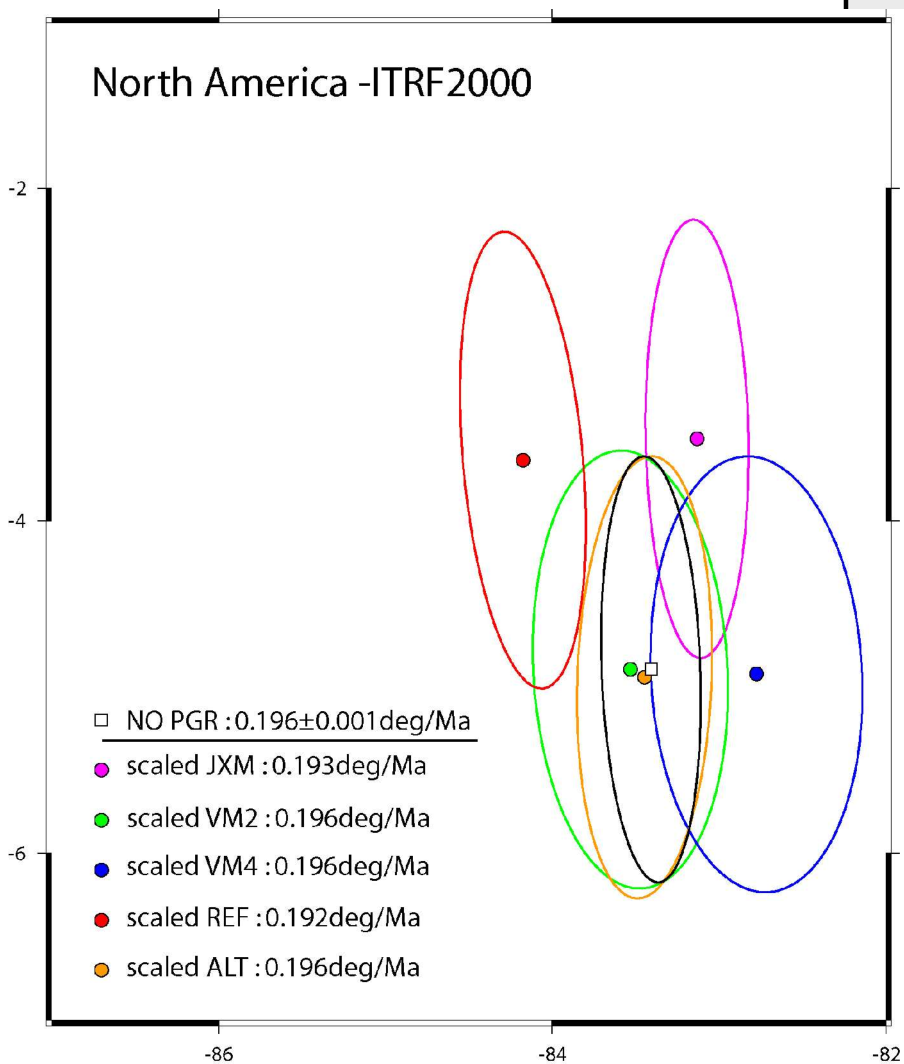


1: Eurasia
2: North America
3: Antarctica
4: South America
5: Australia

blue cross: No PGR
red x: VM2
black square: VM4
black triangle: REF
blue triangle: ALT
red diamond: JXM

Separating rigid body motion from PGS





Scaled JXM:
Differential velocities:
0.35 mm/yr to the south in Europe
0.55 mm/yr to the west in Siberia

Is there consistency between observation and model predictions?

- Regional intermodel differences larger than the uncertainties in the observed velocity field, particularly for North America and Eurasia.
- Space-geodetic observations provide valuable constraints for these models.
- ICE-5G-based predictions inconsistent with the observed velocity field in North America.
- Accounting for the PGR signal in the determination of the rigid body rotation improves the estimates for N.A. and Eurasia.