

**From earthquake catalogs to hazard:
an overview of the seismicity-derived
component of the hazard calculation
AND questions and discussion about
earthquake catalogs for 2014 NSHM
update**

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USGS - Golden, CO
2014 NSHM update, IMW workshop
6/14/2012**

USGS hazard model: Western US

Faults

- IMW: ~ 300 crustal faults
- PNW: crustal + megathrust
- CA: UCERF/WGCEP

Distribution for $M_{\text{char}} \geq 6.5$

Distribution for dip: 40, 50, 60 deg

67% char + 33% GR for CA,IMW



Ground motion

Crustal: NGA (out to 200 km)

Subduction: various

&

Site condition $V_{s30} = 760\text{m/s}_-$

Shallow Seismicity ($d < 35$ km)

- 1) Declustered catalog $M_w \geq 4$
- 2) Completeness:
 - Coastal CA: 1933, 1900, 1850
 - Other WUS: 1963, 1930, 1850
- 3) $b = 0.80$
- 4) 10^a grids (spatial distribution seismicity rates):
 - Coastal CA
 - Extensional WUS
 - Non-extensional WUSAdjust for mag uncertainty
Background “floor” (five zones)
- 5) 50-km smoothing (+ anisotropic in CA)
 $M_{\text{max}} = 7.0$ mostly, < 7.0 near faults

Deep Seismicity

Geodetic Sources

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2008 WUS declustered catalog

Source catalogs in preference order:

Pancha et al (2006): ~200 eqks, M_w 4.8+, 1868-1999 (M_w estimates; recommended @ 2006 wksp)

CGS (Felzer&Cao,2007): ~2100 eqks, M_w & m_L 4+, 1769-2006 (preferred over Pancha in UCERF zone)

Engdahl & Villasenor (2002): 18 eqks, mag 5.5+, 1902–2001

Stover & Coffman (1993): ~110 eqks, mag 4.5+, 1872-1989

Stover, Reagor & Algermissen: ~150 eqks, mag 4+, 1917-1985 (includes many smaller eqks than Stover & Coffman)

PDE: ~550 eqks, mag 4+, 1961-2006 (used for updates)

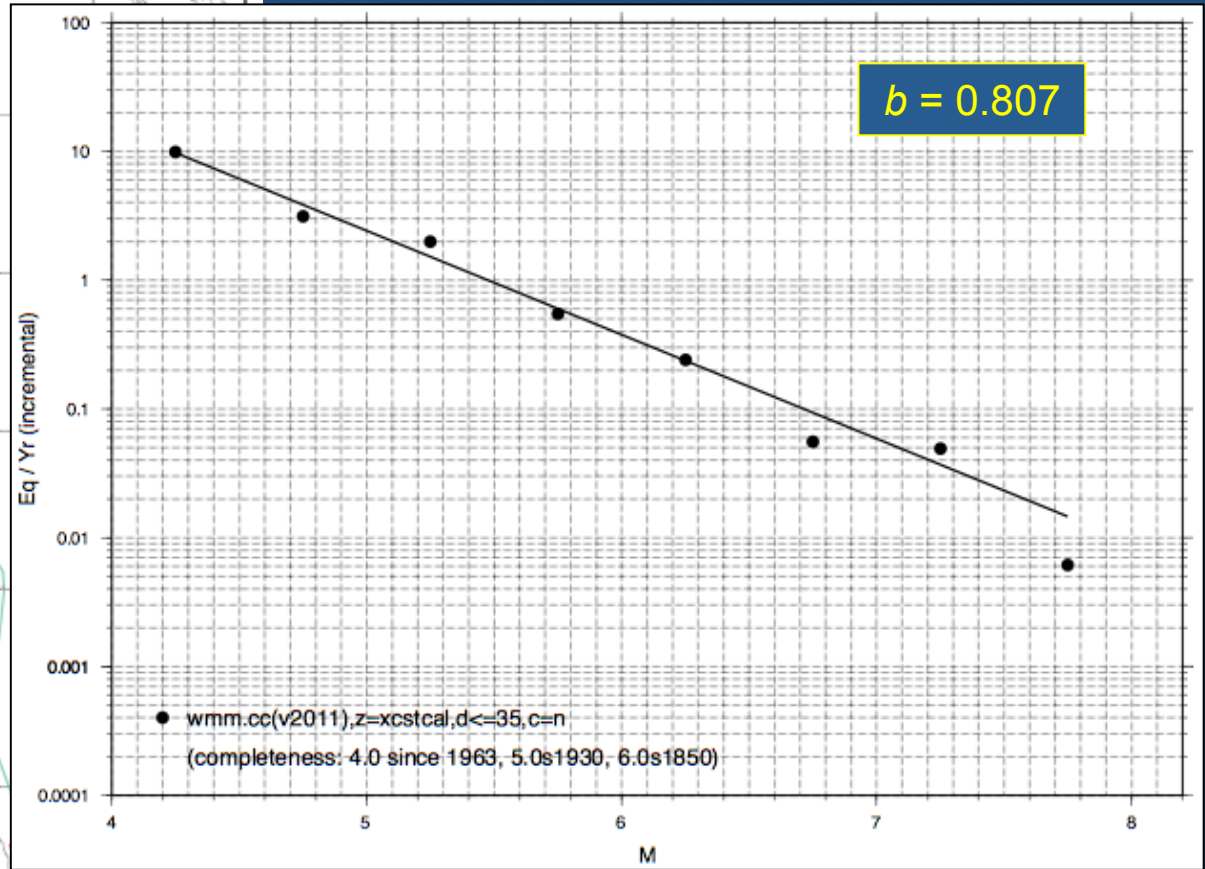
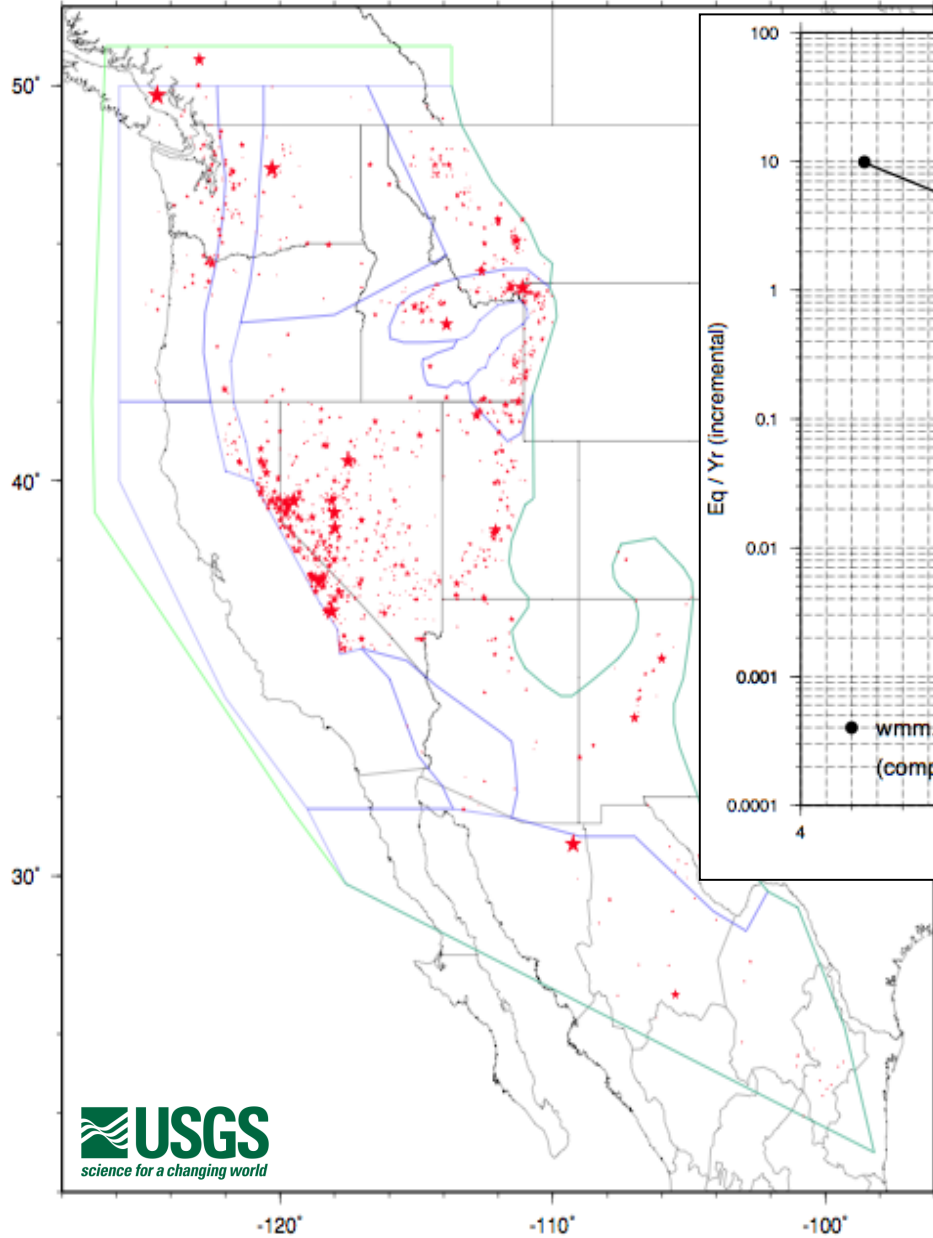
DNAG: ~150 eqks, mag 4+, 1877-1981

* (we are considering adding the Herrmann M_w catalog)

WUS catalog processing & “agrid”

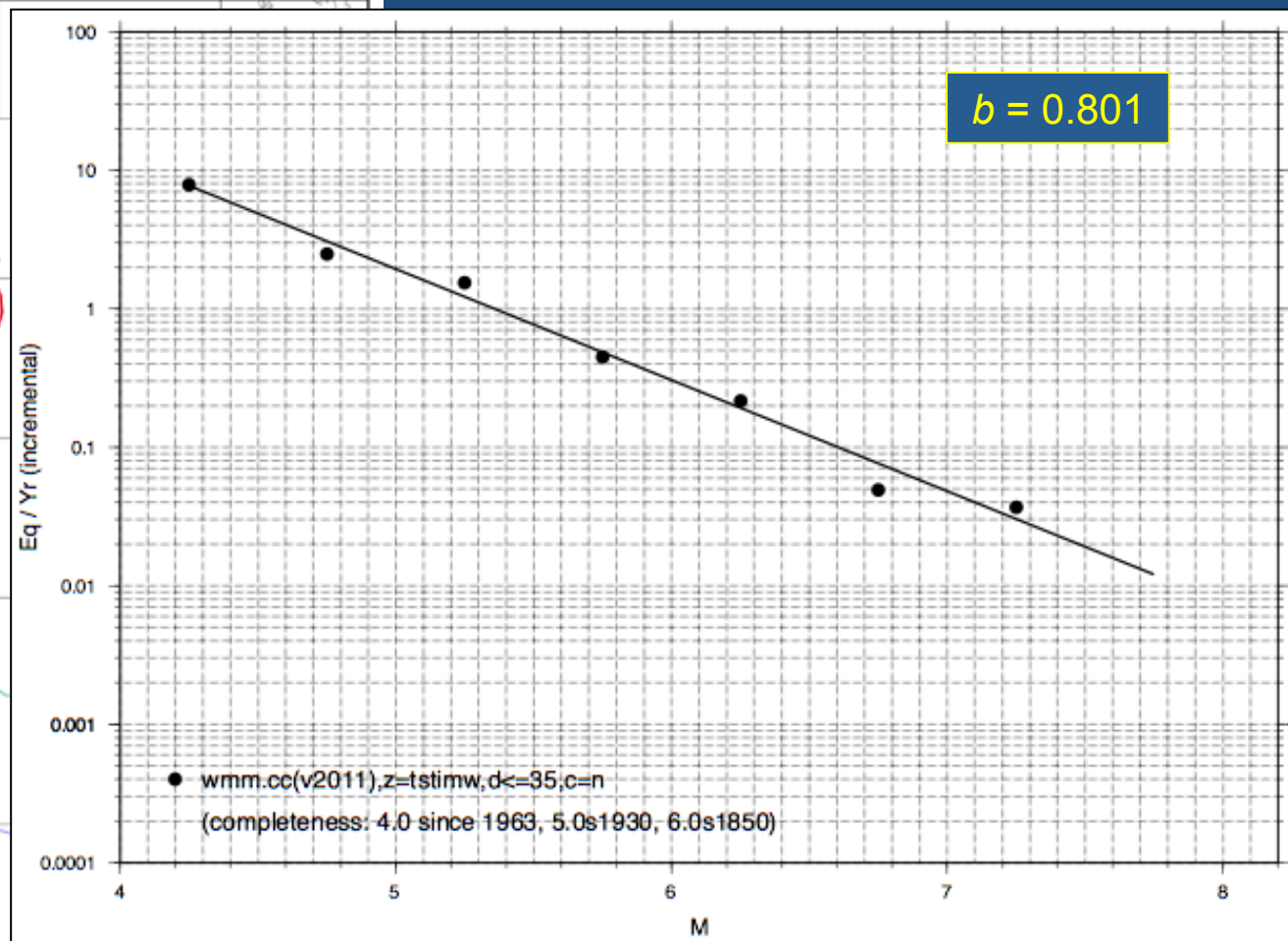
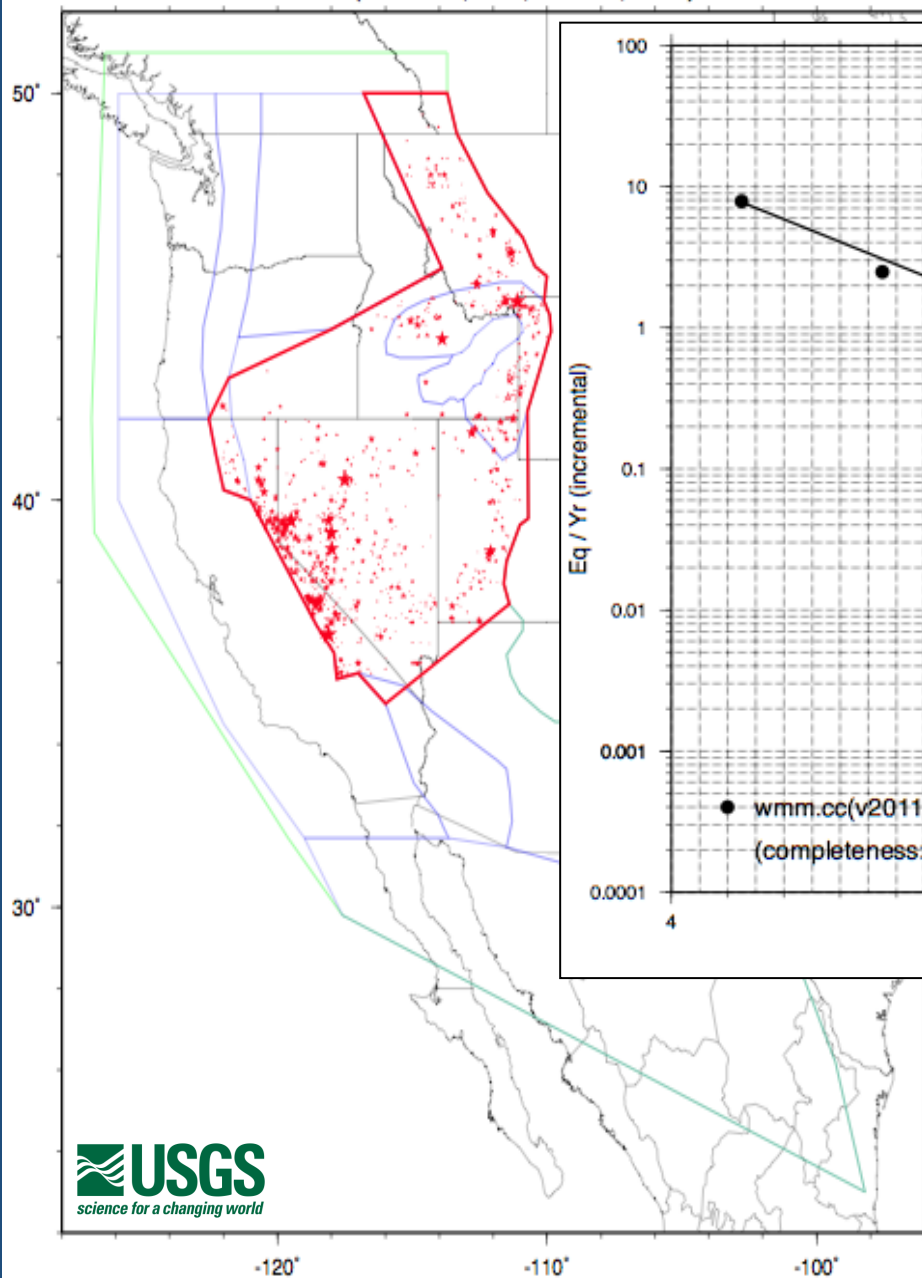
- 1) convert magnitude to M_w (as needed; use published rules for active-tectonic regions)
- 2) concatenate, sort, remove duplicates
- 3) decluster (G&K) and delete non-tectonic eqks
- 4) analyze: completeness & b
- 5) Calculate “agrid”
 - adjust for mag uncertainty
 - smooth (gaussian, 50 km correlation length)
 - include background floor

wmm.cc (1850-2011, M \geq 4, z=wus_xcstcal/xoffshore/xGOC, d \leq 35)



WUS declustered catalog M \geq 4, 1850-2011
(exclude eqks in Coastal CA zone, offshore
northern CA, Gulf of CA)

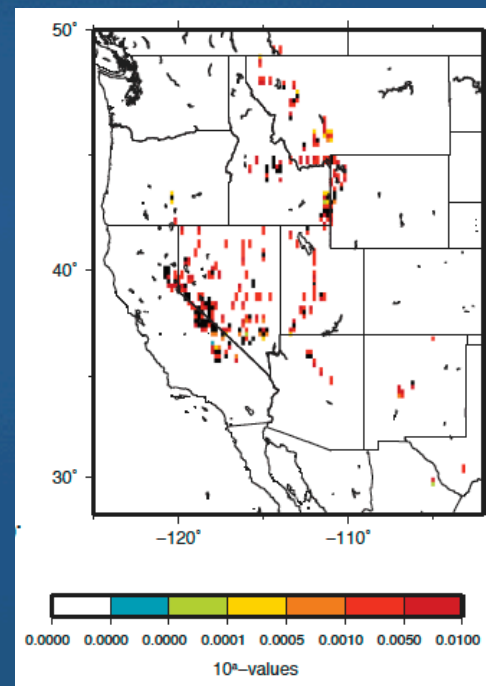
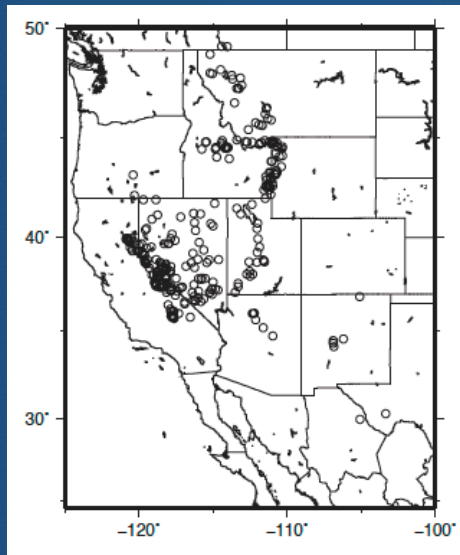
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For comparison: IMW test zone
WUS declustered catalog M \geq 4, 1850-2011

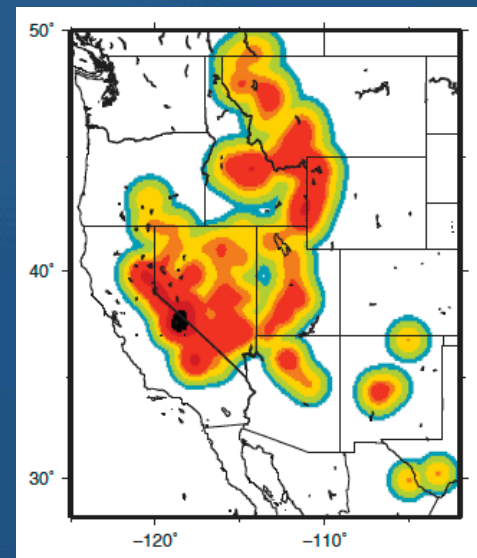
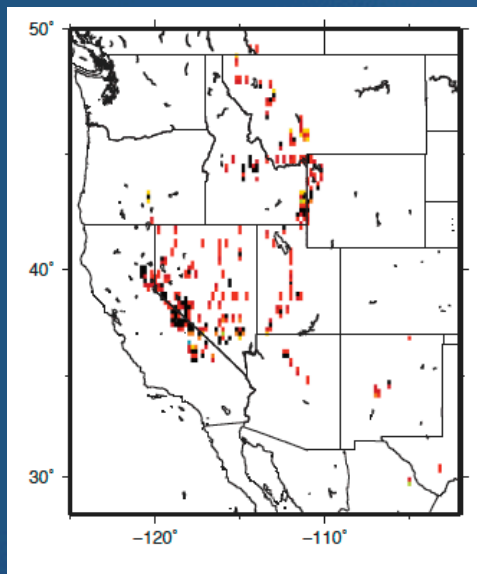
Process for calculating agrids (10^a values)

- ✓ Calculate total number of M4+ earthquakes in 0.1-by-0.1 degree grid cells
- ✓ Calculate cumulative seismicity rate (10^A)



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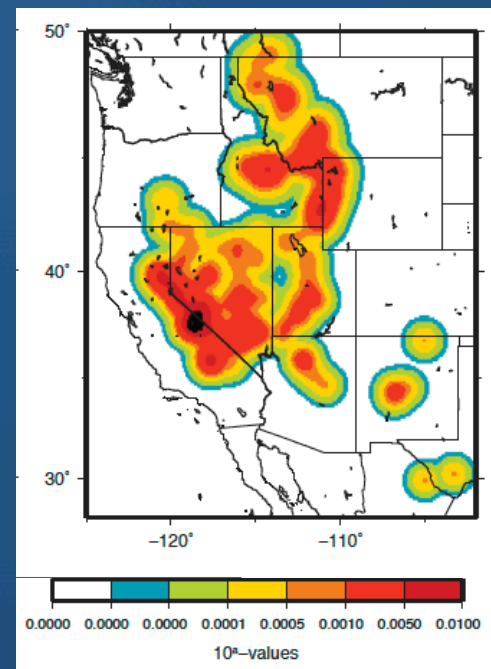
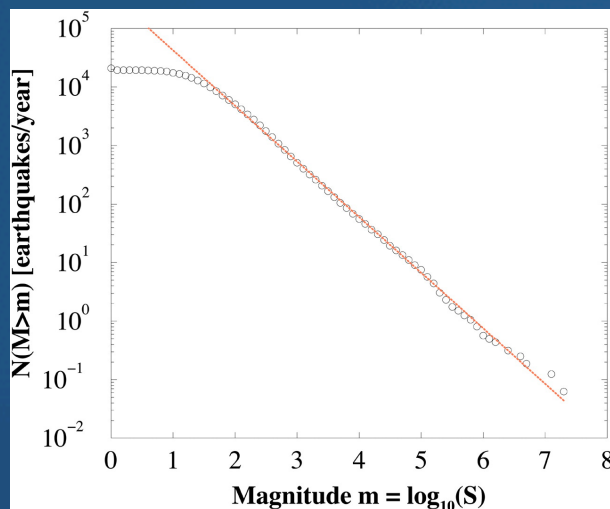
- ✓ Calculate total number of M4+ earthquakes in 0.1-by-0.1 degree grid cells
- ✓ Calculate cumulative seismicity rate (10^A)
- ✓ Modify rates to account for completeness levels (Weichert method)
- ✓ Convert from cumulative to incremental seismicity (10^a)
- ✓ Spatially smooth 10^a values



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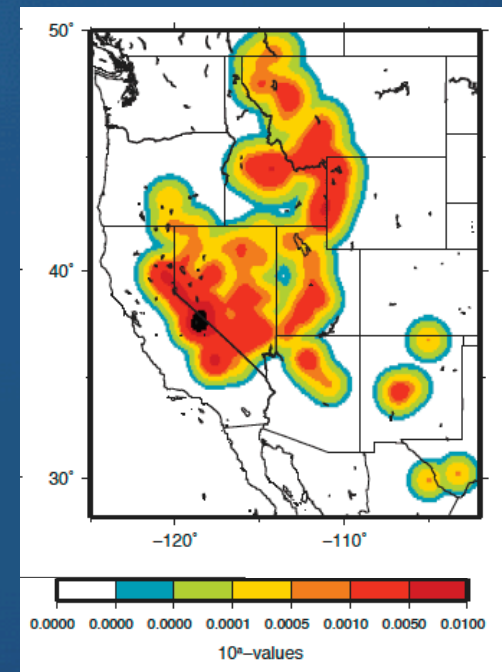
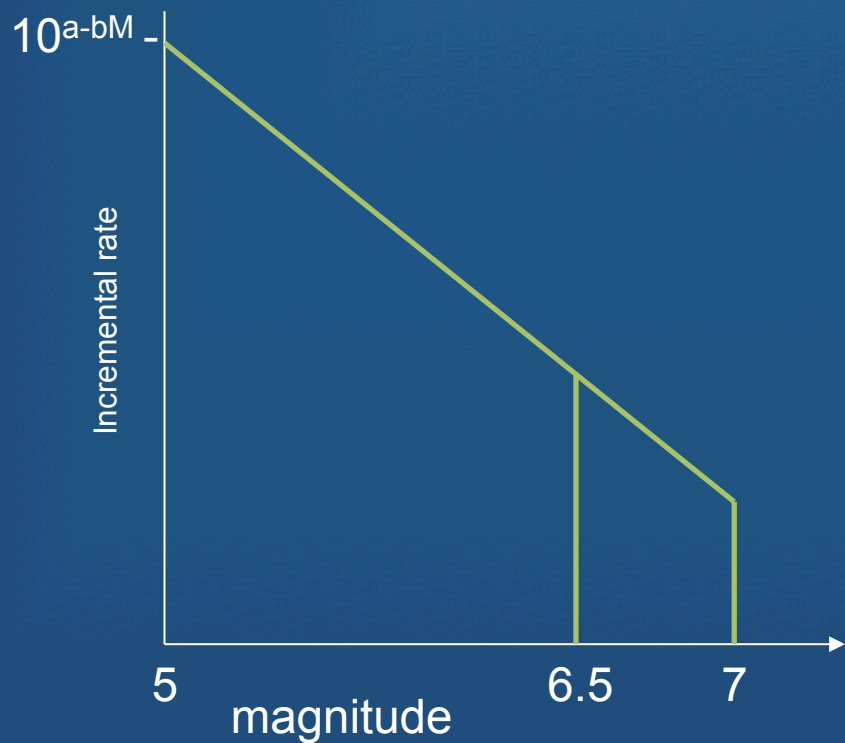
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** 10^a values represent annual rate of M0 earthquake for each grid cell **

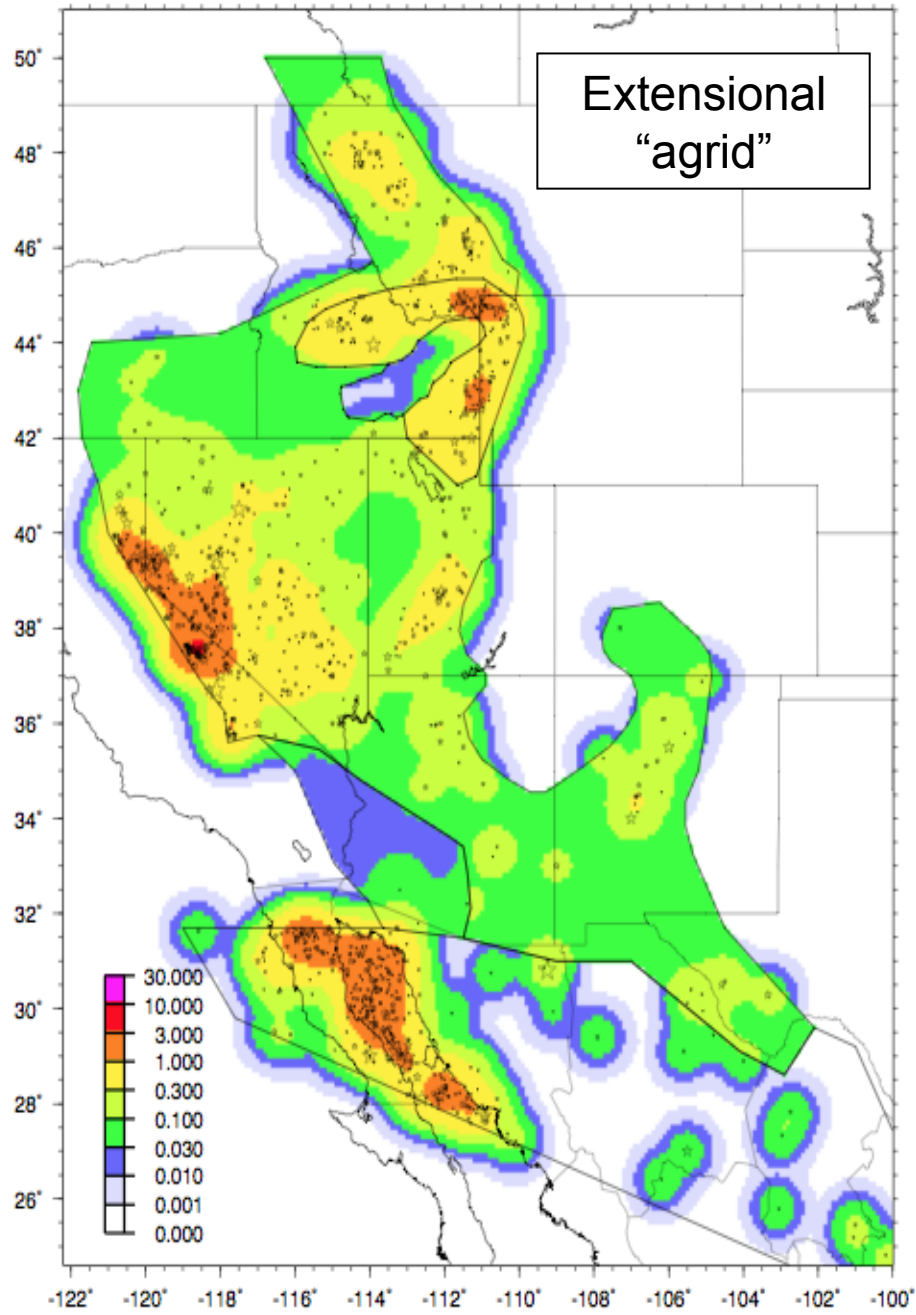


Laterally-variable seismicity rates (agrids) for the smoothed-gridded seismic hazard calculation

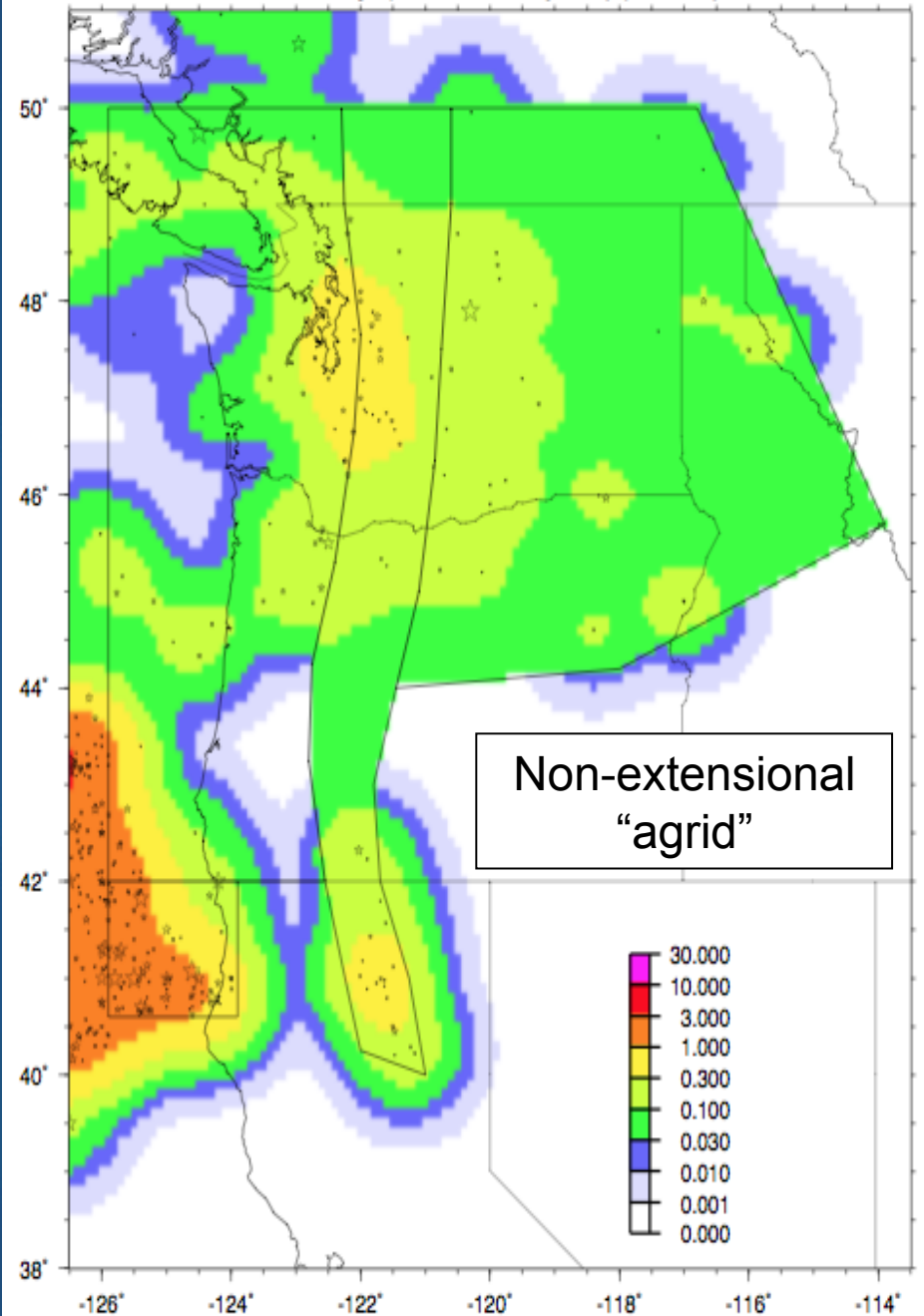
- Background model: Use catalog to calculate 10^a for GR distribution.



10^{sl} /cell/yr (wmm_wusext.cch) (0.1,50,3)



10^{sl} /cell/yr (wmm_wuscmp.cch) (0.1,50,3)



Issues with earthquake catalogs

✓ Catalog mix

- Should NSHM 2014 update include more local and regional catalogs? (local knowledge vs. loss of regional/national magnitude consistency)
 - Role of ANSS/PDE catalog?
 - M_W for all moderate eqks (Herrmann)?
- Utah earthquake catalog (Arabasz)
 - Treatment of Pancha et al. catalog

- ✓ Non-tectonic and anomalous eqks: We currently delete some Utah coal mining events. Are there more we should know about (at the M4 level)? Are there any issues with induced seismicity? How to model?
- ✓ Regionalize completeness & b -value analysis?
- ✓ Corrections for mag uncertainty?
- ✓ Implementation of background “floor” – 1/3 weighting on adaptive seismicity rate floor value?

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Identification of non-tectonic earthquakes

- Special studies & published listings. Examples:
 - Mining-related seismicity (e.g., Colorado; Kirkham & Rogers, ColoradoGS Bulletin, 2000)
 - Fluid injection at Paradox Valley, CO (Ake)
 - US Nuclear Tests July 1945 through September 1992 (DOE/NV-209-REV15, 2000)
- *Ad hoc* inquiries about specific events
- Explosion flag in PDE listing

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CA: uncertainty for (mostly) m_L (from KFelzer's work)

Time Period	σ
1972-present	~ 0.1
1932-1971	~ 0.2
1850-1931	~ 0.3

CEUS: uncertainty for "observed" M_w

Time Period	$\sigma [M M_{obs}]$
1920–1959	0.30
1960–1975	0.15
1975–1984	0.125
1985–present	0.10

From CEUS-SSC (Chapter 3), citing Johnston (1996) and Harvard M_w catalog

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Implementation of background floor for seismicity rates

- ✓ Floor seismicity rate calculated from M4 events within tectonic regions
- ✓ Adaptive (1/3) weighting to floor value applied where smoothed seismicity rates fall below floor value

