

Atmospheric Mercury near Salmon Falls Creek Reservoir in Southern Idaho

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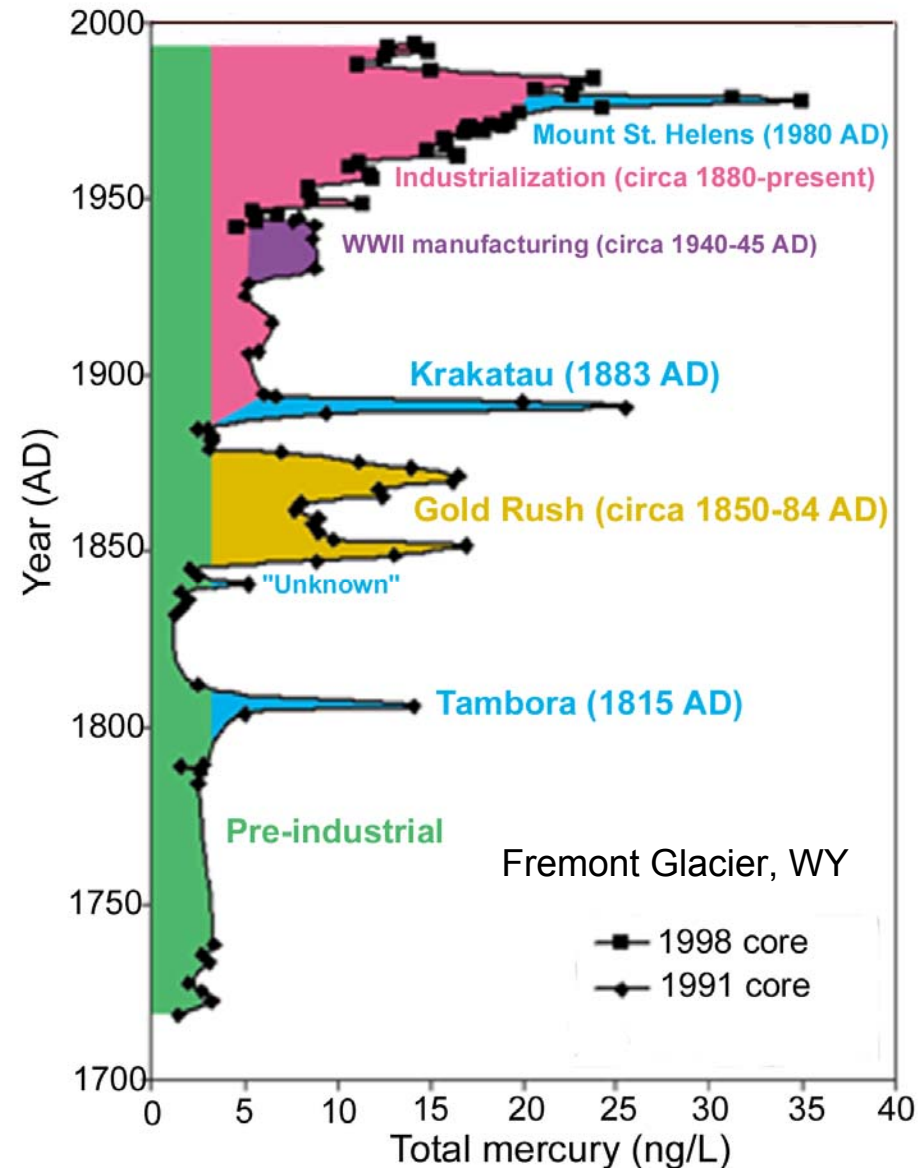


Overview




- Overview of the atmospheric pathway for mercury contamination in water bodies
- Air sampling/ dry deposition methods
- Summary of Salmon Falls Creek Reservoir sampling results - summer 05 – fall 06
- Conclusions



Why do we care so much about atmospheric inputs??




- Remote lake sediment and glacier ice core records show 3x-20x increases in Hg deposition over last 100 yrs – attributed to increases anthropogenic emission sources
- Air deposition rates have been directly linked to fish tissue methylHg (Harris et al., 2007, National Academy of Science Proceedings)



Atmospheric Mercury Fate Processes

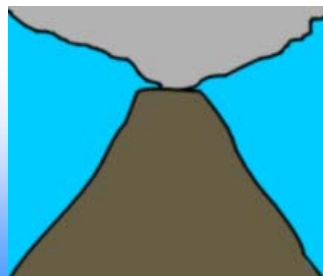
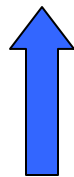
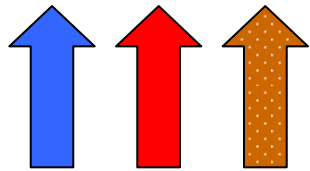
-  Gaseous Hg^0 , GEM (>99%)
-  Reactive Gaseous Hg^{+2} , RGM (<1%)
-  Particulate Hg^{+2} , HgP (<1%)

 \rightarrow 
RGM *reduced* to GEM
by SO_2 , others?

 \rightarrow 

GEM *oxidized* to RGM/HgP species
by O_3 , OH, reactive halogens
Dominant

Primary
Anthropogenic
Emissions

Natural
emissions



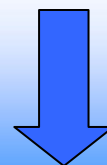
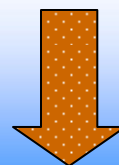
Wet deposition
Dry deposition

Low Conc
High Vd

Low Conc
Mod. Vd

High Conc
Low Vd

GEM
re-emission??

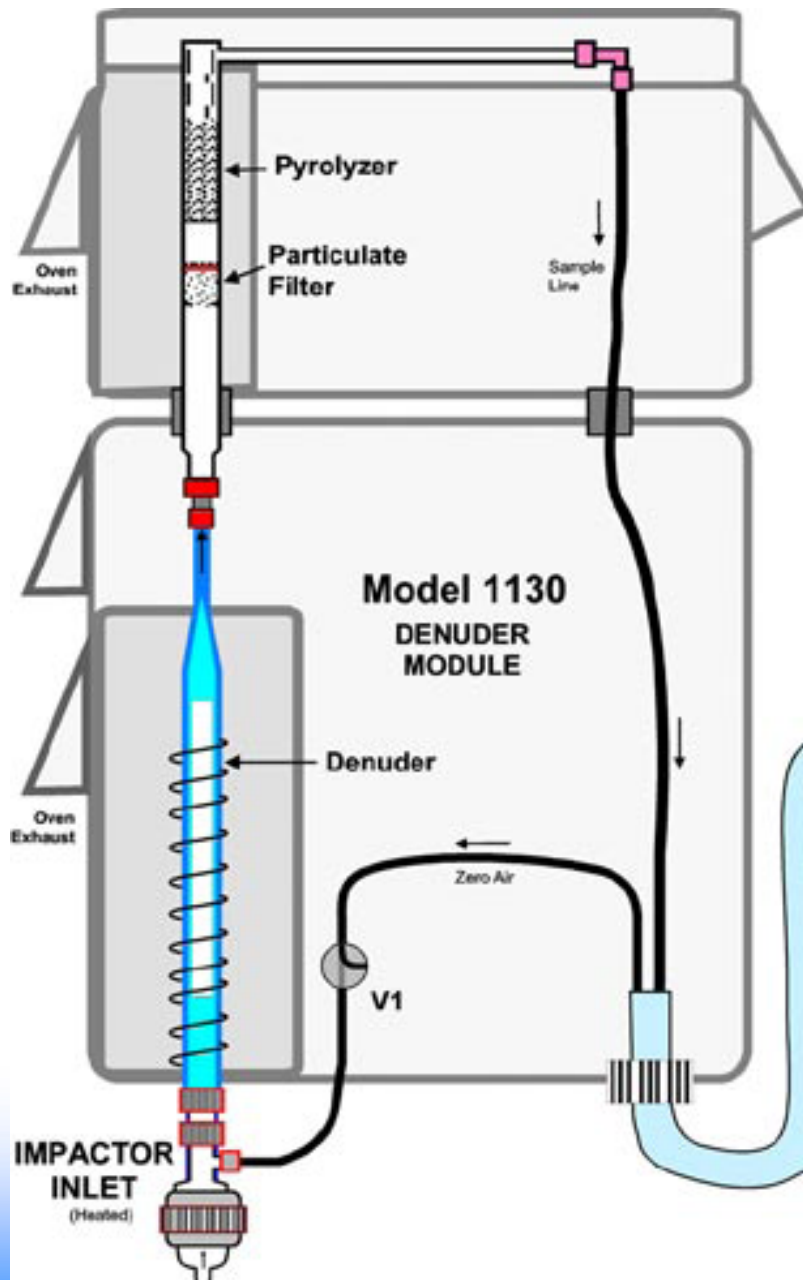


Air Sampling Methods

- Continuous, near real-time sampling with Tekran® instruments
 - 5-min GEM Tekran 2537A
 - 1-hr RGM Tekran 1130/2537A
- Met (WD,WS,AT,RH,SR,BP)



Tekran System

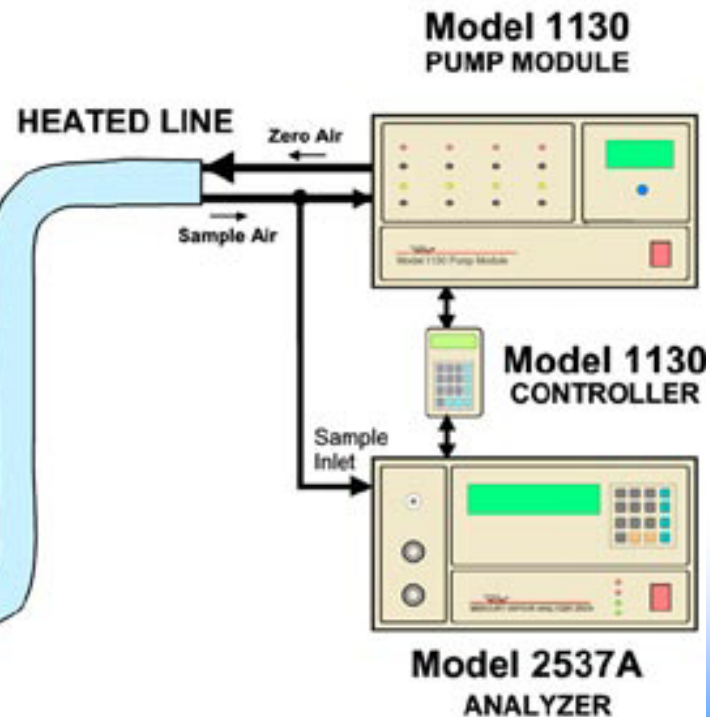


**Model 1135
PARTICULATE
MODULE**

Detection limits:

GEM < 0.1 ng/m³ (bkg 1.5 ng/m³)

RGM/HgP < 1 pg/m³ (bkg 0 – 10 pg/m³)



**Model 1130
PUMP MODULE**

**Model 1130
CONTROLLER**

**Model 2537A
ANALYZER**



Dry Deposition Methods

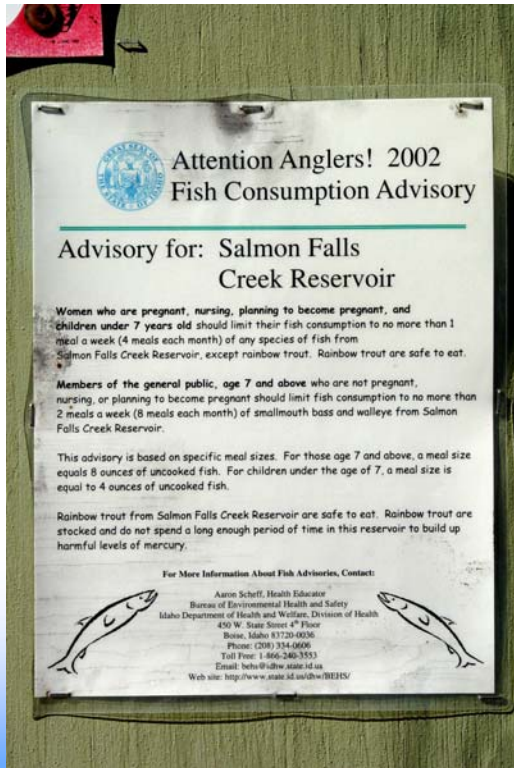
- $F_{\text{dry}} = -V_d \times C_g$ “inferential model”
 - $F_{\text{dry}} =$ dry dep flux ($\text{ng m}^{-2} \text{hr}^{-1}$)
 - $V_d =$ dry dep velocity (m s^{-1})
 - $C_g =$ GEM, RGM concentration (ng m^{-3})
- $V_d = (R_a + R_b + R_c)^{-1}$ “resistance model”
 - $R_a =$ aerodynamic resistance from on-site turbulence parameters
 - $R_b =$ quasi-laminar resistance from Hg diffusivities and air density
 - $R_c =$ seasonal canopy/surface resistance from properties of depositing species and local surface conditions (e.g., seasonal LAI, z_0)
- Gives species-specific hourly V_d s with diurnal variation.
- see Wesley (Atmos Env. 23, 1989) and Lin (Atmos Env. 40, 2006)

DEQ Hg air study started at Salmon Falls Creek Reservoir (SFCR) in July 2005

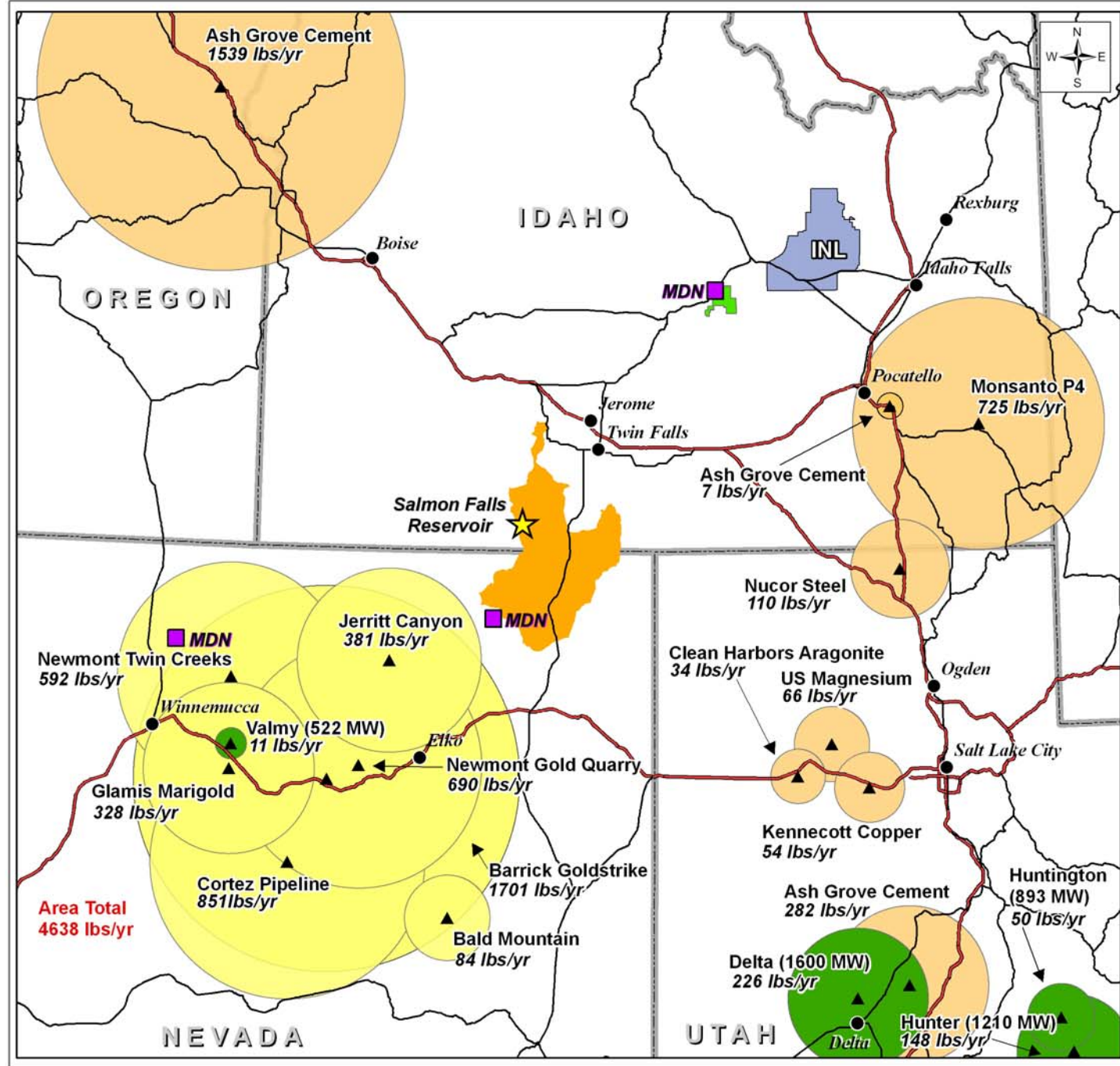


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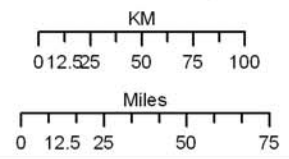
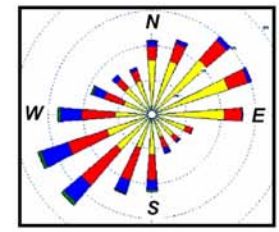


Regional Mercury Air Emission Sources (2005 EPA TRI)

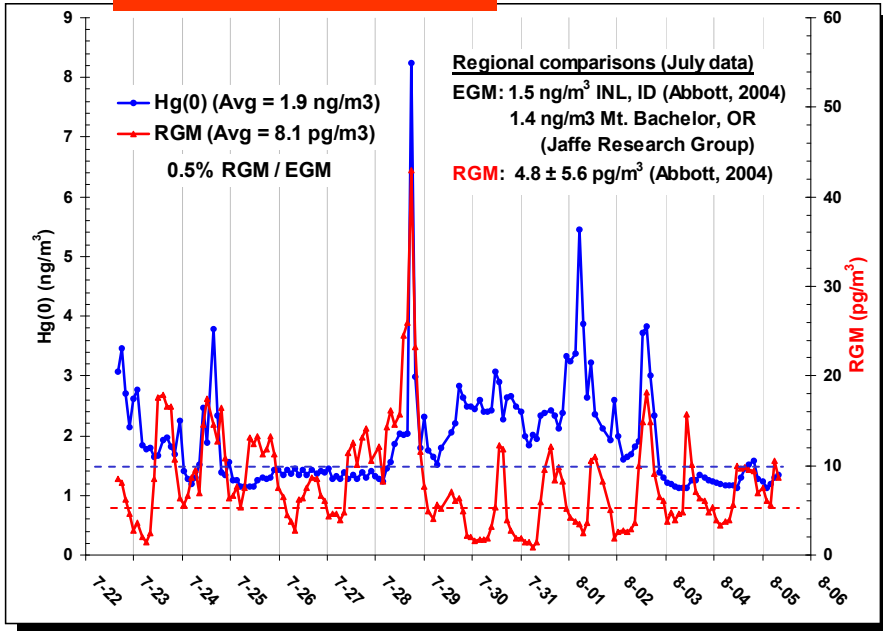


Legend

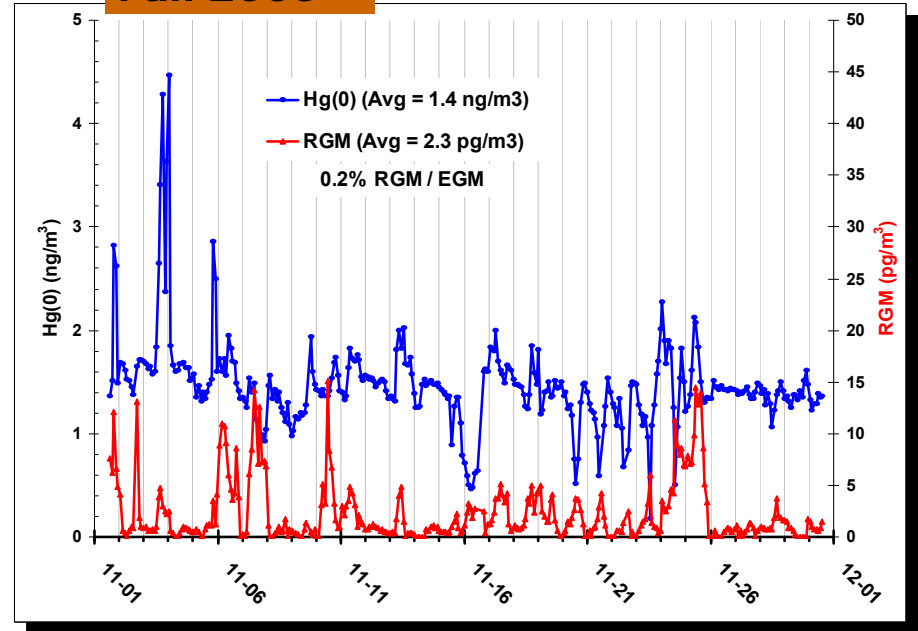
- ▲ Source Locations
- Coal-fired Power Plant
- Gold Mine
- Other Source
- Mercury Deposition Network Sampler
- Cities and Towns
- 👉 Salmon Falls Watershe
- ⊕ State Boundary
- 🛣 Interstate
- 🛤 State/US Highway



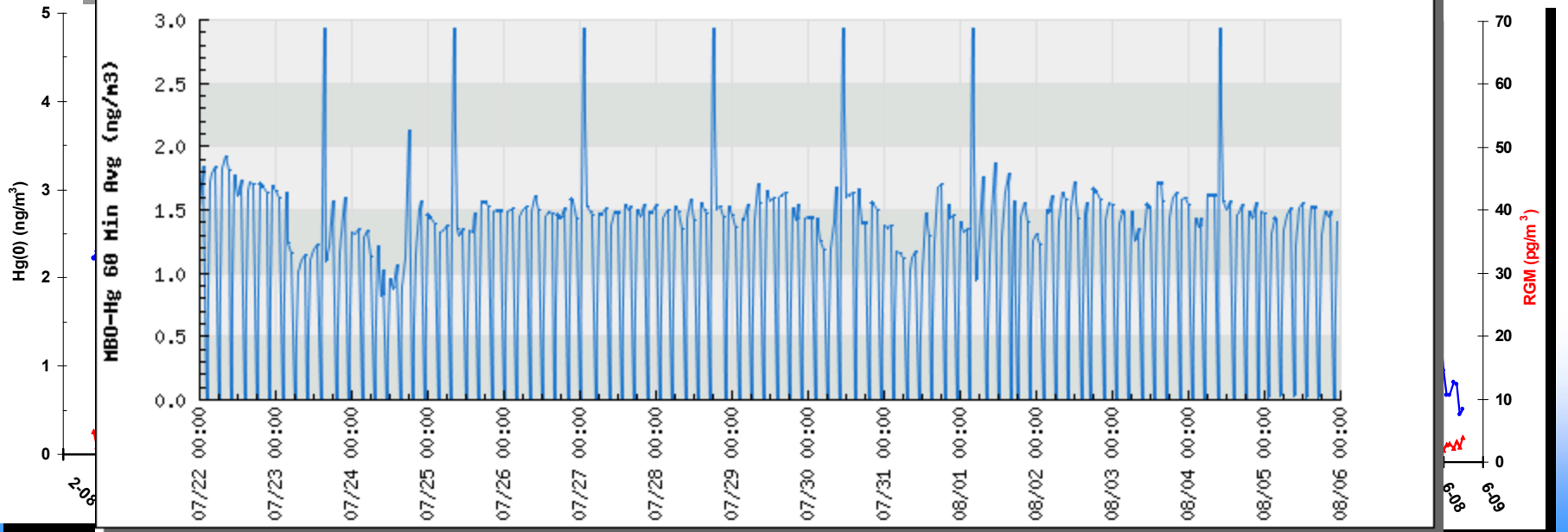
Summer 2005



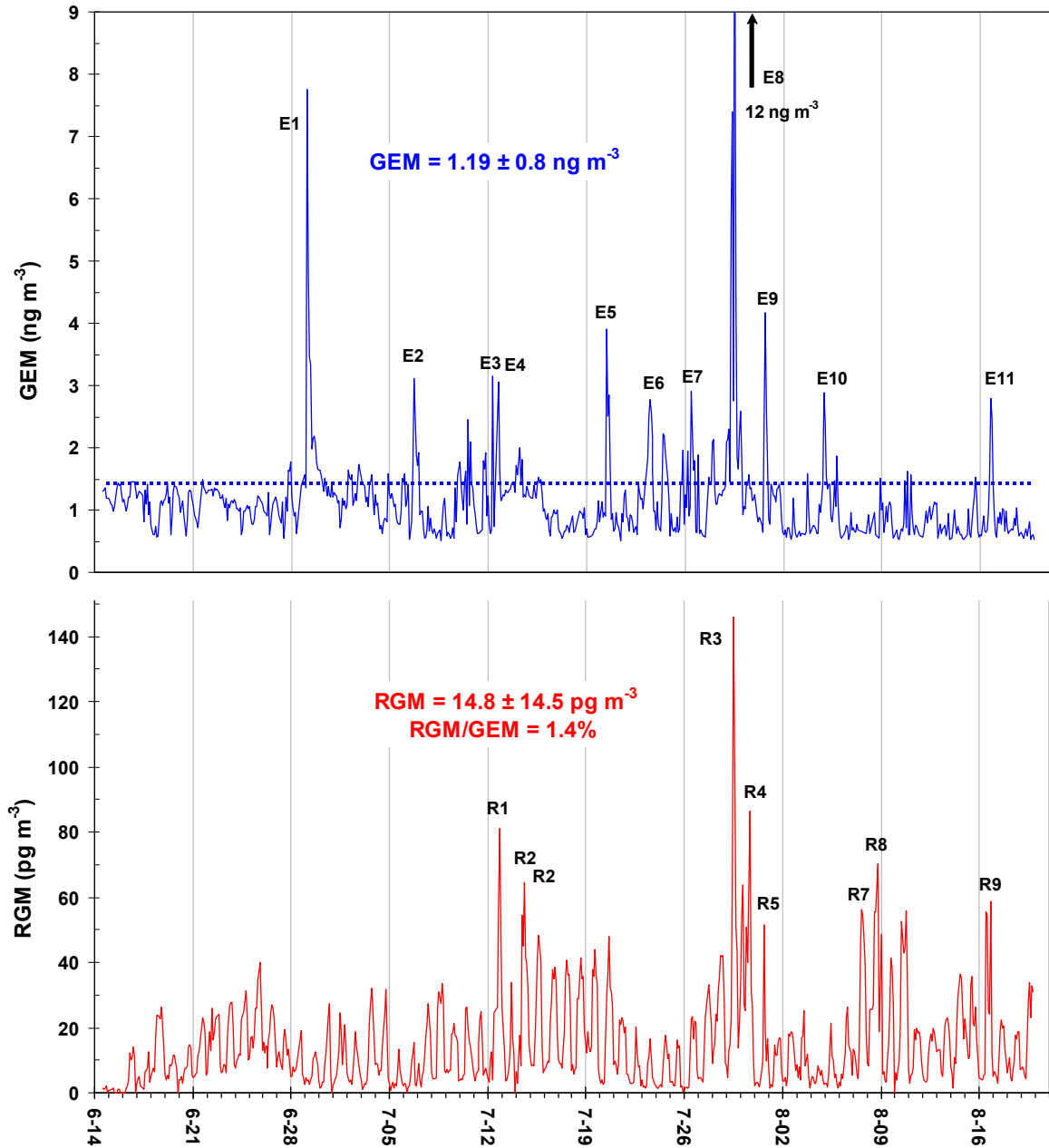
Fall 2005



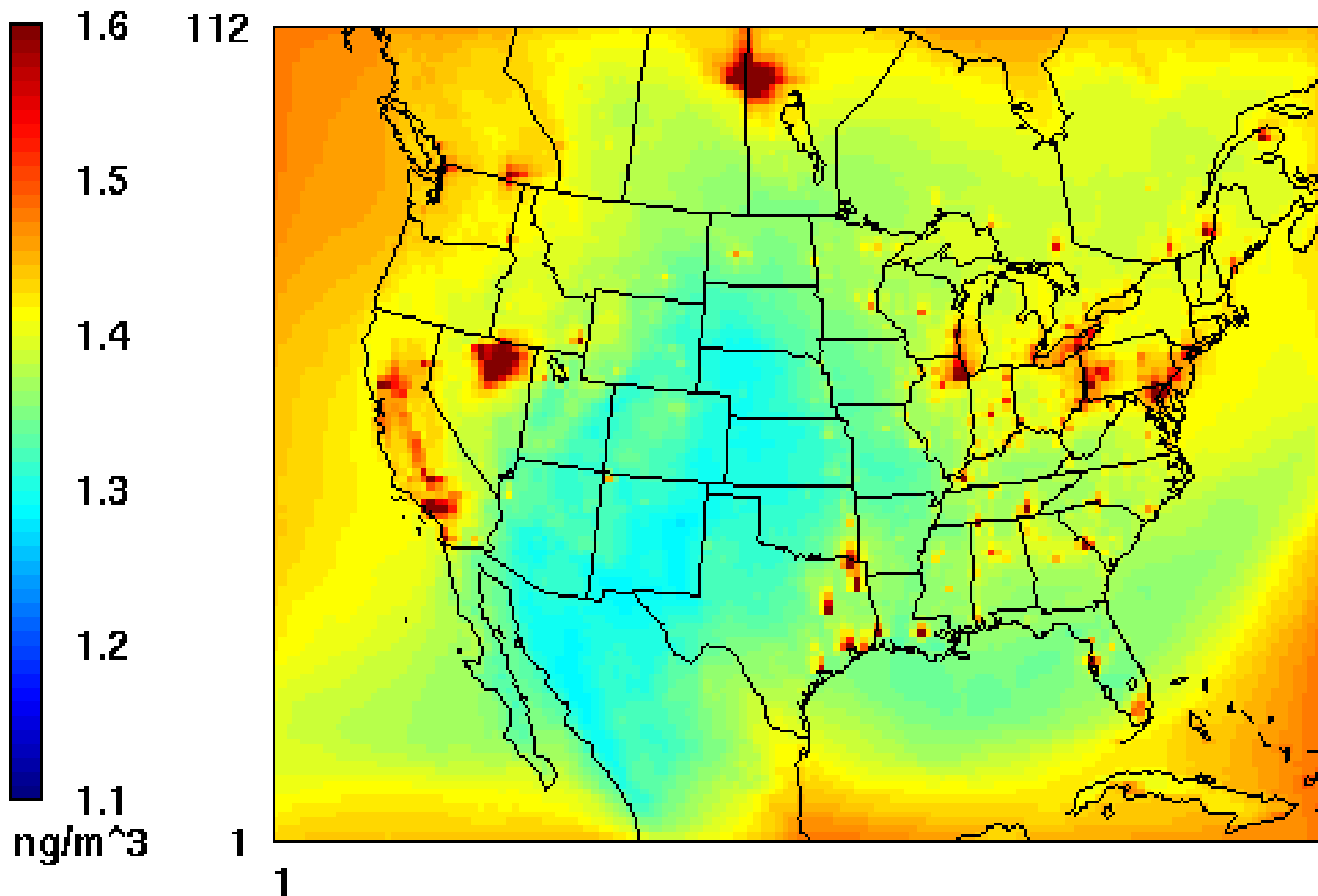
Mount Bachelor, Oregon (trans-Pacific input) – Jaffe et al.



Summer 2006



TGM Air Concentrations – Model Predictions (Lin, AE 41, 2007)



Dry Deposition Estimates

- Dominated by GEM in warm seasons

$V_d = 0.03, 0.04, 0.0008, 0.0004$ cm/s
(spring, summer, fall, winter)

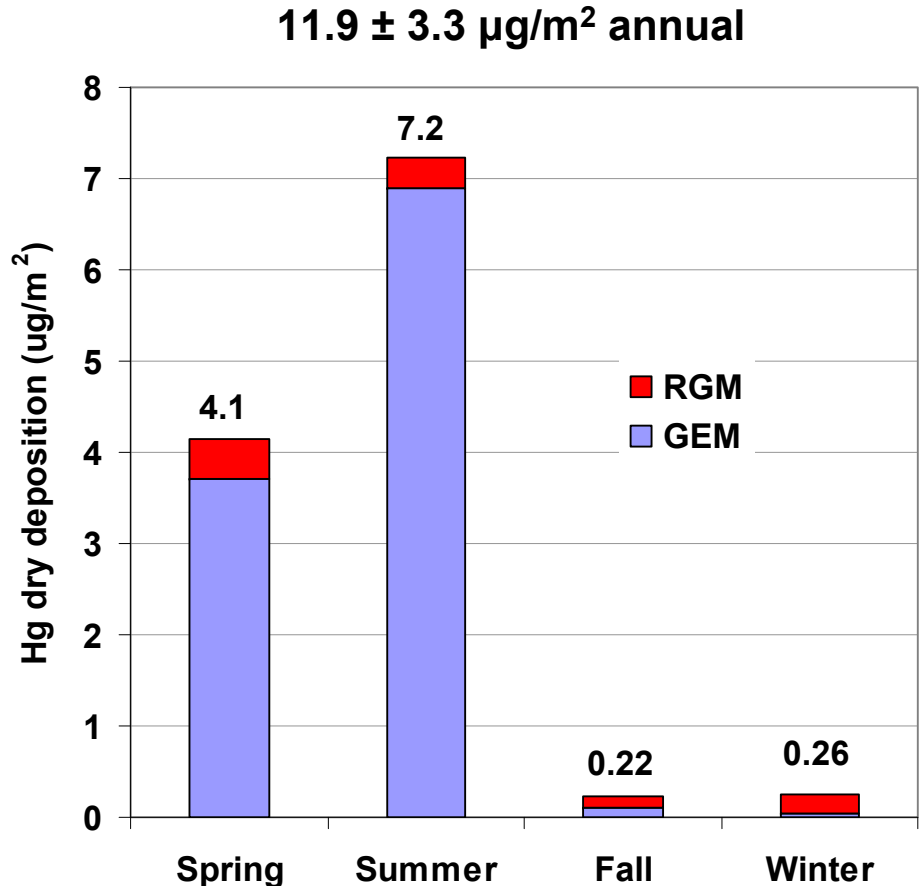
- RGM in cold seasons

$V_d = 0.5, 0.4, 0.5, 0.8$ cm/s (spring, summer, fall, winter)

High RGM – low surface resistance from decreased veg cover

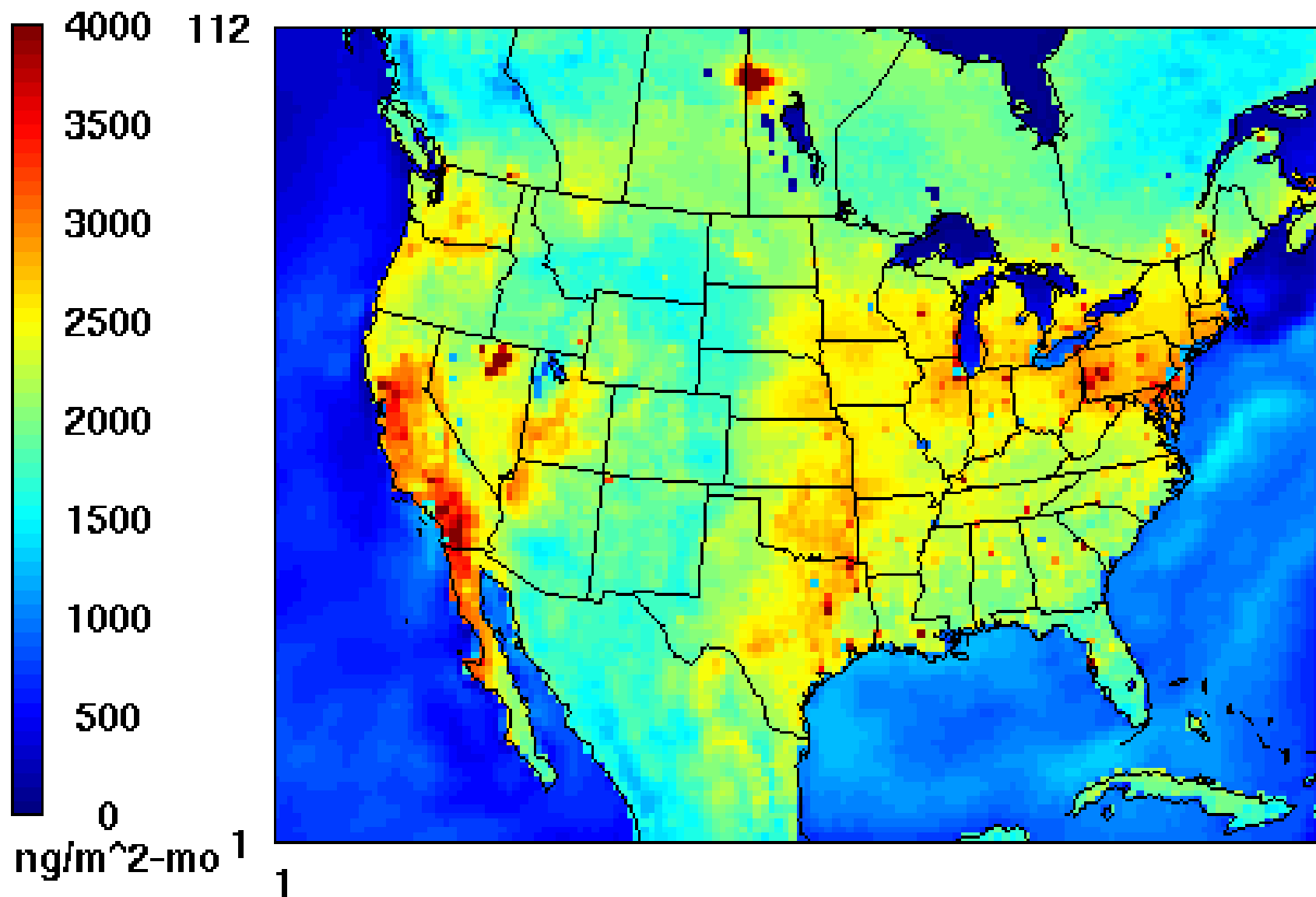
Low GEM – high surface resistance from cold ground surface

- Dry ~ 2/3 of total (wet+dry)
- Model estimates ~ 8-9 $\mu\text{g}/\text{m}^2$
- NM (Caldwell 2006) ~ 6 $\mu\text{g}/\text{m}^2$
- NV (Lyman 2007) ~ 11 $\mu\text{g}/\text{m}^2$

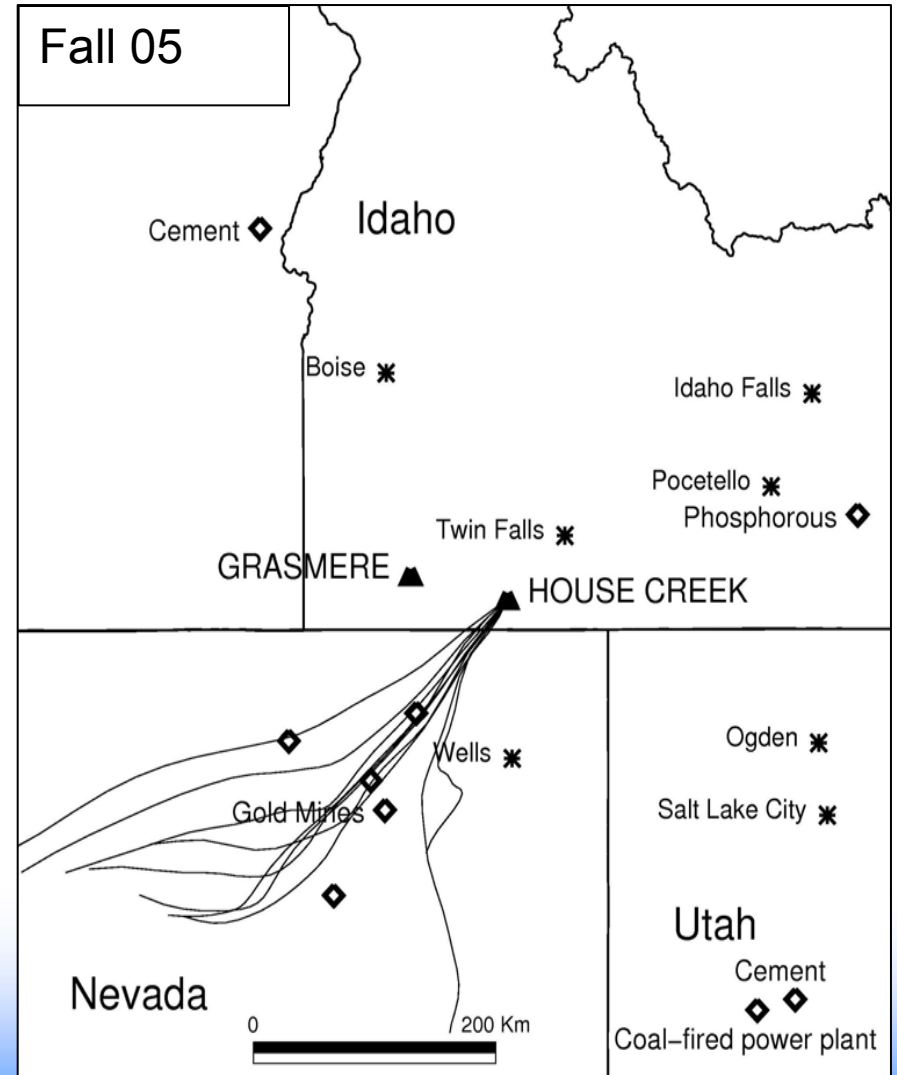
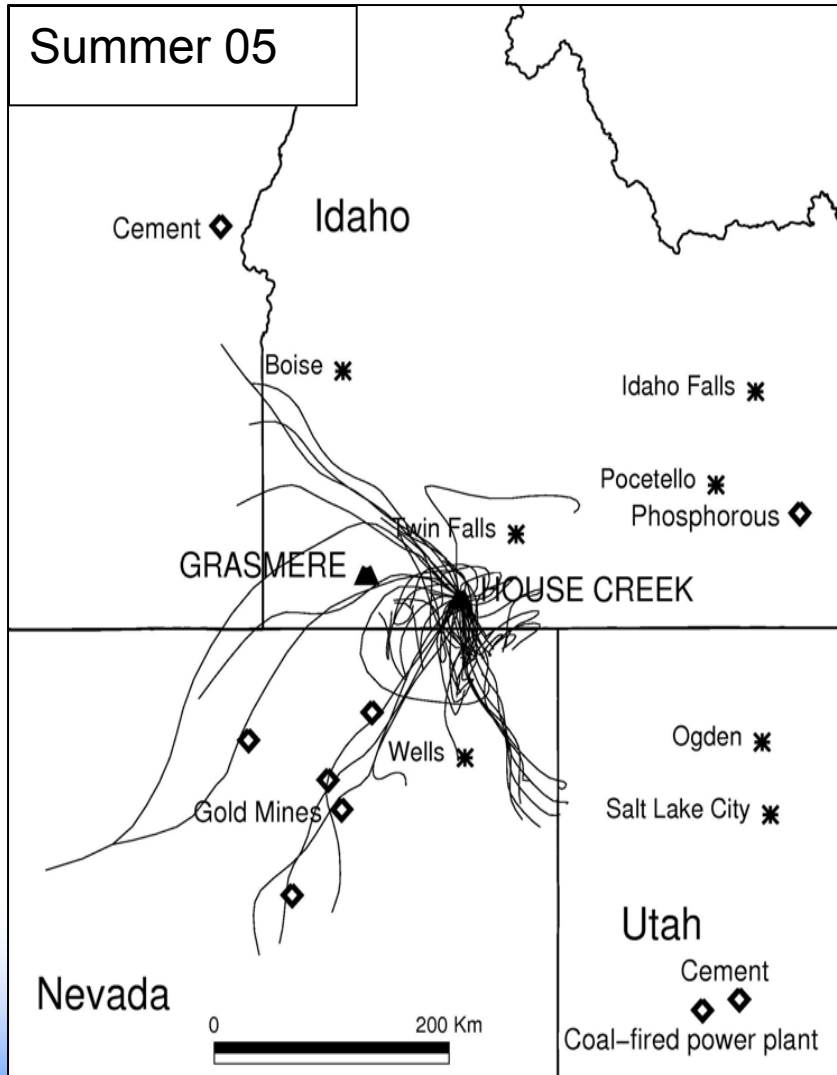


Does not account for GEM re-emission loss

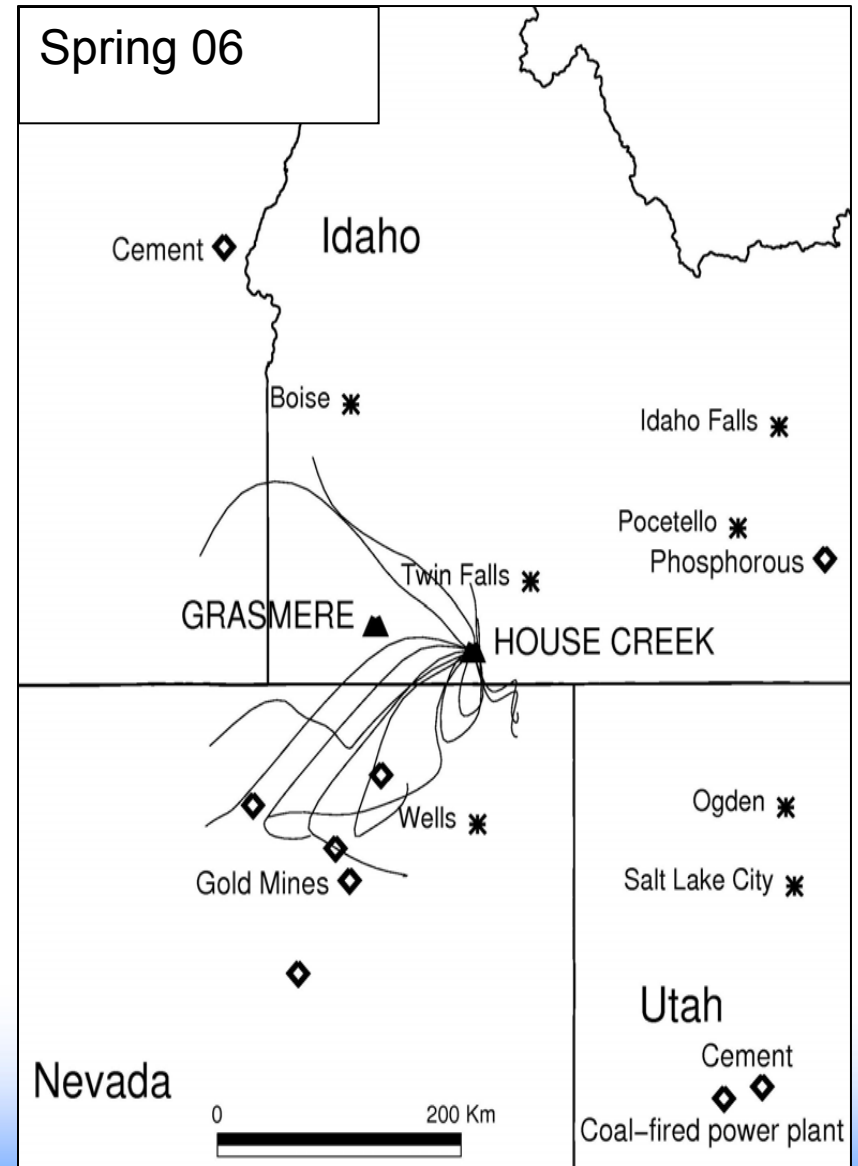
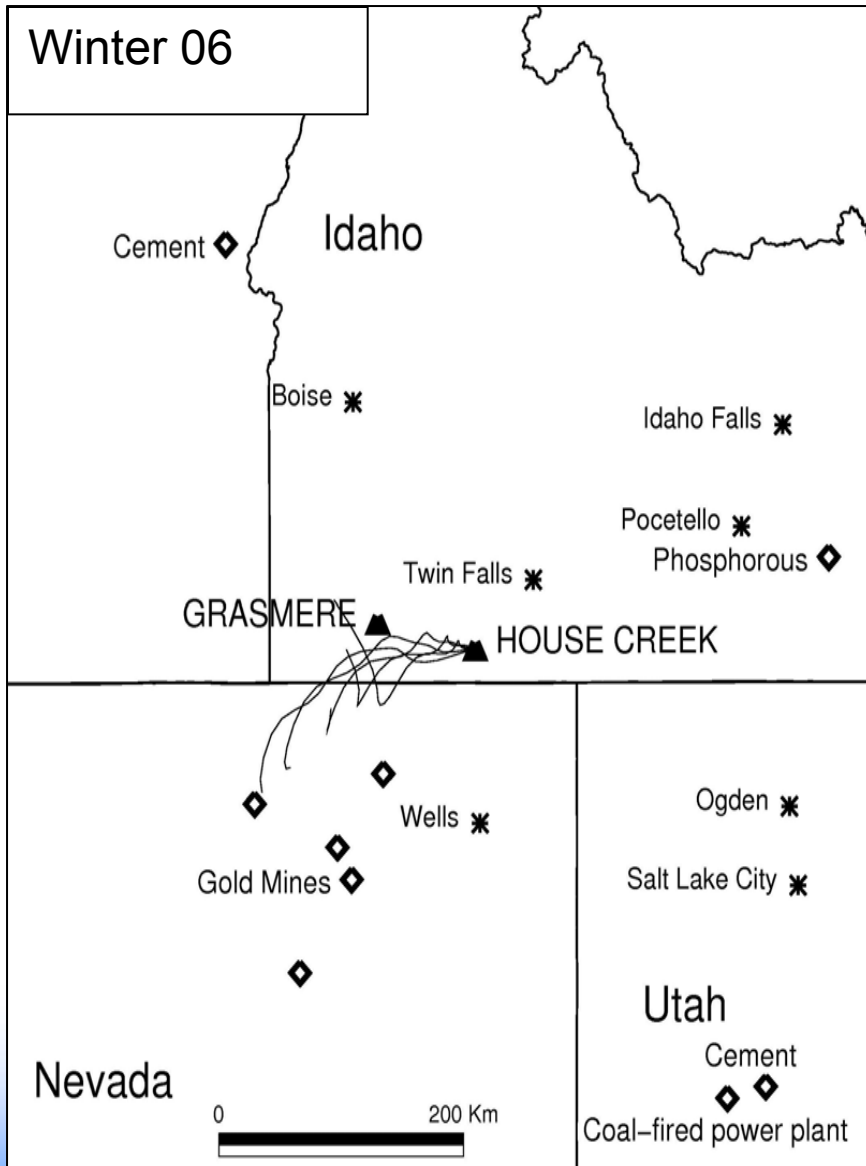
Dry Deposition – Model Predictions (Lin, AE 41, 2007)



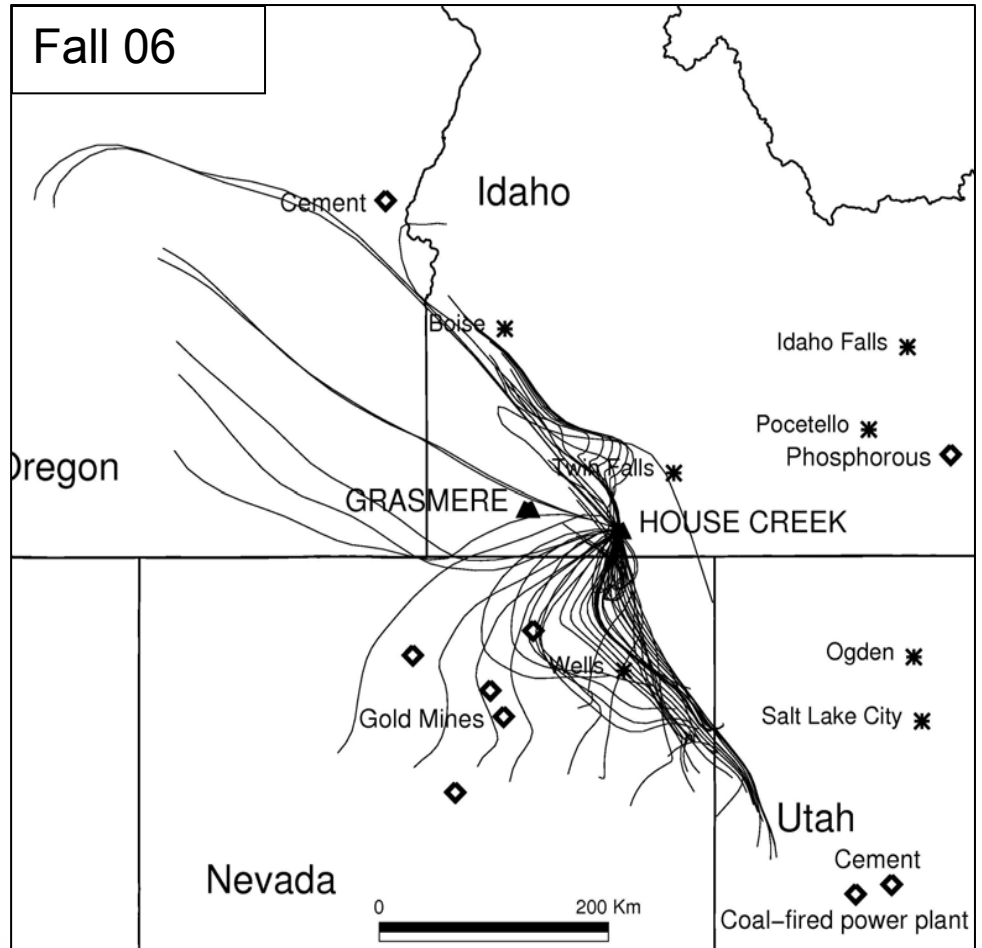
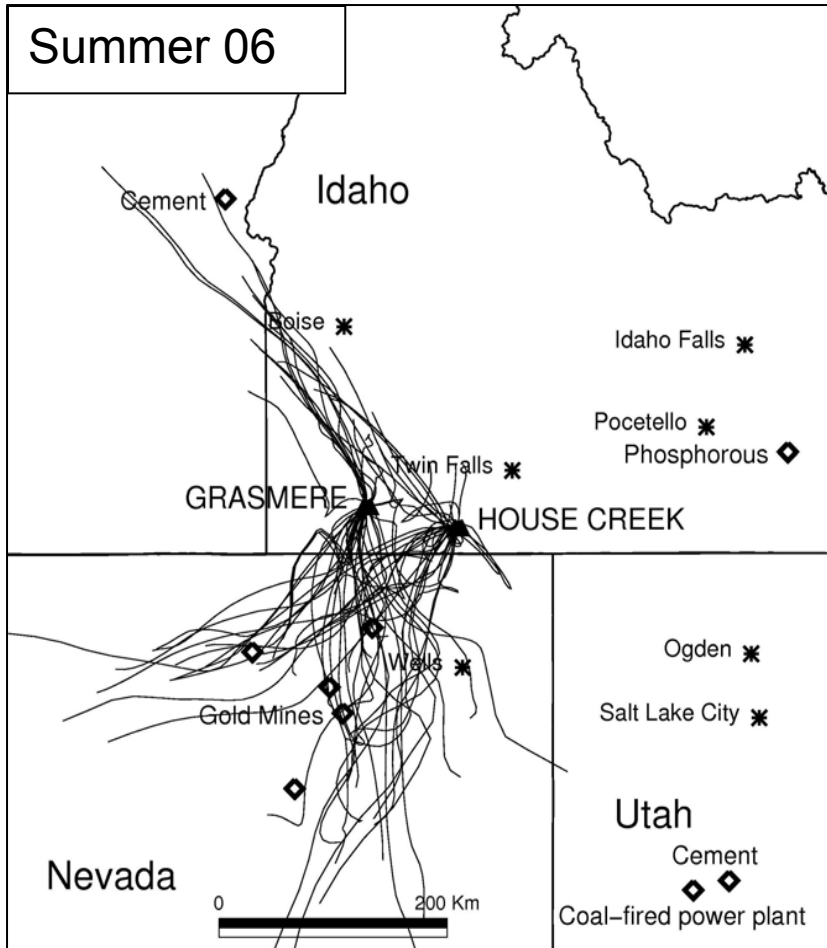
HYSPLIT 4 Back-trajectories for GEM events ($>2.2 \text{ ng/m}^3$)



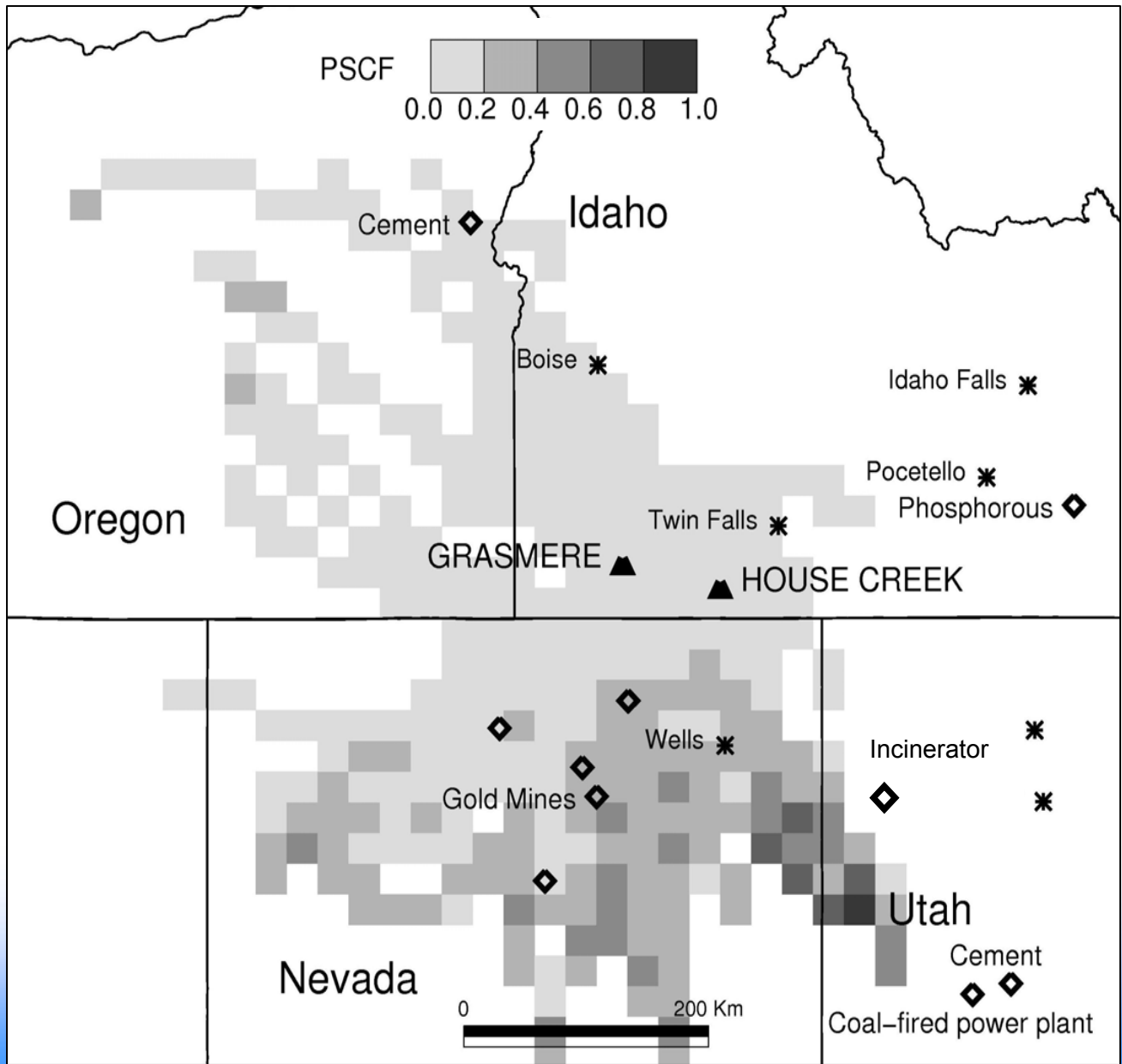
GEM events >2.2 ng/m³



GEM events >2.2 ng/m³



Potential Source Contribution Function (PSCF)



Conclusions

- Speciated Hg air concentrations relatively high and variable during warm season; low background during cold seasons.
- Annual dry deposition ($11.9 \mu\text{g}/\text{m}^2$) is similar to regional scale model predictions and other regional measurement studies, although ours is dominated by GEM. Unknown GEM losses.
- Periodic elevated GEM events observed primarily during warm seasons associated with air masses primarily from the SE (western Utah) and SW (northern NV) with fewer inputs from the NW. These events are likely due to regional anthropogenic point sources based on signal strength and published emissions for both these sources and known naturally enriched sources in the region.
- EPA10 RARE project starting this fall to better identify contributing sources using receptor modeling techniques (e.g., chemical signatures and positive matrix factorization – PMF). GEM flux may also be measured.

Madison Declaration on Mercury Pollution

(Ambio 36, 2007)

Source Attribution of atmospheric mercury deposition expert panel:

“It is possible to infer local, regional, and global atmospheric sources of mercury, depending upon the level of uncertainty considered acceptable....”

Source attribution for sources located between local and global scales (regional sources) has “the greatest uncertainty.”

This is generally what we’re dealing with in Idaho -

i.e., if you’re waiting for 100% proof of where the Hg is coming from, you’ll be waiting a long time.

How can Back-trajectories determine source locations?

