Supplementary Information for Modelling the Fate of Mercury Emissions from Artisanal and Small Scale Gold Mining

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S1 Emission domain relief

Figure S1. Emissions and relief of the South-East Asian Domains, emissions in mol km$^{-2}$ hr$^{-1}$
Figure S2. Emissions and relief of the African Domains, emissions in mol km$^{-2}$ hr$^{-1}$
Figure S3. Normalised Hg Deposition vs. distance from emission source for the South American domains. The left colour bar represents deposition to land, the right to seas and oceans.

(a) Bolivia

(b) Columbia

(c) Brazil

(d) Guyana
Figure S4. Normalised Hg Deposition vs. distance from emission source for the South-East Asian domains. The left colour bar represents deposition to land, the right to seas and oceans.

(a) Mekong

(b) Sumatra

(c) Kalimantan

(d) Papua New Guinea

Mekong region, slow oxidation and slow foliar uptake

Sumatra, slow oxidation and slow foliar uptake

Kalimantan, slow oxidation and slow foliar uptake

Papua New Guinea, slow oxidation and slow foliar uptake
**Figure S5.** Normalised Hg Deposition vs. distance from emission source for the African domains. The left colour bar represents deposition to land, the right to seas and oceans.

(a) Ghana  
(b) Burkina Faso  
(c) Senegal  
(d) Sudan  
(e) Lake Victoria
S3  Deposition Distance Barcharts

Note on deposition velocity
Figure S6. Deposition vs. distance, South-East Asian emission domains. Percentages of the total within domain deposition

Deposition vs. Distance ($v_d = 2 \text{ cm/s}$)

<table>
<thead>
<tr>
<th>Distance range (km)</th>
<th>Sumatra, Slow</th>
<th>Sumatra, Fast</th>
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<tbody>
<tr>
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<th>Kalimantan, Fast</th>
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<td>&gt; 10000</td>
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<table>
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<th>Mekong, Fast</th>
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</thead>
<tbody>
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<tr>
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<table>
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<th>Papua New Guinea, Fast</th>
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<tr>
<td>&gt; 10000</td>
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</tr>
</tbody>
</table>
Figure S7. Deposition vs. distance, South-East Asian emission domains. Percentages of the total within domain deposition

Deposition vs. Distance ($v_d = 2$ cm s$^{-1}$)

- **Colombia, Slow**
- **Colombia, Fast**
- **Brazil, Slow**
- **Brazil, Fast**
- **Bolivia, Slow**
- **Bolivia, Fast**
- **Guyana, Slow**
- **Guyana, Fast**

Distance range (km) vs. % deposition for each domain, with different colors representing different processes:

- *Leaf*
- *DD*
- *Conv*
- *non-Conv*
- *Total*
Figure S8. Deposition vs. distance, African emission domains. Percentages of the total within domain deposition

Deposition vs. Distance ($v_d = 2 \text{ cm s}^{-1}$)

Burkina Faso, Slow

Burkina Faso, Fast

Sudan, Slow

Sudan, Fast

Ghana, Slow

Ghana, Fast

Senegal, Slow

Senegal, Fast

Lake Victoria, Slow

Lake Victoria, Fast

Leaf DD Conv non-Conv Total

Distance range (km)

% deposition

S9
These maps show the deposition from the simulations using the most rapid oxidation rate and the fastest foliar uptake, illustrating the differences in deposition fields for the different domains and different deposition pathways. The normalisation is to the maximum deposition for each pathway for each domain.

**Figure S9.** Normalised deposition from the domain in the Mekong region

Mekong River Domain, fast oxidation, rapid foliar uptake
**Figure S10.** Normalised deposition from the domain in Sumatra

*Sumatra Domain, fast oxidation, rapid foliar uptake*

**Figure S11.** Normalised deposition from the domain in Kalimantan

*Kalimantan Domain, fast oxidation, rapid foliar uptake*
Figure S12. Normalised deposition from the domain in Papua New Guinea
Papua New Guinea Domain, fast oxidation, rapid foliar uptake

Figure S13. Normalised deposition from the domain in Colombia
Colombia Domain, fast oxidation, rapid foliar uptake
Figure S14. Normalised deposition from the domain in Bolivia

Bolivia Domain, fast oxidation, rapid foliar uptake

Figure S15. Normalised deposition from the domain in Brazil

Brazil Domain, fast oxidation, rapid foliar uptake
Figure S16. Normalised deposition from the domain in Guyana

Guyana Domain, fast oxidation, rapid foliar uptake

Figure S17. Normalised deposition from the domain in Ghana

Ghana Domain, fast oxidation, rapid foliar uptake
Figure S18. Normalised deposition from the domain in Burkina Faso

**Burkina Faso Domain, fast oxidation, rapid foliar uptake**

- Foliar uptake
- Convective deposition
- Non-convective deposition
- Dry deposition

Figure S19. Normalised deposition from the domain in Senegal

**Senegal Domain, fast oxidation, rapid foliar uptake**

- Foliar uptake
- Convective deposition
- Non-convective deposition
- Dry deposition
Figure S20. Normalised deposition from the domain in Sudan

Sudan Domain, fast oxidation, rapid foliar uptake

Figure S21. Normalised deposition from the domain near Lake Victoria

Lake Victoria Domain, fast oxidation, rapid foliar uptake
SUBROUTINE Hg_tracer_ASGM (id, dtstep, ktau, pbl_h, chem, t_phy, p_phy, rho_phy, dz8w, chem_opt, num_chem, &
   z, ht, ids, ide, jds, jde, kds, kde, &
   ims, ime, jms, jme, kms, kme, &
   its, ite, jts, jte, kts, kte, &
   lai, raincv_hg, rainncv_hg, Hg_dep, moist, area2d)

IMPLICIT NONE

INTEGER, INTENT(IN) :: id
INTEGER, INTENT(IN) :: ktau, chem_opt, num_chem
INTEGER, INTENT(IN) :: ids, ide, jds, jde, kds, kde
INTEGER, INTENT(IN) :: ims, ime, jms, jme, kms, kme
INTEGER, INTENT(IN) :: its, ite, jts, jte, kts, kte
REAL, DIMENSION(ims:ime, kms:kme, jms:jme, num_chem), INTENT(INOUT) :: chem
REAL, DIMENSION(ims:ime, kms:kme, jms:jme, num_Hg_dep), INTENT(INOUT) :: Hg_dep
REAL, DIMENSION(ims:ime, kms:kme, jms:jme), INTENT(IN) :: t_phy, p_phy, rho_phy, dz8w, z
REAL, DIMENSION(ims:ime, kms:kme, jms:jme, num_moist), INTENT(INOUT) :: moist
REAL, DIMENSION(ims:ime, jms:jme), INTENT(IN) :: PBL_H, HT, area2d
REAL, DIMENSION(ims:ime, jms:jme), INTENT(IN) :: lai, raincv_hg, rainncv_hg
REAL, INTENT(IN) :: dtstep

!local variables
REAL, DIMENSION(ims:ime, jms:jme) :: fraction_on_ground
REAL :: colsum_hgii_180_slo_asgm
REAL :: scav_hgii_180_slo_asgm
REAL :: fraction_this_cell, frac, mass_deposited_this_lev, lost_fraction
REAL :: Hg_em_sum, hg_mass, hg_scav_fac, wet_hg_mass, ppm2mgm3
REAL :: LWC, ppm2ngm3, ng_per_L, ngL_sum, ngL_average, dz8wsun, qr_sum, qr_average
INTEGER :: count_pbl, count_trop, qr_count
37: INTEGER :: i, j, k
38:
39:
50 40:
41: !!! Uptake by vegetation
42:
43:
44:    do i = its, ite
45:      do j = jts, jte
46:        Leaf_lo = lai(i,j)*9.218e-5*dtstep/1.4 ! dtstep is in seconds (unlike the chemistry timesteps)
47:        Leaf_mid = lai(i,j)*0.001777*dtstep/1.4
48:        Leaf_hi = lai(i,j)*0.0002632*dtstep/1.4
49:
60 50:
51:        if (Leaf_lo.gt.1.) Leaf_lo = 1.
52:        if (Leaf_mid.gt.1.) Leaf_mid = 1.
53:        if (Leaf_hi.gt.1.) Leaf_hi = 1.
54:
55:        do k = 1,1
56:          hg_mass=((200.59 * p_phy(i,1,j)) / (t_phy(i,1,j) * 8.314472)) * 1.e-6 ! ppm to mug/m3 *1e-6 to remove the emission exaggeration
57:          Hg_dep(i,1,j,p_hg180_slo_asgm) = Hg_dep(i,1,j,p_hg180_slo_asgm)+hg_mass*chem(i,k,j,p_hg_180_slo_asgm)
58:          chem(i,k,j,p_hg_180_slo_asgm) = chem(i,k,j,p_hg_180_slo_asgm)*(1. - (Leaf_lo / dz8w(i,1,j))
59:            enddo
60 60:       enddo
61:   enddo
62:
63:
64: !!! Rain
75 65: !!! convective
66:
67:
68: do i = its, ite
69: do j = jts, jte
80 70: if (raincv_hg(i,j).gt.0.1) then
71:   dz8wsun = 0.
72:   ppm2ngm3 = 0.
73:   colsum_hgii_180_slo_asgm = 0.
74:   colsum_hgii_270_slo_asgm = 0.
do k = kts, kte
    if ( p_phy(i,k,j) .gt. 18000.) dz8wsum = dz8wsum + dz8w(i,k,j)
enddo

do k = kts, kte
    if ( p_phy(i,k,j) .gt. 18000. and dz8wsum .gt. 100.) then
        ppm2ngm3 = ((200.59 * p_phy(i,k,j)) / (t_phy(i,k,j) * 8.314472)) * 1000. * 1.e-6 ! this is in ngm3 (mg/m3 * 1.e6)
        colsum_hgii_180_slo_asgm = colsum_hgii_180_slo_asgm + ppm2ngm3*chem(i,k,j,p_hgii_180_slo_asgm)*dz8w(i,k,j)
    else
        continue
    endif
enddo

if ( colsum_hgii_180_slo_asgm .gt. 1.e-13) then
    Hg_dep(i,1,j,p_hg180_105cdep_cfpp) = Hg_dep(i,1,j,p_hg180_105cdep_cfpp) + 750.* (colsum_hgii_180_slo_asgm)
    scav_hgii_180_slo_asgm = (colsum_hgii_180_slo_asgm - (750.*(colsum_hgii_180_slo_asgm/dz8wsum)))
else
    scav_hgii_180_slo_asgm = 1.0
endif

do k = kts, kte
    if ( p_phy(i,k,j) .gt. 18000. and dz8wsum .gt. 100.) then
        chem(i,k,j,p_hgii_180_slo_asgm) = scav_hgii_180_slo_asgm*chem(i,k,j,p_hgii_180_slo_asgm)
    else
        continue
    endif
enddo

else
    continue
endif
113: enddo
114: enddo
115:
116: ! non-convective
117: do i = its, ite
118: do j = jts, jte
119: if (rainncv_hg(i,j).gt.0.1) then
120: dz8wsum=0.
121: ppm2ngm3=0.
122: colsum_hgii_180_slo_asgm=0.
123: colsum_hgii_270_slo_asgm=0.
124: colsum_hgii_360_slo_asgm=0.
125: colsum_hgii_180_110cfpp=0.
126: colsum_hgii_270_110cfpp=0.
127: colsum_hgii_360_110cfpp=0.
128: colsum_hgii_180_115cfpp=0.
129: colsum_hgii_270_115cfpp=0.
130: colsum_hgii_360_115cfpp=0.
131: do k=kte
132: if (p_phy(i,k,j).gt.60000.) dz8wsum=dz8wsum + dz8w(i,k,j)
133: enddo
134:
135: do k=kte
136: if (p_phy(i,k,j).gt.60000. and dz8wsum.gt.100.) then
137: ppm2ngm3 = ((200.59 * p_phy(i,k,j)) / (t_phy(i,k,j) * 8.314472)) * 1000. * 1.e-6 ! this is in ngm/m3
138: colsum_hgii_180_slo_asgm = colsum_hgii_180_slo_asgm + ppm2ngm3*chem(i,k,j,p_hgii_180_slo_asgm)*dz8w(i,k,j)
139: else
140: continue
141: endif
142: enddo
143:
144: if (colsum_hgii_180_slo_asgm.gt.1.e-13) then
145: Hg_dep(i,1,j,p_hg180_105ncdep_cfpp) = Hg_dep(i,1,j,p_hg180_105ncdep_cfpp)+750.*(colsum_hgii_180_slo_asgm)
146: scav_hgii_180_slo_asgm=(colsum_hgii_180_slo_asgm -(750.*(colsum_hgii_180_slo_asgm/dz8wsum)))
147: else
148: scav_hgii_180_slo_asgm=1.0
149: endif
150: do k=kte
151: }
if (p_phy(i,k,j) .gt. 60000.0 .and. dz8wsum .gt. 100.) then
  chem(i,k,j,p_hgii_180_slo_asgm) = scav_hgii_180_slo_asgm*chem(i,k,j,p_hgii_180_slo_asgm)
else
  continue
endif
enddo
else
  continue
endif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif

d! dry_dep
do i = its, ite
do j = jts, jte
do k = 1, 1
  ppm2mgm3 = ((200.59 * p_phy(i,k,j)) / (t_phy(i,k,j) * 8.314472)) * 0.001
  Hg_dep(i,1,j,p_hg180_l05_dd Cfpp) = Hg_dep(i,1,j,p_hg180_l05_dd Cfpp) + ppm2mgm3 * chem(i,k,j,p_hgii_180_slo_asgm)
  chem(i,k,j,p_hgii_180_slo_asgm) = chem(i,k,j,p_hgii_180_slo_asgm) * (1. - (0.01 * dtstep))
enddo
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
dendif
end subroutine Hg_tracer_ASGM