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

Ian M. Hedgecock, Francesco De Simone, Francesco Carbone, and Nicola Pirrone

CNR-Institute of Atmospheric Pollution Research, 87036 Rende, Italy

Correspondence: Ian M. Hedgecock (ian.hedgecock@iia.cnr.it)

S1 Emission domain relief

Figure S1. Emissions and relief of the South-East Asian Domains, emissions in $\mathrm{mol\,km^{-2}\,hr^{-1}}$

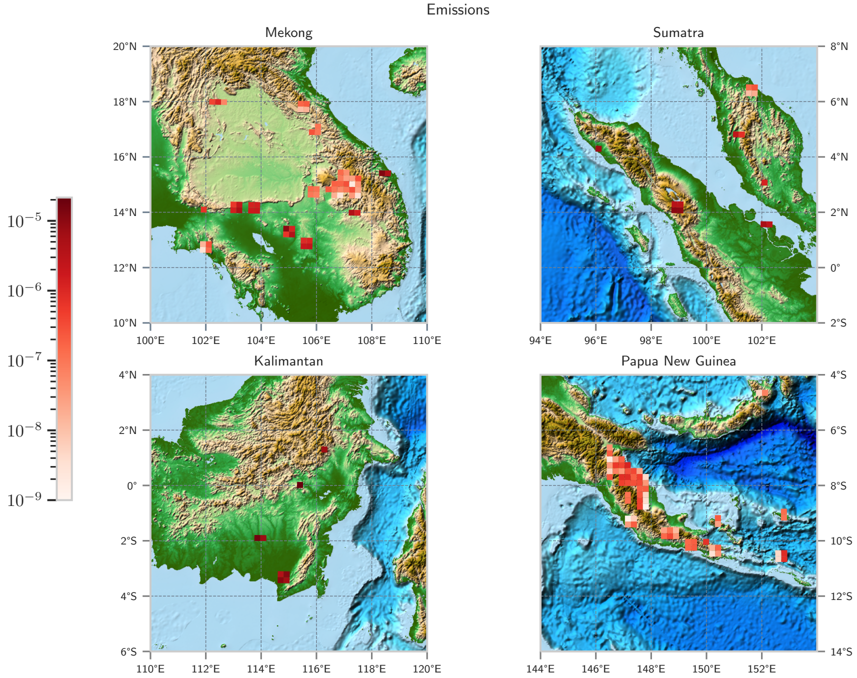
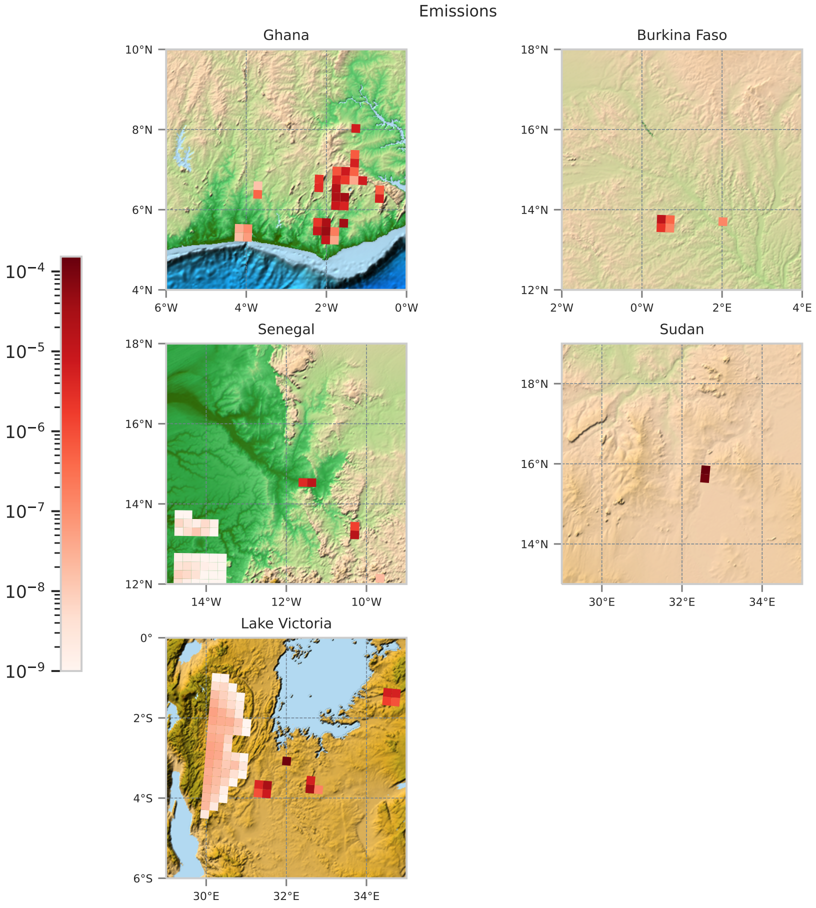


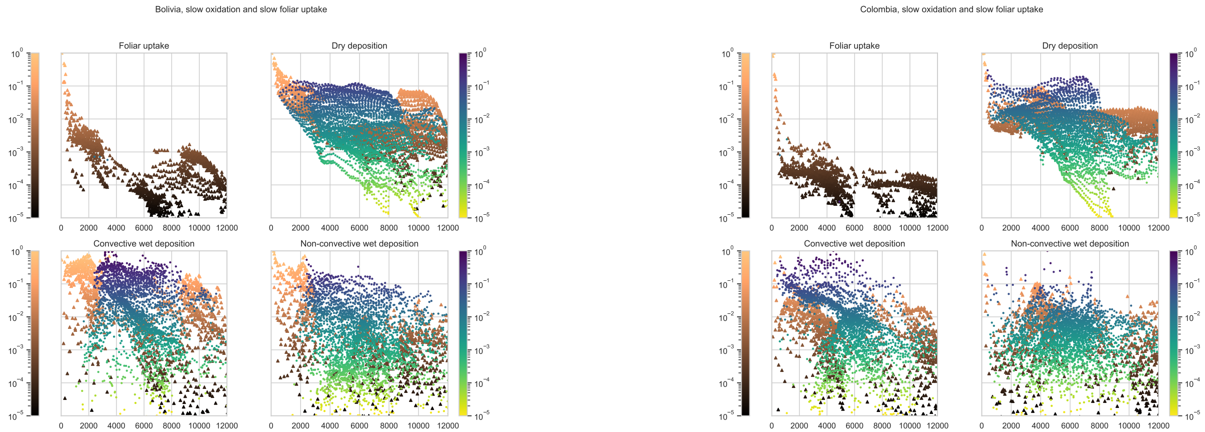
Figure S2. Emissions and relief of the African Domains, emissions in $\mathrm{mol\,km^{-2}\,hr^{-1}}$



S2 Land-Sea Deposition Distance plots

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

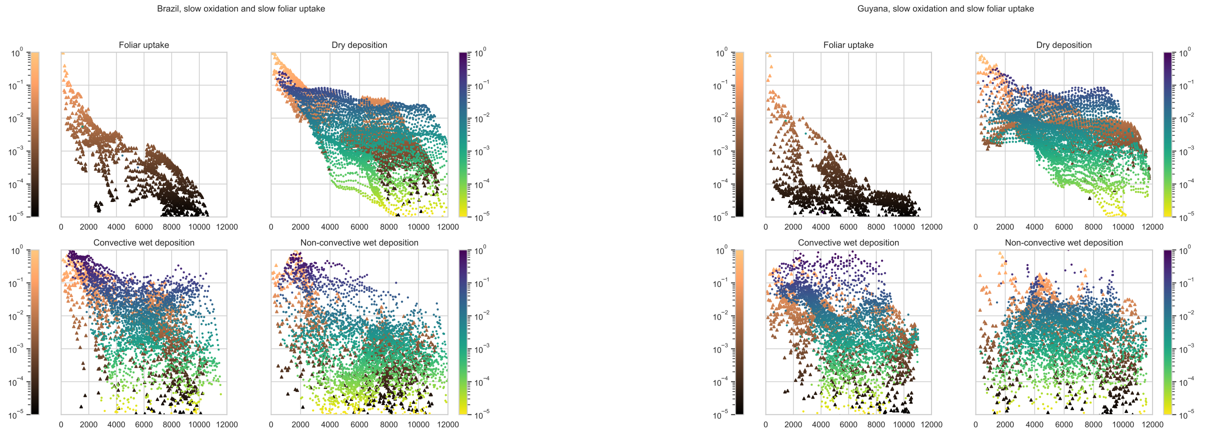
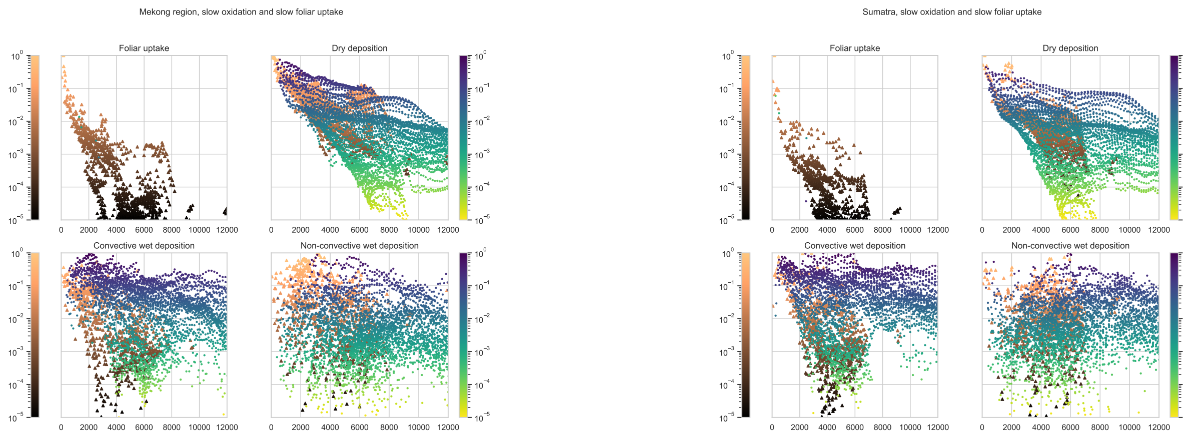
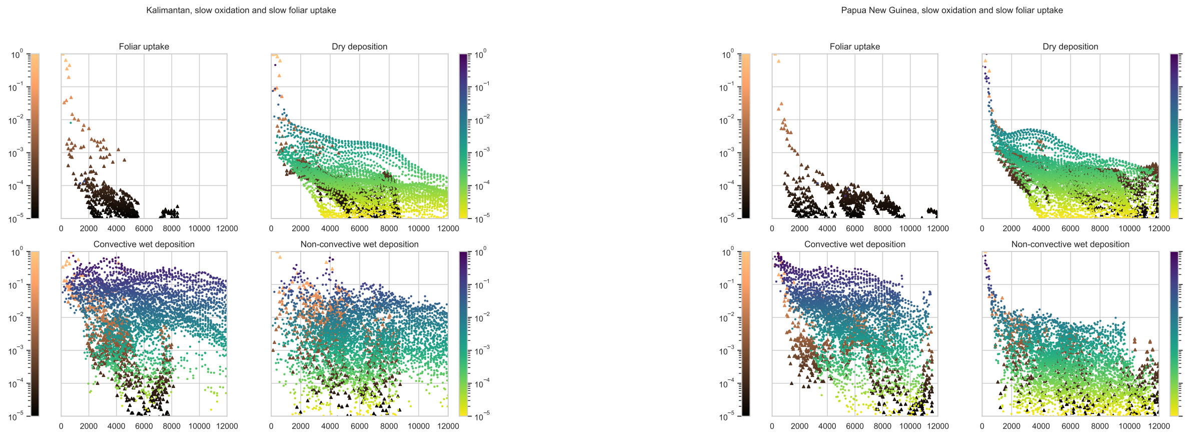


Figure S4. Normalised Hg Deposition vs. distance from emission source for the South-East Asian domains. The left colour bar represents deposition to land, the right to seas and oceans



(a) Mekong

(b) Sumatra

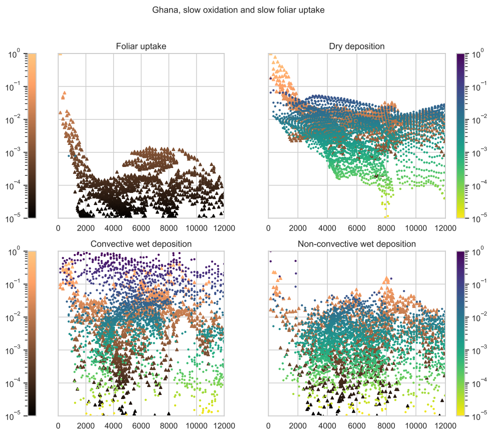


(c) Kalimantan

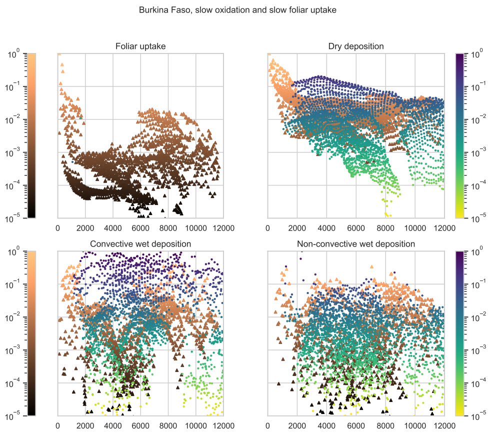
(d) Papua New Guinea

Figure S5. Normalised Hg Deposition vs. distance from emission source for theAfrican domains. The left colour bar represents deposition to land, the right to seas and oceans

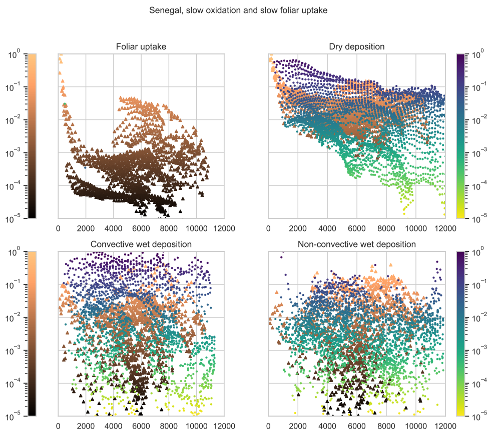
(a) Ghana



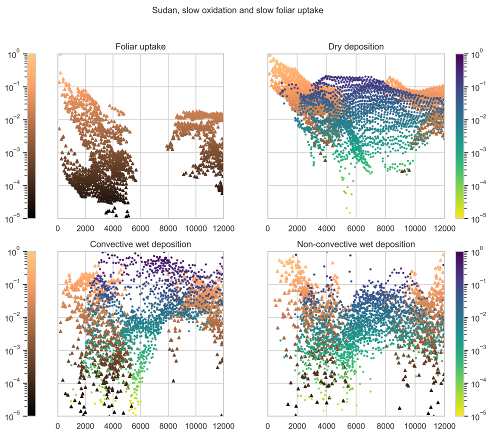
(b) Burkina Faso



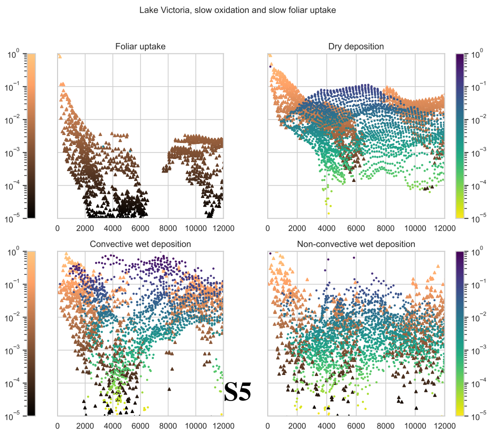
(c) Senegal



(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

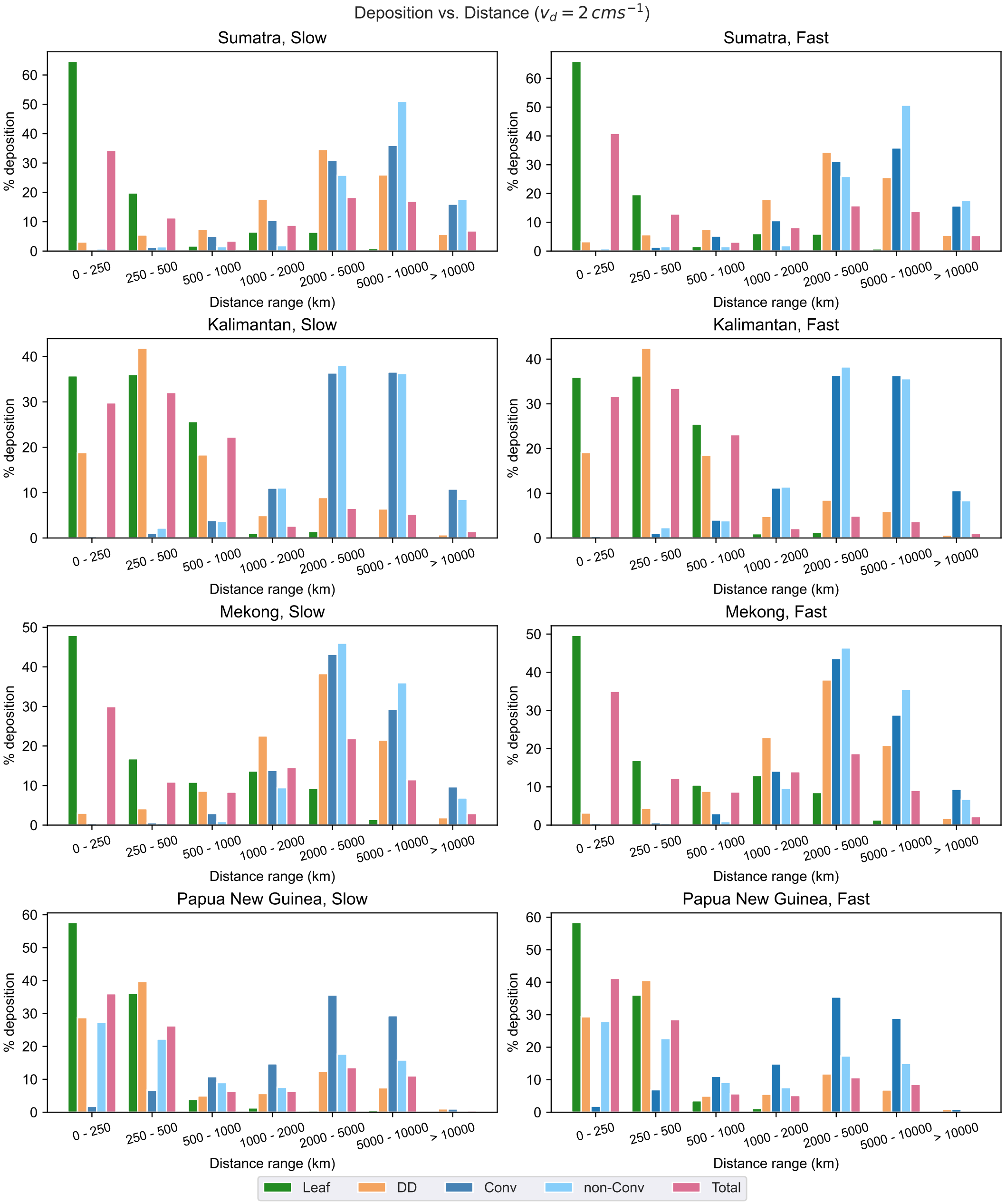


Figure S7. Deposition vs. distance, South-East Asian emission domains. Percentages of the total within domain deposition

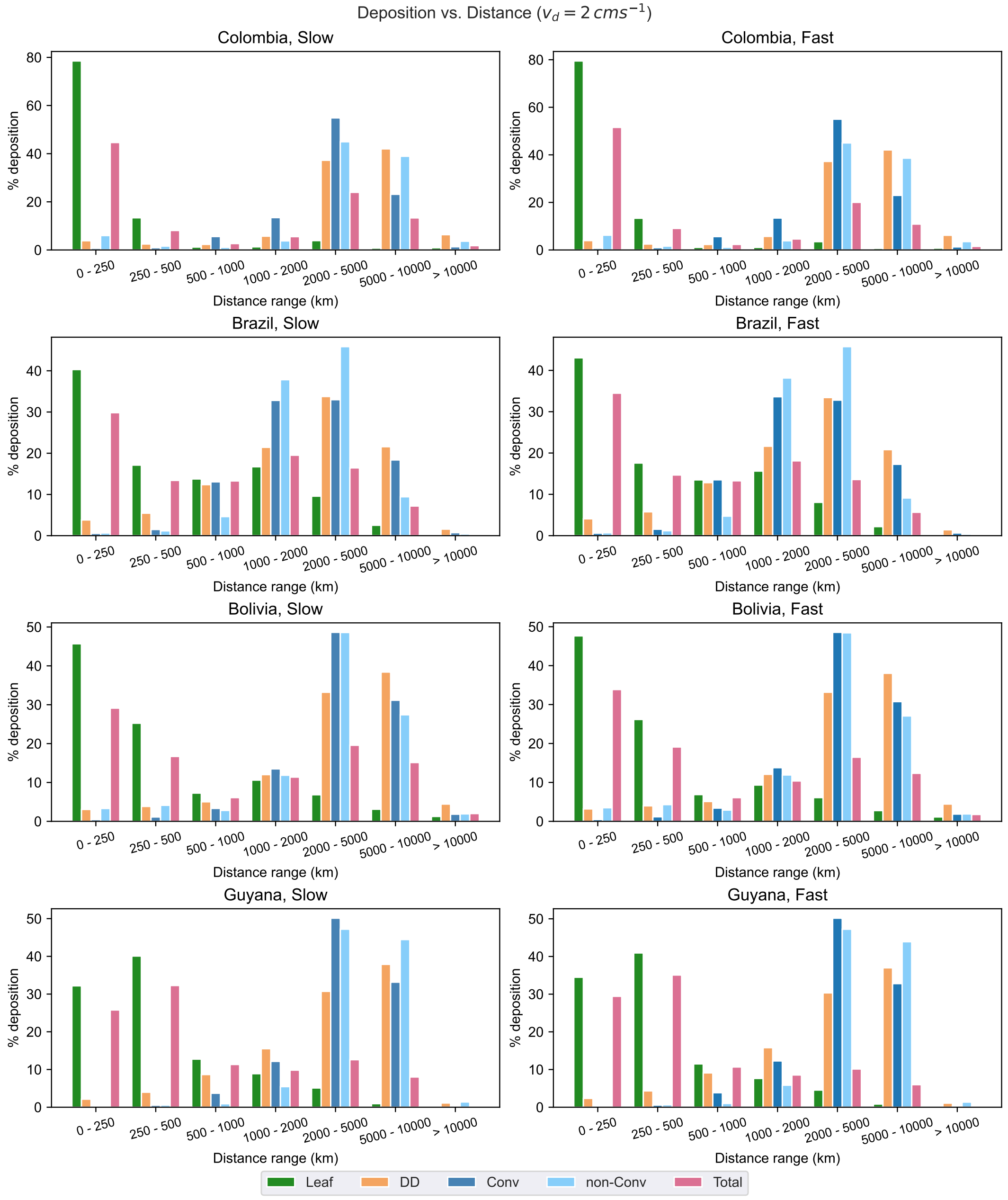
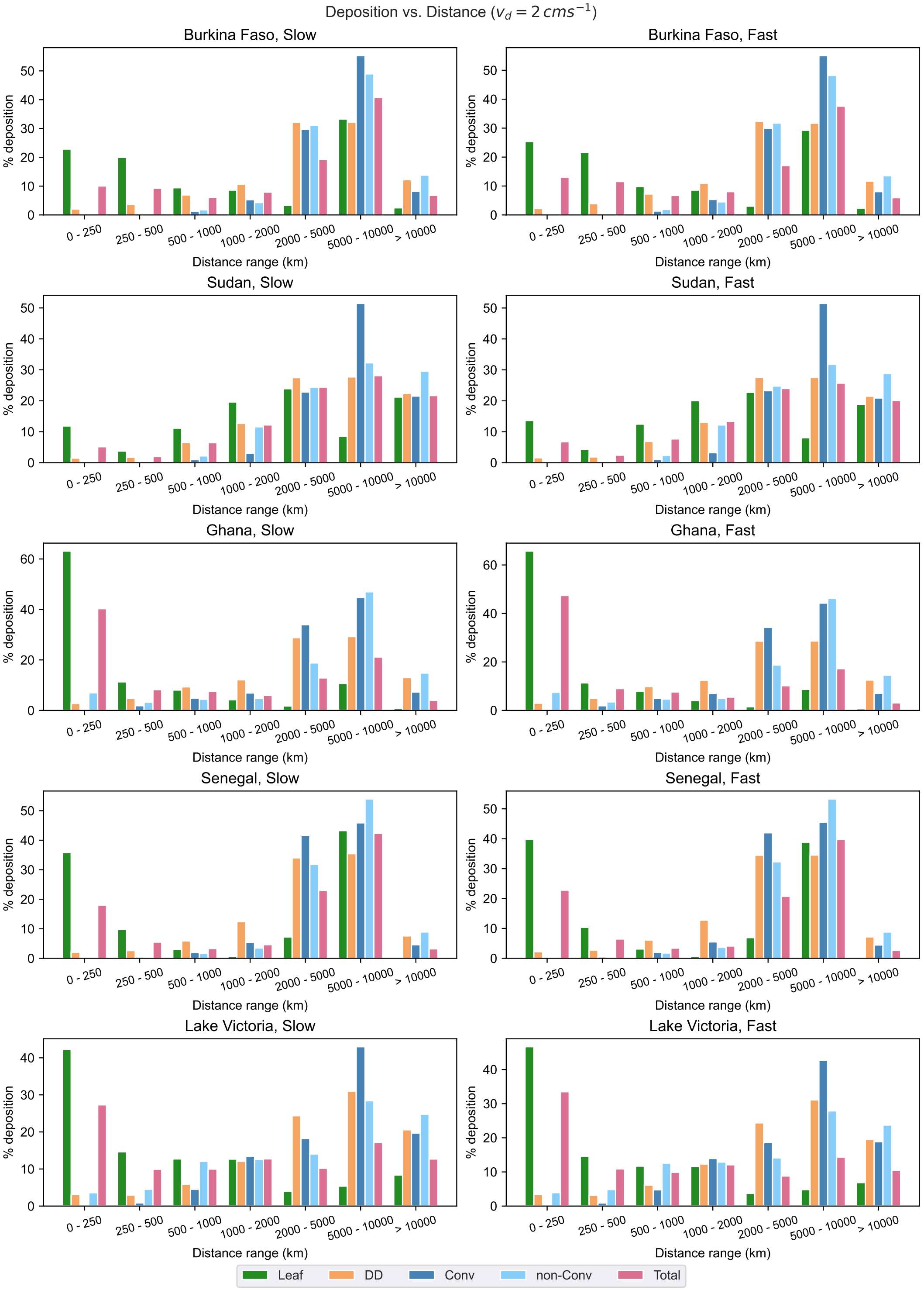


Figure S8. Deposition vs. distance, African emission domains. Percentages of the total within domain deposition



5 S4 Deposition Maps

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

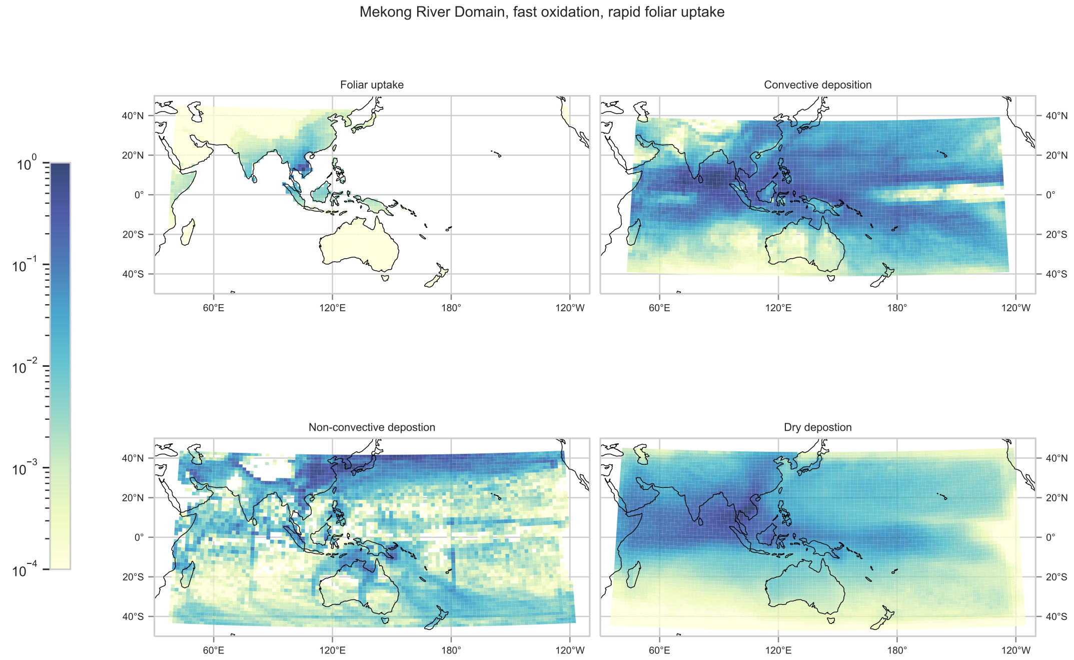
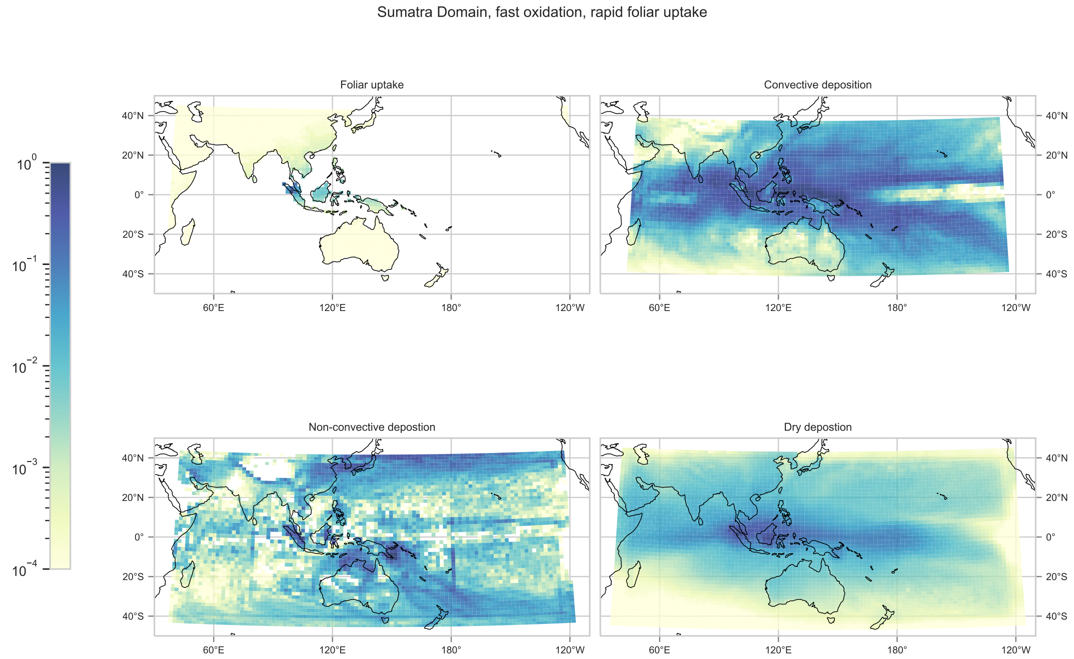


Figure S10. Normalised deposition from the domain in Sumatra



Sumatra Domain, fast oxidation, rapid foliar uptake

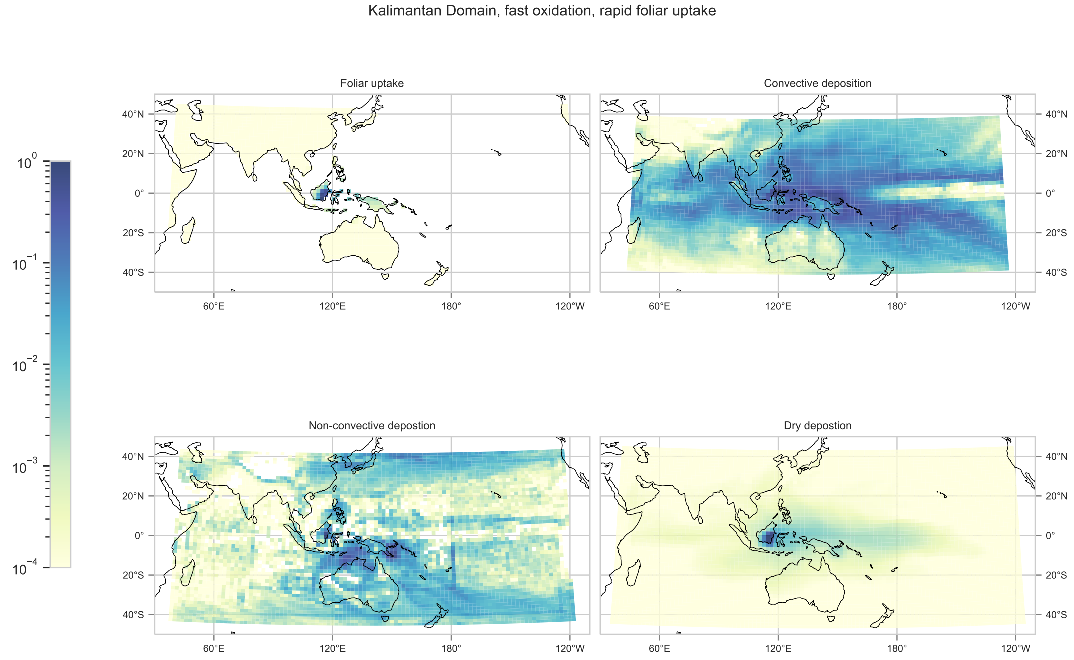
Foliar uptake

Convective deposition

Non-convective depostion

Dry depostion

Figure S11. Normalised deposition from the domain in Kalimantan



Kalimantan Domain, fast oxidation, rapid foliar uptake

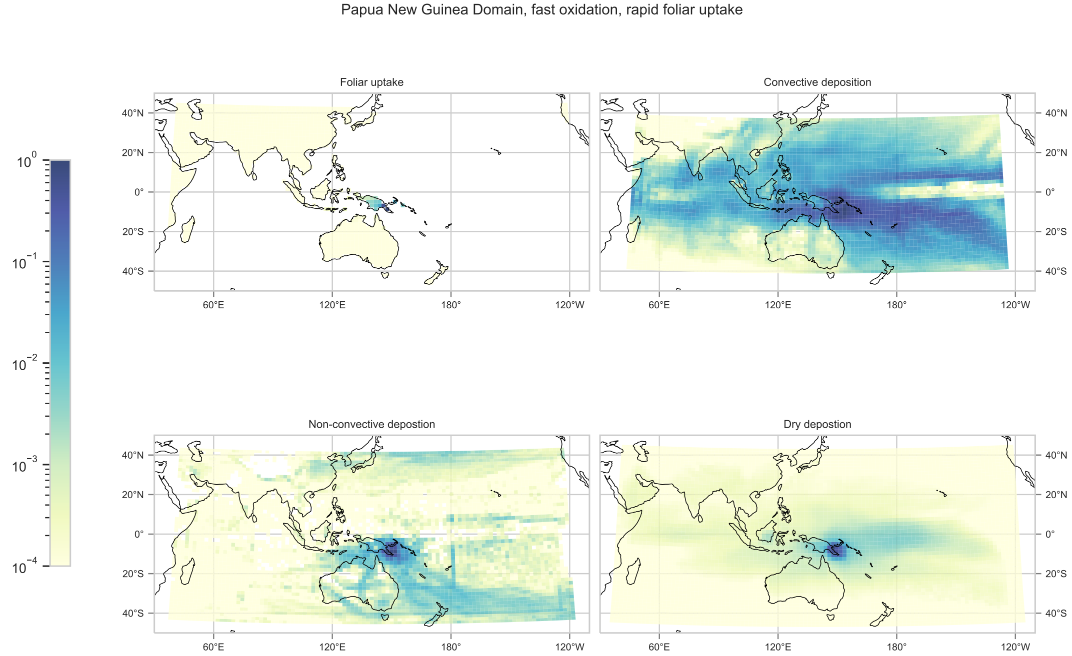
Foliar uptake

Convective deposition

Non-convective depostion

Dry depostion

Figure S12. Normalised deposition from the domain in Papua New Guinea



Papua New Guinea Domain, fast oxidation, rapid foliar uptake

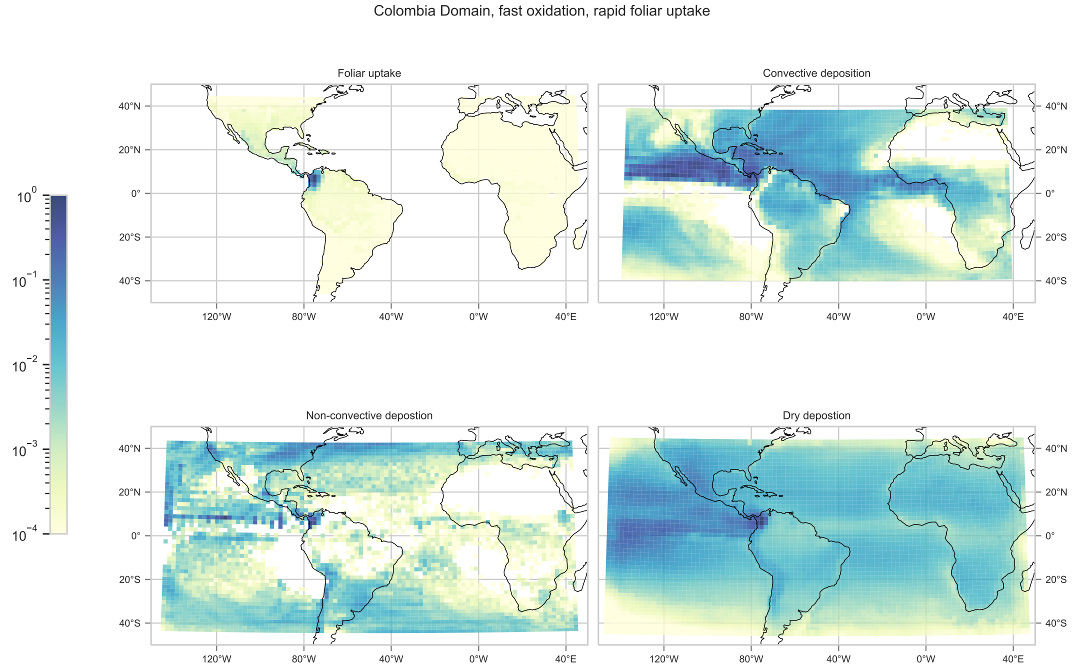
Foliar uptake

Convective deposition

Non-convective depostion

Dry depostion

Figure S13. Normalised deposition from the domain in Colombia



Colombia Domain, fast oxidation, rapid foliar uptake

Foliar uptake

Convective deposition

Non-convective depostion

Dry depostion

Figure S14. Normalised deposition from the domain in Bolivia

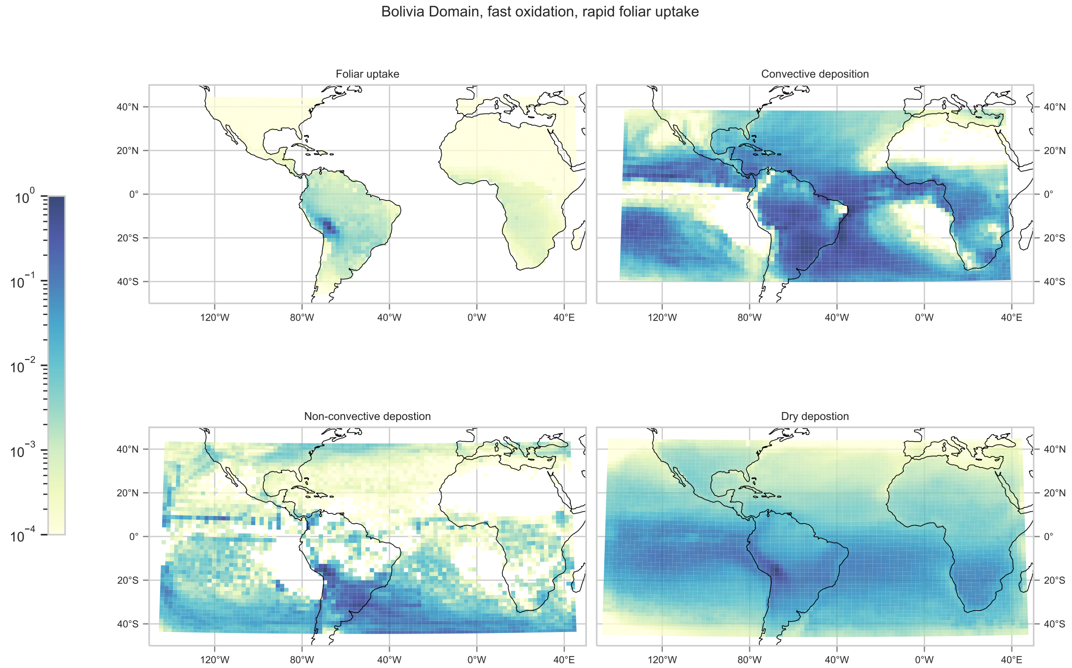


Figure S15. Normalised deposition from the domain in Brazil

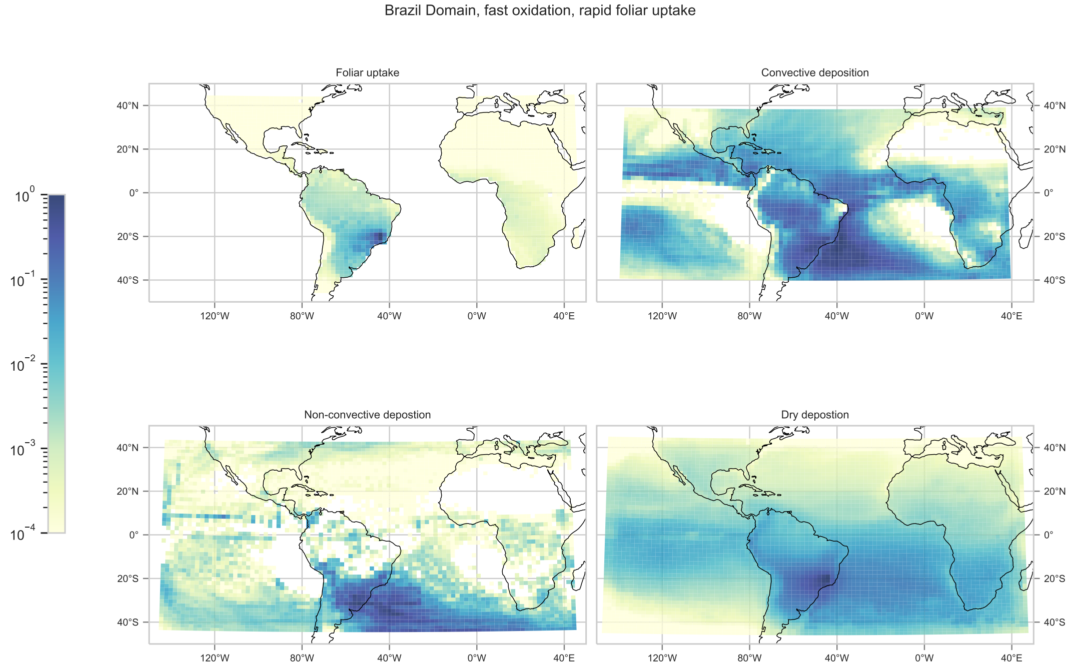


Figure S16. Normalised deposition from the domain in Guyana

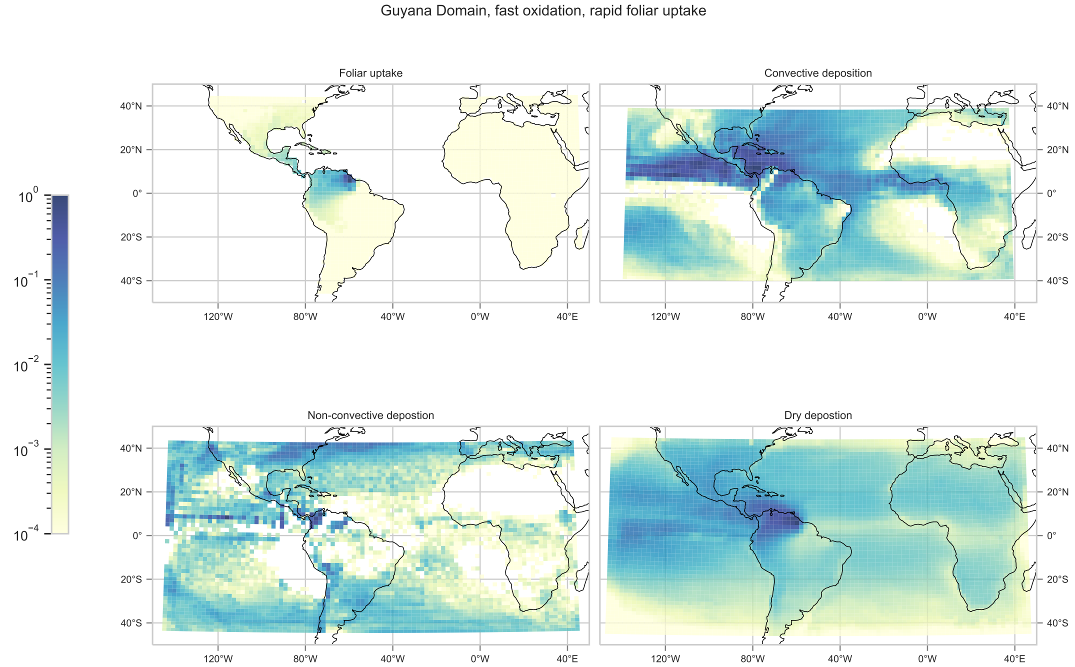


Figure S17. Normalised deposition from the domain in Ghana

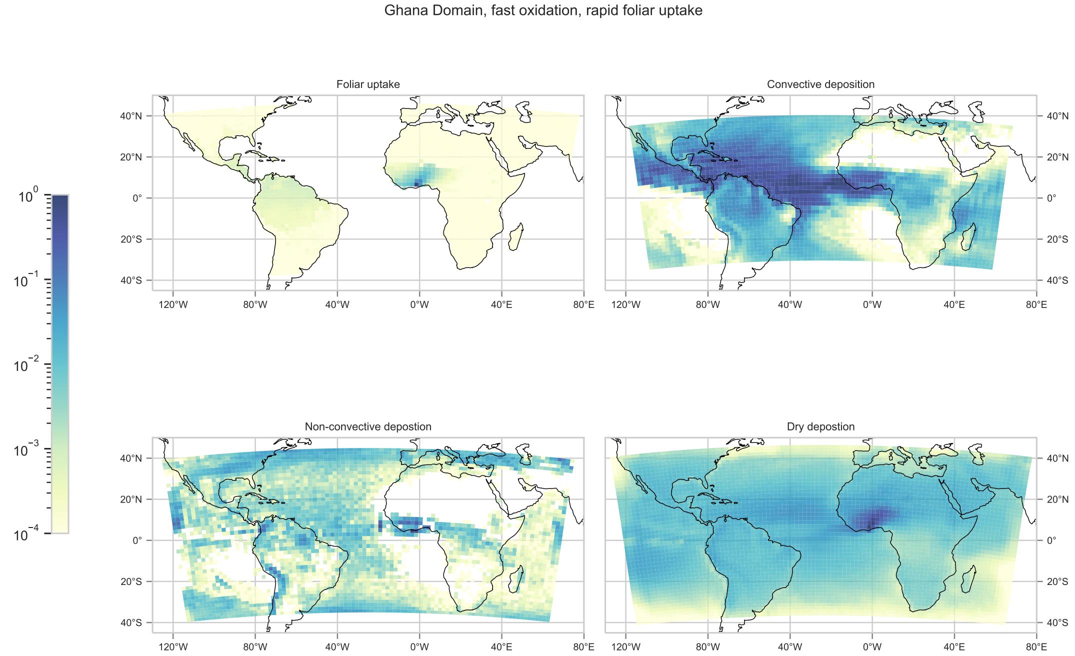


Figure S18. Normalised deposition from the domain in Burkina Faso

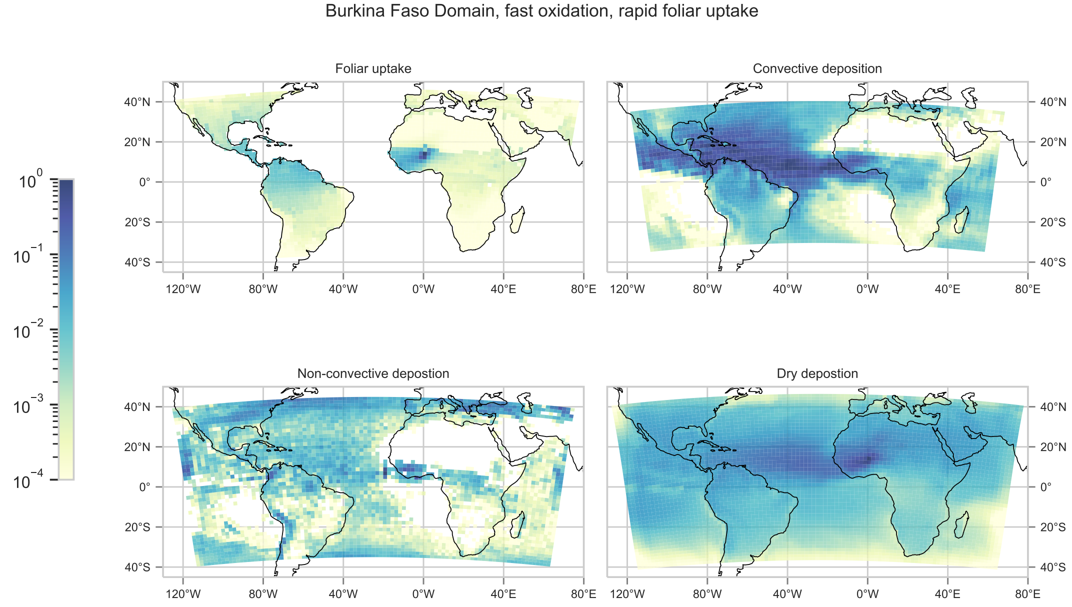


Figure S19. Normalised deposition from the domain in Senegal

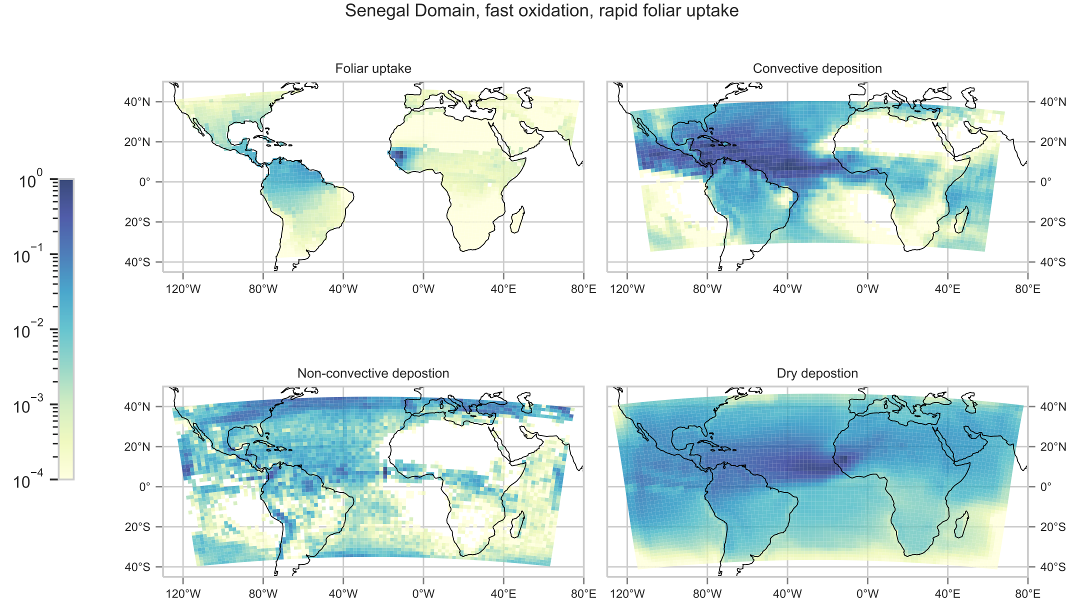


Figure S20. Normalised deposition from the domain in Sudan

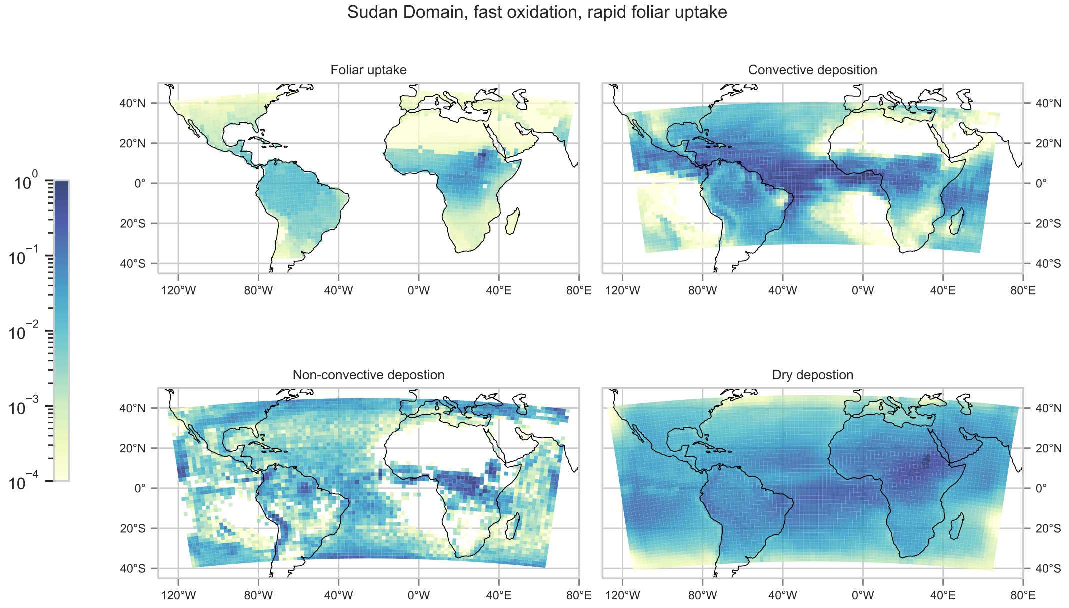
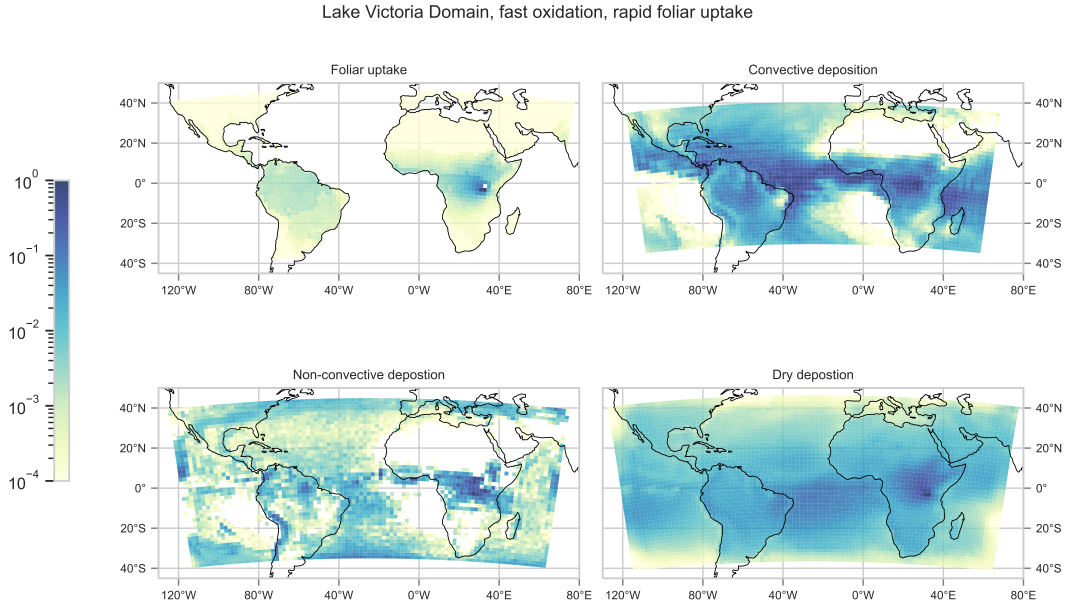


Figure S21. Normalised deposition from the domain near Lake Victoria



S5 Vegetation uptake module

```
MODULE module_veg_uptake

USE module_hg_lai_data
USE module_state_description

CONTAINS

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, 1, 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, dz8wsum, qr_sum, qr_average
      INTEGER               :: count_pbl, count_trop, qr_count
```

```
       INTEGER            :: i,j,k



 !! Uptake by vegatation


          do i = its ,ite
          do j = jts ,jte
             Leaf_lo = lai(i,j)*9.218e-5*dtstep/1.4 !dtstep is in seconds (unlike the chemistry time
             Leaf_mid = lai(i,j)*0.0001777*dtstep/1.4
             Leaf_hi = lai(i,j)*0.0002632*dtstep/1.4

             if (Leaf_lo.gt.1.) Leaf_lo = 1.
             if (Leaf_mid.gt.1.) Leaf_mid = 1.
             if (Leaf_hi.gt.1.) Leaf_hi = 1.

          do k = 1,1
              hg_mass=((200.59 * p_phy(i,1,j)) / (t_phy(i,1,j) * 8.314472)) * 1.e-6  !ppm to mug/m3
              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_h

             chem(i,k,j,p_hg_180_slo_asgm) = chem(i,k,j,p_hg_180_slo_asgm)*(1. - (Leaf_lo / dz8w(i,1
          enddo
          enddo
          enddo


!! Rain
!!convective


do i = its ,ite
do j = jts ,jte
if (raincv_hg(i,j).gt.0.1) then
            dz8wsum=0.
            ppm2ngm3=0.
            colsum_hgii_180_slo_asgm=0.
            colsum_hgii_270_slo_asgm=0.
```

```
           colsum_hgii_360_slo_asgm=0.
           colsum_hgii_180_l10cfpp=0.
           colsum_hgii_270_l10cfpp=0.
           colsum_hgii_360_l10cfpp=0.
           colsum_hgii_180_l15cfpp=0.
           colsum_hgii_270_l15cfpp=0.
           colsum_hgii_360_l15cfpp=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
              colsum_hgii_180_slo_asgm=colsum_hgii_180_slo_asgm+ppm2ngm3*chem(i,k,j,p_hgii_180_slo_
           else
            continue
           endif
           enddo


          if (colsum_hgii_180_slo_asgm.gt.1.e-13) then
            Hg_dep(i,1,j,p_hg180_l05cdep_cfpp) = Hg_dep(i,1,j,p_hg180_l05cdep_cfpp)+750.*(colsum_hg
            scav_hgii_180_slo_asgm=(colsum_hgii_180_slo_asgm -(750.*(colsum_hgii_180_slo_asgm/dz8wsu
          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_asg
             else
             continue
             endif
          enddo

else
  continue
endif
```

```
enddo
enddo

! non-convective
do i = its ,ite
do j = jts ,jte
if (rainncv_hg(i,j).gt.0.1) then
           dz8wsum=0.
           ppm2ngm3=0.
           colsum_hgii_180_slo_asgm=0.
           colsum_hgii_270_slo_asgm=0.
           colsum_hgii_360_slo_asgm=0.
           colsum_hgii_180_l10cfpp=0.
           colsum_hgii_270_l10cfpp=0.
           colsum_hgii_360_l10cfpp=0.
           colsum_hgii_180_l15cfpp=0.
           colsum_hgii_270_l15cfpp=0.
           colsum_hgii_360_l15cfpp=0.
           do k=kts,kte
           if (p_phy(i,k,j).gt.60000.) dz8wsum=dz8wsum + dz8w(i,k,j)
           enddo

           do k=kts,kte
              if (p_phy(i,k,j).gt.60000..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
              colsum_hgii_180_slo_asgm=colsum_hgii_180_slo_asgm+ppm2ngm3*chem(i,k,j,p_hgii_180_slo_
              else
              continue
              endif
           enddo

          if (colsum_hgii_180_slo_asgm.gt.1.e-13) then
            Hg_dep(i,1,j,p_hg180_l05ncdep_cfpp) = Hg_dep(i,1,j,p_hg180_l05ncdep_cfpp)+750.*(colsum_
            scav_hgii_180_slo_asgm=(colsum_hgii_180_slo_asgm -(750.*(colsum_hgii_180_slo_asgm/dz8wsu
          else
            scav_hgii_180_slo_asgm=1.0
          endif
          do k=kts,kte
```

```
             if (p_phy(i,k,j).gt.60000..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_asg

             else
             continue
             endif
          enddo

else
  continue
endif
enddo
enddo

! 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
              chem(i,k,j,p_hgii_180_slo_asgm) = chem(i,k,j,p_hgii_180_slo_asgm) * (1.- (0.01 * dtst
          enddo
enddo
enddo

        end subroutine Hg_tracer_ASGM
```