HTO transport and OBT formation in atmosphere-vegetation-soil system: Numerical experiments on wet deposition of HTO

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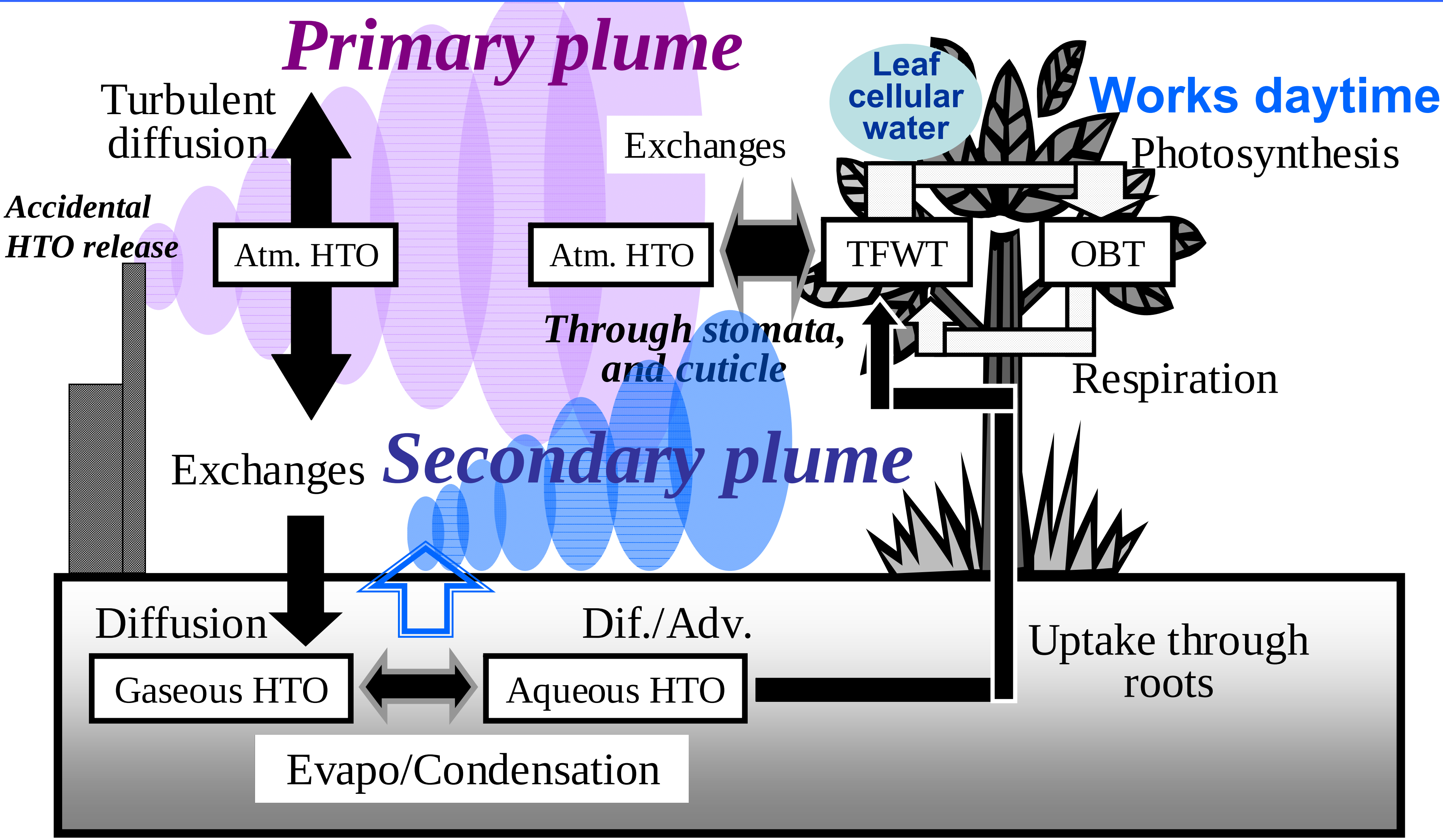
1.1 Background; HTO transport in land surface



- **In case of nighttime release:**
  - **OBT production may be dominated by secondary plume**
  - **Formed daytime, when the primary plume disappeared and secondary plume exists**

1.2 Background; Aftereffects of wet deposition

Rainfall during passage of the primary plume…

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Increased HTO conc. in soil through wet deposition

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Heightened air HTO conc. in the secondary plume

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Larger OBT production in the re-emission phase

Theoretical concepts

↕

Difficulty in conducting thorough field experiments for nighttime wet deposition & successive OBT formation

How much does wet deposition increase OBT formation?

2. Objectives and Approaches

Objectives

1. Evaluating aftereffects of nighttime wet-deposition on OBT production
2. Understanding behavior of HTO transport & OBT production in land surface after wet deposition

Approaches

- ➢Employing a sophisticated tritium-transport-model SOLVEG-II
- ➢Numerical exp. assuming a hypothetical HTO-deposition at night

2. Main results obtained

Objectives

1. Evaluating aftereffects of nighttime wet-deposition on OBT production
2. Understanding behavior of HTO transport & OBT production in land surface after wet deposition

Main results obtained

1. Nighttime wet-deposition having larger rain HTO conc. actually increases OBT production, by an order or more

2. Importance of rain interception; Rain interception/evaporation with leaves increases HTO conc. in canopy air

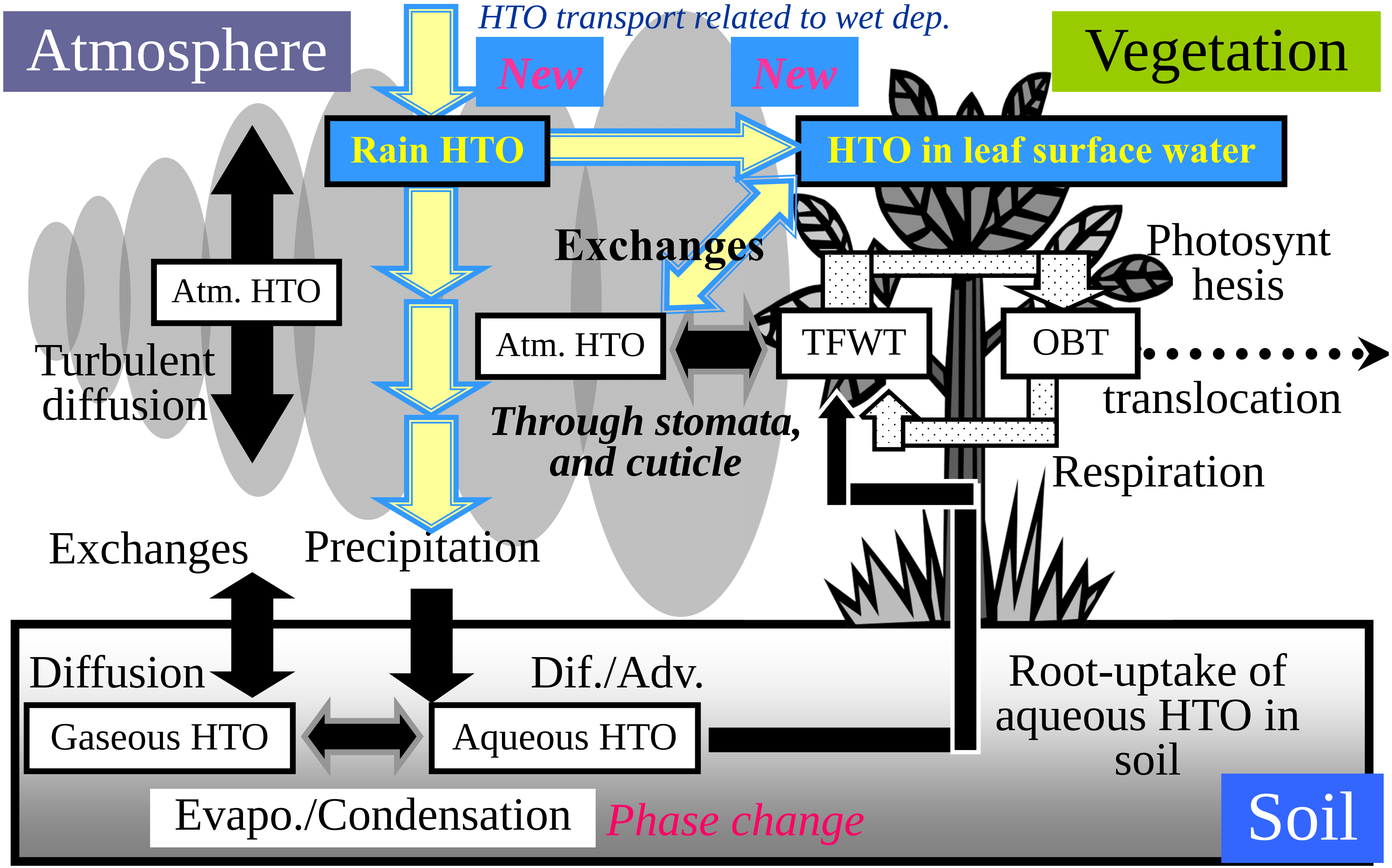
   ⇒ Especially increases OBT production at daytime wet-deposition

Contents of the presentation

3. Introduction of SOLVEG-II

3.1 Processes considered in SOLVEG-II

SOLVEG-II; Transport and exchange for heat, momentum, water and CO_2
(Yamazawa, 2001; Nagai, 2005)



4. Numerical experiments; Calculation conditions

4.1 Numerical experiments; Calculation conditions

Site (actually-existing site)

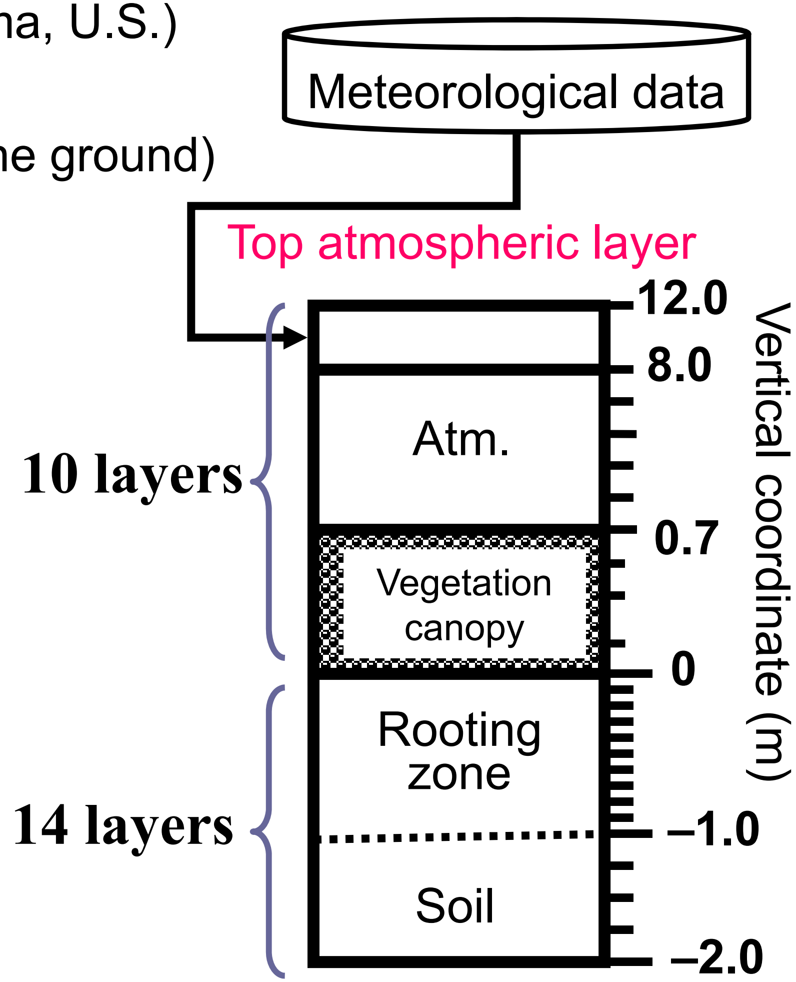
- AmeriFlux observation site (Oklahoma, U.S.)
- Vegetation: C4 grass (0-0.7 m above the ground)
- Soil texture: Silty-clay loam

Input data

- Half-hourly averaged meteorological dataset

  (Air temperature, specific humidity, wind velocity, precipitation, radiations, CO_2 conc.)

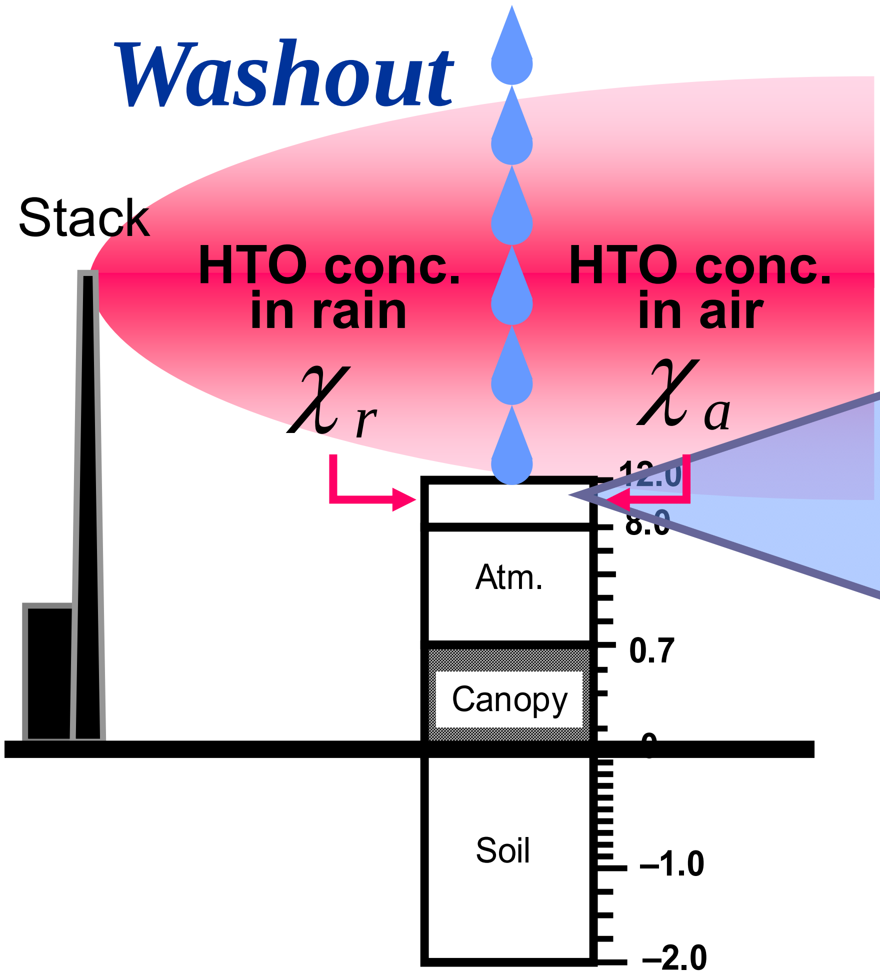
Model settings

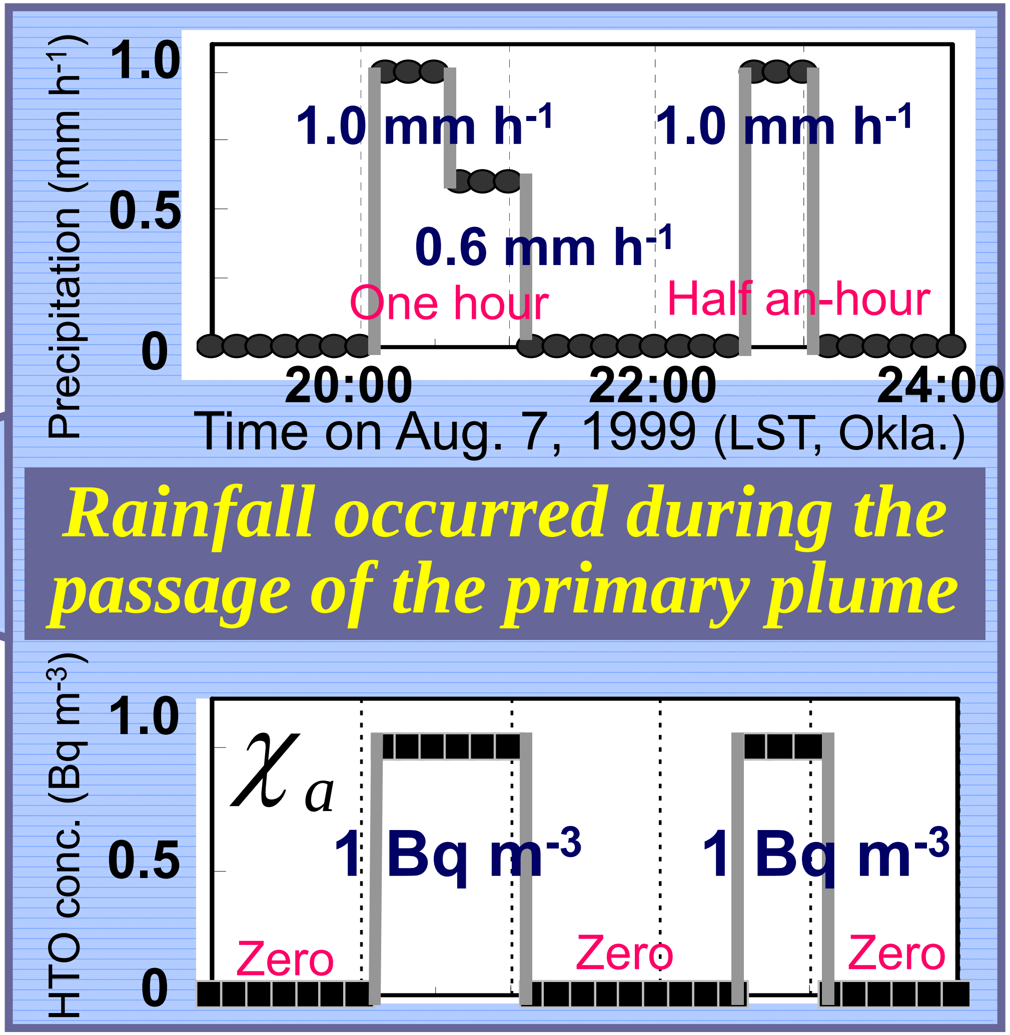


4.2 Wet deposition scenario

χ_a ; Corresponds to air HTO concentration in the primary plume (INPUT DATA)

χ_r; Need to be specified, but depends on HTO washout beyond SOLVEG system

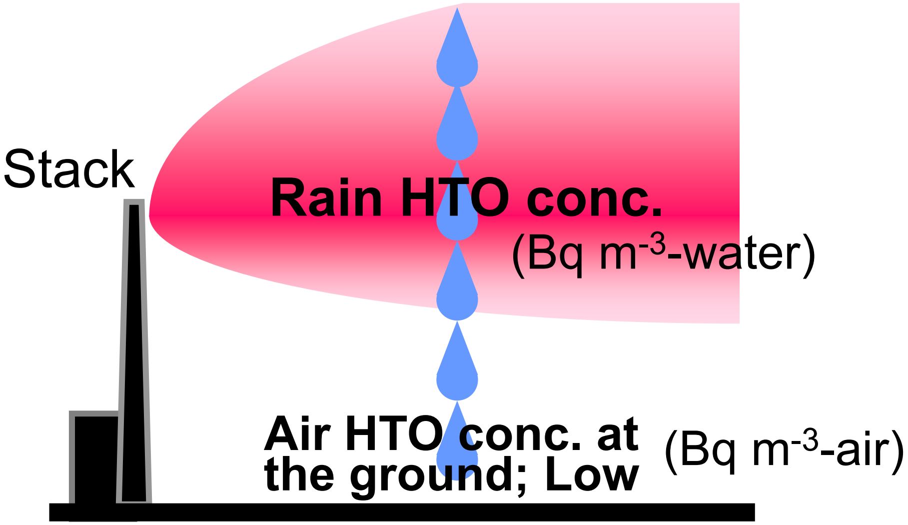




Need to relate HTO conc. in rain and air at the model top

4.3 Theoretical consideration for washout process

1. Plume remains at a higher altitude

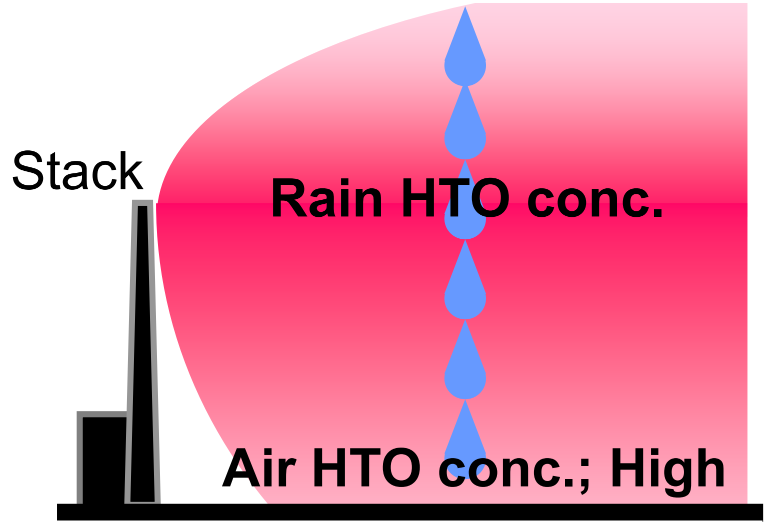


Smaller

Rain HTO conc. (Bq m^{-3}-water) > Equilibrium HTO conc. (Bq m^{-3}-water)

≈ *10-folded case*

2. Plume reaches to the ground surface



Larger

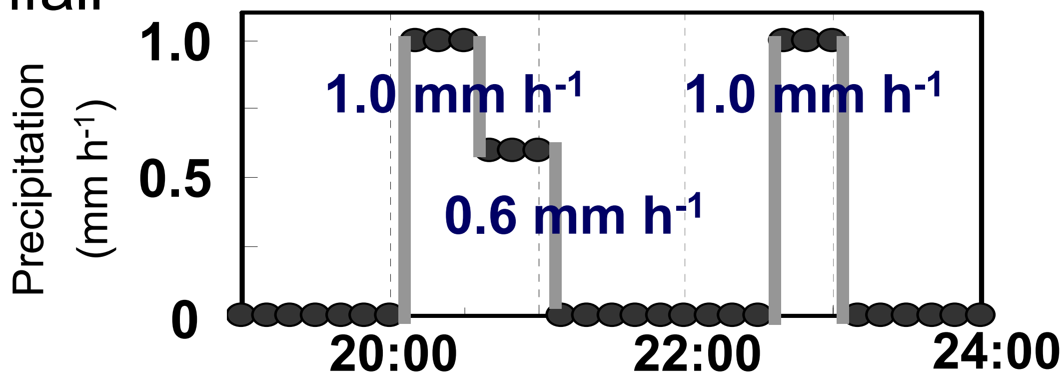
Rain HTO conc. < Equilibrium HTO conc.

≈ *0.1-folded case*

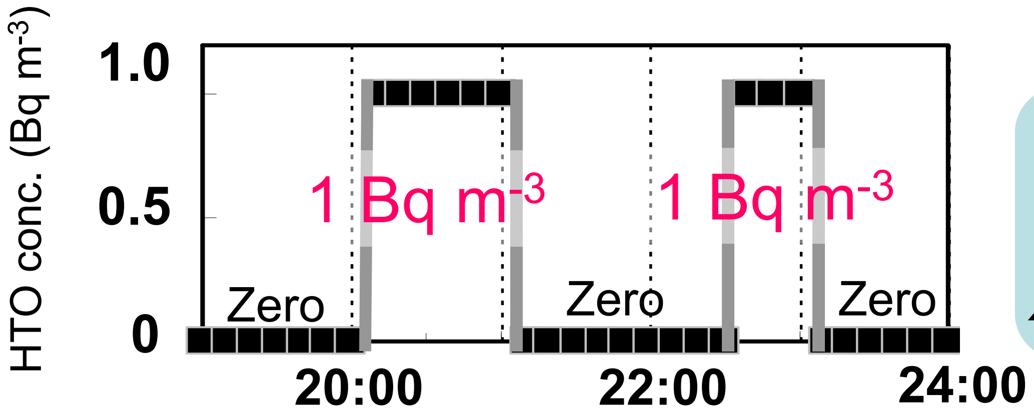
- Belot (1998); Rain HTO conc. ranges from 0.1-fold to 10-fold of the equilibrium value for air HTO conc. at the ground level
- Two scenarios for rain HTO; 10-folded case, and, 0.1-folded case (next slide)

4.3 Summary of calculation conditions

- Rainfall



- Air HTO conc. in primary plume at the ground level = 1 Bq m^{-3}; Reference



Equilibrium rain HTO concentration

$\chi_{re} = 50$ kBq m^{-3}-water

- Rain HTO conc.; Two patterns were assumed
  - 0.1-folded case: $\chi_r = 5$ kBq m^{-3}-water
  - 10-folded case: $\chi_r = 500$ kBq m^{-3}-water

5. Numerical experiments; Calculation results

6. Test calculations

Elaborating effects of wet deposition on OBT formation at various situations.

6. Test calculations by tuning cal. conditions

● Previously-assumed scenario and conditions: Control case

(1) Soil texture; Silty-clay loam
(2) Precipitation intensity; 1.0, 0.6, 1.0 mm h^{-1}
(3) Nighttime scenario; 20:00, 20:30, 22:30

● Each condition is independently tuned;

(1) Soil texture → Sand

● Seeing effects of hydraulic characteristics in soil

(2) Precipitation intensity → 3-fold, 1/3-fold of the control

(3.0, 1.8, 3.0 mm h^{-1}) (0.3, 0.2, 0.3 mm h^{-1})

● Evaluating effects of HTO infiltration into soil

(3) Numerical exp. under daytime scenario

● To clarify effects from plant-physiological activities

7. Summary and Conclusions

7.1 Summary in table

Effects of wet deposition on the successive OBT production

Scenario	Night		Day
	10-folded	0.1-folded	10-folded
Dominative process affecting OBT production	Re-emission	Primary plume	Rain interception and evaporation with leaves
OBT amount at nine-day after the deposition (10^{-6}Bq m^{-2})			(Amount of dep. differs)
Difference in OBT amount between silty-clay loam & sand	Less than factor of 1.5	(no need)	(no need)
Change in "fraction of deposited HTO fixed as OBT" under preci. intens. 0.3–3.0 mm h^{-1}	Less than factor of 1.3	(no need)	(no need)

7.2 Conclusions

For Dr. Galeriu, We now preparing obtained results for ICRER. Then the results are briefly summarized here. Please do not hesitate to e-mail me if you need more detailed information. (Ota)

1. Numerical experiments on HTO transport and OBT formation after nighttime weak rain → OBT production differed by a factor of 17 between two cases, each of which assumes rain HTO conc. being 0.1-folded and 10-folded of equilibrium HTO conc. for air HTO in the primary plume.

2. Numerical experiments for daytime weak rain → OBT production was increased due to the heightened air HTO conc. through rain interception/evaporation with leaves

3. Test cal 1: Soil texture was changed from silty-clay loam (control) to sand, for the night case → Difference in OBT amount fixed over nine days after the night rain between two texture cases was less than 1.5

4. Test cal 2: Precipitation intensity was changed to 1/3-folded and three folded of the control value, for the night case → Fraction of deposited HTO fixed as OBT decreased by a factor of 1.3 as precipitation increases from 1/3-folded to 3-folded value