Yale-NUIST Center on Atmospheric Environment
耶鲁-南京信息工程大学大气环境中心

DEUTERIUM EXCESS OF ATMOSPHERIC WATER VAPOR: HOW ROBUST IS IT AS A TRACER OF WATER SOURCE?

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Stable Water Vapor Isotopes Database

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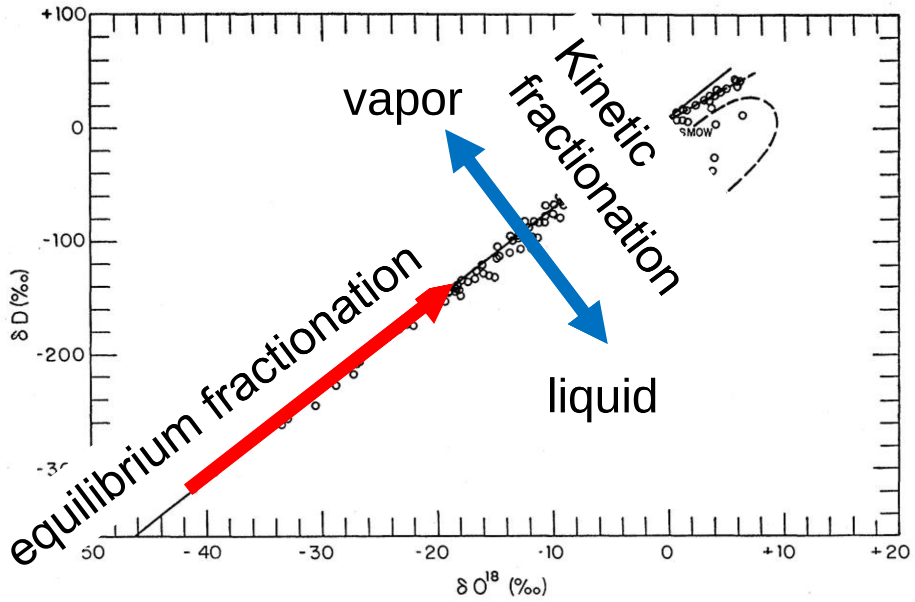
Hosted by Yale University and sponsored by the U. S. National Science Foundation, the Stable Water Vapor Isotope Database (SWVID) website archives high-frequency vapor isotope data collected with instruments based on infrared isotopic spectroscopy. The goal of this centralized data depository is to facilitate investigation that transcends disciplinary and geographic boundaries.

Click on the interactive map to view individual site information

Water Vapor Isotopes Monitoring Sites

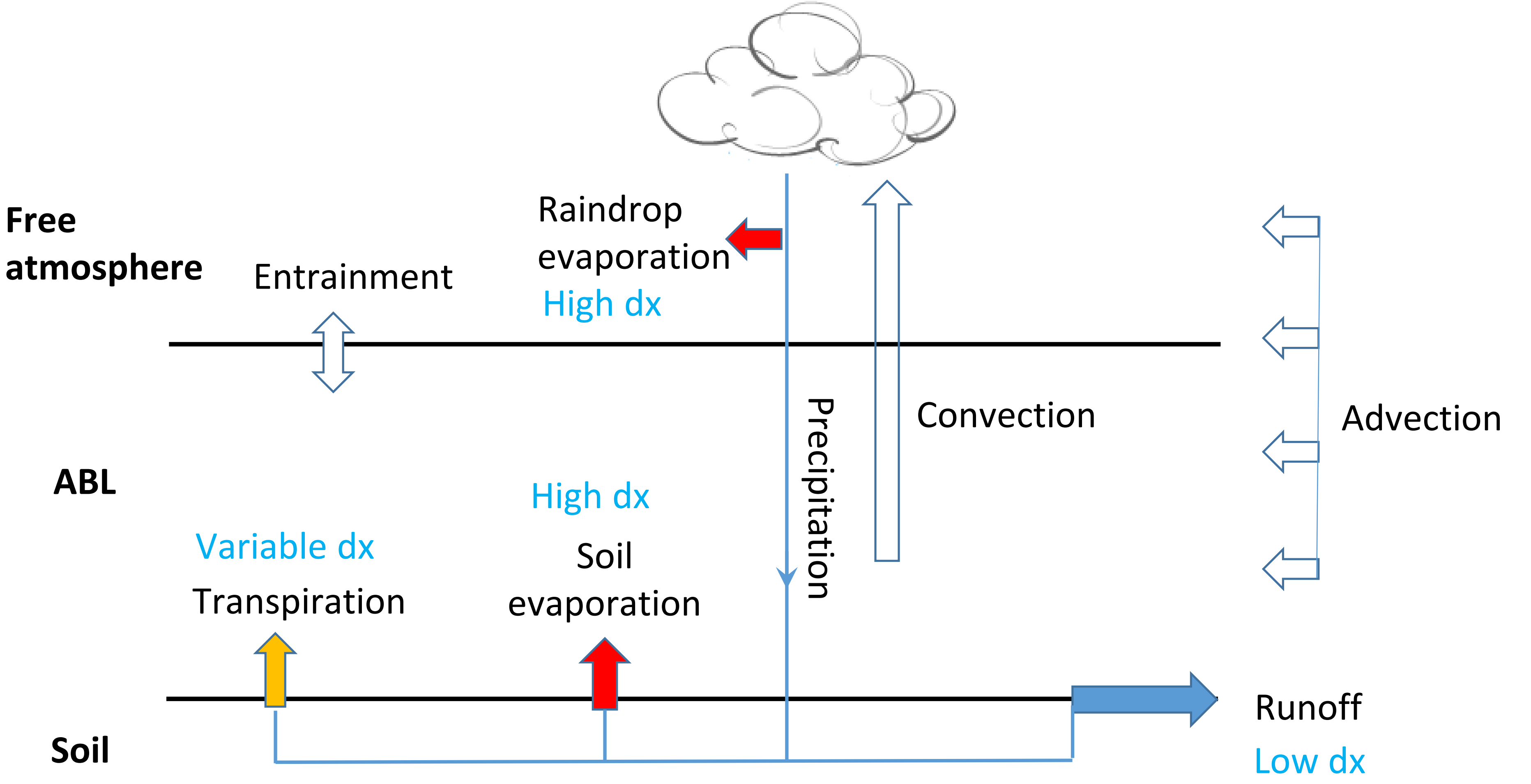
Background

- **Deuterium excess:** A measure of the abundance of the D isotope relative to the ^{18}O isotope. This relative abundance is in reference to the global mean meteoric water line: $d_x = \delta D - 8 \times \delta^{18}O$
- **Properties:**
  - *Equilibrium fractionation* does not change deuterium excess
  - *Kinetic fractionation* causes d_x in the vapor phase to increase and d_x in the liquid phase to decrease

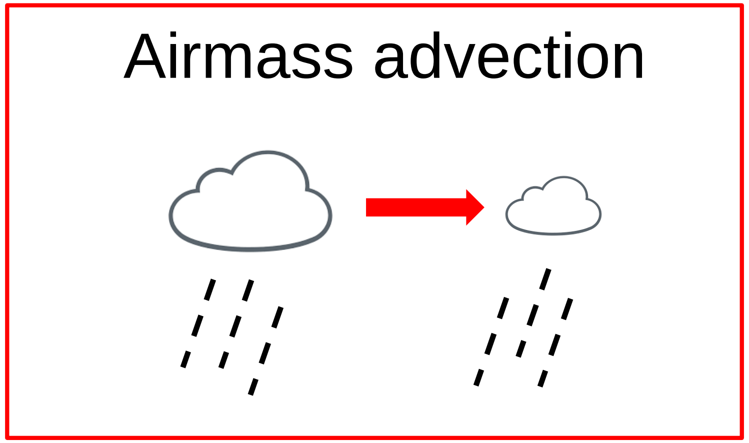


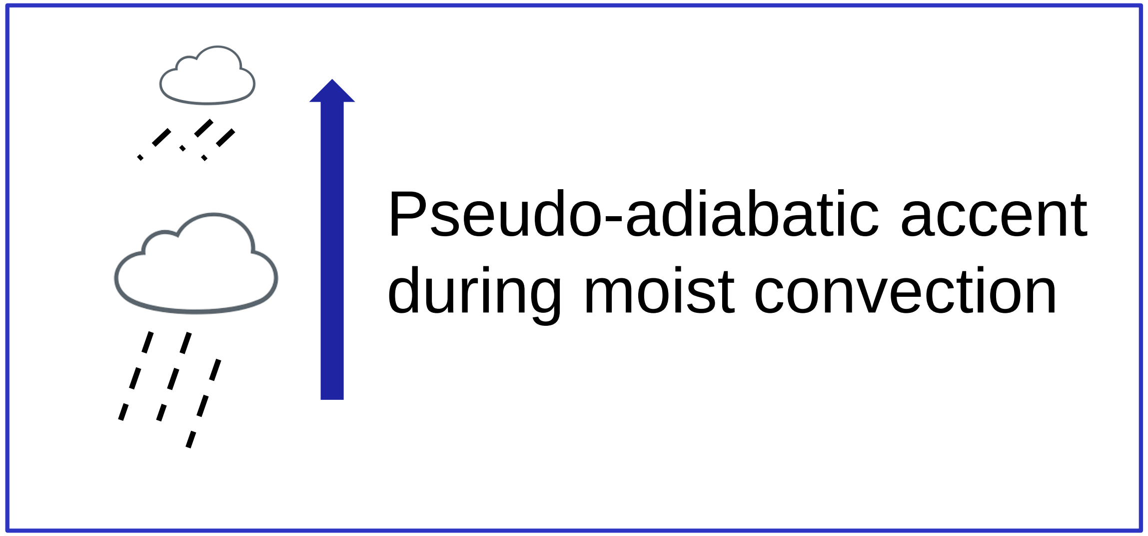
Source: Craig (1961)

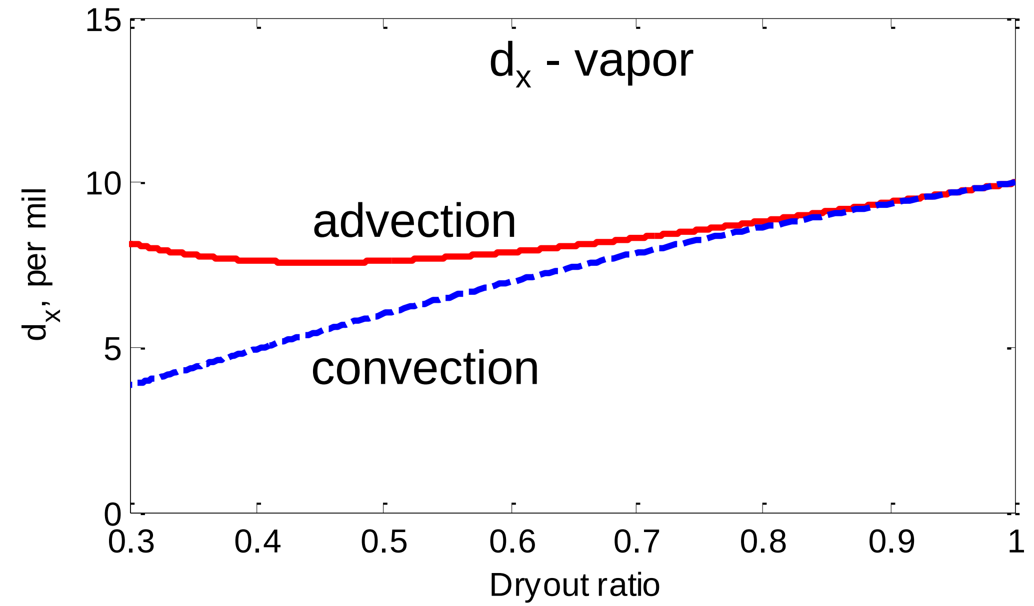
Isotopic interactions between three pools of water (soil, ABL and free atmosphere)

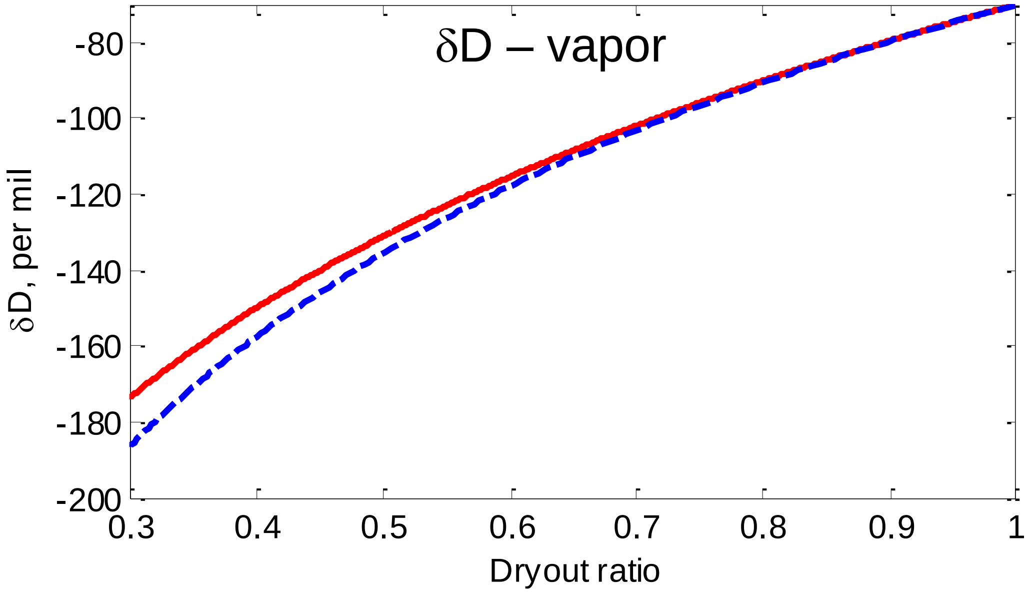


Rayleigh distillation

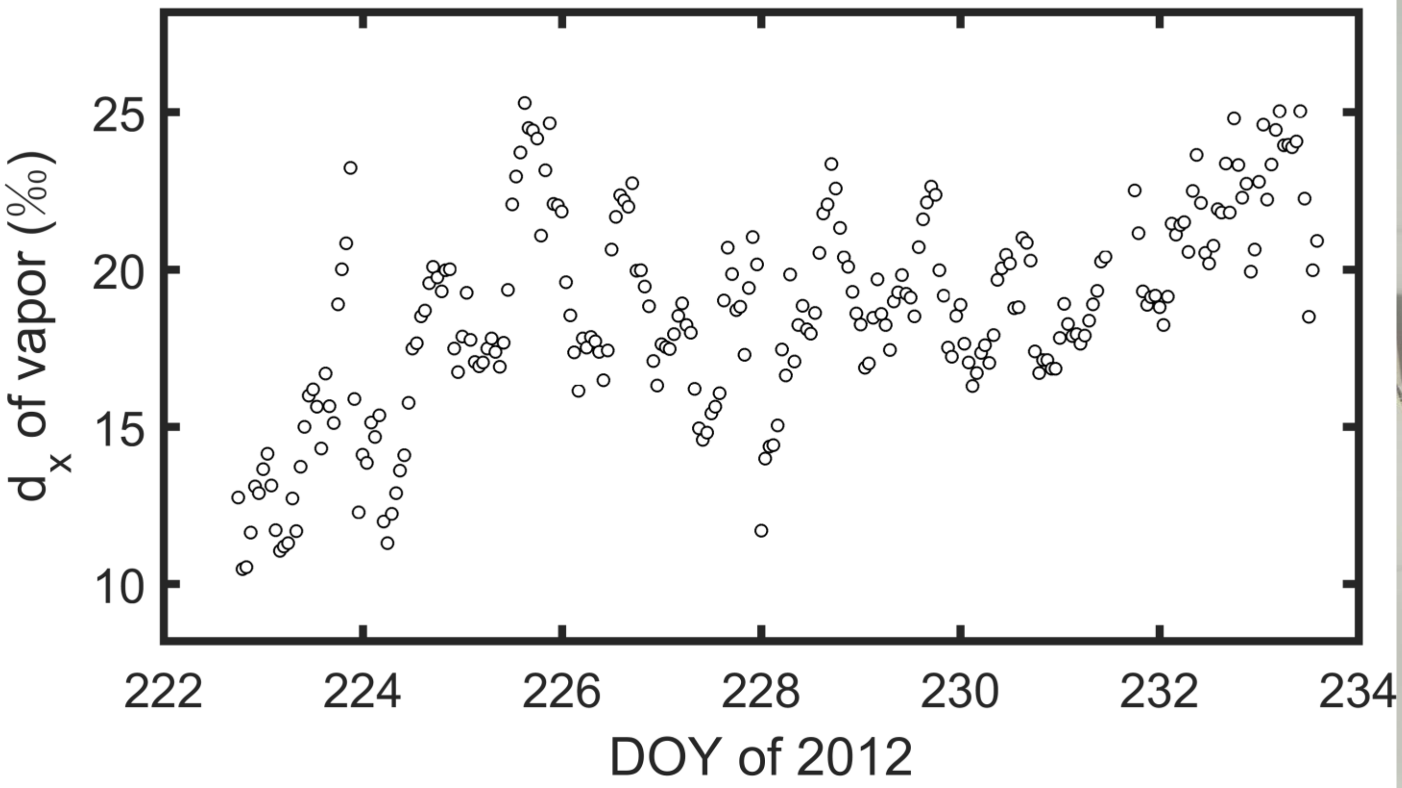






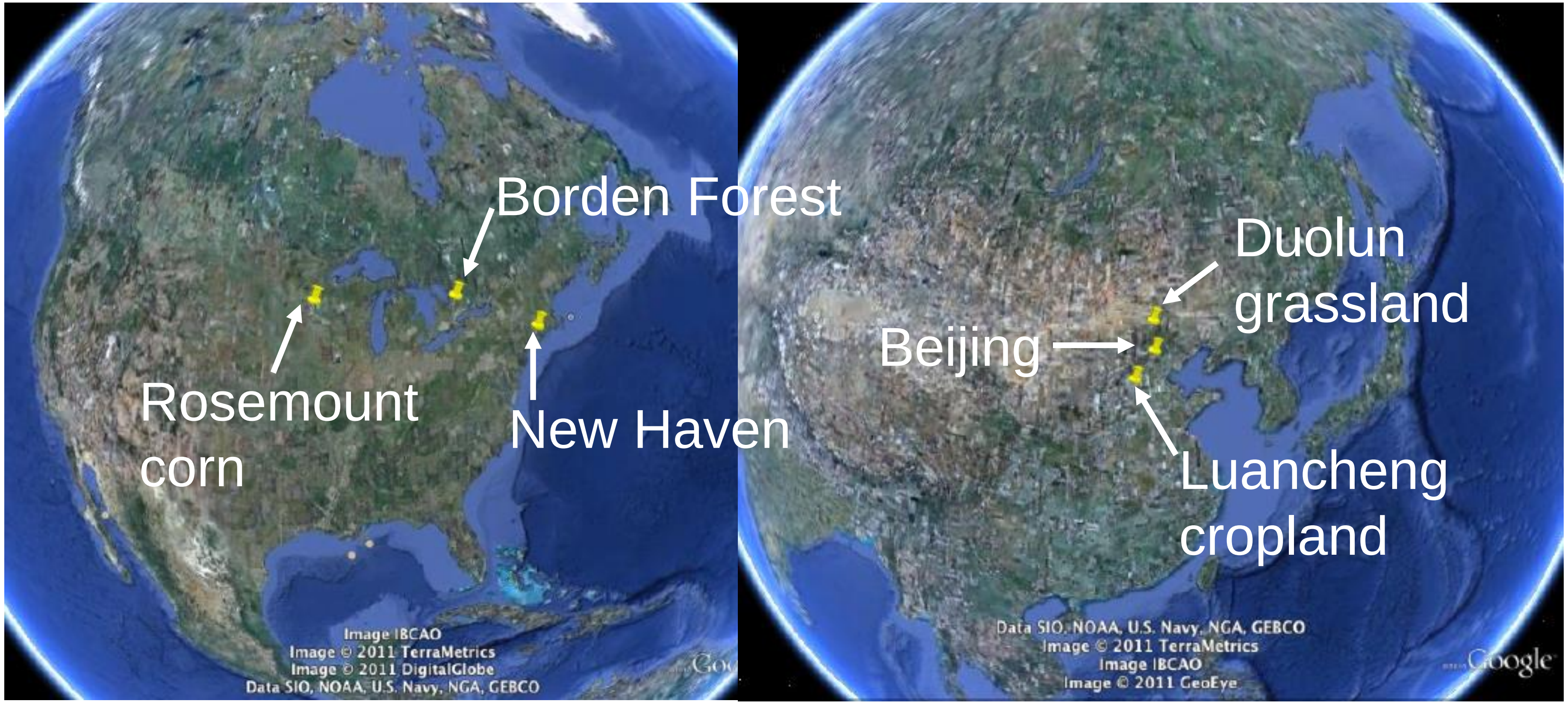


Deuterium excess of water vapor, Lake Taihu



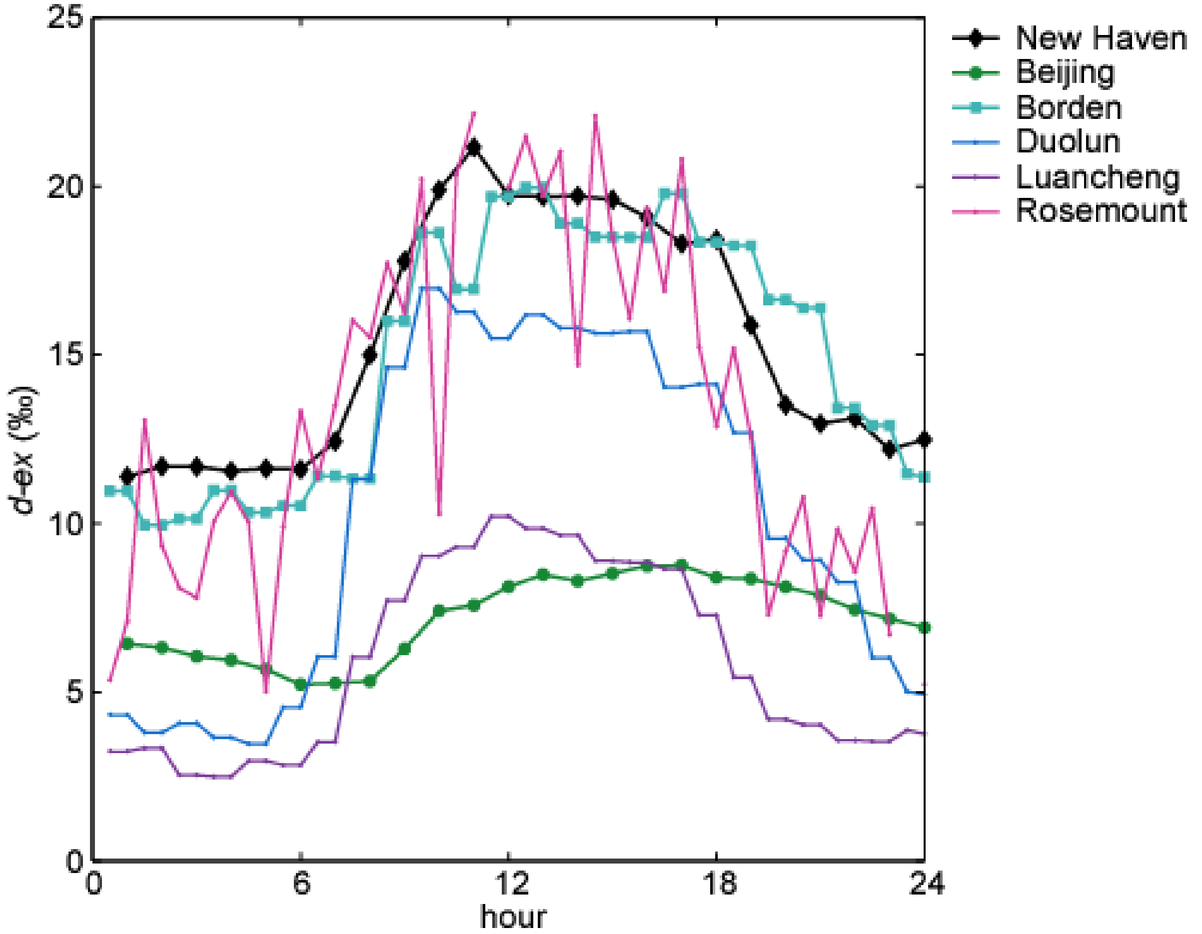
Xiao, Lee, Hu et al. (2012): J Geophysical Research -- Atmospheres

A cross-site analysis of d_x of vapor near the ground

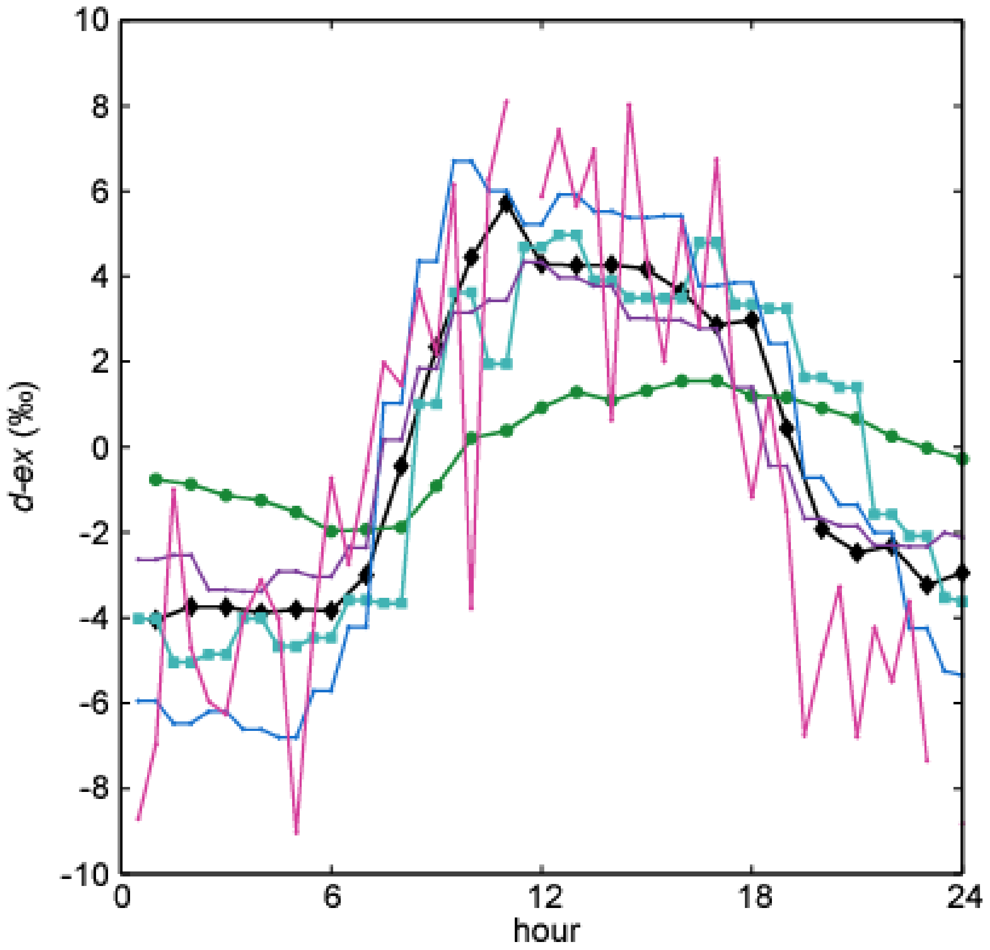


A cross-site analysis of d_x of vapor near the ground

Diurnal Composite

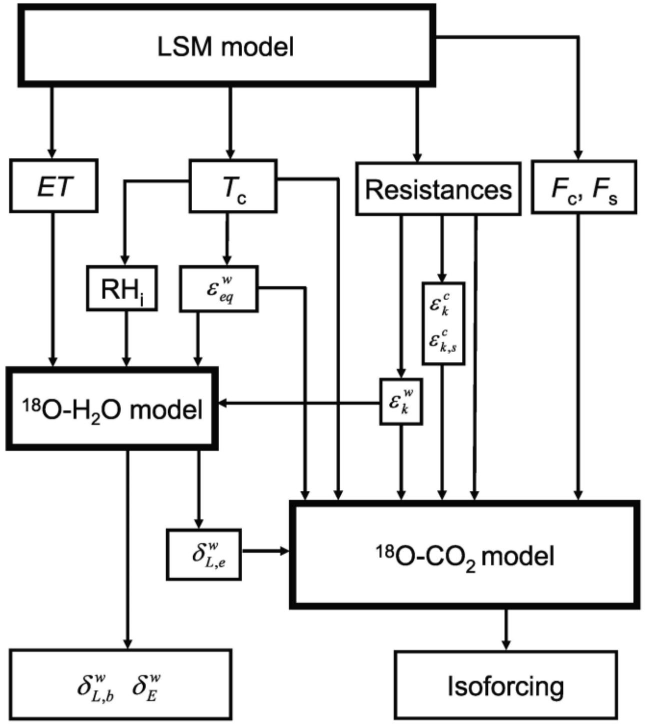


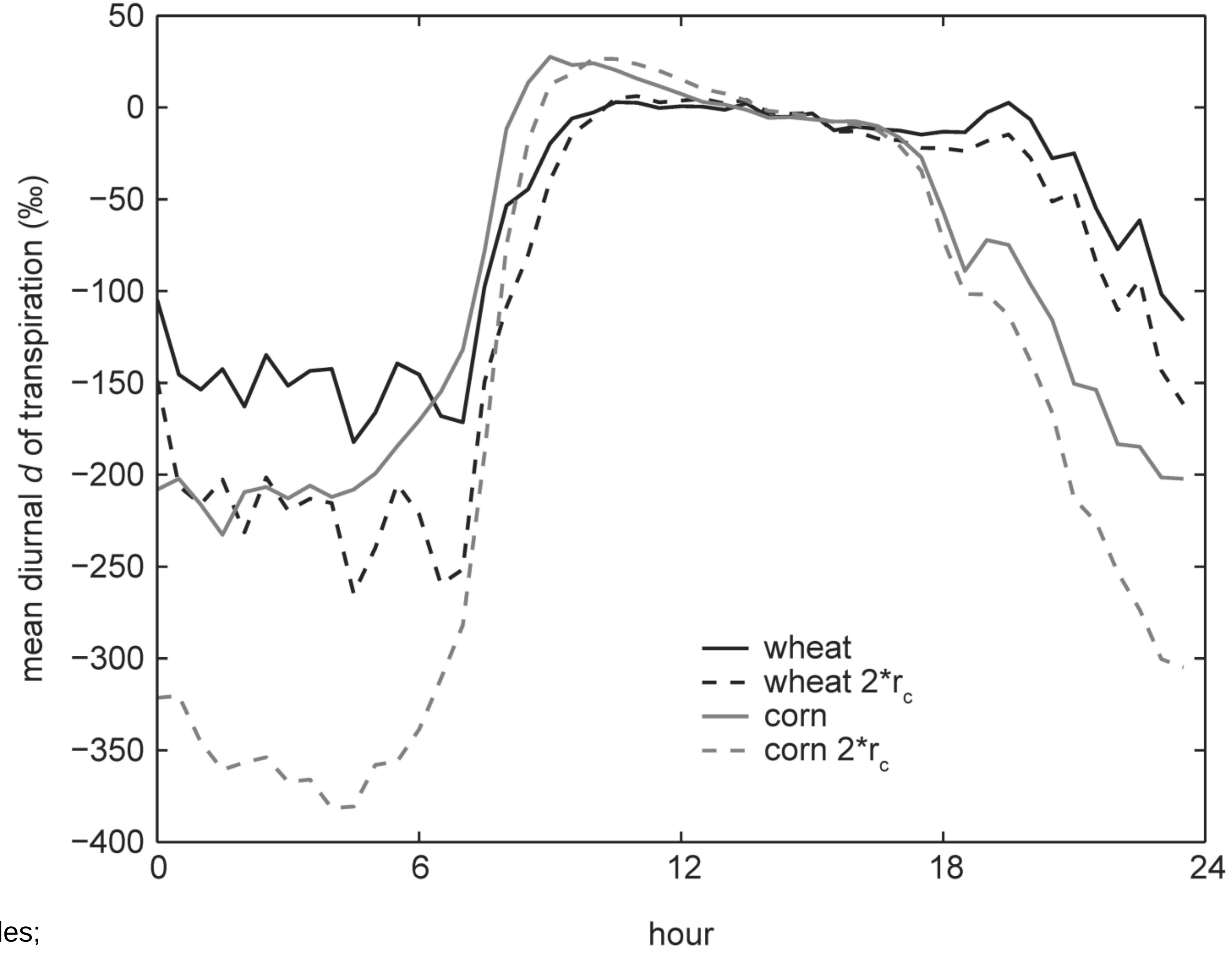
Diurnal Composite with mean removed



Source: Welp, Lee, Griffis et al. (2012): Global Biogeochemical Cycles

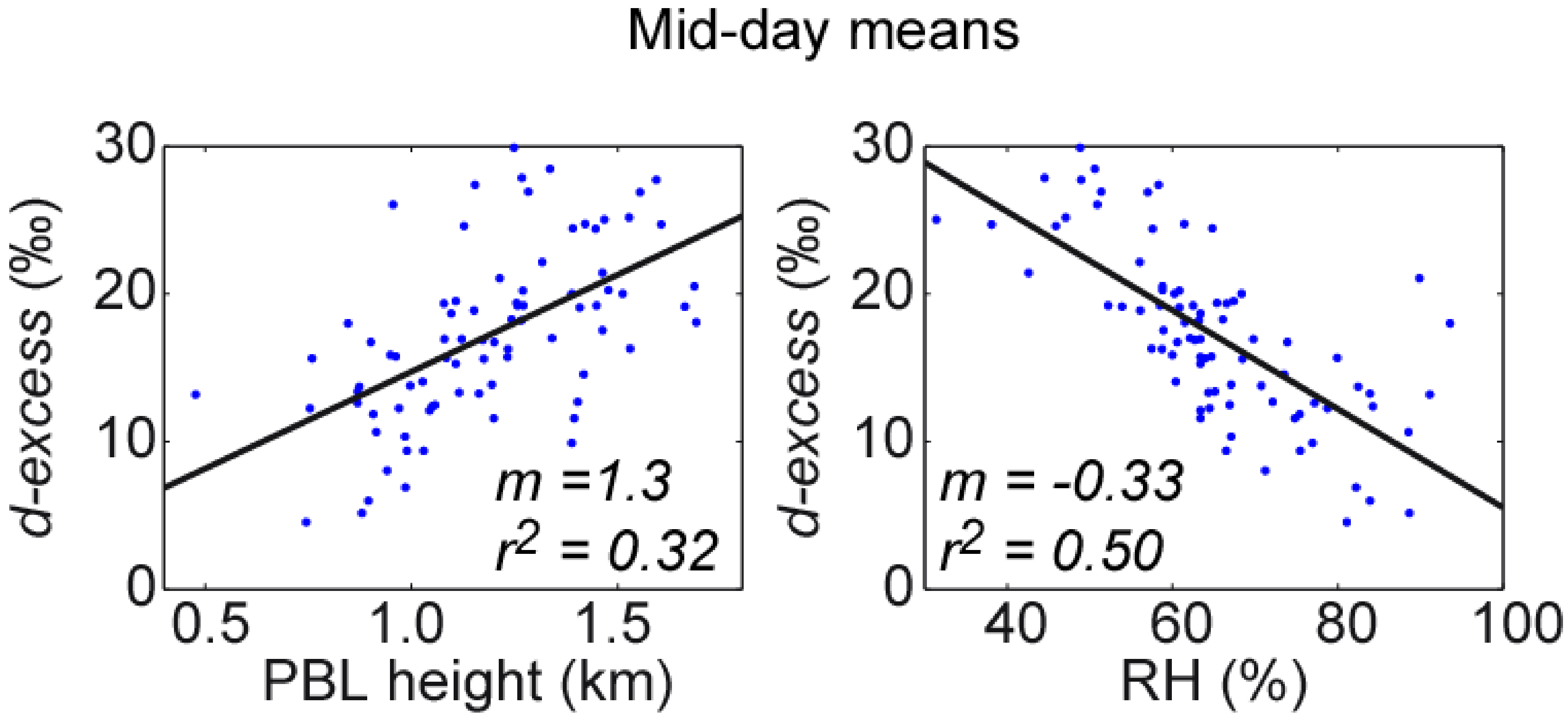
Deuterium excess of transpired water according to the SiLSM model





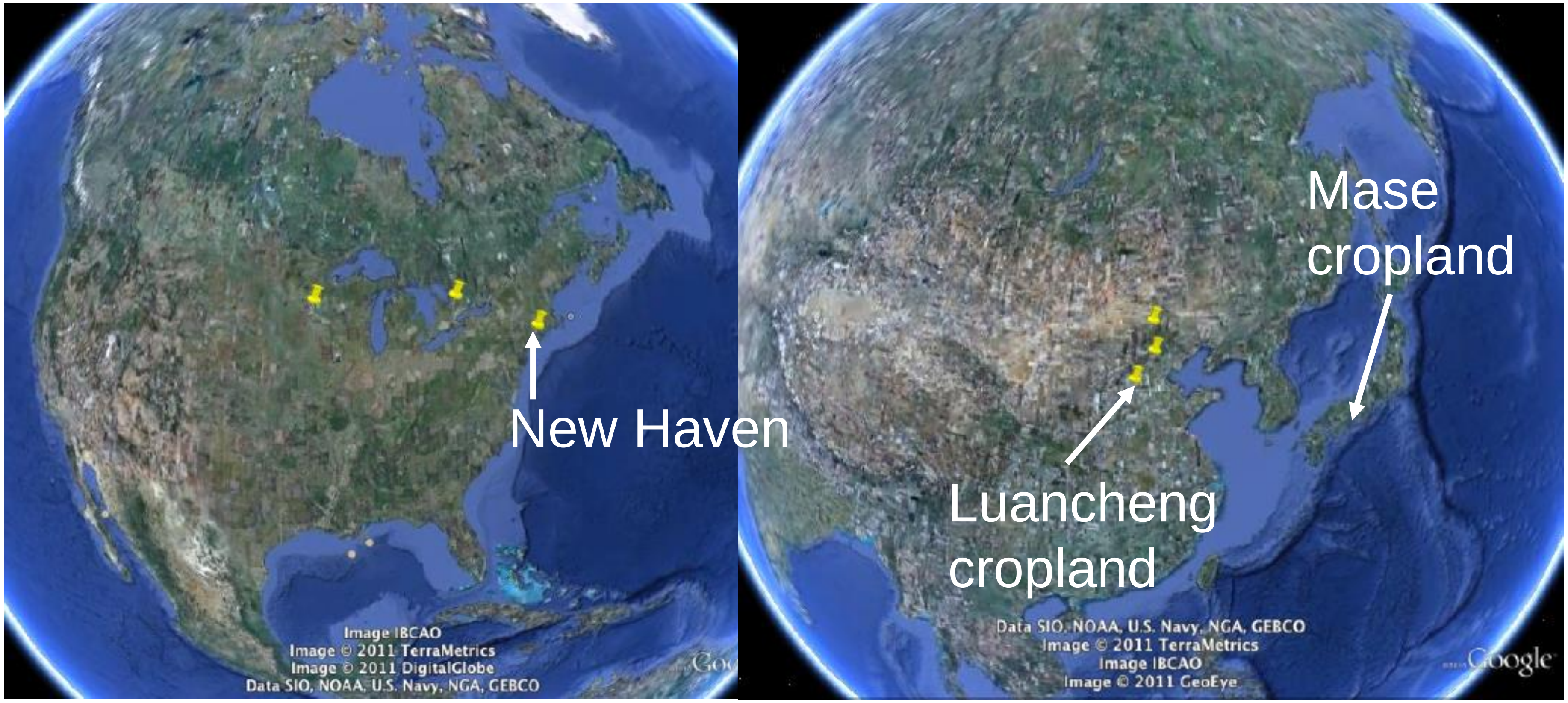
Sources: Welp, Lee, Griffis et al. (2012): Global Biogeochemical Cycles;
Xiao, Lee, Griffis et al. (2010) J Geophysical Research- Biogeosciences

A cross-site analysis of d_x of vapor near the ground

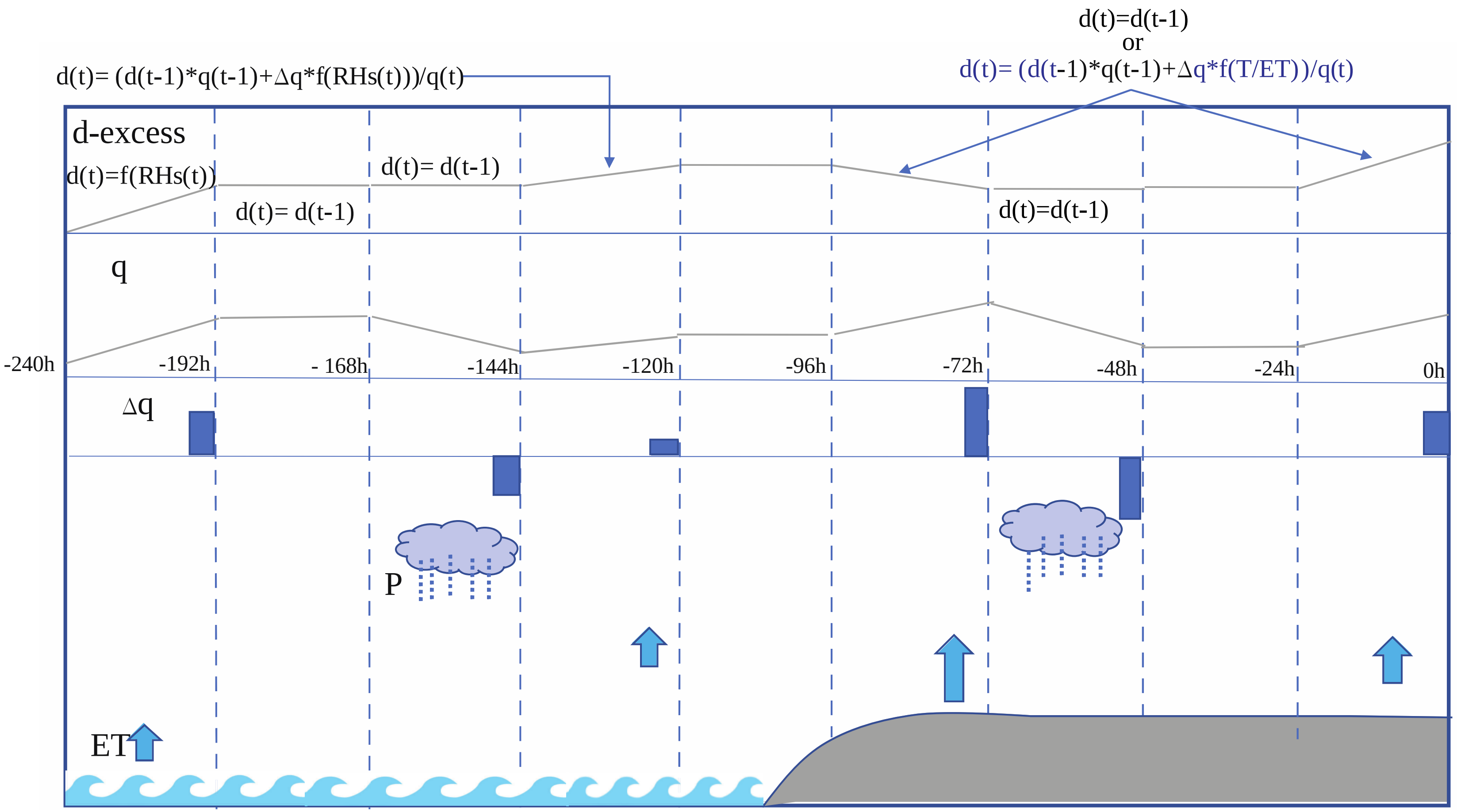


Source: Welp, Lee, Griffis et al. (2012): Global Biogeochemical Cycles

Trajectory analysis of atmospheric moisture source and transport: study sites



Trajectory analysis of atmospheric moisture source and transport: Conceptual framework

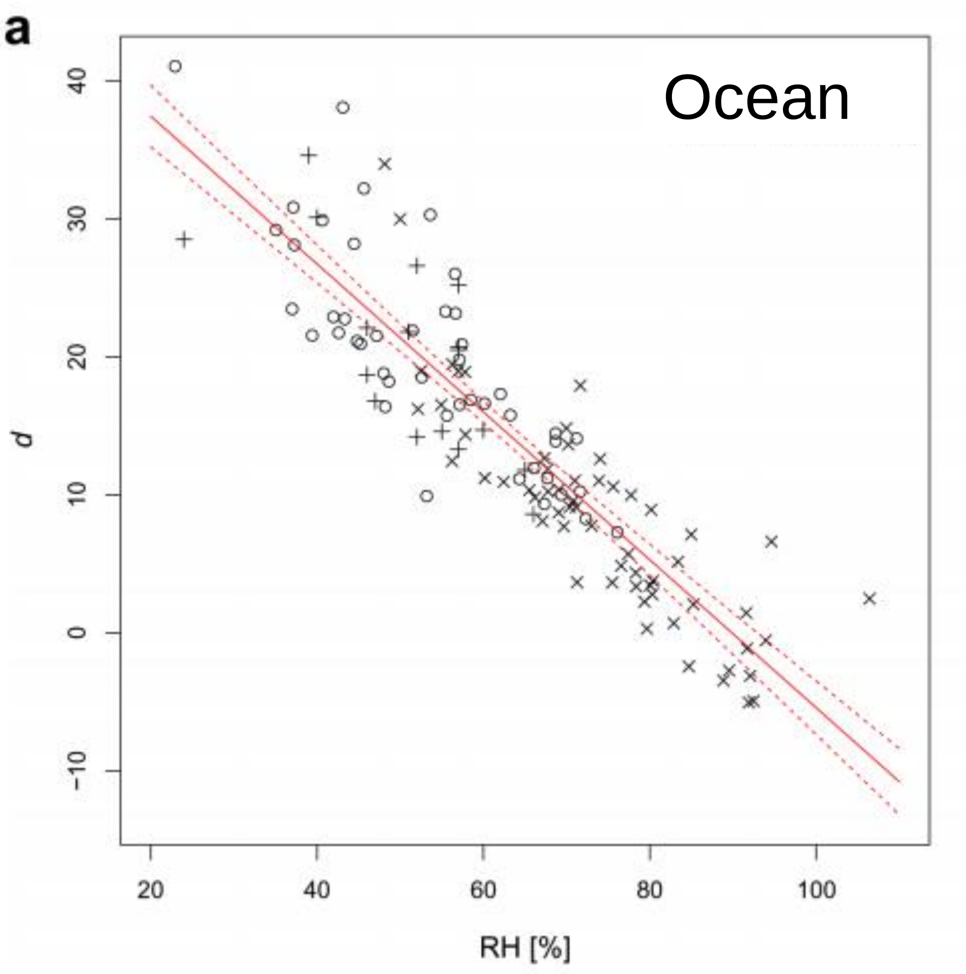


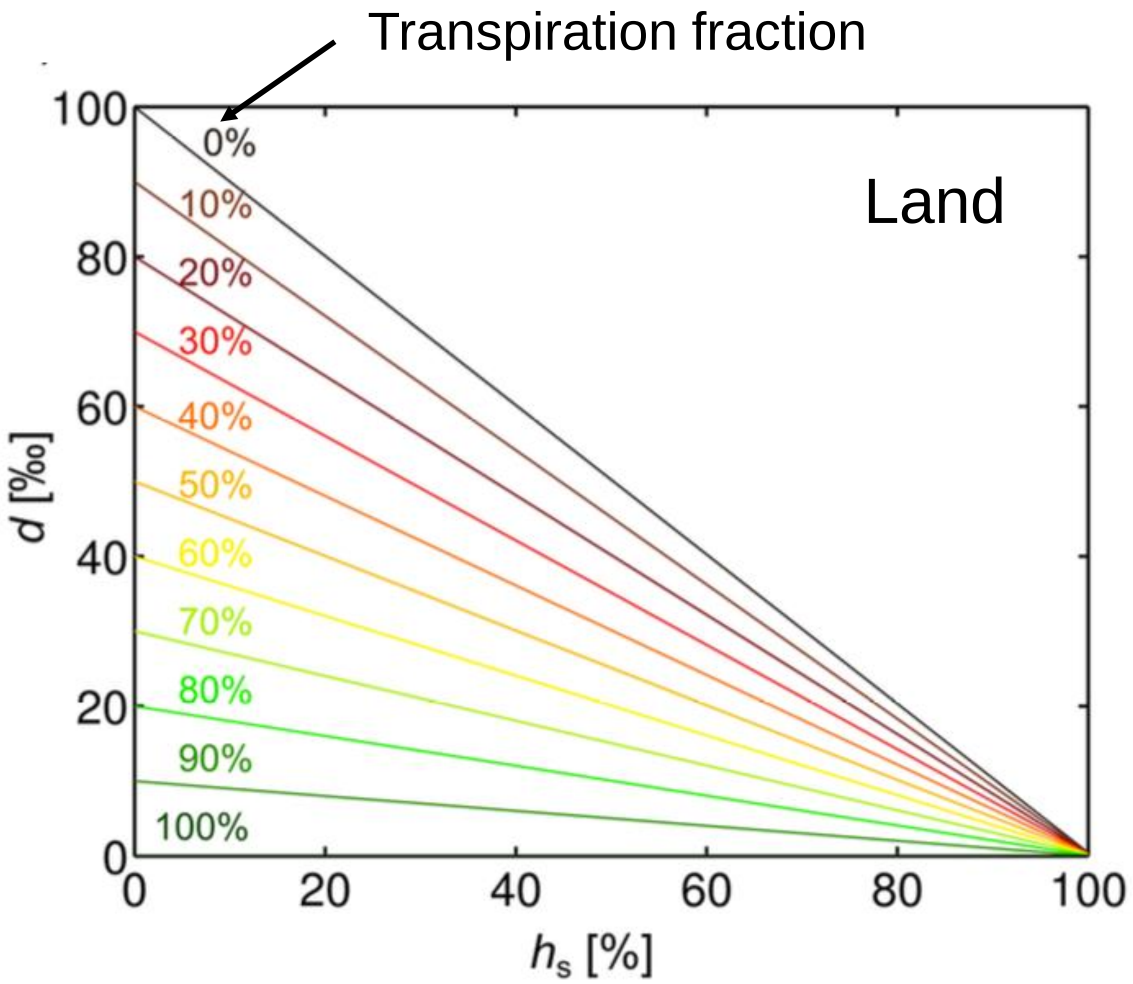
Time interval: 3hr ;

forcing data: gdas 1deg

model: Hysplit

Deuterium excess of evaporated vapor over the ocean and the land

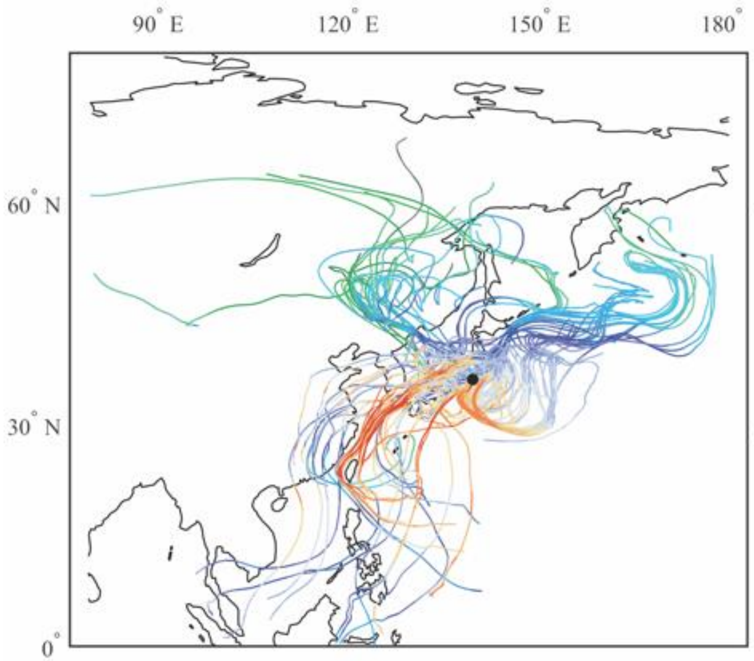




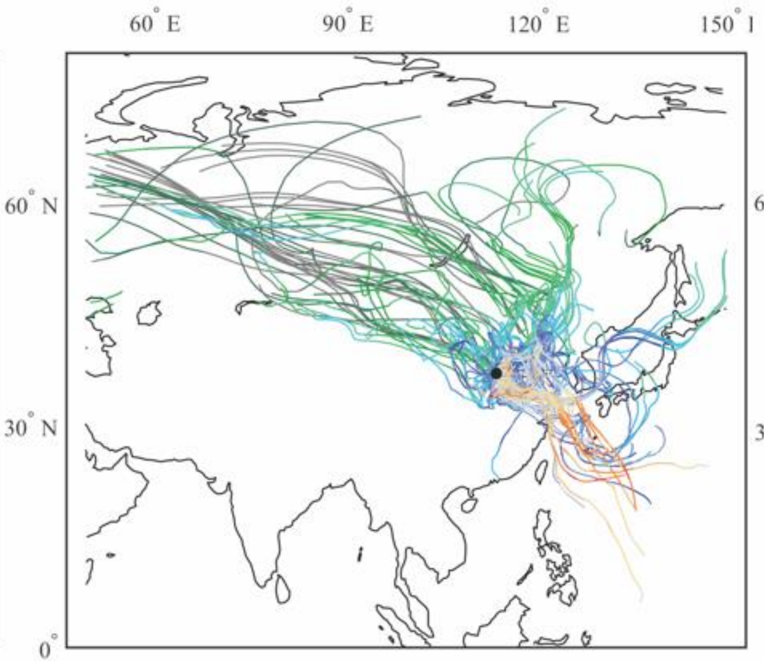
Sources: Aemisegger et al. (2014) Atmos Chem Phys; Pfahl and Sodemann (2014), Atmos Chem Phys

Trajectory analysis of atmospheric moisture source and transport: trajectory patterns (August)

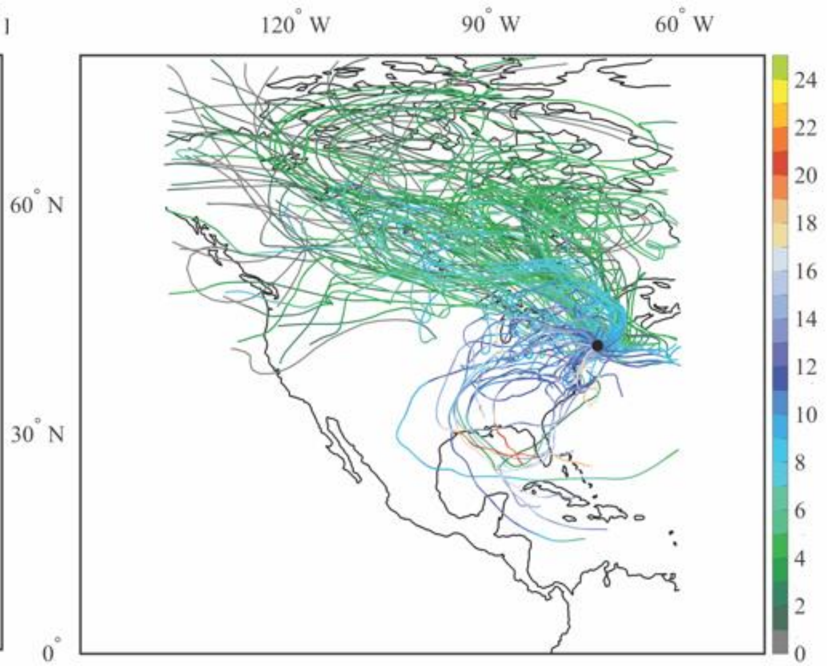
Mase, Japan



Luancheng, China

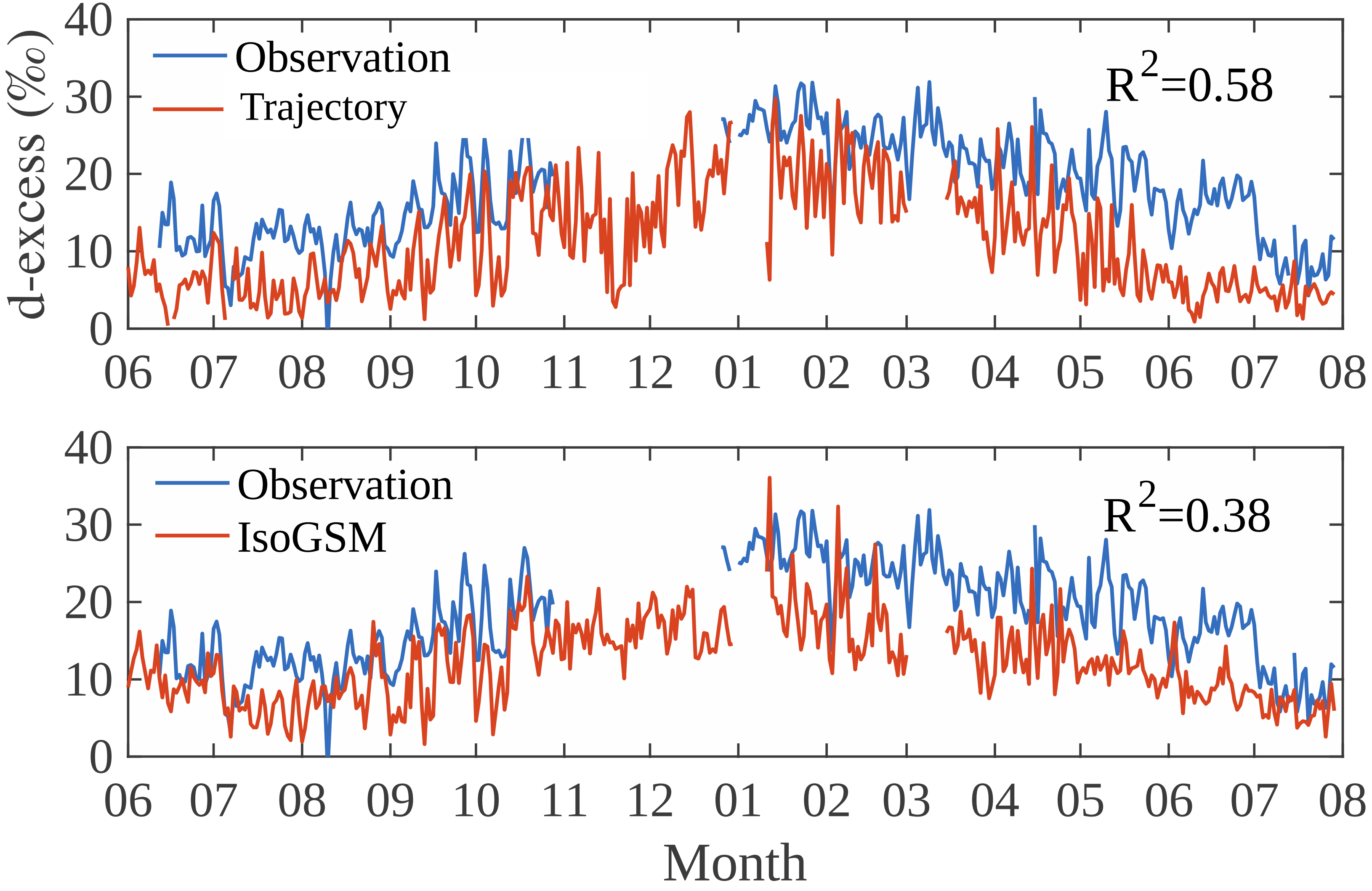


New Haven, USA



Comparison between observed and calculated vapor dx

Mase, Japan



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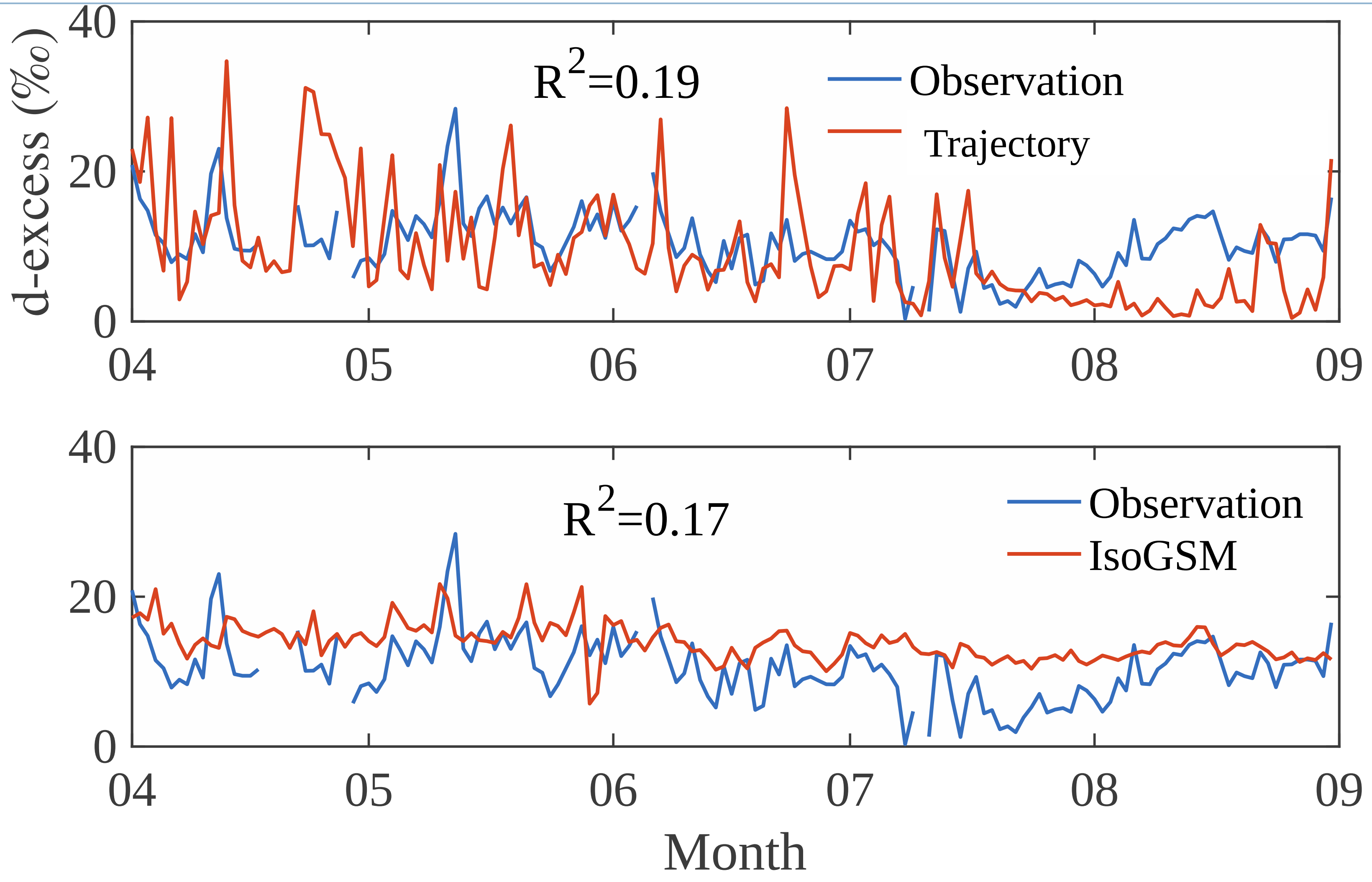

Comparison between observed and calculated vapor dx

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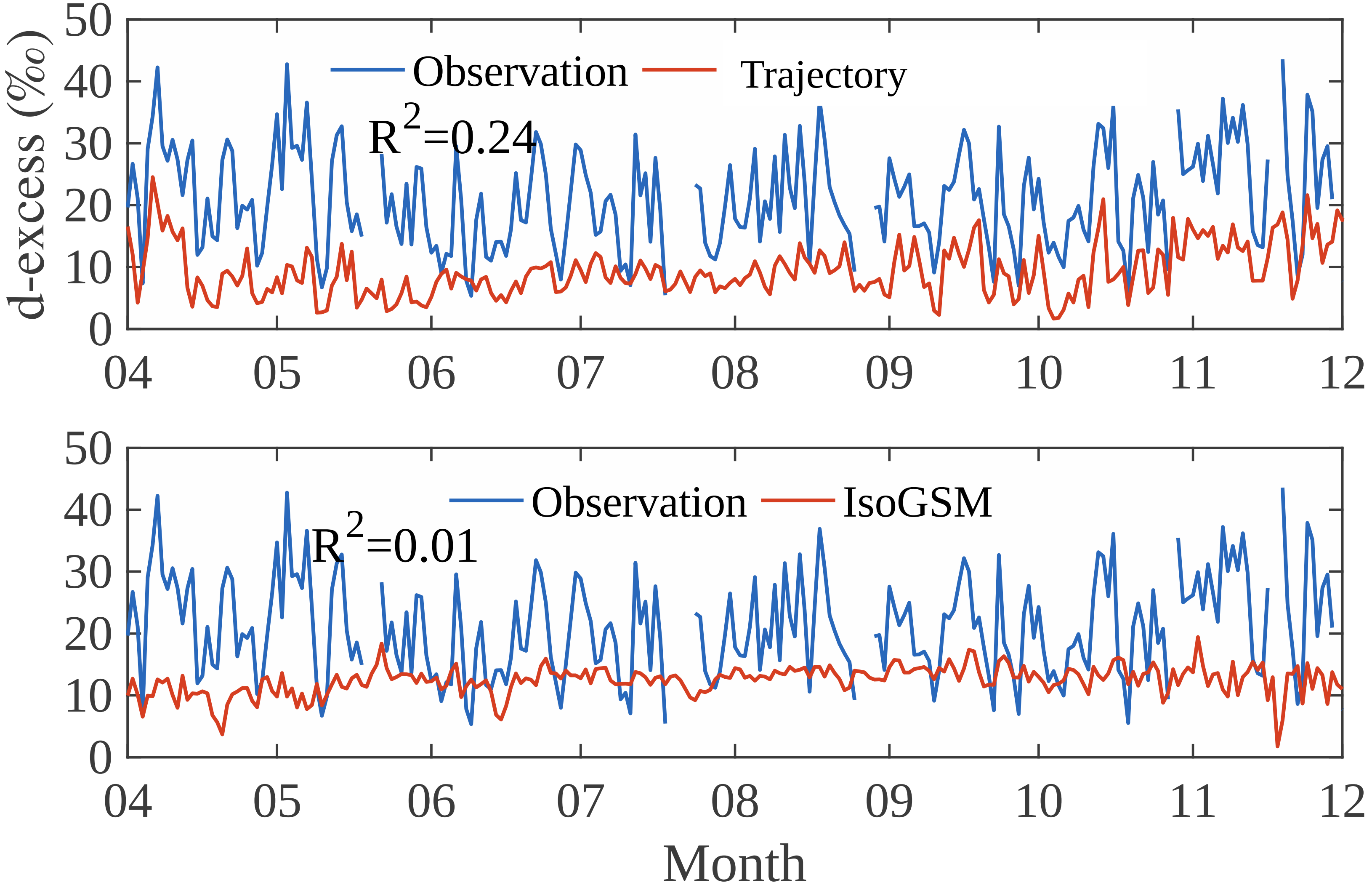
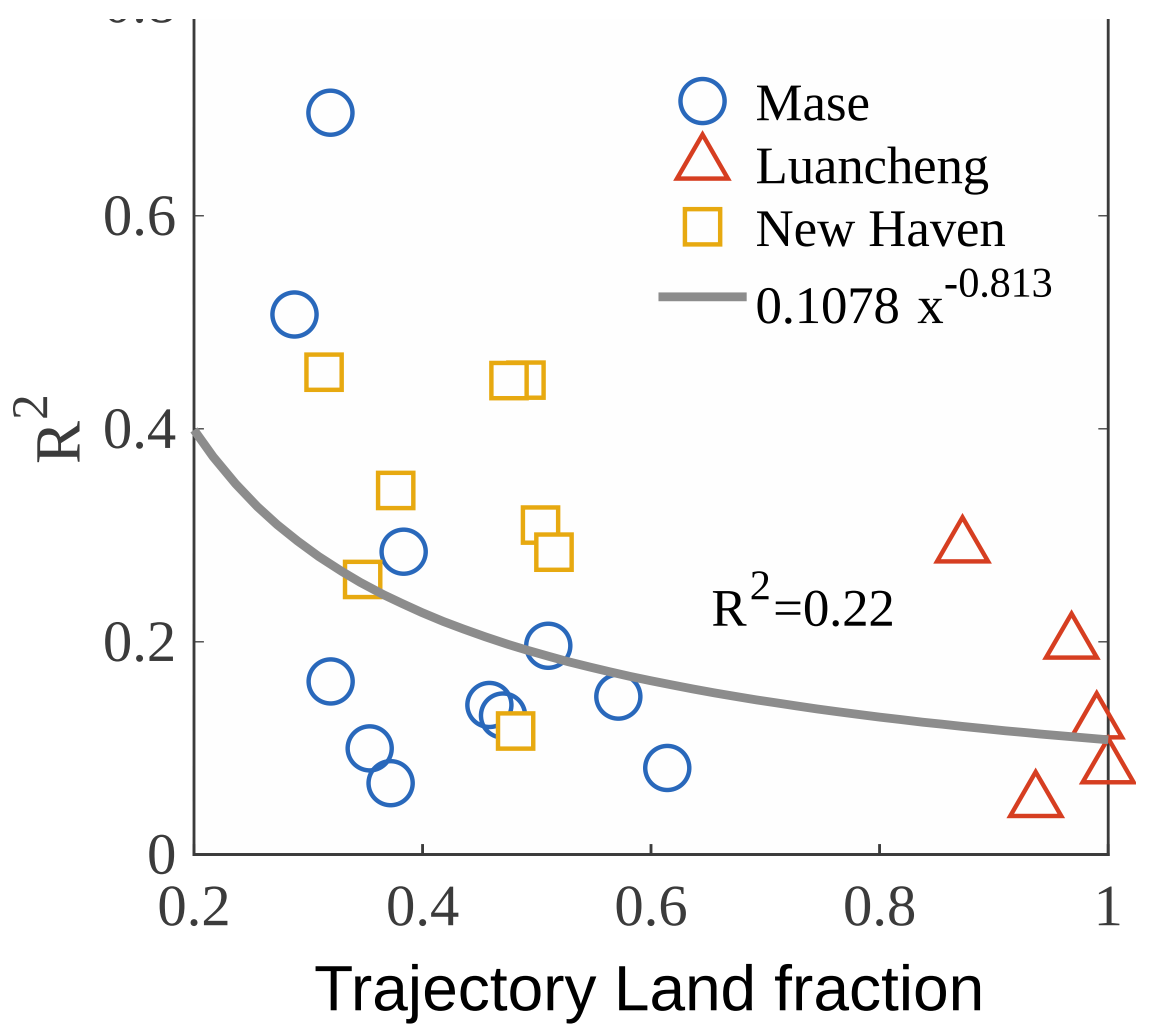
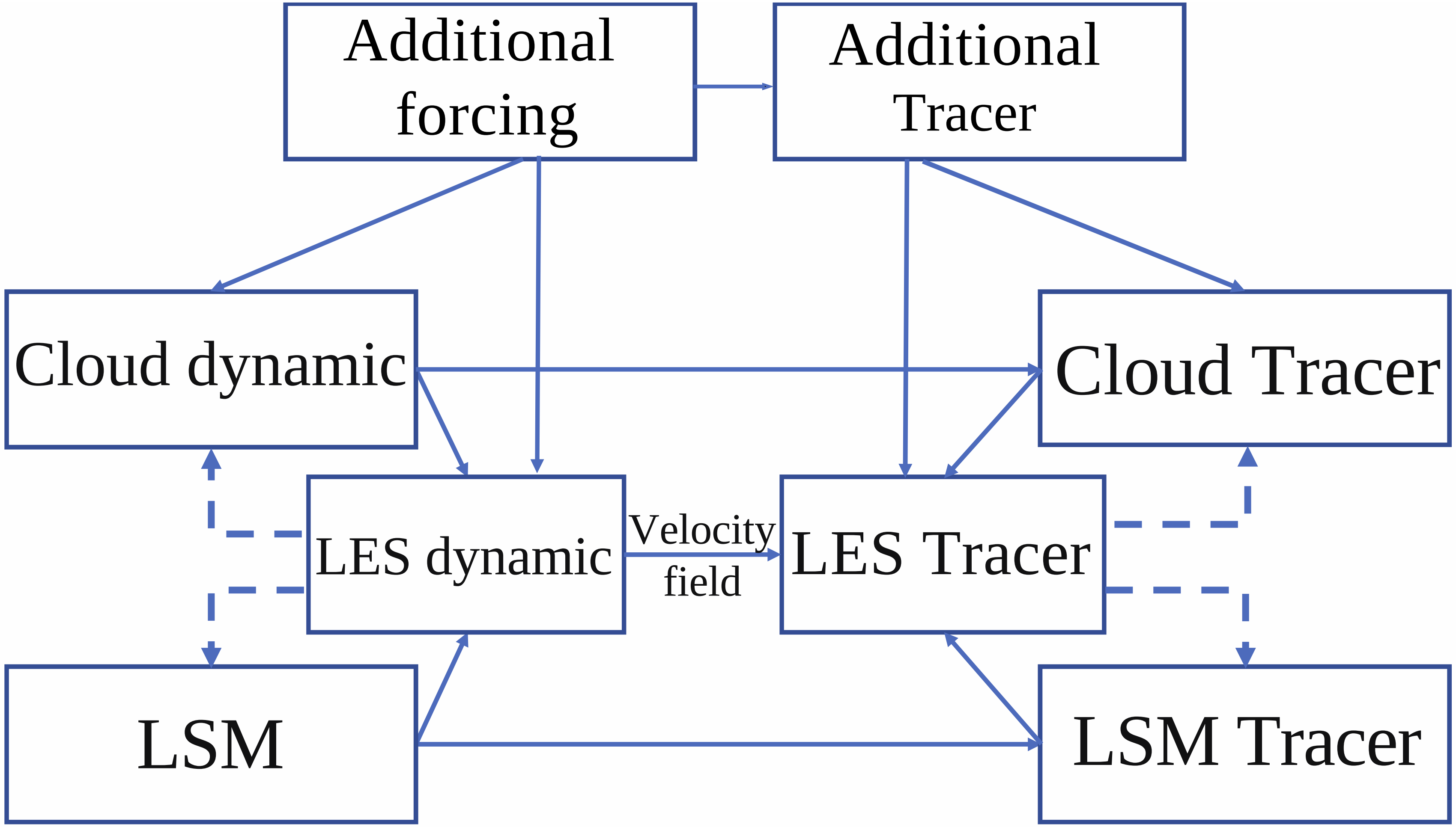


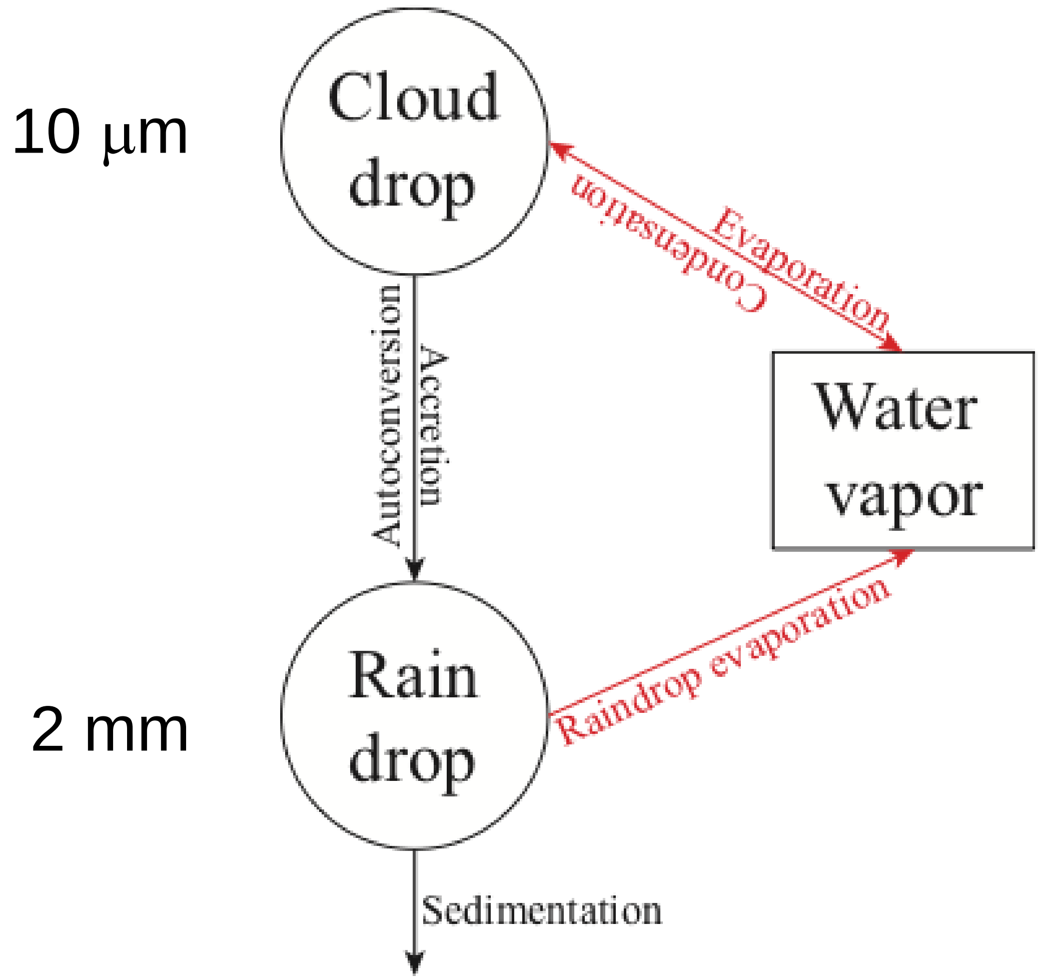
Correlation between observed and calculated d_x of midday water vapor



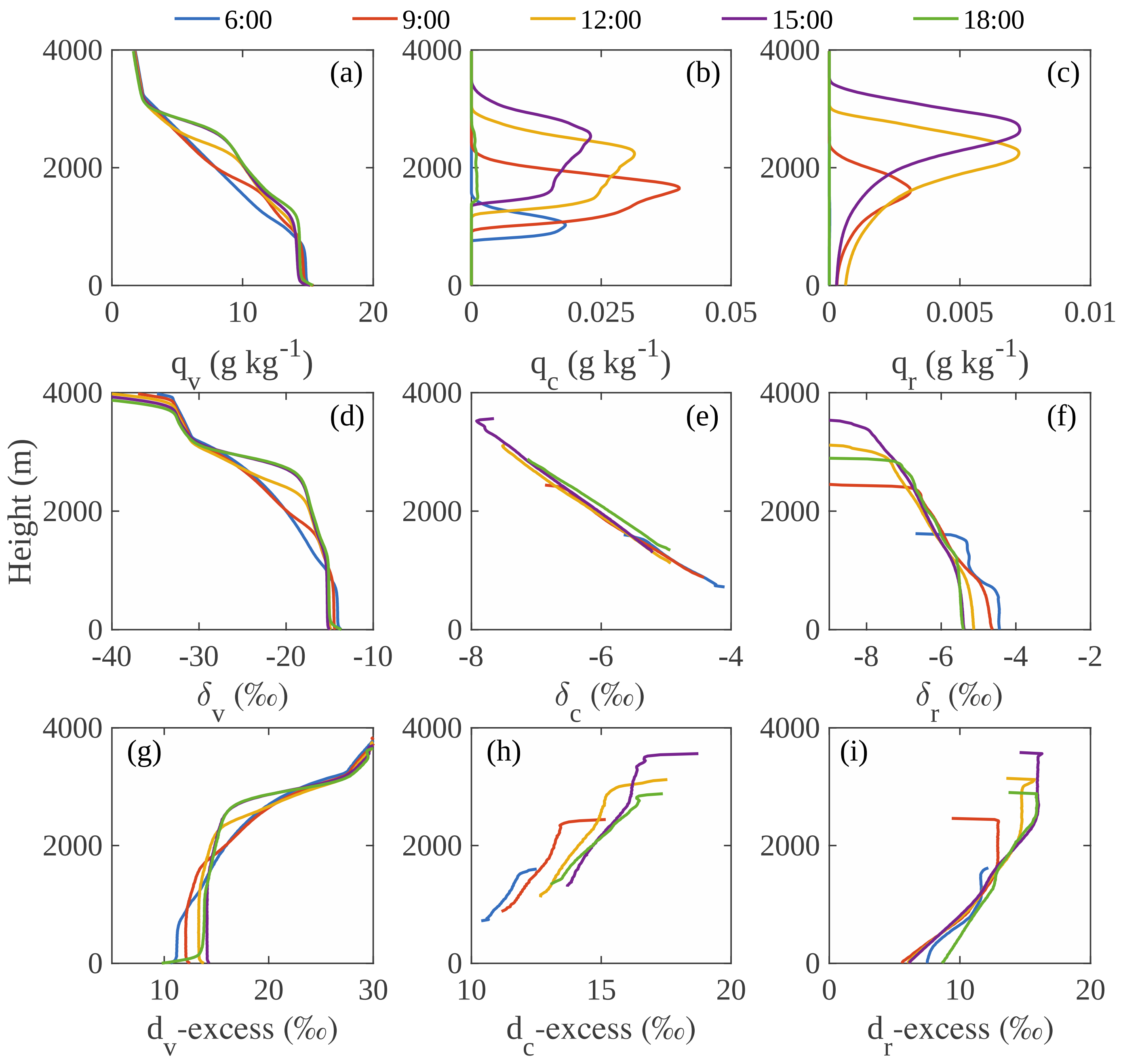
An isotope coupled LSM–LES-Cloud modelling system (ISOLESC)



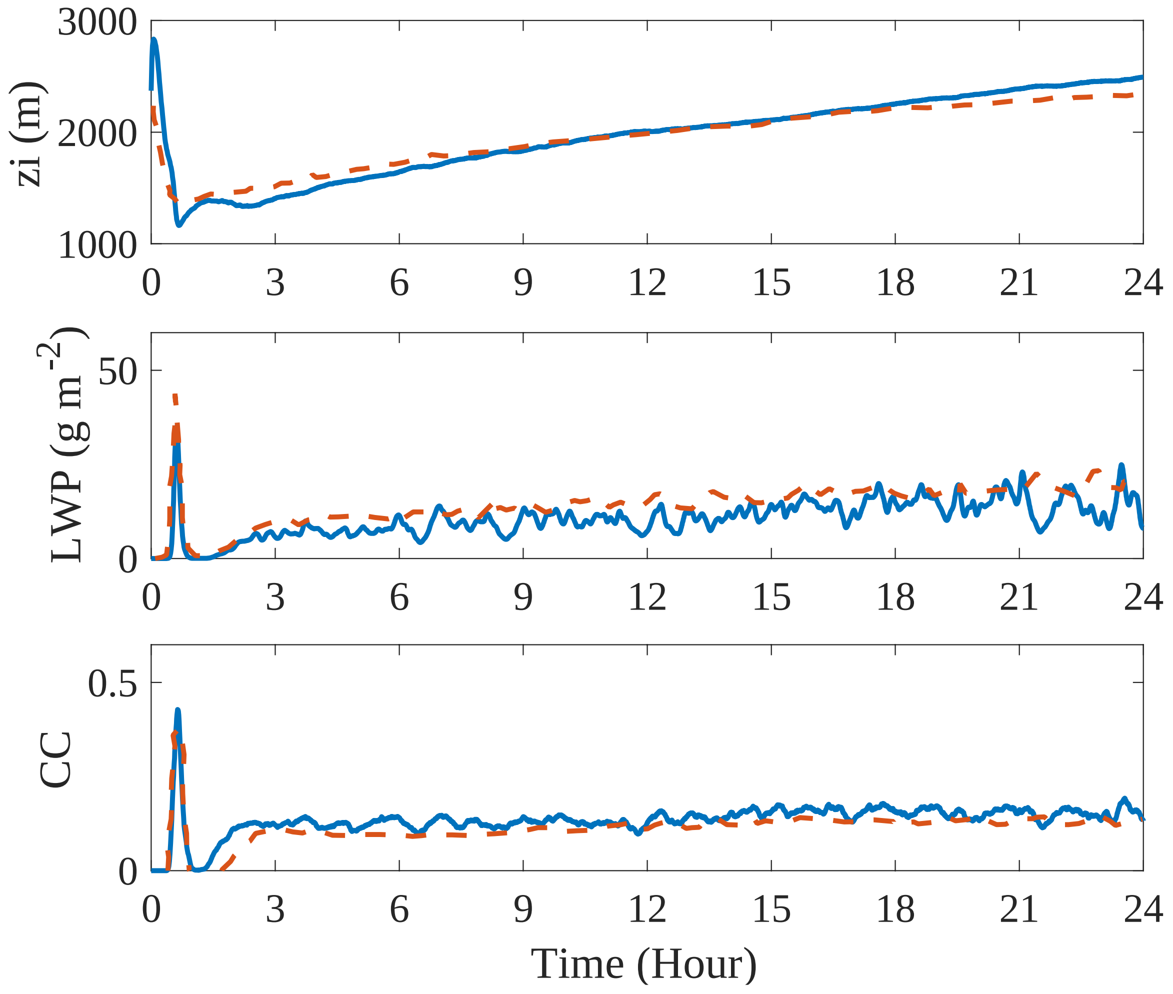
Isotopic interactions among water pools



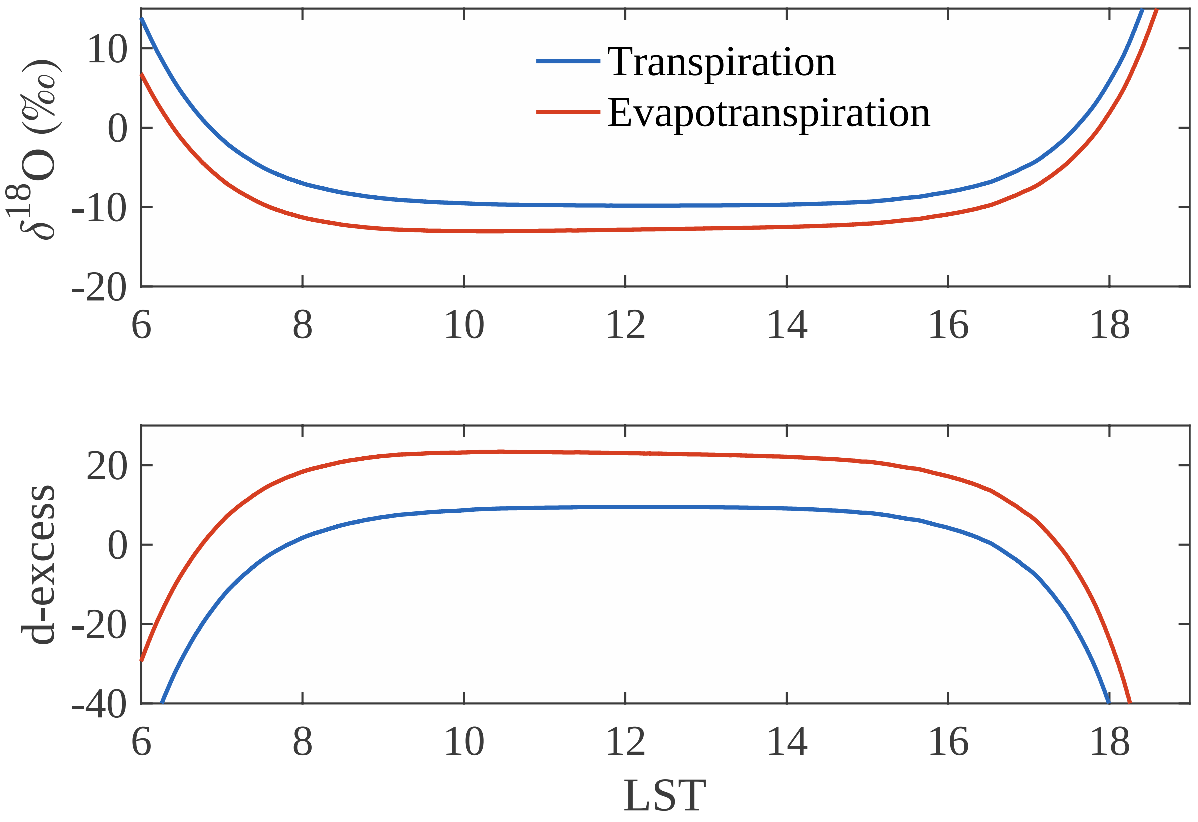
ISOLESC model outputs



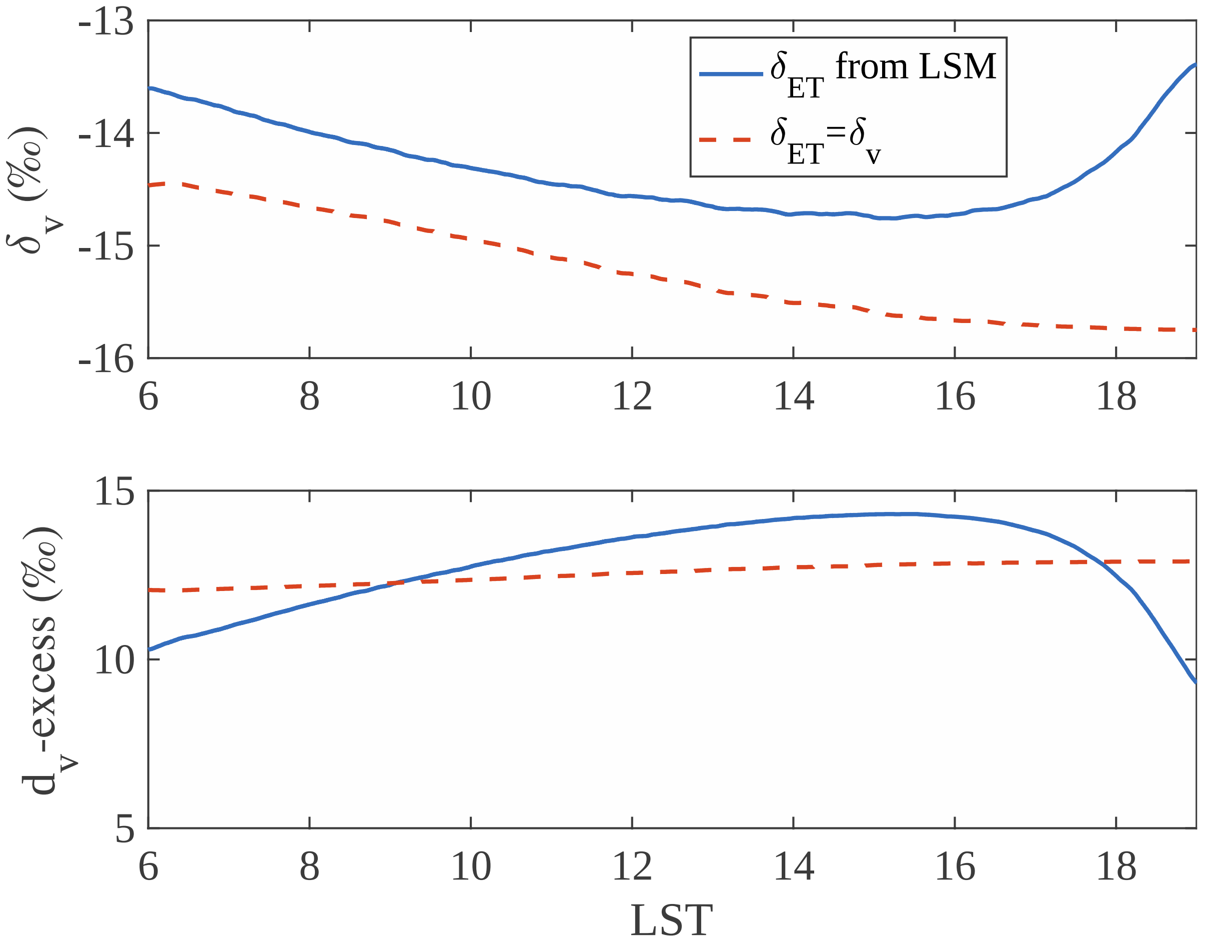
Validation of ISOLESC



^{18}O and deuterium excess of ET



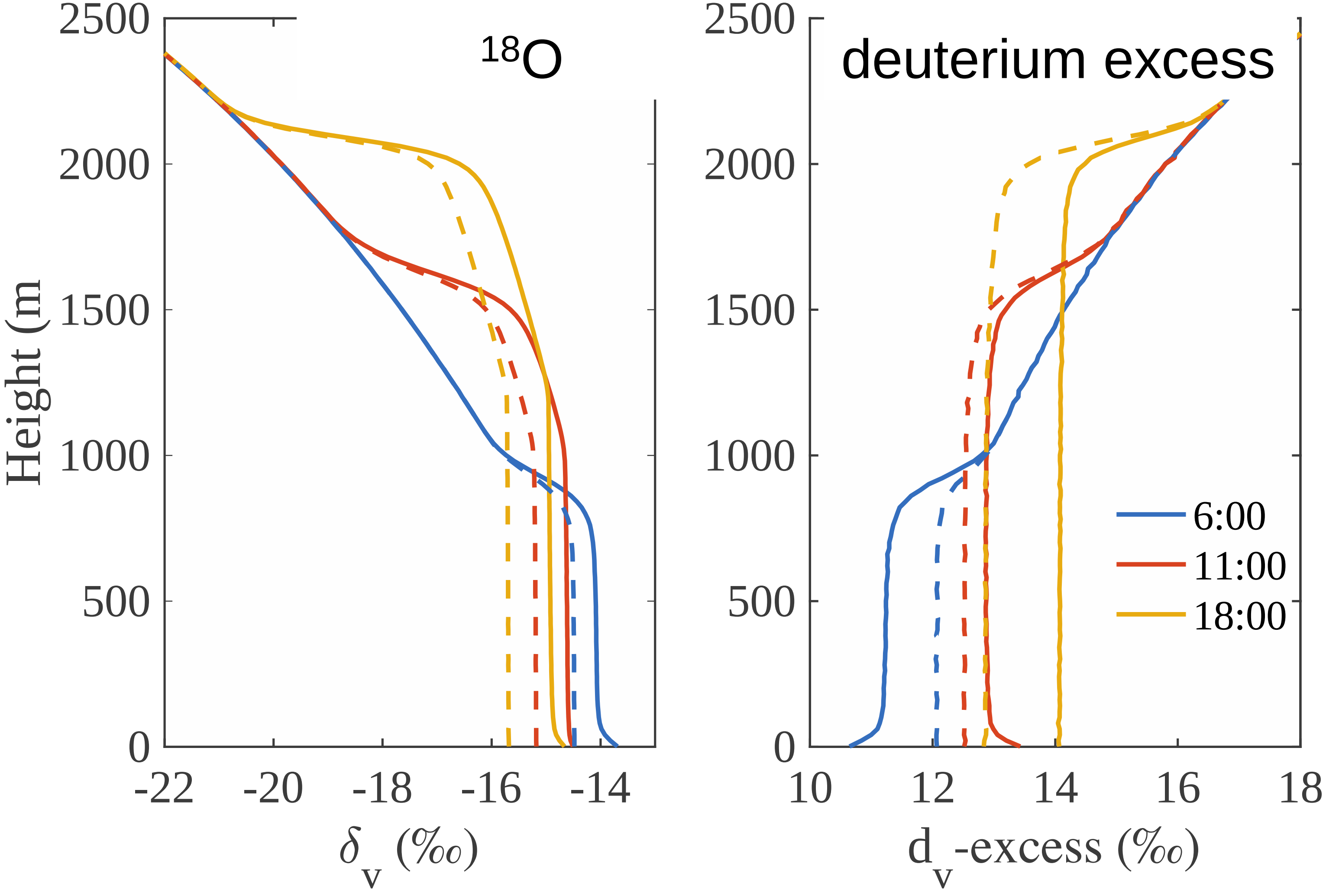
^{18}O and deuterium excess of surface water vapor in two cloud-free ABLs



^{18}O

deuterium excess

Time evolution of ^{18}O and d_x of water vapor in two cloud-free ABLs

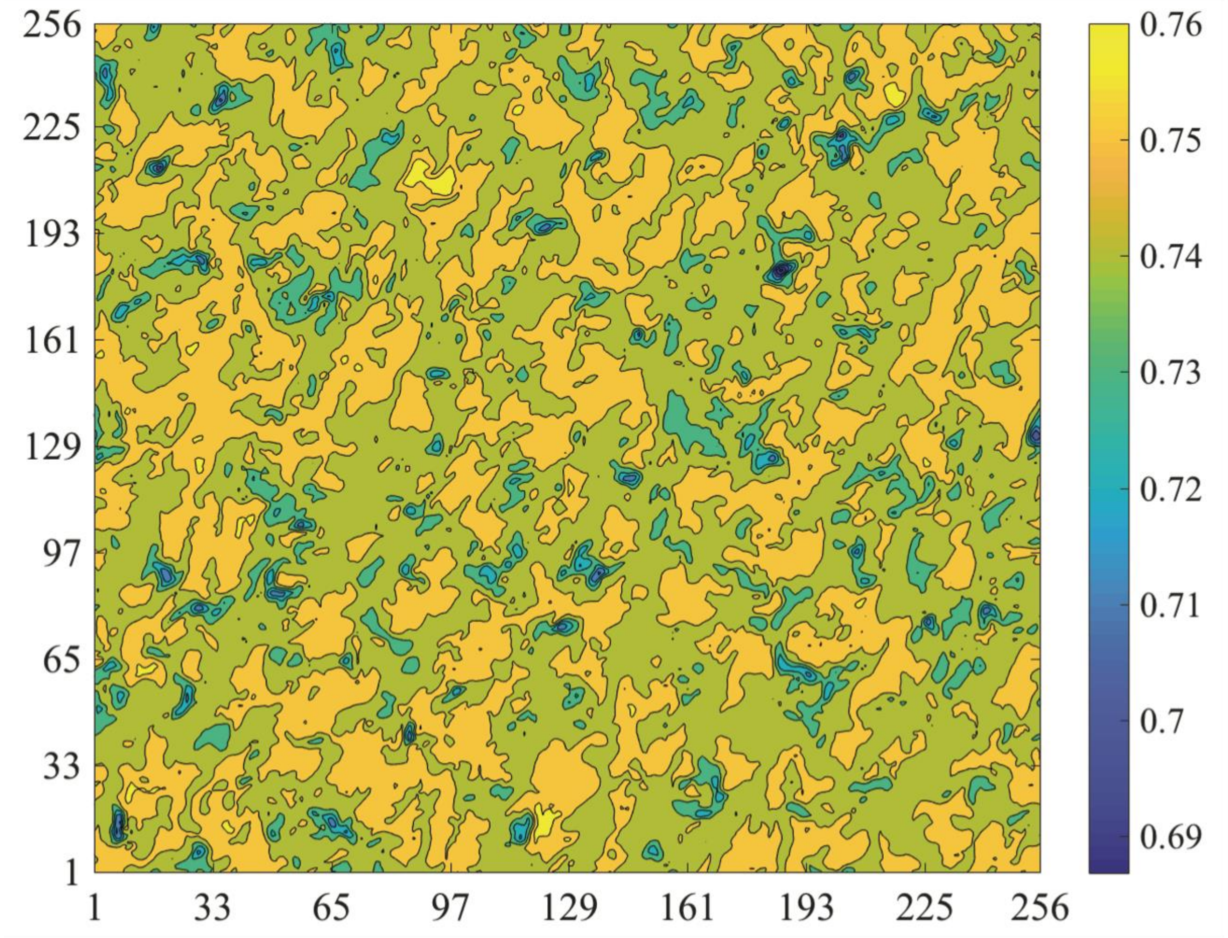


Solid lines: δ_{ET} from LSM

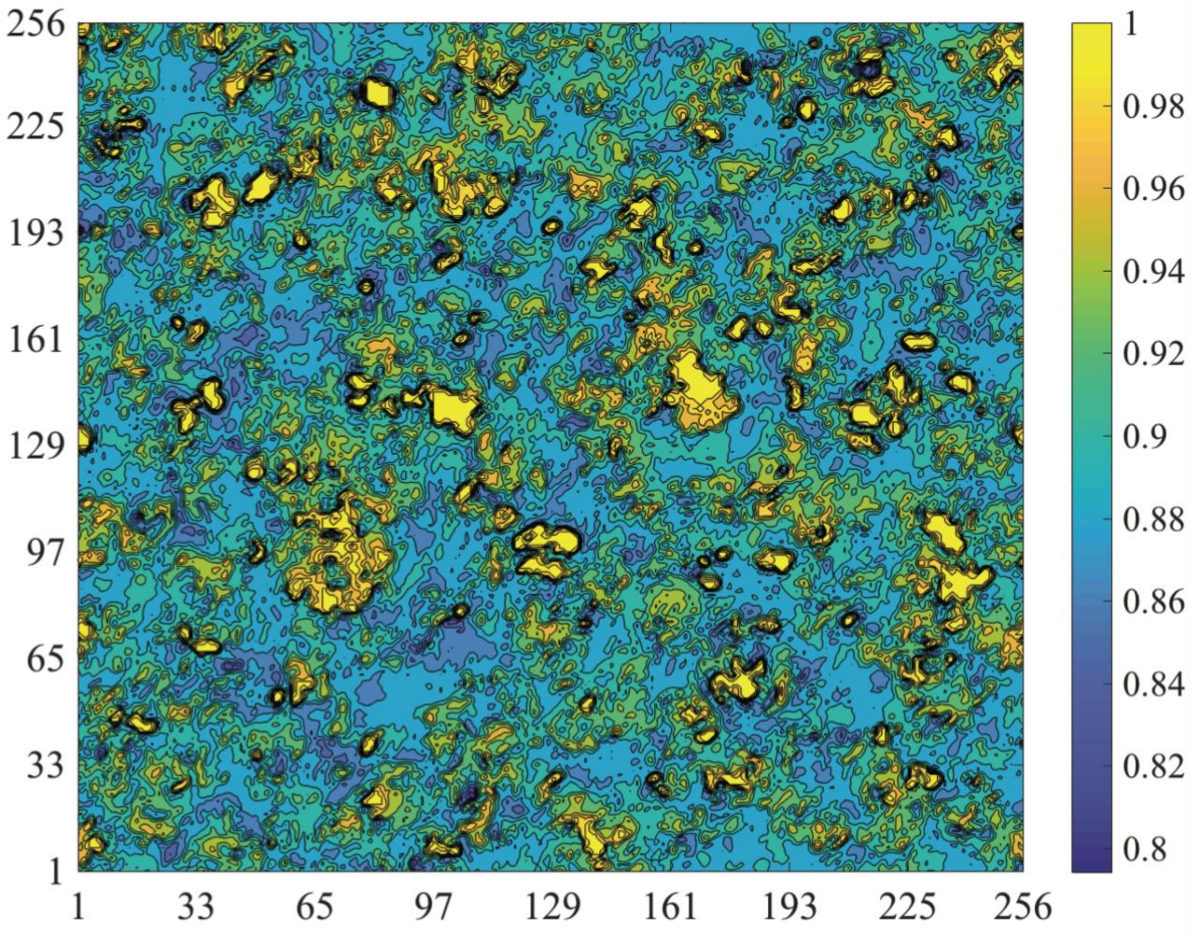
Dashed lines: $\delta_{ET} = \delta_v$

Relative humidity in the sub-cloud and cloud layers

Sub-cloud layer



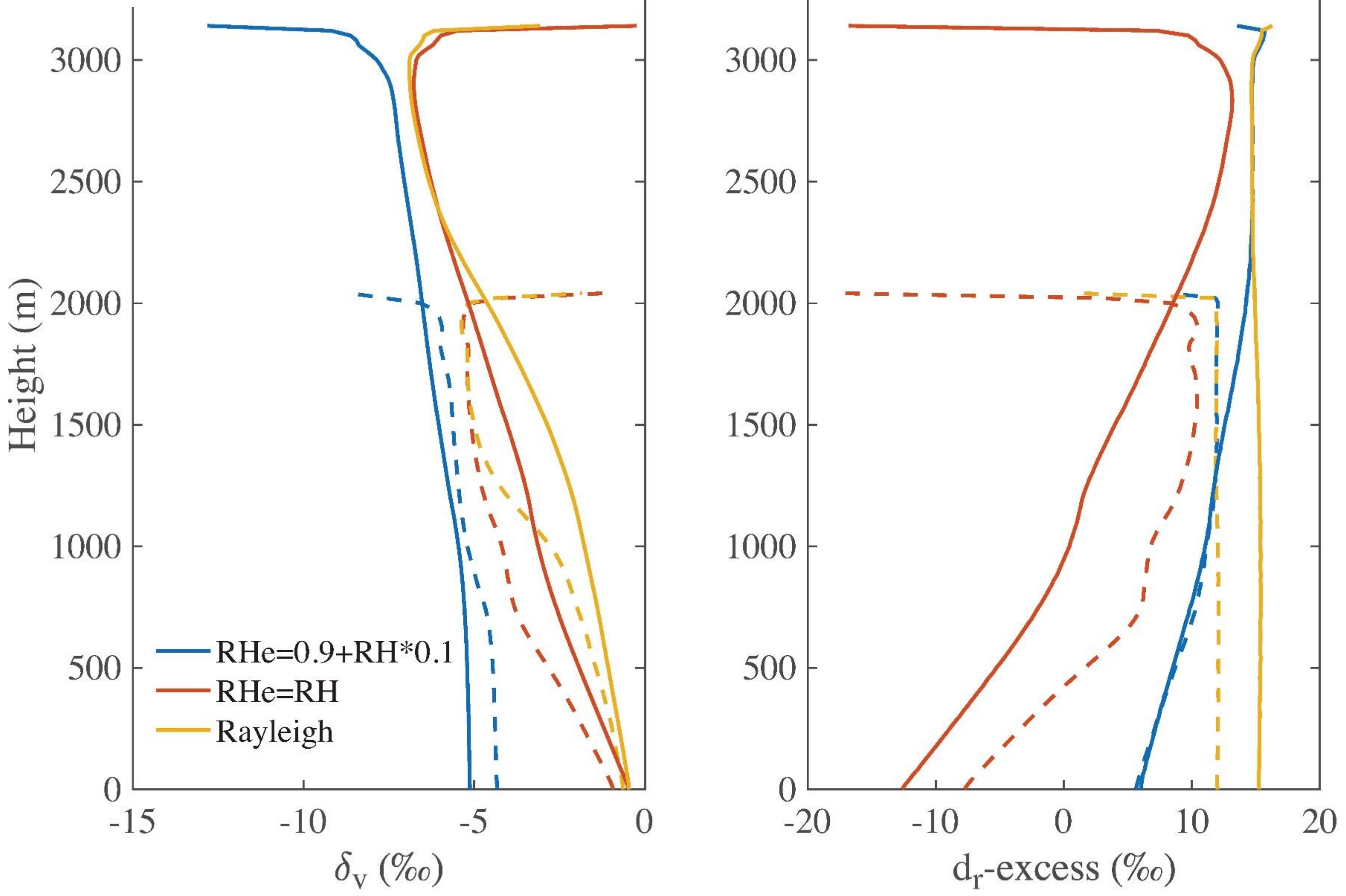
Cloud layer



Parameterizations of raindrop evaporation

^{18}O of raindrop

Deuterium excess of raindrop



Solid lines: fine grids

Dashed lines: coarse grids

Summary

- Entrainment and land evapotranspiration are contributors to d_x diurnal variations
- Vapor d_x is a robust tracer of oceanic moisture sources but has limited ability to explain continental moisture sources
- Raindrop evaporation will reduce the deuterium excess of rainwater
- The ISOLESC model hypothesizes that water vapor in the free atmosphere has large d_x values

Springer Atmospheric Sciences

Xuhui Lee

Fundamentals of Boundary-Layer Meteorology

This textbook introduces a set of fundamental equations that govern the conservation of mass (dry air, water vapor, trace gas), momentum and energy in the lower atmosphere. Simplifications of each of these equations are made in the context of boundary-layer processes. Extended from these equations the author then discusses a key set of issues, including (1) turbulence generation and destruction, (2) force balances in various portions of the lower atmosphere, (3) canopy flow, (4) tracer diffusion and footprint theory, (5) principles of flux measurement and interpretation, (6) models for land evaporation, (7) models for surface temperature response to land use change, and (8) boundary layer budget calculations for heat, water vapor and carbon dioxide. Problem sets are supplied at the end of each chapter to reinforce the concepts and theory presented in the main text. This volume offers the accumulation of insights gained by the author during his academic career as a researcher and teacher in the field of boundary-layer meteorology.

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