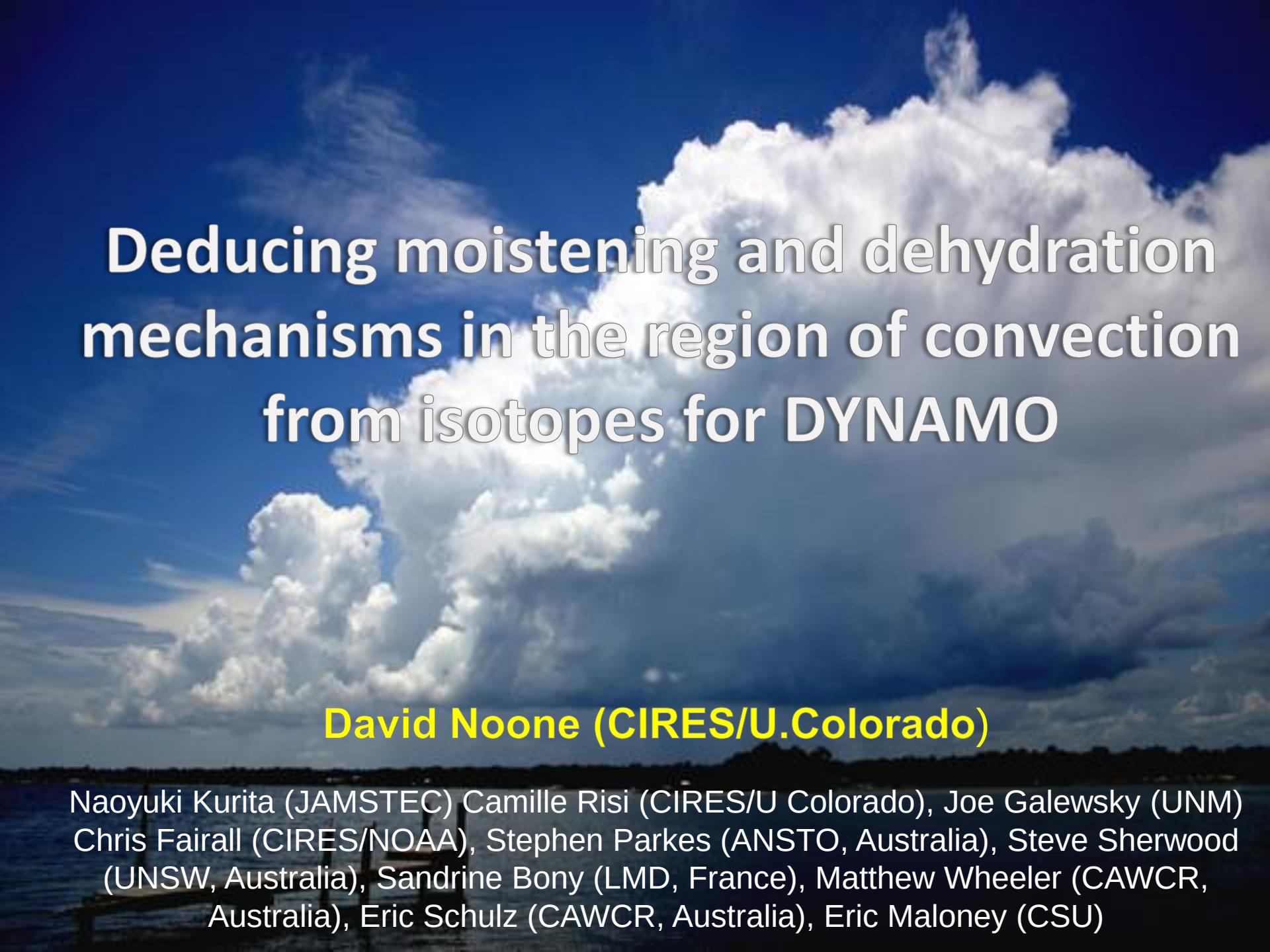

Deducing moistening and dehydration mechanisms in the region of convection from isotopes for DYNAMO

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Naoyuki Kurita (JAMSTEC) Camille Risi (CIRES/U Colorado), Joe Galewsky (UNM) Chris Fairall (CIRES/NOAA), Stephen Parkes (ANSTO, Australia), Steve Sherwood (UNSW, Australia), Sandrine Bony (LMD, France), Matthew Wheeler (CAWCR, Australia), Eric Schulz (CAWCR, Australia), Eric Maloney (CSU)

Summary

Isotopic composition of water…

1. Provides measure of processes because of equilibrium and kinetic fractionation
2. Allows better closure of water budgets (balance of contributing fluxes)
3. Ensures models get right answer for right reason (or, *"why the wrong answer"*)

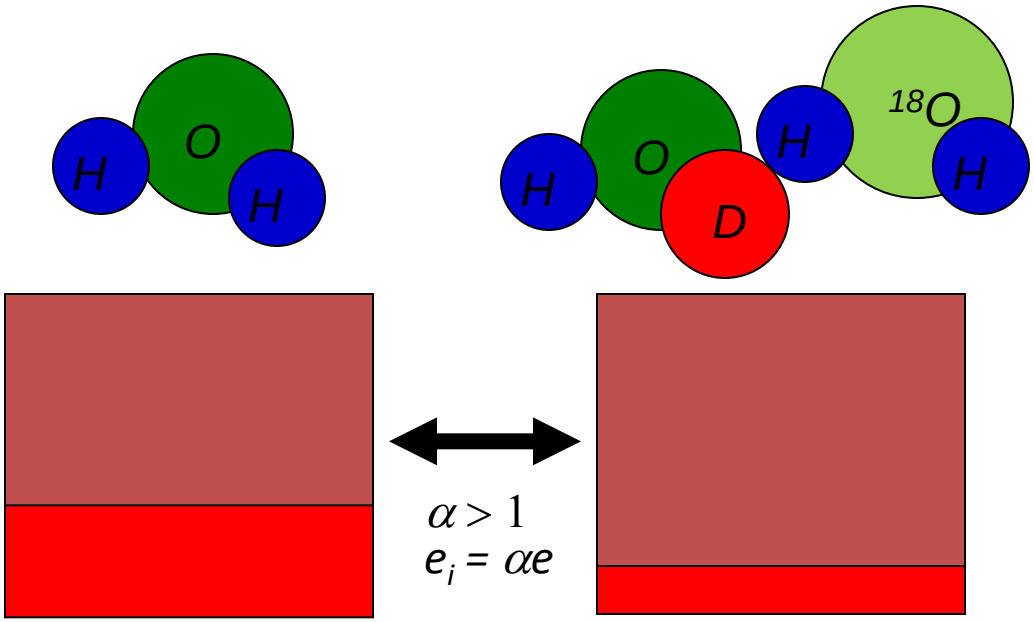
DYNAMO objectives:

- Provide mechanistic understating of surface exchange processes, cloud dynamics, regional humidity budgets…
- … and compare this with what is modeled
  (identify shortcomings in GCMs, cloud scale models)

Scientific targets:

- Sources of moisture (local, off equatorial, other sources)
- Air-sea flux (gas exchange, sea spray)
- Convective cloud dynamics
  (detrainment, subsidence profiles, sub-saturated downdrafts)
- Reevaporation of falling rain
- Boundary layer humidity controls (exchange of low entropy air at MBL top)

Reminder of isotope physics



Ratio of HDO to H_2O

Measured as a difference from ocean water.

$$\delta = \frac{R}{R_{ocn}} - 1$$

Equilibrium fractionation about 8 times stronger for ^{18}O relative to ^{2}H

Non-equilibrium diffusion faster for smaller molecules ($HDO/H_2{}^{18}O$). (evaporation, condensation to ice)

Two simple isotope models…

Condensation

Vapor becomes depleted as heavy removed preferentially

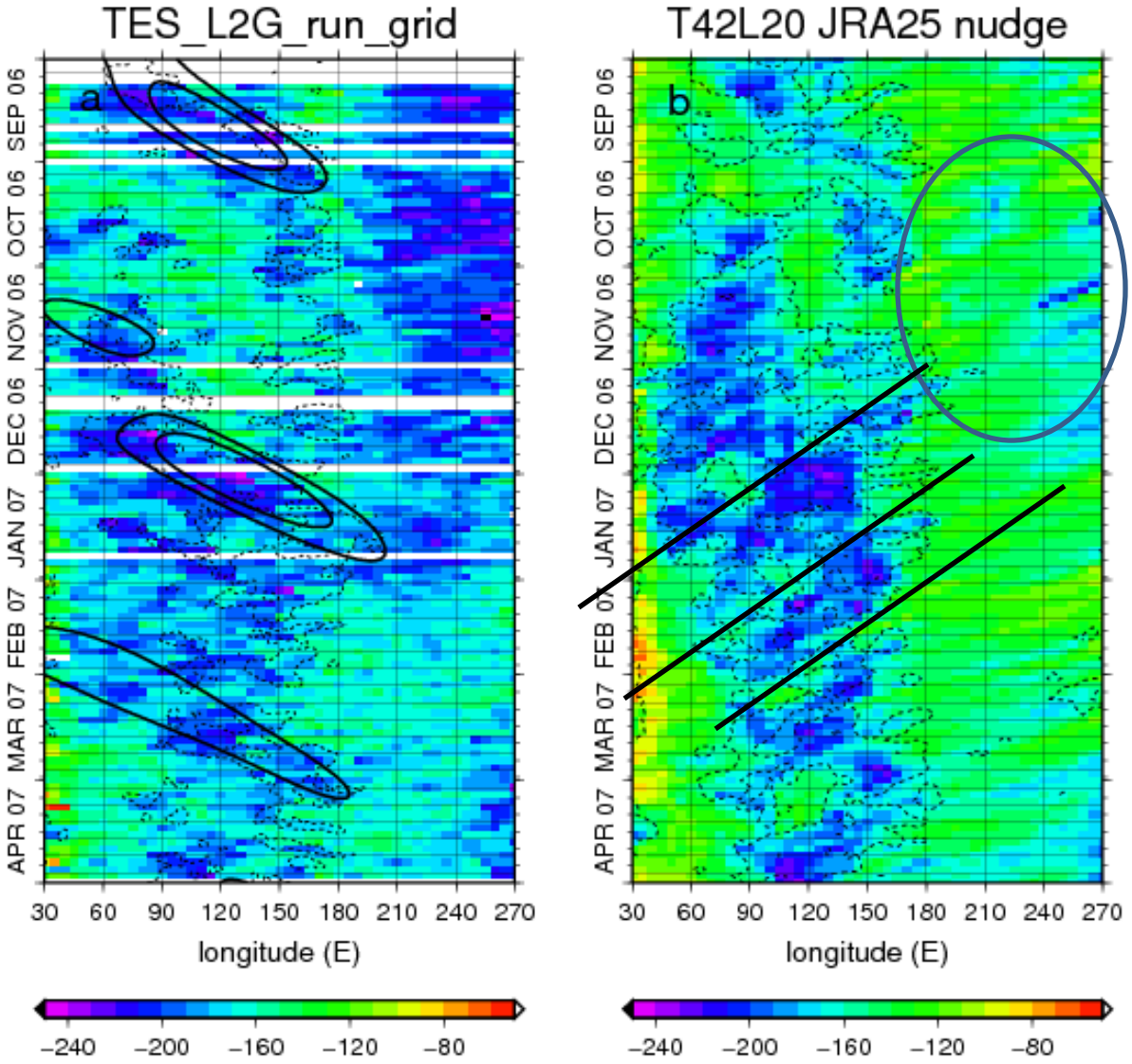
Evaporation

Returns to isotopic composition of the (ocean/land) source.

Conditions under which condensation occurs is different from the conditions when evaporation occurs, allowing isotopes to "tag" air masses/sources

MISMO TES versus model

NASA Tropospheric Emission Spectrometer (TES), derived HDO/H2O ratio



OLR in solid contours

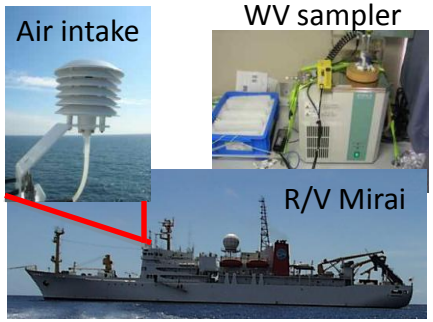
Delta D shaded

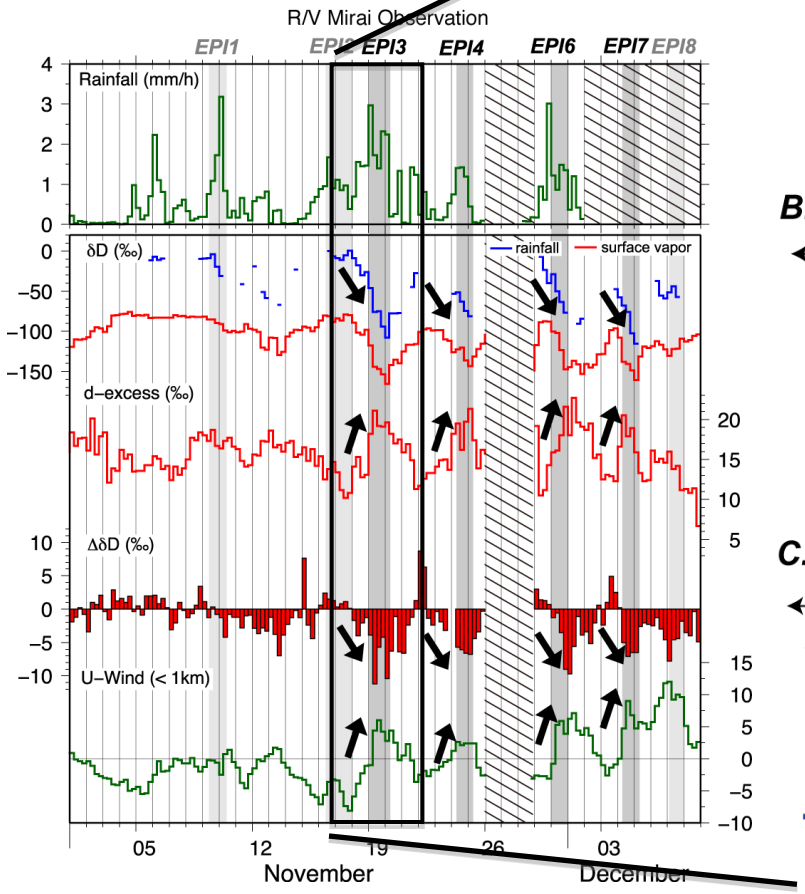
Model fails to capture subsidence

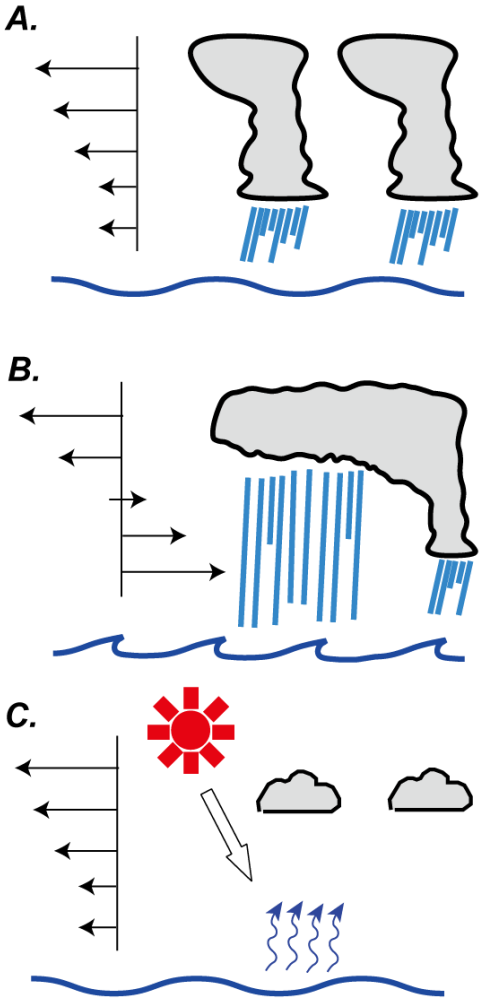
Model does not capture easterly propagation

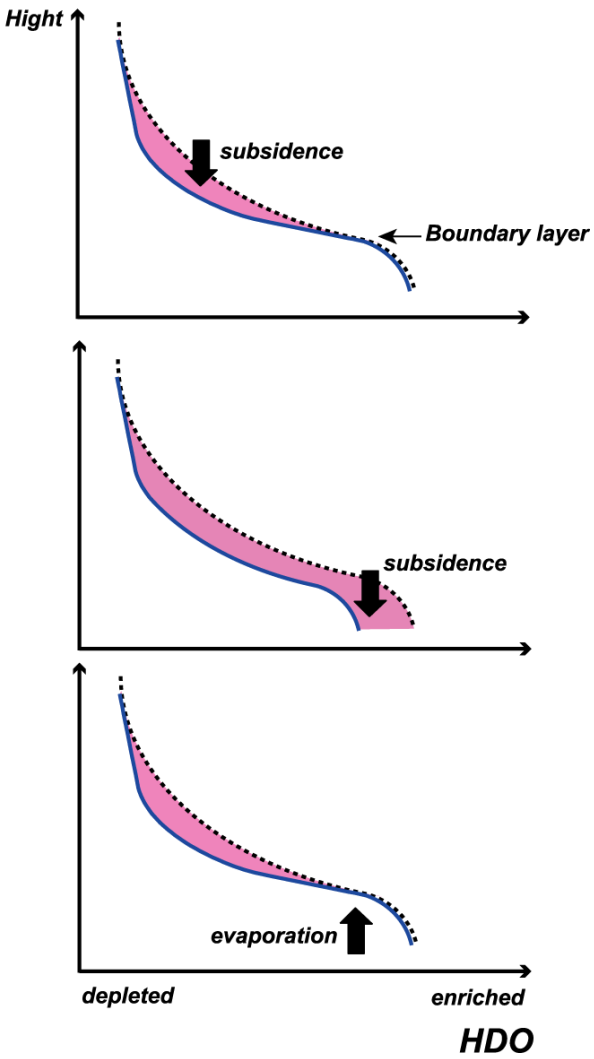
True situation dominated by easterly flow/advection, while model dominated by cloud processes

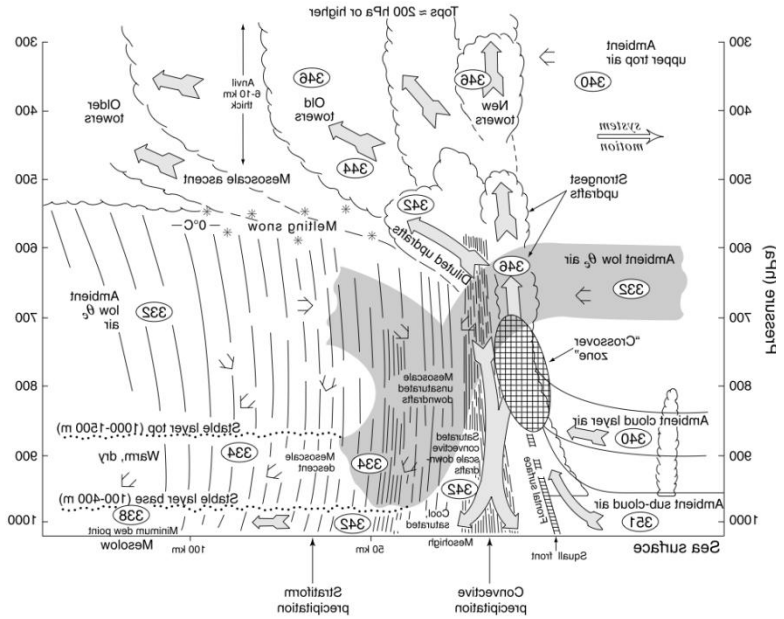
Water Isotope Observation during the MISMO (Kurita et al.)



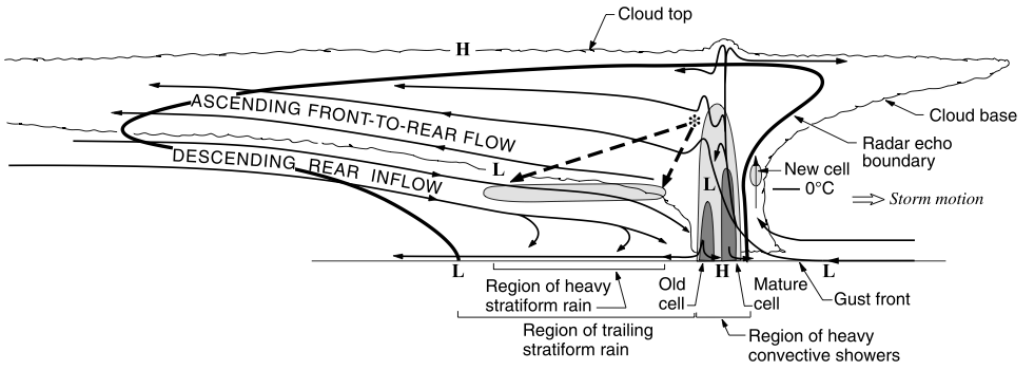








Zipser [1977]



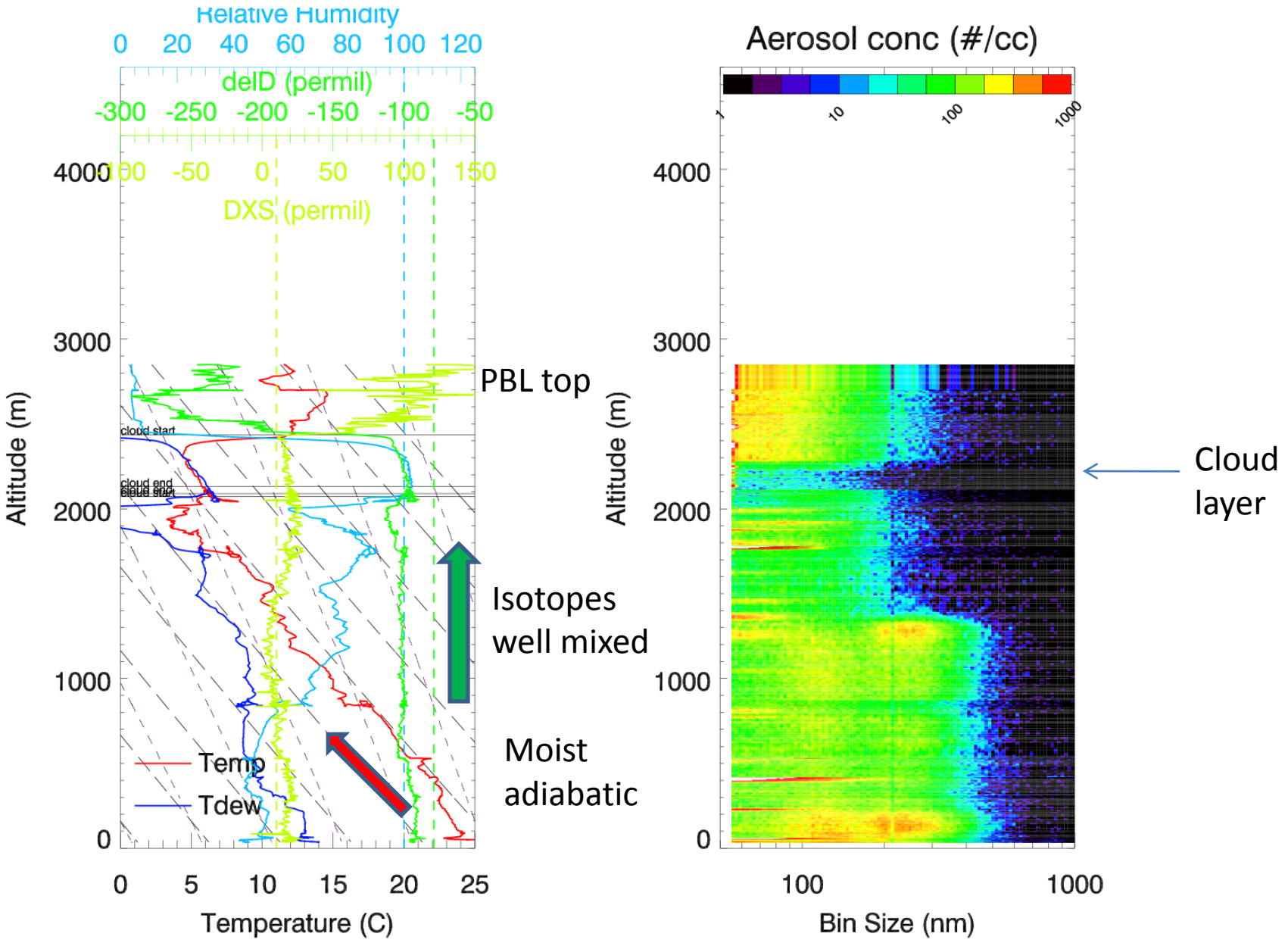
House et al., [1989]

Subsidence does not reach at the surface?

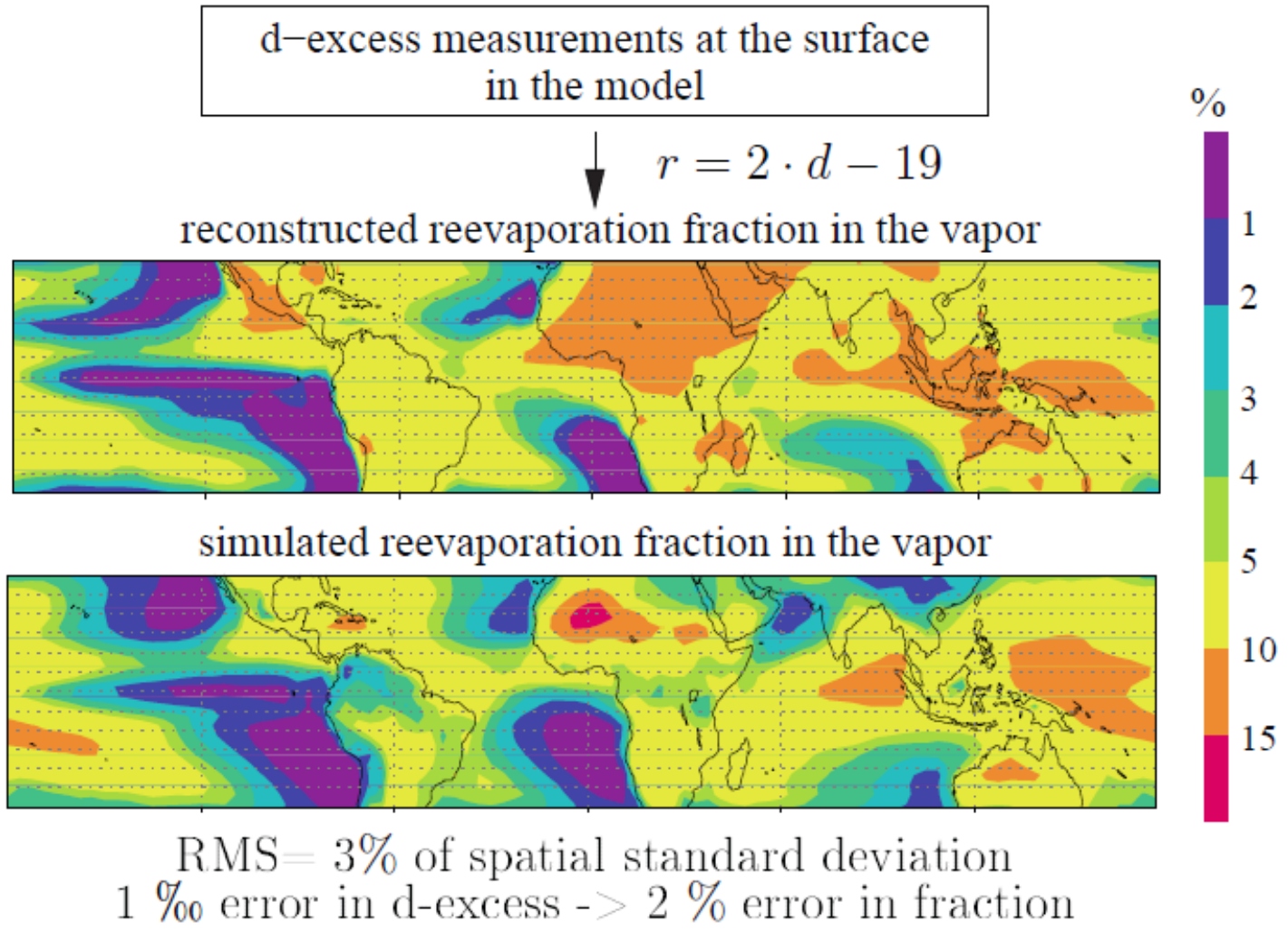
Isotope depletion in the tropics → Air mass descent from the high altitude

The minimum peaks of isotope signal corresponded to the maximum fraction of the stratiform rainfall.

PBL profiles (Hawaii)



Rain evaporation fraction



Risi et al., in prep

Isotopes modules for Dynamo (Noone et al., Colorado)

Objectives: Air-sea flux, convective cloud dynamics, boundary layer humidity controls
: Process understanding, new target for model testing/intercomparison

Observations

Island sites

Vapor:

Gan (UNM Picarro, Galwesky)
Diego Garcia (TBD as needed)
Cocos (ANSTO Picarro, Parkes)
Darwin (ANSTO Picarro+FTS, Parkes)
Reunion Island (FTS, Schneider)

Precipitation:

JAMSTEC sample network (Kurita)
CIRES disdrometers at select sites

Ship platform

NOAA RV (JAMSTEC LGR, plus CU Picarro flux, Kurita/Noone/Fairall)
Miari (JAMSTEC Picarro, Kurita)
Southern Surveyor (UNSW Picarro, McCabe/Sherwood/Schulz)

Aircraft

NOAA P3 (CIRES Picarro, Noone/Fairall)

Satellite

TES/IASI (JPL/Eumetop), GoSat (JAXA), SCHIMACHY (Frankenberg/Noone)

Modeling

Model intercomparison

Isotope enabled column models, plus runs forced with observed winds

NCAR CAM3/5 (Noone), LMDZ (Bony/Risi), MIROC (Kurita), GISS (Schmidt), isoGSM (Yoshimura),ECHam (Hoffmann), HadAM (Sime), WRF cloud resolved (Blossey), others

Integration with non-isotope work

Coordination with Maloney (CSU) and Wheeler (CAWCR) to integrate experiment design with DYNAMO/CINDY simulations
Common forcing with column models and parameterization tests.
Additional diagnostics for surface/cloud water tracers.

Funding requests: 1) NOAA for US ship/aircraft observations
2) NSF for modeling, supplementary obs. and coordination

Conclusions/status

Isotope element provides clear opportunities for integration of modeling and observation (process diagnostics, limitations in parameterizations, leads to improvments)

International community (support from CAWCR, JAMSTEC, LMD) and modeling

Isotope "products"

- Estimate entrainment profile
- Model representation of vertical transport (updraft plumes, large sale subsidence, subsaturated downdrafts)
- Direct measure of rain evaporation
- Rate of exchange at air-sea interface and sea spray

Critical components for DYNAMO

- Integration of measurements on ship/surface platforms
- Aircraft profiles from PBL to troposphere in clear sky, below cloud, cloud penetrations
- Coordination of modeling activities (likely under GEWEX)