Water vapor isotopic measurements to evaluate the representation of moist processes in models during Madden-Julian oscillation

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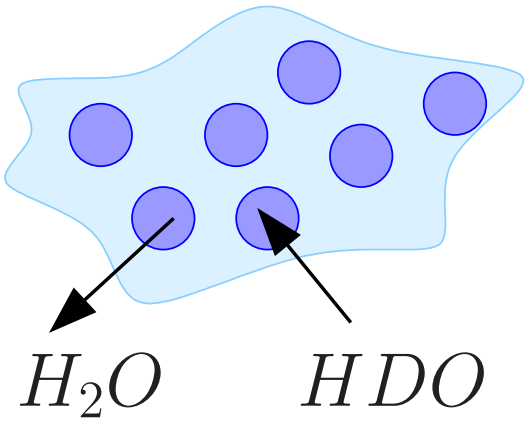
Montreal, August 21, 2014

Water isotopes



- Water isotopes track cloud processes *(e.g. Moyer et al 1996, Webster and Heymsfield 2003, Lawrence et al 2009, Worden et al 2007, Risi et al 2008, Lee et al 2009, Berkelhammer et al 2011...)*

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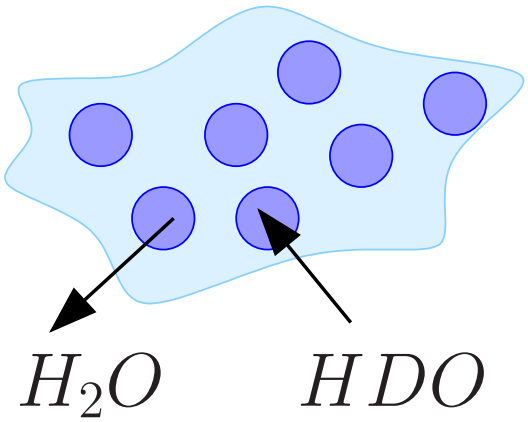

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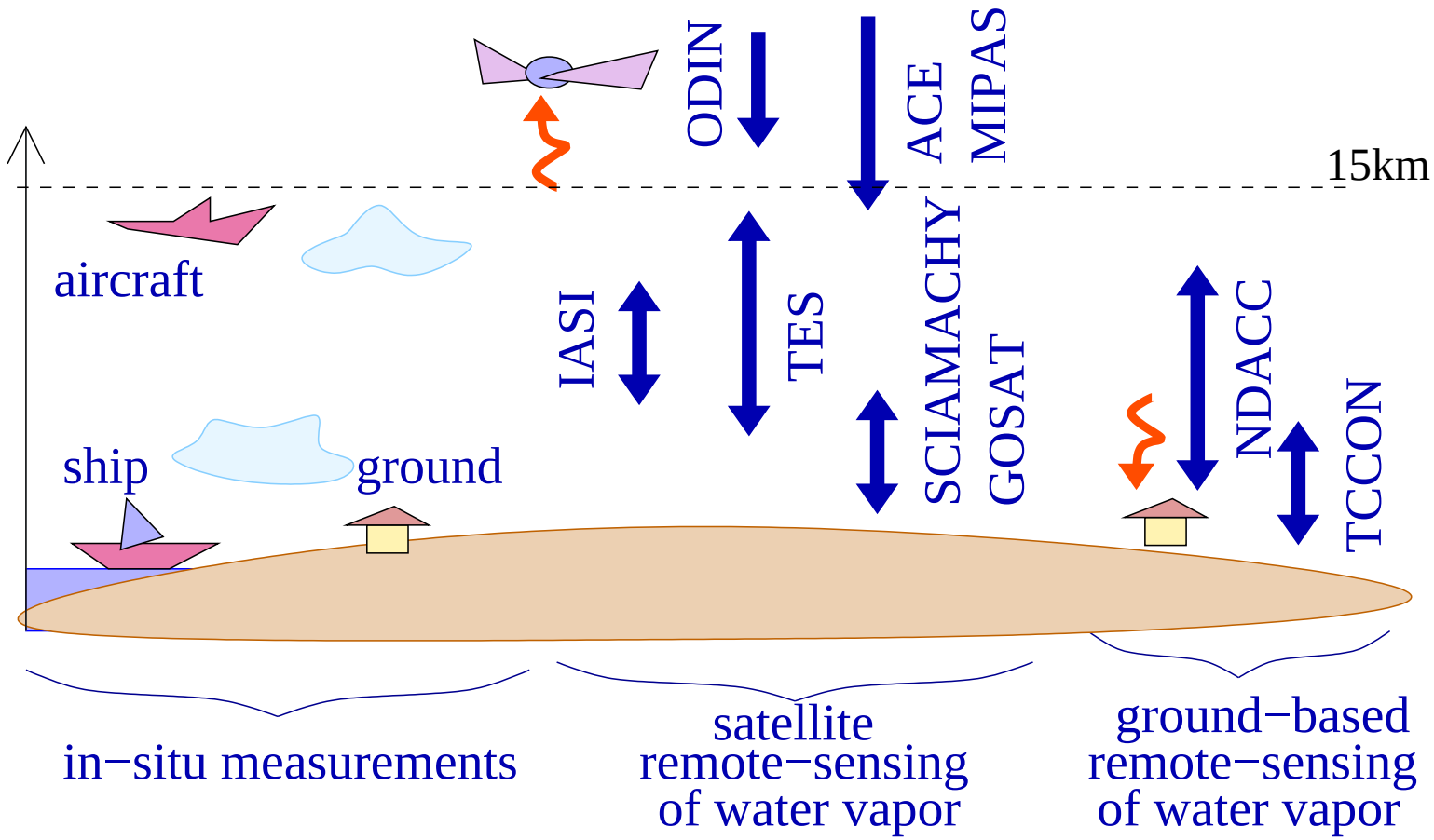
- General goal: To what extent model-data comparison of water vapor isotopes could help evaluate GCMs, understand cause of their biases?
- In this talk: Water vapor isotopes sensitive to relative roles of shallow convection, deep convection and large-scale condensation parameterizations
  $\Rightarrow$ water isotopic measurements to evaluate relative roles of cloud parameterizations during different phases of the MJO?

Water isotopes measurements and modeling

- Measuring water vapor δD (HDO/H_2O anomaly in ‰):



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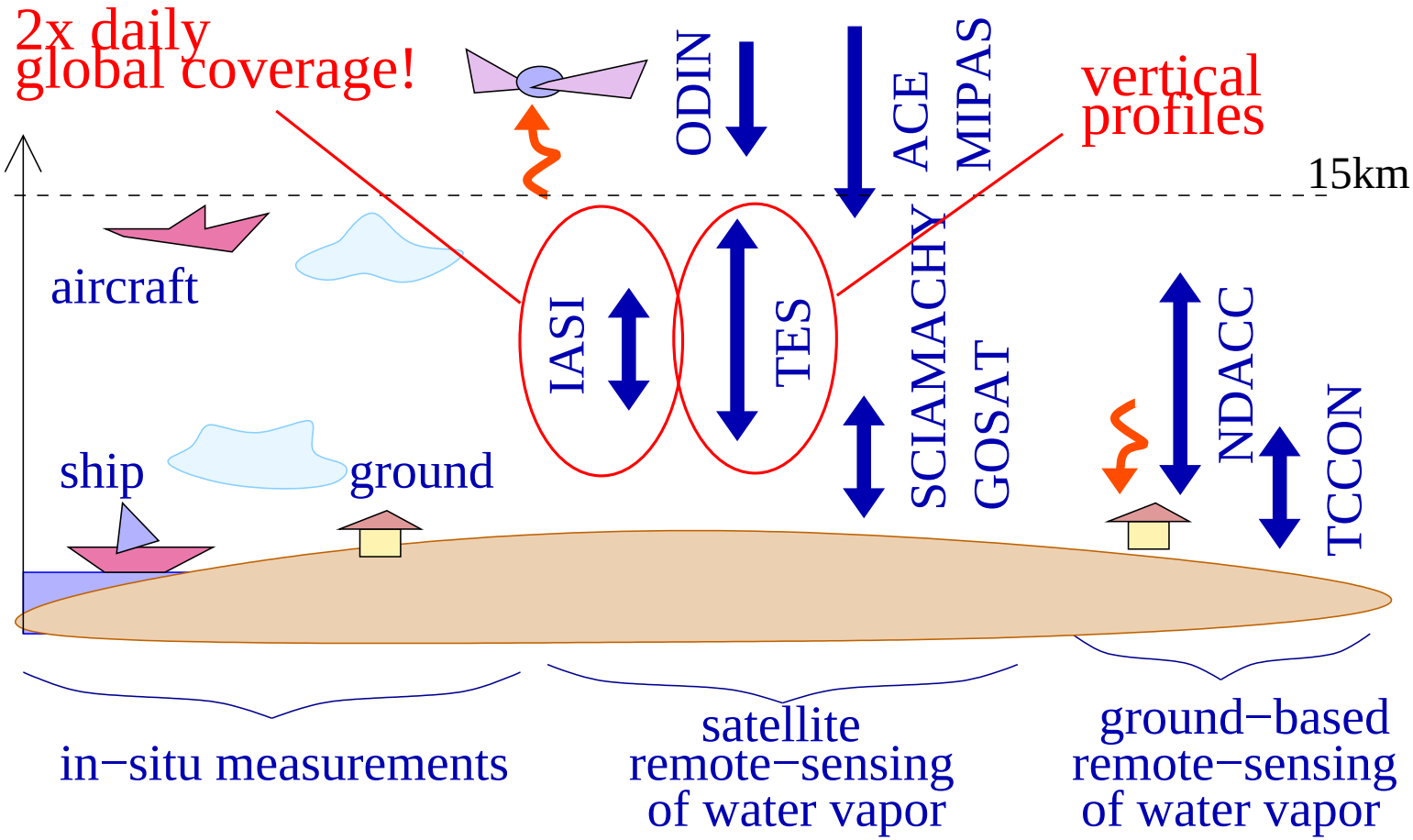

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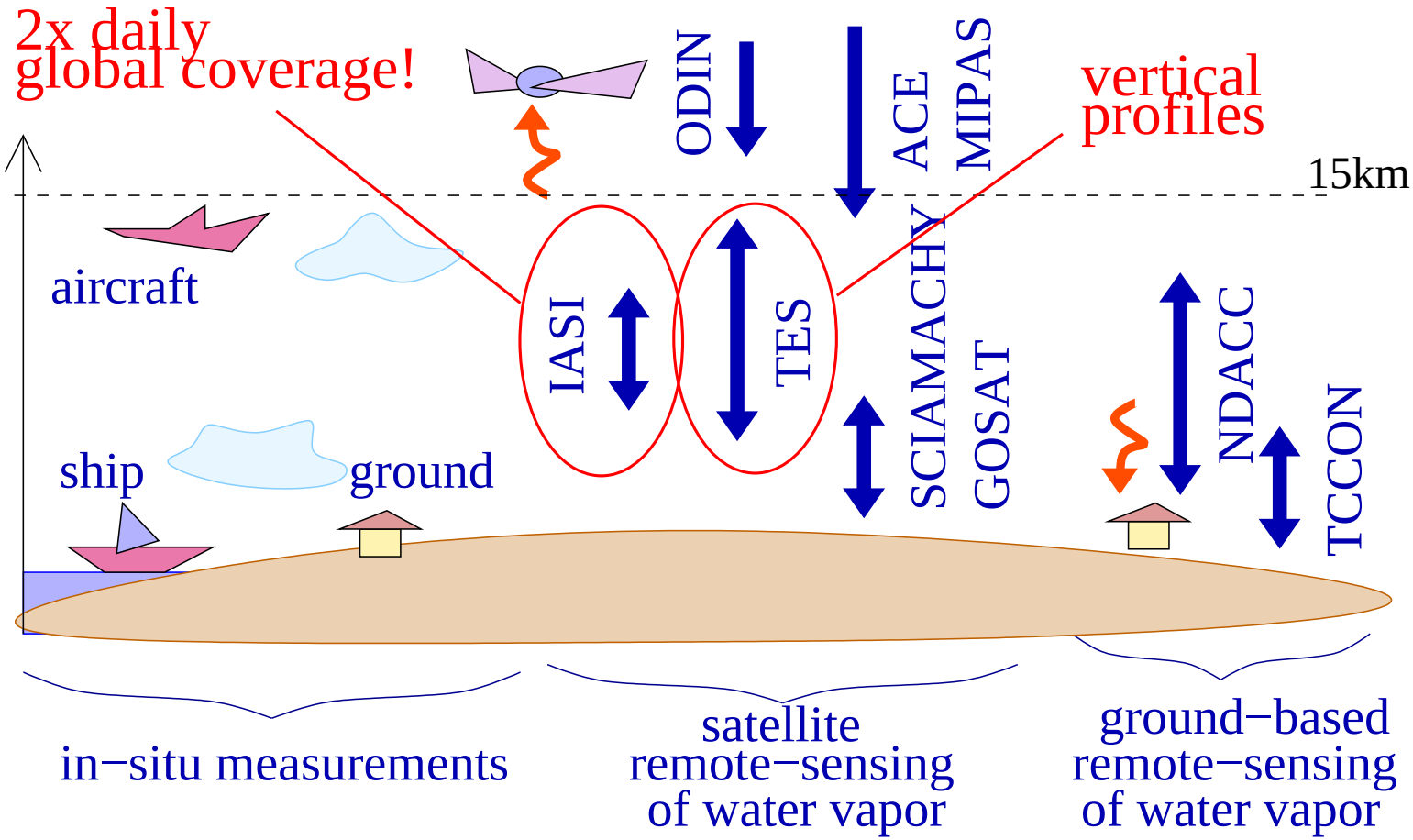
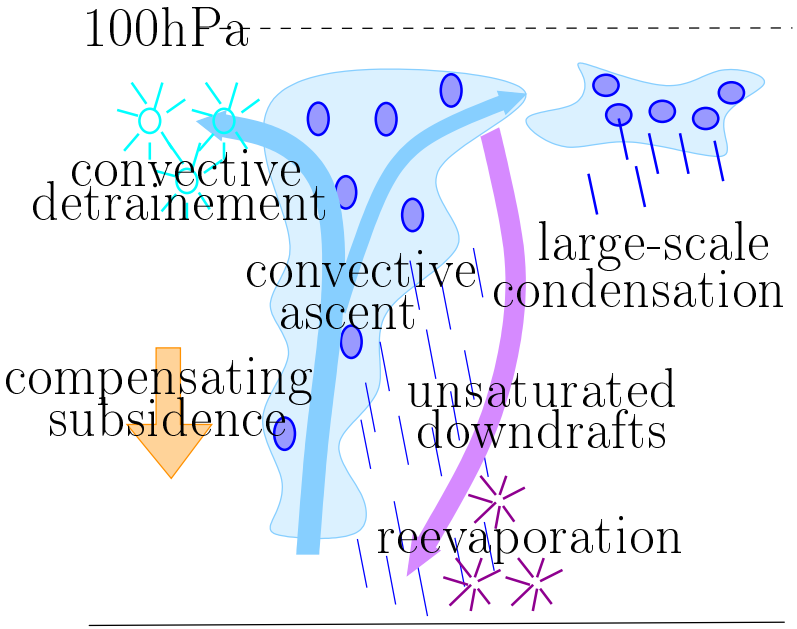
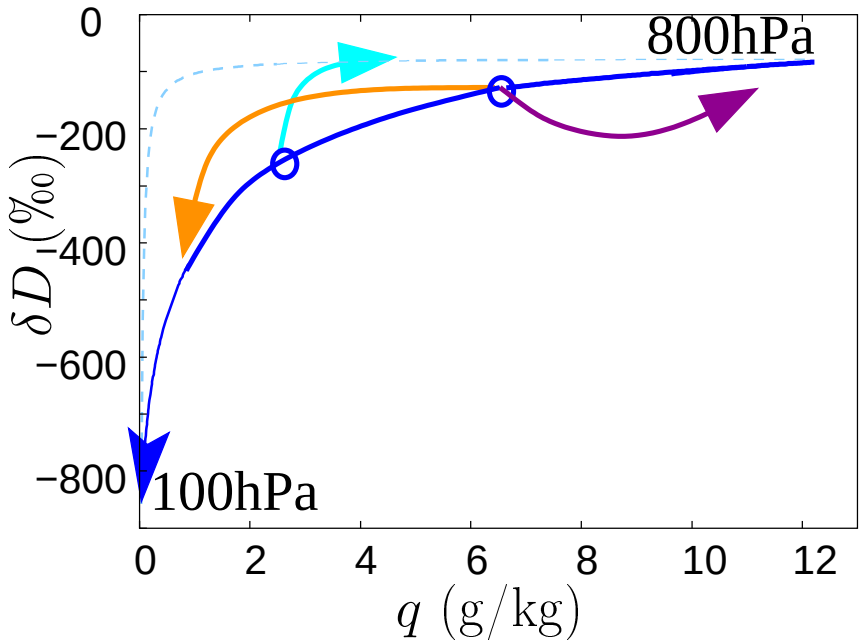


- Isotopic modelling: 9 GCM, 3 RCM, 2-3 CRM/LES...
  In this study: LMDZ

Moistening and dehydrating processes have different δD signatures

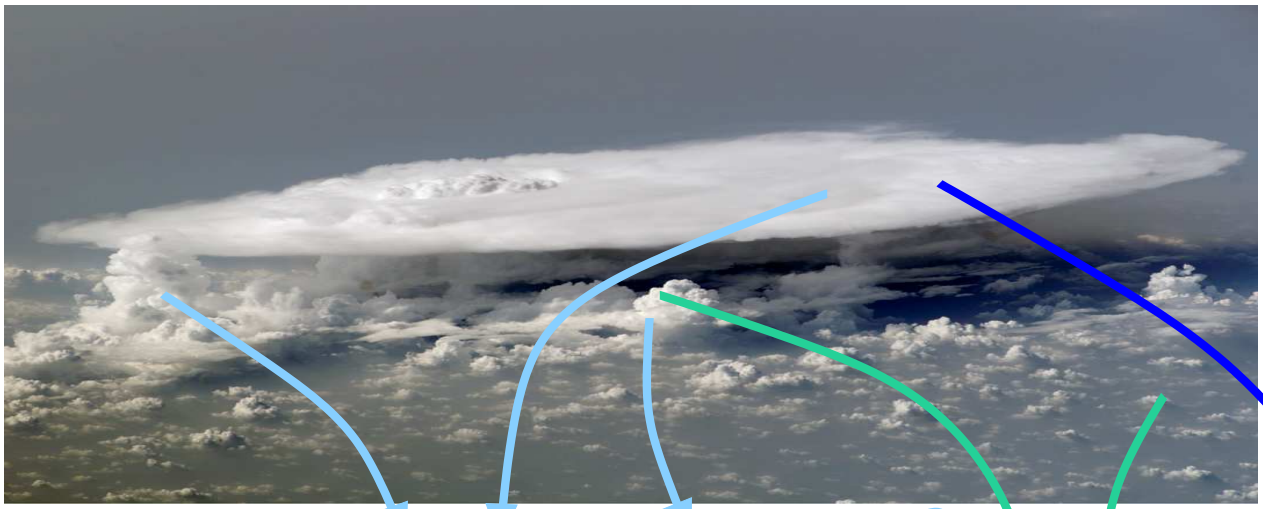


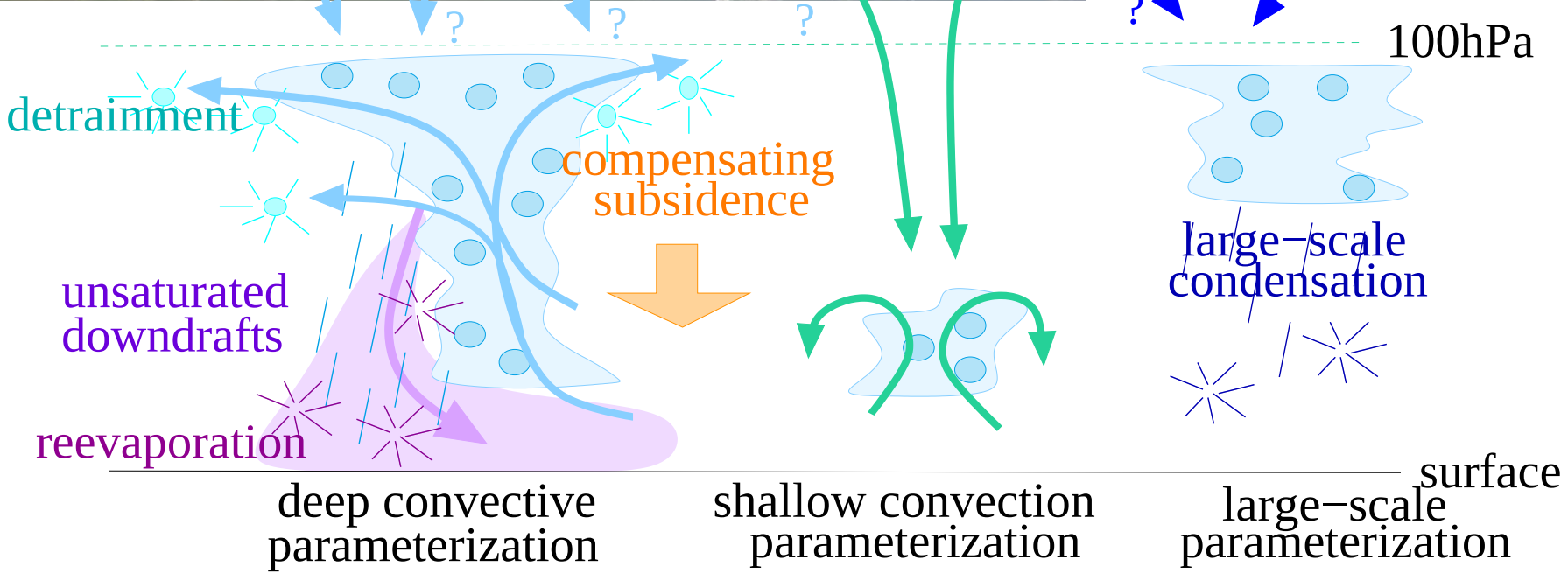


large−scale condensation
detrainment
subsidence
rain reevaporation

⇒distinguish between different moistening or dehydrating processes

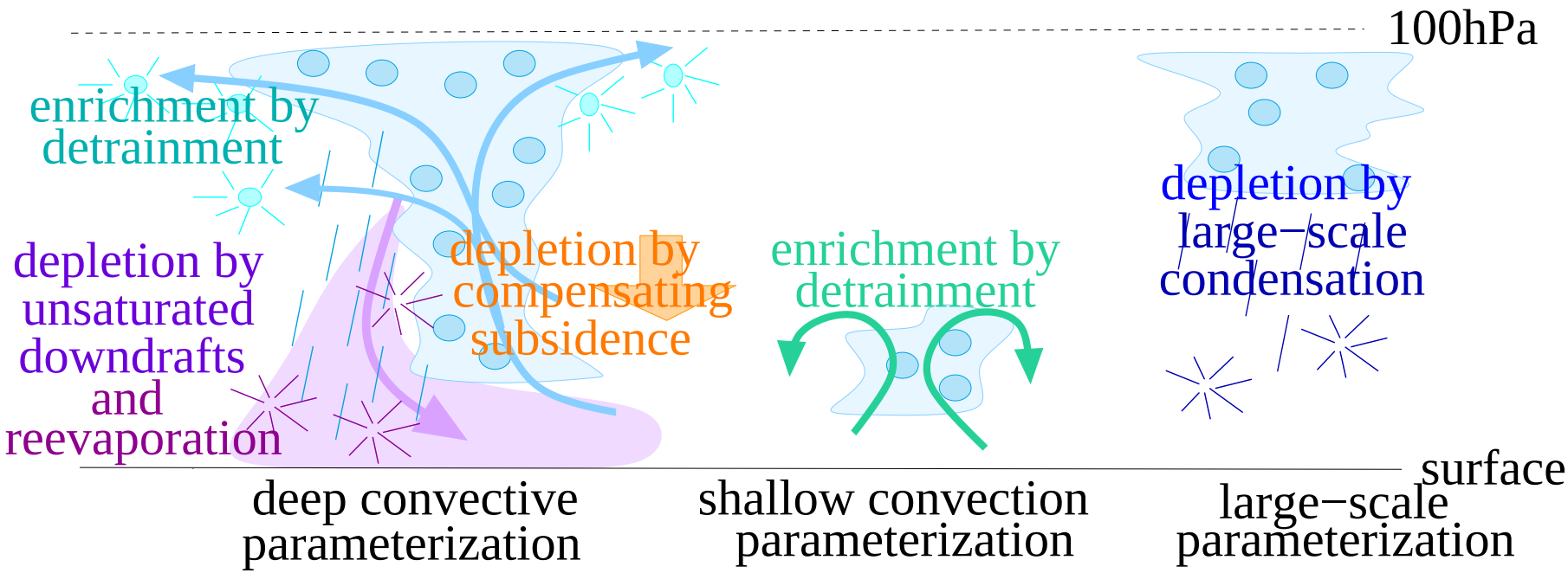
Relative importance of cloud schemes





δD signature of the different cloud schemes

- Study using LMDZ, and TES and IASI observations:
  - In upper trop, vapor more depleted when large-scale condensation than deep convection.
  - In lower trop, vapor more enriched when shallow convection than deep convection.



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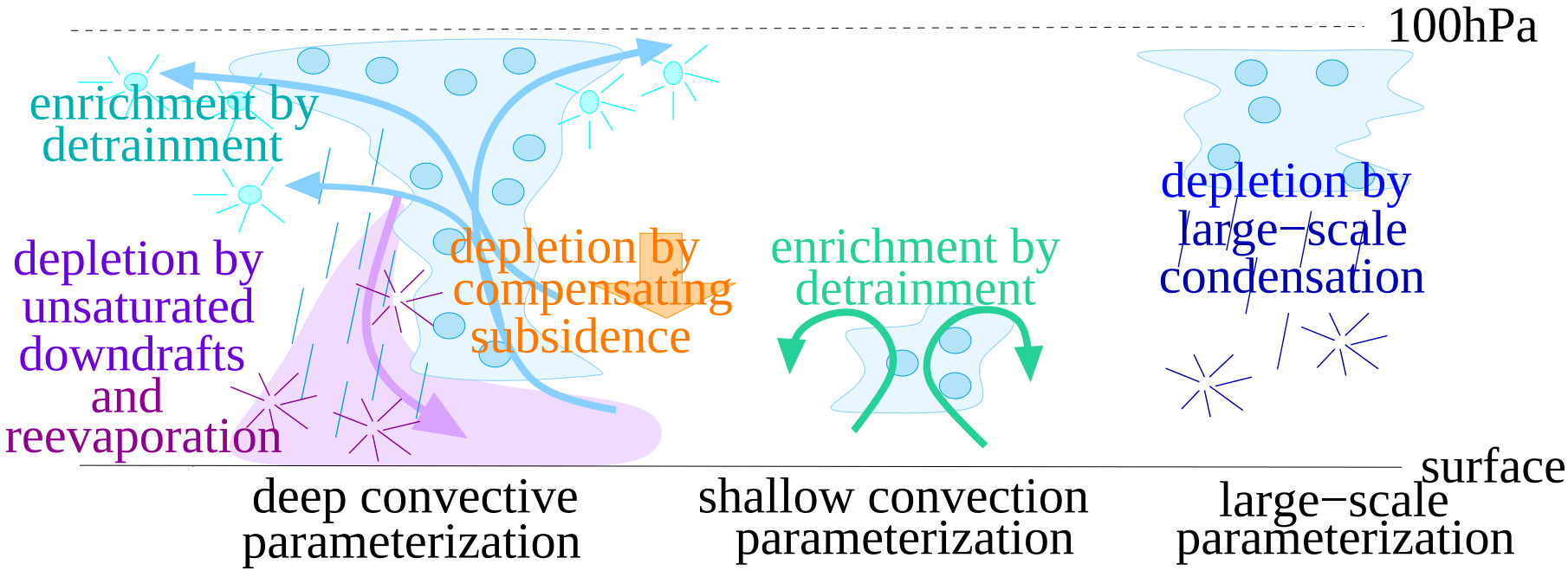

⇒evaluate relative roles of deep conv, shallow conv and large-scale precip and underlying heating profiles?

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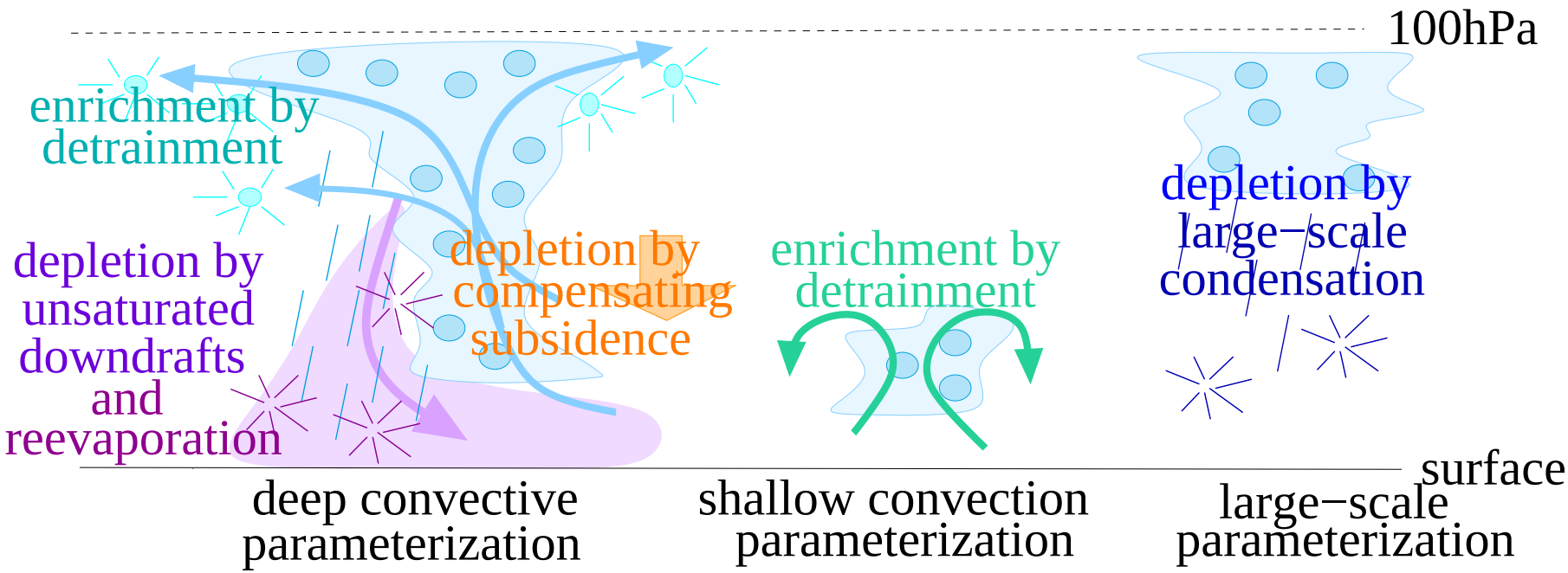
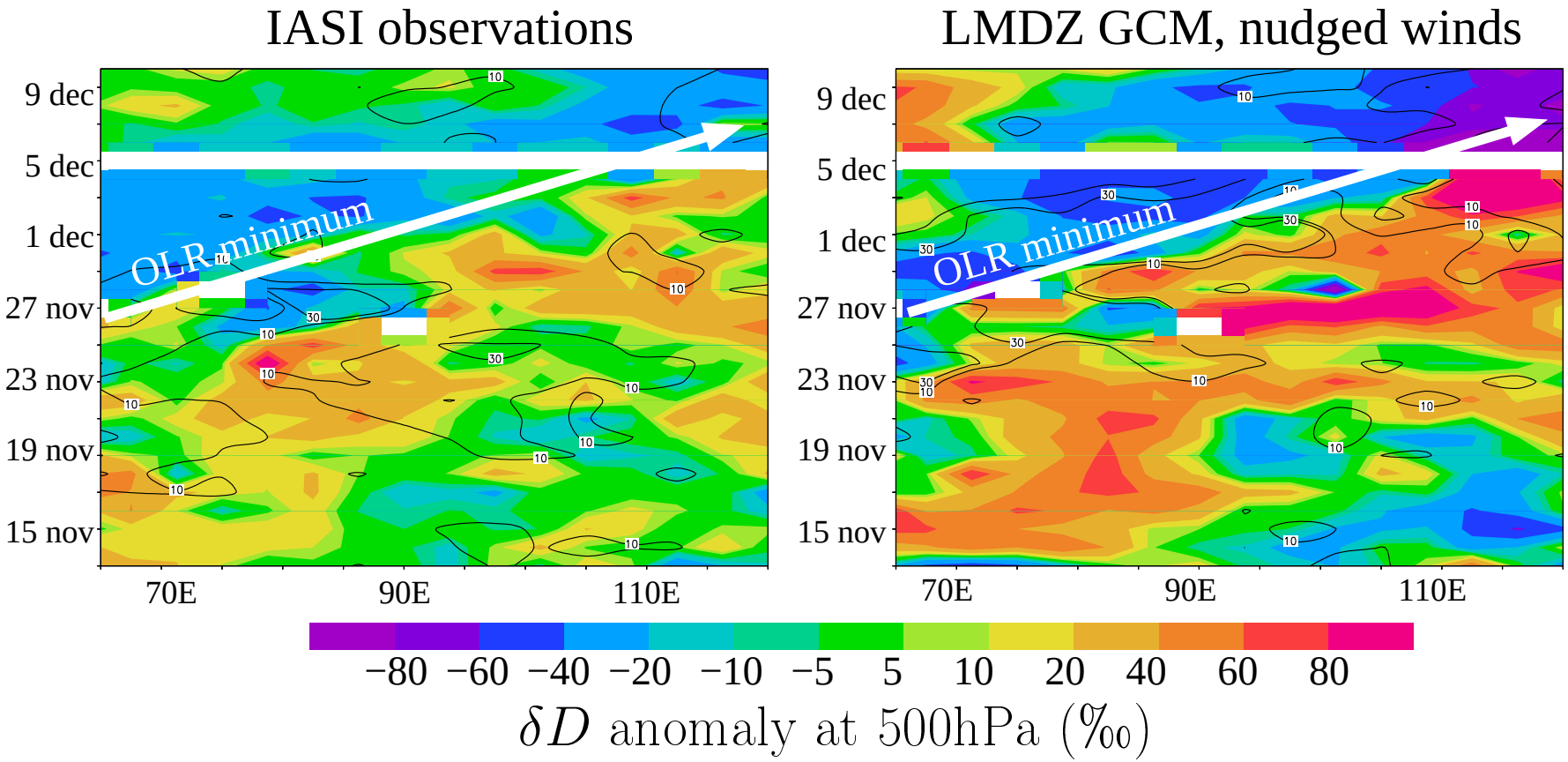


⇒evaluate relative roles of deep conv, shallow conv and large-scale precip and underlying heating profiles?

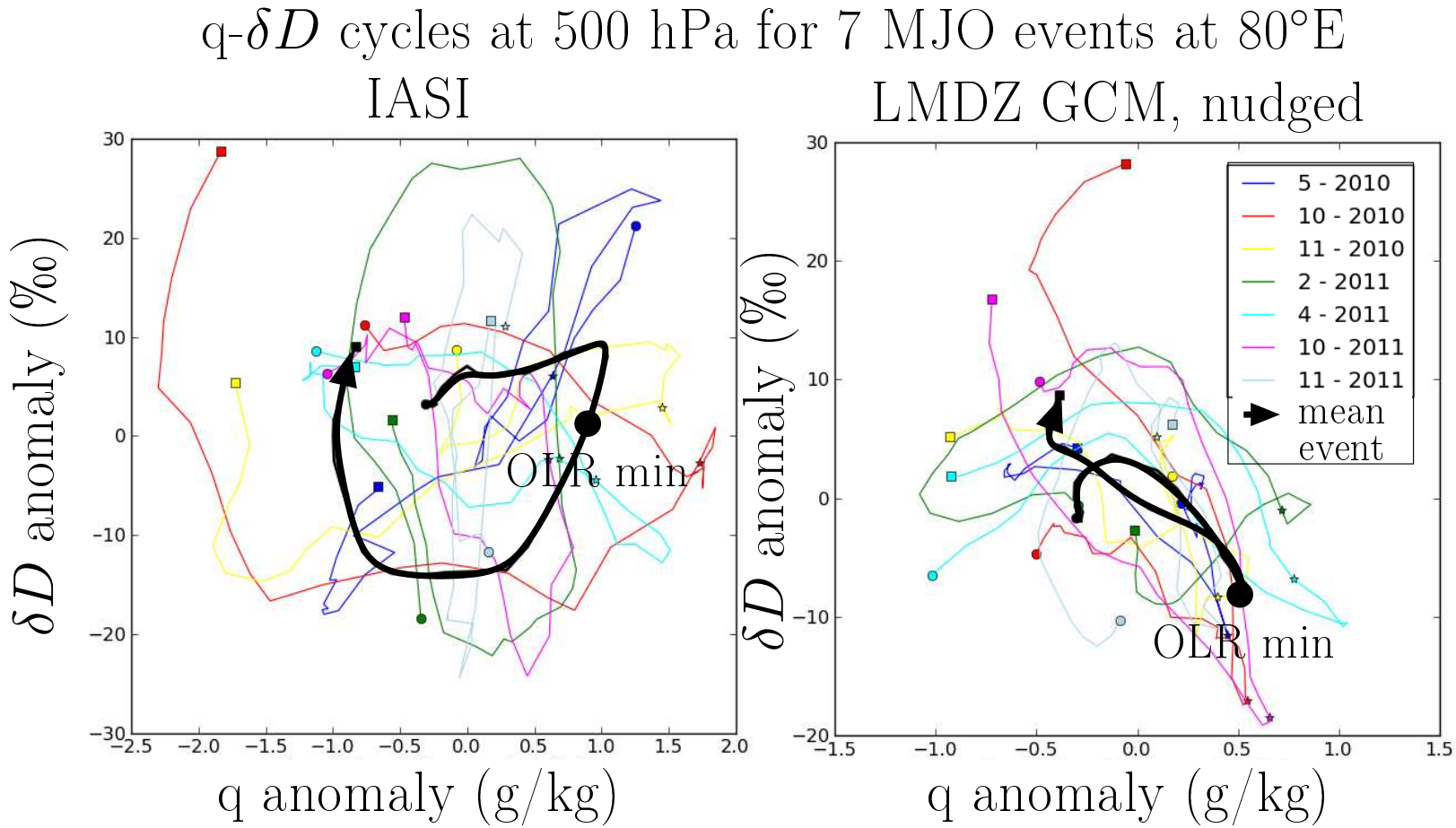
- e.g. during MJO?

Cindy Dynamo campaign case



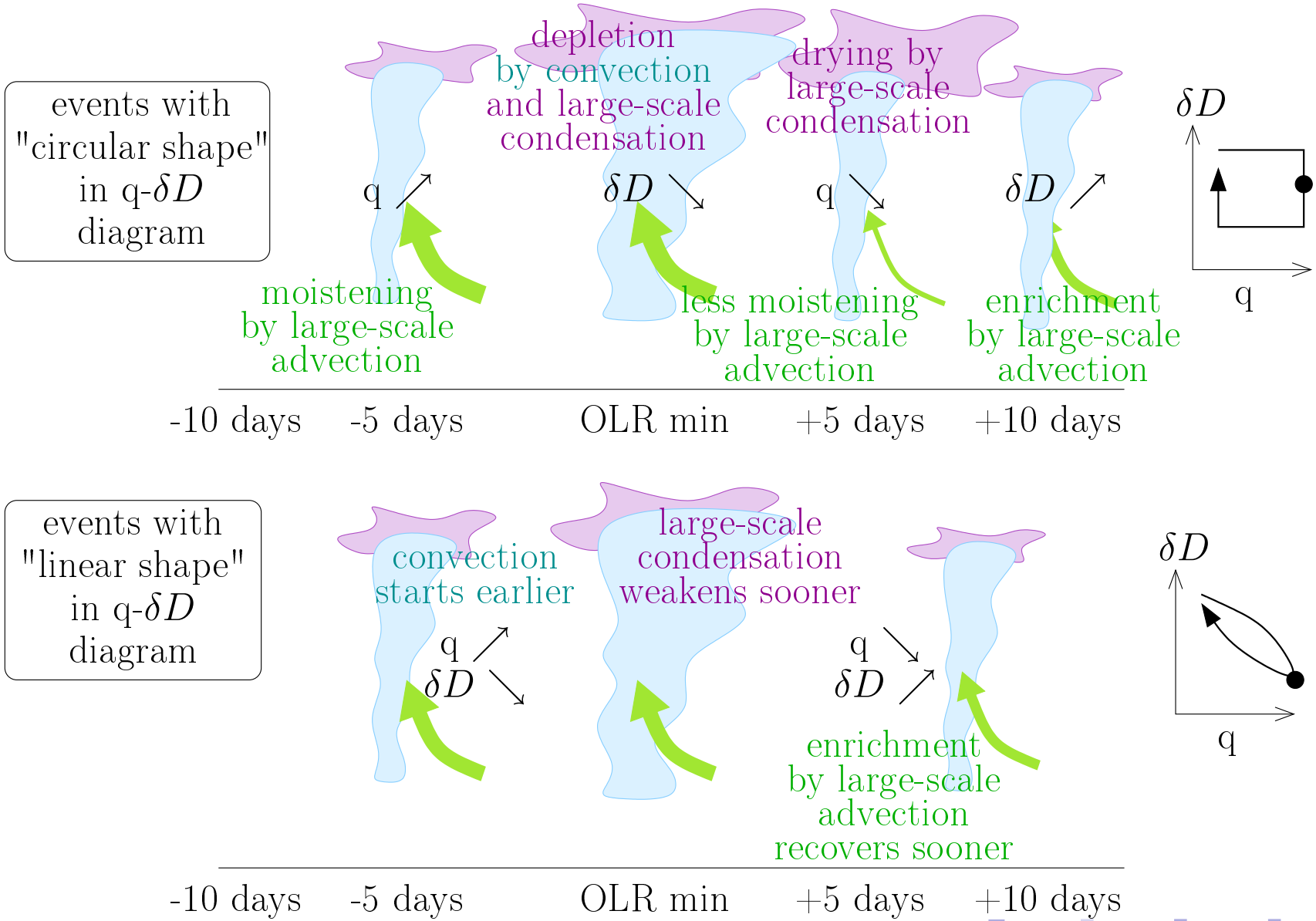
- Observed q max 1 days before OLR min
- Observed δD min 3 days after OLR min
- LMDZ captures the lag for this case

q-δD cycles in Indian Ocean in 2007-2008

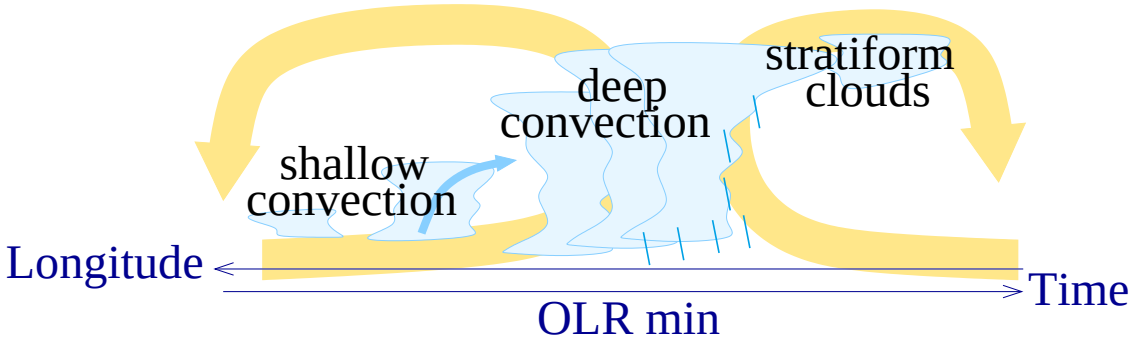


- Observations: “circular”, clockwise shape
- LMDZ: sometimes circular, too often “linear”: why?

What determines $q - \delta D$ shape in LMDZ?



Discussion of $q - \delta D$ cycles



e.g. Lin et al 2003, Benedikt and Randall 2007, Riley and Mapes 2011, review by Zhang et al 2005

- "circular shape": consistent with previous obs. studies?
  - convective $\longrightarrow$ stratiform transition: consistent with cloud & latent heating observations
  - moistening before by large-scale advection in LMDZ rather than shallow convection: nudging artifact?

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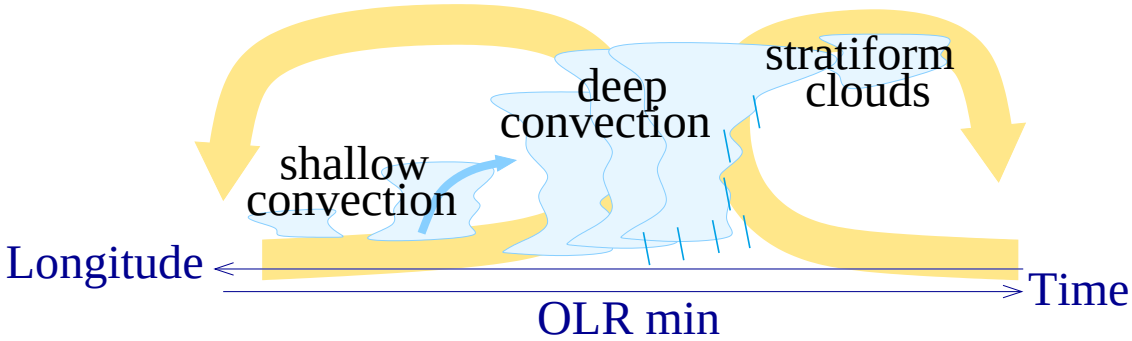

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- LMDZ too "in phase": 1) Convection triggers too soon?
  2) Large-scale condensation not maintained long enough?
  3) Large-scale advective enrichment recovers too soon?
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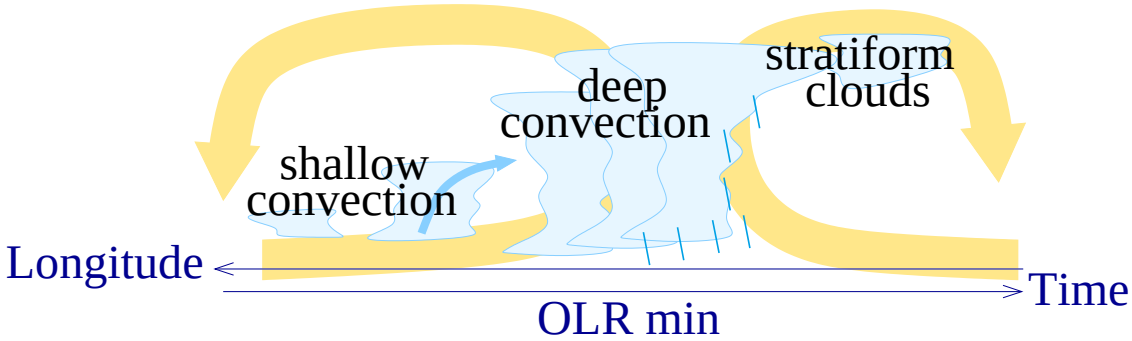

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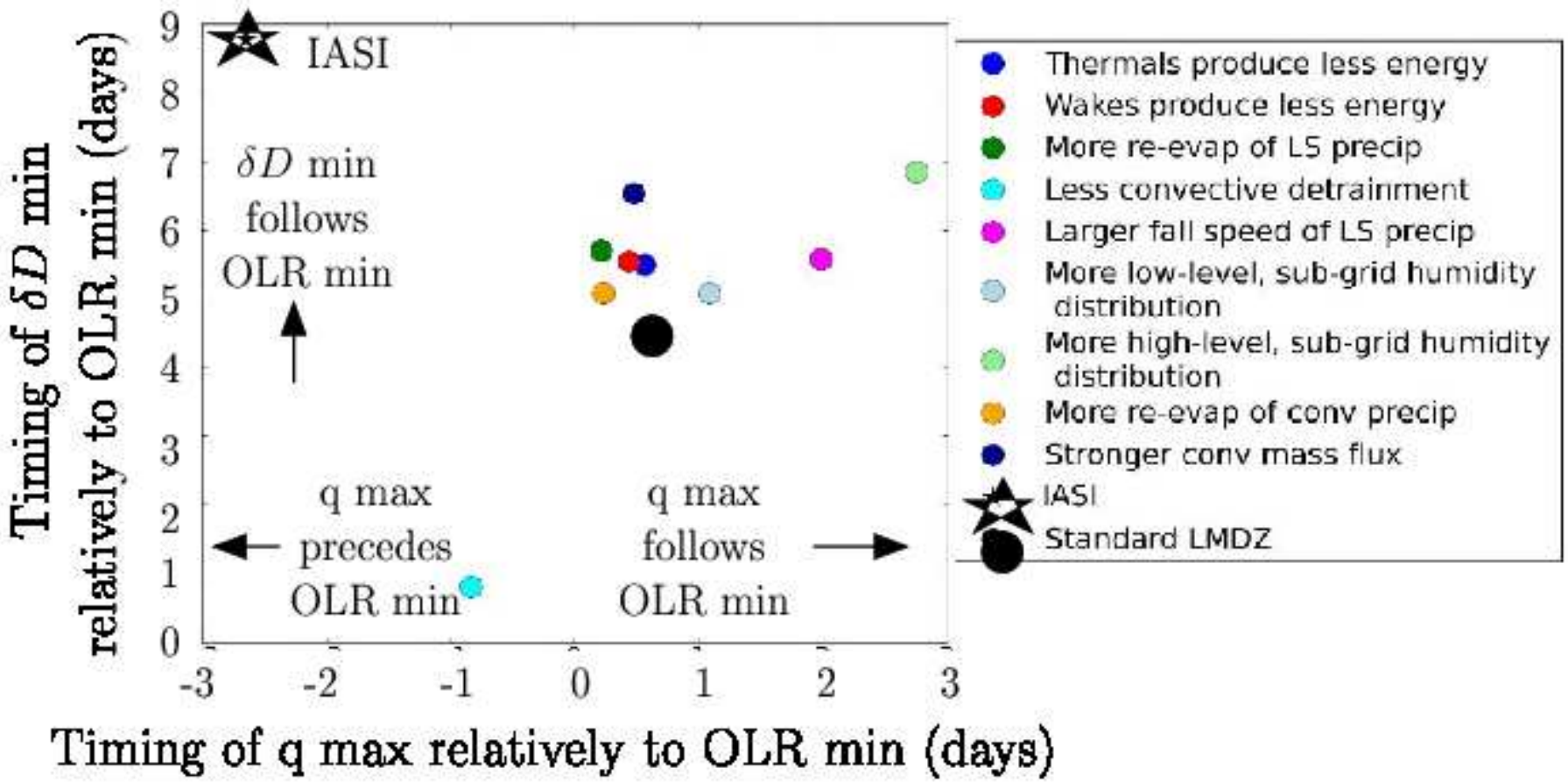
- $q - \delta D$ useful for model evaluation?

Sensitivity tests with LMDZ



- $q - \delta D$ shape sensitive to convection/cloud parameters
- How to get closer to observations?

Summary and perspectives

- $q - \delta D$ cycles during MJO informs about the relative timing of shallow convection, deep convection, large-scale condensation and large-scale advection
- Potentially useful for model evaluation
- Still lot of work to fully understand both data and model behavior
  - Deepen LMDZ analysis
  - Investigate free runs $\Longrightarrow$ avoid nudging artifact?
  - Help from CRMs? $\Longrightarrow$ understand processes, compare GCM-data
  - Exploit better the Cindy Dynamo campaign data?