Presence of continental and Bay of Bengal moisture in the rainwater $\delta^{18}O$ signature at Kolkata, India during South-West monsoon

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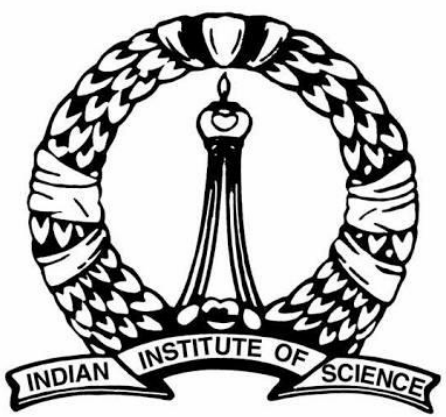
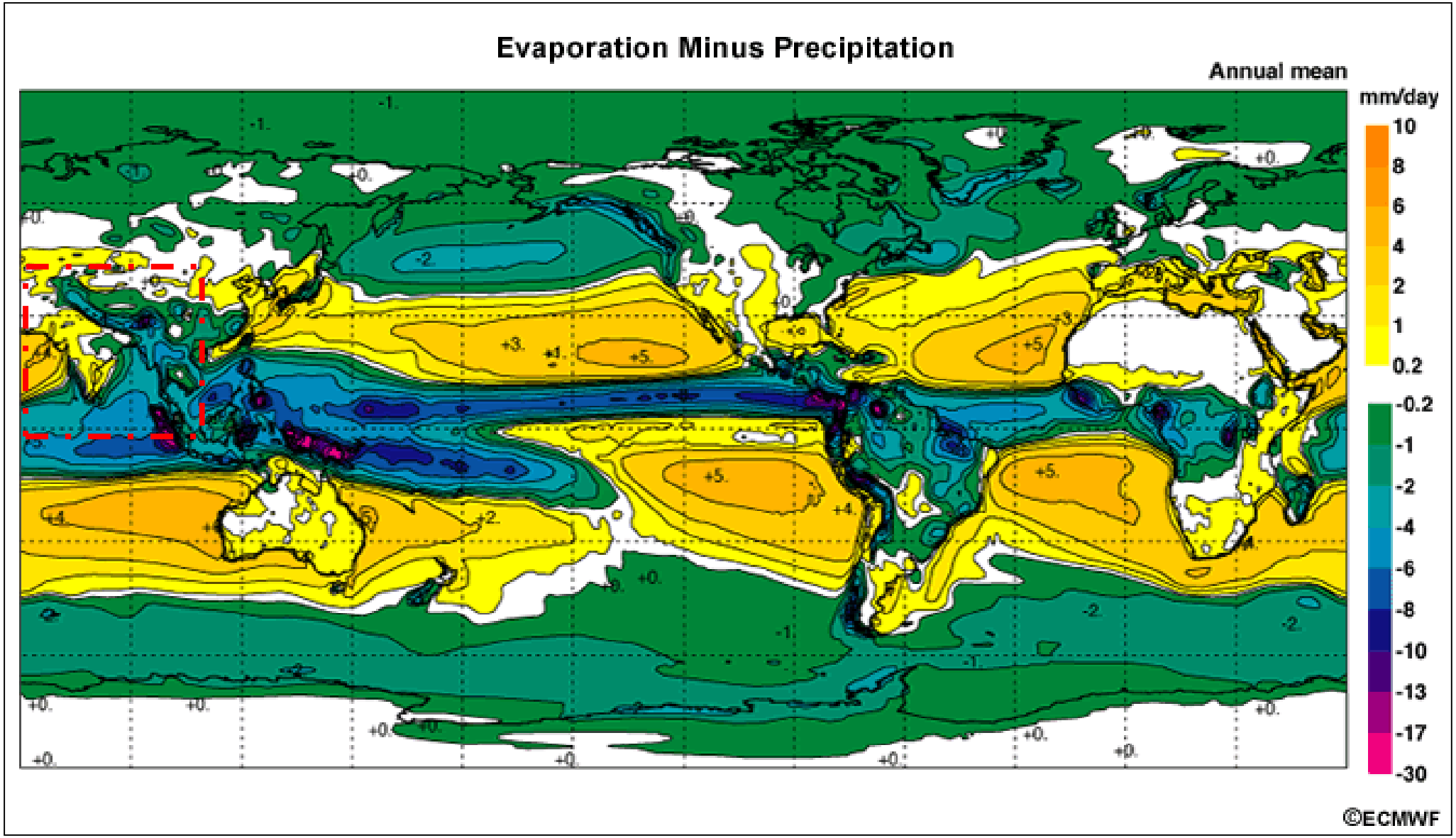


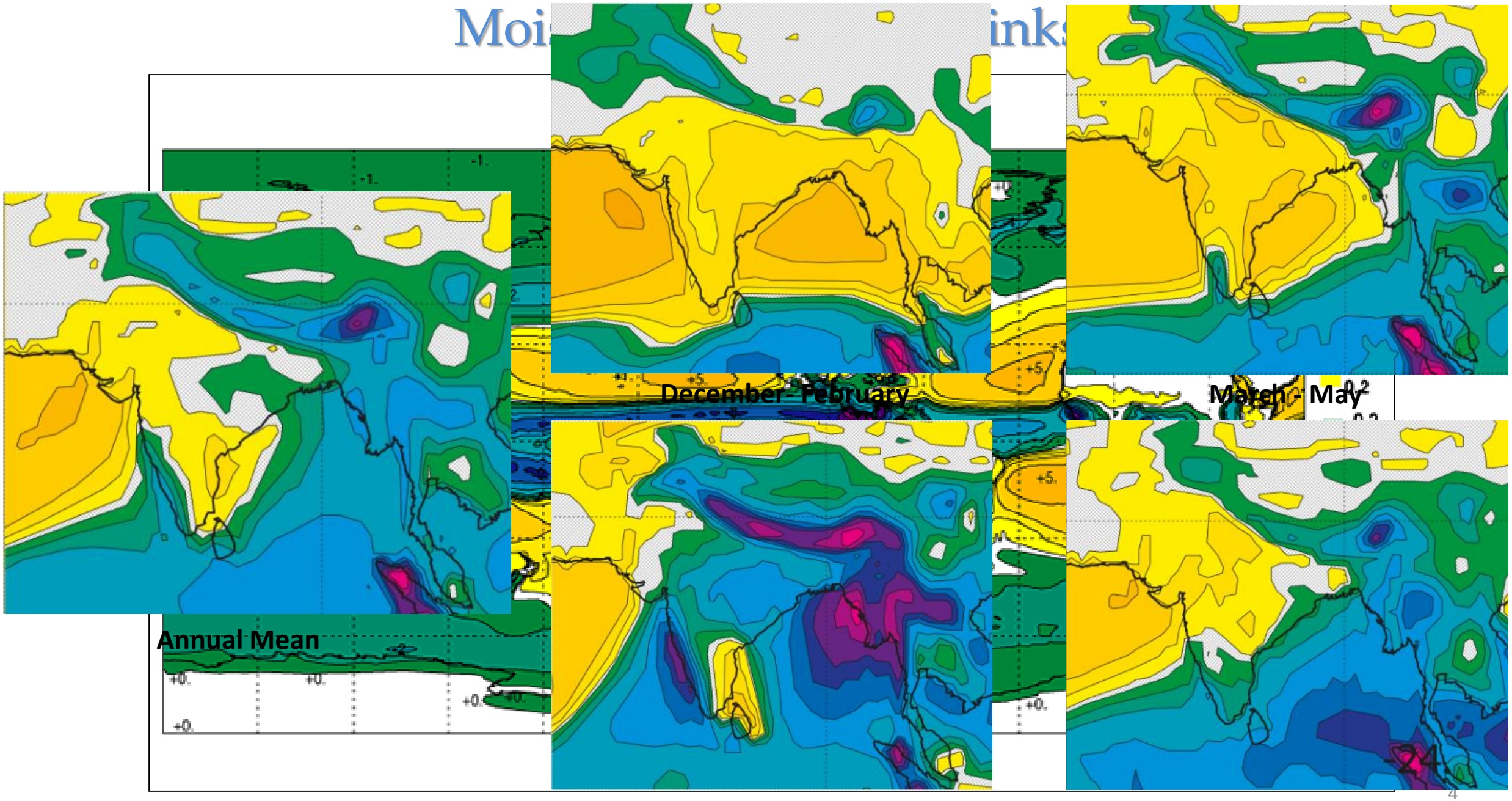
Outline

- Introduction
  - Moisture sources and sinks
  - Stable isotopes in the hydrological cycle
  - South-west monsoon
  - Isotopic studies over the Indian Subcontinent
- Objectives
- Data Used
- Model description
- Results and conclusions

Moisture sources and sinks



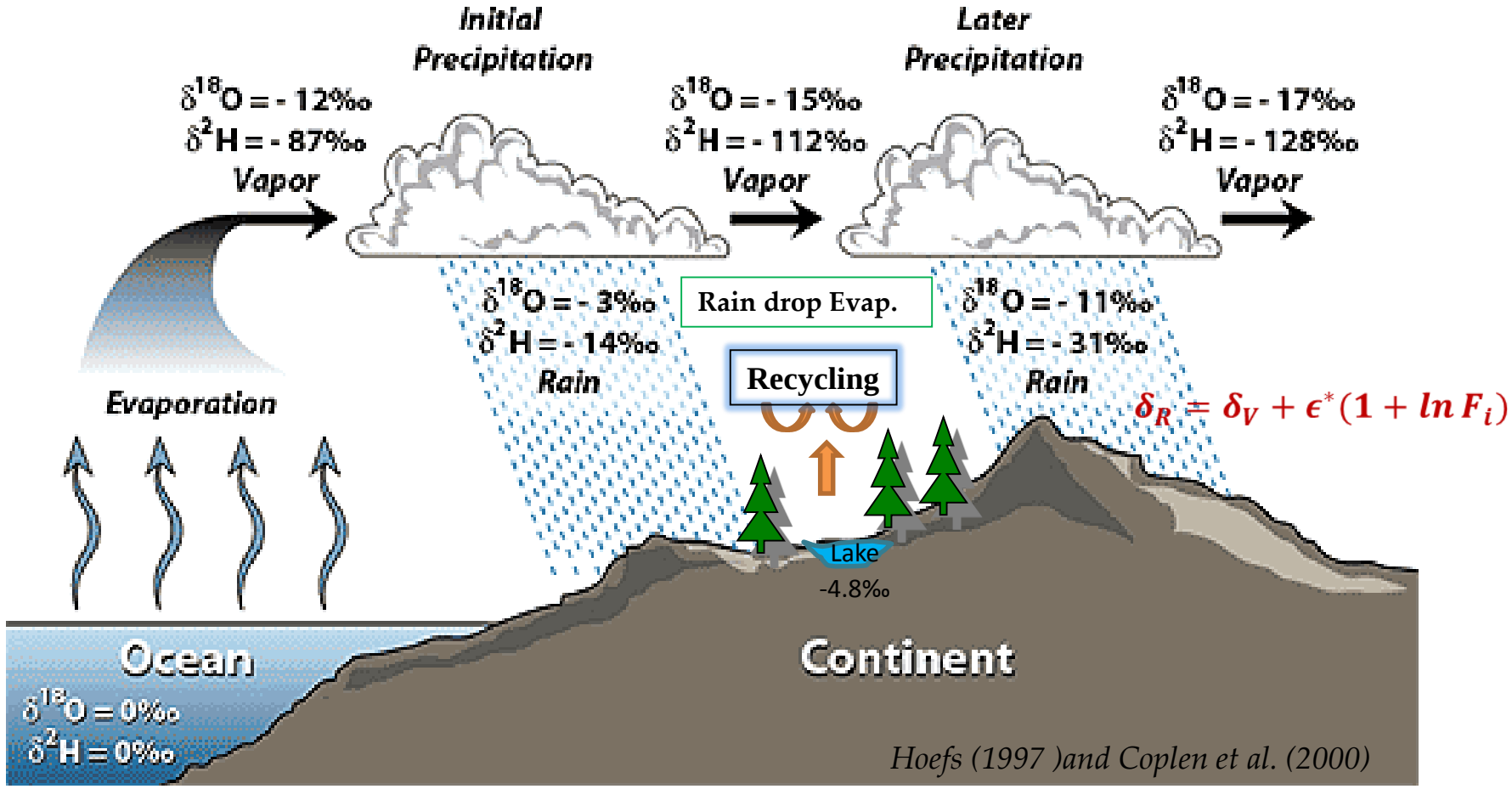
Moi inks


Annual Mean
December - February
March - May
June - August
September - November

Stable Isotopes in the Hydrological Cycle

Rayleigh distillation model, *Daansgard 1964*

$$\delta_v = (\delta_{vo}+1) \times F_i^{\alpha-1} - 1$$



$$\delta_R = \delta_V + \epsilon^*(1 + ln\, F_i)$$

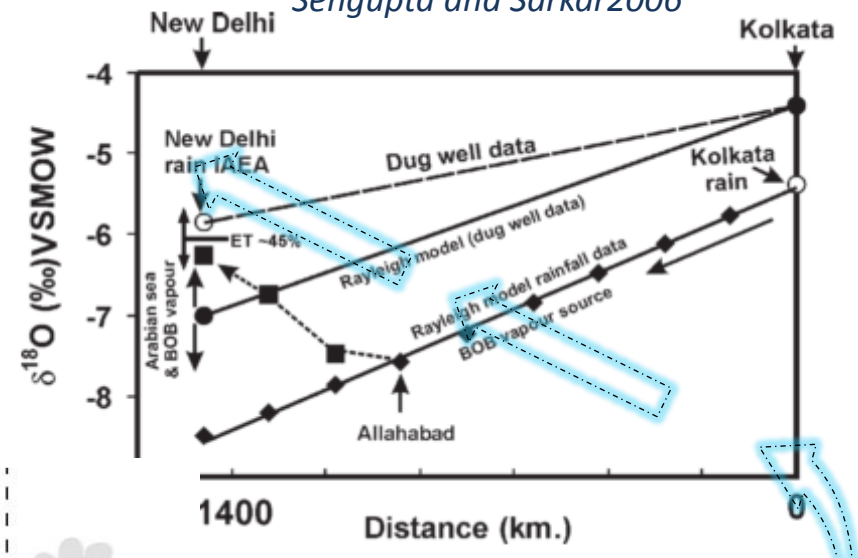
$$\delta_{Ei} = \frac{\delta_l - h\delta_a - \epsilon^* + \epsilon}{1 - h}$$

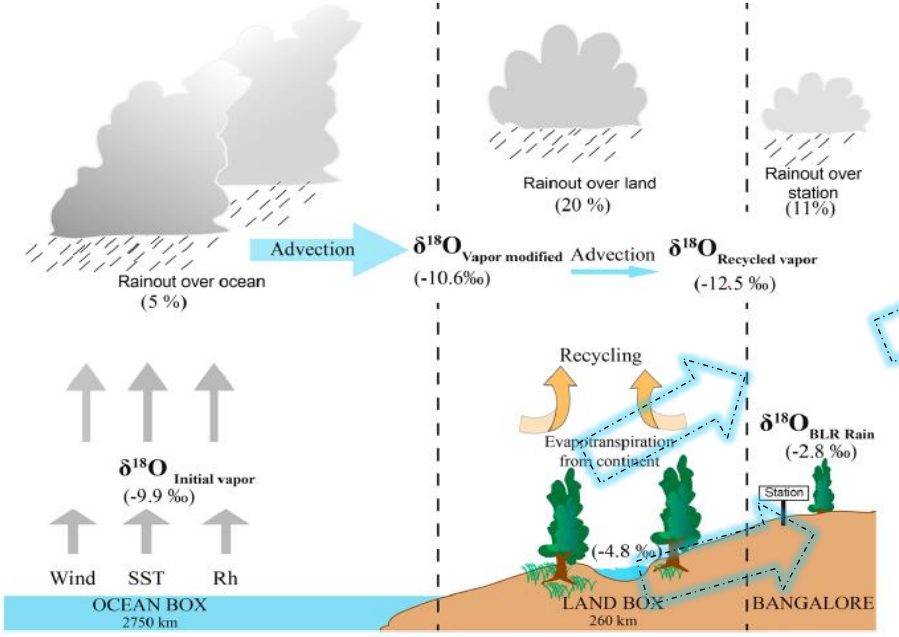
Langmuir resistance model
Craig and Gordon (1965)

- Equilibrium factor
- Kinetic factor
- Relative humidity

Isotopic Studies over the Indian Region

Sengupta and Sarkar2006





Bay of Bengal

Bangalore

Rahul P et al 2016

Objectives

- How much is the peninsular moisture contribution to rain at Kolkata?
- Is the isotopic signature retained as the moisture packet moves from Bengaluru to Kolkata?
- How much uptake of Bay of Bengal moisture is contributing to precipitation at Kolkata?

Data and Sources

- Precipitation: TRMM (Daily and Monthly time scales) 2.5 degree spatial resolution (http://trmm.gsfc.nasa.gov/)

- Total Precipitable Water, Air Temperature, Relative Humidity, Wind Speed: NCEP-DOE Reanalysis 2 (http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.html)

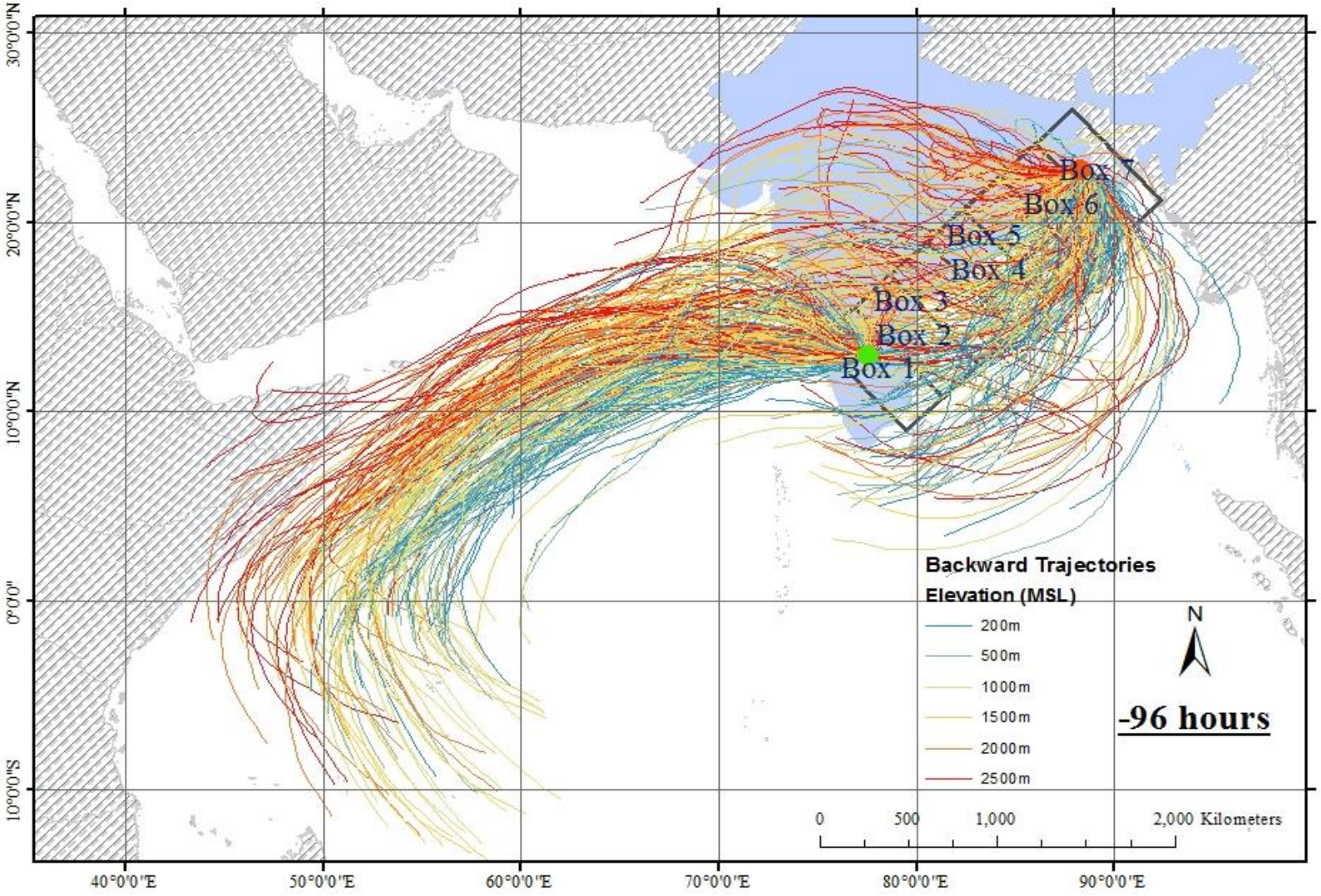
- Global Sea Water Oxygen-18 Database (http://data.giss.nasa.gov/o18data/)

- Oxygen and hydrogen isotopic compositions (IAEA-GNIP): (http://www-naweb.iaea.org/napc/ih/IHS_resources_gnip.html) Kolkata and Bangalore. (2003-2004)

- Isotopic composition of rainfall over Bay of Bengal.

Backward Trajectory analysis

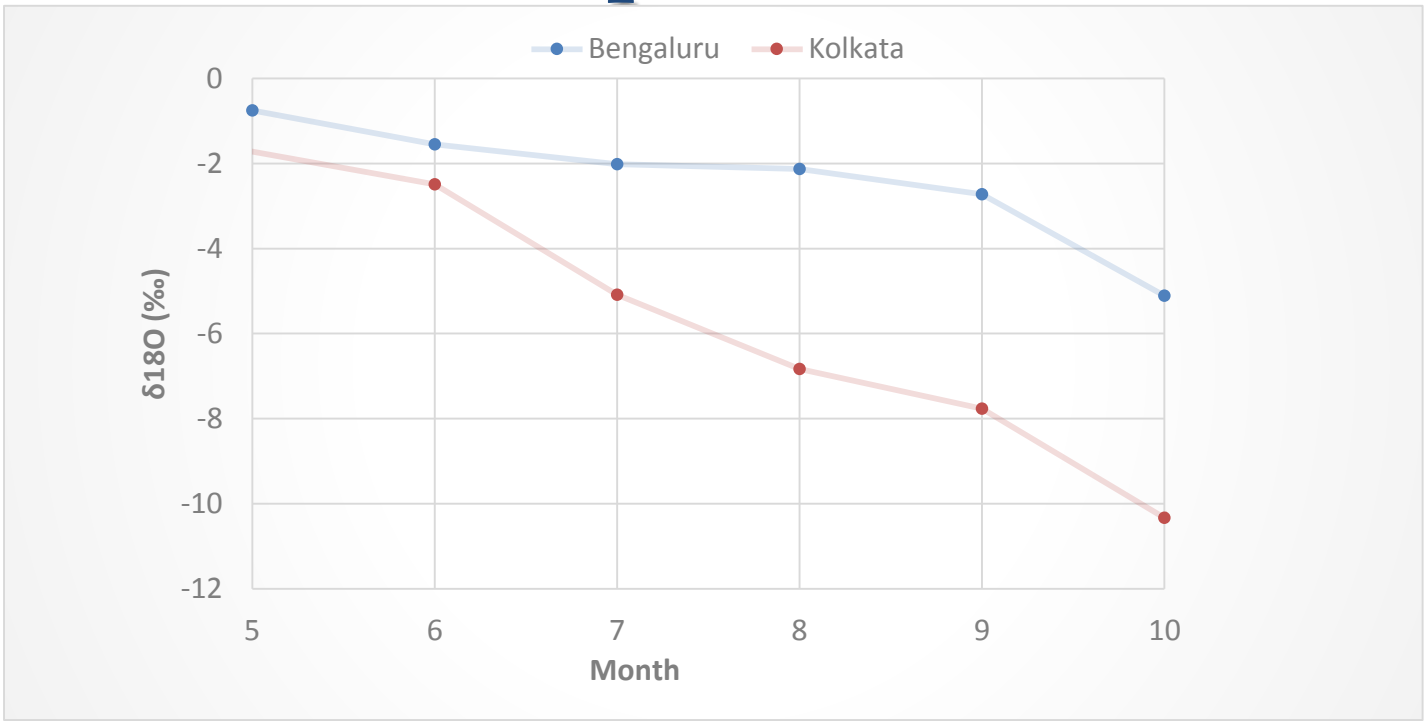
Backward air-mass Trajectories (-48 hours, -72 Hours and -96 hours prior to a rainy day at 200m, 500m, 1000m, 1500m, 2000m and 2500m above MSL for a single year (2004) at Bengaluru and Kolkata during all rainy days of the SW Monsoon



Three types of moisture sources can be identified, originating from:

- Arabian Sea,
- Bay of Bengal
- Continent.

Rainfall isotopic characteristics

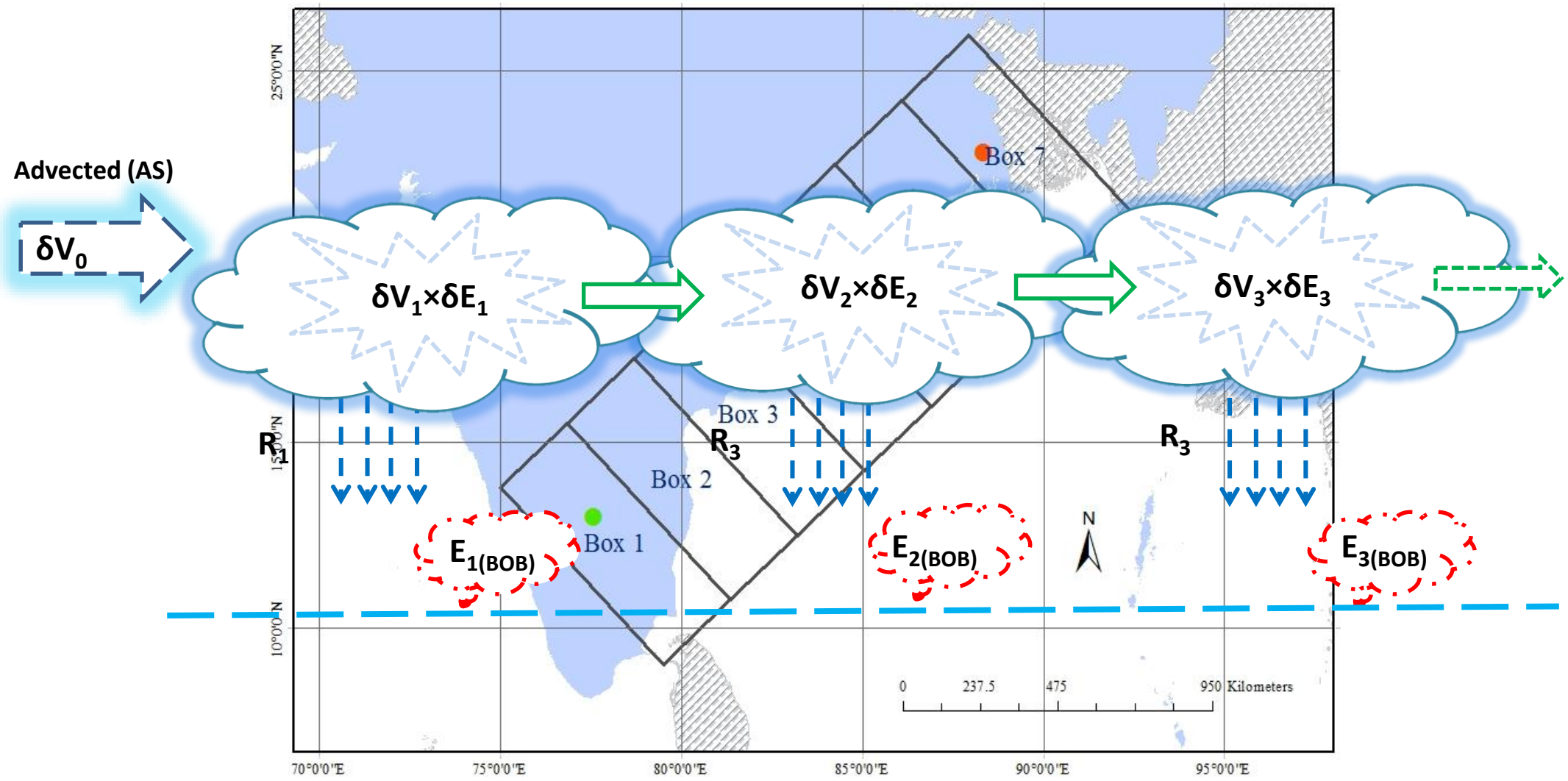


IAEA-GNIP

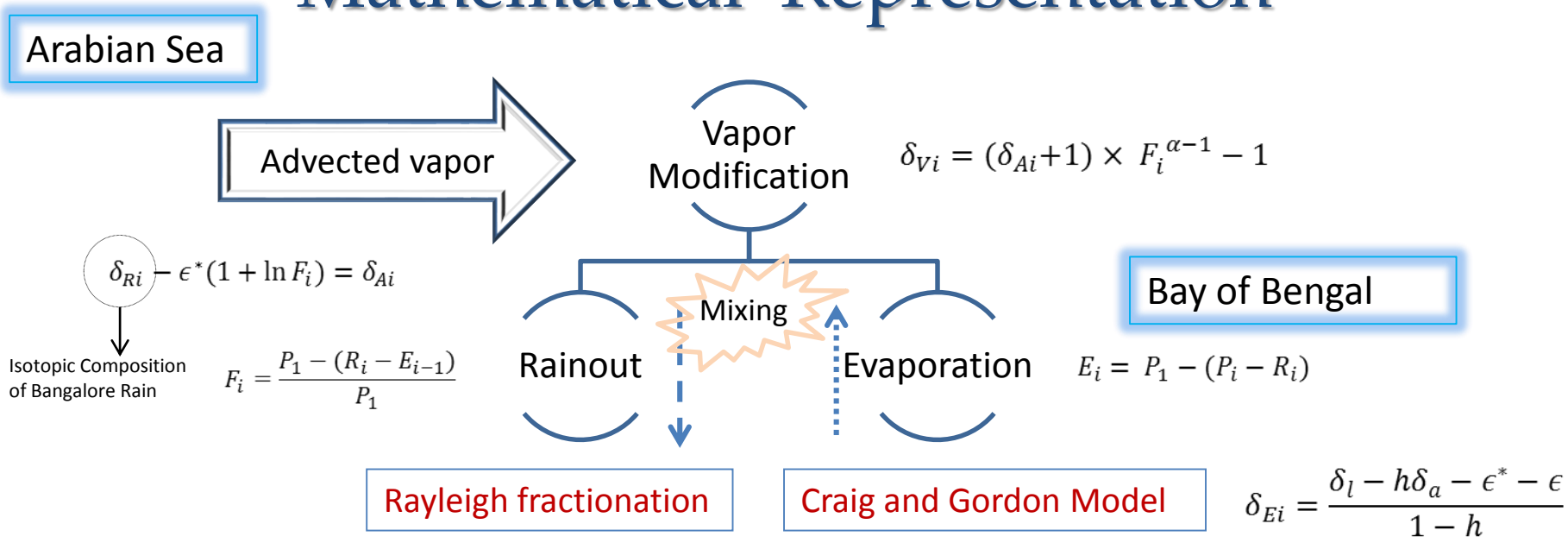
- The depletion (JJAS) follows a similar trend for both the sample sites suggesting they presumably receive moisture from same source. The isotopic composition decreases steadily and follows a similar pattern for both sites reaching minimum value in October.

- Hence we should be able to explain the precipitation at Kolkata employing Rayleigh distillation

Modelling the isotopic composition



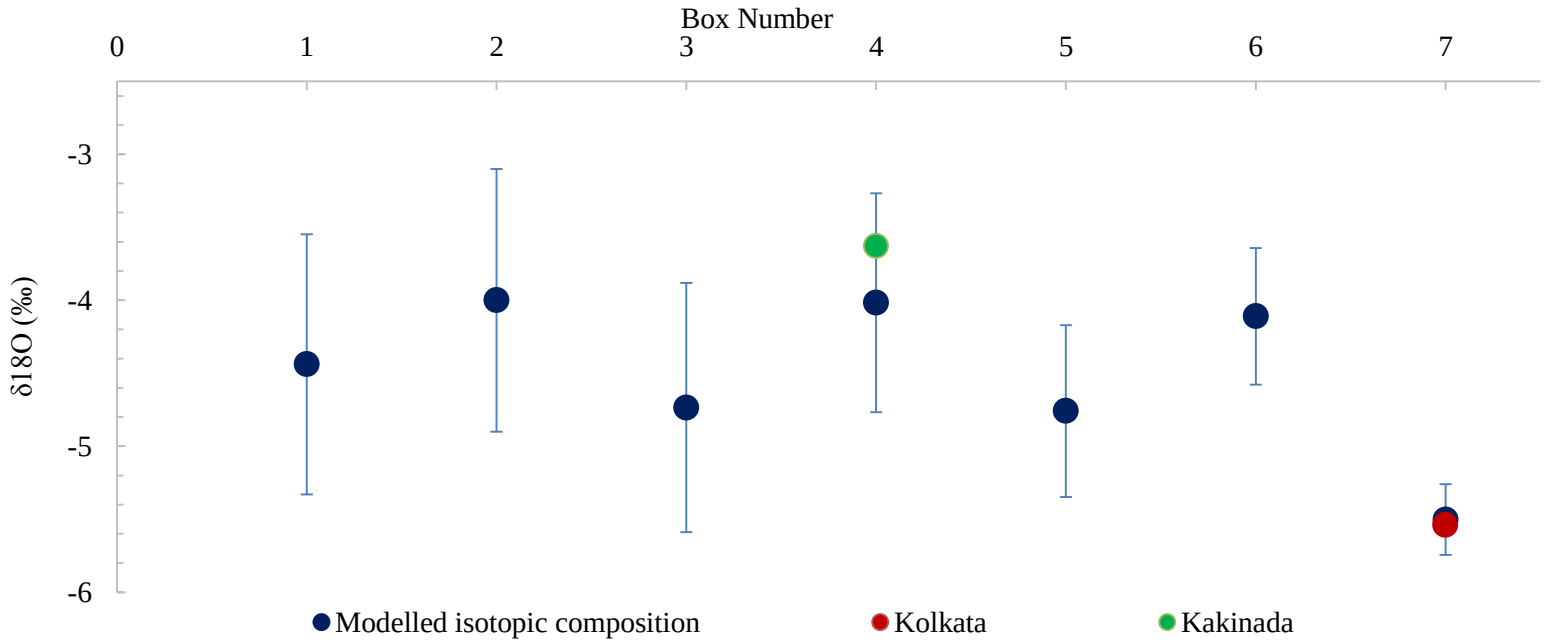
Mathematical Representation



- δ_R, δ_A is the isotopic composition of rain and advected vapour respectively.
- δ_V is the isotopic composition of the vapour over the ith box after mixing of advected and evaporation component and rainout,
- **F** is the fraction of vapour remaining in the air-mass.
- α is the equilibrium fractionation factor $\epsilon^*=(\alpha\text{-}1)^*1000$, ϵ is the kinetic enrichment factor
- **P** is the Total Precipitable Water (Reanalysis 2), **R** is the rainfall (TRMM) and **E** is the evaporation over each box respectively in mm.

Model output results

$\delta^{18}O$ Rain BOB= -2.37 (‰)	Bengaluru $\delta^{18}O$ Rain (‰)	Kolkata $\delta^{18}O$ Rain (‰)	
		Observed	Modelled
JJAS	**-1.61(±0.97)**	**-5.54(±1.99)**	**-5.50(±0.24)**
June	-0.76 (±2.64)	-2.49 (±3.24)	**-6.46(±0.86)**
July	-0.97 (±3.18)	-5.08 (±2.43)	**-5.63(±0.34)**
August	-1.82 (±2.96)	-6.83 (±2.27)	**-5.34(±2.15)**
September	-2.9 (±3.22)	-7.76 (±3.05)	**-7.03(±2.52)**



Conclusions

- Modelled value of $\delta^{18}O$ of rain at Kolkata for the SW monsoon=**-5.50‰**
- Actual Value of $\delta^{18}O$ of Rain at Kolkata during the SW monsoon=**-5.54 ‰**

The Isotopic signature of Bangalore is completely lost albeit the significant contribution of the moisture from Bay of Bengal

To explain the isotopic composition of precipitation at Kolkata during the SW-Monsoon, it is necessary to invoke 55-65% moisture from the Bay of Bengal whereas the peninsular contribution varies from 35%-45%.

Thank You