

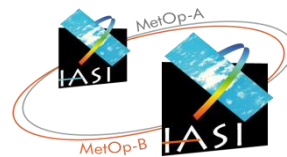
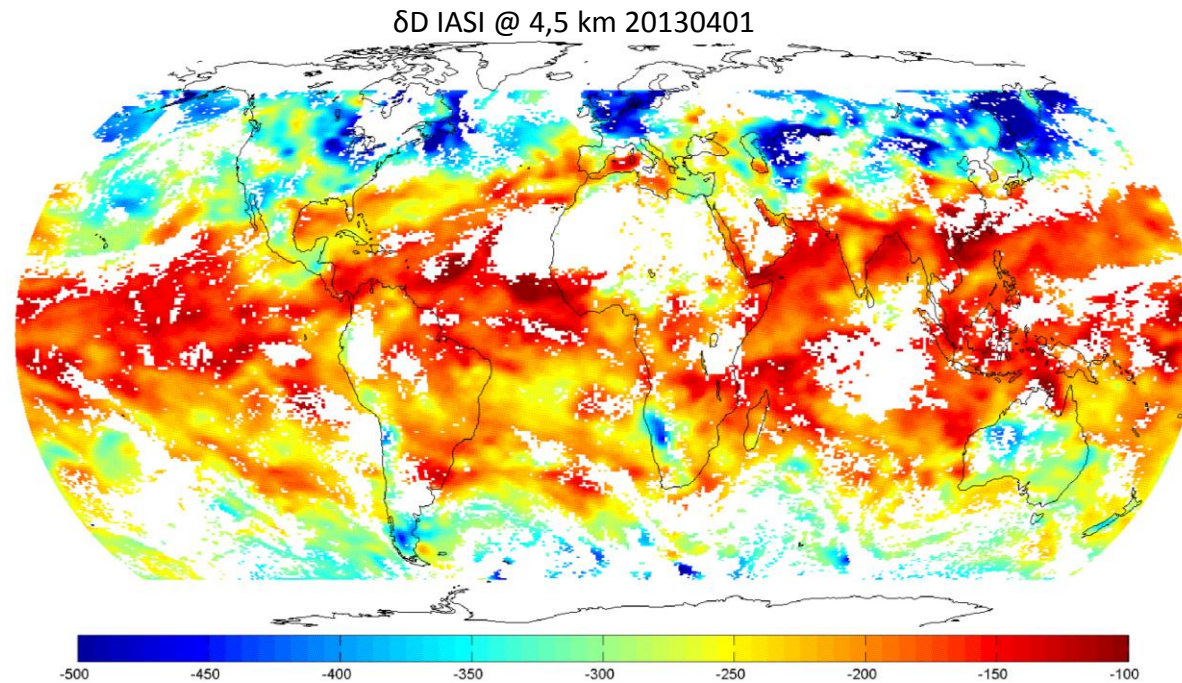
# Hydrological processes as seen with high resolution distributions of $\delta D$ derived from IASI/MetOp

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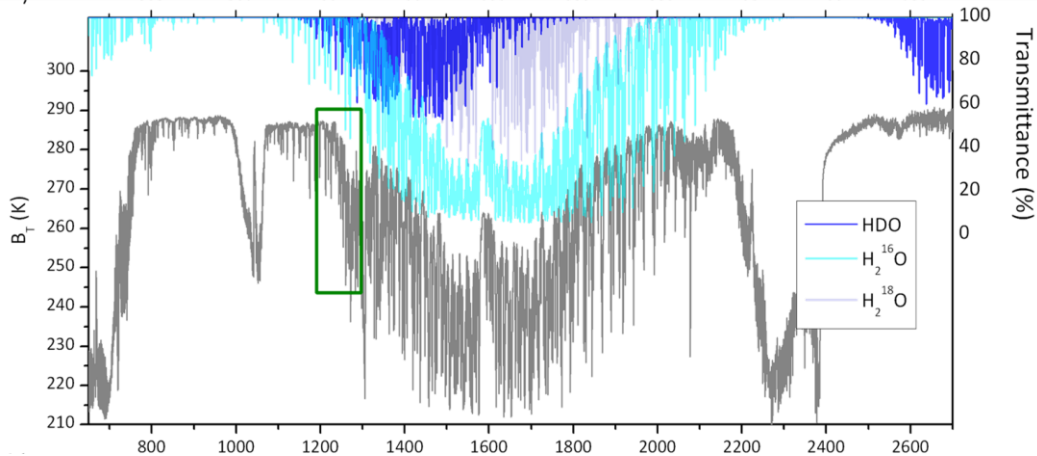
(3)Spectroscopie de l'atmosphère, Université Libre de Bruxelles, Bruxelles, Belgique



# Outline

1. IASI mission
2.  $\delta D$  retrieval from IASI spectra
3. Global distributions
4. Examples of hydrological processes as seen by IASI
  - 5.1 South Pacific:  
condensate detrainment by low clouds
  - 5.2 Izana-North Atlantic:  
airmasses sources, turbulent mixing
  - 5.3 Tropics:  
isotopic fingerprint of convection's depth, amount  
effect in water vapour
6. Conclusions

# IASI mission (Infrared Atmospheric Sounding Interferometer)



## 1° Instrumental characteristics:

Fourier Transform Interferometer  
Measurement of the thermal emission of the atmosphere:

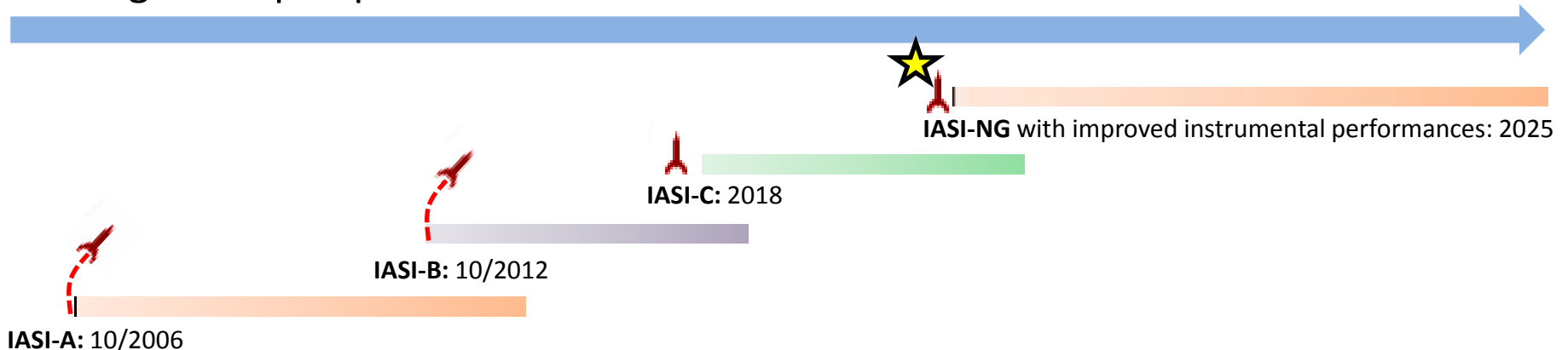
- over a **broad spectral range**:  $650 \rightarrow 2700 cm^{-1}$
- with a **low radiometric noise**:  $SNR > 300$
- with a **good spectral resolution**:  $0,5 cm^{-1}$

## 2° Sampling characteristics:

- Medium ground pixel size: 12 km (nadir)
- Geosynchronous orbit (9.30 AM and 9.30PM)
- One measurement almost everywhere  $2x/j$
- 1,3 millions spectra a day

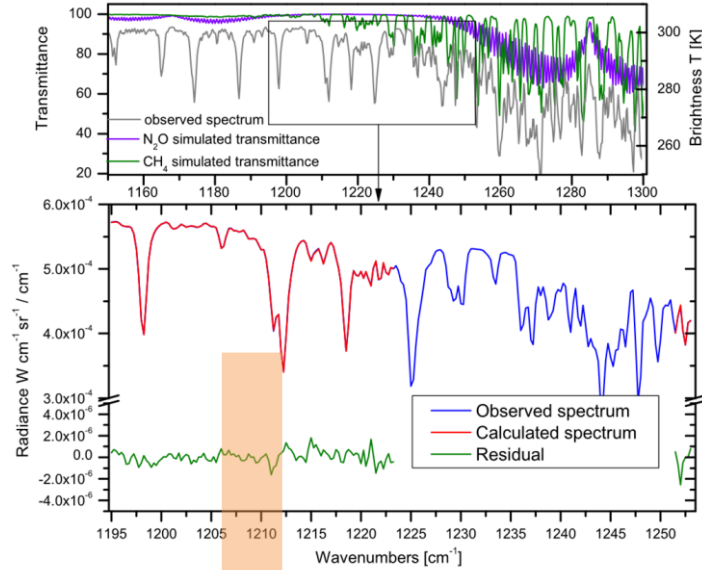


## 3° Long-term perspective:



# Retrieval of $\delta D$ profiles from IASI [Lacour et al., 2012]

## Inversion setup [Lacour et al., 2012]



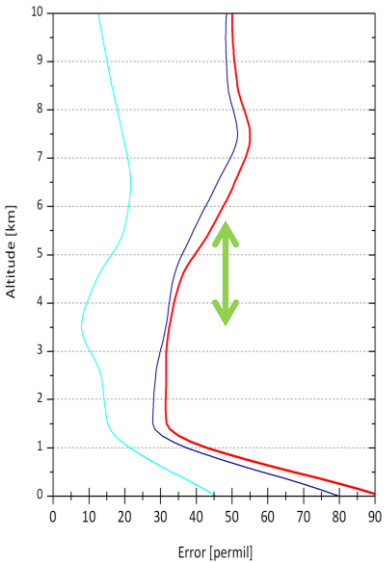
Inverse problem  
 With a constraint on  $\log(\text{HDO}/\text{H}_2\text{O})$   
 [Worden et al., 2006; Schneider et al., 2006]

- Short spectral range 1195-1253  $\text{cm}^{-1}$
- Full inversion on the 10 first layers of the atmosphere
- Temperature profiles from EUMETSAT L2
- cloud flag < 10 %

**Fast inversion**

$\delta D$  profiles with 1-2 DOFS  
 Limited vertical sensitivity (mainly in the FT)

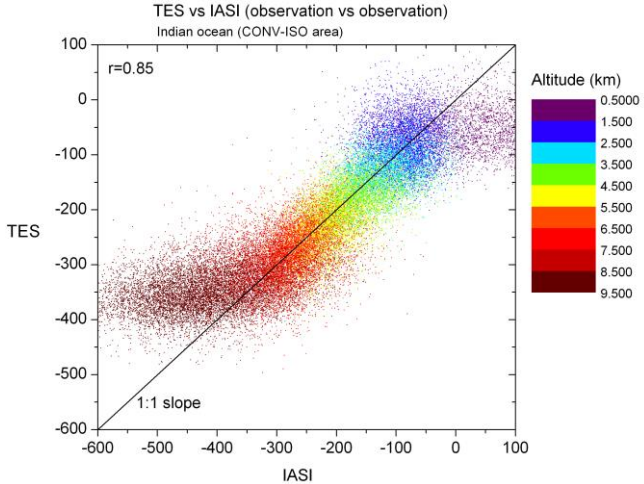
## Error budget



Total error  
 Error due to measurement noise  
 Error due to temperature profile error  
**38 permil**  
 Reduced by  $\sqrt{N}$  when using averages of N measurements

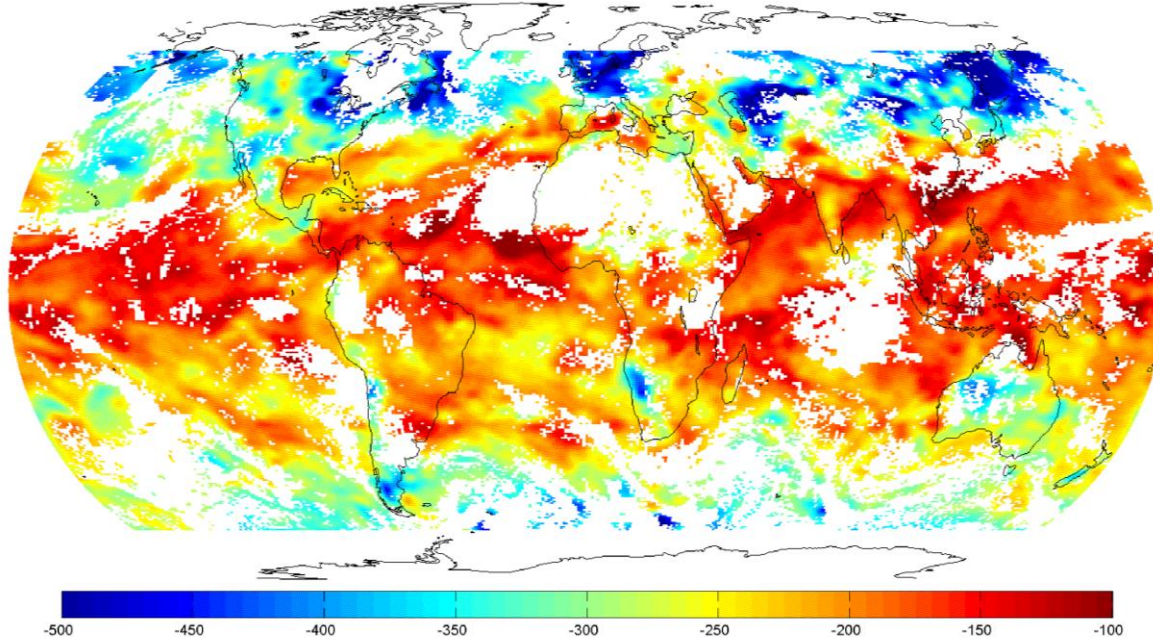
## Cross-validation (vs TES and FTIRs)

[Lacour et al., 2015]

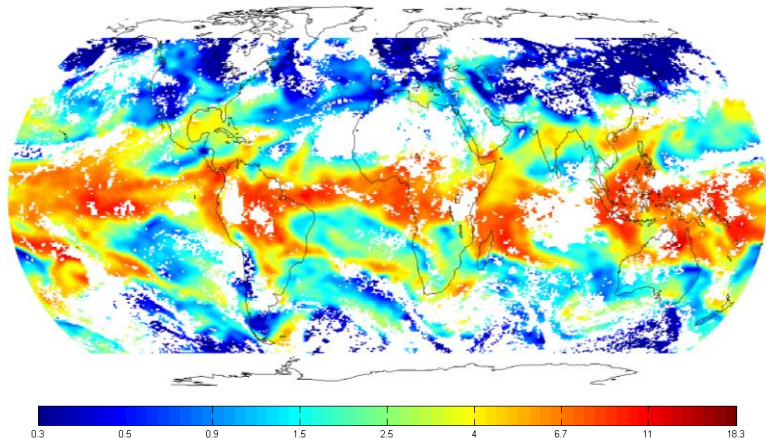


# Global distributions from IASI ?

IASI daily global distributions (1 day)  $\delta D$  at 4,5 km



q at 4.5 km [g/kg]



2013.04.01

AM and PM averaged

IASI-A + IASI-B (1 hour diff)

IASI-A + IASI-B ~2 600 000 spectra

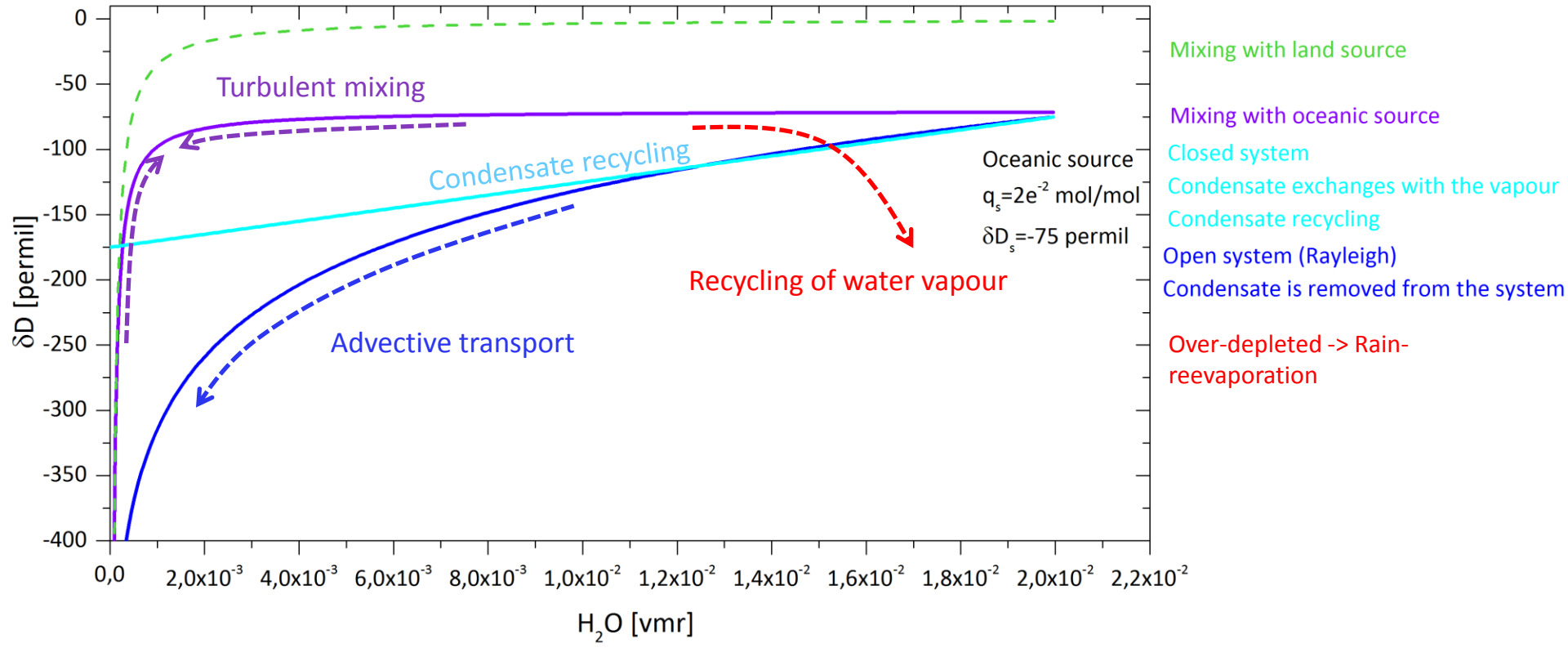
Clear sky ~400 000 observations



Massive amount of data... Not retrieved

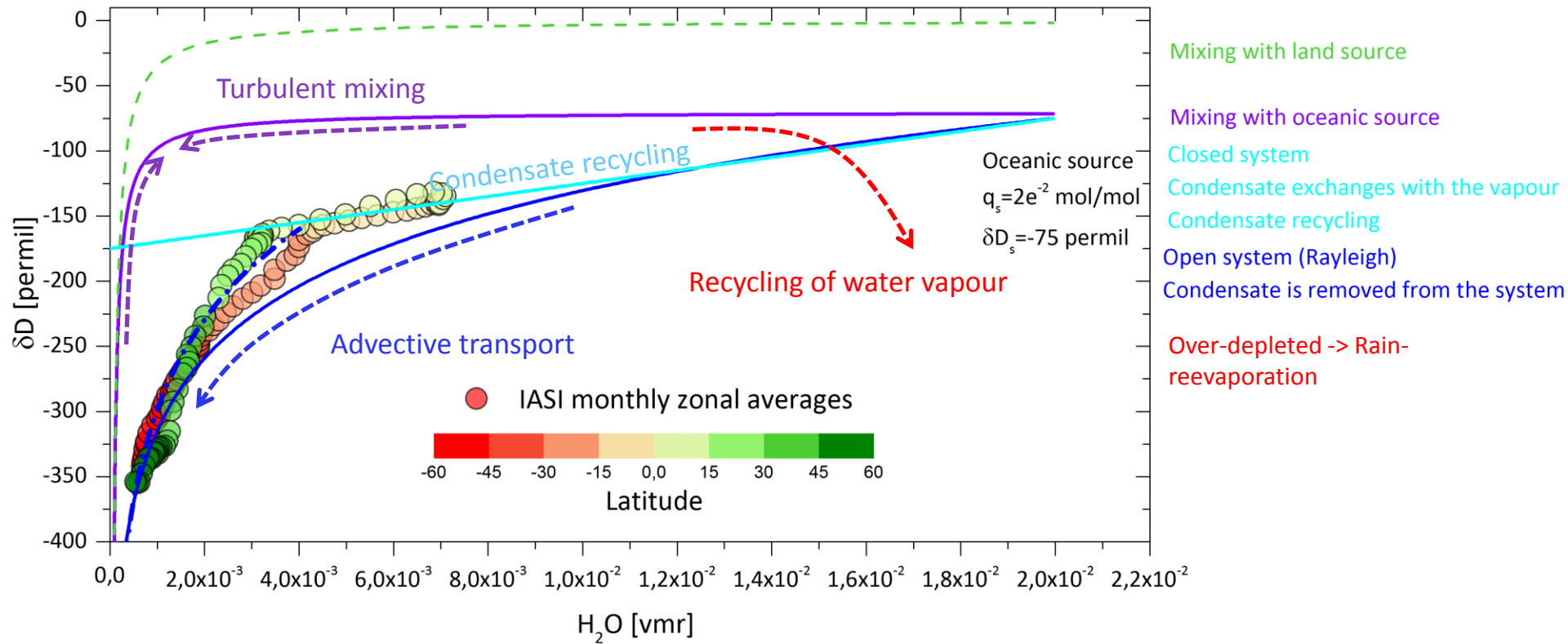
# Simple isotopic models in the vapour

From [Noone 2012]

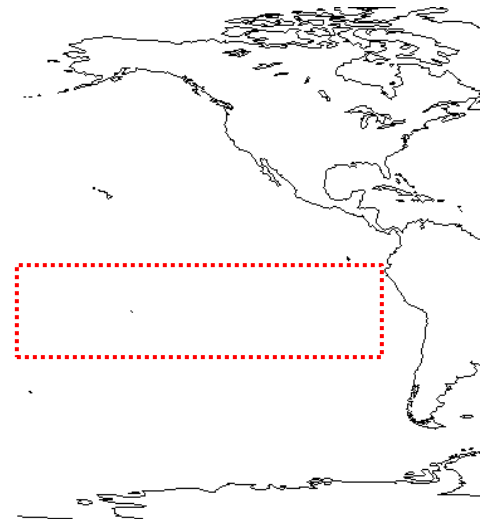
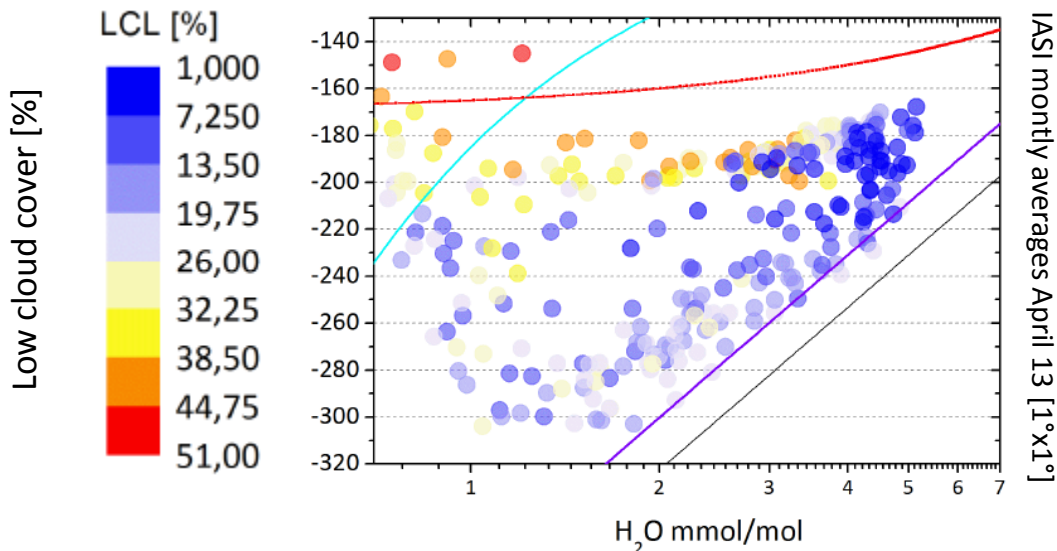


# Simple isotopic models in the vapour

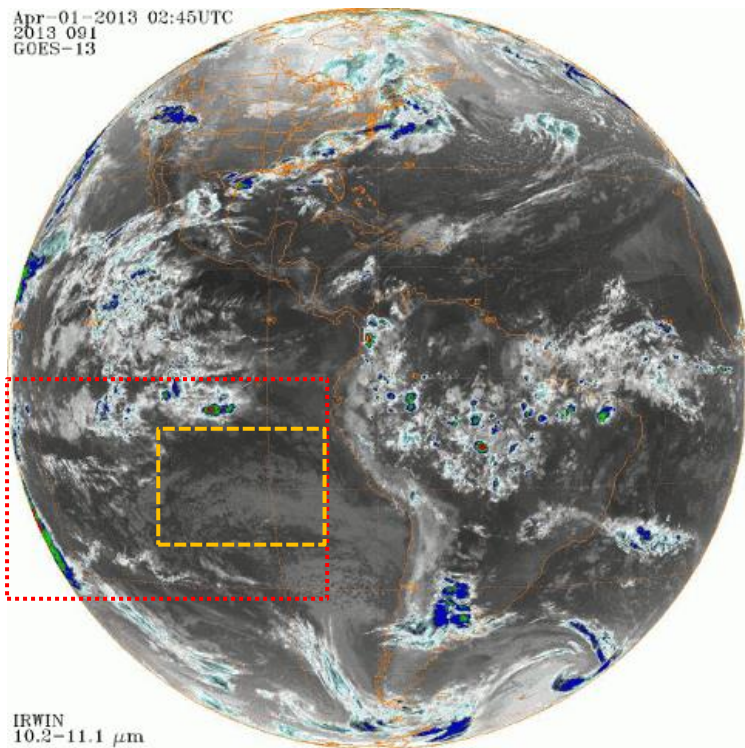
From [Noone 2012]



# South Pacific: cloud detrainment

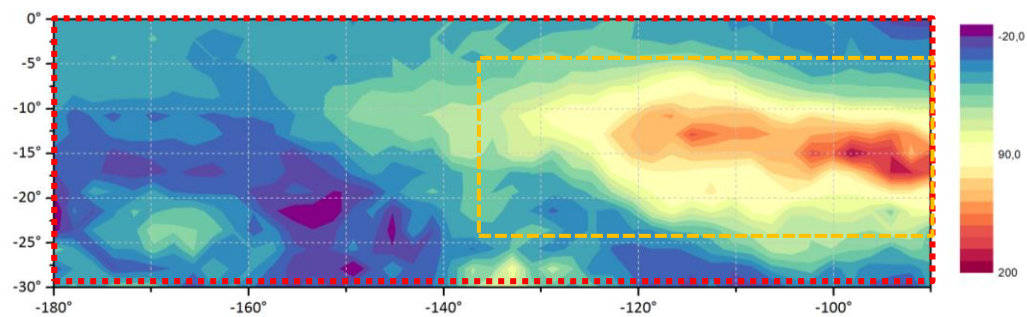


Apr-01-2013 02:45UTC  
2013 091  
GOES-13

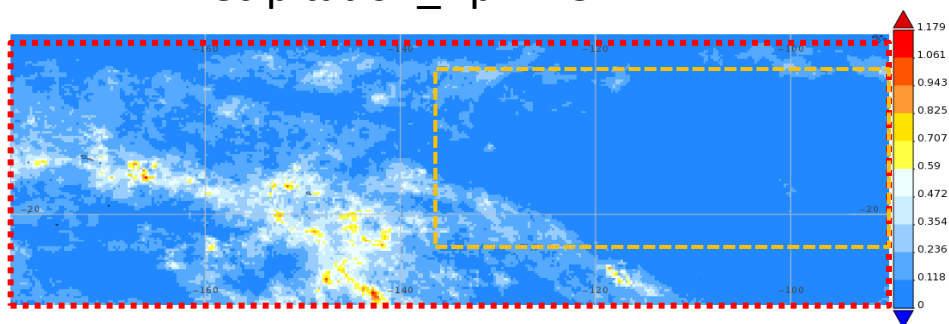


IRWIN  
10.2-11.1 μm

## Deviation from Rayleigh



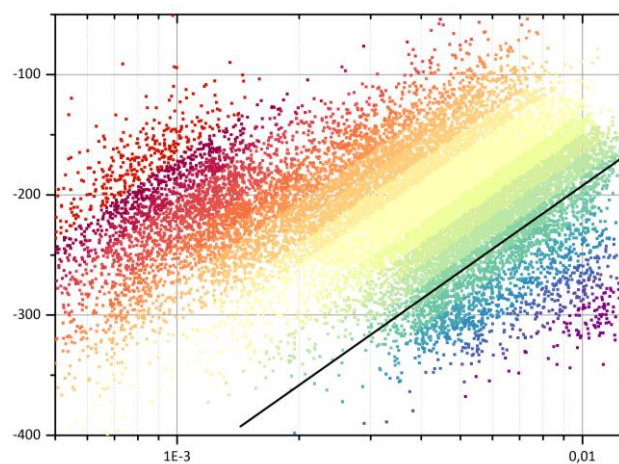
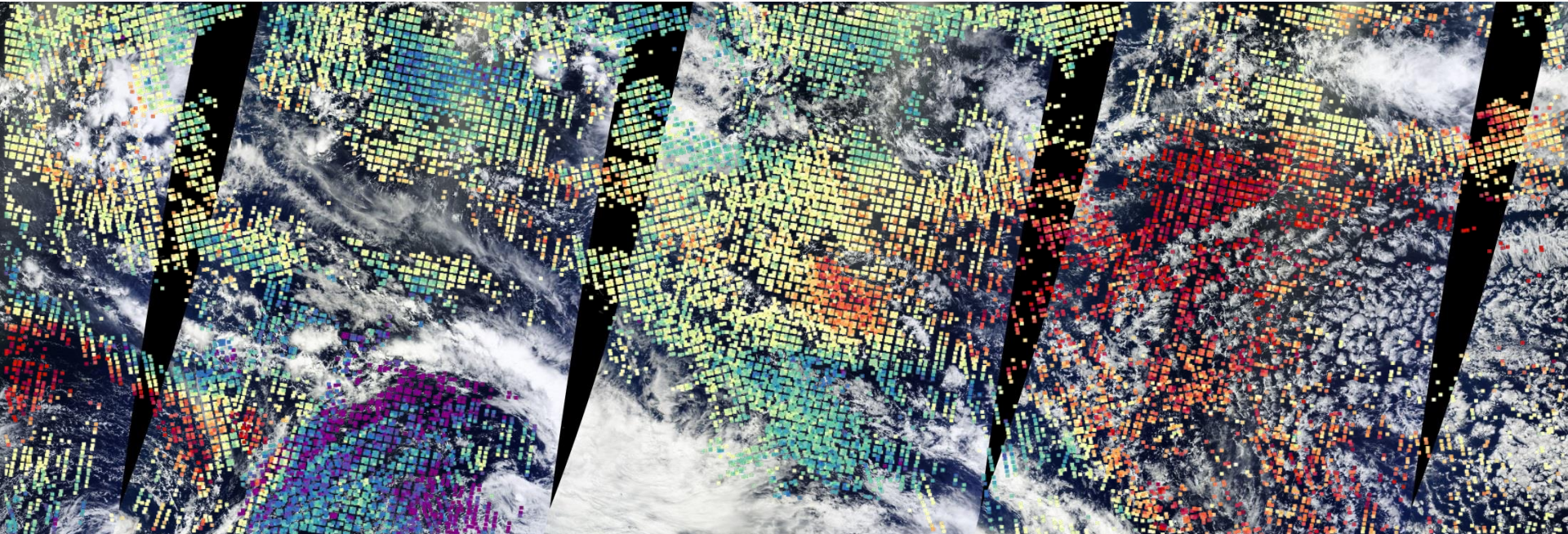
## Precipitation\_April 13 < TRMM





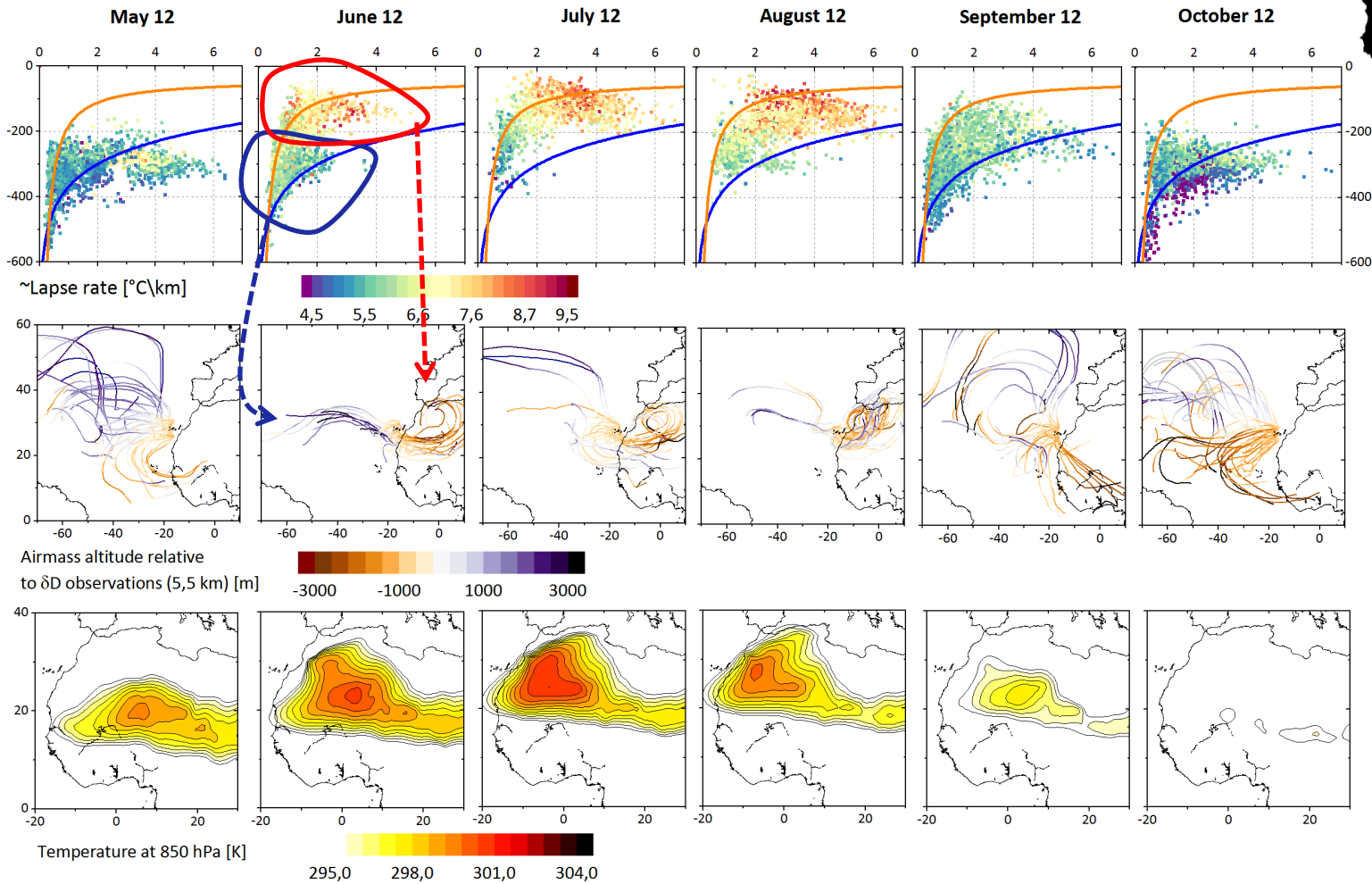
# IASI sampling around clouds

20130401\_indiviudalobs



2D colorscale  
(deviation from a standard Rayleigh)

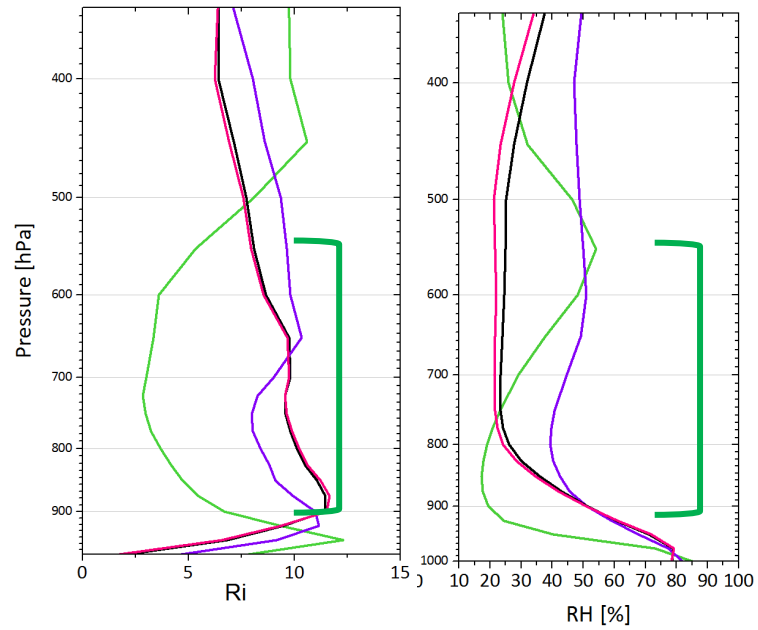
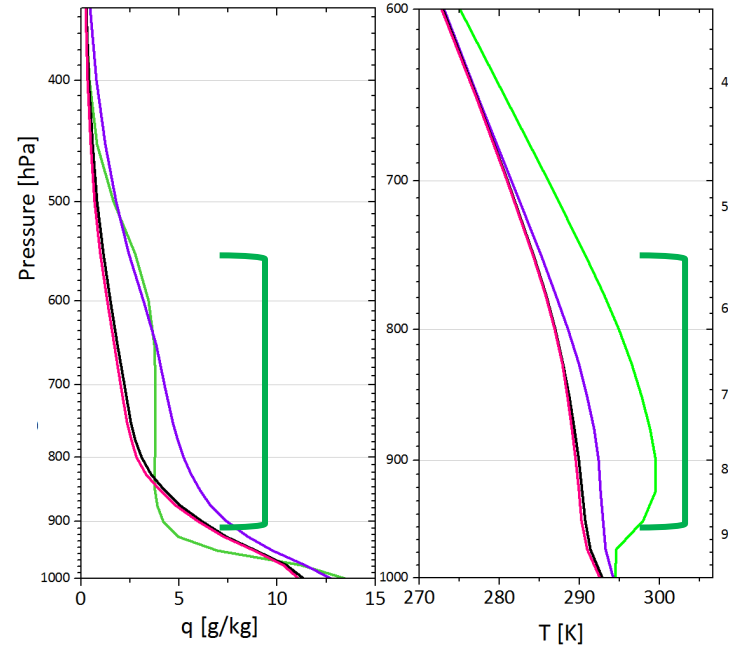
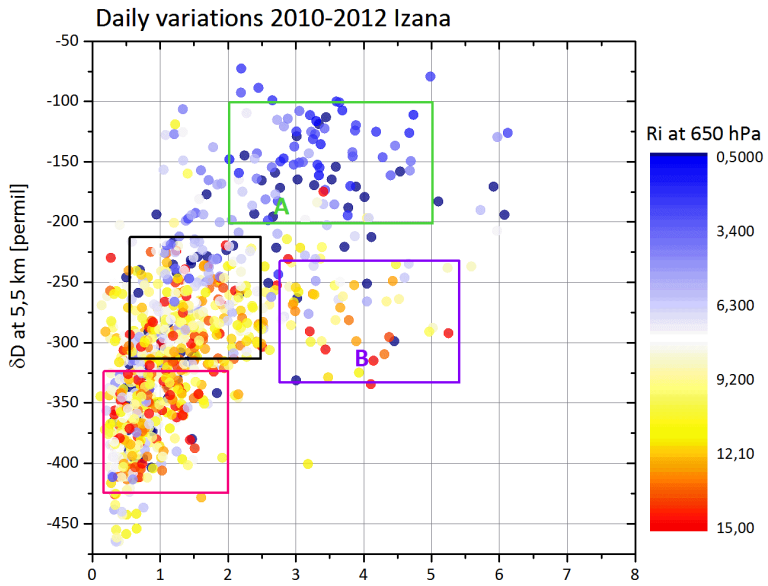
# Izana: Sources and turbulent mixing



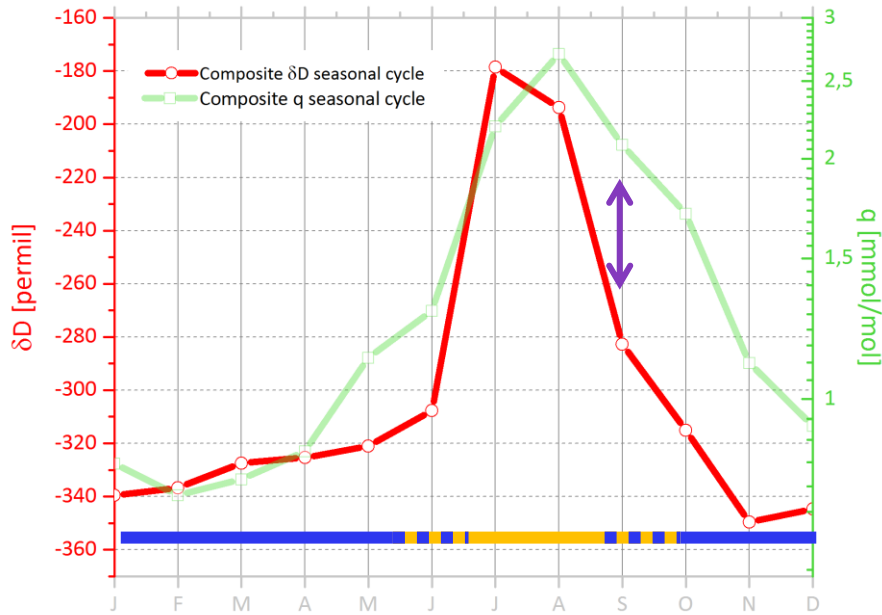
Formation of the Saharan Heat Low

Thermal depression which strongly influences dynamic and hydrologic cycle of the region

# Izana: Sources and turbulent mixing



# Izana: Interpretation of the seasonal cycle



Seasonal cycle strongly influenced by the SHL formation

2 distincts airmasses origins:

- Atlantic Ocean – Western Africa

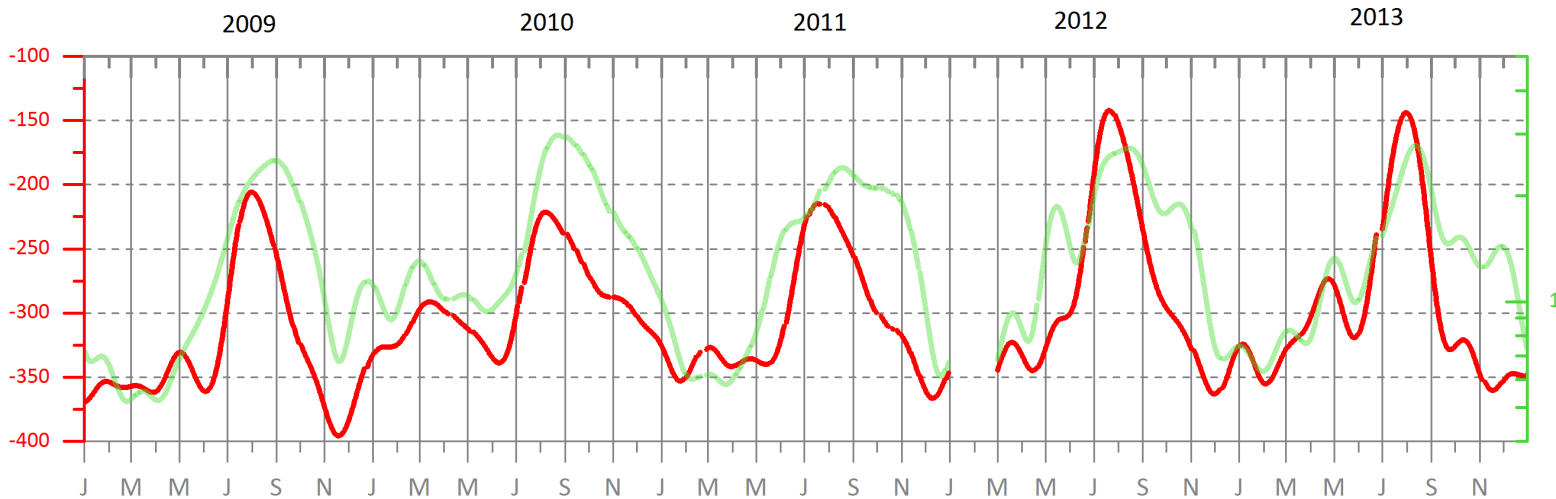
Summer July-August:

- Turbulent Mixing
- Deep boundary layers

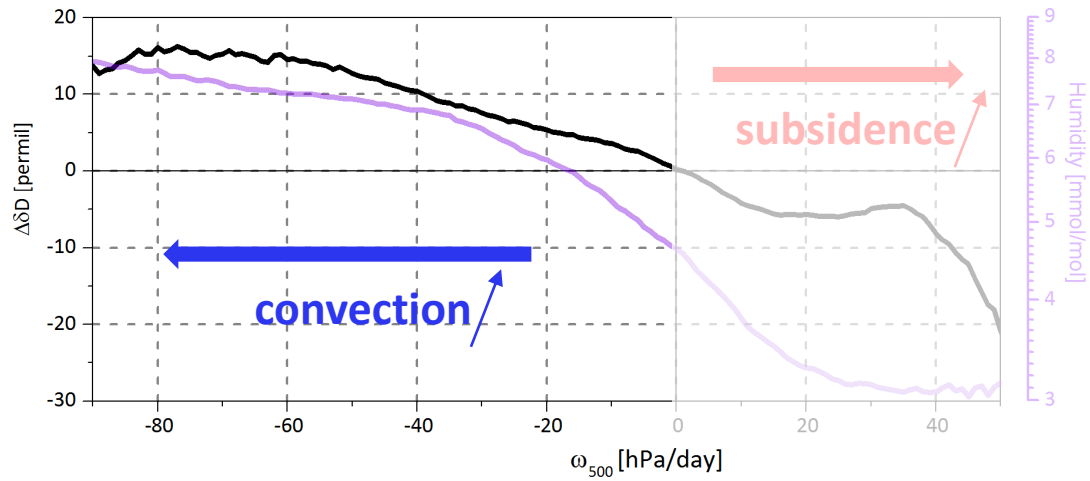
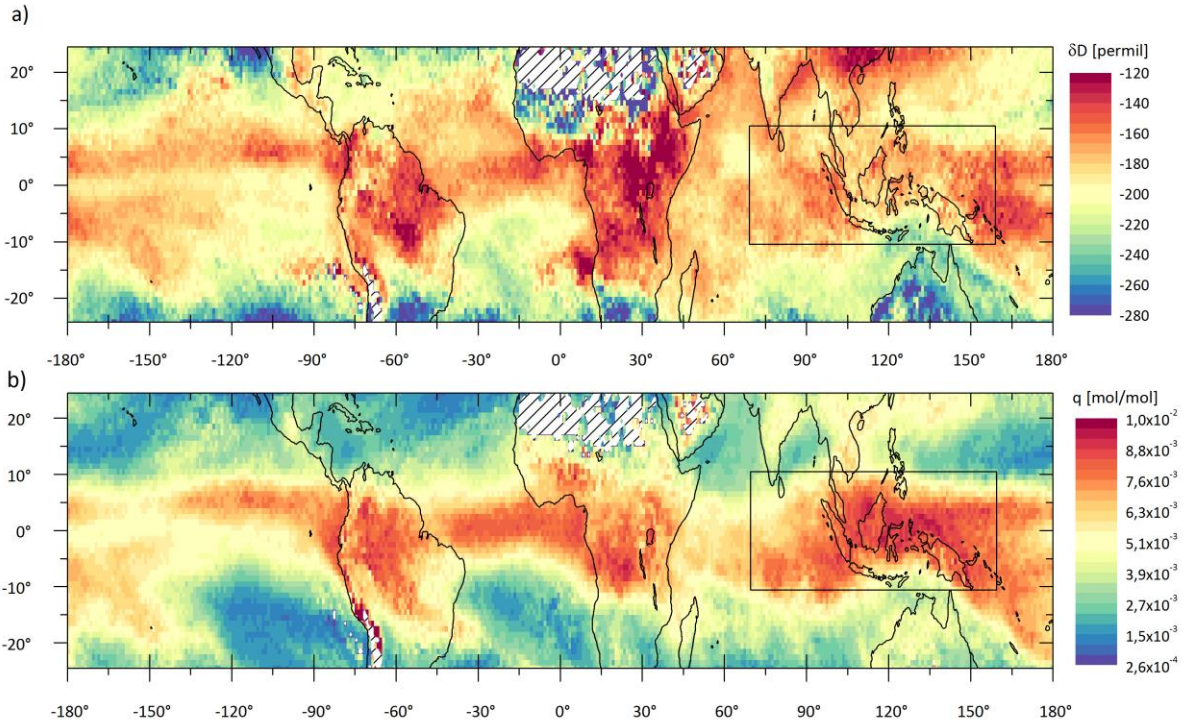
September:

- Wet convection

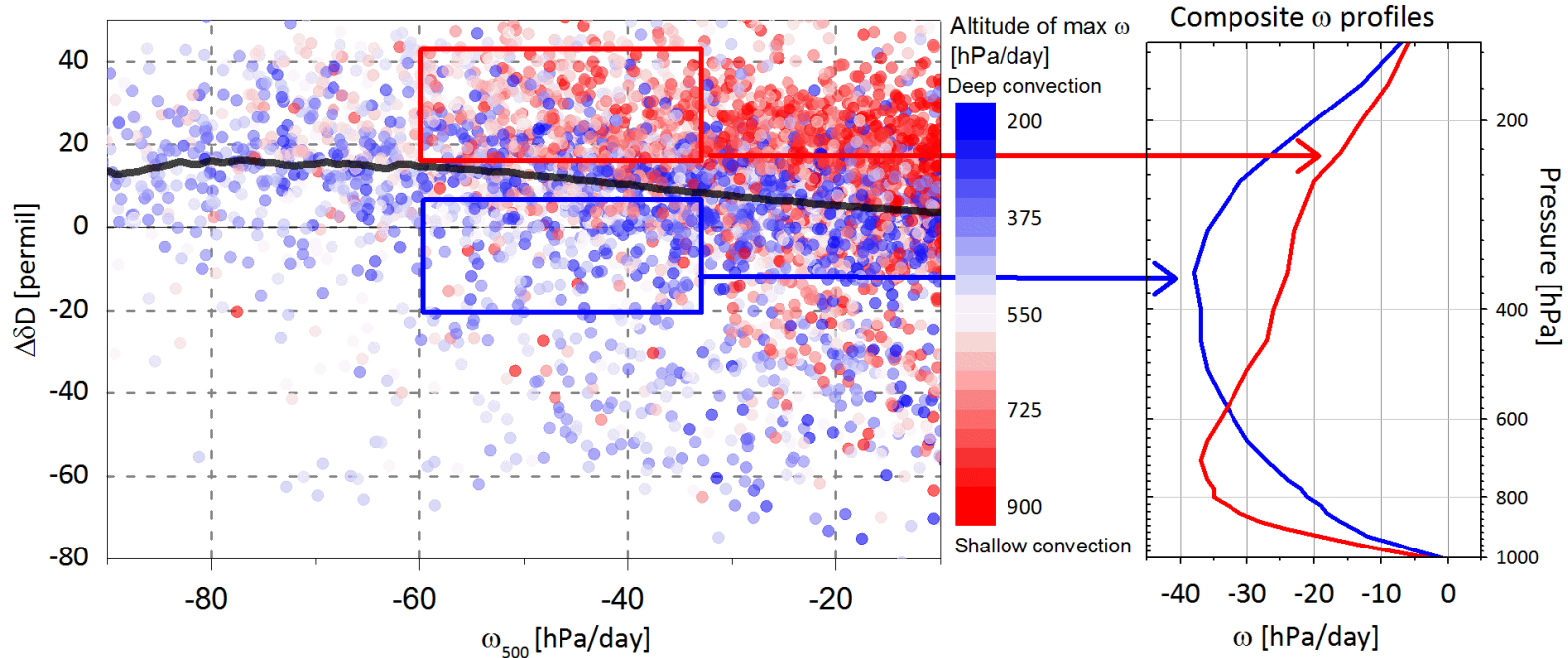
Strong inter-annual variations of  $\delta D$ , not H<sub>2</sub>O. Enriched years = more turbulent years



# Tropics: 1st order control = dynamic ( $\omega_{500}$ )



# Tropics: Isotopic footprint of convection's depth



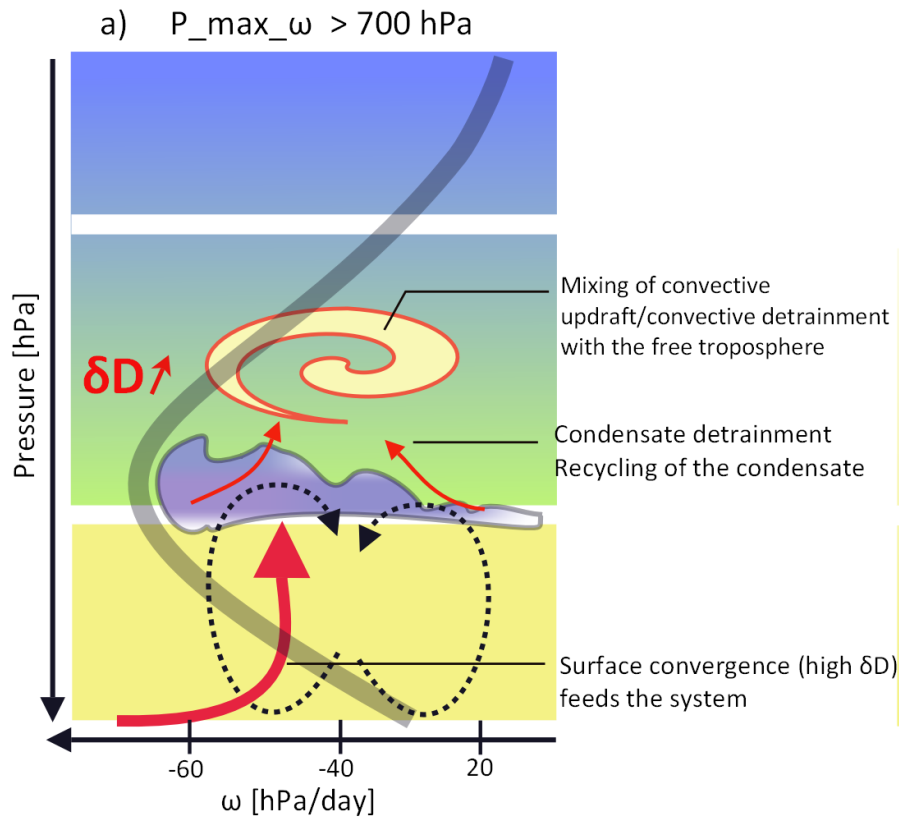
- Important scatter around the mean  $\delta D$ - $w$  relation

Convection's depth gives to water vapour a particular isotopic footprint

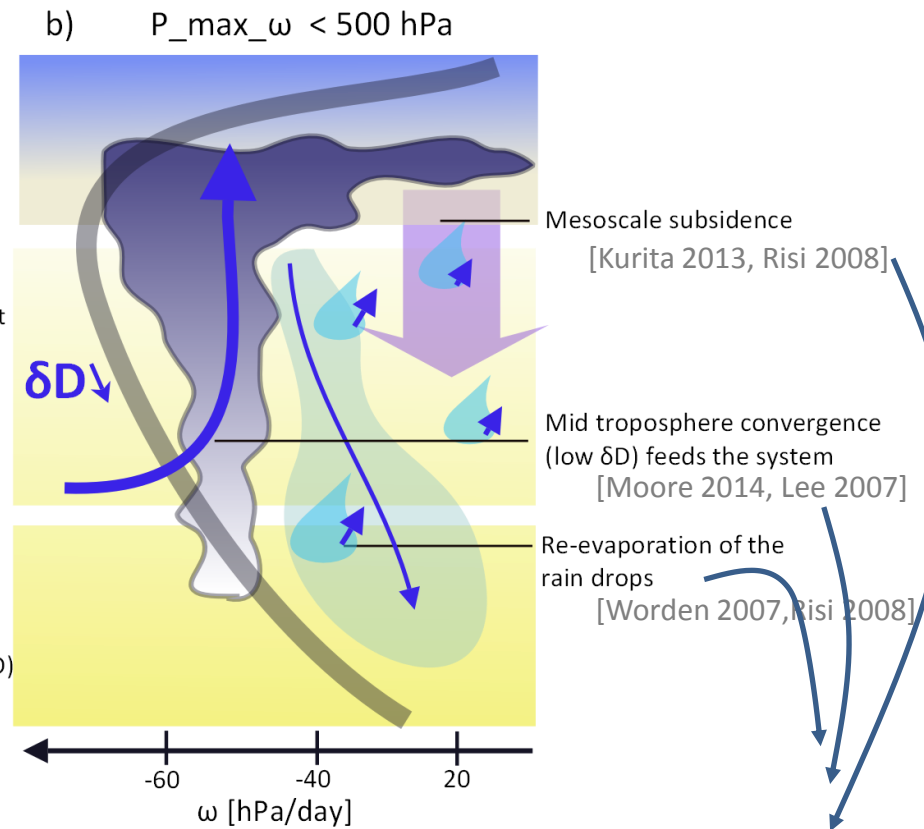
Representation of mixing depth suggested to be in a great part responsible of climate sensitivity uncertainty [Sherwood et al., 2014]. Difficult to assess from obs

# Tropics: Isotopic footprint of convection's depth

## Enriching mechanisms



## Depleting mechanisms

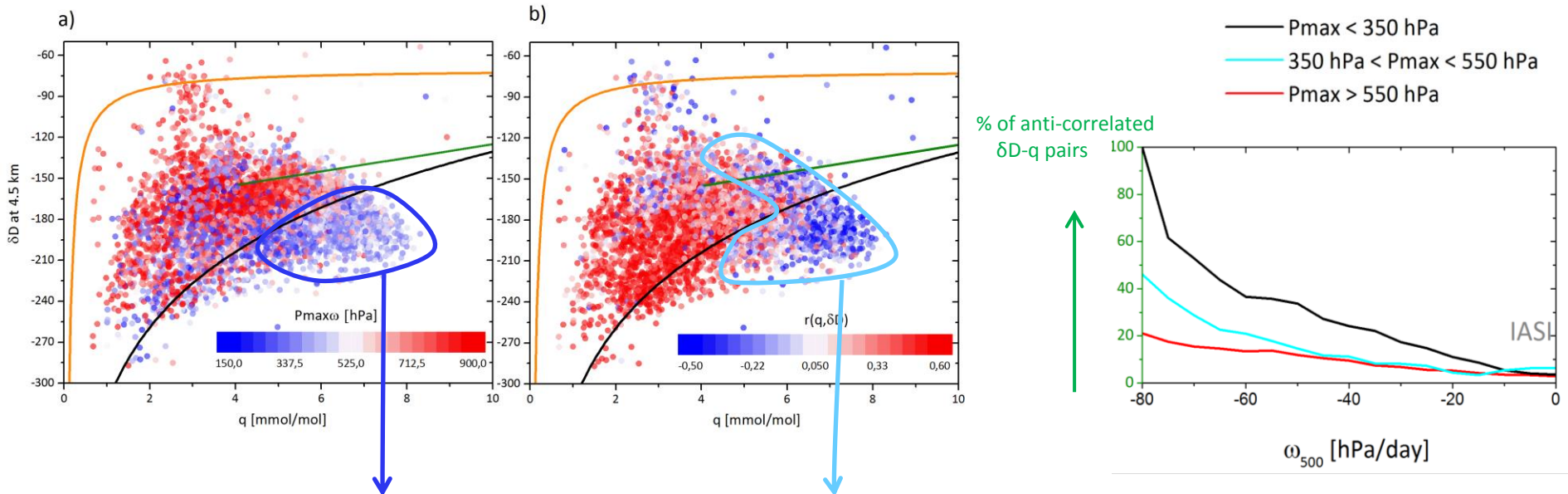


Different interpretations of the dominant control on the amount effect in the precipitations..

# Tropics: Isotopic footprint of convection's depth

Amount effect **in the vapour**? « Decrease of  $\delta D$  associated with an increase of  $q$  »  
Not the same than the amount effect **in the precipitations**

Analyse of  $\delta D$ - $q$  monthly averages for convective regimes only ( $w_{500} < 0$ )  
IASI: temporal correlation between daily average for each month



Rain re-evaporation is often associated with deep convection

Amount effect<sub>v</sub> is associated with the rain re-evaporation but not only

The amount effect in water vapour is more frequent for deep convection



# Conclusions

- IASI  $\delta D$  profiles contain a lot of information on hydrological processes
- Numerous processes can be inferred directly from IASI observations:
  - cloud detrainment
  - different airmasses sources
  - turbulent mixing
  - evapotranspiration
  - depth of convective mixing
  - amount effect in the water vapour
- Still lot of work to understand the observations
- Need of better interpreting frames than simple models

# Space remote sensing of $\delta D$

○ Only  $\delta D$  can be retrieved from space

○ Instrument type:

Visée Limbe IR

UTLS

ACE  
MIPAS

Nadir TIR

Free  
tropo.

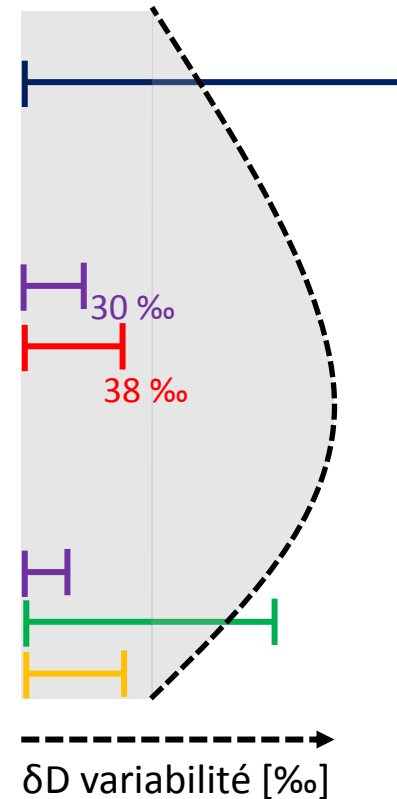
TES/AURA  
**IASI**  
GOSAT (TIR)

Nadir SWIR

Low  
tropo.

SCIAMACHY  
GOSAT (SWIR)

○ Precision ( on 1 measurement):



○ Number of measurement by day:

TES

|

~ 1 TES measurement for 200 IASI measurements

IASI



