Detection of plain-mountain circulation from long series of data

Influence on atmospheric composition measured at the « Pic du Midi » mountain top

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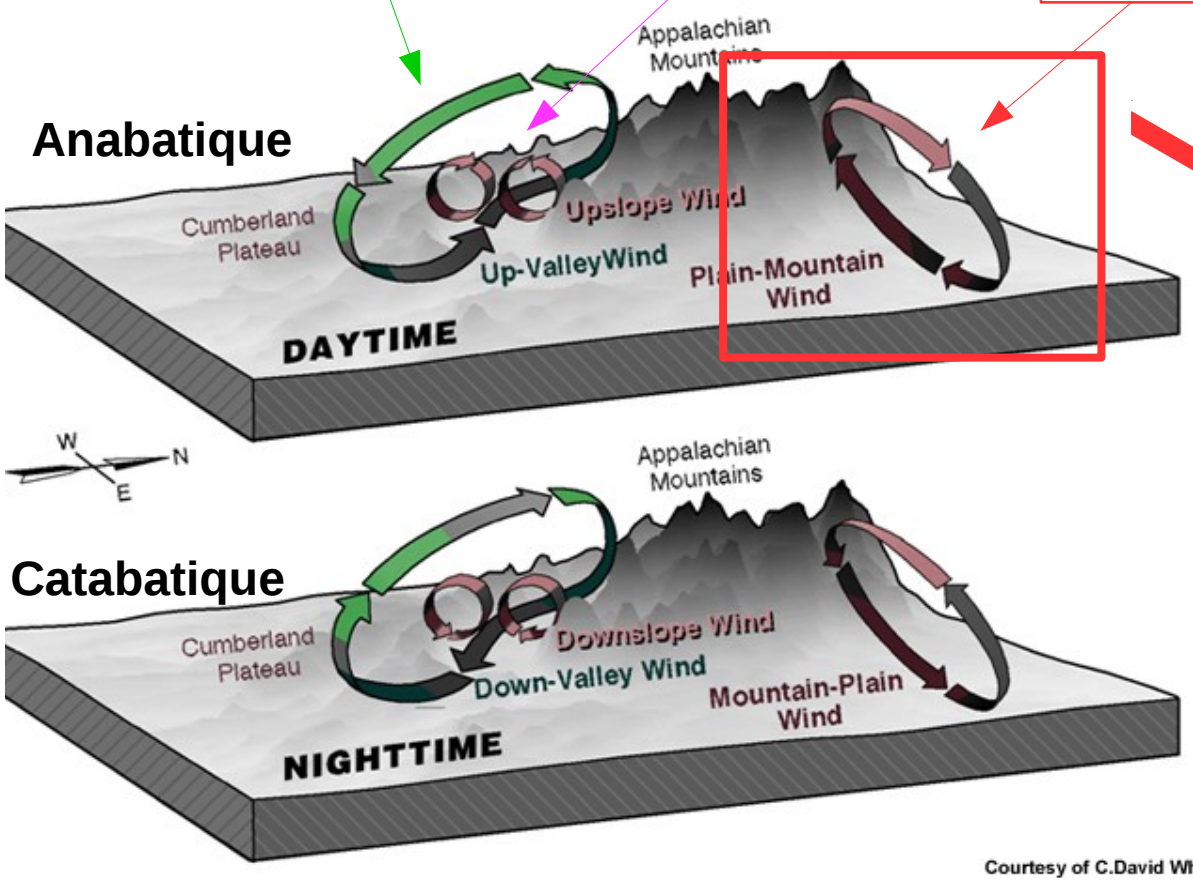
Thermal circulations - Issue

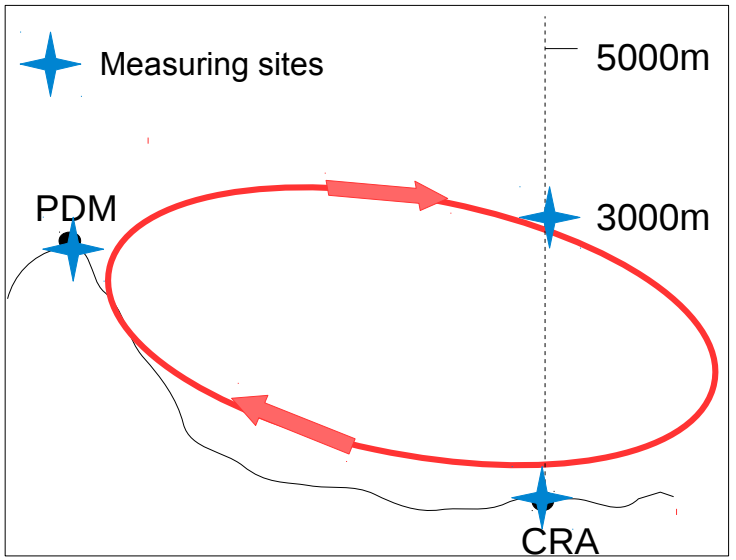
Valley winds

Slope winds

Mountain-plain « larger scale » cell



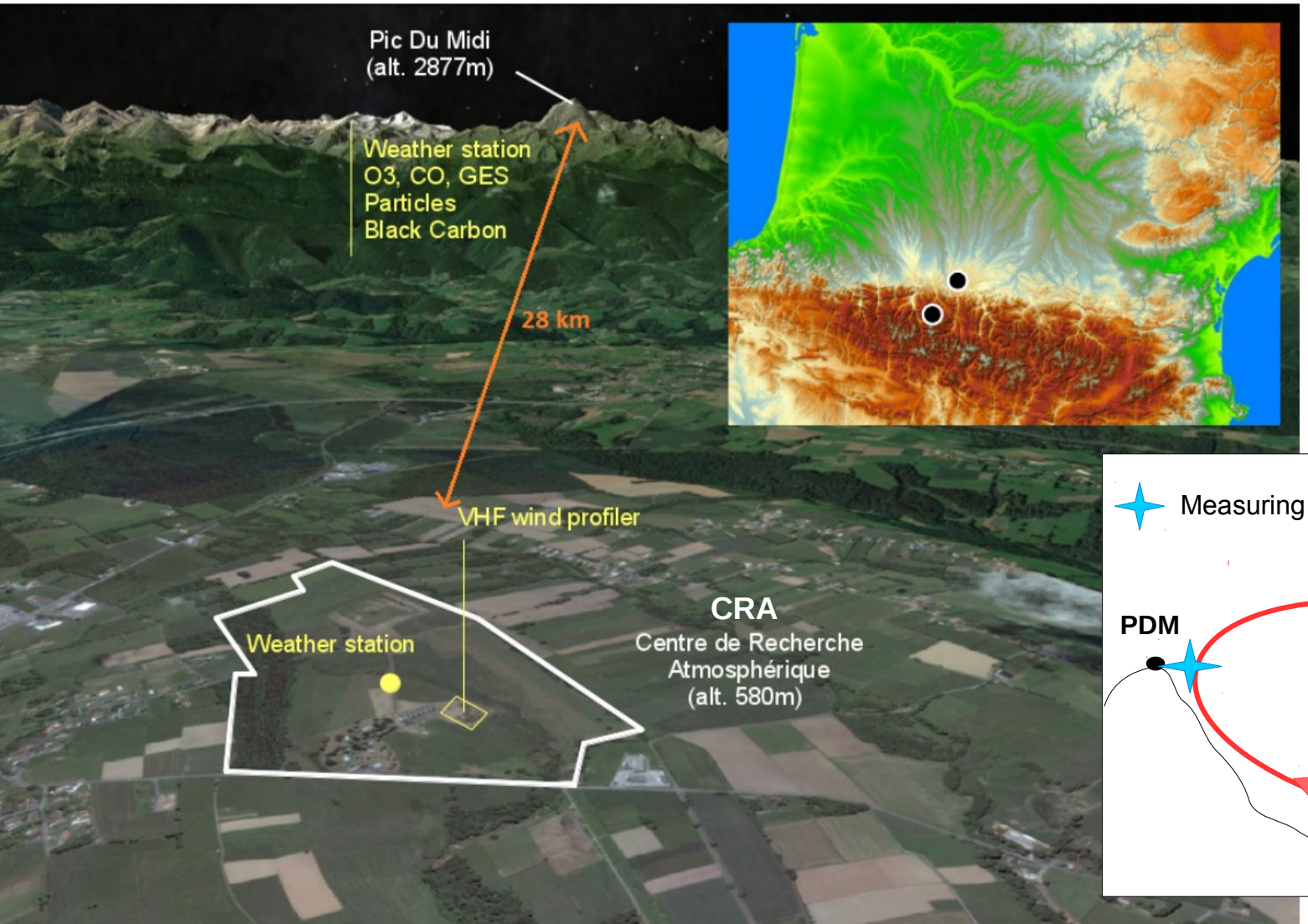
Courtesy of C.David Whiteman



Can we detect this circulation from our long term observations at P2OA ?
And deduce its impact on the chemistry measurements made at Pic du Midi ?

Sites and data

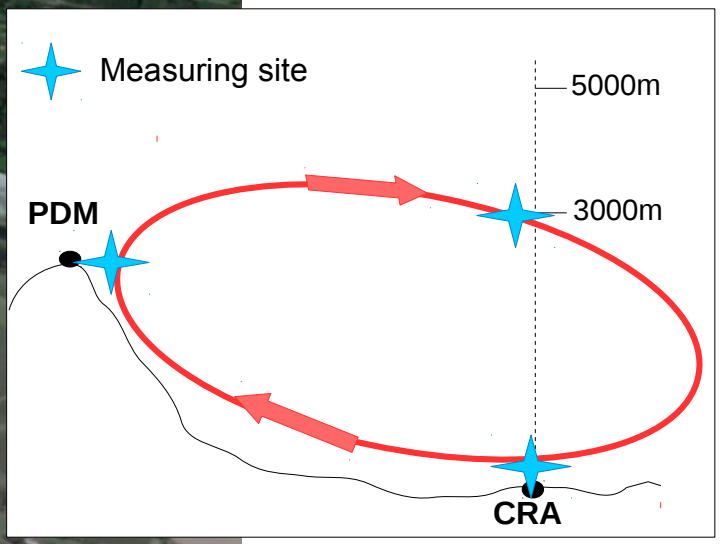
Considered period : 10 years 2006-2015



Dataset :

10 years of hourly data
2006-2015

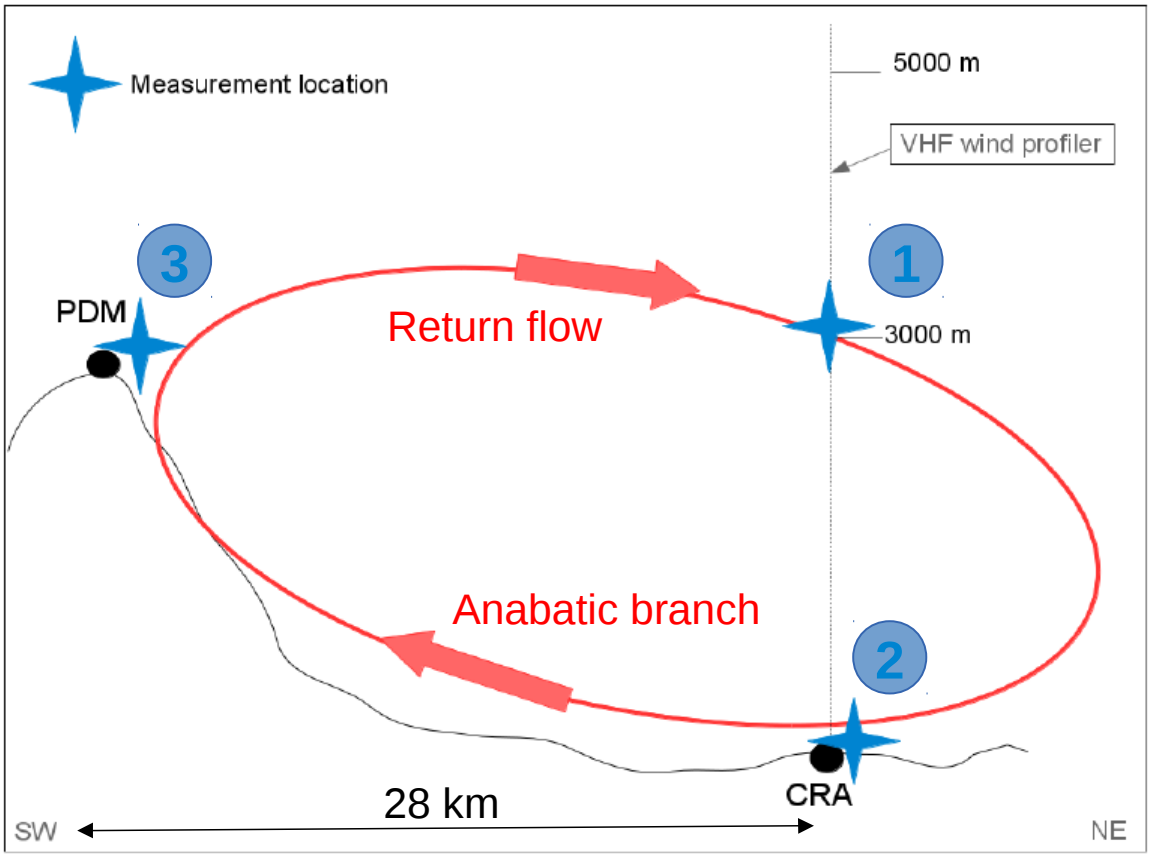
Meteorological variables
O3, CO2, CO, CH4,
Particles



Methodology

Hypotethis :

If well settled,
the circulation cell should be detected
from those three points of views

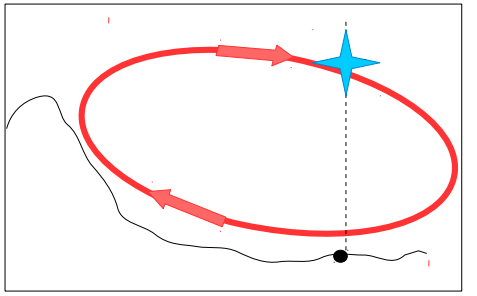


Method 1 : Detects **return flow** at 3km altitude (wind from CRA VHF wind radar)

Method 2 : Detects **mountain breeze** at surface at CRA (10 m wind)

Method 3 : Ranks days **from most to least anabatic**, with an in situ BL tracer
Griffiths et al. 2013 (water vapour at Pic du Midi)

Detection method (1/3)
Method 1 (VHF 3000 m)

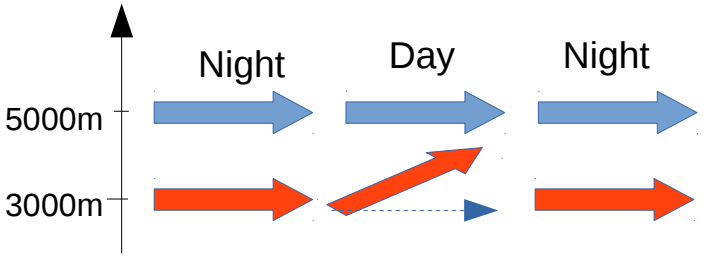


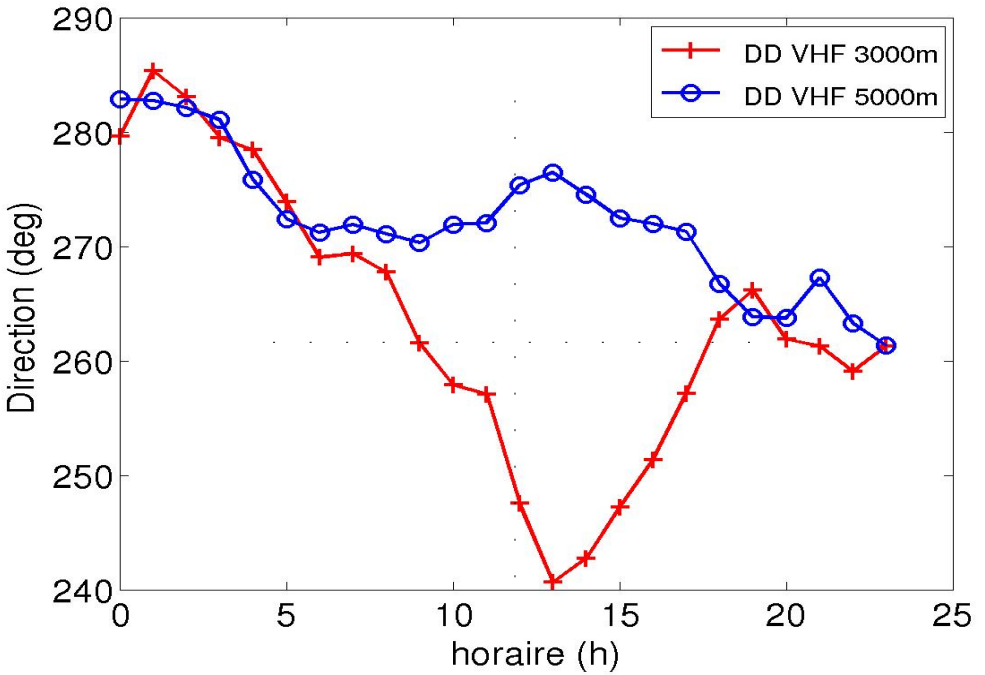
Objective: To detect the return flow of the cell in altitude

→ Added daytime southerly component at 3000 m altitude

→ Deviation of the flow at 3000 m toward North, not visible at 5000 m

Westerly case :





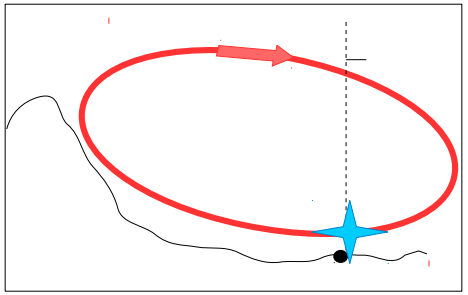
Criteria :

Deviation toward North and/or Change in windspeed } Day

Alignment } Nuit

Night/day/night Alternance

Detection method (2/3)
Method 2 (surface wind at CRA)

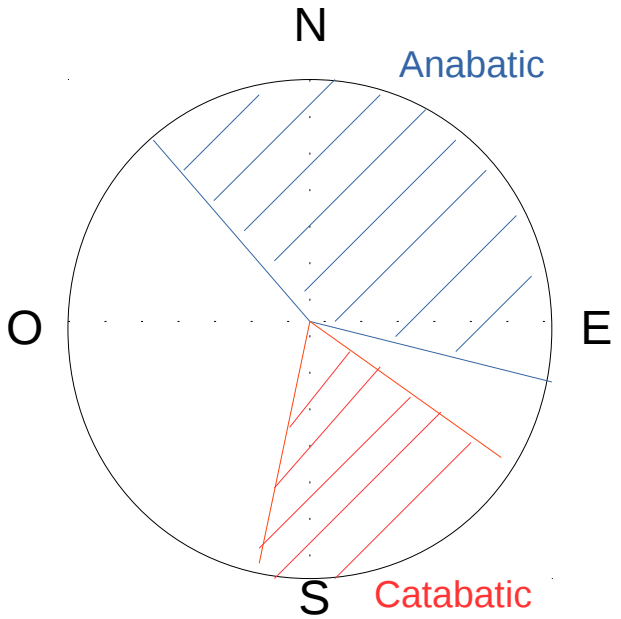


Objective : To detect the mountain breeze at surface at CRA based on the wind direction alternance between night and day

Based on previous work by
Barneoud Paul, Beck Stephane, Lafrique Pierre, Lagnoux Bertrand, 2010 (master internship) : *Climatology of the instrumented site of Laboratoire d'Aérologie*

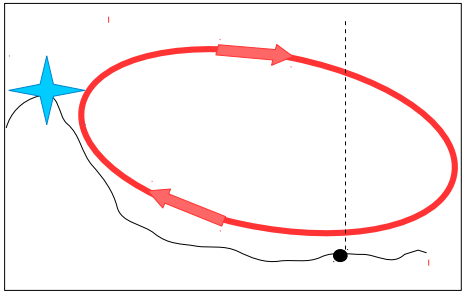
Criteria :

Wind direction within 330°-110° during daytime
Wind direction within 130°-190° during nighttime
Alternance over 3 successive half-days



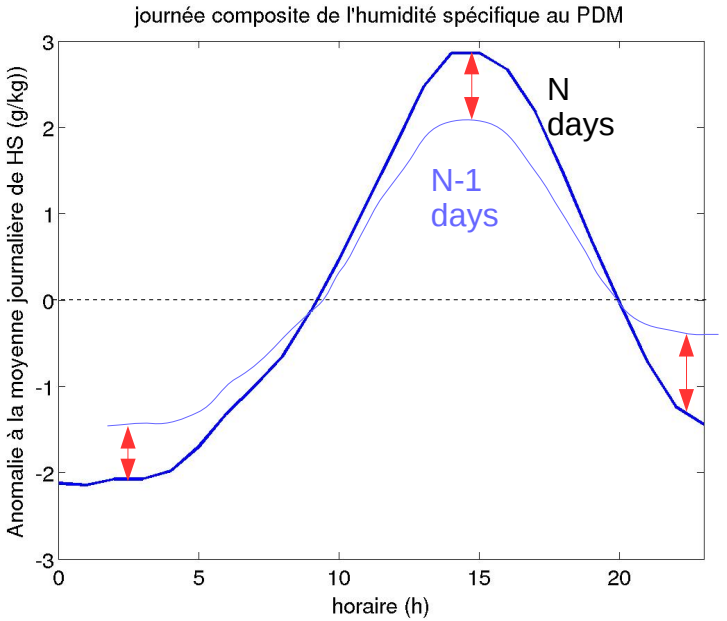
Detection method (3/3)
Method 3 (in-situ tracer at PDM)

Obective: Ranking days from most to least anabatic
By use of a composite diurnal cycle of a BL tracer
(composite day = average over ensemble of days)



Based on A.D. Griffiths et al. (ACP, 2014) : quantifies the influence of anabatic winds on Jungfrau measurements, using Radon 222 tracer

Applied here on **water vapour** scalar at Pic du Midi.



<u>Hypothesis and Principle :</u>

Anabatic days show a typical diurnal cycle

Removal of one anabatic day
→ decrease of cycle amplitude

Ranking according to the impact on the composite day of the ensemble

Detection method (3/3)
Method 3 (in-situ tracer at PDM)

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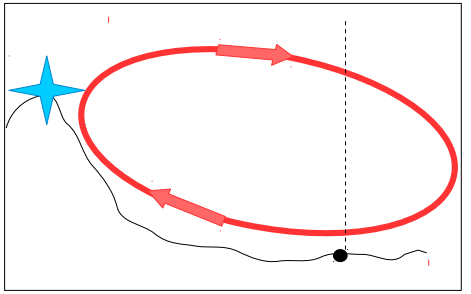

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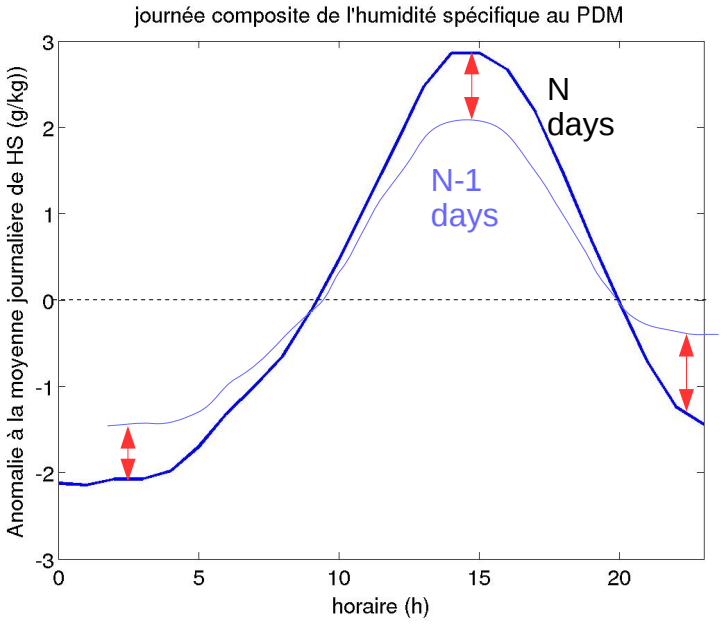
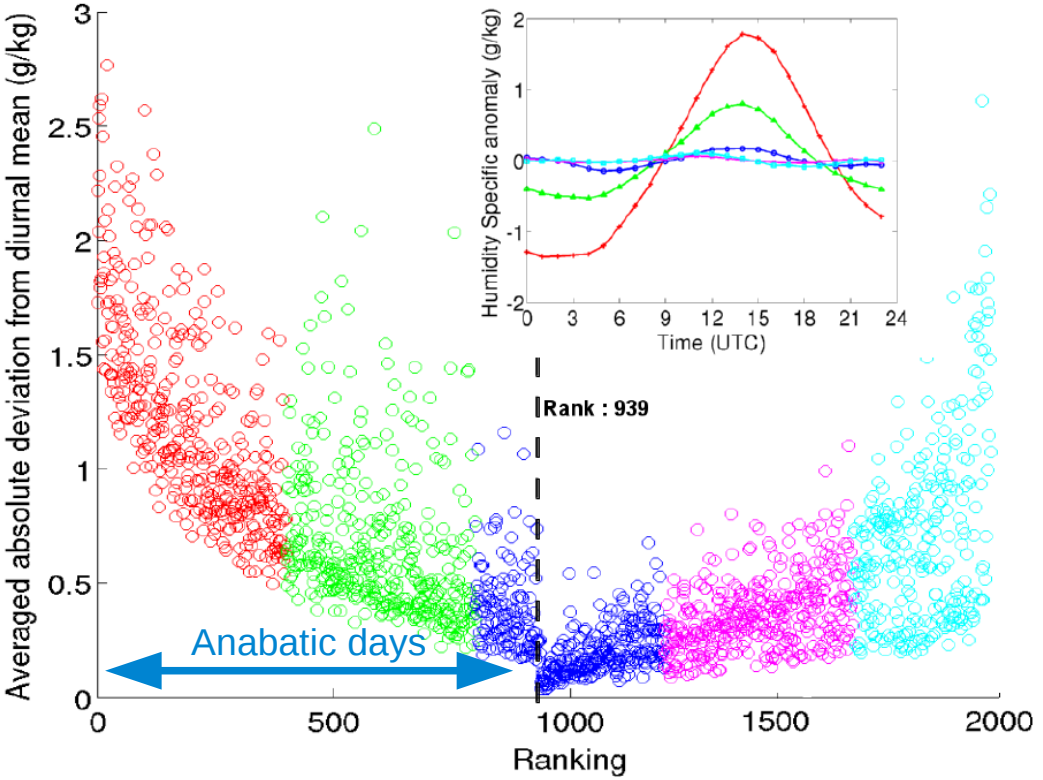
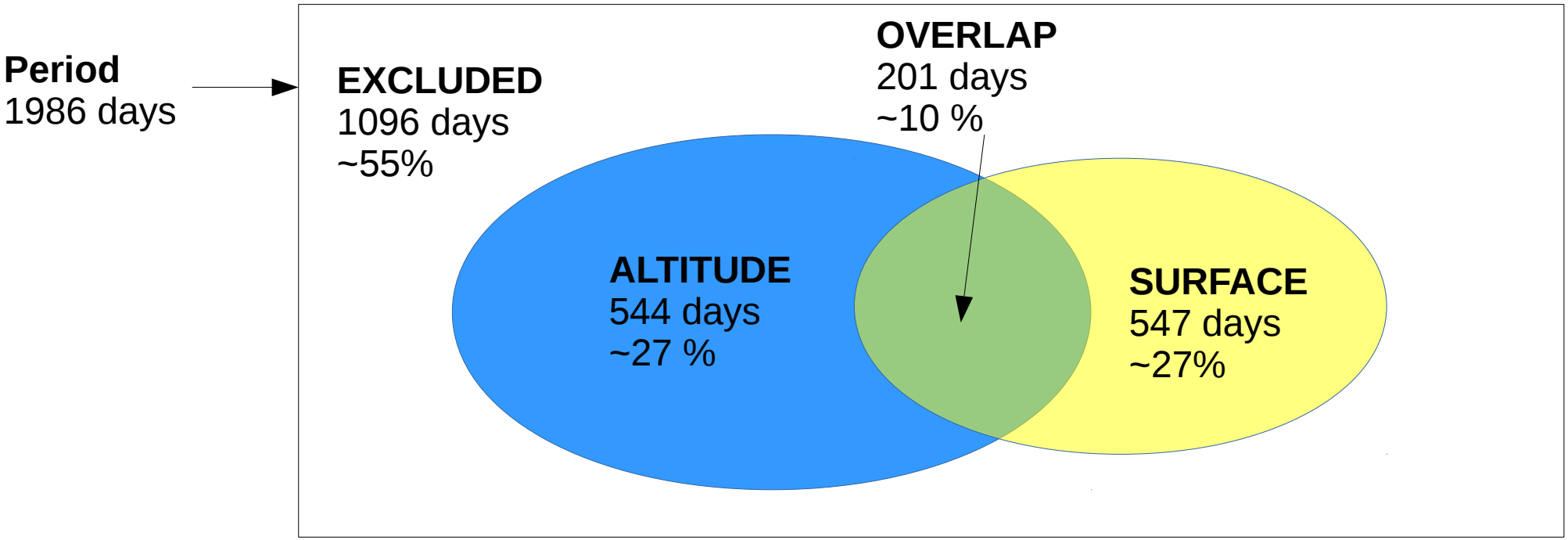




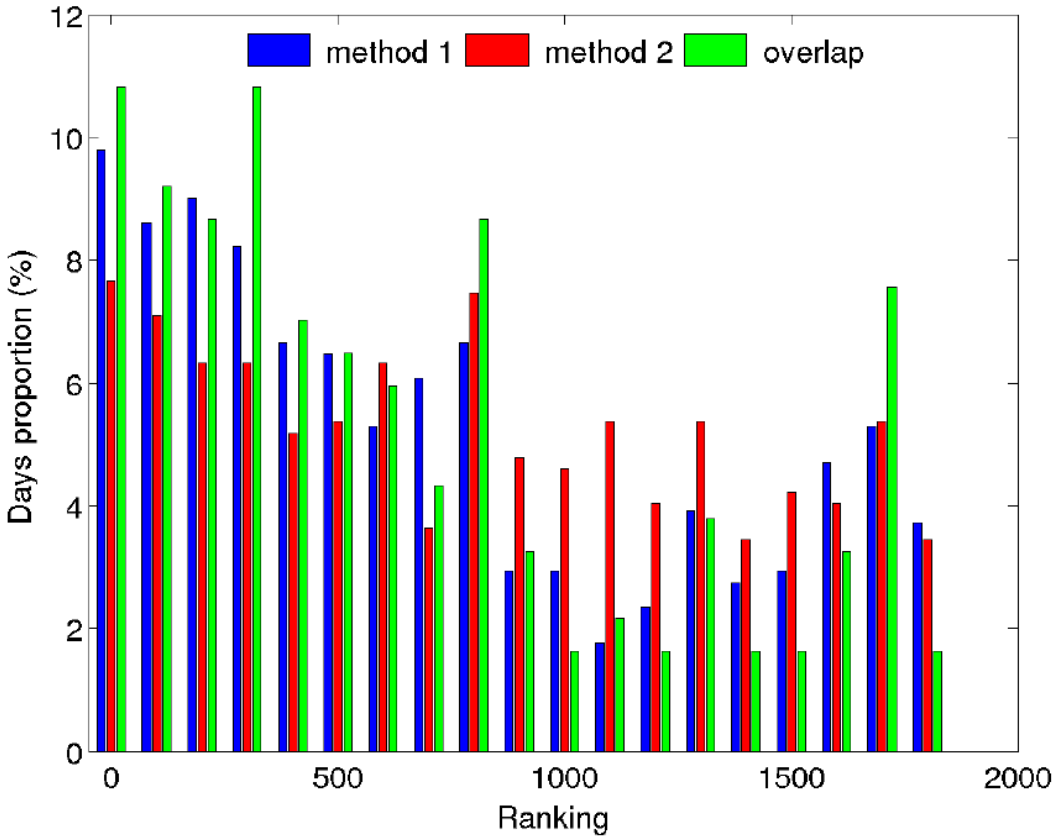
Selected ensembles from Methods 1 and 2

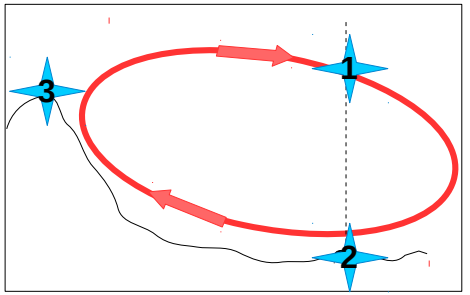


- **Occurrences consistent** with previous studies
- 10 % of overlap → not always observe large scale cell + breeze at surface at CRA
  also **Stringency** of criteria

Method consistencies and differences

Method-3 ranked days selected by Methods 1 and 2



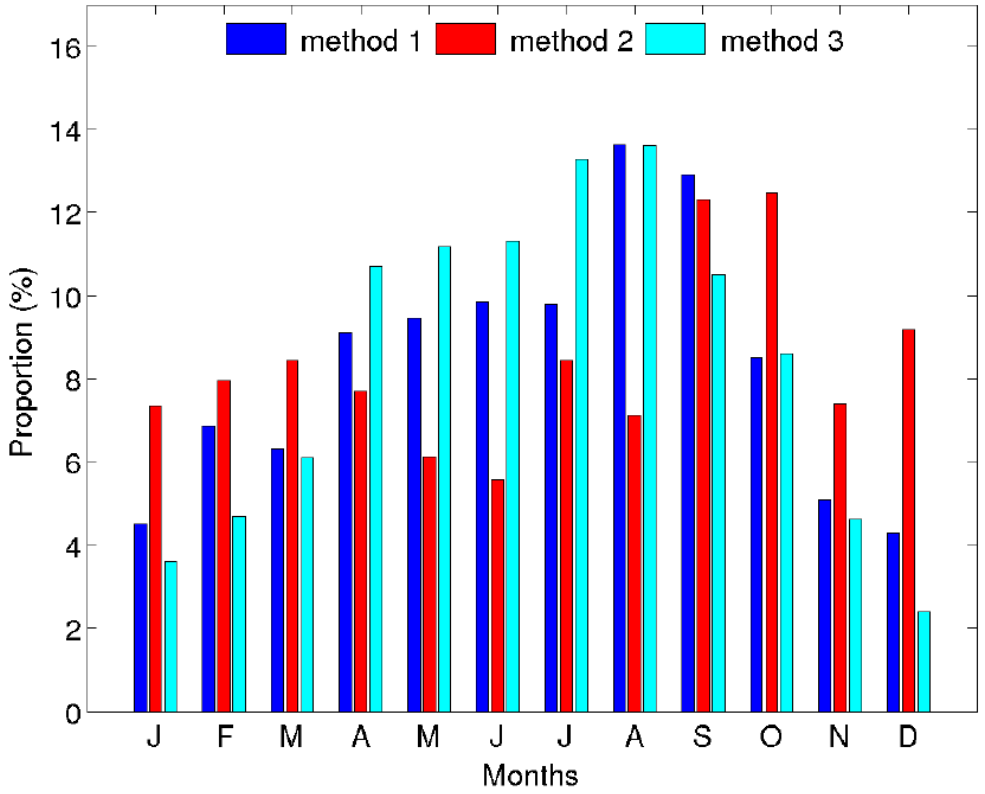


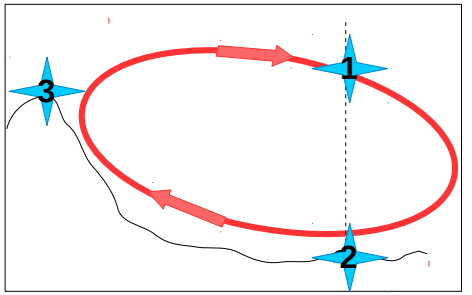
- 70% of Method-1 selected set, and 60 % of Method-2 selected set are ranked in anabatic days by Method 3

- 75 % of overlap Method1/Method2 ranked in anabatic days

Method consistencies and differences

Seasonality of selected days





- Methods 1 and 2 based in altitude have similar seasonality, with max in Summer
- Method-2 (surface/plain) has a different seasonality : more spread over the year, max in transitional seasons

Method consistencies and differences

Diurnal cycles of wind direction **at surface at CRA** for ‘selected’ and ‘unselected’ days

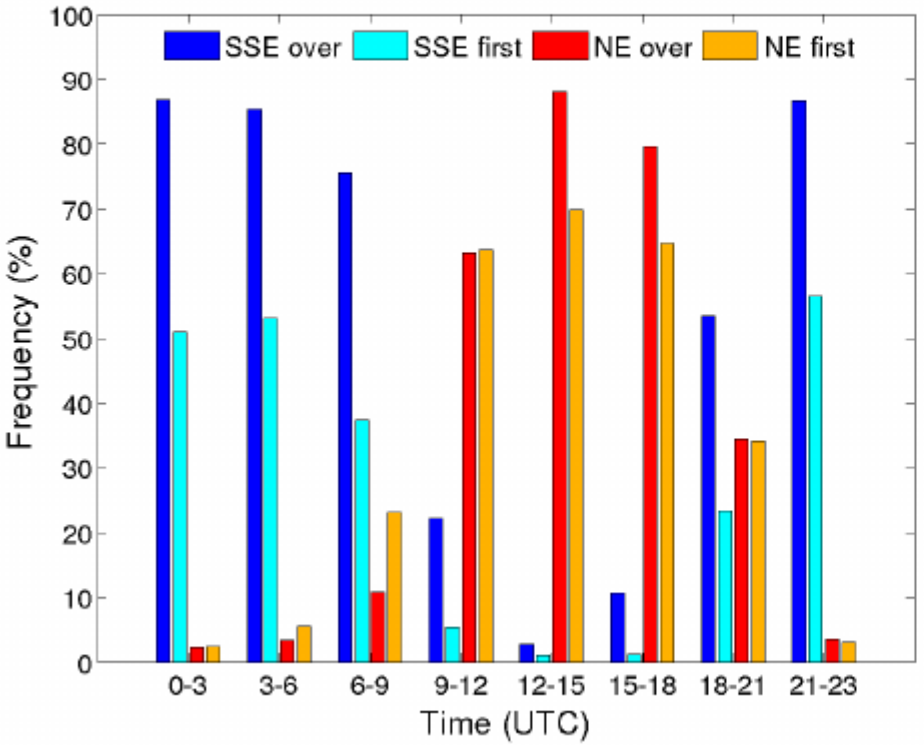
‘selected’

Method 1 & Method 2 overlap
Method 3 first ranked days

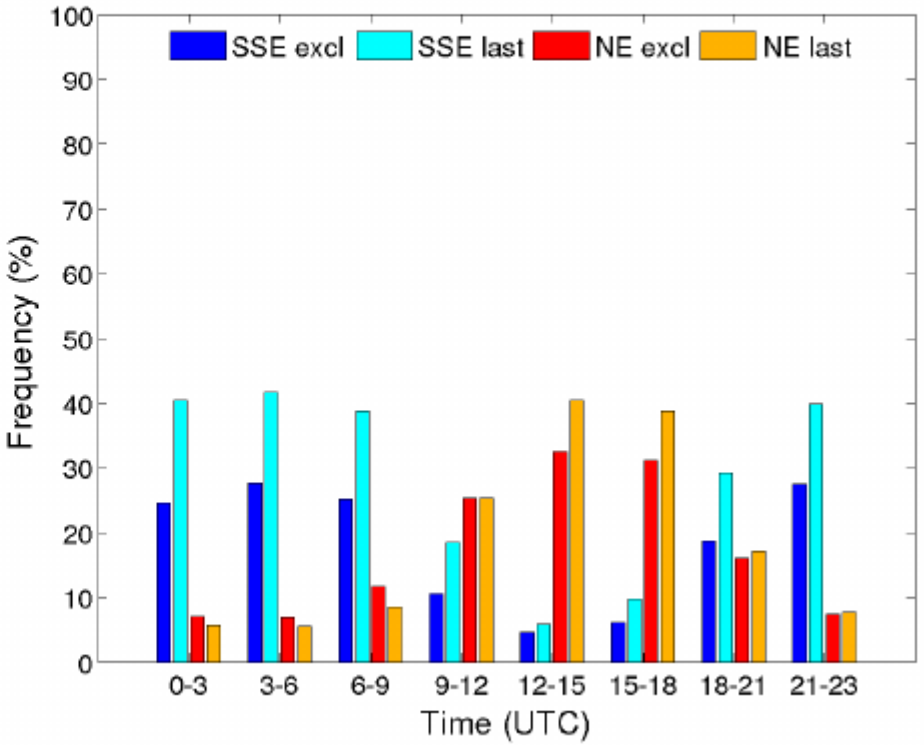
‘unselected’

Method 1 & Method 2 excluded days
Method 3 last ranked days

Selected sets - Surface CRA



Unselected sets - Surface CRA

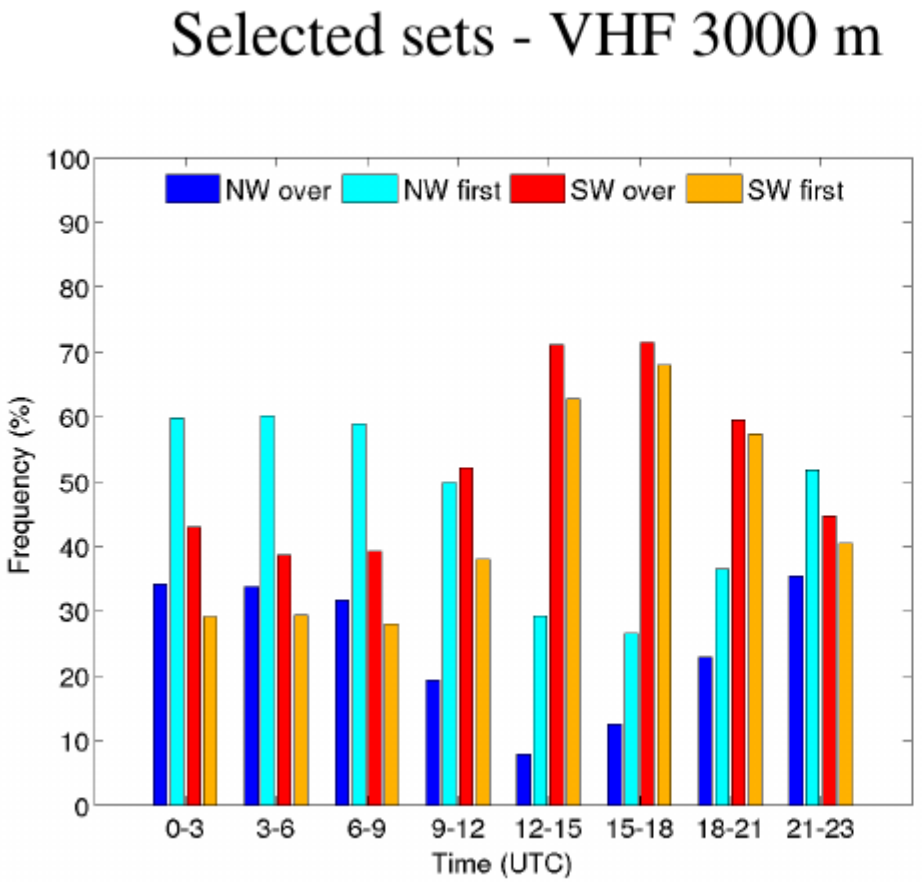


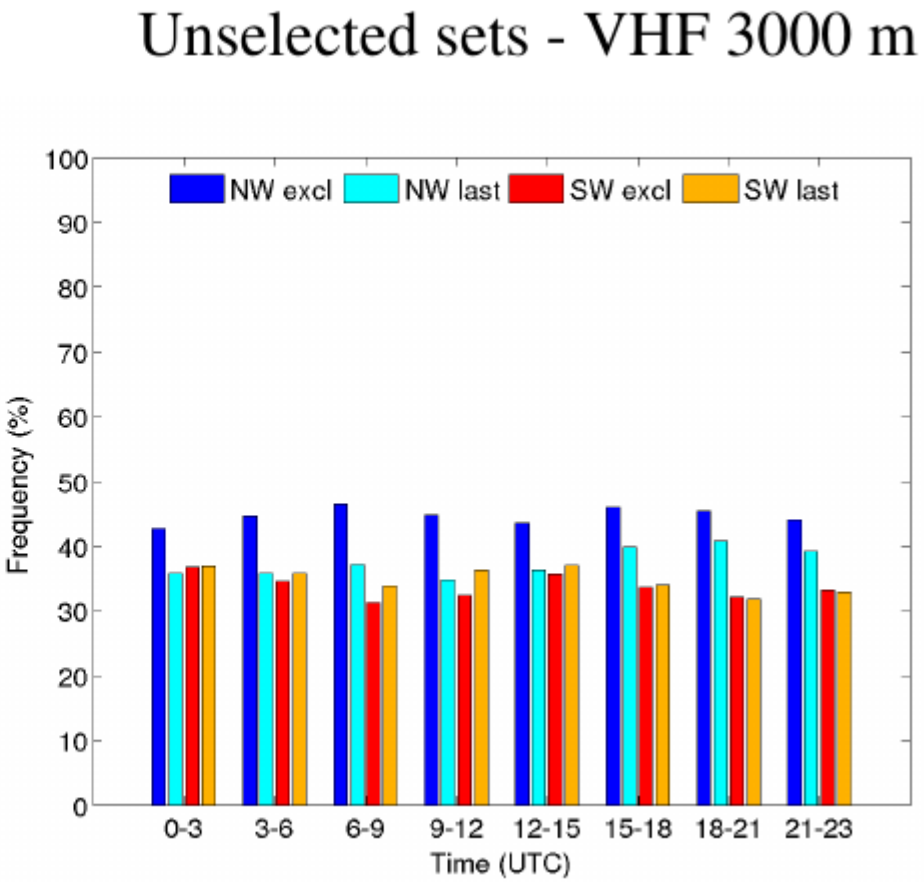
Method consistencies and differences

Diurnal cycles of wind direction **in altitude return flow** for ‘selected’ and ‘unselected’ days

Method 1 & Method 2 overlap
Method 3 first ranked days

Method 1 & Method 2 excluded days
Method 3 last ranked days





Method consistencies and differences

Diurnal cycles of wind direction **at surface at Pic du Midi** for ‘selected’ and ‘unselected’ days

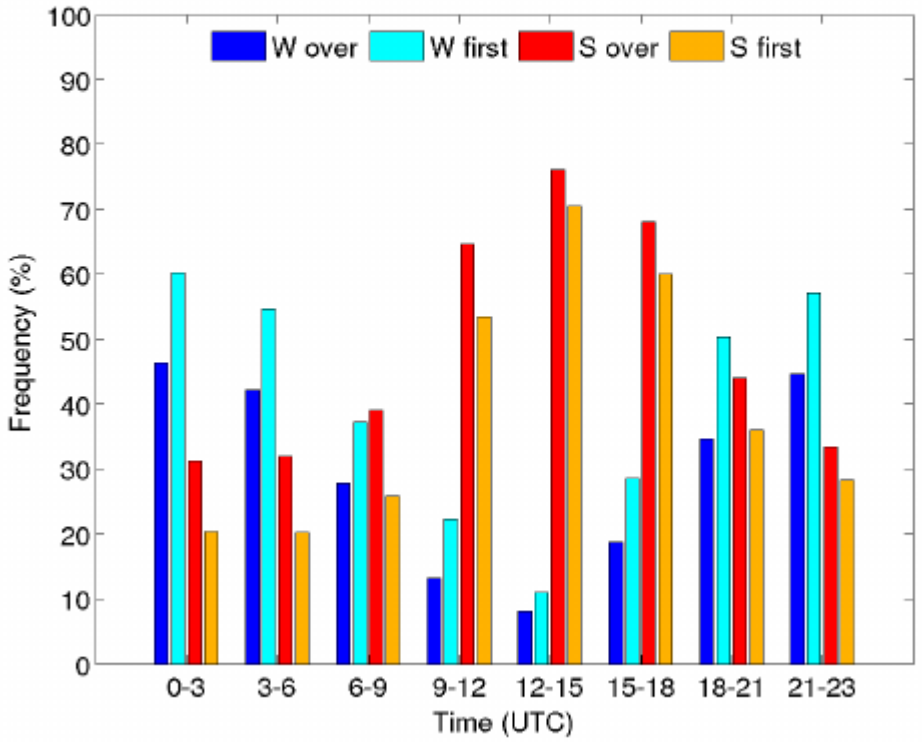
‘selected’

Method 1 & Method 2 overlap
Method 3 first ranked days

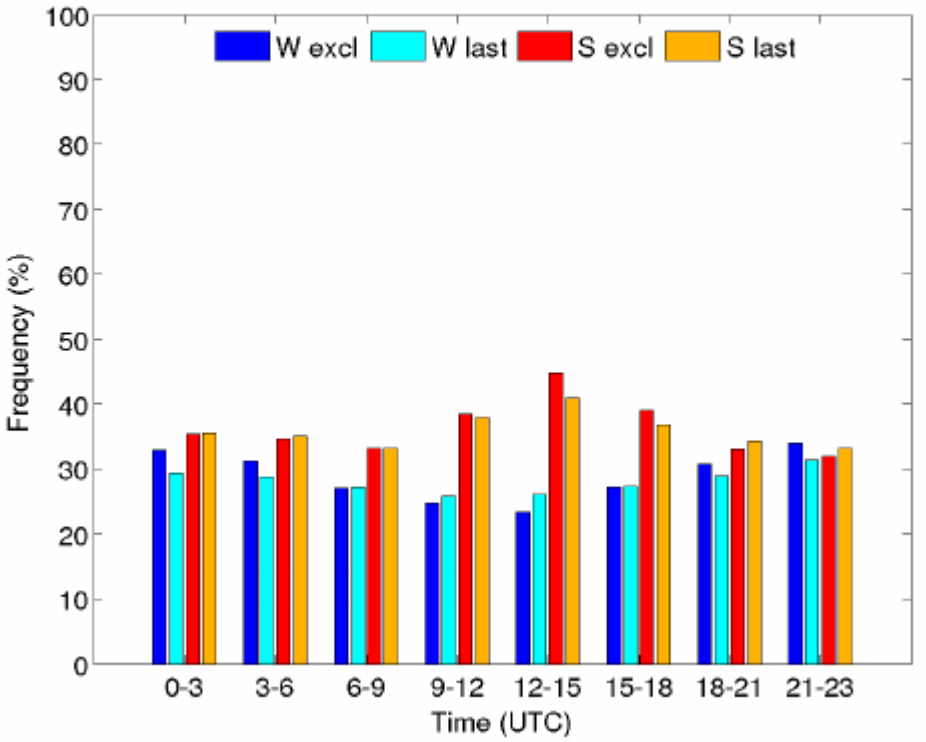
‘unselected’

Method 1 & Method 2 excluded days
Method 3 last ranked days

Selected sets - Surface PDM

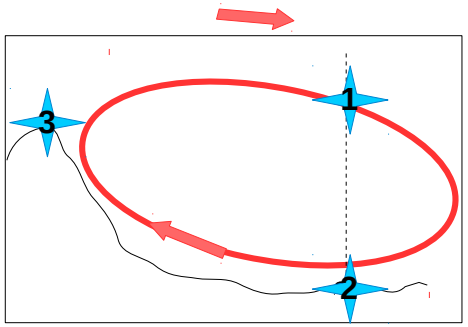


Unselected sets - Surface PDM



Impact on chemistry components at Pic du Midi

‘Selected ‘ days
‘Unselected’ days

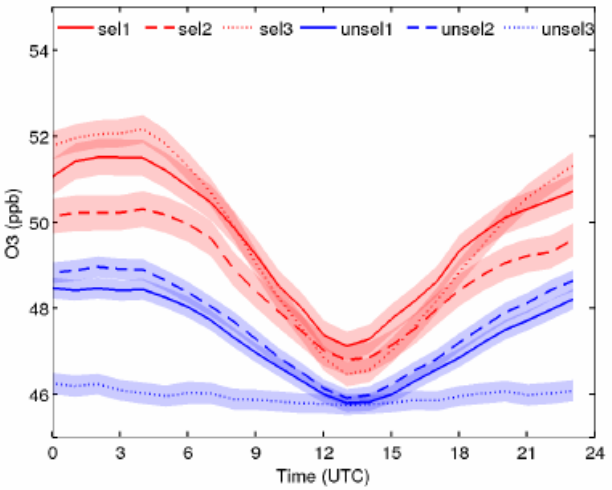


1 ——————

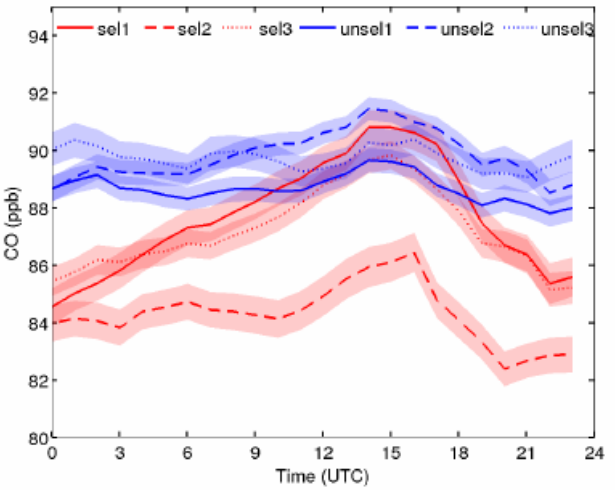
2 - - - - - - - - - - - - - - -

3 ....

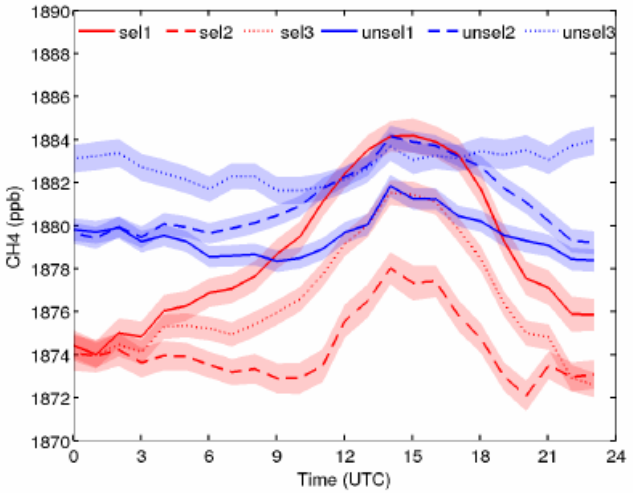
(a) Ozone



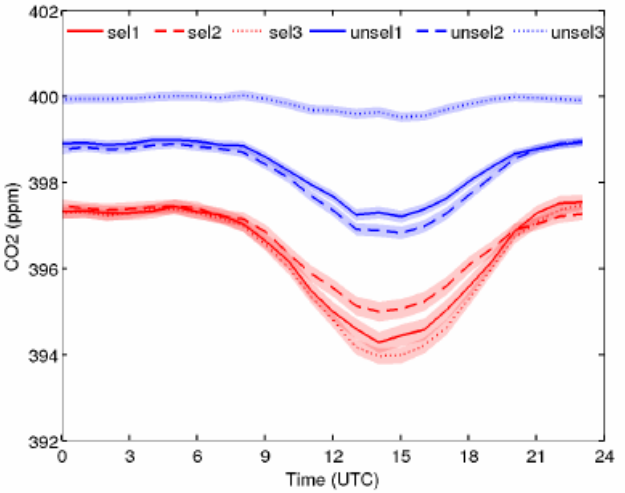
(b) Carbon monoxide



(c) Methane



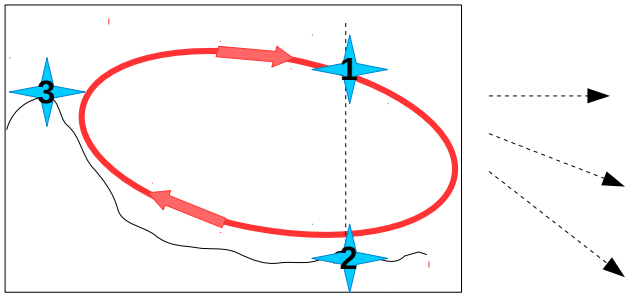
(d) Carbon dioxide

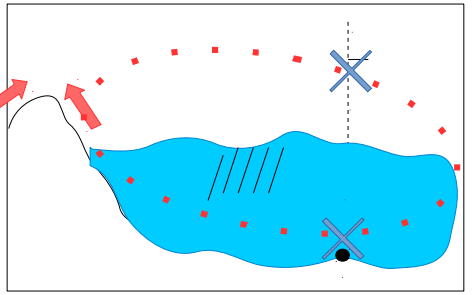


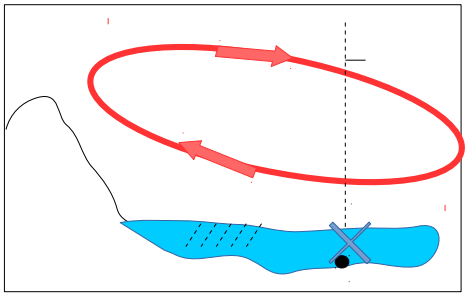
Conclusions and prospectives

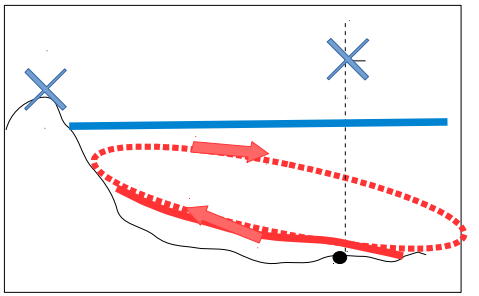
Three independent methods to detect the plain-mountain circulation cell

- show consistency together
- also reveal the local phenomena that can be observed independently









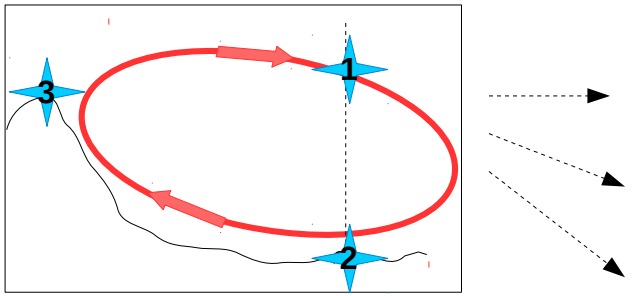
Pic du Midi : - variablity can be linked to very local circulations
- « easy » to observe a diurnal cycle on humidity

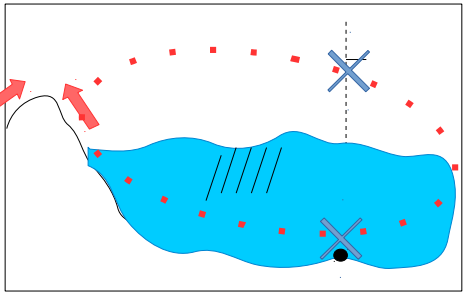
Breeze at CRA :
- can be disabled by moist low layers (→ circulation cell above)
- can be observed without local phenomenon at Pic du Midi nor return flow at 3000m

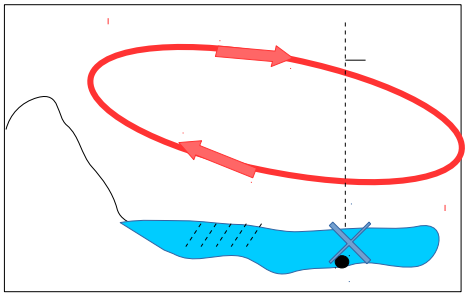
Altitude return flow from VHF : - remains difficult to detect

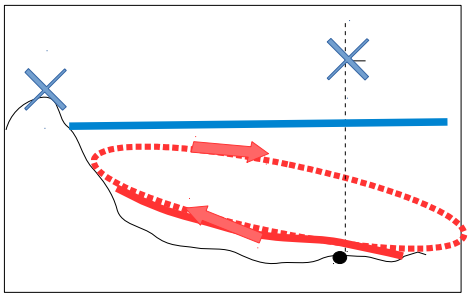
Conclusions and prospectives

Three independent methods to detect the plain-mountain circulation cell
- show consistency together
- also reveal the local phenomena that can be observed independently







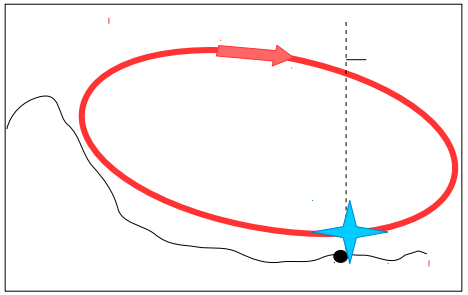


Prospectives :

- Use of Radon 22 at Pic du Midi
  (now measured since 2015)
- Test and cross with different methods
  of mountain breeze detection at CRA
- Understand those situations
  when the phenomena are observed separately

Thank you for your attention

Detection method (2/3)
Method 2 (surface wind at CRA)



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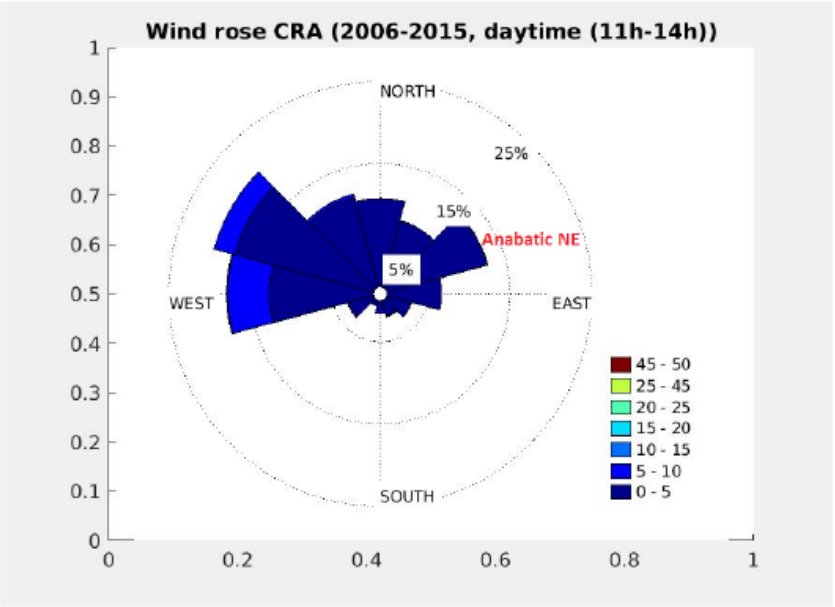
Daytime - Surface CRA



Nighttime - Surface CRA