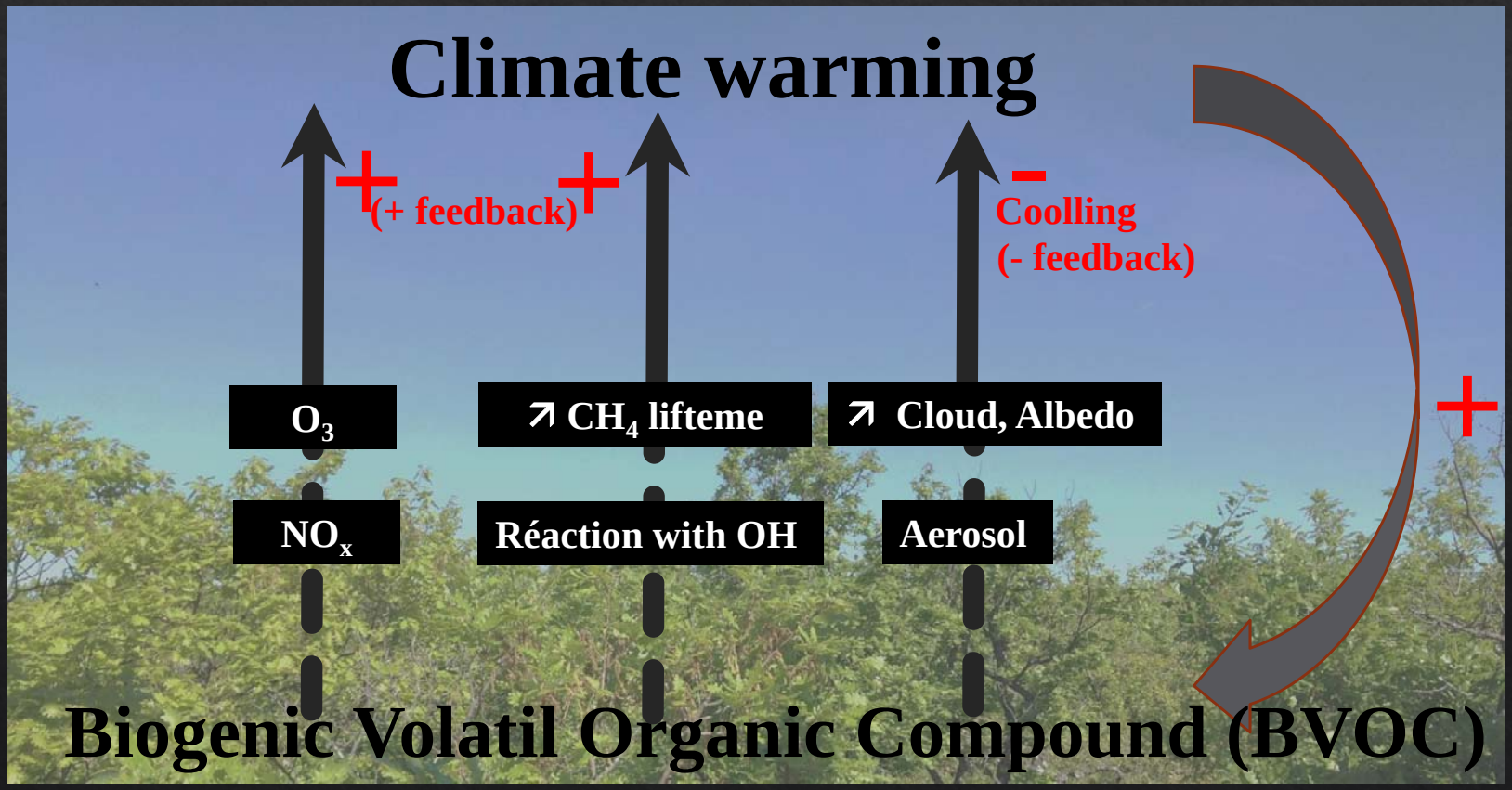
Réponse de la forêt à des scénarios de sécheresse appliqués à moyen et long termes en milieu naturel : étude des COVB du chêne pubescent, principal émetteur d'isoprène en région méditerranéenne

Thèse de Amélie Saunier soutenue le 16 mai 2016
Sous la direction de Catherine Fernandez & Elena Ormeño

Présentée par E Ormeno pour le CS d'Air PACA le 18 déc 2017

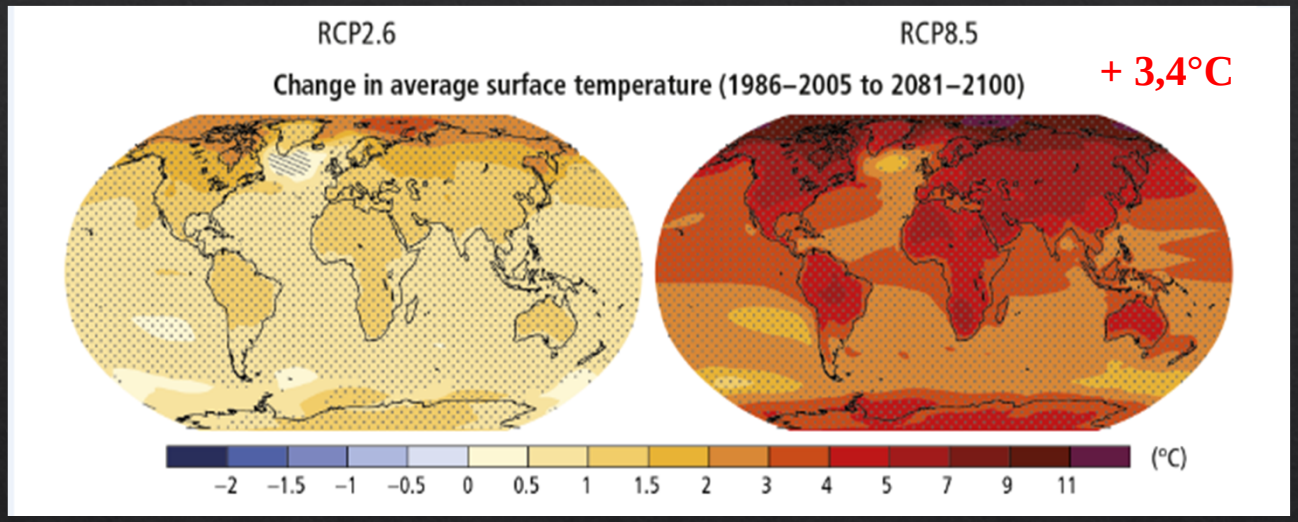
Climate change influences BVOC emissions with eventual impacts on atmospheric pollution and +/- feedbacks on climate

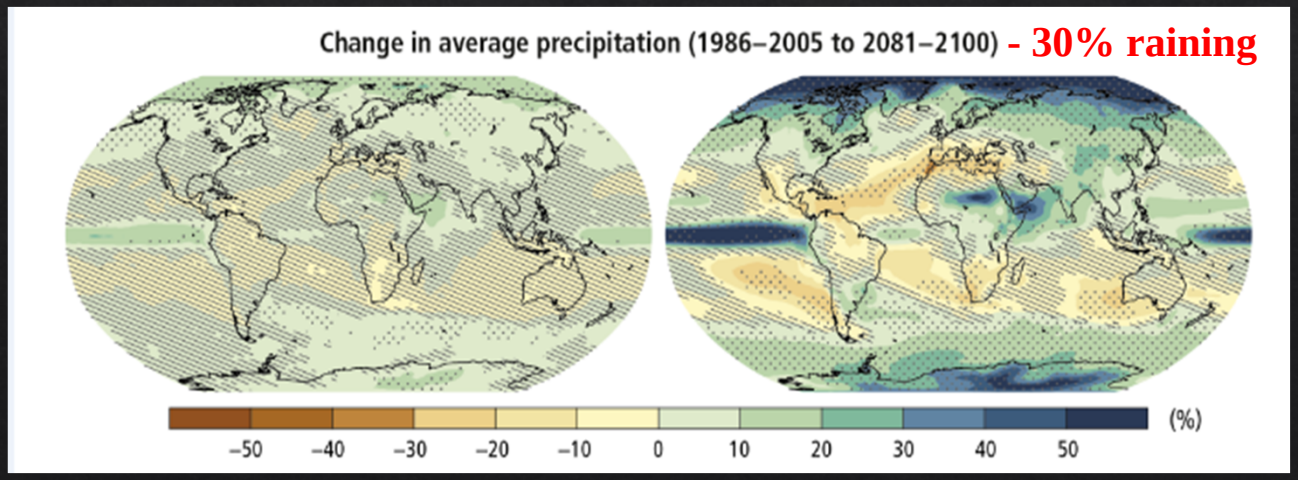


Plants release to the atmosphere 1- 30% of the CO_2 as BVOC

BVOC confer protection against stress (e.g. high temperatures

In the Mediterranean region, warming will be coupled to drought during summer





Giorgi and Lionello 2008 ; Somot et al, 2008 ; IPCC 2013

How aggravated and recurrent drought influences BVOC emissions *in situ* is only known for monoterpene emissions (*Quercus ilex*, Study performed at CEFE Montpelier).

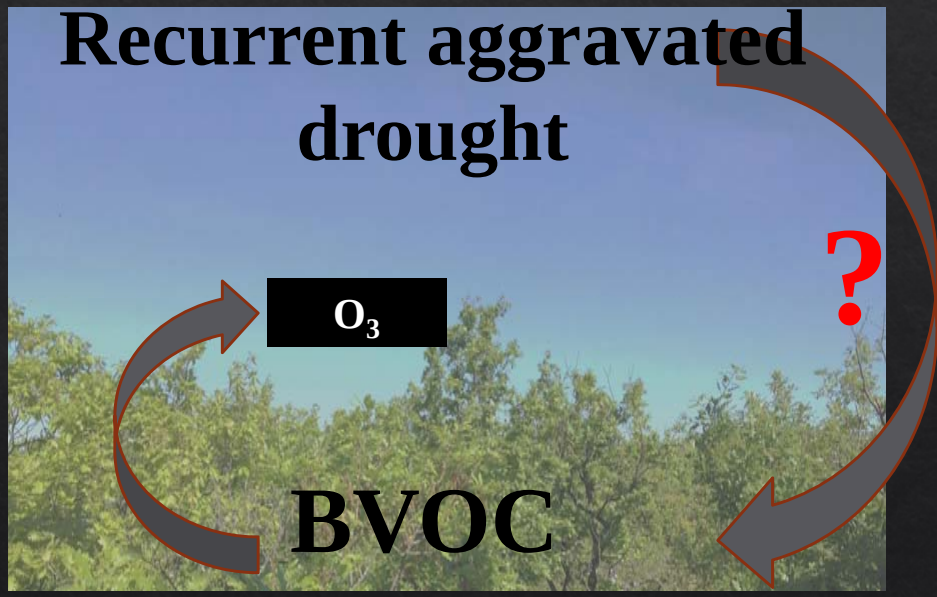
Objectifs

Evaluate the impact of **recurrent aggravated drought over years** on highly volatile BVOCs, in a highly representative Mediterranean forest.

- Isoprene but also <C5 volatiles,

In collaboration with LCE (Massalya)

- Downy oak forest (*Quercus pubescens*)



Estimate Downy oak contribution to O_3 formation at a regional scale under different drought scenarios.

- Collaboration with AIR PACA, LSCE.

Why Downy oak (*Quercus pubescens*) ?

- This decidous species occupies 2 millions ha in Europe and 418 000 ha in Southern France (especially PACA, Rhône-Alpes and Languedoc-Roussillon, Bonin & Romane, 1996)

- The highest isoprene emitter in the Mediterranrean area & the 2nd most important in Europe (Simon *et al*. 2005 ; Keenan et al. 2009, travaux de thèse d'Anne-Cyrielle Génard)

Occurrence of Downy oak in the North Mediterranean Bassin

Quézel and Médail, 2003

Occurrence of Downy Oak in France

Inventaire Forestier National

O_3HP : Oak Observatory at OHP

- Experimental study with a rain exclusion system that allowed to remove ~30% natural rain (33-35%) since may 2012.
- Two plots : natural drought plot & recurrent drought plot

Rain exclusion roof

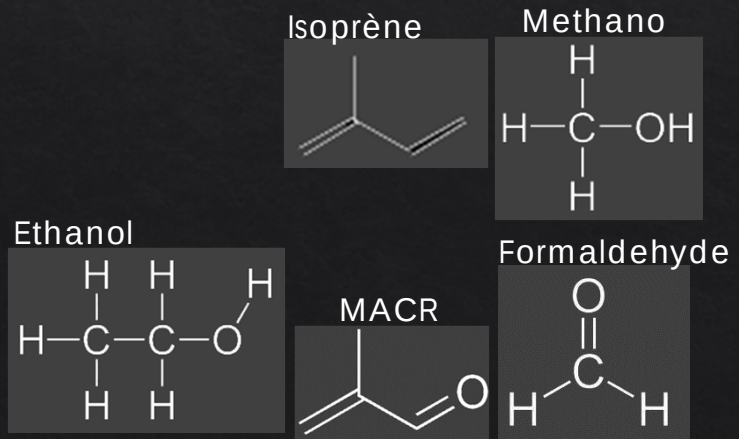
Corridors to avoid soil disturbance

Measurements over the seasonal cycle (3 times/year)

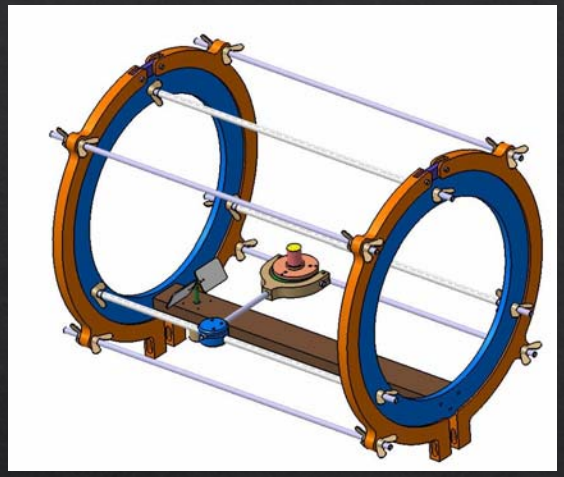
- 3th year of recurrent drought => humid year (2014)
- 4th year of recurrent drought => dry year (2015)

On-line BVOC emissions PTR-ToF-MS (screening 10 < m/z < 500), in collaboration with LCE-MASSALYA (B. Temime-Roussel, H Wotham)

- Isoprene
- Isoprene degradation productis (MVK, MACR, ISOPOOH)
- Methanol
- Formaldehyde
- Acetaldehyde
- Acetone



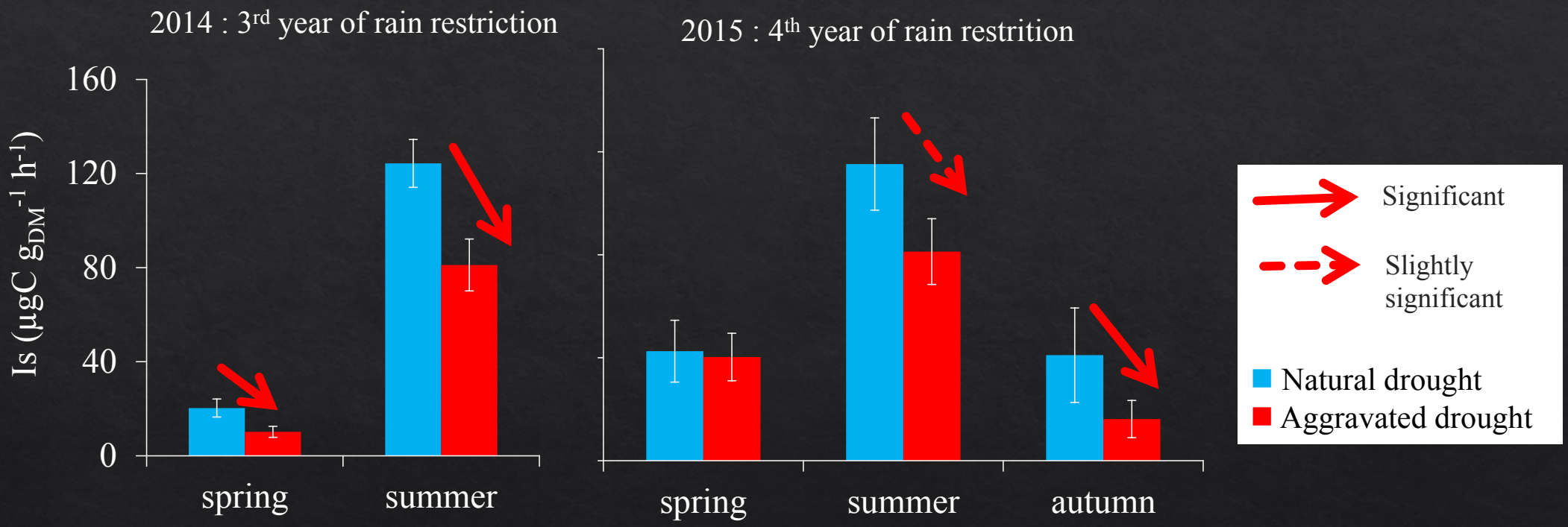
Dynamic chambre enclosures



Collaboration with UMS OHP LSCE

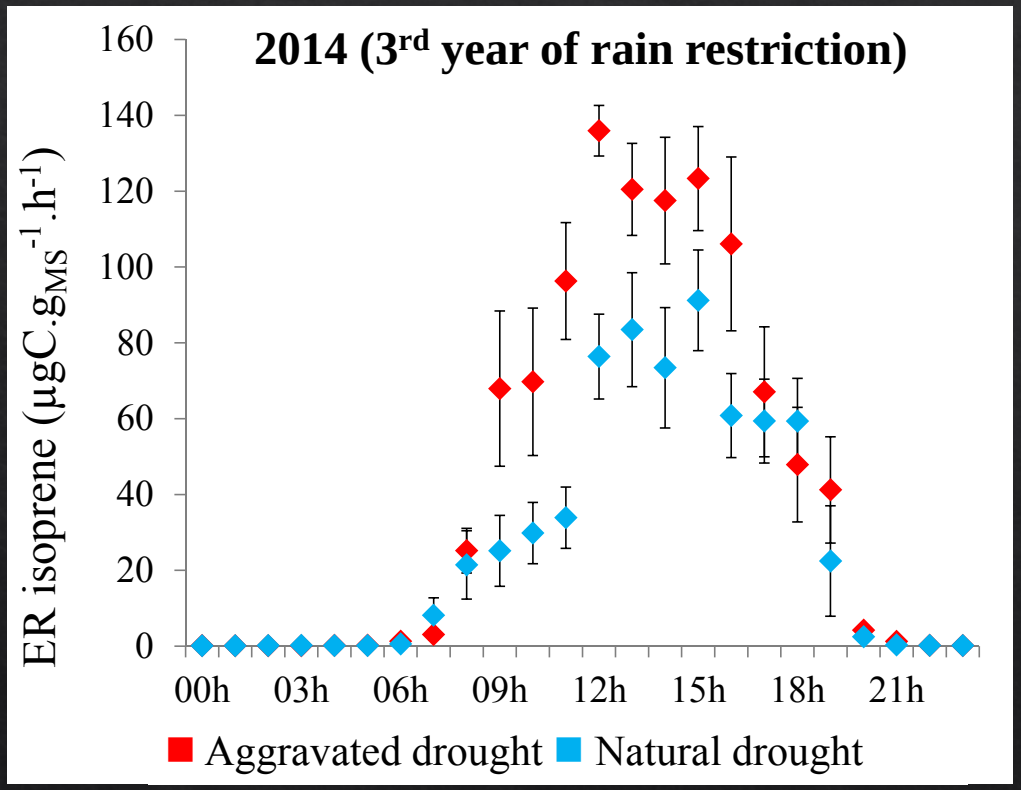
Programs that have allowed to build up these chambers (chronological order):
ANR CANOPEE (2010-2013)
EC2CO-ICRAM (2012)
ANR-Sec-Prime (2012-2017)

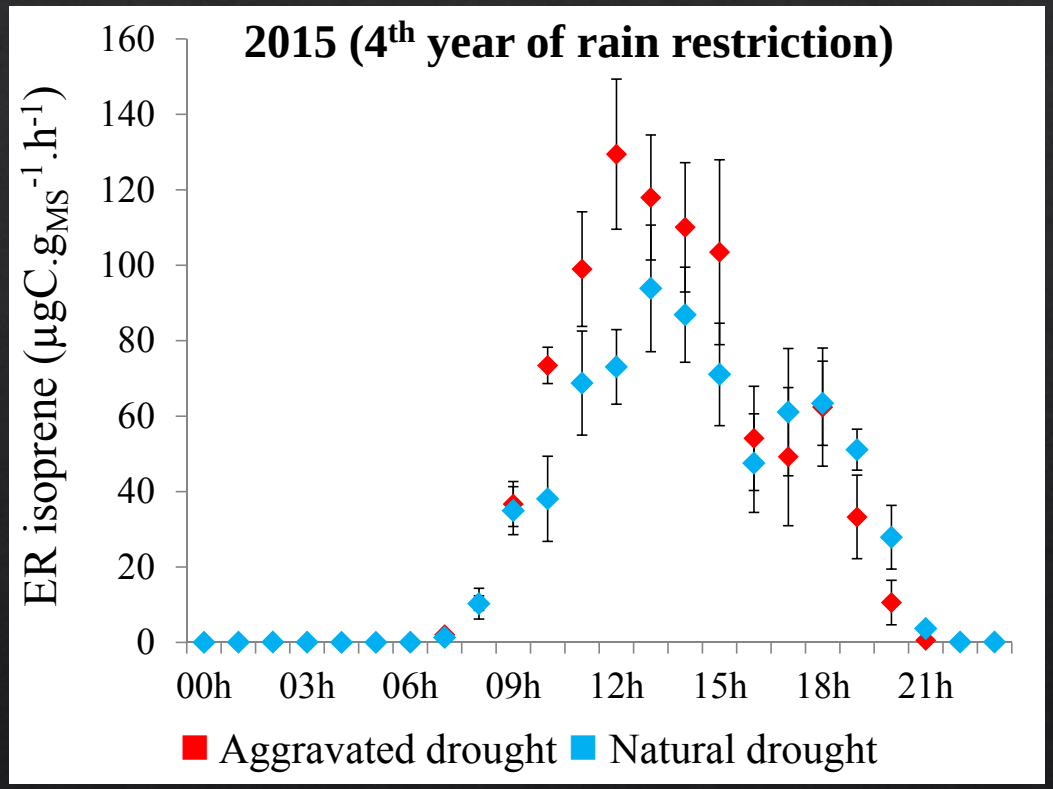
Seasonal course of isoprene emissions under recurrent aggravated drought and natural drought



- Very high emission rate of Downy oak → Is = 120 µgC.gDM^{-1}.h^{-1}
- Isoprene emission reduction under recurrent aggravated drought (80 µgC.gDM^{-1}.h^{-1}) → **SCENARIO DOWN**
- Similar isoprene emission rates in 2014 and 2015 despite the higher dryness in 2015

Daily course of isoprene emissions in summer under recurrent aggravated drought and natural drought

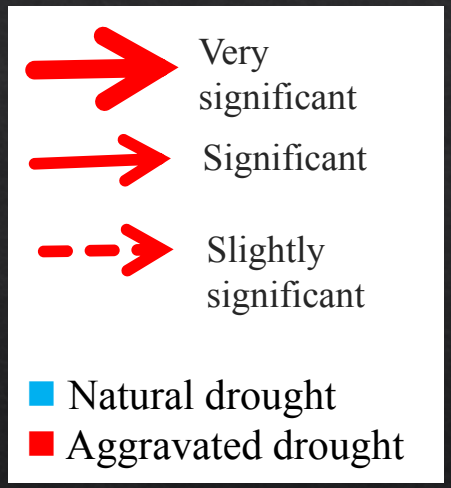




- Significant isoprene emission reduction under recurrent aggravated drought

Opposite results during some months of the 1st year of rain restriction (2012-2013, PhD AC Genard)

Figure under review



- Significant isoprene emission increase in August under recurrent aggravated drought → **SCENARIO UP**

What are the consequences of drought – related isoprene changes on O_3 : modelling approach

Collaboration with AIR PACA, O_3 assessment in PACA using CHIMERE

Period for assessing $[isoprene]_{atm}$ and O_3 : été 2003 (heat-wave + high O_3)

3 scenarios :

Scenario REF

EF ~68 $\mu gC.g_{MS}^{-1}.h^{-1}$ (MEGAN)

Scenario UP

reflects the ↗isoprene under short term rain restriction

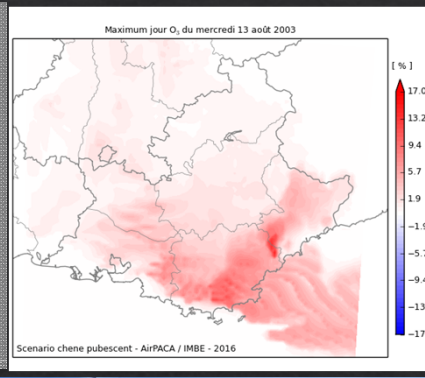
+83% (August data in 2012, EF~140, AC Genard PhD, Biogeosciences under review)

-Scenario DOWN

reflects the ↘ isoprene under recurrent rain restriction

+ 26% (July data 2014, Saunier et al., Frontiers in Plant Science 2017)

ATMOSPHERE



ATMOSPHERE

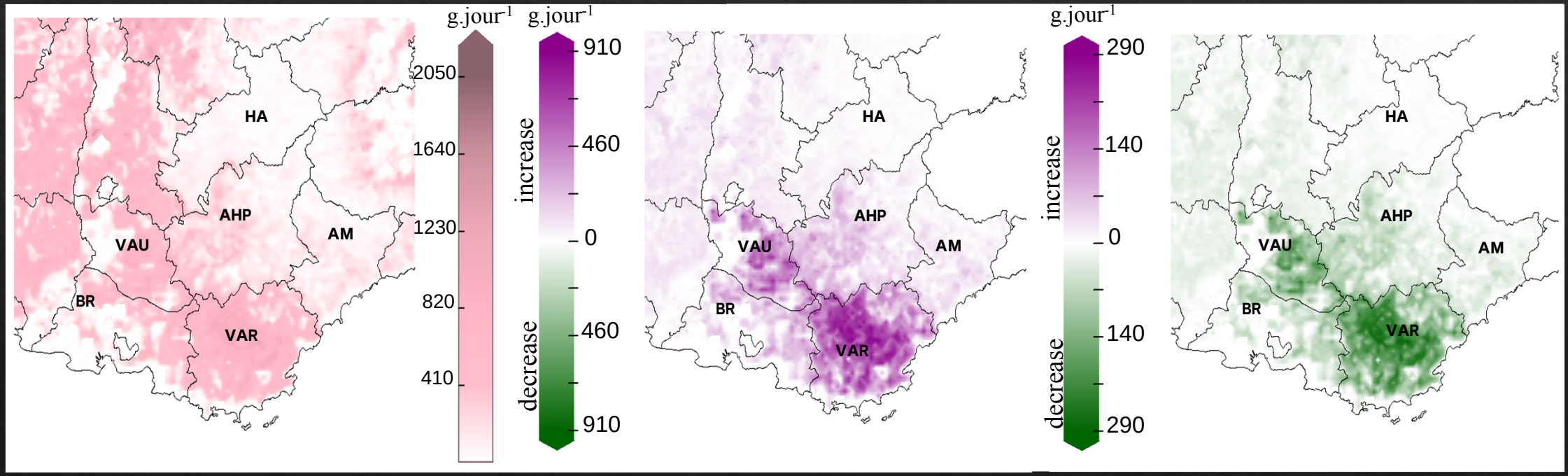
INDIVIDU

Assessing Downy oak contribution to atmospheric isoprene in the PACA region under different drought scenarios

REF (natural drought)

Scenario UP (aggravated drought for 1 year or short-term)

Scenario DOWN (aggravated drought for 3-4 years , longer term)



HA = Hautes Alpes, AHP = Alpes de Haute Provence,
VAU =Vaucluse, VAR = var, AM = Alpes Martimes
BR = Bouches du Rhône

↗ $[isoprene]_{atm}$

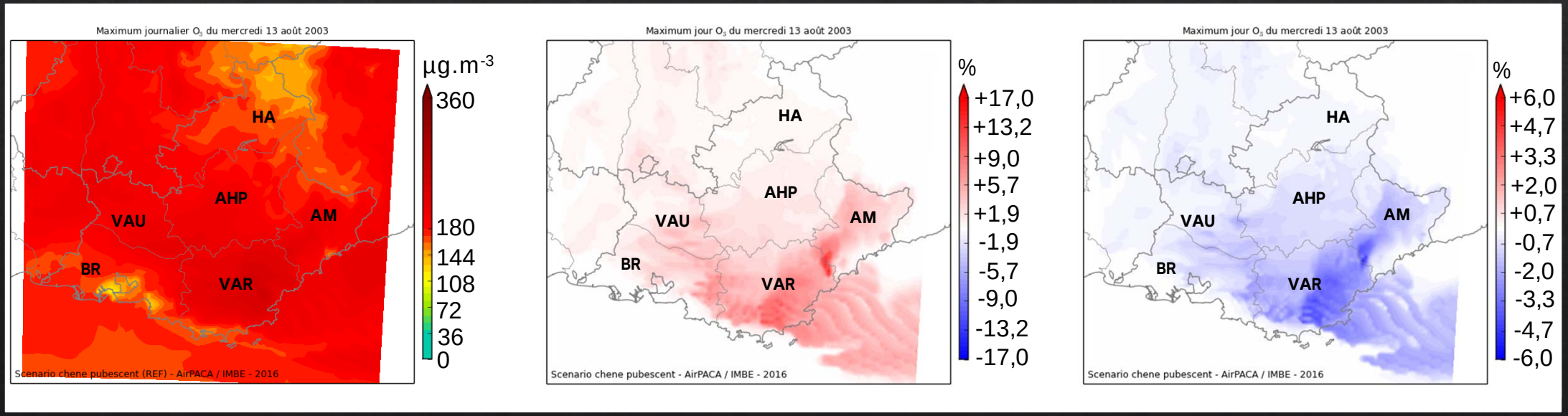
↘ $[isoprene]_{atm}$

Consequences for Downy oak contribution to O_3 in the PACA region under different drought scenarios

REF (natural drought)

Scenario UP (aggravated drought for 1 year (short-term)

Scenario DOWN (aggravated drought for 3-4 years , long-term)



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BR = Bouches du Rhône

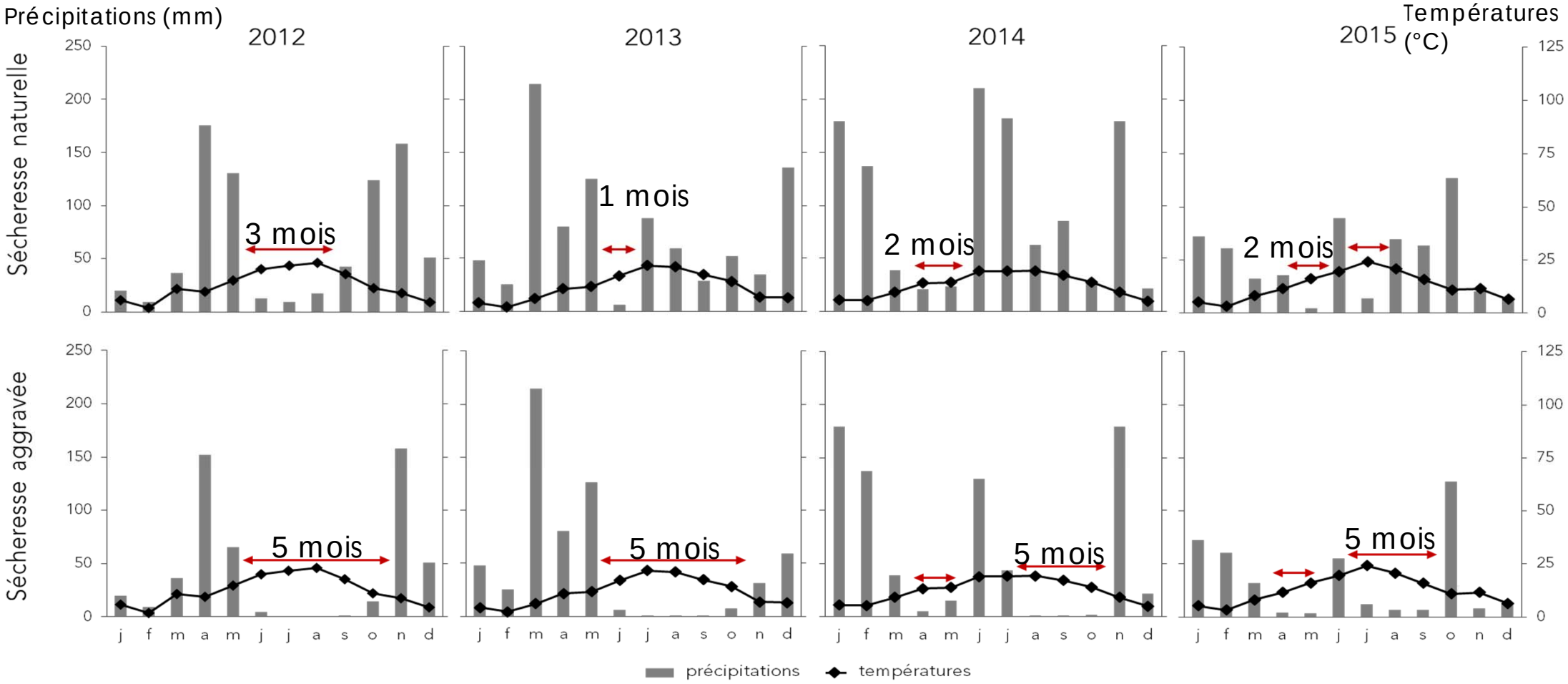
↗ $[O_3]_{atm}$

↘ $[O_3]_{atm}$

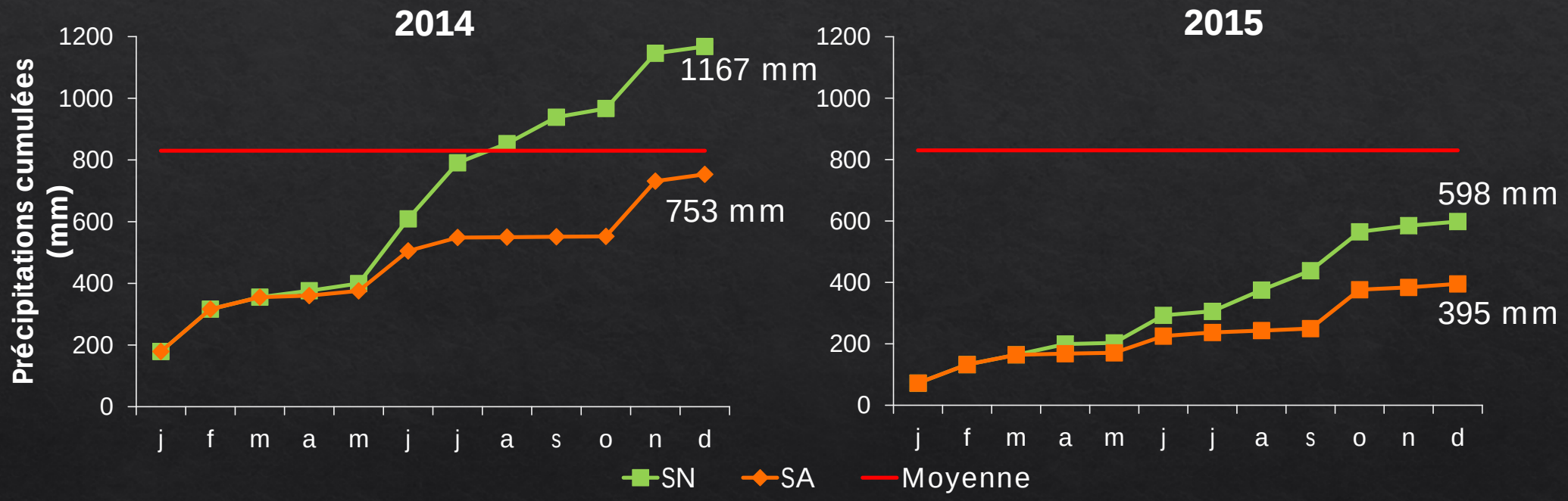
- Isoprene emissions are highly dependent on drought, with changes varying with drought intensity , season and time scale.
- Ponctual and recurrent drought modifies the global O_3 budget in the PACA Region, with opposite results.
- Ongoing modelling in collaboration with AIR PACA is necessary in order to model O_3:
  - taking into account the real emission factor of Downy oak under natural drought since: actual EF~68, while real EF_{summer} ~ 80 µgC g_{DM}^{-1} h^{-1} in 2012 and 120 µgC g_{DM}^{-1} h^{-1} in 2014& 2015
  - integrating the seasonal course of isoprene emissions
  - during periods different than 2003
  - including maps abouts background O_3 pollution (O_3 > 120 µg.m^{-3}.$8h^{-1}$) and peak O_3 (µg.m^{-3}.h^{-1})
  - regular meetings with AIR PACA (A Armangaud, D Piga) (every 6 months)


Thanks for your
attention

➢ Diagrammes ombrothermiques :



➢ Précipitations cumulées :



Moyenne précipitations = 830 mm
(calculée sur la période 1967-2000)

2014 = année humide
2015 = année sèche

Santonja *et al.* (2015); Saunier *et al.*