KASCADE

DE LA RECHERCHE À L'INDUSTRIE

cea

CADARACHE

LA

LABORATOIRE D'AÉROLOGIE

Down-valley winds in stable stratification – results from the KASCADE field experiment

Gert-Jan Duine[1,2]

Pierre Durand[1], Thierry Hedde[2], Pierre Roubin[2], Peter Kalverla[2,3], Gert-Jan Steeneveld[3]

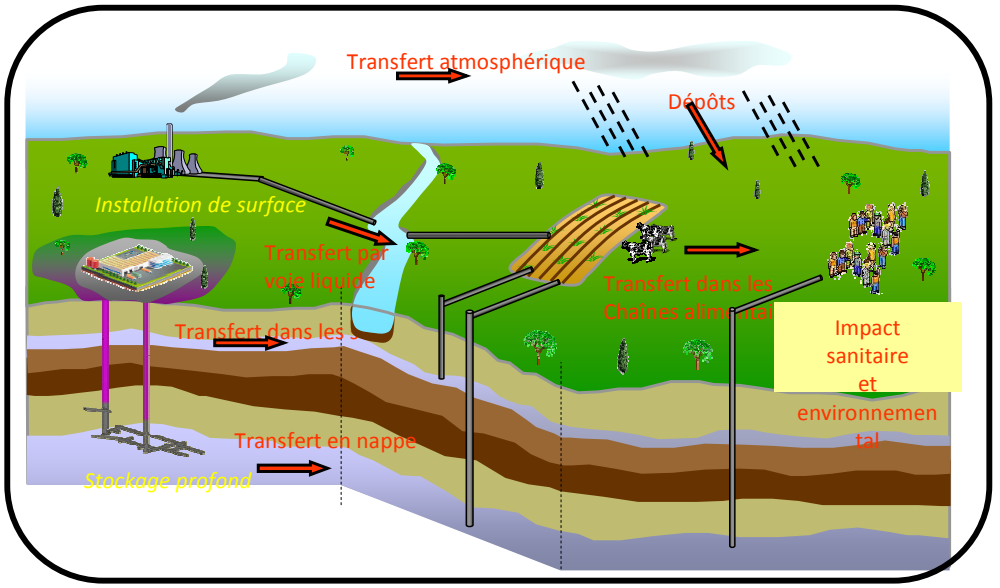
1: Laboratoire d'Aérologie, Université de Toulouse

2: LMTE, CEA Cadarache

3: MAQ, Wageningen University

BLLAST workshop, WUR, 9 February2016

Context



LMTE:

Laboratoire de Modélisation des Transferts dans l'Environnement

Reference unit for impact calculations CEA

(Atmospheric, hydrologic and soil environments)

CEA: Atomic Energy Agency

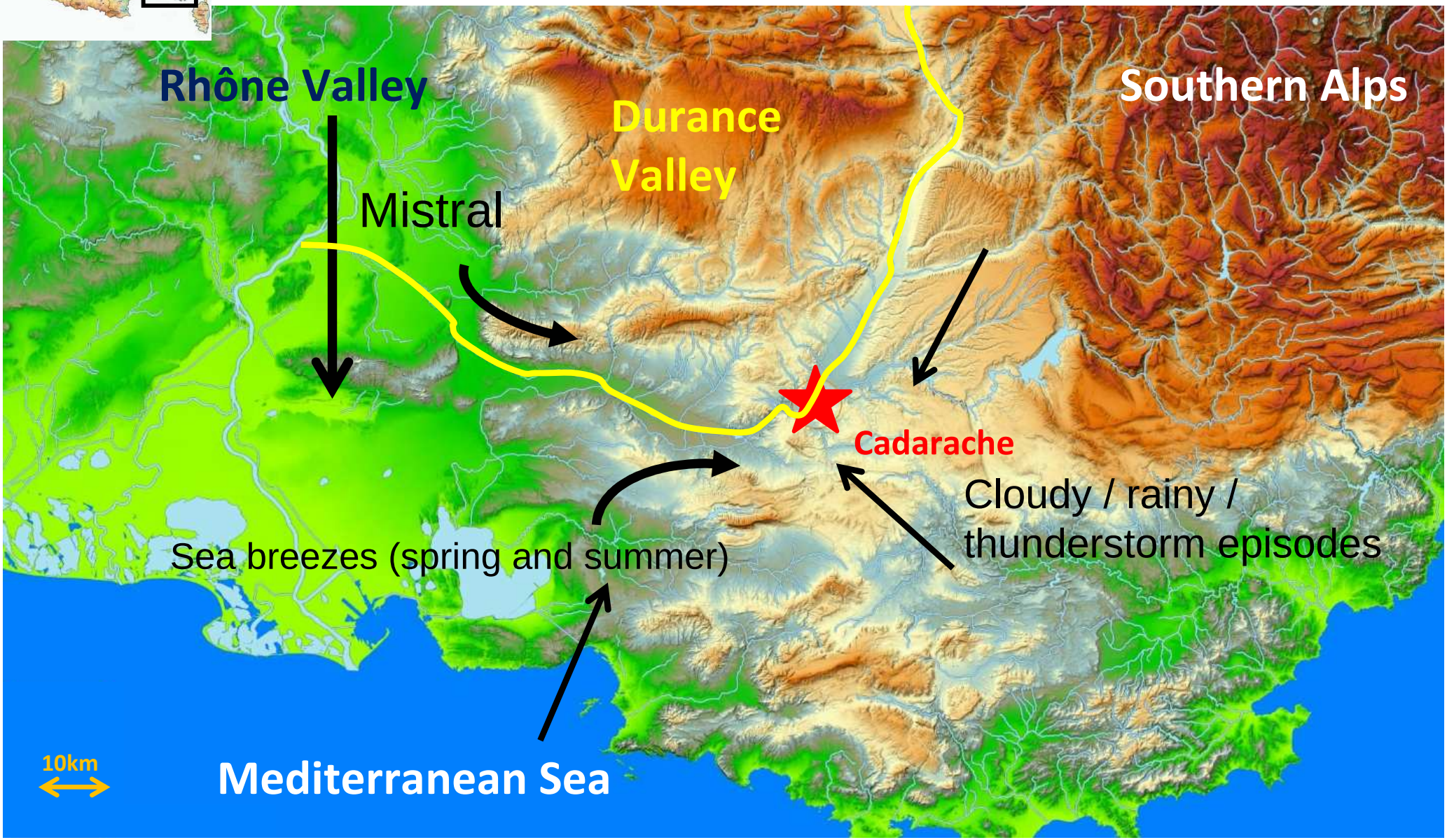
- Radiological and chemical contaminants
- Chronical and accidental releases

Critical knowledge for atmospheric environment:

- Boundary layer processes
- Atmospheric dispersion

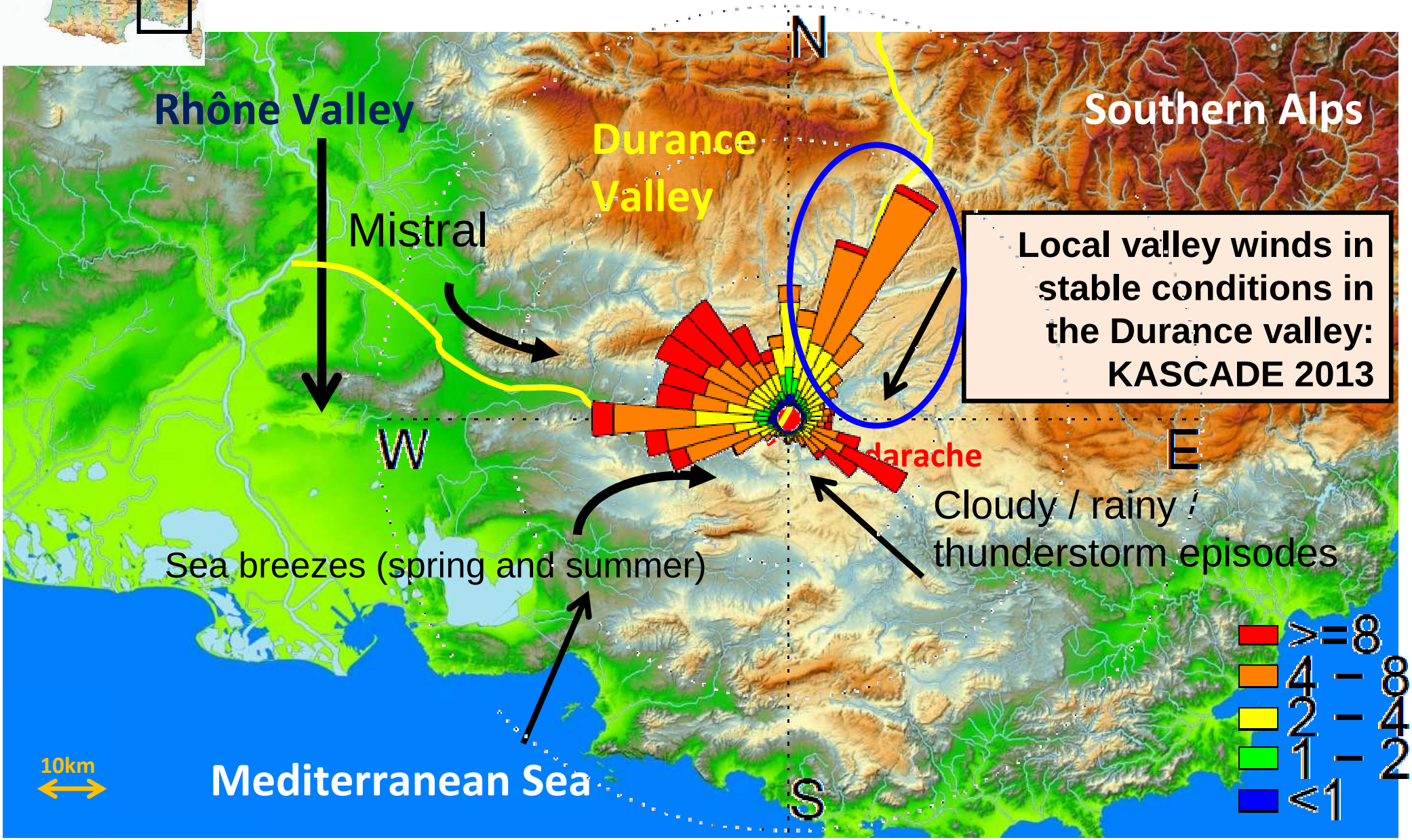
Study area: the Provence

- Large variety in orography and land use
- Influences of different synoptical and local meteorological events

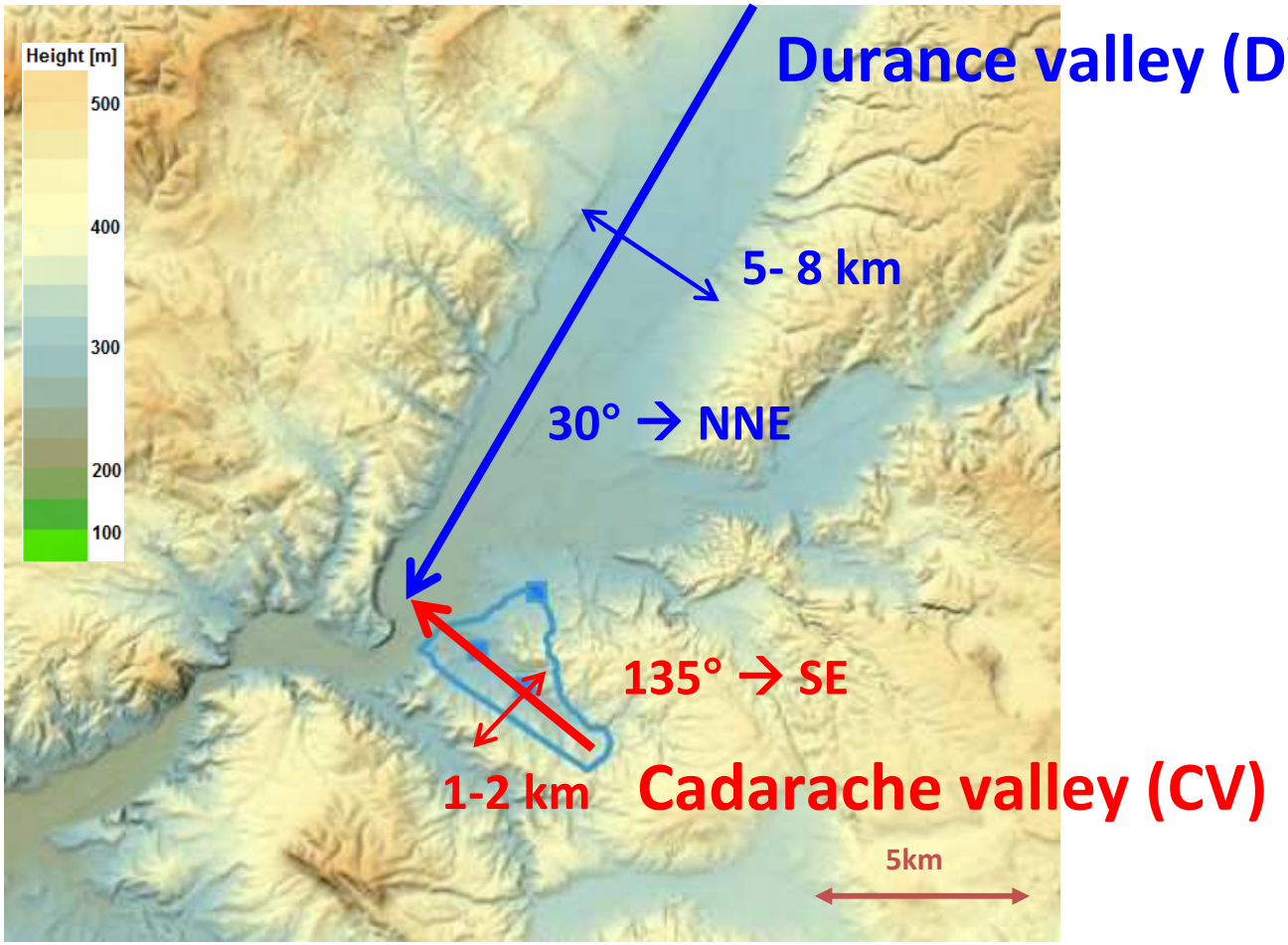


Study area: the Provence

- Large variety in orography and land use
- Influences of different synoptical and local meteorological events



Two distinct valleys



- Shallow valleys (100 – 200 m deep)
- Weak slopes (**CV: 1.2°** and **DV: 0.2°**)
- Both valleys modify differently **local winds** and consequently the **dispersion**

KASCADE winter of 2013

KAtabatic winds and **S**tability over **CA**darache for the **D**ispersion of **E**ffluents

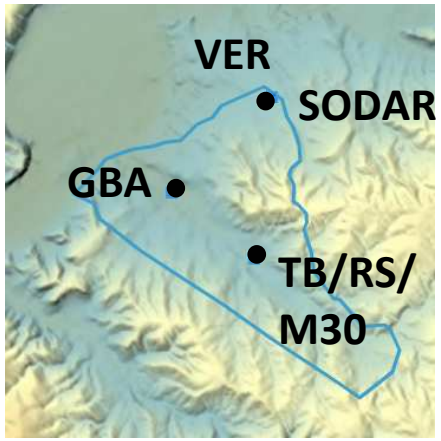
Continuous observations (Dec. 2012 – Mar. 2013):

- 3 meteorological stations (GBA, VER, M30)
- Sodar

Intensive observation periods (IOPs):

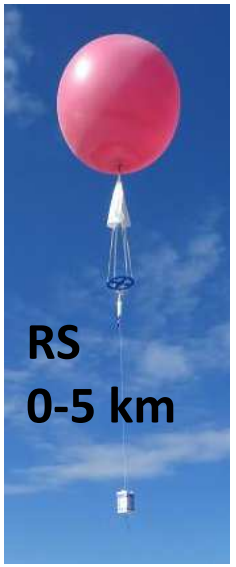
- Tethered balloon sessions
- Radio-soundings

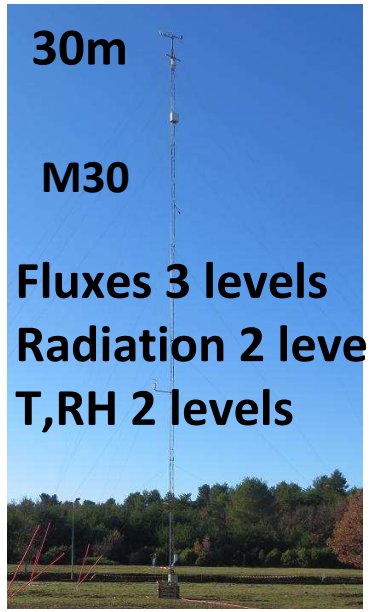
KASCADE



Goals:

- Needed to describe processes related to stability:
  - Characterize atmospheric stability over Cadarache
  - Characterize winds in Cadarache and Durance valleys
- Improve prognostic modeling





Why stability?

- High occurrence with high potential risk
- Turbulence → complex interplay and smaller scales

During winter: Longer nights, weaker solar insolation → higher chance of observing stability and its consequences

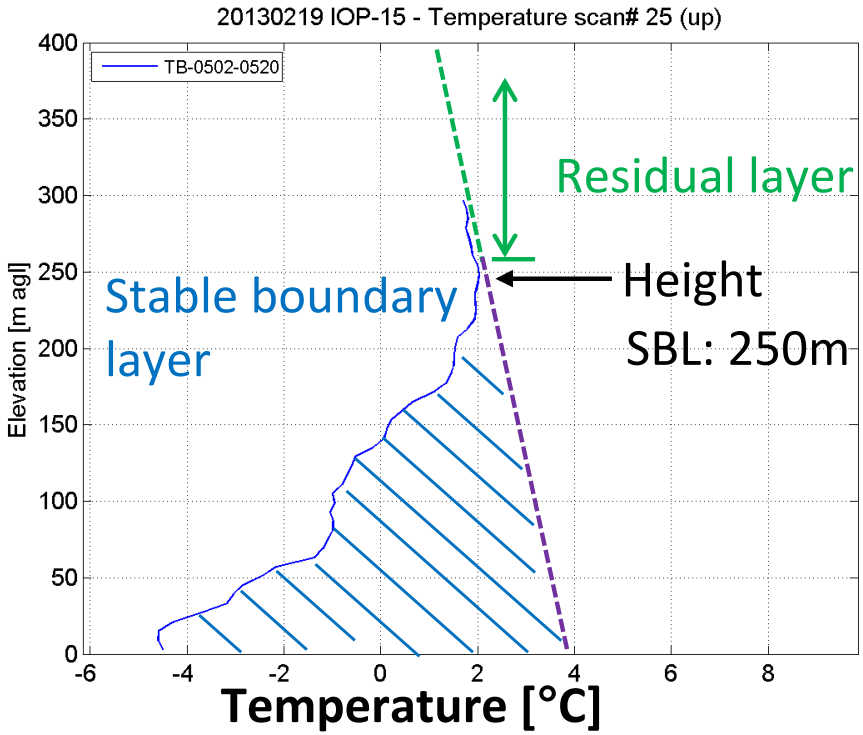
From 14 January 2013 to 02 March 2013:
- 23 IOPs in total, focus around sunset- and sunrise transitions
- 760 TB soundings, 61 radio-soundings

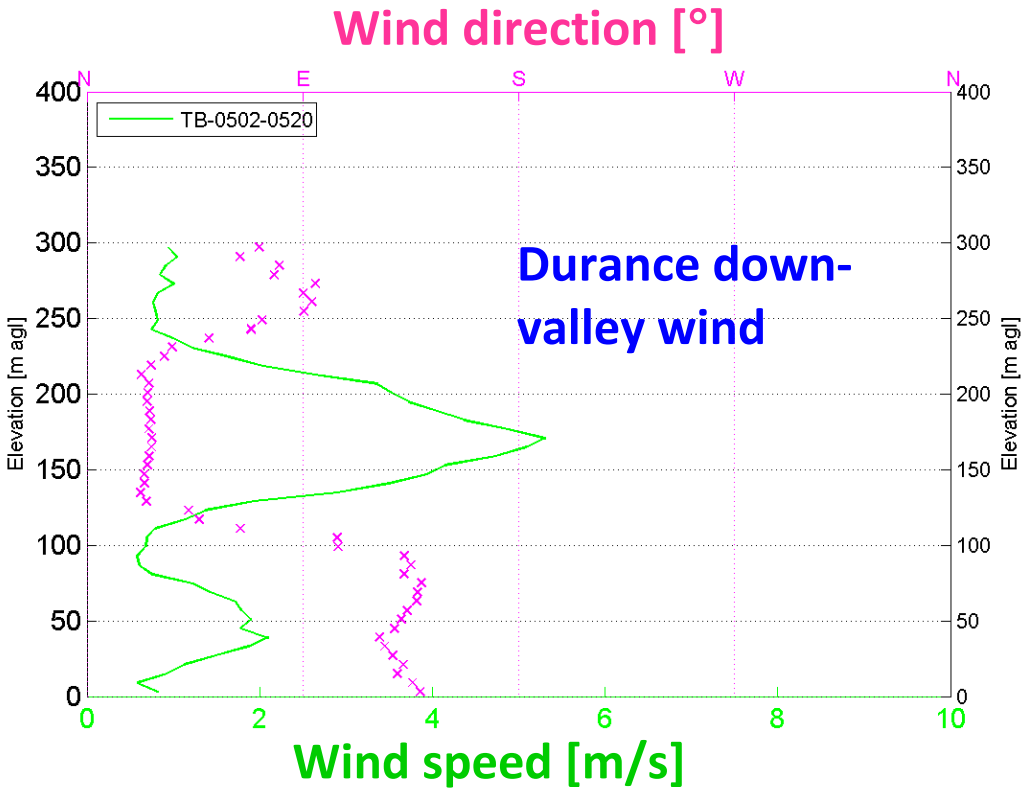
Intercomparison and sensor corrections:

G. Duine (2014), *KASCADE 2013 Instruments Calibration Campaign*, CEA Technical report

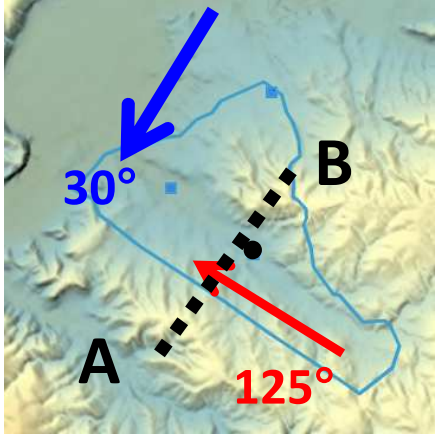
In the vertical

Before sunrise: IOP 15 at 05:00 UTC

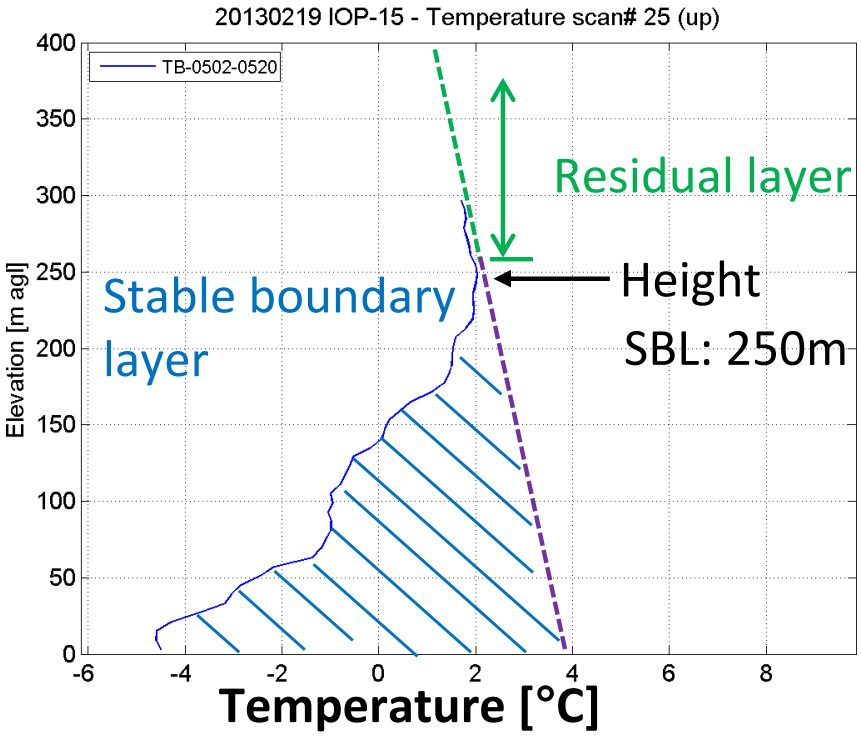


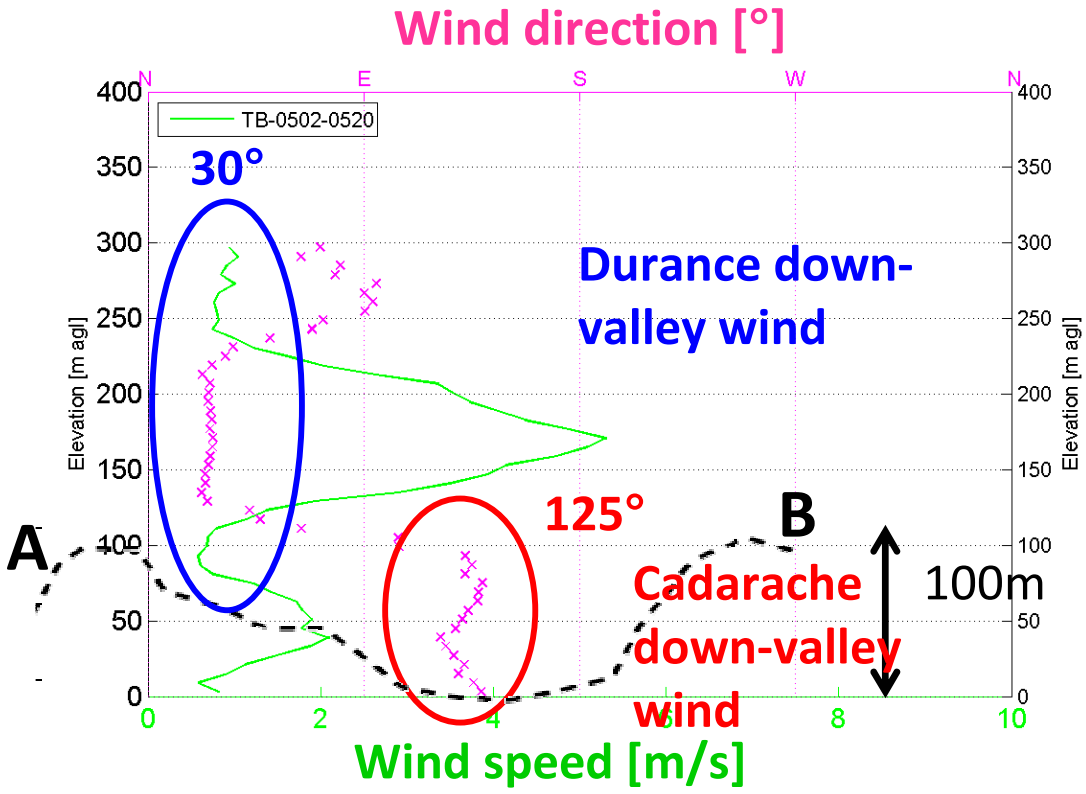


In the vertical



Before sunrise: IOP 15 at 05:00 UTC

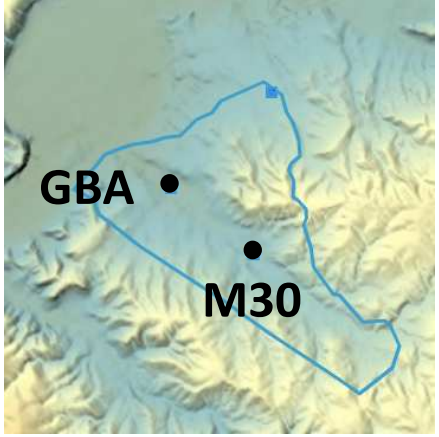


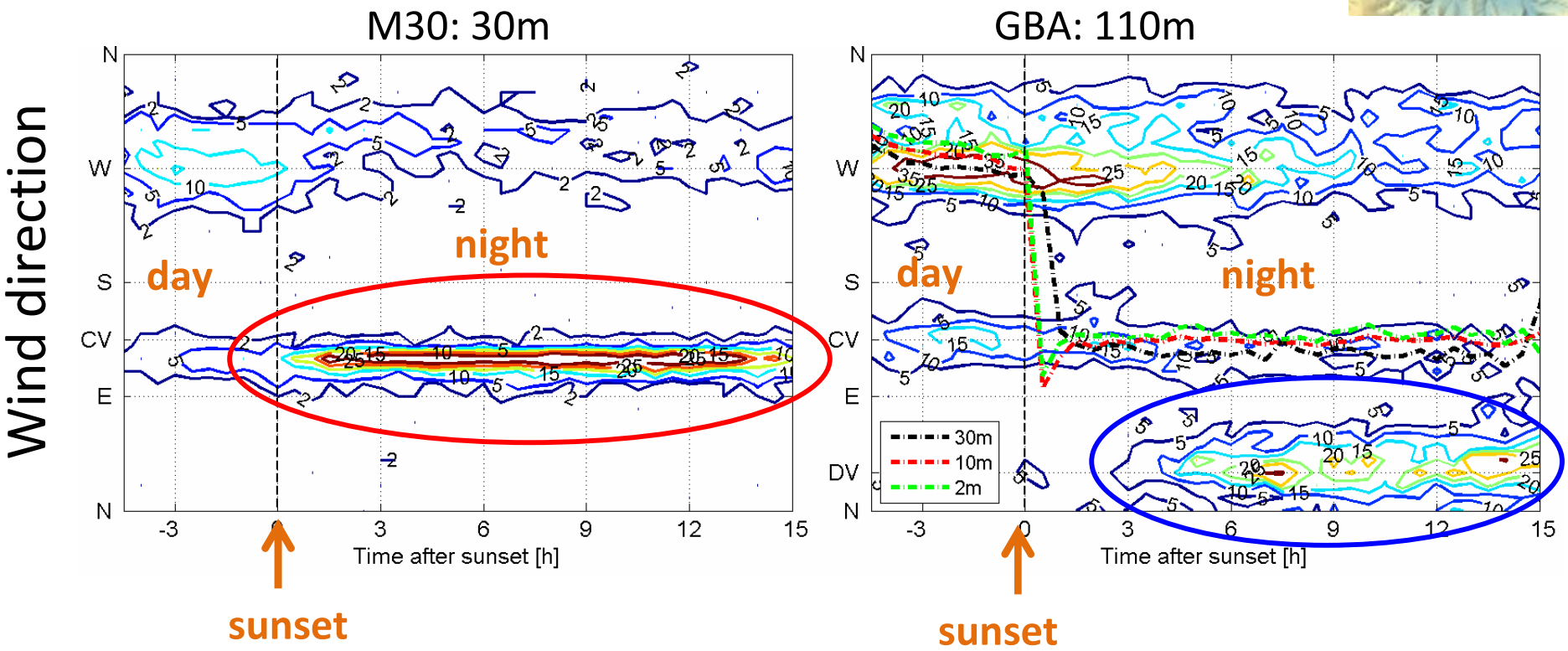


- **1 - 4 m/s**
- **Restricted to valley depth**

Timing of flows: onset

Full KASCADE climatology:
Data from 13/12/2012 to 18/03/2013





Cadarache down-valley (CDV) wind

Short response time (< 1 hr)

Durance down-valley (DDV) wind

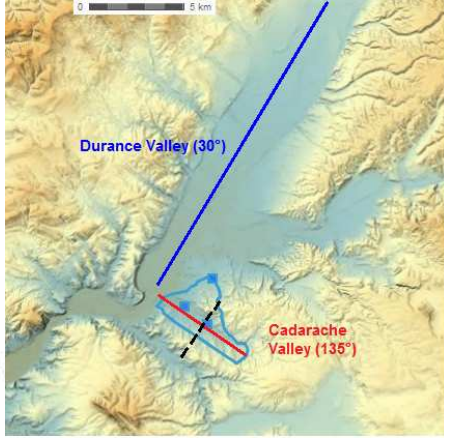
Long response time (3-9 hrs)

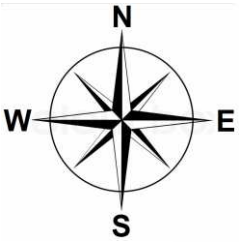
Timing cessation of same order

(Based on ensemble of 22 IOPs of KASCADE)

Valley wind phenomenology

under weak synoptic forcing and clear skies

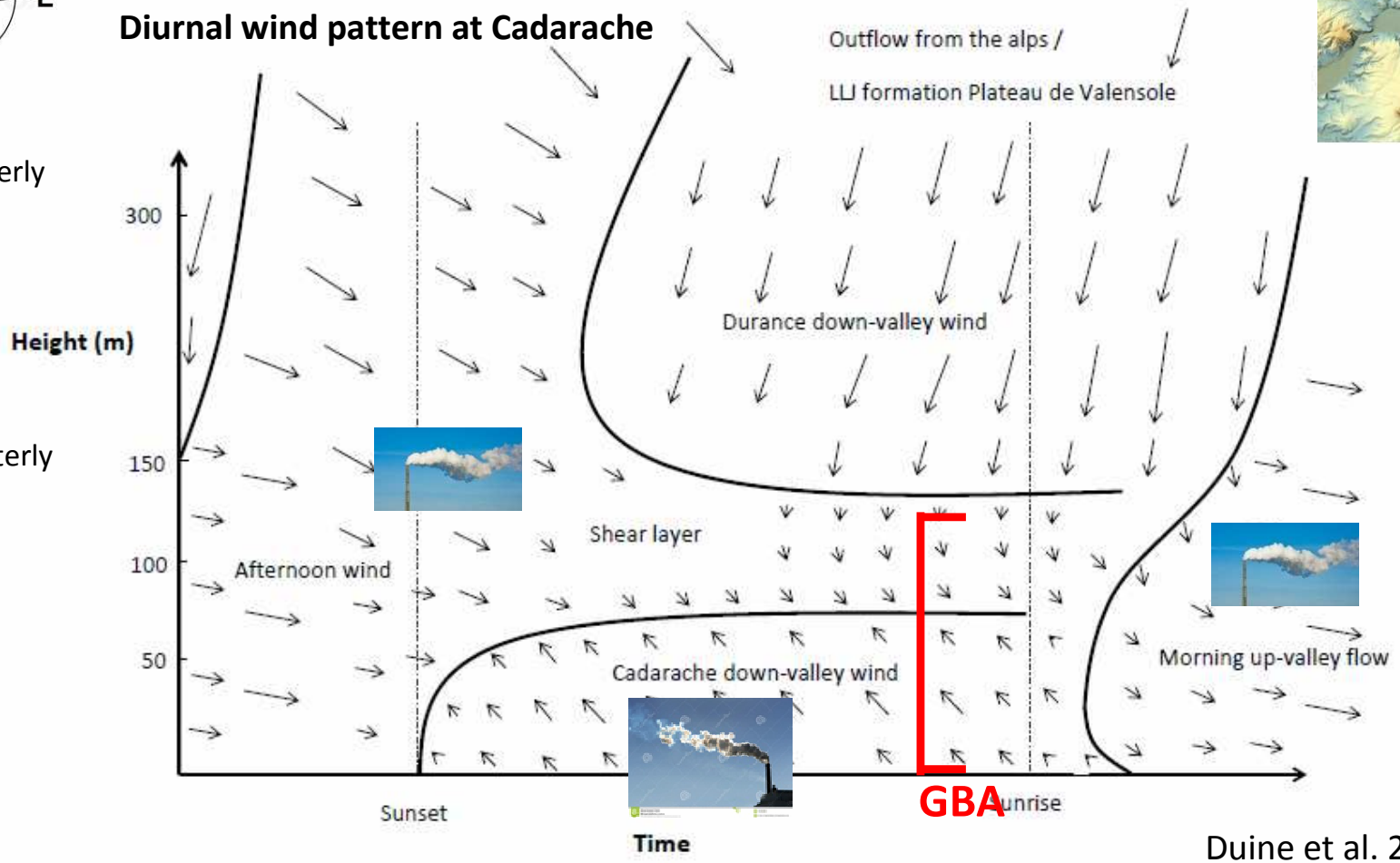




Southeasterly wind:

Northwesterly wind:

Diurnal wind pattern at Cadarache

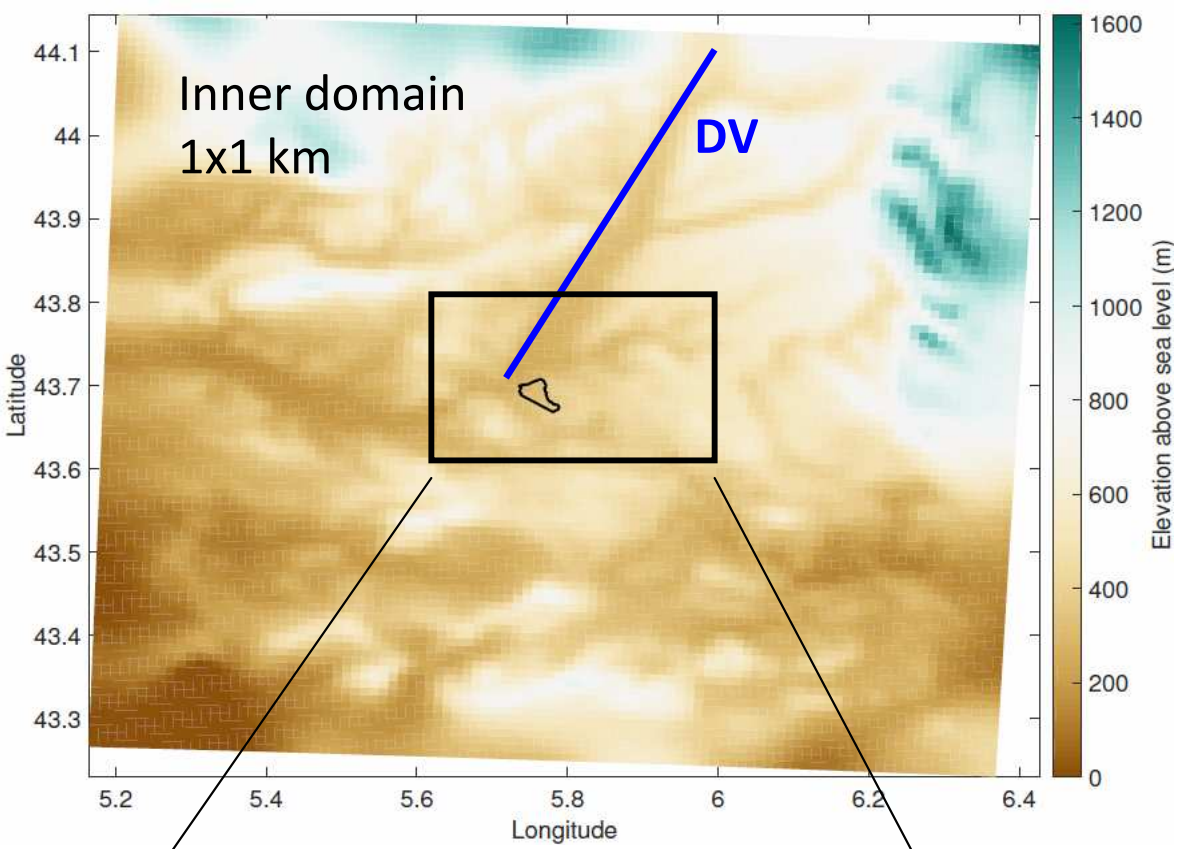


Duine et al. 2015, *submitted to QJRMS*

- Dominant down-valley winds, related to stability
- Consequences for pollutant dispersion
- Knowledge can be used for numerical modeling validation
- High variability below 110 m

Modeling with WRF - orography

SRTM database : 90 m



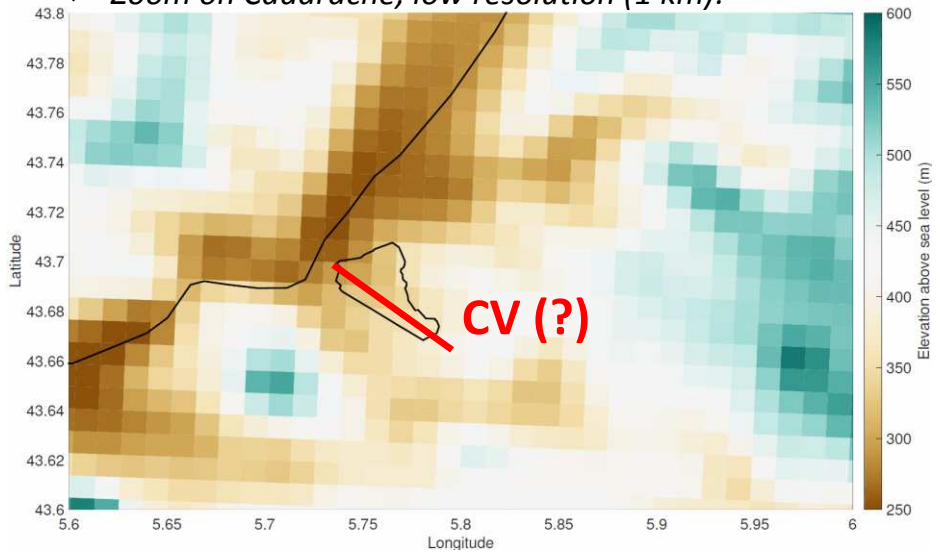
Horizontal resolution of 1 km

-**Durance valley (DV)** width 5-8 km: sufficiently resolved

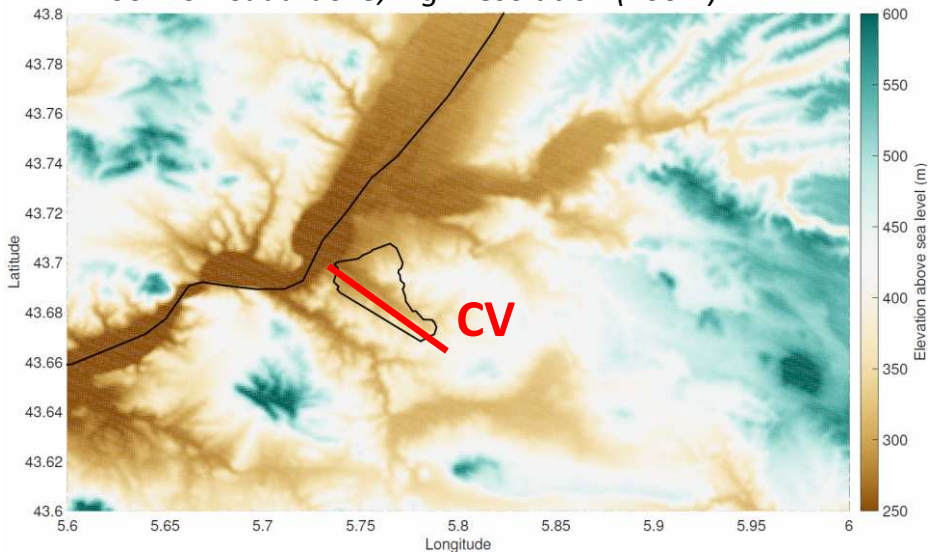
-**Cadarache valley (CV)** needs higher resolution (≈200 m) so:

- High computational cost
- Subgrid parameterization revised
- LES mode

Zoom on Cadarache; low resolution (1 km):



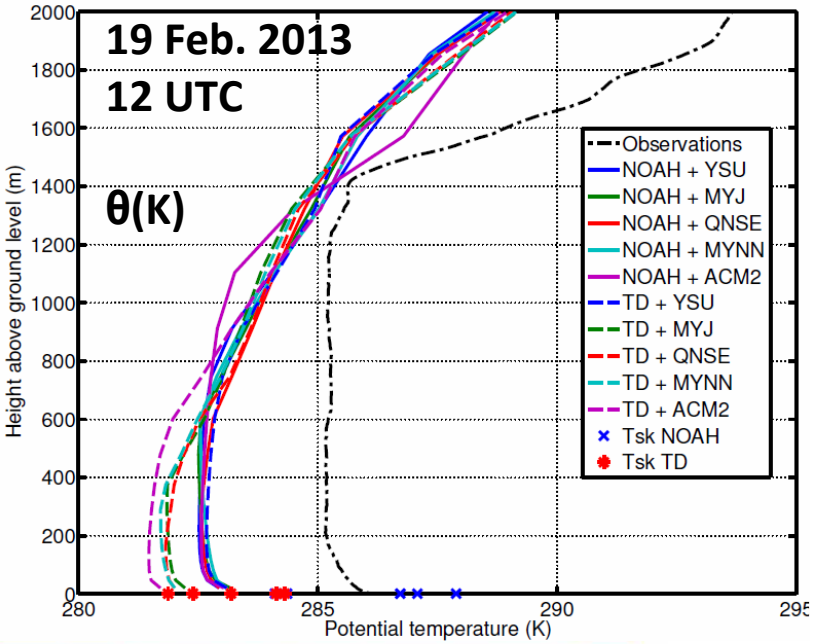
Zoom on Cadarache; high resolution (100m):



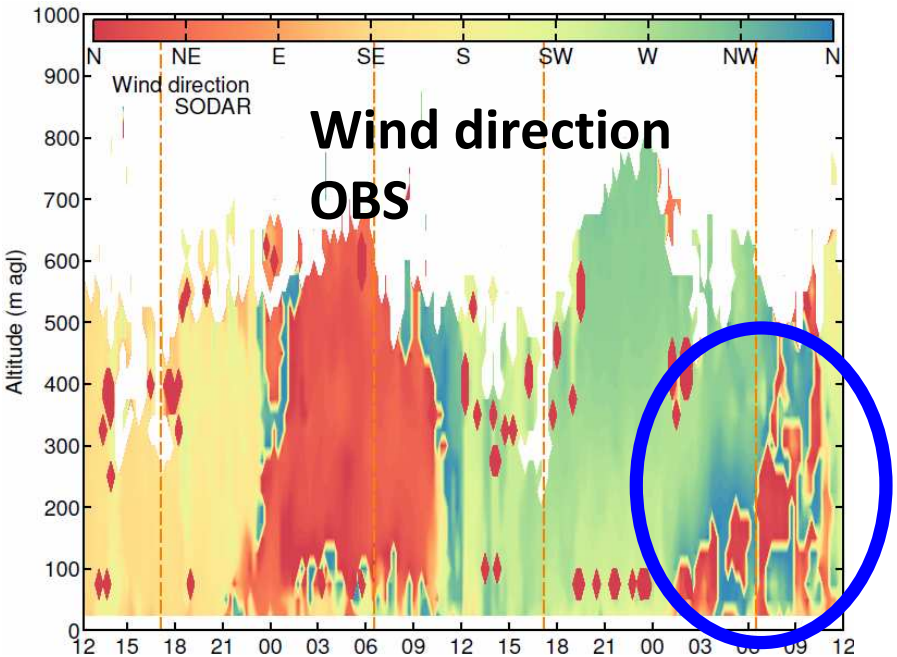
Define reference configuration

Sensitivity tests and checks:

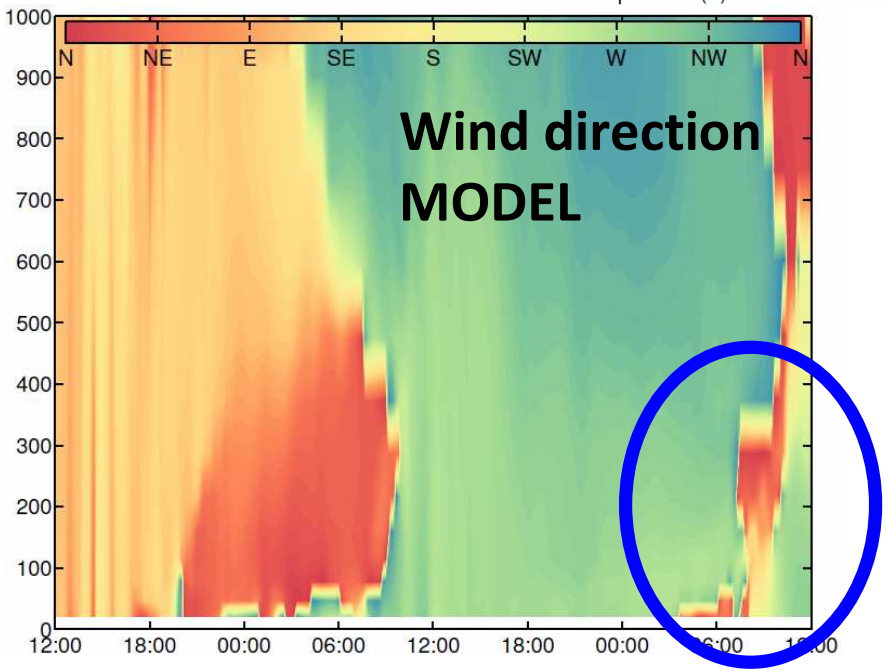
1) PBL and land surface schemes
2) Soil moisture content
3) Atmosphere-surface coupling
4) Radiation schemes
5) Initial & boundary conditions
6) Vertical resolution (46 vs. 35 layers)
7) Inner domain size



No or no realistic improvements. A DDV wind is nevertheless simulated:



Hour UTC between 18/02/2013 and 20/02/2013



Hour UTC between 18/02/2013 and 20/02/2013

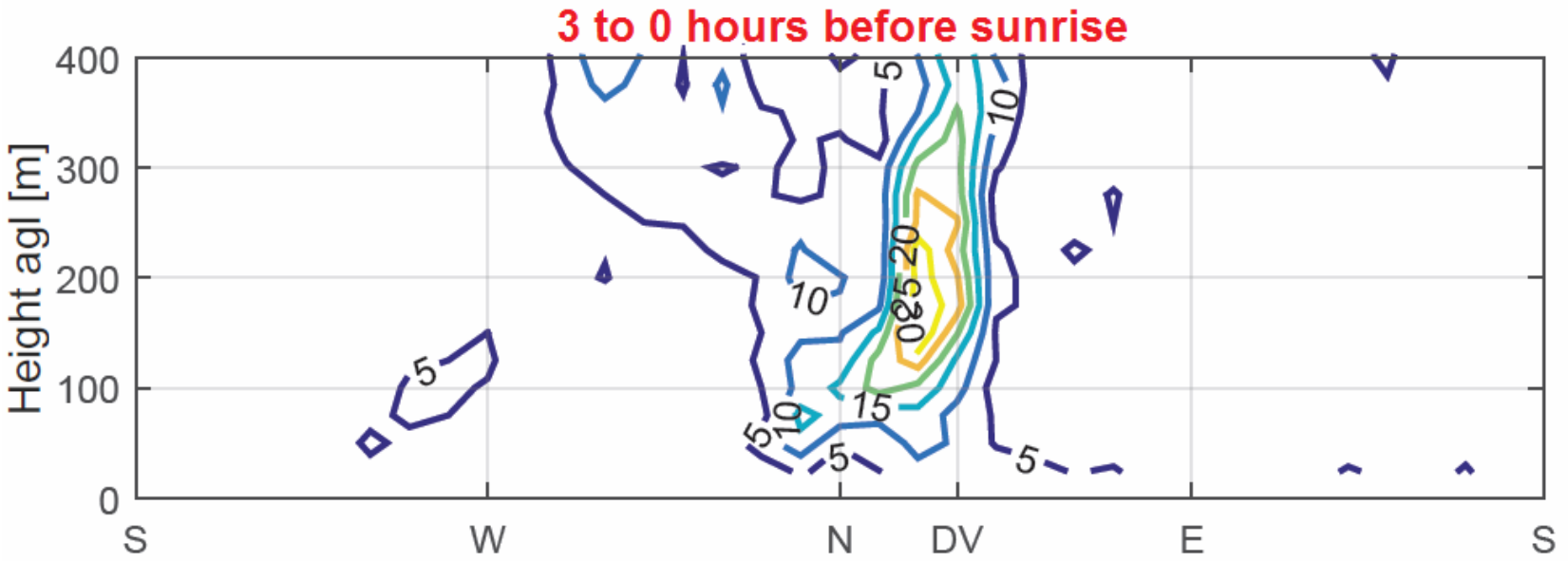
Kalverla et al. 2016, *JAMC,* accepted.

Model evaluation

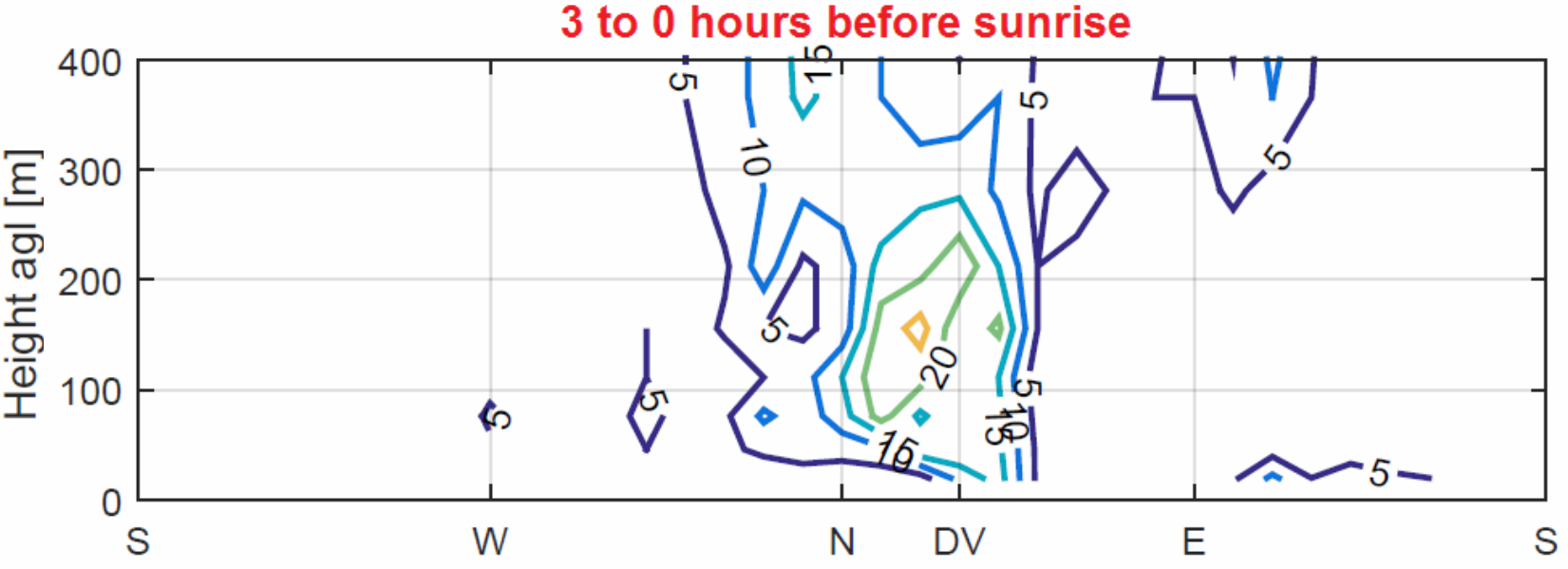
Based on ensemble of observed and simulated 23 IOPs

Diurnal wind pattern

OBSERVATIONS SODAR

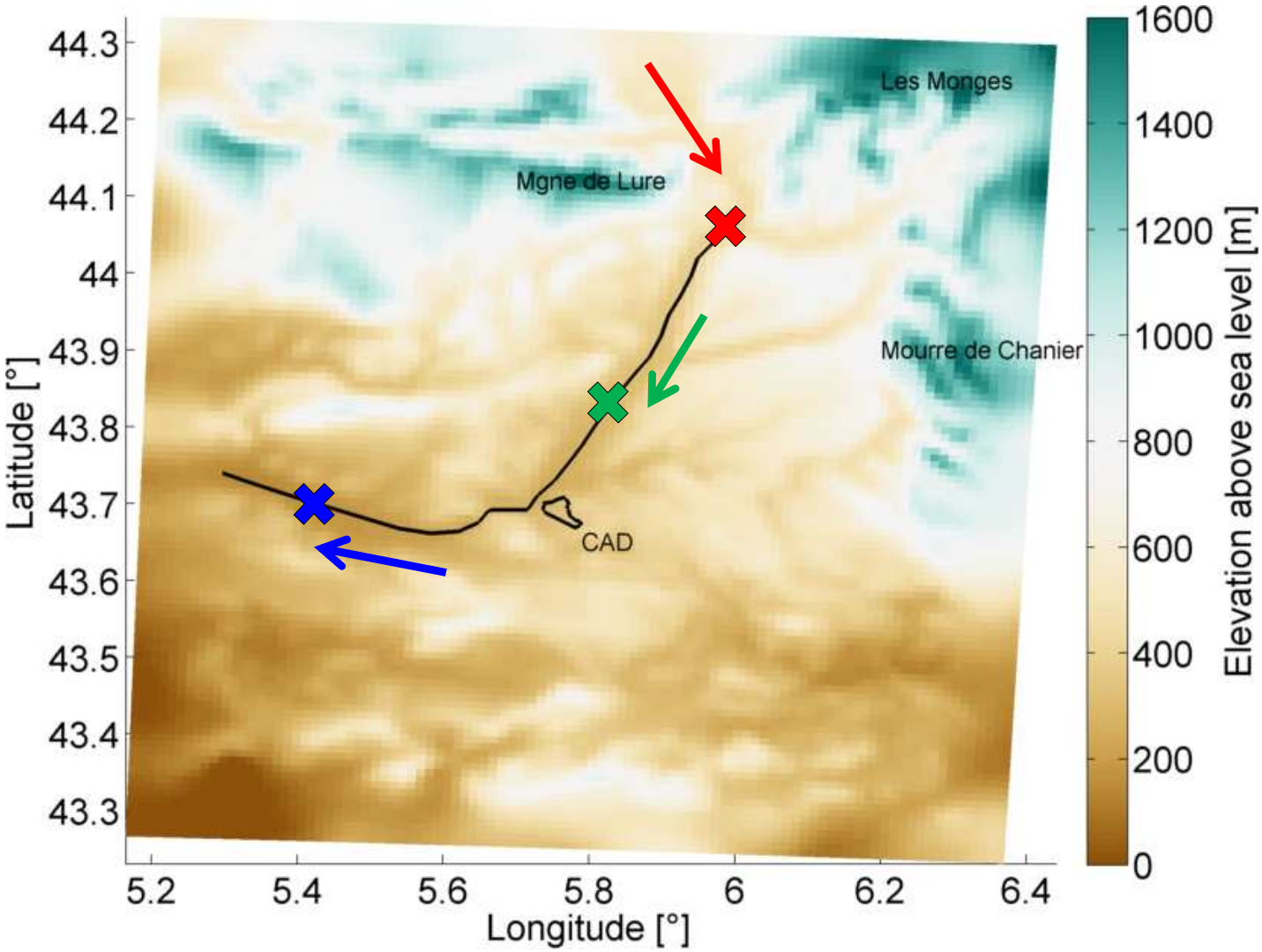


MODEL



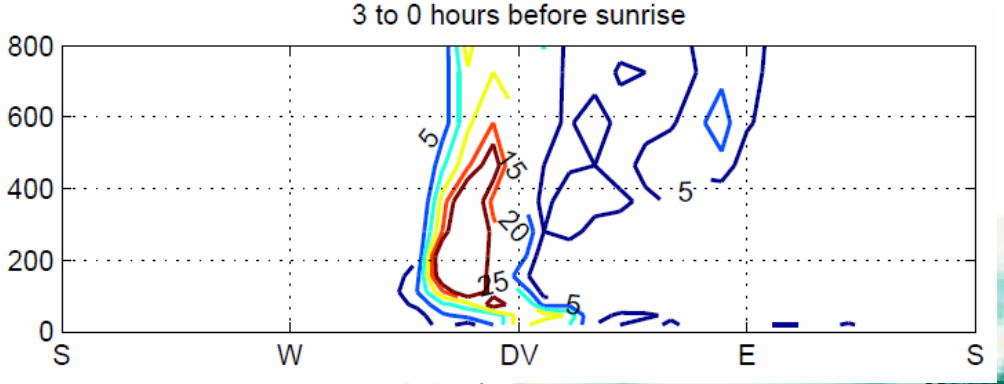
DDV wind along the valley

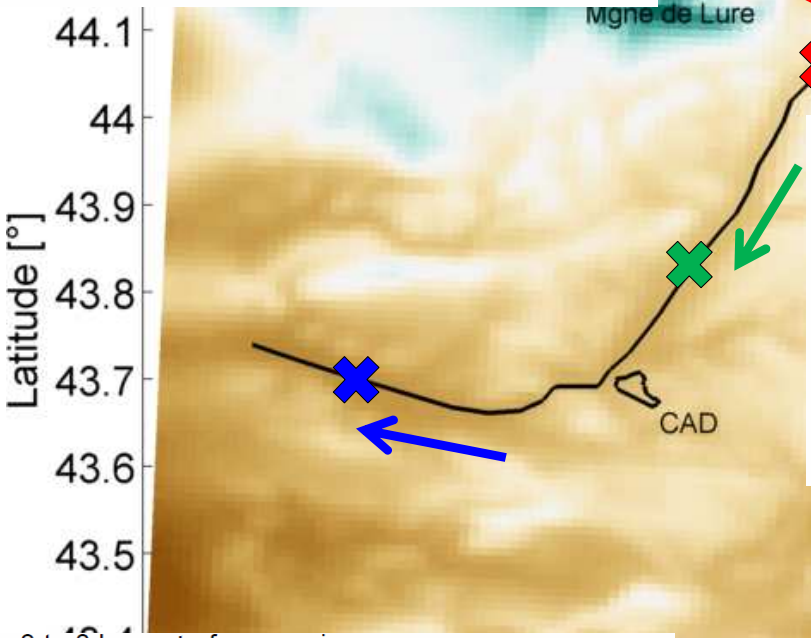
Based on ensemble of 23 simulated IOPs
Around sunrise → mature state

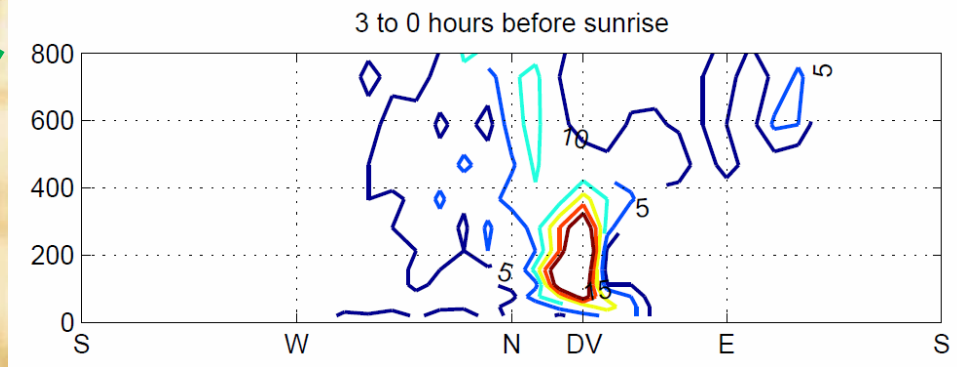


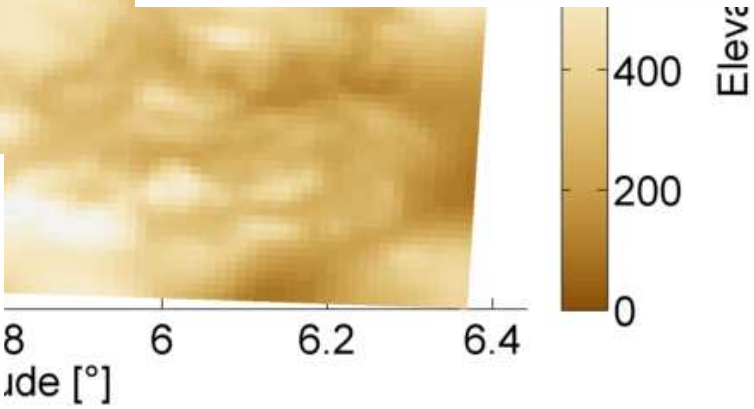
DDV wind along the valley

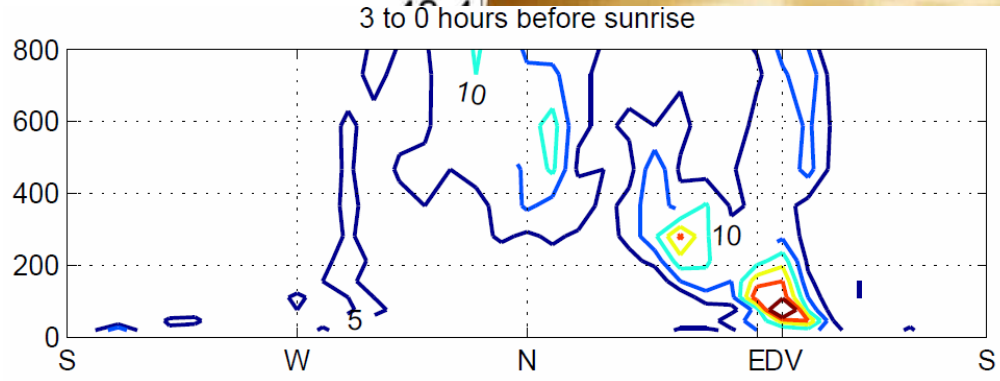
Based on ensemble of 23 simulated IOPs
Around sunrise → mature state



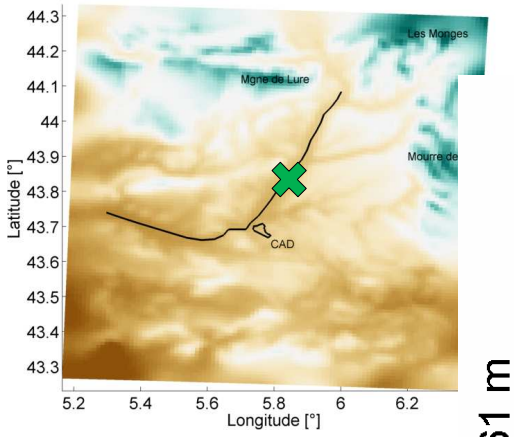


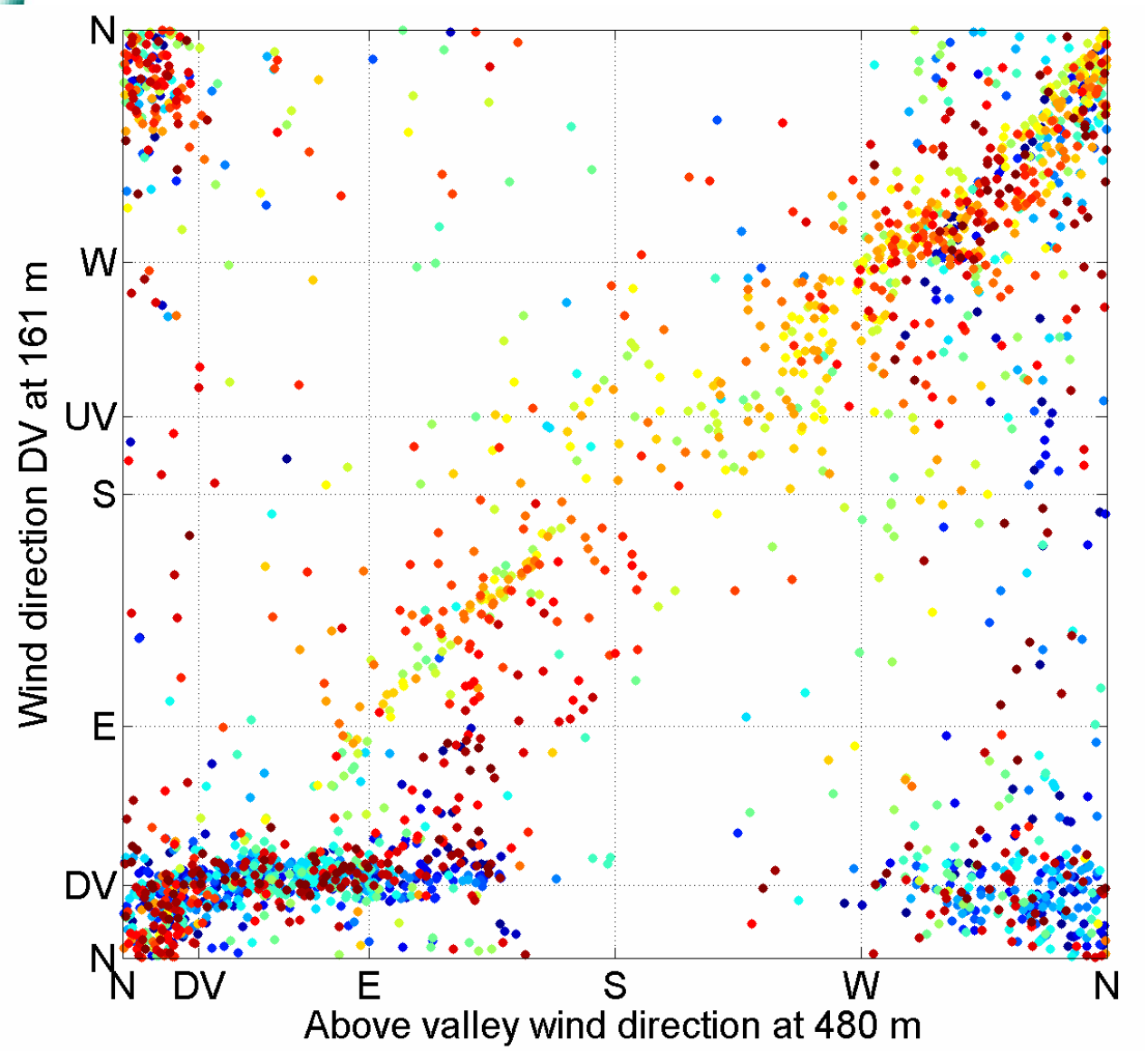






Main driver DDV wind

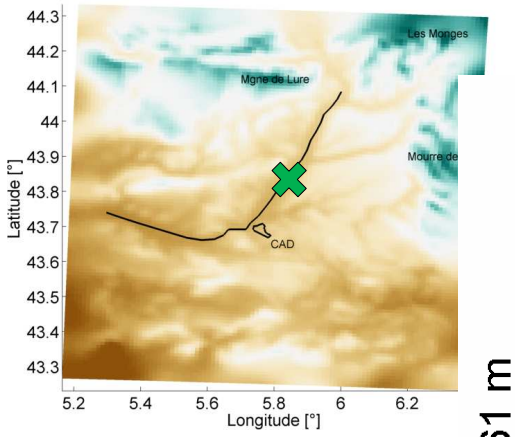




Hours [UTC]

✖	0-1
✖	1-2
✖	2-3
✖	3-4
✖	4-5
✖	5-6
✖	6-7
✖	7-8
✖	8-9
✖	9-10
✖	10-11
✖	11-12
✖	12-13
✖	13-14
✖	14-15
✖	15-16
✖	16-17
✖	17-18
✖	18-19
✖	19-20
✖	20-21
✖	21-22
✖	22-23
✖	23-24

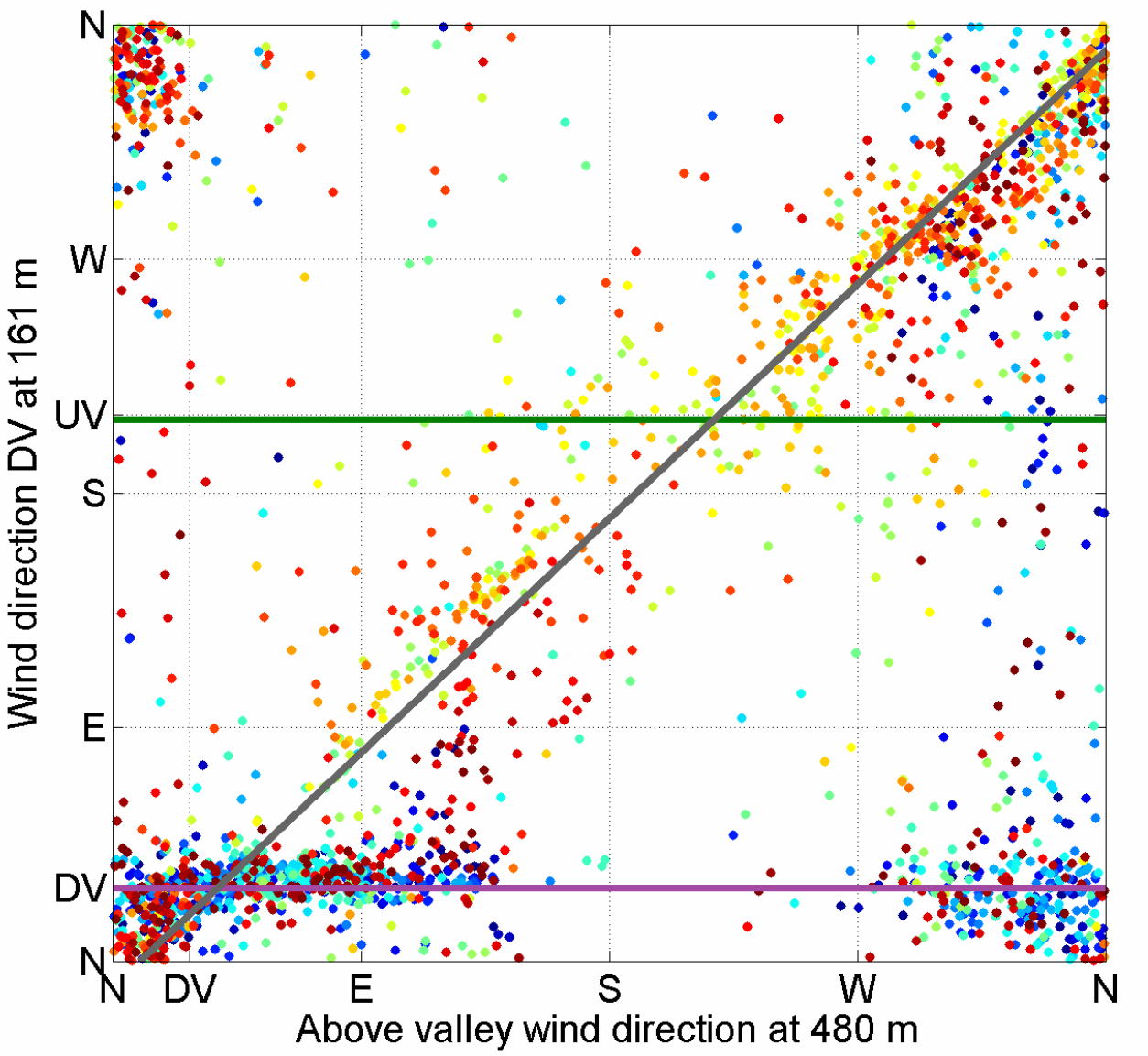
Main driver DDV wind



Downward momentum transport

Thermally driven up-valley

Thermally driven down-valley



Hours [UTC]

0-1	
1-2	
2-3	
3-4	
4-5	
5-6	
6-7	
7-8	
8-9	
9-10	
10-11	
11-12	
12-13	
13-14	
14-15	
15-16	
16-17	
17-18	
18-19	
19-20	
20-21	
21-22	
22-23	
23-24	

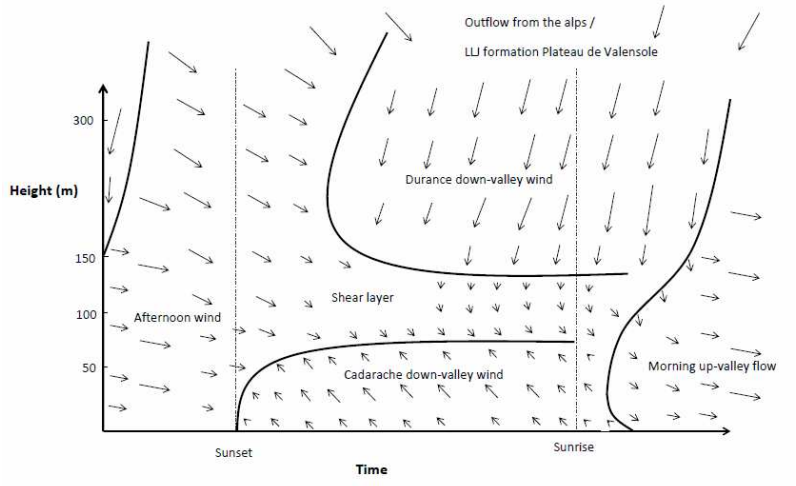
Nocturnal drainage is the main mechanism for **Durance down-valley wind**

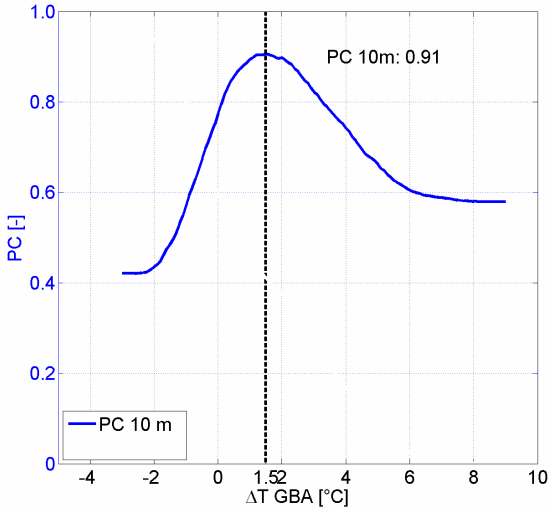
Summary

- **KASCADE: First study** of **stable stratification** and consequent **down-valley winds** in southeastern France (Provence)
- Necessary for local and regional **dispersion impact studies** related to the **Cadarache** site

OBSERVATIONS:

- **Field campaign KASCADE** allowed to **observe** and **characterize** two dominant **down-valley winds** of two connected valleys of different size: the Durance valley and the smaller tributary the Cadarache valley:
  - The Cadarache down-valley (CDV) wind, thermally driven, nighttime duration dependent
  - The Durance down-valley (DDV) wind, related to stability and forcing at a regional scale, strongest after sunrise
- **Nowcasting** of CDV wind with remote measurements possible

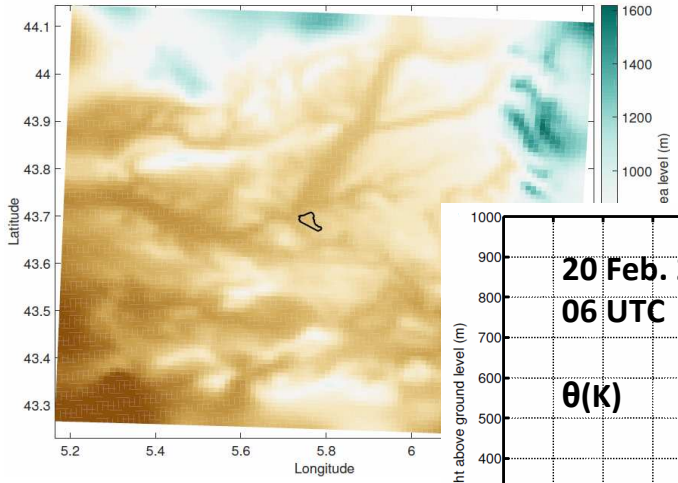


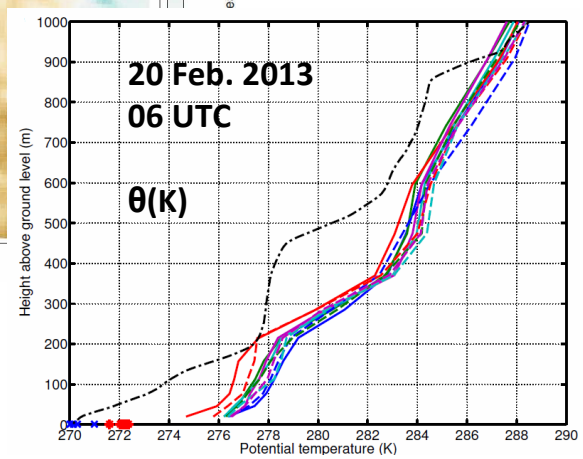


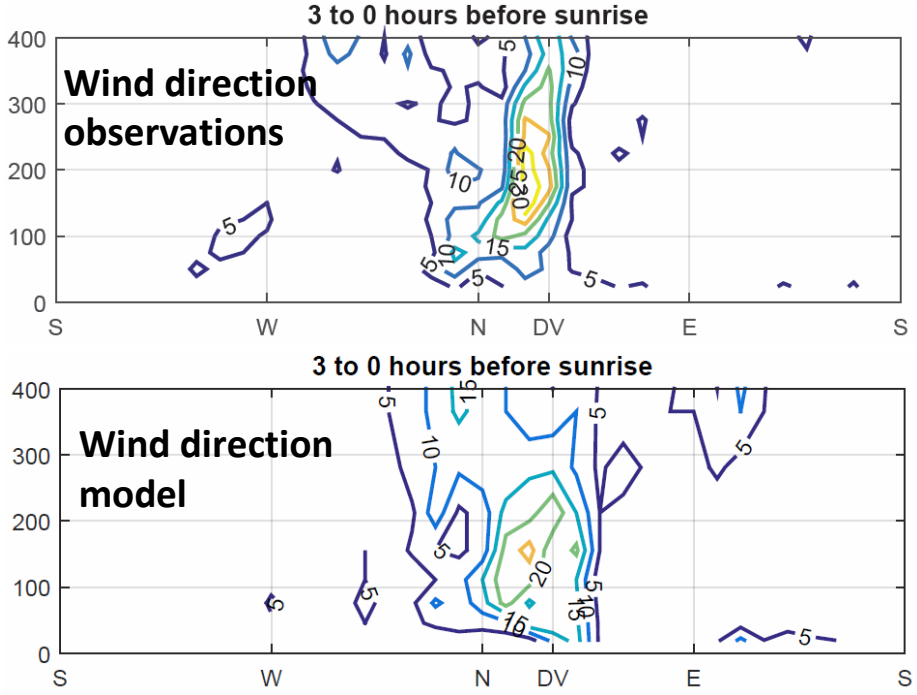
Summary

KASCADE

- **First study** of **stable stratification** and consequent **down-valley winds** in southeastern France (Provence)
- Necessary for local and regional **dispersion impact studies** related to the **Cadarache** site







SIMULATIONS:

- **WRF** set-up for the study area to study DDV wind
- **Resistent** to performed sensitivity tests
- **Evaluation** performed in local and spatial sense
- On **1-km resolution** WRF **simulates** DDV winds

  → important for larger scale dispersion and future DDV wind studies

Perspectives

KASCADE

- FLEXPART dispersion model coupled to the WRF model

  … a novel PhD-thesis related to dispersion studies started last October (Florian Dupuy)

<u>More generalization is needed:</u>

- No attempt has been made yet to link the CDV **wind speed or depth** to **above-valley wind conditions**, or available **heat budget observations**
- **Radiation divergence** observations in complex terrain are scarce, available for Cadarache Valley
- **Idealized case studies:**
  - Necessary to fully comprehend the DDV wind and its **relation to terrain geometry**
  - **High-resolution modeling** to simulate CDV wind

Data free of use:

http://kascade.sedoo.fr

(Background, phd-thesis, articles, etc…)

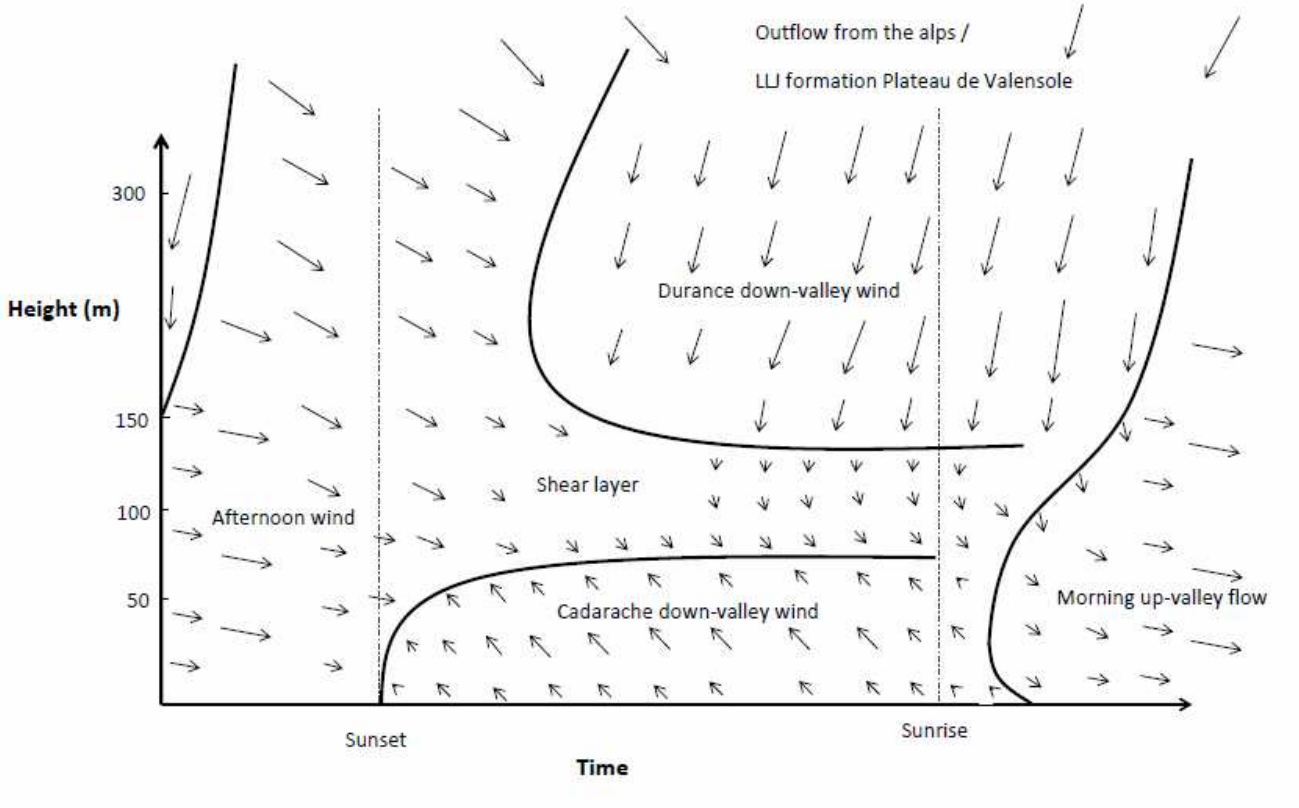
Duine, Gert-Jan. *Characterization of down-valley winds in stable stratification from the KASCADE field campaign and WRF mesoscale simulations*. PhD thesis, Universite Toulouse III Paul Sabatier, 2015.

Kalverla, PC, Duine GJ, Steeneveld GJ, Hedde T, 2016. E*valuation of the Weather Research and Forecasting model in the Durance Valley complex terrain during the KASCADE field campaign.* Journal of Applied Meteorology and Climatology, in press

Thanks for your attention

Questions?

Diurnal wind pattern at Cadarache



gert-jan.duine@aero.obs-mip.fr

http://kascade.sedoo.fr/