# Apport potentiel de l'activité d'éclair 3D à haute résolution observée par le réseau SAETTA dans le cadre de l'observatoire atmosphérique CORSiCA*

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** Chimie/aérosol (Cap Corse) et physique des nuages/électricité (SAETTA)*

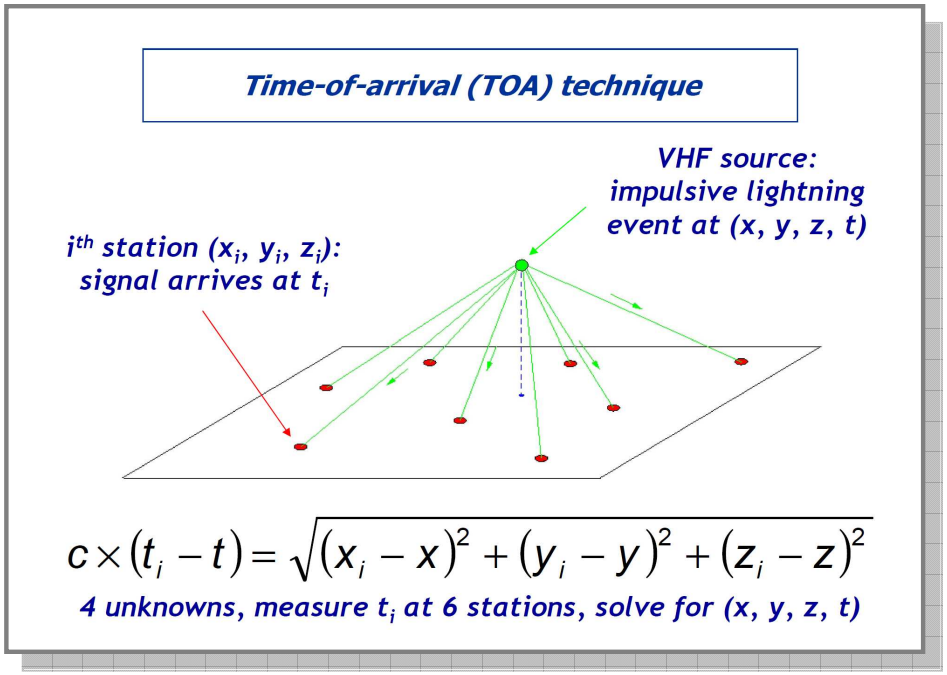
# SAETTA du point de vue technique:

## ➢ Déploiement de 12 stations LMA

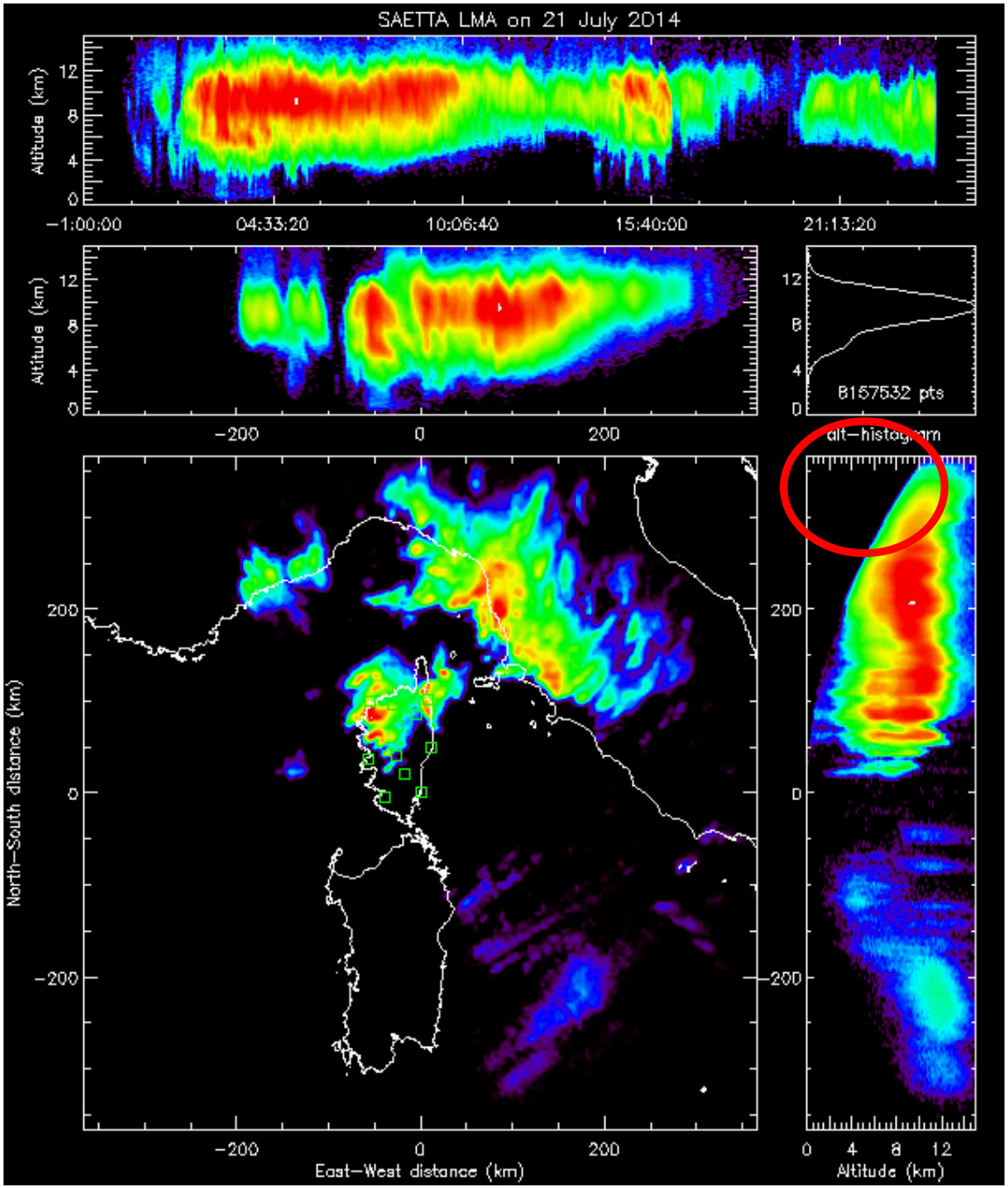
- Lightning Mapping Array, New Mexico Tech, USA
- Etendue: 70 km ↔ et 110 km ↕; portée: ∅ 600 km
- Résolution temporelle: 80 µs
- Position 3D: technique TOA

## ➢ Transmission temps réel

- Téléphonie 3G Orange
- Affichage site web




# Ateliers de Modélisation de l'Atmosphère
# Toulouse, 18-22 janvier 2016

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## ➢ Transmission temps réel

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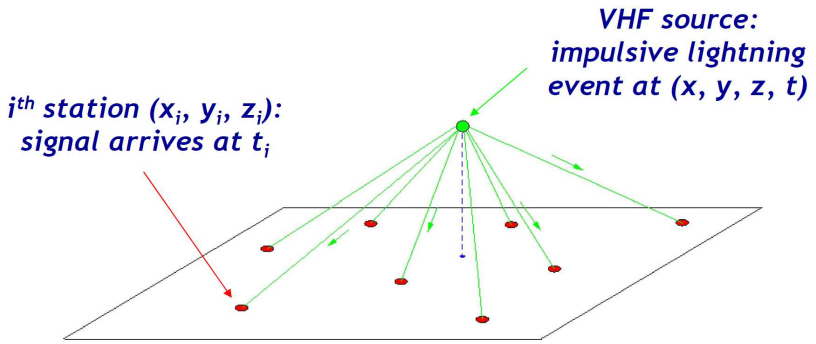
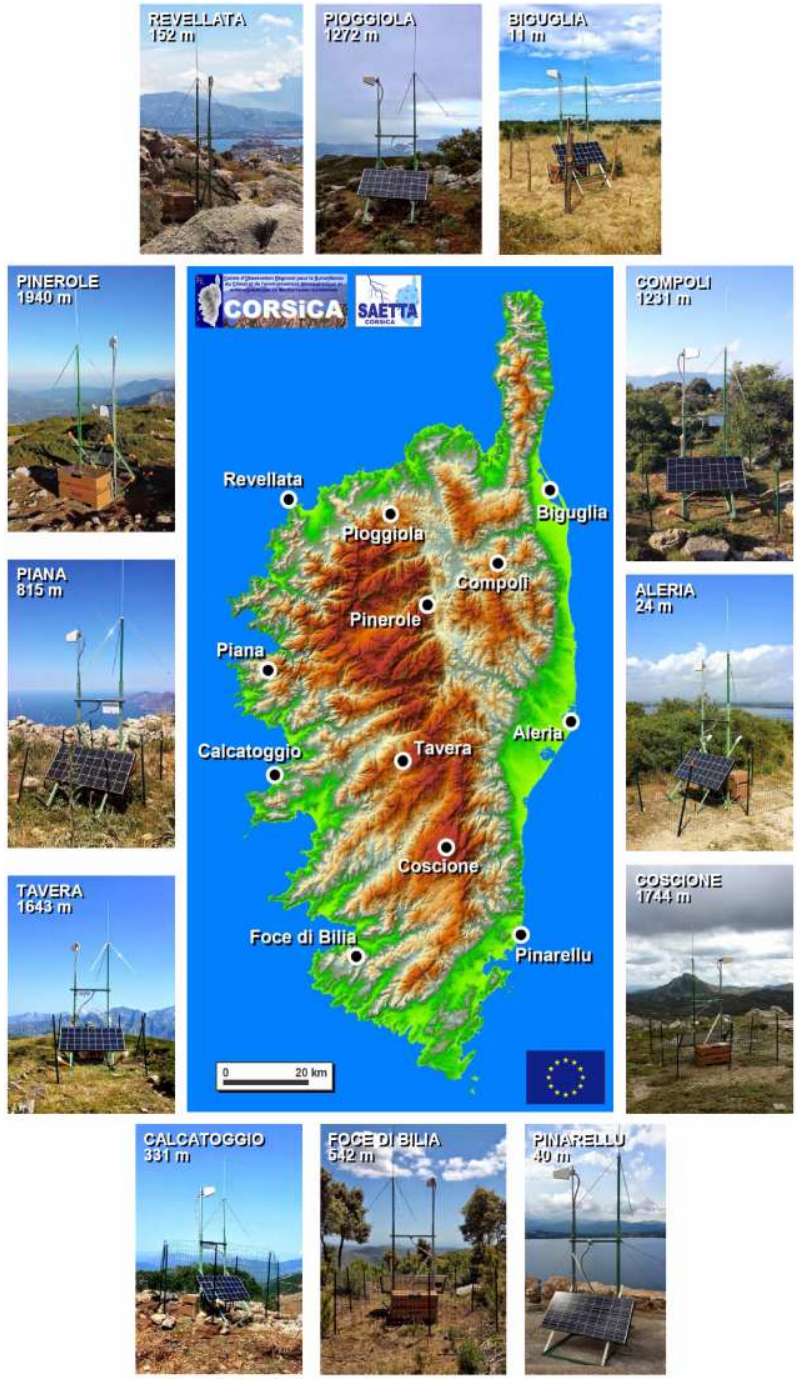
*Time-of-arrival (TOA) technique*

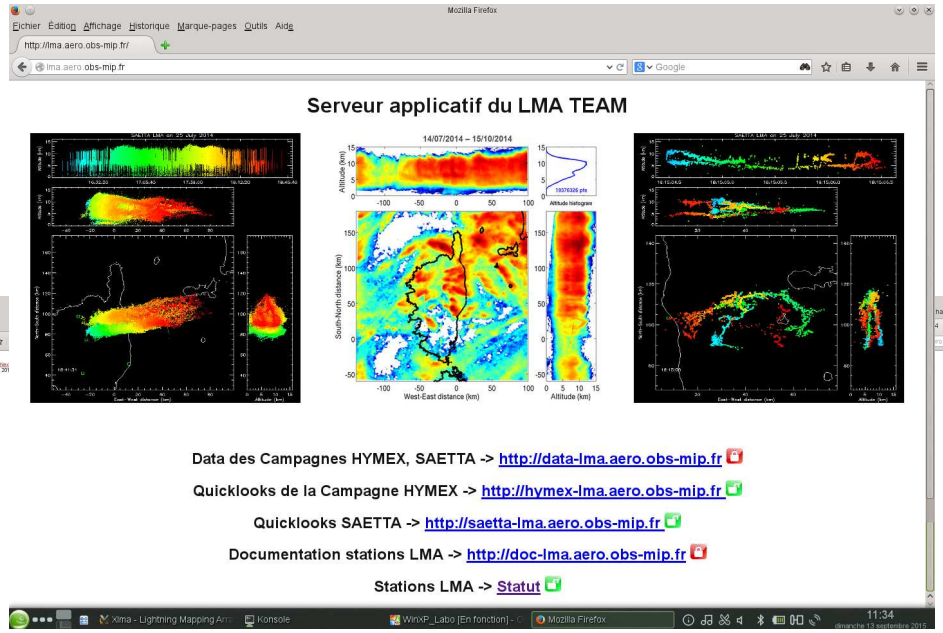



$$c \times (t_i - t) = \sqrt{(x_i - x)^2 + (y_i - y)^2 + (z_i - z)^2}$$

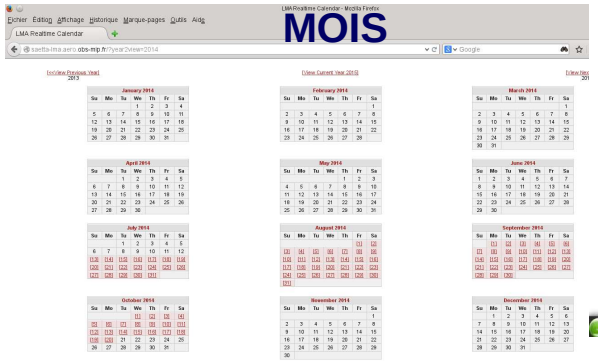
*4 unknowns, measure $t_i$ at 6 stations, solve for (x, y, z, t)*



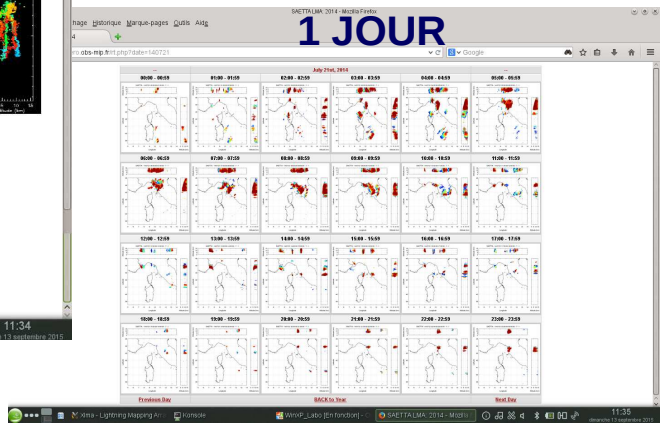
# Serveur: http://lma.aero.obs-mip.fr



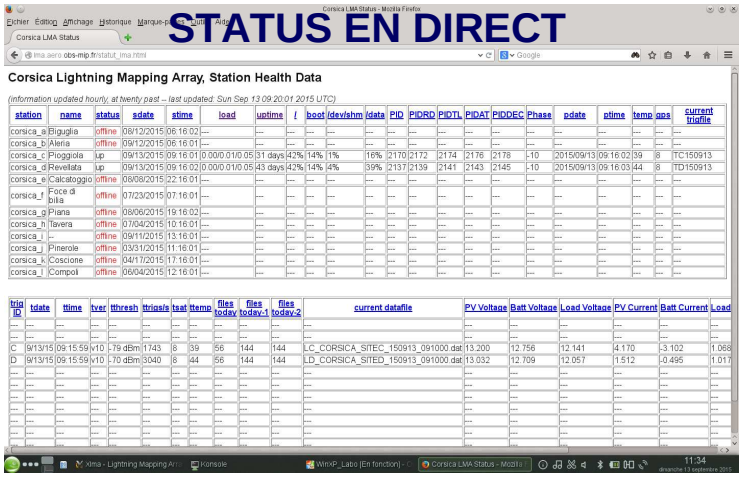

## MOIS



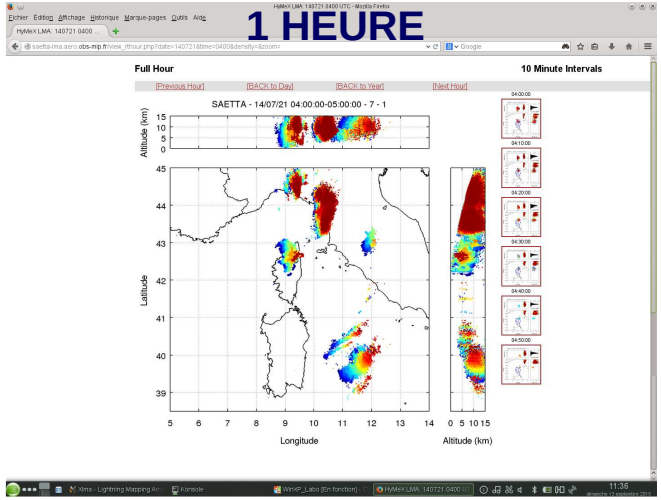
## 1 JOUR



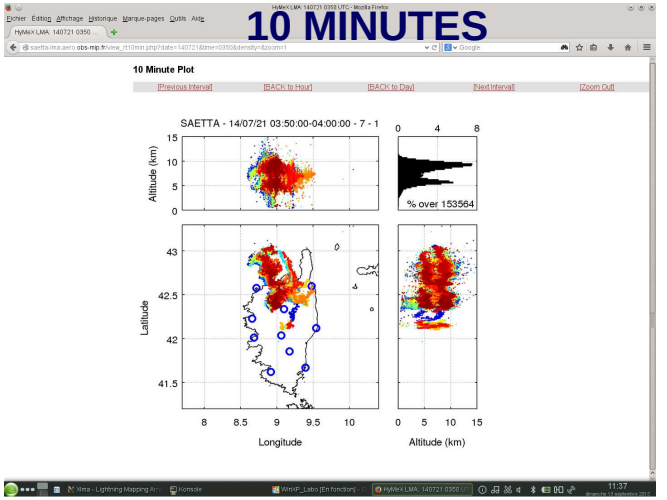
## STATUS EN DIRECT




## 1 HEURE




## 10 MINUTES

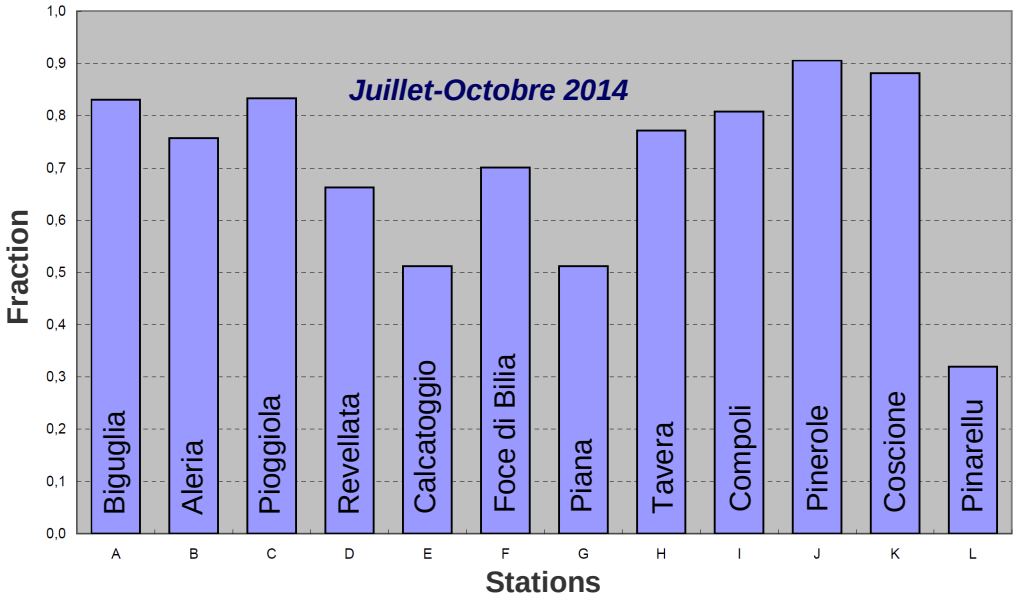


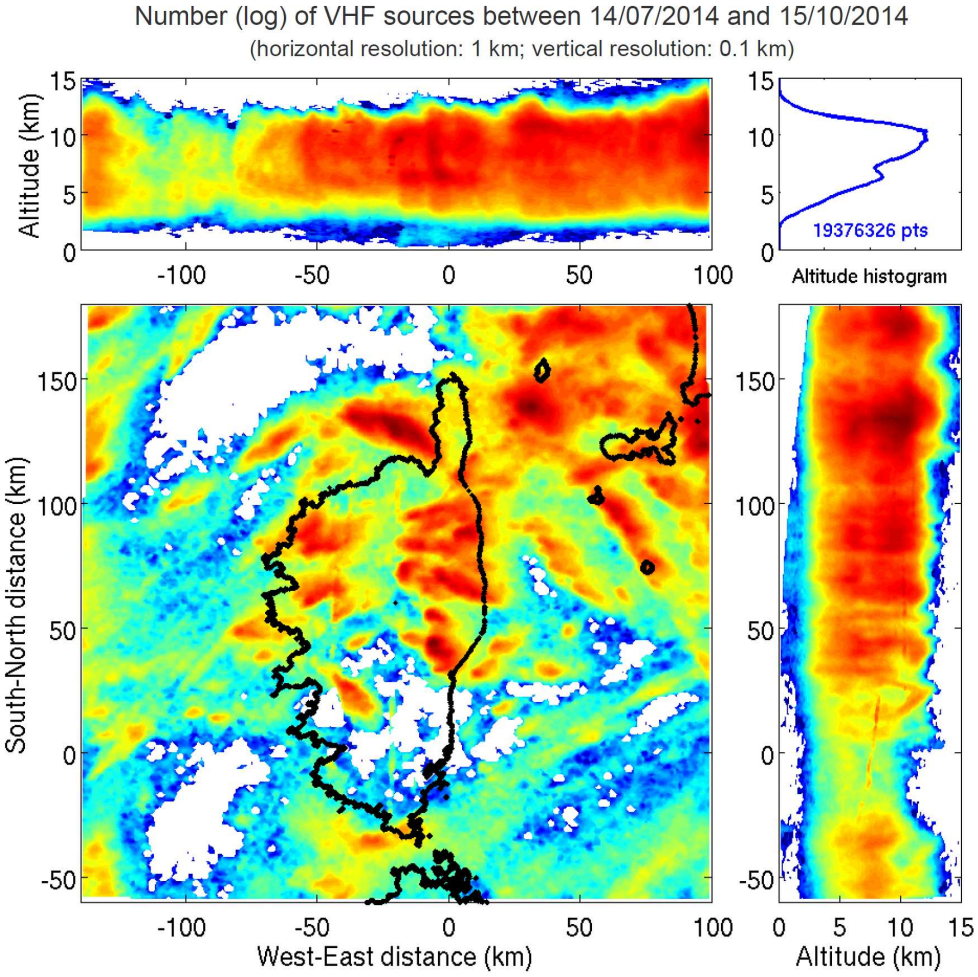
## Volume de données produites

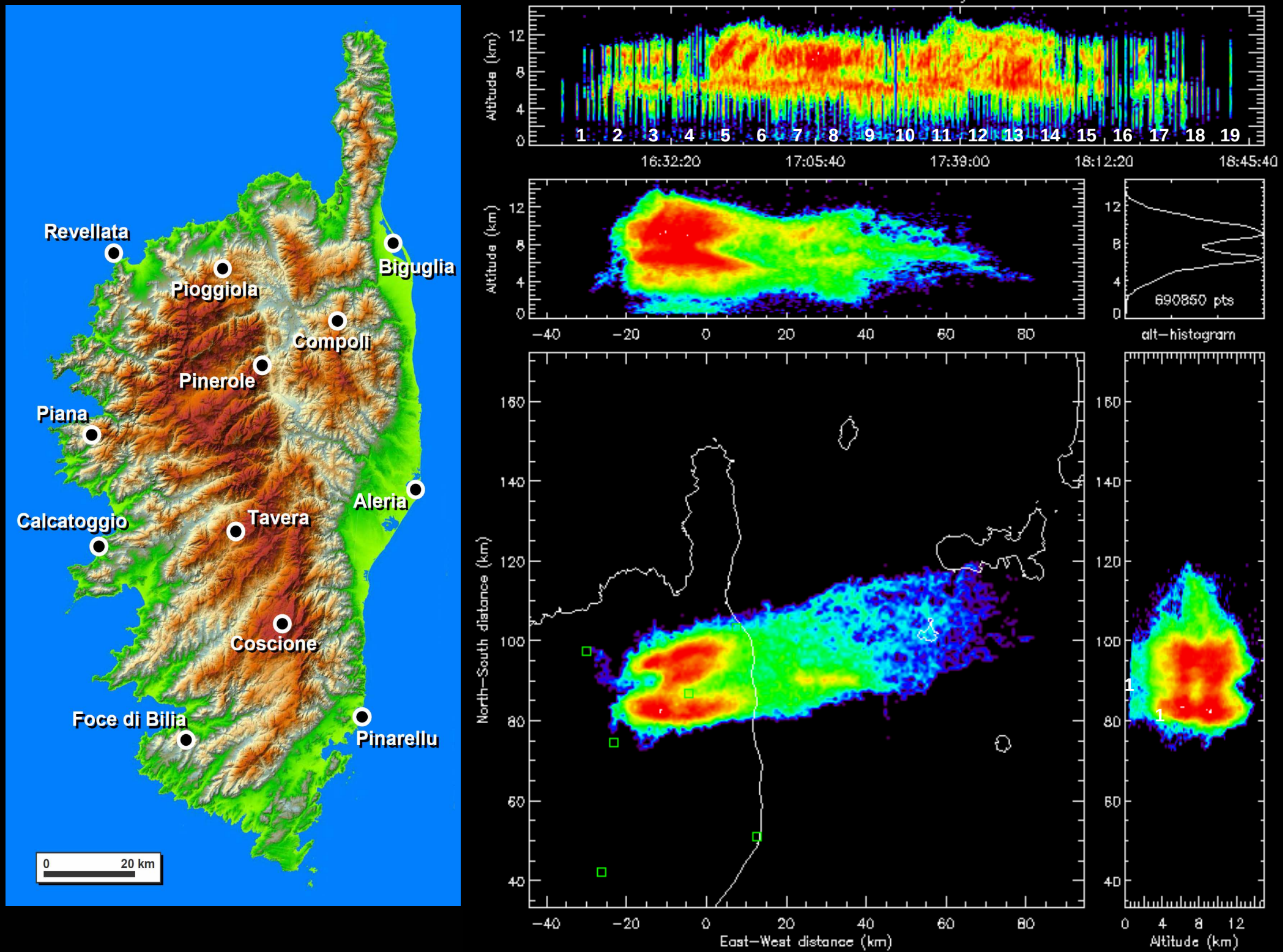
| Année | Période | Données brutes | Données élaborées | Quicklooks | Données de suivi (gps, batteries, temp…) |
|---|---|---|---|---|---|
| 2014 | 13/07-20/10 | 1.27 To | 6.78 Go | 1.18 Go | 0.96 Go |
| 2015 | 11/04-01/12 | 1.85 To | 4.96 Go | 1.14 Go | 1.66 Go |

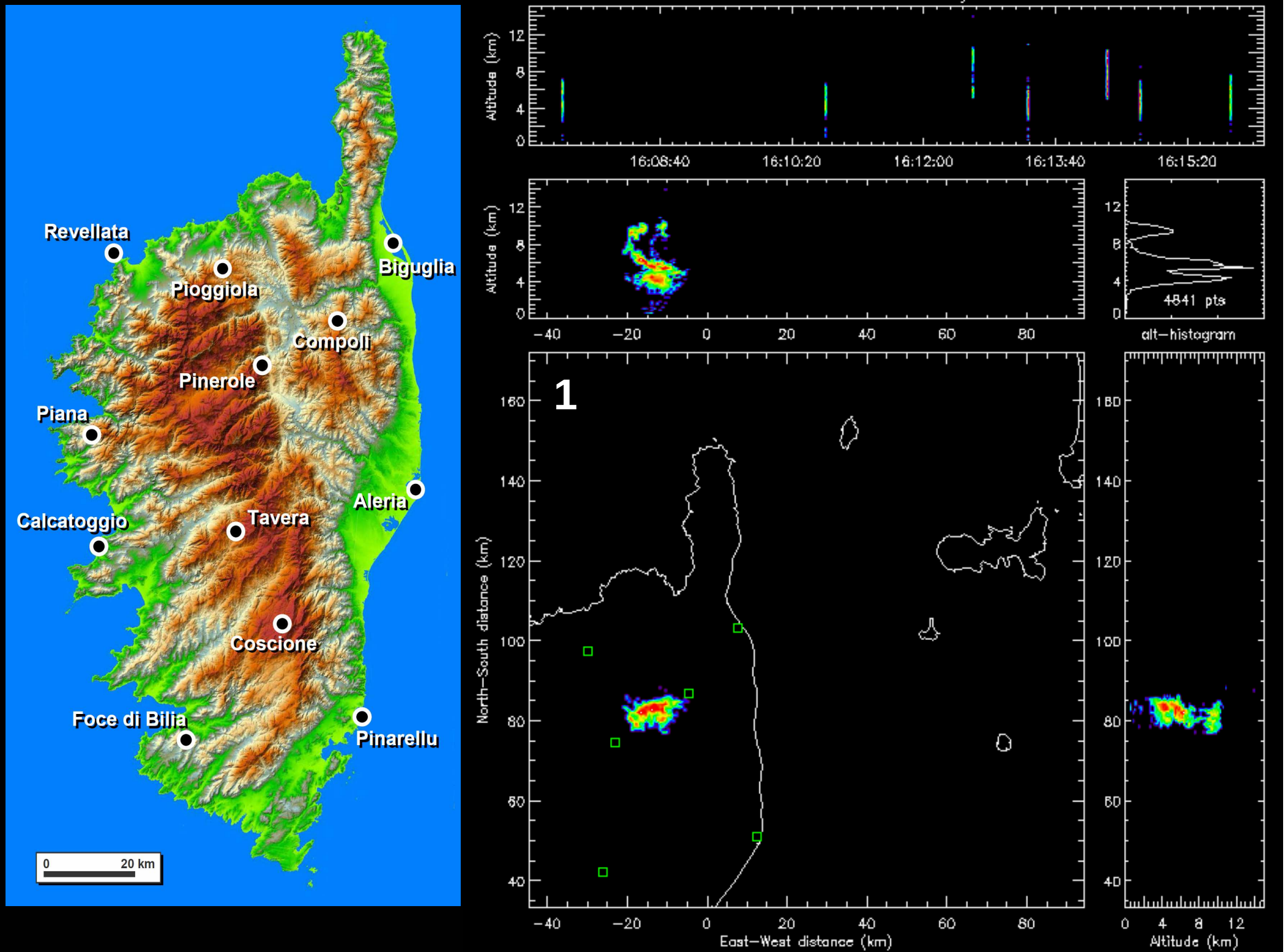
# Climatologie des éclairs en 2014

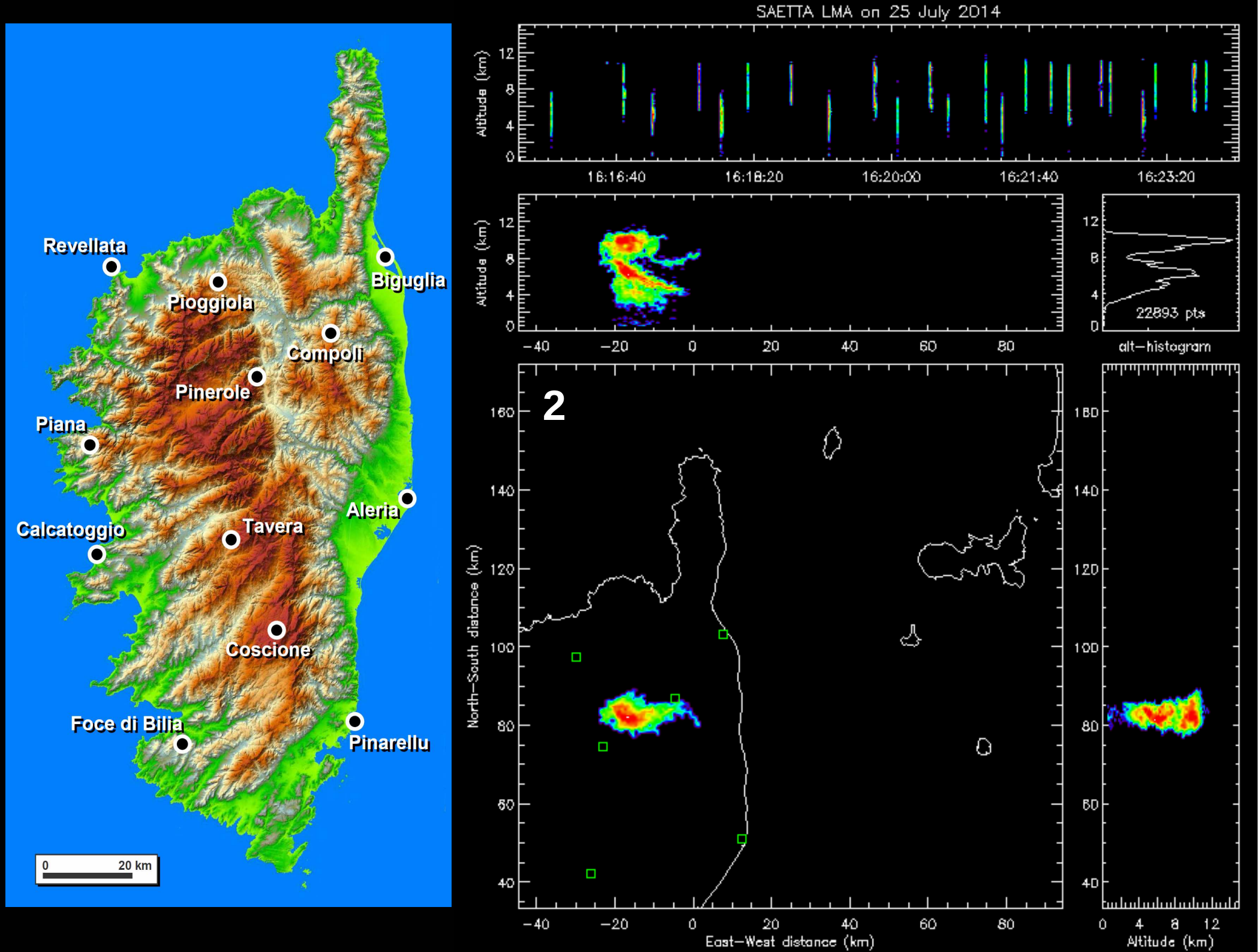
## Contribution de chaque station à la détermination des sources

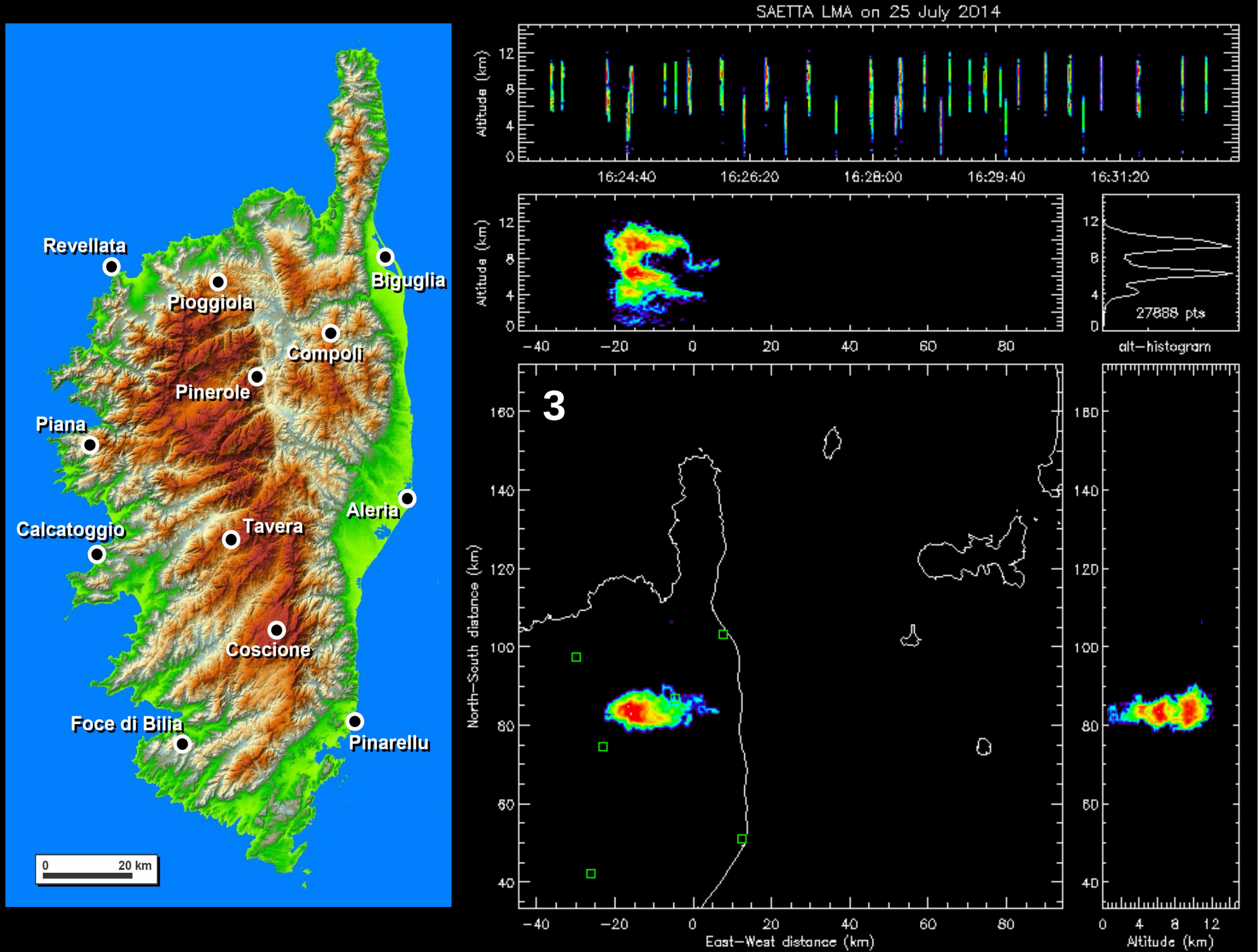


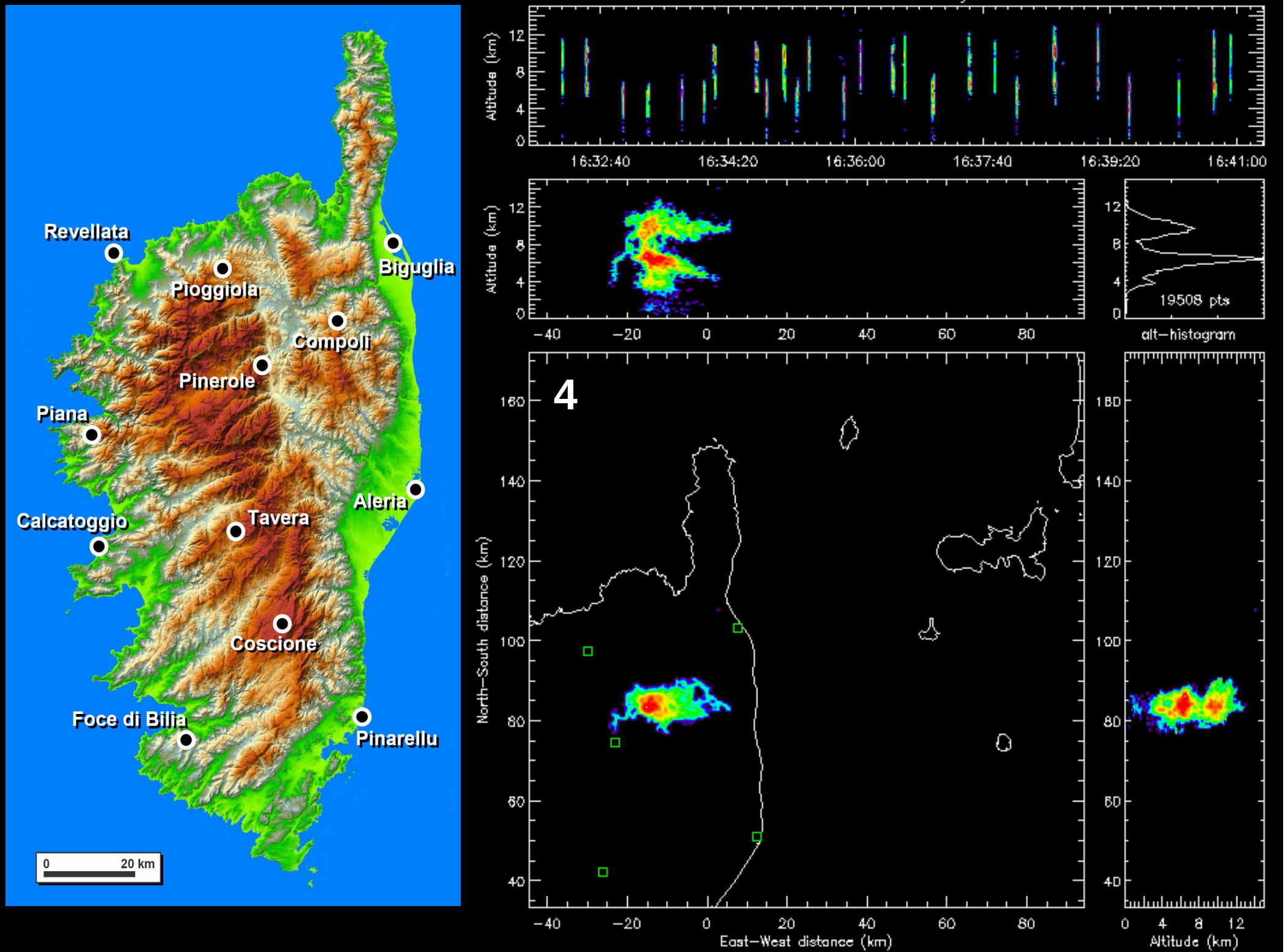



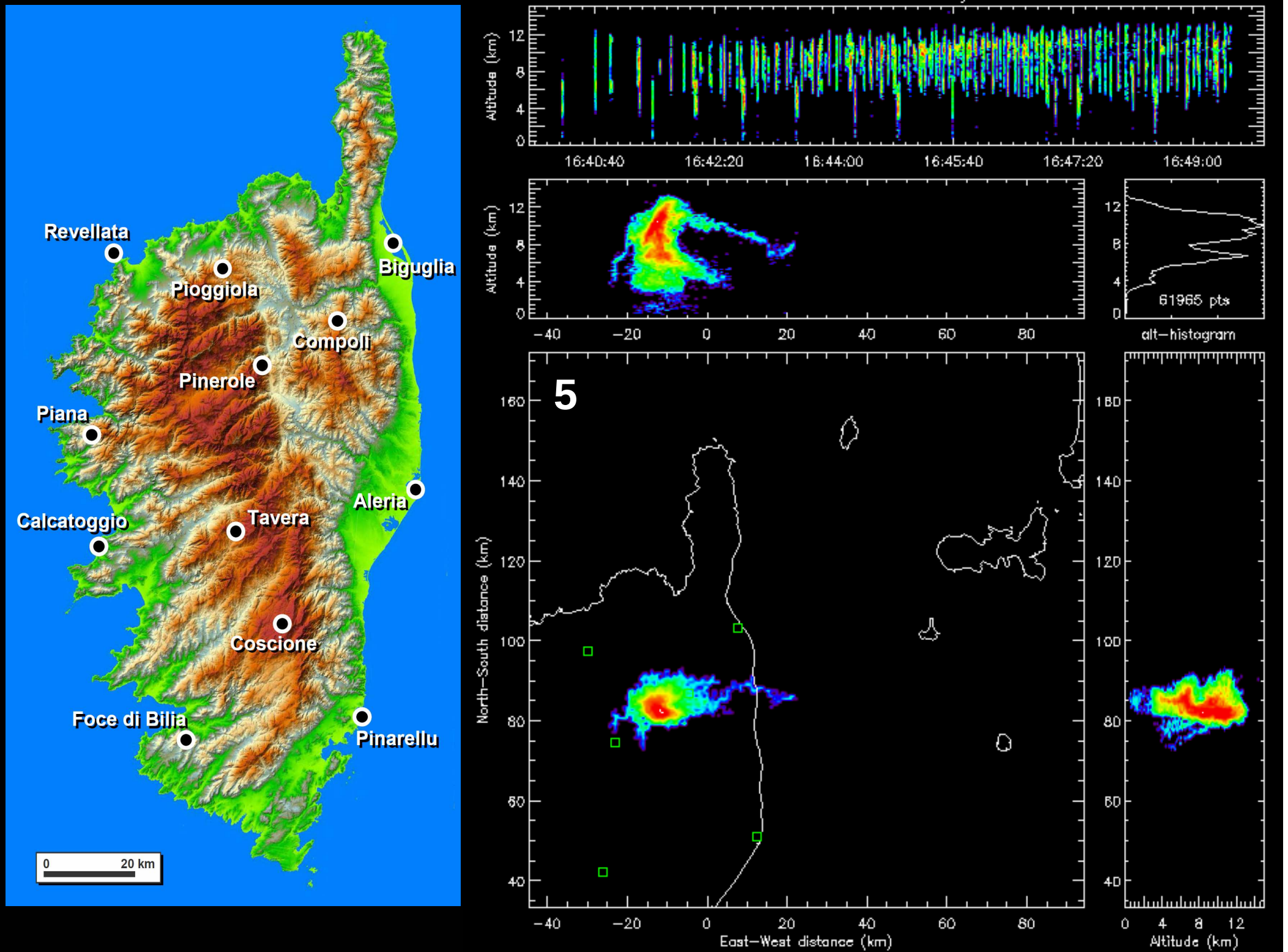

SAETTA LMA on 25 July 2014
Altitude (km)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
16:32:20
17:05:40
17:39:00
18:12:20
18:45:40
690850 pts
alt-histogram
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

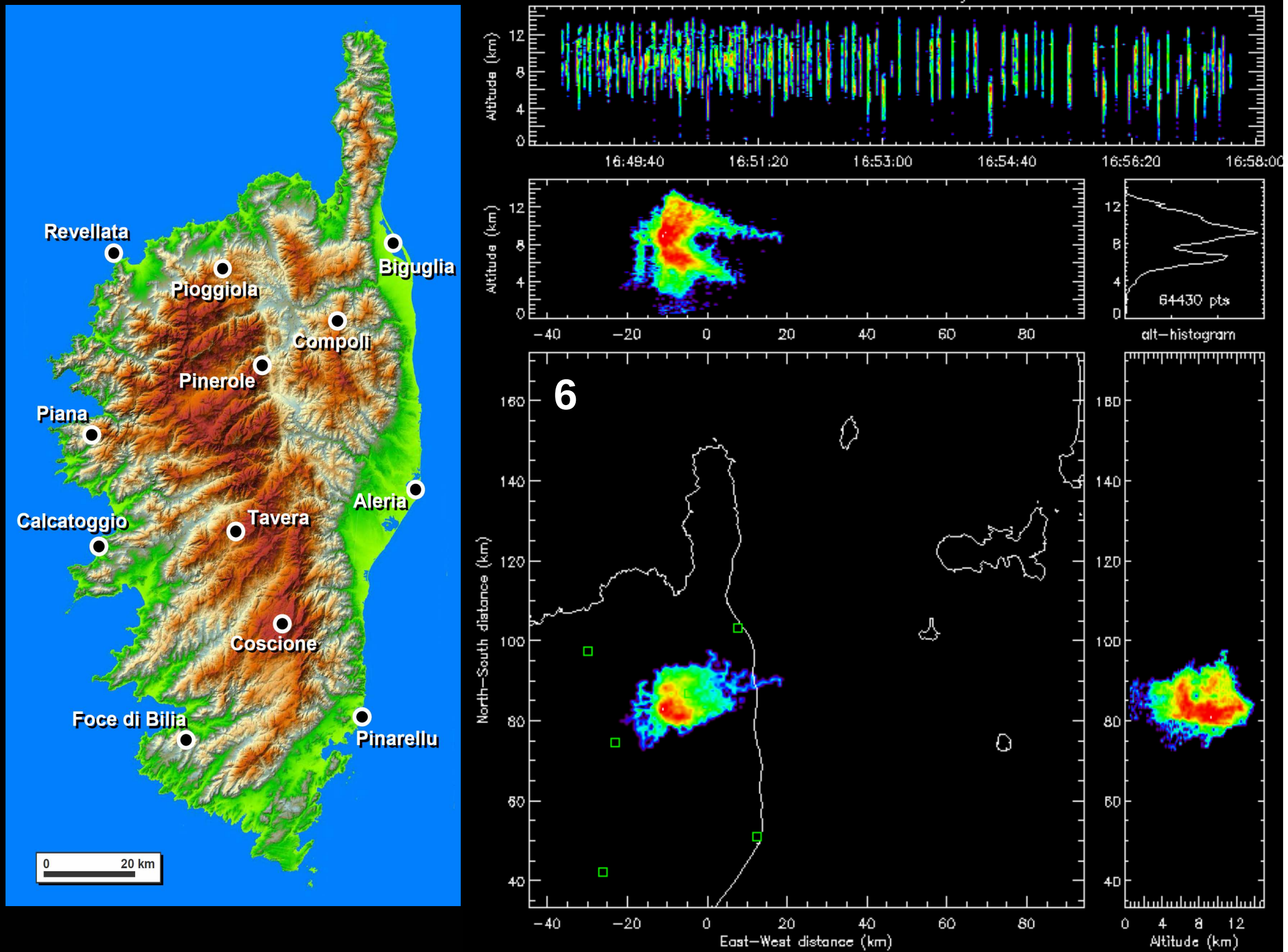

SAETTA LMA on 25 July 2014
Altitude (km)
16:08:40
16:10:20
16:12:00
16:13:40
16:15:20
4841 pts
alt-histogram
1
North-South distance (km)
East-West distance (km)
Altitude (km)
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km

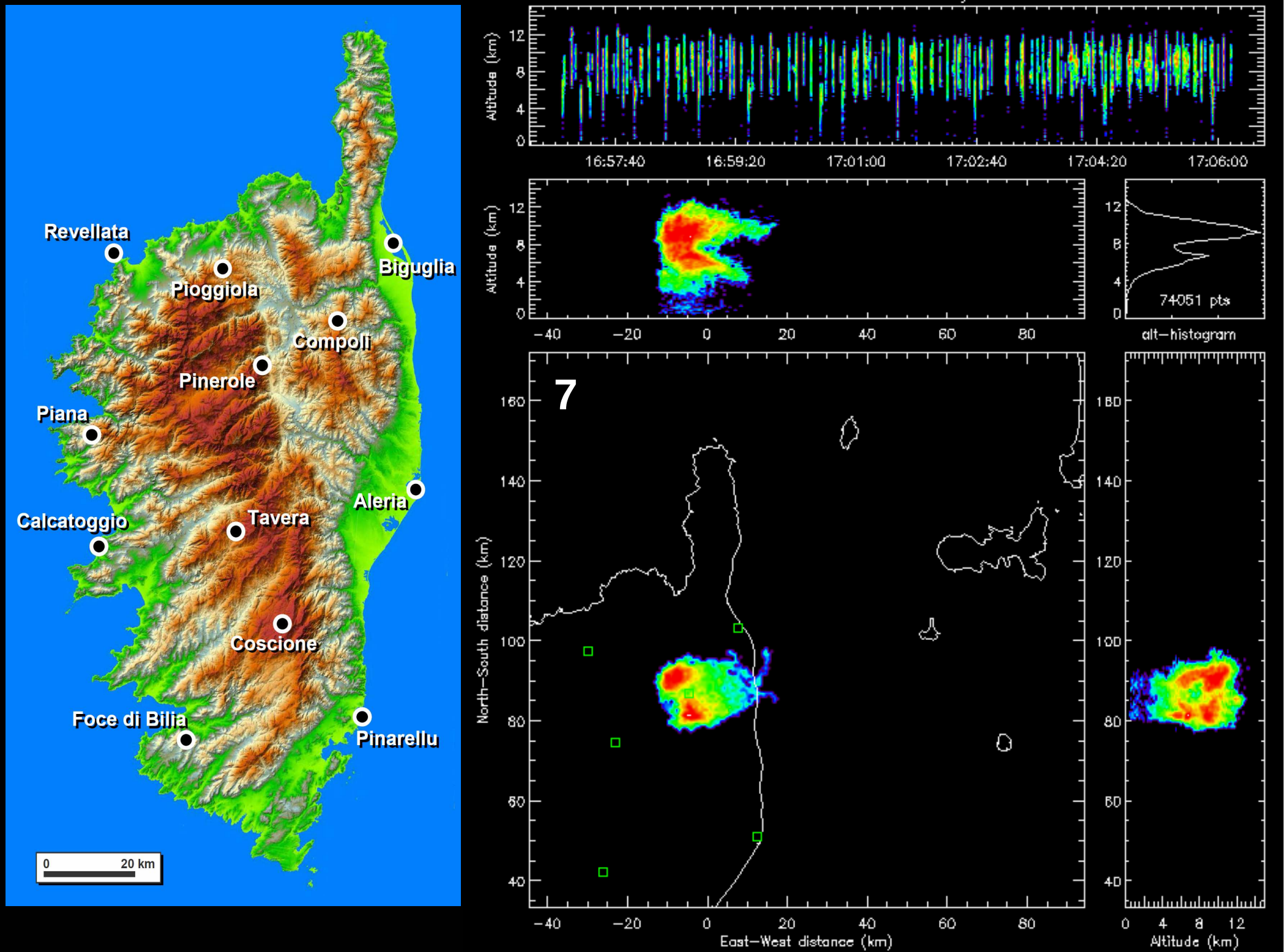

SAETTA LMA on 25 July 2014
Altitude (km)
16:16:40
16:18:20
16:20:00
16:21:40
16:23:20
22893 pts
alt-histogram
2
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

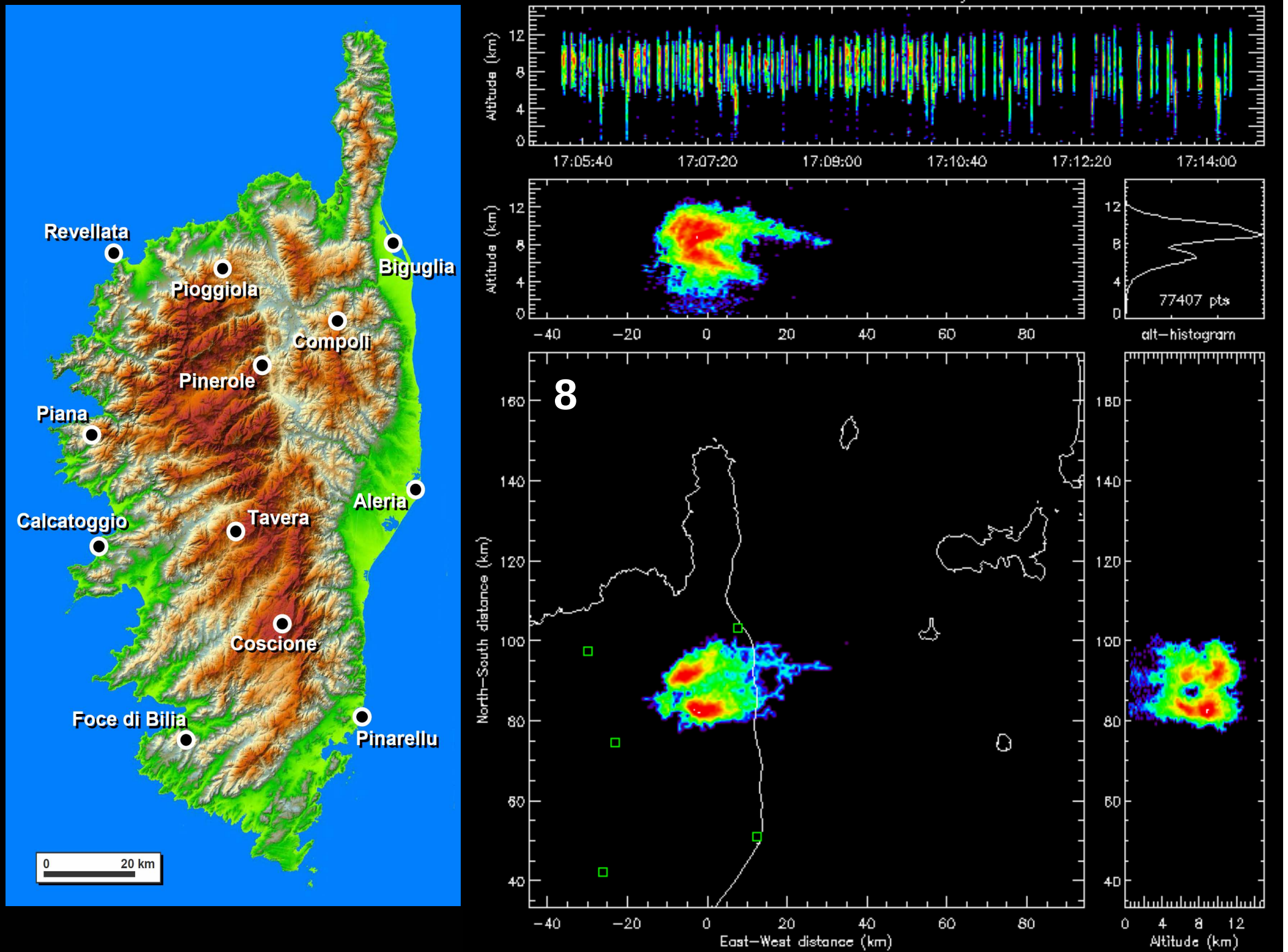

SAETTA LMA on 25 July 2014
Altitude (km)
16:24:40
16:26:20
16:28:00
16:29:40
16:31:20
27888 pts
alt-histogram
3
North-South distance (km)
East-West distance (km)
Altitude (km)
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km

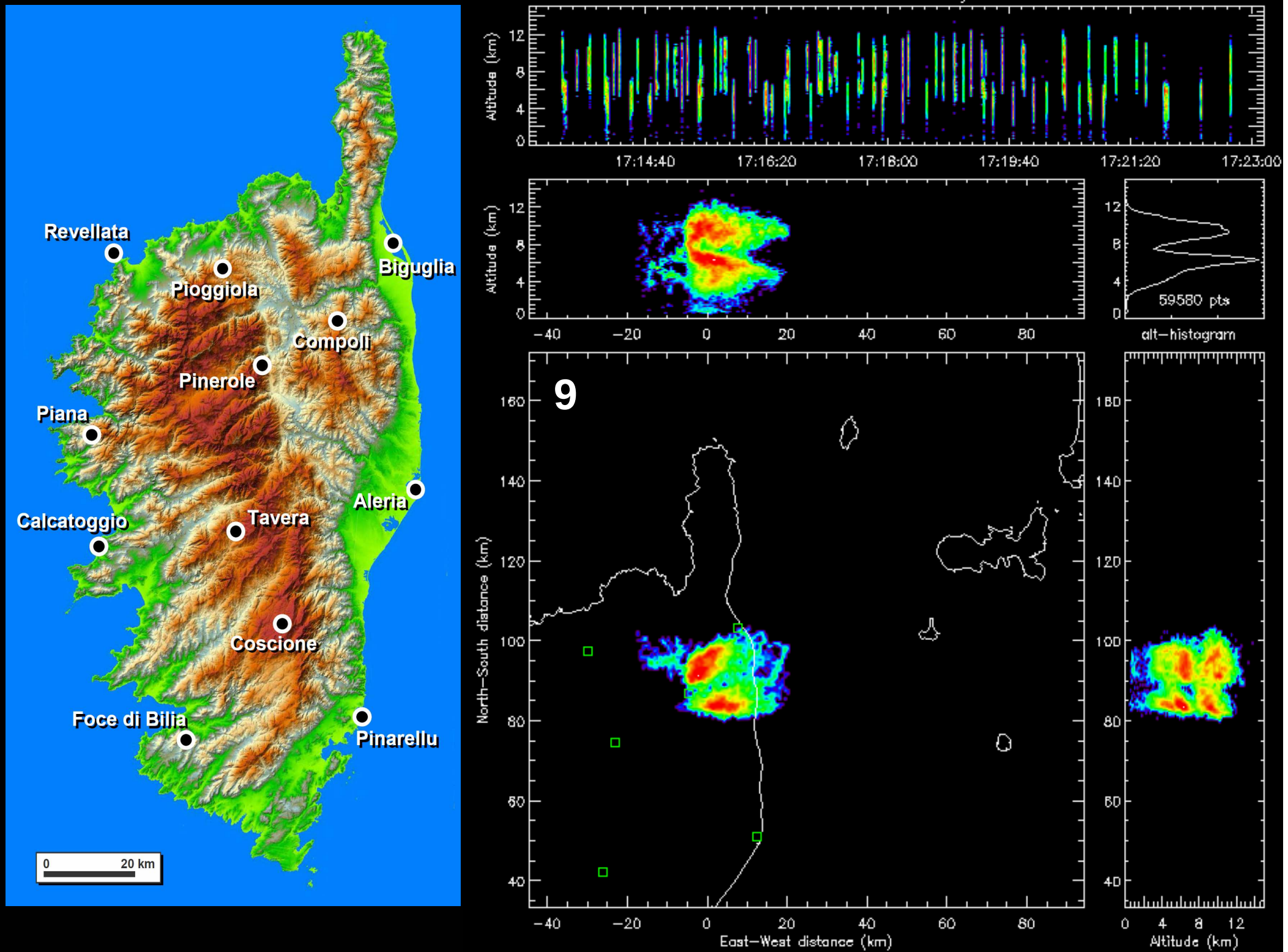

SAETTA LMA on 25 July 2014
Altitude (km)
16:32:40
16:34:20
16:36:00
16:37:40
16:39:20
16:41:00
19508 pts
alt-histogram
4
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

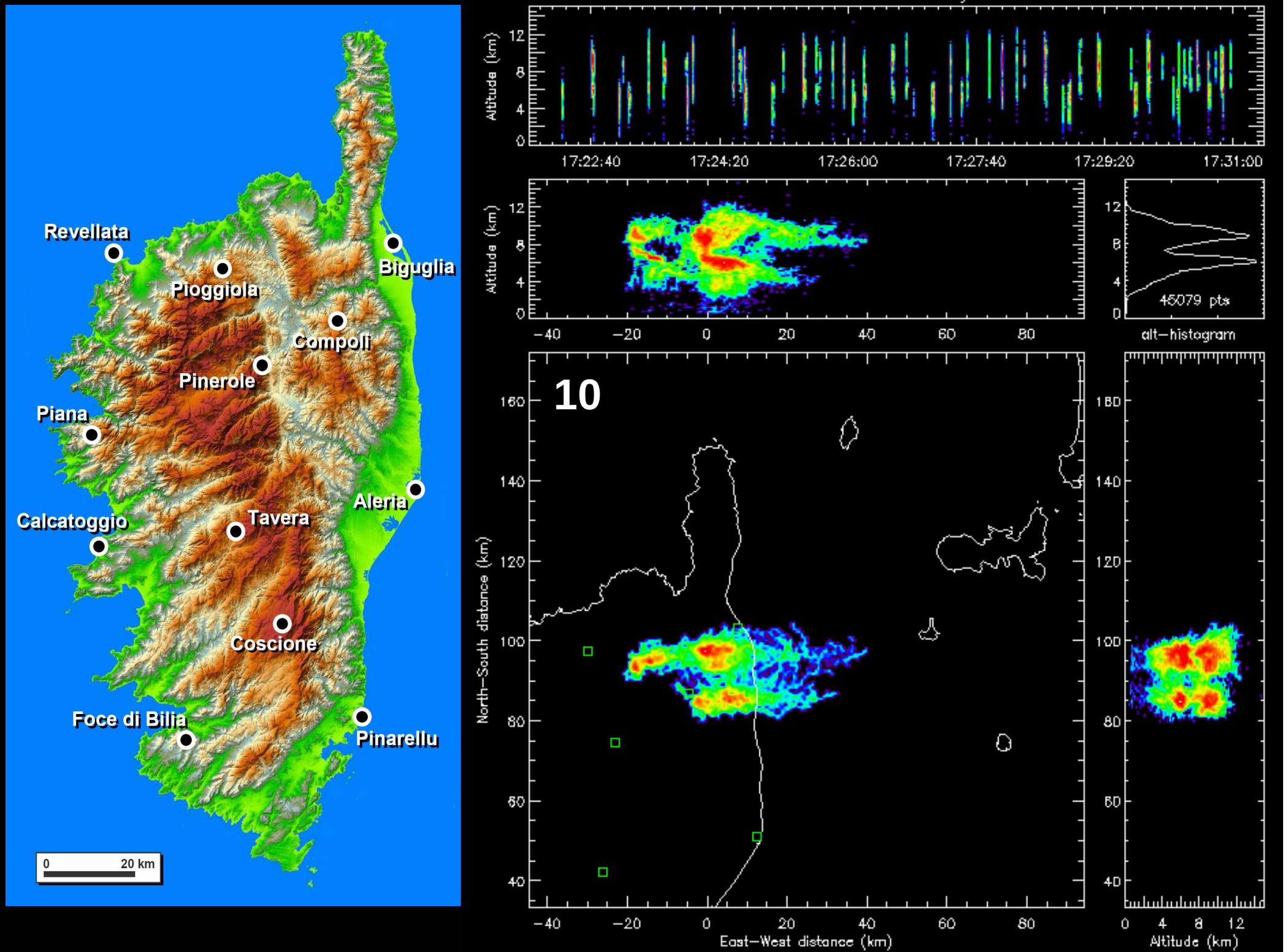

SAETTA LMA on 25 July 2014
Altitude (km)
16:40:40
16:42:20
16:44:00
16:45:40
16:47:20
16:49:00
61965 pts
alt-histogram
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
5
North-South distance (km)
East-West distance (km)
Altitude (km)

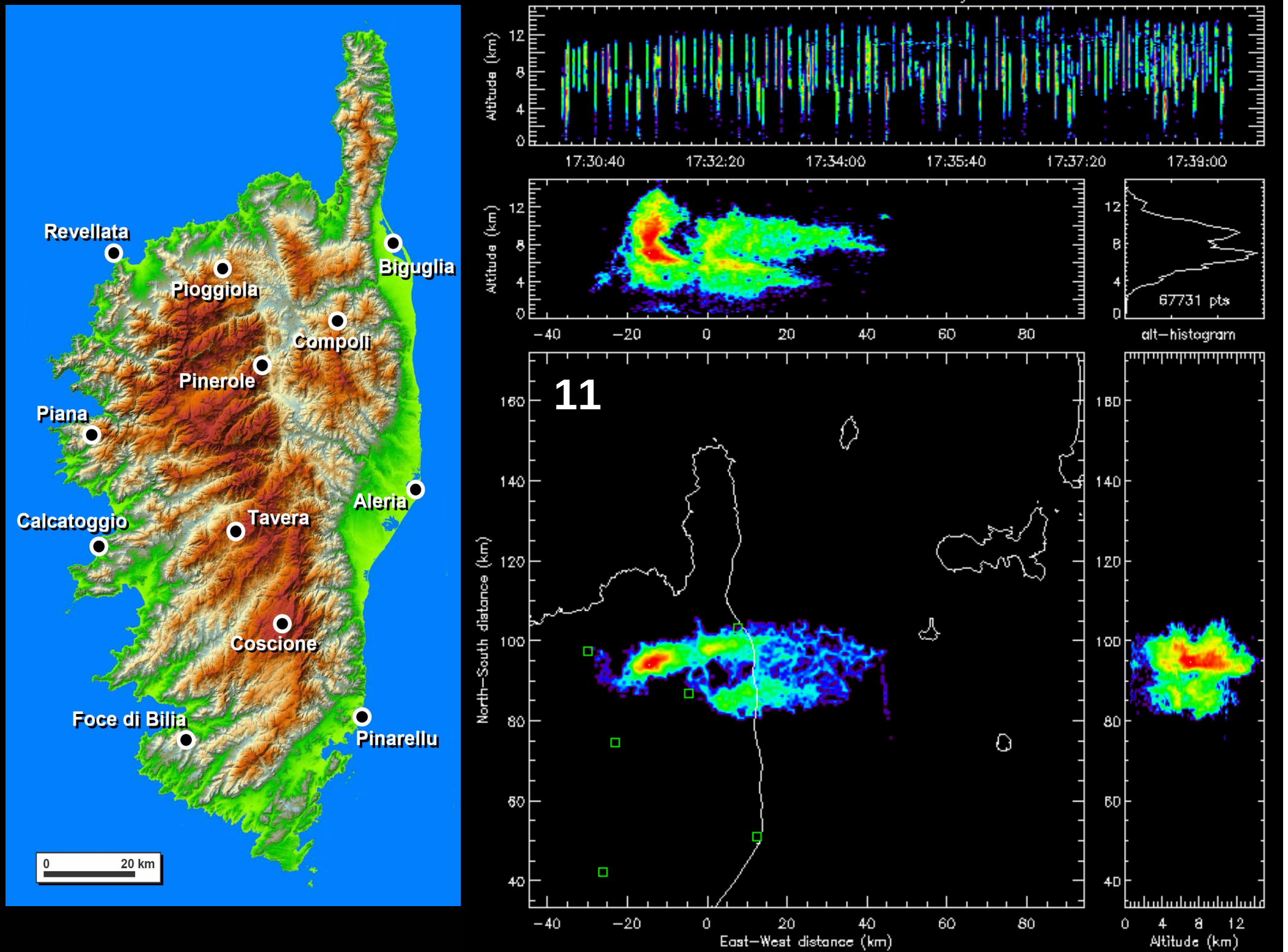

SAETTA LMA on 25 July 2014
Altitude (km)
16:49:40
16:51:20
16:53:00
16:54:40
16:56:20
16:58:00
64430 pts
alt-histogram
6
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

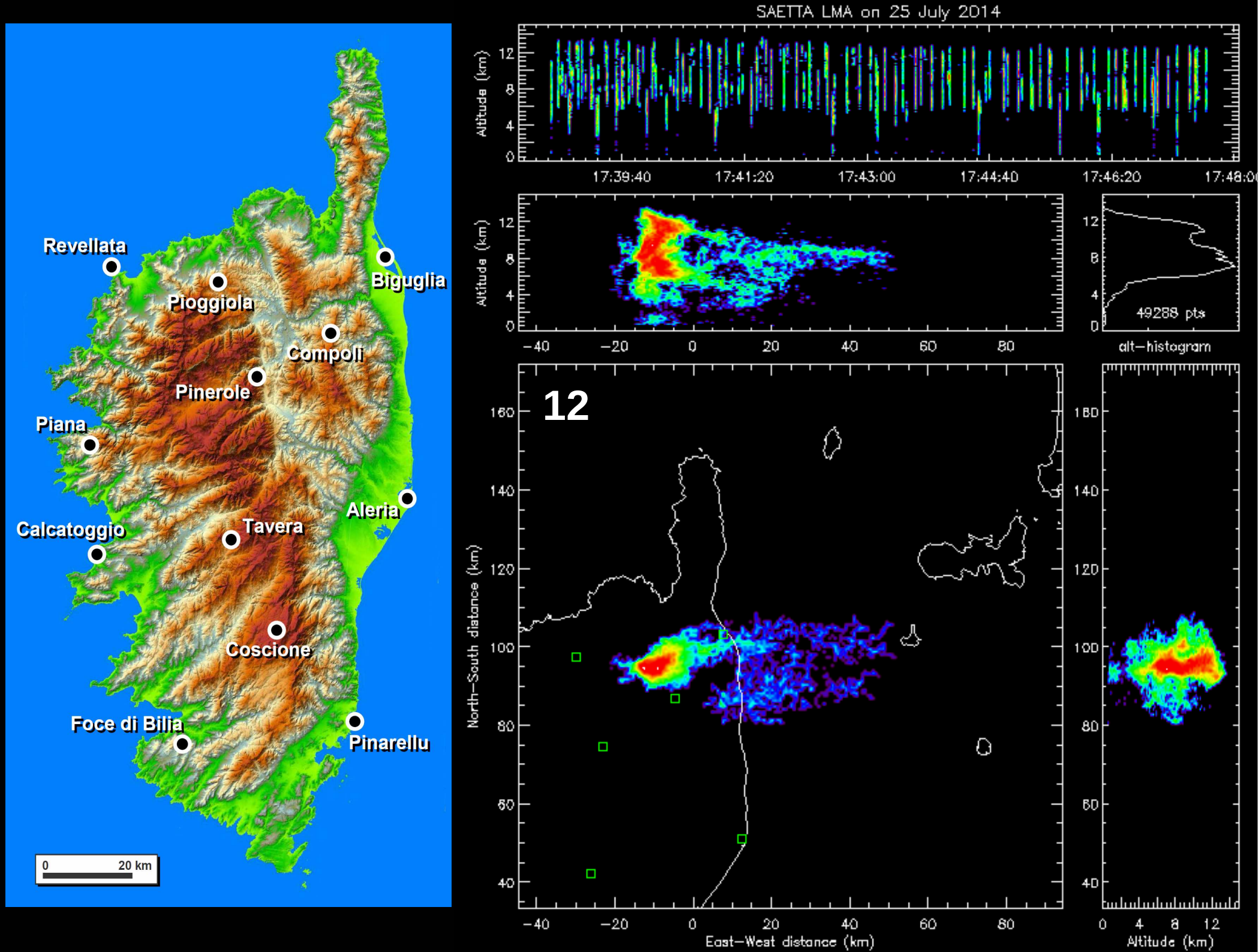

SAETTA LMA on 25 July 2014
Altitude (km)
16:57:40
16:59:20
17:01:00
17:02:40
17:04:20
17:06:00
74051 pts
alt-histogram
7
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

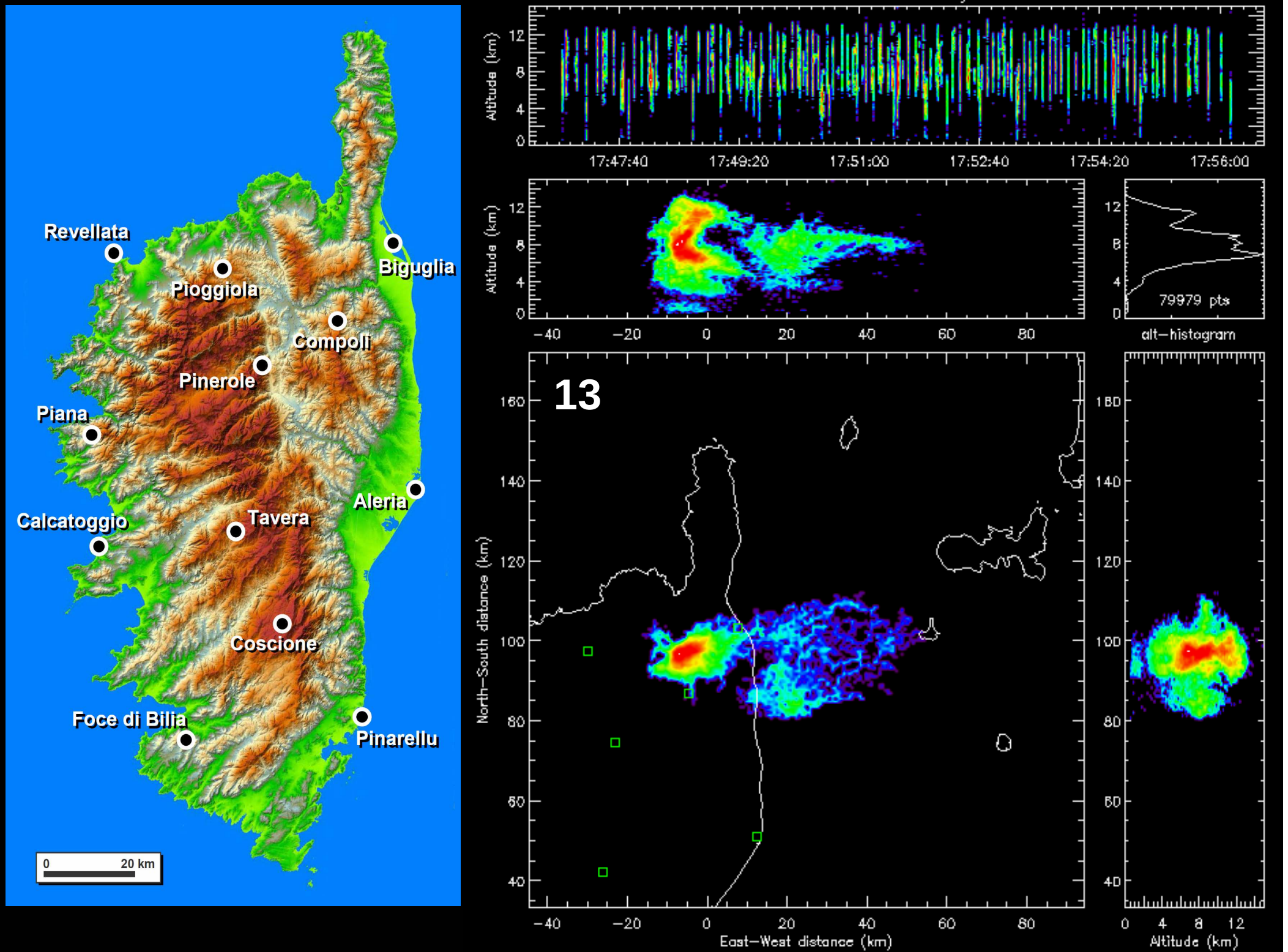

SAETTA LMA on 25 July 2014
Altitude (km)
17:05:40
17:07:20
17:09:00
17:10:40
17:12:20
17:14:00
77407 pts
alt-histogram
8
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

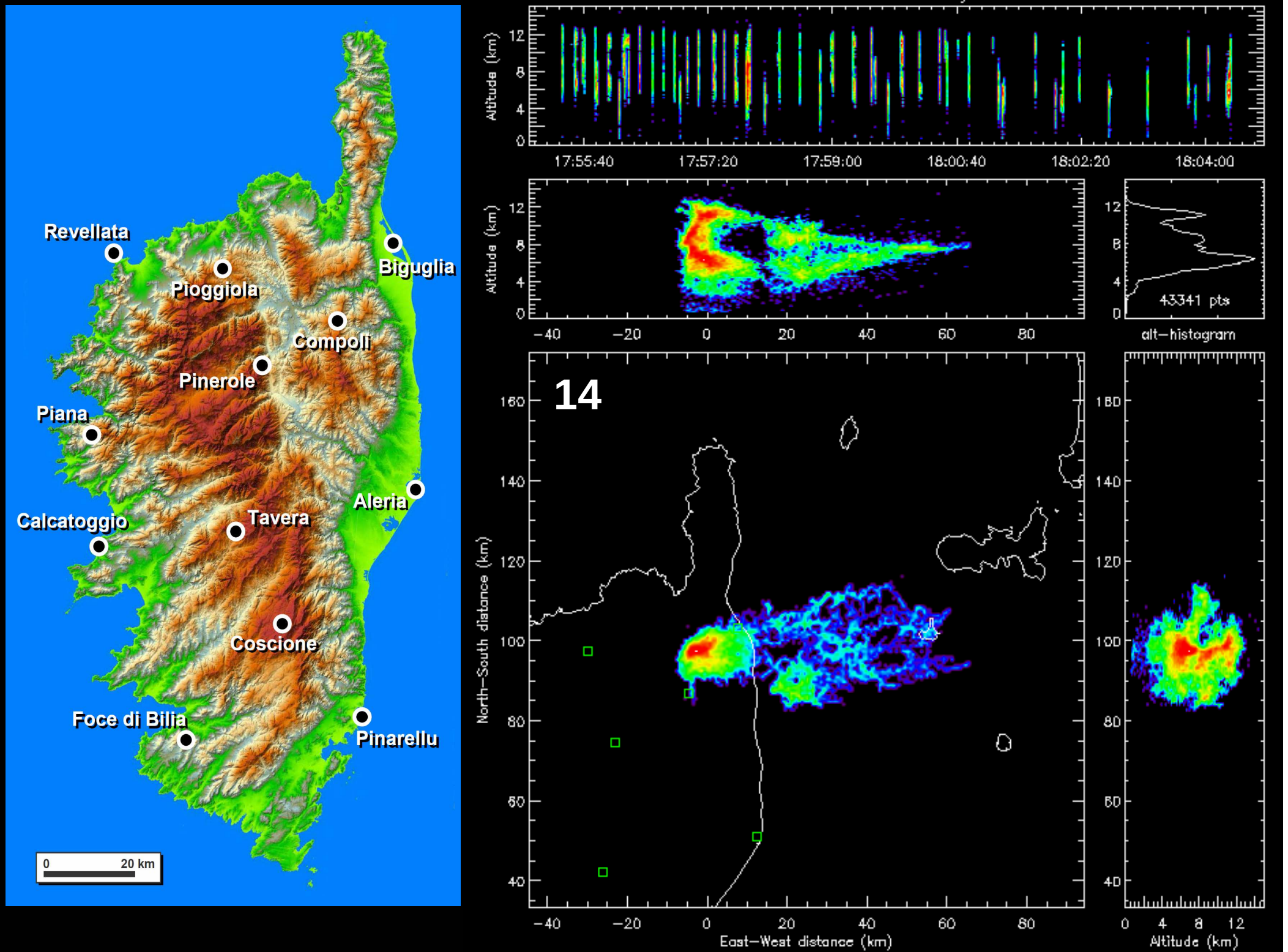

SAETTA LMA on 25 July 2014
Altitude (km)
17:14:40
17:16:20
17:18:00
17:19:40
17:21:20
17:23:00
59580 pts
alt-histogram
9
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

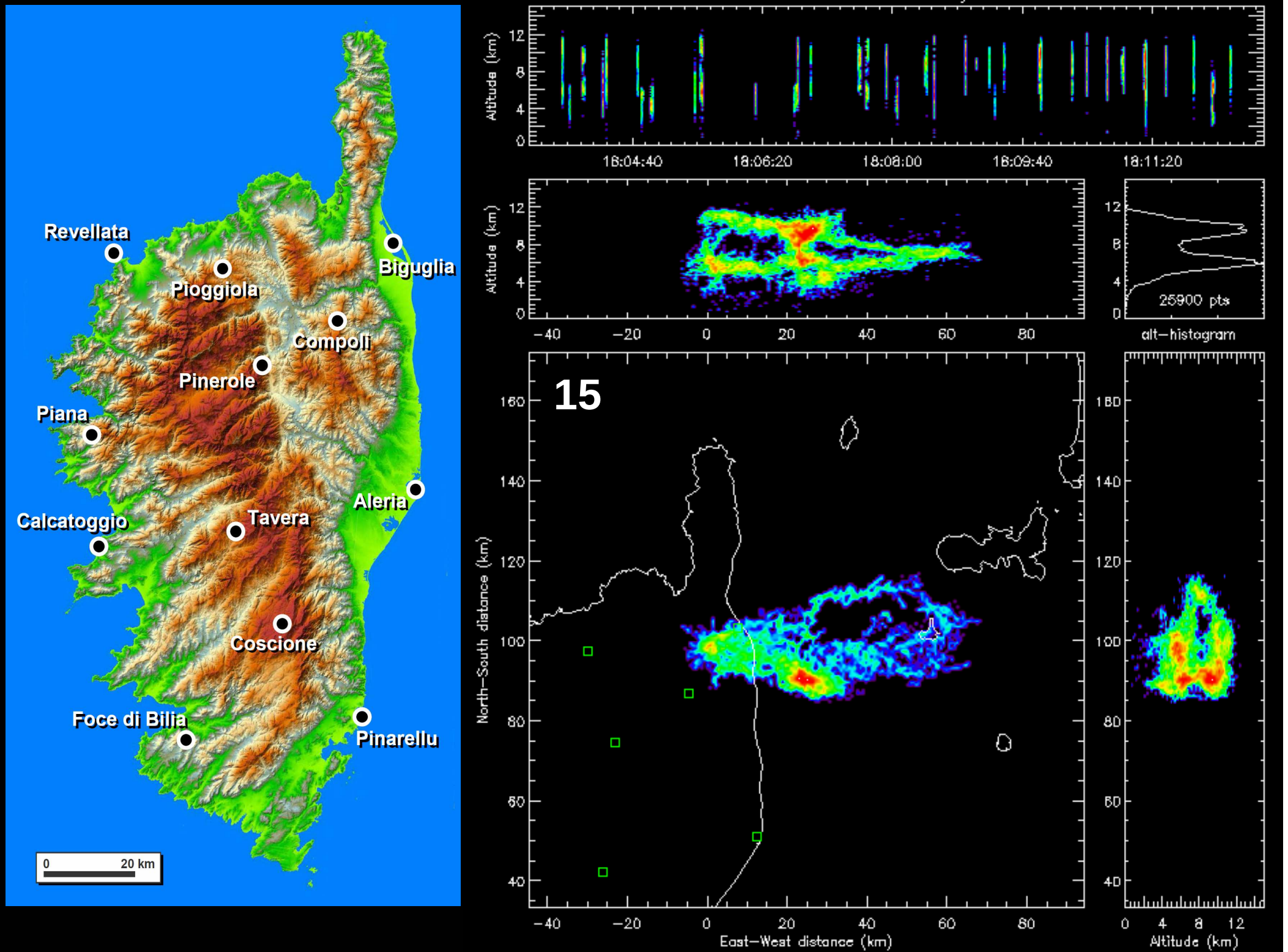

SAETTA LMA on 25 July 2014
Altitude (km)
17:22:40
17:24:20
17:26:00
17:27:40
17:29:20
17:31:00
45079 pts
alt-histogram
10
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

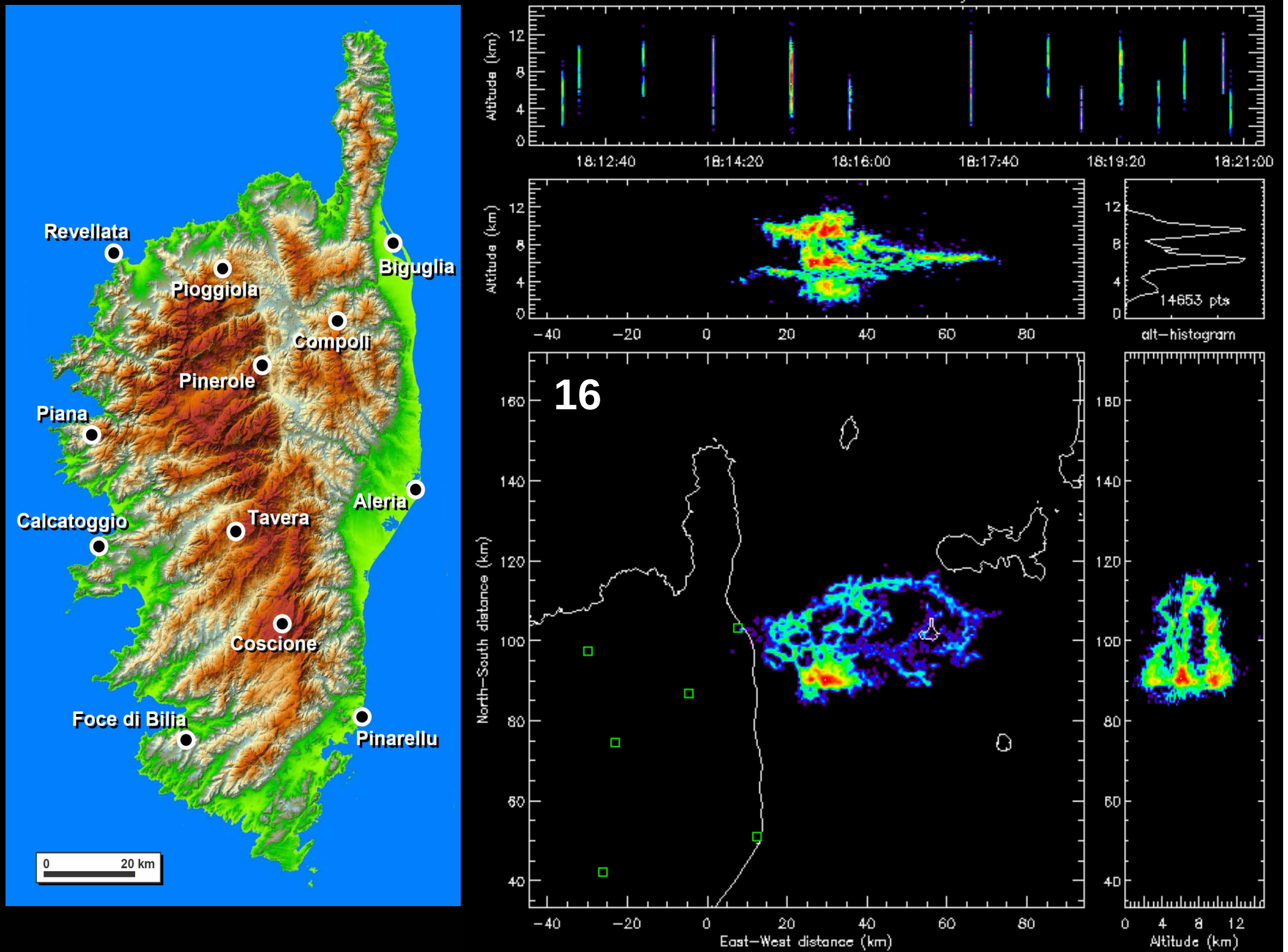

SAETTA LMA on 25 July 2014
Altitude (km)
17:30:40
17:32:20
17:34:00
17:35:40
17:37:20
17:39:00
67731 pts
alt-histogram
11
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

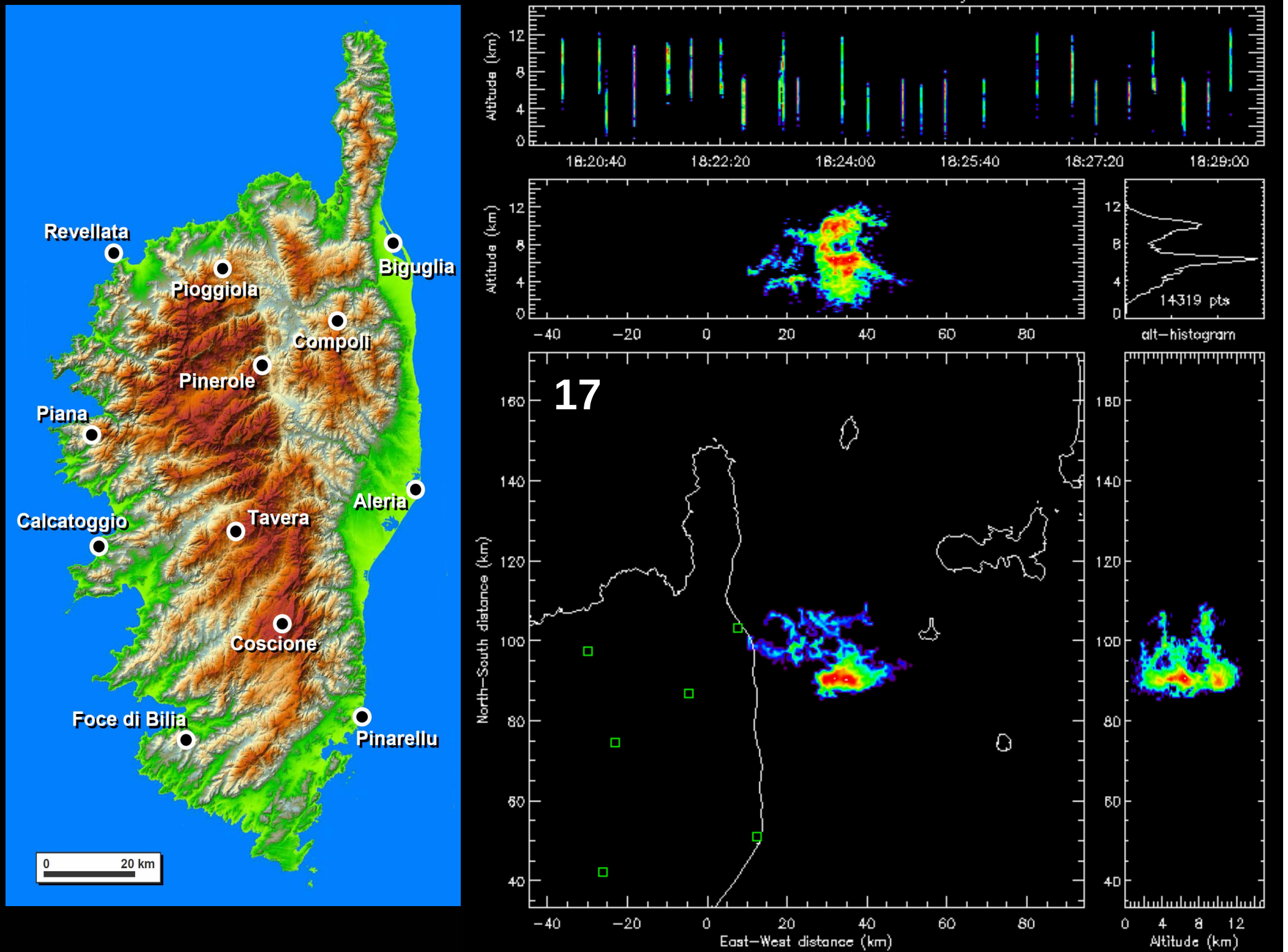

SAETTA LMA on 25 July 2014
Altitude (km)
17:39:40
17:41:20
17:43:00
17:44:40
17:46:20
49288 pts
alt-histogram
12
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

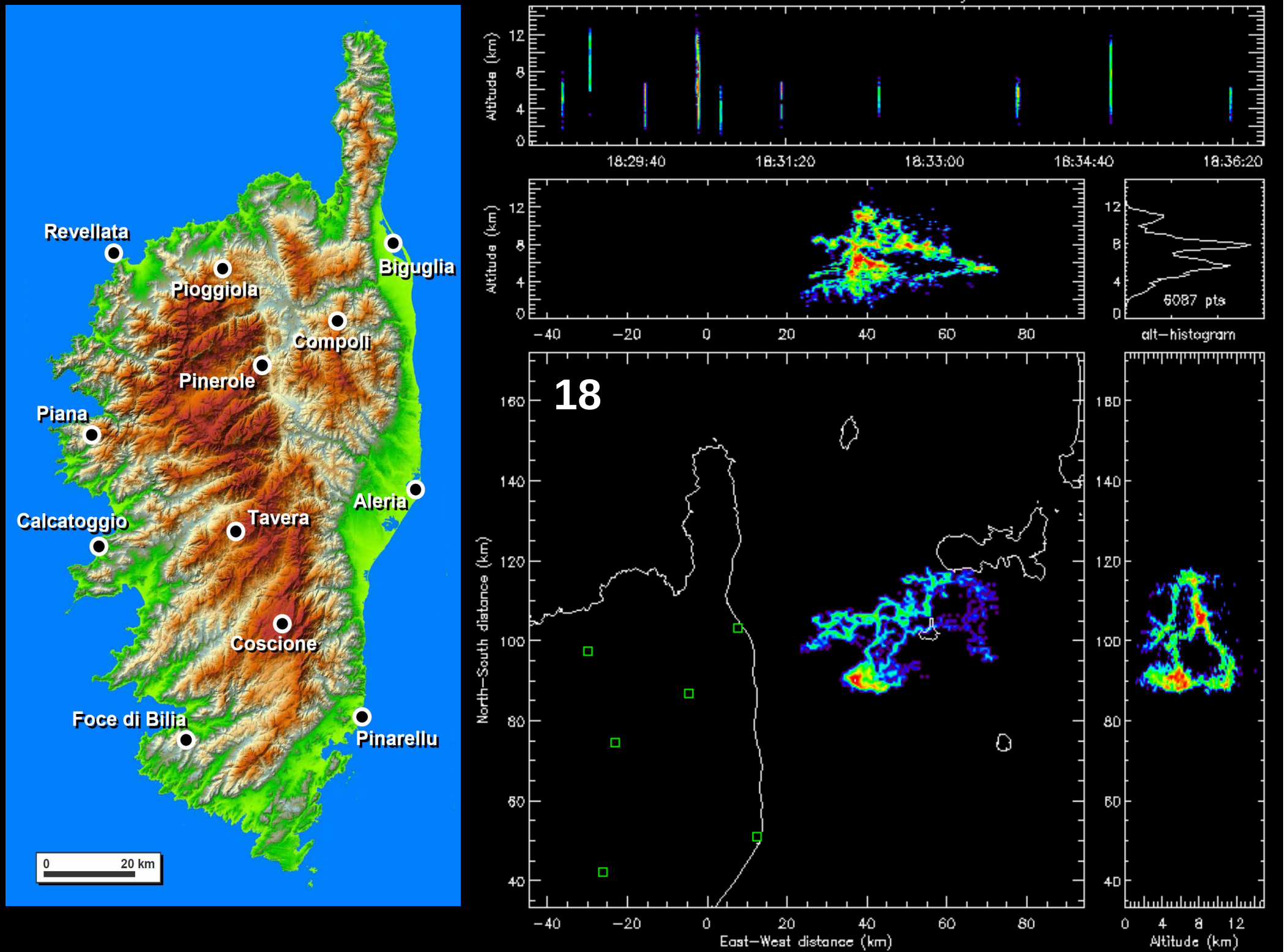

SAETTA LMA on 25 July 2014
Altitude (km)
17:47:40
17:49:20
17:51:00
17:52:40
17:54:20
17:56:00
79979 pts
alt-histogram
13
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

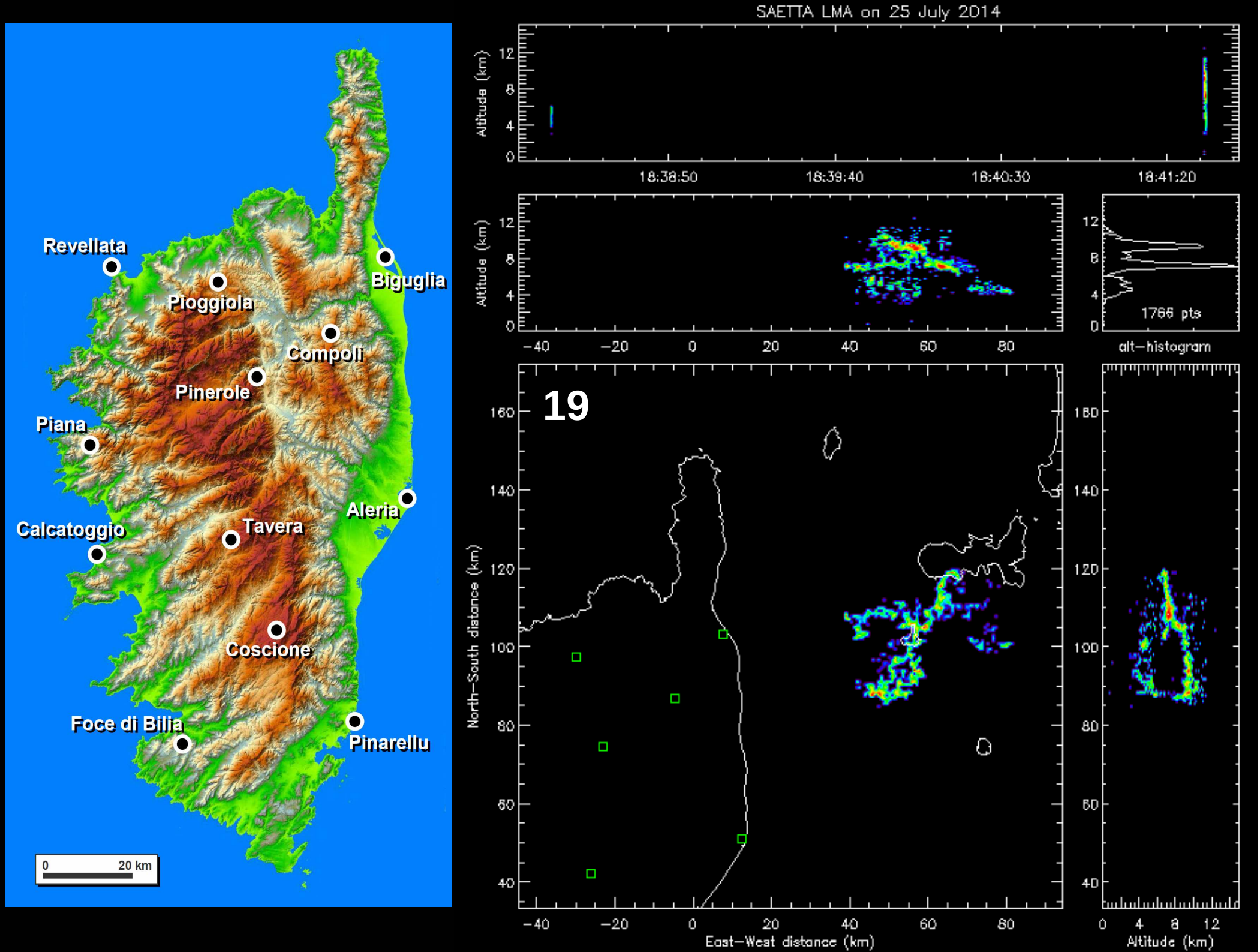

SAETTA LMA on 25 July 2014
Altitude (km)
17:55:40
17:57:20
17:59:00
18:00:40
18:02:20
18:04:00
43341 pts
alt-histogram
14
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

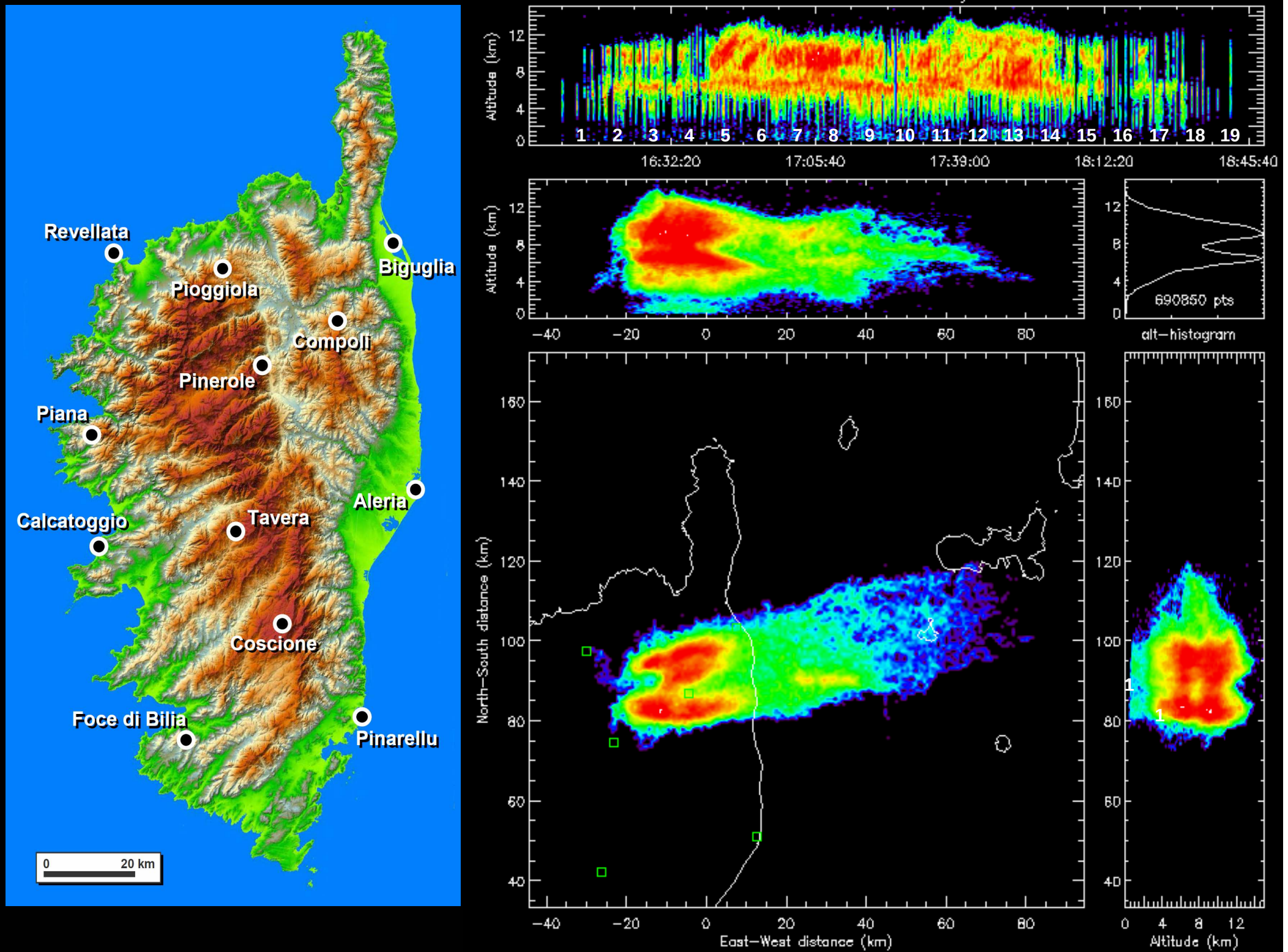

SAETTA LMA on 25 July 2014
Altitude (km)
16:04:40
16:06:20
16:08:00
16:09:40
16:11:20
25900 pts
alt-histogram
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
15
North-South distance (km)
East-West distance (km)
Altitude (km)

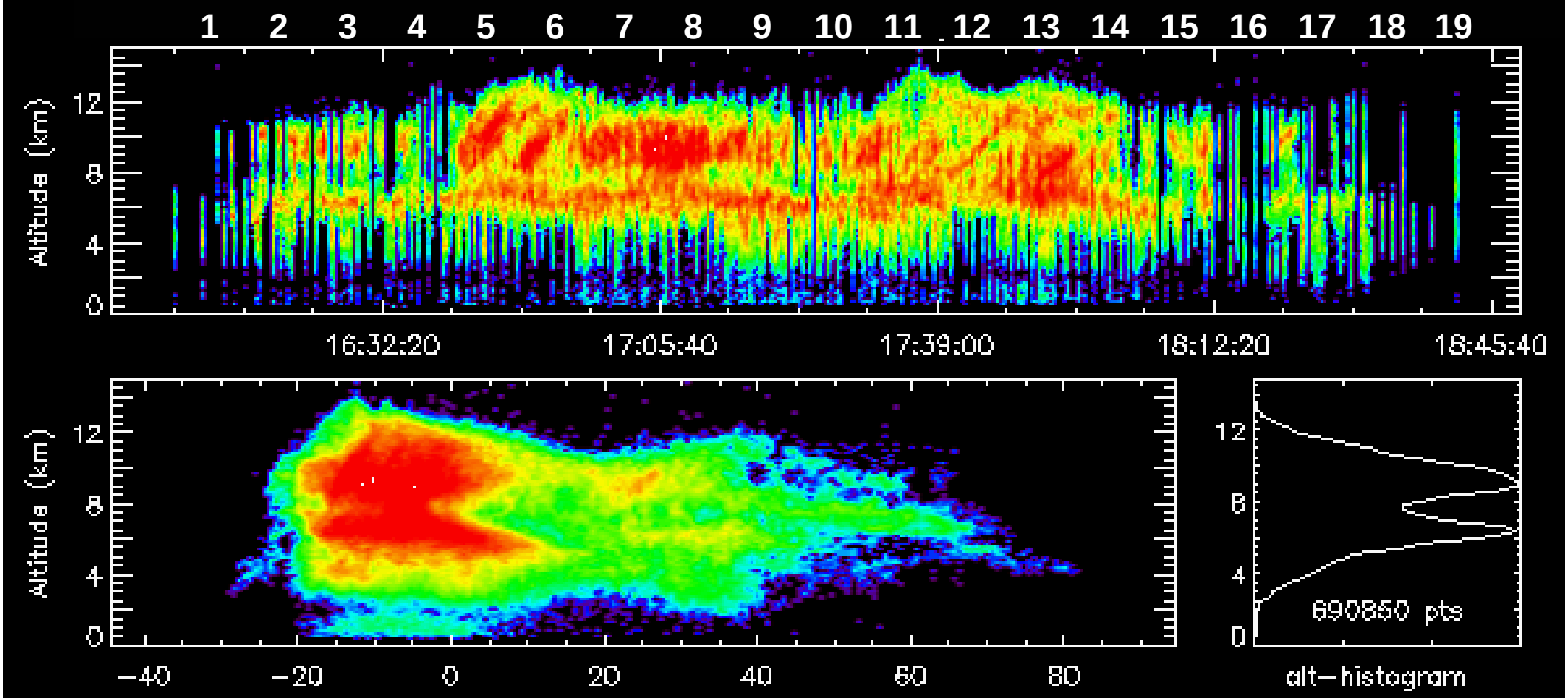

SAETTA LMA on 25 July 2014
Altitude (km)
18:12:40
18:14:20
18:16:00
18:17:40
18:19:20
18:21:00
14653 pts
alt-histogram
16
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)


SAETTA LMA on 25 July 2014
Altitude (km)
18:20:40
18:22:20
18:24:00
18:25:40
18:27:20
18:29:00
14319 pts
alt-histogram
17
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)

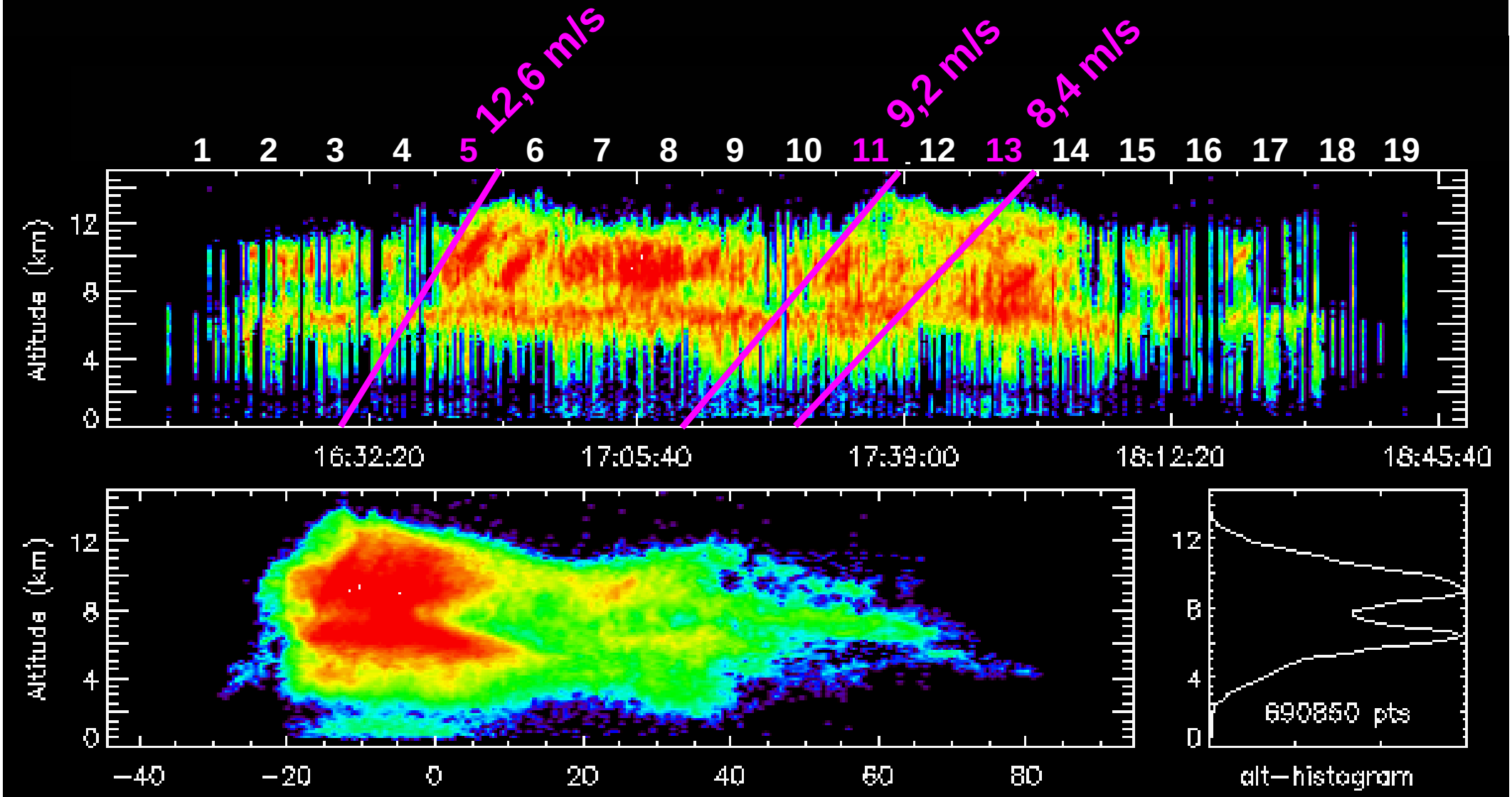

SAETTA LMA on 25 July 2014
Altitude (km)
18:29:40
18:31:20
18:33:00
18:34:40
18:36:20
6087 pts
alt-histogram
18
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km
North-South distance (km)
East-West distance (km)
Altitude (km)


SAETTA LMA on 25 July 2014
Altitude (km)
18:38:50
18:39:40
18:40:30
18:41:20
1766 pts
alt-histogram
19
North-South distance (km)
East-West distance (km)
Altitude (km)
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0
20 km

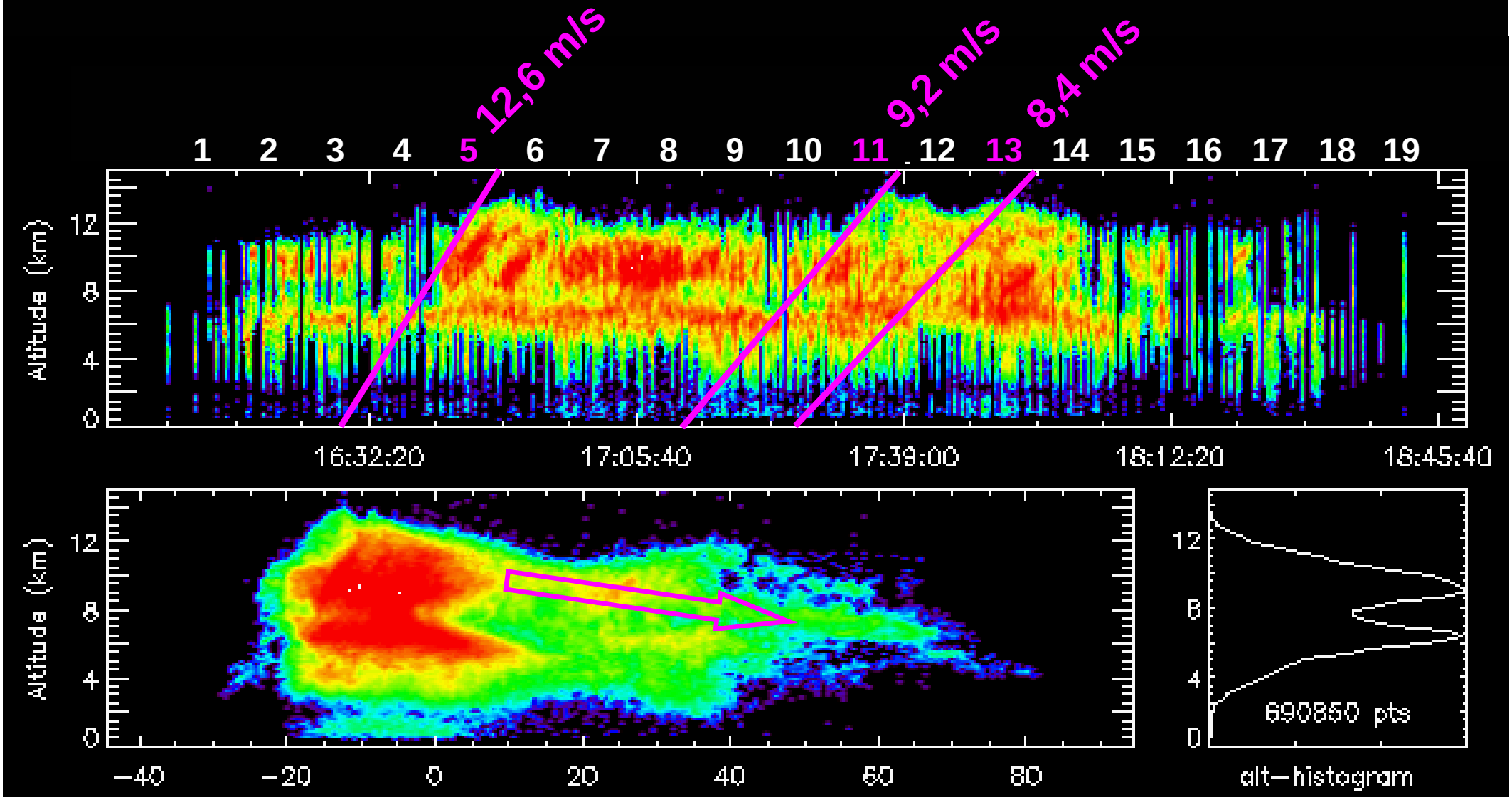

SAETTA LMA on 25 July 2014
Altitude (km)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
16:32:20
17:05:40
17:39:00
18:12:20
18:45:40
690850 pts
alt-histogram
Revellata
Pioggiola
Biguglia
Compoli
Pinerole
Piana
Aleria
Calcatoggio
Tavera
Coscione
Foce di Bilia
Pinarellu
0 20 km
North-South distance (km)
East-West distance (km)
Altitude (km)


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Altitude (km)
0
4
8
12
16:32:20
17:05:40
17:39:00
18:12:20
18:45:40
Altitude (km)
0
4
8
12
−40
−20
0
20
40
60
80
690850 pts
alt−histogram

# Signature "électrique" des poussées convectives

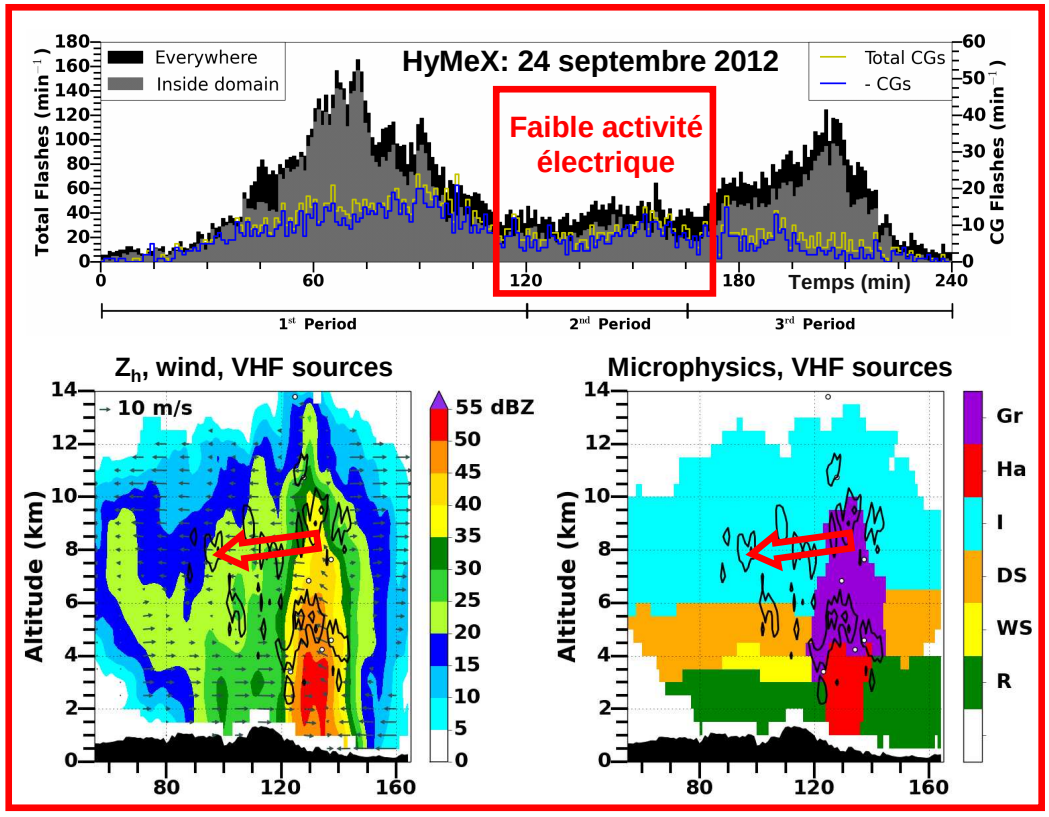


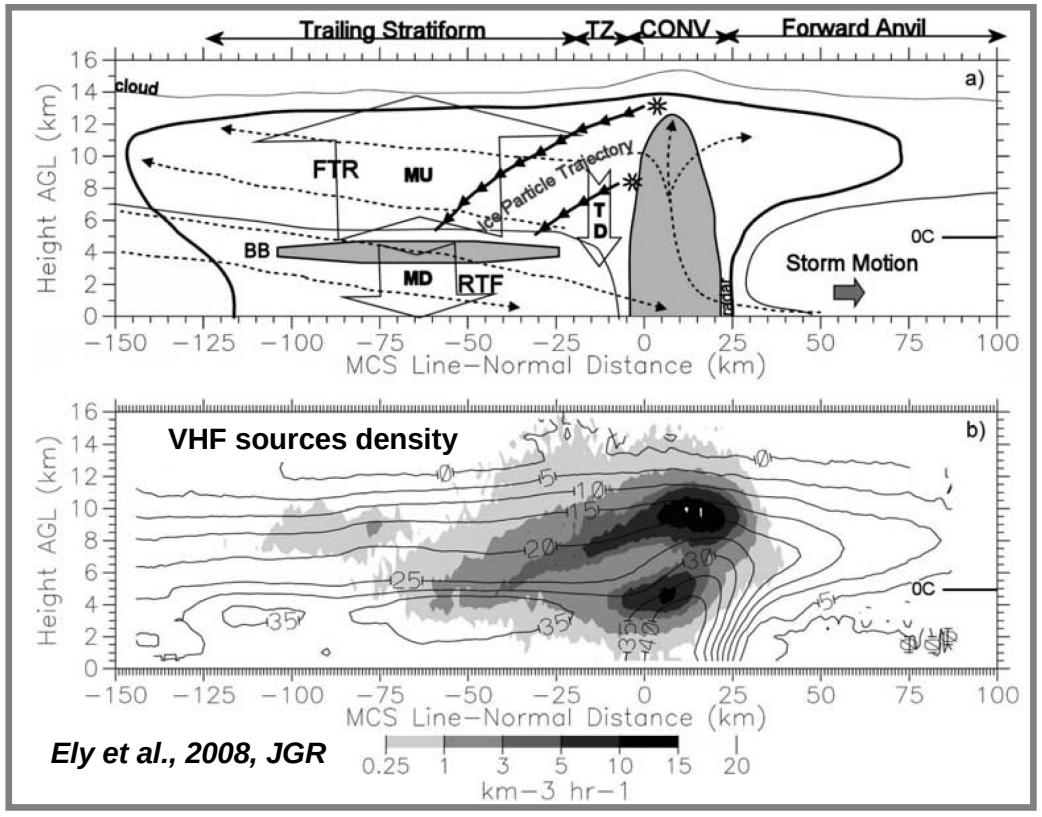
# Signature "électrique" des poussées convectives




# Signature "électrique" du transport des cristaux de glace chargés dans la partie stratiforme

# Signature "électrique" du transport des cristaux de glace dans la partie stratiforme *(Ribaud et al., 2016, QJRMS)*




- Etage supérieur: ramification des éclairs sur les cristaux de glace chargés
- Cristaux de glace transportés hors de la zone convective dans la partie stratiforme
- Diminution de la charge électrique dans la zone convective
- Diminution du champ électrique (déclenchement des éclairs moins efficace)
- Diminution du taux d'éclair

# Electrical scheme of MesoNH

3 CRM (Mansell et al., 2002; Barthe et Pinty, 2007; Fierro et al., 2013) with a complete explicit 3D electrical scheme

**electrical charges + electric field + lightning flashes**

Coupling with cloud μphysics (NI charging process TAKAH/SAUND) and physics of the ions

Numerical method

$$\varepsilon \cdot \nabla \cdot \vec{E} = q_{total}$$

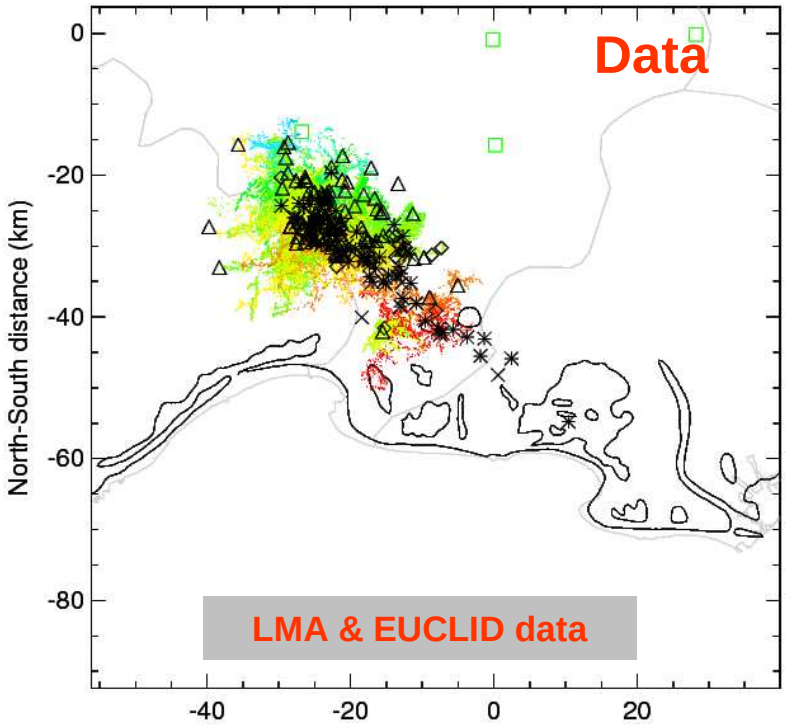
**(Eq. is solved for $V$ with $\vec{E} = -\vec{\nabla} V$ and BC)**

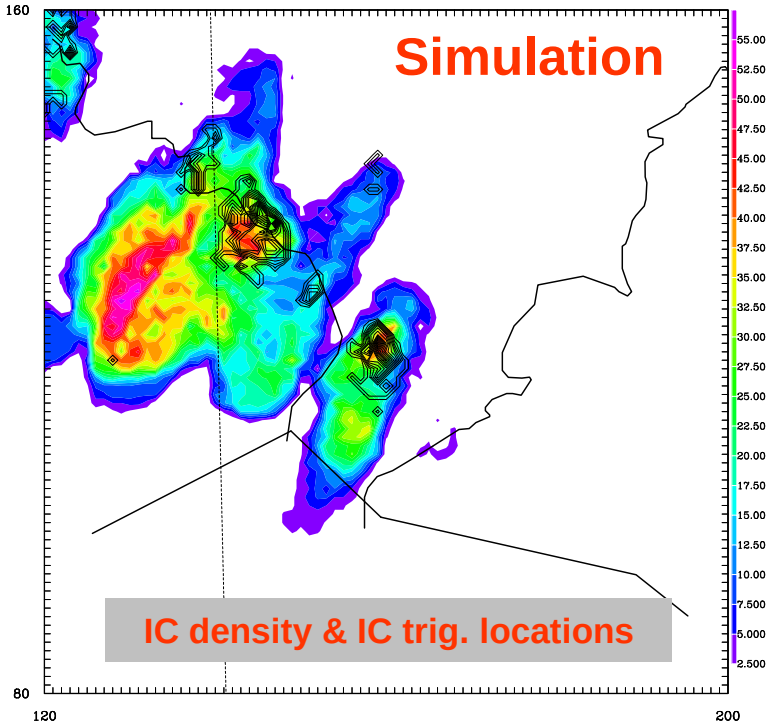
**$||E|| > E_{trig}$**

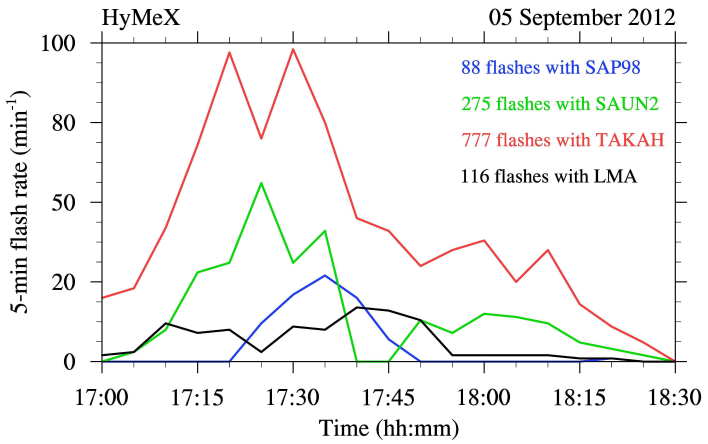
Conceptual model leaders & branches
➔ Partial charge neutralization

**Continuous charging** (μphysics) → **Discrete discharging** (flashes)

# The 5 September 2012 case: close view of "Montpellier" storm



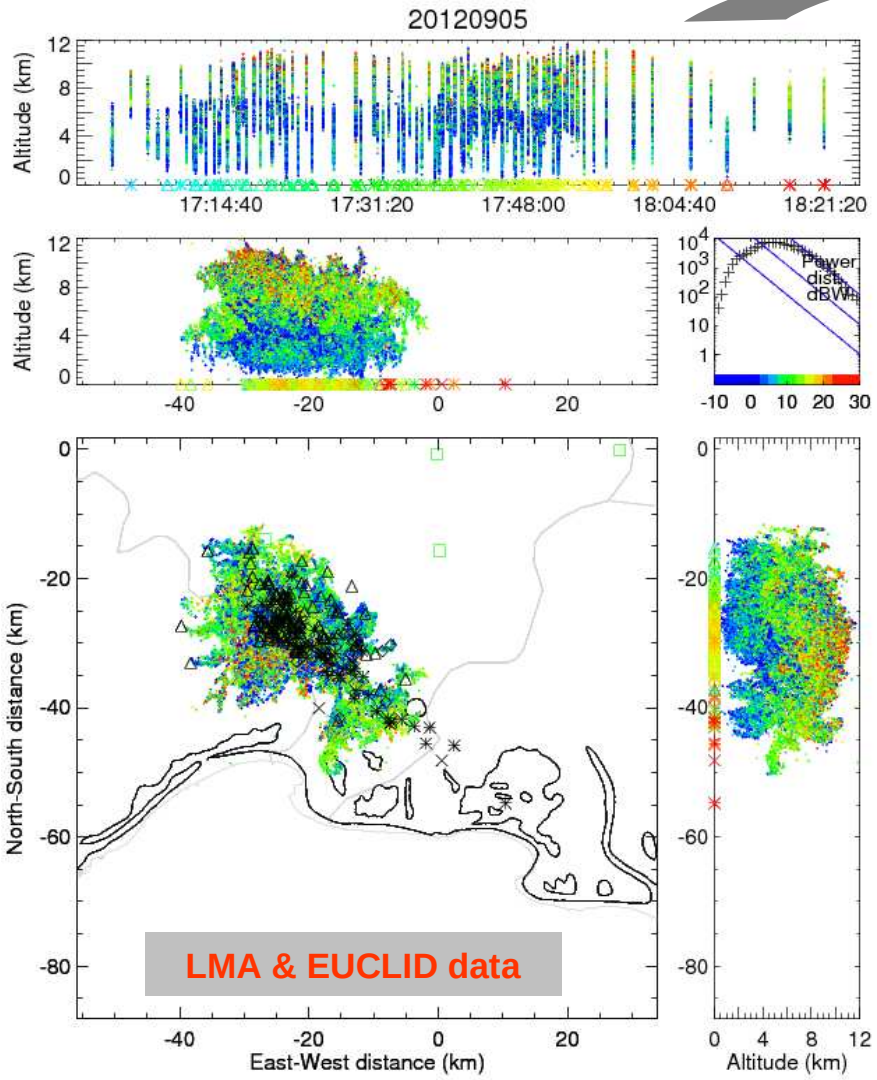



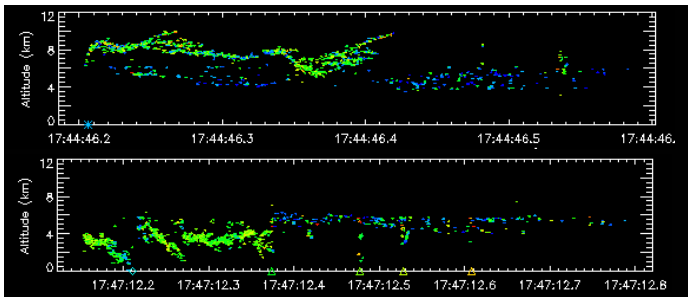

## Simulation:

+ accurate location and duration of the storm
+ flash rate (SAUN2 & SAP98)
- lack of CG

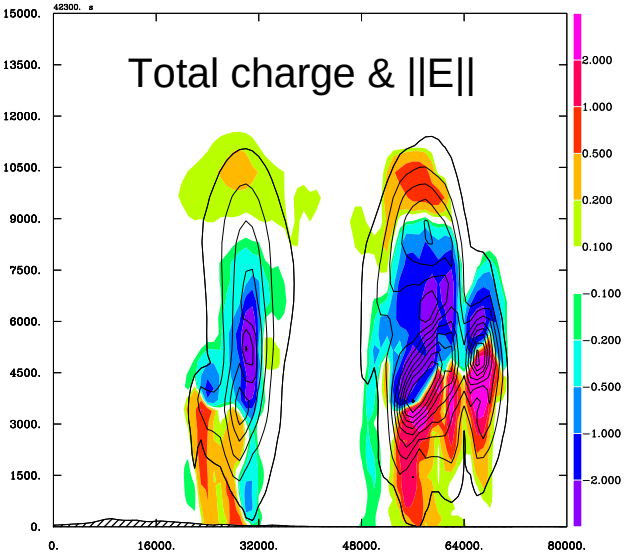
# The 5 September 2012 case: electrical charges at 17:45



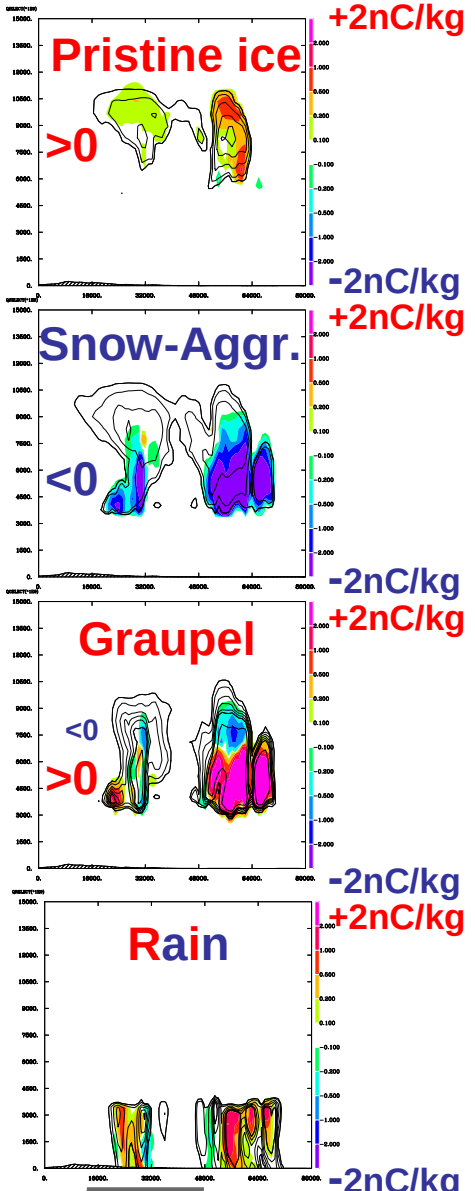

High & low level flashes




➔ **Tripole charge structure**

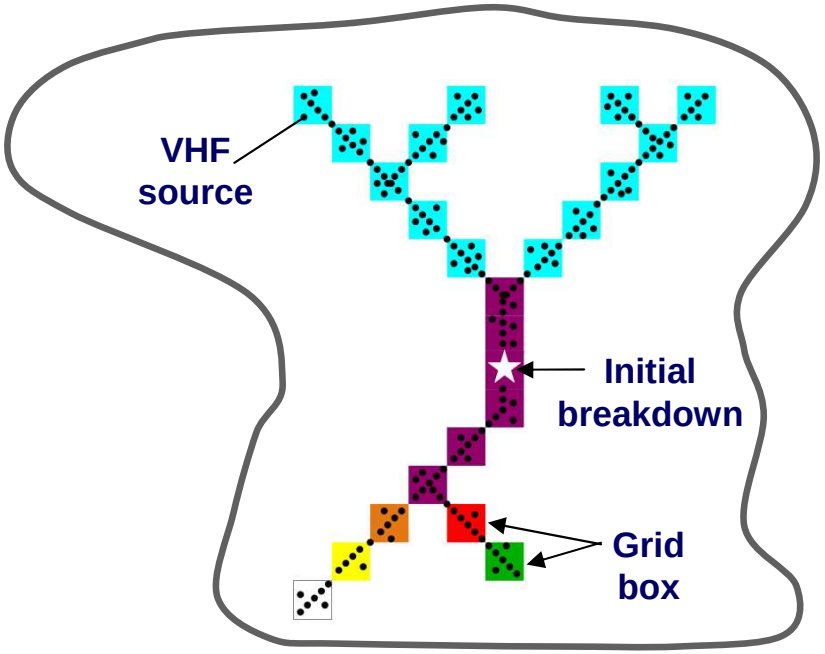


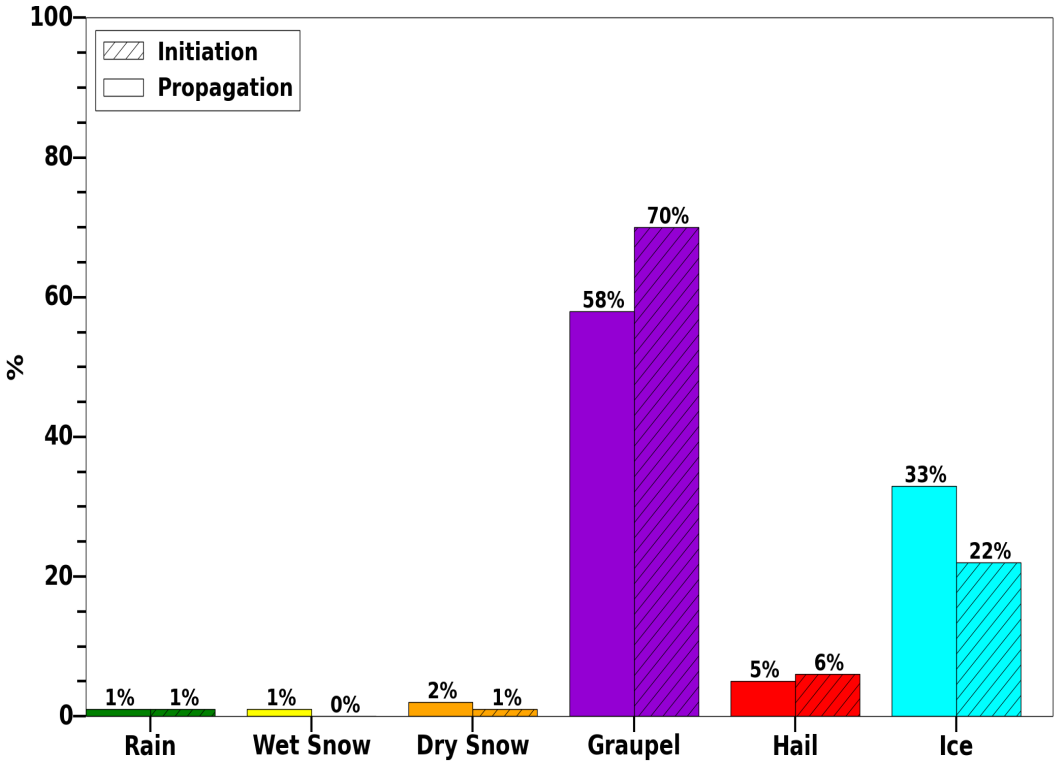

**||E|| max ~ 100 kV/m**



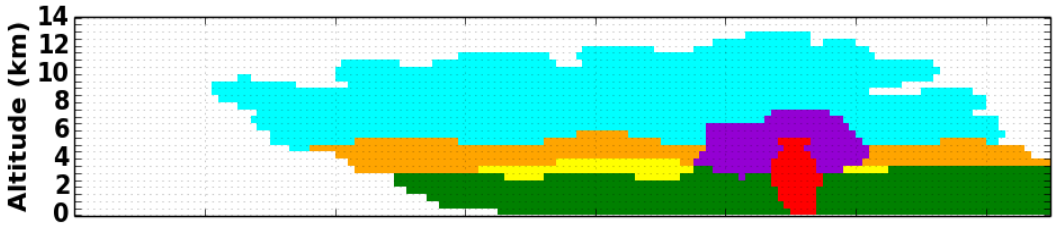
# Sources VHF vs microphysique: première quantification

*(Ribaud et al., 2016, QJRMS)*



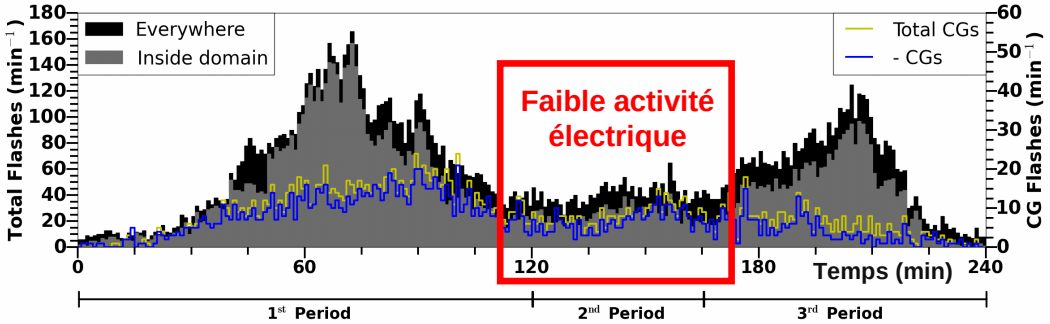




- Propagation des éclairs dans les zones contenant du **graupel** (58%) et de **glace** (33%)
- Déclenchement des éclairs dans les zones contenant du **graupel** (70%) et de la **glace** (22%)

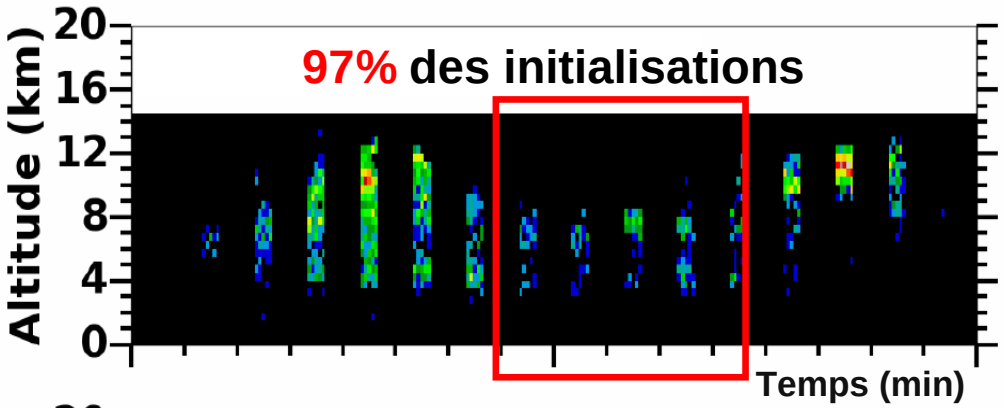


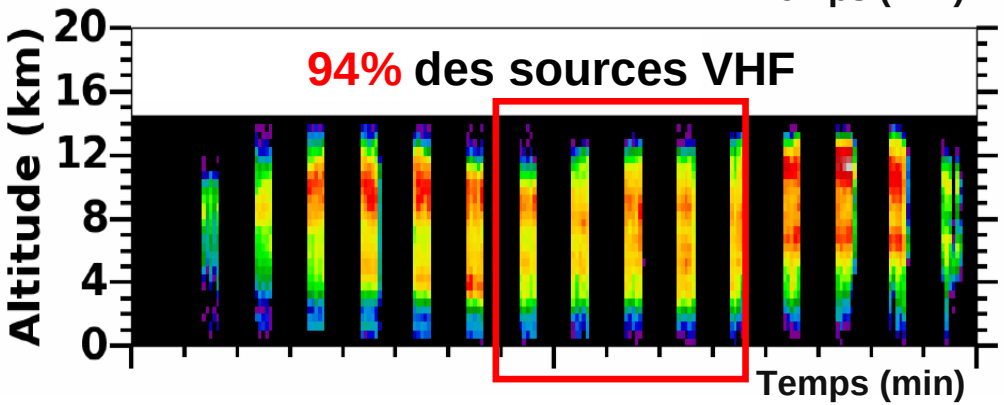
# HyMeX: cas du 24 Septembre 2012

*(Ribaud et al., 2016, QJRMS)*

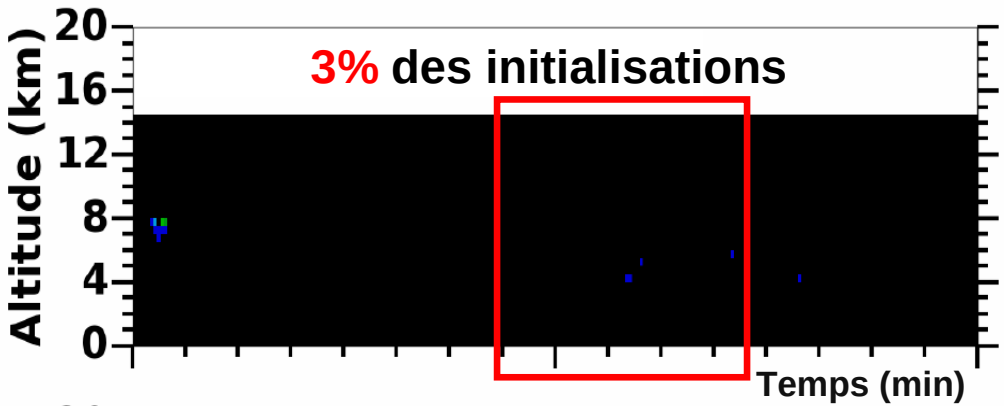


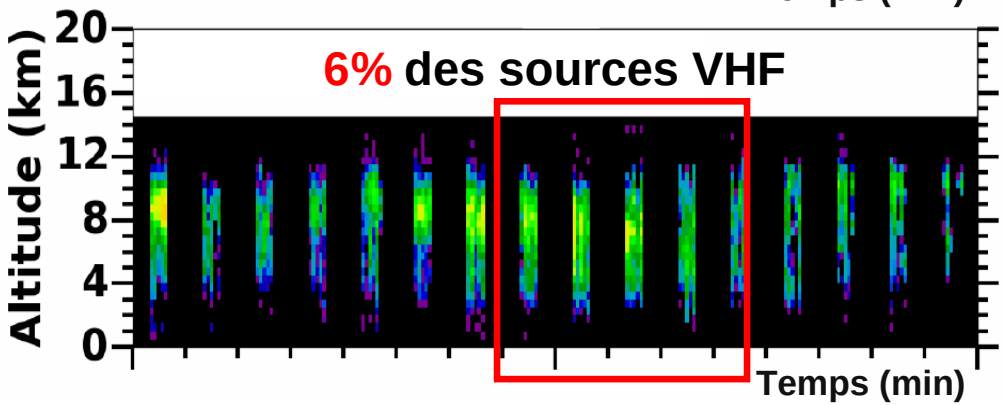

## ZONE CONVECTIVE



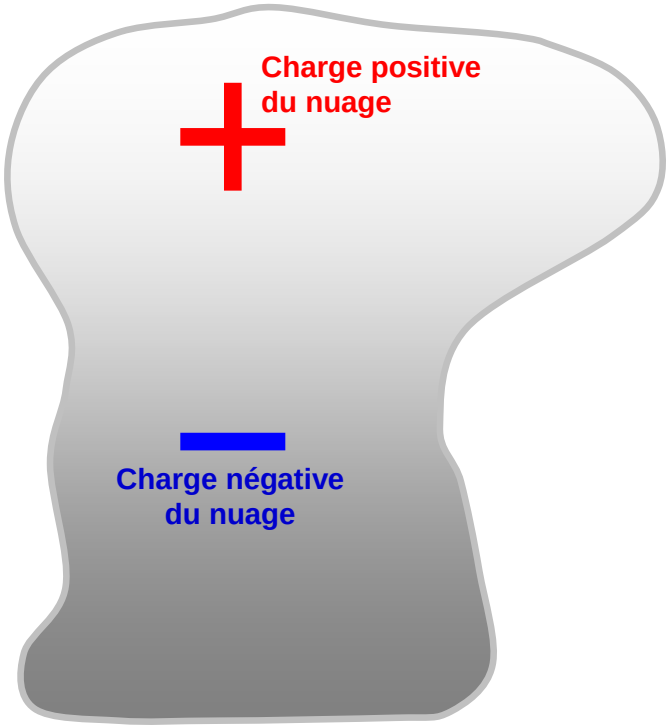

## ZONE STRATIFORME

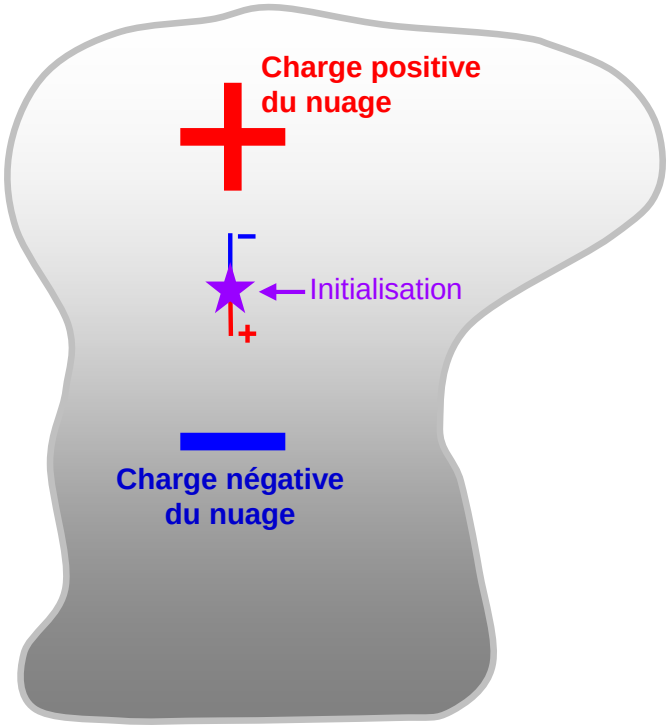


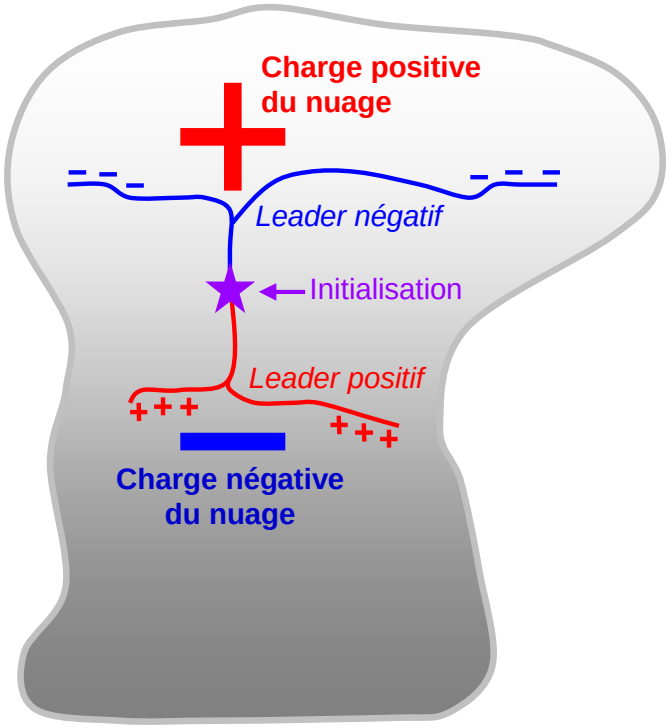



# Conclusion: intérêt des observations d'éclairs 3D

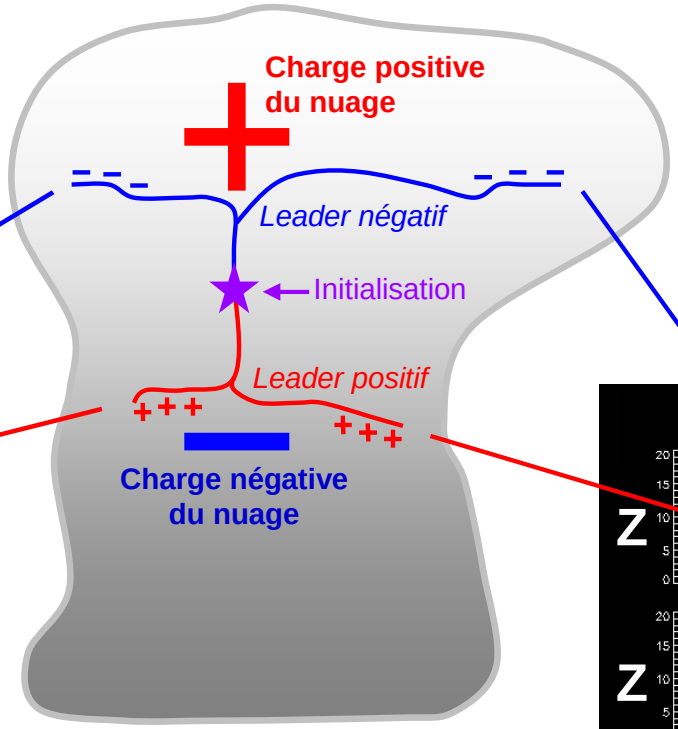
- **Positionnement précis dans l'espace et dans le temps des cellules orageuses avec une très grande résolution temporelle** (*densité de sources VHF similaire à la réflectivité radar)*
- **Indicateur de comportements microphysiques et dynamiques: poussées convectives, transport des cristaux de glace en zone stratiforme, localisation des cristaux de glace et du graupel**
- **Validation du schéma électrique de Méso-NH (J.-P. Pinty, C. Bovalo, E. Defer et C. Barthe)**
- **Observations utilisables pour l'assimilation de données ⇒ travaux précurseurs d'O. Caumont**


Charge positive
du nuage
Charge négative
du nuage

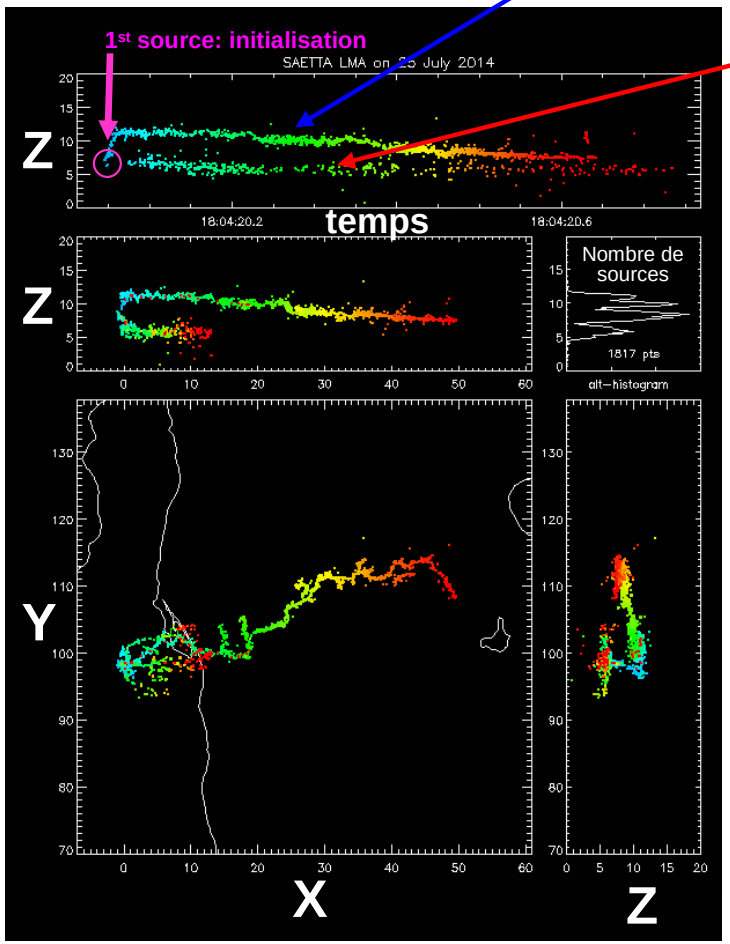

Charge positive
du nuage
Initialisation
Charge négative
du nuage


Charge positive
du nuage
Leader négatif
Initialisation
Leader positif
Charge négative
du nuage

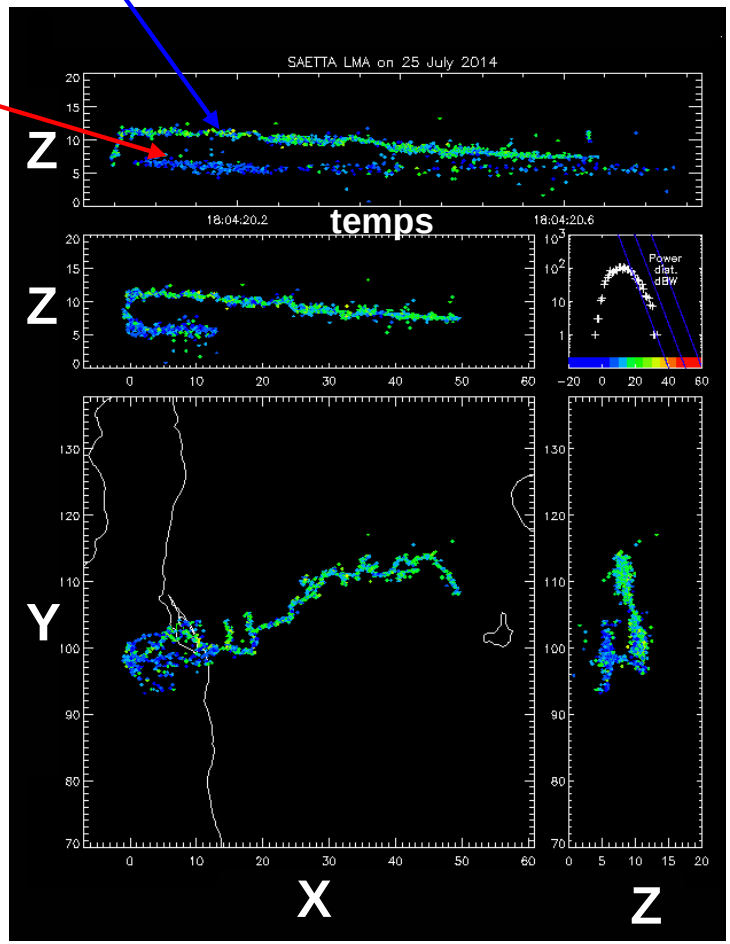
# Clefs de lecture de l'affichage




Couleur fonction du temps




Couleur fonction de la puissance




*Leader négatif:*
*Courant intermittent (di/dt↗)*
*Puissance rayonnée forte*
***Nombreuses sources** détectées*

*Leader positif:*
*Courant continu (di/dt↘)*
*Puissance rayonnée faible*
***Peu de sources** détectées*

# HyMeX: cas du 24 Septembre 2012