



# IPHEN - A REAL TIME NETWORK FOR PHENOLOGICAL MONITORING AND MODELLING IN ITALY

L. Mariani (1), R. Alilla (2), **G. Cola** (1), G. Dal Monte (2), C. Epifani (2), G. Puppi (3), and O. Failla (1)

(1) University of Milan, Milan, Italy, (2) CRA (Agricultural Research Council), Research unit for Climatology and Meteorology applied to Agriculture, Rome, Italy, (3) University of Bologna, Bologna, Italy



# THE IPHEN PROJECT

**IPHEN** was promoted by a group of Italian phenologists during a workshop held in Rome (14-15 dec 2005) and the first products were issued in March 2006

a co-operative project finalized to **phenological monitoring and modelling** for the regular production and broadcast of weekly phenological maps for wild vegetation and crops



# THE IPHEN PROJECT

## PHENOLOGICAL MONITORING NETWORK

Co-operation of  
Universities, Research  
Institutes, Extension  
Services and other  
Associations

## PHENOLOGICAL MODELS

Development,  
Calibration and  
Validation of  
phenological models for  
different species and  
varieties

## PRODUCTS

Weekly phenological maps for Italy based on  
observations and models

A painting of a terraced landscape. The foreground and middle ground are filled with numerous rectangular fields of various colors, including shades of orange, red, yellow, green, and purple. Some fields contain small, stylized trees or plants. In the background, there are rolling hills and mountains rendered in muted, earthy tones of blue, green, and brown. The overall style is that of a traditional painting, possibly a tapestry or a mural, with visible brushstrokes and a rich, textured appearance.

# **PHENOLOGICAL MONITORING NETWORK**

# THE NETWORK

**Co-ordinator** – CRA-Cma (Council for Agricultural Research - Research unit for meteorology)

## **Participants**

### ***Universities***

- Università degli Studi di Milano – Facoltà di Agraria Dipartimento di Produzione Vegetale
- Università degli Studi di Bologna - Facoltà di Agraria, Dip. di Biologia Evoluzionistica; Dip. di Produzione Vegetale, Dip. di Scienze e Tecnologie Agroambientali
- Università Cattolica del Sacro Cuore
- Università degli Studi di Firenze Centro Interdipartimentale di Bioclimatologia CIBIC-UNIFI
- Università degli Studi di Palermo (Motisi)

Università degli Studi di Pisa - Centro Interdipartimentale di Ricerche Agro-Ambientali "Enrico Avanzi"

- Università degli Studi di Roma Tor Vergata – Dip. di Biologia
- Università degli Studi di Udine
- Università degli Studi di Sassari
- Università degli Studi dell'Aquila – Dip. di Scienze Ambientali
- Università degli Studi di Torino

### ***Cra Institutes***

- CRA-CMA
- Centro di ricerca per la viticoltura (Conegliano TV) (CRA-VIT)
- Centro di ricerca per l'olivicoltura e l'industria olearia (Rende) (CRA-OLI)
- Unità di ricerca per l'uva da tavola e la vitivinicoltura in ambiente mediterraneo (Turi BA) (CRA-UTV)

# THE NETWORK

## ***Other research institutions***

- Fondazione Edmund Mach - S. Michele, Trento
- Istituto di Biometeorologia Ibimet

## ***Associations***

- AIA - Associazione Italiana di Aerobiologia [www.ilpolline.it](http://www.ilpolline.it)
- AIAM - Associazione Italiana di Agrometeorologia. [www.agrometeorologia.it](http://www.agrometeorologia.it)
- Unaapi, Unione Nazionale Associazioni Apicoltori Italiani [www.mieliditalia.it](http://www.mieliditalia.it)

## ***Agrometeorological and extension services***

- Regione Sicilia – Servizio Informativo Agrometeorologico Siciliano
- Regione Calabria - Arssa Calabria – Servizio Agrometeorologico
- Regione Emilia Romagna - Arpa Emilia Romagna - Servizio Idrometeorologico
- Regione Lazio - ARSIAL
- Consorzio di Difesa di Brindisi CODIVABRI
- Regione Sardegna - Arpa Sardegna
- Regione Liguria – Ass.to Agricoltura, Settore Servizi alle Imprese Agricole C.A.A.R. (Centro di Agrometeorologia Applicata Regionale)
- Regione Piemonte - Ass.to Agricoltura
- Regione Val d'Aosta - Institut Agricole Régional
- Amministrazione Provinciale di Pesaro ed Urbino (Ufficio Ambiente - Serv.4.3)
- Agenzia Servizi Settore Agroalimentare delle Marche

# THE MONITORING - BBCH scale adoption

## FOR ALL THE MONITORED SPECIES

### BBCH-scale (olive)

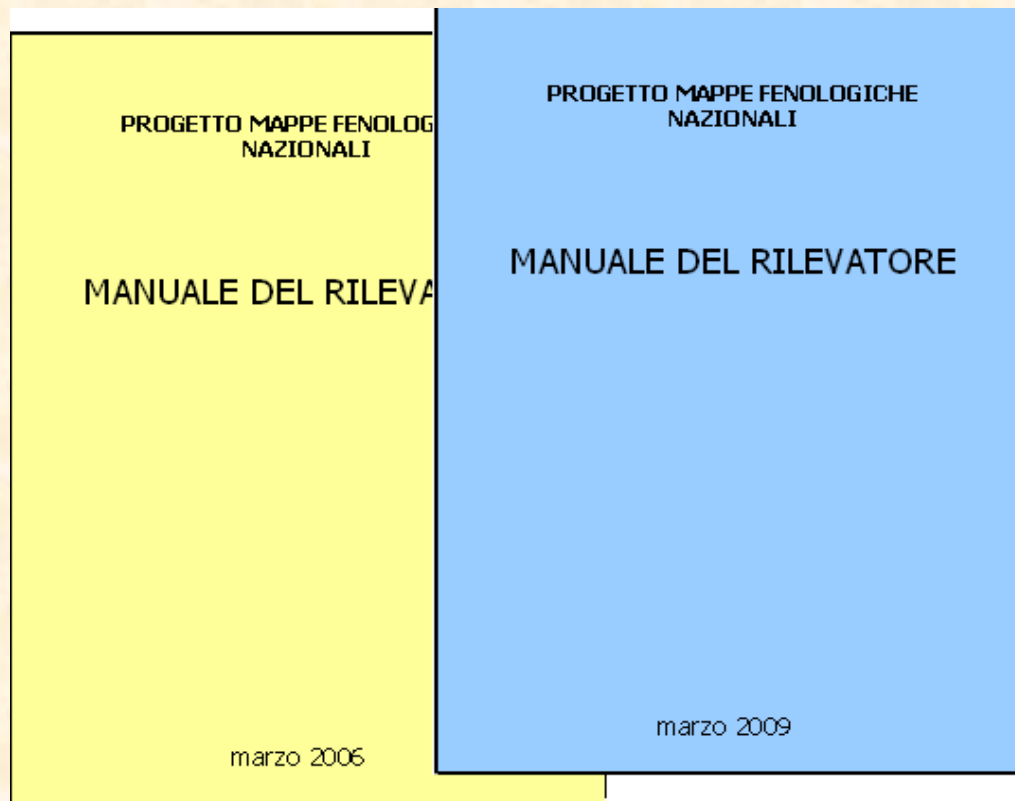
Growth stage	Code	Description
0: Bud development	00	Foliar buds at the apex of shoots grown the previous crop-year are completely closed, sharp-pointed, stemless and ochrecoloured.
	01	Foliar buds start to swell and open, showing the new foliar primordia.
	03	Foliar buds lengthen and separate from the base.
	07	External small leaves open, not completely separated, remaining joined by apices.
	09	External small leaves opening further with their tips inter crossing.
1: Leaf development	11	First leaves completely separated. Grey-greenish coloured.
	15	The leaves are more separated without reaching their final size. First leaves turn greenish on the upperside.
	19	Leaves get the typical variety size and shape.
3: Shoot development	31	Shoots reach 10% of final size.
	33	Shoots reach 30% of final size.
	37	Shoots reach 70% of final size.

# MONITORING - DOCUMENTATION

## Manuals with observational standard

### Standard sheets for observational site characterization

### Weekly observation sheets



**Scheda Iniziale per *Cupressus sempervirens***  
da compilare a inizio stagione e trasmettere a [lugi.mariani@unimi.it](mailto:lugi.mariani@unimi.it)

rilevatore	
sigla stazione *	
località, comune e provincia	
Habitat **	
altitudine	
pendenza	
esposizione	
varietà	
Coordinate***	

**Istruzioni per la compilazione**  
(\* Sigla comprendente la sigla della provincia: ad es. Bologna-giardini Margherita: BO2)  
(\*\*) ad es. siepe tra i campi, margine di bosco, boscaglia ripariale, parco pubblico)  
(\*\*\*) coordinate (possibilmente geografiche, indicando se sessagesimali o sessadecimali)

**Scheda settimanale per *Cupressus sempervirens***

- rilevatore
- stazione
- data di rilievo
- identificativo dell'individuo (numero progressivo)
- fase fenologica raggiunta secondo la scala prescelta (\*)
- aspetto generale dell'individuo rilevato (\*\*)
- note: segnalare eventi che possano aver alterato il normale sviluppo fenologico della singola pianta (potature, patologie o altri danni)
- note generali: segnalare eventi che possano aver alterato il normale sviluppo fenologico nella zona (ad es. gelate, siccità prolungata)

rilevatore										
stazione										
data di rilievo										
pianta	1	2	3	4	5	6	7	8	9	10
Scala BBCH										
Scala G.F.I.										
Scala Torrigiani										
aspetto pianta										
note										
note generali										

(\*) i rilievi fenologici vanno eseguiti sui singoli individui con la scala prescelta: indicare la fase fenologica più avanzata presente in almeno il 10% degli organi della pianta.  
(\*\*) indicare lo stato vegetativo osservato secondo le classi: ottimo, normale, scadente.

# MONITORING - investigated species and varieties

	2006	2007	2008	2009	2010	2011
<i>Vitis vinifera L. cv Cabernet s.</i>	X	X	X	X	X	X
<i>Vitis vinifera L. cv Chardonnay</i>	X	X	X	X	X	X
<i>Sambucus nigra L.</i>	X	X	X	X	X	X
<i>Cupressus sempervirens L.</i>			X	X	X	X
<i>Cupressus arizonica Greene</i>			X	X	X	X
<i>Olea europaea L.</i>					X	X
<i>Robinia pseudoacacia L.</i>					X	X

A painting of a terraced landscape. The foreground and middle ground are filled with numerous rectangular fields of various colors, including shades of orange, red, yellow, green, and purple. Some fields contain small, stylized trees or plants. In the background, a range of mountains is depicted in muted, earthy tones of blue, green, and brown. The overall style is that of a traditional painting, possibly a tapestry or a mural, with a focus on color and form.

# PHENOLOGICAL MODELS

# THE NHH MODELLING APPROACH

Phenological rhythms of plants are ruled by a **biological clock** that is generally hard to read (it is strictly related to hormones and plant physiology)

For this reason a **thermal clock** is often considered instead of the biological clock

Limitations: linearity of response is a pre-requisite for our thermometric sensors. Plants are not true thermometers (their biological goals justify non linear responses to temperatures or the same answer to different thermal forcing).



# THE NHH MODELLING APPROACH

## How to read the thermal clock of plants

**Thermal Units:** standard approach adopted since Réaumur times (XVIIIth century).

**Normal Heat Hours (NHH):** Hourly temperatures normalized by means of a response curve representing the effectiveness of temperature for plant phenology (T Vs development)

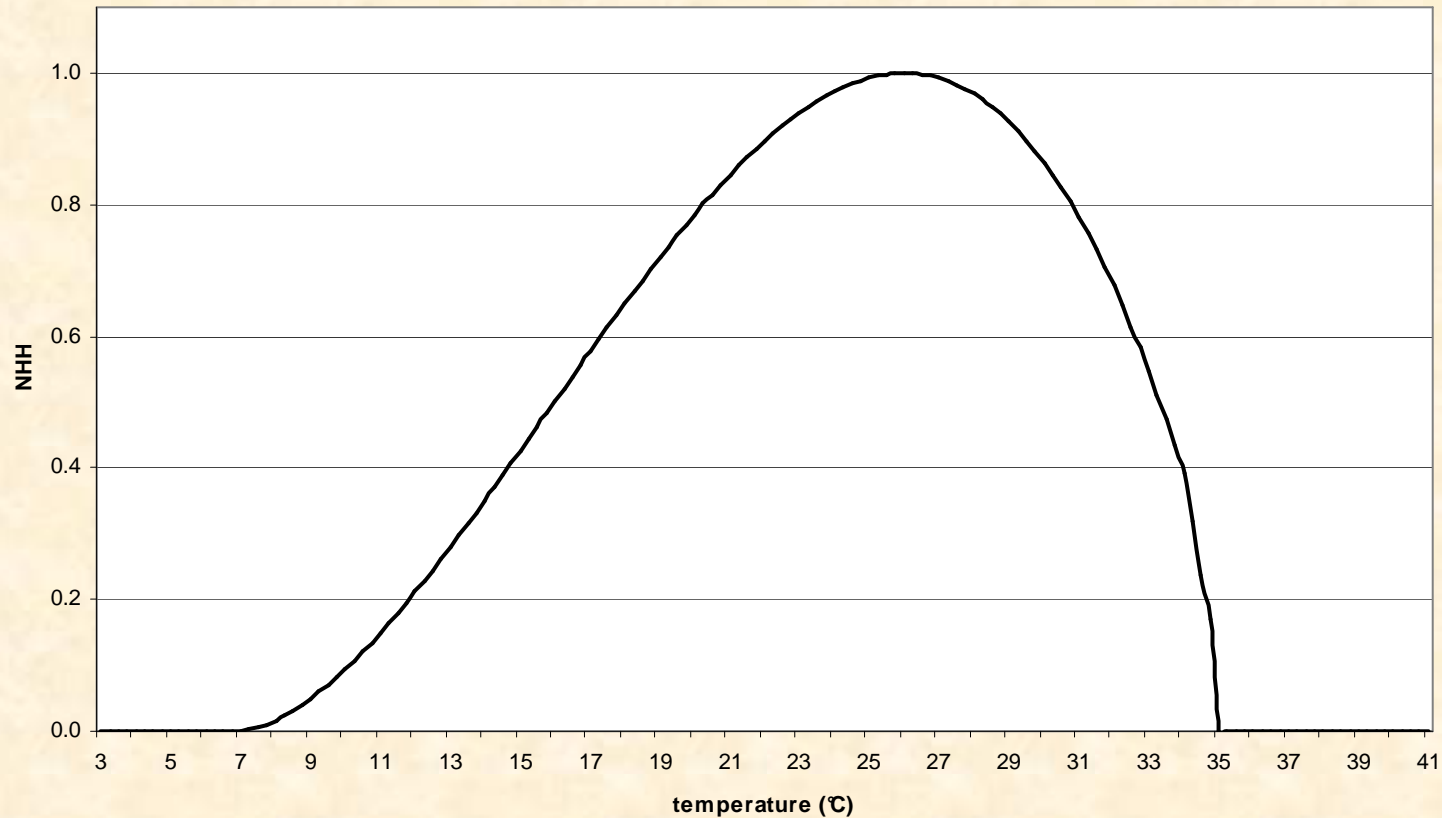
**Advantage of NHH: they overcome the main limitation of thermal units – the overestimation of super-optimal temperatures**

Beta function (Wang & Engel, 1998)

Temperature Response Model (Weikai & Hunt, 1999)

# How NHH approach works

Grapevine Response Curve



**NHH SUMS based model**

**NHH thresholds -> Phenological Stage (BBCH)**

## NHH-parameterization of the beta function

	TEMPERATURE		
	Minimum Cardinal	Optimal	Maximum cardinal
<i>Vitis vinifera</i>	7	26	35
<i>Olea europaea</i>	7	26	35
<i>Robinia pseudoacacia</i>	10	22	38
<i>Sambucus nigra</i>	1	20	32
<i>Cupressus sempervirens</i>	0	8	17

Models calibration and validation based on:

1 - hystorical phenological data gathered by the iphen network

2- hystorical meteorological data from national agrometeorological network (RAN - CRA-CMA)

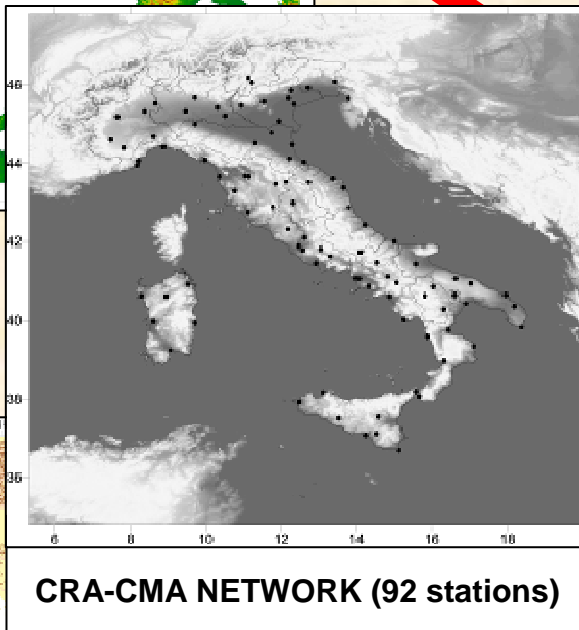
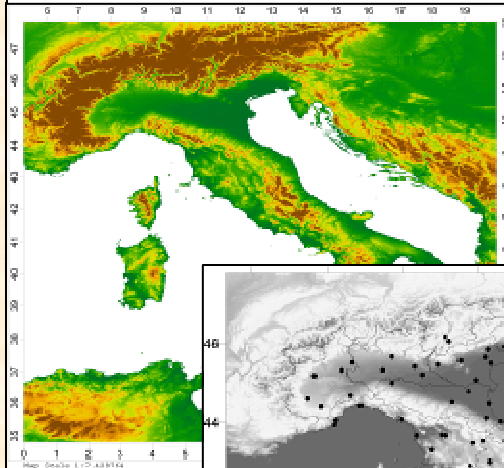
The image is a vibrant, abstract landscape painting. The foreground is dominated by a complex, patchwork of fields in various colors including shades of orange, red, yellow, and brown. These fields are separated by thin, dark lines, suggesting a grid or a series of small plots. In the middle ground, there are clusters of small, stylized trees in shades of purple and blue. The background features rolling hills and mountains in muted tones of blue, green, and grey, with some darker, more textured areas. The overall style is reminiscent of a map or a topographical drawing, but with a rich, painterly quality. The text 'MAP PRODUCTION' is centered over the middle of the image in a bold, black, sans-serif font.

# MAP PRODUCTION

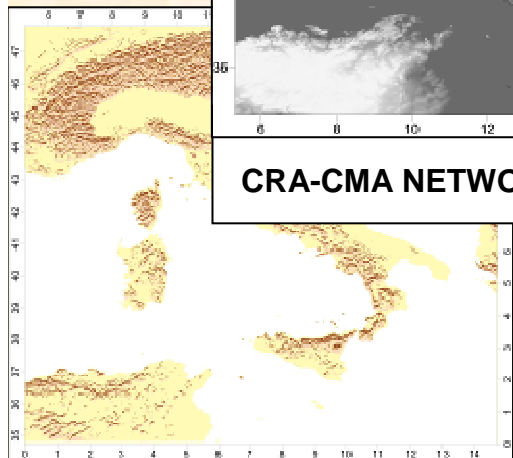
# PHENOLOGICAL ANALYSIS – STEP 1

## Daily Temperature Fields

DTM – CELL: 2 km<sup>2</sup>

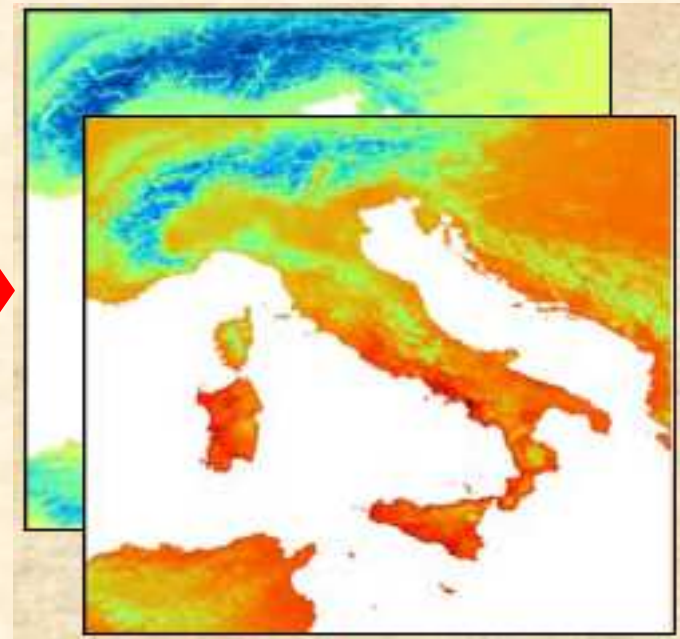


CRA-CMA NETWORK (92 stations)



ASPECT

Daily maximum and minimum temperature maps



Spatialization of station data by means of the Shepard's method applied to data previously homogenized for height and aspect

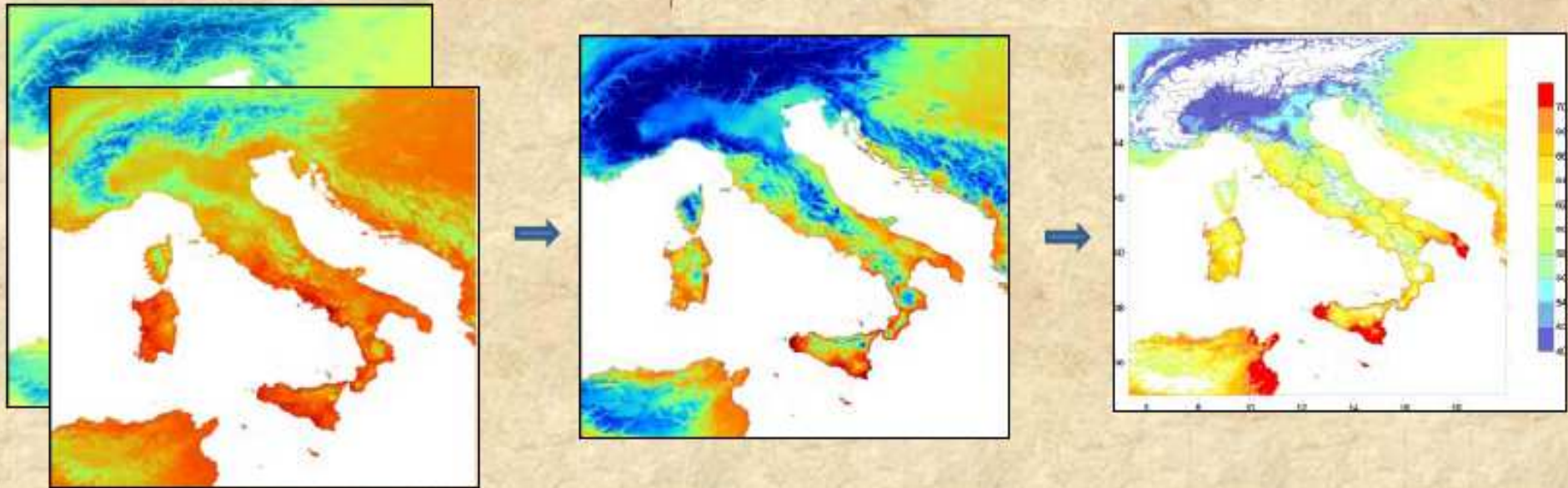
# PHENOLOGICAL ANALYSIS – STEP 2

## First Guess Map

Daily maximum and minimum temperature maps

NHH sums

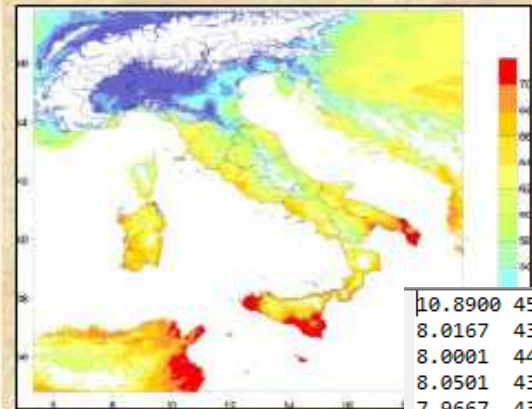
First Guess  
(Phenological model)



# PHENOLOGICAL ANALYSIS – STEP 3

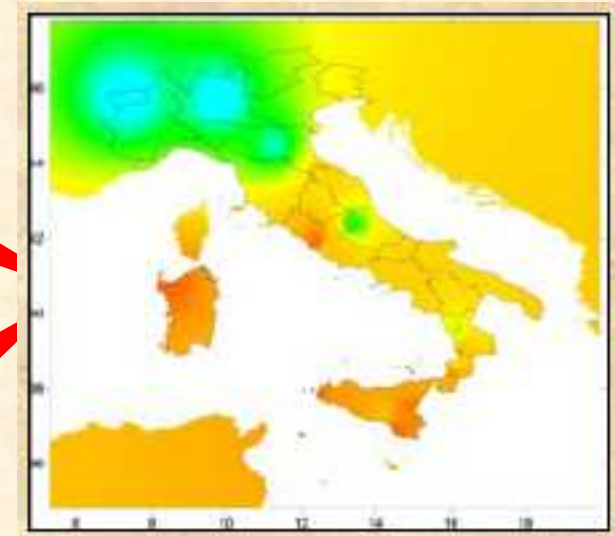
## Error Field

match between first guess  
and monitoring data



10.8900	45.9070	100	75	TN05
8.0167	43.9167	210	74.8	IM01
8.0001	44.0501	198	74.2	IM02
8.0501	43.9167	120	75	IM03
7.9667	43.9667	201	74.2	IM04
8.0501	43.9001	186	75	IM05
9.9335	44.9333	150	75	GE01
8.2501	44.1334	100	79	SV01
9.9861	44.0993	30	78	SP02
11.2001	43.7834	50	77	FI01
12.3001	42.3334	250	75.3	VT01
12.8080	41.6970	294	75	RM06
13.7501	42.9668	200	77	AP03
12.8834	43.7501	230	79	PU01
12.9834	43.7500	132	75	PU02
13.0833	43.5000	322	75	AN01
13.4334	43.3667	230	75.5	MC03
12.8330	42.8331	168	79	PZ01
16.2000	39.5500	150	76.7	CS02
16.2000	39.5501	200	76.4	CS03
16.6834	39.5500	270	79	CS04
16.2668	39.2334	460	75.2	CS05
16.6428	39.6043	29	79	CS06
16.2849	39.2433	460	75.4	CS07
16.1501	38.3167	350	76	CZ02
17.0300	39.1100	139	77.4	KR03
15.9167	38.3500	126	76.5	RC01
16.0167	38.3334	260	75.5	RC02

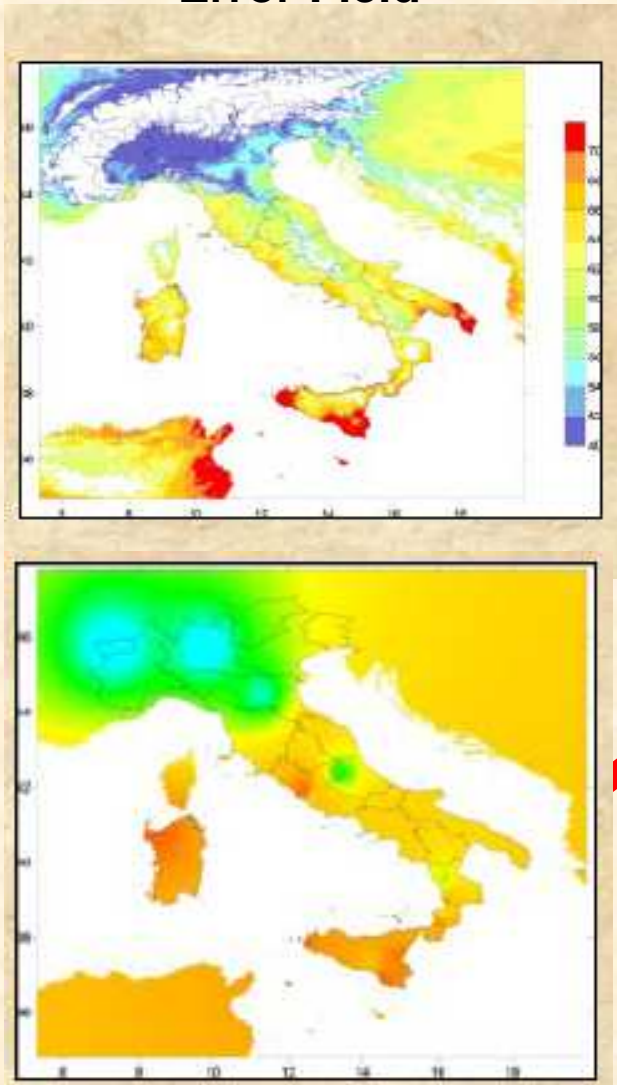
Error Field



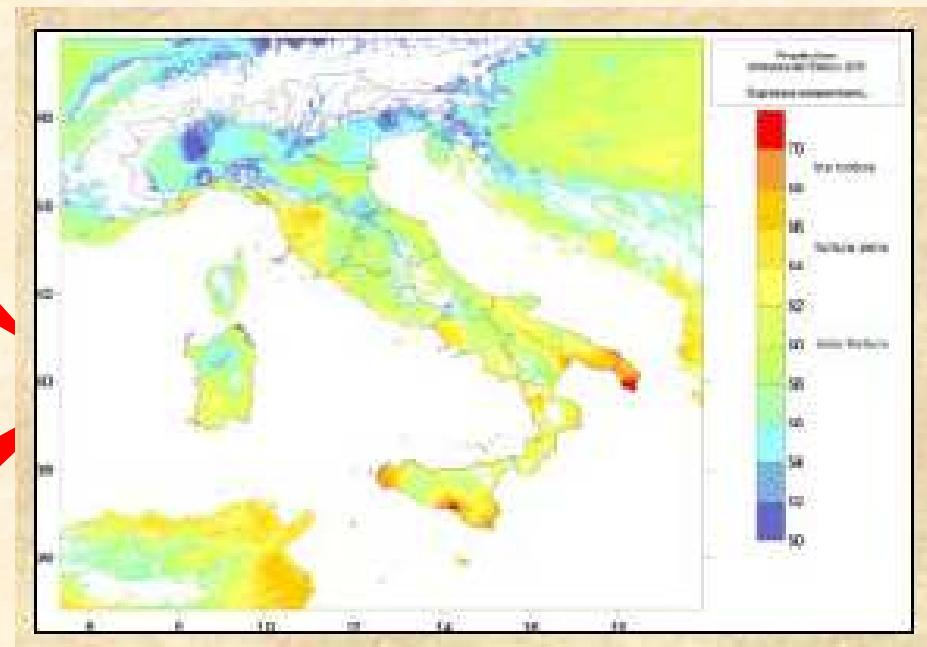
# PHENOLOGICAL ANALYSIS – STEP 4

## Final Map

### First Guess Correction with Error Field

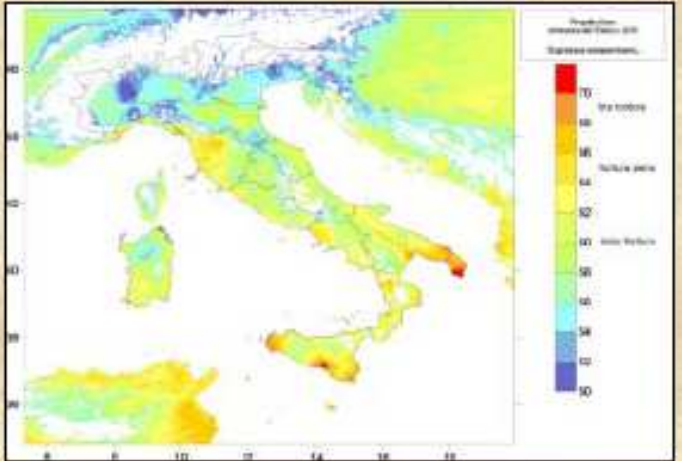


### Final Map

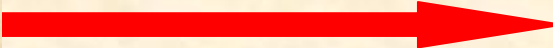


# PHENOLOGICAL FORECAST

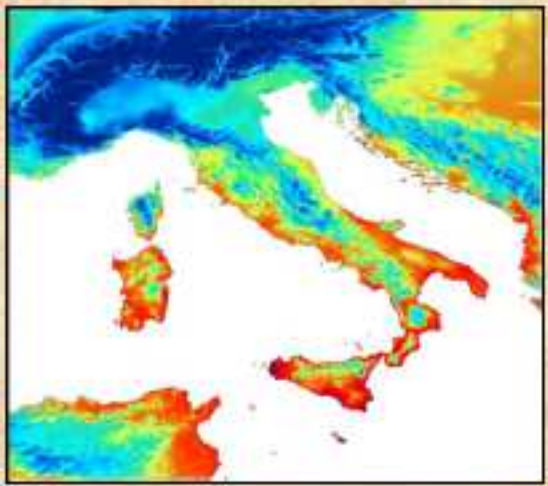
Final Analysis Map



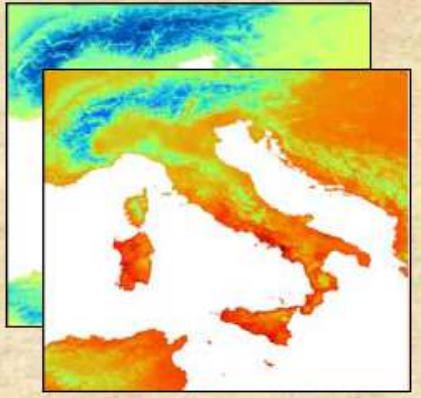
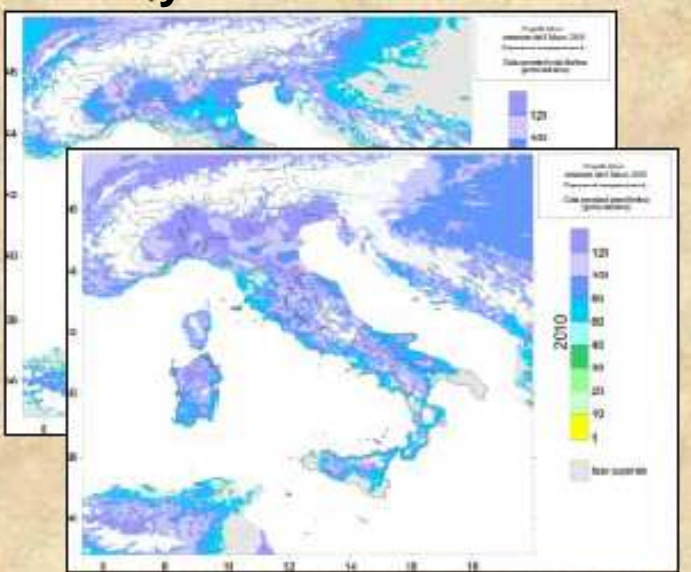
REVERSE MODEL



Actual NHHsums



Forecast Maps  
Days of Occurrence



Daily Thermal Fields  
GFS  
Climatology



An abstract landscape painting featuring a patchwork of fields in various colors like orange, yellow, green, and purple. The background shows rolling hills and mountains in shades of blue and grey. The text "SOME EXAMPLES" is centered over the middle of the image.

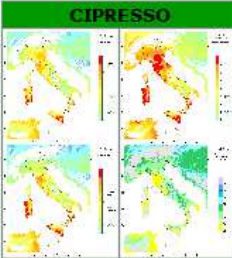
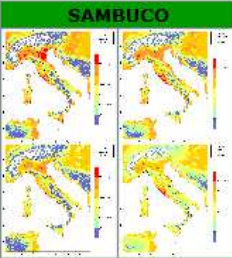
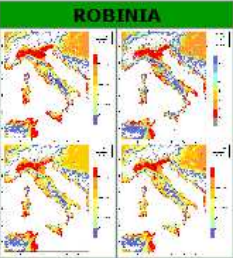
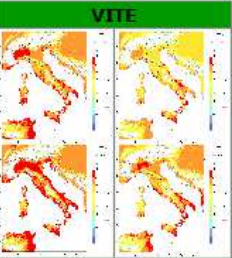
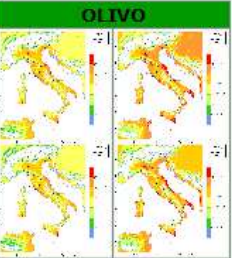
**SOME EXAMPLES**

# <http://www.cra-cma.it/iphen/mappe.asp>

Progetto "Rete fenologica italiana"  
**IPHEN**  
Italian Phenological Network

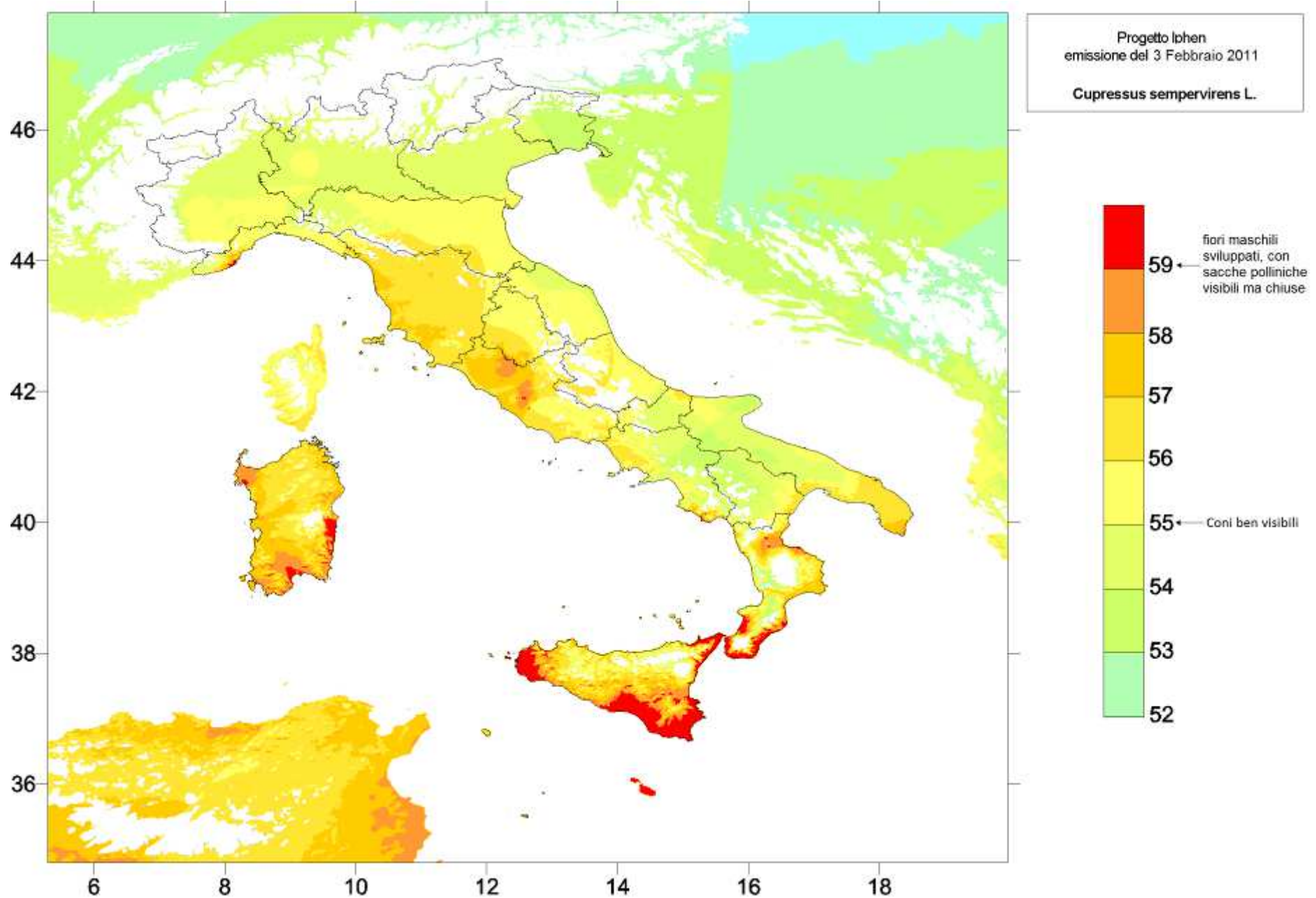
[Introduzione](#) | [Partecipanti](#) | [Documenti](#) | [Mappe](#) | [Rilievi \(accesso riservato\)](#)

### CARTE FENOLOGICHE 2011

CIPRESSO	SAMBUCO	ROBINIA	VITE	OLIVO
				
TUTTE le carte del Cipresso	TUTTE le carte del Sambuco	TUTTE le carte della Robinia	TUTTE le carte della Vite	TUTTE le carte dell'OLIVO

Carte 2010  
Carte 2009  
Carte 2008

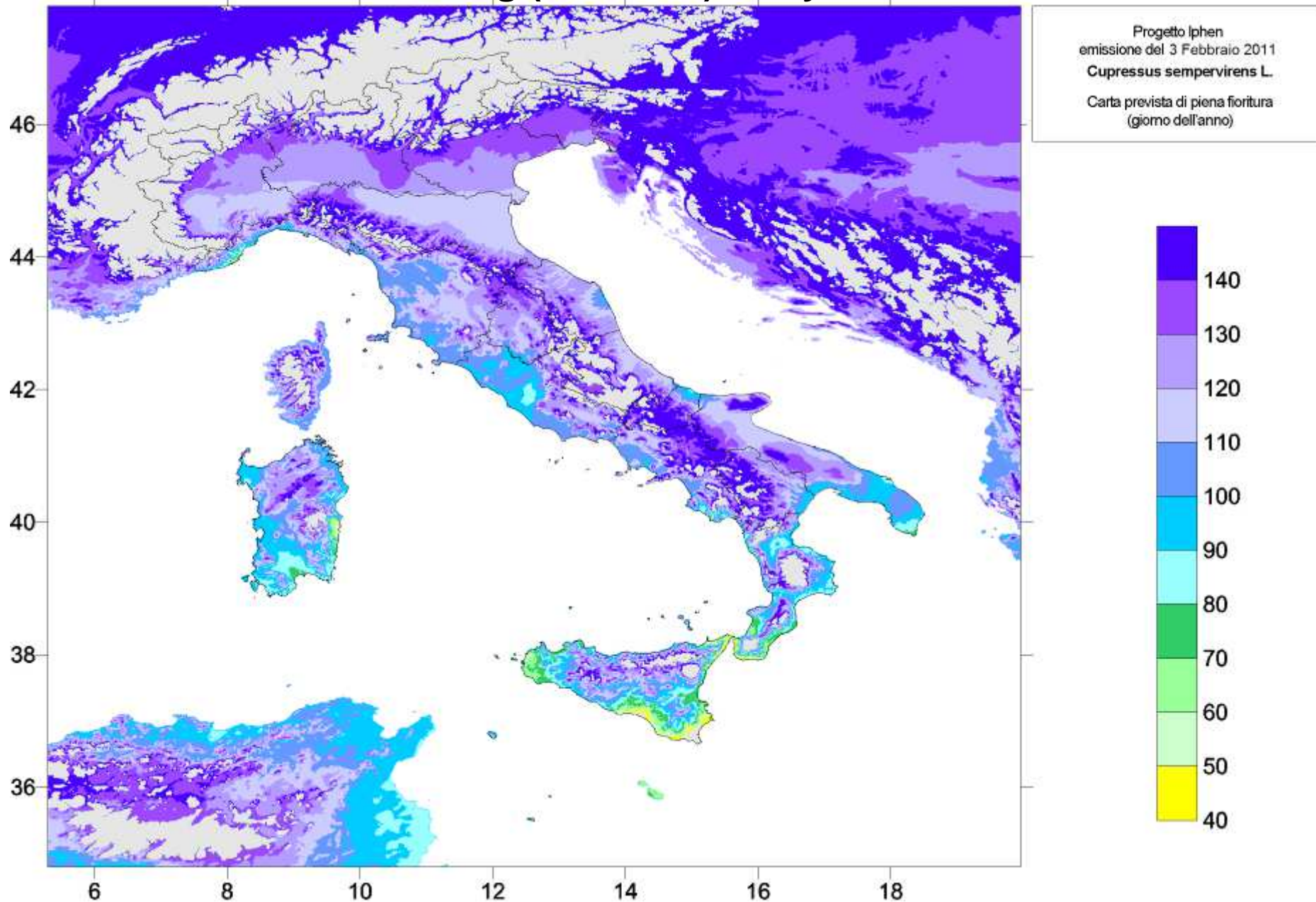
# ANALYSIS MAP - *Cupressus sempervirens* L.



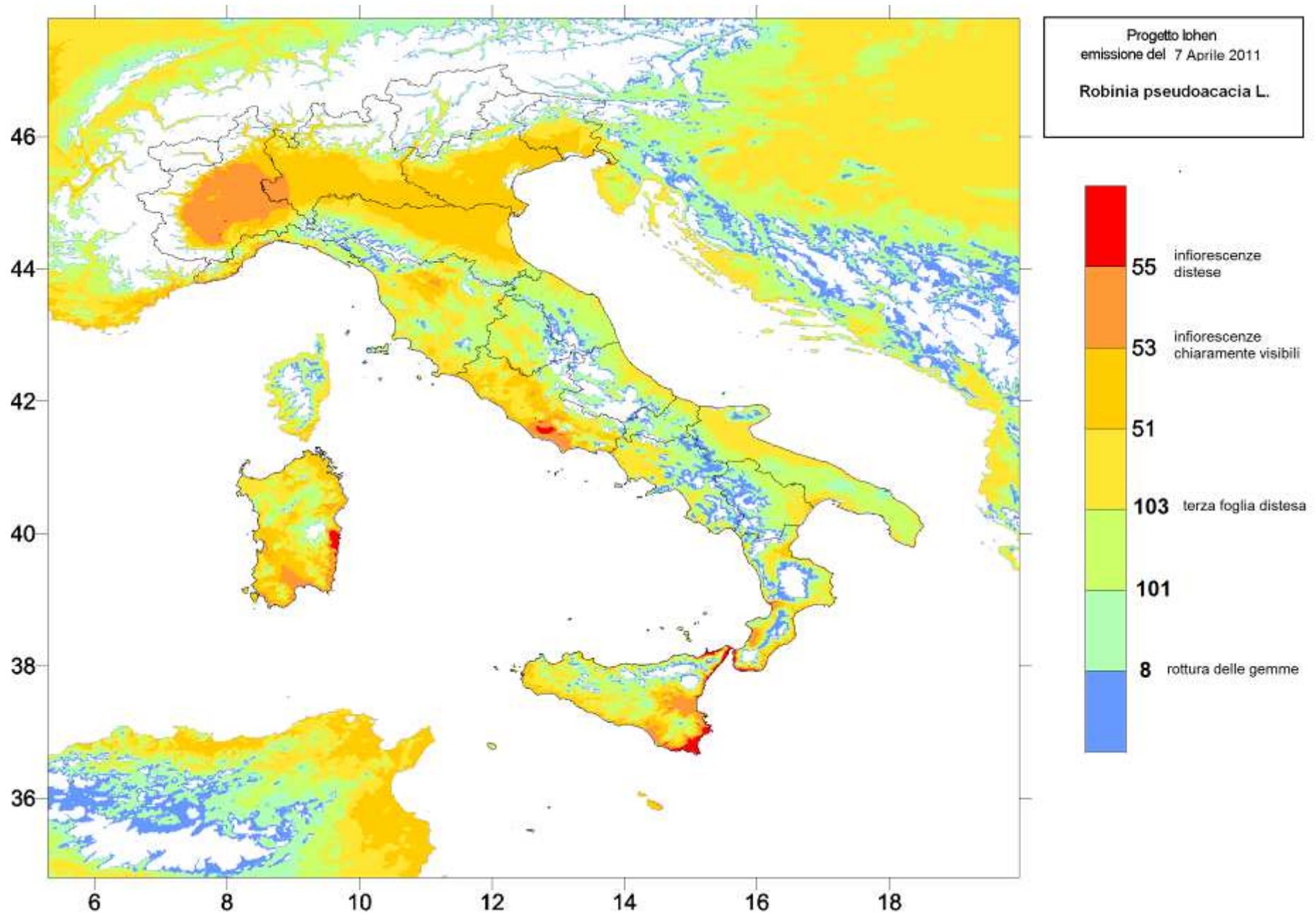


# FORECAST MAP - *Cupressus sempervirens* L.

## Full flowering (BBCH 65) – day of occurrence

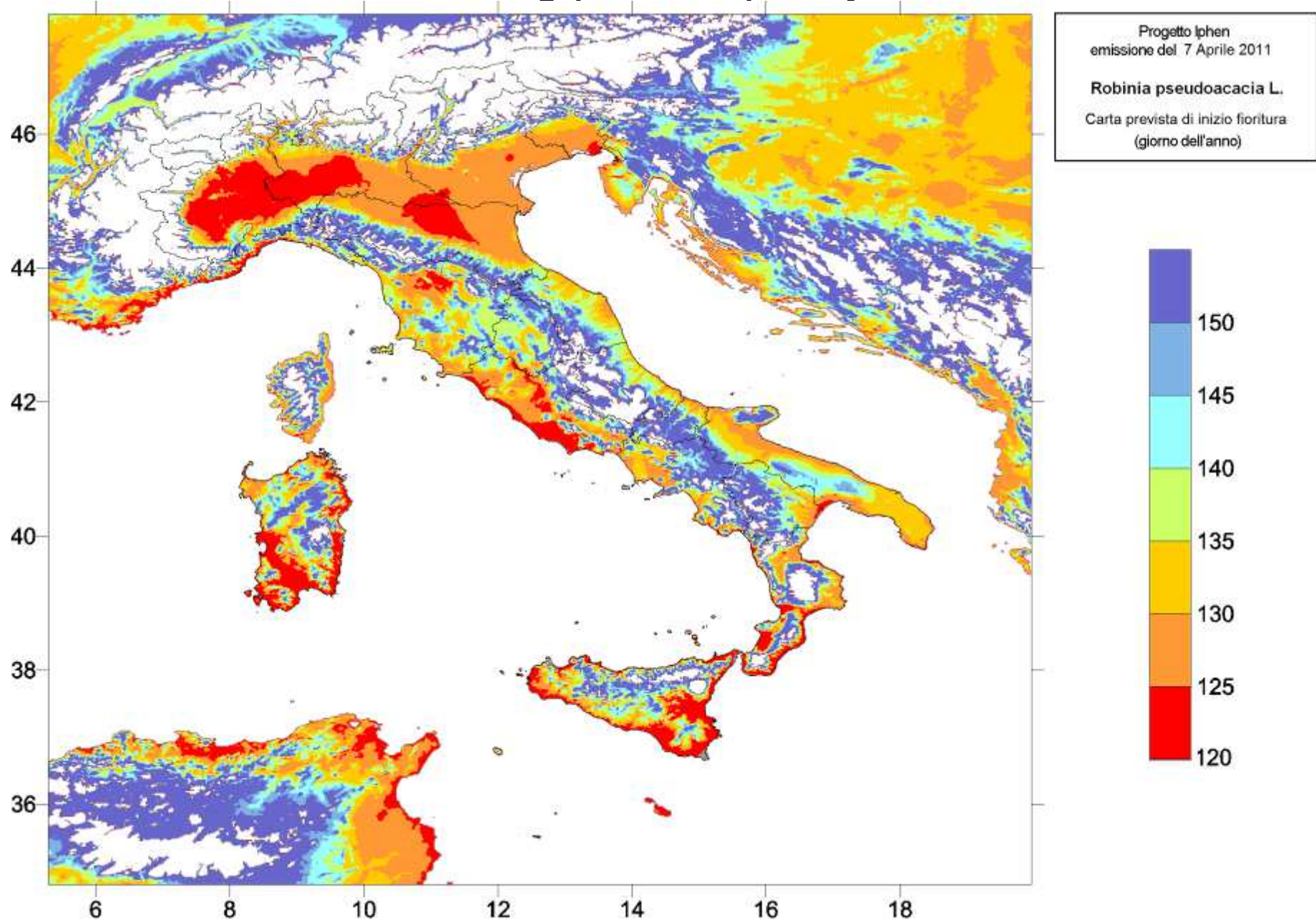


# ANALYSIS MAP - Robinia pseudoacacia L.



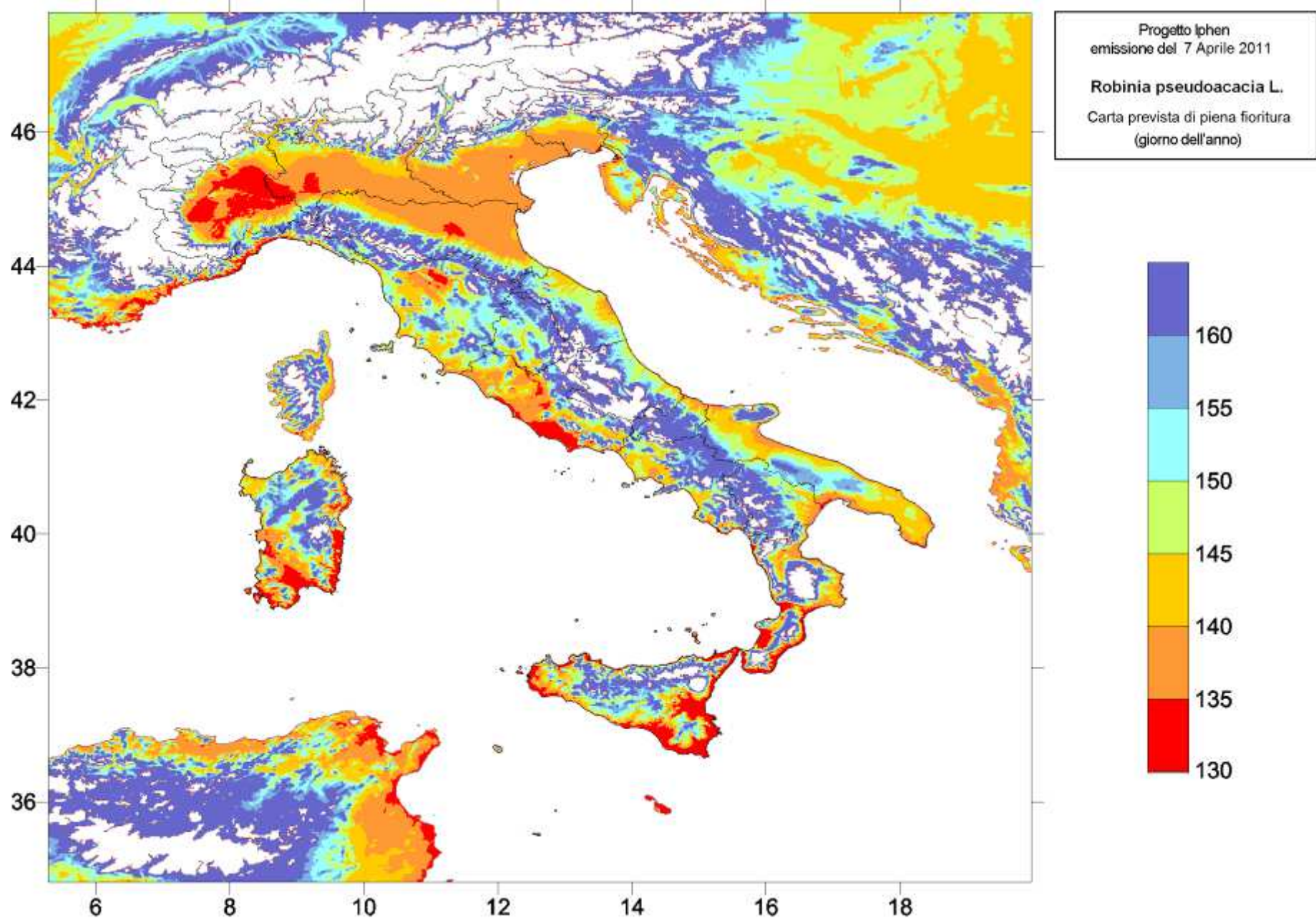
# FORECAST MAP - Robinia pseudoacacia L.

## Start of flowering (BBCH 61) – day of occurrence

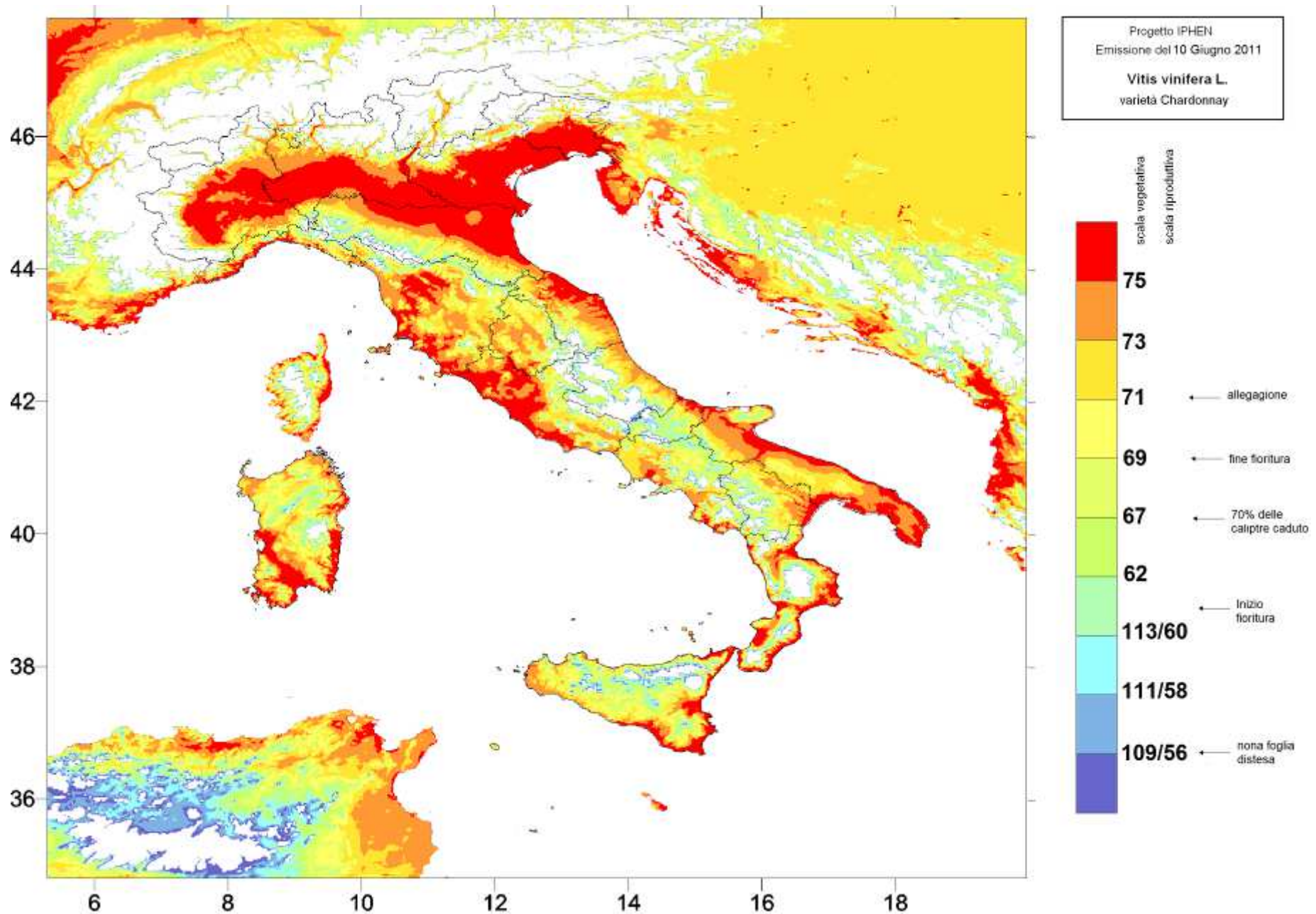


# FORECAST MAP - Robinia pseudoacacia L.

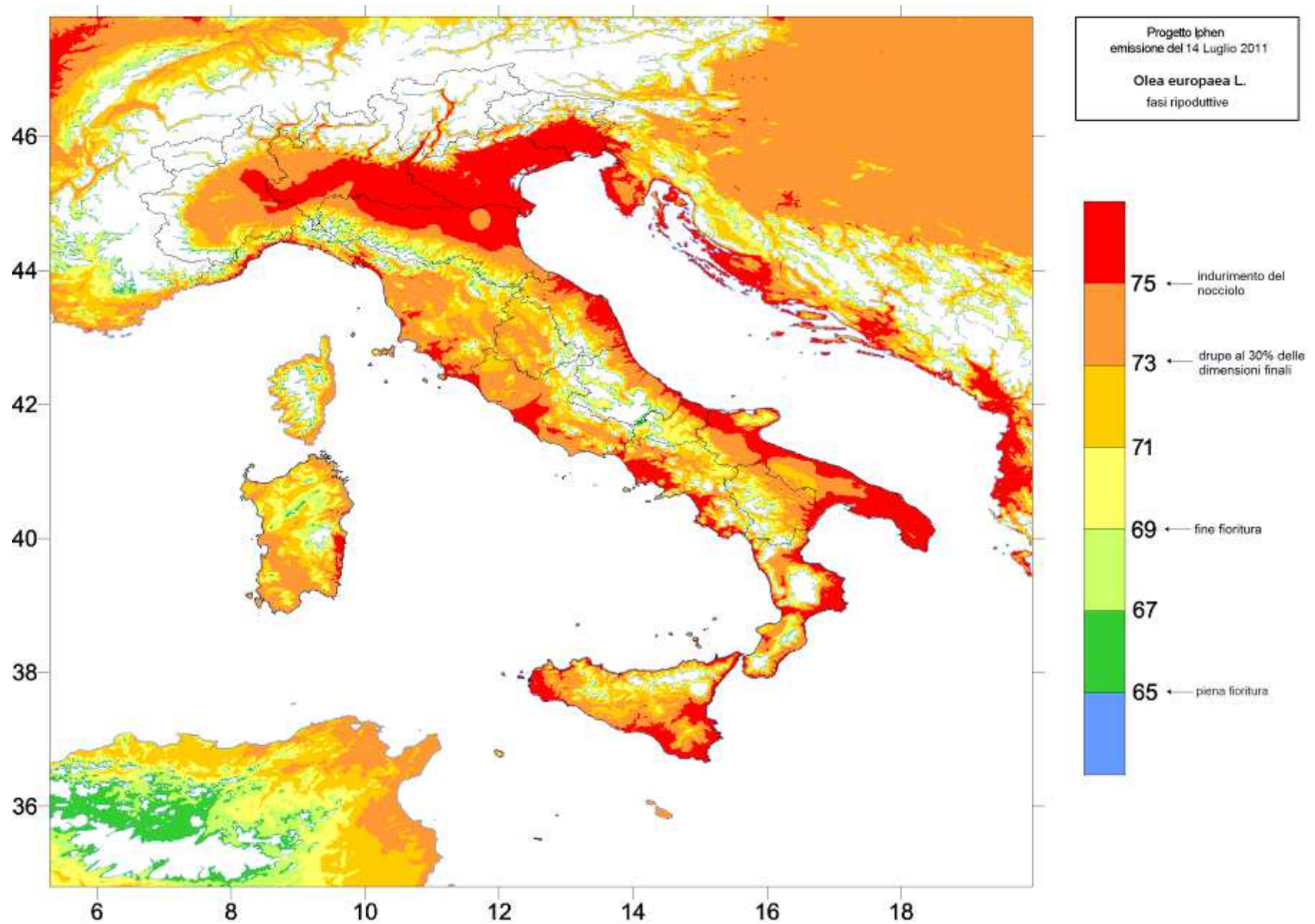
## Full flowering (BBCH 65) – day of occurrence



# ANALYSIS MAP - *Vitis vinifera* L. - Chardonnay



# ANALYSIS MAP - Olea europaea L.



## RELEVANT ISSUES

**CONTINUITY** – since 2006 – 5<sup>th</sup> year

4 weeks without map broadcasting over the last 89 weeks  
(the last hole was yesterday: EMS fault!)

### **DIRECT INVOLVEMENT OF PHENOLOGISTS**

The effort of monitoring is translated in an useful product  
overcoming the classic “no fundings syndrome”: TIME  
SERIES ARE GROWING UP

We put the Italian phenologist in network and the network is  
lasting long (**yearly IPHEN Meeting**)

## **PERSPECTIVES**

**Activation of Regional/Local releases of the IPHEN model (resolution of about 200 m) useful for local meteorological and phenological networks (first prototypes are already operational in Sadegna and Liguria)**

**Extension to new species / varieties  
(Liguria - 10 local varieties of grapevine like Pigato and Vermentino)**

**New forecast procedures**

**Ending of prototypal phase, beginning of release of operational CRA  
CMA products**

**More strict involvement of subjects that need phenological observations (e.g.: health authorities, agricultural authorities, operators of the agri-food chain (farmers, input-supply-industry, agro-food-industry and food distribution)**

**Extension to other European countries (maybe...)**

A scenic landscape photograph featuring a vineyard in the foreground with bright green leaves. In the background, there are rolling green mountains covered in dense forest, with a prominent peak on the left. The sky is filled with soft, white and grey clouds. The text "Thank you for your kind attention" is centered over the middle of the image.

**Thank you for your kind attention**