ROLE OF MARITIME TRANSPORTATION IN THE DIFFUSION OF COVID-19 IN CROATIA VIA THE ERG APPROACH

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In collaboration with:

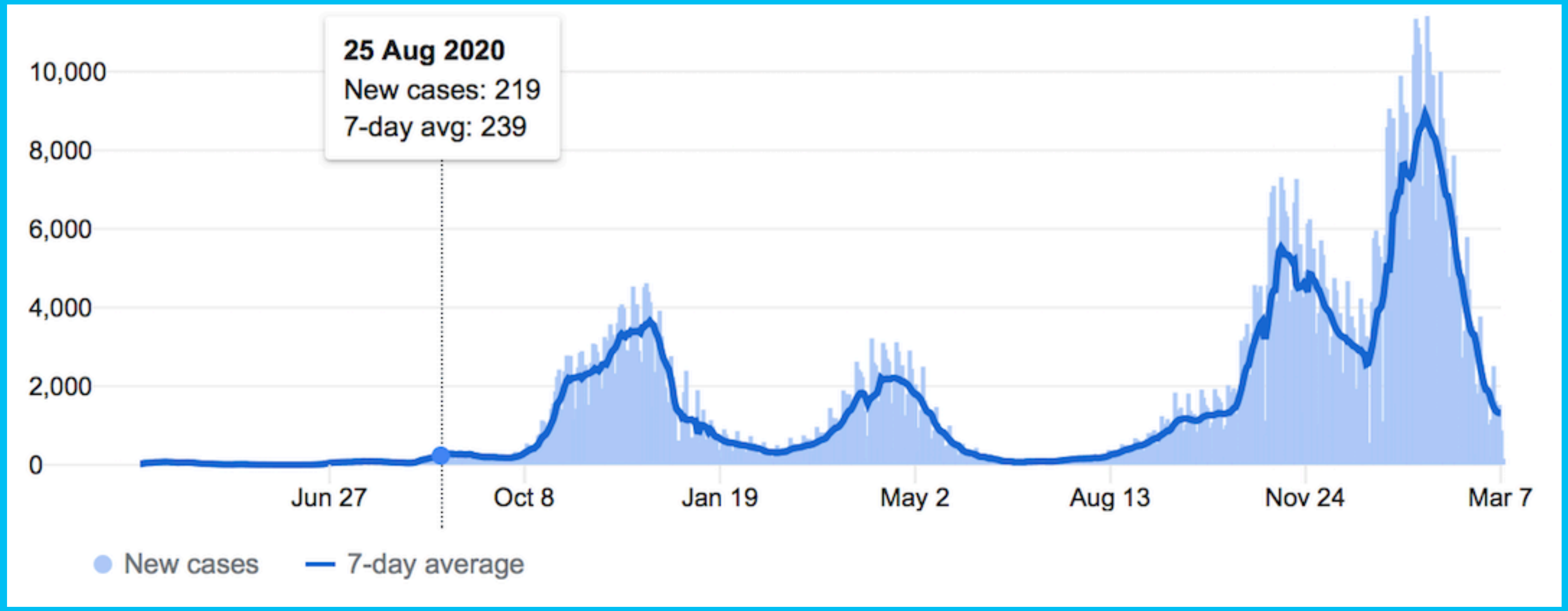
Interreg Italy - Croatia GUTTA EUROPEAN UNION

SVEUČILIŠTE U RIJECI

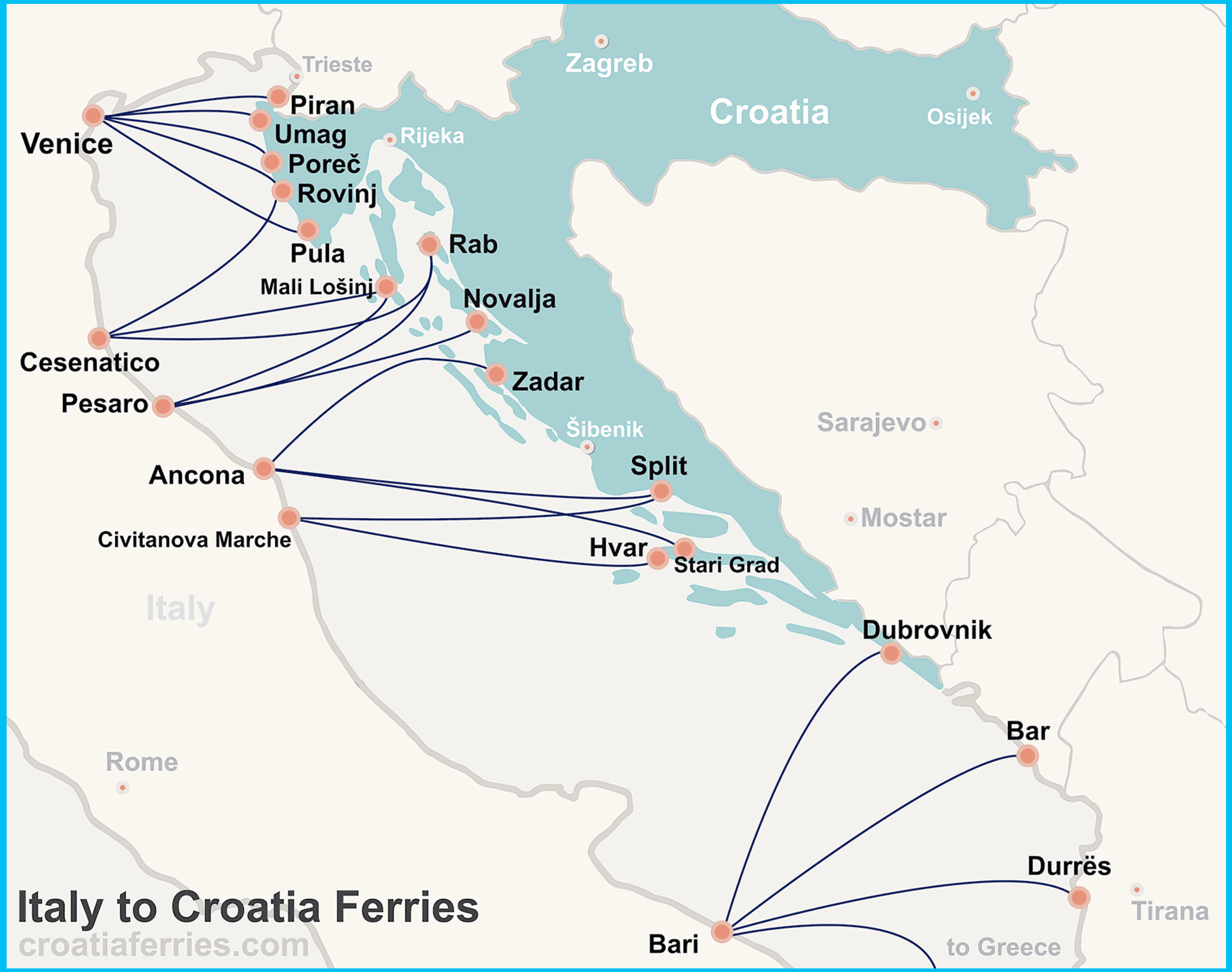
REPUBLIC OF CROATIA Ministry of the Sea, Transport and Infrastructure

How did the project start?

COVID-19 ‘waves’ in Croatia



Maritime transportation resumes in June 2020 (CIMIS data)



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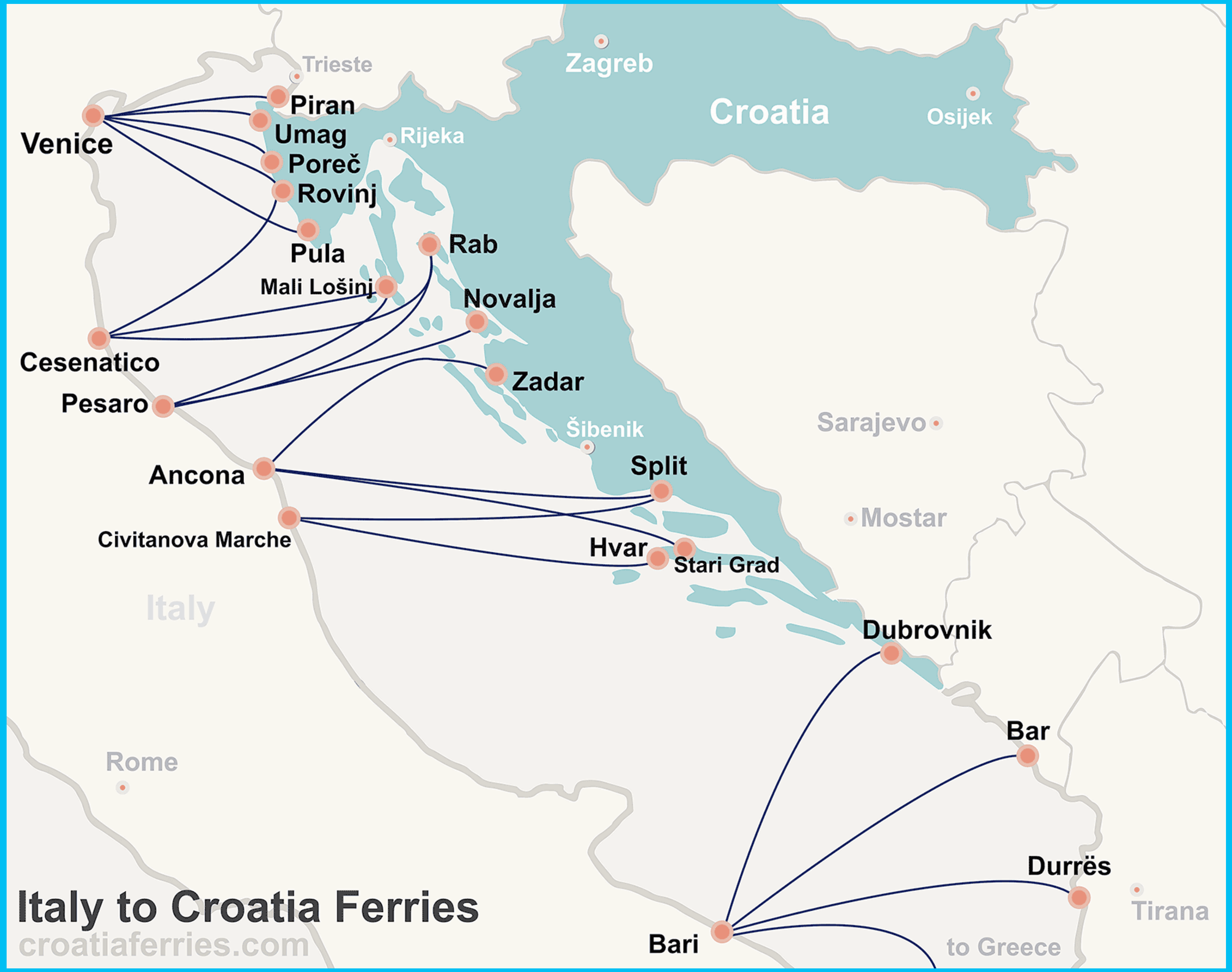

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Q: can we understand the role of Maritime Tr. in the diffusion of COVID-19 in Croatia?

eRG is the ideal Mathematical tool

EPIDEMIOLOGICAL RENORMALISATION GROUP

frontiers

Renormalisation Group Approach to Pandemics...

M. Della Morte, D. Orlando and F. Sannino, Frontiers of Physics 8, 144

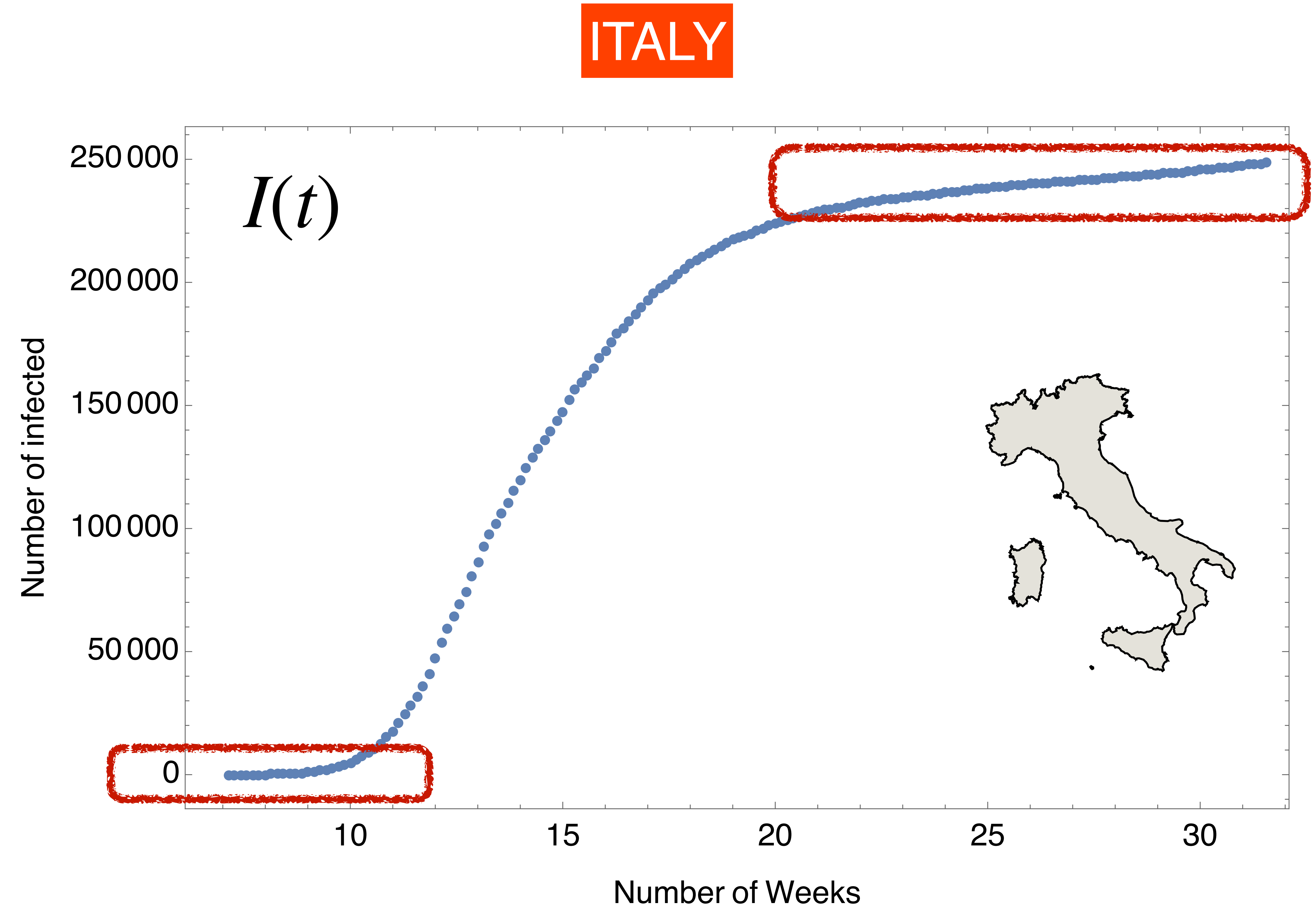
EPIDEMIC

LARGE AND SHORT TIME SCALE INVARIANCE

- Short times = obvious time invariance
- Long time = approx time invariance
- Approx time dilation can be encoded in an effective interaction strength

$$\alpha(t) = \ln I(t) \quad \text{or} \quad I(t)$$

Cumulative total number of infected



EPIDEMIC RENORMALISATION GROUP (eRG) IN A NUTSHELL

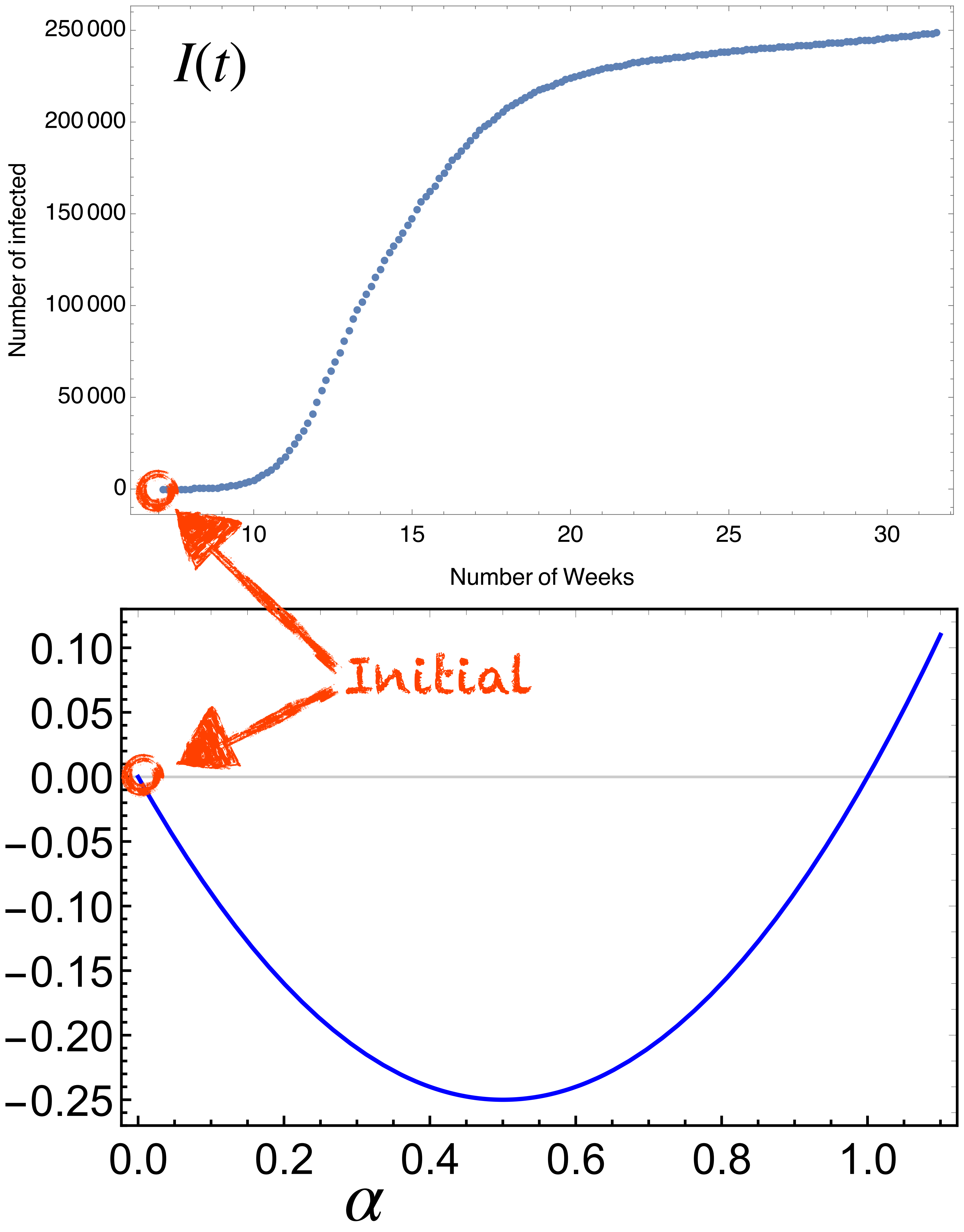
- The beta function encodes the underlying (pandemic) dynamics

$$-\beta(\alpha) \equiv \frac{d\alpha}{dt} = \gamma\alpha\left(1 - \frac{\alpha}{a}\right)$$

- The solution is

$$\alpha(t) = \frac{a\, e^{\gamma t}}{b + e^{\gamma t}}$$

- With b an integration constant



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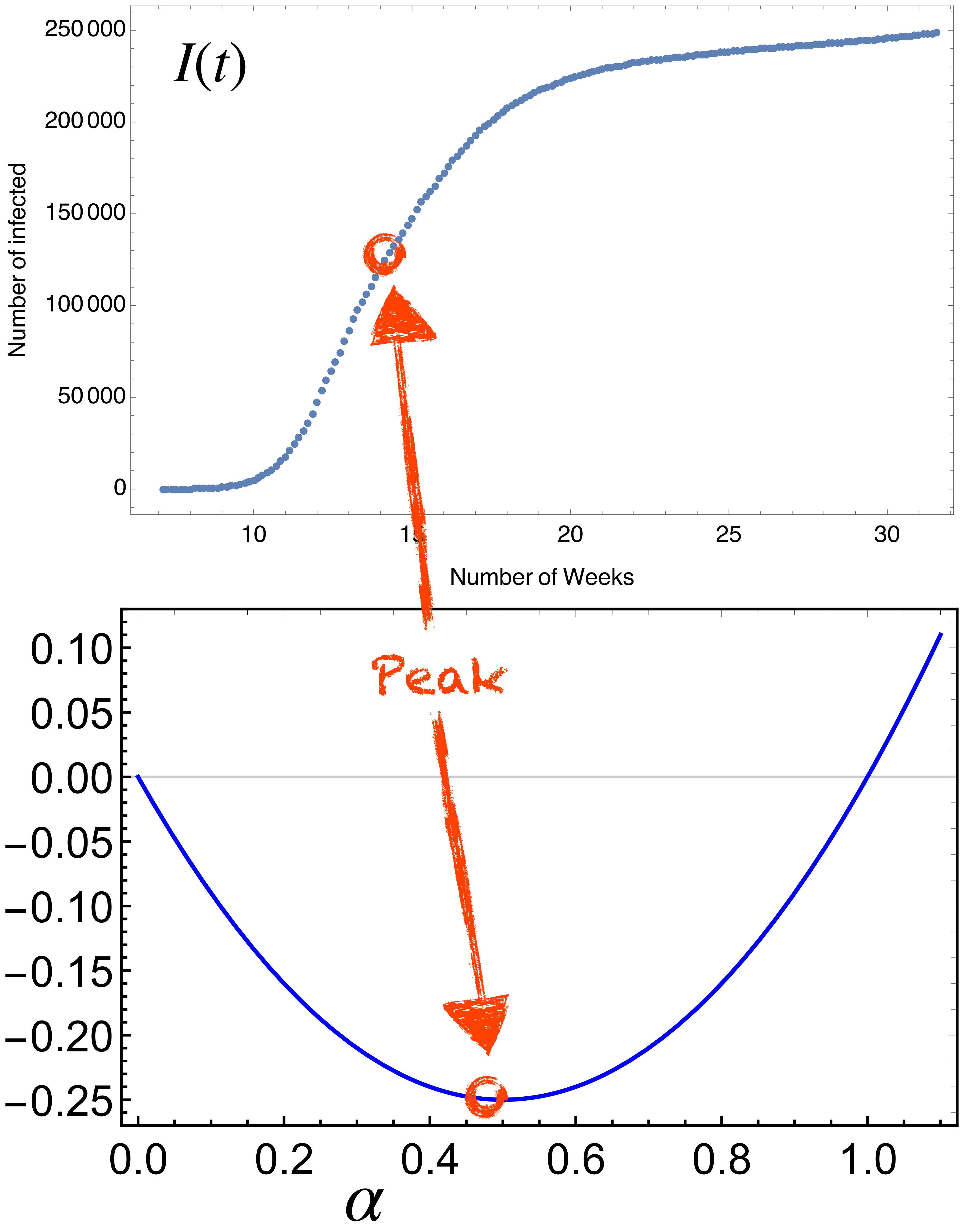

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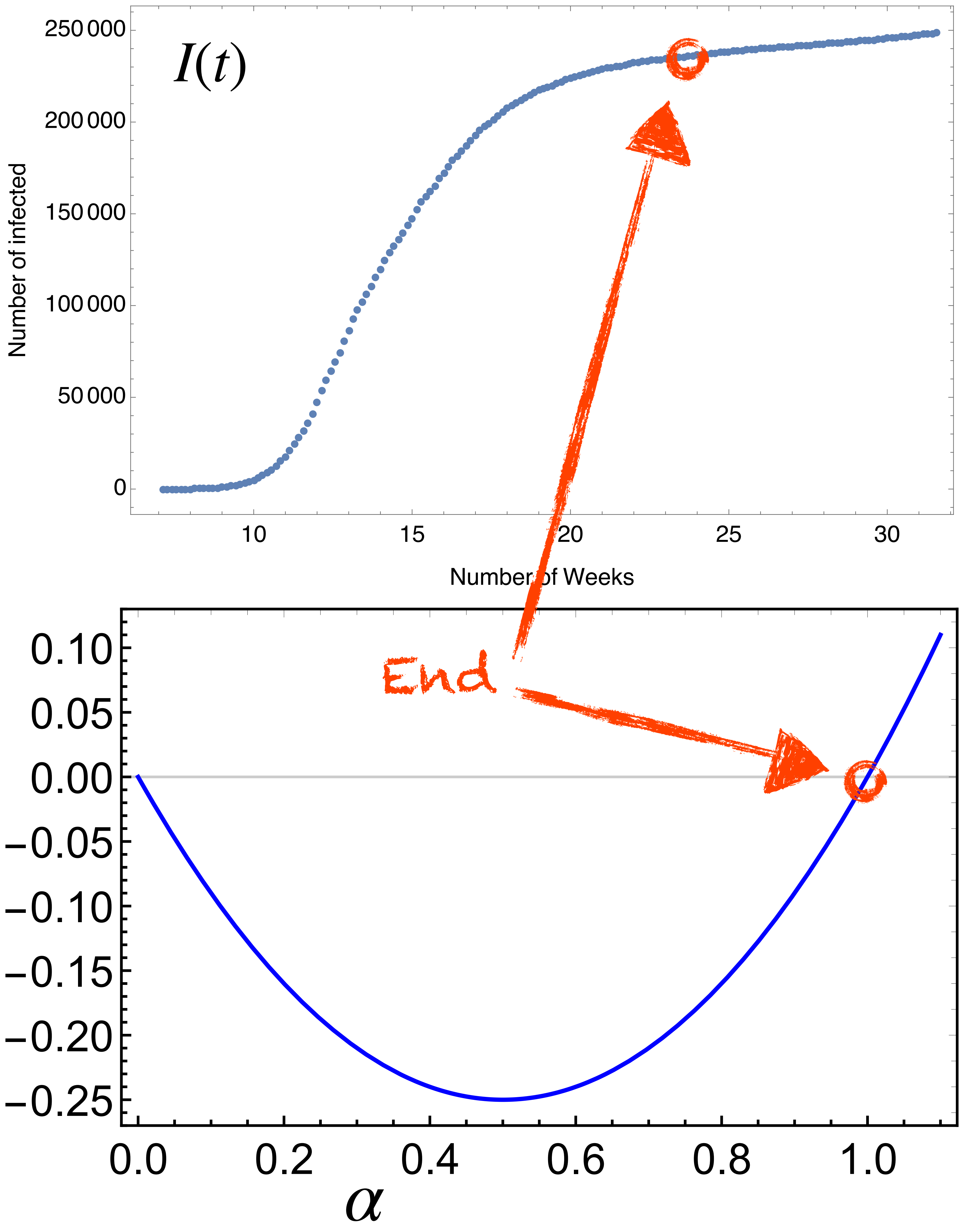
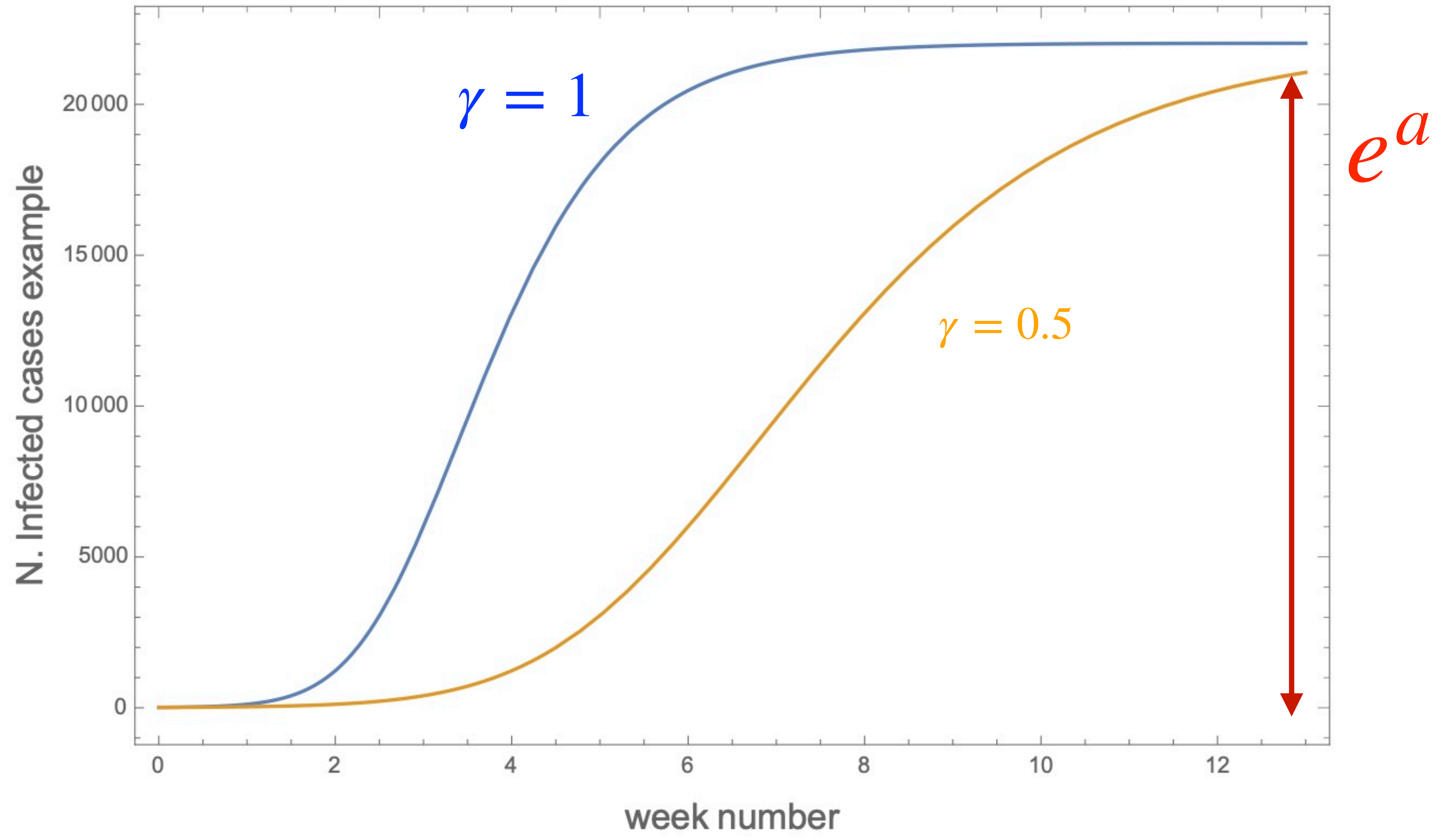
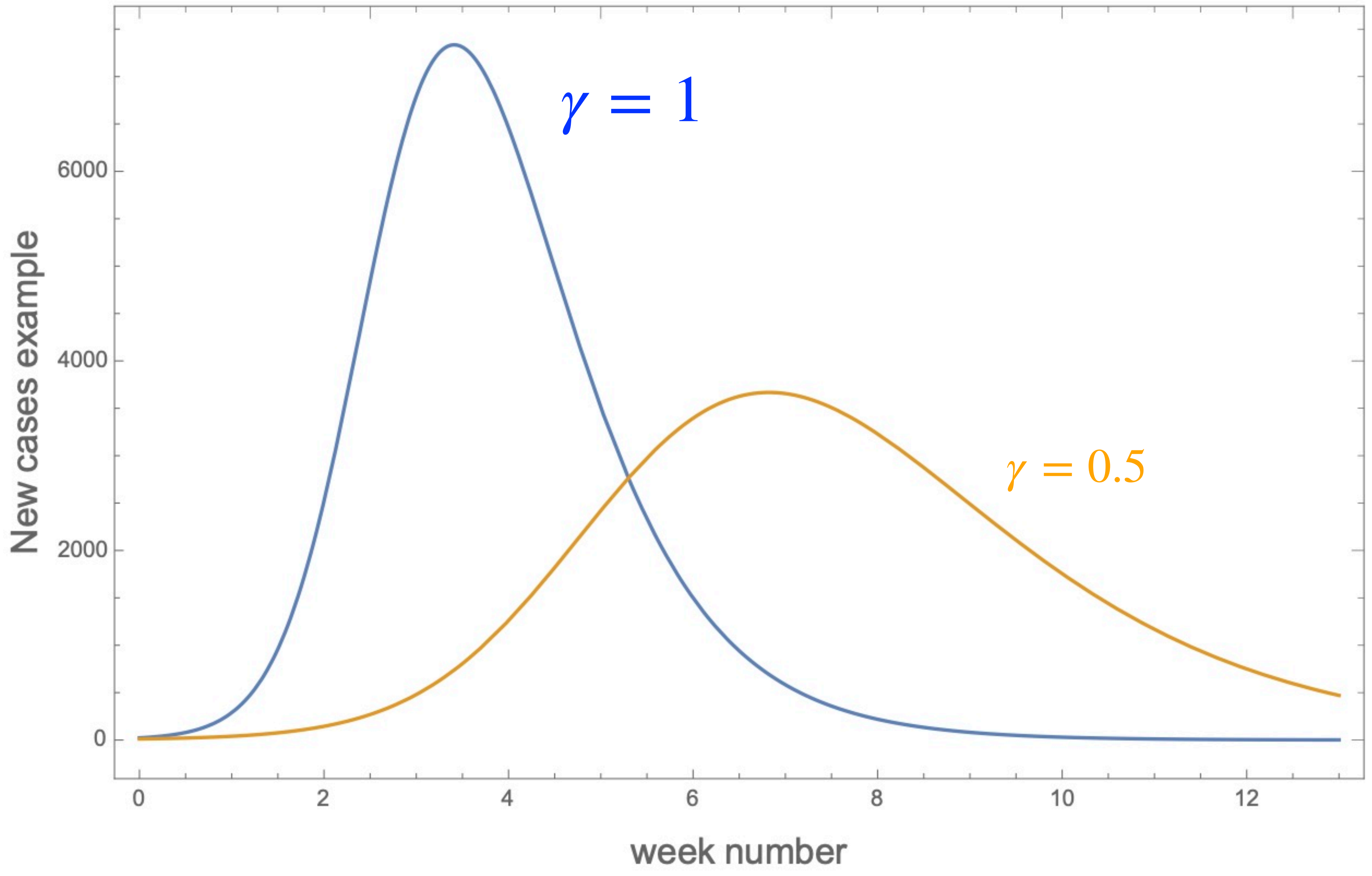


eRG

$$\alpha(t) = \frac{a\, e^{\gamma t}}{b + e^{\gamma t}}$$

- γ controls the infection rate and the flattening of the epidemic curve.





- e^a is the total number of infected

- b is a temporal shift

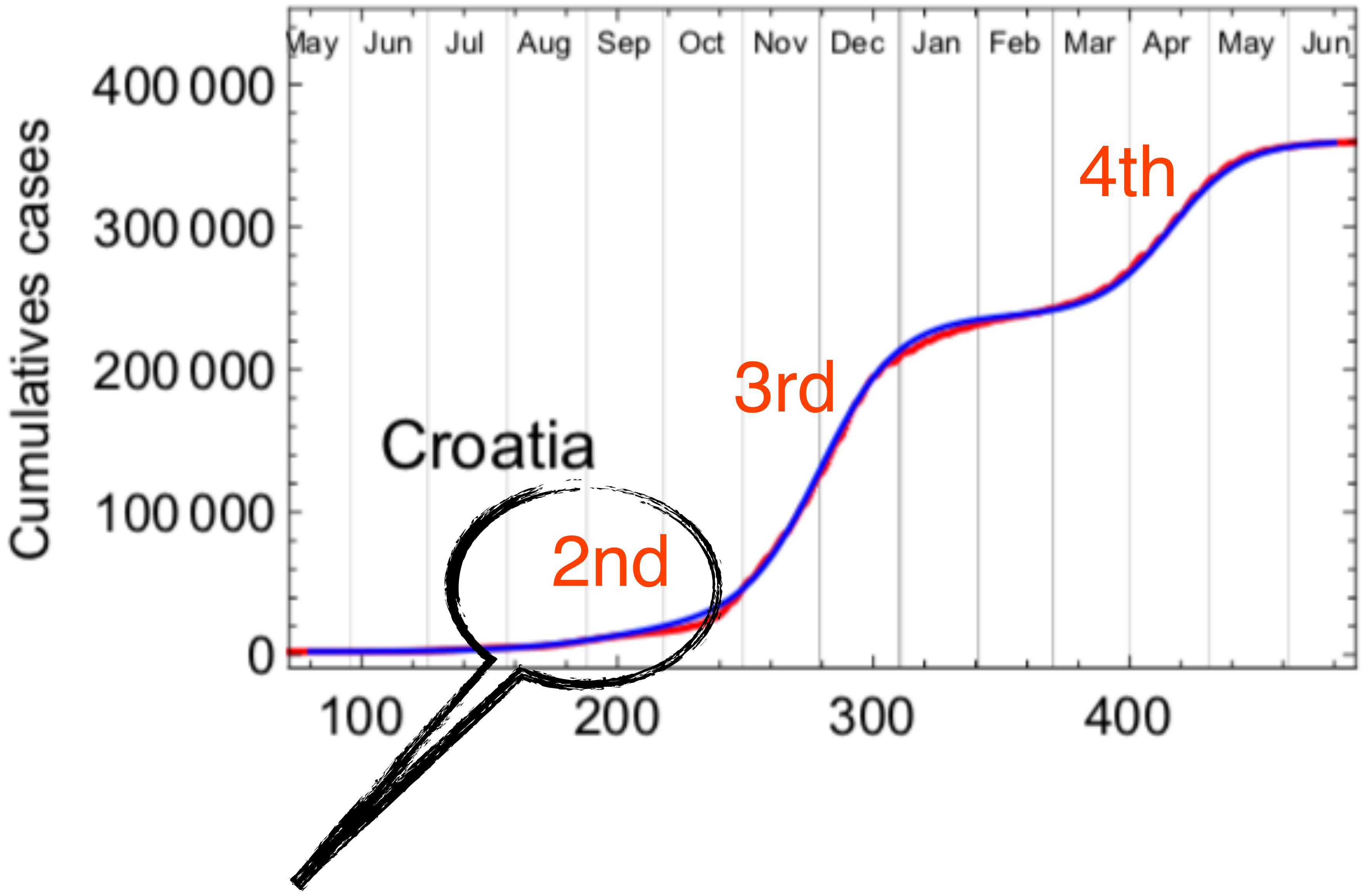
Time structure well reproduced

eRG IN CROATIA

$$\alpha(t) = \frac{a\, e^{\gamma t}}{b + e^{\gamma t}}$$

Different waves can be fitted and compared:

For second wave (Aug-Sep 2020),
$\gamma = 0.105(4)$, $a = 11593(164)$
For third wave (Nov-Dec 2020),
$\gamma = 0.066(1)$, $a = 216153(787)$
For fourth wave (Mar-May 2021),
$\gamma = 0.072(1)$, $a = 122131(213)$



Focus on the 2nd wave (initial phase of diffusion):
more likely to be influenced by people's mobility!

THE ROLE OF TRAVELING

nature SCIENTIFIC REPORTS

Interplay of social distancing and border restrictions….

G. Cacciapaglia and F. Sannino Sci Rep 10, 15828 (2020)

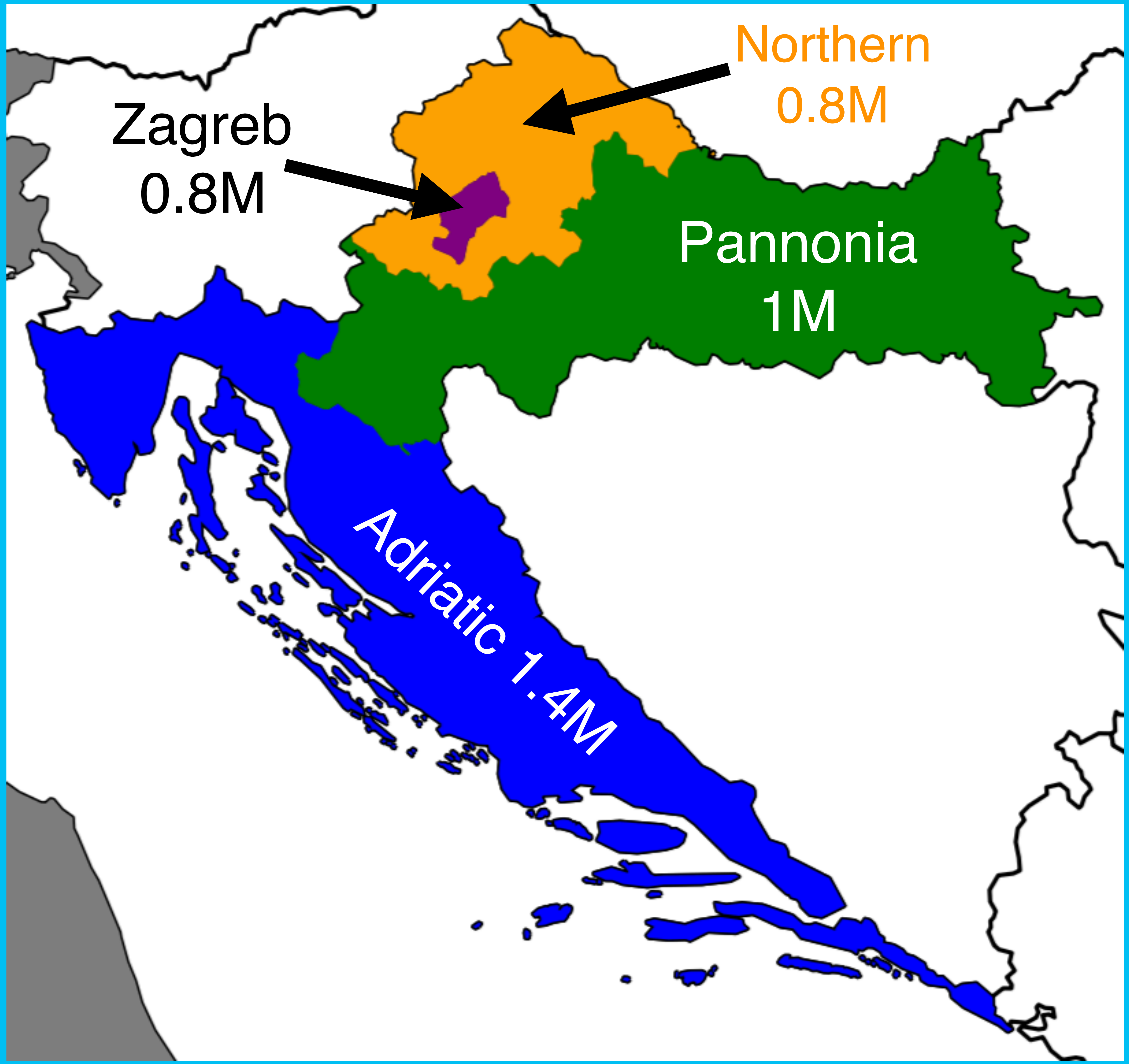
Second wave COVID-19 pandemics in Europe: A Temporal Playbook

G. Cacciapaglia, C. Cot and F. Sannino Sci Rep 10, 15514 (2020)

TRANSPORTATION IMPACTS THE SECOND WAVE

- Each NUTS-2 region = one eRG
- Fit parameters of second wave
- Consider mobility from and to abroad
- Peak delay in each region can be
- predicted by the eRG framework
- and number of travelers

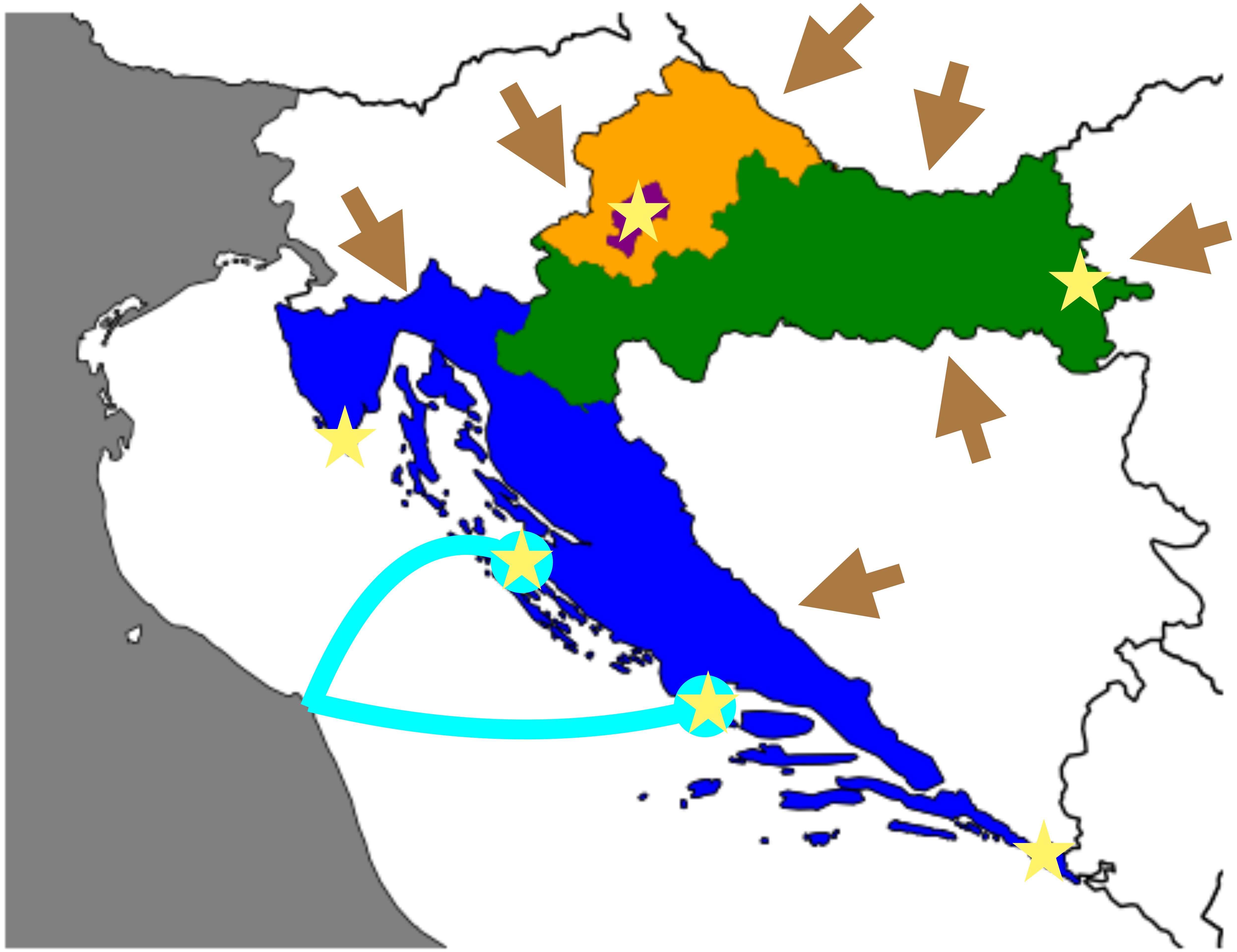
NUTS-2 regions



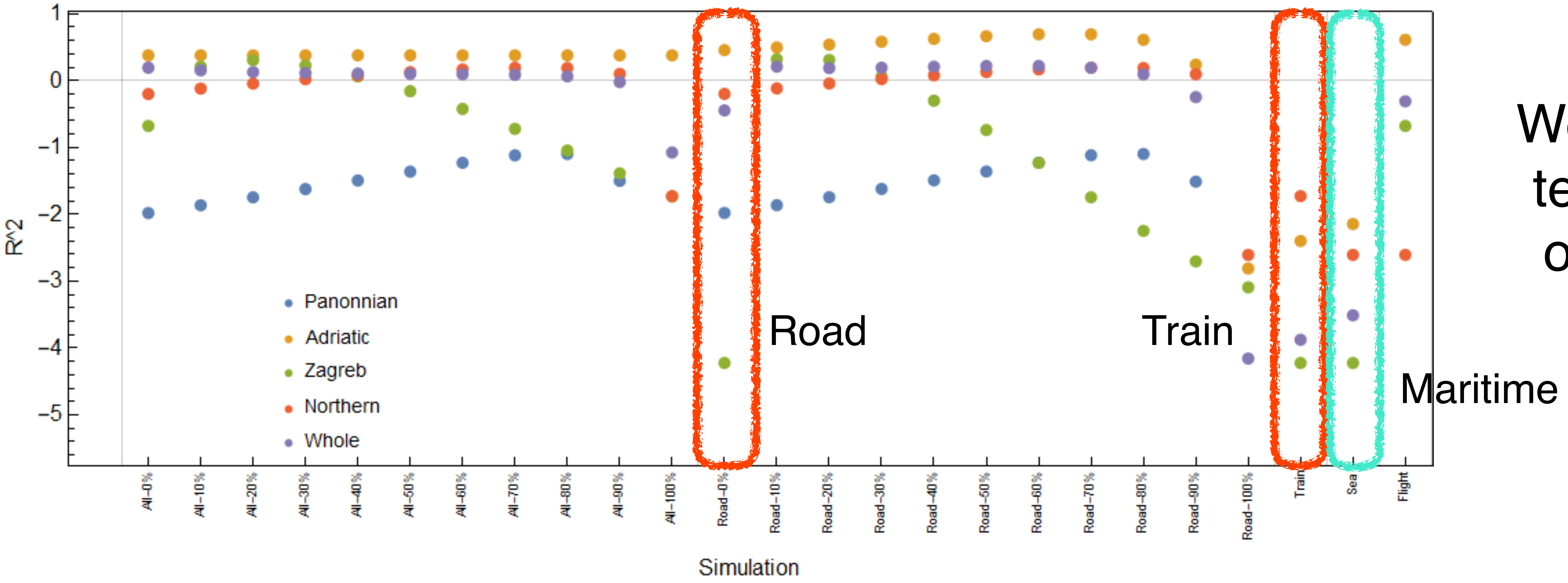
MOBILITY DATA FROM MMPI AND UNIRI

	Vector	Name	Provider	Resolution		#datapoints
				Time	Space	
Maritime	Ferries	CIMIS	MMPI	weekly	by port	1360
Terrestrial	Cars	Highway data	UNIRI	summer	borders	1
	Trains	Railway data	UNIRI	annual	borders	1
Airborne	Planes	Air traffic data	MMPI	monthly	airports	21
Epidemiology	—	New cases	MMPI	daily	county	575

- Data used as input on the eRG
- Internal mobility data missing
- Issue with Zagreb: terrestrial connection important but missing!
- Hence, we artificially rerouted a fraction of the terrestrial travellers to other regions.



RESULTS FROM THE SIMULATIONS



We did several preliminary tests to determine impact of various transportation means

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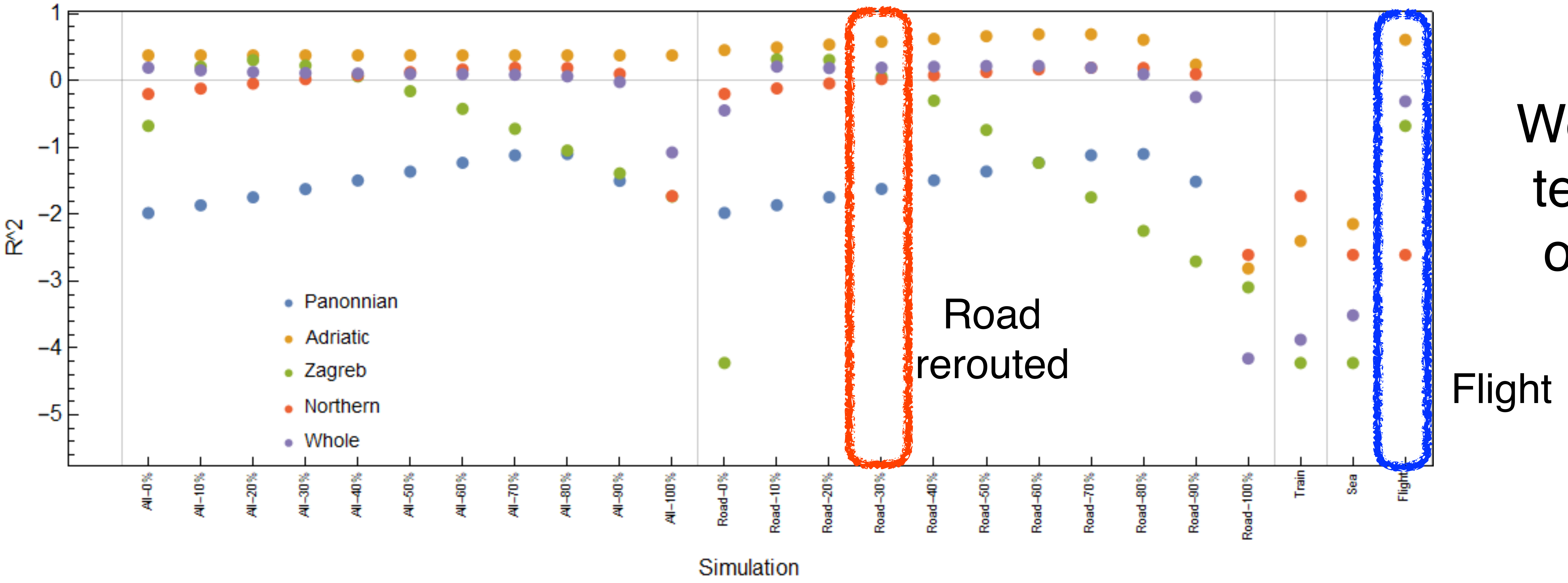

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- Road, Train and Maritime alone do not reproduce well the data, especially Zagreb.
- Flight alone do better, but not ideal (Northern).
- Rerouting 30-40% road traffic to Zagreb improves dramatically the fit.

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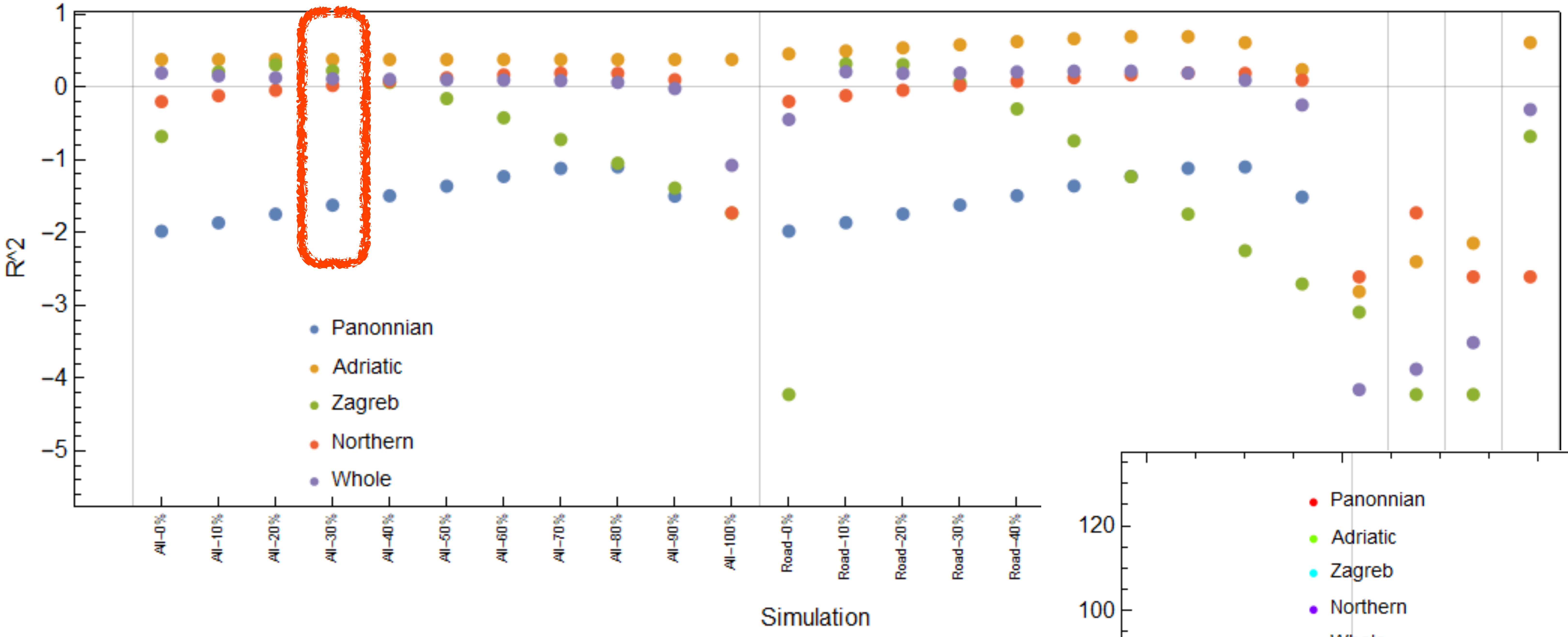

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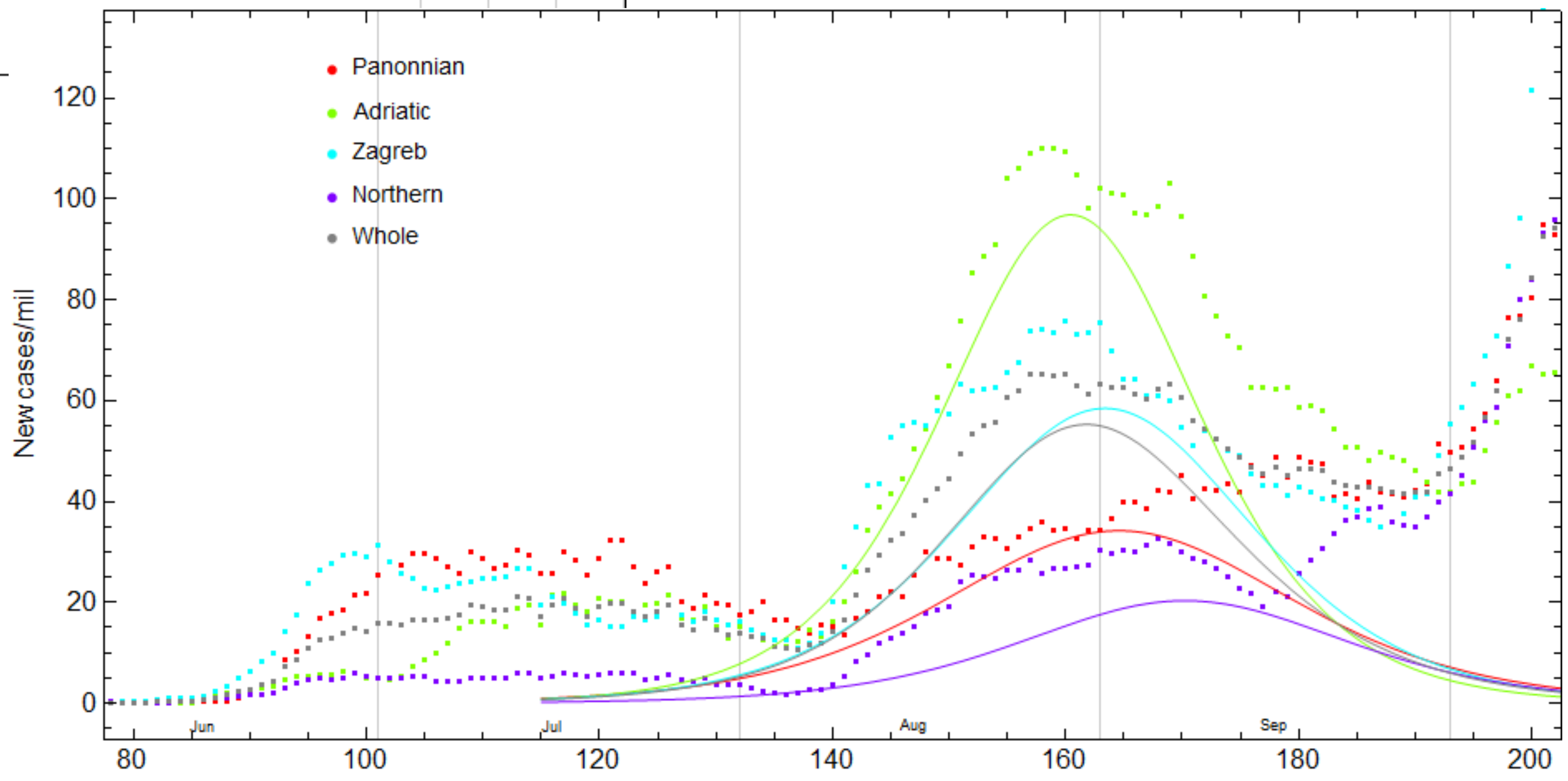


- Best fit: 30% rerouting to Zagreb + all other transportation (flight)
- Pannonia has poor fit to eRG model [optimisation of regions]

LOOKING AHEAD

- Evidence that maritime transportation played <u>no role</u> in COVID-19 diffusion in Croatia
- COVID-19 diffusion mainly due to road mobility and flights
- We will perform additional tests and simulations to confirm this result (final results at the Lecce meeting).
- Help strategy for early response to a future pandemic.

BACKUP

INCLUDING TRAVELLERS

- Consider different regions of the world exchanging travellers

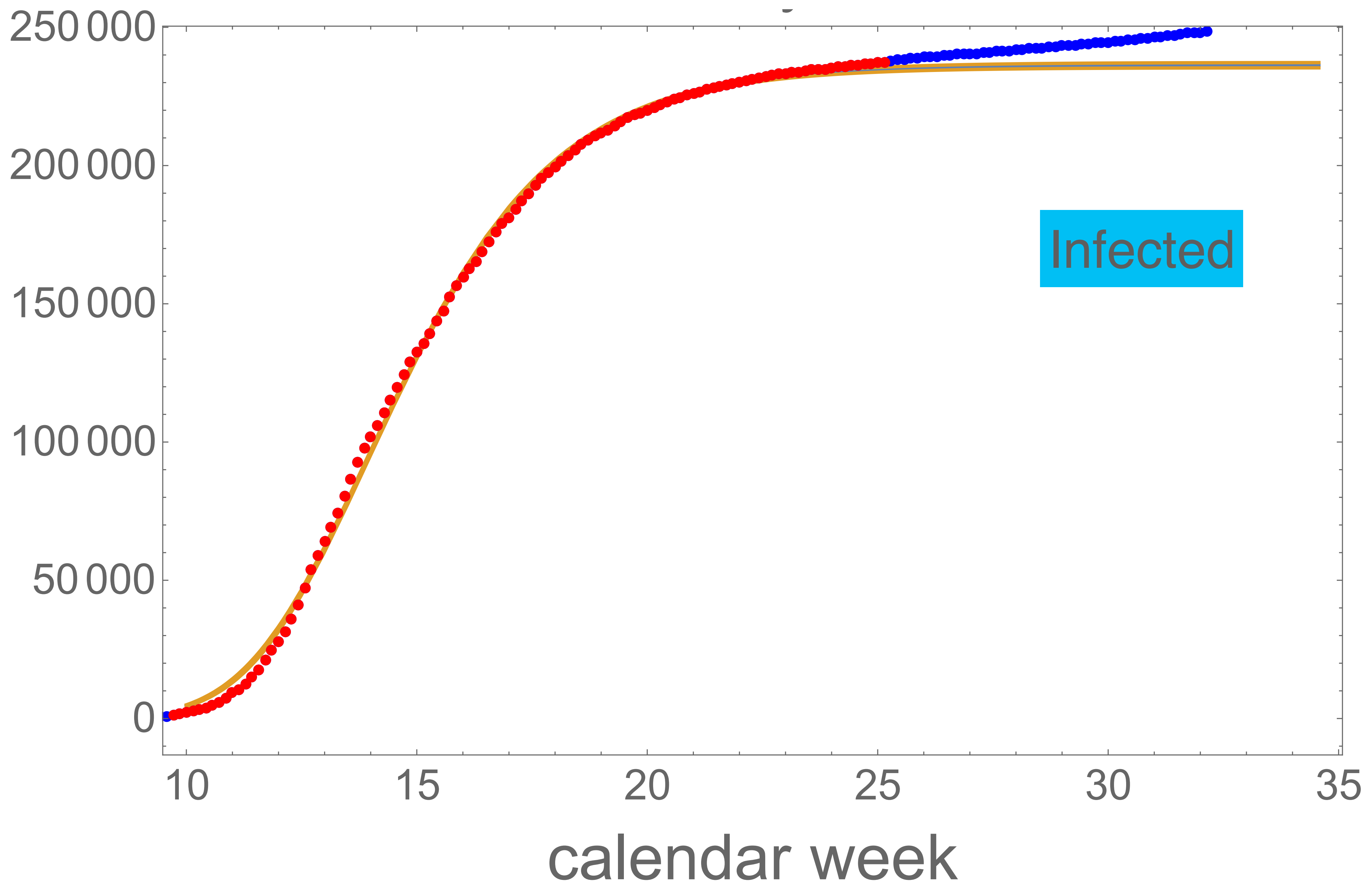
- For each county i we have a beta function + an exchange term

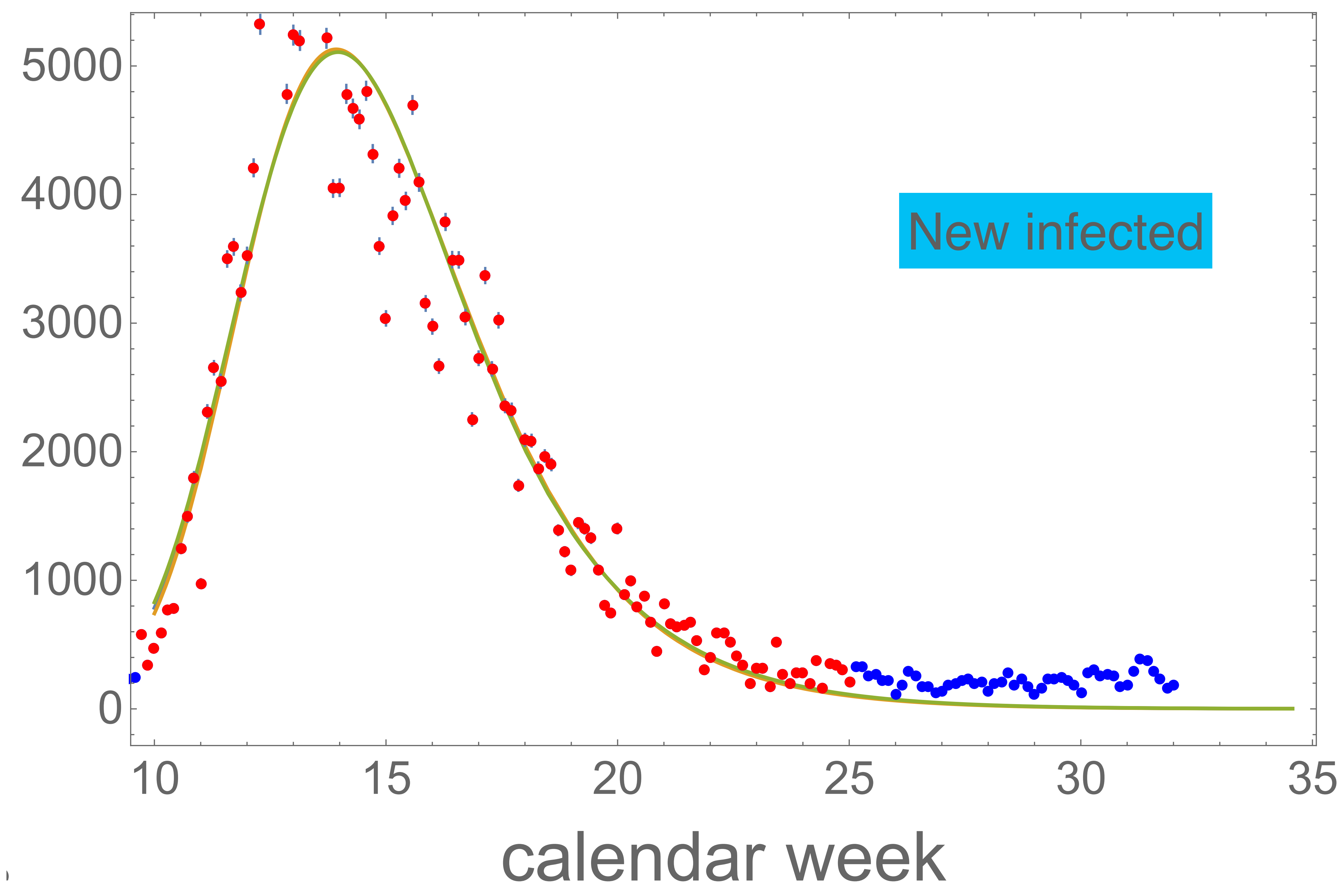
$$\frac{d\alpha_i}{dt} = \gamma_i \alpha_i \left(1 - \frac{\alpha_i}{a_i}\right) + \sum_{j \neq i} \frac{k_{ij}}{n_{mi}} (e^{\alpha_j - \alpha_i} - 1) \qquad \alpha_i(t) = \ln \mathrm{I_i(t)} \ ,$$

- n_{mi} is the population of region i in millions

- k_{ij} proportional to # of weekly travellers from region i to region j and vice-versa in millions

ITALY





$a = 12.373 \pm 0.005$

$\gamma = 0.447 \pm 0.009$

$b = 41 \pm 5$

γ controls the ‘flatness’ of the curve