Modelling the second wave of COVID-19 infections in France and Italy via a Stochastic SEIR model

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OBJECTIVE

To handle uncertainties in Statistical and Epidemiological models
used for COVID19 real-time extrapolations

~ similar to climate sciences:

EXTERNAL SENSITIVITY

-Testing Capabilities
-Political Choices (including lockdown, distancing measures, use of masks)
-Possibility to comply with lockdown (greatly depends on social status)
-Imported cases from other countries

INTRINSIC SENSITIVITY

-Virus Characteristics
-Age
-Sex
-Weather
-Population Density
-Immunity to other Coronavirus?

=> Too many unknown parameters. We opt for simple ways to handle uncertainties

SENSITIVITY IN SEIR MODELS

$$\frac{dS}{dt} = -\lambda S(t)I(t)$$
$$\frac{dE}{dt} = \lambda S(t)I(t) - \alpha E(t)$$
$$\frac{dI}{dt} = \alpha E(t) - \gamma I(t)$$
$$\frac{dR}{dt} = \gamma I(t).$$

Susceptible **S(t);**

Exposed **E(t)**

Infected **I(t);**

Recovered **R(t)**

Infection rate **λ**

Recovery rate **γ**

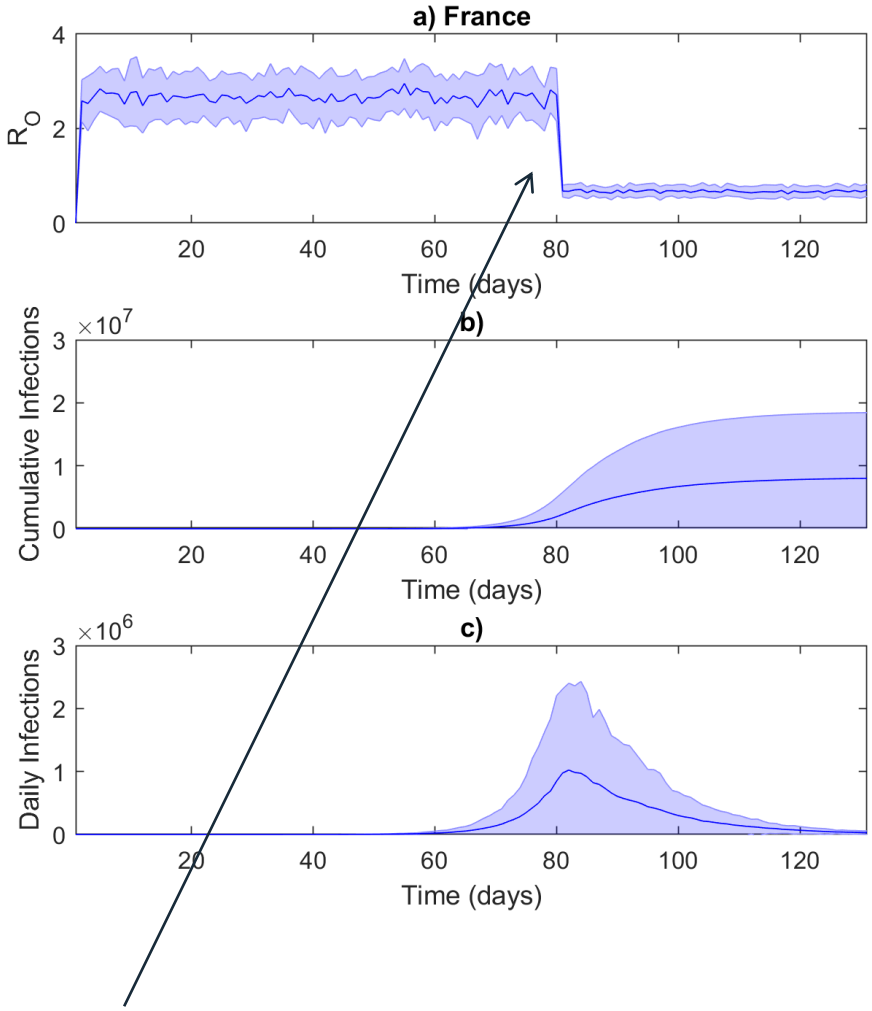
Incubation rate **α**

R0= λ/γ~2.8

In the SEIR model, parameters **are assumed constant.** They can vary due to the confinement measures, changes in the virus characteristics, geographical and climatic features

⇒ **$\beta(t) = \beta_0 + \eta(t;0,\sigma^2)$** where η(t;0,) is a Gaussian/Lognormal noise with variance **$\sigma^2 = 0.2*\beta_0$** **Condensate all the uncertainties!**

STOCHASTIC VS DETERMINISTIC MODEL



$\lambda = 1./S(1)$

$\alpha = 0.27$

$\gamma = 0.37$

$I(1) = 1$ (Reported on Dec 27th)

$S(1) = 67\ 000\ 0000$

$E(1) = R(1) = 0$

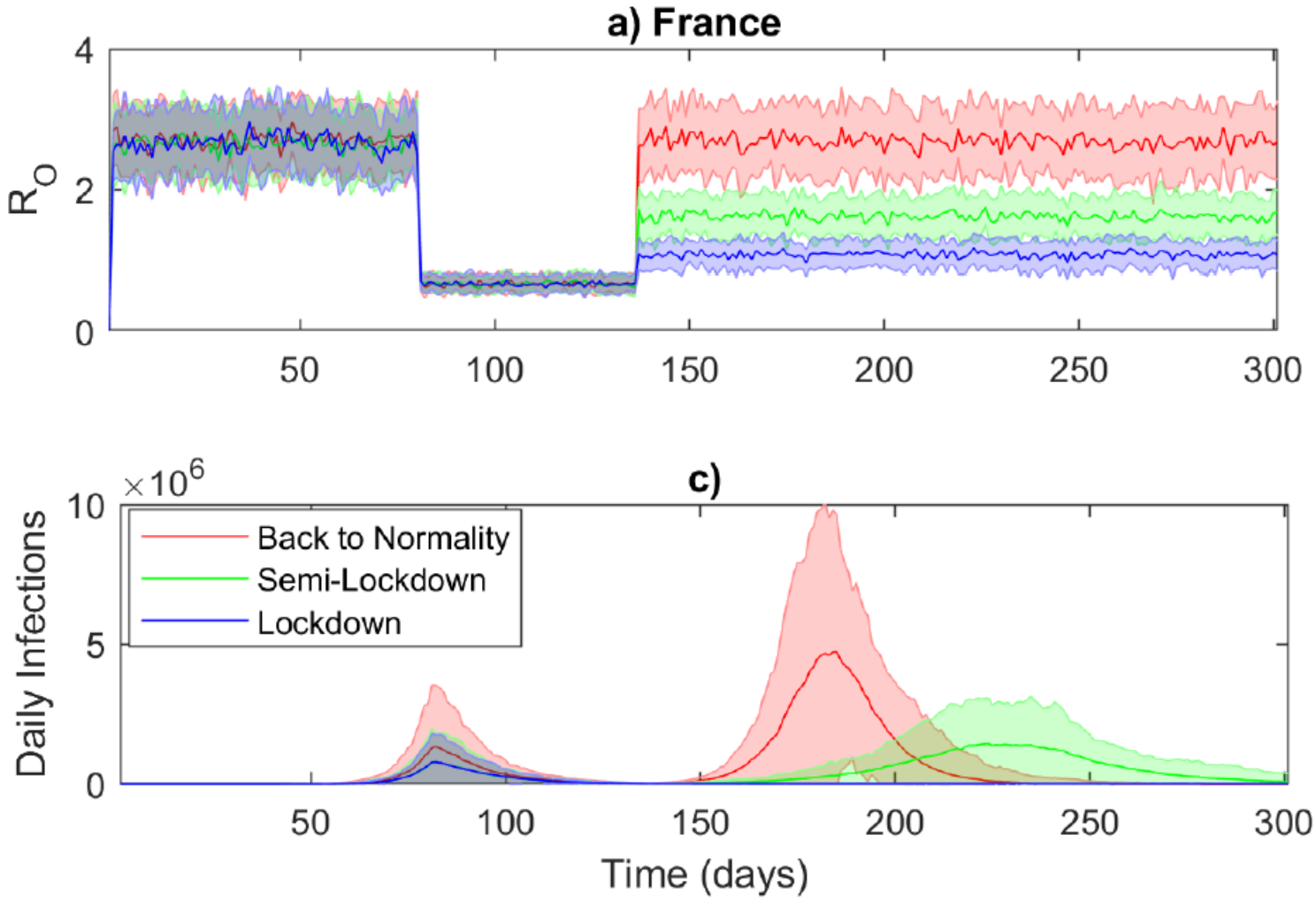
Solid line : deterministic forecast

Bar: 3 standard dev over 30 realisations

Confinement: Infection rate $\lambda = \lambda/4$ on March 17th (based on mobility data)

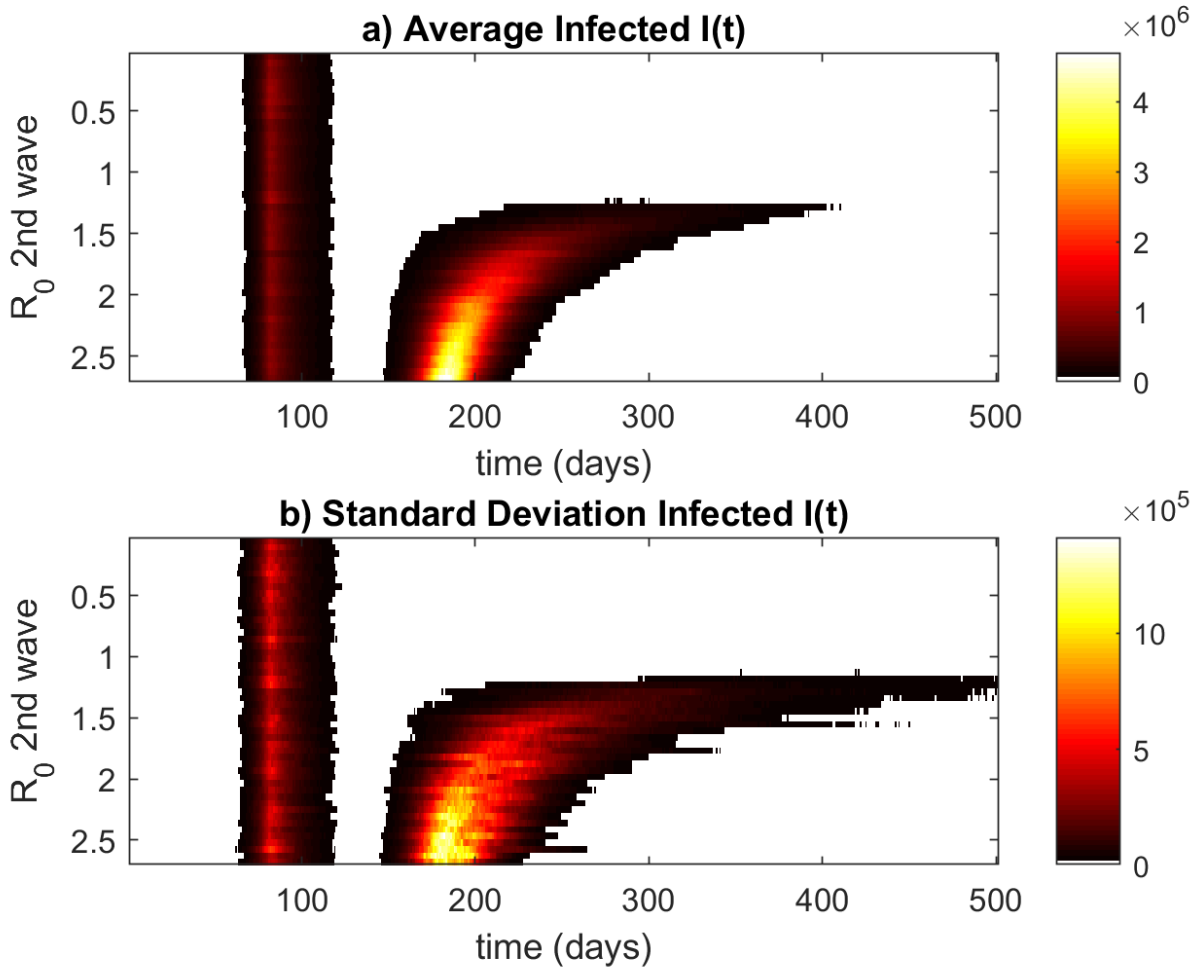
SECOND WAVE

After the lockdown is realeased, different scenarios for France



PHASE DIAGRAMS

After the lockdown is realeased, all scenarios for France



DISCUSSION

1) It is not straightforward to extrapolate long term behavior of epidemic growth due to the high level of sensitivity of the dynamics to virus characteristics (intrinsic sensitivity) and the lack of good quality data (external sensitivity).

2) Asymptotic estimates of COVID19 infections should be accompanied by large uncertainties

3) Using more complex models might not be an advantage if they are initialized with missing or incomplete data => overfitting

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