# Bulletin GPoM-epidemiologic no 2

## Coronavirus Covid-19 outbreak (2019-2020)

**26 February 2020**


# From January 31 to February 25

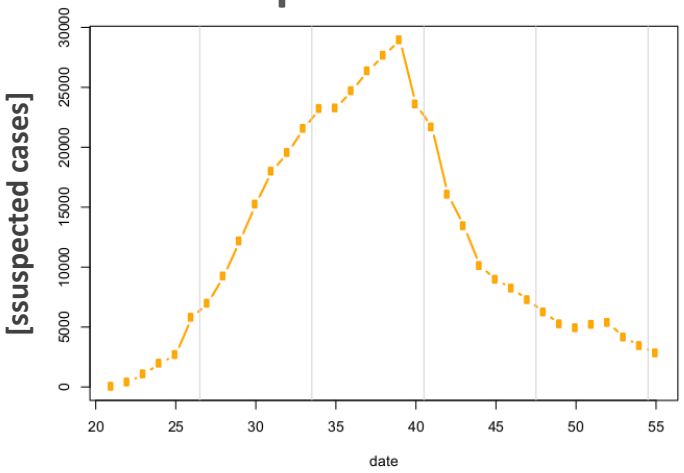
- A model was obtained on February 6th for the outbreak of Covid-19 **in China** using data from January 21 to February 5 (CESBIO, internal report)
- This model couples dynamically three variables:
  - $C(t)$ the number of additional confirmed cases per day
  - $s(t)$ the number of additional severe cases per day
  - $D(t)$ the number of additional deaths per day
- This model suggested that the dynamical behavior of the outbreak had been **on a transient** and was **close to** reach a **stationnary regime**
- This model also gave a strong argument for a **chaotic behavior**: both **deterministic** and **unpredictable**

# From January 31 to February 25

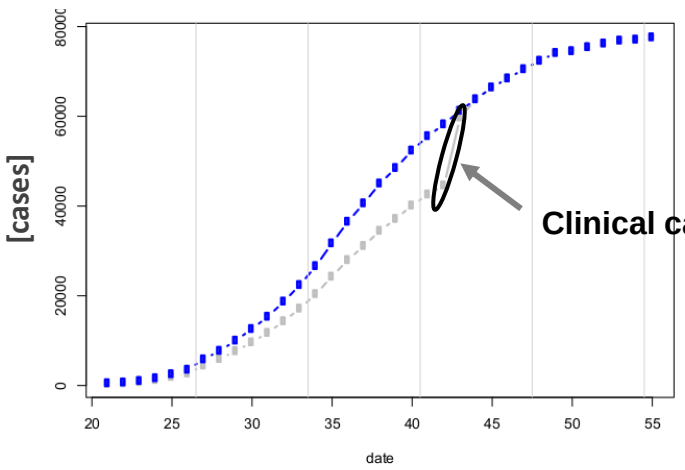
- This Bulletin no 2 (26th February) aims to **update** this preliminary analysis and **discuss** the **recent evolutions**
- On Februray 12th, a **new methodology** has been used to monitor the outbreak (see daily monitoring). This impacts the estimates by a factor of **+30%** for the **contaminated cases**, and around **+10%** of **severe cases** and **deaths**.
- **Corrections** were **applied** to the observational data on the period January 21 to February 11 to compensate this effect (see next Figure).

# Daily monitoring

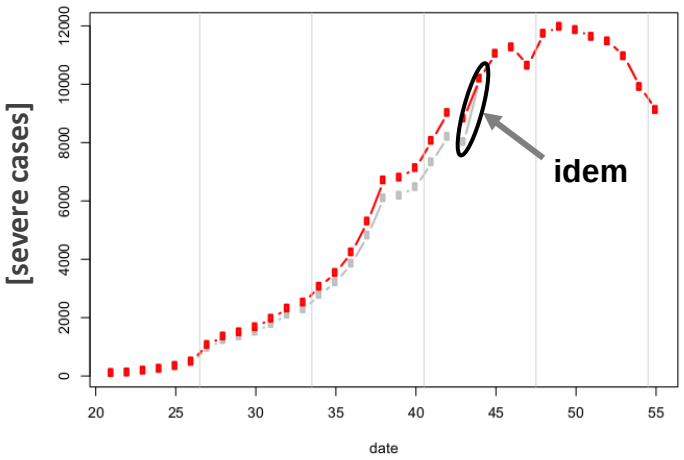
## Suspected cases



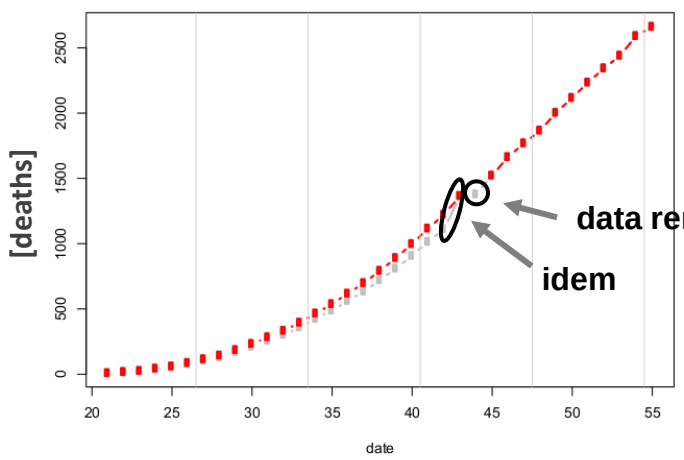

## Cumulated confirmed cases* $C_{\Sigma}(t)$




## Severe cases* $s(t)$




## Cumulated deaths* $D_{\Sigma}(t)$




*Data before correction in light gray

Original data from the official national Chinese website

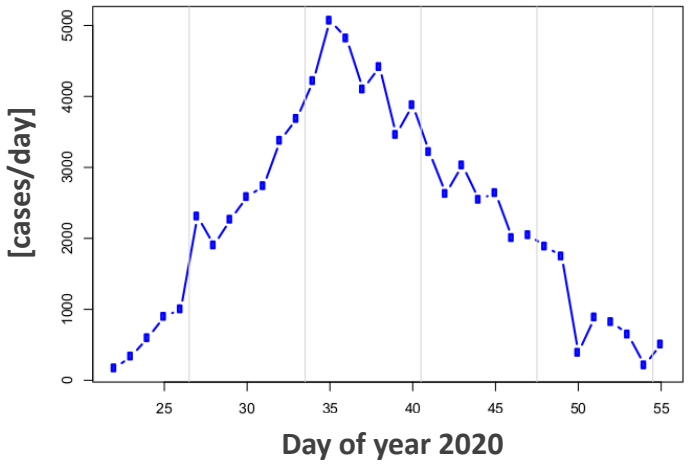
卫生应急办公室

# Recent evolutions

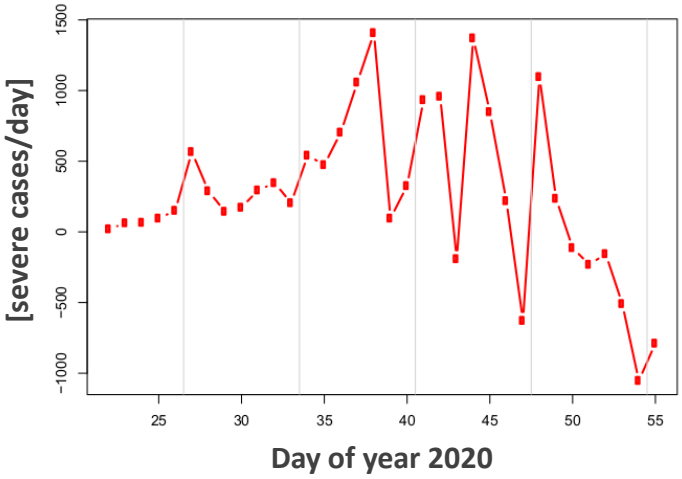
- The number of suspected cases have strongly reduced during the period ranging from February 8 to 13. This quick reduction is due, in part, to the reclassification from suspected to clinically confirmed
- A maximum in the outbreak progression by the beginning of February (see also next Figure)
- A threshold of severe cases per day has been reached last week and a decrease has been intiated during the last 3 days
- After a long and close to linear increase, the number of deaths per day has apparently stabilized, in a range between 100 and 140 deaths per day (see next Figure)

# Day to day difference

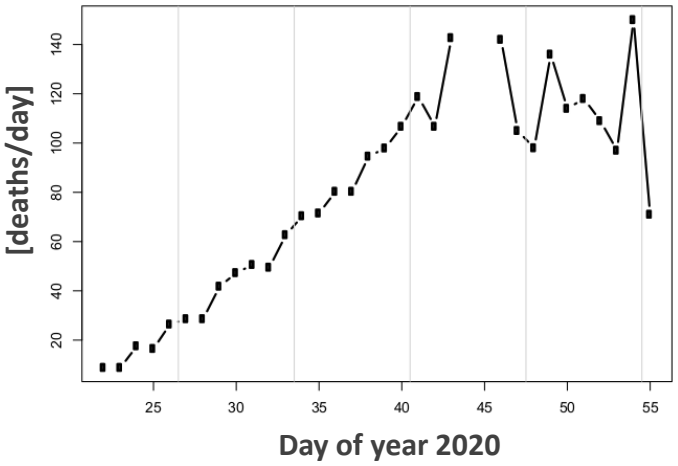
## Confirmed $C(t)$




## Severe $s(t)$




## Deaths $D(t)$




Original data from the official national Chinese website

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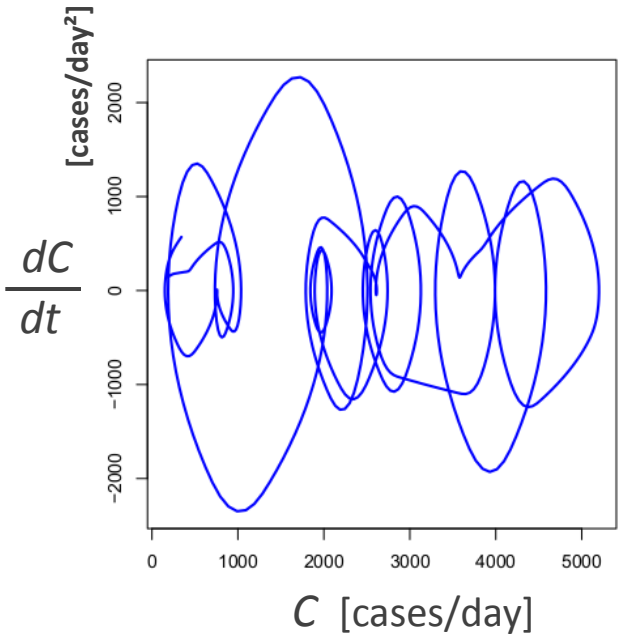
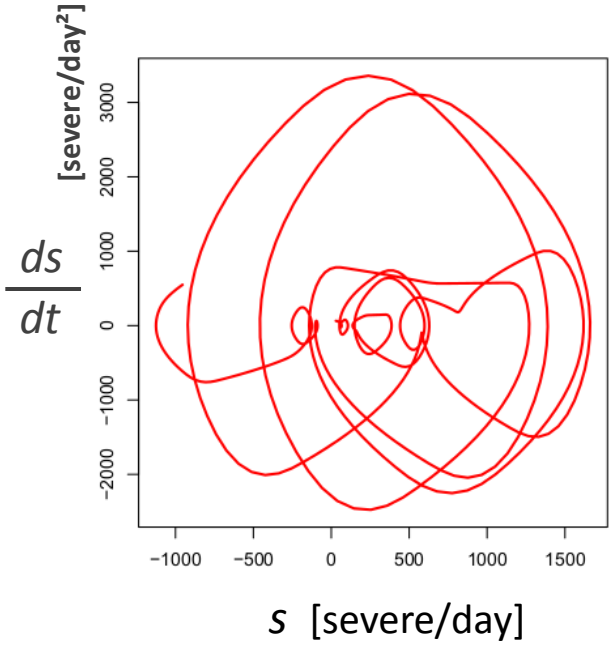
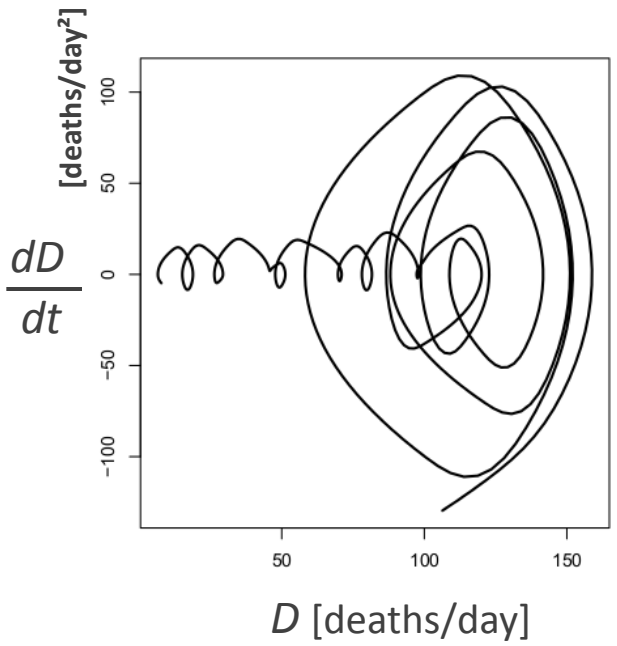
# Recent evolutions: differential phase space

- The differential phase space provides portraits of the dynamical behavior as it can be seen from various observed variables (see next Figure)
- The portraits reconstructed from $C(t)$ and $s(t)$ (resp. in blue and red) show that large ranges of these variables have been visited: [0; 5000] additional confirmed cases per day and [–1000; 1500] severe cases per day, respectively. Presently, both these two variables are now close to a minimum
- Contrarily, the portrait reconstructed from $D_1(t)$ suggests a long transient (from 0 to 100 deaths per day) until the dynamic could settle down on a stationary situation, potentially a chaotic attractor [100; 150] deaths per day).
- The present situation may probably correspond to the delayed peak of death that likely results from the confirmed cases that have accumulated

# Differential Phase portraits (coronavirus Covid-19)



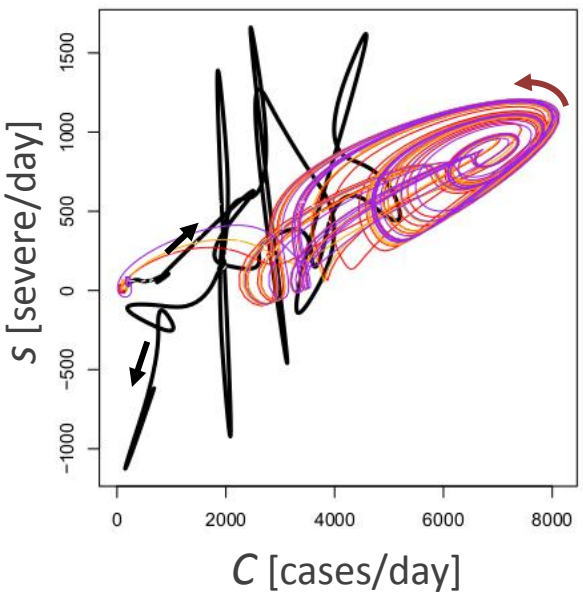



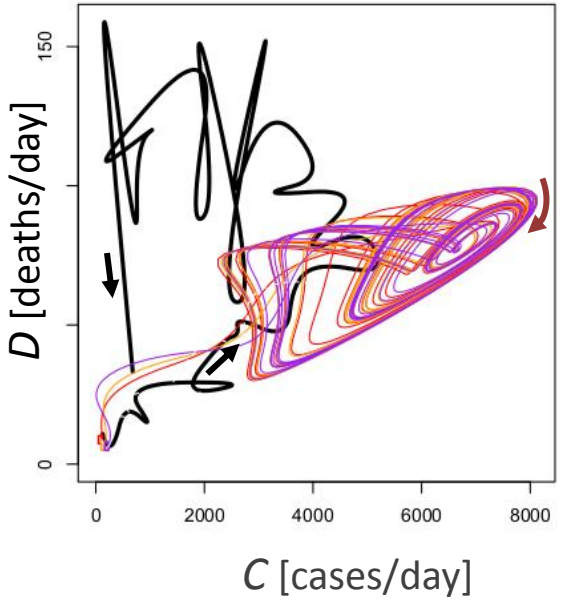
# Model ↔ data

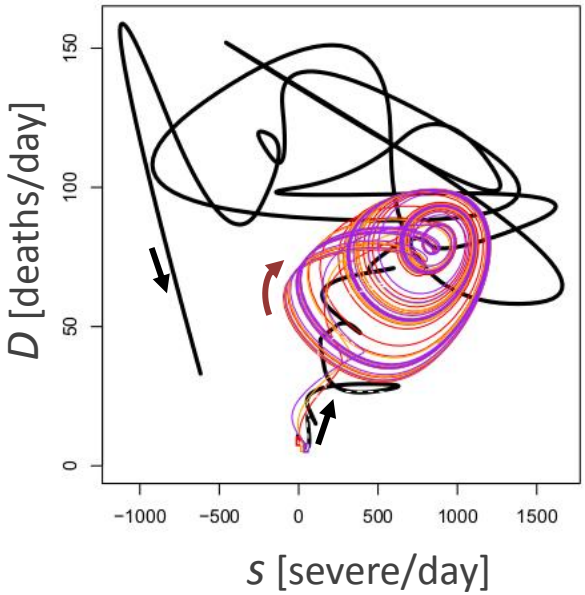
- The comparison between the model and the observations (next two Figures) suggests that

- (1) By its action, human enabled to slow down – and minimize – the propagation of the disease, at least as it can be seen from the number of confirmed contaminations perday $C(t)$ and severe cases per day $s(t)$
- (2) human action did not permit to minimize the number of deaths; it only avoided it to exceed a threshold. Due to a delay effect, the decline is expected soon. However, no definitive sign of this decrease has been obtained yet from this variable and restarts cannot be completely excluded

# Phase portraits projections (coronavirus Covid-19)




Observations*

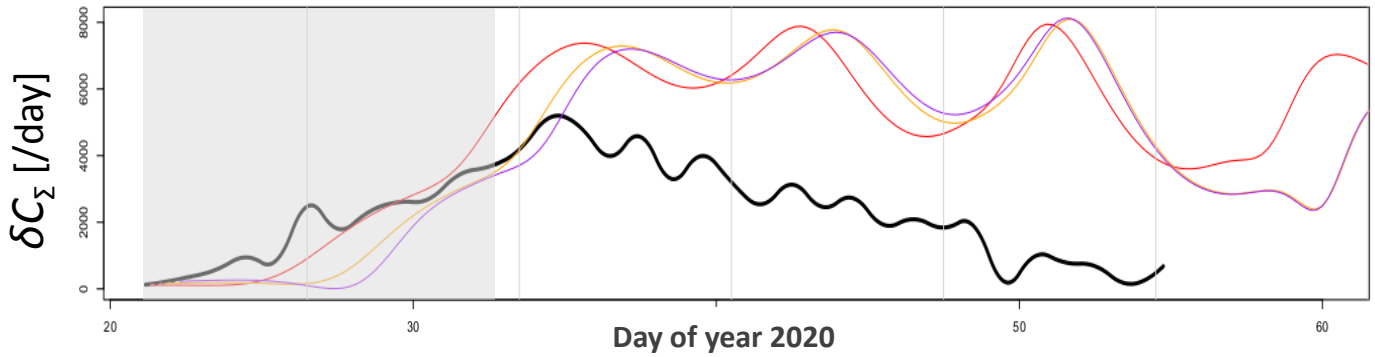
Model (GPoM**) (from different initial conditions)

* Data from the official national Chinese website 卫生应急办公室

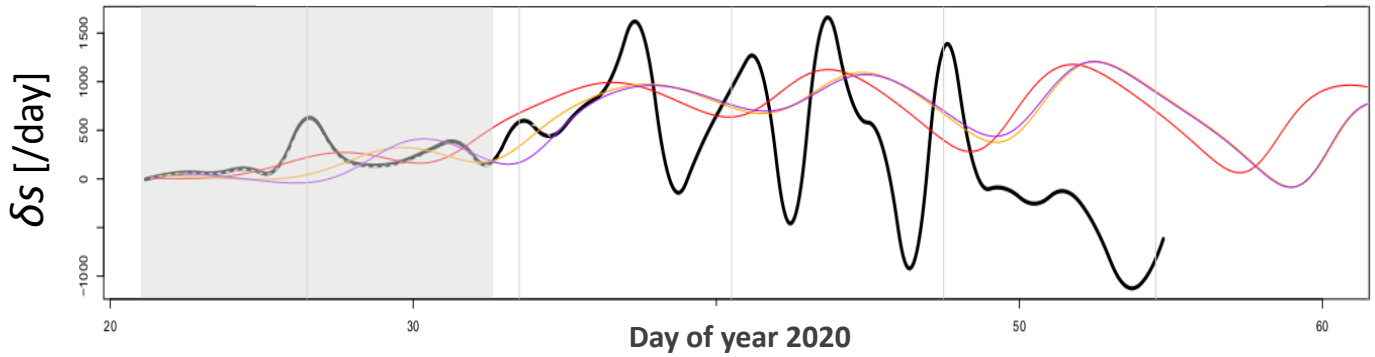
** Model obtain with the GPoM R package

# Coronavirus Covid-19

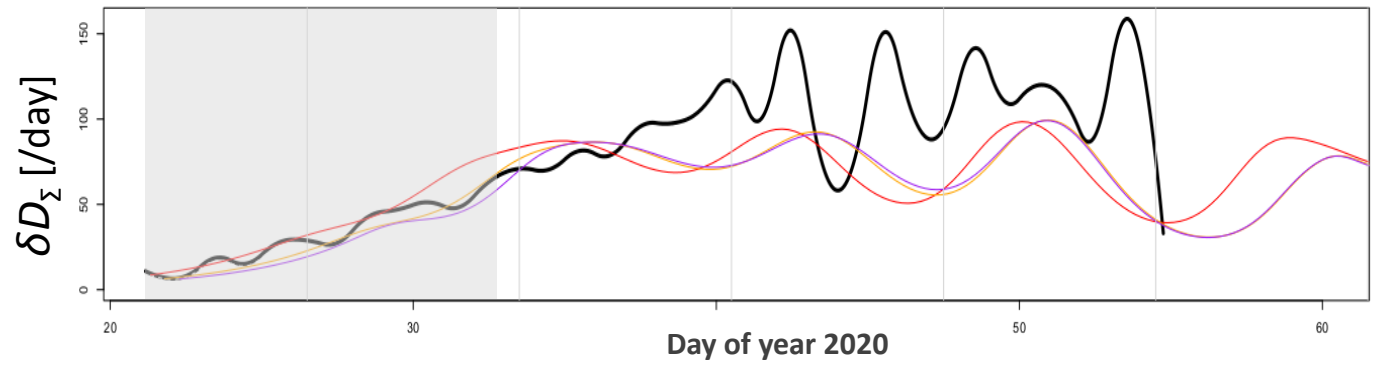
## Daily additional Confirmed cases




## Daily number of Severe cases




## Daily Deaths




Observations*

Observations used for model identification (days 21-31)

Model (GPoM**) (from different initial conditions)

* Data from the official national Chinese website **卫生应急办公室**

** Model obtain with the GPoM R package

# Discussion

**Positive points (at present)**

- On February 5th, the model was able to predict that the peak would soon be reached, which was confirmed the next days
- The model suggests very large oscillations of the number of severe cases which was confirmed by the data (observed oscillations were even quicker than the modelled ones)
- Realistic estimations of the three variables during the transient and dynamically still coherent for the number of severe cases and deaths

**Negative points (at present)**

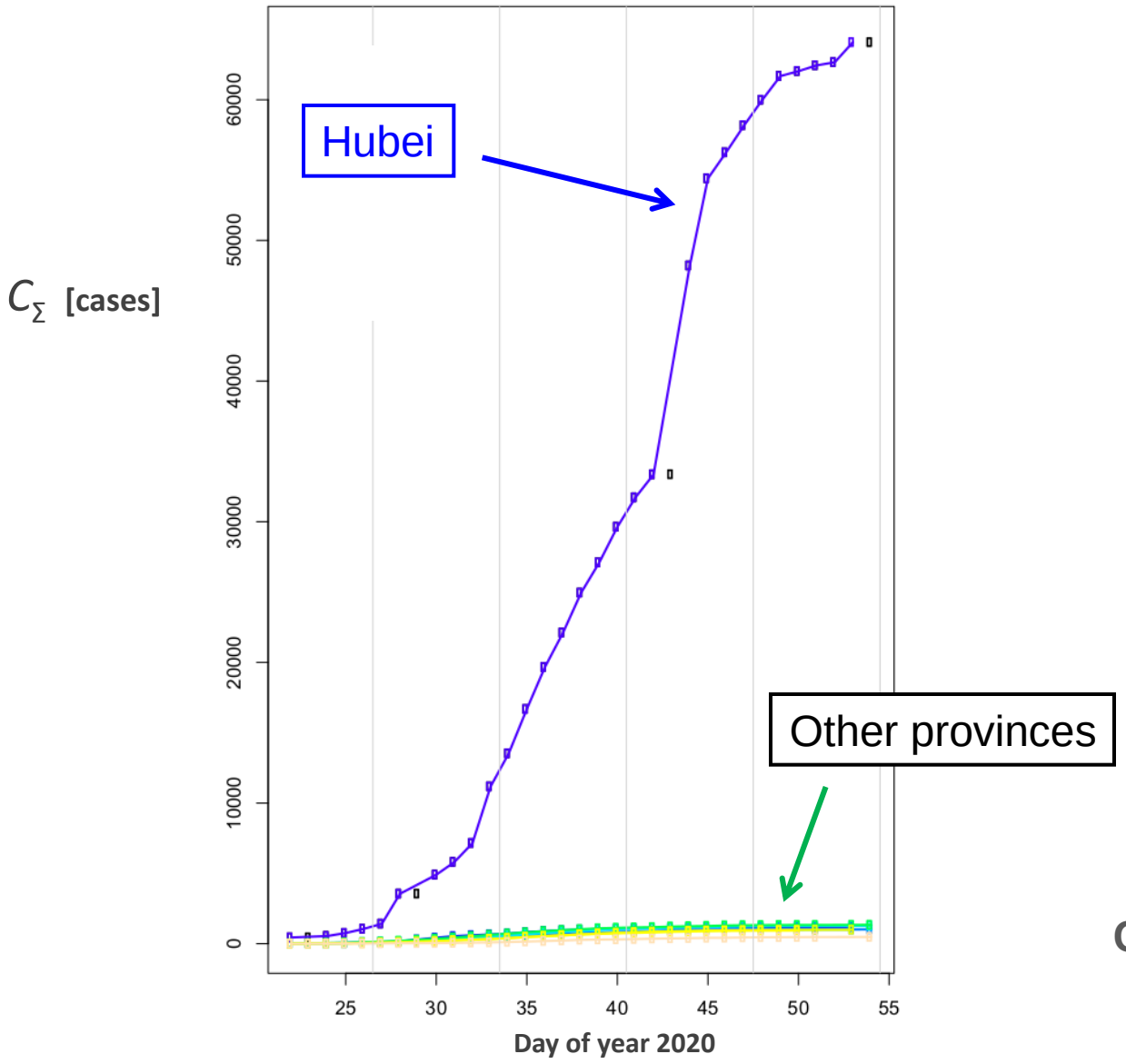
- The model was not able to predict the recent maximum number of confirmed cases (maximum was expected to reach 6000-8000 cases/day whereas it reached ~4000 only) and the following decrease
- But this may directly result from the human action (which was not taken into account by the model after the model was obtained). This action enabled to modify the dynamic of the outbreak by slowing it down

# Provinces intercomparison

- The magnitude of the outbreak in the **Hubei province** is around 50 times larger than in the other most affected provinces (the **Zhejiang**, **Henan**, **Gouangdong**, **Hunan**, **Anhui** and **Jiangxi**) which is quite surprising (see next Figure)

- Note that the outbreak was relatively lower in the other Chinese provinces

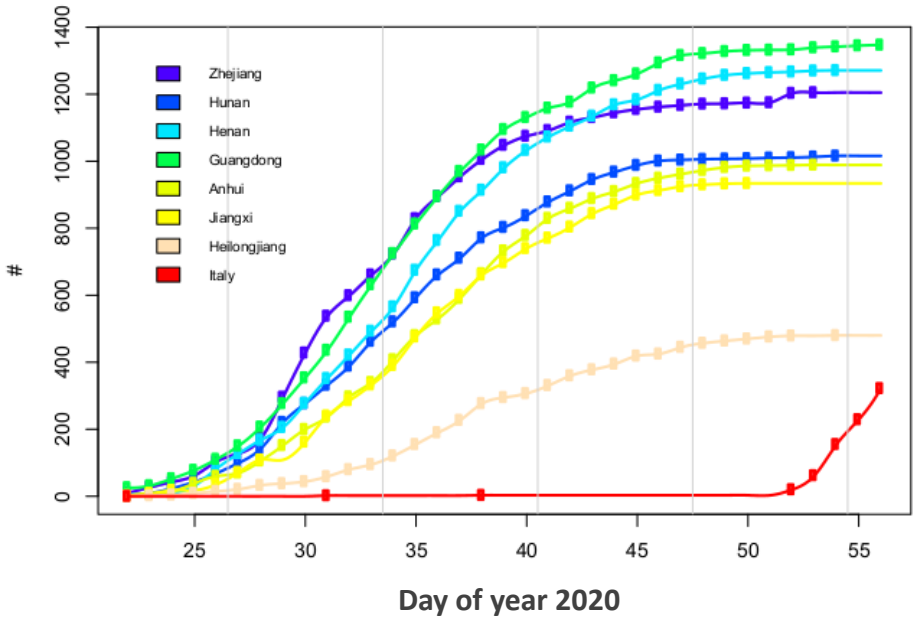
# Cumulated cases per province (coronavirus Covid-19)



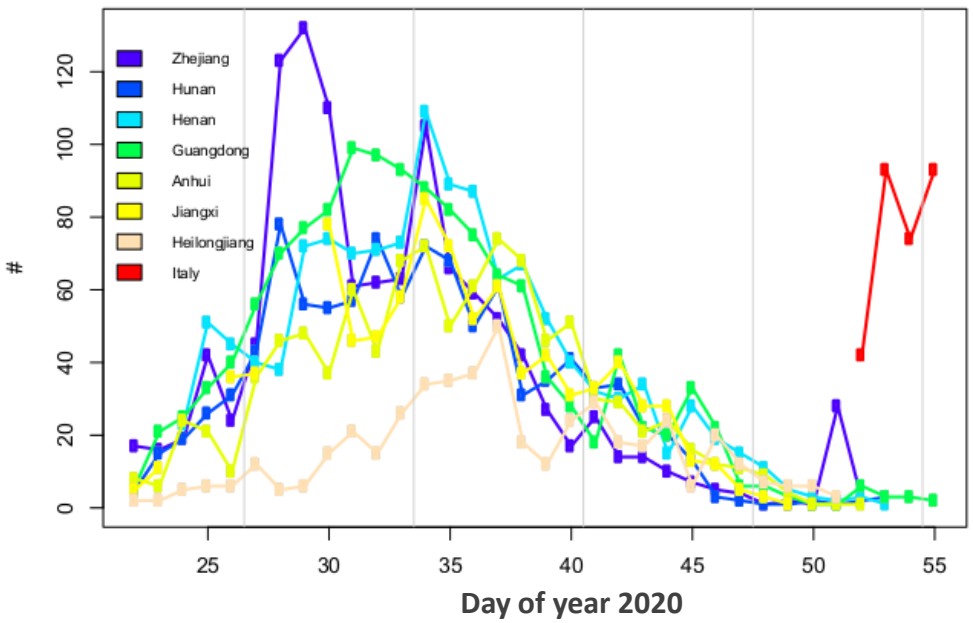

Data from CSSE JHU

# Confirmed cases

$C_\Sigma$ [cases]




$C$ [cases/day]



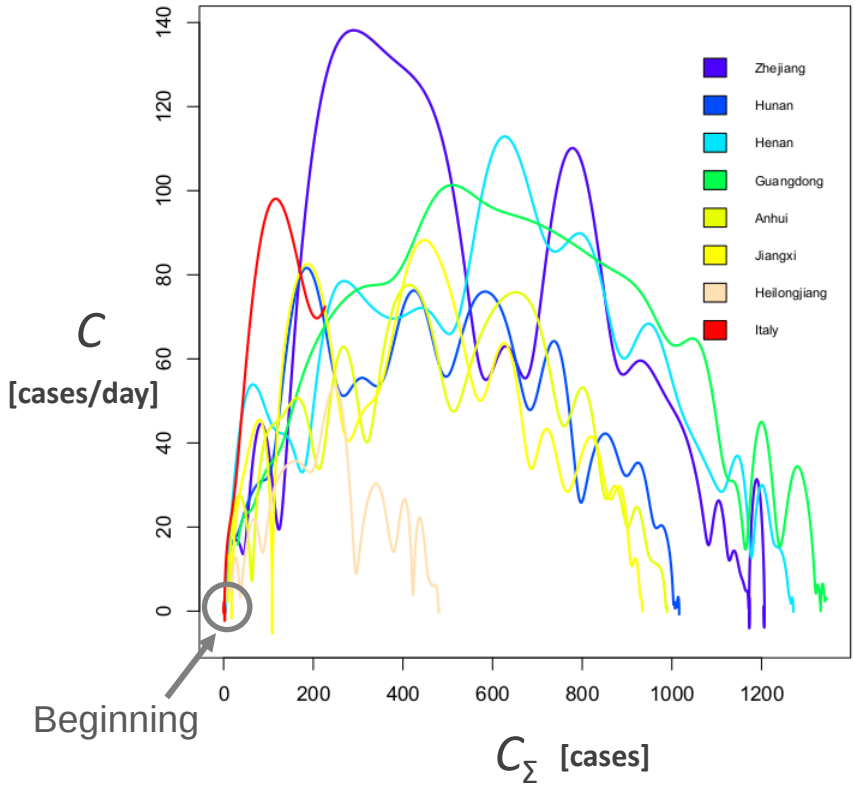

Data from CSSE JHU

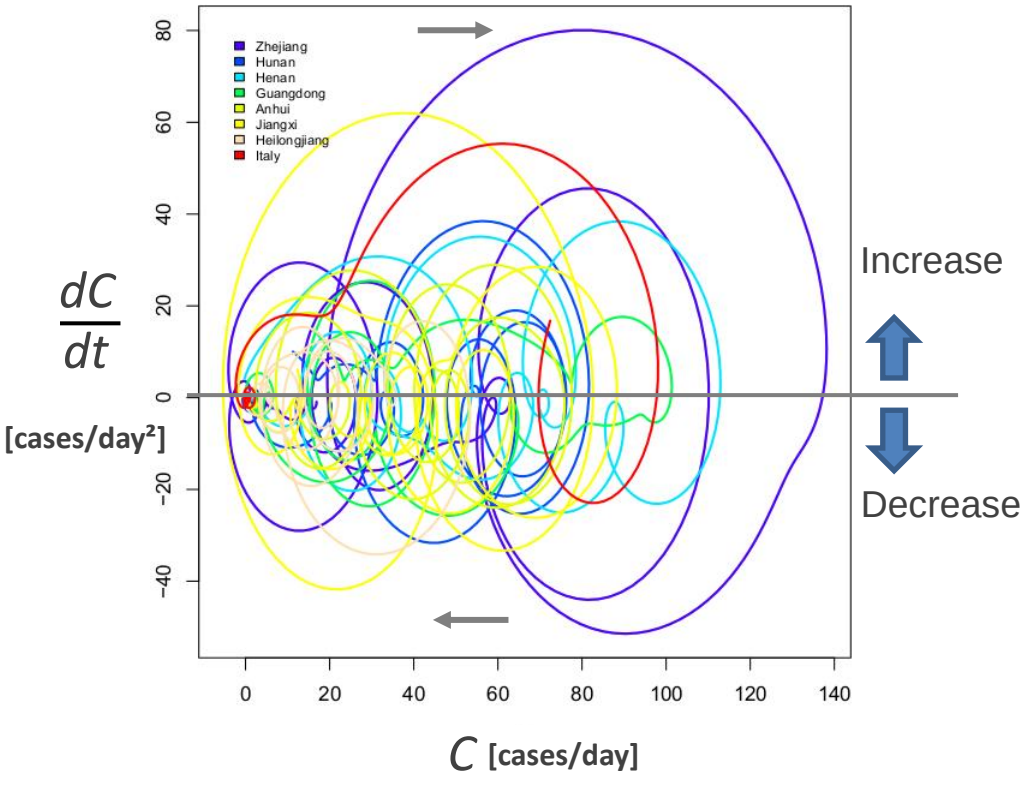
# Italy

- Presently, the outbreak **in Italy** (in red) is comparatavely similar to what was observed in **Zhejiang**, **Hunan**, **Henan**, **Gouangdong**, **Anhui** and **Jiangxi** , that is, the main affected provinces after **Hubei (far behind)**

- The **Heilongjiang** province is also reported for comparison because it has experienced a late start

# Phase Space




Data from CSSE JHU

# Italy

- Dynamically speaking (see phase portraits on last Figure), the outbreak **in Italy** (in red) is similar to what was observed in **Zhejiang**, **Hunan**, **Henan**, **Gouangdong**, **Anhui** and **Jiangxi**.
- It can be noted however that the range of 80 to 100 cases per day was reached quicker in Italy than in these six provinces
- At this stage, it is difficult to know if these earlier evolutions are fully represantative of the evolution to come
- Presently, a behavior similar to what was observed in these six provinces appears the most probable
- However, although less probable at this stage, **scenarios** of major increase or quick decrease (see for example the example in **Heilongjiang** province) cannot be excluded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Territories Risks Ecosystems