Forecasting the Flu with Simple Nonlinear Models

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Methodology

Main Idea: Use a single differential equation to describe wILI "incidence" as a function of cumulative wILI.

1.) Start with wILI incidence as a function of time and add noise

2.) Smooth and interpolate the (reported + noise) incidence data

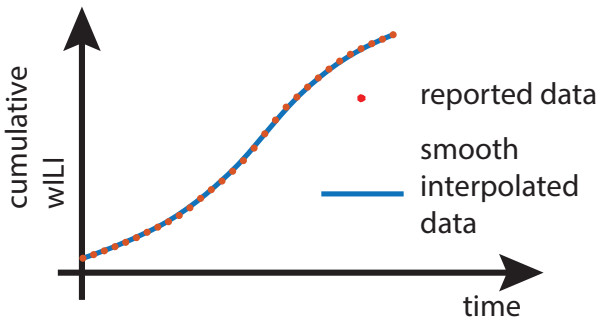
3.) Plot the resulting curve in the (N = cumulative wILI, G = wILI incidence) plane

4.) Fit each model to the $G(N)$ curve and solve the differential equation $dN/dt = G(N)$ to make predictions and identify various targets

5.) Repeat above process $K \geq 1000$ times and combine all predictions into histograms to approximate a probability distribution function

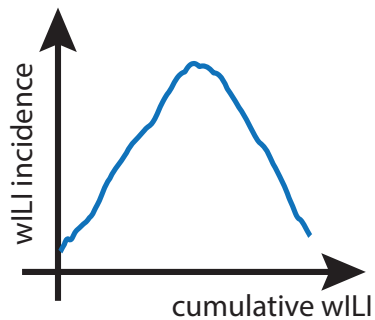
Methodology

1) Smooth and interpolate cumulative wILI curve

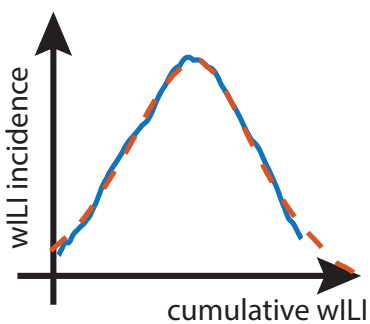


Calculate wILI "incidence" from interpolated data

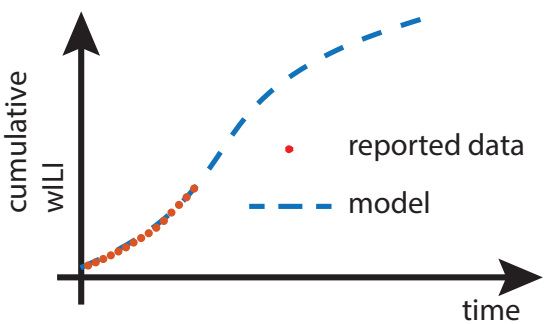
2) Plot wILI incidence in terms of cumulative wILI



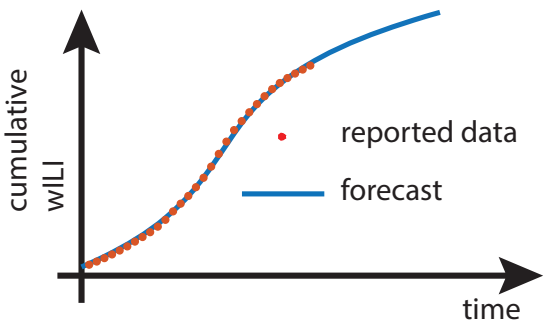
3) Approximate plot by model-specific function



4) Match model-specific function to available cumulative wILI data

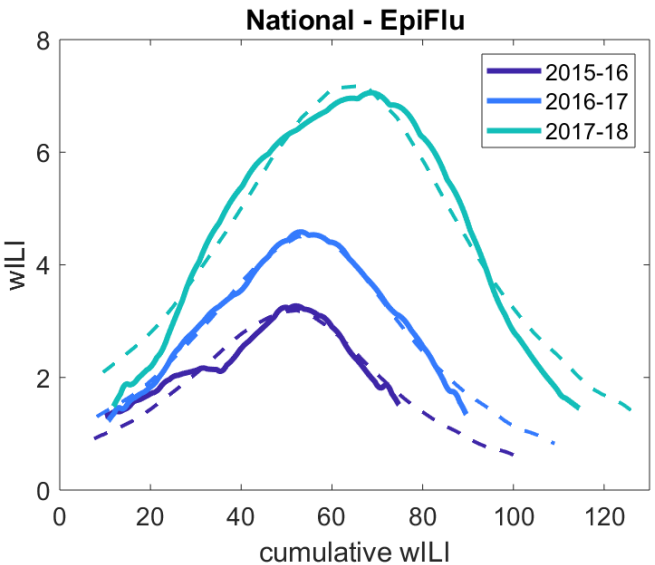


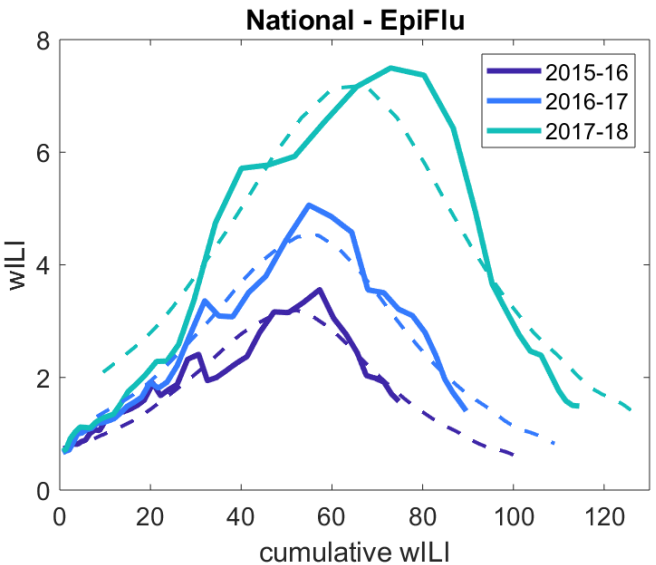
5) Use model-specific function to forecast cumulative wILI data



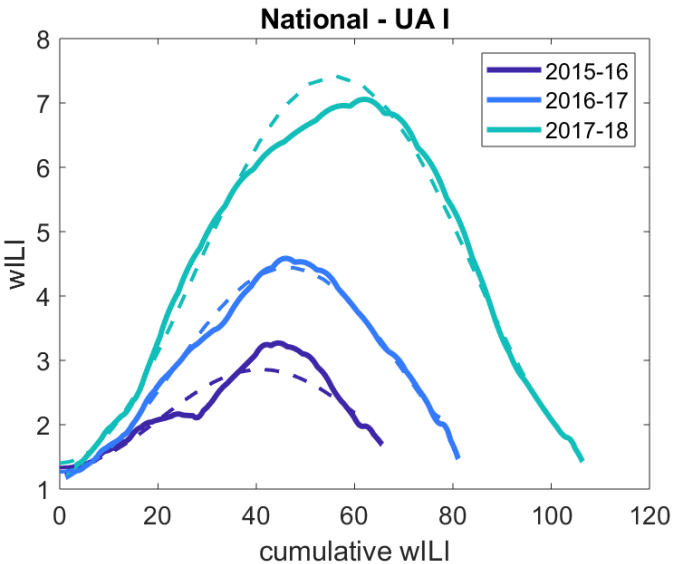
EpiFlu

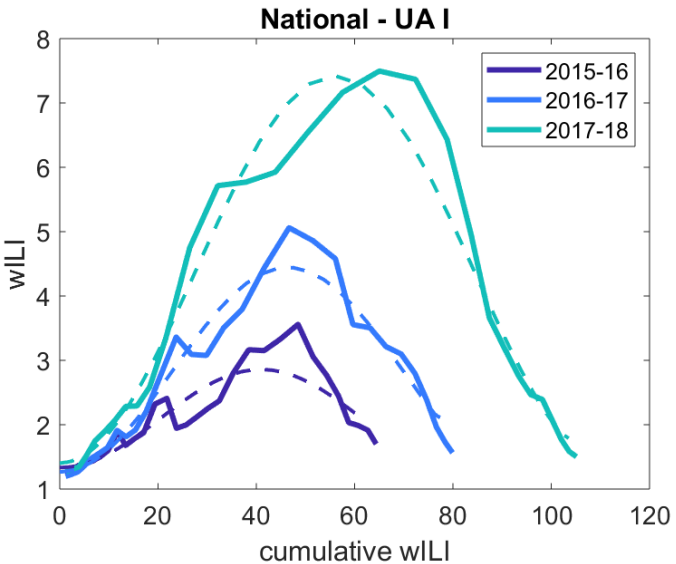
EpiFlu matches the data to an incidence/cumulative cases curve obtained by averaging over regional and national historical data.



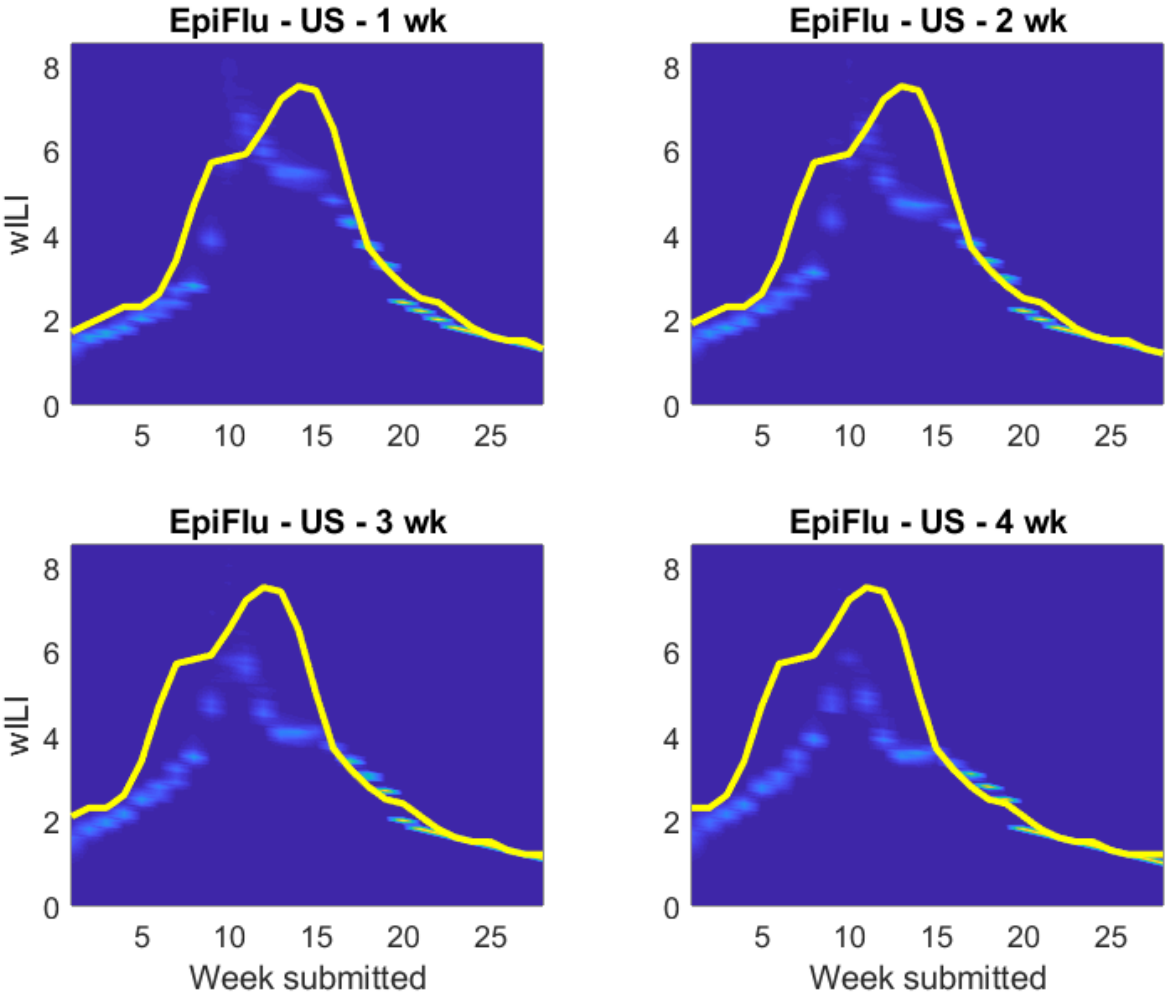


UA I matches the data to an incidence/cumulative cases curve given by a cosine function, $dN/dt = \alpha \cos(\beta G) + \gamma$





EpiFlu Results



US Scores:

1 wk: -2.00

2 wk: -2.31

3 wk: -2.73

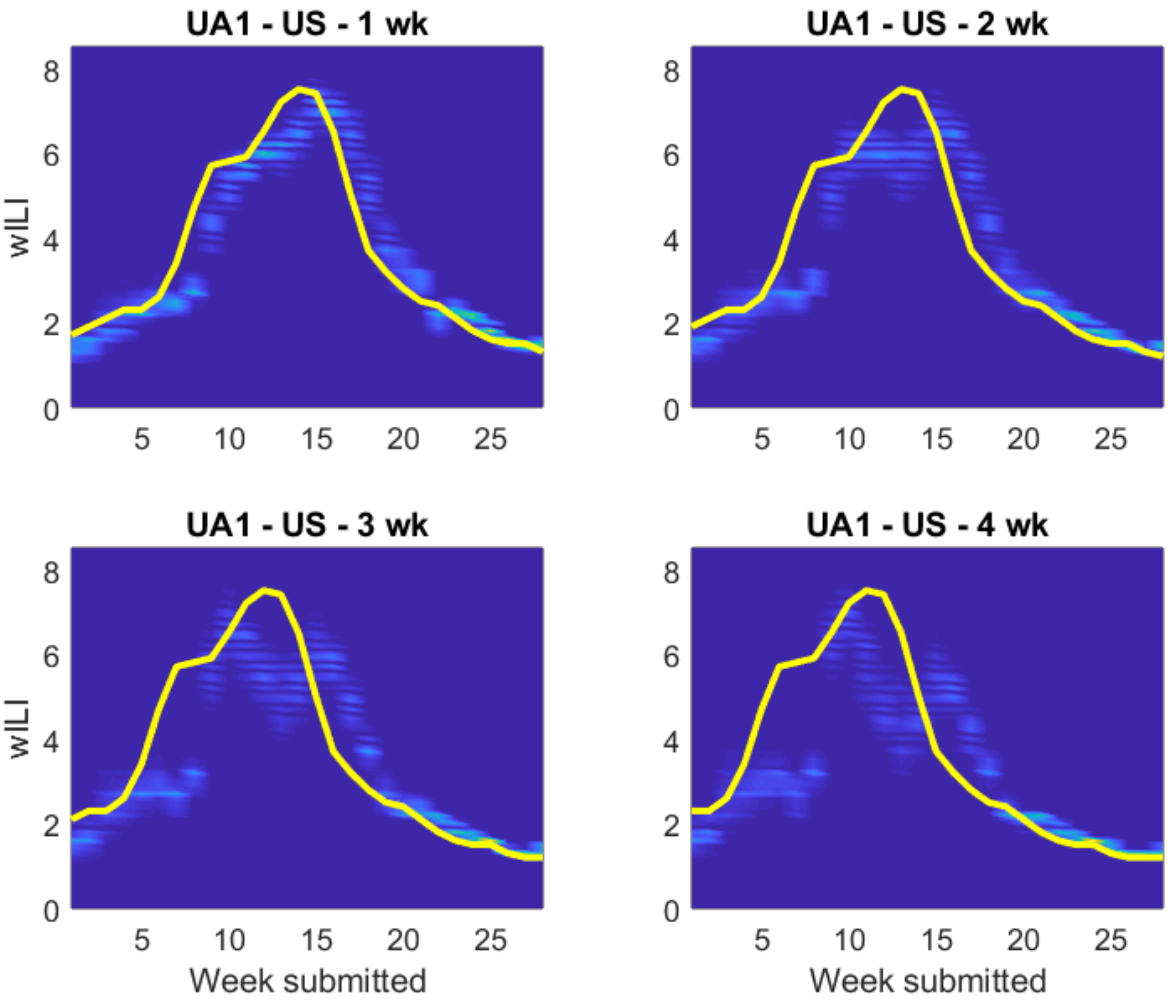
4 wk: -3.03

Onset: -0.99

Peak: -3.10

Peak wk: -2.53

UA I Results



US Scores:

1 wk: -1.94

2 wk: -2.48

3 wk: -3.21

4 wk: -3.57

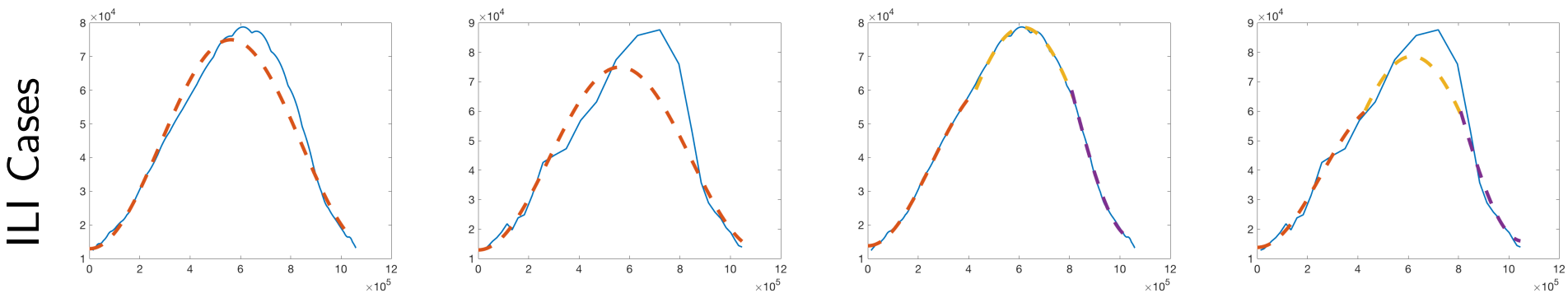
Onset: -0.48

Peak: -4.56

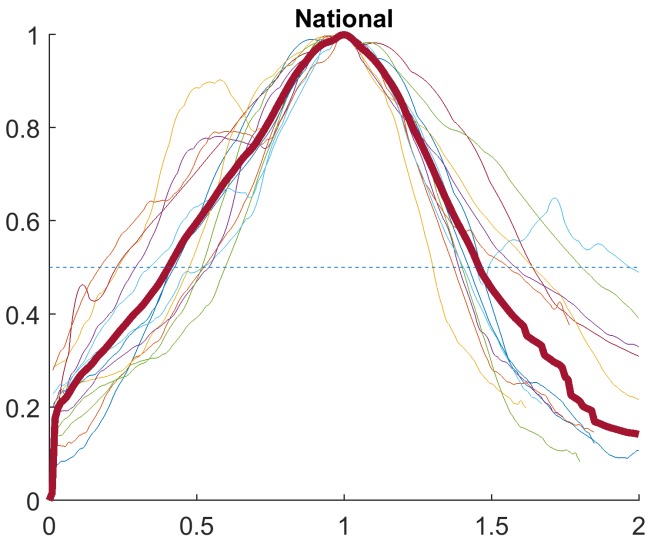
Peak wk: -1.56

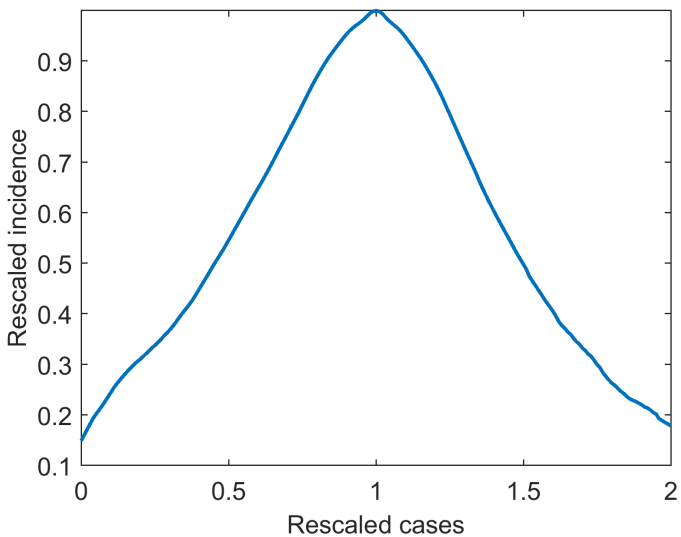
Discussion

- Errors and problems
  - Near the beginning of the season, failed to predict severity of influenza this year (peak percent)
  - Shape of model curve failed to match the data this year
- Things to try next year
  - Fit model to ILI incidence data and then convert predictions into predictions of wILI
  - Use data assimilation techniques to fit model parameters



EpiFlu matches the data to an incidence/cumulative cases curve estimated from previous flu seasons





Left: Incidence as a function of cumulative cases for 13 flu seasons where each curve is such that $G_i \rightarrow G_i / \max(G_i)$ and $C_i \rightarrow C_i / L$, where $L =< C_i^* >$ and $G(C_i^*) = \max(G_i)$.
Right: A single rescaled incidence/cumulative cases "GC-curve" is obtained by averaging over regional and national historical data.

Back