Modeling Apple Tree Bud burst time and frost risk in Iran

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Weather and Climate-Related Hazards

- Hail
- Avalanches
- Flash floods
- Tornadoes
- Wildland fires & haze
- Mud & landslides
- Ice Storms
- Dust storms
- Storm (winds)
- Storm surges
- Heavy precipitations (rain or snow)
- River basin flooding
- Heat wave - Frost
- Droughts

- Lightning
- Wildland fires
- Mud & landslides
- Tornadoes
- Avalanches
- Flash floods
- Hail
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- Storm (winds)
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- Lightning
Nearly 90% of disasters are related to hydro-meteorological hazards.
Percent of damage on Agriculture products 2002-2007
We cannot avoid hazards
…but we can Prevent Them from Becoming Disasters

Source: World Resources Institute
Components of Disaster Risk Management

\[ \text{RISK} = f(\text{Hazard}, \text{Vulnerability}, \text{Exposure}) \]
Frost Damage Risk (FDR)

\[ FDR = f(\text{Frost occurrence, Vulnerability, Exposure}) \]
**Frost Occurrence**: Probability of Frost occurrences

**Vulnerability**: susceptibility of plant to losses

**Exposure**: How much is a plant in the exposure of Frost
Components of Frost Risk Management

- Severity
- Duration
- Frequency—probabilities
- Spatial extent
- etc

Frost Occurrence
Components of Frost Risk Management

- Crop growth
- Canopy volume
- Phenological Phase
- Land use practices
- Place of plants
- Local Topography
- Plant nutrition
- etc
Components of Frost Risk Management

- Protection Methods
- Harvesting time
- Early warning Time
- Accuracy of forecasting
- etc
Integration of Components
Quantifying Climatologically Frost Damage Risk
Geographical Classification
Effective parameters on frost damage risk

✓ Climatological parameters
✓ Geographical Parameters
✓ Plant characteristics
Climatological parameters

- Minimum Air Temperature
- Wind
- Cloudiness
- Frost Duration
- Decreasing rate of temperature before frost
- Increasing rate of temperature after frost
Gepgraphical Parameters

- Elevation
- Longitude
- latitude
- Aspect and Slope
- Day Length
- Distance from sea
Plant Characteristics and farm management

✓ Plant and variety
✓ Date of Sowing
✓ Phenological phase
✓ Place of farm
✓ Method of protecting against frost
Frost Damage Risk Assessment

- Geographical Parameters
- Climatologically parameters
- Plant Characteristics and farm management

Frost Damage Risk Assessment
Frost Damage Risk Map
MODELING APPLE TREE BUD BURST TIME AND FROST RISK IN IRAN

Meteorological Science

Agricultural Science

Agricultural Meteorology

Decreasing frost damage
Importance of the study

• There are important agricultural regions in Northeast and Northwest of Iran, with late spring frosts causing a lot of damage on agricultural plants, especially fruit trees. Late spring frosts occur every year at the time of apple budding and cause a lot of financial losses to the growers.

• According to report of Iran agricultural Bank the loss of the last frost in spring of 2004 to apples in Iran has been estimated over 600 million US$. 
Concept

• The bud burst phase of orchard trees is the most critical phase in relation to low temperature and frost. Therefore, predicting the time of bud burst is very important. If a model can predict the time of budding, it would be possible to protect buds from late spring frosts.
Overview

- In this study the budding time of apple trees at two agrometeorological stations in Northeast and Northwest of Iran was predicted by using a chilling and forcing model. Data of years 2002 to 2006 was used to calibrate the bud burst prediction model and respective information from year 2007 to validate it. By comparing frost occurrence of 75% with the date of predicted bud burst, the regional hazard of frost damage on apple budding was estimated.
1) Frost occurrence probability

- Last spring frost dates, for several probabilities as derived using the Pearson type III distribution before and after a given date. The probability of frost occurrences on or after 30 March is 50% in Golmakan and 24 March in Kahriz, meaning that in 50% of years, the last spring frost occurs on or after 30 March in Golmakan and 24 March in Kahriz.
Probability paper fit with Pearson type III distribution for the late frosts of Golmakan station
Probability paper fit with Pearson type III distribution for the late frosts of Golmakan Kahriz
2) Calibration and Validation of bud burst prediction model

The minimum and maximum air temperatures along with phenological observations made on 16 apple trees at each station for the years of 2002, 2003, 2004, 2005, and 2006 were used to select suitable chill requirements (Cr) and threshold temperatures (Tc) for the model. The model was run for Tc from 5 to 8°C and Cr from -130 till -180 units.
chill ($C_D$) and anti-chill ($C_A$) accumulation from Leaf out to bud burst for year 2003 ($T_c=5$, $C_R=-150$) for Golmakan, year 2002 (as an example)
Calibration and Validation of bud burst prediction model (continue)

- The lowest RMSE for Kahriz (3.2 days) was found when \( T_c = 8 \) and \( CR = -150 \).

- The best combination for Golmakan (RMSE = 5 days) was identified when \( T_c = 5 \) and \( CR = -150 \).
3) Frost occurrences related to Predicted bud burst time

The modeled timings of bud burst in year 2008 were compared with the frost probability occurrences. For Golmakan, the probability of a late spring frost before 10 April 2008 is 70 % and for Kahriz, the probability of a late spring frost before 1 April 2008 is 75 % ). Because of the high risk probabilities, it is necessary for farmers and growers to apply appropriate means and methods/management to protect apple buds from frost damage
Last words

• This study is an example of how we can combine meteorology with agriculture to reduce damage of a disaster.
• We can do it for other natural disasters such as drought, land slide, earthquake
• We should talk about the damage risk of disasters with a mathematical language (quantifying them )
Thank you for your consideration