Improvement of late blight forecasting

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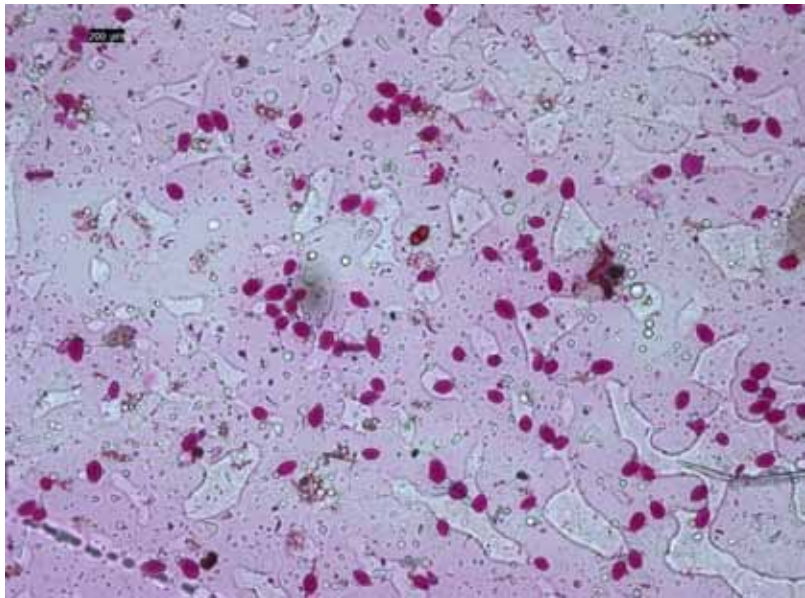
NORPHYT Field trial

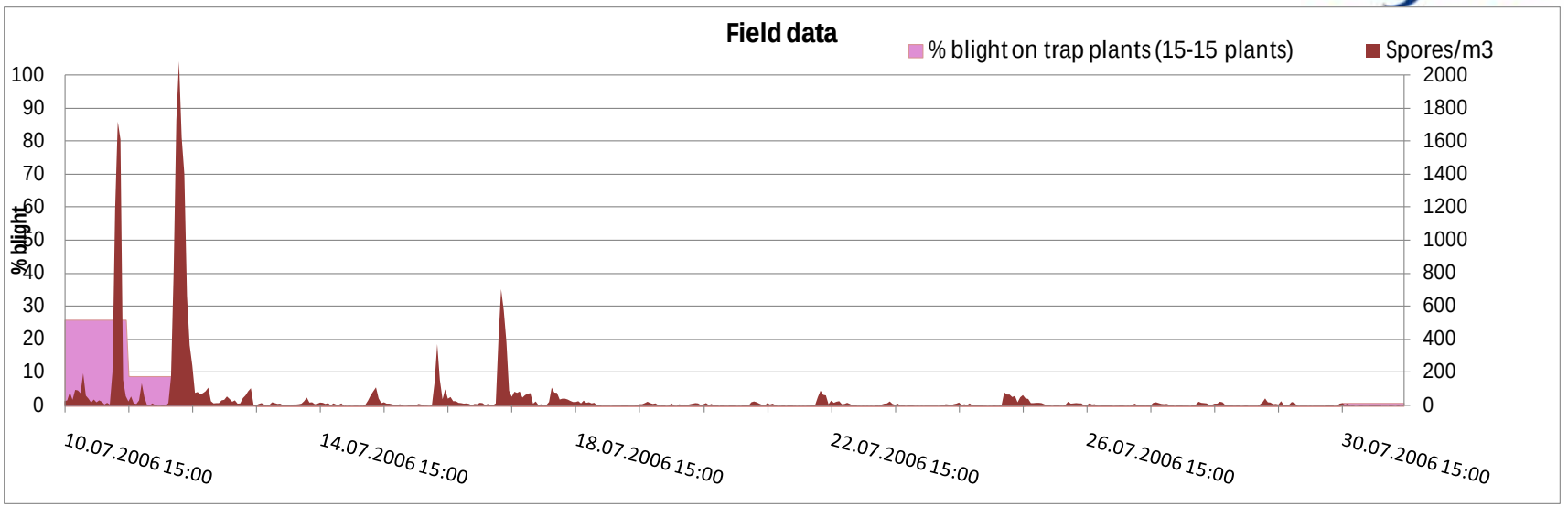
- **Field inoculated with late blight**
- **Spore trap**
- **Every day 4 plants were exposed from 8-15=> Incubated wet**
- **Every day 4 plants were exposed from 15-15 the following day=> Incubated dry**

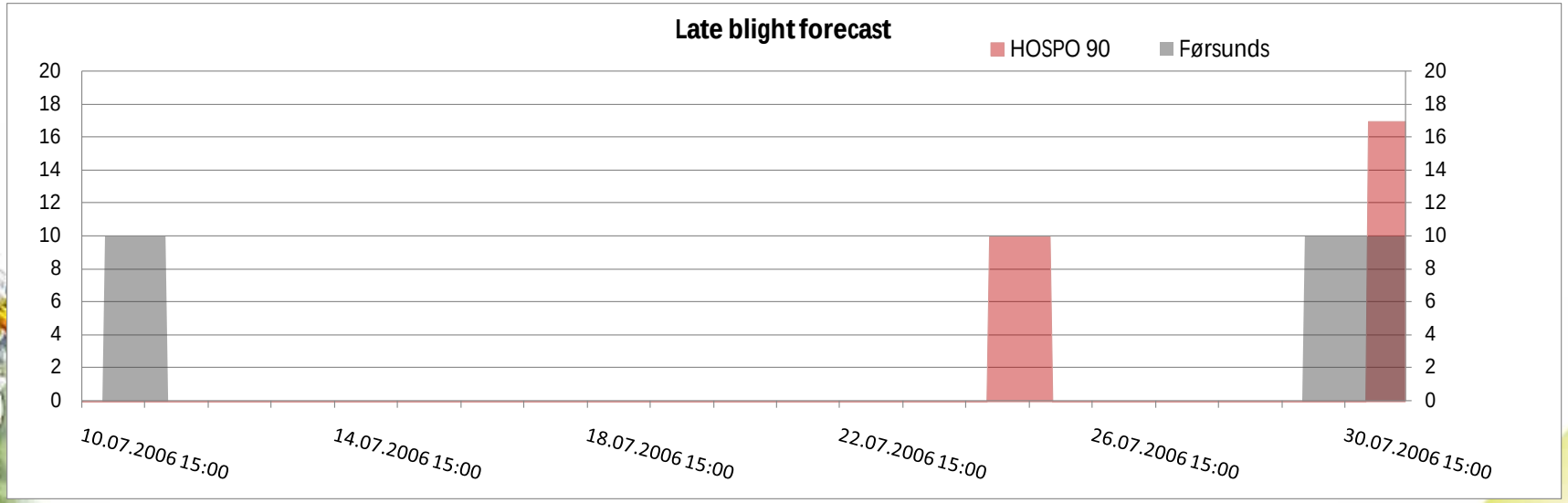
- **Weather data were recorded 1 kilometer from the field trial**

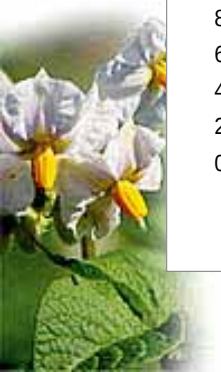
Spores were stained and counted



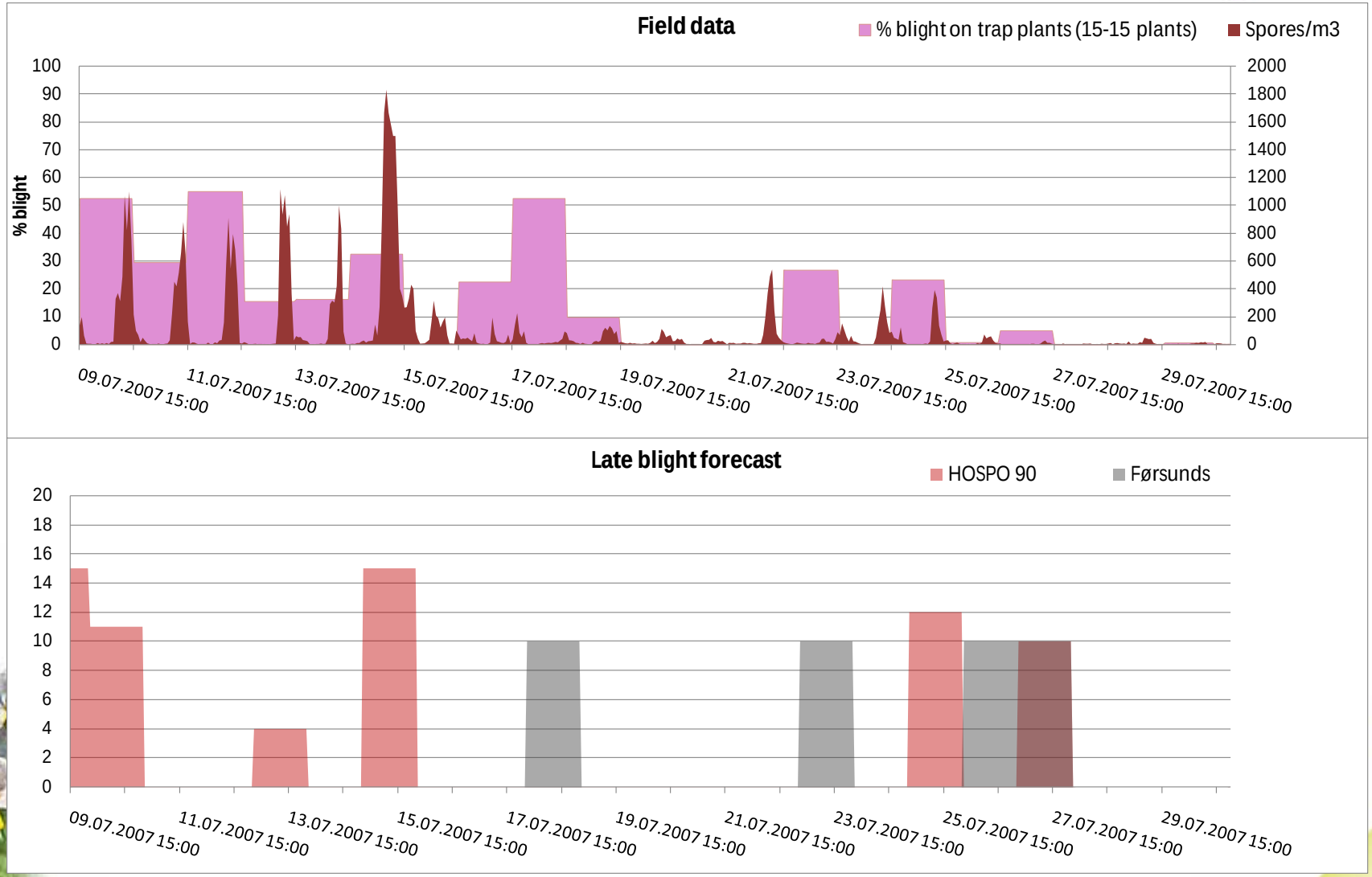
NORPHYT field trial in 2006



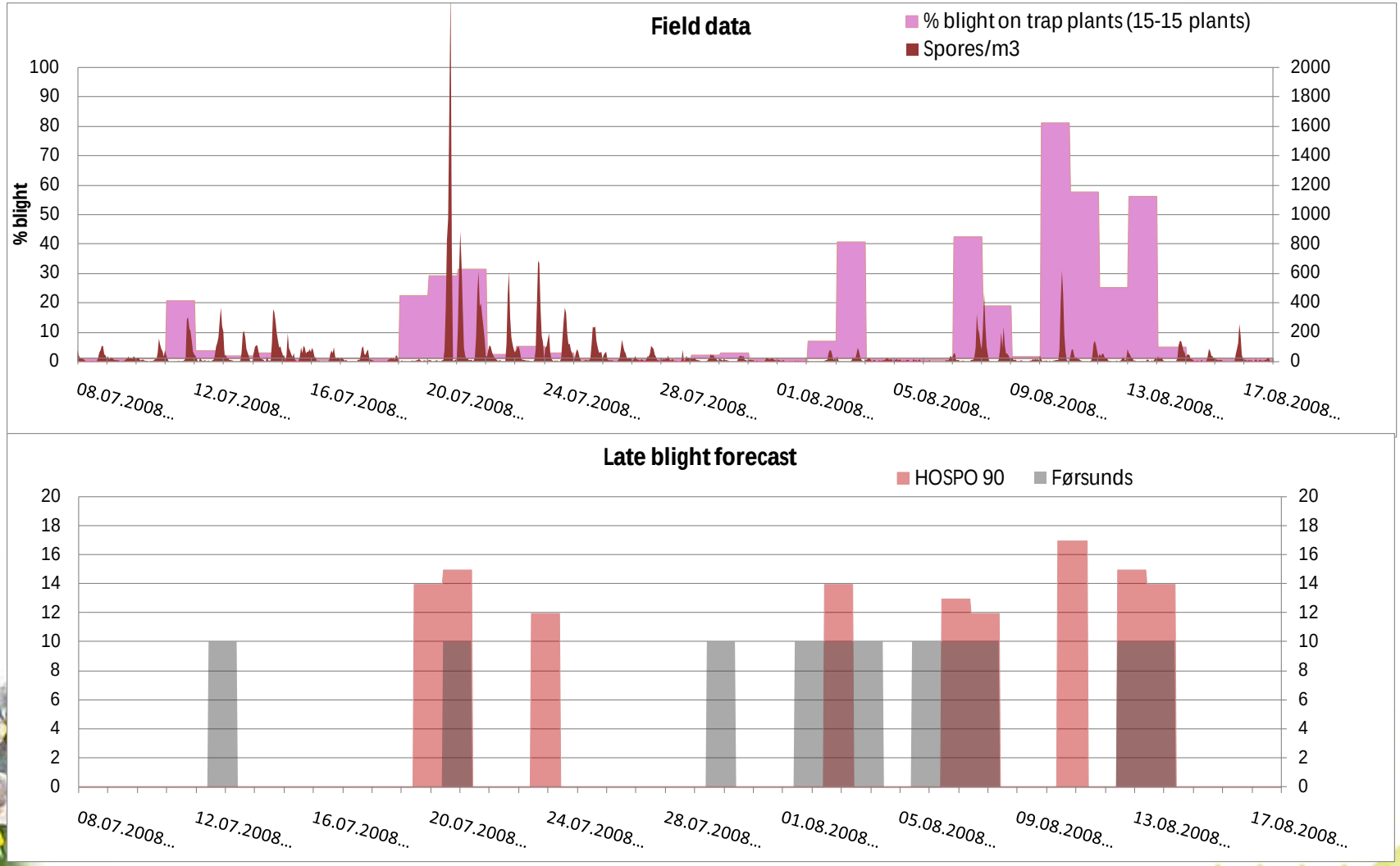




NORPHYT field trial in 2007



NORPHYT field trial in 2008



New Late Blight Model
Based on hourly weather data:

- **$T_{(t)}$ - Temperature at 2 m hourly mean *(TM)***
- **$RH_{(t)}$ - Relative humidity at 2 m hourly mean *(UM)***
- **$rain_{(t)}$ - rain in mm pr hour *(RR)***
- **$Qo_{(t)/}$ - short wave global radiation hourly mean in W/ m^2 *(Q0)***
- **$leafwetness_{(t)}$ - leaf wetness duration in minutes 2 m *(BT)***
- **WVD $_{(t)}$ - Water vapor deficiency hourly mean in Pa**
  = (Saturation $pressure_{(t)}$ - Partial $pressure_{(t)}$)/1000
- **Saturation $pressure_{(t)}$ - Saturation pressure in kPa**
  = 0.61078*EKSP(17.269* $T_{(t)}$ /($T_{(t)}$ +237.3))
- **Partial $pressure_{(t)}$ - Partial pressure in kPa**
  = $RH_{(t)}$ * Saturation pressure (in kPa) /100

Spore production

- ***Long humid periods are suitable for spore production, at moderate humidity the process goes slower.***
- **Humid hours 1: $HH1_{(t)}$=1 when $WVD_{(t)}$< 220 Pa, else set $HH1_{(t)}$=0.**
- **Humid hours 2: $HH2_{(t)}$=1 when $WVD_{(t)}$< 520 Pa, else set $HH2_{(t)}$=0.**
- **Temperature sum Humid Hours: $TSHH_{(t)}= HH2_{(t)}*((HH1_{(t)}*T_{(t)})+ TSHH_{(t-1)})$ when $HH1_{(t)}$=1, $TSHH_{(t)}= HH2_{(t)}*0,75*TSHH_{(t-1)}$ when $HH1_{(t)}$=0**
- **Spore producing hour: $SPH_{(t)}$= 1 when $TSHH_{(t)}$ > =80 else $SPH_{(t)}$ =0.**

- ***The amount of viable attached sporangia is increased during spore production hours and reduced by drought, and some spores are washed off during rain.***
- **Viable attached spore: $VAS_{(t)}=((VAS_{(t-1)}*0,975*(1-((WVD_{(t)}- 220)/6000)))+ SPH_{(t)})/(1+(rain_{(t)}*0,1))$**

Spore release

- ***The spores are released into the air by a drop in the humidity or increased radiation, but the release is inhibited at high leaf wetness.***
- **Increased radiation: $RAD_{(t)}$=1 when $Qo_{(t)}$-$Qo_{(t-1)}$>2, else set $RAD_{(t)}$=0.**
- **Drop: $DROP_{(t)}$= 1 when $WVD_{(t)}$-$WVD_{(t-1)}$>=12, else set $DROP_{(t)}$=0**
- **Release to air: $RTA_{(t)}$ =$RAD_{(1)}$+$DROP_{(t)}$**
- **Inhibition of release to air: $IRTA_{(t)}$= 1-(leafwetness$_{(t)}$)/65)**

- ***The amount of viable released spores is strongly inhibited by solar radiation. The spore load is also reduced by precipitation and by germination.***
- **Survival factor of released spores : $SFRS_{(t)}$=(1-($Qo_{(t)}$-270)/540)/1,5**
- **Viable released spores: $VRS_{(t)}$ = (((($VAS_{(t)}$*$RTA_{(t)}$* $IRTA_{(t)}$*$SFRS_{(t)}$)+ ($VRS_{(t-1)}$*0,9 *$SFRS_{(t)}$))/(1+(rain$_{(t)}$*0,1)))/(1+($TSWH_{(t-1)}$*0,01))**

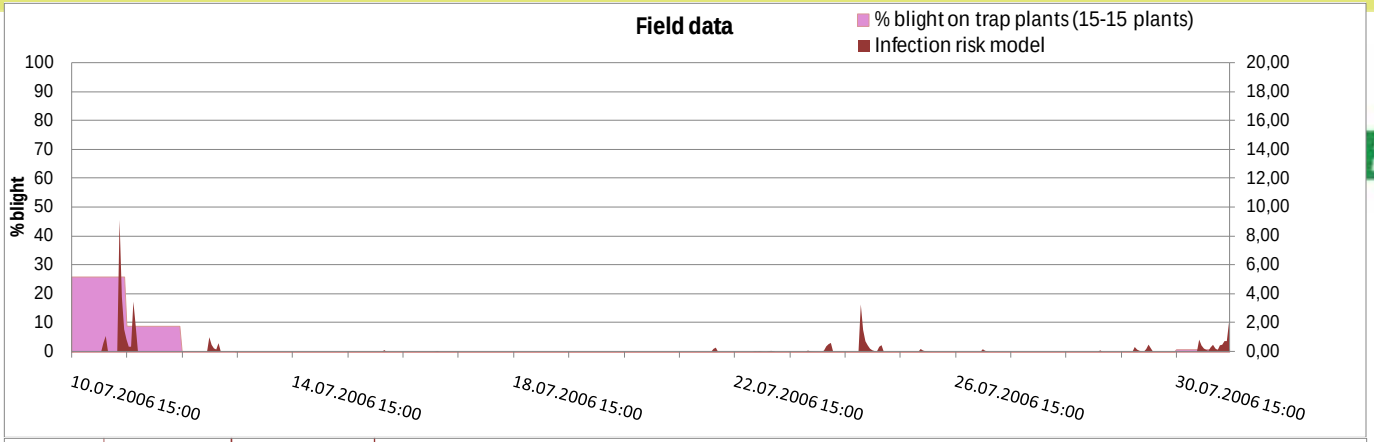
Infection

- **The leaf wetness duration have to be sufficient for the spores to germinate and infect.**
- **Wetness starts: $WHS_{(t)}$=1 when $rain_{(t)}$>0,1 mm or (($WVD_{(t-1)}$+$WVD_{(t)}$)< 180 Pa or $leafwetness_{(t)}$> 42 minutes or $leafwetness_{(t-2)}$+ $leafwetness_{(t-1)}$ + $leafwetness_{(t)}$> 122 minutes), else set $WHS_{(t)}$=0**
- **Wetness continuation: $WHC_{(t)}$=1 when ($WVD_{(t)}$< 405 Pa) , else set $WHC_{(t)}$=0**
- **Wetness duration: $WD_{(t)}=WHE_{(t)}*(WD_{(t-1)}+WHS_{(t)})$**
- **Wet hours: $WH_{(t)}$=1 when $WD_{(t)}$>0, else set $WH_{(t)}$=0**
- **Temperature sum Wet Hours: $TSWH_{(t)}= (WH_{(t)}*(T_{(t)} + WH_{(t+1)}*(T_{(t+1)} + WH_{(t+2)}*(T_{(t+2)} + WH_{(t+3)}*(T_{(t+3)} + WH_{(t+4)}*(T_{(t+4)})))))$ when $WHS_{(t)}$=1, else set $TSWH_{(t)}$=0**
- **Infection risk: $IR_{(t)}$=1 when $TSWH_{(t)}$>40 else set $IR_{(t)}$=0**

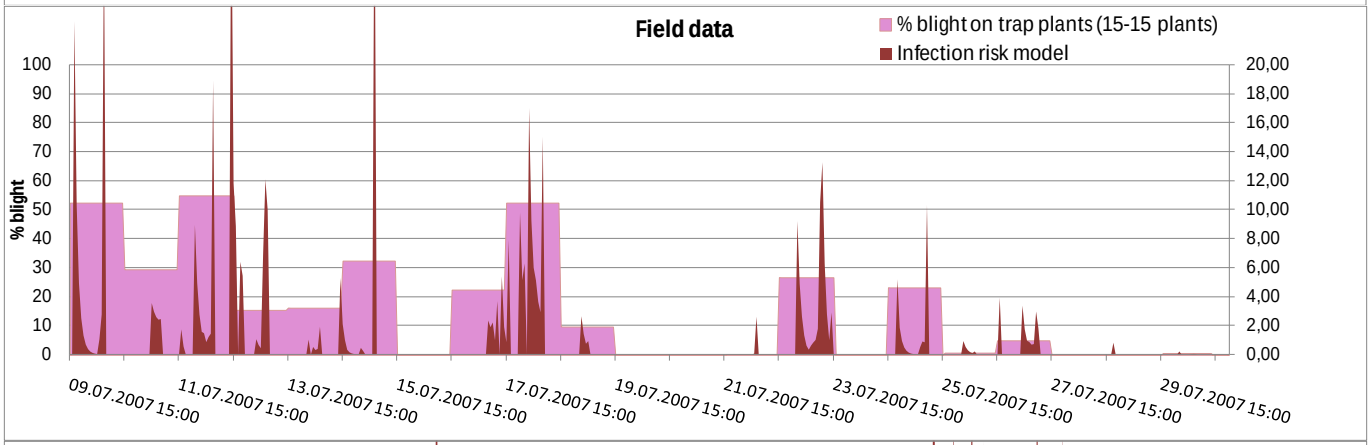
The blight risk

- ***The risk of blight development is a function of the amount of viable released spores and the duration of the leaf wetness.***
- **Risk of late blight infections:** $RISK_{(t)} = TSWH_{(t)} * VRS_{(t)} * IR_{(t+2)}$
- **When** $RISK_{(t)} < 1$ **low risk**
- **When** $RISK_{(t)}$ **between 1 – 2,5 moderat risk**
- **When** $RISK_{(t)} > 2,5$ **high risk**

2006



2007



2008