Integrating crop growth simulation and remote sensing: some recent experiences

Herman van Keulen

Plant Research International

and

Group Plant Production Systems

Presentation largely based on:

Integrating crop growth simulation and remote sensing to improve resource use efficiency in farming systems

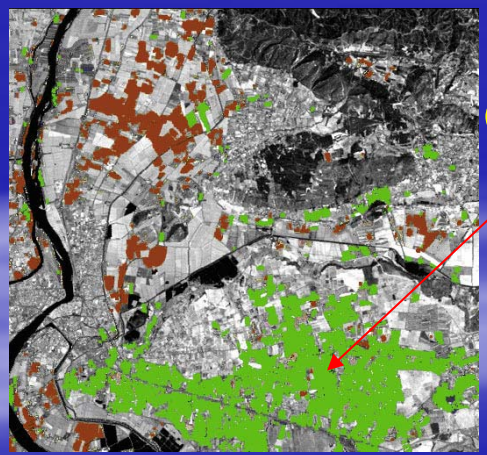
Raymond Jongschaap

AN EXPERIENCE

Predicting wheat production at regional scale by integration of remote sensing data with a simulation model

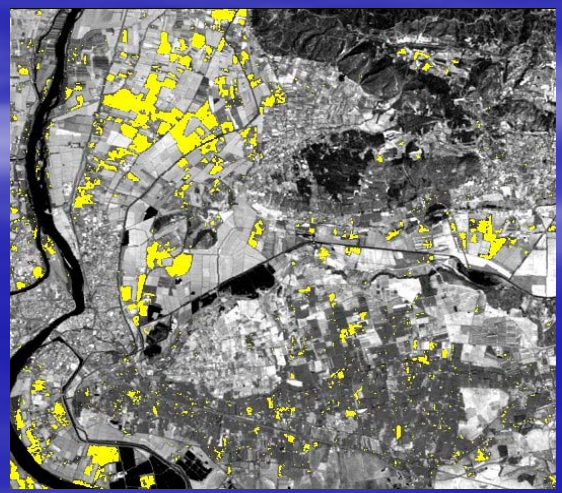
METHODOLOGY

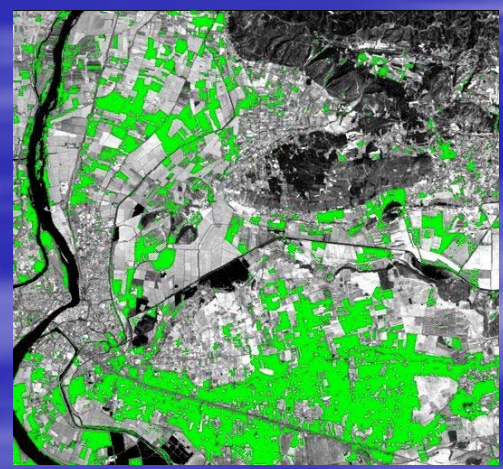
1. Optical remote sensing data (SPOT HRV XS and Landsat 5 TM) to **locate** winter wheat crops in the region



GRASS

WHEAT



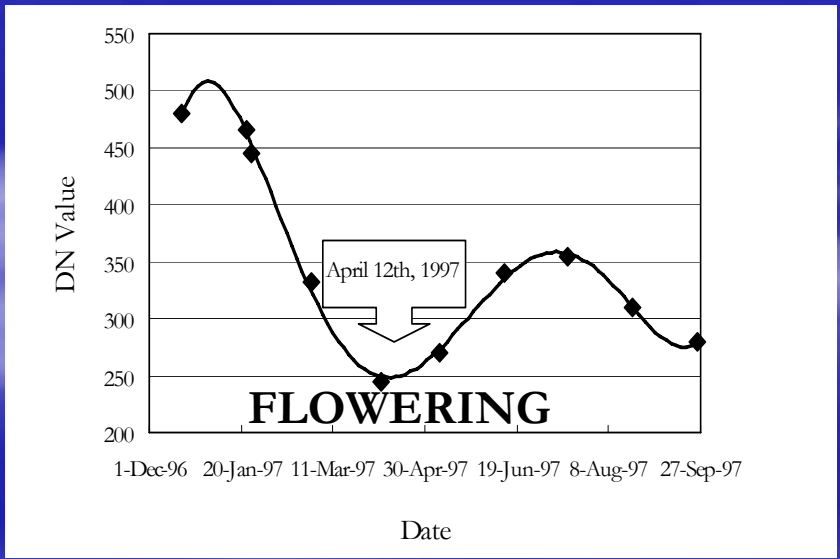


GREEN IN LATE SUMMER - NDVI

GREEN IN WINTER - NDVI

METHODOLOGY

2. Radar remote sensing data (ERS-SAR C-band) to determine wheat flowering dates for the region



RADAR SIGNALS IN TIME

MOISTURE IN GROWING CROP 'MASKS' RADAR SIGNAL FROM SOIL

DURING RIPENING RADAR SIGNAL OF SOIL RE-APPEARS

METHODOLOGY

3. Field observations from pilot areas to calibrate a wheat growth model to local conditions

4. Flowering dates combined with regional soil data to extrapolate the simulation model from a point-based to a regional application

METHODOLOGY

5. **Potential and sub-optimal conditions for wheat growth are assumed to determine the yield gap, the difference between (simulated) potential and (simulated and observed) actual production**

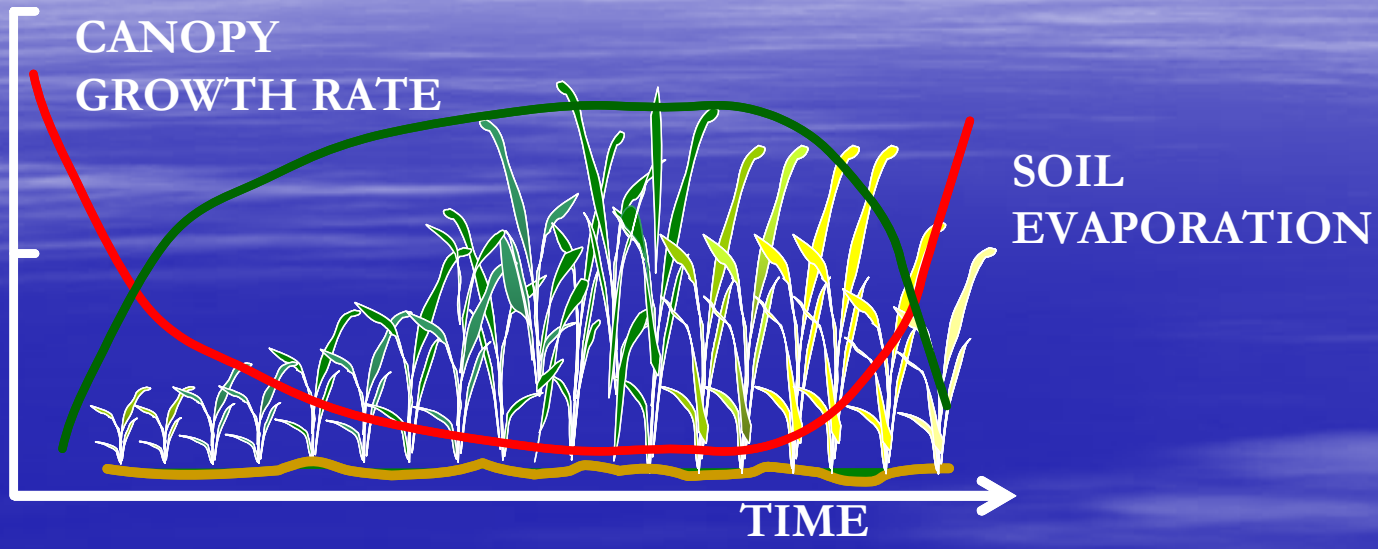
Scenario	Soil type	Area (ha)	Yield (t ha^{-1})	Production (P) (t)	Regional production (t)
1 Potential	-	3000	11.35 (1.02)	34050	34050
2 Water-limited	1	2700	6.08 (0.51)	16416	17997
	2	300	5.27 (0.39)	1581	
3 Water- and nitrogen-limited	1	2700	4.70 (0.28)	12690	13947
	2	300	4.19 (0.21)	1257	

METHODOLOGY

6. Actual **production statistics** from the production region are used to **evaluate** simulation results.

Department	Region	Total Production	Area	Yield	SIMULATED
		(t)	(ha)	(t ha^{-1})	SOIL1/SOIL2
82	*Midi-Pyrénées* (*MP*)	540600	104400	5.18	5.84/5.02
83	*Provence Alpes-Côte d'Azur* (*PAC*)	518500	98100	5.29	4.53/4.05

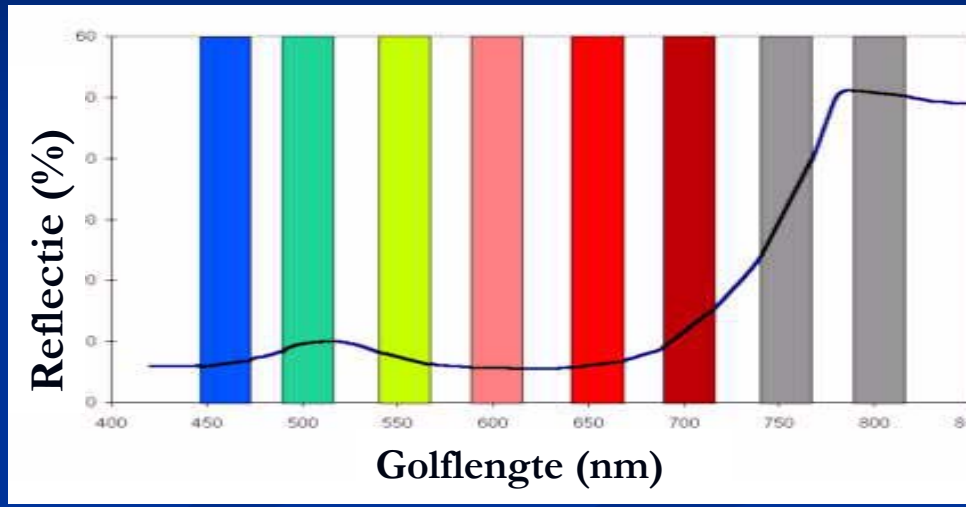
ANOTHER EXPERIENCE



Run-time calibration of simulation models by integrating remote sensing estimates of leaf area index and canopy nitrogen

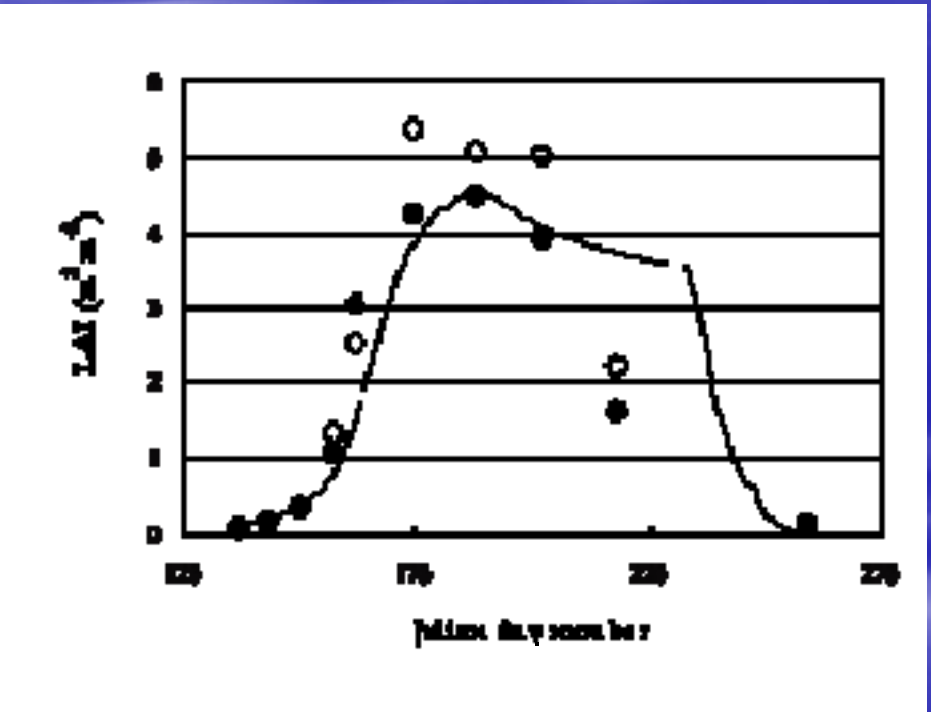
TRANSLATION

- Relation between sensor-information and important vegetation characteristics

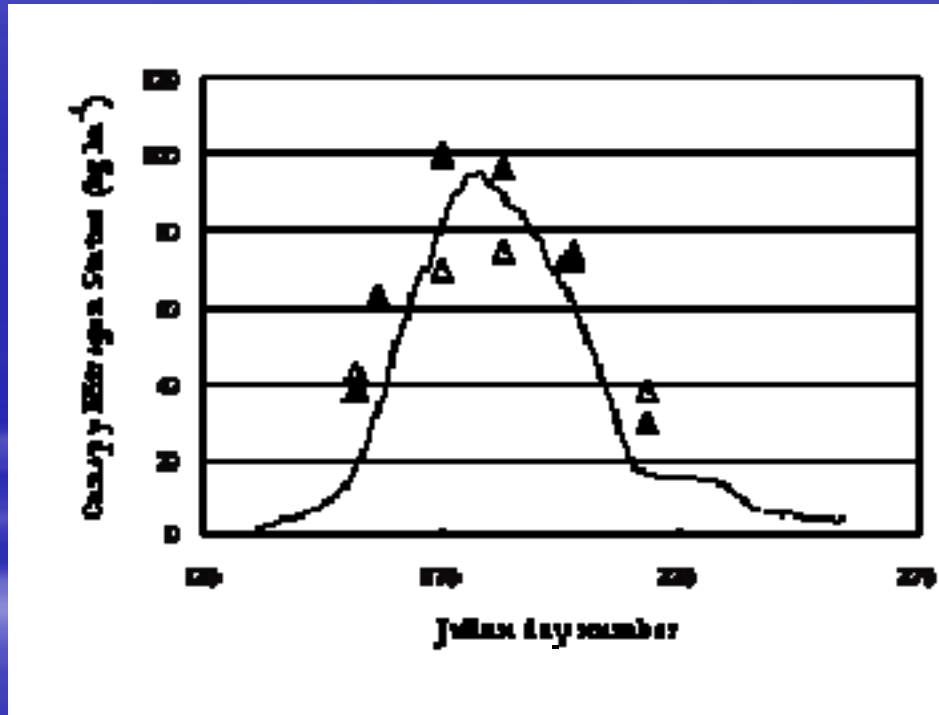


Vegetation Index	Crop characteristic
NDVI	Green plant material
WDVI	Leaf area (index)
λREP	Chlorophyll/Nitrogen content

CROP CHARACTERISTICS
OBSERVATIONS/BASE RUN



SIMULATED AND MEASURED LAI



SIMULATED AND MEASURED CANOPY NITROGEN

RESETTING SIMULATION VALUES

THE SMALLER THE BETTER

ROOT MEAN SQUARE ERROR

Scenario	Integration[a)]				Leaf area index		Canopy nitrogen		Soil inorganic nitrogen	
	LAI	*Ncan*	*%*	*Sn*	*(n=40)*		*(n=34)*		*(n=27)*	
0	-	-	-	-	*0.84*	*(100)*	*13.7*	*(100)*	*30.4*	*(100)*
1	+	-	-	-	0.61	(73)	12.2	(89)	24.1	(79)
2	-	+	-	-	0.86	(102)	12.0	(88)	33.3	(110)
3	+	+	-	-	0.61	(73)	12.0	(88)	26.0	(86)
4	+	-	-	+	0.61	(73)	12.2	(89)	24.2	(80)
5	-	+	-	+	0.85	(101)	12.0	(88)	34.7	(114)
6	+	+	-	+	0.61	(73)	12.0	(88)	29.3	(96)
7	+	-	+	-	0.61	(73)	12.7	(93)	23.3	(77)
8	-	+	+	-	0.85	(101)	12.0	(88)	33.3	(110)
9	+	+	+	-	0.61	(73)	12.0	(88)	24.9	(82)
10	+	-	+	+	0.61	(73)	12.7	(93)	23.3	(77)
11	-	+	+	+	0.85	(101)	12.0	(88)	34.7	(114)
12	+	+	+	+	0.61	(73)	12.0	(88)	28.9	(95)

BASE RUN

INTERNAL ADJUSTMENT MODEL

CONCLUSION

introduction of field-based remote sensing observations for run-time adjustment of dynamic crop growth simulation models enhances simulation accuracy of important variables (such as LAI, canopy nitrogen status and soil inorganic nitrogen content)

HOWEVER…..

ACQUISITION OF SUCH INFORMATION IS

TIME-CONSUMING

LABORIOUS

UNCERTAIN

WE MOVE FORWARD, BUT SLOWLY…