Interoperable platform of agricultural decision support

WG5 AGRICULTURE AND FOOD SECURITY
GEOSS TOKYO
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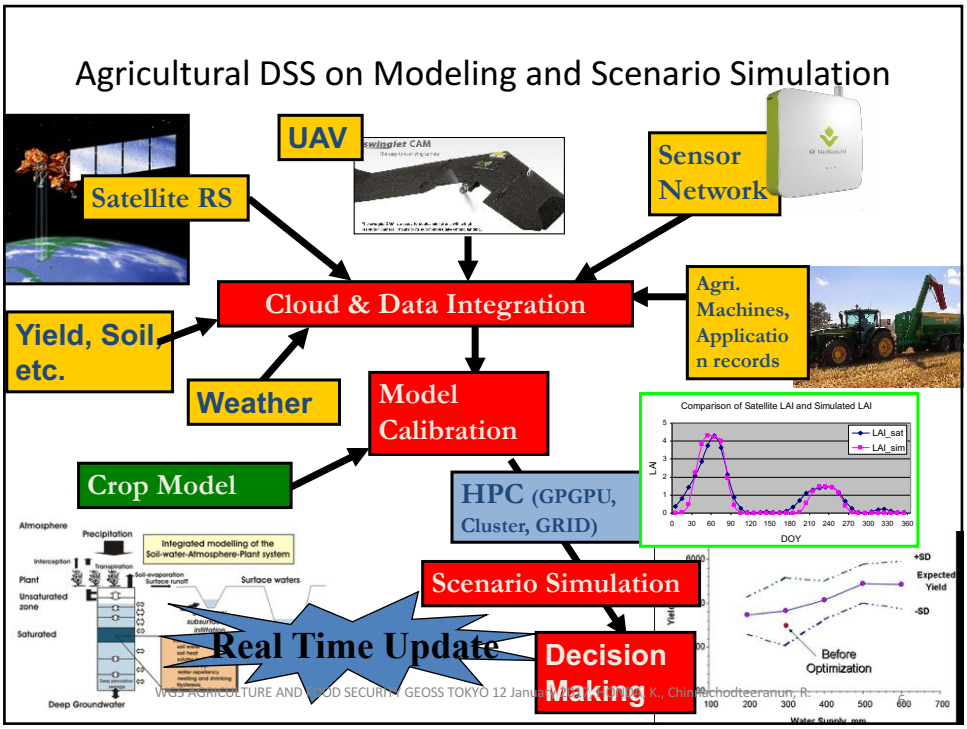
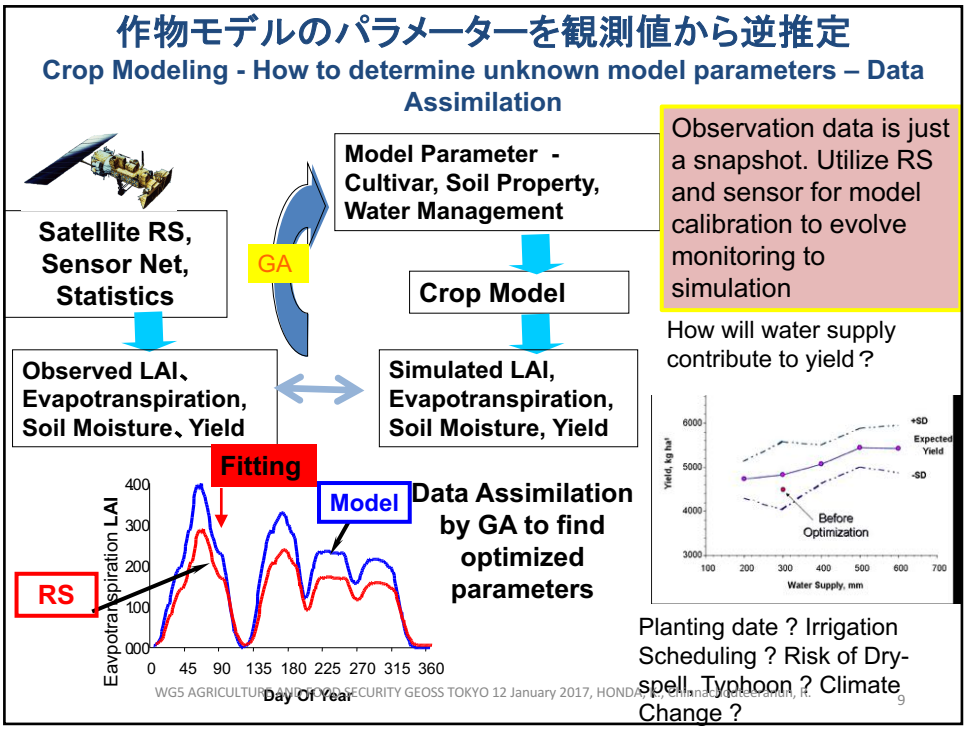
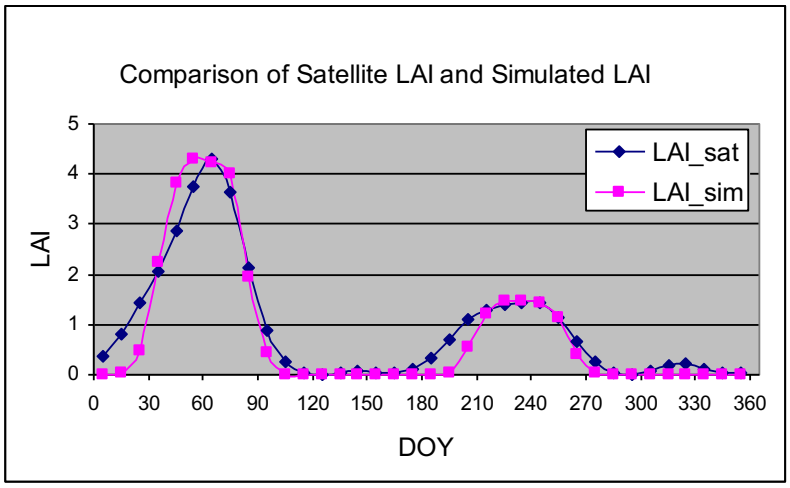
HONDA Kiyoshi, Rassarin Chinncachodteeranun
Chubu University

Contents

- Framework of DSS
  - Sensing and Modeling
  - Uncertainty
- Interoperable Platform with Web Services
  - Interoperable data infrastructure
  - Agro-Web Services (Web API)


Agricultural DSS on Modeling and Scenario Simulation
Satellite RS
UAV
Sensor Network
Cloud & Data Integration
Agri. Machines, Application records
Yield, Soil, etc.
Weather
Model Calibration
Crop Model
HPC (GPGPU, Cluster, GRID)
Scenario Simulation
Real Time Update
Decision Making
Comparison of Satellite LAI and Simulated LAI
LAI_sat
LAI_sim
LAI
DOY
Integrated modeling of the Soil-water-Atmosphere-Plant system
Atmosphere
Precipitation
Plant
Unsaturated zone
Saturated
Surface waters
Deep Groundwater
+SD
Expected Yield
-SD
Before Optimization
Water Supply, mm


作物モデルのパラメーターを観測値から逆推定
Crop Modeling - How to determine unknown model parameters – Data Assimilation
Satellite RS, Sensor Net, Statistics
GA
Model Parameter - Cultivar, Soil Property, Water Management
Crop Model
Observed LAI、Evapotranspiration, Soil Moisture、Yield
Simulated LAI, Evapotranspiration, Soil Moisture, Yield
Observation data is just a snapshot. Utilize RS and sensor for model calibration to evolve monitoring to simulation
How will water supply contribute to yield？
Fitting
Model
RS
Data Assimilation by GA to find optimized parameters
Eavpotranspiration LAI
Day Of Year
+SD
Expected Yield
-SD
Before Optimization
Water Supply, mm
Planting date ? Irrigation Scheduling ? Risk of Dry-spell, Typhoon ? Climate Change ?



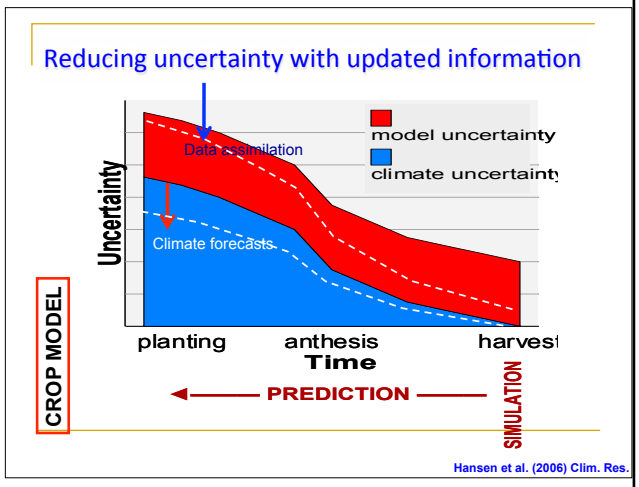
- Estimated parameters
- DOYCrop1 = 19
- DOYCrop2 = 188
- Crop.Int.Crop2 = 0.32
- Fitness = 4.537
- Generation found = 31 (popsize=5)
- Calculation time approximate 15 minutes

Uncertainty

- Simulating for one cropping season.
  - Ok, parameters fixed, then can predict the yield ?
- Weather ?
  - Use normal (average of weather variables of a day for year) ?
  - Probability to have exact normal weather ?
  - Climate Change Impact, use GCM output ? 100km average weather variables ?
- Model and its parameters ?
  - Can simulate 100% exact ?
  - Are the model parameters exact ?

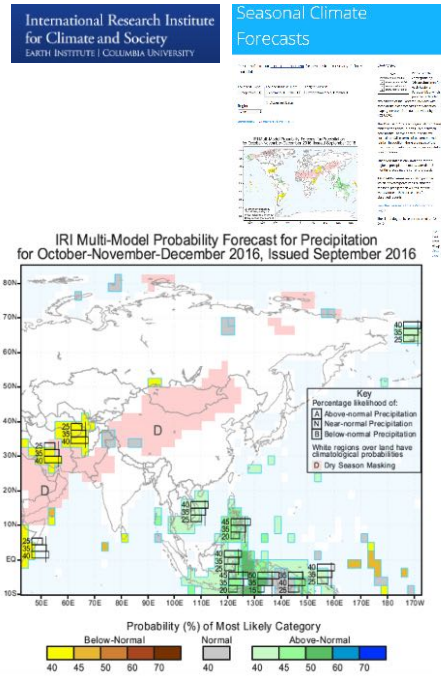
不確実性とどのようにつきあうか
How to Reduce Uncertainty in Prediction

- Big Uncertainty in Weather
  - 100 of Weather Scenarios
  - Yield as a Distribution
  - Field Sensor Network
  - Climate Forecasts
- Uncertainty in Model
  - Real-time Data Assimilation

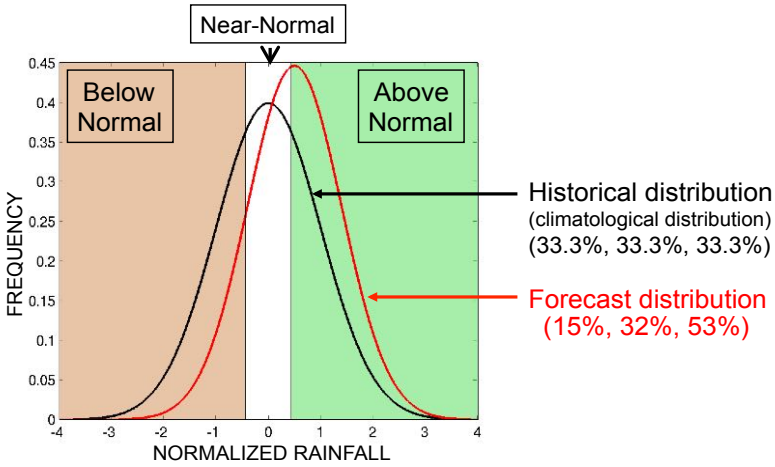


Seasonal Forecast

- Published as the probability of AN,NN,BN
- If no anomaly is expected, then 33:33:33
- This AN,NN,BN is used to adjust the probability density function(pdf)



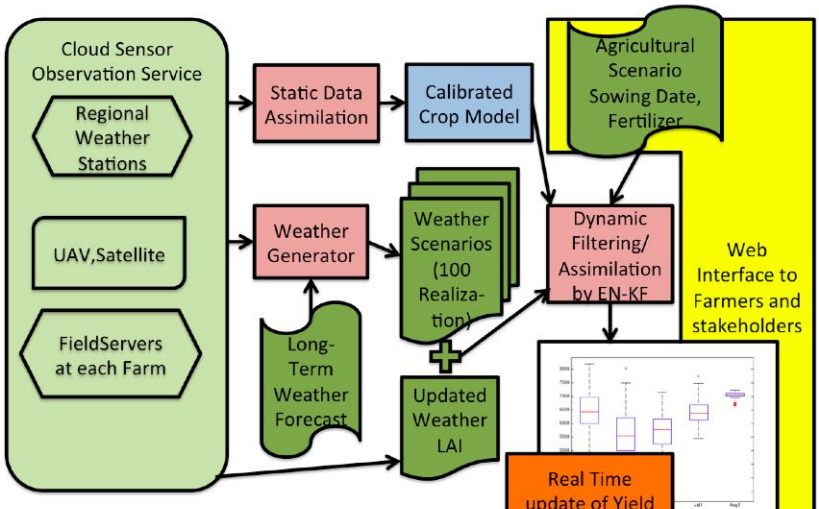
Seasonal Climate Forecast



The concept of probabilistic seasonal climate forecast (*Courtesy of: Michael Tippett, Columbia University, NY*)

Courtesy: A novel approach for downscaling probabilistic seasonal climate forecasts: parametric or non-parametric, A.V.M Ines and E.Han

A Framework of DSS System



- Integrated data (RS, UAV, Field Sensor/Obs.) for Assimilation
- Reducing uncertainty as time passes through by weather and data assimilation
- Up-to-date prediction as probability distribution and filtering
- Standard Web Services and Web Interface for information service

Tomorrow's Crop

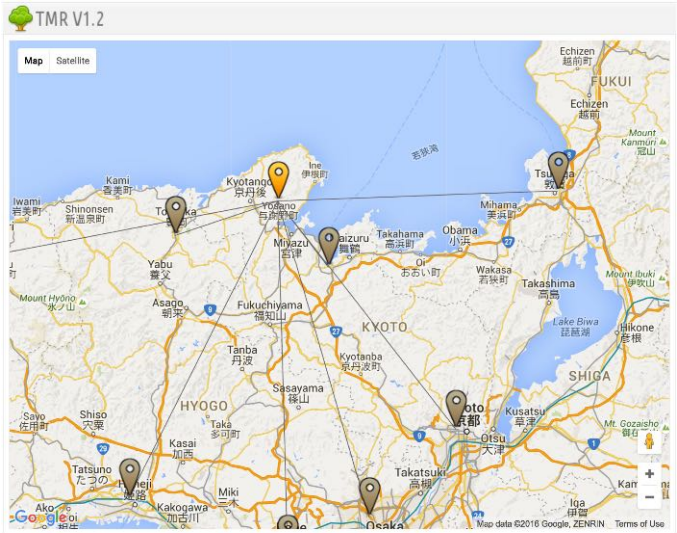
Tomorrow's Crop (TMC) is an on-line tool based on DSSAT crop simulation systems. Users can see how planting date influences yield as probability distributions that are based on 100 of possible weather scenarios generated from historical weather data. Currently, it has two components, which are Tomorrow's Rice (TMR) and Tomorrow's Wheat (TMW).

- TMR collects the historical weather data from IRI, Columbia University (daily minimum temperature, maximum temperatures and rainfall) and NASA (daily solar radiation). TMR also estimate the impact of climate change by applying World Bank's climate change data set.
- TMW collects the historical weather data from CloudSense via OGC's SOS(Sensor Observation Service). The original data source is NIAES's agro-weather data derived by model calculation from AMeDAS data. Currently only Memuro and Obihiro data is provided. The cultivar parameters of Kitahonami variety was calibrated against yield and field observation by a research project between Chubu University and IHI Corporation.

Visit (TMR | TMW).

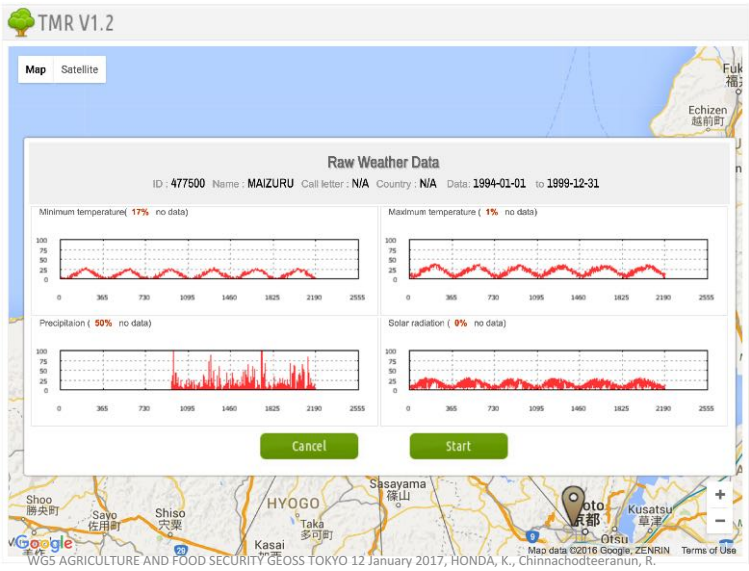
20

Where is your farm ?

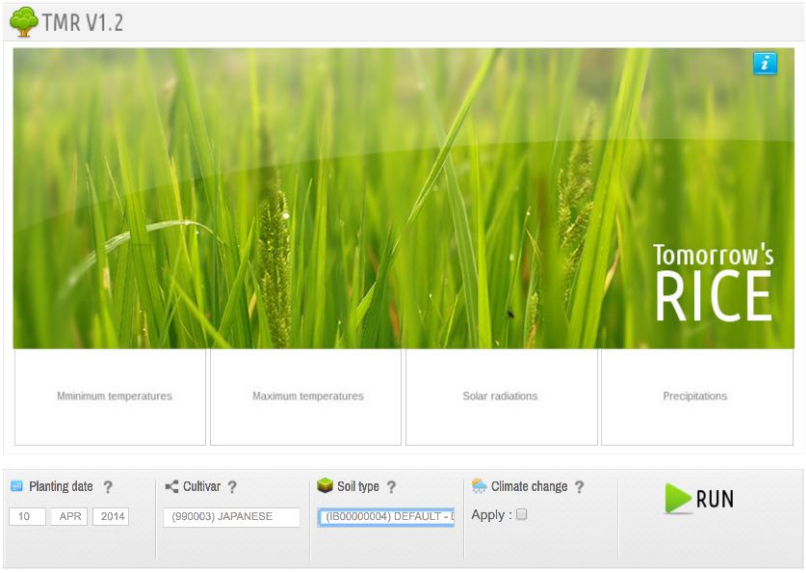


About TMR V1.2 Project | Help | Contact us

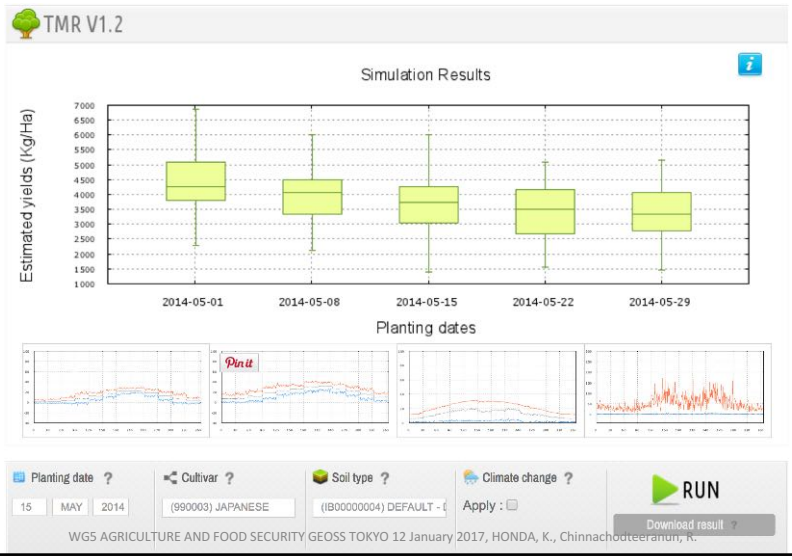
Check the historical weather data



Date ? Cultivar ? Soil Type ?

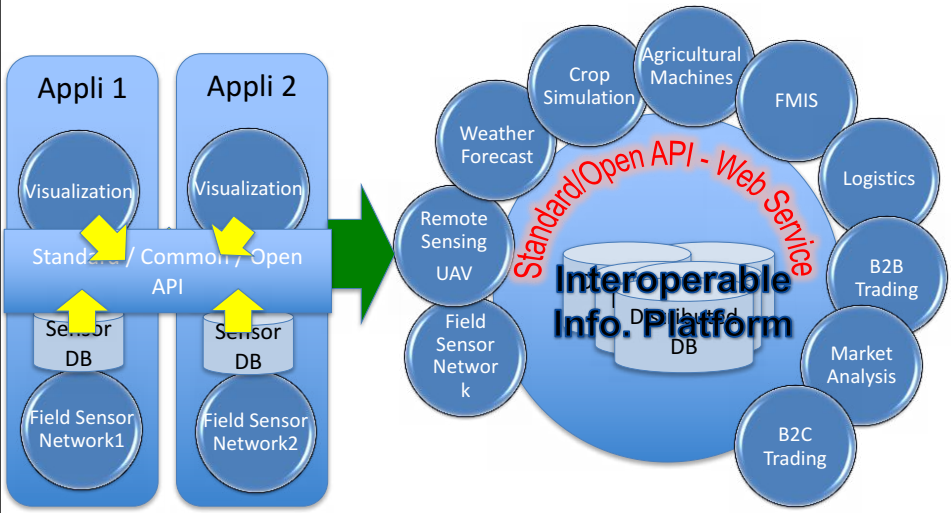


3 Apr is the best, then gradually reduces. In May 20% lower yield



Interoperable Platform with Web Services

Isolated System to Interoperable Integrated System



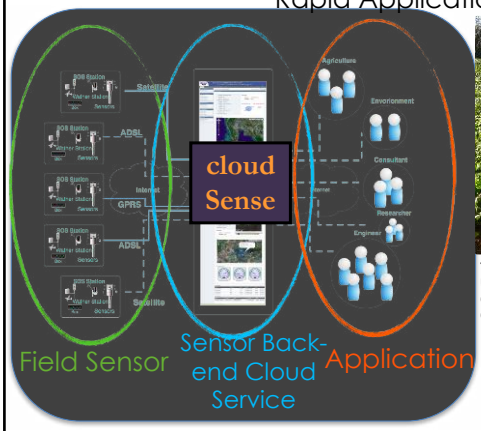
Standard Web API for Geospatial Data

- OGC's standard Web Service
  - WMS (Web Map Service), WCS (Web Coverage Service)
  - WFS (Web Feature Service), WPS (Web Processing Service)
  - SOS (Sensor Observation Service)
- Providing sensor metadata and data
  - Applications can find sensors, metadata, and data
  - 3 major queries
    - GetCapabilities -> platforms, observed properties…
    - DescribeSensor -> SensorML
    - GetObservation -> O&M doc

クラウドでセンサーの共通処理を提供

Cloud Based Sensor Back-end Service

Data Collection with Sensor Plug&Play, Metadata Management, Publishing
Rapid Application Development



The project is organized by University of Tokyo, University COOP in Japan and Fujitsu Design Co., Ltd., AIT.

Spinach Promotion from Thailand to Japan. Application on the cloud Service

Asia Pacific ICT Alliance Award 2010

Winner
Tools and Infrastructure Applications Category

OGC's Standard Web Service: Sensor Observation Service(SOS) enables Rapid, Low Cost and Flexible Application Dlevelopment

DSS on Interoperable Data Infrastructure

インターオペラブルな空間情報基盤がアプリケーションへ情報を標準API Web Serviceで提供

Real-Time Decision Support for High-Yield, Low-Risk Cropping

Monitoring | Work Logging | Scenario Simulation

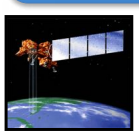
Web Application Intuitive User I/F

OGC API

Providing Unified Access to Geo-Spatial Data

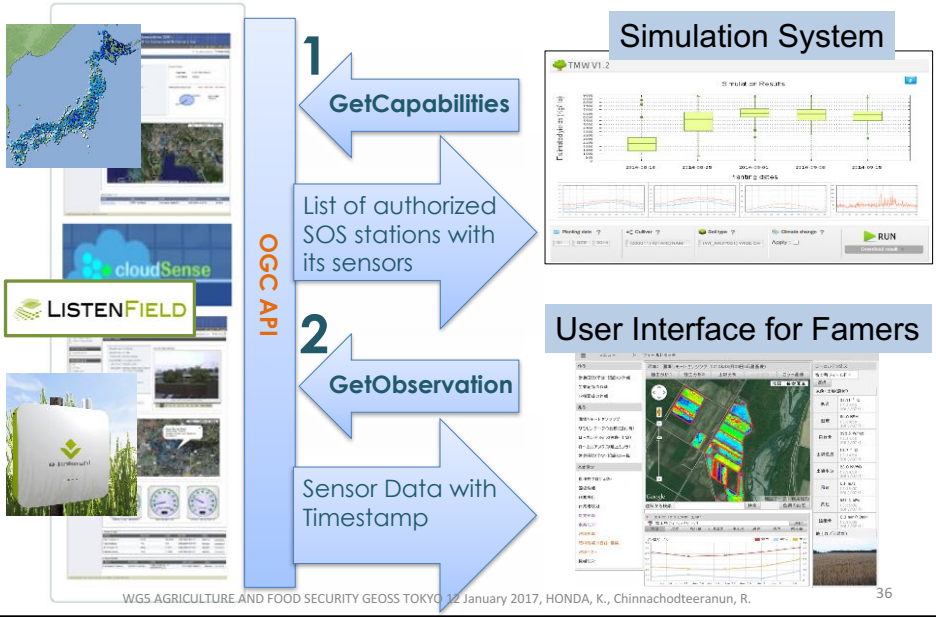
Satellite / Aircraft / UAV observation | Field Sensor Network

Interoperable Sensing Data Infrastructure




Heterogenious Sensing Layer

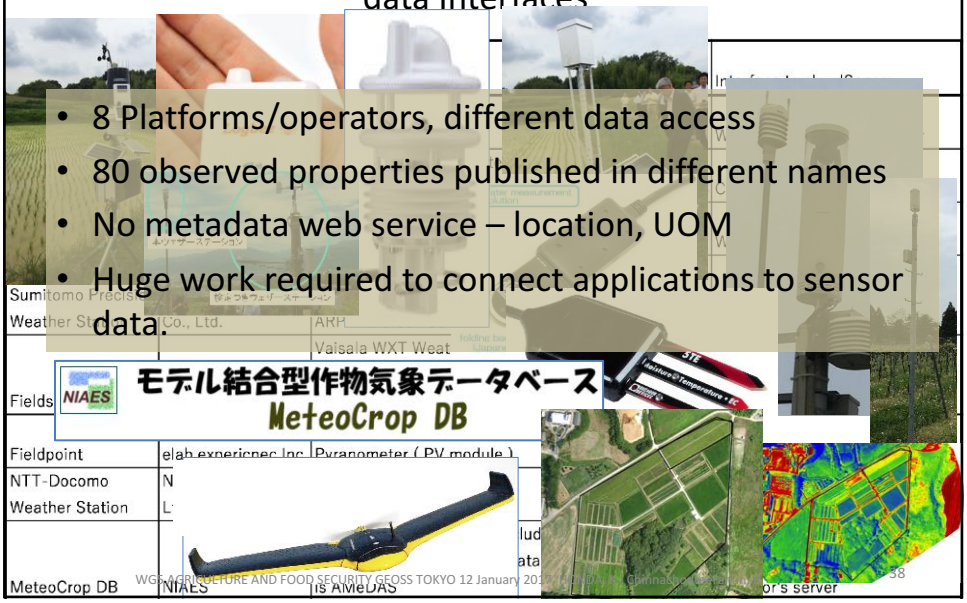
Giving Interoperability to heterogeneous sensing data via OGC Standard Web Service



InterAct Project - Dynamic Cropping Calendar

8 types of platforms, with multiple sub systems and sensors, data Interfaces

- 8 Platforms/operators, different data access
- 80 observed properties published in different names
- No metadata web service – location, UOM
- Huge work required to connect applications to sensor data.



Observable Property Naming Rule

- SOS – have to describe observable property
- how to describe Observable Property is not defined
- MachineReadable - > Machine Understandable Semantic Web Service
- TimeWindow+TimWindowUOM+Agregration_Target_PhysicalProperty
- 10minutes_maximum_wind_speed [UCUM UOM]
- Going to be announced to as a guideline from a Ministry in Japan

集約時間数値		×	集約時間単位		×	集約方法		×	計測項目（計測対象_物理現象）	
timewindow value			timewindow uom			aggregation			observableProperty	
JPN	ENG		JPN	ENG		JPN	ENG		JPN	ENG
数値	numeric		秒	second		瞬時値*			気温	air_temperature
			分	minute		積算	accumulated		土壌温度	soil_temperature
			時間	hour		積算	cumulative		地表面温度	land_surface_temperature
			日	day		合計	amount_of		海面温度	sea_surface_temperature
			週	week		持続時間	duration_of		水温	water_temperature
			月	month		合計	sum		全天日射	solar_irradiance
			年	year		平均	average		降水量	precipitation
			1年間の	annual*		平均	mean		雨量	rainfall
						最大	maximum		他多数	to be filled by many others
						最高	maximum			
						最小	minimum			
						最低	minimum			

Published as a guideline
- naming rules, UOM, metadata format -

http://www.kantei.go.jp/jp/singi/it2/senmon_bunka/nougyou.html

- Ministry of Internal Affairs and Communication, Japan

•＜H28-GL2＞ Guidelines on environment information data items in agricultural IT System (recommended for implementation) (31 Mar 2016) (PDF) (Word)
Table 1 UOM as Reference （Excel ／ CSV）
Table 2 Base names and UOM （Excel／ CSV）
Table 3 Examples of names with aggregation information （Excel ／ CSV）
Table 4 Metadata format on TOR for data use （Excel）
Table 5 Metadata format on sensor specification and observation conditions（Excel）
Table 6 Metadata format on data （Excel）

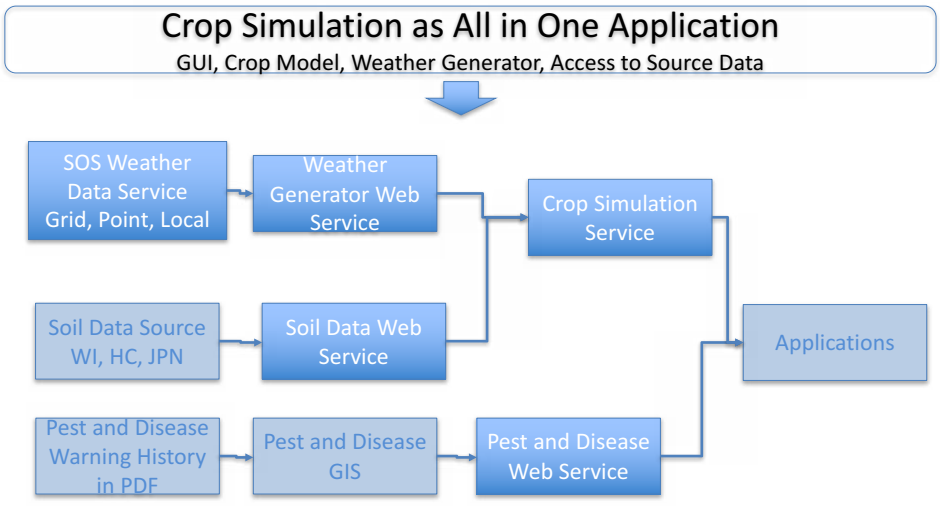
•＜H28-GL2＞ Guidelines on environment information data items in agricultural IT System (recommended for implementation)
•農業ITシステムで用いる環境情報のデータ項目に関する個別ガイドライン（本格運用版）
（平成28年3月31日取りまとめ）(PDF形式)
※ガイドラインの本文やデータをご利用される方はこちら本文 （Word形式）
別表1 基準となる単位表 （Excel形式 ／ CSV形式）
別表2 基本項目名・単位表 （Excel形式 ／ CSV形式）
別表3 集計・追加情報を付加した項目名例 （Excel形式 ／ CSV形式）
別表4 サービス利用条件のメタ情報記録フォーマット （Excel形式）
別表5 センサーの仕様及び計測条件のメタ情報記録フォーマット（Excel形式）
別表6 計測結果のメタ情報記録フォーマット （Excel形式）

Partially supported by InterAct Project Ministry of Agriculture, Japan [visit]

International Collaboration on Standardization of Naming Rule

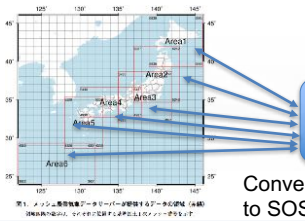
- Joint development of ALFAE and agGateway(PAIL)
  - North America, Latin America
- To have common or interchangeable namespaces
- agGateway Japan to be established

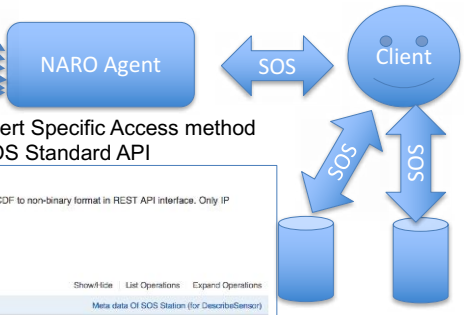
Crop Modeling on Hierarchical Web Services (Web API)



Grid Weather Data to SOS Service
NARO 1km Grid in Japan

- Weather data is becoming gridded by sophisticated interpolation techniques.
- Hiding specific data structure and access method by SOS to give interoperability
- Important to generate weather scenario in automatic model runs





Convert Specific Access method to SOS Standard API

Partially supported by Cross-ministerial, Strategic Innovation, Promotion Program (SIP), Min of Agriculture, Japan

NARO Agent API

Returns NARO meta data of SOS and observed data by converting NARO NetCDF to non-binary format in REST API interface. Only IP registered clients can access this API.

1km Mesh Manual (Japanese)

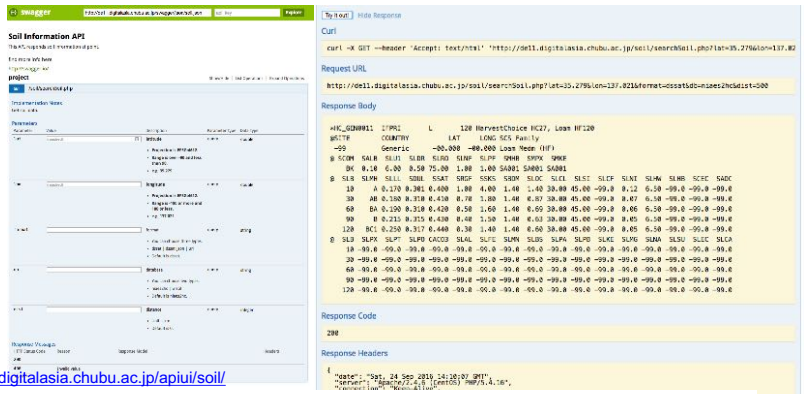
NARO OpenDAP

SOS Show/Hide | List Operations | Expand Operations

GET	/api/sos/describesensor/{proc}	Meta data Of SOS Station (for DescribeSensor)
GET	/api/sos/getcapabilities	Meta data Of SOS Station (for GetCapabilities)
GET	/api/sos/getobservation/{offering}	Measured Data Of Specified Location, Period and Data Types (for GetObservation API)

Soil Web API

- Soil physical property is important for running models.
- Web service to provide soil property from lat/lon
- World Soil DB WI.SOL (point data)
- Fusing with Japanese soil database
- Directly generate soil parameter in DSSAT native, DSSAT json format or key value in soil database of DSSAT
- Important Web Service to automate model runs



Partially supported by InterAct Project Ministry of Agriculture, Japan [visit]

http://de11.digitalasia.chubu.ac.jp/apiui/soil/

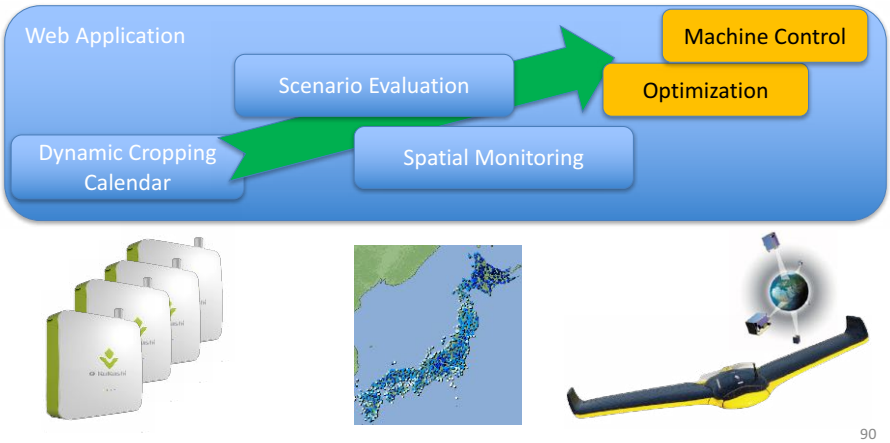
http://de11.digitalasia.chubu.ac.jp/soil/searchSoil.php?lat=35.279&lon=137.021&format=dssat&db=jpsol_pd&dist=5

Agro-CPS

CPS:
Cyber Physical System

DSS and Actuation on Interoperable Web Services

- Work Optimization based on Spatial Monitoring and Scenario Evaluation
- Applications on Interoperable Web Service Platform



Thank you !

www.hondalab.net www.researchgate.net

future internet MDPI

Article

Sensor Observation Service API for Providing Gridded Climate Data to Agricultural Applications

Rassarin Chinnachodteeranun [1,*] and Kiyoshi Honda [2]

Article

Designing and Implementing Weather Generators as Web Services

Rassarin Chinnachodteeranun [1,*], Nguyen Duy Hung [2], Kiyoshi Honda [3], Amor V. M. Ines [4,5] and Eunjin Han [5,6]