



Jet Propulsion Laboratory
California Institute of Technology

Remote sensing and data assimilation for drought monitoring and forecast in RHEAS Framework

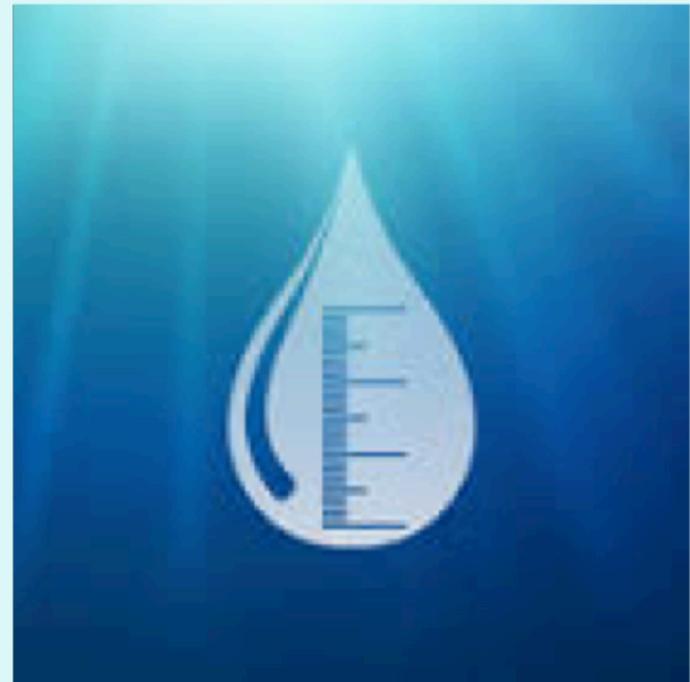
Narendra N. Das

Kostas Andreadis, Stephanie Granger,

28 March 2016

Briefing for Mekong River Commission

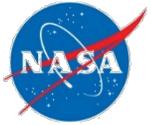
Phnom Penh, Cambodia



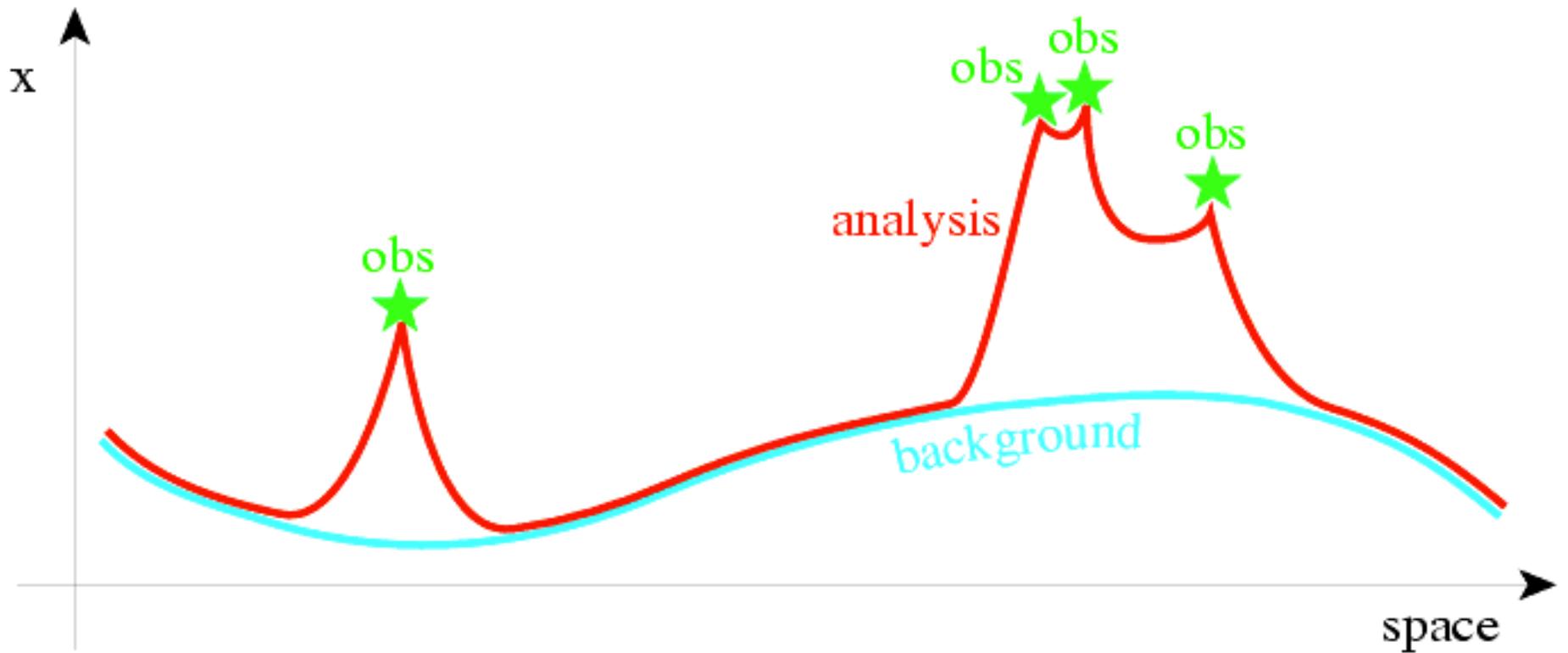


Background

- Availability of remote sensing observations has increased
- “Big data” era
- Need a way to make sense of all these data
- ***Data assimilation*** offers the framework to merge observations and models
 - constraints based on physics
 - account for uncertainties in both models and observations
 - allow for the indirect estimation of non-observed variables



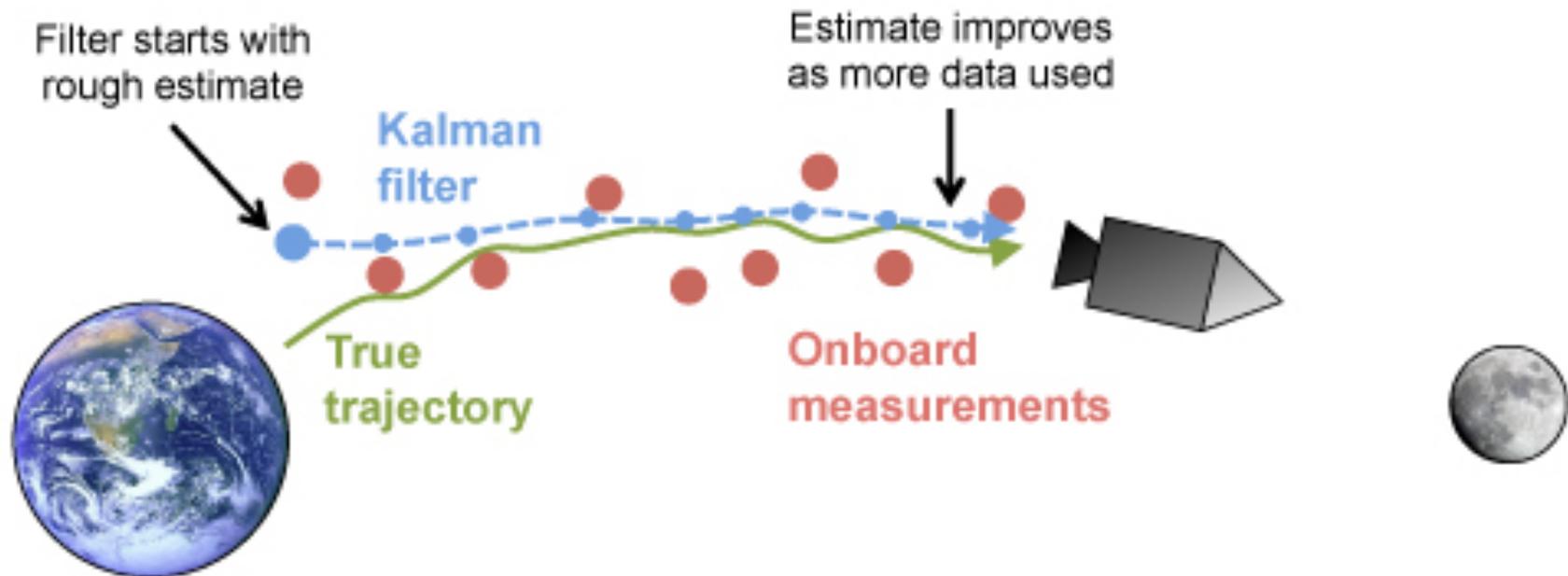
Data assimilation





Kalman filtering

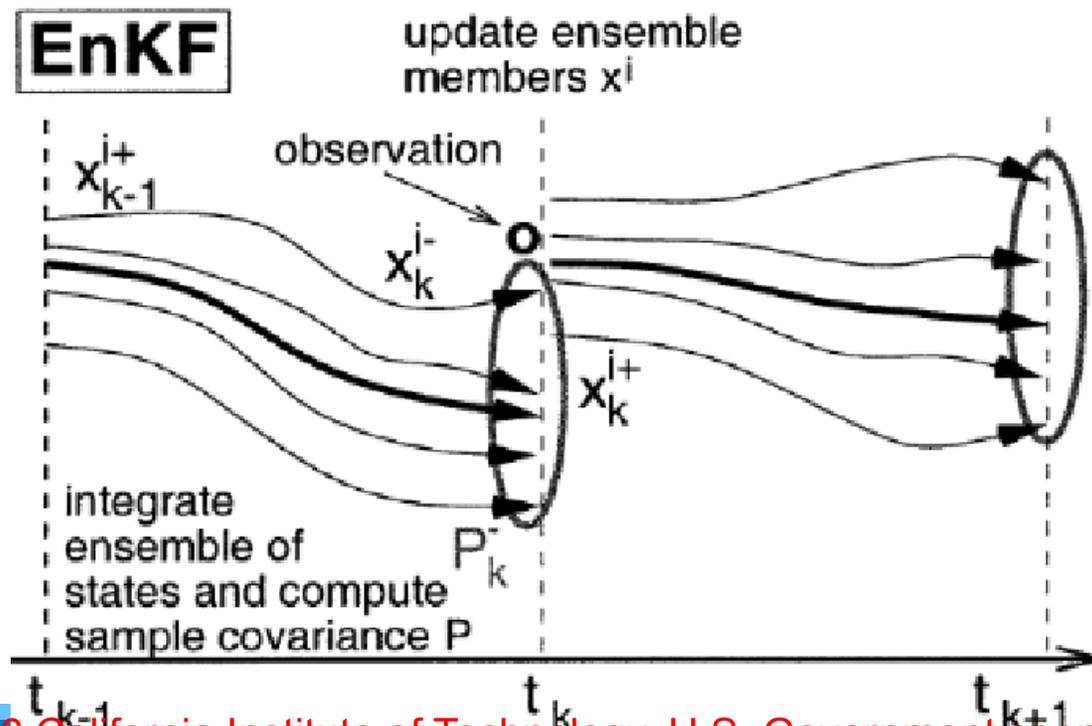
- Kalman filters are one of the most important techniques in optimal estimation
- Long history of applications
- A Kalman filter was used to take Apollo 11 to the moon!





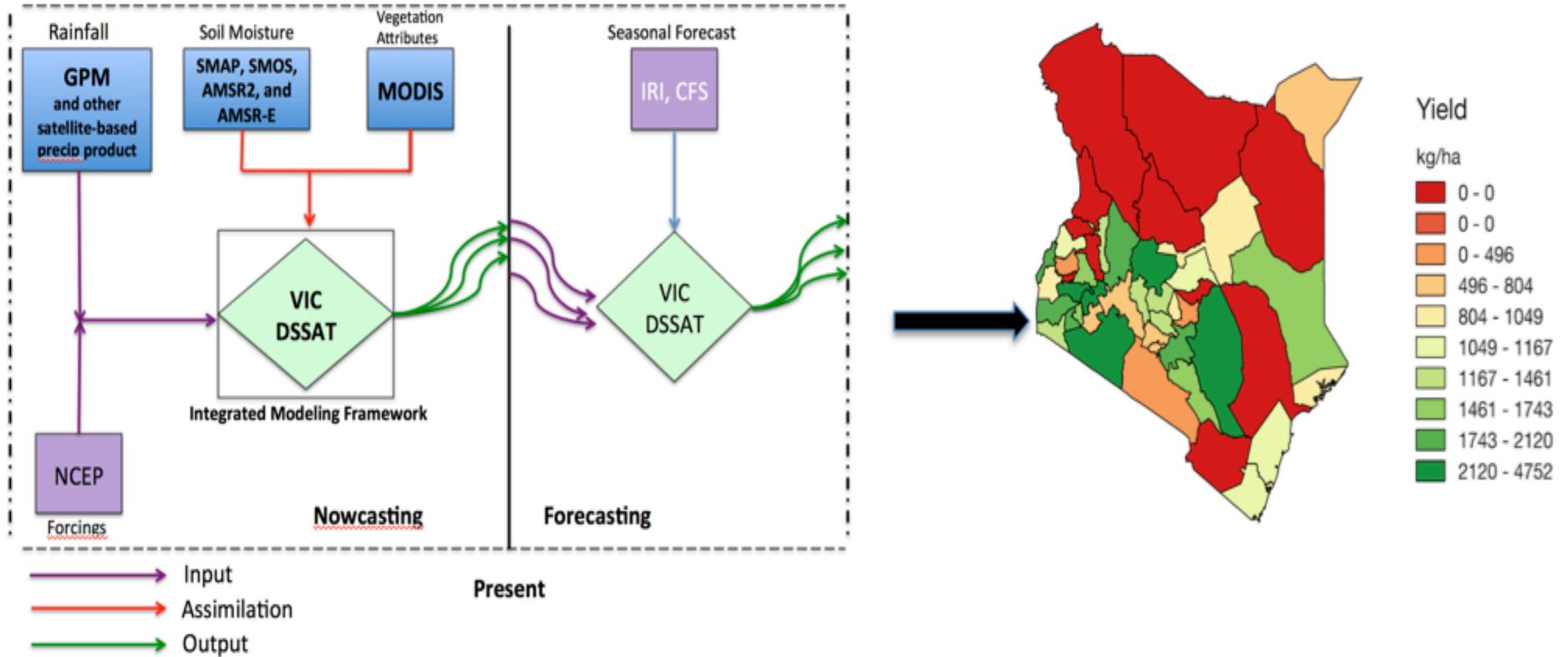
Ensemble Kalman Filter

- Widely used technique in Earth Sciences
- Ensemble Kalman Filter (EnKF)
- Represents uncertainty through an ensemble of model trajectories
- Easy implementation





RHEAS Modeling Concept





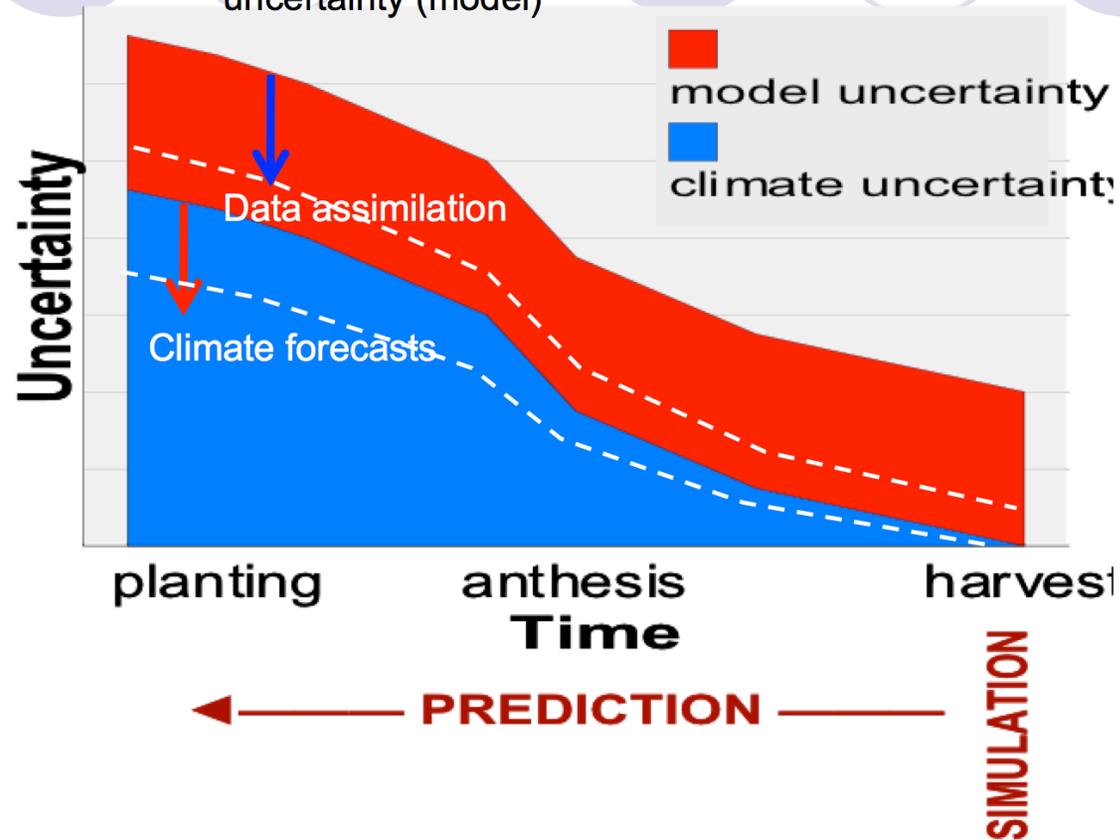
Modeling Concept of Forecast in Crop Modeling

Motivation

Note:

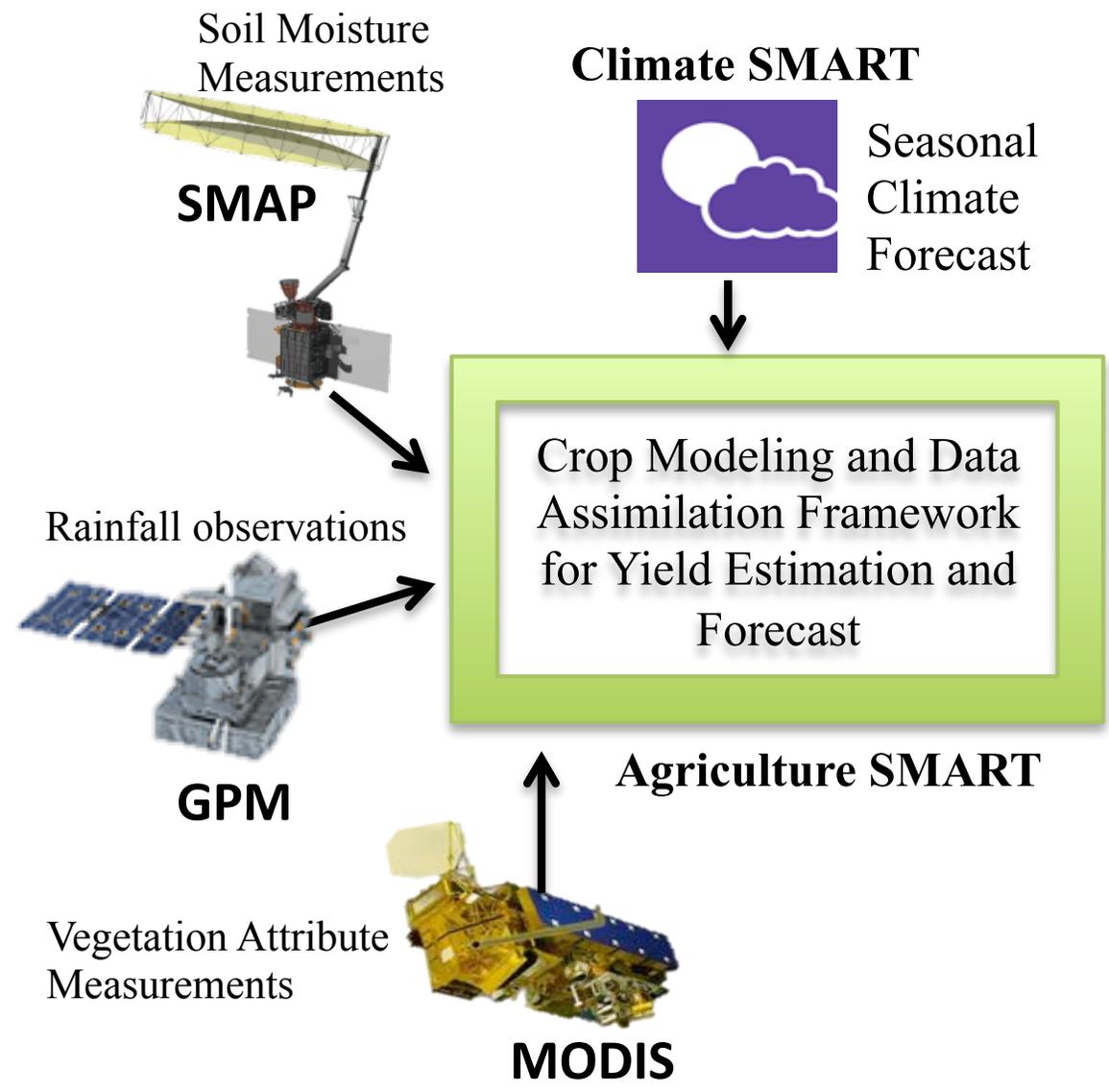
Skillful climate forecast can reduce crop yield prediction uncertainty (climate)

+ Data assimilation of RS can reduce crop yield prediction uncertainty (model)



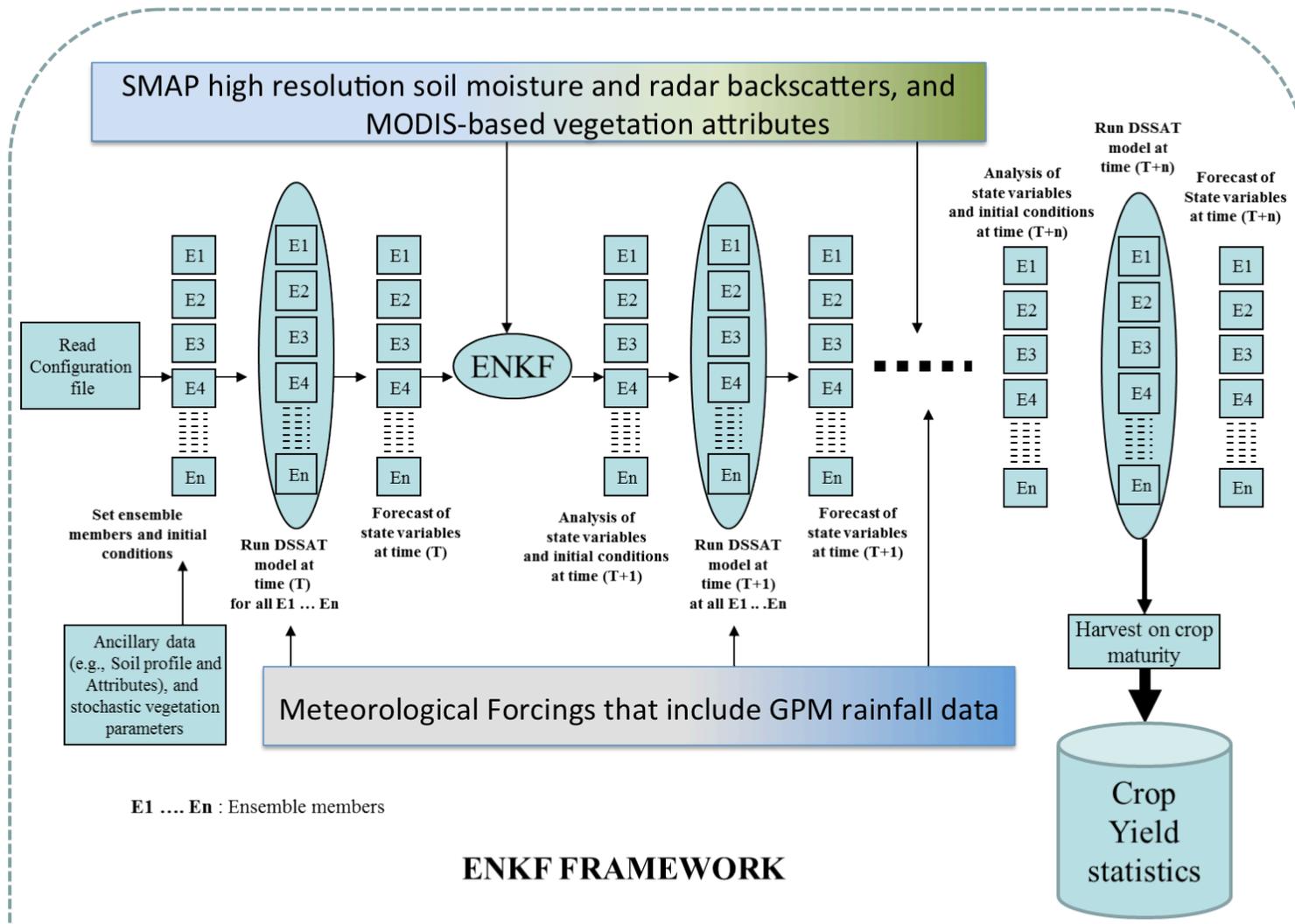


**Water SMART
NASA Satellite Observations**



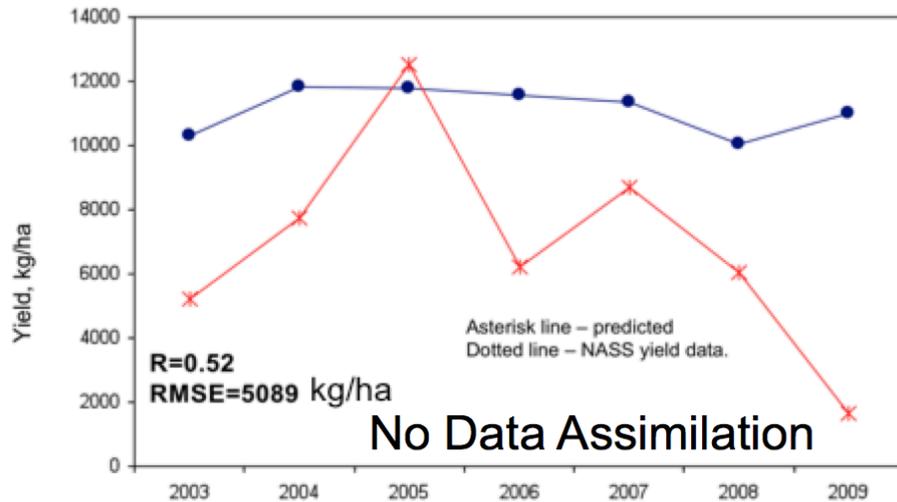
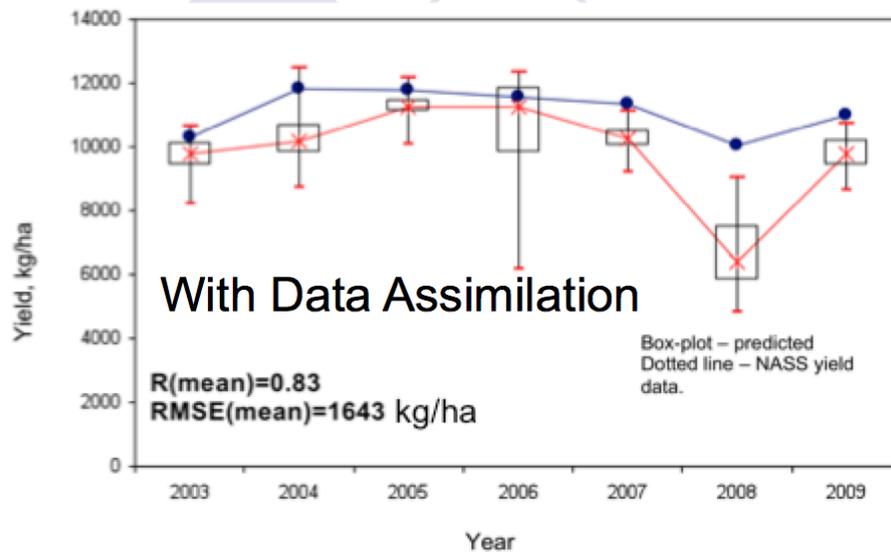


DSSAT Modeling in RHEAS

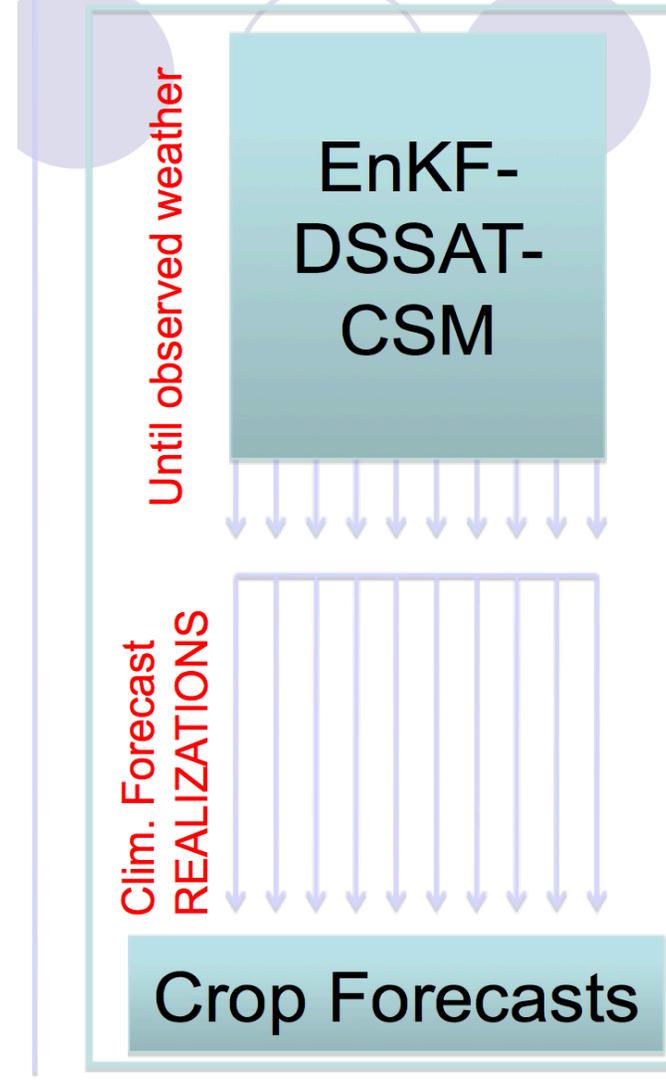




EnKF-DSSAT-CSM: Story Co., Iowa



EnKF-DSSAT-CSM-CF framework





Data Inputs for RHEAS System

Variable	Details	Model	VIC Required?	DSSAT Required?	Current Status - Minimally sufficient data to effectively run model	Current Status - Additional / more local data to enhance model outputs	Comment	Production Implications
Precipitation		VIC, DSSAT	Yes	Yes	GPM, TRMM	Gauges for evaluation of satellite products; Regionally calibrated rainfall estimates	Key model driver --> Need to evaluate GPM data accuracy in the region	
Air temperature		VIC, DSSAT	Yes	Yes	MERRA, NCEP	In-situ for evaluation of satellite products	Maximum and minimum daily	
Wind speed		VIC	Yes	No	MERRA, NCEP	None		
Soils	Soil depth, % sand, % clay, bulk density, Residual water content, saturated water content	VIC, DSSAT	Yes	Yes	ISRIC 1 km gridded global dataset	Soil surveys		Code assimilation algorithm
Agricultural management	**Planting dates, Irrigation practices, Fertilizer application	DSSAT	No	Yes	SAGE, Baseline for each country based on the published data, Secondary information may come from Sentinel-based planting signals	Local information		
Cultivars and crop areas	Primarily focused on rice.	DSSAT	No	Yes	MARS crop mask. GEOGLAM. Literature.	Crop mask from MRC. Local information.	Tri provided this to Rishi (Thailand, Cambodia, Vietnam; Laos and Myanmar TBE)	



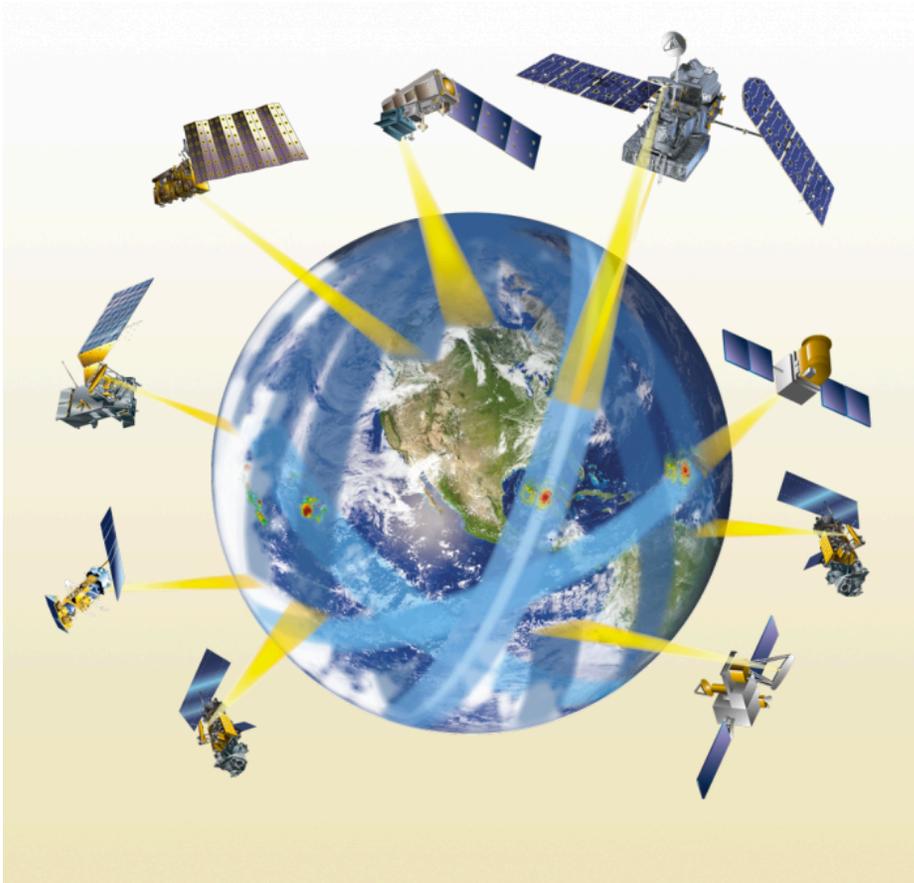
Data Inputs for RHEAS System cont'

Shortwave radiation		VIC, DSSAT	No	Yes	<i>Derived, NASA POWER</i>	<i>Flux tower for validation</i>	<i>Can be calculated internally by VIC. Depends on min/max temperature, NCEP underperformed.</i>	NASA POWER will be ~50km "soon"
Relative humidity		VIC	No	No	<i>Derived</i>	<i>None</i>	<i>Can be calculated internally by VIC</i>	
Soil moisture		VIC, DSSAT	No	No	<i>SMOS, SMAP</i>	<i>In-situ for validation</i>	<i>If available, can be assimilated</i>	Sentinel/SMAP hybrid soil moisture product can be added (1km resolution).
Leaf Area Index	8-day MODIS product	VIC, DSSAT	No	No	<i>MODIS</i>	<i>None</i>	<i>If available, can be assimilated</i>	
Evapotranspiration		VIC	No	No	<i>MODIS</i>	<i>Flux tower for validation</i>	<i>If available, can be assimilated</i>	
Streamflow		VIC	No	No	<i>GRDC stations</i>	<i>Additional stations, Virtual gauge tool</i>	<i>Used for calibration and validation.</i>	VIC needs to be calibrated outside of RHEAS. Need to select data that are representative of flow conditions (reliability of rating curves). Also need to select stations that have minimal impact from diversions etc. (probably best to focus pre-2000). Altimetry-derived water levels can be used as a proxy for streamflow.
Crop yield		DSSAT	No	No	<i>FAO, World Bank</i>	<i>Local information</i>	<i>Used for calibration</i>	Thailand has report with statistics from 1981. MRC will attempt to gather crop yield data for rest of countries.

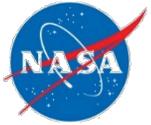


Precipitation

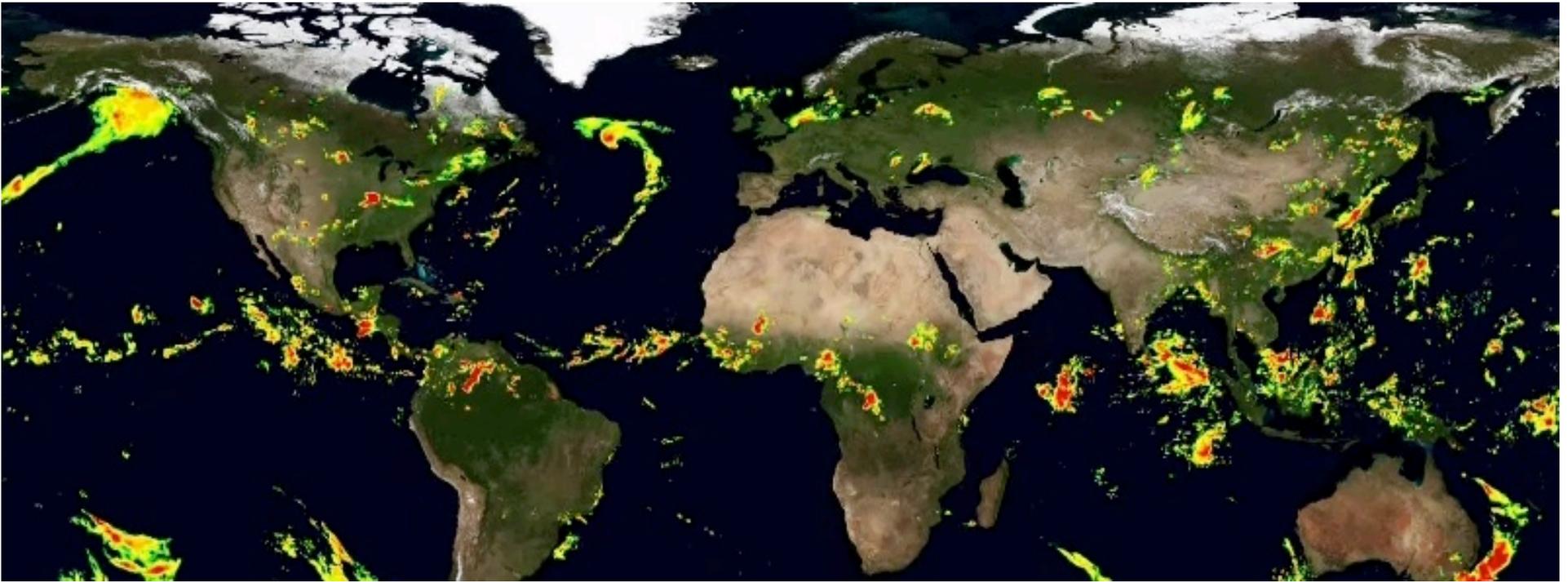
- The Global Precipitation Measurement (GPM) mission launched Feb. 27, 2014



- Constellation of satellites
- Dual-frequency radar & Microwave imager



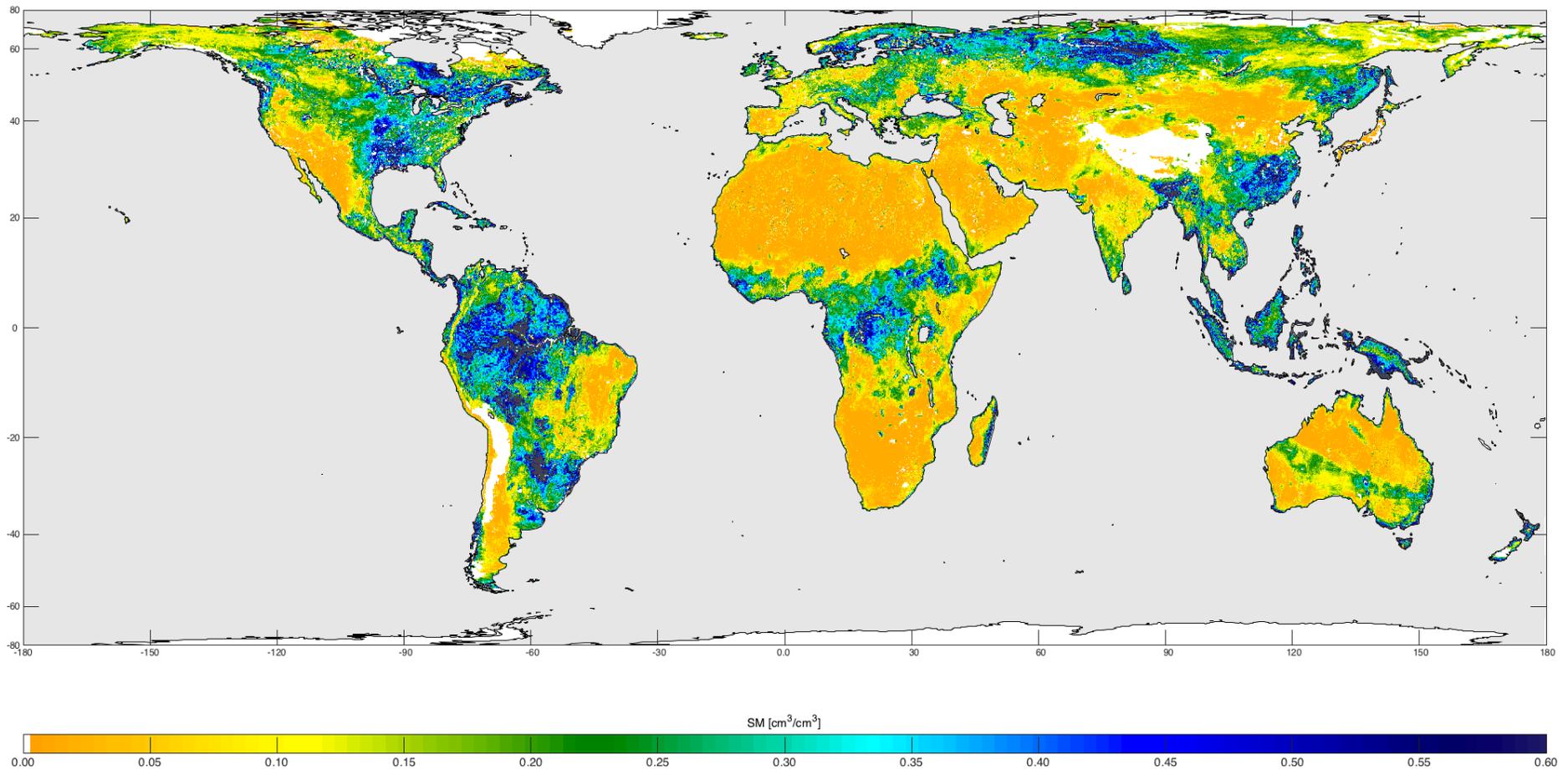
Precipitation



Global Precipitation Mission Data



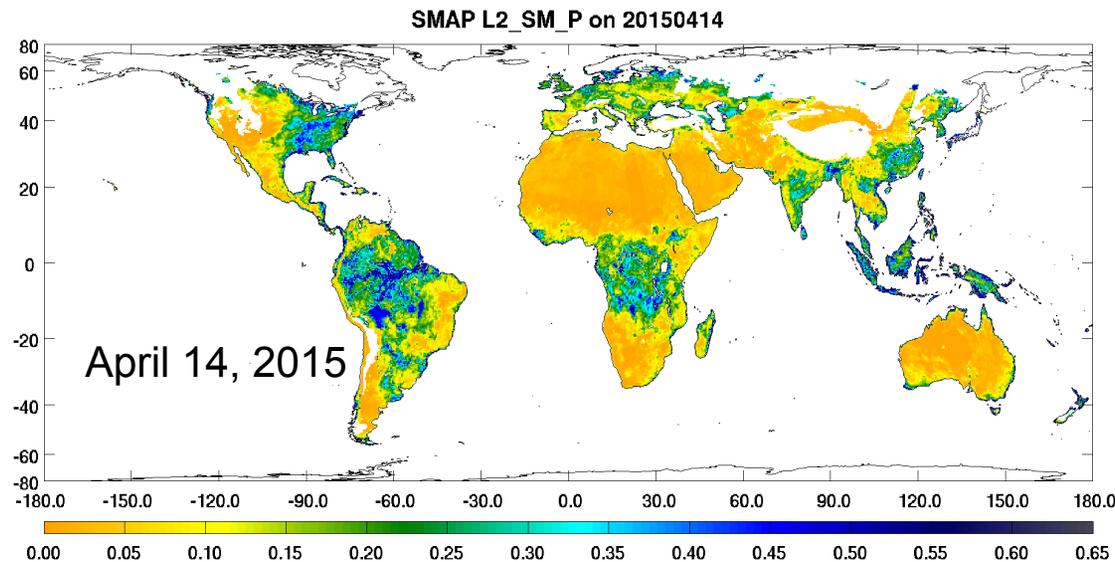
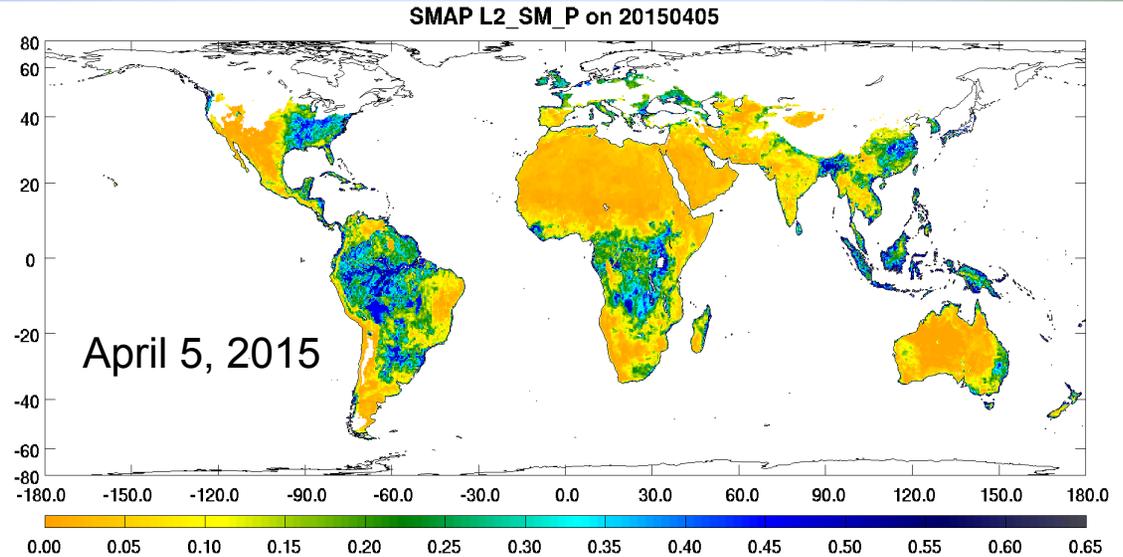
Soil moisture





Soil Moisture - Observed Changes

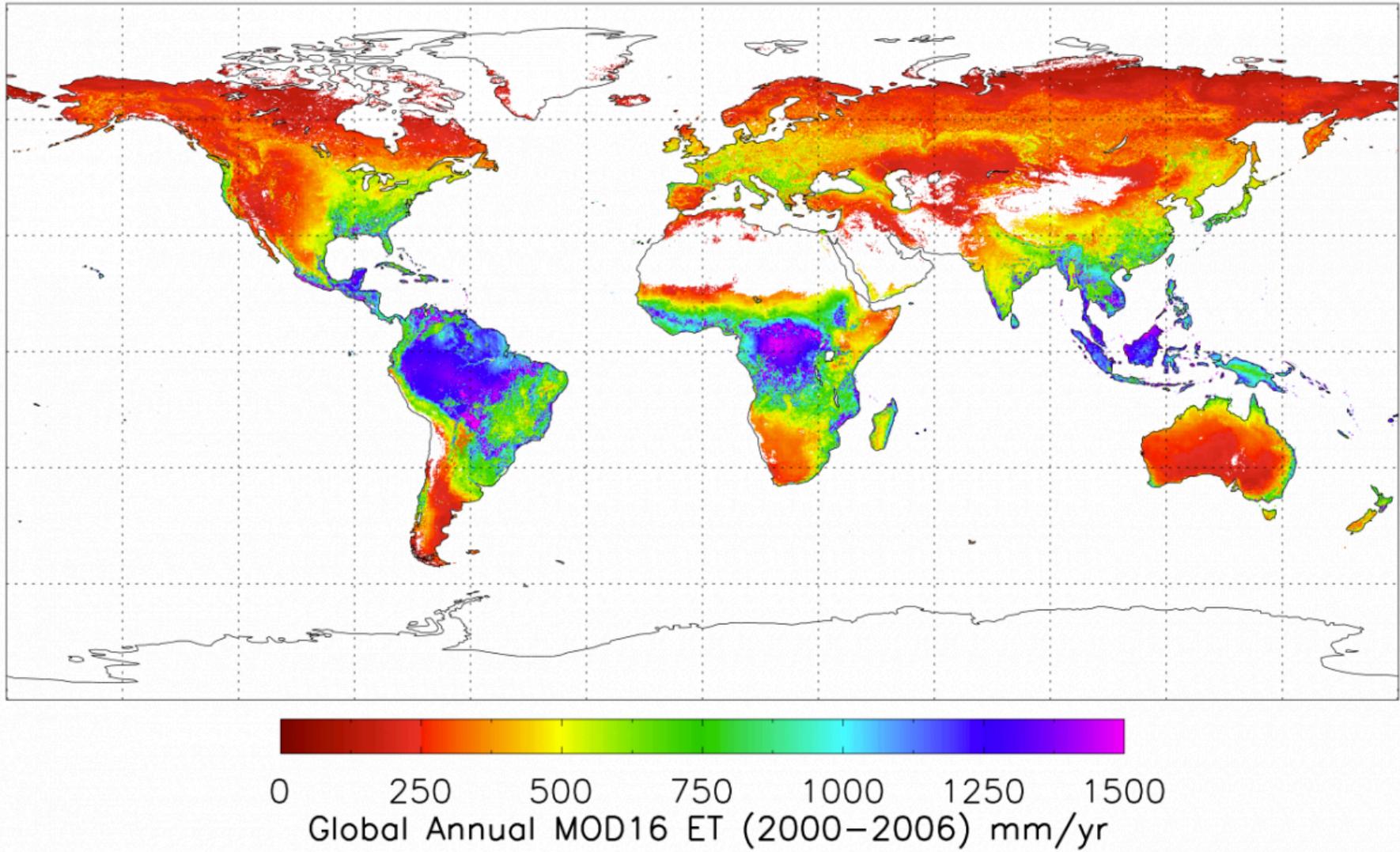
- Passive (36 km) data processed into soil moisture 3-day global images centered on April 5 and 14, 2015
- Soil moisture patterns agree with expected geographical soil moisture distribution



- Soil moisture changes are evident in the time-sequence
- Rainfall in India, Bangladesh, and Vietnam
- Dry-down in eastern Australia and Argentina



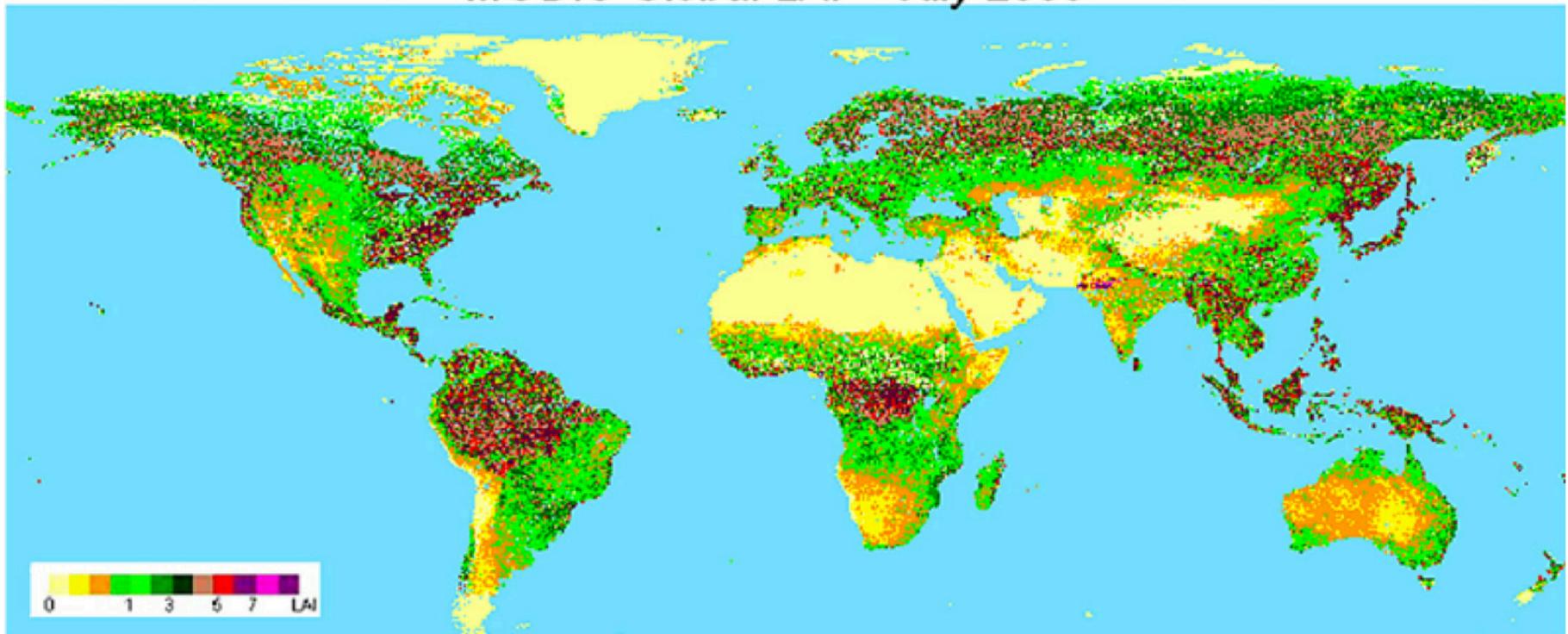
Evapotranspiration





Vegetation dynamics

MODIS Global LAI – July 2003





The End

Thank you!

Questions?