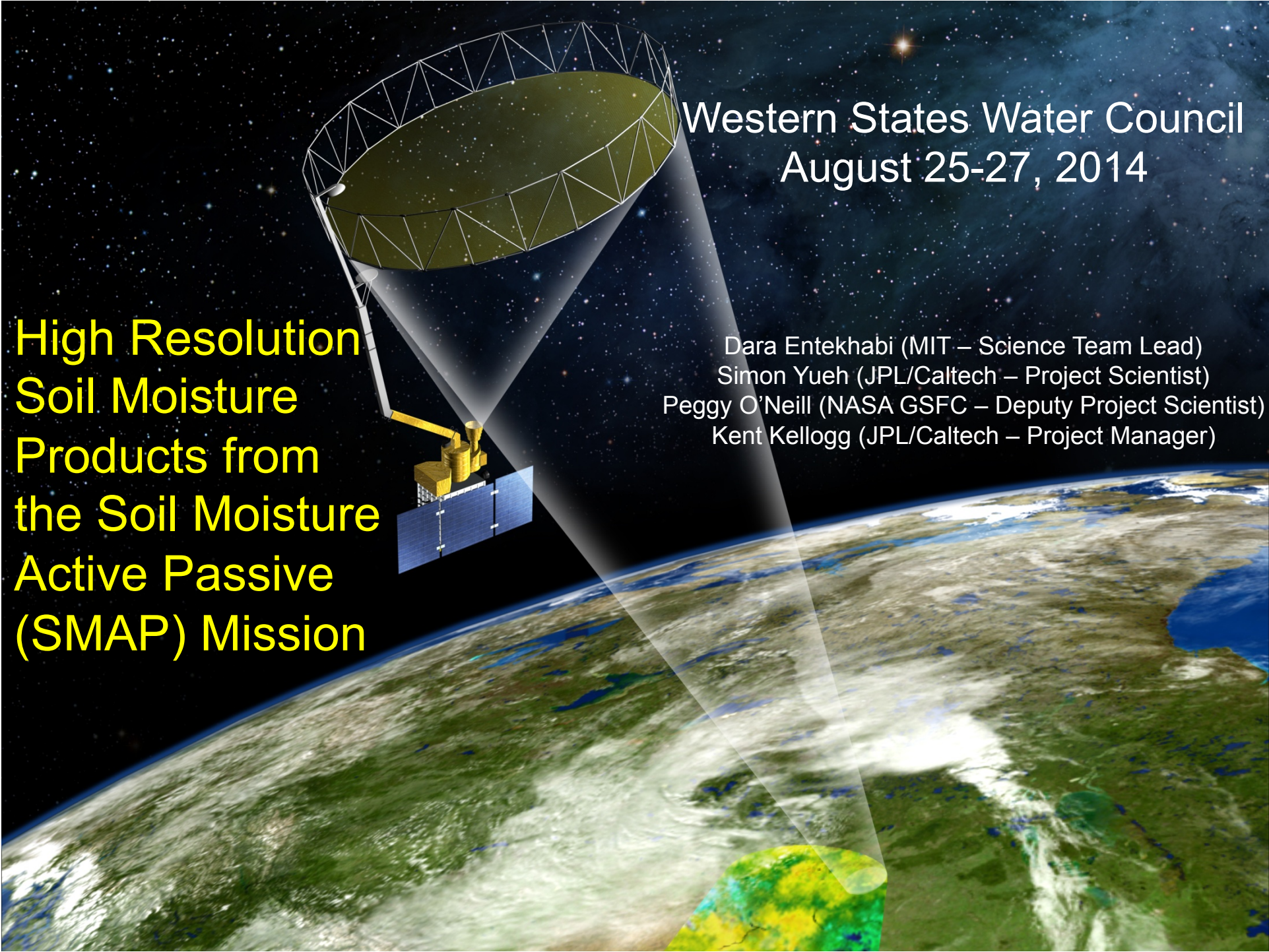




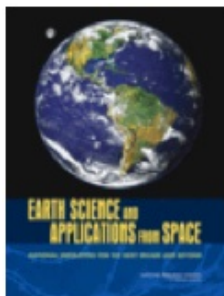
Western States Water Council
August 25-27, 2014

High Resolution
Soil Moisture
Products from
the Soil Moisture
Active Passive
(SMAP) Mission

Dara Entekhabi (MIT – Science Team Lead)
Simon Yueh (JPL/Caltech – Project Scientist)
Peggy O'Neill (NASA GSFC – Deputy Project Scientist)
Kent Kellogg (JPL/Caltech – Project Manager)

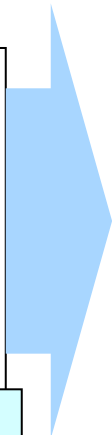


Project Context



US National Research Council Report: “Earth Science and Applications from Space: National Imperatives for the next

SMAP is one of four missions recommended by the NRC “Decadal Survey” for launch in the 2010–2013 time frame



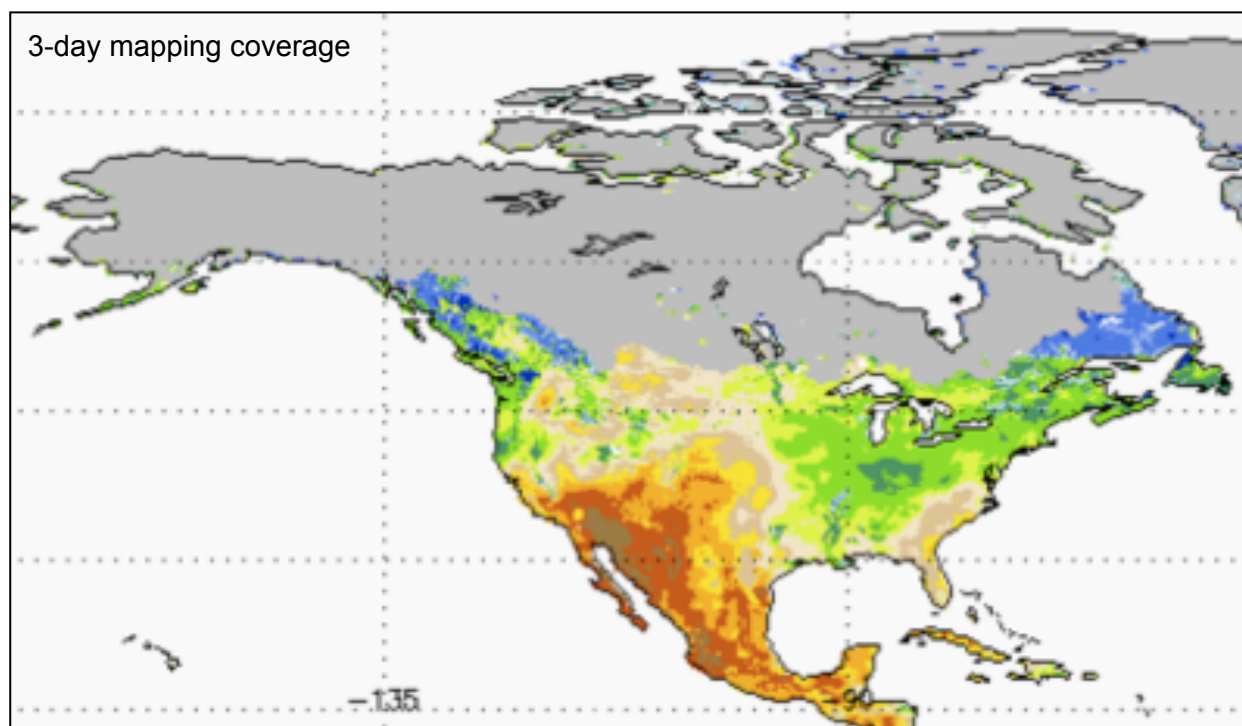
Tier 1: 2010–2013 Launch	
	Soil Moisture Active Passive (SMAP)
	ICESAT II
	DESDynI
	CLARREO
Tier 2: 2013–2016 Launch	
	SWOT
	HYSPIRI
	ASCENDS
	GEO-CAPE
	ACE
Tier 3: 2016–2020 Launch	
	LIST
	PATH
	GRACE-II
	SCLP
	GACM
	3D-WINDS



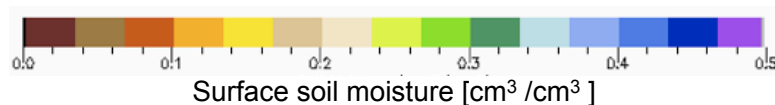
SMAP Science Introduction



SMAP will provide high-resolution (10 km or 6 miles) and frequent-revisit (2 to 3 Days) global observations of soil moisture and freeze/thaw state



Frozen Landscape





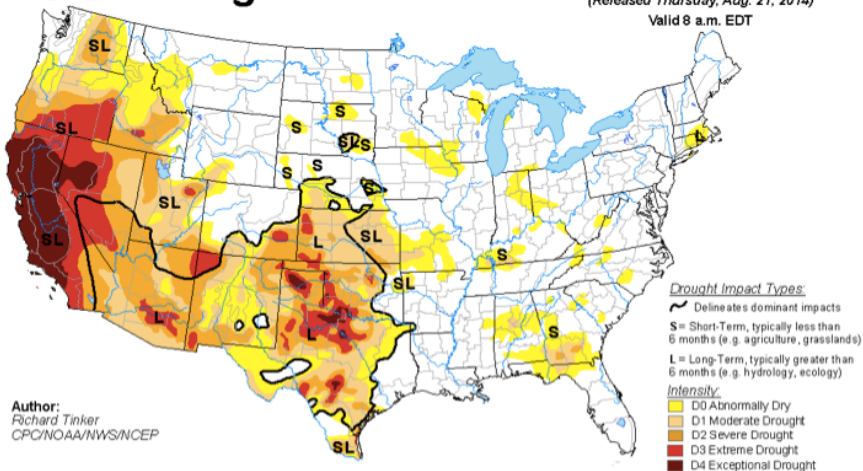
Why Soil Moisture?



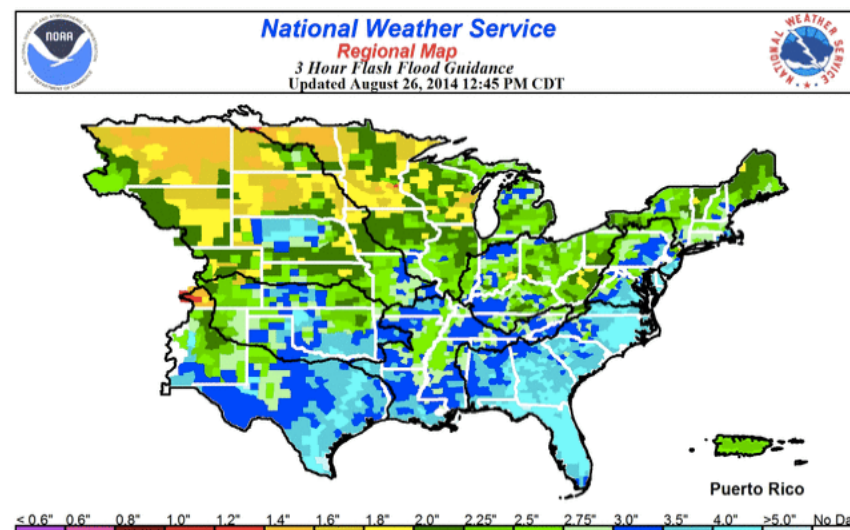
Current Operational Drought Monitoring (NDMC and NIDIS)

U.S. Drought Monitor

August 19, 2014
(Released Thursday, Aug. 21, 2014)
Valid 8 a.m. EDT



Current NWS Operational Flash Flood Guidance (FFG)



Current: Empirical Soil Moisture Indices Based on Rainfall and Air Temperature
(By County and Climate Divisions ~60-80 km)

Future: SMAP Soil Moisture Observations at better than 9 km



Why Soil Moisture?

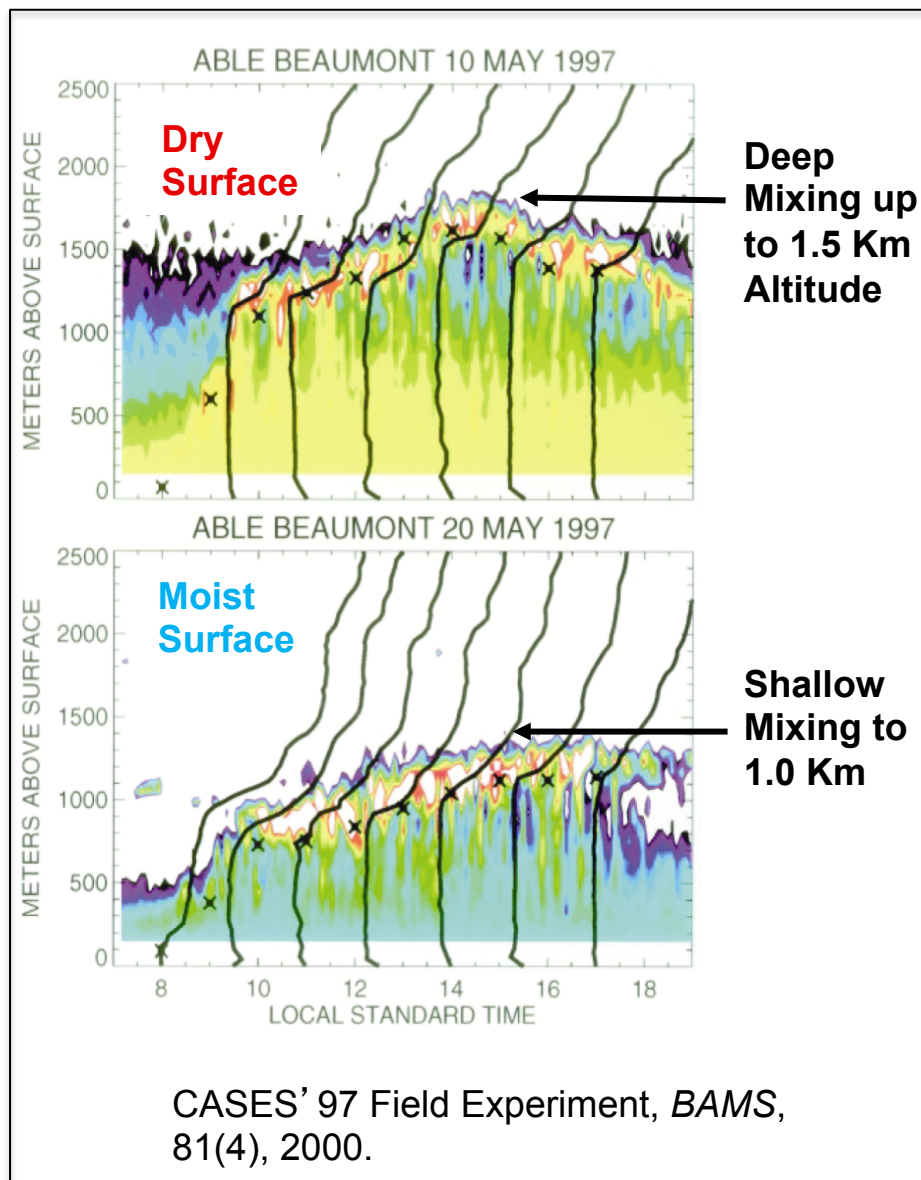
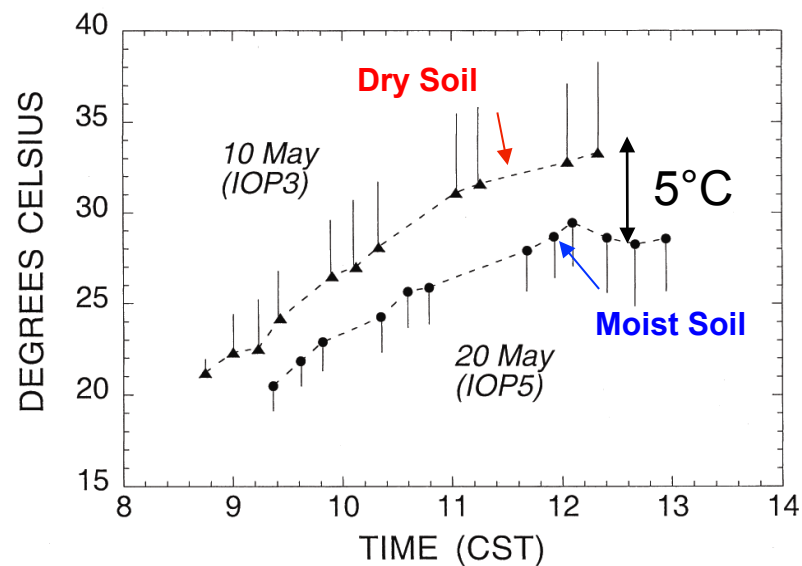


An Example of Impacts With Field Observations Only – No Models

May 10 Dry soil, clear, mild winds. ($LE \approx H$)

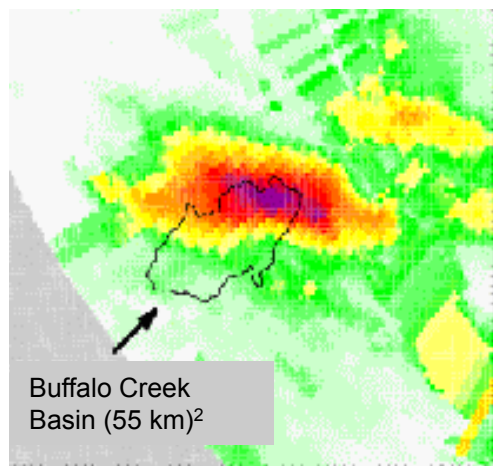
May 18 90 mm Rain

May 20 Moist soil, clear, mild winds. ($LE > H$)



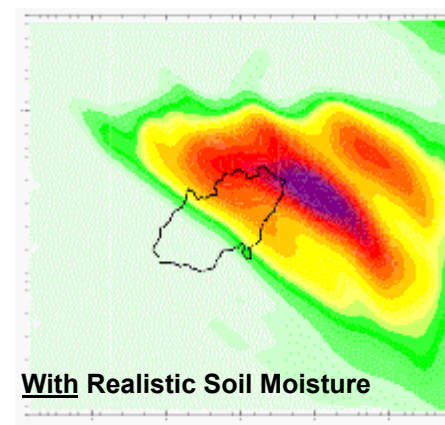
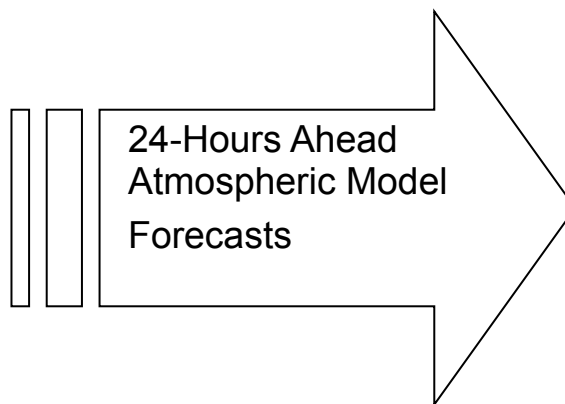


Soil Moisture and Weather

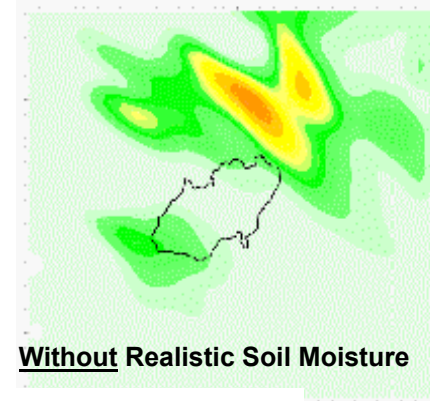


Observed Rainfall
0000Z to 0400Z 13/7/96

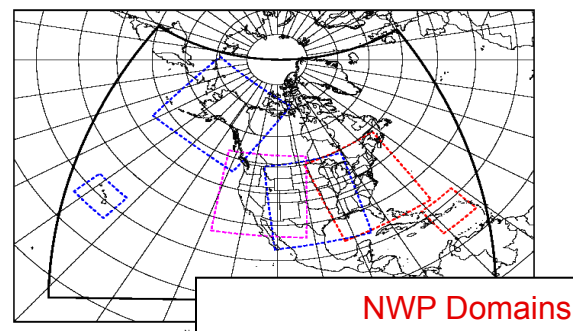
Chen, et al. (2001), *J. Atmos. Sci.*, 58, 3204–3223.



With Realistic Soil Moisture



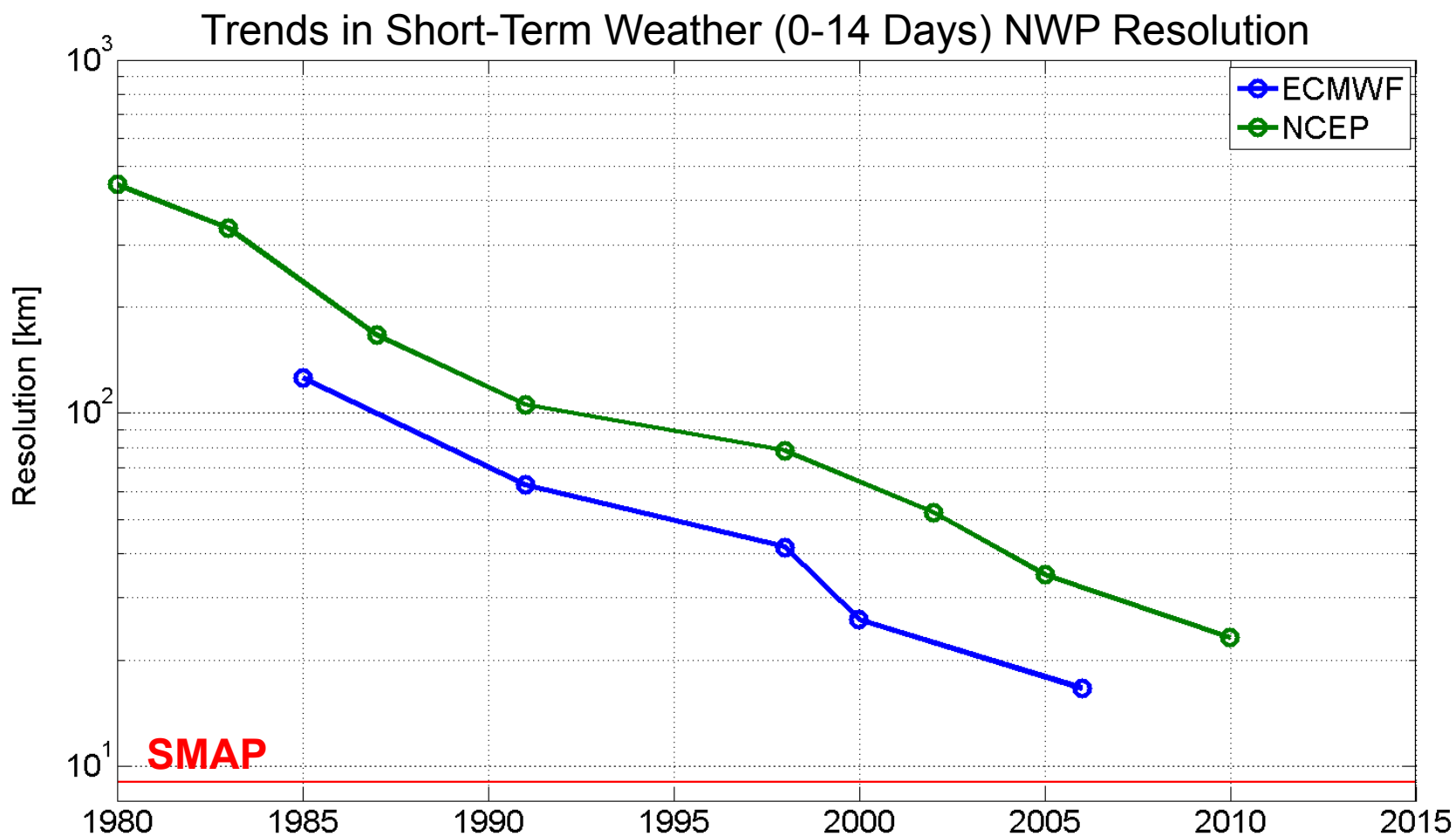
Without Realistic Soil Moisture



NWP Domains



Numerical Weather Prediction (NWP)



Sources:

Global Forecast/Analysis System Bulletins

http://www.emc.ncep.noaa.gov/gmb/STATS/html/model_changes.html

The ECMWF Forecasting System Since 1979

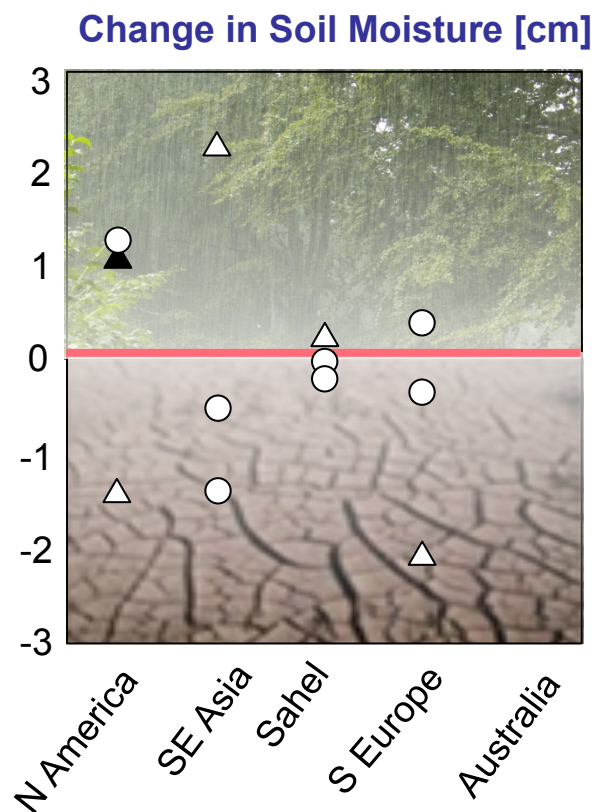
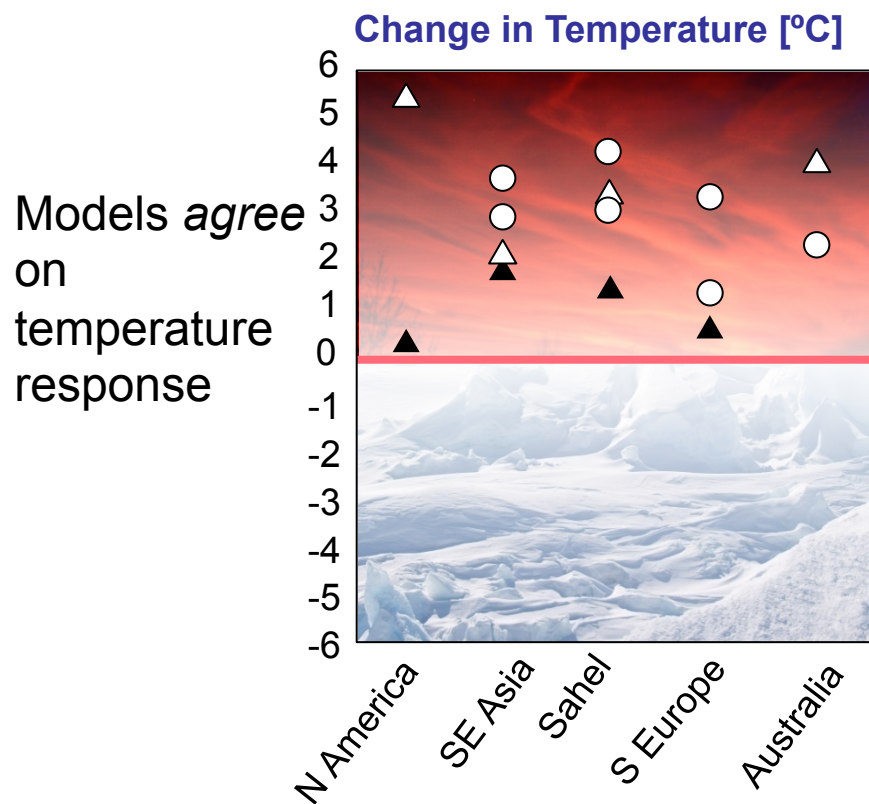
http://ecmwf.int/products/forecasts/guide/The_general_circulation_model.html



From Weather to Climate: Impacts



Intergovernmental Panel on Climate Change (IPCC) climate model projections by region:



Models *disagree* on the **sign** of moisture change

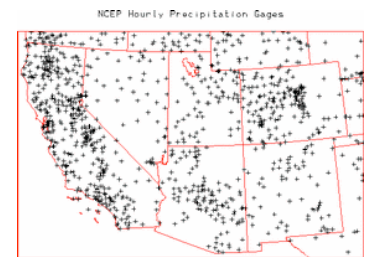
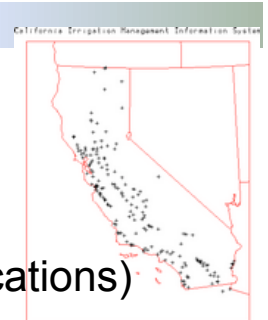


Western US Environmental Monitoring Stations



There is a rich set of networks across Western US to monitor near-surface weather conditions. Examples are:

1. California Irrigation Management Information System (CIMIS) Network (~118 locations)
2. NOAA Standard Weather Stations (~388 in California)
3. NOAA/NWS California Air Quality Monitoring Network (~158 locations)
4. NOAA Road Weather Information System (RWIS) (~14 locations)
5. Fort Irwin Weather Station Network (~16 locations)
6. United States Bureau of Reclamation (USBR) Agricultural Weather Networks (AgriMet)
7. Union Pacific Railroad Weather Station Network

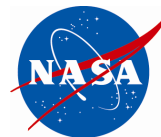


...and several more operated by local, county, and regional agencies and organizations. **Most measure standard weather variables like precipitation, air temperature, wind-speed and wind direction, etc.**

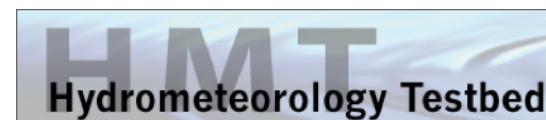
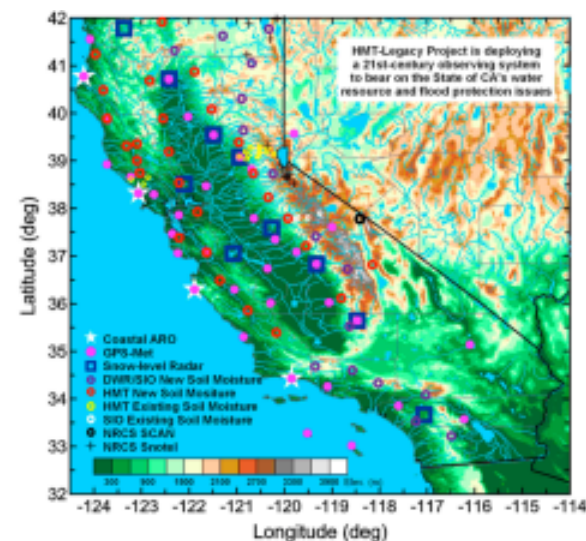
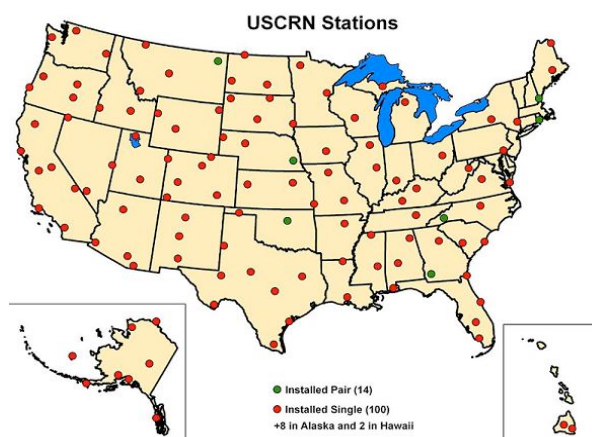
Source: <http://www.eol.ucar.edu/projects/hydrometnet/california/>



Western US Soil Moisture Monitoring Stations



Networks that include **soil moisture** measurements, taken together, provide point-sampling of soil moisture with 100 km mean spacing.

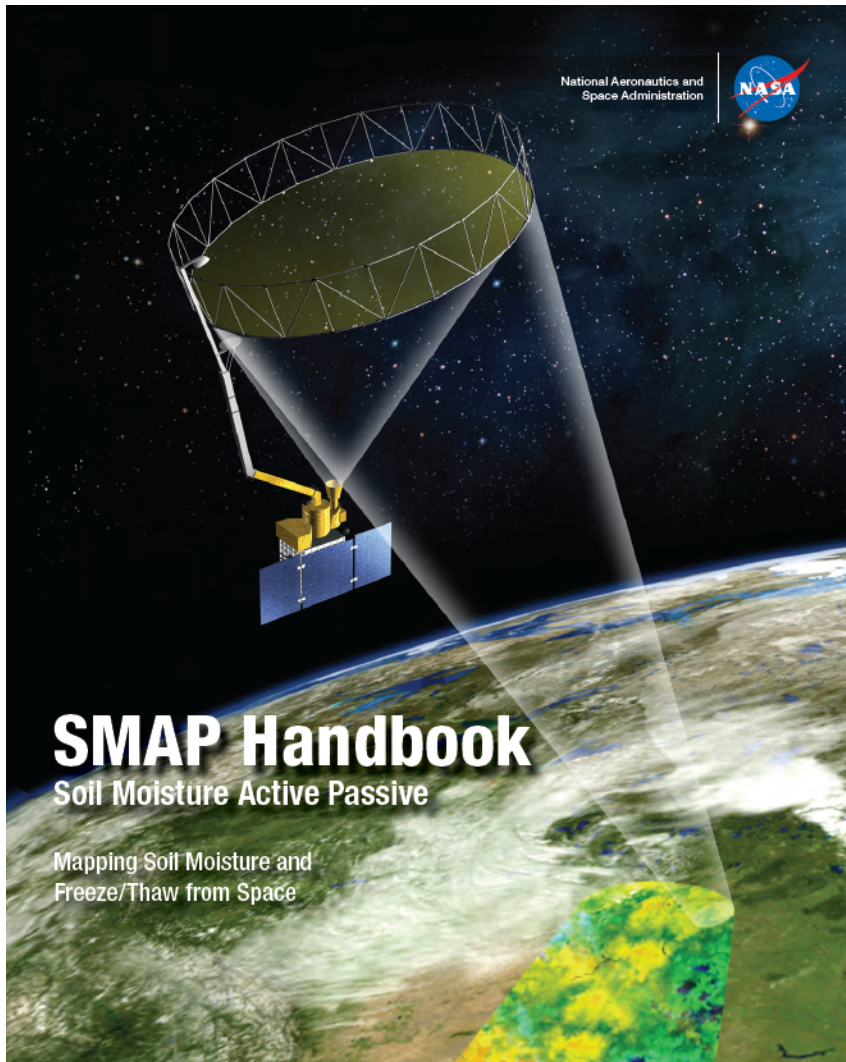


Resolution and sampling is inadequate to characterize the surface moisture state especially where there are strong climate and terrain gradients (Western US).



National Aeronautics and
Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

SMAP Mission Concept



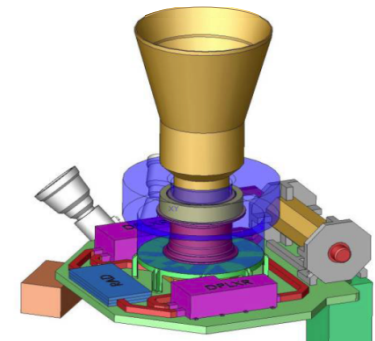
L-band unfocused SAR and radiometer system, offset-fed 6 m light-weight deployable mesh reflector. Shared feed for

- 1.26 GHz dual-pol Radar 1-3 km (30% nadir gap)
- 1.4 GHz polarimetric Radiometer at 40 km (-3 dB)

Conical scan, fixed incidence angle

Contiguous 1000 km swath 2-3 days revisit

Sun-synchronous 6am/6pm orbit (680 km)



Electronic Version at <http://smap.jpl.nasa.gov/Imperative/>

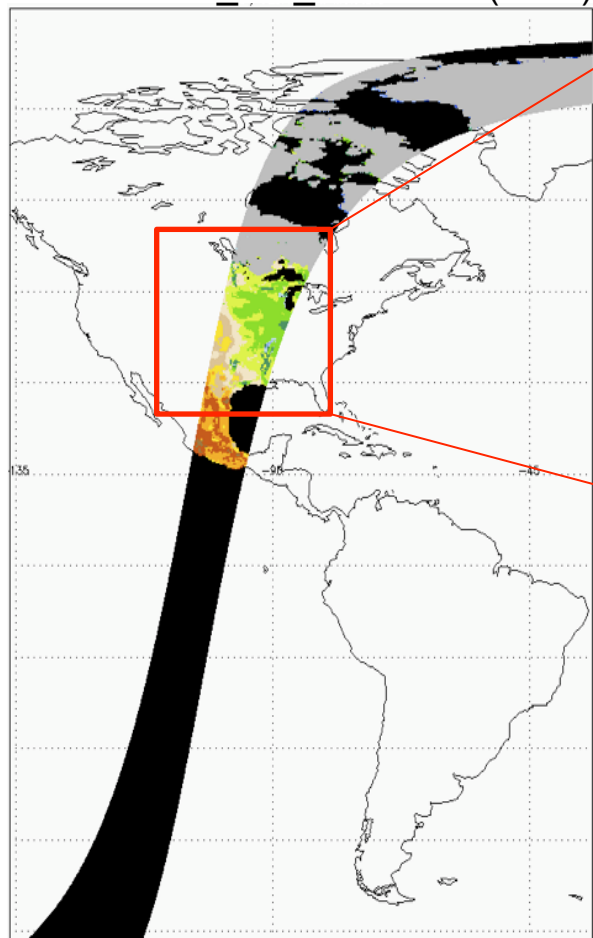
Print Version Available (182 Pages): smap_science@jpl.nasa.gov



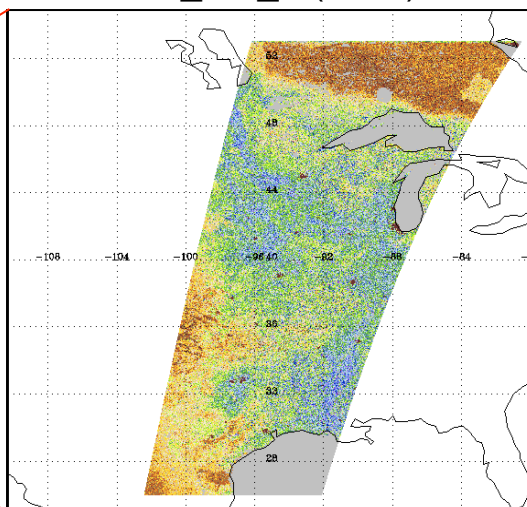
Level 2 Product Examples



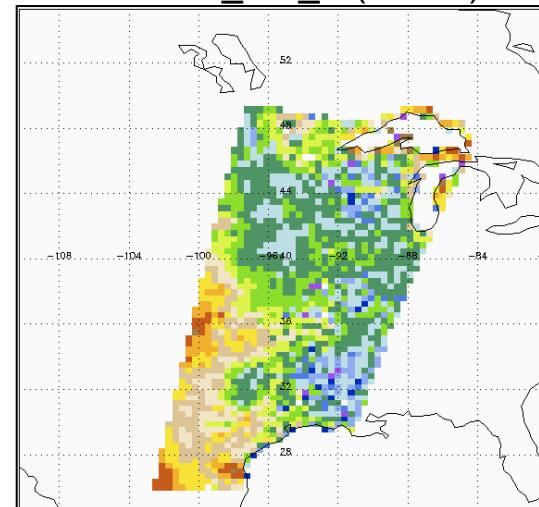
Half-orbit L2_SM_A Product (3 km)



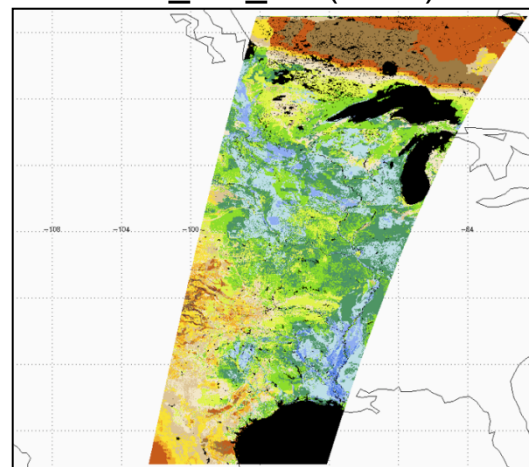
L2_SM_A (3 km)



L2_SM_P (36 km)



L2_SM_AP (9 km)



Volumetric Soil Moisture (cm^3/cm^3)



Active-Passive
Product Combines
Radiometer with
Better Sensitivity
with Radar with
Better Resolution



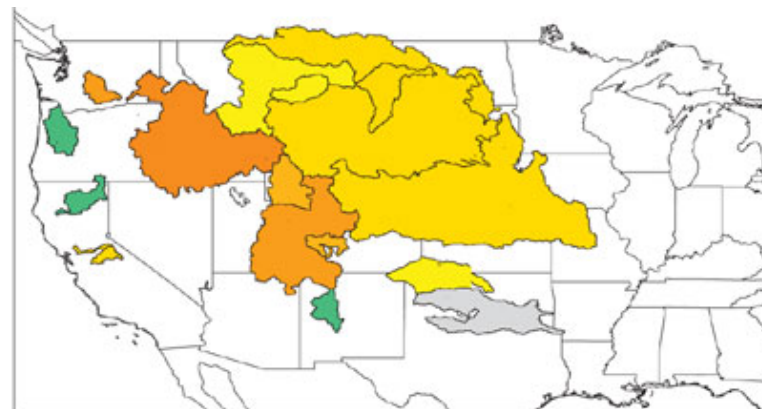
Snow-Fed Streamflow Forecast Skill



**Perfect World (Snow and Soil Moisture Known):
Upper Limit to Forecast Skill (Range 0 to 1)**



Realistic Skill With Snow and Soil Moisture



c Contribution of Snow Information



d Contribution of Soil Moisture Information

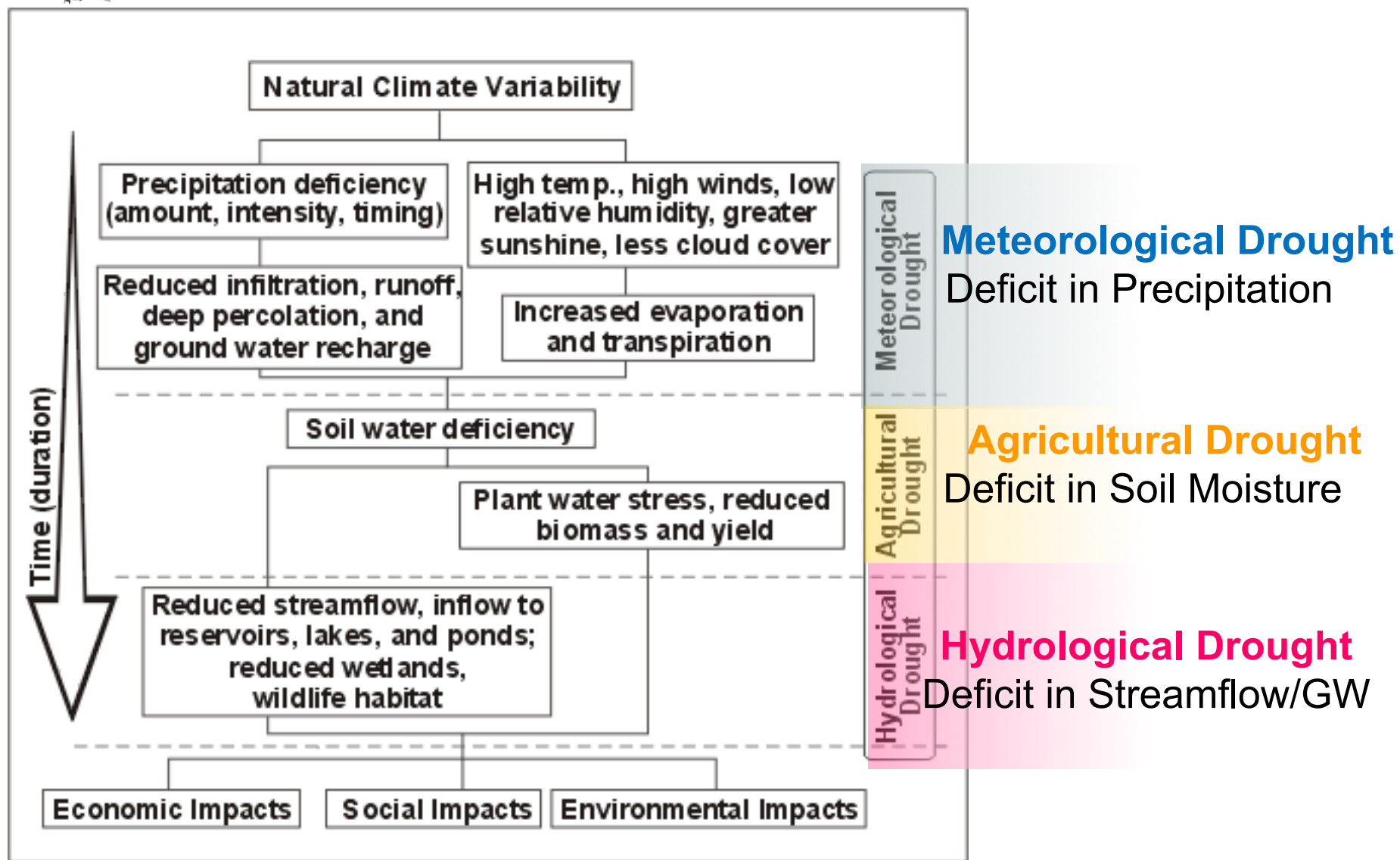


Koster et al., 2010: Skill in streamflow forecasts derived from large-scale estimates of soil moisture and snow, *Nature Geoscience* 3, 613-616.



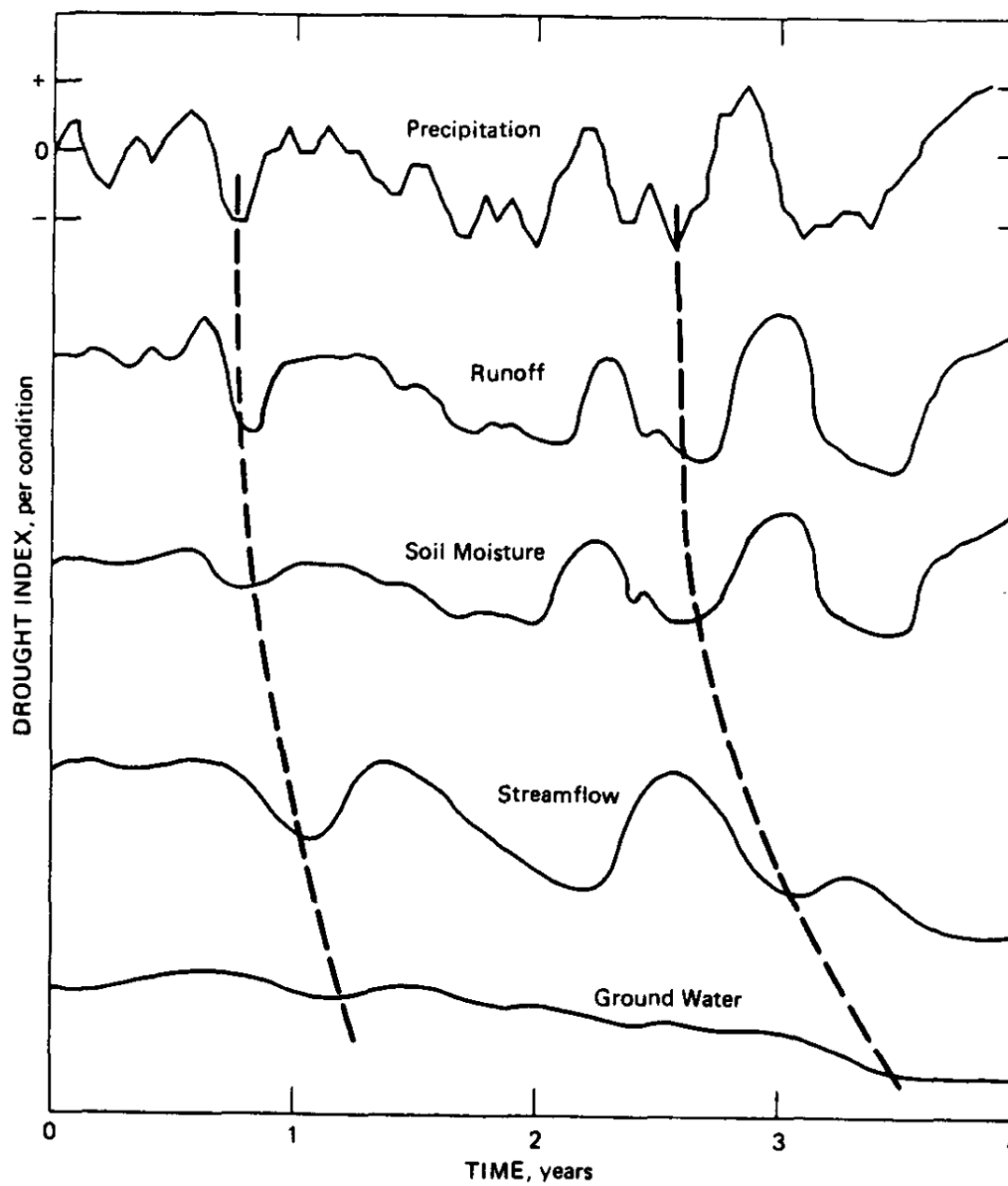


Drought Definitions





Drought Cascade



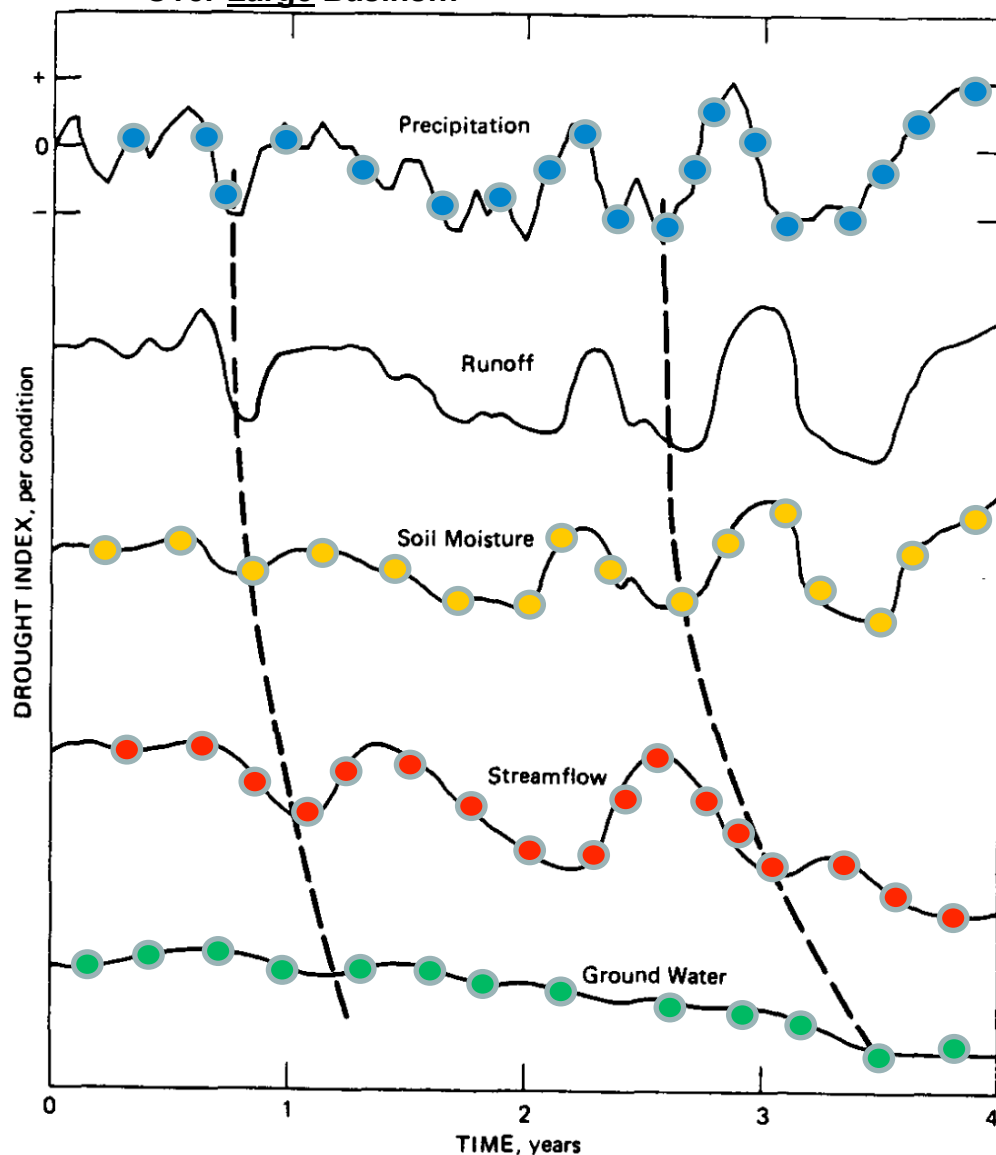
Chagnon (1987)



Multi-Mission Hydrologic Application: Drought Cascade



Over Large Basins...



GPM (Meteorological Drought)
Precipitation Deficit

SMAP (Agricultural Drought)
Soil Moisture Deficit

SWOT (Hydrological Drought)
Streamflow Deficit

GRACE-FO (Hydrological Drought)
Groundwater Deficit

aveat: Missions Overlap



Summary



- NASA SMAP Mission Now in Preparation for Launch on January 8, 2015
- The Instruments are Meeting Requirements; The SMAP Project Will Deliver Unprecedented Products for Science and Applications
- High-Resolution (9 km) Mapping Information on Surface and Rootzone Soil Moisture, Together With in situ and Other Satellite Products, Enable New Capabilities for Monitoring and Forecasting Western Region Hydrology
- The SMAP *Early-Adopter* Program is a Force-Multiplier in the Use of NASA Observations in Applications