Spatio-Temporal Soil Moisture Dry-down for Understanding Drought Mechanisms

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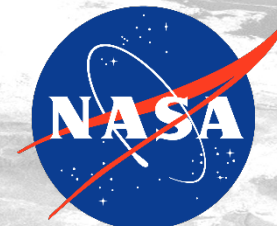
AMS 2023 Annual Meeting

January 8-12,2023

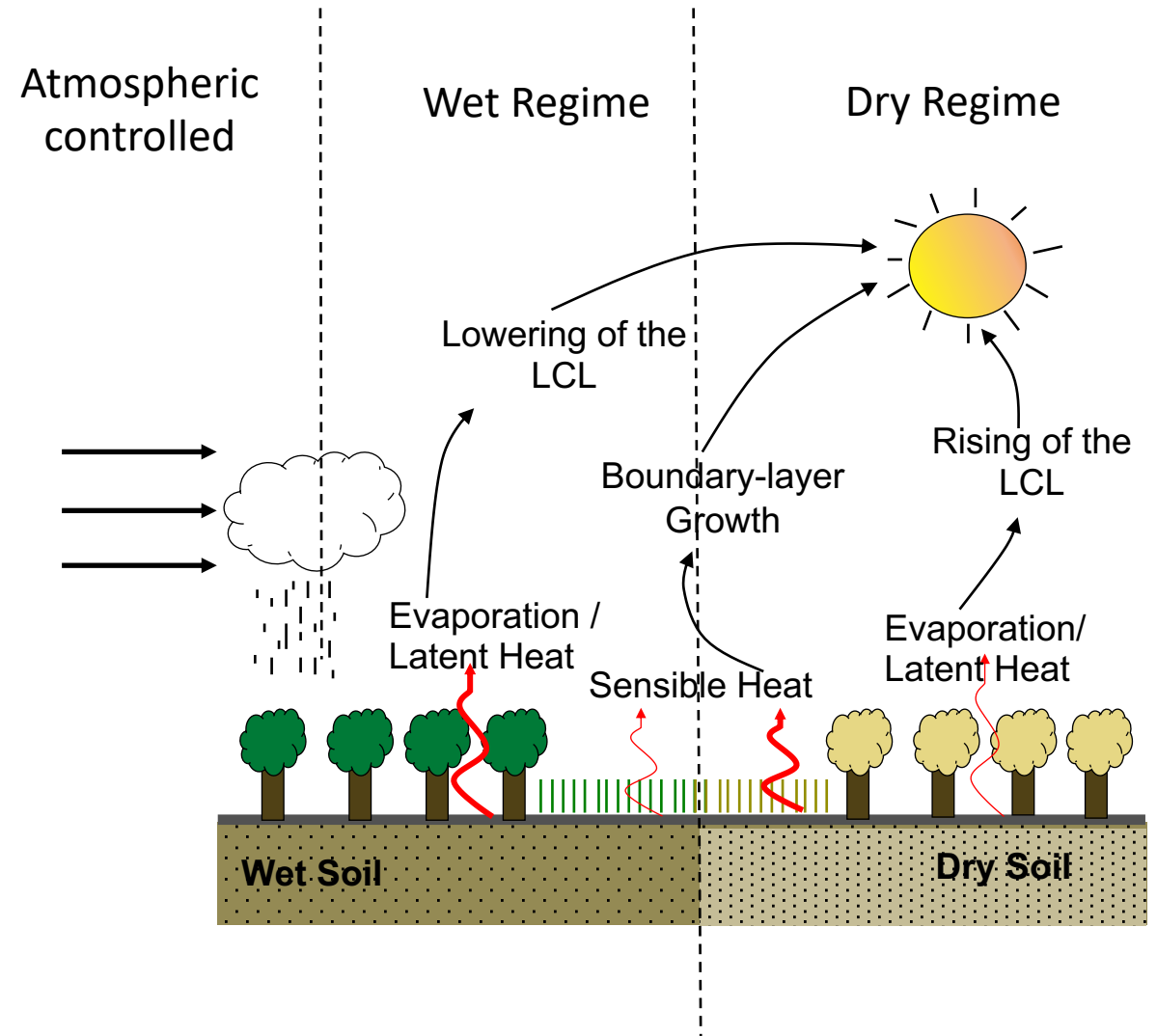**ID #413503**

Why soil moisture?

Key variable

- Monitor the exchange of water and heat energy among land and atmosphere
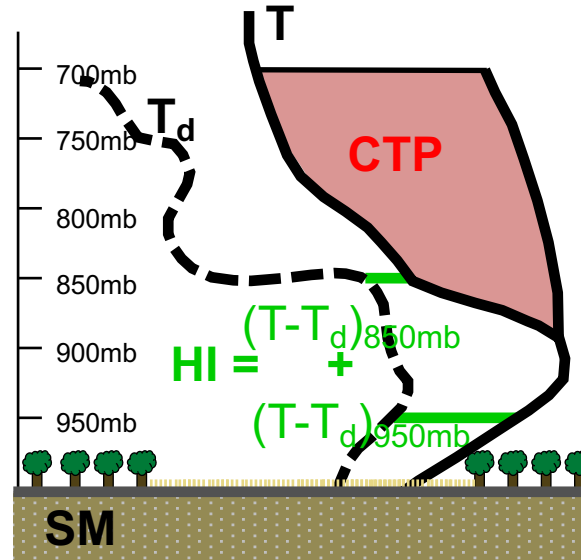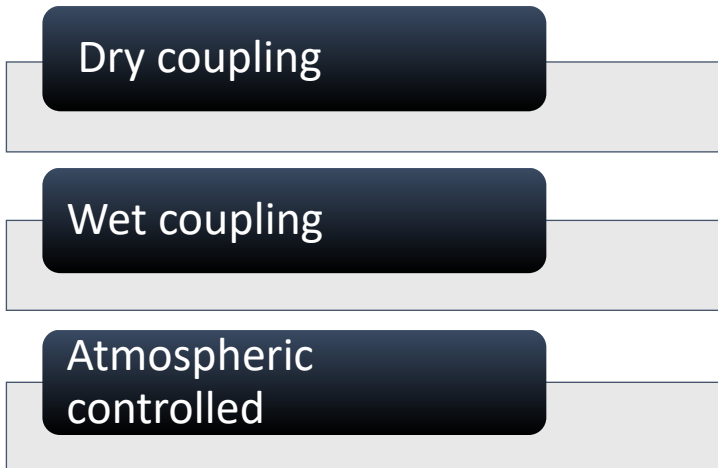
Essential role

- Development of atmospheric response

Summarize coupling regime

- Based on the soil and atmospheric characteristics

Atmospheric controlled

Wet Regime

Dry Regime

Lowering of the LCL

Boundary-layer Growth

Rising of the LCL

Evaporation / Latent Heat

Sensible Heat

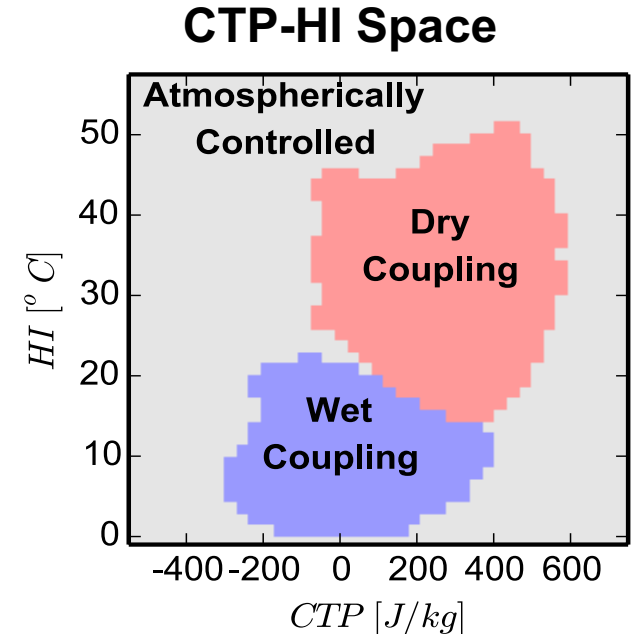Evaporation/ Latent Heat

Wet Soil

Dry Soil

Coupling Classification

- **Goal:** Land-atmosphere interaction-based **drought evolution** using satellite retrieval and reanalysis dataset

- Soil moisture data as a **land state in conjunction with atmospheric response** use to generate coupling regime.
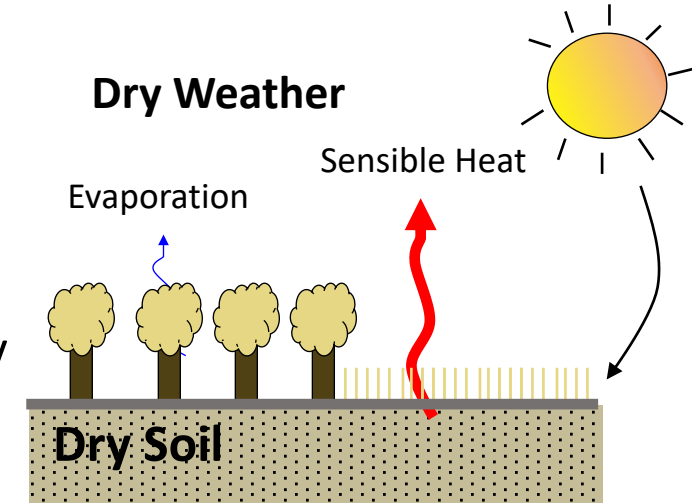
Dry coupling

Wet coupling

Atmospheric controlled

CTP-HI Space

Atmospherically Controlled

Dry Coupling

Wet Coupling

$$HI = (T-T_d)_{850mb} + (T-T_d)_{950mb}$$

Historic Sample

Findell and Eltahir (2003) and extended by Roundy et al. (2013)

Significance of Soil Moisture Dry-Down

Dry Weather

Evaporation

Sensible Heat

Dry Soil

- Scenario: dry weather and dry soil → moisture depleted rapidly → Indicator of drought induced water stress → Rate of change in top layer SM → Identify from soil moisture dry down (**SDD**) analysis.

Objective

1. To assess the global soil moisture dry-down at a temporal scale.
2. What is the role of various dataset product in various coupling regime.
3. How does **SMAP** soil moisture compare to **Reanalysis** for **understanding** the coupling and drought evolution within this framework?

Note: CTP –HI remains consistent to get Coupling Classification
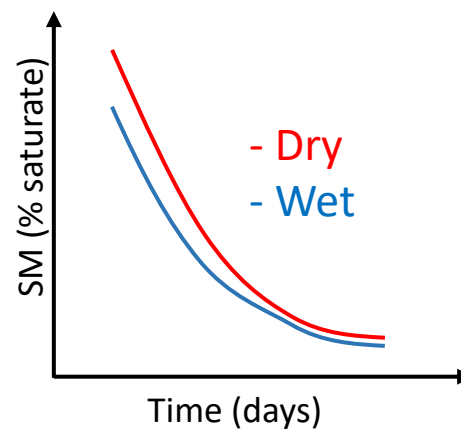**Study area:** The United States
Temporal Scale: May to September (2015 to 2021)

Data Product	Variable	Data length
SMAP L3 (Soil Moisture Active Passive - Enhanced Level 3 Radiometer)	**SM**	**2015 to 2021**
SMAP level 4 (Assimilated soil moisture)	**SM**	**2015 to 2021**
MERRA2 (Modern-Era Retrospective analysis for Research and Applications, Version 2)	**SM**	**2015 to 2021**
CFSR (Climate Forecast System Reanalysis)	**SM**	**2015 to 2021**

Characteristics
Dry-down curve

SM (% saturate)

Time (days)

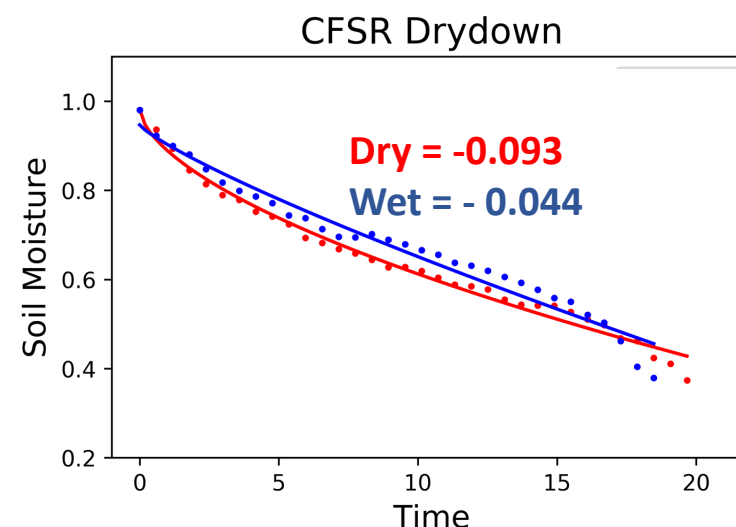SM (% saturate)

Time (days)

SM (% saturate)

$(y = mx^p + b)$

Time (days)
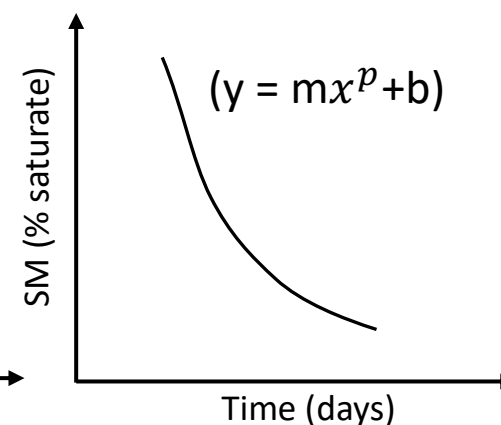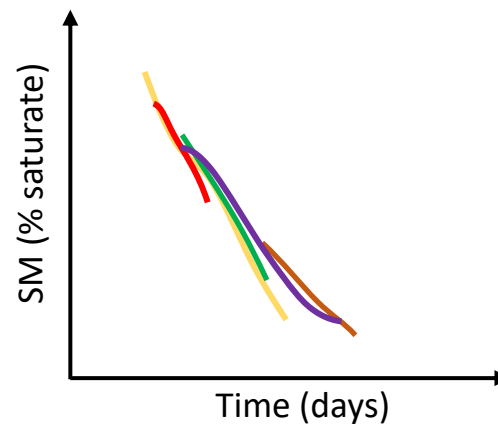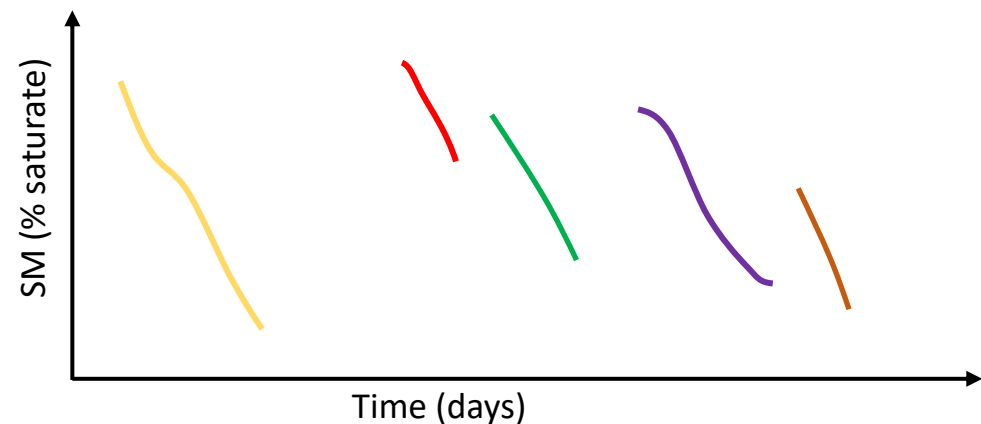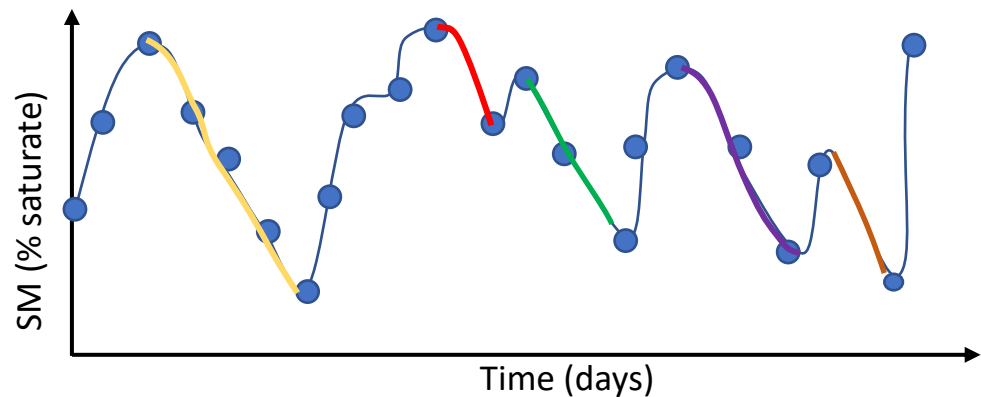
Curve fitting : Non-linear regression
Optimize : Highest goodness of fit (R^2)

SM (% saturate)

Time (days)

SM (% saturate)

- Dry
- Wet

Time (days)

Investigate behavior

• Dry coupling
• Wet coupling
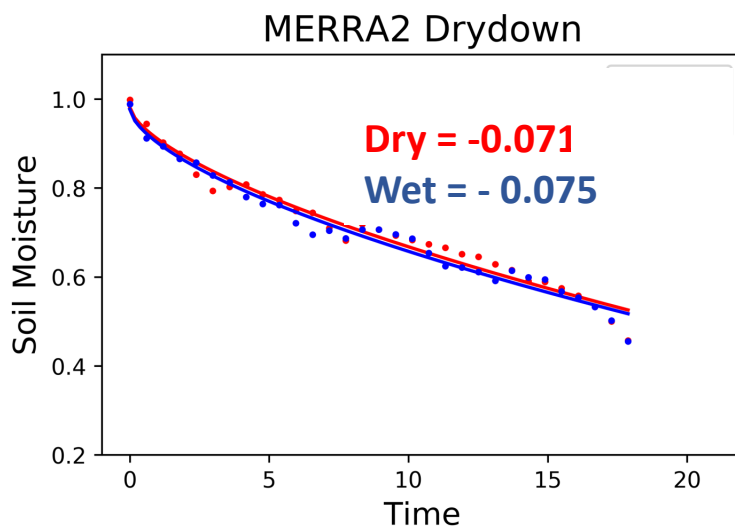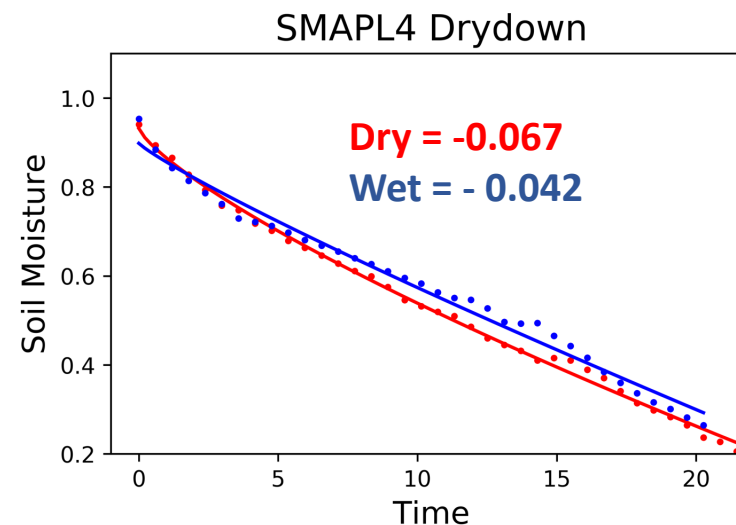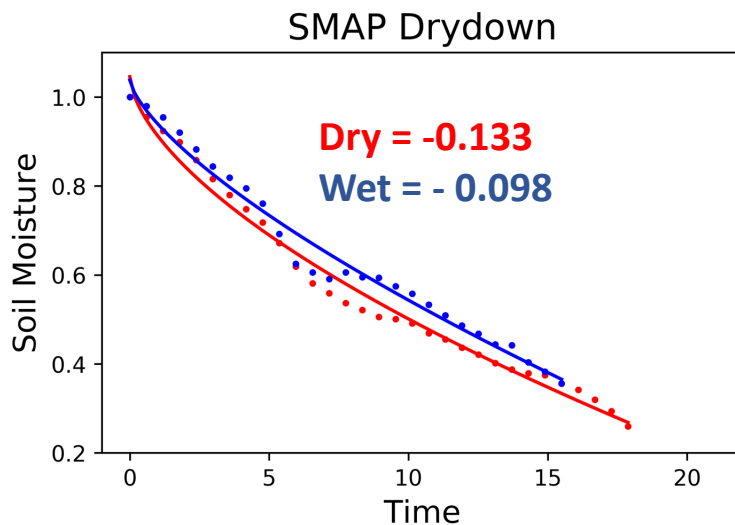
Dry Down

Dry coupling
Wet coupling

Curve fitting = (y = $\mathbf{m}x^p$ +b)
m = slope
   = rate of change
Grid location: 38.95, -95.25
(Lawrence, Kansas)

SMAP Drydown
Dry = -0.133
Wet = - 0.098

SMAPL4 Drydown
Dry = -0.067
Wet = - 0.042

MERRA2 Drydown
Dry = -0.071
Wet = - 0.075

CFSR Drydown
Dry = -0.093
Wet = - 0.044

- SMAP SM dry faster
- Time required to dry down in MERRA2 is similar with SMAP. However, drying amount of MERRA2 is less
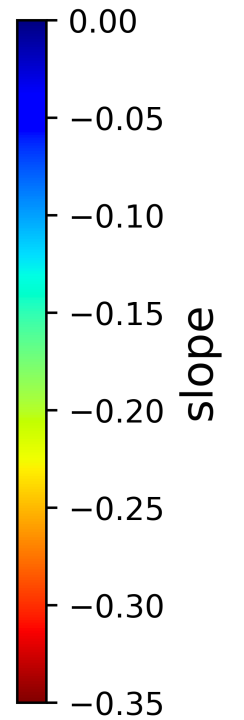- SMAPL4 takes longer time to dry out

Note: Result varies from one location to another

Rate of drying

Wet Coupling
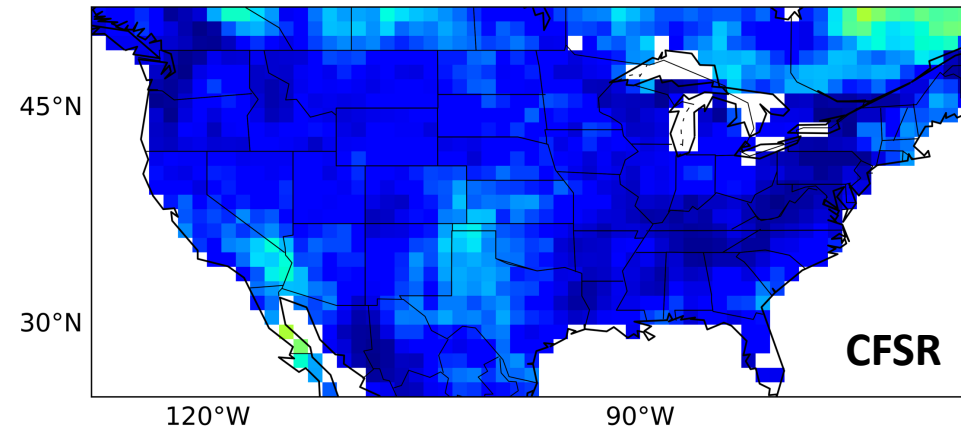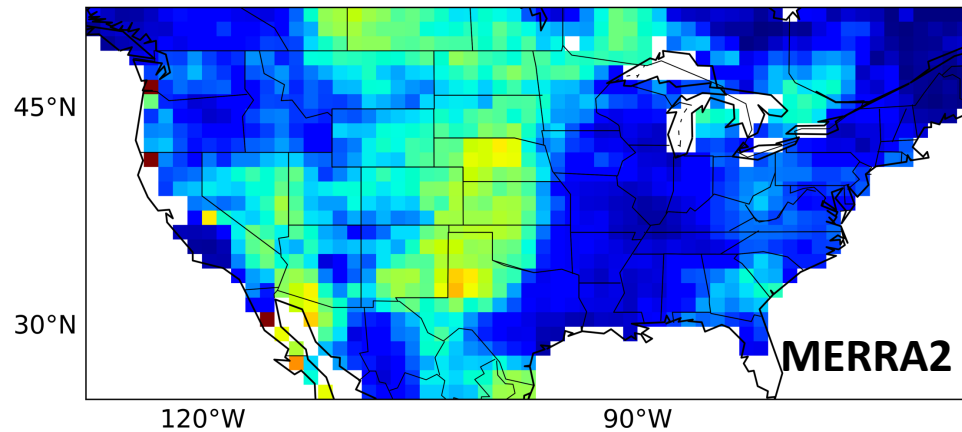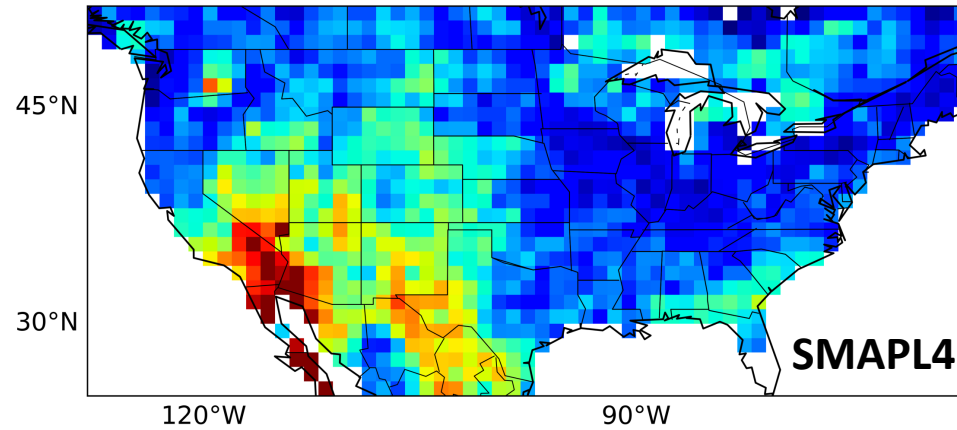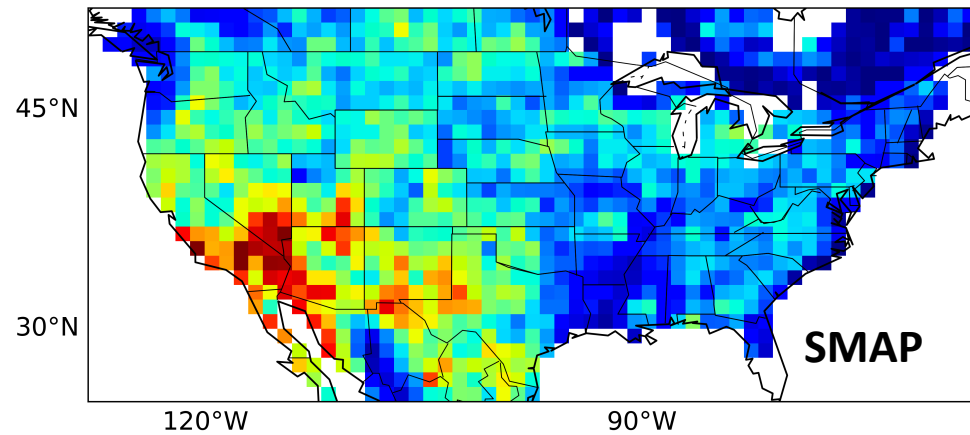
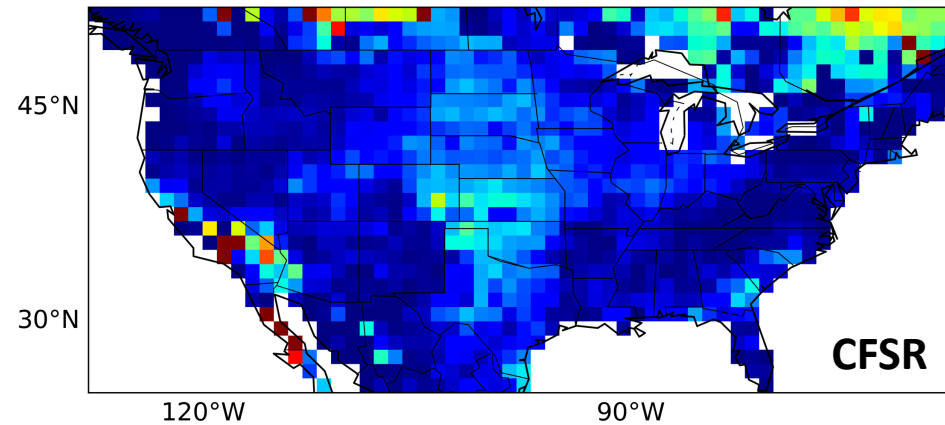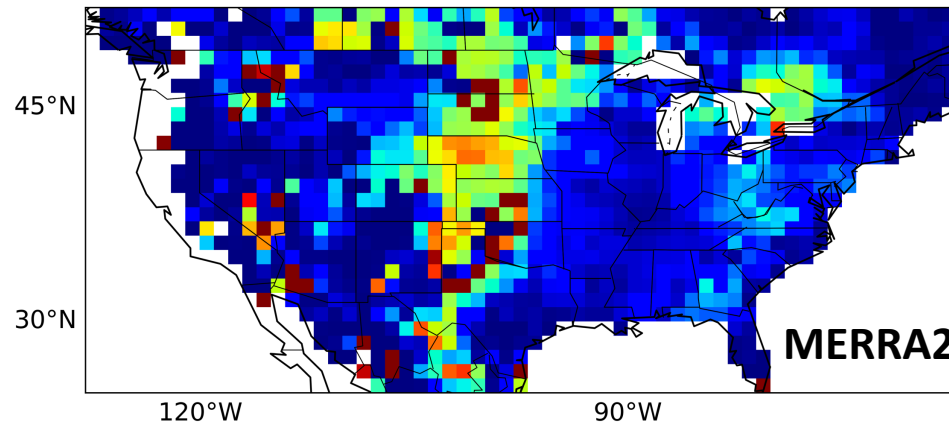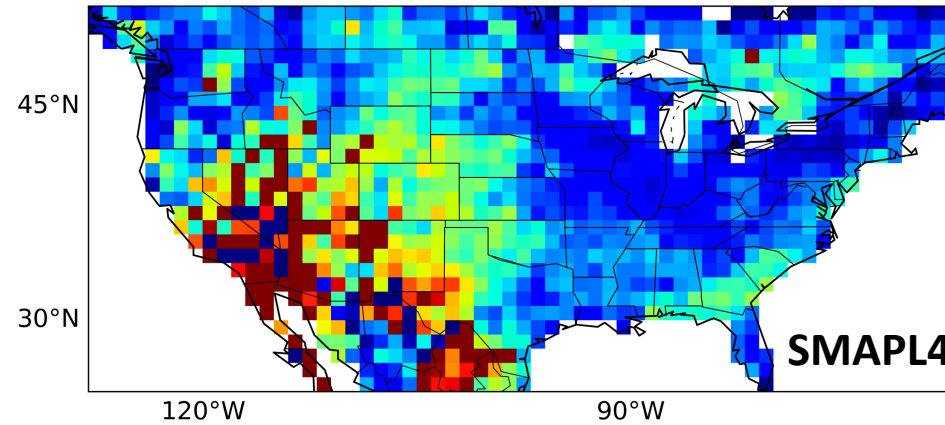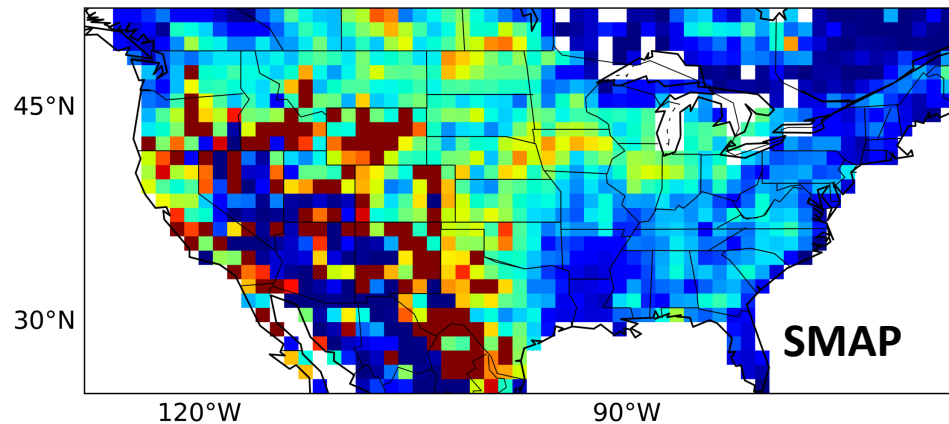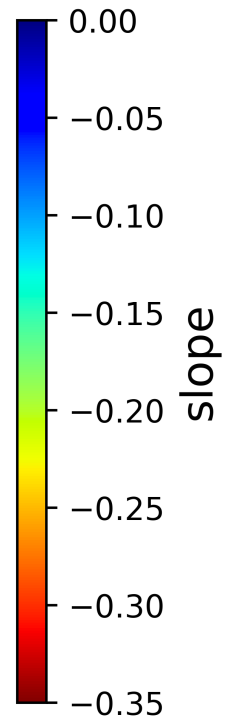- Soil dry faster in western mountain region of USA
- CFSR have less variability in drying rate

Dry Coupling

Rate of drying

- Noisy results on western USA could be Influence by atmospheric demand.
- Rate of change for SMAPL4 is summarize the results from SMAP and MERRA2 in western USA

Persistency

Persistency: Measure of continuousness
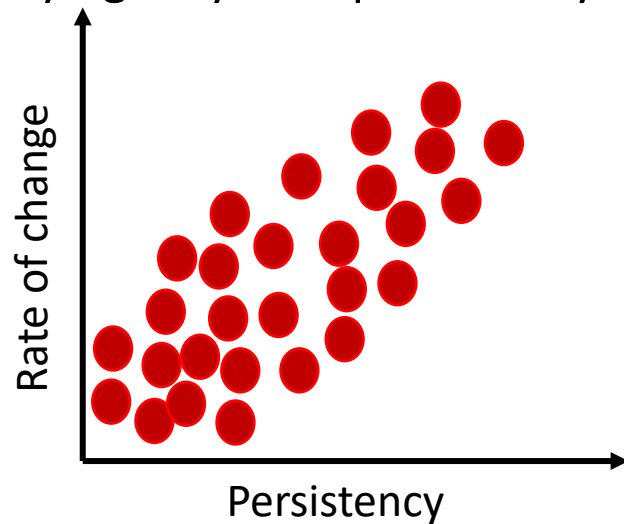
Application : Coupling regime

Hypothesis : Rate of dry-down in dry regime increases with high persistency

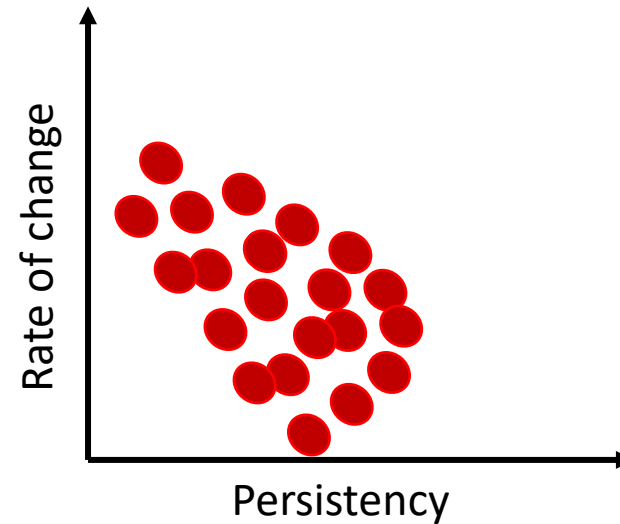: Rate of dry down in wet regime increases with less persistency

→ Loosing moisture

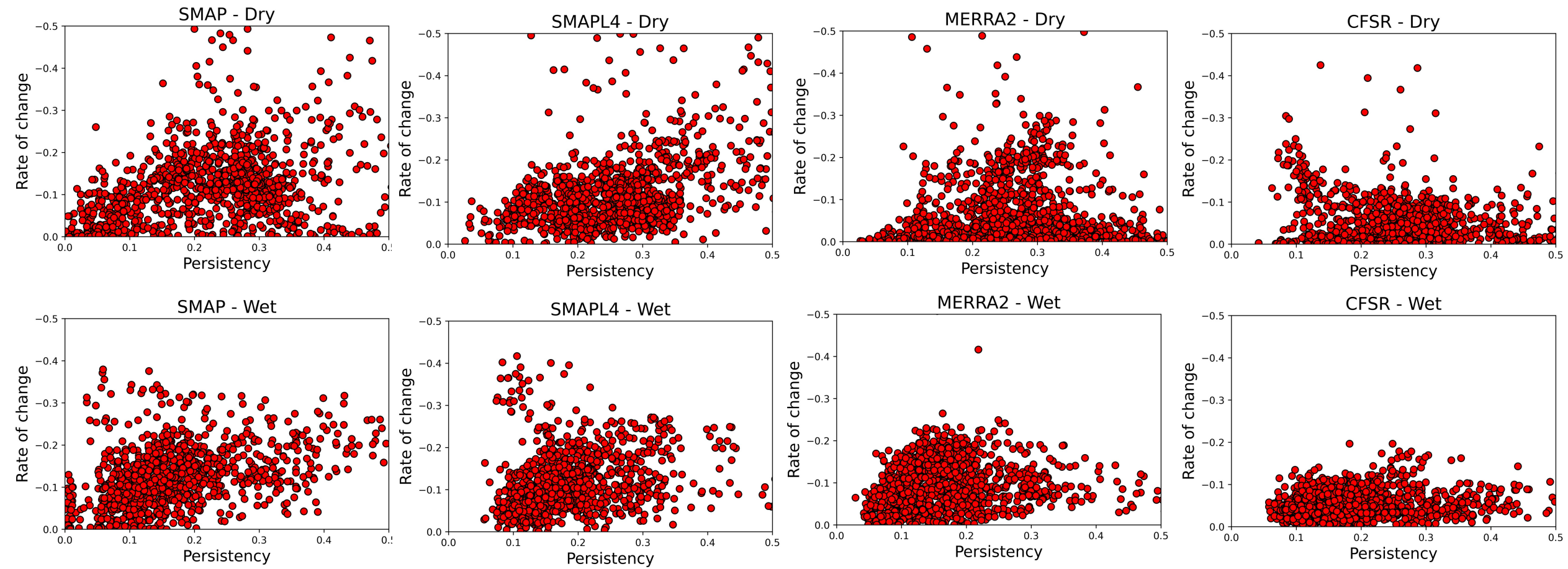→ reaching into dry regime

How rate of drying vary with persistency?

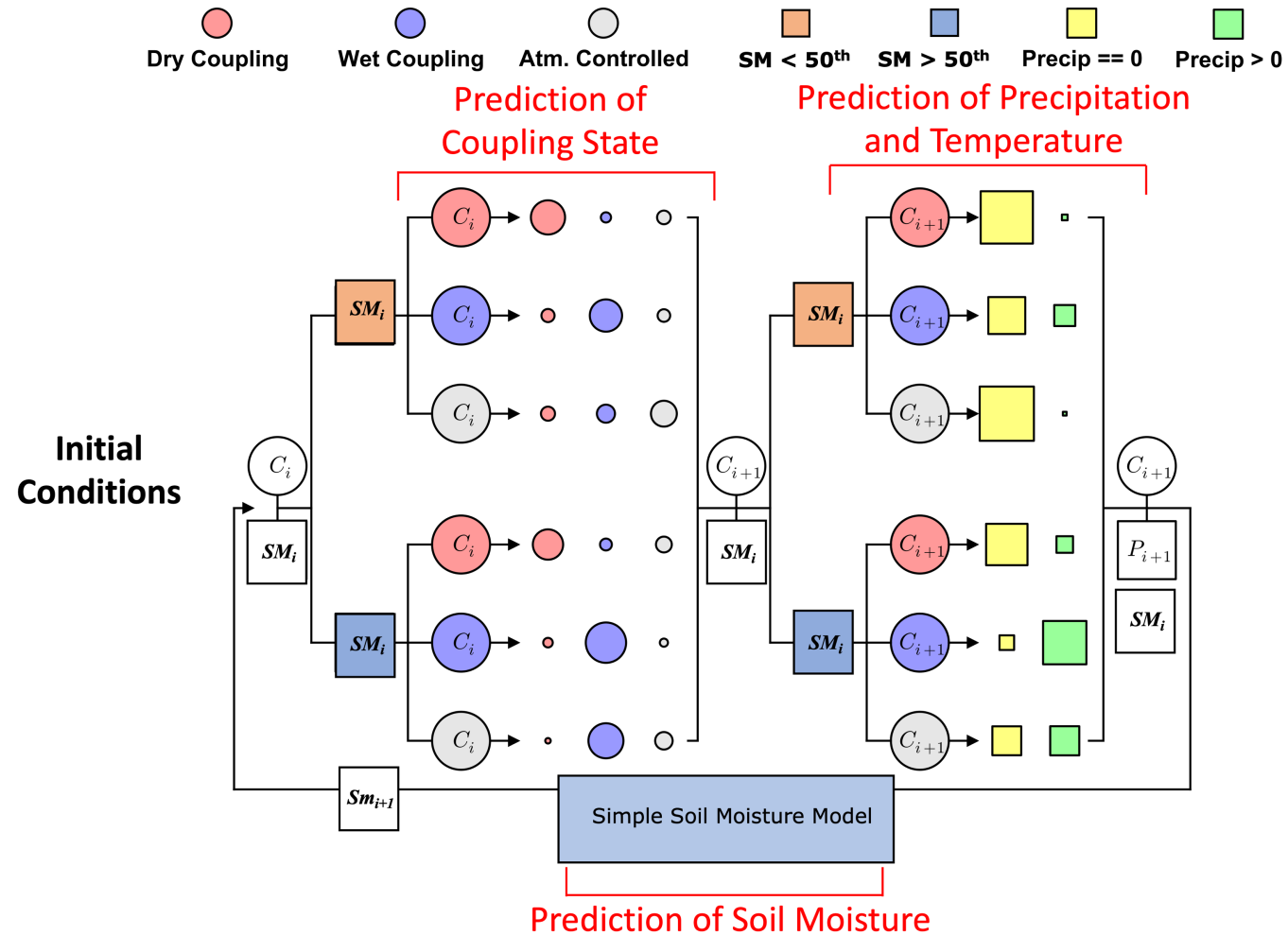**Dry Coupling**

Wet Coupling

Rate of drying vs Persistency

- SMAP, SAMPL4, and MERRA2 have expected results in dry regime
- Results of SMAPL4 is between SMAP and MERRA2 during wet regime
- CFSR have low rate of change over the range of persistency for dry and wet regime

Conclusion and Future work

- Similarity and difference between SMAP and SMAPL4
- SMAP dry faster
- High rate of drying increases the persistency in dry regime.
- ❖ In future,
- How does dry-down for various coupling regime changes with different CTP-HI.
- Need to look at intercept or exponential
- Difference dry down between dry and wet coupling
- Impact of vegetation on dry-down.
- ❖ Application:
- Incorporate dry-down characteristics for prediction of soil moisture in stochastic model for drought forecast followed by persistency of atmospheric response.

Thank You!