Estimates of Smoke Aerosols Using Machine Learning and Climate Forecast Information
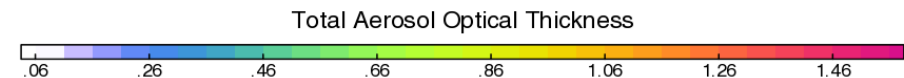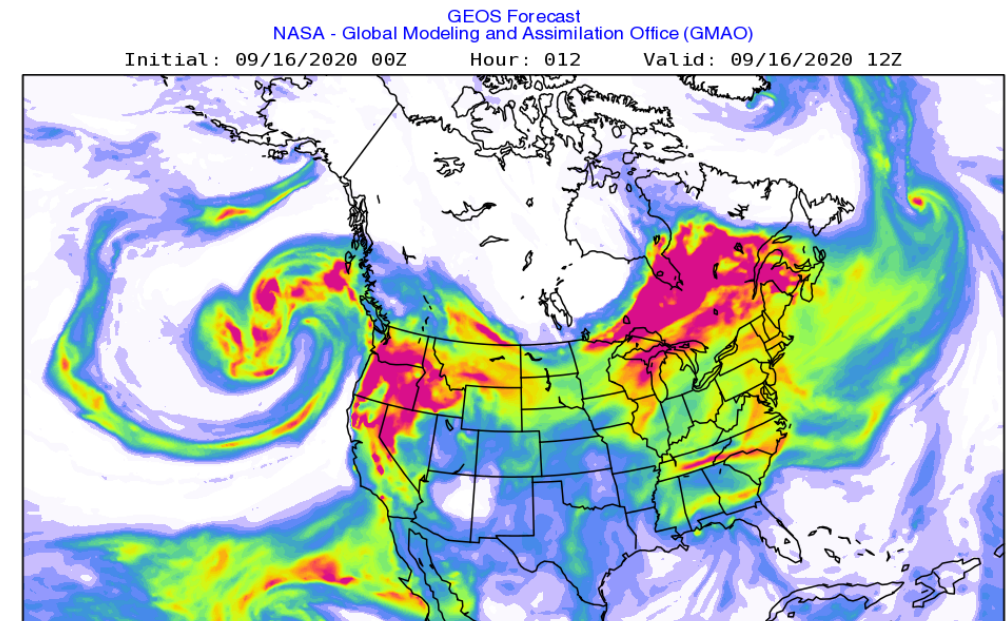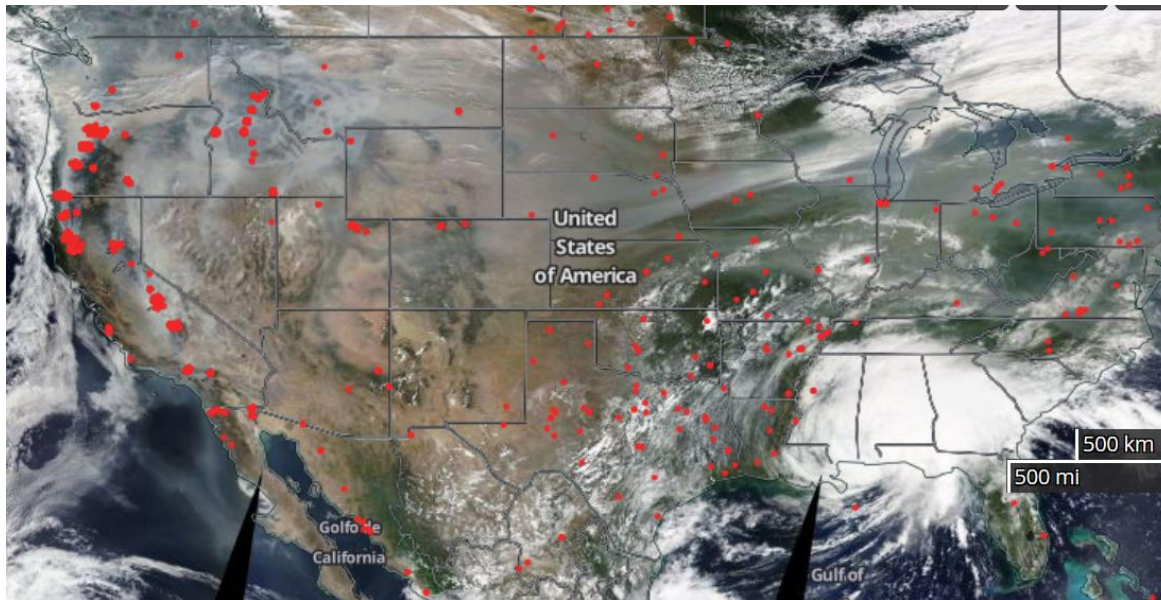
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**VIIRS from WorldView (left) and GEOS-5 AOD (right) for Sept 16, 2020**
Smoke aerosols from wildfire has spread across Pacific Ocean, and affected large areas of North America and beyond

Introduction: Wildfire activities under changing climate

- Wildfire activity is strongly influenced by climate/weather, fuel, ignition agents and human activities.

- Observations and model studies have shown human-induced climate change leads to an increase in areas burned and fire frequency/severity as well as extends wildfire seasons.

- OC/BC emissions in MERRA-2, estimated from satellite fire radiative power (Darmenov and da Silva, 2015)
- Large annual variability and spatial variation among sub-regions
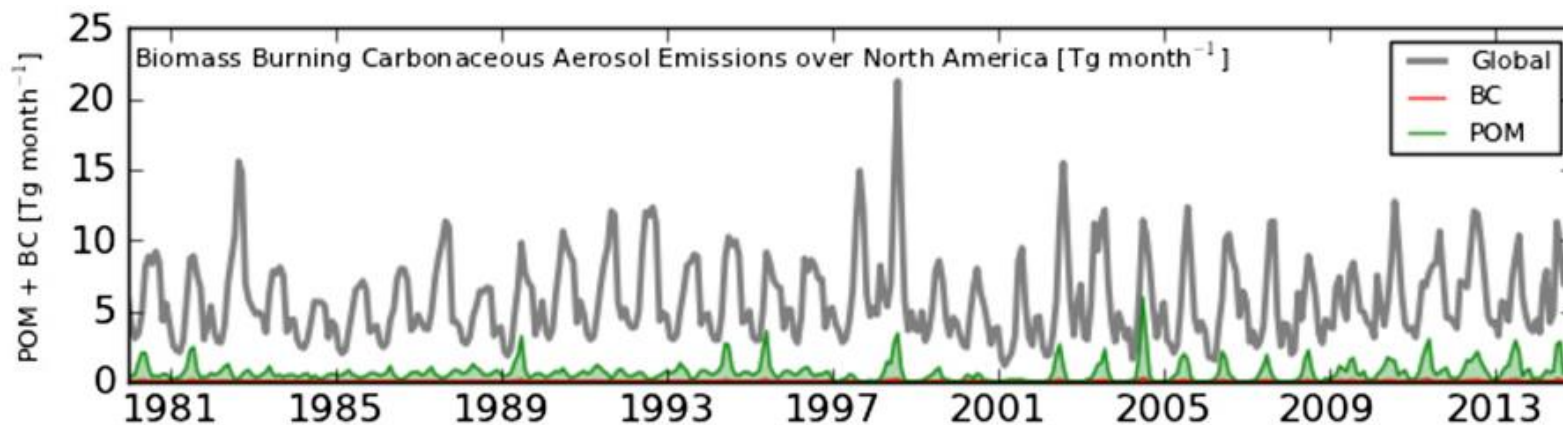
RANDLES et al., (2017)
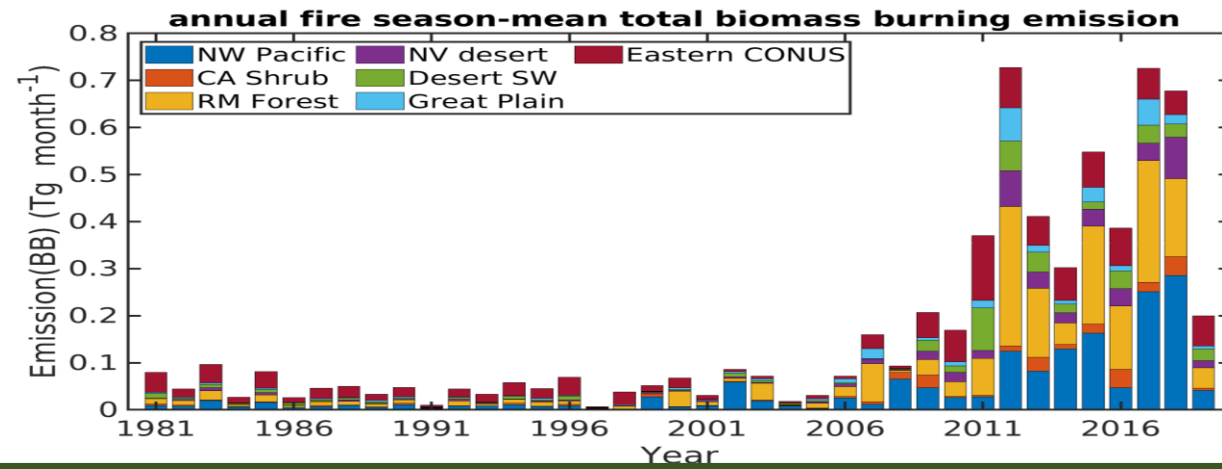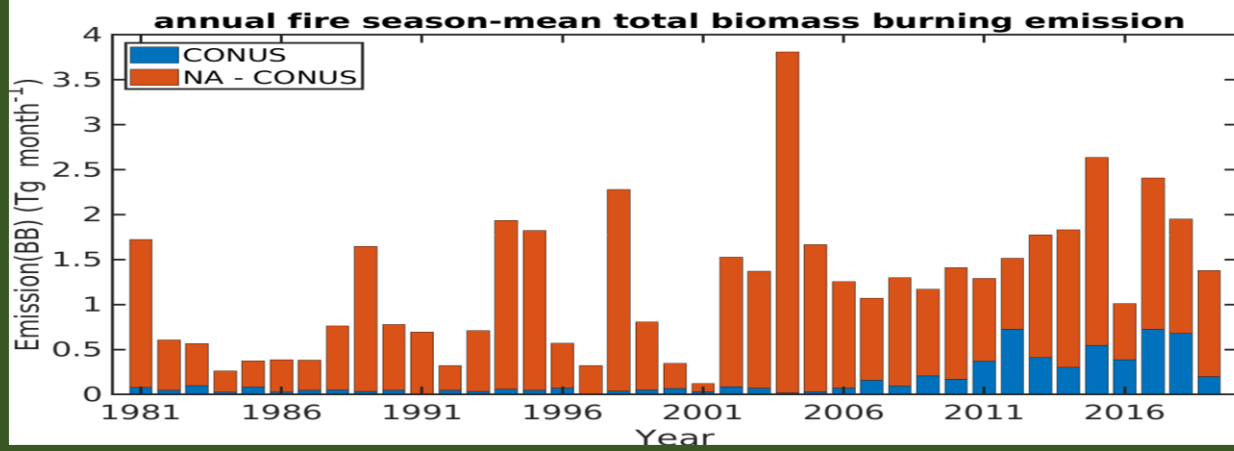
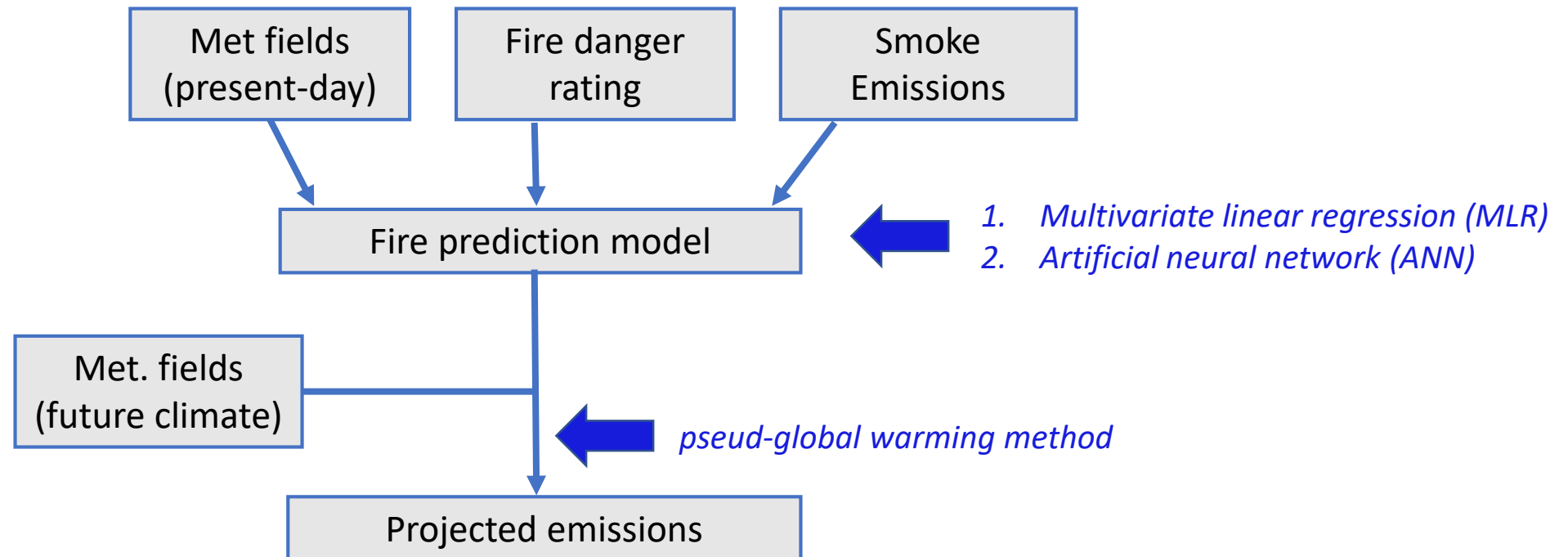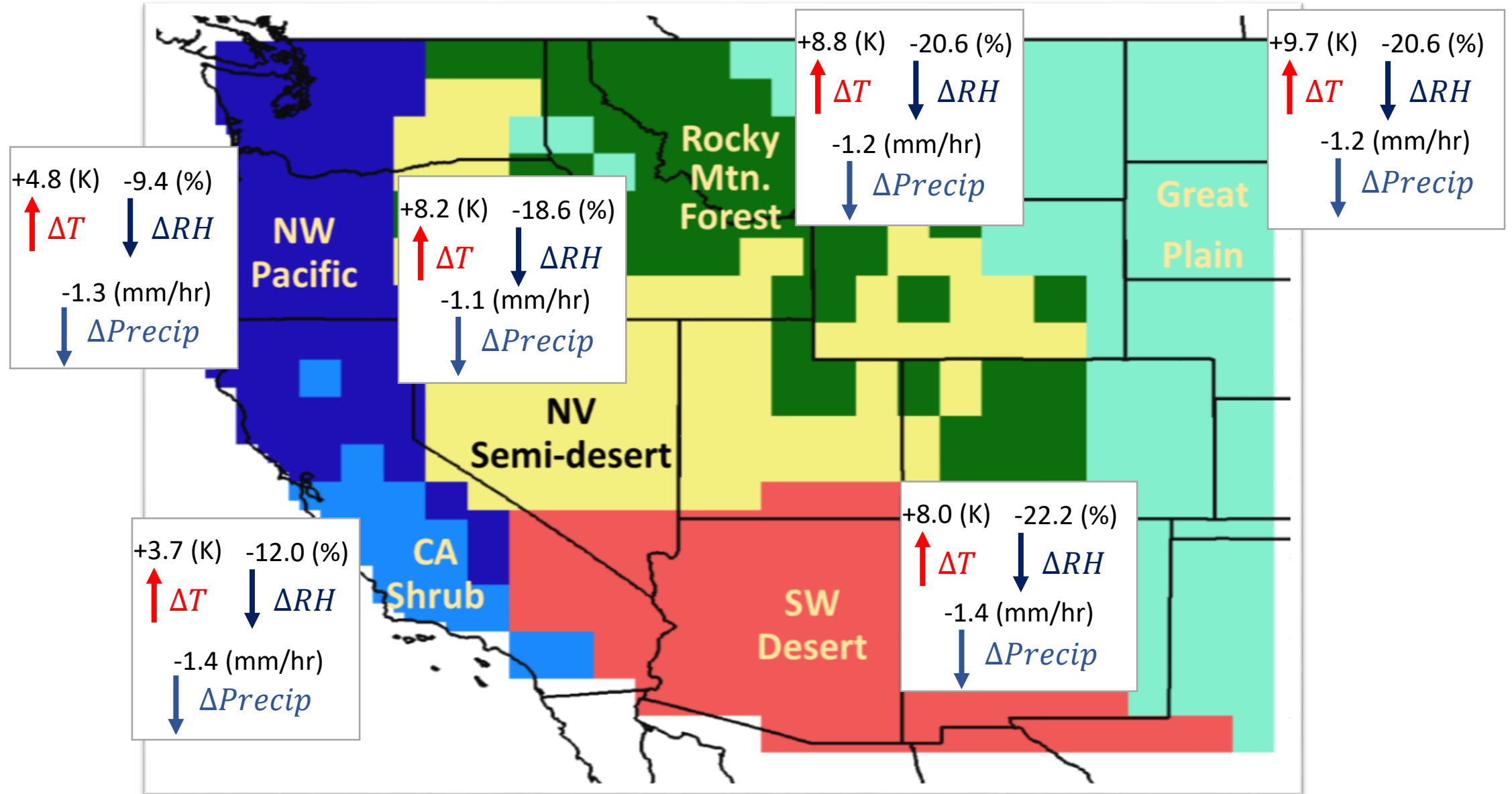- Objective: investigate future regional trends of fire weather extremes and their associated wildfire emissions.

- Methodology: regress satellite derived biomass burning onto simulated meteorological fields and fire indices.

- Dataset:

  1. Time-slice High Resolution Atmosphere Model (HiRAM): Current climate conditions (2000-2015); Future climate conditions (2086-2100, under the Representative Concentration Pathway (RCP) 8.5 scenario

  2. Smoke emissions from MERRA-2: Quick Fire Emissions Dataset (QFED) which is compiled from satellite-observed fire radiative power and fire locations

  3. Fire Weather Index (FWI): The FWI system uses four variables (local noon-time surface temperature, relative humidity (RH), wind speed, and 24-h accumulated rainfall) to calculates daily fuel moisture codes and fire behavior indices.

Projection: warmer, drier, and reduced rainfall
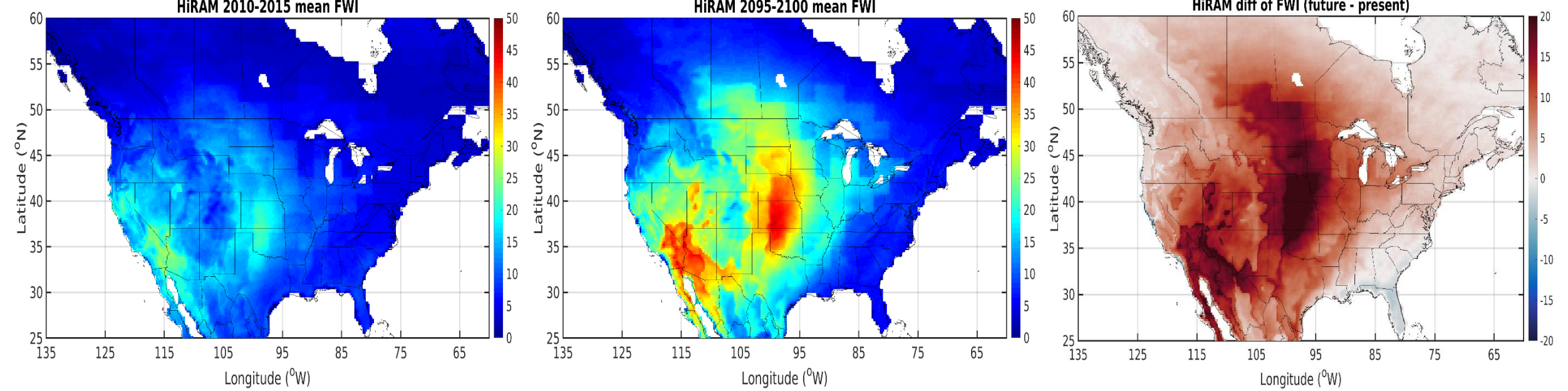
+4.8 (K) -9.4 (%) ΔT ΔRH
-1.3 (mm/hr) $\Delta Precip$

+3.7 (K) -12.0 (%) ΔT ΔRH
-1.4 (mm/hr) $\Delta Precip$

+8.2 (K) -18.6 (%) ΔT ΔRH
-1.1 (mm/hr) $\Delta Precip$

+8.8 (K) -20.6 (%) ΔT ΔRH
-1.2 (mm/hr) $\Delta Precip$

+9.7 (K) -20.6 (%) ΔT ΔRH
-1.2 (mm/hr) $\Delta Precip$

+8.0 (K) -22.2 (%) ΔT ΔRH
-1.4 (mm/hr) $\Delta Precip$

NW Pacific
Rocky Mtn. Forest
Great Plain
NV Semi-desert
CA Shrub
SW Desert

$$\Delta T = \overline{T_{2095-2100}} - \overline{T_{2010-2015}}$$

HiRAM 2010-2015 mean FWI — HiRAM 2095-2100 mean FWI — HiRAM diff of FWI (future - present)

- FWI significantly increases over southwestern and central US in the end of 21st century.
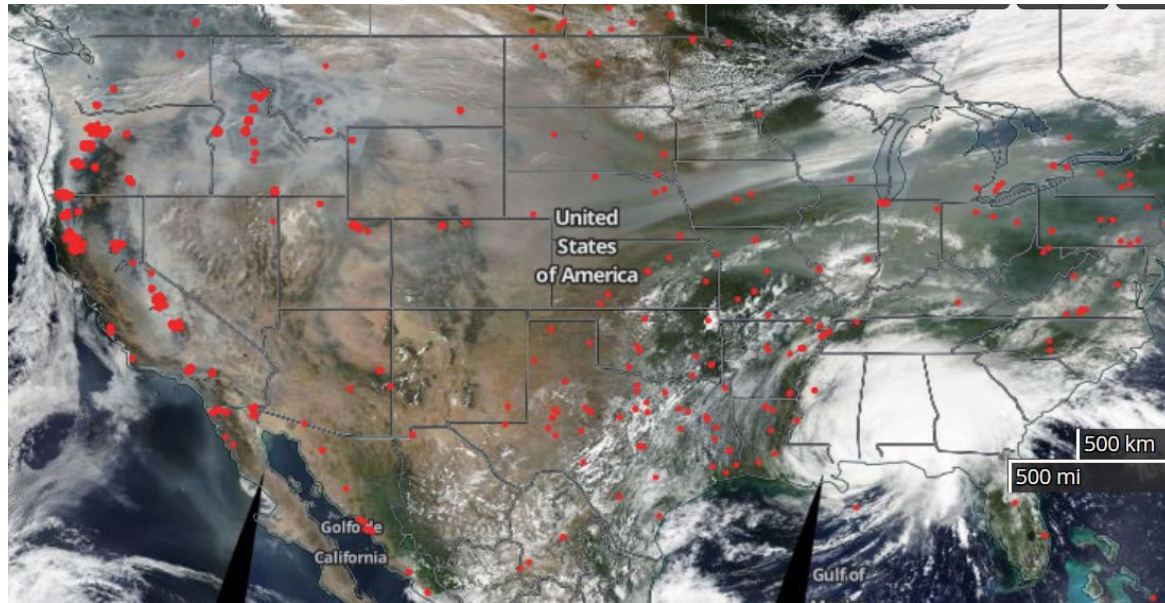- Project increased emissions over western states, except for NV semi-desert (for ANN) and Desert SW (MRL)

ANN

MLR
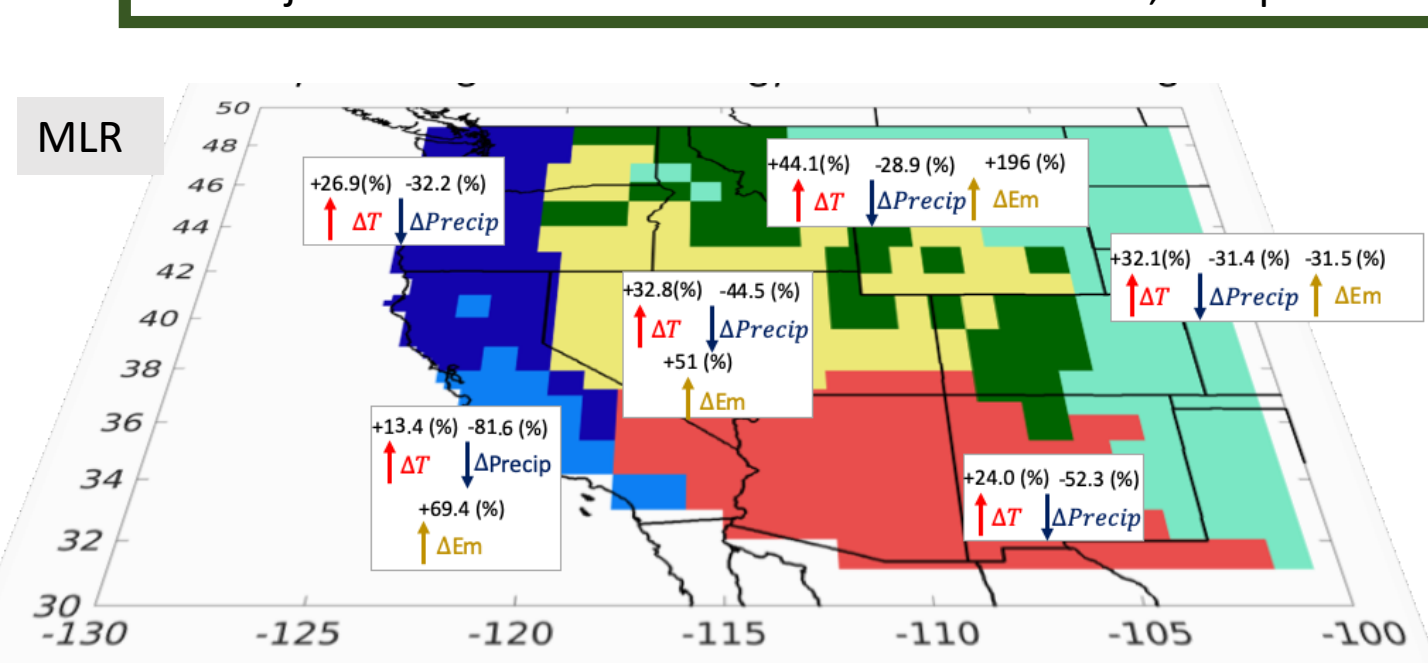
Emission (μg m^{-2} hr^{-1})	MERRA-2 (2005-2019)	Project (NN-Sigmoid)	$\dfrac{Project\_NN\_Sig}{MERRA-2}$
Pacific NW	**197.00**	**538.40**	**2.73**
CA Shrub	**128.74**	**134.66**	**1.05**
RM Forest	**140.39**	**353.72**	**2.52**
NV semi-desert	**36.68**	**7.65**	**0.21**
Desert SW	**42.49**	**63.79**	**1.50**
Great Plain	**18.61**	**59.03**	**3.18**

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Conclusions

- Smoke emissions estimated from satellite are analyzed
  - Large annual variability and regional differences
  - Smoke emissions increase over western states in past 15-year
- Time-slice AGCM is used to project fire activity and emissions
  - FWI significantly increases over southwestern and central US in the end of 21st century.
  - Project increased emissions over western states, except for desert sub-regions