rain-days-hitmiss

December 25, 2021

1 Calculate hit/miss rates for pr, and resp. upper atm averages.

.

- this version loads netcdf files directly via xarray
- "Gridmet data" can now be replaced with any model's output

1.0.1 TODO items

- better graphs (i.e. include lat/lon scale)

[1]:
```
from IPython import display
import numpy as np

#from skimage.metrics import structural_similarity as ssim
import copy
```

[2]:
```
# load netcdf files directly via xarray
import xarray as xr
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy
```

2 Configuration

[3]:
```
# Ordering: nRow ordering: obs, raw, RegCM4, WRF, MPAS, CNN, SDSM, KDDM, MBCn,␣
 ↪LOCA
mpi_sigfiles=['/glade/work/mcginnis/DCA/data/gen/final/gridmet/hist/prec.hist.
 ↪gridMET.obs.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mpi/hist/prec.hist.MPI-ESM-LR.raw.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mpi/rcp85/prec.rcp85.MPI-ESM-LR.raw.day.
 ↪2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/regcm4/hist/prec.hist.MPI-ESM-LR.RegCM4.
 ↪day.1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/regcm4/rcp85/prec.rcp85.MPI-ESM-LR.
 ↪RegCM4.day.2075-2100.NAM-22i.SGP.x098.y36.nc',
```

```
'/glade/work/mcginnis/DCA/data/gen/final/wrf/hist/prec.hist.MPI-ESM-LR.WRF.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/wrf/rcp85/prec.rcp85.MPI-ESM-LR.WRF.day.
 ↪2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mpas/hist/prec.hist.MPI-ESM-LR.MPAS.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mpas/rcp85/prec.rcp85.MPI-ESM-LR.MPAS.
 ↪day.2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/cnn/hist/prec.hist.MPI-ESM-LR.CNN.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/cnn/rcp85/prec.rcp85.MPI-ESM-LR.CNN.day.
 ↪2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/sdsm/hist/prec.hist.MPI-ESM-LR.SDSM.day.
 ↪1976-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/sdsm/rcp85/prec.rcp85.MPI-ESM-LR.SDSM.day.
 ↪2070-2099.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/kddm/hist/prec.hist.MPI-ESM-LR.KDDM.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/kddm/rcp85/prec.rcp85.MPI-ESM-LR.KDDM.
 ↪day.2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mbcn/hist/prec.hist.MPI-ESM-LR.MBCn.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/mbcn/rcp85/prec.rcp85.MPI-ESM-LR.MBCn.
 ↪day.2075-2100.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/loca/hist/prec.hist.MPI-ESM-LR.LOCA.day.
 ↪1980-2005.NAM-22i.SGP.x098.y36.nc',
'/glade/work/mcginnis/DCA/data/gen/final/loca/rcp85/prec.rcp85.MPI-ESM-LR.LOCA.
 ↪day.2075-2100.NAM-22i.SGP.x098.y36.nc']
```

3 Compact Configuration

[4]:
```
sigdir = '/glade/work/mcginnis/DCA/data/gen/final'
def model2absfilepath(mn, exp, x, y):
    if mn == 'obs' or mn == 'gridMET':
        mn = 'gridMET'
        filename = 'prec.{}.gridMET.{}.day.1980-2005.NAM-22i.SGP.x0{}.y{}.nc'.
 ↪format(exp, 'obs', x, y)
    elif mn == 'raw' or mn == 'mpi':
        mn = 'mpi'
        if exp == 'hist':
            filename = 'prec.{}.MPI-ESM-LR.{}.day.1980-2005.NAM-22i.SGP.x0{}.y{}.
 ↪nc'.format(exp, 'raw', x, y)
        elif exp == 'rcp85':
            filename = 'prec.{}.MPI-ESM-LR.{}.day.2075-2100.NAM-22i.SGP.x0{}.y{}.
 ↪nc'.format(exp, 'raw', x, y)
```

```
        else: print("Unknown experiment!")
    elif mn == 'SDSM':  # starts at 1976
        if exp == 'hist':
            filename = 'prec.{}.MPI-ESM-LR.{}.day.1976-2005.NAM-22i.SGP.x0{}.y{}.
↪nc'.format(exp, mn, x, y)
        elif exp == 'rcp85':
            filename = 'prec.{}.MPI-ESM-LR.{}.day.2070-2099.NAM-22i.SGP.x0{}.y{}.
↪nc'.format(exp, mn, x, y)
        else: print("Unknown experiment!")

    elif exp == 'hist':
        filename = 'prec.{}.MPI-ESM-LR.{}.day.1980-2005.NAM-22i.SGP.x0{}.y{}.nc'.
↪format(exp, mn, x, y)
    elif exp == 'rcp85':
        filename = 'prec.{}.MPI-ESM-LR.{}.day.2075-2100.NAM-22i.SGP.x0{}.y{}.nc'.
↪format(exp, mn, x, y)
    else: print("Unknown experiment!")
    return sigdir + '/' + mn.lower() + '/' + exp + '/' + filename
```

[6]:
```
# test single file
model2absfilepath('RegCM4', 'rcp85', 98, 36)
```

[6]:
```
'/glade/work/mcginnis/DCA/data/gen/final/regcm4/rcp85/prec.rcp85.MPI-ESM-
LR.RegCM4.day.2075-2100.NAM-22i.SGP.x098.y36.nc'
```

[7]:
```
# create list of abs filepaths
[model2absfilepath(ff, 'hist', 98, 36) for ff in␣
↪['obs','raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
```

[7]:
```
['/glade/work/mcginnis/DCA/data/gen/final/gridmet/hist/prec.hist.gridMET.obs.day
.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/mpi/hist/prec.hist.MPI-ESM-
LR.raw.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/regcm4/hist/prec.hist.MPI-ESM-
LR.RegCM4.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/wrf/hist/prec.hist.MPI-ESM-
LR.WRF.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/mpas/hist/prec.hist.MPI-ESM-
LR.MPAS.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/cnn/hist/prec.hist.MPI-ESM-
LR.CNN.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/sdsm/hist/prec.hist.MPI-ESM-
LR.SDSM.day.1976-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/kddm/hist/prec.hist.MPI-ESM-
LR.KDDM.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/mbcn/hist/prec.hist.MPI-ESM-
```

```
LR.MBCn.day.1980-2005.NAM-22i.SGP.x098.y36.nc',
 '/glade/work/mcginnis/DCA/data/gen/final/loca/hist/prec.hist.MPI-ESM-
LR.LOCA.day.1980-2005.NAM-22i.SGP.x098.y36.nc']
```

3.0.1 Load model output data

[8]:
```
##################
## LOAD GRIDMET ##
##################
# 1980-1989
istart = 365
#ndays = 3653  # 1980-1989
ndays = 13515 # 1980-2016

dv1 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪prec128_gridmetA_1979-2016.nc')['prec'][istart:istart+ndays]
# dv2 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪tmax128_gridmetA_1979-2016.nc')['tmax'][istart:istart+ndays]
# dv3 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪tmin128_gridmetA_1979-2016.nc')['tmin'][istart:istart+ndays]
# dv4 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪uas128_gridmetA_1979-2016.nc')['uas'][istart:istart+ndays]
# dv5 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪vas128_gridmetA_1979-2016.nc')['vas'][istart:istart+ndays]
# dv6 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪huss128_gridmetA_1979-2016.nc')['huss'][istart:istart+ndays]
# dv7 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪rsds128_gridmetA_1979-2016.nc')['rsds'][istart:istart+ndays]
# dv8 = xr.open_dataset('/glade/work/dkorytin/srgan_data/
 ↪miss128_gridmetB_1979-2016.nc')['miss'][istart:istart+ndays]
```

3.0.2 Load MPI UATM data

[9]:
```
############################
## LOAD ERAI data: daily ##
############################
def load_uatm_erai():
    global mdv1,mdv2,mdv3,mdv4,mdv5,mdv6,mdv7,mdv8,mnvars

    # load eraionmpi
    #mndays = 11688      # 1979-2010
    mstart = 365
    mndays = 13515       # 1980-2016
    mnvars = 8*1
    mdv1 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/U850.ERAI.
 ↪MPIGRID.1979-2018.nc')['U'][mstart:mstart+mndays*1]
```

```
    mdv2 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/V850.ERAI.
↪MPIGRID.1979-2018.nc')['V'][mstart:mstart+mndays*1]
    mdv3 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/Q850.ERAI.
↪MPIGRID.1979-2018.nc')['Q'][mstart:mstart+mndays*1]
    mdv4 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/T700.ERAI.
↪MPIGRID.1979-2018.nc')['T'][mstart:mstart+mndays*1]
    mdv5 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/Z700.ERAI.
↪MPIGRID.1979-2018.nc')['Z'][mstart:mstart+mndays*1]
    mdv6 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/Z500.ERAI.
↪MPIGRID.1979-2018.nc')['Z'][mstart:mstart+mndays*1]
    mdv7 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/U250.ERAI.
↪MPIGRID.1979-2018.nc')['U'][mstart:mstart+mndays*1]
    mdv8 = xr.open_dataset('/glade/scratch/dkorytin/erai-on-mpigrid/V250.ERAI.
↪MPIGRID.1979-2018.nc')['V'][mstart:mstart+mndays*1]

    print("Days loaded", len(mdv7))
```

[10]:
```
###################
## LOAD MPI      ##
###################
def load_uatm_mpi_hist():
    global mdv1,mdv2,mdv3,mdv4,mdv5,mdv6,mdv7,mdv8,mnvars

    mnvars = 8

    d='/glade/p/ral/risc/rmccrary/CMIP5_CORDEX/NAmerica/MPI-ESM-LR/native/
↪historical/'

    mdv1 = xr.
↪open_dataset(d+'U_MPI-ESM-LR_historical_r1i1p1_NAmerica_p850_19500101-20051231_dayavg_mpigrid
↪nc')['U'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv2 = xr.
↪open_dataset(d+'V_MPI-ESM-LR_historical_r1i1p1_NAmerica_p850_19500101-20051231_dayavg_mpigrid
↪nc')['V'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv3 = xr.
↪open_dataset(d+'Q_MPI-ESM-LR_historical_r1i1p1_NAmerica_p850_19500101-20051231_dayavg_mpigrid
↪nc')['Q'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv4 = xr.
↪open_dataset(d+'T_MPI-ESM-LR_historical_r1i1p1_NAmerica_p700_19500101-20051231_dayavg_mpigrid
↪nc')['T'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
```

```
    mdv5 = xr.
↪open_dataset(d+'Z_MPI-ESM-LR_historical_r1i1p1_NAmerica_p700_19500101-20051231_dayavg_mpigrid
↪nc')['Z'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv6 = xr.
↪open_dataset(d+'Z_MPI-ESM-LR_historical_r1i1p1_NAmerica_p500_19500101-20051231_dayavg_mpigrid
↪nc')['Z'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv7 = xr.
↪open_dataset(d+'U_MPI-ESM-LR_historical_r1i1p1_NAmerica_p250_19500101-20051231_dayavg_mpigrid
↪nc')['U'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv8 = xr.
↪open_dataset(d+'V_MPI-ESM-LR_historical_r1i1p1_NAmerica_p250_19500101-20051231_dayavg_mpigrid
↪nc')['V'].sel(time=slice('1976-01-01T00:00:00', '2006-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))

def load_uatm_mpi_future():
    global mdv1,mdv2,mdv3,mdv4,mdv5,mdv6,mdv7,mdv8,mnvars

    d='/glade/p/ral/risc/rmccrary/CMIP5_CORDEX/NAmerica/MPI-ESM-LR/native/rcp85/'

    mnvars = 8
    mdv1 = xr.
↪open_dataset(d+'U_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p850_20060101-21001231_dayavg_mpigrid.
↪nc')['U'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv2 = xr.
↪open_dataset(d+'V_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p850_20060101-21001231_dayavg_mpigrid.
↪nc')['V'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv3 = xr.
↪open_dataset(d+'Q_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p850_20060101-21001231_dayavg_mpigrid.
↪nc')['Q'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv4 = xr.
↪open_dataset(d+'T_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p700_20060101-21001231_dayavg_mpigrid.
↪nc')['T'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv5 = xr.
↪open_dataset(d+'Z_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p700_20060101-21001231_dayavg_mpigrid.
↪nc')['Z'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
```

```
    mdv6 = xr.
↪open_dataset(d+'Z_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p500_20060101-21001231_dayavg_mpigrid.
↪nc')['Z'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv7 = xr.
↪open_dataset(d+'U_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p250_20060101-21001231_dayavg_mpigrid.
↪nc')['U'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))
    mdv8 = xr.
↪open_dataset(d+'V_MPI-ESM-LR_rcp85_r1i1p1_NAmerica_p250_20060101-21001231_dayavg_mpigrid.
↪nc')['V'].sel(time=slice('2006-01-01T00:00:00', '2101-01-01T00:00:00'),␣
↪lat=slice(23,56), lon=slice(-113,-80))

#load_uatm_mpi_future()
```

4 Plot routines

[11]:
```
# plot average rain inputs
def plot_8v(isample):
    varmames = ['U850', 'V850', 'Q850', 'T700', 'Z700', 'Z500', 'U250', 'V250']
    units = ['m/s', 'm/s', 'kg/kg', 'K', 'mb', 'mb', 'm/s', 'm/s']
    fig, axarr = plt.subplots(1, 8, figsize = (20,20))
    for ii in range(8):
        plot = axarr[ii].imshow(isample[ii])
        cbar = fig.colorbar(plot, ax=axarr[ii], orientation="horizontal",␣
↪fraction=0.046, pad=0.016)
        cbar.set_label(units[ii])
        axarr[ii].set_title(varmames[ii])
    plt.show()
```

[66]:
```
# POSTAGE STAMP LAYOUT
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy
import cartopy.feature as cfeature

from os.path import basename
from mpl_toolkits.axes_grid1.inset_locator import inset_axes
import matplotlib.ticker as ticker
from matplotlib import ticker

import warnings
warnings.filterwarnings("ignore")
```

```
#def plot_postage(avginput_list, title):
def plot_postage(avginput_list, model_names, miss_counts, all_days_count, title):

    varmames = ['U850', 'V850', 'Q850', 'T700', 'Z700', 'Z500', 'U250', 'V250']
    units = ['m/s', 'm/s', 'kg/kg', 'K', 'mb', 'mb', 'm/s', 'm/s']

    # remove models with < 25 hit/miss counts
    avginput_list2 = []
    model_names2 = []
    miss_counts2 = []
    for ii in range(len(avginput_list)):
        if miss_counts[ii] >= 25:
            avginput_list2.append(avginput_list[ii])
            model_names2.append(model_names[ii])
            miss_counts2.append(miss_counts[ii])

    # find min/max values for entire sigfiles set
    vmin = np.ones(8)*9999
    vmax = np.ones(8)*-9999
    for vii in range(8):
        # find min
        all_plots = np.array(copy.deepcopy(avginput_list2))
        all_plots[np.isnan(all_plots)] = 9999
        vmin[vii] = all_plots[:,vii].min()
        # find max
        all_plots = np.array(copy.deepcopy(avginput_list2))
        all_plots[np.isnan(all_plots)] = -9999
        vmax[vii] = all_plots[:,vii].max()


    # CLIM colors
    cmaps = ['PiYG', 'PuOr', 'BrBG', 'RdBu_r', 'Spectral', 'Spectral', 'PiYG',␣
↪'PuOr']  # CLIM
    # ALL Ranges centered on zero for U, V
    for ii in range(8):
        vmin[ii] = -max(abs(vmin[ii]), abs(vmax[ii]))
        vmax[ii] = max(abs(vmin[ii]), abs(vmax[ii]))


    #fig, axarr = plt.subplots(nrows=3, ncols=8, figsize = (10,10*(3/8.+0.0)),␣
↪gridspec_kw={'hspace': 0.0, 'wspace': 0.0, 'height_ratios':[1,1,1.3]})
    fig, axarr = plt.subplots(nrows=len(avginput_list2), ncols=8, figsize =␣
↪(20,20*(len(avginput_list2)/8.+0.0)), subplot_kw={'projection': ccrs.
↪PlateCarree()}, gridspec_kw={'hspace': 0.0, 'wspace': 0.0, 'height_ratios':
↪[1]*(len(avginput_list2)-1)+[1.313]})
    lon = mdv1[0].lon
    lat = mdv1[0].lat
```

```
    # plots
    for jj in range(len(avginput_list2)):

        for ii in range(8):
            axarr[jj,ii].coastlines()
            axarr[jj,ii].add_feature(cfeature.STATES)
            img_extent = (lon.min(), lon.max(), lat.min(), lat.max())

            #plot = axarr[jj,ii].imshow(avginput[ii][::-1,:], vmin=vmin[ii],␣
↪vmax=vmax[ii], cmap=cmaps[ii])
            plot = axarr[jj,ii].imshow(avginput_list2[jj][ii][::-1,:],␣
↪vmin=vmin[ii], vmax=vmax[ii], cmap=cmaps[ii], origin='upper',␣
↪extent=img_extent, transform=ccrs.PlateCarree())
            #plot = axarr[jj,ii].imshow(avginput_list2[jj][ii][::-1,:],␣
↪cmap=cmaps[ii], origin='upper', extent=img_extent, transform=ccrs.
↪PlateCarree())

            # show y tics on first column
            if ii==0:
                axarr[jj,ii].get_yaxis().set_visible(True)
                axarr[jj,ii].tick_params(labelsize='xx-small')

                # We need to draw the canvas, otherwise the labels won't be␣
↪positioned and
                # won't have values yet.
                fig.canvas.draw()

                # lat range: 56 to 23
                labels = [item.get_text() for item in axarr[jj,ii].
↪get_yticklabels()]
                #labels = ['56','46','36','26']
                axarr[jj,ii].set_yticklabels(labels)

            ## show y labels on last column
            #if ii==7:
                ##axarr[jj,ii].get_yaxis().set_visible(True)
                ##axarr[jj,ii].tick_params(labelsize='xx-small')
                #
                #cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.03, pad=0.2)
                #
                #
                ##ax.set_ylabel("Label", rotation=270)
                #
```

```
                ##cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="vertical", fraction=0.046, pad=0.016)
                #cbar.set_label('dry', rotation=90, size='xx-small')
                #cbar.ax.tick_params(labelsize='xx-small')




            if ii>=1:
                axarr[jj,ii].get_yaxis().set_visible(False)
                axarr[jj,ii].tick_params(labelsize='xx-small')



            if jj == 0:
                axarr[jj,ii].set_title(varmames[ii])
                axarr[jj,ii].get_xaxis().set_visible(False)
                axarr[jj,ii].tick_params(labelsize='xx-small')

            if jj==1:
                axarr[jj,ii].get_xaxis().set_visible(False)
                #axarr[jj,ii].tick_params(labelsize='xx-small')

            # show custom tics on bottom row: lon=slice(-113,-80)
            if jj==len(avginput_list2)-1:
                axarr[jj,ii].get_xaxis().set_visible(True)
                axarr[jj,ii].tick_params(labelsize='xx-small')

                # We need to draw the canvas, otherwise the labels won't be␣
↪positioned and
                # won't have values yet.
                fig.canvas.draw()

                labels = [item.get_text() for item in axarr[jj,ii].
↪get_xticklabels()]
                #labels[1] = '-113'
                #labels[2] = '-103'
                #labels[3] = '-93'
                ##labels[4] = '-83'
                axarr[jj,ii].set_xticklabels(labels)



            # colorbar only on 3rd postage stamp
            if jj==len(avginput_list2)-1:
```

```
                # use scientific notation on 3rd column colorbar only
                if ii == 2:
                    def fmt(x, pos):
                        a, b = '{:.1e}'.format(x).split('e')
                        b = int(b)
                        return r'${}e{}$'.format(a, b)
                    cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format=ticker.
↪FuncFormatter(fmt))
                    #cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format='%.0e')␣
↪#format=ticker.FuncFormatter(fmt))
                    #cbar.set_ticks([0.2, 0.4, 0.6, 0.8])
                    #cbar.set_ticklabels(["A", "B", "C", "D"])
                    tick_locator = ticker.MaxNLocator(nbins=4)
                    cbar.locator = tick_locator
                    cbar.update_ticks()
                else:
                    cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format=None)

                cbar.set_label(units[ii], size='xx-small')
                cbar.ax.tick_params(labelsize='xx-small')

            # row titles
            #sigfilename = basename(sigfile)
            ##print ("days:", count, ", model:", sigfilename)
            #label = ' '.join(sigfn1.split('.')[3:4])
            label = 'nolabel'

            nrows = len(avginput_list2)
            #plt.figtext(0.09, 1-(1.4/nrows)-jj*(.73/nrows), label+':␣
↪'+str(int(counts[jj]*100))+'%', fontsize=11, rotation=90)
            #plt.figtext(0.095, 1-(1.55/9)-jj*(.74/nrows), label+':␣
↪'+str(int(counts1[jj]*100))+'%', fontsize=11, weight='normal', rotation=90)
            #plt.figtext(0.095, 1-(1.3/(5+nrows))-jj*(.72/nrows),␣
↪model_names2[jj]+': '+str(int(miss_counts2[jj]))+'/
↪'+str(int(all_days_count))+'', fontsize=11, weight='normal', rotation=90)
            plt.figtext(0.095, .65+(0.023*nrows)-jj*(.72/nrows),␣
↪model_names2[jj]+': '+str(int(miss_counts2[jj]))+'/
↪'+str(int(all_days_count))+'', fontsize=11, weight='normal', rotation=90)



#         # row title
```

```
#         sigfilename = basename(sigfile)
#         #print ("days:", count, ", model:", sigfilename)
#         rowtitle = ' '.join(sigfilename.split('.')[0:4]) # + ' Count:␣
↪'+str(counts)

        # title
        #fig.suptitle(title, y=1.05, fontsize=14)
        #fig.suptitle(title, y=1-(.5/nrows), fontsize=14, fontweight="bold")
        fig.suptitle(title, y=0.92 + .08/nrows, fontsize=14)


        #plt.subplots_adjust(left=0.1, right=0.9, bottom=0.1, top=0.9, wspace=0,␣
↪hspace=0)
        #plt.subplots_adjust(wspace=0, hspace=0)
        #plt.subplots_adjust(wspace=0.0, hspace=0, right=0.7)

    plt.show()
```

[23]:
```
def plot_3x3_matrix(avginput_matrix_list, vii, title):
    cmaps = ['PiYG', 'PuOr', 'BrBG', 'RdBu_r', 'Spectral', 'Spectral', 'PiYG',␣
↪'PuOr']  # CLIM
    varmames = ['U850', 'V850', 'Q850', 'T700', 'Z700', 'Z500', 'U250', 'V250']
    units = ['m/s', 'm/s', 'kg/kg', 'K', 'mb', 'mb', 'm/s', 'm/s']

    # find min/max values for entire sigfiles set
    vmin = np.zeros(8)
    vmax = np.zeros(8)
    # find min
    all_plots = np.array(copy.deepcopy(avginput_matrix_list))
    all_plots[np.isnan(all_plots)] = 9999
    vmin[vii] = all_plots[:,vii].min()
    # find max
    all_plots = np.array(copy.deepcopy(avginput_matrix_list))
    all_plots[np.isnan(all_plots)] = -9999
    vmax[vii] = all_plots[:,vii].max()


    #fig, axarr = plt.subplots(nrows=3, ncols=8, figsize = (10,10*(3/8.+0.0)),␣
↪gridspec_kw={'hspace': 0.0, 'wspace': 0.0, 'height_ratios':[1,1,1.3]})
    fig, axarr = plt.subplots(nrows=3, ncols=3, figsize = (10,10),␣
↪subplot_kw={'projection': ccrs.PlateCarree()}, gridspec_kw={'hspace': 0.0,␣
↪'wspace': 0.0, 'height_ratios':[1, 1,1.313]})
    lon = mdv1[0].lon
    lat = mdv1[0].lat

    # plots
```

```
   for jj in range(3):

       for ii in range(3):
           axarr[jj,ii].coastlines()
           axarr[jj,ii].add_feature(cfeature.STATES)
           img_extent = (lon.min(), lon.max(), lat.min(), lat.max())

           #plot = axarr[jj,ii].imshow(avginput[ii][::-1,:], vmin=vmin[ii],␣
↪vmax=vmax[ii], cmap=cmaps[ii])
           plot = axarr[jj,ii].imshow(avginput_matrix_list[jj*3+ii][vii][::-1,:
↪], vmin=vmin[vii], vmax=vmax[vii], cmap=cmaps[vii], origin='upper',␣
↪extent=img_extent, transform=ccrs.PlateCarree())

                       # show y tics on first column
           if ii==0:
               axarr[jj,ii].get_yaxis().set_visible(True)
               axarr[jj,ii].tick_params(labelsize='xx-small')

               # We need to draw the canvas, otherwise the labels won't be␣
↪positioned and
               # won't have values yet.
               fig.canvas.draw()

               # lat range: 56 to 23
               labels = [item.get_text() for item in axarr[jj,ii].
↪get_yticklabels()]
               #labels = ['56','46','36','26']
               axarr[jj,ii].set_yticklabels(labels)
           if ii>=1:
               axarr[jj,ii].get_yaxis().set_visible(False)
               axarr[jj,ii].tick_params(labelsize='xx-small')



           if jj == 0:
               axarr[jj,ii].set_title(varmames[vii])
               axarr[jj,ii].get_xaxis().set_visible(False)
               axarr[jj,ii].tick_params(labelsize='xx-small')

           if jj==1:
               axarr[jj,ii].get_xaxis().set_visible(False)
               #axarr[jj,ii].tick_params(labelsize='xx-small')

           # show custom tics on bottom row: lon=slice(-113,-80)
           if jj==3-1:
               axarr[jj,ii].get_xaxis().set_visible(True)
               axarr[jj,ii].tick_params(labelsize='xx-small')
```

```
                # We need to draw the canvas, otherwise the labels won't be␣
↪positioned and
                # won't have values yet.
                fig.canvas.draw()

                labels = [item.get_text() for item in axarr[jj,ii].
↪get_xticklabels()]
                #labels[1] = '-113'
                #labels[2] = '-103'
                #labels[3] = '-93'
                ##labels[4] = '-83'
                axarr[jj,ii].set_xticklabels(labels)



            # colorbar only on 3rd postage stamp
            if jj==3-1:
                # use scientific notation on 3rd column colorbar only
                if vii == 2:
                    def fmt(x, pos):
                        a, b = '{:.1e}'.format(x).split('e')
                        b = int(b)
                        return r'${}e{}$'.format(a, b)
                    cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format=ticker.
↪FuncFormatter(fmt))
                    #cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format='%.0e')␣
↪#format=ticker.FuncFormatter(fmt))
                    #cbar.set_ticks([0.2, 0.4, 0.6, 0.8])
                    #cbar.set_ticklabels(["A", "B", "C", "D"])
                    tick_locator = ticker.MaxNLocator(nbins=4)
                    cbar.locator = tick_locator
                    cbar.update_ticks()
                else:
                    cbar = fig.colorbar(plot, ax=axarr[jj,ii],␣
↪orientation="horizontal", fraction=0.0385, pad=0.2, format=None)

                cbar.set_label(units[vii], size='xx-small')
                cbar.ax.tick_params(labelsize='xx-small')
    fig.suptitle(title, y=0.95, fontsize=14)
    plt.show()
```

5 Averaging code

[14]:
```
###################
## UATM averages ##
###################

def calc_uatm_average(mpr_min, mpr_max, rainsignal, ymin, ymax):
    # global inputs: dv[1-8], mdv[1-8], mnvars
    mnvars = 8

    # initialize accumulators
    indices = []
    distribution = []
    raw_ires = len(mdv1[0])
    raininput = np.zeros((mnvars, raw_ires, raw_ires))
    raincount = 0

    for ii in range(0,len(rainsignal)):
        mpr = rainsignal[ii]

        # May = 5
        if mpr["time.month"] == 5 and mpr["time.year"] >= ymin and mpr["time.
↪year"] <= ymax:



            if mpr >= mpr_min and mpr < mpr_max:
                distribution.append(mpr)
                indices.append(ii)

                #mpr = dv1[ii].sel(lat=slice(32.125,38.125), lon=slice(-101.
↪875,-93.875)).mean()

                # find matching input sample
                #ot= dv1[ii-1]['time']
                ot = str(np.array(mpr['time']))

                mdv1.sel(time=ot,method='nearest')
                isample = [mdv1.sel(time=ot,method='nearest'),mdv2.
↪sel(time=ot,method='nearest'),mdv3.sel(time=ot,method='nearest'),mdv4.
↪sel(time=ot,method='nearest'),mdv5.sel(time=ot,method='nearest'),mdv6.
↪sel(time=ot,method='nearest'),mdv7.sel(time=ot,method='nearest'),mdv8.
↪sel(time=ot,method='nearest')]
                #ot= dv1[ii]['time']
                #assert ot["time.day"]==isample[0]['time.day'], "Days are not␣
↪equal"
                isample = np.array(isample)
```

```
                raininput += isample
                raincount += 1

    raininput /= raincount
    #print("days:", raincount)

    return raininput, raincount, distribution, indices
```

6 Postage stamp plots

6.0.1 Historical

[15]:
```
# hist
mpidry_methodmoist_list = []; mpidry_methodmoist_counts = []
mpidry_methodwet_list = []; mpidry_methodwet_counts = []
mpimoist_methoddry_list = []; mpimoist_methoddry_counts = []
mpimoist_methodwet_list = []; mpimoist_methodwet_counts = []
mpiwet_methoddry_list = []; mpiwet_methoddry_counts = []
mpiwet_methodmoist_list = []; mpiwet_methodmoist_counts = []

mpidry_methoddry_list = []; mpidry_methoddry_counts = []
mpimoist_methodmoist_list = []; mpimoist_methodmoist_counts = []
mpiwet_methodwet_list = []; mpiwet_methodwet_counts = []


# Count misses
# global inputs: dv[1-8], mdv[1-8], mnvars
mnvars = 8

# Load UATM data
load_uatm_mpi_hist()

rainsignal_mpi = xr.open_dataset(model2absfilepath('raw', 'hist', 98,␣
 ↪36))['prec']

# list of models
mnames = ['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']
#sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['obs','raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]


model_counts = []
```

```
for mii in [0,1,2,4,5,6,7,8]: #range(1): #len(sigfiles_hist)):
    sigfilename = sigfiles[mii]

    rainsignal = xr.open_dataset(sigfilename)['prec']

    # calc hit/miss
    mpidry_methodmoist = 0
    mpidry_methodwet = 0
    mpimoist_methoddry = 0
    mpimoist_methodwet = 0
    mpiwet_methoddry = 0
    mpiwet_methodmoist = 0

    mpidry_methoddry = 0
    mpimoist_methodmoist = 0
    mpiwet_methodwet = 0

    mpi_maydays_count = 0

    # initialize uatm accumulators
    raw_ires = len(mdv1[0])
    raininput_mpidry_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpidry_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_mpidry_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_methodall = np.zeros((mnvars, raw_ires, raw_ires))


    for ii in range(len(rainsignal_mpi)):
        pr_mpi = rainsignal_mpi[ii]

        if pr_mpi["time.month"] == 5:    # May

            # find matching input sample
            ot = pr_mpi['time']
            #pr_method = rainsignal.sel(time=ot,method='nearest')
            pr_method = rainsignal[ii]


            #print(ii, pr_mpi['time'], pr_method['time'])
```

```
            #isample = [mdv1.sel(time=ot,method='nearest'),mdv2.
↪sel(time=ot,method='nearest'),mdv3.sel(time=ot,method='nearest'),mdv4.
↪sel(time=ot,method='nearest'),mdv5.sel(time=ot,method='nearest'),mdv6.
↪sel(time=ot,method='nearest'),mdv7.sel(time=ot,method='nearest'),mdv8.
↪sel(time=ot,method='nearest')]
            isample =␣
↪[mdv1[ii],mdv2[ii],mdv3[ii],mdv4[ii],mdv5[ii],mdv6[ii],mdv7[ii],mdv8[ii]]
            #isample = np.array(isample)

            # Keep track of how many days were in May
            mpi_maydays_count += 1
            raininput_methodall += isample


            # 1: count mpidry_methodmoist
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method < 3.0:
                mpidry_methodmoist += 1
                raininput_mpidry_methodmoist += isample

            # 2: count mpidry_methodwet
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method >= 3.0:
                mpidry_methodwet += 1
                raininput_mpidry_methodwet += isample

            # 3: count mpimoist_methoddry
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method < 0.254:
                mpimoist_methoddry += 1
                raininput_mpimoist_methoddry += isample

            # 4: count mpimoist_methodwet
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 3.0:
                mpimoist_methodwet += 1
                raininput_mpimoist_methodwet += isample

            # 5: count mpiwet_methoddry
            if pr_mpi >= 3.0 and pr_method < 0.254:
                mpiwet_methoddry += 1
                raininput_mpiwet_methoddry += isample

            # 6: count mpiwet_methodmoist
            if pr_mpi >= 3.0 and pr_method >= 0.254 and pr_method < 3.0:
                mpiwet_methodmoist += 1
                raininput_mpiwet_methodmoist += isample

            # ---- diagnol self values ------
            # 7: count mpidry_methoddry
            if pr_mpi < 0.254 and pr_method < 0.254:
```

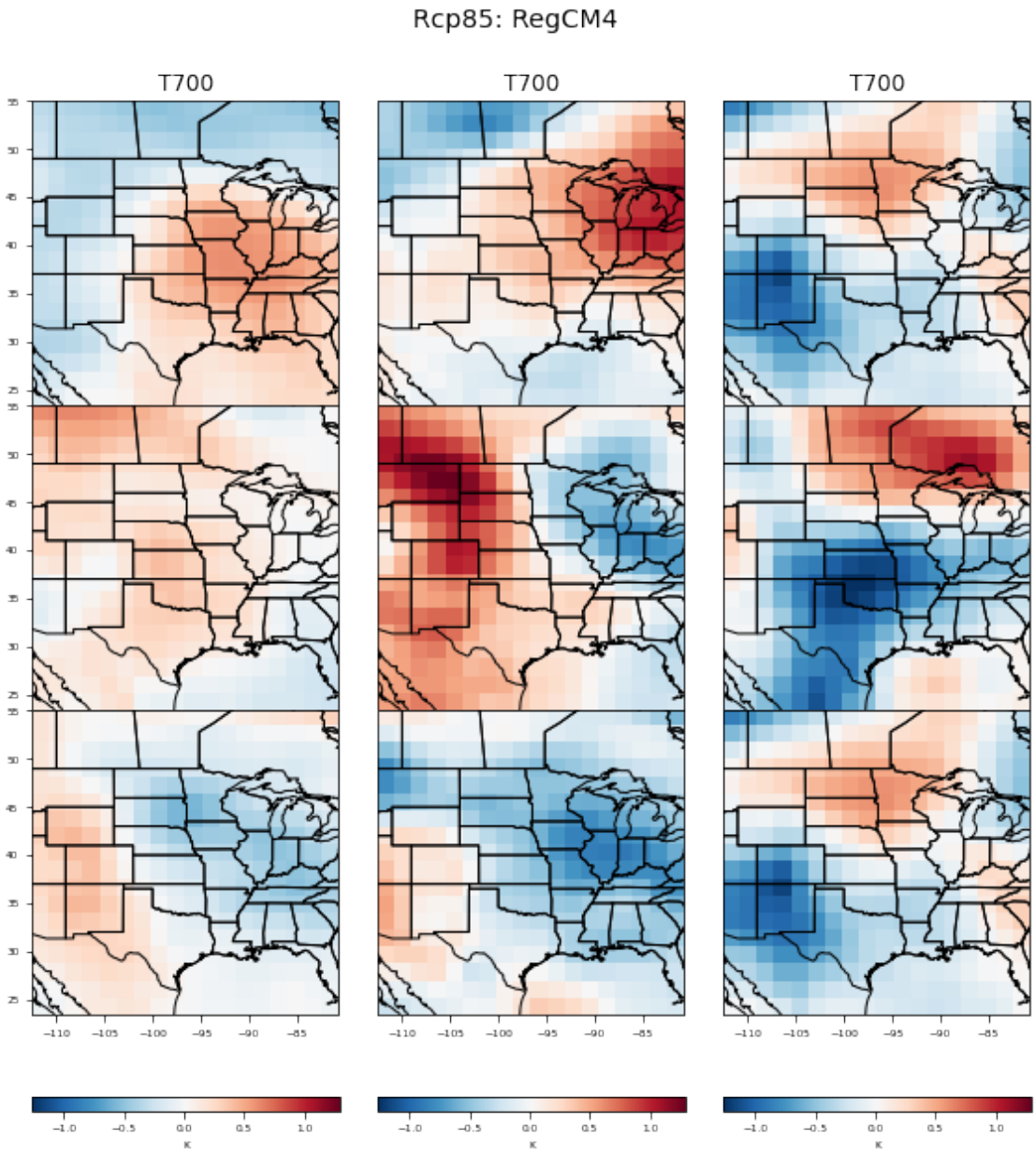
```
                mpidry_methoddry += 1
                raininput_mpidry_methoddry += isample
            # 8: count mpimoist_methodmoist
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 0.254 and␣
↪pr_method < 3.0:
                mpimoist_methodmoist += 1
                raininput_mpimoist_methodmoist += isample
            # 9: count mpiwet_methodwet
            if pr_mpi >= 3.0 and pr_method >= 3.0:
                mpiwet_methodwet += 1
                raininput_mpiwet_methodwet += isample


    print("Model:", mnames[mii])
    print("Method: Dry, Moist, Wet")
    print("MPI dry: ",  mpidry_methoddry, mpidry_methodmoist, mpidry_methodwet)
    print("MPI moist: ",  mpimoist_methoddry, mpimoist_methodmoist,␣
↪mpimoist_methodwet)
    print("MPI wet: ",  mpiwet_methoddry, mpiwet_methodmoist, mpiwet_methodwet)
    print()

    #print(mii, mpidry_methodmoist, mpimoist_methoddry, mpimoist_methodwet,␣
↪mpiwet_methoddry, mpiwet_methodmoist, mpimoist_methodwet)
    ## plot uatm
    #plot_8v(raininput_mpidry_methodmoist/mpidry_methodmoist)
    #plot_8v(raininput_mpimoist_methoddry/mpimoist_methoddry)
    #plot_8v(raininput_mpimoist_methodwet/mpimoist_methodwet)
    #plot_8v(raininput_mpiwet_methoddry/mpiwet_methoddry)

    # save to list
    #mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry)
    mpidry_methodmoist_list.append(raininput_mpidry_methodmoist/
↪mpidry_methodmoist - raininput_methodall/mpi_maydays_count)
    mpidry_methodmoist_counts.append(mpidry_methodmoist)

    mpidry_methodwet_list.append(raininput_mpidry_methodwet/mpidry_methodwet -␣
↪raininput_methodall/mpi_maydays_count)
    mpidry_methodwet_counts.append(mpidry_methodwet)

    mpimoist_methoddry_list.append(raininput_mpimoist_methoddry/
↪mpimoist_methoddry - raininput_methodall/mpi_maydays_count)
    mpimoist_methoddry_counts.append(mpimoist_methoddry)

    mpimoist_methodwet_list.append(raininput_mpimoist_methodwet/
↪mpimoist_methodwet - raininput_methodall/mpi_maydays_count)
    mpimoist_methodwet_counts.append(mpimoist_methodwet)
```

```
    mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry -␣
↪raininput_methodall/mpi_maydays_count)
    mpiwet_methoddry_counts.append(mpiwet_methoddry)

    mpiwet_methodmoist_list.append(raininput_mpiwet_methodmoist/
↪mpiwet_methodmoist - raininput_methodall/mpi_maydays_count)
    mpiwet_methodmoist_counts.append(mpiwet_methodmoist)

    # ---- diagnol self values ------
    mpidry_methoddry_list.append(raininput_mpidry_methoddry/mpidry_methoddry -␣
↪raininput_methodall/mpi_maydays_count)
    mpidry_methoddry_counts.append(mpidry_methoddry)

    mpimoist_methodmoist_list.append(raininput_mpimoist_methodmoist/
↪mpimoist_methodmoist - raininput_methodall/mpi_maydays_count)
    mpimoist_methodmoist_counts.append(mpimoist_methodmoist)

    mpiwet_methodwet_list.append(raininput_mpiwet_methodwet/mpiwet_methodwet -␣
↪raininput_methodall/mpi_maydays_count)
    mpiwet_methodwet_counts.append(mpiwet_methodwet)
```

```
Model: raw
Method: Dry, Moist, Wet
MPI dry:  342 0 0
MPI moist:  0 210 0
MPI wet:  0 0 254

Model: RegCM4
Method: Dry, Moist, Wet
MPI dry:  216 67 59
MPI moist:  124 37 49
MPI wet:  145 38 71

Model: WRF
Method: Dry, Moist, Wet
MPI dry:  125 83 134
MPI moist:  74 58 78
MPI wet:  90 59 105

Model: CNN
Method: Dry, Moist, Wet
MPI dry:  266 58 17
MPI moist:  106 56 48
```

```
MPI wet:  64 65 125

Model: SDSM
Method: Dry, Moist, Wet
MPI dry:  185 54 103
MPI moist:  126 29 55
MPI wet:  144 50 60

Model: KDDM
Method: Dry, Moist, Wet
MPI dry:  342 0 0
MPI moist:  83 127 0
MPI wet:  0 20 234

Model: MBCn
Method: Dry, Moist, Wet
MPI dry:  299 40 3
MPI moist:  144 61 5
MPI wet:  3 42 209

Model: LOCA
Method: Dry, Moist, Wet
MPI dry:  310 32 0
MPI moist:  47 114 49
MPI wet:  1 46 207
```

[16]:
```
# 3x3 matrix test on chosen UATM variable & 1st model
avginput_matrix_list = []
avginput_matrix_list.append(mpidry_methoddry_list[1])
avginput_matrix_list.append(mpidry_methodmoist_list[1])
avginput_matrix_list.append(mpidry_methodwet_list[1])
avginput_matrix_list.append(mpimoist_methoddry_list[1])
avginput_matrix_list.append(mpimoist_methodmoist_list[1])
avginput_matrix_list.append(mpimoist_methodwet_list[1])
avginput_matrix_list.append(mpiwet_methoddry_list[1])
avginput_matrix_list.append(mpiwet_methodmoist_list[1])
avginput_matrix_list.append(mpidry_methodwet_list[1])
plot_3x3_matrix(avginput_matrix_list, 3, 'Rcp85: RegCM4')
```



6.0.2 3x3 bar graphs: Historical

[17]:
```
mpiwet_methodmoist_counts, mpiwet_methoddry_counts
```

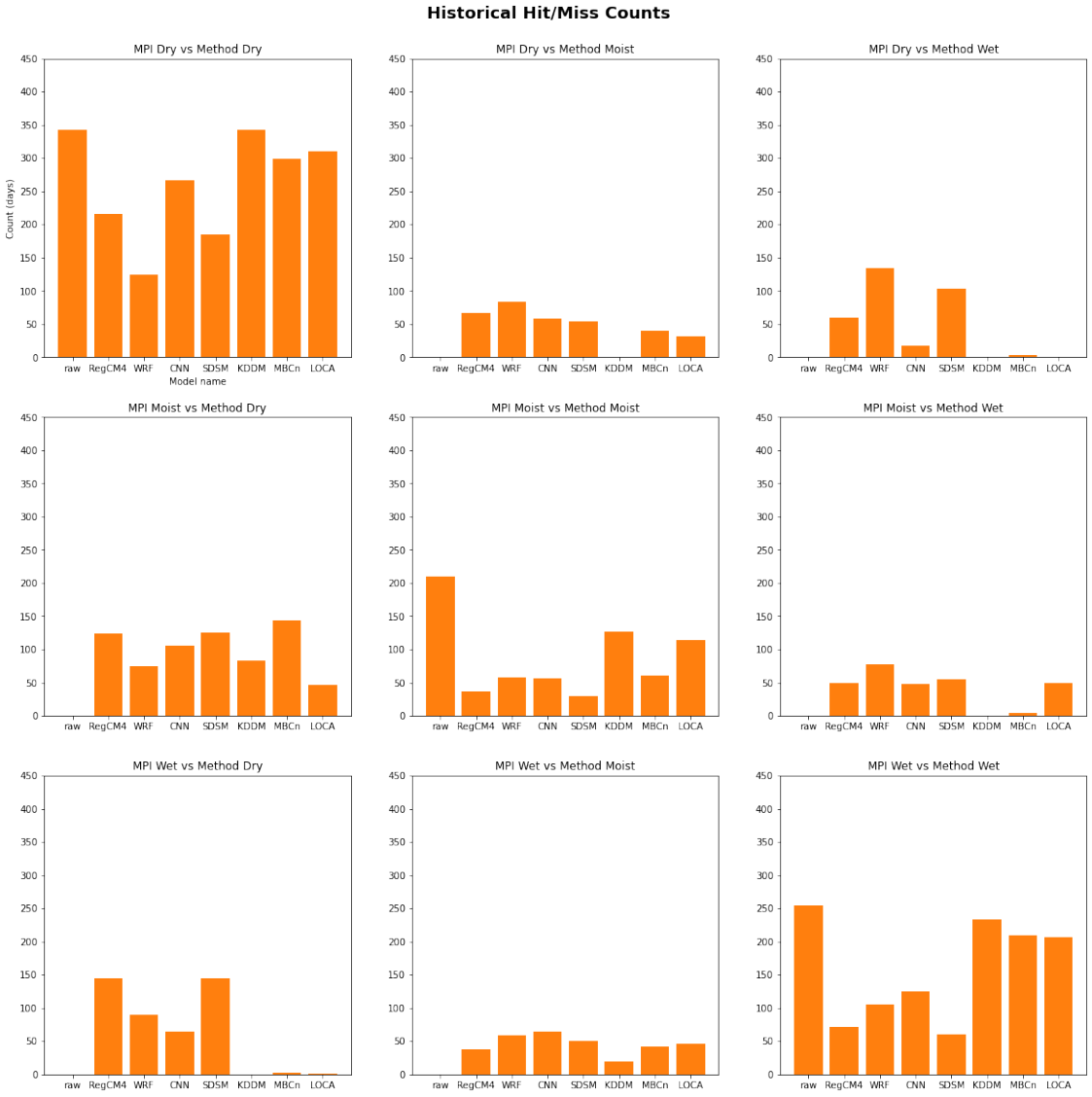
[17]:
```
([0, 38, 59, 65, 50, 20, 42, 46], [0, 145, 90, 64, 144, 0, 3, 1])
```

[18]:
```
# Dry
labels = ['Hist', 'Rcp85']
```

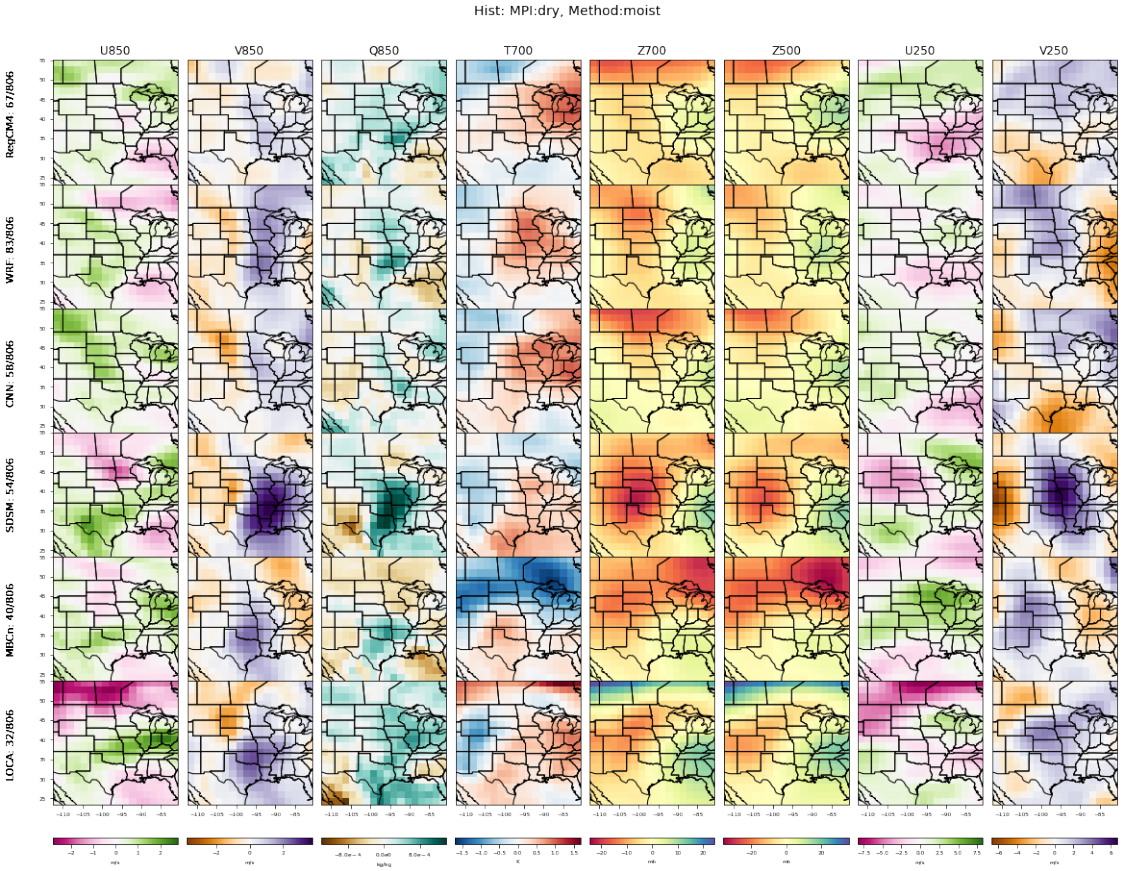
```
labels = ['Dry: hist', 'Dry: rcp85','Moist: hist', 'Moist: rcp85', 'Wet: hist',␣
 ↪'Wet: rcp85']
names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']


mn = len(mpiwet_methodmoist_counts)
xc = range(mn)
xd = [xx-.1 for xx in xc]
xm = [xx for xx in xc]
xw = [xx+.1 for xx in xc]

fig, axarr = plt.subplots(nrows=3, ncols=3, figsize = (20,20))

# 1,1
axarr[0,0].bar(xm, mpidry_methoddry_counts, width=.8, color='tab:orange')
#axarr[0].axis('tight')
#axarr[0,0].axis('off')
axarr[0,0].set_xlabel('Model name')
axarr[0,0].set_ylabel('Count (days)')
axarr[0,0].set_xticks(xc)
axarr[0,0].set_xticklabels(names)
axarr[0,0].set_ylim([0, 450])
axarr[0,0].set_title('MPI Dry vs Method Dry')
# 1,2
axarr[0,1].bar(xm, mpidry_methodmoist_counts, width=.8, color='tab:orange')
axarr[0,1].set_ylim([0, 450])
axarr[0,1].set_xticks(xc)
axarr[0,1].set_xticklabels(names)
axarr[0,1].set_title('MPI Dry vs Method Moist')
# 1,3
axarr[0,2].bar(xm, mpidry_methodwet_counts, width=.8, color='tab:orange')
axarr[0,2].set_ylim([0, 450])
axarr[0,2].set_xticks(xc)
axarr[0,2].set_xticklabels(names)
axarr[0,2].set_title('MPI Dry vs Method Wet')

# 2,1
axarr[1,0].bar(xm, mpimoist_methoddry_counts, width=.8, color='tab:orange')
axarr[1,0].set_ylim([0, 450])
axarr[1,0].set_xticks(xc)
axarr[1,0].set_xticklabels(names)
axarr[1,0].set_title('MPI Moist vs Method Dry')
# 2,2
axarr[1,1].bar(xm, mpimoist_methodmoist_counts, width=.8, color='tab:orange')
axarr[1,1].set_ylim([0, 450])
axarr[1,1].set_xticks(xc)
axarr[1,1].set_xticklabels(names)
```

```
axarr[1,1].set_title('MPI Moist vs Method Moist')
# 2,3
axarr[1,2].bar(xm, mpimoist_methodwet_counts, width=.8, color='tab:orange')
axarr[1,2].set_ylim([0, 450])
axarr[1,2].set_xticks(xc)
axarr[1,2].set_xticklabels(names)
axarr[1,2].set_title('MPI Moist vs Method Wet')

# 3,1
axarr[2,0].bar(xm, mpiwet_methoddry_counts, width=.8, color='tab:orange')
axarr[2,0].set_ylim([0, 450])
axarr[2,0].set_xticks(xc)
axarr[2,0].set_xticklabels(names)
axarr[2,0].set_title('MPI Wet vs Method Dry')
# 3,2
axarr[2,1].bar(xm, mpiwet_methodmoist_counts, width=.8, color='tab:orange')
axarr[2,1].set_ylim([0, 450])
axarr[2,1].set_xticks(xc)
axarr[2,1].set_xticklabels(names)
axarr[2,1].set_title('MPI Wet vs Method Moist')
# 3,3
axarr[2,2].bar(xm, mpiwet_methodwet_counts, width=.8, color='tab:orange')
axarr[2,2].set_ylim([0, 450])
axarr[2,2].set_xticks(xc)
axarr[2,2].set_xticklabels(names)
axarr[2,2].set_title('MPI Wet vs Method Wet')

# title
#fig.suptitle('Historical Hit/Miss Counts', y=0.92, x=.15, fontsize=18,␣
 ↪fontweight="bold")
fig.suptitle('Historical Hit/Miss Counts', y=0.92, fontsize=18,␣
 ↪fontweight="bold")
```

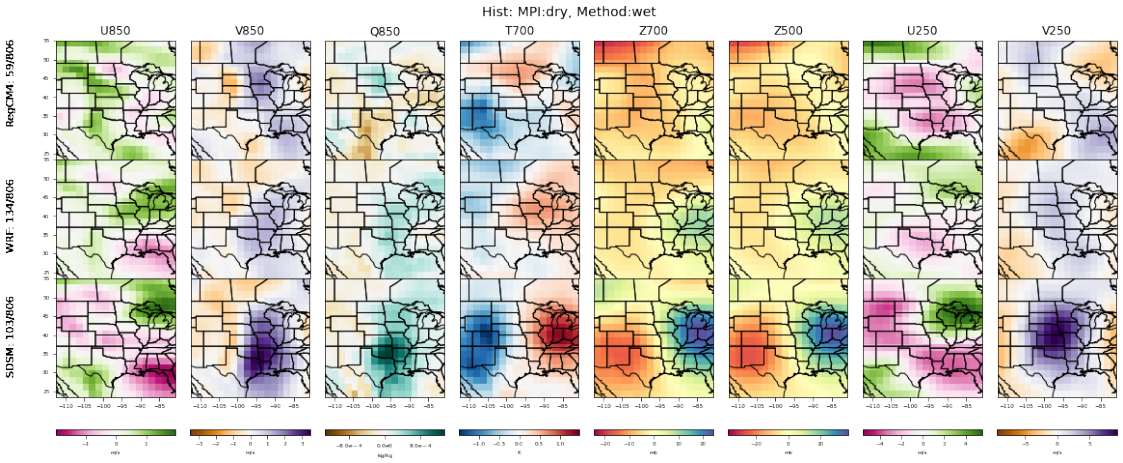
[18]: Text(0.5, 0.92, 'Historical Hit/Miss Counts')



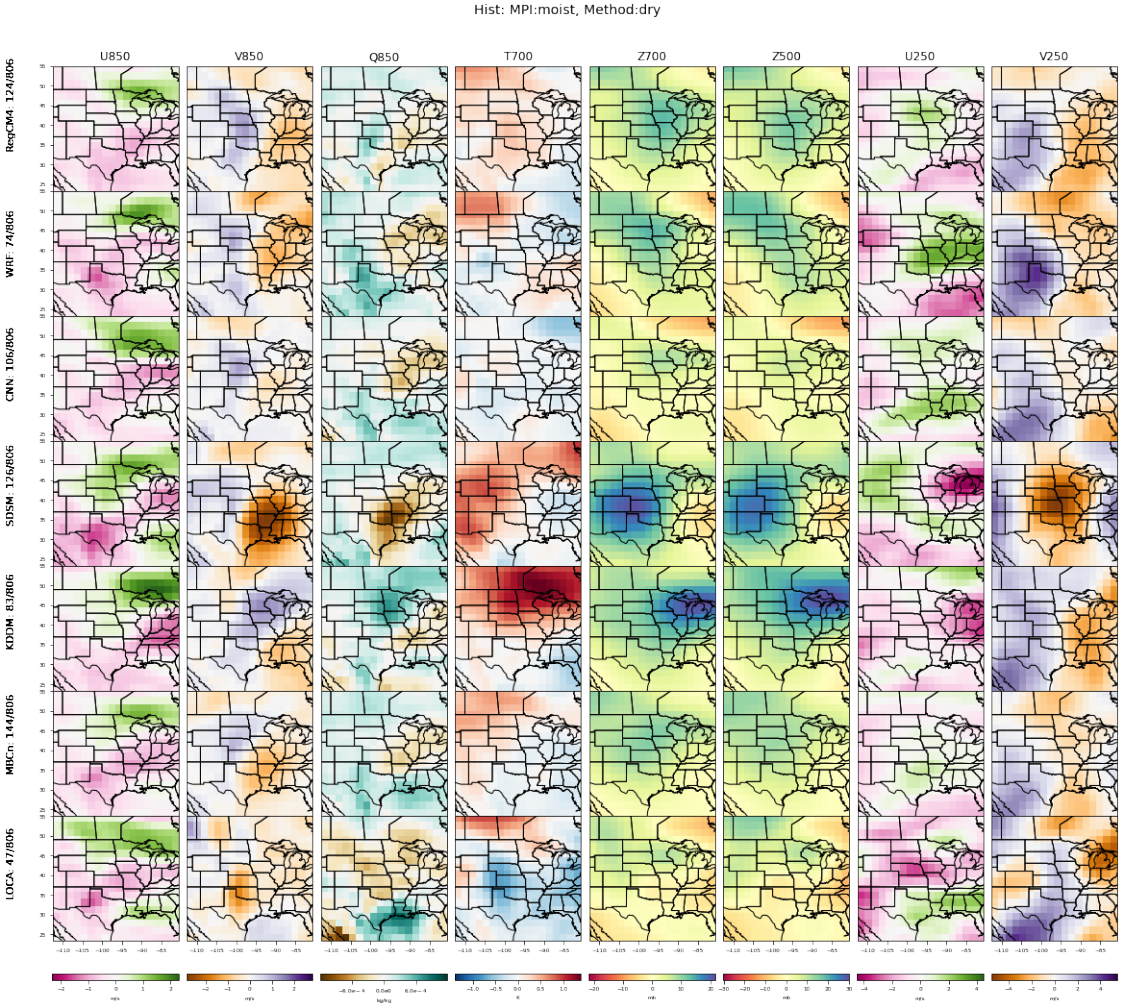
[67]:
```
model_names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']
plot_postage(mpidry_methodmoist_list, model_names, mpidry_methodmoist_counts,␣
 ↪mpi_maydays_count, 'Hist: MPI:dry, Method:moist')
```



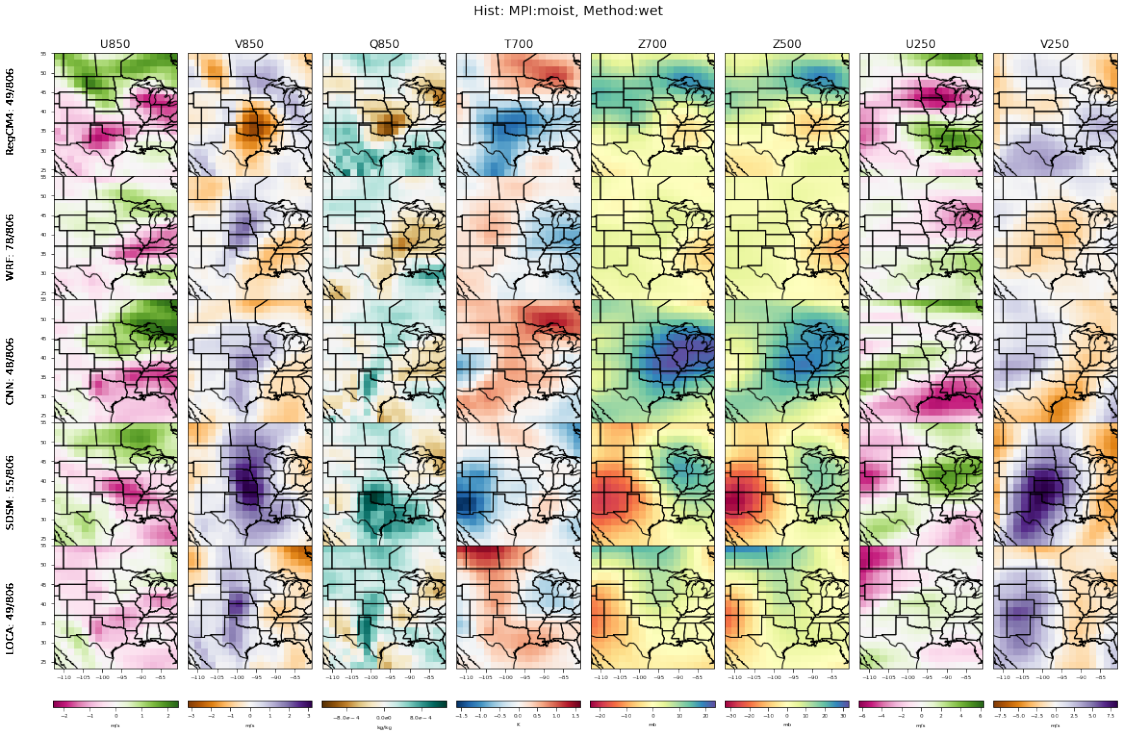
[68]:
```
plot_postage(mpidry_methodwet_list, model_names, mpidry_methodwet_counts,␣
 ↪mpi_maydays_count, 'Hist: MPI:dry, Method:wet')
```



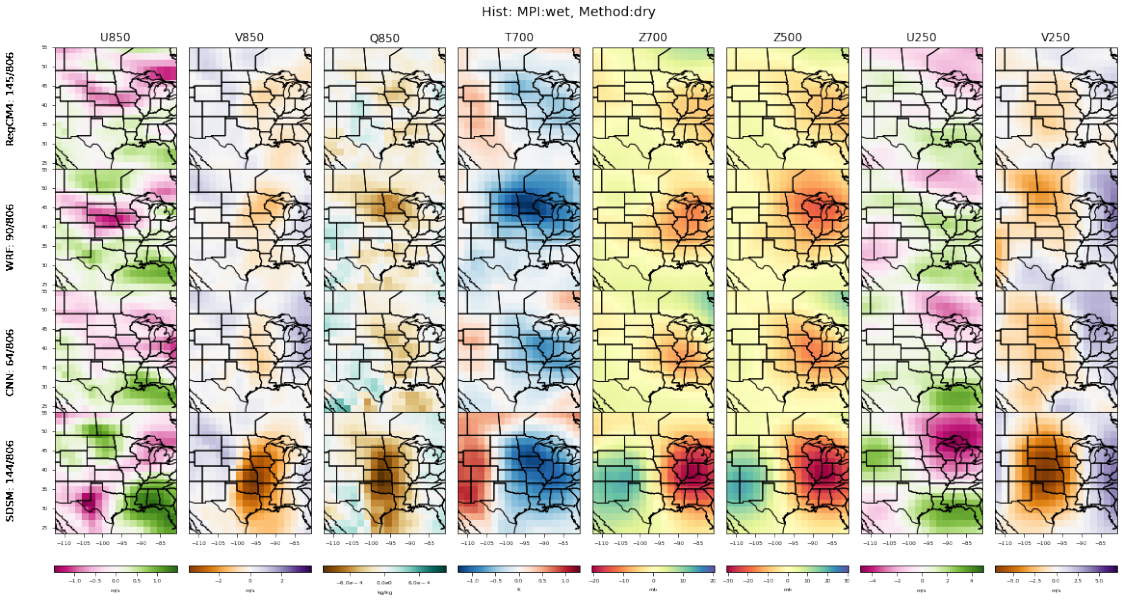
[69]:
```
plot_postage(mpimoist_methoddry_list, model_names, mpimoist_methoddry_counts,␣
↪mpi_maydays_count, 'Hist: MPI:moist, Method:dry')
```



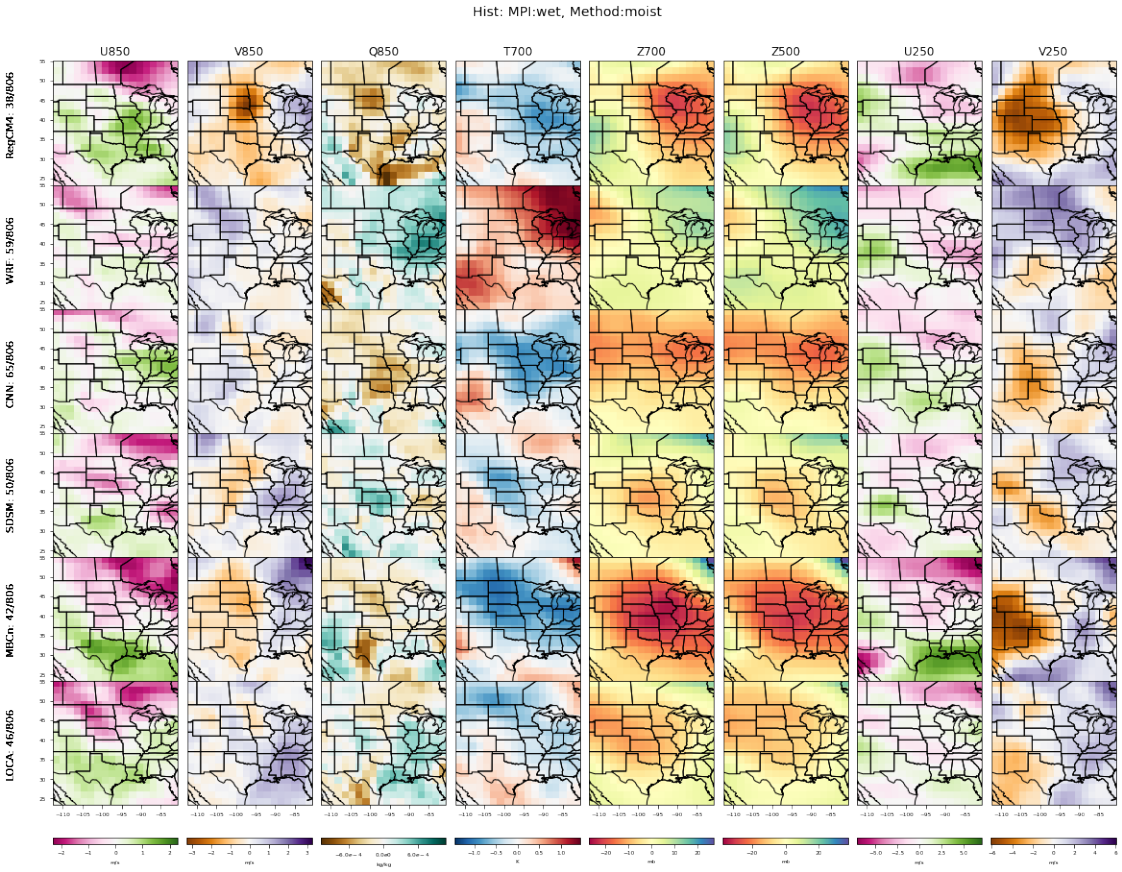
[70]:
```
plot_postage(mpimoist_methodwet_list, model_names, mpimoist_methodwet_counts,␣
↪mpi_maydays_count, 'Hist: MPI:moist, Method:wet')
```



[71]:
```
plot_postage(mpiwet_methoddry_list, model_names, mpiwet_methoddry_counts,␣
↪mpi_maydays_count, 'Hist: MPI:wet, Method:dry')
```



[72]:
```
plot_postage(mpiwet_methodmoist_list, model_names, mpiwet_methodmoist_counts,␣
↪mpi_maydays_count, 'Hist: MPI:wet, Method:moist')
```



6.0.3 Rcp85

[73]:
```
# rcp85
mpidry_methodmoist_list = []; mpidry_methodmoist_counts = []
mpidry_methodwet_list = []; mpidry_methodwet_counts = []
mpimoist_methoddry_list = []; mpimoist_methoddry_counts = []
mpimoist_methodwet_list = []; mpimoist_methodwet_counts = []
mpiwet_methoddry_list = []; mpiwet_methoddry_counts = []
mpiwet_methodmoist_list = []; mpiwet_methodmoist_counts = []

mpidry_methoddry_list = []; mpidry_methoddry_counts = []
mpimoist_methodmoist_list = []; mpimoist_methodmoist_counts = []
mpiwet_methodwet_list = []; mpiwet_methodwet_counts = []


# Count misses
```

```
# global inputs: dv[1-8], mdv[1-8], mnvars
mnvars = 8

# Load UATM data
load_uatm_mpi_future()

rainsignal_mpi = xr.open_dataset(model2absfilepath('raw', 'rcp85', 98,␣
 ↪36))['prec']

# list of models
#sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['obs','raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
mnames = ['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']
sigfiles = [model2absfilepath(ff, 'rcp85', 98, 36) for ff in␣
 ↪['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
#sigfiles = [model2absfilepath(ff, 'rcp85', 98, 36) for ff in␣
 ↪['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']]

model_counts = []
for mii in [0,1,2,4,5,6,7,8]: #range(1): #len(sigfiles_hist)):
    sigfilename = sigfiles[mii]

    rainsignal = xr.open_dataset(sigfilename)['prec']

    # calc hit/miss
    mpidry_methodmoist = 0
    mpidry_methodwet = 0
    mpimoist_methoddry = 0
    mpimoist_methodwet = 0
    mpiwet_methoddry = 0
    mpiwet_methodmoist = 0

    mpidry_methoddry = 0
    mpimoist_methodmoist = 0
    mpiwet_methodwet = 0

    mpi_maydays_count = 0

    # initialize uatm accumulators
    raw_ires = len(mdv1[0])
    raininput_mpidry_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpidry_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
```

```
    raininput_mpidry_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_methodall = np.zeros((mnvars, raw_ires, raw_ires))


    for ii in range(len(rainsignal_mpi)):
        pr_mpi = rainsignal_mpi[ii]

        if pr_mpi["time.month"] == 5:     # May
            # Keep track of how many days were in May
            mpi_maydays_count += 1
            raininput_methodall += isample


            # find matching input sample
            ot = pr_mpi['time']
            #pr_method = rainsignal.sel(time=ot,method='nearest')
            pr_method = rainsignal[ii]


            #print(ii, pr_mpi['time'], pr_method['time'])
            #isample = [mdv1.sel(time=ot,method='nearest'),mdv2.
↪sel(time=ot,method='nearest'),mdv3.sel(time=ot,method='nearest'),mdv4.
↪sel(time=ot,method='nearest'),mdv5.sel(time=ot,method='nearest'),mdv6.
↪sel(time=ot,method='nearest'),mdv7.sel(time=ot,method='nearest'),mdv8.
↪sel(time=ot,method='nearest')]
            isample =␣
↪[mdv1[ii],mdv2[ii],mdv3[ii],mdv4[ii],mdv5[ii],mdv6[ii],mdv7[ii],mdv8[ii]]
            #isample = np.array(isample)

            # 1: count mpidry_methodmoist
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method < 3.0:
                mpidry_methodmoist += 1
                raininput_mpidry_methodmoist += isample

            # 2: count mpidry_methodwet
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method >= 3.0:
                mpidry_methodwet += 1
                raininput_mpidry_methodwet += isample

            # 3: count mpimoist_methoddry
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method < 0.254:
                mpimoist_methoddry += 1
                raininput_mpimoist_methoddry += isample
```

```
            # 4: count mpimoist_methodwet
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 3.0:
                mpimoist_methodwet += 1
                raininput_mpimoist_methodwet += isample

            # 5: count mpiwet_methoddry
            if pr_mpi >= 3.0 and pr_method < 0.254:
                mpiwet_methoddry += 1
                raininput_mpiwet_methoddry += isample

            # 6: count mpiwet_methodmoist
            if pr_mpi >= 3.0 and pr_method >= 0.254 and pr_method < 3.0:
                mpiwet_methodmoist += 1
                raininput_mpiwet_methodmoist += isample

            # ---- diagnol self values ------
            # 7: count mpidry_methoddry
            if pr_mpi < 0.254 and pr_method < 0.254:
                mpidry_methoddry += 1
                raininput_mpidry_methoddry += isample
            # 8: count mpimoist_methodmoist
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 0.254 and␣
↪pr_method < 3.0:
                mpimoist_methodmoist += 1
                raininput_mpimoist_methodmoist += isample
            # 9: count mpiwet_methodwet
            if pr_mpi >= 3.0 and pr_method >= 3.0:
                mpiwet_methodwet += 1
                raininput_mpiwet_methodwet += isample


    print("Model:", mnames[mii])
    print("Method: Dry, Moist, Wet")
    print("MPI dry: ",  mpidry_methoddry, mpidry_methodmoist, mpidry_methodwet)
    print("MPI moist: ",  mpimoist_methoddry, mpimoist_methodmoist,␣
↪mpimoist_methodwet)
    print("MPI wet: ",  mpiwet_methoddry, mpiwet_methodmoist, mpiwet_methodwet)
    print()

    #print(mii, mpidry_methodmoist, mpimoist_methoddry, mpimoist_methodwet,␣
↪mpiwet_methoddry, mpiwet_methodmoist, mpimoist_methodwet)
    ## plot uatm
    #plot_8v(raininput_mpidry_methodmoist/mpidry_methodmoist)
    #plot_8v(raininput_mpimoist_methoddry/mpimoist_methoddry)
    #plot_8v(raininput_mpimoist_methodwet/mpimoist_methodwet)
    #plot_8v(raininput_mpiwet_methoddry/mpiwet_methoddry)
```

```
    # save to list
    #mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry)
    mpidry_methodmoist_list.append(raininput_mpidry_methodmoist/
↪mpidry_methodmoist - raininput_methodall/mpi_maydays_count)
    mpidry_methodmoist_counts.append(mpidry_methodmoist)

    mpidry_methodwet_list.append(raininput_mpidry_methodwet/mpidry_methodwet -␣
↪raininput_methodall/mpi_maydays_count)
    mpidry_methodwet_counts.append(mpidry_methodwet)

    mpimoist_methoddry_list.append(raininput_mpimoist_methoddry/
↪mpimoist_methoddry - raininput_methodall/mpi_maydays_count)
    mpimoist_methoddry_counts.append(mpimoist_methoddry)

    mpimoist_methodwet_list.append(raininput_mpimoist_methodwet/
↪mpimoist_methodwet - raininput_methodall/mpi_maydays_count)
    mpimoist_methodwet_counts.append(mpimoist_methodwet)

    mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry -␣
↪raininput_methodall/mpi_maydays_count)
    mpiwet_methoddry_counts.append(mpiwet_methoddry)

    mpiwet_methodmoist_list.append(raininput_mpiwet_methodmoist/
↪mpiwet_methodmoist - raininput_methodall/mpi_maydays_count)
    mpiwet_methodmoist_counts.append(mpiwet_methodmoist)

    # ---- diagnol self values ------
    mpidry_methoddry_list.append(raininput_mpidry_methoddry/mpidry_methoddry -␣
↪raininput_methodall/mpi_maydays_count)
    mpidry_methoddry_counts.append(mpidry_methoddry)

    mpimoist_methodmoist_list.append(raininput_mpimoist_methodmoist/
↪mpimoist_methodmoist - raininput_methodall/mpi_maydays_count)
    mpimoist_methodmoist_counts.append(mpimoist_methodmoist)

    mpiwet_methodwet_list.append(raininput_mpiwet_methodwet/mpiwet_methodwet -␣
↪raininput_methodall/mpi_maydays_count)
    mpiwet_methodwet_counts.append(mpiwet_methodwet)
```

```
Model: raw
Method: Dry, Moist, Wet
MPI dry:  421 0 0
MPI moist:  0 166 0
MPI wet:  0 0 219

Model: RegCM4
Method: Dry, Moist, Wet
```

```
MPI dry:  279 66 76
MPI moist:  82 33 51
MPI wet:  99 35 85

Model: WRF
Method: Dry, Moist, Wet
MPI dry:  179 68 174
MPI moist:  63 32 71
MPI wet:  90 42 87

Model: CNN
Method: Dry, Moist, Wet
MPI dry:  319 60 28
MPI moist:  87 39 40
MPI wet:  50 60 109

Model: SDSM
Method: Dry, Moist, Wet
MPI dry:  231 69 121
MPI moist:  91 17 58
MPI wet:  141 25 53

Model: KDDM
Method: Dry, Moist, Wet
MPI dry:  421 0 0
MPI moist:  79 87 0
MPI wet:  0 18 201

Model: MBCn
Method: Dry, Moist, Wet
MPI dry:  377 41 3
MPI moist:  109 52 5
MPI wet:  1 27 191

Model: LOCA
Method: Dry, Moist, Wet
MPI dry:  407 14 0
MPI moist:  53 78 35
MPI wet:  2 39 178
```

6.0.4 3x3 bar graphs: Rcp85

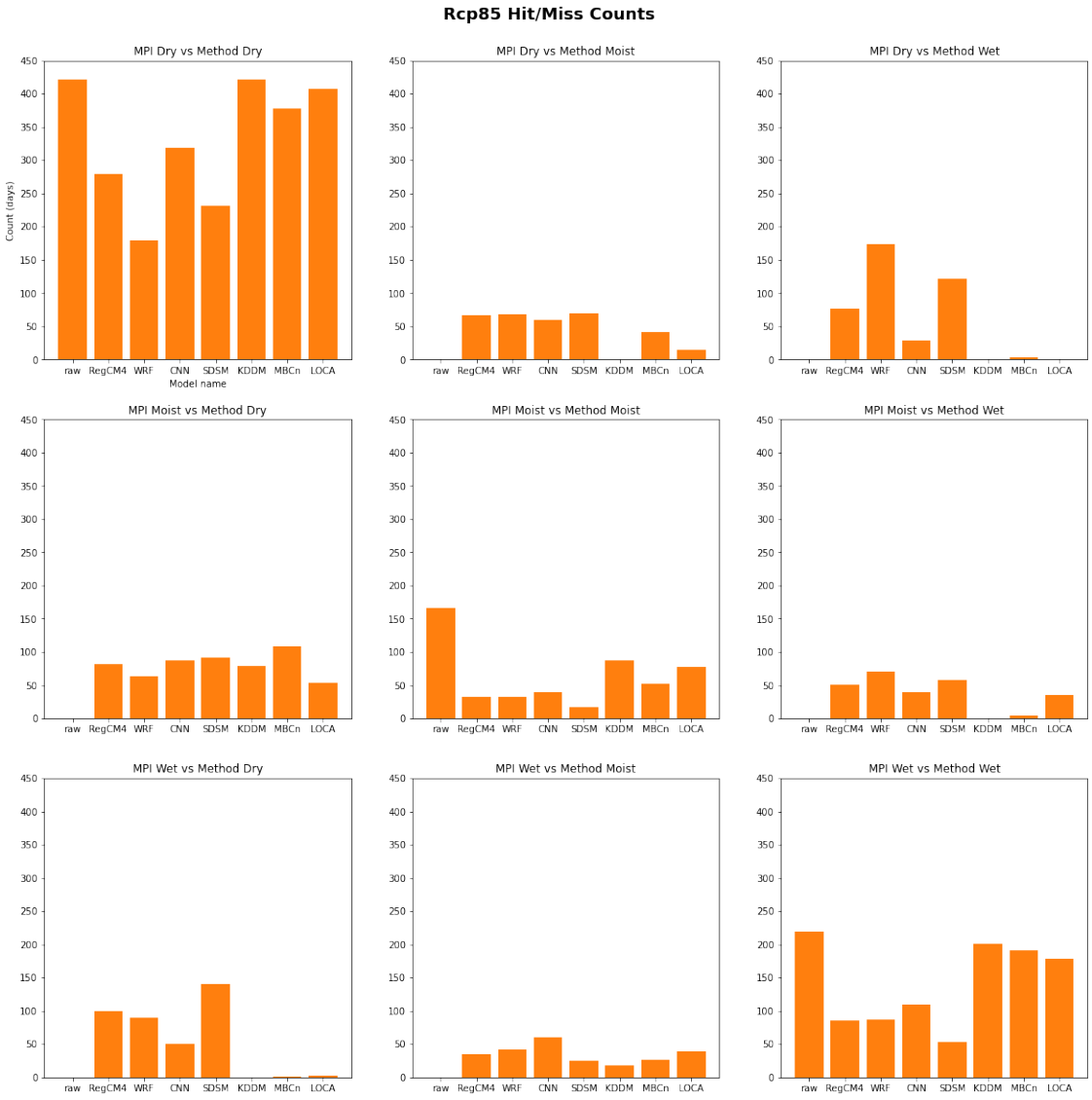
[74]:
```
mpiwet_methodmoist_counts, mpiwet_methoddry_counts
```

[74]:
```
([0, 35, 42, 60, 25, 18, 27, 39], [0, 99, 90, 50, 141, 0, 1, 2])
```

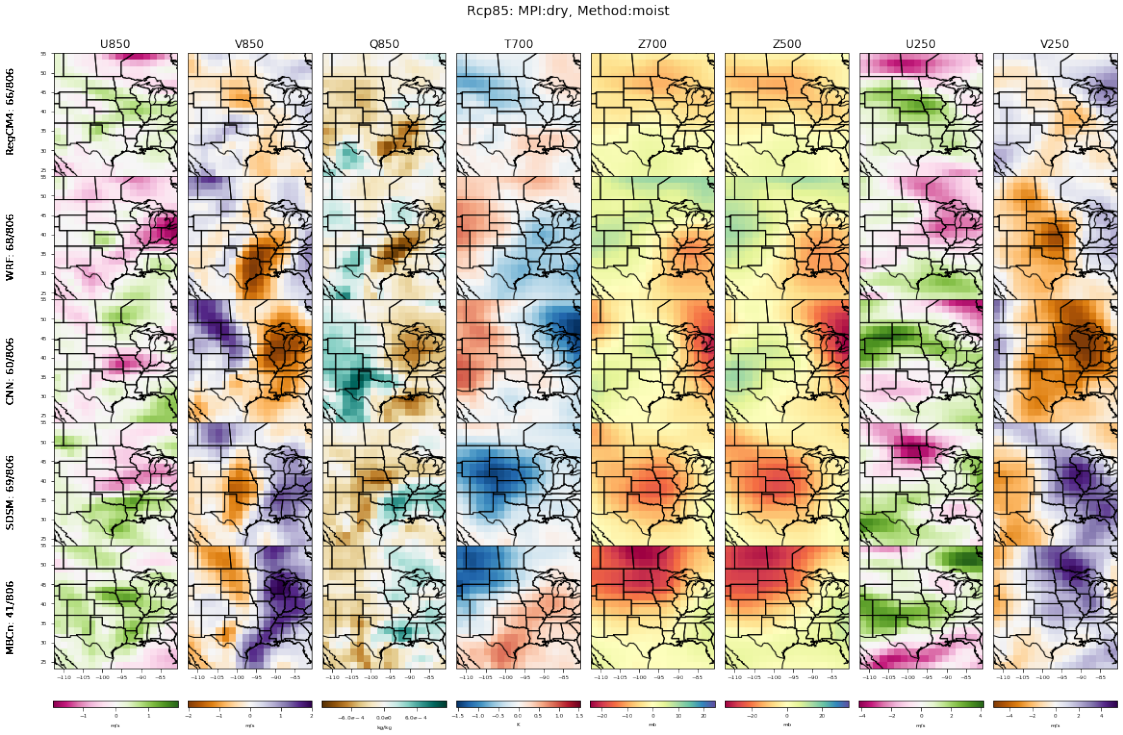
[75]:
```
# Dry
labels = ['Hist', 'Rcp85']
labels = ['Dry: hist', 'Dry: rcp85','Moist: hist', 'Moist: rcp85', 'Wet: hist',␣
 ↪'Wet: rcp85']
names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']


mn = len(mpiwet_methodmoist_counts)
xc = range(mn)
xd = [xx-.1 for xx in xc]
xm = [xx for xx in xc]
xw = [xx+.1 for xx in xc]

fig, axarr = plt.subplots(nrows=3, ncols=3, figsize = (20,20))

# 1,1
axarr[0,0].bar(xm, mpidry_methoddry_counts, width=.8, color='tab:orange')
#axarr[0].axis('tight')
#axarr[0,0].axis('off')
axarr[0,0].set_xlabel('Model name')
axarr[0,0].set_ylabel('Count (days)')
axarr[0,0].set_xticks(xc)
axarr[0,0].set_xticklabels(names)
axarr[0,0].set_ylim([0, 450])
axarr[0,0].set_title('MPI Dry vs Method Dry')
# 1,2
axarr[0,1].bar(xm, mpidry_methodmoist_counts, width=.8, color='tab:orange')
axarr[0,1].set_ylim([0, 450])
axarr[0,1].set_xticks(xc)
axarr[0,1].set_xticklabels(names)
axarr[0,1].set_title('MPI Dry vs Method Moist')
# 1,3
axarr[0,2].bar(xm, mpidry_methodwet_counts, width=.8, color='tab:orange')
axarr[0,2].set_ylim([0, 450])
axarr[0,2].set_xticks(xc)
axarr[0,2].set_xticklabels(names)
axarr[0,2].set_title('MPI Dry vs Method Wet')

# 2,1
axarr[1,0].bar(xm, mpimoist_methoddry_counts, width=.8, color='tab:orange')
axarr[1,0].set_ylim([0, 450])
axarr[1,0].set_xticks(xc)
axarr[1,0].set_xticklabels(names)
axarr[1,0].set_title('MPI Moist vs Method Dry')
# 2,2
axarr[1,1].bar(xm, mpimoist_methodmoist_counts, width=.8, color='tab:orange')
axarr[1,1].set_ylim([0, 450])
```

```
axarr[1,1].set_xticks(xc)
axarr[1,1].set_xticklabels(names)
axarr[1,1].set_title('MPI Moist vs Method Moist')
# 2,3
axarr[1,2].bar(xm, mpimoist_methodwet_counts, width=.8, color='tab:orange')
axarr[1,2].set_ylim([0, 450])
axarr[1,2].set_xticks(xc)
axarr[1,2].set_xticklabels(names)
axarr[1,2].set_title('MPI Moist vs Method Wet')

# 3,1
axarr[2,0].bar(xm, mpiwet_methoddry_counts, width=.8, color='tab:orange')
axarr[2,0].set_ylim([0, 450])
axarr[2,0].set_xticks(xc)
axarr[2,0].set_xticklabels(names)
axarr[2,0].set_title('MPI Wet vs Method Dry')
# 3,2
axarr[2,1].bar(xm, mpiwet_methodmoist_counts, width=.8, color='tab:orange')
axarr[2,1].set_ylim([0, 450])
axarr[2,1].set_xticks(xc)
axarr[2,1].set_xticklabels(names)
axarr[2,1].set_title('MPI Wet vs Method Moist')
# 3,3
axarr[2,2].bar(xm, mpiwet_methodwet_counts, width=.8, color='tab:orange')
axarr[2,2].set_ylim([0, 450])
axarr[2,2].set_xticks(xc)
axarr[2,2].set_xticklabels(names)
axarr[2,2].set_title('MPI Wet vs Method Wet')

# title
#fig.suptitle('Historical Hit/Miss Counts', y=0.92, x=.15, fontsize=18,␣
 ↪fontweight="bold")
fig.suptitle('Rcp85 Hit/Miss Counts', y=0.92, fontsize=18, fontweight="bold")
```

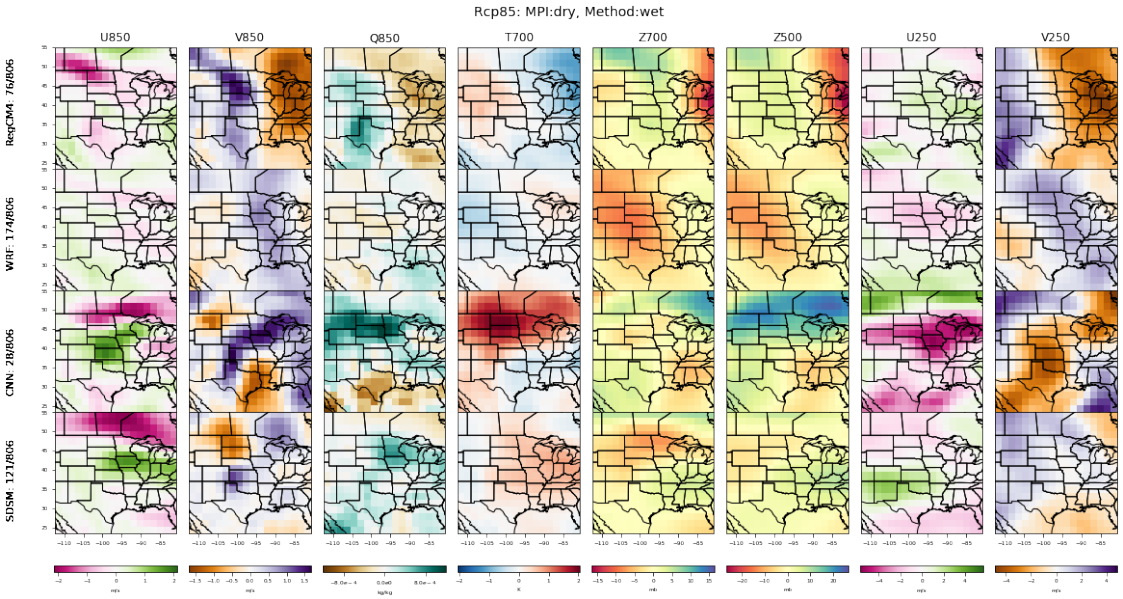
[75]: Text(0.5, 0.92, 'Rcp85 Hit/Miss Counts')



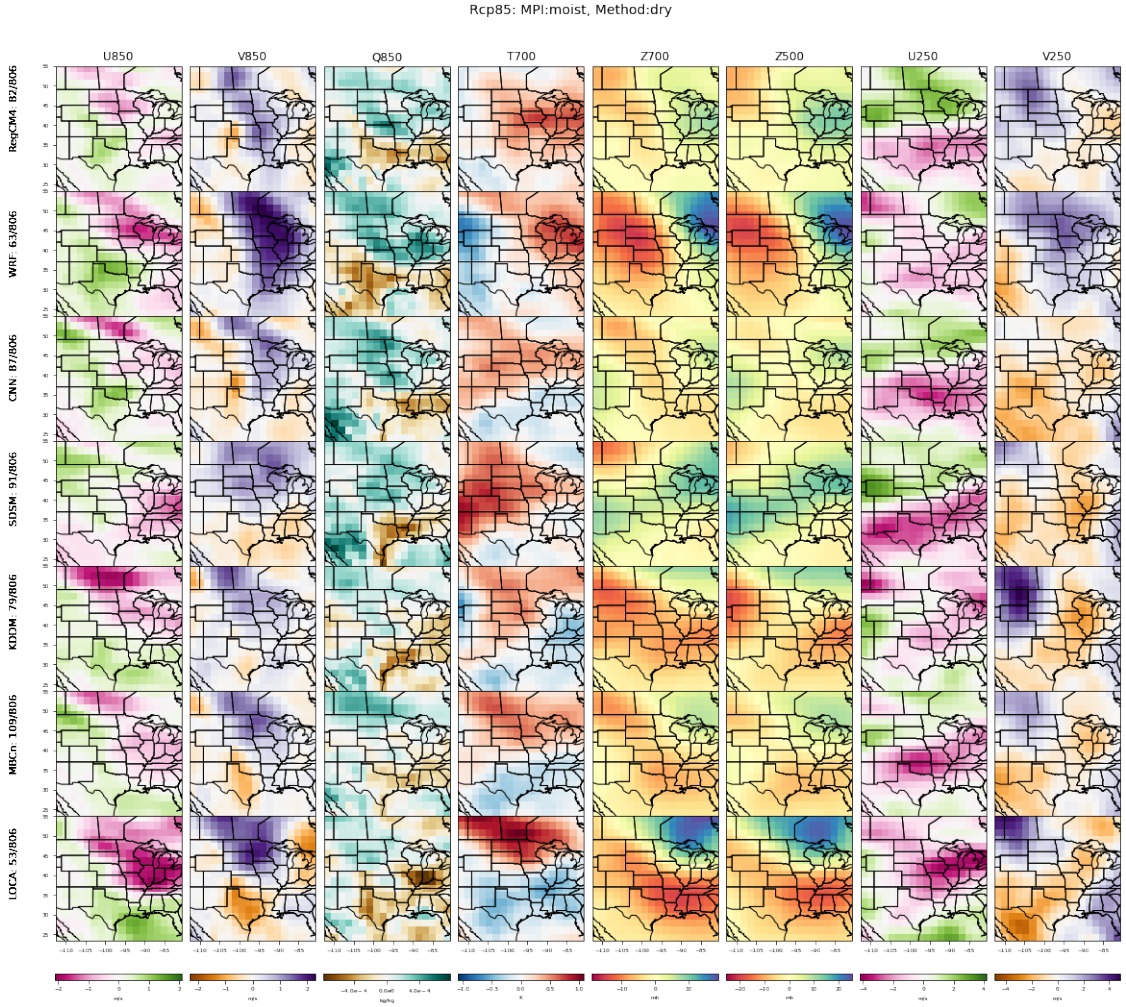
[76]:
```
# UATM hit/miss plots: Rcp85
model_names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']
#mpiwet_methoddry_counts
plot_postage(mpidry_methodmoist_list, model_names, mpidry_methodmoist_counts,␣
 ↪mpi_maydays_count, 'Rcp85: MPI:dry, Method:moist')
```



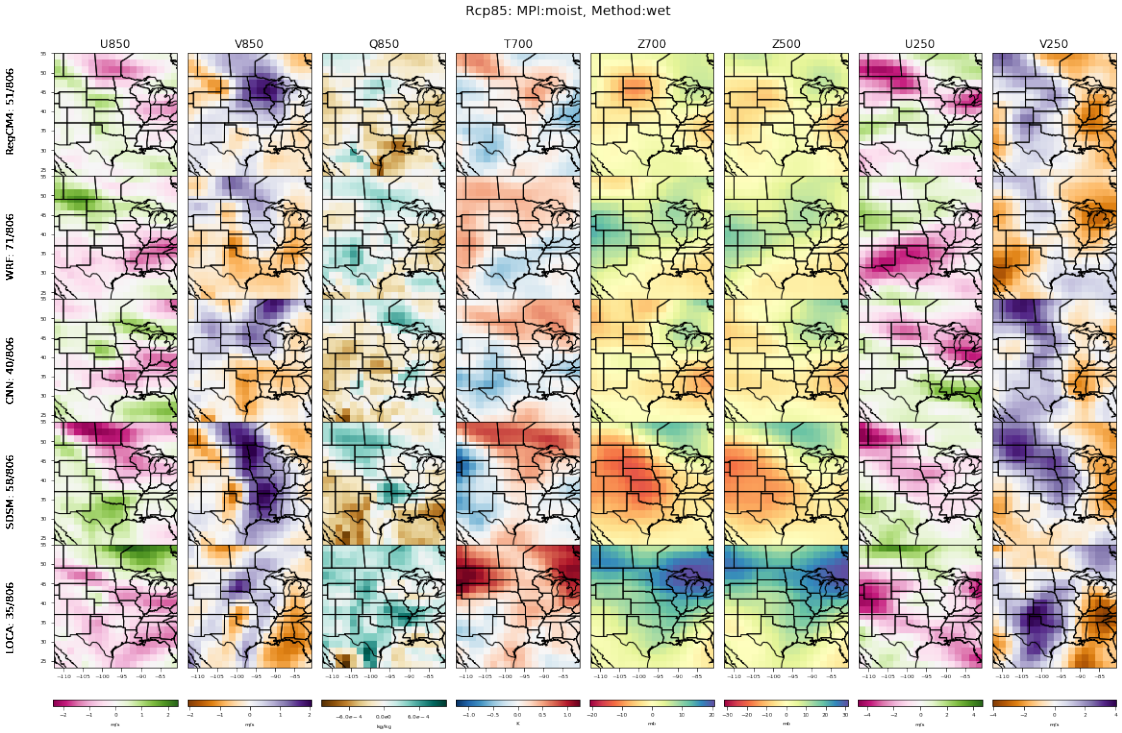
[77]:
```
plot_postage(mpidry_methodwet_list, model_names, mpidry_methodwet_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:dry, Method:wet')
```



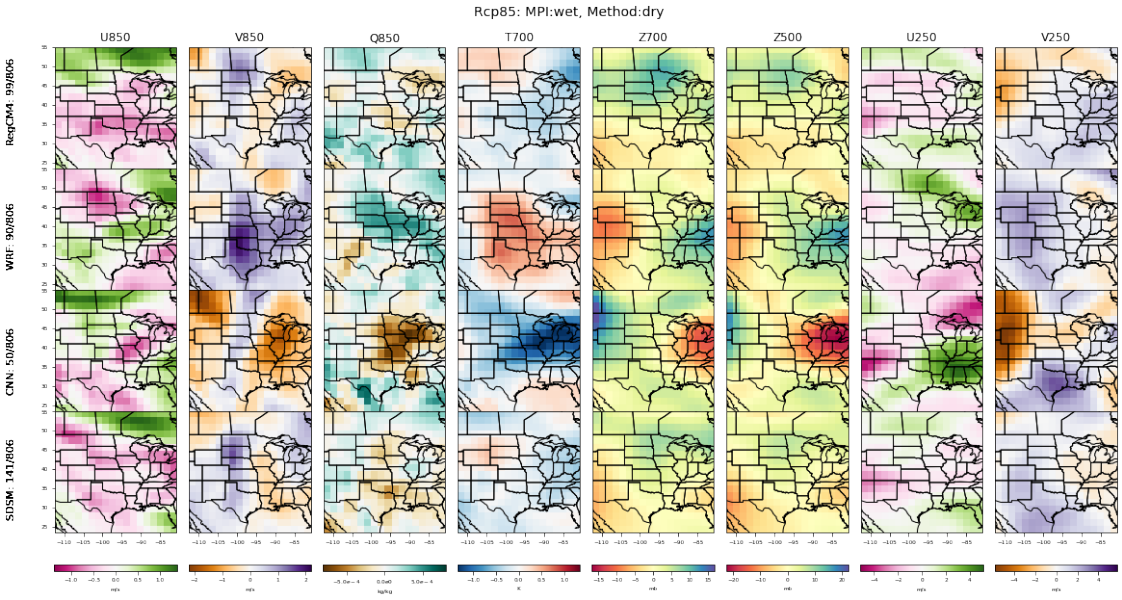
[78]:
```
plot_postage(mpimoist_methoddry_list, model_names, mpimoist_methoddry_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:moist, Method:dry')
```



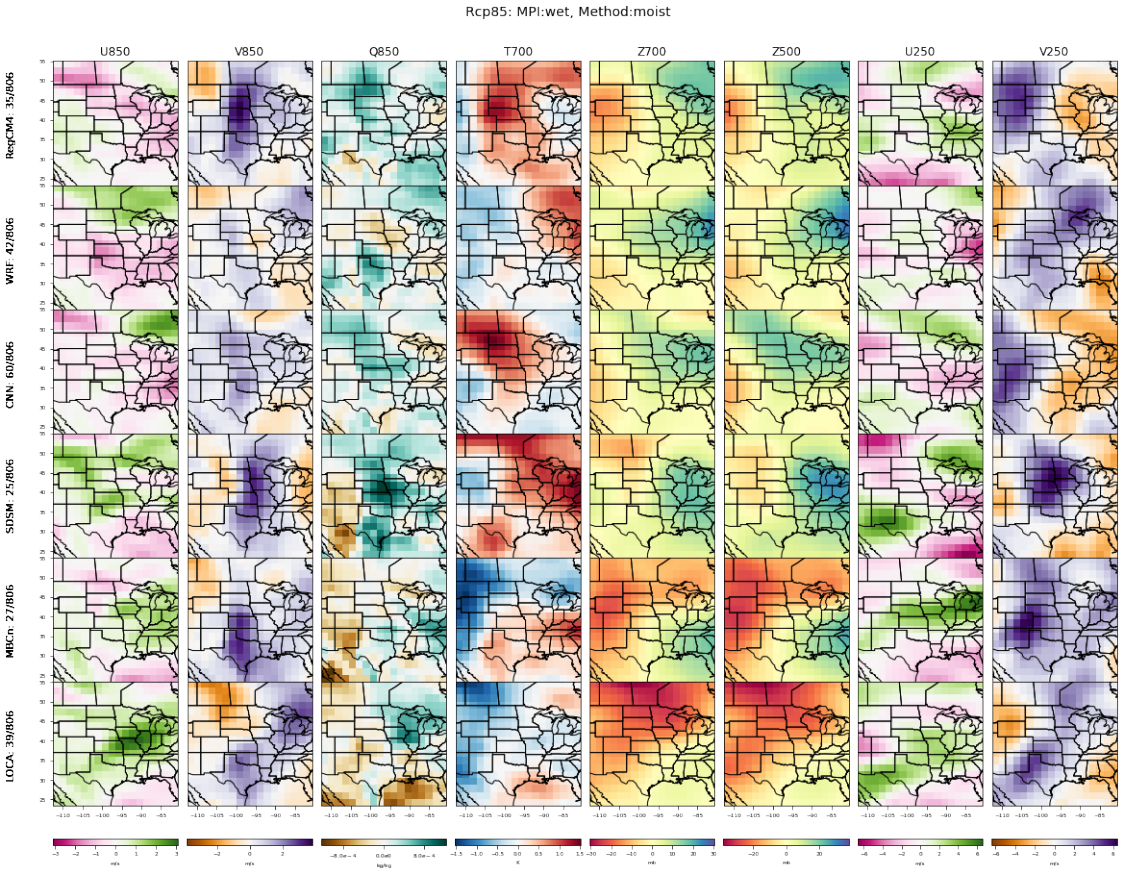
[79]:
```
plot_postage(mpimoist_methodwet_list, model_names, mpimoist_methodwet_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:moist, Method:wet')
```



[80]:
```
plot_postage(mpiwet_methoddry_list, model_names, mpiwet_methoddry_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:wet, Method:dry')
```



[81]:
```
plot_postage(mpiwet_methodmoist_list, model_names, mpiwet_methodmoist_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:wet, Method:moist')
```



7 Section 2: Hit/miss diff

7.0.1 Historical

[82]:
```
# hist
mpidry_methodmoist_list = []; mpidry_methodmoist_counts = []
mpidry_methodwet_list = []; mpidry_methodwet_counts = []
mpimoist_methoddry_list = []; mpimoist_methoddry_counts = []
mpimoist_methodwet_list = []; mpimoist_methodwet_counts = []
mpiwet_methoddry_list = []; mpiwet_methoddry_counts = []
mpiwet_methodmoist_list = []; mpiwet_methodmoist_counts = []

mpidry_methoddry_list = []; mpidry_methoddry_counts = []
mpimoist_methodmoist_list = []; mpimoist_methodmoist_counts = []
mpiwet_methodwet_list = []; mpiwet_methodwet_counts = []
```

```
mpidry_list = []; mpidry_counts = []
mpimoist_list = []; mpimoist_counts = []
mpiwet_list = []; mpiwet_counts = []


# Count misses
# global inputs: dv[1-8], mdv[1-8], mnvars
mnvars = 8

# Load UATM data
load_uatm_mpi_hist()

rainsignal_mpi = xr.open_dataset(model2absfilepath('raw', 'hist', 98,␣
 ↪36))['prec']

# list of models
#sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['obs','raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]


model_counts = []
for mii in [0,1,2,4,5,6,7,8]: #range(1): #len(sigfiles_hist)):
    sigfilename = sigfiles[mii]

    rainsignal = xr.open_dataset(sigfilename)['prec']

    # calc hit/miss
    mpidry_methodmoist = 0
    mpidry_methodwet = 0
    mpimoist_methoddry = 0
    mpimoist_methodwet = 0
    mpiwet_methoddry = 0
    mpiwet_methodmoist = 0

    mpidry_methoddry = 0
    mpimoist_methodmoist = 0
    mpiwet_methodwet = 0

    mpidry = 0
    mpimoist = 0
    mpiwet = 0

    mpi_maydays_count = 0

    # initialize uatm accumulators
```

```
    raw_ires = len(mdv1[0])
    raininput_mpidry_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpidry_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_mpidry_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_mpidry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_methodall = np.zeros((mnvars, raw_ires, raw_ires))


    for ii in range(len(rainsignal_mpi)):
        pr_mpi = rainsignal_mpi[ii]

        if pr_mpi["time.month"] == 5:    # May
            # Keep track of how many days were in May
            mpi_maydays_count += 1
            raininput_methodall += isample


            # find matching input sample
            ot = pr_mpi['time']
            #pr_method = rainsignal.sel(time=ot,method='nearest')
            pr_method = rainsignal[ii]


            #print(ii, pr_mpi['time'], pr_method['time'])
            #isample = [mdv1.sel(time=ot,method='nearest'),mdv2.
↪sel(time=ot,method='nearest'),mdv3.sel(time=ot,method='nearest'),mdv4.
↪sel(time=ot,method='nearest'),mdv5.sel(time=ot,method='nearest'),mdv6.
↪sel(time=ot,method='nearest'),mdv7.sel(time=ot,method='nearest'),mdv8.
↪sel(time=ot,method='nearest')]
            isample =␣
↪[mdv1[ii],mdv2[ii],mdv3[ii],mdv4[ii],mdv5[ii],mdv6[ii],mdv7[ii],mdv8[ii]]
            #isample = np.array(isample)

            # 1: count mpidry_methodmoist
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method < 3.0:
                mpidry_methodmoist += 1
```

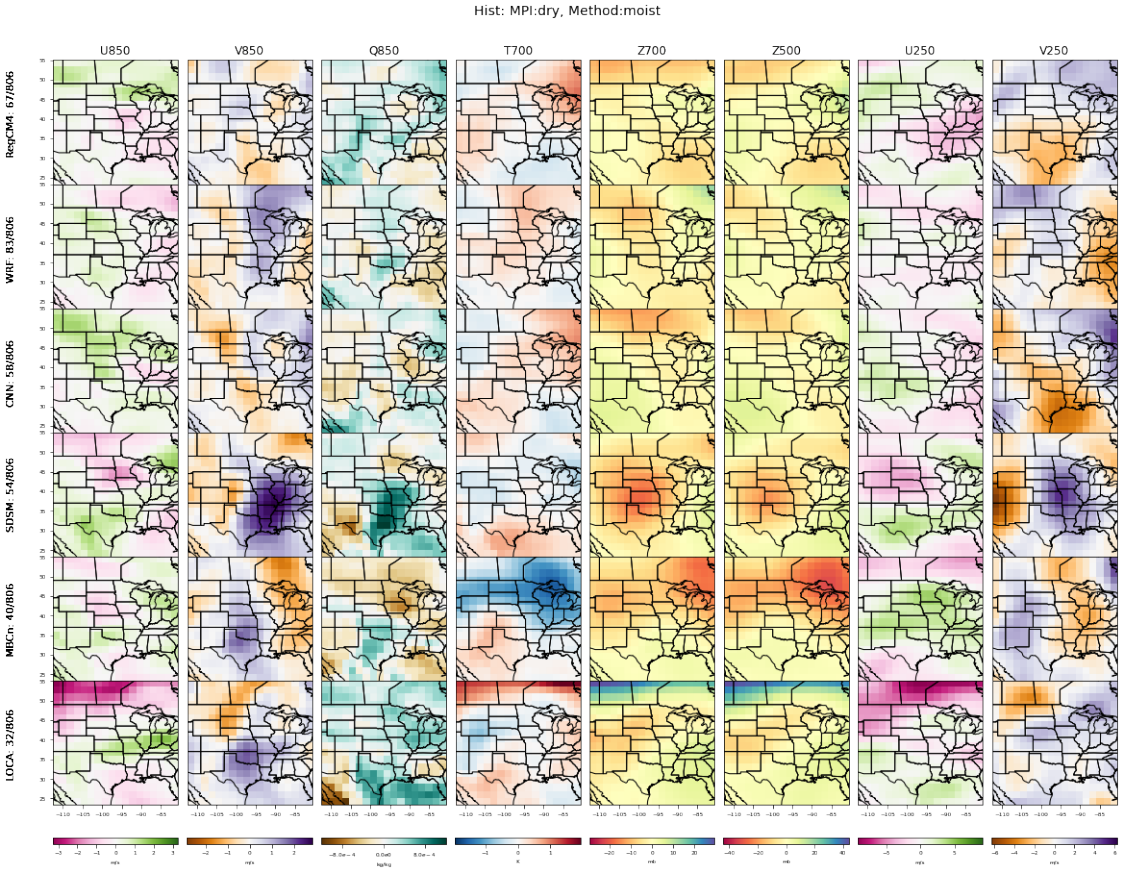
```
                raininput_mpidry_methodmoist += isample

            # 2: count mpidry_methodwet
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method >= 3.0:
                mpidry_methodwet += 1
                raininput_mpidry_methodwet += isample

            # 3: count mpimoist_methoddry
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method < 0.254:
                mpimoist_methoddry += 1
                raininput_mpimoist_methoddry += isample

            # 4: count mpimoist_methodwet
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 3.0:
                mpimoist_methodwet += 1
                raininput_mpimoist_methodwet += isample

            # 5: count mpiwet_methoddry
            if pr_mpi >= 3.0 and pr_method < 0.254:
                mpiwet_methoddry += 1
                raininput_mpiwet_methoddry += isample

            # 6: count mpiwet_methodmoist
            if pr_mpi >= 3.0 and pr_method >= 0.254 and pr_method < 3.0:
                mpiwet_methodmoist += 1
                raininput_mpiwet_methodmoist += isample

            # ---- diagnol self values ------
            # 7: count mpidry_methoddry
            if pr_mpi < 0.254 and pr_method < 0.254:
                mpidry_methoddry += 1
                raininput_mpidry_methoddry += isample
            # 8: count mpimoist_methodmoist
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 0.254 and␣
↪pr_method < 3.0:
                mpimoist_methodmoist += 1
                raininput_mpimoist_methodmoist += isample
            # 9: count mpiwet_methodwet
            if pr_mpi >= 3.0 and pr_method >= 3.0:
                mpiwet_methodwet += 1
                raininput_mpiwet_methodwet += isample

            # ---- just mpi ------
            # count mpidry
            if pr_mpi < 0.254:
                mpidry += 1
                raininput_mpidry += isample
```

```
            # count mpimoist
            if pr_mpi >= 0.254 and pr_mpi < 3.0:
                mpimoist += 1
                raininput_mpimoist += isample
            # count mpiwet
            if pr_mpi >= 3.0:
                mpiwet += 1
                raininput_mpiwet += isample


#     print("Model:", mnames[mii])
#     print("Method: Dry, Moist, Wet")
#     print("MPI dry: ",  mpidry_methoddry, mpidry_methodmoist, mpidry_methodwet)
#     print("MPI moist: ",  mpimoist_methoddry, mpimoist_methodmoist,␣
 ↪mpimoist_methodwet)
#     print("MPI wet: ",  mpiwet_methoddry, mpiwet_methodmoist, mpiwet_methodwet)
#     print()

    print(mii, mpidry_methodmoist, mpimoist_methoddry, mpimoist_methodwet,␣
 ↪mpiwet_methoddry, mpiwet_methodmoist, mpimoist_methodwet)
    ## plot uatm
    #plot_8v(raininput_mpidry_methodmoist/mpidry_methodmoist)
    #plot_8v(raininput_mpimoist_methoddry/mpimoist_methoddry)
    #plot_8v(raininput_mpimoist_methodwet/mpimoist_methodwet)
    #plot_8v(raininput_mpiwet_methoddry/mpiwet_methoddry)

    # save to list
    #mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry)
    mpidry_methodmoist_list.append(raininput_mpidry_methodmoist/
 ↪mpidry_methodmoist - raininput_mpidry/mpidry)
    mpidry_methodmoist_counts.append(mpidry_methodmoist)

    mpidry_methodwet_list.append(raininput_mpidry_methodwet/mpidry_methodwet -␣
 ↪raininput_mpidry/mpidry)
    mpidry_methodwet_counts.append(mpidry_methodwet)

    mpimoist_methoddry_list.append(raininput_mpimoist_methoddry/
 ↪mpimoist_methoddry - raininput_mpimoist/mpimoist)
    mpimoist_methoddry_counts.append(mpimoist_methoddry)

    mpimoist_methodwet_list.append(raininput_mpimoist_methodwet/
 ↪mpimoist_methodwet - raininput_mpimoist/mpimoist)
    mpimoist_methodwet_counts.append(mpimoist_methodwet)

    mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry -␣
 ↪raininput_mpiwet/mpiwet)
```

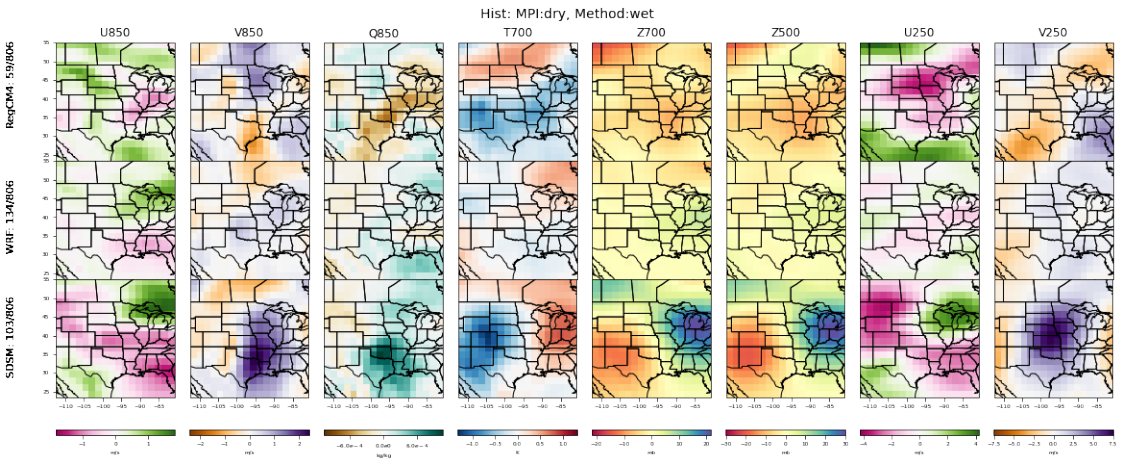
```
    mpiwet_methoddry_counts.append(mpiwet_methoddry)

    mpiwet_methodmoist_list.append(raininput_mpiwet_methodmoist/
↪mpiwet_methodmoist - raininput_mpiwet/mpiwet)
    mpiwet_methodmoist_counts.append(mpiwet_methodmoist)

    # ---- diagnol self values ------
    mpidry_methoddry_list.append(raininput_mpidry_methoddry/mpidry_methoddry -␣
↪raininput_mpidry/mpidry)
    mpidry_methoddry_counts.append(mpidry_methoddry)

    mpimoist_methodmoist_list.append(raininput_mpimoist_methodmoist/
↪mpimoist_methodmoist - raininput_mpimoist/mpimoist)
    mpimoist_methodmoist_counts.append(mpimoist_methodmoist)

    mpiwet_methodwet_list.append(raininput_mpiwet_methodwet/mpiwet_methodwet -␣
↪raininput_mpiwet/mpiwet)
    mpiwet_methodwet_counts.append(mpiwet_methodwet)
```

```
0 0 0 0 0 0 0
1 67 124 49 145 38 49
2 83 74 78 90 59 78
4 58 106 48 64 65 48
5 54 126 55 144 50 55
6 0 83 0 0 20 0
7 40 144 5 3 42 5
8 32 47 49 1 46 49
```

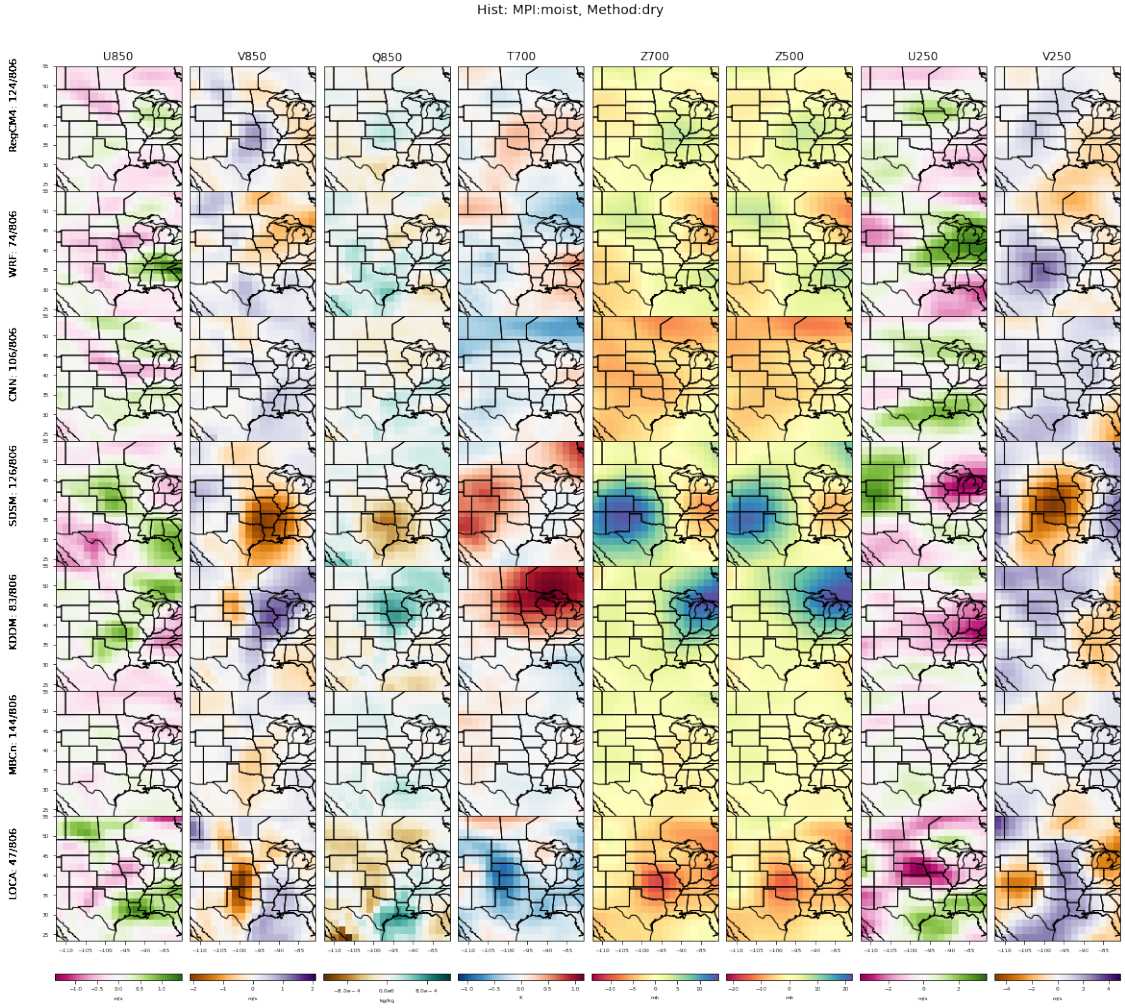
[83]:
```
model_names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']
plot_postage(mpidry_methodmoist_list, model_names, mpidry_methodmoist_counts,␣
 ↪mpi_maydays_count, 'Hist: MPI:dry, Method:moist')
```



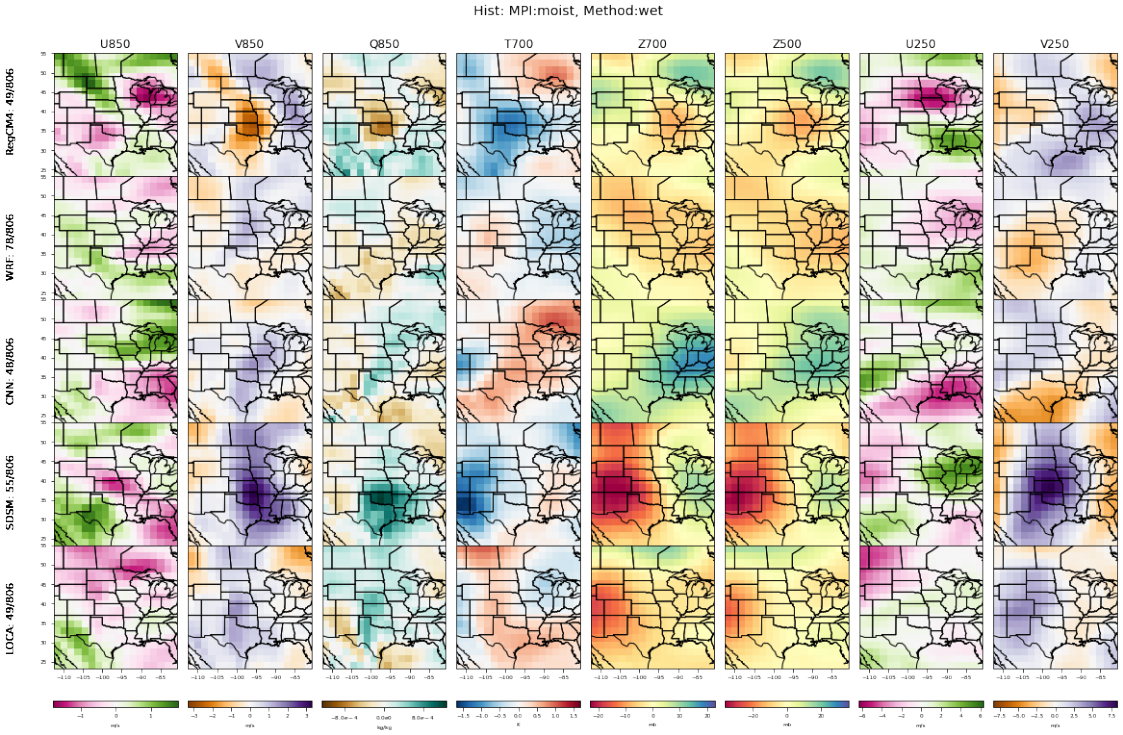
[84]:
```
plot_postage(mpidry_methodwet_list, model_names, mpidry_methodwet_counts,␣
 ↪mpi_maydays_count, 'Hist: MPI:dry, Method:wet')
```



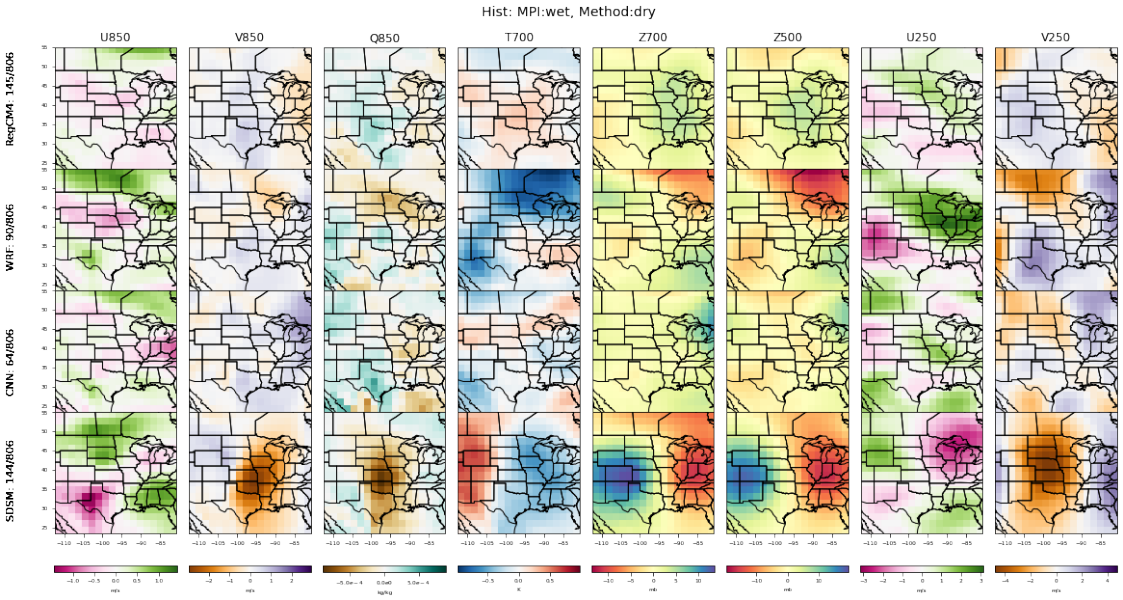
[85]:
```
plot_postage(mpimoist_methoddry_list, model_names, mpimoist_methoddry_counts,␣
↪mpi_maydays_count, 'Hist: MPI:moist, Method:dry')
```



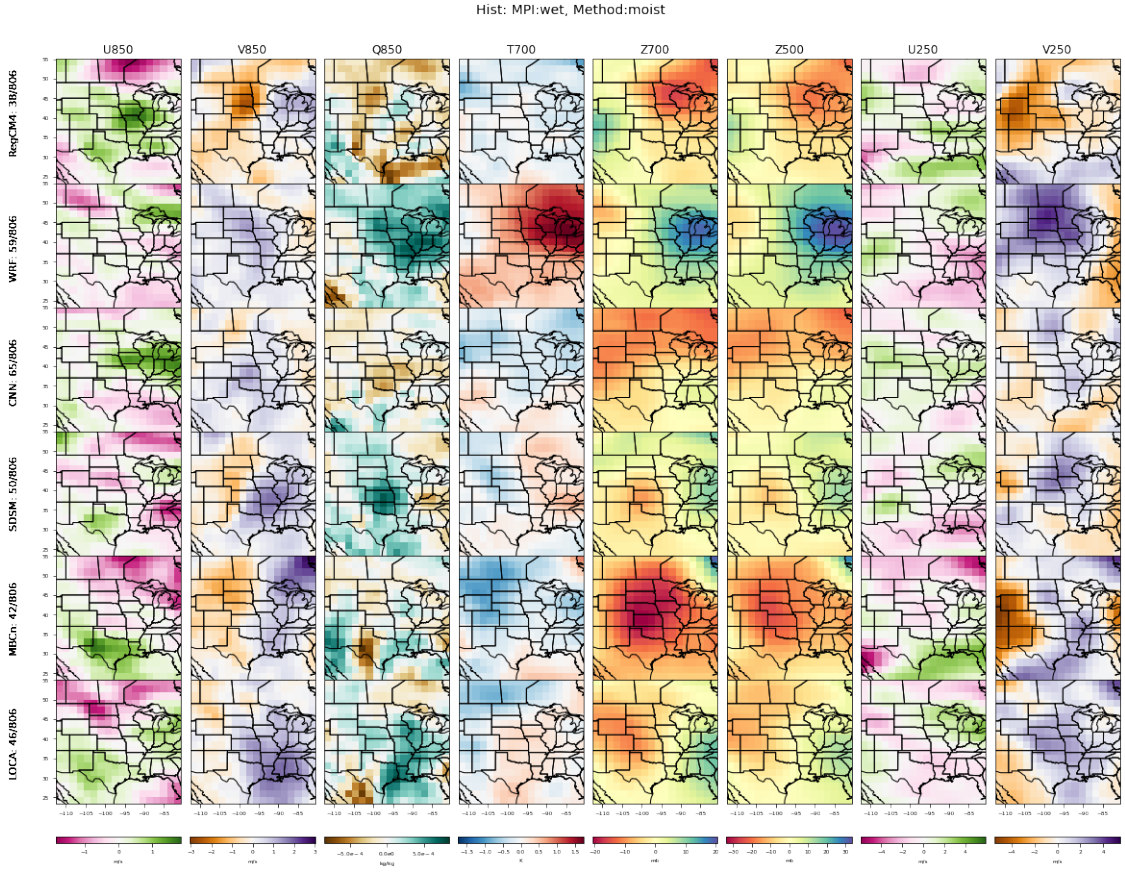
[86]:
```
plot_postage(mpimoist_methodwet_list, model_names, mpimoist_methodwet_counts,␣
↪mpi_maydays_count, 'Hist: MPI:moist, Method:wet')
```



[87]:
```
plot_postage(mpiwet_methoddry_list, model_names, mpiwet_methoddry_counts,␣
↪mpi_maydays_count, 'Hist: MPI:wet, Method:dry')
```



[88]:
```
plot_postage(mpiwet_methodmoist_list, model_names, mpiwet_methodmoist_counts,␣
↪mpi_maydays_count, 'Hist: MPI:wet, Method:moist')
```



7.0.2 Rcp85

[89]:
```
# hist
mpidry_methodmoist_list = []; mpidry_methodmoist_counts = []
mpidry_methodwet_list = []; mpidry_methodwet_counts = []
mpimoist_methoddry_list = []; mpimoist_methoddry_counts = []
mpimoist_methodwet_list = []; mpimoist_methodwet_counts = []
mpiwet_methoddry_list = []; mpiwet_methoddry_counts = []
mpiwet_methodmoist_list = []; mpiwet_methodmoist_counts = []

mpidry_methoddry_list = []; mpidry_methoddry_counts = []
mpimoist_methodmoist_list = []; mpimoist_methodmoist_counts = []
mpiwet_methodwet_list = []; mpiwet_methodwet_counts = []

mpidry_list = []; mpidry_counts = []
mpimoist_list = []; mpimoist_counts = []
```

```
mpiwet_list = []; mpiwet_counts = []


# Count misses
# global inputs: dv[1-8], mdv[1-8], mnvars
mnvars = 8

# Load UATM data
load_uatm_mpi_future()

rainsignal_mpi = xr.open_dataset(model2absfilepath('raw', 'rcp85', 98,␣
 ↪36))['prec']

# list of models
#sigfiles = [model2absfilepath(ff, 'hist', 98, 36) for ff in␣
 ↪['obs','raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]
mnames = ['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']
sigfiles = [model2absfilepath(ff, 'rcp85', 98, 36) for ff in␣
 ↪['raw','RegCM4','WRF','MPAS','CNN','SDSM','KDDM','MBCn','LOCA']]


model_counts = []
for mii in [0,1,2,4,5,6,7,8]: #range(1): #len(sigfiles_hist)):
    sigfilename = sigfiles[mii]

    rainsignal = xr.open_dataset(sigfilename)['prec']

    # calc hit/miss
    mpidry_methodmoist = 0
    mpidry_methodwet = 0
    mpimoist_methoddry = 0
    mpimoist_methodwet = 0
    mpiwet_methoddry = 0
    mpiwet_methodmoist = 0

    mpidry_methoddry = 0
    mpimoist_methodmoist = 0
    mpiwet_methodwet = 0

    mpidry = 0
    mpimoist = 0
    mpiwet = 0

    mpi_maydays_count = 0

    # initialize uatm accumulators
    raw_ires = len(mdv1[0])
```

```
    raininput_mpidry_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpidry_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodwet = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_mpidry_methoddry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist_methodmoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet_methodwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_mpidry = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpimoist = np.zeros((mnvars, raw_ires, raw_ires))
    raininput_mpiwet = np.zeros((mnvars, raw_ires, raw_ires))

    raininput_methodall = np.zeros((mnvars, raw_ires, raw_ires))


    for ii in range(len(rainsignal_mpi)):
        pr_mpi = rainsignal_mpi[ii]

        if pr_mpi["time.month"] == 5:    # May
            # Keep track of how many days were in May
            mpi_maydays_count += 1
            raininput_methodall += isample


            # find matching input sample
            ot = pr_mpi['time']
            #pr_method = rainsignal.sel(time=ot,method='nearest')
            pr_method = rainsignal[ii]


            #print(ii, pr_mpi['time'], pr_method['time'])
            #isample = [mdv1.sel(time=ot,method='nearest'),mdv2.
↪sel(time=ot,method='nearest'),mdv3.sel(time=ot,method='nearest'),mdv4.
↪sel(time=ot,method='nearest'),mdv5.sel(time=ot,method='nearest'),mdv6.
↪sel(time=ot,method='nearest'),mdv7.sel(time=ot,method='nearest'),mdv8.
↪sel(time=ot,method='nearest')]
            isample =␣
↪[mdv1[ii],mdv2[ii],mdv3[ii],mdv4[ii],mdv5[ii],mdv6[ii],mdv7[ii],mdv8[ii]]
            #isample = np.array(isample)

            # 1: count mpidry_methodmoist
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method < 3.0:
                mpidry_methodmoist += 1
                raininput_mpidry_methodmoist += isample
```

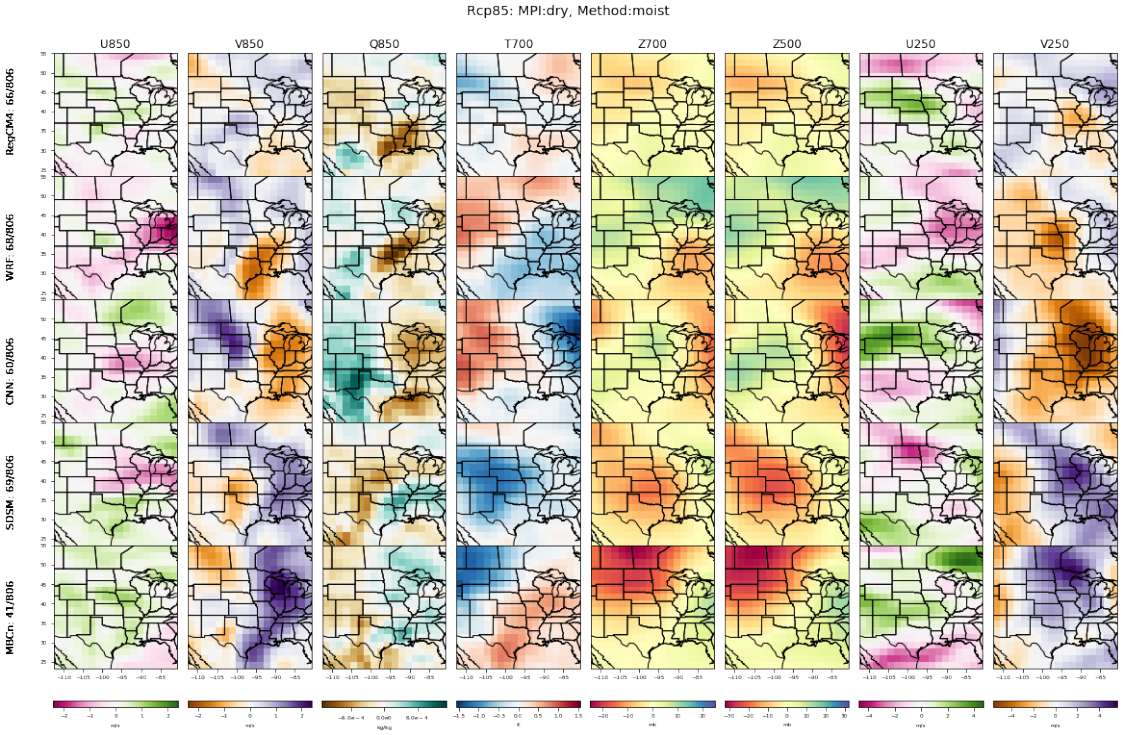
```
            # 2: count mpidry_methodwet
            if pr_mpi < 0.254 and pr_method >= 0.254 and pr_method >= 3.0:
                mpidry_methodwet += 1
                raininput_mpidry_methodwet += isample

            # 3: count mpimoist_methoddry
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method < 0.254:
                mpimoist_methoddry += 1
                raininput_mpimoist_methoddry += isample

            # 4: count mpimoist_methodwet
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 3.0:
                mpimoist_methodwet += 1
                raininput_mpimoist_methodwet += isample

            # 5: count mpiwet_methoddry
            if pr_mpi >= 3.0 and pr_method < 0.254:
                mpiwet_methoddry += 1
                raininput_mpiwet_methoddry += isample

            # 6: count mpiwet_methodmoist
            if pr_mpi >= 3.0 and pr_method >= 0.254 and pr_method < 3.0:
                mpiwet_methodmoist += 1
                raininput_mpiwet_methodmoist += isample

            # ---- diagnol self values ------
            # 7: count mpidry_methoddry
            if pr_mpi < 0.254 and pr_method < 0.254:
                mpidry_methoddry += 1
                raininput_mpidry_methoddry += isample
            # 8: count mpimoist_methodmoist
            if pr_mpi >= 0.254 and pr_mpi < 3.0 and pr_method >= 0.254 and␣
↪pr_method < 3.0:
                mpimoist_methodmoist += 1
                raininput_mpimoist_methodmoist += isample
            # 9: count mpiwet_methodwet
            if pr_mpi >= 3.0 and pr_method >= 3.0:
                mpiwet_methodwet += 1
                raininput_mpiwet_methodwet += isample

            # ---- just mpi ------
            # count mpidry
            if pr_mpi < 0.254:
                mpidry += 1
                raininput_mpidry += isample
            # count mpimoist
```

```
            if pr_mpi >= 0.254 and pr_mpi < 3.0:
                mpimoist += 1
                raininput_mpimoist += isample
            # count mpiwet
            if pr_mpi >= 3.0:
                mpiwet += 1
                raininput_mpiwet += isample


#     print("Model:", mnames[mii])
#     print("Method: Dry, Moist, Wet")
#     print("MPI dry: ",  mpidry_methoddry, mpidry_methodmoist, mpidry_methodwet)
#     print("MPI moist: ",  mpimoist_methoddry, mpimoist_methodmoist,␣
 ↪mpimoist_methodwet)
#     print("MPI wet: ",  mpiwet_methoddry, mpiwet_methodmoist, mpiwet_methodwet)
#     print()

    print(mii, mpidry_methodmoist, mpimoist_methoddry, mpimoist_methodwet,␣
 ↪mpiwet_methoddry, mpiwet_methodmoist, mpimoist_methodwet)
    ## plot uatm
    #plot_8v(raininput_mpidry_methodmoist/mpidry_methodmoist)
    #plot_8v(raininput_mpimoist_methoddry/mpimoist_methoddry)
    #plot_8v(raininput_mpimoist_methodwet/mpimoist_methodwet)
    #plot_8v(raininput_mpiwet_methoddry/mpiwet_methoddry)

    # save to list
    #mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry)
    mpidry_methodmoist_list.append(raininput_mpidry_methodmoist/
 ↪mpidry_methodmoist - raininput_mpidry/mpidry)
    mpidry_methodmoist_counts.append(mpidry_methodmoist)

    mpidry_methodwet_list.append(raininput_mpidry_methodwet/mpidry_methodwet -␣
 ↪raininput_mpidry/mpidry)
    mpidry_methodwet_counts.append(mpidry_methodwet)

    mpimoist_methoddry_list.append(raininput_mpimoist_methoddry/
 ↪mpimoist_methoddry - raininput_mpimoist/mpimoist)
    mpimoist_methoddry_counts.append(mpimoist_methoddry)

    mpimoist_methodwet_list.append(raininput_mpimoist_methodwet/
 ↪mpimoist_methodwet - raininput_mpimoist/mpimoist)
    mpimoist_methodwet_counts.append(mpimoist_methodwet)

    mpiwet_methoddry_list.append(raininput_mpiwet_methoddry/mpiwet_methoddry -␣
 ↪raininput_mpiwet/mpiwet)
    mpiwet_methoddry_counts.append(mpiwet_methoddry)
```

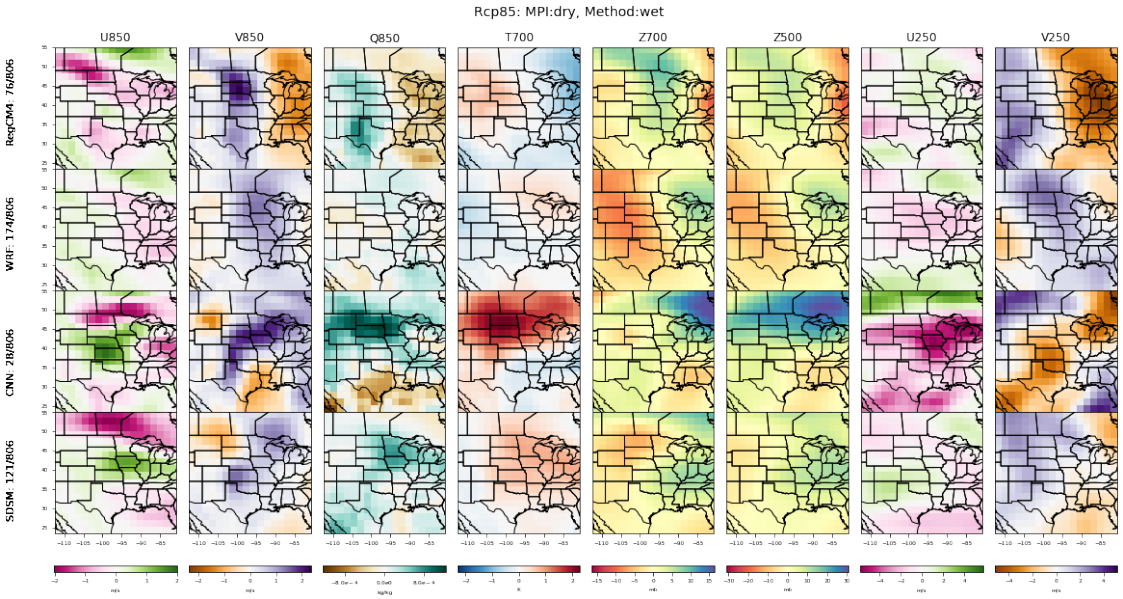
```
    mpiwet_methodmoist_list.append(raininput_mpiwet_methodmoist/
↪mpiwet_methodmoist - raininput_mpiwet/mpiwet)
    mpiwet_methodmoist_counts.append(mpiwet_methodmoist)

    # ---- diagnol self values ------
    mpidry_methoddry_list.append(raininput_mpidry_methoddry/mpidry_methoddry -␣
↪raininput_mpidry/mpidry)
    mpidry_methoddry_counts.append(mpidry_methoddry)

    mpimoist_methodmoist_list.append(raininput_mpimoist_methodmoist/
↪mpimoist_methodmoist - raininput_mpimoist/mpimoist)
    mpimoist_methodmoist_counts.append(mpimoist_methodmoist)

    mpiwet_methodwet_list.append(raininput_mpiwet_methodwet/mpiwet_methodwet -␣
↪raininput_mpiwet/mpiwet)
    mpiwet_methodwet_counts.append(mpiwet_methodwet)
```

```
0 0 0 0 0 0 0
1 66 82 51 99 35 51
2 68 63 71 90 42 71
4 60 87 40 50 60 40
5 69 91 58 141 25 58
6 0 79 0 0 18 0
7 41 109 5 1 27 5
8 14 53 35 2 39 35
```

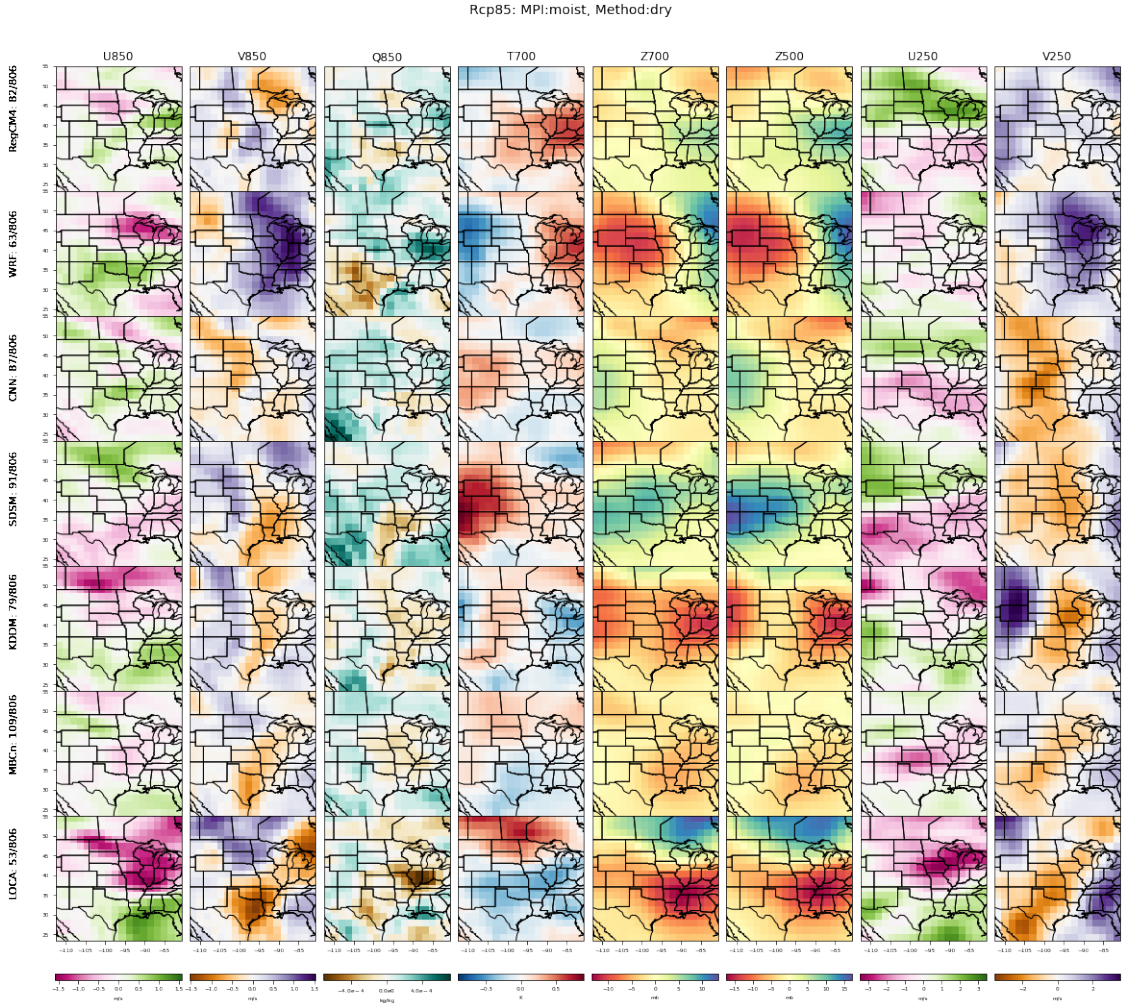
[90]:
```
model_names = ['raw','RegCM4','WRF','CNN','SDSM','KDDM','MBCn','LOCA']
plot_postage(mpidry_methodmoist_list, model_names, mpidry_methodmoist_counts,␣
 ↪mpi_maydays_count, 'Rcp85: MPI:dry, Method:moist')
```



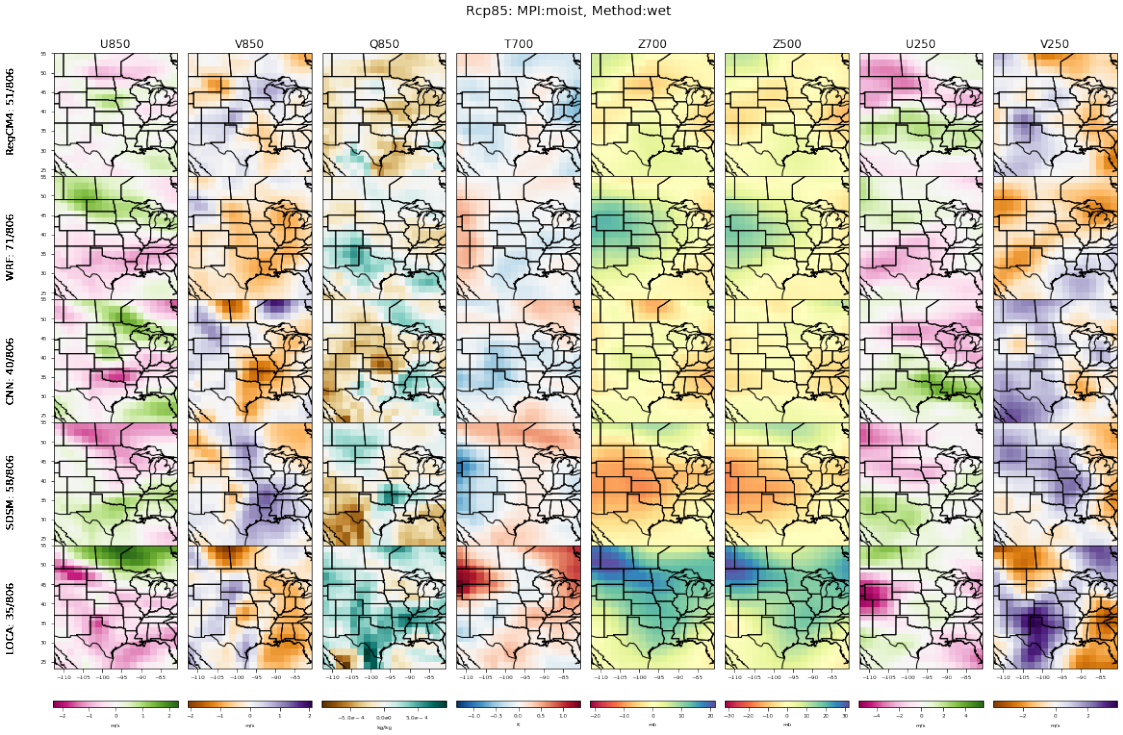
[91]:
```
plot_postage(mpidry_methodwet_list, model_names, mpidry_methodwet_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:dry, Method:wet')
```



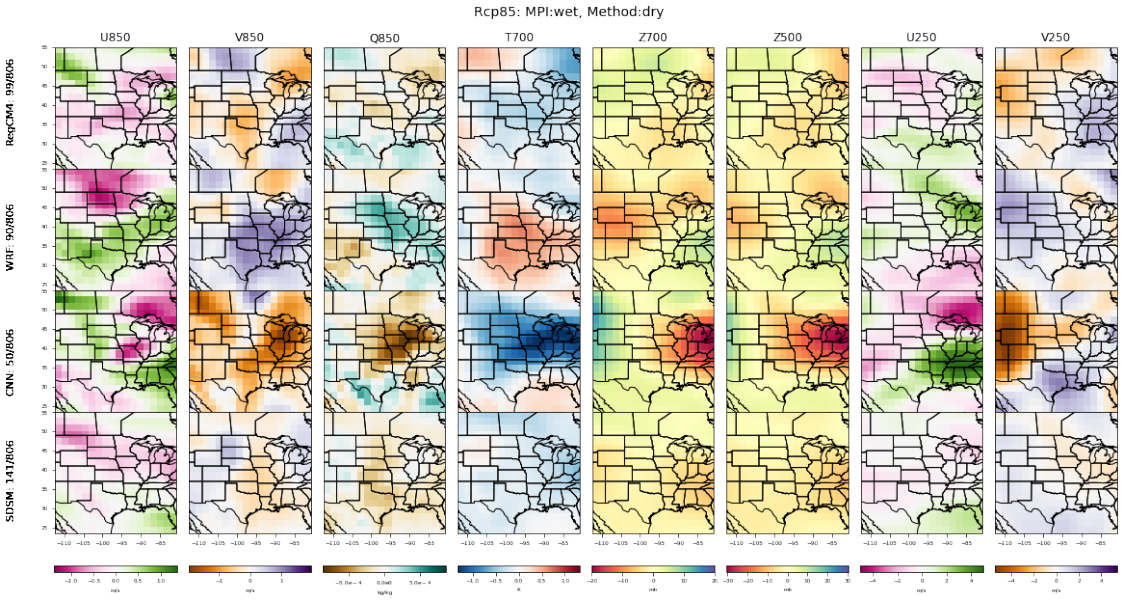
[92]:
```
plot_postage(mpimoist_methoddry_list, model_names, mpimoist_methoddry_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:moist, Method:dry')
```



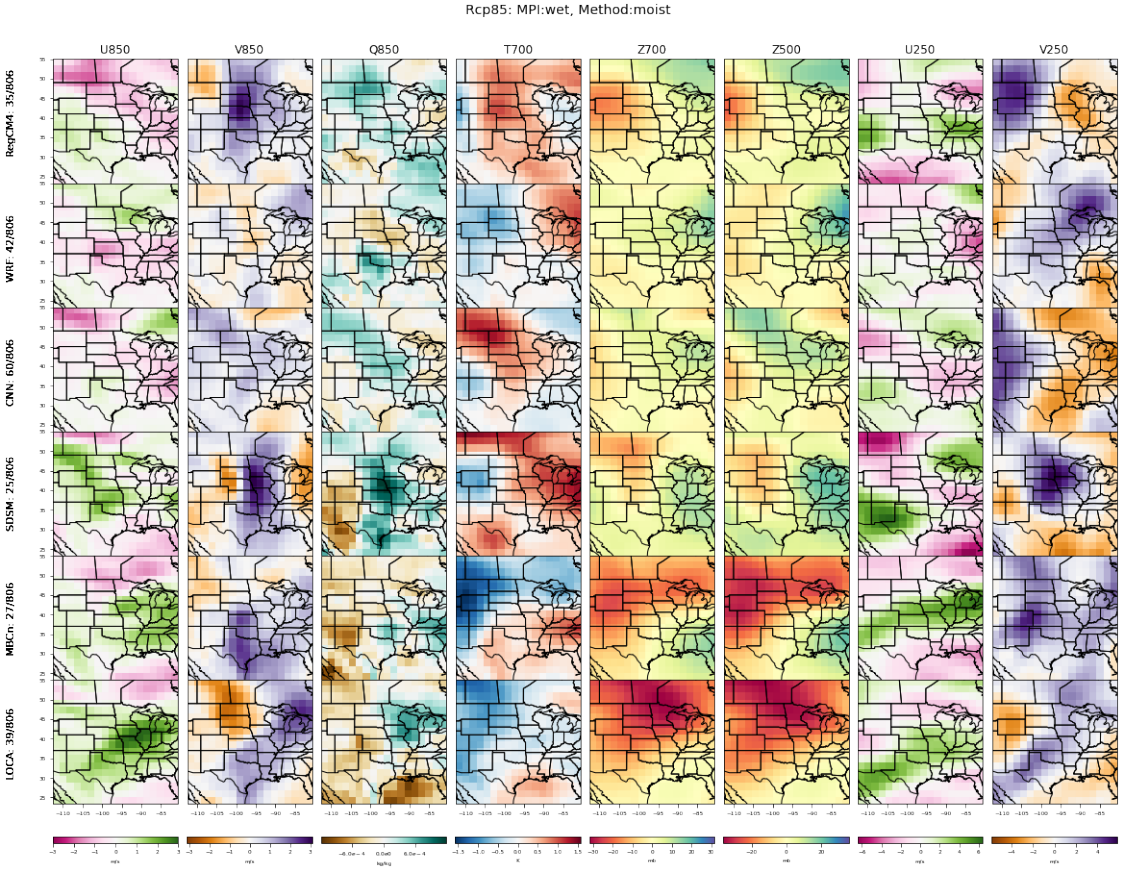
[93]:
```
plot_postage(mpimoist_methodwet_list, model_names, mpimoist_methodwet_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:moist, Method:wet')
```



[94]:
```
plot_postage(mpiwet_methoddry_list, model_names, mpiwet_methoddry_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:wet, Method:dry')
```



[95]:
```
plot_postage(mpiwet_methodmoist_list, model_names, mpiwet_methodmoist_counts,␣
↪mpi_maydays_count, 'Rcp85: MPI:wet, Method:moist')
```



[ ]:
```

```