SNOW-17 a priori parameterization Update

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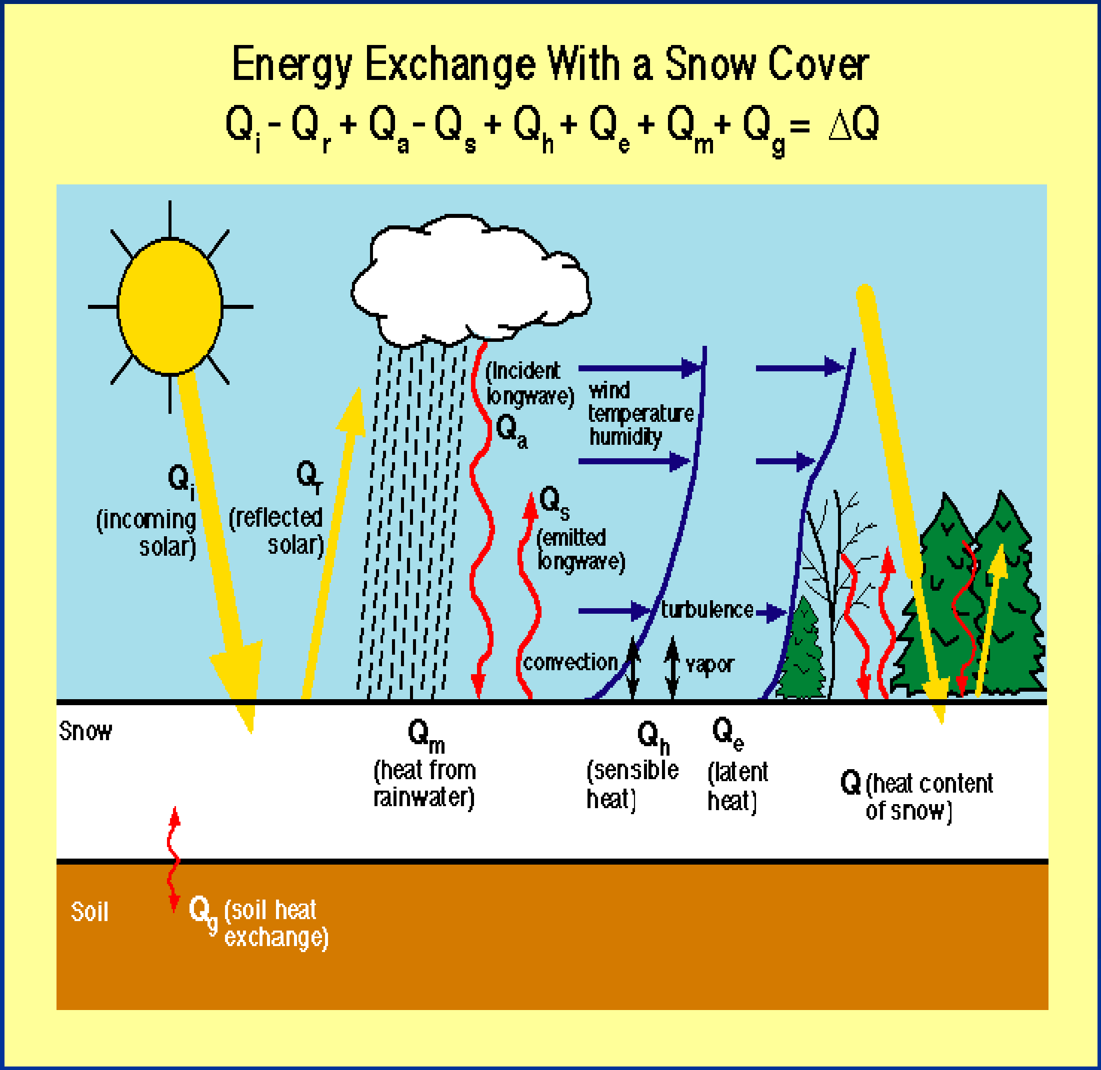
Outline

1. Background
2. MFMAX & MFMIN parameterization
3. UADJ parameterization
4. Snow-17 run with new parameters
5. Planned work

Background

SNOW-17 overview



Features:

- Point snow accumulation & ablation model and later applied to basin-wide through lumped model
- Conceptual model to simplify energy balance in snow pack
- Use 12 parameters
- Two input variables (air temp and precipitation)

Background

Distributed SNOW-17

- SNOW-17 runs at each HRAP pixel (~4km).
- Other parameters need to be generated based on physiographical and/or climate properties as a starting point (a priori parameter)

  e.g.

  - MFMAX/MIN can be related to latitude, slope, aspect, forest, wind climatology.
  - UADJ and SCF can be related to wind climatology.

Background

Current status of a priori parameterization

	Parameter	Description	*A Priori* grids available for CONUS?
Major	SCF	Snow Correction Factor	In progress
	MFMAX	Maximum Melt Factor	Yes [1]
	MFMIN	Minimum Melt Factor	Yes [1]
	UADJ	Ave. wind function during rain-on-snow	Yes [2]
	SI	Areal SWE above which there is always 100% snow cover	No
	ADC	Areal Depletion Curve	Removed or simplified as straight line
Minor	NMF	Negative Melt Factor	No
	TIPM	Antecedent snow temperature index	No
	MBASE	Base temperature for non-rain melt factors	No
	PXTEMP	Temperature that separates rain from snow	No
	PLWHC	Percent liquid water holding capacity	No
	DAYGM	Daily Ground Melt	No

Notes:
1. ½ hrap available
2. Monthly grid
3. Looking for DEM & forest grid data for Alaska

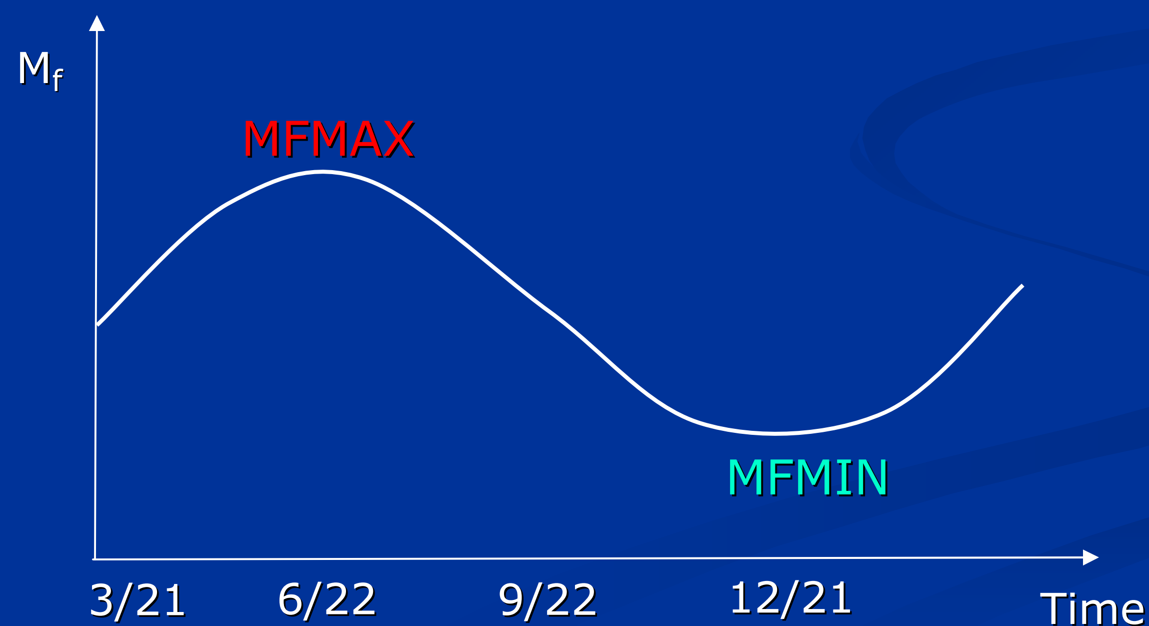
MFMAX & MFMIN parameterization

MFMAX & MFMIN overview

- Melt rate [mm/Δt] computation in no-rain condition
- Temperature index eq. with melt factor (M_f :mm/6hr/°C)

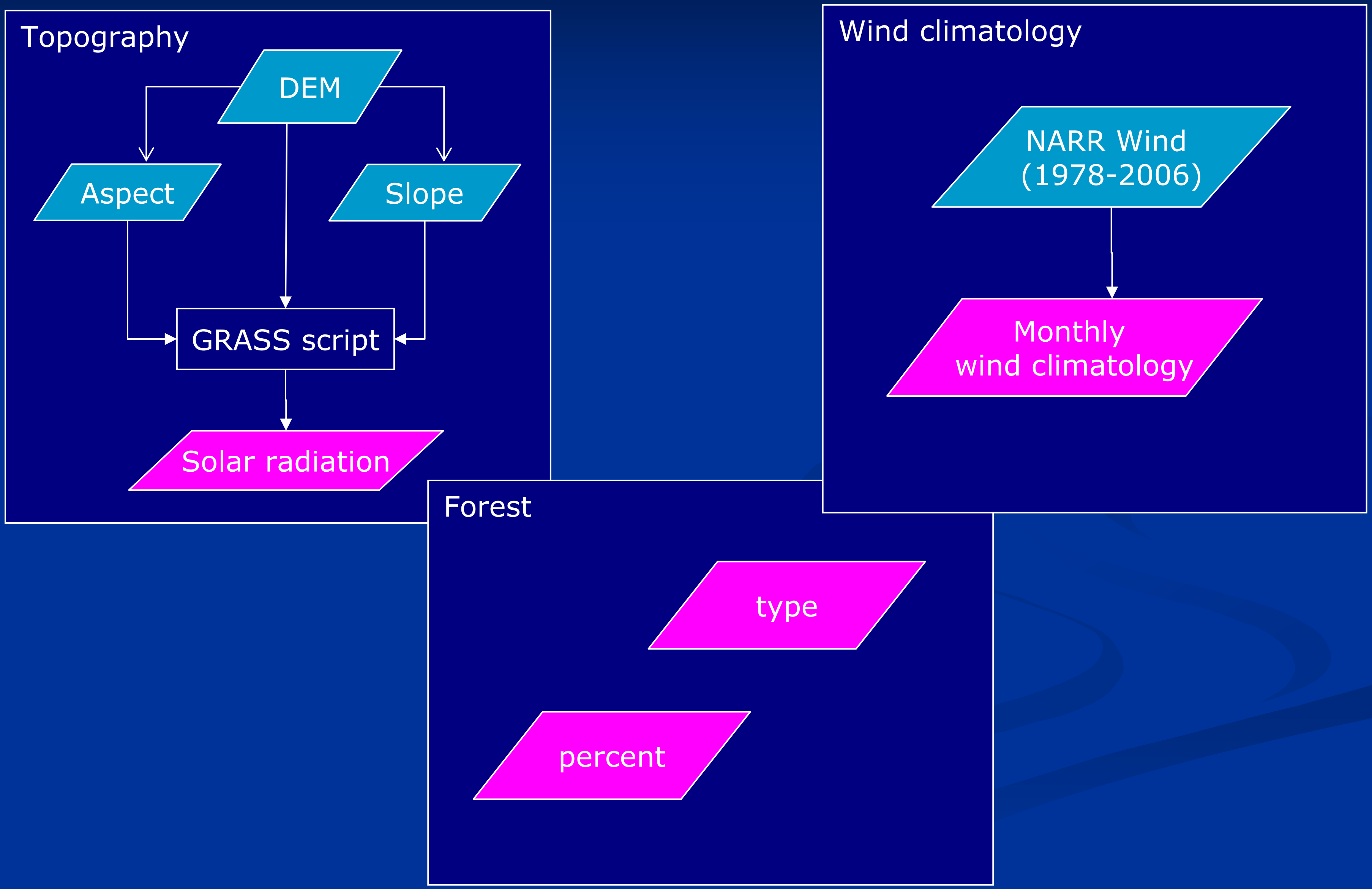
$$h_c = M_f \cdot T$$

$$M_f = f(MFMAX, MFMIN)$$



MFMAX & MFMIN parameterization

Physiographic & Climate Grids



MFMAX & MFMIN parameterization

Methods

1. Based on recommended values (Anderson, 2002)

Forest Cover	MFMAX	MFMIN
Coniferous forest /persistent cloud cover	0.5 -0.7	0.2 - 0.4
Mixed forest Coniferous plus open and/or deciduous	0.8 – 1.2	0.1-0.3
Predominantly Deciduous	1.0-1.4	0.2- 0.6
Open Areas flat terrain	1.5-2.2	0.2-0.6
Mountainous terrain	0.9-1.3	0.1-0.3

Use forest density and type, aspect and slope grids

2. Based on Energy balance model (new)

- Use computed solar radiation
- Use monthly wind climatology
- Use forest density and type

MFMAX & MFMIN parameterization

Method 2

Snowmelt from simplified energy balance equation (non-rain)

$$h_c = [\underbrace{1.03}_{\text{Radiation}} + \underbrace{2.04 + 0.42 \cdot u}_{\text{Sensible \& latent heat}}] \cdot T$$

Popov (1963)

h_c: melt rate [mm/°C/day]
T: daily average air temperature [°C]
u: Wind speed 10m above surface [m/s]

Assumption

- Clear sky
- Spring time
- Flat and no forest
- Snow albedo = 0.5

MFMAX & MFMIN parameterization

Account for topography & forest effect on radiation

$$h_c = \left[1.03 \cdot \left(1 - g\right) \cdot R_{DB} + 2.04 + 0.42 \cdot u\right] \cdot T$$

Forest effect on radiation
g: Forest percent

Topography effect on radiation

Flat area: $R_{db}=1$
Shaded area: $R_{db} < 1$
Exposed area: $R_{db} > 1$

MFMAX & MFMIN parameterization

Simplified energy equation = SNOW-17 equation

$$MFMAX = \frac{1.03 \cdot (1 - g) \cdot R_{DB} + 2.04 + 0.42 \cdot u}{2(R + 1)}$$

$$MFMIN = R \cdot MFMAX$$

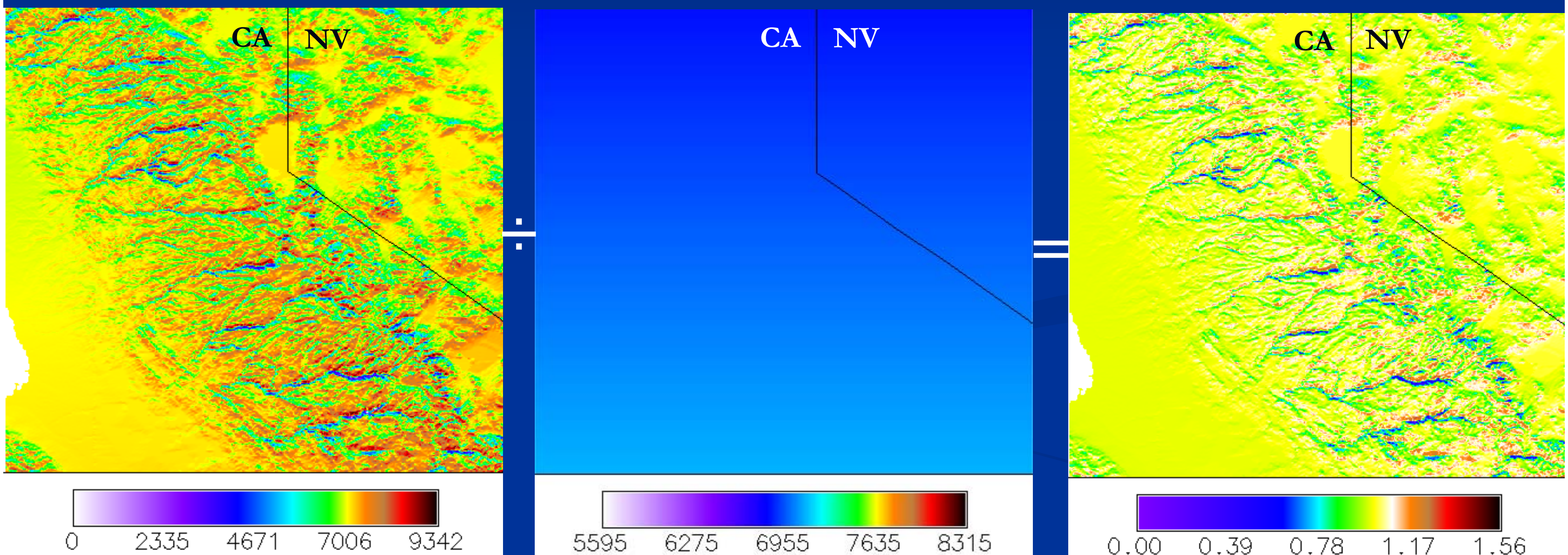
Need to determine "R" and "R_{DB}"

MFMAX & MFMIN parameterization

Derivation of R_{DB} Grid

R_{DB}: Ratio of radiation with topo to radiation with no topo

Daily solar radiation (3/21) | Daily solar radiation no topo (3/21) | R_{DB}



Unit: Wh/m^2/day | Unit: Wh/m^2/day | No Unit

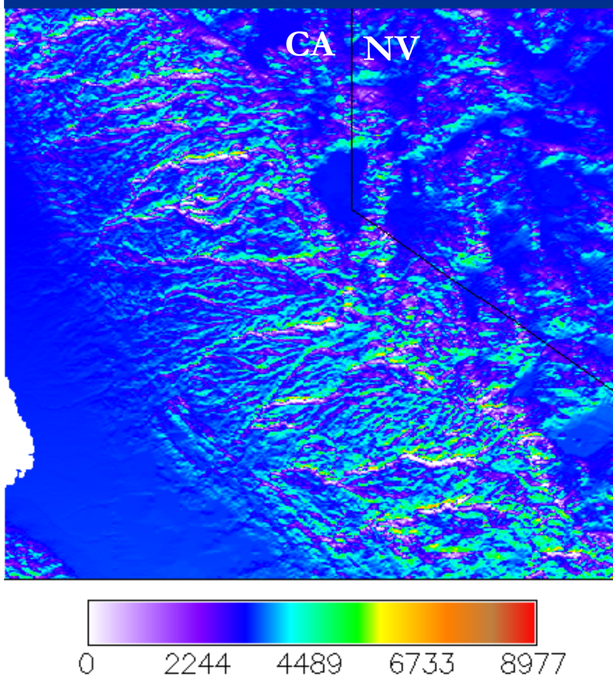
CONUS

MFMAX & MFMIN parameterization

Derivation of R grid

R: Ratio of winter radiation to summer radiation

Daily radiation (12/21)



Unit: Wh/m^2/day

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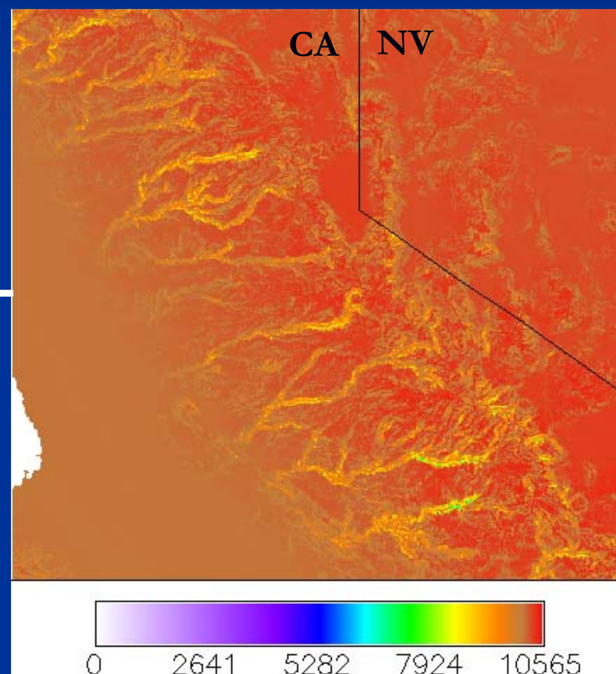
Daily radiation (6/22)



Unit: Wh/m^2/day

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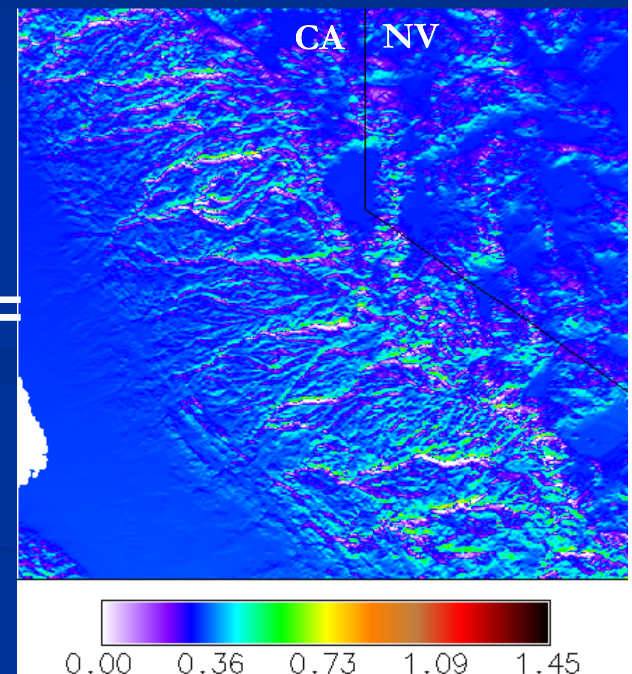
R

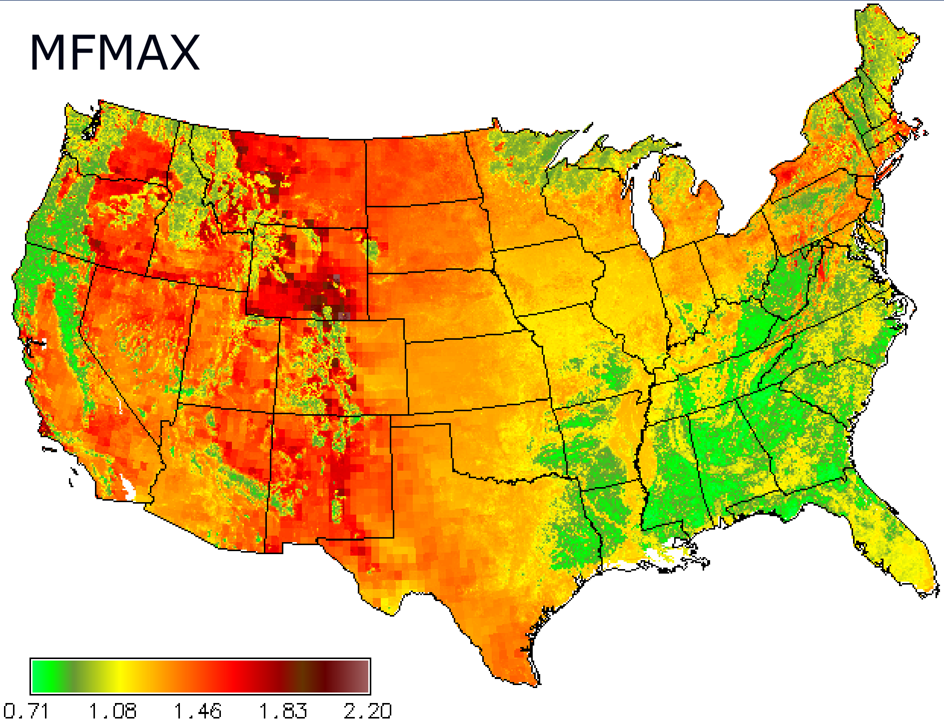


No Unit

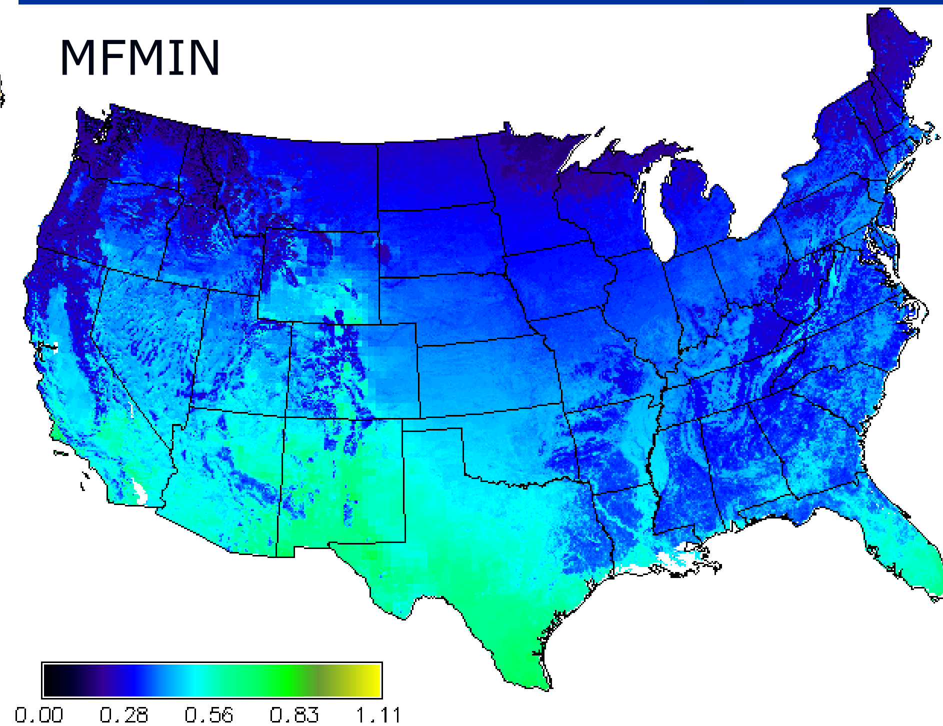
CONUS

MFMAX & MFMIN parameterization

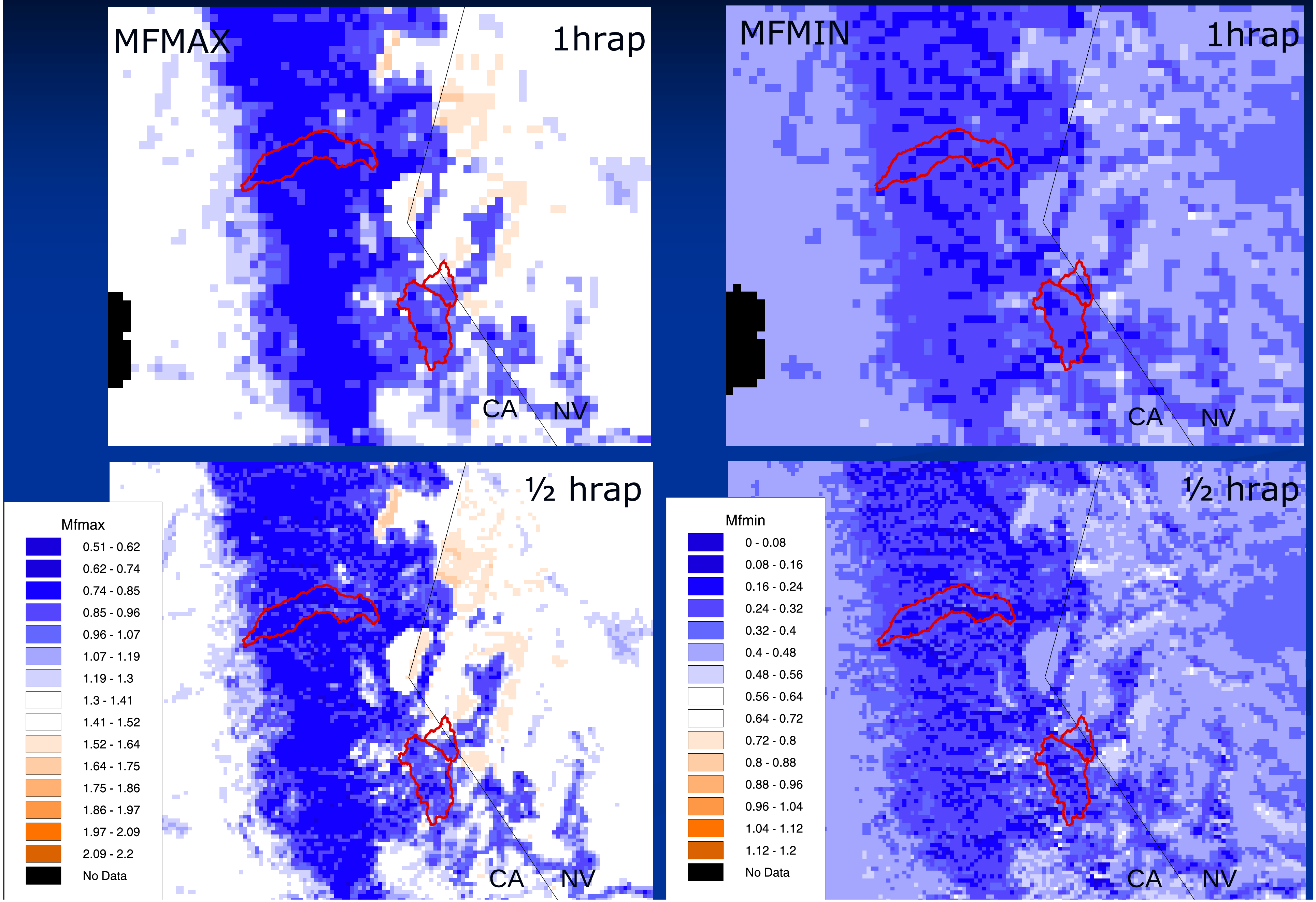
MFMAX



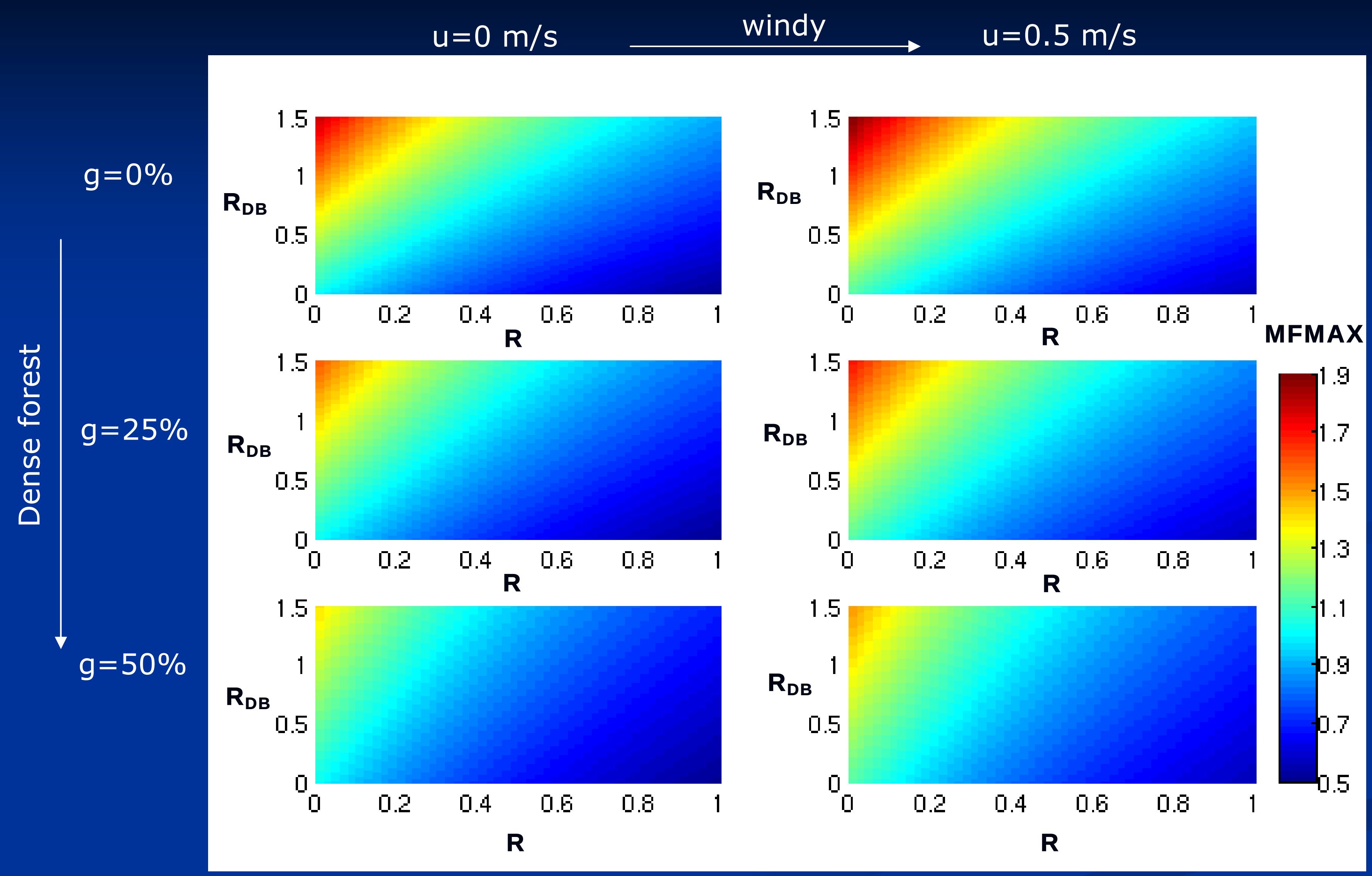
MFMIN



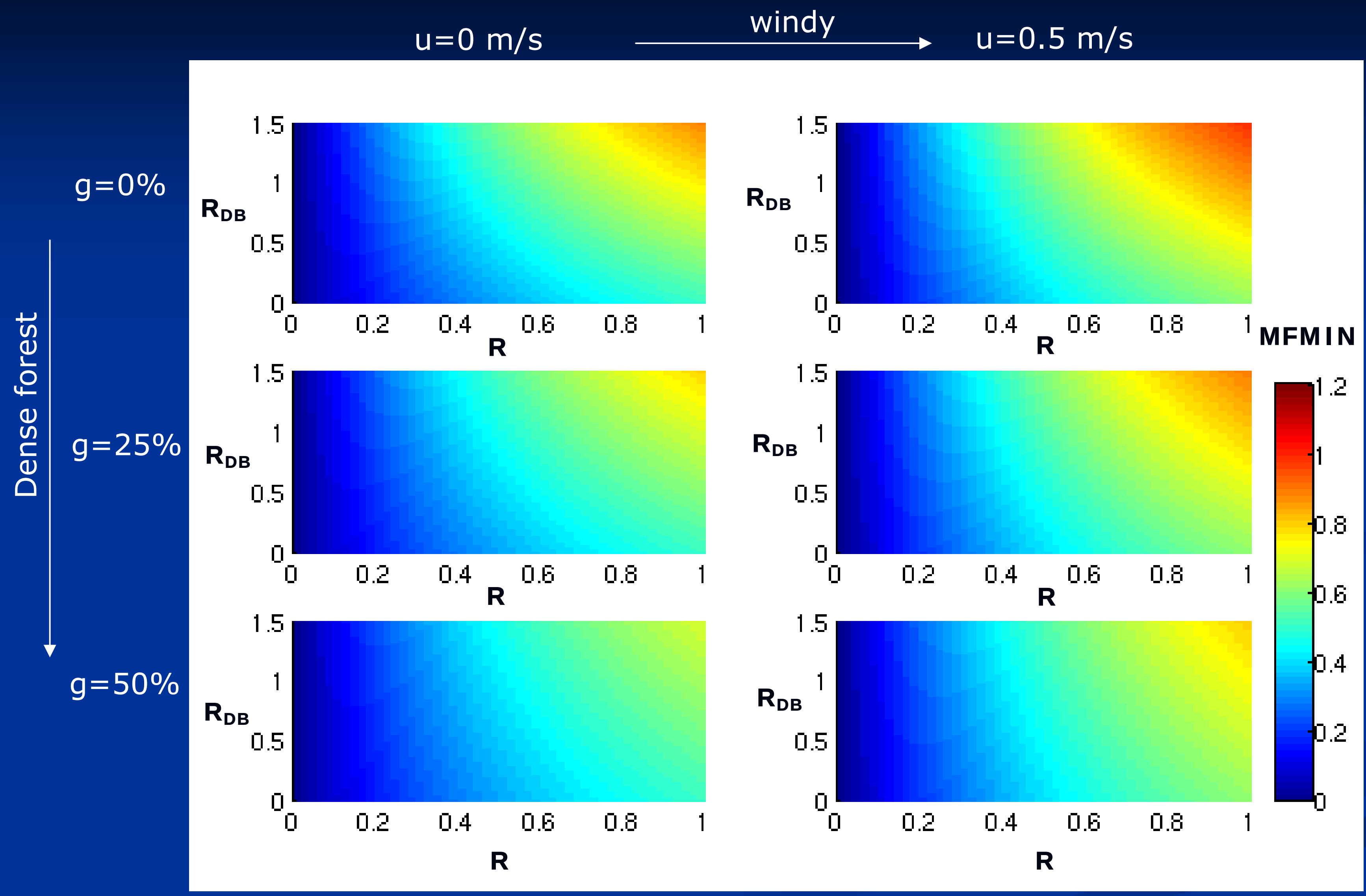
MFMAX & MFMIN –Resolution effect



MFMAX range


u=0 m/s
windy
u=0.5 m/s
g=0%
g=25%
g=50%
Dense forest
R_DB
R
MFMAX
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5

MFMIN range


u=0 m/s
windy
u=0.5 m/s
Dense forest
g=0%
g=25%
g=50%
RDB
R
MFMIN
0
0.2
0.4
0.6
0.8
1
1.2
0.5
1.5

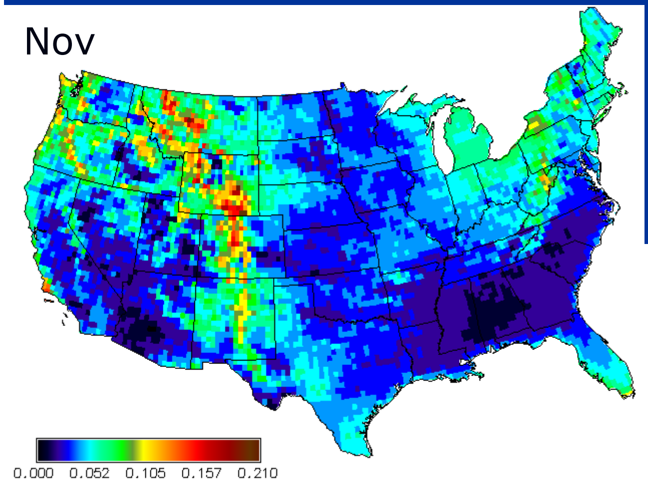
UADJ parameterization

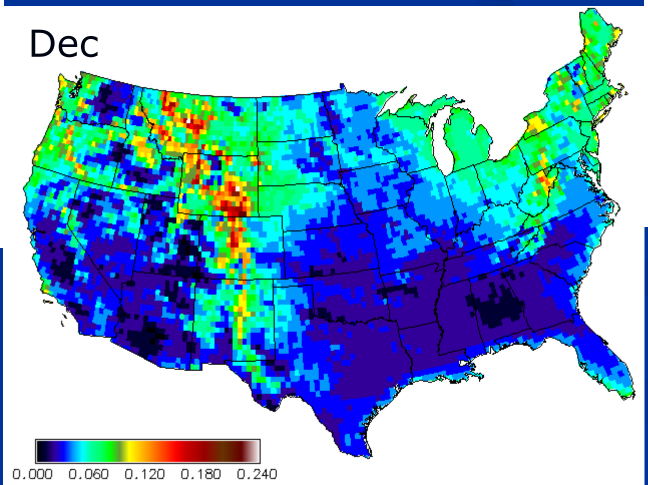
- UADJ = 0.002 x *U* (Anderson, 1976)

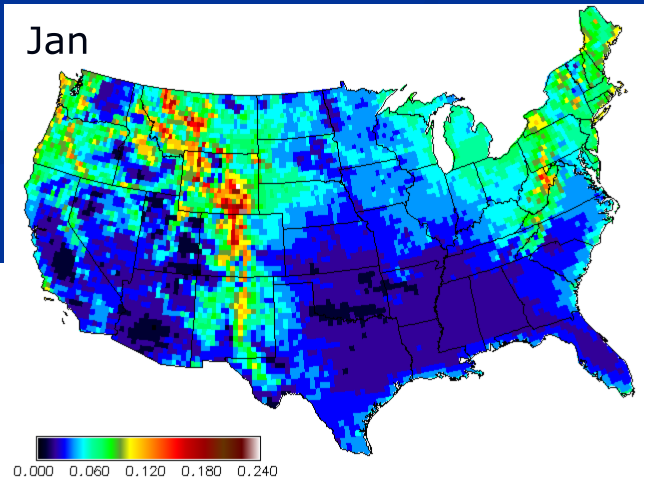
  where *U*: 6hr. wind travel (km) at 1m above snow surface

- Used monthly wind climatology (10 m above surface) from NARR

- Adjust wind speed at 1m above surface using a wind profile (Golubev et al. 1992)

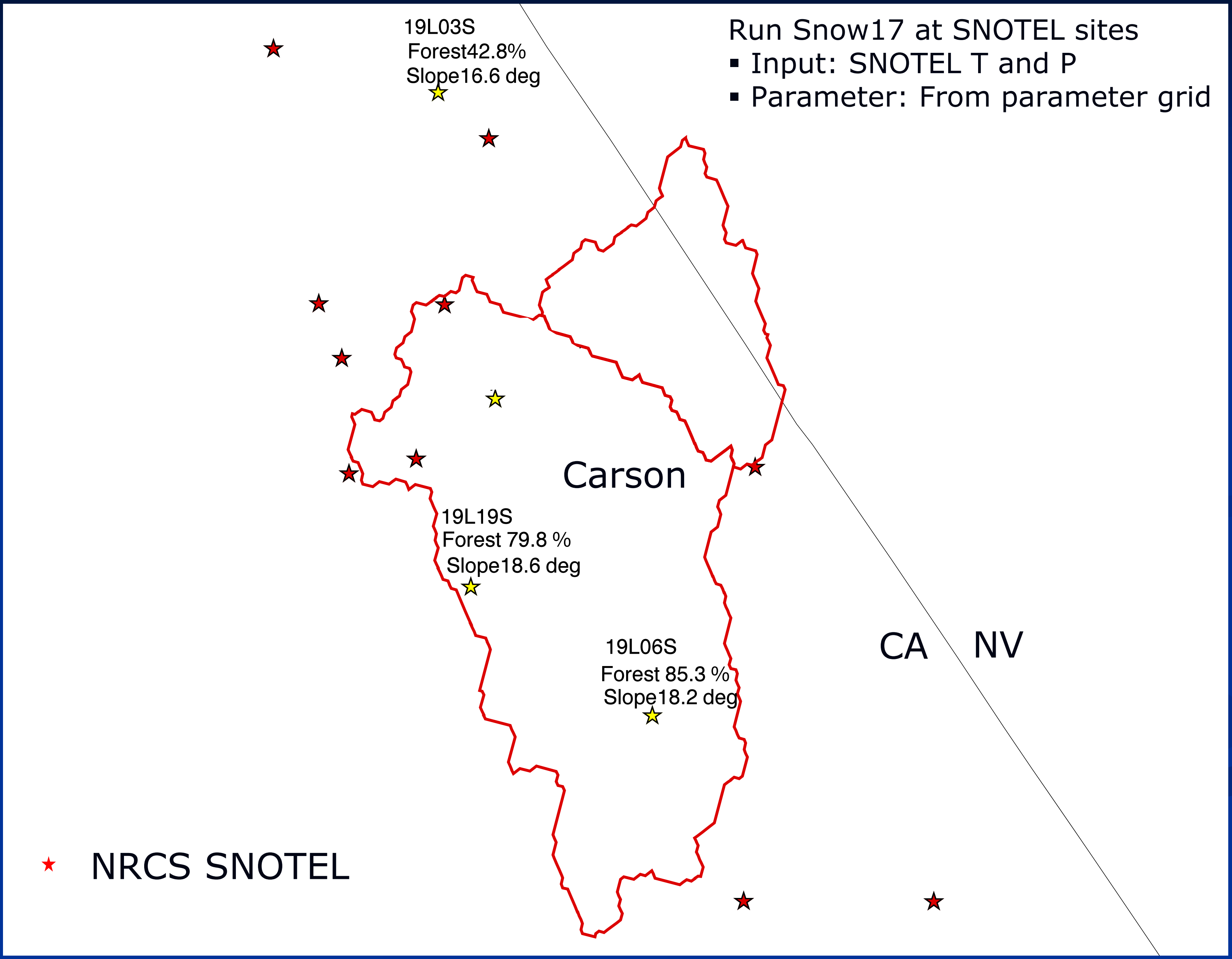




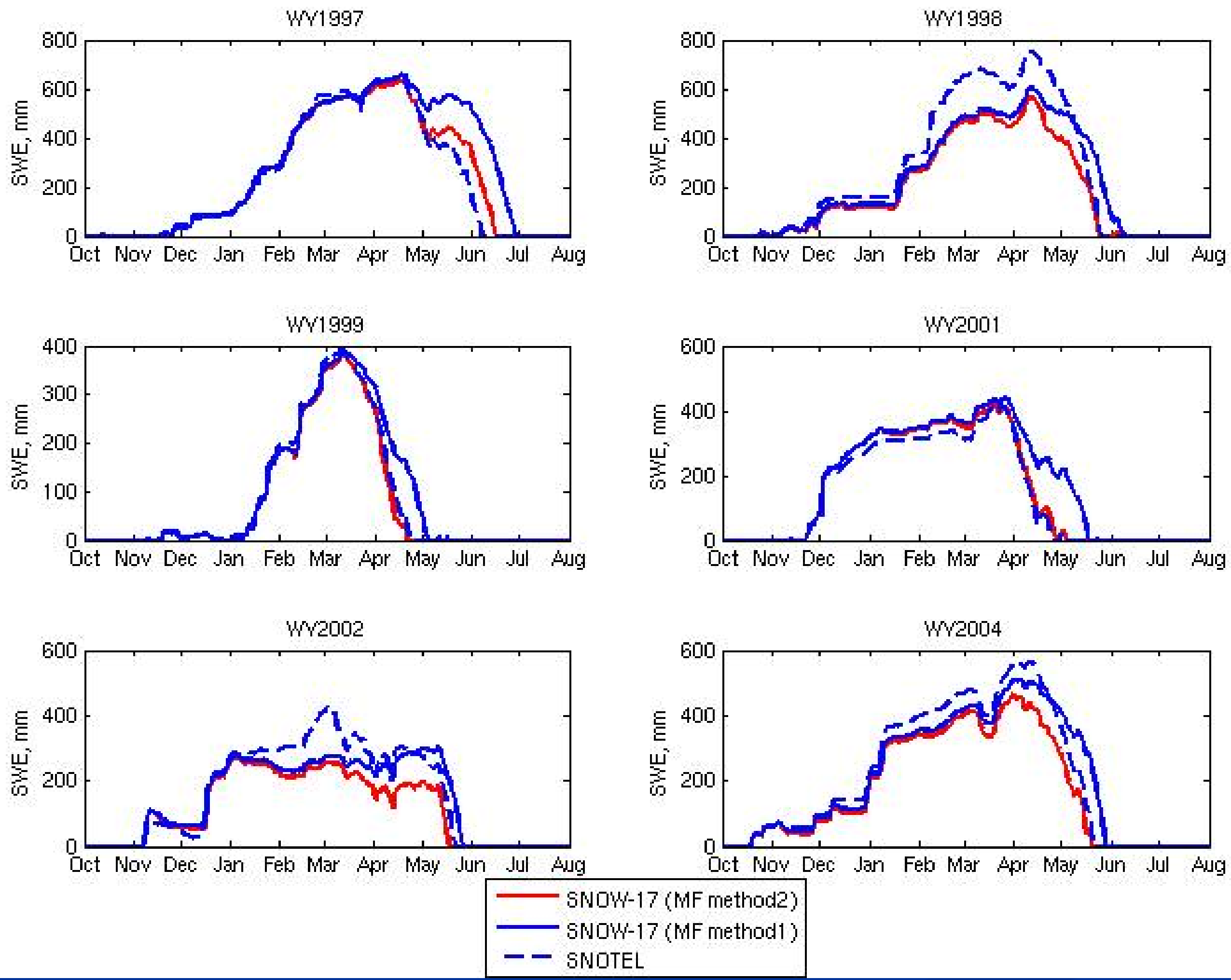


Snow17 simulation

Run Snow17 at SNOTEL sites
- Input: SNOTEL T and P
- Parameter: From parameter grid



Snow17 simulation

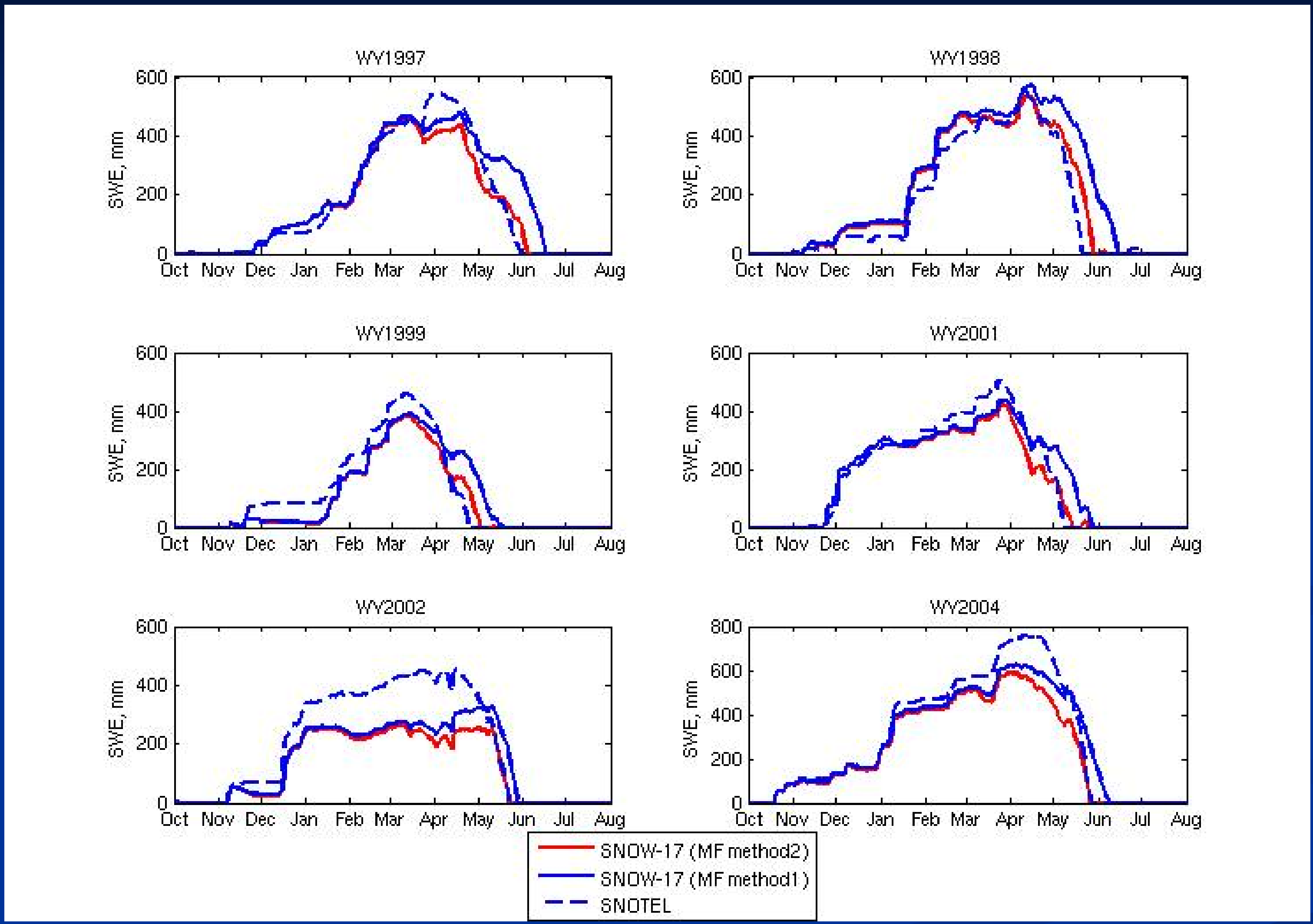


19L03S
Slope 16.6 degree
Forest 42.8 %

UADJ=0.05

MFMAX		MFMIN	
Method 2	Method 1	Method 2	Method 1
1.21	0.7	0.43	0.4

Snow17 simulation

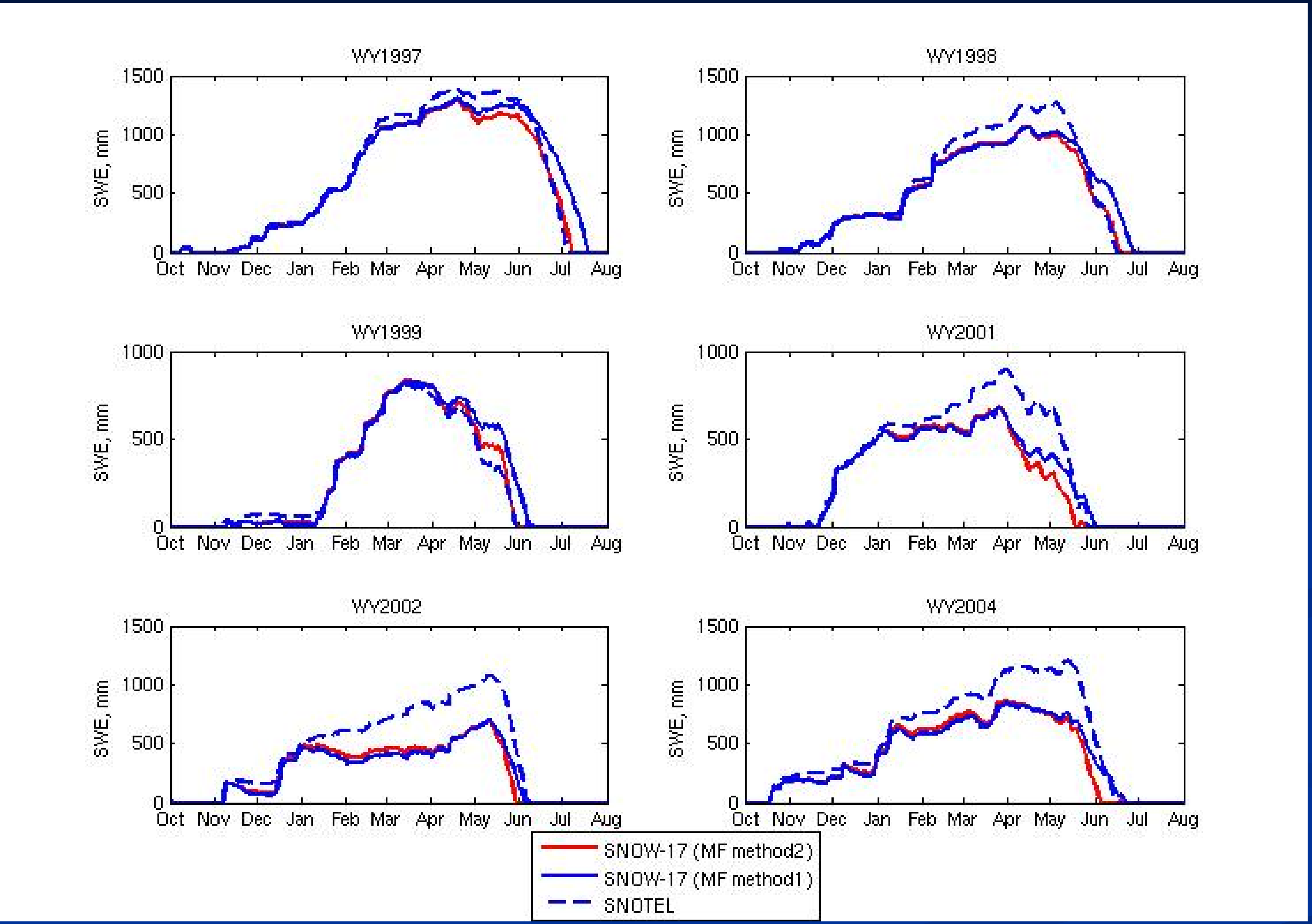


UADJ=0.04

19L06S
Slope 18.2 degree
Forest 85.3 %

MFMAX		MFMIN	
Method 2	Method 1	Method 2	Method 1
0.76	0.55	0.35	0.25

Snow17 simulation



UADJ=0.09

19L19S
Slope 18.6 degree
Forest 79.8 %

MFMAX		MFMIN	
Method 2	Method 1	Method 2	Method 1
0.76	0.55	0.35	0.25

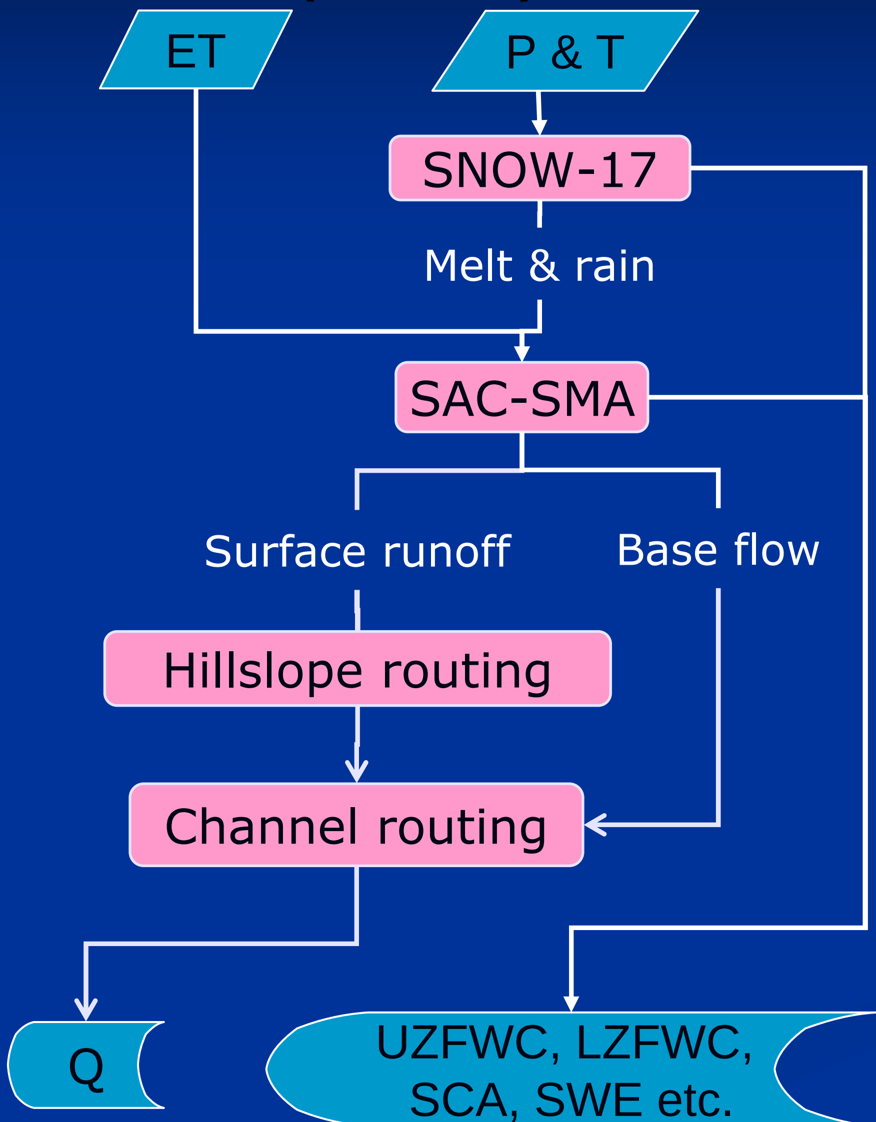
Planned Work

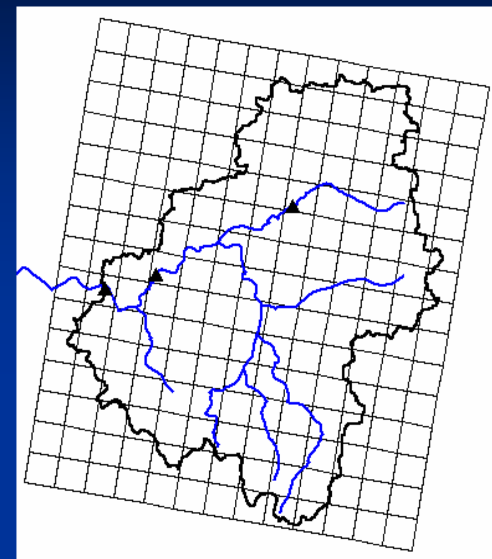
- Continue a priori parameterization
  - MFMAX/MIN, UADJ (suggestions are welcome for improvement)
  - SCF
  - Minor parameters
  - Parameterization for Alaska/Hawaii
- Evaluation
  - A priori grid vs. RFC calibrated parameters
  - Evaluation on basin-wide SWE and SCA
    - Distributed SNOW-17 SWE vs. SNODAS product
    - Distributed SNOW-17 SCA vs. MODIS SCA
  - Evaluation on streamflow in snowmelt dominated basin
    - Conduct basin study for different climate regions (East, West and continental)
    - comparing flow from the distributed and calibrated lumped model.
- Calibration

Appendix Slide

Background

Research Distributed hydrologic model (RDHM) overview





Features:

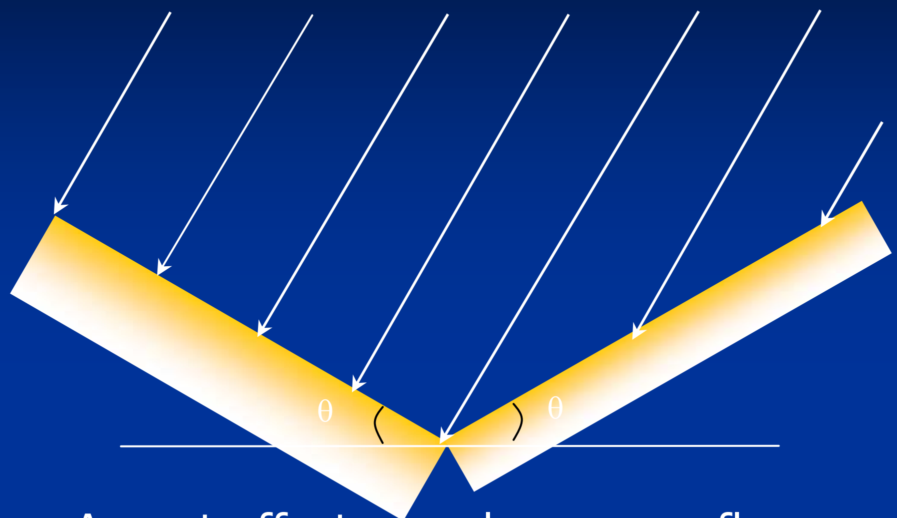
- Modular and flexible system
- Gridded structure
- Independent snow and rainfall-runoff models for each grid cell
- Hillslope routing and channel routing of runoff

MF parameterization

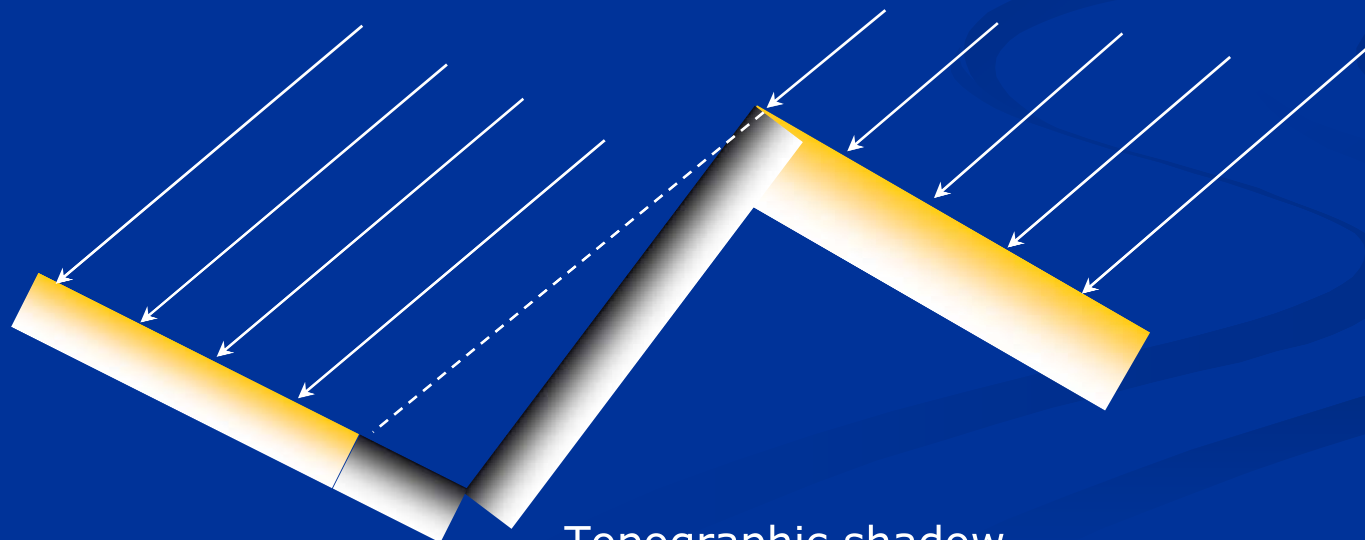
Method 1

1. Forest type at each HRAP: mixed, conifer, deciduous, open.
2. A pixel is open if the forest % < 20%.
3. Depending on the forest type, recommended ranges of MFMAX and MFMIN values are selected from the table (Anderson, 2002).
4. From the selected range, a parameter value is determined based on the dominant aspect.
   - The highest value assigned to a south facing pixel,
   - The lowest value assigned to a north facing cells.
   - For other aspect, values linearly increase starting from north to south.
   - Median value assigned to flat (slope <1 %), facing west or east.

Topographic effect on clear sky solar radiation



Aspect effect on solar energy flux

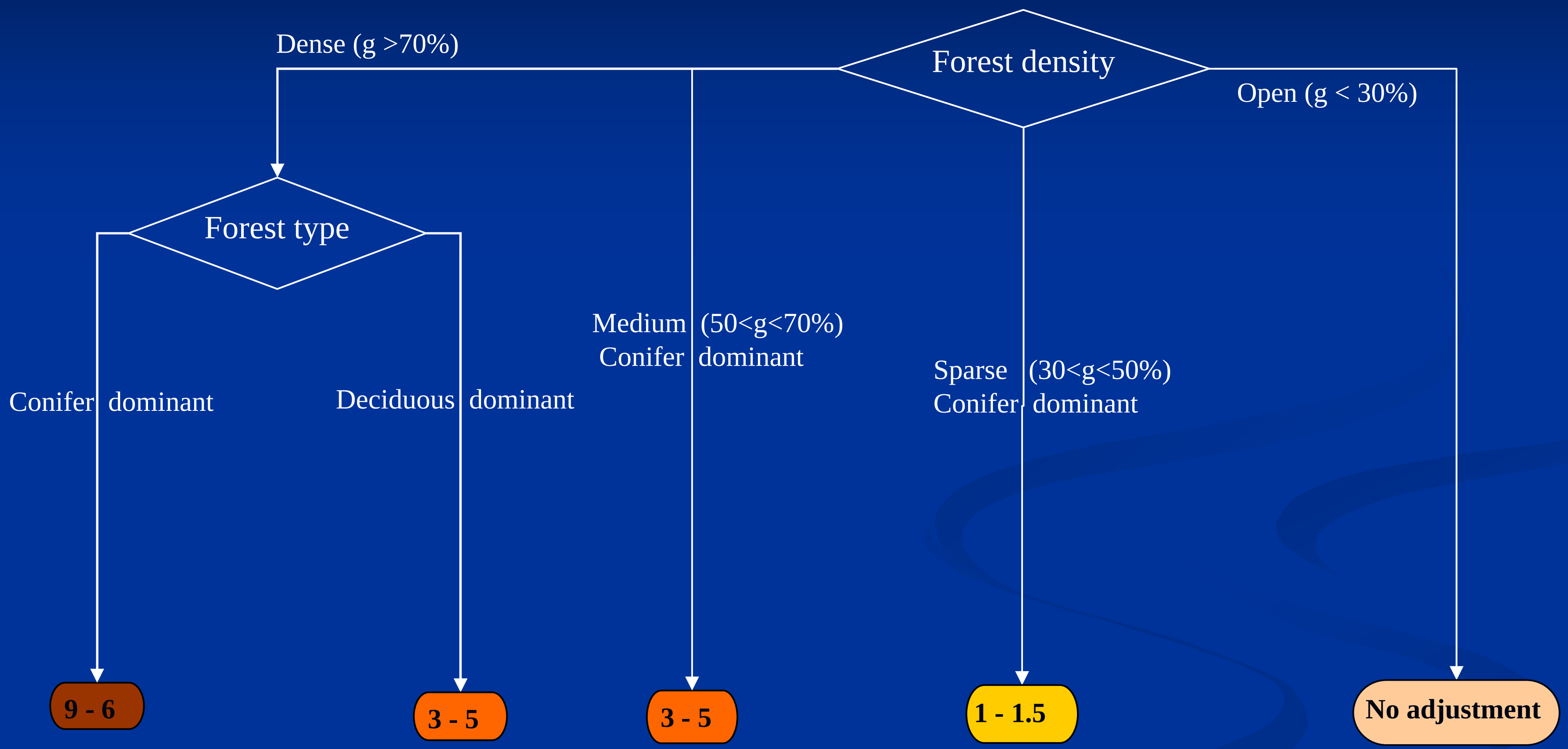


Topographic shadow

8 11

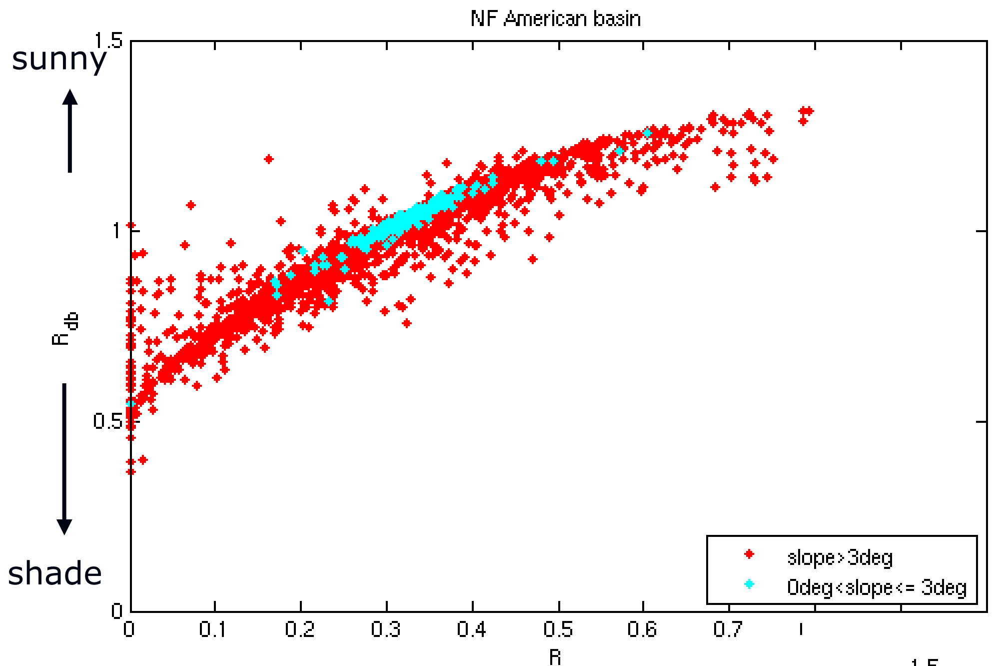
Wind adjustment

Adjustment factor –depends on forest % and type

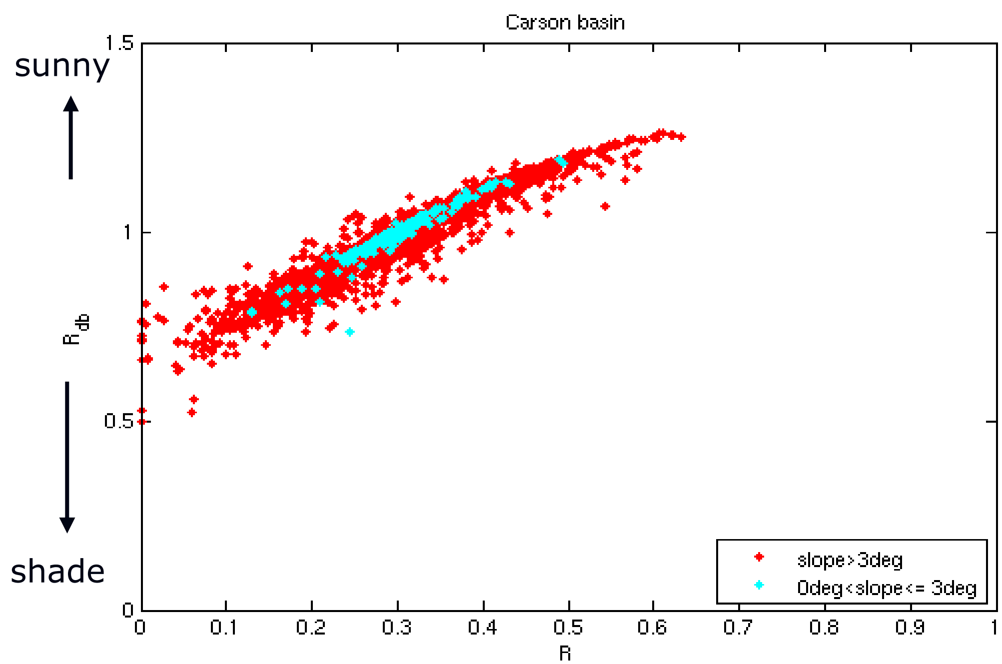


Apollov et al. (1974)

Scatter plots of R vs. R_{db}



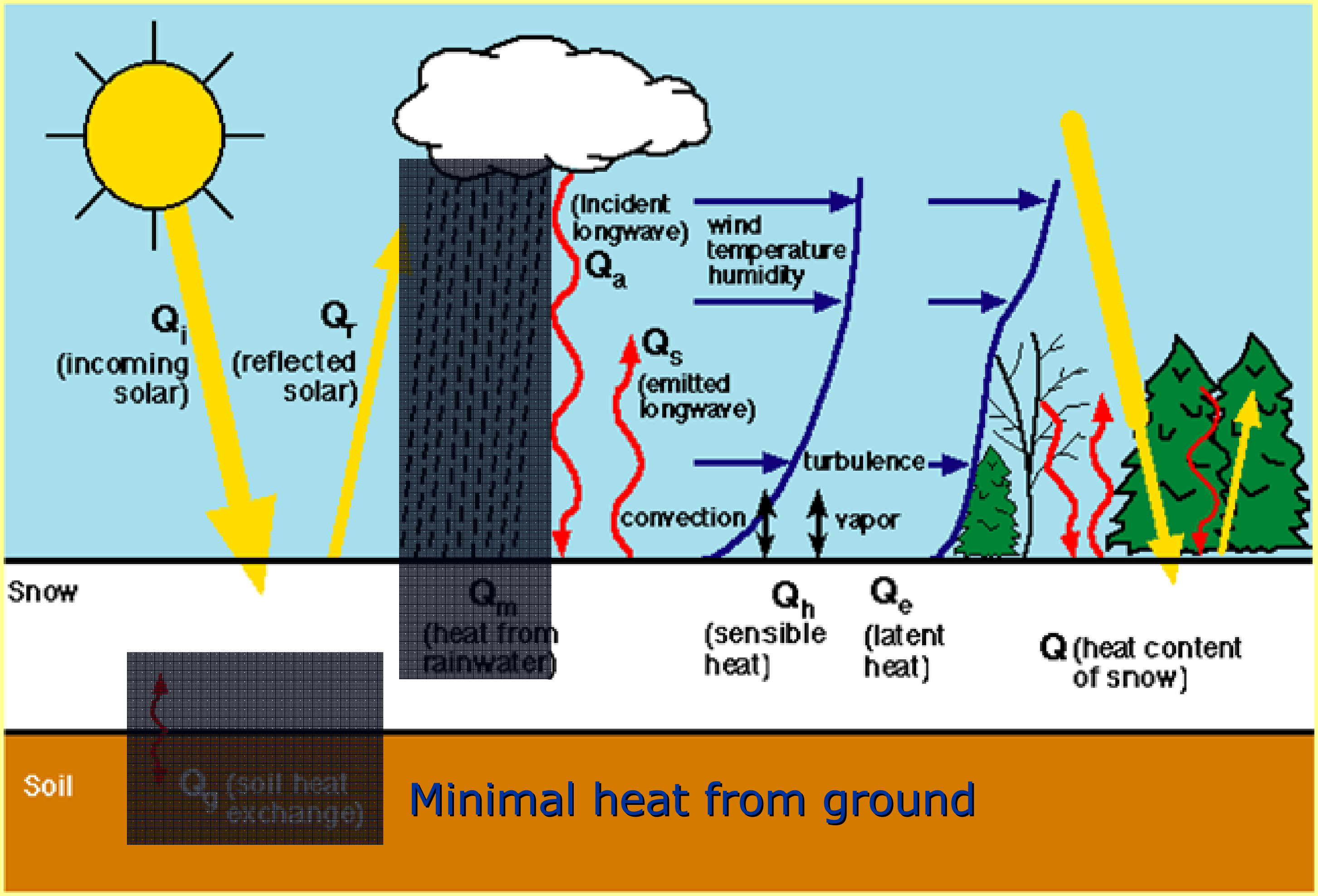
NF American & Carson



R~0.3 -> Flat & no topographic shadow around Sierra Nevada, CA

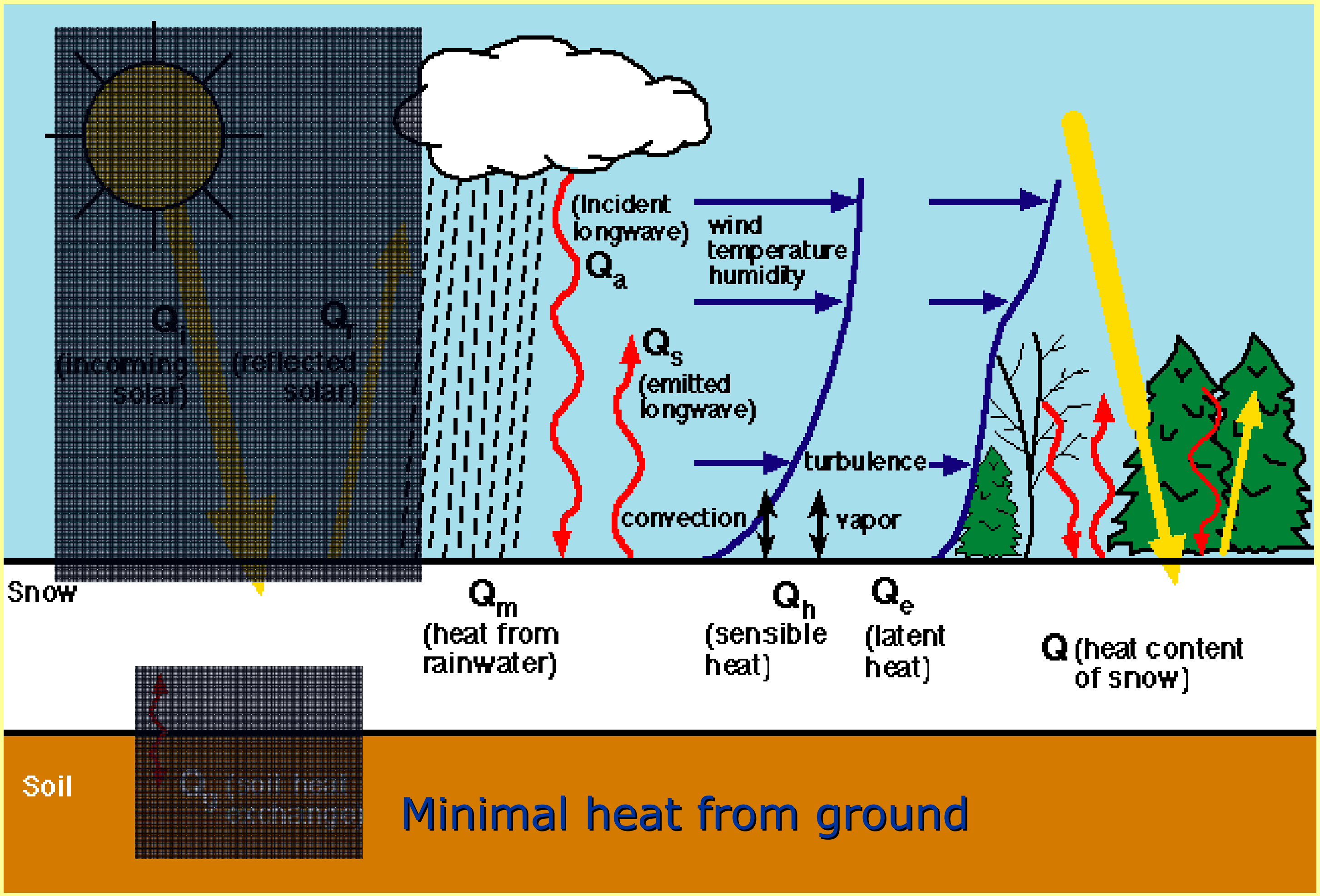
Energy input for non-rain cond.

$$Q_i - Q_r + Q_a - Q_s + Q_h + Q_e + \cancel{Q_m} + \cancel{Q_g} = \Delta Q$$



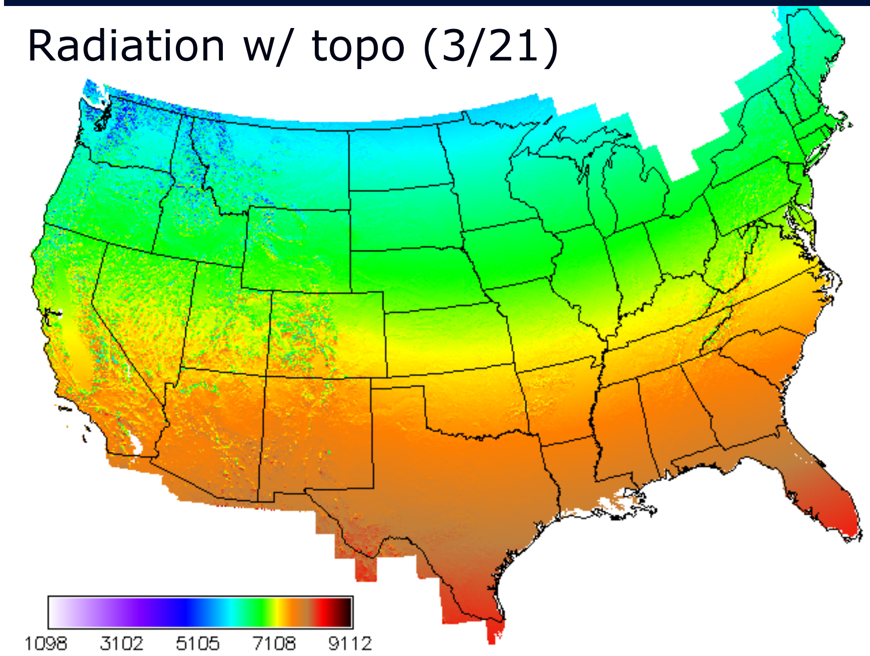
Energy input for Rain-on-snow cond.

$$\cancel{Q_i} - \cancel{Q_r} + Q_a - Q_s + Q_h + Q_e + Q_m + \cancel{Q_g} = \Delta Q$$



CONUS R_{DB}

Radiation w/ topo (3/21)



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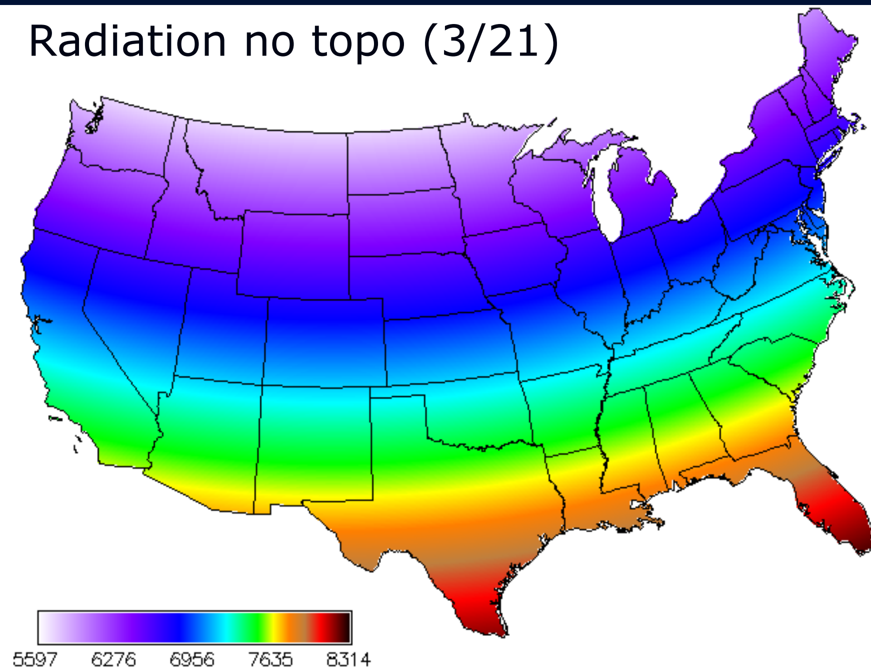
Radiation no topo (3/21)



Unit: Wh/m^2/day

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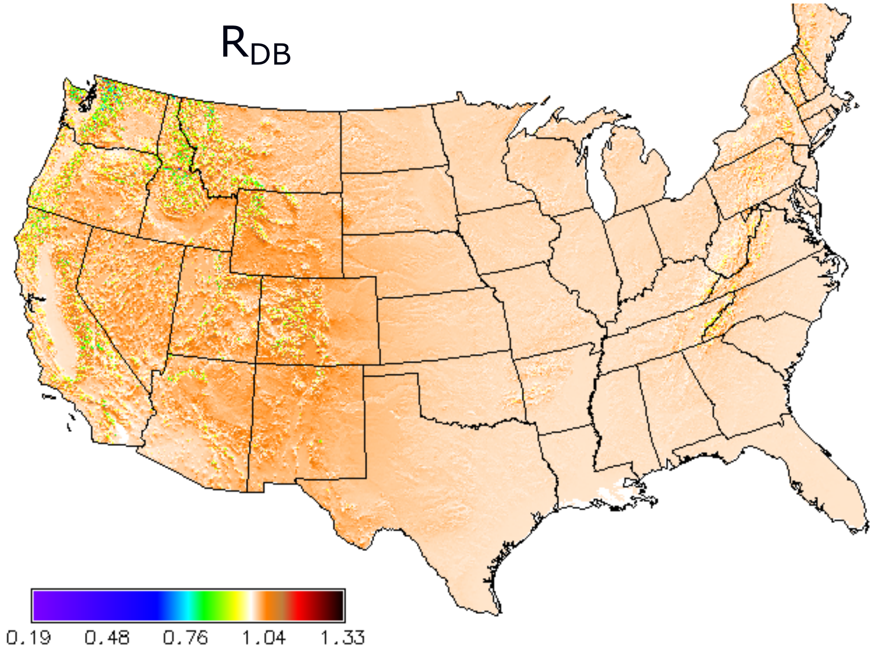
R_{DB}

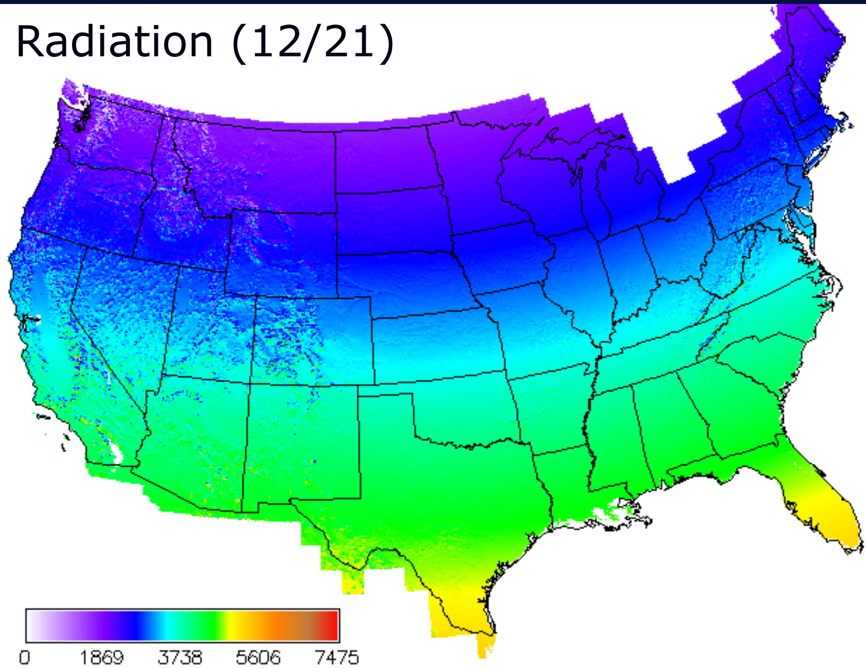


Unit: Wh/m^2/day

No Unit

CONUS R

Radiation (12/21)



Unit: Wh/m^2/day

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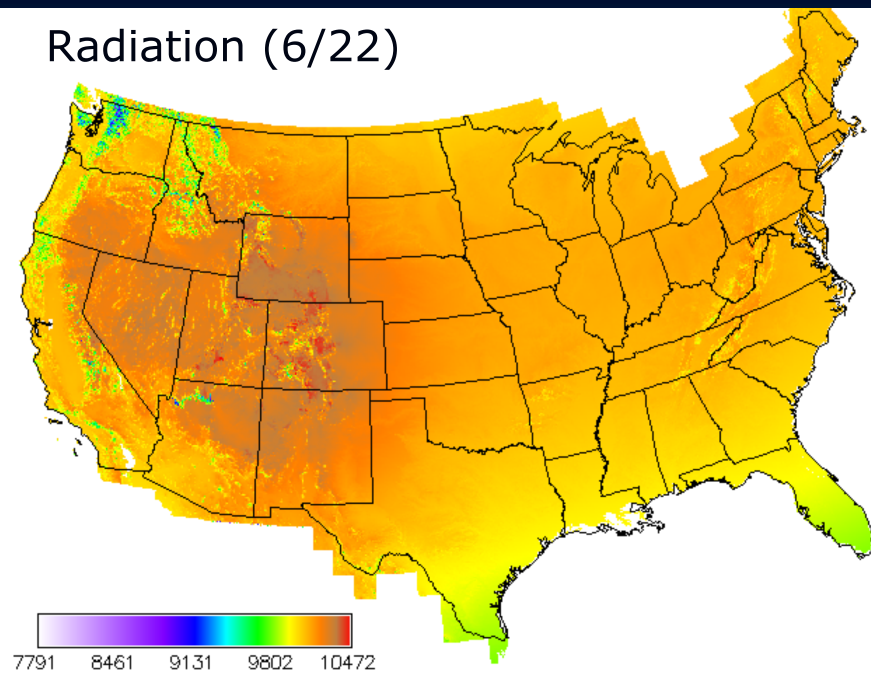
Radiation (6/22)



Unit: Wh/m^2/day

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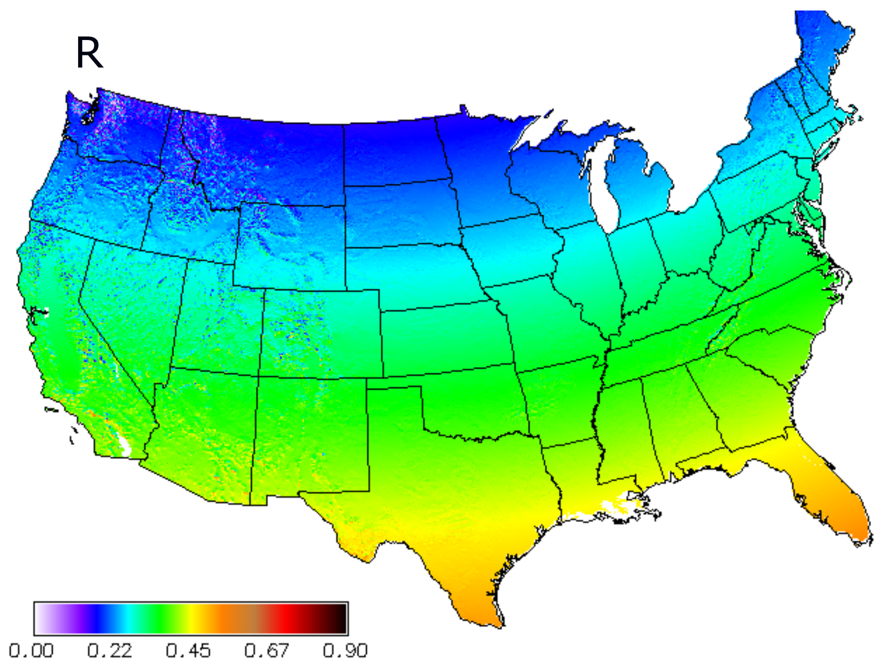
R



No Unit

Misc.

1 Wh=3600 J : the amount of energy transferred if work is done at an average rate of one watt for one hour