Evaluation of AMPS Forecasts for Varied Synoptic Regimes

John J. Cassano and Mark W. Seefeldt

University of Colorado

Cooperative Institute for Research in Environmental Sciences
and
Department of Atmospheric and Oceanic Sciences

What are SOMs?

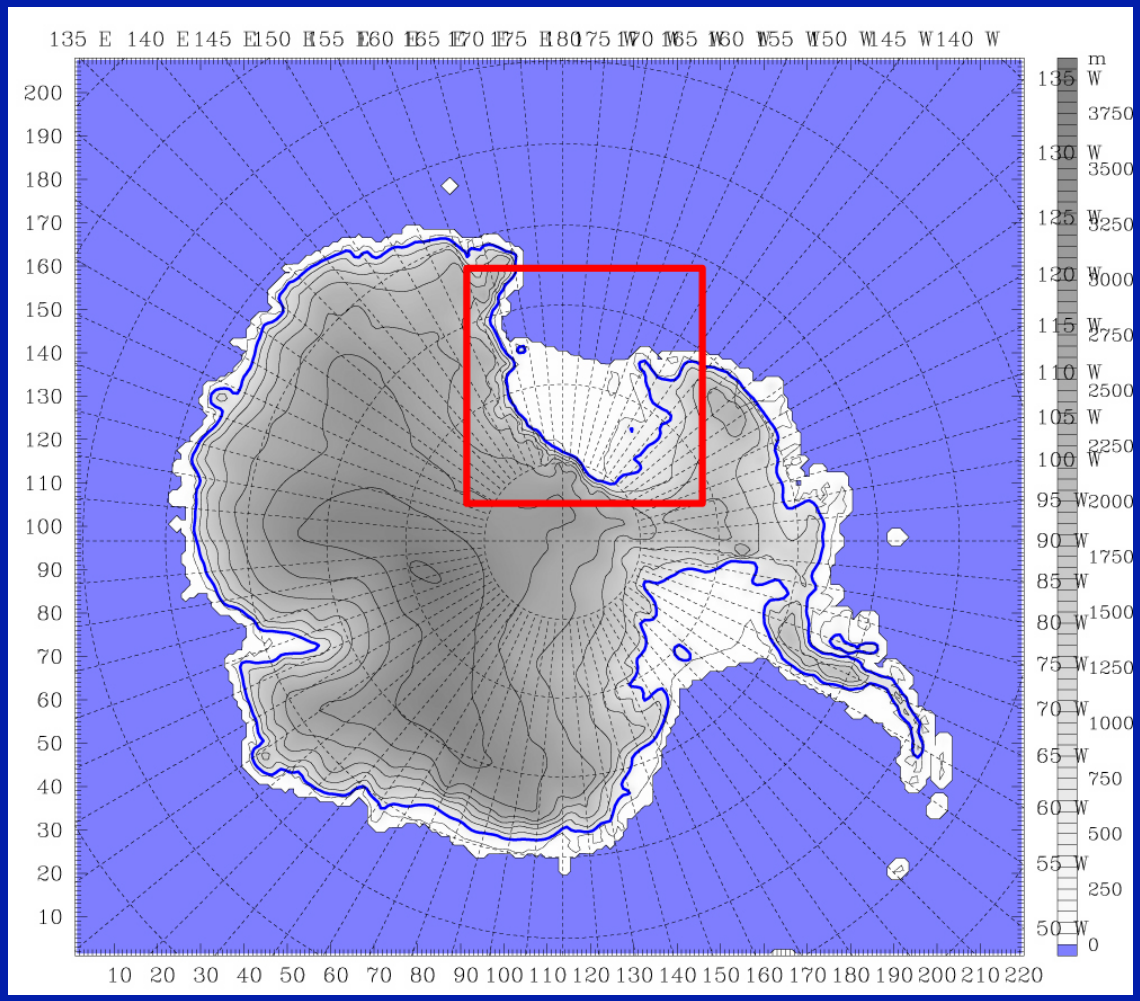
- SOM - Self-Organizing Map
- SOM technique uses an unsupervised learning algorithm
- Clusters data into a user selected number of nodes
- SOM algorithm defines nodes that are representative of the data in the training set
- SOMs are in use across a wide range of disciplines
  - Climate applications of SOMs
    - Hewitson and Crane (2002) *Climate Research*
    - Cassano et al. (2006) *Climate Dynamics*
    - Cassano et al. (2006) *International Journal of Climatology*
    - Lynch et al. (2006) *International Journal of Climatology*

Application of SOM Analysis to AMPS Data

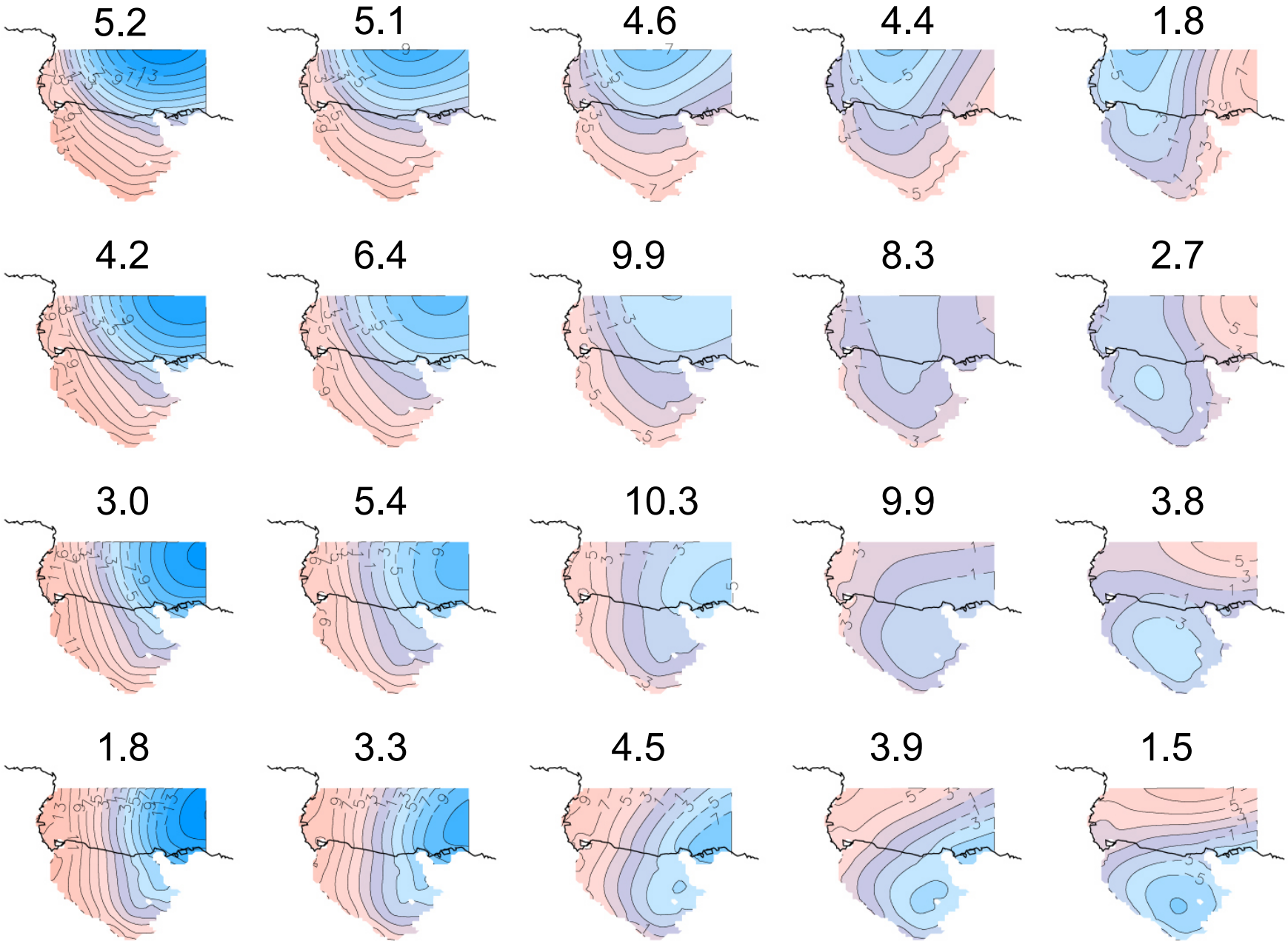
- Train SOM with AMPS SLP data
  - Result is a synoptic pattern classification
- Calculate frequency of occurrence of synoptic patterns
  - Annual and seasonal
  - As a function of forecast duration (0, 12, 24, 36, 60h forecasts)
- Misprediction of AMPS synoptic patterns
- Model validation statistics for specific synoptic patterns

AMPS Data for SOM Analysis

- SLP over Ross Sea sector of AMPS 30 km model domain
- AMPS MM5 simulations from Nov 2001 through Dec 2005
  - 9823 forecast times
- Evaluate forecasts at 12h intervals
  - 000: 0, 3, 6, 9 h
  - 012: 12, 15, 18, 21 h
  - 024: 24, 27, 30, 33 h
  - 036: 36, 39, 42, 45 h
  - 048: 48, 51, 54, 57 h
  - 060: 60, 63, 66, 69 h



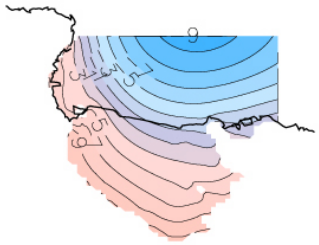
Synoptic Pattern Classification: 000



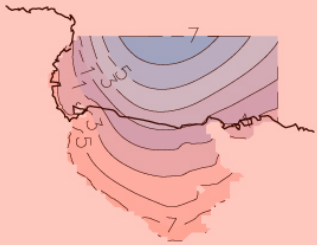
Frequency of Occurrence (000 : 060)

5.2 : 4.2

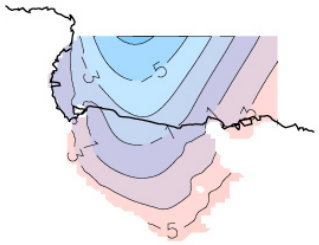
5.1 : 5.3



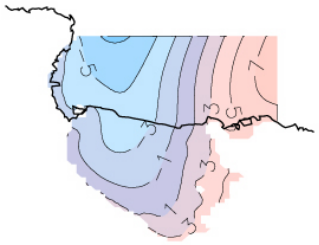
4.6 : 6.0



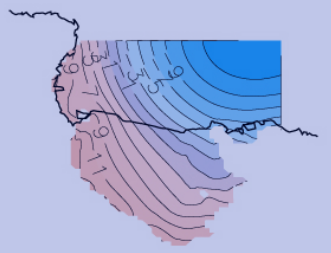
4.4 : 4.7



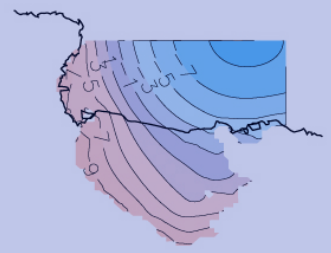
1.8 : 2.1



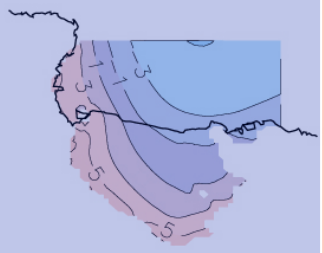
4.2 : 3.0



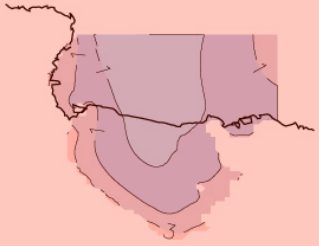
6.4 : 5.1



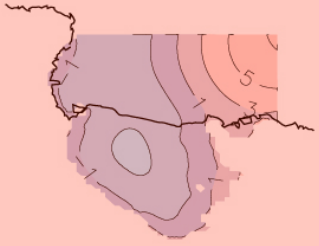
9.9 : 8.4



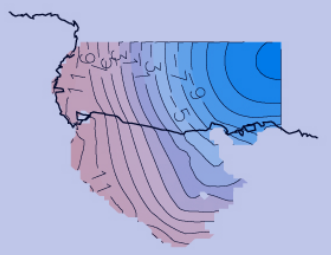
8.3 : 10.1



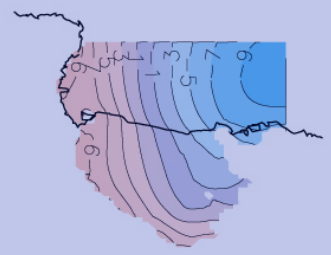
2.7 : 4.1



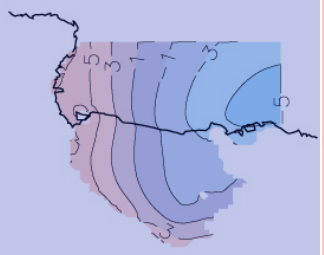
3.0 : 2.1



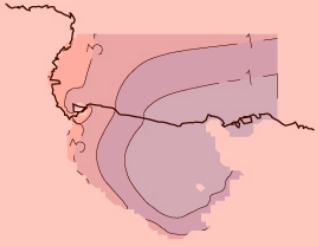
5.4 : 4.4



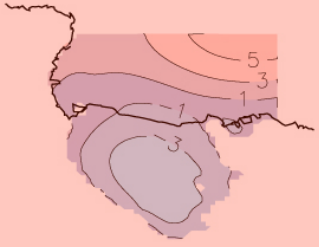
10.3 : 8.3



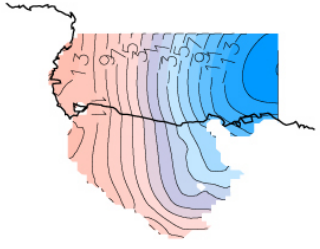
9.9 : 12.8



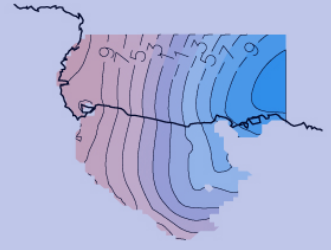
3.8 : 4.5



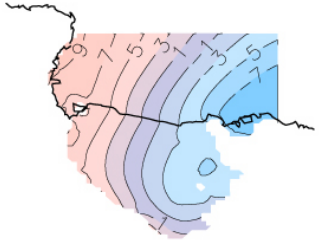
1.8 : 1.5



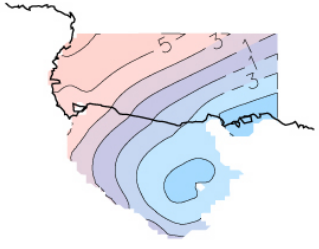
3.3 : 2.5



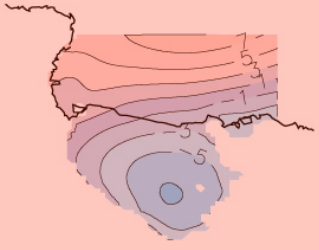
4.5 : 4.6



3.9 : 3.9



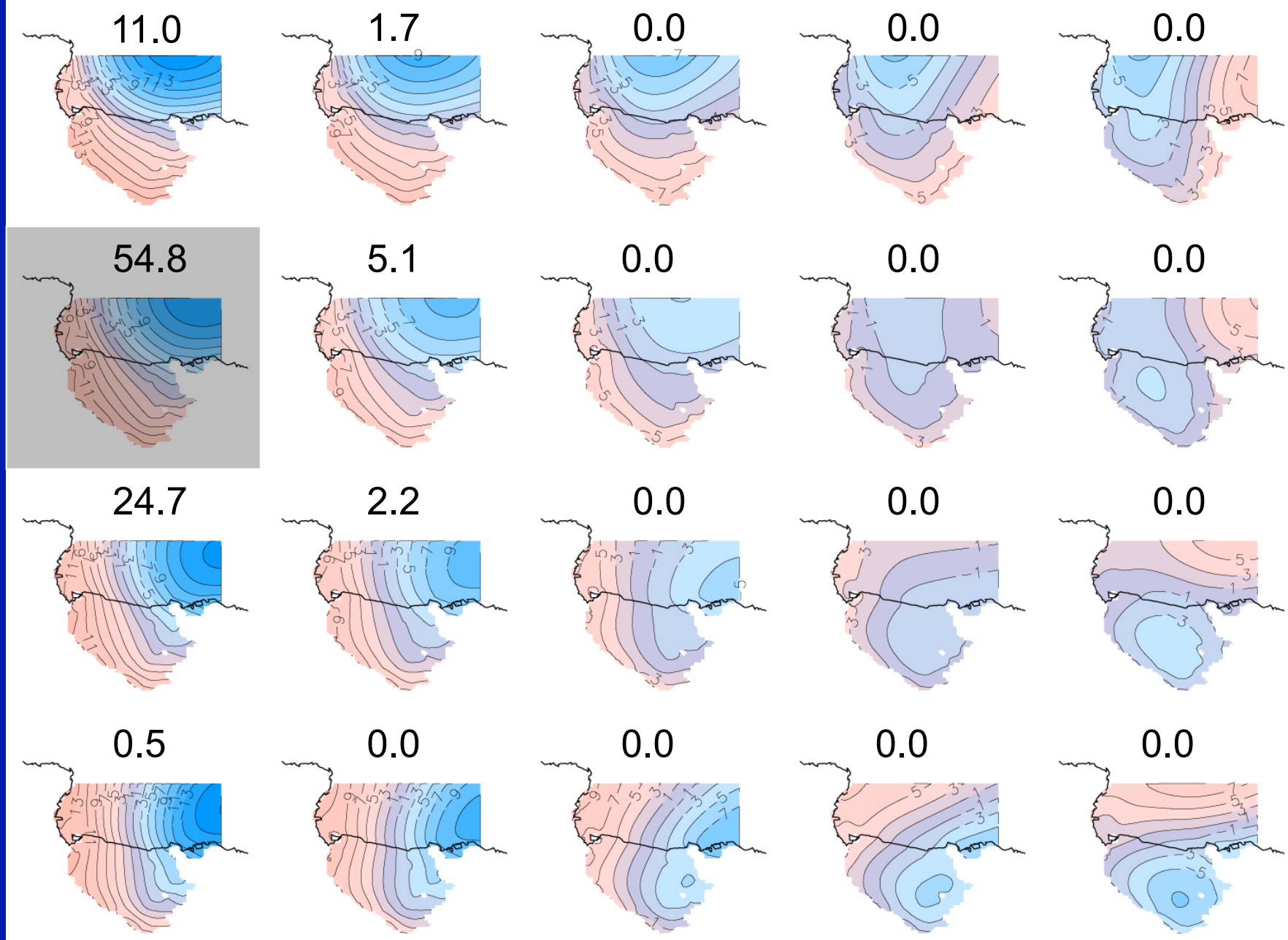
1.5 : 2.6



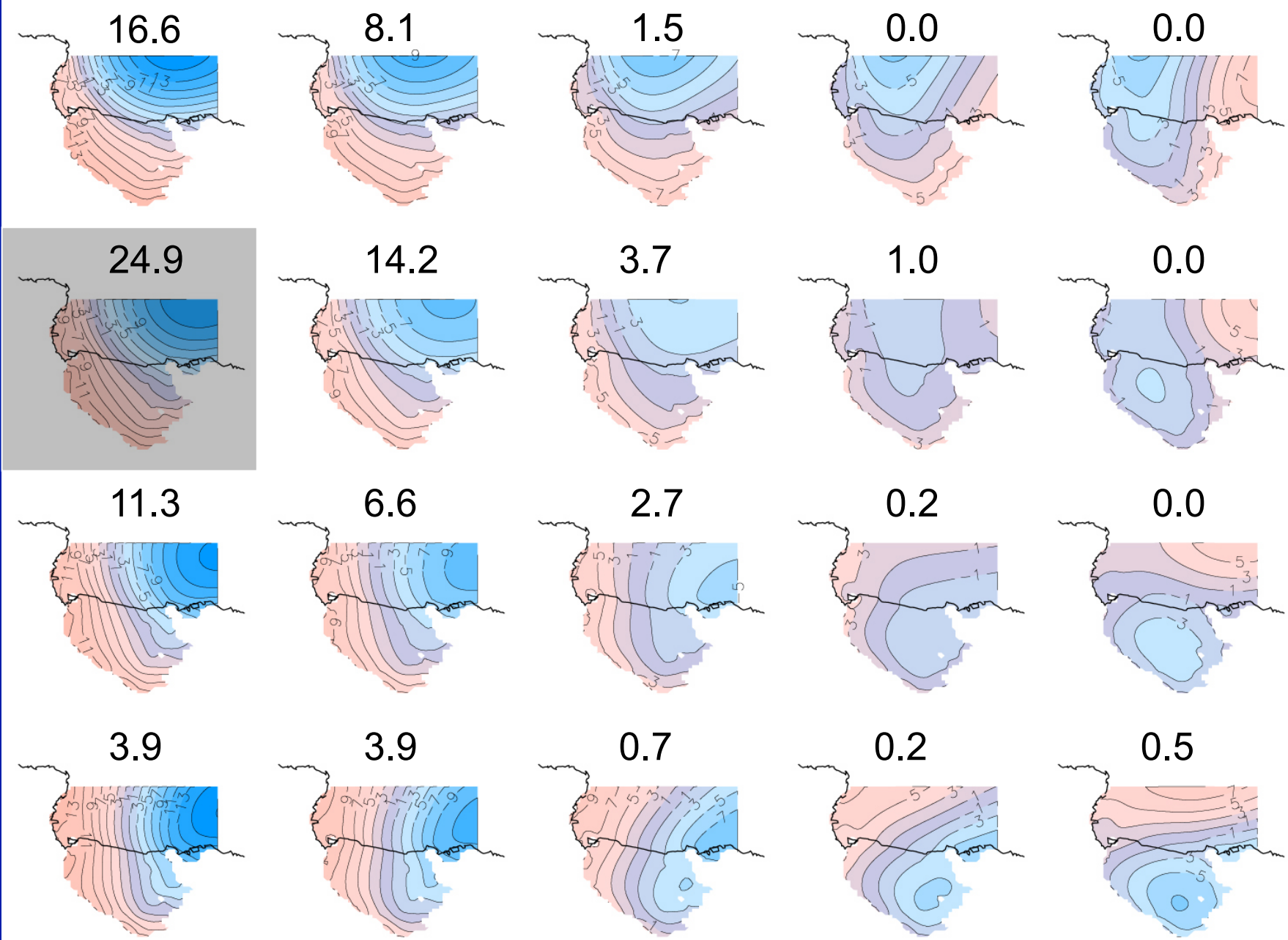
Misprediction of Synoptic Patterns

- Consider all of the time periods for which the model 000 h forecasts map to a particular node
  - For these time periods determine which nodes the longer duration model forecasts map to
- Calculate:
  - Percent of cases that map to the correct node
  - Mis-mapping of model predictions between nodes

AMPS 012 Forecasts: Node (1,2)



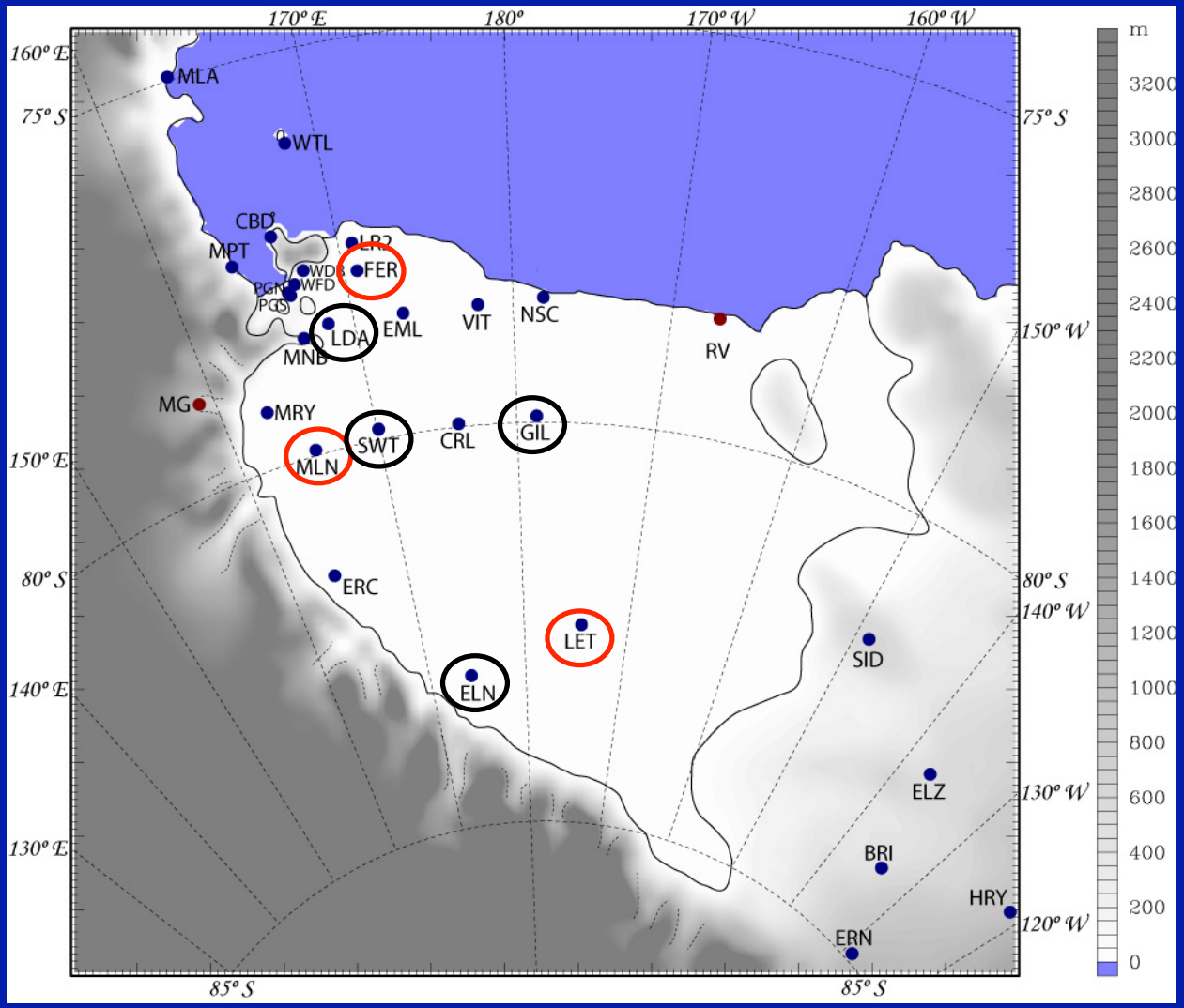
AMPS 060 Forecasts: Node (1,2)

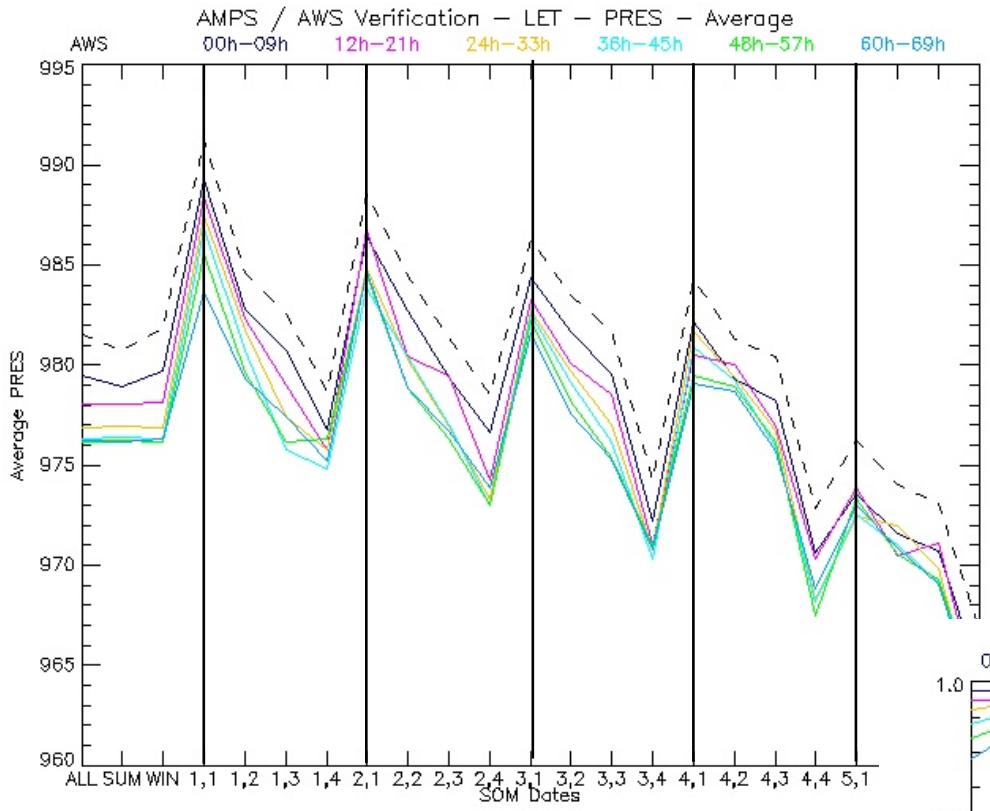


Model Errors for Synoptic Patterns

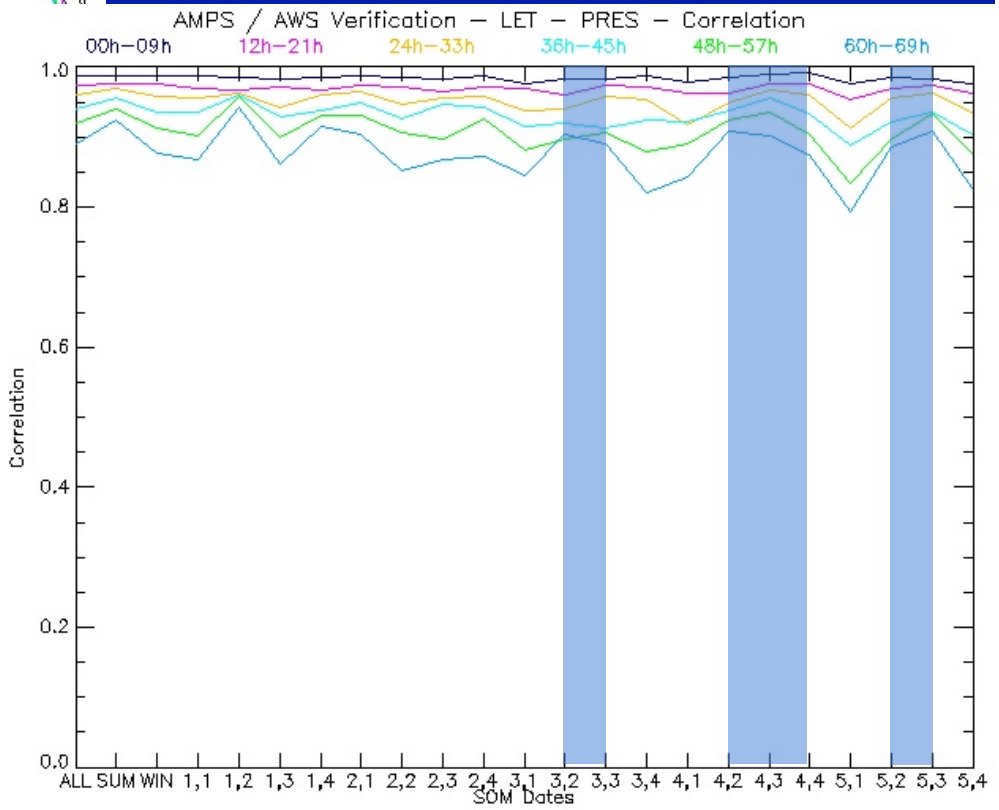
- Determine how observations (or model state) varies as a function of SOM identified nodes
- Compare model predictions to AWS observations
- Calculate model validation statistics for all time periods that map to each node
- Look for model errors that vary from node to node

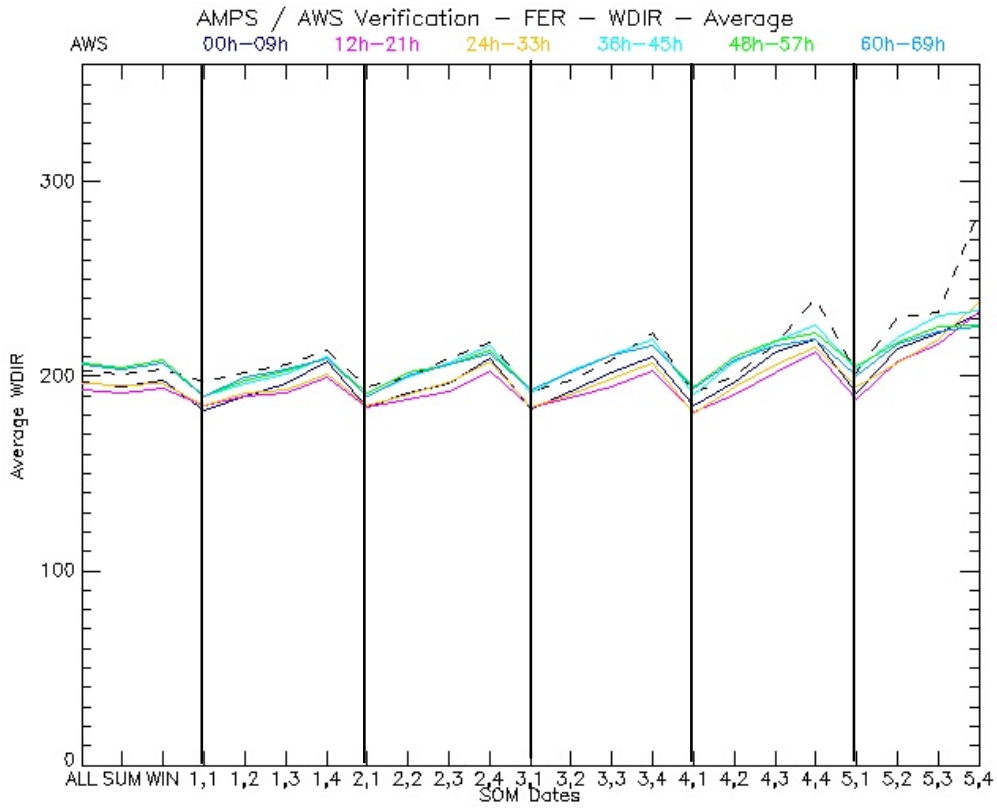
AWS Sites Used for SOM Analysis



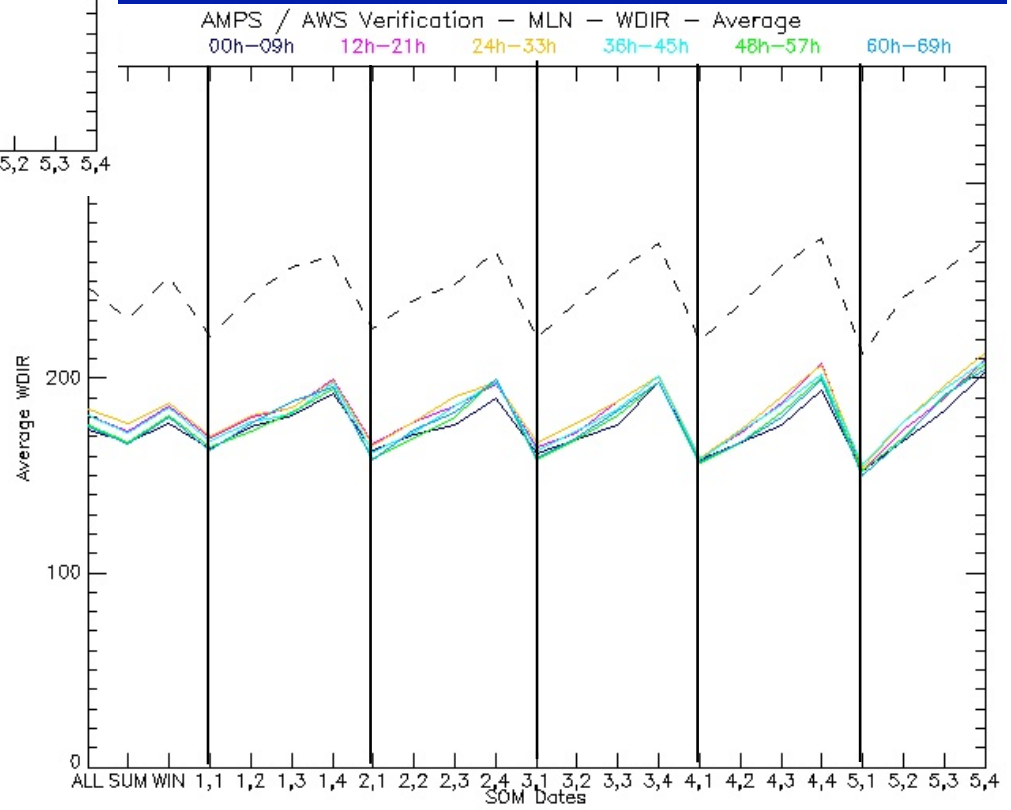


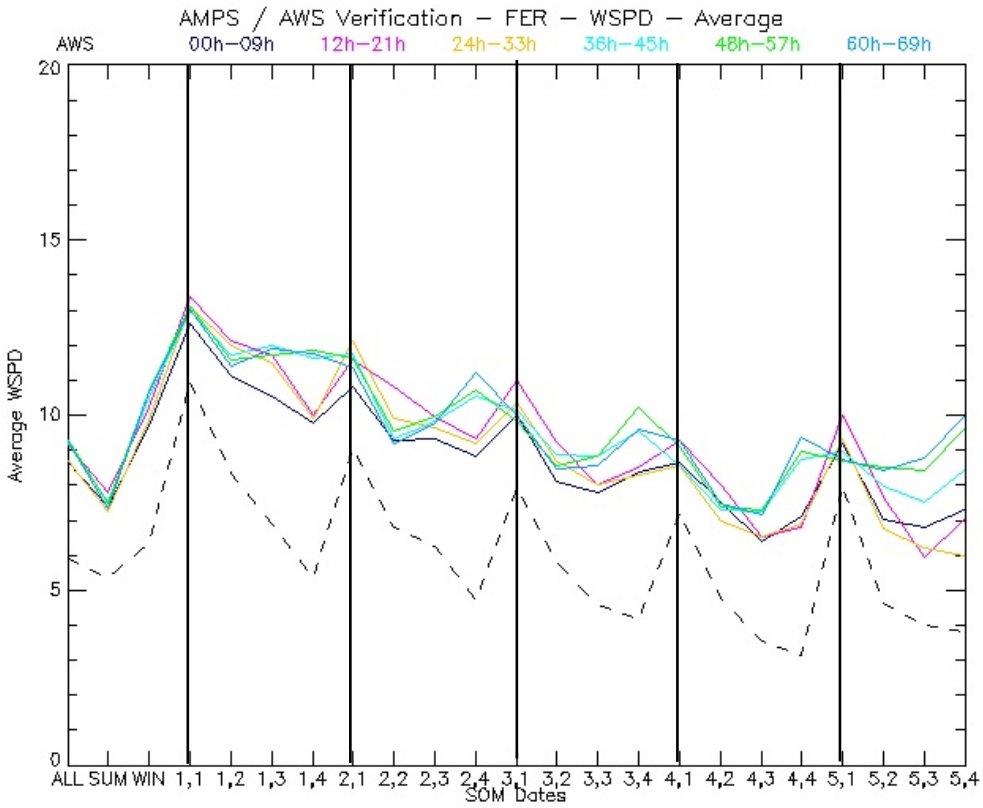
Lettau: Pressure



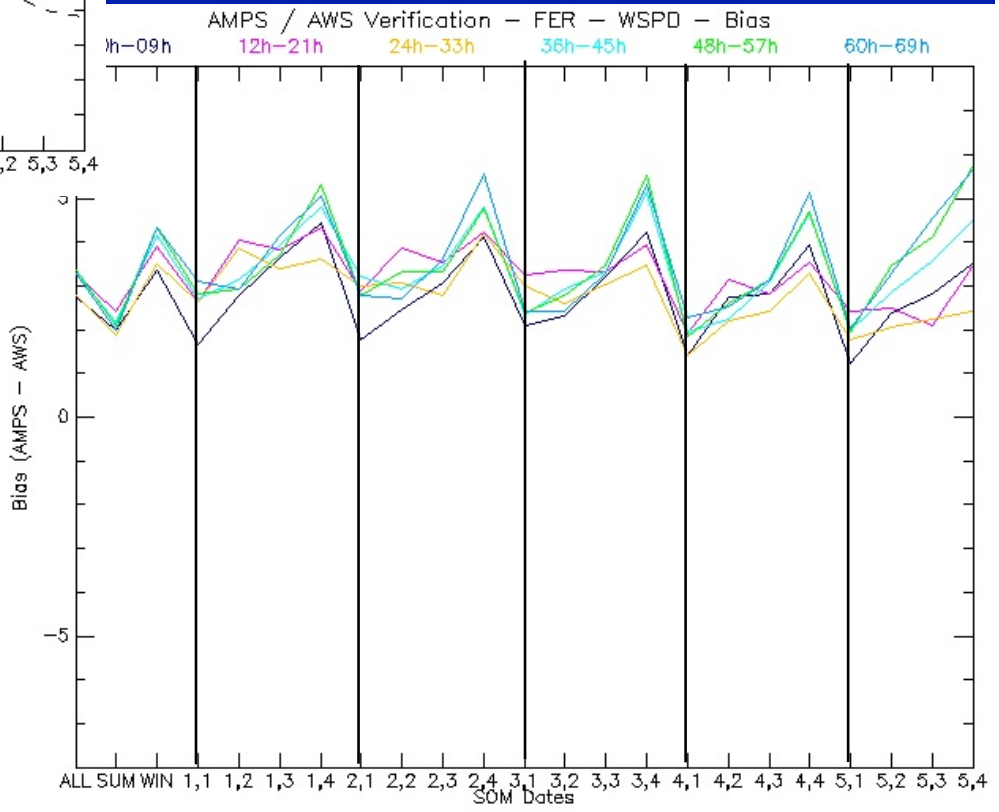


Ferrell and Marilyn: Wind Direction





Ferrell: Wind Speed



Conclusions / Future Work

- The use of SOMs provides an alternate method of evaluating model performance
  - Identify synoptic patterns which are over or underpredicted
  - Determine model tendency for misprediction of certain synoptic types
  - Provide information on model errors related to specific synoptic patterns
- Manuscript for *Weather and Forecasting*
- Attribution of model errors to circulation and non-circulation related components
  - Ex: model precipitation

Outline

- What are SOMs?
- Application of SOMs for model evaluation studies
- Application of SOM Analysis to AMPS data
- Conclusions / Future Work

“Typical” Model Evaluation Strategy

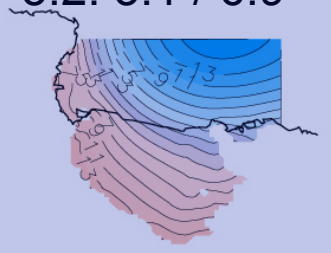
- Compare modeled and observed fields directly
  - Time series of observed and modeled variables
  - Model validation statistics (bias, RMSE, correlation, etc.)
- Case Study Evaluations
- Compare model data with observational analyses
  - Ex. Difference of monthly or seasonal mean sea-level pressure

"Typical" Model Evaluation Strategy

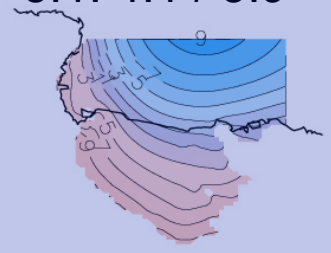
- Advantages
  - Simple techniques with easy interpretation
  - Highlights differences between models and analyses and also inter-model differences
- Disadvantages
  - Neglects differences in synoptic events
    - These events are the items of interest for operational weather forecasting applications
    - Similar seasonal mean SLP may mask differences in simulated synoptic climatology
  - Can be difficult to gain physical insight into the source of model errors

Seasonal Frequency of Occurrence (Annual: Summer / Winter)

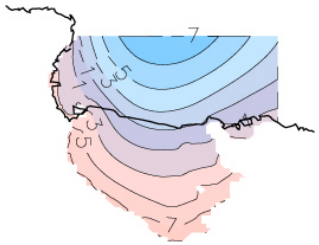
5.2: 3.1 / 6.9



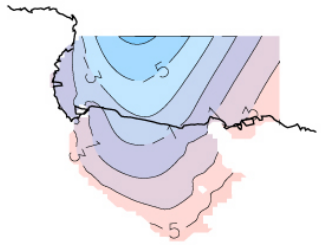
5.1: 4.1 / 5.9



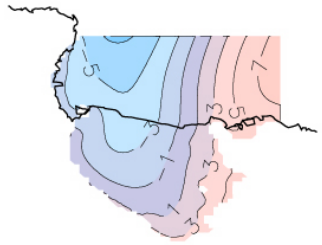
4.6: 4.4 / 4.8



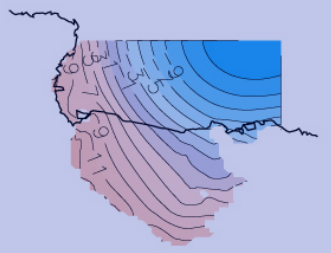
4.4: 4.5 / 4.3



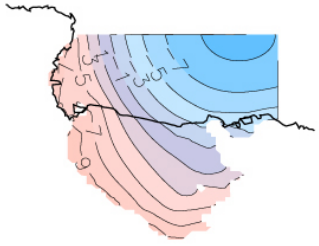
1.8: 1.7 / 1.9



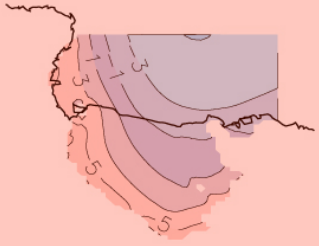
4.2: 2.6 / 5.4



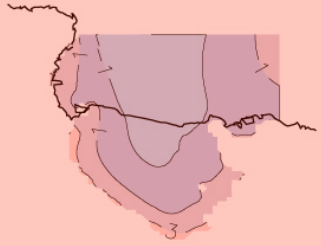
6.4: 6.2 / 6.6



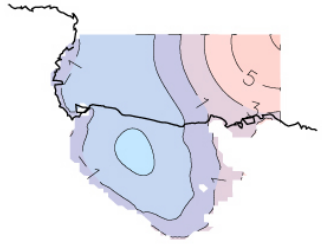
9.9: 12.9 / 7.5



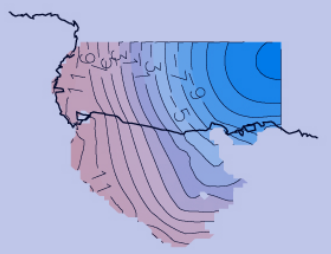
8.3: 11.9 / 5.5



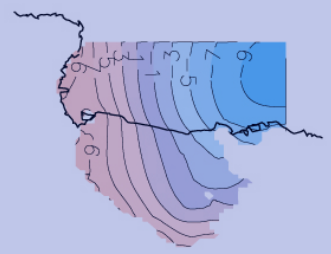
2.7: 2.7 / 2.7



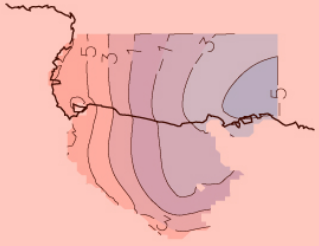
3.0: 1.4 / 4.2



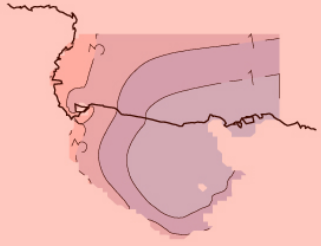
5.4: 4.5 / 6.1



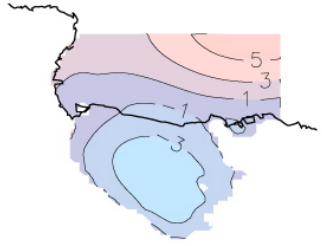
10.3: 13.2 / 8.0



9.9: 14.1 / 6.6

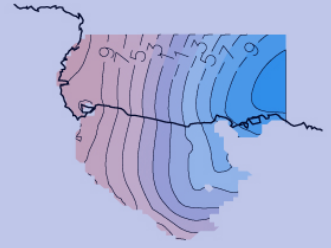


3.8: 4.2 / 3.5

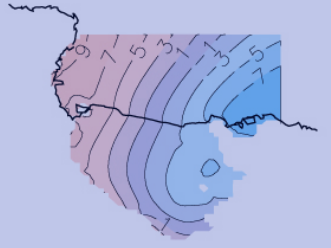


1.8: 0.3 / 3.0

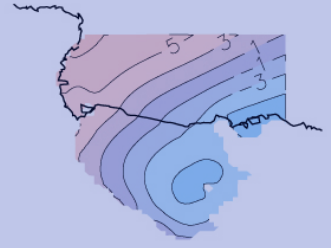
3.3: 1.5 / 4.8



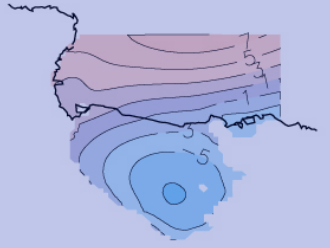
4.5: 2.8 / 5.9



3.9: 3.0 / 4.6

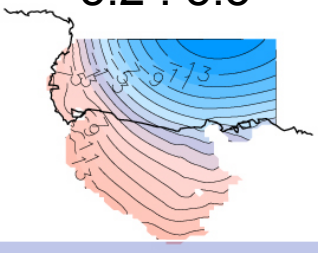


1.5: 1.0 / 1.9

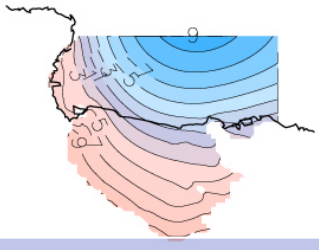


Frequency of Occurrence (000 : 012)

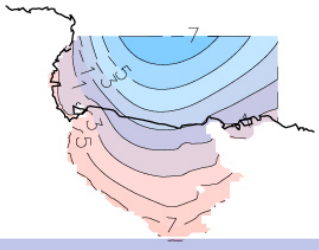
5.2 : 5.3



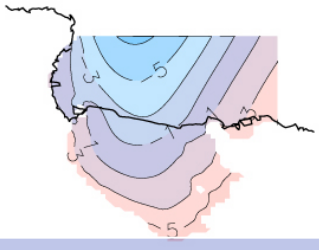
5.1 : 4.6



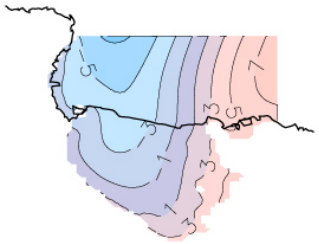
4.6 : 4.8



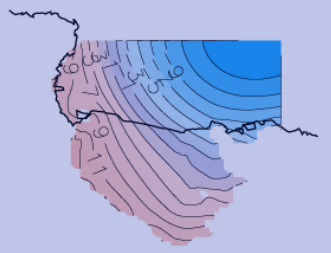
4.4 : 4.0



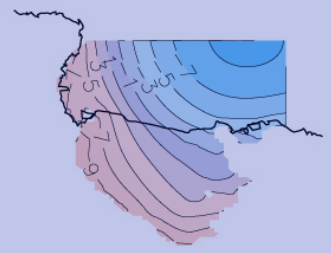
1.8 : 1.8



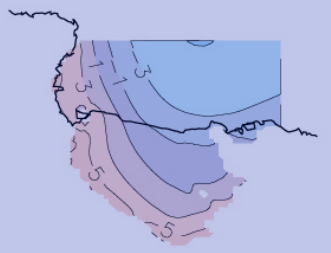
4.2 : 3.6



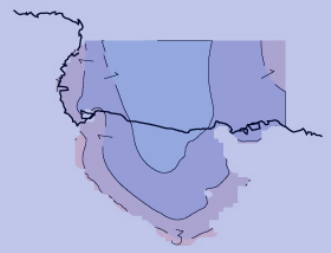
6.4 : 5.6



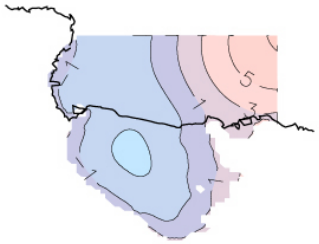
9.9 : 8.5



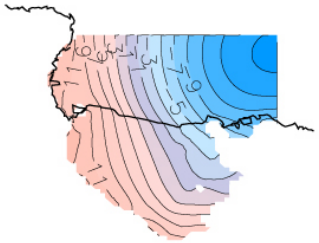
8.3 : 7.4



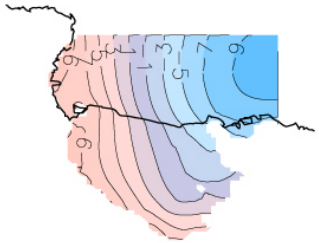
2.7 : 2.7



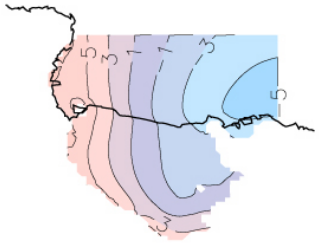
3.0 : 3.2



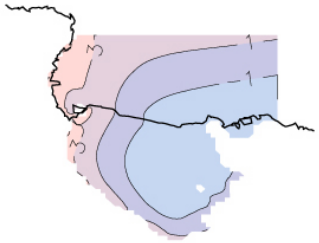
5.4 : 5.1



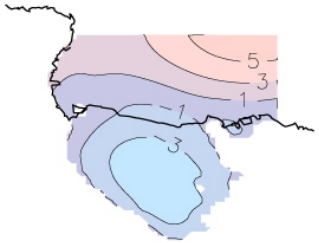
10.3 : 10.5



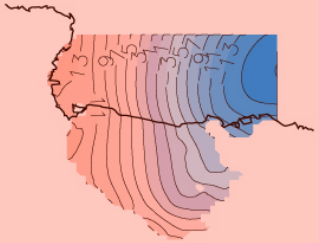
9.9 : 10.4



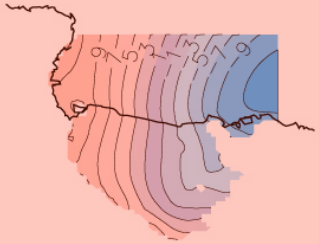
3.8 : 4.0



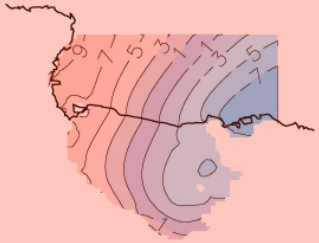
1.8 : 2.4



3.3 : 4.0

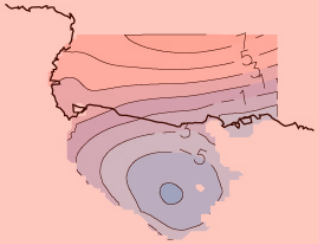


4.5 : 5.7



3.9 : 4.3

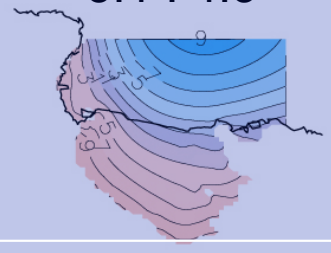
1.5 : 2.1



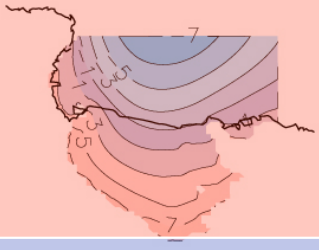
Frequency of Occurrence (000 : 036)

5.2 : 4.8

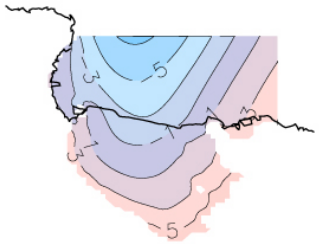
5.1 : 4.3



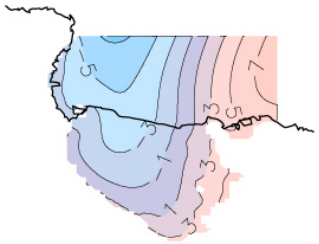
4.6 : 5.3



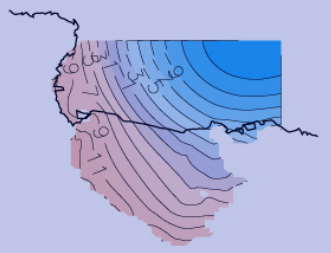
4.4 : 3.8



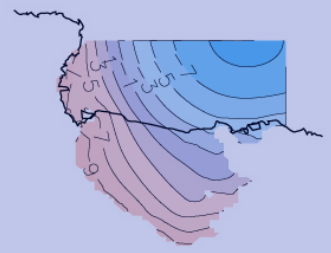
1.8 : 2.1



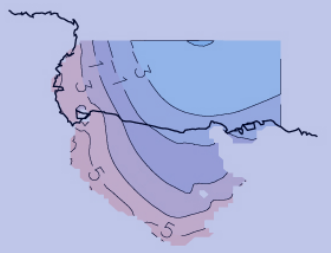
4.2 : 2.9



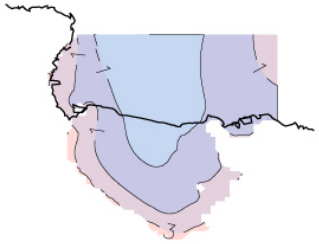
6.4 : 4.4



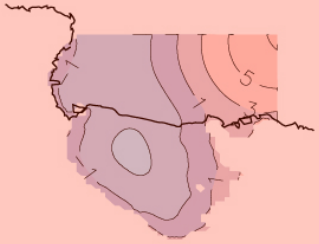
9.9 : 7.8



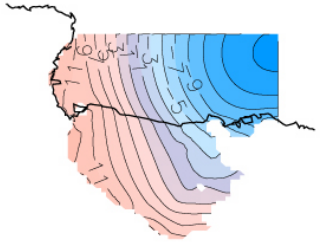
8.3 : 8.0



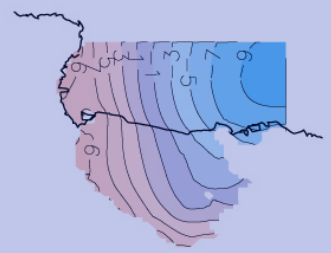
2.7 : 3.6



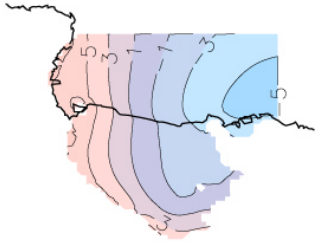
3.0 : 2.6



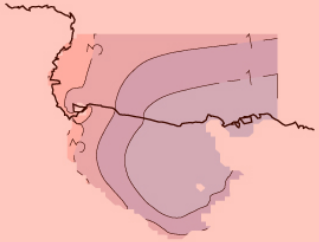
5.4 : 4.3



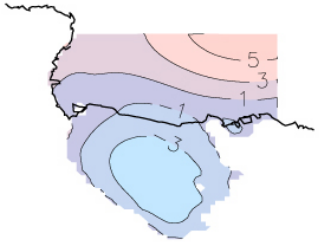
10.3 : 10.3



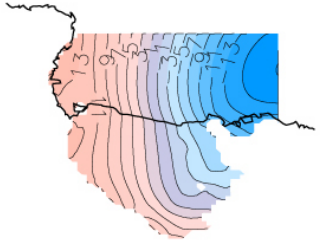
9.9 : 12.6



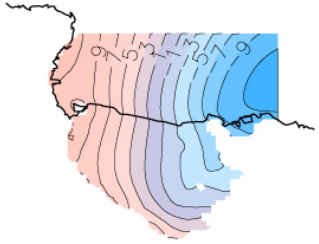
3.8 : 4.3



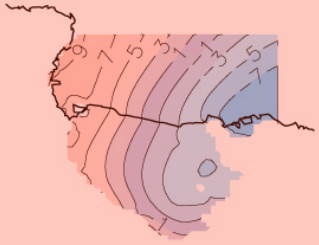
1.8 : 1.9



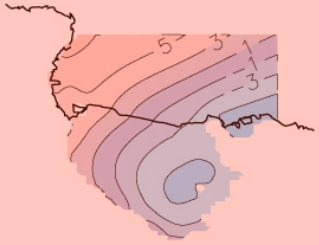
3.3 : 3.3



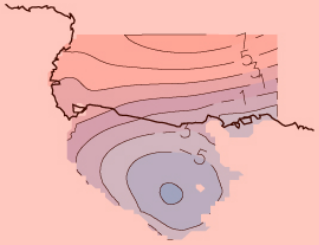
4.5 : 5.7



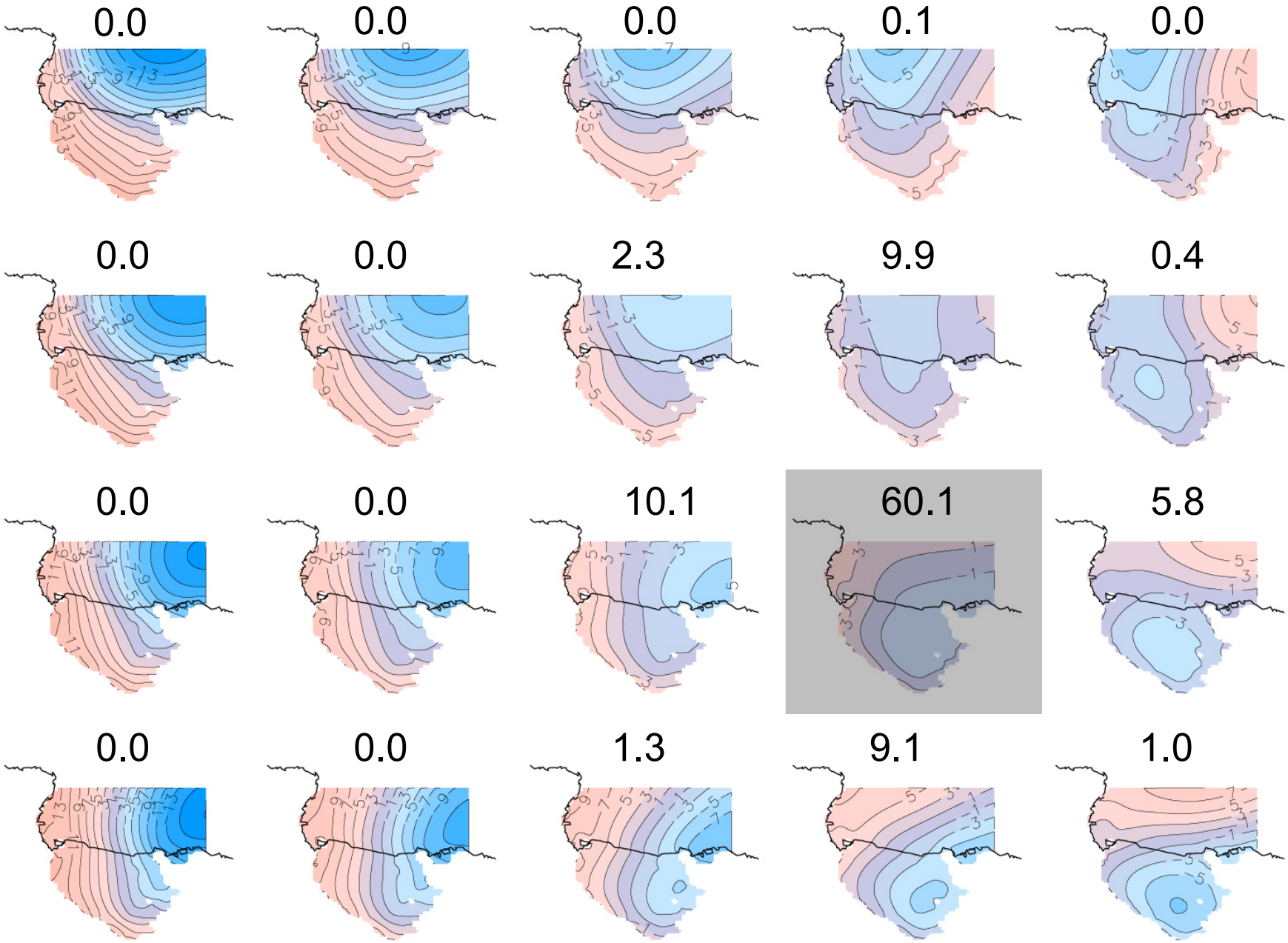
3.9 : 5.1



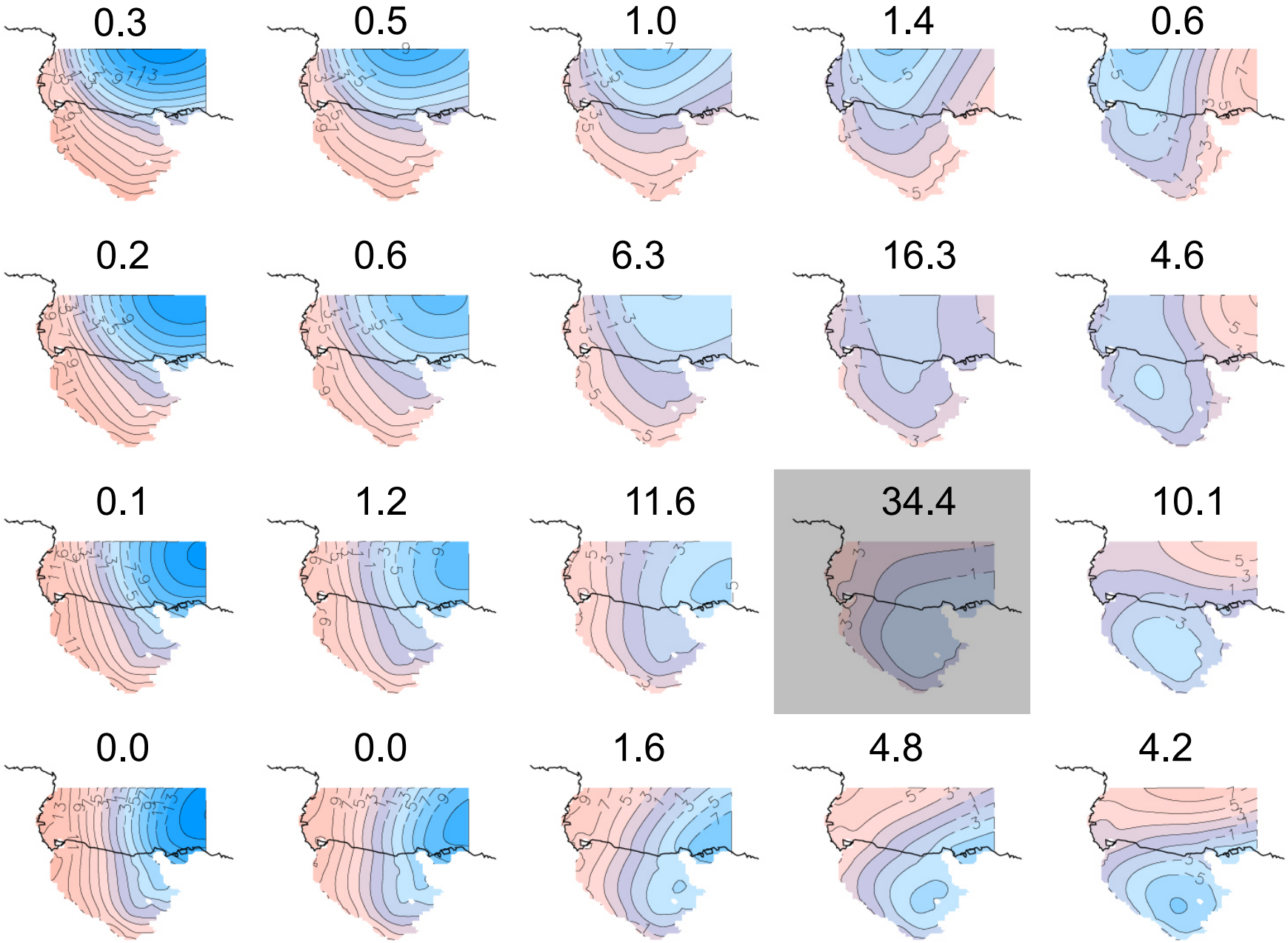
1.5 : 3.0

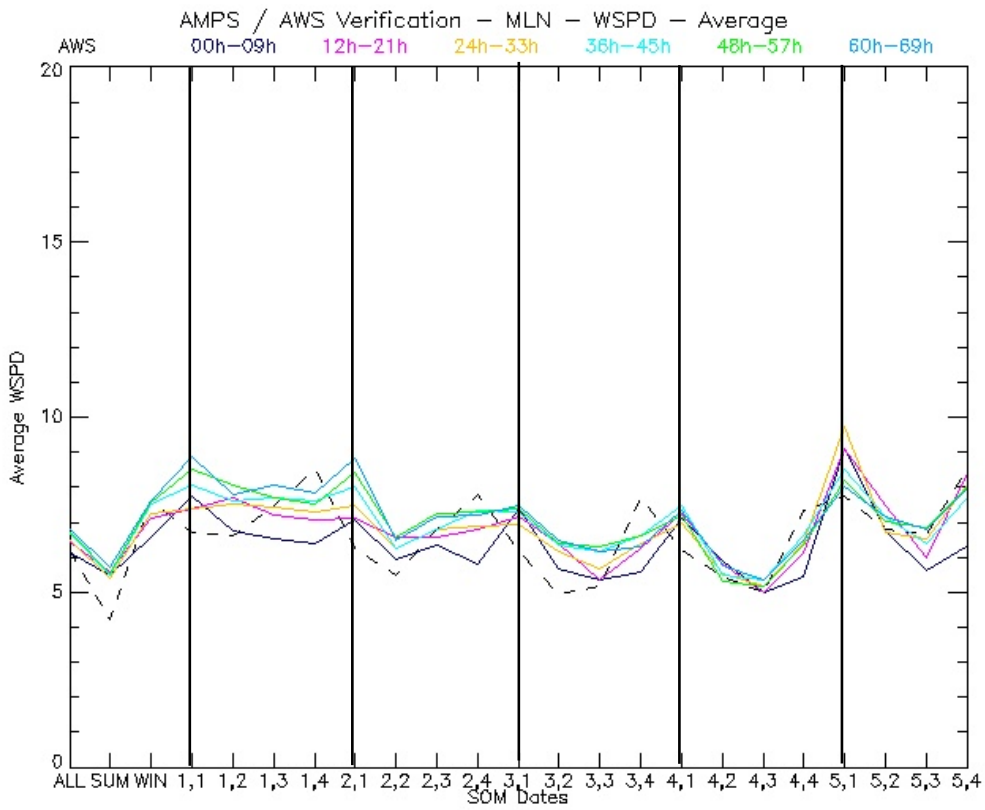


AMPS 012 Forecasts: Node (4,3)



AMPS 060 Forecasts: Node (4,3)





Marilyn: Wind Speed