

NW-AIRQUEST 2016 Annual Meeting, June 15-17, 2016, Pullman, WA

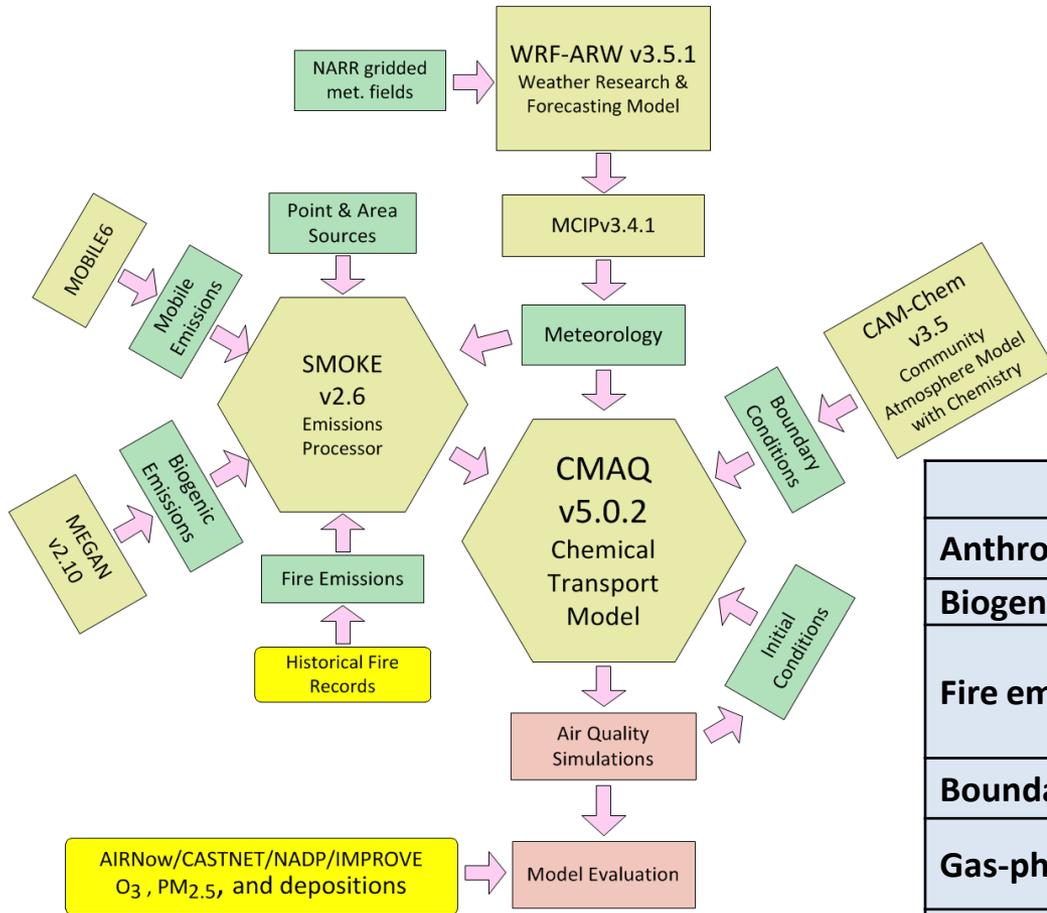
A Preliminary Atmospheric Nitrogen Budget in the Pacific Northwest

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Motivation

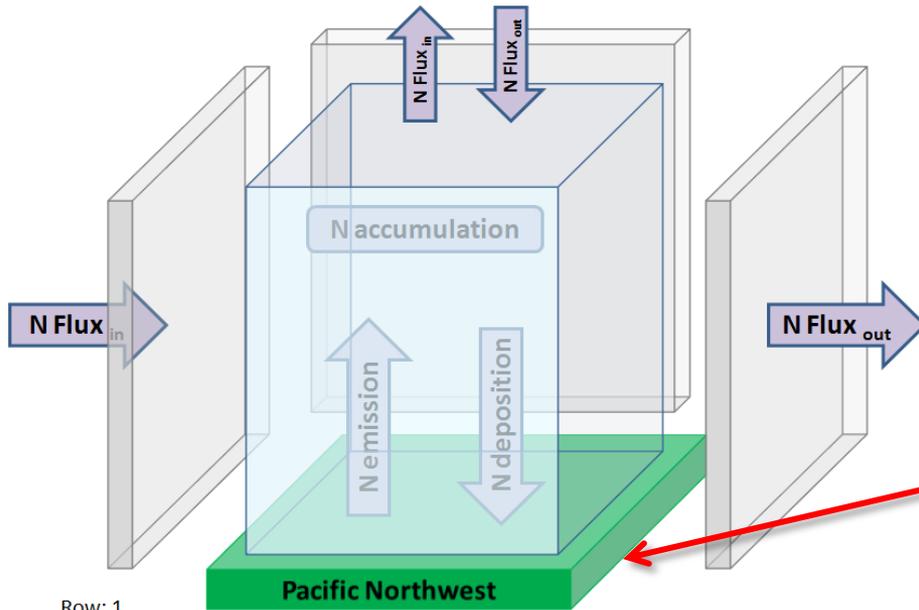
- N inputs into the environment: N emissions have increased >10 times from the preindustrial level (Holland et al., 1999, Galloway et al., 2003).
- Ecological impacts of elevated N deposition (Galloway et al., 2008):
 - nutrient imbalance
 - loss of N-sensitive plant species
 - invasion of non-native species
 - soil and surface water acidifications
- Inter-annual variability plays an important role in watershed biogeochemical processes in the western U.S. (Fenn et al., 2003).
 - Wintertime N wet deposition rates in the Pacific Northwest were modulated by ENSO events (Nergui et al., in review GBC).
- Atmospheric N budget is the first step in an overall N budget for the region as part of our BioEarth project.

WRF-MEGAN-SMOKE-CMAQ Modeling



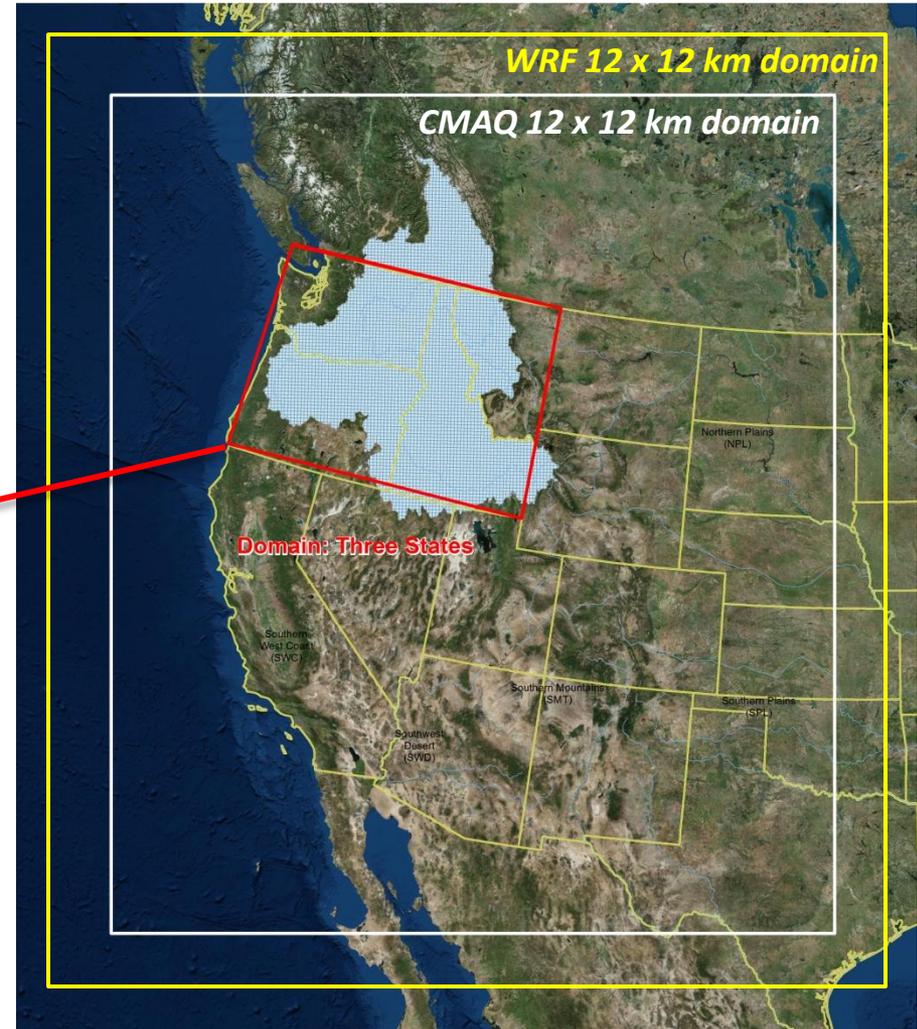
CMAQ, version 5.0.2	
Anthropogenic emissions	NEI2002
Biogenic emissions	MEGAN, version 2.10
Fire emissions	BlueSky modeling framework with historical fire records
Boundary condition	CAM-Chem, version 3.5
Gas-phase chemistry	CB05 photochemical mechanism
Aerosol module	Fifth-generation of CMAQ aerosol mechanism
Cloud module	Asymmetric Convective Method (Pleim, 2007)

An Atmospheric N Budget over the Pacific Northwest



Row: 1
Column: vertical 37 layers

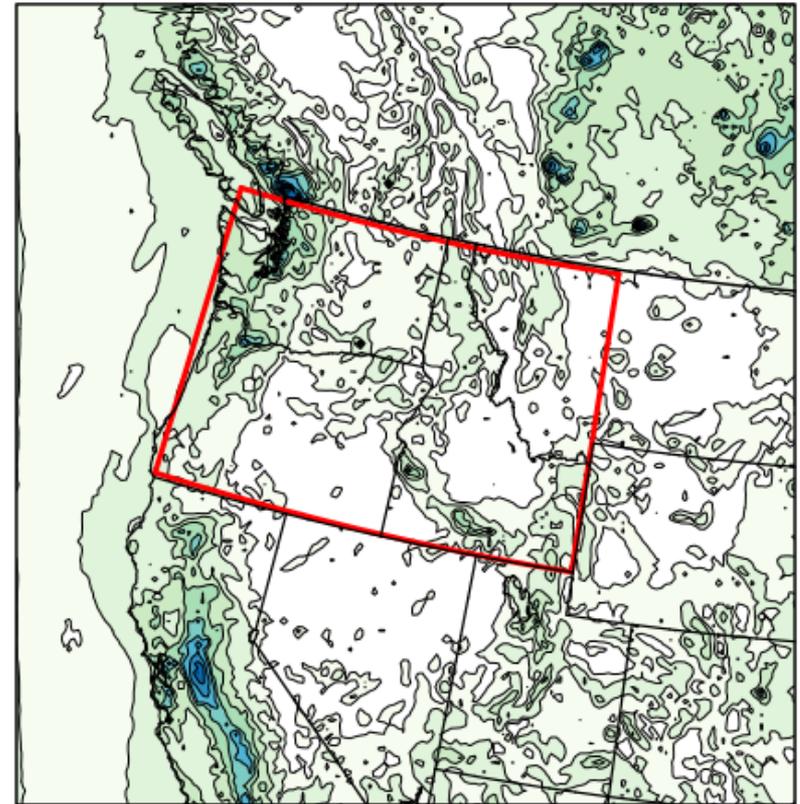
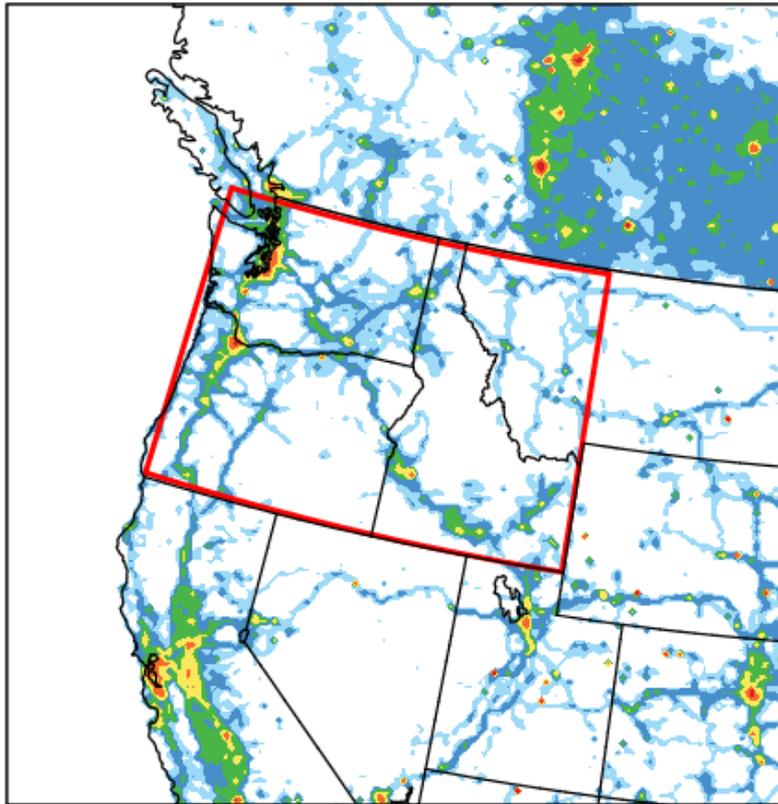
- 12 x 12 km domain over Washington, Oregon, and Idaho states
- During the 1997/98 El Nino and the 1998/99 La Nino years



Surface N fluxes for December 1997

Total N emission (20.4 Gg N)

Total N deposition (10.1 Gg N)

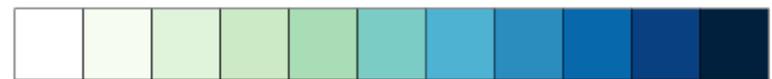


Mg N/grid

Mg N/grid

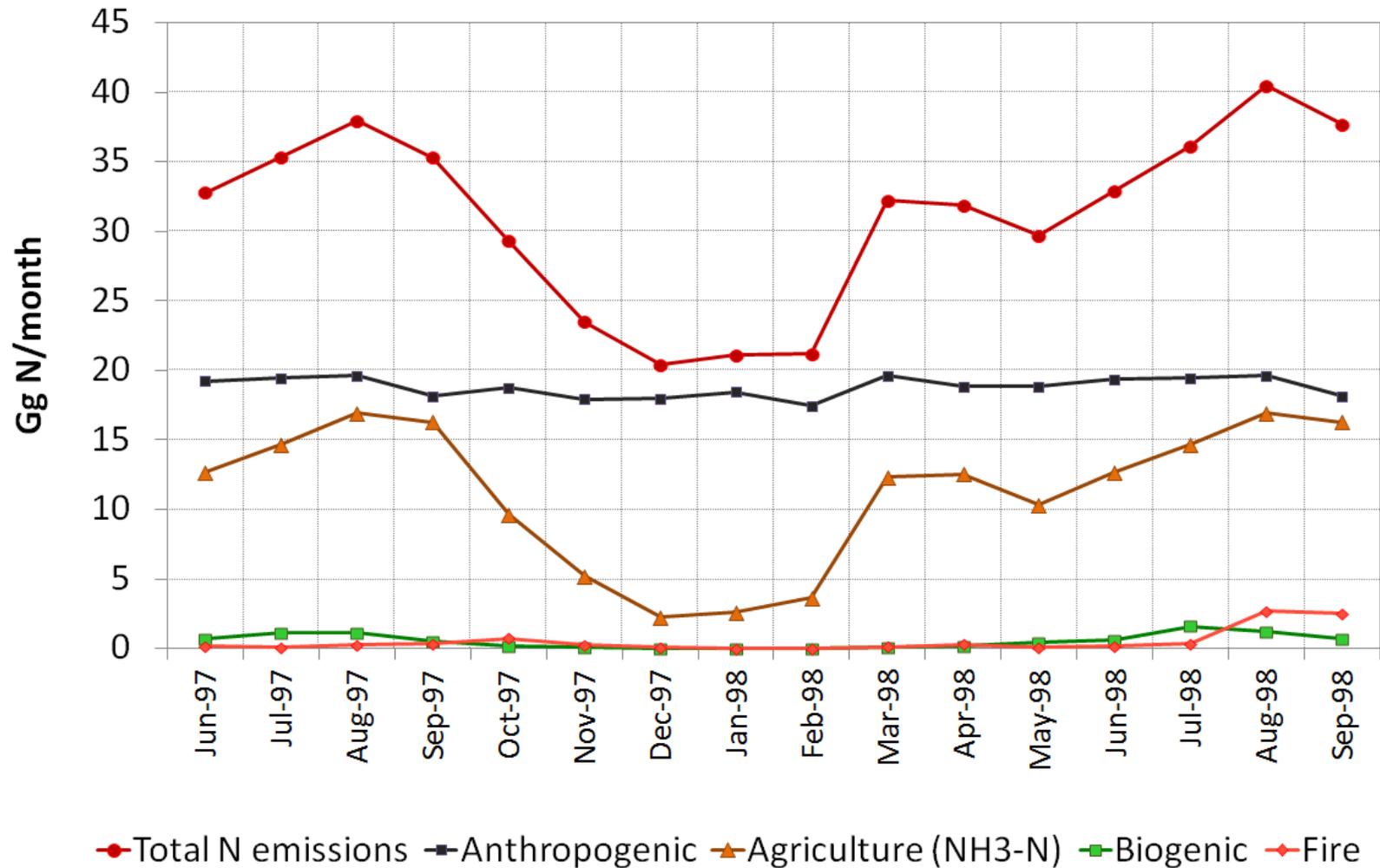


1 3 10 30 100 300 1000

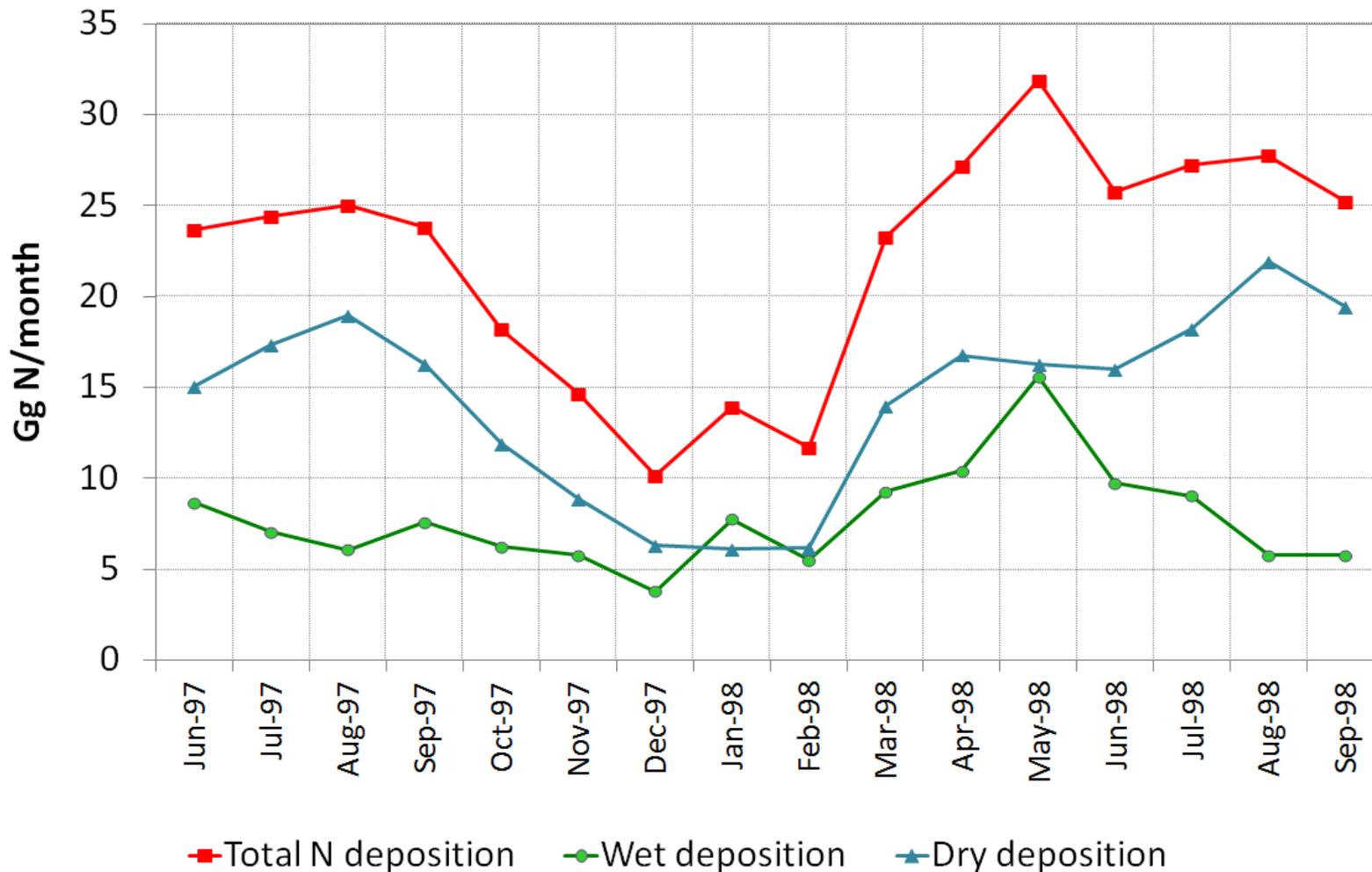


1 2 4 6 8 10 15 20 25 30

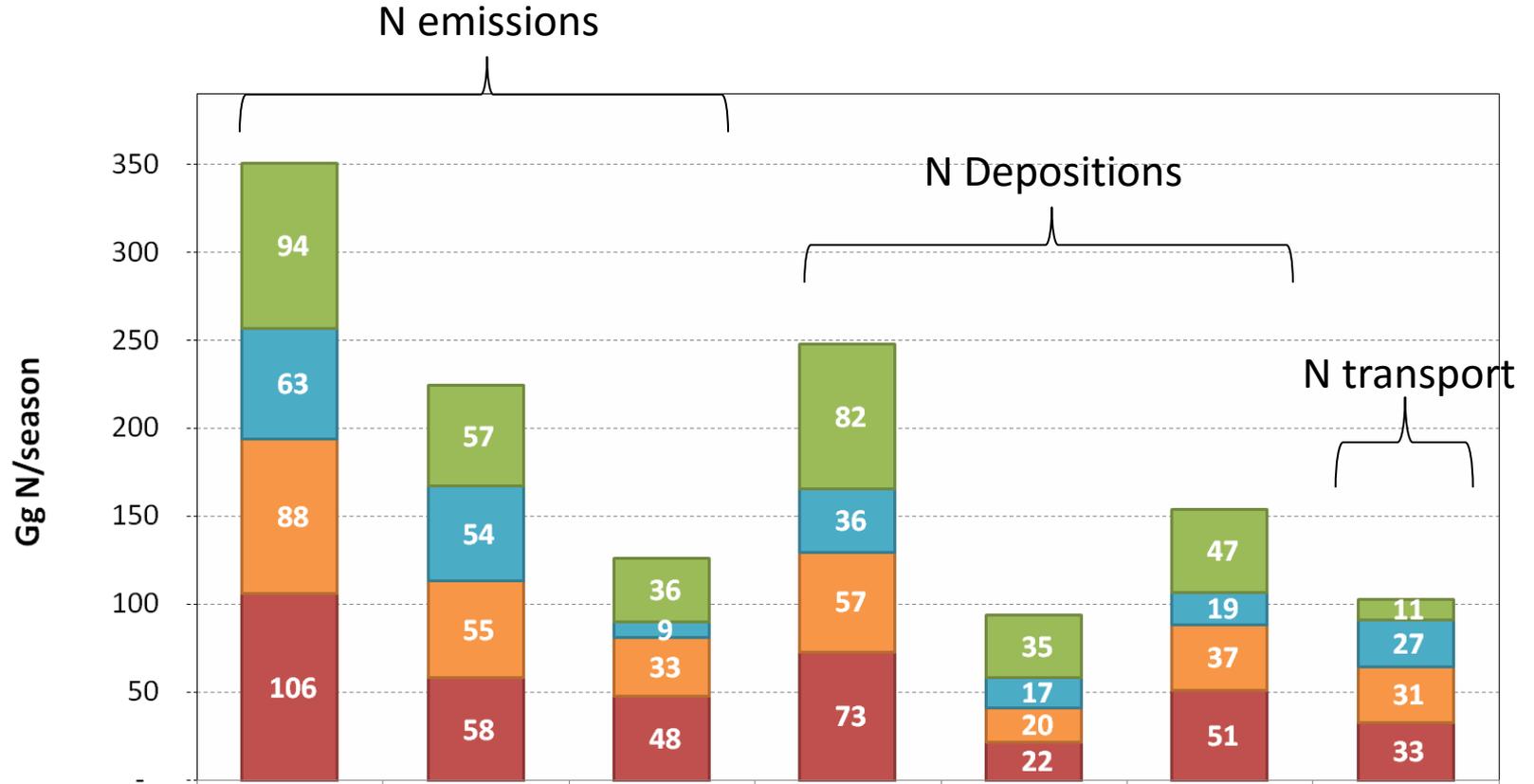
Monthly N Emission by Source Type



Monthly Dry and Wet N Deposition



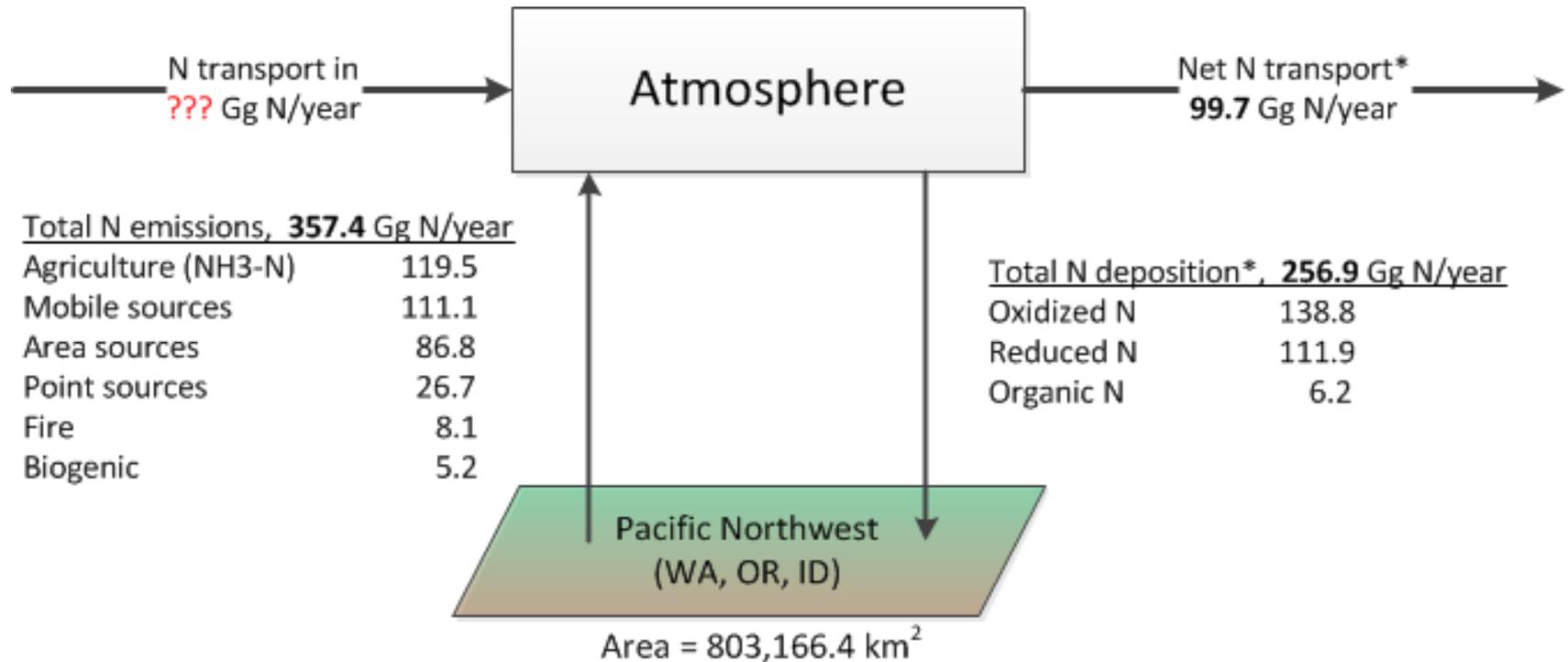
Seasonal N Budgets



	Total N Emis	N emis_mb-egu-ind.	N emis_ag-biogenic-fire	Total N dep	N wet dep	N dry dep	Net N transport
■ Spring 1998	94	57	36	82	35	47	11
■ Winter 1997 (El Nino)	63	54	9	36	17	19	27
■ Fall 1997	88	55	33	57	20	37	31
■ Summer 1997	106	58	48	73	22	51	33

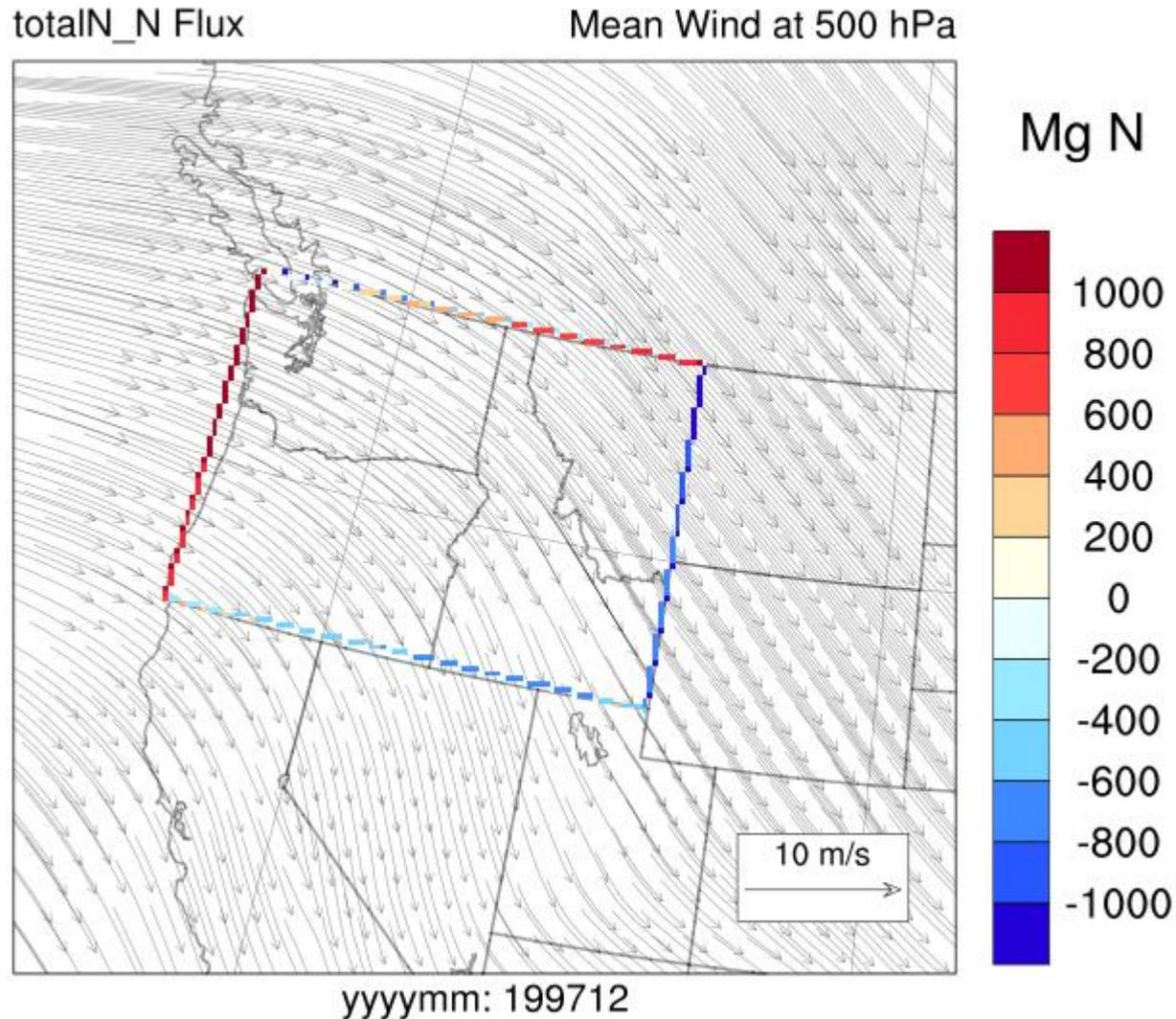
Spatially and seasonally integrated atmospheric N fluxes in the 1997/98 El Nino year

Annual N Budget for 1998

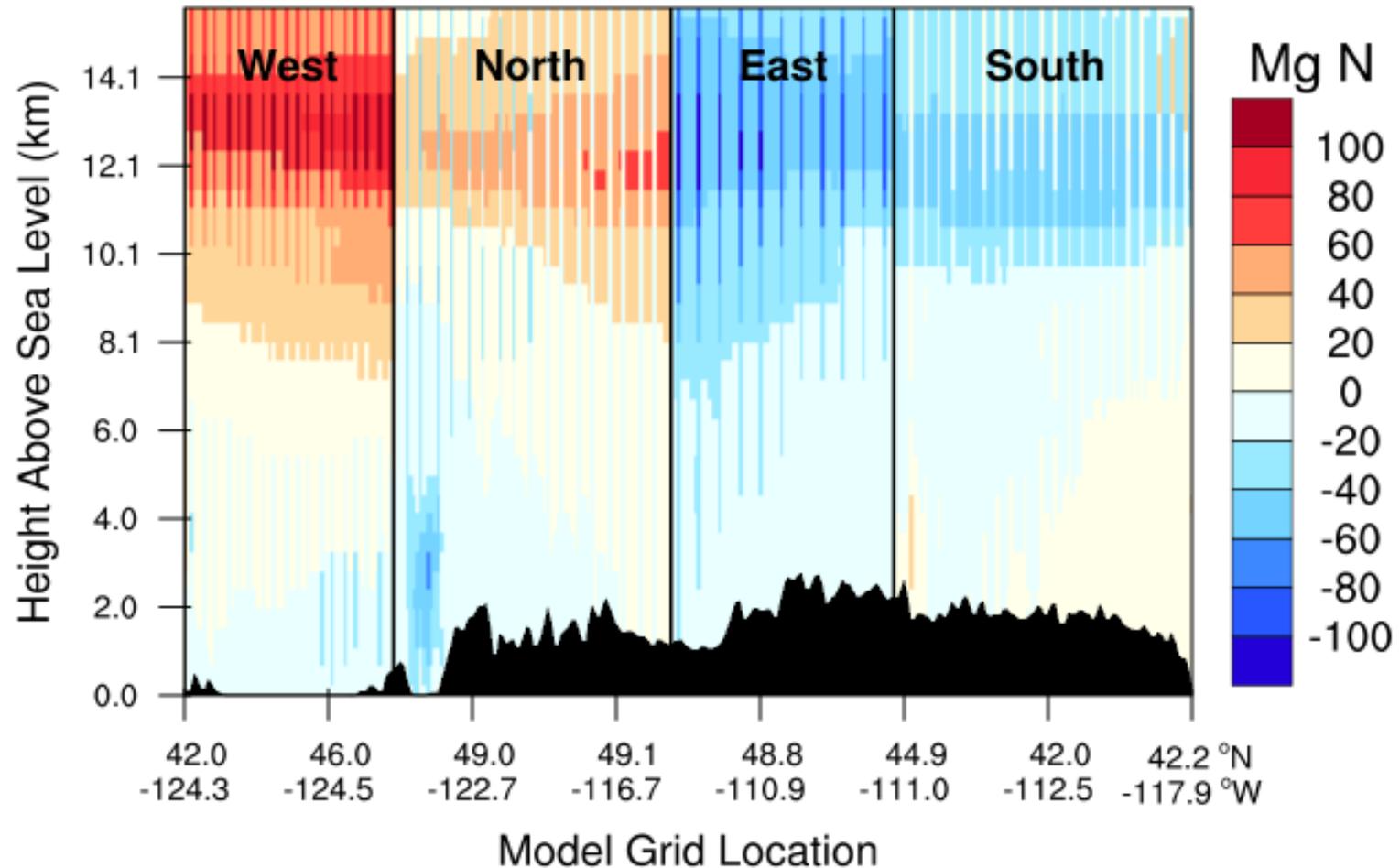


Considered N species: NO, NO₂, NH₃, HNO₃, N₂O₅, HONO, PAN, ANO₃, ANH₄, and organic nitrate.

Vertically-integrated Boundary N Flux

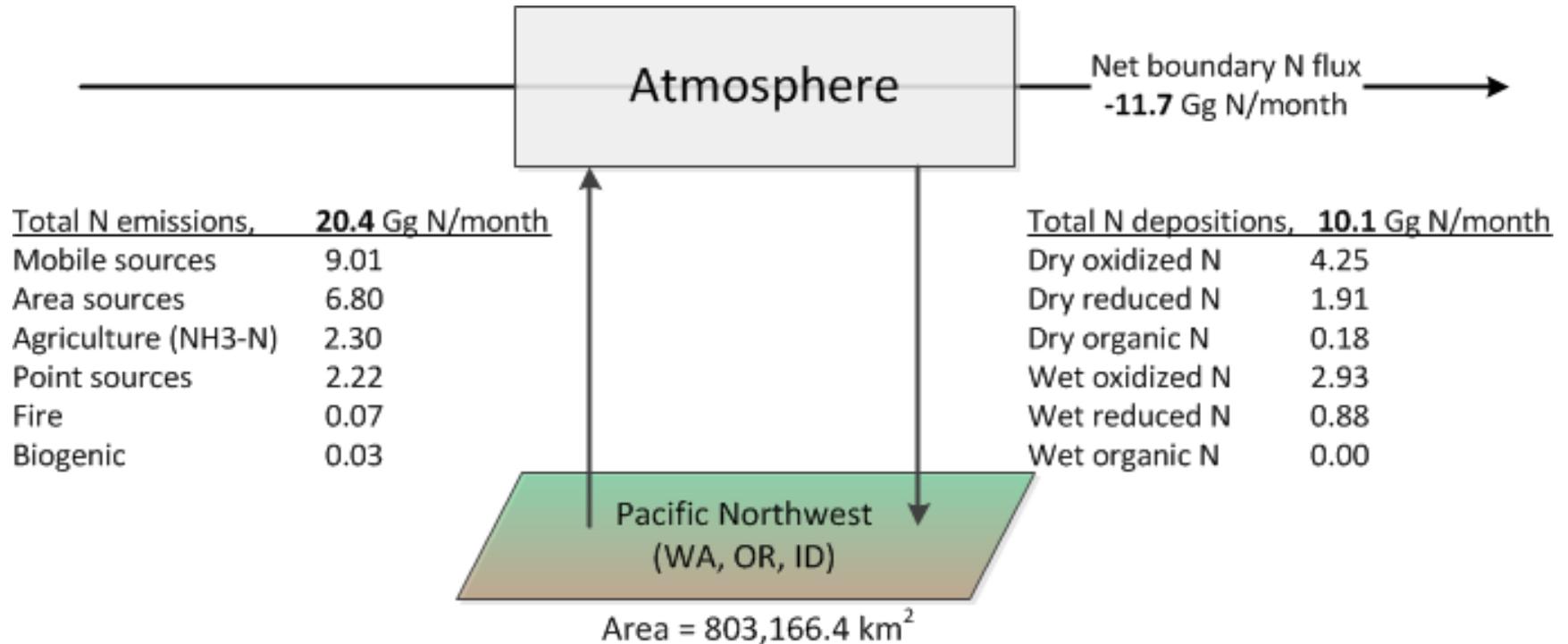


Boundary N Fluxes for December 1997



Considered N species: N2O5, HONO, PAN, PANX, PNA, NTR, CRON, CRNO, CRN2, CRPX, OPAN, **NOX_N**, and **TNO3_N**.

Atmospheric N Budget for December 1997



Considered N species: NO, NO₂, NH₃, HNO₃, N₂O₅, HONO, PAN, ANO₃, ANH₄, and organic nitrate.

Summary

- Total N emissions in the three states were about 357 Gg N in 1998, with 96% from human activities.
- A total of 257 Gg N/year was deposited in the region. It equals to 72% of regional emissions.
- Dry deposition was dominant (>60% of the total deposition) for all seasons.
- Based on emission and deposition fluxes, about 100 Gg N/year was transported out of the region in 1998.

Future work

- Calculate seasonal and annual net N transport of the region.
- Complete the 1998/99 La Niña year simulation.
- Combine the results with terrestrial and aquatic N budgets to yield a complete N budget for the region and for the Columbia River Basin as a major synthesis product for the BioEarth project.

THANK YOU.

EXTRA

WRF and CMAQ model configuration

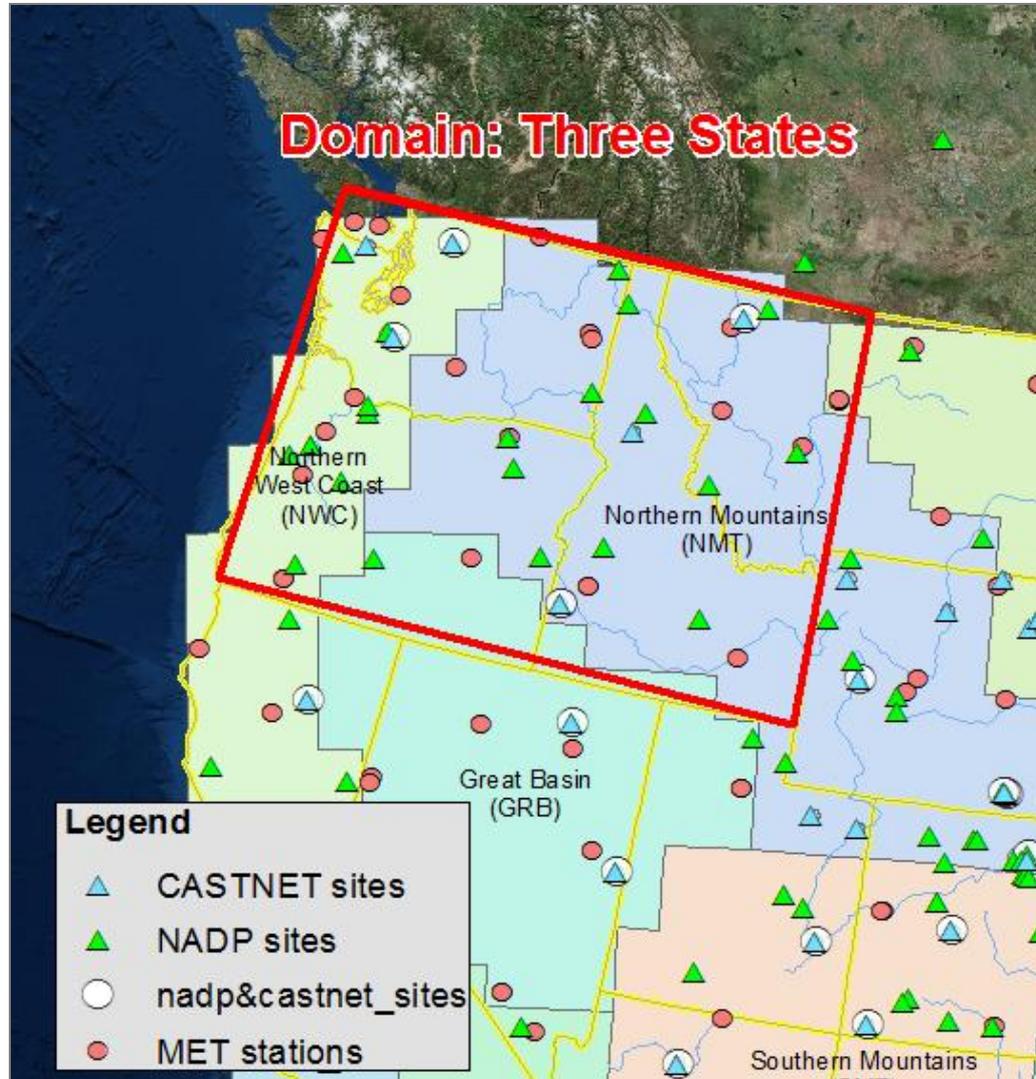
WRF-ARW, version 3.5.1	
Microphysics parameterization	Thompson scheme (new for V3.1)
Cummulus parameterization	New GFS Simplified Arakawa-Schubert (SAS) scheme from YSU
Longwave radiation	RRTMG longwave radiation
Shortwave radiation	RRTMG shortwave radiation
Boundary layer physics	YSU PBL scheme
Surface layer physics	MM5 Monin-Obukhov scheme
Land surface physics	Unified Noah Land-surface model

CMAQ, version 5.0.2	
Anthropogenic emission	NEI2002
Biogenic emission	MEGANv2.10, historical fire emission records
Boundary condition	CAM-Chem
Gas-phase chemistry	SAPRC99 photochemical mechanism
Aerosol module	Sixth-generation CMAQ aerosol mechanism
Cloud module	Asymmetric Convective Method (Pleim, 2007)

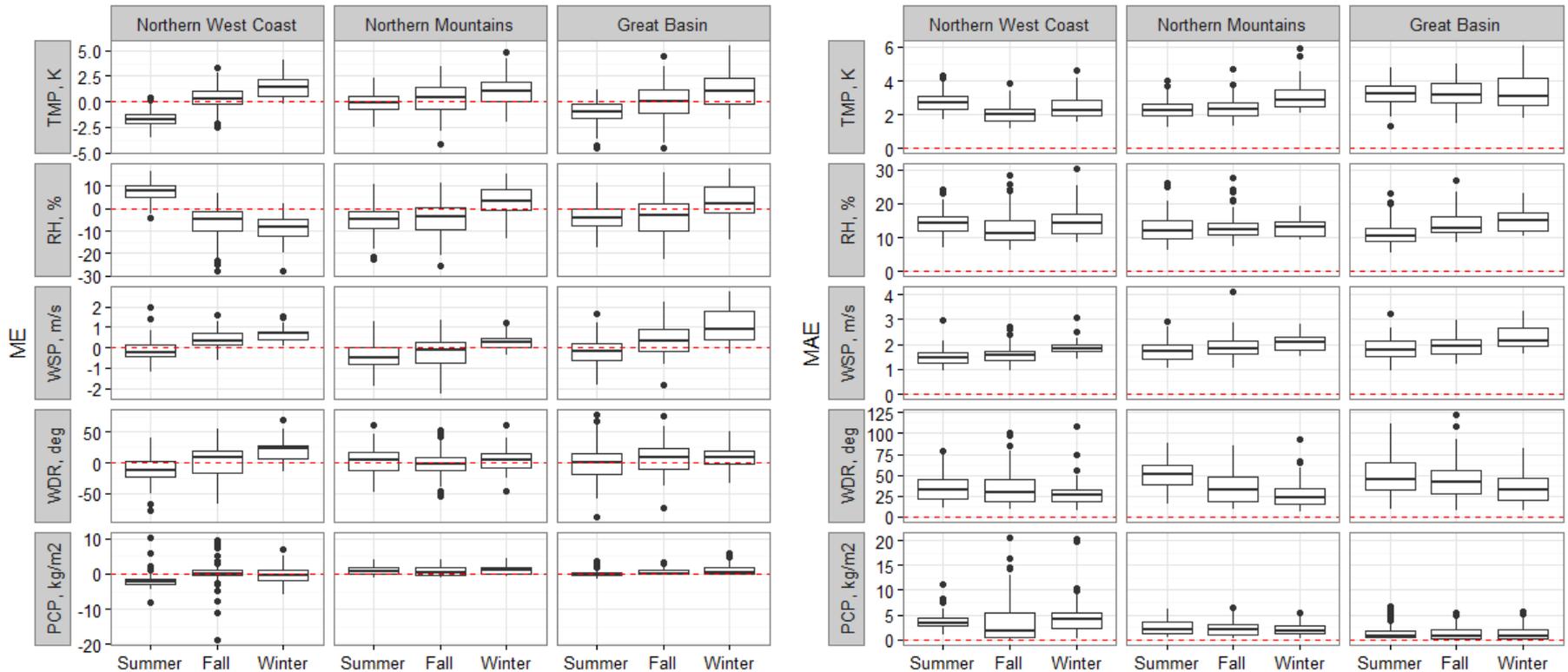
N species in the NEI-2002

NEI 2002 emission category		onroad	other	point	nonpoint	other	ag	alm	nonpt	nonpt fire	nonroad	afdust	other	hfire	MEGAN
SMOKE emission processing		Mobile sources		Point sources			Area sources							Fire	Biogenic
N species unit															
NH3	moles/s	*	*	*	*	*	*	*	*	*	*		*	*	*
NO	moles/s	*	*	*	*	*		*	*	*	*		*	*	*
NO2	moles/s	*	*	*	*	*		*	*	*	*		*	*	
NR	moles/s														*
PNO3	g/s	*	*	*	*	*		*	*	*	*	*	*	*	

Observation locations

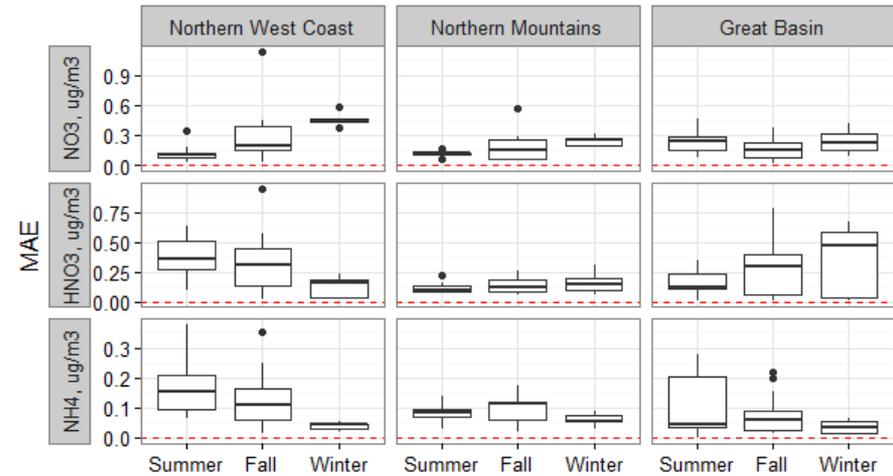
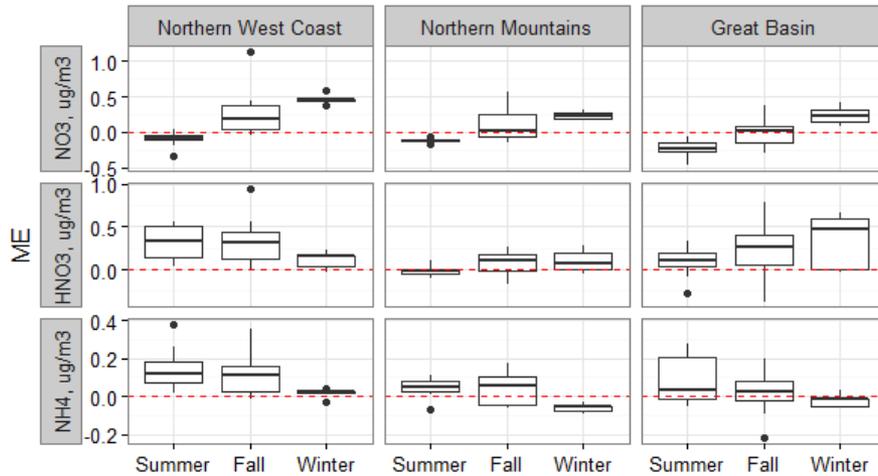


WRF model performance

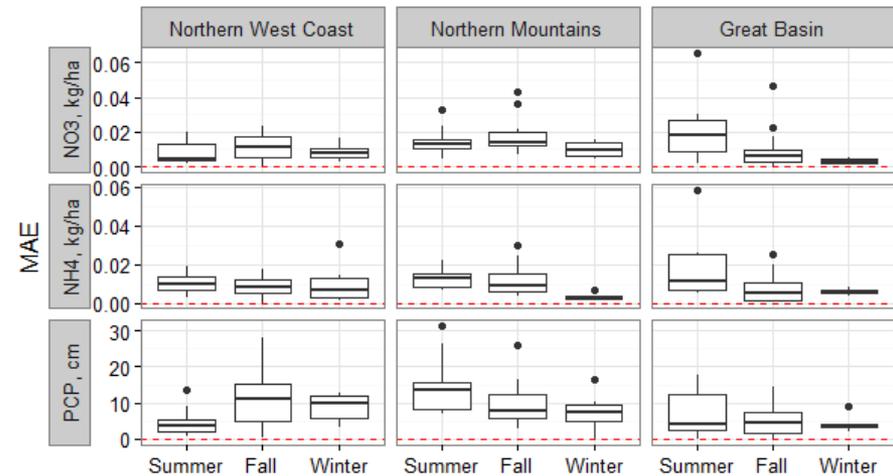
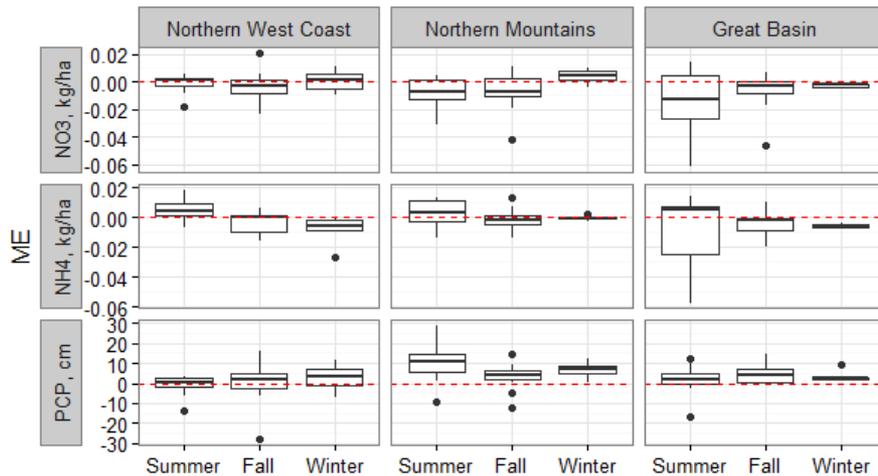


CMAQ model performance

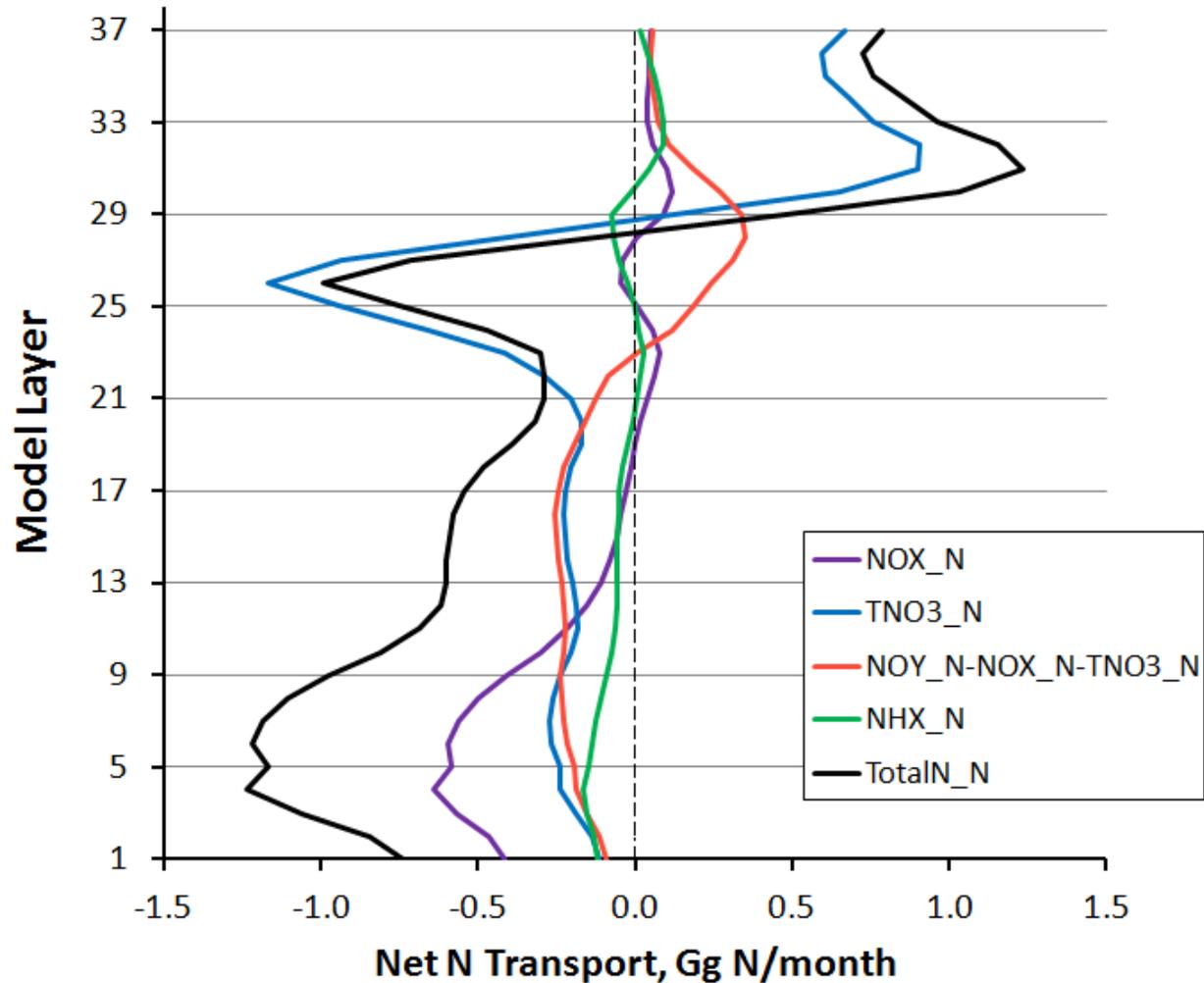
N concentration



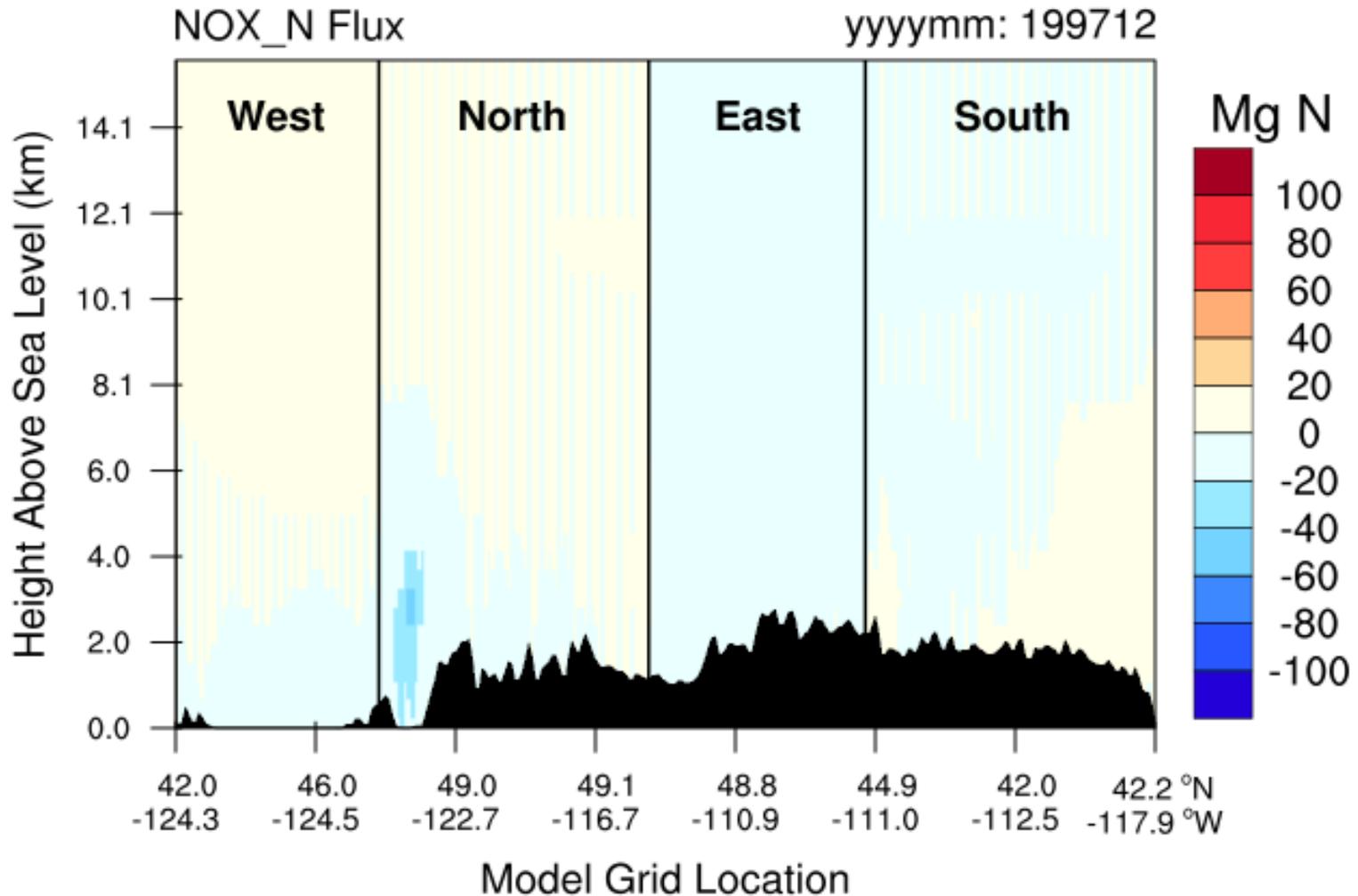
N wet deposition



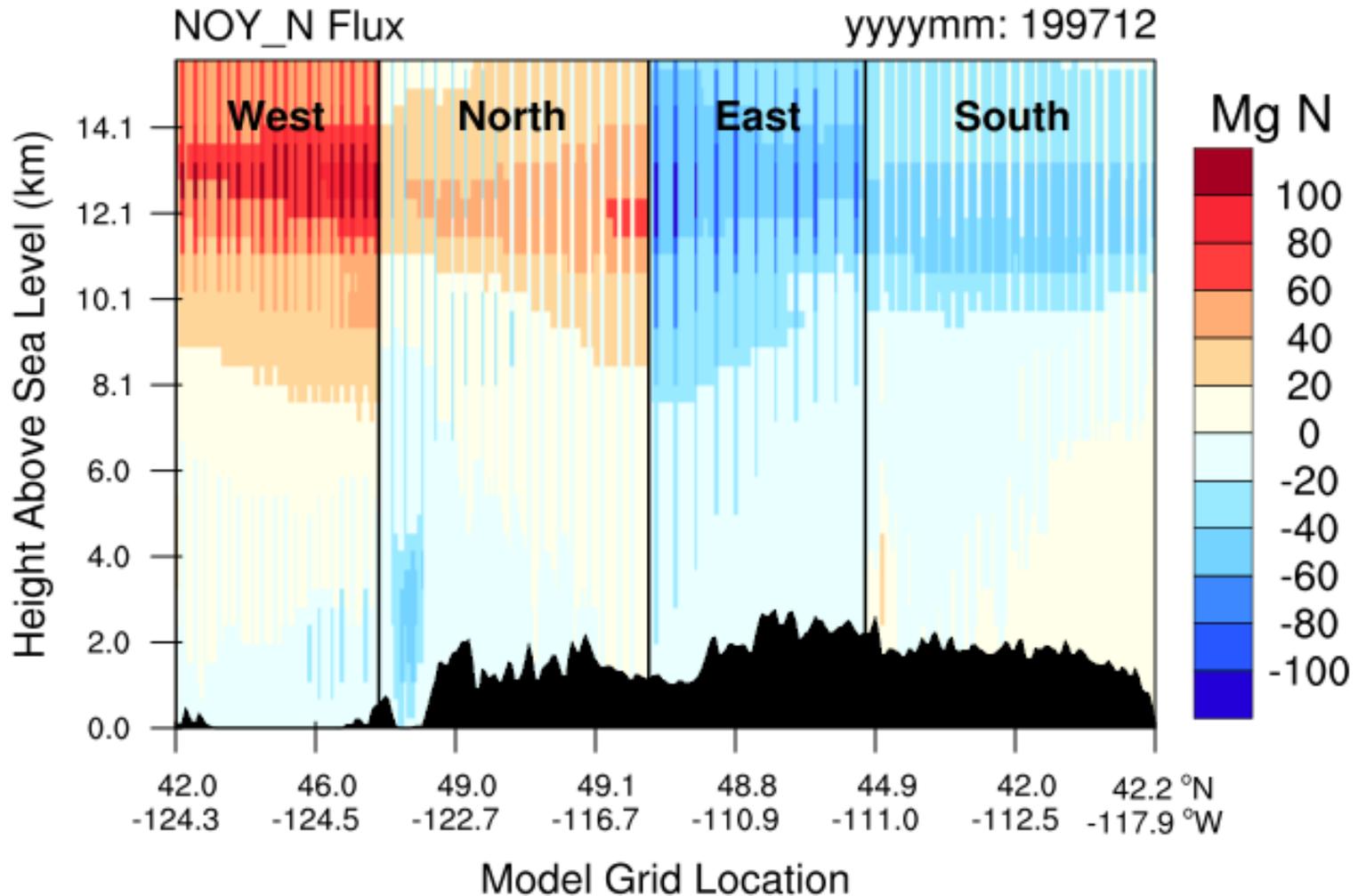
Net N flux through three states' boundary December 1997



Boundary NO_x-N Fluxes for December 1997

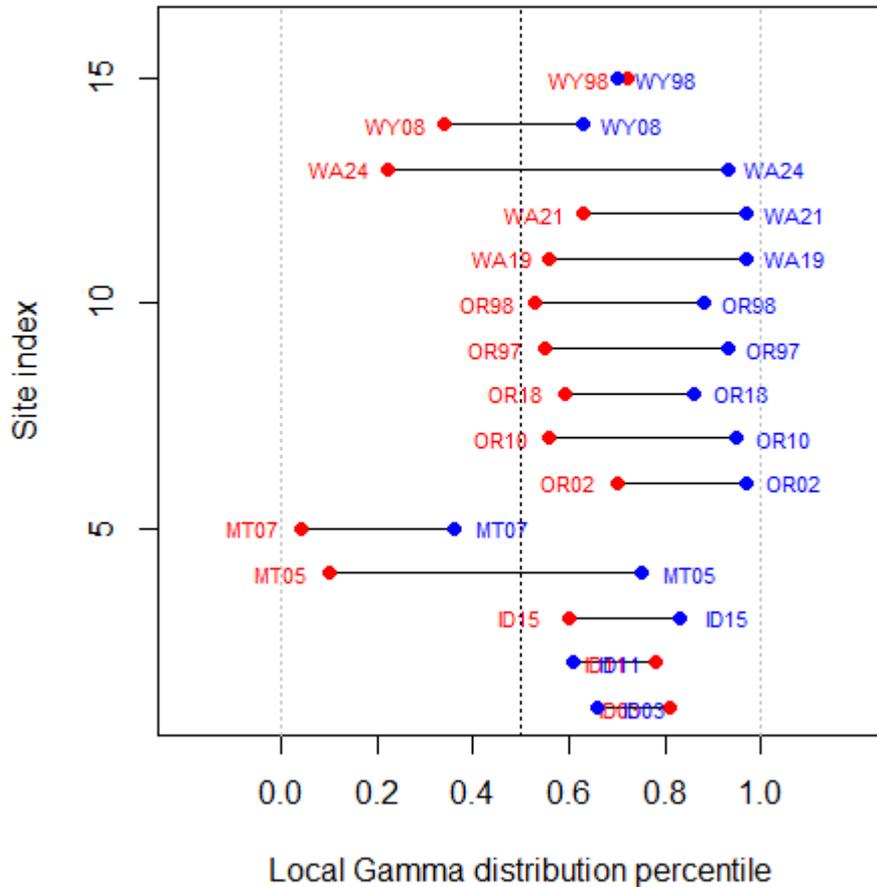


Boundary NO_y-N Fluxes for December 1997



Wintertime anomalies during 1998 El Nino and 1999 La Nina

Precipitation



Total N wet deposition

