

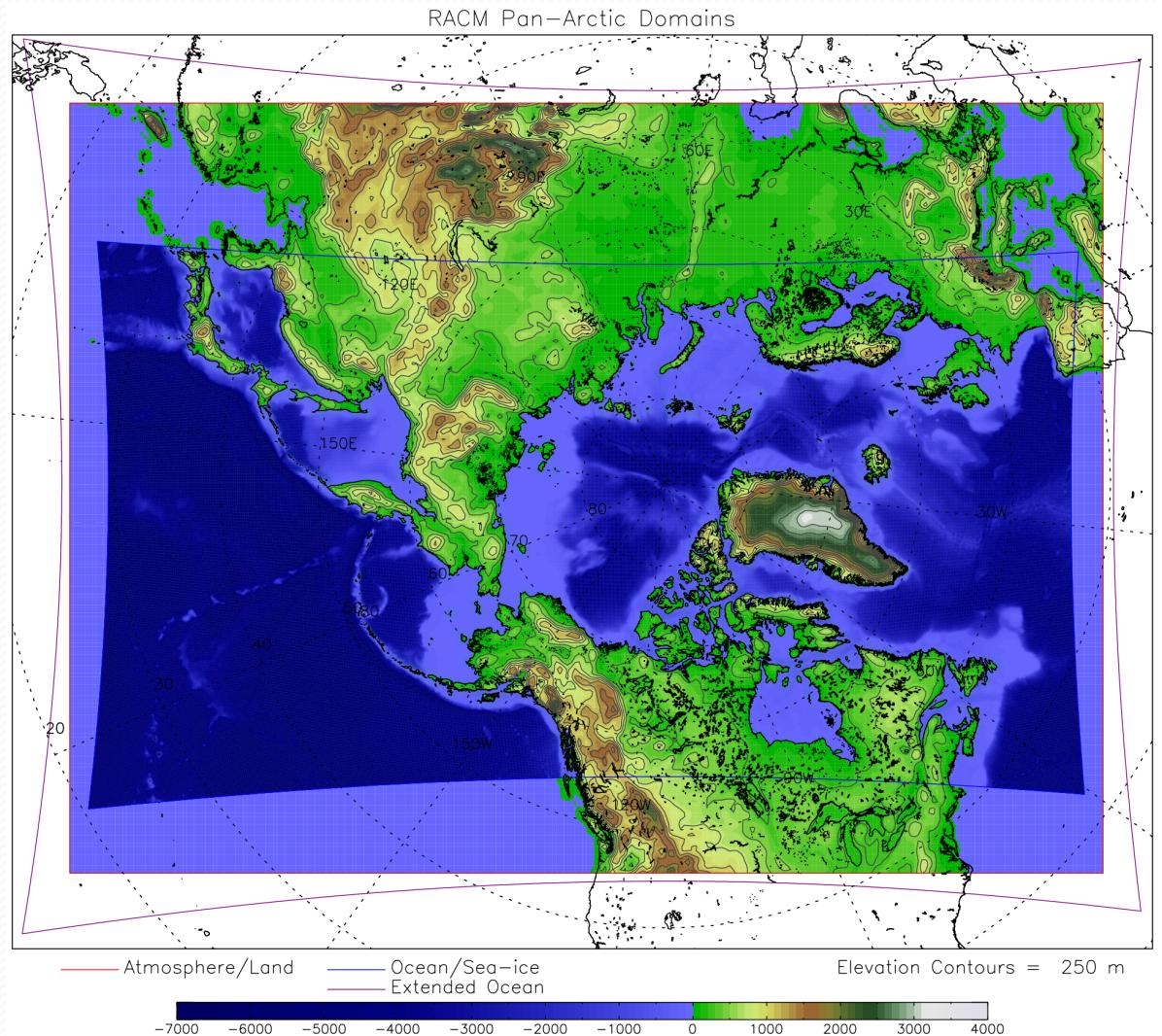
CORDEX Arctic Simulations: Initial Results from the Weather Research and Forecasting Model

John J. Cassano and Matthew E. Higgins

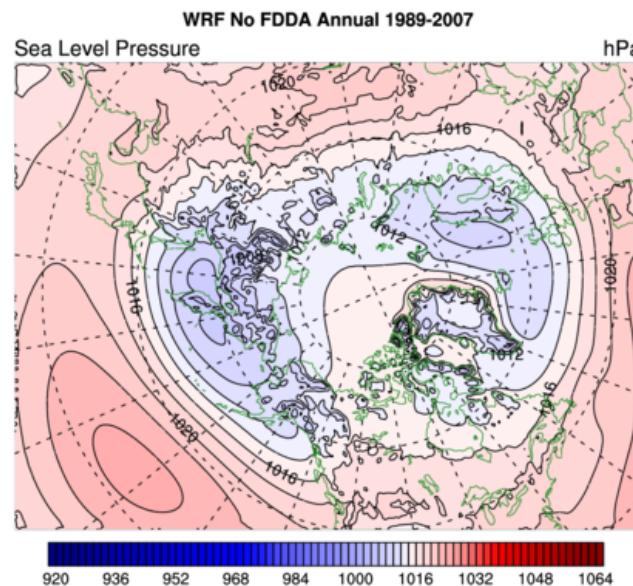
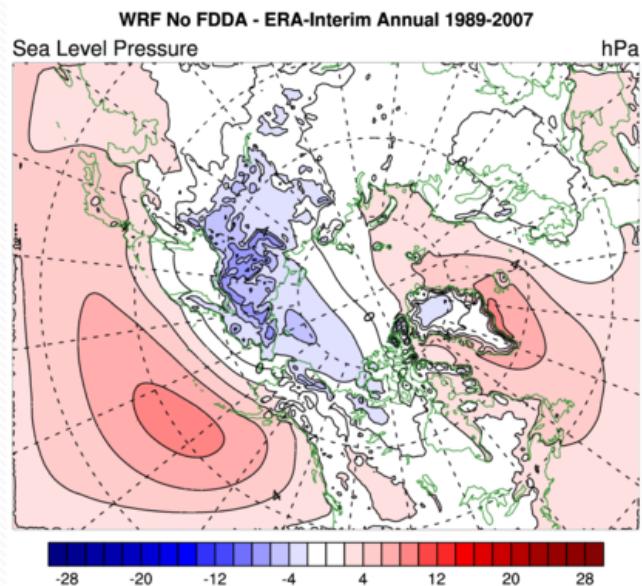
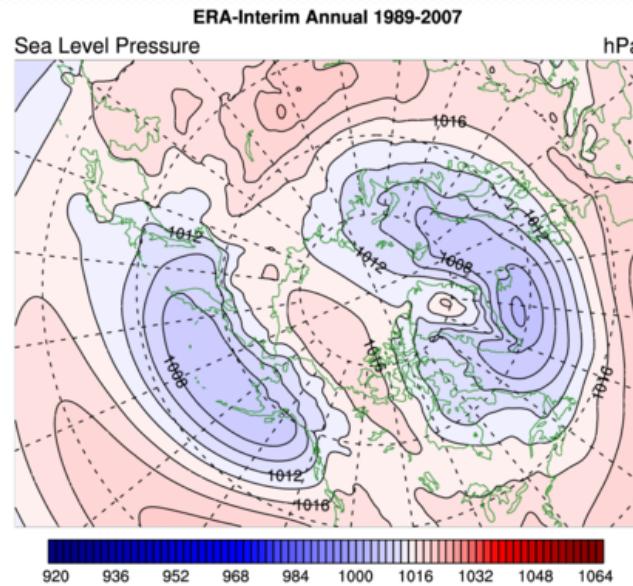
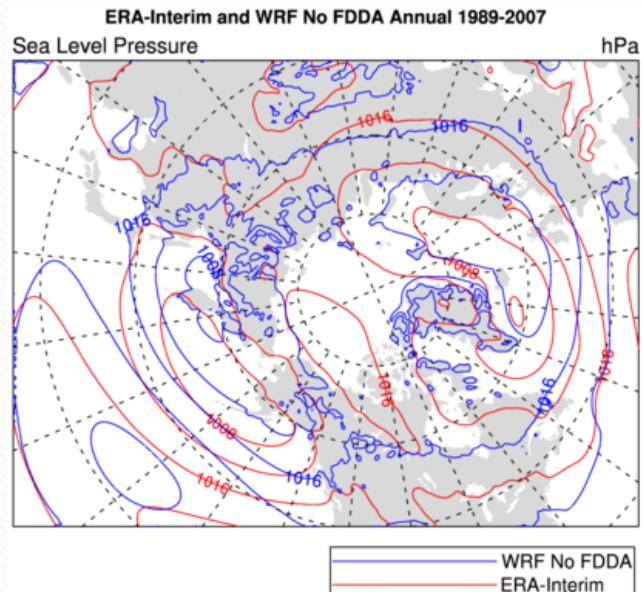
University of Colorado
Cooperative Institute for Research in Environmental Sciences
and
Department of Atmospheric and Oceanic Sciences

CORDEX Simulations

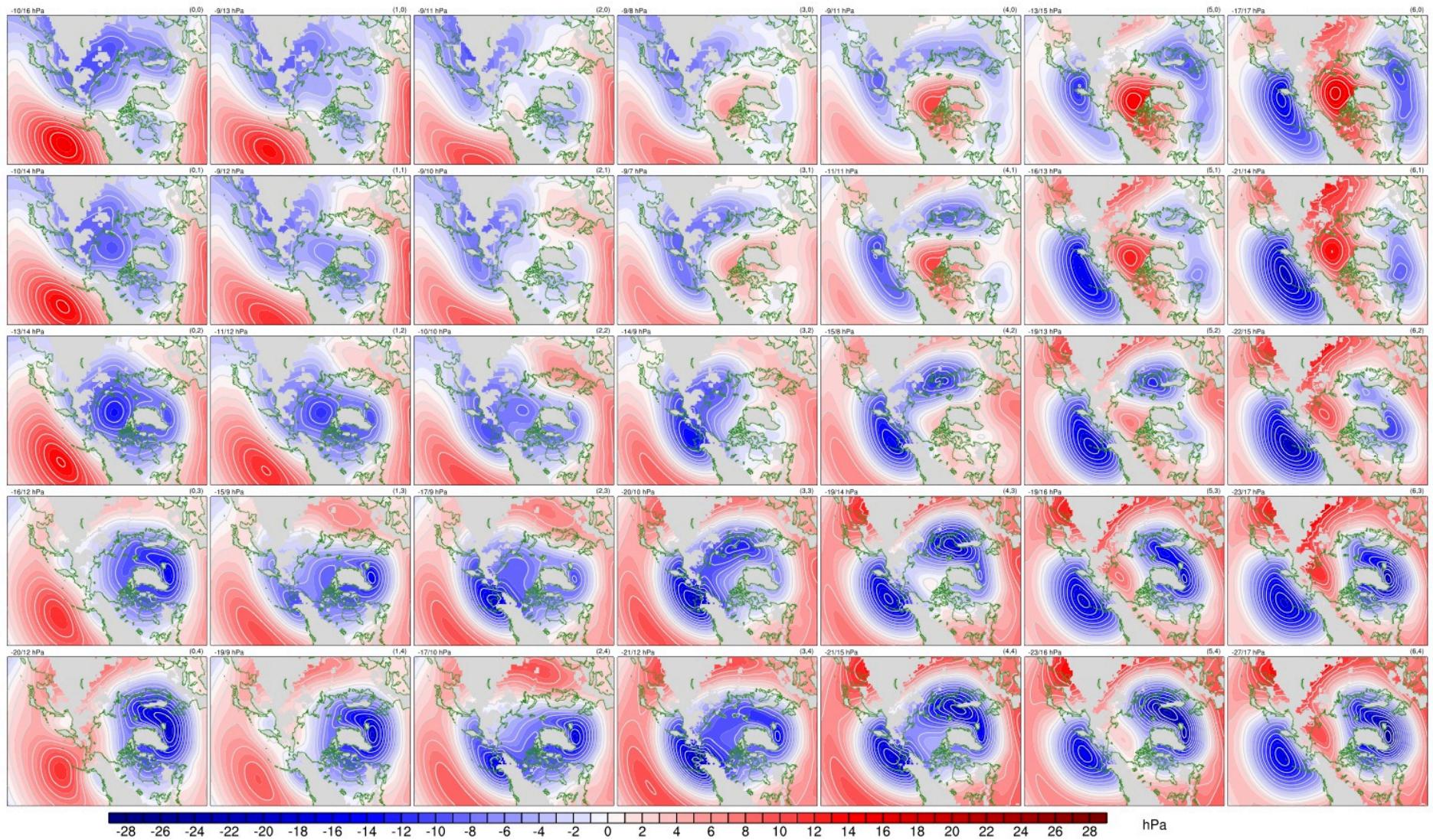
- WRF simulations on Arctic domain
- Simulations for 1989 to 2007 forced with ERA-Interim
- Comparison of non-nudged and spectral nudged simulations
- Fully coupled RACM simulations are planned



Annual SLP



Synoptic Patterns



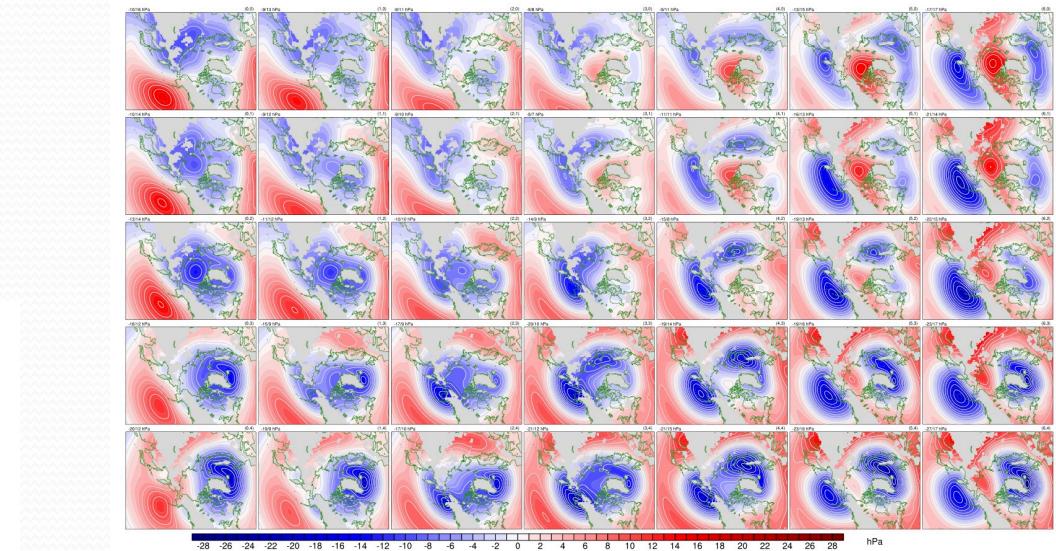
Synoptic Pattern Frequency

ERA-Interim SLP SOM Pattern Frequency - All Year

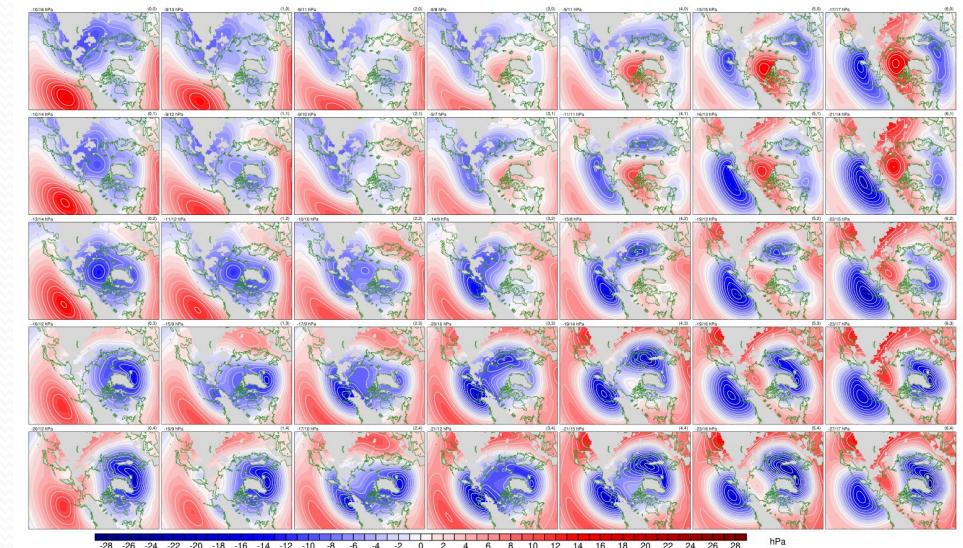
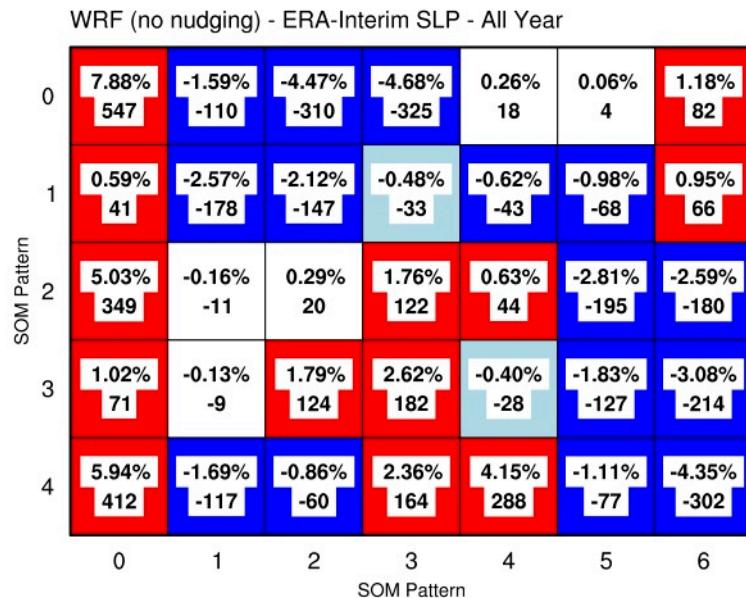
	0	1	2	3	4	5	6
0	1.95% 135	3.70% 257	6.17% 428	6.49% 450	3.30% 229	3.07% 213	2.57% 178
1	1.71% 119	3.93% 273	3.78% 262	3.14% 218	2.71% 188	1.93% 134	2.45% 170
2	0.81% 56	1.89% 131	1.92% 133	2.20% 153	1.82% 126	4.02% 279	3.95% 274
3	1.84% 128	2.05% 142	1.35% 94	1.35% 94	2.08% 144	2.46% 171	4.70% 326
4	2.19% 152	3.72% 258	3.66% 254	1.10% 76	1.34% 93	3.31% 230	5.35% 371

WRF (no nudging) SLP SOM Pattern Frequency - All Year

	0	1	2	3	4	5	6
0	9.83% 682	2.12% 147	1.70% 118	1.80% 125	3.56% 247	3.13% 217	3.75% 260
1	2.31% 160	1.37% 95	1.66% 115	2.67% 185	2.09% 145	0.95% 66	3.40% 236
2	5.84% 405	1.73% 120	2.20% 153	3.96% 275	2.45% 170	1.21% 84	1.35% 94
3	2.87% 199	1.92% 133	3.14% 218	3.98% 276	1.67% 116	0.63% 44	1.61% 112
4	8.13% 564	2.03% 141	2.80% 194	3.46% 240	5.49% 381	2.20% 153	0.99% 69

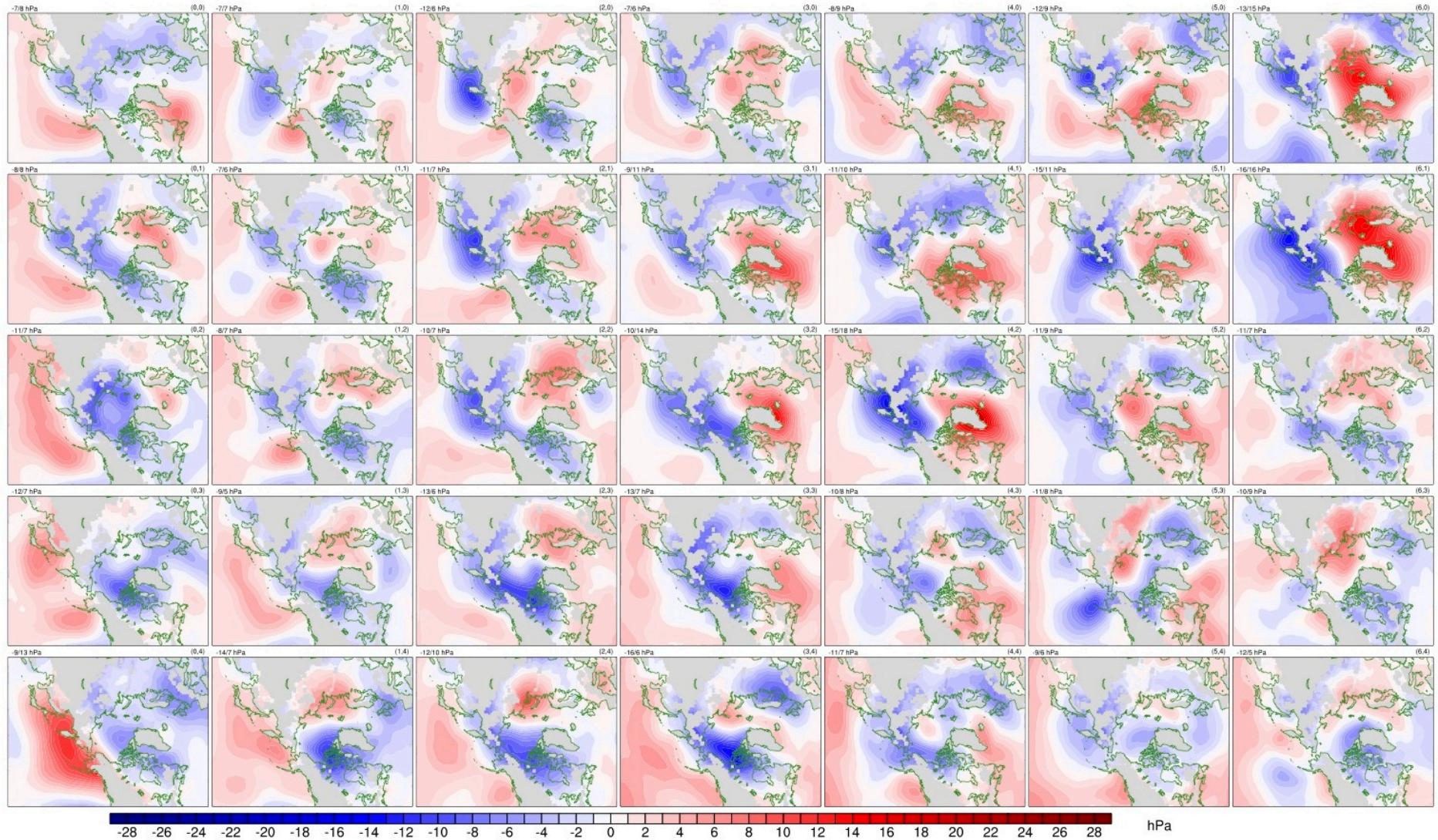


Synoptic Pattern Frequency

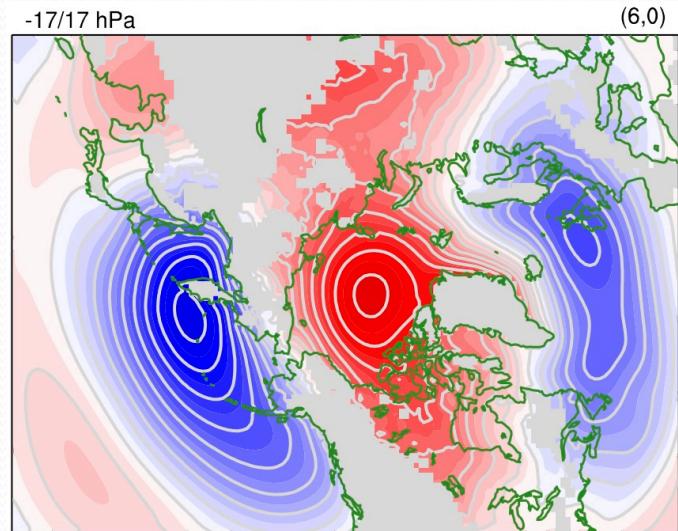
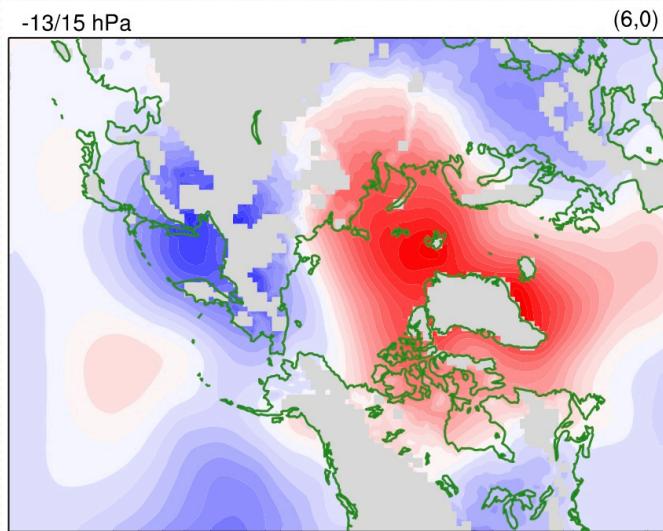
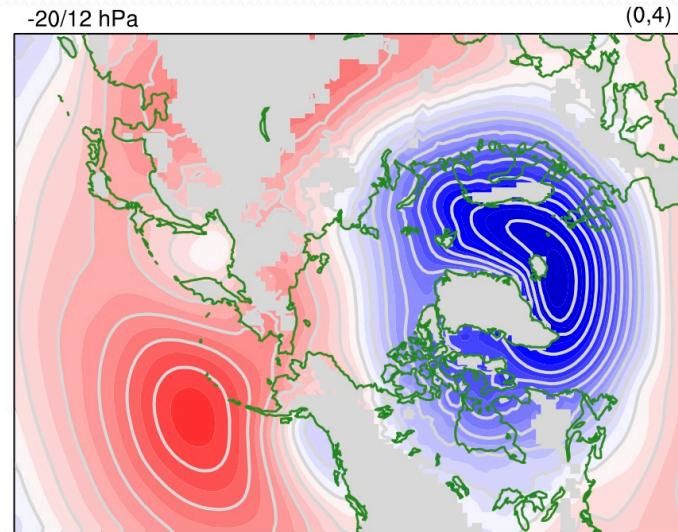
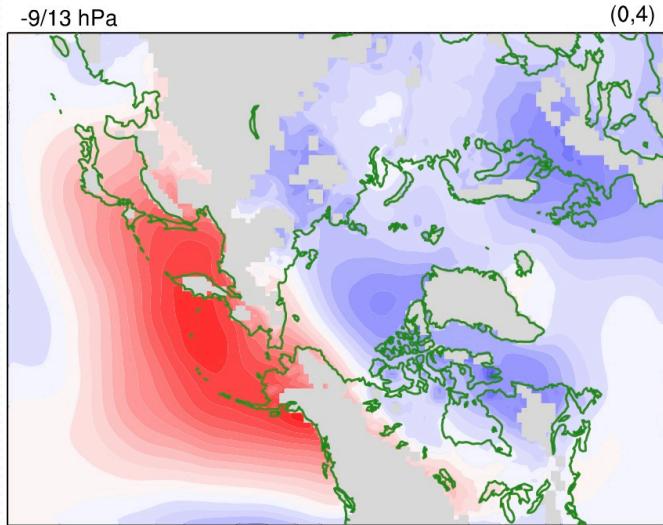


Intra-Pattern Variability

WRF (no spectral nudging) - ERA-Interim SLP Anomaly All Year



Intra-Pattern Variability



Attribution of SLP Differences

$$SLP_{annual} = \sum_i f_i SLP_i$$

f_i – weather pattern frequency

SLP_i - weather pattern daily SLP (mb)

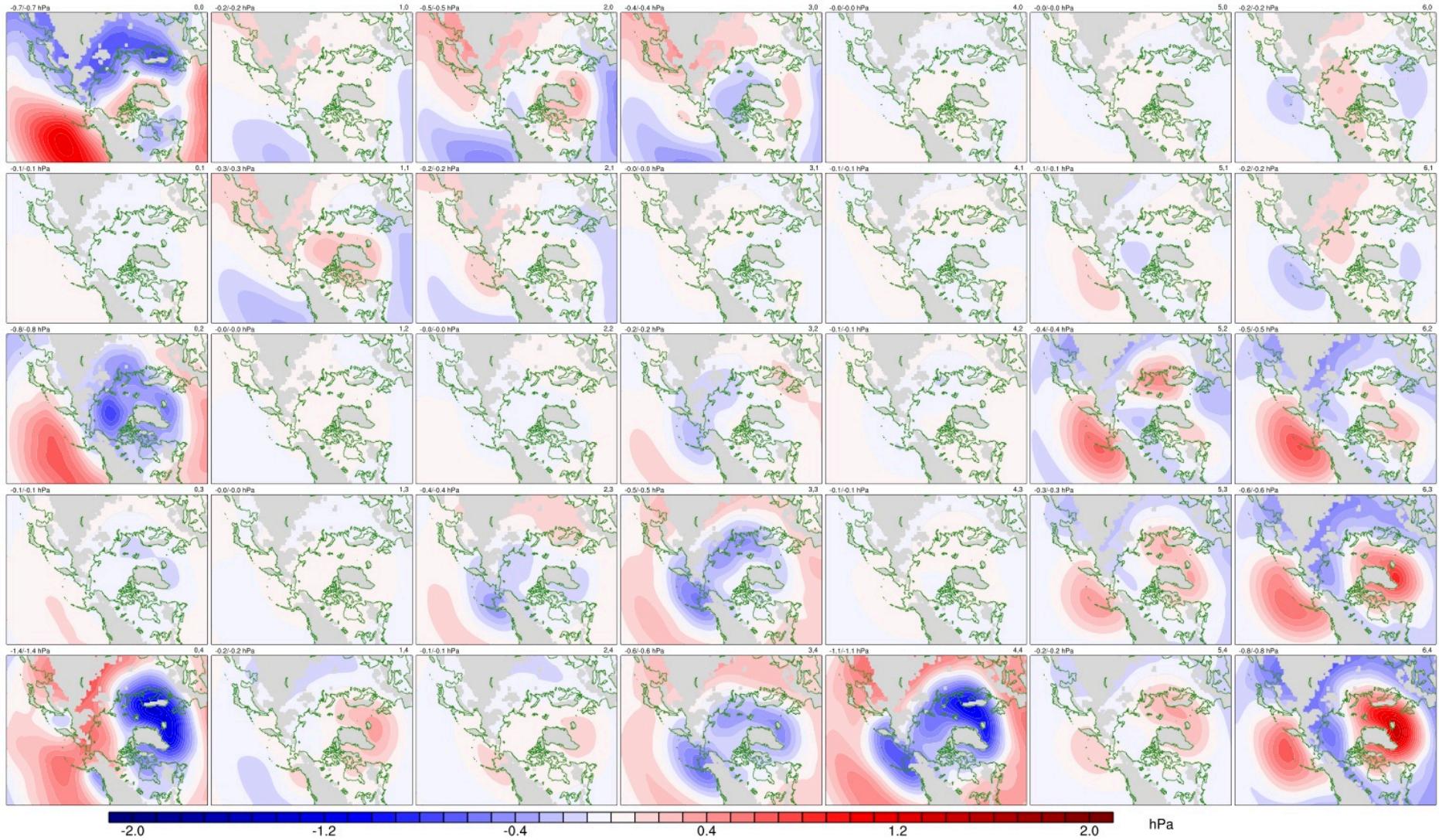
SLP_{annual} – annual mean SLP

$$SLP_{WRF} = \sum_i (f_i + \Delta f_i)(SLP_i + \Delta SLP_i)$$

$$SLP_{WRF} = \sum_i f_i SLP_i + \Delta f_i SLP_i + f_i \Delta SLP_i + \Delta f_i \Delta SLP_i$$

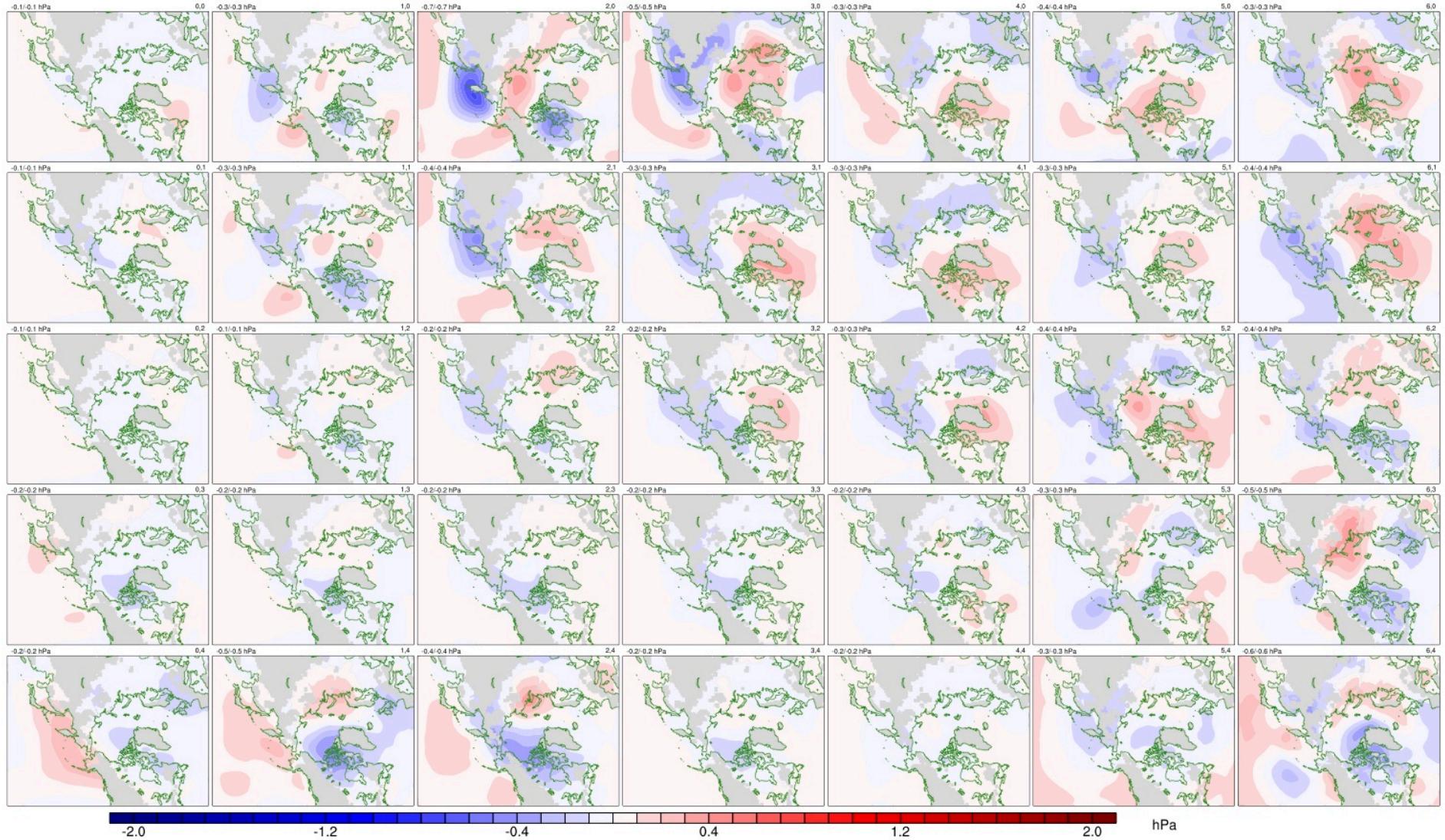
$$SLP_{WRF} = \sum_i f_i SLP_i + \Delta f_i SLP_i + f_i \Delta SLP_i + \Delta f_i \Delta SLP_i$$

Dynamic contribution toward WRF (no spectral nudging) - ERA-Interim SLP difference All Year



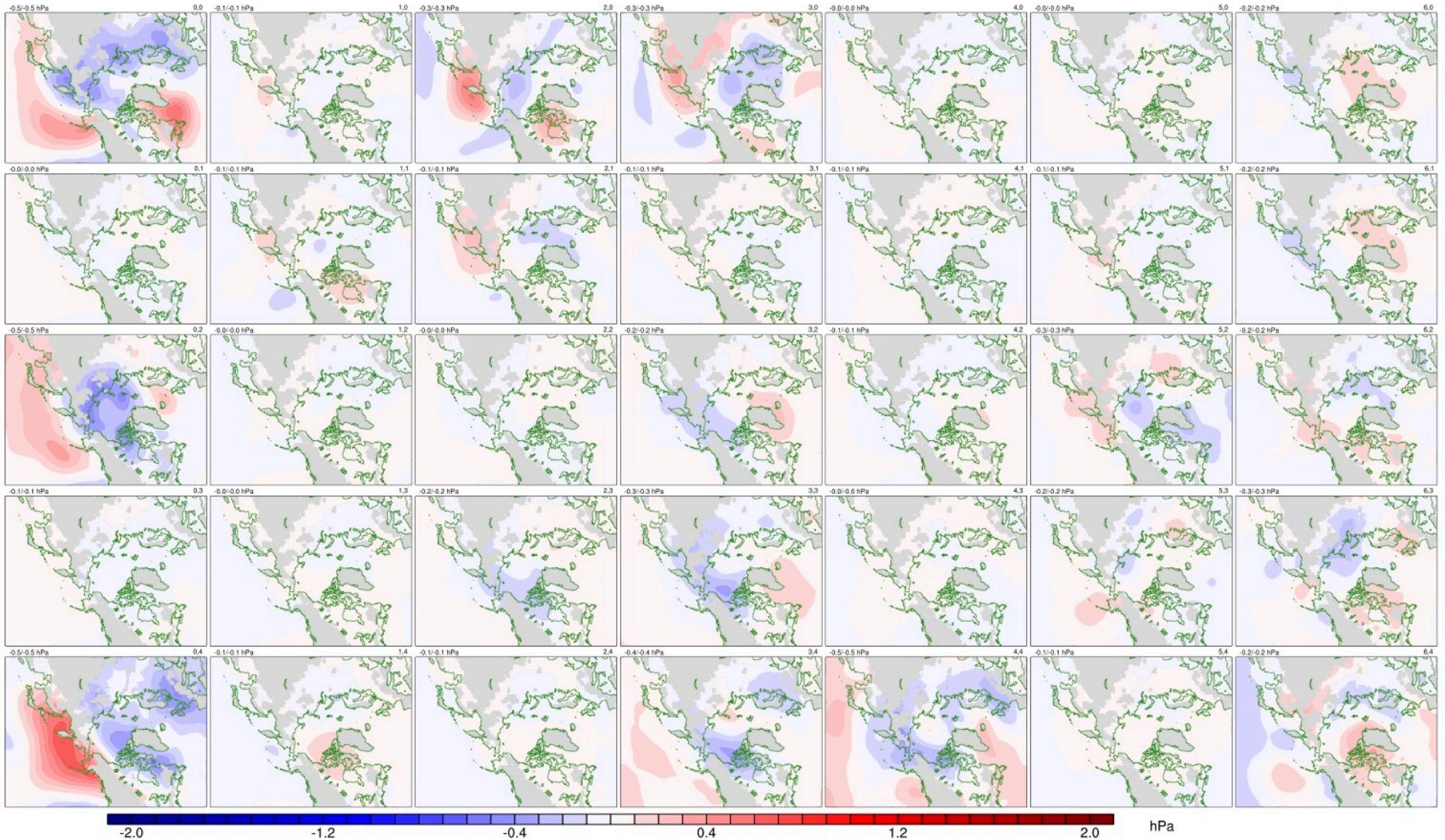
$$SLP_{WRF} = \sum_i f_i SLP_i + \Delta f_i SLP_i + f_i \Delta SLP_i + \Delta f_i \Delta SLP_i$$

Intra-pattern variability contribution toward WRF (no spectral nudging) - ERA-Interim SLP difference All Year



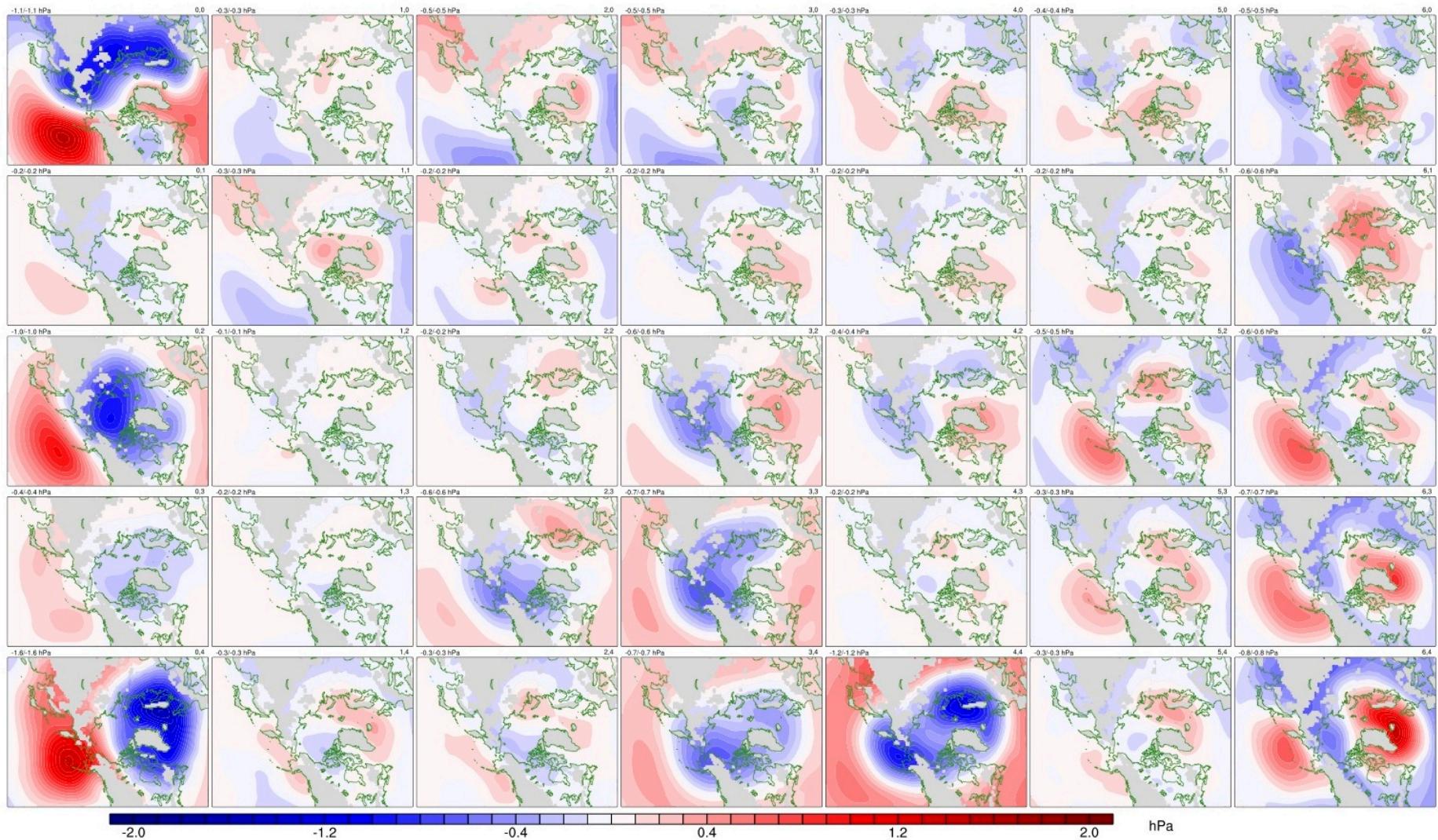
$$SLP_{WRF} = \sum_i f_i SLP_i + \Delta f_i SLP_i + f_i \Delta SLP_i + \boxed{\Delta f_i \Delta SLP_i}$$

Combined term contribution toward WRF (no spectral nudging) - ERA-Interim SLP difference All Year



$$SLP_{WRF} = \sum_i f_i SLP_i + \Delta f_i SLP_i + f_i \Delta SLP_i + \Delta f_i \Delta SLP_i$$

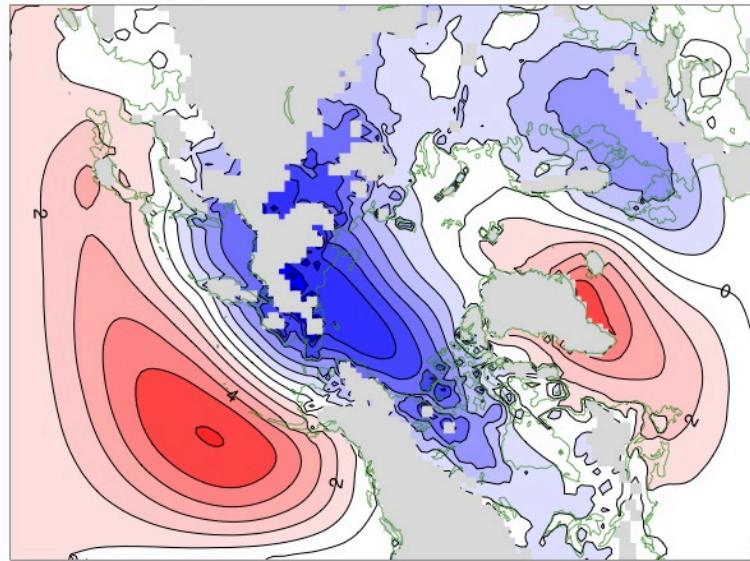
Total contribution toward WRF (no spectral nudging) - ERA-Interim SLP difference All Year



WRF (no spectral nudging) - ERA-Interim SLP difference All Year

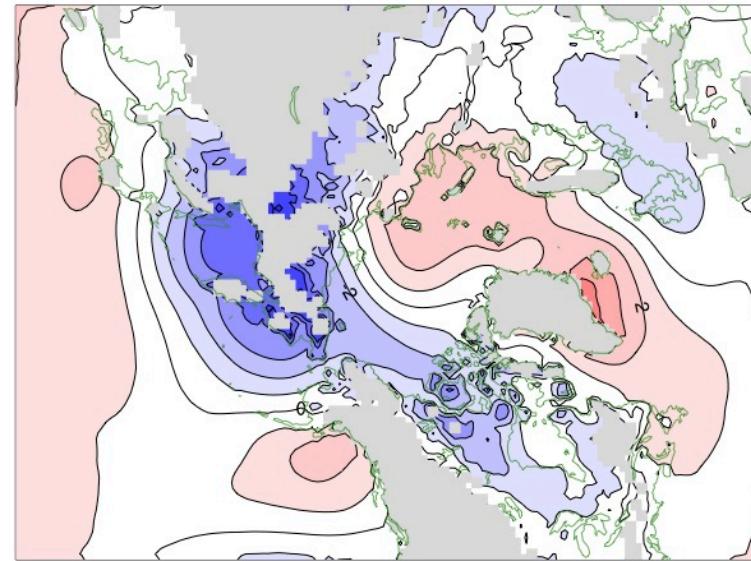
Total Difference

100.00 %



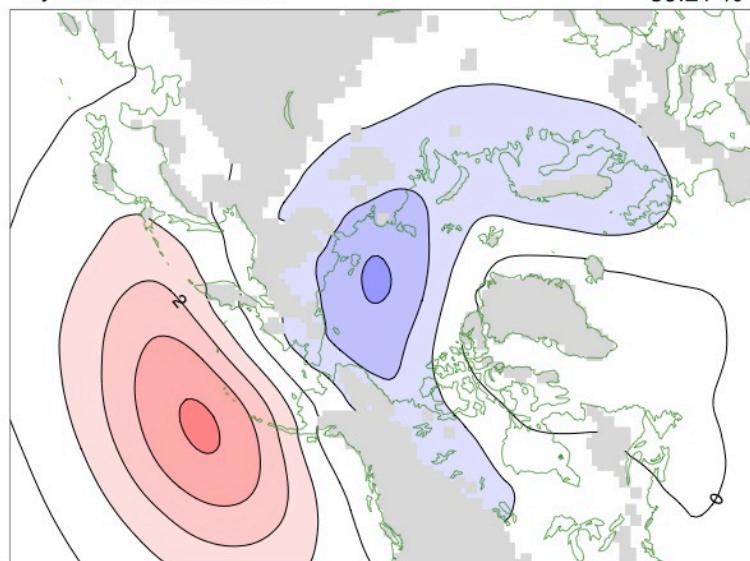
Intra-pattern Contribution

42.08 %



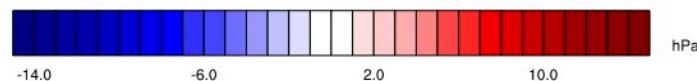
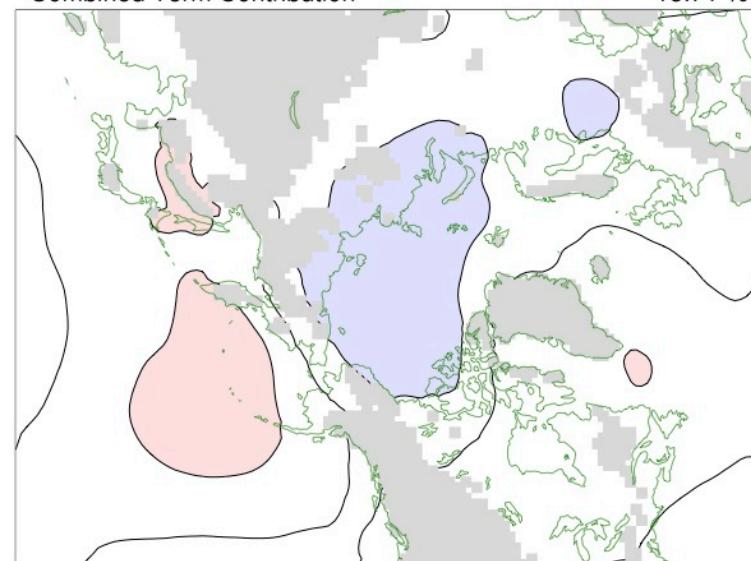
Dynamical Contribution

39.21 %

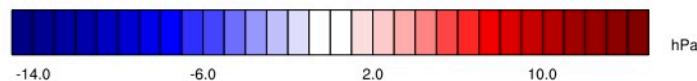
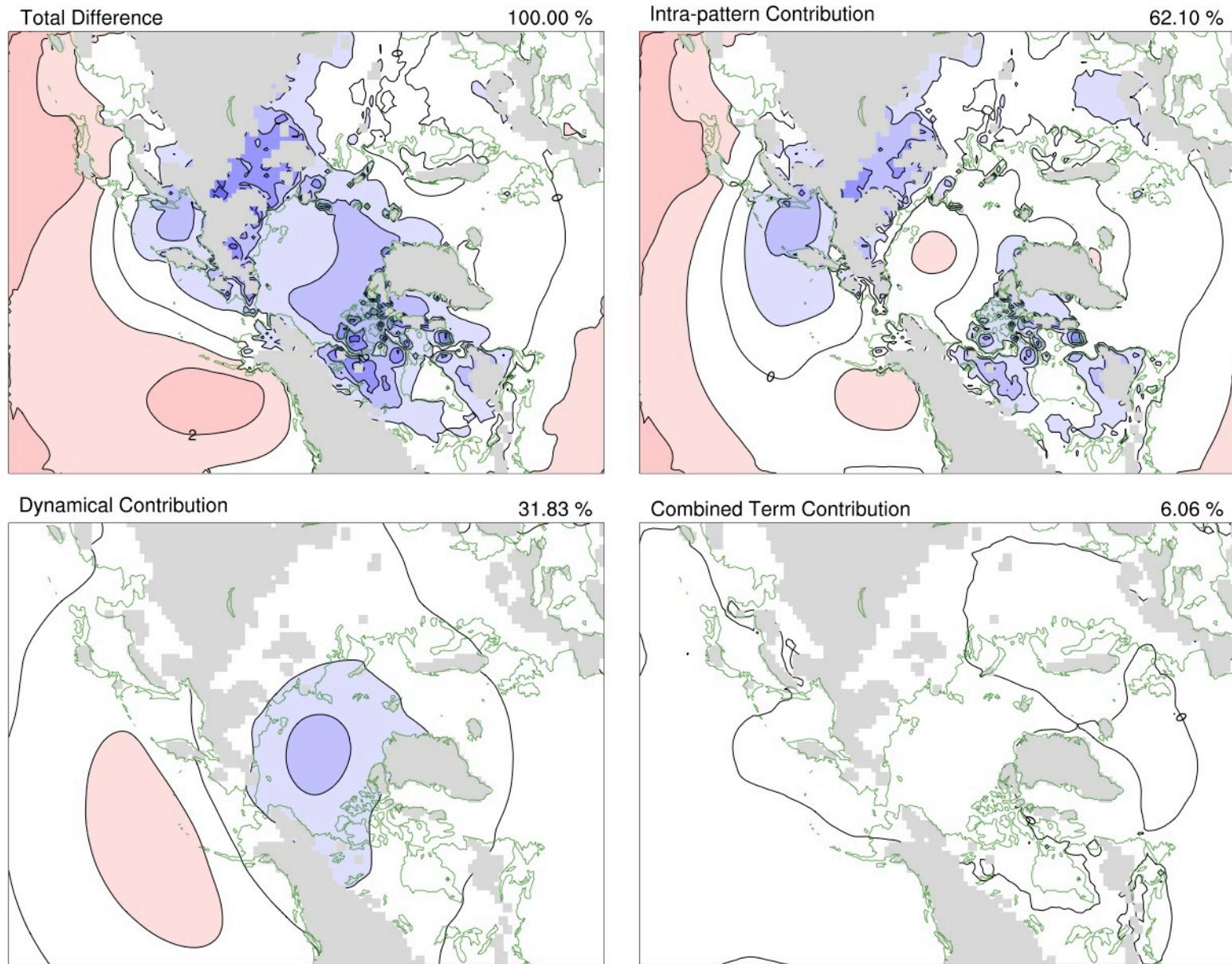


Combined Term Contribution

18.71 %



WRF (with spectral nudging) - ERA-Interim SLP difference All Year

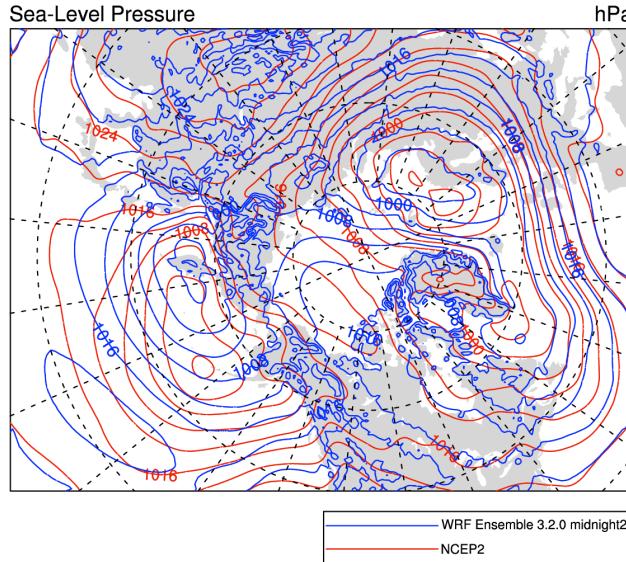


Conclusions

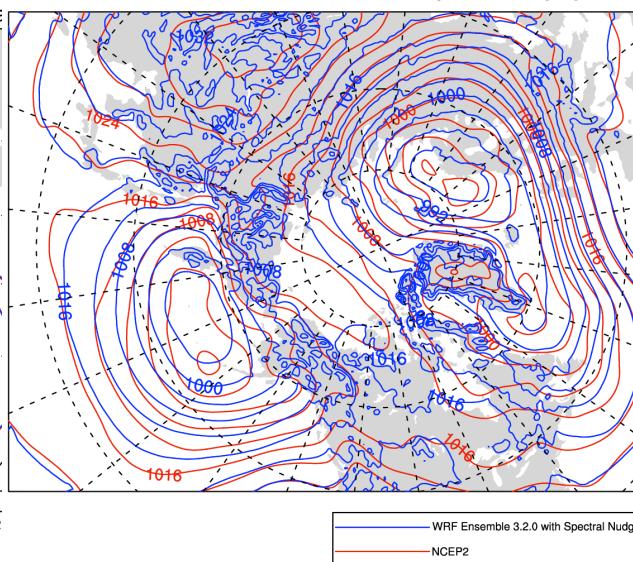
- WRF has a positive SLP bias in the North Pacific and around Greenland
- WRF has a negative SLP bias in the western Arctic and over Europe
- 60% of these errors are due to errors in WRF's synoptic climatology (frequency of weather patterns)
- 40% of these errors are due to differences for specific weather patterns (intra-pattern variability)
 - These errors are tied to specific topographic features
- The use of spectral nudging reduces the model biases by reducing the frequency errors, but intra-pattern errors remain qualitatively similar

Future Updates to WRF

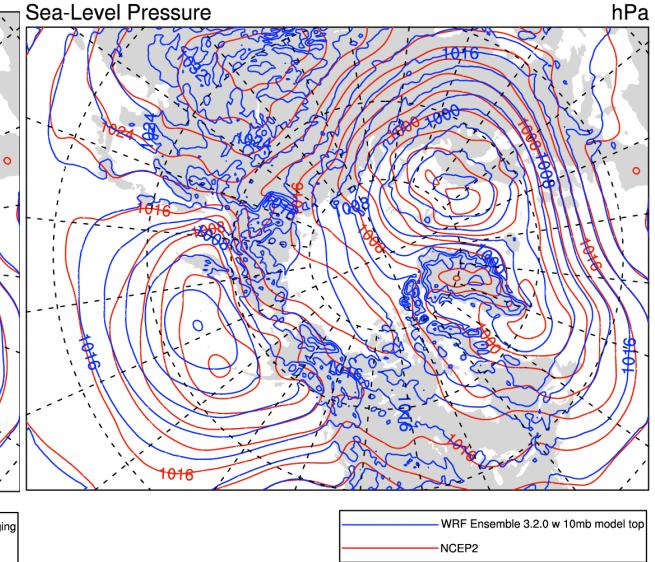
NCEP2 and WRF Ensemble 3.2.0 midnight2



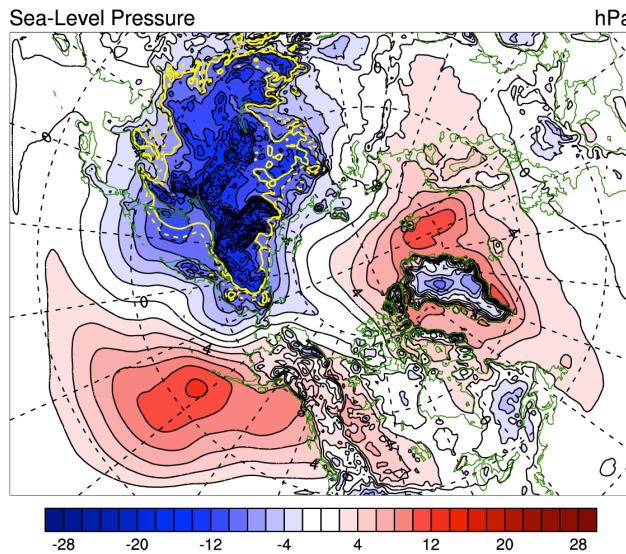
NCEP2 and WRF Ensemble 3.2.0 with Spectral Nudging



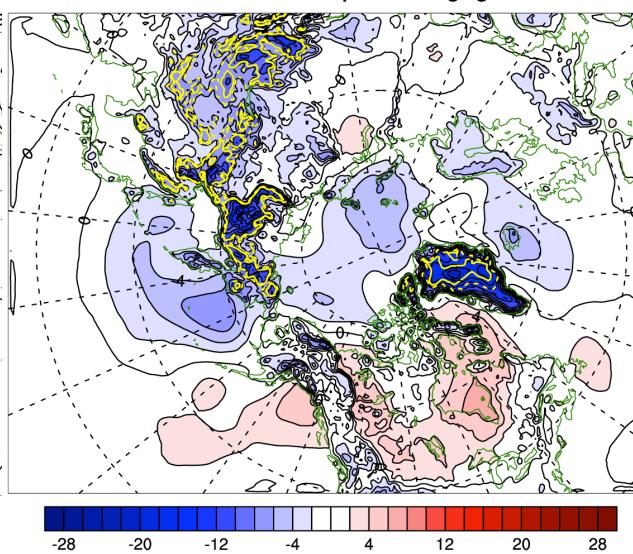
NCEP2 and WRF Ensemble 3.2.0 w 10mb model top



WRF Ensemble 3.2.0 midnight2 - NCEP2



WRF Ensemble 3.2.0 with Spectral Nudging - NCEP2



WRF Ensemble 3.2.0 w 10mb model top - NCEP2

