# Perturbing GEFS surface parameters

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# Surface variables/parameters perturbed

- Roughness length for momentum (z0)
- Roughness length for heat (zt)
- Soil hydraulic conductivity (SHC)

# Overview: GEFS surface parameters

- Roughness lengths for momentum and heat
  - Climatological values for surface roughness length are set based on vegetation type and combined with wind, temperature and pressure to compute surface exchange coefficients
- Soil hydraulic conductivity
  - Saturation values are set based on soil type
  - SHC is computed using those and soil moisture content

# Application of perturbations

- Perturbation patterns:
  - Use random spatial structures for the perturbations; same software used to generate SPPT patterns
  - Perturbation patterns are random, fixed for duration of the forecast.
  - Unique perturbation patterns for each case and each ensemble member.

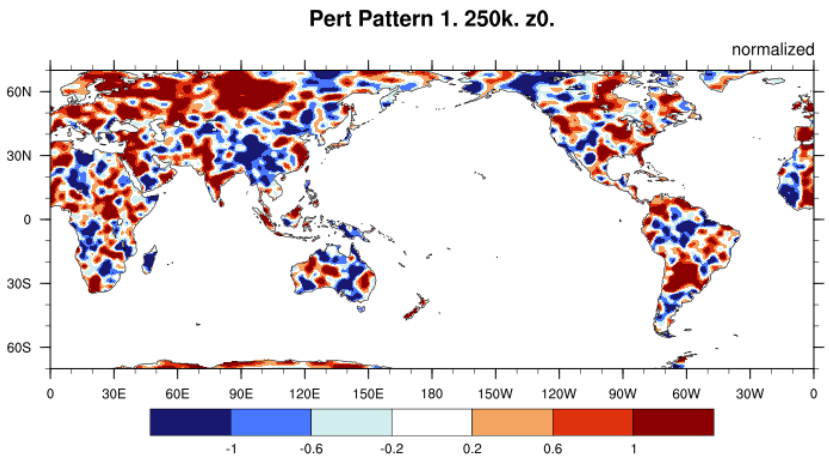
- What is a reasonable scale for the amplitude of the perturbations?
  - Momentum roughness length, z0: factor of 0.316 to 3.16 of current. Logarithmic scaling between those limits: z0' = z0*10^a, with -0.5<a<0.5. Pertz0 std dev= 0.25
  - Heat/momentum roughness length ratio, zt/z0: 10^(-4) to 10^(-1). Perturbed similarly to momentum roughness length. Pertzt std dev= 0.15
  - Soil hydraulic conductivity, SHC: perturb exponent b by +- one standard deviation around the current estimate for the soil type. Pertshc std dev= 0.40

- What is the decorrelation length scale that should be used for the perturbations?
  - Most initial experiments conducted with relatively short (250km) length scale
  - Additional experiments conducted with 2000km length scale

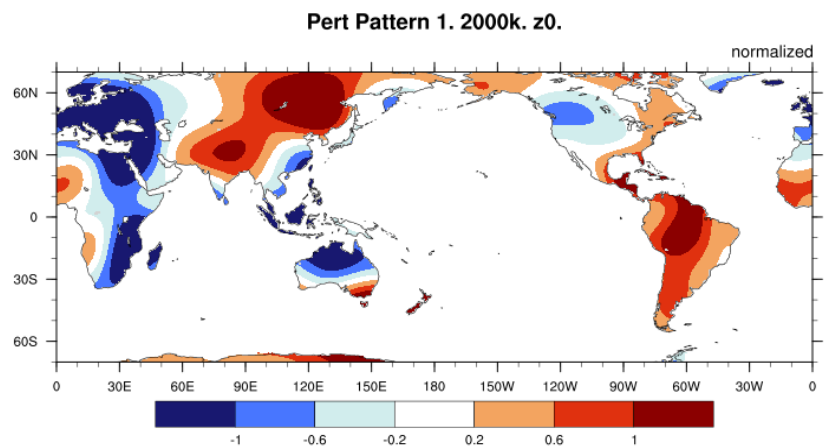
# Experimental details

- How many? 6 experiments
  - Control (atmospheric perturbations only)
  - Individual perturbations:
    - a) z0,
    - b) zt/z0,
    - c) SHC,
  - Multiple perturbations:
    - a) z0 + SHC,
    - b) z0 + SHC + zt/z0
- Resolution
  - T254
- Number/Length of experiments
  - Initialized every 5 days
  - N. Hemisphere warm season (July & Aug)
  - 5 day forecasts (expect the effects to be noticeable in short term)
- 11 member ensembles

# Sample perturbation patterns




Length scale = 250 km

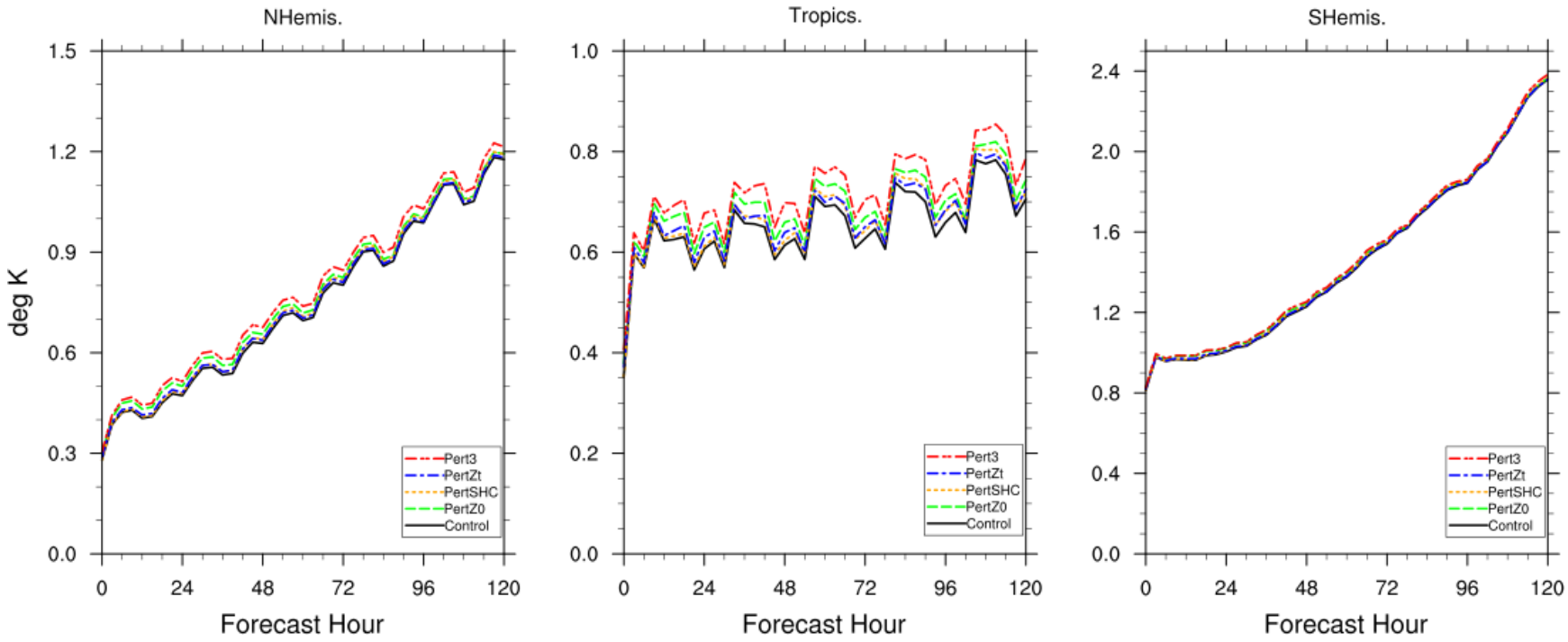


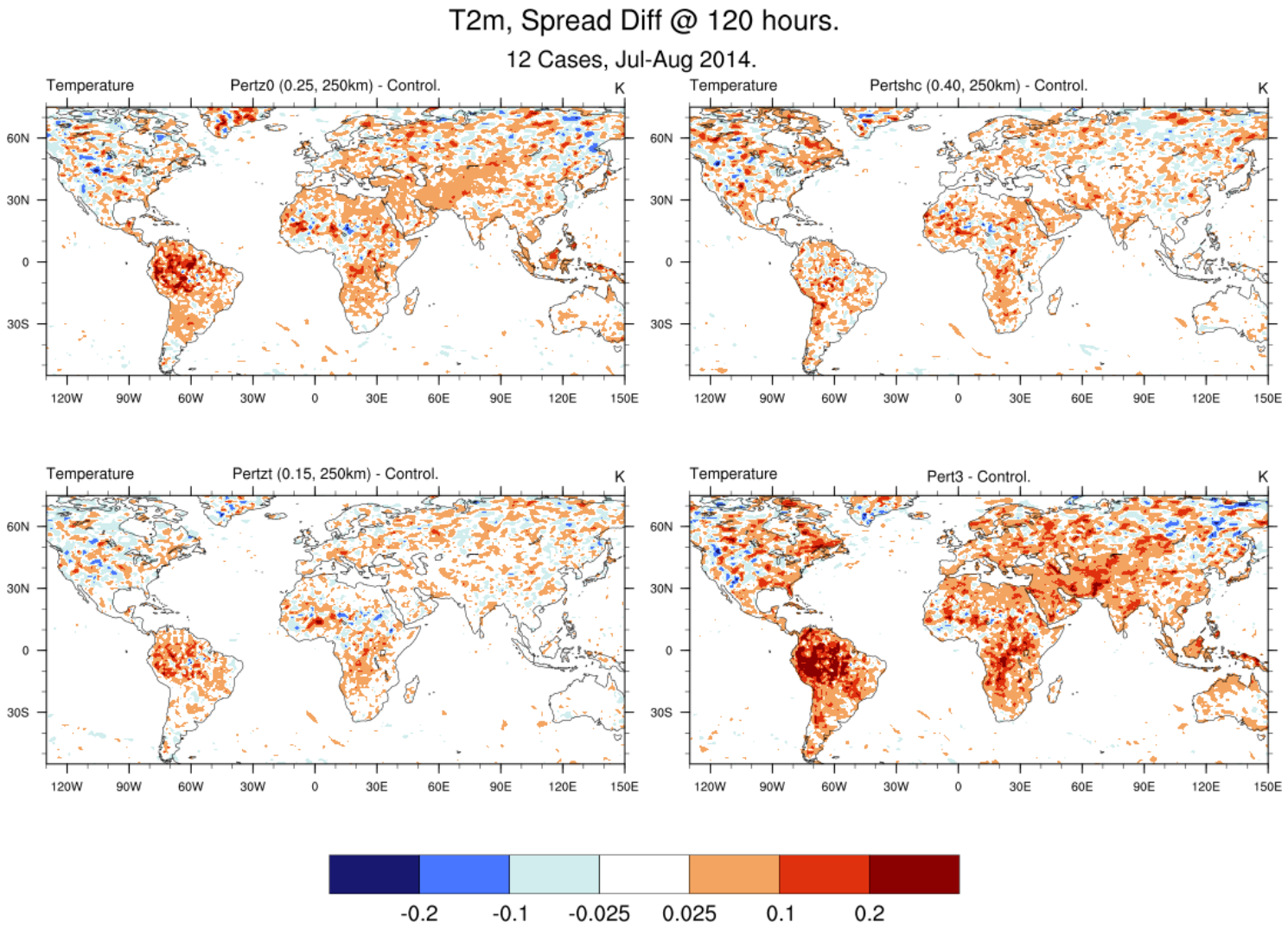

Length scale = 2000 km

# Effects of perturbing different surface parameters

- Control (no surface perturbations)
- Individual parameters perturbed:
    a) z0,
    b) zt/z0,
    c) SHC,
- Multiple parameters perturbed:
    d) z0 + SHC + zt/z0

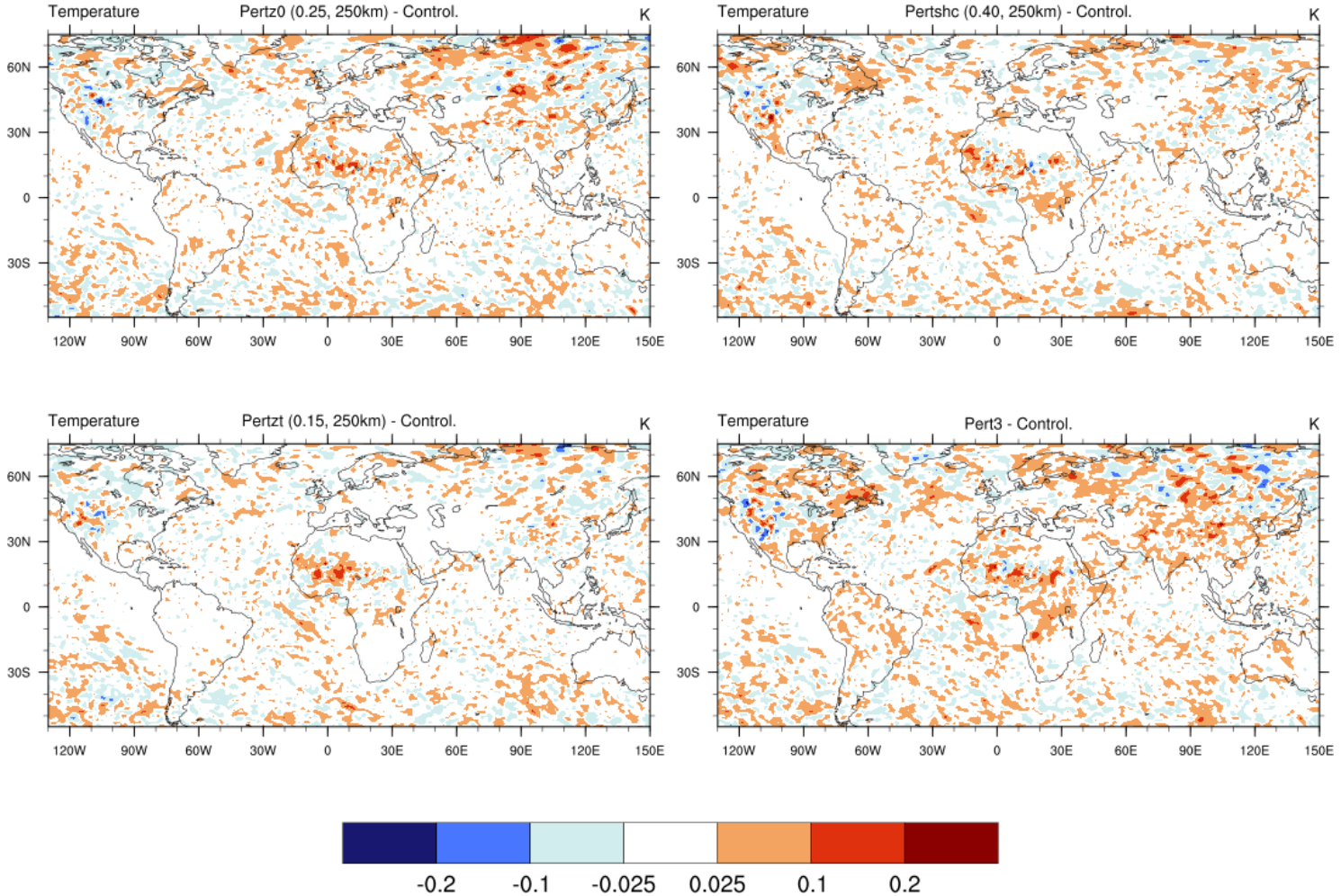
# T2m, Spread, Land. 12 Cases, Jul-Aug 2014.



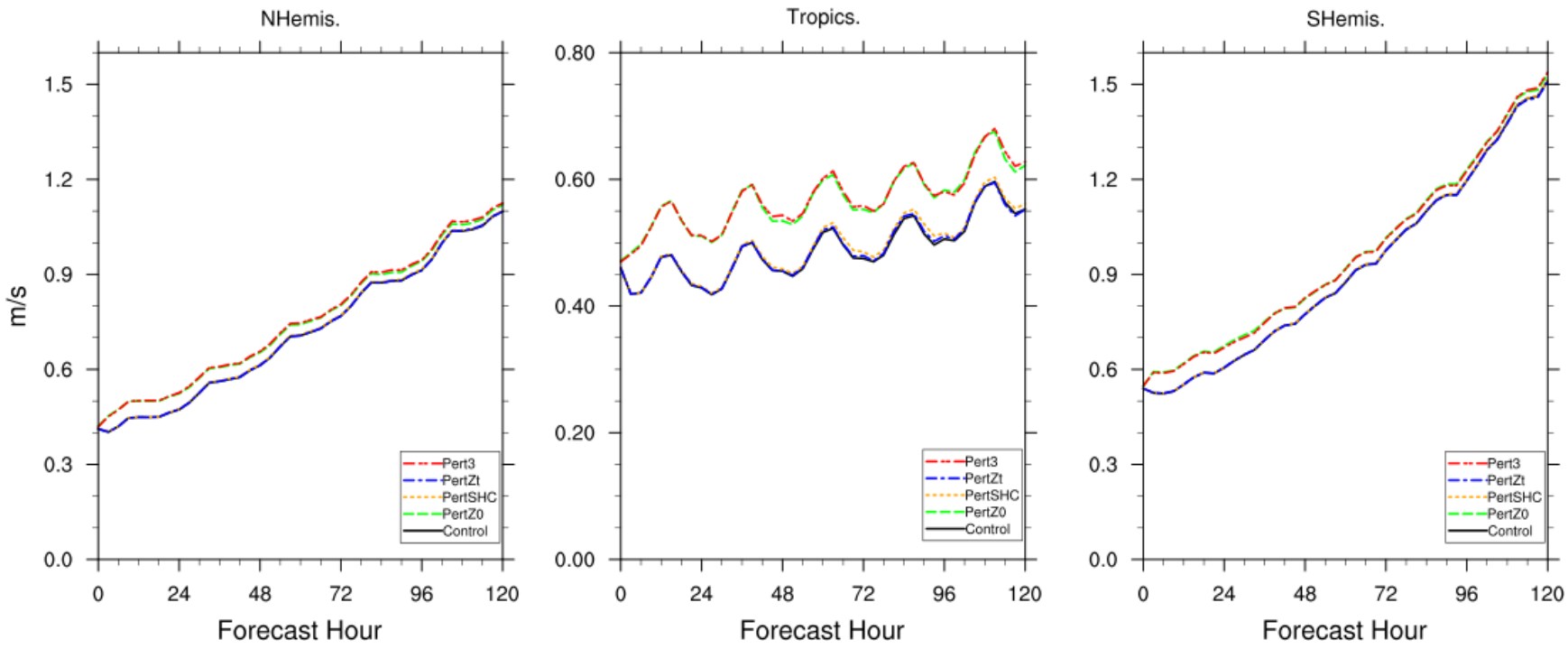

T2m, Spread Diff @ 120 hours.
12 Cases, Jul-Aug 2014.
Temperature
Pertz0 (0.25, 250km) - Control.
K
Temperature
Pertshc (0.40, 250km) - Control.
K
Temperature
Pertzt (0.15, 250km) - Control.
K
Temperature
Pert3 - Control.
K
60N
30N
0
30S
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
-0.2
-0.1
-0.025
0.025
0.1
0.2

# T850mb, Spread Diff @ 120 hours.

12 Cases, Jul-Aug 2014.

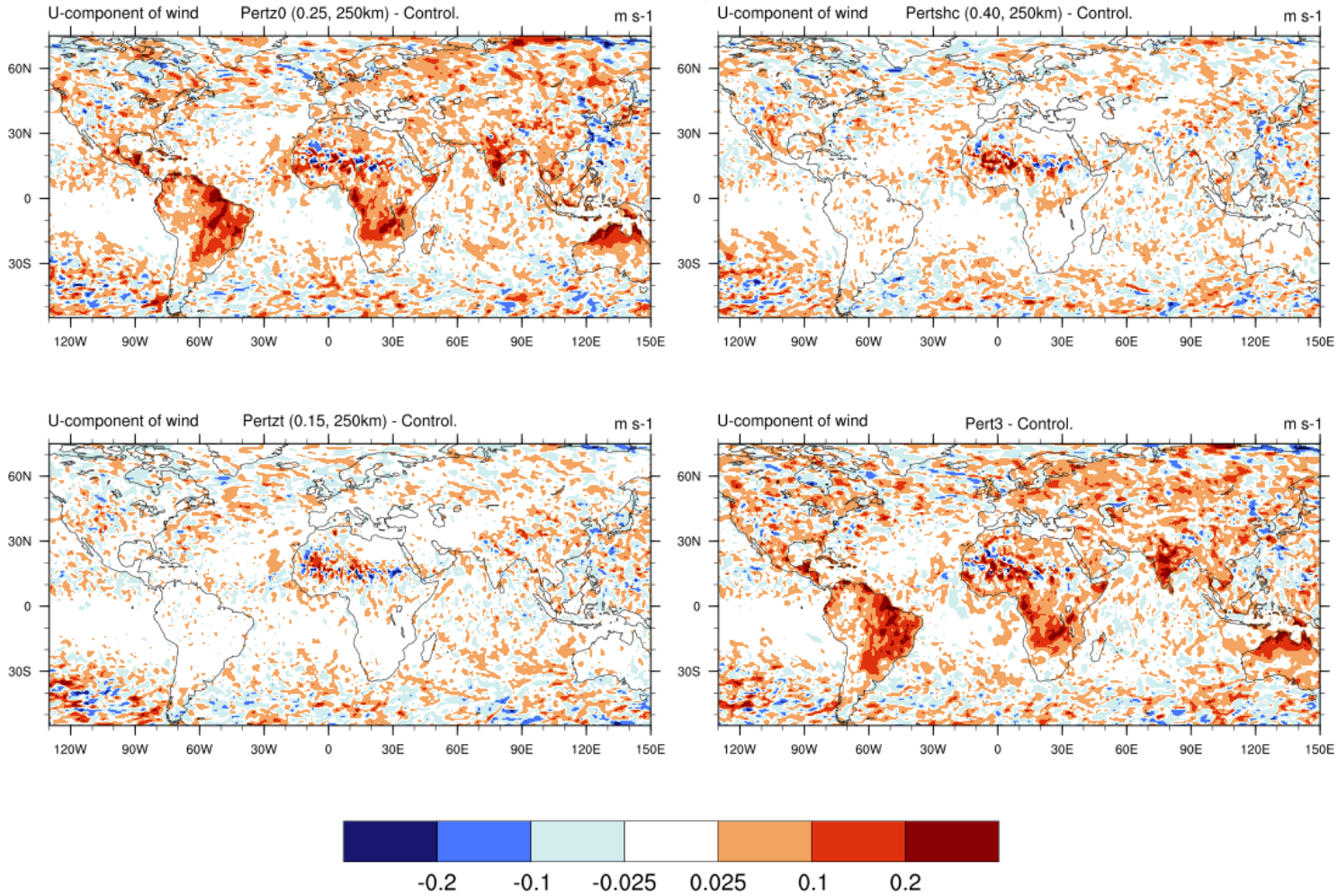


# U10m, Spread, Land. 12 Cases, Jul-Aug 2014.



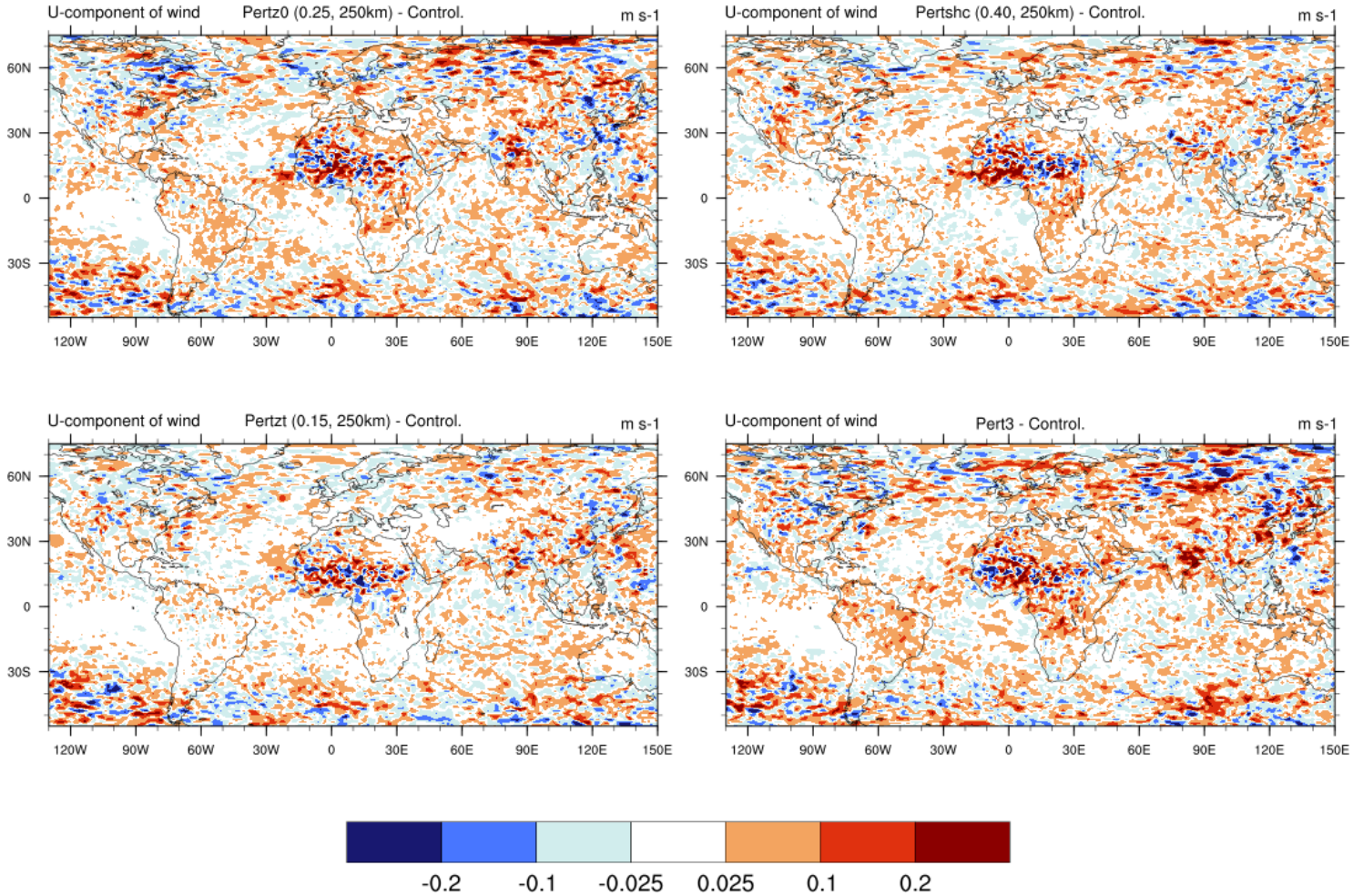
# U10m, Spread Diff @ 120 hours.

12 Cases, Jul-Aug 2014.



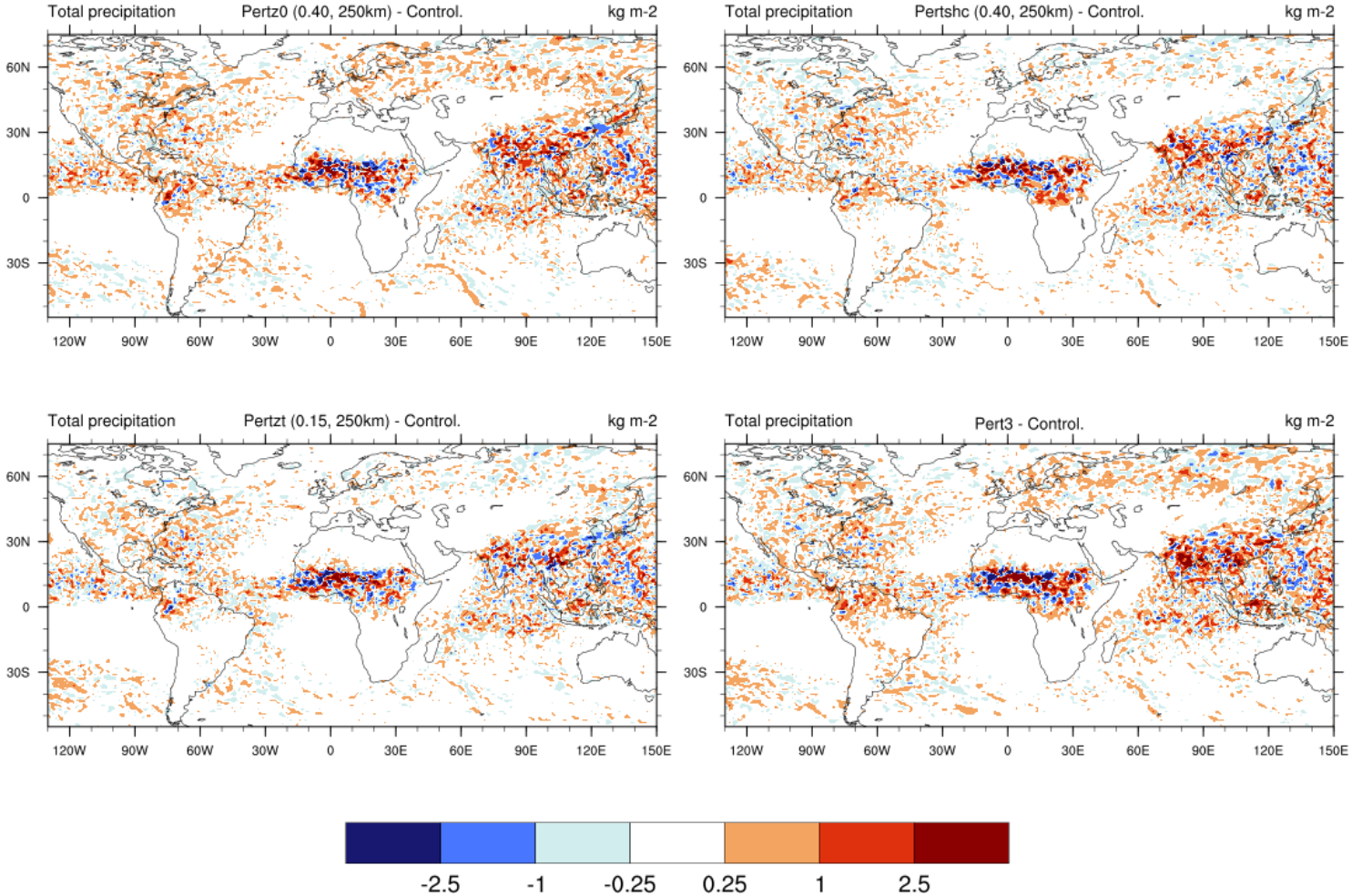
# U850mb, Spread Diff, 120 hours.

12 Cases, Jul-Aug 2014.



# APCP, Spread Diff, 120 hours.

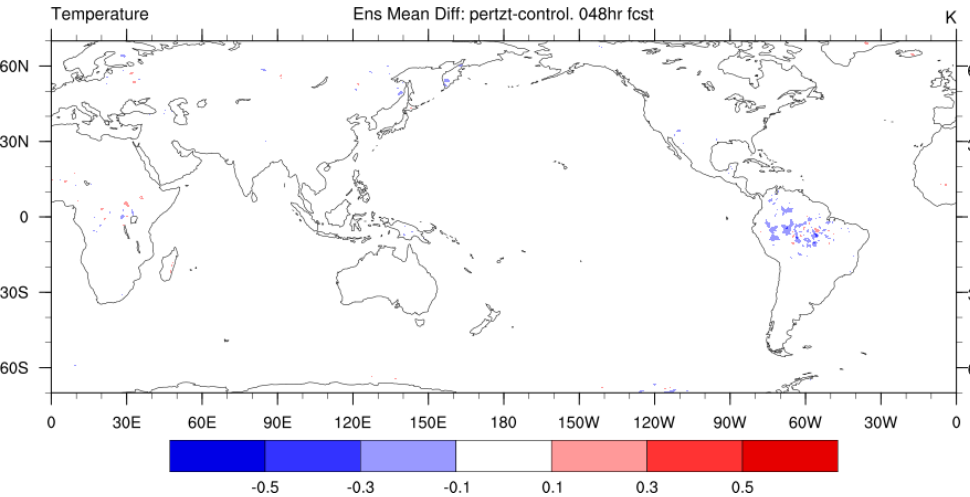
12 Cases, Jul-Aug 2014.



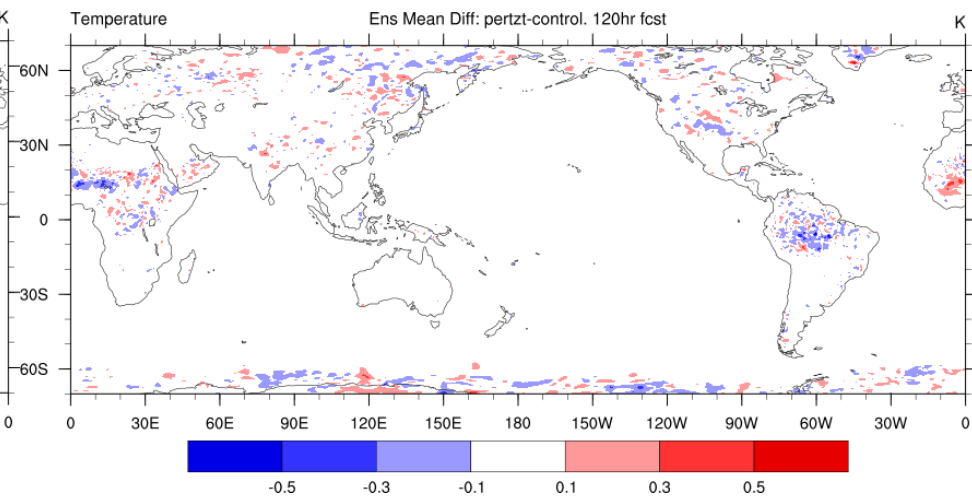
# zt/z0 ratio perturbations – T2m

## Mean

48h

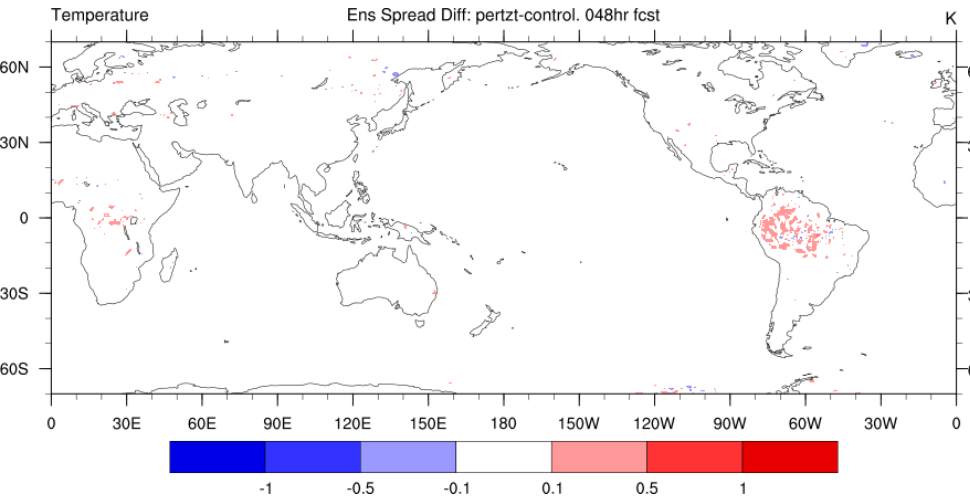



120h

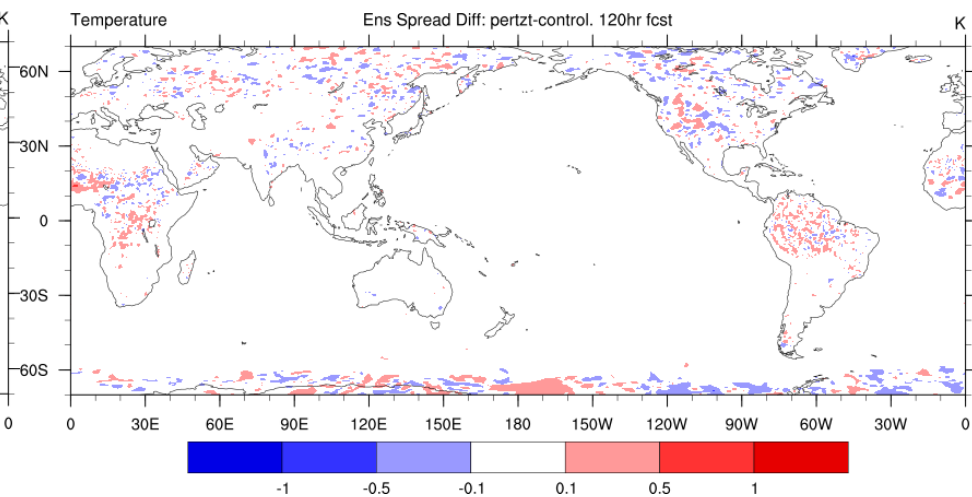



## Spread

48h




120h



# Conclusions (1)

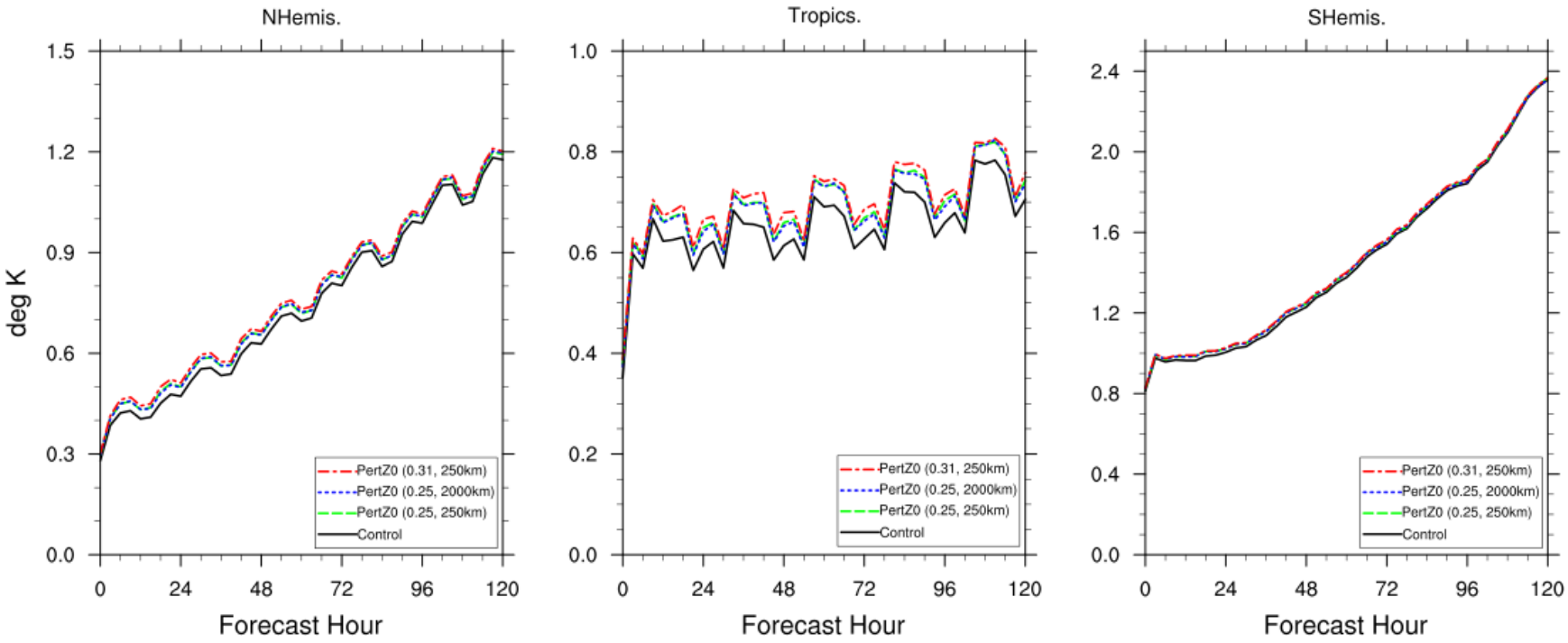
## Effects of perturbing different surface parameters

- Responses to land surface parameter perturbations generally small
- Z0 (momentum roughness length) perturbations generate somewhat larger responses than Zt/Z0 or SHC
- Geographic region of largest response varies with variable
- Perturbations propagate to larger (T2m) or smaller scales (APCP) depending on the variable
- Combining perturbations for different surface parameters enhances spread

# Effects of Z0 perturbations of different magnitude or length scale

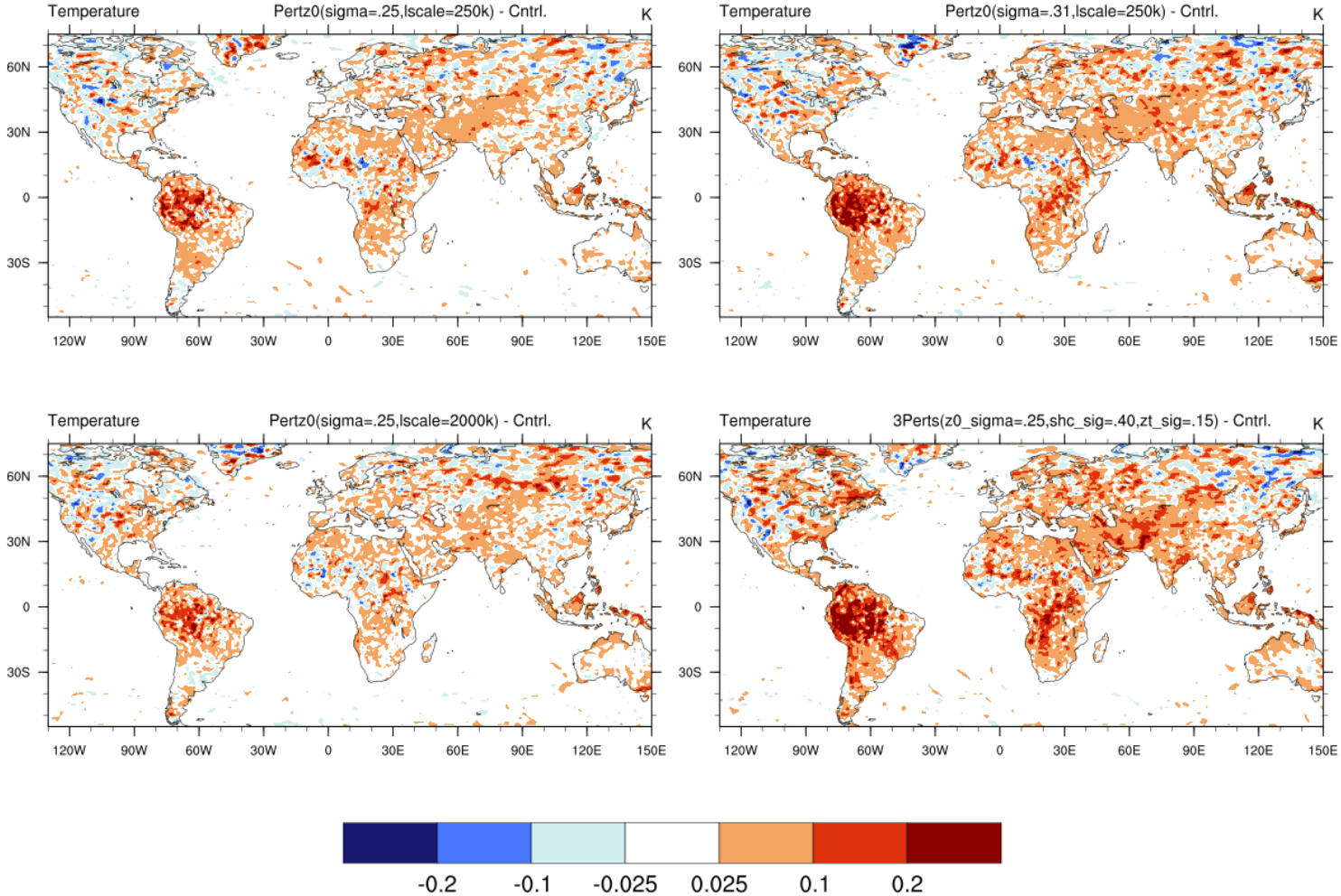
- Control (no surface perturbations)
- Varying z0 perturbations:
    a) z0: sigma=0.25, lscale=250k
    b) z0: sigma=0.25, lscale=2000k
    c) z0: sigma=0.31, lscale=250k
- Multiple parameters perturbed:
    d) z0 + SHC + zt/z0

# T2m, Spread, Land. 12 Cases, Jul-Aug 2014.

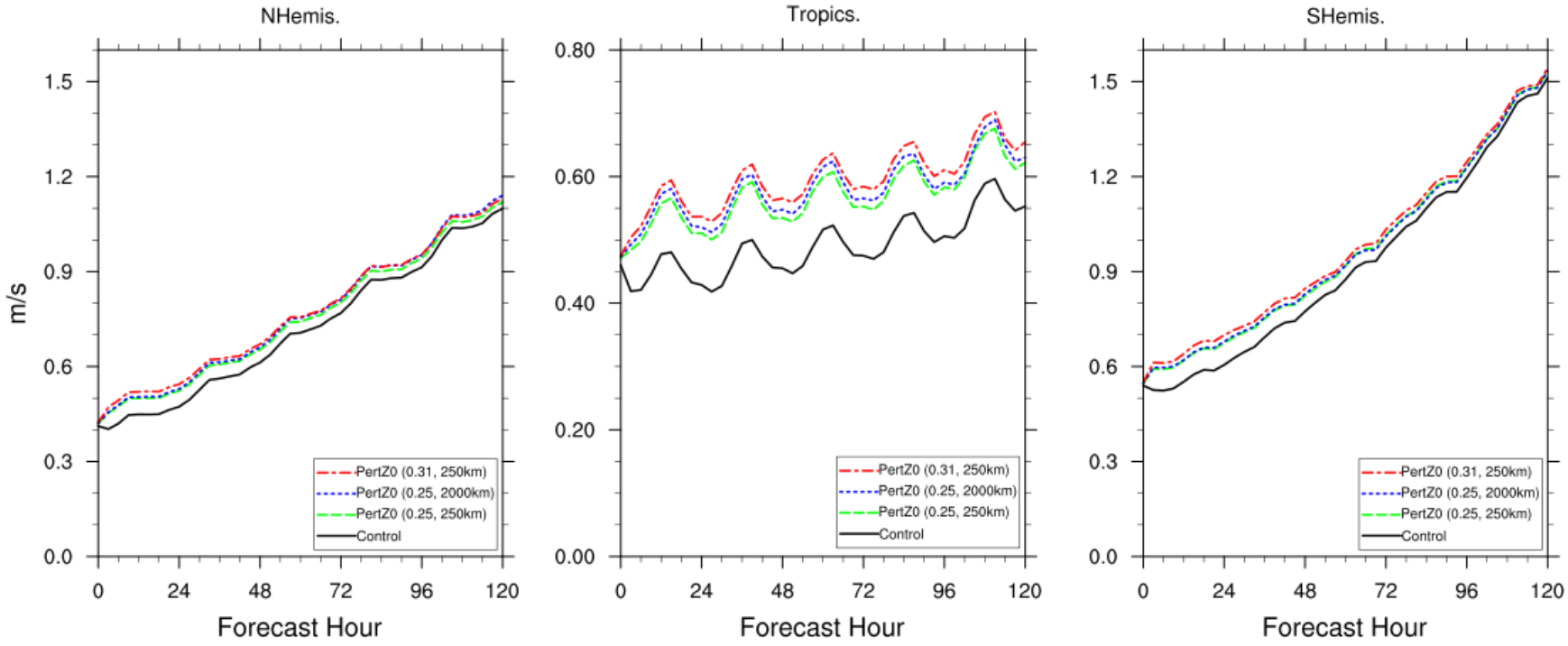


# T2m, Spread Diff @ 120 hours.

12 Cases, Jul-Aug 2014.

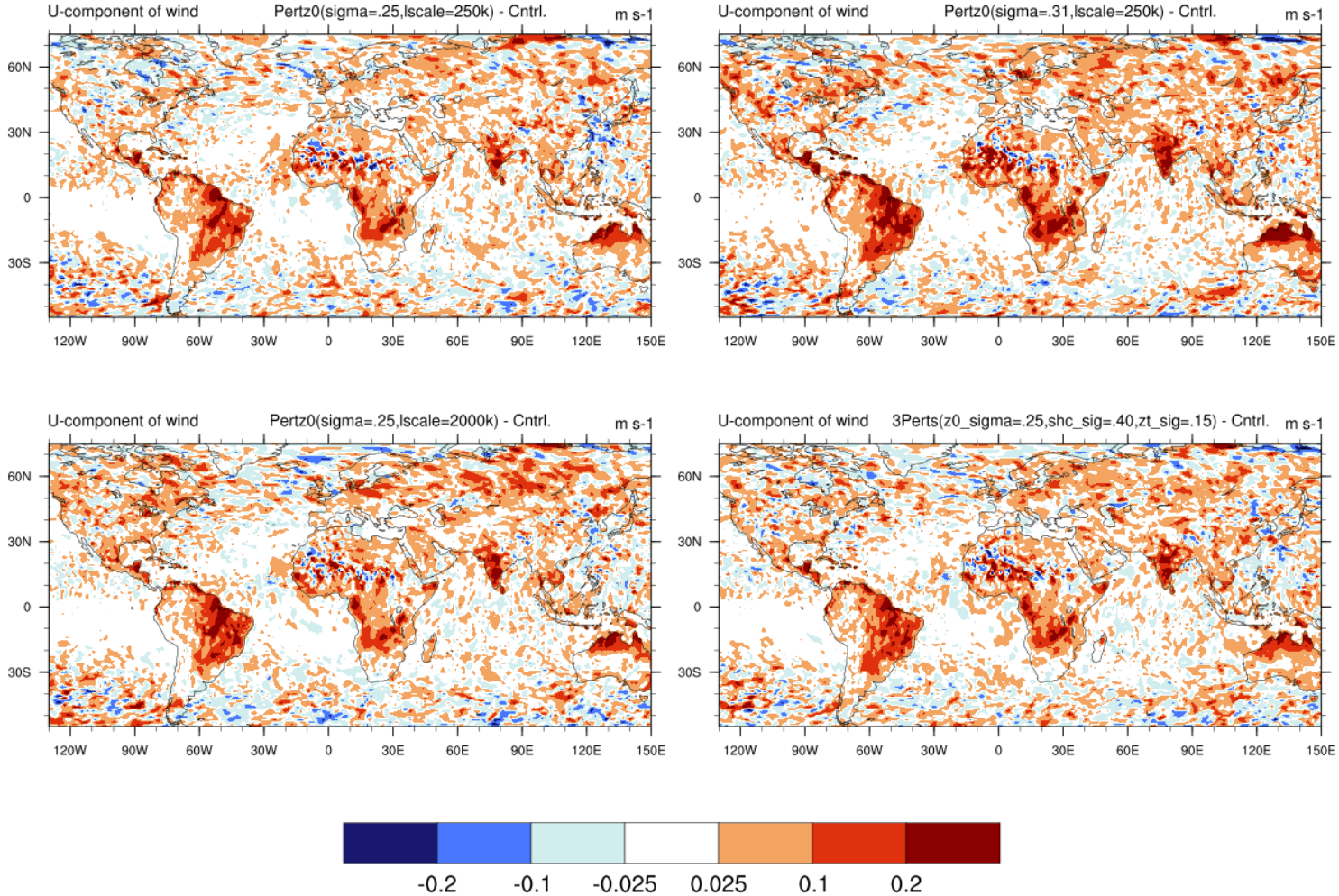


# U10m, Spread, Land. 12 Cases, Jul-Aug 2014.



# U10m, Spread Diff @ 120 hours.

12 Cases, Jul-Aug 2014.



# Conclusions (2)

## Effects of z0 perturbations for different magnitude and length scales

- Increase in z0 perturbation magnitude increases spread (up to the point where the model blows up)
- Scale of the response is similar for 250km and 2000km perturbation patterns

# Impact of magnitude of zt/z0 perturbations

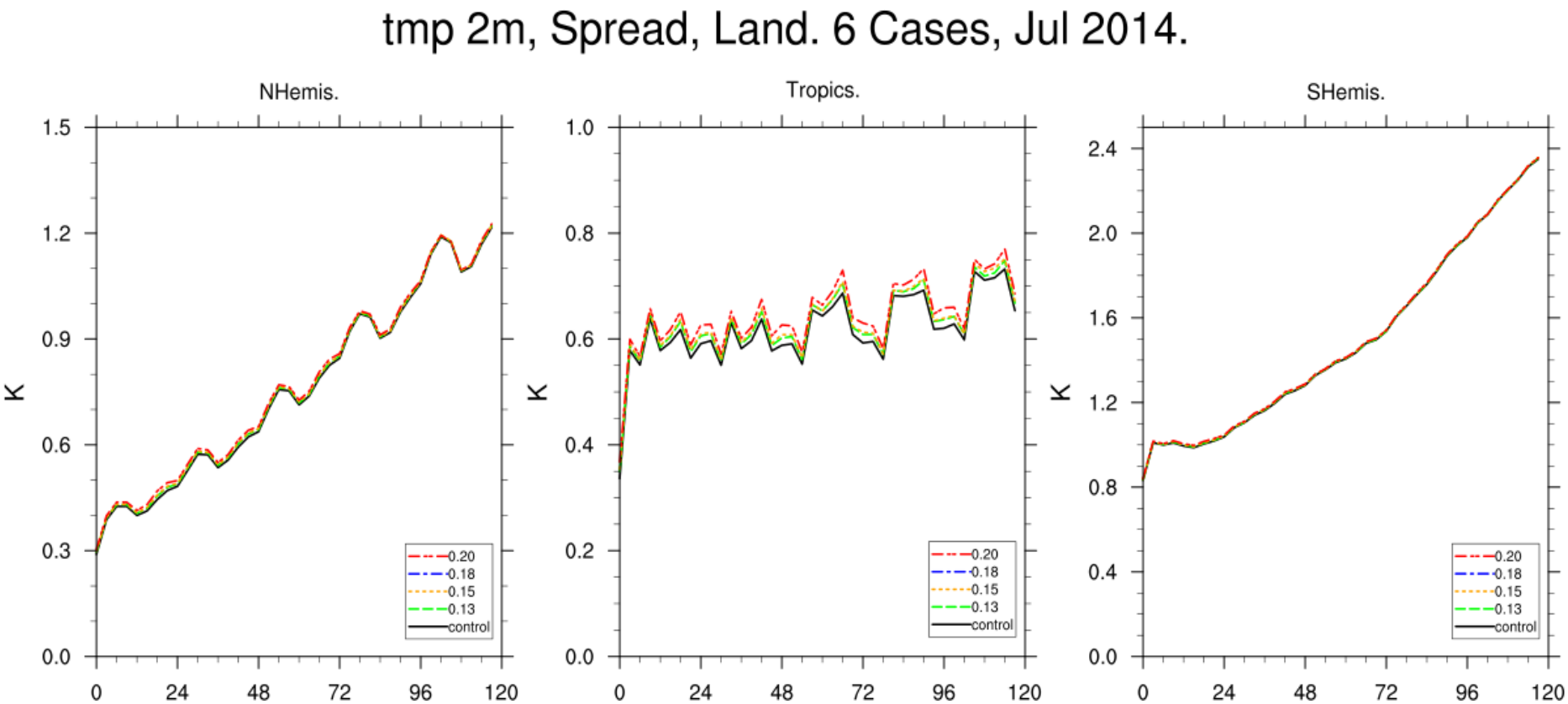
- Control (no surface perturbations)
- Varying zt/z0 perturbations:

  a) zt/z0 : sigma=0.13, lscale=250km

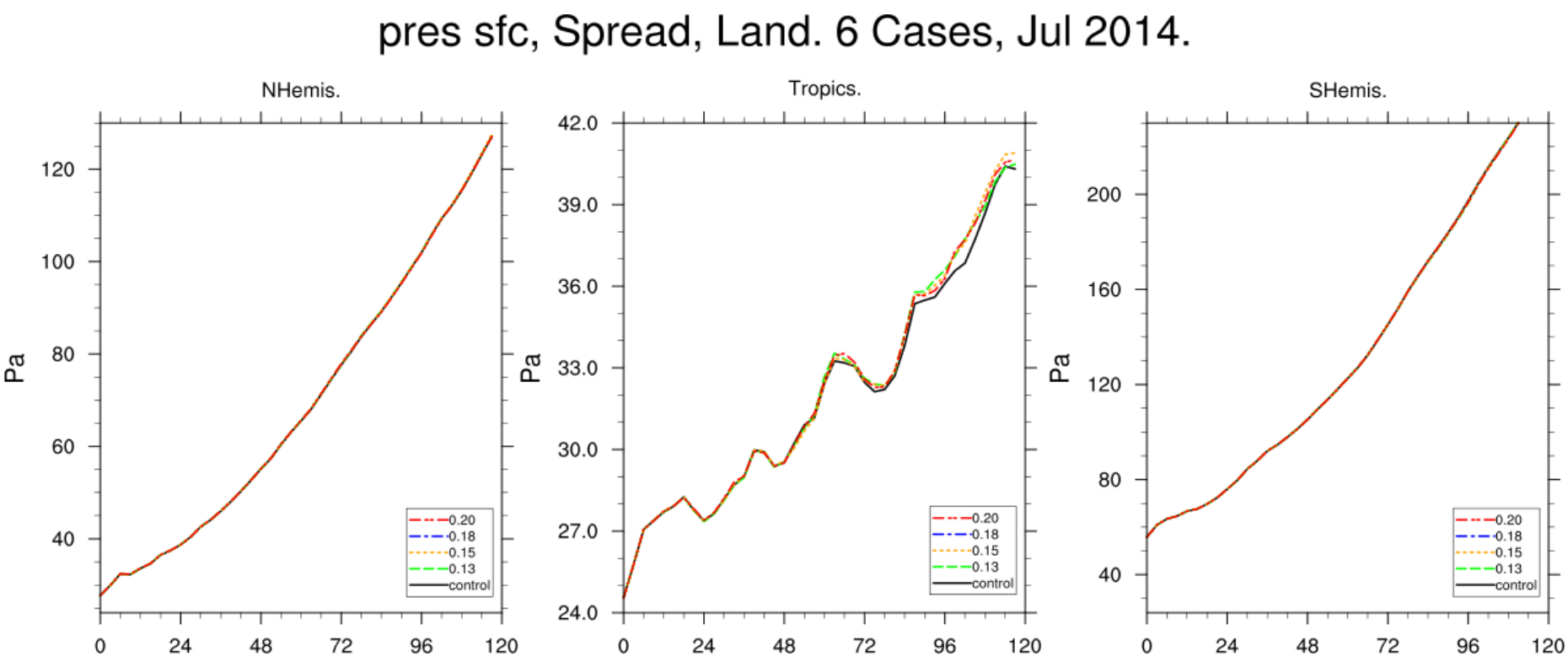
  b) zt/z0 : sigma=0.15, lscale=250km

  c) zt/z0 : sigma=0.20, lscale=250km

# Impact of magnitude of zt/z0 perturbations



# Impact of magnitude of zt/z0 perturbations




Non-linear response in surface pressure spread in the tropics to zt/z0 magnitude increase

# Conclusions (3)

## Impact of zt/z0 perturbation magnitudes

- Unrealistic values for surface pressure when using large z0 or zt/z0 perturbations
- In the tropics, smaller zt/z0 perturbations can have larger spread in surface pressure than larger perturbations – non-linear response in surface pressure