4th VALUE Training School
Validation of Regional Climate Change Projections

Towards Process-based Validation II

Douglas Maraun

Wegener Center for Climate and Global Change

Outline

Rationale

Sensitivity studies

Using dynamical models to validate statistical models

Using statistical models to validate dynamical models

Ideas for a process-oriented intercomparison

Rationale

Sensitivity studies

Using dynamical models to validate statistical models

Using statistical models to validate dynamical models

Ideas for a process-oriented intercomparison

Why process based validation?

Why process based validation?

- Identify “over-tuning”:
  How do they perform for non-tuned aspects?
  Are the models right for the right reasons?

- Uncertainty attribution:
  Why is a model wrong?
  Where could I improve my model?

- Confidence in projections:
  Are the relevant processes realistically simulated to capture climate change?

Experiments vs. diagnostics

One may vary different parts/ingredients of a validation to gain insight:

- **Different types of experiments**
  (varying boundary conditions)
- **Sensitivity studies within one experiment**
  (varying predictors, parameterisations, resolutions, etc.
- **Different types of diagnostics**
  (select a range of diagnostic indices)

Mutual use of statistical and dynamical models

Different possible settings/questions

- How can dynamical models help to evaluate statistical models?
- How can statistical models be used to evaluate dynamical models?
- How can the representation of physical processes be inter-compared for both?

Rationale

Sensitivity studies

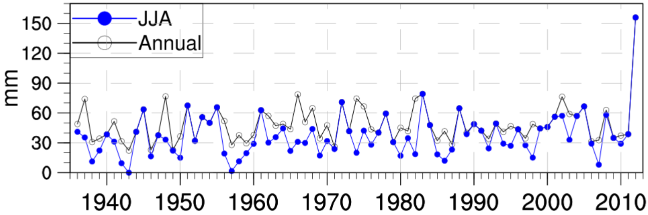
Using dynamical models to validate statistical models

Using statistical models to validate dynamical models

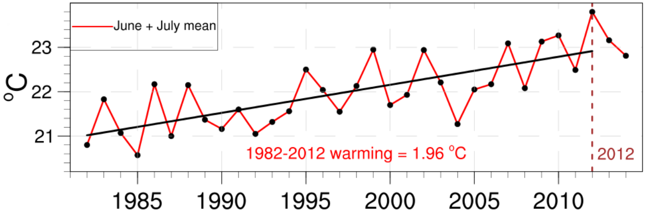
Ideas for a process-oriented intercomparison

6 Jul 2012 precipitation extreme at Krymsk

Precipitation Maximum



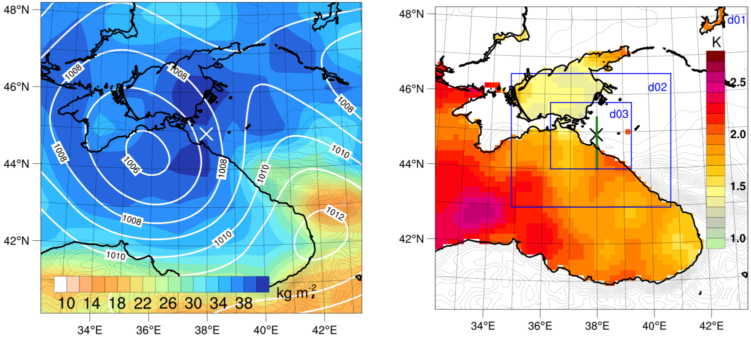
Black Sea SST Trend



What is the role of sea surface warming?

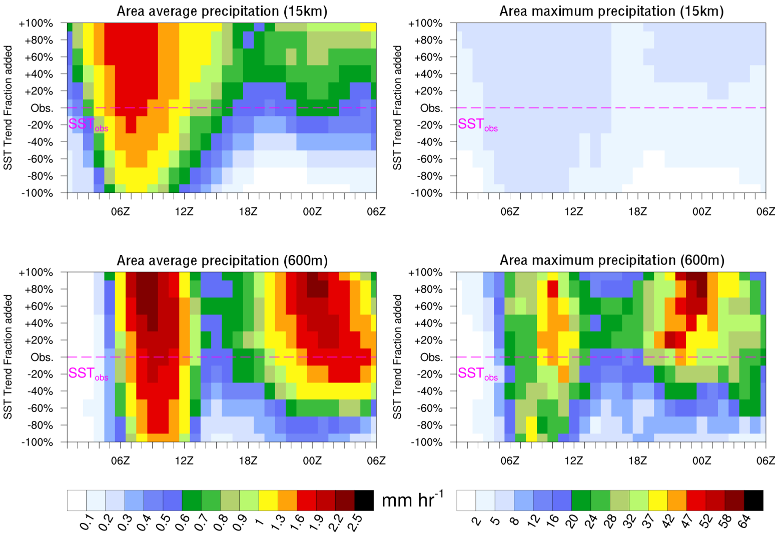
Meredith et al., Nat. Geosci., 2015

Experimental Design



- Simulate the event with WRF, triple nesting;
  horizontal resolution: 15km, 3km, 600m;
- boundary conditions: NCEP Final Analysis; NOAA-OI SST;
- spectral nudging in outer domain for upper level winds;
- vary SST incrementally, 6 ensemble members each.

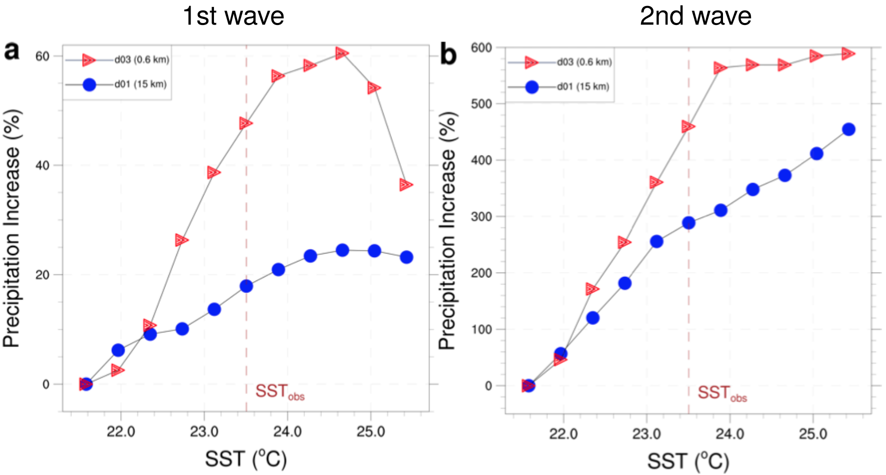
(Potential) added value of convection resolution



Meredith et al., JGR, minor rev.

Tipping point comparison

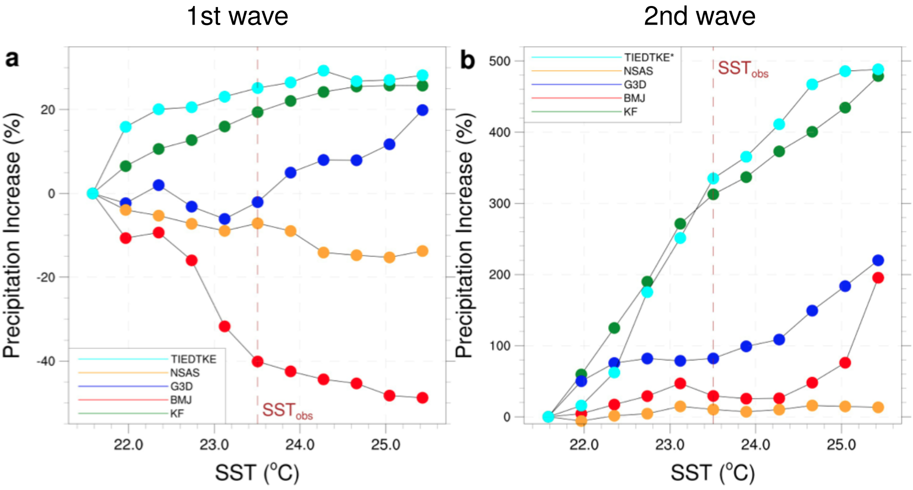
Red: convection permitting; blue: parameterised convection



Meredith et al., JGR, minor rev.

Tipping point comparison

Different convection parameterisation schemes

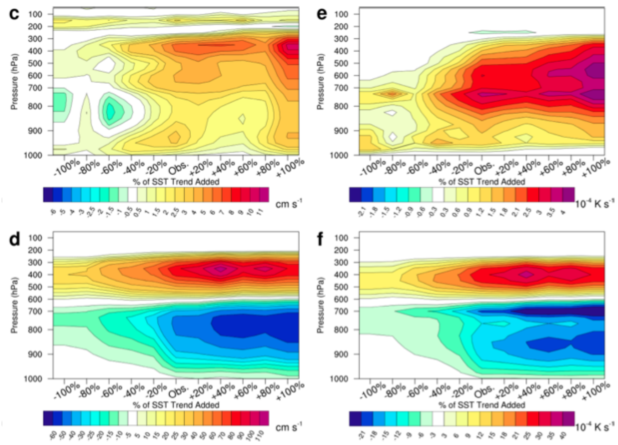


Meredith et al., JGR, minor rev.

Different physical response

Top: parameterised convection; bottom: convection permitting

downdraft latent heating



Meredith et al., JGR, minor rev.

Rationale

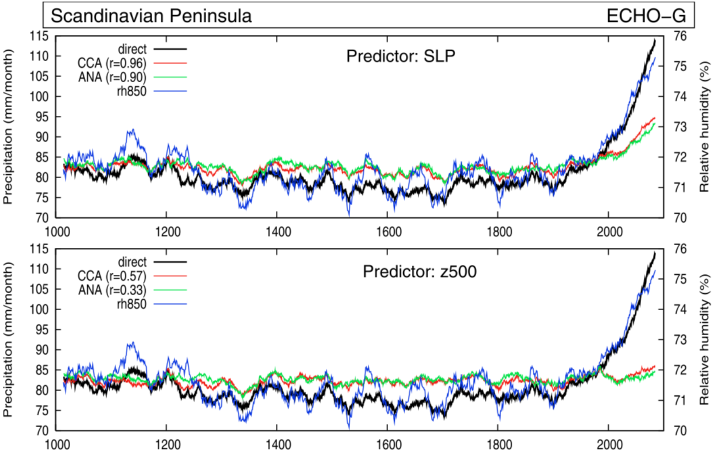
Sensitivity studies

Using dynamical models to validate statistical models

Using statistical models to validate dynamical models

Ideas for a process-oriented intercomparison

Pseudo reality approaches

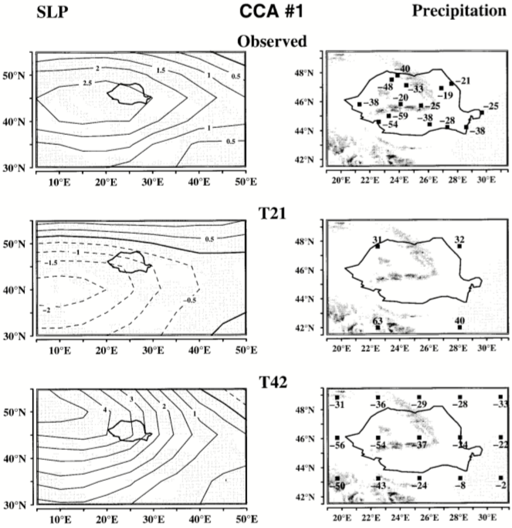


Charles et al., JGR, 1999; Frias et al., GRL, 2006; Vrac et al., GRL, 2007; Maraun, GRL, 2012; Maraun et al., EF, 2015

Using statistical models to validate dynamical models · GCM studies

Precipitation in Romania (circulation)

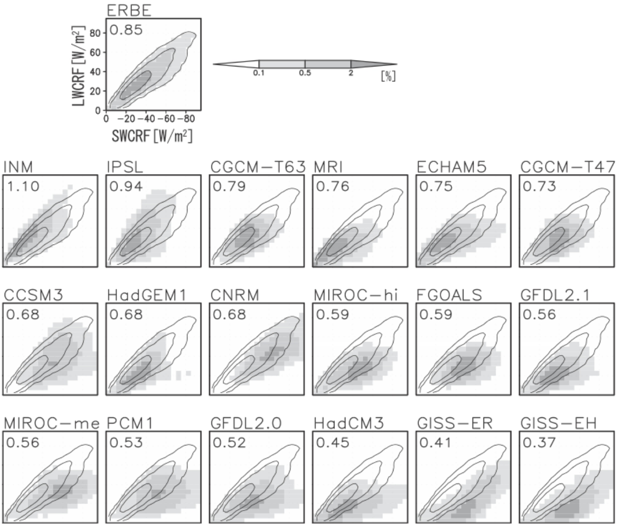
CCA between winter SLP and precipitation simulated by ECHAM3



Busuioc et al., J Climate, 1999

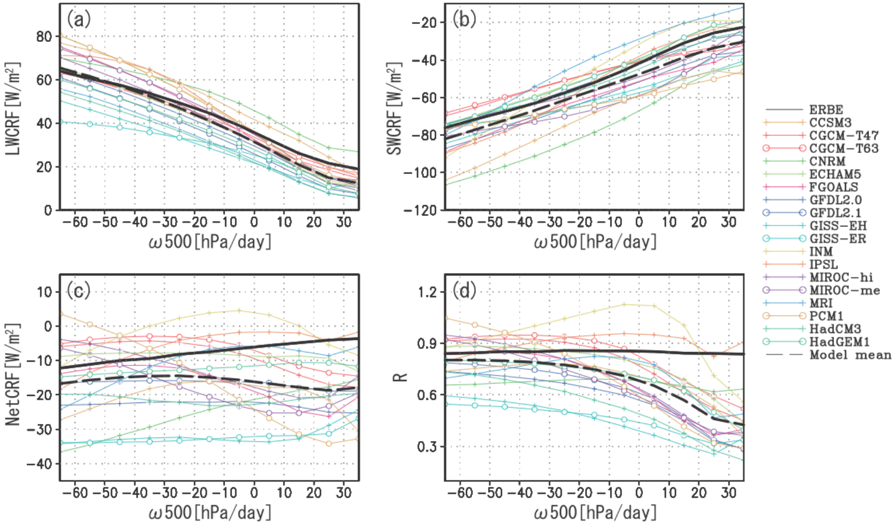
Tropical cloud radiative forcing

Multivariate analyses



Ichikawa et al., J Climate, 2012

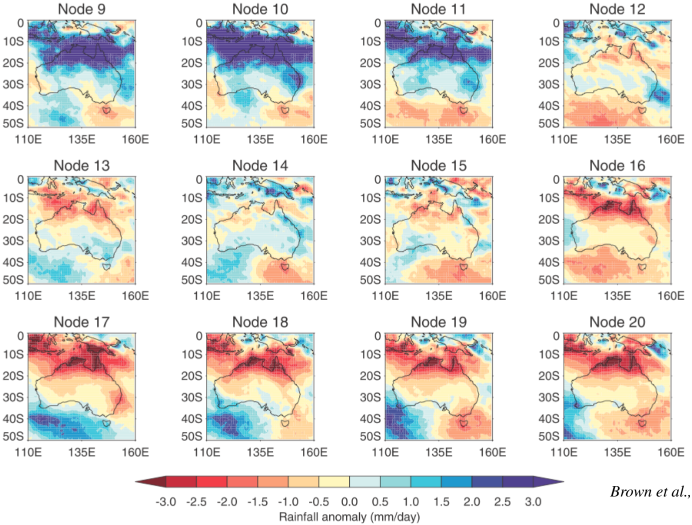
Tropical cloud radiative forcing (large-scale vertical motion)



Ichikawa et al., J Climate, 2012

Precipitation in Australia (circulation)

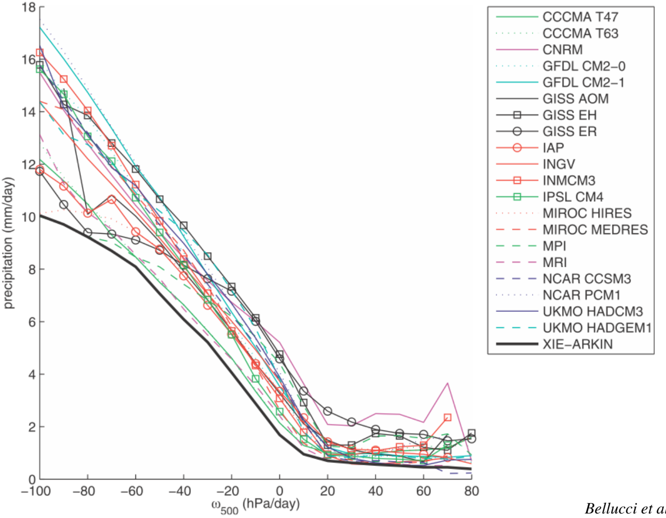
Mean precipitation for different weather types (nodes of self-organised-maps); NCEP and GPCP data



Brown et al., J Climate, 2010

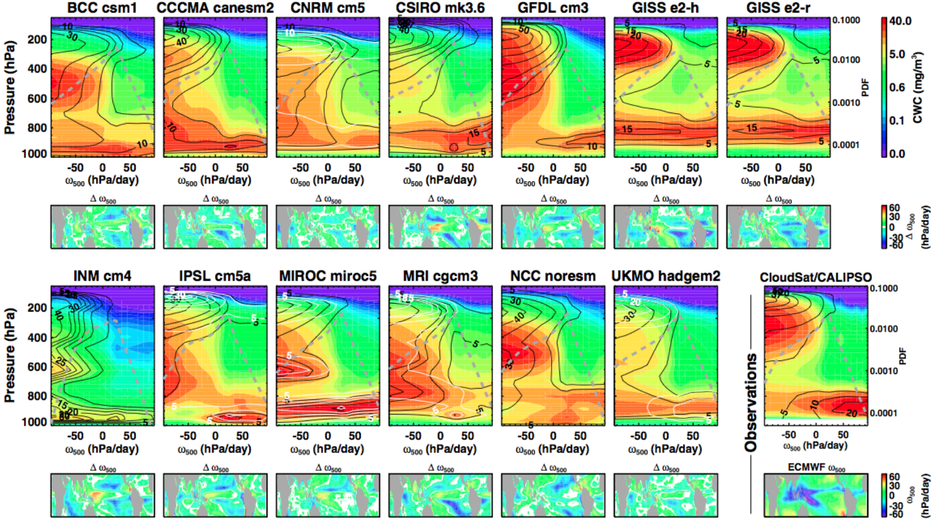
Double ITCZ (vertical resolution)

Mean precipitation for different vertical circulation regimes, 20S-0, 150W-100W.



Bellucci et al., J Climate, 2010

Cloud water content (vertical velocity)

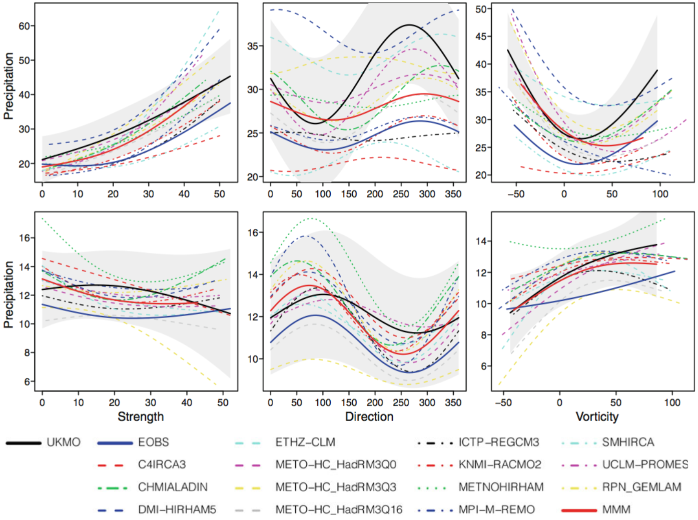


Su et al., J Geophys. Res., 2013

Using statistical models to validate dynamical models · RCM studies

Precipitation extremes in UK (circulation)

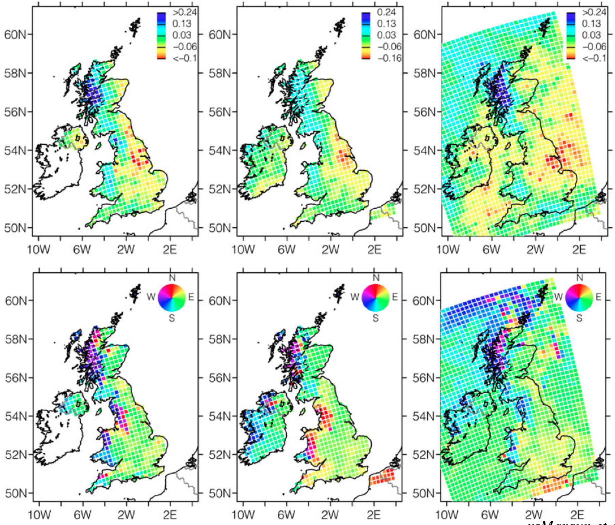
Relationship between median of monthly maximum precipitation and airflow indices; top: Kinnlochewe; bottom: Sandringham house



Maraun et al., Clim. Dynam., 2012

Precipitation extremes in UK (circulation)

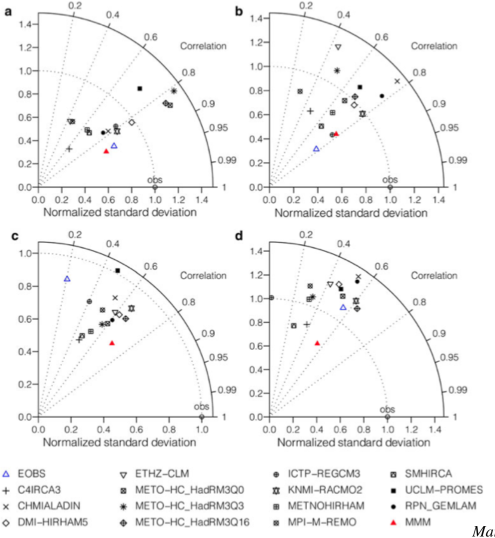
Top: dependence on flow strength; bottom: dependence on flow direction; left: UKMO data, centre: E-OBS, right: KNMI RACMO2



xsMaraun et al., Clim. Dynam., 2012

Precipitation extremes in UK (circulation)

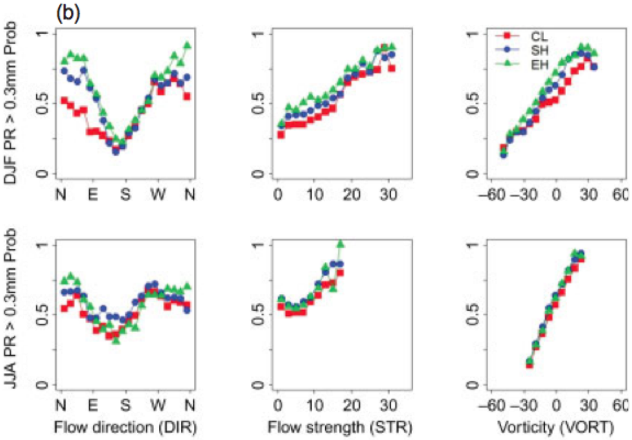
Taylor diagrams; a) anti-cyclonic vorticity, b) cyclonic vorticity, c) airflow direction, d) amplitude of direction dependence



Maraun et al., Clim. Dynam., 2012

Precipitation probability in Czech Republic (circulation)

CL: central lowlands; SH: southern highlands, EH: eastern highlands



Plavcova et al., Int. J. Climatol., 2014

Precipitation extremes in Czech Republic (circulation)

Table 6. Normalized relative occurrence of extreme precipitation per circulation types in the EH region.

	N	NE	W	NW	C	CN	CNE	CE	CSE	CS	CW	CNW
DJF												
OBS			2.61	2.75	3.76							
HIRHAM				2.44	4.01			3.62			2.67	
RACMO			1.91		6.27		7.39	6.08	4.07			
RegCM				2.19	2.26				3.82		4.11	
REMO	4.01			2.53	3.09		6.17	4.93				
RCA				2.79			6.22			3.90		
JJA												
OBS	4.28	2.93			3.95	4.37	5.18					
HIRHAM	3.76				3.61	12.74	6.99					
RACMO	3.75	4.16				8.46	4.03					
RegCM	4.47	3.07				5.65	5.15					5.56
REMO		2.84			5.90	3.87	3.93					
RCA	3.30				6.43	4.52						

Only ratios significantly greater than 1 at the 0.05 level (estimated by block bootstrapping, $R = 1000$) are shown.

Plavcova et al., Int. J. Climatol., 2014

Rationale

Sensitivity studies

Using dynamical models to validate statistical models

Using statistical models to validate dynamical models

Ideas for a process-oriented intercomparison

Steps of a process-oriented intercomparison

GEOMAR

1. Define relevant “weather regimes” for particular phenomenon of interest, at different spatial and temporal scales (e.g., meso-scale; synoptic scale; intr-annual, interannual, decadal variability);

2. Investigate relationship between weather regimes and local/regional surface climate;

3. assess the representation of this relationship in different downscaling models.